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CAJUN DART 95 KILOMETER SOUNDING ROCKET

Prepared under Contract No. NAS 8-20687 by
Bruce Bollermann and Robert L. Walker

SPACE DATA CORPORATION

For

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

ABSTRACT

The Cajun Dart vehicle has been developed to conduct low cost meteorological soundings to altitudes of 95 kilometers (310,000 feet). The vehicle consists of a first-stage Cajun solid-propellant rocket motor and a second-stage non-propulsive dart. Rocket motor burnout occurs in a few seconds and at a low altitude. A high velocity is imparted to the dart which separates from the motor and coasts to apogee. Since the dart has a high ballistic coefficient, the drag losses of the system are minimized. The wind-measurement payload which has been used with the Cajun Dart consists of thin Mylar chaff strips which have been aluminized for radar reflection. This chaff payload is ejected at apogee altitude, and a radar track of the resulting chaff cloud provides wind information from 65 to 90 kilometers (215,000 to 295,000 feet). Other small diameter payloads, such as inflatable spheres, have been flown with the Cajun Dart.

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1331 South 26th Street
Phoenix, Arizona

For

Aero-Astrodynamics Laboratory

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER

TABLE OF CONTENTS

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 NAS8-20687.

INTRODUCTION

In February of 1964 the Aero-Astrodynamics Laboratory of the George C. Marshall Space Flight Center solicited proposals for a rocket vehicle system to measure winds in the altitude region from 70 to 90 kilometers (230,000 to 295,000 feet). The system subsequently selected was the Cajun Dart vehicle with a radar-reflective chaff payload. Development and initial flight testing of the vehicle and payload was accomplished by Space Data Corporation under contract NAS8-11624 with subsequent production units supplied under contracts NAS8-18057 and NAS8-20687. The Cajun Dart vehicle has also been used to carry combination inflatable sphere and chaff payloads to an altitude of 95 kilometers (310,000 feet).

DEVELOPMENT PROGRAM

The Cajun Dart vehicle was designed with a readily available Cajun rocket motor and a non-propulsive high ballistic coefficient dart. Launch lugs are employed on the rocket motor for single rail launching, and fins were designed for the Cajun motor for vehicle stability. An interstage was designed to retain the dart to the rocket motor during propulsive flight. This interstage permits rapid stage separation without interference during thrust tail-off of the booster. An electrically actuated delay train was designed into the dart together with a payload ejection charge. Light-weight aluminized Mylar chaff is packaged into the payload compartment of the dart for high altitude wind determination.

The initial six flight tests of the Cajun Dart system were successfully conducted during August 1964 at Eglin Air Force Base. An additional quantity of fifty-four units were shipped to Cape Kennedy for operational use. Improvements in the initial design were made during a second Cajun Dart contract which called for delivery of seven additional units to Cape Kennedy. The improvements included a redesigned interstage and the incorporation of an ablative coating on the booster fins. These modifications have been proven in flight test, and indications are that they have improved performance and reliability of the vehicle. An additional twenty vehicles have been delivered to Cape Kennedy for routine use under a third contract. The Naval Ordnance Laboratories and the Sandia Corporation have procured additional Cajun Dart vehicles subsequent to the development of the vehicle for NASA.

VEHICLE DESCRIPTION

The Cajun Dart, as shown in Figure 1, is a two-stage sounding rocket with a solid-propellant rocket motor as the first stage and a non-propulsive dart as the second stage. At launch the overall vehicle weight is 89 kilograms (196.4 pounds), and the overall length is 4.05 meters (13.3 feet). More detailed vehicle dimensions are presented in Figure 2.

The first stage of the vehicle consists of the Cajun Mod III rocket motor, an igniter, a booster fin set, an interstage and a forward launch lug. The Cajun motor is manufactured by the Thiokol Chemical Corporation, Elkton, Maryland. The motor is 2.6 meters (102 inches) long and has a principal diameter of 16.5 centimeters (6.5 inches). The motor less flight hardware weighs 76 kilograms (168 pounds) and contains 53.7 kilograms (118.5 pounds) of propellant. The nominal motor burning time of 2.8 seconds, with a total impulse of 11,450 kilogram-seconds (25,250 pound-seconds), yields a vehicle burnout velocity of slightly over 1,525 meters per second (5,000 feet per second) at an altitude of 2,140 meters (7,000 feet). The Cajun thrust and propellant weight vs. time schedule is presented in Table 1.

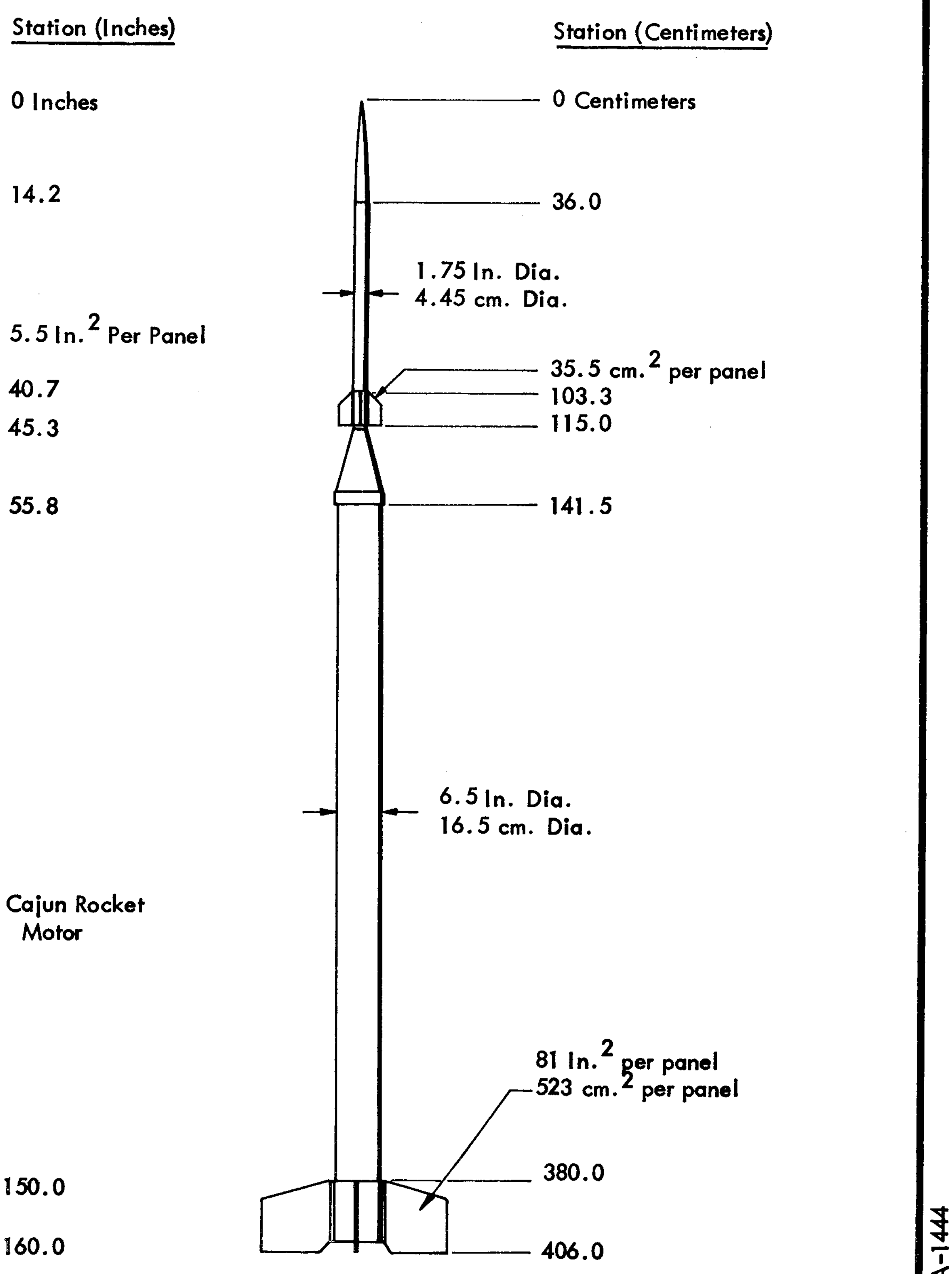
The rocket motor igniter, booster fin set, interstage and forward launch lug are manufactured by Space Data Corporation. The igniter consists of a combustible plastic tube containing two Flare Northern Model 209 squibs, 7.5 grams of ignition powder and 90 grams of USF-2A ignition granules. The two squibs are wired in parallel and have a 1 ampere/1 watt rating per AFMTC Form 87. The leads into the igniter are twisted and shielded. They terminate in a self-shorting connector. Pertinent electrical information for the squibs is listed in Table 2.

The booster fin set is screwed onto the rocket motor at the launch site, and is used to impart stability to the vehicle system during propulsive flight. The fin set also contains the aft launch lug as an integral structure. The forward launch lug is integral with its mounting ring which is mated to the forward end of the rocket motor. This mounting ring is retained by the interstage assembly which is screwed onto the forward end of the motor. In addition to providing structural coupling between the booster and second-stage dart, the interstage provides electrical leads and a connector to energize the dart delay at launch.

The second-stage dart, as shown in Figure 3, is 4.45 centimeters (1.75 inches) in diameter, 131.0 centimeters (51.7 inches) long and weighs 7.82 kilograms (17.28 pounds). The dart is non-propulsive and functions as a low drag payload housing for coasting efficiency. The nose of the dart has been designed to minimize wave drag, and the aft end of the dart has been boattailed to minimize base drag. A cross-section view of the dart assembly is shown in Figure 4. The forward end of the dart consists of a steel ogive with a lead

