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METEOROLOGICAL DATA REPORT

UNGUIDED ROCKET IMPACT DISPERSION
AT WHITE SANDS MISSILE RANGE, NEW MEXICO
(September 1969)

BY

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AND
MARJORIE McLARDIE HOIDALE

ATMOSPHERIC SCIENCES OFFICE
WHITE SANDS MISSILE RANGE, NEW MEXICO

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ABSTRACT

Impact dispersion data, in tabular and graphic form, are presented for 182 Aerobees, 78 Athenas, 115 Nike boosted rockets (Nike Apache, Nike Hydac, Nike Apache Nicap, Nike Cajun, Nike Javelin) and 249 ARCAS launched from White Sands Missile Range, New Mexico or the Utah Launch Complex, Green River, Utah during 1965-69. The mean miss for the Aerobee launches is 9.6 statute miles, for the Athena 12.3, for all Nike configurations 12.1, and for the ARCAS 6.9.

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INTRODUCTION

The statistical scatter of the actual impact points about the predicted impact point of an unguided rocket is the rocket's impact dispersion.

The causes of rocket impact dispersion can be divided into five (5) basic categories: 1) variations in atmospheric components, 2) variations in rocket components, 3) rocket misalignments, 4) launcher misalignments, and 5) factors which do not vary but are not precisely evaluated or are unaccounted for.

Before an unguided rocket is flight-tested, a theoretical dispersion study is usually performed to determine an estimate of its dispersion. This analysis can be made using a trajectory simulation program in a high-speed computer. The best estimates available of the perturbing factors can be put in the program and the impact points can be compared with the nominal impact point. When this procedure is used, it is ordinarily assumed that the perturbing factors act independently.

This report presents the actual impact dispersion of Athena (2nd stage), Aerobee-150, ARCAS, and Nike-boosted rockets fired at White Sands Missile Range, New Mexico (WSMR). No attempt is made to isolate the various causes of dispersion.

The actual impact points were taken from surveys when available. Elsewhere, radar or SOTIM* impact data were used.

A brief description of each rocket precedes the graphical and tabular presentation of its impact dispersion.

This information should be helpful for range planning and safety considerations.

* Sonic Observation of Trajectory and Impact of Missiles.

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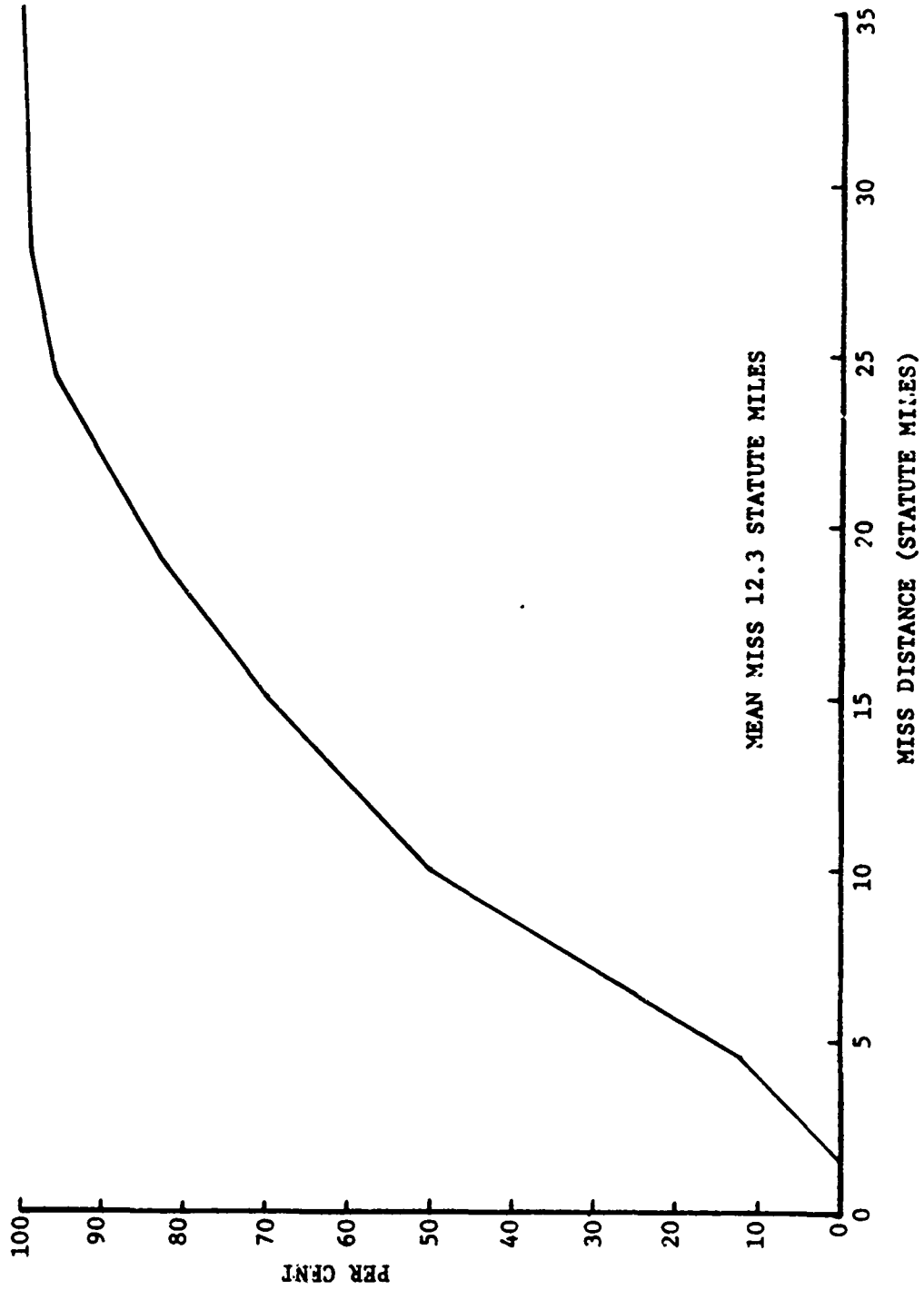
ATHENA

