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SA-6 PREDICTED STANDARD TRAJECTORY AND DISPERSION ANALYSIS(U)

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Technical Memorandum X-53031

SA-6 PREDICTED STANDARD TRAJECTORY AND DISPERSION ANALYSIS

By J. L. Crafts

ABSTRACT

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This report presents the standard predicted trajectory for Saturn I vehicle SA-6 to be flown over the Atlantic Missile Range. Dispersion results from 2-σ perturbations and impact dispersion of the recoverable camera capsules and launch escape system are also presented. The trajectory shaping and a brief vehicle configuration description are provided. A nominal trajectory will insert the S-IV stage and payload into a near-circular orbit with a perigee and apogee of 183.1 km and 229.4 km, respectively. This orbit has a nominal lifetime of 4.8 days. This trajectory is based on mass and propulsion data provided by P&VE Laboratory. SA-6 will be the first Block II vehicle to be flown with closed loop guidance during the burn of the S-IV stage. This trajectory assumes the Fischer Ellipsoid of 1960 as the reference ellipsoid.

Cont. **

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FLIGHT MECHANICS BRANCH
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(C) SUMMARY

The Saturn I vehicle SA-6 will be the second Block II vehicle to be flown. The primary missions of the flight will be to test the S-I, S-IV propulsion, structure, guidance and control systems, and separation sequence.

The pitch tilt program is biased to create an angle-of-attack of approximately 4° during the high dynamic pressure region. The pitch attitude command is preset in the first stage by means of a continuously rotating cam device. Closed loop guidance will be implemented in the second stage of this flight.

It is predicted that inboard engine cut-off will occur at 140.07 seconds after first motion, and outboard engine cut-off at 146.07 seconds after first motion. The vehicle will be at an altitude of 70 km where a single plane separation between the S-I and S-IV stages will occur. The S-IV stage will ignite and burn continuously until approximately 627.6 seconds after first motion, at which time the S-IV stage and payload will be injected into an orbit having perigee and apogee altitudes of 183.1 and 229.4 km, respectively.

A 2 σ dispersion study generated around the nominal trajectory provides general performance behavior of the two live stages. These dispersions result in a maximum lifetime of 5.1 days and a minimum lifetime of 4.5 days (not considering prediction uncertainties).

The impact coordinates of the camera capsules for nominal and disturbed first stage flight conditions are determined. The nominal impact occurs at approximately 26.3 degrees north geodetic latitude and 72.8 degrees west longitude, which is 805 km downrange. Two-sigma disturbances in the first stage performance result in a flight plane impact range dispersion of ± 30.5 km and a cross range impact dispersion of approximately ± 6 km. An engine-out failure can shorten the impact range by as much as 236 km.

Paraballoon deployment occurs at an altitude of 4.3 km. Under the influence of a 2σ wind, the capsules can deviate an additional 2.5 km.

The impact coordinates of the Launch Escape System for the nominal and disturbed first stage flight conditions are given in Figure 9. The nominal impact occurs at approximately 26.07 degrees north geodetic latitude and 72.09 degrees west longitude, which is 881 km downrange. The two sigma disturbances in the first stage performance result in a flight plane impact range dispersion of ± 30 km and a cross range impact dispersion of approximately ± 3 km.

(C) INTRODUCTION

The SA-6 vehicle consists of the S-I and S-IV live stages, an interstage, an instrument unit, and a boilerplate configuration of the Apollo spacecraft as a payload (see Figure 1).

The S-I stage propulsion system configuration is generally the same as in Block I, but the LOX and fuel cell lengths have been extended to provide an increased tankage capability. For the Block II tests the H-1 engines in this stage are uprated to a nominal sea level thrust of 836,300 newtons (188,000 lbf) each. Aerodynamic stabilizing fins will be mounted on the aft end of the first stage.

The S-IV second stage is a liquid-hydrogen liquid-oxygen propulsion system, generating thrust through six concentrically located RL-10A3 engines, each rated at 66,700 newtons (15,000 lbf) vacuum thrust. A single plane separation mode will be employed. The instrument unit is located just forward of the S-IV stage and aft of the payload. The boilerplate Apollo configuration will be employed for this flight.

The SA-6 vehicle is scheduled to be launched in May from the Atlantic Missile Range Facilities, Complex 37, Pad B. Prior to tilting, the vehicle will execute a 15 degree roll maneuver so as to become aligned with the 105 degree East of North flight azimuth. The boost stage pitch tilt program is biased to create a 4 degree angle-of-attack during the high dynamic pressure region. Closed loop guidance will be implemented in the second stage for the first time. The second stage steering equation and the associated coefficients are presented in Table 16. The S-IV stage thrust will be terminated when space-fixed velocity reaches 7805.95 m/sec.

Perturbations resulting from estimated 2σ variations in mass, specific impulse, flow rate, atmospheric parameters, wind, and second stage propellant loading are applied to the standard trajectory flight plane. The corresponding dispersions are root-sum-squared positively,

negatively, and totally so that a reasonable performance envelope about the predicted standard can be defined.

SA-6 will have 8 recoverable camera capsules mounted on the frustum of the S-I/S-IV interstage to monitor the separation sequence and the inside of two LOX tanks during flight. The camera capsules will be ejected 25 seconds after separation at an angle of 20° to the S-I center line with a velocity of 8 meters per second relative to the S-I stage. Upon ejection, flaps on the aft end of the capsule will extend for stability during re-entry. The capsules will follow a ballistic path to an altitude of approximately 4.3 km where the flap assembly will be ejected and paraballoons will be deployed. A schematic of the capsule is given in Figure 5.

The dispersion caused by 2σ perturbations and engine-out conditions is shown in Figures 7 and 8 respectively.

The LES will be jettisoned 10.3 seconds after S-IV mainstage ignition. One solid propellant engine with an impulse of 155,700 N-sec will burn for approximately 1.3 seconds to pull the LES away from the S-IV mainstage. The dispersion caused by 2σ perturbations is presented in Figure 9.

(C) DESCRIPTION

The SA-6 trajectory is shaped to create a 4 degree angle-of-attack during the period of highest dynamic pressure in order to evaluate control forces, fin loads, and establish stability ratios more accurately than was possible on SA-5. In order not to exceed an angle-of-attack limit of 5.5 degrees, a headwind limit of 27 m/sec must be enforced. The probability of this limit not being exceeded in May or June is 99.8% according to R-AERO-Y.

The standard flight profile is based upon nominal operation of all vehicle and flight supporting components, with the exception of the S-IV stage propellant utilization system. 753.4 kg (1,661 lbm) of ballast was removed from the payload assembly to assure that enough propellant will be left in the S-IV stage to take care of any 2σ disturbance which might occur. The total propellant consumed during S-IV mainstage and thrust buildup is 45,092 kg (99,411 lbm).

Prior to the programmed pitch tilting, the vehicle will execute a roll maneuver from the 90 degree (East of North) lift-off azimuth to the 105 degree flight azimuth. The nominal roll rate is 3 degrees/second (Reference 2).

The vehicle pitch program is referenced to a space-fixed vertical defined at the instant of launch. Pitch tilting takes place about an axis normal to a space-fixed plane containing the reference line and the down-range direction at launch. The first stage pitch attitude command presented in Table 15 is a function of time from lift-off and is preset into the vehicle by a continuously rotating cam device. The second stage will use closed loop guidance. The steering equation and the associated coefficients are given in Table 16.

The launch date for SA-6 is during the month of May. This pitch tilt program can be used through the month of September (low wind months).

A tilt arrest angle of 67 degrees is programmed at 134 seconds after lift-off to ensure ample damping time for various sloshing and transient motions in order to avoid premature cut-off and separation sequencing.

After separation, tilt arrest is continued until 164.07 seconds after lift-off, allowing ample time for the LES tower and ullage casings to be jettisoned. Closed loop guidance is then implemented, directing the S-IV stage along the optimum path to cut-off.

The complete powered flight tilt program is presented graphically in Figure 2 and in detailed tabular form in Table 15. The nominal powered flight profile is presented in Figure 3. A sequence of major events is given in Table 1.

Introduction of estimated 2σ magnitude perturbations to the first and second stage trajectories provides the dispersion results presented in Tables 7A through 14C. These perturbations and methods of application are as follows.

First Stage Variations:

(1) Nominal Lift-Off Mass $\pm$ 2268 kg ($\pm$ 5,000 lbm)
(2) $\pm$ 1% Specific Impulse (applied as $\pm$ 1% thrust)
(3) $\pm$ 1% Flow Rate
(4) $\pm 2\sigma$ Atmospheric Density Variation
(5) $\pm 2\sigma$ Ambient Pressure Variation
(6) $\pm 2\sigma$ Flight Plane Winds (Figure 4)
(7) 2σ Right and Left Cross Winds

The density and ambient pressure variations are of the form set forth in Reference 3 and presented here:

$$\rho_{var} = \rho(1 + \Delta\rho); \quad \Delta\rho = \pm\sqrt{a}\ (e^{by})$$
$$P_{var} = P(1 + \Delta P); \quad \Delta P = \pm\sqrt{a}\ (e^{by})$$

where $a = 100$ (2σ case); $b = 0.01842\ km^{-1}$; y = altitude in km

In all first stage variations, the S-IV stage is assumed to perform nominally (as in the standard) after separation from the S-I stage.

Second Stage Variations:

(1) Nominal Lift-Off Mass ± 136 kg (± 300 lbm)
(2) ± .5% Specific Impulse (applied as ± .5% thrust)
(3) ± .5% Flow Rate
(4) Nominal Propellant Loading ± 453.6 kg (± 1,000 lbm)

The S-I stage is assumed to perform nominally, with only the S-IV propellant loading variation ($\pm 2\sigma$) reflecting back into the first stage vehicle lift-off mass. Effect on S-I stage performance of the 136 kg (300 lbm) S-IV dry mass variation was neglected.

The root-sum-squares of the variables are obtained in the following manner:

$$\text{Positive RSS} = + \sqrt{\Sigma(+\triangle P)^2}$$

$$\text{Negative RSS} = + \sqrt{\Sigma(-\triangle P)^2}$$

$$\text{RSS} = \frac{\text{Positive RSS} + \text{Negative RSS}}{2}$$

Where $\triangle P$ = (variation value) - (standard value)

The recoverable camera capsule consists of an aluminum shell, the camera, a quartz window, re-entry equipment, and recovery aids. The quartz window is held in place by a stainless steel retainer ring. O-rings prevent water leakage around the window after impact. Internal capsule temperature is maintained at an acceptable level by an inner lining of light weight insulating material. Teflon seals isolate the quartz window. The capsule shell is waterproofed to withstand salt water immersion.

The capsule is 7.75 inches in diameter and has a mass of approximately 25.4 kg (56 lbm).

The LES is approximately 25.9 inches in diameter and has a mass of approximately 2,992 kg. It is jettisoned 10.3 seconds after S-IV mainstage ignition by one solid propellant engine. It is canted 2.5° with the vehicle centerline, but its nozzles are canted in such a way to cause the 155,700 N-sec impulse to act parallel to the centerline.

(C) RESULTS

The predicted standard powered flight trajectory terminates with the unseparated spent S-IV stage and payload being inserted into an orbit having the following elements:

Altitude of Perigee	183.12 km
Altitude of Apogee	229.36 km
Semi-Major Axis	6,579.24 km
Eccentricity	.0035
Inclination	31.77 deg
Longitude of Ascending Node	158.89 deg
Argument of Perigee	99.96 deg
Period	88.5 min
Time of Apogee	43.9 min from lift-off

The nominal lifetime in orbit as given by R-AERO-FO is 4.8 days.

A detailed presentation of the predicted trajectory parameters is presented in Tables 2A through 6C. The trajectory with significant time points denoted is presented in five sections. They are: (1) S-I stage boost flight; (2) S-IV stage ullage rocket operation after separation but prior to mainstage ignition; (3) S-IV mainstage operation; (4) S-I stage retro-rocket operation after separation; and (5) S-I stage ballistic flight to impact.

The dispersion results are presented in Tables 7A through 14C to categorize for this specific mission the performance behavior of the two live stages of the Saturn I vehicle.

The camera capsule impacts due to 2σ perturbations in the first stage are given in Figure 7. These result in a flight plane dispersion of ± 30.5 km and a cross range dispersion of approximately ± 6 km. An engine-out failure can shorten the impact range by as much as 236 km. These data are presented in Figure 8. Under the influence of a 2σ wind, the capsule can deviate approximately 2.5 km after parabaloon deployment. Velocity increment at ejection and the possible deviation after paraballoon deployment can cause a lateral displacement around each of the impact points of approximately ± 4.7 km. The capsule from the nominal trajectory will impact at 26.3177 degrees north geodetic latitude and 72.8072 degrees west longitude. This point is 805 km downrange. These predicted impact points were derived in a similar manner to those on SA-5. Seven out of eight capsules on SA-5 were recovered in an area centered 915 km downrange from the launch site, 22 km beyond the planned impact point. The pattern was displaced 13 km northward from the flight line but had drifted within 3.7 km at the time of recovery.

The LES impacts due to 2σ perturbations in the first stage are given in Figure 9. These result in a flight plane dispersion of approximately ± 30 km and a cross range dispersion of approximately ± 3 km. The impact coordinates from the nominal trajectory are 26.07 deg north geodetic latitude and 72.09 degrees west longitude and 881 km downrange.

TABLE 1

NOMINAL SEQUENCE OF EVENTS

Time of Event (From Lift-Off)	
0.0 sec	Lift-Off
8.0 sec	Initiate Roll
13.0 sec	Terminate Roll
15.0 sec	Initiate Pitch Tilt
134.0 sec	Tilt Arrest
134.1 sec	Signal from Sequencer to Enable Level Sensors
138.1 sec	S-I Stage Level Sensor Signal
140.07 sec	Inboard Cut-Off (S-I Stage)
146.07 sec	Outboard Cut-Off (S-I Stage)
146.39 sec	Ullage Rocket Ignition (S-IV Stage)
146.47 sec	Separation, Immediately Followed by Retro Rocket Ignition on S-I Stage
148.17 sec	S-IV Mainstage Ignition
158.47 sec	Jettison Ullage Rocket Casings and Launch Escape Tower
160.47 sec	Switch Attitude Error Signal to ST-124-S
164.07 sec	Initiate Active Guidance
171.47 sec	Jettison Camera Capsules
565.64 sec	LES Nominal Impact Time
589.75 sec	S-I Booster Nominal Impact Time
593.17 sec	Signal from Sequencer to Arm LOX Cut-Off Capability
604.07 sec	Camera Capsule Nominal Impact Time
627.57 sec	S-IV Stage Cut-Off

TABLE 2A
S-I STAGE BOOST TRAJECTORY

TIME (SEC)	GRØUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELØCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATIØN V DØT 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	512906	0	6725364	0.00	44130
5.0	-0.00	0.07	409.3	87.51	3.81	499487	186	6811093	0.05	22927
10.0	-0.00	0.21	410.5	84.70	4.25	486067	836	6867977	0.11	48020
15.0	-0.00	0.46	413.1	81.61	4.67	472537	2062	6914951	0.17	86962
20.0	-0.01	0.82	419.0	78.34	5.09	459006	3935	6956169	0.25	125798
25.0	0.02	1.31	432.0	75.12	5.57	445451	6487	7003874	0.33	174390
30.0	0.09	1.93	452.3	72.12	6.17	431895	9738	7059078	0.41	216578
35.0	0.25	2.70	481.2	69.58	6.96	418340	13711	7120401	0.51	242652
40.0	0.54	3.61	518.9	67.67	7.83	404784	18377	7184287	0.63	305813
45.0	0.98	4.67	560.0	65.93	8.59	391244	23549	7249052	0.76	414693
50.0	1.59	5.89	604.3	64.43	9.12	377704	28713	7316690	0.91	615817
55.0	2.38	7.28	650.4	63.28	8.63	364132	33070	7382959	1.07	1190693
60.0	3.34	8.81	694.9	62.65	8.76	350561	35478	7444928	1.23	1518036
65.0	4.50	10.47	742.2	62.01	9.68	336965	36888	7503649	1.41	1558884
70.0	5.86	12.30	794.5	61.25	11.17	323369	37139	7559184	1.63	1417939
75.0	7.43	14.30	855.1	60.47	13.11	309776	35730	7608572	1.88	1180415
80.0	9.27	16.52	927.4	59.95	15.23	296182	32276	7646902	2.15	939880
85.0	11.44	18.95	1011.6	59.68	17.49	282674	26994	7676576	2.40	703776
90.0	13.98	21.62	1107.9	59.63	19.79	269165	21880	7699208	2.68	511133
95.0	16.98	24.55	1217.0	59.90	22.12	255652	17289	7713595	3.00	360085
100.0	20.49	27.72	1338.6	60.45	24.50	242139	13341	7721581	3.35	249968
105.0	24.60	31.14	1472.5	61.16	26.98	228632	9940	7723614	3.73	168616
110.0	29.36	34.82	1618.7	61.92	29.58	215124	7114	7720718	4.09	111326
115.0	34.84	38.76	1778.1	62.72	32.36	201638	4974	7712035	4.47	72995
120.0	41.11	42.96	1951.8	63.56	35.40	188152	3446	7701629	4.87	47009
125.0	48.24	47.44	2141.3	64.43	38.81	174701	2369	7695082	5.31	30729
130.0	56.33	52.20	2348.9	65.34	42.69	161250	1670	7688692	5.91	20489
134.0	63.56	56.20	2529.5	66.08	46.19	150494	1277	7669022	6.58	14436
135.0	65.48	57.23	2576.9	66.25	47.10	147805	1191	7657361	6.78	13034
140.0	75.77	62.58	2828.0	67.00	52.35	134361	799	7626233	7.89	7865
1) 140.1	75.92	62.65	2831.7	67.01	52.42	134209	794	7626205	7.91	7809
145.0	87.06	68.17	2967.1	67.67	25.66	126831	439	3785618	8.79	4192
(2) 146.1	89.54	69.36	2995.1	67.80	26.02	125447	382	3785393	8.99	3629
(3) 146.5	90.48	69.82	3001.8	67.85	-1.54	124948	361	324413	9.06	3424

