NASA CONTRACTOR REPORT

NASA CR-61238

June 30, 1968

NASA CR-61238

SUPER LOKI DART METEOROLOGICAL ROCKET SYSTEM

Prepared under Contract No. NAS 8-20797 by
Bruce Bollermann and Robert L. Walker

SPACE DATA CORPORATION

For

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER
Huntsville, Alabama

June 30, 1968 NASA CR-61238

SUPER LOKI DART METEOROLOGICAL ROCKET SYSTEM (Final Report)

By

Bruce Bollermann and Robert L. Walker

Prepared under Contract No. NAS 8-20797 by

SPACE DATA CORPORATION
Phoenix, Arizona

For

Aero-Astrodynamics Laboratory

NASA-GEORG C. MARSHALL SPACE FLIGHT CENTER

FOREWORD

This document presents the results of work performed by the Space Data Corporation, Phoenix, Arizona, in support of the Aerospace Environment Division, Aero-Astrodynamics Laboratory, Marshall Space Flight Center, Huntsville, Alabama, under contract NAS8-20797.

Appreciation is given to Mr. Robert Turner of the above laboratory for his support of this program and to the personnel of the White Sands Missile Range for their cooperation in the initial flight testing of the Super Loki Dart.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1. INTRODUCTION

The Super Loki Dart Meteorological rocket system has been developed for NASA - Marshall Space Flight Center to obtain high-altitude (85 km) wind data with a low cost rocket vehicle and a radar-reflective chaff payload. The Super Loki Dart consists of a scale-up of the older Loki Dart system which has been in use for many years to gather wind data to altitudes up to 65 km. The Super Loki Dart two-stage vehicle consists of a high-impulse solid-propellant rocket motor as the first stage, and a non-propulsive dart which contains the chaff payload as the second stage.

Altitudes as high as 125 km have been obtained with this vehicle system during the development flight tests at White Sands Missile Range. Altitudes to 113 km are expected for flights from sea level launch sites. A helical-rail launcher has been developed to impart spin or roll to the vehicle prior to release in order to minimize impact dispersion and associated range safety problems.

The basic Super Loki rocket motor can be used to propel larger diameter instrumented dart systems to altitudes on the order of 85 km to upgrade the atmospheric temperature profile measurements currently being conducted by the standard-size Loki.

2. DEVELOPMENT PROGRAM

The Super Loki Dart vehicle has been designed as a low cost replacement for the Cajun Dart for high altitude wind measurements. The goal of the Super Loki system was to achieve an altitude of at least 95 km at less than one-half the cost of the Cajun Dart. A further goal was versatility of the Super Loki rocket motor so that it could be used to propel darts of various sizes containing various kinds of meteorological payloads.

Design efforts were initiated during July 1967, and the first static firing of the rocket motor was conducted during November. Three additional static firings were conducted through January 1968 to verify the initial results and obtain a reliability history. All static firings were completely successful and the results were repeatable.

A series of five development flight tests were conducted at the White Sands Missile Range during the months of April and May 1968. The three units which were radar tracked over apogee achieved altitudes of about 125 km. Late radar aquisition of the descending chaff cloud from a fourth unit permitted an estimate of apogee altitude slightly over 125 km. A fifth unit was not tracked bv radar, and no estimate of performance could be made. The White Sands performance data indicated that the vehicle should be able to achieve altitudes of about 113 km from sea level launch sites. Therefore, the design was frozen, and the remaining twenty units in the contract were sent to Cape Kennedy for operational use. Complete range safety and performance documentation was supplied to conclude the current program.

3. VEHICLE DESCRIPTION

3.1 General.

The Super Loki Dart as shown in Figure 3.1 is a two-stage sounding vehicle consisting of a solid-propellant Super Loki rocket motor as the first stage and a non-propulsive dart containing the payload as the second stage. A dimensional sketch of the vehicle is shown in Figure 3.2. This vehicle is essentially a scaled-up version of the standard Loki Dart vehicle as indicated in Figure 3.3.

3.2 Rocket Motor.

The Super Loki rocket motor consists of an aluminum case with an internal burning cast-in-the-case solid propellant. Major design characteristics of the rocket motor are presented in Table 3.1. An aluminum interstage coupling structure is located at the head end of the rocket motor. The propellant fuel is a polysulfide polymer and the oxidizer is ammonium perchlorate. A photograph of the rocket motor is shown in Figure 3.4. The igniter consists of two parallel 1 watt/ 1 ampere no-fire squibs and an appropriate ignition charge. The igniter is separable from the motor and is installed at the launch site. A cross-section view of the Super Loki rocket motor with the igniter installed is shown in Figure 3.5.

3.3 Dart.

The high altitude chaff dart as shown in Figure 3.6 for the Super Loki system consists of a steel cylindrical body with a steel ogive and an aluminum tail piece. The cylindrical body contains the chaff payload which is packaged into split steel staves. The ogive is retained at the forward end of body with shear-screws which are sheared during payload expulsion out from the forward end of the dart. The tail piece contains an electrically-actuated 145-second pyrotechnic time delay and a small payload ejection charge. Four steel fins are roll-pinned into the dart tail for flight stability. The aft end of the dart tail is boattailed to reduce aerodynamic drag and to be used to mate the dart to the booster. A cross-section view of the chaff dart is shown in Figure 3.7. Major chaff dart characteristics are presented in Table 3.2.

SUPER LOKI VEHICLE CONFIGURATION

FIGURE 3.1

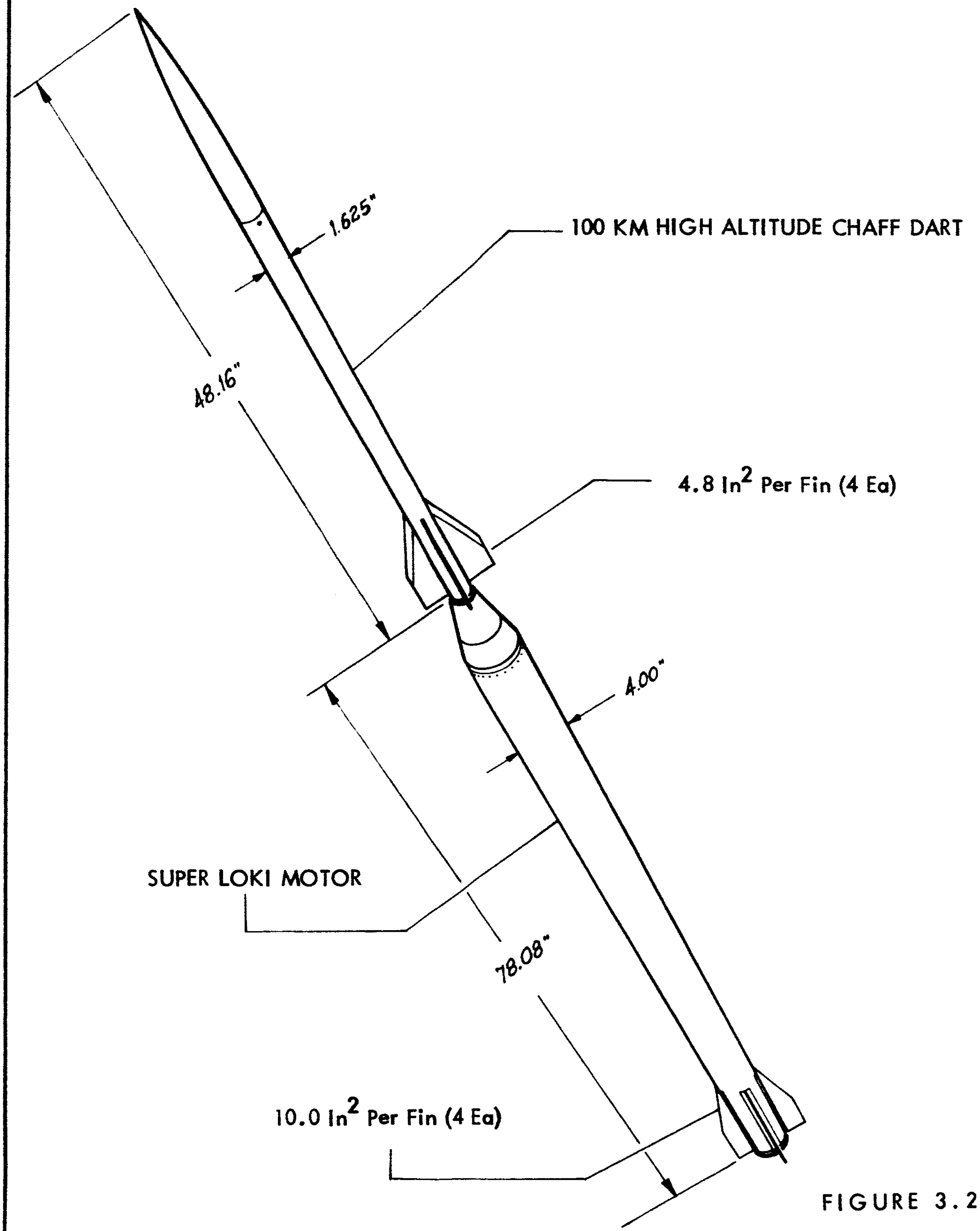
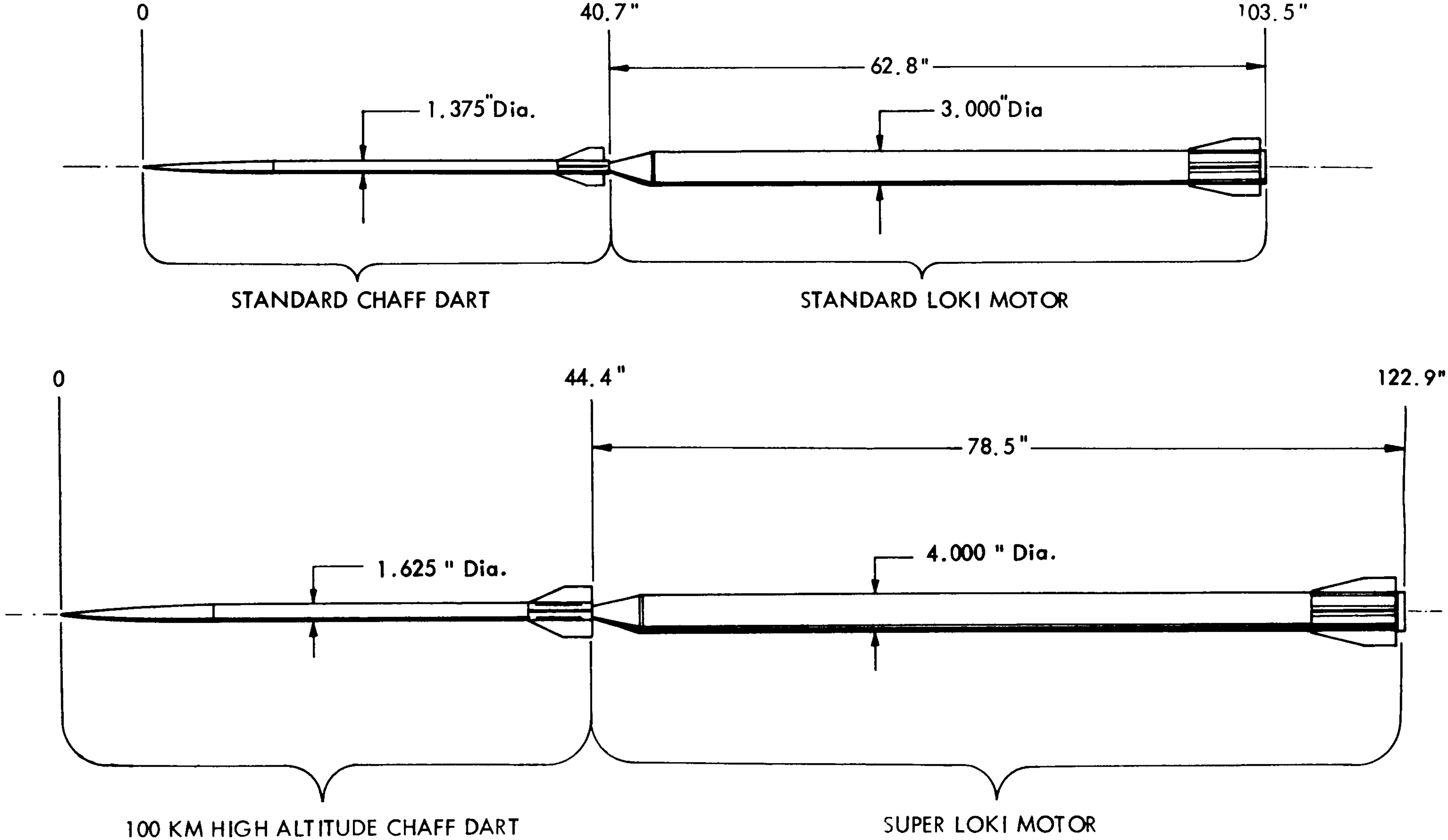


FIGURE 3.2

HIGH ALTITUDE SUPER LOKI CHAFF DART VEHICLE CONFIGURATION



HIGH-ALTITUDE SUPER LOKI CHAFF DART (100 KM) VEHICLE CONFIGURATION COMPARED WITH STANDARD LOKI-DART VEHICLE

FIGURE 3.3

A-1362

TABLE 3.1

SUPER LOKI ROCKET MOTOR DESIGN CHARACTERISTICS SUMMARY

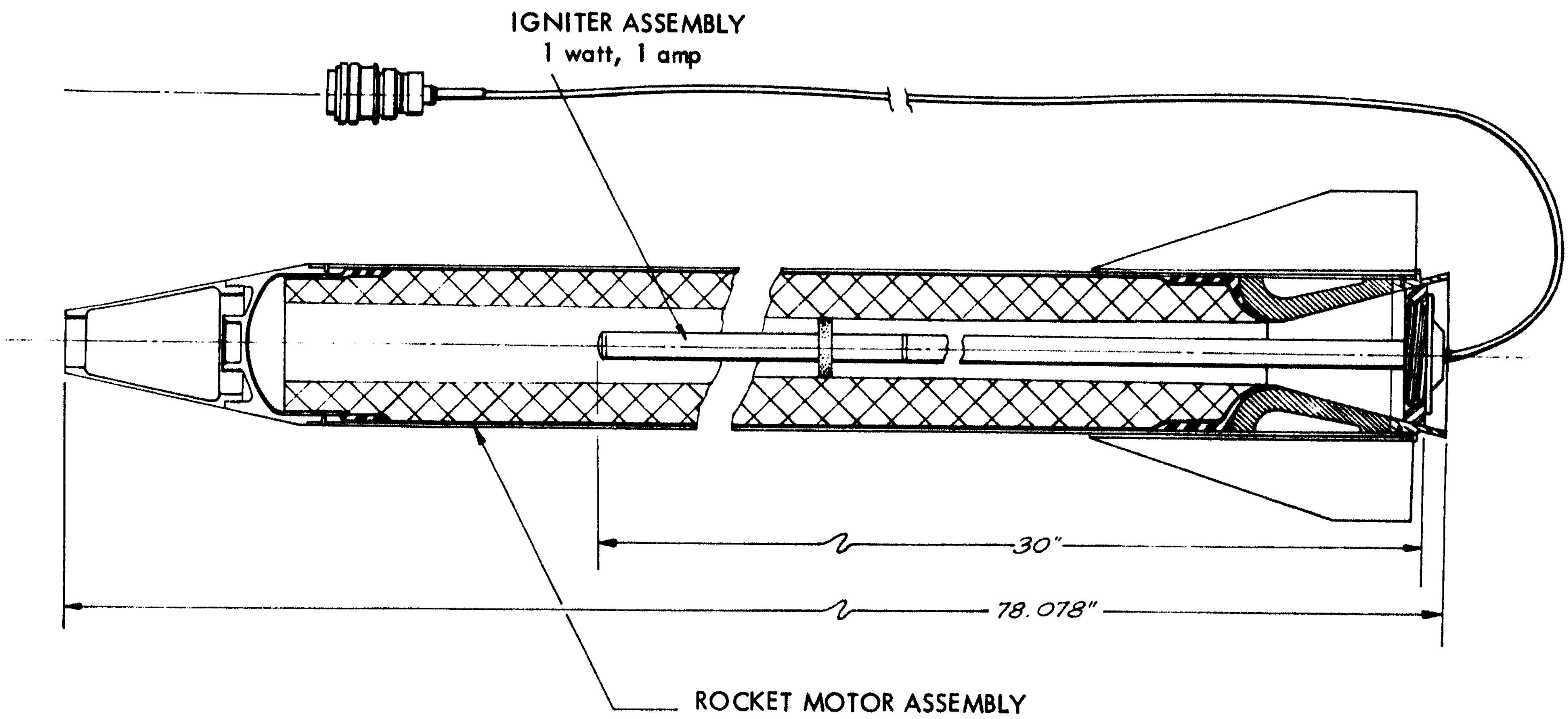
Length (inches)	78
Diameter (inches)	4
Weights:	
Inert Motor With Interstage (kg)	5.26 (11.6 lb)
Propellant (kg)	16.87 (37.2 lb)
Total (kg)	22.14 (48.8 lb)
Motor Mass Fraction	0.76
Burning Time (seconds)	2.0
Chamber Pressure:	
Maximum (Atmospheres)	100.02 (1470 PSIg)
Average (Atmospheres)	83.69 (1230 PSIg)
Thrust at Sea Level:	
Maximum (kg)	2608.20 (5750 lb)
Average (kg)	2018.52 (4450 lb)
Total Impulse at Sea Level (nt-sec)	3.96 (8900 lb-sec)
Specific Impulse at Sea Level	239

TABLE 3.2 SUPER LOKI CHAFF DART DESIGN CHARACTERISTICS

Length	122.33 cm (48.16 inches)
Diameter	4.13 cm (1.625 inches)
Weight	6.12 kg (13.5 pounds)
Payload Volume	491.61 cm^3 (30 $inches^3$)

SUPER LOKI ROCKET MOTOR

FIGURE 3.4

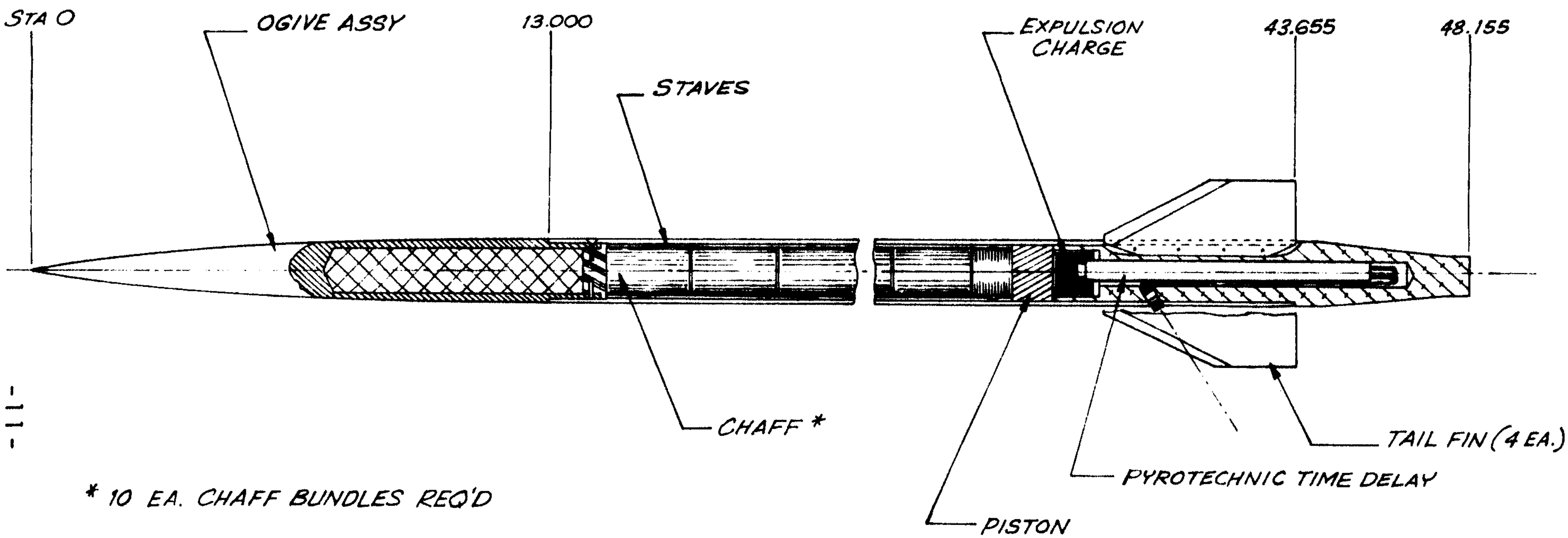


CROSS-SECTION VIEW OF SUPER LOKI ROCKET MOTOR
WITH IGNITER INSTALLED

FIGURE 3.5

SUPER LOKI CHAFF DART

FIGURE 3.6



CROSS SECTION VIEW OF SUPER LOKI CHAFF DART

FIGURE 3.7

The payload consists of 0.0127 mm (0.5 mil) "S"-band, aluminumized-mylar chaff.

3.4 Launcher Description.

The Super Loki Launcher consists of four helical rails which complete approximately one-third of a revolution throughout the launch rail length. The launch rail assembly as shown in Figure 3.8 consists of six cast aluminum sections which are bolted together to form a continuous 4.39 m (12 feet) long rail assembly. The four internal rails are equally spaced and form four continuous helices throughout the 4.39 meter (12 feet) length. The edges of the rails are stepped to support the vehicle by the dart fins and the rocket motor nozzle ring. The outside diameter of the launch rail assembly is 26.04 cm (10-1/4 inches).

The purpose of the launch rail is to impart an 8.5 rps spin to the vehicle by constraining the dart fins to a helical path during their travel along the launch rails. The aft end of the motor travels for 4.39 meter (12 feet) prior to its release from the launcher.

The Super Loki Launch Rail Assembly can be mounted to any suitable launcher base by means of forward and aft mounting brackets. A launcher base specifically designed for this rail as shown in Figure 3.9.

A pullaway umbilical harness is provided with the launch rail assembly to retract the dart firing line during first motion of the vehicle.

3.5 Vehicle Mass Properties.

The mass properties of the Super Loki Dart Vehicle are presented in Table 3.3. Vehicle center-of-gravity vs time is presented in Figure 3.10. Vehicle pitch moment of inertia vs time is presented in Figure 3.11.

