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SA-10 FLIGHT MECHANICAL SUMMARY

by AERO-ASTRODYNAMICS LABORATORY

NASA

George C. Marshall
Space Flight Center,
Huntsville, Alabama

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ABSTRACT

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This report presents the Flight Mechanical Summary for Saturn I vehicle SA-10 to be launched from Pad 37B, Eastern Test Range on a flight azimuth of 95.2 degrees East-of-North. A successful flight will insert the spent S-IV stage and payload consisting of an Apollo boilerplate (BP-9) and a Meteoroid Technology Satellite (Pegasus C) into a 535 km circular orbit. Included is a discussion of the operational predicted trajectory with its orbital mission objectives and constraints, guidance, sequencing, and insertion parameters. The three-sigma envelope of thrust, flow rate, liftoff mass, and wind speed variations is given, along with impact data, in the Range Safety part of this report. A study of wind disturbances, three-sigma C_1 and C_2 variations, and $\pm$ 10% control gain deviations shows the vehicle to be structurally capable of withstanding the expected winds during the launch period. Pertinent tracking and telemetry ground coverage data are presented for powered and orbital flight phases.

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SA-10 FLIGHT MECHANICAL SUMMARY

FLIGHT MECHANICS BRANCH
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SUMMARY

The trajectory for SA-10 is shaped to insert the S-IV stage/Pegasus C combination into a circular orbit at approximately 535 km altitude, measured at insertion. The predicted nominal orbital lifetime is 725 days. The probabilities of achieving guidance cutoff and of not permitting the LH_2 residuals to exceed 250 lbm have been equalized at a value of 95.5%.

The pitch program for the S-I stage is identical to that of SA-8 and essentially provides a minimum angle of attack through the high dynamic pressure region. The Iterative Guidance Mode (IGM) is employed to guide the S-IV stage in pitch, with a delta minimum guidance mode in cross range.

The S-I booster will propel the vehicle to an altitude of 88.94 km and range of 79.70 km. After separation of the S-I and S-IV stages, and approximately 2 seconds of ullage rocket operation, S-IV mainstage ignition occurs. The S-IV main engines burn continuously until the guidance computer initiates the Guidance Cutoff Signal (GCS), which will occur when the inertial velocity reaches 7592 m/s. After 10 seconds elapse to permit complete thrust decay, orbital insertion will occur at 642.085 seconds after liftoff.

The vehicle wind limit is no less than 65 m/s from any azimuth and is more than twice the three-sigma maximum wind for the predicted month of launch. The fueled vehicle free standing and launch release surface wind limits are 16.9 and 10.3 m/s, respectively.

A 95.5% confidence level exists of not exceeding roll and tumble rates of 9 deg/sec and 2 deg/sec, respectively.

PART I
TRAJECTORY

A. INTRODUCTION

The Block II vehicle SA-10, consisting of two live stages, Instrument Unit, Apollo Boilerplate, and Pegasus Payload (Figure I, 1 & 2), is scheduled to ascend from Launch Complex 37B, Eastern Test Range Facilities in the summer of 1965. SA-10 will have a launch azimuth of 90 degrees East-of-North, and will roll into a 95.2 degree East-of-North flight azimuth.

This trajectory is based on propulsion (References 1 and 2) and mass (Reference 3) data provided by P&VE Laboratory. The first stage will be propelled by eight Rocketdyne H-1 engines providing a total thrust of 1.5 million pounds. Six 15,000 pound thrust, Pratt & Whitney, RL10A-3 engines power the S-IV stage during flight. The S-I stage measure 6.5 meters in diameter and 24.5 meters in length. The S-IV stage is basically a 5.6 meter-diameter cylinder measuring 12.5 meters in length. With the Instrument Unit, Payload and Launch Escape System (LES), the total vehicle configuration stands approximately 57.3 meters and has a liftoff mass of 511,709 kg (1,128,124 lbm). Found in Reference 4 is a more complete description of the vehicle and payload. There will be no onboard camera coverage of separation, and likewise, no television monitoring of Pegasus deployment.

B. DESCRIPTION

The SA-10 vehicle will lift off from Pad 37B, rising vertically for 9 seconds in order to clear the launch facilities and then simultaneously begin its pitch program and roll maneuver. The roll rate will be nominally one degree per second.

The first stage trajectory was shaped to minimize aerodynamic moments during the period of highest dynamic pressure. The tilt program is not biased for wind as the launch date occurs during a low wind period. The entire flight program was optimized to attain the maximum performance while achieving the desired orbital mission objectives which, briefly, are:

1. Provide a near-circular orbit in the region of 500 km altitude (270 nautical miles) at the end of one year.

2. Insert into an orbit having an inclination of approximately 28.87 degrees.

3. Maximize guidance cutoff probability.

4. Minimize residual LH_2 at guidance cutoff.

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

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

The Saturn guidance system, Iterative Guidance Mode (IGM), implemented approximately 18 seconds after separation, will guide the S-IV vehicle to the desired terminal conditions. Guidance Cutoff Signal (GCS) is sent by the onboard computer (ASC-15) when the inertial velocity reaches 7592.0 m/s.

B. DESCRIPTION (CONT.)

Orbital insertion is defined to occur 10 seconds after the Guidance Cutoff Signal is generated by the guidance computer. Upon GCS the S-IV stage undergoes a 180-second duration non-propulsive venting period to reduce residual hydrogen in the tank. At the end of this period the vents close followed one second later by separation of the Apollo boilerplate from the Pegasus C/S-IV stage combination. The Pegasus satellite will begin its wind deployment 60 seconds after Apollo boilerplate separation, requiring approximately 60 seconds for this function.

C. RESULTS

The orbital mission objectives are achieved to the following degree:

1. The nominal orbital altitude after one year is 500 km. An orbital altitude history for nominal and minus three-sigma atmospheric conditions is presented in Figure I-3.

2. The nominal inclination of the osculating conic at the time of insertion is 28.88 degrees.

3. The probability of a guidance cutoff is 95.5%.

4. The probability of LH_2 residuals not exceeding 250 lbm is 95.5%.

A summary of the SA-10 vehicle characteristics, trajectory history and insertion and orbital conditions is presented in Table I-I. Predicted vehicle characteristics to be used for post-flight evaluation are presented in Table I-II. The S-I stage pitch steering program, the S-IV guidance terminal conditions and the vehicle sequence of events are detailed in Tables I-III, -IV, and -V, respectively. A brief mass characteristics outline is presented in Table I-VI. The powered flight trajectory from liftoff to Pegasus/Apollo boilerplate separation and the S-I stage retro and coast-to-impact trajectory are presented in detail in Table I-VII, A through J.

The flight profile is graphically presented in Figure I-4 with its nominal pitch steering program presented in Figure I-5.

The earliest S-I inboard engine failure which still results in guidance cutoff is 90 seconds after liftoff. An outboard failure will not permit a guidance cutoff, but failure after 140 seconds from liftoff will result in an orbit with perigee greater than 400 km altitude.

Table I-I
SA-10 FLIGHT DATA

(All values are inertial where applicable unless otherwise denoted.)

A. LAUNCH & TRAJECTORY DATA

Launch Complex and Pad	37B
Latitude at Launch (Geodetic)	28.53185 degrees (N)
Longitude at Launch	80.56495 degrees (W)
Launch Azimuth	90° E of N
Flight Azimuth	95.2° E of N
S-I Stage Roll Angle	5.2 degrees
S-I Stage Mach One	55 seconds
S-I Stage Maximum Dynamic Pressure	67 seconds
S-I Stage Pitch Angle at Tilt Arrest	52.45 degrees
S-I Stage Velocity at OECO (Inertially Ref) (Earth Ref)	3051.17 m/s 2714.87 m/s
S-I Stage Path Angle at OECO (Inertially Ref) (Earth Ref)	56.810 degrees 52.032 degrees
S-I Stage Altitude at OECO	88.94 km
S-I Stage Range at OECO	79.70 km
S-IV Stage Guidance Cutoff Signal (GCS)	632.085 sec
S-IV Stage Velocity at GCS	7592.00 m/s
S-IV Stage Path Angle at GCS	89.994 degrees
S-IV Stage Altitude at GCS	535.754 km
S-IV Range at GCS	1844.208 km
S-IV Stage Latitude at GCS (Geocentric) S-IV Stage Longitude at GCS	25.270 degrees 62.297 degrees (West)

B. INSERTION CONDITIONS

Insertion Time	642.085 seconds
Velocity	7595.0 m/s
Path Angle (against local vertical)	90.0008 degrees
Altitude (oblate earth)	535.708 km

SA-10 FLIGHT DATA (CONT.)

Range	1910.20 km
Latitude (Geocentric)	25.111 degrees
Longitude	61.665 degrees (West)
Azimuth	104.759 degrees

C. ORBITAL CHARACTERISTICS (spherical earth; R_e= 6,378.165 km)

Perigee Altitude	531.6 km
Apogee Altitude	531.9 km
Anomalistic Period	95.27 min
Semi-Major Axis	6909.9 km
Eccentricity	.00002
Inclination	28.88 degrees
Longitude of Ascending Node	176.5 degrees (East)
Argument of Perigee	258.5 degrees
True anomaly at Insertion	220.0246 degrees
Eccentric Anomaly at Insertion	220.0254 degrees
Mean Anomaly at Insertion	220.0261 degrees
Regression Rate of Node	-6.6 deg/day
Rate of Change of Argument of Perigee	+10.7 deg/day
Vis Viva Energy (Twice Total Energy)	-57.77 Km^2/sec^2
Nominal Lifetime	725 days
-3σ Lifetime	532 days
Ballistic Parameters for Tumbling Vehicle C_DA	265 m^2
Post Venting Orbital Mass	10323 kgs
Ballistic Coefficient C_DA/m	.026 m^2/kg

TABLE I-II

PREDICTED VEHICLE CHARACTERISTICS FOR FLIGHT EVALUATION COMPARISON

S-I Stage

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

$$F_T = F_1 + F_2,$$

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

F_1 = 6,776,786 newtons (1,523,482 lbf)

F_2 = 13,732 newtons (3,087 lbf)

F_T = 6,790,518 newtons (1,526,569 lbf)

The S-I flow rate is derived as follows:

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

where W_{aux} = Ice, trapped environment, and chilldown.

$\therefore \dot{W}_T$ = 2682 kg/sec (5913.5 lbs/sec)

I_{sp} = 258.1 sec

S-IV Stage

The S-IV stage thrust averages are vacuum values averaged from 1.8 second to 480.0 seconds of S-IV flight time.

$$F_T = F_1 + F_2 + F_3,$$

TABLE I-II
(continued)

where F_1 is the engine thrust along longitudinal axis = 397486 newtons (89358 lbf)

F_2 = Thrust due to cluster effect = -2785 newtons (-626 lbf)

F_3 = Helium heater and leakage thrust through chilldown ducts = 734 newtons (165 lbf)

F_T = 395,435 newtons (88,897 lbf).

The flow rate is also obtained from 1.8 seconds to 480.0 seconds of S-IV flight time.

$\dot{W}_T$ = 95 kg/sec (208.8 lbs/sec)

I_{sp} = 425.8 sec

TABLE I-III

PITCH TILT PROGRAM FOR SATURN I VEHICLE SA-10

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

TABLE I-III (CONT)

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

*Time of IGM

TABLE I-IV
IGM TERMINAL CONDITIONS

The following defines the necessary IGM terminal conditions.

η_T = Terminal Radius Vector

$\dot{\eta}_T$ = Terminal Time Rate Change of η_T

$\dot{\xi}_T$ = Terminal Tangential Velocity

V_T = Terminal Total Velocity $= \sqrt{\dot{\eta}_T^2 + \dot{\xi}_T^2}$)

$\ddot{\eta}_{gT}$ = Terminal Radial Acceleration Due to Gravity

$\ddot{\xi}_{gT}$ = Terminal Tangential Acceleration Due to Gravity

T' = Time-To-Go (initially)

V_{ex} = Exhaust Velocity ($g_o \cdot I_{sp}$)

The values for the above for SA-10 are as follows:

η_T = 6910000.0 meters

$\dot{\eta}_T$ = +1.64 meters/sec

$\dot{\xi}_T$ = 7591.46 meters/sec

V_T = 7591.46 meters/sec

$\ddot{\eta}_{gT}$ = -8.35 meters/sec^2

$\ddot{\xi}_{gT}$ = 0

T' = 465.0 sec (initially)

V_{ex} = 4200.0 meters/sec

TABLE I-V

SA-10 SEQUENCE OF EVENTS

TIME (From Liftoff)	EVENT
0.0	Liftoff
9.0	Initiate Roll and Pitch Tilt
14.2	Terminate Roll
137.7	Signal from Sequencer to Enable Level Sensors
138.0	Tilt Arrest
141.7	S-I Stage Level Sensor Signal
143.52	Inboard Cutoff (S-I Stage)
149.52	Outboard Cutoff (S-I Stage)
150.22	Ullage Rocket Ignition (S-IV Stage)
150.32	Separation, Immediately Followed by Retro Rocket Ignition (S-I Stage)
152.02	S-IV Mainstage Ignition
154.02	Ullage Rocket Thrust Termination
162.32	Jettison Ullage Rocket Casing and LES
168.00	Initiate Active Guidance
595.00	Signal from Sequencer to Arm LOX Cutoff Capability
632.085	S-IV Stage Guidance Cutoff Signal
642.085	End of Powered Flight
812.085	Close Blowdown Non-Propellant Vents
813.085	Start S-IV Pegasus/Apollo Separation
873.085	Begin Pegasus Wing Deployment
933.085	Terminate Wing Deployment

TABLE I-VI

SA-10 Mass Characteristics

Total Mass at Liftoff	511,709 kg	(1,128,124 lbm)
Mass at First Stage Cutoff (OECO)	117,035 kg	(258,018 lbm)
Mainstage Consumption During First Stage of Flight (To Separation)	392,332 kg	(864,943 lbm)
Mass at Second Stage Ignition (152.02 sec)	62,339 kg	(137,435 lbm)
Mass at Second Stage Cutoff (632.09 sec)	15,527 kg	(34,230 lbm)
Mainstage Consumption During Second Stage of Flight	45,315 kg	(99,903 lbm)
Flight Performance Reserve at S-IV Cutoff	341 kg LOX 48 kg LH_2	(530 lbm) (106 lbm)
Orbiting Payload	10,323 kg	(22,758 lbm)

TABLE I-VII-A

S-I STAGE NOMINAL TRAJECTORY

	TIME (SEC)	GROUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELOCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATION V 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	511709	0	6591447	0.00	44130
	5.0	-0.00	0.07	409.3	87.60	3.69	498417	173	6729211	0.05	21561
	10.0	-0.00	0.21	410.5	84.91	4.05	485126	772	6746657	0.11	43611
	15.0	-0.00	0.44	413.3	81.95	4.52	471745	1904	6808281	0.17	69583
	20.0	0.00	0.79	418.7	78.76	4.99	458364	3669	6864335	0.24	99172
	25.0	0.02	1.26	427.5	75.41	5.49	444908	6119	6917385	0.32	133807
	30.0	0.06	1.87	440.8	72.00	6.02	431453	9250	6978002	0.40	177049
	35.0	0.13	2.63	459.3	68.67	6.59	417964	12988	7045927	0.50	235500
	40.0	0.25	3.54	483.5	65.55	7.19	404475	17177	7118720	0.61	306280
	45.0	0.44	4.63	513.5	62.74	7.76	390969	21559	7193932	0.73	417967
	50.0	0.73	5.90	549.1	60.36	8.21	377464	25740	7268606	0.86	595333
	55.0	1.13	7.35	588.8	58.52	8.12	363927	29117	7337010	1.01	983131
	60.0	1.67	8.97	631.6	57.21	8.81	350391	31255	7398730	1.17	1091850
	65.0	2.36	10.77	680.9	56.19	10.00	336818	32486	7458789	1.36	1057379
	70.0	3.24	12.76	737.9	55.38	11.52	323245	32432	7514121	1.58	942661
	75.0	4.35	14.97	803.9	54.76	13.30	309685	30424	7566491	1.83	785143
	80.0	5.72	17.41	879.5	54.31	15.25	296125	26312	7609216	2.09	614399
	85.0	7.40	20.11	965.6	54.02	17.32	282638	21043	7641497	2.33	447029
	90.0	9.44	23.09	1062.2	53.88	19.39	269151	16359	7660389	2.60	313563
	95.0	11.89	26.38	1169.1	53.88	21.48	255675	12323	7668134	2.91	213636
	100.0	14.78	29.99	1286.7	53.99	23.65	242198	8913	7669710	3.23	137667
	105.0	18.18	33.95	1415.1	54.17	25.91	228753	6155	7667569	3.57	84429
	110.0	22.14	38.28	1554.9	54.42	28.30	215307	4086	7659471	3.92	51775
	115.0	26.69	43.00	1706.8	54.70	30.87	201895	2629	7647119	4.29	31156
	120.0	31.91	48.15	1872.1	55.01	33.74	188484	1660	7634580	4.70	18507
	125.0	37.86	53.75	2052.4	55.33	36.98	175122	1053	7623263	5.31	9112
	130.0	44.60	59.83	2249.7	55.65	40.66	161761	625	7607077	6.10	2985
	135.0	52.21	66.45	2466.4	55.95	44.89	148468	330	7586496	7.07	746
	140.0	60.78	73.66	2705.9	56.23	49.89	135176	148	7563821	8.24	55
(1)	143.5	67.44	79.12	2890.2	56.37	53.97	125842	74	7544386	9.22	60
	145.0	70.39	81.50	2937.1	56.47	25.64	122997	52	3885402	9.55	54
(2)	149.5	79.70	88.94	3051.2	56.81	25.27	117035	15	3643556	10.08	21
	150.0	80.76	89.78	3057.3	56.86	-3.25	116304	13	301796	10.10	18
(3)	150.3	81.40	90.28	3056.4	56.89	-3.51	116248	12	270425	10.07	16

