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SA-8 OPERATIONAL TRAJECTORY

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*George C. Marshall  
Space Flight Center,  
Huntsville, Alabama*

TECHNICAL MEMORANDUM X- 53262

SA-8 OPERATIONAL TRAJECTORY

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ABSTRACT

This report presents the operational predicted trajectory for Saturn I vehicle SA-8 to be flown over the Atlantic Missile Range. Included is a discussion of the vehicle and mission objectives, the trajectory shaping and constraints and a brief description of the vehicle. Wind limit criteria and range safety aspects are also summarized.

A successful flight will insert the depleted S-IV stage and payload into an orbit with perigee and apogee altitudes of 510 km and 754 km, respectively. This orbit has a nominal lifetime of 1200 days.

The payload consists of an Apollo boilerplate (BP-26) and a Meteoroid Technology Satellite (Pegasus). BP-26 is used to simulate the characteristics of an Apollo spacecraft whose ultimate mission will be a manned lunar landing and return to earth. After insertion into orbit, Pegasus will be exposed and, after wing deployment, will transmit micrometeoroid data to earth upon telemetered command.

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER

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TRAJECTORY SECTION  
FLIGHT MECHANICS BRANCH  
FLIGHT EVALUATION AND OPERATIONS STUDIES DIVISION  
AERO-ASTRODYNAMICS LABORATORY

## TABLE OF CONTENTS

	Page
I. INTRODUCTION.....	2
II. DESCRIPTION.....	2-3
III. RESULTS.....	4-13
IV. TABLES.....	14-29
V. FIGURES.....	30-34
VI. APPENDICES.....	35-41

LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
I	Fact Sheet.....	5-9
II	Pitch Tilt Program.....	10-11
III	Sequence of Events.....	12-13
IV-A	S-I Stage Nominal Trajectory.....	14
IV-B	S-I Stage Nominal Trajectory.....	15
V-A	S-IV Ullage Portion Trajectory.....	16
V-B	S-IV Ullage Portion Trajectory.....	17
VI-A	S-IV Stage Nominal Trajectory.....	18-19
VI-B	S-IV Stage Nominal Trajectory.....	20-21
VII-A	S-I Retro Portion Trajectory.....	22
VII-B	S-I Retro Portion Trajectory.....	23
VIII-A	S-I Coast to Impact Trajectory.....	24-26
VIII-B	S-I Coast to Impact Trajectory.....	27-29

## LIST OF ILLUSTRATIONS

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1	Pegasus Satellite.....	30
2	SA-8 Configuration.....	31
3	Altitude Versus Range.....	32
4	Chi Pitch Versus Time.....	33
5	Wind Speed Launch Criteria.....	34

TECHNICAL MEMORANDUM X- 53262

SA-8 OPERATIONAL TRAJECTORY

SUMMARY

ABSV

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The trajectory for SA-8 was optimized to insert the S-IV stage and payload into an elliptical orbit with perigee and apogee altitudes of 510 km and 754 km, respectively. This orbit has a predicted nominal lifetime of 1200 days.

The S-I stage pitch program was shaped to minimize the angle of attack through the region of high dynamic pressure under non-wind conditions. The S-IV stage uses the Iterative Guidance Mode (IGM) to guide an optimum path in the pitch plane and the delta minimum mode for cross range guidance.

The S-I booster will propel the vehicle to an altitude of 89 km with a range of 81 km. After separation of the two stage vehicle and approximately 2 sec of ullage rocket operation, the S-IV main stage will ignite. The S-IV main engines will burn until the guidance computer initiates Guidance Cutoff Signal (GCS), which occurs when the inertial velocity reaches 7672.06 m/s. Then, after 10 seconds to allow thrust decay, orbital insertion occurs at 638.58 sec from liftoff. Conditions at time of insertion: A velocity of 7675.18 m/s; a path angle (inertially referenced from the local vertical) of 90.000 deg; initial perigee altitude of 506.5 km and a corresponding apogee altitude of 751.2 km when referenced to a spherical earth of 6378.165 km.

The earliest S-I inboard engine failure which still results in a guidance cutoff is 90 seconds after liftoff. An outboard failure will not permit a guidance cutoff, but failure after 140 seconds from liftoff will result in at least a circular orbit (approximately 510 km altitude).

Author

## SECTION I. INTRODUCTION

The Block II vehicle SA-8, consisting of two live stages, Instrument Unit, Apollo Boilerplate, and Pegasus Payload (Figure 1), is scheduled to ascend from Launch Complex 37B, Atlantic Missile Range Facilities in late May. SA-8 will have a launch azimuth of 90 deg East-of-North (105 deg East-of-North flight azimuth).

This trajectory is based on propulsion (References 1 and 2) and mass (Reference 3) data provided by P&VE Laboratory. The first stage will be propelled by eight Rocketdyne H-1 engines providing a total thrust of 1.5 million pounds. Six 15,000 pound-thrust, Pratt & Whitney, RL10A-3 engines power the S-IV stage during flight. The S-I stage measures 6.5 meters in diameter and 24.5 meters in length. The S-IV stage is basically a 5.6 meter-diameter cylinder measuring 12.5 meters in length. With the Instrument Unit, Payload and Launch Escape System (LES), the total vehicle configuration stands approximately 57.3 meters and has a liftoff mass of 1,129,768 pounds. Found in Reference 4 is a more complete description of the vehicle and payload (see Figure 2). There will be no onboard camera coverage of separation.

Lifetime information presented in this report was obtained from the Operations Studies Branch, R-AERO-FO. The structurally imposed wind limits and Pegasus angular rate limitations summarized in Appendices A and B are provided by R-AERO-FMS. The Range Safety Summary, Appendix C, is provided by R-AERO-FMR.

## SECTION II. DESCRIPTION

The SA-8 vehicle will lift off from Pad 37B, rising vertically for 9 sec in order to clear the launch facilities and then simultaneously begin its pitch program and roll maneuver. The roll rate will be nominally one deg per second.

The first stage trajectory was shaped to minimize aerodynamic moments during the period of highest dynamic pressure. The tilt program is not biased for wind as the launch date is in a low wind



period. The entire flight program was optimized to attain the maximum performance while achieving the desired orbital mission objectives and constraints which, briefly are:

1. Guarantee a one-year lifetime
2. Guarantee a guidance cutoff
3. Limit the apogee altitude to approximately 750 km
4. Have a minimum of residual propellant at guidance cutoff.

A tilt arrest of 52.45 deg is programmed at 138 sec after liftoff to ensure ample damping time for various sloshing and transient motions in order to avoid premature cutoff and separation sequences. The separation sequence of events is commanded from a timer which is initiated by propellant level sensors (Reference 5).

After separation, tilt arrest is continued until 168 sec after liftoff, allowing sufficient time for the LES tower and ullage casings to be jettisoned. The Launch Escape System has only one active motor, the jettison motor. This motor provides the capability of separating the LES from the Command Module (CM) during an abort mode or during normal flight.

The Saturn guidance system, Iterative Guidance Mode (IGM), implemented approximately 17 sec after separation, will guide the S-IV vehicle to the desired terminal conditions. IGM terminal conditions are given in Appendix D. Guidance Cutoff Signal (GCS) is sent by the onboard computer (ASC-15) when the inertial velocity reaches 7672.06 m/s.

Orbital insertion is defined as 10 sec after GCS. Insertion conditions are given in Table 1. After GCS, the S-IV vehicle undergoes a 180 sec venting period to reduce LH<sub>2</sub> residuals. At this time the blowdown non-propulsive vents are closed and, one sec later, the Pegasus S-IV combination separates from the Apollo Boilerplate (809.58 sec flight time). The Pegasus satellite begins its wing deployment 60 sec after separation and terminates approximately 60 sec later (929.58 sec after liftoff).

The complete flight profile is presented in Figure 3 with the nominal pitch tilt program graphically presented in Figure 4.

### SECTION III. RESULTS

The SA-8 fact sheet found in Table I contains a summary of the vehicle characteristics, trajectory history and insertion and orbital conditions. Table II contains the tilt program and Table III the sequence of events for SA-8.

A detailed presentation of the predicted operational trajectory parameters is given in Tables IV through VIII. Table IV contains the S-I stage boost flight; Table V the S-IV ullage portion; Table VI the S-IV mainstage and orbital portion of flight to separation. The velocity increment imparted to the S-IV/Pegasus B at separation is 0.3 m/sec. The most sensitive direction for the delta velocity to affect the orbital shapes is along the total velocity direction. Normally the Pegasus velocity will be decreased, with maximum effect being reduction in apogee altitude by approximately 1 km. Table VII contains the S-I retro portion; Table VIII contains the S-I stage ballistic flight to impact. The S-I impact coordinates from the nominal trajectory are 25.7748 deg North geodetic latitude and 71.3160 deg West longitude and 965.97 km downrange.

No dispersion analysis was done from the SA-8 nominal trajectory due to its similarity to SA-9.

TABLE I  
SA-8 FACT SHEET

I. Mission

Vehicle	SA-8
Payload	Apollo Boilerplate and Pegasus Satellite

II. Configuration

S-I Stage	8 engines at (188k lbf)	836,266 newtons per engine (rated)
S-IV Stage	6 engines at ( 15k lbf)	66,723 newtons per engine (rated)
Payload	Orbital Configuration 22,651 lbm Apollo Boilerplate and Pegasus Satellite	

III. Mass Characteristics

Total Mass at Lift-Off	512,454 kg	(1,129,768 lbm)
Mass at First Stage Cutoff (OECO)	117,375 kg	( 258,767 lbm)
Mainstage Consumption During First Stage of Flight (To Separation)	392,769 kg	( 865,907 lbm)
Mass at Second Stage Ignition (152.29 sec)	62,109 kg	( 136,926 lbm)
Mass at Second Stage Cutoff (628.58 sec)	15,343 kg	( 33,826 lbm)
Mainstage Consumption During Second Stage of Flight	45,297 kg	( 99,863 lbm)
Flight Performance Reserve at S-IV Cutoff	236 kg LOX	( 522 lbm)
	48 kg LH <sub>2</sub>	(105 lbm)
Instrumentation Unit	1,212 kg	( 2,673 lbm)
Orbiting Payload (Pegasus Satellite)*	10,275 kg	( 22,651 lbm)

\*After Separation

NOTE: All values are inertial where applicable unless otherwise denoted

TABLE I (CONT)

## IV Trajectory and Orbit

A. Launch

Launch Complex and Pad	37B
Latitude	28.53185406 deg
Longitude	80.56495285 deg
Launch Azimuth	90° E of N
Flight Azimuth	105° E of N

B. Trajectory HistoryFirst Stage

S-I Stage Roll Tilt Initiation	9 sec
S-I Stage Pitch Tilt Initiation	9 sec
S-I Stage Roll Tilt Termination	24 sec
S-I Stage Roll Angle	15 deg
S-I Stage Mach One	55 sec
S-I Stage Maximum Dynamic Pressure	68 sec
S-I Level Sensors Enabled	138 sec
S-I Stage Pitch Tilt Arrest	138 sec
S-I Stage Pitch Angle at Tilt Arrest	52.45 deg
S-I Stage Inboard Engine Cutoff (IECO)	143.79 sec
S-I Stage Outboard Engine Cutoff (OECO)	149.79 sec
S-I Stage Velocity at OECO (Inertially Ref)	3,028.68 m/sec
(Earth Ref)	2,700.60 m/sec
S-I Stage Path Angle at OECO (Inertially Ref)	56.893 deg
(Earth Ref)	52.226 deg
S-I Stage Altitude at OECO	88.08 km
S-I Stage Range at OECO	79.54 km

TABLE I (CONT)

<u>Separation</u>	
Ullage Ignition (S-IV Stage)	150.49 sec
S-I/S-IV Separation	150.59 sec
Retro-Rocket Ignition (S-I Stage)	150.59 sec
<u>Second Stage</u>	
S-IV Stage (Main) Ignition	152.29 sec
S-IV Stage 90% Thrust Attained	1.8 sec (Approx.)
S-IV Stage Ullage Rocket Cutoff	154.29 sec
S-IV Stage Ullage Casing and LES Jettison	162.59 sec
S-IV Stage Guidance Initiation	168 sec
S-IV Stage Guidance Cutoff Signal (GCS)	628.582 sec
S-IV Stage Velocity at GCS	7,672.06 m/sec
S-IV Stage Path Angle at GCS	90.005 deg
S-IV Stage Altitude at GCS	509.642 km
S-IV Stage Range at GCS	1,856.39 km
S-IV Stage Latitude at GCS (Geocentric)	22.5547 deg
S-IV Stage Longitude at GCS	63.2171 deg (West)
<u>C. Insertion Conditions</u>	
Time	638.582 sec
Velocity	7,675.18 m/sec
Path Angle (Against Local Vertical)	89.9997 deg
Altitude (Oblate Earth)	509.570 km
Range	1,923.53 km
Latitude (Geocentric)	22.304 deg

TABLE I (CONT)

Longitude	62.6233 deg (West)
Azimuth	113.2214 deg
Excess Circular Velocity	66.14 m/sec
D. Orbital Characteristics (Spherical Earth; $R_e = 6,378.165$ km)	
Perigee Altitude	506.5 km
Apogee Altitude	751.2 km
Anomalistic Period	97.29 min
Semi-Major Axis	7,007 km
Eccentricity	.01746
Inclination	31.763 deg
Longitude of Ascending Node*	158.87 deg (East)
Argument of Perigee	133.85 deg
True Anomaly at Insertion	.0183 deg
Eccentric Anomaly at Insertion	.0180 deg
Mean Anomaly at Insertion	.0176 deg
Regression Rate of Node	-6.1 deg/day
Rate of Change of Argument of Perigee	9.4 deg/day
Vis Viva Energy (Twice Total Energy)	-56.99 km <sup>2</sup> /sec <sup>2</sup>
E. Lifetime Characteristics	
Nominal Lifetime	1,200 days
Guaranteed Lifetime	844 days
Ballistic Parameters for Tumbling Vehicle	
$C_{DA}$	265 m <sup>2</sup>

\*Only flight time is reflected due to uncertainty of sidereal time of launch.