The Athena is a multi-staged, fin-stabilized rocket fired from a zero-length launcher at Green River, Utah to impact on WSMR. The first two stages are unguided and require impact predictions. Since the second stage is most wind sensitive, its impact dispersion is presented.

A meteorological real-time system (1-3) in which wind data from the launch site are transmitted over commercial data lines to a high-speed computer at WSMR is used for these firings. The computer reduces the wind data, applies it to a trajectory simulation (4), and selects launcher settings using iterative techniques.

The peak altitude for the 2nd stage of the Athena is approximately 170 statute miles MSL and its nominal impact range is approximately 455 statute miles.

CUMULATIVE RELATIVE FREQUENCY DISTRIBUTION OF ATHENA
(SECOND STAGE) IMPACT MISS DISTANCES [78 CASES]
WHITE SANDS MISSILE RANGE, NEW MEXICO
1966-69



ATHENA (SECOND STAGE) DISPERSION
 WHITE SANDS MISSILE RANGE, NEW MEXICO
 1966-69

YEAR	TOTAL FIRINGS	CUMULATIVE MEAN MISS STATUTE MILES	RELATIVE FREQUENCY DISTRIBUTION OF ATHENA IMPACT MISS DISTANCES (PER CENT)									
			STATUTE MILES									
			0 ≤ 5	> 5 ≤ 10	> 10 ≤ 15	> 15 ≤ 20	> 20 ≤ 25	> 25 ≤ 30	> 30 ≤ 35	> 35 ≤ 40		
1966	28	12.8	7	41	19	15	15	4				
1967	30	11.6	17	28	28	17	7	3				
1968	16	13.7	13	44	6	6	25					6
1969 thru 13 FEB	4	7.5		75	25							

1966-69	78	12.3	12	38	20	13	13	3			1
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Two Athena launches were excluded from this dispersion analysis:
 9 June 1966 - unknown impact
 9 February 1967 - second stage malfunction

