SSR-107
(TN-AP-67-279)

AAP-IA LAUNCH VEHICLE PERFORMANCE AND PRELIMINARY RANGE SAFETY ANALYSES

Volume 2 RANGE SAFETY

CONTRACT NAS8-4016 SCHEDULE II, VEHICLE SYSTEMS INTEGRATION

SPACE DIVISION CHRYSLER CORPORATION

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AAP-1A LAUNCH VEHICLE PERFORMANCE AND PRELIMINARY RANGE SAFETY ANALYSES
VOLUME 2 - RANGE SAFETY

NOVEMBER 1967

BY

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PREFACE

This technical note consists of two volumes. Volume 1 documents eight nominal trajectories associated with the two stage uprated Saturn IB-AAP-1A mission (SA-207 CSM configuration). This volume, Volume 2, contains data and results of a preliminary range safety analysis applicable to the trajectories documented in Volume 1. The analysis documented herein has been scoped to meet the requirements of the range control office and was accomplished under MSFC-1, Amendment 38, SSR-107 issued 13 September 1967, and entitled "AAP-1A Launch Vehicle Performance and Preliminary Range Safety Study". The scheduled delivery date for the document and two cape magnetic tapes is 13 November 1967.

SUMMARY

This volume presents range safety data and results for an uprated Saturn IB (AS-207/CSM) configuration into an 87 x 140 n. mi. elliptical orbit and is related to the AAP-1A mission. Generalized range safety data are contained in TR-AP-66-1. Certain data have been compiled on magnetic tapes in the format specified by the range control office.

Eight nominal trajectories were developed for this study - a northeast launch and a southeast launch for each of four orbit inclinations. Associated with orbit inclinations of 50°, 45°, 40°, and 35° are northeast flight azimuths of 45°, 51.3°, 57.2°, and 66.7°, respectively and southeast flight azimuths of 131.9°, 125.3°, 118.25°, and 110.1°, respectively.

The in-plane length of S-IB stage impact containment zones related to both northeast and southeast trajectories varies between 44.3 km and 47.5 km. The in-plane length of ullage-rocket cases impact containment zones varies between 58.1 km and 63.2 km.

Since land masses are overflown, an impact and casualty probability study was conducted. Dwell times for the continental land masses overflown vary from 6.76 to 8.68 seconds for the northeast launches and from 0.37 to 93.28 seconds for the southeast launches. For the northeast launches, probability of impact varies from 4.22×10^{-4} to 5.42×10^{-4} and casualty probability varies from 3.47×10^{-6} to 5.12×10^{-5}. For the southeast launches, probability of impact varies from 2.29×10^{-5} to 5.82×10^{-3} and casualty probability varies from 1.19×10^{-6} to 2.78×10^{-5}.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Section 1.0 - INTRODUCTION

The purpose of SSR-107, with respect to range safety analysis, is to determine Saturn IB in-plane flight corridors for northeast and southeast launches related to orbital inclinations of 50°, 45°, 40° and 35°, respectively, in order that the Range may assess the potential hazards involved in such flights. Volumes 1 and 2 of this technical note, along with the data compiled on two associated cape magnetic tapes, document the work done to satisfy SSR-107.

A description of the study requirements delineated in the SSR follows.

A. Use a two stage uprated Saturn IB launch vehicle (SA-207) with a CSM configuration for insertion into 87 x 140 n. mi. elliptical orbits having inclinations of 50°, 45°, 40° and 35° for both northeast and southeast launches, respectively.

B. Generate a nominal, a 3σ maximum, and a 3σ minimum trajectory for each launch azimuth.

C. Prepare the data in report form and on two cape magnetic tapes in the proper format as specified by the range office.

Contained herein are the expected $\pm 3\sigma$ in-plane (referred to as maximum and minimum, respectively) trajectory deviations from the intended flight path; data related to the expected impacts of the expended S-IB stage and ullage-rocket cases; and downrange land impact and casualty probabilities for each flight azimuth. The cape magnetic tapes associated with this analysis are CCSD Reel No. 4194 containing data for the northeast launches and CCSD Reel No. 0895 containing data for the southeast launches.

Section 2.0 - NORTHEAST LAUNCH AZIMUTHS

Formal range safety data requirements are defined for the launch agency by the Deputy Commander of tests (Reference 1). An outboard profile of the launch vehicle configuration for the AAP-1A mission is presented in Figure 1. The following sections present the required trajectory data associated with the standard and in-plane dispersed trajectories for the northeast launch azimuths.

2.1 Standard Trajectories

The standard trajectories correspond to the nominal trajectories documented in Volume 1 of this Technical Note (Reference 2). Shown in Figure 2 are the IIP traces for each launch azimuth. The range safety required data for these trajectories are contained on the cape magnetic tape (CCSD Reel No. 4194) in Record 12, Files 2, 5, 8, and 11. A nominal sequence of events is presented in Table 1.

2.2 Dispersed Trajectories

Listed below are the combined off-nominal parameter variations about the respective standard trajectories which define the in-plane dispersed trajectories. Figure 3 presents the annual wind profile envelopes, as documented in Reference 3, which are applicable to the northeast launch azimuths. The range safety data requirements prescribed by the range control office, in connection with the following trajectories, are contained in Record 12, Files 3, 4, 6, 7, 9, 10, 12, and 13 on the cape magnetic tape identified in Section 2.1.

45° Flt. Az. (i = 50°)

Maximum	S-IB Stage:	+1.7% Thrust & Flow Rate, 45° TW.
	S-IVB Stage:	+3.0% Thrust & Flow Rate, 45° TW.
Minimum	S-IB Stage:	-2.6% Thrust & Flow Rate, 45° HW.
	S-IVB Stage:	-3.0% Thrust & Flow Rate, 45° HW.

51.3° Flt. Az. (i = 45°)

Maximum	S-IB Stage:	+1.7% Thrust & Flow Rate, 51.3° TW.
	S-IVB Stage:	+3.0% Thrust & Flow Rate, 51.3° TW.
Minimum	S-IB Stage:	-2.6% Thrust & Flow Rate, 51.3° HW.
	S-IVB Stage:	-3.0% Thrust & Flow Rate, 51.3° HW.

57.2° Flt. Az. (i = 40°)

Maximum	S-IB Stage:	+1.7% Thrust & Flow Rate, 57.2° TW.
	S-IVB Stage:	+3.0% Thrust & Flow Rate, 57.2° TW.

Minimum	S-IB Stage:	-2.6% Thrust & Flow Rate, 57.2° HW.
	S-IVB Stage:	-3.0% Thrust & Flow Rate, 57.2° HW.

66.7° Flt. Az. (i = 35°)

Maximum	S-IB Stage:	+1.7% Thrust & Flow Rate, 66.7° TW.
	S-IVB Stage:	+3.0% Thrust & Flow Rate, 66.7° TW.
Minimum	S-IB Stage:	-2.6% Thrust & Flow Rate, 66.7° HW.
	S-IVB Stage:	-3.0% Thrust & Flow Rate, 66.7° HW.

2.3 Impact of Staging Re-entry Bodies

Impact data for the expended S-IB stage and ullage-rocket cases for both the standard and perturbed trajectories are presented in the following tables and are illustrated in Figure 4. The dotted lines in Figure 4 represent the maximum boundaries of impact points for $\pm 3\sigma$ performing launch vehicles. These boundaries are symmetrical about the standard and may be applied to any of the trajectories shown. The following data reflect atmospheric re-entry and retro-rocket firing where applicable.