TABLE I (CONT)

Post Venting Orbital Mass	10,275 kg
Ballistic Coefficient ( $C_D A/M$ )	.026 m <sup>2</sup> /kg

V. Control

Active Sensors                      Rate Gyro and Vehicle-Fixed Accelerometers

VI. Guidance

1. First Stage                                      Time Function Polynomial
2. Second Stage
  - (a) In Plane (IGM)
  - (b) Crossrange (Delta Min)

TABLE II

## PITCH TILT PROGRAM FOR SATURN I VEHICLE SA-8

Flight Time (sec)	(deg)	Flight Time (sec)	(deg)	Flight Time (sec)	(deg)
0	0	33	6.70	66	24.65
1	0	34	7.15	67	25.25
2	0	35	7.65	68	25.80
3	0	36	8.10	69	26.35
4	0	37	8.60	70	26.95
5	0	38	9.10	71	27.50
6	0	39	9.60	72	28.10
7	0	40	10.10	73	28.65
8	0	41	10.65	74	29.15
9	0	42	11.10	75	29.75
10	0.25	43	11.70	76	30.30
11	0.30	44	12.25	77	30.80
12	0.45	45	12.80	78	31.40
13	0.60	46	13.30	79	31.90
14	0.65	47	13.90	80	32.45
15	0.90	48	14.40	81	33.00
16	1.05	49	14.90	82	33.50
17	1.25	50	15.50	83	34.05
18	1.45	51	16.10	84	34.50
19	1.70	52	16.60	85	35.00
20	1.95	53	17.15	86	35.50
21	2.25	54	17.75	87	36.00
22	2.50	55	18.30	88	36.45
23	2.85	56	18.85	89	36.90
24	3.20	57	19.45	90	37.40
25	3.50	58	20.00	91	37.85
26	3.85	59	20.60	92	38.25
27	4.25	60	21.20	93	38.75
28	4.60	61	21.75	94	39.15
29	5.00	62	22.35	95	39.65
30	5.45	63	22.90	96	40.00
31	5.85	64	23.50	97	40.40
32	6.25	65	24.05	98	40.85



TABLE II (CONT'D)

Flight Time (sec)	(deg)	Flight Time (sec)	(deg)
99	41.20	134	51.75
100	41.65	135	51.75
101	42.00	136	52.15
102	42.35	137	52.40
103	42.80	138	52.45
104	43.15	*168	52.45
105	43.50		
106	43.85		
107	44.25	*Time of IGM	
108	44.60		
109	44.90		
110	45.25		
111	45.55		
112	45.90		
113	46.25		
114	46.50		
115	46.85		
116	47.15		
117	47.50		
118	47.70		
119	48.05		
120	48.35		
121	48.60		
122	48.85		
123	49.10		
124	49.40		
125	49.65		
126	49.90		
127	50.15		
128	50.40		
129	50.60		
130	50.85		
131	51.10		
132	51.30		
133	51.50		

TABLE III  
SA-8 SEQUENCE OF EVENTS

Time (From Lift-off)	Event
0	Lift-off
9.0	Initiate Roll and Pitch Tilt
24.0	Terminate Roll
138.0	Signal from Sequencer to Enable Level Sensors
138.0	Tilt Arrest
142.0	S-I Stage Level Sensor Signal
143.79	Inboard Cutoff (S-I Stage)
149.79	Outboard Cutoff (S-I Stage)
150.49	Ullage Rocket Ignition (S-IV Stage)
150.59	Separation, Immediately Followed by Retro Rocket Ignition (S-I Stage)
152.29	S-IV Mainstage Ignition
154.29	Ullage Rocket Thrust Termination
162.59	Jettison Ullage Rocket Casing and LES
168.	Initiate Active Guidance
591.	Signal from Sequencer to Arm LOX Cutoff Capability
628.582	S-IV Stage Guidance Cutoff Signal
638.582	End of Powered Flight
808.582	Close Blowdown Non-Propellant Vents

TABLE III (CONT'D)

809.582	Start S-IV Pegasus/Apollo Separation
869.582	Begin Pegasus Wing Deployment
929.582	Terminate Wing Deployment

TABLE IV-A  
S-I STAGE NOMINAL TRAJECTORY

TIME (SEC)	GROUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELOCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATION V DDT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
0.0	0.00	0.03	408.9	90.00	0.00	512454	0	6561766	0.00	44130
5.0	-0.00	0.07	409.3	87.64	3.68	499130	167	6734407	0.05	21345
10.0	-0.00	0.20	410.5	84.94	4.07	485806	763	6767009	0.10	43351
15.0	-0.00	0.44	413.3	81.98	4.50	472388	1890	6807521	0.17	69335
20.0	0.00	0.78	418.6	78.81	4.94	458970	3634	6849373	0.24	98599
25.0	0.02	1.25	427.2	75.49	5.42	445517	6043	6894554	0.31	132581
30.0	0.05	1.86	440.2	72.13	5.94	432063	9114	6949222	0.40	174985
35.0	0.13	2.61	458.2	68.83	6.49	418597	12775	7011122	0.49	232203
40.0	0.25	3.52	481.7	65.72	7.08	405131	16874	7077682	0.60	299830
45.0	0.44	4.59	510.9	62.92	7.64	391668	21168	7146534	0.72	406176
50.0	0.72	5.84	545.6	60.54	8.10	378205	25286	7217692	0.85	575768
55.0	1.12	7.27	584.4	58.67	8.06	364716	28679	7286398	0.99	943544
60.0	1.65	8.88	626.2	57.34	8.66	351228	30835	7349355	1.15	1083360
65.0	2.34	10.66	674.3	56.31	9.82	337698	32118	7410945	1.34	1055521
70.0	3.21	12.62	729.9	55.49	11.32	324168	33396	7467592	1.56	945552
75.0	4.31	14.80	794.2	54.86	13.07	310648	33396	7520701	1.80	792418
80.0	5.67	17.20	868.1	54.39	14.99	297128	26524	7563996	2.06	625607
85.0	7.33	19.86	952.3	54.09	17.04	283678	21359	7598590	2.30	459046
90.0	9.35	22.79	1047.0	53.95	19.12	270229	16704	7621156	2.57	323337
95.0	11.77	26.02	1152.1	53.94	21.21	256776	12665	7634261	2.87	222280
100.0	14.63	29.58	1267.8	54.04	23.37	243323	9241	7639022	3.20	144658
105.0	17.99	33.47	1394.3	54.22	25.62	229891	6434	7638283	3.53	88961
110.0	21.90	37.73	1532.2	54.47	28.01	216458	4306	7637132	3.88	55047
115.0	26.41	42.38	1682.4	54.75	30.59	203043	2790	7629379	4.24	33279
120.0	31.58	47.44	1845.9	55.06	33.43	189628	1771	7620251	4.65	19853
125.0	37.47	52.95	2024.2	55.39	36.64	176255	1129	7610172	5.23	10372
130.0	44.15	58.94	2219.4	55.71	40.28	162881	680	7594647	6.00	3458
135.0	51.69	65.46	2433.9	56.02	44.48	149571	368	7577804	6.94	928
140.0	60.18	72.55	2670.8	56.30	49.37	136260	170	7549507	8.09	97
143.8	67.31	78.35	2867.5	56.45	53.71	126203	83	7529378	9.11	62
145.0	69.71	80.28	2907.2	56.53	26.10	123761	63	3963859	9.38	58
(2) 149.8	79.54	88.08	3028.7	56.89	25.35	117375	17	3660189	10.02	24
150.0	80.06	88.49	3034.3	56.91	12.19	116884	16	2106452	10.04	23
(3) 150.6	81.23	89.40	3034.0	56.98	-3.48	116601	14	271659	10.04	19

- (1) IEEO
- (2) OEEO
- (3) Separation

TABLE IV-B  
S-I STAGE NOMINAL TRAJECTORY

EARTH FIXED PARAMETERS										LONGITUDE		GEOD. LAT.		GEOC. LAT.	
TIME (SEC)	XXE (KM)	YYE (KM)	ZZE (KM)	DXE (M/SEC)	DYE (M/SEC)	DZE (M/SEC)	VEL (M/SEC)	PATH ANGLE (DEG)	(POSITIVE WEST) (DEG)	(POSITIVE NORTH) (DEG)	(POSITIVE NORTH) (DEG)	(POSITIVE NORTH) (DEG)			
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	80.5650	28.5319	28.3707	28.3707			
5.0	-0.0	0.1	-0.0	-0.0	16.9	-0.0	16.9	0.28	80.5650	28.5319	28.3707	28.3707			
10.0	-0.0	0.2	-0.0	-0.1	36.2	-0.1	36.2	0.30	80.5650	28.5319	28.3707	28.3707			
15.0	-0.0	0.4	-0.0	0.3	57.6	-0.1	57.6	0.34	80.5649	28.5319	28.3707	28.3707			
20.0	0.0	0.8	-0.0	1.7	81.2	-0.1	81.2	1.16	80.5649	28.5319	28.3707	28.3707			
25.0	0.0	1.3	-0.0	4.7	107.0	-0.1	107.1	2.51	80.5648	28.5319	28.3707	28.3707			
30.0	0.1	1.9	-0.0	10.2	135.1	-0.1	135.5	4.29	80.5644	28.5318	28.3706	28.3706			
35.0	0.1	2.6	-0.0	18.8	165.5	-0.0	166.5	6.43	80.5637	28.5316	28.3705	28.3705			
40.0	0.2	3.5	-0.0	31.0	198.1	0.0	200.5	8.84	80.5625	28.5314	28.3702	28.3702			
45.0	0.4	4.6	-0.0	47.2	232.6	0.1	237.3	11.42	80.5606	28.5309	28.3698	28.3698			
50.0	0.7	5.8	-0.0	67.8	268.3	0.2	276.7	14.13	80.5578	28.5303	28.3691	28.3691			
55.0	1.1	7.3	0.0	92.5	303.8	0.4	317.6	16.88	80.5538	28.5294	28.3682	28.3682			
60.0	1.7	8.9	0.0	121.2	337.8	0.5	358.9	19.67	80.5486	28.5282	28.3670	28.3670			
65.0	2.3	10.7	0.0	155.6	373.9	0.7	405.0	22.53	80.5418	28.5266	28.3654	28.3654			
70.0	3.2	12.6	0.0	196.7	413.3	1.0	457.7	25.38	80.5332	28.5246	28.3634	28.3634			
75.0	4.3	14.8	0.0	245.4	456.8	1.3	518.6	28.16	80.5224	28.5220	28.3609	28.3609			
80.0	5.7	17.2	0.0	302.5	505.0	1.6	588.6	30.83	80.5090	28.5188	28.3577	28.3577			
85.0	7.4	19.9	0.0	368.8	557.8	2.0	668.7	33.36	80.4925	28.5149	28.3538	28.3538			
90.0	9.4	22.8	0.0	444.8	615.2	2.5	759.1	35.74	80.4727	28.5101	28.3490	28.3490			
95.0	11.8	26.0	0.1	530.5	676.8	3.0	859.9	37.94	80.4488	28.5044	28.3434	28.3434			
100.0	14.7	29.6	0.1	626.2	742.5	3.6	971.3	39.97	80.4206	28.4977	28.3366	28.3366			
105.0	18.1	33.4	0.1	732.2	812.5	4.4	1093.7	41.82	80.3875	28.4897	28.3287	28.3287			
110.0	22.1	37.7	0.1	848.9	886.9	5.2	1227.7	43.51	80.3489	28.4804	28.3194	28.3194			
115.0	26.6	42.3	0.1	977.1	966.1	6.0	1374.1	45.05	80.3045	28.4697	28.3087	28.3087			
120.0	31.9	47.4	0.2	1117.7	1050.7	7.0	1534.0	46.45	80.2536	28.4573	28.2964	28.2964			
125.0	37.8	52.8	0.2	1272.1	1141.4	8.1	1709.1	47.72	80.1957	28.4432	28.2824	28.2824			
130.0	44.6	58.8	0.3	1441.7	1239.2	9.4	1901.2	48.88	80.1300	28.4272	28.2664	28.2664			
135.0	52.3	65.2	0.3	1628.7	1345.9	10.8	2112.8	49.92	80.0558	28.4090	28.2483	28.2483			
140.0	60.9	72.3	0.4	1835.2	1463.1	12.4	2347.1	50.85	79.9723	28.3885	28.2279	28.2279			
(1) 143.8	68.2	78.0	0.4	2005.7	1562.1	13.8	2542.3	51.44	79.9022	28.3713	28.2107	28.2107			
(2) 149.8	80.7	87.6	0.5	2041.8	1579.4	14.2	2581.6	51.61	79.8786	28.3655	28.2049	28.2049			
(2) 150.0	81.2	88.0	0.5	2156.3	1625.9	15.8	2700.6	52.23	79.7821	28.3416	28.1811	28.1811			
(3) 150.6	82.4	88.9	0.5	2161.6	1627.9	15.9	2706.1	52.26	79.7769	28.3403	28.1798	28.1798			
				2163.5	1624.3	16.0	2705.4	52.33	79.7655	28.3374	28.1770	28.1770			