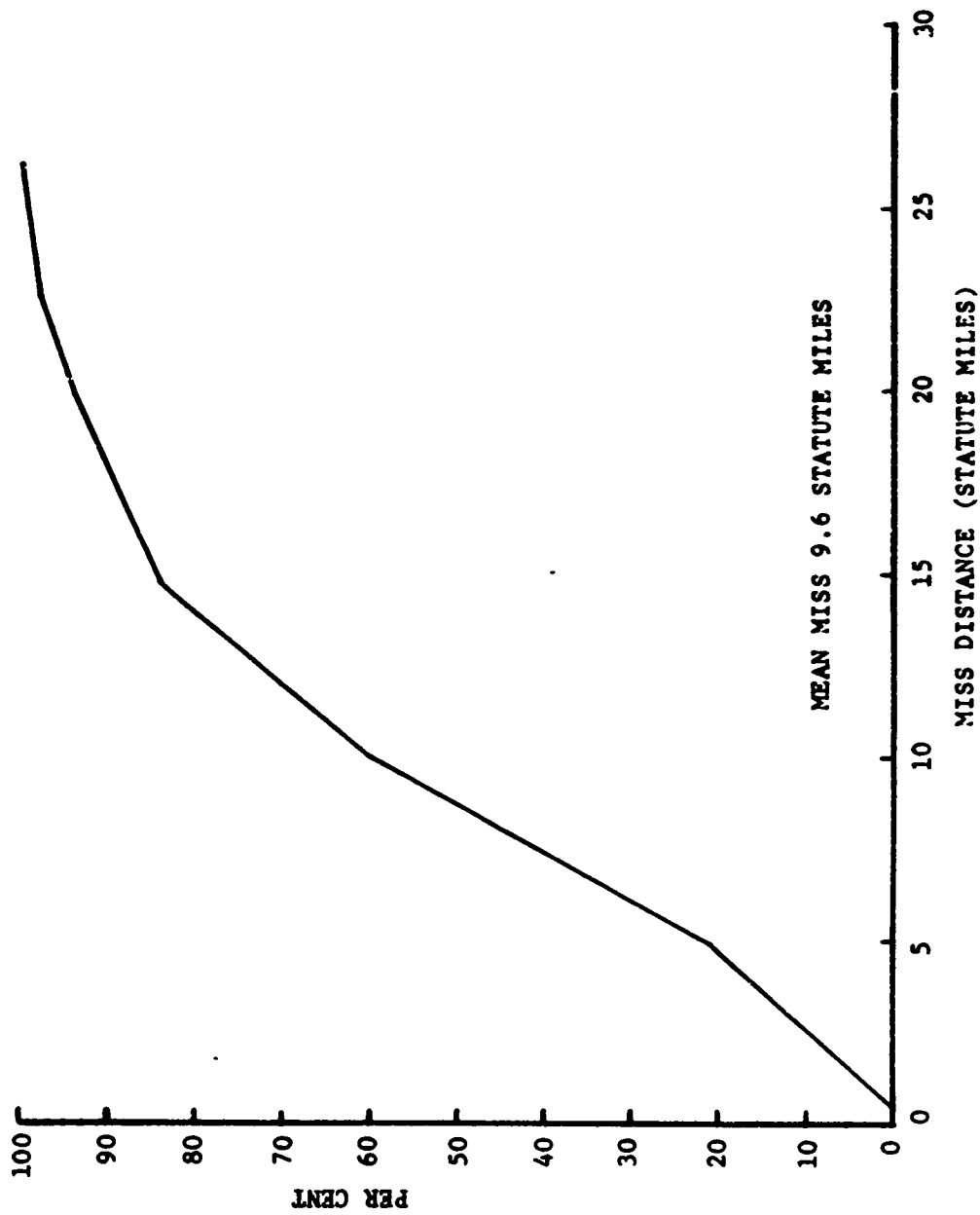
AEROBEE - 150

The Aerobee-150 is a slow acceleration, liquid propellant, fin-stabilized rocket used to carry payloads from 150 to 500 pounds to altitudes from 75 to 190 miles MSL when launched at WSMR (4,000 feet MSL). A solid propellant booster is used to increase the rocket's exit velocity from a 150 foot tower.

The nominal rocket impact range is 50 statute miles, although this may vary, depending on the wind situation and project requirements.

The wind-weighting technique is used for Aerobee-150 impact predictions at WSMR.

CUMULATIVE RELATIVE FREQUENCY DISTRIBUTION OF AEROBEE 150
IMPACT MISS DISTANCES [182 CASES]
WHITE SANDS MISSILE RANGE, NEW MEXICO
1965-69



AEROBEE 150 DISPERSION
 WHITE SANDS MISSILE RANGE, NEW MEXICO
 1965-69

YEAR	TOTAL FIRINGS	CUMULATIVE MEAN MISS STATUTE MILES	RELATIVE FREQUENCY DISTRIBUTION OF AEROBEE 150 IMPACT MISS DISTANCES (PER CENT)					
			STATUTE MILES					
			0 ≤ 5	> 5 ≤ 10	> 10 ≤ 15	> 15 ≤ 20	> 20 ≤ 25	> 25 ≤ 30
1965	42	11.1	10	48	15	13	10	5
1966	37	9.7	12	47	24	18		
1967	42	8.7	31	33	26	7		2
1968	45	9.2	28	30	30	5	5	3
1969 thru 26 APR	16	8.8	25	44	19	13		

1965-69	182	9.6	21	40	23	10	3	2
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The following Aerobee 150 launches were excluded from this dispersion analysis:

1965	2 malfunctions	Number of Aerobees cut:	1965	2
1966	3 malfunctions		1966	2
1968	3 malfunctions; 2 dummy payload rail launches		1968	1

