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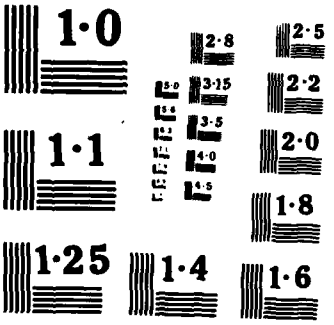
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THESIS

DISPERSION SENSITIVITY OF THE EIGHT INCH
ADVANCED RAMJET MUNITIONS TECHNOLOGY
PROJECTILE DUE TO WIND
AND MINOR THRUST ERRORS

by

Steven Ronald Poole

September 1984

Thesis Advisor: A. E. Fuhs

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Defence Advanced Research
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Advanced Ramjet Munitions Technology (ARMT) is an ongoing project within the Defense Advanced Research Projects Agency (DARPA) to research ramjet munitions. The ARMT eight inch projectile uses ramjet thrust for a boosted trajectory, but operates on a thrust drag balance concept to create a pseudo-vacuum trajectory during powered flight. The trajectory was

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analysed using an IBM-370 computer simulation for three and five degrees of freedom. Work was also done to adapt the Ballistics Research Laboratories six degrees of freedom program to the IBM system. Projectile aerodynamic and mass properties were obtained from the Norden Systems Wind Tunnel Data. Dispersion from the vacuum trajectory due to wind prior to ramjet burnout proved minor. Dispersion due to constant thrust errors under 5% was within a 600 foot radius at terminal guidance over a range of 33 miles.

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Dispersion Sensitivity of the Eight Inch Advanced Ramjet Munitions Technology Projectile Due to Wind and Minor Thrust Errors

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

Advanced Ramjet Munitions Technology (ARMT) is an ongoing project within the Defence Advanced Research Projects Agency (DARPA) to research ramjet munitions.The ARMT eight inch projectile uses ramjet thrust for a boosted trajectory, but operates on a thrust drag balance concept to create a pseudo vacuum trajectory during powered flight.The trajectory was analyzed using an IBM 370 computer simulation for three and five degrees of freedom. Work was also done to adapt the Ballistics Research Laboratories six degrees of freedom program to the IBM system.Projectile aerodynamic and mass properties were obtained from the Norden Systems Wind Tunnel Data. Dispersion from the vacuum trajectory due to wind prior to ramjet burnout proved minor.Dispersion due to constant thrust errors under 5% was within a 600 foot radius at terminal guidance over a range of 33 miles.

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TABLE OF SYMBOLS AND ABBREVIATIONS

ABBREVIATIONS:

AIFS -ADVANCED INDIRECT FIRE SYSTEM

ARMT -ADVANCED RAMJET MUNITIONS TECHNOLOGY

BRL -BALLISTICS RESEARCH LABORATORY

IODE -INTERACTIVE ORDINARY DIFFERENTIAL EQUATION SOLVER

NPGS -NAVAL POSTGRADUATE SCHOOL

SYMBOLS:

FORMULA	PROGRAMS	DESCRIPTION	UNITS
α	A	angle of attack	radians
β	B	sideslip angle	radians
δ	DE	angle between body axis and inertial axis (yaw plane)	radians
γ	GA	angle between inertial axis and relative wind,yaw plane	radians
λ	LAMBDA	wavelength	feet
ρ	RO	air density	$lbf\text{-}s^2/ft^4$
ω	-	angular velocity	rads/sec
Ω	O	angle between relative wind and inertial axis (pitch plane)	radians
θ	THE	angle between body axis and inertial axis(yaw)	radians
C_d	CD	drag coefficient	

C_{do}	CDO	zero lift drag coefficient	
C_l	CL	lift coefficient	
C_{l_α}		slope lift coefficient	
C_m	CM	moment coefficient	
C_{m_α}	CMA	slope moment coefficient	
C_{mq}	CMT	damping coefficient	
Xcp		centre of pressure location(from spike)	inches
Xcg		centre of gravity location(from spike)	inches
C	C	thrust error coefficient	
d	DI	projectile diameter	inches
D	DRAG	Drag	lbf
Dw		Drag due to wind	lbf
f		frequency	Hz
g	G	gravity	ft/sec
I	I	moment of inertia	slug-ft
Isp	ISP	specific impulse	"sec"
L	L	lift	lbf
Lw		net lift due to transients	lbf
m	M	mass	lbm
q	Q	dynamic pressure	lbf/ft^2-s^2
U	V	relative wind	ft/sec
V		initial velocity projectile	ft/sec

Vcg	VCG	centre of gravity velocity	ft/sec
Vw	VW (3 deg) VWXY(5 deg) VWXZ(5deg)	wind velocity	ft/sec
Vwo		initial wind speed	ft/sec
X	X	range	ft
Y	Y	crossrange	ft
Z	Z	height	ft

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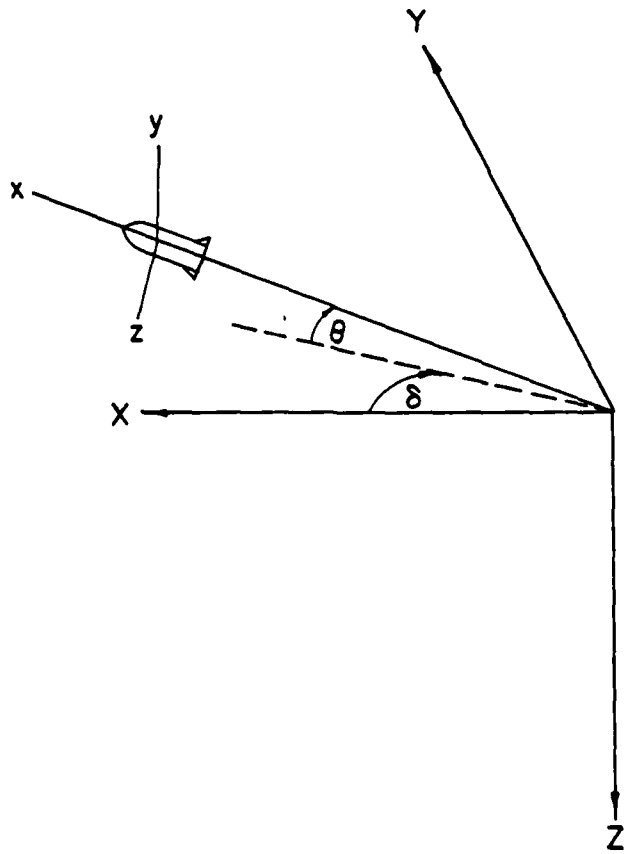

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I would be remiss if I did not thank my wife, Marie Josee, and my two children,Crista and Eric, for helping create the atmosphere I needed to succeed in the academic environment.

I. INTRODUCTION

A. ARMT OPERATIONAL CONCEPT

Conventional artillery uses unguided projectiles to destroy a variety of targets including armored vehicles. Ballistic information and professional experience are used to direct fire onto a target with little chance of a direct hit in the first few rounds. A forward observer provides feedback to the guns for correction until the target is destroyed with subsequent rounds.Generally this approach is limited to the 30 kilometer range and often point target locations are not known.

The ARMT projectile,formerly called AIFS, changes the conventional concept by providing a fire and forget,boosted and terminally guided projectile with a highly predictable trajectory.Conventional heat seekers and target identification systems are short range and require a blunt nose which has high drag. Active radar is not practical. Long ranges of 60 kilometers are achieved by using solid fuel ramjet propulsion with an axisymmetric air inlet spike. An accurately predicted trajectory is achieved by ensuring thrust equals drag to produce zero axial acceleration and create a pseudo-vacuum trajectory during powered flight. At a preset time (near ideal condition ramjet burnout) the inlet spike is discarded and canards are deployed for

terminal guidance control. A passive or reflected target energy system will be used for terminal guidance. Research is ongoing and sponsored by DARPA. Projectile characteristics are at Appendix A.

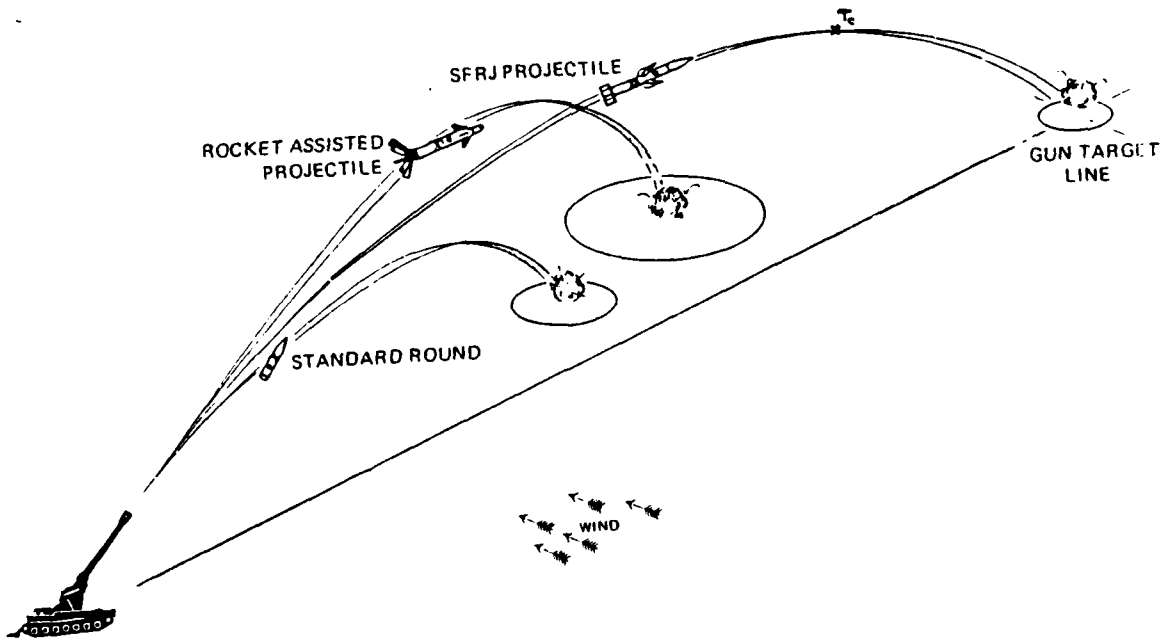

Figure 1-1 ARMT Trajectory Concept

B. THRUST DRAG BALANCE CONCEPT

Balanced thrust drag implies that the thrust equals the drag vectors during powered flight. The aim of the balance is to negate meteorological variations throughout the trajectory by reducing all force vectors to zero except gravity. The resulting pseudo-vacuum trajectory is highly predictable. The balance is accomplished by measuring axial acceleration and maintaining it at zero.Appendix B explores this concept in detail. The potential errors include transients due to wind induced reactions and measurement errors in the technical application of the balance in flight. Further, any asymmetries such as aerodynamic misalignment or thrust will produce a lateral force which must be offset by a small roll rate(sixth degree of freedom). This allows longitudinal forces to be the significant forces.

The concept of thrust drag balance is best demonstrated in Figures 1-2 and 1-3.In Figure 1-2 the centre of gravity of the projectile is flying at an angle of attack (alpha) with a velocity vector (Vcg) relative to a fixed earth reference frame. The aerodynamic forces are lift(L) and drag(D). Assuming static static stability and neglecting transient dynamics, the angle of attack becomes zero, which

reduces lift to zero.If thrust equals drag then only the gravitational force exists.

If a crosswind(Vw) is applied, the projectile cocks into the wind because of the aerodynamic force acting on the centre of pressure. Adjusting the thrust and again assuming static stability the drag can be offset as shown in Figure 1-3 by applying the correct thrust.For future reference the component of drag normal to the plane containing Vcg is Dw.

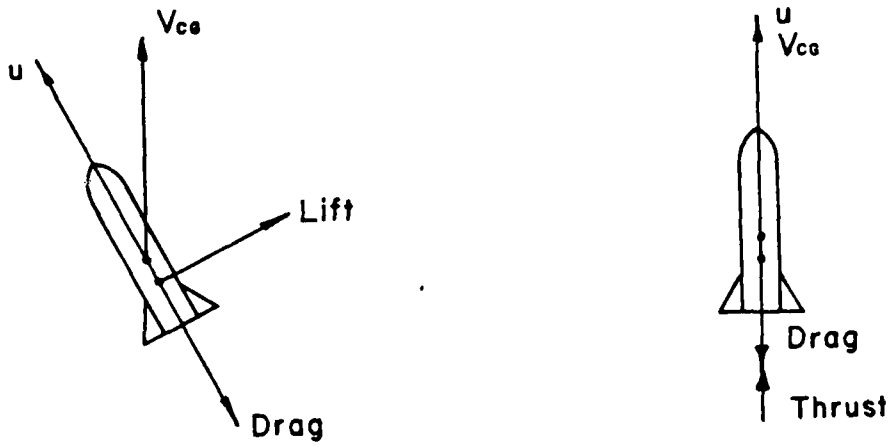

Figure 1-2 Projectile Dynamics Thrust Equals Drag

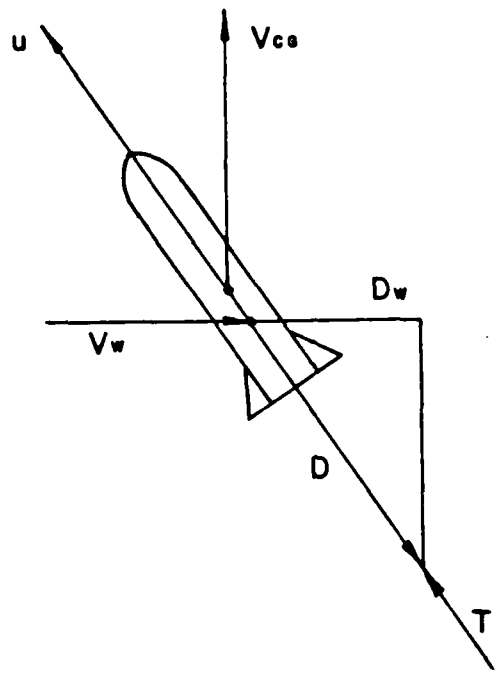

Figure 1-3 Projectile Dynamics With Crosswind

If a tailwind or headwind is applied, thrust is adjusted to compensate in the same manner.

The dynamics or transient effects due to wind which create damped oscillatory motion have a cumulative net lift effect(as shown in Figure 1-4) as angle of attack is proportional to lift.The area under the curve in Figure 1-4

does not average to zero due to the damping. For future reference this lift due to wind will be referred to as Lw.

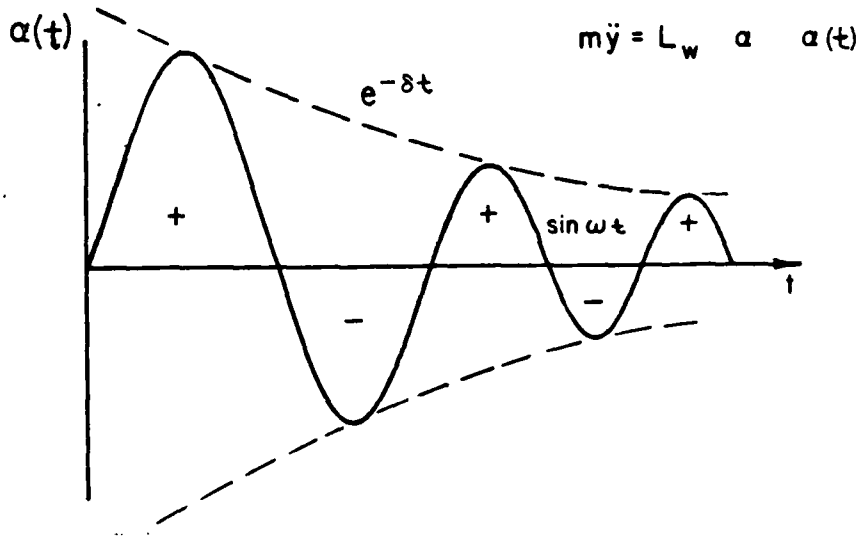

Figure 1-4 Angle Of Attack Versus Time

Calculations integrating alpha(t) twice to demonstrate the above in the yaw or pitch plane are at Appendix B.

C. THESIS SCOPE

It is emphasized that the scope of this thesis is to analyze dispersion from the pseudo-vacuum trajectory at terminal guidance time for the eight inch ARMT projectile.In colloquial terms the "basket " from which the projectile will be guided to target was determined. Further, this basket is based on thrust errors and wind effects for a

launch angle of 45 degrees and muzzle velocity of MACH 2.2 at sea level. Linearized aerodynamics were used in all calculations. No attempt was made to establish a "footprint" for projectile impact.

II. TRAJECTORY ANALYSIS METHODOLOGY

A. VACUUM TRAJECTORY ANALYSIS

A short and simple BASIC program was written to establish the vacuum trajectory and fuel burn time of the projectile in a two dimensional scenario where thrust exactly equaled drag. The Standard U.S. Atmosphere was used and the drag coefficient linearized [Reference 1]. The program listing and baseline data are at Appendix D. The key parameters and equations used are listed at Appendices A and D.The baseline pseudo-vacuum trajectory is shown in Figure 2-1.

B. THREE-DEGREES-OF-FREEDOM MODEL

The computer simulation was established using the Interactive Ordinary Differential Equation (IODE) library program at NPGS. A listing of the three degrees of freedom equations is in the IODE specifications at Appendix E. The simulation is based on wind tunnel results from Norden Systems [References 2 and 3] and assumes a horizontal plane at 30000 feet altitude.This height was chosen as significant flight time is at altitude and the time of flight in this plane was near actual flight time. Primarily the model was used to study crosswind effects but resonance with the projectile short period was simulated. Different thrust

scenarios were also used. Figure 2-2 depicts the model in the X-Y plane.

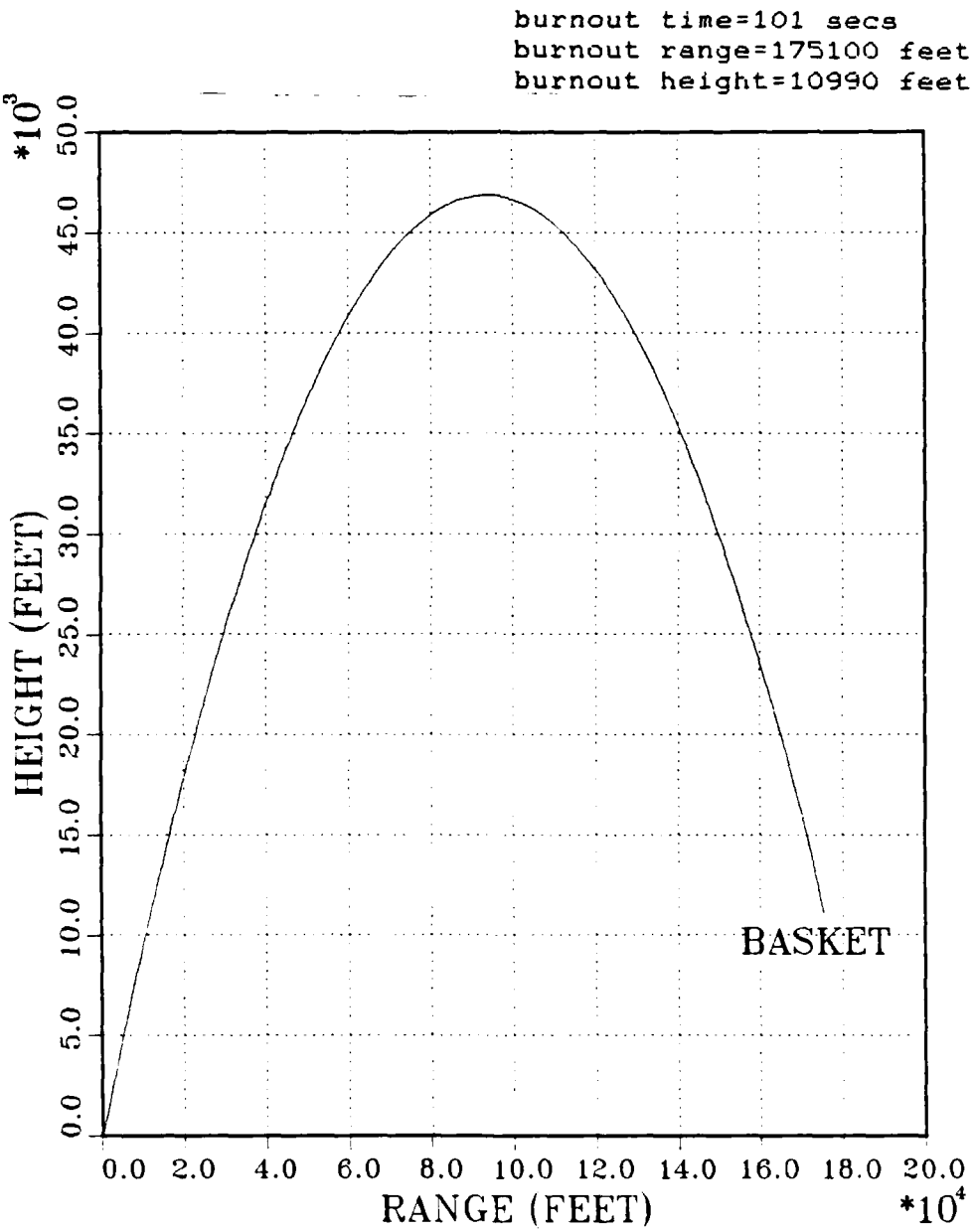

Figure 2-1 ARMT Pseudo-vacuum Trajectory

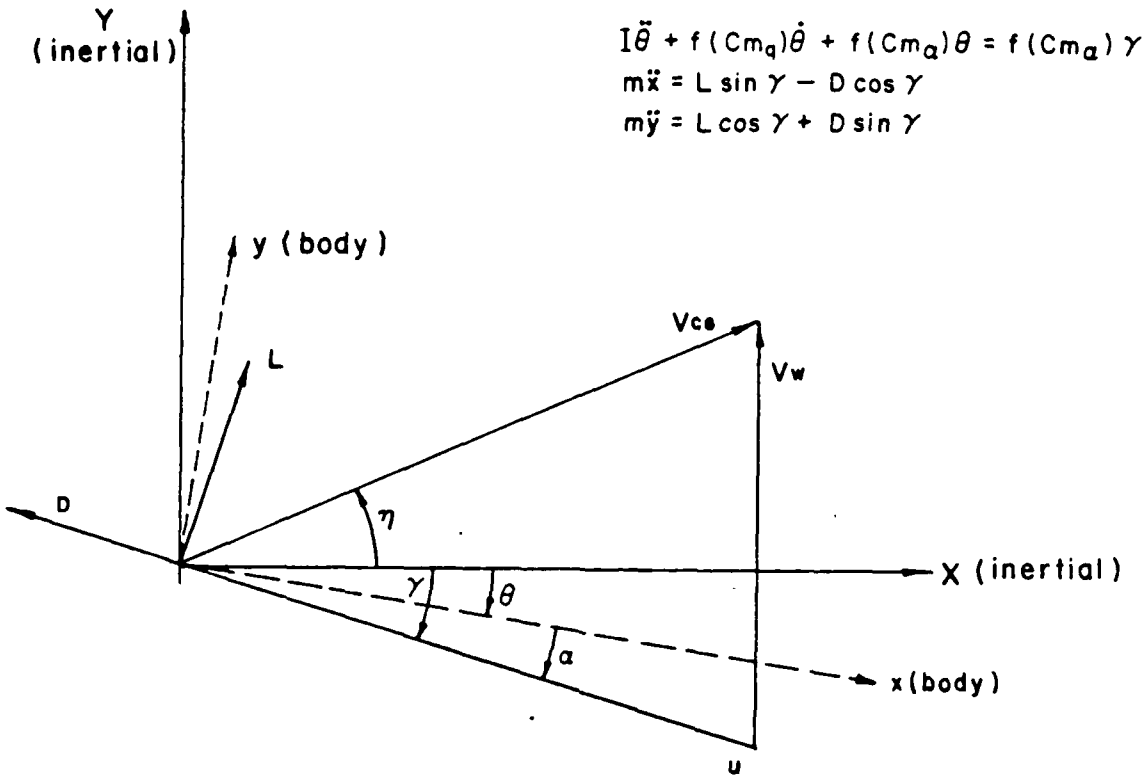

Figure 2-2 Three Degrees Freedom Model (Yaw Plane)

The crosswinds were varied in intensity and duration to analyze crossrange dispersion. As well thrust was varied as a function of drag by scaling the drag. Cmq predictions were approximately -190 to -205 by Norden Systems [Reference 2] and an analysis was done to determine the effects of varying this damping coefficient. To further study the projectile characteristics, trajectories were simulated with no thrust or mass attenuation with varying wind profiles. Figure 2-3 ,

shows the baseline three-degrees-of-freedom trajectory of thrust equals drag with no wind.

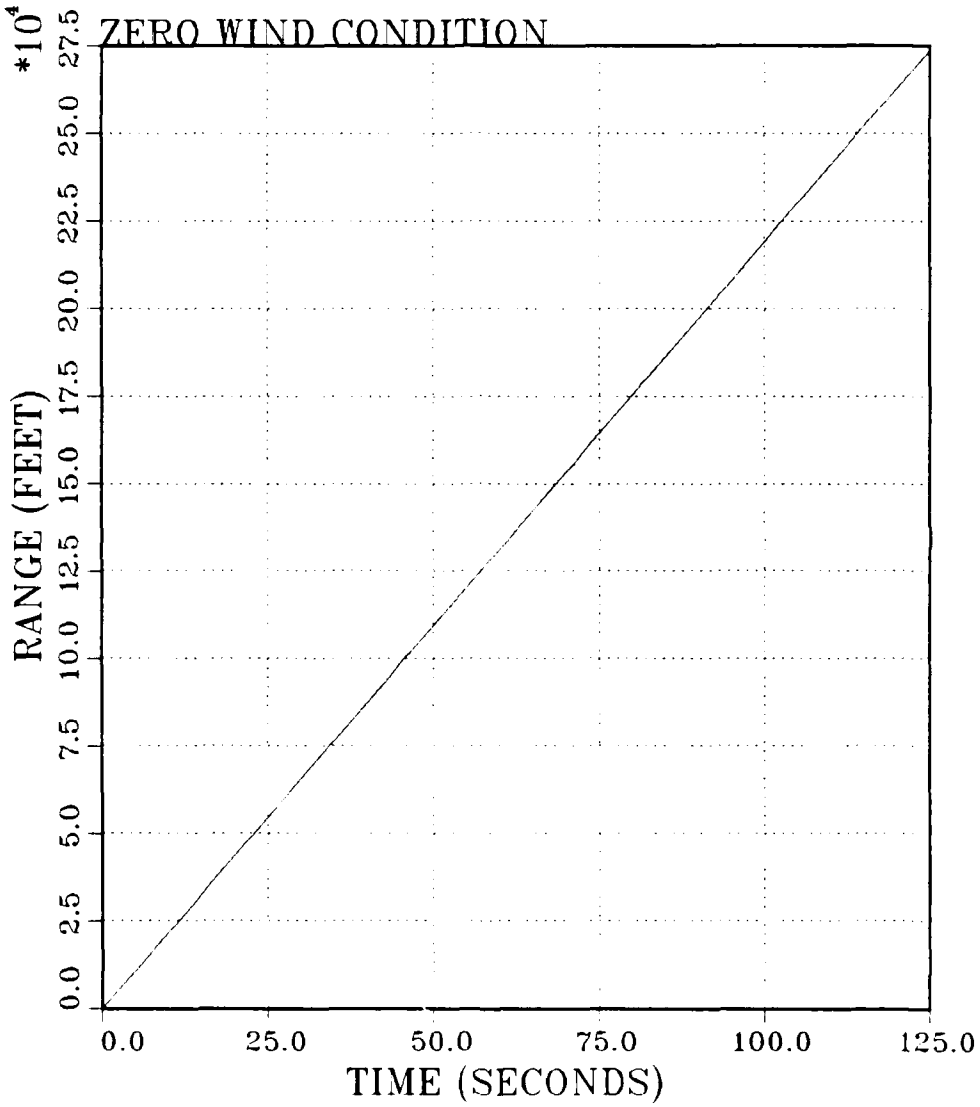

Figure 2-3 Baseline Three-Degrees-Of-Freedom Trajectory

C. FIVE-DEGREES-OF-FREEDOM MODEL

Again the IODE program was used to solve a five degrees of freedom system of equations. The roll plane was neglected for the following reasons:

-the program could not accept sufficient functions to define six degrees of freedom.

-the fins are expected to damp out initial spin due to gun rifling (900 RPM) in the first few seconds of flight. Sufficient spin to average projectile asymmetry errors to zero but not enough to significantly affect dynamics will remain.(ie. gyroscopic effects and Magnus effects)

-the initial spin damping dynamics are beyond the scope of this thesis.

The projectile was assumed to be axisymmetric allowing for ease of calculations in the yaw and pitch planes. Figures 2-2 and 2-4 depict the yaw and pitch planes for the model,respectively.

A listing of the equations is provided in the IODE specifications at Appendix F. Trajectory simulations were run with varying wind profiles and thrust error scenarios. Terminal guidance time (Tc) was determined by the baseline five degrees of freedom trajectory shown at Figure 2-1 as 101 seconds. This trajectory has no wind and thrust exactly equaled drag until discard of the air inlet spike and

canard deployment.All simulations assumed a 45 degree launch angle and Mach 2.2 muzzle velocity. Dispersion from the pseudo-vacuum trajectory was measured at terminal guidance time including the following variables:

-X=range at 101 seconds
-Y=crossrange at 101 seconds
-Z=height at 101 seconds
-Tb=burnout time
-Vcg=speed at time 101 seconds

Dispersion is defined as the difference between value for perturbed trajectories and the baseline trajectory.

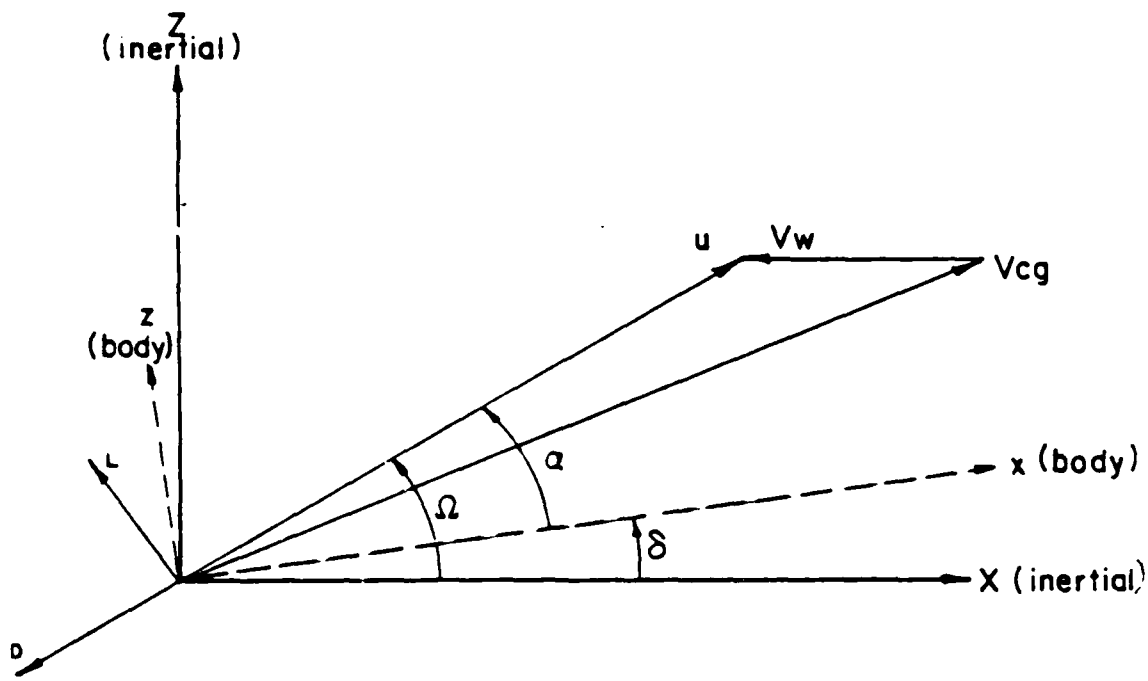

Figure 2-4 Five-Degrees-Of-Freedom Pitch Plane Model

D. SIX-DEGREES-OF-FREEDOM MODEL

The Ballistics Research Laboratories (Aberdeen) six degrees of freedom model HTRAJ was obtained and adapted for use on the NPGS IBM 370 system. The adapted listing is included as Appendix G. Program compilation was achieved but output data was not satisfactory due primarily to input data syntax problems. Further,the program requires extensive modification to be able to vary thrust as a function of drag with the ease of the previous models already described. Time was not available to correct these problems. Detailed documentation on the program HTRAJ is available through BRL.

III. TRAJECTORY RESULTS

A. THREE DEGREES OF FREEDOM

1. Crosswind And Thrust Error Sensitivity

Figures 3-1 and 3-2 show the effects of constant thrust errors as a percentage of drag with no wind.Recall that the three-degrees-of freedom trajectory is at constant altitude.The figures therefore represent a thrust error sensitivity in terms of burn time and range variations due to drag or thrust.The trajectories all pass nearly through the 218000 foot range mark at t=100 seconds, but the burnout ranges are significantly different due to the varying burn times resulting from projectile thrust.Figure 3-2 demonstrates the obvious conclusion that the burnout time decreases as thrust increases.

Figure 3-3 combines the effects of constant crosswinds and thrust errors to demonstrate resultant cross range dispersion.The constant wind velocity lines are very nearly linear, and the pattern is essentially a shift about the zero-zero point. If thrust is less than drag, the dispersion is in the direction of the wind vector.If thrust is greater than drag then the overcompensation produces a dispersion opposite to the wind vector.

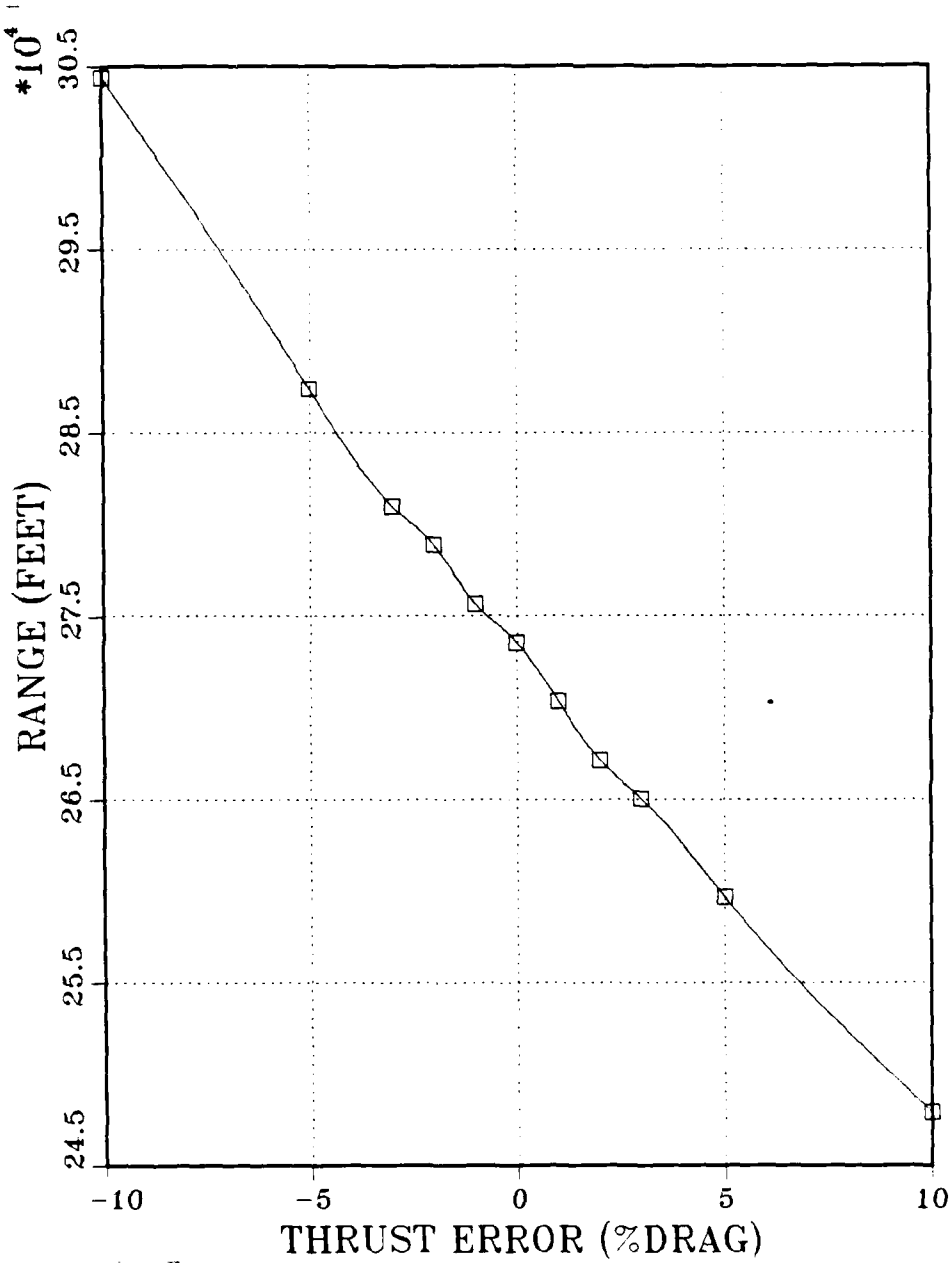

Figure 3-1 Thrust Error Sensitivity (Range)
Three Degrees Of Freedom

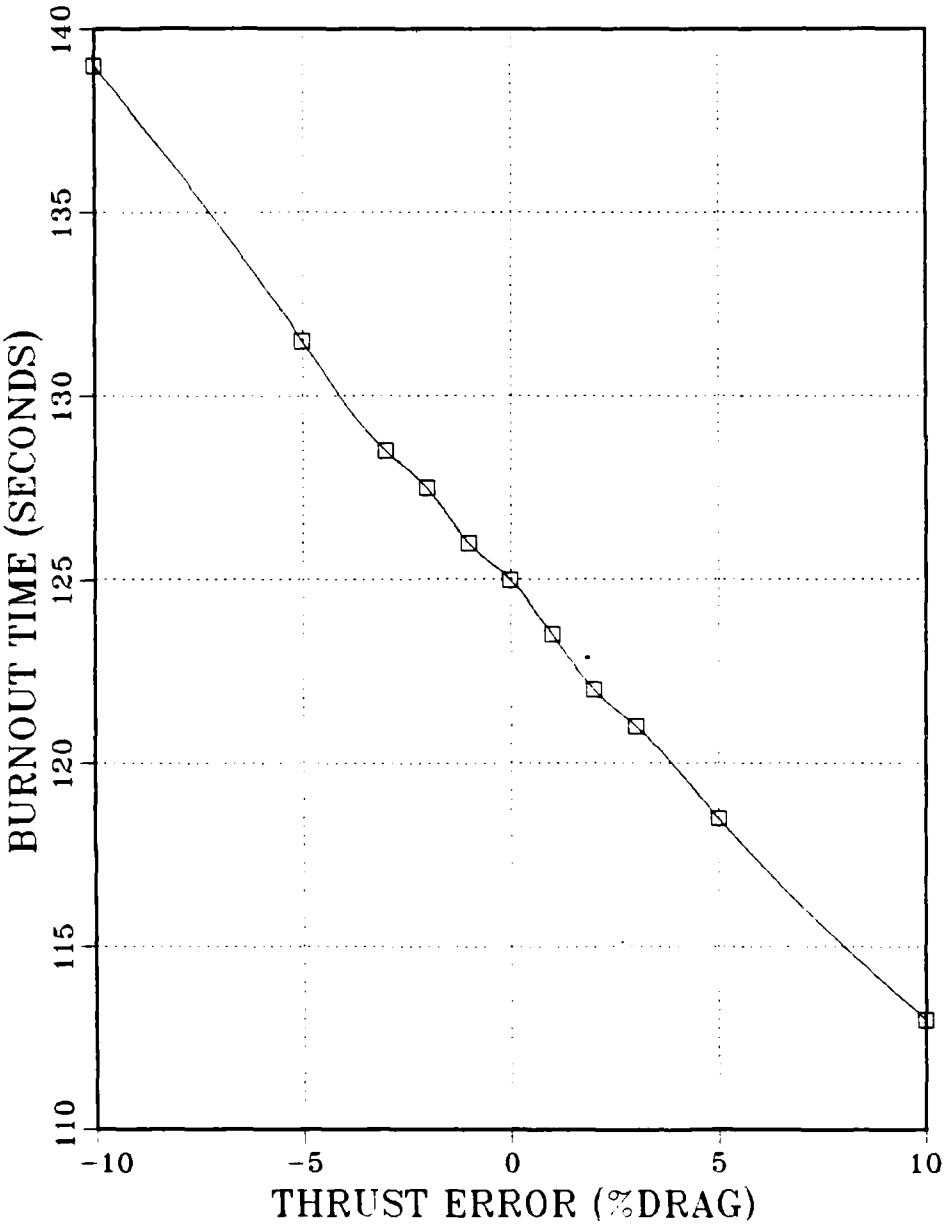

Figure 3-2 Thrust Error Sensitivity (Burntime)
Three Degrees Of Freedom

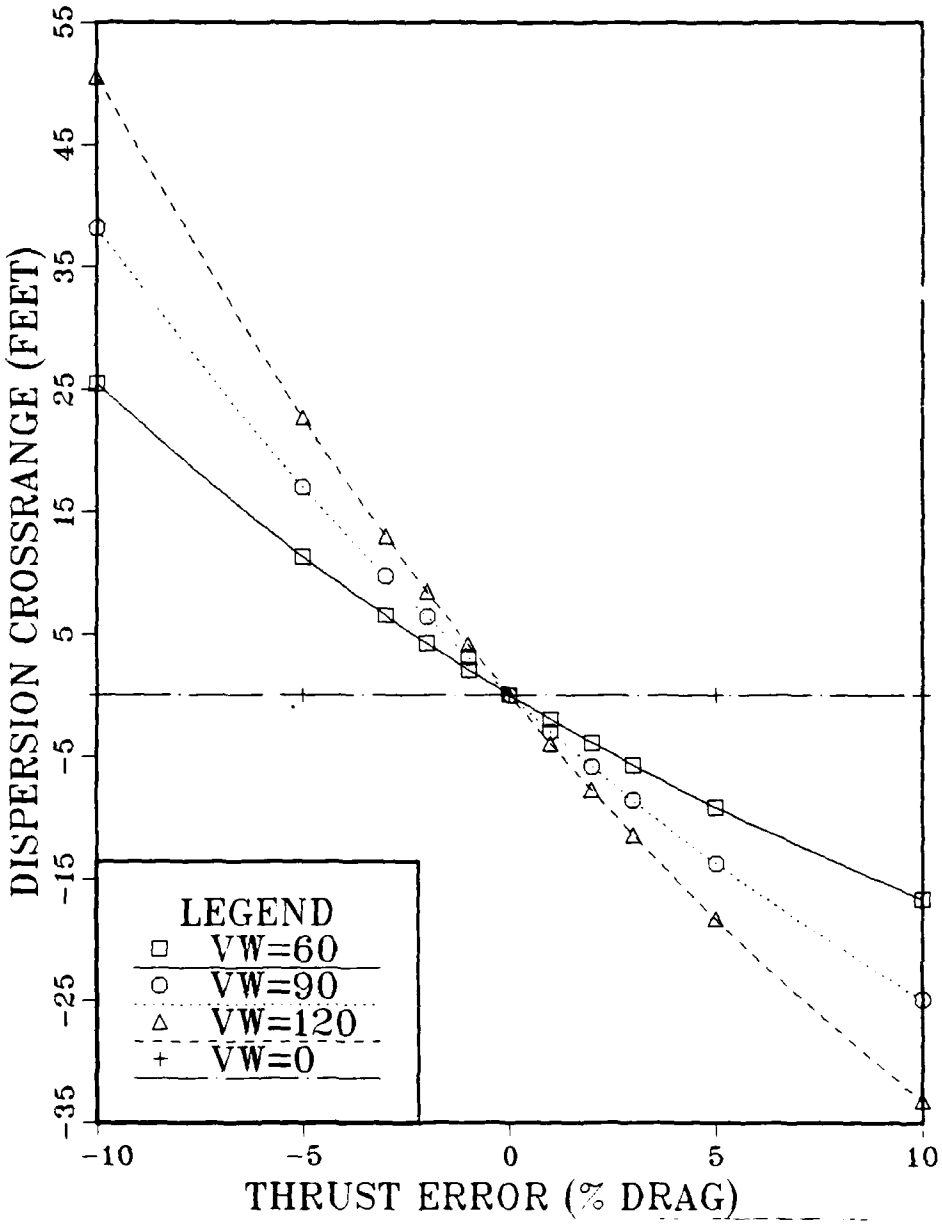

Figure 3-3 Crosswind Sensitivity Three Degrees Of Freedom

Of interest was the dispersion due to the same wind profiles without thrust or mass loss. This represents an absolute dispersion with a given wind profile. These results are in Table 3.1.

Table 3.1 No Thrust Crosswind Effects
Three Degrees of Freedom

Thrust=0 t=125 seconds

vw (ft/sec)	dispersion (feet) crossrange
0	0
60	195.76
90	293.80
120	392.02

The data clearly shows that crosswinds have a minimal effect in the thrusted scenarios.The dispersion in the thrust-equals- drag case is due to the transients (Lw) and is negligible as well. This is illustrated at Table 3.2.

Table 3.2 Dispersion Due to Net Lift from Transients

Thrust=drag	
vw (feet/sec)	dispersion (feet) crossrange
0	0
60	.018
90	.027
120	.036

Angle of attack damped to virtually zero during the trajectories (see Figure E-3) but the absolute maximum values were also recorded.Figure 3-4 demonstrates the relation between angle of attack (alpha) and the wind velocity.Thrust errors had virtually no effect on the angle of attack magnitude.