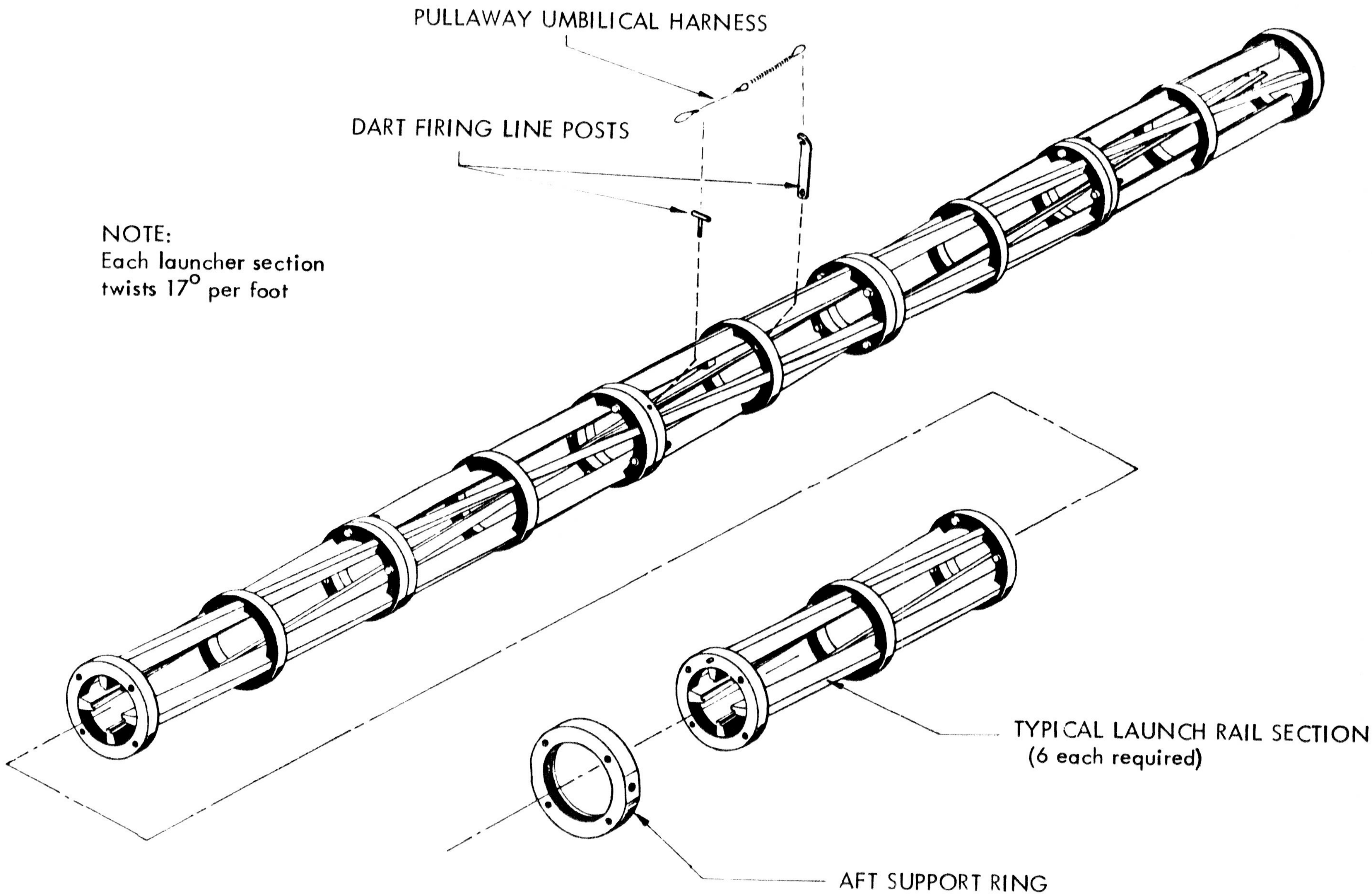


FIGURE 3.8 SUPER LOKI LAUNCH RAIL ASSEMBLY

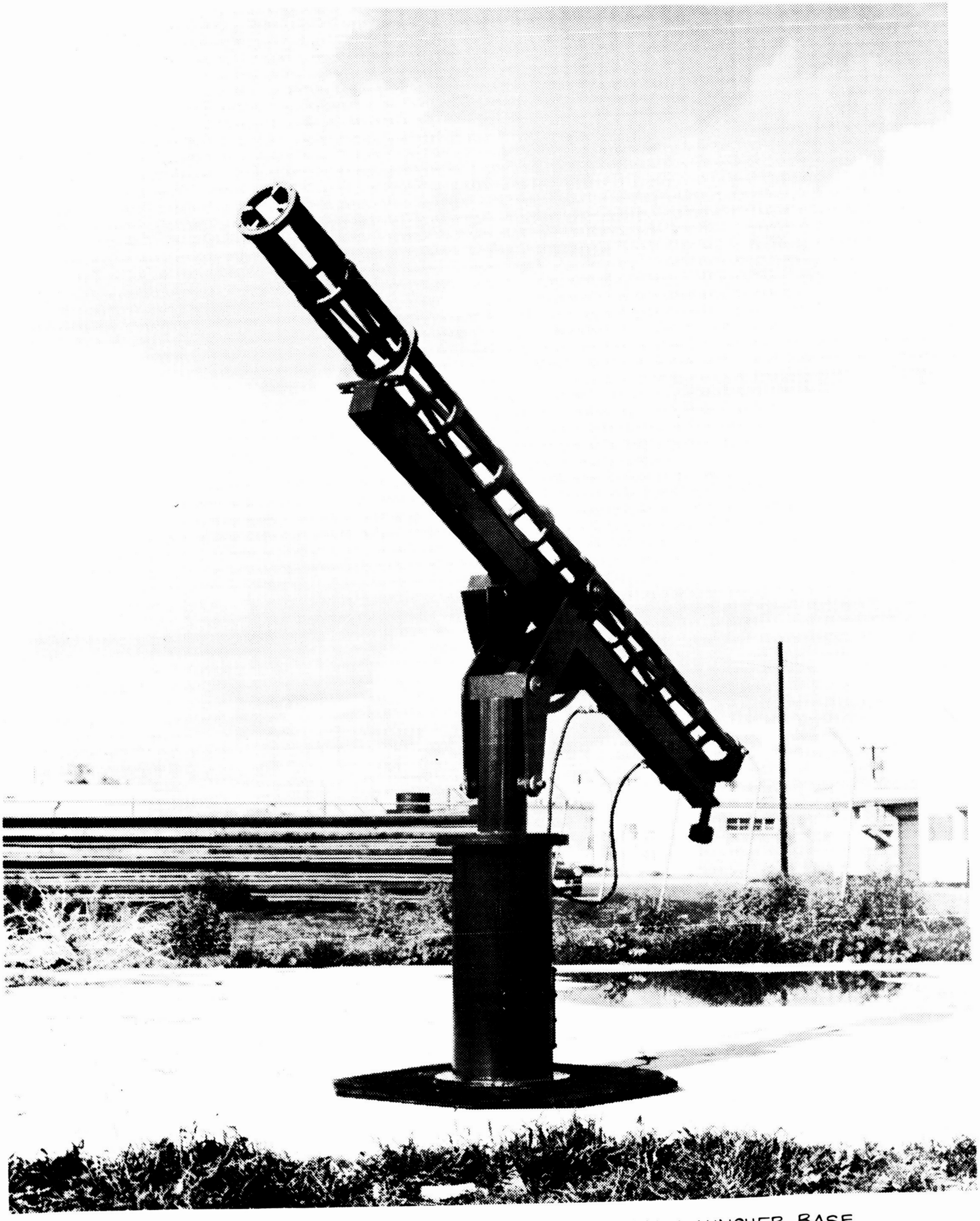


FIGURE 3.9 SUPER LOKI LAUNCH RAIL ON TYPICAL LAUNCHER BASE

TABLE 3.3

SUPER LOKI DART VEHICLE MASS PROPERTIES

Chaff Dart:	
Weight	6.12 kg (13.50 lb)
Center-of-Gravity	87.63 cm (34.5 inches) from aft end of dart
Pitch Moment of Inertia	0.610 $kg\text{-}m^2$ (0.450 $slug/ft^2$)
Booster:	
Loaded Weight	22.19 kg (48.93 lb)
Expended Weight	5.28 kg (11.63 lb)
Loaded Center-of-Gravity	85.6 cm (33.70 inches) from aft end of motor
Expended Center-of-Gravity	85.09 cm (33.50 inches) from aft end of motor
Load Pitch Moment of Inertia	7.28 $kg\text{-}m^2$ (5.37 $slug/ft^2$)
Expended Pitch Moment of Inertia	3.08 $kg\text{-}m^2$(2.27 $slug/ft^2$)
Vehicle:	
Launch Weight	28.32 kg (62.43 lb)
Burnout Weight	11.40 kg (25.13 lb)
Launch Center-of-Gravity	118.36 cm (46.6 inches) from aft end of motor
Burnout Center of Gravity	173.74 cm (68.4 inches) from aft end of motor
Launch Pitch Moment of Inertia	20.42 $kg\text{-}m^2$ (15.06 $slug/ft^2$)
Burnout Pitch Moment of Inertia	10.56 $kg\text{-}m^2$ (7.79 $slug/ft^2$)

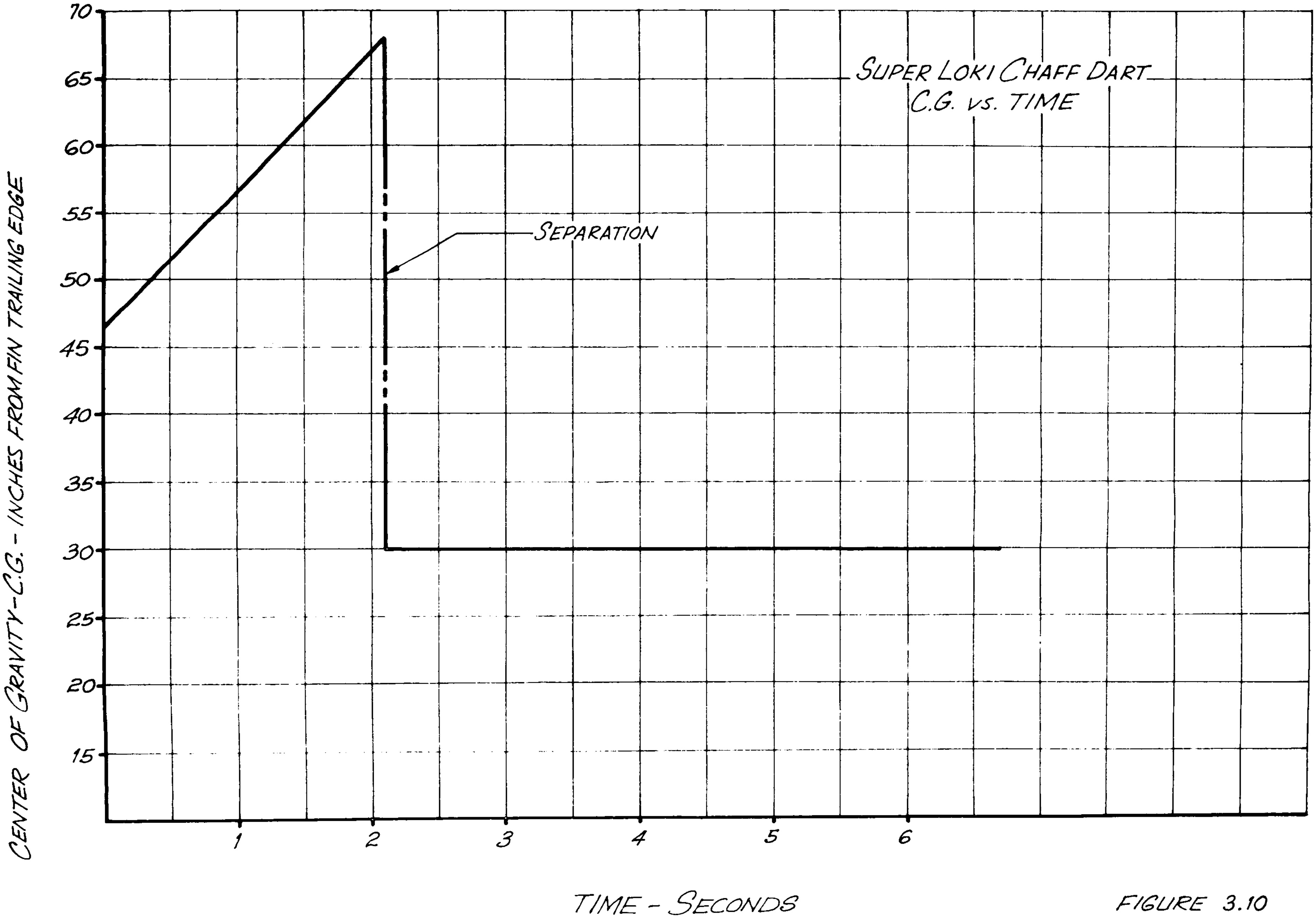

SUPER LOKI CHAFF DART
C.G. vs. TIME
SEPARATION
CENTER OF GRAVITY-C.G. - INCHES FROM FIN TRAILING EDGE
TIME - SECONDS
70
65
60
55
50
45
40
35
30
25
20
15
1
2
3
4
5
6

FIGURE 3.10

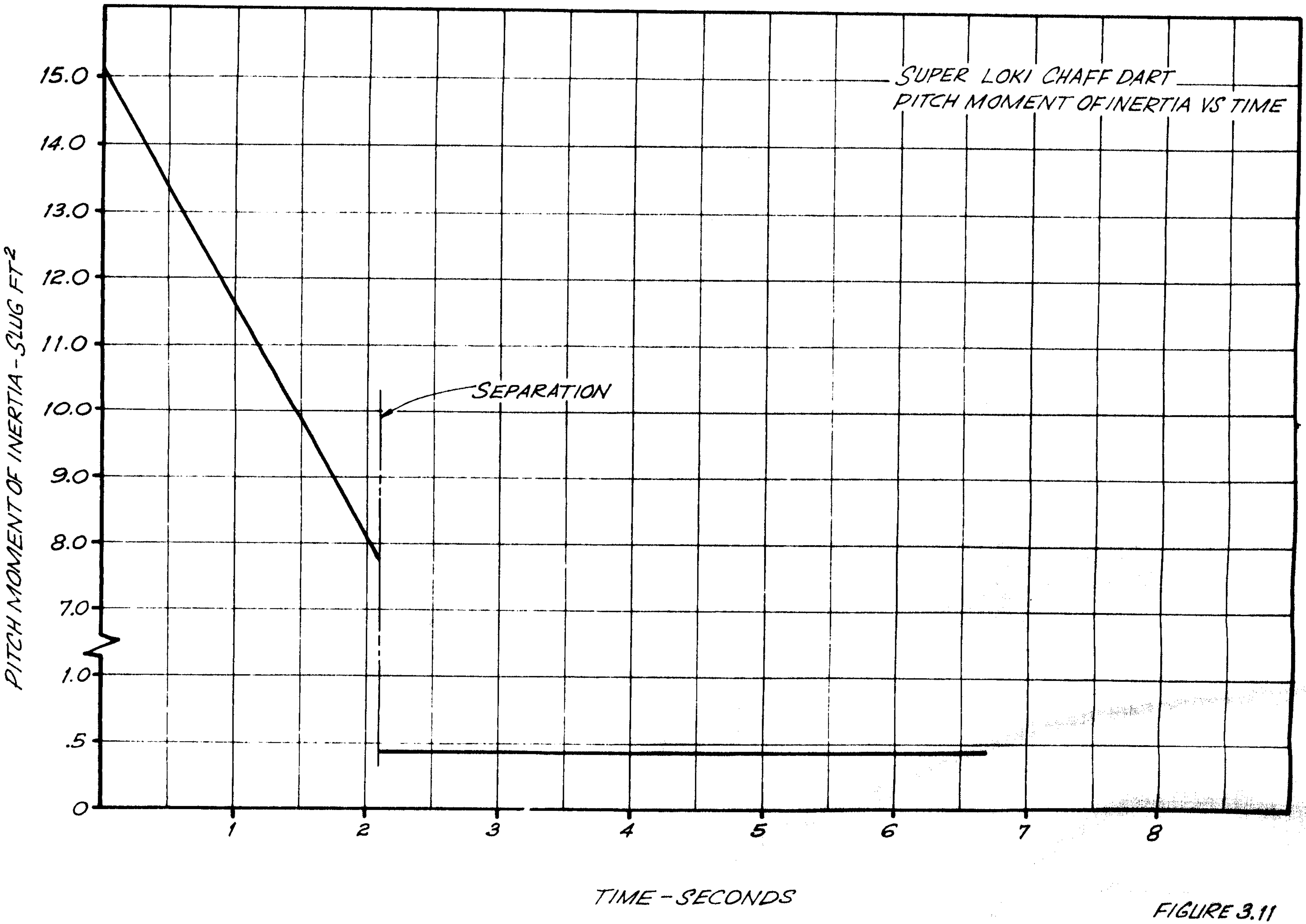

SUPER LOKI CHAFF DART
PITCH MOMENT OF INERTIA VS TIME
SEPARATION
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
1.0
.5
0
1
2
3
4
5
6
7
8
PITCH MOMENT OF INERTIA - SLUG FT²
TIME - SECONDS

FIGURE 3.11

4. AERODYNAMIC DATA

The aerodynamic data for the Super Loki Dart vehicle is presented as follows:

Figure 4.1 C_{N_α} vs Mach No., First Stage

Figure 4.2 C_{N_α} vs Mach No., Dart

Figure 4.3 C_p vs Mach No., First Stage

Figure 4.4 C_p vs Mach No., Dart

The Super Loki Dart is stable during two-stage propulsive flight at essentially a zero degree angle of attack. After dart separation at motor burnout, the dart coasts to apogee in a stable flight made at essentially a zero degree angle of attack in the sensible atmosphere. After rocket motor burnout and stage separation, the expended booster becomes unstable and tumbles. Eventually the booster descends in a flat spin to impact at a relatively slow rate of speed. The drag coefficients for the various stage configurations are presented in Table 4.1.

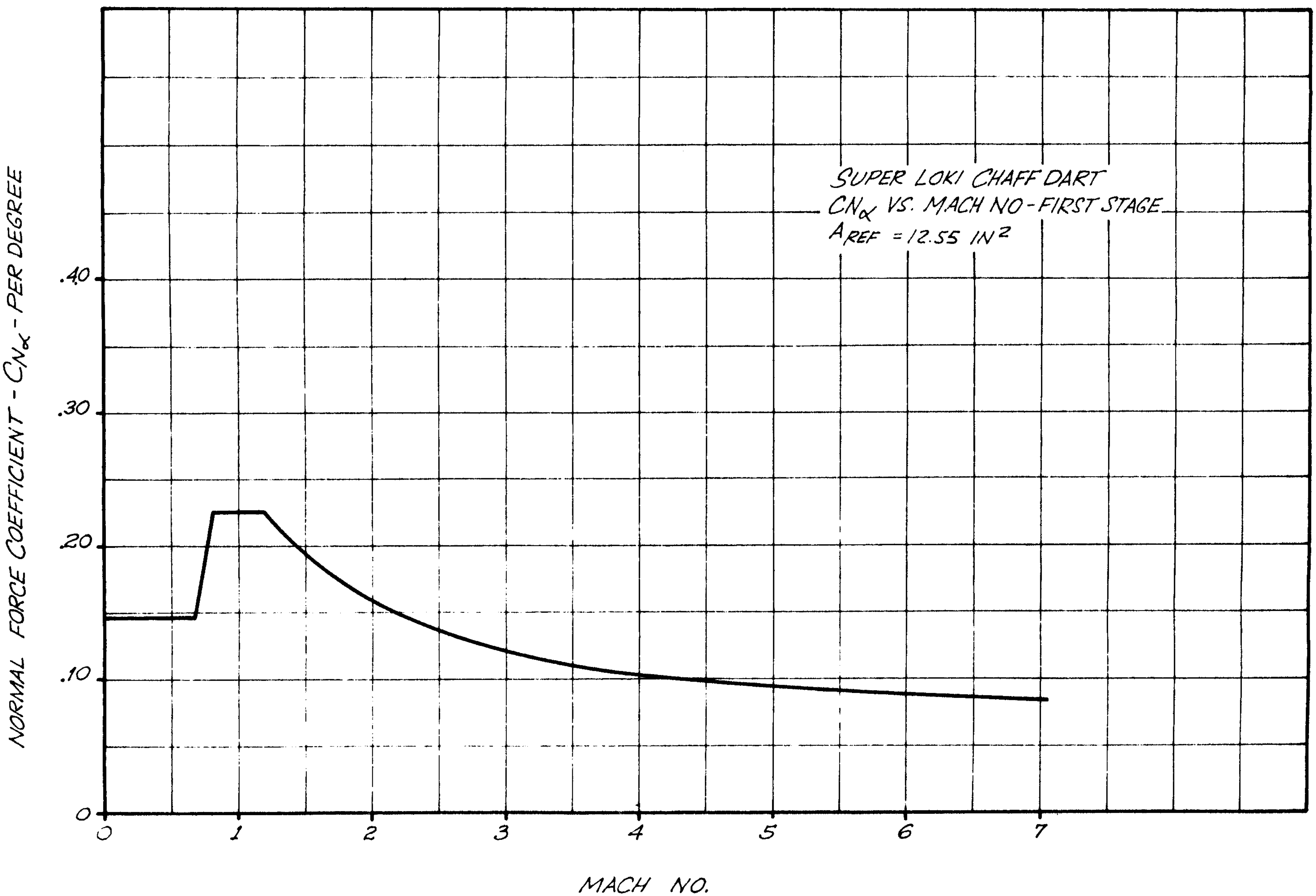

SUPER LOKI CHAFF DART
CN_{α} VS. MACH NO - FIRST STAGE
A_{REF} = 12.55 IN^2
NORMAL FORCE COEFFICIENT - CN_{α} - PER DEGREE
0
.10
.20
.30
.40
0
1
2
3
4
5
6
7
MACH NO.

FIGURE 4.1

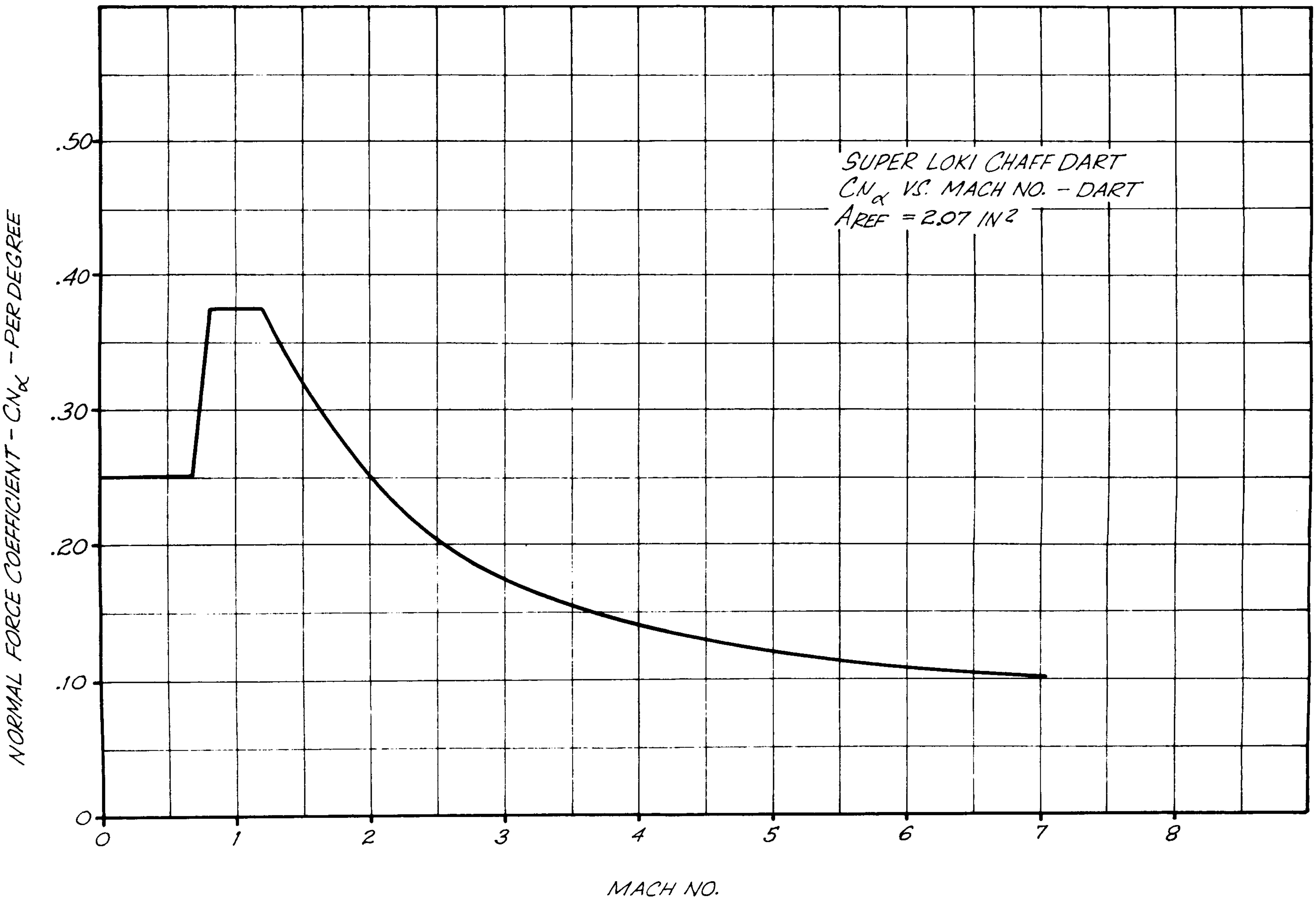

SUPER LOKI CHAFF DART
CNα VS. MACH NO. - DART
AREF = 2.07 IN2
NORMAL FORCE COEFFICIENT - CNα - PER DEGREE
.50
.40
.30
.20
.10
0
0
1
2
3
4
5
6
7
8
MACH NO.