(1) IECO
(2) OECO
(3) Separation

TABLE I-VII-B

S-I STAGE NOMINAL TRAJECTORY

EARTH FIXED PARAMETERS

	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)
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	80.5650	28.5319	28.3707
	5.0	-0.0	0.1	-0.0	-0.0	17.1	-0.0	17.1	0.21	80.5650	28.5319	28.3707
	10.0	-0.0	0.2	-0.0	-0.1	36.4	-0.0	36.4	0.25	80.5650	28.5319	28.3707
	15.0	-0.0	0.4	-0.0	0.3	57.9	-0.0	57.9	0.33	80.5650	28.5319	28.3707
	20.0	0.0	0.8	-0.0	1.7	81.6	-0.0	81.6	1.17	80.5649	28.5319	28.3707
	25.0	0.0	1.3	-0.0	4.7	107.7	-0.0	107.8	2.51	80.5648	28.5319	28.3707
	30.0	0.1	1.9	-0.0	10.2	136.2	-0.0	136.6	4.29	80.5644	28.5319	28.3707
	35.0	0.1	2.6	-0.0	18.8	167.0	0.0	168.1	6.42	80.5637	28.5318	28.3706
	40.0	0.3	3.5	-0.0	31.1	200.1	0.0	202.5	8.82	80.5624	28.5317	28.3706
	45.0	0.4	4.6	-0.0	47.5	235.2	0.1	240.0	11.39	80.5604	28.5316	28.3704
	50.0	0.7	5.9	0.0	68.2	271.5	0.1	280.0	14.09	80.5575	28.5314	28.3702
	55.0	1.1	7.3	0.0	93.1	307.4	0.2	321.2	16.82	80.5534	28.5311	28.3699
	60.0	1.7	9.0	0.0	122.0	342.0	0.3	363.1	19.60	80.5480	28.5307	28.3695
	65.0	2.4	10.8	0.0	156.8	378.8	0.5	410.0	22.45	80.5409	28.5302	28.3690
	70.0	3.2	12.8	0.0	198.4	419.1	0.6	463.7	25.28	80.5320	28.5295	28.3683
	75.0	4.4	15.0	0.0	247.7	463.6	0.8	525.6	28.06	80.5207	28.5286	28.3674
	80.0	5.7	17.4	0.0	305.6	512.8	1.1	597.0	30.72	80.5067	28.5275	28.3663
	85.0	7.4	20.1	0.0	372.7	566.8	1.4	678.4	33.24	80.4896	28.5261	28.3649
	90.0	9.5	23.1	0.0	449.5	625.3	1.7	770.2	35.61	80.4688	28.5244	28.3633
	95.0	11.9	26.4	0.0	536.2	688.1	2.2	872.3	37.80	80.4440	28.5224	28.3612
	100.0	14.9	30.0	0.1	632.9	754.9	2.6	985.1	39.83	80.4145	28.5200	28.3588
	105.0	18.3	33.9	0.1	739.9	826.0	3.2	1109.0	41.67	80.3799	28.5171	28.3560
	110.0	22.3	38.2	0.1	857.7	901.6	3.9	1244.4	43.36	80.3397	28.5138	28.3527
	115.0	26.9	42.9	0.1	986.9	981.9	4.5	1392.2	44.89	80.2934	28.5099	28.3488
	120.0	32.2	48.1	0.1	1128.6	1067.7	5.3	1553.6	46.29	80.2403	28.5054	28.3443
	125.0	38.2	53.6	0.2	1284.1	1159.6	6.1	1730.2	47.56	80.1798	28.5003	28.3392
	130.0	45.0	59.7	0.2	1455.1	1258.9	7.1	1924.1	48.72	80.1113	28.4944	28.3334
	135.0	52.8	66.2	0.2	1643.5	1367.0	8.2	2137.7	49.76	80.0339	28.4877	28.3267
	140.0	61.5	73.4	0.3	1851.8	1486.0	9.4	2374.3	50.69	79.9468	28.4802	28.3192
(1)	143.5	68.3	78.8	0.3	2011.2	1579.0	10.4	2557.0	51.24	79.8792	28.4742	28.3132
	145.0	71.3	81.1	0.3	2053.9	1599.2	10.7	2603.1	51.45	79.8492	28.4716	28.3106
(2)	149.5	80.8	88.4	0.4	2161.4	1642.8	12.0	2714.9	52.03	79.7546	28.4631	28.3022
	150.0	81.9	89.3	0.4	2168.1	1643.6	12.1	2720.7	52.09	79.7439	28.4622	28.3013
(3)	150.3	82.6	89.8	0.4	2168.6	1641.3	12.1	2719.7	52.13	79.7374	28.4616	28.3007

(1) IECO
(2) OECO
(3) Separation

TABLE I-VII-C

S-IV ULLAGE PORTION 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)
150.3	81.40	90.28	3056.4	56.89	-4.84	62419	12	62517	10.07	100
151.0	82.83	91.41	3053.6	56.98	-4.83	62387	9	62517	9.97	80
152.0	84.99	93.10	3049.3	57.11	-4.80	62339	7	62517.	9.81	57

TABLE I-VII-D

S-IV ULLAGE PORTION TRAJECTORY

EARTH FIXED PARAMETERS

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)
150.3	82.6	89.8	0.4	2168.6	1641.3	12.1	2719.7	52.13	79.7374	28.4616	28.3007
151.0	84.0	90.9	0.4	2168.9	1635.4	12.3	2716.4	52.22	79.7228	28.4603	28.2994
152.0	86.3	92.5	0.4	2169.4	1626.6	12.4	2711.5	52.36	79.7009	28.4583	28.2974

TABLE I-VII-E

S-IV STAGE NOMINAL TRAJECTORY

	TIME (SEC)	GROUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELOCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATION V DOT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
	152.0	84.99	93.10	3049.3	57.11	-4.79	62339	7	63320	9.81	57
	153.0	87.07	94.72	3045.4	57.23	-4.46	62301	5	82619	9.67	42
	162.3	106.93	109.87	3056.8	58.29	1.02	61429	0	407548	8.39	3
	163.0	108.39	110.97	3058.0	58.37	1.20	59920	0	407254	8.23	3
(1)	168.0	119.20	118.93	3067.1	58.92	1.32	59435	0	405374	7.25	1
	173.0	130.11	126.79	3076.5	59.45	1.38	58949	0	403725	6.10	0
	183.0	152.18	142.25	3094.8	60.34	1.40	57984	0	402334	4.82	0
	193.0	174.57	157.41	3114.4	61.16	1.69	57020	0	401122	4.20	0
	203.0	197.29	172.28	3136.7	61.99	1.96	56060	0	400025	3.95	0
	213.0	220.36	186.86	3161.6	62.81	2.24	55101	0	399861	3.83	0
	223.0	243.80	201.16	3189.3	63.63	2.52	54142	0	399719	3.75	0
	233.0	267.62	215.18	3219.7	64.45	2.81	53182	0	399227	3.69	0
	243.0	291.86	228.92	3252.9	65.25	3.10	52224	0	398836	3.65	0
	253.0	316.52	242.40	3288.9	66.06	3.38	51268	0	398074	3.63	0
	263.0	341.64	255.60	3327.6	66.85	3.67	50315	0	397165	3.61	0
	273.0	367.22	268.54	3369.2	67.64	3.97	49364	0	396399	3.60	0
	283.0	393.30	281.22	3413.6	68.42	4.27	48416	0	395780	3.60	0
	293.0	419.89	293.63	3460.9	69.20	4.58	47471	0	395369	3.60	0
	303.0	447.02	305.78	3511.3	69.96	4.90	46525	0	395204	3.61	0
	313.0	474.71	317.67	3564.8	70.72	5.22	45581	0	395083	3.63	0
	323.0	502.99	329.30	3621.4	71.46	5.56	44637	0	395094	3.66	0
	333.0	531.88	340.68	3681.4	72.20	5.90	43692	0	395159	3.69	0
	343.0	561.40	351.79	3744.6	72.92	6.24	42747	0	395033	3.72	0
	353.0	591.59	362.64	3811.2	73.64	6.59	41803	0	394763	3.76	0
	363.0	622.47	373.24	3881.1	74.34	6.94	40860	0	394422	3.80	0
	373.0	654.07	383.56	3954.5	75.04	7.30	39918	0	394175	3.85	0
	383.0	686.41	393.62	4031.5	75.73	7.67	38977	0	393953	3.90	0
	393.0	719.54	403.41	4112.1	76.40	8.06	38036	0	393959	3.96	0
	403.0	753.46	412.92	4196.5	77.07	8.45	37095	0	394008	4.02	0
	413.0	788.23	422.16	4284.8	77.72	8.86	36153	0	394217	4.09	0
	423.0	823.87	431.11	4377.1	78.37	9.27	35212	0	394277	4.16	0
	433.0	860.42	439.77	4473.5	79.01	9.70	34270	0	394269	4.24	0
	443.0	897.91	448.13	4574.1	79.63	10.13	33328	0	394104	4.33	0
	453.0	936.37	456.19	4679.1	80.25	10.58	32386	0	393904	4.41	0
	463.0	975.86	463.93	4788.4	80.86	11.04	31446	0	393702	4.51	0
	473.0	1016.39	471.36	4902.4	81.46	11.52	30506	0	393581	4.60	0
	483.0	1058.02	478.45	5021.3	82.05	12.02	29566	0	393455	4.71	0
	493.0	1100.79	485.20	5145.1	82.63	12.55	28627	0	393542	4.82	0
	503.0	1144.73	491.60	5274.3	83.20	13.10	27688	0	393715	4.93	0
	513.0	1189.91	497.64	5409.1	83.76	13.68	26748	0	393820	5.05	0

TABLE I-VII-E (CONT)
S-IV STAGE NOMINAL TRAJECTORY

	TIME (SEC)	GROUND DISTANCE (KM)	ALTITUDE (KM)	SPACE FIXED VELOCITY (M/SEC)	SPACE FIXED PATH ANGLE (DEG)	ACCELERATION V DOT EARTH-FIXED (M/SEC SQ)	MASS (KG)	DYNAMIC PRESSURE (N/M SQ)	THRUST (N)	MACH	DRAG (N)
	523.0	1236.37	503.30	5549.7	84.32	14.30	25807	0	394048	5.18	0
	533.0	1284.17	508.57	5696.6	84.86	14.94	24866	0	394280	5.32	0
	543.0	1333.35	513.43	5850.1	85.40	15.63	23924	0	394498	5.46	0
	553.0	1383.99	517.88	6010.6	85.93	16.36	22981	0	394649	5.61	0
	563.0	1436.14	521.90	6178.6	86.45	17.13	22038	0	394684	5.78	0
	573.0	1489.88	525.46	6354.4	86.97	17.95	21095	0	394685	5.94	0
	583.0	1545.28	528.54	6538.6	87.48	18.84	20152	0	394645	6.12	0
	593.0	1602.42	531.12	6732.0	88.00	19.79	19209	0	394505	6.31	0
	603.0	1661.39	533.16	6935.1	88.51	20.81	18267	0	394339	6.51	0
	613.0	1722.28	534.64	7149.0	89.02	21.94	17325	0	394278	6.72	0
	623.0	1785.19	535.52	7374.6	89.53	23.22	16383	0	394403	6.94	0
(2)	632.1	1844.21	535.75	7592.0	89.99	24.68	15527	0	396449	7.16	0
	633.1	1850.81	535.75	7594.4	90.00	0.75	15506	0	11947	7.16	0
(3)	642.1	1910.20	535.71	7595.0	90.00	0.01	15497	0	0	7.16	0
(4)	812.1	3032.34	534.75	7595.5	90.01	.01	15383	0	0	7.17	0
(5)	813.1	3038.95	534.74	7595.5	90.01	.01	10787	0	0	7.17	0
(6)	873.1	3435.08	534.51	7595.5	90.01	.01	10765	0	0	7.17	0
(7)	933.1	3831.25	533.92	7596.0	90.01	.01	10323	0	0	7.17	0

(1) Initiate Active Guidance
(2) GCS
(3) Insertion
(4) Close LH_2, non-propulsive vent valves
(5) Pegasus/Apollo boilerplate separation
(6) Begin wing deployment
(7) Terminate Wing deployment

TABLE I-VII-F

S-IV STAGE NOMINAL TRAJECTORY

	EARTH FIXED PARAMETERS										
	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)
	152.0	86.3	92.5	0.4	2169.4	1626.6	12.4	2711.5	52.36	79.7009	28.4583	28.2974
	153.0	88.4	94.1	0.4	2170.0	1618.3	12.6	2707.0	52.49	79.6798	28.4564	28.2955
	162.3	108.8	109.0	0.5	2213.1	1569.1	14.0	2713.0	53.69	79.4781	28.4380	28.2772
	163.0	110.3	110.0	0.6	2216.5	1565.7	14.1	2713.8	53.77	79.4632	28.4366	28.2758
(1)	168.0	121.4	117.8	0.6	2241.4	1541.0	14.7	2720.1	54.40	79.3535	28.4264	28.2656
	173.0	132.7	125.4	0.7	2265.9	1517.0	16.6	2726.8	55.01	79.2428	28.4160	28.2552
	183.0	155.6	140.4	0.9	2309.2	1476.0	21.0	2740.7	56.03	79.0189	28.3943	28.2336
	193.0	178.9	155.0	1.1	2351.3	1437.8	24.8	2756.1	56.97	78.7919	28.3716	28.2110
	203.0	202.6	169.2	1.4	2395.7	1399.0	28.3	2774.4	57.93	78.5617	28.3479	28.1874
	213.0	226.8	182.9	1.7	2441.9	1360.3	31.3	2795.4	58.88	78.3281	28.3231	28.1627
	223.0	251.5	196.4	2.0	2490.0	1321.5	34.2	2819.2	59.84	78.0909	28.2974	28.1370
	233.0	276.6	209.4	2.4	2540.1	1282.7	36.8	2845.8	60.79	77.8500	28.2706	28.1103
	243.0	302.3	222.0	2.7	2592.2	1243.6	39.3	2875.3	61.73	77.6050	28.2427	28.0826
	253.0	328.5	234.2	3.2	2646.4	1204.1	41.8	2907.8	62.67	77.3559	28.2137	28.0537
	263.0	355.2	246.1	3.6	2702.6	1164.2	44.3	2943.0	63.61	77.1023	28.1836	28.0237
	273.0	382.5	257.5	4.0	2760.9	1123.7	46.8	2981.2	64.54	76.8442	28.1523	27.9925
	283.0	410.4	268.6	4.5	2821.4	1082.6	49.3	3022.4	65.46	76.5813	28.1197	27.9601
	293.0	439.0	279.2	5.0	2884.2	1040.7	51.9	3066.7	66.37	76.3134	28.0859	27.9263
	303.0	468.1	289.4	5.6	2949.3	998.1	54.6	3114.0	67.27	76.0403	28.0506	27.8912
	313.0	498.0	299.1	6.1	3016.7	954.5	57.5	3164.7	68.16	75.7617	28.0140	27.8547
	323.0	528.5	308.5	6.7	3086.7	909.9	60.4	3218.6	69.04	75.4775	27.9758	27.8167
	333.0	559.7	317.3	7.3	3159.2	864.3	63.5	3275.9	69.90	75.1873	27.9361	27.7771
	343.0	591.7	325.7	8.0	3234.2	817.3	66.6	3336.6	70.76	74.8910	27.8947	27.7359
	353.0	624.4	333.7	8.7	3311.9	768.9	70.0	3400.7	71.60	74.5883	27.8516	27.6929
	363.0	657.9	341.1	9.4	3392.3	718.9	73.4	3468.4	72.42	74.2790	27.8066	27.6481
	373.0	692.3	348.0	10.1	3475.3	667.2	76.9	3539.6	73.24	73.9627	27.7597	27.6014
	383.0	727.4	354.5	10.9	3561.1	613.6	80.6	3614.5	74.04	73.6393	27.7108	27.5527
	393.0	763.5	360.3	11.7	3649.7	557.9	84.4	3693.1	74.83	73.3084	27.6598	27.5019
	403.0	800.4	365.6	12.6	3741.3	500.0	88.4	3775.6	75.60	72.9699	27.6066	27.4489
	413.0	838.3	370.3	13.5	3835.9	439.8	92.5	3862.1	76.36	72.6233	27.5511	27.3936
	423.0	877.2	374.4	14.5	3933.6	377.0	96.7	3952.8	77.10	72.2685	27.4931	27.3358
	433.0	917.0	377.8	15.4	4034.3	311.5	101.0	4047.6	77.83	71.9050	27.4325	27.2755
	443.0	957.9	380.6	16.5	4138.3	243.0	105.5	4146.7	78.55	71.5326	27.3692	27.2124
	453.0	999.8	382.7	17.6	4245.4	171.2	110.1	4250.3	79.26	71.1510	27.3031	27.1466
	463.0	1042.8	384.0	18.7	4355.8	96.0	114.9	4358.4	79.95	70.7599	27.2340	27.0777
	473.0	1086.9	384.6	19.9	4469.5	17.0	119.8	4471.1	80.63	70.3588	27.1617	27.0057
	483.0	1132.2	384.4	21.1	4586.6	-65.9	124.9	4588.8	81.29	69.9475	27.0862	26.9305
	493.0	1178.7	383.3	22.4	4707.3	-153.0	130.1	4711.6	81.95	69.5256	27.0071	26.8518
	503.0	1226.3	381.3	23.7	4831.8	-244.5	135.5	4839.8	82.59	69.0926	26.9244	26.7694
	513.0	1275.3	378.4	25.1	4960.0	-340.9	141.1	4973.7	83.21	68.6483	26.8379	26.6832

TABLE I-VII-F (CONT.)

S-IV STAGE NOMINAL TRAJECTORY

EARTH FIXED PARAMETERS

	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)
	523.0	1325.6	374.4	26.5	5092.3	-442.6	146.8	5113.6	83.83	68.1921	26.7473	26.5929
	533.0	1377.2	369.5	28.0	5228.7	-549.6	152.7	5259.7	84.43	67.7236	26.6524	26.4984
	543.0	1430.1	363.4	29.6	5369.5	-662.6	158.8	5412.6	85.03	67.2423	26.5529	26.3994
	553.0	1484.6	356.2	31.2	5514.8	-782.1	165.1	5572.5	85.61	66.7477	26.4487	26.2955
	563.0	1540.5	347.8	32.9	5664.9	-908.7	171.6	5739.9	86.18	66.2393	26.3394	26.1867
	573.0	1597.9	338.0	34.6	5819.8	-1043.1	178.3	5915.2	86.74	65.7165	26.2247	26.0725
	583.0	1656.9	326.9	36.4	5979.8	-1185.9	185.2	6099.1	87.30	65.1786	26.1043	25.9526
	593.0	1717.5	314.3	38.3	6145.2	-1338.1	192.3	6292.2	87.85	64.6251	25.9780	25.8267
	603.0	1779.8	300.1	40.3	6316.2	-1500.7	199.6	6495.1	88.40	64.0551	25.8452	25.6945
	613.0	1843.8	284.2	42.3	6493.0	-1674.7	207.2	6708.7	88.95	63.4680	25.7055	25.5555
	623.0	1909.7	266.5	44.4	6676.4	-1861.3	215.0	6934.3	89.50	62.8628	25.5586	25.4092
(2)	632.1	1971.1	248.8	46.4	6850.3	-2042.1	222.3	7151.7	89.99	62.2966	25.4185	25.2696
	633.1	1978.0	246.8	46.6	6850.3	-2050.5	222.7	7154.1	90.00	62.2334	25.4027	25.2539
(3)	642.1	2039.5	228.0	48.6	6831.3	-2114.7	226.3	7154.7	90.00	61.6650	25.2589	25.1107
(4)	812.1	3163.2	-231.7	92.3	6353.5	-3280.3	284.9	7156.0	90.01	51.2061	22.1034	21.9695
(5)	813.1	3169.5	-235.0	92.6	6350.1	-3286.9	285.2	7156.0	90.01	51.1461	22.0825	21.9488
(6)	873.1	3544.1	-444.0	110.2	6133.1	-3675.7	301.4	7156.5	90.01	47.5844	20.7855	20.6581
(7)	933.1	3905.0	-675.8	128.7	5892.3	-4050.4	315.0	7157.1	90.01	44.0888	19.4052	19.2850

(1) Initiate Active Guidance
(2) GCS
(3) Insertion
(4) Close LH_2 non-propellant vent valves
(5) Pegasus/Apollo boilerplate separation
(6) Begin Wing deployment
(7) Terminate Wing deployment

MARSHALL SPACE FLIGHT CENTER

TABLE I-VII-G

S-I RETRO PORTION 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)
(1)	150.3	81.40	90.28	3056.4	56.89	-10.99	53929	12	275724	10.07	1828
	151.0	82.83	91.41	3048.6	56.99	-13.42	53663	9	406239	9.95	1453
	151.3	83.51	91.94	3044.3	57.04	-14.60	53537	8	468726	9.89	1306
	152.3	85.62	93.59	3028.9	57.18	-16.85	53194	6	587092	9.70	942
(2)	152.8	86.56	94.32	3023.2	57.25	-5.80	53117	5	6	9.62	816

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

MARSHALL SPACE FLIGHT CENTER

TABLE I-VII-H

S-I RETRO PORTION TRAJECTORY

	EARTH FIXED PARAMETERS								LØNGITUDE (PØSITIVE WEST) (DEG)	GEØD. LAT. (PØSITIVE NØRTH) (DEG)	GEØC. LAT. (PØSITIVE NØRTH) (DEG)
	TIME (SEC)	XXXE (KM)	YYYE (KM)	ZZZE (KM)	DXXE (M/SEC)	DYYE (M/SEC)	DZZE (M/SEC)	VELØCITY (M/SEC)	PATH ANGLE (DEG)			
(1)	150.3	82.6	89.8	0.4	2168.6	1641.3	12.1	2719.7	52.13	79.7374	28.4616	28.3007
	151.0	84.0	90.9	0.4	2165.0	1632.3	12.2	2711.4	52.23	79.7228	28.4603	28.2994
	151.3	84.7	91.4	0.4	2162.8	1627.7	12.3	2706.9	52.27	79.7159	28.4597	28.2988
	152.3	86.9	93.0	0.4	2154.3	1612.1	12.4	2690.7	52.41	79.6945	28.4578	28.2968
(2)	152.8	87.9	93.7	0.4	2151.6	1605.9	12.4	2684.8	52.47	79.6850	28.4569	28.2960

