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TITLE

SIDEWINDER ARCAS PERFORMANCE CHARACTERISTICS

SUBMITTED UNDER	
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FOREWORD

This report presents the results of analyses performed to determine the flight characteristics of the Sidewinder-Arcas required to obtain range acceptance at the NASA Wallops Island Launch Facility. These analyses were performed by the Missiles and Space Division (MSD) of LTV Aerospace Corporation in support of the NASA Langley Research Center Flight Vehicle Systems Division (NASA-LRC-FVSD) under Dallas Support Item No. 5 to NASA LRC Contract NAS1-6957.

SUMMARY

This report presents the results of analyses performed to determine certain of the flight characteristics of the Sidewinder-Arcas sounding rocket required to obtain range acceptance at the NASA Wallops Island Launch Facility. In addition, a procedure and the required information to compensate for the effects of winds during flight has been developed for a nominal, 12-pound payload weight 80-degree launch elevation angle, trajectory. This procedure consists of determining the adjustment in launcher settings required to correct for errors in second stage impact location due to winds.

The aerodynamic and rocket motor characteristics, mass inertia properties and sequence of events utilized in these analyses are presented. These data were supplied by NASA-LRC-FVSD with the exception of aerodynamic coefficients for axial force and roll characteristics which were developed as a part of this contract.

Results of these analyses have been reviewed with NASA-LRC-FVSD and NASA-WI range safety personnel and there appears to be no problem in obtaining range acceptance as far as performance and flight characteristics are concerned. The performance analysis indicates that the Sidewinder-Arcas vehicle can place a 12-pound payload to an altitude in excess of 400,000 feet.

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LIST OF SYMBOLS

A_Z	launch azimuth, deg.
C_{A_o}	axial force coefficient
C_l	rolling moment coefficient
C_{l_p}	roll damping derivative, 1/deg.
C_{l_δ}	fin deflection rolling moment derivative, 1/deg.
C_m	pitching moment coefficient
C_{m_α}	angle of attack pitch moment derivative, 1/rad.
C_{m_δ}	fin deflection pitch moment derivative, 1/rad.
C_{m_ϕ}	joint misalignment pitch moment derivative, 1/deg.
$C_{m_{Q_{REF}}}$	pitch damping derivative, 1/rad.
C_{N_α}	angle of attack normal force derivative, 1/rad.
C_{N_δ}	fin deflection normal force derivative, 1/rad.
d	reference length, ft.
f(Z)	wind weighting function
h	altitude, ft.
I	pitch, yaw moment of inertia, slug-ft^2
l_{CG}	center of gravity location from l_{REF}, positive from the nose toward the base, ft.
l_{REF}	body reference station, ft.
M_{Y_Q}	jet damping term, ft-lb/rad/sec
m	mass, slugs
p	roll rate, rad/sec.
$\bar{q}$	dynamic pressure, lb/ft^2
R	impact range, ft.

LIST OF SYMBOLS (Continued)

S	reference area, ft^2
T	thrust, lb.
u	velocity component along longitudinal axis, ft/sec
V	relative velocity, ft/sec.
W_C	crosswind component, ft/sec.
W_E	east wind component, ft/sec.
W_N	north wind component, ft/sec.
W_R	range wind component, ft/sec.
ΔR	impact displacement due to range wind, ft.
ΔR_D	impact range correction required, ft.
ΔC	impact displacement due to crosswind, ft^2
$\Delta\theta$	launch elevation angle adjustment, deg.
α	angle of attack, deg.
β	angle of sideslip, deg.
δ_A	Arcas fin cant or misalignment angle per fin, deg.
δ_C	unit crosswind effect, ft/ft/sec.
δ_R	unit range wind effect, ft/ft/sec.
δ_S	Sidewinder fin misalignment per fin, deg.
ϵ	launch azimuth adjustment, deg.
θ	launch elevation angle, deg.
$\dot{\theta}$	pitch rate, deg/sec
η	resultant angle of attack of spin axis, deg.
σ_T	thrust misalignment, deg.
ξ	damping ratio
ϕ	joint misalignment, deg.
ω_o	pitch natural frequency, rad/sec.

LIST OF SYMBOLS (Continued)

Subscripts

0	initial value; initial coordinate system
1	second coordinate system; lower altitude
2	higher altitude
CG	referenced to center of gravity

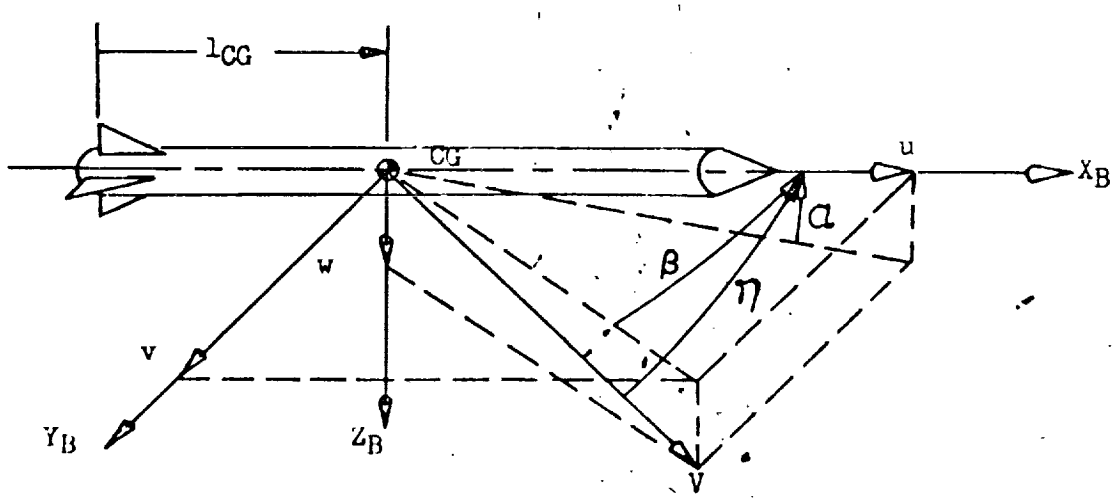
Superscripts

0	initial coordinate system
1	second coordinate system

NOTE: Symbols with dot indicate first derivative with respect to time

VEHICLE AXIS SYSTEM

X_B, Y_B, Z_B are body axes.



1.0 INTRODUCTION

This report presents the results of engineering analyses of the Sidewinder-Arcas sounding rocket. These analyses were performed under Dallas Support Item No. 5 to Contract NAS1-6957. To obtain acceptance by Wallops Station for launch of the Sidewinder Arcas vehicle, certain data are required for range safety and mission planning purposes. The objective of this effort is to provide the necessary performance, aerodynamic, and flight dynamic information.

Specific tasks in the analyses included determining the drag, roll damping derivative, and rolling moment derivative of the vehicle; calculating a nominal trajectory based on a 12-pound payload and an 80-degree launch elevation angle; calculating additional trajectories for other combinations of payload weights of 12, 14, and 16 pounds and launch elevation angles of 75, 80, and 85 degrees; performing a dispersion analysis based on the nominal trajectory and certain error sources; developing wind compensation data for the nominal trajectory; defining the pitch-roll resonance flight conditions; and determining the dynamic response of the vehicle to thrust and vehicle misalignments.

The results of the aerodynamic analysis combined with the vehicle configurational data supplied by NASA-LRC give the input data for the trajectory analysis. The results of this effort are presented in graphical and tabular form. For the nominal trajectory, certain trajectory parameters are plotted as time histories; data from the other trajectories are presented parametrically over the ranges of payload weight and launch elevation angle considered. To allow more precise evaluation of specific trajectory parameters, computer print-outs of the trajectory parameters including radar tracking data are presented in Appendix A.

The vehicle data supplied by LRC have been enclosed in an effort to include all relevant data in one document. Since the Sidewinder motor performance is classified, thrust and acceleration data during Sidewinder boost have been removed from the computer printouts and placed in the classified Appendix B. This will permit wider distribution and more convenient handling of this volume.

2.0 VEHICLE CONFIGURATIONAL DATA AND ANALYSIS

The Sidewinder-Arcas is a two-stage unguided rolling fin-stabilized sounding rocket used to place small payloads to altitudes in excess of 60 n. miles. A sketch of the vehicle is presented in Figure 2-1, and the mission sequence is indicated in Figure 2-2. The four fins at the base of both the Sidewinder and Arcas stages provide the required aerodynamic stability during atmospheric flight. The Sidewinder fins are nominally set at zero cant angle. The Arcas fins are preset to a cant angle sufficient to induce a high spin rate during second stage flight. This spin rate provides additional stability and also reduces the effects of vehicle and thrust misalignments on dispersion.

In this section the configurational data used in the trajectory simulations are presented.

2.1 Aerodynamic Data and Analysis

A portion of the aerodynamic coefficients required for the Sidewinder-Arcas analysis were supplied by NASA-LRC, and the remainder were calculated by MSD as a specific task in the analysis. The task consisted of determining the zero-lift drag coefficients, roll damping derivatives, and rolling moment derivatives as a function of Mach number for both first and second stage operation.

In developing the zero-lift drag coefficients, the fin drag contribution was estimated using the methods and data from Reference 1, and the wave drag of the nose is based on data from Reference 1 and unpublished design curves. The body skin friction drag was predicted using the Prandtl-Schlichting equations with correction by Eckerts' reference temperature method. The drag contributions due to steps and protuberances were estimated using References 2 and 3. Base drag was estimated using the base pressure of a cylindrical afterbody.

The roll damping derivatives and rolling moment derivatives were calculated using the methods of Reference 4. The fin-alone normal force derivatives were derived from Reference 1, supersonic linearized theory, and unpublished design curves. The wing-body-tail interference and downwash factors were calculated using Reference 5, as was recommended in Reference 4.

In the development of the aerodynamic data, it was found that the canted Arcas fins create a downwash on the Sidewinder fins; this has a significant effect on the total vehicle roll characteristics. The downwash almost completely cancels the effectiveness of the deflected Arcas fins in the subsonic and low transonic regions. In the low supersonic region, the downwash effect is greater and creates a roll reversal.

2.1.1 Nominal Vehicle Aerodynamic Coefficients

The aerodynamic coefficients for the Sidewinder/Arcas/payload configuration, shown in Figure 2-1, are presented in Table 2-1 and in Figures 2-3, 2-4, 2-7, 2-8 and 2-9. These coefficients are applicable for the entire vehicle and are representative of the vehicle's characteristics through first stage (Sidewinder) flight. The axial force coefficient, C_{A_o}, rolling moment derivative, C_{l_δ}, and the roll damping derivative, C_{l_p}, were calculated by MSD as a part of this analysis and are plotted in Figures 2-3 and 2-4. The remaining derivatives were supplied by NASA-LRC in unpublished form.

The aerodynamic coefficients for the Arcas/payload configuration given in Table 2-2 and in Figures 2-5, 2-6, 2-7, 2-8, and 2-9 represent the vehicle's characteristics following separation of the Sidewinder booster stage. Axial force coefficients are presented for Arcas powered flight and for coasting flight, both before and after Arcas powered flight. As in the case of the total vehicle configuration, C_{A_o}, C_{l_δ}, and C_{l_p} were determined

by MSD and the remainder of the coefficients were supplied by NASA-LRC in unpublished form.

Since the completion of the results documented in this report, the NASA-LRC supplied aerodynamic data (C_{N_α}, C_{m_α} and C_{m_Q}) have been updated by NASA-LRC to reflect recent refinements in their computer program for generating slender-body aerodynamic characteristics. However, the changes in the aforementioned data are small (less than 10%), and it has been determined by NASA-LRC that the effects of these data changes on the performance characteristics presented in this document are negligible. The updated aerodynamic data are to be documented in a future NASA-LRC report.

Axial force coefficients for both the Sidewinder and Arcas spent booster stages are presented in Table 2-3 and Figure 2-10. These data were used in computing trajectories to impact for the Sidewinder after separation from the Arcas and for the Arcas after separation from the nosecone.

2.1.2 Dispersion Analysis Aerodynamic Coefficients

2.1.2.1 Sidewinder Fin Misalignment

Aerodynamic coefficients for vehicle and fin misalignments were required for the impact dispersion analysis. Sidewinder fin misalignment was considered likely in three distinct modes: 1) fins misaligned in a manner to alter the nominal roll rate, 2) two fins misaligned to produce a pitching moment, and 3) two fins misaligned so that a yawing moment is produced. These modes represent extremes since in the most probable case the fins would not be misaligned the same amount in the same direction.

The rolling moment derivative, $C_{l_{\delta_s}}$, for the Sidewinder fin roll misalignment case was calculated by MSD and is presented in Table 2-4. The rolling moment coefficient for the total vehicle is determined by adding the effect of the Sidewinder fin misalignment to the nominal Arcas fin rolling moment coefficient. The rolling moment coefficient

for the vehicle, C_l, as given in Table 2-4, is the sum of the Sidewinder rolling moment derivative, $C_{l_{\delta_s}}$, multiplied by a fin misalignment of 0.1 degree and the Arcas rolling moment derivative from Table 2-1, C_{l_δ}, multipled by a nominal fin cant angle of 0.35 degree. Since the contribution of the misaligned Sidewinder fins is more than five times larger than the contribution of the canted Arcas fins, the magnitude of the vehicle roll rate for the dispersion trajectory will be increased over the nominal case whether the two effects are added or subtracted, and the direction depends on the direction of the Sidewinder fin misalignment.

For the two remaining possibilities of Sidewinder fin misalignment, moment coefficients are given in Table 2-5. These coefficients, which are applicable to both pitch and yaw cases, were obtained by converting the fin deflection pitching moment, C_{m_δ}, and normal force, C_{N_δ}, derivatives into a moment about the center of gravity. The fin deflection derivatives were supplied by NASA-LRC in unpublished form.

2.1.2.2 Arcas Fin Misalignment

For Arcas fin misalignment, the same three possibilities exist that were analyzed for the Sidewinder fin misalignment. The roll misalignment case, however, can be handled by using the rolling moment derivative, C_{l_δ}, in Table 2-2. The misalignment angle can be either added or subtracted to the nominal cant angle, and the roll rate for the dispersion trajectory will be increased or decreased accordingly.

Moment coefficients for Arcas fin misalignment producing pitch or yaw moments are given in Table 2-6. The left part of Table 2-6 was used for first stage flight, and the right part, for second stage flight. The moment coefficients, which are applicable in either the pitch or yaw direction, were obtained by converting fin deflection derivatives supplied by NASA-LRC into moment coefficients about the

center of gravity.

2.1.2.3 Stage Misalignment

To determine the effects on impact points of misalignments at the joints of the vehicle, normal force and moment coefficients were supplied by NASA-LRC. These moment coefficients were transferred to the center of gravity and are given in Table 2-7 for a 0.25 degree misalignment at the Sidewinder/Arcas joint and in Table 2-8 for a 0.375 degree misalignment at the Arcas/payload joint. The left part of Table 2-8 was used for first stage flight, and the right part, for second stage flight.

2.2 Propulsion Data

Propulsion data in the form of vacuum thrust and propellant weight remaining are given in Table 2-9 for the Arcas motor. Since the Sidewinder thrust is classified, the thrust and propellant weight data for this motor are contained in Appendix B. The data as received from NASA-LRC were in the form of sea level thrust. Since the NEMAR computer program (Reference (6)) requires vacuum thrust, the LRC data were modified by adding the product of sea level atmospheric pressure and exit area to the thrust value for each time point, except ignition and burnout.

2.3 Weight, Center of Gravity, and Moment of Inertia Data

Weight, center of gravity, and moment of inertia data are presented in Tables 2-10, 2-11, and 2-12 for the 12, 14, and 16 pound payloads, respectively. These data are given as a function of time during powered flight. The pitch moment of inertia, as supplied by LRC, was referenced to the aft end of each configuration. The inertias were transferred to a center of gravity referenced to comply with the NEMAR computer program input requirements.

TABLE 2-1

AERODYNAMIC COEFFICIENTS FOR THE SIDEWINDER/ARCAS/PAYLOAD CONFIGURATION

MACH NO.	C_{A_o}	C_{l_δ} 1/deg.	C_{l_p} 1/deg.
0	0.1073	0.00154	-0.0329
0.2	0.1082	0.00134	-0.0329
0.4	0.1096	0.00115	-0.0330
0.6	0.1130	0.00094	-0.0332
0.8	0.1189	0.00074	-0.0335
0.9	0.1236	0.00059	-0.0338
1.0	0.1342	0.00037	-0.0355
1.1	0.1393	0.00006	-0.0388
1.2	0.1393	-0.00039	-0.0414
1.3	0.1391	-0.00082	-0.0436
1.4	0.1382	-0.00069	-0.0452
1.5	0.1372	-0.00045	-0.0461
2.0	0.1301	0.00069	-0.0446

MACH NO.	C_{N_α} 1/rad.	C_{m_α} 1/rad.	$C_{m_{\alpha REF}}$ 1/rad.
0	5.01	16.21	-247.49
0.2	5.02	16.31	-246.44
0.4	5.07	16.45	-249.64
0.6	5.09	16.67	-251.82
0.8	5.25	17.19	-257.88
1.0	5.50	17.97	-268.79
1.2	5.80	19.09	-281.55
1.4	6.10	20.31	-303.27
1.6	6.10	20.31	-305.23

NOTE: Reference area = 1 ft^2
Reference length = 1 ft.
Moment reference is the aft end of the Sidewinder
4 Arcas fins deflected for C_{l_δ}

TABLE 2-2

AERODYNAMIC COEFFICIENTS FOR THE ARCAS/PAYLOAD CONFIGURATION

MACH NO.	C_{A_o} COAST	C_{A_o} THRUST	C_{l_δ} 1/deg.	C_{l_p} 1/deg.
1.0	0.06073	0.05698	0.00538	-0.00427
1.2	0.06073	0.05698	0.00770	-0.00566
1.4	0.05786	0.05444	0.00778	-0.00574
2.0	0.04991	0.04726	0.00712	-0.00525
3.0	0.03898	0.03732	0.00567	-0.00419
4.0	0.03191	0.03070	0.00443	-0.00328
5.0	0.02705	0.02628	0.00360	-0.00268

MACH NO.	C_{N_α} 1/rad.	C_{m_α} 1/rad.	C_{m_Q} REF 1/rad.
1.2	2.31	2.78	-27.89
1.4	2.10	2.70	-27.73
2.0	1.71	2.48	-25.94
2.5	1.48	2.60	-28.43
3.0	1.34	2.74	-31.02
3.5	1.21	2.81	-32.28
4.0	1.26	2.82	-32.11
4.5	1.24	2.77	-31.67
10.0	1.24	2.77	-31.35

NOTE: Reference area = 1 ft^2
Reference length = 1 ft.
Moment reference is the aft end of the Arcas
4 Arcas fins deflected for C_{l_δ}

TABLE 2-3

SPENT STAGE DRAG COEFFICIENTS

MACH NO.	C_{A_o} SIDEWINDER	C_{A_o} ARCAS
0	0.155	0.117
0.4	0.158	0.129
0.6	0.161	0.132
0.8	0.165	0.148
1.0	0.183	0.163
1.2	0.190	0.163
1.4	0.196	0.183
1.6	0.201	0.187
1.8	0.201	0.188
2.0	0.201	0.190
2.2	--	0.199
2.4	--	0.202

NOTE: Angle of attack = 0
Reference area = 1 ft^2

TABLE 2-4

ROLLING MOMENT COEFFICIENTS FOR SIDEWINDER FIN MISALIGNMENT

MACH NO.	$C_{l_{\delta_s}}$ 1/deg.	C_l
0	0.0290	0.00344
0.2	0.0291	0.00338
0.4	0.0294	0.00334
0.6	0.0298	0.00331
0.8	0.0303	0.00329
0.9	0.0307	0.00328
1.0	0.0321	0.00334
1.1	0.0360	0.00326
1.2	0.0391	0.00377
1.3	0.0413	0.00384
1.4	0.0426	0.00402
1.5	0.0430	0.00414
2.0	0.0405	0.00381

NOTE: $C_l = C_{l_\delta} \times \delta_A + C_{l_{\delta_s}} \times \delta_s$

where C_{l_δ} = total rolling moment derivative (Table 2-1)

δ_A = Arcas fin cant angle per fin (4 fins deflected), 0.35 degrees.

$C_{l_{\delta_s}}$ = Sidewinder rolling moment derivative.

δ_s = Sidewinder fin misalignment angle per fin (4 fins deflected), 0.10 degrees

TABLE 2-5

MOMENT COEFFICIENTS FOR SIDEWINDER FIN MISALIGNMENT, PITCH AND YAW CASES

MACH NO.	C_{m_δ} * 1/rad.	C_{N_δ} 1/rad.	C_m, C_n **
0	1.80	2.43	-0.0220
0.2	1.80	2.43	-0.0225
0.4	1.81	2.44	-0.0229
0.6	1.81	2.44	-0.0234
0.8	1.84	2.48	-0.0242
0.9	1.88	2.54	-0.0250
1.0	1.92	2.60	-0.0258
1.1	1.95	2.64	-0.0264
1.2	1.98	2.68	-0.0270
1.3	2.04	2.74	-0.0279
1.4	2.08	2.81	-0.0291
1.5	2.08	2.81	-0.0302
2.0	2.08	2.81	-0.0302

Reference Area = 1 ft^2

* Referenced to aft end of Sidewinder
** Referenced to instantaneous center of gravity

$$C_m = \left[C_{m_\delta} - C_{N_\delta}\left(\frac{l_{cg}}{d}\right)\right]\left[\frac{\delta_s}{180/\Pi}\right]$$

l_{CG} = instantaneous center of gravity location

d = reference length = 1 ft.

δ_s = Sidewinder fin misalignment = 0.1 deg.

TABLE 2-6

MOMENT COEFFICIENTS FOR ARCAS FIN MISALIGNMENT, PITCH AND YAW CASES

SIDEWINDER/ARCAS/PAYLOAD CONFIGURATION			
MACH NO.	C_{m_δ} * 1/rad.	C_{N_δ} 1/rad.	C_m, C_n**
0	5.95	0.87	0.001376
0.2	5.96	0.87	0.001235
0.4	6.17	0.90	0.001143
0.6	6.22	0.91	0.000968
0.8	6.45	0.94	0.000884
0.9	6.73	0.98	0.000847
1.0	7.01	1.02	0.000805
1.1	7.69	1.12	0.000770
1.2	8.38	1.22	0.000743
1.3	8.27	1.21	0.000534
1.4	8.15	1.20	0.000529
1.5	8.15	1.20	-0.000212
2.0	8.15	1.20	-0.000212

ARCAS/PAYLOAD CONFIGURATION			
MACH NO.	C_{m_δ} * 1/rad.	C_{N_δ} 1/rad.	C_m, C_n**
0	0.643	0.87	-0.00363
1.0	0.757	1.02	-0.00426
1.2	0.906	1.22	-0.00509
1.4	0.880	1.19	-0.00523
2.0	0.737	1.00	-0.00483
3.0	0.525	0.71	-0.00366
4.0	0.439	0.59	-0.00306
5.0	0.415	0.57	-0.00280

* Referenced to base of stage
** Referenced to center of gravity

C_m equation given in Table 2-5

Reference length = 1.0 ft.

Reference area = 1.0 ft^2

TABLE 2-7

MOMENT COEFFICIENTS FOR SIDEWINDER/ARCAS MISALIGNMENT, PITCH AND YAW CASES

MACH NO.	$C_{m_\phi}\phi$
0	0.0146
0.2	0.0140
0.4	0.0135
0.6	0.0129
0.8	0.0123
0.9	0.0116
1.0	0.0118
1.1	0.0118
1.2	0.0114
1.3	0.0107
1.4	0.0100
1.5	0.0083
2.0	0.0083

NOTE: Referenced to center of gravity

0.25 deg. joint misalignment at station 78.485

Reference length = 1.0 ft

Reference Area = 1.0 ft^2

TABLE 2-8

MOMENT COEFFICIENTS FOR ARCAS/PAYLOAD MISALIGNMENT, PITCH AND YAW CASES

SIDEWINDER/ARCAS/PAYLOAD CONFIGURATION	
MACH NO.	$C_{m_\phi}\phi$
0	0.0205
2.0	0.0205

ARCAS/PAYLOAD CONFIGURATION	
MACH NO.	$C_{m_\phi}\phi$
0	0.00588
1.0	0.00588
1.2	0.00588
1.4	0.00569
2.0	0.00482
3.0	0.00583
4.0	0.00561
5.0	0.00568

NOTE: Referenced to instantaneous center of gravity during boost

0.375 deg. joint misalignment at station 151.448

Reference length = 1.0 ft.

Reference area = 1.0 ft^2

TABLE 2-9

ARCAS THRUST AND PROPELLANT WEIGHT

TIME	SEA LEVEL THRUST lb	VACUUM THRUST lb	PROPELLANT WEIGHT REMAINING lb
0.0	0	0	43.102
0.1	200	237	42.958
0.3	225	262	42.671
0.5	242	279	42.384
1.0	254	291	41.665
1.5	249	286	40.947
2.0	286	323	42.229
2.4	305	342	39.654
3.0	316	353	38.792
4.0	336	373	37.355
5.0	340	377	35.904
6.0	345	382	34.482
7.0	348	385	33.045
8.0	357	394	31.608
9.0	362	399	30.172
10.0	358	395	28.747
15.0	352	389	21.551
20.0	330	367	14.353
22.0	318	355	11.495
24.0	316	353	8.621
26.0	314	351	5.748
27.0	312	349	4.311
27.5	296	333	3.592
28.0	242	279	2.874
28.5	161	189	2.155
29.0	67	104	1.438
30.0	0	0	0

Nozzle Exit Area = 2.55 in^2

TABLE 2-10

WEIGHT, CENTER OF GRAVITY, AND MOMENTS OF INERTIA FOR 12-POUND PAYLOAD*

EVENT	TIME sec	WEIGHT lb	PITCH INERTIA slug-ft^2 (A)	ROLL INERTIA slug-ft^2	CENTER OF GRAVITY ft (B)
Sidewinder Ignition	0	173.891	84.677	0.263552	5.9326
	1.0	155.888	78.164	0.249671	6.2680
	1.4	148.687	75.199	0.244119	6.4249
	1.8	141.486	71.984	0.238560	6.5978
	2.2	134.285	68.479	0.233015	6.7892
Sidewinder Burnout	2.4	130.684	66.608	0.230238	6.8928
Coast	2.4	80.843	8.570	0.0563262	3.09642
	5.0	80.843	8.570	0.0563262	3.09642
Arcas Ignition	5.0	80.693	8.520	0.0563257	3.10175
	10.0	73.495	7.314	0.0530591	3.31958
	15.0	66.338	6.561	0.0498116	3.50358
	20.0	59.142	6.205	0.0465452	3.64375
	25.0	51.944	6.106	0.0432789	3.72025
	30.0	44.789	6.088	0.0400317	3.70350
Arcas Burnout	35.0	37.591	5.869	0.0367650	3.53875

* Of this 12-pound payload, ~~6.2~~ 11.08 pounds are separated at apogee.
(A) About center of gravity.
(B) From aft end of each stage.

TABLE 2-11

WEIGHT, CENTER OF GRAVITY, AND MOMENTS OF INERTIA FOR 14-POUND PAYLOAD *

EVENT	TIME sec	WEIGHT lb	PITCH INERTIA slug-ft^2(A)	ROLL INERTIA slug-ft^2	CENTER OF GRAVITY ft (B)
Sidewinder Ignition	0	175.891	87.678	0.264032	6.0121
	1.0	157.888	80.881	0.250151	6.3523
	1.4	150.687	77.788	0.244599	6.5111
	1.8	143.486	74.434	0.239040	6.6861
	2.2	136.285	70.782	0.233495	6.8792
Sidewinder Burnout	2.4	132.684	68.833	0.230718	6.9837
Coast	2.4	82.843	9.291	0.0568062	3.33361
	5.0	82.843	9.291	0.0568062	3.33361
Arcas Ignition	5.0	82.693	9.240	0.0568057	3.33924
	10.0	75.495	7.956	0.0535391	3.57394
	15.0	68.338	7.143	0.0502916	3.77919
	20.0	61.142	6.748	0.0470252	3.94722
	25.0	53.944	6.636	0.0437589	4.06137
	30.0	46.789	6.638	0.0405117	4.09750
Arcas Burnout	35.0	39.591	6.494	0.0372450	4.01271

* Of this 14-pound payload, 8.2 pounds are separated at apogee.
(A) About center of gravity.
(B) From aft end of each stage.

TABLE 2-12

WEIGHT, CENTER OF GRAVITY, AND MOMENTS OF INERTIA FOR 16-POUND PAYLOAD*

EVENT	TIME sec	WEIGHT lb	PITCH INERTIA slug-ft^2(A)	ROLL INERTIA slug-ft^2	CENTER OF GRAVITY ft (B)
Sidewinder Ignition	0	177.891	90.615	0.264512	6.0897
	1.0	159.888	83.532	0.250631	6.4344
	1.4	152.687	80.311	0.245079	6.5951
	1.8	145.486	76.822	0.239520	6.7717
	2.2	138.285	73.022	0.233975	6.9666
Sidewinder Burnout	2.4	134.684	70.996	0.231198	7.0718
Coast	2.4	84.843	10.126	0.0572862	3.55961
	5.0	84.843	10.126	0.0572862	3.55961
Arcas Ignition	5.0	84.693	10.072	0.0572857	3.56551
	10.0	77.495	8.725	0.0540191	3.81517
	15.0	70.338	7.870	0.0507716	4.03913
	20.0	63.142	7.458	0.0475052	4.23146
	25.0	55.944	7.357	0.0442389	4.37810
	30.0	48.789	7.413	0.0409917	4.45920
Arcas Burnout	35.0	41.591	7.389	0.0377250	4.44108

* Of this 16-pound payload, 10.2 pounds are separated at apogee.
(A) About center of gravity.
(B) From aft end of each stage.

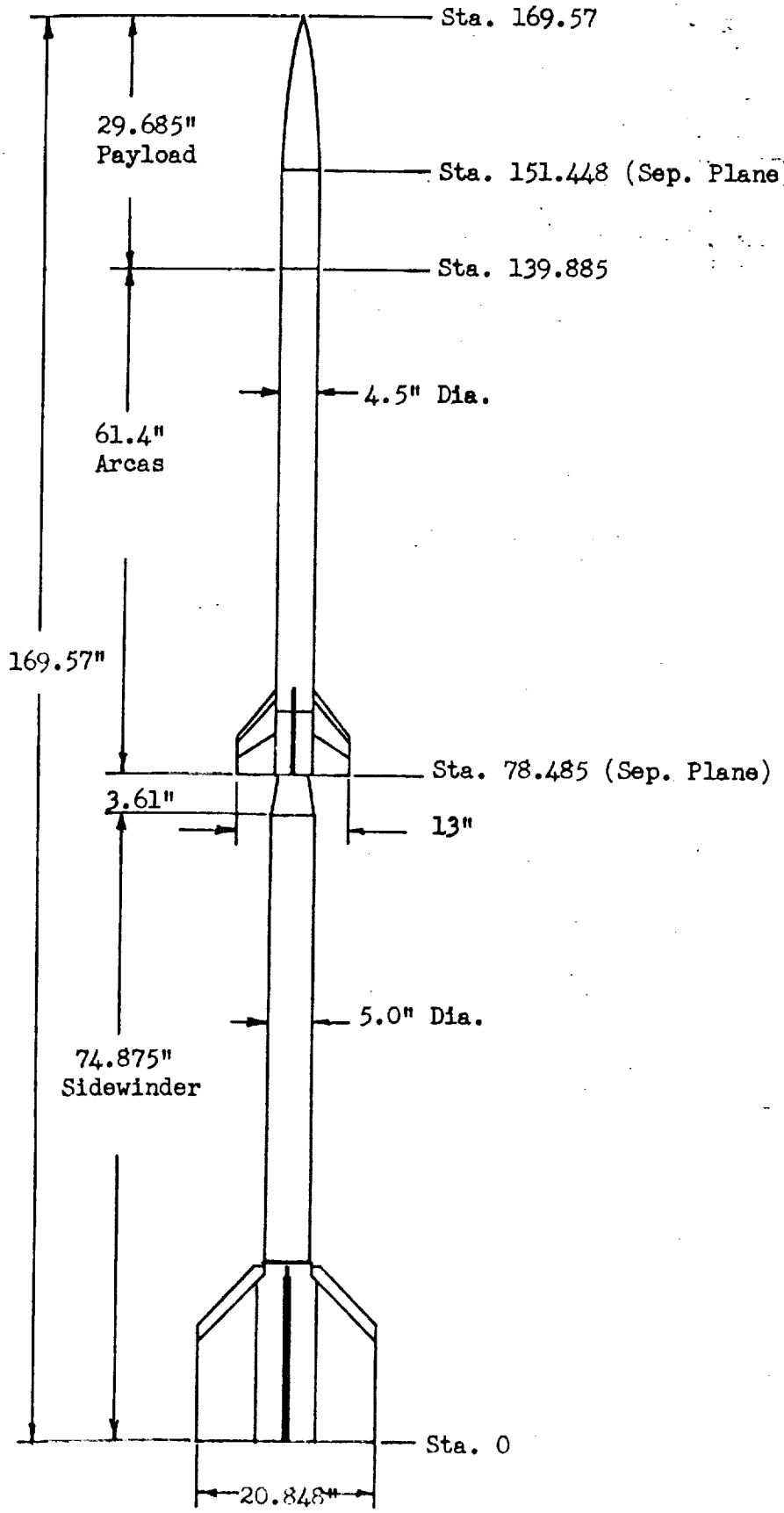


FIGURE 2-1
SIDEWINDER-ARCAS SOUNDING ROCKET

FIGURE 2-2
MISSION SEQUENCE PROFILE

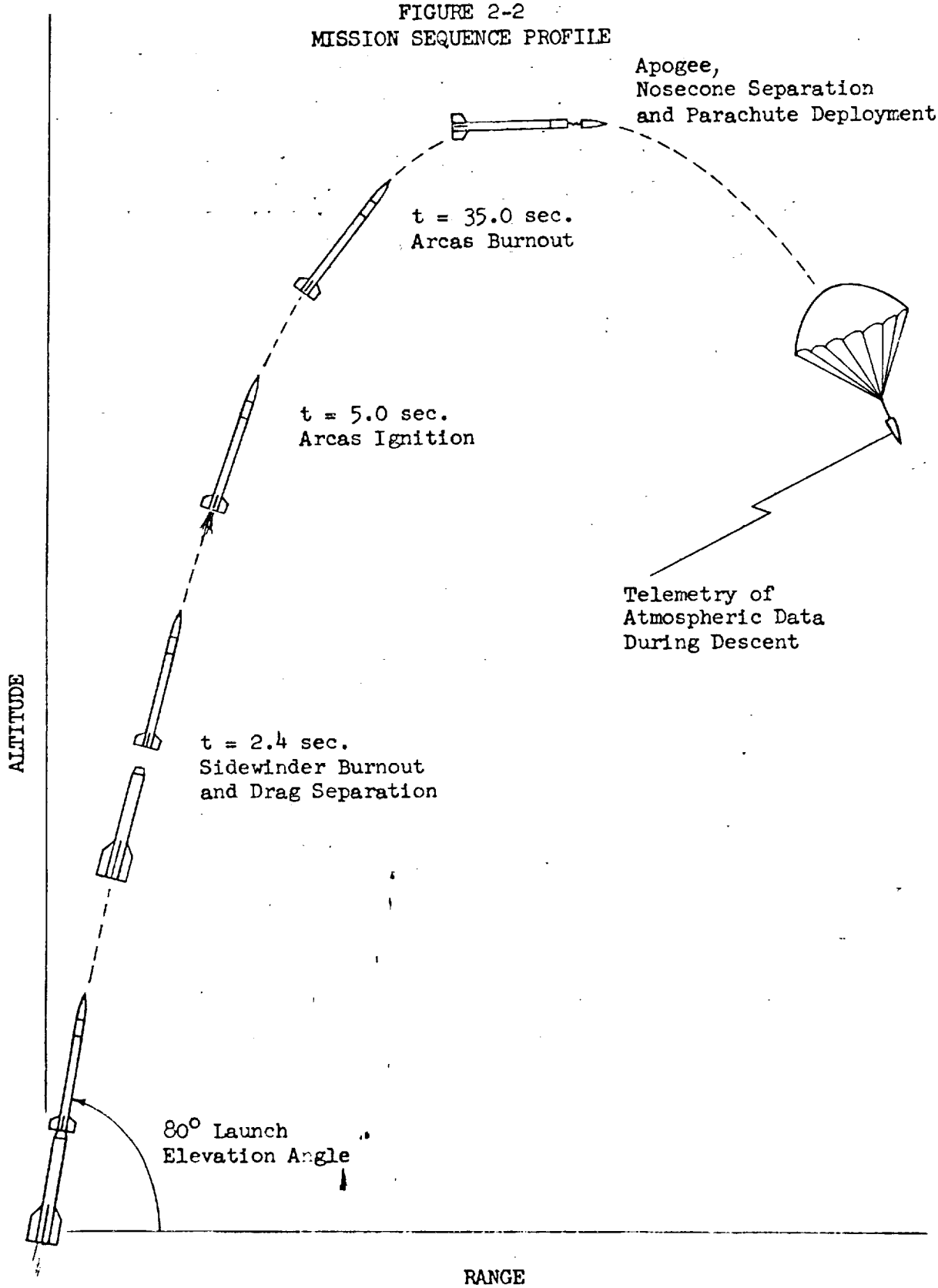
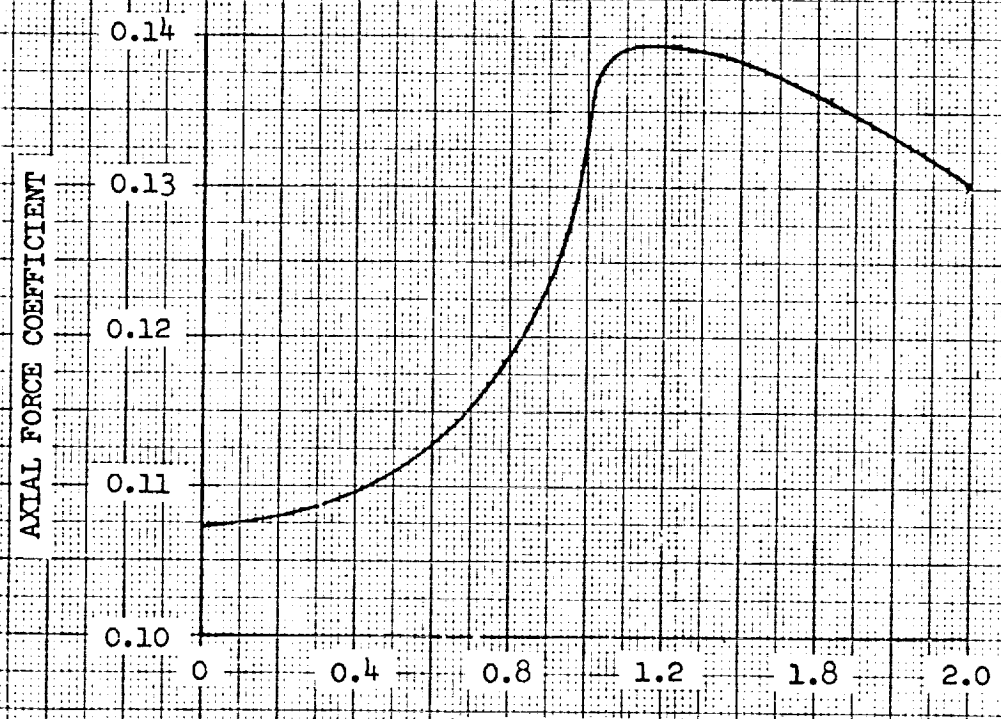