FIGURE 1. CAJUN DART ASSEMBLY

FIGURE 2 CAJUN DART VEHICLE DIMENSIONS



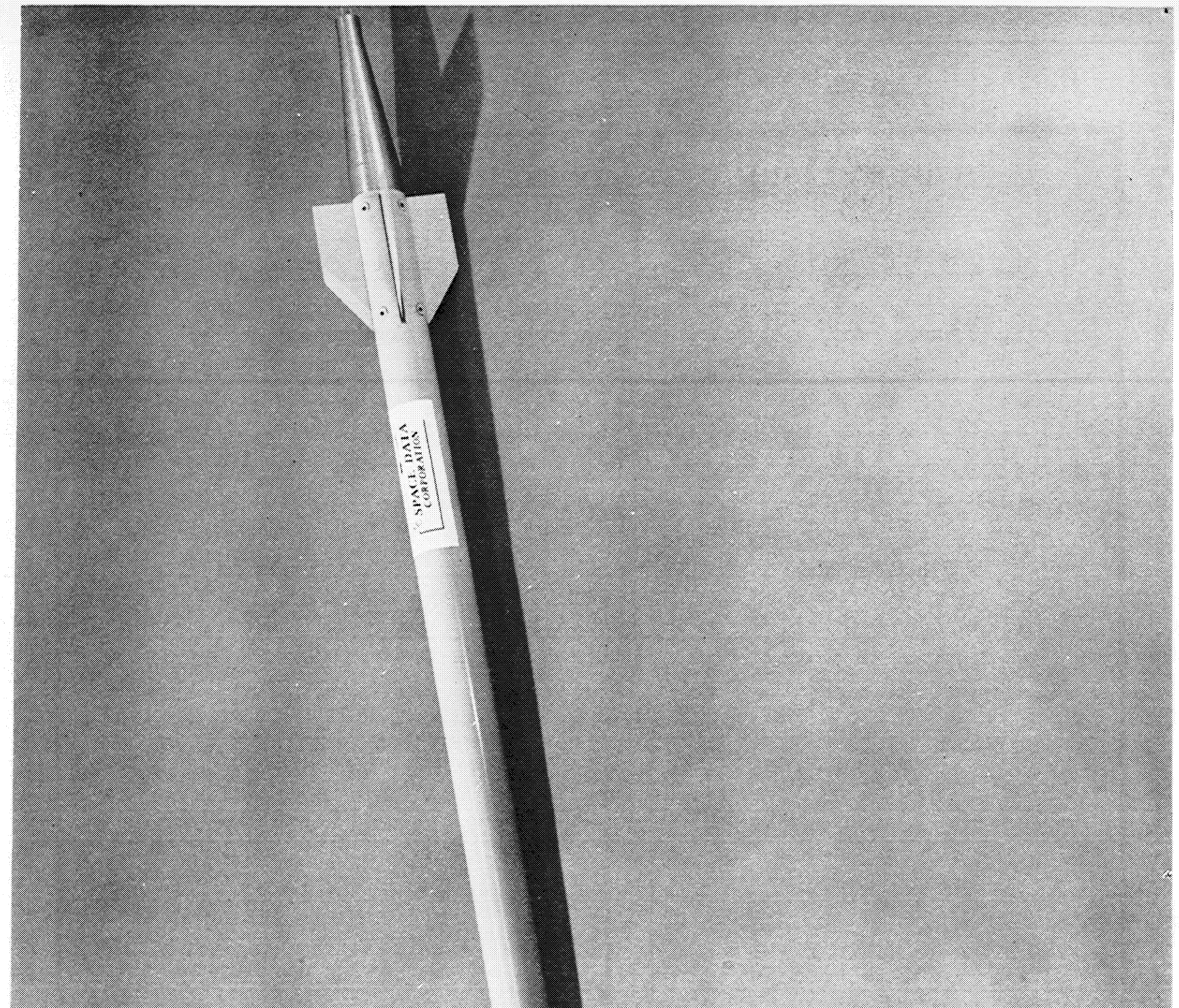


FIGURE 3. DART

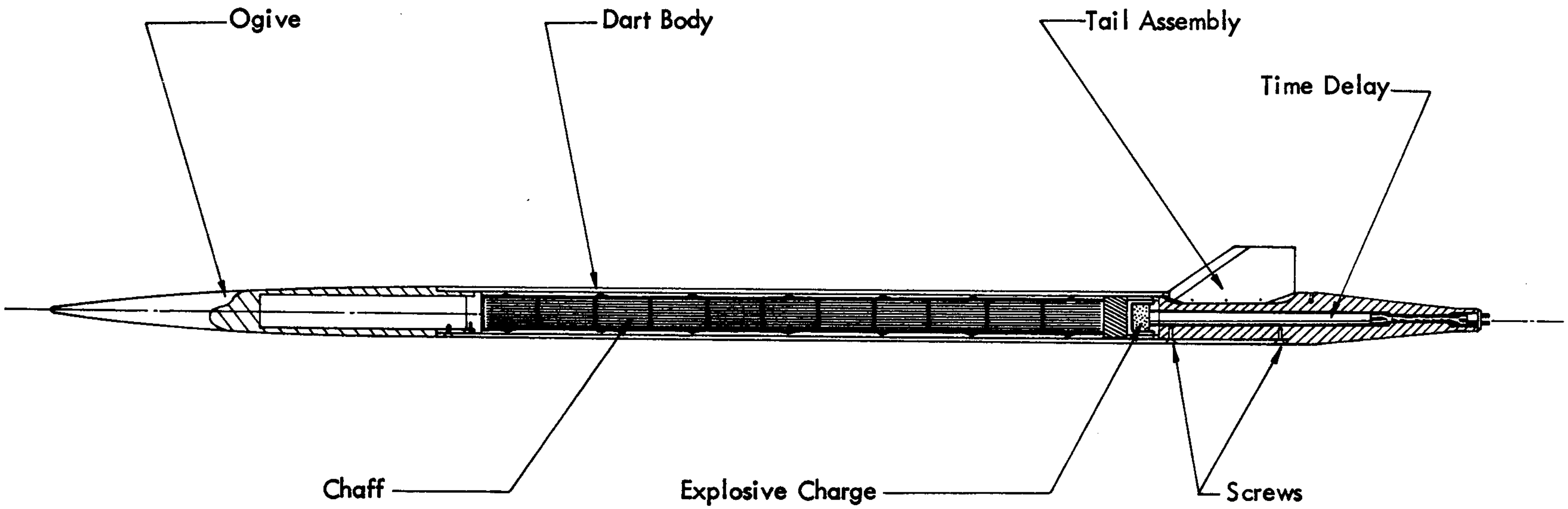


FIGURE 4 CAJUN DART ASSEMBLY

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TABLE I. CAJUN ROCKET MOTOR THRUST AND PROPELLANT WEIGHT SCHEDULE

Time	Thrust		Propellant Weight	
0.0 seconds	973 kg	2145 lb	53.75 kg	118.50 lb
0.1	3243 kg	7150 lb	52.97 kg	116.77 lb
0.4	3243 kg	7150 lb	48.30 kg	106.48 lb
1.7	3753 kg	8275 lb	26.48 kg	58.37 lb
2.2	3846 kg	8478 lb	17.36 kg	38.27 lb
2.6	4170 kg	9194 lb	9.67 kg	21.31 lb
2.8	4448 kg	9807 lb	5.53 kg	12.19 lb
2.9	4170 kg	9194 lb	3.46 kg	7.63 lb
3.	3475 kg	7662 lb	1.63 kg	3.59 lb
3.1	0	0	0.79kg	1.75 lb
3.5	0	0	0	0

lb. x 0.4536 = kg

TABLE 2. ELECTRICAL CHARACTERISTICS OF ROCKET MOTOR IGNITER SQUIBS

Resistance (1 squib)	.95 - 1.25 ohms
Maximum No Fire	1.8 amperes
Minimum All Fire	2.4 amperes
Recommended Firing Current	4.5 amperes
Igniter Resistance	0.45 to 1.00 ohms

ballast insert to insure aerodynamic stability and provide a high ballistic coefficient. The dart body houses the payload which is contained within two split steel staves. A small piston is located aft of the payload staves and forward of the hot gas separation charge. When this charge is initiated, the piston forces the steel payload staves against the ogive causing shear screws, which retain the ogive to the dart body, to yield. The continued generation of gas pressure by the separation charge forces the piston to eject the payload staves out from the forward end of the dart body. The separation charge is ignited by an electrically-initiated 145 second pyrotechnic time delay which is incorporated in the dart tail section just aft of the separation charge. The pyrotechnic time delay is connected in parallel with the rocket motor igniter and is initiated at launch.

The characteristics of the squib in the delay initiator are given in Table 3.

Leads for the time delay terminate in a male connector which is located at the aft end of the dart. This connector mates with the matching female connector located in the booster interstage during assembly at the launch site of the dart to the booster. Four dart tail fins are provided for aerodynamic stability during the coasting flight. The dart components are shown in Figure 5.

The payload which has been used for the majority of the Cajun Dart Flights is 0.00127 centimeters (0.0005-inch) thick aluminized Mylar "S" band chaff. The payload volume available for the chaff payload is 490 cubic centimeters (30 $in.^3$). Upon ejection of the payload staves from the dart body at apogee, the staves separate and the chaff bundles are free to disperse and follow the wind.

The Cajun Dart is launched from a simple rail in an underslung launch configuration. This launch rail can be attached to any suitable launcher framework structure which is capable of supporting the weight of the launch rail and vehicle, and which provides for the setting and locking of launch elevation and azimuth angles. Typical examples of launcher configurations are shown in Figures 6 and 7.

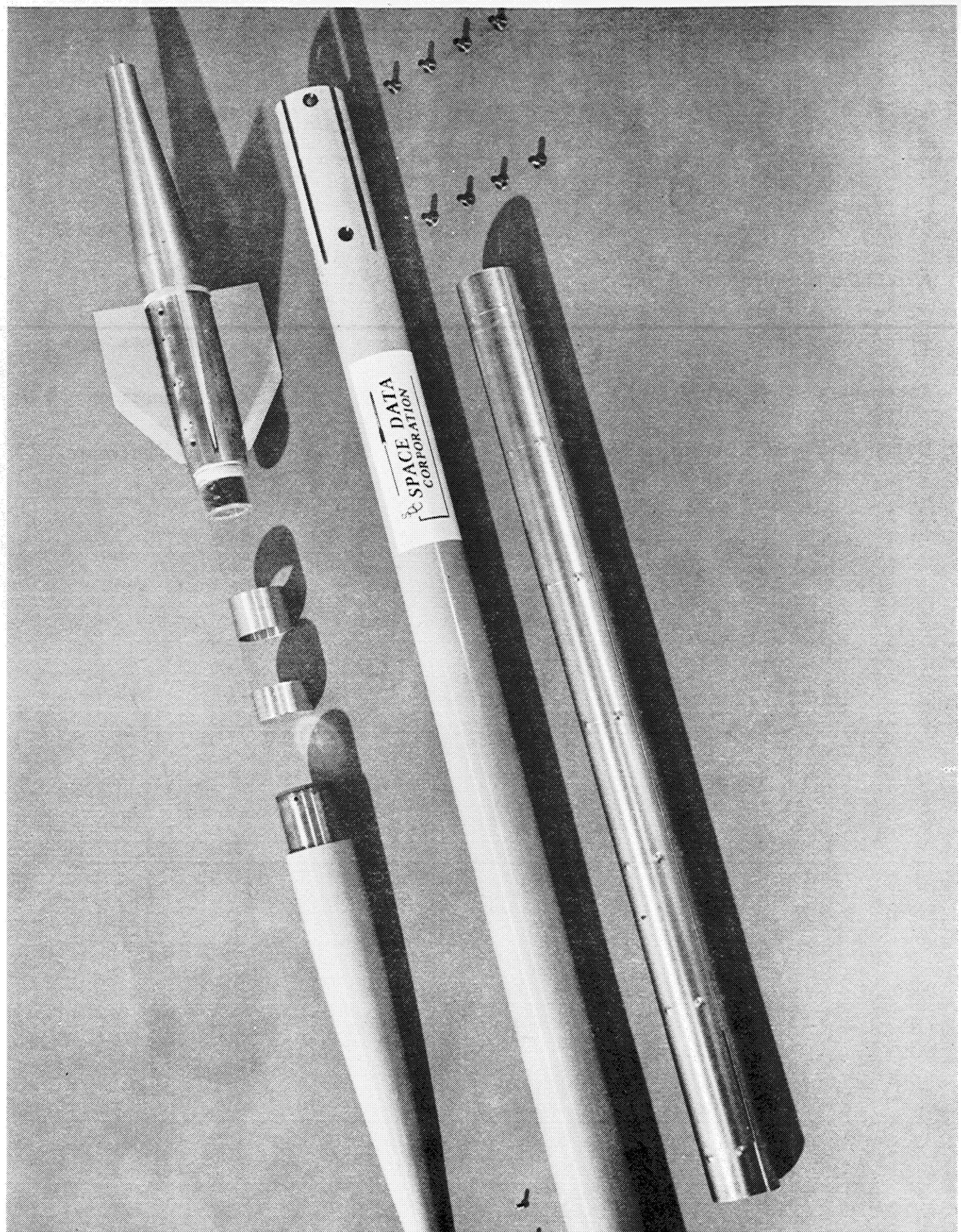

FIGURE 5. DART COMPONENTS

TABLE 3. DART DELAY SQUIB ELECTRICAL CHARACTERISTICS

Resistance	1.0 ± 0.3 ohms
Maximum No Fire	0.5 amperes
Minimum All Fire	1.0 amperes
Recommended Firing Current	2.0 amperes
Delay-Bridgewire Initiation to Flash	145 ± 15 seconds