(1) IECO

(2) OEEO

(3) Separation

TABLE V-A  
S-IV ULLAGE PORTION TRAJECTORY

TIME (SEC)	GROUND DISTANCE (KM)	ALFITUDE (KM)	SPACE FIXED VELOCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATION V DOT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
150.6	81.23	89.40	3034.0	56.98	-4.81	62186	14	62517	10.04	117
151.0	82.09	90.08	3032.2	57.03	-4.80	62167	12	62517	10.03	103
152.3	84.81	92.20	3026.8	57.19	-4.77	62109	8	62517	9.83	68

TABLE V-B

S-IV ULLAGE PORTION TRAJECTORY

TIME (SEC)	XXE (KM)	YYE (KM)	ZZE (KM)	EARTH FIXED PARAMETERS			PATH ANGLE (DEG)	LONGITUDE		LAT.	
				DXE (M/SEC)	DYVE (M/SEC)	DZVE (M/SEC)		(POSITIVE WEST) (DEG)	(POSITIVE NORTH) (DEG)	(POSITIVE NORTH) (DEG)	(POSITIVE NORTH) (DEG)
150.6	82.4	88.9	0.5	2163.5	1624.3	16.0	52.33	79.7655	28.3374	28.1770	
151.0	83.3	89.5	0.5	2163.7	1620.8	16.1	52.38	79.7570	28.3353	28.1749	
152.3	86.1	91.6	0.5	2164.3	1609.7	16.4	52.56	79.7303	28.3287	28.1682	

TABLE VI-A  
S-IV STAGE NOMINAL TRAJECTORY

TIME (SEC)	GROUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELOCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATION V DDT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
152.3	84.81	92.20	3026.8	57.19	-4.76	62109	8	63320	9.83	68
153.0	86.31	93.36	3024.1	57.28	-4.42	62080	6	83206	9.73	54
162.6	106.69	108.79	3033.4	58.39	1.10	61216	0	408862	8.43	4
163.0	107.57	109.44	3034.1	58.44	1.27	59763	0	408832	8.38	4
(1) 168.0	118.35	117.32	3043.5	59.00	1.41	59273	0	408464	7.39	1
173.0	129.22	125.10	3053.3	59.53	1.49	58783	0	408118	6.29	0
183.0	151.24	140.40	3073.1	60.45	1.65	57803	0	407690	4.91	0
193.0	173.61	155.38	3095.3	61.35	1.95	56824	0	406958	4.24	0
203.0	196.35	170.05	3120.4	62.25	2.24	55845	0	406473	3.97	0
213.0	219.49	184.40	3148.2	63.14	2.53	54869	0	405844	3.84	0
223.0	243.03	198.45	3178.9	64.03	2.83	53892	0	406131	3.77	0
233.0	267.01	212.20	3212.5	64.91	3.13	52914	0	405393	3.72	0
243.0	291.44	225.66	3248.8	65.78	3.41	51940	0	404173	3.67	0
253.0	316.34	238.81	3287.9	66.65	3.70	50971	0	402800	3.65	0
263.0	341.72	251.68	3329.7	67.50	3.99	50005	0	401393	3.64	0
273.0	367.62	264.25	3374.3	68.35	4.28	49045	0	399979	3.64	0
283.0	394.05	276.54	3421.7	69.18	4.58	48088	0	399181	3.64	0
293.0	421.03	288.53	3472.2	70.00	4.90	47134	0	398618	3.65	0
303.0	448.58	300.23	3525.6	70.81	5.22	46180	0	398204	3.66	0
313.0	476.73	311.65	3582.2	71.61	5.55	45227	0	397936	3.68	0
323.0	505.50	322.79	3641.9	72.39	5.89	44275	0	397888	3.71	0
333.0	534.91	333.64	3705.0	73.16	6.23	43323	0	397799	3.75	0
343.0	565.00	344.20	3771.4	73.91	6.58	42371	0	397660	3.79	0
353.0	595.78	354.49	3841.2	74.65	6.93	41419	0	397310	3.83	0
363.0	627.29	364.48	3914.4	75.38	7.29	40468	0	397027	3.88	0
373.0	659.55	374.19	3991.0	76.09	7.65	39520	0	396389	3.93	0
383.0	692.59	383.61	4071.2	76.79	8.02	38572	0	395900	3.98	0
393.0	726.44	392.74	4155.0	77.47	8.40	37626	0	395628	4.04	0
403.0	761.12	401.58	4242.6	78.14	8.80	36680	0	395632	4.11	0
413.0	796.68	410.11	4334.2	78.80	9.21	35734	0	395733	4.18	0
423.0	833.13	418.35	4429.8	79.44	9.63	34787	0	395877	4.26	0
433.0	870.53	426.28	4529.6	80.06	10.07	33840	0	395952	4.35	0
443.0	908.90	433.91	4633.7	80.68	10.51	32893	0	395679	4.44	0
453.0	948.28	441.22	4742.2	81.28	10.96	31947	0	395300	4.53	0
463.0	988.70	448.21	4855.1	81.87	11.43	31002	0	395006	4.63	0
473.0	1030.22	454.88	4972.8	82.44	11.92	30057	0	394828	4.73	0
483.0	1072.86	461.21	5095.5	83.00	12.43	29114	0	394843	4.84	0
493.0	1116.68	467.21	5223.4	83.55	12.98	28170	0	395077	4.96	0
503.0	1161.72	472.85	5356.8	84.09	13.56	27225	0	395270	5.08	0
513.0	1208.02	478.15	5496.0	84.62	14.16	26280	0	395529	5.21	0



TABLE VI-A (CONT)  
S-IV STAGE NOMINAL TRAJECTORY

TIME (SEC)	GROUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELOCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATION V DOT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
523.0	1255.66	483.08	5641.4	85.13	14.79	25334	0	395520	5.34	0
533.0	1304.67	487.63	5793.1	85.63	15.45	24388	0	395259	5.48	0
543.0	1355.12	491.80	5951.5	86.12	16.15	23443	0	395233	5.63	0
553.0	1407.07	495.58	6117.3	86.60	16.92	22498	0	395532	5.79	0
563.0	1460.59	498.94	6290.9	87.07	17.74	21551	0	395778	5.95	0
573.0	1515.75	501.89	6472.9	87.54	18.62	20604	0	395898	6.13	0
583.0	1572.64	504.40	6664.0	87.99	19.56	19657	0	396003	6.32	0
593.0	1631.34	506.45	6864.7	88.44	20.57	18709	0	395790	6.52	0
603.0	1691.95	508.01	7076.0	88.88	21.67	17762	0	395580	6.72	0
613.0	1754.56	509.07	7298.7	89.33	22.87	16817	0	395241	6.95	0
623.0	1819.29	509.59	7534.1	89.76	24.26	15871	0	395227	7.18	0
(2) 628.6	1856.39	509.64	7672.1	90.00	25.21	15343	0	396538	7.32	0
(3) 633.1	1886.60	509.61	7675.2	90.01	0.01	15313	0	0	7.33	0
(3) 638.6	1923.53	509.57	7675.2	90.00	0.01	15313	0	0	7.33	0
683.6	2221.75	509.42	7675.2	89.95	0	15300	0	0	7.33	0
733.6	2257.46	509.57	7674.8	89.90	-.01	15285	0	0	7.33	0
783.6	2893.12	510.09	7674.0	89.85	-.01	15271	0	0	7.33	0
(4) 809.6	3067.64	510.49	7673.5	89.82	-.02	15263	0	0	7.33	0