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

TABLE I-VII-I S-I COAST TO IMPACT TRAJECTORY

MARSHALL SPACE FLIGHT CENTER

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)
152.8	86.56	94.32	3023.2	57.25	-5.80	53117	5	0	9.62	817
155.0	91.24	97.95	3011.8	57.54	-5.75	53117	3	0	9.32	419
161.0	103.79	107.49	2981.5	58.33	-5.62	53117	1	0	8.35	80
167.0	116.29	116.73	2951.9	59.13	-5.49	53117	0	0	7.17	19
173.0	128.76	125.66	2923.2	59.95	-5.36	53117	0	0	5.89	6
179.0	141.18	134.28	2895.2	60.79	-5.22	53117	0	0	4.98	2
185.0	153.57	142.61	2868.0	61.64	-5.08	53117	0	0	4.39	1
191.0	165.91	150.63	2841.7	62.50	-4.94	53117	0	0	3.97	1
197.0	178.23	158.34	2816.1	63.38	-4.80	53117	0	0	3.71	1
203.0	190.51	165.76	2791.4	64.28	-4.65	53117	0	0	3.53	0
209.0	202.75	172.87	2767.6	65.19	-4.50	53117	0	0	3.40	0
215.0	214.97	179.69	2744.6	66.11	-4.34	53117	0	0	3.30	0
221.0	227.15	186.20	2722.5	67.05	-4.19	53117	0	0	3.21	0
227.0	239.31	192.42	2701.2	68.01	-4.02	53117	0	0	3.13	0
233.0	251.44	198.33	2680.9	68.97	-3.86	53117	0	0	3.07	0
239.0	263.55	203.95	2661.5	69.95	-3.69	53117	0	0	3.01	0
245.0	275.63	209.27	2643.0	70.95	-3.52	53117	0	0	2.95	0
251.0	287.68	214.29	2625.5	71.96	-3.34	53117	0	0	2.90	0
257.0	299.72	219.02	2608.9	72.98	-3.16	53117	0	0	2.85	0
263.0	311.74	223.45	2593.3	74.01	-2.98	53117	0	0	2.81	0
269.0	323.74	227.59	2578.6	75.05	-2.79	53117	0	0	2.76	0
275.0	335.72	231.42	2564.9	76.11	-2.60	53117	0	0	2.73	0
281.0	347.68	234.97	2552.3	77.17	-2.40	53117	0	0	2.70	0
287.0	359.63	238.22	2540.6	78.25	-2.21	53117	0	0	2.67	0
293.0	371.57	241.17	2530.0	79.33	-2.01	53117	0	0	2.64	0
299.0	383.49	243.83	2520.4	80.42	-1.81	53117	0	0	2.62	0
305.0	395.41	246.19	2511.8	81.52	-1.60	53117	0	0	2.60	0
311.0	407.31	248.26	2504.3	82.63	-1.39	53117	0	0	2.58	0
317.0	419.21	250.04	2497.8	83.74	-1.18	53117	0	0	2.57	0
323.0	431.09	251.52	2492.4	84.86	-0.97	53117	0	0	2.55	0
329.0	442.98	252.71	2488.1	85.98	-0.76	53117	0	0	2.54	0
335.0	454.86	253.60	2484.8	87.10	-0.55	53117	0	0	2.54	0
341.0	466.73	254.21	2482.6	88.23	-0.33	53117	0	0	2.53	0
347.0	478.61	254.51	2481.5	89.36	-0.12	53117	0	0	2.53	0
350.4	485.35	254.56	2481.3	90.00	0.00	53117	0	0	2.53	0
353.0	490.48	254.53	2481.4	90.49	0.10	53117	0	0	2.53	0
359.0	502.35	254.25	2482.4	91.62	0.31	53117	0	0	2.53	0
365.0	514.23	253.68	2484.5	92.74	0.53	53117	0	0	2.54	0
371.0	526.11	252.81	2487.6	93.87	0.74	53117	0	0	2.54	0
377.0	537.99	251.65	2491.9	94.99	0.95	53117	0	0	2.55	0

TABLE I-VII-I(CONT) S-I COAST TO IMPACT TRAJECTORY

MARSHALL SPACE FLIGHT CENTER

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)
383.0	549.88	250.20	2497.1	96.11	1.16	53117	0	0	2.57	0
389.0	561.78	248.45	2503.5	97.22	1.37	53117	0	0	2.58	0
395.0	573.68	246.41	2510.9	98.33	1.58	53117	0	0	2.60	0
401.0	585.60	244.08	2519.3	99.43	1.79	53117	0	0	2.62	0
407.0	597.52	241.45	2528.8	100.52	1.99	53117	0	0	2.64	0
413.0	609.46	238.53	2539.3	101.61	2.19	53117	0	0	2.67	0
419.0	621.41	235.31	2550.8	102.68	2.39	53117	0	0	2.69	0
425.0	633.38	231.80	2563.4	103.75	2.58	53117	0	0	2.73	0
431.0	645.36	227.99	2576.9	104.80	2.77	53117	0	0	2.76	0
437.0	657.36	223.88	2591.5	105.85	2.96	53117	0	0	2.80	0
443.0	669.37	219.48	2607.0	106.88	3.14	53117	0	0	2.85	0
449.0	681.41	214.79	2623.4	107.90	3.32	53117	0	0	2.89	0
455.0	693.47	209.79	2640.9	108.91	3.50	53117	0	0	2.94	0
461.0	705.55	204.50	2659.2	109.91	3.67	53117	0	0	3.00	0
467.0	717.66	198.92	2678.5	110.89	3.84	53117	0	0	3.06	0
473.0	729.79	193.03	2698.8	111.86	4.01	53117	0	0	3.12	0
479.0	741.95	186.84	2719.9	112.82	4.17	53117	0	0	3.20	0
485.0	754.14	180.36	2741.9	113.76	4.33	53117	0	0	3.29	0
491.0	766.35	173.58	2764.8	114.68	4.48	53117	0	0	3.39	0
497.0	778.60	166.49	2788.5	115.60	4.63	53117	0	0	3.52	0
503.0	790.88	159.11	2813.1	116.49	4.78	53117	0	0	3.69	1
509.0	803.19	151.42	2838.6	117.37	4.93	53117	0	0	3.94	1
515.0	815.54	143.43	2864.8	118.24	5.07	53117	0	0	4.34	1
521.0	827.93	135.14	2891.9	119.09	5.21	53117	0	0	4.91	2
527.0	840.36	126.55	2919.8	119.93	5.34	53117	0	0	5.78	5
533.0	852.82	117.65	2948.4	120.75	5.47	53117	0	0	7.07	17
539.0	865.33	108.44	2977.9	121.56	5.60	53117	0	0	8.26	69
544.3	876.49	100.00	3004.7	122.26	5.71	53117	2	0	9.16	292
551.0	890.48	89.11	3038.9	123.13	5.81	53117	14	0	10.03	2246
557.0	903.12	78.99	3069.9	123.89	5.72	53117	87	0	9.86	13643
563.0	915.80	68.56	3098.5	124.63	4.86	53117	417	0	9.29	65571
569.0	928.49	57.86	3115.5	125.34	1.31	53117	1673	0	8.75	260288
575.0	941.08	46.98	3090.0	125.98	-11.39	53117	6127	0	8.41	941291
581.0	953.16	36.27	2898.8	126.34	-61.40	53117	23557	0	8.21	3604040
587.0	963.36	26.99	2258.7	125.63	-145.17	53117	55422	0	6.46	8060514
593.0	969.89	20.81	1411.0	122.56	-120.37	53117	48051	0	3.73	6754262
599.0	973.22	17.41	890.9	117.44	-59.53	53117	23082	0	1.96	3541422
605.0	974.85	15.51	650.6	112.31	-26.40	53117	9827	0	1.09	1812641
611.0	975.71	14.24	555.2	109.79	-7.19	53117	5807	0	0.75	828873
617.0	976.25	13.16	519.1	109.90	-2.88	53117	5267	0	0.66	629547

TABLE I-VII-I (CONT) S-I COAST TO IMPACT TRAJECTORY

MARSHALL SPACE FLIGHT CENTER

	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)
	623.0	976.63	12.12	495.5	110.12	-1.84	53117	5206	0	0.60	593282
	629.0	976.88	11.11	478.2	110.09	-1.56	53117	5241	0	0.56	589202
	635.0	977.06	10.15	465.1	109.79	-1.38	53117	5266	0	0.52	585361
	641.0	977.17	9.22	455.3	109.31	-1.24	53117	5280	0	0.49	581012
	647.0	977.25	8.34	448.0	108.73	-1.12	53117	5281	0	0.46	576051
	653.0	977.30	7.49	442.7	108.12	-1.01	53117	5278	0	0.43	571101
	659.0	977.33	6.68	438.7	107.51	-0.92	53117	5273	0	0.41	566517
	665.0	977.35	5.91	435.7	106.91	-0.86	53117	5267	0	0.39	563157
	671.0	977.36	5.16	433.3	106.32	-0.80	53117	5254	0	0.37	560090
	677.0	977.37	4.45	431.5	105.76	-0.74	53117	5238	0	0.35	556963
	683.0	977.37	3.76	429.9	105.23	-0.68	53117	5223	0	0.34	553997
	689.0	977.38	3.09	428.7	104.73	-0.63	53117	5209	0	0.32	551258
	695.0	977.38	2.45	427.6	104.26	-0.58	53117	5195	0	0.31	548701
	701.0	977.38	1.83	426.7	103.83	-0.54	53117	5182	0	0.30	546282
	707.0	977.38	1.22	425.9	103.43	-0.49	53117	5169	0	0.29	543965
	713.0	977.38	0.64	425.1	103.06	-0.45	53117	5155	0	0.28	541716
	719.0	977.39	0.07	424.5	102.73	-0.41	53117	5142	0	0.27	539516
(1)	719.8	977.39	-0.00	424.4	102.68	-0.40	53117	5140	0	0.27	539239

(1) Theoretical Ballistic Impact

TABLE I-VII-J S-I COAST TO IMPACT TRAJECTORY

MARSHALL SPACE FLIGHT CENTER

EARTH FIXED PARAMETERS

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)
152.8	87.9	93.7	0.4	2151.6	1605.9	12.4	2684.8	52.47	79.6850	28.4569	28.2960
155.0	92.7	97.3	0.4	2150.8	1585.3	12.8	2671.9	52.77	79.6375	28.4526	28.2917
161.0	105.6	106.6	0.5	2148.7	1530.1	13.8	2637.8	53.60	79.5100	28.4409	28.2801
167.0	118.4	115.6	0.6	2146.6	1475.0	14.8	2604.5	54.45	79.3831	28.4291	28.2683
173.0	131.3	124.3	0.7	2144.4	1420.1	15.8	2572.0	55.31	79.2566	28.4172	28.2564
179.0	144.2	132.7	0.8	2142.1	1365.3	16.8	2540.3	56.20	79.1305	28.4051	28.2444
185.0	157.0	140.7	0.9	2139.8	1310.7	17.8	2509.3	57.12	79.0049	28.3929	28.2322
191.0	169.9	148.4	1.0	2137.4	1256.2	18.8	2479.3	58.05	78.8797	28.3805	28.2199
197.0	182.7	155.8	1.1	2134.9	1201.9	19.7	2450.0	59.01	78.7548	28.3681	28.2075
203.0	195.5	162.8	1.2	2132.4	1147.7	20.7	2421.7	59.98	78.6304	28.3554	28.1949
209.0	208.3	169.6	1.4	2129.8	1093.6	21.7	2394.3	60.98	78.5063	28.3427	28.1822
215.0	221.0	176.0	1.5	2127.2	1039.6	22.6	2367.7	62.01	78.3826	28.3297	28.1693
221.0	233.8	182.0	1.6	2124.5	985.8	23.6	2342.1	63.05	78.2592	28.3167	28.1563
227.0	246.5	187.8	1.8	2121.7	932.0	24.5	2317.5	64.12	78.1362	28.3035	28.1432
233.0	259.2	193.2	1.9	2118.9	878.4	25.5	2293.9	65.21	78.0134	28.2902	28.1299
239.0	271.9	198.3	2.1	2116.0	824.9	26.4	2271.2	66.32	77.8910	28.2767	28.1165
245.0	284.6	203.1	2.3	2113.0	771.4	27.3	2249.6	67.45	77.7688	28.2631	28.1029
251.0	297.3	207.6	2.4	2110.0	718.1	28.3	2229.0	68.60	77.6469	28.2494	28.0892
257.0	310.0	211.7	2.6	2106.9	664.8	29.2	2209.5	69.78	77.5253	28.2355	28.0754
263.0	322.6	215.6	2.8	2103.8	611.7	30.1	2191.1	70.97	77.4039	28.2215	28.0614
269.0	335.2	219.1	3.0	2100.6	558.5	31.0	2173.8	72.18	77.2827	28.2073	28.0473
275.0	347.8	222.3	3.1	2097.4	505.5	31.9	2157.7	73.42	77.1617	28.1930	28.0331
281.0	360.4	225.1	3.3	2094.1	452.5	32.8	2142.7	74.66	77.0410	28.1786	28.0187
287.0	372.9	227.7	3.5	2090.7	399.6	33.7	2128.8	75.93	76.9204	28.1640	28.0042
293.0	385.5	229.9	3.7	2087.3	346.7	34.5	2116.2	77.21	76.8000	28.1492	27.9895
299.0	398.0	231.9	4.0	2083.8	293.9	35.4	2104.7	78.51	76.6798	28.1344	27.9747
305.0	410.5	233.5	4.2	2080.3	241.2	36.3	2094.5	79.82	76.5597	28.1193	27.9597
311.0	422.9	234.8	4.4	2076.7	188.4	37.1	2085.5	81.14	76.4398	28.1042	27.9446
317.0	435.4	235.7	4.6	2073.0	135.7	38.0	2077.8	82.47	76.3200	28.0888	27.9293
323.0	447.8	236.4	4.8	2069.3	83.1	38.8	2071.3	83.81	76.2003	28.0734	27.9139
329.0	460.2	236.7	5.1	2065.5	30.4	39.7	2066.1	85.16	76.0807	28.0578	27.8983
335.0	472.6	236.8	5.3	2061.7	-22.2	40.5	2062.2	86.51	75.9612	28.0420	27.8826
341.0	485.0	236.5	5.6	2057.8	-74.8	41.3	2059.6	87.87	75.8417	28.0261	27.8668
347.0	497.3	235.9	5.8	2053.8	-127.4	42.1	2058.2	89.23	75.7223	28.0100	27.8508
350.4	504.3	235.4	6.0	2051.6	-157.2	42.6	2058.0	90.00	75.6546	28.0008	27.8416
353.0	509.6	234.9	6.1	2049.8	-179.9	42.9	2058.1	90.59	75.6030	27.9938	27.8346
359.0	521.9	233.7	6.3	2045.7	-232.5	43.7	2059.4	91.95	75.4837	27.9774	27.8183
365.0	534.2	232.1	6.6	2041.6	-285.1	44.5	2061.9	93.31	75.3645	27.9609	27.8018
371.0	546.4	230.3	6.9	2037.4	-337.7	45.3	2065.7	94.66	75.2452	27.9442	27.7852
377.0	558.6	228.1	7.1	2033.1	-390.3	46.1	2070.8	96.01	75.1260	27.9273	27.7684

TABLE I-VII-J (CONT) S-I COAST TO IMPACT TRAJECTORY

MARSHALL SPACE FLIGHT CENTER

EARTH FIXED PARAMETERS

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)
383.0	570.8	225.6	7.4	2028.8	-442.9	46.8	2077.1	97.35	75.0067	27.9103	27.7515
389.0	582.9	222.8	7.7	2024.4	-495.5	47.6	2084.7	98.68	74.8874	27.8932	27.7344
395.0	595.1	219.6	8.0	2020.0	-548.2	48.3	2093.6	100.00	74.7681	27.8758	27.7171
401.0	607.2	216.2	8.3	2015.4	-600.9	49.1	2103.7	101.31	74.6487	27.8583	27.6997
407.0	619.3	212.4	8.6	2010.9	-653.6	49.8	2115.0	102.61	74.5293	27.8407	27.6821
413.0	631.3	208.4	8.9	2006.2	-706.4	50.5	2127.5	103.89	74.4098	27.8228	27.6643
419.0	643.3	204.0	9.2	2001.5	-759.2	51.3	2141.2	105.16	74.2902	27.8048	27.6463
425.0	655.3	199.2	9.5	1996.7	-812.0	52.0	2156.1	106.41	74.1705	27.7866	27.6282
431.0	667.3	194.2	9.8	1991.9	-864.9	52.7	2172.2	107.64	74.0507	27.7683	27.6099
437.0	679.2	188.9	10.1	1986.9	-917.9	53.4	2189.4	108.8(	73.9307	27.7497	27.5915
443.0	691.1	183.2	10.5	1981.9	-970.9	54.0	2207.7	110.0(	73.8107	27.7310	27.5728
449.0	703.0	177.2	10.8	1976.9	-1024.1	54.7	2227.1	111.23	73.6905	27.7121	27.5540
455.0	714.9	170.9	11.1	1971.8	-1077.2	55.4	2247.5	112.39	73.5701	27.6930	27.5350
461.0	726.7	164.3	11.4	1966.6	-1130.5	56.0	2269.0	113.52	73.4495	27.6738	27.5158
467.0	738.5	157.3	11.8	1961.3	-1183.8	56.7	2291.6	114.63	73.3288	27.6543	27.4964
473.0	750.2	150.1	12.1	1955.9	-1237.3	57.3	2315.1	115.73	73.2078	27.6347	27.4769
479.0	761.9	142.5	12.5	1950.5	-1290.8	58.0	2339.6	116.79	73.0866	27.6149	27.4571
485.0	773.6	134.6	12.8	1945.0	-1344.4	58.6	2365.1	117.84	72.9652	27.5948	27.4372
491.0	785.3	126.4	13.2	1939.4	-1398.1	59.2	2391.6	118.87	72.8436	27.5746	27.4170
497.0	796.9	117.8	13.5	1933.8	-1452.0	59.8	2418.9	119.87	72.7217	27.5542	27.3967
503.0	808.5	108.9	13.9	1928.0	-1505.9	60.4	2447.2	120.85	72.5995	27.5335	27.3761
509.0	820.0	99.7	14.3	1922.2	-1560.0	60.9	2476.3	121.81	72.4771	27.5127	27.3553
515.0	831.5	90.2	14.6	1916.3	-1614.2	61.5	2506.3	122.74	72.3543	27.4916	27.3344
521.0	843.0	80.4	15.0	1910.3	-1668.5	62.1	2537.1	123.66	72.2313	27.4704	27.3132
527.0	854.5	70.2	15.4	1904.2	-1722.9	62.6	2568.8	124.55	72.1079	27.4489	27.2918
533.0	865.9	59.7	15.7	1898.1	-1777.5	63.2	2601.2	125.42	71.9841	27.4272	27.2702
539.0	877.2	48.9	16.1	1891.8	-1832.3	63.7	2634.4	126.27	71.8600	27.4053	27.2483
544.3	887.3	39.0	16.5	1886.2	-1881.1	64.1	2664.6	127.01	71.7494	27.3856	27.2287
551.0	899.9	26.2	16.9	1878.9	-1942.2	64.7	2703.1	127.91	71.6107	27.3607	27.2040
557.0	911.1	14.4	17.3	1871.9	-1996.9	65.2	2737.8	128.69	71.4855	27.3381	27.1815
563.0	922.3	2.3	17.7	1862.7	-2049.5	65.6	2770.2	129.46	71.3599	27.3153	27.1587
569.0	933.5	-10.2	18.1	1845.2	-2093.0	65.6	2791.0	130.22	71.2343	27.2923	27.1358
575.0	944.4	-22.8	18.5	1799.4	-2103.7	64.7	2769.1	130.96	71.1098	27.2693	27.1129
581.0	954.8	-35.2	18.8	1646.7	-1986.2	59.8	2580.8	131.73	70.9903	27.2471	27.0908
587.0	963.6	-45.9	19.2	1211.4	-1516.1	44.5	1941.1	132.68	70.8895	27.2283	27.0721
593.0	969.1	-53.0	19.4	655.0	-869.0	24.4	1088.5	134.23	70.8250	27.2162	27.0600
599.0	971.9	-56.8	19.5	312.7	-463.6	11.8	559.3	137.21	70.7921	27.2100	27.0538
605.0	973.2	-59.0	19.5	149.8	-273.0	5.8	311.5	142.45	70.7760	27.2069	27.0508
611.0	973.9	-60.4	19.5	79.4	-202.5	3.2	217.5	149.79	70.7675	27.2053	27.0492
617.0	974.3	-61.5	19.6	46.8	-186.1	2.1	191.8	157.09	70.7622	27.2043	27.0481