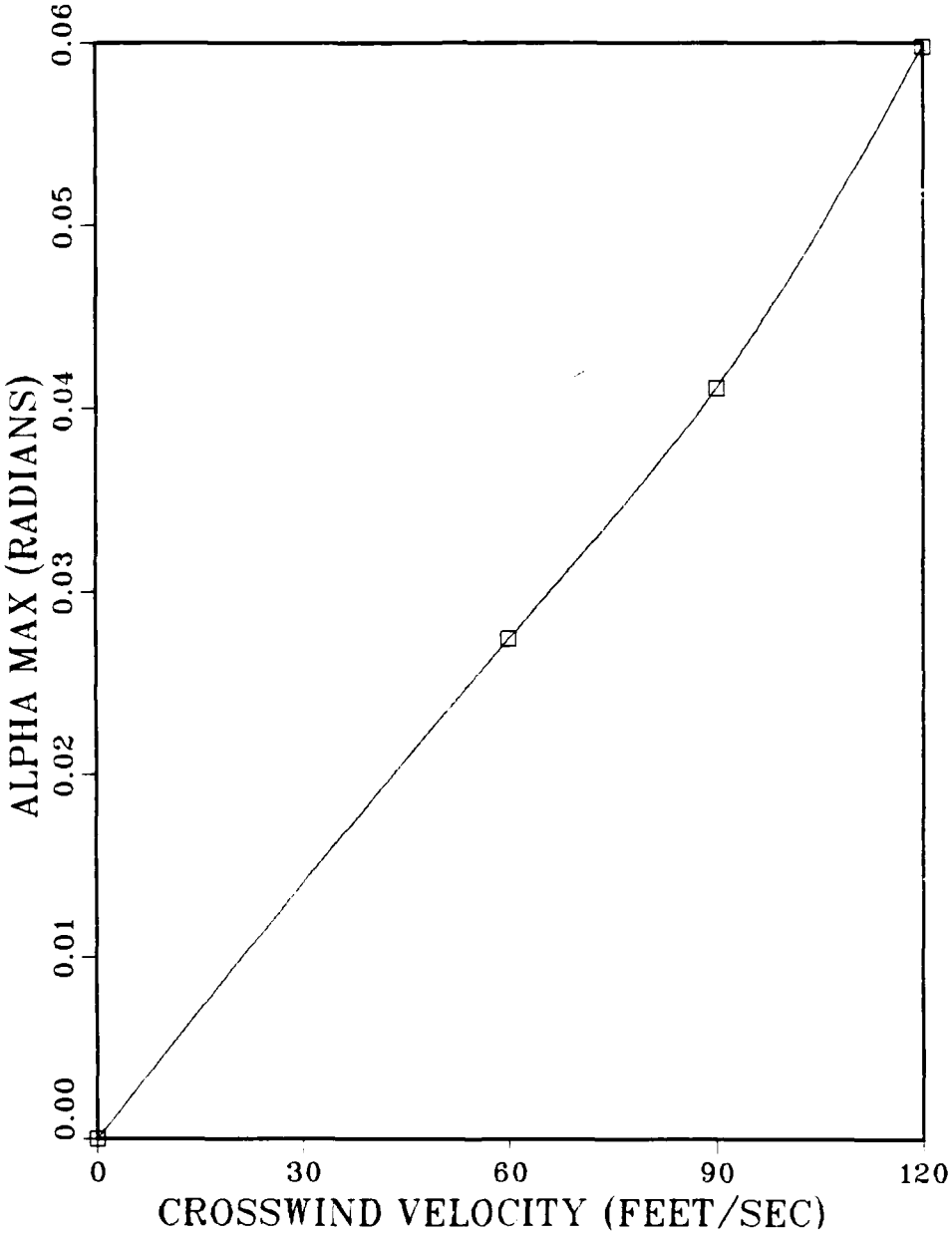

Figure 3-4 Wind Effects On Maximum Angle Of Attack

2. Damping Coefficient Effects

The magnitude of Cmq was determined to be approximately -200 in the flight speed ranges of the ARMT projectile [Reference 4]. To determine if this coefficient significantly affected dispersion Cmq was varied from 0 to 1.9×10^6 and the dispersion recorded. Figure 3-5 shows the relation between Cmq and dispersion (crossrange) with a constant wind of 60 feet/second and time of 125 seconds.

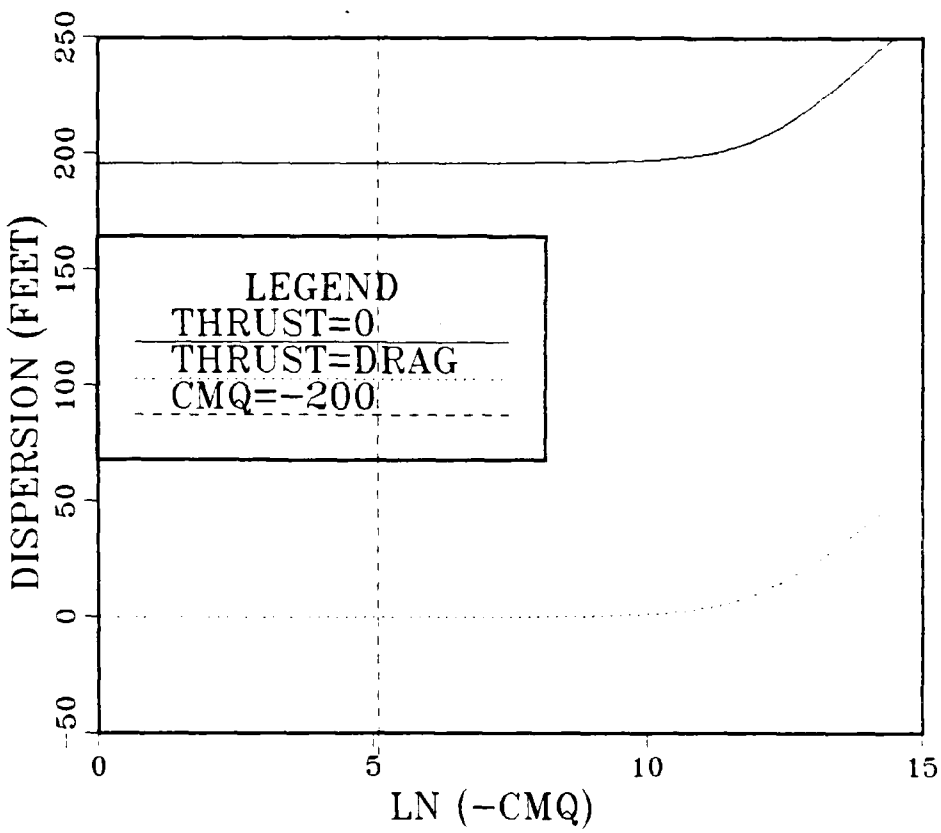

Figure 3-5 Damping Coefficient Effects

Careful examination of Figure 3-5 shows that dispersion increases slightly for realistic values of Cmq and is therefore proportional to Cmq.Due to the small sensitivity of dispersion to Cmq for all practical purposes one can conclude dispersion is independent to Cmq.(The increased dispersion proportional to Cmq can be explained as the difference in the areas under a highly damped sinusoid versus a non-damped sinusoid is considerable.)

3. Sinusoidal Wind Analysis

To test the effects of phase angles and wavelengths on the projectile dynamics a sinusoidal wind was input to test the model.The wind (Vw) was of the form Vo sin(2 PI Vo t/lambda + phase) where Vo was set at 60 feet/second.Figures 3-6 and 3-7 show the trajectories for the sine and cosine winds to burnout at thrust equal to 90% drag.(Lambda=range and lambda=.5 range)Of note is the fact that the sine wind produces a continuous dispersion while the cosine wind does not when thrust does not equal drag.This discovery led to an expanded study of different phase and wavelength sinusoidal wind inputs for various thrust scenarios.As well a simplified model was constructed as shown at Figure 3-8 and calculations confirmed the three degrees of freedom model results.Figures 3-9 and 3-10 depict the results of the calculations.

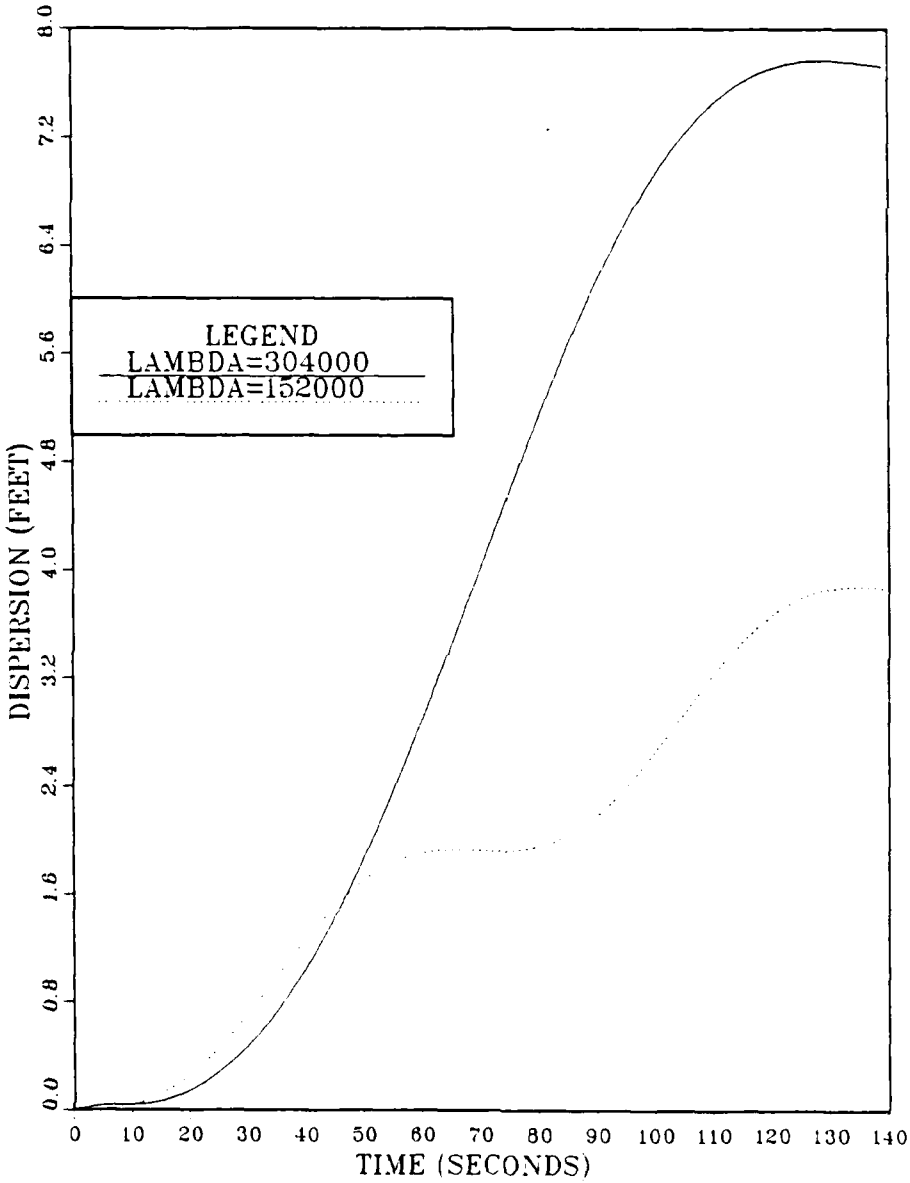

Figure 3-6 Sinusoidal Wind Effects (Sine)

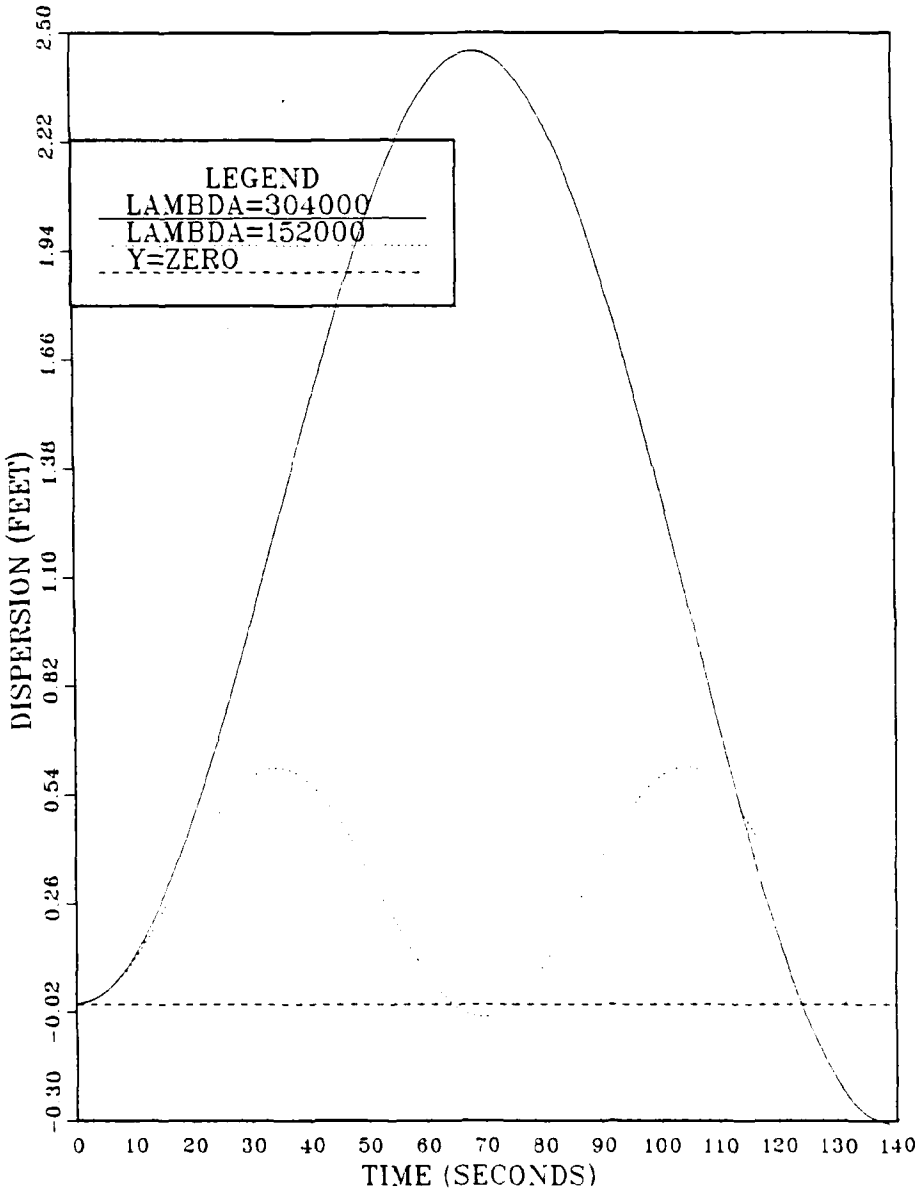

Figure 3-7 Sinusoidal Wind Effects (Cosine)

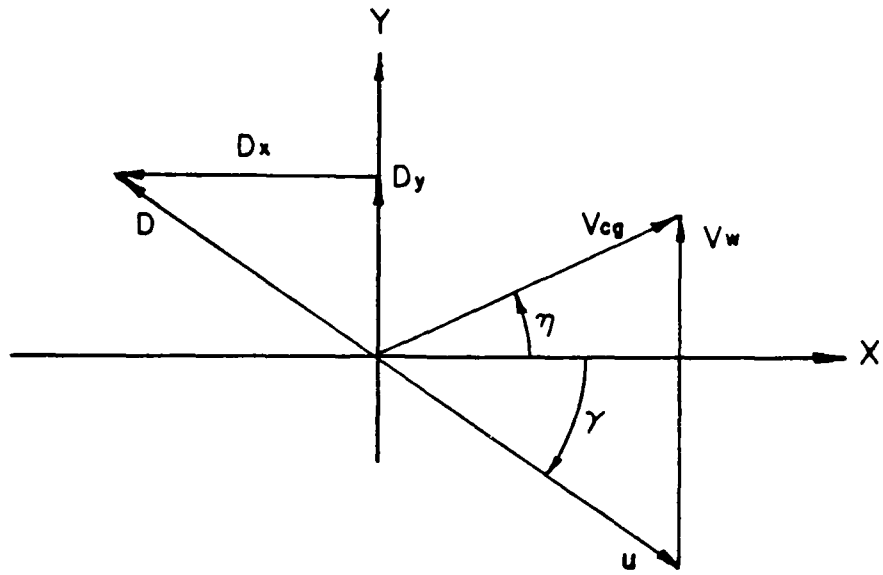

Figure 3-8 Simplified Three Degrees Of Freedom Model

The simplified model was used to analytically evaluate the crossrange dispersion (y) in the cases of sine and cosine winds to confirm the validity of the three-degrees-of-freedom model.Calculations follow:

General equations of motion in the y direction from Figure 3-8 are:

M dVy/dt =Dy which approximately equals D(Vw-Vy)/Vxo

if Vxo=Vo=constant.Then transforming the equation we get:

dVy/dt + D/(MVo)Vy = D/(MVo) Vw(t)

or in time differentiated notation:

$$\ddot{y} + B\,\dot{y} = B\,Vw(t) \quad \text{if } D/(MVo) = B$$

If a cosine wind $Vw(t)=Vwo \cos(2\ PI\ Vo\ t/\lambda)$ is applied and the differential equation solved we have:

$$y(t)/\lambda = K\left[e^{-Bt} - \cos(2\ PI\ Vo\ t/\lambda) + \frac{D\lambda \sin(2\ PI\ Vo\ t/\lambda)}{2\ PI\ m\ Vo^2}\right]$$

$$\text{let } K = \frac{2\ \dfrac{1/2\ m\ Vo^2\ Vwo}{D\lambda\ Vo}}{1 + \left[\dfrac{4\ PI\ D\lambda}{1/2\ m\ Vo^2}\right]^2}$$

Figure 3-9 graphically depicts the results as t increases.A zero asymptote is observed and this conforms with model results.

Now if a sine wind $Vw(t)= Vwo \sin(2\ Pi\ Vo\ t/\lambda)$ is applied and the differential equation solved:

$$y(t)/\lambda = K\left[\frac{D\lambda}{4\ PI\ 1/2\ m\ Vo^2}(1-\cos(2\ PI\ Vo\ t/\lambda)) - \sin(2\ PI\ VO\ t/\lambda) + \frac{4\ PI(1/2\ mVo^2)}{D\lambda}(1-e^{-Bt})\right]$$

Figure 3-10 graphically depicts these results as t increases.The asymptote is

$$K\left[\frac{(4\ PI\ 1/2\ m\ Vo^2)}{D\lambda}\ (1-e^{-Bt})\right]$$

and this conforms to the model also.

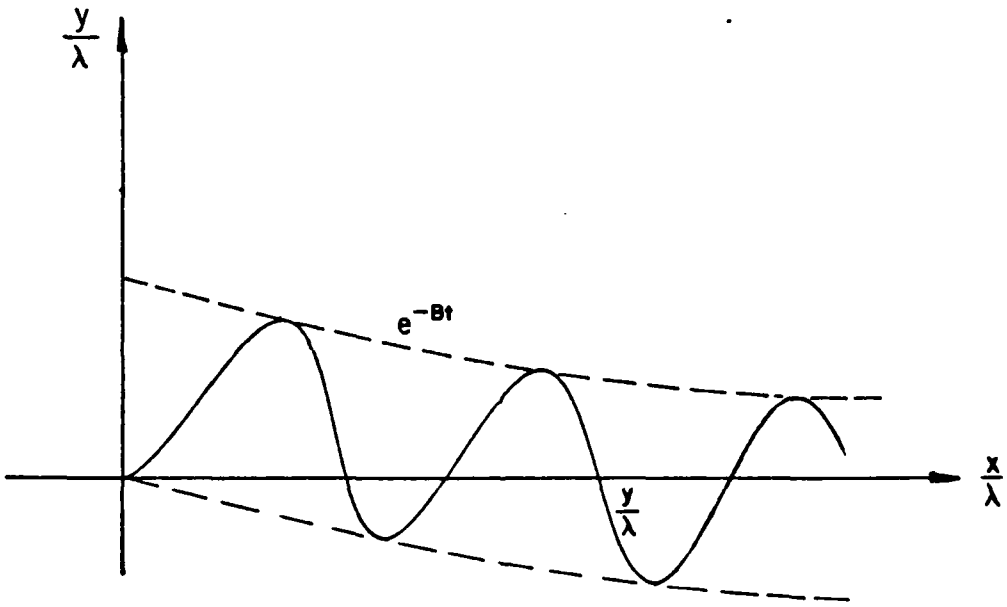

Figure 3-9 Cosine Wind Analysis Results

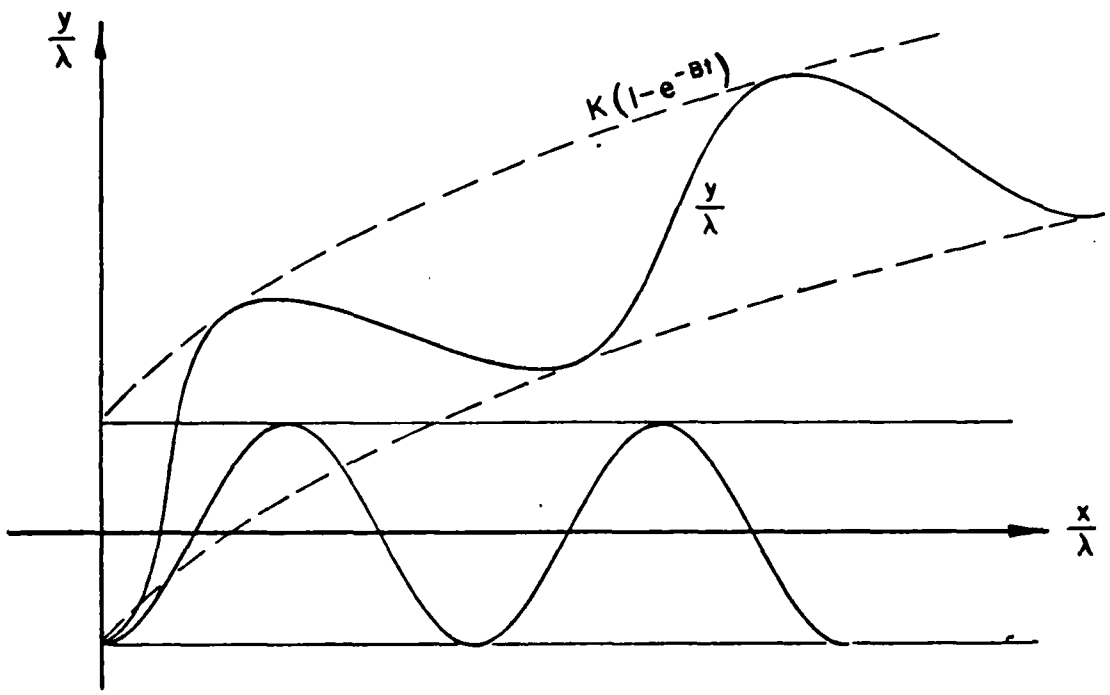

Figure 3-10 Sine Wind Analysis Results

The constant wind case was also derived:

$Vw(t) = Vw$ and the solved differential equation is:

$$y(t) = Vw\ t - Vw\ m\ Vo/D\ e^{-Bt}$$

and as t increases y approaches Vw t.

Specific calculations were done to confirm dispersion results at burnout.The calculations were based on:

$y = dy/dx\ X = 1/Vo\ dy/dt\ X$

$Vwo = 60$ ft/sec

$Vo = 2190$ ft/sec

$\lambda = 304000$ ft

$t = \lambda/Vo$

$D = 1/2\ \rho\ Vo^2\ A\ Cd$ (=226 lbf)

Thrust=.9D therefore D=22.6 lbf

M=225 lbm

Taking the time derivative of the cosine wind y(t) dispersion formula derived earlier we get

$$dy/dt = K\left[-Be^{-Bt} + \frac{2\ PI\ Vo}{\lambda}\sin(2\ PI\ Vo\ t/\lambda) + \frac{D\lambda}{4\ PI\ 1/2\ mVo^2} \cdot \frac{2\ PI\ Vo}{\lambda}\cos(2\ PI\ Vo\ t/\lambda)\right]$$

at $t = \lambda/Vo$ the equation becomes:

$$dy/dt = K(-Be^{-B\lambda/Vo} + B)$$

and substituting the values into the approximationn for y; y=0 ft.

Now, performing the same operations on the sine wind dispersion equation :

$$dy/dt = K\left[\frac{D\lambda}{4\ PI\ 1/2\ mVo^2} \cdot \frac{2\ PI\ Vo}{\lambda} \sin(2\ PI\ Vo\ t/\lambda) - \frac{2\ PI\ Vo}{\lambda} \cos\left(\frac{2\ PI\ Vo\ t}{\lambda}\right) + \left(\frac{4\ PI\ 1/2\ m\ Vo^2}{D\lambda}\right) \cdot (Be^{-Bt})\right]$$

and at $t = \lambda Vo$

$$dy/dt = K\left[\frac{-2\ PI\ Vo}{\lambda} - \frac{4\ PI\ 1/2\ m\ Vo^2}{D\lambda} \cdot Be^{-Bt}\right]$$

and y=20 ft approximately.

Finally, taking the constant wind dispersion formula and taking its derivative :

$$dy/dt = Vw - Vw\ e^{-Bt}$$

and y= 10 ft approximately.

These results are consistent with the three-degrees-of-freedom model considering the initial approximations.

To study the short period resonance phenomenom the phase and wavelength wind variations were documented in

detail for a condition of thrust equal to 90% drag.Figures 3-11 to 3-13 show the crossrange dispersion effects from wavelengths of 5000 (lambda = .016 range) to 303000(lambda÷range) feet and the phase angle variations from 0 to 2 PI.At approximately 9850 feet the dispersion characteristics were no longer symmetric but remained under one foot.This is demonstrated at Figure 3-14.A crossrange dispersion contour was constructed at Figure 3-15 but this did not emphasize the resonance phenomenon sufficiently due to linearized aerodynamics and small dispersion magnitudes.The parameters that varied most significantly near resonance were angle of attack and burn time.Indeed,it is clear that the projectile is unstable in this region with a maximum angle of attack of 1.21 radians(70 degrees).Due to the increased angle of attack, drag increased and burn time decreased in the order of seven seconds (5%) compared to the baseline trajectory. This clearly affected the range at burnout.Due to large angle of attack the linearized aerodynamics are not valid.Projectile performance at wind resonance is worthy of additional analysis.It was decided to demonstrate resonance by plotting the maximum angle of attack (alpha) versus wavelength with different thrust/ drag scenarios.The resonance results are at Figure 3-16.The projectile natural frequency is estimated at 0.22 Hz. Resonance was confirmed in the 0.22 Hz regime for thrust

errors under 10% including varying Vwo.This was necessary as the system is non-linear and Vwo could have affected resonance.It was noted that the curve shifted and increased or decreased in magnitude slightly in each case.This is due to the non-linearity of the system equations and the variations in Vo during flight.The absolute case of no thrust showed resonance at 10000 feet with a maximum angle of attack of 1.25 radians(72 degrees).

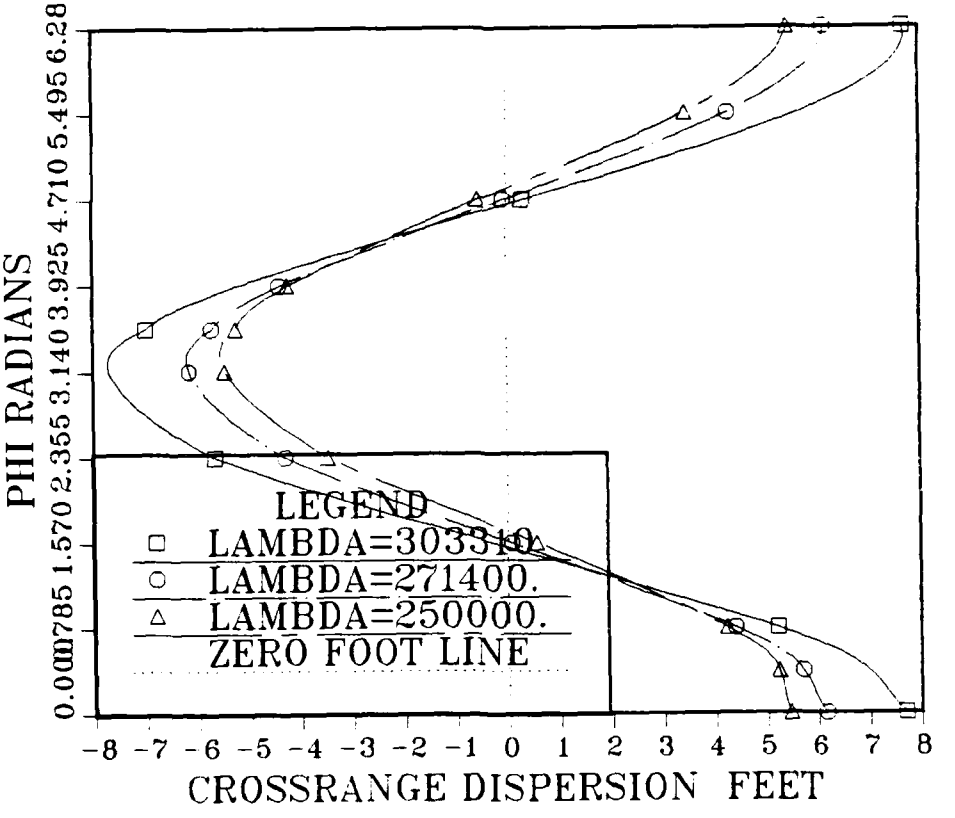

Figure 3-11 Dispersion Versus Wind Phase Angle(Large Lambda)

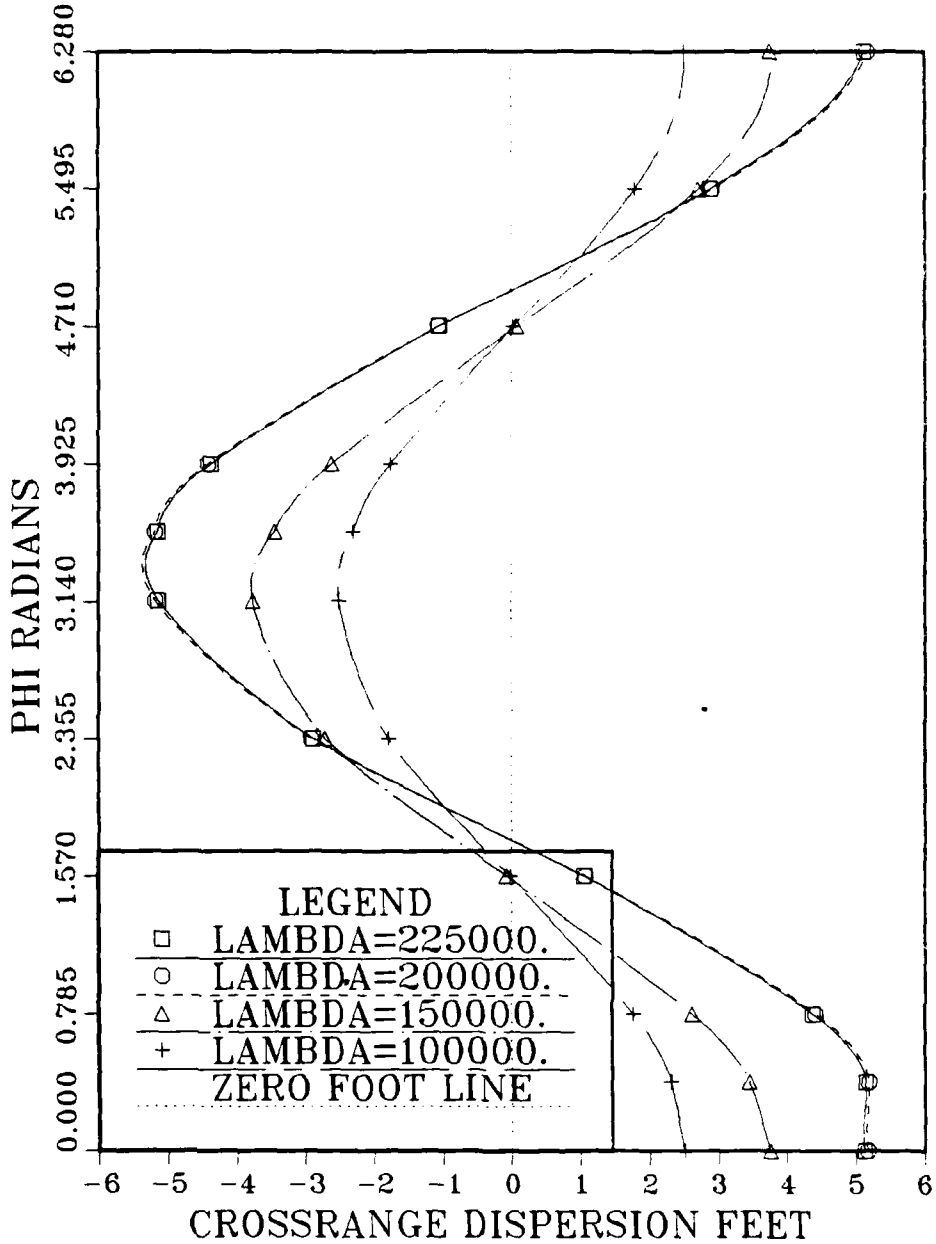

Figure 3-12 Dispersion Versus Phase Angle
(Medium Lambda)

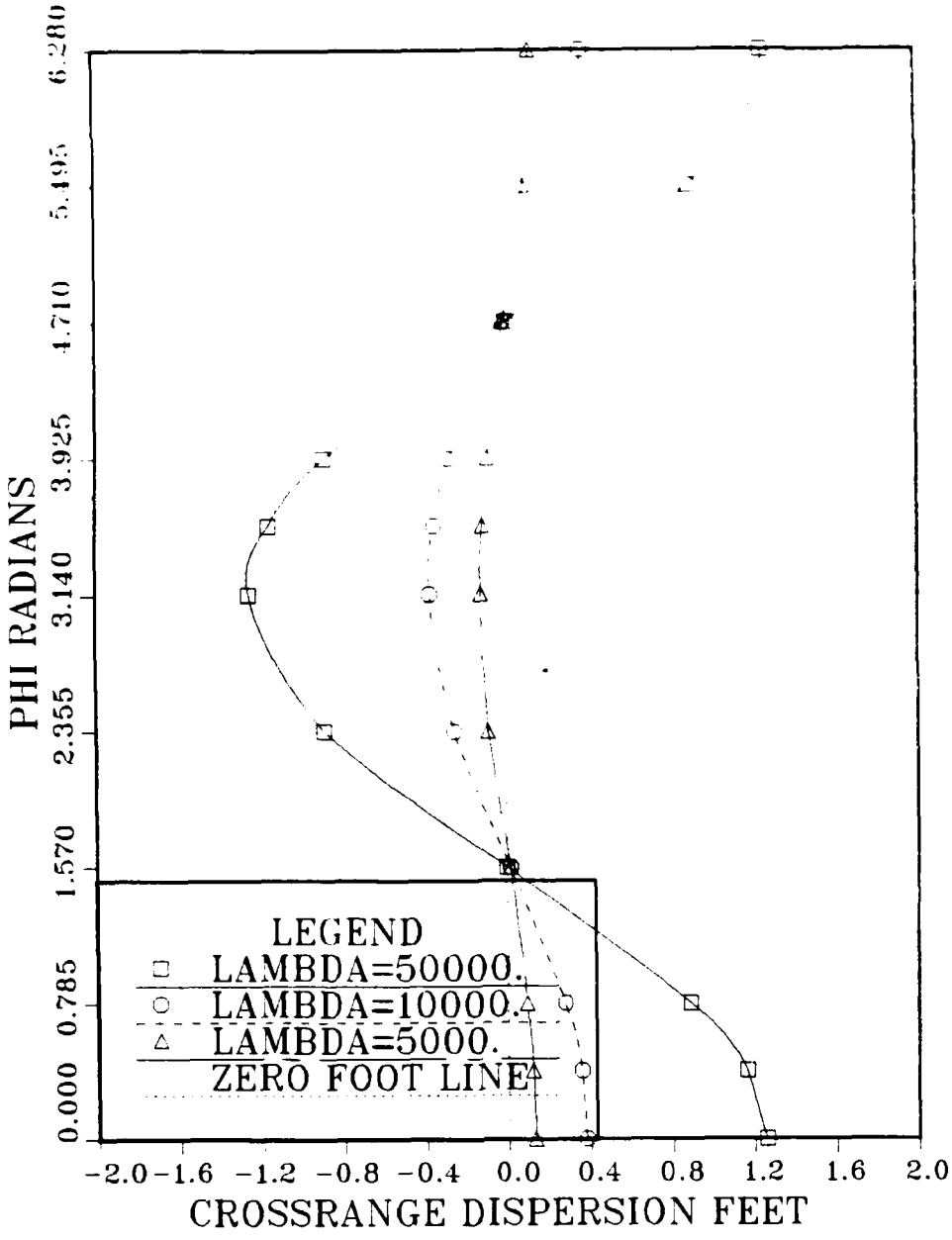

Figure 3-13 Dispersion Versus Phase Angle(Small Lambda)

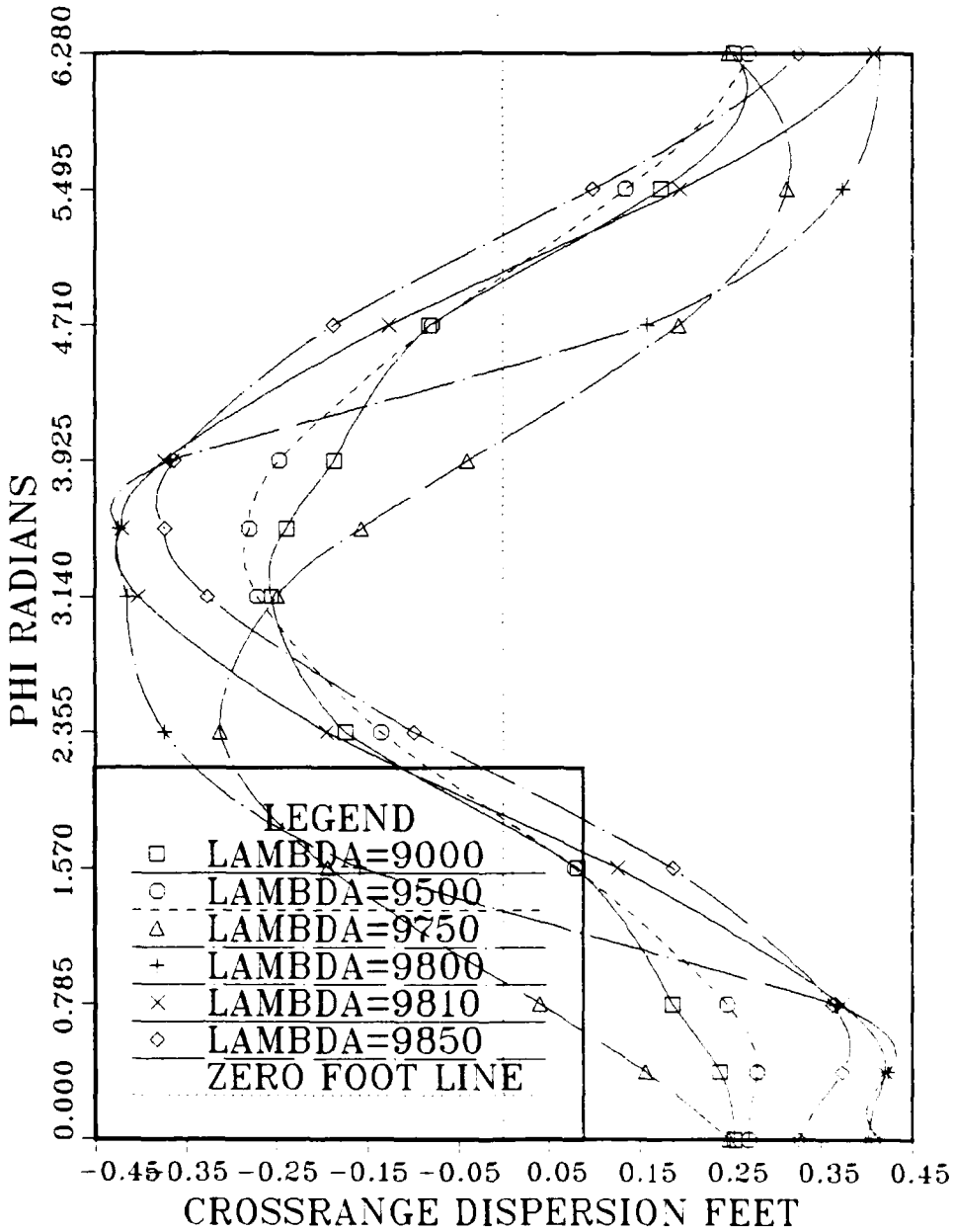

Figure 3-14 Dispersion Versus Phase Angle
Resonance Lambda

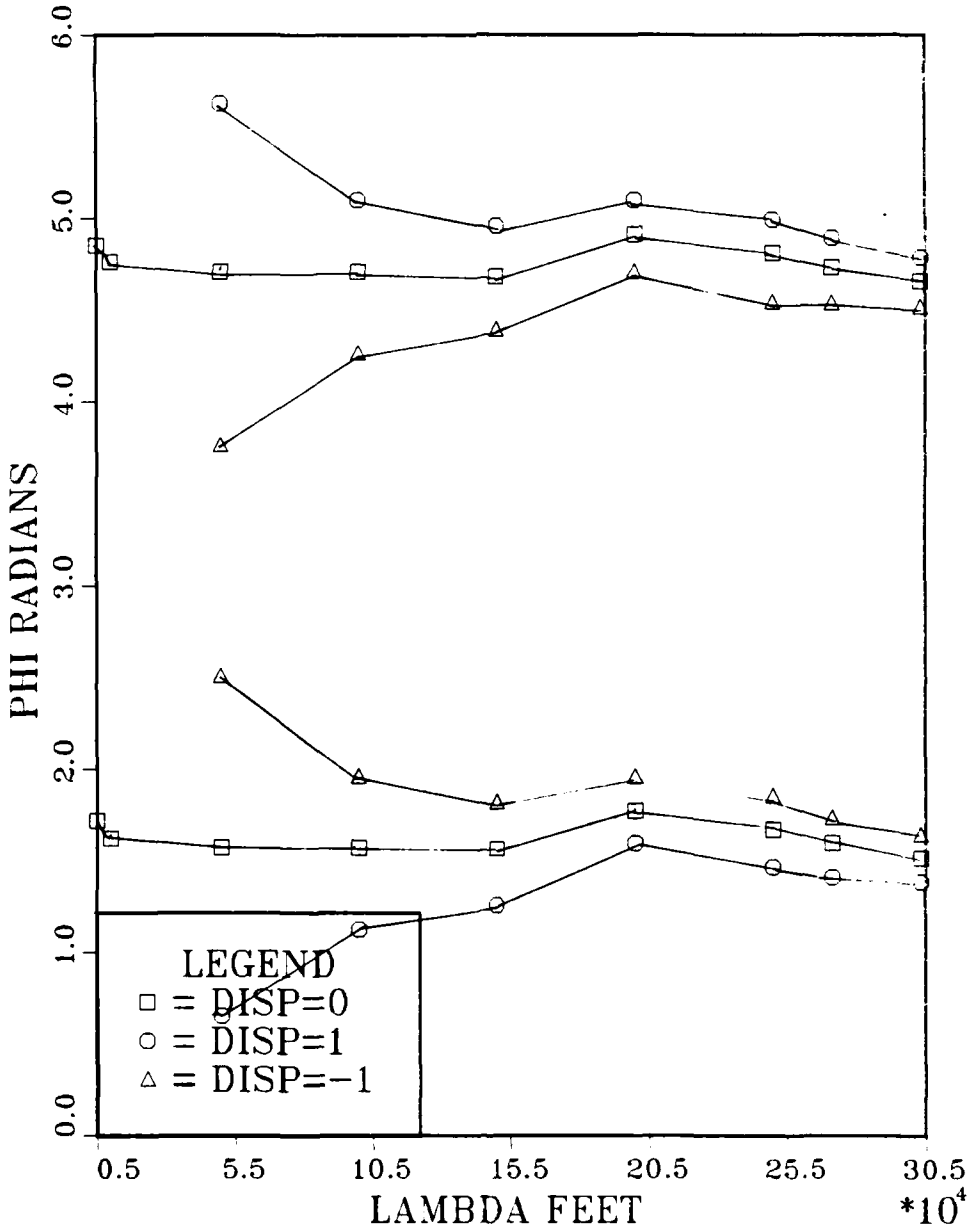

Figure 3-15 Phase Angle Versus Wavelength

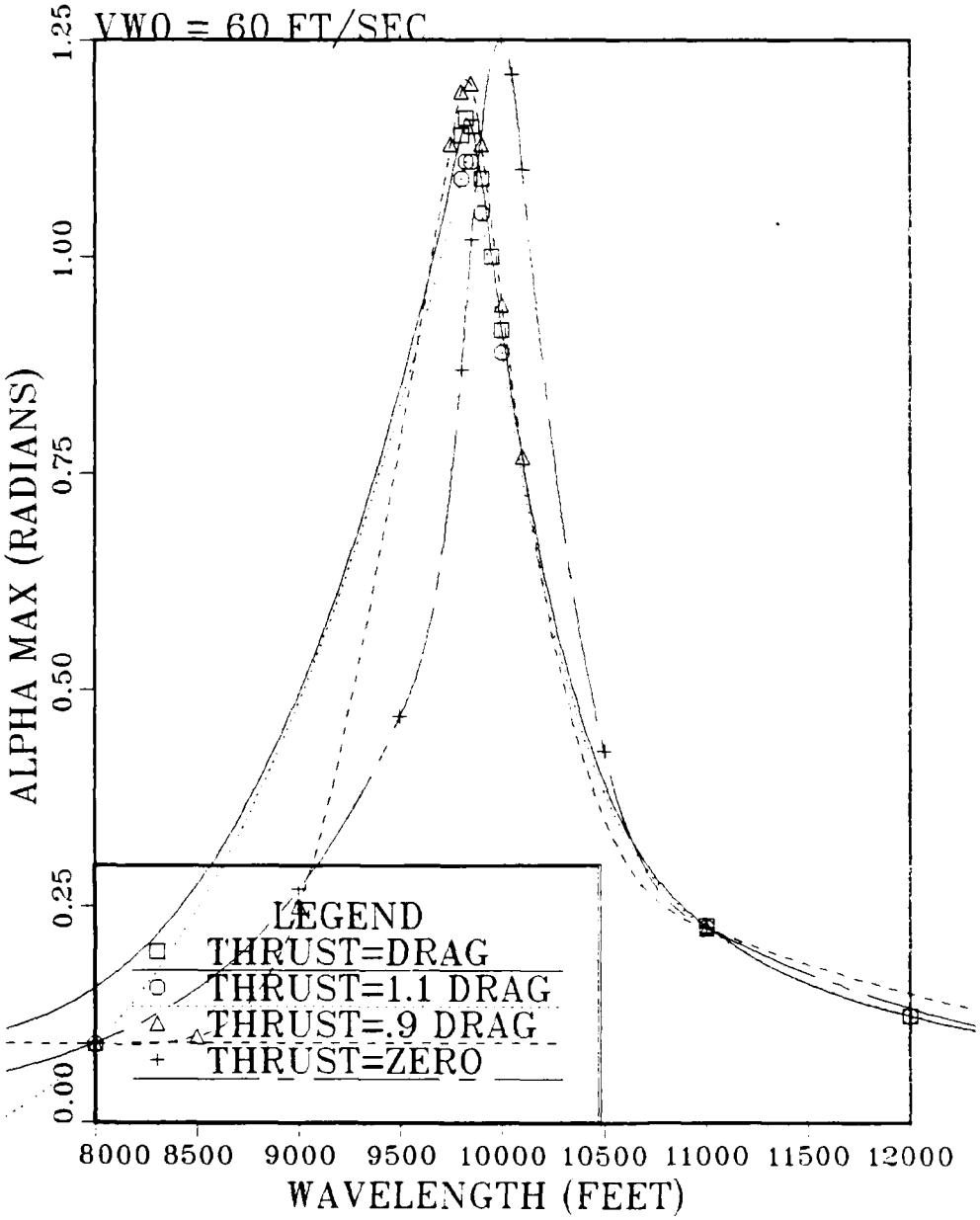

Figure 3-16 Detrimental Resonance Between Projectile Short Period and Spatial Frequency of Wind Profile

It is clear that if the wind profile experienced by the projectile has harmonic content near the natural frequency then the round will be unstable and/or have large dispersion at burnout. This is best illustrated by viewing the wind as Vw(t) with reference to the projectile. By a Fourier transform of the wind profile resonance with projectile natural frequency (fn) will be evident in the frequency domain.The wind oscillations need only be velocity variations with the appropriate harmonic content.Figure 3-17, which illustrates this concept, shows fn coinciding with a maximum of Vw(f). One would anticipate stability problems for this case.