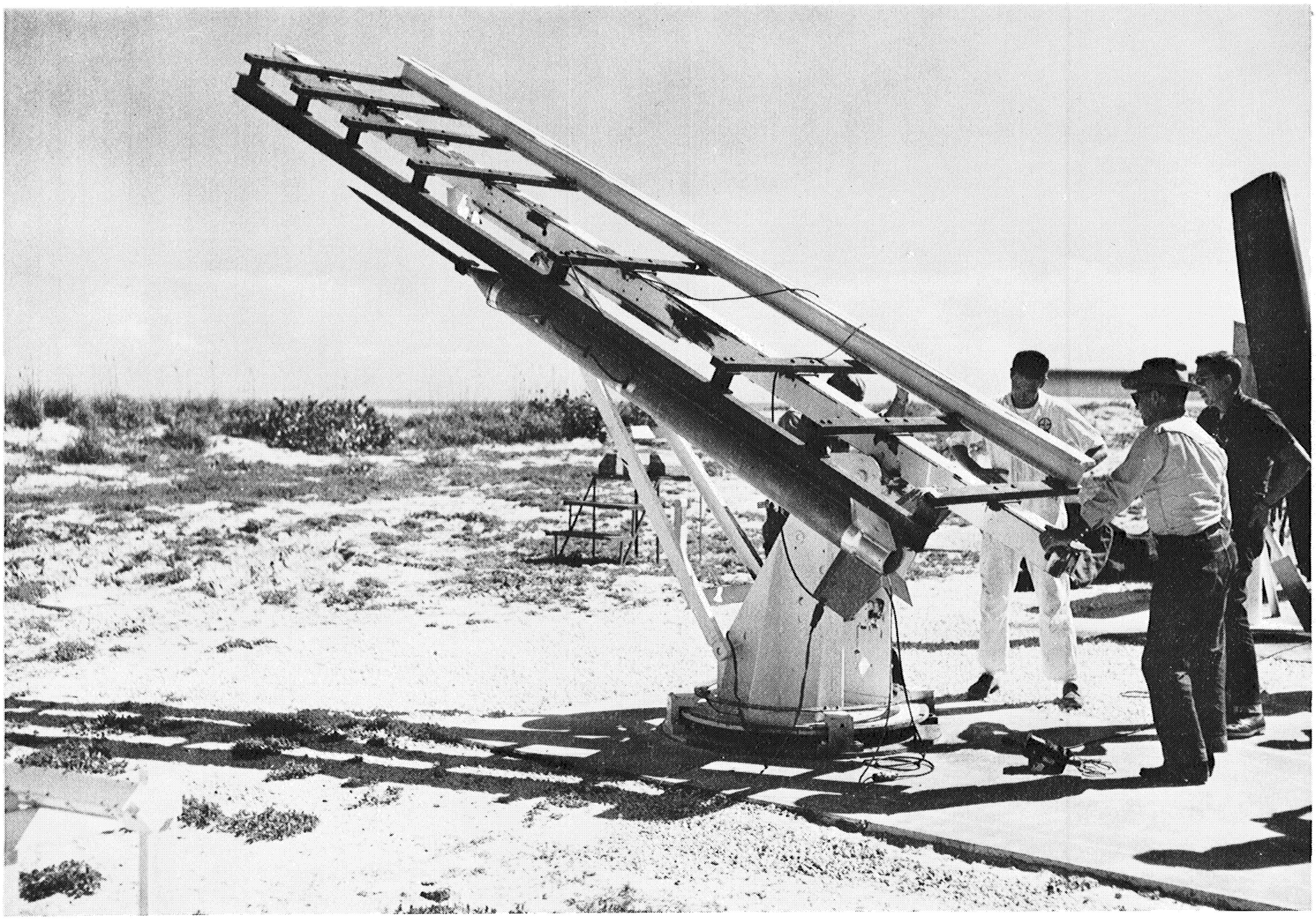

FIGURE 6. TYPICAL CAJUN DART LAUNCHER

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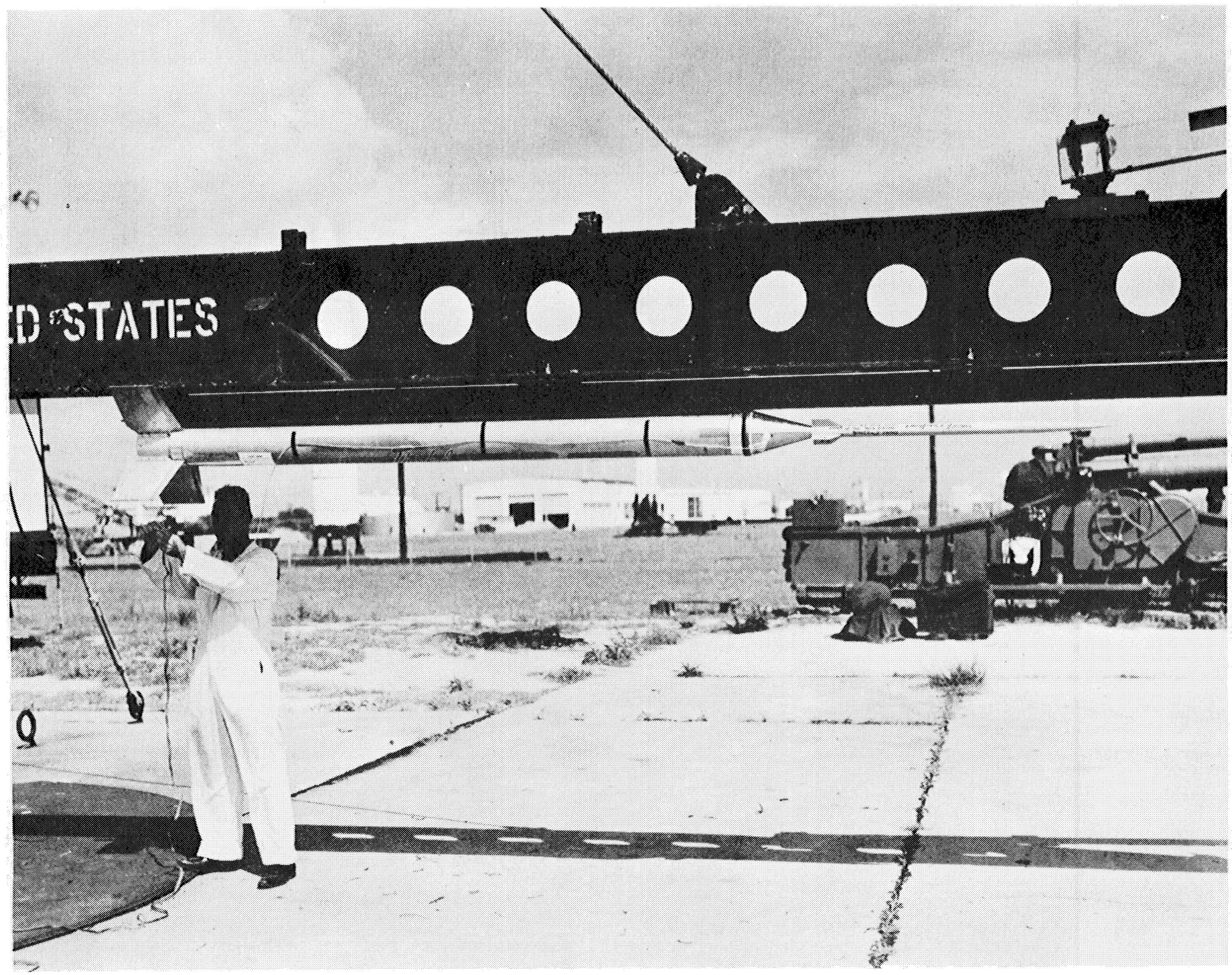


FIGURE 7. TYPICAL CAJUN DART LAUNCHER

The Cajun Dart vehicle has a nominal apogee altitude of 95 kilometers (310,000 feet). At Cajun burnout, separation of the dart from the Cajun booster is caused by the aerodynamic drag differential between the two stages. After separation the dart coasts to apogee, and the payload is ejected by means of the pyrotechnic delay and separation charge. Both booster and dart impact points can be predicted by a wind-weighting process which is described herein.

A performance summary for the Cajun Dart vehicle is presented in Table 4. More detailed performance data are presented graphically in the Figures as follows:

Figure 8	Dart Altitude vs. Time, 80°QE
Figure 9	Dart Altitude vs. Range, 80°QE
Figure 10	Dart Altitude vs. Range, Various QE's
Figure 11	Cajun Booster Altitude vs. Range, Various QE's
Figure 12	Cajun Booster Maximum Altitude and Impact Range vs. Launch Angle
Figure 13	Vehicle Velocity vs. Time, 80° QE
Figure 14	Vehicle Spin Rate vs. Time, 80°QE

Flight tests have shown that the Cajun booster becomes unstable after stage separation, and the booster trajectories fall short of predicted stable flight trajectories. Figures 11 and 12 have been compiled from the actual flight test data for unstable boosters.

Impact dispersion areas for both the dart and the Cajun booster are presented in Figure 15. These dispersion areas are nominal, and assume that the vehicle launch angles have been corrected for the prevailing wind effects. The nominal impact points for either the booster or the dart may be displaced to allow launch angles not corrected for these wind effects. Ellipses of the same size as indicated in Figure 15 may be constructed about the displaced nominal impact points to determine the predicted dispersion zones under any given set of wind conditions.

A wind-weighting procedure is used to determine the nominal impact points of the booster and dart or to correct the launch angles to obtain a desired nominal impact point. Table 5 presents the wind-weighting factors and unit wind effects for the booster and dart. The measured pre-launch wind profile is divided into the indicated altitude increments, the average wind velocity in each increment is multiplied by the respective wind-weighting factor, and the resulting weighted winds are broken into North-South and East-West components. Next the weighted wind components are summed to obtain the ballistic wind components. The ballistic wind may also be resolved into components parallel and perpendicular to the nominal flight path azimuth. The launcher elevation angle may be corrected by adding to the desired no-wind elevation angle the product of the ballistic wind component, which is parallel to the intended flight path azimuth, times the unit wind effect. The launcher azimuth angle may be corrected by adding to the desired no-wind azimuth angle the product of the perpendicular ballistic wind component and the unit wind effect divided by the cosine of the no-wind elevation angle. An example of a typical launcher setting calculation is presented in Table 6.

TABLE 4. CAJUN DART PERFORMANCE SUMMARY, 80 ° SEA LEVEL LAUNCH

METRIC UNITS

Stage I	Time (sec)	Altitude (meters)	Range (meters)	Velocity (mps)
Ignition	0.00	0.	0.	0.
Maximum Acceleration	3.00	1,940.	390.	1,555.
Burnout and Separation	3.20	2,240.	453.	1,540.
Maximum Altitude	8.00	3,230.	700.	6.1
Impact	122.00	0.	732.	25.9
Stage II				
Maximum Altitude	140.36	93,000.	36,800.	259.
Impact	279.91	0.	73,300.	1,310.

TABLE 4. Continued. CAJUN DART PERFORMANCE SUMMARY, 80° SEA LEVEL LAUNCH

ENGLISH UNITS

Stage I	Time (sec)	Altitude (feet)	Range (feet)	Velocity (fps)
Ignition	0.00	0.	0.	0.
Maximum Acceleration	3.00	6,373.	1,283.	5,117.
Burnout and Separation	3.20	7,378.	1,486.	5,061.
Maximum Altitude	8.00	10,600.	2,300.	20.
Impact	122.00	0.	2,400.	85.
Stage II				
Maximum Altitude	140.36	305,190.	120,440.	850.
Impact	279.91	0.	240,800.	4,300.