FIGURE 2-3
ZERO-LIFT AXIAL FORCE COEFFICIENT
FOR SIDEWINDER BOOST

REF. AREA = 1 FT^2



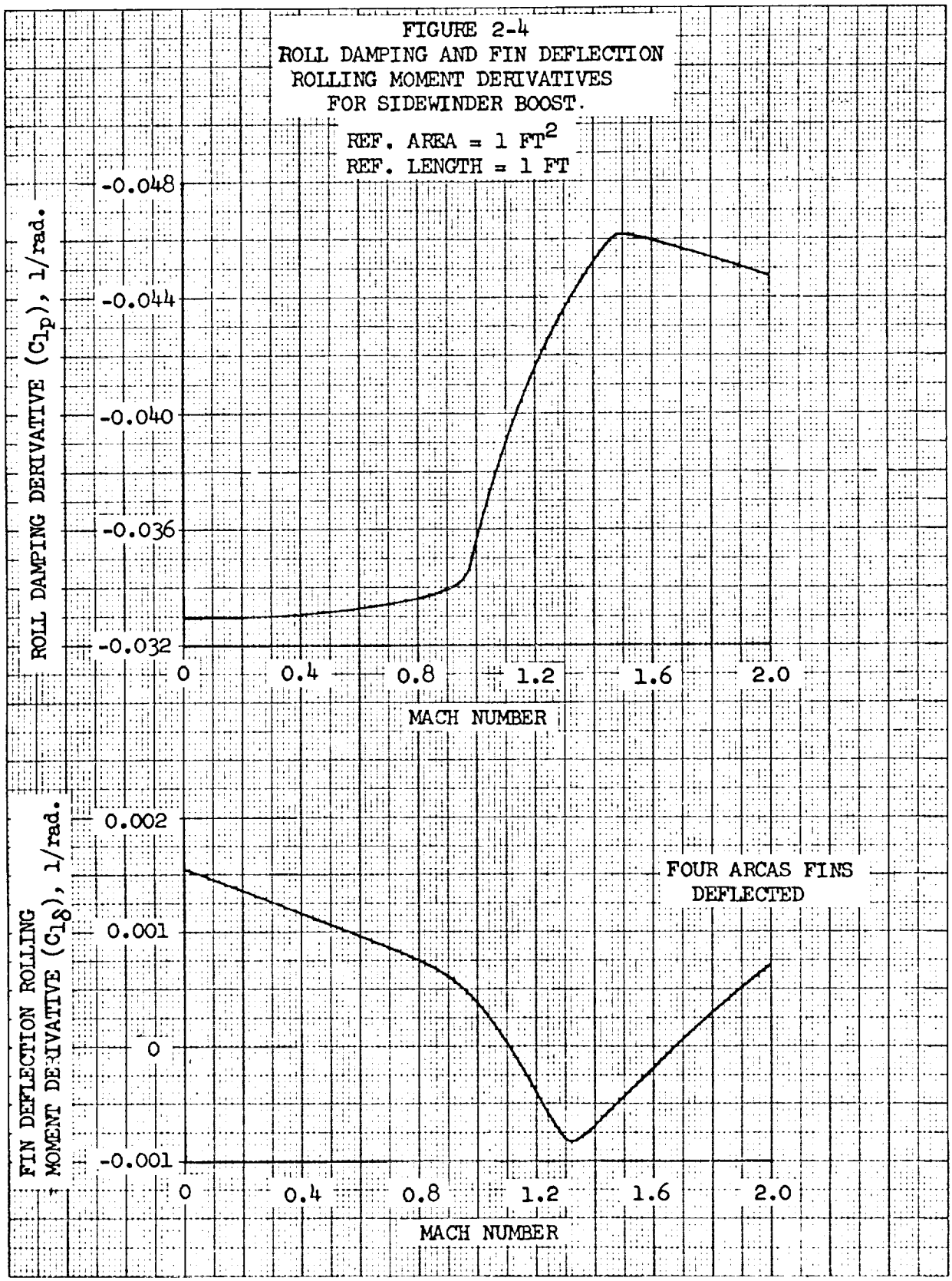
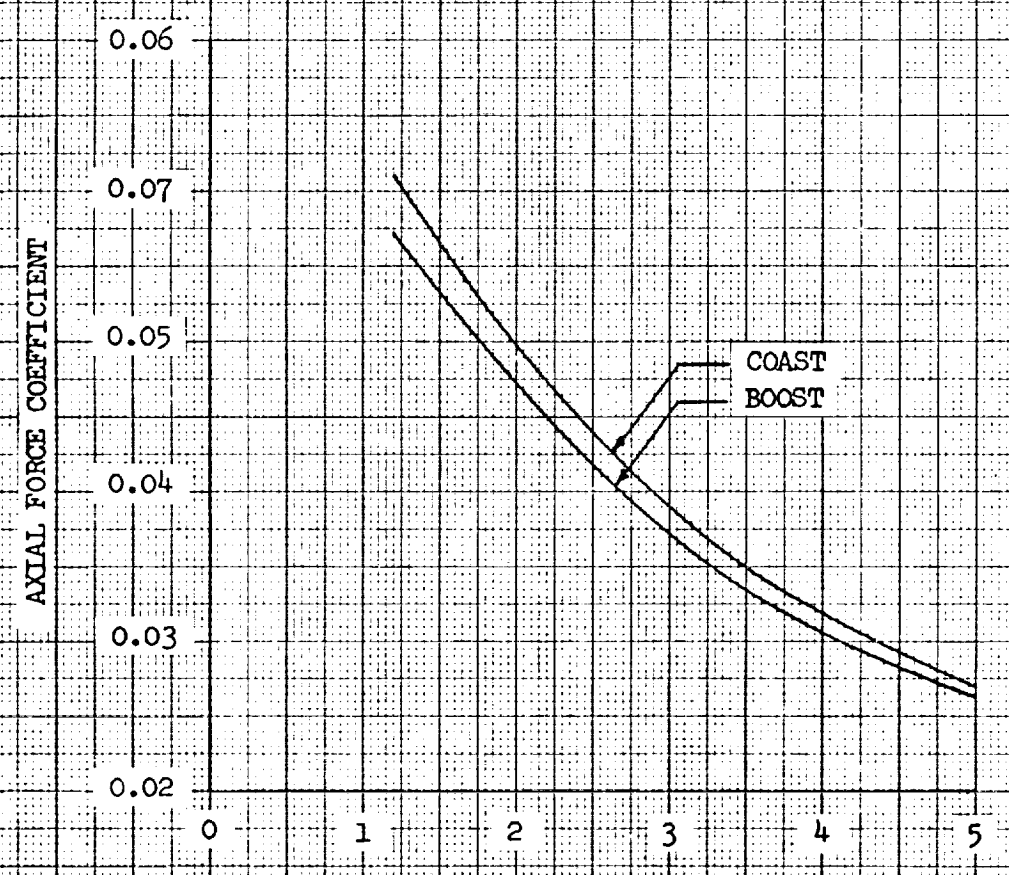


FIGURE 2-4
ROLL DAMPING AND FIN DEFLECTION ROLLING MOMENT DERIVATIVES FOR SIDEWINDER BOOST.

FIGURE 2-5
ZERO-LIFT AXIAL FORCE COEFFICIENT
FOR ARCAS BOOST AND COAST

REF. AREA = 1 FT^2



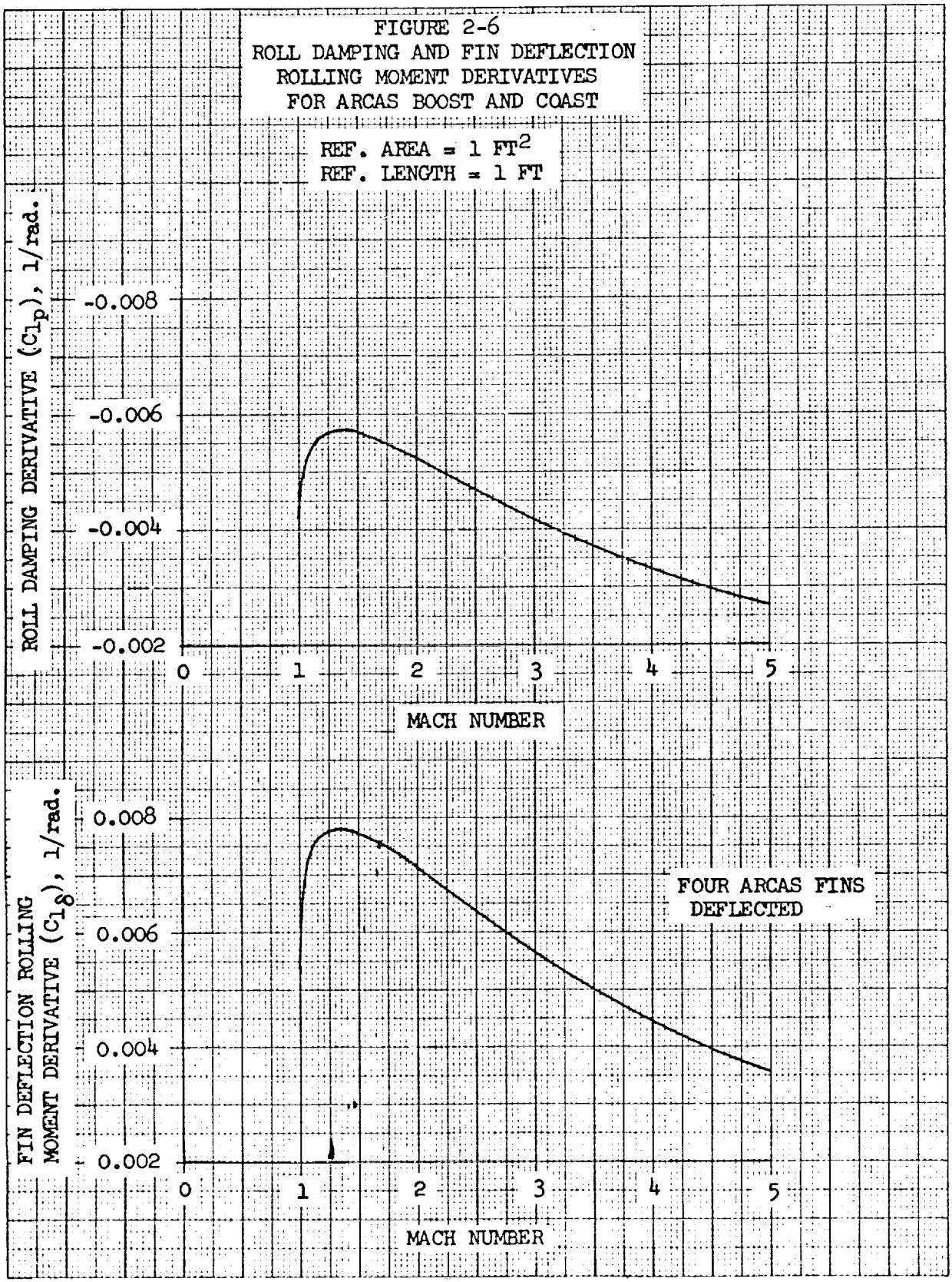


FIGURE 2-6
ROLL DAMPING AND FIN DEFLECTION
ROLLING MOMENT DERIVATIVES
FOR ARCAS BOOST AND COAST

REF. AREA = 1 FT^2
REF. LENGTH = 1 FT

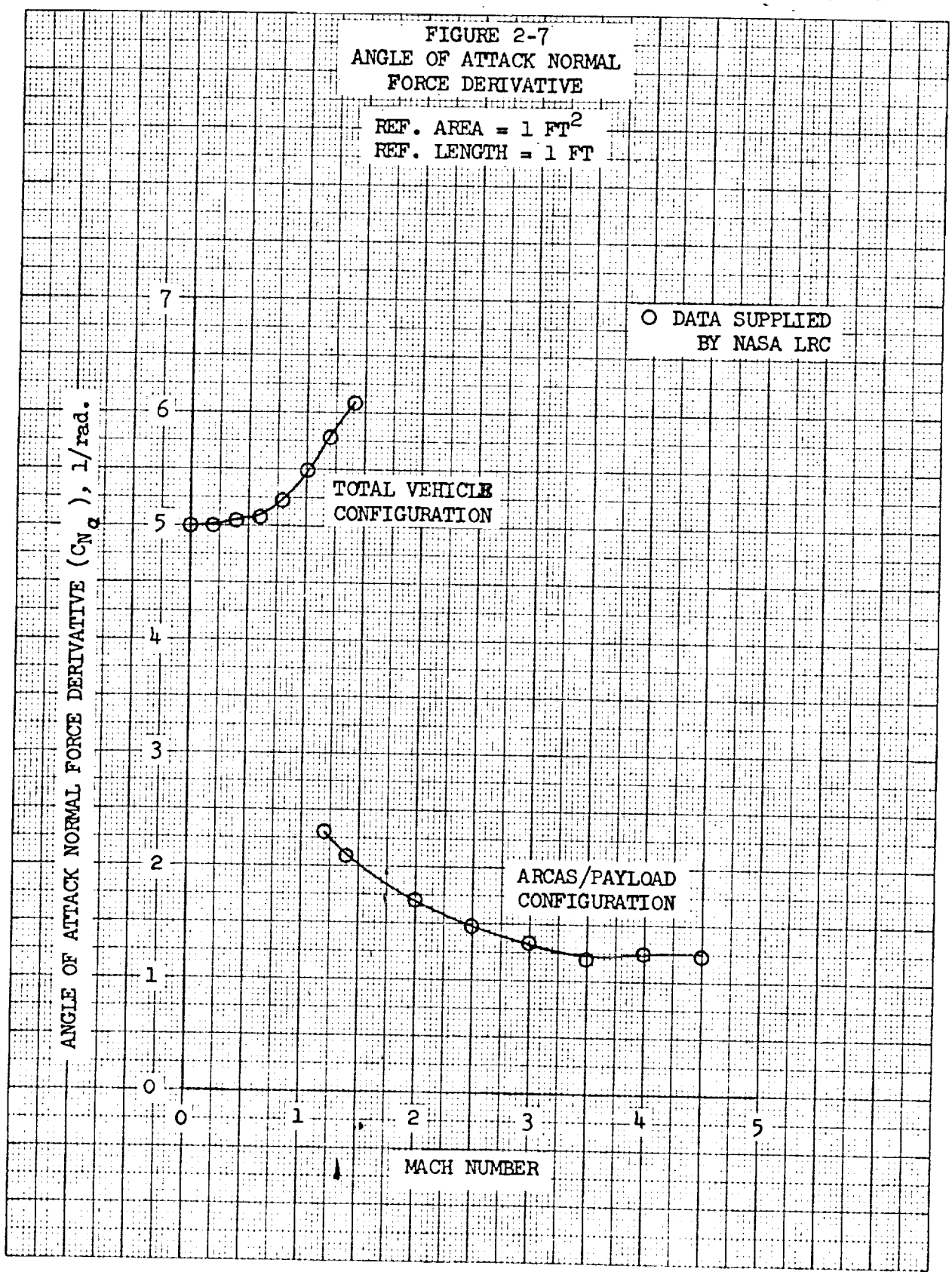


FIGURE 2-7
ANGLE OF ATTACK NORMAL FORCE DERIVATIVE

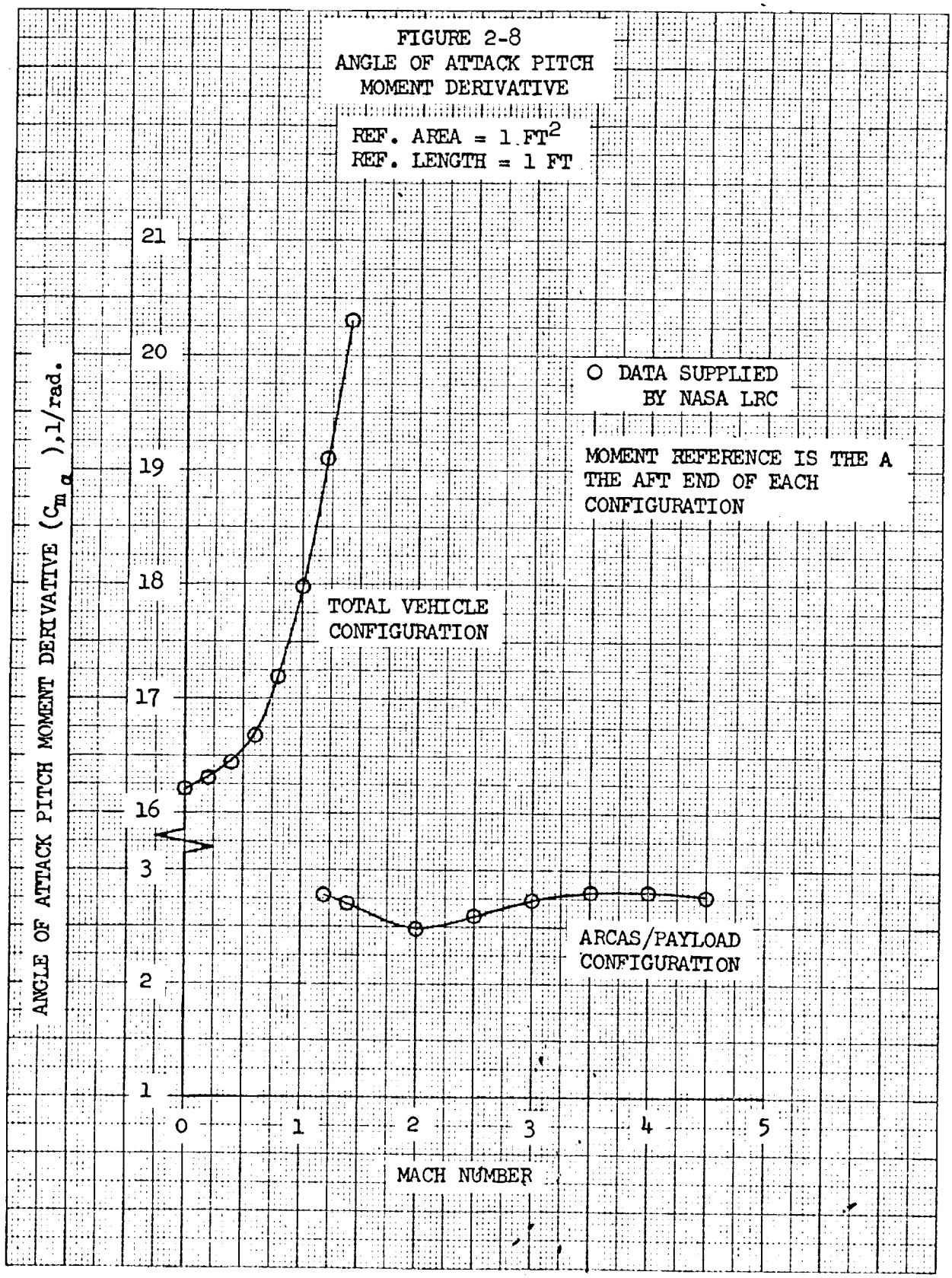


FIGURE 2-8
ANGLE OF ATTACK PITCH
MOMENT DERIVATIVE
REF. AREA = 1 FT2
REF. LENGTH = 1 FT
O DATA SUPPLIED
BY NASA LRC
MOMENT REFERENCE IS THE A
THE AFT END OF EACH
CONFIGURATION
TOTAL VEHICLE
CONFIGURATION
ARCAS/PAYLOAD
CONFIGURATION
ANGLE OF ATTACK PITCH MOMENT DERIVATIVE (Cmα),1/rad.
MACH NUMBER
21
20
19
18
17
16
3
2
1
0
1
2
3
4
5

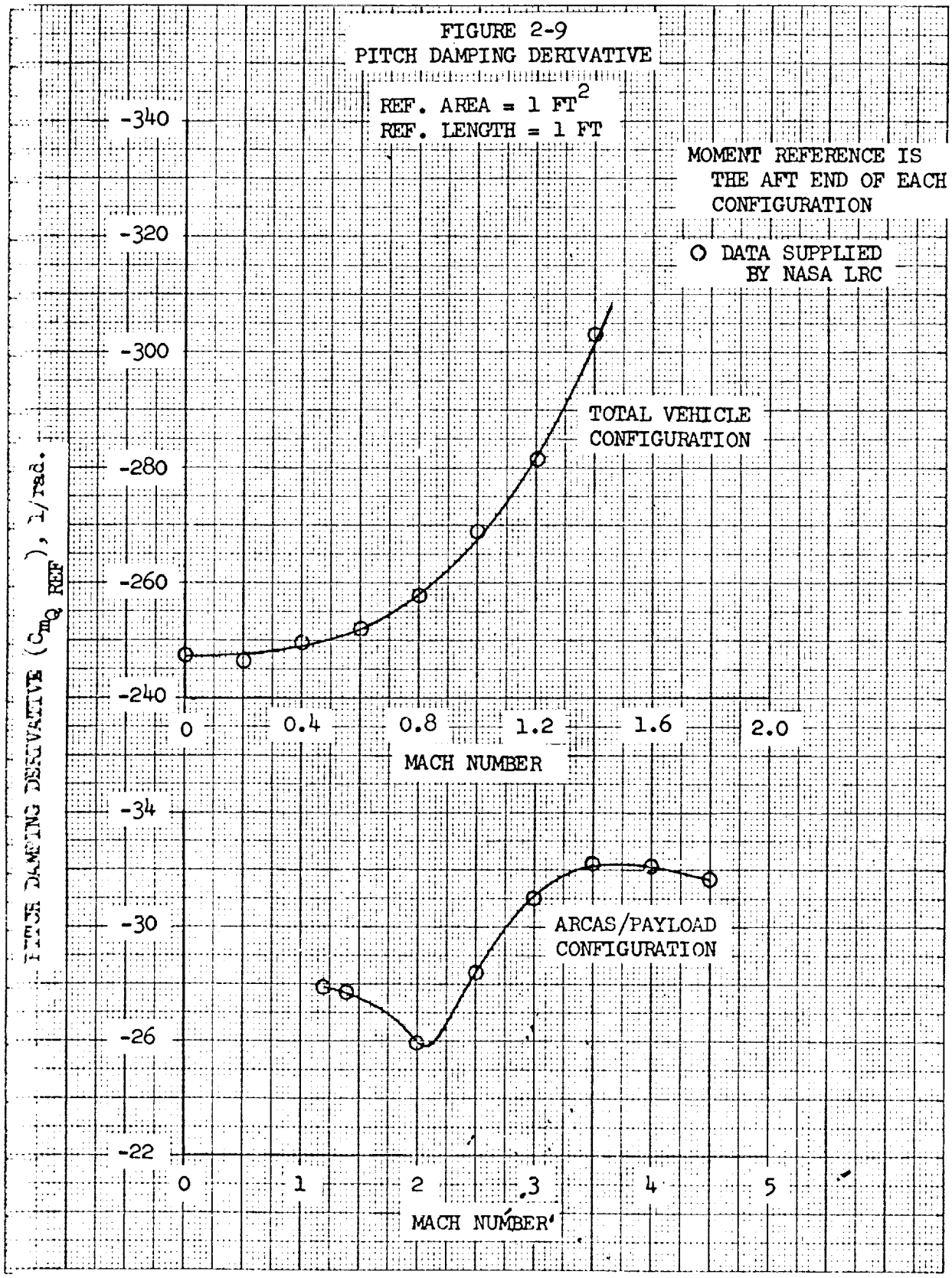


FIGURE 2-9
PITCH DAMPING DERIVATIVE

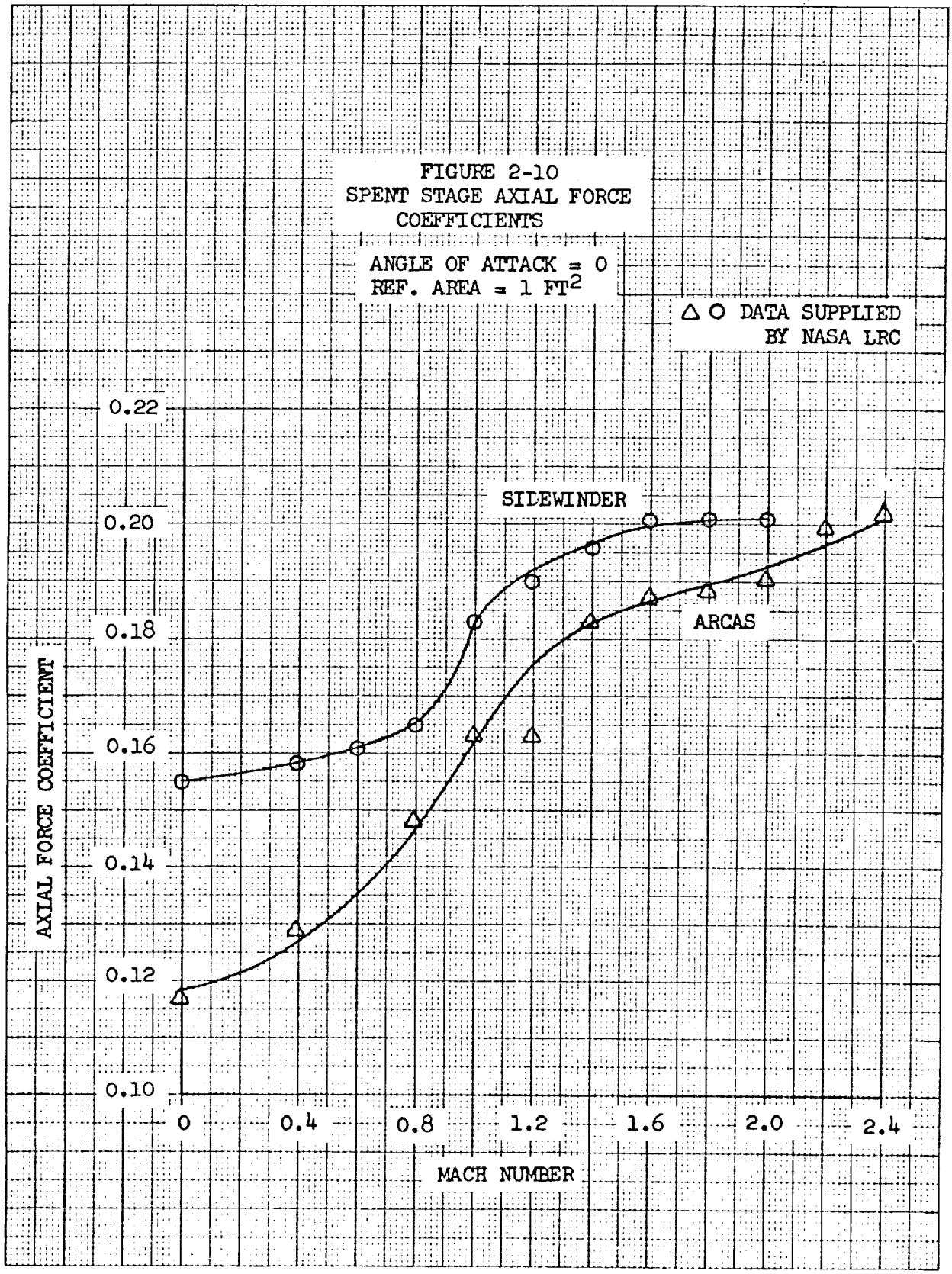


FIGURE 2-10
SPENT STAGE AXIAL FORCE COEFFICIENTS

3.0 VEHICLE PERFORMANCE

3.1 Mission Description

The Sidewinder-Arcas vehicle is launched from a rail-type launcher which is preset for the desired launch azimuth and launch elevation angles. After a burning time of 2.4 seconds, the booster drag-separates from the second stage. Ignition of the second stage is timed to occur 5 seconds after liftoff; the nominal second stage burning time is 30 seconds. The vehicle then coasts to apogee where the nosecone is separated and is parachuted to the surface. The mission sequence is indicated in Figure 2-2.

The vehicle is to be launched from the Nike-Ajax area at Wallops Island. The FPS-16 and FPQ-6 radars are used for tracking the vehicle and the payload. Geographic locations and altitudes for the launch site and the tracking radars are given in Table 3-1.

3.2 Method of Trajectory Computation

The MSD Near Earth Mission Analysis Routine (NEMAR) was used to calculate the Sidewinder-Arcas trajectories. NEMAR, described in Reference 6, has the capability of simulating a vehicle either as a point mass or a six degree-of-freedom rigid body. The atmosphere model is the U. S.Standard Atmosphere, 1962, and an oblate, rotating earth model is used.

To calculate the Sidewinder-Arcas powered flight trajectories accurately, the six degree-of-freedom rigid-body simulation was used. The vehicle's motion along the launch rail was integrated to determine the vehicle velocity and time of flight at the end of the launch rail. These values were then used as start conditions for the six degree-of-freedom computation. The conditions at the end of the launch rail for all combinations of payload weight and launch elevation angle are given in Table 3-2.

Since the vehicle attains an altitude of about 35,000 feet at second stage burnout, the trajectory simulation was changed to the point-mass constant inertial attitude simulation at this point. By using a point-mass simulation, a large amount of computer time is saved with negligible error since the atmosphere effects on the trajectory are slight above the Arcas burnout altitude.

Trajectories for the spent Sidewinder and Arcas motor cases were calculated with a point-mass simulation. The angle of attack was held to zero for the spent stage trajectories since drag data was provided only for this case.

Radar tracking parameters including slant range, slant range rate, azimuth, azimuth rate, elevation, elevation rate, and ground range were calculated for both radar sites. These radar data were computed for all trajectories up to apogee. In addition, radar data were computed for the Arcas spent stage trajectory from apogee to impact for a launch elevation angle of 80 degrees and a payload weight of 12 pounds.

3.3 Nominal Trajectory

The nominal trajectory for this study is based on a 12-pound payload weight and an 80-degree launch elevation angle. Trajectories for the other combinations of launch elevation angle and payload weight are discussed in Section 3.5.4. A computer printout of the nominal trajectory, including radar tracking data, is enclosed in Appendix A; the thrust and acceleration values during Sidewinder boost have been removed and placed in Appendix B since Sidewinder thrust is classified.

For the nominal trajectory, Figure 3-1 shows time histories of altitude, velocity, and range, and Figure 3-2 shows flight path angle,

dynamic pressure, and Mach number. The descent portions of these histories are based on the Arcas spent stage with the nosecone being jettisoned at apogee. The ground track of the nominal trajectory is plotted on a map in Figure 3-3. Also indicated is the Arcas spent stage impact area which will be discussed in Section 4.0. An altitude-range trajectory profile for the nominal trajectory is given in Figure 3-4. The Sidewinder and Arcas spent stage trajectories are shown.

3.4 Additional Trajectory Data

In addition to the nominal, trajectories were calculated for other combinations of launch elevation angle and payload weight. Computer print-outs of these additional trajectories are available at NASA-LRC. Altitude-range profiles for these trajectories are plotted in Figures 3-5, 3-6, and 3-7 for the 12, 14, and 16-pound payloads, respectively. Each figure gives plots for 75, 80, and 85-degree launch elevation angles. The descent portions of these profiles are based on the Arcas spent stage.

Maximum dynamic pressure is shown in Figure 3-8 for first stage flight and in Figure 3-9 for second stage. In each figure, data are given for 12, 14, and 16-pound payloads as functions of launch elevation angle.

Apogee altitude is plotted in Figure 3-10 as a function of payload weight and in Figure 3-11 as a function of launch elevation angle. Data are presented for the three launch elevation angles in Figure 3-10 and for the three payload weights in Figure 3-11.

Sidewinder impact range is shown in Figure 3-12 as a function of payload weight. Curves are presented for launch elevation angles of 75, 80, and 85 degrees. Figure 3-12 shows that the impact range for each launch elevation angle is almost constant over the range of payload weights considered.

Arcas impact range is presented in Figure 3-13 for the three launch elevation angles as a function of payload weight and in Figure 3-14 for the three payload weights as a function of launch elevation angle.

Time from lift-off to apogee and impact of the Arcas spent stage for the three payload weights are shown as a function of launch elevation angle in Figures 3-15 and 3-16.

TABLE 3-1

LAUNCH SITE AND TRACKING RADAR LOCATION

LAUNCH SITE LOCATION

Latitude = 37.837987 deg. N. (geodetic)

Longitude = 75.482895 deg. W.

Altitude = 8.0 ft.

TRACKING RADAR FPS-16 LOCATION

Latitude = 37.841308 deg. N. (geodetic)

Longitude = 75.485094 deg. W.

Altitude = 52.73 ft.

TRACKING RADAR FPQ-6 LOCATION

Latitude = 37.860229 deg. N. (geodetic)

Longitude = 75.509309 deg. W.

Altitude = 61.18 ft.

TABLE 3-2

CONDITIONS AT END OF LAUNCH RAIL

LAUNCH ELEVATION ANGLE deg	PAYLOAD WEIGHT lb	TIME sec	VELOCITY ft/sec	ALTITUDE ft
75	12	0.189	118.1	17.63
75	14	0.190	117.4	17.63
75	16	0.191	116.8	17.63
80	12	0.189	118.0	17.85
80	14	0.190	117.3	17.85
80	16	0.191	116.7	17.85
85	12	0.189	117.9	17.97
85	14	0.190	117.2	17.97
85	16	0.191	116.6	17.97

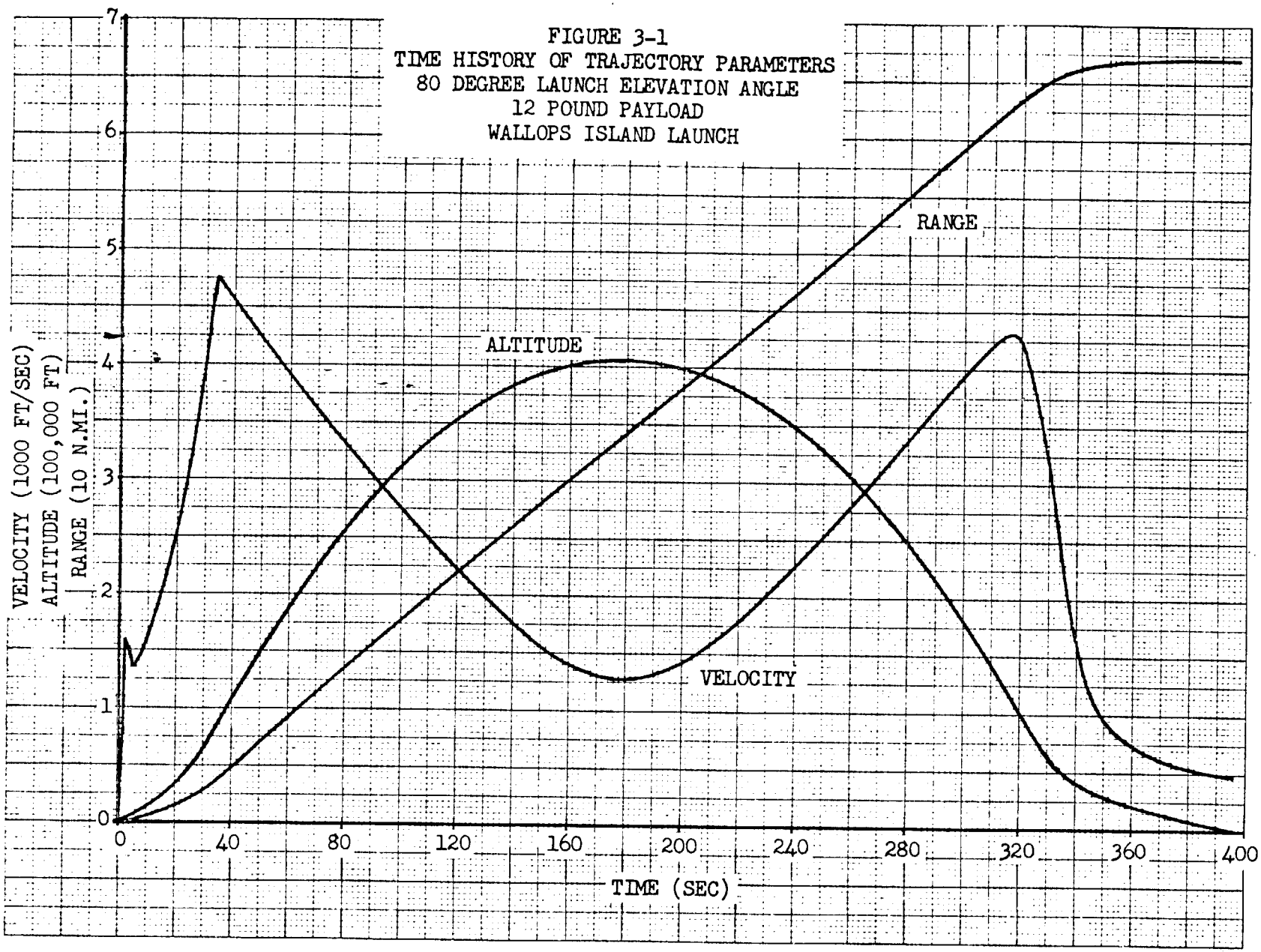
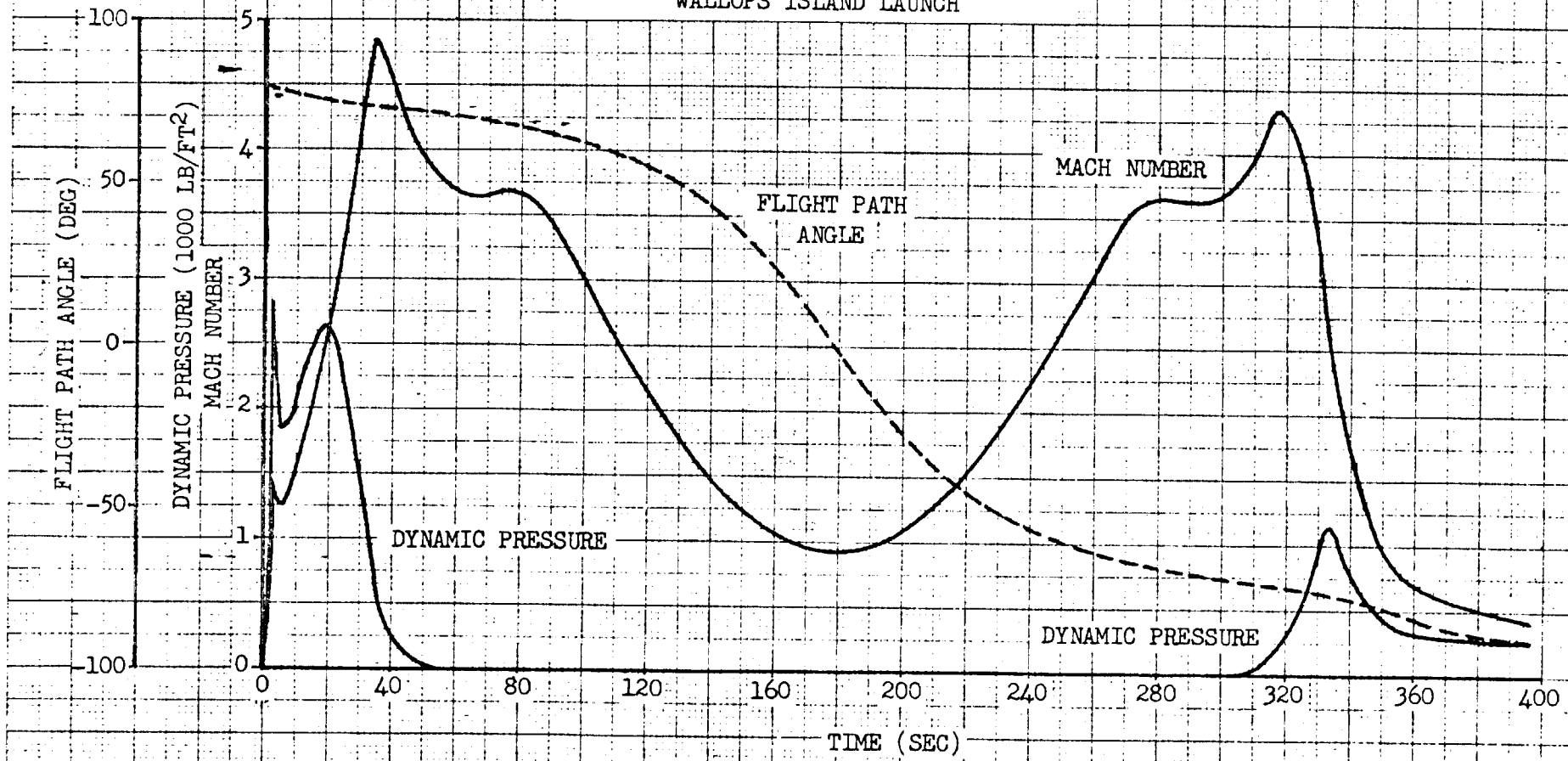


FIGURE 3-1
TIME HISTORY OF TRAJECTORY PARAMETERS
80 DEGREE LAUNCH ELEVATION ANGLE
12 POUND PAYLOAD
WALLOPS ISLAND LAUNCH

FIGURE 3-2
TIME HISTORY OF TRAJECTORY PARAMETERS
80 DEGREE LAUNCH ELEVATION ANGLE
12 POUND PAYLOAD
WALLOPS ISLAND LAUNCH



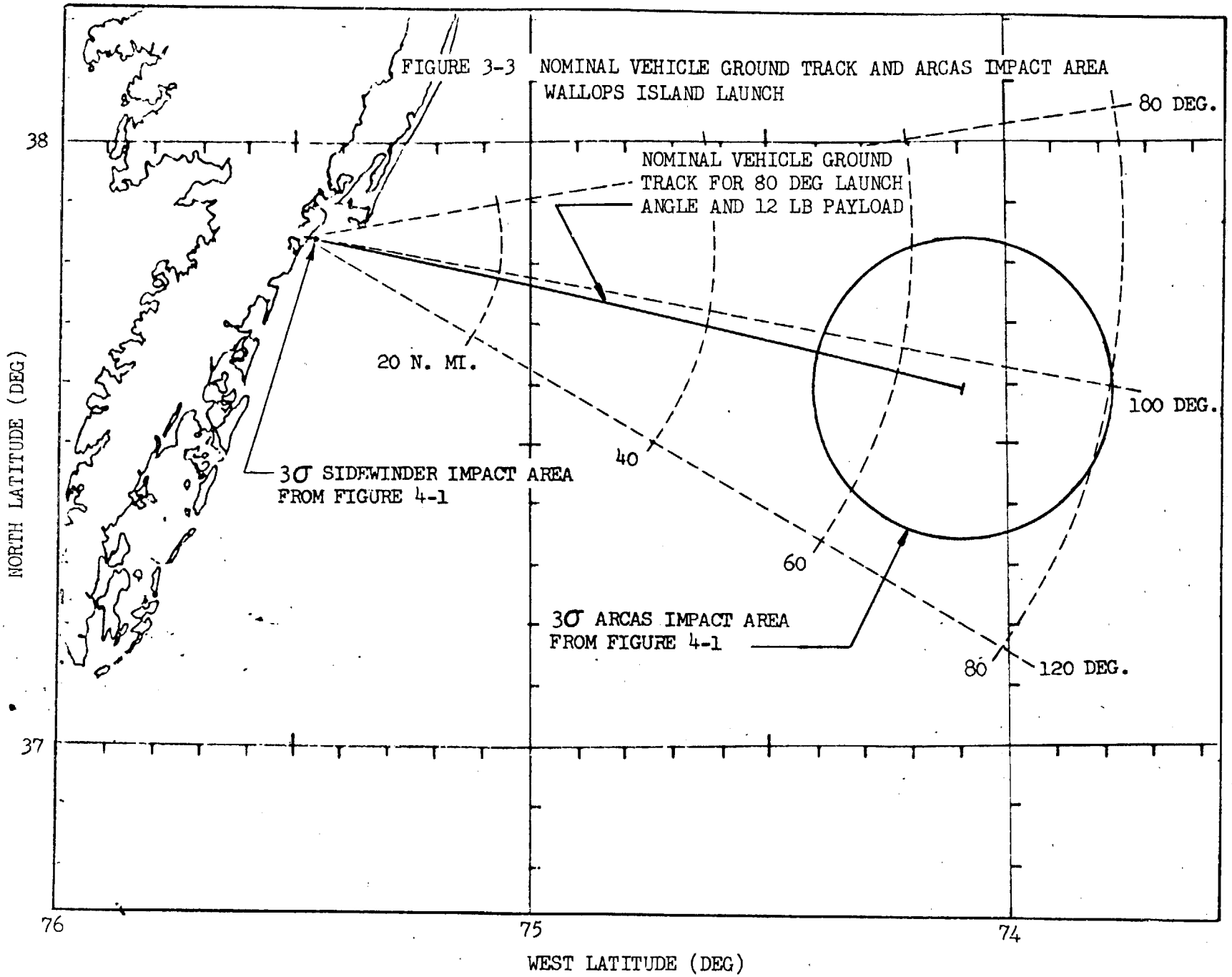


FIGURE 3-3 NOMINAL VEHICLE GROUND TRACK AND ARCAS IMPACT AREA WALLOPS ISLAND LAUNCH

KEUFFEL & ESSER CO.