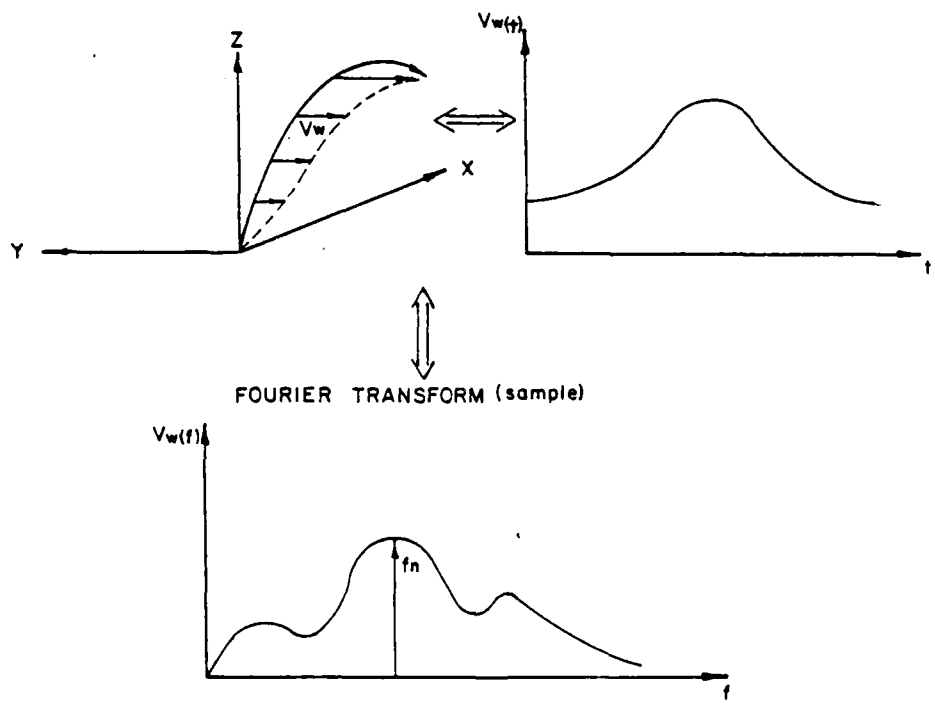

Figure 3-17 Fourier Transform Of Wind Profile Concept

Calculations for the long period resonance or phugoid show that the phugoid is irrelevant as flight time is too short:

$T=4.44*Vo/g=301.8$ seconds [Reference 3]

The results of the sinusoidal winds were also compared with the aerodynamic jump phenomenom outlined in BRL report 1077 [Reference 4]. At first glance the sinusoidal wind results appear consistent with aerojump,but detailed calculations show otherwise. The rate of change of initial angle of attack is critical to aerojump and is easily incorporated into the aerojump equation.The results for the sine wind are a function of wavelength and of the same form as the simplified model results but the cosine wind and constant wind both yielded a small aerojump proportional to the initial wind.The magnitudes of the aerojump dispersions were more consistent with the net lift transient effects. Further, continuous perturbations in the form of wind after time zero are not in the aerojump equations and for all practical purposes the phenomenom is not observed in the model.These results should have been apparent before calculations were performed. Aerojump equations are not appropriate for non-zero wind conditions.Clearly, when wind is included the aerojump equations cannot predict dispersion.

B. FIVE DEGREES OF FREEDOM

As previously stated dispersion was measured from the ideal pseudo-vacuum trajectory at a fixed time for initiation of terminal guidance (Tc) 101 seconds.Thrust error sensitivity in the zero wind condition is presented in Figures 3-18 and 3-19.In these two figures it is clear that thrust errors can have a significant impact on the location of the projectile at the Tc.Figure 3-18 indicates that as thrust increases the dispersion moves downrange as expected.Figure 3-19 shows that as thrust increases the height of the projectile at Tc decreases. Due to added thrust the projectile is located at a point further along the parabolic trajectory; hence the height is less.

As well Figure 3-20 shows these effects on available burn time of the ramjet.For thrust equals drag burnout at 101 seconds exactly equals the Tc.With less thrust, terminal guidance is initiated before all the propellant is burned. Conversely, when thrust exceeds drag, burnout occurs prior to initiation of terminal guidance.Assuming this fixed time for initiation of terminal guidance, the projectile may experience up to seven seconds of unpowered flight (7% error) before the guidance is deployed. The period of unpowered flight with associated high drag will cause major dispersions as shown in subsequent figures.

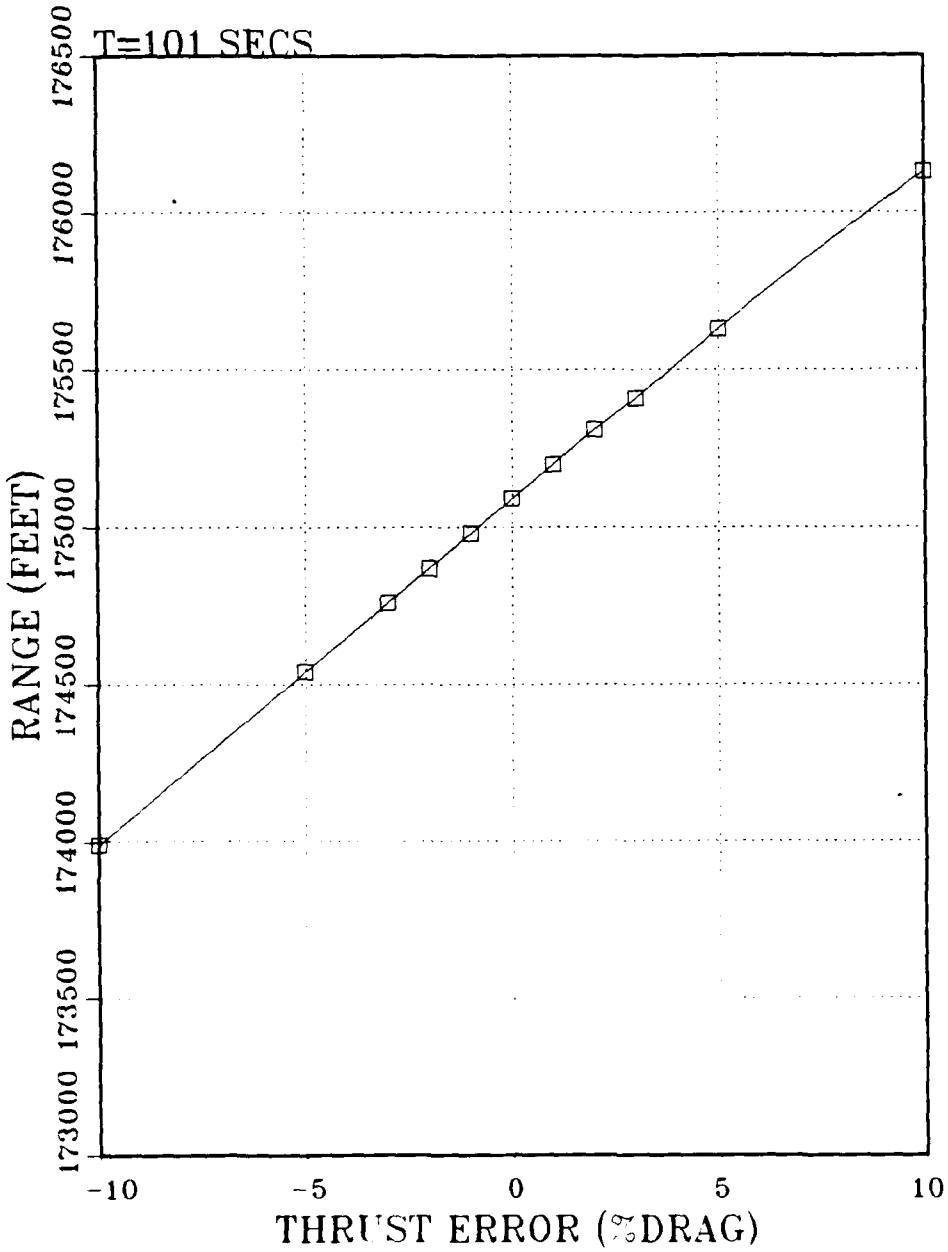

Figure 3-18 Thrust Error Effects (Range)

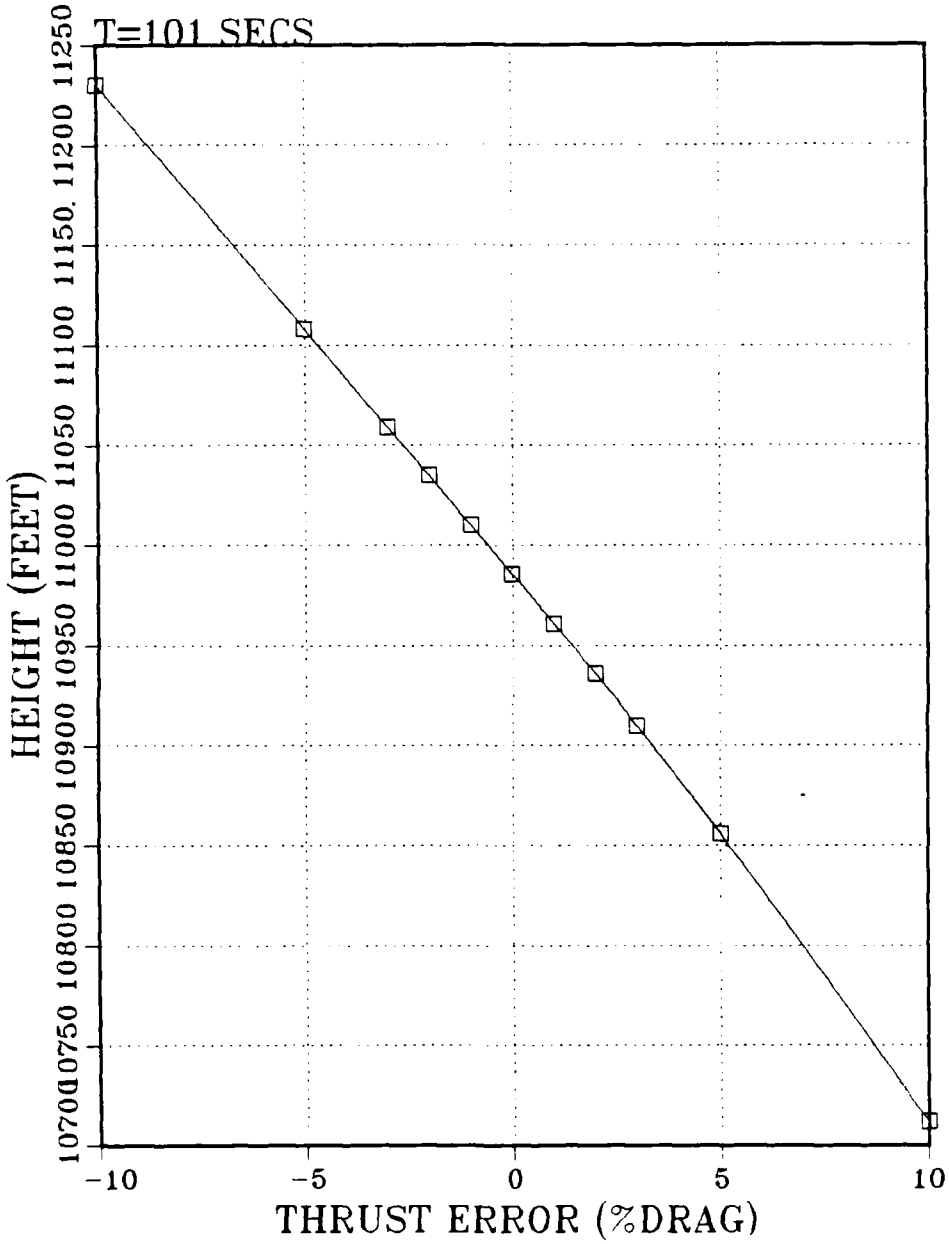

Figure 3-19 Thrust Error Effects (Height)

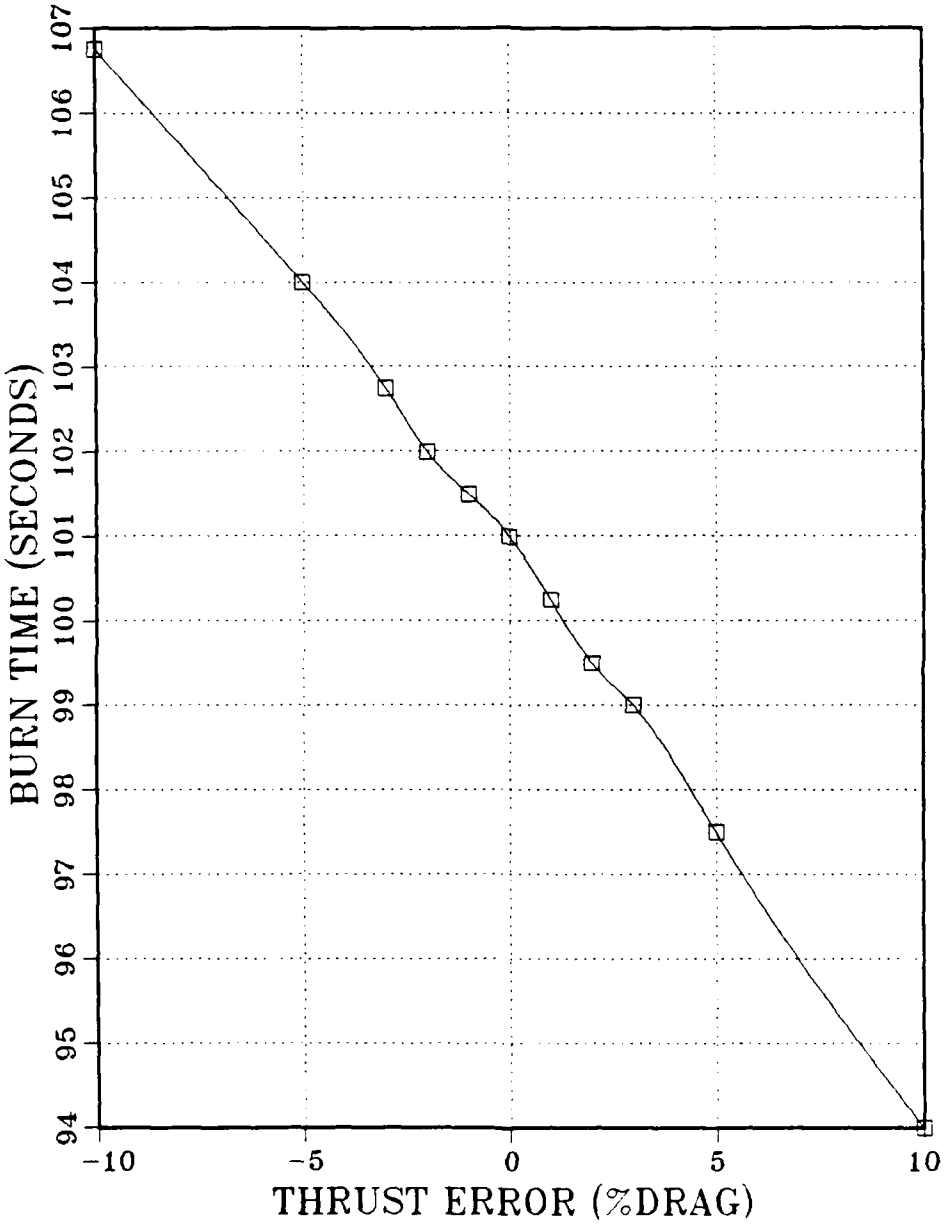

Figure 3-20 Thrust Error Effects (Burn Time)

Crosswind sensitivity results were very much the same as the three degree simulation.In fact the results appear even more linear with the same rotation about the zero zero point as in Figure 3-21.The gross features of Figure 3-3 and 3-21 are identical but Figure 3-3 shows dispersion at burnout whereas Figure 3-21 shows dispersion at Tc.

The crossrange dispersion results of a no thrust projectile with constant crosswind profiles and with thrust equal to drag (transients effects) are at Tables 3.3 and 3.4 respectively.

Table 3.3 No Thrust Wind Effects
Five Degrees

Thrust =0 time=101 seconds

Vwxy(feet/sec)	dispersion (feet) crossrange
0	0
30	92.51
60	185.11
90	272.90
120	370.97

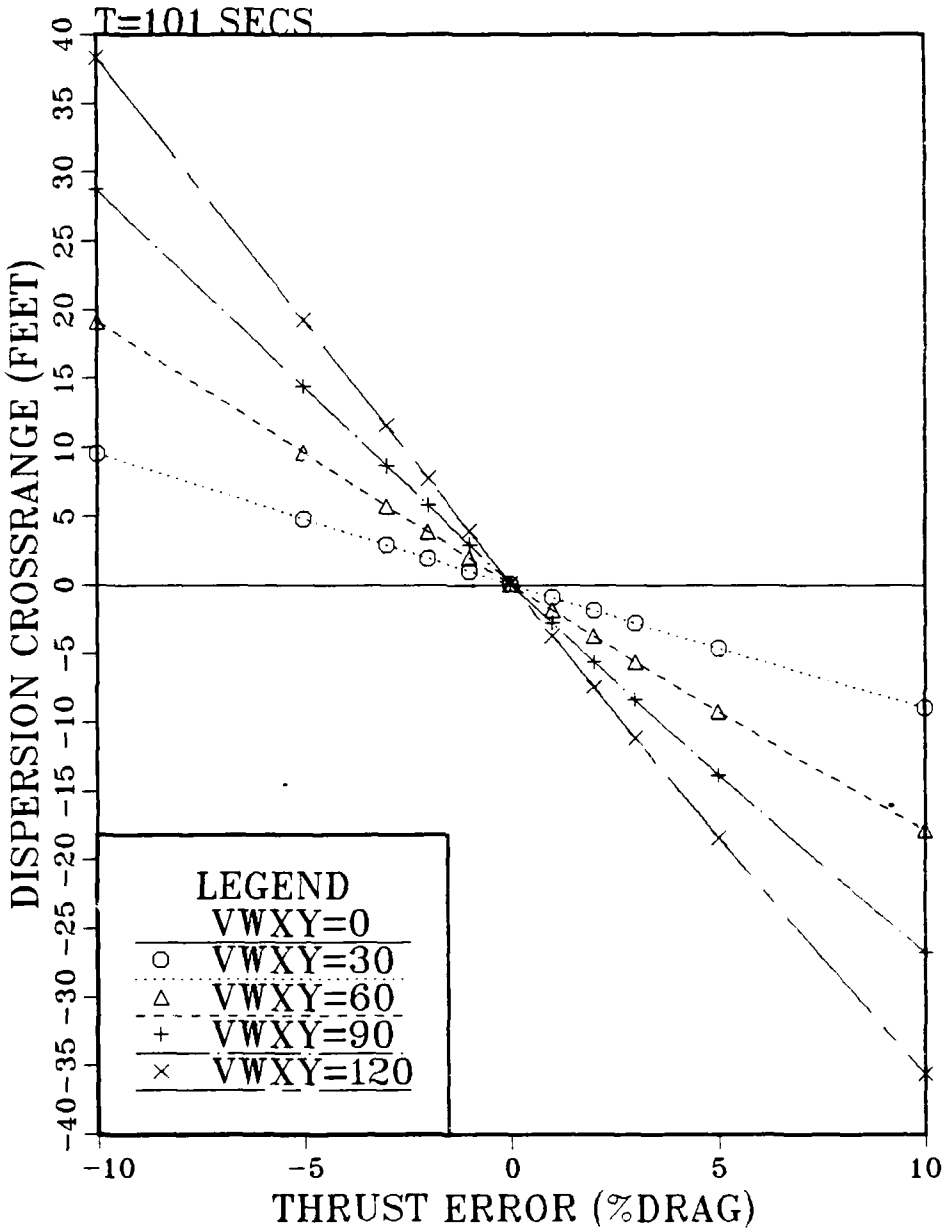

Figure 3-21 Crosswind Effects Five Degrees

Table 3.4 Dispersion Due to Net Lift from Transients

Thrust=drag time=101 secs

Vwxy(feet/sec)	dispersion(feet)
0	0
30	.0202
60	.0413
90	.0643
120	.0919

Burn time was not significantly affected by crosswinds.

Headwind and tailwind effects on range,height and burntime in different thrust scenarios are shown in Figures 3-22 to 3-26. It is clear that dispersion from the pseudo-vacuum trajectory is minimized when thrust nearly equals drag. It is also apparent that the overthrusted trajectories involve greater dispersion as burnout occurs prior to terminal guidance and unpowered flight occurs for some time dependent on the scenario.This same error is observed in the case of headwinds and is most clear in the Figures 3-22B to 3-25B about the thrust equal to drag axis. (Note that Figure 3-22 to 3-25 inclusive have A,B and C sub-figures which are simply enlargements of key portions of the respective main figure).

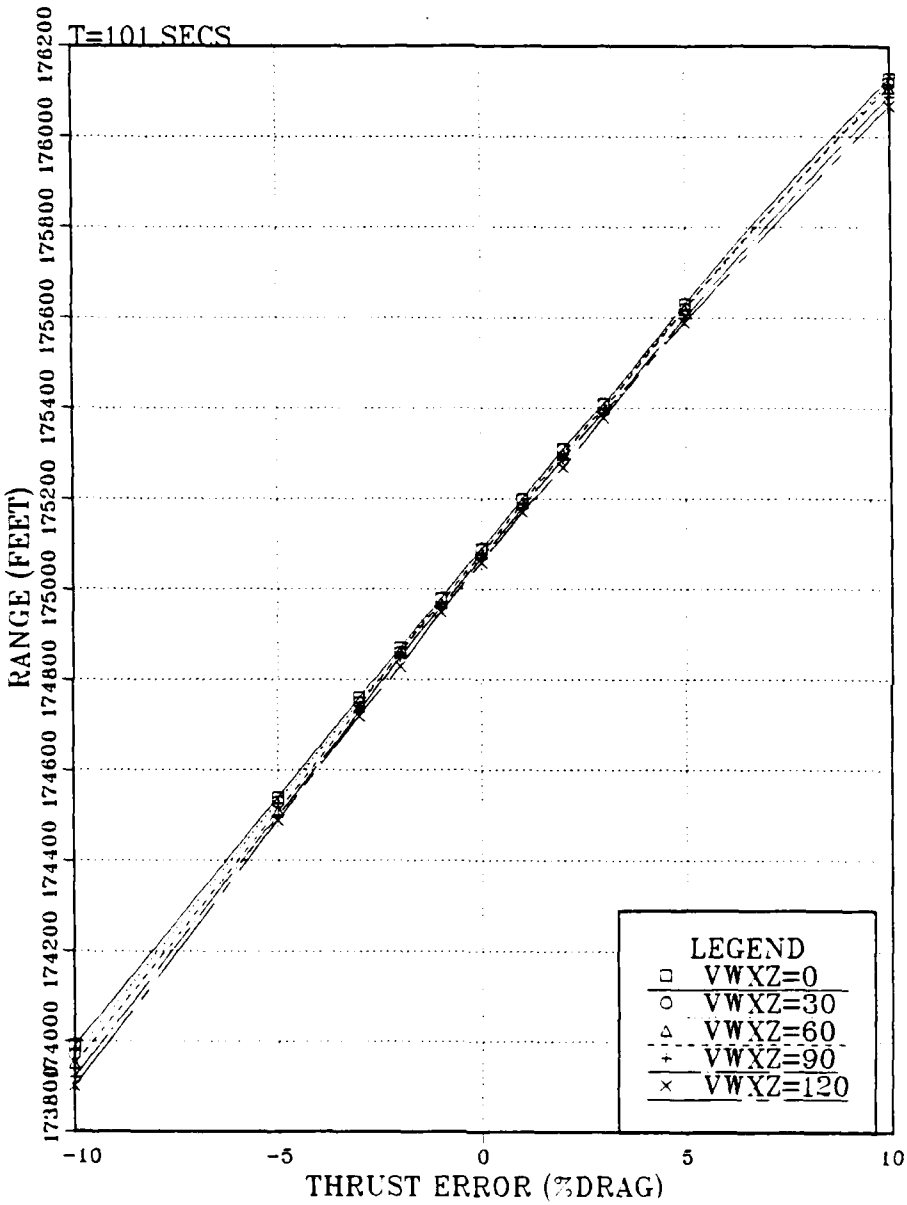

Figure 3-22 Headwind Sensitivity (Range)

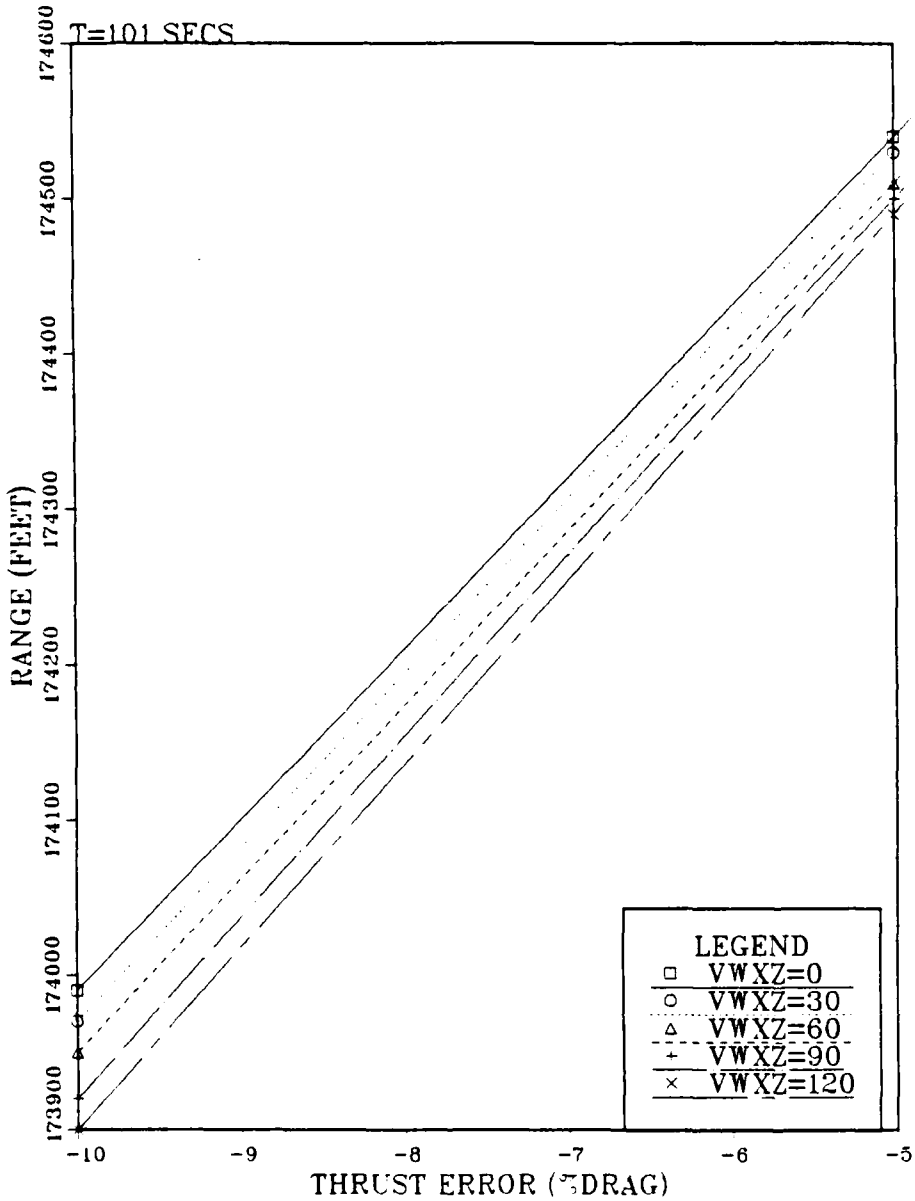

Figure 3-22A Headwind Sensitivity (Range)

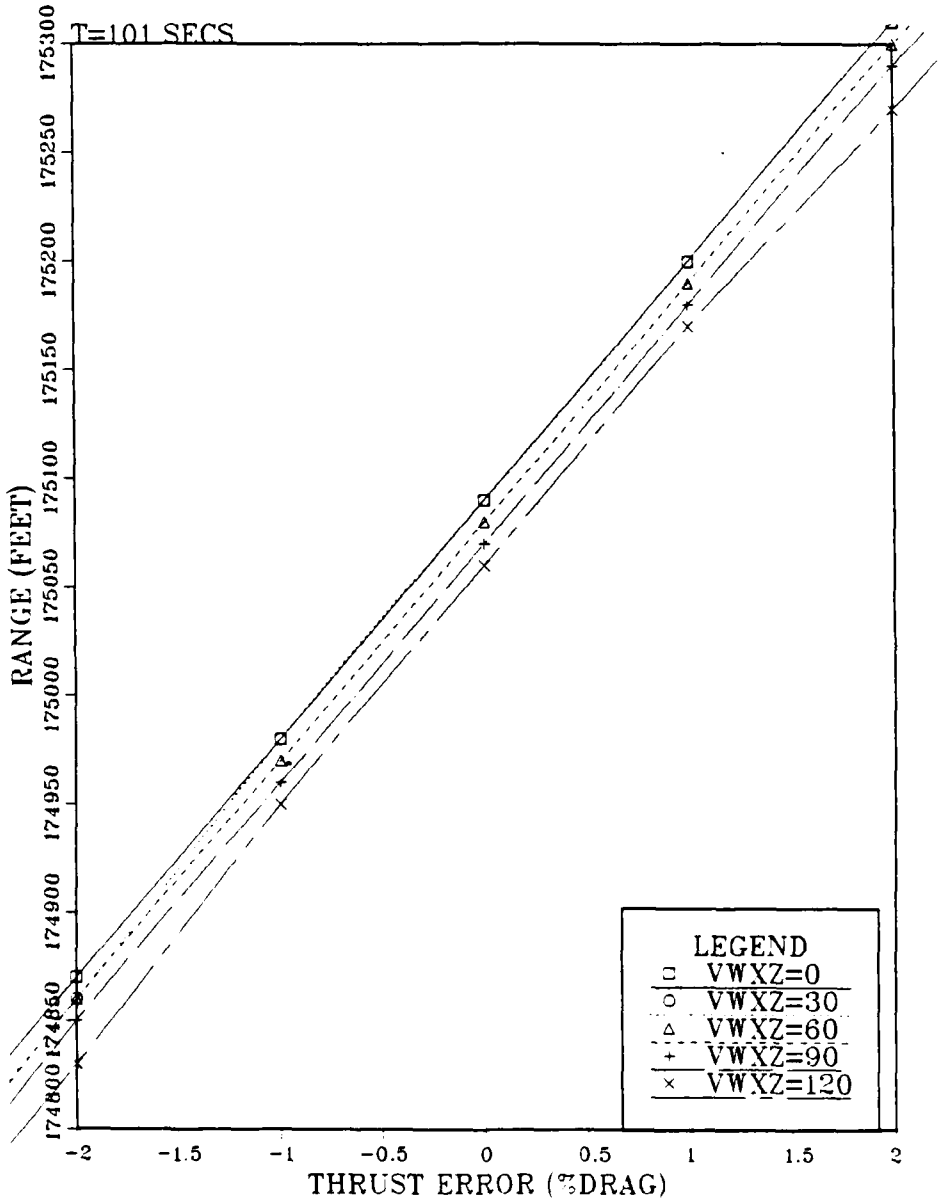

Figure 3-22B Headwind Sensitivity (Range)

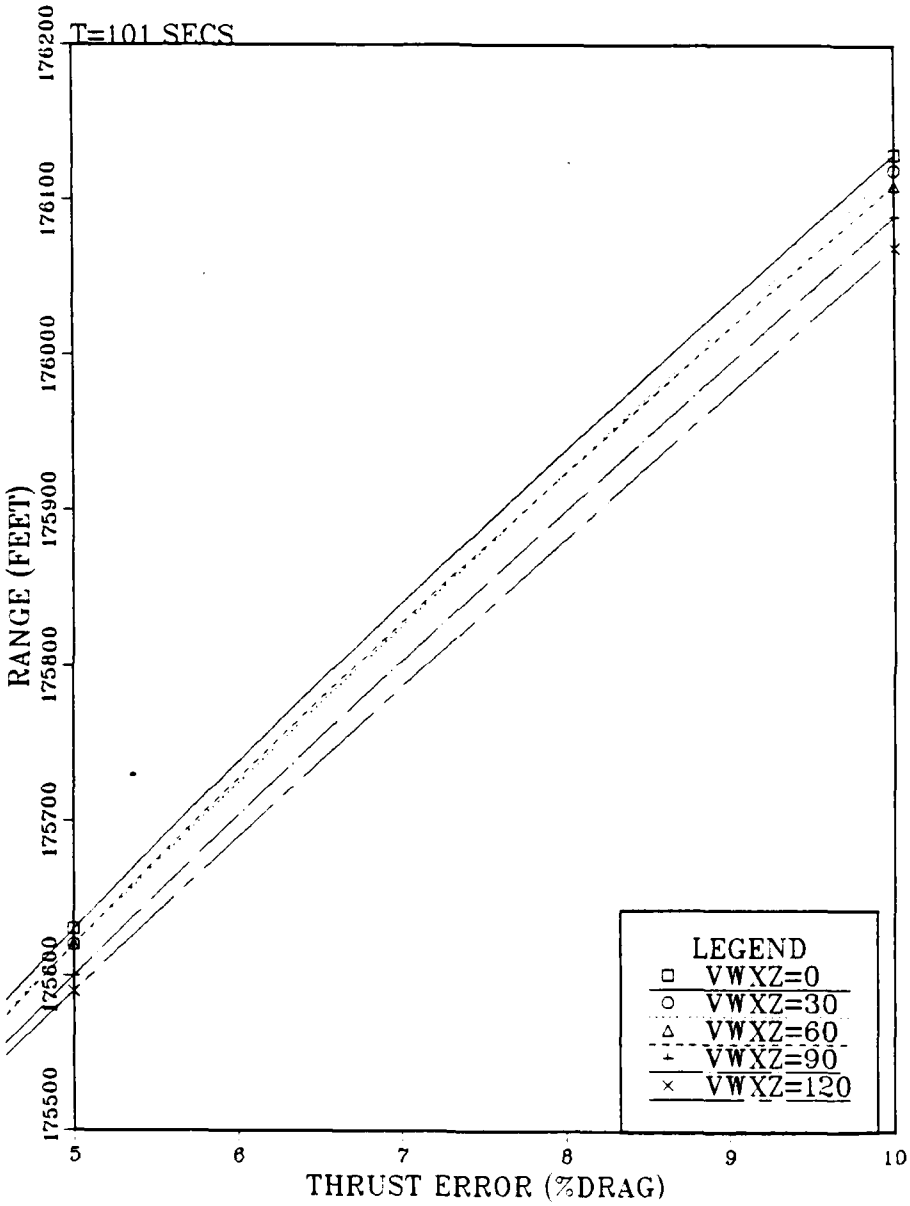

Figure 3-22C Headwind Sensitivity (Range)

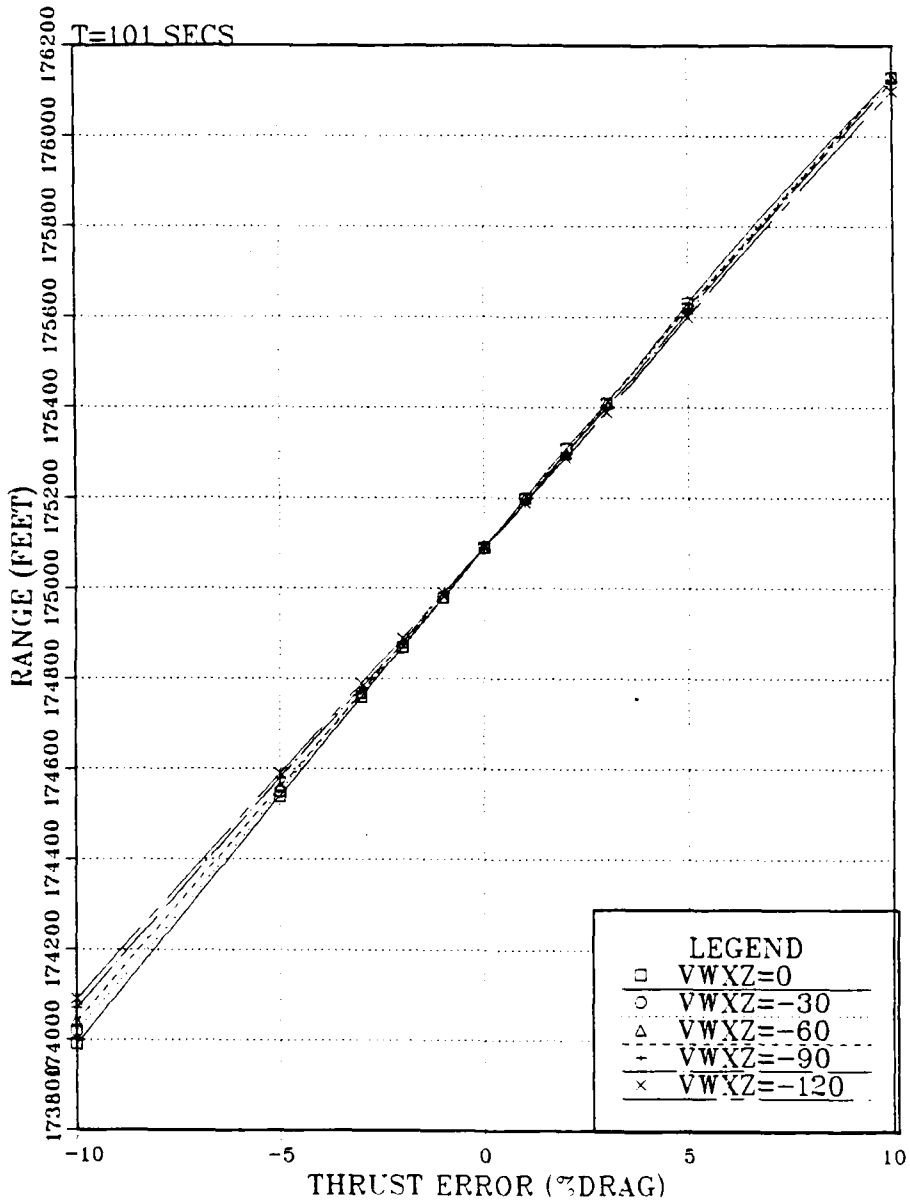

Figure 3-23 Tailwind Sensitivity (Range)

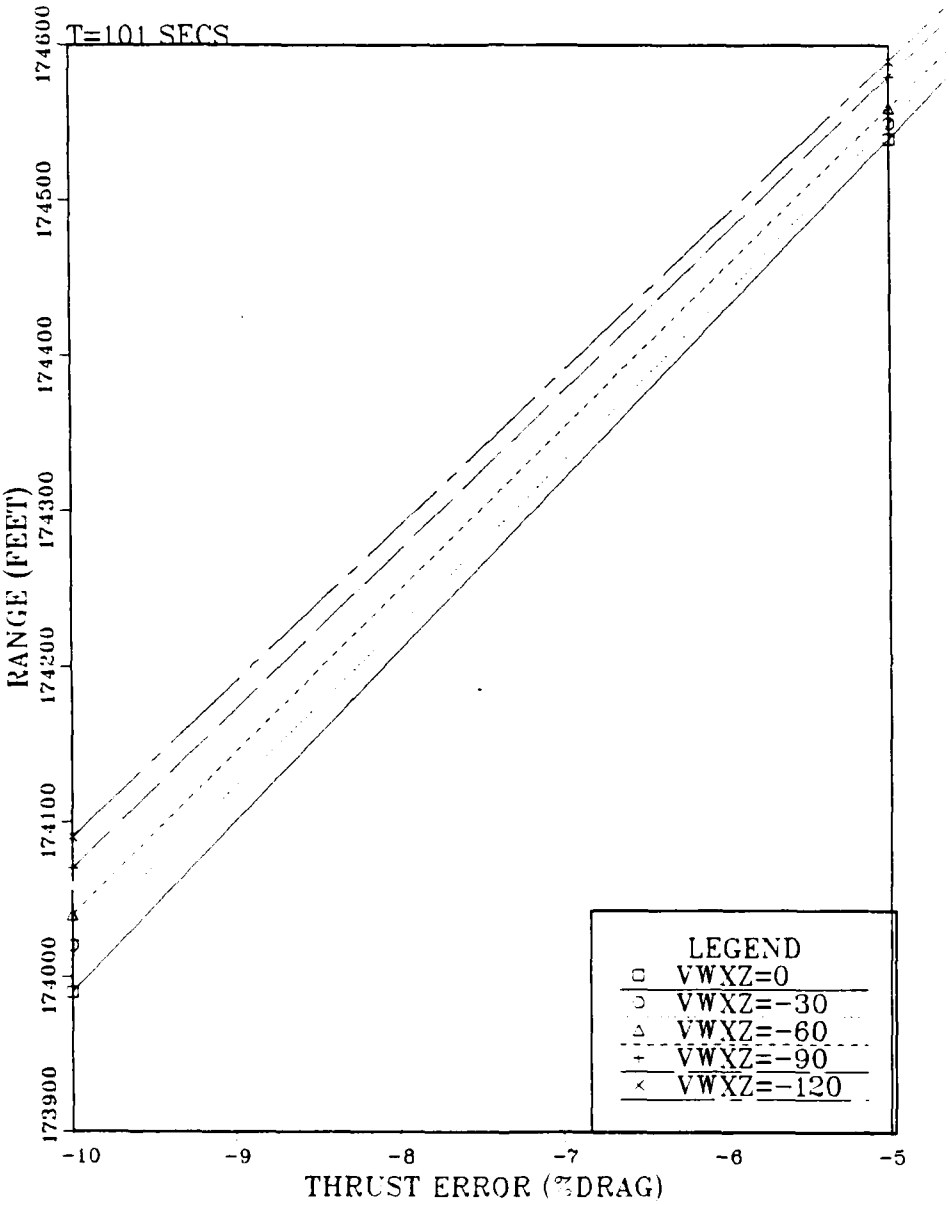

Figure 3-23A Tailwind Sensitivity (Range)

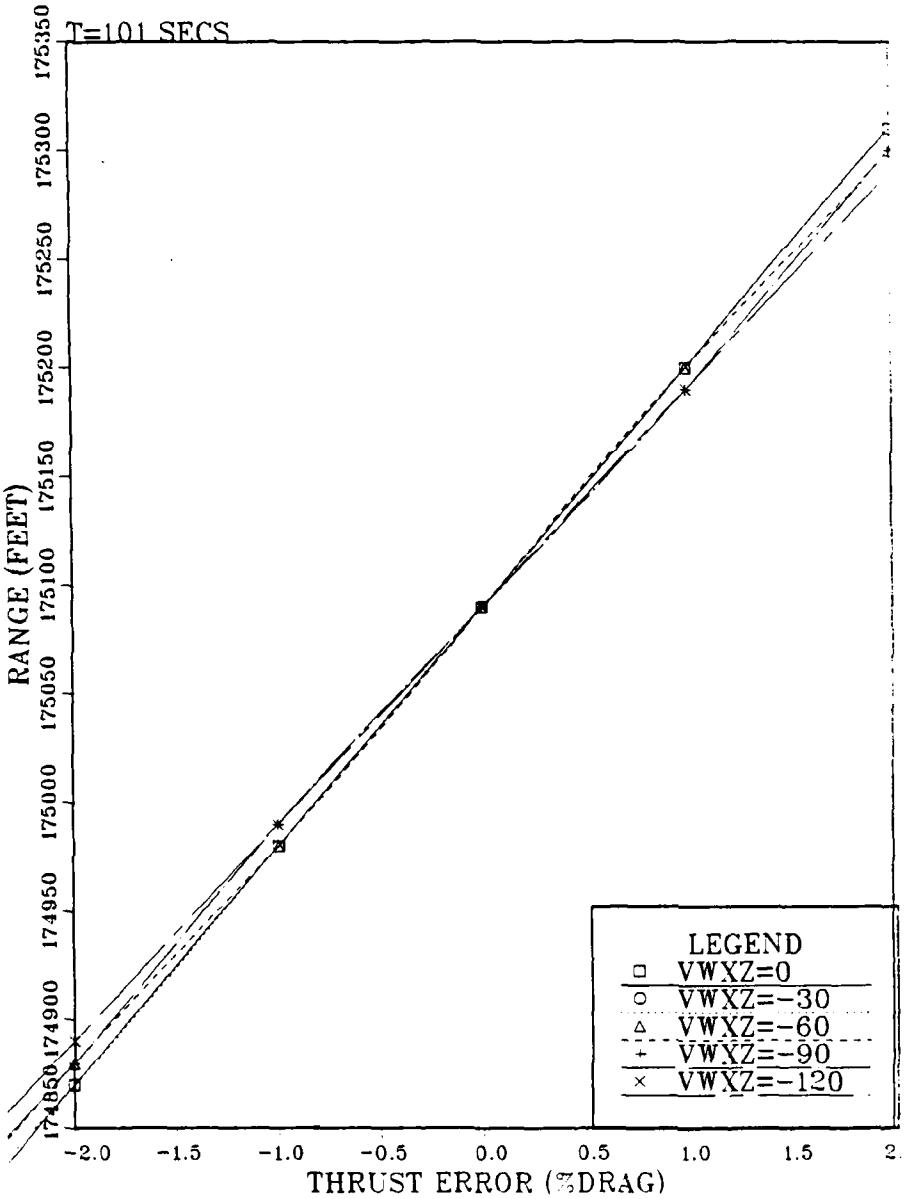

Figure 3-23B Tailwind Sensitivity (Range)