FIGURE 4.2

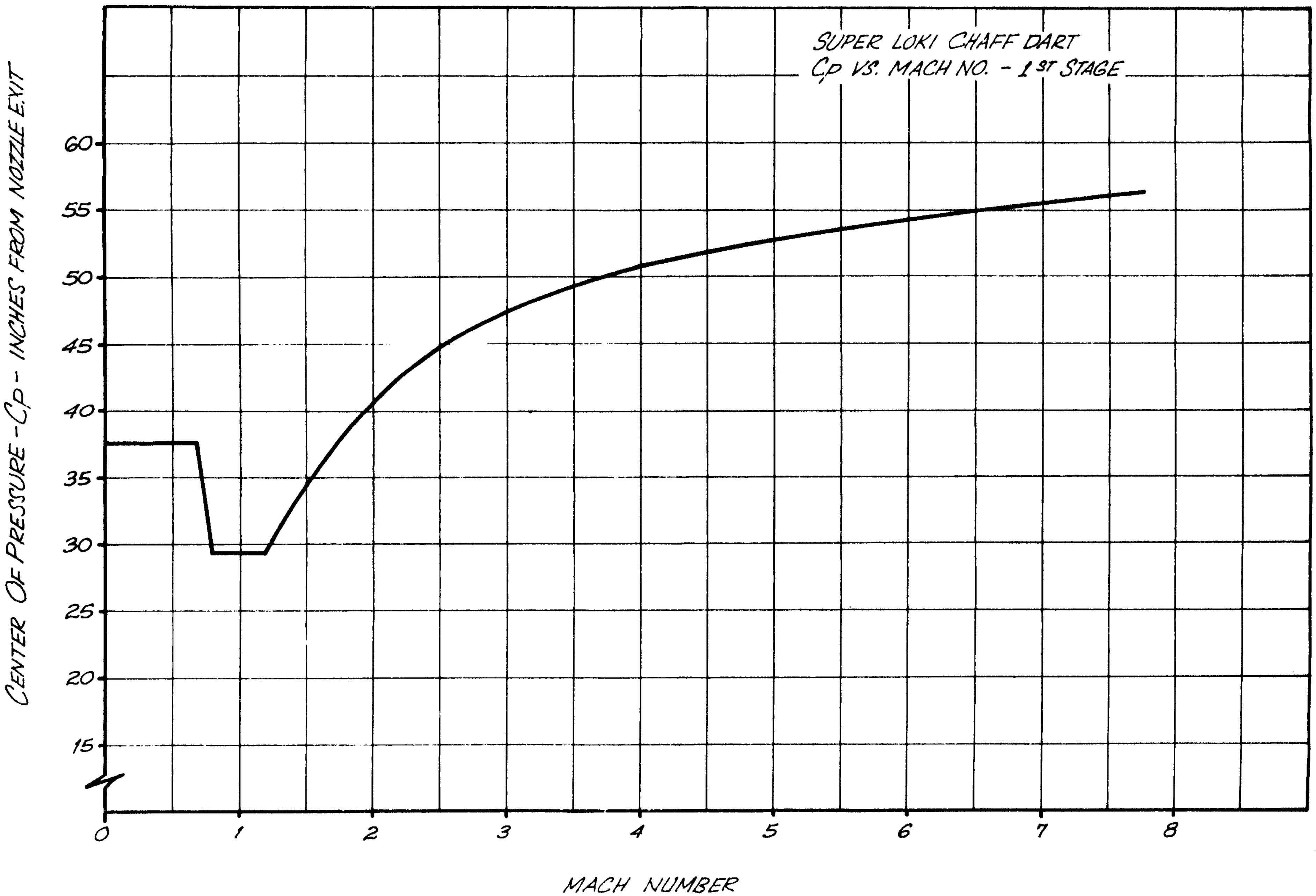

SUPER LOKI CHAFF DART
Cp VS. MACH NO. - 1ST STAGE
CENTER OF PRESSURE - Cp - INCHES FROM NOZZLE EXIT
60
55
50
45
40
35
30
25
20
15
0
1
2
3
4
5
6
7
8
MACH NUMBER

FIGURE 4.3

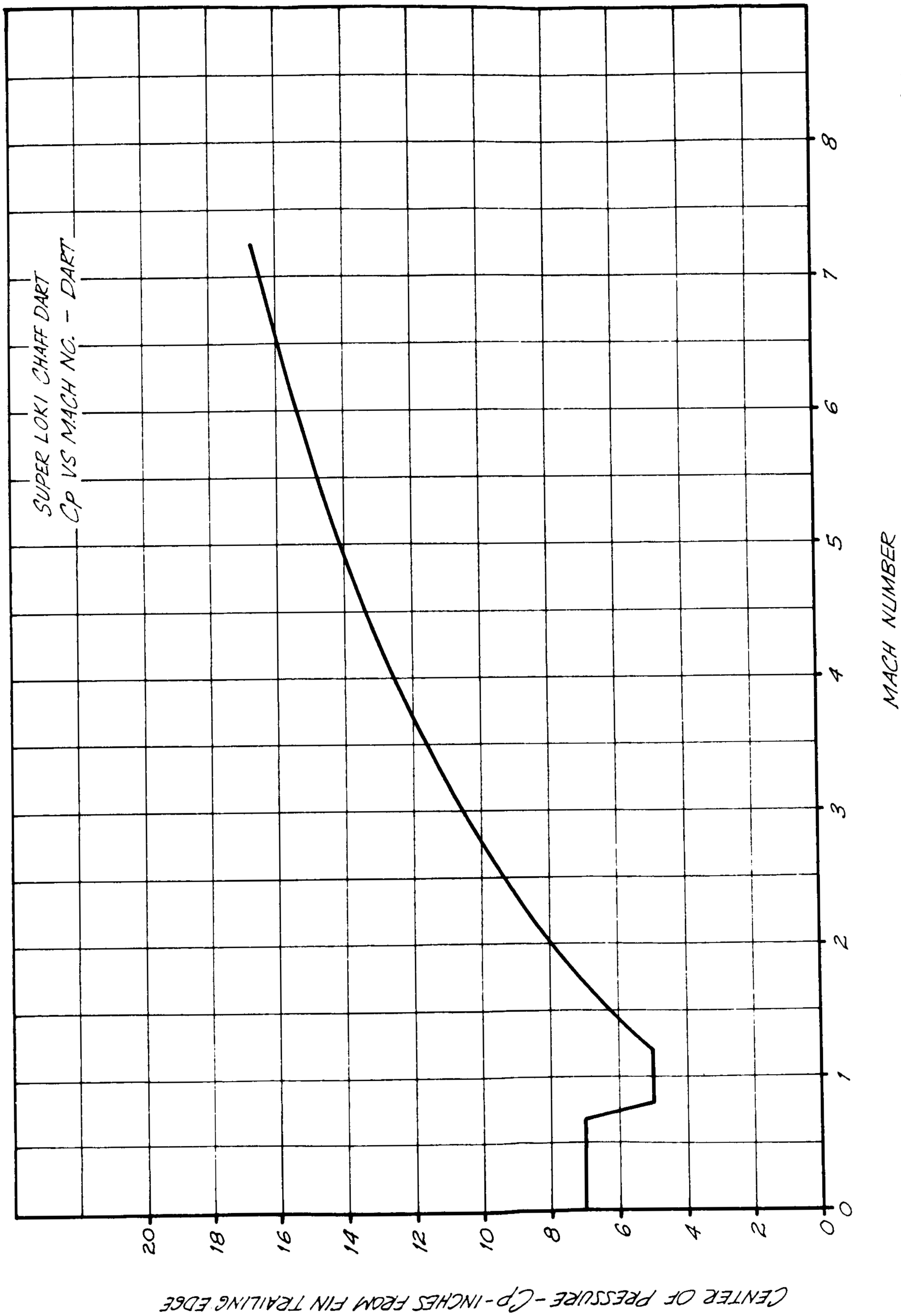

SUPER LOKI CHAFF DART
Cp VS MACH NO. - DART
MACH NUMBER
0 1 2 3 4 5 6 7 8
CENTER OF PRESSURE - Cp - INCHES FROM FIN TRAILING EDGE
0 2 4 6 8 10 12 14 16 18 20

FIGURE 4.4

TABLE 4.1

DRAG COEFFICIENT DATA

Super Loki Dart Vehicle - Two Stages
Reference Area 85.47 cm^2 (0.0920 ft^2)

Mach No.	C_D
0	0.400
0.50	0.420
0.80	0.430
0.81	0.930
1.40	0.930
1.50	0.880
1.75	0.770
2.00	0.682
2.25	0.620
2.50	0.570
2.75	0.533
3.00	0.500
3.25	0.470
3.50	0.440
3.75	0.420
4.00	0.397
4.25	0.380
4.50	0.360
4.75	0.345
5.00	0.331
5.25	0.320
5.50	0.310
5.75	0.300
6.00	0.290
7.00	0.260

Dart - Coasting
Reference Area 9.84 cm^2 (0.0107 ft^2)
Stage Weight - 6.12 kg (13.50 lb)

Mach No.	C_D
0	0.350
0.90	0.350
1.00	0.576
1.50	0.576
1.75	0.489
2.00	0.432
2.25	0.393
2.50	0.365
2.75	0.345
3.00	0.329
3.50	0.308
4.00	0.294
4.50	0.284
5.00	0.277
6.00	0.277
7.00	0.262
8.00	0.262

Expended Booster - Unstable
Stage Weight - 5.28 kg (11.63 lb)
Reference Area - 80.22 cm^2 (0.0872 ft^2)

Mach No.	C_D
0	22.423
1.00	22.423
2.00	15.376
3.00	6.407
4.00	1.068
5.00	0.945
10.00	0.945

5. VEHICLE PERFORMANCE

The nominal trajectory data for the Super Loki Dart launched from sea level altitudes is presented in the series of graphs as follows:

Figure 5.1	Altitude vs Range, 80° QE, Dart
Figure 5.2	Altitude vs Time, 80° QE, Dart
Figure 5.3	Velocity vs Time, 80° QE Dart
Figure 5.4	Altitude vs Range, Various QE's
Figure 5.5	Apogee Altitude and Impact Range vs QE, Dart
Figure 5.6	Altitude vs Range, 80° QE, Booster
Figure 5.7	Altitude vs Time, 80° QE, Booster
Figure 5.8	Apogee Altitude and Impact Range vs QE, Booster

A summary of the major trajectory points for the Super Loki Dart vehicle is presented in Table 5.1. The nominal trajectory details are presented in Table 5.2.

The dart trajectory is based upon stable dart flight prior to and after stage separation. The booster trajectory is based upon stable flight to the point of stage separation. After stage separation, the booster goes unstable and decelerates rapidly to a slow velocity. The booster then descends rather slowly in a flat spin.

The vehicle spin or roll rate profile is presented in Figure 5.9. The vehicle is launched from a helical-rail launcher which imparts a spin rate of 8.5 rps during launch. The booster and dart fins are canted to control the roll rate during the boost and coast phases of flight.

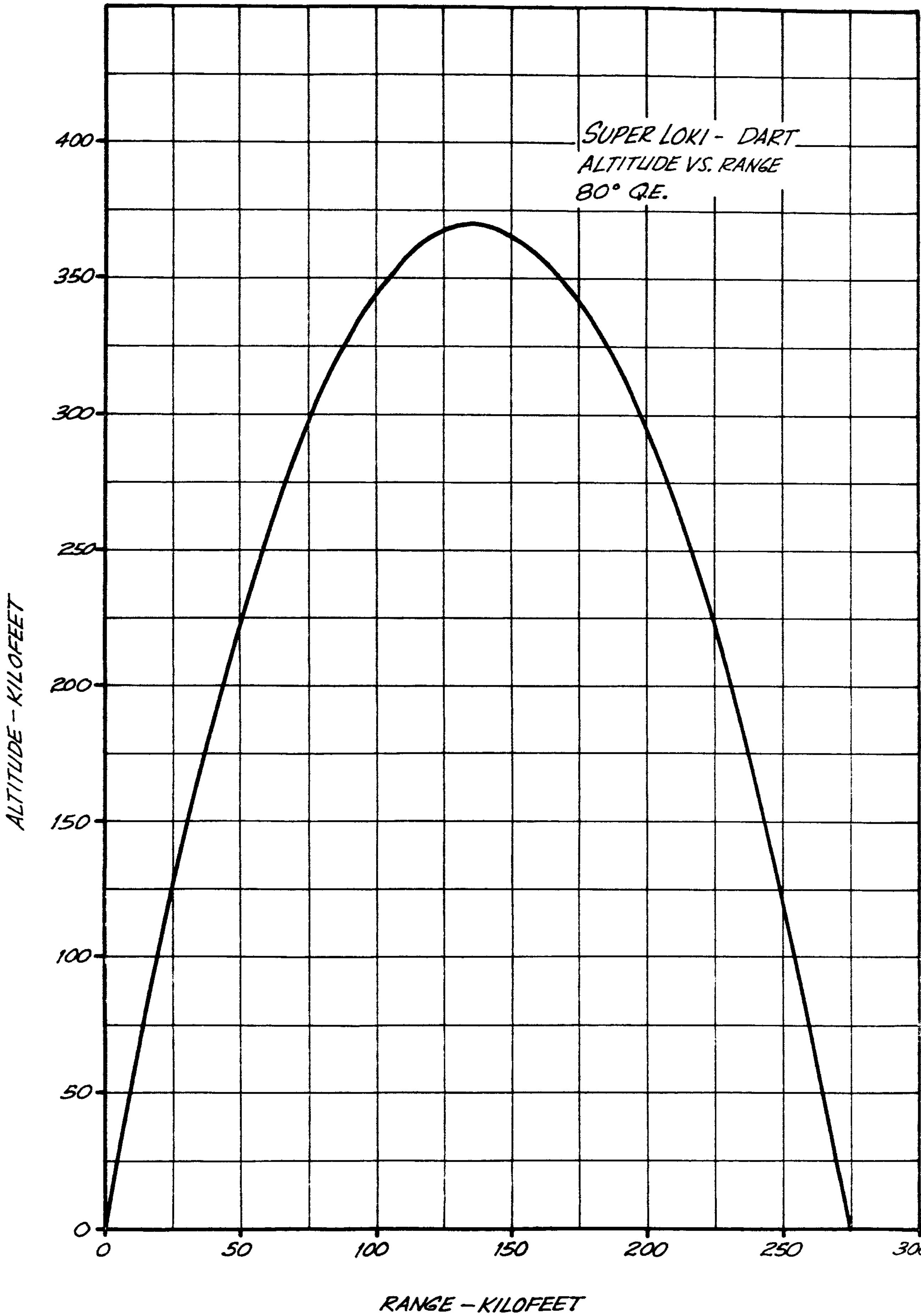

SUPER LOKI - DART
ALTITUDE VS. RANGE
80° QE.
ALTITUDE - KILOFEET
RANGE - KILOFEET
0
50
100
150
200
250
300
350
400

FIGURE 5.1

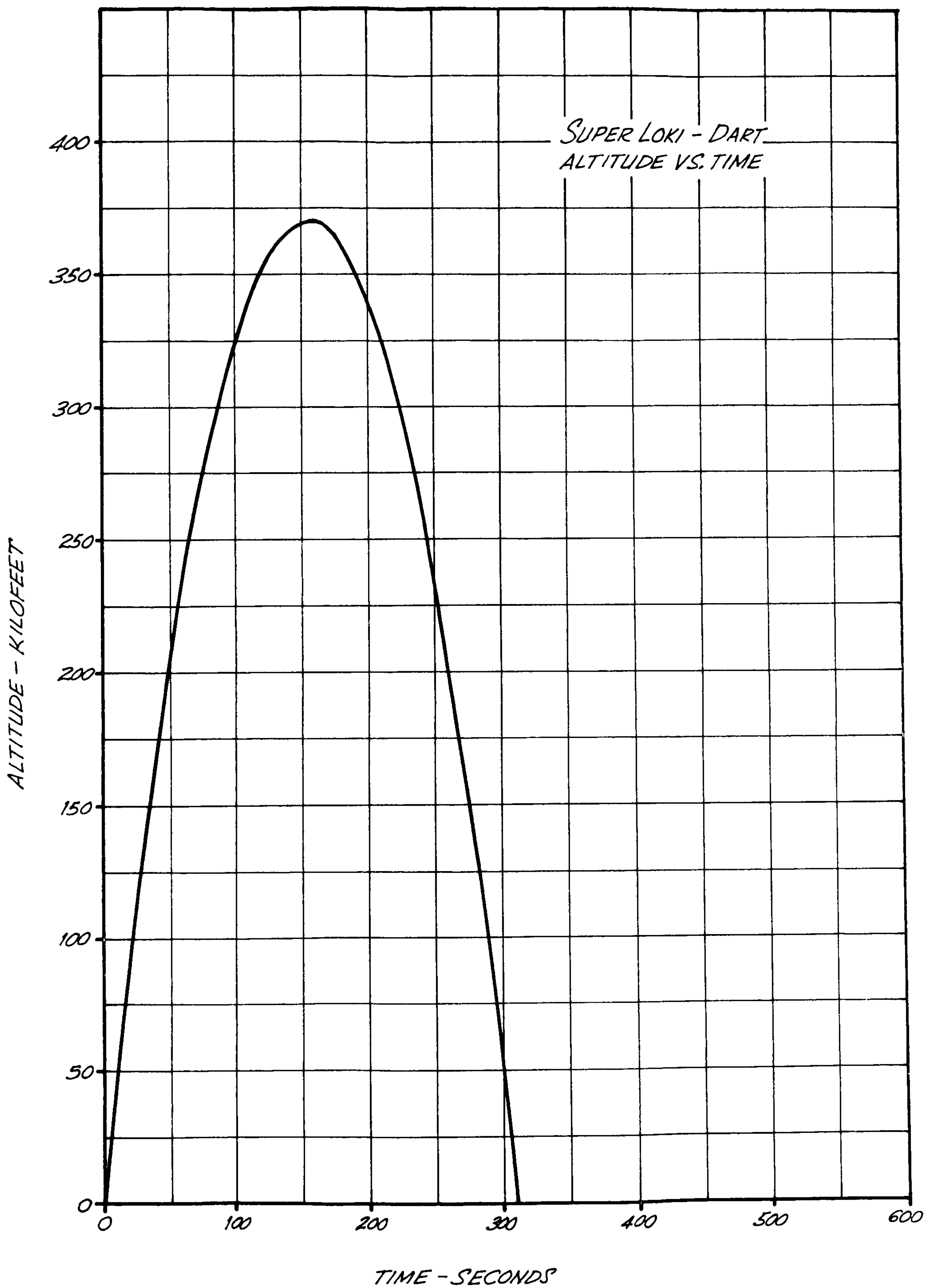

SUPER LOKI - DART
ALTITUDE VS. TIME
ALTITUDE - KILOFEET
400
350
300
250
200
150
100
50
0
0
100
200
300
400
500
600
TIME - SECONDS

FIGURE 5.2

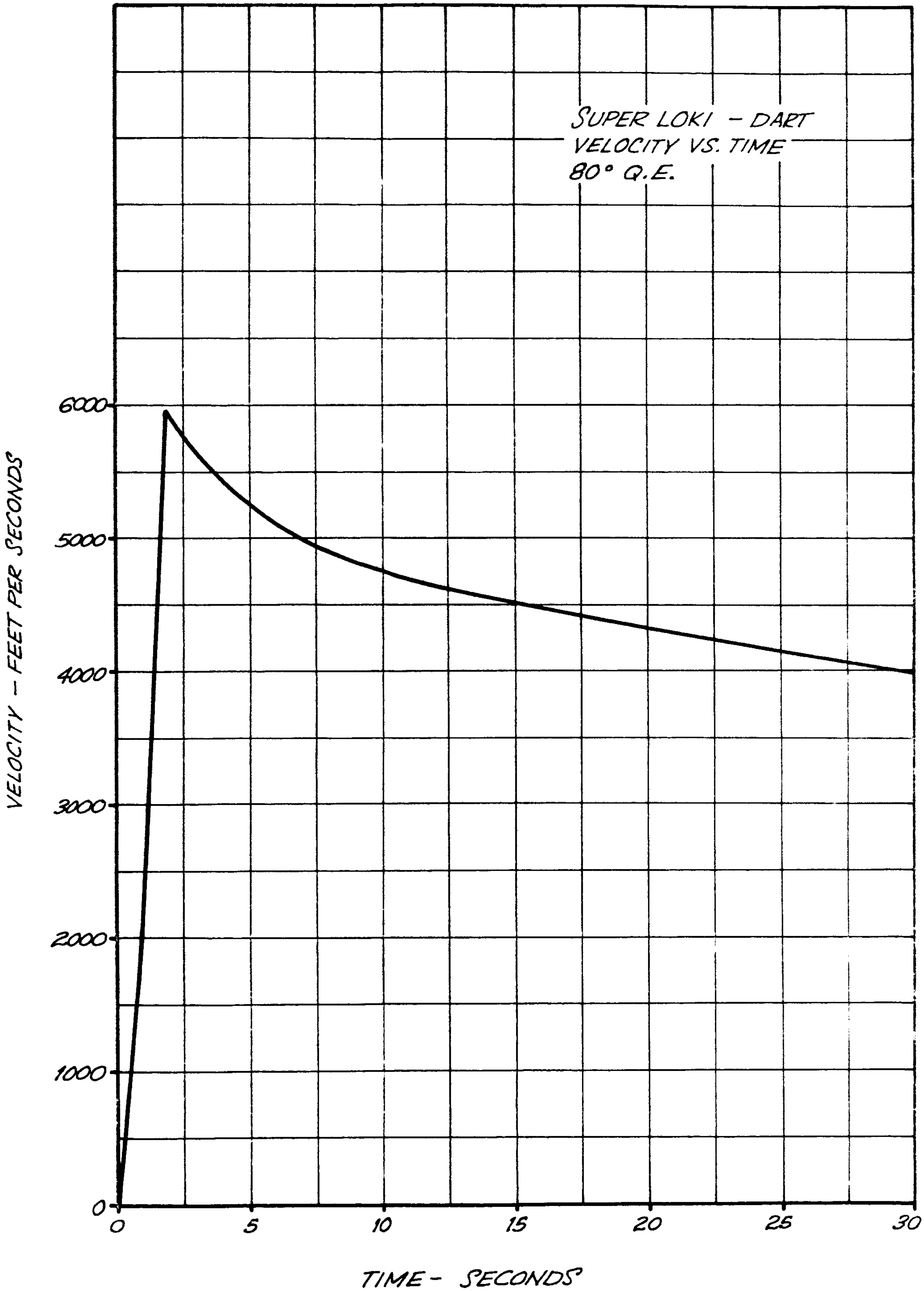

SUPER LOKI - DART
VELOCITY VS. TIME
80° Q.E.
6000
5000
4000
3000
2000
1000
0
VELOCITY - FEET PER SECONDS
0
5
10
15
20
25
30
TIME - SECONDS