(1) Initiate Active Guidance

(2) GCS

(3) Insertion

(4) S-IV Pegasus/Apollo Separation

TABLE VI-B

## S-IV STAGE NOMINAL TRAJECTORY

20	TIME (SEC)	XXE (KM)	YYE (KM)	ZZE (KM)	EARTH FIXED PARAMETERS				PATH ANGLE (DEG)	LØNGITUDE (PØSITIVE WEST) (DEG)	GEØD. LAT. (PØSITIVE NØRTH) (DEG)	GEØC. LAT. (PØSITIVE NØRTH) (DEG)
					DXE (M/SEC)	DYE (M/SEC)	DZE (M/SEC)	VELØCITY (M/SEC)				
	152.3	86.1	91.6	0.5	2164.3	1609.7	16.4	2697.3	52.56	79.7303	28.3287	28.1682
	153.0	87.6	92.8	0.6	2164.7	1603.7	16.5	2694.1	52.65	79.7156	28.3250	28.1646
	162.6	108.6	107.9	0.7	2207.2	1551.4	18.4	2698.0	53.90	79.5156	28.2749	28.1147
	163.0	109.5	108.5	0.7	2209.3	1549.4	18.5	2698.5	53.95	79.5070	28.2728	28.1126
(1)	168.0	120.6	116.2	0.8	2234.4	1524.8	19.4	2705.2	54.58	79.4014	28.2461	28.0860
	173.0	131.8	123.8	0.9	2259.2	1501.0	21.7	2712.5	55.20	79.2949	28.2191	28.0591
	183.0	154.7	138.6	1.2	2304.4	1459.6	27.2	2727.9	56.25	79.0795	28.1638	28.0040
	193.0	177.9	153.0	1.5	2350.7	1419.0	31.9	2746.0	57.28	78.8611	28.1068	27.9472
	203.0	201.7	166.9	1.8	2399.2	1377.9	36.0	2767.0	58.32	78.6393	28.0482	27.8888
	213.0	225.9	180.5	2.2	2449.5	1336.8	39.6	2790.8	59.36	78.4141	27.9880	27.8288
	223.0	250.7	193.7	2.6	2501.8	1295.6	42.9	2817.6	60.40	78.1852	27.9260	27.7671
	233.0	276.0	206.4	3.0	2555.9	1254.2	45.9	2847.4	61.42	77.9524	27.8624	27.7037
	243.0	301.8	218.8	3.5	2612.0	1212.4	48.8	2880.1	62.44	77.7157	27.7969	27.6385
	253.0	328.2	230.7	4.0	2670.1	1170.1	51.5	2915.7	63.45	77.4747	27.7297	27.5715
	263.0	355.2	242.2	4.5	2730.0	1127.3	54.3	2954.1	64.45	77.2293	27.6605	27.5026
	273.0	382.8	253.2	5.1	2791.9	1083.7	57.0	2995.4	65.44	76.9794	27.5893	27.4317
	283.0	411.1	263.8	5.7	2855.9	1039.4	59.8	3039.7	66.42	76.7247	27.5161	27.3588
	293.0	439.9	274.0	6.3	2922.0	994.3	62.7	3087.1	67.38	76.4651	27.4408	27.2837
	303.0	469.5	283.7	6.9	2990.3	948.4	65.7	3137.7	68.33	76.2004	27.3632	27.2064
	313.0	499.8	293.0	7.6	3060.8	901.5	68.8	3191.6	69.26	75.9304	27.2833	27.1268
	323.0	530.7	301.7	8.3	3133.8	853.6	72.0	3248.8	70.18	75.6549	27.2009	27.0448
	333.0	562.4	310.0	9.1	3209.2	804.6	75.3	3309.4	71.07	75.3737	27.1160	26.9602
	343.0	594.9	317.8	9.8	3287.1	754.4	78.8	3373.5	71.95	75.0866	27.0285	26.8730
	353.0	628.2	325.1	10.6	3367.5	702.7	82.4	3441.0	72.82	74.7933	26.9382	26.7831
	363.0	662.3	331.9	11.5	3450.5	649.5	86.0	3512.2	73.66	74.4937	26.8449	26.6902
	373.0	697.2	338.1	12.4	3536.1	594.5	89.8	3586.9	74.48	74.1875	26.7487	26.5943
	383.0	733.0	343.8	13.3	3624.3	537.7	93.8	3665.2	75.29	73.8745	26.6493	26.4953
	393.0	769.7	348.8	14.2	3715.3	478.9	97.8	3747.3	76.08	73.5545	26.5466	26.3931
	403.0	807.3	353.3	15.2	3809.1	417.9	101.9	3833.3	76.85	73.2271	26.4405	26.2874
	413.0	845.9	357.2	16.3	3905.8	354.7	106.2	3923.3	77.61	72.8923	26.3308	26.1781
	423.0	885.4	360.4	17.4	4005.6	289.0	110.5	4017.5	78.34	72.5496	26.2174	26.0652
	433.0	926.0	363.0	18.5	4108.5	220.7	115.0	4116.0	79.05	72.1989	26.1000	25.9483
	443.0	967.6	364.8	19.7	4214.5	149.6	119.5	4218.9	79.75	71.8399	25.9787	25.8274
	453.0	1010.3	365.9	20.9	4323.7	75.3	124.2	4326.2	80.43	71.4722	25.8530	25.7023
	463.0	1054.1	366.3	22.1	4436.2	-2.3	129.0	4438.1	81.10	71.0956	25.7229	25.5728
	473.0	1099.1	365.9	23.5	4552.0	-83.5	133.9	4554.8	81.74	70.7097	25.5882	25.4386
	483.0	1145.2	364.6	24.8	4671.4	-168.5	139.0	4676.5	82.37	70.3144	25.4486	25.2996
	493.0	1192.5	362.5	26.2	4794.5	-257.5	144.1	4803.6	82.99	69.9091	25.3040	25.1556
	503.0	1241.1	359.5	27.7	4921.5	-350.7	149.4	4936.3	83.59	69.4937	25.1540	25.0363
	513.0	1290.9	355.5	29.2	5052.6	-448.7	154.7	5074.8	84.17	69.0676	24.9985	24.8515

TABLE VI-B (CONT)

S-IV STAGE NOMINAL TRAJECTORY

TIME (SEC)	EARTH FIXED PARAMETERS										LONGITUDE (POSITIVE WEST) (DEG)		GEO. LAT. (POSITIVE NORTH) (DEG)		GEOG. LAT. (POSITIVE NORTH) (DEG)	
	XXE (KM)	YYE (KM)	ZZE (KM)	DXE (M/SEC)	DYE (M/SEC)	DZE (M/SEC)	VELOCITY (M/SEC)	PATH ANGLE (DEG)	WEST	NORTH	WEST	NORTH	WEST	NORTH		
523.0	1342.1	350.5	30.8	5187.8	-551.8	160.2	5219.6	84.74	68.6305	24.8372	24.6908					
533.0	1394.7	344.4	32.4	5327.4	-660.2	165.9	5370.7	85.29	68.1820	24.6698	24.5241					
543.0	1448.7	337.3	34.1	5471.5	-774.5	171.6	5528.7	85.83	67.7216	24.4959	24.3511					
553.0	1504.2	328.9	35.9	5620.4	-895.1	177.5	5694.0	86.35	67.2489	24.3153	24.1713					
563.0	1561.1	319.3	37.7	5774.5	-1022.6	183.5	5867.2	86.86	66.7633	24.1277	23.9845					
573.0	1619.7	308.4	39.5	5934.1	-1157.7	189.6	6049.0	87.36	66.2644	23.9326	23.7902					
583.0	1679.8	296.2	41.5	6099.5	-1301.1	195.9	6239.8	87.85	65.7514	23.7296	23.5881					
593.0	1741.7	282.4	43.4	6270.9	-1453.8	202.3	6440.4	88.34	65.2239	23.5182	23.3778					
603.0	1805.3	267.0	45.5	6448.7	-1616.7	208.8	6651.5	88.81	64.6810	23.2981	23.1587					
613.0	1870.7	250.0	47.6	6633.2	-1791.1	215.5	6874.1	89.29	64.1221	23.0687	22.9303					
623.0	1937.9	231.2	49.8	6825.3	-1977.6	222.3	7109.5	89.75	63.5462	22.8294	22.6922					
(2) 628.6	1976.4	219.8	51.1	6936.7	-2087.3	226.1	7247.5	90.01	63.2171	22.6913	22.5547					
633.1	2007.6	210.4	52.1	6929.7	-2121.1	227.7	7250.6	90.01	62.9496	22.5783	22.4422					
(3) 638.6	2045.6	198.6	53.3	6917.5	-2160.5	229.6	7250.6	90.00	62.6233	22.4395	22.3041					
683.6	2350.6	95.6	63.9	6810.6	-2476.0	244.2	7250.9	89.95	60.0130	21.2915	21.1616					
733.6	2687.7	-37.0	76.5	6672.8	-2824.8	258.9	7250.7	89.90	57.1272	19.9447	19.8216					
783.6	3017.6	-186.8	89.7	6516.9	-3165.8	271.6	7250.2	89.84	54.2947	18.5451	18.4293					
(4) 809.6	3185.9	-271.3	96.9	6428.7	-3339.8	277.5	7249.8	89.81	52.8419	17.7980	17.6863					

(1) Initiate Active Guidance

(2) GCS

(3) Insertion

(4) S-IV Pegasus/Apollo Separation

TABLE VII-A  
S-I RETRO PORTION TRAJECTORY

N	TIME (SEC)	GRØUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELOCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATION V DØT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
(1)	150.6	81.23	89.40	3034.0	56.98	-10.91	54515	14	275724	10.04	2135
	151.0	82.09	90.07	3029.5	57.04	-12.36	54356	12	354417	10.02	1877
	151.6	83.33	91.04	3021.9	57.12	-14.48	54124	10	468726	9.91	1539
	152.6	85.44	92.68	3006.6	57.27	-16.70	53781	7	587092	9.72	1108
(2)	153.0	86.38	93.40	3001.0	57.34	-5.78	53704	6	3	9.64	960

- (1) Retro Ignition  
(2) Retro E. T. D.

TABLE VII-B  
S-I RETRO PORTION TRAJECTORY

TIME (SEC)	EARTH FIXED PARAMETERS					PATH ANGLE (DEG)	LONGITUDE (POSITIVE WEST) (DEG)		GEOG. LAT. (POSITIVE NORTH) (DEG)		GEOG. LAT. (POSITIVE NORTH) (DEG)	
	XXE (KM)	YYE (KM)	ZZE (KM)	DXE (M/SEC)	DYE (M/SEC)		DZE (M/SEC)	VELCITY (M/SEC)	WEST (DEG)	NORTH (DEG)	WEST (DEG)	NORTH (DEG)
(1) 150.6	82.4	88.9	0.5	2163.5	1624.3	16.0	2705.4	79.7655	28.3374	79.7655	28.3374	28.1770
151.0	83.3	89.5	0.5	2161.5	1619.1	16.1	2700.7	79.7570	28.3353	79.7570	28.3353	28.1749
151.6	84.6	90.5	0.5	2157.7	1610.9	16.2	2692.8	79.7448	28.3323	79.7448	28.3323	28.1718
152.6	86.7	92.1	0.6	2149.3	1595.3	16.3	2676.7	79.7242	28.3272	79.7242	28.3272	28.1667
(2) 153.0	87.7	92.8	0.6	2146.6	1589.1	16.4	2670.9	79.7149	28.3248	79.7149	28.3248	28.1644

(1) Retro Ignition  
(2) Retro. E. T. D.

TABLE VIII-A

S-I COAST TO IMPACT TRAJECTORY

TIME (SEC)	GRØUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELOCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATION V DØT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
153.0	86.38	93.40	3001.0	57.34	-5.78	53704	6	0	9.64	961
156.0	92.57	98.16	2985.8	57.73	-5.71	53704	3	0	9.24	399
162.0	105.08	117.56	2955.7	58.53	-5.57	53704	1	0	8.29	78
168.0	117.55	116.66	2926.3	59.34	-5.44	53704	0	0	7.13	19
174.0	129.99	125.45	2897.8	60.17	-5.31	53704	0	0	5.88	6
180.0	142.38	133.93	2870.0	61.02	-5.17	53704	0	0	4.98	3
186.0	154.73	142.11	2843.1	61.88	-5.03	53704	0	0	4.39	1
192.0	167.05	149.99	2816.9	62.76	-4.89	53704	0	0	3.96	1
198.0	179.34	157.57	2791.6	63.65	-4.74	53704	0	0	3.70	1
204.0	191.59	164.84	2767.2	64.56	-4.59	53704	0	0	3.53	0
210.0	203.81	171.81	2743.6	65.48	-4.44	53704	0	0	3.39	0
216.0	216.00	178.48	2720.9	66.42	-4.28	53704	0	0	3.29	0
222.0	228.16	184.85	2699.0	67.37	-4.12	53704	0	0	3.20	0
228.0	240.29	190.92	2678.1	68.34	-3.95	53704	0	0	3.12	0
234.0	252.40	196.69	2658.1	69.32	-3.78	53704	0	0	3.06	0
240.0	264.49	202.17	2639.0	70.32	-3.61	53704	0	0	3.00	0
246.0	276.55	207.34	2620.8	71.32	-3.44	53704	0	0	2.94	0
252.0	288.58	212.22	2603.6	72.35	-3.26	53704	0	0	2.89	0
258.0	300.60	216.80	2587.4	73.38	-3.08	53704	0	0	2.85	0
264.0	312.60	221.08	2572.1	74.43	-2.89	53704	0	0	2.80	0
270.0	324.58	225.06	2557.9	75.48	-2.70	53704	0	0	2.76	0
276.0	336.55	228.75	2544.6	76.55	-2.51	53704	0	0	2.73	0
282.0	348.50	232.15	2532.4	77.63	-2.31	53704	0	0	2.69	0
288.0	360.43	235.24	2521.2	78.72	-2.11	53704	0	0	2.67	0
294.0	372.36	238.05	2511.0	79.81	-1.91	53704	0	0	2.64	0
300.0	384.27	240.55	2501.8	80.92	-1.70	53704	0	0	2.62	0
306.0	396.17	242.76	2493.7	82.03	-1.50	53704	0	0	2.60	0
312.0	408.06	244.68	2486.7	83.15	-1.29	53704	0	0	2.59	0
318.0	419.95	246.30	2480.8	84.27	-1.08	53704	0	0	2.57	0
324.0	431.83	247.63	2475.9	85.40	-0.86	53704	0	0	2.56	0
330.0	443.70	248.67	2472.0	86.54	-0.65	53704	0	0	2.55	0
336.0	455.58	249.40	2469.3	87.67	-0.43	53704	0	0	2.54	0
342.0	467.45	249.85	2467.6	88.81	-0.22	53704	0	0	2.54	0
348.0	479.31	250.00	2467.1	89.95	-0.00	53704	0	0	2.54	0
348.3	479.87	250.00	2467.1	90.00	0.01	53704	0	0	2.54	0
354.0	491.18	249.86	2467.6	91.09	0.21	53704	0	0	2.54	0
360.0	503.05	249.42	2469.2	92.22	0.43	53704	0	0	2.54	0
366.0	514.92	248.69	2471.8	93.36	0.64	53704	0	0	2.55	0
372.0	526.80	247.66	2475.6	94.49	0.86	53704	0	0	2.56	0
378.0	538.68	246.34	2480.4	95.62	1.07	53704	0	0	2.57	0