ARCAS

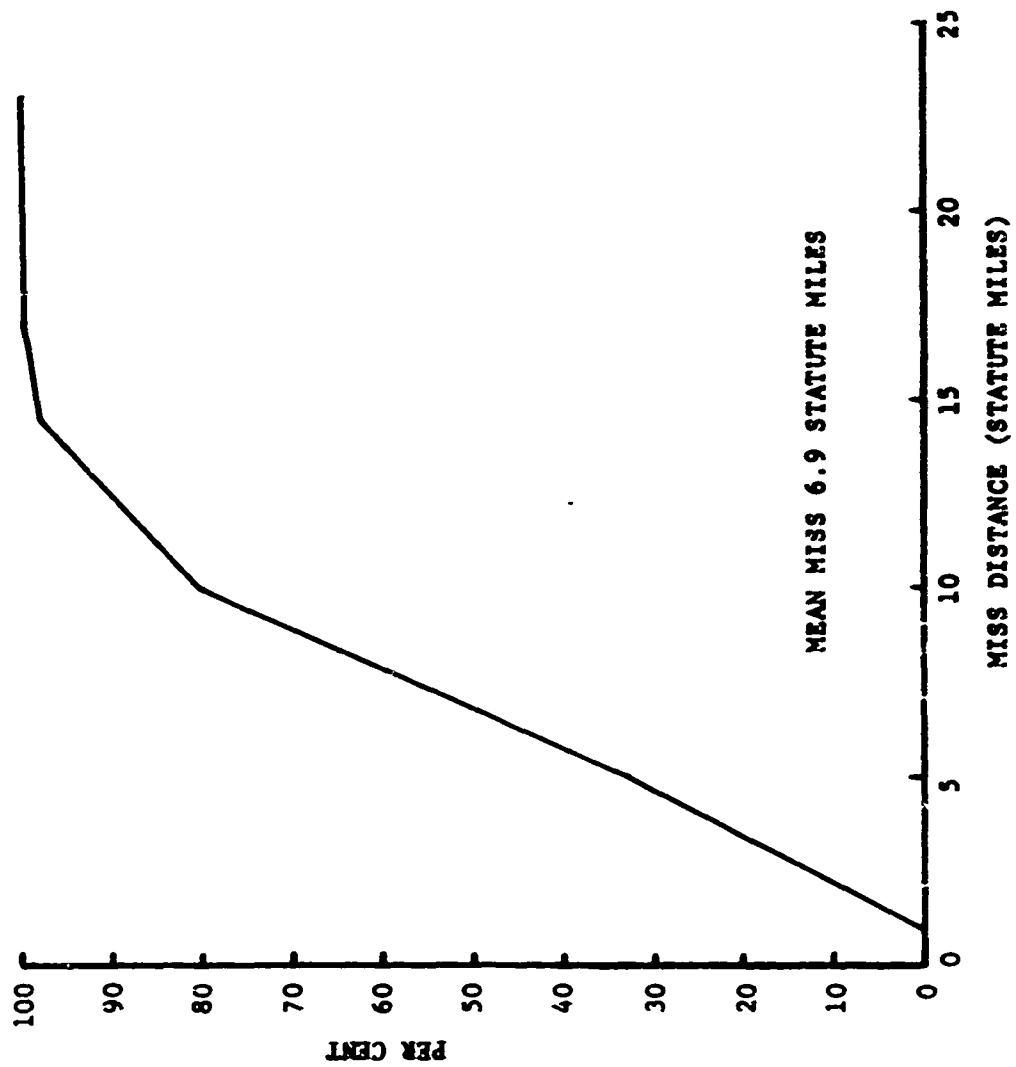
The ARCAS is an end-burning, slow acceleration, fin-stabilized, meteorological rocket used to carry a 6.5 pound payload to approximately 45 miles MSL.

A gas-generator is used to increase the exit velocity of the rocket from an 18 foot launch tube.

The nominal rocket impact range is approximately 35 statute miles at WSMR.

The wind-weighting technique is used for ARCAS impact predictions at WSMR.

CUMULATIVE RELATIVE FREQUENCY DISTRIBUTION OF ARCAS
IMPACT MISS DISTANCES [249 CASES]
WHITE SANDS MISSILE RANGE, NEW MEXICO
1967-68



**ARCAS (GAS GENERATED) DISPERSION
WHITE SANDS MISSILE RANGE, NEW MEXICO
1967-68**

YEAR	TOTAL FIRINGS	CUMULATIVE MEAN MISS STATUTE MILES	RELATIVE FREQUENCY DISTRIBUTION OF ARCAS IMPACT MISS DISTANCES (PER CENT)				
			STATUTE MILES				
			0 ≤ 5	> 5 ≤ 10	> 10 ≤ 15	> 15 ≤ 20	> 20 ≤ 25
1967	123	6.2	41	43	15	0	1
1968	126	7.7	25	51	21	4	0

1967-68	249	6.9	33	47	18	2	1
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The following ARCAS launches were excluded from this dispersion analysis:
 1967 4 malfunctions 6 unknown impacts
 1968 17 malfunctions 8 unknown impacts

NIKE - BOOSTED ROCKETS

The Nike-boosted rockets were combined in this analysis since they all showed similar impact dispersion characteristics.

Each Nike-boosted rocket utilizes a Nike M-5 booster which gives the second stage an initial impulse so that it coasts to an altitude of from 35,000 to 50,000 feet MSL prior to second-stage ignition.

The second-stage motors are, in order of higher performance: Hydac, Javelin, Apache, and Cajun.