(1) Inboard Cut-Off
(2) Outboard Cut-Off
(3) Separation

TABLE 2B
S-I STAGE BOOST TRAJECTORY

	EARTH FIXED PARAMETERS									
TIME (SEC)	XXXE (KM)	YYYE (KM)	ZZZE (KM)	DXXE (M/SEC)	DYYE (M/SEC)	DZZE (M/SEC)	VELØCITY (M/SEC)	PATH ANGLE (DEG)	LØNGITUDE (PØSITIVE WEST) (DEG)	GEØD. LAT. (PØSITIVE NØRTH) (DEG)	GEØC. LAT. (PØSITIVE NØRTH) (DEG)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.5650	28.5319	28.3707
5.0	-0.0	0.1	-0.0	-0.1	17.8	-0.1	17.8	0.49	80.5650	28.5319	28.3707
10.0	-0.0	0.2	-0.0	-0.2	38.0	-0.1	38.0	0.51	80.5650	28.5319	28.3707
15.0	-0.0	0.5	-0.0	-0.4	60.3	-0.2	60.3	0.51	80.5650	28.5319	28.3707
20.0	-0.0	0.8	-0.0	1.3	84.6	-0.2	84.7	0.92	80.5650	28.5319	28.3707
25.0	0.0	1.3	-0.0	8.7	110.9	-0.3	111.3	4.45	80.5647	28.5319	28.3707
30.0	0.1	1.9	-0.0	22.0	138.8	-0.3	140.6	8.99	80.5640	28.5317	28.3705
35.0	0.3	2.7	-0.0	43.1	167.9	-0.2	173.3	14.37	80.5624	28.5314	28.3702
40.0	0.5	3.6	-0.0	72.9	197.1	-0.1	210.2	20.26	80.5596	28.5307	28.3696
45.0	1.0	4.7	-0.0	105.0	228.3	-0.0	251.3	24.65	80.5552	28.5297	28.3686
50.0	1.6	5.9	-0.0	139.5	260.7	0.1	295.7	28.09	80.5492	28.5283	28.3672
55.0	2.4	7.3	-0.0	175.9	292.2	0.2	341.1	30.99	80.5414	28.5265	28.3654
60.0	3.4	8.8	-0.0	212.8	319.0	0.4	383.5	33.64	80.5319	28.5243	28.3631
65.0	4.5	10.5	-0.0	251.6	348.0	0.6	429.4	35.78	80.5205	28.5216	28.3605
70.0	5.9	12.3	0.0	293.3	381.6	0.9	481.3	37.45	80.5071	28.5185	28.3573
75.0	7.5	14.3	0.0	341.3	420.9	1.2	541.9	38.93	80.4915	28.5148	28.3536
80.0	9.3	16.5	0.0	400.7	463.5	1.5	612.7	40.72	80.4734	28.5105	28.3493
85.0	11.5	18.9	0.0	471.9	509.5	1.9	694.5	42.67	80.4520	28.5054	28.3443
90.0	14.0	21.6	0.0	555.3	558.6	2.4	787.6	44.66	80.4269	28.4994	28.3383
95.0	17.1	24.5	0.0	653.1	608.1	2.9	892.4	46.85	80.3974	28.4923	28.3313
100.0	20.6	27.7	0.1	765.6	657.1	3.5	1008.9	49.13	80.3628	28.4840	28.3230
105.0	24.7	31.1	0.1	891.9	706.1	4.1	1137.6	51.37	80.3223	28.4742	28.3133
110.0	29.5	34.8	0.1	1031.2	756.5	4.9	1278.9	53.43	80.2754	28.4629	28.3020
115.0	35.1	38.7	0.1	1184.5	807.7	5.8	1433.7	55.36	80.2215	28.4499	28.2890
120.0	41.4	42.8	0.2	1353.1	859.4	6.7	1602.9	57.17	80.1598	28.4349	28.2740
125.0	48.6	47.3	0.2	1538.5	911.4	7.9	1788.3	58.88	80.0895	28.4178	28.2570
130.0	56.8	51.9	0.2	1743.3	963.4	9.2	1991.8	60.52	80.0100	28.3983	28.2376
134.0	64.2	55.9	0.3	1922.4	1005.2	10.3	2169.4	61.78	79.9389	28.3809	28.2203
135.0	66.1	56.9	0.3	1969.2	1016.2	10.7	2216.0	62.07	79.9201	28.3763	28.2157
140.0	76.6	62.1	0.3	2216.1	1077.1	12.4	2464.1	63.36	79.8189	28.3513	28.1908
(1) 140.1	76.7	62.2	0.3	2219.8	1078.1	12.4	2467.7	63.37	79.8174	28.3510	28.1904
145.0	88.0	67.6	0.4	2359.6	1093.5	13.9	2600.7	64.31	79.7080	28.3239	28.1635
(2) 146.1	90.6	68.7	0.4	2388.5	1096.4	14.2	2628.1	64.50	79.6837	28.3178	28.1574
(3) 146.5	91.5	69.2	0.4	2395.9	1095.9	14.4	2634.7	64.56	79.6745	28.3155	28.1552

(1) Inboard Cut-Off
(2) Outboard Cut-Off
(3) Separation

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TABLE 3A
S-IV STAGE ULLAGE TRAJECTORY

TIME (SEC)	GRØUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELØCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATIØN V DØT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
146.5	90.48	69.82	3001.8	67.85	-3.18	65998	361	62517	9.06	1244
148.2	94.48	71.73	2997.3	68.10	-3.13	65894	275	62517	9.22	946

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TABLE 3B
S-IV STAGE ULLAGE TRAJECTORY

TIME (SEC)	XXXE (KM)	YYYE (KM)	ZZZE (KM)	DXXE (M/SEC)	DYYE (M/SEC)	DZZE (M/SEC)	VELØCITY (M/SEC)	PATH ANGLE (DEG)	LØNGITUDE (PØSITIVE WEST) (DEG)	GEØD. LAT. (PØSITIVE NØRTH) (DEG)	GEØC. LAT. (PØSITIVE NØRTH) (DEG)
				EARTH FIXED PARAMETERS							
146.5	91.5	69.2	0.4	2395.9	1095.9	14.4	2634.7	64.56	79.6745	28.3155	28.1552
148.2	95.6	71.0	0.5	2396.9	1080.8	14.7	2629.3	64.84	79.6352	28.3058	28.1454

TABLE 4A
S-IV MAINSTAGE TRAJECTORY

TIME (SEC)	GRØUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELØCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATIØN V DØT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
148.2	94.48	71.73	2997.3	68.10	-3.14	65894	275	62517	9.22	1803
149.0	96.43	72.65	2995.3	68.22	-2.72	65858	240	90307	9.31	1821
169.0	144.37	93.67	3050.4	70.91	2.94	60880	5	396482	10.36	-545
189.0	194.24	112.56	3122.6	73.33	3.59	59006	0	397203	10.62	-587
209.0	246.14	129.44	3206.4	75.61	4.19	57128	0	396698	10.92	-585
229.0	300.20	144.38	3301.2	77.72	4.81	55242	0	397649	11.27	-582
249.0	356.52	157.45	3406.7	79.67	5.37	53354	0	397514	11.66	-578
269.0	415.25	168.74	3522.8	81.45	5.94	51464	0	397933	12.10	-575
289.0	476.51	178.32	3649.3	83.07	6.49	49572	0	398056	12.58	-572
309.0	540.45	186.27	3786.1	84.53	7.03	47679	0	398088	13.11	-570
329.0	607.22	192.67	3933.1	85.83	7.56	45787	0	397892	13.67	-568
349.0	677.00	197.62	4090.2	86.97	8.07	43899	0	396999	14.28	-566
369.0	749.95	201.22	4257.2	87.96	8.60	42017	0	396232	14.92	-564
389.0	826.25	203.58	4434.9	88.81	9.16	40139	0	396074	15.61	-564
409.0	906.10	204.79	4624.1	89.53	9.78	38259	0	396711	16.34	-565
429.0	989.75	204.97	4825.7	90.13	10.41	36376	0	396756	17.13	-565
449.0	1077.43	204.23	5040.3	90.61	11.08	34493	0	396740	17.96	-566
469.0	1169.41	202.71	5268.6	90.96	11.80	32610	0	396738	18.84	-568
489.0	1265.98	200.56	5512.1	91.20	12.59	30727	0	396699	19.79	-569
509.0	1367.47	197.96	5772.2	91.32	13.47	28846	0	396712	20.80	-571
529.0	1474.22	195.09	6050.9	91.34	14.46	26964	0	396788	21.88	-574
549.0	1586.64	192.16	6350.6	91.25	15.58	25082	0	396995	23.04	-576
569.0	1705.17	189.41	6675.0	91.05	16.92	23195	0	397858	24.30	-579
589.0	1830.33	187.11	7027.9	90.76	18.45	21304	0	398121	25.67	-581
609.0	1962.71	185.56	7413.4	90.35	20.15	19416	0	396379	27.16	-583
627.6	2092.60	185.14	7806.0	89.88	22.25	17668	0	398078	28.69	-586

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TABLE 4B
S-IV MAINSTAGE TRAJECTORY

TIME (SEC)	XXXE (KM)	YYYE (KM)	ZZZE (KM)	DXXE (M/SEC)	DYYE (M/SEC)	DZZE (M/SEC)	VELØCITY (M/SEC)	PATH ANGLE (DEG)	LØNGITUDE (PØSITIVE WEST) (DEG)	GEØD. LAT. (PØSITIVE NØRTH) (DEG)	GEØC. LAT. (PØSITIVE NØRTH) (DEG)
				EARTH FIXED PARAMETERS							
148.2	95.6	71.0	0.5	2396.9	1080.8	14.7	2629.3	64.84	79.6352	28.3058	28.1454
149.0	97.6	71.9	0.5	2397.5	1073.5	15.2	2626.9	64.97	79.6161	28.3010	28.1407
169.0	146.5	92.0	0.9	2503.0	939.5	27.1	2673.7	68.09	79.1465	28.1817	28.0218
189.0	197.7	109.6	1.5	2614.8	814.6	34.4	2739.0	70.91	78.6597	28.0545	27.8951
209.0	251.2	124.6	2.3	2730.9	689.9	39.7	2817.0	73.57	78.1545	27.9193	27.7604
229.0	307.0	137.2	3.1	2851.1	566.1	44.6	2907.1	76.03	77.6300	27.7759	27.6176
249.0	365.2	147.2	4.0	2975.7	442.7	49.5	3008.9	78.29	77.0850	27.6239	27.4661
269.0	426.0	154.9	5.1	3105.1	319.6	54.8	3122.0	80.35	76.5187	27.4625	27.3054
289.0	489.5	160.0	6.2	3239.8	196.2	60.5	3246.3	82.21	75.9300	27.2912	27.1347
309.0	555.7	162.7	7.5	3380.0	72.3	66.6	3381.5	83.87	75.3175	27.1091	26.9533
329.0	624.7	162.9	8.9	3526.2	-52.4	73.0	3527.4	85.35	74.6803	26.9155	26.7604
349.0	696.8	160.6	10.4	3678.6	-177.9	79.9	3683.7	86.64	74.0170	26.7094	26.5552
369.0	771.9	155.8	12.1	3837.3	-304.4	87.0	3850.3	87.75	73.3265	26.4901	26.3368
389.0	850.3	148.4	13.9	4003.4	-432.6	94.6	4027.8	88.69	72.6073	26.2565	26.1041
409.0	932.1	138.5	15.9	4177.9	-563.5	102.5	4217.0	89.49	71.8579	26.0075	25.8562
429.0	1017.5	125.9	18.0	4361.9	-697.9	110.8	4418.8	90.14	71.0766	25.7420	25.5917
449.0	1106.6	110.5	20.3	4555.9	-835.7	119.6	4633.5	90.66	70.2617	25.4585	25.3094
469.0	1199.8	92.4	22.8	4761.1	-977.6	128.8	4862.1	91.04	69.4111	25.1556	25.0079
489.0	1297.2	71.4	25.5	4978.6	-1124.4	138.5	5105.9	91.29	68.5230	24.8317	24.6854
509.0	1399.0	47.4	28.4	5210.0	-1276.7	148.7	5366.2	91.42	67.5949	24.4852	24.3403
529.0	1505.7	20.3	31.4	5457.3	-1435.8	159.5	5645.3	91.44	66.6244	24.1139	23.9707
549.0	1617.4	-10.1	34.7	5722.5	-1602.9	171.0	5945.2	91.33	65.6088	23.7156	23.5743
569.0	1734.7	-43.9	38.3	6009.1	-1780.2	183.2	6269.9	91.12	64.5450	23.2880	23.1486
589.0	1858.0	-81.4	42.1	6320.4	-1969.6	196.2	6623.1	90.80	63.4293	22.8281	22.6908
609.0	1987.7	-122.8	46.1	6660.1	-2172.8	210.2	7008.7	90.37	62.2577	22.3327	22.1978
627.6	2114.5	-165.0	50.2	7005.7	-2376.9	224.1	7401.4	89.88	61.1164	21.8380	21.7055

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TABLE 5A
S-I STAGE POST-SEPARATION RETRO 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)
146.5	90.48	69.82	3001.8	67.85	-9.73	58025	361	-269352	9.06	57175
148.9	96.22	72.55	2972.4	68.22	-4.71	57061	239	0	9.22	37898

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TABLE 5B
S-I STAGE POST-SEPARATION RETRO TRAJECTORY

	EARTH FIXED PARAMETERS										
TIME (SEC)	XXXE (KM)	YYYE (KM)	ZZZE (KM)	DXXE (M/SEC)	DYYE (M/SEC)	DZZE (M/SEC)	VELØCITY (M/SEC)	PATH ANGLE (DEG)	LØNGITUDE (PØSITIVE WEST) (DEG)	GEØD. LAT. (PØSITIVE NØRTH) (DEG)	GEØC. LAT. (PØSITIVE NØRTH) (DEG)
146.5	91.5	69.2	0.4	2395.9	1095.9	14.4	2634.7	64.56	79.6745	28.3155	28.1552
148.9	97.4	71.8	0.5	2376.1	1065.2	14.9	2604.0	64.95	79.6181	28.3015	28.1412

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TABLE 6A
S-I STAGE POST-SEPARATION FREE FLIGHT TRAJECTORY

TIME (SEC)	GRØUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELØCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATIØN V DØT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
148.9	96.22	72.55	2972.4	68.22	-4.71	57061	239	0	9.22	37966
151.0	101.07	74.82	2963.8	68.53	-4.46	57061	169	0	9.42	26867
171.0	147.45	94.78	2896.1	71.56	-3.46	57061	3	0	9.76	533
191.0	193.52	111.40	2841.0	74.71	-2.88	56857	0	0	9.51	23
211.0	239.34	124.68	2796.3	77.97	-2.28	56857	0	0	9.31	4
231.0	284.98	134.64	2762.4	81.31	-1.65	56857	0	0	9.16	2
251.0	330.48	141.30	2739.6	84.72	-1.00	56857	0	0	9.06	1
271.0	375.90	144.65	2728.0	88.17	-0.34	56857	0	0	9.00	1
281.7	400.12	145.09	2726.5	90.02	0.01	56857	0	0	9.00	1
291.0	421.29	144.70	2727.8	91.64	0.32	56857	0	0	9.00	1
311.0	466.72	141.45	2738.9	95.09	0.98	56857	0	0	9.05	1
331.0	512.22	134.91	2761.2	98.50	1.63	56857	0	0	9.16	2
351.0	557.87	125.05	2794.6	101.85	2.26	56857	0	0	9.31	4
371.0	603.70	111.87	2838.8	105.11	2.86	56857	0	0	9.50	21
385.8	637.73	100.00	2878.1	107.45	3.28	56857	1	0	9.68	189
391.0	649.79	95.37	2893.4	108.26	3.43	56857	3	0	9.75	472
411.0	696.17	75.52	2956.0	111.30	3.55	56857	151	0	9.47	23979
431.0	742.61	52.46	2977.4	114.16	-3.18	56857	2798	0	7.77	435783
451.0	784.35	28.84	2228.8	115.93	-94.79	56857	38891	0	6.22	5676322
471.0	801.04	17.52	768.8	111.09	-31.61	56857	12519	0	1.45	2165996
491.0	804.15	13.43	527.1	110.58	-2.23	56857	5608	0	0.69	635613
511.0	805.09	9.89	470.3	110.60	-1.51	56857	5974	0	0.55	634372
531.0	805.35	6.84	445.9	108.40	-1.11	56857	5908	0	0.45	616783
551.0	805.42	4.22	436.1	106.25	-0.81	56857	5815	0	0.37	600132
571.0	805.43	1.93	431.4	104.50	-0.61	56857	5751	0	0.32	588825
589.8	805.44	0.00	428.7	103.23	-0.45	56857	5698	0	0.28	579982

TABLE 6B
S-I STAGE POST-SEPARATION FREE FLIGHT TRAJECTORY

TIME (SEC)	XXXE (KM)	YYYE (KM)	ZZZE (KM)	DXXE (M/SEC)	DYYE (M/SEC)	DZZE (M/SEC)	VELOCITY (M/SEC)	PATH ANGLE (DEG)	LONGITUDE (POSITIVE WEST) (DEG)	GEOD. LAT. (POSITIVE NORTH) (DEG)	GEOC. LAT. (POSITIVE NORTH) (DEG)
				EARTH FIXED PARAMETERS							
148.9	97.4	71.8	0.5	2376.1	1065.2	14.9	2604.0	64.95	79.6181	28.3015	28.1412
151.0	102.3	74.0	0.5	2374.5	1045.4	15.3	2594.5	65.29	79.5706	28.2896	28.1293
171.0	149.7	93.1	0.8	2366.1	859.7	19.2	2517.5	68.66	79.1161	28.1747	28.0149
191.0	197.0	108.4	1.3	2359.1	676.0	23.0	2454.1	72.23	78.6660	28.0584	27.8990
211.0	244.1	120.1	1.8	2351.2	493.1	26.6	2402.5	75.96	78.2195	27.9405	27.7815
231.0	291.0	128.1	2.3	2342.4	311.0	30.1	2363.2	79.83	77.7760	27.8209	27.6624
251.0	337.7	132.5	3.0	2332.8	129.5	33.4	2336.6	83.81	77.3350	27.6997	27.5416
271.0	384.3	133.3	3.7	2322.3	-51.8	36.6	2323.2	87.85	76.8960	27.5766	27.4190
281.7	409.1	132.3	4.1	2316.3	-148.5	38.2	2321.4	90.02	76.6624	27.5101	27.3528
291.0	430.6	130.5	4.4	2310.9	-232.9	39.6	2322.9	91.92	76.4585	27.4516	27.2944
311.0	476.7	124.0	5.2	2298.6	-414.0	42.5	2336.0	95.97	76.0218	27.3245	27.1679
331.0	522.6	113.9	6.1	2285.4	-595.4	45.2	2362.1	99.95	75.5856	27.1953	27.0392
351.0	568.1	100.2	7.1	2271.3	-777.1	47.7	2401.1	103.82	75.1493	27.0638	26.9082
371.0	613.4	82.8	8.0	2256.3	-959.5	50.0	2452.3	107.56	74.7123	26.9298	26.7748
385.8	646.7	67.6	8.8	2244.5	-1094.7	51.6	2497.7	110.21	74.3888	26.8292	26.6746
391.0	658.4	61.8	9.1	2240.2	-1142.5	52.2	2515.2	111.13	74.2743	26.7933	26.6388
411.0	703.0	37.1	10.1	2221.2	-1325.5	54.1	2587.2	114.52	73.8346	26.6541	26.5001
431.0	747.0	8.9	11.2	2158.6	-1481.5	54.8	2618.7	117.73	73.3956	26.5129	26.3595
451.0	785.8	-19.5	12.2	1472.7	-1165.5	38.8	1878.5	121.25	73.0022	26.3845	26.2316
471.0	801.0	-32.8	12.6	272.6	-313.5	7.5	415.5	131.73	72.8451	26.3327	26.1800
491.0	803.6	-37.3	12.7	55.5	-193.9	1.7	201.7	156.74	72.8159	26.3230	26.1703
511.0	804.1	-40.9	12.7	2.7	-167.1	0.2	167.2	171.78	72.8071	26.3200	26.1674
531.0	804.0	-44.0	12.7	-12.0	-140.4	-0.2	140.9	177.58	72.8047	26.3191	26.1665
551.0	803.7	-46.6	12.7	-14.1	-121.2	-0.3	122.0	179.34	72.8041	26.3189	26.1663
571.0	803.4	-48.9	12.7	-13.3	-107.2	-0.3	108.0	179.74	72.8040	26.3188	26.1662
589.8	803.2	-50.8	12.7	-12.2	-97.4	-0.3	98.1	179.82	72.8039	26.3188	26.1661

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TABLE 7A

S-I STAGE CUTØFF PARAMETERS
RESULTING FRØM PERFØRMANCE AND ATMØSPHERIC VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE

VARIATIØNS	TIME (FRØM LIFTØFF)		PATH ANGLE FRØM LØCAL VERTICAL		VELØCITY (EARTH FIXED)		ALTITUDE		RANGE (FRØM LAUNCH)	
	T (SEC)	ΔT (SEC)	ϑ (DEG)	$\Delta\vartheta$ (DEG)	V (M/SEC)	ΔV (M/SEC)	ALT (M)	ΔALT (M)	RANGE (M)	Δ RANGE (M)
STANDARD	146.07		64.50		2628.1		69363.		89536.	
NØMINAL MASS + 2268 kg	146.07	0.00	64.66	0.16	2591.3	-36.9	68262.	-1101.	88552.	-984.
NØMINAL MASS - 2268 kg	146.07	0.00	64.34	-0.16	2665.8	37.7	70484.	1121.	90535.	999.
SPECIFIC IMPULSE + 1%	146.07	0.00	64.24	-0.26	2668.2	40.1	71143.	1779.	90885.	1349.
SPECIFIC IMPULSE - 1%	146.07	0.00	64.76	0.26	2587.7	-40.4	67593.	-1771.	88171.	-1365.
FLØW RATE + 1%	144.67	-1.40	64.11	-0.39	2594.1	-34.1	68523.	-841.	87014.	-2522.
FLØW RATE - 1%	147.47	1.40	64.87	0.38	2661.4	33.2	70184.	820.	92077.	2540.
DENSITY INCREASE	146.07	0.00	64.76	0.26	2604.7	-23.5	68023.	-1341.	88465.	-1071.
DENSITY DECREASE	146.07	0.00	64.23	-0.26	2651.4	23.3	70729.	1366.	90608.	1072.
AMBIENT PRESSURE INCREASE	146.07	0.00	64.65	0.16	2614.4	-13.7	68196.	-1167.	88872.	-664.
AMBIENT PRESSURE DECREASE	146.07	0.00	64.34	-0.15	2641.2	13.1	70505.	1141.	90168.	632.
2σ TAILWIND	146.07	0.00	64.71	0.21	2651.4	23.3	69144.	-219.	92339.	2803.
2σ HEADWIND	146.07	0.00	64.36	-0.14	2620.3	-7.8	69573.	209.	88532.	-1004.
2σ RIGHT CROSS WIND	146.07	0.00	64.52	0.02	2630.3	2.1	69335.	-29.	89809.	273.
2σ LEFT CROSS WIND	146.07	0.00	64.46	-0.03	2624.1	-4.1	69382.	19.	89059.	-478.
PØSITIVE RSS		1.40		0.61		73.4		2882.		4330.
NEGATIVE RSS		1.40		0.60		70.5		2875.		3467.
RSS		1.40		0.61		72.0		2878.		3898.