TABLE I-VII-J(CONT) S-I COAST TO IMPACT TRAJECTORY

MARSHALL SPACE FLIGHT CENTER

EARTH FIXED PARAMETERS

	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)
	623.0	974.5	-62.6	19.6	24.9	-176.4	1.3	178.1	163.16	70.7585	27.2036	27.0474
	629.0	974.6	-63.6	19.6	9.6	-167.7	0.7	168.0	167.91	70.7559	27.2031	27.0469
	635.0	974.6	-64.6	19.6	-0.8	-159.2	0.3	159.2	171.48	70.7542	27.2027	27.0466
	641.0	974.6	-65.5	19.6	-7.7	-151.1	0.0	151.3	174.11	70.7531	27.2025	27.0464
	647.0	974.5	-66.4	19.6	-12.1	-143.7	-0.1	144.2	175.99	70.7523	27.2023	27.0462
	653.0	974.4	-67.3	19.6	-14.7	-137.0	-0.2	137.8	177.30	70.7519	27.2022	27.0461
	659.0	974.3	-68.1	19.6	-16.1	-131.0	-0.3	132.0	178.20	70.7516	27.2022	27.0460
	665.0	974.2	-68.8	19.6	-16.8	-125.6	-0.4	126.7	178.81	70.7514	27.2021	27.0460
	671.0	974.1	-69.6	19.6	-17.0	-120.6	-0.4	121.8	179.20	70.7512	27.2021	27.0459
	677.0	974.0	-70.3	19.6	-16.9	-115.9	-0.4	117.2	179.46	70.7512	27.2020	27.0459
	683.0	973.9	-71.0	19.6	-16.6	-111.7	-0.4	112.9	179.61	70.7511	27.2020	27.0459
	689.0	973.8	-71.6	19.6	-16.2	-107.8	-0.4	109.0	179.71	70.7511	27.2020	27.0459
	695.0	973.7	-72.3	19.6	-15.8	-104.2	-0.4	105.4	179.76	70.7511	27.2020	27.0458
	701.0	973.6	-72.9	19.6	-15.3	-100.8	-0.3	102.0	179.79	70.7510	27.2020	27.0458
	707.0	973.6	-73.5	19.6	-14.9	-97.8	-0.3	98.9	179.81	70.7510	27.2019	27.0458
	713.0	973.5	-74.1	19.6	-14.5	-95.0	-0.3	96.1	179.82	70.7510	27.2019	27.0458
	719.0	973.4	-74.6	19.6	-14.1	-92.4	-0.3	93.5	179.82	70.7510	27.2019	27.0458
(1)	719.8	973.4	-74.7	19.6	-14.1	-92.1	-0.3	93.2	179.82	70.7510	27.2019	27.0458

(1) Theoretical Ballistic Impact.

FIG. I-1. SATURN SA-10 VEHICLE

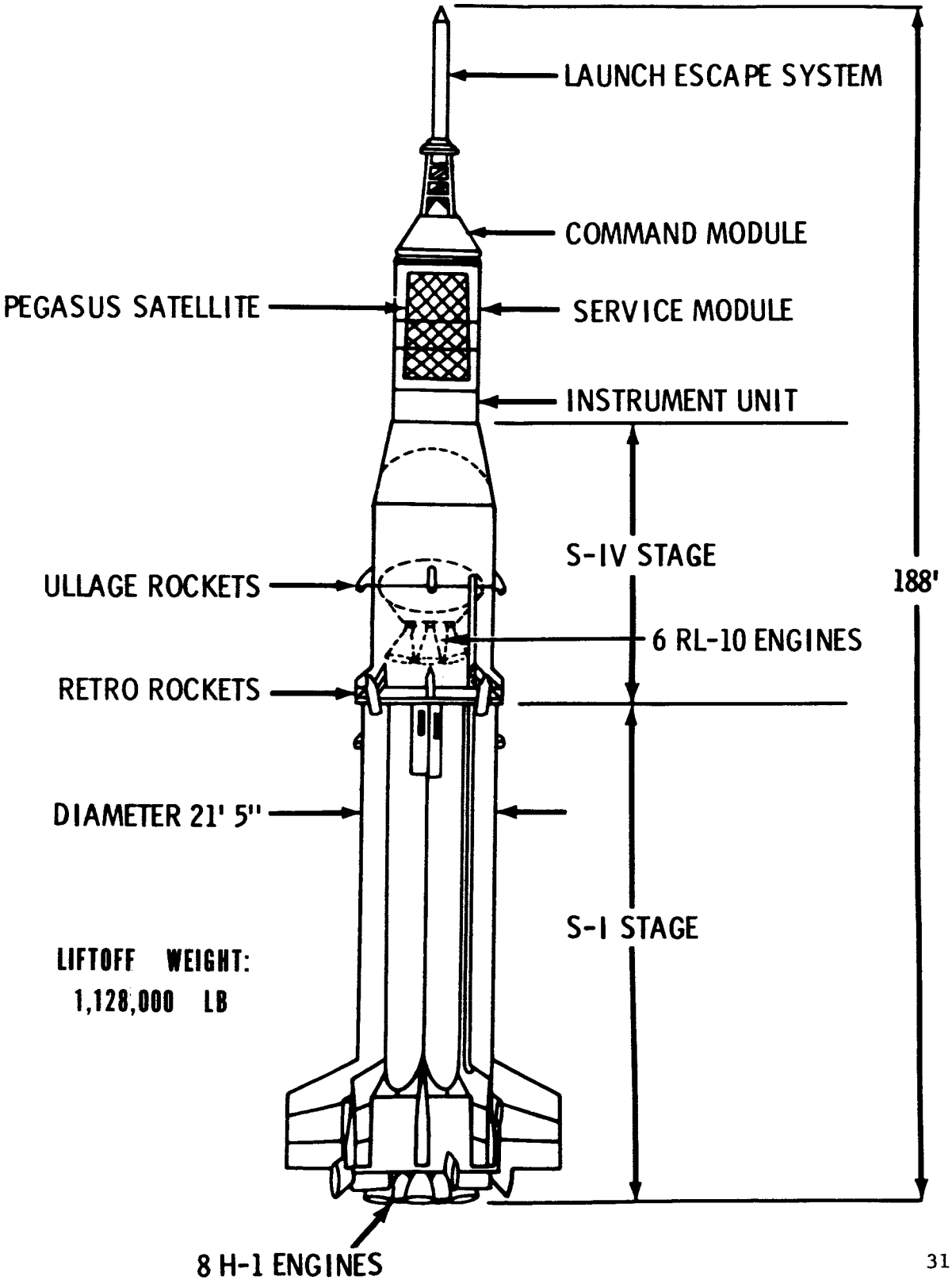
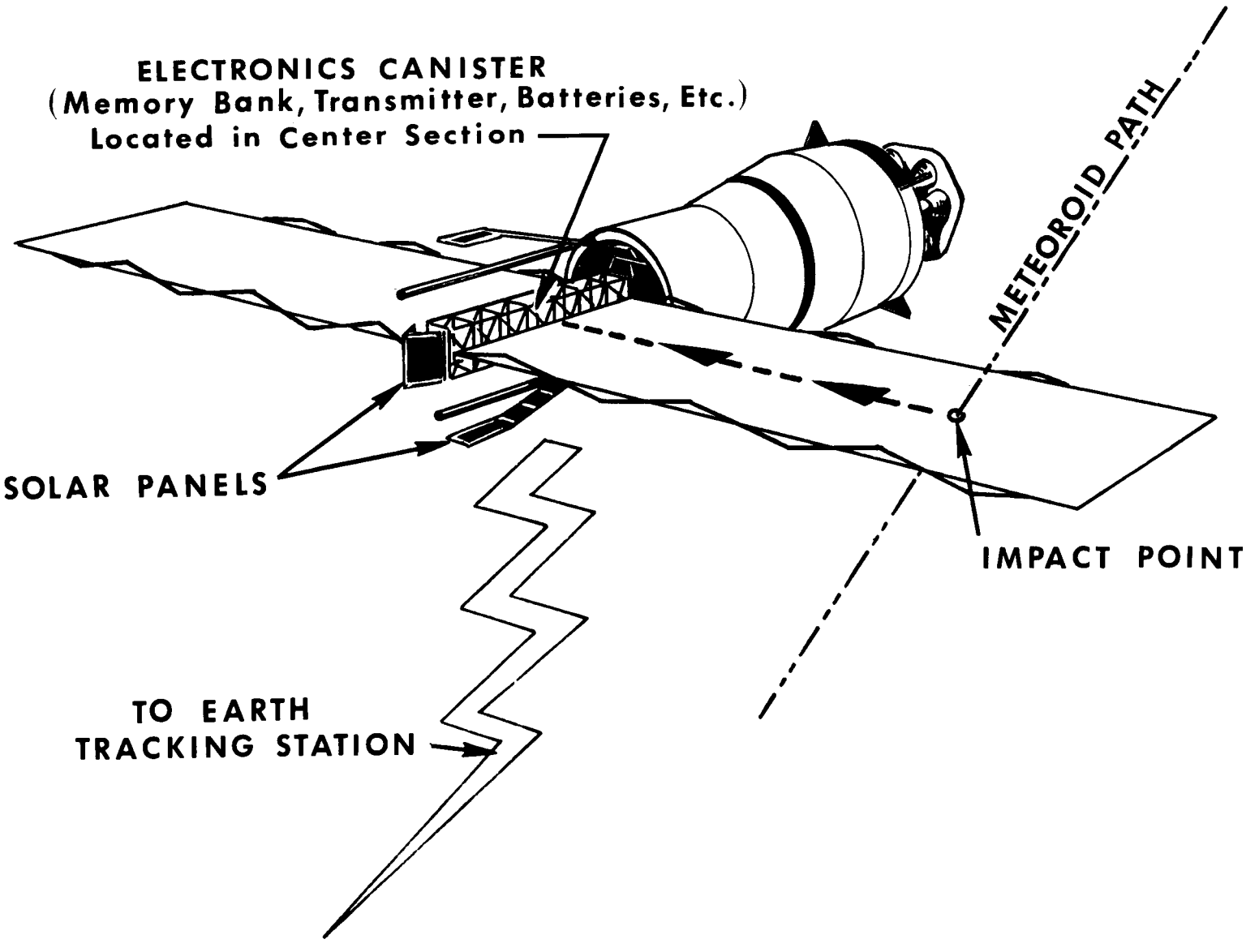