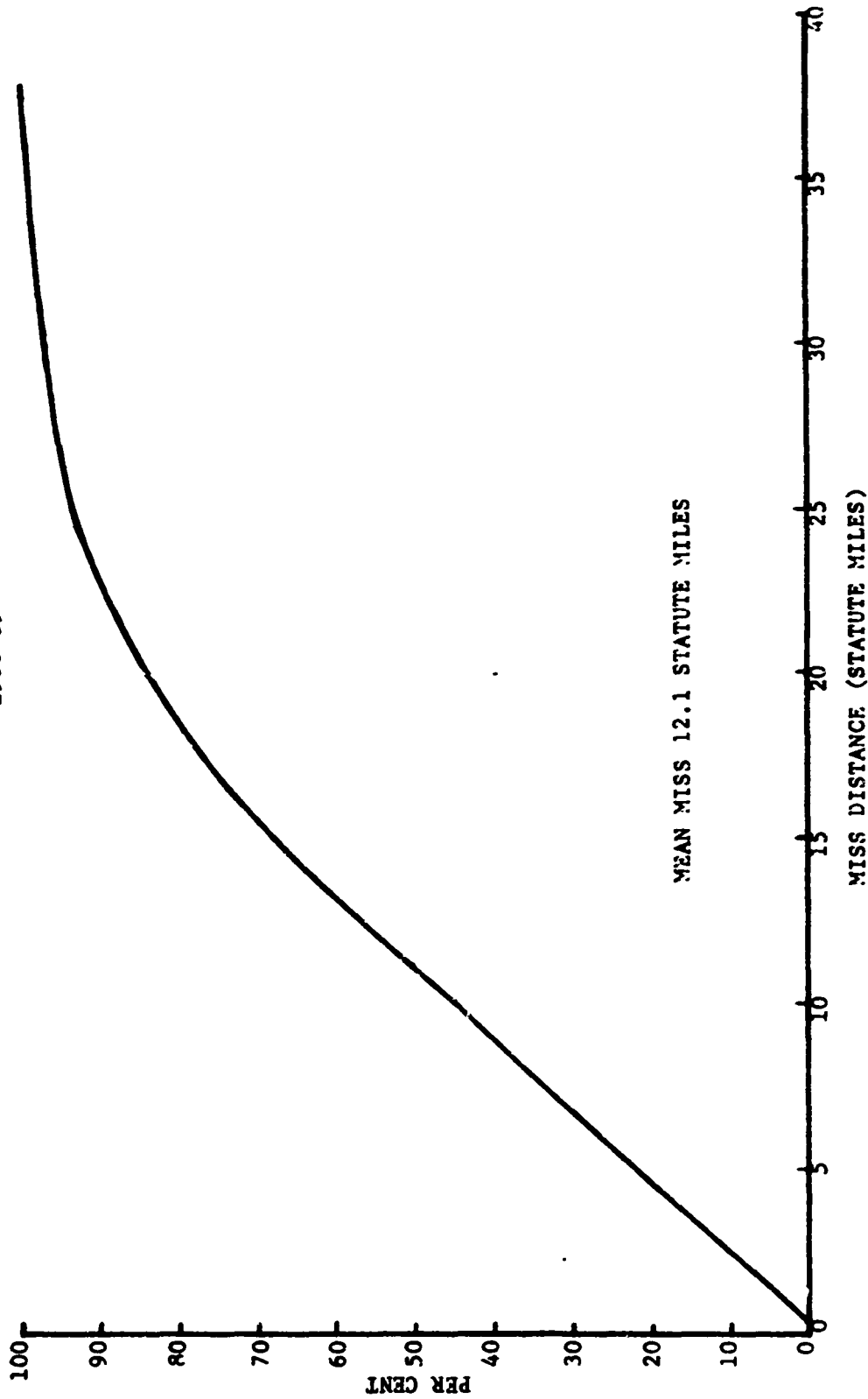
The Nike-Hydac carries a 220 pound payload to approximately 135 miles MSL; the Nike-Javelin carries a 150 pound payload to approximately 120 miles MSL; the Nike-Apache carries a 70 pound payload to approximately 135 miles MSL; and the Nike-Cajun carries a 70 pound payload to approximately 95 miles MSL.

Although all Nike-boosted rockets were combined for the overall dispersion analysis, a table showing impact data for the individual firings follows the dispersion analysis.

The nominal impact range for Nike-boosted rockets at WSMR varies from 50 to 70 statute miles.

The wind-weighting technique is used for impact predictions of Nike-boosted rockets fired at WSMR.

CUMULATIVE RELATIVE FREQUENCY
 DISTRIBUTION OF NIKE BOOSTED ROCKET*
 IMPACT MISS DISTANCES [115 CASES]
 WHITE SANDS MISSILE RANGE, NEW MEXICO
 1966-69



*NIKE APACHE, NIKE HYDAC, NIKE APACHE NICAP, NIKE CAJUN, NIKE JAVELIN

DISPERSION OF NIKE BOOSTED ROCKETS*
WHITE SANDS MISSILE RANGE, NEW MEXICO

1966-69

YEAR	TOTAL FIRINGS	CUMULATIVE MEAN MISS STATUTE MILES	RELATIVE FREQUENCY DISTRIBUTION OF NIKE BOOSTED ROCKET IMPACT MISS DISTANCES (PER CENT)									
			STATUTE MILES									
			0 ≤ 5	> 5 ≤ 10	> 10 ≤ 15	> 15 ≤ 20	> 20 ≤ 25	> 25 ≤ 30	> 30 ≤ 35	> 35 ≤ 40		
1966	52	11.8	20	31	16	18	8	2	4			
1967	41	13.2	17	19	31	14	8	8			1	
1968	18	10.4	35	18	18	12						
1969 thru 27 FEB	4	14.6		25	50	25						
1966-69	115	12.1	21	25	23	16	9	4	2		1	

The following Nike boosted launches were excluded from this dispersion analysis:
 1966 3 malfunctions
 1967 5 malfunctions
 1968 1 malfunction