TABLE 7B

S-I STAGE CUT-OFF PARAMETERS
RESULTING FRØM PERFØRMANCE AND ATMØSPHERIC VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE

VARIATIØNS	TIME (FRØM LIFTØFF)		X PØSITIØN (EARTH FIXED)		Y PØSITIØN (EARTH FIXED)		Z PØSITIØN (EARTH FIXED)	
	T (SEC)	ΔT (SEC)	X (M)	ΔX (M)	Y (M)	ΔY (M)	Z (M)	ΔZ (M)
STANDARD	146.07		90558.		68727.		428.	
NØMINAL MASS + 2268 kg	146.07	0.00	89547.	-1011.	67640.	-1087.	422.	-6.
NØMINAL MASS - 2268 kg	146.07	0.00	91584.	1026.	69834.	1106.	434.	6.
SPECIFIC IMPULSE + 1%	146.07	0.00	91948.	1390.	70487.	1760.	437.	10.
SPECIFIC IMPULSE - 1%	146.07	0.00	89152.	-1406.	66976.	-1752.	418.	-10.
FLØW RATE + 1%	144.67	-1.40	87997.	-2561.	67922.	-805.	412.	-15.
FLØW RATE - 1%	147.47	1.40	93138.	2580.	69511.	784.	443.	16.
DENSITY INCREASE	146.07	0.00	89456.	-1102.	67402.	-1326.	419.	-9.
DENSITY DECREASE	146.07	0.00	91662.	1104.	70077.	1350.	436.	8.
AMBIENT PRESSURE INCREASE	146.07	0.00	89869.	-689.	67570.	-1158.	422.	-6.
AMBIENT PRESSURE DECREASE	146.07	0.00	91214.	656.	69859.	1132.	434.	6.
2σ TAILWIND	146.07	0.00	93383.	2825.	68468.	-260.	1194.	766.
2σ HEADWIND	146.07	0.00	89546.	-1012.	68951.	224.	107.	-321.
2σ RIGHT CROSS WIND	146.07	0.00	90830.	272.	68695.	-32.	-615.	-1043.
2σ LEFT CROSS WIND	146.07	0.00	90052.	-506.	68753.	26.	2241.	1813.
PØSITIVE RSS		1.40		4398.		2844.		1969.
NEGATIVE RSS		1.40		3539.		2840.		1091.
RSS		1.40		3969.		2842.		1530.

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TABLE 8A

S-IV STAGE INSERTION PARAMETERS
RESULTING FRØM PERFØRMANCE AND ATMØSPHERIC VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE DURING S-I STAGE ØPERATIØN

VARIATIØNS	TIME (FRØM LIFTØFF)		PATH ANGLE (SPACE FIXED)		VELØCITY (SPACE FIXED)		ALTITUDE		RANGE (FRØM LAUNCH)	
	T (SEC)	△T (SEC)	ϑ (DEG)	△ϑ (DEG)	V* (DEG)	△V* (DEG)	ALT (M)	△ALT (M)	RANGE (M)	△RANGE (M)
STANDARD	627.56		89.88		7806.0		185134.		2092602.	
NØMINAL MASS + 2268 kg	630.05	2.49	89.87	-0.01	7806.0	0.0	185026.	-108.	2087898.	-4704.
NØMINAL MASS - 2268 kg	625.08	-2.48	89.89	0.01	7806.0	0.0	185197.	64.	2097169.	4567.
SPECIFIC IMPULSE + 1%	624.89	-2.67	89.88	-0.00	7806.0	0.0	185165.	31.	2097792.	5190.
SPECIFIC IMPULSE - 1%	630.38	2.82	89.88	-0.00	7806.0	0.0	185035.	-99.	2087078.	-5524.
FLØW RATE + 1%	628.34	0.78	89.83	-0.06	7806.0	0.0	184973.	-160.	2086117.	-6486.
FLØW RATE - 1%	626.86	-0.70	89.94	0.06	7806.0	0.0	185265.	132.	2098716.	6114.
DENSITY INCREASE	629.24	1.68	89.89	0.01	7806.0	0.0	185113.	-20.	2089205.	-3398.
DENSITY DECREASE	625.96	-1.60	89.87	-0.01	7806.0	0.0	185123.	-11.	2095887.	3284.
AMBIENT PRESSURE INCREASE	628.57	1.01	89.89	0.01	7806.0	0.0	185131.	-3.	2090492.	-2111.
AMBIENT PRESSURE DECREASE	626.62	-0.94	89.87	-0.01	7806.0	0.0	185124.	-9.	2094577.	1975.
2σ TAILWIND	626.18	-1.38	89.88	-0.00	7806.0	0.0	185331.	198.	2098161.	5559.
2σ HEADWIND	628.03	0.47	89.88	-0.00	7806.0	0.0	185039.	-95.	2090532.	-2071.
2σ RIGHT CROSS WIND	627.63	0.07	89.88	-0.00	7806.0	0.0	185142.	9.	2092883.	281.
2σ LEFT CROSS WIND	627.94	0.38	89.88	-0.00	7806.0	0.0	185094.	-40.	2091455.	-1147.
PØSITIVE RSS		4.35		0.06		0.0		248.		11439.
NEGATIVE RSS		4.37		0.06		0.0		241.		10785.
RSS		4.36		0.06		0.0		245.		11112.

TABLE 8B

S-IV STAGE INSERTION PARAMETERS
RESULTING FRØM PERFØRMANCE AND ATMØSPHERIC VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE DURING S-I STAGE ØPERATIØN

VARIATIØNS	TIME (FRØM LIFTØFF)		LØNGITUDE (PØSITIVE WEST ØF GREENWICH)		GEØCENTRIC LAT (PØSITIVE NØRTH ØF EQUATØR)		GEØDETIC LAT (PØSITIVE NØRTH ØF EQUATØR)	
	T (SEC)	ΔT (SEC)	λ (DEG)	$\Delta\lambda$ (DEG)	ϕ' (DEG)	$\Delta\phi'$ (DEG)	ϕ (DEG)	$\Delta\phi$ (DEG)
STANDARD	627.56		61.1164		21.7055		21.8380	
NØMINAL MASS + 2268 kg	630.05	2.49	61.1588	0.0424	21.7210	C.C155	21.8535	0.0156
NØMINAL MASS - 2268 kg	625.08	-2.48	61.0752	-0.0412	21.6905	-C.C150	21.8229	-0.0151
SPECIFIC IMPULSE + 1%	624.89	-2.67	61.0696	-C.C468	21.6884	-0.0172	21.8207	-0.0172
SPECIFIC IMPULSE - 1%	630.38	2.82	61.1662	0.0498	21.7238	0.C183	21.8563	0.0184
FLØW RATE + 1%	628.34	0.78	61.1739	0.0574	21.7290	C.C235	21.8615	0.0236
FLØW RATE - 1%	626.86	-0.70	61.0623	-0.0541	21.6834	-C.0222	21.8157	-0.0223
DENSITY INCREASE	629.24	1.68	61.1470	0.0306	21.7168	0.0113	21.8493	0.0113
DENSITY DECREASE	625.96	-1.60	61.C869	-0.0296	21.6946	-0.C1C9	21.8270	-0.0110
AMBIENT PRESSURE INCREASE	628.57	1.01	61.1354	0.0190	21.7126	0.CC70	21.8450	0.0071
AMBIENT PRESSURE DECREASE	626.62	-0.94	61.0986	-0.0178	21.6989	-C.C066	21.8313	-0.0066
2σ TAILWIND	626.18	-1.38	61.0667	-0.0498	21.6865	-C.0190	21.8188	-0.0191
2σ HEADWIND	628.03	0.47	61.1349	0.0185	21.7126	0.0071	21.8451	0.0071
2σ RIGHT CROSS WIND	627.63	0.07	61.1143	-0.0021	21.7037	-0.0019	21.8361	-0.0019
2σ LEFT CROSS WIND	627.94	0.38	61.1260	0.0096	21.7108	C.0053	21.8433	0.0053
PØSITIVE RSS		4.35		0.0965		0.0371		0.0373
NEGATIVE RSS		4.37		0.1024		0.0392		0.0394
RSS		4.36		0.0994		0.0382		0.0384

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TABLE 8C

S-IV STAGE INSERTION PARAMETERS
RESULTING FRØM PERFØRMANCE AND ATMØSPHERIC VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE DURING S-I STAGE ØPERATIØN

VARIATIØNS	TIME (FRØM LIFTØFF)		X PØSITIØN (EARTH FIXED)		Y PØSITIØN (EARTH FIXED)		Z PØSITIØN (EARTH FIXED)	
	T (SEC)	ΔT (SEC)	X (M)	ΔX (M)	Y (M)	ΔY (M)	Z (M)	ΔZ (M)
STANDARD	627.56		2114493.		-164984.		50163.	
NØMINAL MASS + 2268 kg	630.05	2.49	2109870.	-4623.	-163528.	1456.	50327.	165.
NØMINAL MASS - 2268 kg	625.08	-2.48	2118967.	4474.	-166440.	-1456.	49996.	-167.
SPECIFIC IMPULSE + 1%	624.89	-2.67	2119563.	5071.	-166677.	-1693.	49985.	-177.
SPECIFIC IMPULSE - 1%	630.38	2.82	2109073.	-5419.	-163248.	1736.	50347.	184.
FLØW RATE + 1%	628.34	0.78	2108121.	-6372.	-162988.	1996.	50124.	-39.
FLØW RATE - 1%	626.86	-0.70	2120491.	5998.	-166890.	-1906.	50202.	39.
DENSITY INCREASE	629.24	1.68	2111173.	-3320.	-163878.	1107.	50272.	109.
DENSITY DECREASE	625.96	-1.60	2117692.	3199.	-166084.	-1100.	50059.	-104.
AMBIENT PRESSURE INCREASE	628.57	1.01	2112433.	-2059.	-164288.	697.	50228.	65.
AMBIENT PRESSURE DECREASE	626.62	-0.94	2116415.	1923.	-165648.	-664.	50102.	-60.
2σ TAILWIND	626.18	-1.38	2119975.	5483.	-166643.	-1659.	50058.	-104.
2σ HEADWIND	628.03	0.47	2112444.	-2049.	-164387.	597.	50200.	37.
2σ RIGHT CROSS WIND	627.63	0.07	2114766.	274.	-165069.	-85.	50270.	108.
2σ LEFT CROSS WIND	627.94	0.38	2113366.	-1127.	-164642.	342.	50012.	-151.
PØSITIVE RSS		4.35		11215.		3362.		303.
NEGATIVE RSS		4.37		10586.		3609.		330.
RSS		4.36		10901.		3486.		316.

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TABLE 9A

S-IV STAGE INSERTION PARAMETERS
RESULTING FRØM S-IV STAGE PERFØRMANCE VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE

VARIATIØNS	TIME (FRØM LIFTØFF)		PATH ANGLE (SPACE FIXED)		VELØCITY (SPACE FIXED)		ALTITUDE		RANGE (FRØM LAUNCH)	
	T (SEC)	Δ T (SEC)	ϑ (DEG)	$\Delta\vartheta$ (DEG)	V* (M/SEC)	Δ V* (M/SEC)	ALT (M)	ΔALT (M)	RANGE (M)	Δ RANGE (M)
STANDARD	627.56		89.88		7806.C		185134.		2092602.	
NØMINAL MASS + 136 kg	628.69	1.13	89.88	0.00	7806.0	C.0	185122.	-11.	2096950.	4348.
NØMINAL MASS - 136 kg	626.43	-1.13	89.88	0.00	7806.0	C.0	185140.	6.	2088252.	-4350.
SPECIFIC IMPULSE + 0.5%	626.24	-1.32	89.88	C.00	7806.0	0.0	185290.	156.	2088852.	-3750.
SPECIFIC IMPULSE - 0.5%	628.89	1.33	89.88	0.00	7806.C	0.0	184973.	-161.	2096352.	3750.
FLØW RATE + 0.5%	626.27	-1.29	89.88	0.00	7806.0	C.0	184990.	-144.	2086328.	-6275.
FLØW RATE - 0.5%	628.87	1.31	89.89	0.00	7806.0	C.0	185266.	133.	2098879.	6277.
+ 2σ PROPELLANT LOADING	631.34	3.78	89.89	C.00	7806.0	0.0	185076.	-58.	2107090.	14488.
- 2σ PROPELLANT LOADING	623.78	-3.78	89.88	0.00	7806.C	0.0	185135.	2.	2078C92.	-14510.
PØSITIVE RSS		4.37		0.00		C.0		205.		16801.
NEGATIVE RSS		4.36		0.00		C.C		224.		16820.
RSS		4.36		0.00		C.0		214.		16810.

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TABLE 9B

S-IV STAGE INSERTION PARAMETERS
RESULTING FRØM S-IV STAGE PERFØRMANCE VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE

VARIATIØNS	TIME (FRØM LIFTØFF)		LØNGITUDE (PØSITIVE WEST ØF GREENWICH)		GEØCENTRIC LAT (PØSITIVE NØRTH ØF EQUATØR)		GEØDETIC LAT (PØSITIVE NØRTH ØF EQUATØR)	
	T (SEC)	ΔT (SEC)	λ (DEG)	Δλ (DEG)	Ø' (DEG)	ΔØ' (DEG)	Ø (DEG)	ΔØ (DEG)
STANDARD	627.56		61.1164		21.7055		21.8380	
NØMINAL MASS + 136 kg	628.69	1.13	61.0786	-0.0379	21.6885	-0.0170	21.8208	-0.0171
NØMINAL MASS - 136 kg	626.43	-1.13	61.1543	0.0379	21.7226	0.0170	21.8551	0.0171
SPECIFIC IMPULSE + 0.5%	626.24	-1.32	61.1489	0.0325	21.7205	0.0149	21.8530	0.0150
SPECIFIC IMPULSE - 0.5%	628.89	1.33	61.0839	-0.0325	21.6906	-0.0150	21.8229	-0.0150
FLØW RATE + 0.5%	626.27	-1.29	61.1712	0.0548	21.7298	0.0243	21.8624	0.0244
FLØW RATE - 0.5%	628.87	1.31	61.0616	-0.0548	21.6812	-0.0243	21.8135	-0.0245
+ 2σ PROPELLANT LOADING	631.34	3.78	60.9903	-0.1261	21.6487	-0.0568	21.7809	-0.0571
- 2σ PROPELLANT LOADING	623.78	-3.78	61.2428	0.1264	21.7623	0.0568	21.8950	0.0570
PØSITIVE RSS		4.37		0.1465		0.0658		0.0661
NEGATIVE RSS		4.36		0.1463		0.0658		0.0662
RSS		4.36		0.1464		0.0658		0.0661

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TABLE 9C

S-IV STAGE INSERTION PARAMETERS
RESULTING FRØM S-IV STAGE PERFØRMANCE VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE

VARIATIØNS	TIME (FRØM LIFTØFF)		X PØSITIØN (EARTH FIXED)		Y PØSITIØN (EARTH FIXED)		Z PØSITIØN (EARTH FIXED)	
	T (SEC)	ΔT (SEC)	X (M)	ΔX (M)	Y (M)	ΔY (M)	Z (M)	Δ Z (M)
STANDARD	627.56		2114493.		-164984.		50163.	
NØMINAL MASS + 136 kg	628.69	1.13	2118721.	4228.	-166439.	-1454.	50350.	187.
NØMINAL MASS - 136 kg	626.43	-1.13	2110260.	-4233.	-163537.	1447.	49976.	-187.
SPECIFIC IMPULSE + 0.5%	626.24	-1.32	2110893.	-3600.	-163594.	1390.	49970.	-193.
SPECIFIC IMPULSE - 0.5%	628.89	1.33	2118090.	3597.	-166381.	-1397.	50356.	194.
FLØW RATE + 0.5%	626.27	-1.29	2108337.	-6156.	-163042.	1942.	49924.	-238.
FLØW RATE - 0.5%	628.87	1.31	2120645.	6152.	-166943.	-1959.	50403.	240.
+ 2σ PROPELLANT LOADING	631.34	3.78	2128571.	14078.	-169860.	-4876.	50787.	625.
- 2σ PROPELLANT LOADING	623.78	-3.78	2100364.	-14129.	-160186.	4798.	49540.	-622.
PØSITIVE RSS		4.37		16336.		5551.		722.
NEGATIVE RSS		4.36		16383.		5628.		718.
RSS		4.36		16359.		5590.		720.