TABLE VIII-A (CONT)  
S-I COAST TO IMPACT TRAJECTORY

TIME (SEC)	GROUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELOCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATION V DOT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
384.0	550.57	244.72	2486.3	96.75	1.28	53704	0	0	2.58	0
390.0	562.47	242.81	2493.3	97.86	1.49	53704	0	0	2.60	0
396.0	574.37	240.61	2501.3	98.98	1.70	53704	0	0	2.62	0
402.0	586.29	238.11	2510.4	100.08	1.90	53704	0	0	2.64	0
408.0	598.22	235.31	2520.5	101.18	2.11	53704	0	0	2.67	0
414.0	610.16	232.22	2531.7	102.27	2.31	53704	0	0	2.69	0
420.0	622.11	228.84	2543.8	103.35	2.50	53704	0	0	2.73	0
426.0	634.08	225.15	2557.0	104.42	2.70	53704	0	0	2.76	0
432.0	646.07	221.18	2571.2	105.47	2.89	53704	0	0	2.80	0
438.0	658.07	216.90	2586.4	106.52	3.07	53704	0	0	2.84	0
444.0	670.10	212.33	2602.6	107.55	3.25	53704	0	0	2.89	0
450.0	682.14	207.46	2619.7	108.58	3.43	53704	0	0	2.94	0
456.0	694.21	202.29	2637.8	109.59	3.61	53704	0	0	3.00	0
462.0	706.30	196.83	2656.9	110.58	3.78	53704	0	0	3.06	0
468.0	718.42	191.06	2676.8	111.56	3.95	53704	0	0	3.12	0
474.0	730.56	185.00	2697.7	112.53	4.11	53704	0	0	3.20	0
480.0	742.73	178.64	2719.5	113.48	4.27	53704	0	0	3.29	0
486.0	754.93	171.97	2742.2	114.42	4.43	53704	0	0	3.39	0
492.0	767.16	165.01	2765.7	115.35	4.58	53704	0	0	3.52	0
498.0	779.42	157.74	2790.1	116.25	4.74	53704	0	0	3.70	1
504.0	791.72	150.17	2815.4	117.15	4.88	53704	0	0	3.96	1
510.0	804.05	142.30	2841.5	118.03	5.03	53704	0	0	4.38	1
516.0	816.42	134.13	2868.4	118.89	5.17	53704	0	0	4.96	2
522.0	828.82	125.65	2896.1	119.74	5.30	53704	0	0	5.85	6
528.0	841.27	116.87	2924.6	120.57	5.44	53704	0	0	7.11	19
534.0	853.75	107.78	2953.9	121.39	5.57	53704	0	0	8.27	76
539.0	864.15	100.00	2978.8	122.05	5.67	53704	2	0	9.10	288
540.0	866.28	98.38	2983.9	122.19	5.69	53704	2	0	9.23	383
546.0	878.85	88.68	3014.6	122.97	5.78	53704	15	0	9.97	2405
552.0	891.47	78.67	3045.5	123.74	5.88	53704	90	0	9.78	14191
558.0	904.12	68.36	3073.9	124.50	4.82	53704	424	0	9.23	66671
564.0	916.79	57.77	3091.0	125.22	1.35	53704	1672	0	8.69	259575
570.0	929.35	47.00	3066.6	125.87	-10.98	53704	6046	0	8.36	927979
576.0	941.42	36.39	2882.5	126.26	-59.13	53704	23024	0	8.18	3520068
582.0	951.66	27.13	2262.7	125.62	-142.04	53704	54825	0	6.49	7980175
588.0	958.29	20.90	1423.1	122.70	-121.08	53704	48843	0	3.79	6865668
594.0	961.70	17.46	899.1	117.66	-60.62	53704	23884	0	2.00	3637890
600.0	963.38	15.52	655.8	112.47	-27.20	53704	10197	0	1.11	1873455
606.0	964.26	14.25	598.5	109.77	-7.59	53704	5911	0	0.76	857889
612.0	964.81	13.15	522.6	109.82	-2.93	53704	5323	0	0.66	638129

TABLE VIII-A (CONT)  
S-I COAST TO IMPACT TRAJECTORY

TIME (SEC)	GROUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELOCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATION V DOT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
618.0	965.19	12.11	499.4	110.02	-1.87	53704	5256	0	0.60	600298
624.0	965.45	11.10	482.5	109.98	-1.57	53704	5294	0	0.56	595526
630.0	965.63	10.13	469.7	109.67	-1.39	53704	5321	0	0.52	591897
636.0	965.75	9.21	460.1	109.18	-1.25	53704	5337	0	0.49	587656
642.0	965.83	8.32	452.9	108.60	-1.13	53704	5340	0	0.46	582726
648.0	965.88	7.47	447.6	107.99	-1.02	53704	5337	0	0.43	577741
654.0	965.91	6.66	443.7	107.38	-0.93	53704	5332	0	0.41	573102
660.0	965.93	5.88	440.7	106.78	-0.86	53704	5326	0	0.39	569616
666.0	965.95	5.13	438.4	106.19	-0.80	53704	5313	0	0.37	566548
672.0	965.95	4.41	436.5	105.63	-0.74	53704	5297	0	0.36	563369
678.0	965.96	3.72	435.0	105.10	-0.69	53704	5282	0	0.34	560355
684.0	965.96	3.05	433.7	104.61	-0.63	53704	5267	0	0.33	557550
690.0	965.97	2.41	432.7	104.14	-0.58	53704	5253	0	0.31	554933
696.0	965.97	1.78	431.7	103.71	-0.54	53704	5239	0	0.30	552454
702.0	965.97	1.18	430.9	103.31	-0.50	53704	5226	0	0.29	550077
708.0	965.97	0.59	430.2	102.95	-0.45	53704	5212	0	0.28	547767
714.0	965.97	0.02	429.6	102.61	-0.41	53704	5199	0	0.27	545511
(1) 714.2	965.97	-0.00	429.6	102.60	-0.41	53704	5198	0	0.27	545427

(1) Theoretical Ballistic Impact



TABLE VIII-B

## S-I COAST TO IMPACT TRAJECTORY

TIME (SEC)	XXE (KM)	YYE (KM)	ZZE (KM)	EARTH FIXED PARAMETERS			PATH ANGLE (DEG)	LONGITUDE (POSITIVE WEST) (DEG)	GEOD. LAT. (POSITIVE NORTH) (DEG)	GEOD. LAT. (POSITIVE NORTH) (DEG)
				DXE (M/SEC)	DYE (M/SEC)	DZE (M/SEC)				
153.0	87.7	92.8	0.6	2146.6	1589.1	16.4	2670.9	79.7149	28.3248	28.1644
156.0	94.1	97.5	0.6	2145.6	1561.7	17.0	2653.9	79.6542	28.3097	28.1493
162.0	106.9	106.7	0.7	2143.6	1506.4	18.2	2620.0	79.5315	28.2789	28.1187
168.0	119.8	115.6	0.8	2141.5	1451.3	19.4	2587.0	79.4092	28.2480	28.0879
174.0	132.6	124.1	0.9	2139.3	1396.3	20.6	2554.7	79.2875	28.2171	28.0571
180.0	145.5	132.3	1.1	2137.1	1341.5	21.7	2523.3	79.1662	28.1861	28.0262
186.0	158.3	140.2	1.2	2134.8	1286.8	22.9	2492.7	79.0454	28.1550	27.9952
192.0	171.1	147.8	1.3	2132.4	1232.3	24.0	2463.0	78.9250	28.1238	27.9642
198.0	183.9	155.0	1.5	2130.0	1177.9	25.1	2434.1	78.8051	28.0926	27.9330
204.0	196.6	161.9	1.6	2127.5	1123.6	26.2	2406.1	78.6855	28.0612	27.9018
210.0	209.4	168.5	1.8	2124.9	1069.5	27.3	2379.1	78.5664	28.0298	27.8705
216.0	222.1	174.7	2.0	2122.3	1015.4	28.4	2352.9	78.4476	27.9983	27.8391
222.0	234.9	180.6	2.2	2119.7	961.5	29.5	2327.7	78.3293	27.9667	27.8076
228.0	247.6	186.3	2.3	2116.9	907.7	30.5	2303.5	78.2112	27.9350	27.7760
234.0	260.3	191.5	2.5	2114.1	854.0	31.6	2280.3	78.0936	27.9032	27.7443
240.0	272.9	196.5	2.7	2111.3	800.4	32.6	2258.1	77.9762	27.8713	27.7126
246.0	285.6	201.1	2.9	2108.3	746.8	33.6	2237.0	77.8592	27.8393	27.6807
252.0	298.2	205.5	3.1	2105.3	693.4	34.6	2216.9	77.7424	27.8072	27.6487
258.0	310.9	209.5	3.3	2102.3	640.1	35.6	2197.9	77.6260	27.7750	27.6167
264.0	323.5	213.1	3.5	2099.2	586.8	36.6	2180.0	77.5098	27.7427	27.5845
270.0	336.0	216.5	3.8	2096.0	533.6	37.6	2163.2	77.3939	27.7103	27.5522
276.0	348.6	219.6	4.0	2092.8	480.4	38.5	2147.6	77.2782	27.6778	27.5198
282.0	361.2	222.3	4.2	2089.5	427.4	39.4	2133.1	77.1628	27.6452	27.4873
288.0	373.7	224.7	4.5	2086.2	374.3	40.4	2119.9	77.0475	27.6124	27.4547
294.0	386.2	226.8	4.7	2082.8	321.4	41.3	2107.8	76.9325	27.5796	27.4220
300.0	398.7	228.5	5.0	2079.3	268.5	42.2	2097.0	76.8177	27.5466	27.3892
306.0	411.1	230.0	5.2	2075.8	215.6	43.0	2087.4	76.7031	27.5135	27.3562
312.0	423.6	231.1	5.5	2072.2	162.7	43.9	2079.0	76.5886	27.4803	27.3231
318.0	436.0	231.9	5.7	2068.5	109.9	44.8	2071.9	76.4743	27.4470	27.2899
324.0	448.4	232.4	6.0	2064.8	57.1	45.6	2066.1	76.3602	27.4135	27.2566
330.0	460.8	232.6	6.3	2061.0	4.4	46.4	2061.6	76.2461	27.3799	27.2231
336.0	473.1	232.5	6.6	2057.2	-48.3	47.2	2058.3	76.1322	27.3462	27.1895
342.0	485.5	232.0	6.9	2053.3	-101.1	48.0	2056.4	76.0185	27.3124	27.1558
348.0	497.8	231.3	7.1	2049.4	-153.8	48.8	2055.7	75.9048	27.2784	27.1219
348.3	498.4	231.2	7.2	2049.2	-156.3	48.8	2055.7	75.8994	27.2768	27.1203
354.0	510.1	230.2	7.4	2045.3	-206.5	49.6	2056.3	75.7912	27.2442	27.0879
360.0	522.3	228.8	7.7	2041.3	-259.2	50.3	2058.3	75.6776	27.2100	27.0538
366.0	534.6	227.1	8.0	2037.1	-311.9	51.0	2061.5	75.5641	27.1755	27.0195
372.0	546.8	225.1	8.4	2032.9	-364.6	51.8	2066.0	75.4507	27.1410	26.9851
378.0	559.0	222.7	8.7	2028.6	-417.4	52.5	2071.8	75.3373	27.1062	26.9505