FIGURE 8 CAJUN-DART ALTITUDE VS TIME*

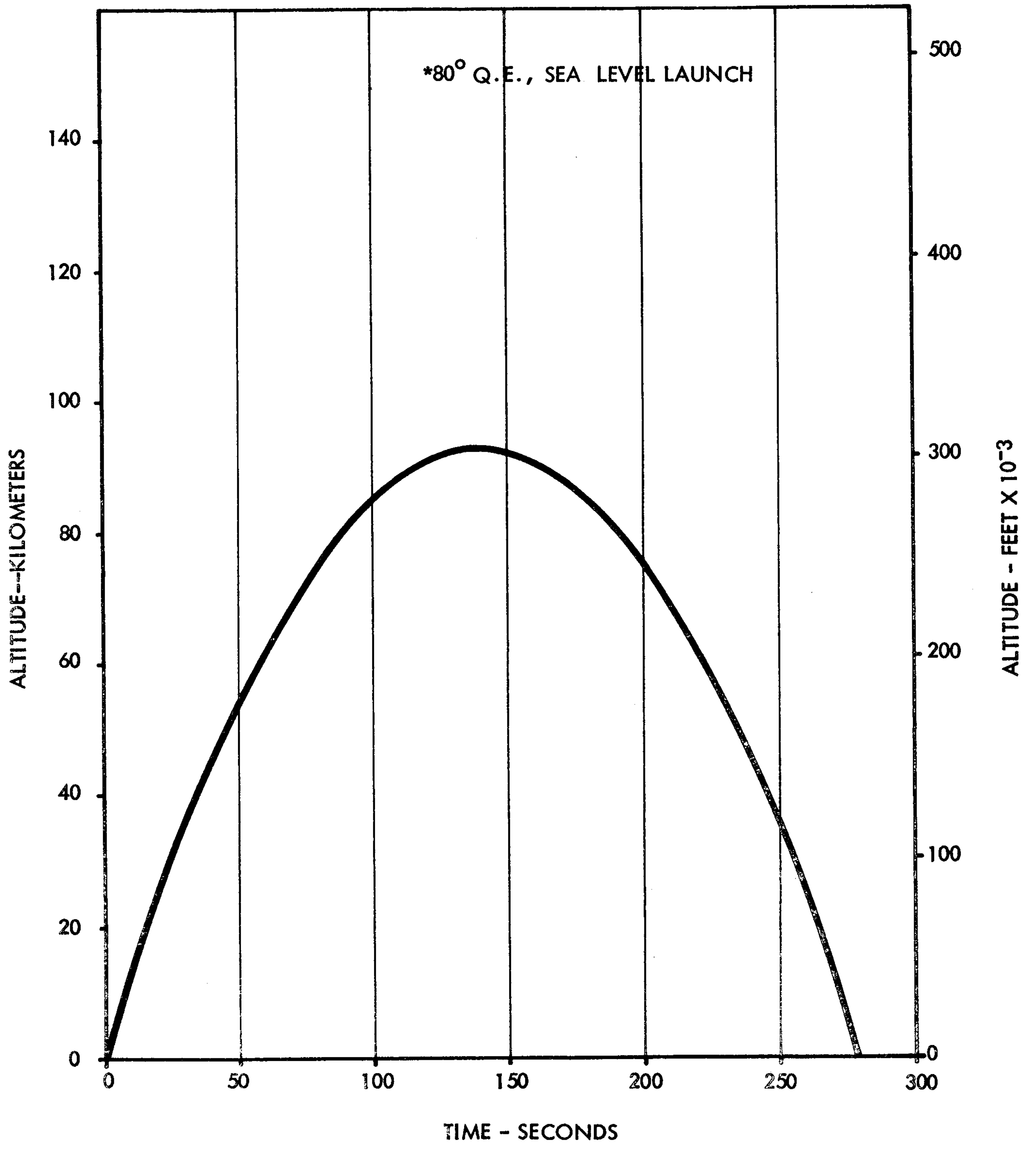


FIGURE 9 CAJUN-DART ALTITUDE VS. RANGE*

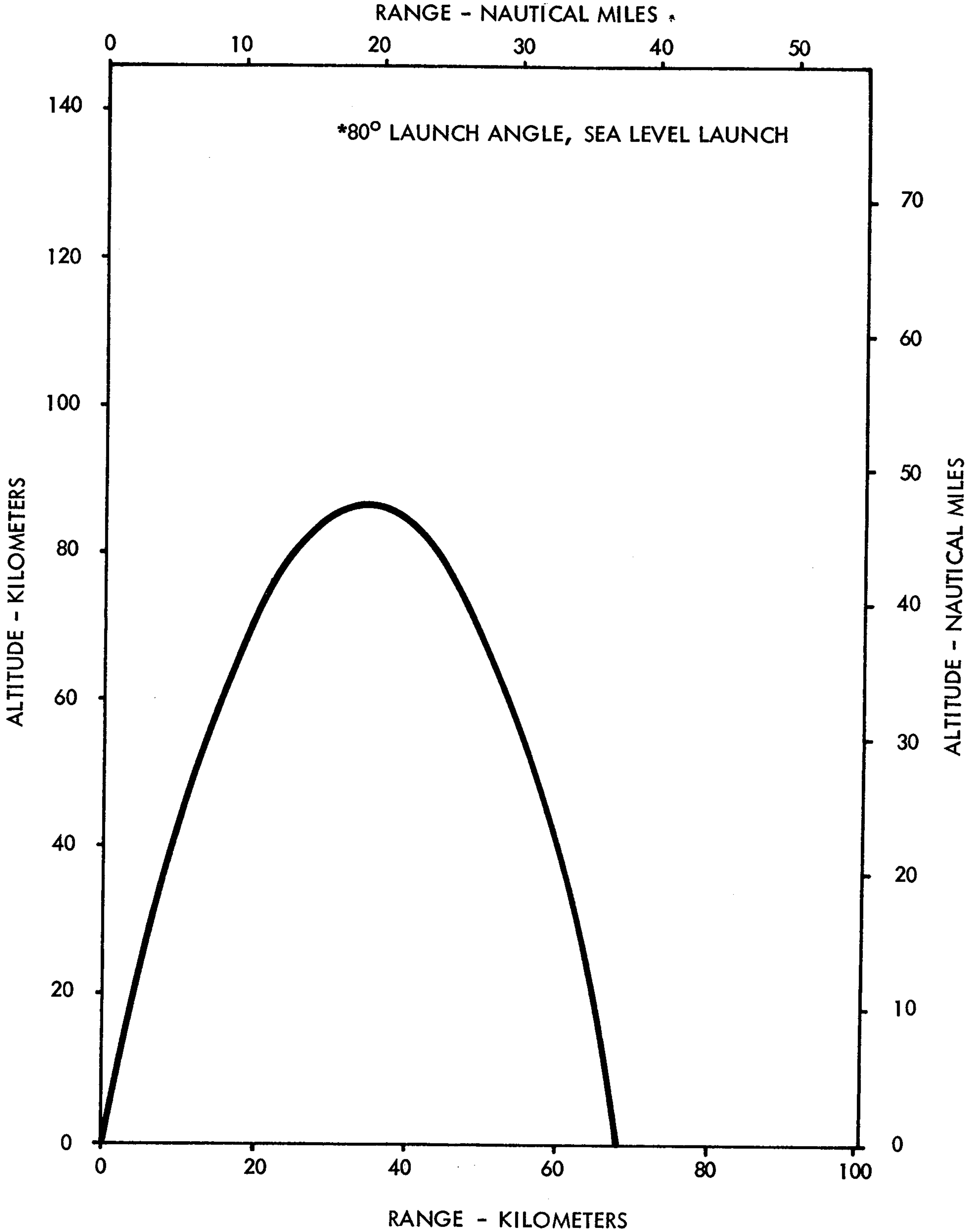


FIGURE 10 CAJUN-DART ALTITUDE VS. RANGE AT VARIOUS LAUNCH ANGLES*

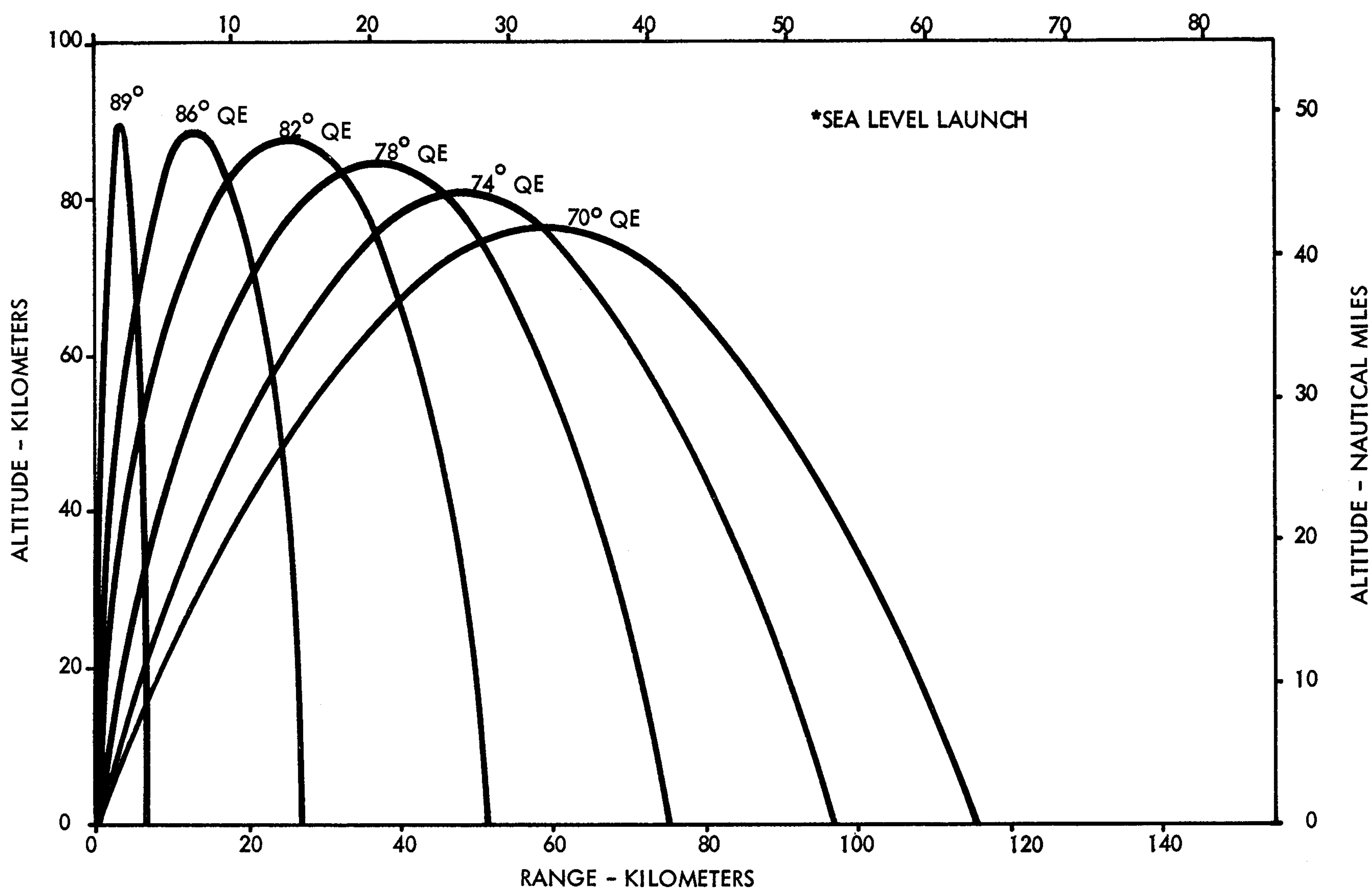


FIGURE 11 CAJUN FIRST STAGE BOOSTER ALTITUDE VS. TIME*