S-IB Stage

Trajectory	Latitude (deg N)	Longitude (deg W)	Time Remaining (sec)	Range (km)	Range (n mi)
45° Flt. Az.(i = 50°)					
Standard	31.6928	76.8514	394.8	501.3	270.7
Maximum	31.8322	76.6776	401.9	523.9	282.9
Minimum	31.5469	77.0324	382.9	477.7	257.9
51.3° Flt. Az.(i =45°)					
Standard	31.2979	76.4784	394.4	500.1	270.0
Maximum	31.4199	76.2877	401.5	522.7	282.2
Minimum	31.1704	76.6775	382.5	476.4	257.2
57.2° Flt. Az.(i = 40°)					
Standard	30.8975	76.1802	394.1	499.0	269.4
Maximum	31.0067	75.9660	401.1	522.8	282.3
Minimum	30.7890	76.3931	382.4	475.3	256.6
66.7° Flt. Az.(i = 35°)					
Standard	30.2050	75.8030	394.1	498.2	269.0
Maximum	30.2816	75.5719	401.1	522.0	281.9
Minimum	30.1296	76.0329	382.4	474.5	256.2

Ullage-Rocket Cases

Trajectory	Latitude (deg N)	Longitude (deg W)	Time Remaining (sec)	Range (km)	Range (n mi)
45° Flt. Az. (i = 50°)					
Standard	31.8492	76.6587	597.2	526.5	284.3
Maximum	32.0401	76.4223	605.6	557.3	300.9
Minimum	31.6622	76.8906	584.3	496.3	268.0
51.3° Flt. Az.(i = 45°)					
Standard	31.4334	76.2680	596.8	525.1	283.5
Maximum	31.6006	76.0085	605.3	555.9	300.2
Minimum	31.2696	76.5236	583.9	494.7	267.1
57.2° Flt. Az. (i = 40°)					
Standard	31.0120	75.9561	596.6	523.9	282.9
Maximum	31.1633	75.6626	604.9	556.5	300.5
Minimum	30.8719	76.2307	583.7	493.4	266.4
66.7° Flt. Az. (i = 35°)					
Standard	30.2842	75.5616	596.6	523.0	282.4
Maximum	30.3908	75.2447	604.9	555.7	300.1
Minimum	30.1865	75.8582	583.8	492.5	265.9

2.4 3σ Flight Corridor

The pitch plane corridor limits are defined by the respective maximum and minimum flight profiles. S-IVB stage guidance target conditions: inertial velocity (V), radius (R), flight path angle (γ), inclination angle (i), and argument of descending node (θ_n) for a $\pm 3\sigma$ vehicle flight profile are virtually unchanged from those of the standard. These conditions along with other pertinent conditions at GCS are presented in Table 2. The $\pm 3\sigma$ pitch plane flight profile illustrated in Figure 5 is for the 45° flight azimuth (i = 50°). These data are deemed typical for the other trajectories as well.

Deviations in pertinent parameters, from the standard, which result from the respective maximum and minimum flight profiles are listed below.

	S-IB/S-IVB Stage Separation		S-IB Stage
	Inert. Vel. (m/sec)	Altitude (m)	Impact Range (km)
45° Flt. Az. (i = 50°)			
Maximum	+25.85	+ 842.37	+22.6

Minimum	-17.80	-1995.87	-23.6
51.3° Flt. Az. (i = 45°)			
Maximum	+25.75	+ 845.43	+22.6
Minimum	-17.54	-1997.43	-23.7
57.2° Flt. Az. (i = 40°)			
Maximum	+27.96	+ 775.12	+23.8
Minimum	-17.33	-1986.62	-23.7
66.7° Flt. Az. (i = 35°)			
Maximum	+27.89	+ 776.56	+23.8
Minimum	-17.09	-1984.87	-23.7

Trajectory IIP times associated with the overfly of land masses are presented in table 3. Data are shown for the continental land masses of Eurasia, Africa, and South America. All times (seconds) are referenced to lift off.

2.5 Downrange Impact and Casualty Probability

Illustrated in Figures 2, 4 and 6 are pertinent range safety data related to the northeast launch azimuths, such as, instantaneous impact point (IIP) traces, S-IB stage and ullage-rocket cases impact, crossrange impact corridors, etc. associated with the various trajectory profiles considered in this study. The lateral impact corridors are approximately $\pm$ 100 km.

The probability of a malfunctioning vehicle impacting on land is calculated as:

S-IB Stage Flight

$$P_I = P(F)_1 \cdot P(F)_x \cdot P(F)_y$$

S-IVB Stage Flight

$$P_I = P(S)_1 \cdot P(F)_2 \cdot P(F)_x \cdot P(F)_y$$

where: $P(S)_1$ = Probability of successful first stage operation.
$P(F)_1$ = Probability of first stage failure.
$P(F)_2$ = Probability of second stage failure.
$P(F)_x$ = Probability of failure in downrange (x) direction.
$P(F)_y$ = Probability of failure in crossrange (y) direction.

The probability of injuring a person downrange is calculated as:

$$P_{IP} = P_I \cdot \frac{N}{A} \cdot L_A$$

where: P_I = Probability of impact.

$\frac{N}{A}$ = Population Density.

L_A = Lethal area of impacting vehicle:

S-IB Stage powered flight = 37,744 sq. ft.
S-IVB Stage powered flight = 19,400 sq. ft.

45° Flt. Az. (i = 50°)

The probability of impact within the range safety lateral corridor for Eurasia is:

$$P_{I_{EU}} = .957 \cdot .030 \cdot \frac{7.86}{460.20} \cdot 1 = 4.90 \times 10^{-4}$$

The probability of impact for individual countries within the range safety lateral corridor is:

COUNTRY	Δt	P_I
Great Britain	0.34	2.44×10^{-6}
France	2.40	1.50×10^{-4}
Switzerland	0.48	2.89×10^{-5}
Italy	0.77	4.80×10^{-5}
Yugoslavia	1.04	3.24×10^{-5}
Albania	0.22	1.37×10^{-5}
Greece	0.27	1.68×10^{-5}
Turkey	0.44	1.65×10^{-5}
Cyprus (Is.)	0.09	6.46×10^{-7}
Israel	0.10	6.24×10^{-6}
Egypt	0.04	8.95×10^{-8}
Jordan	0.26	1.62×10^{-5}
Saudi Arabia	0.97	6.05×10^{-5}
Aden	0.08	5.00×10^{-6}
Socotra (Is.)	0.02	9.61×10^{-7}

The probability of injuring a person as a result of debris impact within the confines of the range safety lateral corridor for Eurasia is:

$$P_{IP_{EU}} = (4.90 \times 10^{-4}) \cdot 150 \cdot \frac{19,400}{27,878,400} = 5.12 \times 10^{-5}$$

The probability of injuring a person for individual countries within the range safety lateral corridor is:

COUNTRY	$\frac{N}{A}$	P_{IP}
Great Britain	190	3.23×10^{-7}
France	175	1.82×10^{-5}

Switzerland	250	5.02×10^{-6}
Italy	410	1.37×10^{-5}
Yugoslavia	95	2.14×10^{-6}
Albania	75	7.16×10^{-7}
Greece	95	1.11×10^{-6}
Turkey	120	1.38×10^{-6}
Cyprus (Is.)	45	2.02×10^{-8}
Israel	95	4.12×10^{-7}
Egypt	65	4.05×10^{-9}
Jordan	25	2.82×10^{-7}
Saudi Arabia	2	8.42×10^{-8}
Aden	2	6.95×10^{-9}
Socotra (Is.)	4	2.68×10^{-9}

51.3° Flt. Az. (i = 45°)

The probability of impact within the range safety lateral corridor for Eurasia - Africa is:

$$P_{I_{EU-A}} = .957 \cdot .030 \cdot \frac{6.76}{460.20} \cdot 1 = 4.22 \times 10^{-4}$$

The probability of impact for individual countries within the range safety lateral corridor is:

COUNTRY	Δt	P_I
Spain	3.05	1.90×10^{-4}
France	0.44	7.03×10^{-7}
Minorca (Is.)	0.14	1.07×10^{-7}
Sardinia (Is.)	0.34	1.06×10^{-5}
Sicily (Is.)	0.52	8.90×10^{-6}
Libya	0.35	2.18×10^{-5}
Egypt	1.04	6.49×10^{-5}
Sudan	0.16	9.62×10^{-6}
Saudi Arabia	0.14	3.34×10^{-6}
Yemen	0.13	8.11×10^{-6}
Aden	0.05	3.12×10^{-6}
Somalia	0.14	8.73×10^{-6}

The probability of injuring a person as a result of debris impact within the confines of the range safety lateral corridor for Eurasia-Africa is:

$$P_{IP_{EU-A}} = (4.22 \times 10^{-4}) \cdot 150 \cdot \frac{19,400}{27,878,400} = 4.40 \times 10^{-5}$$

The probability of injuring a person for individual countries within the range safety lateral corridor is:

COUNTRY	$\frac{N}{A}$	P_{IP}
Spain	200	2.65×10^{-5}
France	200	9.78×10^{-8}

Minorca (Is.)	175	1.30×10^{-8}
Sardinia (Is.)	45	3.32×10^{-7}
Sicily (Is.)	300	1.86×10^{-6}
Libya	15	2.28×10^{-7}
Egypt	75	3.39×10^{-6}
Sudan	10	6.70×10^{-8}
Saudi Arabia	10	2.32×10^{-8}
Yemen	35	1.98×10^{-7}
Aden	35	7.60×10^{-8}
Somalia	10	6.08×10^{-8}

<u>57.2° Flt. Az. (i = 40°)</u>

The probability of impact within the range safety lateral corridor for Europe - Africa is:

$$P_{I_{E-A}} = .957 \cdot .030 \cdot \frac{8.68}{460.20} \cdot 1 = 5.42 \times 10^{-4}$$

The probability of impact for individual countries within the range safety lateral corridor is:

COUNTRY	Δt	P_I
Portugal	0.70	4.15×10^{-5}
Spain	1.28	7.59×10^{-5}
Morocco	1.05	1.80×10^{-5}
Algeria	2.60	1.62×10^{-4}
Tunisia	0.19	9.17×10^{-6}
Libya	2.14	1.34×10^{-4}
Egypt	0.14	4.37×10^{-6}
Sudan	0.95	5.93×10^{-5}
Ethiopia	0.52	3.24×10^{-5}
Somalia	0.11	6.86×10^{-6}

The probability of injuring a person as a result of debris impact within the confines of the range safety lateral corridor for Europe - Africa is:

$$P_{IP_{E-A}} = (5.42 \times 10^{-4}) \cdot 30 \cdot \frac{19,400}{27,878,400} = 1.13 \times 10^{-5}$$

The probability of injuring a person for individual countries within the range safety lateral corridor is:

COUNTRY	$\frac{N}{A}$	P_{IP}
Portugal	90	2.60×10^{-6}
Spain	90	4.75×10^{-6}
Morocco	50	6.25×10^{-7}

Algeria	20	2.26×10^{-6}
Tunisia	2	1.28×10^{-8}
Libya	1	9.29×10^{-8}
Egypt	.5	1.52×10^{-9}
Sudan	10	4.12×10^{-7}
Ethiopia	20	4.51×10^{-7}
Somalia	15	7.16×10^{-8}

66.7° Flt. Az. (i = 35°)

The probability of impact within the range safety lateral corridor for Africa is:

$$P_{I_A} = .957 \cdot .030 \cdot \frac{8.00}{460.20} \cdot 1 = 5.00 \times 10^{-4}$$

The probability of impact for individual countries within the range safety lateral corridor is:

COUNTRY	Δt	P_I
Sidi Ifni	0.15	1.67×10^{-6}
Morocco	0.85	5.30×10^{-5}
Algeria	3.98	2.48×10^{-4}
Niger	1.02	6.36×10^{-5}
Chad	0.75	4.68×10^{-5}
Sudan	1.05	6.55×10^{-5}
Ethiopia	0.05	1.12×10^{-7}
Uganda	0.04	2.04×10^{-8}
Kenya	0.38	2.37×10^{-5}
Somalia	0.07	3.86×10^{-6}

The probability of injuring a person as a result of debris impact within the confines of the range safety lateral corridor for Africa is:

$$P_{IP_A} = (5.00 \times 10^{-4}) \cdot 10 \cdot \frac{19,400}{27,878,400} = 3.47 \times 10^{-6}$$

The probability of injuring a person for individual countries within the range safety lateral corridor is:

COUNTRY	$\frac{N}{A}$	P_{IP}
Sidi Ifni	15	1.75×10^{-8}
Morocco	10	3.69×10^{-7}
Algeria	2	3.46×10^{-7}
Niger	2	8.86×10^{-8}
Chad	4	1.30×10^{-7}
Sudan	15	6.84×10^{-7}
Ethiopia	2	1.56×10^{-10}
Uganda	15	2.13×10^{-10}
Kenya	10	1.65×10^{-7}
Somalia	15	4.03×10^{-8}

Section 3.0 - SOUTHEAST LAUNCH AZIMUTHS

The following sections present the required trajectory data associated with the standard and in-plane dispersed trajectories for the southeast launch azimuths.

3.1 Standard Trajectories

General information pertaining to this section was presented previously in Section 2.1. The range safety required data for these trajectories are contained on the cape magnetic tape (CCSD Reel No. 0895) in Record 12, Files 2, 5, 8, and 11.

3.2 Dispersed Trajectories

Listed below are the combined off-nominal parameter variations about the respective standard trajectories which define the in-plane dispersed trajectories. Figure 7 presents the annual wind profile envelopes, as documented in Reference 3, which are applicable to the southeast launch azimuths. The range safety data requirements prescribed by the range control office, in connection with the following trajectories, are contained in Record 12, Files 3, 4, 6, 7, 9, 10, 12, and 13 on the cape magnetic tape identified in Section 3.1.

131.9°Flt. Az. (i = 50°)

Maximum	S-IB Stage:	+1.7% Thrust & Flow Rate, 131.9° TW.
	S-IVB Stage:	+3.0% Thrust & Flow Rate, 131.9° TW.
Minimum	S-IB Stage:	-2.6% Thrust & Flow Rate, 131.9° HW.
	S-IVB Stage:	-3.0% Thrust & Flow Rate, 131.9° HW.

125.3° Flt. Az.(i = 45°)

Maximum	S-IB Stage:	+1.7% Thrust & Flow Rate, 125.3° TW.
	S-IVB Stage:	+3.0% Thrust & Flow Rate, 125.3° TW.
Minimum	S-IB Stage:	-2.6% Thrust & Flow Rate, 125.3° HW.
	S-IVB Stage:	-3.0% Thrust & Flow Rate, 125.3° HW.

118.25° Flt. Az. (i = 40°)

Maximum	S-IB Stage:	+1.7% Thrust & Flow Rate, 118.25° TW.
	S-IVB Stage:	+3.0% Thrust & Flow Rate, 118.25° TW.
Minimum	S-IB Stage:	-2.6% Thrust & Flow Rate, 118.25° HW.
	S-IVB Stage:	-3.0% Thrust & Flow Rate, 118.25° HW.

110.1° Flt. Az. (i = 35°)

Maximum	S-IB Stage:	+1.7% Thrust & Flow Rate, 110.1° TW.
	S-IVB Stage:	+3.0% Thrust & Flow Rate, 110.1° TW.
Minimum	S-IB Stage:	-2.6% Thrust & Flow Rate, 110.1° HW.
	S-IVB Stage:	-3.0% Thrust & Flow Rate, 110.1° HW.

3.3 Impact of Staging Re-entry Bodies

General information pertaining to this section was presented previously in Section 2.3.

S-IB Stage

Trajectory	Latitude (deg N)	Longitude (deg W)	Time Remaining (sec)	Range (km)	Range (n mi)
131.9° Flt. Az. (i = 50°)					
Standard	25.3411	76.9954	393.3	499.6	269.8
Maximum	25.2053	76.8449	400.4	520.9	281.3
Minimum	25.4895	77.1551	381.1	476.6	257.3
125.3° Flt. Az. (i = 45°)					
Standard	25.7381	76.6064	393.4	498.8	269.3
Maximum	25.6107	76.4271	400.4	521.7	281.7
Minimum	25.8688	76.7844	381.4	475.8	256.9
118.25° Flt. Az. (i = 40°)					
Standard	26.2046	76.2481	393.4	497.9	268.8
Maximum	26.0973	76.0526	400.4	520.8	281.2
Minimum	26.3148	76.4435	381.4	474.9	256.4
110.1° Flt. Az. (i = 35°)					
Standard	26.7807	75.8956	394.3	499.1	269.5
Maximum	26.7054	75.6961	400.0	520.7	281.2
Minimum	26.8738	76.1311	381.3	473.5	255.7

Ullage-Rocket Cases

Trajectory	Latitude (deg N)	Longitude (deg W)	Time Remaining (sec)	Range (km)	Range (n mi)
131.9° Flt. Az. (i = 50°)					
Standard	25.1805	76.8254	595.6	524.3	283.1
Maximum	24.9979	76.6213	603.7	553.1	298.7
Minimum	25.3693	77.0289	582.7	495.0	267.3

125.3° Flt. Az. (i = 45°)

Standard	25.5965	76.4167	595.7	523.5	282.7
Maximum	25.4239	76.1714	603.8	554.7	299.5
Minimum	25.7634	76.6448	582.9	494.0	266.7

118.25° Flt. Az. (i = 40°)

Standard	26.0856	76.0404	595.7	522.6	282.2
Maximum	25.9407	75.7728	603.8	553.8	299.0
Minimum	26.2264	76.2909	582.8	493.0	266.2

110.1° Flt. Az. (i = 35°)

Standard	26.6980	75.6897	595.4	521.6	281.6
Maximum	26.5858	75.3899	603.5	553.9	299.1
Minimum	26.8077	75.9697	582.8	491.2	265.2

3.4 3σ Flight Corridor

General information pertaining to this section was presented previously in Section 2.4.