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TABLE 10A

S-IV STAGE APØGEE PARAMETERS
RESULTING FRØM PERFØRMANCE AND ATMØSPHERIC VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE DURING S-I STAGE ØPERATIØN

VARIATIØNS	TIME (FRØM LIFTØFF)		PATH ANGLE (SPACE FIXED)		VELØCITY (SPACE FIXED)		ALTITUDE		RANGE (FRØM LAUNCH)	
	T (SEC)	ΔT (SEC)	ϑ (DEG)	$\Delta\vartheta$ (DEG)	V* (DEG)	ΔV* (DEG)	ALT (M)	ΔALT (M)	RANGE (M)	ΔRANGE (M)
STANDARD	2578.20		90.00		7769.6		218800.		15859618.	
NØMINAL MASS + 2268 kg	2539.99	-38.21	90.00	0.00	7768.7	-0.9	219397.	597.	15565931.	-293686.
NØMINAL MASS - 2268 kg	2614.09	35.89	90.00	0.00	7770.4	0.8	218211.	-588.	16117284.	257666.
SPECIFIC IMPULSE + 1%	2562.37	-15.84	90.00	0.00	7769.1	-0.5	219244.	444.	15766155.	-93463.
SPECIFIC IMPULSE - 1%	2575.63	-2.57	90.00	0.00	7769.8	0.1	218565.	-235.	15816500.	-43118.
FLØW RATE + 1%	2415.46	-162.75	90.00	0.00	7763.7	-5.9	223252.	4453.	14718093.	-1141524.
FLØW RATE - 1%	2860.47	282.27	90.00	0.00	7774.3	4.7	214587.	-4213.	17837340.	1977722.
DENSITY INCREASE	2616.02	37.82	90.00	0.00	7770.6	1.0	217950.	-850.	16102216.	242599.
DENSITY DECREASE	2529.89	-48.31	90.00	0.00	7768.2	-1.4	219929.	1130.	15533623.	-325995.
AMBIENT PRESSURE INCREASE	2620.71	42.50	90.00	0.00	7770.7	1.1	217907.	-892.	16142998.	283380.
AMBIENT PRESSURE DECREASE	2535.66	-42.54	90.00	0.00	7768.4	-1.3	219840.	1041.	15750897.	-108720.
2σ TAILWIND	2574.91	-3.29	90.00	0.00	7769.0	-0.6	219533.	734.	15849543.	-10075.
2σ HEADWIND	2566.08	-12.12	90.00	0.00	7769.6	-0.1	218737.	-63.	15769662.	-89956.
2σ RIGHT CROSS WIND	2563.34	-14.87	90.00	0.00	7769.2	-0.4	219160.	360.	15760950.	-98668.
2σ LEFT CROSS WIND	2570.65	-7.55	90.00	0.00	7769.5	-0.1	218852.	52.	15798556.	-61062.
PØSITIVE RSS		290.17		0.00		5.0		4838.		2029023.
NEGATIVE RSS		181.06		0.00		6.3		4435.		1240836.
RSS		235.62		0.00		5.7		4637.		1634929.

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TABLE 10B

S-IV STAGE APØGEE PARAMETERS
RESULTING FRØM PERFØRMANCE AND ATMØSPHERIC VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE DURING S-I STAGE ØPERATIØN

VARIATIØNS	TIME (FRØM LIFTØFF)		LØNGITUDE (PØSITIVE WEST ØF GREENWICH)		GEØCENTRIC LAT (PØSITIVE NØRTH ØF EQUATØR)		GEØDETIC LAT (PØSITIVE NØRTH ØF EQUATØR)	
	T (SEC)	ΔT (SEC)	λ (DEG)	Δλ (DEG)	Ø' (DEG)	ΔØ' (DEG)	Ø (DEG)	ΔØ (DEG)
STANDARD	2578.20		303.9671		-31.6776		-31.8517	
NØMINAL MASS + 2268 kg	2539.99	-38.21	307.0681	3.1009	-31.5187	0.1588	-31.6924	0.1593
NØMINAL MASS - 2268 kg	2614.09	35.89	301.2383	-2.7288	-31.7482	-0.0707	-31.9226	-0.0709
SPECIFIC IMPULSE + 1%	2562.37	-15.84	304.9547	0.9875	-31.6315	0.0460	-31.8055	0.0462
SPECIFIC IMPULSE - 1%	2575.63	-2.57	304.4236	0.4564	-31.6627	0.0149	-31.8368	0.0149
FLØW RATE + 1%	2415.46	-162.75	315.9132	11.9460	-30.5868	1.0907	-30.7576	1.0941
FLØW RATE - 1%	2860.47	282.27	283.0959	-20.8712	-30.5815	1.0960	-30.7523	1.0995
DENSITY INCREASE	2616.02	37.82	301.3986	-2.5686	-31.7506	-0.0731	-31.9250	-0.0733
DENSITY DECREASE	2529.89	-48.31	307.4074	3.4402	-31.4899	0.1877	-31.6635	0.1882
AMBIENT PRESSURE INCREASE	2620.71	42.50	300.9662	-3.0010	-31.7560	-0.0785	-31.9305	-0.0787
AMBIENT PRESSURE DECREASE	2535.66	-42.54	305.1154	1.1483	-31.6209	0.0567	-31.7949	0.0568
2σ TAILWIND	2574.91	-3.29	304.0734	0.1062	-31.6709	0.0067	-31.8450	0.0067
2σ HEADWIND	2566.08	-12.12	304.9182	0.9511	-31.6376	0.0399	-31.8117	0.0401
2σ RIGHT CROSS WIND	2563.34	-14.87	305.0102	1.0430	-31.6327	0.0448	-31.8068	0.0450
2σ LEFT CROSS WIND	2570.65	-7.55	304.6127	0.6456	-31.6504	0.0272	-31.8245	0.0273
PØSITIVE RSS		290.17		13.0031		1.5688		1.5738
NEGATIVE RSS		181.06		21.4163		0.1284		0.1288
RSS		235.62		17.2097		0.8486		0.8513

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TABLE 11A

S-IV STAGE APØGEE PARAMETERS
RESULTING FRØM S-IV STAGE PERFØRMANCE VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE

VARIATIØNS	TIME (FRØM LIFTØFF)		PATH ANGLE (SPACE FIXED)		VELØCITY (SPACE FIXED)		ALTITUDE		RANGE (FRØM LAUNCH)	
	T (SEC)	△ T (SEC)	ϑ (DEG)	△ ϑ (DEG)	V* (DEG)	△ V* (DEG)	ALT (M)	△ ALT (M)	RANGE (M)	△RANGE (M)
STANDARD	2578.20		90.00		7769.6		218800.		15859618.	
NØMINAL MASS + 136 kg	2581.71	3.50	90.00	0.00	7769.8	0.1	218695.	-105.	15881474.	21856.
NØMINAL MASS - 136 kg	2574.27	-3.93	90.00	0.00	7769.5	-0.1	218884.	84.	15834010.	-25607.
SPECIFIC IMPULSE + 0.5%	2582.07	3.87	90.00	0.00	7769.3	-0.3	219234.	434.	15888855.	29237.
SPECIFIC IMPULSE - 0.5%	2573.18	-5.02	90.00	0.00	7769.9	0.3	218403.	-397.	15812239.	-47379.
FLØW RATE + 0.5%	2565.48	-12.72	90.00	0.00	7769.7	0.1	218576.	-223.	15965308.	105691.
FLØW RATE - 0.5%	2594.09	15.89	90.00	0.00	7769.7	0.0	218936.	136.	15970064.	110446.
+ 2σ PROPELLANT LOADING	2593.34	15.14	90.00	0.00	7770.1	0.5	218344.	-456.	15946531.	86913.
- 2σ PROPELLANT LOADING	2568.64	-9.56	90.00	0.00	7769.4	-0.2	218971.	172.	15794457.	-65161.
PØSITIVE RSS		22.56		0.00		0.6		494.		179597.
NEGATIVE RSS		17.14		0.00		0.4		653.		84536.
RSS		19.85		0.00		0.5		573.		132067.

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TABLE 11B

S-IV STAGE APØGEE PARAMETERS
RESULTING FRØM S-IV STAGE PERFØRMANCE VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE

VARIATIØNS	TIME (FRØM LIFTØFF)		LØNGITUDE (PØSITIVE WEST ØF GREENWICH)		GEØCENTRIC LAT (PØSITIVE NØRTH ØF EQUATØR)		GEØDETIC LAT (PØSITIVE NØRTH ØF EQUATØR)	
	T (SEC)	ΔT (SEC)	λ (DEG)	Δλ (DEG)	Ø' (DEG)	ΔØ' (DEG)	Ø (DEG)	ΔØ (DEG)
STANDARD	2578.20		303.9671		-31.6776		-31.8517	
NØMINAL MASS + 136 kg	2581.71	3.50	303.7360	-0.2311	-31.6868	-0.0093	-31.8610	-0.0093
NØMINAL MASS - 136 kg	2574.27	-3.93	304.2379	0.2707	-31.6662	0.0114	-31.8403	0.0114
SPECIFIC IMPULSE + 0.5%	2582.07	3.87	303.6578	-0.3094	-31.6884	-0.0108	-31.8626	-0.0109
SPECIFIC IMPULSE - 0.5%	2573.18	-5.02	304.4683	0.5011	-31.6580	0.0195	-31.8321	0.0196
FLØW RATE + 0.5%	2565.48	-12.72	302.8482	-1.1189	-31.7119	-0.0344	-31.8862	-0.0345
FLØW RATE - 0.5%	2594.09	15.89	302.7984	-1.1688	-31.7174	-0.0399	-31.8917	-0.0400
+ 2σ PROPELLANT LOADING	2593.34	15.14	303.0477	-0.9194	-31.7115	-0.0340	-31.8858	-0.0341
- 2σ PROPELLANT LOADING	2568.64	-9.56	304.6559	0.6887	-31.6471	0.0305	-31.8212	0.0306
PØSITIVE RSS		22.56		0.8937		0.0379		0.0381
NEGATIVE RSS		17.14		1.9007		0.0642		0.0644
RSS		19.85		1.3972		0.0511		0.0512

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TABLE 12A

S-IV STAGE PERIGEE PARAMETERS
RESULTING FRØM PERFØRMANCE AND ATMØSPHERIC VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE DURING S-I STAGE ØPERATIØN

VARIATIØNS	TIME (FRØM LIFTØFF)		PATH ANGLE (SPACE FIXED)		VELØCITY (SPACE FIXED)		ALTITUDE		RANGE (FRØM LAUNCH)	
	T (SEC)	△T (SEC)	ϑ (DEG)	△ϑ (DEG)	V* (DEG)	△V* (DEG)	ALT (M)	△ALT (M)	RANGE (M)	△RANGE (M)
STANDARD	5230.99		90.00		7813.0		182245.		5009629.2	
NØMINAL MASS + 2268 kg	5192.16	-38.83	90.00	0.00	7814.2	1.2	181107.	-1138.	5309505.0	299875.8
NØMINAL MASS - 2268 kg	5265.38	34.39	90.00	0.00	7812.0	-0.9	183113.	868.	4745648.1	-263981.1
SPECIFIC IMPULSE + 1%	5214.28	-16.71	90.00	0.00	7813.4	0.4	181911.	-334.	5106054.9	96425.7
SPECIFIC IMPULSE - 1%	5228.54	-2.45	90.00	0.00	7813.1	0.1	182067.	-178.	5052096.6	42467.4
FLØW RATE + 1%	5068.07	-162.92	90.00	0.00	7819.3	6.3	176457.	-5788.	6185773.9	1176144.7
FLØW RATE - 1%	5513.89	282.90	90.00	0.00	7807.9	-5.0	186114.	3869.	3004818.2	-2004810.9
DENSITY INCREASE	5268.42	37.43	90.00	0.00	7812.0	-1.0	183037.	792.	4759886.7	-249742.4
DENSITY DECREASE	5182.21	-48.78	90.00	0.00	7814.4	1.5	180973.	-1272.	5344847.5	335218.3
AMBIENT PRESSURE INCREASE	5273.26	42.27	90.00	0.00	7811.9	-1.1	183159.	913.	4718600.7	-291028.5
AMBIENT PRESSURE DECREASE	5187.58	-43.41	90.00	0.00	7814.3	1.3	181112.	-1133.	5312664.4	303035.2
2σ TAILWIND	5227.68	-3.31	90.00	0.00	7813.2	0.2	182297.	52.	5023194.1	13564.9
2σ HEADWIND	5218.87	-12.12	90.00	0.00	7813.3	0.3	181891.	-354.	5100363.6	90734.4
2σ RIGHT CROSS WIND	5216.96	-14.03	90.00	0.00	7813.4	0.4	181896.	-349.	5111493.4	101864.2
2σ LEFT CROSS WIND	5223.16	-7.83	90.00	0.00	7813.2	0.2	182021.	-224.	5071527.8	61898.6
PØSITIVE RSS		290.53		0.00		6.7		4145.		1308116.7
NEGATIVE RSS		181.70		0.00		5.3		6176.		2058159.8
RSS		236.11		0.00		6.0		5160.		1683138.2

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TABLE 12B

S-IV STAGE PERIGEE PARAMETERS
RESULTING FRØM PERFØRMANCE AND ATMØSPHERIC VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE DURING S-I STAGE ØPERATIØN

VARIATIØNS	TIME (FRØM LIFTØFF)		LØNGITUDE (PØSITIVE WEST ØF GREENWICH)		GEØCENTRIC LAT (PØSITIVE NØRTH ØF EQUATØR)		GEØDETIC LAT (PØSITIVE NØRTH ØF EQUATØR)	
	T (SEC)	ΔT (SEC)	λ (DEG)	Δλ (DEG)	Ø' (DEG)	ΔØ' (DEG)	Ø (DEG)	ΔØ (DEG)
STANDARD	5230.99		132.9631		31.7373		31.9116	
NØMINAL MASS + 2268 kg	5192.16	-38.83	136.1628	3.1997	31.6271	-0.11C2	31.8011	-0.1105
NØMINAL MASS - 2268 kg	5265.38	34.39	130.1382	-2.8249	31.7608	C.C235	31.9352	0.0236
SPECIFIC IMPULSE + 1%	5214.28	-16.71	133.9924	1.0292	31.7071	-0.0302	31.8814	-0.0302
SPECIFIC IMPULSE - 1%	5228.54	-2.45	133.4176	0.4545	31.7301	-0.0072	31.9044	-0.0072
FLØW RATE + 1%	5068.07	-162.92	145.4014	12.4382	30.7946	-0.9427	30.9660	-0.9456
FLØW RATE - 1%	5513.89	282.90	111.5624	-21.4007	30.1955	-1.5418	30.3650	-1.5467
DENSITY INCREASE	5268.42	37.43	13C.2915	-2.6716	31.7657	0.0284	31.9402	0.0285
DENSITY DECREASE	5182.21	-48.78	136.5376	3.5745	31.6C25	-0.1348	31.7764	-0.1352
AMBIENT PRESSURE INCREASE	5273.26	42.27	129.8493	-3.1139	31.7634	0.C261	31.9378	0.0262
AMBIENT PRESSURE DECREASE	5187.58	-43.41	136.1954	3.2322	31.6209	-C.1164	31.7949	-0.1167
2σ TAILWIND	5227.68	-3.31	133.1076	C.1445	31.7318	-0.0055	31.9061	-0.0055
2σ HEADWIND	5218.87	-12.12	133.9325	0.9694	31.7132	-0.0241	31.8875	-0.0242
2σ RIGHT CROSS WIND	5216.96	-14.03	134.0513	1.0881	31.7093	-0.C280	31.8835	-0.0281
2σ LEFT CROSS WIND	5223.16	-7.83	133.6244	0.6612	31.7208	-C.C165	31.8951	-0.0165
PØSITIVE RSS		290.53		13.8571		0.0452		0.0453
NEGATIVE RSS		181.70		21.9728		1.8199		1.8257
RSS		236.11		17.9150		0.9326		0.9355

TABLE 13A

S-IV STAGE PERIGEE PARAMETERS
RESULTING FRØM S-IV STAGE PERFØRMANCE VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE

VARIATIØNS	TIME (FRØM LIFTØFF)		PATH ANGLE (SPACE FIXED)		VELØCITY (SPACE FIXED)		ALTITUDE		RANGE (FRØM LAUNCH)	
	T (SEC)	△T (SEC)	ϑ (DEG)	△ϑ (DEG)	V* (DEG)	△V* (DEG)	ALT (M)	△ALT (M)	RANGE (M)	△RANGE (M)
STANDARD	5230.99		90.00		7813.0		182245.		5009629.	
NØMINAL MASS + 136 kg	5235.07	4.08	90.00	0.00	7812.9	-0.1	182316.	71.	4987243.	-22387.
NØMINAL MASS - 136 kg	5227.00	-3.99	90.00	0.00	7813.1	0.1	182173.	-72.	5035828.	26199.
SPECIFIC IMPULSE + 0.5%	5234.43	3.44	90.00	0.00	7813.0	0.0	182430.	185.	4981800.	-27830.
SPECIFIC IMPULSE - 0.5%	5224.87	-6.11	90.00	0.00	7813.1	0.1	181994.	-251.	5055399.	45770.
FLØW RATE + 0.5%	5217.87	-13.12	90.00	0.00	7813.2	0.2	181880.	-365.	5100164.	90535.
FLØW RATE - 0.5%	5247.44	16.45	90.00	0.00	7812.7	-0.3	182674.	429.	4898794.	-110835.
+ 2σ PROPELLANT LOADING	5245.66	14.67	90.00	0.00	7812.6	-0.3	182496.	251.	4919439.	-90190.
- 2σ PROPELLANT LOADING	5220.26	-10.73	90.00	0.00	7813.2	0.2	182053.	-192.	5075714.	66085.
PØSITIVE RSS		22.68		0.00		0.3		535.		123875.
NEGATIVE RSS		18.46		0.00		0.5		488.		147290.
RSS		20.57		0.00		0.4		511.		135582.