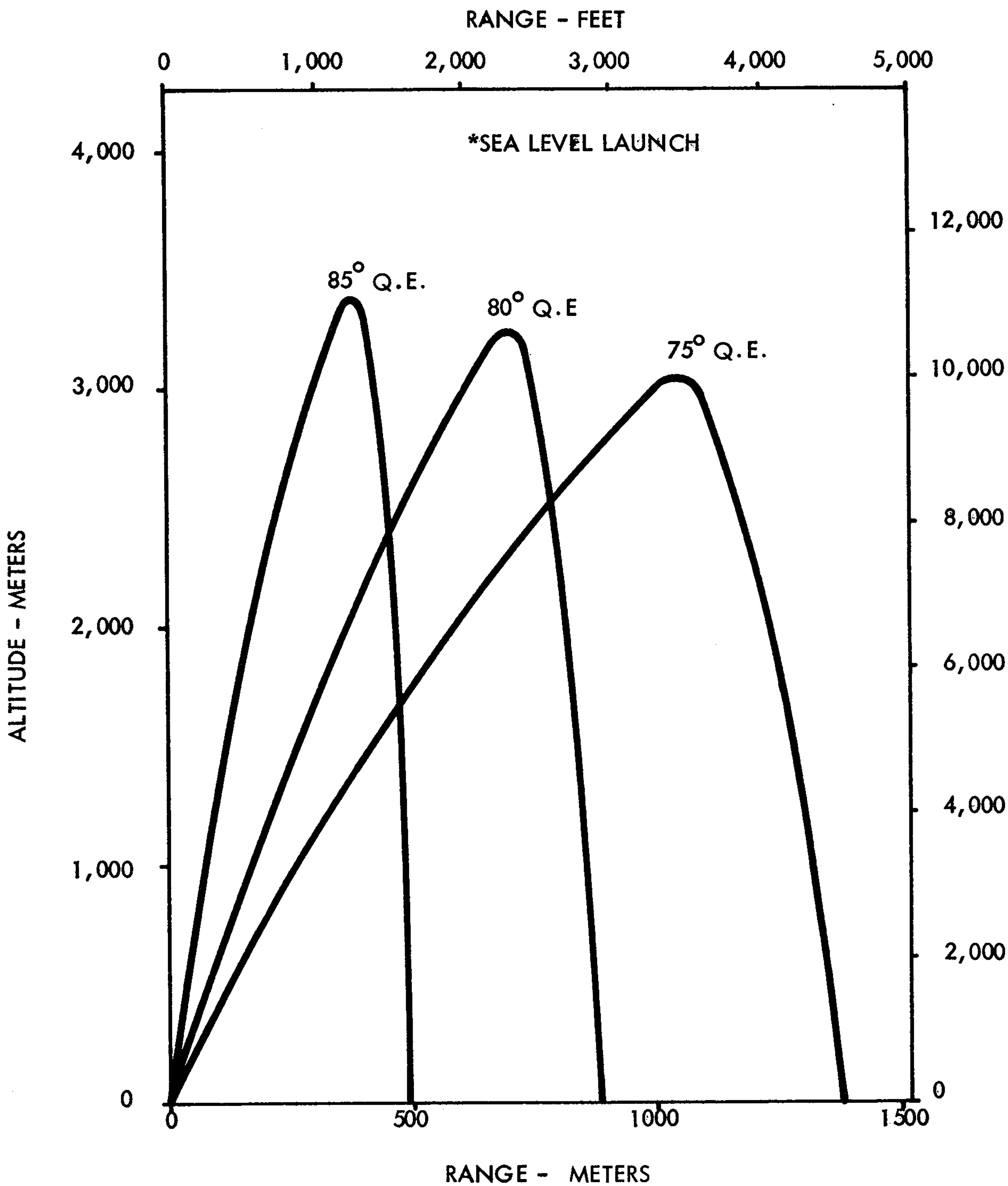


FIGURE 12 CAJUN FIRST STAGE BOOSTER IMPACT RANGE AND MAXIMUM ALTITUDE VS. LAUNCH ANGLE*

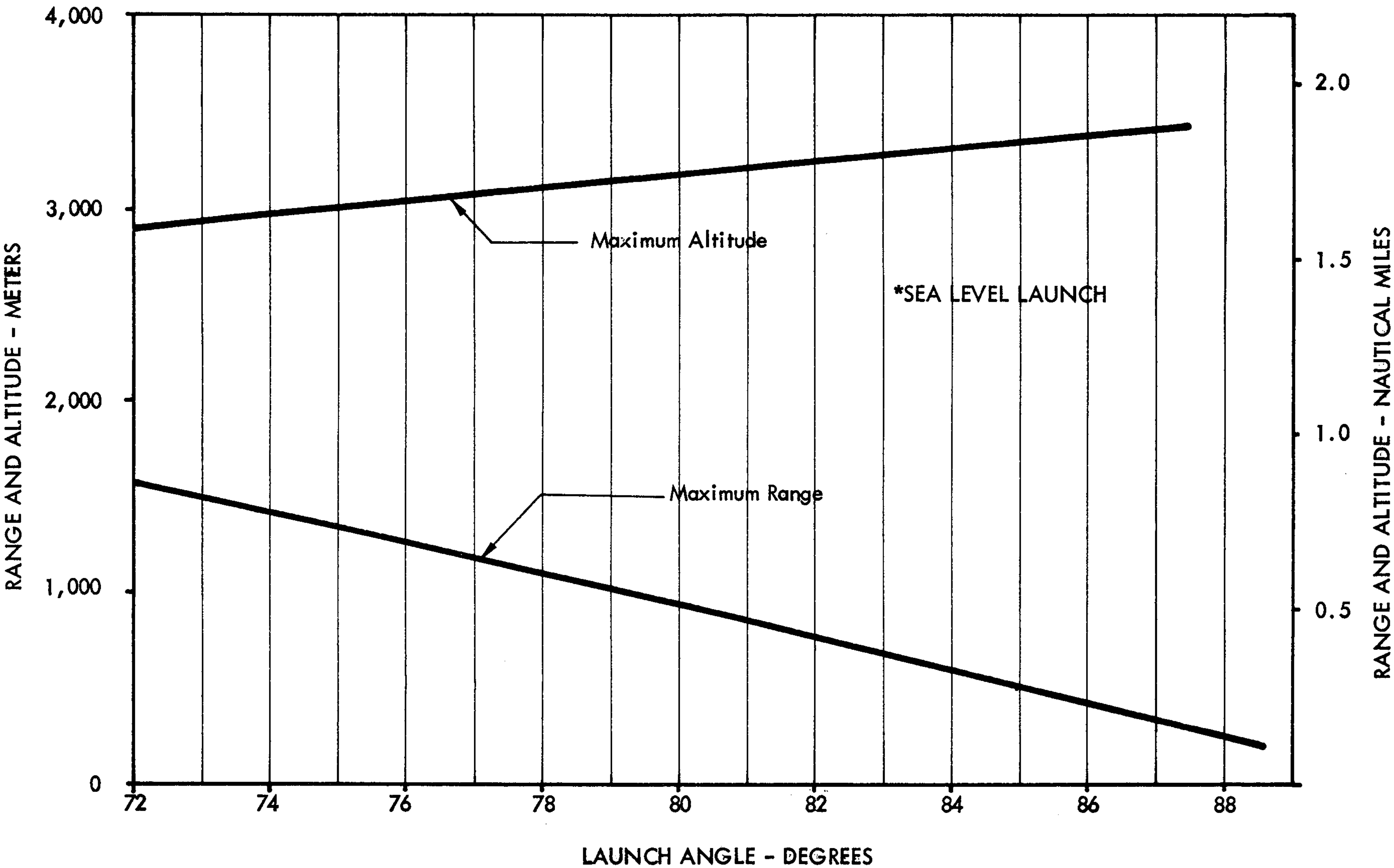


FIGURE 13 CAJUN-DART VELOCITY VS. TIME

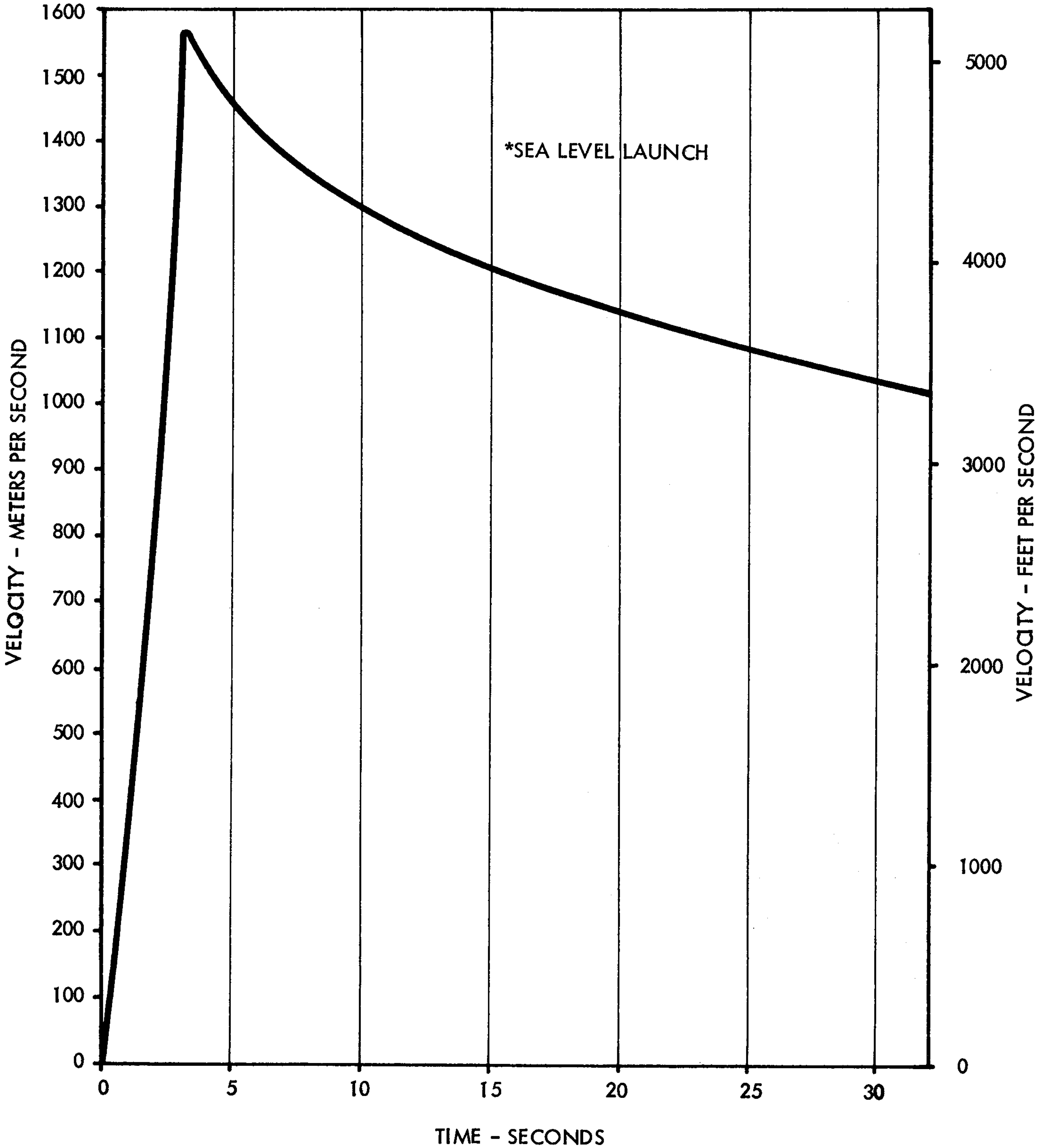
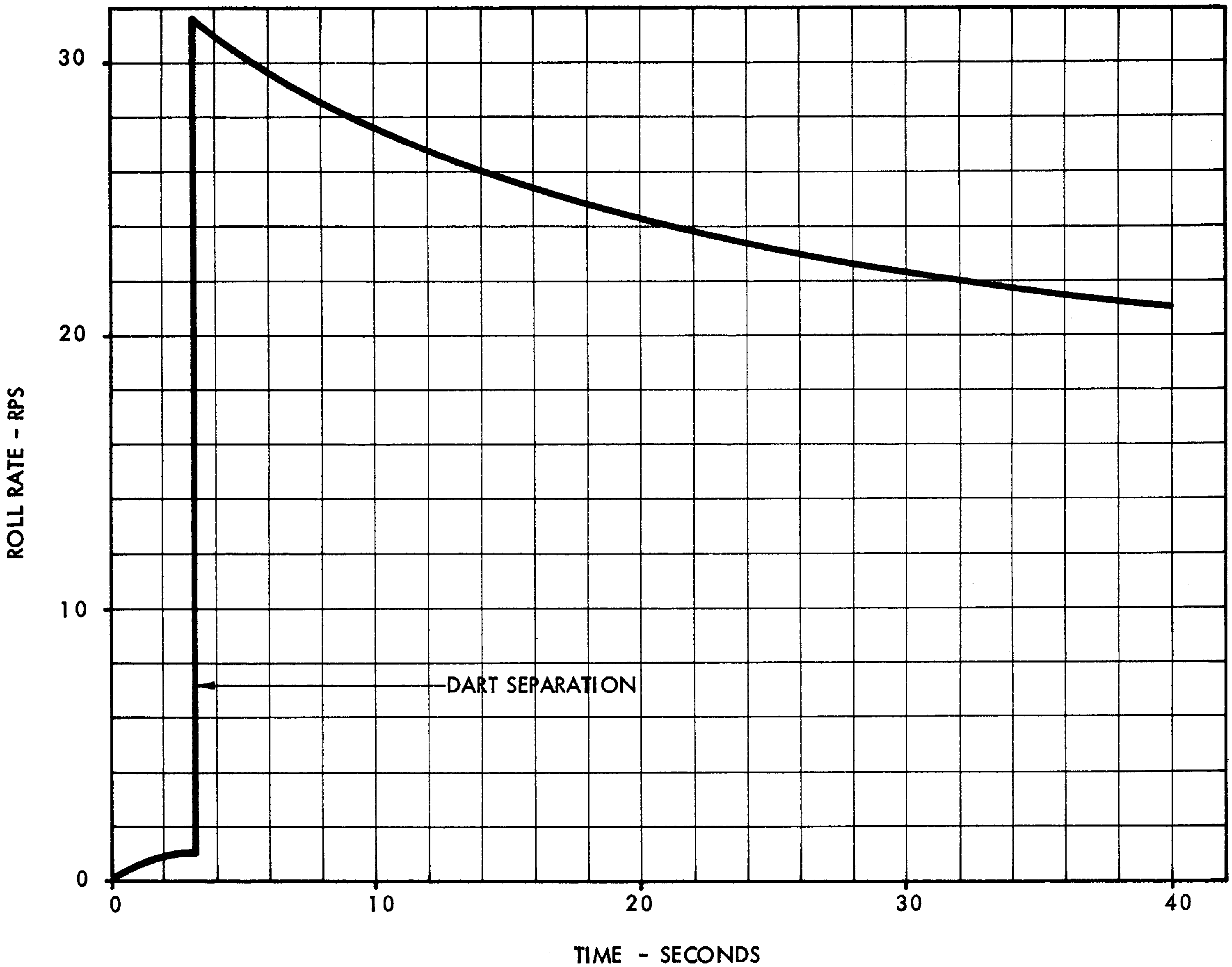