TABLE VIII-B (CONT)  
S-I COAST TO IMPACT TRAJECTORY

EARTH FIXED PARAMETERS										LONGITUDE		GEOD. LAT.		GEOD. LAT.		
TIME	XXE	YYE	ZZE	DXXE	DYDE	DZZE	VELØCITY	PATH	(POSITIVE	(WEST)	(POSITIVE	(NØRTH)	(POSITIVE	(NØRTH)	(DEG)	(DEG)
(SEC)	(KM)	(KM)	(KM)	(M/SEC)	(M/SEC)	(M/SEC)	(M/SEC)	ANGLE	(DEG)	(DEG)	(DEG)	(DEG)	(DEG)	(DEG)	(DEG)	(DEG)
384.0	571.1	220.1	9.0	2024.3	-470.1	53.2	2078.9	98.08	75.2240	27.0714	26.9157	26.9157	26.9157	26.9157	26.9157	26.9157
390.0	583.3	217.1	9.3	2019.9	-522.9	53.8	2087.2	99.41	75.1106	27.0363	26.8808	26.8808	26.8808	26.8808	26.8808	26.8808
396.0	595.4	213.8	9.6	2015.5	-575.7	54.5	2096.8	100.73	74.9972	27.0011	26.8458	26.8458	26.8458	26.8458	26.8458	26.8458
402.0	607.4	210.2	10.0	2010.9	-628.5	55.1	2107.6	102.04	74.8839	26.9657	26.8105	26.8105	26.8105	26.8105	26.8105	26.8105
408.0	619.5	206.2	10.3	2006.3	-681.4	55.8	2119.6	103.33	74.7705	26.9302	26.7752	26.7752	26.7752	26.7752	26.7752	26.7752
414.0	631.5	202.0	10.6	2001.7	-734.3	56.4	2132.9	104.61	74.6571	26.8945	26.7396	26.7396	26.7396	26.7396	26.7396	26.7396
420.0	643.5	197.4	11.0	1996.9	-787.3	57.0	2147.3	105.87	74.5436	26.8586	26.7039	26.7039	26.7039	26.7039	26.7039	26.7039
426.0	655.5	192.5	11.3	1992.1	-840.3	57.5	2162.9	107.12	74.4300	26.8226	26.6680	26.6680	26.6680	26.6680	26.6680	26.6680
432.0	667.4	187.3	11.7	1987.3	-893.4	58.1	2179.6	108.34	74.3164	26.7864	26.6319	26.6319	26.6319	26.6319	26.6319	26.6319
438.0	679.3	181.8	12.0	1982.3	-946.5	58.7	2197.5	109.55	74.2027	26.7499	26.5956	26.5956	26.5956	26.5956	26.5956	26.5956
444.0	691.2	176.0	12.4	1977.3	-999.8	59.2	2216.5	110.74	74.0889	26.7133	26.5591	26.5591	26.5591	26.5591	26.5591	26.5591
450.0	703.0	169.8	12.7	1972.2	-1053.0	59.7	2236.5	111.91	73.9750	26.6765	26.5225	26.5225	26.5225	26.5225	26.5225	26.5225
456.0	714.9	163.3	13.1	1967.1	-1106.4	60.2	2257.7	113.06	73.8610	26.6396	26.4856	26.4856	26.4856	26.4856	26.4856	26.4856
462.0	726.7	156.5	13.4	1961.8	-1159.8	60.7	2279.8	114.18	73.7469	26.6024	26.4486	26.4486	26.4486	26.4486	26.4486	26.4486
468.0	738.4	149.4	13.8	1956.5	-1213.3	61.1	2303.0	115.29	73.6325	26.5650	26.4114	26.4114	26.4114	26.4114	26.4114	26.4114
474.0	750.1	142.0	14.2	1951.2	-1267.0	61.6	2327.2	116.37	73.5181	26.5274	26.3739	26.3739	26.3739	26.3739	26.3739	26.3739
480.0	761.8	134.2	14.5	1945.7	-1320.7	62.0	2352.4	117.43	73.4034	26.4896	26.3363	26.3363	26.3363	26.3363	26.3363	26.3363
486.0	773.5	126.1	14.9	1940.2	-1374.5	62.4	2378.5	118.47	73.2886	26.4515	26.2984	26.2984	26.2984	26.2984	26.2984	26.2984
492.0	785.1	117.7	15.3	1934.5	-1428.4	62.8	2405.6	119.48	73.1736	26.4133	26.2603	26.2603	26.2603	26.2603	26.2603	26.2603
498.0	796.7	109.0	15.7	1928.8	-1482.4	63.2	2433.5	120.48	73.0583	26.3748	26.2220	26.2220	26.2220	26.2220	26.2220	26.2220
504.0	808.3	99.9	16.1	1923.1	-1536.6	63.6	2462.4	121.45	72.9429	26.3361	26.1834	26.1834	26.1834	26.1834	26.1834	26.1834
510.0	819.8	90.6	16.4	1917.2	-1590.8	63.9	2492.1	122.40	72.8272	26.2972	26.1447	26.1447	26.1447	26.1447	26.1447	26.1447
516.0	831.3	80.8	16.8	1911.3	-1645.2	64.3	2522.7	123.32	72.7112	26.2580	26.1057	26.1057	26.1057	26.1057	26.1057	26.1057
522.0	842.7	70.8	17.2	1905.2	-1699.8	64.6	2554.1	124.23	72.5950	26.2186	26.0664	26.0664	26.0664	26.0664	26.0664	26.0664
528.0	854.1	60.5	17.6	1899.1	-1754.5	64.9	2586.3	125.11	72.4785	26.1789	26.0269	26.0269	26.0269	26.0269	26.0269	26.0269
534.0	865.5	49.8	18.0	1892.9	-1809.3	65.1	2619.3	125.97	72.3617	26.1390	25.9872	25.9872	25.9872	25.9872	25.9872	25.9872
539.0	874.9	40.6	18.3	1887.6	-1854.9	65.4	2647.3	126.67	72.2446	26.1057	25.9540	25.9540	25.9540	25.9540	25.9540	25.9540
540.0	876.8	38.7	18.4	1886.6	-1864.2	65.4	2653.1	126.81	72.2246	26.0989	25.9472	25.9472	25.9472	25.9472	25.9472	25.9472
546.0	888.1	27.4	18.8	1880.1	-1919.3	65.6	2687.5	127.63	72.1272	26.0584	25.9069	25.9069	25.9069	25.9069	25.9069	25.9069
552.0	899.4	15.7	19.2	1873.1	-1974.0	65.8	2722.0	128.43	72.0094	26.0177	25.8664	25.8664	25.8664	25.8664	25.8664	25.8664
558.0	910.6	3.7	19.6	1863.8	-2026.7	65.9	2754.2	129.20	71.8914	25.9768	25.8256	25.8256	25.8256	25.8256	25.8256	25.8256
564.0	921.7	-8.6	20.0	1846.4	-2070.4	65.7	2774.9	129.97	71.7734	25.9357	25.7847	25.7847	25.7847	25.7847	25.7847	25.7847
570.0	932.7	-21.1	20.3	1801.2	-2082.3	64.5	2754.0	130.72	71.6564	25.8948	25.7440	25.7440	25.7440	25.7440	25.7440	25.7440
576.0	943.2	-33.3	20.7	1652.2	-1971.1	59.5	2572.7	131.50	71.5441	25.8555	25.7048	25.7048	25.7048	25.7048	25.7048	25.7048
582.0	952.0	-44.0	21.0	1226.7	-1518.6	44.5	1952.7	132.45	71.4489	25.8220	25.6714	25.6714	25.6714	25.6714	25.6714	25.6714
588.0	957.6	-51.2	21.2	670.9	-879.9	24.5	1106.8	133.99	71.3873	25.8002	25.6498	25.6498	25.6498	25.6498	25.6498	25.6498
594.0	960.5	-55.1	21.4	322.4	-471.5	11.9	571.3	136.93	71.3556	25.7890	25.6386	25.6386	25.6386	25.6386	25.6386	25.6386
600.0	961.8	-57.3	21.4	154.9	-277.3	5.8	317.7	142.09	71.3400	25.7835	25.6391	25.6391	25.6391	25.6391	25.6391	25.6391
606.0	962.5	-58.7	21.4	81.8	-203.6	3.2	219.5	149.39	71.3319	25.7806	25.6303	25.6303	25.6303	25.6303	25.6303	25.6303
612.0	962.9	-59.8	21.4	48.4	-186.7	2.0	192.9	156.73	71.3268	25.7788	25.6284	25.6284	25.6284	25.6284	25.6284	25.6284

TABLE VIII-B (CONT)

S-I COAST TO IMPACT TRAJECTORY

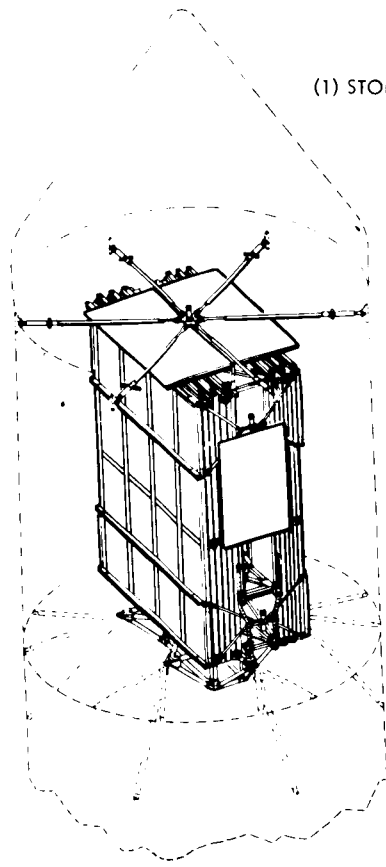
EARTH FIXED PARAMETERS

LONGITUDE (POSITIVE WEST) (DEG)      LATITUDE (POSITIVE NORTH) (DEG)      LONGITUDE (POSITIVE WEST) (DEG)      LATITUDE (POSITIVE NORTH) (DEG)

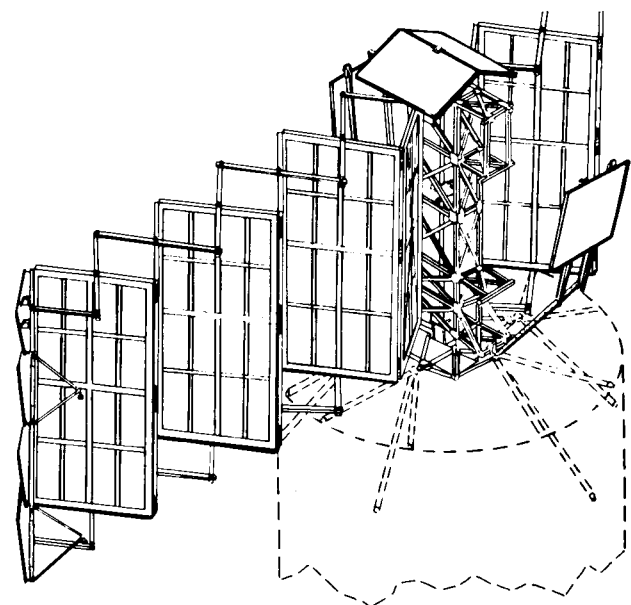
TIME (SEC)	XXE (KM)	YYE (KM)	ZZE (KM)	DXE (M/SEC)	DYE (M/SEC)	DZE (M/SEC)	VELOCITY (M/SEC)	PATH ANGLE (DEG)	LONGITUDE (POSITIVE WEST) (DEG)	LATITUDE (POSITIVE NORTH) (DEG)
618.0	963.1	-60.9	21.5	26.1	-177.0	1.2	178.9	162.87	71.3232	25.7775
624.0	963.2	-61.9	21.5	10.6	-168.4	0.6	168.7	167.67	71.3208	25.7767
630.0	963.2	-62.9	21.5	-0.1	-159.9	0.2	159.9	171.30	71.3191	25.7761
636.0	963.2	-63.9	21.5	-7.1	-151.8	-0.1	152.0	173.97	71.3180	25.7757
642.0	963.2	-64.7	21.5	-11.6	-144.4	-0.2	144.9	175.88	71.3173	25.7754
648.0	963.1	-65.6	21.5	-14.3	-137.7	-0.3	138.4	177.22	71.3169	25.7752
654.0	963.0	-66.4	21.5	-15.9	-131.6	-0.4	132.6	178.14	71.3166	25.7751
660.0	962.9	-67.2	21.5	-16.6	-126.1	-0.4	127.2	178.76	71.3164	25.7750
666.0	962.8	-67.9	21.4	-16.8	-121.1	-0.5	122.2	179.17	71.3163	25.7750
672.0	962.7	-68.6	21.4	-16.7	-116.4	-0.5	117.6	179.43	71.3162	25.7749
678.0	962.6	-69.3	21.4	-16.4	-112.1	-0.4	113.3	179.59	71.3161	25.7749
684.0	962.5	-70.0	21.4	-16.1	-108.2	-0.4	109.4	179.69	71.3161	25.7749
690.0	962.4	-70.6	21.4	-15.6	-104.6	-0.4	105.7	179.75	71.3161	25.7749
696.0	962.3	-71.2	21.4	-15.2	-101.2	-0.4	102.3	179.79	71.3161	25.7748
702.0	962.2	-71.8	21.4	-14.8	-98.1	-0.4	99.2	179.81	71.3160	25.7748
708.0	962.1	-72.4	21.4	-14.4	-95.3	-0.4	96.4	179.82	71.3160	25.7748
714.0	962.0	-73.0	21.4	-14.0	-92.8	-0.4	93.8	179.83	71.3160	25.7748
714.2	962.0	-73.0	21.4	-14.0	-92.7	-0.4	93.7	179.83	71.3160	25.7748