Deviations in pertinent parameters, from the standard, which result from the respective maximum and minimum flight profiles are listed below.

	S-IB/S-IVB Stage Separation		S-IB Stage
	Inert. Vel. (m/sec)	Altitude (m)	Impact Range (km)
131.9° Flt. Az. (i = 50°)			
Maximum	+23.22	+ 918.62	+21.3
Minimum	-15.38	-2087.62	-23.0
125.3° Flt. Az. (i = 45°)			
Maximum	+26.08	+ 833.62	+22.9
Minimum	-15.45	-2054.30	-23.0
118.25° Flt. Az. (i = 40°)			
Maximum	+25.99	+ 833.81	+22.9
Minimum	-15.23	-2056.05	-23.0
110.1° Flt. Az. (i = 35°)			
Maximum	+27.38	+ 782.81	+21.6
Minimum	-16.16	-2013.05	-25.6

3.5 Downrange Impact and Casualty Probability

Pertinent range safety data related to the southeast launch azimuths are illustrated in Figures 2, 4, 6, and 8. General information pertaining to this section was previously presented in Section 2.5.

131.9° Flt. Az. (i = 50°)

The probability of impact within the range safety lateral corridor for South America is:

$$P_{I_{SA}} = .957 \cdot .030 \cdot \frac{93.28}{460.20} \cdot 1 = 5.82 \times 10^{-3}$$

The probability of impact for individual countries within the range safety lateral corridor is:

COUNTRY	Δt	P_I
Grand Bahama	6.00	1.54×10^{-3}
Great Abaco	6.00	5.00×10^{-4}
Nassau	2.00	6.78×10^{-5}
Mayaguana	7.00	7.82×10^{-6}
Great Inagua	9.00	1.27×10^{-4}
Haiti	15.00	2.57×10^{-4}
Dominican Republic	42.00	2.62×10^{-3}
Venezuela	33.00	2.06×10^{-3}
Guiana	30.00	1.87×10^{-3}
Brazil	30.28	1.89×10^{-3}

The probability of injuring a person as a result of debris impact within the confines of the range safety lateral corridor for South America is:

$$P_{IP_{SA}} = (5.82 \times 10^{-3}) \cdot 5 \cdot \frac{19,400}{27,878,400} = 2.02 \times 10^{-5}$$

The probability of injuring a person for individual countries within the range safety lateral corridor is:

COUNTRY	$\frac{N}{A}$	P_{IP}
Grand Bahama	45	9.38×10^{-5}
Great Abaco	35	2.37×10^{-5}
Nassau	50	4.59×10^{-6}
Mayaguana	30	1.63×10^{-7}
Great Inagua	40	3.54×10^{-6}
Haiti	5	8.93×10^{-7}
Dominican Republic	45	8.21×10^{-5}
Venezuela	2	2.87×10^{-6}
Guiana	2	2.60×10^{-6}
Brazil	10	1.31×10^{-7}

125.3° Flt. Az. (i = 45°)

The probability of impact within the range safety lateral corridor for South America is:

$$P_{I_{SA}} = .957 \cdot .030 \cdot \frac{35.54}{460.20} \cdot 1 = 2.22 \times 10^{-3}$$

The probability of impact for individual countries within the range safety lateral corridor is:

COUNTRY	Δt	P_I
Grand Bahama	4.00	3.96×10^{-4}
Great Abaco	9.00	2.42×10^{-3}
Mayaguana	8.00	2.65×10^{-4}
Dominican Republic	28.00	8.73×10^{-4}
Puerto Rico	33.00	1.03×10^{-3}
Lesser Antilles	14.00	4.88×10^{-4}
Guiana	13.00	8.11×10^{-4}
Brazil	22.54	1.41×10^{-3}

The probability of injuring a person as a result of debris impact within the confines of the range safety lateral corridor for South America is:

$$P_{IP_{SA}} = (2.22 \times 10^{-3}) \cdot 18 \cdot \frac{19,400}{27,878,400} = 2.78 \times 10^{-5}$$

The probability of injuring a person for individual countries within the range safety lateral corridor is:

COUNTRY	$\frac{N}{A}$	P_{IP}
Grand Bahama	45	2.42×10^{-5}
Great Abaco	35	1.15×10^{-4}
Mayaguana	30	1.08×10^{-5}
Dominican Republic	45	2.73×10^{-5}
Puerto Rico	250	1.79×10^{-4}
Lesser Antilles	250	8.49×10^{-5}
Guiana	15	8.47×10^{-6}
Brazil	20	1.96×10^{-5}

118.25° Flt. Az. (i = 40°)

The probability of impact within the range safety lateral corridor for South America is:

$$P_{I_{SA}} = .957 \cdot .030 \cdot \frac{3.82}{460.20} \cdot 1 = 2.38 \times 10^{-4}$$

The probability of impact for individual countries within the range safety lateral corridor is:

COUNTRY	Δt	P_I
Brand Bahama	2.06	4.17×10^{-5}
Great Abaco	9.00	1.04×10^{-3}
Virgin Is.	18.00	2.07×10^{-4}
Lesser Antilles	18.00	9.98×10^{-4}
Brazil	3.82	2.38×10^{-4}

The probability of injuring a person as a result of debris impact within the confines of the range safety lateral corridor for South America is:

$$P_{IP_{SA}} = (2.38 \times 10^{-4}) \cdot 100 \cdot \frac{19,400}{27,878,400} = 1.66 \times 10^{-5}$$

The probability of injuring a person for individual countries within the range safety lateral corridor is:

COUNTRY	$\frac{N}{A}$	P_{IP}
Grand Bahama	45	2.54×10^{-6}
Great Abaco	35	4.95×10^{-5}
Virgin Is.	250	3.59×10^{-5}
Lesser Antilles	250	1.74×10^{-4}
Brazil	100	1.66×10^{-5}

<u>110.1° Flt. Az. (i = 35°)</u>

The probability of impact within the range safety lateral corridor for Africa is:

$$P_{I_A} = .957 \cdot .030 \cdot \frac{0.37}{460.20} \cdot 1 = 2.29 \times 10^{-5}$$

The probability of impact for individual countries within the range safety lateral corridor is:

COUNTRY	Δt	P_I
Great Abaco	7.93	1.19×10^{-4}
Union of South Africa	0.37	2.29×10^{-5}

The probability of injuring a person as a result of debris impact within the confines of the range safety lateral corridor for Africa is:

$$P_{IP_A} = (2.29 \times 10^{-5}) \cdot 75 \cdot \frac{19,400}{27,878,400} \quad 1.19 \times 10^{-6}$$

The probability of injuring a person for individual countries within the range safety lateral corridor is:

COUNTRY	$\frac{N}{A}$	P_{IP}
Great Abaco	35	5.62×10^{-6}
Union of South Africa	75	1.19×10^{-6}

Section 4.0 - REFERENCES

1) AFETRM 127-1, Safety Range Safety Manual, dated 1 November 1966.

2) CCSD TN-AP-67-279, AAP-1A Launch Vehicle Performance and Preliminary Range Safety Analyses Volume 1- Vehicle Performance, dated November 1967.

3) MSFC R-AERO-Y-118-66, Cape Kennedy Wind Component Statistics, 0-60 km Altitude, for All Flight Azimuths for Monthly and Annual Reference Periods, dated October 25, 1966.

Section 5.0 - GOVERNMENT FURNISHED DOCUMENTATION

The Government Furnished Documentation listed below was used in the preparation of this document.