FIGURE 14 CAJUN-DART VEHICLE, ROLL RATE VS. TIME



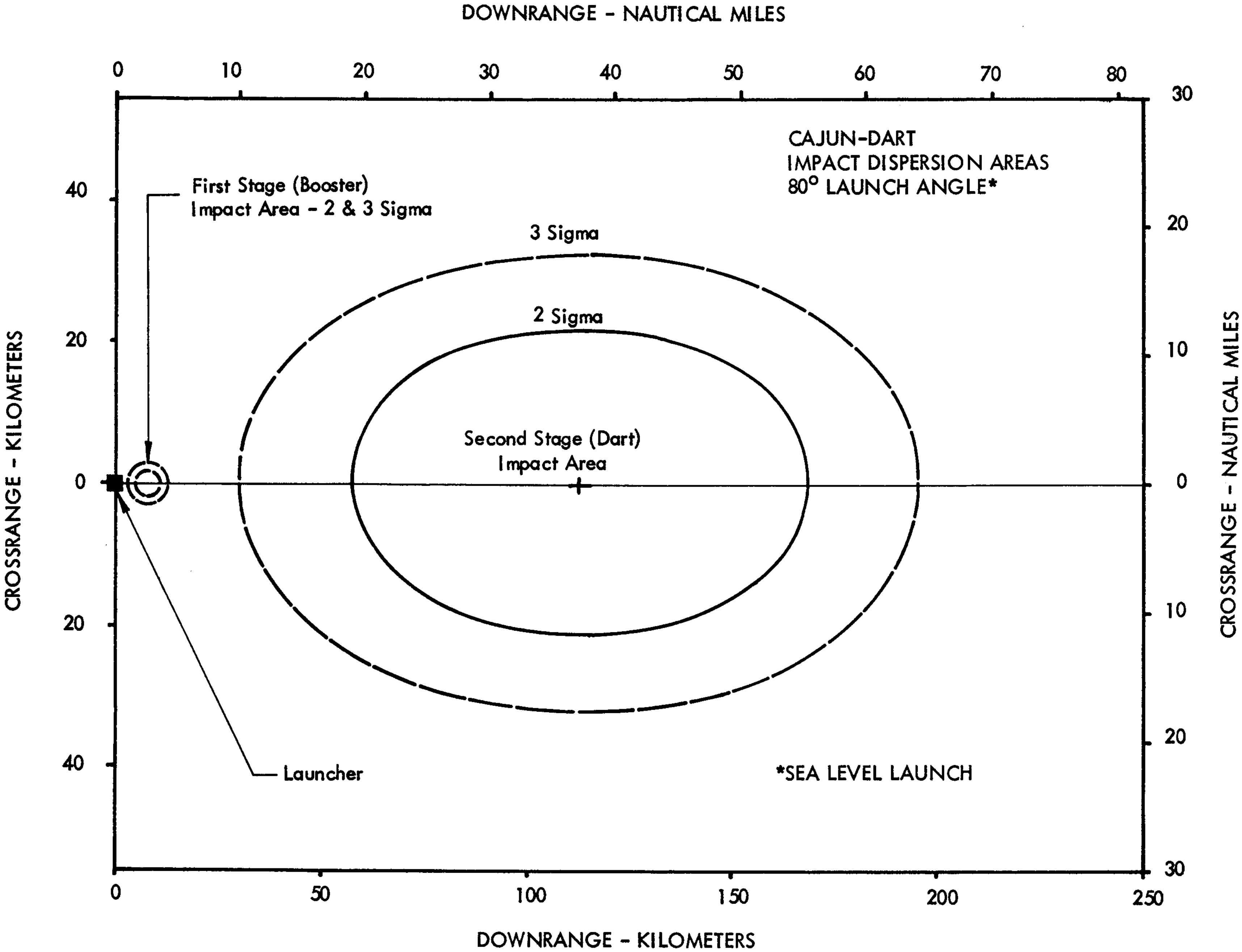

DOWNRANGE - NAUTICAL MILES
0
10
20
30
40
50
60
70
80
CAJUN-DART
IMPACT DISPERSION AREAS
80° LAUNCH ANGLE*
First Stage (Booster)
Impact Area - 2 & 3 Sigma
3 Sigma
2 Sigma
Second Stage (Dart)
Impact Area
Launcher
*SEA LEVEL LAUNCH
CROSSRANGE - KILOMETERS
40
20
0
20
40
CROSSRANGE - NAUTICAL MILES
30
20
10
0
10
20
30
0
50
100
150
200
250
DOWNRANGE - KILOMETERS

FIGURE 15

TABLE 5. CAJUN DART WIND-WEIGHTING FACTORS

Altitude Increment		Dart	Booster
0-30 meters	0-100 ft.	0.42	0.43
30-61 meters	100-200 ft.	0.16	0.17
61-91 meters	200-300 ft.	0.08	0.08
91-122 meters	300-400 ft.	0.06	0.05
122-152 meters	400-500 ft.	0.03	0.03
152-304 meters	500-1000 ft.	0.09	0.10
304-2280 meters	1000-7500 ft.	0.16	0.14

Unit Wind Effect:

Dart Vehicle - (0.525 degrees elevation/mps of wind
(0.270 degrees elevation/knot of wind

Booster - (219 m/mps of wind
(370 ft/knot of wind

TABLE 6. WIND-WEIGHTING EXAMPLE

Altitude Increment	Wind Factor	Measured Wind Velocity	Wind Azimuth	Ballistic Wind	N-S Component	E-W Component
1-100 ft.	.42	11.0 knots	110°	4.620 knots	-1.580 knots	4.341 knots
100-200	.16	11.5	106°	1.840	-0.507	1.769
200-300	.08	12.3	104°	.984	-0.238	0.955
300-400	.06	13.4	109°	.804	-0.262	0.760
400-500	.03	12.4	106°	.372	-0.103	0.358
500-1000	.09	11.7	103°	1.053	-0.237	1.026
1000-7500	.16	10.4	99°	1.664	-0.260	1.644
		Ballistic Wind Components			-3.187 knots	10.853 knots

Total Ballistic Wind = $-3.187^2 + 10.853^2$ = 11.311 knots

Ballistic Wind Direction = Arc Tan $\frac{-3.187}{10.853}$ = 106.4°

For nominal no-wind launcher settings to be 80° QE and 90° Az. the above calculations indicate a headwind of 10.853 knots and a side wind from the right of 3.187 knots.

Adjusted QE = 80 + .270 (10.853) = 82.9°

Adjusted AZ = $90 + \frac{.270\,(-3.187)}{\text{Cos } 80^\circ}$ = 85.0°

NOTES:

1. North to South winds are positive (+)
   South to North winds are negative (-)

2. East to West Winds are positive (+)
   West to East winds are negative (-)

FLIGHT TEST DATA

To date a total of more than sixty flights have been completed with the Cajun Dart vehicle. Flight reliability has been high as indicated by the flight summary of Table 7. Radar acquisition was not accomplished on six of the flights. One flight failure was caused by a rocket motor malfunction, and a second flight failure occurred with a lightweight experimental interstage design. All of the remaining fifty-two flights produced useful wind data.

Chaff with a very low ballistic coefficient, i.e., low weight-to-drag ratio, has been used to successfully gather wind data in the 65 kilometer to 90 kilometer region (215,000 to 295,000 feet) with the Cajun Dart. The chaff payload and carrier vehicle are quite inexpensive, and measurements can be made with standard range radar. The measurements are not restricted to any particular period of the day, and data reduction is automated by the use of developed computer programs. For these reasons the chaff technique has been selected as the primary wind sensing system for the Cajun Dart program. Typical descent rate and descent time curves for the Cajun Dart chaff payload are presented in Figures 16 and 17 respectively. Upper atmosphere wind profiles derived from early Cajun Dart flights are presented in Figures 18 and 19. These data indicate that wind speeds as great as 61 meters per second (200 feet per second) are not uncommon at altitudes above 76 kilometers (250,000 feet).

TABLE 7. CAJUN-DART FLIGHT TEST SUMMARY

FLIGHT NO.	DATE	LAUNCH SITE	TEST RESULTS
1	19 Aug. 64	Eglin AFB	Data Obtained
2	21 Aug. 64	Eglin AFB	Data Obtained
3	24 Aug. 64	Eglin AFB	Data Obtained
4	28 Aug. 64	Eglin AFB	Data Obtained
5	16 Oct. 64	Eglin AFB	Data Obtained
6	22 Oct. 64	Eglin AFB	No Data
7	17 Feb. 65	AFETR	Data Obtained
8	24 Feb. 65	AFETR	Data Obtained
9	26 Feb. 65	AFETR	Data Obtained
10	5 Mar. 65	AFETR	No Acquisition
11	10 Mar. 65	AFETR	Data Obtained
12	17 Mar. 65	AFETR	Data Obtained
13	24 Mar. 65	AFETR	Data Obtained
14	31 Mar. 65	AFETR	Data Obtained
15	7 Apr. 65	AFETR	Data Obtained
16	14 Apr. 65	AFETR	Data Obtained
17	21 Apr. 65	AFETR	Data Obtained
18	28 Apr. 65	AFETR	No Acquisition
19	12 May 65	AFETR	Data Obtained
20	26 May 65	AFETR	Data Obtained
21	2 June 65	AFETR	Data Obtained
22	11 June 65	AFETR	Data Obtained
23	16 June 65	AFETR	Data Obtained
24	23 June 65	AFETR	Data Obtained
25	30 June 65	AFETR	Data Obtained
26	7 July 65	AFETR	Data Obtained
27	14 July 65	AFETR	Data Obtained
28	21 July 65	AFETR	Data Obtained
29	23 July 65	AFETR	Data Obtained
30	28 July 65	AFETR	Data Obtained
31	13 Aug. 65	AFETR	Data Obtained
32	18 Aug. 65	AFETR	Data Obtained
33	25 Aug. 65	AFETR	Data Obtained
34	9 Sept. 65	AFETR	Data Obtained
35	17 Sept. 65	AFETR	Data Obtained
36	22 Sept. 65	AFETR	Data Obtained
37	29 Sept. 65	AFETR	Data Obtained

TABLE 7 - (continued)

FLIGHT NO.	DATE	LAUNCH SITE	TEST RESULTS
38	6 Oct. 65	AFETR	Data Obtained
39	13 Oct. 65	AFETR	No Acquisition
40	20 Oct. 65	AFETR	Data Obtained
41	27 Oct. 65	AFETR	No Data
42	1 Nov. 65	AFETR	Data Obtained
43	8 Nov. 65	AFETR	No Acquisition
44	17 Nov. 65	AFETR	Data Obtained
45	24 Nov. 65	AFETR	Data Obtained
46	29 Nov. 65	AFETR	Data Obtained
47	8 Dec. 65	AFETR	Data Obtained
48	17 Dec. 65	AFETR	Data Obtained
49	22 Dec. 65	AFETR	Data Obtained
50	5 Jan. 66	AFETR	Data Obtained
51	12 Jan. 66	AFETR	No Acquisition
52	19 Jan. 66	AFETR	Data Obtained
53	27 Jan. 66	AFETR	Data Obtained
54	19 Feb. 66	AFETR	Data Obtained
55	25 Feb. 66	AFETR	Data Obtained
56	26 Feb. 66	AFETR	Data Obtained
57	4 July 66	AFETR	No Data
58	6 July 66	AFETR	Data Obtained
59	24 Aug. 66	AFETR	Data Obtained
60	25 Aug. 66	AFETR	Data Obtained