(1)

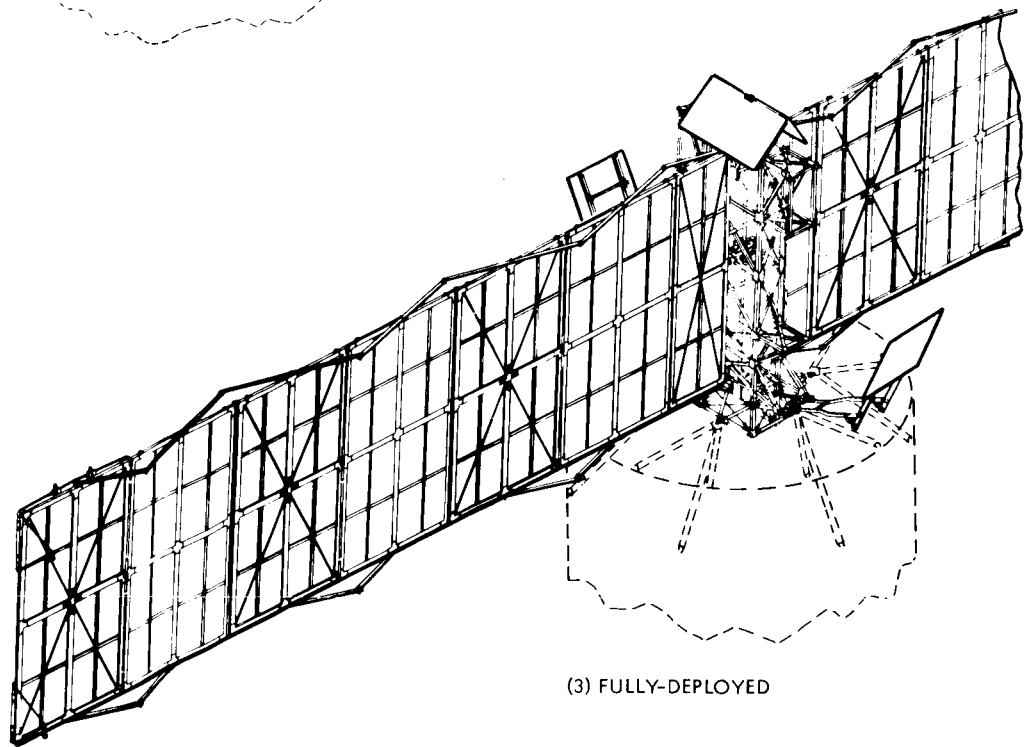
(1) Theoretical Ballistic Impact



(1) STORED

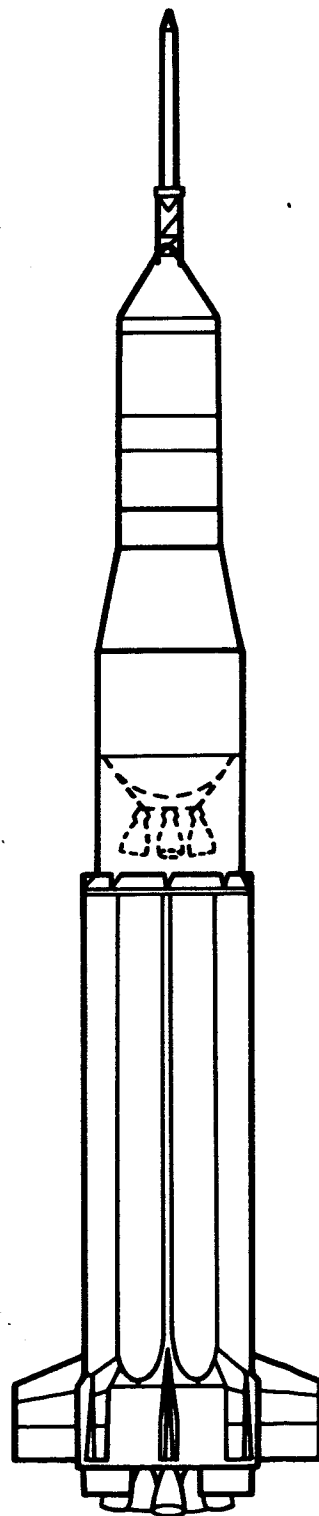


(2) SEMI-DEPLOYED



(3) FULLY-DEPLOYED

**FIG. I. PEGASUS SATELLITE**



**PAYLOAD**

**INSTRUMENT UNIT**

**S-IV STAGE**

**S-I STAGE AND  
INTERSTAGE**

**FIG. 2. SA-8 CONFIGURATION**

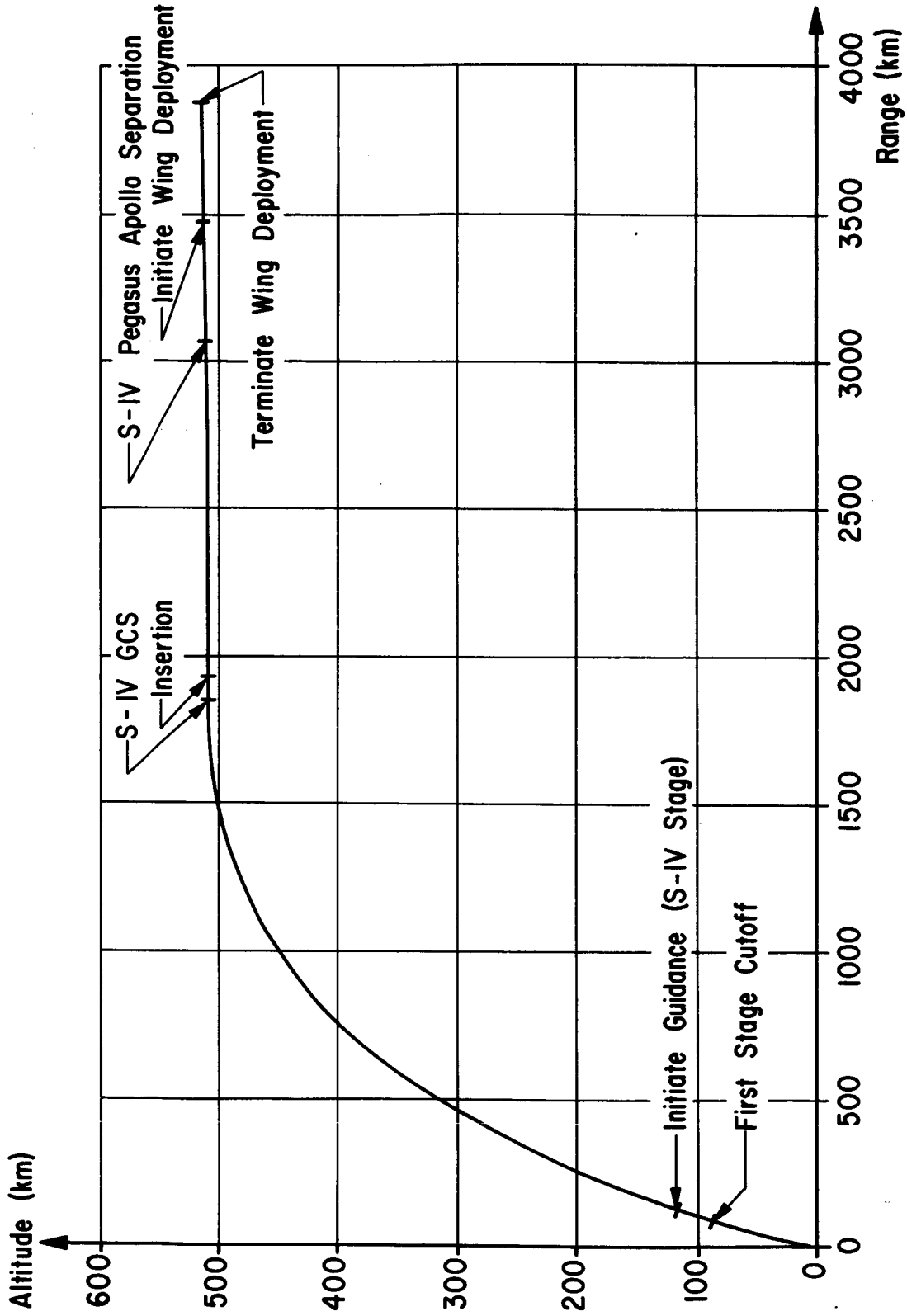


FIG. 3. ALTITUDE VERSUS RANGE

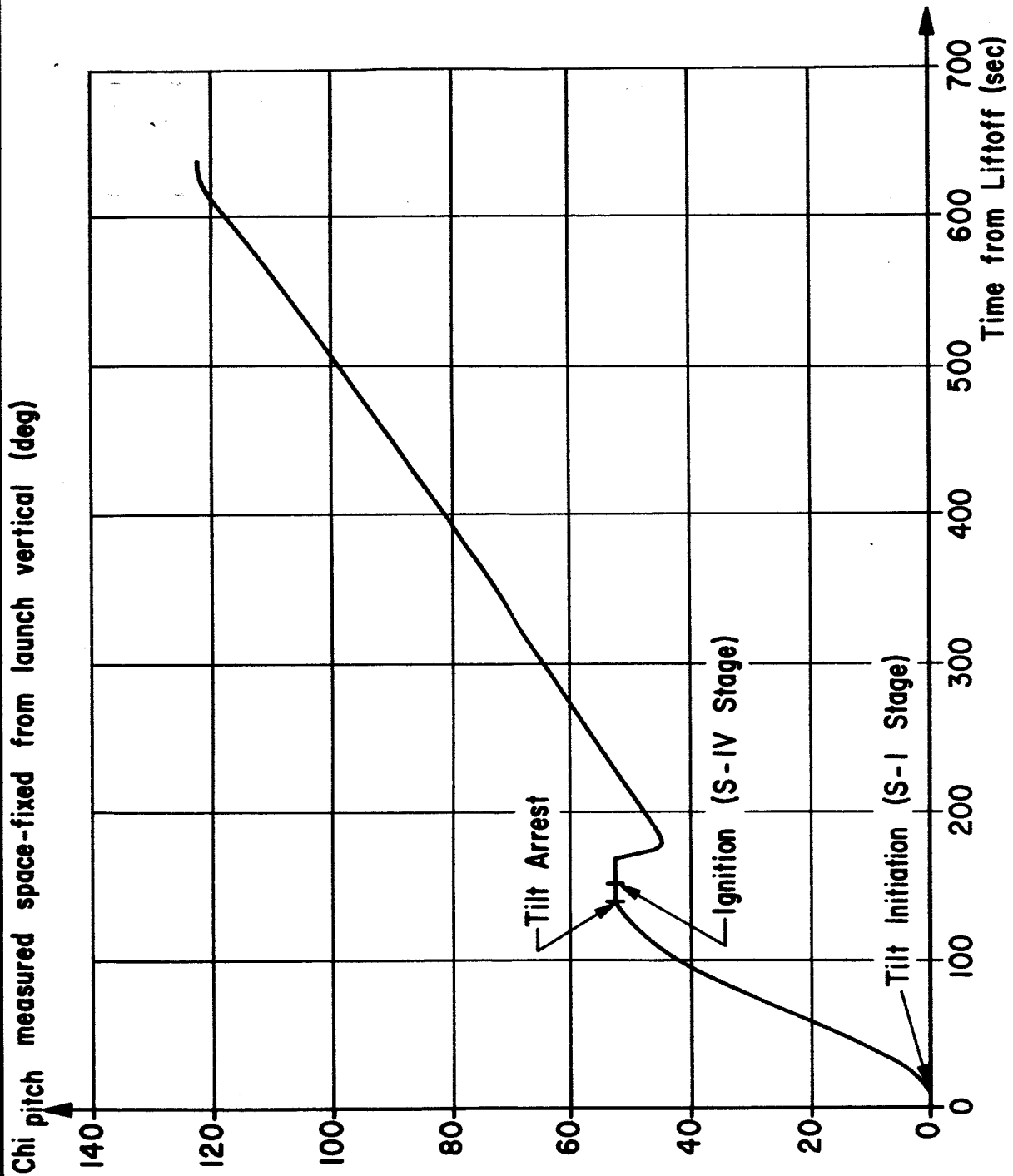


FIG. 4. CHI PITCH VERSUS TIME

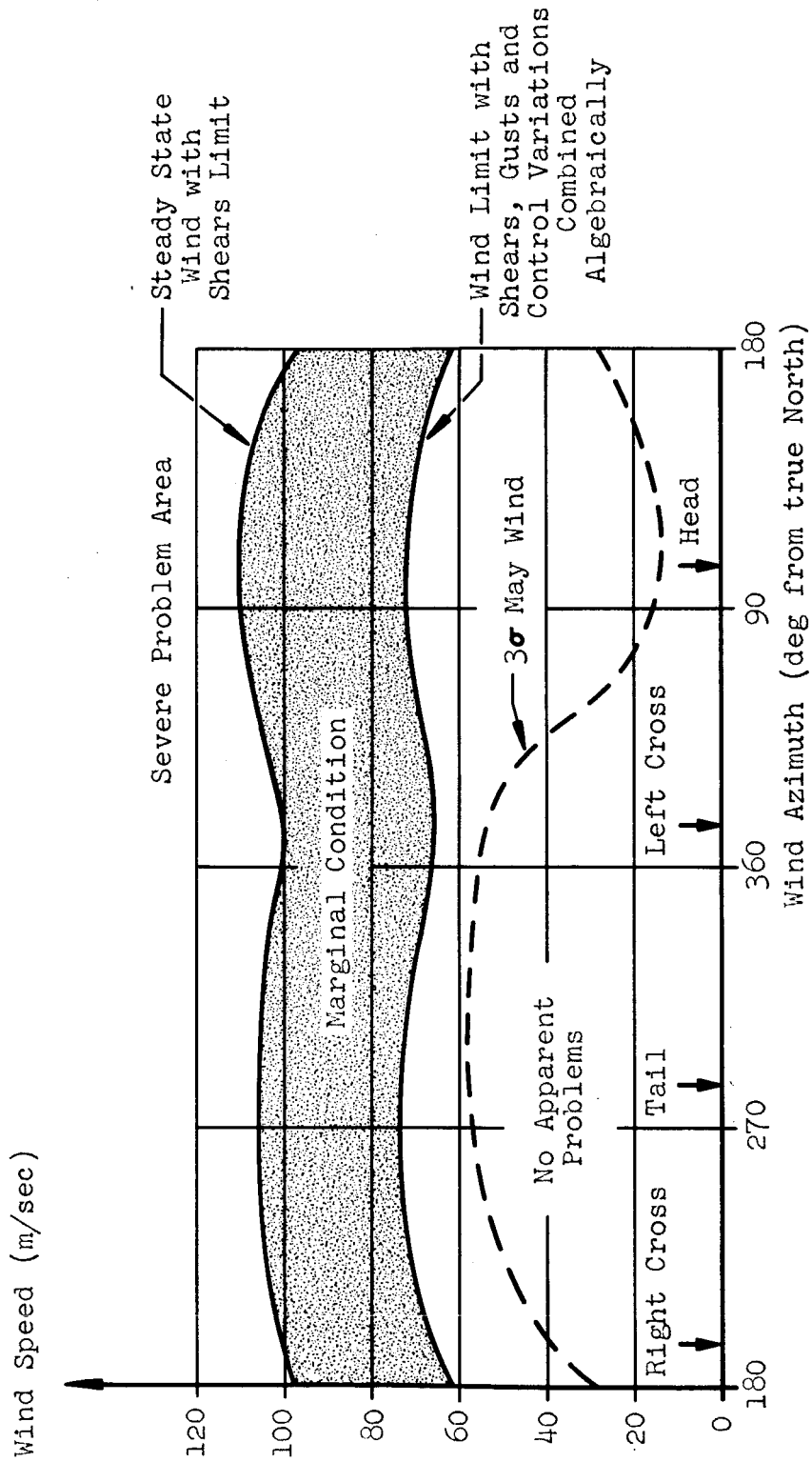


FIG. 5. SA-8 APPROXIMATE WIND SPEED LIMITS  
VERSUS WIND AZIMUTH FOR MAXIMUM DYNAMIC PRESSURE TIME POINT



## APPENDIX A

Wind speed limits for the SA-8 vehicle have been determined for the maximum dynamic pressure region. These limits are established based on structural capabilities of the space vehicle as given by R-P&VE-SLL. Structural data furnished are functions angle of attack ( $\alpha$ ), gimbal angle ( $\beta$ ), and dynamic pressure ( $q$ ). Disturbances, other than the wind, used to establish these limits are 99% shears and gusts,  $3\sigma$   $C_1$  and  $C_2$  variations and  $\pm 10\%$  variation in the control gains.

Figure 5 shows the wind speed limits as a function of wind azimuth for the predicted maximum dynamic pressure time point. This figure shows the limits for various assumptions and combinations of disturbances upon which a decision for launch might be based. Wind magnitudes within the shaded portion of the curve could cause launch problems and a preflight simulation would be necessary for a launch decision. Wind magnitudes above the shaded portion could cause severe launch problems or make launch impossible. Wind magnitudes below the shaded portion create no apparent launch problems but, under exceptional conditions, even winds of this magnitude may still lead to structural problems; therefore, a limited amount of preflight simulation will still be performed.

## APPENDIX B

The SA-8 post insertion venting analysis provides a 95.5% confidence level of not exceeding the 9 deg/sec roll and 2 deg/sec tumble rate limits outlined in Reference 6 . This analysis reflects the structural changes that are being incorporated for this vehicle; i, e., the interchange of O<sub>2</sub> and H<sub>2</sub> non-propulsive vents. It also includes the best estimate of impingement effects of vented H<sub>2</sub> gases on the Pegasus wing structure (based on SA-9 flight evaluation data), as well as perturbations due to misalignments, c.g. shifts, etc.

## APPENDIX C

### Range Safety Data for SA-8

The range safety data presented in Reference 7 consists of booster and LES impact areas, effects of range safety flight termination, land impact probabilities, injury probabilities, turning rate effects and other pertinent information.

The following parameters were varied to obtain the  $3\sigma$  envelope for range safety purposes: thrust, flow rate, liftoff weight, and wind speed. Impact data for this envelope is given in tabular form and consists of instantaneous cutoff time, geodetic latitude, longitude, remaining flight time, and range along the earth's surface from launch to impact.

The vehicle velocity vector turning data for the nominal trajectory is graphically presented. In particular, the total velocity vector magnitude and orientation in the lateral direction is presented as a time function from the point of malfunction (engine gimbal deflection), applied in the yaw plane.

The probability of the S-IV stage dropping short of orbital insertion is .13. The probability of impacting on land can be calculated as follows:

$$P_I = \frac{\Delta t}{T_B} \times P_F$$

$P_I$  = probability of impacting on land area

$\Delta t$  = dwell time (IIP transit time)

$T_B$  = total burn time of second stage

$P_F$  = probability of any failure causing the 2nd stage to drop short

for SA-8:  $P_I = 9.45 \times 10^{-4}$

APPENDIX C (CONT'D)

Subdividing the impact probabilities for individual countries:

<u>Land Area</u>	<u>Dwell Time</u>	<u>Impact Probability</u>
South West Africa	1.3	$3.5 \times 10^{-4}$