FIGURE 3-4

ALTITUDE-RANGE TRAJECTORY PROFILE
80 DEGREE LAUNCH ELEVATION ANGLE
12 POUND PAYLOAD
WALLOPS ISLAND LAUNCH

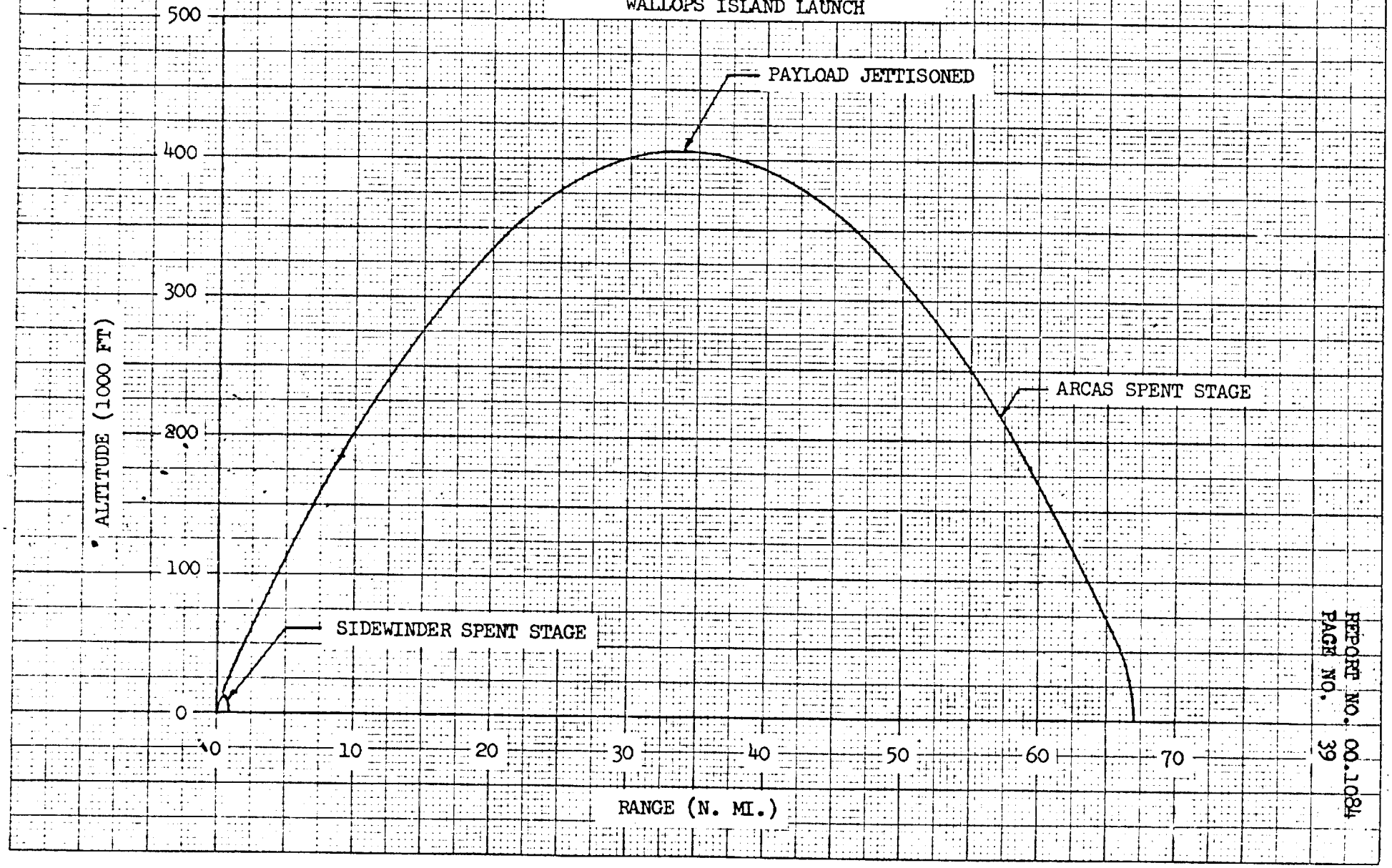


FIGURE 3-5
ALTITUDE-RANGE TRAJECTORY PROFILE
PAYLOAD WEIGHT = 12 LB.
WALLOPS ISLAND LAUNCH

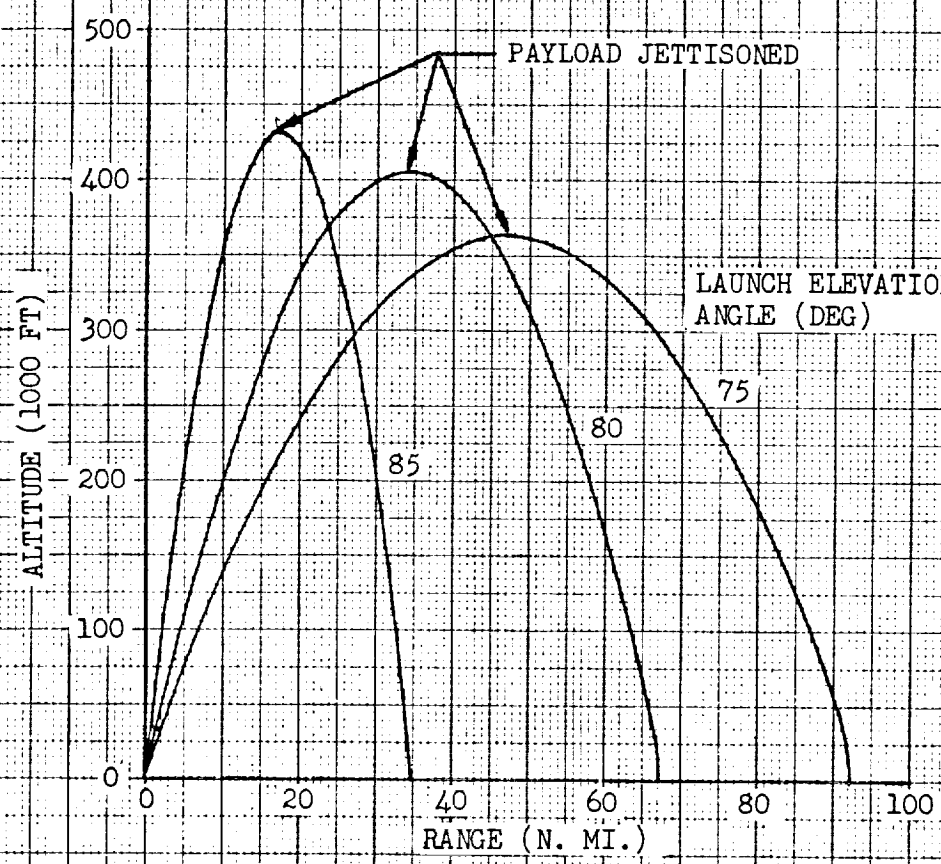
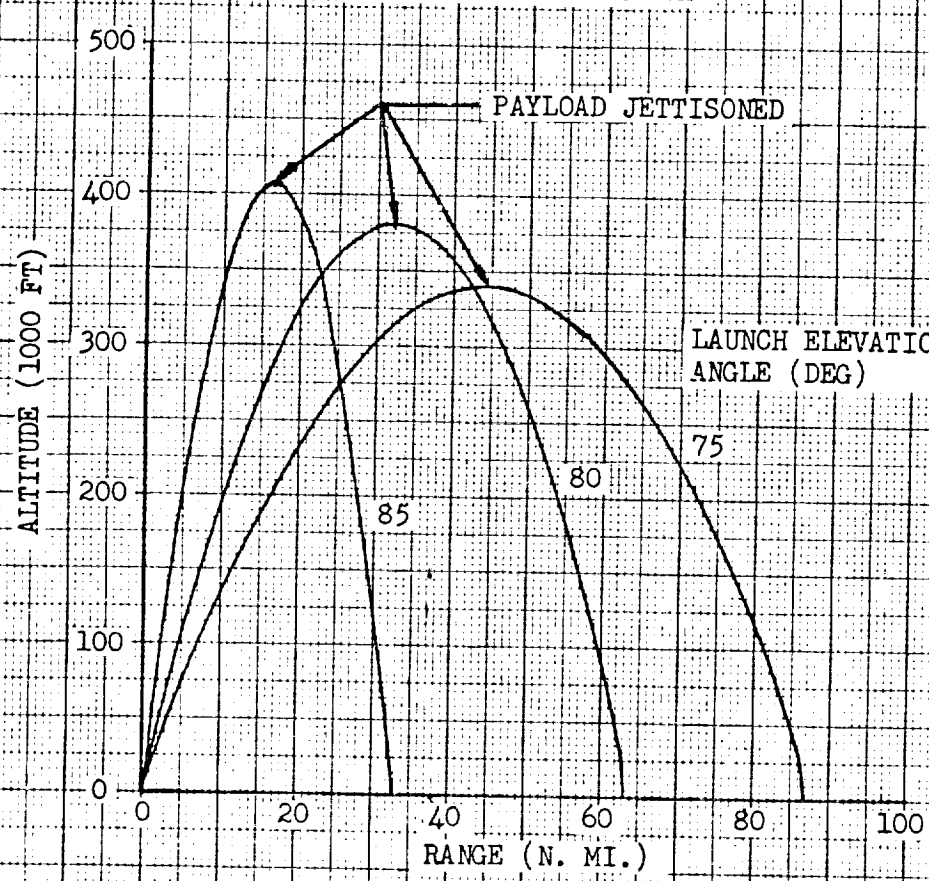


FIGURE 3-6
ALTITUDE-RANGE TRAJECTORY PROFILE
PAYLOAD WEIGHT = 14 LB.
WALLOPS ISLAND LAUNCH



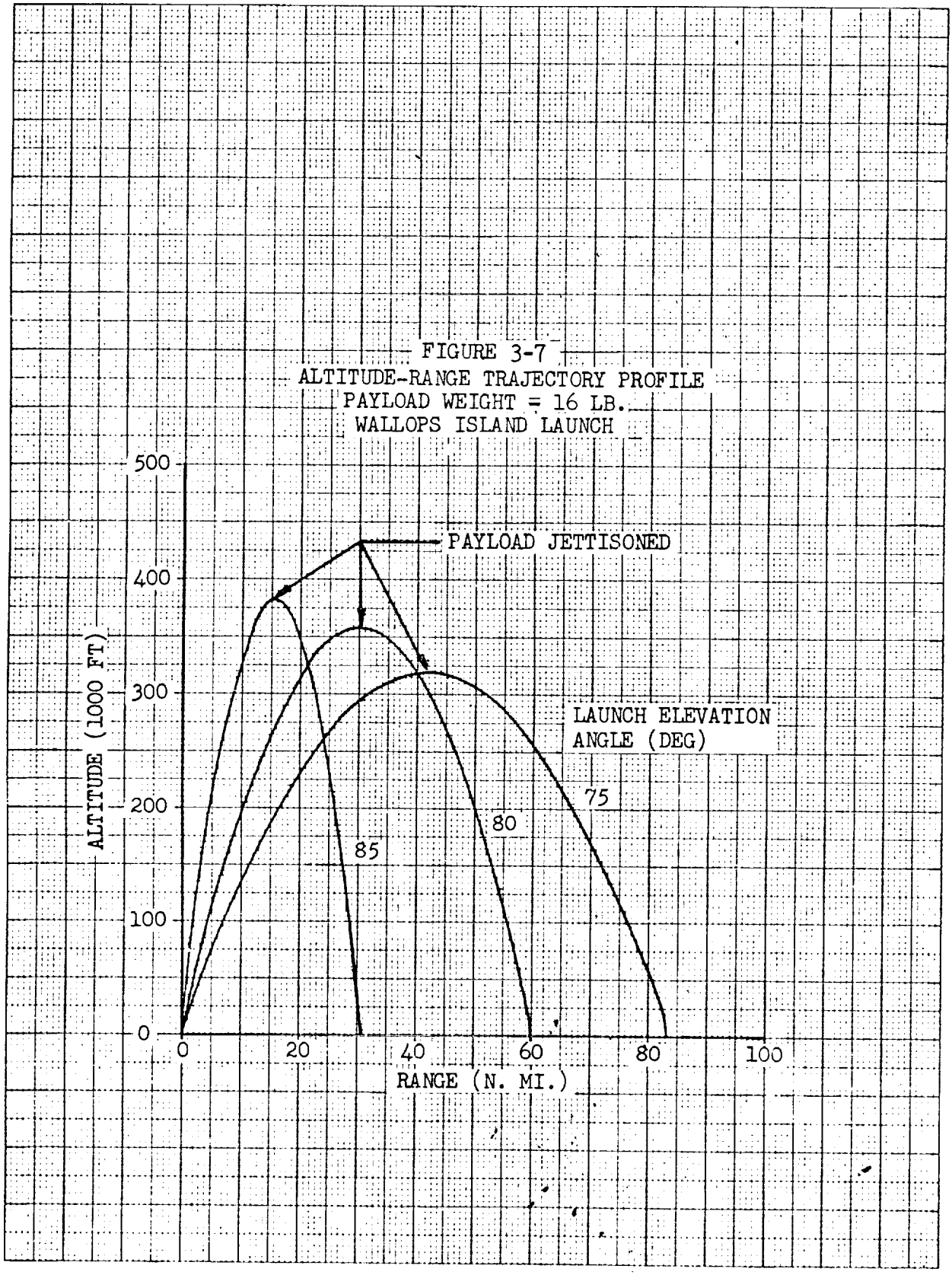


FIGURE 3-7
ALTITUDE-RANGE TRAJECTORY PROFILE
PAYLOAD WEIGHT = 16 LB.
WALLOPS ISLAND LAUNCH

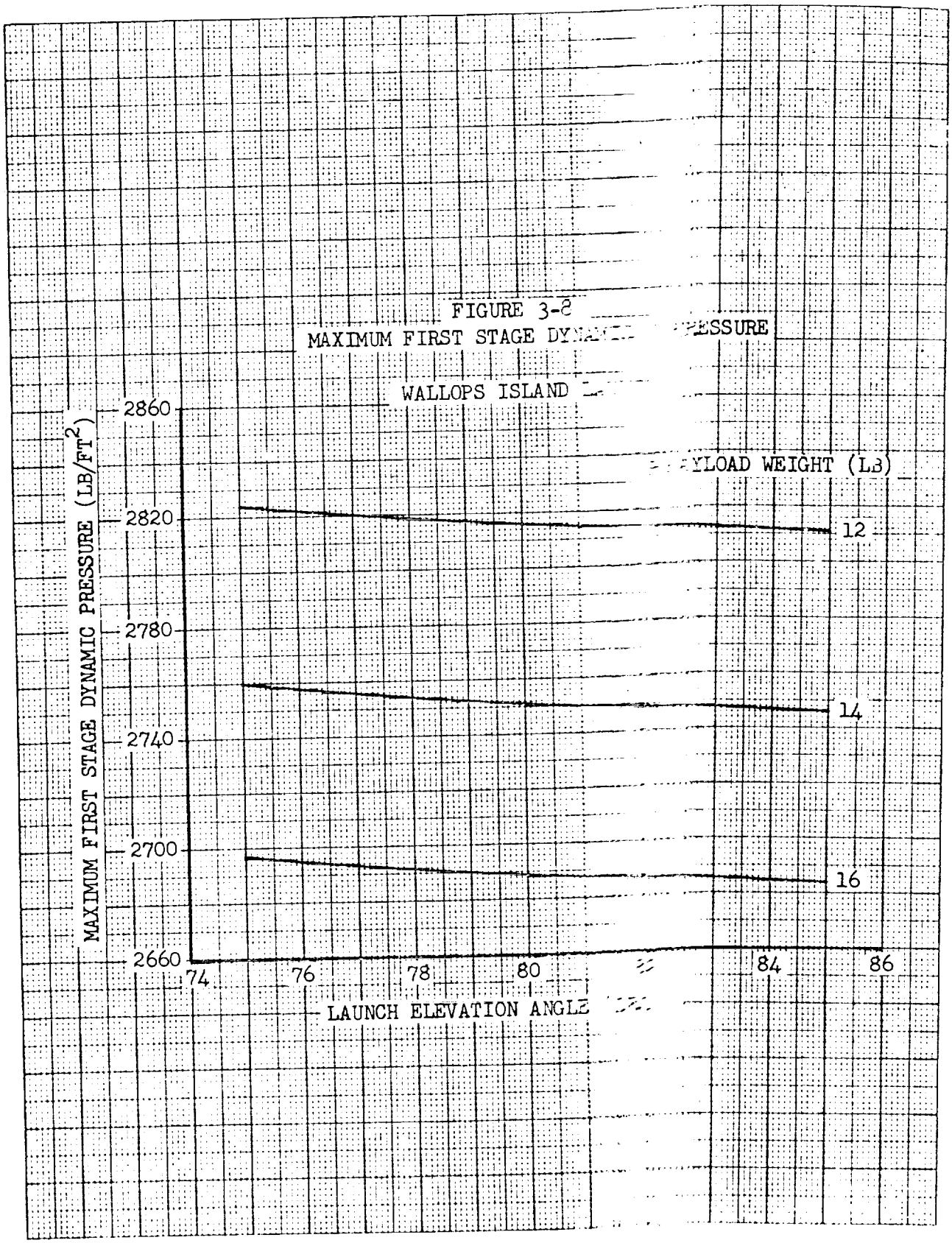


FIGURE 3-8
MAXIMUM FIRST STAGE DYNAMIC PRESSURE
WALLOPS ISLAND
PAYLOAD WEIGHT (LB)
LAUNCH ELEVATION ANGLE

FIGURE 3-9
MAXIMUM SECOND STAGE DYNAMIC PRESSURE

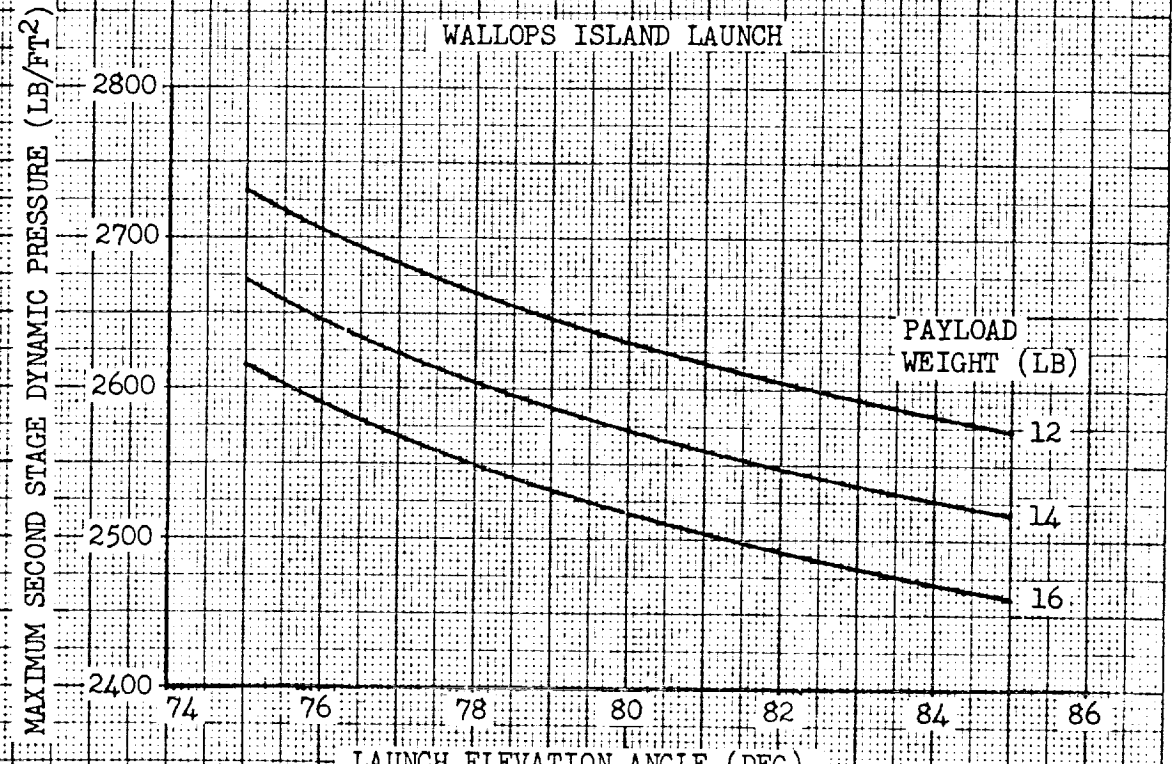
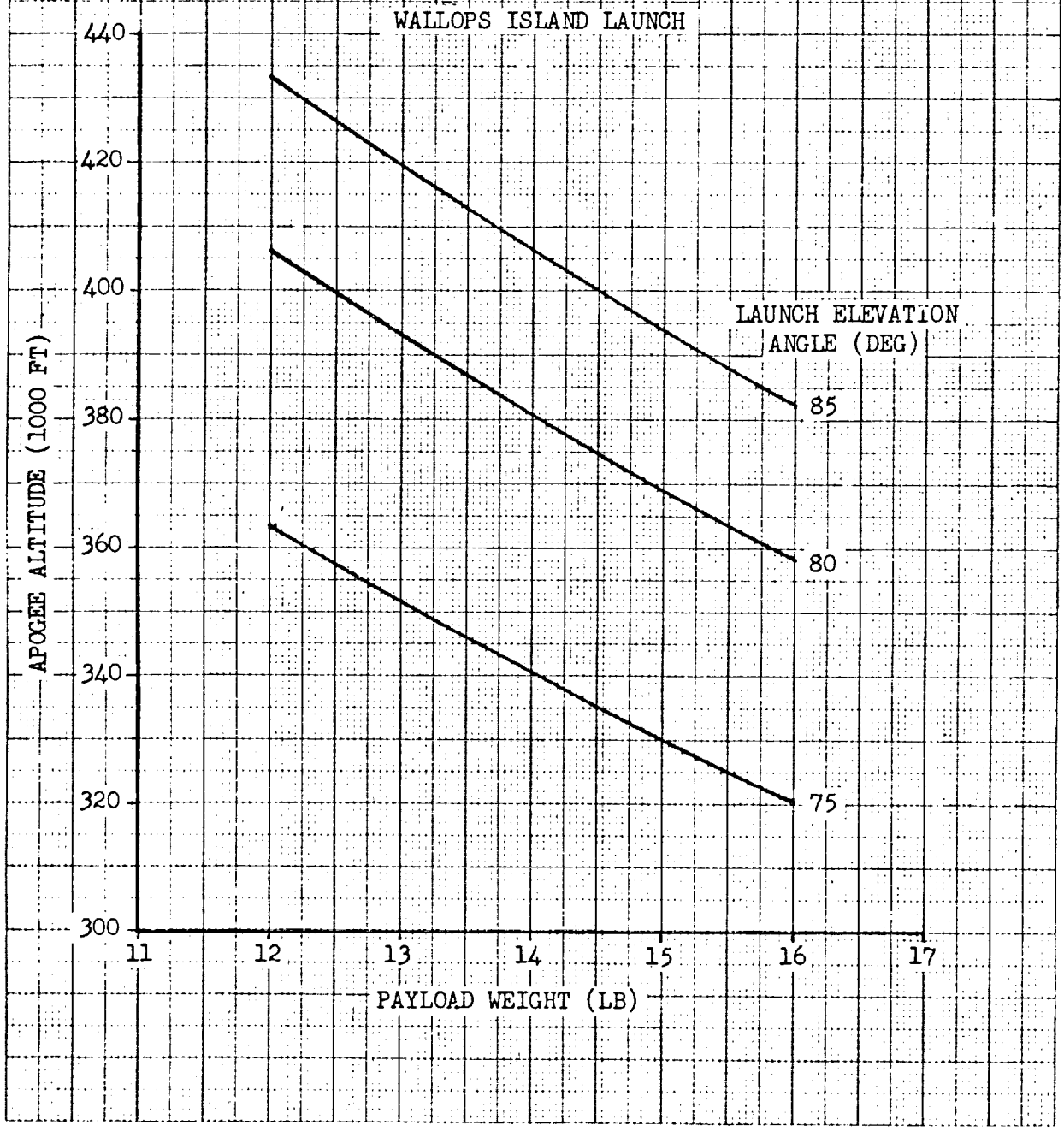


FIGURE 3-10
APOGEE ALTITUDE AS A FUNCTION
OF PAYLOAD WEIGHT



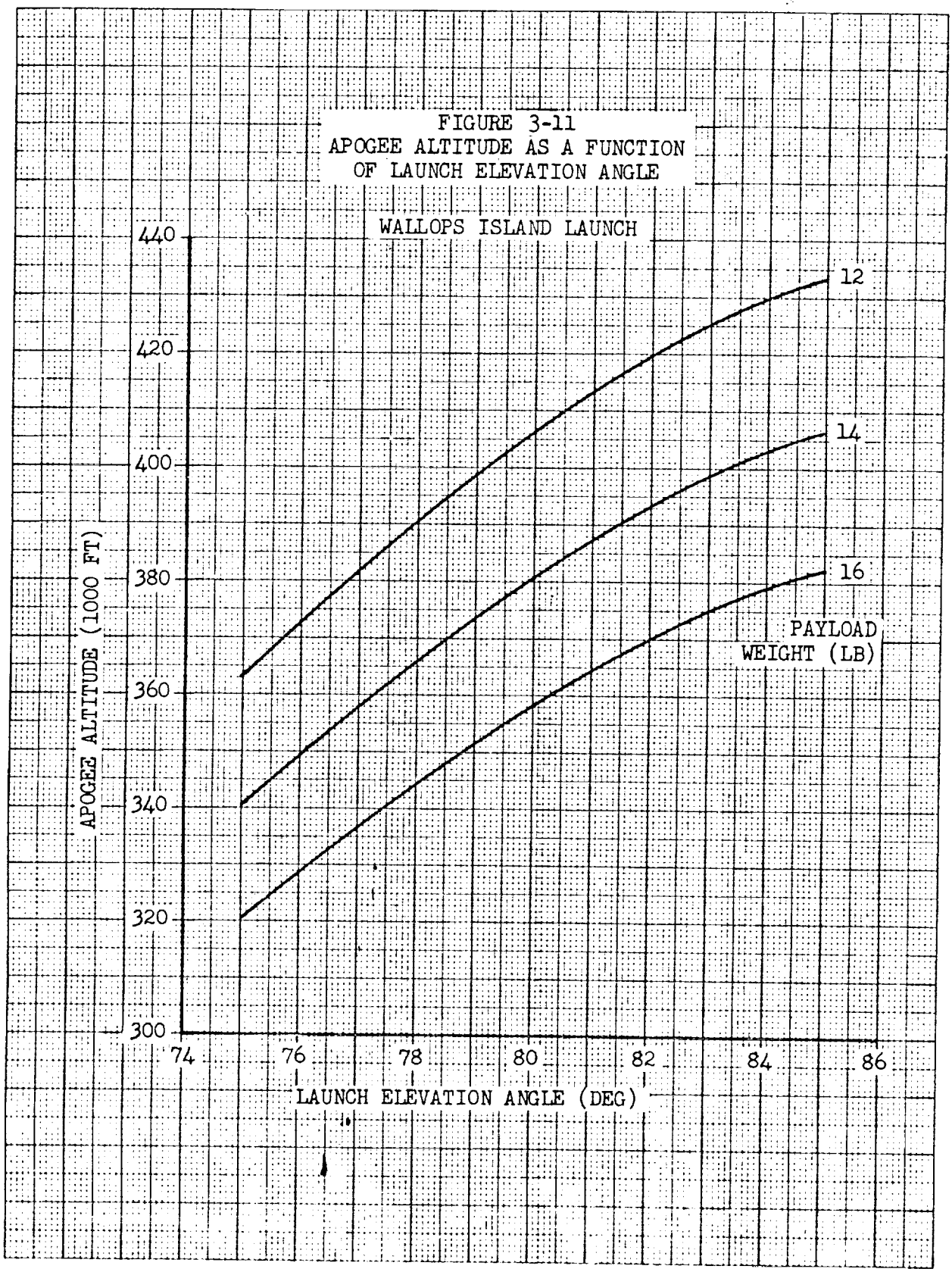
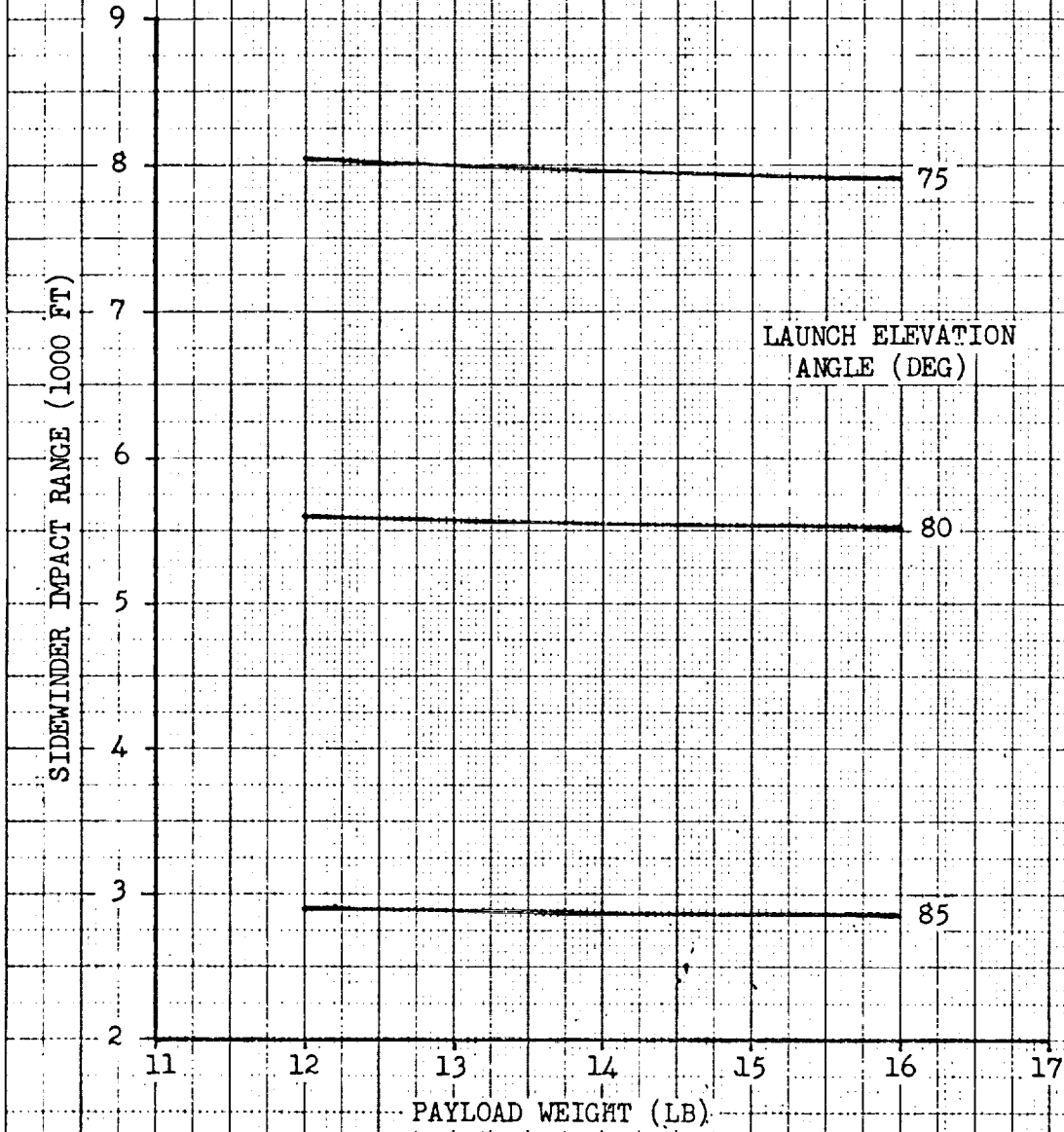