*NIKE APACHE, NIKE HYDAC, NIKE APACHE NICAP, NIKE CAJUN, NIKE JAVELIN

NIKE APACHE
1966-1968

YEAR	MISSILE	DATE	TIME	PAYLOAD lbs.	PREDICTED 2nd Stage Impact	ACTUAL 2nd Stage Impact	MISS S. Miles	
1968	Speedball II R119 SN 53	2 Feb	1657M	92	49.8S	38.5S	12.4	
	STV070 SRN02	27 Feb	1054M	71	46.0S	49.6S	16.3	
	Speedball II R121 SN54	25 Apr	1006M	85	44.2S	44.0S	17.0	
	Speedball II R122 SN55	8 May	1025M	85	49.8S	59.3S	20.4	
	DRS NASA 14.363 GT	4 Jun	1037M	150	50.0N	41.3N	9.5	
	DRS NASA 14.335 GT	10 Jun	1115M	116.5	49.8N	52.1N	2.3	
	DRS NASA 14.336 UA	12 Aug	0238M	115	50.0N	49.6N	0.4	
	DRS NASA 14.301 UA	20 Aug	1332M	115	50.0N	52.6N	14.3	
	DRS NASA 14.352 UA	4 Dec	1111M	115	49.9N	53.8N	3.9	
	DRS NASA 14.353 UA	14 Dec	0810M	115	50.0N	57.1N	8.1	
	1967	Speedball R096 SN42	11 Jan	1022M	92	39.0S	45.2S	11.3
		Speedball R097 SN43	16 Feb	1323M	45	39.0S	45.2S	19.5

NIKE APACHE (CONT)

1966-1968

YEAR	MISSILE	DATE	TIME	PAYLOAD lbs.	PREDICTED 2nd Stage Impact	ACTUAL 2nd Stage Impact	MISS S. Miles
1967	Speedball R098 SN44	21 Feb	1404M	75	49.8S	47.6S	7.1E
	Speedball II R099 SN45	2 May	1145M	79.5	44.5S	44.3S	11.6E
	Speedball II R100 SN96	17 May	0900M	60.0	48.9S	37.6S	1.9E
	Speedball II R101 SN47	24 May	1110M	77.5	47.3S	53.5S	0.7W
	Speedball II R102 SN 48	5 July	1533M	71	49.8S	64.7S	1.9E
	STV SR57	7 July	0853M	71	43.9S	41.5S	5.8W
	Speedball II R103 SN51	26 July	1010M	60	49.8S	18.1S	1.6E
	Speedball II R104 SN50	26 July	1200M	88	49.8S	51.9S	8.2E
	Speedball II R105 SN49	1 Aug	1325M	68	44.5S	39.9S	27.6E
	Speedball II R106 SN42	2 Aug	1434M	55	49.8S	2.4S	3.9E
	DRS NASA 14.343 GT	4 Aug	2000M	115	43.8N	54.1N	0.7E
	Speedball II R107 SN43	9 Aug	1406M	68	49.8S	55.4S	22.3E
							Malfunction
							Malfunction
							Malfunction

NIKE APACHE (CONT)

1966-1968

YEAR	MISSILE	DATE	TIME	PAYLOAD lbs.	PREDICTED 2nd Stage Impact	ACTUAL 2nd Stage Impact	MISS S. Miles	
1967	Speedball II R108 SN52	22 Aug	1337M	60	49.8S	46.5S	16.8	
	Speedball II R109 SN44	12 Sept	1826M	80	49.8S	50.2S	4.3	
	Speedball II R110 SN45	19 Sept	1253M	80	49.9S	41.2S	Malfunction	
	Speedball II R111 SN46	20 Sept	1100M	80	42.3S	44.1S	3.7	
	Speedball II R112 SN37	22 Sept	1430M	80	49.8S	46.9S	4.5	
	Speedball II R113 SN48	25 Sept	1158M	57	49.8S	49.2S	2.9	
	Speedball II R114 SN49	25 Sept	1600M	57	49.8S	49.0S	4.1	
	Speedball II R115 SN50	26 Sept	1030M	57	46.4S	45.2S	29.9	
	Speedball II R116 SN51	26 Sept	1430M	78	49.8S	52.0S	10.9	
	1966	STV SR022	18 Jan	1306M	55	61.0N	61.0N	24.4
		STV SR023	24 Jan	1304M	55	63.8N	73.0N	18.5
		STV SR024	11 Mar	1200M	76.5	49.8N	32.5N	19.6
		STV SR025	11 Mar	1402M	70	63.7N	3.3N	Malfunction
						0.0	24.2E	