TABLE 13B

S-IV STAGE PERIGEE PARAMETERS
RESULTING FRØM S-IV STAGE PERFØRMANCE VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE

VARIATIØNS	TIME (FRØM LIFTØFF)		LØNGITUDE (PØSITIVE WEST ØF GREENWICH)		GEØCENTRIC LAT (PØSITIVE NØRTH ØF EQUATØR)		GEØDETIC LAT (PØSITIVE NØRTH ØF EQUATØR)	
	T (SEC)	ΔT (SEC)	λ (DEG)	$\Delta\lambda$ (DEG)	ϕ' (DEG)	$\Delta\phi'$ (DEG)	ϕ (DEG)	$\Delta\phi$ (DEG)
STANDARD	5230.99		132.9631		31.7373		31.9116	
NØMINAL MASS + 136 kg	5235.07	4.08	132.7240	-0.2392	31.7428	0.0055	31.9171	0.0055
NØMINAL MASS - 136 kg	5227.00	-3.99	133.2430	0.2798	31.7304	-0.0069	31.9047	-0.0069
SPECIFIC IMPULSE + 0.5%	5234.43	3.44	132.6655	-0.2976	31.7426	0.0053	31.9169	0.0053
SPECIFIC IMPULSE - 0.5%	5224.87	-6.11	133.4523	0.4892	31.7265	-0.0108	31.9008	-0.0109
FLØW RATE + 0.5%	5217.87	-13.12	133.9301	0.9670	31.7119	-0.0254	31.8862	-0.0254
FLØW RATE - 0.5%	5247.44	16.45	131.7781	-1.1851	31.7572	0.0199	31.9316	0.0200
+ 2σ PROPELLANT LOADING	5245.66	14.67	131.9992	-0.9639	31.7558	0.0185	31.9302	0.0185
- 2σ PROPELLANT LOADING	5220.26	-10.73	133.6688	0.7056	31.7181	-0.0192	31.8924	-0.0192
PØSITIVE RSS		22.68		1.3231		0.0282		0.0283
NEGATIVE RSS		18.46		1.5746		0.0343		0.0344
RSS		20.57		1.4488		0.0312		0.0313

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TABLE 14A

S-I STAGE IMPACT PARAMETERS
RESULTING FRØM PERFØRMANCE AND ATMØSPHERIC VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE

VARIATIØNS	TIME (FRØM LIFTØFF)		PATH ANGLE FRØM LØCAL VERTICAL		VELØCITY (EARTH FIXED)		ALTITUDE		RANGE (FRØM LAUNCH)	
	T (SEC)	Δ T (SEC)	ϑ (DEG)	$\Delta\vartheta$ (DEG)	V (M/SEC)	Δ V (M/SEC)	ALT (M)	Δ ALT (M)	RANGE (M)	Δ RANGE (M)
STANDARD	589.75		179.81		98.1		0.		805431.	
NØMINAL MASS + 2268 kg	583.17	-6.58	179.81	0.00	98.1	0.0	0.	0.	780185.	-25245.
NØMINAL MASS - 2268 kg	596.53	6.78	179.81	0.00	98.1	0.0	0.	0.	831655.	26224.
SPECIFIC IMPULSE + 1%	598.11	8.36	179.81	0.00	98.1	0.0	0.	0.	836073.	30643.
SPECIFIC IMPULSE - 1%	581.45	-8.30	179.81	0.00	98.1	0.0	0.	0.	775116.	-30314.
FLØW RATE + 1%	586.55	-3.20	179.81	0.00	98.1	0.0	0.	0.	787800.	-17631.
FLØW RATE - 1%	592.87	3.12	179.81	0.00	98.1	0.0	0.	0.	822727.	17297.
DENSITY INCREASE	583.85	-5.91	179.81	0.00	98.1	0.0	0.	0.	785369.	-20062.
DENSITY DECREASE	595.71	5.96	179.81	0.00	98.1	0.0	0.	0.	825603.	20173.
AMBIENT PRESSURE INCREASE	585.95	-3.80	179.81	0.00	98.1	0.0	0.	0.	792684.	-12747.
AMBIENT PRESSURE DECREASE	593.43	3.68	179.81	0.00	98.1	0.0	0.	0.	817673.	12243.
2σ TAILWIND	590.73	0.98	179.81	0.00	98.1	0.0	0.	0.	817435.	12005.
2σ HEADWIND	590.05	0.30	179.81	0.00	98.1	0.0	0.	0.	802536.	-2895.
2σ RIGHT CROSS WIND	589.81	0.06	179.81	0.00	98.1	0.0	0.	0.	806488.	1057.
2σ LEFT CROSS WIND	589.51	-0.25	179.81	0.00	98.1	0.0	0.	0.	803200.	-2231.
PØSITIVE RSS		13.26		0.00		0.0		0.		51263.
NEGATIVE RSS		13.11		0.00		0.0		0.		49451.
RSS		13.18		0.00		0.0		0.		50357.

TABLE 14B

S-I STAGE IMPACT PARAMETERS
RESULTING FRØM PERFØRMANCE AND ATMØSPHERIC VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE

VARIATIØNS	TIME (FRØM LIFTØFF)		LØNGITUDE (PØSITIVE WEST ØF GREENWICH)		GEØCENTRIC LAT (PØSITIVE NØRTH ØF EQUATØR)		GEØDETIC LAT (PØSITIVE NØRTH ØF EQUATØR)	
	T (SEC)	ΔT (SEC)	λ (DEG)	Δλ (DEG)	ø' (DEG)	Δø' (DEG)	ø (DEG)	Δø (DEG)
STANDARD	589.75		72.8041		26.1662		26.3187	
NØMINAL MASS + 2268 kg	583.17	-6.58	73.0419	0.2379	26.2433	0.0772	26.3962	0.0775
NØMINAL MASS - 2268 kg	596.53	6.78	72.5574	-0.2467	26.0855	-0.0807	26.2377	-0.0810
SPECIFIC IMPULSE +1%	598.11	8.36	72.5160	-0.2881	26.0716	-0.0946	26.2237	-0.0950
SPECIFIC IMPULSE -1%	581.45	-8.30	73.0897	0.2856	26.2590	0.0928	26.4119	0.0932
FLØW RATE +1%	586.55	-3.20	72.9704	0.1664	26.2194	0.0532	26.3721	0.0534
FLØW RATE -1%	592.87	3.12	72.6410	-0.1631	26.1137	-0.0524	26.2660	-0.0526
DENSITY INCREASE	583.85	-5.91	72.9929	0.1888	26.2280	0.0619	26.3808	0.0621
DENSITY DECREASE	595.71	5.96	72.6145	-0.1896	26.1036	-0.0625	26.2559	-0.0628
AMBIENT PRESSURE INCREASE	585.95	-3.80	72.9240	0.1199	26.2055	0.0393	26.3582	0.0395
AMBIENT PRESSURE DECREASE	593.43	3.68	72.6890	-0.1151	26.1283	-0.0379	26.2806	-0.0381
2σ TAILWIND	590.73	0.98	72.6994	-0.1047	26.1083	-0.0578	26.2606	-0.0581
2σ HEADWIND	590.05	0.30	72.8272	0.0231	26.1857	0.0195	26.3383	0.0196
2σ RIGHT CROSS WIND	589.81	0.06	72.7819	-0.0222	26.1942	0.0280	26.3468	0.0281
2σ LEFT CROSS WIND	589.51	-0.25	72.8452	0.0411	26.1226	-0.0436	26.2749	-0.0438
PØSITIVE RSS		13.26		0.4670		0.1547		0.1554
NEGATIVE RSS		13.11		0.4807		0.1697		0.1704
RSS		13.18		0.4738		0.1622		0.1629

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TABLE 14C

S-I STAGE IMPACT PARAMETERS
RESULTING FRØM PERFØRMANCE AND ATMØSPHERIC VARIATIØNS ØF A TWØ-SIGMA MAGNITUDE

VARIATIØNS	TIME (FRØM LIFTØFF)		X PØSITIØN (EARTH FIXED)		Y PØSITIØN (EARTH FIXED)		Z PØSITIØN (EARTH FIXED)	
	T (SEC)	ΔT (SEC)	X (M)	ΔX (M)	Y (M)	ΔY (M)	Z (M)	ΔZ (M)
STANDARD	589.75		803192.		-50772.		12694.	
NØMINAL MASS + 2268 kg	583.17	-6.58	778148.	-25044.	-47643.	3129.	12100.	-594.
NØMINAL MASS - 2268 kg	596.53	6.78	829194.	26002.	-54128.	-3355.	13322.	628.
SPECIFIC IMPULSE + 1%	598.11	8.36	833573.	30381.	-54704.	-3931.	13459.	765.
SPECIFIC IMPULSE - 1%	581.45	-8.30	773118.	-30074.	-47027.	3746.	11955.	-739.
FLØW RATE + 1%	586.55	-3.20	785701.	-17490.	-48576.	2196.	12364.	-330.
FLØW RATE - 1%	592.87	3.12	820345.	17153.	-52974.	-2201.	13020.	326.
DENSITY INCREASE	583.85	-5.91	783292.	-19900.	-48277.	2495.	12162.	-532.
DENSITY DECREASE	595.71	5.96	823194.	20002.	-53344.	-2572.	13238.	544.
AMBIENT PRESSURE INCREASE	585.95	-3.80	790548.	-12643.	-49180.	1592.	12359.	-335.
AMBIENT PRESSURE DECREASE	593.43	3.68	815332.	12140.	-52326.	-1553.	13020.	326.
2 σ TAILWIND	590.73	0.98	815053.	11862.	-52296.	-1523.	15456.	2762.
2 σ HEADWIND	590.05	0.30	800340.	-2852.	-50408.	364.	11372.	-1322.
2 σ RIGHT CROSS WIND	589.81	0.06	804290.	1099.	-50905.	-132.	9036.	-3658.
2 σ LEFT CROSS WIND	589.51	-0.25	800863.	-2329.	-50493.	279.	18596.	5902.
PØSITIVE RSS		13.26		50820.		6133.		6629.
NEGATIVE RSS		13.11		49061.		6552.		4066.
RSS		13.18		49941.		6342.		5348.

[redacted]

[redacted]

TABLE 15

FIRST STAGE PITCH TILT PROGRAM FOR SATURN I VEHICLE SA-6

Flight Time (sec)	X (deg)*	Flight Time (sec)	X (deg)*	Flight Time (sec)	X (deg)*	Flight Time (sec)	X (deg)*
0	0	37	19.44	74	34.20	111	56.38
1	0	38	20.30	75	34.85	112	56.87
2	0	39	20.88	76	35.51	113	57.36
3	0	40	21.35	77	36.15	114	57.86
4	0	41	21.82	78	36.79	115	58.35
5	0	42	22.15	79	37.42	116	58.84
6	0	43	22.60	80	38.04	117	59.34
7	0	44	23.05	81	38.65	118	59.83
8	0	45	23.55	82	39.26	119	60.32
9	0	46	24.00	83	39.86	120	60.82
10	0	47	24.45	84	40.45	121	61.31
11	0	48	24.85	85	41.03	122	61.80
12	0	49	25.10	86	41.61	123	62.30
13	0	50	25.55	87	42.28	124	62.79
14	0	51	25.95	88	42.94	125	63.28
15	0	52	26.15	89	43.68	126	63.78
16	.48	53	26.55	90	44.41	127	64.27
17	1.09	54	26.99	91	45.12	128	64.76
18	1.74	55	27.40	92	45.83	129	65.26
19	2.39	56	27.82	93	46.51	130	65.75
20	3.27	57	28.23	94	47.19	131	66.17
21	4.15	58	28.64	95	47.84	132	66.60
22	4.99	59	28.96	96	48.49	133	66.85
23	5.69	60	29.29	97	49.12	134	67.00
24	6.39	61	29.56	98	49.75	CHI ARREST	
25	7.19	62	29.84	99	50.35		
26	7.99	63	30.10	100	50.95		
27	8.87	64	30.37	101	51.44		
28	9.75	65	30.62	102	51.94		
29	10.71	66	30.87	103	52.43		
30	11.66	67	31.11	104	52.92		
31	12.69	68	31.35	105	53.42		
32	13.72	69	31.57	106	53.91		
33	14.82	70	31.80	107	54.40		
34	15.92	71	32.33	108	54.90		
35	17.08	72	32.86	109	55.39		
36	18.23	73	33.53	110	55.88		

*Measured space-fixed from launch vertical (Reference 10).

TABLE 16

SECOND STAGE STEERING EQUATION *

$$\chi p = A_1 + A_2x + A_3y + A_4\dot{x} + A_5\dot{y} + A_6\frac{F}{m} + A_7T + A_8xy + A_9\dot{x}y + A_{10}\dot{x}^2 + A_{11}x\dot{y} + A_{12}y\dot{y} + A_{13}y\frac{F}{m} + A_{14}(\frac{F}{m})^2 + A_{15}\dot{x}T + A_{16}T^2 + A_{17}x^3 + A_{18}xy^2 + A_{19}y\dot{x}^2 + A_{20}y^2\frac{F}{m} + A_{21}y\dot{x}\frac{F}{m} + A_{22}x\dot{y}\frac{F}{m} + A_{23}\dot{x}\dot{y}\frac{F}{m} + A_{24}\dot{y}(\frac{F}{m})^2 + A_{25}x^2T + A_{26}y^2T + A_{27}y\dot{x}T + A_{28}\dot{x}\dot{y}T + A_{29}\dot{x}\frac{F}{m}T + A_{30}(\frac{F}{m})^2T + A_{31}xT^2 + A_{32}\dot{x}T^2 + A_{33}\dot{y}T^2.$$

VARIABLE	COEFFICIENT	VARIABLE	COEFFICIENT
A_1	$-.38819016 \times 10^{+2}$	A_{18}	$.23911714 \times 10^{-16}$
A_2	$.36608441 \times 10^{-5}$	A_{19}	$-.28013517 \times 10^{-11}$
A_3	$-.50399775 \times 10^{-3}$	A_{20}	$.58251509 \times 10^{-11}$
A_4	$-.65673288 \times 10^{-1}$	A_{21}	$-.66542957 \times 10^{-9}$
A_5	$.78848666 \times 10^{-1}$	A_{22}	$-.26290587 \times 10^{-9}$
A_6	$.78960371 \times 10^{+1}$	A_{23}	$-.10951379 \times 10^{-6}$
A_7	$.96218603 \times 10^{0}$	A_{24}	$.22721801 \times 10^{-4}$
A_8	$.49583253 \times 10^{-9}$	A_{25}	$.90608805 \times 10^{-13}$
A_9	$.19192036 \times 10^{-6}$	A_{26}	$-.13793533 \times 10^{-12}$
A_{10}	$.10608304 \times 10^{-4}$	A_{27}	$-.14992977 \times 10^{-9}$
A_{11}	$-.71545723 \times 10^{-7}$	A_{28}	$.79442788 \times 10^{-8}$
A_{12}	$.15238895 \times 10^{-6}$	A_{29}	$-.15858595 \times 10^{-5}$
A_{13}	$.36148663 \times 10^{-4}$	A_{30}	$.28478054 \times 10^{-3}$
A_{14}	$-.55735608 \times 10^{-1}$	A_{31}	$.33341993 \times 10^{-9}$
A_{15}	$-.18185596 \times 10^{-3}$	A_{32}	$.19609307 \times 10^{-6}$
A_{16}	$-.13521339 \times 10^{-2}$	A_{33}	$.25250709 \times 10^{-6}$
A_{17}	$-.10493679 \times 10^{-17}$		

The S-IV stage thrust will be terminated when space-fixed velocity reaches 7805.95 m/sec.