FIGURE 3-11
APOGEE ALTITUDE AS A FUNCTION
OF LAUNCH ELEVATION ANGLE

FIGURE 3-12
SIDEWINDER IMPACT RANGE

WALLOPS ISLAND LAUNCH



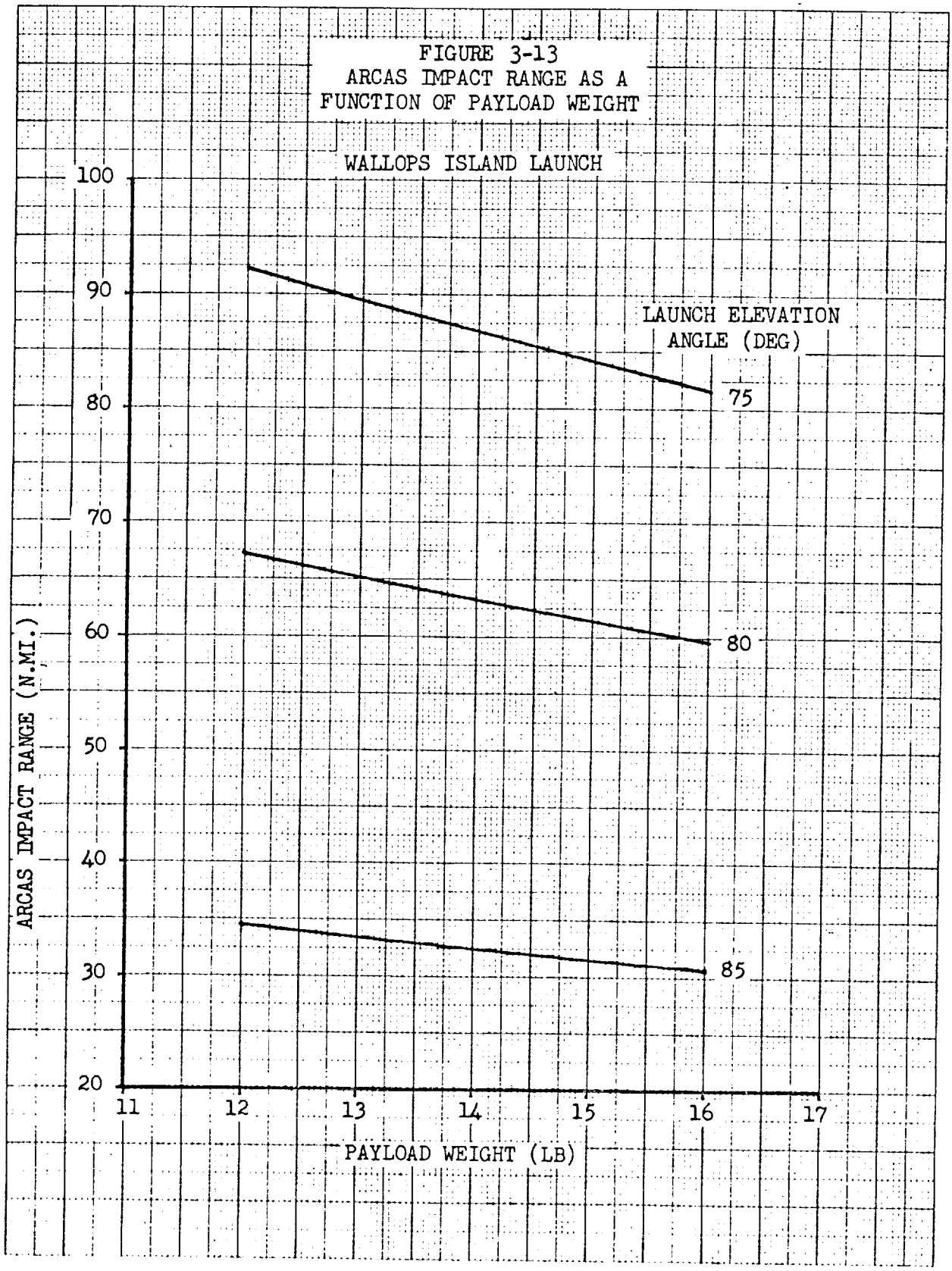


FIGURE 3-13
ARCAS IMPACT RANGE AS A FUNCTION OF PAYLOAD WEIGHT

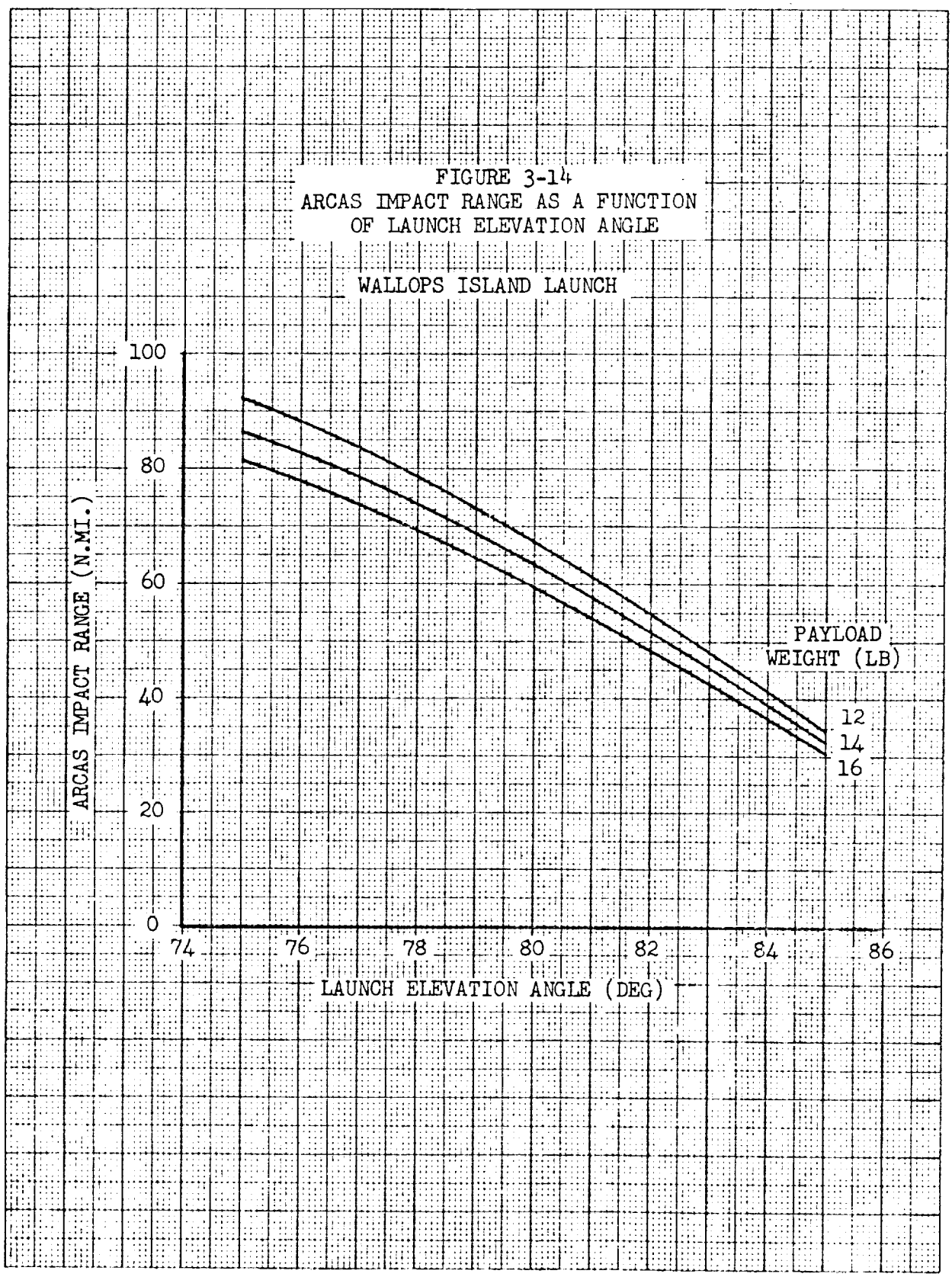


FIGURE 3-14
ARCAS IMPACT RANGE AS A FUNCTION
OF LAUNCH ELEVATION ANGLE

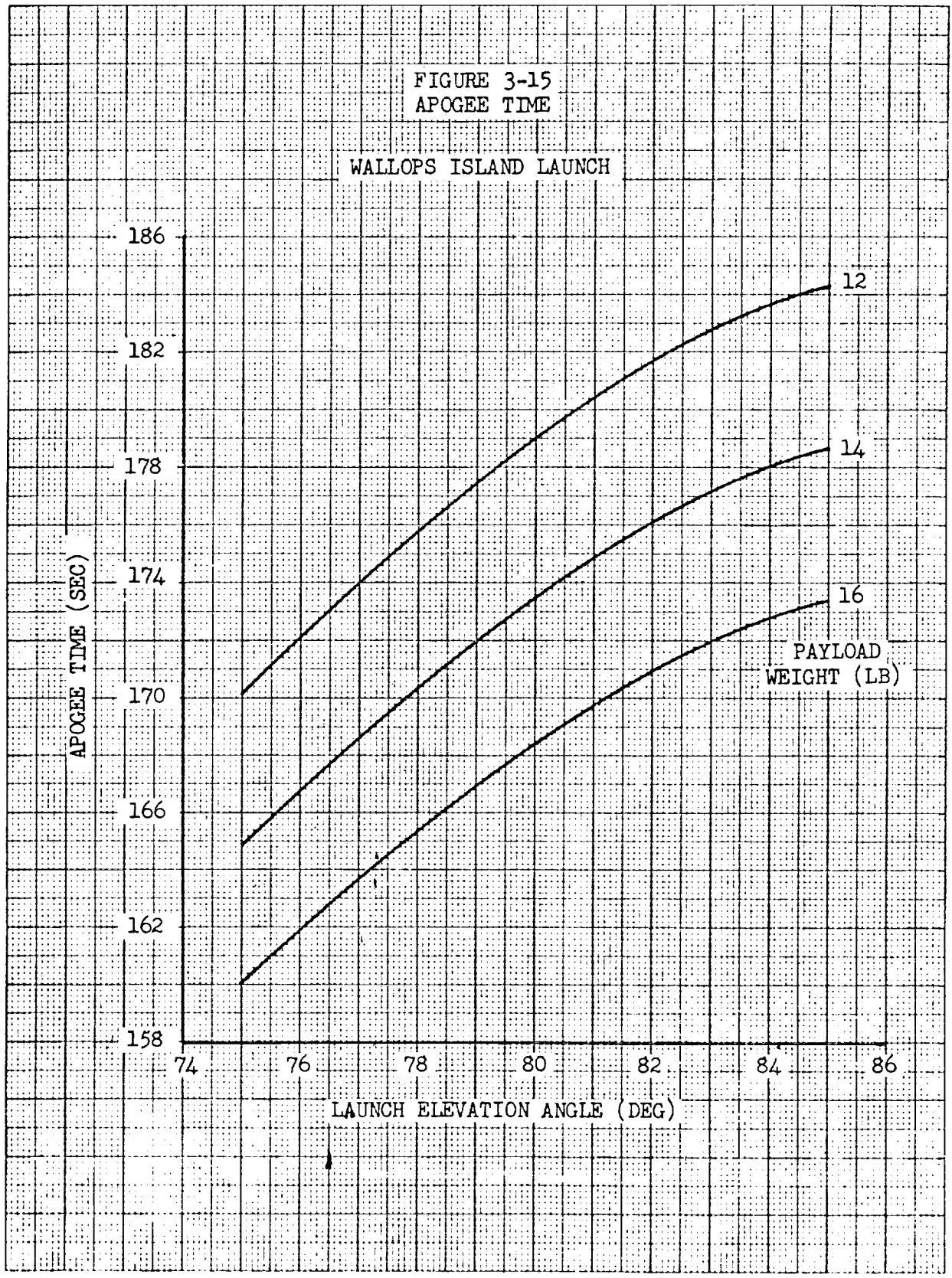


FIGURE 3-15
APOGEE TIME
WALLOPS ISLAND LAUNCH
186
182
178
174
170
166
162
158
APOGEE TIME (SEC)
12
14
16
PAYLOAD
WEIGHT (LB)
74
76
78
80
82
84
86
LAUNCH ELEVATION ANGLE (DEG)

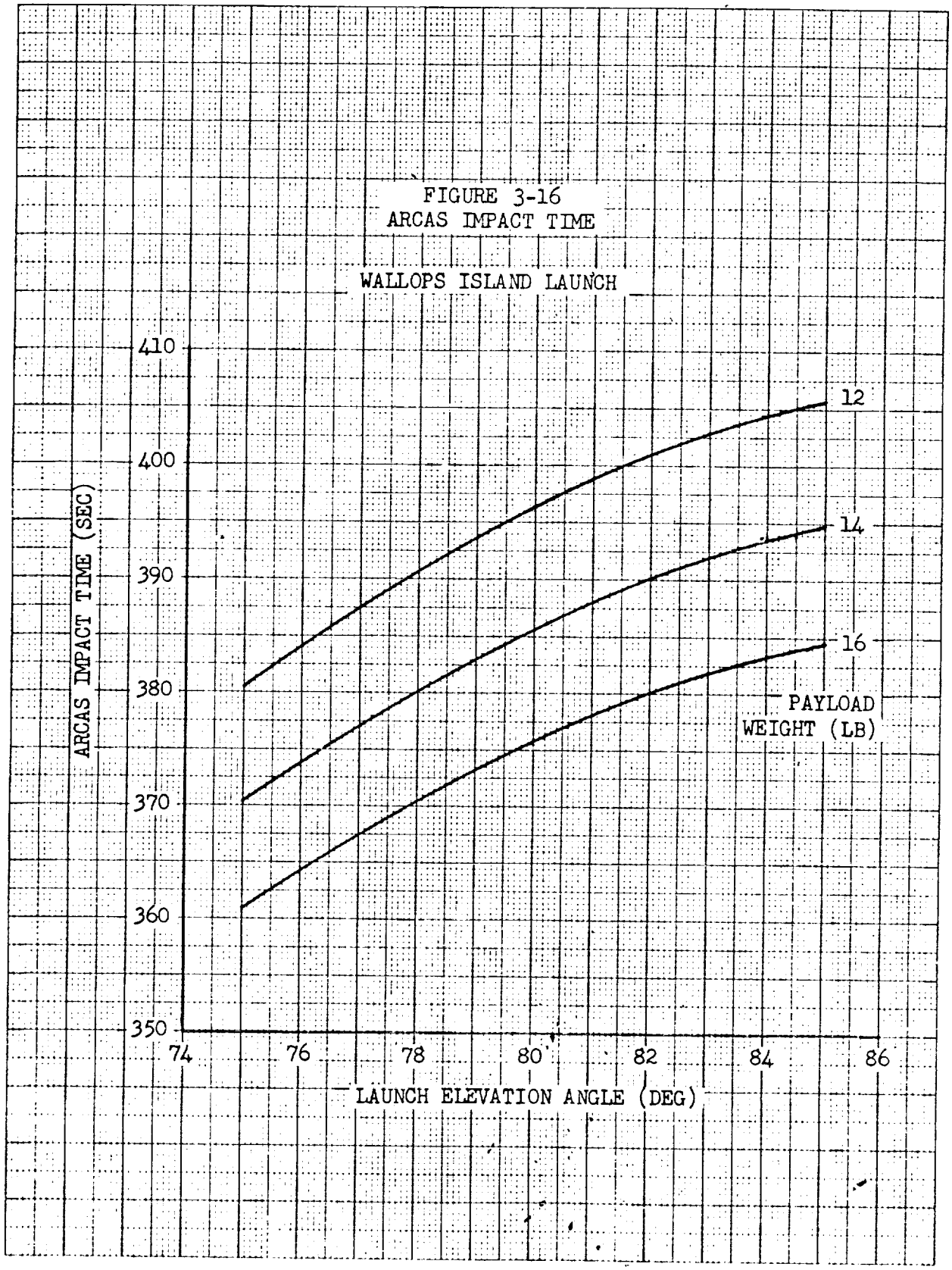


FIGURE 3-16
ARCAS IMPACT TIME

WALLOPS ISLAND LAUNCH

4.0 IMPACT DISPERSION ANALYSIS

A major requirement for mission planning and flight safety considerations is to know the expected impact dispersions for the spent booster stages. This section presents the results of an impact dispersion analysis conducted on both the Sidewinder and Arcas stages. Vehicle, launcher, and environmental factors which can produce deviations in the trajectory were considered. The magnitudes of these factors are unknown before launch and therefore cannot be compensated for by a simple launcher correction.

The sources of error considered in this study include prediction inaccuracies in such parameters as motor thrust and aerodynamic coefficients; parameters which are difficult to measure accurately, such as launcher settings; and factors which change during the time between measurement and launch, such as winds. The purpose of this study was to determine the impact dispersion areas in which the normally functioning Sidewinder and Arcas stages will fall.

4.1 Method of Calculation

To determine the deviations in the Sidewinder and Arcas spent stage impact locations, the error sources were introduced individually into the nominal trajectory. The resulting impact locations were then compared with the nominal. For the Sidewinder, a rectangular coordinate system, with the x axis oriented along the launch azimuth in a plane tangent to the earth at the launch site, and y and z axes to the right and up, respectively, was used to determine impact dispersion. For each error source the deviations in impact point location from the nominal in terms of x and y were calculated and assumed to be downrange and crossrange deviations, respectively. These deviations, in x and y, were then root-sum-squared to obtain total expected components of downrange and crossrange dispersion. The errors resulting from measurement in this coordinate system rather than along the curved surface

of the earth are negligible since the total impact range is only 5,600 feet.

For the Arcas impact location, the latitude and longitude coordinates of the impact point were used to determine the downrange and crossrange deviations from the nominal impact point location. The downrange direction is defined as being along a line passing through the nominal impact point location at an azimuth of 100 degrees. The crossrange direction is normal to the downrange line. The downrange and crossrange deviations from nominal were each root-sum-squared to obtain the semi-major and semi-minor axes of the Arcas elliptical impact area.

Trajectories for certain error sources were calculated with a point mass simulation, and the deviations were compared to a nominal point-mass trajectory. These error sources include launch elevation angle, launch azimuth, Sidewinder thrust, Arcas thrust, drag during Sidewinder boost and spent stage flight, drag during Arcas boost, coast, and spent stage flight, Arcas burnout weight, and Arcas ignition delay. Trajectories for the remaining error sources were calculated with a six degree-of-freedom spinning simulation, and the resulting deviations were compared to the nominal six degree-of-freedom spinning trajectory.

4.2 Results

The results of the dispersion analysis are given in Table 4-1. The individual error sources and magnitudes, which were supplied by NASA-LRC, are indicated along with their effects on the Sidewinder and Arcas spent stage impact locations. The deviations in the uprange and downrange directions were assumed to be equal. Also indicated are the root-sum-square values of the Sidewinder and Arcas downrange and crossrange deviations. The magnitudes of the error sources are three sigma values. When the

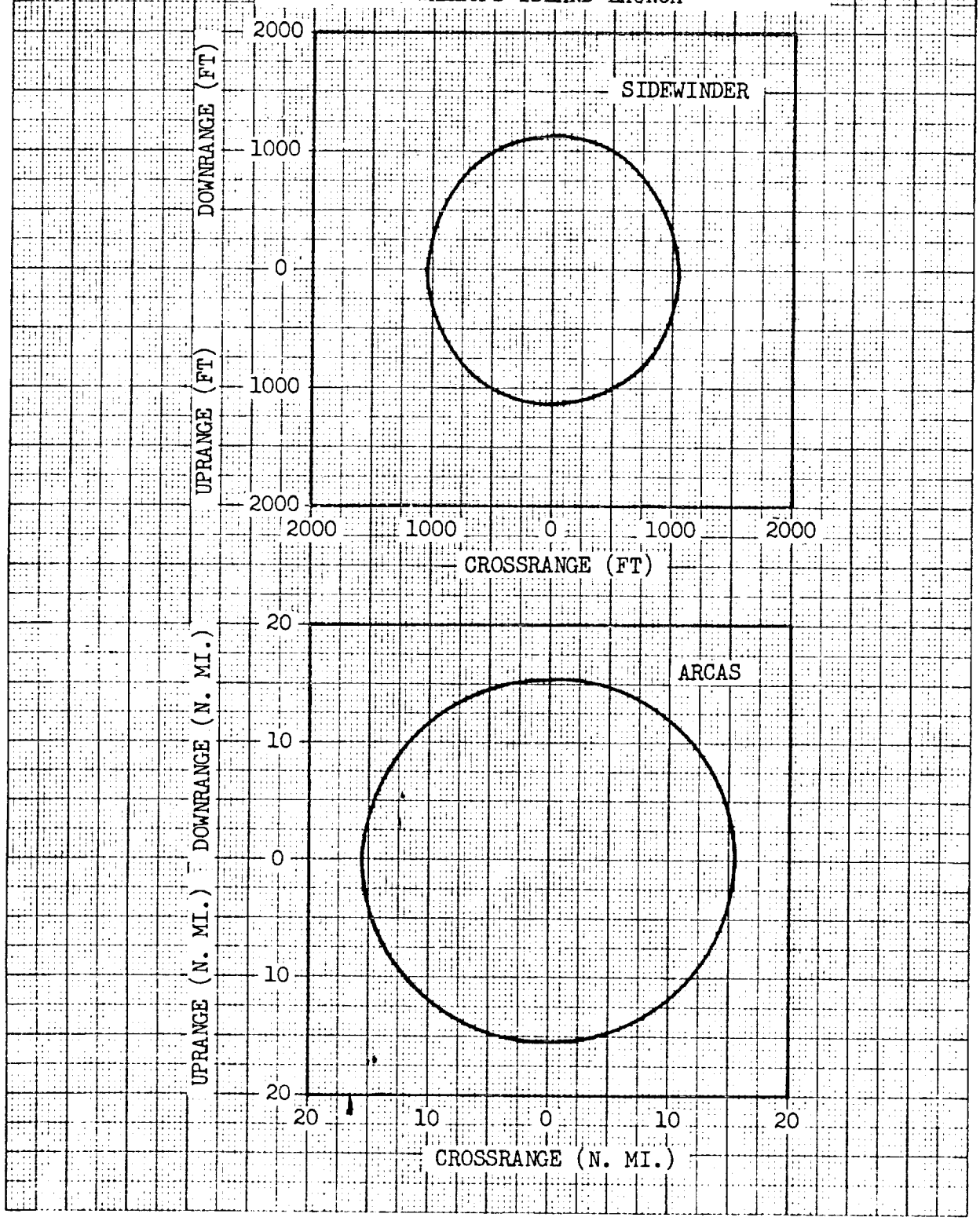
root-sum-squares of the deviations are represented by a two-dimensional downrange and crossrange normal distribution, the probability level is 98.9 percent. The root-sum-square values are 1128 feet downrange and 1054 feet crossrange for the Sidewinder and 15.43 nautical miles downrange and 15.62 nautical miles crossrange for the Arcas. These deviations are plotted as elliptical impact areas in Figure 4-1. In addition, the Arcas impact area is plotted on the map in Figure 3-2.

TABLE 4-1

SIDEWINDER-ARCAS
DISPERSION ANALYSIS SUMMARY

ERROR SOURCE AND 3σ MAGNITUDE	3σ DEVIATIONS AT IMPACT			
	SPENT SIDEWINDER MOTOR		SPENT ARCAS MOTOR	
	DOWN RANGE ft	CROSS RANGE ft	DOWN RANGE n.mi.	CROSS RANGE n.mi.
LAUNCH CONDITION ERRORS				
0.25° Launch Azimuth	0	25	0.01	0.30
0.25° Launch Elevation Angle	121	0	1.50	0.04
10 ft/sec Uncompensated Crosswind	1	728	0.22	12.16
10 ft/sec Uncompensated Range Wind	734	10	10.62	0.24
PROPULSION ERRORS				
5% Sidewinder Thrust	158	2	1.60	0.11
3% Arcas Thrust	-	-	4.67	0.27
0.1° Sidewinder Thrust Misalign., Pitch	698	23	8.08	0.01
0.1° Sidewinder Thrust Misalign., Yaw	11	723	0.27	9.17
0.1° Arcas Thrust Misalign., Pitch	-	-	0.36	0.03
0.1° Arcas Thrust Misalign., Yaw	-	-	0.03	0.36
AERODYNAMIC UNCERTAINTIES				
10% Drag, Sidewinder Boost and Spent Stage Flt.	395	8	0.20	0.01
10% Drag, Arcas Coast, Boost, and Spent Stg. Flt.	-	-	4.16	0.23
VEHICLE AND FIN MISALIGNMENTS				
0.25° Sidewinder/Arcas Vehicle Misalign., Pitch	75	6	1.04	0.44
0.25° Sidewinder/Arcas Vehicle Misalign., Yaw	6	75	0.44	1.04
0.375° Arcas/Payload Misalign., Pitch	132	11	2.14	0.13
0.375° Arcas/Payload Misalign., Yaw	10	142	0.02	2.36
0.1° Sidewinder Fin Misalign., Pitch	165	15	2.06	0.22
0.1° Sidewinder Fin Misalign., Yaw	13	178	0.15	2.13
0.1° Arcas Fin Misalign., Roll	0	0	0.01	0.00
0.1° Arcas Fin Misalign., Pitch	5	1	0.09	0.41
0.1° Arcas Fin Misalign., Yaw	0	5	0.19	0.24
WEIGHT AND SEQUENCING ERRORS				
1 lb. Arcas Burnout Weight	16	0	2.10	0.12
0.5 sec. Arcas Ignition Delay	-	-	1.08	0.03
ROOT SUM SQUARE	1128	1054	15.43	15.62

FIGURE 4-1 THREE SIGMA IMPACT AREAS
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD
WALLOPS ISLAND LAUNCH



5.0 WIND COMPENSATION ANALYSIS

The wind compensation method used for the Sidewinder-Arcas is similar to that used for the Nike-Tomahawk in Reference 7. Basically, the method consists of determining the wind weighting function, the unit wind effects, and the range derivative for the vehicle and then using an iterative procedure to calculate launch azimuth and launch elevation angle adjustments that will maintain the Arcas nominal impact location. The wind compensation analysis for the Sidewinder-Arcas was based on the nominal trajectory having an 80-degree launch elevation angle and a 12-pound payload.

5.1 Wind Weighting Function

The wind weighting function depicts the sensitivity of a given rocket vehicle to wind as a function of altitude. The function is a ratio of the displacement due to a uniform wind existing between the ground level and some altitude Z to the displacement due to a uniform wind from the ground level to 100000 feet. In equation form,

$$f(Z) = \frac{\text{Impact displacement due to a uniform wind from } h=0 \text{ to } h=Z}{\text{Impact displacement due to a uniform wind from } h=0 \text{ to } h=100000 \text{ ft.}} \qquad (1)$$

The effect of a wind layer existing between altitudes h_1 and h_2 can be expressed as $\Delta f(Z) = f(Z_2) - f(Z_1)$ where $f(Z_2)$ is wind weighting function between 0 and altitude h_2 and $f(Z_1)$ between 0 and altitude h_1.

The wind weighting function points calculated for the Sidewinder-Arcas vehicle are given in Table 5-1 and plotted in Figure 5-1 for a payload weight of 12 pounds. The function was checked and was found to be applicable to all launch elevation angles between 75 and 85 degrees. According to Reference 7, the function is applicable for the range of payload weights considered.

5.2 Unit Wind Effects

To use the wind weighting function for other launch elevation angles and for winds from any direction, the unit wind effects are determined. Trajectories were calculated with a 1 foot-per-second wind existing between altitudes of 0 and 100000 feet. The displacement of the impact point due to this wind is called the unit wind effect. Wind directions along and normal to the 100-degree launch azimuth were used to determine the range wind and cross wind effects. Variations in unit wind effects due to changing the launch elevation angle were also determined. These effects are plotted in Figure 5-2 for a 12-pound payload. Downrange and crossrange are assumed to be the deviations from the nominal impact location, due to wind, as measured in the x-y-z coordinate system used for the Sidewinder impact dispersion. This makes the determination of downrange and crossrange simpler since these data are available for each of the trajectories. The accuracy of the results is not affected since the true downrange and crossrange dispersions are not required.

5.3 Range Derivative

The range derivative is used in wind compensation to correct the impact point in an uprange or downrange direction by adjusting the launch elevation angle. The derivative is determined by first curve-fitting impact range as a function of launch elevation angle. The method of least squares was used, and a sixth order polynomial was found to be the most accurate. The polynomial was then differentiated at various launch elevation angles to obtain the range derivative. These values are plotted in Figure 5-3 for a 12-pound payload.

5.4 Wind Compensation Example

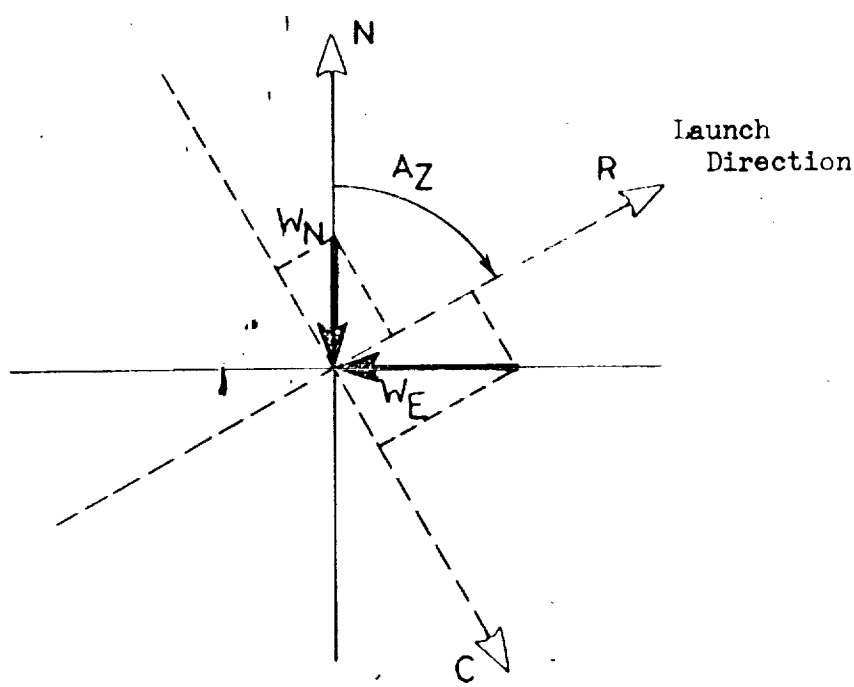
5.4.1 Ballistic Wind Computation

A ballistic wind computation example is given in Table 5-2. The first, second, and third columns of this table give the wind altitude layers and the corresponding north-south and east-west wind components. The fourth column

indicates the wind weighting function values, f(Z), from Figure 5-1. The values given in Table 5-2 correspond to the highest altitude in each layer. Thus, the fifth column, $\Delta f(Z)$, gives the change in wind weighting function for each altitude layer. To calculate the ballistic wind, the $\Delta f(Z)$ values are multiplied by each of the wind components as shown in the $\Delta F(Z)\ W_N$ and $\Delta f(Z)\ W_E$ columns. The totals of these two columns represent the components of the ballistic wind, 11.88 feet per second from the south and 4.19 feet per second from the west. Theoretically, uniform wind having these components, between altitudes of 0 and 100000 feet, will have the same effect on the Arcas spent stage impact location as the sample wind profile given in the first three columns of Table 5-2.

5.4.2 Launch Azimuth and Launch Elevation Angle Adjustments

An iteration procedure is used in calculating the adjustments in launch azimuth and launch elevation angle to compensate for variation in Arcas impact location due to wind effects. The ballistic wind must first be resolved into components along and perpendicular to the launch azimuth. The general equations for this conversion are



$$W_R = W_N \cos A_Z + W_E \sin A_Z \qquad (2)$$

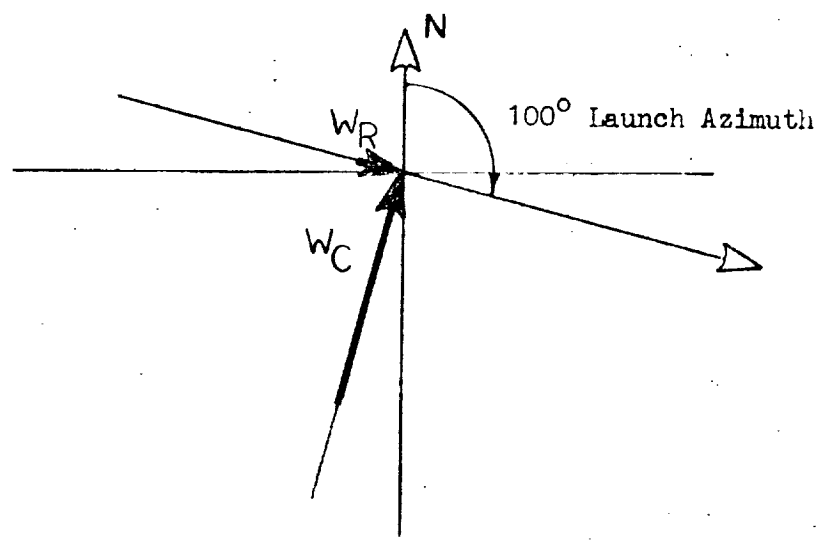
$$W_C = W_N \sin A_Z - W_E \cos A_Z \qquad (3)$$

Positive wind components are defined as north to south, east to west, headwind, and left to right crosswind. For a launch azimuth of 100 degrees and the ballistic wind components given in Table 5-2, the downrange and crossrange wind components are

$$W_R = (-11.88) \cos 100 + (-4.19) \sin 100 = -2.07 \text{ ft/sec}$$

$$W_C = (-11.88) \sin 100 - (-4.19) \cos 100 = -12.42 \text{ ft/sec}$$

These components are indicated in the sketch below.



The wind effects due to downrange and crossrange wind components are the products of the components and the appropriate values of the unit wind effects given in Figure 5-2. For a launch elevation angle of 80 degrees, the crossrange unit wind effect, δ_C, is 7380 feet per feet per second, and the downrange unit wind effect, δ_R, is 6190 feet per feet per second.

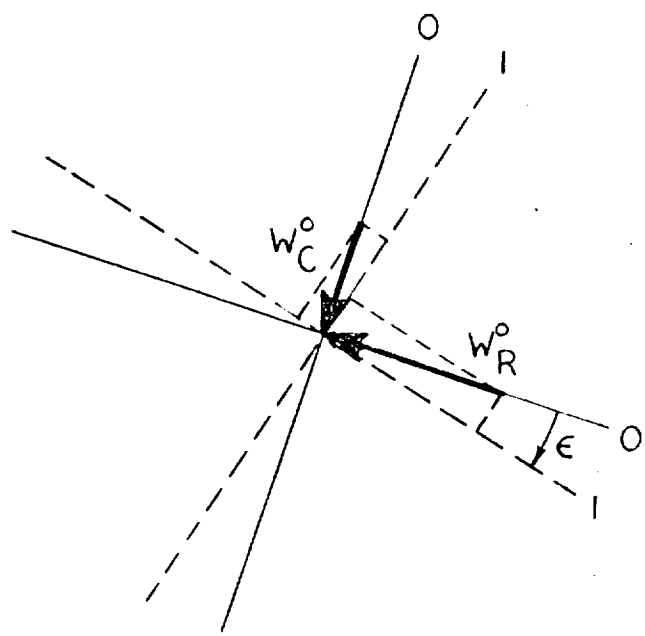
The wind effects on the impact location are therefore

$$R = W_R \delta_R = (-2.07)(6190) = -12813 \text{ ft.} \qquad (4)$$

$$C = W_C \delta_C = (-12.42)(7380) = -91660 \text{ ft.} \qquad (5)$$

Since positive displacements are in the opposite direction of the positive wind components, the Arcas spent stage under these wind conditions will impact 12813 feet uprange and 91660 right of nominal.

To determine the azimuth adjustment, ϵ , to correct for the wind effects, a set of transformation equations must be defined. If the coordinate system containing the nominal azimuth plane is identified as (0-0), the transformation to any other system (1-1) is

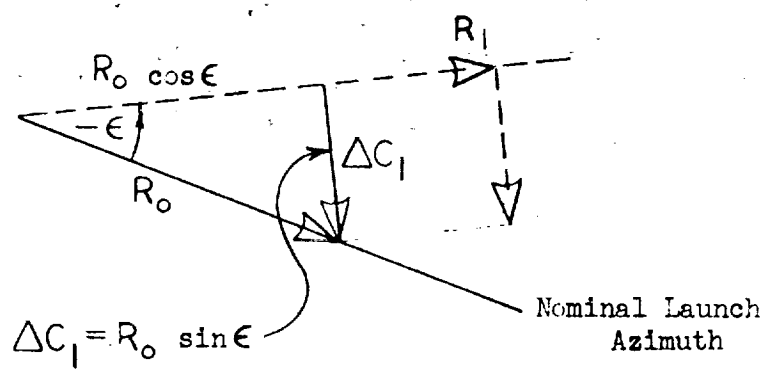


$$W_C^1 = W_C^o \cos \epsilon + W_R^o \sin \epsilon \qquad (6)$$

$$W_R^1 = -W_C^o \sin \epsilon + W_R^o \cos \epsilon \qquad (7)$$

The azimuth correction ϵ is defined as being positive in a clockwise direction.

In the sketch below, the relation of the nominal azimuth, the azimuth correction, the nominal impact range, R_o, and the crossrange wind effect are shown.



From the sketch and the transformation equations, the crossrange wind effect is

$$\Delta C_1 = R_o \sin\epsilon = \delta_C W_C^1$$
$$= \delta_C (W_C^o \cos\epsilon + W_R^o \sin\epsilon)$$
$$= \delta_C W_C^o \cos\epsilon + \delta_C W_R^o \sin\epsilon \qquad (8)$$

Then the azimuth correction is given by

$$\tan\epsilon = \frac{\delta_C W_R^o}{R^o - \delta_C W_R^o} \qquad (9)$$

For the sample problem

$$\epsilon = \tan^{-1} \frac{(7380)(-12.42)}{407306-(7380)(-2.07)} = -12.24^o$$

Thus the first iteration on the azimuth correction indicates that the launch azimuth should be

$$A_Z = 100 - 12.24 = 87.76^o$$

To determine the launch elevation angle correction, the downrange wind component for the corrected launch azimuth is calculated by Equation 7. This is

$$W_R^1 = -(-12.42) \sin(-12.24) + (-2.07) \cos(-12.24)$$
$$= -4.65 \text{ ft/sec.}$$

The wind effect is therefore

$$\Delta R_1 = W_R' \delta_R = (-4.65)(6190) = -28784 \text{ ft} \qquad (10)$$

Since the desired impact range is $R_o \cos \epsilon$ according to the sketch above, the range correction required is the difference between this value and the sum of the nominal impact range and the wind effect. In equation form, this is

$$\Delta R_D = R_o \cos \epsilon - (R_o + \Delta R_1) \qquad (11)$$

$$= (407306) \cos(-12.42) - \left[407306 + (-28784)\right]$$

$$= 19526 \text{ ft}$$

The launch elevation angle correction is

$$\Delta\theta = \frac{\Delta R_D}{dR/d\theta} = \frac{19526}{-36200} = -0.54^\circ \qquad (12)$$

where $d_R/d\theta$ is the range derivative obtained from Figure 5-3 at the nominal launch elevation angle of 80 degrees. The corrected launch elevation angle is therefore

$$\theta = 80 - 0.54 = 79.46^\circ$$

To proceed with the second iteration, the unit wind effects must be obtained from Figure 5-2 for a launch elevation angle of 79.46 degrees. These are

$$\delta_R = 7315 \text{ ft/ft/sec}$$

$$\delta_C = 6000 \text{ ft/ft/sec}$$

The second calculation of the azimuth correction by Equation 9 is

$$\epsilon = \tan^{-1} \frac{(7315)(-12.42)}{407306 - (7315)(-2.07)} = -12.14^\circ$$

and the corrected azimuth is therefore

$$A_Z = 100 - 12.14 = 87.86^\circ$$

The downrange wind component for this azimuth calculated by Equation 7 is

$$W_R^1 = -(-12.42) \sin(-12.14) + (-2.07) \cos(-12.14)$$

$$= -4.63 \text{ ft/sec}$$

The wind effect in the range direction from Equation 10 is

$$\Delta R_1 = W_R \delta_R = (-4.63)(6000) = -27780 \text{ ft}$$

As a result, the range correction required, Equation 11, is

$$\Delta R_D = R_o \cos \epsilon - (R_o + \Delta R_1)$$

$$= (407306) \cos(-12.14) - \left[407306 + (-27780)\right]$$

$$= 18673 \text{ ft}$$

The launch elevation correction from Equation 10 is

$$\Delta\theta = \frac{\Delta R_D}{dR/d\theta} = \frac{18673}{-36200} = -0.52^\circ$$

and the corrected elevation angle is

$$\theta = 80 - 0.52 = 79.48^\circ$$

The two iterations have indicated launch azimuths of 87.76 and 87.86 degrees and launch elevation angles of 79.46 and 79.48 degrees. Since the reading of the unit wind effects in Figure 5-2 for last value of the launch elevation angle cannot be improved over the previous value, the iteration procedure is stopped. Therefore, the adjustments in launch azimuth and launch elevation angles to compensate for the wind have converged in two iterations.

TABLE 5-1

WIND WEIGHTING FUNCTION
12-POUND PAYLOAD

ALTITUDE	f(Z)	$\Delta f(Z)$
0	0	0
50	0.207	0.207
200	0.530	0.323
500	0.708	0.178
1000	0.811	0.103
2100*	0.857	0.046
5900**	0.831	-0.026
12000	0.868	0.037
25000	0.930	0.062
45000	0.968	0.038
70000	0.981	0.013
100000	1.000	0.019

*Approximate First-Stage Burnout Altitude
**Approximate Second-Stage Ignition Altitude

TABLE 5-2

BALLISTIC WIND COMPUTATION EXAMPLE

ALTITUDE LAYER	W_N ft/sec	W_E ft/sec	f(Z)	$\Delta f(Z)$	$\Delta f(Z) W_N$ ft/sec	$\Delta f(Z) W_E$ ft/sec
0-50	-10.3	+5.9	0.207	0.207	-2.13	+1.22
50-100	-14.5	+4.4	0.360	0.153	-2.22	+0.67
100-200	-12.0	+7.5	0.529	0.169	-2.04	+1.27
200-300	-17.6	+9.0	0.615	0.086	-1.51	+0.77
300-500	-12.9	+0.5	0.708	0.093	-1.20	+0.05
500-1000	-17.2	-5.3	0.811	0.103	-1.77	-0.55
1000-2000	-16.3	-13.2	0.853	0.042	-0.69	-0.55
2000-3000	-14.4	-16.6	0.847	-0.006	-0.08	-0.10
3000-4000	-12.9	-19.1	0.835	-0.012	-0.15	-0.23
4000-5000	-10.1	-21.8	0.830	-0.005	-0.05	-0.11
5000-7000	-5.6	-26.4	0.835	0.005	-0.03	-0.13
7000-12000	-10.3	-17.3	0.868	0.033	-0.34	-0.57
12000-20000	+2.7	-38.2	0.913	0.045	+0.12	-1.72
20000-30000	+15.9	-75.2	0.942	0.029	+0.46	-2.18
30000-45000	-0.8	-59.2	0.968	0.026	-0.02	-1.54
45000-60000	-11.4	-20.7	0.982	0.014	-0.16	-0.29
60000-100000	-3.9	-11.3	1.000	0.018	-0.07	-0.20
BALLISTIC WIND COMPONENTS					-11.88	-4.19

BALLISTIC WIND SPEED = 12.60 ft/sec

BALLISTIC WIND DIRECTION = 199.4 deg.