FIGURE 5.3

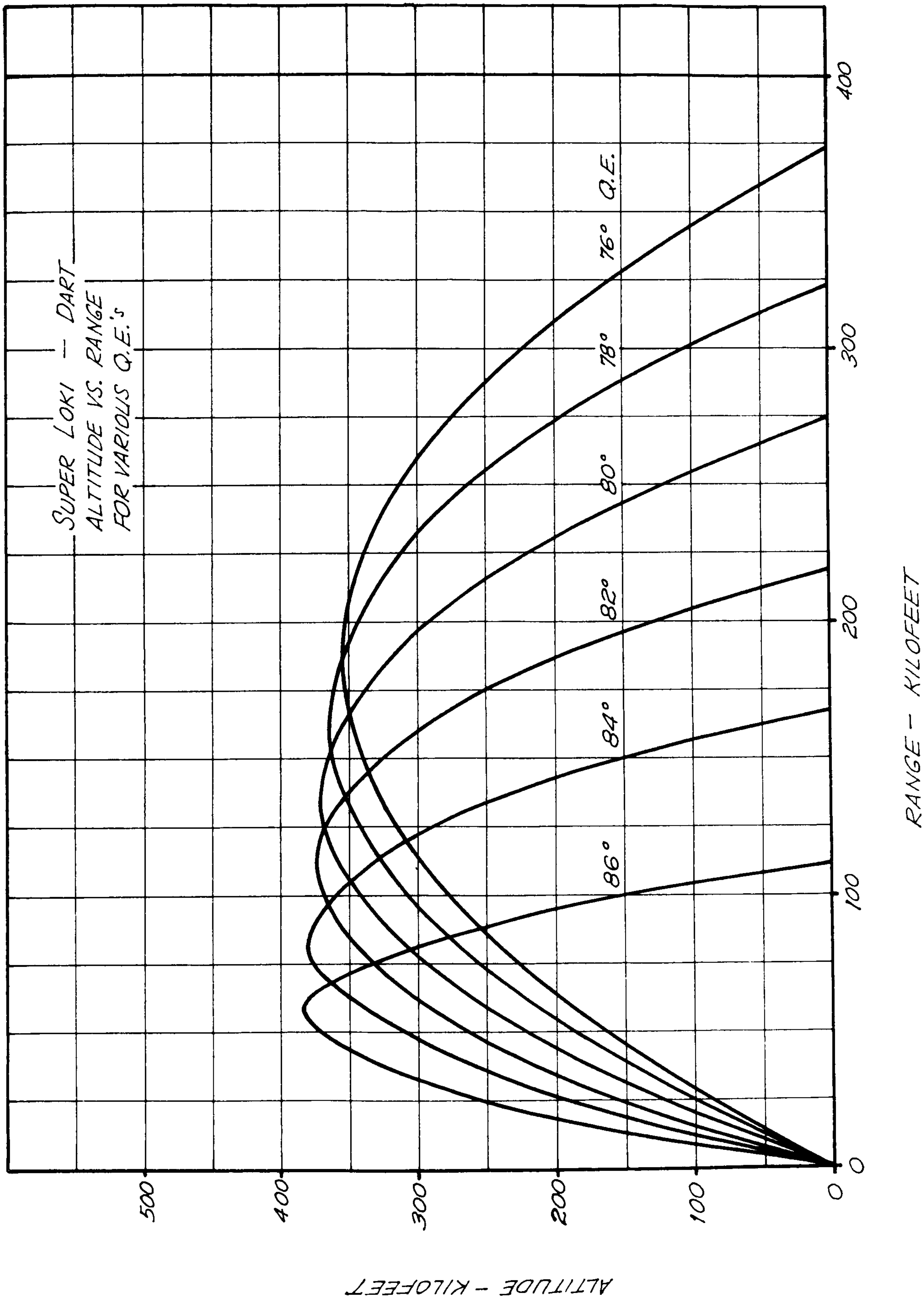
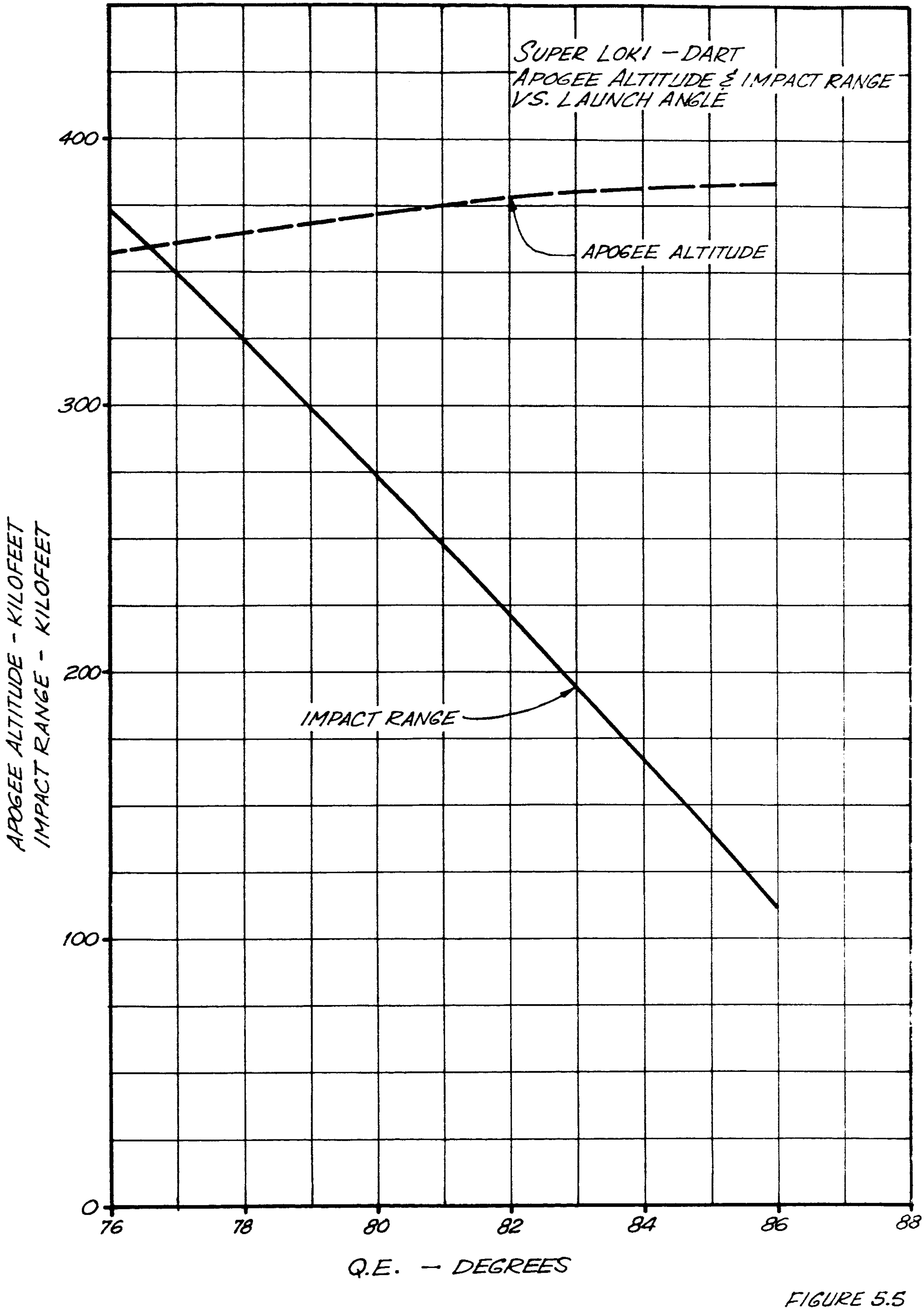

SUPER LOKI — DART
ALTITUDE VS. RANGE
FOR VARIOUS Q.E.'s
76° Q.E.
78°
80°
82°
84°
86°
0
100
200
300
400
500
RANGE – KILOFEET
ALTITUDE – KILOFEET

FIGURE 5.4



SUPER LOKI – DART
APOGEE ALTITUDE & IMPACT RANGE
VS. LAUNCH ANGLE
APOGEE ALTITUDE
IMPACT RANGE
APOGEE ALTITUDE - KILOFEET
IMPACT RANGE - KILOFEET
400
300
200
100
0
76
78
80
82
84
86
88
Q.E. – DEGREES

FIGURE 5.5

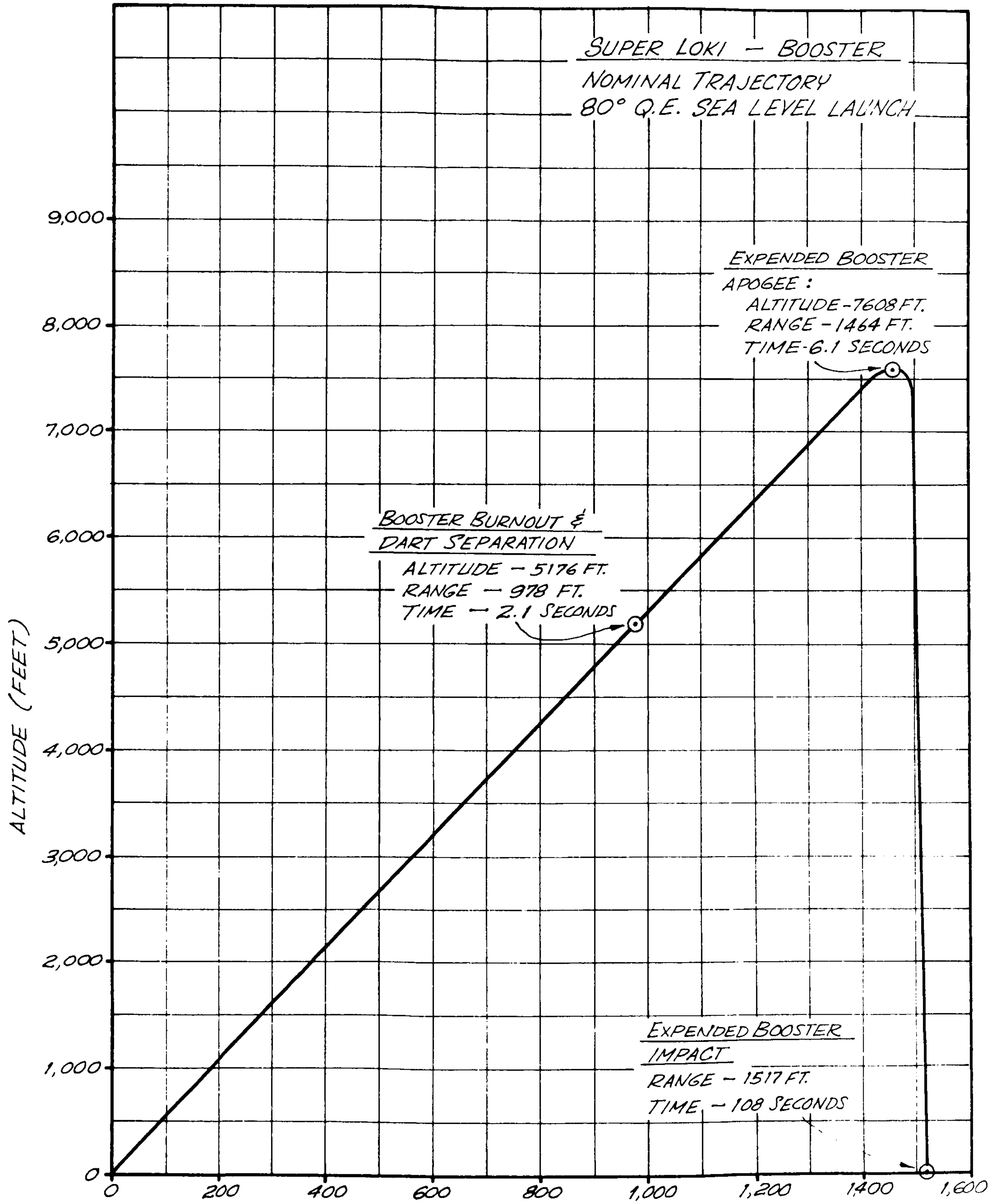

SUPER LOKI — BOOSTER
NOMINAL TRAJECTORY
80° Q.E. SEA LEVEL LAUNCH
EXPENDED BOOSTER
APOGEE :
ALTITUDE-7608 FT.
RANGE - 1464 FT.
TIME-6.1 SECONDS
BOOSTER BURNOUT &
DART SEPARATION
ALTITUDE — 5176 FT.
RANGE — 978 FT.
TIME — 2.1 SECONDS
EXPENDED BOOSTER
IMPACT
RANGE — 1517 FT.
TIME — 108 SECONDS
ALTITUDE (FEET)
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
200
400
600
800
1,000
1,200
1,400
1,600

FIGURE 5.6

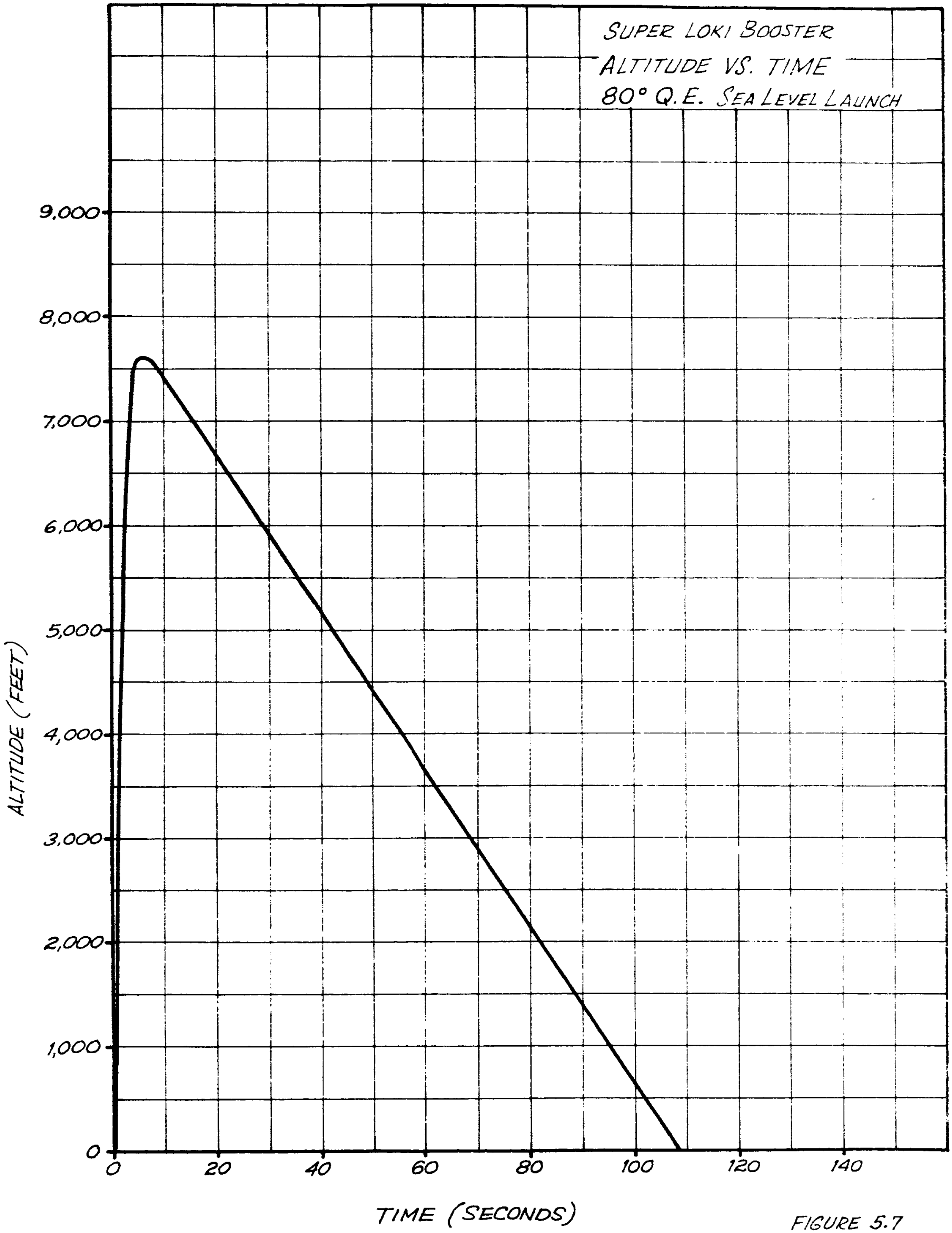

SUPER LOKI BOOSTER
ALTITUDE VS. TIME
80° Q.E. SEA LEVEL LAUNCH
ALTITUDE (FEET)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
0
20
40
60
80
100
120
140
TIME (SECONDS)

FIGURE 5.7

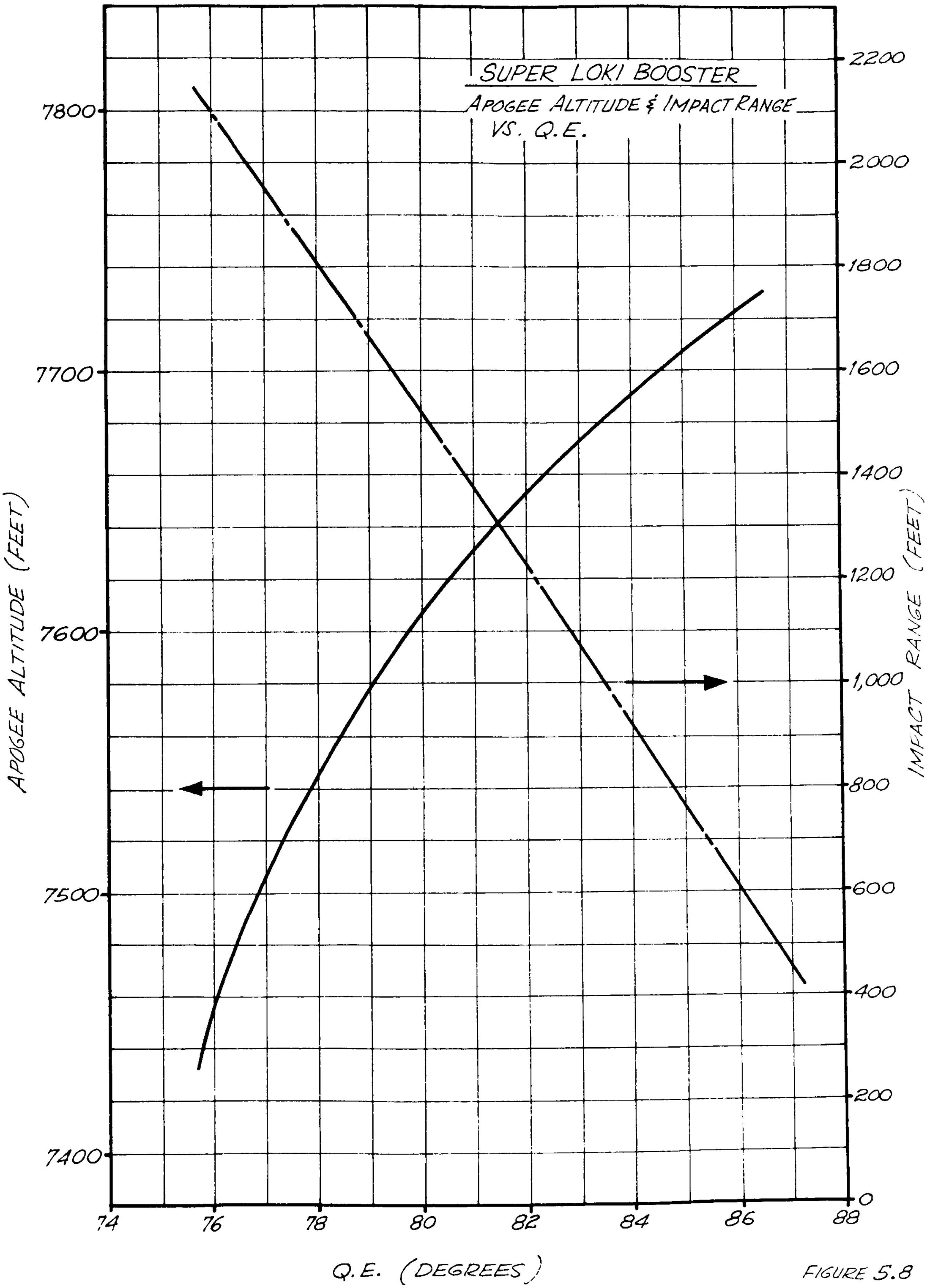

SUPER LOKI BOOSTER
APOGEE ALTITUDE & IMPACT RANGE
VS. Q.E.
7800
7700
7600
7500
7400
APOGEE ALTITUDE (FEET)
2200
2000
1800
1600
1400
1200
1,000
800
600
400
200
0
IMPACT RANGE (FEET)
74
76
78
80
82
84
86
88
Q.E. (DEGREES)

FIGURE 5.8

TABLE 5.1

NOMINAL TRAJECTORY SUMMARY

SUPER LOKI DART, 80° Q.E. SEA LEVEL LAUNCH

	Booster	Dart
Burnout Altitude (m)	1577.6 m(5,176 ft)	1577.6 m (5,176 ft)
Burnout Range (m)	298.1 m (978 ft)	298.1 m (978 ft)
Burnout Time (sec)	2.1	2.1
Apogee Altitude (m)	2318.9 m (7,608 ft)	113.4 km (372,000 ft)
Apogee Range (m)	446.2 m (1,464 ft)	41.8 km (137,000 ft)
Apogee Time (sec)	6.1	6.1
Impact Range (m)	462.4 m (1,517 ft)	83.8 km (275,000 ft)
Impact Time (sec)	108	309

TABLE 5.2

SUPER LOKI DART TRAJECTORY DATA

COMPUTER PRINTOUTS

TWO DEGREE OF FREEDOM - POINT MASS SIMULATION SPACE DATA CORP

RUN 1 SUPER LOKI - DART
11.63 LB INERT WT 13.5 LB,1 5/8 DIA DART
80 DEG SEA LEVEL DRAG TABLES 3010 AND 4004

0.025	0.092	80.000	62.330	0.953
0.100	150000.031	0.000	0.000	1000.000
0.000	0.000	0.000	10.000	
25.130	37.200	1.000	100.000	

** OUTPUT UNITS **

FEET SECONDS POUNDS(FORCE) POUNDS(MASS) DEGREES

TIME	ALT	VEL	RANGE	MACH	Q	ANG	THRUST	DRAG	MASS	ACC/G	VVERT
0.0	0.	0	0.	0.0	0.	80.0	0.	0	62.3	-0.98	0
0.1	6.	138	1.	0.1	22.	79.8	2887.	0	61.1	47.13	136
0.2	27.	289	4.	0.3	99.	79.6	2927.	3	59.9	47.59	285
0.3	63.	448	11.	0.4	238.	79.5	3041.	9	58.6	50.34	440
0.4	115.	619	21.	0.6	455.	79.5	3277.	17	57.2	55.28	609
0.5	185.	808	34.	0.7	773.	79.4	3513.	30	55.8	60.67	795
0.6	275.	1015	50.	0.9	1216.	79.4	3797.	104	54.1	66.33	998
0.7	386.	1242	71.	1.1	1815.	79.4	4082.	155	52.4	72.94	1221
0.8	520.	1491	96.	1.3	2604.	79.3	4367.	222	50.7	79.67	1465
0.9	680.	1762	126.	1.6	3621.	79.3	4622.	281	48.7	87.00	1732
1.0	867.	2059	161.	1.8	4914.	79.3	4878.	332	46.7	95.09	2023
1.1	1085.	2379	203.	2.1	6519.	79.3	5016.	388	44.5	101.82	2338
1.2	1336.	2721	250.	2.4	8465.	79.3	5154.	451	42.4	108.74	2674
1.3	1621.	3083	304.	2.8	10777.	79.2	5196.	524	40.1	114.34	3029
1.4	1942.	3463	364.	3.1	13472.	79.2	5238.	601	37.9	120.23	3403
1.5	2302.	3864	432.	3.5	16588.	79.2	5277.	673	35.7	126.75	3796
1.6	2702.	4283	508.	3.9	20140.	79.2	5231.	757	33.4	131.89	4208
1.7	3145.	4728	592.	4.3	24219.	79.2	5350.	840	31.1	142.08	4645
1.8	3633.	5211	685.	4.7	28995.	79.2	5469.	923	28.8	154.61	5120
1.9	4168.	5662	786.	5.1	33684.	79.2	4312.	1005	26.7	126.90	5562
2.0	4739.	5925	895.	5.4	36259.	79.2	1744.	1047	25.3	42.26	5821
2.1	5176.	5893	978.	5.4	35388.	79.2	0.	1025	25.1	-33.91	5789