*References 8 and 9

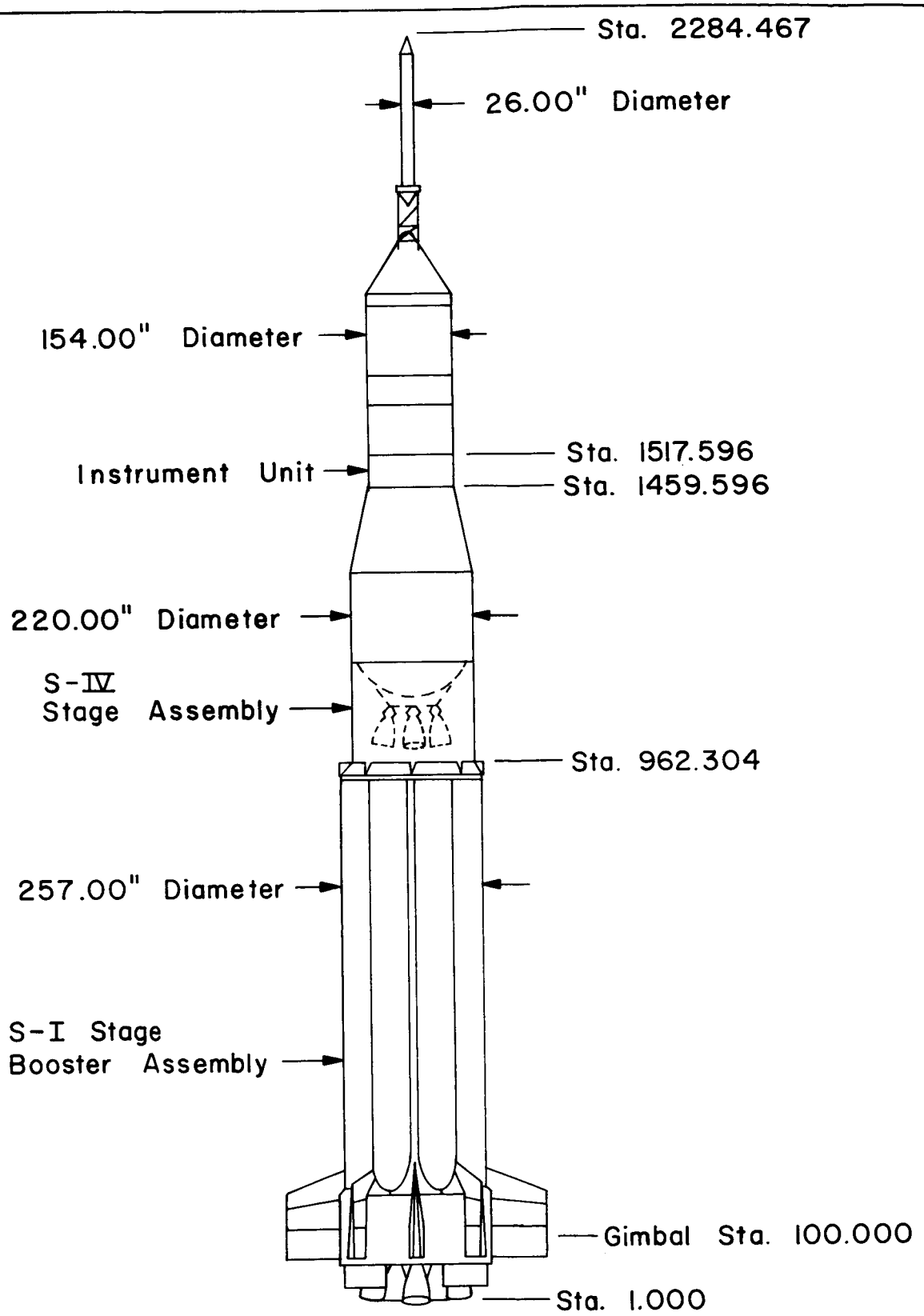


FIG. 1. SA-6 CONFIGURATION

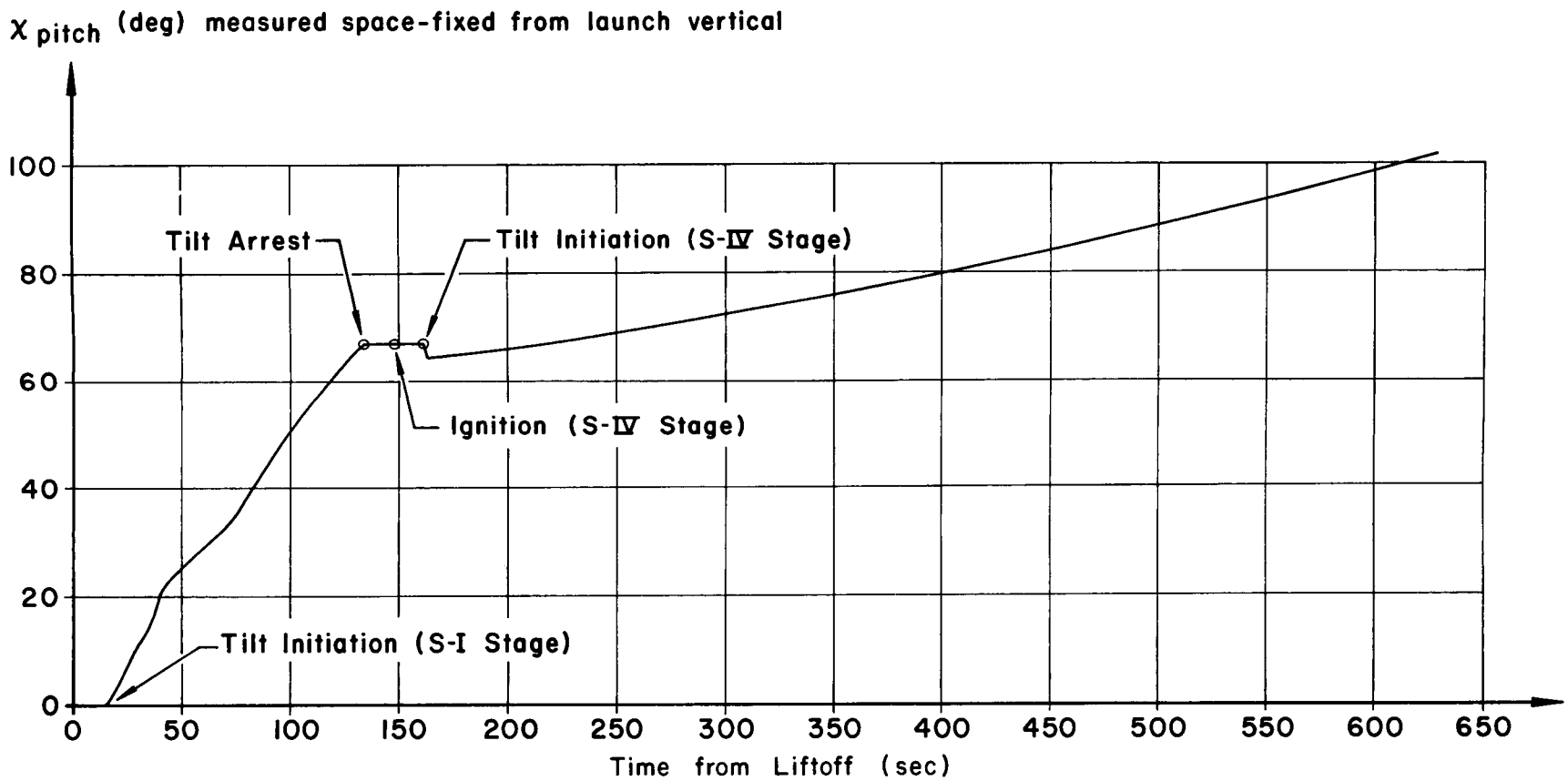


FIG. 2. BIASED PITCH TILT PROGRAM FOR SATURN I: SA-6

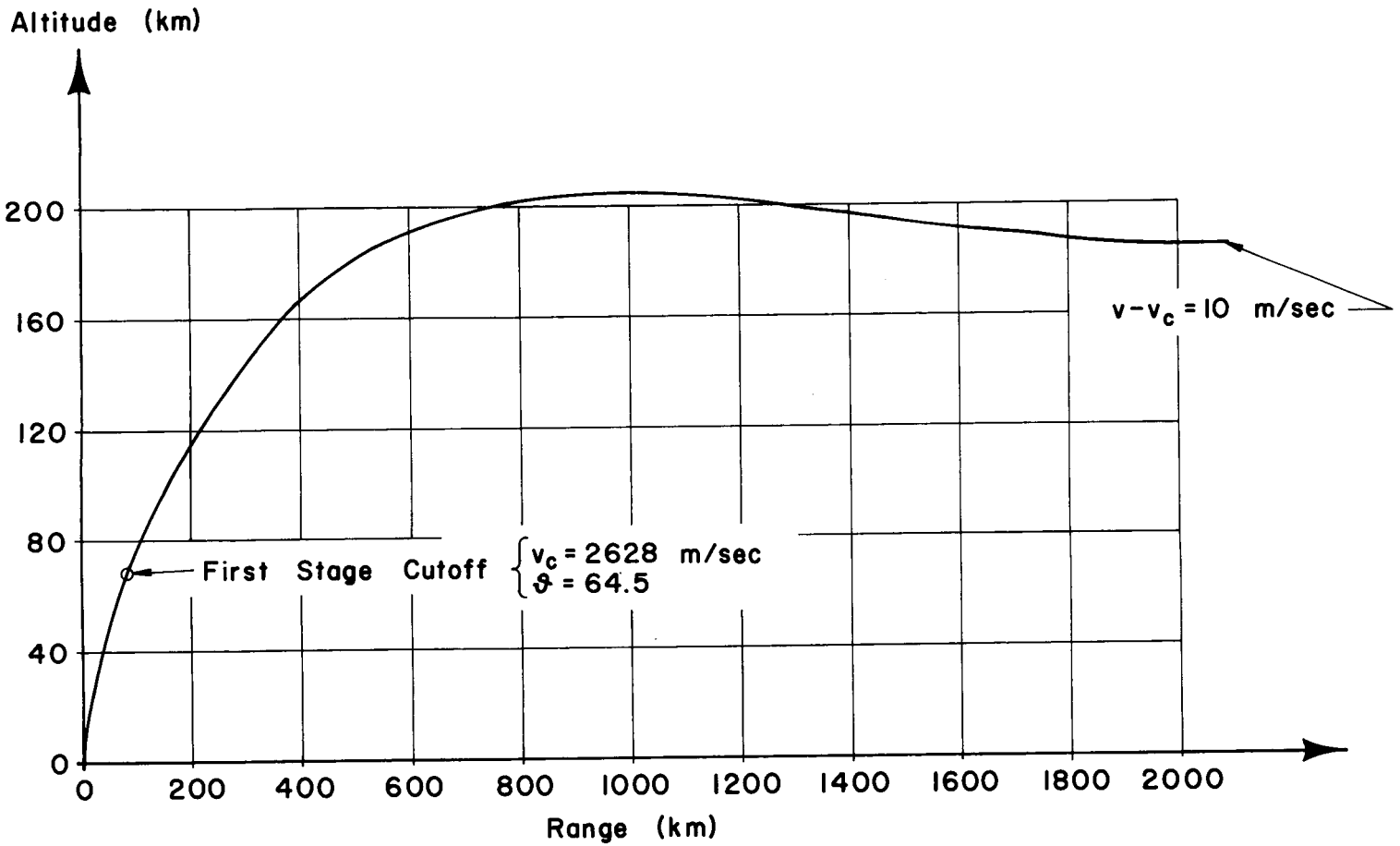


FIG. 3. POWERED FLIGHT TRAJECTORY FOR SATURN I : SA-6 (105° AZIMUTH)

[redacted]

[redacted]

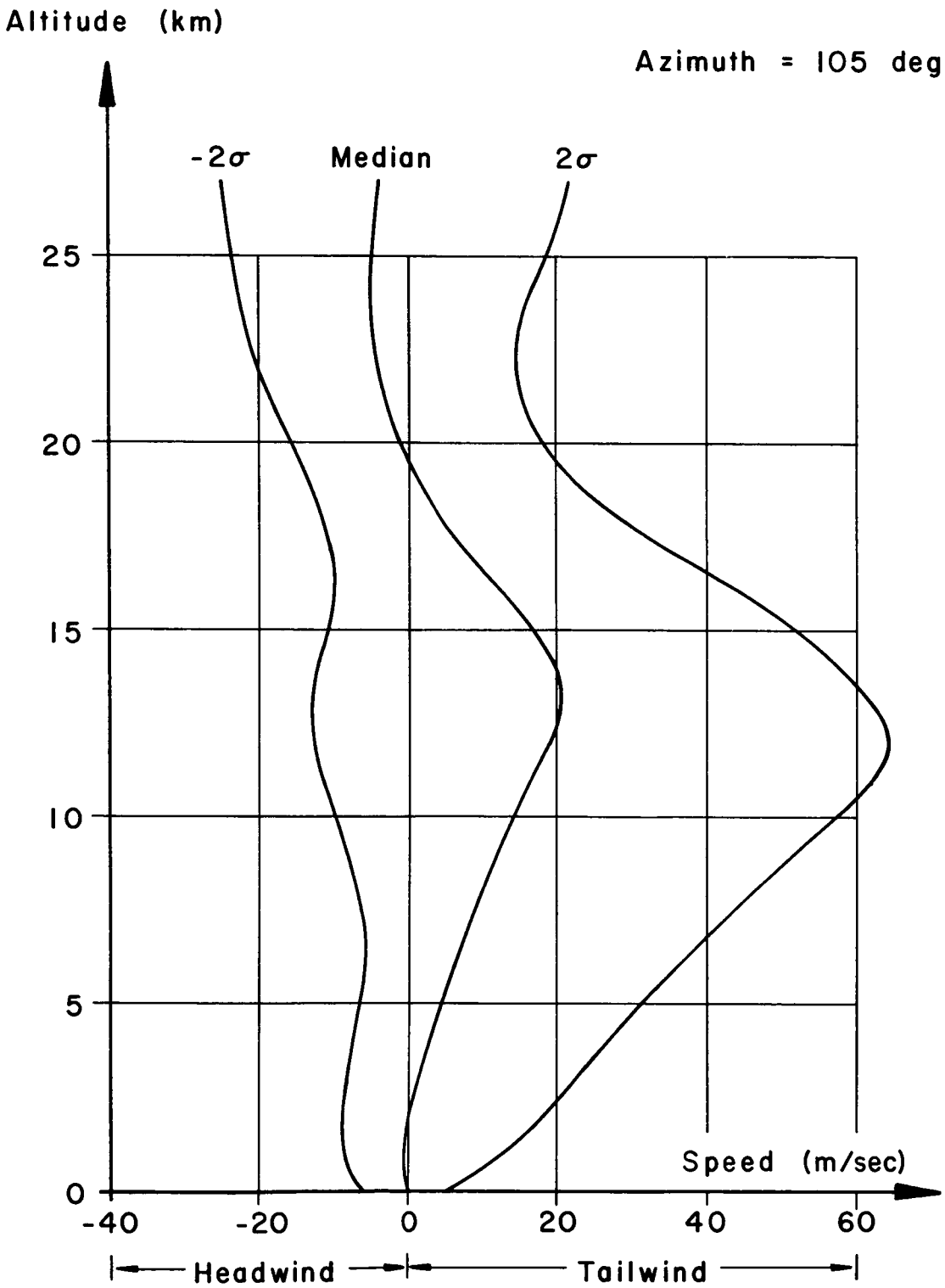
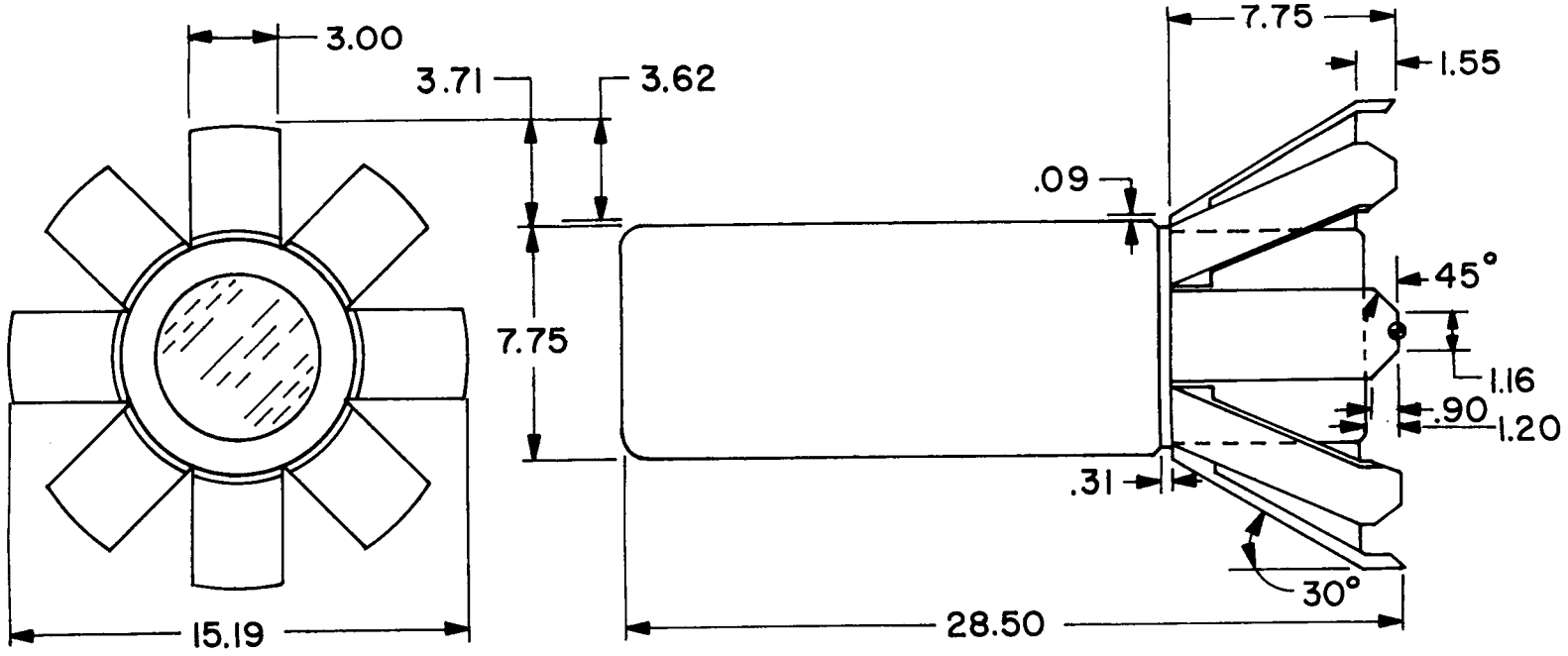


FIG. 4. ANNUAL FLIGHT PLANE WIND PROFILE



All Dimen. In Inches

FIG. 5. SATURN SA-6 RECOVERABLE CAMERA CAPSULE
APPROX. WT.=56 POUNDS (25.4 kg mass)

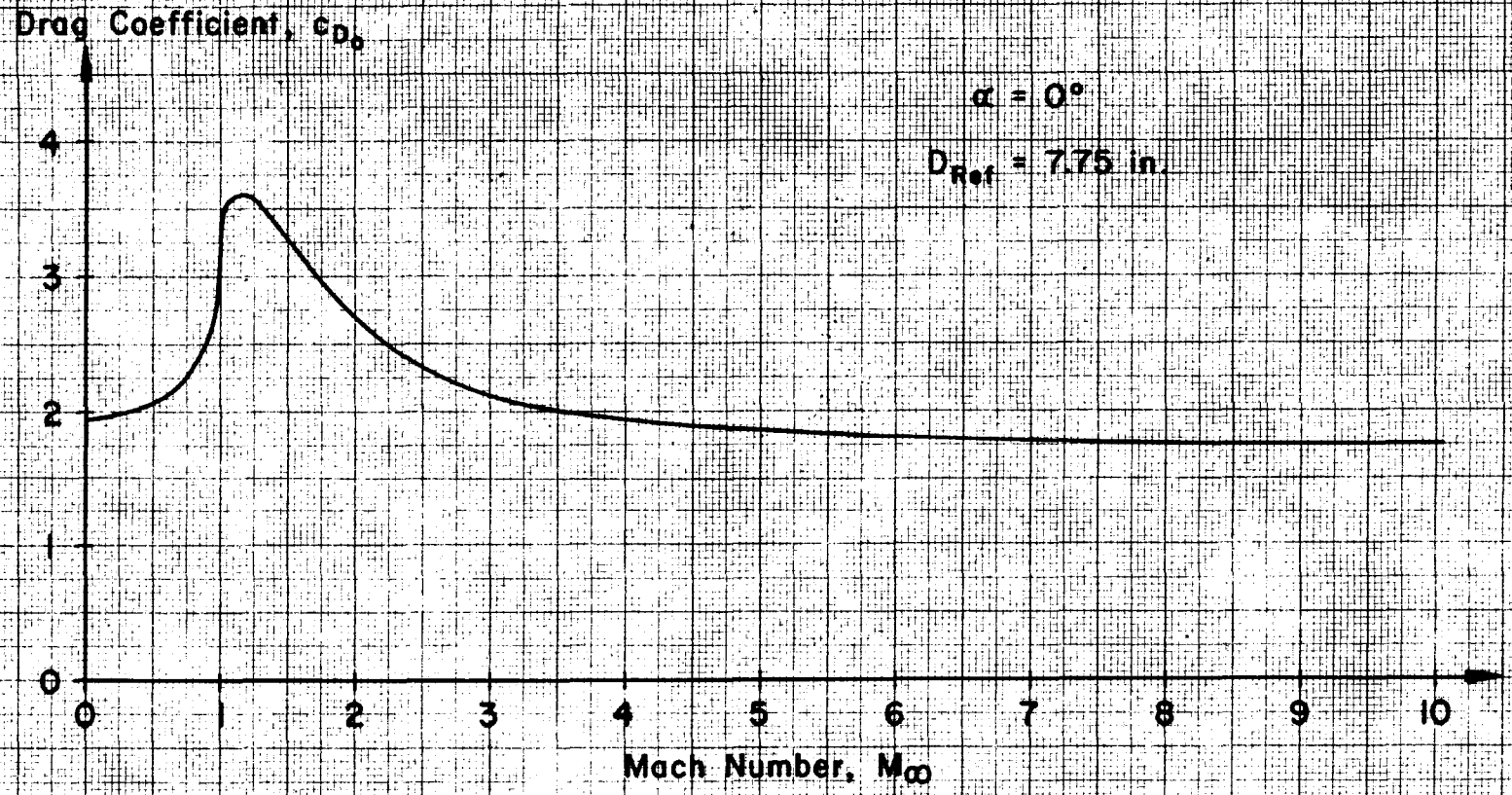


FIG. 6. RECOVERABLE CAMERA CAPSULE
TOTAL DRAG COEFFICIENT VERSUS MACH NUMBER

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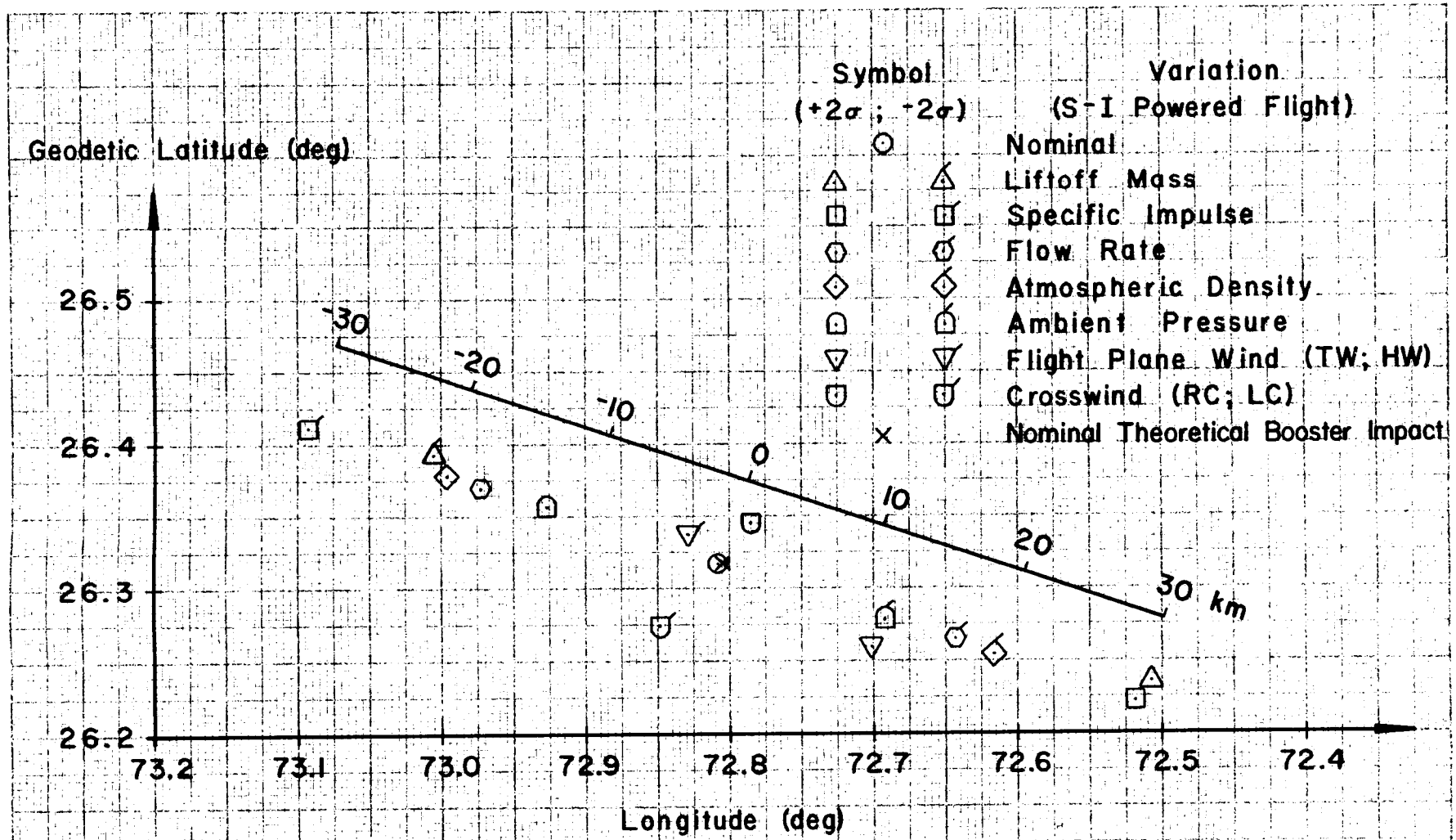