FIG. I-2. PEGASUS 'FINDS' A METEOROID



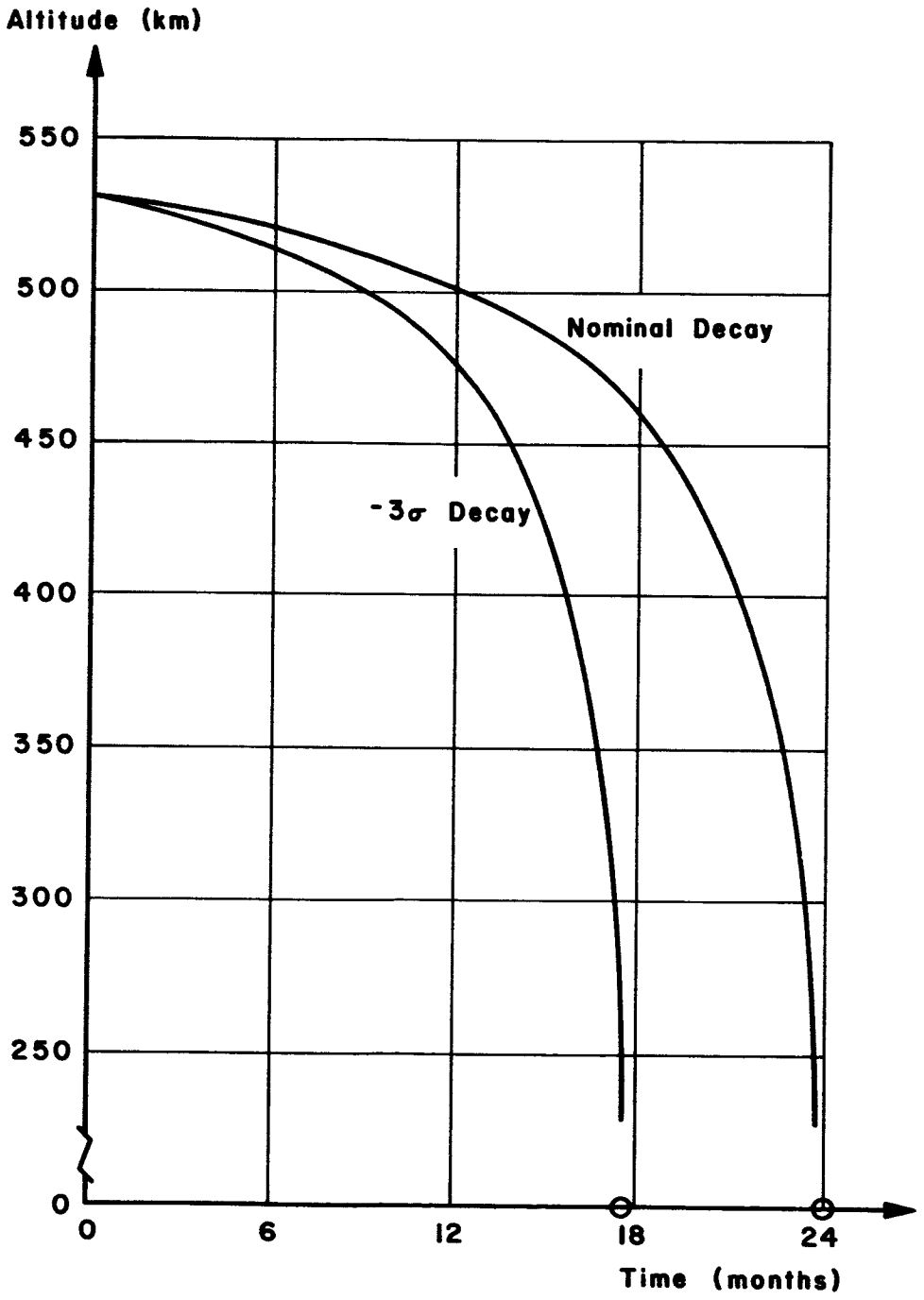


FIG. I-3. SA-10 / PEGASUS C DECAY HISTORY

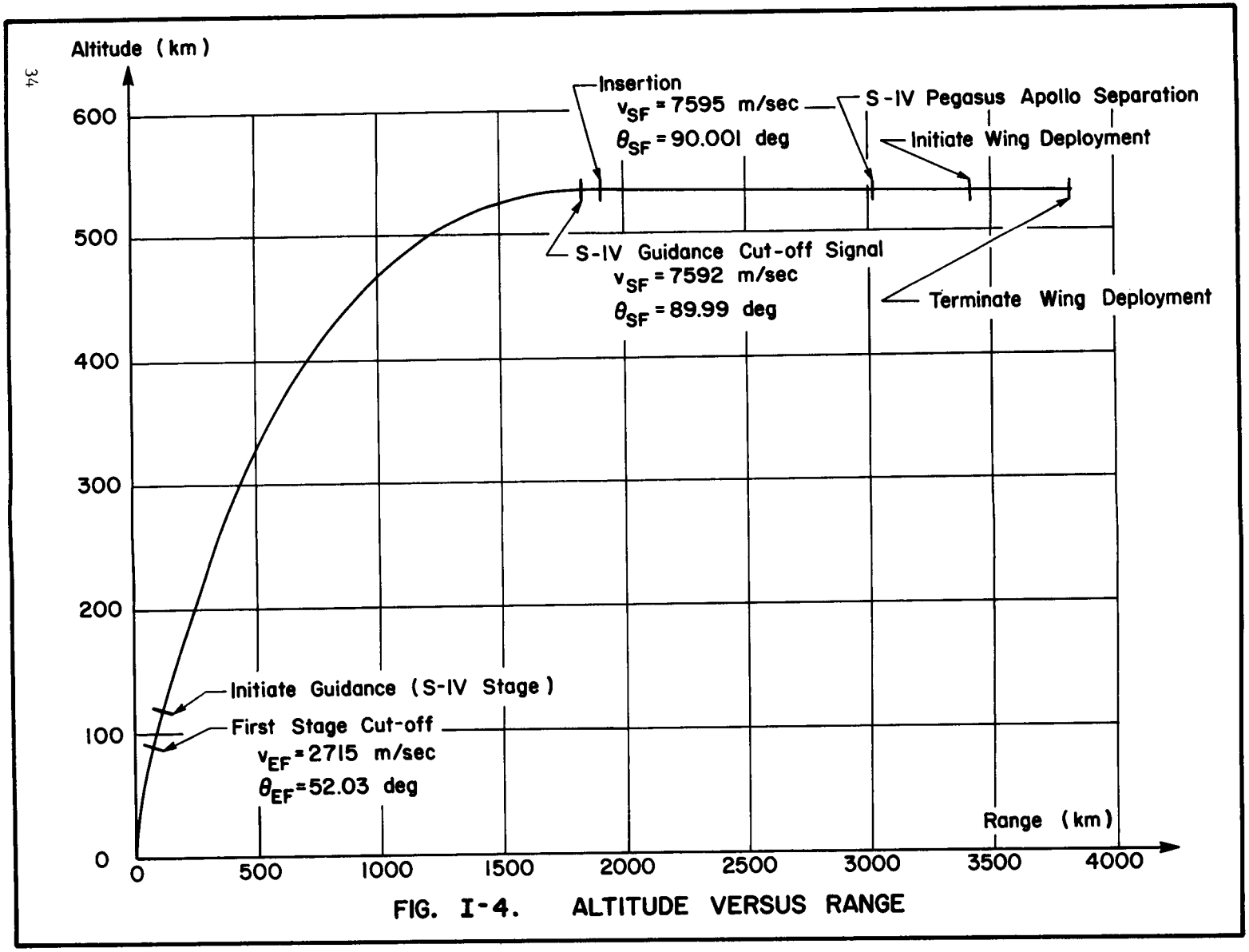


FIG. I-4. ALTITUDE VERSUS RANGE

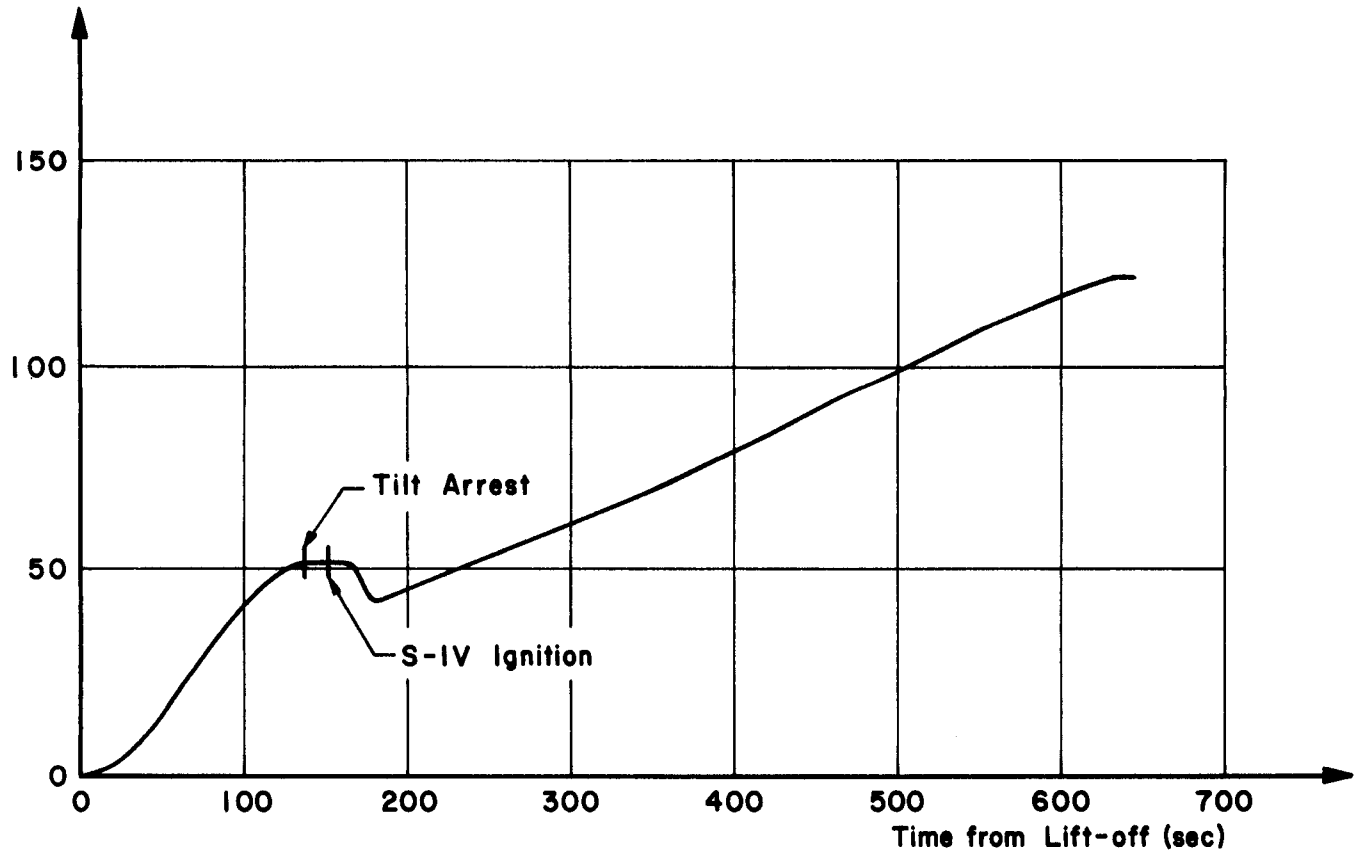


FIG. I-5. CHI PITCH VERSUS TIME

PART II

LAUNCH CRITERIA AND ORBITAL VENTING STATUS

A. LAUNCH CRITERIA

Mr. Sullivan/pac/876-3579
DATE June 24, 1965
R-AERO-FM-21-65

TO Distribution

FROM Chief, Flight Mechanics Branch, R-AERO-FM

SUBJECT Wind Launch Criteria for SA-10

REFERENCE
(a) R-P&VE-SLL-65-6, "Structural Strength of SA-8 and SA-9 Vehicles," January 22, 1965
(b) SA-10 Preliminary Predicted Trajectory, Unpublished
(c) Saturn I, Block II Design Criteria Book
(d) M-AERO-G-53-63, "Cape Canaveral, Florida, Wind Profile Envelopes for Selected Flight Azimuths," March 28, 1963
(e) I-MICH-OA Letter Dated June 3, 1965

1. Wind speed limits for the SA-10 vehicle have been determined for the maximum dynamic pressure time point (t = 68 sec). These limits are established based on structural capabilities of the space vehicle as given in Reference (a). The structural capabilities of the space vehicle have been coordinated with MSC and are in agreement with structural limits imposed by them. Structural data furnished are a function of angle of attack (α), gimbal angle (β), and dynamic pressure (q). Disturbances other than the wind used to establish these limits are 99% shears and gusts (Reference (c)), 3 σ c_1 and c_2 variations, and ± 10% variation in the control gains. Trajectory data used are those obtained from Reference (b).

2. Figure 1 shows the wind speed limits as a function of wind azimuth for the maximum dynamic pressure time point (t = 68 sec). This figure shows the limits for various assumptions and combinations of disturbances upon which a decision for launch might be based. Wind magnitudes within the shaded portion of the figure could cause launch problems and a preflight simulation would be necessary for a launch decision. Wind magnitudes above the shaded portion of the figure could cause launch problems or make launch impossible. Wind magnitudes below the shaded portion create no apparent launch problems. But, under exceptional conditions, even winds of this magnitude may still lead to structural problems; therefore, a limited amount of flight simulation will still be performed.

3. Figure 2 shows the limiting wind from the most critical direction probability-wise, which is the tailwind. These wind limits are shown over flight time, assuming the same disturbances and combination of disturbances as used for Figure 1. Also shown on this figure is the 3 σ wind for the month of July (Reference (d)). Figure 3 shows the angle-of-attack limit and gimbal angle limit as a function of flight time for the same disturbances.

The gimbal angle limit shown here is derived in combination with the angle-of-attack limit and does not utilize the full gimbal angle capability of the vehicle, which is eight degrees. Also shown on this figure are the angle-of-attack and gimbal angle for the 3 σ July wind as a function of flight time. Predicted median winds for July are less than 5 m/s and, therefore, are not shown since their effect would be negligible.

4. The Saturn Block II vehicle, fueled, was designed to be structurally capable of withstanding the highest wind speed that may occur 99.9 per cent of the time, during any monthly period, while free-standing on the launch pad. During periods when ground wind conditions are predicted to exceed the 99.9 per cent peak wind speeds, the vehicle must be placed in a service structure or secured in such a manner that no additional wind loading conditions will be encountered by the vehicle; otherwise a risk of loss due to structural failure must be assumed. The free-standing SA-10 vehicle, unfueled, can withstand peak winds of approximately 34.7 knots (Reference (e).

Surface Wind Restriction: Referenced to 60 feet above natural grade.

	Steady State Velocity (knots)	(m/sec)	Peak Velocity (knots)	(m/sec)
Vehicle Free-Standing (Fueled)	33 max	16.9	46 max	23.7
Launch Release	20 max	10.3	28 max	14.4

Using the 60 foot reference level (as agreed on between KSC and MSFC) the vehicle cannot be launched during peak winds exceeding 14.4 m/sec at this level. The probability of a peak wind exceeding 14.4 m/sec at 60 foot level above natural grade during July (excluding hurricanes) is less than .005. Winds of this magnitude create no control or collision problems during liftoff. If the launch should be made in August, the restrictions are less severe since the predicted winds for August are lower than predicted winds for July.

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3 Enc:
Figures 1-3

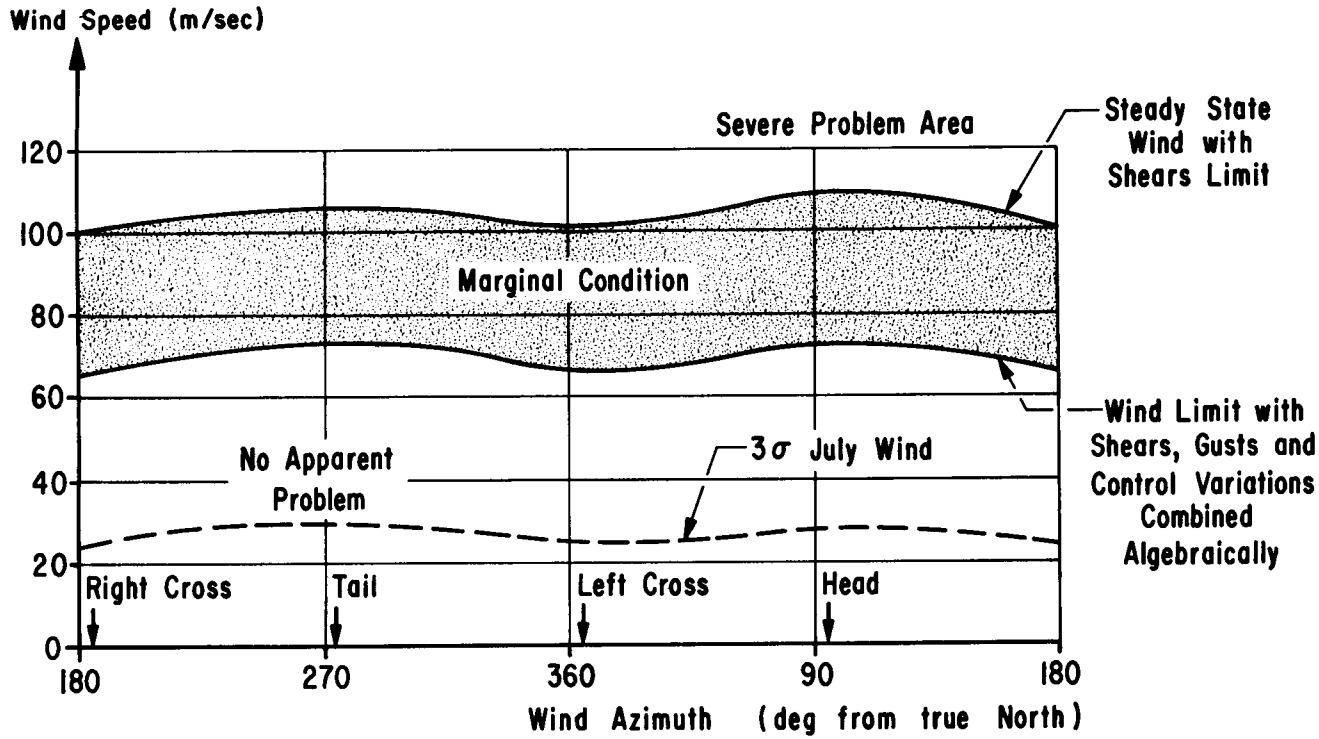


FIG. 1. SA-10 APPROXIMATE WIND SPEED LIMITS VERSUS WIND AZIMUTH FOR MAXIMUM DYNAMIC PRESSURE TIME POINT

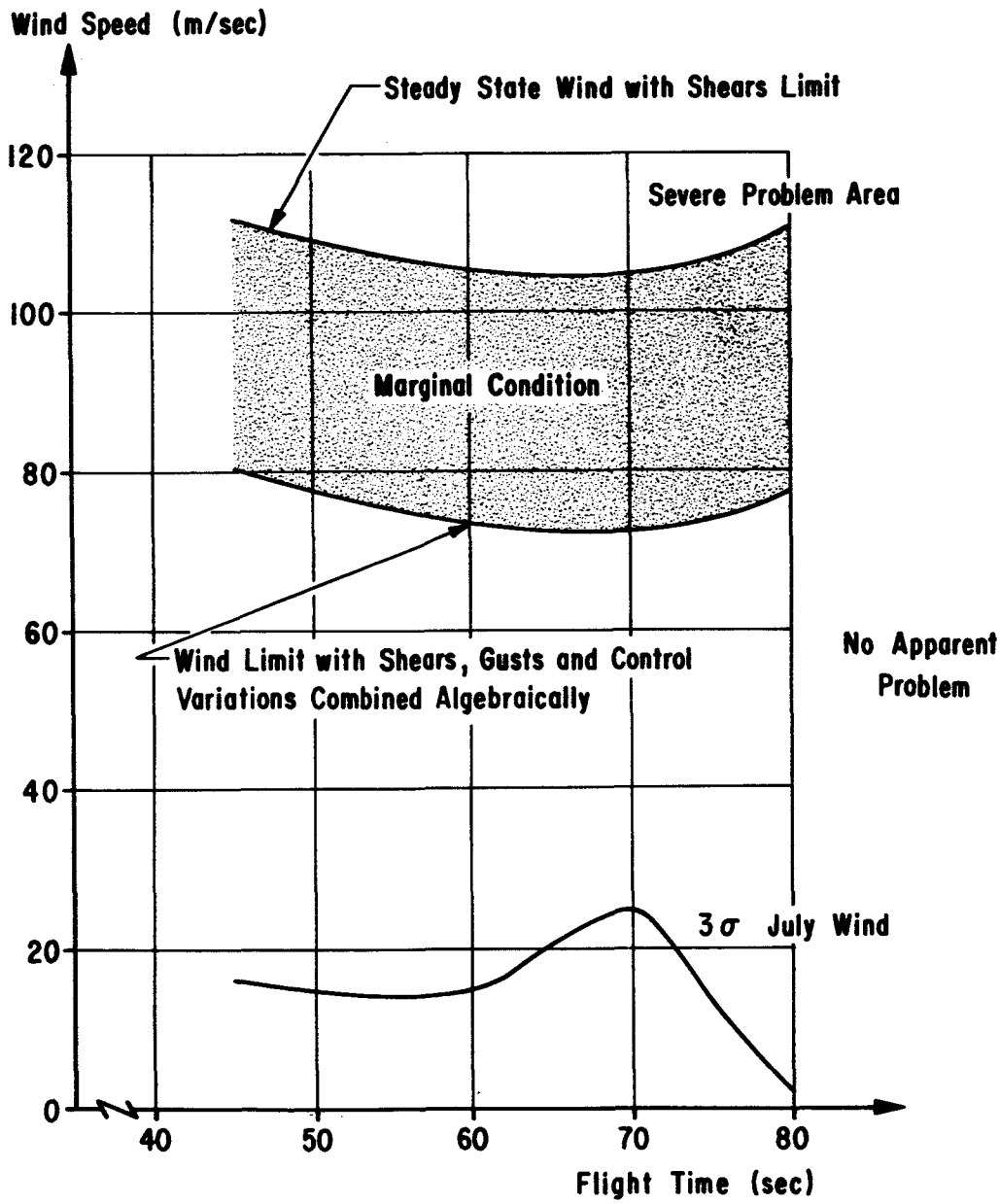


FIG. 2. TAILWIND LIMIT VERSUS FLIGHT TIME

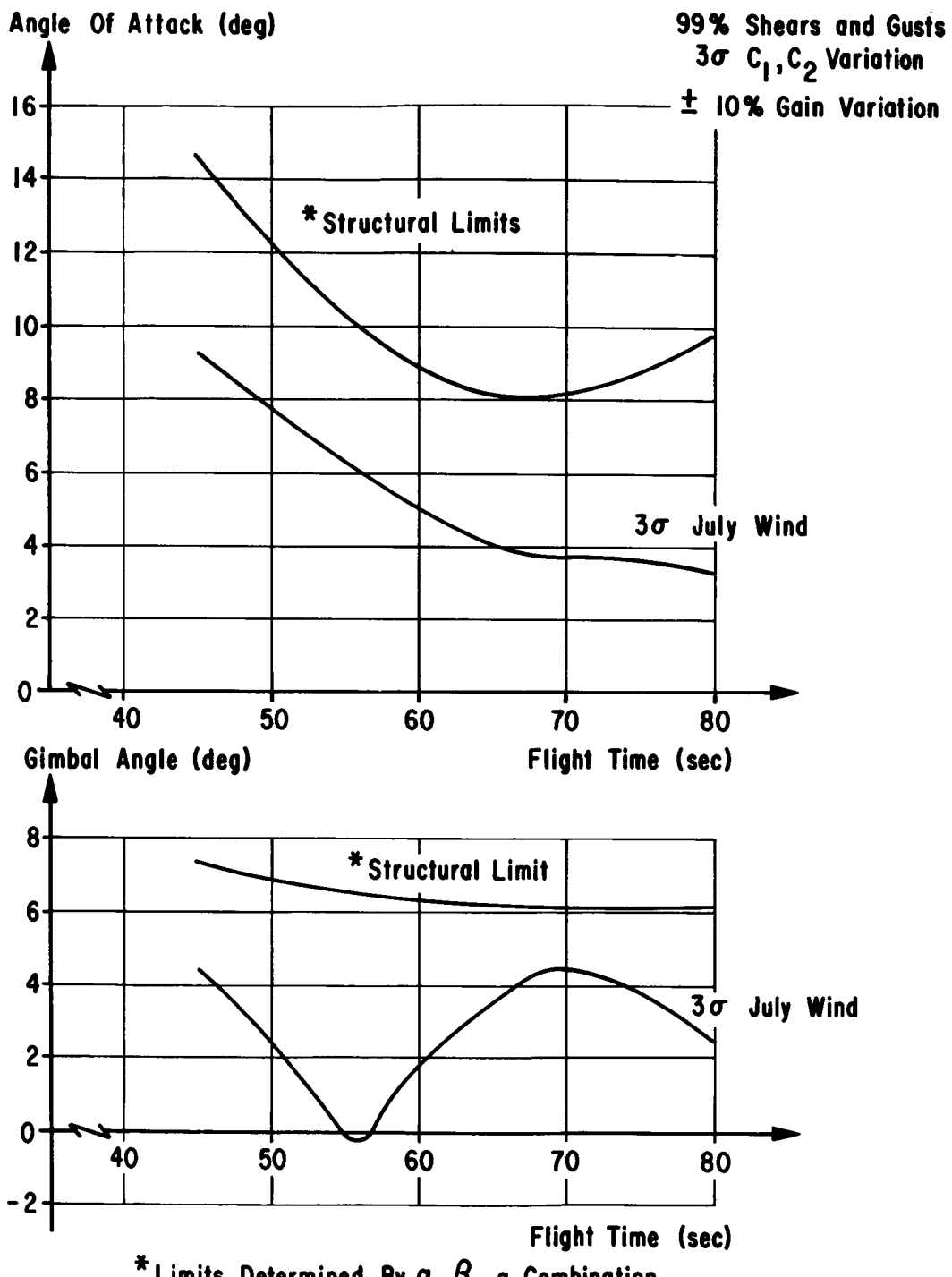


FIG. 3. ANGLE OF ATTACK AND GIMBAL ANGLE VERSUS FLIGHT TIME

B. ORBITAL VENTING STATUS

The SA-10 post insertion venting analysis provides a 95.5% confidence level of not exceeding the 9 deg/sec roll and 2 deg/sec tumble rate limits outlined in Reference 6 . This analysis reflects the structural changes that are being incorporated for this vehicle; i.e., the interchange of O_2 and H_2 non-propulsive vents. It also includes the best estimate of impingement effects of vented H_2 gases on the Pegasus wing structure (based on SA-9 flight evaluation data), as well as perturbations due to misalignments, c.g. shifts, etc.

PART III

Range Safety Data Summary for SA-10

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

The following parameters were varied to obtain the 3 σ envelope for range safety purposes: thrust, flow rate, liftoff weight, and wind speed. Impact data for this envelope is given in tabular form and consists of instantaneous cutoff time, geodetic latitude, longitude, remaining flight time, and range along the earth's surface from launch to impact. (See Reference 7).

The vehicle velocity vector turning data for the nominal trajectory is graphically presented. In particular, the total velocity vector magnitude and orientation in the lateral direction is presented as a time function from the point of malfunction (engine gimbal deflection), applied in the yaw plane. (See Reference 7).