Positive Wind Components:
1) North to South
2) East to West

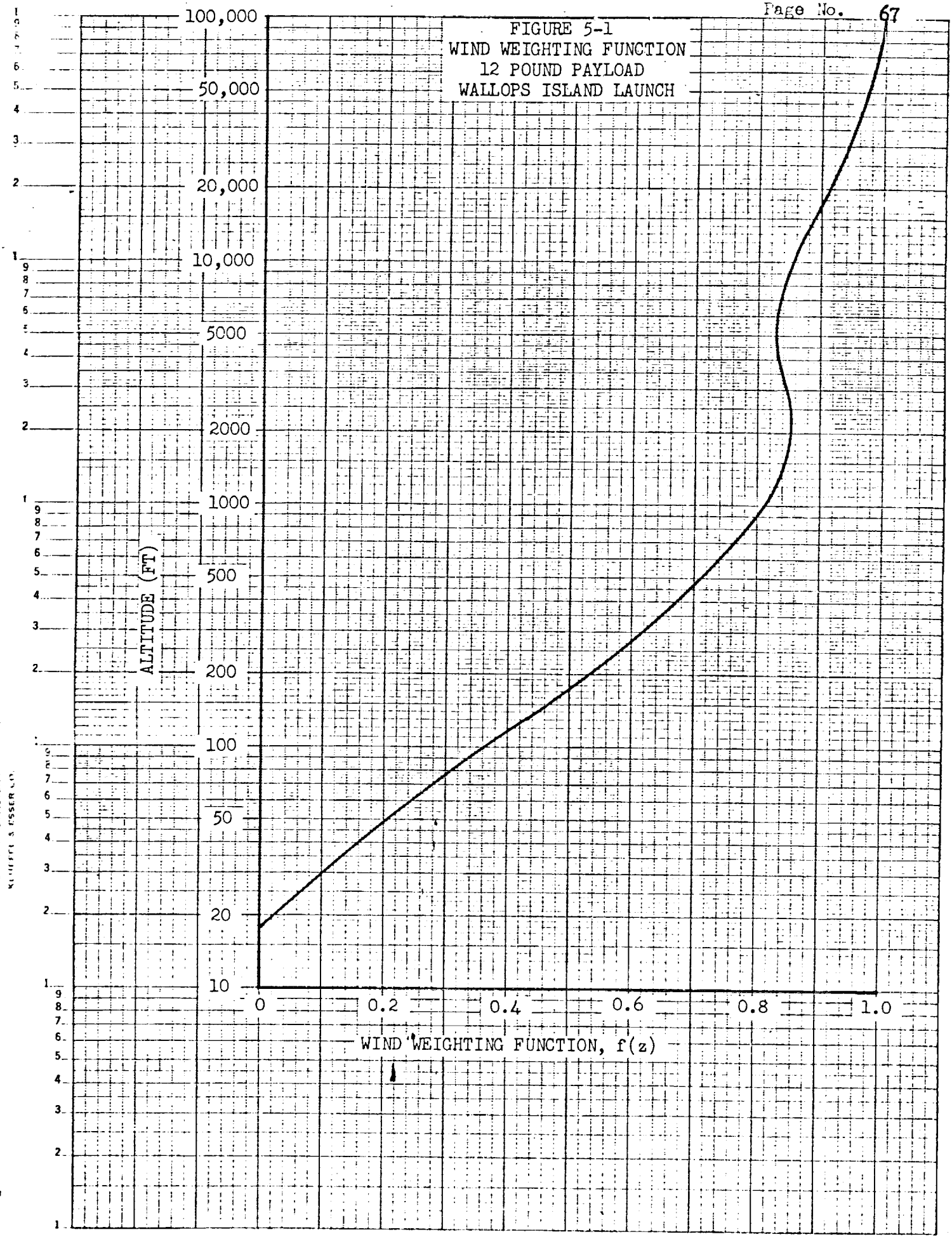


FIGURE 5-1
WIND WEIGHTING FUNCTION
12 POUND PAYLOAD
WALLOPS ISLAND LAUNCH

K+E SEMI-LOGARITHMIC 46 6213

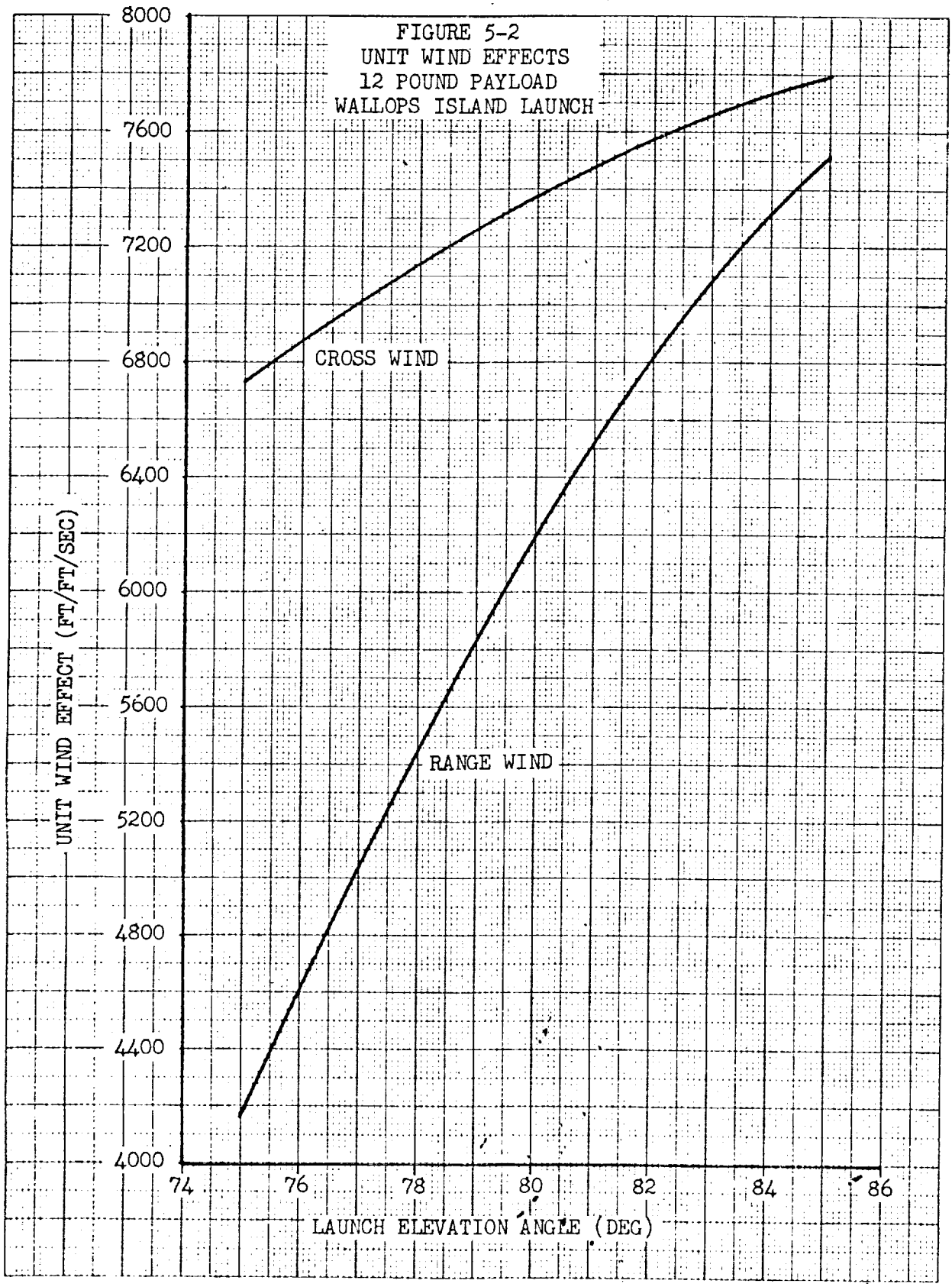


FIGURE 5-2
UNIT WIND EFFECTS
12 POUND PAYLOAD
WALLOPS ISLAND LAUNCH
CROSS WIND
RANGE WIND
UNIT WIND EFFECT (FT/FT/SEC)
8000
7600
7200
6800
6400
6000
5600
5200
4800
4400
4000
74
76
78
80
82
84
86
LAUNCH ELEVATION ANGLE (DEG)

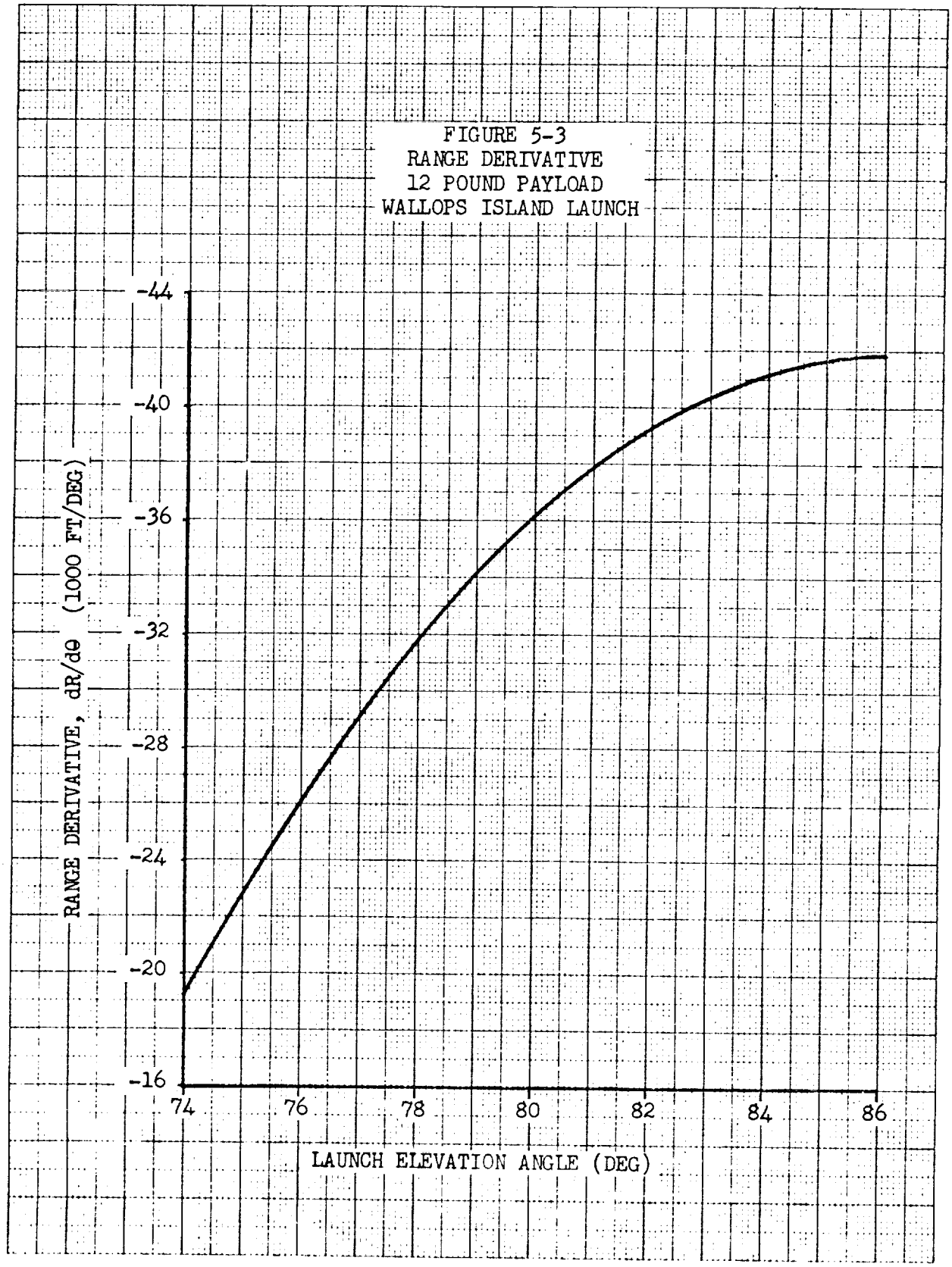


FIGURE 5-3
RANGE DERIVATIVE
12 POUND PAYLOAD
WALLOPS ISLAND LAUNCH

6.0 VEHICLE DYNAMIC ANALYSIS

The Sidewinder-Arcas dynamic analysis included determining the roll-pitch resonance conditions and the dynamic response to thrust and aerodynamic misalignments. Pitch natural frequency, the amplification of trim angle of attack caused by rolling, and the envelope of angle of attack amplitudes caused by fin, nose, and thrust misalignments applied throughout spinning flight are derived and presented for the nominal trajectory. The vehicle static margin history was also determined.

6.1 Pitch Natural Frequency

The pitch natural frequency of the Sidewinder-Arcas vehicle as derived in Reference 8 is

$$\omega_o^2 = (C_{m_\alpha})_{CG}\, d\, S\, \bar{q}/I$$

The natural frequency and roll rate are presented in Figure 6-1 for a six degree-of-freedom nominal trajectory (12 pound payload, 80 degree launch elevation angle). The roll rate with the Sidewinder fin misalignment (discussed in Section 2.2.1) is also shown in Figure 6-1.

The static margin used in this analysis is presented as a function of time in Figure 6-2. The static margin for two other payload weights is also shown. The curve for a 12-pound payload is based on the aerodynamic data originally supplied by NASA-LRC (Table 2-2); the curves for 14 and 16 pounds are based on the revised aerodynamic coefficients in Table 2-3 which were used in the computation of trajectories for 14 and 16-pound payloads.

6.2 Disturbance Moments

The body-fixed disturbance moments can be expressed as static trim angles of attack in the non-rolling case which are given by

$$\Delta\eta_{p=0} = \frac{C_{m_\phi}\phi}{(C_{m_\alpha})_{CG}}$$, for ϕ = .375° at Arcas-P.L. separation plane (see Table 2-9)

$$\Delta\eta_{p=0} = \frac{(C_{m\delta})_{CG}\delta_A}{(C_{m\alpha})_{CG}}$$ for δ_A = 0.1° misalignment of two fins in one plane (see Table 2-7)

$$= \frac{T\ \sigma_T\ (l_{cg}-l_n)}{(C_{m\alpha})_{CG}\ dSq},$$ for 0.1° thrust misalignment σ_T, where $l_{cg}-l_n$ is the moment arm from the c.g. to the nozzle throat

These static trim angles of attack are presented in the lower part of Figure 6-3.

6.3 Pitch-Roll Resonance Amplification Factor

A body fixed moment on a spinning vehicle applies an oscillating moment to the body due to the component of the rotating moment projected onto an inertial axis normal to the body spin axis. This produces an oscillatory angle of attack of the spin axis given by the usual equation for resonant response of a second order system

$$\frac{\eta_p}{\eta_{p=0}} = \frac{1}{(p/\omega_o)^2 + 2\ \xi\ (p/\omega_o) + 1}$$

from which the peak response at resonance is given by

$$\frac{\eta_{p=\omega_o}}{\eta_{p=0}} = \frac{1}{2\xi}, \text{ when } p = i\ \omega_o.$$

The damping ratio, ξ, is derived from

$$2\ \xi\ \omega_o = C_{N_\alpha}\frac{Sq}{mV} - (C_{m_Q})_{CG}\frac{d^2}{2V}\frac{Sq}{I}\left(\frac{T}{mV} - \frac{M_{Y_Q}}{I}\right)$$

Derivation of similar expressions may be found in Reference 8. The ratio of roll to transverse inertia is neglected because it is small. The term $\frac{T}{mV}$ is derived from the effect of longitudinal acceleration on the normal force equation as follows. (This term was neglected in

Reference 8, Appendices A and C, in reducing the 6-degree-of-freedom equations to 4 degrees of freedom). Substituting the longitudinal acceleration equation, $m\dot{u} = T$, into the definition of $\dot{w}$ with variable velocity, $\dot{w} = u\dot{\alpha} + \dot{u}\alpha$ gives $\dot{\alpha} = \frac{\dot{w}}{u} - \frac{T}{mu}\alpha$ so that the 4-degree-of-freedom equation for $\dot{\alpha}$ contains a term modifying the normal force curve slope. Thus,

$$\dot{\alpha} = \frac{\dot{\theta}}{mV} - \left(\frac{T}{mV} + \frac{C_{N_\alpha} S \bar{q}}{mV}\right)\alpha$$

The $\dot{\beta}$ equation contains a similar modification by symmetry.

6.4 Resultant Angle of Attack Due to Pitch-Roll Resonance

The amplification factor (paragraph 6.3) is applied to the trim angle of attack (paragraph 6.2) to produce the resultant angle of attack shown in the upper part of Figure 6.3. The resultant angle of attack amplitude which would occur at each instant if the system were continuously excited by the sinusoidal forcing function existing at that instant. Since a number of oscillations are required for a damped system to build up or decay to its steady amplitude, the actual angle of attack response should appear to lag the steady state values calculated here.

In the upper part of Figure 6-3, the solid curves show the resultant angle of attack based on the nominal spin rate produced by 0.35° of Arcas fin cant. The dashed curves show the peak amplitude which would be obtained at any instant if the vehicle were rolling at an off-nominal spin frequency equal to the pitch frequency. Therefore, the dashed curve represents either the peak amplitude for pitch-roll resonance with off-nominal roll rates or

a time history of resultant angle of attack if roll lock-in occurs. Since both of these latter cases are outside the scope of this study, the probability of their occurrence has not been considered.

The effects of the three Arcas misalignments are plotted for the Arcas stage only. Roll resonant amplification does not occur during Sidewinder burning since the roll rate is negligible until Arcas separation.

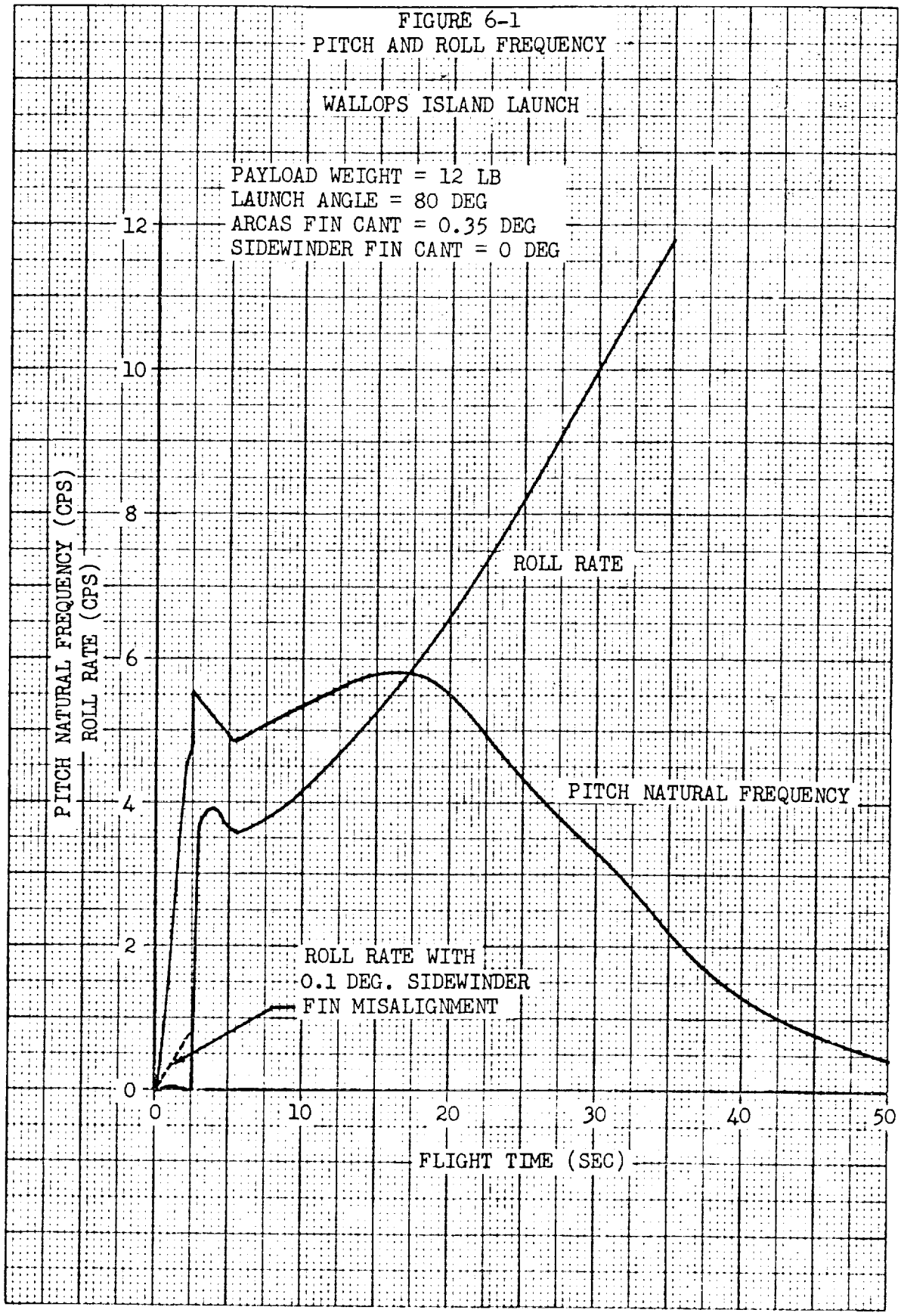


FIGURE 6-1
PITCH AND ROLL FREQUENCY

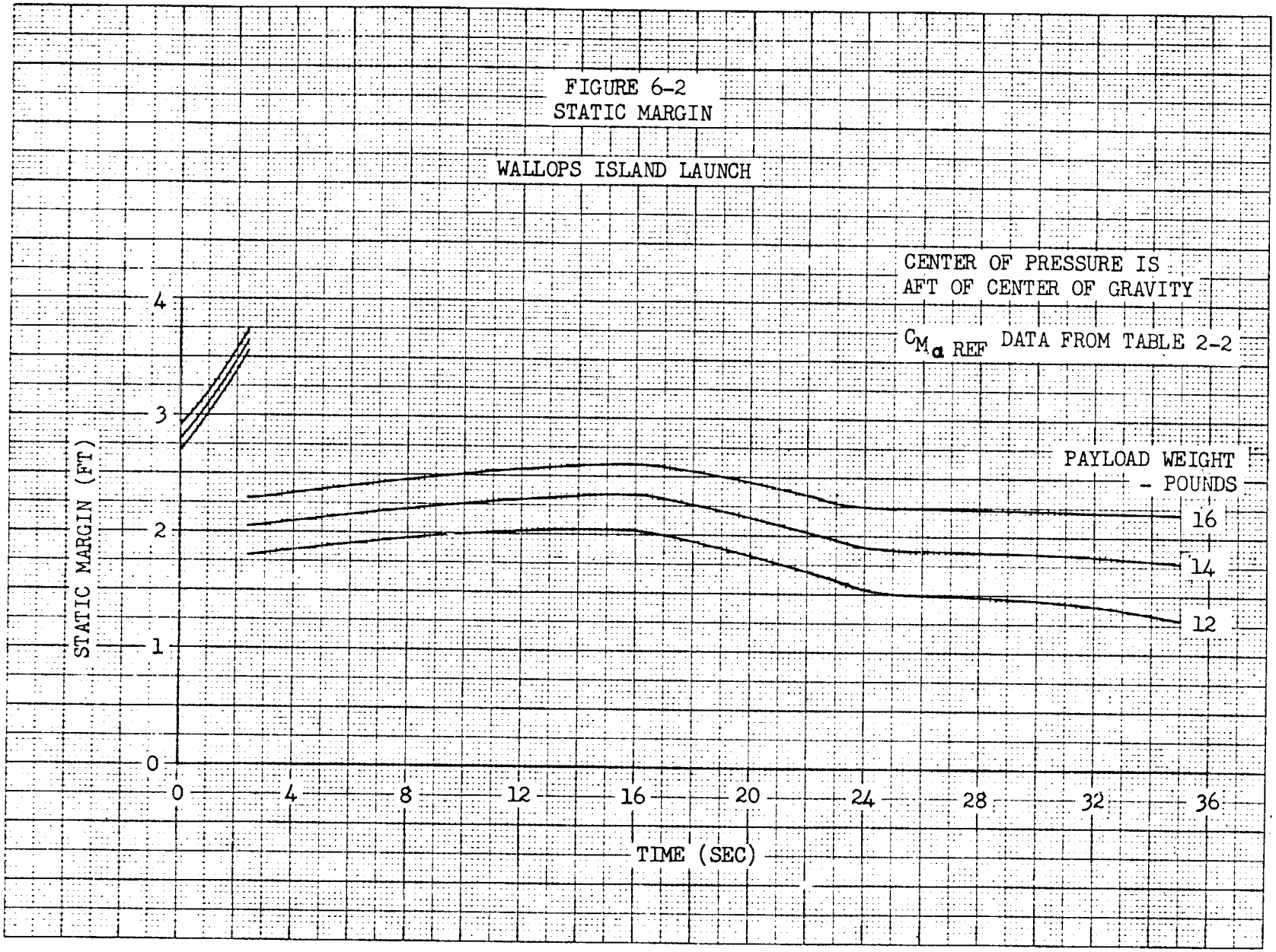
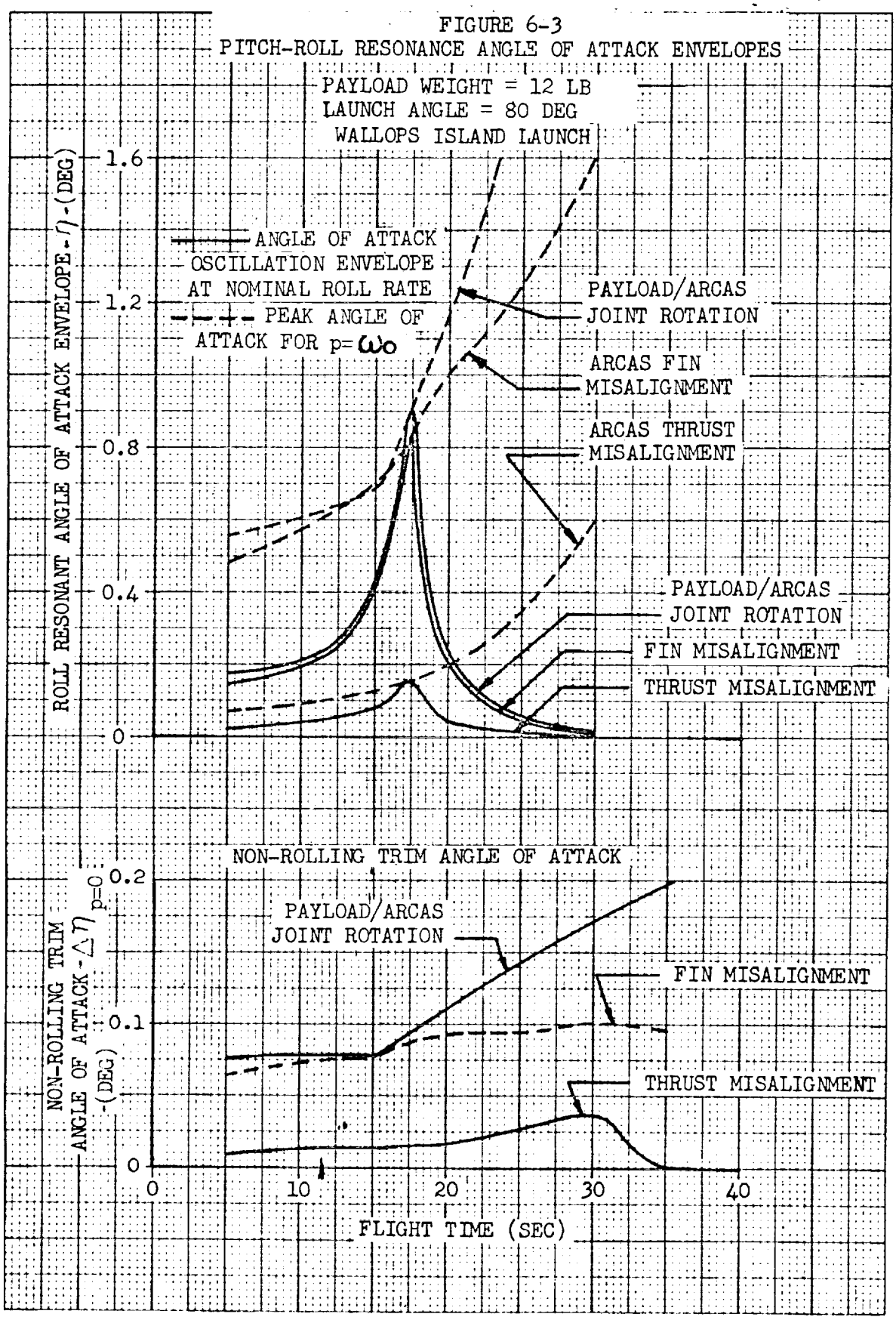


FIGURE 6-2
STATIC MARGIN

FIGURE 6-3
PITCH-ROLL RESONANCE ANGLE OF ATTACK ENVELOPES



REFERENCES

(1) Ellison, D. E., et al, "USAF Stability and Control DATCOM," Flight Control Division, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, November 1965.

(2) Post, J., "Methods for Estimating Drag Penalties Associated with Aerodynamic Tolerances for Supersonic Missiles," Vought Aeronautics Division, Chance Vought Corporation Memo AER-EDM-770, 29 June 1961.

(3) Hoerner, S. F., Fluid-Dynamic Drag, published by the author, 1953.

(4) Wasson, R. A., Jr., "Method for Calculating Roll Effectiveness and Roll Damping Derivatives for a Wing-Body-Tail Missile Configuration," LTV Aerospace Corporation, Missiles and Space Division, Memo 3-52400/8DM-44, 18 April 1968. (Confidential)

(5) Pitts, W. C., et al, "Lift and Center of Pressure of Wing-Body-Tail Combinations at Subsonic, Transonic, and Supersonic Speeds," NACA TR 1307, 1957.

(6) Everett, H. U., et al, "The Near-Earth Mission Analysis Trajectory Routine, LV-VC-27," LTV Aerospace Corporation, Missiles and Space Division, Report No. 00.251, 4 October 1963.

(7) "NASA NIKE-TOMAHAWK HANDBOOK," Prepared for National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland, by Thiokol Chemical Corporation, Astro-Met Division, P. O. Box 1497, Ogden, Utah, under Contract NAS5-9693, Item No. 6, Job Order No. 721R67-04, 19 December 1966.

(8) Whitlock, C. H., "Comparison of Steady-State and Six-Degree-of-Freedom Analyses of Pitch-roll Resonance Conditions for a Long Slender Sounding Rocket," NASA TN-D-1816, June, 1963.

APPENDIX A

This appendix presents tabulated data for the nominal (12 pound payload, 80 degree launch elevation angle) trajectory. The information presented includes (a) the ascent trajectory, from the end of the rail to apogee, (b) the Sidewinder spent stage trajectory, (c) the Arcas spent stage trajectory and (d) radar tracking parameters for the ascent trajectory and the Arcas spent stage trajectory. A glossary of terms used in the tabulations precedes each type of tabulation shown.

The thrust and acceleration values during Sidewinder operation have been removed from the trajectory printout to avoid compromising the Sidewinder thrust which is classified. These data are presented in the classified Appendix B.

DEFINITION OF TERMS FOR DIGITAL COMPUTER

TRAJECTORY PROGRAM NEMAR

ROUTINE NO. LV-VC-27

The terms which appear as tabular functions of time on the various pages of routine NEMAR are defined below.

Page A

WEIGHT	total vehicle weight (lbs.)
THRUST	total thrust force (lbs.)
I-VEL	inertial velocity; velocity with respect to non-rotating frame of reference (ft./sec.)
GC RAD	geocentric radial distance (ft.)
ALT	altitude (ft.)
RANGE	great circle, earth surface range from input launch site coordinates to vehicle (n. mi.)
MACH	airspeed divided by local sound speed
DYN. P	dynamic pressure; one-half density times airspeed squared (lbs./ft.^{2})
GD LAT	geodetic latitude (deg.)
GC LAT	geocentric latitude (deg.)
LONG	Greenwich longitude, positive east (deg.)
THETA-SIG	the local geocentric pitch attitude angle minus the great circle inertial range angle; approximately equal to the pitch attitude referenced to the launch site geocentric horizon.

Page B

ALPHA	angle of attack; angle between the body x (longitudinal) axis and the airspeed vector projection on the body x, z (pitch) plane
A-ALPHA	product of dynamic pressure and angle of attack (lbs./ft.^{2})
BETA	yaw angle; angle between the body x (longitudinal) axis and the airspeed vector projection on the body x, y (yaw) plane (deg.)
I-GAM	geocentric path angle of the inertial velocity vector (deg.)
R-GAM	geocentric path angle of the earth-relative velocity vector (deg.)
I-ZETA	heading of the inertial velocity vector measured clockwise from north on the geocentric horizontal plane (deg.)
R-ZETA	heading of the earth-relative velocity vector measured clockwise from north on the geocentric horizontal plane (deg.)
PHI	roll angle with respect to local geocentric vertical (deg.)
PSI	heading of the body x (longitudinal) axis measured clockwise from north on the geocentric horizontal plane
THETA	angle between the body x (longitudinal) axis and the geocentric horizontal plane (deg.)
Q-INTG	the integral of inertial pitch rate: $\int_{to}^{t} Q dt$ (deg.)
Q-COMM	the command pitch rate (deg./sec.)
PITCH ERR	the guidance system pitch attitude error (deg.)

Page C

P, Q, R	body axes angular velocities about longitudinal, lateral, and vertical axes respectively (deg./sec.)
A, Y, N	axial, side, and normal aerodynamic forces respectively (lbs.)
NX, NY, NZ	body axes components of load factor (g units)
VELOCITY AIR REL	airspeed or velocity with respect to the air mass (ft./sec.)
VELOCITY REL	earth relative velocity or velocity with respect to the frame of reference that rotates with the earth (ft./sec.)
WIND VEL	horizontal wind speed (ft./sec.)
WIND DIR	direction from which the wind is blowing, measured clockwise from north (deg.)
NX-INTG	integral of the load factor along the body x axis (ft./sec.)

Page D

HXDOT, HYDOT, HZDOT	body axes components of time rates of change of angular momentum (ft. lbs.)
PCONT, QCONT, RCONT	control surface deflections or reaction control motors thrust (deg. or lbs)
NERR	an index to denote which integrated variable is controlling the integration step size
STEPS GOOD	number of successful integration steps
STEPS BAD	number of unsuccessful integration steps
VELOCITY LOSSES: AERO	velocity loss due to aerodynamic forces: first integral of aerodynamic force per unit mass component along relative velocity vector
GRAVITY	velocity loss due to gravity: first integral of gravity force per unit mass component along relative velocity vector
PRESSURE	velocity loss due to ambient pressure acting over rocket nozzle exit area: first integral of pressure force component along relative velocity vector
ALPHA	velocity loss due to thrust vector non-alignment with relative velocity vector
IDEAL VELOCITY	velocity which the vehicle would attain in a field-free vacuum if it starts from rest and follows a rectilinear path; the first integral of vacuum thrust per unit mass.

Page E Range Coordinates and Velocities

Definition: The range coordinate system has axes XL, YL, and ZL. The XL, YL plane is tangent to the spheroid at the launch site, the XL axis is in the direction of the launch azimuth, the ZL axis is vertical, positive up, and the YL axis completes the right-hand system.

XL, YL, ZL	coordinates in the range coordinate system (ft.)
XLDOT, YLDOT, ZLDOT	velocity components in the range coordinate system (ft./sec.)
RXY	tangent plane range; $RXY = (XL^2 + YL^2)^{\frac{1}{2}}$ (ft.)
GAM-L	path angle of the earth-relative velocity vector with respect to the launch site tangent plane (deg.)
VEL-L	velocity with respect to the launch site (ft./sec.)

Page F Instantaneous Impact Points (IIP)

Definition: The instantaneous impact point (IIP) is the intersection of the two-body path, defined by the position and velocity on the boost trajectory, with the spheroidal earth model. The vehicle would follow the two-body path in the absence of aerodynamic, propulsive, and oblate earth gravity forces.

TIME-I	time of IIP from problem start time (sec.)
LAT-I	geodetic latitude of IIP (deg.)
LONG-I	Greenwich longitude of IIP, measured positive eastward (deg.)
RANGE	great circle range over the spheroidal earth to the IIP (n. m.)
XL-I YL-I ZL-I	coordinates of the IIP in the range coordinate system. See Page E for definition of the range coordinate system (ft.)