FIG. 7. DISPERSION ABOUT NOMINAL CAMERA CAPSULE IMPACT POINT

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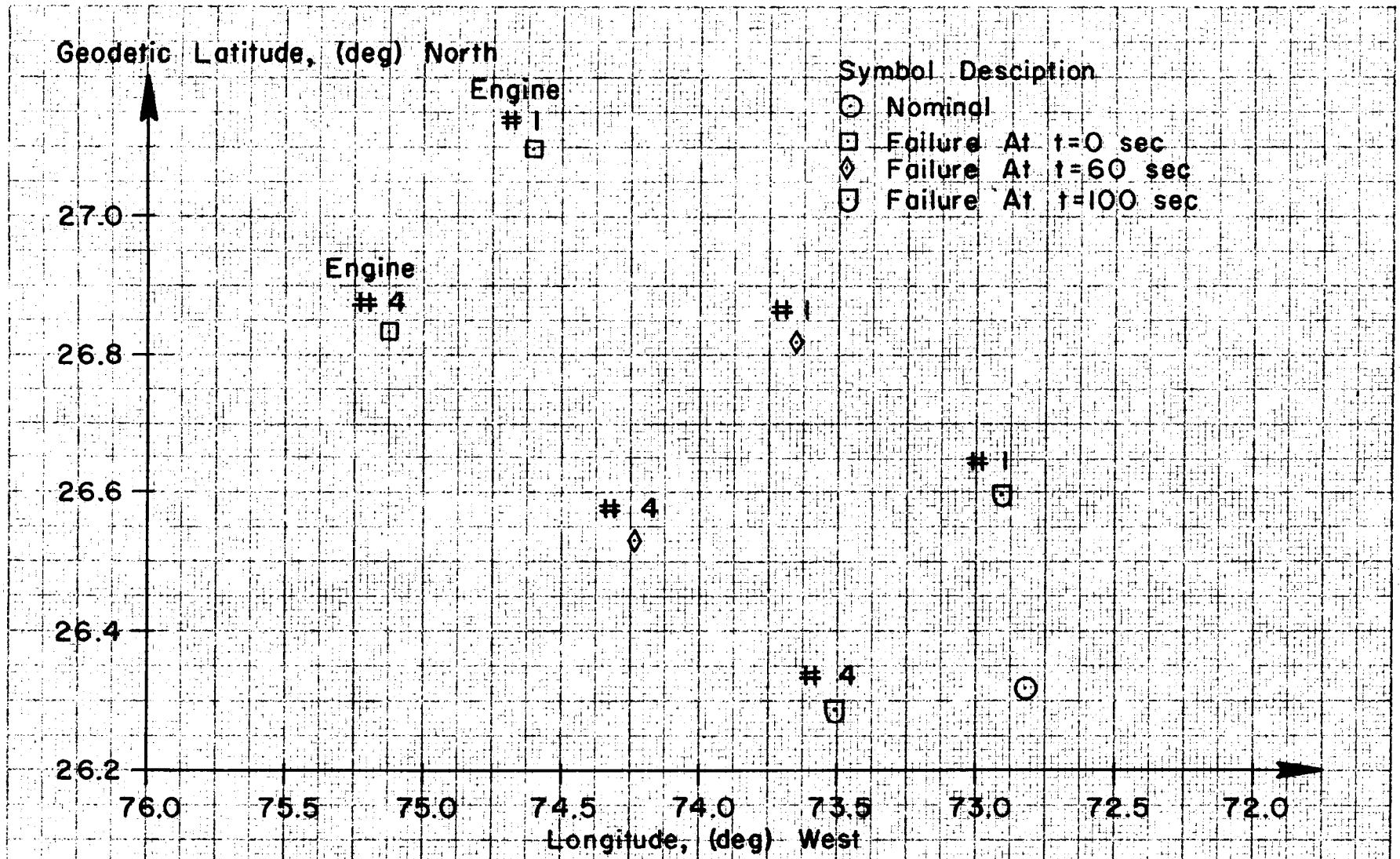

FIG. 8. LATITUDE AND LONGITUDE OF CAMERA CAPSULE IMPACT POINTS FOR ENGINE OUT CASES

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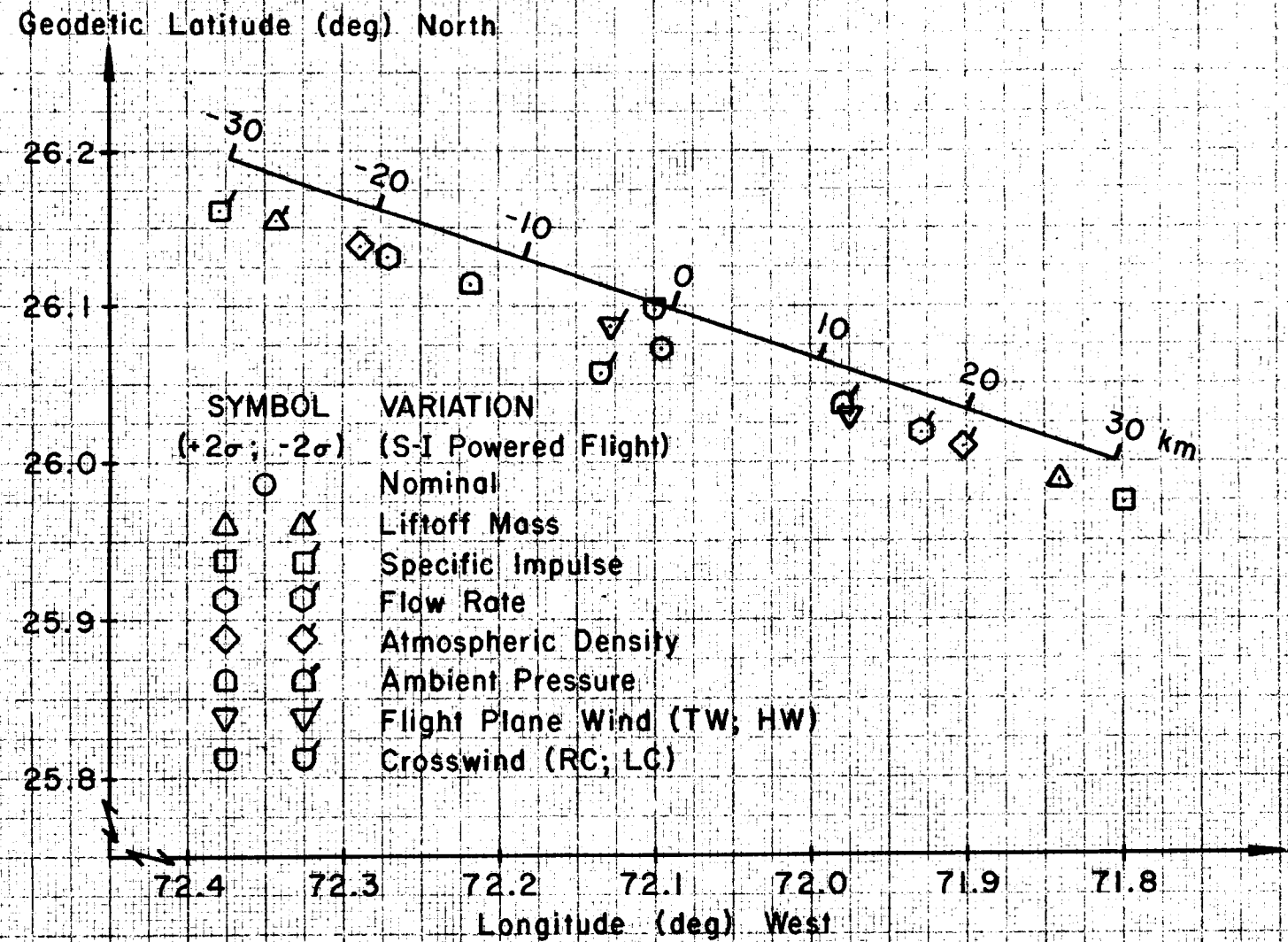

FIG. 9. 2σ IMPACT DISPERSION FOR LAUNCH ESCAPE SYSTEM

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REFERENCES

1. M-AERO-G-53-63, "Cape Canaveral, Florida, Wind Profile Envelope for Selected Flight Azimuths," dated March 28, 1963, (U).

2. Memorandum from Chief, Flight Dynamics Branch, Astrionics Division, M-ASTR-F, "Lift-Off Roll Maneuver Rate for SA-5 and SA-6," dated October 29, 1962, (U).

3. MTP-AERO-61-11, "Range of Density Variability From Surface to 120 km. Altitude," dated February 23, 1961, (U).

4. M-AERO-A-98-62, "Revised Aerodynamic Characteristics of Saturn Vehicles, SA-6 and SA-7,"dated December 7, 1962, (U).

5. M-AERO-A-96-63, "Estimated Power-On Drag of the Saturn I Block II Vehicles During Second Stage Flight," dated September 11, 1963, (U).

6. M-AERO-A-94-63, "Estimated Aerodynamic Characteristics of the Saturn I Second Stage Vehicle, dated September 4, 1963, (U).

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9. Memorandum from Chief, Flight Mechanics Branch, R-AERO-FM, "Pitch Tilt Program and Passive Guidance Polynomial for Saturn I Vehicle SA-6," dated January 17, 1964, (U).

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11. R-P&VE-VOI-64-33, "SA-6 Flight Sequence Requirements," dated April 6, 1964, (U).

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13. R-ASTR-F-2, "Saturn SA-6 and/or SA-7 S-I Stage Control Gains and Shaping Networks with Associated Pole-Zeros and Frequency Response Curves," dated January 16, 1964, (U).

14. R-ASTR-F-1, "Saturn SA-6 and/or SA-7, S-IV Stage Control Gains and Shaping Networks with Associated Pole-Zeros and Frequency Response Curves," dated January 15, 1964, (U).

15. "Saturn I Instrumentation Systems Description SA-6 Volume I," dated October 31, 1963, (U).

APPROVAL NASA TM X-53031

SA-6 PREDICTED STANDARD TRAJECTORY
AND DISPERSION ANALYSIS

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Memorandum

TO Distribution

DATE May 5, 1964

R-AERO-FM-4-64

FROM Chief, Flight Mechanics Branch
R-AERO-FM

SUBJECT Addendum to Technical Memorandum X-53031, "SA-6 Predicted Standard Trajectory and Dispersion Analysis," April 6, 1964, (C)

REFERENCES (a) R-P&VE-VAW-64-56, "Final Mass Characteristics of the Saturn I, SA-6 Vehicle," April 21, 1964, (C)
(b) R-AERO-AD-64-45, "Static Stability and Drag Characteristics for the Saturn I, Block II (SA-6 and SA-7)," April 10, 1964, (U)

1. The purpose of this memorandum is to present a revised predicted trajectory for SA-6. In order to better evaluate vehicle systems, it has been agreed to publish revised trajectory data which reflect any changes of importance to flight evaluation. This revision is due to revised aerodynamic data presented in reference (b). The unusual trends in these data at high Mach numbers ($M > 5$) are due to laminar separation on the launch escape system and reattachment on the command module. Small changes below $M = 5$ were due to the removal of the separator from the LES. The mass characteristics, as given in reference (a), were used for this trajectory.

2. The changes referred to in paragraph 1 result in a velocity increase of approximately 25 m/sec at S-I cut-off signal. The velocity increase occurs after the vehicle passes through the high dynamic pressure region. The S-IV stage will cut off approximately 1.8 seconds sooner than predicted in NASA TM X-53031, due to the velocity increase of the S-I stage.

3. The results given in paragraph 2 are not significant so far as performance or guidance and control are concerned. The tilt program and guidance polynomial remain the same as given in NASA TM X-53031. There is no significant difference in the insertion altitude and path angle, even though the time is approximately 1.8 seconds earlier. The orbital elements are as follows:

Altitude of Perigee	182.15 km
Altitude of Apogee	229.90 km
Semi-Major Axis	6,579.03 km
Eccentricity	.0036
Inclination	31.76 deg
Longitude of Ascending Node	158.90 deg
Argument of Perigee	96.61 deg
Period	88.51 min
Time of Apogee	[illegible] min

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May 5, 1964

4. A detailed presentation of the predicted trajectory parameters is given in Tables 1A through 5C. The trajectory, with significant time points denoted, is presented in five sections. They are (1) S-I stage boost flight; (2) S-IV stage ullage rocket operation after separation but prior to main-stage ignition; (3) S-IV mainstage operation; (4) S-I stage retro-rocket operation after separation; and (5) S-I stage ballistic flight to impact.

5. The nominal booster impact point is geodetic latitude (N) 26.2535°, longitude (W) 72.6068°. This effectively shifts the dispersion ellipses involving booster, cameras, and LES down range by approximately 21 km. The change in the turning rates is less than 1% and the probability analysis as given in Range Safety Data Report #2-64 has not changed.

Lloyd O. Stone

Lloyd O. Stone

APPROVED:

for F. A. Speer
Chief, Flt Eval & Opns Studies Division

E. D. Geissler
Director, Aero-Astrodynamics Laboratory

10 Enc:
Tables 2A through 6B

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TABLE 2A
S-I STAGE BOOST 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)
	0.0	0.00	0.03	408.9	90.00	0.00	513125	0	6725364	0.00	44130
	5.0	-0.00	0.07	409.2	87.51	3.81	499705	185	6811087	0.05	22057
	10.0	-0.00	0.21	410.5	84.70	4.25	486286	835	6867952	0.11	45358
	15.0	-0.00	0.46	413.1	81.61	4.70	472756	2063	6914915	0.17	70858
	20.0	-0.01	0.82	419.0	78.32	5.14	459225	3954	6956175	0.25	102927
	25.0	0.02	1.31	432.2	75.06	5.63	445670	6541	7004031	0.33	143701
	30.0	0.09	1.94	452.6	72.04	6.22	432114	9839	7059474	0.42	193360
	35.0	0.25	2.71	481.6	69.50	6.92	418559	13825	7121064	0.52	255527
	40.0	0.54	3.62	519.3	67.63	7.74	405003	18442	7185108	0.63	337478
	45.0	0.98	4.69	560.0	65.94	8.41	391463	23494	7249841	0.76	482765
	50.0	1.59	5.90	603.2	64.50	8.77	377923	28422	7317236	0.90	744258
	55.0	2.37	7.28	647.5	63.46	8.73	364351	32390	7382883	1.06	1149445
	60.0	3.33	8.80	694.6	62.69	9.55	350779	35435	7444511	1.23	1236767
	65.0	4.50	10.47	746.1	61.87	10.72	337184	37639	7503544	1.43	1204502
	70.0	5.87	12.32	802.8	60.96	12.11	323588	38475	7559813	1.66	1112251
	75.0	7.48	14.37	867.3	60.08	13.87	309994	37144	7610083	1.93	941804
	80.0	9.37	16.65	942.9	59.54	15.86	296401	33339	7648910	2.21	747875
	85.0	11.59	19.15	1030.1	59.29	17.99	282892	27544	7678579	2.47	557028
	90.0	14.20	21.91	1128.7	59.27	20.17	269384	22027	7700885	2.75	401183
	95.0	17.27	24.92	1239.6	59.57	22.41	255870	17156	7714880	3.07	278054
	100.0	20.87	28.18	1362.3	60.12	24.71	242357	13037	7722557	3.43	188172
	105.0	25.06	31.70	1497.0	60.82	27.12	228848	9529	7724310	3.80	123820
	110.0	29.90	35.48	1643.7	61.57	29.65	215339	6705	7721181	4.16	81291
	115.0	35.47	39.52	1803.3	62.36	32.37	201851	4623	7712329	4.53	53929
	120.0	41.82	43.84	1977.0	63.20	35.36	188363	3165	7701812	4.93	34966
	125.0	49.04	48.42	2166.4	64.09	38.76	174910	2170	7695189	5.38	18626
	130.0	57.21	53.29	2373.8	65.04	42.62	161457	1505	7688750	5.99	9738
	134.0	64.51	57.38	2554.3	65.81	46.11	150700	1150	7669062	6.72	4957
	135.0	66.44	58.43	2601.7	65.99	47.03	148011	1068	7657402	6.92	3820
	140.0	76.82	63.88	2852.5	66.76	52.28	134565	696	7626259	8.07	589
(1)	140.1	76.98	63.96	2856.2	66.77	52.36	134377	692	7626231	8.09	569
	143.0	83.56	67.28	2939.8	67.18	24.95	129631	484	3786050	8.62	172
(2)	146.1	90.69	70.79	3019.4	67.57	25.97	125649	319	3785399	9.21	240
(3)	146.5	91.64	71.25	3026.1	67.62	-1.55	125151	301	324408	9.28	236

(1) Inboard Cut-Off
(2) Outboard Cut-Off
(3) Separation

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TABLE 2B
S-I STAGE BOOST TRAJECTORY