****

COAST STAGE A= 0.0107 M= 13.50 T1=***** T2= 1.0 N= 0

2.1	5320.	5886	1005.	5.4	35150.	79.2	0.	103	13.5	-8.64	5782
3.1	10976.	5637	2083.	5.3	27062.	79.1	0.	79	13.5	-6.90	5537
4.1	16411.	5437	3125.	5.2	21124.	79.1	0.	62	13.5	-5.61	5339
5.1	21666.	5272	4139.	5.1	16651.	79.0	0.	49	13.5	-4.63	5176
6.1	26773.	5136	5130.	5.1	13210.	78.9	0.	39	13.5	-3.88	5041
7.1	31756.	5021	6103.	5.1	10525.	78.9	0.	31	13.5	-3.29	4927
8.1	36634.	4923	7062.	5.1	8357.	78.8	0.	24	13.5	-2.81	4830
9.1	41421.	4839	8009.	5.0	6427.	78.7	0.	19	13.5	-2.39	4746
10.1	46131.	4767	8948.	4.9	4979.	78.6	0.	14	13.5	-2.07	4675
11.1	50774.	4704	9879.	4.9	3883.	78.6	0.	11	13.5	-1.83	4612
12.1	55358.	4648	10806.	4.8	3045.	78.5	0.	9	13.5	-1.65	4556
13.1	59888.	4598	11727.	4.7	2398.	78.4	0.	7	13.5	-1.51	4505
14.1	64369.	4551	12646.	4.7	1897.	78.3	0.	5	13.5	-1.39	4458
15.1	68805.	4507	13561.	4.7	1500.	78.2	0.	4	13.5	-1.30	4414
16.1	73197.	4466	14474.	4.6	1188.	78.2	0.	3	13.5	-1.23	4372
17.1	77550.	4427	15386.	4.6	946.	78.1	0.	2	13.5	-1.18	4333
18.1	81863.	4390	16296.	4.5	755.	78.0	0.	2	13.5	-1.14	4295
19.1	86140.	4354	17205.	4.5	605.	77.9	0.	1	13.5	-1.10	4258
20.1	90380.	4319	18113.	4.4	487.	77.8	0.	1	13.5	-1.08	4222
21.1	94585.	4284	19021.	4.3	392.	77.7	0.	1	13.5	-1.05	4187
22.1	98755.	4250	19927.	4.2	317.	77.6	0.	0	13.5	-1.04	4153
23.1	102890.	4217	20834.	4.2	258.	77.5	0.	0	13.5	-1.02	4119
24.1	106992.	4184	21739.	4.1	209.	77.4	0.	0	13.5	-1.01	4085
25.1	111061.	4152	22645.	4.0	169.	77.4	0.	0	13.5	-1.00	4052
26.1	115197.	4119	23573.	4.0	136.	77.3	0.	0	13.5	-0.99	4018
27.1	119198.	4087	24478.	3.9	111.	77.2	0.	0	13.5	-0.99	3985
28.1	123167.	4055	25383.	3.9	91.	77.1	0.	0	13.5	-0.98	3953
29.1	127104.	4023	26288.	3.8	75.	77.0	0.	0	13.5	-0.98	3920
30.1	131008.	3992	27192.	3.8	62.	76.9	0.	0	13.5	-0.97	3888
31.1	134880.	3960	28097.	3.7	51.	76.7	0.	0	13.5	-0.97	3856
32.1	138720.	3929	29001.	3.6	43.	76.6	0.	0	13.5	-0.97	3824
33.1	142527.	3898	29906.	3.6	36.	76.5	0.	0	13.5	-0.96	3792
34.1	146302.	3867	30810.	3.5	30.	76.4	0.	0	13.5	-0.96	3760
35.1	150046.	3836	31714.	3.5	25.	76.3	0.	0	13.5	-0.96	3728

EXOATMOSPHERE RESULTS

TIME	ALT	RANGE	ALT(KM)	RANGE(KM)
0.420316E 02	0.175046E 06	0.378177E 05	0.533542E 02	0.115268E 02
0.493989E 02	0.200046E 06	0.443199E 05	0.609742E 02	0.135087E 02
0.573292E 02	0.225046E 06	0.519202E 05	0.685942E 02	0.158253E 02
0.659739E 02	0.250046E 06	0.595918E 05	0.762143E 02	0.181636E 02
0.755670E 02	0.275046E 06	0.681075E 05	0.838343E 02	0.207592E 02
0.865085E 02	0.300046E 06	0.778279E 05	0.914543E 02	0.237220E 02
0.995975E 02	0.325046E 06	0.894804E 05	0.990744E 02	0.272737E 02
0.117018E 03	0.350046E 06	0.105091E 06	0.106694E 03	0.320318E 02
0.209511E 03	0.325046E 06	0.185352E 06	0.990744E 02	0.564955E 02
0.222600E 03	0.300046E 06	0.197004E 06	0.914543E 02	0.600472E 02
0.233542E 03	0.275046E 06	0.206725E 06	0.838343E 02	0.630100E 02
0.243135E 03	0.250046E 06	0.215240E 06	0.762143E 02	0.656056E 02
0.251779E 03	0.225046E 06	0.222912E 06	0.685942E 02	0.679439E 02
0.259710E 03	0.200046E 06	0.230512E 06	0.609742E 02	0.702605E 02
0.267077E 03	0.175046E 06	0.237014E 06	0.533542E 02	0.722423E 02
0.273985E 03	0.150046E 06	0.243117E 06	0.457342E 02	0.741026E 02
0.280511E 03	0.125046E 06	0.248887E 06	0.381142E 02	0.758610E 02
0.286709E 03	0.100046E 06	0.254372E 06	0.304941E 02	0.775329E 02
0.292625E 03	0.750462E 05	0.260038E 06	0.228741E 02	0.792598E 02
0.298293E 03	0.500461E 05	0.265044E 06	0.152541E 02	0.807859E 02
0.303742E 03	0.250461E 05	0.269862E 06	0.763410E 01	0.822543E 02
0.308995E 03	0.461875E 02	0.274891E 06	0.140779E-01	0.837871E 02
0.314070E 03	-0.249538E 05	0.279375E 06	-0.760594E 01	0.851538E 02

ORBITAL PARAMETERS

E	A	P	QC
0.998788E 00	0.106557E 08	0.258070E 05	0.220312E-01

APOGEE CONDITIONS

TIME	ALT	RANGE	ALT(KM)	RANGE(KM)
0.154554E 03	0.371891E 06	0.137416E 06	0.113352E 03	0.418846E 02

IMPACT CONDITIONS

TIME	ALT	RANGE	ALT(KM)	RANGE(KM)
0.309004E 03	0.000000E 00	0.274891E 06	0.000000E 00	0.837871E 02

TWO DEGREE OF FREEDOM - POINT MASS SIMULATION   SPACE DATA CORP

SUPER LOKI DART BOOSTER TRAJECTORY
11.63 LB INERT WT.   13.5 LB 15/8 DIA DART
80 DEG SEA LEVEL   DRAG TABLE 3010 AND UNSTABLE B

0.025	0.092	80.000	62.330	0.953
0.100	150000.031	0.000	0.000	1000.000
0.000	0.000	0.000	20.000	
25.130	37.200	1.000	100.000	

** OUTPUT UNITS **

FEET   SECONDS   POUNDS(FORCE)   POUNDS(MASS)   DEGREES

TIME	ALT	VEL	RANGE	MACH	Q	ANG	THRUST	DRAG	MASS	ACC/G	VVERT
0.0	0.	0	0.	0.0	0.	80.0	0.	0	62.3	-0.98	0
0.1	6.	138	1.	0.1	22.	79.8	2887.	0	62.1	47.13	136
0.2	27.	289	4.	0.3	99.	79.6	2927.	3	59.9	47.55	285
0.3	63.	448	11.	0.4	238.	79.5	3041.	9	58.6	50.34	440
0.4	115.	619	21.	0.6	455.	79.5	3277.	17	57.2	55.28	609
0.5	185.	808	34.	0.7	773.	79.4	3515.	30	55.8	60.07	795
0.6	275.	1015	50.	0.9	1216.	79.4	3797.	104	54.1	66.55	998
0.7	386.	1242	71.	1.1	1815.	79.4	4082.	155	52.4	72.94	1221
0.8	520.	1491	96.	1.3	2604.	79.3	4367.	222	50.7	79.67	1465
0.9	680.	1762	126.	1.6	3621.	79.3	4622.	281	48.7	87.30	1732
1.0	867.	2059	161.	1.8	4914.	79.3	4878.	332	46.7	95.09	2023
1.1	1085.	2379	203.	2.1	6519.	79.3	5016.	388	44.5	101.82	2338
1.2	1336.	2721	250.	2.4	8465.	79.3	5154.	451	42.4	108.74	2674
1.3	1621.	3083	304.	2.8	10777.	79.2	5196.	524	40.1	114.54	3029
1.4	1942.	3463	364.	3.1	13472.	79.2	5238.	601	37.9	120.25	3403
1.5	2302.	3864	432.	3.5	16588.	79.2	5277.	673	35.7	126.75	3796
1.6	2702.	4283	508.	3.9	20140.	79.2	5231.	757	33.4	131.89	4208
1.7	3145.	4728	592.	4.3	24219.	79.2	5350.	840	31.1	142.08	4645
1.8	3633.	5211	685.	4.7	28995.	79.2	5469.	923	28.8	154.61	5120
1.9	4168.	5662	786.	5.1	33684.	79.2	4312.	1005	26.7	126.90	5562
2.0	4739.	5925	895.	5.4	36259.	79.2	1744.	1047	25.5	42.26	5821
2.1	5176.	5895	978.	5.4	35388.	79.2	0.	1025	25.1	-33.91	5789

****

COAST STAGE A= 0.0872 M= 11.63 T1=***** T2= 2.0 N= 1

TIME	ALT	VEL	RANGE	MACH	Q	ANG	THRUST	DRAG	MASS	ACC/G	VVERT
2.1	5318.	5692	1005.	5.2	32874.	79.2	0.	2709	11.6	******	5592
4.1	7524.	96	1429.	0.1	8.	76.0	0.	17	11.6	-2.45	93
6.1	7608.	14	1464.	0.0	0.	14.5	0.	0	11.6	-0.31	4
8.1	7556.	51	1489.	0.0	2.	-78.5	0.	4	11.6	0.55	-50
10.1	7429.	72	1504.	0.1	5.	-85.8	0.	9	11.6	0.15	-72
12.1	7277.	77	1511.	0.1	5.	-88.2	0.	11	11.6	0.03	-77
14.1	7121.	78	1515.	0.1	5.	-89.2	0.	11	11.6	0.00	-78
16.1	6964.	78	1516.	0.1	5.	-89.6	0.	11	11.6	-0.00	-78
18.1	6807.	78	1517.	0.1	5.	-89.8	0.	11	11.6	-0.00	-78
20.1	6650.	78	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-78
22.1	6494.	78	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-78
24.1	6338.	77	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-77
26.1	6180.	77	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-77
28.1	6025.	77	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-77
30.1	5870.	77	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-77
32.1	5716.	77	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-77
34.1	5562.	76	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-76
36.1	5408.	76	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-76
38.1	5255.	76	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-76
40.1	5102.	76	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-76
42.1	4949.	76	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-76
44.1	4797.	76	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-76
46.1	4645.	75	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-75
48.1	4493.	75	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-75
50.1	4342.	75	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-75
52.1	4191.	75	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-75
54.1	4040.	75	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-75
56.1	3890.	75	1517.	0.1	5.	-89.9	0.	11	11.6	-0.00	-75

58.1	3740.	74	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-74
60.1	3591.	74	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-74
62.1	3442.	74	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-74
64.1	3293.	74	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-74
66.1	3144.	74	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-74
68.1	2996.	74	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-74
70.1	2848.	73	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-73
72.1	2700.	73	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-73
74.1	2553.	73	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-73
76.1	2406.	73	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-73
78.1	2260.	73	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-73
80.1	2113.	73	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-73
82.1	1967.	72	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-72
84.1	1822.	72	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-72
86.1	1676.	72	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-72
88.1	1531.	72	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-72
90.1	1387.	72	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-72
92.1	1242.	72	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-72
94.1	1098.	71	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-71
96.1	955.	71	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-71
98.1	811.	71	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-71
100.1	668.	71	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-71
102.1	525.	71	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-71
104.1	382.	71	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-71
106.1	240.	71	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-71
108.1	98.	70	1517.	0.1	5.	-89.9	0.	11	11.6	-0.000	-70

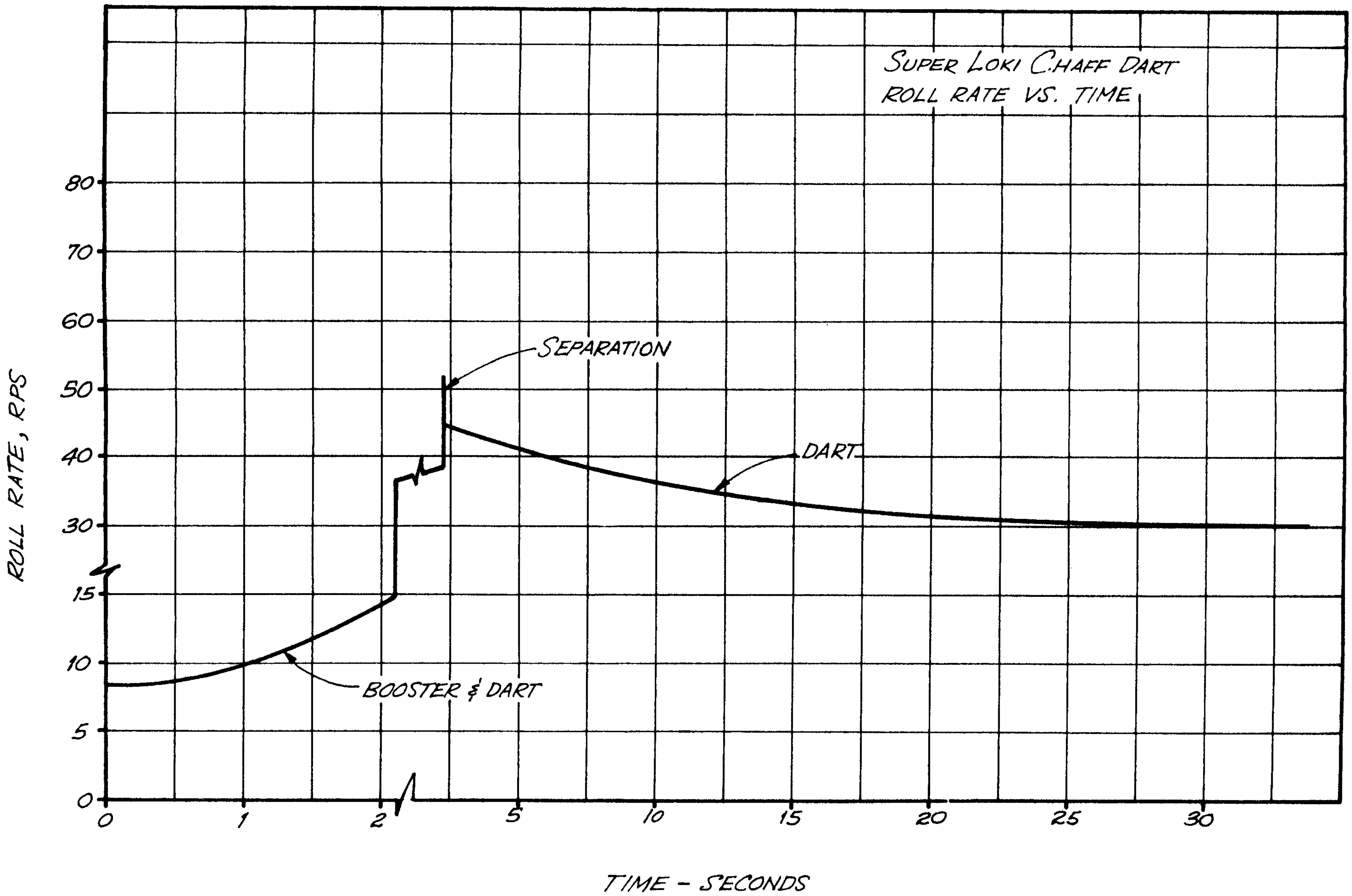

SUPER LOKI CHAFF DART
ROLL RATE VS. TIME
SEPARATION
DART
BOOSTER & DART
ROLL RATE, RPS
80
70
60
50
40
30
15
10
5
0
0
1
2
5
10
15
20
25
30
TIME - SECONDS

FIGURE 5.9

6. RANGE SAFETY DATA

Complete range safety documentation has previously been presented in Space Data Corporation's TM-309, and the results are summarized as follows:

Table 6.1	Ordnance Data
Table 6.2	Impact Dispersion Data
Figure 6.1	Dart Wind-Weighting Data
Figure 6.2	Booster Wind-Weighting Data

TABLE 6.1

ORDNANCE DATA

Item	Explosive		Electrical Squib Characteristics		
	Weight	Type	No-Fire	Resistance	All-Fire
Rocket Motor Propellant	16.87 kg 37.20 lb	Polysulfide, Ammonium Perchlorate	-	-	-
Rocket Motor Igniter (2 squibs in parallel)	50 grams	Cupric Oxide Aluminum Powder	1 watt/ 1 amp 5- minutes each squib	1.15 ohms $\pm$ 0.15 ohms each squib	5.0 amps each squib
Dart Payload Separation Device with 145-second Time Delay	5 grams	Boron Potassium Nitrate	1 watt/ 1 amp 5 - minute	1.05 ohms $\pm$ 0.25 ohms	5.0 amp

TABLE 6.2

IMPACT DISPERSION DATA

Vehicle Stage	Dart	Booster
80° QE Impact Range	83.8 km (275,000 ft)	462 m (1,517 ft)
Maximum Three-Sigma Impact Dispersion Radius	9,516 m (31,220 ft)	136 m (447 feet)

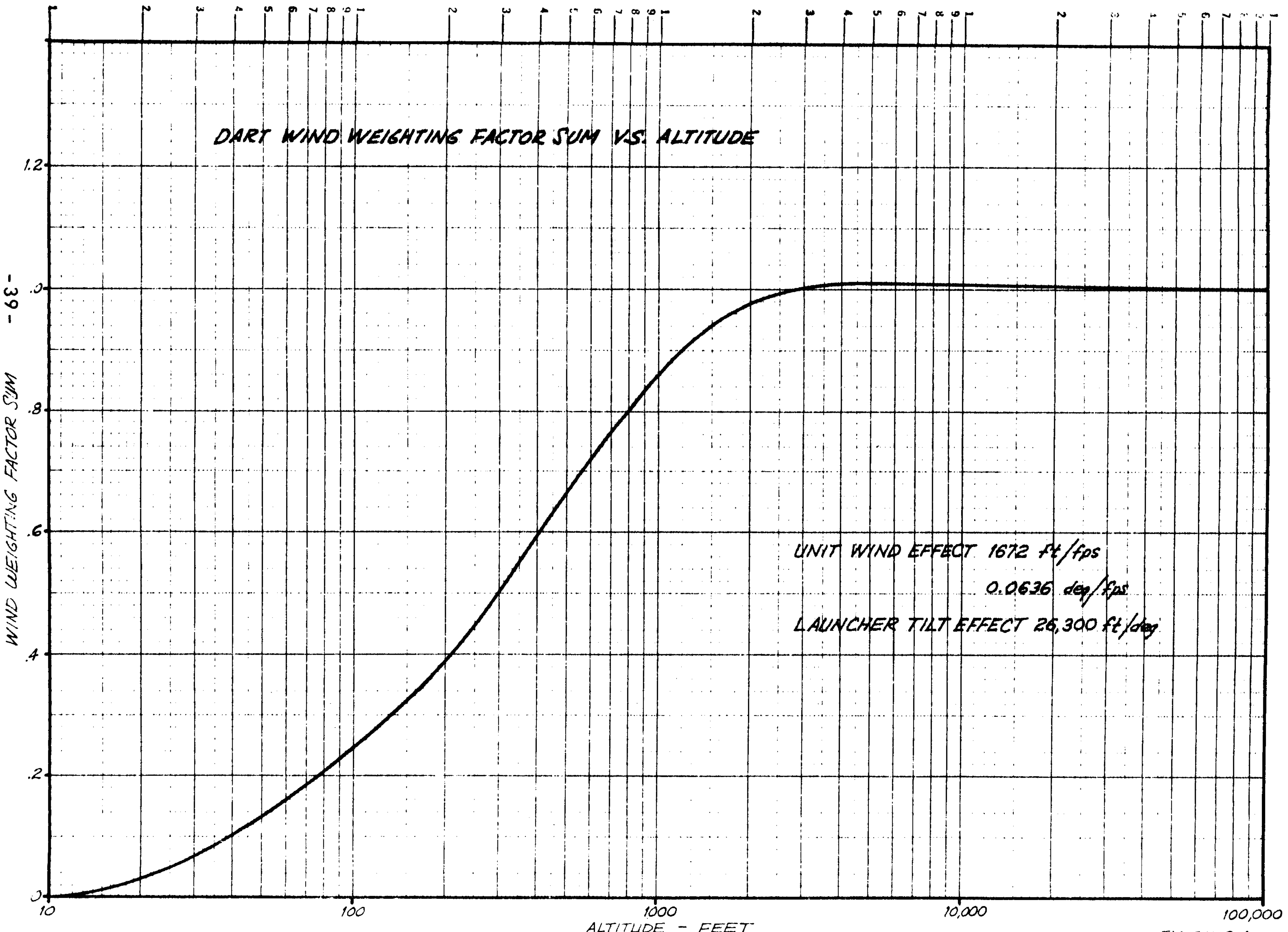
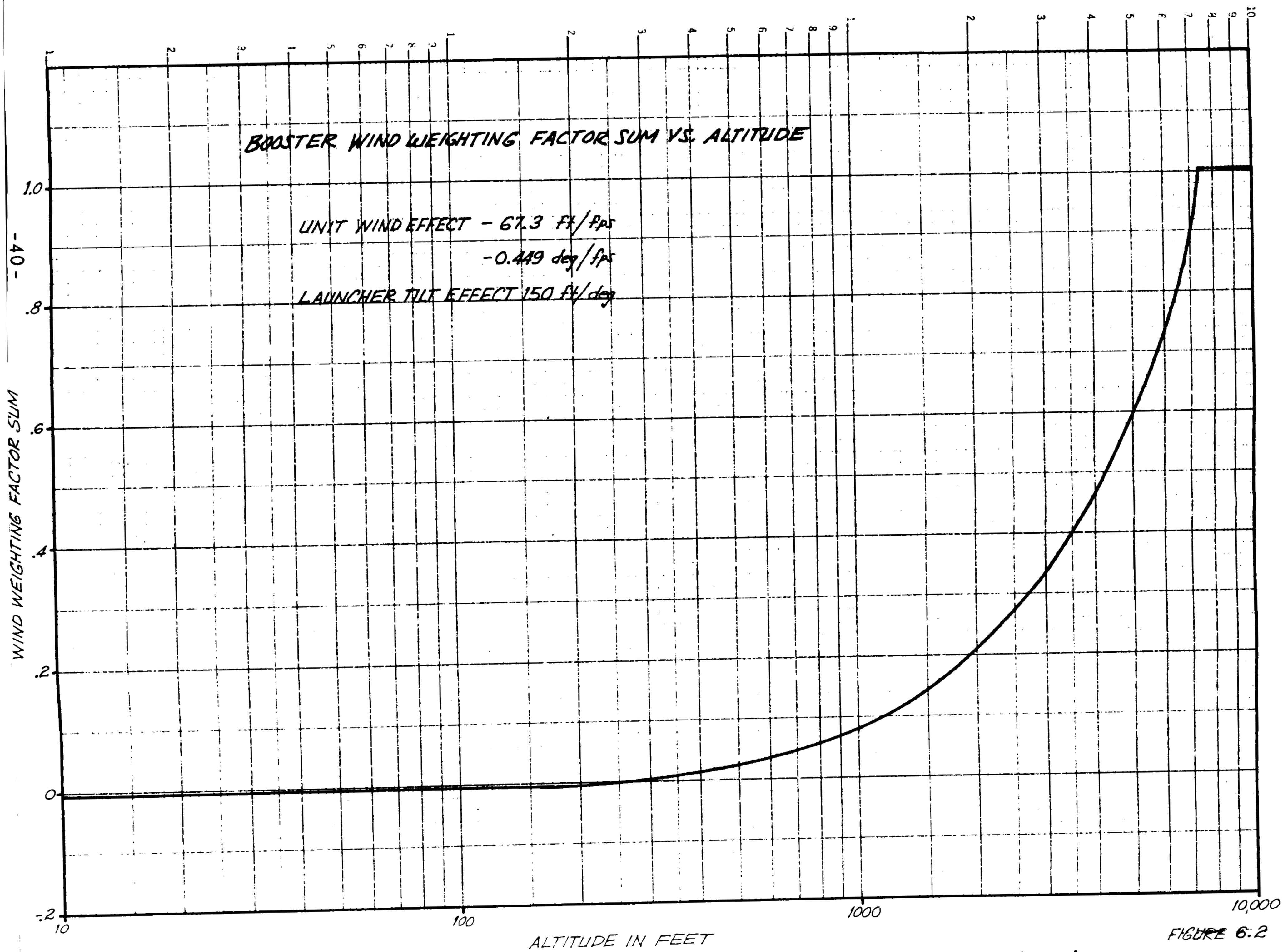

DART WIND WEIGHTING FACTOR SUM VS. ALTITUDE
UNIT WIND EFFECT 1672 ft/fps
0.0636 deg/fps
LAUNCHER TILT EFFECT 26,300 ft/deg
WIND WEIGHTING FACTOR SUM
1.2
1.0
.8
.6
.4
.2
0
10
100
1000
10,000
100,000
ALTITUDE - FEET

FIGURE 6.1



BOOSTER WIND WEIGHTING FACTOR SUM VS. ALTITUDE
UNIT WIND EFFECT - 67.3 ft/fps
-0.449 deg/fps
LAUNCHER TILT EFFECT 150 ft/deg
WIND WEIGHTING FACTOR SUM
1.0
.8
.6
.4
.2
0
-.2
10
100
1000
10,000
ALTITUDE IN FEET

FIGURE 6.2

7. VEHICLE ASSEMBLY, CHECKOUT AND LAUNCH PROCEDURES

The Super Loki Dart system is supplied in three component parts shown in Figure 7.1, as follows:

1. Super Loki Rocket Igniter.
2. Super Loki Rocket Motor
3. Super Loki Chaff Dart

At the launch site the dart is assembled to the rocket motor, the vehicle is inserted into the launcher, the dart initiator leads are connected to the dart tail and the igniter is installed in the rocket motor. After a continuity check through the igniter and dart leads separately, the system is ready to launch.