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

$$P_I = \frac{\Delta t}{T_B} \quad X \quad P_F$$

P_I = probability of impacting on land area

Δ_t = dwell time (IIP transit time)

T_B = total burn time of second stage

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

For SA-10: $P_I = \frac{4.9}{480.1} \quad X \quad .13 = 1.3 \times 10^{-3}$

PART III (CONT'D)

Subdividing the impact probabilities for individual countries:

Land Area	Dwell Time	Impact Probability
Angola	2.8	7.6×10^{-4}
Rhodesia & Nyasaland	1.5	4.1×10^{-4}
Bechuanaland	.1	2.6×10^{-5}
Mozambique	.3	8.1×10^{-5}
Madagascar	.2	5.3×10^{-5}

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

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

where

P_{IP} = probability of injuring a person

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

A_L = lethal area

The probability of injuring a person, by overflying land is:

$$P_{IP} = 4.7 \times 10^{-6}$$

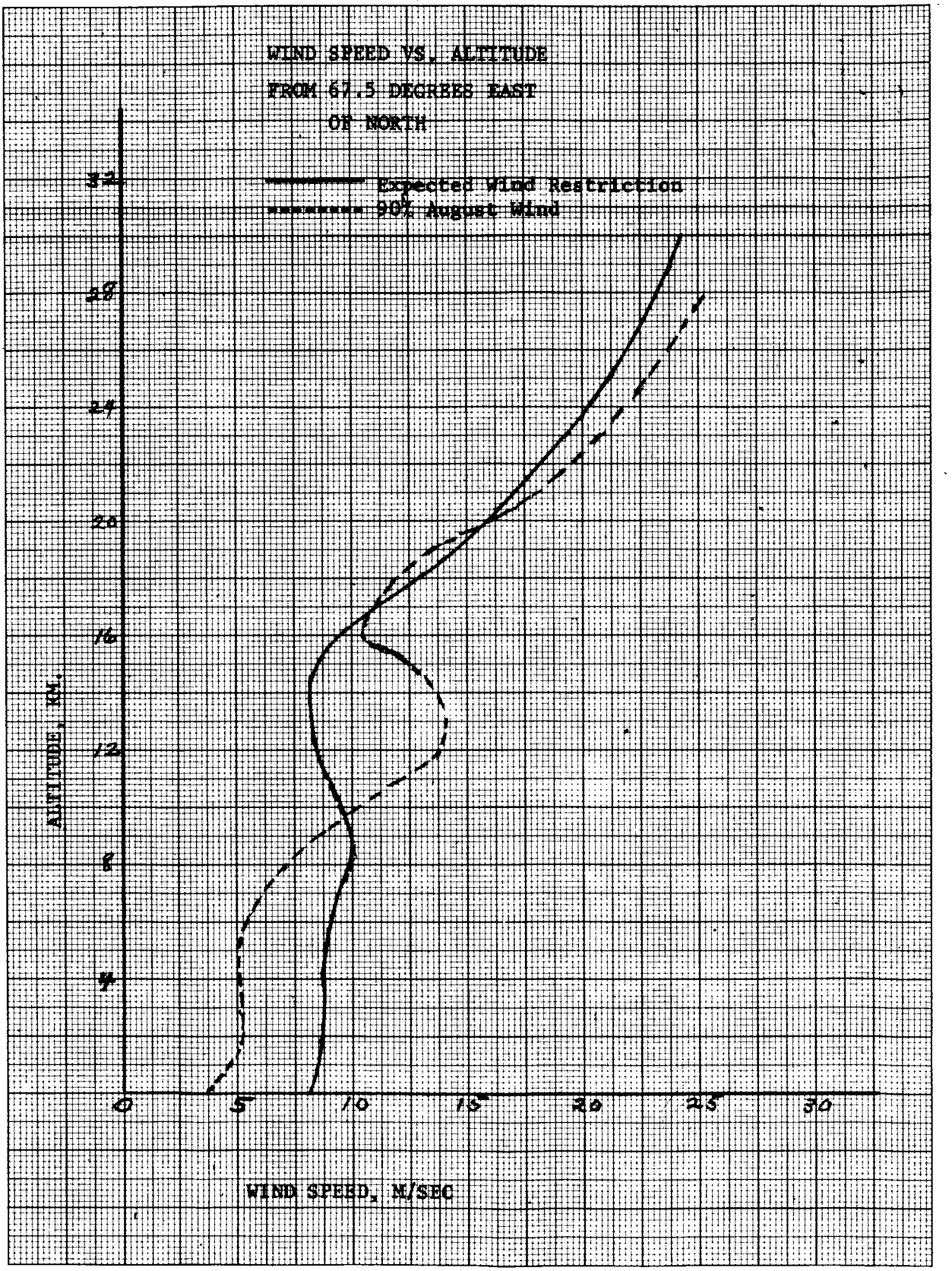
The probability of injuring a person, subdivided by Nation:

Nation	P_I	N/L_A (Per Sq. Mi.)	P_{IP}
Angola	7.6×10^{-4}	25	3.4×10^{-6}
Rhodesia & Nyasaland	4.1×10^{-4}	12	8.8×10^{-7}
Bechuanaland	2.6×10^{-5}	1	4.7×10^{-9}
Mozambique	8.1×10^{-5}	25	3.6×10^{-7}
Madagascar	5.3×10^{-5}	21	2.0×10^{-7}

PAD AREA STUDY

To avoid any impact of maximum distance pieces due to destruct, on critical areas, the wind profile in Figure III-1 should not be exceeded.

FIGURE III-1


WIND SPEED VS. ALTITUDE
FROM 67.5 DEGREES EAST
OF NORTH
Expected Wind Restriction
90% August Wind
32
28
24
20
16
12
8
4
0
5
10
15
20
25
30
ALTITUDE, KM.
WIND SPEED, M/SEC

PART IV
TRACKING

Data pertinent to the expected ground coverage of the SA-10 vehicle for primary tracking and telemetry stations are presented. Tracking coverage during the powered flight phase will be provided by C-band radar, ODOP Uprange, GLOTRAC, MISTRAM and close-in optical systems. For orbital flight C-band radars will provide coverage for about five revolutions after which MINITRACK will be the sole tracking source.

Powered Flight

A map defining the vehicle ground trace during powered flight and the coverage redundancy for primary ground sites is shown in Figure IV-1. As seen in the map, the entire powered flight is visible through the period of the Pegasus wing deployment to at least one ground station with a minimum of three station coverage to the time of shroud separation.

A detailed assessment of the visibility of the vehicle to each ground station scheduled to receive telemetry data and track the onboard electronic systems is presented in Figures IV-2 through IV-9. Elevation angle and slant range histories are shown from liftoff through Pegasus wing deployment or loss by the last C-band radar at Antigua. The Antigua station views the final deployment phase at a minimum elevation angle of 7 deg and a maximum slant range of 2000 km.

Elevation and slant range histories for the Green Mountain station at Huntsville,Alabama, are given in Figure IV-10. The maximum elevation angle reached for Green Mountain is 9.5 deg with an elevation of approximately 1 deg at S-IV cutoff.

The Fort Myers MINITRACK station will also provide coverage during powered flight. Slant range, elevation angle and azimuth angle histories are given in Figure IV-11. Fort Myers views S-IV cutoff at an elevation of 5 deg, an azimuth of 89 deg East-of-North and a slant range of 2110 km.

Orbital Flight

Primary tracking immediately following S-IV cutoff and insertion into orbit is provided by C-band radar stations. A summary of this coverage is given in Table IV-I.

TABLE IV-I Post Insertion Ground Coverage

Station	Elevation at S-IV Cutoff	Time Above Zero Deg Elevation
MILA	7 deg	105 sec
Patrick	7	105
Grand Bahama	11	150
Grand Turk	23	245
Bermuda	29	310
Antigua	25	410

The locus of ground projections during the initial five orbital revolutions, with the ground network and visibility areas for C-band radar and MINITRACK superimposed, are shown in Figures IV-12 and IV-13, respectively.

Close approach range and maximum elevation angles for each of the first five revolutions are tabulated in Table IV-II for those stations having maximum elevation angles of at least 10 deg.

TABLE IV-II Orbital Ground Coverage

	Rev 1		Rev 2		Rev 3		Rev 4		Rev 5	
	ϵ*	R*	ϵ	R	ϵ	R	ϵ	R	ϵ	R
RADAR	deg	km	deg	km	deg	km	deg	km	deg	km
MILA	44	739	13	1574						
Patrick	45	725	14	1558						
Antigua	83	537	15	1457						
Bermuda	13	1607								
Ascension	19	1301	66	573	14	1532				
Carnarvon	68	561	18	1338						
Hawaii	75	550	39	803	31	950	53	654	42	761
White Sands	50	685	27	1044						
Pretoria	33	887	81	533	54	635	84	528	31	923
MINITRACK										
Ft. Myers	63	597	18	1343						
Quito			19	1310	66	574	11	1681		
Lima					24	1105	53	646		
Santiago							12	1638		
Johannesburg	32	904	82	532	54	639	81	531	33	895
Woomera										
Goldstone	33	902	25	1103						

* ϵ Maximum Elevation Angle
* R Close Approach Range

The Green Mountain station will view the first orbital pass 99 minutes after liftoff at zero deg elevation, an azimuth of 263 deg East-of-North and a slant range of 2671 km. Time above zero deg elevation will be 11 minutes. The close apprach range will be 1180 km at a maximum elevation of 22 deg.