	EARTH FIXED PARAMETERS										
TIME (SEC)	XXXE (KM)	YYYE (KM)	ZZZE (KM)	DXXE (M/SEC)	DYYE (M/SEC)	DZZE (M/SEC)	VELØCITY (M/SEC)	PATH ANGLE (DEG)	LØNGITUDE (PØSITIVE WEST) (DEG)	GEØD. LAT. (PØSITIVE NØRTH) (DEG)	GEØC. LAT. (PØSITIVE NØRTH) (DEG)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.67	80.5650	28.5319	28.3707
5.0	-0.0	0.1	-0.0	-0.1	17.8	-0.1	17.8	0.49	80.5650	28.5319	28.3707
10.0	-0.0	0.2	-0.0	-0.2	37.9	-0.1	37.9	0.51	80.5650	28.5319	28.3707
15.0	-0.0	0.5	-0.0	-0.4	60.3	-0.2	60.3	0.51	80.5650	28.5319	28.3707
20.0	-0.0	0.8	-0.0	1.3	84.9	-0.2	84.9	0.92	80.5650	28.5319	28.3707
25.0	0.0	1.3	-0.0	8.8	111.4	-0.3	111.7	4.47	80.5647	28.5319	28.3707
30.0	0.1	1.9	-0.0	22.2	139.6	-0.3	141.3	9.00	80.5640	28.5317	28.3705
35.0	0.3	2.7	-0.0	43.3	168.6	-0.2	174.1	14.37	80.5624	28.5314	28.3702
40.0	0.5	3.6	-0.0	73.2	197.6	-0.1	210.7	20.28	80.5596	28.5307	28.3696
45.0	1.0	4.7	-0.0	105.0	228.2	-0.0	251.2	24.66	80.5552	28.5297	28.3686
50.0	1.6	5.9	-0.0	138.8	259.5	0.1	294.3	28.08	80.5492	28.5283	28.3672
55.0	2.4	7.3	-0.0	174.2	289.1	0.2	337.6	31.01	80.5415	28.5265	28.3654
60.0	3.3	8.8	-0.0	212.8	318.4	0.4	383.0	33.68	80.5320	28.5243	28.3632
65.0	4.5	10.5	-0.0	254.1	351.3	0.6	433.6	35.80	80.5205	28.5216	28.3605
70.0	5.9	12.3	0.0	298.6	389.2	0.9	490.6	37.40	80.5069	28.5184	28.3573
75.0	7.5	14.4	0.0	349.1	431.9	1.2	555.4	38.83	80.4911	28.5147	28.3535
80.0	9.4	16.6	0.0	410.9	477.1	1.6	629.6	40.61	80.4725	28.5102	28.3491
85.0	11.6	19.1	0.0	484.4	524.9	2.0	714.2	42.56	80.4506	28.5050	28.3439
90.0	14.3	21.9	0.0	569.8	575.1	2.5	809.6	44.56	80.4248	28.4988	28.3378
95.0	17.4	24.9	0.0	669.2	625.6	3.0	916.0	46.73	80.3945	28.4916	28.3306
100.0	21.0	28.1	0.1	782.5	675.6	3.6	1033.8	48.96	80.3591	28.4831	28.3221
105.0	25.2	31.7	0.1	909.3	725.7	4.3	1163.3	51.14	80.3178	28.4731	28.3122
110.0	30.1	35.4	0.1	1048.7	776.9	5.1	1305.2	53.16	80.2701	28.4616	28.3007
115.0	35.7	39.4	0.1	1202.0	828.9	6.0	1460.1	55.05	80.2153	28.4483	28.2875
120.0	42.1	43.7	0.2	1370.4	881.3	7.0	1629.3	56.84	80.1527	28.4332	28.2723
125.0	49.4	48.2	0.2	1555.9	933.4	8.1	1814.4	58.56	80.0817	28.4158	28.2551
130.0	57.7	53.0	0.2	1761.0	984.7	9.4	2017.7	60.23	80.0013	28.3962	28.2355
134.0	65.1	57.0	0.3	1940.5	1025.8	10.6	2194.9	61.52	79.9296	28.3786	28.2180
135.0	67.1	58.1	0.3	1987.4	1036.6	10.9	2241.5	61.82	79.9106	28.3739	28.2133
140.0	77.6	63.4	0.4	2234.5	1096.9	12.6	2489.2	63.12	79.8086	28.3488	28.1883
(1) 140.1	77.8	63.5	0.4	2238.1	1097.9	12.6	2492.9	63.14	79.8070	28.3484	28.1879
143.0	84.5	66.7	0.4	2324.1	1108.2	13.5	2574.9	63.71	79.7424	28.3324	28.1719
(2) 146.1	91.7	70.1	0.4	2406.8	1116.0	14.5	2653.0	64.27	79.6724	28.3150	28.1546
(3) 146.5	92.7	70.6	0.4	2414.2	1115.6	14.6	2659.6	64.33	79.6631	28.3127	28.1523

(1) Inboard Cut-Off
(2) Outboard Cut-Off
(3) Separation

[redacted]

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TABLE 3A
S-IV STAGE ULLAGE TRAJECTORY

TIME (SEC)	GRØUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELØCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATIØN V DØT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
146.5	91.64	71.25	3026.1	67.62	-3.21	65831	301	62517	9.28	1039
146.5	91.71	71.29	3026.0	67.63	-3.21	65831	299	62517	9.28	1034
148.2	95.67	73.19	3021.5	67.87	-3.16	65831	226	62517	9.46	780

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[redacted]

TABLE 3B
S-IV STAGE ULLAGE TRAJECTORY

TIME (SEC)	XXXE (KM)	YYYE (KM)	ZZZE (KM)	DXXE (M/SEC)	DYYE (M/SEC)	DZZE (M/SEC)	VELØCITY (M/SEC)	PATH ANGLE (DEG)	LØNGITUDE (PØSITIVE WEST) (DEG)	GEØD. LAT. (PØSITIVE NØRTH) (DEG)	GEØC. LAT. (PØSITIVE NØRTH) (DEG)
				EARTH FIXED PARAMETERS							
146.5	92.7	70.6	0.4	2414.2	1115.6	14.6	2659.6	64.33	79.6631	28.3127	28.1523
146.5	92.8	70.6	0.4	2414.3	1115.3	14.6	2659.5	64.34	79.6624	28.3125	28.1521
148.2	96.8	72.5	0.5	2415.2	1100.5	15.0	2654.2	64.60	79.6235	28.3028	28.1425

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TABLE 4A
S-IV MAINSTAGE 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)
148.2	95.67	73.19	3021.5	67.87	-3.17	65831	226	62517	9.46	1381
149.0	97.64	74.13	3019.5	67.99	-2.74	65795	196	90318	9.55	1284
169.0	145.92	95.57	3074.2	70.67	2.93	60868	3	396482	10.46	-563
189.0	196.15	114.81	3146.7	73.16	3.60	58994	0	397203	10.71	-590
209.0	248.45	131.97	3230.9	75.50	4.22	57117	0	396698	11.01	-588
229.0	302.93	147.12	3326.5	77.66	4.84	55230	0	397649	11.36	-585
249.0	359.72	160.34	3433.0	79.66	5.42	53342	0	397514	11.76	-581
269.0	418.93	171.70	3550.1	81.48	6.00	51452	0	397933	12.21	-578
289.0	480.70	181.30	3677.9	83.13	6.55	49560	0	398056	12.69	-575
309.0	545.18	189.22	3816.0	84.62	7.10	47668	0	398088	13.22	-573
329.0	612.53	195.53	3964.4	85.94	7.63	45775	0	397892	13.79	-570
349.0	682.91	200.35	4122.9	87.11	8.14	43887	0	396999	14.40	-568
369.0	756.48	203.77	4291.3	88.11	8.67	42005	0	396232	15.05	-566
389.0	833.43	205.91	4470.3	88.97	9.23	40127	0	396074	15.75	-566
409.0	913.95	206.88	4660.7	89.70	9.84	38248	0	396711	16.49	-566
429.0	998.29	206.78	4863.5	90.30	10.46	36364	0	396756	17.27	-566
449.0	1086.69	205.75	5079.0	90.77	11.12	34481	0	396740	18.11	-567
469.0	1179.40	203.94	5308.3	91.11	11.84	32598	0	396738	19.00	-568
489.0	1276.73	201.50	5552.4	91.34	12.62	30715	0	396699	19.95	-569
509.0	1378.99	198.61	5813.0	91.45	13.49	28834	0	396712	20.96	-571
529.0	1486.52	195.48	6092.0	91.44	14.47	26952	0	396788	22.04	-573
549.0	1599.73	192.33	6391.8	91.33	15.58	25070	0	396995	23.20	-575
569.0	1719.05	189.42	6716.1	91.10	16.91	23183	0	397858	24.46	-578
589.0	1845.01	187.03	7068.8	90.77	18.42	21292	0	398121	25.83	-580
609.0	1978.18	185.49	7453.7	90.33	20.12	19405	0	396379	27.32	-582
625.8	2095.83	185.15	7806.0	89.87	21.99	17825	0	397896	28.69	-585

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TABLE 4B
S-IV MAINSTAGE TRAJECTORY

TIME (SEC)	XXXE (KM)	YYYE (KM)	ZZZE (KM)	DXXE (M/SEC)	DYYE (M/SEC)	DZZE (M/SEC)	VELOCITY (M/SEC)	PATH ANGLE (DEG)	LONGITUDE (POSITIVE WEST) (DEG)	GEOD. LAT. (POSITIVE NORTH) (DEG)	GEOC. LAT. (POSITIVE NORTH) (DEG)
				EARTH FIXED PARAMETERS							
148.2	96.8	72.5	0.5	2415.2	1100.5	15.0	2654.2	64.60	79.6235	28.3028	28.1425
149.0	98.8	73.4	0.5	2415.9	1093.2	15.3	2651.7	64.73	79.6042	28.2980	28.1377
169.0	148.2	93.9	0.9	2521.9	958.4	27.1	2698.0	67.84	79.1314	28.1779	28.0180
189.0	199.7	111.7	1.5	2635.8	828.9	34.4	2763.3	70.74	78.6410	28.0497	27.8903
209.0	253.6	127.0	2.3	2753.7	700.2	39.8	2841.6	73.46	78.1320	27.9135	27.7546
229.0	309.9	139.8	3.1	2875.5	572.5	44.7	2932.3	75.97	77.6033	27.7689	27.6106
249.0	368.7	149.9	4.1	3001.7	445.4	49.8	3035.0	78.28	77.0540	27.6155	27.4578
269.0	430.0	157.6	5.1	3132.5	318.5	55.1	3149.2	80.38	76.4831	27.4527	27.2956
289.0	494.0	162.7	6.3	3268.5	191.5	60.9	3274.7	82.28	75.8895	27.2798	27.1234
309.0	560.8	165.2	7.6	3409.9	64.1	67.0	3411.2	83.98	75.2720	27.0960	26.9403
329.0	630.4	165.2	9.0	3557.1	-64.0	73.5	3558.5	85.48	74.6296	26.9005	26.7456
349.0	703.1	162.7	10.5	3710.4	-192.7	80.4	3716.2	86.79	73.9608	26.6925	26.5384
369.0	778.9	157.5	12.2	3869.9	-322.2	87.6	3884.2	87.91	73.2646	26.4710	26.3178
389.0	857.9	149.8	14.0	4036.6	-453.3	95.1	4063.1	88.87	72.5395	26.2352	26.0829
409.0	940.4	139.4	16.0	4211.6	-586.8	103.1	4253.5	89.67	71.7841	25.9838	25.8325
429.0	1026.5	126.3	18.1	4395.9	-723.5	111.4	4456.5	90.32	70.9966	25.7156	25.5655
449.0	1116.3	110.4	20.4	4590.2	-863.4	120.2	4672.2	90.83	70.1754	25.4294	25.2805
469.0	1210.2	91.7	22.9	4795.4	-1007.0	129.4	4901.7	91.21	69.3185	25.1236	24.9760
489.0	1308.2	70.1	25.6	5013.0	-1155.0	139.1	5146.2	91.45	68.4239	24.7967	24.6505
509.0	1410.8	45.5	28.5	5244.4	-1308.1	149.4	5407.1	91.56	67.4893	24.4469	24.3023
529.0	1518.1	17.7	31.6	5491.5	-1467.5	160.2	5686.4	91.55	66.5123	24.0722	23.9293
549.0	1630.5	-13.3	34.9	5756.6	-1634.3	171.7	5986.5	91.42	65.4903	23.6705	23.5293
569.0	1748.5	-47.7	38.5	6043.0	-1810.5	183.9	6311.1	91.17	64.4200	23.2392	23.1000
589.0	1872.4	-85.8	42.3	6354.3	-1997.9	197.0	6664.0	90.82	63.2981	22.7755	22.6385
609.0	2002.9	-127.7	46.4	6694.2	-2198.4	211.0	7049.0	90.34	62.1204	22.2762	22.1416
625.8	2117.6	-166.0	50.0	7005.1	-2378.8	223.6	7401.4	89.86	61.0872	21.8277	21.6952

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TABLE 5A
S-I STAGE POST-SEPARATION RETRO 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)
146.5	91.64	71.25	3026.1	67.62	-9.58	58277	301	269352	9.28	47744
146.5	91.71	71.29	3025.8	67.63	-9.67	58262	299	274977	9.28	47501
148.9	97.43	74.03	2997.0	67.99	-4.62	57313	196	0	9.46	31045

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TABLE 5B
S-I STAGE POST-SEPARATION RETRO TRAJECTORY

TIME (SEC)	XXXE (KM)	YYYE (KM)	ZZZE (KM)	DXXE (M/SEC)	DYYE (M/SEC)	DZZE (M/SEC)	VELØCITY (M/SEC)	PATH ANGLE (DEG)	LØNGITUDE (PØSITIVE WEST) (DEG)	GEØD. LAT. (PØSITIVE NØRTH) (DEG)	GEØC. LAT. (PØSITIVE NØRTH) (DEG)
				EARTH FIXED PARAMETERS							
146.5	92.7	70.6	0.4	2414.2	1115.6	14.6	2659.6	64.33	79.6631	28.3127	28.1523
146.5	92.8	70.6	0.4	2414.1	1115.3	14.6	2659.3	64.34	79.6624	28.3125	28.1521
148.9	98.6	73.3	0.5	2394.9	1085.1	15.1	2629.2	64.71	79.6063	28.2985	28.1382

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TABLE 6A
S-I STAGE POST-SEPARATION FREE FLIGHT 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)
148.9	97.43	74.03	2997.0	67.99	-4.62	57313	196	0	9.46	31106
150.0	99.96	75.24	2992.6	68.15	-4.50	57313	162	0	9.58	25778
170.0	146.72	95.79	2923.8	71.13	-3.53	57313	3	0	9.87	444
190.0	193.15	113.01	2867.2	74.23	-2.96	57109	0	0	9.62	18
210.0	239.33	126.89	2821.0	77.44	-2.37	57109	0	0	9.41	4
230.0	285.30	137.47	2785.3	80.74	-1.75	57109	0	0	9.25	2
250.0	331.13	144.75	2760.6	84.11	-1.12	57109	0	0	9.14	1
270.0	376.87	148.74	2747.0	87.52	-0.47	57109	0	0	9.08	1
284.6	410.24	149.57	2744.1	90.02	0.01	57109	0	0	9.06	1
290.0	422.58	149.43	2744.5	90.95	0.19	57109	0	0	9.07	1
310.0	468.30	146.84	2753.3	94.37	0.84	57109	0	0	9.11	1
330.0	514.09	140.96	2773.2	97.76	1.49	57109	0	0	9.20	1
350.0	560.01	131.79	2804.1	101.09	2.11	57109	0	0	9.34	2
370.0	606.12	119.30	2845.7	104.34	2.71	57109	0	0	9.52	8
390.0	652.46	103.50	2897.8	107.49	3.29	57109	1	0	9.76	102
393.9	661.62	100.00	2909.3	108.10	3.39	57109	1	0	9.81	194
410.0	699.09	84.37	2959.6	110.53	3.75	57109	30	0	10.03	4776
430.0	746.00	61.93	3014.6	113.43	1.58	57109	1000	0	8.45	157861
450.0	791.53	37.08	2781.3	115.92	-44.77	57109	18285	0	7.65	2833839
470.0	818.87	19.97	1098.5	113.66	-63.24	57109	26155	0	2.57	3939664
490.0	824.43	14.70	562.0	109.55	-3.64	57109	5626	0	0.77	680110
510.0	825.85	11.05	485.7	111.00	-1.58	57109	5927	0	0.59	633976
530.0	826.27	7.82	452.3	109.22	-1.25	57109	5973	0	0.47	626827
550.0	826.37	5.06	438.9	106.96	-0.90	57109	5869	0	0.39	607865
570.0	826.40	2.67	433.0	105.06	-0.67	57109	5798	0	0.33	595088
590.0	826.41	0.54	429.6	103.58	-0.50	57109	5739	0	0.29	585174
595.4	826.41	0.00	429.0	103.25	-0.45	57109	5724	0	0.28	582680

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TABLE 6B
S-I STAGE POST-SEPARATION FREE FLIGHT TRAJECTORY

TIME (SEC)	XXXE (KM)	YYYE (KM)	ZZZE (KM)	DXXE (M/SEC)	DYYE (M/SEC)	DZZE (M/SEC)	VELØCITY (M/SEC)	PATH ANGLE (DEG)	LØNGITUDE (PØSITIVE WEST) (DEG)	GEØD. LAT. (PØSITIVE NØRTH) (DEG)	GEØC. LAT. (PØSITIVE NØRTH) (DEG)
				EARTH FIXED PARAMETERS							
148.9	98.6	73.3	0.5	2394.9	1085.1	15.1	2629.2	64.71	79.6063	28.2985	28.1382
150.0	101.2	74.4	0.5	2394.1	1074.8	15.3	2624.3	64.88	79.5814	28.2923	28.1320
170.0	149.0	94.1	0.8	2385.8	889.2	19.3	2546.2	68.20	79.1233	28.1765	28.0167
190.0	196.6	110.0	1.3	2378.7	705.6	23.1	2481.3	71.70	78.6696	28.0593	27.8999
210.0	244.1	122.3	1.8	2370.8	523.0	26.8	2427.9	75.37	78.2196	27.9405	27.7816
230.0	291.5	131.0	2.3	2362.0	341.1	30.3	2386.7	79.18	77.7728	27.8201	27.6616
250.0	338.6	136.0	3.0	2352.3	159.7	33.7	2357.9	83.10	77.3286	27.6980	27.5399
270.0	385.5	137.3	3.7	2341.7	-21.3	36.9	2342.0	87.09	76.8866	27.5740	27.4164
284.6	419.7	136.1	4.2	2333.4	-153.3	39.2	2338.7	90.03	76.5648	27.4823	27.3250
290.0	432.3	135.1	4.5	2330.2	-202.1	40.0	2339.3	91.11	76.4461	27.4481	27.2910
310.0	478.7	129.3	5.3	2317.8	-382.8	42.9	2349.6	95.12	76.0066	27.3201	27.1639
330.0	525.0	119.8	6.2	2304.5	-563.8	45.6	2372.9	99.06	75.5677	27.1901	27.0340
350.0	570.9	106.7	7.1	2290.3	-745.1	48.2	2408.9	102.94	75.1287	27.0577	26.9021
370.0	616.6	90.0	8.1	2275.1	-927.0	50.6	2457.3	106.67	74.6893	26.9229	26.7676
390.0	661.9	69.6	9.1	2258.9	-1109.6	52.8	2517.3	110.24	74.2489	26.7855	26.6310
393.9	670.8	65.2	9.3	2255.6	-1145.7	53.2	2530.5	110.93	74.1620	26.7581	26.6038
410.0	706.9	45.6	10.2	2241.4	-1292.9	54.8	2588.2	113.64	73.8069	26.6454	26.4915
430.0	751.5	17.9	11.3	2208.8	-1468.4	56.3	2653.0	116.86	73.3636	26.5027	26.3493
450.0	794.0	-12.3	12.4	1934.8	-1468.5	51.2	2429.5	120.03	72.9346	26.3624	26.2097
470.0	819.1	-32.7	13.1	540.9	-514.9	14.9	746.9	126.17	72.6775	26.2774	26.1249
490.0	823.9	-38.6	13.2	91.6	-201.7	2.7	221.5	148.11	72.6252	26.2600	26.1076
510.0	824.9	-42.4	13.3	14.6	-177.4	0.6	178.0	167.81	72.6120	26.2555	26.1031
530.0	824.9	-45.7	13.3	-9.6	-148.9	-0.2	149.2	176.20	72.6080	26.2541	26.1018
550.0	824.6	-48.4	13.3	-14.4	-127.2	-0.3	128.0	178.96	72.6071	26.2537	26.1014
570.0	824.3	-50.8	13.3	-14.0	-111.6	-0.3	112.5	179.67	72.6068	26.2536	26.1013
590.0	824.1	-52.9	13.3	-12.8	-100.1	-0.3	100.9	179.81	72.6068	26.2536	26.1012
595.4	824.0	-53.4	13.3	-12.5	-97.5	-0.3	98.3	179.82	72.6068	26.2535	26.1012

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