FIGURE 16 CAJUN-DART MYLAR CHAFF DESCENT DATA*

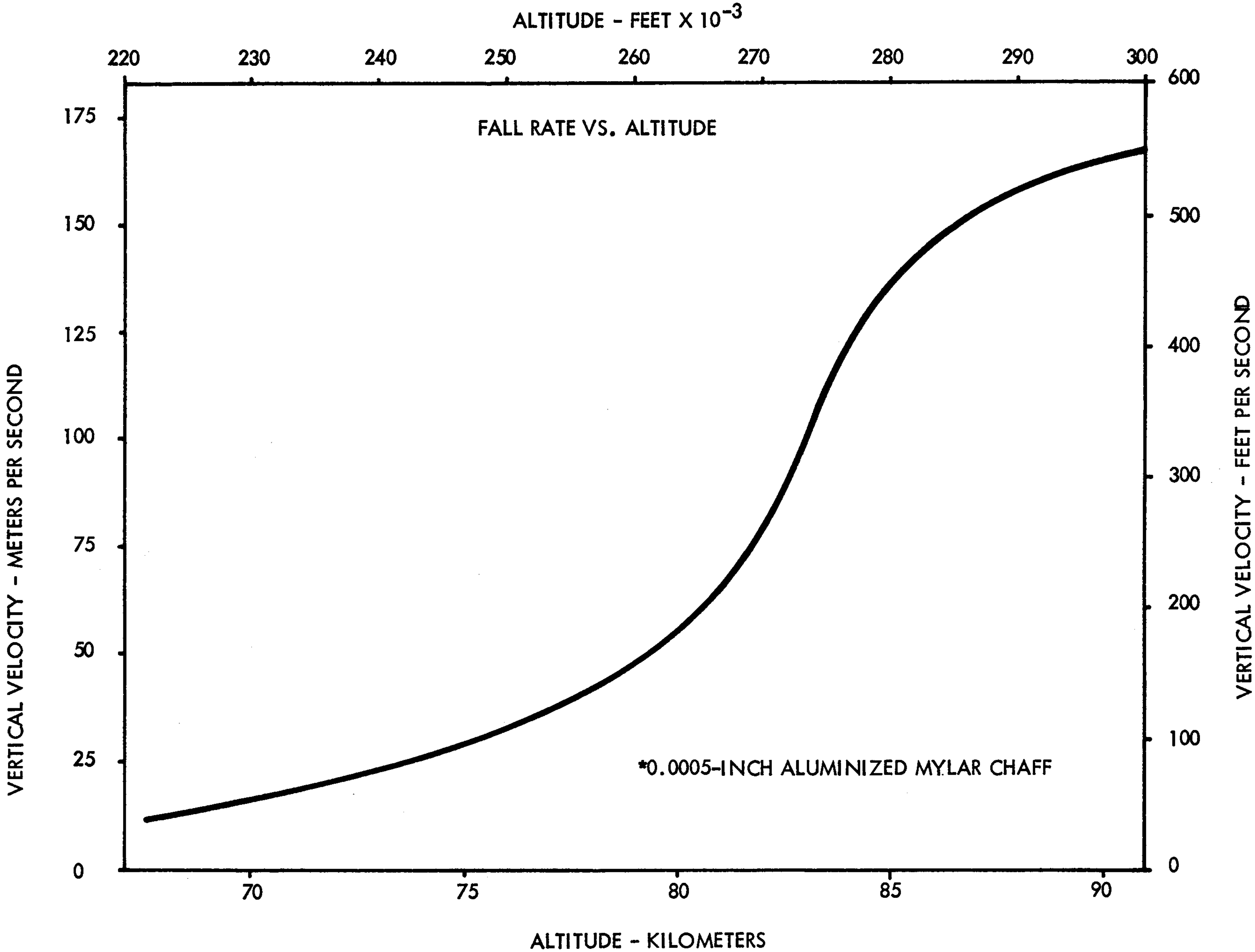
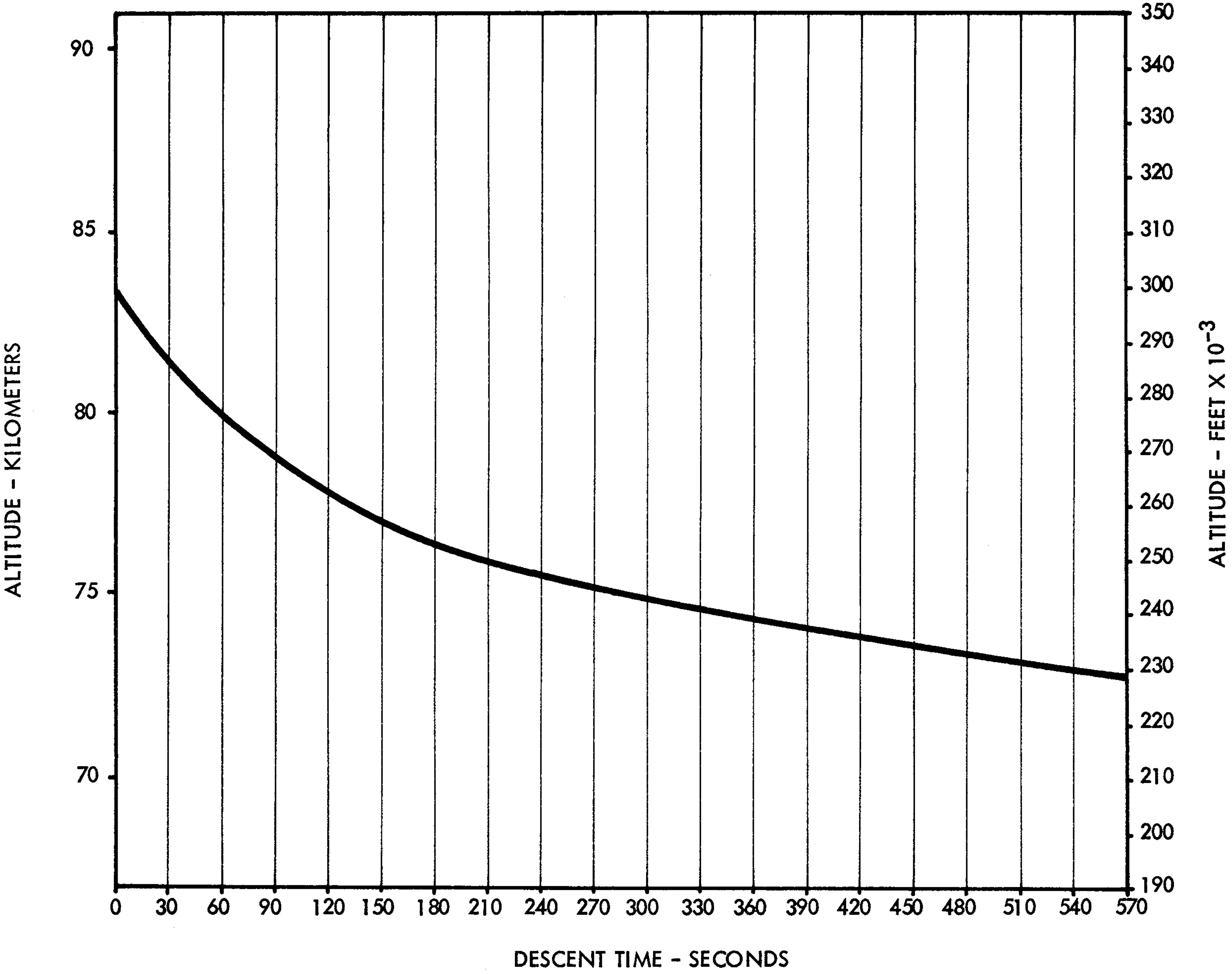