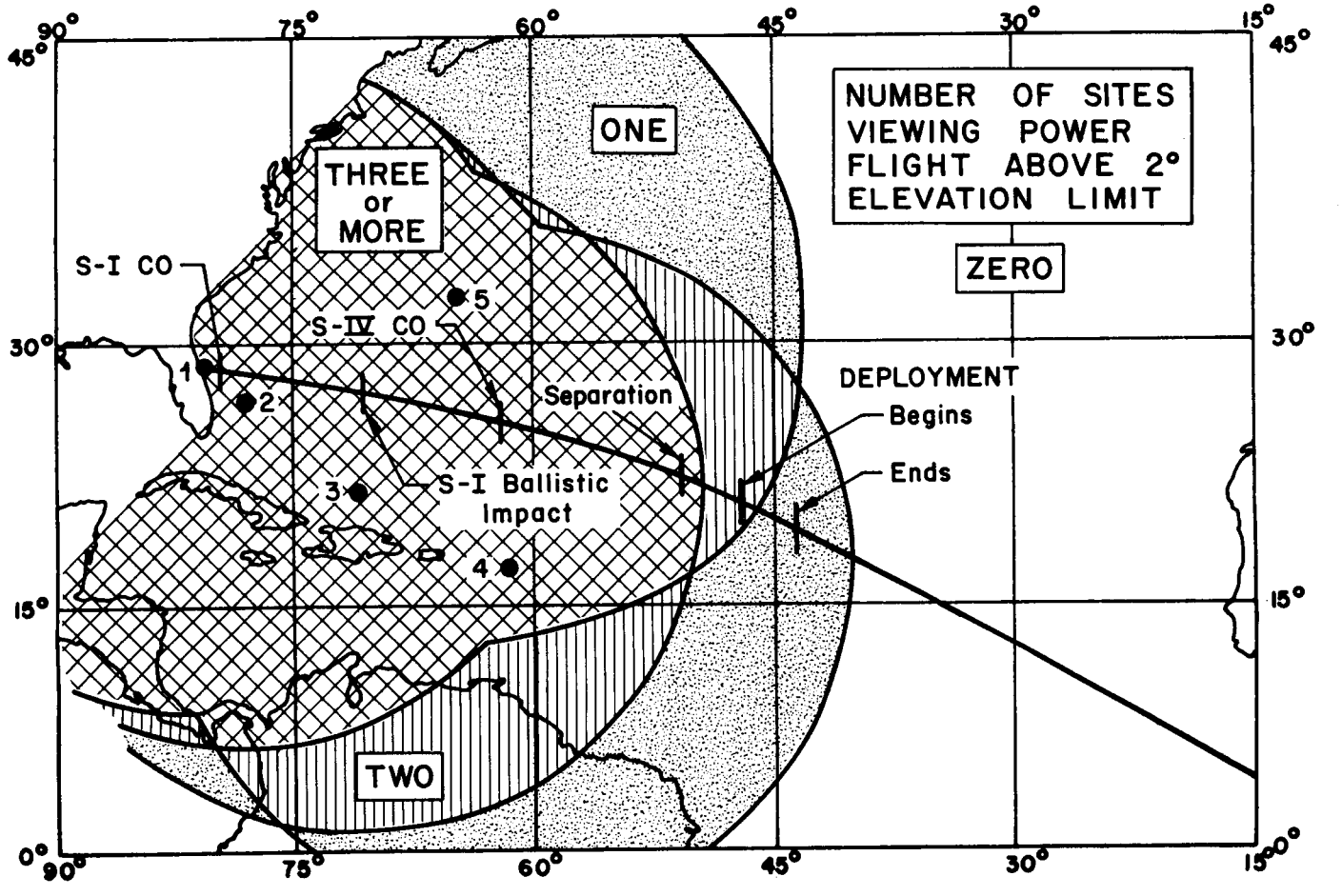


FIG. IV-1. POWERED FLIGHT VISIBILITY

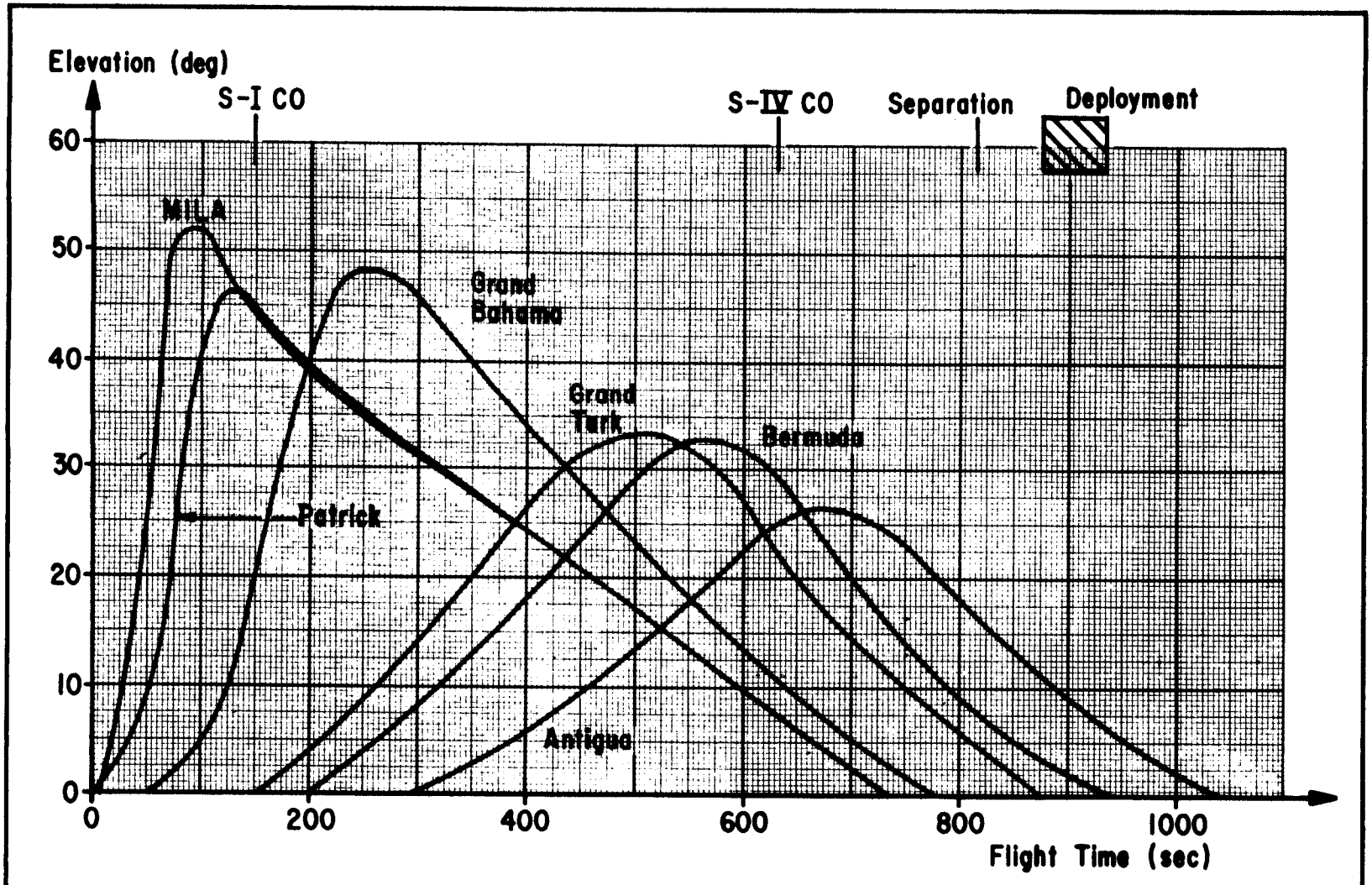


FIG. IV-2. RADAR ELEVATION HISTORIES

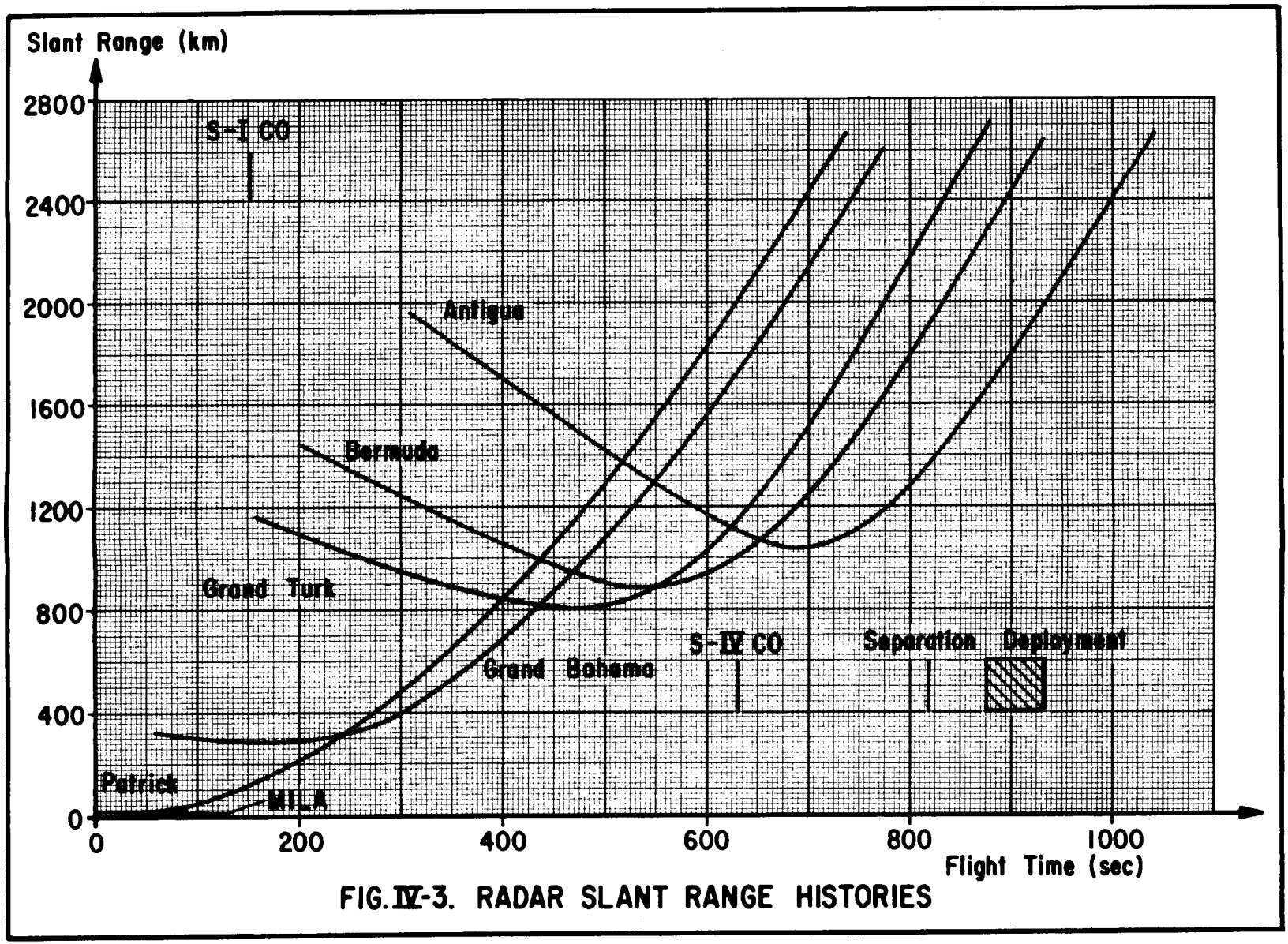


FIG. IV-3. RADAR SLANT RANGE HISTORIES

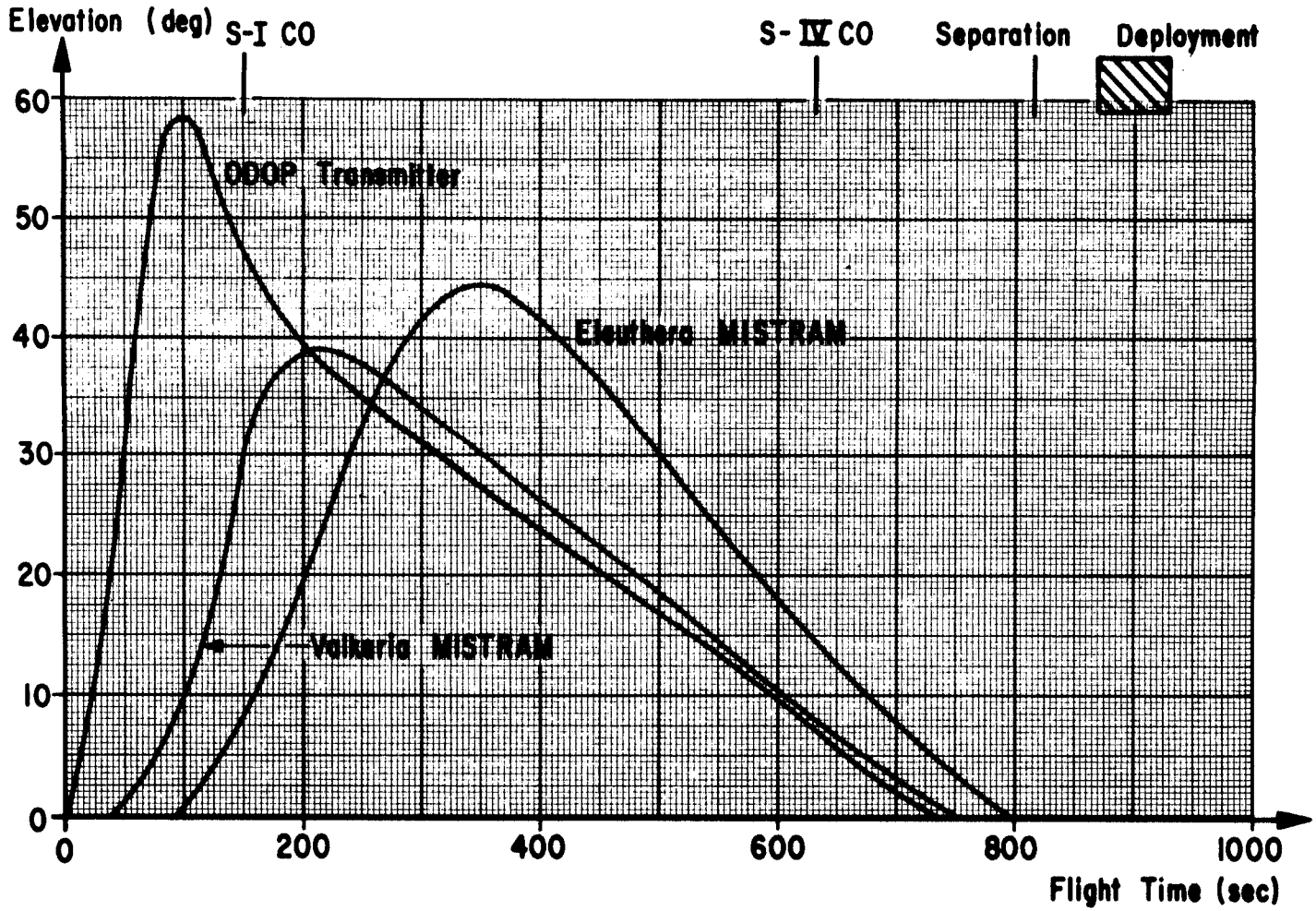


FIG. IV-4. MISTRAM - ODOP ELEVATION HISTORIES

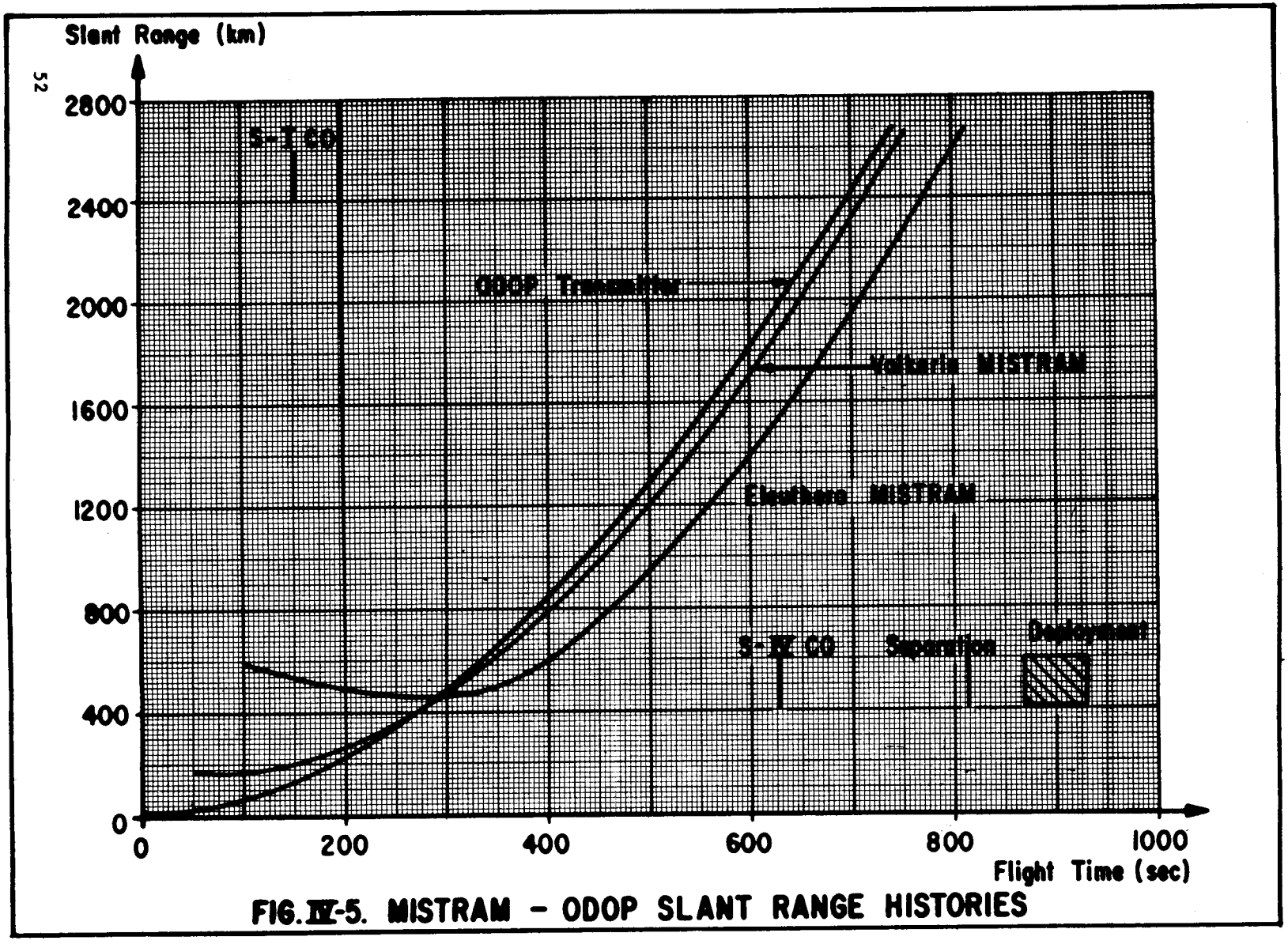


FIG. IV-5. MISTRAM - ODOP SLANT RANGE HISTORIES

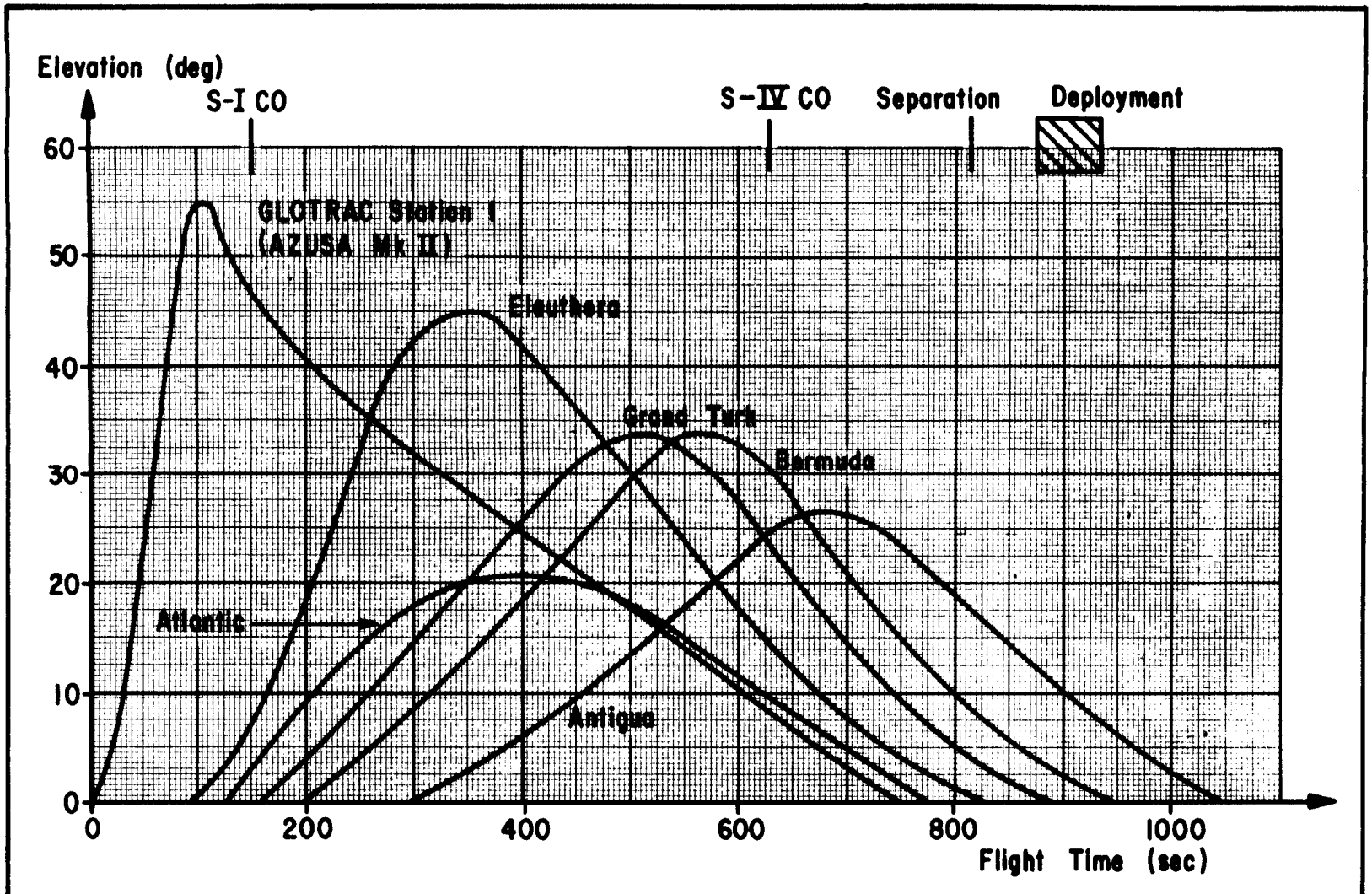


FIG. IV-6. GLOTRAC ELEVATION HISTORIES

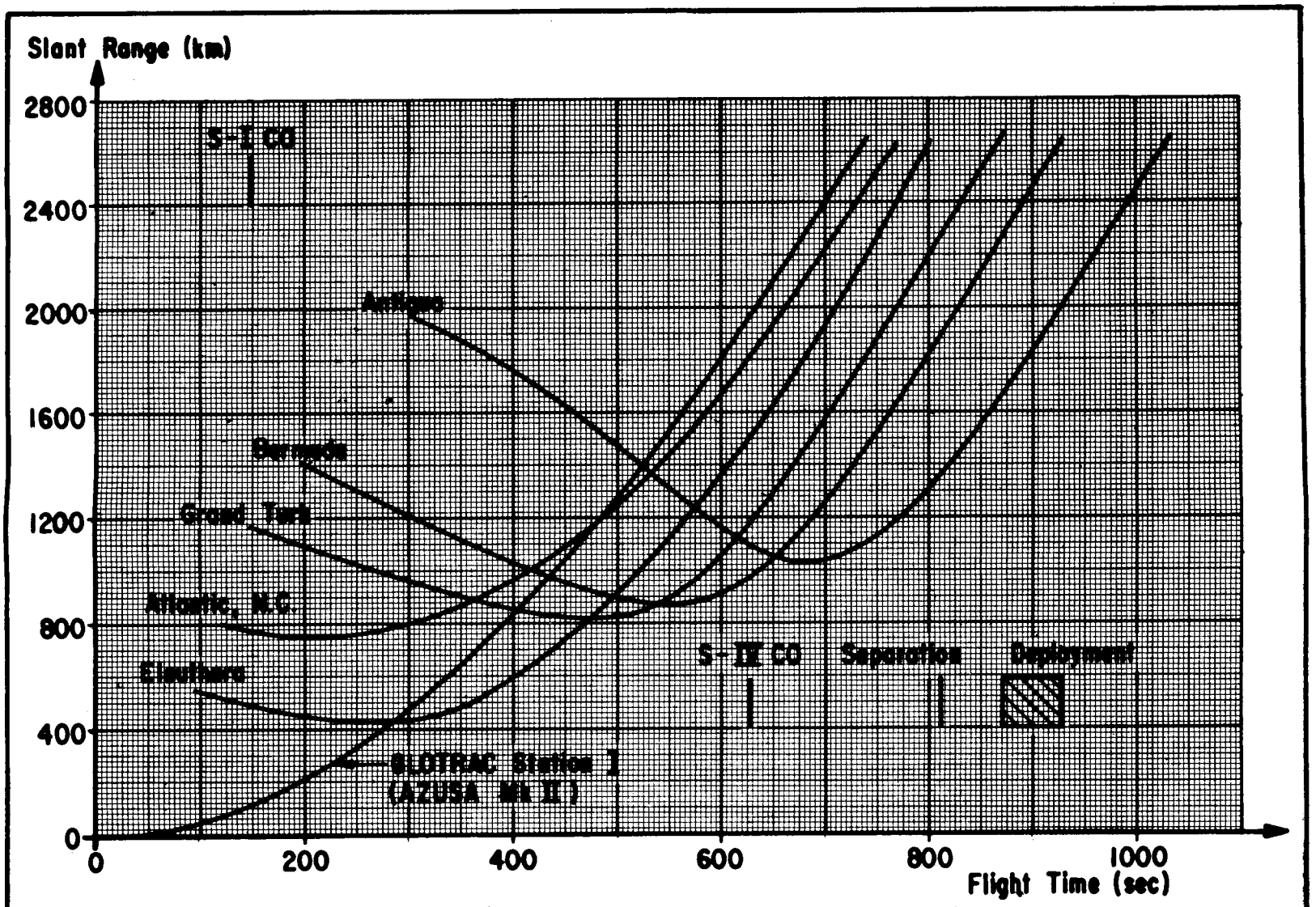


FIG. IV-7 GLOTRAC SLANT RANGE HISTORIES

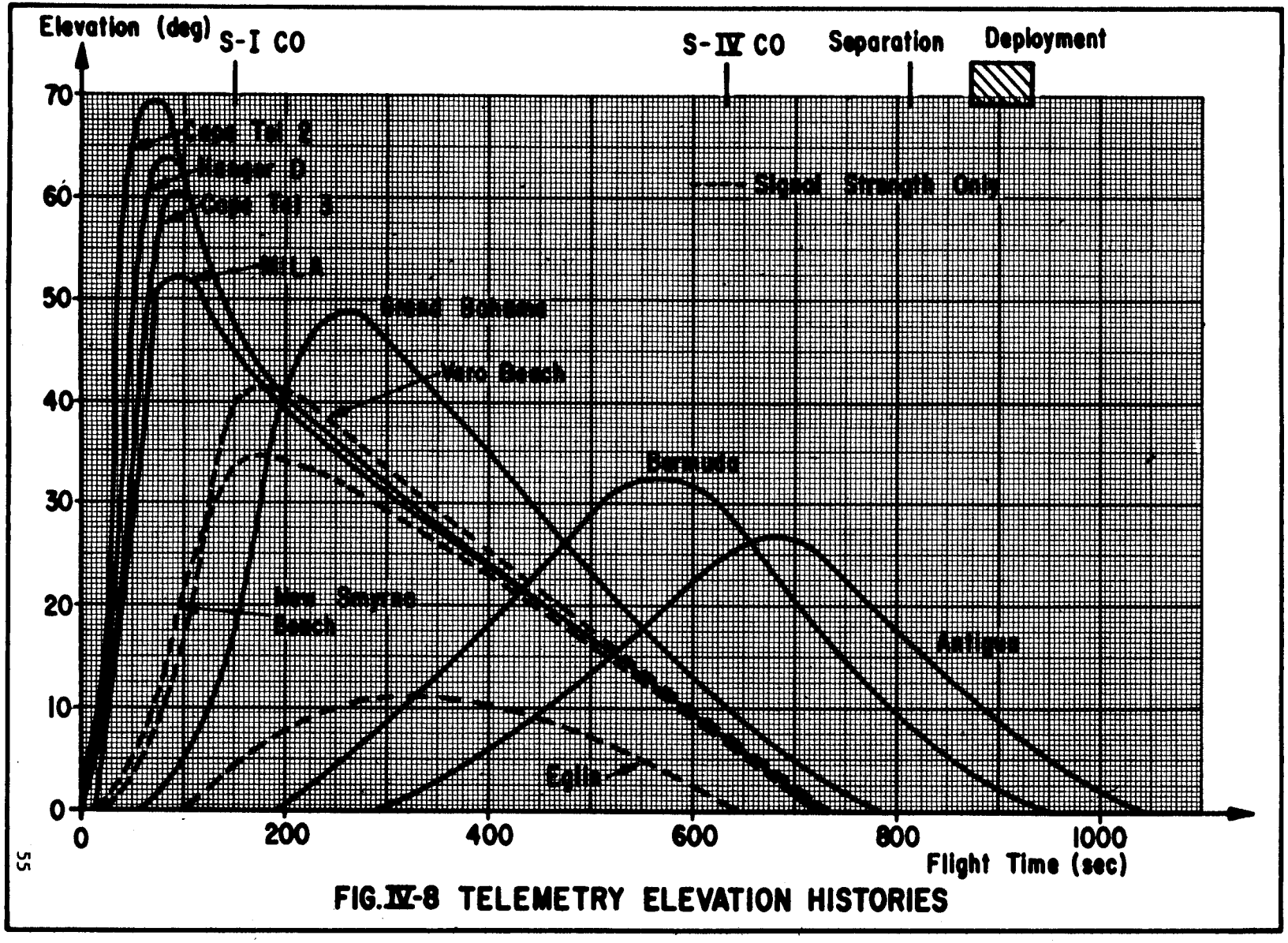


FIG. IV-8 TELEMETRY ELEVATION HISTORIES