A step-by-step procedure for vehicle assembly, checkout and launch is presented as follows:

1. Remove dart and rocket motor from shipping boxes.

2. Insert aft end of dart into forward end of rocket motor as shown in Figure 7.2, assuring that anti-roll pin in dart tail is aligned with slot in motor headplate dart alignment cup.

3. Insert aft end of assembled vehicle into forward end of launch rails as shown in Figure 7.3, and slide vehicle back until dart fins reach launch rails.

4. Align dart fins with the four launch rails as shown in Figure 7.4, so the booster fins will be located between the rails as shown in Figure 7.5.

5. Slide the vehicle completely back to the rear of the launcher as shown in Figure 7.6.

6. Assemble the dart firing leads to the dart tail by means of the respective connectors utilizing the pullaway harness shown in Figure 7.7.

7. Assemble igniter into aft end of rocket motor by screwing igniter base into rocket motor nozzle closure.

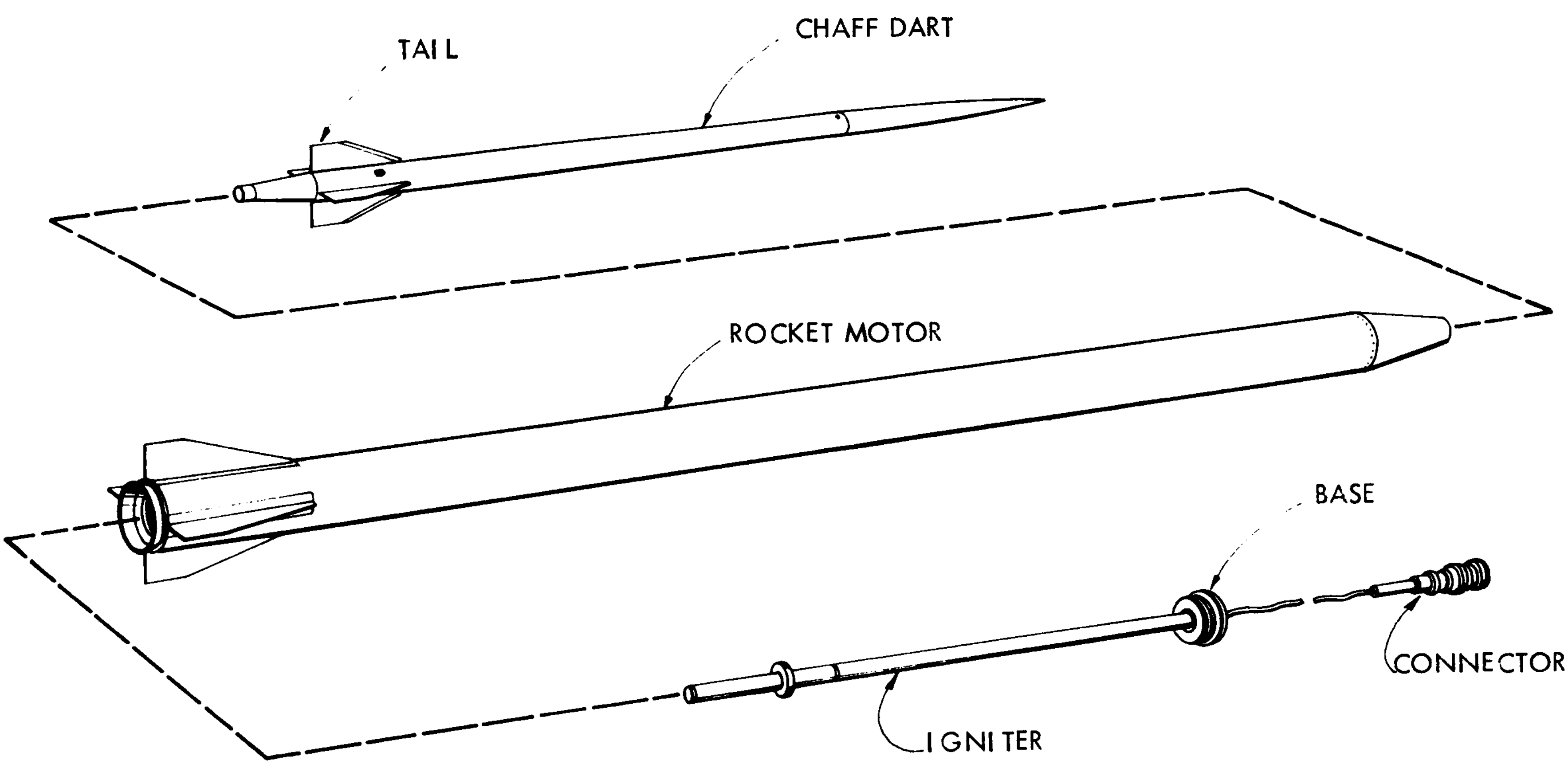


FIGURE 7.1 SUPER LOKI DART SYSTEM COMPONENTS

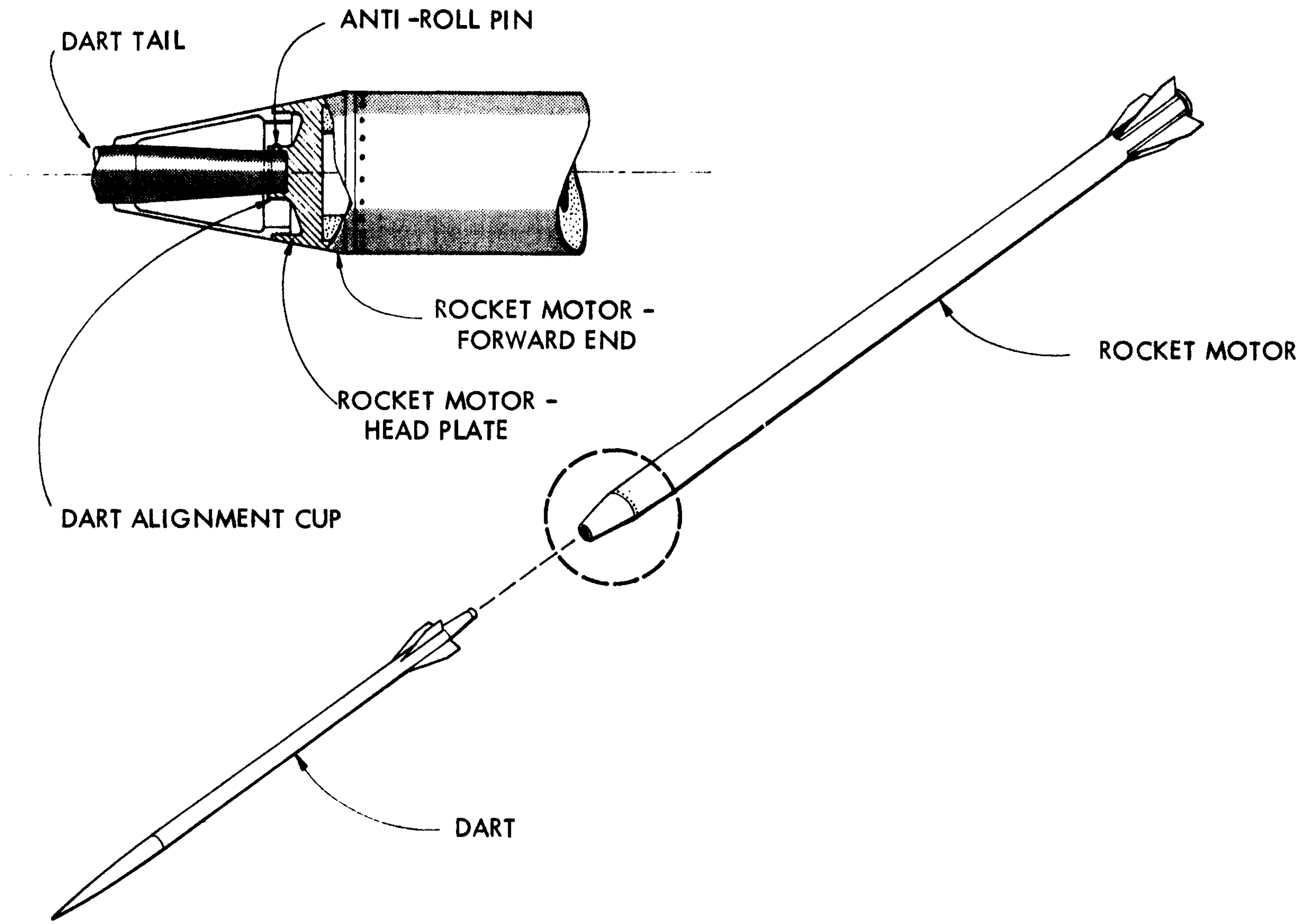


FIGURE 7.2 SUPER LOKI VEHICLE ASSEMBLY

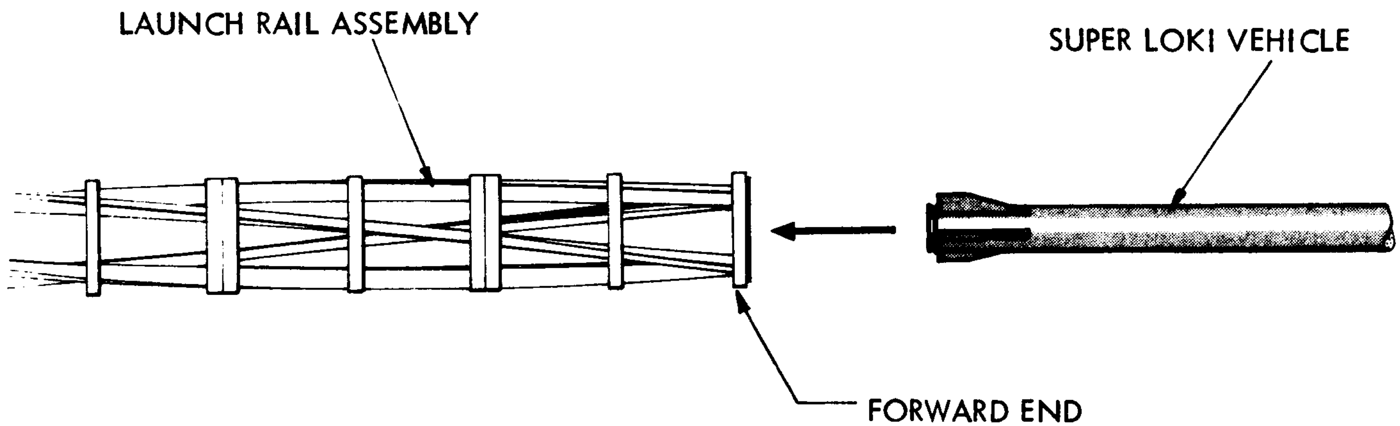


FIGURE 7.3 LAUNCH INSTALLATION - INITIAL

FIGURE 7.4 LAUNCH INSTALLATION - INTERMEDIATE (FORWARD VIEW)

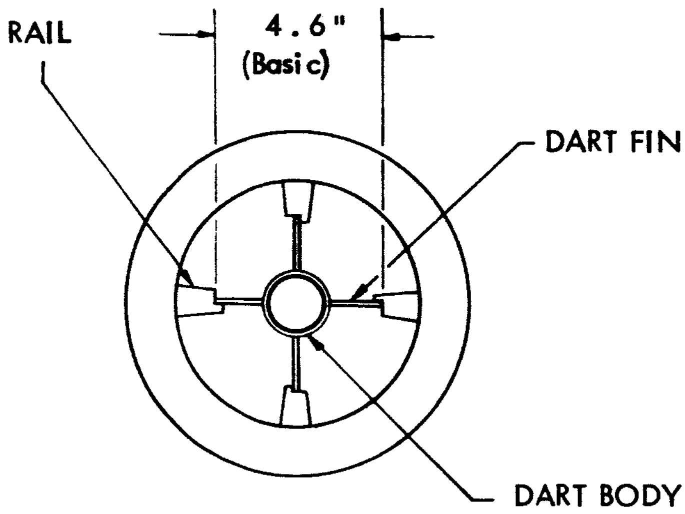
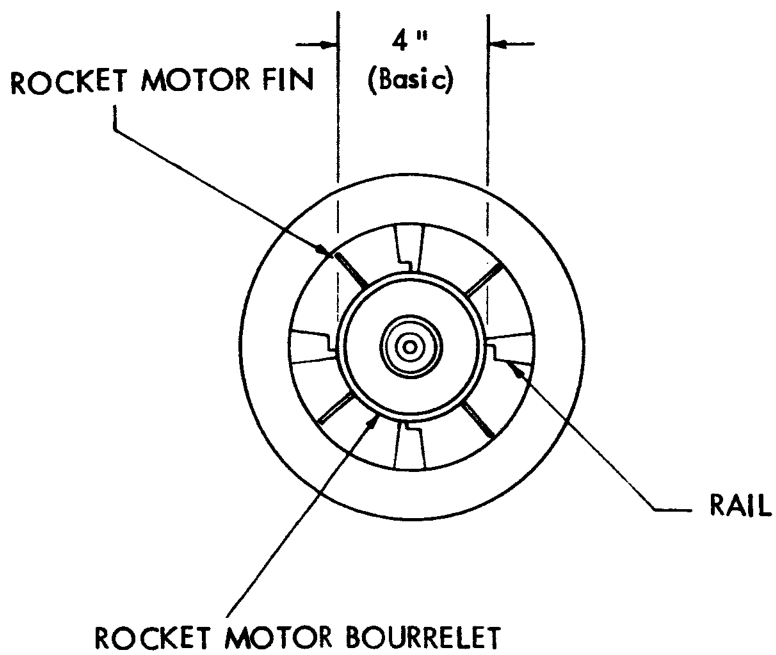


FIGURE 7.5 LAUNCH INSTALLATION - INTERMEDIATE (REAR VIEW)



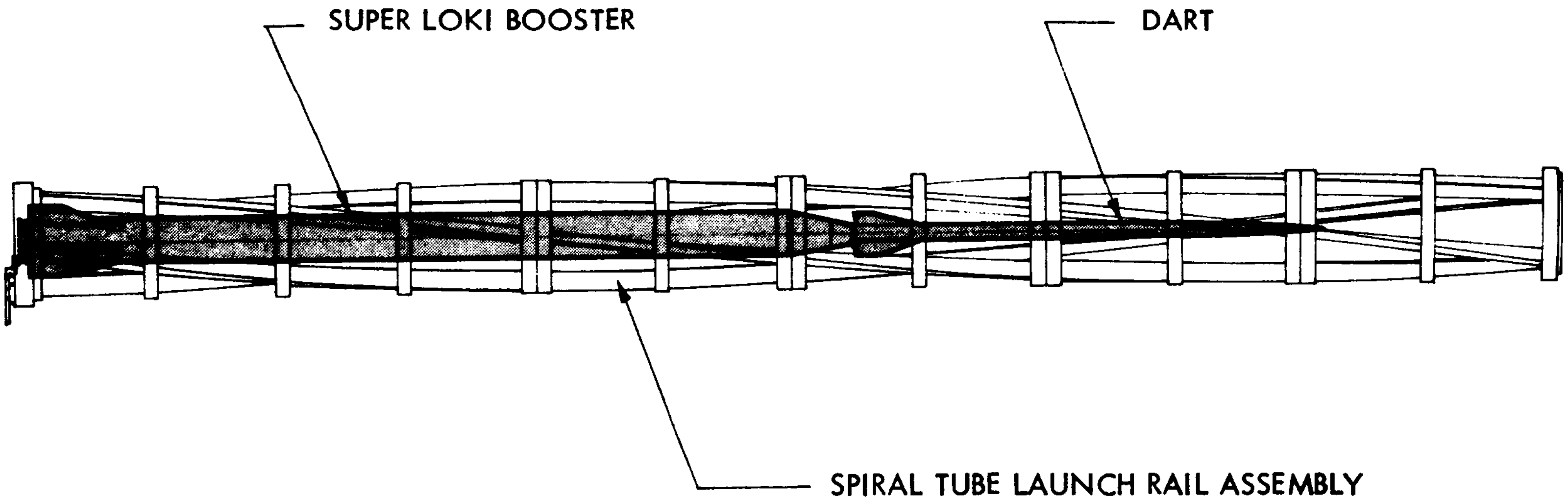


FIGURE 7.6 LAUNCH INSTALLATION - FINAL

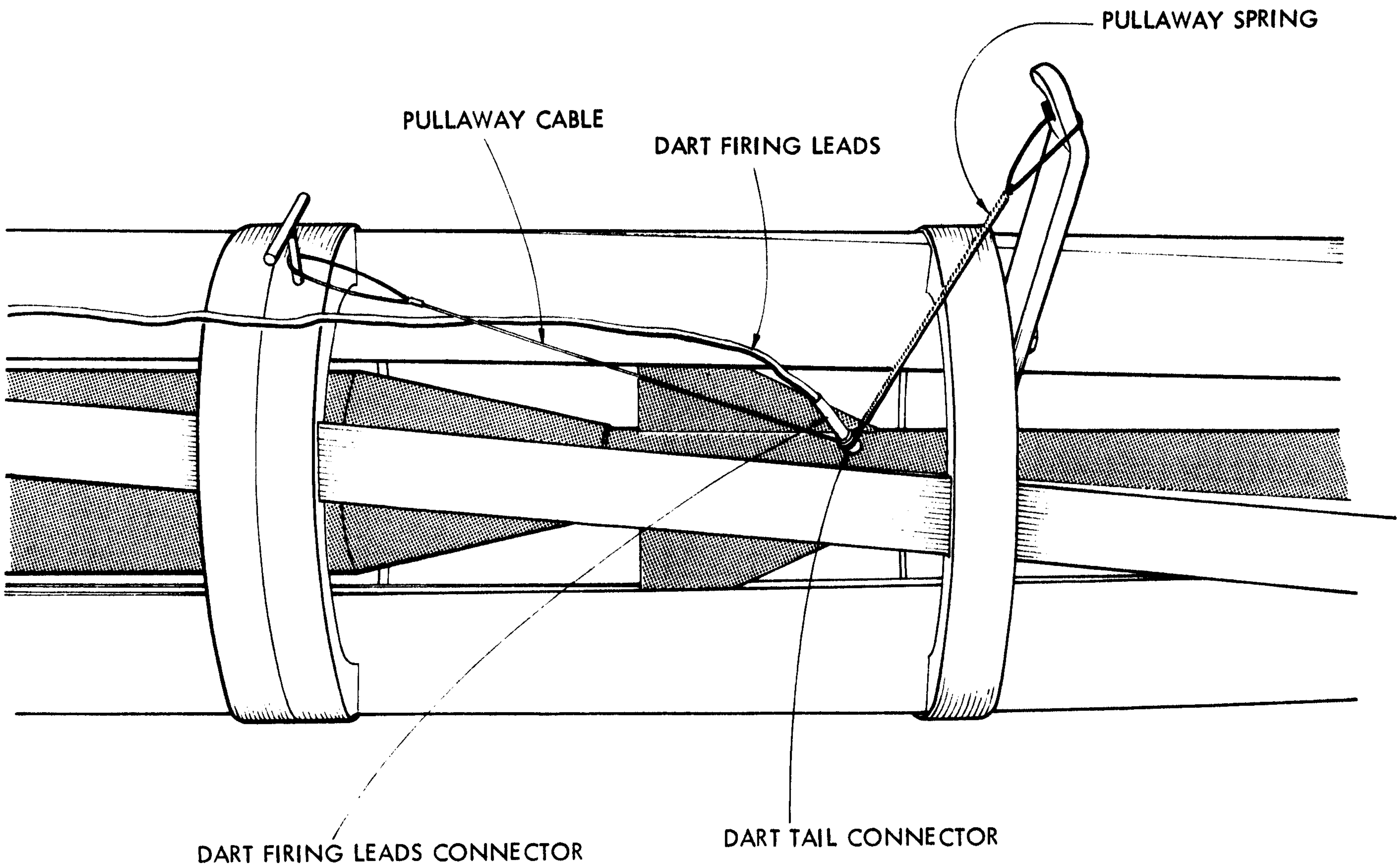


FIGURE 7.7 DART FIRING LINE CONNECTION

8. Perform continuity test of dart initiator through firing leads. Resistance should be within 0.80 to 1.30 ohms.

9. Perform continuity test of igniter through firing leads connector positions C and D. Resistance should be within 0.50 to 0.70 ohms.

10. Vehicle is now ready for launch. Provide at least 5.0 amperes to fire dart delay and 10.0 amperes to fire rocket motor igniter. Dart initiator ignition reliability will be enhanced by supplying initiation current of 5.0 amperes at T-5 seconds (i.e., 5 seconds before rocket motor is ignited.)

8. DEVELOPMENT FLIGHT TEST RESULTS

A series of five developmental flight tests of the Super Loki Dart were conducted at the White Sands Missile Range to prove out the vehicle system. As is the custom at White Sands for Loki Dart type vehicles, the launch angles were not adjusted for wind effects, and all vehicles were launched at an azimuth setting of 344 degrees, even though surface level winds varied from 1.03 m/sec to 12.87 m/sec (2 to 25 knots). Complete radar tracks were obtained for flights number 2, 4 and 5, and these agreed quite well with the theoretical trajectory. A late radar aquisition of the descending chaff payload for flight number 1 permitted an estimate of apogee altitude for this flight. No radar data was obtained for flight number 3. A summary of the flight test results is presented in Table 8.1. Since, after apogee, the radar tracks the descending chaff target rather than the vehicle, the vehicle impact data had to be estimated from the apogee data.

A plot of the estimated dart impacts is presented in Figure 8.1. These impact displacements from the nominal include the full effect of the winds, since launcher adjustments were not made to compensate for wind effects.

At least four of the vehicles in this flight test series performed in accordance with the theoretical trajectories and demonstrated impact dispersions within predicted values. Although the fifth vehicle was not tracked by radar, visual observation indicated a normal flight at least through the propulsive phase.