GOVERNMENT FURNISHED DOCUMENTATION

DELIVERABLE ITEM NO. SSR-107

GFDA NO.	DATE MSFC APPROVAL	DESCRIPTION OF GFD REQ'D.	IDENTIFICATION OF GFD
0700001 Rev. A	October 2, 1967 October 11,1967	Mission Profile	Launch from pad 34 into 87 x 140 n. mi. elliptical orbits, using northerly and southerly azimuths for planar flight to orbital inclinations of 35°, 40°, 45°, and 50°.
0700002	October 2, 1967	Mass Characteristics	CCSD TN-AP-67-186
0700003	October 2, 1967	Propulsion Data	CCSD TN-AP-67-186
0700004	October 2, 1967	Aerodynamic Coefficient Data	CCSD TN-AP-67-182

Section 6.0 - DISTRIBUTION

W. H. Mann, Jr.	I-1/1B-E	(1)
L. M. McNair	R-AERO-P	(56 copies, 1 reproducible and 2 magnetic tapes)

TABLE 1

SEQUENCE OF EVENTS

Event	Time (Sec)
Lift-off	0.0
Initiate Pitch Maneuver	10.0
Tilt Arrest	130.3
Inboard Engine Cutoff (IECO)	137.3
Outboard Engine Cutoff (OECO)	140.3
Physical Separation	141.6
J-2 Engine Start	146.3
Engine Mixture Ratio Stepup	147.6
Jettison Ullage Rocket Cases	156.3
Jettison LES, Initiate Active Guidance	175.9
Engine Mixture Ratio Stepdown	426.3
J-2 Engine Cutoff	606.5
Time of Epoch	616.5

BOOSTER GUIDANCE CUTOFF SIGNAL (GCS) CONDITIONS

TABLE 2

Northeast Flight Azimuths

Flight Azimuth		45°	51.3°	57.2°	66.7°
Time	sec	606.51 ± 24	606.51 ± 24	606.52 ± 24	606.52 ± 24
Inertial Velocity (V)	m/sec	7836.40	7836.40	7836.40	7836.40
Altitude	km	169.77	169.16	168.46	167.62
Radius (R)	km	6539.28	6539.27	6539.28	6539.27
Flight Path Angle (γ)	deg	90.00	90.00	90.00	90.00
Latitude	deg	39.65 ± 0.35	37.96 ± 0.29	35.99 ± 0.21	33.59 ± 0.12
Longitude	deg	65.20 ± 0.59	63.87 ± 0.64	62.78 ± 0.66	61.93 ± 0.67
Range	km	1875.21 ± 65	1870.52 ± 65	1865.64 ± 64	1862.10 ± 64
Inclination (i)	deg	50.00	45.00	40.00	35.00
Arg. of Desc. Node (θ_N)	deg	154.20	148.40	141.00	130.70

Southeast Flight Azimuths

Flight Azimuth		131.9°	125.3°	118.25°	110.1°
Time	sec	606.52 ± 24	606.52 ± 24	606.52 ± 24	606.52 ± 24
Inertial Velocity (V)	m/sec	7836.40	7836.40	7836.40	7836.40
Altitude	km	162.70	162.99	163.36	163.86
Radius (R)	km	6539.27	6539.27	6539.27	6539.27
Flight Path Angle (γ)	deg	90.00	90.00	90.00	90.00
Latitude	deg	15.97 ± 0.48	17.31 ± 0.44	19.02 ± 0.39	21.09 ± 0.32
Longitude	deg	68.25 ± 0.35	66.84 ± 0.40	65.38 ± 0.46	63.99 ± 0.52
Range	km	1879.24 ± 65	1873.72 ± 65	1868.88 ± 65	1864.49 ± 64
Inclination (i)	deg	50.00	45.00	40.00	35.00
Arg. of Desc. Node (θ_N)	deg	28.65	34.30	41.80	52.28

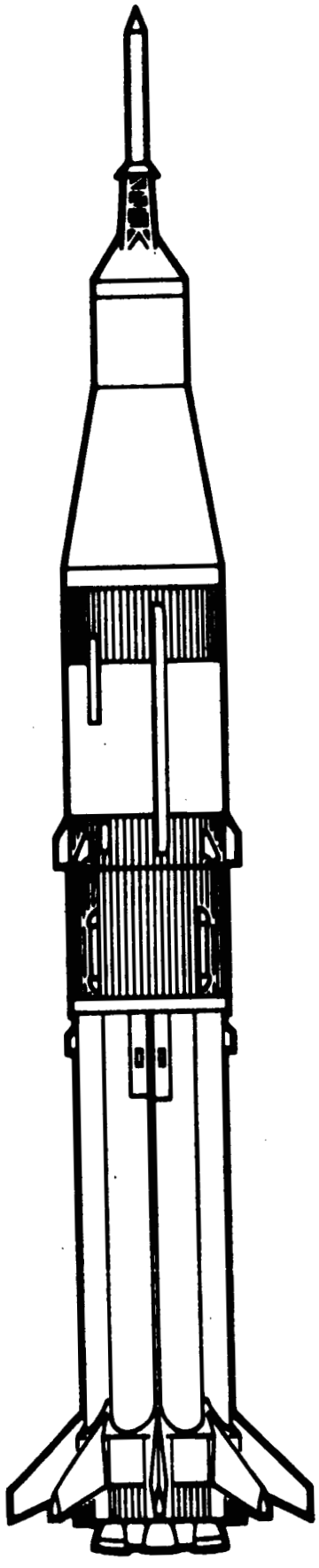
NOTE: V, R, γ, i, and θ_N are S-IVB Stage guidance control cutoff conditions.

TABLE 3

TRAJECTORY IIP TIMES ASSOCIATED WITH OVERFLY OF LAND MASS
(Eurasia, Africa, and South America)

Trajectory	TB3 (OECO)	Enter Land Mass	Leave Land Mass
45° Flt. Az. (i = 50°)			
Standard	140.32	594.21	602.44
Maximum	137.97	574.91	582.69
Minimum	144.07	616.64	625.56
51.3° Flt. Az. (i = 45°)			
Standard	140.32	593.51	602.57
Maximum	137.97	574.20	582.79
Minimum	144.07	616.00	625.73
57.2° Flt. Az. (i = 40°)			
Standard	140.32	593.91	602.59
Maximum	137.97	574.47	582.69
Minimum	144.07	616.40	625.73
66.7° Flt. Az. (i = 35°)			
Standard	140.32	594.55	602.55
Maximum	137.97	575.00	582.60
Minimum	144.07	617.10	625.69
131.9° Flt. Az. (i = 50°)			
Standard	140.32	502.00	595.28
Maximum	137.97	490.00	576.09
Minimum	144.07	520.00	617.78
125.3° Flt. Az. (i = 45°)			
Standard	140.32	556.00	593.73
Maximum	137.97	539.00	574.35
Minimum	144.07	575.00	616.00
118.25° Flt. Az. (i = 40°)			
Standard	140.32	589.06	592.88
Maximum	137.97	570.00	573.65
Minimum	144.07	611.00	615.24
110.1° Flt. Az. (i = 35°)			
Standard	140.32	602.17	602.54
Maximum	137.97	582.26	582.63
Minimum	144.07	625.25	625.66