FIGURE 17 CAJUN-DART MYLAR CHAFF DESCENT DATA*



SUMMARY OF RESULTS - CAJUN-DART WIND MEASUREMENTS (EGLIN AFB, FLORIDA

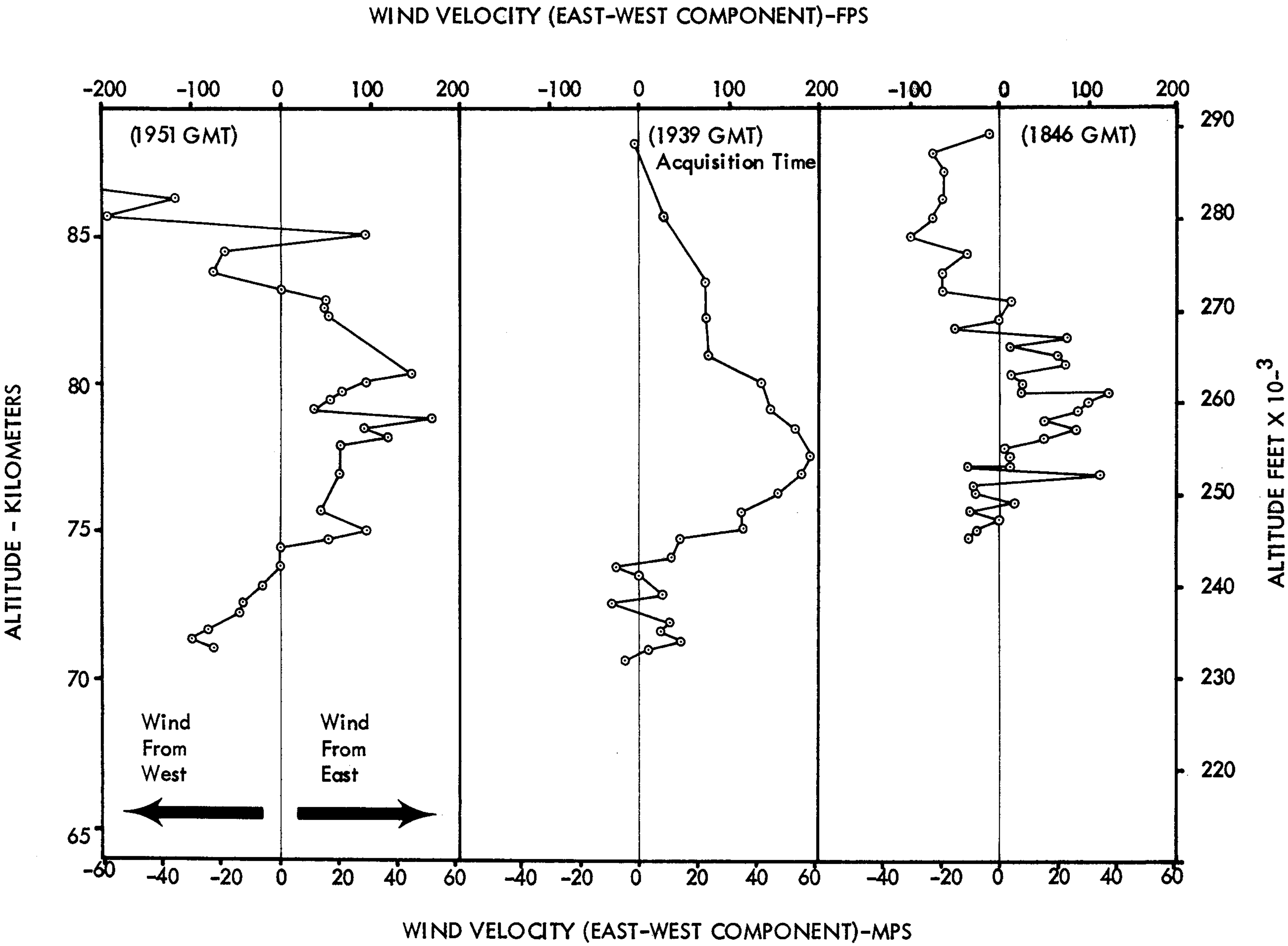


FIGURE 18

SUMMARY OF RESULTS - CAJUN-DART WIND MEASUREMENTS EGLIN AFB, FLORIDA

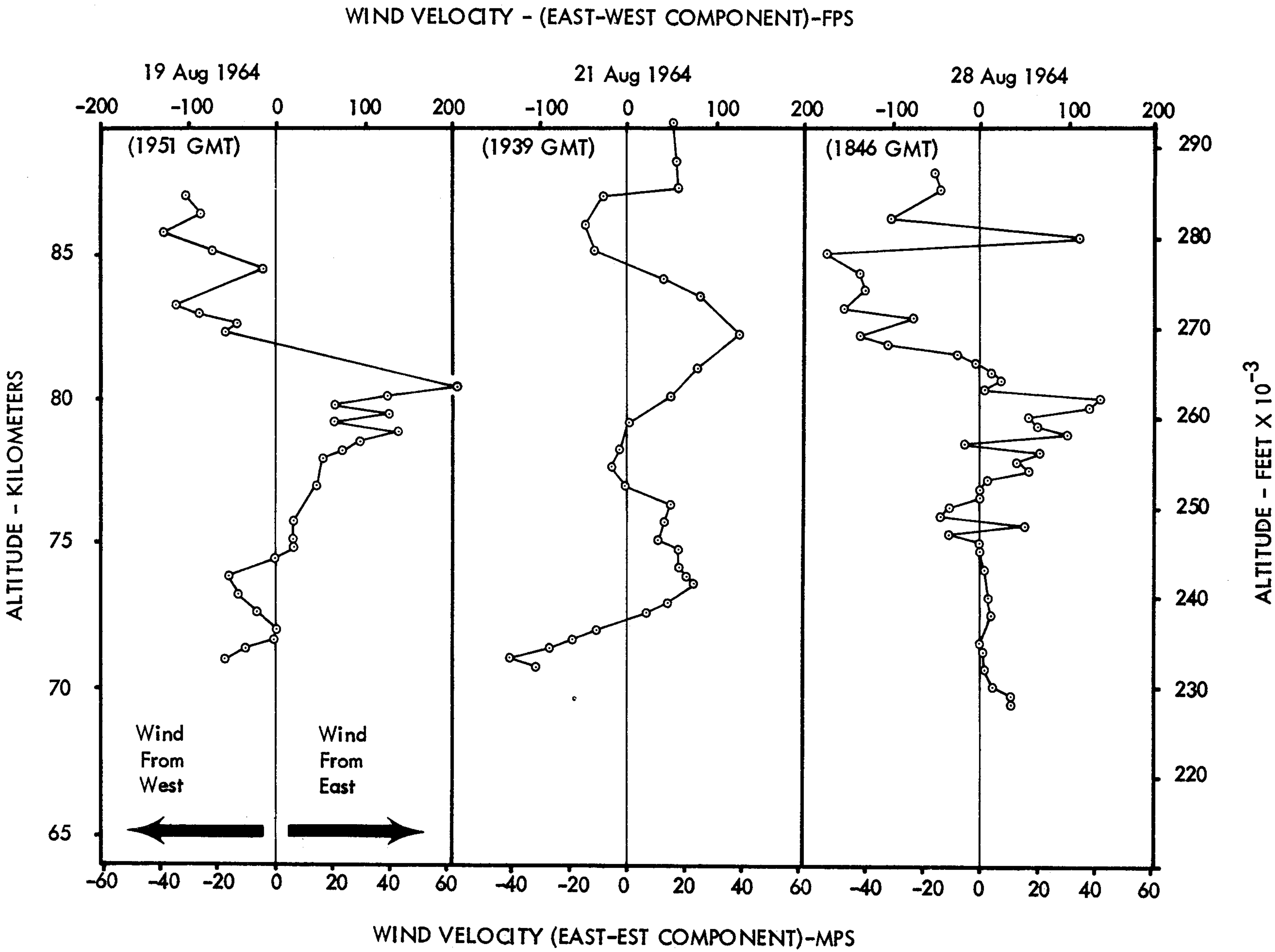


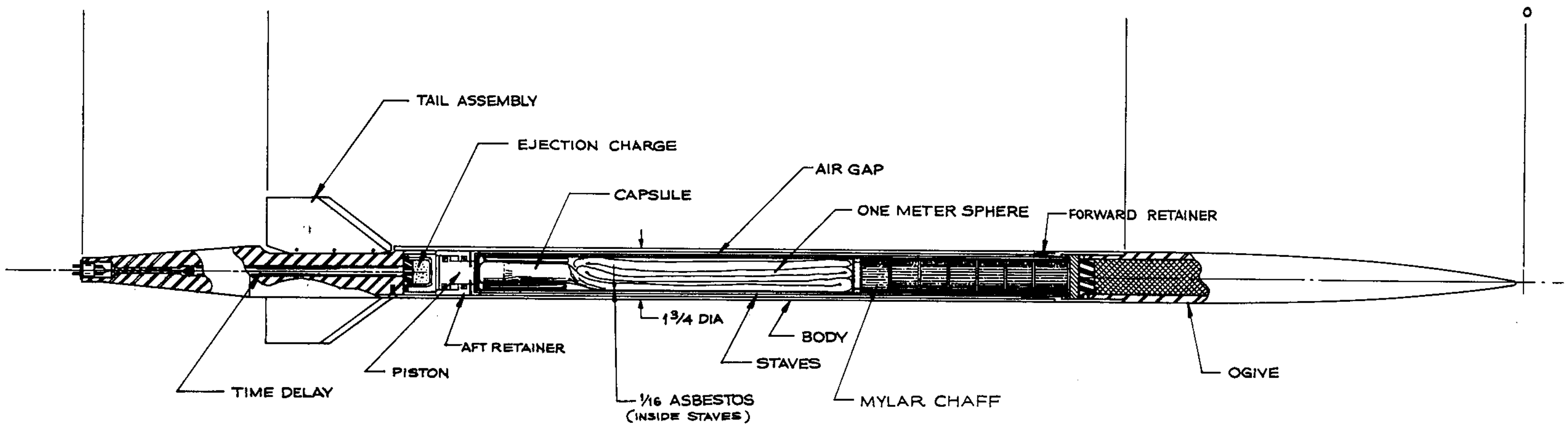
FIGURE 19

A COMBINATION PAYLOAD

By combining the chaff and an inflatable sphere into a combination payload, such as shown in Figure 20, both winds and density may be independently measured. This kind of payload combination has been successfully flight tested by the Naval Ordnance Laboratories as indicated in Table 8. During these flights it was found that a second radar could acquire the faster descending sphere target from among the chaff and maintain independent track. Since the chaff falls more slowly, it can be used to determine the higher altitude winds more accurately. When the chaff disperses at a level of about 65 kilometers (215,000 feet), the sphere can then be used for the wind data. In fact, the sphere becomes an excellent wind sensor below this altitude and can be tracked all the way down to sea level if desired. The fall rate of the inflated sphere is a measure of the atmospheric density. Generally the sphere collapses at about 40 kilometers (122,000 feet) and cannot reliably be used as a density sensor below this altitude. However, even the collapsed sphere has proven to be a good wind sensor.

Radar tracking of the aluminized sphere surface during descent provides the basic data from which atmospheric density and winds are derived. Flight tests to 95 kilometers (310,000 feet) have demonstrated that sufficient radar return is available for reliable tracking. The major sphere characteristics are presented in Table 9. Descent data for the Cajun Dart sphere is presented in Figure 21. After deployment at apogee, the sphere increases velocity and becomes supersonic at an altitude of about 90 kilometers (295,000 feet). Drag deceleration in the lower-altitude, higher-density atmosphere retards the descent velocity so that it becomes subsonic at an altitude of about 76 kilometers (250,000 feet). Thus a range of drag coefficient data must be employed to retrieve density data throughout the descent profile.

The Eastern Test Range has a 100 kilometer (330,000 feet) falling sphere computer program which has been developed by the University of Dayton for USAF Cambridge Research Laboratories to derive both density and winds from falling sphere radar tracking data. This program automates the data reduction and can be used in conjunction with the Cajun Dart inflatable sphere. Quite accurate wind data can be derived from the falling sphere below an altitude of 70 kilometers (230,000 feet). Although the sphere descends at a faster rate than the chaff, the wind lag or response error is automatically reduced from the radar data by the above program providing terminal velocity of the sphere is achieved.



CAJUN DART COMBINATION PAYLOAD ASSEMBLY

FIGURE 20

TABLE 8. NOL CAJUN-DART COMBINATION

CHAFF AND SPHERE FLIGHTS

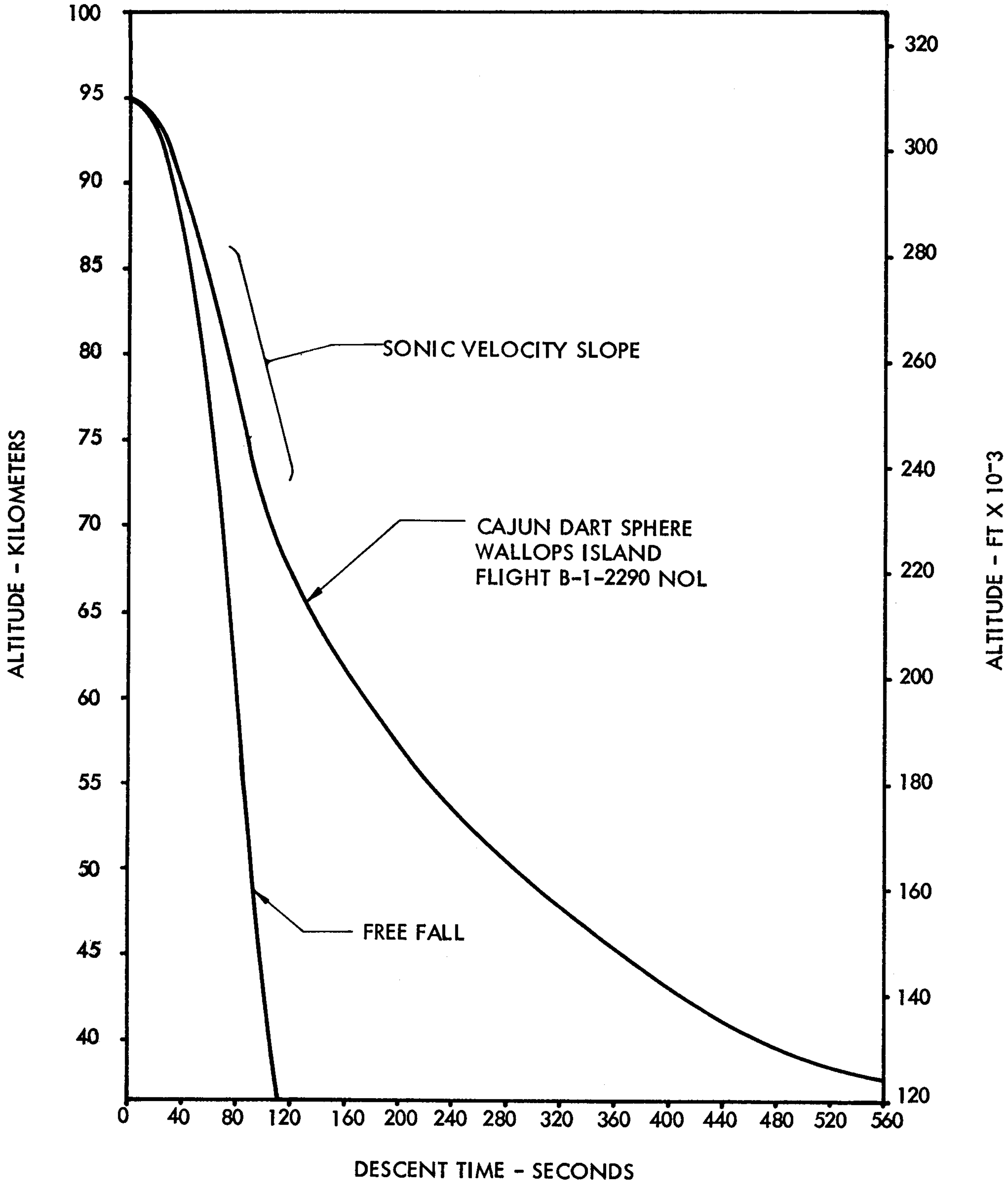
Date	Range	Flight No.	Apogee Altitude
15 Apr 66	Wallops	B-1-2289	93 km (306,000 Feet)
5 May 66	Wallops	B-1-2290	93 km (307,000 Feet)
16 Jun 66	Wallops	B-1-2291	93 km (307,000 Feet)
28 Jun 66	Wallops	B-1-2292	96 km (316,000 Feet)

NOTE: Sphere operated reliably on all flights. Sphere remained supersonic down to an altitude of about 76 km (250,000 ft.).

TABLE 9. MAJOR CHARACTERISTICS OF CAJUN DART INFLATABLE SPHERE

Inflated Diameter	1.0 meter
Total Weight	98 grams
Cross-Section-Area-to-Weight Ratio	7.95 cm^2/gm
Radar Reflector	Aluminized Surface
Apogee Altitude	95 km (310,000 feet)
Measurement Altitude Range	40-80 km (122,000 ft. to 265,000 ft)

FIGURE 21. CAJUN DART INFLATABLE SPHERE DESCENT DATA



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