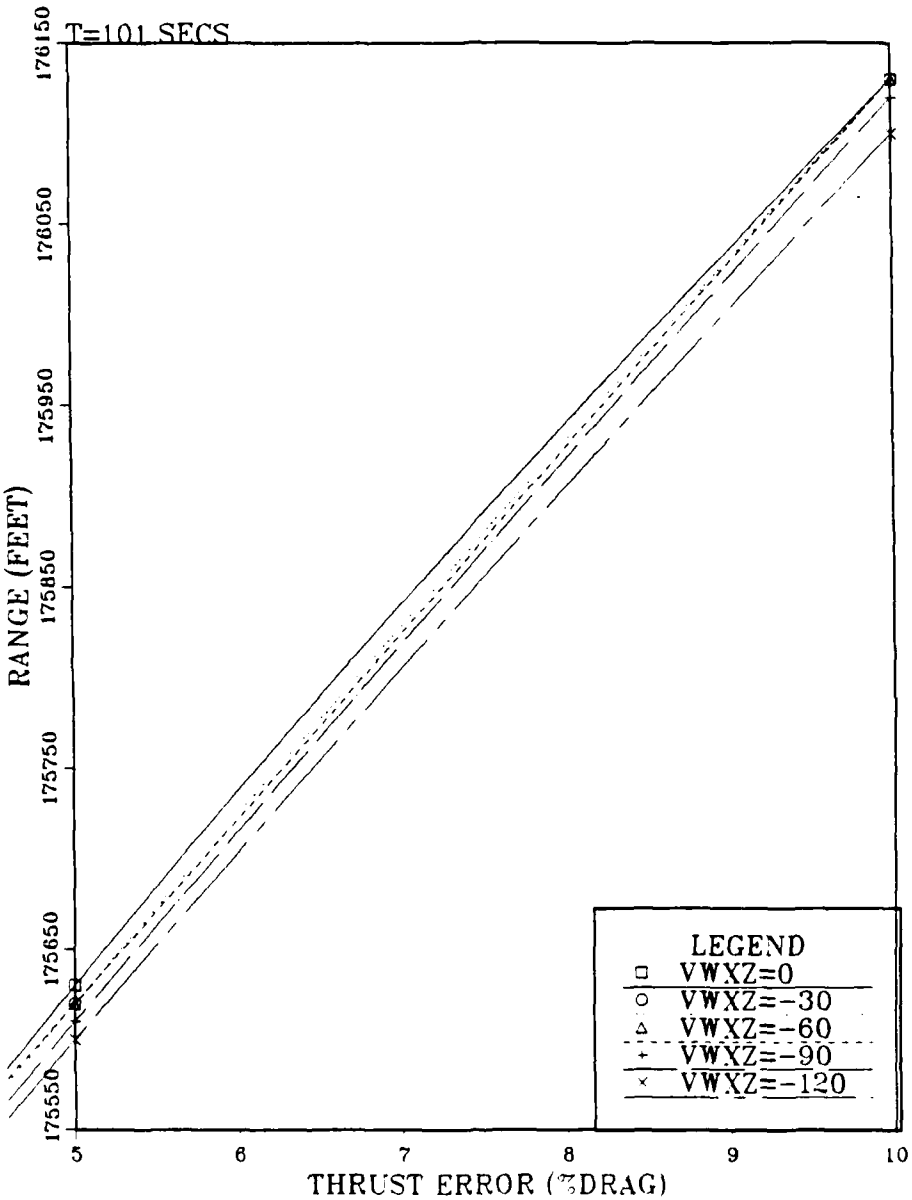

Figure 3-23C Tailwind Sensitivity (Range)

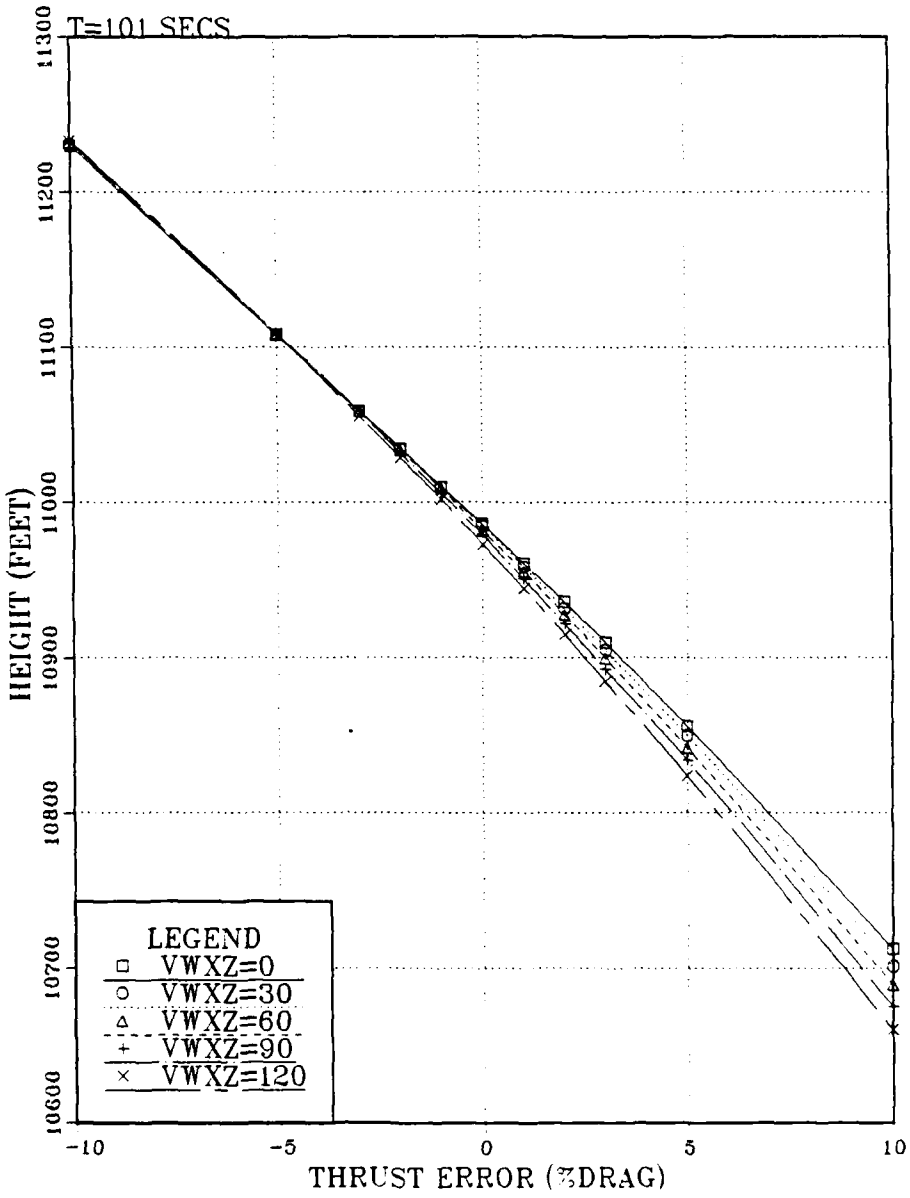

Figure 3-24 Headwind Sensitivity (Height)

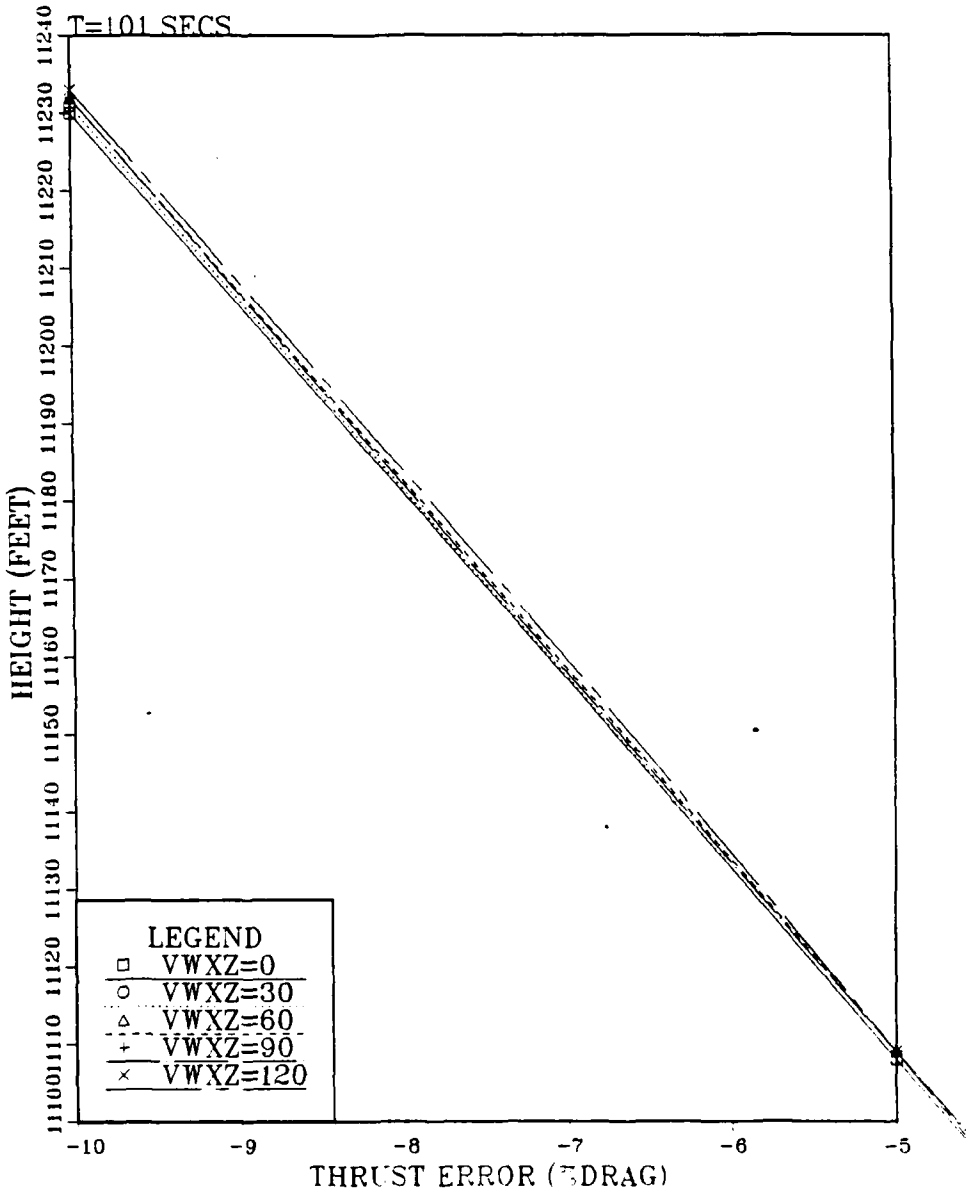

Figure 3-24A Headwind Sensitivity (Height)

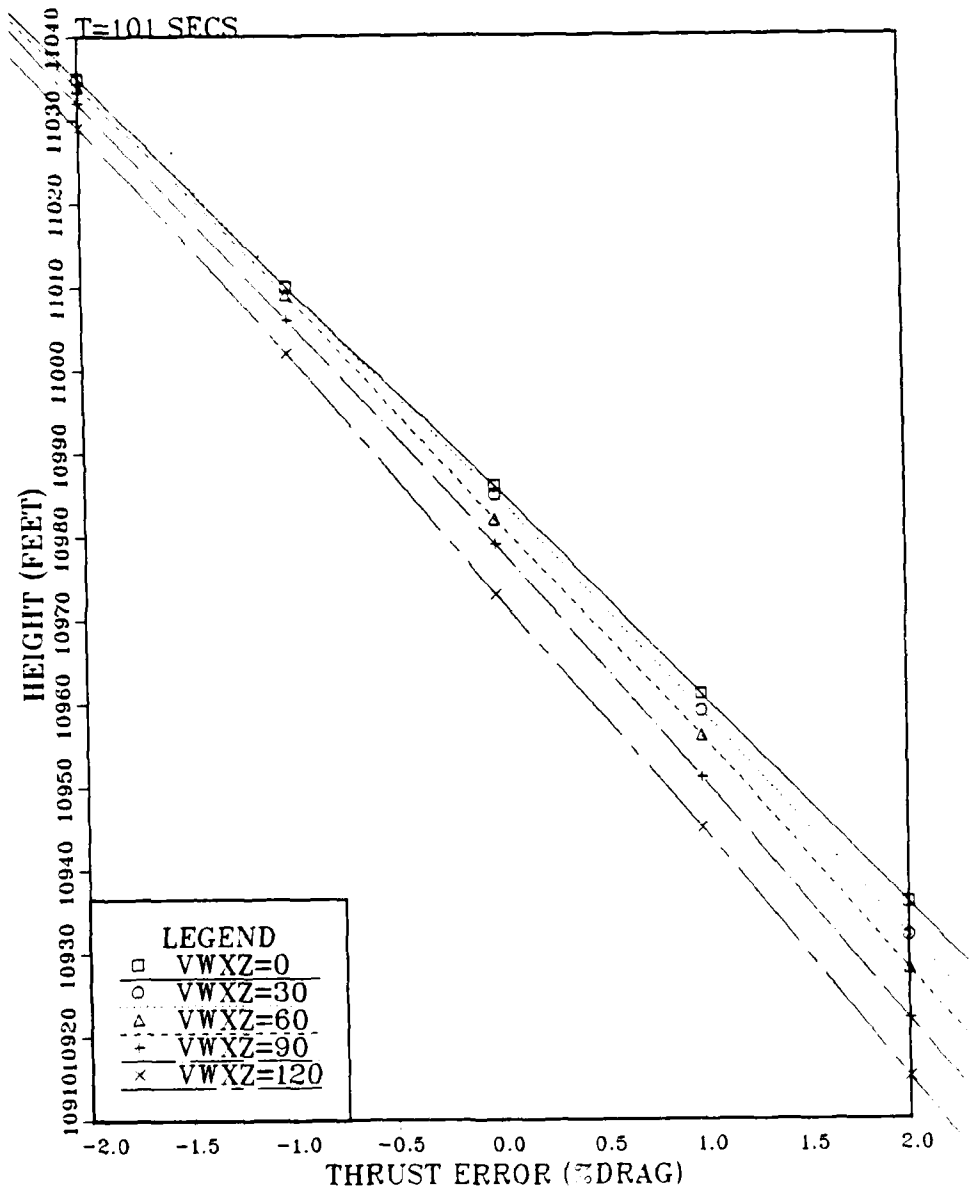

Figure 3-24B Headwind Sensitivity (Height)

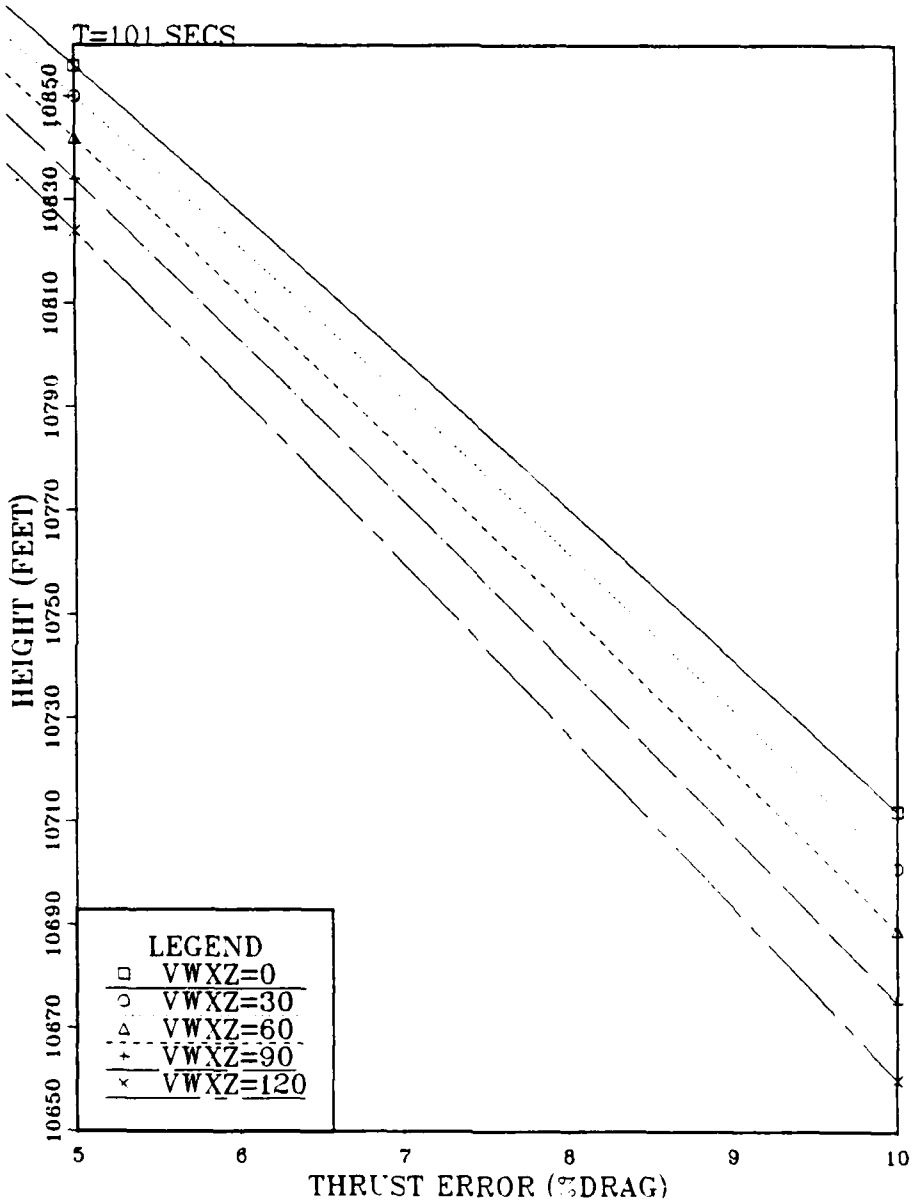

Figure 3-24C Headwind Sensitivity (Height)

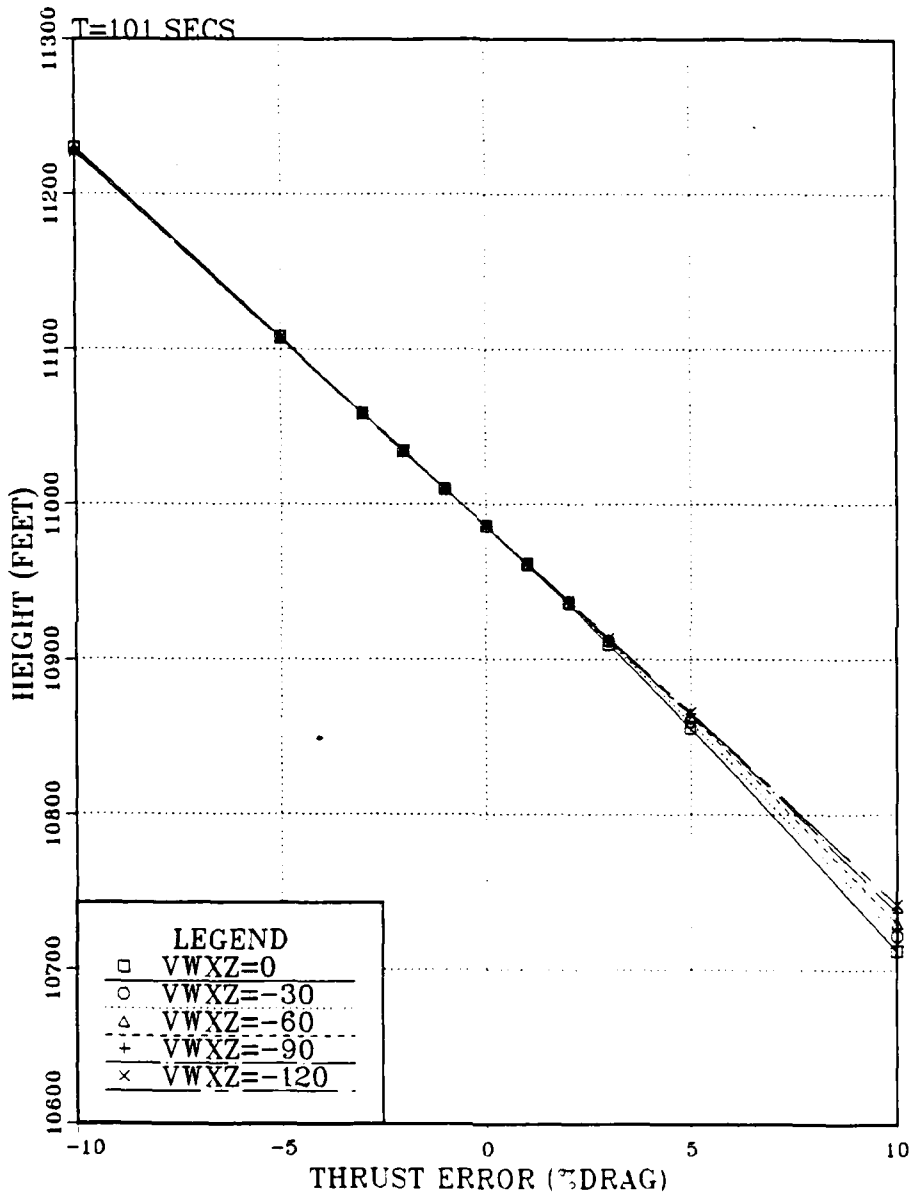

Figure 3-25 Tailwind Sensitivity (Height)

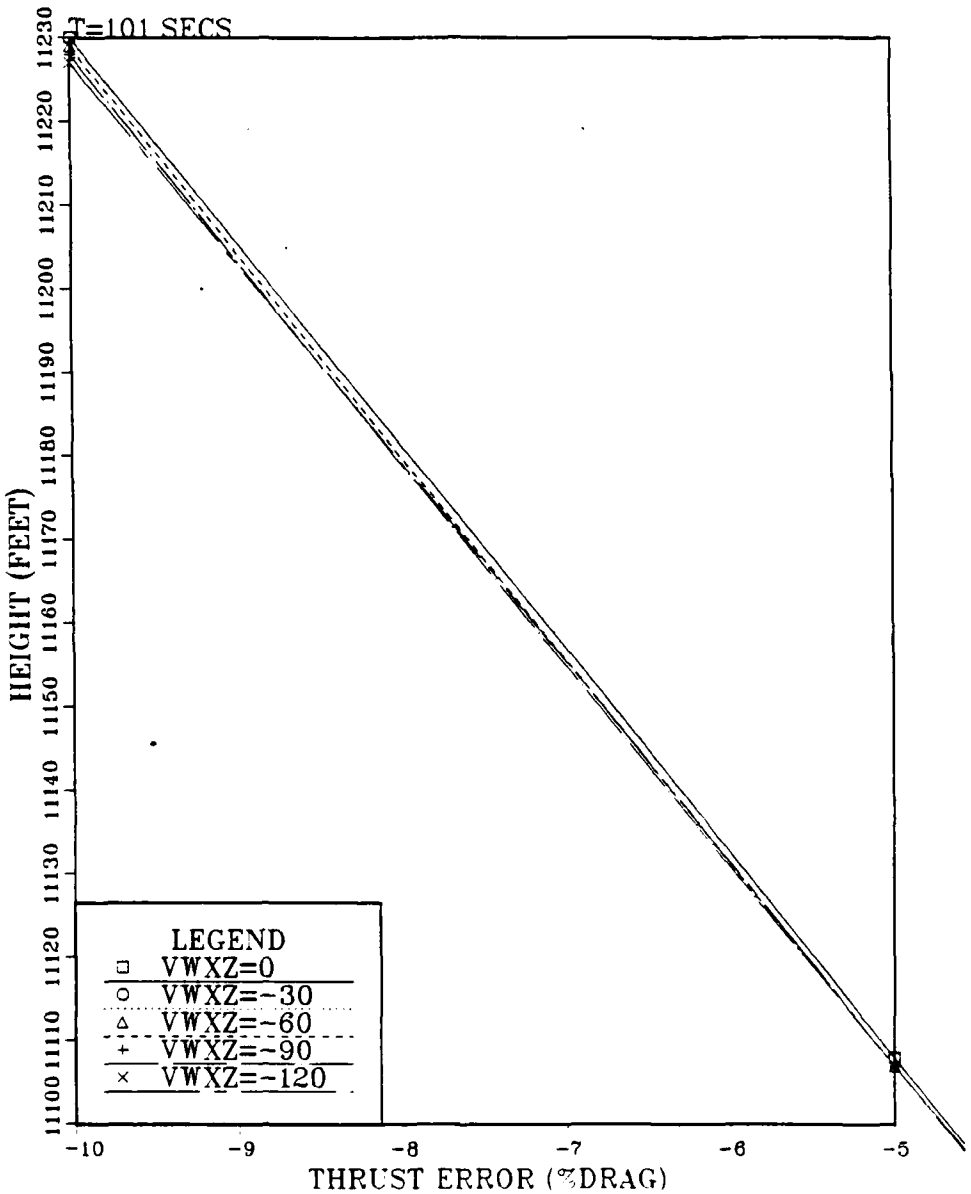

Figure 3-25A Tailwind Sensitivity (Height)

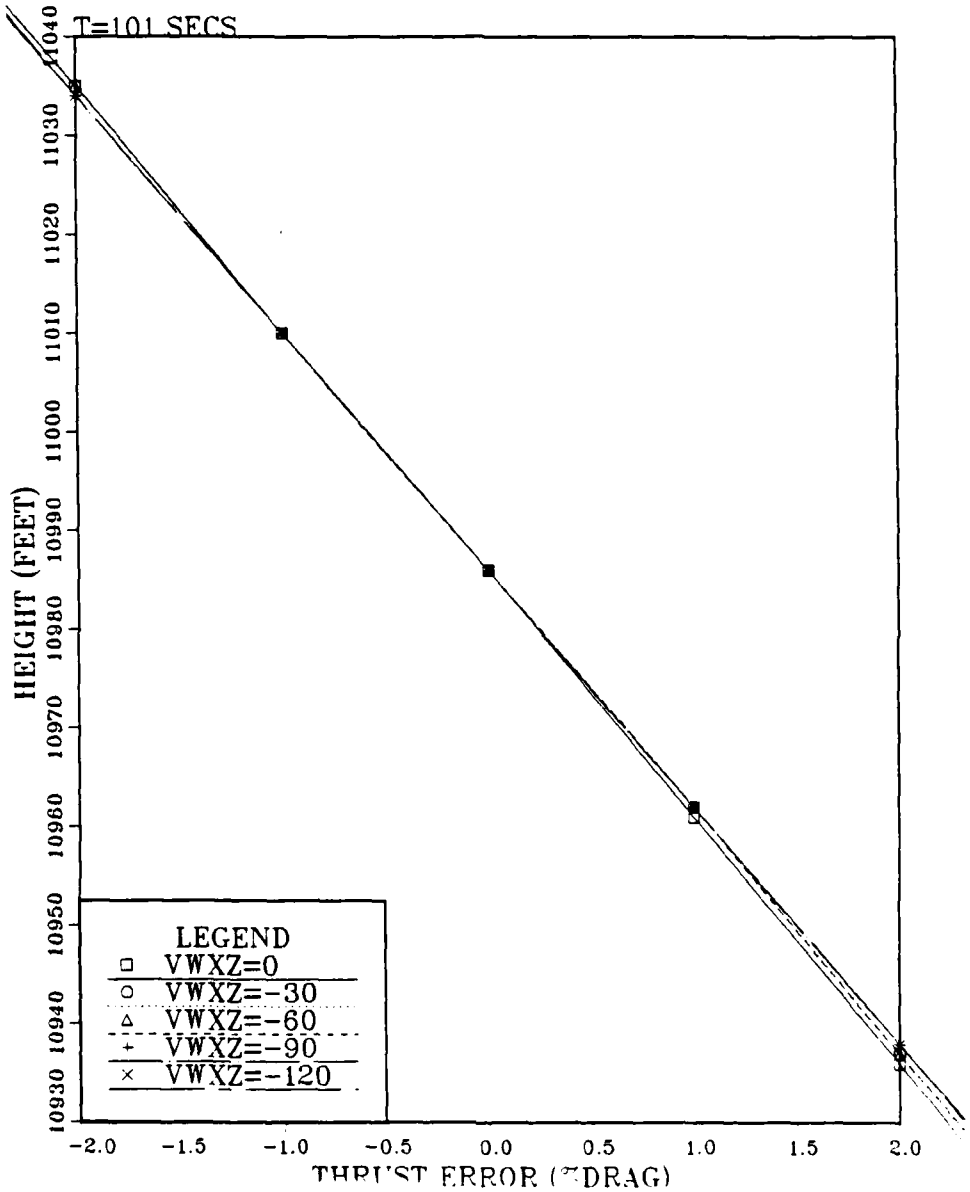

Figure 3-25B Tailwind Sensitivity (Height)

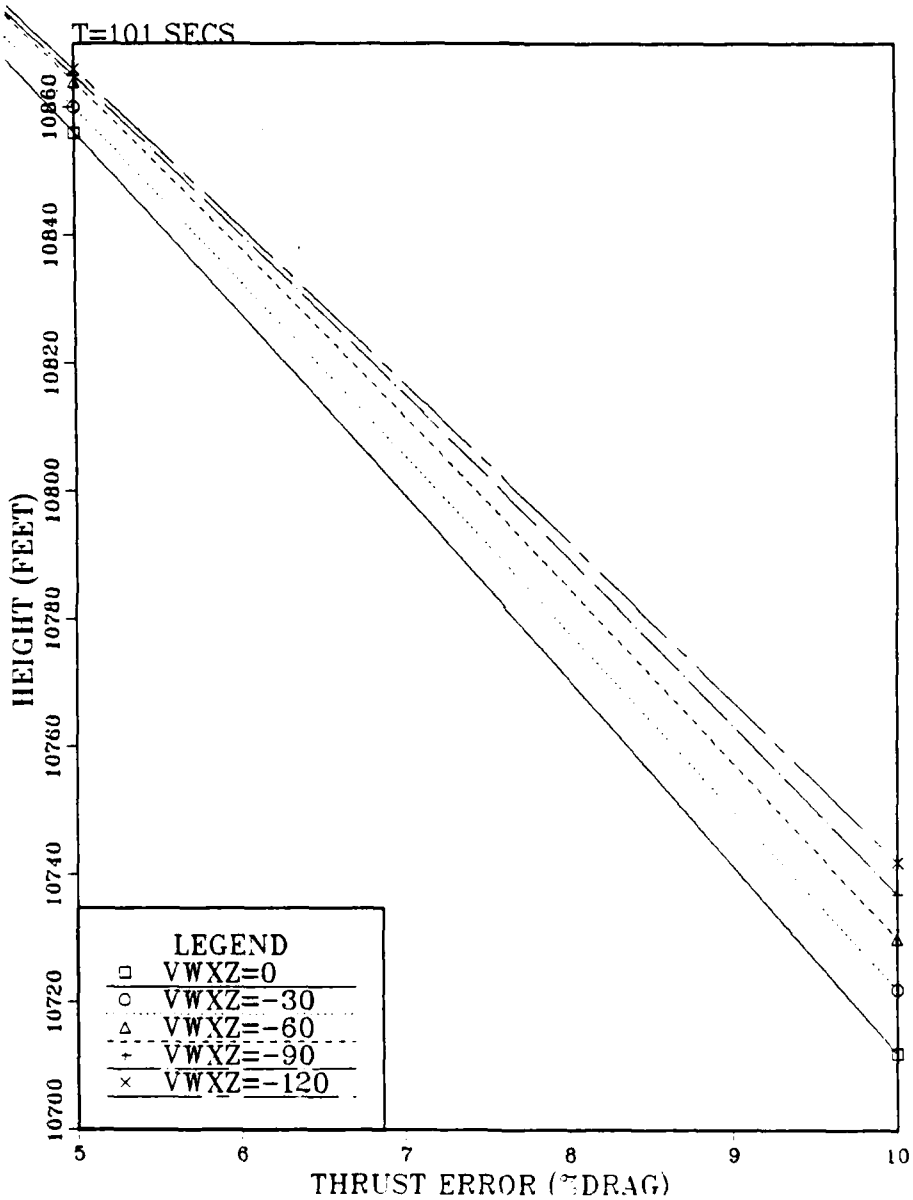

Figure 3-25C Tailwind Sensitivity (Height)

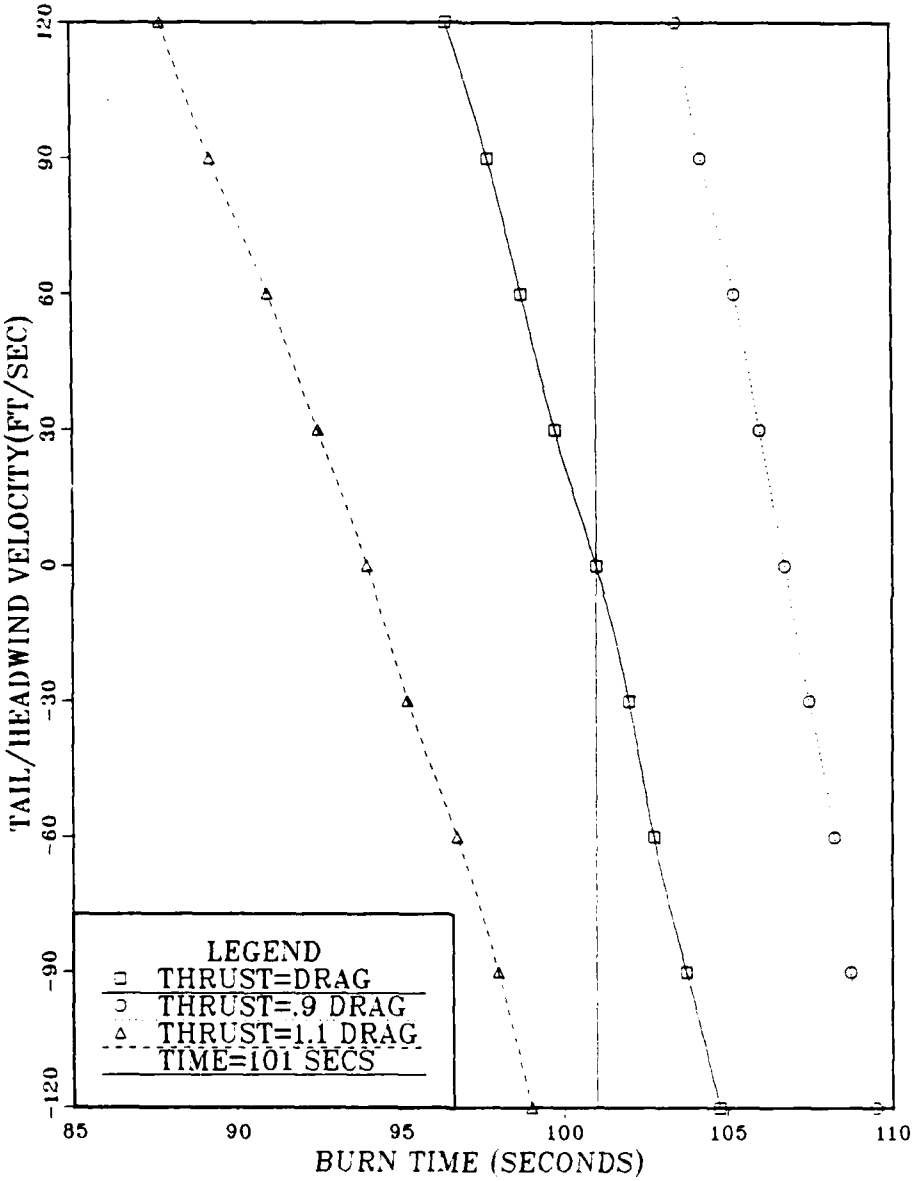

Figure 3-26 Tail/Headwind Effects (Burntime)

Deviations from the ideal trajectory were correlated and tabulated in Table 3.5.Results were conservatively linearized and are presented in that manner. Wind errors are read in addition to the thrust errors at the left of the table.For example:

If thrust error=-5%
crosswind=120 ft/sec

predicted dispersion is X=-540 ft
Y=19 ft
Z=130 ft ;from ideal basket.

Table 3.5 Dispersion Analysis Results

	Thrust Errors		Winds continuous 120 ft/sec				
			Cross	Head		Tail	
Errors	X	Z	Y	X	Z	X	Z
0 %	0	0	.1	30	7	.1	.1
1 %	110	25	4	30	15	10	1
2 %	220	50	8	40	20	20	2
5 %	540	130	19	50	32	50	10
10 %	1100	345	38	90	50	100	30

Velocities at time 101 seconds were measured and are shown at Figure 3-27.The total variation of extreme cases is from 2285 feet/sec to 2315 feet/sec, or only 30 feet/sec.

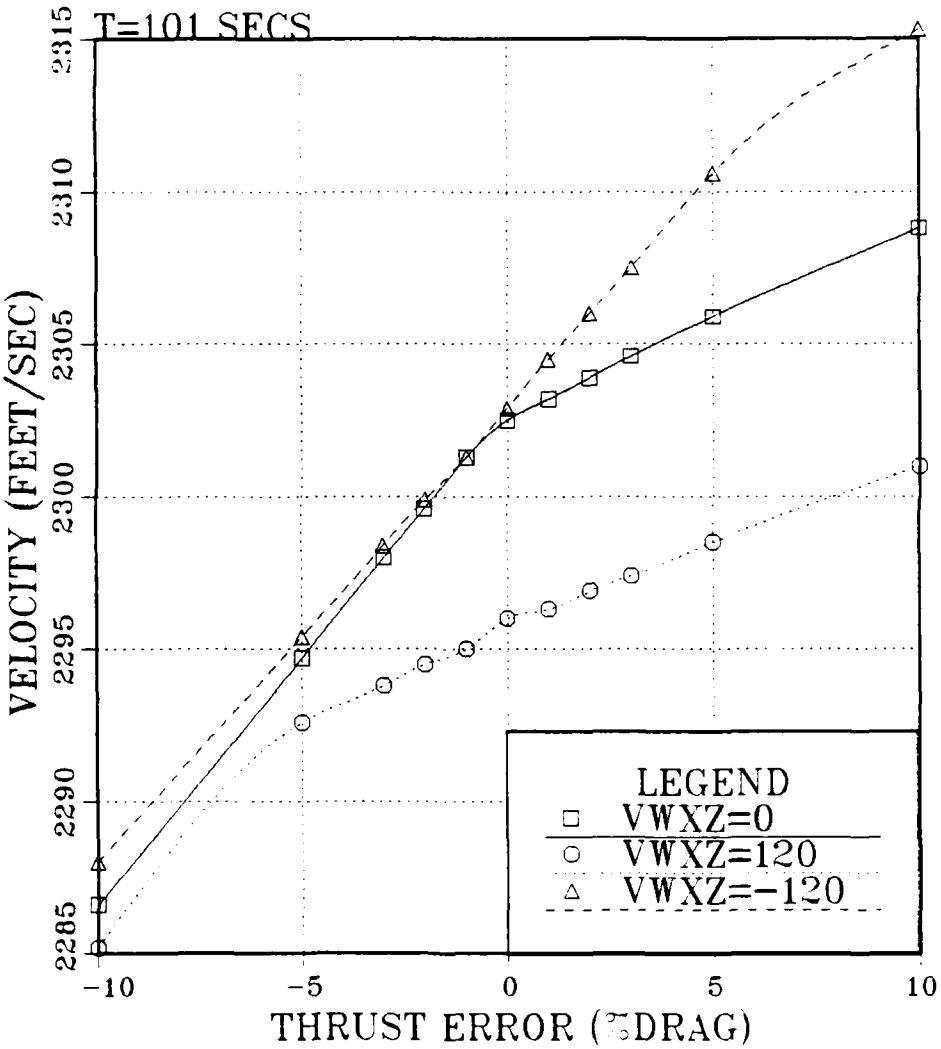

Figure 3-27 Velocity Sensitivity

Wind effects during near thrust equals drag portions of the trajectory were very small.The critical factor affecting the dispersion will be the setting of the terminal guidance clock in the projectile.This presents several options for setting initiation of terminal guidance:

-Fixed time irrespective of trajectory (ie. elevation of gun).Burn time would be shorter at less than 45 degree launch and the basket would be more sensitive to wind and thrust errors.As well the trajectory would change and so would the predicted basket.

-Fixed time for a given trajectory.This requires analysis of the sensitivity to elevation of the gun and a manual Tc setting method for gunners.

-Ramjet burnout.This would ensure that Tc occurred at an "optimum" point almost exactly on the pseudo-vacuum trajectory but the location along it at Tc would be difficult to predict.

-At given pressure for altitude [Reference 5].This would establish accurate baskets for given gun elevations assuming the altitude chosen was before ramjet burnout.

Several trajectories were simulated with a varying wind profile as a function of altitude in the Standard Atmosphere.These are shown at Figure 3-28 as compared to the pseudo-vacuum trajectory.

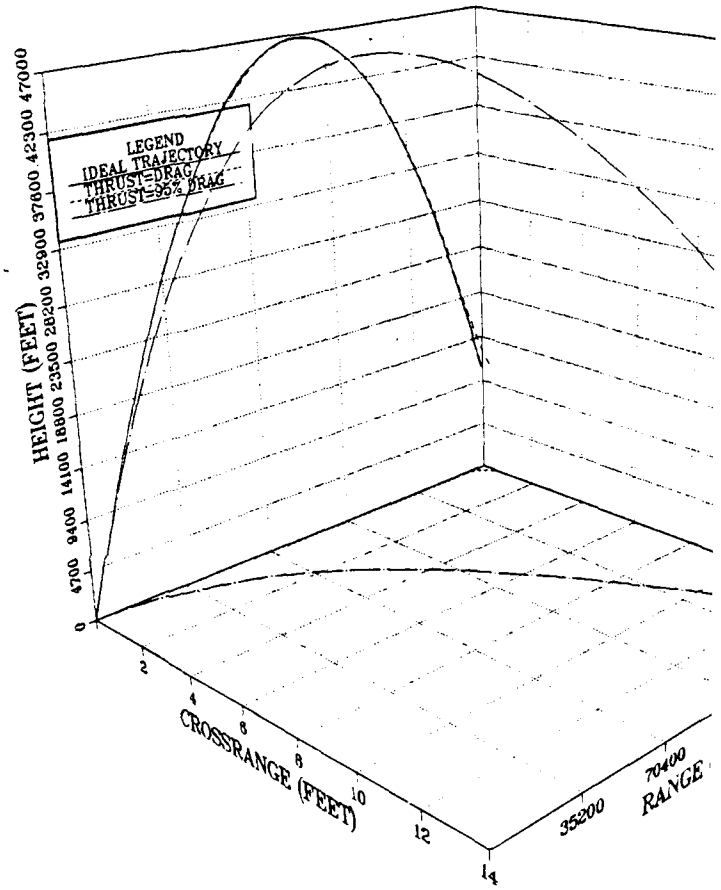

Figure 3-28 Three Dimensional Trajectory Dependent Wind Profile

IV. CONCLUSIONS

Generally this thesis confirms the viability of th pseudo-vacuum trajectory from a thrust equals dra projectile.Indeed winds up to 120 feet per second and thrus errors up to five percent created dispersions of less tha 600 feet over a range of 175090 feet for the ARM projectile.

Specifically the following conclusions are made:

-the drag due to wind (Dw) is the aerodynami force which creates the most dispersion.

-the net lift due to transients (Lw) is a mino aerodynamic force in creating dispersion.

-the dispersion is proportional to the dampin coefficient (Cmq),although for practical values of Cm dispersion can be treated as insensitive to Cmq.

-the projectile resonance or short period is a approximately 0.22 Hz and is unstable in th resonance regime due to variable wind profiles.The phugoi is irrelevant.

-thrust errors are the most significant error contributing to dispersion.

-winds have a minor effect on dispersion durin powered flight when thrust approximates drag

except where harmonic content near resonance is contained in the wind profile.

-headwinds create greater dispersion as ramjet burnout occurs before terminal guidance is initiated.Crosswinds and tailwinds generally will have minimal effects.

Recommendations for further study related to this thesis are:

-Dynamics at launch including the initial spin damping, Magnus effects and aerodynamic jump.

-Dynamics at terminal guidance including air inlet spike ejection and canard deployment.

-Complete adaptation of *BRL HTRAJ* on the *NPGS IBM* system to use non-linear aerodynamics.

APPENDIX A-PROJECTILE CHARACTERISTICS

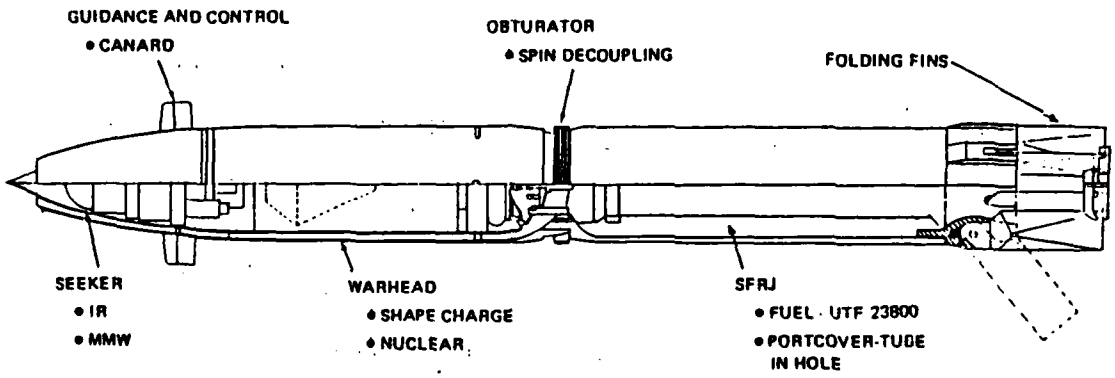

Figure A-1 ARMT Projectile Baseline Design

The following characteristics are obtained from References 2 and 6.

length=72 inches

diameter=8 inches

launch weight=225 lbm

launch CG=39.4 inches from spike apex

fuel weight=27 lbm (CG at 52.0 inches from apex)

impulse=950 "seconds"

Mass Property Equations:

CG=(225x39.4)-(52.0xfuel burned)/(225-fuel burned) in

Izz=.35-(.0019xfuel burned) in slug-ft

Ixx=Iyy=18.8-(.0423xfuel burned) in slug-ft

Aerodynamic Coefficient Equations:

$Cd=Cdo + .5 \times Cl \times \sin(\alpha)$

$Cdo= -.1025 \times MACH + .5015 \quad (1.8< MACH < 2.2)$

$Cm=Cl\ (Xcg-Xcp)/d$

$Cl=Cl_{\alpha} \times \alpha$

Key Wind Tunnel Results (per degree):

MACH=1.8

Cdo=.317 Cmq=-203

α	0	2	4	6	8	10
Cl	0	.18	.38	.62	.92	1.3
Xcp	45.4	45.6	48.2	49.7	50.2	50.0

MACH=2.2

Cdo=.276 Cmq=-190

α	0	2	4	6	8	10
Cl	0	.19	.40	.65	.95	1.3
Xcp	42.9	42.9	44.6	45.1	46.0	44.6

Cmq=d(Cm)/d(qd/2V)

Initial Muzzle Spin Rate 30 PI radians /sec

APPENDIX B TRANSIENT ANGLE OF ATTACK CALCULATIONS

The following equation of motion applies to the dynamics of angle of attack (alpha) oscillations due to the torque equation described in the three-degrees-of-freedom model.

$$m\ddot{y} = Lw \text{ which is proportional to alpha}(t)$$

where angle of attack is of the form :

$$\alpha(t) = e^{-\delta t} \sin(wt)$$ where δ is the damping constant and w is the angular velocity. Therefore:

$$my \doteq \int_0^t \int_0^T \alpha(t)\, dt\, dT$$

$$= \int_0^t \int_0^T e^{-\delta t} \sin(wt)\, dt\, dT$$

$$= \int_0^t \left[\frac{e^{-\delta T}\,(-\delta \sin(wT) - w\cos(wT)) + w}{\delta^2 + w^2} \right] dT$$

$$= \frac{\left[\begin{array}{l} wt(\delta^2 + w^2) - 2\delta w + \\ e^{-\delta t}(\delta^2 \sin(wt) + 2\delta w\cos(wt) - w^2 \sin(wt)) \end{array} \right]}{(\delta^2 + w^2)^2}$$

When t=0, the equation reduces to:

$-2\delta w + 1(2\delta w) = 0$ which is expected if the initial condition is zero.(ie. dispersion at zero equals zero at time zero).