NIKE APACHE (CONT)
1966-1968

YEAR	MISSILE	DATE	TIME	PAYLOAD lbs.	PREDICTED		ACTUAL		MISS S. Miles
					2nd Stage Impact	2nd Stage Impact	2nd Stage Impact	2nd Stage Impact	
1966	STV SR026	29 Mar	1214M	70	69.7N	6.1W	68.1N	12.0W	6.1
	STV SR027	21 Apr	1145M	70.3	70.0N	0.0	78.3N	15.6W	17.7
	STV SR028	21 Apr	1403M	70	70.0N	0.0	77.9N	13.7W	15.8
	STV SR029	2 May	0826M	80	59.8N	5.2W	53.2N	24.0W	19.9
	STV SR030	2 May	1047M	80	59.8N	5.2W	41.7N	10.7E	24.1
	STV SR031	24 May	1600M	74.8	69.9N	3.7W	95.4N	18.2E	33.6
	STV SR032	2 Jun	1043M	74.8	69.7N	6.1W	5.8N	1.5W	Malfunction
	Photometric SR033	7 Jun	0344M	68.5	68.4N	3.6W	67.4N	10.0W	6.4
	Photometric SR034	13 Jun	0344M	68.5	59.8N	5.2W	65.7N	10.4W	7.9
	STV SR034	28 July	1100M	81	69.7N	8.7W	71.3N	7.9W	1.8
	ERDA 66-24	1 Aug	0100M	65	65.7N	5.8W	67.0N	8.3E	14.2
	ERDA 66-25	1 Aug	0306M	65	71.7N	6.3W	12.3N	5.8W	Malfunction
	ERDA 66-26	1 Aug	0600M	65	79.7N	7.0W	88.9N	6.2W	9.2
	ERDA 66-22	1 Aug	1211M	68	69.9N	6.1W	70.7N	6.0W	0.8
	ERDA 66-23	1 Aug	1505M	68	59.8N	5.2W	66.0N	5.1E	12.0

NIKE APACHE (CONT)
1966-1968

YEAR	MISSILE	DATE	TIME	PAYLOAD lbs.	PREDICTED 2nd Stage Impact	ACTUAL 2nd Stage Impact	MISS S. Miles
1966	Speedball II R87 SN33	3 Aug	1100M	65	49.8S 18.1E	33.6S 12.9E	17.0
	STV SR035	4 Aug	0330M	111.5	54.8N 4.8W	49.1N 4.0W	5.8
	DRS NASA 14.170 UA	15 Aug	1435M	115	52.3N 4.6W	57.6N 2.1W	5.9
	STV SRC36	30 Aug	0840M	83	69.9N 4.3W	56.3N 8.9W	14.3
	STV SRC37	9 Sept	0900M	73.5	69.7N 6.1W	74.6N 11.2W	7.1
	Speedball II R88 SN34	9 Sept	1450M	83.8	49.8S 18.1E	60.5S 34.9E	19.9
	Speedball II R089 SN35	28 Sept	1120M	65	49.8S 18.1E	47.5S 10.0E	8.4
	Speedball II R090 SN36	5 Oct	1404M	65	49.8S 18.1E	72.3S 18.0E	22.5
	Speedball II R091 SN37	12 Oct	1048M	80	49.8S 18.1E	58.6S 13.0E	10.2
	Speedball II R092 SN38	12 Oct	1341M	80	49.8S 18.1E	61.7S 25.8E	14.2
	DRS NASA 14.299 UA	18 Nov	1515M	115	48.4N 3.4W	68.5N 0.0	20.4
	Speedball II R093 SN39	18 Nov	1400M	45	39.0S 18.2E	37.1S 20.6E	3.1
	Speedball II R094 SN40	18 Nov	1600M	45	36.9N 16.2E	20.3S 14.4E	16.7
	Speedball II R095 SN41	18 Nov	1800M	45	39.0S 18.2E	45.5S 20.3E	6.8

NIKE-HYDAC
1966-1969

YEAR	MISSILE	DATE	TIME	PAYLOAD lbs.	PREDICTED		ACTUAL		MISS S. Miles
					2nd Stage Impact	2nd Stage Impact	2nd Stage Impact	2nd Stage Impact	
1969	STV75 SR06	14 Jan	0630M	215	69.0N	2.4W	90.5N	7.0W	22.0
	STV82	4 Feb	0811M	305	69.9N	3.7W	62.5N	15.4W	13.8
	STV83	4 Feb	0900M	220	68.9N	12.2W	63.3N	0.7E	14.1
	STV84	27 Feb	0914M	220	73.9N	13.0W	81.8N	15.8W	8.4
1968	STV SR071	12 Aug	0614M	218	60.0N	0.0	59.9N	12.5W	12.5
	STV SR072	4 Sept	0805M	210	69.9N	3.1W	82.2N	15.5W	17.5
	STV SR073	5 Sept	0600M	218	69.9N	3.7W	72.9N	3.8W	3.0
	STV SR074	5 Sept	0800M	218	69.9N	3.7W	70.6N	6.4W	2.8
	STV SR076	10 Oct	0630M	223	69.9N	3.7W	81.2N	22.8E	Malfunction
	95-68-4-604	17 Oct	1530M	400	44.6N	2.3W	42.6N	5.5W	3.6
	95-68-5-604	22 Oct	0900M	400	61.3N	3.2W	65.0N	11.3W	8.9
1967	STV SR077	24 Oct	0703M	217	71.0N	2.5W	89.6N	17.5W	23.9
	STV SR045	5 Jan	0900M	233	68.6N	3.0W	64.5N	7.5W	6.1
	STV SR046	24 Jan	1100M	233	58.0N	1.0W	44.8N	3.9W	13.6
	STV SR047	24 Jan	1329M	233	70.0N	2.0W	90.9N	12.8E	25.6