FIGURE 1



CSM CONFIGURATION

FIGURE 2

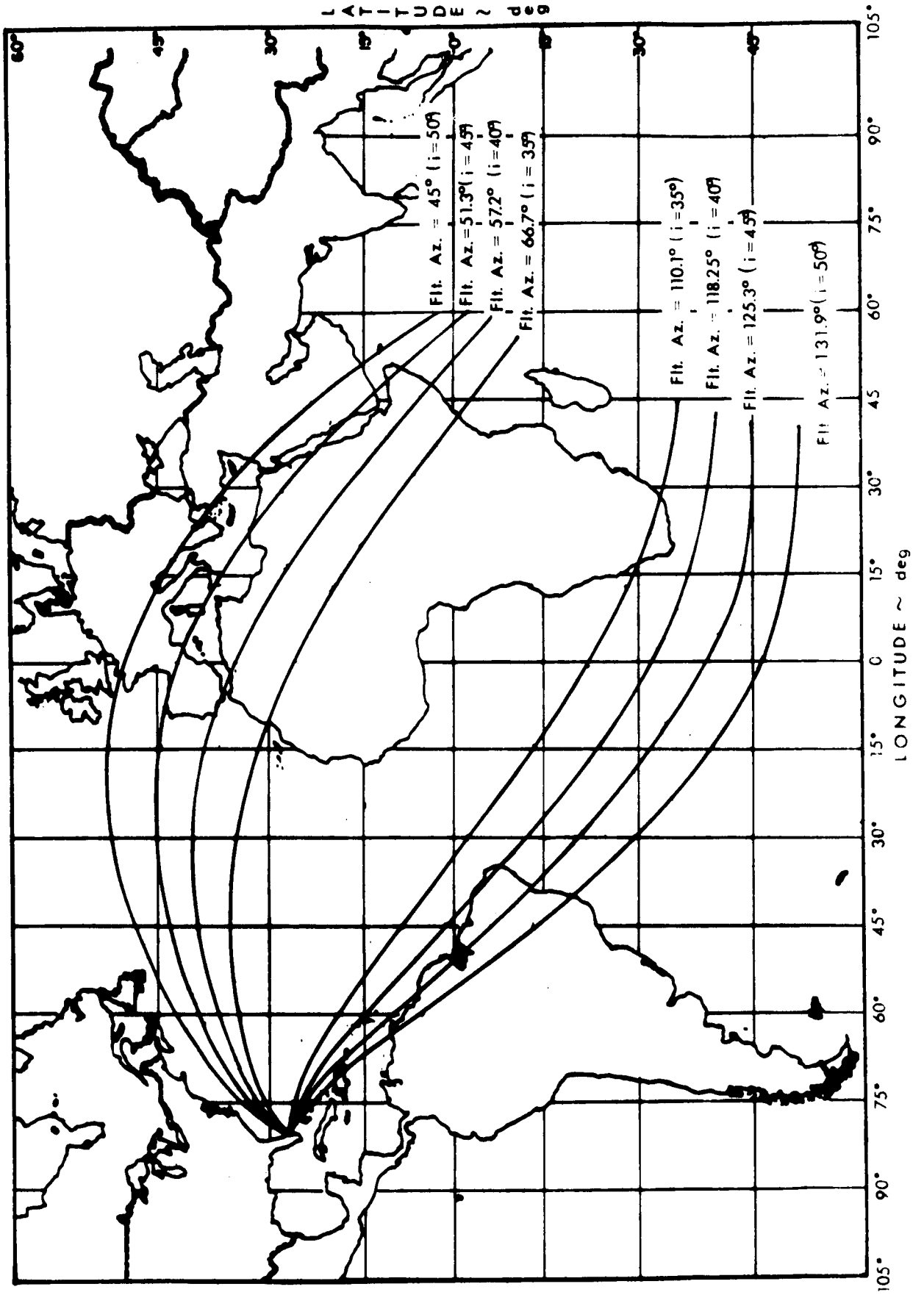

SATURN IB-AAP-1A STANDARD TRAJECTORY INSTANTANEOUS IMPACT TRACES
LATITUDE ~ deg
LONGITUDE ~ deg
Flt. Az. = 45° (i=50°)
Flt. Az.=51.3°(i=45°)
Flt. Az. = 57.2° (i=40°)
Flt. Az. = 66.7° (i = 35°)
Flt. Az. = 110.1° (i=35°)
Flt. Az. = 118.25° (i=40°)
Flt. Az. = 125.3° (i=45°)
Flt Az. = 131.9°(i=50°)