TABLE 8.1

SUPER LOKI DART FLIGHT TEST SUMMARY

Flight Number	Flight Date	Launch Location	Launch Settings Elevation (degrees)	Launch Settings Azimuth (degrees)	Apogee Altitude (Feet)	Apogee Time (Sec)	Estimated Impact Range (Feet)	Estimated Impact Azimuth (Degrees)	Surface Wind Degrees	Surface Wind Knots
1	22Apr68	WSMR	85	344	420,000 (est)	168 (est)	No Radar Track Over Apogee		270	25
2	6May68	WSMR	80	344	410,000	165	306,000	340	280	20
3	6May68	WSMR	80	344	No Radar Track				270	20
4	20May68	WSMR	80	344	411,000	160	316,000	349	240	2
5	20May68	WSMR	80	344	405,000	162	311,000	347	180	10
Theoretical Trajectory		WSMR	80	344	409,500	162	301,113	344	-	-

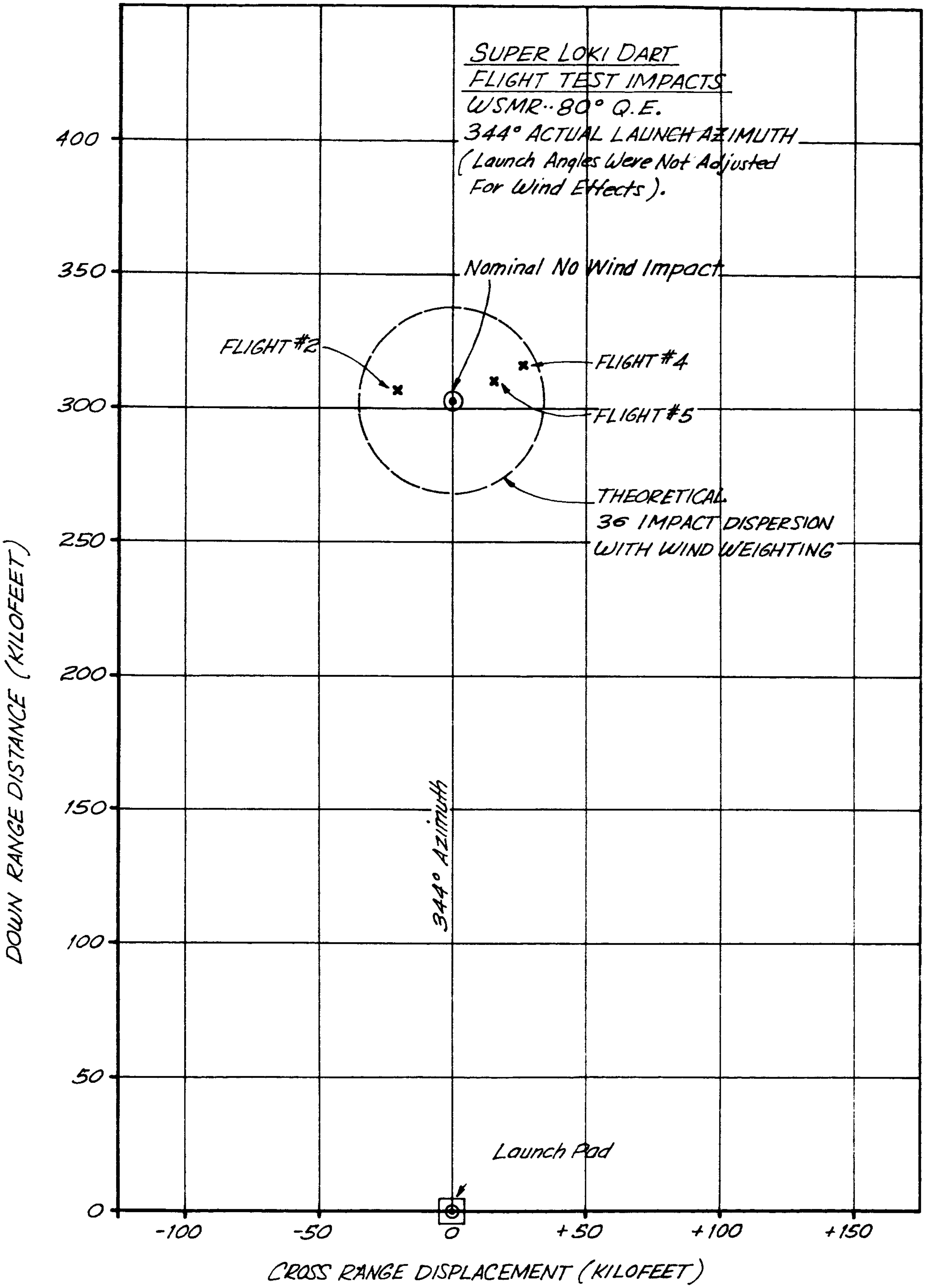

SUPER LOKI DART
FLIGHT TEST IMPACTS
WSMR··80° Q.E.
344° ACTUAL LAUNCH AZIMUTH
(Launch Angles Were Not Adjusted For Wind Effects).
Nominal No Wind Impact
FLIGHT #2
FLIGHT #4
FLIGHT #5
THEORETICAL 3σ IMPACT DISPERSION WITH WIND WEIGHTING
344° Azimuth
Launch Pad
400
350
300
250
200
150
100
50
0
-100
-50
0
+50
+100
+150
DOWN RANGE DISTANCE (KILOFEET)
CROSS RANGE DISPLACEMENT (KILOFEET)

FIGURE 8.1

9. HIGH ALTITUDE WIND PROFILE MEASUREMENT

The Super Loki Dart payload consists of 0.0127mm (0.5 mil) thickness aluminized Mylar chaff. This chaff is cut to "S" band radar dipole length which is the same as full wavelength for the "C" band radar. Thus both "S" band and "C" band radars may be used for tracking. The advantage of this chaff, over other possible radar targets, is that it has the lowest sectional density available for a radar target, and therefore, results in the slowest fall rates for wind tracking.

As can be seen from the theoretical fall rate curves of Figure 9.1, the higher the apogee and ejection altitude, the faster the descent velocity is at altitudes above 85 km. Wind shear measurement error is a function of the square of the descent velocity, therefore, it is important to obtain as slow a descent rate as possible throughout the altitude region of interest. Since the current program requires wind data for sea level launch sites from an altitude of 85 km to 65 km, the apogee altitude of the system should be about 90 km.

The developmental flight tests at the White Sands Missile Range (1219 m - 4,000 ft. launch elevation) were primarily to test vehicle performance and the apogee altitudes were too high for optimum wind measurement. The sea level launches should result in apogees close to the optimum for the stated measurement requirements.

Although the flights at White Sands were too high for optimum wind measurement, the data is presented here as an example. The chaff descent profiles for the White Sands flights were quite similar and are represented by Figure 9.2. The matching fall rate profile as shown in Figure 9.3 indicates that maximum descent velocities of over 609.6 m/sec (2,000 fps) were obtained at an altitude of about 90 km.

The high altitude wind profiles derived from the Super Loki flights at White Sands are presented in Figure 9.4. The wind profiles obtained from the High Energy Loki (apogee 85 km) and the regular Loki (apogee 65 km) chaff targets are also plotted for comparison purposes. From sea level launch sites wind data is expected at higher altitudes with the Super Loki system since the vehicle apogee will be lower and the chaff descent rates not as great.

THEORETICAL FALL RATE OF 0.5 mil MYLAR CHAFF
(289 m/sec (950 fps) HORIZONTAL VELOCITY AT APOGEE)

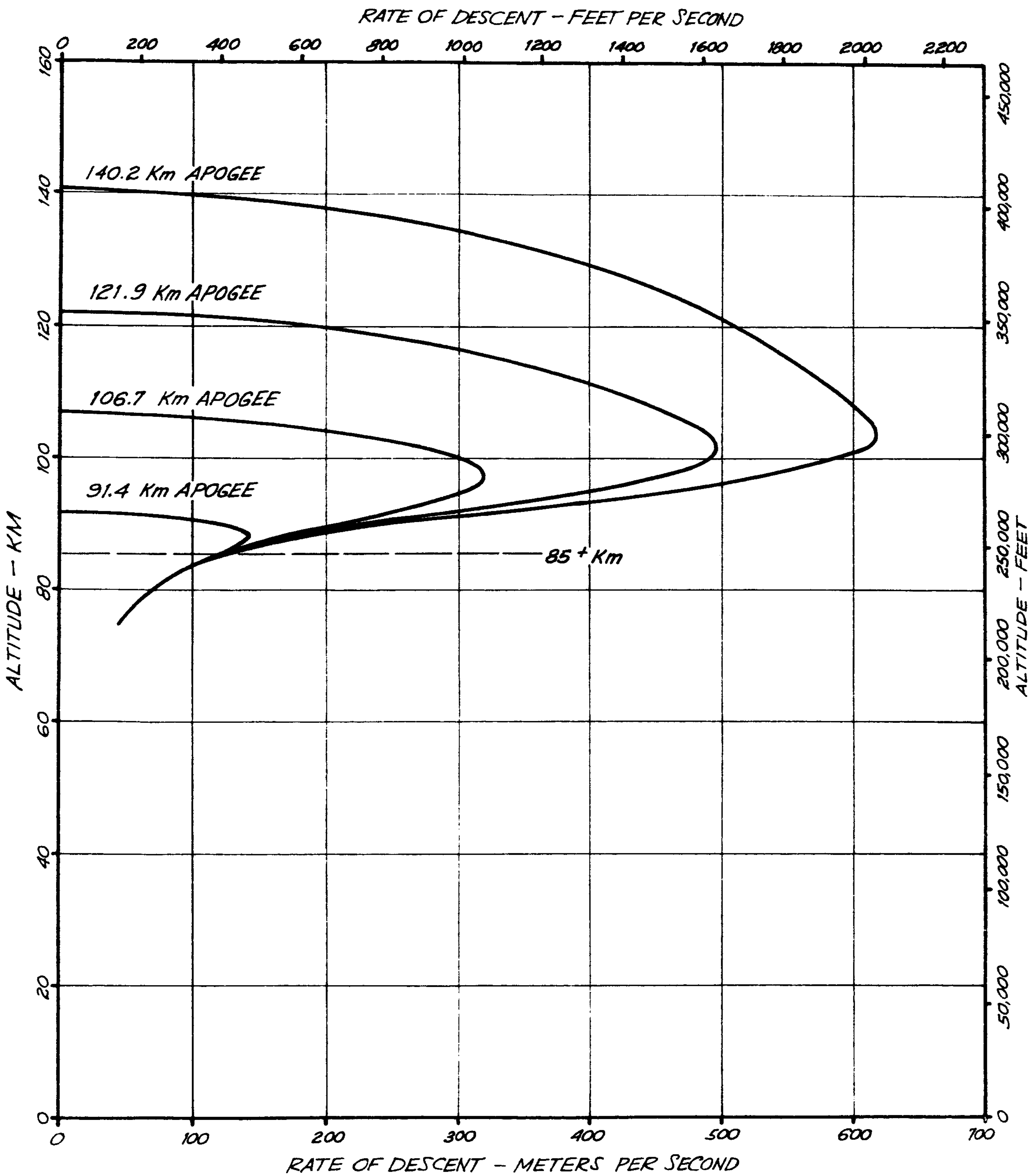


FIGURE 9.1

FIGURE 9.2 TYPICAL CHAFF DESCENT PROFILE WSMR FLIGHT TEST SERIES

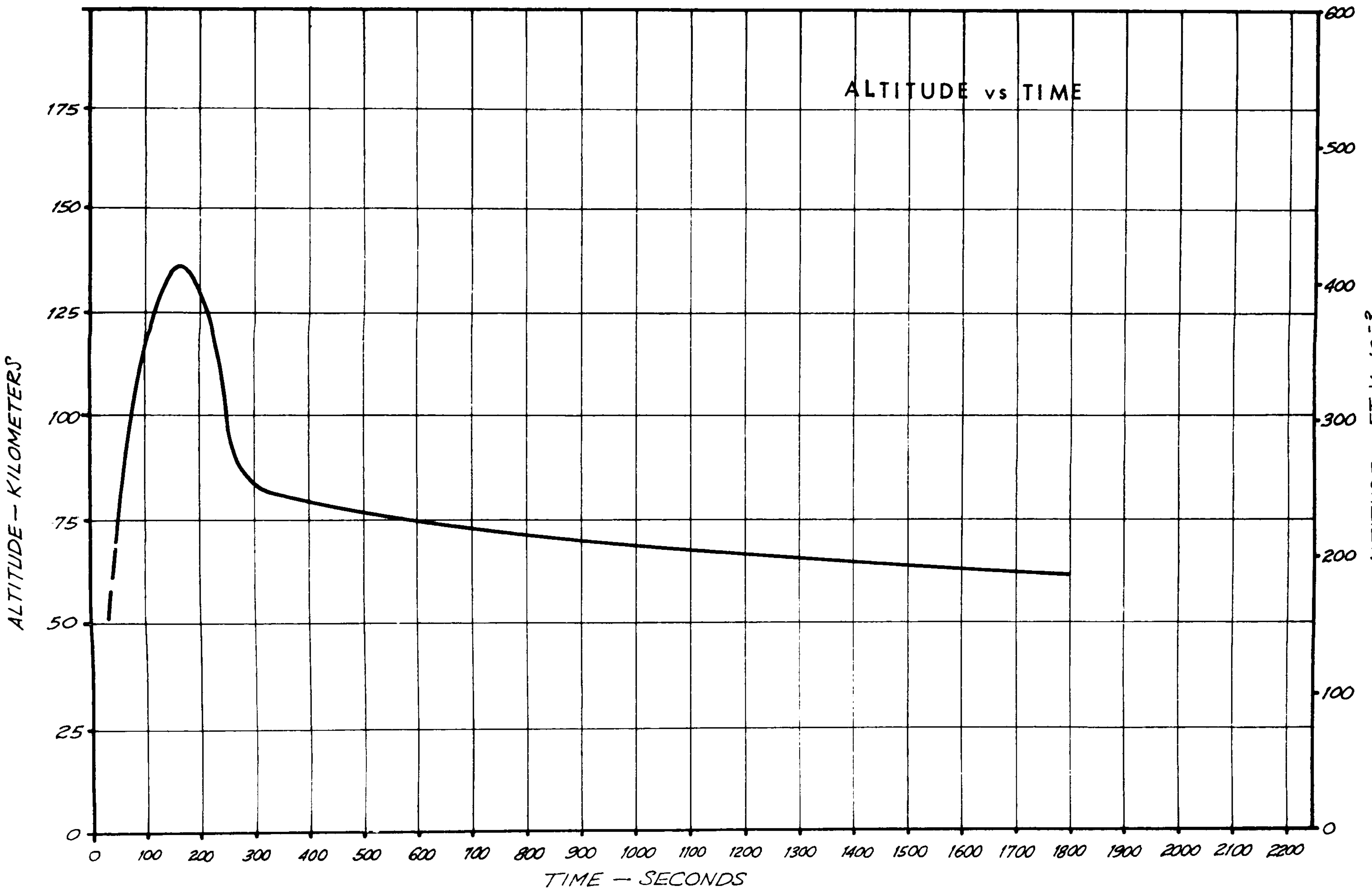


FIGURE 9.3 TYPICAL CHAFF FALL RATE PROFILE FOR WSMR FLIGHTS
SUPER LOKI #4 - FALL RATE vs ALTITUDE

20 May 1968

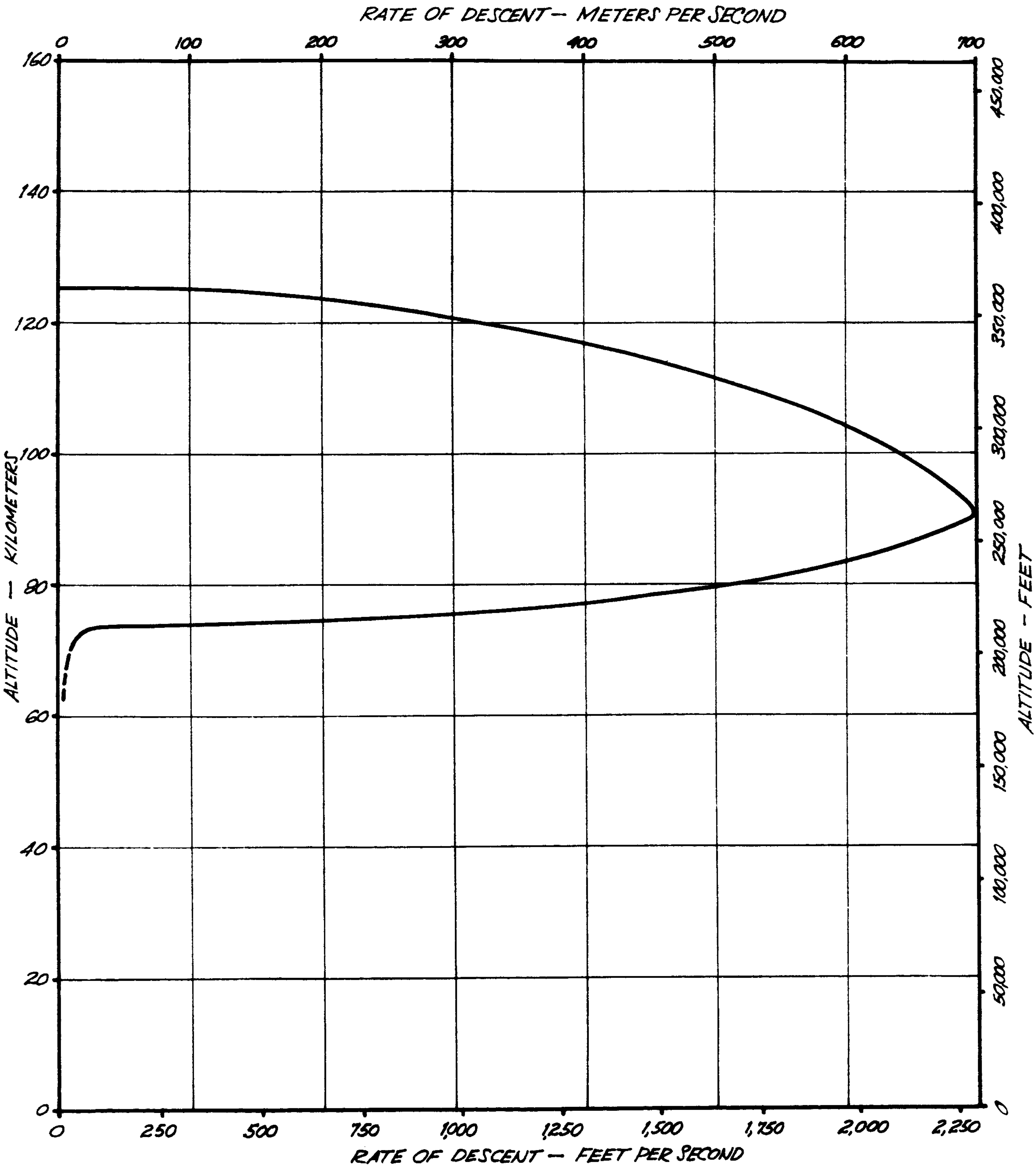


FIGURE 9.4

HIGH ALTITUDE WIND DATA, WHITE SANDS MISSILE RANGE

22 April 68
0900 MOT

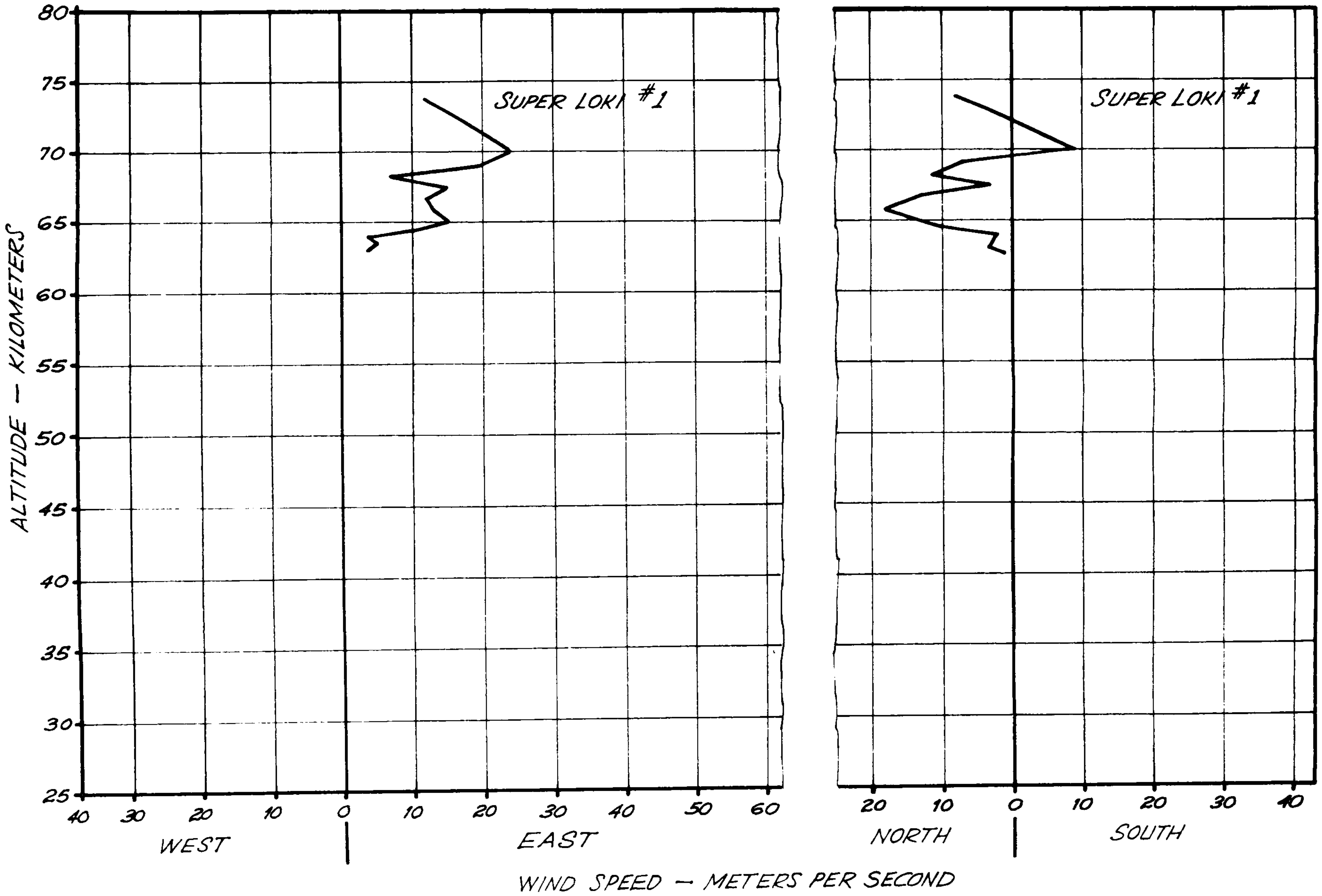
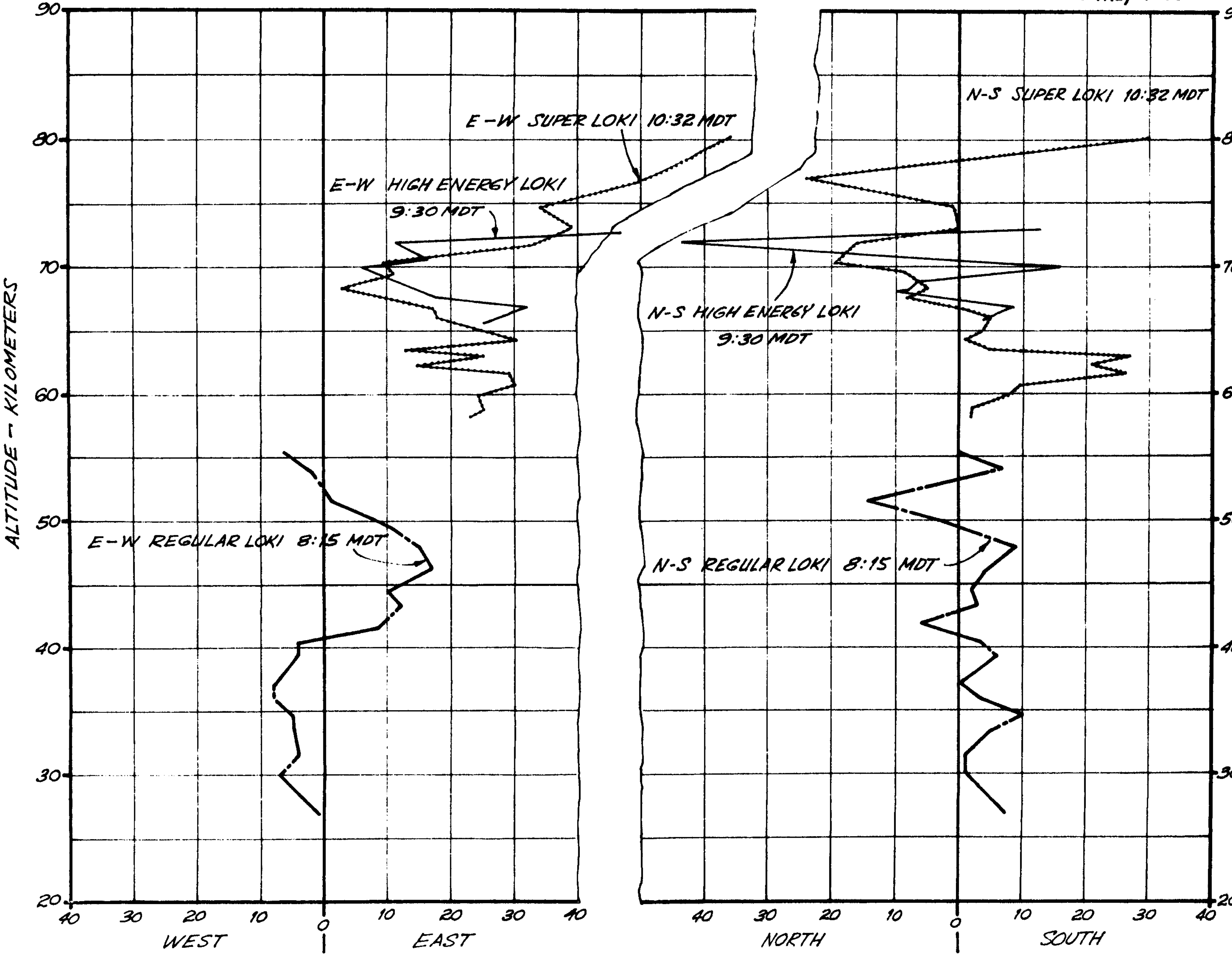