STRATOLER-ROCKS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

PAGE 2A

INITIAL VALUES OF GEOCENTRIC EULER ANGLES AND PAYLOAD

PHI = 0. THETA = 80.000 PSI = 100.000 PAYLOAD = 12.00

TIME SEC	WEIGHT LBS	THRUST LBS	I-VEL FT/SEC	GC RAD (- FT OR N MI -)	ALT	RANGE N MI	MACH	DYN. P LBS/FT2	GD LAT DEG	GC LAT DEG	LONG DEG	THETA-SIG DEG
.10	170.		1232.30	20899499.	17.	0.00	0.11	16.5405	37.8380	37.6517	-75.4829	80.000
0.50	165.		1318.57	20899571.	90.	0.01	0.32	153.9884	37.8380	37.6517	-75.4829	79.931
1.00	156.		1539.48	20899847.	366.	0.01	0.68	684.6385	37.8379	37.6517	-75.4827	79.416
1.50	147.		1860.95	20900331.	849.	0.03	1.09	1705.8380	37.8379	37.6516	-75.4824	79.300
2.00	139.		2144.91	20901025.	1543.	0.05	1.41	2778.6436	37.8378	37.6516	-75.4819	79.173
2.40	131.		2167.24	20901650.	2168.	0.07	1.43	2816.3219	37.8377	37.6515	-75.4815	79.083
2.[illegible]	81.	0.	2167.24	20901650.	2168.	0.07	1.43	2816.3219	37.8377	37.6515	-75.4815	79.083
2.50	81.	0.	2159.58	20901805.	2323.	0.08	1.43	2769.7761	37.8377	37.6515	-75.4814	79.061
3.00	81.	0.	2122.63	20902569.	3087.	0.10	1.39	2550.9306	37.8376	37.6514	-75.4809	78.952
3.50	81.	0.	2087.79	20903311.	3829.	0.12	1.35	2353.1577	37.8376	37.6513	-75.4804	78.835
4.00	81.	0.	2054.87	20904031.	4549.	0.15	1.32	2173.9426	37.8375	37.6513	-75.4799	78.715
4.50	81.	0.	2023.73	20904730.	5248.	0.17	1.28	2011.1490	37.8374	37.6512	-75.4794	78.590
5.00	81.	0.	1994.23	20905410.	5928.	0.19	1.25	1862.9007	37.8373	37.6511	-75.4789	78.460
5.[illegible]	81.	-30.	1994.23	20905410.	5928.	0.19	1.25	1862.9007	37.8373	37.6511	-75.4789	78.460
5.50	80.	250.	1999.27	20906080.	6597.	0.22	1.26	1835.7736	37.8373	37.6511	-75.4785	78.325
6.00	79.	262.	2013.39	20906755.	7272.	0.24	1.27	1838.1033	37.8372	37.6510	-75.4780	78.192
6.50	79.	258.	2028.52	20907438.	7955.	0.26	1.29	1842.4784	37.8371	37.6509	-75.4775	78.058
7.00	78.	296.	2046.79	20908128.	8646.	0.29	1.31	1855.5350	37.8370	37.6509	-75.4770	77.923
7.50	77.	317.	2070.56	20908831.	9348.	0.31	1.34	1884.2087	37.8370	37.6508	-75.4765	77.792
8.00	76.	327.	2097.12	20909547.	10064.	0.34	1.37	1919.3682	37.8369	37.6507	-75.4760	77.66[illegible]
8.50	75.	333.	2125.79	20910277.	10795.	0.36	1.41	1958.5302	37.8368	37.6506	-75.4755	77.53[illegible]
9.00	75.	343.	2156.67	20911024.	11541.	0.39	1.44	2001.7899	37.8367	37.6506	-75.4749	77.402
9.50	74.	354.	2189.09	20911788.	12305.	0.42	1.48	2046.7027	37.8366	37.6505	-75.4743	77.275
10.00	73.	354.	2222.37	20912569.	13086.	0.45	1.52	2091.0442	37.8365	37.6504	-75.4737	77.150
10.50	73.	357.	2256.58	20913369.	13885.	0.48	1.56	2134.7913	37.8364	37.6503	-75.4731	77.027
11.00	72.	361.	2291.81	20914186.	14703.	0.51	1.60	2178.0319	37.8363	37.6502	-75.4724	76.905
11.50	71.	363.	2328.00	20915023.	15539.	0.54	1.65	2220.4141	37.8362	37.6501	-75.4718	76.785
12.00	71.	365.	2365.10	20915879.	16395.	0.58	1.69	2261.5558	37.8361	37.6500	-75.4711	76.668
12.50	70.	370.	2403.45	20916754.	17271.	0.61	1.74	2302.1953	37.8360	37.6499	-75.4704	76.551
13.00	69.	375.	2443.41	20917650.	18166.	0.64	1.79	2343.1405	37.8359	37.6498	-75.4697	76.437
13.50	68.	379.	2484.82	20918568.	19084.	0.68	1.84	2383.6050	37.8358	37.6497	-75.4689	76.324
14.00	68.	382.	2527.55	20919507.	20023.	0.72	1.89	2422.9118	37.8357	37.6496	-75.4681	76.213
14.50	67.	340.	2571.17	20920468.	20984.	0.76	1.94	2459.6516	37.8355	37.6495	-75.4673	76.[illegible]
15.00	66.	377.	2615.27	20921452.	21967.	0.80	1.99	2492.4223	37.8354	37.6493	-75.4665	75.997
15.50	66.	379.	2660.03	20922459.	22974.	0.84	2.05	2521.5616	37.8353	37.6492	-75.4656	75.892
16.00	65.	379.	2705.64	20923488.	24004.	0.88	2.11	2547.4040	37.8351	37.6491	-75.4648	75.788
16.50	64.	379.	2752.15	20924542.	25057.	0.93	2.16	2569.8705	37.8350	37.6490	-75.4639	75.685
17.00	63.	379.	2799.63	20925619.	26134.	0.97	2.22	2588.9084	37.8348	37.6488	-75.4629	75.583
17.50	63.	379.	2846.14	20926720.	27235.	1.02	2.28	2604.4877	37.8347	37.6487	-75.4620	75.482
18.00	62.	379.	2897.76	20927846.	28361.	1.06	2.35	2616.5829	37.8345	37.6485	-75.4610	75.383
18.50	61.	379.	2948.56	20928997.	29512.	1.11	2.41	2625.1217	37.8344	37.6484	-75.4600	75.290
19.00	61.	379.	3000.62	20930175.	30689.	1.16	2.48	2630.0074	37.8342	37.6482	-75.4589	75.[illegible]
19.50	60.	379.	3054.01	20931378.	31892.	1.22	2.55	2631.2653	37.8340	37.6481	-75.4578	75.[illegible]
20.00	59.	379.	3108.82	20932609.	33123.	1.27	2.62	2628.7762	37.8339	37.6479	-75.4567	75.[illegible]
20.50	59.	379.	3164.93	20933867.	34380.	1.33	2.70	2622.1340	37.8337	37.6477	-75.4556	74.927

SIDE-INDEP-ARCAS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

P-I, THETA, PSI, I-GAM, R-GAM, I-ZETA, R-ZETA ARE GEOCENTRIC REFERENCED

TIME SEC	ALPHA DEG	Q-ALPHA LB/SQ FT	BETA DEG	I-GAM DEG	R-GAM DEG	I-ZETA DEG	R-ZETA DEG	PHI DEG	PSI DEG	THETA DEG	Q-INTG DEG	Q-COMM DEG/SEC	PITCH ERR DEG
0.19	-0.00	-0.	0.00	5.411	80.000	90.166	100.000	0.000	100.000	80.000	0.	0.	0.
0.50	0.21	32.	0.00	15.602	79.725	90.505	100.031	0.237	100.009	79.932	-0.069	0.	0.
1.00	-0.04	-25.	-0.00	29.162	79.456	91.040	100.063	3.147	100.067	79.419	-0.583	0.	0.
1.50	0.31	25.	0.00	39.828	79.291	91.583	100.085	8.669	100.084	79.305	-0.698	0.	0.
2.00	0.00	9.	0.00	45.745	79.174	91.973	100.102	5.441	100.102	79.177	-0.826	0.	0.
2.40	0.00	3.	0.00	46.062	79.091	92.013	100.114	-0.636	100.114	79.092	-0.913	0.	0.
2.40	0.00	3.	0.00	46.062	79.091	92.013	100.114	-0.636	100.114	79.092	-0.913	0.	0.
2.50	0.00	0.	0.00	45.911	79.070	92.007	100.117	30.999	100.117	79.070	-0.935	0.	0.
3.00	-0.00	-1.	-0.00	45.159	78.961	91.978	100.133	-110.202	100.133	78.961	-0.921	0.	0.
3.50	-0.00	-1.	-0.00	44.415	78.847	91.951	100.149	-118.776	100.149	78.848	-0.921	0.	0.
4.00	-0.00	-1.	-0.00	43.679	78.729	91.925	100.165	-134.245	100.164	78.730	-0.922	0.	0.
4.50	-0.00	-2.	-0.00	42.950	78.606	91.900	100.181	-167.567	100.180	78.607	-0.927	0.	0.
5.00	-0.00	-1.	0.00	42.228	78.478	91.877	100.197	140.938	100.197	78.479	-0.937	0.	0.
5.00	-0.00	-1.	0.00	42.228	78.478	91.877	100.197	140.938	100.197	78.479	-0.937	0.	0.
5.50	0.00	0.	0.00	42.223	78.346	91.902	100.213	75.044	100.213	78.347	-0.941	0.	0.
6.00	0.00	2.	0.00	42.404	78.214	91.939	100.229	8.733	100.229	78.215	-0.932	0.	0.
6.50	0.00	1.	-0.00	42.602	78.083	91.978	100.245	-51.604	100.245	78.084	-0.921	0.	0.
7.00	-0.00	-0.	-0.00	42.855	77.951	92.021	100.260	-104.461	100.260	77.952	-0.919	0.	0.
7.50	-0.00	-1.	-0.00	43.207	77.821	92.072	100.276	-147.792	100.275	77.822	-0.924	0.	0.
8.00	-0.00	-2.	-0.00	43.598	77.691	92.127	100.291	-179.001	100.290	77.692	-0.930	0.	0.
8.50	-0.00	-1.	0.00	44.012	77.563	92.184	100.305	163.544	100.305	77.564	-0.933	0.	0.
9.00	-0.00	-1.	0.00	44.449	77.437	92.244	100.319	161.176	100.319	77.438	-0.933	0.	0.
9.50	-0.00	-1.	-0.00	44.893	77.312	92.306	100.333	175.222	100.333	77.313	-0.931	0.	0.
10.00	-0.00	-1.	-0.00	45.333	77.189	92.368	100.347	-153.526	100.347	77.190	-0.926	0.	0.
10.50	-0.00	-0.	-0.00	45.769	77.068	92.431	100.361	-104.613	100.360	77.069	-0.921	0.	0.
11.00	0.00	1.	-0.00	46.203	76.949	92.495	100.374	-37.624	100.374	76.950	-0.925	0.	0.
11.50	0.00	1.	0.00	46.631	76.831	92.559	100.387	47.896	100.387	76.832	-0.937	0.	0.
12.00	-0.00	-1.	0.00	47.055	76.716	92.625	100.399	152.364	100.399	76.716	-0.934	0.	0.
12.50	0.00	0.	-0.00	47.478	76.602	92.691	100.412	-83.796	100.412	76.602	-0.923	0.	0.
13.00	0.00	1.	0.00	47.903	76.489	92.758	100.424	60.003	100.424	76.490	-0.937	0.	0.
13.50	-0.00	-1.	-0.00	48.328	76.379	92.827	100.436	-135.531	100.436	76.379	-0.926	0.	0.
14.00	0.00	1.	0.00	48.750	76.270	92.896	100.448	50.294	100.448	76.271	-0.936	0.	0.
14.50	-0.00	-0.	-0.00	49.164	76.164	92.965	100.459	-101.951	100.459	76.164	-0.924	0.	0.
15.00	-0.00	-1.	0.00	49.565	76.059	93.035	100.471	128.096	100.471	76.059	-0.936	0.	0.
15.50	0.00	2.	0.00	49.956	75.956	93.104	100.482	20.603	100.483	75.956	-0.934	0.	0.
16.00	0.00	1.	-0.00	50.339	75.854	93.174	100.493	-64.300	100.493	75.855	-0.928	0.	0.
16.50	-0.00	-1.	-0.00	50.714	75.754	93.243	100.504	-126.336	100.504	75.755	-0.930	0.	0.
17.00	-0.00	-1.	-0.00	51.082	75.656	93.313	100.515	-165.172	100.515	75.657	-0.934	0.	0.
17.50	-0.00	-1.	-0.00	51.444	75.560	93.383	100.525	179.567	100.525	75.560	-0.935	0.	0.
18.00	-0.00	-1.	-0.00	51.800	75.465	93.454	100.536	-171.715	100.536	75.465	-0.935	0.	0.
18.50	-0.00	-1.	-0.00	52.150	75.372	93.525	100.546	-138.589	100.546	75.372	-0.932	0.	0.
19.00	0.00	0.	-0.00	52.496	75.280	93.596	100.556	-80.585	100.556	75.281	-0.931	0.	0.
19.50	0.00	1.	0.00	52.837	75.190	93.667	100.566	2.760	100.566	75.191	-0.935	0.	0.
20.00	-0.00	-0.	0.00	53.175	75.102	93.739	100.576	112.009	100.576	75.102	-0.939	0.	0.
20.50	-0.00	-0.	-0.00	53.507	75.015	93.811	100.586	-112.318	100.586	75.016	-0.931	0.	0.

SIDEWINDER-ARCAS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSC
ROUTINE NO. LVVC27
PROBLEM NO. 1

TIME	ANGULAR VELOCITIES P	Q	R	AERO FORCES A	Y	N	LOAD FACTORS NX	NY	NZ	VELOCITIES AIR REL	REL	WIND VEL	DIR	ACC INTG NX-INTG
SEC	(DEG/SEC)			(LBS)						(FT/SEC)		FT/SEC	DEG	FT/SEC
0.19	0.	0.	0.	1.79	0.0	-0.0		-0.00	0.00	118.	118.0	0.	0.	0.
0.5	1.99	-0.73	0.02	16.79	0.1	2.8		-0.00	-0.02	360.	360.4	0.	0.	252.3
1.00	9.63	.19	-0.21	79.07	-0.2	-2.3		0.00	0.01	763.	763.1	0.	0.	670.7
1.50	8.11	-0.79	0.02	236.73	0.4	2.4		-0.00	-0.02	1213.	1213.0	0.	0.	1136.5
2.00	-14.22	-0.16	0.02	383.77	0.1	0.9		-0.00	-0.01	1564.	1564.1	0.	0.	1503.4
2.40	-14.85	-0.19	0.00	388.25	0.0	0.4		-0.00	-0.00	1589.	1589.3	0.	0.	1541.2
2.50	-14.85	-0.19	0.00	161.67	0.0	0.1	-2.00	-0.00	-0.00	1589.	1589.3	0.	0.	1541.2
2.50	593.82	-0.19	0.12	159.29	0.0	0.0	-1.97	-0.00	-0.00	1580.	1579.8	0.	0.	1534.8
3.00	1396.13	0.08	-0.22	148.02	-0.1	-0.0	-1.83	0.00	0.00	1533.	1533.5	0.	0.	1504.3
3.50	1424.42	0.11	-0.21	137.78	-0.1	-0.0	-1.70	0.00	0.00	1489.	1489.3	0.	0.	1475.8
4.00	1391.79	.17	-0.18	128.38	-0.0	-0.0	-1.59	0.00	0.00	1447.	1447.0	0.	0.	1449.4
4.50	1355.85	0.25	-0.16	119.73	-0.0	-0.1	-1.48	0.00	0.00	1407.	1406.6	0.	0.	1424.7
5.00	1319.23	0.21	0.16	111.77	0.0	-0.1	-1.38	-0.00	0.00	1368.	1367.9	0.	0.	1401.7
5.50	1324.25	-0.26	0.25	103.26	0.1	0.0	1.83	-0.00	-0.00	1372.	1371.8	0.	0.	1421.4
6.00	1312.49	-0.26	0.25	102.99	0.0	0.1	2.01	-0.00	-0.00	1387.	1387.0	0.	0.	1452.3
6.50	1326.52	-0.17	-0.21	102.81	-0.0	0.0	1.98	0.00	-0.00	1403.	1403.3	0.	0.	1484.4
7.00	1342.87	0.06	-0.26	103.03	-0.1	-0.0	2.48	0.00	0.00	1423.	1423.5	0.	0.	1520.2
7.50	1364.77	0.22	-0.15	103.94	-0.0	-0.0	2.77	0.00	0.00	1450.	1450.2	0.	0.	1562.6
8.00	1390.95	0.26	-0.01	105.12	-0.0	-0.1	2.91	0.00	0.00	1480.	1480.2	0.	0.	1608.3
8.50	1419.71	0.25	0.07	106.43	0.0	-0.1	3.06	-0.00	0.00	1513.	1512.5	0.	0.	1656.3
9.00	1451.35	0.24	0.08	107.91	0.0	-0.1	3.21	-0.00	0.00	1547.	1547.3	0.	0.	1705.8
9.50	1485.[illegible]	0.25	0.02	109.40	-0.0	-0.1	3.26	0.00	0.00	1584.	1583.7	0.	0.	1758.8
10.00	1520.[illegible]	.22	-0.12	110.79	-0.0	-0.0	3.31	0.00	0.00	1621.	1620.9	0.	0.	1811.7
10.50	1555.31	0.06	-0.24	112.07	-0.0	-0.0	3.37	0.00	0.00	1659.	1659.0	0.	0.	1865.4
11.00	1592.42	-0.19	-0.14	113.25	-0.0	0.0	3.43	0.00	-0.00	1698.	1698.1	0.	0.	1920.2
11.50	1629.92	-0.16	0.18	114.31	0.0	0.0	3.48	-0.00	-0.00	1738.	1738.0	0.	0.	1975.8
12.00	1666.22	0.21	0.11	115.23	0.0	-0.0	3.54	-0.00	0.00	1779.	1778.9	0.	0.	2032.2
12.50	1707.48	-0.03	-0.23	116.04	-0.0	0.0	3.64	0.00	-0.00	1821.	1820.9	0.	0.	2089.9
13.00	1748.11	-0.11	0.20	116.76	0.0	0.0	3.74	-0.00	-0.00	1865.	1864.6	0.	0.	2149.2
13.50	1790.18	0.16	-0.16	117.35	-0.0	-0.0	3.81	0.00	0.00	1910.	1909.8	0.	0.	2209.9
14.00	1833.49	-0.14	0.17	117.79	0.0	0.0	3.90	-0.00	-0.00	1956.	1956.2	0.	0.	2272.0
14.50	1877.52	0.04	-0.21	118.02	-0.0	-0.0	3.91	0.00	0.00	2003.	2003.4	0.	0.	2334.8
15.00	1922.60	0.03	0.17	117.98	0.0	-0.0	3.94	-0.00	0.00	2051.	2051.0	0.	0.	2397.9
15.50	1967.62	-0.20	0.08	117.95	0.0	0.0	3.98	-0.00	-0.00	2099.	2099.1	0.	0.	2461.6
16.00	2013.05	-0.10	-0.18	117.72	-0.0	0.0	4.03	0.00	-0.00	2148.	2148.0	0.	0.	2526.0
16.50	2059.11	0.12	-0.17	117.28	-0.0	-0.0	4.08	0.00	0.00	2198.	2197.7	0.	0.	2591.3
17.00	2105.23	0.19	-0.06	116.61	-0.0	-0.0	4.14	0.00	0.00	2248.	2248.3	0.	0.	2657.4
17.50	2153.42	0.00	-0.00	115.72	-0.0	-0.0	4.20	0.00	0.00	2300.	2299.9	0.	0.	2724.5
18.00	2201.91	0.19	-0.03	114.60	-0.0	-0.0	4.27	0.00	0.00	2353.	2352.5	0.	0.	2792.7
18.50	2251.09	0.14	-0.13	113.27	-0.0	-0.0	4.34	0.00	0.00	2406.	2406.2	0.	0.	2861.9
19.00	2301.32	-0.03	-0.19	111.71	-0.0	0.0	4.42	0.00	-0.00	2461.	2461.2	0.	0.	2932.4
19.50	2352.56	-0.18	0.01	109.93	0.0	0.0	4.50	-0.00	-0.00	2517.	2517.4	0.	0.	3004.1
20.00	2404.37	0.07	0.17	107.93	0.0	-0.0	4.59	-0.00	0.00	2575.	2575.1	0.	0.	3077.2
20.50	2456.24	0.14	-0.17	105.70	-0.0	-0.0	4.66	0.00	0.00	2634.	2633.9	0.	0.	3151.6

SIDEWINDER-ARCAS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH — LTV AEROSPACE CORP.-MSD — PAGE 10
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD — ROUTINE NO. LVVC27
PROBLEM NO. 1

TIME SEC	HX-DOT (FT LBS)	HY-DOT (FT LBS)	HZ-DOT (FT LBS)	P-CONT (DEG OR LBS)	Q-CONT (DEG OR LBS)	R-CONT (DEG OR LBS)	NERR	STEPS GOOD	STEPS BAD	VELOCITY LOSSES IN FT/SEC AERO	GRAVITY	PRESSURE	ALPHA	IDEAL VELOCITY
0.10	0.0	0.0	0.0	0.	0.	0.	0	0	0	0.	0.	0.	0.	0.
0.50	0.1	-7.1	0.2	0.	0.	0.	22	11	4	0.5	9.8	6.7	0.0	259.4
1.00	0.1	6.4	-0.5	0.	0.	0.	22	34	7	4.9	25.7	17.9	0.0	693.5
1.50	-0.2	-7.4	1.3	0.	0.	0.	22	73	16	20.5	41.4	29.6	0.0	1186.5
2.00	0.0	-2.2	0.2	0.	0.	0.	21	125	30	56.7	57.2	41.8	0.0	1601.8
2.40	-0.0	-0.1	-0.1	0.	0.	0.	22	152	34	94.4	69.9	51.8	0.0	1687.4
2.40	7.7	-0.1	-0.0	0.	0.	0.	22	152	34	94.4	69.9	51.8	0.0	1687.4
2.50	4.5	0.3	0.2	0.	0.	0.	22	175	40	100.8	73.0	51.8	0.0	1687.4
3.00	0.3	-0.8	-0.3	0.	0.	0.	21	245	50	131.3	88.8	51.8	0.0	1687.4
3.50	-0.0	-0.3	-0.4	0.	0.	0.	23	294	52	159.7	104.6	51.8	0.0	1687.4
4.00	-0.1	-0.7	-0.6	0.	0.	0.	23	342	55	186.2	120.3	51.8	0.0	1687.4
4.50	-0.1	-0.2	-0.9	0.	0.	0.	23	388	55	210.9	136.1	51.8	0.0	1687.4
5.00	-0.1	0.6	-0.7	0.	0.	0.	23	435	57	233.9	151.8	51.8	0.0	1687.4
5.00	-0.1	0.6	-0.7	0.	0.	0.	23	435	57	233.9	151.8	51.8	0.0	1687.4
5.50	-0.0	0.9	0.2	0.	0.	0.	23	484	62	254.7	167.6	57.8	0.0	1733.8
6.00	0.0	0.2	0.9	0.	0.	0.	22	531	65	275.5	183.3	63.6	0.0	1791.4
6.50	0.0	-0.7	0.6	0.	0.	0.	22	579	68	296.5	199.0	69.4	0.0	1850.2
7.00	0.0	-0.9	-0.2	0.	0.	0.	23	626	69	317.6	214.7	75.1	0.0	1912.9
7.50	0.0	-0.5	-0.7	0.	0.	0.	21	675	73	339.1	230.4	80.6	0.0	1982.4
8.00	0.0	-0.0	-0.9	0.	0.	0.	23	723	76	361.0	246.1	86.1	0.0	2055.4
8.50	0.0	0.2	-0.8	0.	0.	0.	22	772	78	383.4	261.8	91.5	0.0	2131.2
9.00	0.1	0.3	-0.8	0.	0.	0.	22	822	80	406.3	277.5	96.7	0.0	2209.8
9.50	0.0	-0.1	-0.9	0.	0.	0.	22	873	83	429.8	293.1	101.9	0.0	2290.5
10.00	0.0	-0.4	-0.7	0.	0.	0.	21	925	84	453.7	308.8	106.9	0.0	2372.4
10.50	0.0	-0.3	-0.2	0.	0.	0.	21	981	86	478.2	324.4	111.9	0.0	2455.6
11.00	0.0	-0.5	0.7	0.	0.	0.	22	1033	87	503.3	340.1	116.7	0.0	2540.1
11.50	0.1	0.5	0.6	0.	0.	0.	23	1088	91	528.8	355.7	121.4	0.0	2626.0
12.00	0.1	0.4	-0.8	0.	0.	0.	23	1143	92	554.8	371.3	126.0	0.0	2713.1
12.50	0.1	-0.5	0.1	0.	0.	0.	23	1199	93	581.3	387.0	130.5	0.0	2801.7
13.00	0.1	0.7	0.4	0.	0.	0.	23	1256	94	608.2	402.6	134.9	0.0	2892.3
13.50	0.1	-0.6	-0.6	0.	0.	0.	21	1314	95	635.6	418.2	139.2	0.0	2984.7
14.00	0.1	0.5	0.5	0.	0.	0.	22	1373	97	663.3	433.7	143.3	0.0	3078.6
14.50	0.1	-0.5	-0.2	0.	0.	0.	22	1434	102	691.5	449.3	147.4	0.0	3173.6
15.00	0.1	0.5	-0.5	0.	0.	0.	21	1496	103	719.9	464.9	151.3	0.0	3269.1
15.50	0.1	0.3	0.8	0.	0.	0.	22	1562	106	748.7	480.5	155.1	0.0	3365.4
16.00	0.1	-0.7	0.4	0.	0.	0.	23	1626	106	777.8	496.0	158.7	0.0	3462.5
16.50	0.1	-0.7	-0.5	0.	0.	0.	23	1692	108	807.0	511.6	162.3	0.0	3560.6
17.00	0.1	-0.2	-0.8	0.	0.	0.	22	1758	108	836.5	527.1	165.7	0.0	3659.6
17.50	0.1	-0.1	-0.8	0.	0.	0.	22	1825	110	866.2	542.6	169.0	0.0	3759.7
18.00	0.1	-0.1	-0.8	0.	0.	0.	22	1893	110	895.9	558.1	172.2	0.0	3860.7
18.50	0.1	-0.6	-0.6	0.	0.	0.	22	1962	110	925.6	573.7	175.2	0.0	3962.7
19.00	0.1	-0.8	0.2	0.	0.	0.	23	2033	110	955.3	589.2	178.1	0.0	4065.8
19.50	0.1	0.1	0.8	0.	0.	0.	22	2104	111	984.9	604.7	181.0	0.0	4169.9
20.00	0.1	0.8	-0.3	0.	0.	0.	23	2177	111	1014.3	620.1	183.6	0.0	4275.2
20.50	0.1	-0.8	-0.3	0.	0.	0.	23	2252	112	1043.6	635.6	186.2	0.0	4381.4

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SIDEWINDER-ARCAS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSC
ROUTINE NO. LVVC27
PROBLEM NO. 1

PAGE 1E

RANGE COORDINATES AND VELOCITIES

TIME SEC	XL (FT)	YL (FT)	ZL (FT)	XL-DOT (FT/SEC)	YL-DOT (FT/SEC)	ZL-DOT (FT/SEC)	RXY FT	GAM-L DEG	VEL-L FT/SEC	R-DOT FT/SEC
0.19	26.0	-5.5	9.7	20.56	-0.37	116.20	27.	79.966	118.0	58.8
0.50	39.1	-5.4	82.4	64.49	-1.17	354.61	39.	79.691	360.4	347.4
1.00	89.8	-6.7	357.9	140.05	-2.56	750.09	90.	79.422	763.1	761.5
1.50	180.9	-8.4	841.3	226.10	-4.15	1191.78	181.	79.256	1213.0	1212.7
2.00	313.3	-10.9	1535.1	294.67	-5.44	1536.10	313.	79.139	1564.1	1564.0
2.40	433.8	-13.1	2160.5	301.70	-5.59	1560.43	434.	79.055	1589.3	1589.3
2.40	433.8	-13.1	2160.5	301.70	-5.59	1560.43	434.	79.055	1589.3	1589.3
2.50	463.8	-13.5	2315.9	300.47	-5.57	1550.95	464.	79.034	1579.8	1579.8
3.00	612.4	-16.5	3079.9	294.53	-5.49	1504.91	613.	78.925	1533.5	1533.5
3.50	758.5	-19.2	3821.2	288.95	-5.42	1460.97	759.	78.811	1489.3	1489.3
4.00	901.7	-21.8	4541.0	283.69	-5.35	1418.96	902.	78.692	1447.0	1447.0
4.50	1042.2	-24.5	5240.5	278.73	-5.28	1378.72	1042.	78.569	1406.6	1406.6
5.00	1180.3	-27.1	5920.1	274.06	-5.22	1340.11	1181.	76.440	1367.9	1367.8
5.00	1180.3	-27.1	5920.1	274.06	-5.22	1340.11	1181.	78.440	1367.9	1367.8
5.50	1317.9	-29.7	6589.5	277.94	-5.32	1343.35	1318.	78.308	1371.8	1371.8
6.00	1458.4	-32.4	7264.6	284.15	-5.47	1357.56	1459.	76.176	1387.0	1386.9
6.50	1602.3	-35.2	7947.3	290.67	-5.62	1372.90	1603.	78.044	1403.3	1403.3
7.00	1749.4	-38.0	8638.1	298.04	-5.79	1391.91	1750.	77.912	1423.5	1423.4
7.50	1900.5	-41.0	9340.3	306.88	-5.99	1417.36	1901.	77.781	1450.2	1450.1
8.00	2056.3	-44.1	10056.0	316.50	-6.21	1445.94	2057.	77.651	1480.2	1480.0
8.50	2217.0	-47.2	10786.6	326.72	-6.44	1476.79	2218.	77.523	1512.5	1512.3
9.00	2383.3	-50.4	11533.1	337.58	-6.68	1510.01	2384.	77.396	1547.3	1547.1
9.50	2554.9	-53.9	12296.8	348.89	-6.94	1544.78	2555.	77.271	1583.7	1583.5
10.00	2732.2	-57.5	13078.1	360.49	-7.20	1580.30	2733.	77.147	1620.9	1620.6
10.50	2915.3	-61.0	13877.3	372.40	-7.47	1616.65	2916.	77.026	1659.0	1658.7
11.00	3104.5	-64.9	14695.0	384.63	-7.76	1653.92	3105.	76.906	1698.1	1697.7
11.50	3299.9	-68.8	15531.4	397.17	-8.04	1692.04	3301.	76.788	1738.0	1737.7
12.00	3501.9	-72.9	16387.0	410.02	-8.34	1730.96	3503.	76.671	1778.9	1778.4
12.50	3710.1	-77.2	17262.5	423.25	-8.65	1771.04	3711.	76.557	1820.9	1820.5
13.00	3925.2	-81.6	18158.3	436.98	-8.97	1812.68	3926.	76.444	1864.6	1864.1
13.50	4147.1	-86.1	19075.5	451.16	-9.30	1855.70	4148.	76.333	1909.8	1909.2
14.00	4376.2	-90.9	20014.3	465.74	-9.64	1899.93	4377.	76.223	1955.2	1955.6
14.50	4612.8	-95.9	20975.5	480.63	-9.99	1944.91	4614.	76.116	2003.4	2002.8
15.00	4857.1	-100.8	21959.1	495.71	-10.35	1990.18	4858.	76.010	2051.0	2050.3
15.50	5108.7	-106.1	22965.7	511.04	-10.71	2035.95	5110.	75.907	2099.1	2098.4
16.00	5368.1	-111.6	23995.3	526.65	-11.09	2082.42	5369.	75.804	2148.0	2147.2
16.50	5635.3	-117.3	25048.3	542.57	-11.47	2129.66	5637.	75.704	2197.7	2196.8
17.00	5910.6	-123.1	26125.1	558.82	-11.86	2177.73	5912.	75.605	2248.3	2247.4
17.50	6194.1	-129.2	27226.2	575.41	-12.26	2226.71	6195.	75.508	2299.9	2298.9
18.00	6486.2	-135.3	28352.0	592.37	-12.68	2276.67	6488.	75.412	2352.5	2351.5
18.50	6786.7	-141.7	29503.0	609.72	-13.10	2327.68	6788.	75.318	2406.2	2405.2
19.00	7096.0	-148.4	30679.8	627.48	-13.54	2379.83	7098.	75.226	2461.2	2460.1
19.50	7414.2	-155.3	31883.0	645.68	-13.98	2433.19	7416.	75.135	2517.4	2516.2
20.00	7741.7	-162.4	33113.2	664.33	-14.45	2487.85	7743.	75.046	2575.1	2573.9
20.50	8078.8	-169.7	34371.0	683.41	-14.92	2543.69	8081.	74.958	2633.9	2632.6

SIDEWINDER-ARCAS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

INSTANTANEOUS IMPACT POINTS

TIME SEC	TIME-I SEC	LAT-I DEG	LONG-I DEG	RANGE N MI	XL-I (FT	YL-I	ZL-I)
0.19	7.6	37.8379	-75.4824	0.0	178.	-7.	-11.
0.50	22.8	37.8372	-75.4780	0.2	1473.	-22.	-10.
1.00	48.2	37.8346	-75.4603	1.1	6654.	-91.	-11.
1.50	76.5	37.8292	-75.4253	2.8	16964.	-258.	-17.
2.00	98.9	37.8231	-75.3862	4.7	28482.	-473.	-30.
2.40	101.2	37.8224	-75.3816	4.9	29838.	-502.	-31.
2.40	101.2	37.8224	-75.3816	4.9	29838.	-502.	-31.
2.50	100.5	37.8225	-75.3823	4.9	29606.	-497.	-31.
3.00	99.0	37.8231	-75.3861	4.7	28510.	-478.	-30.
3.50	97.2	37.8236	-75.3895	4.5	27511.	-461.	-28.
4.00	95.7	37.8241	-75.3926	4.4	26596.	-445.	-27.
4.50	94.2	37.8245	-75.3954	4.2	25759.	-431.	-27.
5.00	92.8	37.8249	-75.3980	4.1	24990.	-418.	-26.
5.00	92.8	37.8249	-75.3980	4.1	24990.	-418.	-26.
5.50	94.0	37.8246	-75.3958	4.2	25646.	-433.	-26.
6.00	95.8	37.8240	-75.3922	4.4	26694.	-456.	-27.
6.50	97.7	37.8234	-75.3885	4.6	27807.	-481.	-28.
7.00	99.7	37.8227	-75.3841	4.8	29080.	-509.	-30.
7.50	102.2	37.8219	-75.3789	5.0	30629.	-543.	-33.
8.00	104.8	37.8209	-75.3731	5.3	32347.	-581.	-35.
8.50	107.6	37.8199	-75.3667	5.6	34210.	-624.	-38.
9.00	110.5	37.8188	-75.3599	6.0	36231.	-670.	-41.
9.50	113.5	37.8177	-75.3526	6.4	38386.	-720.	-45.
10.00	116.5	37.8164	-75.3449	6.7	40646.	-773.	-50.
10.50	119.6	37.8151	-75.3368	7.1	43018.	-830.	-55.
11.00	122.7	37.8138	-75.3284	7.5	45512.	-890.	-60.
11.50	125.9	37.8123	-75.3195	8.0	48129.	-954.	-66.
12.00	129.1	37.8108	-75.3102	8.4	50870.	-1023.	-72.
12.50	132.4	37.8092	-75.3004	8.9	53760.	-1096.	-79.
13.00	135.8	37.8076	-75.2900	9.4	56825.	-1174.	-87.
13.50	139.2	37.8058	-75.2790	9.9	60066.	-1258.	-96.
14.00	142.8	37.8039	-75.2674	10.5	63480.	-1348.	-106.
14.50	146.4	37.8019	-75.2553	11.1	67047.	-1443.	-118.
15.00	150.0	37.7998	-75.2428	11.7	70744.	-1543.	-130.
15.50	153.6	37.7977	-75.2298	12.3	74587.	-1649.	-143.
16.00	157.3	37.7954	-75.2162	13.0	78593.	-1760.	-158.
16.50	161.1	37.7931	-75.2020	13.7	82770.	-1878.	-174.
17.00	164.9	37.7906	-75.1873	14.4	87129.	-2003.	-192.
17.50	168.7	37.7881	-75.1718	15.1	91681.	-2135.	-211.
18.00	172.6	37.7854	-75.1557	15.9	96437.	-2275.	-233.
18.50	176.5	37.7826	-75.1389	16.7	101411.	-2423.	-255.
19.00	180.7	37.7796	-75.1213	17.6	106616.	-2580.	-282.
19.50	184.8	37.7765	-75.1028	18.5	112066.	-2747.	-310.
20.00	189.0	37.7732	-75.0835	19.4	117778.	-2924.	-342.
20.50	193.3	37.7698	-75.0632	20.4	123751.	-3111.	-376.

SIDEWINDER-A-CAS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

TIME SEC	WEIGHT LBS	THRUST LBS	I-VEL FT/SEC	GC RAD (- FT OR N MI -)	ALT	RANGE N MI	MACH	DYN. P LBS/FT2	GD LAT DEG	GC LAT DEG	LONG DEG	THETA-SIG DEG
21.00	58.	374.	3222.23	20935153.	35667.	1.38	2.78	2610.7503	37.8335	37.6476	-75.4544	74.839
21.50	57.	374.	3280.83	20936468.	36981.	1.44	2.85	2575.6234	37.8333	37.6474	-75.4532	74.753
22.00	56.	373.	3340.95	20937813.	38326.	1.50	2.91	2526.2644	37.8331	37.6472	-75.4520	74.666
22.50	56.	371.	3402.67	20939187.	39700.	1.56	2.98	2474.4992	37.8329	37.6470	-75.4507	74.583
23.00	55.	369.	3465.99	20940593.	41105.	1.63	3.05	2420.4181	37.8327	37.6468	-75.4494	74.502
23.50	54.	367.	3530.85	20942030.	42542.	1.69	3.11	2363.9722	37.8325	37.6466	-75.4480	74.422
24.00	53.	365.	3597.31	20943499.	44011.	1.76	3.19	2305.3137	37.8323	37.6464	-75.4466	74.343
24.50	53.	364.	3665.41	20945002.	45513.	1.83	3.26	2244.5688	37.8320	37.6462	-75.4452	74.265
25.00	52.	362.	3735.18	20946538.	47049.	1.90	3.33	2182.0308	37.8318	37.6460	-75.4438	74.190
25.50	51.	359.	3806.57	20948108.	48620.	1.97	3.41	2117.6045	37.8316	37.6457	-75.4423	74.115
26.00	51.	357.	3879.49	20949715.	50226.	2.05	3.49	2051.3655	37.8313	37.6455	-75.4407	74.041
26.50	50.	354.	3953.97	20951356.	51867.	2.12	3.57	1983.6252	37.8311	37.6453	-75.4391	73.970
27.00	49.	351.	4030.05	20953035.	53546.	2.20	3.65	1914.5492	37.8308	37.6450	-75.4375	73.899
27.50	49.	351.	4108.17	20954751.	55262.	2.28	3.73	1844.8288	37.8305	37.6448	-75.4358	73.830
28.00	48.	351.	4188.76	20956506.	57016.	2.37	3.82	1775.0423	37.8303	37.6445	-75.4341	73.762
28.50	47.	351.	4271.90	20958301.	58810.	2.45	3.90	1705.2225	37.8300	37.6443	-75.4324	73.695
29.00	46.	35 .	4357.62	20960136.	60645.	2.54	3.99	1635.4810	37.8297	37.6440	-75.4305	73.630
29.50	45.	352.	4445.95	20962014.	62523.	2.63	4.09	1565.8784	37.8294	37.6437	-75.4287	73.566
30.00	45.	350.	4536.87	20963935.	64443.	2.72	4.18	1496.5253	37.8291	37.6434	-75.4268	73.503
30.50	44.	350.	4630.45	20965901.	66409.	2.82	4.28	1426.3741	37.8288	37.6431	-75.4248	73.442
31.00	43.	349.	4726.77	20967912.	68420.	2.91	4.38	1354.4054	37.8285	37.6428	-75.4226	73.382
31.50	43.	349.	4825.80	20969971.	70479.	3.01	4.47	1283.6897	37.8281	37.6425	-75.4207	73.323
32.00	42.	349.	4927.50	20972079.	72586.	3.12	4.57	1214.3150	37.8278	37.6422	-75.4186	73.265
32.50	41.	332.	5029.10	20974235.	74742.	3.22	4.67	1144.9620	37.8274	37.6419	-75.4164	73.208
33.00	40.	278.	5120.38	20976439.	76945.	3.33	4.76	1071.4371	37.8271	37.6415	-75.4142	73.153
33.50	40.	197.	5188.23	20978681.	79187.	3.44	4.82	990.1453	37.8267	37.6412	-75.4119	73.098
34.00	39.	123.	5223.81	20980948.	81453.	3.55	4.85	901.2720	37.8264	37.6408	-75.4096	73.044
34.50	38.	51.	5231.79	20983224.	83729.	3.67	4.85	810.5381	37.8260	37.6405	-75.4073	72.990
35.00	38.	-1.	5219.72	20985497.	86002.	3.78	4.83	722.9930	37.8256	37.6401	-75.4049	72.936
35.00	38.	0.	5219.72	20985497.	86002.	3.78	4.83	722.9930	37.8256	37.6401	-75.4049	72.936
39.47	38.	0.	5030.00	21007522.	108023.	4.89	4.54	234.0975	37.8219	37.6366	-75.3320	72.936
50.00	38.	0.	4729.61	21049268.	149761.	7.12	3.93	30.9380	37.8146	37.6297	-75.3368	72.935
60.00	38.	0.	4459.07	21087655.	188139.	9.26	3.68	6.2658	37.8073	37.6228	-75.2924	72.935
70.00	38.	0.	4200.40	21122896.	223372.	11.39	3.64	1.4255	37.8001	37.6158	-75.2485	72.935
80.00	38.	0.	3951.85	21155011.	255478.	13.51	3.67	0.2999	37.7928	37.6088	-75.2049	72.935
90.00	38.	0.	3714.17	21184011.	284470.	15.61	3.43	0.0518	37.7855	37.6018	-75.1616	72.934
100.00	38.	0.	3488.99	21209904.	310354.	17.69	3.00	0.0096	37.7781	37.5947	-75.1185	72.934
110.00	38.	0.	3278.50	21232698.	333140.	19.79	2.55	0.0023	37.7708	37.5875	-75.0757	72.934
120.00	38.	0.	3085.42	21252399.	352833.	21.88	2.14	0.0007	37.7634	37.5803	-75.0330	72.934
130.00	38.	0.	2912.98	21269014.	369439.	23.93	1.77	0.0002	37.7559	37.5730	-74.9905	72.933
140.00	38.	0.	2764.81	21282547.	382963.	26.00	1.47	0.0001	37.7485	37.5657	-74.9481	72.933
150.00	38.	0.	2644.82	21293001.	393409.	28.06	1.25	0.0001	37.7410	37.5583	-74.9058	72.933
160.00	38.	0.	2556.83	21300381.	400779.	30.12	1.06	0.0000	37.7334	37.5508	-74.8637	72.933
170.00	38.	0.	2504.10	21304687.	405077.	32.17	0.95	0.0000	37.7258	37.5433	-74.8215	72.933
179.02	38.	0.	2486.63	21305937.	406319.	34.03	0.92	0.0000	37.7190	37.5365	-74.7836	72.932

SIDE-INDER-ARCAS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

PHI, THETA, PSI, I-GAM, R-GAM, I-ZETA, R-ZETA ARE GEOCENTRIC REFERENCED

TIME SEC	ALPHA DEG	Q-ALPHA LB/SQ FT	BETA DEG	I-GAM DEG	R-GAM DEG	I-ZETA DEG	R-ZETA DEG	PHI DEG	PSI DEG	THETA DEG	Q-INTG DEG	Q-COMM DEG/SEC	PITCH ERR DEG
21.00	0.00	1.	0.00	53.833	74.930	93.884	100.596	50.258	100.596	74.930	-0.938	0.	0.
21.50	-0.00	-0.	-0.00	54.153	74.846	93.956	100.605	-119.831	100.605	74.847	-0.932	0.	0.
22.00	-0.00	-0.	0.00	54.469	74.764	94.029	100.615	97.819	100.615	74.765	-0.939	0.	0.
22.50	0.00	1.	0.00	54.782	74.684	94.102	100.624	-16.307	100.624	74.684	-0.934	0.	0.
23.00	-0.00	-0.	-0.00	55.090	74.605	94.175	100.633	-101.657	100.633	74.605	-0.932	0.	0.
23.50	-0.00	-1.	-0.00	55.393	74.527	94.249	100.643	-157.617	100.642	74.527	-0.934	0.	0.
24.00	-0.00	-1.	-0.00	55.692	74.451	94.323	100.652	176.391	100.652	74.451	-0.935	0.	0.
24.50	-0.00	-1.	-0.00	55.987	74.376	94.397	100.661	-179.096	100.661	74.377	-0.935	0.	0.
25.00	-0.00	-1.	-0.00	56.277	74.303	94.471	100.670	-143.560	100.669	74.303	-0.933	0.	0.
25.50	0.00	0.	-0.00	56.562	74.231	94.545	100.679	-76.504	100.678	74.231	-0.932	0.	0.
26.00	0.00	1.	0.00	56.841	74.161	94.619	100.687	22.530	100.687	74.161	-0.936	0.	0.
26.50	-0.00	-1.	0.00	57.115	74.092	94.693	100.696	153.939	100.696	74.092	-0.936	0.	0.
27.00	0.00	1.	-0.00	57.384	74.024	94.767	100.705	-41.905	100.704	74.024	-0.933	0.	0.
27.50	-0.00	-1.	-0.00	57.649	73.958	94.841	100.713	155.334	100.713	73.958	-0.936	0.	0.
28.00	0.00	0.	0.00	57.913	73.893	94.915	100.722	26.054	100.722	73.893	-0.936	0.	0.
28.50	0.00	0.	-0.00	58.174	73.829	94.990	100.730	-69.265	100.730	73.830	-0.933	0.	0.
29.00	-0.00	-0.	-0.00	58.433	73.767	95.066	100.739	-130.143	100.739	73.767	-0.933	0.	0.
29.50	-0.00	-0.	-0.00	58.689	73.706	95.141	100.747	-156.107	100.747	73.707	-0.934	0.	0.
30.00	-0.00	-0.	-0.00	58.943	73.647	95.217	100.756	-146.658	100.755	73.647	-0.933	0.	0.
30.50	0.00	0.	-0.00	59.193	73.588	95.293	100.764	-101.359	100.764	73.589	-0.933	0.	0.
31.00	0.00	0.	0.00	59.440	73.532	95.369	100.772	-19.857	100.772	73.532	-0.934	0.	0.
31.50	-0.00	-0.	0.00	59.684	73.476	95.446	100.780	98.107	100.780	73.476	-0.936	0.	0.
32.00	0.00	0.	-0.00	59.924	73.421	95.522	100.789	-107.288	100.788	73.422	-0.933	0.	0.
32.50	-0.00	-0.	0.00	60.152	73.368	95.596	100.797	84.009	100.796	73.368	-0.936	0.	0.
33.00	0.00	0.	0.00	60.344	73.316	95.663	100.805	-48.414	100.804	73.316	-0.933	0.	0.
33.50	-0.00	-0.	-0.00	60.468	73.265	95.715	100.813	-146.281	100.812	73.265	-0.934	0.	0.
34.00	-0.00	-0.	-0.00	60.509	73.214	95.747	100.821	146.813	100.820	73.215	-0.935	0.	0.
34.50	-0.00	-0.	0.00	60.481	73.164	95.763	100.829	105.578	100.828	73.164	-0.936	0.	0.
35.00	-0.00	-0.	0.00	60.402	73.113	95.767	100.837	84.122	100.836	73.113	-0.936	0.	0.
35.00	-0.00	-0.	0.00	60.402	73.113	95.767	100.837	84.122	100.836	73.113	-0.936	0.	0.
39.97	0.04	8.	0.46	59.496	72.677	95.751	100.911	84.133	100.873	73.148	-0.936	0.	0.
50.00	0.12	4.	1.49	57.694	71.676	95.766	101.060	84.154	100.947	73.217	-0.936	0.	0.
60.00	0.22	1.	2.80	55.637	70.396	95.814	101.215	84.176	101.320	73.285	-0.936	0.	0.
70.00	0.35	0.	4.37	53.295	68.849	95.872	101.370	84.197	101.393	73.353	-0.936	0.	0.
80.00	0.50	0.	6.22	50.642	67.004	95.933	101.524	84.219	101.166	73.421	-0.936	0.	0.
90.00	0.67	0.	8.43	47.640	64.796	95.996	101.676	84.241	101.239	73.489	-0.936	0.	0.
100.00	0.89	0.	11.09	44.242	62.127	96.058	101.824	84.262	101.312	73.556	-0.936	0.	0.
110.00	1.16	0.	14.33	40.396	58.662	96.121	101.970	84.284	101.384	73.623	-0.936	0.	0.
120.00	1.50	0.	18.35	36.050	54.809	96.183	102.113	84.306	101.457	73.690	-0.936	0.	0.
130.00	1.96	0.	23.40	31.161	49.712	96.245	102.253	84.328	101.529	73.757	-0.936	0.	0.
140.00	2.60	0.	29.82	25.707	43.234	96.307	102.389	84.350	101.602	73.824	-0.936	0.	0.
150.00	3.54	0.	39.04	19.702	34.987	96.369	102.522	84.373	101.675	73.891	-0.936	0.	0.
160.00	5.09	0.	48.43	13.210	24.654	96.431	102.652	84.395	101.747	73.957	-0.936	0.	0.
170.00	8.12	0.	61.00	6.352	12.283	96.493	102.778	84.418	101.820	74.024	-0.936	0.	0.
179.02	15.24	0.	73.61	-0.000	-0.000	96.549	102.889	84.438	101.886	74.084	-0.936	0.	0.