FIGURE 3

ANNUAL WIND PROFILE ENVELOPES

NORTHEAST FLIGHT AZIMUTHS

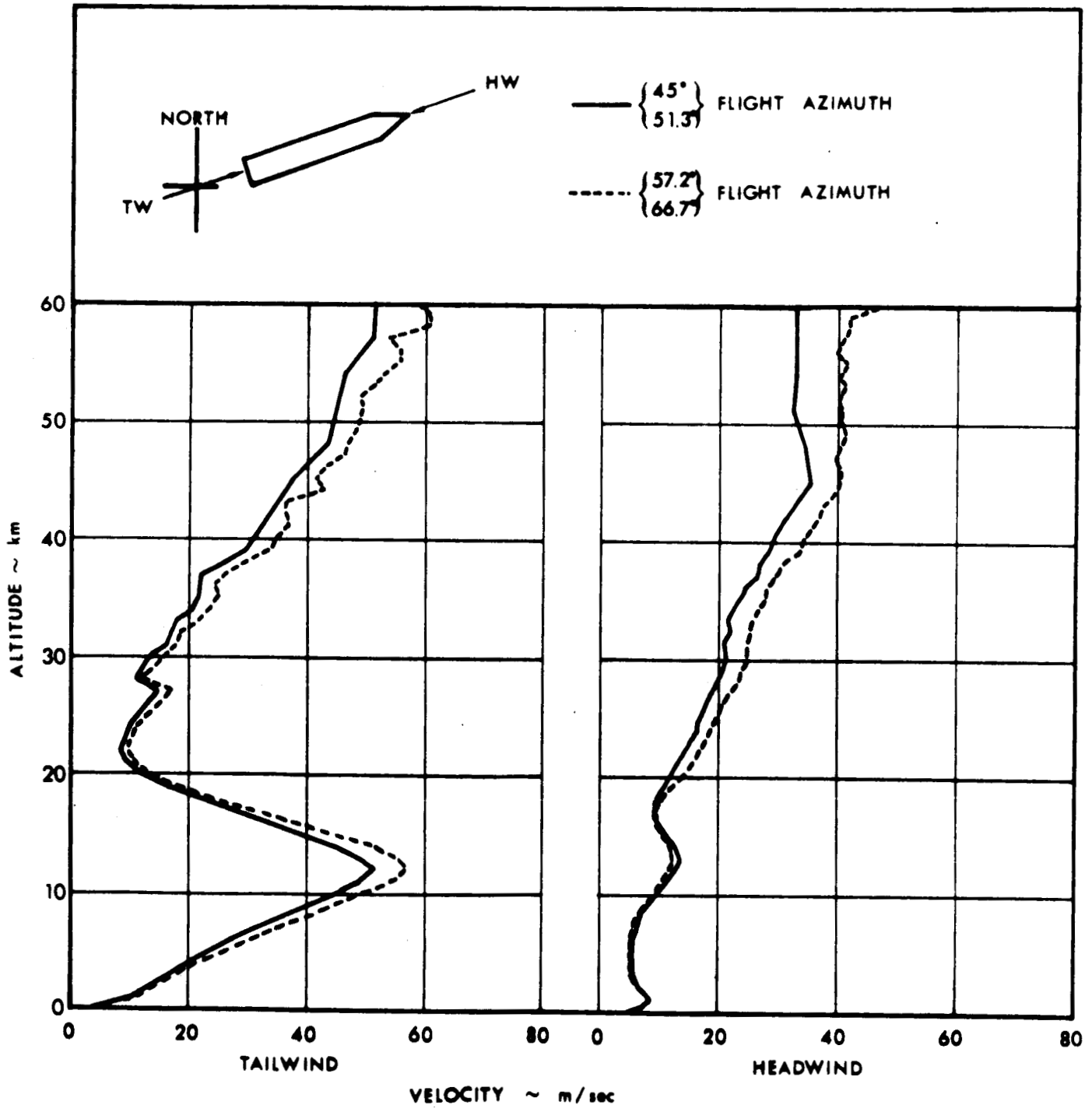


FIGURE 4

IMPACT DISPERSIONS FOR STAGING RE-ENTRY BODIES

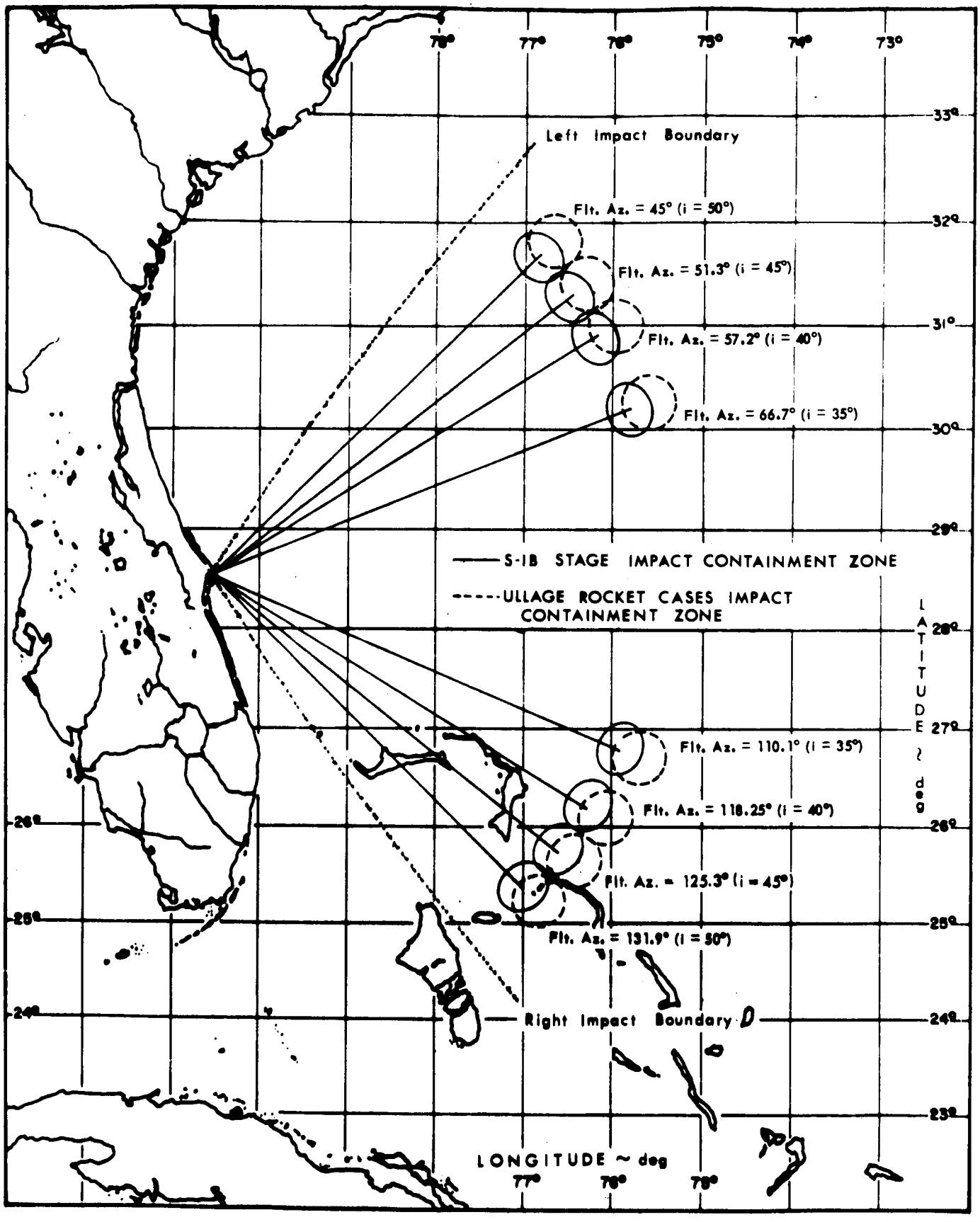


FIGURE 5

PITCH PLANE FLIGHT PROFILE

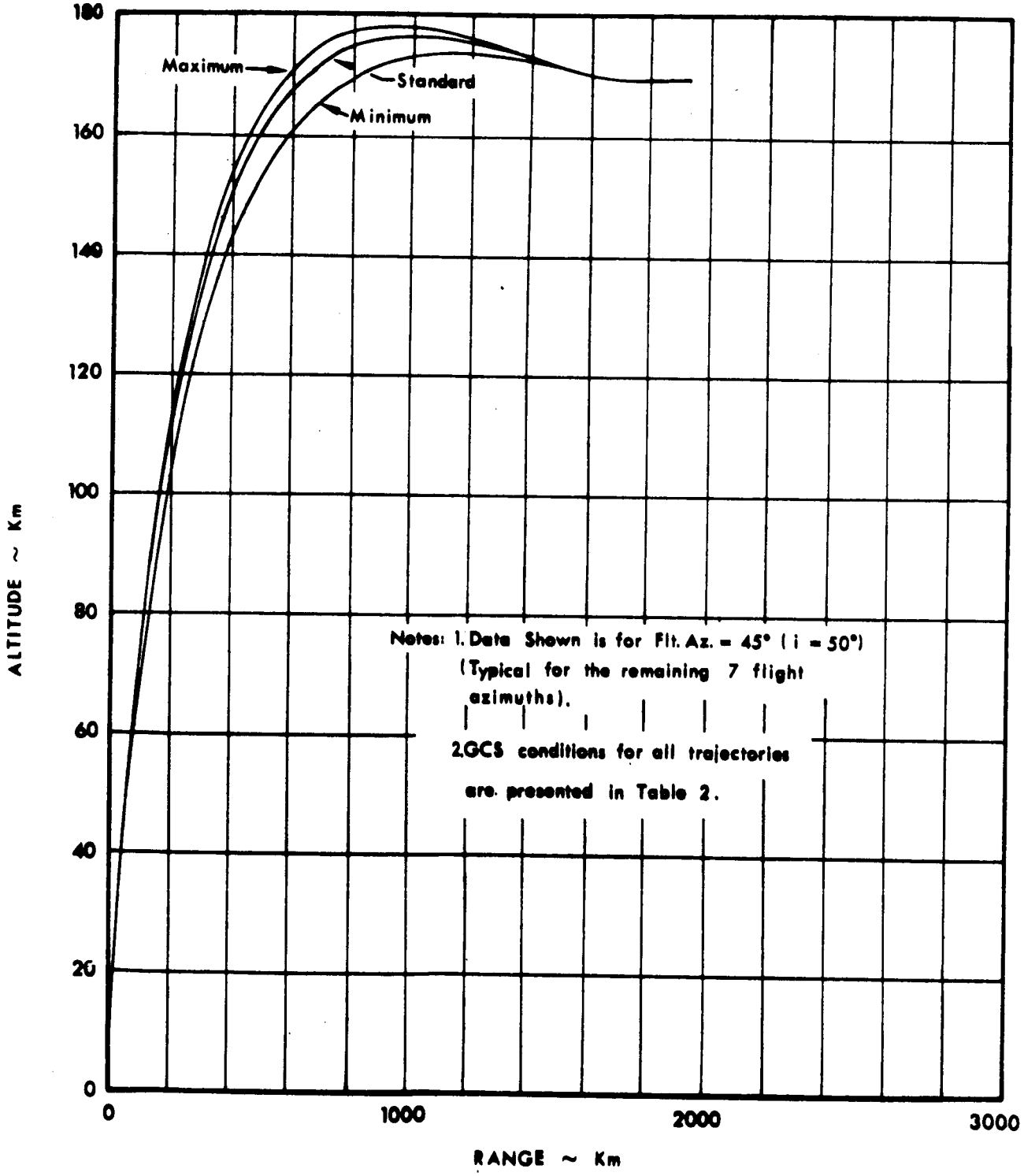


FIGURE 6

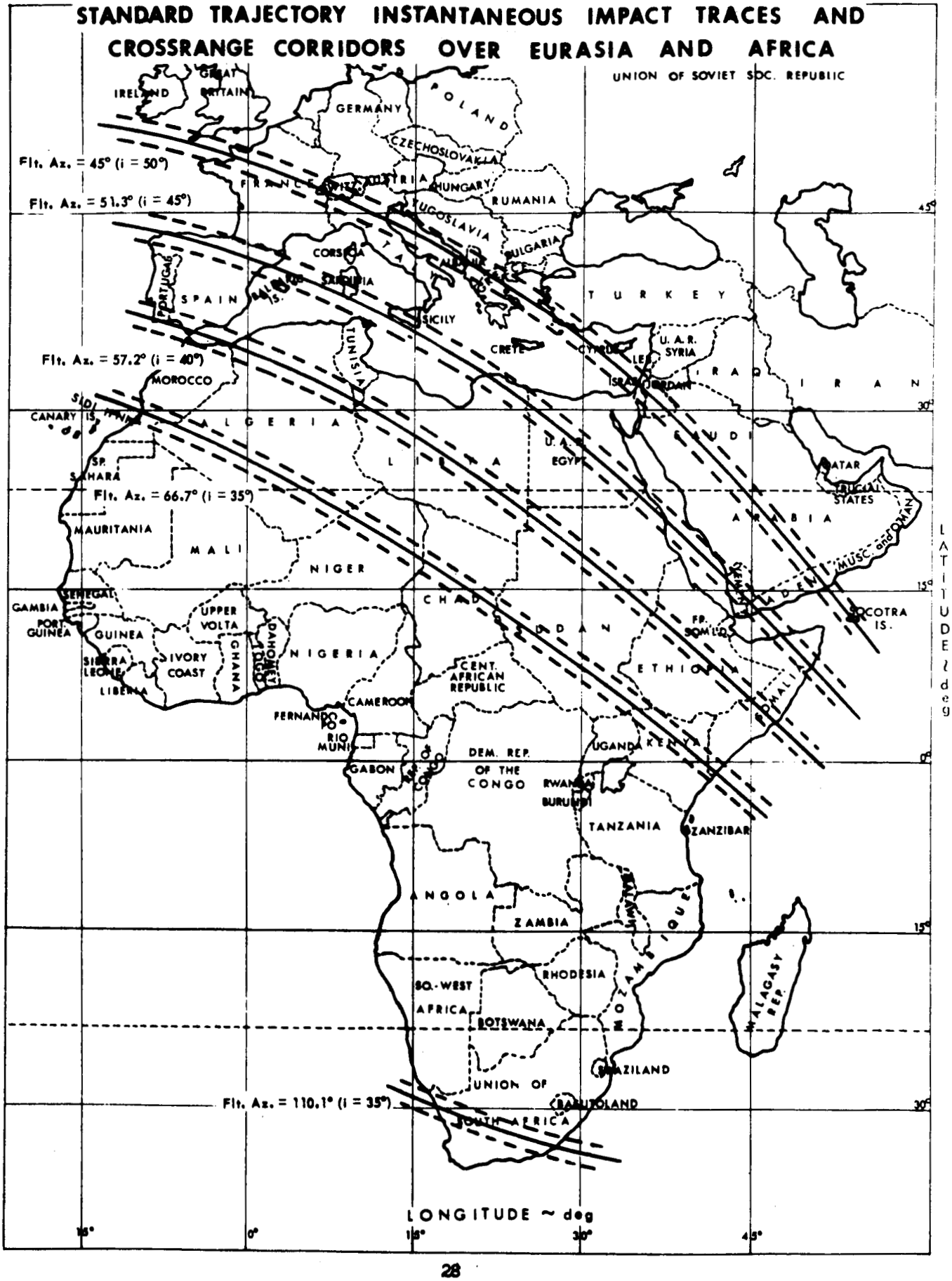

STANDARD TRAJECTORY INSTANTANEOUS IMPACT TRACES AND CROSSRANGE CORRIDORS OVER EURASIA AND AFRICA
UNION OF SOVIET SOC. REPUBLIC
Flt. Az. = 45° (i = 50°)
Flt. Az. = 51.3° (i = 45°)
Flt. Az. = 57.2° (i = 40°)
Flt. Az. = 66.7° (i = 35°)
Flt. Az. = 110.1° (i = 35°)
GREAT BRITAIN
IRELAND
GERMANY
POLAND
CZECHOSLOVAKIA
AUSTRIA
HUNGARY
RUMANIA
YUGOSLAVIA
BULGARIA
FRANCE
SPAIN
PORTUGAL
CORSICA
SARDINIA
SICILY
TURKEY
CRETE
CYPRUS
U.A.R. SYRIA
LEB.
ISRAEL
JORDAN
IRAQ
IRAN
SAUDI ARABIA