As t approaches infinity the equation value approaches infinite dispersion, but the oscillations of alpha have damped out. Note that the first derivative, proportional to velocity, tends to a constant value:

$(w/(\delta^2 + w^2))/m$ as t approaches infinity which is also to be expected.

APPENDIX C-PSEUDO-VACUUM TRAJECTORY CONCEPT

The basic concepts behind the pseudo-vacuum are not always readily apparent.This appendix analyzes the basic equations of motion in the following sequence of cases to illustrates the concept:

vacuum trajectory

atmosphere trajectory

thrusted trajectory

wind influenced trajectory

thrust equal drag trajectory

In Figure C-1 (curve 1) the applicable equations of motion are:

$$m\ddot{x}_1 = 0$$

$$m\ddot{z}_1 = -mg$$

An accelometer on the projectile in the z direction would measure no acceleration as it is in free fall already. This is similar to a satellite orbit or someone on an elevator in free fall.

When atmosphere is added the key equations are:

$$m\ddot{x}_2 = -D_x = -1/2\ \rho\ U_x^2\ A\ C_d$$

$$m\ddot{z}_2 = -D_z - mg$$

where U is relative wind and D is atmospheric drag.In this

case Ux=Vx and Uz=Vz.This trajectory is represented by curve 2.An accelometer in the x direction measures Dx/m and Dz/m in the z direction.

If thrust is added, the trajectory is as shown at curve 3(thrust greater than drag).The key equations are then:

$$m\ddot{x}_3 = -D_x + T_x$$

$$m\ddot{z}_3 = -D_z + T_z - mg$$

Accelerometers would measure (Tx-Dx)/m and (Ty-Dy)/m respectively.If thrust equals drag the trajectory would be curve 1.

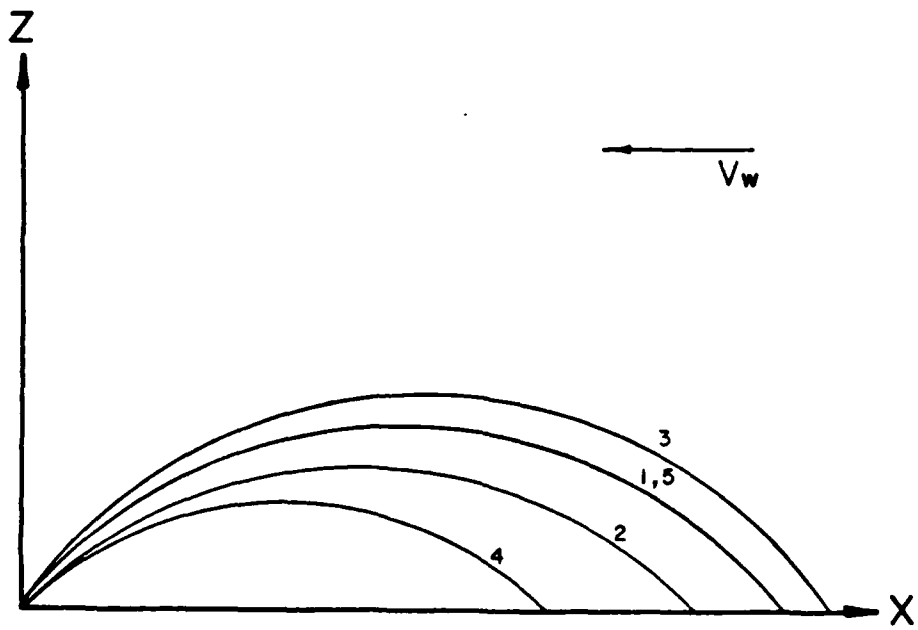

Figure C-1 Pseudo-Vacuum Trajectory Concept Curves

In Figure C-1 wind (Vw) has been added for the curve #4 in the x direction.The new equations are :

$$m\ddot{x}_4 = (-D_x + Dw) + T_x$$

$$m\ddot{z}_4 = -D_z + T_z - mg$$

where $Dx + Dw = 1/2\ \rho\ U_x^2\ C_d\ A$

and Ux(wind relative to the projectile) =Vx+Vw. With no thrust curve 4 results.

Finally, if thrust is added to equal drag the following equations are valid:

$$m\ddot{x}_5 = 0 \text{ or } T_x = D_x + Dw$$

$$m\ddot{z}_5 = -mg \text{ or } T_z = D_z$$

The accelerometer(s) read the acceleration caused by any differences in the thrust and drag forces (zero in this case).

It is clear that curves 1 and 5 are equal (and 3 if thrust=drag) but the burntime of a ramjet will not be equal in each case due to different drag profiles.

$$t = (\text{mass fuel})(Isp)/\text{thrust}$$

Therefore headwinds will require more thrust and burntime will be shorter.Conversely tailwinds allow longer

burning.Burnout will occur on the vacuum trajectory but not at the same point, as shown in Figure C-2.

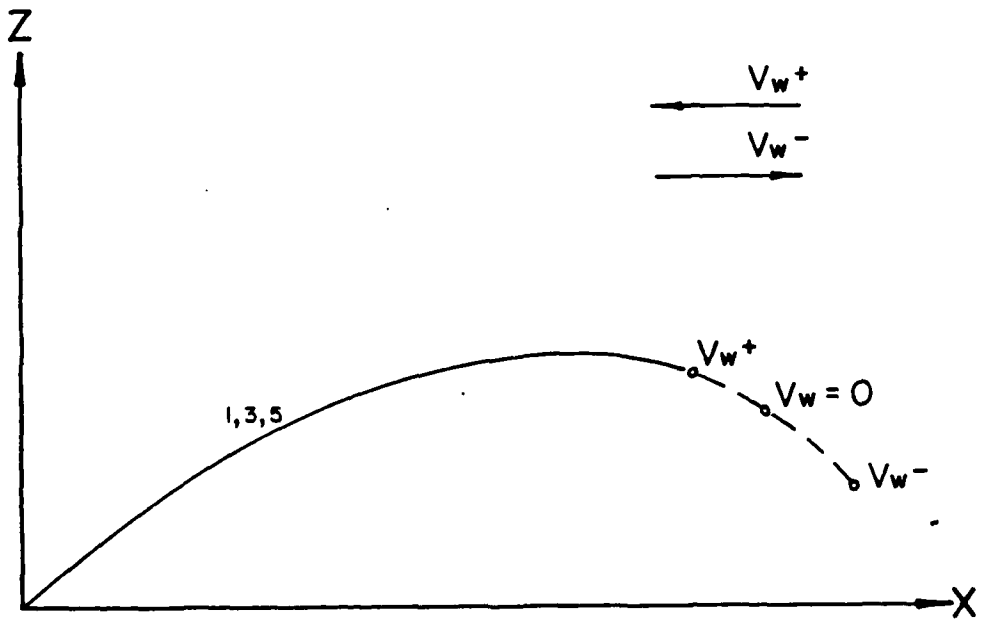

Figure C-2 Burnout Variations

APPENDIX D PSEUDO-VACUUM TRAJECTORY PROGRAM

```
10 DIM X(300),Y(300),RO(300),D(300),MDOT(300),M(300),V(300)
12 DIM CDO(300),MA(300)
15 DIM T(300)
20 MMIN=198
30 ISP=950
40 DELT=.5
50 M(1)=225
60 THETA=.7853981634000006#
70 VO=2452
75 LPRINT "TIME","X","Y","MASS","SPEED"
80 FOR I=1 TO 300
90   X(I)=VO*COS(THETA)*T(I)
100  Y(I)=(VO*SIN(THETA)*T(I))-(16.087*T(I)^2)
110  V(I)=((VO*COS(THETA))^2+(VO*SIN(THETA)-
     32.174*T(I))^2)^.5
120  TEMP =518.688-.0035662*Y(I)
150  RO(I)=(2116.22*(1-(.0035662*Y(I)/518.688))^5.256)/
     (1716.5*TEMP)
155  IF Y(I))=36089! THEN RO(I)=.001271
157 IF Y(I))=36089! THEN TEMP=389.99
158 MA(I)=V(I)/SQR(1.4*1716.3*TEMP)
159 CDO(I)=.5015-.1025*MA(I)
160  D(I)=.276*.5*RO(I)*.3491*V(I)^2
161 D(I)=D(I)/.276*CDO(I)
170  MDOT(I+1)=D(I)/ISP
180  M(I+1)=M(I)-MDOT(I)*DELT
190  T(I+1)=T(I)+DELT
195 LPRINT T(I),X(I),Y(I),M(I),V(I)
200  IF M(I+1)<=MMIN GOTO 220
210 NEXT I
220  LPRINT "RAMJET BURNOUT BETWEEN T=";T(I);"AND";T(I+1)
```

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TIME	X	Y	MASS	SPEED
0	0	0	225	2452
.5	866.913	862.891	225	2440.65
1	1733.83	1717.74	224.637	2429.36
1.5	2600.74	2564.54	224.286	2418.11
2	3467.65	3403.3	223.947	2406.93
2.5	4334.57	4234.02	223.618	2395.8
3	5201.48	5056.7	223.3	2384.73
3.5	6068.39	5871.32	222.993	2373.71
4	6935.3	6677.91	222.695	2362.75
4.5	7802.22	7476.46	222.407	2351.85
5	8669.13	8266.96	222.128	2341.01
5.5	9536.04	9049.41	221.858	2330.24
6	10403	9823.82	221.597	2319.52
6.5	11269.9	10590.2	221.344	2308.86
7	12136.8	11348.5	221.099	2298.27
7.5	13003.7	12098.8	220.861	2287.74
8	13870.6	12841	220.631	2277.28
8.5	14737.5	13575.2	220.409	2266.89
9	15604.4	14301.4	220.193	2256.55
9.5	16471.3	15019.5	219.983	2246.29
10	17338.3	15729.6	219.781	2236.1
10.5	18205.2	16431.6	219.584	2225.98
11	19072.1	17125.6	219.394	2215.92
11.5	19939	17811.5	219.209	2205.94
12	20805.9	18489.4	219.03	2196.03
12.5	21672.8	19159.2	218.856	2186.2
13	22539.7	19821	218.687	2176.43
13.5	23406.7	20474.8	218.523	2166.75
14	24273.6	21120.5	218.364	2157.14
14.5	25140.5	21758.2	218.21	2147.61
15	26007.4	22387.8	218.061	2138.15
15.5	26874.3	23009.4	217.915	2128.78
16	27741.2	23622.9	217.774	2119.49
16.5	28608.1	24228.4	217.637	2110.27
17	29475	24825.9	217.504	2101.14
17.5	30342	25415.3	217.374	2092.1
18	31208.9	25996.7	217.248	2083.14
18.5	32075.8	26570	217.126	2074.27
19	32942.7	27135.3	217.007	2065.48
19.5	33809.6	27692.5	216.891	2056.78
20	34676.5	28241.7	216.778	2048.17
20.5	35543.4	28782.9	216.669	2039.65
21	36410.3	29316	216.562	2031.23
21.5	37277.3	29841	216.458	2022.89
22	38144.2	30358.1	216.357	2014.65
22.5	39011.1	30867	216.258	2006.51
23	39878	31368	216.162	1998.46
23.5	40744.9	31860.9	216.068	1990.51
24	41611.8	32345.7	215.977	1982.66
24.5	42478.7	32822.5	215.888	1974.9
25	43345.7	33291.3	215.801	1967.25
25.5	44212.6	33752	215.717	1959.7
26	45079.5	34204.7	215.634	1952.26
26.5	45946.4	34649.3	215.553	1944.91
27	46813.3	35085.9	215.474	1937.68
27.5	47680.2	35514.4	215.397	1930.55
28	48547.1	35934.9	215.322	1923.53
28.5	49414	36347.4	215.249	1916.62
29	50281	36751.8	215.177	1909.82
29.5	51147.9	37148.2	215.048	1903.13

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30	52014.8	37538.5	214.921	1896.55
30.5	52881.7	37916.8	214.794	1890.09
31	53748.6	38289	214.668	1883.74
31.5	54615.5	38653.2	214.542	1877.51
32	55482.4	39009.3	214.417	1871.4
32.5	56349.3	39357.4	214.292	1865.4
33	57216.3	39697.5	214.168	1859.53
33.5	58083.2	40029.5	214.045	1853.78
34	58950.1	40353.5	213.922	1848.14
34.5	59817	40669.5	213.799	1842.64
35	60683.9	40977.3	213.677	1837.25
35.5	61550.8	41277.2	213.556	1831.99
36	62417.7	41569	213.435	1826.86
36.5	63284.6	41852.7	213.314	1821.86
37	64151.6	42128.5	213.194	1816.98
37.5	65018.5	42396.1	213.075	1812.24
38	65885.4	42655.8	212.956	1807.62
38.5	66752.3	42907.3	212.837	1803.14
39	67619.2	43150.9	212.719	1798.79
39.5	68486.1	43386.4	212.601	1794.57
40	69353	43613.8	212.483	1790.49
40.5	70220	43833.3	212.366	1786.54
41	71086.9	44044.6	212.249	1782.73
41.5	71953.8	44247.9	212.133	1779.06
42	72820.7	44443.2	212.017	1775.52
42.5	73687.6	44630.5	211.901	1772.12
43	74554.5	44809.7	211.786	1768.87
43.5	75421.4	44980.8	211.671	1765.75
44	76288.3	45143.9	211.556	1762.78
44.5	77155.3	45299	211.441	1759.95
45	78022.2	45446	211.327	1757.26
45.5	78889.1	45585	211.213	1754.71
46	79756	45715.9	211.099	1752.31
46.5	80622.9	45838.8	210.986	1750.05
47	81489.8	45953.6	210.873	1747.94
47.5	82356.7	46060.4	210.76	1745.97
48	83223.7	46159.2	210.647	1744.15
48.5	84090.6	46249.9	210.534	1742.47
49	84957.5	46332.6	210.421	1740.95
49.5	85824.4	46407.2	210.309	1739.57
50	86691.3	46473.8	210.197	1738.34
50.5	87558.2	46532.3	210.085	1737.25
51	88425.1	46582.8	209.973	1736.32
51.5	89292	46625.3	209.861	1735.53
52	90158.9	46659.7	209.749	1734.89
52.5	91025.9	46686.1	209.637	1734.4
53	91892.8	46704.4	209.526	1734.06
53.5	92759.7	46714.7	209.414	1733.87
54	93626.6	46716.9	209.302	1733.83
54.5	94493.5	46711.1	209.191	1733.94
55	95360.4	46697.3	209.079	1734.19
55.5	96227.3	46675.3	208.967	1734.6
56	97094.3	46645.5	208.856	1735.16
56.5	97961.2	46607.4	208.744	1735.86
57	98828.1	46561.4	208.632	1736.71
57.5	99695	46507.4	208.521	1737.72
58	100562	46445.2	208.409	1738.86
58.5	101429	46375.1	208.297	1740.16
59	102296	46296.9	208.185	1741.61
59.5	103163	46210.6	208.073	1743.2
60	104030	46116.4	207.96	1744.94
60.5	104896	46014	207.848	1746.82
61	105763	45903.6	207.735	1748.86
61.5	106630	45785.2	207.623	1751.03
62	107497	45658.8	207.51	1753.36
62.5	108364	45524.3	207.396	1755.85

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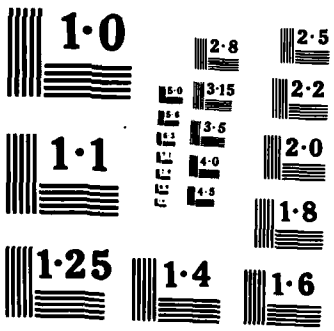
1·0
2·8
2·5
3·15
2·2
3·5
1·1
4·0
2·0
4·5
1·8
1·25
1·4
1·6

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63	109231	45381.7	207.283	1758.45
63.5	110098	45231.1	207.169	1761.18
64	110965	45072.5	207.056	1764.08
64.5	111832	44905.8	206.942	1767.12
65	112699	44731.1	206.827	1770.3
65.5	113566	44548.4	206.713	1773.61
66	114433	44357.5	206.598	1777.07
66.5	115299	44158.7	206.482	1780.67
67	116166	43951.8	206.367	1784.4
67.5	117033	43736.9	206.251	1788.28
68	117900	43513.9	206.135	1792.28
68.5	118767	43282.9	206.018	1796.43
69	119634	43043.8	205.901	1800.7
69.5	120501	42796.6	205.784	1805.11
70	121368	42541.5	205.666	1809.65
70.5	122235	42278.4	205.548	1814.33
71	123102	42007.2	205.43	1819.13
71.5	123969	41727.8	205.311	1824.06
72	124835	41440.4	205.191	1829.13
72.5	125702	41145.1	205.072	1834.31
73	126569	40841.7	204.951	1839.63
73.5	127436	40530.2	204.831	1845.07
74	128303	40210.7	204.709	1850.63
74.5	129170	39883.1	204.588	1856.32
75	130037	39547.5	204.466	1862.12
75.5	130904	39204	204.343	1868.05
76	131771	38852.3	204.22	1874.1
76.5	132638	38492.6	204.096	1880.26
77	133505	38124.8	203.972	1886.55
77.5	134372	37749	203.847	1892.94
78	135238	37365.1	203.721	1899.46
78.5	136105	36973.2	203.595	1906.08
79	136972	36573.3	203.469	1912.82
79.5	137839	36165.2	203.342	1919.67
80	138706	35749.3	203.214	1926.63
80.5	139573	35325.3	203.086	1933.7
81	140440	34893.1	203.013	1940.88
81.5	141307	34453	202.939	1948.16
82	142174	34004.7	202.863	1955.55
82.5	143041	33548.5	202.785	1963.04
83	143908	33084.2	202.705	1970.63
83.5	144774	32611.9	202.624	1978.33
84	145641	32131.5	202.54	1986.13
84.5	146508	31643.2	202.454	1994.03
85	147375	31146.6	202.367	2002.02
85.5	148242	30642.1	202.277	2010.11
86	149109	30129.7	202.184	2018.3
86.5	149976	29608.9	202.09	2026.58
87	150843	29080.4	201.992	2034.96
87.5	151710	28543.7	201.893	2043.42
88	152577	27999	201.79	2051.98
88.5	153444	27446.2	201.685	2060.63
89	154311	26885.3	201.577	2069.37
89.5	155177	26316.6	201.466	2078.19
90	156044	25739.6	201.352	2087.11
90.5	156911	25154.7	201.235	2096.1
91	157778	24561.8	201.114	2105.19
91.5	158645	23960.8	200.99	2114.35
92	159512	23351.6	200.863	2123.6
92.5	160379	22734.5	200.732	2132.93
93	161246	22109.3	200.597	2142.34
93.5	162113	21476.1	200.458	2151.83
94	162980	20834.9	200.315	2161.39
94.5	163847	20185.7	200.168	2171.04
95	164713	19528.3	200.016	2180.76
95.5	165580	[illegible]	[illegible]	[illegible]

REPRODUCED AT GOVERNMENT EXPE

96	166447	18189.5	199.699	2200.42
96.5	167314	17508	199.533	2210.36
97	168181	16818.6	199.362	2220.38
97.5	169048	16121	199.186	2230.46
98	169915	15415.4	199.004	2240.62
98.5	170782	14701.8	198.817	2250.84
99	171649	13980	198.623	2261.13
99.5	172516	13250.3	198.424	2271.49
100	173383	12512.6	198.218	2281.92
100.5	174250	11766.9	198.006	2292.41

RAMJET BURNOUT BETWEEN T= 100.5 AND 101

APPENDIX E- THREE DEGREES OF FREEDOM RESULTS

```
VARIABLES & INITIAL CONDITIONS:
XDOT = 2188.67000
X = .0
YDOT = .0
Y = .0
THEDOT = .0
THETA = .0
M = 225.0000000
T = .0

CONSTANTS:
PHASE = .0
CMA = -2.30800000
A = .34910000000
DI = .66666700000
CMT = 190.0000000
CDO = .27600000000
PI = 3.141592654
ISP = 950.0000000
LAMBDA = 15000.00000
PI8 = .392699081E17

SPECIAL FUNCTIONS:
ETA = ATAN(YDOT/XDOT)
VCG = (XDOT**2+YDOT**2)**.5
VW = 0
GAMMA = ATAN((YDOT+VW)/XDOT)
V = (XDOT**2+(YDOT+VW)**2)**.5
Q = .5*.00089068*V**2
K = C*DI*A
THEDBL = (CMA*K*(THETA-GAMMA)-((CMT*K*DI*THEDOT)/(V*2)))/I
ALPHA = GAMMA-THETA
CD = CDO+.5*CL*SIN(ALPHA)
CL = .091*ALPHA
L = CL*Q*A
D = C*CD*Q*A
XDBL = (L*SIN(GAMMA)-D*COS(GAMMA))/M
YDBL = (L*COS(GAMMA)+D*SIN(GAMMA))/M
C = C
MDOT = (1-C)*(CDO+.5*CL*SIN(ALPHA))*Q*A/(-ISP)
DELM = 225-M
I = (18.6-.0423*DELM)*32.2

DERIVATIVES:
D(XDOT)/D(T) = =
```

```
     XDBL
D(X /D(T ) = =
     XDOT
D(YDOT /D(T ) = =
     YDBL
D(Y /D(T ) = =
     YDOT
D(THEDOT/D(T ) = =
     THEDBL
D(THETA /D(T ) = =
     THEDOT
D(M /D(T ) = =
     MDOT

OUTPUTS:
   TITLE: THREE DEGREE CROSSWIND TRIAL
   TABULATE: T        X        Y        VCG      V        MDOT
      AT INTERVAL    .5000000000
   PLOT: X
      AGAINST: T
   PLOT: Y
      AGAINST: T
   PLOT: ALPHA
      AGAINST: T      AT INTERVAL    .2500000000

END CALCULATION WHEN M .LE. 198.000
```

THREE DEGREE CROSSWIND TRIAL

T	X	Y	VCG	V	MDOT
.0	.0	.0	2188.7	2188.7	-.21637
.50000	1094.3	.0	2188.7	2188.7	-.21637
1.0000	2188.7	.0	2188.7	2188.7	-.21637
1.5000	3283.0	.0	2188.7	2188.7	-.21637
2.0000	4377.3	.0	2188.7	2188.7	-.21637
2.5000	5471.7	.0	2188.7	2188.7	-.21637
3.0000	6566.0	.0	2188.7	2188.7	-.21637
3.5000	7660.3	.0	2188.7	2188.7	-.21637
4.0000	8754.7	.0	2188.7	2188.7	-.21637
4.5000	9849.0	.0	2188.7	2188.7	-.21637
5.0000	10943.	.0	2188.7	2188.7	-.21637
5.5000	12038.	.0	2188.7	2188.7	-.21637
6.0000	13132.	.0	2188.7	2188.7	-.21637
6.5000	14226.	.0	2188.7	2188.7	-.21637
7.0000	15321.	.0	2188.7	2188.7	-.21637
7.5000	16415.	.0	2188.7	2188.7	-.21637
8.0000	17509.	.0	2188.7	2188.7	-.21637
8.5000	18604.	.0	2188.7	2188.7	-.21637

9.0000	19698.	.0	2188.7	2188.7	-.21637
9.5000	20792.	.0	2188.7	2188.7	-.21637
10.000	21887.	.0	2188.7	2188.7	-.21637
10.500	22981.	.0	2188.7	2188.7	-.21637
11.000	24075.	.0	2188.7	2188.7	-.21637
11.500	25170.	.0	2188.7	2188.7	-.21637
12.000	26264.	.0	2188.7	2188.7	-.21637
12.500	27358.	.0	2188.7	2188.7	-.21637
13.000	28453.	.0	2188.7	2188.7	-.21637
13.500	29547.	.0	2188.7	2188.7	-.21637
14.000	30641.	.0	2188.7	2188.7	-.21637
14.500	31736.	.0	2188.7	2188.7	-.21637
15.000	32830.	.0	2188.7	2188.7	-.21637
15.500	33924.	.0	2188.7	2188.7	-.21637
16.000	35019.	.0	2188.7	2188.7	-.21637
16.500	36113.	.0	2188.7	2188.7	-.21637
17.000	37207.	.0	2188.7	2188.7	-.21637
17.500	38302.	.0	2188.7	2188.7	-.21637
18.000	39396.	.0	2188.7	2188.7	-.21637
18.500	40490.	.0	2188.7	2188.7	-.21637
19.000	41585.	.0	2188.7	2188.7	-.21637
19.500	42679.	.0	2188.7	2188.7	-.21637
20.000	43773.	.0	2188.7	2188.7	-.21637
20.500	44868.	.0	2188.7	2188.7	-.21637
21.000	45962.	.0	2188.7	2188.7	-.21637
21.500	47056.	.0	2188.7	2188.7	-.21637
22.000	48151.	.0	2188.7	2188.7	-.21637
22.500	49245.	.0	2188.7	2188.7	-.21637
23.000	50339.	.0	2188.7	2188.7	-.21637
23.500	51434.	.0	2188.7	2188.7	-.21637
24.000	52528.	.0	2188.7	2188.7	-.21637
24.500	53622.	.0	2188.7	2188.7	-.21637
25.000	54717.	.0	2188.7	2188.7	-.21637
25.500	55811.	.0	2188.7	2188.7	-.21637
26.000	56905.	.0	2188.7	2188.7	-.21637
26.500	58000.	.0	2188.7	2188.7	-.21637
27.000	59094.	.0	2188.7	2188.7	-.21637
27.500	60188.	.0	2188.7	2188.7	-.21637
28.000	61283.	.0	2188.7	2188.7	-.21637
28.500	62377.	.0	2188.7	2188.7	-.21637
29.000	63471.	.0	2188.7	2188.7	-.21637
29.500	64566.	.0	2188.7	2188.7	-.21637
30.000	65660.	.0	2188.7	2188.7	-.21637
30.500	66754.	.0	2188.7	2188.7	-.21637
31.000	67849.	.0	2188.7	2188.7	-.21637
31.500	68943.	.0	2188.7	2188.7	-.21637
32.000	70037.	.0	2188.7	2188.7	-.21637
32.500	71132.	.0	2188.7	2188.7	-.21637

33.000	72226.	.0	2188.7	2188.7	-.21637

T	X	Y	VCG	V	MDOT
33.500	73320.	.0	2188.7	2188.7	-.21637
34.000	74415.	.0	2188.7	2188.7	-.21637
34.500	75509.	.0	2188.7	2188.7	-.21637
35.000	76603.	.0	2188.7	2188.7	-.21637
35.500	77698.	.0	2188.7	2188.7	-.21637
36.000	78792.	.0	2188.7	2188.7	-.21637
36.500	79886.	.0	2188.7	2188.7	-.21637
37.000	80981.	.0	2188.7	2188.7	-.21637
37.500	82075.	.0	2188.7	2188.7	-.21637
38.000	83169.	.0	2188.7	2188.7	-.21637
38.500	84264.	.0	2188.7	2188.7	-.21637
39.000	85358.	.0	2188.7	2188.7	-.21637
39.500	86452.	.0	2188.7	2188.7	-.21637
40.000	87547.	.0	2188.7	2188.7	-.21637
40.500	88641.	.0	2188.7	2188.7	-.21637
41.000	89735.	.0	2188.7	2188.7	-.21637
41.500	90830.	.0	2188.7	2188.7	-.21637
42.000	91924.	.0	2188.7	2188.7	-.21637
42.500	93018.	.0	2188.7	2188.7	-.21637
43.000	94113.	.0	2188.7	2188.7	-.21637
43.500	95207.	.0	2188.7	2188.7	-.21637
44.000	96301.	.0	2188.7	2188.7	-.21637
44.500	97396.	.0	2188.7	2188.7	-.21637
45.000	98490.	.0	2188.7	2188.7	-.21637
45.500	99584.	.0	2188.7	2188.7	-.21637
46.000	.10068D+06	.0	2188.7	2188.7	-.21637
46.500	.10177D+06	.0	2188.7	2188.7	-.21637
47.000	.10287D+06	.0	2188.7	2188.7	-.21637
47.500	.10396D+06	.0	2188.7	2188.7	-.21637
48.000	.10506D+06	.0	2188.7	2188.7	-.21637
48.500	.10615D+06	.0	2188.7	2188.7	-.21637
49.000	.10724D+06	.0	2188.7	2188.7	-.21637
49.500	.10834D+06	.0	2188.7	2188.7	-.21637
50.000	.10943D+06	.0	2188.7	2188.7	-.21637
50.500	.11053D+06	.0	2188.7	2188.7	-.21637
51.000	.11162D+06	.0	2188.7	2188.7	-.21637
51.500	.11272D+06	.0	2188.7	2188.7	-.21637
52.000	.11381D+06	.0	2188.7	2188.7	-.21637
52.500	.11491D+06	.0	2188.7	2188.7	-.21637
53.000	.11600D+06	.0	2188.7	2188.7	-.21637
53.500	.11709D+06	.0	2188.7	2188.7	-.21637
54.000	.11819D+06	.0	2188.7	2188.7	-.21637
54.500	.11928D+06	.0	2188.7	2188.7	-.21637
55.000	.12038D+06	.0	2188.7	2188.7	-.21637
55.500	.12147D+06	.0	2188.7	2188.7	-.21637

56.000	.12257D+06	.0	2188.7	2188.7	-.21637
56.500	.12366D+06	.0	2188.7	2188.7	-.21637
57.000	.12475D+06	.0	2188.7	2188.7	-.21637
57.500	.12585D+06	.0	2188.7	2188.7	-.21637
58.000	.12694D+06	.0	2188.7	2188.7	-.21637
58.500	.12804D+06	.0	2188.7	2188.7	-.21637
59.000	.12913D+06	.0	2188.7	2188.7	-.21637
59.500	.13023D+06	.0	2188.7	2188.7	-.21637
60.000	.13132D+06	.0	2188.7	2188.7	-.21637
60.500	.13241D+06	.0	2188.7	2188.7	-.21637
61.000	.13351D+06	.0	2188.7	2188.7	-.21637
61.500	.13460D+06	.0	2188.7	2188.7	-.21637
62.000	.13570D+06	.0	2188.7	2188.7	-.21637
62.500	.13679D+06	.0	2188.7	2188.7	-.21637
63.000	.13789D+06	.0	2188.7	2188.7	-.21637
63.500	.13898D+06	.0	2188.7	2188.7	-.21637
64.000	.14007D+06	.0	2188.7	2188.7	-.21637
64.500	.14117D+06	.0	2188.7	2188.7	-.21637
65.000	.14226D+06	.0	2188.7	2188.7	-.21637
65.500	.14336D+06	.0	2188.7	2188.7	-.21637
66.000	.14445D+06	.0	2188.7	2188.7	-.21637
66.500	.14555D+06	.0	2188.7	2188.7	-.21637
67.000	.14664D+06	.0	2188.7	2188.7	-.21637
67.500	.14774D+06	.0	2188.7	2188.7	-.21637
68.000	.14883D+06	.0	2188.7	2188.7	-.21637

T	X	Y	VCG	V	MDOT
68.500	.14992D+06	.0	2188.7	2188.7	-.21637
69.000	.15102D+06	.0	2188.7	2188.7	-.21637
69.500	.15211D+06	.0	2188.7	2188.7	-.21637
70.000	.15321D+06	.0	2188.7	2188.7	-.21637
70.500	.15430D+06	.0	2188.7	2188.7	-.21637
71.000	.15540D+06	.0	2188.7	2188.7	-.21637
71.500	.15649D+06	.0	2188.7	2188.7	-.21637
72.000	.15758D+06	.0	2188.7	2188.7	-.21637
72.500	.15868D+06	.0	2188.7	2188.7	-.21637
73.000	.15977D+06	.0	2188.7	2188.7	-.21637
73.500	.16087D+06	.0	2188.7	2188.7	-.21637
74.000	.16196D+06	.0	2188.7	2188.7	-.21637
74.500	.16306D+06	.0	2188.7	2188.7	-.21637
75.000	.16415D+06	.0	2188.7	2188.7	-.21637
75.500	.16524D+06	.0	2188.7	2188.7	-.21637
76.000	.16634D+06	.0	2188.7	2188.7	-.21637
76.500	.16743D+06	.0	2188.7	2188.7	-.21637
77.000	.16853D+06	.0	2188.7	2188.7	-.21637
77.500	.16962D+06	.0	2188.7	2188.7	-.21637
78.000	.17072D+06	.0	2188.7	2188.7	-.21637
78.500	.17181D+06	.0	2188.7	2188.7	-.21637

79.000	.17290D+06	.0	2188.7	2188.7	-.21637
79.500	.17400D+06	.0	2188.7	2188.7	-.21637
80.000	.17509D+06	.0	2188.7	2188.7	-.21637
80.500	.17619D+06	.0	2188.7	2188.7	-.21637
81.000	.17728D+06	.0	2188.7	2188.7	-.21637
81.500	.17838D+06	.0	2188.7	2188.7	-.21637
82.000	.17947D+06	.0	2188.7	2188.7	-.21637
82.500	.18057D+06	.0	2188.7	2188.7	-.21637
83.000	.18166D+06	.0	2188.7	2188.7	-.21637
83.500	.18275D+06	.0	2188.7	2188.7	-.21637
84.000	.18385D+06	.0	2188.7	2188.7	-.21637
84.500	.18494D+06	.0	2188.7	2188.7	-.21637
85.000	.18604D+06	.0	2188.7	2188.7	-.21637
85.500	.18713D+06	.0	2188.7	2188.7	-.21637
86.000	.18823D+06	.0	2188.7	2188.7	-.21637
86.500	.18932D+06	.0	2188.7	2188.7	-.21637
87.000	.19041D+06	.0	2188.7	2188.7	-.21637
87.500	.19151D+06	.0	2188.7	2188.7	-.21637
88.000	.19260D+06	.0	2188.7	2188.7	-.21637
88.500	.19370D+06	.0	2188.7	2188.7	-.21637
89.000	.19479D+06	.0	2188.7	2188.7	-.21637
89.500	.19589D+06	.0	2188.7	2188.7	-.21637
90.000	.19698D+06	.0	2188.7	2188.7	-.21637
90.500	.19807D+06	.0	2188.7	2188.7	-.21637
91.000	.19917D+06	.0	2188.7	2188.7	-.21637
91.500	.20026D+06	.0	2188.7	2188.7	-.21637
92.000	.20136D+06	.0	2188.7	2188.7	-.21637
92.500	.20245D+06	.0	2188.7	2188.7	-.21637
93.000	.20355D+06	.0	2188.7	2188.7	-.21637
93.500	.20464D+06	.0	2188.7	2188.7	-.21637
94.000	.20573D+06	.0	2188.7	2188.7	-.21637
94.500	.20683D+06	.0	2188.7	2188.7	-.21637
95.000	.20792D+06	.0	2188.7	2188.7	-.21637
95.500	.20902D+06	.0	2188.7	2188.7	-.21637
96.000	.21011D+06	.0	2188.7	2188.7	-.21637
96.500	.21121D+06	.0	2188.7	2188.7	-.21637
97.000	.21230D+06	.0	2188.7	2188.7	-.21637
97.500	.21340D+06	.0	2188.7	2188.7	-.21637
98.000	.21449D+06	.0	2188.7	2188.7	-.21637
98.500	.21558D+06	.0	2188.7	2188.7	-.21637
99.000	.21668D+06	.0	2188.7	2188.7	-.21637
99.500	.21777D+06	.0	2188.7	2188.7	-.21637
100.00	.21887D+06	.0	2188.7	2188.7	-.21637
100.50	.21996D+06	.0	2188.7	2188.7	-.21637
101.00	.22106D+06	.0	2188.7	2188.7	-.21637
101.50	.22215D+06	.0	2188.7	2188.7	-.21637
102.00	.22324D+06	.0	2188.7	2188.7	-.21637
102.50	.22434D+06	.0	2188.7	2188.7	-.21637

103.00	.22543D+06	.0	2188.7	2188.7	-.21637

T	X	Y	VCG	V	MDOT
103.50	.22653D+06	.0	2188.7	2188.7	-.21637
104.00	.22762D+06	.0	2188.7	2188.7	-.21637
104.50	.22872D+06	.0	2188.7	2188.7	-.21637
105.00	.22981D+06	.0	2188.7	2188.7	-.21637
105.50	.23090D+06	.0	2188.7	2188.7	-.21637
106.00	.23200D+06	.0	2188.7	2188.7	-.21637
106.50	.23309D+06	.0	2188.7	2188.7	-.21637
107.00	.23419D+06	.0	2188.7	2188.7	-.21637
107.50	.23528D+06	.0	2188.7	2188.7	-.21637
108.00	.23638D+06	.0	2188.7	2188.7	-.21637
108.50	.23747D+06	.0	2188.7	2188.7	-.21637
109.00	.23857D+06	.0	2188.7	2188.7	-.21637
109.50	.23966D+06	.0	2188.7	2188.7	-.21637
110.00	.24075D+06	.0	2188.7	2188.7	-.21637
110.50	.24185D+06	.0	2188.7	2188.7	-.21637
111.00	.24294D+06	.0	2188.7	2188.7	-.21637
111.50	.24404D+06	.0	2188.7	2188.7	-.21637
112.00	.24513D+06	.0	2188.7	2188.7	-.21637
112.50	.24623D+06	.0	2188.7	2188.7	-.21637
113.00	.24732D+06	.0	2188.7	2188.7	-.21637
113.50	.24841D+06	.0	2188.7	2188.7	-.21637
114.00	.24951D+06	.0	2188.7	2188.7	-.21637
114.50	.25060D+06	.0	2188.7	2188.7	-.21637
115.00	.25170D+06	.0	2188.7	2188.7	-.21637
115.50	.25279D+06	.0	2188.7	2188.7	-.21637
116.00	.25389D+06	.0	2188.7	2188.7	-.21637
116.50	.25498D+06	.0	2188.7	2188.7	-.21637
117.00	.25607D+06	.0	2188.7	2188.7	-.21637
117.50	.25717D+06	.0	2188.7	2188.7	-.21637
118.00	.25826D+06	.0	2188.7	2188.7	-.21637
118.50	.25936D+06	.0	2188.7	2188.7	-.21637
119.00	.26045D+06	.0	2188.7	2188.7	-.21637
119.50	.26155D+06	.0	2188.7	2188.7	-.21637
120.00	.26264D+06	.0	2188.7	2188.7	-.21637
120.50	.26373D+06	.0	2188.7	2188.7	-.21637
121.00	.26483D+06	.0	2188.7	2188.7	-.21637
121.50	.26592D+06	.0	2188.7	2188.7	-.21637
122.00	.26702D+06	.0	2188.7	2188.7	-.21637
122.50	.26811D+06	.0	2188.7	2188.7	-.21637
123.00	.26921D+06	.0	2188.7	2188.7	-.21637
123.50	.27030D+06	.0	2188.7	2188.7	-.21637
124.00	.27140D+06	.0	2188.7	2188.7	-.21637
124.50	.27249D+06	.0	2188.7	2188.7	-.21637
125.00	.27358D+06	.0	2188.7	2188.7	-.21637

```
END OF RUN
VARIABLES & INITIAL CONDITIONS:
XDOT = 2188.67000
X = .0
YDOT = .0
Y = .0
THEDOT = .0
THETA = .0
M = 225.00000000
T = .0

CONSTANTS:
PHASE = .0
CMA = -2.30800000
A = .34910000
DI = .666667000
CMT = 190.00000000
CDO = .27600000
PI = 3.14159265
ISP = 950.00000000
LAMBDA = 15000.00000
P18 = .39269908E17

SPECIAL FUNCTIONS:
ETA = ATAN(YDOT/XDOT)
VOG = (XDOT**2+YDOT**2)**.5
VW = 60
GAMMA = ATAN((YDOT+VW)/XDOT)
V = (XDOT**2+(YDOT+VW)**2)**.5
Q = .5*.00085668*V**2
K = C*DI*A
THEDBL = (CMA*K*(THETA-GAMMA)-((CMT*K*DI*THEDOT)/(V*2)))/I
ALPHA = GAMMA-THETA
CD = CDO+.5*CL*SIN(ALPHA)
CL = .091*ALPHA
L = CL*Q*A
D = C*CD*Q*A
XDBL = (L*SIN(GAMMA)-D*COS(GAMMA))/M
YDBL = (L*COS(GAMMA)+D*SIN(GAMMA))/M
C = C
MDOT = (1-C)*(CDO+.5*CL*SIN(ALPHA))*Q*A/(-ISP)
DELM = 225-M
I = (18.8-.0423*DELM)*32.2

DERIVATIVES:
D(XDOT /D(T ) = =
     XDBL
D(X /D(T ) = =
```

```
    XDOT
D(YDCT /D(T  ) = =
    YDBL
D(Y  /D(T  ) = =
    YDOT
D(THEDCT/D(T  ) = =
    THEDBL
D(THETA /D(T  ) = =
    THEDCT
D(M  /D(T  ) = =
    MDCT

OUTPUTS:
   TITLE: THREE DEGREE CROSSWIND TRIAL
   TABULATE: T        X        Y        VCG      V        MDOT
      AT INTERVAL     .5000000000
   PLOT: X
      AGAINST: T
   PLOT: Y
      AGAINST: T
   PLOT: ALPHA
      AGAINST: T       AT INTERVAL     .2500000000

END CALCULATION WHEN M .LE. 198.000
```

THREE DEGREE CROSSWIND TRIAL

T	X	Y	VCG	V	MDOT
.0	.0	.0	2188.7	2189.5	-.21655
.50000	1094.3	.99244D-03	2188.7	2189.5	-.21654
1.0000	2188.7	.35210D-02	2188.7	2189.5	-.21653
1.5000	3283.0	.64466D-02	2188.7	2189.5	-.21653
2.0000	4377.3	.84628D-02	2188.7	2189.5	-.21655
2.5000	5471.7	.86893D-02	2188.7	2189.5	-.21655
3.0000	6566.0	.70662D-02	2188.7	2189.5	-.21654
3.5000	7660.3	.43726D-02	2188.7	2189.5	-.21653
4.0000	8754.7	.18644D-02	2188.7	2189.5	-.21654
4.5000	9849.0	.69992D-03	2188.7	2189.5	-.21655
5.0000	10943.	.14154D-02	2188.7	2189.5	-.21654
5.5000	12038.	.36885D-02	2188.7	2189.5	-.21653
6.0000	13132.	.64935D-02	2188.7	2189.5	-.21653
6.5000	14226.	.85744D-02	2188.7	2189.5	-.21655
7.0000	15321.	.90176D-02	2188.7	2189.5	-.21655
7.5000	16415.	.76630D-02	2188.7	2189.5	-.21654
8.0000	17509.	.51689D-02	2188.7	2189.5	-.21653
8.5000	18604.	.27039D-02	2188.7	2189.5	-.21654
9.0000	19698.	.14109D-02	2188.7	2189.5	-.21655
9.5000	20792.	.18876D-02	2188.7	2189.5	-.21654

10.000	21887.	.39207D-02	2188.7	2189.5	-.21653
10.500	22981.	.65914D-02	2188.7	2189.5	-.21653
11.000	24075.	.87012D-02	2188.7	2189.5	-.21654
11.500	25170.	.93194D-02	2188.7	2189.5	-.21655
12.000	26264.	.82044D-02	2188.7	2189.5	-.21654
12.500	27358.	.59060D-02	2188.7	2189.5	-.21653
13.000	28453.	.35068D-02	2188.7	2189.5	-.21653
13.500	29547.	.21235D-02	2188.7	2189.5	-.21655
14.000	30641.	.23979D-02	2188.7	2189.5	-.21654
14.500	31736.	.42097D-02	2188.7	2189.5	-.21653
15.000	32830.	.67393D-02	2188.7	2189.5	-.21653
15.500	33924.	.88489D-02	2188.7	2189.5	-.21654
16.000	35019.	.96046D-02	2188.7	2189.5	-.21655
16.500	36113.	.86999D-02	2188.7	2189.5	-.21654
17.000	37207.	.65891D-02	2188.7	2189.5	-.21653
17.500	38302.	.42717D-02	2188.7	2189.5	-.21653
18.000	39396.	.28306D-02	2188.7	2189.5	-.21654
18.500	40490.	.29370D-02	2188.7	2189.5	-.21654
19.000	41585.	.45481D-02	2188.7	2189.5	-.21653
19.500	42679.	.69347D-02	2188.7	2189.5	-.21653
20.000	43773.	.90212D-02	2188.7	2189.5	-.21654
20.500	44868.	.98809D-02	2188.7	2189.5	-.21654
21.000	45962.	.91578D-02	2188.7	2189.5	-.21654
21.500	47056.	.72232D-02	2188.7	2189.5	-.21653
22.000	48151.	.49983D-02	2188.7	2189.5	-.21653
22.500	49245.	.35268D-02	2188.7	2189.5	-.21654
23.000	50339.	.34967D-02	2188.7	2189.5	-.21654
23.500	51434.	.49287D-02	2188.7	2189.5	-.21653
24.000	52528.	.71745D-02	2188.7	2189.5	-.21653
24.500	53622.	.92203D-02	2188.7	2189.5	-.21654
25.000	54717.	.10155D-01	2188.7	2189.5	-.21654
25.500	55811.	.95858D-02	2188.7	2189.5	-.21654
26.000	56905.	.78139D-02	2188.7	2189.5	-.21653
26.500	58000.	.56876D-02	2188.7	2189.5	-.21653
27.000	59094.	.42084D-02	2188.7	2189.5	-.21654
27.500	60188.	.40704D-02	2188.7	2189.5	-.21654
28.000	61283.	.53450D-02	2188.7	2189.5	-.21653
28.500	62377.	.74552D-02	2188.7	2189.5	-.21653
29.000	63471.	.94470D-02	2188.7	2189.5	-.21653
29.500	64566.	.10431D-01	2188.7	2189.5	-.21654
30.000	65660.	.99906D-02	2188.7	2189.5	-.21654
30.500	66754.	.83668D-02	2188.7	2189.5	-.21653
31.000	67849.	.63417D-02	2188.7	2189.5	-.21653
31.500	68943.	.48731D-02	2188.7	2189.5	-.21654
32.000	70037.	.46527D-02	2188.7	2189.5	-.21654
32.500	71132.	.57909D-02	2188.7	2189.5	-.21653
33.000	72226.	.77729D-02	2188.7	2189.5	-.21653