SIDE-INDEX-AREAS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

TIME	ANGULAR VELOCITIES P	Q	R	AERO FORCES A	Y	N	LOAD FACTORS NX	NY	NZ	VELOCITIES AIR REL	REL	WIND VEL	DIR	ACC INTG NX-INTG
SEC	(DEG/SEC)			(LBS)						(FT/SEC)		FT/SEC	DEG	FT/SEC
21.00	2512.49	-0.11	0.14	103.23	0.0	0.0	4.73	-0.00	-0.00	2694.	2693.9	0.	0.	3227.6
21.50	2567.57	0.08	-0.15	100.06	-0.0	-0.0	4.81	0.00	0.00	2755.	2755.2	0.	0.	3303.8
22.00	2623.52	0.03	0.17	96.52	0.0	-0.0	4.91	-0.00	0.00	2818.	2817.9	0.	0.	3381.9
22.50	2680.50	-0.16	-0.04	92.91	0.0	0.0	5.01	-0.00	-0.00	2882.	2882.2	0.	0.	3461.7
23.00	2738.65	0.03	-0.16	89.60	-0.0	-0.0	5.10	0.00	0.00	2948.	2948.1	0.	0.	3543.0
23.50	2798.04	0.15	-0.06	86.42	-0.0	-0.0	5.19	0.00	0.00	3015.	3015.4	0.	0.	3625.8
24.00	2858.53	0.16	0.01	83.19	-0.0	-0.0	5.29	0.00	0.00	3084.	3084.3	0.	0.	3710.1
24.50	2920.07	0.15	-0.01	79.92	-0.0	-0.0	5.39	0.00	0.00	3155.	3154.9	0.	0.	3796.0
25.00	2982.63	0.12	-0.09	76.62	-0.0	-0.0	5.49	0.00	0.00	3227.	3227.0	0.	0.	3883.6
25.50	3046.16	-0.04	-0.14	73.29	-0.0	0.0	5.58	0.00	-0.00	3301.	3300.7	0.	0.	3972.7
26.00	3110.54	-0.13	0.06	69.94	0.0	0.0	5.68	-0.00	-0.00	3376.	3375.9	0.	0.	4063.3
26.50	3175.68	0.13	0.06	66.59	0.0	-0.0	5.77	-0.00	0.00	3453.	3452.6	0.	0.	4155.4
27.00	3241.52	-0.11	-0.09	63.25	-0.0	0.0	5.87	0.00	-0.00	3531.	3530.9	0.	0.	4249.0
27.50	3308.06	0.13	0.06	59.93	-0.0	-0.0	6.02	0.00	0.00	3611.	3611.2	0.	0.	4344.7
28.00	3375.50	-0.12	0.06	56.66	0.0	0.0	6.18	-0.00	-0.00	3694.	3693.9	0.	0.	4442.8
28.50	3443.92	-0.05	-0.12	53.44	-0.0	0.0	6.33	0.00	-0.00	3779.	3779.1	0.	0.	4543.4
29.00	3513.28	0.08	-0.10	50.27	-0.0	-0.0	6.49	0.00	0.00	3867.	3867.0	0.	0.	4646.5
29.50	3583.62	0.12	-0.05	47.46	-0.0	-0.0	6.65	0.00	0.00	3957.	3957.4	0.	0.	4752.3
30.00	3654.92	0.10	-0.07	44.73	-0.0	-0.0	6.81	0.00	0.00	4050.	4050.4	0.	0.	4860.6
30.50	3727.22	0.02	-0.12	42.02	-0.0	0.0	6.98	0.00	-0.00	4146.	4146.0	0.	0.	4971.6
31.00	3799.73	-0.12	-0.04	39.33	0.0	0.0	7.15	-0.00	-0.00	4244.	4244.3	0.	0.	5085.2
31.50	3872.88	0.02	0.12	36.72	0.0	-0.0	7.31	-0.00	0.00	4345.	4345.4	0.	0.	5201.5
32.00	3946.29	0.03	-0.11	34.20	-0.0	0.0	7.48	0.00	-0.00	4449.	4449.0	0.	0.	5320.5
32.50	4019.65	-0.01	0.11	31.74	0.0	-0.0	7.28	-0.00	0.00	4552.	4552.5	0.	0.	5439.2
33.00	4090.98	-0.08	-0.08	29.29	0.0	0.0	6.14	-0.00	-0.00	4645.	4645.2	0.	0.	5547.3
33.50	4157.15	0.09	-0.06	26.79	-0.0	-0.0	4.28	0.00	0.00	4714.	4713.8	0.	0.	5631.2
34.00	4214.24	0.09	0.06	24.27	-0.0	-0.0	2.02	0.00	0.00	4749.	4749.3	0.	0.	5682.0
34.50	4259.68	0.03	0.11	21.83	0.0	-0.0	0.76	-0.00	0.00	4757.	4756.5	0.	0.	5704.4
35.00	4293.55	-0.01	0.11	19.54	0.0	-0.0	-0.54	-0.00	0.00	4743.	4743.2	0.	0.	5706.3
35.00	0.	0.	0.	20.15	0.0	-0.0	-0.54	-0.00	0.00	4743.	4743.2	0.	0.	5706.3
39.97	0.	0.	0.	6.85	2.3	0.2	-0.18	-0.06	-0.00	4540.	4539.7	0.	0.	5654.2
50.00	0.	0.	0.	1.00	1.0	0.1	-0.03	-0.03	-0.00	4211.	4211.0	0.	0.	5628.9
60.00	0.	0.	0.	0.21	0.4	0.0	-0.01	-0.01	-0.00	3907.	3907.4	0.	0.	5624.6
70.00	0.	0.	0.	0.05	0.1	0.0	-0.00	-0.00	-0.00	3611.	3610.8	0.	0.	5623.6
80.00	0.	0.	0.	0.01	0.0	0.0	-0.00	-0.00	-0.00	3319.	3319.4	0.	0.	5623.4
90.00	0.	0.	0.	0.00	0.0	0.0	-0.00	-0.00	-0.00	3033.	3033.3	0.	0.	5623.4
100.00	0.	0.	0.	0.00	0.0	0.0	-0.00	-0.00	-0.00	2754.	2753.7	0.	0.	5623.4
110.00	0.	0.	0.	0.00	0.0	0.0	-0.00	-0.00	-0.00	2482.	2482.3	0.	0.	5623.4
120.00	0.	0.	0.	0.00	0.0	0.0	-0.00	-0.00	-0.00	2222.	2221.8	0.	0.	5623.4
130.00	0.	0.	0.	0.00	0.0	0.0	-0.00	-0.00	-0.00	1976.	1976.0	0.	0.	5623.4
140.00	0.	0.	0.	0.00	0.0	0.0	-0.00	-0.00	-0.00	1751.	1750.9	0.	0.	5623.4
150.00	0.	0.	0.	0.00	0.0	0.0	-0.00	-0.00	-0.00	1555.	1555.1	0.	0.	5623.4
160.00	0.	0.	0.	0.	0.	0.	0.	0.	0.	1401.	1400.7	0.	0.	5623.4
170.00	0.	0.	0.	0.	0.	0.	0.	0.	0.	1302.	1302.3	0.	0.	5623.4
179.02	0.	0.	0.	0.	0.	0.	0.	0.	0.	1272.	1272.5	0.	0.	5623.4

SIDEWINDER-AEROBEE SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSC
ROUTINE NO. LVVC27
PROBLEM NO. 1

TIME SEC	HX-DOT FT/SEC	HY-DOT	HZ-DOT	P-CONT (DEG OR LES)	Q-CONT	R-CONT	NERR	STEPS GOOD	STEPS BAD	VELOCITY LOSSES IN FT/SEC AERO	GRAVITY	PRESSURE	ALPHA	IDEAL VELOCITY
21.	0.1	0.5	0.5	0.	0.	0.	22	2327	112	1072.5	651.1	188.7	0.0	4488.2
21.5	0.1	-0.4	-0.4	0.	0.	0.	21	2404	112	1101.1	666.6	191.0	0.0	4595.8
22.	0.1	0.4	-0.1	0.	0.	0.	23	2482	113	1129.0	682.0	193.2	0.0	4704.1
22.5	0.1	-0.2	0.8	0.	0.	0.	22	2561	114	1156.3	697.5	195.3	0.0	4813.2
23.	0.1	-0.4	-0.2	0.	0.	0.	23	2641	115	1182.8	712.9	197.3	0.0	4923.1
23.5	0.1	-0.3	-0.8	0.	0.	0.	22	2723	115	1208.8	728.3	199.2	0.0	5033.8
24.	0.1	0.2	-0.8	0.	0.	0.	22	2806	117	1234.2	743.8	201.0	0.0	5145.3
24.5	0.1	-0.3	-0.8	0.	0.	0.	22	2890	117	1259.0	759.2	202.6	0.0	5257.6
25.	0.1	-0.5	-0.7	0.	0.	0.	21	2976	117	1283.0	774.6	204.2	0.0	5370.9
25.5	0.1	-0.8	0.2	0.	0.	0.	23	3064	121	1306.4	790.0	205.7	0.0	5484.8
26.	0.1	0.3	0.8	0.	0.	0.	21	3153	122	1329.1	805.4	207.1	0.0	5599.5
26.5	0.1	0.4	-0.8	0.	0.	0.	22	3243	123	1351.0	820.8	208.4	0.0	5714.8
27.	0.1	-0.6	0.5	0.	0.	0.	22	3335	123	1372.1	836.1	209.7	0.0	5830.8
27.5	0.1	0.3	-0.8	0.	0.	0.	22	3431	125	1392.4	851.5	210.8	0.0	5947.9
28.	0.1	0.4	0.8	0.	0.	0.	22	3525	127	1411.9	866.9	211.9	0.0	6066.6
28.5	0.1	-0.3	0.3	0.	0.	0.	21	3621	127	1430.7	882.2	212.9	0.0	6186.9
29.	0.1	-0.7	-0.5	0.	0.	0.	23	3719	128	1448.6	897.6	213.8	0.0	6309.0
29.5	0.1	-0.4	-0.8	0.	0.	0.	21	3816	128	1465.7	912.9	214.7	0.0	6432.7
30.	0.1	-0.5	-0.7	0.	0.	0.	21	3919	131	1482.1	928.2	215.5	0.0	6558.3
30.5	0.1	-0.2	-0.1	0.	0.	0.	23	4022	132	1497.8	943.6	216.3	0.0	6685.7
31.	0.1	-0.3	0.8	0.	0.	0.	22	4125	132	1512.8	958.9	217.0	0.0	6815.0
31.5	0.1	0.8	-0.1	0.	0.	0.	21	4230	132	1527.0	974.2	217.6	0.0	6946.2
32.	0.1	-0.8	-0.2	0.	0.	0.	23	4337	134	1540.5	989.5	218.2	0.0	7079.2
32.5	0.1	0.4	0.1	0.	0.	0.	21	4445	135	1553.3	1004.8	218.7	0.0	7211.8
33.	0.	-0.6	0.6	0.	0.	0.	23	4555	137	1565.3	1020.1	219.2	0.0	7331.8
33.5	0.	-0.5	-0.7	0.	0.	0.	21	4666	138	1576.6	1035.3	219.7	0.0	7427.4
34.	0.	0.4	-0.7	0.	0.	0.	22	4780	139	1587.0	1050.6	220.1	0.0	7489.1
34.5	0.	0.8	-0.2	0.	0.	0.	21	4895	141	1596.6	1065.9	220.5	0.0	7521.5
35.	0.	0.	0.1	0.	0.	0.	21	5009	142	1605.3	1081.1	220.8	0.0	7532.5
35.5	0.	0.	0.	0.	0.	0.	21	5009	142	1605.3	1081.1	220.8	0.0	7532.5
36.	0.	0.	0.	0.	0.	0.	14	5016	144	1657.5	1232.4	220.8	0.0	7532.5
36.5	0.	0.	0.	0.	0.	0.	6	5023	145	1683.0	1535.6	220.8	0.0	7532.5
37.	0.	0.	0.	0.	0.	0.	6	5028	145	1687.5	1834.8	220.8	0.0	7532.5
37.5	0.	0.	0.	0.	0.	0.	14	5031	145	1688.6	2130.3	220.8	0.0	7532.5
38.	0.	0.	0.	0.	0.	0.	14	5034	145	1688.8	2421.4	220.8	0.0	7532.5
38.5	0.	0.	0.	0.	0.	0.	6	5036	145	1688.9	2707.4	220.8	0.0	7532.5
39.	0.	0.	0.	0.	0.	0.	14	5037	145	1688.9	2987.0	220.8	0.0	7532.5
39.5	0.	0.	0.	0.	0.	0.	14	5039	145	1688.9	3258.4	220.8	0.0	7532.5
40.	0.	0.	0.	0.	0.	0.	16	5041	145	1688.9	3518.9	220.8	0.0	7532.5
40.5	0.	0.	0.	0.	0.	0.	15	5043	145	1688.9	3764.7	220.8	0.0	7532.5
41.	0.	0.	0.	0.	0.	0.	15	5044	145	1688.9	3989.8	220.8	0.0	7532.5
41.5	0.	0.	0.	0.	0.	0.	15	5045	145	1688.9	4185.6	220.8	0.0	7532.5
42.	0.	0.	0.	0.	0.	0.	14	5046	145	1688.9	4340.0	220.8	0.0	7532.5
42.5	0.	0.	0.	0.	0.	0.	14	5047	145	1688.9	4438.4	220.8	0.0	7532.5
43.02	0.	0.	0.	0.	0.	0.	15	5047	145	1688.9	4469.2	220.8	0.0	7532.5

SIGMA-INCEA-ARCAS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

RANGE COORDINATES AND VELOCITIES

TIME	XL	YL	ZL	XL-DOT	YL-DOT	ZL-DOT	RXY	GAM-L	VEL-L	R-DOT
SEC	(	FT	)	(	FT/SEC	)	FT	DEG	FT/SEC	FT/SEC
20.00	8425.3	-177.2	35657.1	702.89	-15.40	2600.58	8427.	74.872	2693.9	2692.5
21.00	8781.7	-185.1	36971.8	722.80	-15.90	2658.64	8784.	74.787	2755.2	2753.8
22.00	9148.1	-193.1	38315.9	743.20	-16.41	2718.10	9150.	74.704	2817.9	2816.4
22.50	9334.5	-201.7	39690.3	764.12	-16.94	2779.03	9527.	74.622	2882.2	2880.7
23.00	9912.2	-210.3	41095.3	785.55	-17.48	2841.43	9914.	74.542	2948.1	2946.5
23.50	10312.6	-219.0	42531.8	807.49	-18.04	2905.25	10313.	74.463	3015.4	3013.8
24.00	10719.9	-228.3	44000.7	829.95	-18.61	2970.53	10722.	74.386	3084.3	3082.6
24.5	11140.5	-237.7	45502.7	852.94	-19.19	3037.31	11143.	74.310	3154.9	3153.1
25.00	11572.8	-247.4	47038.3	876.48	-19.80	3105.63	11575.	74.236	3227.0	3225.2
25.50	12017.0	-257.4	48608.5	900.55	-20.42	3175.43	12020.	74.163	3300.7	3298.8
26.00	12473.4	-267.9	50214.0	925.12	-21.05	3246.61	12476.	74.091	3375.9	3373.9
26.50	12942.4	-278.5	51855.3	950.21	-21.70	3319.22	12945.	74.021	3452.6	3450.5
27.00	13423.9	-289.5	53533.4	975.83	-22.37	3393.29	13427.	73.952	3530.9	3528.8
27.50	13918.3	-300.9	55248.9	1002.10	-23.05	3469.25	13922.	73.884	3611.2	3609.0
28.00	14425.9	-312.6	57003.1	1029.17	-23.76	3547.54	14429.	73.818	3693.9	3691.7
28.50	14947.5	-324.6	58796.9	1057.03	-24.49	3628.22	14951.	73.753	3779.1	3776.8
29.00	15483.1	-337.1	60631.7	1085.73	-25.24	3711.35	15487.	73.689	3867.0	3864.7
29.50	16033.5	-349.9	62508.6	1115.24	-26.02	3796.91	16037.	73.627	3957.4	3955.0
30.00	16598.6	-363.2	64429.1	1145.59	-26.82	3884.90	16603.	73.566	4050.4	4047.9
30.50	17178.2	-376.8	66393.9	1176.79	-27.65	3975.39	17183.	73.506	4146.0	4143.5
31.00	17773.5	-390.7	68404.8	1208.86	-28.50	4068.44	17780.	73.447	4244.3	4241.5
31.50	18384.1	-405.3	70462.8	1241.79	-29.38	4164.03	18393.	73.390	4345.4	4342.8
32.00	19011.4	-420.2	72569.3	1275.59	-30.28	4262.12	19022.	73.334	4449.0	4446.4
32.50	19663.8	-435.6	74724.9	1309.43	-31.19	4359.97	19669.	73.279	4552.5	4549.9
33.00	20331.4	-451.3	76927.5	1340.28	-32.04	4447.53	20331.	73.225	4645.2	4642.5
33.50	21012.9	-467.5	79168.6	1364.25	-32.72	4511.99	21008.	73.172	4713.8	4711.1
34.00	21692.5	-484.4	81434.2	1378.69	-33.18	4544.71	21694.	73.120	4749.3	4746.5
34.50	22361.1	-501.7	83708.9	1384.94	-33.44	4550.32	22386.	73.067	4756.5	4753.7
35.00	23073.1	-517.5	85981.3	1385.21	-33.56	4536.25	23079.	73.015	4743.2	4740.4
35.00	23073.1	-517.5	85981.3	1335.21	-33.56	4536.25	23079.	73.015	4743.2	4740.4
37.00	29841.8	-995.2	107993.4	1360.17	-33.96	4331.02	29900.	72.560	4539.7	4537.0
50.00	43393.2	-1332.1	149707.7	1334.15	-35.31	3993.91	43395.	71.522	4211.0	4207.6
60.00	56661.5	-1633.7	188054.9	1322.69	-37.03	3676.50	56679.	70.206	3907.4	3901.9
70.00	69845.7	-1922.9	223247.9	1315.56	-38.83	3362.39	69873.	68.623	3610.6	3602.0
80.00	82977.9	-2197.2	255307.0	1310.07	-40.61	3049.62	83006.	66.742	3319.4	3305.[illegible]
90.00	96054.2	-2455.1	284243.4	1305.25	-42.33	2737.77	96089.	64.499	3033.3	3011.8
100.00	109033.8	-2696.7	310065.3	1300.73	-43.99	2426.73	109126.	61.795	2753.7	2721.2
110.00	122[illegible]	-2[illegible]	332780.3	1296.41	-45.58	2116.40	122119.	58.495	2482.3	2433.7
120.00	135012.6	-3025.2	352395.4	1292.27	-47.10	1806.69	135070.	54.407	2221.8	2149.8
130.00	147915.4	-3[illegible]	368916.0	1288.29	-48.55	1497.51	147981.	49.275	1976.0	1869.8
140.00	160779.7	-3[illegible]	382347.0	1284.48	-49.93	1188.77	160854.	42.762	1753.9	1594.2
150.00	173605.6	-3[illegible]	392692.5	1280.84	-51.24	880.38	173690.	34.481	1555.1	1323.5
160.00	186395.3	-3923.4	399955.5	1277.36	-52.47	572.24	186490.	24.114	1400.7	1058.9
170.00	199153.4	-4453.7	404137.9	1274.05	-53.64	264.27	199258.	11.708	1302.3	[illegible]
177.92	210832.6	-[illegible]	405267.1	1271.21	-54.52	-13.46	210747.	-0.516	1272.5	575.1

S1-BATTLEFIELD-ARCAS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
30 DEG LAUNCH ELEVATION ANGLE, 42 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

INSTANTANEOUS IMPACT POINTS

TIME SEC	TIME-I SEC	LAT-I DEG	LONG-I DEG	RANGE N MI	XL-I (FT	YL-I	ZL-I)
[illegible]	207.7	37.7662	-75.0421	21.4	129984.	-3310.	-413.
[illegible]	[illegible].1	37.7625	-75.0201	22.5	136496.	-3520.	-455.
[illegible]	216.6	37.7585	-74.9970	23.6	143317.	-3743.	-501.
22.5[illegible]	211.3	37.7544	-74.9729	24.8	150465.	-3981.	-551.
23.[illegible]	216.0	37.7500	-74.9475	26.0	157953.	-4232.	-606.
23.5[illegible]	220.3	37.7454	-74.9210	27.3	165727.	-4499.	-667.
24.[illegible]	225.7	37.7406	-74.8933	28.7	173986.	-4783.	-734.
24.5[illegible]	230.8	37.7356	-74.8643	30.1	182565.	-5084.	-808.
25.[illegible]	235.9	37.7302	-74.8340	31.6	191544.	-5403.	-886.
25.5[illegible]	241.1	37.7247	-74.8023	33.1	200929.	-5741.	-975.
26.[illegible]	246.5	37.7188	-74.7692	34.7	210725.	-6099.	-1071.
26.5[illegible]	251.9	37.7127	-74.7347	36.4	220948.	-6478.	-1177.
27.[illegible]	257.4	37.7063	-74.6987	38.2	231618.	-6880.	-1291.
27.5[illegible]	262.1	37.6996	-74.6609	40.0	242804.	-7306.	-1418.
28.[illegible]	268.9	37.6924	-74.6212	42.0	254580.	-7762.	-1558.
28.5[illegible]	274.9	37.6849	-74.5794	44.0	266977.	-8249.	-1714.
29.[illegible]	281.1	37.6769	-74.5354	46.2	280028.	-8769.	-1884.
29.5[illegible]	287.4	37.6685	-74.4891	48.4	293760.	-9325.	-2073.
30.[illegible]	294.0	37.6596	-74.4404	50.8	308199.	-9918.	-2280.
30.5[illegible]	300.7	37.6501	-74.3893	53.3	323383.	-10551.	-2509.
31.[illegible]	307.5	37.6402	-74.3355	56.0	339352.	-11228.	-2762.
31.5[illegible]	314.6	37.6297	-74.2790	58.7	356133.	-11950.	-3041.
32.[illegible]	321.9	37.6186	-74.2198	61.6	373751.	-12720.	-3349.
32.5[illegible]	329.2	37.6071	-74.1591	64.6	391798.	-13522.	-3679.
33.[illegible]	335.8	37.5964	-74.1025	67.4	408621.	-14282.	-4001.
33.5[illegible]	341.0	37.5878	-74.0577	69.6	421954.	-14893.	-4265.
34.[illegible]	344.1	37.5826	-74.0302	70.9	430134.	-15274.	-4432.
34.5[illegible]	345.5	37.5802	-74.0180	71.5	433779.	-15448.	-4508.
35.[illegible]	345.6	37.5800	-74.0170	71.6	434085.	-15469.	-4514.
35.[illegible]	345.6	37.5800	-74.0170	71.6	434085.	-15469.	-4514.
35.97	342.6	37.5865	-74.0517	69.9	423747.	-15055.	-4302.
5[illegible]	341.3	37.5910	-74.0771	68.6	414226.	-14834.	-4152.
6[illegible]	341.1	37.5919	-74.0837	68.3	414274.	-14873.	-4112.
7[illegible]	341.1	37.5919	-74.0858	68.2	413687.	-14973.	-4101.
8[illegible]	341.1	37.5917	-74.0864	68.2	413528.	-15089.	-4098.
9[illegible]	341.1	37.5914	-74.0866	68.2	413506.	-15207.	-4097.
10[illegible]	341.1	37.5911	-74.0866	68.2	413519.	-15321.	-4098.
11[illegible]	341.1	37.5907	-74.0866	68.2	413538.	-15430.	-4098.
12[illegible]	341.1	37.5905	-74.0866	68.2	413558.	-15535.	-4099.
13[illegible]	341.1	37.5902	-74.0866	68.2	413578.	-15635.	-4099.
14[illegible]	341.1	37.5899	-74.0866	68.2	413597.	-15730.	-4100.
15[illegible]	341.1	37.5897	-74.0865	68.2	413615.	-15820.	-4100.
16[illegible]	341.1	37.5894	-74.0866	68.2	413632.	-15906.	-4100.
17[illegible]	341.1	37.5892	-74.0866	68.2	413649.	-15986.	-4101.
178.[illegible]	341.1	37.5890	-74.0866	68.2	413664.	-16055.	-4101.

STEP-INCER-SPENT STAGE TRAJECTORY
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSC
ROUTINE NO. LVVC27
PROBLEM NO. 1

INITIAL VALUES OF GEOCENTRIC EULER ANGLES AND PAYLOAD

PHI = 0. THETA = 79.092 PSI = 100.114 PAYLOAD = 0.

TIME SEC	WEIGHT LBS	THRUST LBS	I-VEL FT/SEC	GC RAD (- FT OR N MI -)	ALT	RANGE N MI	MACH	DYN. P LBS/FT2	GD LAT DEG	GC LAT DEG	LONG DEG	THETA-SIG DEG
2.40	50.	0.	2167.20	20901650.	2160.	0.07	1.43	2816.1554	37.8377	37.6515	-75.4815	79.091
10.00	50.	0.	1441.40	20908370.	8887.	0.31	0.50	268.8916	37.8370	37.6508	-75.4766	75.408
20.00	50.	0.	1312.85	20911346.	11863.	0.50	0.14	18.4262	37.8364	37.6502	-75.4727	46.356
29.97	50.	0.	1313.34	20910831.	11347.	0.66	0.21	42.0693	37.8358	37.6497	-75.4694	-65.857
40.00	50.	0.	1342.52	20907570.	8086.	0.79	0.40	171.4136	37.8354	37.6492	-75.4666	-80.970
50.00	50.	0.	1348.08	20902810.	3325.	0.88	0.46	281.3279	37.8351	37.6489	-75.4648	-85.415
56.45	50.	0.	1338.94	20899485.	-0.	0.92	0.46	318.8509	37.8350	37.6487	-75.4640	-86.961

SIDE-INGEST-SPENT STAGE TRAJECTORY
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

PHI, THETA, PSI, I-GAM, R-GAM, I-ZETA, R-ZETA ARE GEOCENTRIC REFERENCED

TIME SEC	ALPHA DEG	Q-ALPHA LB/SQ FT	BETA DEG	I-GAM DEG	R-GAM DEG	I-ZETA DEG	R-ZETA DEG	PHI DEG	PSI DEG	THETA DEG	Q-INTG DEG	Q-COMM DEG/SEC	PITCH ERR DEG
2.40	0.00	3.	-0.00	46.062	79.091	92.013	100.114	0.000	100.114	79.092	0.	-0.22113	0.
10.00	-0.00	-1.	0.02	21.422	75.442	91.061	100.470	0.267	100.409	75.438	-3.683	-0.84906	0.
20.00	-0.02	-0.	0.13	4.724	46.437	90.867	101.095	0.699	100.908	46.422	-32.731	-8.58410	0.
27.97	-0.02	-1.	0.06	-8.930	-65.733	90.827	101.763	0.357	101.623	-65.755	-144.929	-3.36959	0.
40.00	-0.01	-2.	0.01	-18.384	-80.823	90.667	102.512	-0.417	102.455	-80.832	-160.040	-0.67775	0.
50.00	-0.01	-2.	0.00	-22.197	-85.235	90.456	103.534	-1.418	103.490	-85.243	-164.486	-0.29315	0.
56.45	-0.01	-2.	0.00	-22.719	-86.758	90.340	104.497	-2.365	104.456	-86.766	-166.032	-0.19489	0.

SIDE-INDER-SPENT STAGE TRAJECTORY
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVYC27
PROBLEM NO. 1

TIME	ANGULAR VELOCITIES P	Q	R	AERO FORCES A	Y	N	LOAD FACTORS NX	NY	NZ	VELOCITIES AIR REL	REL	WIND VEL	DIR	ACC INTG NX-INTG
SEC	(DEG/SEC		)	(LBS		)				(FT/SEC	)	FT/SEC	DEG	FT/SEC
2.40	0.	-0.22	-0.00	554.38	-0.	0.	-11.12	0.	0.	1589.	1589.3	0.	0.	0.
10.00	0.	-0.85	0.02	42.90	0.	-0.	-0.86	0.	0.	544.	543.9	0.	0.	-806.9
20.00	0.	-8.50	0.13	2.88	0.	-0.	-0.06	0.	0.	149.	149.2	0.	0.	-910.3
29.97	0.	-3.37	0.06	6.59	0.	-0.	-0.13	0.	0.	224.	223.6	0.	0.	-927.4
40.00	0.	-0.68	0.01	27.08	0.	-0.	-0.54	0.	0.	429.	428.9	0.	0.	-1032.9
50.00	0.	-0.29	0.00	44.72	0.	-0.	-0.90	0.	0.	511.	511.1	0.	0.	-1269.9
56.45	0.	-0.19	0.00	50.68	0.	-0.	-1.02	0.	0.	518.	518.0	0.	0.	-1469.9

SIDEWINDER-SPENT STAGE TRAJECTORY
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LV7C27
PROBLEM NO. 1

RANGE COORDINATES AND VELOCITIES

TIME SEC	XL (FT)	YL	ZL	XL-DOT (FT/SEC)	YL-DOT	ZL-DOT	RXY FT	GAM-L DEG	VEL-L FT/SEC	R-DOT FT/SEC
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-5.59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	3031.3	-69.7	11854.6	122.89	-2.30	[illegible]	3031.	[illegible]	[illegible]	[illegible]
29.97	4002.5	-89.0	11338.6	91.71	-2.16	-203.34	4008.	-65.782	223.9	-[illegible]
40.00	4815.3	-108.3	8077.6	68.01	-1.63	-423.48	4817.	-80.874	428.9	-328.9
50.00	5362.2	-121.4	3317.2	41.96	-0.98	-509.34	5364.	-85.289	511.1	-232.2
56.45	5583.5	-126.5	-8.1	28.77	-0.63	-517.16	5590.	-86.815	518.0	29.5

SIDE-INDER-SPENT STAGE TRAJECTORY
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSC
ROUTINE NO. LVVC27
PROBLEM NO. 1

INSTANTANEOUS IMPACT POINTS

TIME SEC	TIME-I SEC	LAT-I DEG	LONG-I DEG	RANGE N MI	XL-I (	YL-I FT	ZL-I)
2.40	101.2	37.8224	-75.3816	4.9	29840.	-503.	-31.
10.00	55.1	37.8338	-75.4557	1.3	8034.	-131.	-12.
20.00	50.8	37.8347	-75.4619	1.0	6200.	-116.	-11.
29.97	51.0	37.8348	-75.4628	1.0	5938.	-123.	-11.
40.00	52.8	37.8349	-75.4636	0.9	5693.	-125.	-11.
50.00	55.6	37.8350	-75.4640	0.9	5576.	-126.	-12.
56.45	56.5	37.8350	-75.4640	0.9	5538.	-127.	-11.

ARCAS SPENT-STAGE TRAJECTORY
[illegible] ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC2[illegible]
PROBLEM NO. 1

INITIAL VALUES OF GEOCENTRIC EULER ANGLES AND PAYLOAD

PHI = 0. THETA = 74.084 PSI = 101.886 PAYLOAD = 0.

TIME SEC	WEIGHT LBS	THRUST LBS	I-VEL FT/SEC	GC RAD (- FT OR N MI -)	ALT	RANGE N MI	MACH	DYN. P LBS/FT2	GC LAT DEG	GC LAT DEG	LONG DEG	THETA-SIG DEG
179.02	31.	0.	2488.67	21305937.	406319.	34.03	0.92	0.0000	37.7190	37.5365	-74.7836	73.518
179.98	31.	0.	2488.85	21305923.	406304.	34.23	0.92	0.0000	37.7183	37.5358	-74.7796	26.526
190.00	31.	0.	2511.69	21304085.	404457.	36.28	0.97	0.0000	37.7106	37.5281	-74.7374	-15.485
200.00	31.	0.	2571.64	21299177.	399540.	38.35	1.09	0.0000	37.7029	37.5203	-74.6953	-27.547
210.00	31.	0.	2666.28	21291195.	391548.	40.41	1.29	0.0001	37.6951	37.5125	-74.6532	-37.510
220.00	31.	0.	2792.19	21280137.	380481.	42.47	1.52	0.0001	37.6873	37.5046	-74.6111	-45.435
230.00	31.	0.	2945.48	21266001.	366335.	44.54	1.85	0.0003	37.6794	37.4966	-74.5688	-51.670
240.00	31.	0.	3122.30	21248782.	349107.	46.62	2.22	0.0008	37.6714	37.4885	-74.5265	-56.599
250.00	31.	0.	3319.07	21228474.	328790.	48.70	2.65	0.0030	37.6634	37.4804	-74.4840	-60.541
260.00	31.	0.	3532.66	21205074.	305379.	50.79	3.10	0.0133	37.6554	37.4721	-74.4414	-63.740
270.00	31.	0.	3760.38	21178573.	278869.	52.90	3.50	0.0737	37.6473	37.4638	-74.3986	-66.375
280.00	31.	0.	3999.79	21148965.	249251.	55.01	3.66	0.4149	37.6391	37.4553	-74.3555	-68.575
290.00	31.	0.	4247.80	21116257.	216533.	57.14	3.63	1.9190	37.6308	37.4468	-74.3123	-70.436
300.00	31.	0.	4497.90	21080454.	180719.	59.27	3.69	8.4208	37.6225	37.4382	-74.2689	-72.032
310.00	31.	0.	4722.91	21041721.	141976.	61.41	3.98	43.0223	37.6141	37.4295	-74.2254	-73.418
320.00	31.	0.	4739.05	21000976.	101221.	63.51	4.29	283.1598	37.6059	37.4210	-74.1828	-74.661
330.00	31.	0.	3756.60	20963724.	63960.	65.30	3.36	987.2391	37.5989	37.4136	-74.1465	-75.951
340.00	31.	0.	2251.92	20940674.	40906.	66.30	1.69	755.7608	37.5950	37.4095	-74.1261	-77.939
350.00	31.	0.	1670.29	20928653.	28882.	66.74	0.95	421.9050	37.5933	37.4077	-74.1173	-81.092
360.00	31.	0.	1483.57	20920565.	20793.	66.94	0.70	320.9759	37.5925	37.4068	-74.1131	-84.495
370.00	31.	0.	1401.62	20913952.	14130.	67.06	0.58	294.3660	37.5920	37.4063	-74.1108	-87.222
380.00	31.	0.	1353.47	20908123.	8350.	67.12	0.51	282.1547	37.5918	37.4060	-74.1096	-89.099
390.00	31.	0.	1322.66	20902861.	3088.	67.14	0.46	274.2098	37.5917	37.4059	-74.1090	-90.283
396.31	31.	0.	1308.91	20899773.	-0.	67.16	0.43	270.7009	37.5916	37.4058	-74.1088	-90.769

ARCAS SPENT-STAGE TRAJECTORY
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

PHI, THETA, PSI, I-GAM, R-GAM, I-ZETA, R-ZETA ARE GEOCENTRIC REFERENCED

TIME SEC	ALPHA DEG	Q-ALPHA LB/SQ FT	BETA DEG	I-GAM DEG	R-GAM DEG	I-ZETA DEG	R-ZETA DEG	PHI DEG	PSI DEG	THETA DEG	Q-INTG DEG	Q-COMM DEG/SEC	PITCH ERR DEG
179.02	74.08	0.	3.65	0.000	0.000	96.549	102.889	0.000	101.886	74.084	0.	-75.48351	0.
179.98	28.42	0.	0.45	-0.677	-1.324	96.555	102.901	1.015	102.984	27.099	-46.981	-29.81937	0.
190.00	-0.01	-0.	0.03	-7.717	-14.837	96.617	103.020	0.995	102.989	-14.846	-88.987	-1.29857	0.
200.00	-0.01	-0.	0.03	-14.514	-26.832	96.679	103.135	0.979	103.107	-26.841	-101.045	-1.10435	0.
210.00	-0.01	-0.	0.02	-20.918	-36.729	96.741	103.247	0.952	103.221	-36.737	-111.007	-0.88964	0.
220.00	-0.01	-0.	0.02	-26.816	-44.588	96.803	103.354	0.918	103.332	-44.595	-118.929	-0.70121	0.
230.00	-0.01	-0.	0.01	-32.157	-50.756	96.864	103.458	0.883	103.438	-50.763	-125.162	-0.55210	0.
240.00	-0.01	-0.	0.01	-36.935	-55.619	96.926	103.558	0.846	103.541	-55.625	-130.099	-0.43879	0.
250.00	-0.01	-0.	0.01	-41.178	-59.494	96.988	103.655	0.811	103.639	-59.500	-134.030	-0.35355	0.
260.00	-0.01	-0.	0.01	-44.931	-62.626	97.051	103.747	0.777	103.733	-62.631	-137.229	-0.28910	0.
270.00	-0.01	-0.	0.01	-48.247	-65.193	97.113	103.836	0.747	103.823	-65.198	-139.962	-0.23986	0.
280.00	-0.00	-0.	0.00	-51.177	-67.326	97.175	103.920	0.718	103.908	-67.331	-142.062	-0.20169	0.
290.00	-0.00	-0.	0.00	-53.768	-69.120	97.236	104.001	0.694	103.990	-69.124	-143.922	-0.17178	0.
300.00	-0.00	-0.	0.00	-56.050	-70.647	97.290	104.078	0.672	104.069	-70.652	-145.517	-0.14814	0.
310.00	-0.00	-0.	0.00	-57.994	-71.966	97.316	104.151	0.654	104.141	-71.970	-146.903	-0.13003	0.
320.00	-0.00	-1.	0.00	-59.148	-73.141	97.159	104.221	0.639	104.211	-73.145	-148.145	-0.12089	0.
330.00	-0.00	-4.	0.00	-56.477	-74.368	95.984	104.291	0.621	104.279	-74.373	-149.434	-0.14905	0.
340.00	-0.01	-4.	0.01	-45.019	-76.306	93.474	104.391	0.574	104.368	-76.311	-151.421	-0.26082	0.
350.00	-0.01	-3.	0.01	-34.141	-79.419	91.830	104.601	0.420	104.558	-79.425	-154.573	-0.34896	0.
360.00	-0.01	-2.	0.01	-28.842	-82.784	91.035	105.013	0.058	104.953	-82.791	-157.975	-0.31473	0.
370.00	-0.01	-2.	0.01	-26.120	-85.477	90.604	105.768	-0.652	105.694	-85.484	-160.702	-0.22863	0.
380.00	-0.01	-2.	0.00	-24.066	-87.319	90.353	107.143	-1.986	107.058	-87.326	-162.579	-0.14968	0.
390.00	-0.01	-2.	0.00	-22.333	-88.470	90.212	109.686	-4.497	109.597	-88.478	-163.765	-0.09120	0.
395.31	-0.01	-2.	0.00	-21.380	-88.934	90.158	112.287	-7.092	112.208	-88.942	-164.254	-0.06491	0.