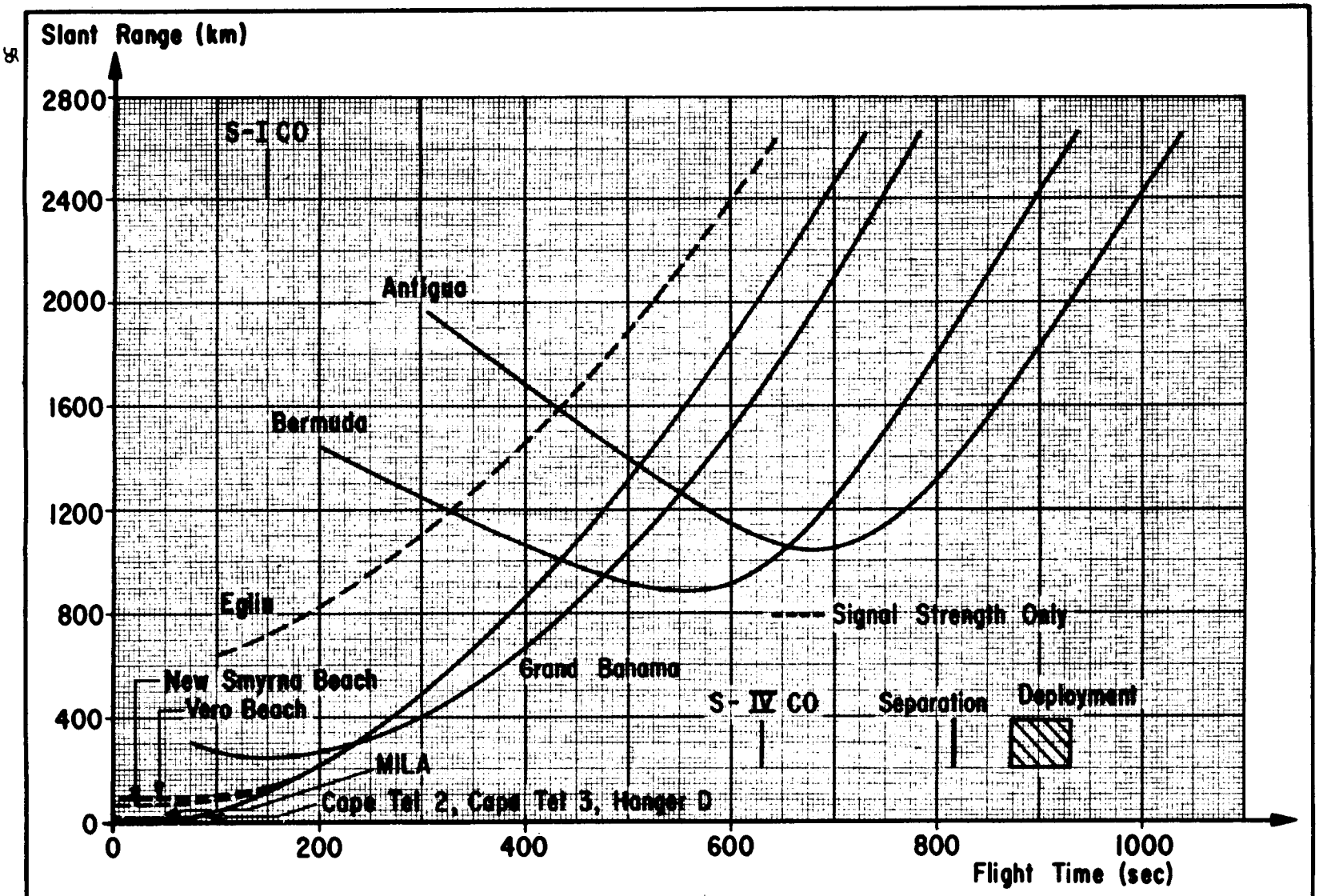
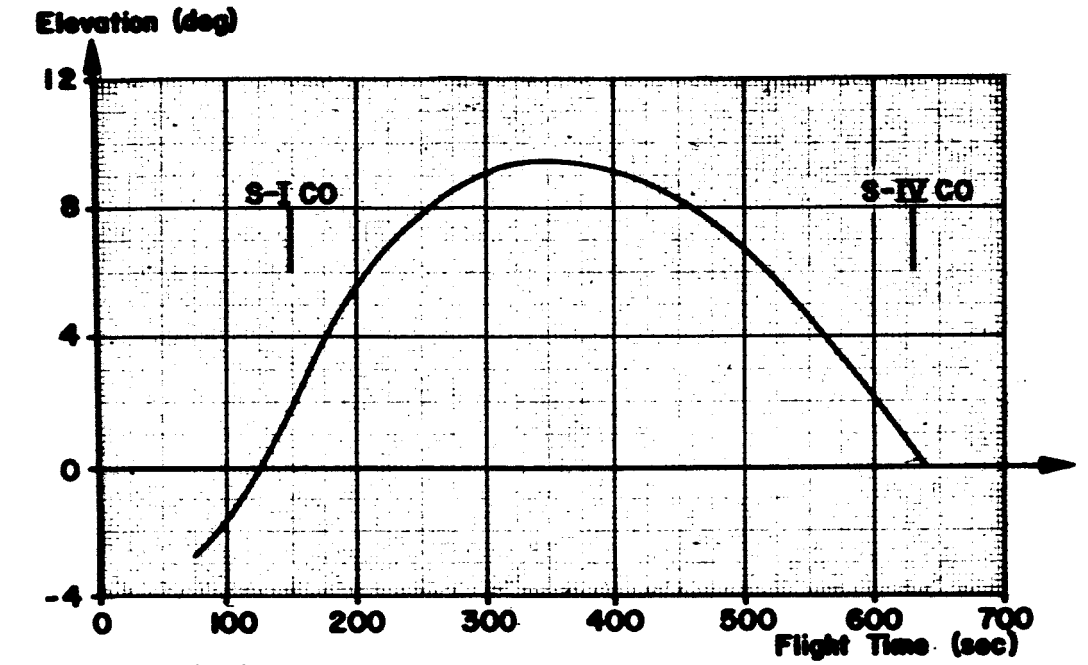


FIG. IV-9. TELEMETRY SLANT RANGE HISTORIES



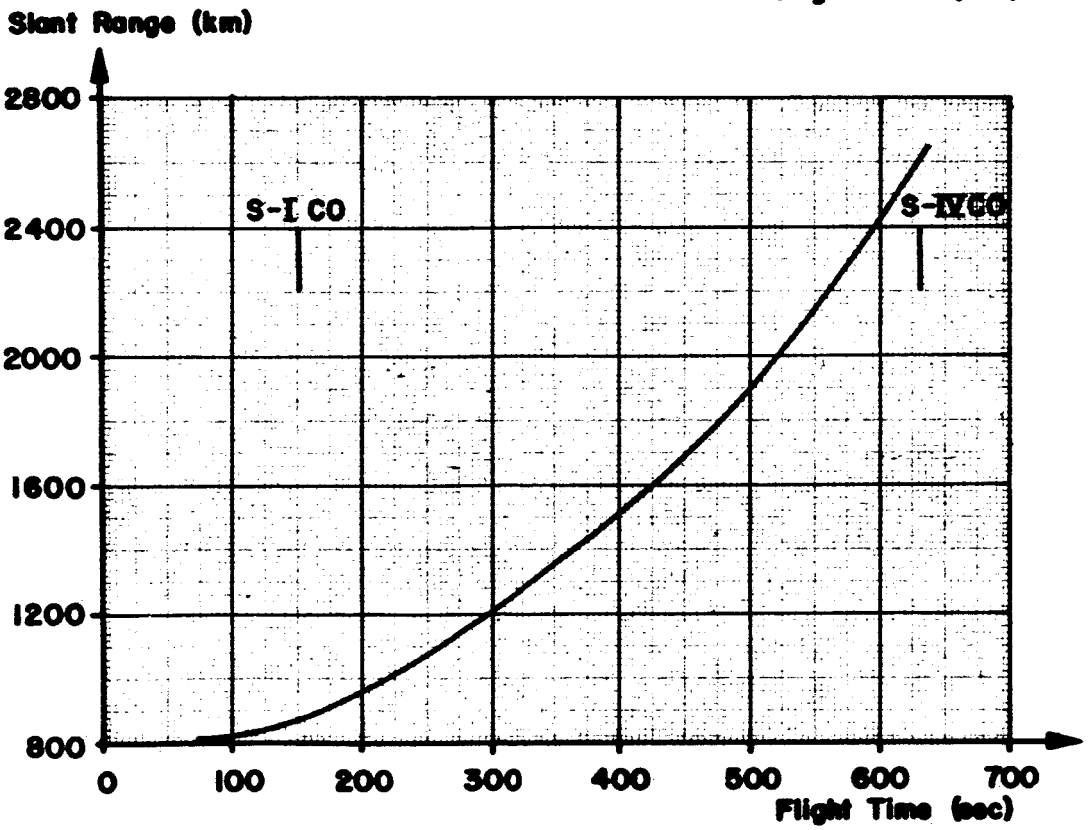
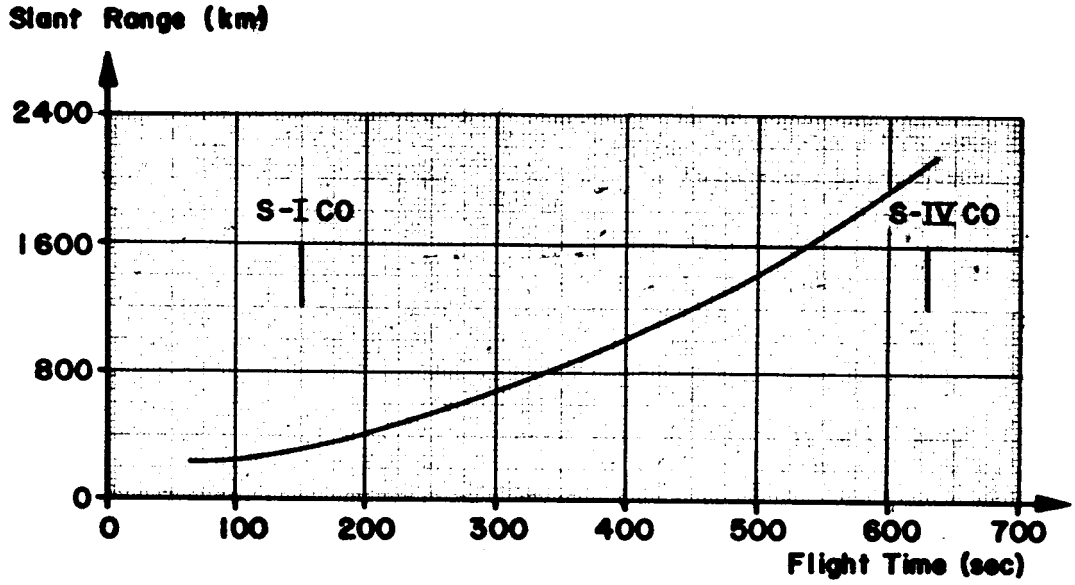


FIG. IV-10. GREEN MOUNTAIN COVERAGE HISTORIES



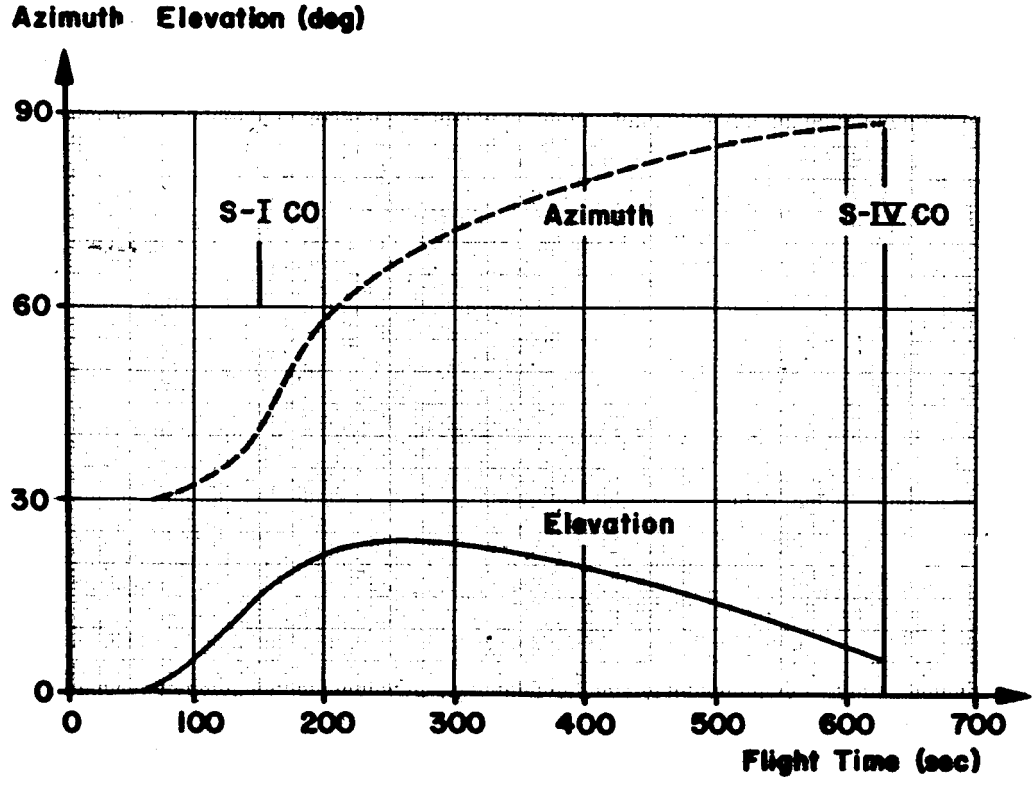


FIG. IV-11. FORT MYERS COVERAGE HISTORIES

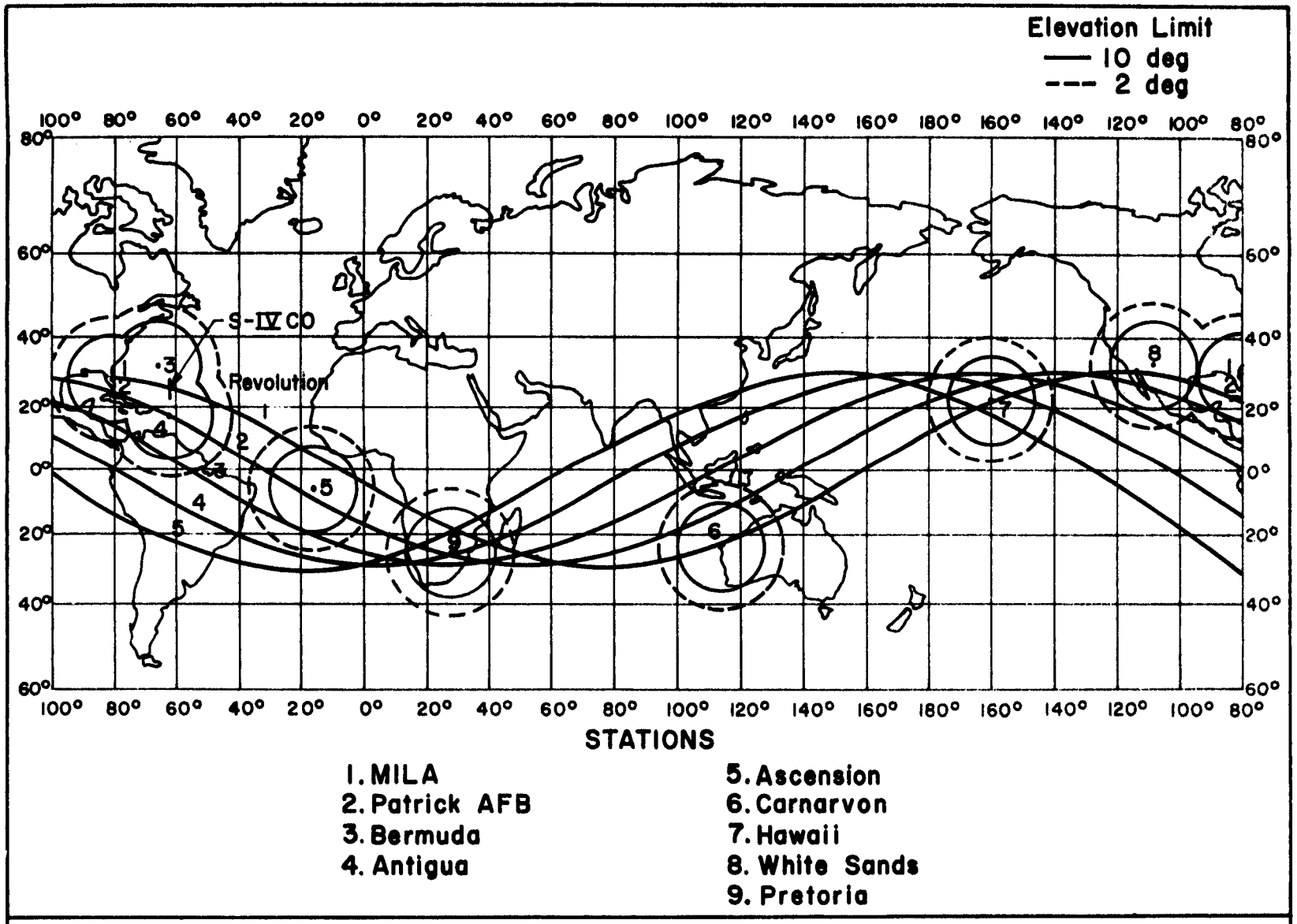


FIG. IV-12. RADAR ORBITAL VISIBILITY

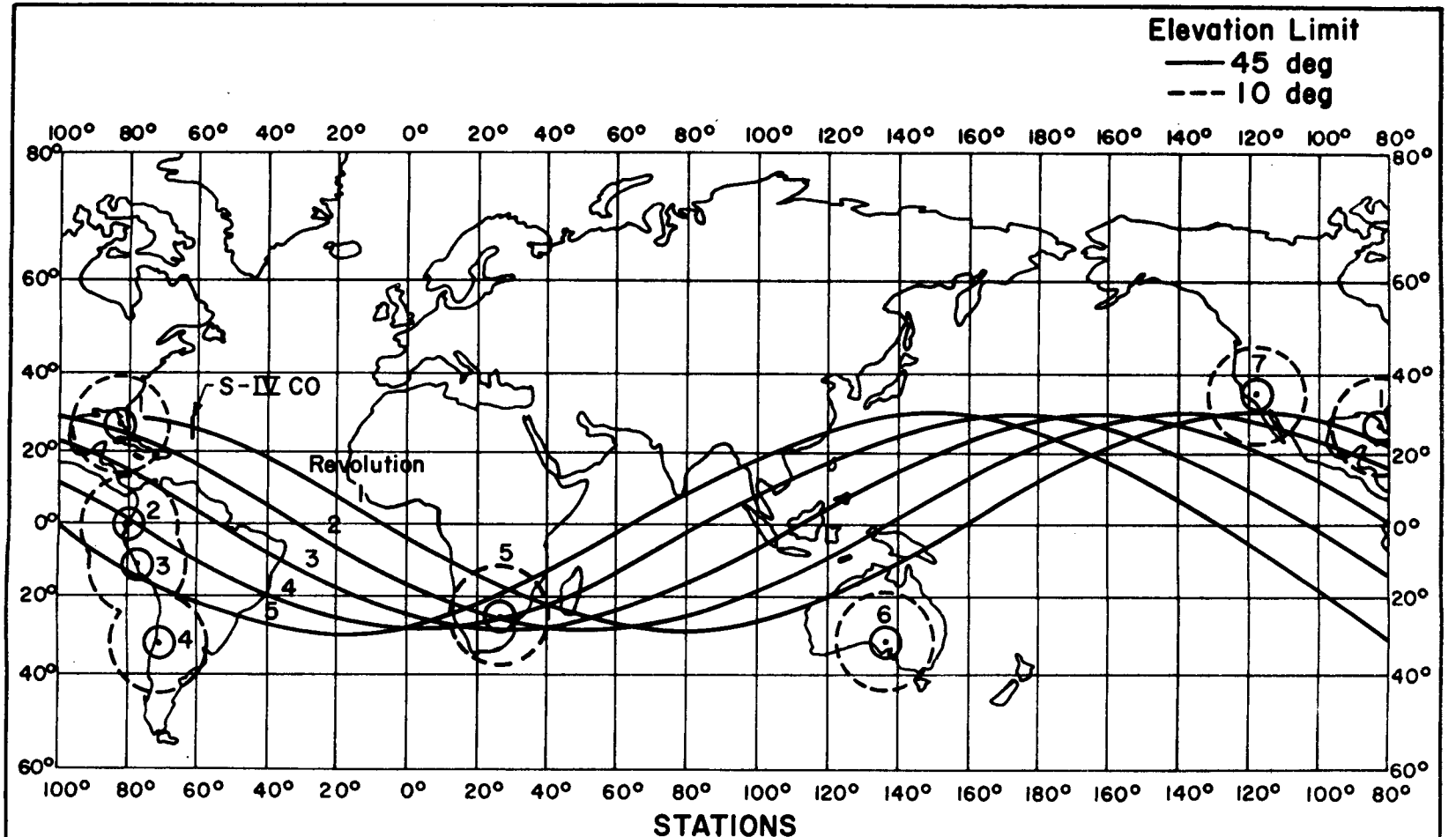


FIG. IV-13. MINITRACK ORBITAL VISIBILITY

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SA-10 FLIGHT MECHANICAL SUMMARY

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

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