T	X	Y	VCG	V	MDOT
33.500	73320.	.97013D-02	2188.7	2189.5	-.21653
34.000	74415.	.10714D-01	2188.7	2189.5	-.21654
34.500	75509.	.10378D-01	2188.7	2189.5	-.21654
35.000	76603.	.88866D-02	2188.7	2189.5	-.21653
35.500	77698.	.69627D-02	2188.7	2189.5	-.21653
36.000	78792.	.55195D-02	2188.7	2189.5	-.21654
36.500	79886.	.52393D-02	2188.7	2189.5	-.21654
37.000	80981.	.62613D-02	2188.7	2189.5	-.21653
37.500	82075.	.81237D-02	2188.7	2189.5	-.21653
38.000	83169.	.99824D-02	2188.7	2189.5	-.21653
38.500	84264.	.11005D-01	2188.7	2189.5	-.21654
39.000	85358.	.10752D-01	2188.7	2189.5	-.21654
39.500	86452.	.93782D-02	2188.7	2189.5	-.21653
40.000	87547.	.75533D-02	2188.7	2189.5	-.21653
40.500	88641.	.61471D-02	2188.7	2189.5	-.21654
41.000	89735.	.58269D-02	2188.7	2189.5	-.21654
41.500	90830.	.67516D-02	2188.7	2189.5	-.21653
42.000	91924.	.85039D-02	2188.7	2189.5	-.21653
42.500	93018.	.10289D-01	2188.7	2189.5	-.21653
43.000	94113.	.11306D-01	2188.7	2189.5	-.21654
43.500	95207.	.11116D-01	2188.7	2189.5	-.21654
44.000	96301.	.98456D-02	2188.7	2189.5	-.21653
44.500	97396.	.81163D-02	2188.7	2189.5	-.21653
45.000	98490.	.67561D-02	2188.7	2189.5	-.21653
45.500	99584.	.64131D-02	2188.7	2189.5	-.21654
46.000	.10068D+06	.72580D-02	2188.7	2189.5	-.21653
46.500	.10177D+06	.89099D-02	2188.7	2189.5	-.21653
47.000	.10287D+06	.10619D-01	2188.7	2189.5	-.21653
47.500	.10396D+06	.11618D-01	2188.7	2189.5	-.21654
48.000	.10506D+06	.11474D-01	2188.7	2189.5	-.21653
48.500	.10615D+06	.10293D-01	2188.7	2189.5	-.21653
49.000	.10724D+06	.86544D-02	2188.7	2189.5	-.21653
49.500	.10834D+06	.73472D-02	2188.7	2189.5	-.21653
50.000	.10943D+06	.69963D-02	2188.7	2189.5	-.21654
50.500	.11053D+06	.77771D-02	2188.7	2189.5	-.21653
51.000	.11162D+06	.93383D-02	2188.7	2189.5	-.21653
51.500	.11272D+06	.10971D-01	2188.7	2189.5	-.21653
52.000	.11381D+06	.11941D-01	2188.7	2189.5	-.21654
52.500	.11491D+06	.11828D-01	2188.7	2189.5	-.21653
53.000	.11600D+06	.10722D-01	2188.7	2189.5	-.21653
53.500	.11709D+06	.91705D-02	2188.7	2189.5	-.21653
54.000	.11819D+06	.79215D-02	2188.7	2189.5	-.21653
54.500	.11928D+06	.75755D-02	2188.7	2189.5	-.21654
55.000	.12038D+06	.83064D-02	2188.7	2189.5	-.21653
55.500	.12147D+06	.97861D-02	2188.7	2189.5	-.21653
56.000	.12257D+06	.11342D-01	2188.7	2189.5	-.21653
56.500	.12366D+06	.12274D-01	2188.7	2189.5	-.21653

57.000	.12475D+06	.12180D-01	2188.7	2189.5	-.21653
57.500	.12585D+06	.11138D-01	2188.7	2189.5	-.21653
58.000	.12694D+06	.96671D-02	2188.7	2189.5	-.21653
58.500	.12804D+06	.84804D-02	2188.7	2189.5	-.21653
59.000	.12913D+06	.81501D-02	2188.7	2189.5	-.21653
59.500	.13023D+06	.88438D-02	2188.7	2189.5	-.21653
60.000	.13132D+06	.10251D-01	2188.7	2189.5	-.21653
60.500	.13241D+06	.11731D-01	2188.7	2189.5	-.21653
61.000	.13351D+06	.12618D-01	2188.7	2189.5	-.21653
61.500	.13460D+06	.12530D-01	2188.7	2189.5	-.21653
62.000	.13570D+06	.11541D-01	2188.7	2189.5	-.21653
62.500	.13679D+06	.10147D-01	2188.7	2189.5	-.21653
63.000	.13789D+06	.90255D-02	2188.7	2189.5	-.21653
63.500	.13898D+06	.87202D-02	2188.7	2189.5	-.21653
64.000	.14007D+06	.93878D-02	2188.7	2189.5	-.21653
64.500	.14117D+06	.10729D-01	2188.7	2189.5	-.21653
65.000	.14226D+06	.12135D-01	2188.7	2189.5	-.21653
65.500	.14336D+06	.12972D-01	2188.7	2189.5	-.21653
66.000	.14445D+06	.12879D-01	2188.7	2189.5	-.21653
66.500	.14555D+06	.11934D-01	2188.7	2189.5	-.21653
67.000	.14664D+06	.10612D-01	2188.7	2189.5	-.21653
67.500	.14774D+06	.95584D-02	2188.7	2189.5	-.21653
68.000	.14883D+06	.92861D-02	2188.7	2189.5	-.21653

T	X	Y	VCG	V	MDOT
68.500	.14992D+06	.99371D-02	2188.7	2189.5	-.21653
69.000	.15102D+06	.11220D-01	2188.7	2189.5	-.21653
69.500	.15211D+06	.12552D-01	2188.7	2189.5	-.21653
70.000	.15321D+06	.13333D-01	2188.7	2189.5	-.21653
70.500	.15430D+06	.13227D-01	2188.7	2189.5	-.21653
71.000	.15540D+06	.12318D-01	2188.7	2189.5	-.21653
71.500	.15649D+06	.11065D-01	2188.7	2189.5	-.21653
72.000	.15758D+06	.10081D-01	2188.7	2189.5	-.21653
72.500	.15868D+06	.98481D-02	2188.7	2189.5	-.21653
73.000	.15977D+06	.10491D-01	2188.7	2189.5	-.21653
73.500	.16087D+06	.11721D-01	2188.7	2189.5	-.21653
74.000	.16196D+06	.12980D-01	2188.7	2189.5	-.21653
74.500	.16306D+06	.13701D-01	2188.7	2189.5	-.21653
75.000	.16415D+06	.13575D-01	2188.7	2189.5	-.21653
75.500	.16524D+06	.12696D-01	2188.7	2189.5	-.21653
76.000	.16634D+06	.11507D-01	2188.7	2189.5	-.21653
76.500	.16743D+06	.10595D-01	2188.7	2189.5	-.21653
77.000	.16853D+06	.10407D-01	2188.7	2189.5	-.21653
77.500	.16962D+06	.11048D-01	2188.7	2189.5	-.21653
78.000	.17072D+06	.12231D-01	2188.7	2189.5	-.21653
78.500	.17181D+06	.13418D-01	2188.7	2189.5	-.21653
79.000	.17290D+06	.14075D-01	2188.7	2189.5	-.21653
79.500	.17400D+06	.13923D-01	2188.7	2189.5	-.21653

80.000	.17509D+06	.13067D-01	2188.7	2189.5	-.21653
80.500	.17619D+06	.11942D-01	2188.7	2189.5	-.21653
81.000	.17728D+06	.11102D-01	2188.7	2189.5	-.21653
81.500	.17838D+06	.10964D-01	2188.7	2189.5	-.21653
82.000	.17947D+06	.11608D-01	2188.7	2189.5	-.21653
82.500	.18057D+06	.12747D-01	2188.7	2189.5	-.21653
83.000	.18166D+06	.13862D-01	2188.7	2189.5	-.21653
83.500	.18275D+06	.14452D-01	2188.7	2189.5	-.21653
84.000	.18385D+06	.14270D-01	2188.7	2189.5	-.21653
84.500	.18494D+06	.13434D-01	2188.7	2189.5	-.21653
85.000	.18604D+06	.12369D-01	2188.7	2189.5	-.21653
85.500	.18713D+06	.11604D-01	2188.7	2189.5	-.21653
86.000	.18823D+06	.11519D-01	2188.7	2189.5	-.21653
86.500	.18932D+06	.12171D-01	2188.7	2189.5	-.21653
87.000	.19041D+06	.13268D-01	2188.7	2189.5	-.21653
87.500	.19151D+06	.14311D-01	2188.7	2189.5	-.21653
88.000	.19260D+06	.14833D-01	2188.7	2189.5	-.21653
88.500	.19370D+06	.14616D-01	2188.7	2189.5	-.21653
89.000	.19479D+06	.13797D-01	2188.7	2189.5	-.21653
89.500	.19589D+06	.12793D-01	2188.7	2189.5	-.21653
90.000	.19698D+06	.12103D-01	2188.7	2189.5	-.21653
90.500	.19807D+06	.12074D-01	2188.7	2189.5	-.21653
91.000	.19917D+06	.12737D-01	2188.7	2189.5	-.21653
91.500	.20026D+06	.13793D-01	2188.7	2189.5	-.21653
92.000	.20136D+06	.14764D-01	2188.7	2189.5	-.21653
92.500	.20245D+06	.15214D-01	2188.7	2189.5	-.21653
93.000	.20355D+06	.14961D-01	2188.7	2189.5	-.21653
93.500	.20464D+06	.14158D-01	2188.7	2189.5	-.21653
94.000	.20573D+06	.13213D-01	2188.7	2189.5	-.21653
94.500	.20683D+06	.12600D-01	2188.7	2189.5	-.21653
95.000	.20792D+06	.12630D-01	2188.7	2189.5	-.21653
95.500	.20902D+06	.13305D-01	2188.7	2189.5	-.21653
96.000	.21011D+06	.14321D-01	2188.7	2189.5	-.21653
96.500	.21121D+06	.15218D-01	2188.7	2189.5	-.21653
97.000	.21230D+06	.15595D-01	2188.7	2189.5	-.21653
97.500	.21340D+06	.15305D-01	2188.7	2189.5	-.21653
98.000	.21449D+06	.14516D-01	2188.7	2189.5	-.21653
98.500	.21558D+06	.13632D-01	2188.7	2189.5	-.21653
99.000	.21668D+06	.13098D-01	2188.7	2189.5	-.21653
99.500	.21777D+06	.13187D-01	2188.7	2189.5	-.21653
100.00	.21887D+06	.13874D-01	2188.7	2189.5	-.21653
100.50	.21996D+06	.14849D-01	2188.7	2189.5	-.21653
101.00	.22106D+06	.15671D-01	2188.7	2189.5	-.21653
101.50	.22215D+06	.15975D-01	2188.7	2189.5	-.21653
102.00	.22324D+06	.15647D-01	2188.7	2189.5	-.21653
102.50	.22434D+06	.14873D-01	2188.7	2189.5	-.21653
103.00	.22543D+06	.14052D-01	2188.7	2189.5	-.21653

T	X	Y	VCG	V	MDCT
103.50	.22653D+06	.13597D-01	2188.7	2189.5	-.21653
104.00	.22762D+06	.13746D-01	2188.7	2189.5	-.21653
104.50	.22872D+06	.14444D-01	2188.7	2189.5	-.21653
105.00	.22981D+06	.15377D-01	2188.7	2189.5	-.21653
105.50	.23090D+06	.16123D-01	2188.7	2189.5	-.21653
106.00	.23200D+06	.16352D-01	2188.7	2189.5	-.21653
106.50	.23309D+06	.15987D-01	2188.7	2189.5	-.21653
107.00	.23419D+06	.15231D-01	2188.7	2189.5	-.21653
107.50	.23528D+06	.14474D-01	2188.7	2189.5	-.21653
108.00	.23638D+06	.14100D-01	2188.7	2189.5	-.21653
108.50	.23747D+06	.14308D-01	2188.7	2189.5	-.21653
109.00	.23857D+06	.15015D-01	2188.7	2189.5	-.21653
109.50	.23966D+06	.15903D-01	2188.7	2189.5	-.21653
110.00	.24075D+06	.16571D-01	2188.7	2189.5	-.21653
110.50	.24185D+06	.16726D-01	2188.7	2189.5	-.21653
111.00	.24294D+06	.16325D-01	2188.7	2189.5	-.21653
111.50	.24404D+06	.15590D-01	2188.7	2189.5	-.21653
112.00	.24513D+06	.14899D-01	2188.7	2189.5	-.21653
112.50	.24623D+06	.14607D-01	2188.7	2189.5	-.21653
113.00	.24732D+06	.14872D-01	2188.7	2189.5	-.21653
113.50	.24841D+06	.15586D-01	2188.7	2189.5	-.21653
114.00	.24951D+06	.16426D-01	2188.7	2189.5	-.21653
114.50	.25060D+06	.17014D-01	2188.7	2189.5	-.21653
115.00	.25170D+06	.17095D-01	2188.7	2189.5	-.21653
115.50	.25279D+06	.16662D-01	2188.7	2189.5	-.21653
116.00	.25389D+06	.15951D-01	2188.7	2189.5	-.21653
116.50	.25498D+06	.15330D-01	2188.7	2189.5	-.21653
117.00	.25607D+06	.15120D-01	2188.7	2189.5	-.21653
117.50	.25717D+06	.15440D-01	2188.7	2189.5	-.21653
118.00	.25826D+06	.16156D-01	2188.7	2189.5	-.21653
118.50	.25936D+06	.16944D-01	2188.7	2189.5	-.21653
119.00	.26045D+06	.17450D-01	2188.7	2189.5	-.21653
119.50	.26155D+06	.17460D-01	2188.7	2189.5	-.21653
120.00	.26264D+06	.16998D-01	2188.7	2189.5	-.21653
120.50	.26373D+06	.16317D-01	2188.7	2189.5	-.21653
121.00	.26483D+06	.15768D-01	2188.7	2189.5	-.21653
121.50	.26592D+06	.15639D-01	2188.7	2189.5	-.21653
122.00	.26702D+06	.16011D-01	2188.7	2189.5	-.21653
122.50	.26811D+06	.16723D-01	2188.7	2189.5	-.21653
123.00	.26921D+06	.17455D-01	2188.7	2189.5	-.21653
123.50	.27030D+06	.17878D-01	2188.7	2189.5	-.21653
124.00	.27140D+06	.17819D-01	2188.7	2189.5	-.21653
124.50	.27249D+06	.17334D-01	2188.7	2189.5	-.21653

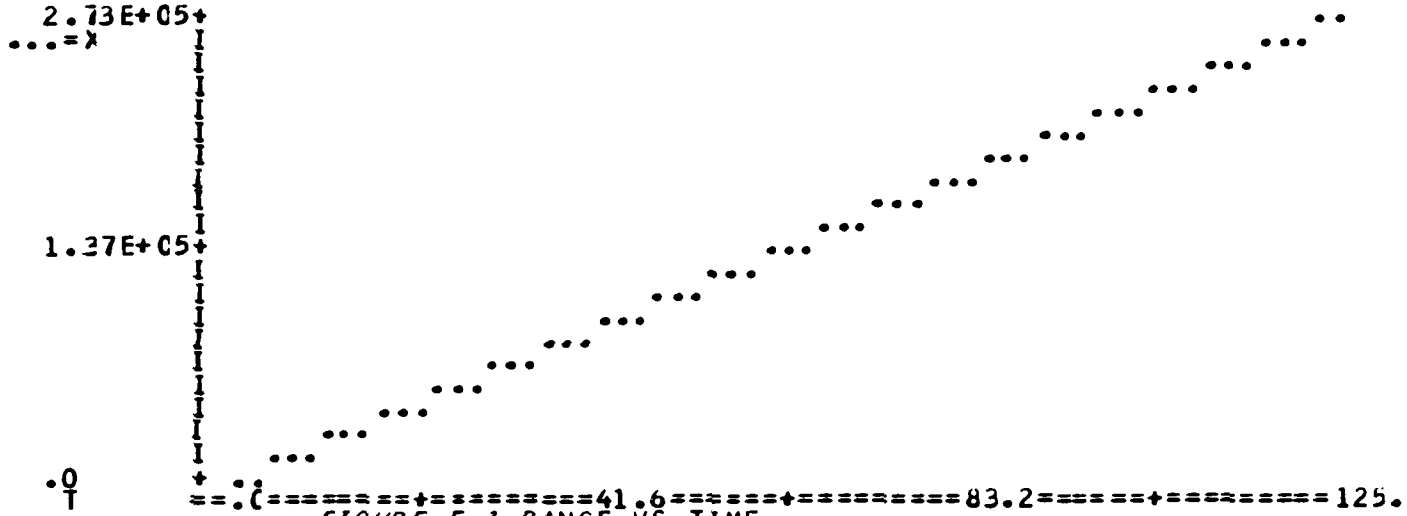
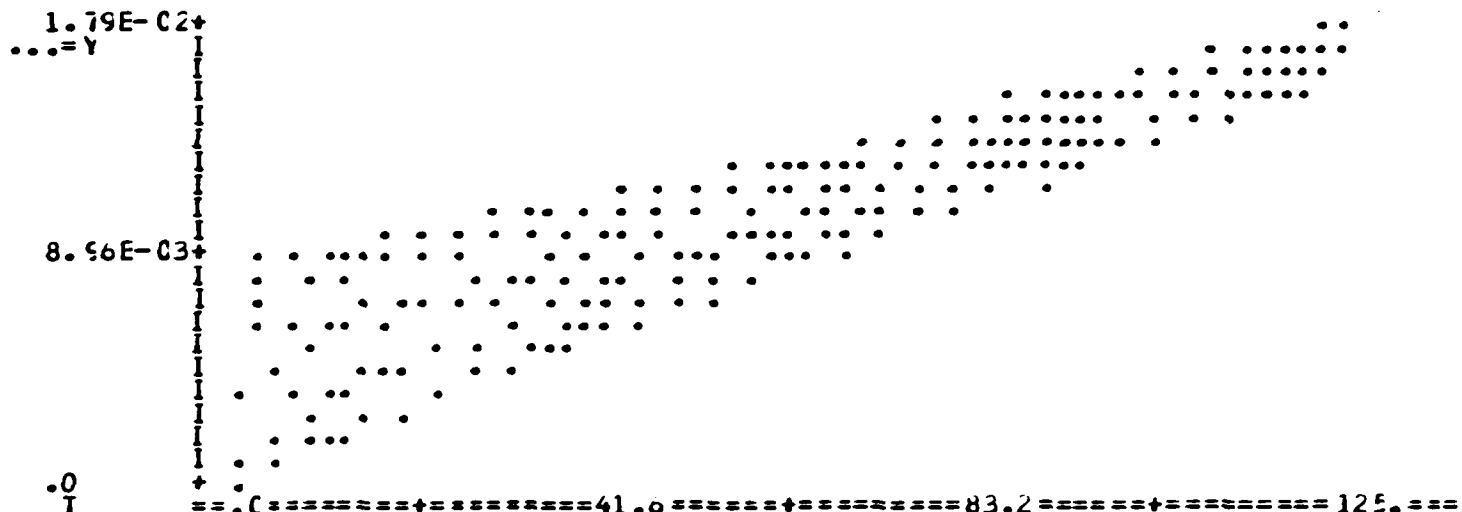


FIGURE E-1 RANGE VS TIME



FIGUR E-2 DISPERSION (Y) VS TIME

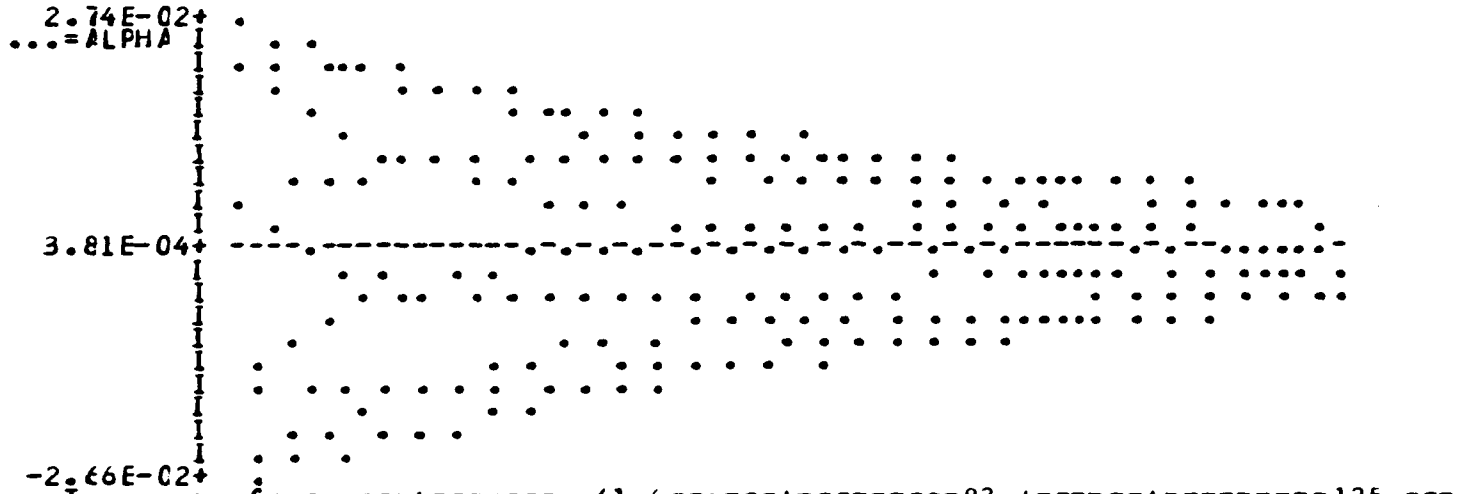


FIGURE E-3 ALPHA VS TIME

APPENDIX F-FIVE DEGREES OF FREEDOM RESULTS

```
VARIABLES & INITIAL CONDITIONS:
XDOT = 1733.564000
X = .0
YDOT = .0
Y = .0
ZDOT = 1733.564000
Z = .0
THEDOT = .0
TH = .0
DELDOT = .0
DE = .7853980000
M = 225.0000000
T = .0

CONSTANTS:
CMA = -2.308000000
A = .3491000000
DI = .666667000
ADI = .2327300000
DI2 = .444444000
CMT = 190.0000000
ISP = 950.0000000
G = 32.17400000
CDO = .2760000000
K = 1.000000000
R = .0

SPECIAL FUNCTIONS:
ROT = (2116.22*(1-(.0035662*Z/518.688))**5.256)/
      (1716.5*(518.688-(.0035662*Z)))
RO = CDEIF(Z,36089,ROT,.001271)
VWXY = 0
VWXZ = 0
GA = ATAN((YDOT+VWXY)/(XDOT+VWXZ))
O = ATAN(ZDOT/(XDOT+VWXZ))
VCG = (XDOT**2+YDOT**2+ZDOT**2)**.5
V = ((XDOT+VWXZ)**2+(YDOT+VWXY)**2+ZDOT**2)**.5
AL = O-DE
BE = GA-TH
Q = (RO*V**2)/2
LY = .091*BE*Q*A
L = .091*AL*Q*A
DY = D*COS(O)/COS(GA)
D = ((-.1025*V/(2402.88*(518.688-(.0035662*Z)))**.5+.5015)
     +.5*(.091*AL)*SIN(AL))*Q*A
```

```
DRAG = D/COS(GA)
C = CDEIF(M,158,1,R)
DELM = 225-M
I = (18.8-.0423*DELM)*32.2
MDOT = (1-C)*DRAG/(-ISP)

DERIVATIVES:
D(XDOT /D(T ) = =
    (L*SIN(O)-C*D*COS(O)+LY*SIN(GA)-C*DY*COS(GA))/M
D(X /D(T ) = =
    XDOT
D(YDOT /D(T ) = =
    (LY*COS(GA)+C*DY*SIN(GA))/M
D(Y /D(T ) = =
    YDOT
D(ZDOT /D(T ) = =
    (L*COS(O)+C*D*SIN(O)-M*G)/M
D(Z /D(T ) = =
    ZDOT
D(THEDOT/D(T ) = =
    (CMA*C*ADI*(TH-GA)-((CMT*Q*ADI*DI*THEDOT)/(V*2)))/I
D(TH /D(T ) = =
    THEDOT
D(DELDOT/D(T ) = =
    (CMA*C*ADI*(DE-O)-((CMT*Q*ADI*DI*DELDOT)/(V*2)))/I
D(DE /D(T ) = =
    DELDOT
D(M /D(T ) = =
    MDOT

OUTPUTS:
   TITLE: FIVE DEGREE
   TABULATE: T        X        Y        Z        MDOT     VCG      M
      AT INTERVAL     .5000000000
   PLOT: X        Z
      AGAINST: T
   PLOT: AL       EE
      AGAINST: T
   PLOT: Y
      AGAINST: T       AT INTERVAL     .2500000000

END CALCULATION WHEN MDOT .GE. .0
```

FIVE DEGREE

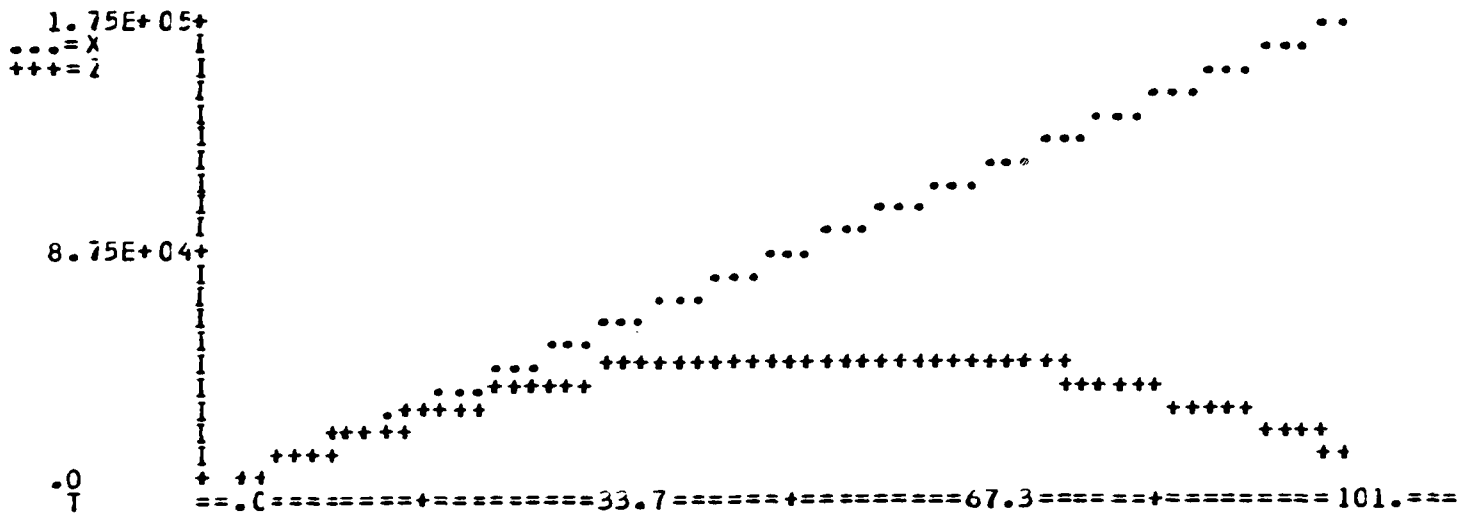
T	X	Y	Z	MDOT	VCG
.0	.0	.0	.0	-.72555	2451.6
.50000	866.78	.0	862.76	-.70183	2440.3
1.0000	1733.6	.0	1717.5	-.67894	2429.0
1.5000	2600.3	.0	2564.1	-.65666	2417.7
2.0000	3467.1	.0	3402.8	-.63556	2406.6
2.5000	4333.9	.0	4233.4	-.61501	2395.4
3.0000	5200.7	.0	5055.9	-.59519	2384.4
3.5000	6067.5	.0	5870.4	-.57607	2373.3
4.0000	6934.3	.0	6676.9	-.55763	2362.4
4.5000	7801.0	.0	7475.3	-.53984	2351.5
5.0000	8667.8	.0	8265.6	-.52267	2340.6
5.5000	9534.6	.0	9046.0	-.50612	2329.9
6.0000	10401.	.0	9822.2	-.49015	2319.1
6.5000	11268.	.0	10588.	-.47474	2308.5
7.0000	12135.	.0	11347.	-.45988	2297.9
7.5000	13002.	.0	12097.	-.44555	2287.4
8.0000	13869.	.0	12839.	-.43172	2276.9
8.5000	14735.	.0	13573.	-.41838	2266.5
9.0000	15602.	.0	14299.	-.40551	2256.2
9.5000	16469.	.0	15017.	-.39310	2245.9
10.000	17336.	.0	15727.	-.38113	2235.7
10.500	18202.	.0	16429.	-.36957	2225.6
11.000	19069.	.0	17123.	-.35843	2215.6
11.500	19936.	.0	17808.	-.34769	2205.6
12.000	20803.	.0	18486.	-.33732	2195.7
12.500	21670.	.0	19156.	-.32732	2185.8
13.000	22536.	.0	19818.	-.31767	2176.1
13.500	23403.	.0	20471.	-.30836	2166.4
14.000	24270.	.0	21117.	-.29938	2156.8
14.500	25137.	.0	21754.	-.29072	2147.2
15.000	26003.	.0	22384.	-.28237	2137.8
15.500	26870.	.0	23005.	-.27431	2128.4
16.000	27737.	.0	23619.	-.26653	2119.1
16.500	28604.	.0	24224.	-.25903	2109.9
17.000	29471.	.0	24821.	-.25180	2100.8
17.500	30337.	.0	25411.	-.24482	2091.7
18.000	31204.	.0	25992.	-.23809	2082.8
18.500	32071.	.0	26565.	-.23159	2073.9
19.000	32938.	.0	27130.	-.22533	2065.1
19.500	33804.	.0	27687.	-.21928	2056.4
20.000	34671.	.0	28236.	-.21345	2047.8
20.500	35538.	.0	28777.	-.20783	2039.3
21.000	36405.	.0	29310.	-.20240	2030.9
21.500	37272.	.0	29835.	-.19717	2022.5
22.000	38138.	.0	30352.	-.19213	2014.3

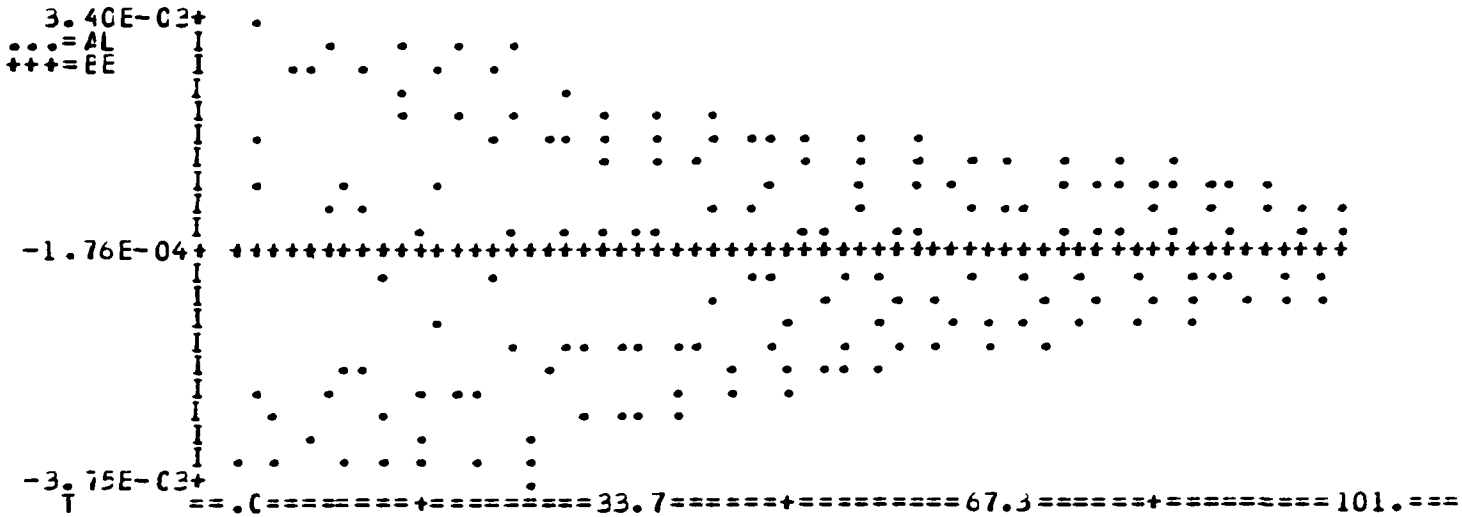
22.500	39005.	.0	30861.	-.18726	2006.1
23.000	39872.	.0	31362.	-.18256	1998.1
23.500	40739.	.0	31855.	-.17803	1990.1
24.000	41605.	.0	32339.	-.17367	1982.3
24.500	42472.	.0	32816.	-.16946	1974.5
25.000	43339.	.0	33285.	-.16539	1966.9
25.500	44206.	.0	33745.	-.16148	1959.3
26.000	45073.	.0	34198.	-.15770	1951.9
26.500	45939.	.0	34642.	-.15406	1944.6
27.000	46806.	.0	35079.	-.15055	1937.3
27.500	47673.	.0	35507.	-.14717	1930.2
28.000	48540.	.0	35928.	-.14391	1923.2
28.500	49407.	.0	36340.	-.25586	1916.3
29.000	50273.	.0	36744.	-.25434	1909.5
29.500	51140.	.0	37140.	-.25285	1902.8
30.000	52007.	.0	37529.	-.25139	1896.2
30.500	52874.	.0	37909.	-.24995	1889.7
31.000	53740.	.0	38281.	-.24855	1883.4
31.500	54607.	.0	38645.	-.24718	1877.2
32.000	55474.	.0	39001.	-.24583	1871.1
32.500	56341.	.0	39349.	-.24452	1865.1
33.000	57208.	.0	39689.	-.24323	1859.2
T	X	Y	Z	MDOT	VCG
33.500	58074.	.0	40021.	-.24197	1853.4
34.000	58941.	.0	40345.	-.24074	1847.8
34.500	59808.	.0	40660.	-.23954	1842.3
35.000	60675.	.0	40968.	-.23837	1836.9
35.500	61541.	.0	41268.	-.23723	1831.7
36.000	62408.	.0	41559.	-.23612	1826.5
36.500	63275.	.0	41843.	-.23504	1821.5
37.000	64142.	.0	42119.	-.23399	1816.6
37.500	65009.	.0	42386.	-.23297	1811.9
38.000	65875.	.0	42646.	-.23198	1807.3
38.500	66742.	.0	42897.	-.23102	1802.8
39.000	67609.	.0	43141.	-.23009	1798.5
39.500	68476.	.0	43376.	-.22919	1794.2
40.000	69342.	.0	43603.	-.22832	1790.2
40.500	70209.	.0	43823.	-.22748	1786.2
41.000	71076.	.0	44034.	-.22667	1782.4
41.500	71943.	.0	44237.	-.22589	1778.7
42.000	72810.	.0	44432.	-.22514	1775.2
42.500	73676.	.0	44619.	-.22442	1771.8
43.000	74543.	.0	44798.	-.22373	1768.6
43.500	75410.	.0	44969.	-.22308	1765.4
44.000	76277.	.0	45132.	-.22245	1762.5
44.500	77143.	.0	45287.	-.22185	1759.6
45.000	78010.	.0	45434.	-.22129	1757.0

T	X	Y	Z	MDOT	VCG
45.500	78877.	.0	45573.	-.22075	1754.4
46.000	79744.	.0	45704.	-.22025	1752.0
46.500	80611.	.0	45826.	-.21977	1749.7
47.000	81477.	.0	45941.	-.21933	1747.6
47.500	82344.	.0	46048.	-.21892	1745.7
48.000	83211.	.0	46146.	-.21854	1743.9
48.500	84078.	.0	46237.	-.21819	1742.2
49.000	84945.	.0	46320.	-.21787	1740.7
49.500	85811.	.0	46394.	-.21758	1739.3
50.000	86678.	.0	46461.	-.21733	1738.1
50.500	87545.	.0	46519.	-.21710	1737.0
51.000	88412.	.0	46569.	-.21691	1736.0
51.500	89278.	.0	46612.	-.21674	1735.3
52.000	90145.	.0	46646.	-.21661	1734.6
52.500	91012.	.0	46672.	-.21651	1734.1
53.000	91879.	.0	46690.	-.21644	1733.8
53.500	92746.	.0	46700.	-.21640	1733.6
54.000	93612.	.0	46703.	-.21639	1733.6
54.500	94479.	.0	46697.	-.21641	1733.7
55.000	95346.	.0	46683.	-.21647	1733.9
55.500	96213.	.0	46661.	-.21655	1734.3
56.000	97079.	.0	46631.	-.21667	1734.9
56.500	97946.	.0	46592.	-.21682	1735.6
57.000	98813.	.0	46546.	-.21699	1736.5
57.500	99680.	.0	46492.	-.21720	1737.5
58.000	.10055D+06	.0	46430.	-.21744	1738.6
58.500	.10141D+06	.0	46360.	-.21772	1739.9
59.000	.10228D+06	.0	46281.	-.21802	1741.4
59.500	.10315D+06	.0	46195.	-.21835	1743.0
60.000	.10401D+06	.0	46100.	-.21872	1744.7
60.500	.10488D+06	.0	45998.	-.21911	1746.6
61.000	.10575D+06	.0	45887.	-.21954	1748.6
61.500	.10661D+06	.0	45769.	-.22000	1750.8
62.000	.10748D+06	.0	45642.	-.22048	1753.1
62.500	.10835D+06	.0	45508.	-.22100	1755.6
63.000	.10921D+06	.0	45365.	-.22155	1758.2
63.500	.11008D+06	.0	45214.	-.22213	1761.0
64.000	.11095D+06	.0	45056.	-.22274	1763.9
64.500	.11181D+06	.0	44889.	-.22339	1766.9
65.000	.11268D+06	.0	44714.	-.22406	1770.1
65.500	.11355D+06	.0	44531.	-.22476	1773.4
66.000	.11442D+06	.0	44340.	-.22549	1776.9
66.500	.11528D+06	.0	44141.	-.22626	1780.5
67.000	.11615D+06	.0	43934.	-.22705	1784.2
67.500	.11702D+06	.0	43719.	-.22788	1788.1
68.000	.11788D+06	.0	43496.	-.22873	1792.1

68.500	.11875D+06	.0	43265.	-.22962	1796.2
69.000	.11962D+06	.0	43025.	-.23053	1800.5
69.500	.12048D+06	.0	42778.	-.23148	1804.9
70.000	.12135D+06	.0	42523.	-.23245	1809.5
70.500	.12222D+06	.0	42260.	-.23346	1814.2
71.000	.12308D+06	.0	41988.	-.23449	1819.0
71.500	.12395D+06	.0	41709.	-.23556	1823.9
72.000	.12482D+06	.0	41421.	-.23665	1829.0
72.500	.12568D+06	.0	41126.	-.23777	1834.1
73.000	.12655D+06	.0	40822.	-.23893	1839.5
73.500	.12742D+06	.0	40511.	-.24011	1844.9
74.000	.12828D+06	.0	40191.	-.24132	1850.5
74.500	.12915D+06	.0	39863.	-.24257	1856.2
75.000	.13002D+06	.0	39528.	-.24384	1862.0
75.500	.13088D+06	.0	39184.	-.24514	1867.9
76.000	.13175D+06	.0	38832.	-.24647	1874.0
76.500	.13262D+06	.0	38472.	-.24783	1880.1
77.000	.13348D+06	.0	38104.	-.24922	1886.4
77.500	.13435D+06	.0	37728.	-.25063	1892.8
78.000	.13522D+06	.0	37344.	-.25208	1899.3
78.500	.13608D+06	.0	36952.	-.25356	1906.0
79.000	.13695D+06	.0	36552.	-.25506	1912.7
79.500	.13782D+06	.0	36144.	-.25659	1919.5
80.000	.13868D+06	.0	35728.	-.14545	1926.5
80.500	.13955D+06	.0	35304.	-.14877	1933.6
81.000	.14042D+06	.0	34872.	-.15221	1940.8
81.500	.14129D+06	.0	34431.	-.15578	1948.0
82.000	.14215D+06	.0	33983.	-.15949	1955.4
82.500	.14302D+06	.0	33527.	-.16333	1962.9
83.000	.14389D+06	.0	33062.	-.16731	1970.5
83.500	.14475D+06	.0	32590.	-.17145	1978.2
84.000	.14562D+06	.0	32109.	-.17573	1986.0
84.500	.14649D+06	.0	31621.	-.18017	1993.9
85.000	.14735D+06	.0	31124.	-.18478	2001.9
85.500	.14822D+06	.0	30619.	-.18956	2010.0
86.000	.14909D+06	.0	30107.	-.19451	2018.2
86.500	.14995D+06	.0	29586.	-.19964	2026.5
87.000	.15082D+06	.0	29057.	-.20497	2034.9
87.500	.15169D+06	.0	28520.	-.21049	2043.3
88.000	.15255D+06	.0	27975.	-.21621	2051.9
88.500	.15342D+06	.0	27423.	-.22214	2060.6
89.000	.15429D+06	.0	26862.	-.22829	2069.3
89.500	.15515D+06	.0	26293.	-.23466	2078.1
90.000	.15602D+06	.0	25716.	-.24127	2087.0
90.500	.15689D+06	.0	25131.	-.24812	2096.0
91.000	.15775D+06	.0	24537.	-.25522	2105.1
91.500	.15862D+06	.0	23936.	-.26258	2114.3
92.000	.15949D+06	.0	23327.	-.27021	2123.5

92.500	.16035D+06	.0	22710.	-.27812	2132.9
93.000	.16122D+06	.0	22085.	-.28632	2142.3
93.500	.16209D+06	.0	21451.	-.29482	2151.8
94.000	.16295D+06	.0	20810.	-.30363	2161.3
94.500	.16382D+06	.0	20160.	-.31276	2171.0
95.000	.16469D+06	.0	19503.	-.32223	2180.7
95.500	.16556D+06	.0	18837.	-.33204	2190.5
96.000	.16642D+06	.0	18164.	-.34222	2200.4
96.500	.16729D+06	.0	17482.	-.35276	2210.3
97.000	.16816D+06	.0	16793.	-.36370	2220.3
97.500	.16902D+06	.0	16095.	-.37503	2230.4
98.000	.16989D+06	.0	15389.	-.38678	2240.6
98.500	.17076D+06	.0	14675.	-.39896	2250.8
99.000	.17162D+06	.0	13954.	-.41159	2261.1
99.500	.17249D+06	.0	13224.	-.42468	2271.5
100.00	.17336D+06	.0	12486.	-.43825	2281.9
100.50	.17422D+06	.0	11740.	-.45232	2292.4
101.00	.17509D+06	.0	10986.	.0	2302.6





VWXY NCW IS 60

FIVE DEGREE

T	X	Y	Z	MDOT	VCG
.0	.0	.0	.0	-.72624	2451.6
.50000	866.78	.37852D-02	862.76	-.70250	2440.3
1.0000	1733.6	.10021D-01	1717.5	-.67959	2429.0
1.5000	2600.3	.10760D-01	2564.1	-.65749	2417.7
2.0000	3467.1	.55895D-02	3402.8	-.63618	2406.6
2.5000	4333.9	.13485D-02	4233.4	-.61561	2395.4
3.0000	5200.7	.32435D-02	5055.9	-.59577	2384.4
3.5000	6067.5	.90122D-02	5870.4	-.57664	2373.3
4.0000	6934.3	.12233D-01	6676.9	-.55818	2362.4
4.5000	7801.0	.97417D-02	7475.3	-.54037	2351.5
5.0000	8667.8	.46356D-02	8265.6	-.52319	2340.6
5.5000	9534.6	.24552D-02	9048.0	-.50662	2329.9
6.0000	10401.	.54170D-02	9822.2	-.49064	2319.1
6.5000	11268.	.10611D-01	10588.	-.47522	2308.5
7.0000	12135.	.13254D-01	11347.	-.46035	2297.9

7.5000	13002.	.11235D-01	12097.	-.44600	2287.4
8.0000	13869.	.67133D-02	12839.	-.43216	2276.9
8.5000	14735.	.38357D-02	13573.	-.41881	2266.5
9.0000	15602.	.50785D-02	14299.	-.40593	2256.2
9.5000	16469.	.94110D-02	15017.	-.39351	2245.9
10.000	17336.	.13454D-01	15727.	-.38152	2235.7
10.500	18202.	.14289D-01	16429.	-.36996	2225.6
11.000	19069.	.11579D-01	17123.	-.35881	2215.6
11.500	19936.	.75549D-02	17808.	-.34805	2205.6
12.000	20803.	.52078D-02	18486.	-.33768	2195.7
12.500	21670.	.61847D-02	19156.	-.32767	2185.8
13.000	22536.	.98313D-02	19818.	-.31801	2176.1
13.500	23403.	.13832D-01	20471.	-.30869	2166.4
14.000	24270.	.15810D-01	21117.	-.29971	2156.8
14.500	25137.	.14769D-01	21754.	-.29104	2147.2
15.000	26003.	.11551D-01	22384.	-.28268	2137.8
15.500	26870.	.81823D-02	23005.	-.27461	2128.4
16.000	27737.	.66373D-02	23619.	-.26683	2119.1
16.500	28604.	.77788D-02	24224.	-.25932	2109.9
17.000	29471.	.11007D-01	24821.	-.25208	2100.8
17.500	30337.	.14697D-01	25411.	-.24509	2091.7
18.000	31204.	.17103D-01	25992.	-.23835	2082.8
18.500	32071.	.17205D-01	26565.	-.23185	2073.9
19.000	32938.	.15131D-01	27130.	-.22558	2065.1
19.500	33804.	.11991D-01	27687.	-.21953	2056.4
20.000	34671.	.93002D-02	28236.	-.21370	2047.8
20.500	35538.	.82863D-02	28777.	-.20807	2039.3
21.000	36405.	.93962D-02	29310.	-.20264	2030.9
21.500	37272.	.12179D-01	29835.	-.19740	2022.5
22.000	38138.	.15545D-01	30352.	-.19235	2014.3
22.500	39005.	.18239D-01	30861.	-.18748	2006.1
23.000	39872.	.19338D-01	31362.	-.18278	1998.1
23.500	40739.	.18558D-01	31855.	-.17825	1990.1
24.000	41605.	.16312D-01	32339.	-.17388	1982.3
24.500	42472.	.13503D-01	32816.	-.16966	1974.5
25.000	43339.	.11174D-01	33285.	-.16559	1966.9
25.500	44206.	.10153D-01	33745.	-.16167	1959.3
26.000	45073.	.10794D-01	34198.	-.15789	1951.9
26.500	45939.	.12901D-01	34642.	-.15425	1944.6
27.000	46806.	.15835D-01	35079.	-.15074	1937.3
27.500	47673.	.18736D-01	35507.	-.14735	1930.2
28.000	48540.	.20803D-01	35928.	-.14409	1923.2
28.500	49407.	.21291D-01	36340.	-.25618	1916.3
29.000	50273.	.19372D-01	36744.	-.25466	1909.5
29.500	51140.	.16046D-01	37140.	-.25317	1902.8
30.000	52007.	.13072D-01	37529.	-.25170	1896.2
30.500	52874.	.11989D-01	37909.	-.25027	1889.7
31.000	53740.	.13369D-01	38281.	-.24887	1883.4