ARCAS SPENT-STAGE TRAJECTORY
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

TIME	ANGULAR VELOCITIES P	Q	R	AERO FORCES A	Y	N	LOAD FACTORS NX	NY	NZ	VELOCITIES AIR REL	REL	WIND VEL	DIR	ACC INTG NX-INTG
SEC	(DEG/SEC		)	(LBS		)				(FT/SEC	)	FT/SEC	DEG	FT/SEC
179.02	0.	-75.48	3.65	0.	0.	0.	0.	0.	0.	1272.	1272.5	0.	0.	0.
179.98	0.	-29.92	0.45	0.	0.	0.	0.	0.	0.	1273.	1272.9	0.	0.	0.
190.00	0.	-1.30	0.03	0.	0.	0.	0.	0.	0.	1317.	1317.0	0.	0.	0.
200.00	0.	-1.10	0.03	0.00	0.0	-0.0	-0.00	-0.00	0.00	1428.	1427.9	0.	0.	-0.0
210.00	0.	-0.89	0.02	0.00	0.0	-0.0	-0.00	-0.00	0.00	1592.	1591.8	0.	0.	-0.0
220.00	0.	-0.70	0.02	0.00	0.0	-0.0	-0.00	-0.00	0.00	1794.	1794.4	0.	0.	-0.0
230.00	0.	-0.55	0.01	0.00	0.0	-0.0	-0.00	-0.00	0.00	2024.	2024.2	0.	0.	-0.0
240.00	0.	-0.44	0.01	0.00	0.0	-0.0	-0.00	-0.00	0.00	2273.	2273.4	0.	0.	-0.0
250.00	0.	-0.35	0.01	0.00	0.0	-0.0	-0.00	-0.00	0.00	2536.	2536.4	0.	0.	-0.0
260.00	0.	-0.29	0.01	0.00	0.0	-0.0	-0.00	-0.00	0.00	2810.	2809.6	0.	0.	-0.0
270.00	0.	-0.24	0.01	0.01	0.0	-0.0	-0.00	-0.00	0.00	3090.	3090.5	0.	0.	-0.1
280.00	0.	-0.20	0.00	0.08	0.0	-0.0	-0.00	-0.00	0.00	3377.	3377.2	0.	0.	-0.5
290.00	0.	-0.17	0.00	0.39	0.0	-0.0	-0.01	-0.00	0.00	3667.	3667.2	0.	0.	-2.6
300.00	0.	-0.15	0.00	1.70	0.0	-0.0	-0.05	-0.00	0.00	3955.	3954.5	0.	0.	-11.6
310.00	0.	-0.13	0.00	8.69	0.0	-0.0	-0.28	-0.00	0.00	4212.	4211.9	0.	0.	-54.2
320.00	0.	-0.12	0.00	57.20	0.0	-0.0	-1.82	-0.00	0.00	4251.	4251.1	0.	0.	-318.2
330.00	0.	-0.15	0.00	199.42	0.0	-0.0	-6.35	-0.00	0.00	3252.	3252.0	0.	0.	-1623.7
340.00	0.	-0.26	0.01	141.68	0.0	-0.0	-4.51	-0.00	0.00	1639.	1639.5	0.	0.	-3545.6
350.00	0.	-0.35	0.01	67.32	0.0	-0.0	-2.14	-0.00	0.00	954.	953.6	0.	0.	-4544.7
360.00	0.	-0.31	0.01	44.88	0.0	-0.0	-1.43	-0.00	0.00	721.	721.4	0.	0.	-5093.8
370.00	0.	-0.23	0.01	38.78	0.0	-0.0	-1.24	-0.00	0.00	619.	619.0	0.	0.	-5515.6
380.00	0.	-0.15	0.00	36.86	0.0	-0.0	-1.17	-0.00	0.00	553.	552.5	0.	0.	-5902.6
390.00	0.	-0.09	0.00	35.60	0.0	-0.0	-1.13	-0.00	0.00	503.	502.8	0.	0.	-6273.5
396.31	0.	-0.06	0.00	35.03	0.0	-0.0	-1.12	-0.00	0.00	477.	477.2	0.	0.	-6501.7

ARCAS SPENT-STAGE TRAJECTORY
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

RANGE COORDINATES AND VELOCITIES

TIME SEC	XL (FT	YL	ZL)	XL-DOT (FT/SEC	YL-DOT	ZL-DOT)	RXY FT	GAM-L DEG	VEL-L FT/SEC	R-DOT FT/SEC
179.02	210626.1	-6927.3	405269.2	1271.26	-54.63	-13.46	210740.	-0.606	1272.5	575.1
179.98	211843.2	-6979.7	405242.1	1270.96	-54.73	-42.95	211958.	-1.933	1272.9	551.5
190.00	224566.1	-7533.5	403265.4	1267.97	-55.75	-351.54	224692.	-15.481	1317.0	310.6
200.00	237231.7	-8095.7	399210.1	1265.16	-56.59	-659.54	237370.	-27.510	1427.9	81.9
210.00	249959.9	-8667.1	390073.8	1262.50	-57.57	-967.73	250020.	-37.442	1591.8	-132.8
220.00	262482.3	-9246.7	378854.5	1260.00	-58.37	-1276.20	262645.	-45.335	1794.4	-330.2
230.00	275070.4	-9834.2	364548.7	1257.67	-59.09	-1585.04	275246.	-51.539	2024.2	-506.4
240.00	287636.2	-10428.4	347152.3	1255.49	-59.74	-1894.34	287825.	-56.435	2273.4	-656.1
250.00	300180.8	-11028.9	326660.1	1253.47	-60.32	-2204.18	300383.	-60.346	2536.4	-773.1
260.00	312706.0	-11634.6	303066.5	1251.59	-60.82	-2514.67	312922.	-63.513	2809.6	-849.4
270.00	325213.0	-12245.0	276364.5	1249.84	-61.25	-2825.83	325443.	-66.115	3090.5	-875.4
280.00	337703.0	-12859.2	246548.0	1248.12	-61.59	-3137.50	337943.	-68.283	3377.2	-839.7
290.00	350171.5	-13476.5	213622.7	1245.97	-61.83	-3448.51	350431.	-70.112	3667.2	-729.9
300.00	362615.7	-14095.4	177593.9	1241.76	-61.88	-3754.02	362890.	-71.676	3954.5	-533.5
310.00	374979.7	-14712.4	138628.6	1227.83	-61.36	-4028.49	375268.	-73.030	4211.9	-242.3
320.00	386991.3	-15313.3	97649.7	1153.22	-57.72	-4091.33	387294.	-74.240	4251.1	119.3
330.00	397141.3	-15821.3	60193.0	813.39	-40.72	-3148.40	397456.	-75.497	3252.0	333.8
340.00	402796.1	-16104.3	37026.2	355.77	-17.79	-1600.32	403113.	-77.451	1639.5	208.3
350.00	405184.3	-16223.5	24954.2	156.03	-7.77	-940.75	405509.	-80.572	953.6	98.1
360.00	406292.7	-16278.6	16843.0	76.05	-3.75	-717.36	406619.	-83.341	721.4	46.4
370.00	406833.7	-16304.9	10217.2	36.27	-1.74	-617.92	407160.	-86.637	619.0	20.8
380.00	407077.1	-16316.3	4381.9	14.62	-0.64	-552.35	407404.	-89.482	552.5	8.7
390.00	407159.9	-16319.5	-882.8	3.19	-0.06	-502.76	407487.	-89.637	502.8	4.3
396.31	407156.2	-16319.2	-3971.5	-0.87	0.14	-477.25	407493.	-89.895	477.2	3.8

ARCAS SPENT-STAGE TRAJECTORY
90 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

INSTANTANEOUS IMPACT POINTS

TIME SEC	TIME-I SEC	LAT-I DEG	LONG-I DEG	RANGE N MI	XL-I (FT)	YL-I	ZL-I
179.02	341.1	37.5890	-74.0866	68.2	413665.	-16042.	-4101.
179.98	341.1	37.5890	-74.0866	68.2	413666.	-16049.	-4101.
190.00	341.1	37.5888	-74.0866	68.2	413681.	-16121.	-4102.
200.00	341.1	37.5886	-74.0866	68.2	413695.	-16188.	-4102.
210.00	341.1	37.5884	-74.0866	68.2	413708.	-16251.	-4102.
220.00	341.1	37.5883	-74.0865	68.2	413720.	-16309.	-4102.
230.00	341.1	37.5881	-74.0865	68.2	413732.	-16363.	-4103.
240.00	341.1	37.5880	-74.0865	68.2	413742.	-16412.	-4103.
250.00	341.1	37.5879	-74.0865	68.2	413752.	-16457.	-4103.
260.00	341.1	37.5878	-74.0865	68.2	413760.	-16497.	-4103.
270.00	341.1	37.5877	-74.0865	68.2	413767.	-16533.	-4103.
280.00	341.1	37.5876	-74.0866	68.2	413769.	-16564.	-4103.
290.00	341.2	37.5875	-74.0866	68.2	413761.	-16590.	-4103.
300.00	341.2	37.5875	-74.0867	68.2	413727.	-16610.	-4103.
310.00	341.5	37.5875	-74.0871	68.2	413627.	-16622.	-4101.
320.00	342.8	37.5877	-74.0882	68.2	413298.	-16617.	-4094.
330.00	348.6	37.5883	-74.0916	68.0	412268.	-16569.	-4074.
340.00	361.2	37.5897	-74.0985	67.7	410234.	-16463.	-4034.
350.00	372.3	37.5908	-74.1042	67.4	408540.	-16376.	-4001.
360.00	380.0	37.5913	-74.1069	67.2	407711.	-16336.	-3985.
370.00	386.2	37.5915	-74.1082	67.2	407349.	-16322.	-3977.
380.00	391.4	37.5916	-74.1086	67.2	407207.	-16318.	-3975.
390.00	395.3	37.5916	-74.1088	67.2	407169.	-16319.	-3974.
396.31	396.3	37.5916	-74.1088	67.2	407166.	-16319.	-3974.

Page H Tracking Station Data

RANGE	slant range from station to vehicle (n. m.)
RANGE-RATE	time rate of change of RANGE (ft/sec)
AZ	azimuth of the vehicle with respect to the tracking station measured clockwise from north on the station geodetic horizontal plane (deg)
AZDOT	time rate of change of AZ (deg/sec)
EL	elevation angle of the vehicle with respect to the station geodetic horizontal plane (deg)
ELDOT	time rate of change of EL (deg/sec)
ASPECT	angle between the vehicle roll axis and the radar line of sight, measured from the nose of the vehicle in shortest direction to the line of sight (deg).

SIE-MICRO-ARCAS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH — LTV AEROSPACE CORP.-MSD — PAGE [illegible]
80 DEG LAUNCH ELEVATION ANGLE- 12 LB PAYLOAD — ROUTINE NO. LV-C27
PROBLEM NO. 1

TRACKING STATION NAME - FPS-16

LATITUDE = [illegible].34131 DEG LONGITUDE = -75.48509 DEG ALTITUDE = 53.73 FT

TIME SEC	RANGE MI	RANGE-RATE FT/SEC	AZ DEG	AZ-DOT DEG/SEC	EL DEG	EL-DOT DEG/SEC	ASPECT DEG	GR RANGE N MI
[illegible]	[illegible]	[illegible]	152.5393	-0.6710	-1.4854	4.3560	94.76	0.84
[illegible]	[illegible]	[illegible]	152.1121	-2.0799	1.5312	14.6435	97.85	0.84
[illegible]	[illegible]	[illegible]	150.5158	-4.3121	12.4569	28.1681	109.21	0.84
[illegible]	[illegible]	[illegible]	147.8265	-6.3984	28.3446	33.3316	125.36	0.84
[illegible]	[illegible]	[illegible]	144.3023	-7.3719	43.5108	25.5834	140.87	0.84
[illegible]	[illegible]	[illegible]	141.4471	-6.7512	51.8877	16.5715	149.52	0.59
[illegible]	[illegible]	[illegible]	141.4471	-6.7512	51.8877	16.5715	149.52	0.59
[illegible]	[illegible]	[illegible]	140.7645	-6.5411	53.4630	14.9523	151.16	0.59
[illegible]	[illegible]	[illegible]	137.7610	-5.6052	59.3378	9.1636	157.33	0.84
[illegible]	[illegible]	[illegible]	135.1505	-4.8359	63.5680	6.3640	161.34	0.84
[illegible]	[illegible]	[illegible]	132.8969	-4.2040	65.6038	4.2517	164.13	0.59
[illegible]	[illegible]	[illegible]	130.9289	-3.6807	67.4315	3.1140	166.19	0.84
[illegible]	[illegible]	[illegible]	129.2014	-3.2447	68.7878	2.3587	167.77	0.84
[illegible]	[illegible]	[illegible]	129.2014	-3.2447	68.7878	2.3587	167.77	0.84
[illegible]	[illegible]	[illegible]	127.6551	-2.9636	69.8413	1.3858	169.03	0.84
[illegible]	[illegible]	[illegible]	126.2341	-2.7339	70.6947	1.5423	170.09	0.59
[illegible]	[illegible]	[illegible]	124.9133	-2.5274	71.3958	1.2771	170.99	0.84
[illegible]	[illegible]	[illegible]	123.7012	-2.3452	71.9804	1.0702	171.76	0.84
[illegible]	[illegible]	[illegible]	122.5674	-2.1900	72.4736	0.9072	172.44	0.94
[illegible]	[illegible]	[illegible]	121.5007	-2.0498	72.8929	0.7749	173.03	0.94
[illegible]	[illegible]	[illegible]	120.5147	-1.9220	73.2527	0.6655	173.57	0.84
[illegible]	[illegible]	[illegible]	119.5830	-1.8054	73.5612	0.5742	174.04	0.94
[illegible]	[illegible]	[illegible]	118.7075	-1.6979	73.8285	0.4969	174.47	0.94
[illegible]	[illegible]	[illegible]	117.8852	-1.5979	74.0602	0.4308	174.85	0.94
[illegible]	[illegible]	[illegible]	117.1096	-1.5045	74.2611	0.3738	175.20	0.94
[illegible]	[illegible]	[illegible]	116.3795	-1.4178	74.4355	0.3244	175.52	0.94
[illegible]	[illegible]	[illegible]	115.6902	-1.3367	74.5868	0.2814	175.81	0.94
[illegible]	[illegible]	[illegible]	115.0372	-1.2611	74.7173	0.2439	176.07	0.94
[illegible]	[illegible]	[illegible]	114.4243	-1.1909	74.8308	0.2108	176.31	0.94
[illegible]	[illegible]	[illegible]	113.8496	-1.1257	74.9298	0.1817	176.53	0.94
[illegible]	[illegible]	[illegible]	113.3024	-1.0650	75.0135	0.1559	176.73	1.11
[illegible]	[illegible]	[illegible]	112.7850	-1.0083	75.0856	0.1329	176.92	1.11
[illegible]	[illegible]	[illegible]	112.2950	-0.9550	75.1471	0.1124	177.09	1.11
[illegible]	[illegible]	[illegible]	111.8209	-0.9045	75.1979	0.0941	177.24	1.26
[illegible]	[illegible]	[illegible]	111.3409	-0.8572	75.2410	0.0775	177.38	1.26
[illegible]	[illegible]	[illegible]	110.9110	-0.8126	75.2760	0.0627	177.51	1.33
[illegible]	[illegible]	[illegible]	110.5749	-0.7708	75.3040	0.0493	177.63	1.26
[illegible]	[illegible]	[illegible]	110.2704	-0.7316	75.3258	0.0372	177.73	1.33
[illegible]	[illegible]	[illegible]	109.9436	-0.6947	75.3416	0.0262	177.83	1.45
[illegible]	[illegible]	[illegible]	109.5749	-0.6600	75.3518	0.0163	177.91	1.45
[illegible]	[illegible]	[illegible]	109.1322	-0.6274	75.3578	0.0073	177.99	1.45
[illegible]	[illegible]	[illegible]	108.3766	-0.5968	75.3594	-0.0008	178.06	1.51
[illegible]	[illegible]	[illegible]	[illegible].3356	-0.5680	75.3572	-0.0083	178.12	1.51
[illegible]	[illegible]	[illegible]	[illegible].3091	-0.5410	75.3513	-0.0150	178.17	1.53
[illegible]	[illegible]	[illegible]	[illegible].3442	-0.5154	75.3420	-0.0212	178.22	1.53

SI [illegible]-AEROBEE SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
50 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO.

PAGE 2H

TRACKING STATION NAME - FPS-16

LATITUDE = 37.44131 DEG LONGITUDE = -75.48509 DEG ALTITUDE = 53.73 FT

TIME SEC	RANGE N MI	RANGE-RATE FT/SEC	AZ DEG	AZ-DOT DEG/SEC	EL DEG	EL-DOT DEG/SEC	ASPECT DEG	GR RANGE N MI
2[illegible]	6.[illegible]58	2642.7	107.7327	-0.4913	75.3301	-0.0248	178.26	1.63
24.5	6.282	2754.3	107.5528	-0.4685	75.3153	-0.0320	178.30	1.78
24.[illegible]	6.512	2816.7	107.3237	-0.4471	75.2932	-0.0367	178.33	1.78
25.5	6.746	2941.[illegible]	107.1064	-0.4269	75.2789	-0.0410	178.35	1.88
26.[illegible]	6.984	2948.9	106.8975	-0.4077	75.2574	-0.0449	178.37	1.88
26.5	7.231	3014.2	106.6977	-0.3896	75.2339	-0.0485	178.39	2.01
27.[illegible]	[illegible]	[illegible]	106.5178	-0.3725	75.2044	-0.0513	178.42	2.01
27.5	[illegible]	[illegible]	[illegible]	-0.3562	75.1821	-0.0538	178.42	2.10
28.[illegible]	[illegible]	[illegible]	106.1519	-0.3409	75.1562	-0.0575	178.42	2.14
28.5	8.[illegible]	3249.5	105.9840	-0.3262	75.1249	-0.0600	178.43	2.22
29.[illegible]	8.544	3317.[illegible]	105.8247	-0.3124	75.0943	-0.0623	178.44	2.34
29.5	8.825	3381.3	105.6715	-0.2992	75.0624	-0.0644	178.44	2.34
30.[illegible]	9.112	3527.6	105.5249	-0.2866	75.0298	-0.0662	178.44	2.45
30.5	[illegible]	3[illegible]	105.3849	-0.2748	74.9962	-0.0680	178.44	2.52
31.[illegible]	9.7[illegible]	3492.5	105.2503	-0.2635	74.9620	-0.0695	178.44	2.55
31.5	10.014	3777.7	105.1214	-0.2528	74.9269	-0.0709	178.44	2.72
32.[illegible]	10.3[illegible]	3853.5	104.9977	-0.2427	74.8911	-0.0722	178.44	2.79
32.5	10.[illegible]	3955.3	104.8797	-0.2330	74.8545	-0.0734	178.44	2.82
33.[illegible]	10.979	4[illegible]	104.7647	-0.2239	74.8176	-0.0744	178.44	2.94
33.5	11.316	4144.5	104.6549	-0.2151	74.7801	-0.0754	178.44	3.03
34.[illegible]	11.6[illegible]	42[illegible]2.8	104.5493	-0.2068	74.7423	-0.0762	178.44	3.11
34.5	12.[illegible]15	43[illegible]7	104.4490	-0.1989	74.7040	-0.0770	178.43	3.20
35.[illegible]	12.376	44[illegible]7.3	104.3505	-0.1913	74.6652	-0.0776	178.43	3.33
35.5	12.747	455[illegible].8	104.2568	-0.1839	74.6263	-0.0781	178.43	3.46
36.[illegible]	13.125	4643.5	104.1666	-0.1764	74.5872	-0.0784	178.43	3.54
36.5	13.51[illegible]	4712.1	104.0805	-0.1683	74.5481	-0.0781	178.43	3.66
37.[illegible]	13.9[illegible]	4747.5	103.9985	-0.1596	74.5092	-0.0773	178.43	3.78
37.5	14.[illegible]21	4754.7	103.9210	-0.1507	74.4709	-0.0762	178.43	3.85
38.[illegible]	14.[illegible]32	47[illegible].4	103.8475	-0.1419	74.4330	-0.0747	178.42	3.96
38.5	14.882	4741.4	103.8475	-0.1419	74.4330	-0.0747	178.42	3.96
39.[illegible]	15.473	4537.9	103.3049	-0.0827	74.0963	-0.0619	178.81	5.06
4[illegible]	25.[illegible]	42[illegible].3	102.7512	-0.0370	73.5288	-0.0541	179.40	7.25
4[illegible]	32.353	3922.7	102.4778	-0.0199	72.9853	-0.0552	179.70	9.40
4[illegible]	38.534	3[illegible].9	102.3240	-0.0117	72.4177	-0.0585	179.26	11.51
4[illegible]	44.219	3[illegible].3	102.2324	-0.0071	71.8129	-0.0626	178.64	13.63
5[illegible]	49.419	3[illegible].3	102.1770	-0.0042	71.1643	-0.0672	177.97	15.73
5[illegible]	54.13[illegible]	2700.9	102.1444	-0.0024	70.4671	-0.0723	177.24	17.81
5[illegible]	5[illegible].391	2[illegible]	102.1270	-0.0012	69.7157	-0.0780	176.46	19.90
6[illegible]	62.154	2151.[illegible]	102.1200	-0.0003	68.9042	-0.0844	175.62	21.98
6[illegible]	65.4[illegible]3	1871.1	102.1205	0.0003	68.0253	-0.0915	174.71	24.04
6[illegible]	68.3[illegible]5	1535.6	102.1264	0.0008	67.0711	-0.0995	173.72	26.10
6[illegible]	70.718	1324.2	102.1362	0.0011	65.0320	-0.1085	172.65	28.16
7[illegible]	73.[illegible]	1[illegible].5	102.1489	0.0014	64.3977	-0.1187	171.48	30.22
7[illegible]	74.21[illegible]	[illegible].7	102.1637	0.0016	63.6532	-0.1303	170.20	32.28
7[illegible]	75.235	577.[illegible]	102.1794	0.0017	62.4256	-0.1421	168.95	34.13

SI-EATLER-[illegible] SPC [illegible] ROCKET, WALLOPS ISLAND LAUNCH
[illegible] DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

TRACKING STATION NAME - FPQ-6

LATITUDE = [illegible] DEG LONGITUDE = -75.50931 DEG ALTITUDE = 61.18 FT

TIME SEC	RANGE N MI	RANGE-RATE FT/SEC	AZ DEG	AZ-DOT DEG/SEC	EL DEG	EL-DOT DEG/SEC	ASPECT DEG	GR RANGE N MI
[illegible]	[illegible]	[illegible]	136.7514	-0.0618	-0.2377	0.5984	97.92	1.92
[illegible]	[illegible]	[illegible]	136.7120	-0.1935	0.1353	1.8226	98.36	1.92
[illegible]	[illegible]	[illegible]	136.5602	-0.4170	1.5461	3.8238	100.19	1.92
[illegible]	[illegible]	[illegible]	136.2412	-0.6643	3.9895	5.9099	102.74	2.01
[illegible]	[illegible]	[illegible]	135.9362	-0.8491	7.4133	7.4567	106.29	2.01
[illegible]	[illegible]	[illegible]	135.5615	-0.8543	10.3987	7.3212	109.36	2.10
[illegible]	[illegible]	[illegible]	135.5615	-0.8543	10.3987	7.3212	109.36	2.10
[illegible]	[illegible]	[illegible]	135.4768	-0.8471	11.1252	7.2098	110.11	2.01
[illegible]	[illegible]	[illegible]	135.0629	-0.8127	14.5919	6.6573	113.49	2.10
[illegible]	[illegible]	[illegible]	134.5634	-0.7807	17.7851	6.1234	117.00	2.10
[illegible]	[illegible]	[illegible]	134.2808	-0.7510	20.7192	5.6175	120.05	2.10
[illegible]	[illegible]	[illegible]	133.9125	-0.7233	23.4090	5.1453	122.86	2.10
[illegible]	[illegible]	[illegible]	133.5574	-0.6974	25.8708	4.7092	125.45	2.10
[illegible]	[illegible]	[illegible]	133.5574	-0.6974	25.8708	4.7092	125.45	2.10
[illegible]	[illegible]	[illegible]	133.2107	-0.6937	28.1533	4.4397	127.86	2.10
[illegible]	[illegible]	[illegible]	132.8633	-0.6954	30.3151	4.2109	130.15	2.14
[illegible]	[illegible]	[illegible]	132.5149	-0.6973	32.3650	3.9894	132.33	2.14
[illegible]	[illegible]	[illegible]	132.1557	-0.7006	34.3069	3.7832	134.40	2.14
[illegible]	[illegible]	[illegible]	131.8139	-0.7065	36.1519	3.5980	136.37	2.22
[illegible]	[illegible]	[illegible]	131.4593	-0.7134	37.9068	3.4234	138.26	2.22
[illegible]	[illegible]	[illegible]	131.1003	-0.7206	39.5767	3.2570	140.05	2.22
[illegible]	[illegible]	[illegible]	130.7380	-0.7281	41.1655	3.0987	141.77	2.26
[illegible]	[illegible]	[illegible]	130.3721	-0.7355	42.6761	2.7468	143.40	2.26
[illegible]	[illegible]	[illegible]	130.0031	-0.7424	44.1127	2.7999	144.96	2.26
[illegible]	[illegible]	[illegible]	129.6303	-0.7487	45.4775	2.6587	146.45	2.34
[illegible]	[illegible]	[illegible]	129.2541	-0.7545	46.7726	2.5235	147.87	2.41
[illegible]	[illegible]	[illegible]	128.8758	-0.7597	48.0019	2.3942	149.22	2.41
[illegible]	[illegible]	[illegible]	128.4945	-0.7643	49.1675	2.2708	150.50	2.45
[illegible]	[illegible]	[illegible]	128.1116	-0.7685	50.2734	2.1537	151.73	2.45
[illegible]	[illegible]	[illegible]	127.7263	-0.7723	51.3223	2.0431	152.90	2.52
[illegible]	[illegible]	[illegible]	127.3392	-0.7758	52.3177	1.9384	154.01	2.52
[illegible]	[illegible]	[illegible]	126.9509	-0.7787	53.2618	1.8392	155.07	2.52
[illegible]	[illegible]	[illegible]	126.5614	-0.7808	54.1579	1.7445	156.08	2.55
[illegible]	[illegible]	[illegible]	126.1697	-0.7821	55.0071	1.6549	157.04	2.62
[illegible]	[illegible]	[illegible]	125.7735	-0.7825	55.8132	1.5694	157.96	2.69
[illegible]	[illegible]	[illegible]	125.3774	-0.7823	56.5775	1.4883	158.83	2.69
[illegible]	[illegible]	[illegible]	124.9965	-0.7814	57.3022	1.4115	159.67	2.72
[illegible]	[illegible]	[illegible]	124.6156	-0.7799	57.9898	1.3388	160.47	2.79
[illegible]	[illegible]	[illegible]	124.2169	-0.7777	58.6419	1.2701	161.23	2.79
[illegible]	[illegible]	[illegible]	123.8233	-0.7750	59.2614	1.2052	161.95	2.88
[illegible]	[illegible]	[illegible]	123.4415	-0.7718	59.8475	1.1440	162.64	2.94
[illegible]	[illegible]	[illegible]	123.0569	-0.7681	60.4050	1.0861	163.30	2.94
[illegible]	[illegible]	[illegible]	122.6737	-0.7640	60.9343	1.0314	163.94	2.97
[illegible]	[illegible]	[illegible]	122.2932	-0.7594	61.4377	0.9798	164.54	3.03
[illegible]	[illegible]	[illegible]	121.9143	-0.7543	61.9144	0.9311	165.12	3.06

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SITE NIKE-ARCAS SOUNDING ROCKET, WALLOPS ISLAND LAUNCH
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

TRACKING STATION NAME - FPQ-6

LATITUDE = 37.36323 DEG LONGITUDE = -75.50931 DEG ALTITUDE = 61.18 FT

TIME SEC	RANGE N MI	RANGE-RATE FT/SEC	AZ DEG	AZ-DOT DEG/SEC	EL DEG	EL-DOT DEG/SEC	ASPECT DEG	GR RANGE N MI
21.00	6.613	2611.1	121.5382	-0.7488	62.3684	0.8850	165.67	3.17
21.50	6.830	2675.7	121.1656	-0.7429	62.7999	0.8413	166.20	3.20
22.00	7.053	2742.4	120.7956	-0.7366	63.2101	0.8000	166.71	3.25
22.50	7.282	2811.5	120.4295	-0.7300	63.6003	0.7610	167.19	3.33
23.00	7.518	2883.0	120.0661	-0.7230	63.9715	0.7240	167.66	3.39
23.50	7.756	2956.7	119.7061	-0.7157	64.3245	0.6891	168.11	3.41
24.00	8.001	3032.5	119.3505	-0.7082	64.6608	0.6559	168.53	3.46
24.50	8.253	3109.3	118.9983	-0.7004	64.9809	0.6245	168.94	3.54
25.00	8.511	3187.3	118.6499	-0.6923	65.2856	0.5947	169.34	3.61
25.50	8.775	3267.7	118.3058	-0.6839	65.5760	0.5665	169.72	3.66
26.00	9.045	3348.4	117.9662	-0.6753	65.8524	0.5396	170.08	3.73
26.50	9.322	3430.5	117.6305	-0.6665	66.1156	0.5141	170.43	3.80
27.00	9.605	3513.1	117.2993	-0.6574	66.3666	0.4899	170.76	3.92
27.50	9.894	3597.5	116.9732	-0.6483	66.6058	0.4669	171.09	3.98
28.00	10.193	3682.3	116.6512	-0.6391	66.8337	0.4451	171.40	4.07
28.50	10.497	3769.5	116.3341	-0.6298	67.0511	0.4244	171.69	4.09
29.00	10.809	3857.2	116.0216	-0.6206	67.2584	0.4049	171.98	4.24
29.50	11.128	3946.3	115.7136	-0.6113	67.4560	0.3863	172.26	4.30
30.00	11.454	4036.9	115.4103	-0.6020	67.6447	0.3686	172.52	4.40
30.50	11.788	4128.1	115.1116	-0.5926	67.8248	0.3518	172.78	4.46
31.00	12.131	4219.9	114.8176	-0.5832	67.9967	0.3358	173.02	4.58
31.50	12.482	4312.3	114.5283	-0.5738	68.1607	0.3206	173.26	4.68
32.00	12.841	4405.3	114.2437	-0.5644	68.3172	0.3061	173.49	4.77
32.50	13.209	4498.1	113.9641	-0.5546	68.4668	0.2921	173.71	4.86
33.00	13.586	4591.1	113.6893	-0.5433	68.6094	0.2779	173.92	4.97
33.50	13.964	4683.1	113.4212	-0.5293	68.7447	0.2631	174.13	5.06
34.00	14.337	4775.7	113.1608	-0.5121	68.8723	0.2474	174.32	5.19
34.50	14.744	4734.7	112.9075	-0.4927	68.9921	0.2314	174.51	5.29
35.00	15.135	4723.4	112.6683	-0.4724	69.1038	0.2158	174.68	5.41
35.50	15.135	4723.4	112.6683	-0.4724	69.1038	0.2158	174.63	5.41
36.97	16.316	4523.7	110.7415	-0.3182	69.8865	0.1129	175.71	6.48
50.00	28.127	4207.2	108.3933	-0.1724	70.5275	0.0290	176.69	8.65
60.00	32.795	3975.9	107.0291	-0.1079	70.6174	-0.0070	177.01	10.78
70.00	38.977	3607.6	106.1389	-0.0734	70.4388	-0.0272	176.98	12.91
80.00	44.470	3312.6	105.5165	-0.0527	70.0957	-0.0407	176.73	15.00
90.00	49.863	3021.3	105.0573	-0.0394	69.6342	-0.0512	176.31	17.10
100.00	54.615	2737.8	104.7142	-0.0303	69.0762	-0.0602	175.77	19.19
110.00	58.873	2464.5	104.4449	-0.0239	68.4318	-0.0686	175.12	21.27
120.00	62.663	2201.7	104.2312	-0.0191	67.7043	-0.0769	174.38	23.34
130.00	65.990	1952.3	104.0586	-0.0155	66.8926	-0.0855	173.55	25.41
140.00	68.863	1718.4	103.9176	-0.0128	65.9928	-0.0946	172.63	27.48
150.00	71.287	1499.1	103.8011	-0.0106	64.9981	-0.1045	171.61	29.53
160.00	73.274	1295.4	103.7040	-0.0089	63.8999	-0.1154	170.49	31.59
170.00	74.832	1106.4	103.6224	-0.0075	62.6866	-0.1275	169.25	33.65
179.92	75.891	945.7	103.5597	-0.0064	61.4623	-0.1397	168.02	35.50

ARCAS SPENT-STAGE TRAJECTORY
80 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

TRACKING STATION NAME - FPS-16

LATITUDE = 37.84131 DEG LONGITUDE = -75.48509 DEG ALTITUDE = 53.73 FT

TIME SEC	RANGE N MI	RANGE-RATE FT/SEC	AZ DEG	AZ-DOT DEG/SEC	EL DEG	EL-DOT DEG/SEC	ASPECT DEG	GR RANGE N MI
179.02	75.235	577.0	102.1745	0.0017	62.4264	-0.1421	168.95	34.12
179.98	75.324	553.5	102.1761	0.0017	62.2896	-0.1435	144.20	34.32
190.00	76.037	312.8	102.1939	0.0018	60.7773	-0.1586	103.73	36.38
200.00	76.362	84.2	102.2122	0.0019	59.1060	-0.1760	93.37	38.44
210.00	76.322	-130.2	102.2311	0.0019	57.2483	-0.1960	85.30	40.49
220.00	75.943	-327.4	102.2501	0.0019	55.1757	-0.2191	79.[illegible]8	42.56
230.00	75.256	-503.3	102.2691	0.0019	52.8553	-0.2457	75.60	44.63
240.00	74.301	-652.8	102.2880	0.0019	50.2497	-0.2764	73.31	46.70
250.00	73.125	-769.5	102.3066	0.0018	47.3126	-0.3117	72.33	48.78
260.00	71.790	-845.5	102.3248	0.0018	43.9989	-0.3519	72.48	50.87
270.00	70.370	-871.3	102.3425	0.0017	40.2569	-0.3973	73.62	52.97
280.00	68.956	-835.5	102.3597	0.0017	36.0364	-0.4475	75.67	55.08
290.00	67.661	-725.6	102.3762	0.0016	31.2969	-0.5010	78.58	57.21
300.00	66.615	-529.4	102.3920	0.0015	26.0154	-0.5547	82.30	59.34
310.00	65.970	-239.3	102.4070	0.0014	20.2242	-0.6011	86.74	61.49
320.00	65.870	122.0	102.4208	0.0013	14.1127	-0.6083	91.64	63.57
330.00	66.297	335.2	102.4318	0.0009	8.5848	-0.4601	95.91	65.35
340.00	66.763	208.8	102.4377	0.0004	5.2281	-0.2297	97.31	66.36
350.00	67.004	98.4	102.4401	0.0002	3.5053	-0.1335	95.91	66.79
360.00	67.118	46.5	102.4411	0.0001	2.3583	-0.1011	93.69	67.00
370.00	67.171	20.9	102.4415	0.0000	1.4258	-0.0868	91.93	67.11
380.00	67.194	8.9	102.4416	-0.0000	0.6062	-0.0775	90.90	67.17
390.00	67.204	4.3	102.4415	-0.0000	-0.1326	-0.0705	90.49	67.20
396.31	67.209	3.8	102.4414	-0.0000	-0.5659	-0.0670	90.45	67.21

ARCAS SPENT-STAGE TRAJECTORY
90 DEG LAUNCH ELEVATION ANGLE, 12 LB PAYLOAD

LTV AEROSPACE CORP.-MSD
ROUTINE NO. LVVC27
PROBLEM NO. 1

TRACKING STATION NAME - FPQ-6

LATITUDE = 37.96023 DEG LONGITUDE = -75.50931 DEG ALTITUDE = 61.18 FT

TIME SEC	RANGE N MI	RANGE-RATE FT/SEC	AZ DEG	AZ-DOT DEG/SEC	EL DEG	EL-DOT DEG/SEC	ASPECT DEG	GR RANGE N MI
179.02	75.881	595.0	103.5560	-0.0064	61.4832	-0.1397	168.02	35.50
179.98	75.972	571.7	103.5499	-0.0063	61.3487	-0.1411	145.11	35.69
190.00	76.717	332.7	103.4913	-0.0054	59.8584	-0.1566	104.62	37.75
200.00	77.076	105.9	103.4413	-0.0046	58.2063	-0.1742	94.25	39.81
210.00	77.073	-106.5	103.3934	-0.0040	56.3661	-0.1943	86.16	41.87
220.00	76.735	-301.5	103.3614	-0.0034	54.3105	-0.2174	80.32	43.93
230.00	76.093	-475.1	103.3293	-0.0030	52.0076	-0.2438	76.42	46.00
240.00	75.186	-622.1	103.3013	-0.0026	49.4207	-0.2742	74.11	48.07
250.00	74.063	-736.5	103.2768	-0.0023	46.5082	-0.3090	73.11	50.15
260.00	72.784	-810.3	103.2551	-0.0020	43.2246	-0.3485	73.23	52.24
270.00	71.423	-834.3	103.2360	-0.0018	39.5215	-0.3929	74.33	54.34
280.00	70.071	-797.6	103.2188	-0.0016	35.3523	-0.4416	76.33	56.46
290.00	68.837	-688.3	103.2033	-0.0015	30.6796	-0.4934	79.18	58.58
300.00	67.852	-494.6	103.1892	-0.0013	25.4832	-0.5453	82.81	60.71
310.00	67.260	-209.5	103.1763	-0.0012	19.7961	-0.5898	87.14	62.85
320.00	67.202	143.3	103.1646	-0.0011	13.8035	-0.5962	91.93	64.94
330.00	67.655	345.0	103.1551	-0.0007	8.3876	-0.4507	96.09	66.73
340.00	68.131	211.8	103.1500	-0.0003	5.0992	-0.2250	97.42	67.73
350.00	68.375	99.5	103.1477	-0.0002	3.4113	-0.1308	95.99	68.16
360.00	68.490	47.1	103.1465	-0.0001	2.2874	-0.0991	93.74	68.37
370.00	68.544	21.2	103.1458	-0.0001	1.3735	-0.0851	91.96	68.48
380.00	68.568	8.9	103.1452	-0.0000	0.5704	-0.0760	90.92	68.54
390.00	68.578	4.3	103.1448	-0.0000	-0.1536	-0.0691	90.48	68.58
396.31	68.582	3.7	103.1446	-0.0000	-0.5783	-0.0656	90.44	68.59