Union South Africa	.8	$2.1 \times 10^{-4}$
Bechuanaland	1.3	$3.5 \times 10^{-4}$
Swaziland	.1	$2.7 \times 10^{-5}$

The probability of injuring a person downrange can be determined in the following manner:

$$P_{IP} = P_I \times \frac{N}{L_A} \times A_L$$

where

$P_{IP}$  = probability of injuring a person

$\frac{N}{L_A}$  = population density of country

$A_L$  = lethal area

The probability of injuring a person by overflying land is:

$$P_{IP} = 2.4 \times 10^{-6}$$

The probability of injuring a person, subdivided by Nation

<u>Nation</u>	<u><math>P_I</math></u>	<u><math>N/LA</math></u> (Per Sq. Mi.)	<u><math>PIP</math></u>
South West Africa	$3.5 \times 10^{-4}$	1	$6.3 \times 10^{-8}$
Union South Africa	$2.1 \times 10^{-4}$	24	$9.0 \times 10^{-7}$
Bechuanaland	$3.5 \times 10^{-4}$	1	$6.3 \times 10^{-8}$
Swaziland	$2.7 \times 10^{-5}$	28	$1.4 \times 10^{-7}$

## APPENDIX D. IGM TERMINAL CONDITIONS

The following defines the necessary IGM terminal conditions.

$\eta_T$	=	Terminal Radius Vector
$\dot{\eta}_T$	=	Terminal Time Rate Change of $\eta_T$
$\dot{\xi}_T$	=	Terminal Tangential Velocity
$V_T$	=	Terminal Total Velocity ( $=\sqrt{\dot{\eta}_T^2 + \dot{\xi}_T^2}$ )
$\ddot{\eta}_{gT}$	=	Terminal Radial Acceleration Due to Gravity
$\ddot{\xi}_{gT}$	=	Terminal Tangential Acceleration Due to Gravity
$T'$	=	Time-To-Go (initially)
$V_{ex}$	=	Exhaust Velocity ( $g_o \cdot I_{sp}$ )

The values for the above for SA-8 are as follows:

$\eta_T$	=	6884489.7 meters
$\dot{\eta}_T$	=	-0.90 meters/sec
$\dot{\xi}_T$	=	7671.5597 meters/sec
$V_T$	=	7671.5597 meters/sec
$\ddot{\eta}_{gT}$	=	-8.4158 meters/sec <sup>2</sup>
$\ddot{\xi}_{gT}$	=	0
$T'$	=	465.0 sec (initially)
$V_{ex}$	=	4200.0 meters/sec

APPENDIX E. PREDICTED VEHICLE CHARACTERISTICS  
FOR FLIGHT EVALUATION COMPARISON

S-I Stage

The S-I thrust averages are obtained by considering the longitudinal components of thrust, reduced to sea level throughout flight. They are as follows:

$$F_T = F_1 + F_2$$

Where  $F_1$  is the main engine thrust average and  $F_2$  is the turbine exhaust thrust average.

$$F_1 = 6,749,611 \text{ newtons} \quad (1,517,373 \text{ lbf})$$

$$F_2 = 12,749 \text{ newtons} \quad (2,866 \text{ lbf})$$

$$F_T = 6,762,360 \text{ newtons} \quad (1,520,239 \text{ lbf})$$

The S-I flow rate is derived as follows:

$$\dot{W} = \left[ W_{(T=0)} - W_{(T=140)} - W_{\text{aux}} \right] / 140$$

Where  $W_{\text{aux}}$  = Ice, trapped environment, and chilldown

$$\therefore \dot{W}_T = 2680 \text{ kg/sec} \quad (5908.2 \text{ lbs/sec})$$

$$I_{\text{sp}} = 257.3 \text{ sec}$$

S-IV Stage

The S-IV stage thrust averages are vacuum values averaged from 1.8 second (when 90% thrust is achieved) to 476.2 seconds of S-IV flight time.

$$F_T = F_1 + F_2 + F_3$$

APPENDIX E. PREDICTED VEHICLE CHARACTERISTICS  
FOR FLIGHT EVALUATION COMPARISON (CONT'D)

Where  $F_1$  is the engine thrust along longitudinal axis = 400002 newtons  
(89924 lbf)

$F_2$  = Thrust due to cluster effect = -2798 newtons (-629 lbf)

$F_3$  = Helium heater and chilldown thrust = 734 newtons (165 lbf)

$F_T$  = 397,938 newtons (89,460 lbf)

The flow rate is also obtained from 1.8 seconds to 476.2 seconds of  
S-IV flight time.

$\dot{W}_T = 95 \text{ kg/sec (210.4 lbs/sec)}$

$I_{sp} = 425.2 \text{ sec}$

## REFERENCES

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2. R-P&VE-PPE-65-M-131, "Final S-IV-8 Propulsion Prediction," April 9, 1965.
3. R-P&VE-VAW-65-62, "Final Predicted Mass Characteristics for the Saturn I, SA-8 Vehicle," May 3, 1965.
4. Saturn SA-8 Vehicle Data Book, March 24, 1965.
5. DWG 10M30137, "Saturn I/SA-8 Flight Sequence," April 30, 1965.
6. I-I/IB-P-65-156, "Angular Rate Limits for SA-8 Pegasus Satellite," March 30, 1965.
7. Range Safety Data Report #3-65, "Range Safety Data for Saturn SA-8," April 22, 1965.



APPROVAL

SA-8 OPERATIONAL TRAJECTORY

By

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and  
Gordon W. Solmon

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.

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