31.500	54607.	.16566D-01	38645.	-.24749	1877.2
32.000	55474.	.20072D-01	39001.	-.24615	1871.1
32.500	56341.	.22266D-01	39349.	-.24483	1865.1
33.000	57208.	.22199D-01	39689.	-.24354	1859.2

T	X	Y	Z	MDOT	VCG
33.500	58074.	.20020D-01	40021.	-.24228	1853.4
34.000	58941.	.16876D-01	40345.	-.24106	1847.8
34.500	59808.	.14340D-01	40660.	-.23986	1842.3
35.000	60675.	.13662D-01	40968.	-.23869	1836.9
35.500	61541.	.15197D-01	41268.	-.23755	1831.7
36.000	62408.	.18265D-01	41559.	-.23644	1826.5
36.500	63275.	.21495D-01	41843.	-.23536	1821.5
37.000	64142.	.23475D-01	42119.	-.23431	1816.6
37.500	65009.	.23394D-01	42386.	-.23328	1811.9
38.000	65875.	.21398D-01	42646.	-.23229	1807.3
38.500	66742.	.18496D-01	42897.	-.23133	1802.8
39.000	67609.	.16080D-01	43141.	-.23040	1798.5
39.500	68476.	.15296D-01	43376.	-.22950	1794.2
40.000	69342.	.16536D-01	43603.	-.22863	1790.2
40.500	70209.	.19284D-01	43823.	-.22779	1786.2
41.000	71076.	.22365D-01	44034.	-.22698	1782.4
41.500	71943.	.24485D-01	44237.	-.22620	1778.7
42.000	72810.	.24797D-01	44432.	-.22545	1775.2
42.500	73676.	.23263D-01	44619.	-.22473	1771.8
43.000	74543.	.20651D-01	44798.	-.22404	1768.6
43.500	75410.	.18185D-01	44969.	-.22338	1765.4
44.000	76277.	.16999D-01	45132.	-.22276	1762.5
44.500	77143.	.17654D-01	45287.	-.22216	1759.6
45.000	78010.	.19906D-01	45434.	-.22160	1757.0
45.500	78877.	.22828D-01	45573.	-.22106	1754.4
46.000	79744.	.25225D-01	45704.	-.22056	1752.0
46.500	80611.	.26145D-01	45826.	-.22008	1749.7
47.000	81477.	.25286D-01	45941.	-.21964	1747.6
47.500	82344.	.23108D-01	46048.	-.21923	1745.7
48.000	83211.	.20623D-01	46146.	-.21885	1743.9
48.500	84078.	.18958D-01	46237.	-.21850	1742.2
49.000	84945.	.18872D-01	46320.	-.21818	1740.7
49.500	85811.	.20447D-01	46394.	-.21789	1739.3
50.000	86678.	.23058D-01	46461.	-.21763	1738.1
50.500	87545.	.25655D-01	46519.	-.21741	1737.0
51.000	88412.	.27209D-01	46569.	-.21721	1736.0
51.500	89278.	.27145D-01	46612.	-.21705	1735.3
52.000	90145.	.25580D-01	46646.	-.21692	1734.6
52.500	91012.	.23258D-01	46672.	-.21681	1734.1
53.000	91879.	.21233D-01	46690.	-.21674	1733.8
53.500	92746.	.20420D-01	46700.	-.21671	1733.6
54.000	93612.	.21210D-01	46703.	-.21670	1733.6

54.500	94479.	.23316D-01	46697.	-.21672	1733.7
55.000	95346.	.25902D-01	46683.	-.21677	1733.9
55.500	96213.	.27937D-01	46661.	-.21686	1734.3
56.000	97079.	.28637D-01	46631.	-.21698	1734.9
56.500	97946.	.27789D-01	46592.	-.21712	1735.6
57.000	98813.	.25838D-01	46546.	-.21730	1736.5
57.500	99680.	.23687D-01	46492.	-.21751	1737.5
58.000	.10055D+06	.22317D-01	46430.	-.21775	1738.6
58.500	.10141D+06	.22365D-01	46360.	-.21802	1739.9
59.000	.10228D+06	.23862D-01	46281.	-.21833	1741.4
59.500	.10315D+06	.26221D-01	46195.	-.21866	1743.0
60.000	.10401D+06	.28492D-01	46100.	-.21903	1744.7
60.500	.10488D+06	.29773D-01	45998.	-.21942	1746.6
61.000	.10575D+06	.29595D-01	45887.	-.21985	1748.6
61.500	.10661D+06	.28117D-01	45769.	-.22030	1750.8
62.000	.10748D+06	.26057D-01	45642.	-.22079	1753.1
62.500	.10835D+06	.24379D-01	45508.	-.22131	1755.6
63.000	.10921D+06	.23873D-01	45365.	-.22186	1758.2
63.500	.11008D+06	.24815D-01	45214.	-.22244	1761.0
64.000	.11095D+06	.26847D-01	45056.	-.22305	1763.9
64.500	.11181D+06	.29139D-01	44889.	-.22370	1766.9
65.000	.11268D+06	.30751D-01	44714.	-.22437	1770.1
65.500	.11355D+06	.31050D-01	44531.	-.22507	1773.4
66.000	.11442D+06	.29986D-01	44340.	-.22580	1776.9
66.500	.11528D+06	.28115D-01	44141.	-.22657	1780.5
67.000	.11615D+06	.26348D-01	43934.	-.22736	1784.2
67.500	.11702D+06	.25545D-01	43719.	-.22819	1788.1
68.000	.11788D+06	.26129D-01	43496.	-.22904	1792.1

T	X	Y	Z	MDOT	VCG
68.500	.11875D+06	.27894D-01	43265.	-.22993	1796.2
69.000	.11962D+06	.30098D-01	43025.	-.23084	1800.5
69.500	.12048D+06	.31805D-01	42778.	-.23179	1804.9
70.000	.12135D+06	.32310D-01	42523.	-.23276	1809.5
70.500	.12222D+06	.31463D-01	42260.	-.23377	1814.2
71.000	.12308D+06	.29741D-01	41988.	-.23480	1819.0
71.500	.12395D+06	.28028D-01	41709.	-.23587	1823.9
72.000	.12482D+06	.27196D-01	41421.	-.23696	1829.0
72.500	.12568D+06	.27705D-01	41126.	-.23809	1834.1
73.000	.12655D+06	.29375D-01	40822.	-.23924	1839.5
73.500	.12742D+06	.31476D-01	40511.	-.24043	1844.9
74.000	.12828D+06	.33075D-01	40191.	-.24164	1850.5
74.500	.12915D+06	.33481D-01	39863.	-.24288	1856.2
75.000	.13002D+06	.32584D-01	39528.	-.24415	1862.0
75.500	.13088D+06	.30910D-01	39184.	-.24545	1867.9
76.000	.13175D+06	.29363D-01	38832.	-.24679	1874.0
76.500	.13262D+06	.28783D-01	38472.	-.24815	1880.1
77.000	.13348D+06	.29529D-01	38104.	-.24953	1886.4

77.500	.13435D+06	.31295D-01	37728.	-.25095	1892.8
78.000	.13522D+06	.33261D-01	37344.	-.25240	1899.3
78.500	.13608D+06	.34509D-01	36952.	-.25387	1906.0
79.000	.13695D+06	.34488D-01	36552.	-.25538	1912.7
79.500	.13782D+06	.33300D-01	36144.	-.25691	1919.5
80.000	.13868D+06	.31662D-01	35728.	-.14563	1926.5
80.500	.13955D+06	.30301D-01	35304.	-.14895	1933.6
81.000	.14042D+06	.29691D-01	34872.	-.15240	1940.8
81.500	.14129D+06	.30086D-01	34431.	-.15597	1948.0
82.000	.14215D+06	.31424D-01	33983.	-.15968	1955.4
82.500	.14302D+06	.33330D-01	33527.	-.16353	1962.9
83.000	.14389D+06	.35222D-01	33062.	-.16752	1970.5
83.500	.14475D+06	.36500D-01	32590.	-.17165	1978.2
84.000	.14562D+06	.36757D-01	32109.	-.17594	1986.0
84.500	.14649D+06	.35945D-01	31621.	-.18039	1993.9
85.000	.14735D+06	.34414D-01	31124.	-.18500	2001.9
85.500	.14822D+06	.32804D-01	30619.	-.18978	2010.0
86.000	.14909D+06	.31813D-01	30107.	-.19474	2018.2
86.500	.14995D+06	.31914D-01	29586.	-.19988	2026.5
87.000	.15082D+06	.33149D-01	29057.	-.20521	2034.9
87.500	.15169D+06	.35076D-01	28520.	-.21073	2043.3
88.000	.15255D+06	.36930D-01	27975.	-.21646	2051.9
88.500	.15342D+06	.37949D-01	27423.	-.22239	2060.6
89.000	.15429D+06	.37726D-01	26862.	-.22855	2069.3
89.500	.15515D+06	.36427D-01	26293.	-.23493	2078.1
90.000	.15602D+06	.34755D-01	25716.	-.24154	2087.0
90.500	.15689D+06	.33625D-01	25131.	-.24839	2096.0
91.000	.15775D+06	.33713D-01	24537.	-.25550	2105.1
91.500	.15862D+06	.35074D-01	23936.	-.26287	2114.3
92.000	.15949D+06	.37065D-01	23327.	-.27051	2123.5
92.500	.16035D+06	.38665D-01	22710.	-.27842	2132.9
93.000	.16122D+06	.39036D-01	22085.	-.28663	2142.3
93.500	.16209D+06	.38040D-01	21451.	-.29514	2151.8
94.000	.16295D+06	.36375D-01	20810.	-.30395	2161.3
94.500	.16382D+06	.35189D-01	20160.	-.31310	2171.0
95.000	.16469D+06	.35365D-01	19503.	-.32257	2180.7
95.500	.16556D+06	.36905D-01	18837.	-.33240	2190.5
96.000	.16642D+06	.38870D-01	18164.	-.34258	2200.4
96.500	.16729D+06	.39981D-01	17482.	-.35314	2210.3
97.000	.16816D+06	.39537D-01	16793.	-.36408	2220.3
97.500	.16902D+06	.37985D-01	16095.	-.37543	2230.4
98.000	.16989D+06	.36651D-01	15389.	-.38719	2240.6
98.500	.17076D+06	.36736D-01	14675.	-.39938	2250.8
99.000	.17162D+06	.38310D-01	13954.	-.41202	2261.1
99.500	.17249D+06	.40178D-01	13224.	-.42512	2271.5
100.00	.17336D+06	.40844D-01	12486.	-.43870	2281.9
100.50	.17422D+06	.39851D-01	11740.	-.45278	2292.4