QATAR
TRUCIAL STATES
MUSC. and OMAN
YEMEN
ADEN
SOCOTRA IS.
FP. SOM. LD.
ETHIOPIA
SOMALIA
KENYA
UGANDA
TANZANIA
ZANZIBAR
MOROCCO
ALGERIA
TUNISIA
LIBYA
U.A.R. EGYPT
CANARY IS.
SP. SAHARA
MAURITANIA
MALI
NIGER
CHAD
SUDAN
SENEGAL
GAMBIA
PORT. GUINEA
GUINEA
SIERRA LEONE
LIBERIA
IVORY COAST
GHANA
UPPER VOLTA
DAHOMEY
TOGO
NIGERIA
CENT. AFRICAN REPUBLIC
CAMEROON
FERNANDO PO
RIO MUNI
GABON
DEM. REP. OF THE CONGO
RWANDA
BURUNDI
ANGOLA
ZAMBIA
MOZAMBIQUE
RHODESIA
SO.-WEST AFRICA
BOTSWANA
SWAZILAND
UNION OF SOUTH AFRICA
BASUTOLAND
MALAGASY REP.
LATITUDE ~ deg
LONGITUDE ~ deg
15°
0°
15°
30°
45°

FIGURE 7

ANNUAL WIND PROFILE ENVELOPES

SOUTHEAST FLIGHT AZIMUTHS

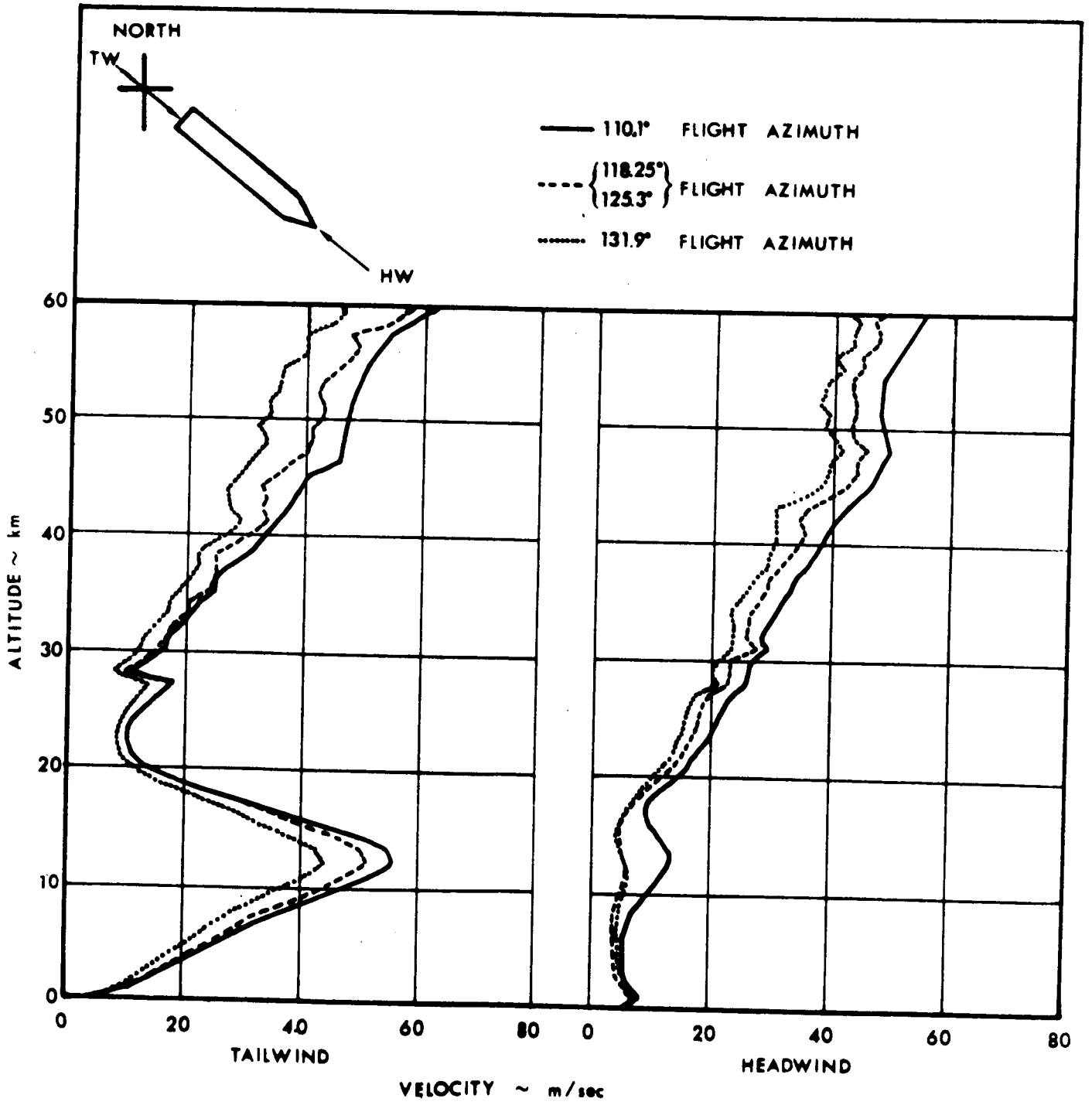


FIGURE 8

STANDARD TRAJECTORY INSTANTANEOUS IMPACT TRACES AND CROSSRANGE CORRIDORS OVER CARRIBEAN ISLANDS AND SOUTH AMERICA