FIGURE 9.4 (Cont.) HIGH ALTITUDE WIND DATA

6 May 1968



HIGH ALTITUDE WIND DATA

20 May 1968 N-S Component

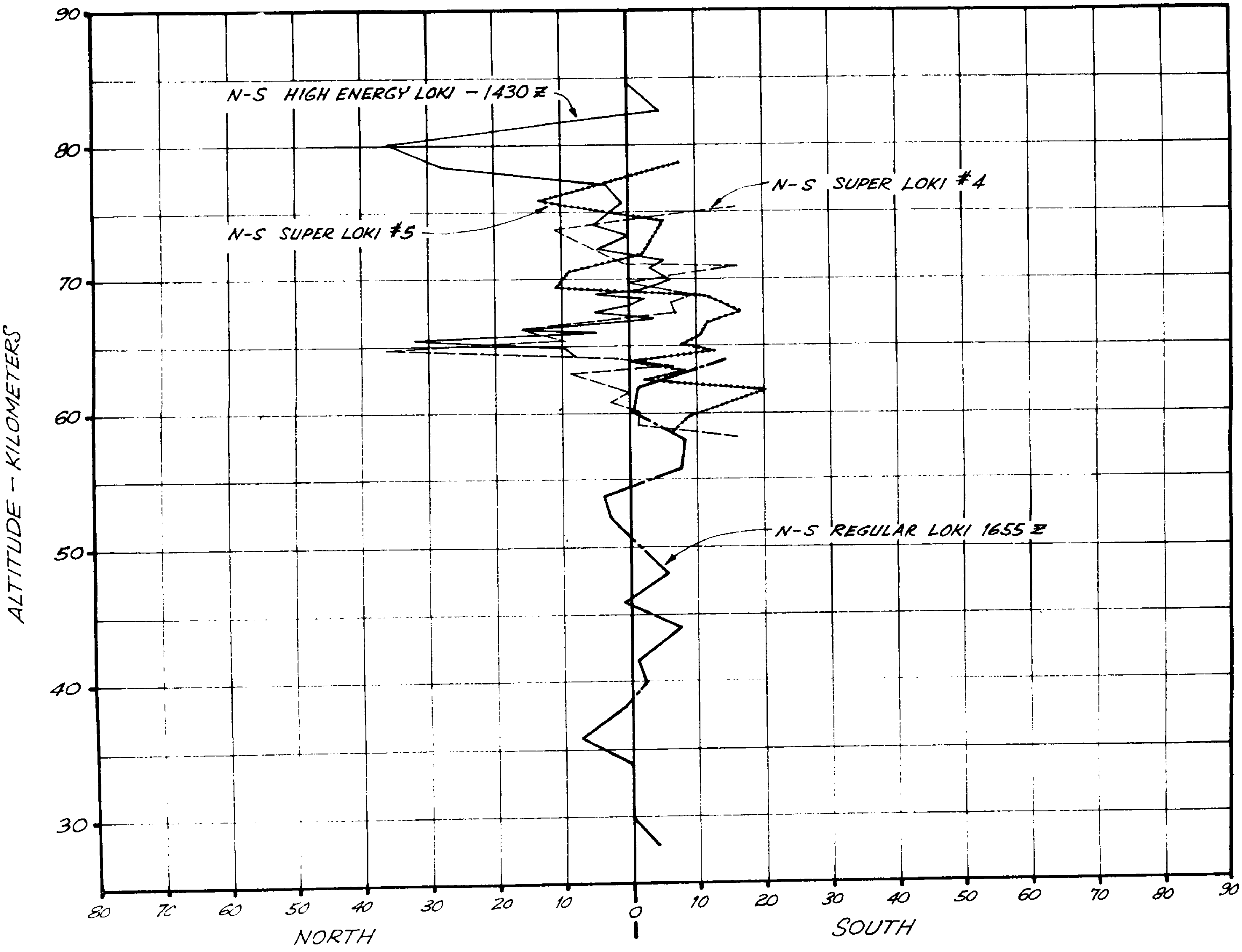
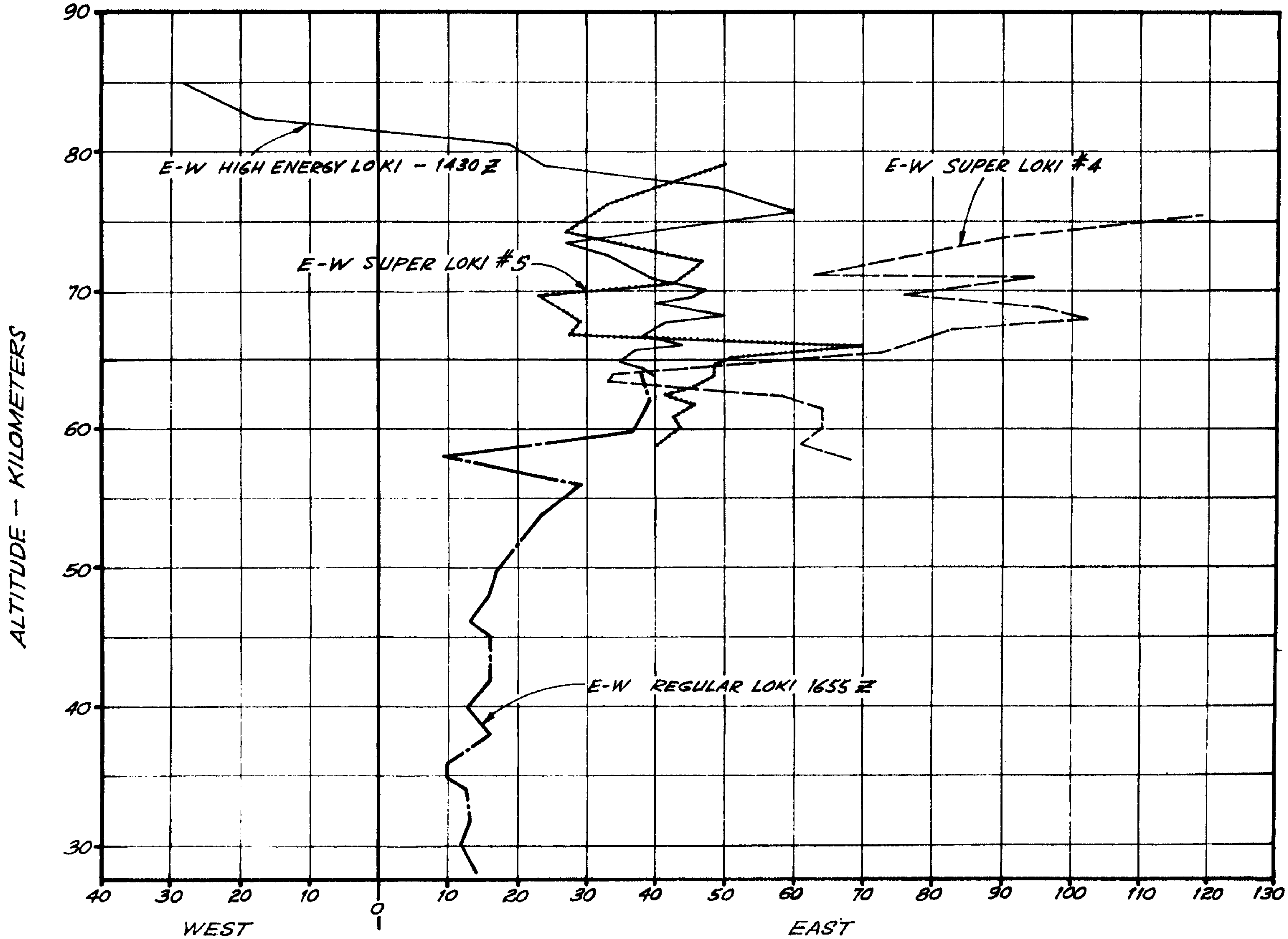


FIGURE 9.4 (Cont.)

FIGURE 9.4 (Cont.)

HIGH ALTITUDE WIND DATA 20 May 1968 E-W Component



10. OTHER APPLICATIONS

The development of a two-inch (5.08 cm) diameter instrument dart for the Super Loki system is proposed as a follow-on to the chaff dart system development to improve the altitude and measurement capability of current instrumented systems. An 85 km apogee is achievable with the proposed instrumented dart system, and the payload volume is more than double that of the current instrumented dart systems. This increased volume can be used for additional sensors, a transponder/telemetry sonde, and most important, an increased-size parachute to obtain significantly slower descent rates of the sonde during the measurement period. Temperature and wind measurement errors of current systems are functions of the square of the descent velocity, and a significant improvement in measurement accuracy can accrue by reducing the parachute descent rate. The cost of this instrumented dart system should not be significantly greater than the current instrumented dart systems.

The proposed Super Loki Instrumented Dart system consists of the Super Loki rocket motor and a two-inch diameter (5.08 cm) dart. The dart is designed to contain a maximum diameter parachute to extend the altitude and improve the accuracy of wind and temperature measurements. Performance of this system is as follows:

Launch Angle	85°
Dart Weight	14 lb (6.35 kg)
Apogee Altitude	85 km
Apogee Range	15 km
Apogee Time	132 sec.
Burnout Velocity	Mach 5.4
Maximum Acceleration	102 g

A nominal trajectory is plotted in Figure 10.1

The two-inch (5.08cm) diameter instrumented dart contains a payload volume of 80 cubic inches (1311.2 cm^3). This is more than twice the payload volume of the 1.437 inch diameter (3.65 cm) instrumented dart which is currently being used. Either a 1680 mc/GMD-(x) or a 403 mc/SMQ-1 sonde can be used with the proposed dart depending upon ground-station equipment. SDC is currently manufacturing both kinds of sondes for the USAF, PMR and WSMR and the Navy, respectively. Descent rates of the sonde system can be slowed to 230 fps (70.1 m/sec) at 61 km with a Super Loki system ($\frac{W}{C_D A}$ = 0.015 lb/ft^2), or 0.073 kg/m^2. Advantages of the Super Loki two-inch (5.08 cm) Instrumented Dart over the current Loki 1.437 (3.65 cm) inch Instrumented Dart are presented in Table 10.1.

SPACE DATA CORPORATION

SUPER LOKI INSTRUMENTED DART NOMINAL TRAJECTORY
85° SEA LEVEL LAUNCH
5.44 KG (12 LB)/5.08 CM (2.000IN) INSTRUMENTED DART

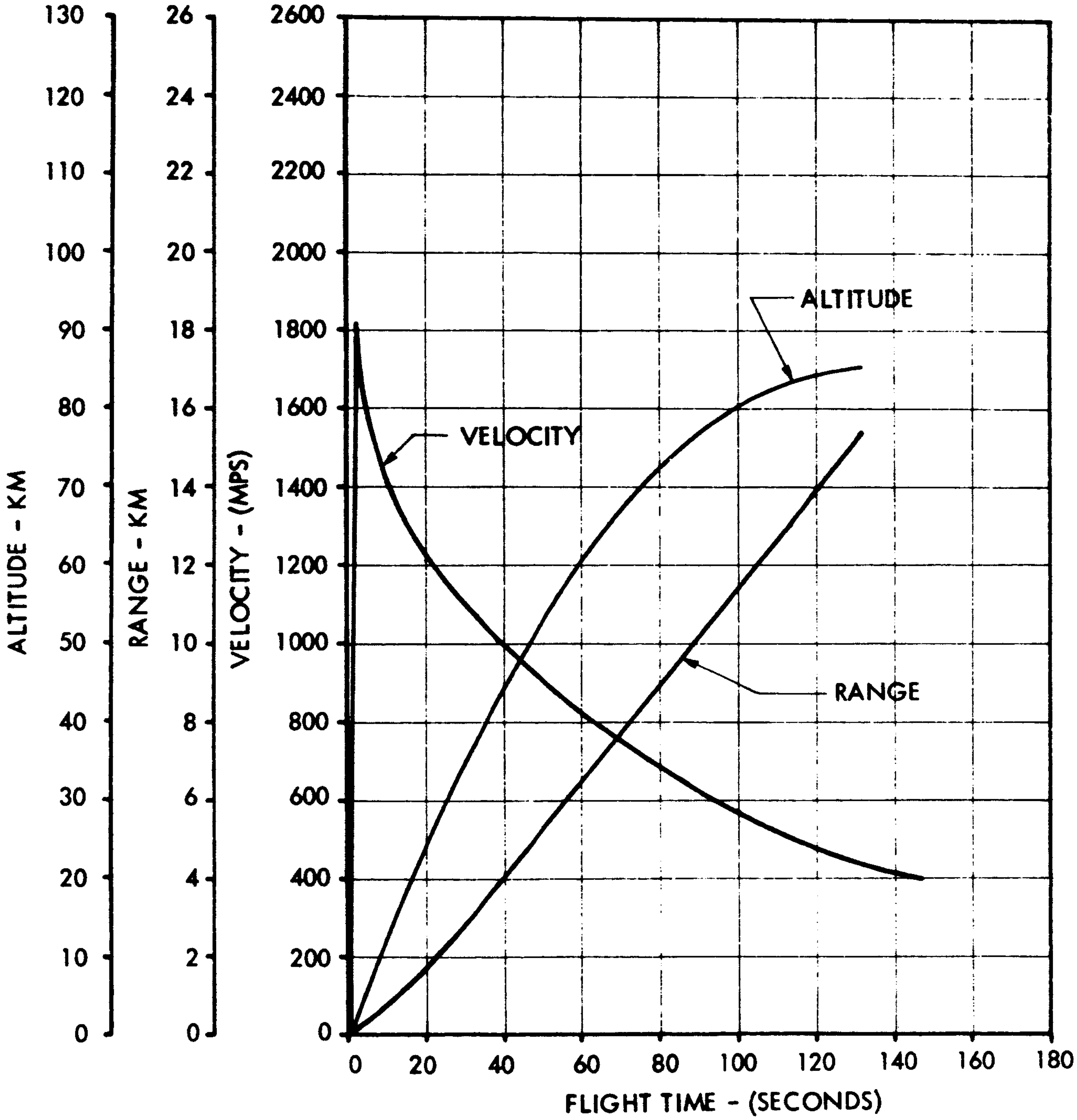


FIGURE 10.1

TABLE 10.1

COMPARISON OF THE SUPER LOKI
5.08 CM INSTRUMENTED DART SYSTEM
WITH THE CURRENT
3.65 CM INSTRUMENTED DART SYSTEM

	Super Loki System	Standard Loki System
Apogee Altitude	85 km	63 km
Dart Diameter	2.0 in (5.08 cm)	1.437 in (3.65 cm)
Payload Volume	80 cu in. ($1311.2\ cm^3$)	33 cu. in. ($540.9\ cm^3$)
Payload Volume Available for Parachute	67 cu in. ($1098.1\ cm^3$)	20 cu in. ($327.8\ cm^3$)
Parachute-Sonde Ballistic Coefficient, W/C_dA	$0.073\ kg/m^2$ ($0.015\ lb/ft^2$)	$0.146\ kg/m^2$ ($0.030\ lb/ft^2$)
Descent Rate at 61 km	70.1 m/sec (230 ft/sec)	$100.6\ m/sec^2$ (330 ft/sec)
Dart Ablative Coating	Not Required	Required

An inflatable falling sphere payload has been suggested by the Army personnel at White Sands Missile Range for use with the existing chaff dart design. Since altitudes of 125 km were obtained at White Sands, reasonably good density data may be derived with the Robin falling sphere payload to altitudes below 90 km with the Super Loki. Since the apogee altitude for a sea level launch will only be about 113 km, the falling sphere density data may be restricted to a maximum altitude of 85 km for sea level sites.

DISTRIBUTION

INTERNAL

R-DIR
Mr. Weidner

R-AS-DIR

Mr. F. Williams

R-ASTR
Dr. Haeussermann

R-P&VE
Dr. Lucas

I-MO-MGR
Dr. F. A. Speer

I-S/AA
Mr. Leland F. Belew

MS-IL (8)

MS-IP

MS-H

R-COMP-R
Mr. R. J. Cochran
Mr. Paul Harness

R-SSL-DIR
Dr. Stuhlinger

R-AERO
Dr. Geissler
Mr. Jean
Mr. W. Vaughan (5)
Mr. O. Smith (2)
Mr. Kaufman
Mr. Daniels
Mr. Turner (25)
Dr. L. DeVries
Mr. S. C Brown
Mr. D. Johnson
Mr. H. J. Horn
Mr. W. K. Dahm
Mr. W. Murphree

R-EO-DIR
Dr. W. Johnson

R-SE-DIR
Mr. L. Richards

EXTERNAL

NASA Representative (25)
S-AK/RKT
Scientific & Technical Information
Facility
Box 33
College Park, Maryland

National Aeronautics & Space Admin
Washington, D. C. 20546
ATTN: Tech Library (2)
Office of Advanced Res & Tech
Office of Manned Space Flight

NASA-Manned Spacecraft Center
2101 Webster Seabrook Road
Houston, Texas 77058
ATTN: Director
Mr. J. Eggelston
Mr. D. Wade
Mr. J. P. Mayer

NASA
Langley Research Center
Langley Station
Hampton, Virginia 23365
ATTN: Director
Mr. Tolefson
Tech Library (2)

NASA
John F. Kennedy Space Center
Kennedy Space Center, Florida 32899
ATTN: Mr. R. Clark
Mr. A. Taiani
Mrs. Russell, Tech Library

NASA
Electronics Research Center
Cambridge, Massachusetts 02142
ATTN: Director
Tech Library

NASA
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
ATTN: Mr. Jack Estes
Technical Library

Mr. J. Giraytys
CODE: W141
Chief, Requirements Branch
U. S. Weather Bureau, ESSA
Silver Spring, Md. 20910

Mr. S. F. Kubinski
CODE: AMSEL-BL-WS-S
Atmospherics Science Office
Atmospherics Sciences Lab.
USA Electronics Command
White Sands Missile Range, NM 88002

Lt./Col. W. D. Kleis, SCWT
Air Force Systems Command
Andrews Air Force Base
Washington, D. C. 20331

Lt./Col. D. E. McPherson, SSOW
SSD Staff Meteorologist
Hq. Space Systems Division
Air Force Systems Command
Los Angeles Air Force Station
Air Force Unit Post Office
Los Angeles, California 90045

Mr. R. Leviton (CRER)
Air Force Cambridge Research Lab.
L. G. Hanscom Field
Bedford, Mass. 01730

Mr. V. S. Hardin (AWVAR)
Air Weather Service
Scott Weather Service
Scott AFB, Ill. 62225

Mr. A. L. Miller
CODE: AIR-5403
Naval Air Systems Command
Wahington, D. C. 20360

Mr. R. M. Fenn
CODE: KXR
U. S. Naval Weapons Laboratory
Dahlgren, Va. 22448

Mr. H. Demboski
CODE: 421
Office of Naval Research
Washington, D. C. 20360

Comd. F. F. Duggan, Jr., USN
CODE: 70
Naval Weather Service
Washington (Navy Yard Annex)
Washington, D. C. 20390

Mr. G. P. Tennyson, Jr.
Meteorology & Sounding Branch
Hq., National Aeronautics & Space
Administration, OSSA
Washington, D.C. 20546

Mr. Kenneth C. Steelman
AMSEL-BL-ED
U. S. Army Electronics Labs.
Fort Monmouth, New Jersey 07703

Commander, Sixth Weather Wing
Andrews Air Force Base
Washington, D.C. 20331

Commander (2)
Air Weather Service (MATS)
U. S. Air Force
Scott Air Force Base, Illinois 62225

Mr. Kenneth Nagler
Spaceflight Meteorology Group
U. S. Department of Commerce
Weather Bureau
Washington, D. C. 20235

Mr. Clyde D. Martin
Technical Staff
Rockwell Corp.
12214 Lakewood Boulevard
Downey, California 90241

Dr. O. Essenwanger, AMSMI-RRA
U.S. Army Missile Command
Redstone Arsenal, Alabama 35809

AMC Technical Library
Redstone Arsenal, Alabama 35809

Meteorological & Geo-Astrophysical
Abstracts
P. O. Box 1735
Washington, D. C. 20300

Mr. Robert Walker (10)
Space Data Corporation
2875 Sky Harbor Boulevard
Suite 204
Phoenix, Arizona

Mr. Bruce Bollermann (10)
Space Data Corporation
2875 Sky Harbor Boulevard
Suite 204
Phoenix, Arizona

Mr. William C. Spreen, FM (3)
National Aeronautics & Space Admin
Office of Space Science & Application
Washington, D. C. 20546

Mr. Norman Sissenwine
Air Force Cambridge Res Labs
L. G. Hanscom Field
Bedford, Mass. 01730

Maj. Ralph R. Ruyle, PGGW
U. S. Air Force
Air Proving Ground Center
Eglin Air Force Base, Florida 32542

Mr. Lawrence B. Smith
Sandia Corporation
Sandia Base
Albuquerque, N. M. 87115

Mr. C. J. Callahan, FC-3
Federal Coordinator Office
U. S. Department of Commerce
ESSA
Washington, D.C. 20235

Mr. O. H. Daniel
CODE: MU 235, Bldg. 800
Pan American World Airways, Inc.
Air Force Western Test Range
Patrick AFB, Fla. 32925

Lt./Col. Dodd, USAF
Det.11, 4th-Weather Group
Air Force Eastern Test Range
Patrick AFB, Fla. 32925

Maj. G. L. Tucker, USAF
CODE: WEA
Air Force Flight Test Center
Edwards AFB, Calif. 93523

Mr. B. F. Walker (PGLW)
Air Proving Ground Center
Eglin AFB, Fla. 32542

Lt./Col. C. J. Loisel, USAF
CODE: SMSW
SAMSO
Los Angeles Unit Post Office
Los Angeles, Calif. 90045

Lt./Col. J. M. Tyndall
CODE: WTW
Air Force Western Test Range
Vandenberg AFB, CA 93437

Mr. N. J. Asbridge (WTWU)
Air Force Western Test Range
Vandenberg AFB, Calif. 93437

Mr. Q. S. Dalton
CODE: 3069
Naval Weapons Center
China Lake, Calif. 93555

National Aeronautics & Space Admin
Office of Space Sciences & Appli
Washington, D. C. 20546
ATTN: Director
Dr. Tepper (3)

Mr. K. R. Jenkins
AMSEL
U. S. Army Electronics R&D Activity
White Sands Missile Range, N.M. 88002

Mr. Lee L. Sims
USAERDAA
Meteorology Department
U. S. Army Electronic Proving Ground
Fort Hauchuca, Arizona 85613

Mr. J. F. Spurling
Associate Member, MWG
Inter-Range Instrumentation Geoup
Meteorological Projects & Systems
Range Engineering Division
Wallops Station, NASA
Wallops Island, Virginia 23337

Major E. V. von Gohren
Aerospace Environmental Consultant
Headquarters 6th Weather Wing (MAC)
Andrews Air Force Base
Washington, D. C. 20331

Mr. W. L. Webb
AMSEL-BL-WS
Atmospheric Sciences Office
Atmospheric Sciences Laboratory
U.S.A. Electronic Command
White Sands Missile Range, N.M. 88002

Lt/Col. J. G. Coblenz
PGLW
U. S. Air Force
Air Proving Ground Center
Eglin Air Force Base, Florida 32542

Mr. B. R. Hixon
CODE: 3252. 30, Box 22
Pacific Missile Range
Point Mugu, Calif. 93041

Capt. T. H. R. O'Neill, USN
Chief, Environmental Sciences Div.
Office of Asst. Director, (RSCH)
OSD/Dept of Defense Rsch & Engr
Room 3C-128, Pentagon
Washington, D. C. 20301

Mr. C. A. Olson
CODE: 7221
Sandia Corporation
Albuquerque, N.M. 87115

Mr. P. E. Carlson
STEDP-TO-M
Meteorology Division
Dugway Proving Ground, Utah 84022

Mr. A. J. Krueger
CODE: 602
Naval Weapons Center
China Lake, California 93555