NIKE HYDAC (CONT)

1966-1969

YEAR	MISSILE	DATE	TIME	PAYLOAD lbs.	PREDICTED 2nd Stage Impact	ACTUAL 2nd Stage Impact	MISS S. Miles
1967	STV SRO48	28 Mar	0933M	233	69.8N 4.9W	69.6N 22.0W	17.1
	DAS STV SRO56	24 May	0721M	233	68.7N 2.4W	47.9N 10.1E	24.3
	STV SRO58	25 Aug	0135M	265	67.9N 3.6W	67.5N 0.9W	2.7
	SR060 SRG02	15 Sept	0041M	270	60.0N 0.0	68.6N 0.0	8.6
	STV SRO59	21 Sept	1000M	215	69.0N 0.0	73.1N 3.8W	5.6
	STV SRO61	11 Oct	2249M	210	70.0N 0.0	76.1N 19.0W	20.0
	STV SRO62	12 Oct	0014M	210	70.0N 1.2E	79.1N 0.4E	9.1
	STV SRO69	11 Dec	1456M	215	64.8N 4.5W	98.6N 12.4E	37.8
	1966	MK12 STV SRO38	20 Sept	0913M	210	69.6N 2.9W	94.0N 26.1W
MK12 STV SRO39		27 Sept	0835M	210	69.9N 2.9W	79.7N 11.1W	12.8
STV SRO40		4 Oct	0802M	233	69.9N 2.9W	66.5N 2.5W	3.4
STV SRO41		25 Oct	1320M	233	69.9N 2.9W	67.9N 4.2W	2.4
MK12 STV SRO42		15 Nov	0845M	233	69.9N 2.4W	80.4N 1.7W	10.5
STV SRO43		22 Nov	0902M	233	69.9N 3.1W	79.5N 27.4W	26.1
STV SRO44		1 Dec	0823M	233	69.9N 2.9W	83.3N 5.5W	13.7

NIKE APACHE NICAP

1967

YEAR	MISSILE	DATE	TIME	PAYLOAD lbs.	PREDICTED 2nd Stage Impact	ACTUAL 2nd Stage Impact	MISS S. Miles
1967	RO-67-1	23 Jan	0001M	65	61.8N	38.4N	Malfunction
	RO-67-2	23 Jan	0300M	65	59.8N	67.4N	4.7W
	RO-67-3	23 Jan	0600M	65	64.8N	16.9N	Malfunction
	RO-67-4	23 Jan	1224M	65	59.8N	82.2N	6.8E
	RO-67-5	26 Jan	1145M	65	75.8N	87.8N	6.1W

NIKE GAJUN

1966

1966	RNO26	22 Apr	1910M	110	65.8N	71.1N	0.0	5.8
	NICAP/1	7 July	0438M	110	62.2N	62.3N	1.9W	5.8
	NICAP/1	15 July	1309M	110	65.6N	65.7N	11.6E	15.0
	NICAP/1	18 July	1540M	110	60.3N	55.5N	1.1E	6.4
	NICAP/1	24 July	0005M	110	58.5N	56.8N	6.7W	2.7
	NICAP/1	24 July	0130M	110	58.5N	63.3N	4.9W	4.8
	NICAP/1	24 July	0300M	110	58.5N	67.5N	0.2W	10.0
	NICAP/1	24 July	0415M	110	58.5N	64.8N	5.2W	6.1
	NICAP/1	24 July	0545M	110	58.5N	60.4N	6.3W	2.5
	NICAP/1	24 July	0700M	110	58.5N	58.0N	7.3W	2.8

NIKE CAJUN (CONT)

1966

YEAR	MISSILE	DATE	TIME	PAYLOAD lbs.	PREDICTED 2nd Stage Impact	ACTUAL 2nd Stage Impact	MISS S. Miles
1966	NASA 10.181A1	25 Oct	1110M	104	52.5N 0.0	55.0N 0.6W	2.6
	NASA 10.1066M	9 Dec	0400M	249	39.4N 7.0W	34.8N 1.8W	6.9

NIKE JAVELIN

1967

1967	MD-67-9.5-2	14 Sept	1930M	180	70.0N 0.0	80.9N 4.4E	11.8
	MD-67-9.5-3	8 Nov	1541M	180	68.0N 2.4W	62.6N 7.4E	11.2

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13. ABSTRACT Impact dispersion data, in tabular and graphic form, are presented for 182 Aerobees, 78 Athenas, 115 Nike-boosted rockets (Nike Apache, Nike Hydac, Nike Apache Nicap, Nike Cajun, Nike Javelin) and 249 ARCAS launched from White Sands Missile Range, New Mexico or the Utah Launch Complex, Green River, Utah during 1965-69. The mean miss for the Aerobee launches is 9.6 statute miles, for the Athena 12.3, for all Nike configurations 12.1, and for the ARCAS 6.9.			

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