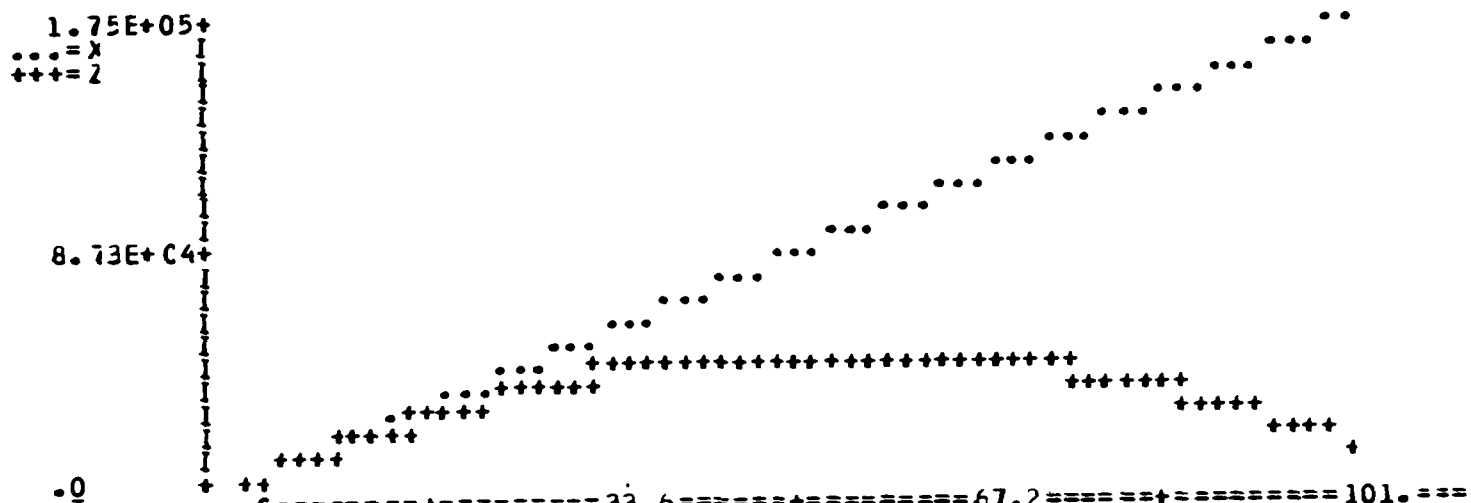


FIGURE F-1 RANGE AND HEIGHT VS TIME

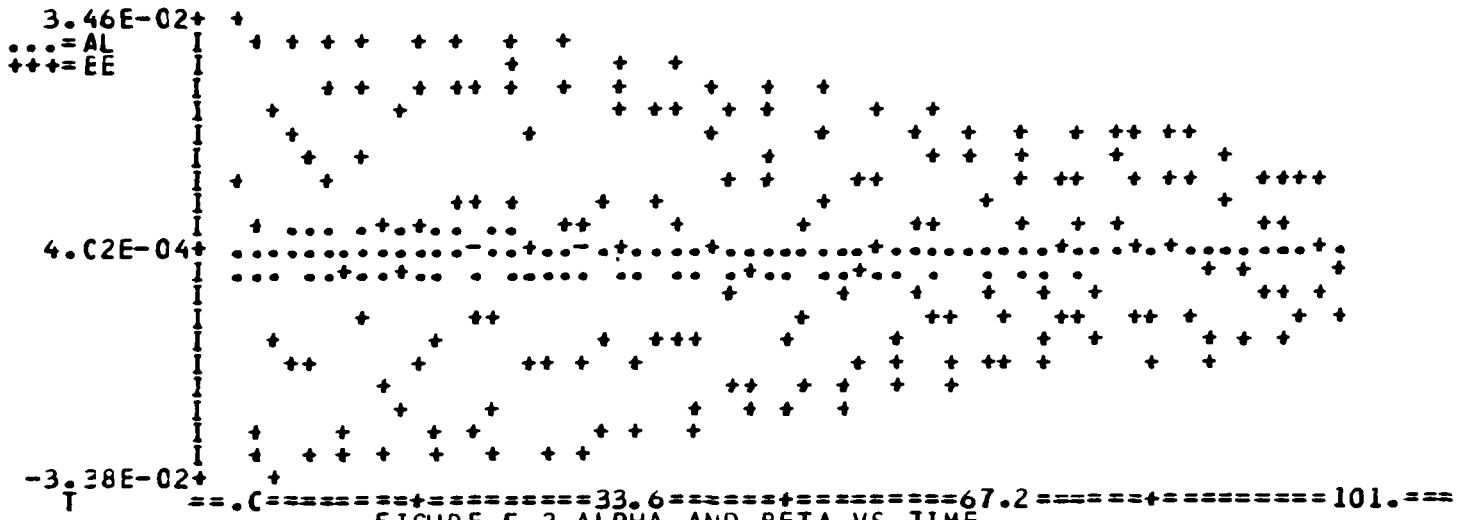


FIGURE F-2 ALPHA AND BETA VS TIME

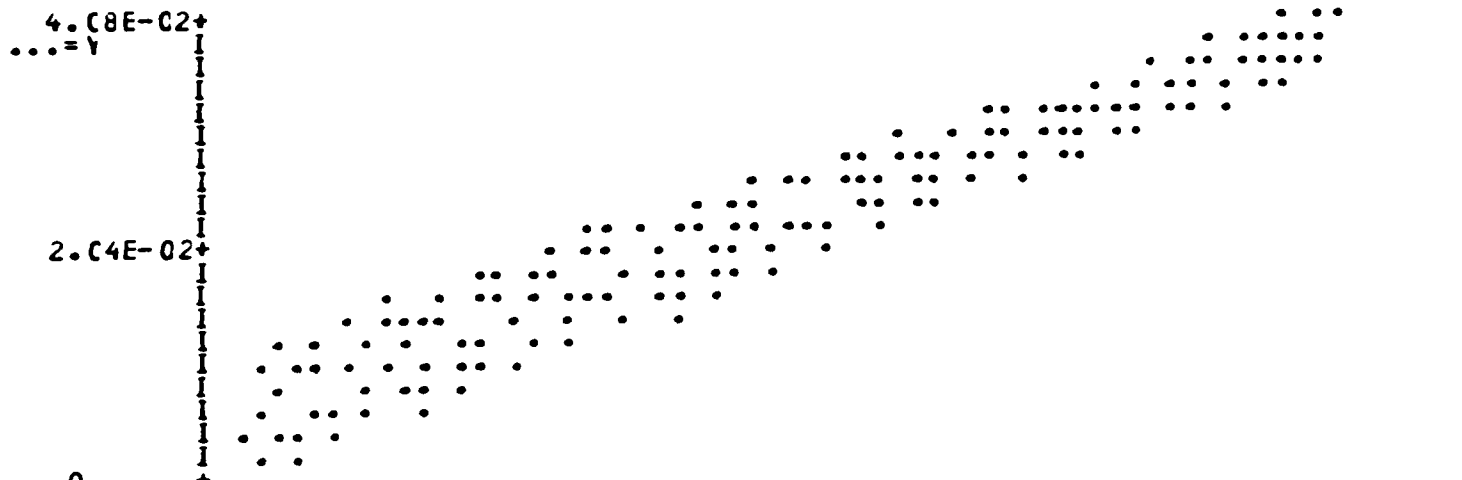


FIGURE F-3 DISPERSICN VS TIME

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C*****************************************************************
C                 APPENDIX G  HTRAJ BRL PRCGRAM
C
C
C*****************************************************************
      DIMENSICN LE(1), C(7), QE(1), WSX(1), PY(2), DPY(2), Y(16), DY(16)
     1  , QC(16), CMMT(162), CMHGT(27), T45(10), EURN(16)
     2  , PR(13), CTP(48), CT1(8), CT2(4), CT3(6), CT4(7), CT5(4),
     3  CT6(5), CT7(7), CT8(5), CT9(6), CT10(4), CT11(10), CT12(5)
      COMMON LE, RN, RK, R2TEM, RNE, C, E, LL, GO, TBMST, TBST, IST, PE,
     1  AE, MTBST, MDI, DELTB, DETFF, XIDEL, XIMAX, IH2B, IH3E, TFUB,
     2  CX1, LZ1, ETB, EPB, EUB, EX1, EZ1, TSRIST, TSRBST, RS, QE, IH2,
     3  IH3, TF, EC, SL, C, UO, SPN, IX1, IX2, IU, AZU, EU, TBM, TL, TDI
     4  , TCE, TE, TE6, TCFF, PTB, PTFF, AZD, MTBM, MF, MTB, ISP, TSRI,
     5  TSRE, TSCF, CGTBM, CGTB, ATBM, ATE, ETBM, LAT, AZ, TMCB, UMCB,
     6  PHMCB, THMCB, TI, XI, YI, ZI, WSX, WSZ, WEX, WBZ, DENSF, PRESF,
     7  TEMPF, SL6D
      COMMON ATM(700), IMZ, IMZ1, IMZ2, NATM, J2, IDGREE(1), IROT,
     1  IREDUC, ITWT, IUPLEG, IUNIT, ISPRT, IRSET, ICURE, ISTIM, ISCCUT,
     2  I3DBUF, I3DP, ISAVE6, ITONQE, IXIAYI, I5DIG, IX2N, IUN, LAM(3),
     3  B, A, SINCE, COSCE, DSQ, IKL, GOFSC, XOUT(1), YOUT, ZCUT, TOF,
     4  AA, IU1, AZU1, EU1, UTL, QEOUT, TEMPN, DENSN, WX, WZ, CDN, IDNN,
     5  CENS, FA, VAS, EC, PP1, PP2, PPP1, PPP2, ETB, CONS2, CONS3, D33,
     6  D44, GCRS, I1, I2, I3, I4, I5, I6, I7, I8, I9, NEX, ICSA, IYP,
     7  IEPC, CSQ, R1TB, R2TBSQ, RETB, RK12, RK2, RNESQ2, RTTB, TRCONS,
     8  ICNP, TST, IT, ITT, ITTT, IFERR, IC1, HDX, CTS, TO, T1, T2, T3,
     9  T4, T5, TALPH, THETA, ALPE, ALPQ1, ALPQ2, ALPQ3, CODE, D22,
     A  IFIRST, J1, J7, PDTOM, PMTOF, TJ(2900), UN, YP, ICODE, ICOT1,
     B  ICOT2, ICCT3, PHI, I6DP, R3, ALPHA, VT, V1, V2, V3, TSTAR, KDB,
     C  KM, KL, KT, XDX, KH, DKDB, DKDBA, MACH, ISUN, SINLAT, COSLAT,
     D  SINAZ, CCSAZ, SINC, CCSD, DEL
      COMMON /ERR/ IER
      COMMON /ECH/ REARTH, GC, AMTOMS, PO, AMTOF, FTCM, ANTUM, RTCD,
     1  DTOM, TWCPHI, AMTCIN, AMTOKN, AMTCMH, FTCM2, CVDTCR, CVMTCR, RSQ
     2  , HA(23), TM(23), ALM(22), HEAD(169)
      EXTERNAL COA,DER
      REAL LE, LL, IST, MDI, IH2B, IH3B, IX3, IH2, IH3, IX1, IX2, IU, MF
     1  , MTB, ISP, LAT, LAM, MTBM, MTBST, IC1, IX2N, IUN, LZ1, KDB, KM,
     2  KL, KT, KH, MACH, ITO, IUEL, IUAZ, IARV, IARH
      DATA PI12 /.2617993878/
      DATA CT1 /4H6 DE,4HG TH,4HROUG,4HH EN,4HTIRE,4HTRAJ,4HECTO,
     14HRY  /
      DATA CT2 /4H ROT,4HATIN,4HG EA,4HRTH /
      DATA CT3 /4H RED,4HUCTI,4HCN  ,4HTRAJ,4HECTC,4HRY  /
      DATA CT4 /4H INP,4HUT S,4HPIN ,4HINST,4HEAD ,4HOF T,4HWIST/
      DATA CT5 /4H HIT,4H ON ,4HUP L,4HEG  /
      DATA CT6 /4H TER,4HMINA,4HTE O,4HN TI,4HME  /
      DATA CT7 /4H PRI,4HNT V,4HELOC,4HITY ,4HVECT,4HOR L,4HINE /
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      DATA CTE /4H SUM,4HMARY,4H HAR,4HD CU,4HTPUT/                     HDU00490
      DATA CTS /4H 3 D,4HEG D,4HURIN,4HG BU,4HRNIN,4HG   /              HDU00500
      DATA CT10 /4H ITE,4HRATE,4H ON ,4HCE  /                           HDU00510
      DATA CT11 /4H TER,4HMINA,4HTE A,4HT TE,4HRM X,4HINST,             HDU00520
     14HEAD ,4HOF T,4HERM ,4HX2  /                                      HDU00530
      DATA CT12 /4H 5 C,4HIGIT,4H TIM,4HE PR,4HINT /                    HDU00540
      INTEGER SYM(19)                                                   HDU00550
      DATA SYM /2H10, 2HPC, 2HIM, 2HIP, 2HTS, 2HAA, 2HTC, 2HIB,         HDU00560
     12HRJ, 2HVC, 2HMC, 2HAC, 2HRI, 2HRT, 2HRC, 2HRS, 2HMM, 2HNA, 2HSS/ HDU00570
      DATA CMHGT /0., 328.08399, 1148.29396, 2460.62992, 4101.04987,    HDU00580
     15741.46982, 7381.88976, 9022.30971, 10662.72966, 12303.14961,     HDU00590
     213943.56955, 15583.98950, 18044.61942, 21325.45932, 24606.29921,  HDU00600
     327887.13911, 31167.97900, 34448.81890, 37729.65879, 41010.49869,  HDU00610
     444291.33858, 47572.17848, 50853.01837, 54133.85827, 57414.69816,  HDU00620
     560695.53806, 63976.37795/                                         HDU00630
C     ASSIGN 167 TO IER                                                 HDU00640
C     NEXT TWO STATEMENTS ARE MINE                                      HDU00650
      INTEGER R(19),CODE,SS,TYPE,DUMMY                                  HDU00660
      DATA DUMMY/1H /                                                   HDU00670
      DO 1 I=1,3833                                                     HDU00680
    1 LE(I)=0.                                                          HDU00690
      JBLRN=1                                                           HDU00700
C     START WITH AEROPACK END WITH 0 IN COL 80                          HDU00710
    2 CALL AEROP                                                        HDU00720
      IF (IRSET.NE.0) GO TO 4                                           HDU00730
      DO 3 I=1,856                                                      HDU00740
    3 LE(I)=0.                                                          HDU00750
      IST=999.99                                                        HDU00760
      ISP=999.99                                                        HDU00770
      TBM=.99999                                                        HDU00780
      ISLN=0                                                            HDU00790
      J2=1                                                              HDU00800
      TSRB=.99999                                                       HDU00810
      DENSF=1.                                                          HDU00820
      PRESF=1.                                                          HDU00830
      TEMPF=1.                                                          HDU00840
      CMETM=0.                                                          HDU00850
      SL=1.                                                             HDU00860
C   CONTROL CARD OPTIONS SET FOR 6DEG,SPIN,FT,STOP TRAJ ON T,FLAT TRAJ  HDU00870
C   4 READ (5,199) R,CODE,SS,TYPE                                       HDU00880
    4 IDGREE(1)=1                                                       HDU00890
C     IRCT=R(2)                                                         HDU00900
C     IREDUC=R(3)                                                       HDU00910
C     ITWT=1                                                            HDU00920
C     IUPLEG=R(5)                                                       HDU00930
C     IUNIT=1                                                           HDU00940
      ISPRT=1                                                           HDU00950
C     IRSET=1                                                           HDU00960
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      ICLRE=1                                                           HDL0C970
C     ISTIM=1                                                           HDU0C980
C     ISCCUT=R(11)                                                      HDL0C990
C     I3CBUR=R(12)                                                      HDU01000
C     I3CP=R(13)                                                        HDL01010
C     ISAVE6=R(14)                                                      HDU01020
C     ITONQE=R(15)                                                      HDU01030
C     IXIAY=R(16)                                                       HDL01040
C     I5DEG=R(17)                                                       HDL01050
C     EXTRA=R(18)                                                       HDU01060
C     IF (EOF(5)) 3000,3001                                             HDL01070
C3000 STOP                                                              HDU01080
C     DECODE (40,170,R(1) )IDGREE,IROT,IREDUC,ITWT,IUPLEG,IUNIT,ISPRT,IRHDU01090
C    1SET,ICLRE,ISTIM,ISCCUT,I3DBUR,I3CP,ISAVE6,ITONQE,IXIAYI,I5DIG     HDL01100
      WRITE (6,220)                                                     HDU01110
      READ (5,210)C,CCDE,SS,TYPE                                        HDU01120
      WRITE (6,210)C,CCDE,SS,TYPE                                       HDL01130
      IF (TYPE.EQ.SYM(1)) GO TO 8                                       HDL01140
      IF (TYPE.EQ.SYM(2)) GO TO 14                                      HDL01150
      IF (TYPE.EQ.SYM(3)) GC TO 16                                      HDU01160
      IF (TYPE.EQ.SYM(4)) GO TO 17                                      HDL01170
      IF (TYPE.EC.SYM(5)) GC TO 18                                      HDU01180
      IF (TYPE.EQ.SYM(6)) GC TO 19                                      HDU01190
      IF (TYPE.EQ.SYM(7)) GO TO 20                                      HDL01200
      IF (TYPE.EQ.SYM(8)) GC TO 21                                      HDL01210
      IF (TYPE.EQ.SYM(9)) GO TO 22                                      HDL01220
      IF (TYPE.EQ.SYM(10)) GC TO 23                                     HDL01230
      IF (TYPE.EQ.SYM(11)) GC TC 24                                     HDU01240
      IF (TYPE.EQ.SYM(12)) GO TO 25                                     HDL01250
      IF (TYPE.EQ.SYM(13)) GC TO 26                                     HDL01260
      IF (TYPE.EQ.SYM(14)) GO TO 27                                     HDU01270
      IF (TYPE.EQ.SYM(15)) GC TO 28                                     HDL01280
      IF (TYPE.EC.SYM(16)) GC TO 29                                     HDL01290
      IF (TYPE.EQ.SYM(17)) GC TO 31                                     HDL01300
      IF (TYPE.EQ.SYM(18)) GC TO 2                                      HDL01310
      IF (TYPE.EQ.SYM(19)) GC TO 30                                     HDU01320
      WRITE (6,200)                                                     HDU01330
      WRITE (6,199) C,CODE,SS,TYPE                                      HDL01340
      STOP                                                              HDU01350
C    7 DECCDE (80,171,R(1) )C                                           HDL01360
C     GO TO (8,14,16,17,18,19,20,21,22,23,24,25,26,27,28,29,31,2,30), I HDL01370
    8 K=1                                                               HDL01380
      J2=2                                                              HDL01390
      CMETM=C.                                                          HDU01400
      ICN=20                                                            HDL01410
      GO TO 10                                                          HDL01420
C     THIS NEXT LCOP INVCLVES MET CARD LCCPS                            HDU01430
    9 REAC (5,171) C,CCDEM,ID                                           HDL01440
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```
      IF (ID.NE.ICN) GO TO 13                                           HDU01450
      ICN=ICN+10                                                        HDU01460
   10 C(2)=ANTCMS*C(2)                                                  HDU01470
      C(3)=ANTCMS*C(3)                                                  HDU01480
      L=K                                                               HDU01490
      DO 11 I=1,7                                                       HDU01500
      ATM(L)=C(I)                                                       HDU01510
   11 L=L+1                                                             HDU01520
      IF (L.LE.693) GO TO 12                                            HDU01530
      WRITE (6,173)                                                     HDU01540
      STOP                                                              HDU01550
   12 K=K+7                                                             HDU01560
      IF (C(1).GE.0.) GO TO 9                                           HDU01570
      ATM(L-7)=ABS(ATM(L-7))                                            HDU01580
      NATM=K-7                                                          HDU01590
      GO TO 4                                                           HDU01600
   13 WRITE (6,172)                                                     HDU01610
      STOP                                                              HDU01620
   14 MTEST=C(1)                                                        HDU01630
      MTB=C(2)                                                          HDU01640
      D=FTOM*C(3)                                                       HDU01650
      CGTB=FTCM*C(4)                                                    HDU01660
      ATB=FTCM2*C(5)                                                    HDU01670
      BTEM=FTCM2*C(6)                                                   HDU01680
      TWIST=C(7)                                                        HDU01690
   15 IF (SS.EQ.DUMMY ) GO TO 4                                         HDU01700
      GO TO 34                                                          HDU01710
   16 LO=FTOM*C(1)                                                      HDU01720
      CE(1)=C(2)                                                        HDU01730
      AZC=C(3)                                                          HDU01740
      BC=C(4)/ANTCM**2                                                  HDU01750
      SL=C(5)                                                           HDU01760
      IH2=C(6)                                                          HDU01770
      IH3=C(7)                                                          HDU01780
      GO TO 15                                                          HDU01790
   17 ITC=C(1)                                                          HDU01800
      IX1=FTCM*C(2)                                                     HDU01810
      IX2=FTCM*C(3)                                                     HDU01820
      IX3=FTCM*C(4)                                                     HDU01830
      IARV=C(5)                                                         HDU01840
      IARH=C(6)                                                         HDU01850
      GO TO 15                                                          HDU01860
   18 DETFF=C(1)                                                        HDU01870
      PTFF=C(2)                                                         HDU01880
      XIDEL=FTCM*C(3)                                                   HDU01890
      AZ=C(4)                                                           HDU01900
      LAT=C(5)                                                          HDU01910
      GO=FTCM*C(6)                                                      HDU01920
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      GO TO 15                                                          HDU01930
   15 Q=C(1)                                                            HDU01940
      TF=C(2)                                                           HDU01950
      E=C(3)                                                            HDU01960
      LL=FTCM*C(4)                                                      HDU01970
      SL6C=C(5)                                                         HDU01980
      GO TO 15                                                          HDU01990
   20 TI=C(1)                                                           HDU02000
      XI0=FTCM*C(2)                                                     HDU02010
      XIMAX=FTCM*C(3)                                                   HDU02020
      YI=FTCM*C(4)                                                      HDU02030
      ZI=FTCM*C(5)                                                      HDU02040
      EX1=FTCM*C(6)                                                     HDU02050
      EZ1=FTCM*C(7)                                                     HDU02060
      GO TO 15                                                          HDU02070
   21 TMCBI=C(1)                                                        HDU02080
      UMCB=FTCM*C(2)                                                    HDU02090
      PHMCB=DTCM*C(3)                                                   HDU02100
      THMCB=DTCM*C(4)                                                   HDU02110
      EUB=FTCM*C(5)                                                     HDU02120
      EPB=DTCM*C(6)                                                     HDU02130
      ETB=DTCM*C(7)                                                     HDU02140
      GO TO 15                                                          HDU02150
   22 R2TBM=FTCM*C(1)                                                   HDU02160
      RNE=FTCM*C(2)                                                     HDU02170
      AE=FTCM2*C(3)                                                     HDU02180
      PE=C(4)/FTCM2                                                     HDU02190
      RN=FTCM*C(5)                                                      HDU02200
      RK=FTCM*C(6)                                                      HDU02210
      GO TO 15                                                          HDU02220
   23 QE(1)=C(1)                                                        HDU02230
      IX2=FTCM*C(2)                                                     HDU02240
      IU=FTCM*C(3)                                                      HDU02250
      AZU=C(4)                                                          HDU02260
      EU=C(5)                                                           HDU02270
      XIMAX=FTCM*C(6)                                                   HDU02280
      XI=XIMAX                                                          HDU02290
      AZC=C(7)                                                          HDU02300
      GO TO 15                                                          HDU02310
   24 WSX(1)=AMTCMS*C(1)                                                HDU02320
      WSZ=AMTCMS*C(2)                                                   HDU02330
      WBX=AMTCMS*C(3)                                                   HDU02340
      WBZ=AMTCMS*C(4)                                                   HDU02350
      DENSF=C(5)                                                        HDU02360
      PRESF=C(6)                                                        HDU02370
      TEMPF=C(7)                                                        HDU02380
      CMETM=C.                                                          HDU02390
      J2=1                                                              HDU02400
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      GO TO 15                                                          HDU02410
   25 IH2B=C(1)/DTOM                                                    HDU02420
      IH3B=C(2)/DTOM                                                    HDU02430
      TFUB=C(3)/FTOM                                                    HDU02440
      CX1=(C(4)/ANTOM**2)/FTCM                                          HDU02450
      LZ1=C(5)/FTCM                                                     HDU02460
      GO TO 15                                                          HDU02470
   26 IST=C(1)                                                          HDU02480
      ISP=C(2)                                                          HDU02490
      MF=C(3)                                                           HDU02500
      LE(1)=FTCM*C(4)                                                   HDU02510
      CGTBM=FTCM*C(5)                                                   HDU02520
      ATBM=FTCM2*C(6)                                                   HDU02530
      MDI=C(7)                                                          HDU02540
      GO TO 15                                                          HDU02550
   27 TBMST=C(1)                                                        HDU02560
      TBM=C(2)                                                          HDU02570
      TBST=C(3)                                                         HDU02580
      TB=C(4)                                                           HDU02590
      TL=C(5)                                                           HDU02600
      TDI=C(6)                                                          HDU02610
      TEE=C(7)                                                          HDU02620
      GO TO 15                                                          HDU02630
   28 DELTB=C(1)                                                        HDU02640
      PTB=C(2)                                                          HDU02650
      TCE=C(3)                                                          HDU02660
      TCFF=C(4)                                                         HDU02670
      GO TO 15                                                          HDU02680
   29 TSRIST=C(1)                                                       HDU02690
      TSRI=C(2)                                                         HDU02700
      TSREST=C(3)                                                       HDU02710
      TSRB=C(4)                                                         HDU02720
      RS=FTCM*C(5)                                                      HDU02730
      TSCF=C(6)                                                         HDU02740
      GO TO 15                                                          HDU02750
   30 ALCNG=C(1)                                                        HDU02760
      RACS=C(2)*1000.                                                   HDU02770
      ADCS=C(3)*1000.                                                   HDU02780
      HACA=C(4)*1000.                                                   HDU02790
      TOCAY=C(5)*1000.                                                  HDU02800
      ISUN=1                                                            HDU02810
      GO TO 15                                                          HDU02820
   31 HGTMDP=C(1)/FTOM                                                  HDU02830
      CMETM=1.                                                          HDU02840
      COCEM=CCCE                                                        HDU02850
      DO 32 I=1,162,6                                                   HDU02860
      K=I+4                                                             HDU02870
      READ (5,171) (CMMT(J),J=I,K)                                      HDU02880
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      IF (CMMT(I).EQ.0..AND.CMMT(I+3).EQ.0..AND.CMMT(I+4).EQ.0.) GO TO 3HDU02890
   13                                                                  HDU02900
      L=CMMT(I)+1.                                                     HDU02910
      IF (L.NE.1+I/6) GO TO 13                                         HDU02920
      CMMT(I)=HGTMDP+CMHGT(L)                                          HDU02930
      CMMT(I+5)=.1*CMMT(I+3)                                           HDU02940
      CMMT(I+3)=348.3676356*CMMT(I+4)/CMMT(I+5)                        HDU02950
   32 CMMT(I+5)=CMMT(I+5)-273.15                                       HDU02960
   33 NMET=6*L                                                         HDU02970
      J2=2                                                             HDU02980
      GO TO 4                                                          HDU02990
   34 IF (Q.EQ.0.) Q=1.2                                               HDU03000
      IF (BC.EQ.0.) BC=MTBST/D**2                                      HDU03010
      IF (SL6D.EQ.0.) SL6D=1.                                          HDU03020
      IF (SL.EQ.0.) SL=1.                                              HDU03030
      GORSQ=GC*RSC                                                     HDU03040
      QSQ=Q**2                                                         HDU03050
      J9=2                                                             HDU03060
      MTBM=0.                                                          HDU03070
      IF (MF.NE.0.) MTBM=MTB+MF+MDI                                    HDU03080
      TMCB=TMCBI                                                       HDU03090
      IF (TMCB.EQ.0.) TMCB=TE6                                         HDU03100
      IF (IUFLEG.NE.0) J9=1                                            HDU03110
      IYP=1                                                            HDU03120
      IF (ICLFE.NE.0) IYP=0                                            HDU03130
      IF (IUNIT.EQ.0) GO TO 35                                         HDU03140
      PMTCF=AMTOF                                                      HDU03150
      FDTCM=1.                                                         HDU03160
      GO TO 36                                                         HDU03170
   35 PMTCF=1.                                                         HDU03180
      FDTCM=CTCM                                                       HDU03190
   36 ITE=0                                                            HDU03200
      IF (IREDUC.EQ.1) ITE=1                                           HDU03210
      IF (CMETM.EQ.0.) GO TO 38                                        HDU03220
      J=1                                                              HDU03230
      DO 37 I=1,NMET,6                                                 HDU03240
      ATM(J)=CMMT(I)                                                   HDU03250
      ATM(J+3)=CMMT(I)                                                 HDU03260
      ATM(J+4)=CMMT(I+3)                                               HDU03270
      ATM(J+5)=CMMT(I+4)                                               HDU03280
      ATM(J+6)=CMMT(I+5)                                               HDU03290
      AZMWD=CVMTCR*(AZ-10.*CMMT(I+1))                                  HDU03300
      WS=.514444444*CMMT(I+2)                                          HDU03310
      ATM(J+1)=-WS*COS(AZMWD)                                          HDU03320
      ATM(J+2)=WS*SIN(AZMWD)                                           HDU03330
   37 J=J+7                                                            HDU03340
      NATM=J-1                                                         HDU03350
   38 SPN=TWIST                                                        HDU03360
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      IF (ITWT.EQ.0) SPN=UO/(TWIST*D)                                   HDU03370
      Y(10)=TWCPHI*SPN                                                  HDU03380
      IF (XIC.EQ.C.) XIO=XIDEL                                          HDU03390
      XI=XIO                                                            HDU03400
      IF (XIDEL.EC.0.) XI=XIMAX                                         HDU03410
      IF (IRECUC.EQ.1) TFN=-TF                                          HDU03420
      ICNP=3                                                            HDU03430
      IF (IARV.EQ.0..AND.IARH.EQ.0.) GC TC 39                           HDU03440
      IUEL=IAFV                                                         HDU03450
      IUAZ=IAFH                                                         HDU03460
      GO TO 4C                                                          HDU03470
   39 IUEL=QE(1)                                                        HDU03480
      IUAZ=AZC                                                          HDU03490
   4C IF (MF.NE.0.) GO TO 41                                            HDU03500
      CGTBM=CCTB                                                        HDU03510
      ATBM=ATB                                                          HDU03520
   41 TALPH=0.                                                          HDU03530
      IC1=11                                                            HDU03540
      ICOT1=11                                                          HDU03550
      ICCT2=12                                                          HDU03560
      ICCT3=13                                                          HDU03570
      ICCT4=14                                                          HDU03580
      WRITE (6,197)                                                     HDU03590
      I=1                                                               HDU03600
      IF (IDCREE(1).EQ.0) GO TO 43                                      HDU03610
      DO 42 J=1,4                                                       HDU03620
      CTP(I)=CT1(J)                                                     HDU03630
   42 I=I+1                                                             HDU03640
   43 IF (IRCT.EC.0) GC TC 45                                           HDU03650
      DO 44 J=1,4                                                       HDU03660
      CTP(I)=CT2(J)                                                     HDU03670
   44 I=I+1                                                             HDU03680
   45 IF (IRECUC.EQ.0) GO TO 47                                         HDU03690
      DO 46 J=1,4                                                       HDU03700
      CTP(I)=CT3(J)                                                     HDU03710
   46 I=I+1                                                             HDU03720
   47 IF (ITWT.EQ.0) GC TC 49                                           HDU03730
      DO 48 J=1,4                                                       HDU03740
      CTP(I)=CT4(J)                                                     HDU03750
   48 I=I+1                                                             HDU03760
   49 IF (IUFLEG.EQ.0) GO TO 51                                         HDU03770
      DO 50 J=1,4                                                       HDU03780
      CTP(I)=CT5(J)                                                     HDU03790
   50 I=I+1                                                             HDU03800
   51 IF (ISTIM.EC.0) GO TO 53                                          HDU03810
      DO 52 J=1,4                                                       HDU03820
      CTP(I)=CT6(4)                                                     HDU03830
   52 I=I+1                                                             HDU03840
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53 IF (ISFFT.EQ.0) GO TO 55                                          HDU03850
   DO 54 J=1,4                                                       HDU03860
   CTP(I)=CT7(J)                                                     HDU03870
54 I=I+1                                                             HDU03880
55 IF (ISCCLT.EQ.0) GO TO 57                                         HDU03890
   DO 56 J=1,4                                                       HDU03900
   CTP(I)=CT8(J)                                                     HDU03910
56 I=I+1                                                             HDU03920
57 IF (I3DELR.EQ.0) GO TO 59                                         HDU03930
   DO 58 J=1,4                                                       HDU03940
   CTP(I)=CT9(J)                                                     HDU03950
58 I=I+1                                                             HDU03960
59 IF (ITCNCE.EQ.0) GO TO 61                                         HDU03970
   DO 60 J=1,4                                                       HDU03980
   CTP(I)=CT10(J)                                                    HDU03990
60 I=I+1                                                             HDU04000
61 IF (IXIAYI.EQ.0) GO TO 63                                         HDU04010
   DO 62 J=1,4                                                       HDU04020
   CTP(I)=CT11(J)                                                    HDU04030
62 I=I+1                                                             HDU04040
63 IF (I5DIG.EQ.0) GO TO 65                                          HDU04050
   DO 64 J=1,4                                                       HDU04060
   CTP(I)=CT12(J)                                                    HDU04070
64 I=I+1                                                             HDU04080
65 I=I-1                                                             HDU04090
   WRITE (6,198) (CTP(J),J=1,I)                                      HDU04100
   ICOTT=0                                                           HDU04110
   WRITE (6,178) CODE                                                HDU04120
   WRITE (6,179)                                                     HDU04130
   PR(1)=MTEST                                                       HDU04140
   PR(2)=MTEM                                                        HDU04150
   PR(3)=MTB                                                         HDU04160
   PR(4)=MF                                                          HDU04170
   PR(5)=MCI                                                         HDU04180
   PR(6)=D/FTOM                                                      HDU04190
   PR(7)=LE(1)/FTOM                                                  HDU04200
   PR(8)=CGTBM/FTCM                                                  HDU04210
   PR(9)=CGTB/FTOM                                                   HDU04220
   PR(10)=ATBM/FTCM2                                                 HDU04230
   PR(11)=ATB/FTOM2                                                  HDU04240
   PR(12)=ETBM/FTOM2                                                 HDU04250
   PR(13)=LL/FTOM                                                    HDU04260
   WRITE (6,180) (PR(I),I=1,13)                                      HDU04270
   IF (ITW1.EQ.0) WRITE (6,181)                                      HDU04280
   IF (ITW1.EQ.1) WRITE (6,177)                                      HDU04290
   PR(1)=CE(1)                                                       HDU04300
   PR(2)=LC/FTCM                                                     HDU04310
   PR(3)=AZ                                                          HDU04320
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PR(4)=AZC                                                          HDU04330
PR(5)=AZL                                                          HDU04340
PR(6)=EL                                                           HDU04350
PR(7)=IL/FTCM                                                      HDU04360
PR(8)=IHIST                                                        HDU04370
PR(9)=IH2                                                          HDU04380
PR(10)=IH3                                                         HDU04390
PR(11)=IUEL                                                        HDU04400
PR(12)=IUAZ                                                        HDU04410
PR(13)=E                                                           HDU04420
WRITE (6,182) (PR(I),I=1,13)                                       HDU04430
WRITE (6,183)                                                      HDU04440
PR(1)=ISI                                                          HDU04450
PR(2)=ISP                                                          HDU04460
PR(3)=R2TBM/FTCM                                                   HDU04470
PR(4)=RNE/FTOM                                                     HDU04480
PR(5)=AE/FTCM2                                                     HDU04490
PR(6)=PE*FTCM2                                                     HDU04500
PR(7)=RN/FTCM                                                      HDU04510
PR(8)=RK/FTCM                                                      HDU04520
PR(9)=RACS                                                         HDU04530
PR(10)=ACOS                                                        HDU04540
PR(11)=HACA                                                        HDU04550
PR(12)=TCDAY                                                       HDU04560
WRITE (6,184) (PR(I),I=1,12)                                       HDU04570
WRITE (6,185)                                                      HDU04580
PR(1)=TEMST                                                        HDU04590
PR(2)=TEM                                                          HDU04600
PR(3)=TBST                                                         HDU04610
PR(4)=TE                                                           HDU04620
PR(5)=TL                                                           HDU04630
PR(6)=TCI                                                          HDU04640
PR(7)=TE6                                                          HDU04650
PR(8)=TSRIST                                                       HDU04660
PR(9)=TSRI                                                         HDU04670
PR(10)=TSRBST                                                      HDU04680
PR(11)=TSRB                                                        HDU04690
PR(12)=RS/FTOM                                                     HDU04700
PR(13)=TSCF                                                        HDU04710
WRITE (6,186) (PR(I),I=1,13)                                       HDU04720
WRITE (6,187)                                                      HDU04730
PR(1)=CELTB                                                        HDU04740
PR(2)=CETFF                                                        HDU04750
PR(3)=PTE                                                          HDU04760
PR(4)=PTFF                                                         HDU04770
PR(5)=TCE                                                          HDU04780
PR(6)=TCFF                                                         HDU04790
PR(7)=LAT                                                          HDU04800
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      PR(8)=ALCNG                                                       HDU04810
      PR(9)=BC*ANTOM**2                                                 HDU04820
      PR(10)=SL                                                         HDU04830
      PR(11)=SL6D                                                       HDU04840
      PR(12)=C                                                          HDU04850
      PR(13)=TF                                                         HDU04860
      WRITE (6,188) (PR(I),I=1,13)                                      HDU04870
      WRITE (6,189)                                                     HDU04880
      PR(1)=ITO                                                         HDU04890
      PR(2)=IX1/FTOM                                                    HDU04900
      PR(3)=IX2/FTOM                                                    HDU04910
      PR(4)=IX3/FTOM                                                    HDU04920
      PR(5)=TI                                                          HDU04930
      PR(6)=X10/FTOM                                                    HDU04940
      PR(7)=XIDEL/FTOM                                                  HDU04950
      PR(8)=XIMAX/FTOM                                                  HDU04960
      PR(9)=YI/FTOM                                                     HDU04970
      PR(10)=ZI/FTOM                                                    HDU04980
      PR(11)=EX1/FTOM                                                   HDU04990
      PR(12)=EZ1/FTOM                                                   HDU05000
      PR(13)=GO/FTOM                                                    HDU05010
      WRITE (6,190) (PR(I),I=1,13)                                      HDU05020
      WRITE (6,191)                                                     HDU05030
      PR(1)=TMCB                                                        HDU05040
      PR(2)=LMCB/FTOM                                                   HDU05050
      PR(3)=PHMCB/DTOM                                                  HDU05060
      PR(4)=THMCB/DTOM                                                  HDU05070
      PR(11)=C.                                                         HDU05080
      PR(5)=ELB/FTOM                                                    HDU05090
      PR(6)=ETE/DTOM                                                    HDU05100
      PR(7)=EFB/DTOM                                                    HDU05110
      PR(12)=LZ1*FTOM                                                   HDU05120
      PR(8)=IH2B*DTOM                                                   HDU05130
      PR(9)=IH3B*DTOM                                                   HDU05140
      PR(10)=TFUB*FTOM                                                  HDU05150
      PR(13)=C.                                                         HDU05160
      PRT=CX1*FTOM*ANTOM**2                                             HDU05170
      IF (ITCNCE.EQ.0) PR(11)=PRT                                       HDU05180
      IF (ITCNCE.NE.0) PR(13)=PRT                                       HDU05190
      WRITE (6,192) (PR(I),I=1,13)                                      HDU05200
      GO TO (66,67), J2                                                 HDU05210
   66 WRITE (6,193)                                                     HDU05220
      PR(1)=WSX(1)/AMTOMS                                               HDU05230
      PR(2)=WSZ/AMTOMS                                                  HDU05240
      PR(3)=WBX/AMTOMS                                                  HDU05250
      PR(4)=WEZ/AMTOMS                                                  HDU05260
      PR(5)=DENSF                                                       HDU05270
      PR(6)=PRESF                                                       HDU05280
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      PR(7)=TEMFF                                                       HDU05290
      WRITE (6,194) (PR(I),I=1,7)                                       HDU05300
      GO TO 65                                                          HDU05310
   67 WRITE (6,195) CODEM                                               HDU05320
      DO 68 I=1,NATM,7                                                  HDU05330
      PR(1)=ATM(I)                                                      HDU05340
      PR(2)=ATM(I+1)/AMTOMS                                             HDU05350
      PR(3)=ATM(I+2)/AMTOMS                                             HDU05360
      PR(4)=ATM(I+3)                                                    HDU05370
      PR(5)=ATM(I+4)                                                    HDU05380
      PR(6)=ATM(I+5)                                                    HDU05390
      PR(7)=ATM(I+6)                                                    HDU05400
   68 WRITE (6,196) (PR(J),J=1,7)                                       HDU05410
   65 SINLAT=SIN(LAT*CVDTCR)                                            HDU05420
      COSLAT=COS(LAT*CVDTCR)                                            HDU05430
      SINAZ=SIN(AZ*CVMTOR)                                              HDU05440
      COSAZ=COS(AZ*CVMTOR)                                              HDU05450
      IF (ISUN.EQ.0) GO TO 70                                           HDU05460
      WP1=AINT(RACS/10000.)                                             HDU05470
      AFP1=RACS-WP1*10000.                                              HDU05480
      FP1=AINT(AFP1/100.)                                               HDU05490
      FP2=AFP1-FP1*100.                                                 HDU05500
      RASD=PI12*(WP1+FP1/60.+FP2/3600.)                                 HDU05510
      WP1=AINT(HACA/10000.)                                             HDU05520
      AFP1=HACA-WP1*10000.                                              HDU05530
      FP1=AINT(AFP1/100.)                                               HDU05540
      FP2=AFP1-FP1*100.                                                 HDU05550
      HAGD=PI12*(WP1+FP1/60.+FP2/3600.)                                 HDU05560
      WP1=AINT(TOCAY/10000.)                                            HDU05570
      AFP1=TOCAY-WP1*10000.                                             HDU05580
      FP1=AINT(AFP1/100.)                                               HDU05590
      FP2=AFP1-FP1*100.                                                 HDU05600
      TOCAYD=PI12*(WP1+FP1/60.+FP2/3600.)                               HDU05610
      WP1=AINT(ADCS/10000.)                                             HDU05620
      AFP1=ADCS-WP1*10000.                                              HDU05630
      FP1=AINT(AFP1/100.)                                               HDU05640
      FP2=AFP1-FP1*100.                                                 HDU05650
      DECLD=CVDTCR*(WP1+FP1/60.+FP2/3600.)                              HDU05660
      DEL=HAGD-RASD                                                     HDU05670
      IF(DEL.LT.0.)DEL=DEL+TWOPHI                                       HDU05680
      DEL=DEL-CVDTOR*ALONG+TOCAYD                                       HDU05690
C     WHAT IS SINCOS SUBROUTINE?                                        HDU05700
C     CALL SINCOS (DECLD,SIND,COSD)                                     HDU05710
      SIND=SIN(DECLD)                                                   HDU05720
      COSD=COS(DECLD)                                                   HDU05730
   70 PP1=10000.                                                        HDU05740
      IFERR=0                                                           HDU05750
      CM=0.                                                             HDU05760
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      IF (IRCT.EQ.1) GO TO 71                                           HDL05770
      LAM(1)=0.                                                         HDL05780
      LAM(2)=0.                                                         HDL05790
      LAM(3)=0.                                                         HDU05600
      GO TO 72                                                          HDL05610
   71 LAM(1)=.0001458424*COSLAT*SINAZ                                   HDL05620
      LAM(2)=.0001458424*SINLAT                                         HDU05630
      LAM(3)=.0001458424*COSLAT*COSAZ                                   HDL05640
   72 JCCE=1                                                            HDU05650
      IF (ITCNCE.EQ.0) GO TO 74                                         HDU05660
      JCCE=2                                                            HDU05670
      WRITE (6,260)                                                     HDU05680
      CALL PNEST (26,QE(1),0.,TL)                                       HDL05690
      TL=(AINT((TL+.0005)*1000.))/1000.                                 HDL05500
      ICOTT=ICOTT+1                                                     HDU05510
      IF (ICCTT.NE.11) GO TO 74                                         HDL05520
   73 WRITE (6,175) UMCB,XI,CCDEM,ICCT1                                 HDL05530
      IEPC=2                                                            HDL05540
      CALL SFFINT (Y,DY,1)                                              HDL05550
      GO TO 4                                                           HDU05560
   74 I6DP=0                                                            HDL05570
      IF (I3DEUR.EQ.0) GO TO 75                                         HDL05580
      ICCT1=ICCT1+100                                                   HDU05590
      ICCT2=ICCT2+100                                                   HDU06000
      ICCT3=ICCT3+100                                                   HDU06010
      ICCT4=ICCT4+100                                                   HDL06020
   75 R3TBM=CGTBM-CGTB                                                  HDL06030
      R3=0.                                                             HDU06040
      TO=MTBM-MTB                                                       HDL06050
      R1TBM=MTBM*R3TBM/TO                                               HDU06060
      RK2=RK*.5                                                         HDU06070
      R1TB=R1TBM-RK2*TO                                                 HDL06080
      RK12=(RK**2)/12.                                                  HDL06090
      R2TBSQ=R2TBM**2-RK12*TO**2                                        HDL06100
      BTB=BTBM-TO*R2TBM**2-MTB*R1TBM**2+MTBM*(R1TBM-R3TBM)**2           HDL06110
      RETB=LE(1)-CGTB                                                   HDU06120
      RTTB=RETB-RN                                                      HDL06130
      DSQ=D**2                                                          HDL06140
      D22 = MTBST/BC                                                    HDU06150
      Y(1)=MTBM                                                         HDL06160
      Y(2)=TBM                                                          HDU06170
      Y(3)=PC                                                           HDL06180
      CONS2=(TBST-TBMST)/(TB-TBM)                                       HDL06190
      SINEU=SIN(EL*CVMTOR)                                              HDU06200
      COSEU=COS(EL*CVMTOR)                                              HDL06210
      SINAZD=SIN(AZD*CVMTOR)                                            HDL06220
      COSAZD=COS(AZD*CVMTOR)                                            [illegible]06230
      SINCE=SIN(CE(1)*CVMTOR)                                           [illegible]06240
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      COSCE=COS(CE(1)*CVMTOR)                                           HDL06250
      COSAZU=COS(AZU*CVMTOR)                                            HDL06260
      SINAZU=SIN(AZU*CVMTOR)                                            HDL06270
      B=BTBM                                                            HDU06280
      TRCCNS=MF*CONS2*ISP/IST                                           HDL06290
      DO 76 I=4,9                                                       HDU06300
   76 Y(I)=0.                                                           HDU06310
      DY(2)=1.0                                                         HDU06320
      IKL=5                                                             HDL06330
      I1=1                                                              HDL06340
      J5=1                                                              HDU06350
      J6=1                                                              HDU06360
      J7=2                                                              HDL06370
      IMZ=0                                                             HDL06380
      IMZ1=0                                                            HDU06390
      IMZ2=0                                                            HDU06400
      IF (UO.NE.0.) GO TO 77                                            HDU06410
      IF (TBM.LT.C.) GO TO 81                                           HDU06420
      Y(4)=IX1                                                          HDU06430
      Y(7)=IL*COSEU*COSAZU                                              HDU06440
      Y(8)=IL*SINEU                                                     HDL06450
      Y(9)=-IL*SINAZU*COSEU                                             HDU06460
      IF (IX2.EQ.C.) GO TO 82                                           HDU06470
      Y(5)=IX2                                                          HDU06480
      J8=1                                                              HDU06490
      GO TO 78                                                          HDU06500
   77 Y(4)=LL*COSCE+IX1                                                 HDU06510
      Y(5)=LL*SINCE+IX2                                                 HDU06520
      Y(7)=UC*COSCE*COSAZC+IU*COSAZU*COSEL                              HDU06530
      Y(8)=UC*SINCE+IU*SINEU                                            HDU06540
      Y(9)=-IL*SINAZU*COSEU+LO*COSQE*SINAZC                             HDU06550
      J8=2                                                              HDU06560
      DY(7)=C                                                           HDU06570
      DY(8)=C                                                           HDU06580
      DY(9)=0                                                           HDU06590
      Y(2)=TL                                                           HDU06600
      IF (ITO.NE.C.) Y(2)=ITO                                           HDU06610
   78 DELT=100.                                                         HDU06620
      PY(1)=C.                                                          HDU06630
      PY(2)=Y(3)                                                        HDU06640
      DPY(1)=1.0                                                        HDU06650
      INN=1                                                             HDL06660
   79 WRITE (6,280)                                                     HDU06670
      CALL RKG (DELT,2,DCA,PY,DPY,QQ,INN)                               HDU06680
      INN=2                                                             HDL06690
      IF (ABS(PY(1)-Y(5)).LT..00001) GO TO 80                           HDL06700
      IF (PY(1).LT.Y(5)) GO TO 79                                       HDU06710
      DELT=Y(5)-PY(1)                                                   HDL06720
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      GO TO 79                                                          HDU06730
   80 Y(3)=PY(2)                                                        HDU06740
      GO TO (82,83), J8                                                 HDU06750
   81 DELT=DELTB                                                        HDU06760
      TIME=0.                                                           HDU06770
      I2=1                                                              HDU06780
      I3=1                                                              HDU06790
      NEC=2                                                             HDU06800
      GO TO 139                                                         HDU06810
   82 DELT=DELTB                                                        HDU06820
      TIME=TL                                                           HDU06830
      Y(2)=0.                                                           HDU06840
      I2=2                                                              HDU06850
      I3=2                                                              HDU06860
      I4=1                                                              HDU06870
      I5=1                                                              HDU06880
      I6=1                                                              HDU06890
      NEC=8                                                             HDU06900
      GO TO 139                                                         HDU06910
   83 I3=3                                                              HDU06920
      I4=2                                                              HDU06930
      I6=2                                                              HDU06940
      I7=1                                                              HDU06950
      I8=1                                                              HDU06960
      I9=1                                                              HDU06970
      NEX=1                                                             HDU06980
      J6=1                                                              HDU06990
      I2=2                                                              HDU07000
      I5=1                                                              HDU07010
      NEC=16                                                            HDU07020
      K1=0                                                              HDU07030
      IFIRST=1                                                          HDU07040
      DELT=DELTB                                                        HDU07050
      IF (TDI.LE.C.) GO TO 84                                           HDU07060
      DELT=DETFF                                                        HDU07070
      I4=3                                                              HDU07080
      I5=2                                                              HDU07090
   84 TIME=TCE+ITO                                                      HDU07100
      D33=DSC*D                                                         HDU07110
      C44=D33*C                                                         HDU07120
      EAR=CVMTOR*IUAZ                                                   HDU07130
      EER=CVMTOR*IUEL                                                   HDU07140
      SINEA=SIN(EAR)                                                    HDU07150
      COSEA=COS(EAR)                                                    HDU07160
      SINEE=SIN(EER)                                                    HDU07170
      COSEE=COS(EER)                                                    HDU07180
      Y(14)=COSEE*COSEA                                                 HDU07190
      Y(15)=SINEE                                                       HDU07200
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      Y(16)=COSEE*SINEA                                                 HDU07210
      ANX=0.                                                            HDU07220
      ISPI=0                                                            HDU07230
      IF (Y(10).LE..0) GO TO 85                                         HDU07240
      A=ATBM                                                            HDU07250
      ANX=Y(10)*A                                                       HDU07260
      CONS3=(ATBM-ATB)/(MTBM-MTB)                                       HDU07270
      CTS=(TSFEST-TSRIST)/(TSRB-TSRI)                                   HDU07280
      GCRS=GC*FS                                                        HDU07290
      RNESQ2=RNE**2*.5                                                  HDU07300
      ISPI=1                                                            HDU07310
      I1=2                                                              HDU07320
      I8=2                                                              HDU07330
      NEC=16                                                            HDU07340
    5 IF (ITCNCE.EQ.0) GO TO 86                                         HDU07350
      WRITE (6,270)                                                     HDU07360
      CALL PNEST (28,QE(1),0.,IH3)                                      HDU07370
      WRITE (6,270)                                                     HDU07380
      CALL PNEST (20,QE(1),0.,BC)                                       HDU07390
      BC=BC/ANTOM**2                                                    HDU07400
   86 BIH2=B*IH2                                                        HDU07410
      Y(11)=ANX*Y(14)-BIH2*SINEE*COSEA-B*IH3*SINEA                      HDU07420
      Y(12)=ANX*Y(15)+BIH2*COSEE                                        HDU07430
      Y(13)=ANX*Y(16)-BIH2*SINEE*SINEA+B*IH3*COSEA                      HDU07440
      DY(7)=0.                                                          HDU07450
      DY(8)=0.                                                          HDU07460
      DY(9)=0.                                                          HDU07470
      ALPE=0.                                                           HDU07480
      ALPQ1=0.                                                          HDU07490
      ALPQ2=0.                                                          HDU07500
      ALPQ3=0.                                                          HDU07510
      T45(1)=QE(1)                                                      HDU07520
      T45(2)=IH2                                                        HDU07530
      T45(3)=IH3                                                        HDU07540
      T45(4)=TF                                                         HDU07550
      T45(5)=0.                                                         HDU07560
      T45(6)=SL                                                         HDU07570
      T45(7)=G                                                          HDU07580
      T45(8)=LO*PMTOF                                                   HDU07590
      T45(9)=CCDE                                                       HDU07600
      T45(10)=ICCT4                                                     HDU07610
      IF (TL.GE.TE6) GO TO 89                                           HDU07620
      DO 87 I=1,10                                                      HDU07630
      J=ITTT+I+2699                                                     HDU07640
   87 TJ(J)=T45(I)                                                      HDU07650
      ITTT=ITTT+10                                                      HDU07660
      I6DP=1                                                            HDU07670
      IF (I3DEUR.EQ.0) GO TO 139                                        HDU07680
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      D22=MTEST/BC                                                      HDL07690
      I6CP=0                                                            HDL07700
      IF (Y(10).GT..0) GC TO 88                                         HDL07710
      I7=2                                                              HDU07720
      I8=3                                                              HDL07730
      NEG=9                                                             HDL07740
      GO TO 135                                                         HDU07750
   88 ISPI=0                                                            HDL07760
      I7=1                                                              HDL07770
      I8=4                                                              HDL07780
      I9=2                                                              HDL07790
      NEG=10                                                            HDU07800
      GO TO 135                                                         HDL07810
   89 ISPI=0                                                            HDL07820
      IF (I3CBLR.NE.0) GC TO 90                                         HDU07830
      ICCT1=ICCT1+100                                                   HDL07840
      ICCT2=ICCT2+100                                                   HDL07850
      ICCT3=ICOT3+10C                                                   HDL07860
      ICCT4=ICOT4+100                                                   HDL07870
      T45(10)=ICOT4                                                     HDU07880
   90 T45(5)=EC/AMTOIN**2                                               HDL07890
      DO 91 I=1,10                                                      HDL07900
      J=ITTT+2655+I                                                     HDU07910
   91 TJ(J)=T45(I)                                                      HDL07920
      ITTT=ITTT+10                                                      HDL07930
      Y(1)=MTE                                                          HDL07940
      DO 92 I=1,16                                                      HDU07950
   92 BURN(I)=Y(I)                                                      HDU07960
      GO TO 114                                                         HDL07970
   93 CONTINUE                                                          HDL07980
      IEPD=5                                                            HDU07990
      WRITE (6,290)                                                     HDU08000
      CALL SPFINT (Y,DY,1)                                              HDL08010
      DELT=DELTB                                                        HDL08020
      PTIME=PTE                                                         HDL08030
      TPRINT=Y(2)+PTB                                                   HDU08040
      TIME=TMCB                                                         HDL08050
      I3=4                                                              HDL08060
      J6=2                                                              HDU08070
      IF (TCI.GT.0.) GC TC 94                                           HDL08080
      GO TO 140                                                         HDL08090
   94 DELT=DETFF                                                        HDL08100
      I3=5                                                              HDU08110
      TIME=TCI                                                          HDU08120
      GO TO 140                                                         HDL08130
   95 IFIRST=0                                                          HDL08140
      JBLRN=2                                                           HDU08150
      INN=1                                                             HDL08160
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      I3=6                                                              HDL08170
      I4=2                                                              HDL08180
      I5=1                                                              HDL08190
      DELT=DELTB                                                        HDL08200
      GO TO 140                                                         HDL08210
   96 JBURN=1                                                           HDL08220
      IEPD=5                                                            HDL08230
      WRITE (6,290)                                                     HDL08240
      CALL SPFINT (Y,DY,1)                                              HDL08250
      TIME=TE                                                           HDL08260
      IF (ABS(TDI-TPRINT).LE..00001) GO TO 97                           HDL08270
      GO TO 140                                                         HDL08280
   97 TPRINT=TPRINT+PTIME                                               HDL08290
      GO TO 140                                                         HDL08300
   98 I3=7                                                              HDL08310
      I5=3                                                              HDL08320
      DELT=DELTFF                                                       HDL08330
      IF (TB.EQ.TMCB) GO TO 100                                         HDL08340
      JBURN=3                                                           HDL08350
      GO TO 139                                                         HDL08360
   99 JBURN=1                                                           HDL08370
      IEPD=5                                                            HDL08380
      WRITE (6,290)                                                     HDL08390
      CALL SPFINT (Y,DY,1)                                              HDL08400
      TIME=TMCB                                                         HDL08410
      I3=9                                                              HDL08420
      GO TO 140                                                         HDL08430
  100 IFIRST=0                                                          HDL08440
      JBURN=4                                                           HDL08450
      GO TO 139                                                         HDL08460
  101 JBURN=1                                                           HDL08470
      IEPD=5                                                            HDL08480
      WRITE (6,290)                                                     HDL08490
      CALL SPFINT (Y,DY,1)                                              HDL08500
      DELT=DELTB                                                        HDL08510
      TIME=TE6                                                          HDL08520
      I3=8                                                              HDL08530
      J6=1                                                              HDL08540
      IF (TDI.GT.0.) GO TO 104                                          HDL08550
  102 IF (ITE.EQ.1) GO TO 103                                           HDL08560
      IF (TMCE.EQ.TE6) GO TO 105                                        HDL08570
      GO TO 140                                                         HDL08580
  103 NEX=2                                                             HDL08590
      GO TO 148                                                         HDL08600
  104 DELT=DELTFF                                                       HDL08610
      GO TO 102                                                         HDL08620
  105 IF (ITCNGE.NE.0) GO TO 106                                        HDL08630
      ICCTT=0                                                           HDL08640
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106 IF (TMCE.EQ.TE6) GC TC 107                                          HDU08650
    IEPC=5                                                              HDU08660
    WRITE (6,290)                                                       HDU08670
    CALL SPRINT (Y,DY,1)                                                HDU08680
107 CO 108 I=1,16                                                       HDU08690
108 BURN(I)=Y(I)                                                        HDU08700
109 IF (I3CBUR.EQ.0.AND.ITONQE.EQ.0) GC TO 110                          HDU08710
    GO TO 112                                                           HDU08720
110 ICCTT=ICCTT+1                                                       HDU08730
    IF (ICCTT.NE.11) GO TO 111                                          HDU08740
    WRITE (6,175) UMCB,XI,CCDEM,ICCT1                                   HDU08750
    IEPD=2                                                              HDU08760
    WRITE (6,290)                                                       HDU08770
    CALL SPRINT (Y,DY,1)                                                HDU08780
    GO TO 167                                                           HDU08790
111 ICCT1=ICCT1+100                                                     HDU08800
    ICCT2=ICCT2+100                                                     HDU08810
    ICCT3=ICCT3+100                                                     HDU08820
    ICCT4=ICCT4+100                                                     HDU08830
112 T45(5)=BC/AMTOIN**2                                                 HDU08840
    T45(6)=SL                                                           HDU08850
    T45(10)=ICCT4                                                       HDU08860
    DO 113 I=1,10                                                       HDU08870
    J=I+ITTT+2659                                                       HDU08880
113 TJ(J)=T45(I)                                                        HDU08890
    ITTT=ITTT+10                                                        HDU08900
    DY(7)=0.                                                            HDU08910
    DY(8)=0.                                                            HDU08920
    DY(9)=0.                                                            HDU08930
    ALPE=0.                                                             HDU08940
    TALPH=0.                                                            HDU08950
114 IF (I3CF.EQ.0) GO TO 115                                            HDU08960
    IKL=12                                                              HDU08970
115 D22=MTBST/BC                                                        HDU08980
    DELT=DETFF                                                          HDU08990
    PTIME=PTFF                                                          HDU09000
    Y(1)=MTE                                                            HDU09010
    DY(1)=0.                                                            HDU09020
    TPRINT=TCFF                                                         HDU09030
    IF (TPRINT.EQ.0.) TPRINT=PTFF+ITO                                   HDU09040
    I4=3                                                                HDU09050
    I5=3                                                                HDU09060
    J6=2                                                                HDU09070
    NEX=1                                                               HDU09080
    K1=0                                                                HDU09090
    NEC=16                                                              HDU09100
    I6DP=0                                                              HDU09110
    IF (ICCREE(1).EQ.0) GO TO 116                                       HDU09120
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      I6DP=1                                                            HDU09130
      J5=2                                                              HDU09140
      INN=1                                                             HDU09150
      IUSA=1                                                            HDU09160
      JJ1=1                                                             HDU09170
      TST=0.                                                            HDU09180
      GO TO 140                                                         HDU09190
  116 TST=0                                                             HDU09200
      IF (Y(10).GT.0.) GO TO 117                                        HDU09210
      I7=2                                                              HDU09220
      I8=3                                                              HDU09230
      NEQ=9                                                             HDU09240
      GO TO 118                                                         HDU09250
  117 IF (ISFI.EQ.1) Y(10)=HDX/A                                        HDU09260
      I7=1                                                              HDU09270
      I8=4                                                              HDU09280
      I9=2                                                              HDU09290
      NEQ=10                                                            HDU09300
  118 INN=1                                                             HDU09310
      IF (J6.EQ.1) J6=3                                                 HDU09320
      IUSA=1                                                            HDU09330
      JJ1=2                                                             HDU09340
      WRITE (6,280)                                                     HDU09350
  119 CALL RKG (DELT,NEQ,DER,Y,DY,QQ,INN)                               HDU09360
      INN=2                                                             HDU09370
      IEXIT=1                                                           HDU09380
  120 IF (I6DP.EQ.1) GO TO 121                                          HDU09390
      T1=Y(10)/TWOPHI                                                   HDU09400
      GO TO 122                                                         HDU09410
  121 T1=0                                                              HDU09420
      IF (A.GT.0.) T1=HDX/(TWOPHI*A)                                    HDU09430
  122 IF (T1.LT.20.) GO TO 125                                          HDU09440
      IF (VT.EQ.0..OR.Y(2).LT.TL) GO TO 125                             HDU09450
      IF(A.EQ.0.) GOTO 125                                              HDU09460
      CAPM=KM*DENS*DSQ*D33/B                                            HDU09470
      CAPP=TWOPHI*T1*D*A/(B*VT)                                         HDU09480
      T1=KDB+DKDB                                                       HDU09490
      IF(I6DP.EQ.1)T1=KDB+DKDBA                                         HDU09500
      T2=DENS*D33/Y(1)                                                  HDU09510
      CAPT=T2*(KL-KT*(Y(1)*DSQ/A))                                      HDU09520
      CAPH=T2*(KL-T1+KH*(Y(1)*DSQ/B))                                   HDU09530
      T1=2.*CAPP*(2.*CAPT-CAPH)                                         HDU09540
      T2=4.*CAPM*CAPH**2-CAPP**2                                        HDU09550
      T3=SIN(.5*ATAN2(T1,T2))                                           HDU09560
      T1=SQRT(SQRT(T1**2+T2**2))                                        HDU09570
      PP1=.5*(CAPP+T1*T3)                                               HDU09580
      PP2=.5*(CAPP-T1*T3)                                               HDU09590
      IF (ABS(PP1).GE.ABS(PP2)) GO TO 123                               HDU09600
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      T1=PP1                                                            HDU09610
      PP1=PP2                                                           HDU09620
      PP2=T1                                                            HDU09630
  123 IF (Y(2).NE.TL) GO TO 124                                         HDU09640
      PRPP1=PF1                                                         HDU09650
      PRPP2=PF2                                                         HDU09660
      PF1=10000.                                                        HDU09670
      PP2=PP1                                                           HDU09680
      PPP1=PP1                                                          HDU09690
      PPF2=PF1                                                          HDU09700
      GO TO 125                                                         HDU09710
  124 T1=DELT*VT/D                                                      HDU09720
      PPF1=(PF1-PRPP1)/T1                                               HDU09730
      PRPP1=PP1                                                         HDU09740
      PPF2=(PF2-PRPP2)/T1                                               HDU09750
      PRPF2=PF2                                                         HDU09760
  125 GO TO (126,141), IEXIT                                            HDU09770
  126 IF (ISTIM.EQ.0) GO TO 128                                         HDU09780
      IF (ABS(TI-Y(2)).LE..00001) GO TO 130                             HDU09790
      IF (K1.EQ.1) GO TO 127                                            HDU09800
      IF (Y(2).GT.TI) GO TO 127                                         HDU09810
      GO TO 145                                                         HDU09820
  127 DELT=TI-Y(2)                                                      HDU09830
      K1=1                                                              HDU09840
      GO TO (140,119), JJ1                                              HDU09850
  128 IF (IXIAYI.EQ.0) GO TO 131                                        HDU09860
      IF (ABS(XI-Y(4)).LE..00001) GO TO 130                             HDU09870
      IF (K1.EQ.1) GO TO 129                                            HDU09880
      IF (Y(4).GT.XI) GO TO 129                                         HDU09890
      GO TO 145                                                         HDU09900
  129 DELT=(XI-Y(4))/Y(7)                                               HDU09910
      K1=1                                                              HDU09920
      GO TO (140,119), JJ1                                              HDU09930
  130 IF (XIDEL.EQ.0.) GO TO 137                                        HDU09940
      IF (ABS(XIMAX-XI).LT.(XIDEL/10.).OR.XI.GT.XIMAX) GO TO 137        HDU09950
      IEPC=5                                                            HDU09960
      WRITE (6,290)                                                     HDU09970
      CALL SPRINT (Y,DY,1)                                              HDU09980
      XI=XIDEL+XI                                                       HDU09990
      DELT=DELTB                                                        HDU10000
      K1=0                                                              HDU10010
      IF (I5.EQ.4) GO TO 145                                            HDU10020
      DELT=DELTF                                                        HDU10030
      GO TO 145                                                         HDU10040
  131 YP=Y(5)                                                           HDU10050
      IF (IYP.GT.0) YP=EC                                               HDU10060
      IF (Y(2).EQ.0.) GO TO 132                                         HDU10070
      IF (ABS(YP-YI).LE..00001) GO TO 137                               HDU10080
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132 IF (K1.EQ.1) GO TO 136                                          HDU10090
    GO TO (133,135), J9                                             HDU10100
133 IF (Y(8).GE.0.) GO TO 134                                       HDU10110
    WRITE (6,176) CODE,ICOT1                                        HDU10120
    IEPC=3                                                          HDU10130
    WRITE (6,250)                                                   HDU10140
    CALL SPRINT (Y,DY,1)                                            HDU10150
    GO TO 4                                                         HDU10160
134 IF (YP.LT.YI) GO TO 145                                         HDU10170
    GO TO 136                                                       HDU10180
135 IF (Y(8).GT.0.) GO TO 145                                       HDU10190
    IF (YP.GT.YI) GO TO 145                                         HDU10200
136 DELT=(YI-YP)/Y(8)                                               HDU10210
    K1=1                                                            HDU10220
    GO TO (140,119), JJ1                                            HDU10230
137 IEPC=5                                                          HDU10240
    NEX=4                                                           HDU10250
    J7=1                                                            HDU10260
    IF (ITE.EQ.1) GO TO 138                                         HDU10270
    WRITE (6,250)                                                   HDU10280
    CALL SPRINT (Y,DY,1)                                            HDU10290
    GO TO 4                                                         HDU10300
138 NEX=5                                                           HDU10310
    J7=2                                                            HDU10320
    WRITE (6,250)                                                   HDU10330
    CALL SPRINT (Y,DY,1)                                            HDU10340
    GO TO 152                                                       HDU10350
139 INN=1                                                           HDU10360
    IUSA=2                                                          HDU10370
    JJ1=1                                                           HDU10380
140 WRITE (6,280)                                                   HDU10390
    CALL RKG (DELT,NEQ,DER,Y,DY,QQ,INN)                             HDU10400
    INN=2                                                           HDU10410
    IEXIT=2                                                         HDU10420
    GO TO 120                                                       HDU10430
141 GO TO (142,96,99,101), JBURN                                    HDU10440
142 GO TO (143,126), J5                                             HDU10450
143 IF(ABS(Y(2)-TIME).LE..00001)GOTO(82,83,93,100,95,98,100,105,    HDU10460
   1101),I3                                                         HDU10470
    IF(Y(2)+DELT.GT.TIME) GOTO 1443                                 HDU10480
    IF(Y(2)+DELT.LT.TIME+.00001) GOTO 144                           HDU10490
1443 DELT=TIME-Y(2)-10.E-15*TIME                                    HDU10500
    GOTO (140,119),JJ1                                              HDU10510
144 IF (NEC.GT.9) GO TO 126                                         HDU10520
145 GO TO (140,146,119), J6                                         HDU10530
146 IF (ABS(Y(2)-TPRINT).LE..00001) GO TO 147                       HDU10540
    K2=0                                                            HDU10550
    IF (Y(2)+DELT.LT.TPRINT) GO TO (140,119), JJ1                   HDU10560
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      K2=1                                                              HDU10570
      SOC=DELT                                                          HDU10580
      DELT=TPRINT-Y(2)                                                  HDU10590
      GO TO (140,119), JJ1                                              HDU10600
  147 IEPD=5                                                            HDU10610
      WRITE (6,290)                                                     HDU10620
      CALL SPRINT (Y,DY,1)                                              HDU10630
      TPRINT=TPRINT+PTIME                                               HDU10640
      IF (K2.EQ.0) GO TO (140,119), JJ1                                 HDU10650
      DELT=SOC                                                          HDU10660
      K2=0                                                              HDU10670
      GO TO (140,119), JJ1                                              HDU10680
  148 UN=UN/PMTOF                                                       HDU10690
      PHI=PHI*DTOM/PDTOM                                                HDU10700
      THETA=THETA*DTOM/PDTOM                                            HDU10710
      TO=UMCE-UN                                                        HDU10720
      T1=PHMCE-PHI                                                      HDU10730
      T2=THMCE-THETA                                                    HDU10740
      IF (TFN.LT.0.) GO TO 149                                          HDU10750
      T3=TO*(TFN-TF)/(UNN-UN)                                           HDU10760
      T4=T1*(H3N-IH3)/(PHIN-PHI)                                        HDU10770
      T5=T2*(H2N-IH2)/(THETAN-THETA)                                    HDU10780
      GO TO 150                                                         HDU10790
  149 T3=TO*TFUB                                                        HDU10800
      T4=T1*IH3B                                                        HDU10810
      T5=T2*IH2B                                                        HDU10820
      TFN=ABS(TFN)                                                      HDU10830
  150 IF (ABS(TO).LT.EUB.AND.ABS(T1).LT.EPB.AND.ABS(T2).LT.ETB) GO TO 15HDU10840
     11                                                                 HDU10850
      TFN=TF                                                            HDU10860
      H2N=IH2                                                           HDU10870
      H3N=IH3                                                           HDU10880
      UNN=UN                                                            HDU10890
      PHIN=PHI                                                          HDU10900
      THETAN=THETA                                                      HDU10910
      TF=TFN+T3                                                         HDU10920
      IH2=H2N+T5                                                        HDU10930
      IH3=H3N+T4                                                        HDU10940
      ICCTT=ICCTT+1                                                     HDU10950
      IF (ICCTT.EQ.10) GO TO 73                                         HDU10960
      ICCT1=ICCT1+10                                                    HDU10970
      ICCT2=ICCT2+10                                                    HDU10980
      ICCT3=ICCT3+10                                                    HDU10990
      ICCT4=ICCT4+10                                                    HDU11000
      GO TO 72                                                          HDU11010
  151 NEX=1                                                             HDU11020
      IF (TMCE.EQ.TE6) GO TO 105                                        HDU11030
      GO TO (140,119), JJ1                                              HDU11040
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152 IF (IXIAYI.EQ.0) GO TO 154                                          HDU11050
    YP=EC                                                               HDU11060
    IF (IYP.EQ.0) YP=Y(5)                                               HDU11070
    IF (ABS(YI-YP).LE.EX1) GO TO 165                                    HDU11080
153 YP=Y(5)                                                             HDU11090
    IF (IYP.NE.0) YP=EC                                                 HDU11100
    TO=YI-YP                                                            HDU11110
    XYI=YP                                                              HDU11120
    GO TO 156                                                           HDU11130
154 IF (ABS(Y(4)-XI).LE.EX1) GO TO 165                                  HDU11140
155 TO=XI-Y(4)                                                          HDU11150
    XYI=Y(4)                                                            HDU11160
156 T2=ZI-Y(6)                                                          HDU11170
    IF (CM.NE.0.) GO TO 164                                             HDU11180
    T1=TO*CXI                                                           HDU11190
    T3=T2*LZI                                                           HDU11200
157 XM=Y(4)                                                             HDU11210
    IF (IXIAYI.EQ.0) GO TO 158                                          HDU11220
    YP=EC                                                               HDU11230
    IF (IYP.EQ.0) YP=Y(5)                                               HDU11240
    XM=YP                                                               HDU11250
158 IF (JCCE-1) 159,159,160                                             HDU11260
159 CM=BC                                                               HDU11270
    BC=BC+T1                                                            HDU11280
    GO TO 161                                                           HDU11290
160 CM=CE(1)                                                            HDU11300
    CE(1)=CE(1)+T1                                                      HDU11310
    IUEL=QE(1)                                                          HDU11320
161 SLM=SL                                                              HDU11330
    ZM=Y(6)                                                             HDU11340
    SL=SL+T3                                                            HDU11350
    IF (T3CEUR.EQ.0.AND.ITONQE.EQ.0) GO TO 162                          HDU11360
    TFN=-TF                                                             HDU11370
    Y(10)=SFN*TWOPHI                                                    HDU11380
    GO TO 72                                                            HDU11390
162 DO 163 I=1,16                                                       HDU11400
163 Y(I)=BLFN(I)                                                        HDU11410
    GO TO 109                                                           HDU11420
164 CQE=QE(1)                                                           HDU11430
    IF (JCCE.EQ.1) CQE=BC                                               HDU11440
    T1=TO*(CM-CQE)/(XM-XYI)                                             HDU11450
    T3=0.                                                               HDU11460
    IF (ABS(ZM-Y(6)).LT..00000001) GO TO 157                            HDU11470
    T3=T2*(SLM-SL)/(ZM-Y(6))                                            HDU11480
    GO TO 157                                                           HDU11490
165 IF (ABS(Y(6)-ZI).LT.EZ1) GO TO 166                                  HDU11500
    IF (IXIAYI.EQ.0) GO TO 155                                          HDU11510
    GO TO 153                                                           HDU11520
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  166 NEX=4                                                                HDU11530
      J7=1                                                                 HDU11540
      IEPD=4                                                               HDU11550
      WRITE (6,290)                                                        HDU11560
      CALL SPRINT (Y,DY,1)                                                 HDU11570
      GO TO 4                                                              HDU11580
  167 CALL SPRINT (Y,DY,2)                                                 HDU11590
      GO TO 4                                                              HDU11600
98765 IFERR=1                                                              HDU11610
      IEPD=5                                                               HDU11620
      WRITE (6,174)                                                        HDU11630
      WRITE (6,169)                                                        HDU11640
      J7=1                                                                 HDU11650
      NEX=4                                                                HDU11660
      J1=4                                                                 HDU11670
      WRITE (6,290)                                                        HDU11680
      CALL SPRINT (Y,DY,1)                                                 HDU11690
      STOP                                                                 HDU11700
  169 FORMAT (38H RUNNING TOO LONG OR HAD TO BE STOPPED)                   HDU11710
  170 FORMAT (18I2)                                                        HDU11720
  171 FORMAT (7F10.6,2X,A5,I3)                                             HDU11730
  172 FORMAT (29H METRO CARDS ARE OUT OF ORDER)                            HDU11740
  173 FORMAT (33H ERROR IN METRO ENLARGE ATM ARRAY)                        HDU11750
  174 FORMAT (2H1 )                                                        HDU11760
  175 FORMAT (20H ITERATED TEN TIMES ,2F10.2,A5,I5)                        HDU11770
  176 FORMAT (38H TRAJECTORY UPLEG WILL NOT REACH BURST,A5,I5)             HDU11780
  177 FORMAT (51H      QE          UO     AZ OF FIRE DELTA AZ AZ WRT VEH,60HHDU11790
     1  EL VEH    UO VEH       SPIN    OMEGAY 0  OMEGAZ 0 INIT'L EUE,20H IHDU11800
     2NIT'L ELA FIN CANT/31H     MILS      FT/SEC      MILS    ,60H    MILS HDU11810
     3    MILS       MILS      FT/SEC     REV/SEC    RAD/SEC ,40H  RAD/SEC HDU11820
     4  MILS       MILS        RAD    /)                                   HDU11830
  178 FORMAT (//55X,15HINPUT FOR CODE ,A5//)                               HDU11840
  179 FORMAT (51H    REF WT     WT TBM     WT (TB)    FUEL WT    DE WT    ,60HHDU11850
     1 DIA MISS  LGTH MISS  CG TBM    CG (TB)     IX TBM    IX (TB)   ,20H IHDU11860
     2Y (TBM)  LGTH LCHR/31H      LB          LB          LB     ,60H    LB HDU11870
     3      LB          FT          FT          FT          FT     ,40H  LB-FT2 HDU11880
     4 LB-FT2     LB-FT2        FT    /)                                   HDU11890
  180 FORMAT (5F10.3,4F10.5,3F10.2,F10.5//)                                HDU11900
  181 FORMAT (51H      QE          UO     AZ OF FIRE DELTA AZ AZ WRT VEH,60HHDU11910
     1  EL VEH    UO VEH       TWIST    OMEGAY 0  OMEGAZ 0 INIT'L EUE,20H IHDU11920
     2NIT'L ELA FIN CANT/31H     MILS      FT/SEC      MILS    ,60H    MILS HDU11930
     3    MILS       MILS      FT/SEC     CAL/REV    RAD/SEC ,40H  RAD/SEC HDU11940
     4  MILS       MILS        RAD    /)                                   HDU11950
  182 FORMAT (2F10.3,4F10.4,F10.3,3F10.5,2F10.4,F10.6//)                   HDU11960
  183 FORMAT (51H      IST         ISP      RAD GY F RAD NOZ EX A JET EX,60HHDU11970
     1 JET PRES  DIST T-T RATIO FL/WT RT ASCEN    APP DECL  HR ANG ,14HFPHDU11980
     2A T OF DAY-Z/41H  LBF-SEC LBF-SEC/LBM      FT          FT    ,60H   HDU11990
     3FT2     LB/FT2       FT          FT/LB     HR/MIN/S  DEG/MIN/,24HS   HR/HDU12000
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   4MIN/S    FR/MIN/S /)                                                  HDU12010
184 FORMAT (2F10.2,F10.4,2F10.6,F10.2,2F10.5,4F11.3//)                    HDU12020
185 FORMAT (51H    T BM ST     T BM      T B ST       T B     T END L   ,60HHDU12030
   1T DEL IGN T END 6DEG T SRIGN ST T SRIGN  T SRB ST     T SRB   ,20H SHDU12040
   2R RAD CL    TF SR  /30H      SEC        SEC        SEC   ,60H     SEC  HDU12050
   3   SEC        SEC        SEC        SEC        SEC    ,30H     SEC    HDU12060
   4  SEC         FT    /)                                                 HDU12070
186 FORMAT (13F10.5//)                                                    HDU12080
187 FORMAT (51H D INT TST D INT FF  D TPRT TST D TPRT FF PRTO TST ,60HHDU12090
   1  PRTO FF  LATITUDE  LONGITUDE.     C          L        L 6DEG ,20H  HDU12100
   2   C          TF      ,/41H      SEC        SEC        SEC        SEC   ,5HDU12110
   30H     SEC        SEC        DEG        DEG      LB/IN2  /)           HDU12120
188 FORMAT (13F10.5//)                                                    HDU12130
189 FORMAT (51H INITIAL T INITIAL X1 INITIAL X2 INITIAL X3 TERM T ,60HHDU12140
   1    MIN X    D X1 PRT    TERM X1    TERM X2    TERM X3    TOL X1   ,20H  HDU12150
   2TOL X3    GRAVITY 0/31H     SEC        FT         FT    ,60H       FT  HDU12160
   3       SEC        FT        FT         FT         FT    ,40H      FT   HDU12170
   4    FT         FT       FT/SEC2 /)                                     HDU12180
190 FORMAT (F10.5,3F10.3,F10.5,5F10.3,F10.5,1PE10.3,0PF10.5//)            HDU12190
191 FORMAT (51H     T MCH     U MCH  GAMMAV MCH GAMMAH MCH  TOL U  T,60HHDU12200
   1OL GAMMAV TOL GAMMAH ADJ OMEGY ADJ OMEG2  ADJUST TF ADJUST C,20H    HDU12210
   2ADJUST L ADJUST QE/31H      SEC       FT/SEC      DEG     ,60H     DEG  HDU12220
   3    FT/SEC      DEG        DEG       RD/S/DEG  RD/S/DEG,40H    1/FT/SECHDU12230
   4 LB/IN2/FT    1/FT     MILS FT /)                                      HDU12240
192 FORMAT (F10.5,F10.3,2F10.5,3F10.2,6F10.5//)                           HDU12250
193 FORMAT (30X,50HRWIND TST CWIND TST  RWIND FF  CWIND FF AIR DENSIT,HDU12260
   120HY AIR PRES  AIR TEMP/30X,30H    MPH        MPH        MPH    ,42H HDU12270
   2    MPH    MULTIPLIER MULTIPLIER MULTIPLIER/)                         HDU12280
194 FORMAT (30X,4F10.5,3F10.7)                                            HDU12290
195 FORMAT (1H1,56X,13HMET FOR CODE ,A5//30X,50H HGT WIND   RWIND         HDU12300
   1CWIND     HGT DPT    AIR DENS ,20H AIR PRES   AIR TEMP /30X,30H     FTHDU12310
   2        MPH        MPH     ,40H     FT       GM/M**3      MB       DEG C HDU12320
   3  /)                                                                   HDU12330
196 FORMAT (30X,F10.3,2F10.5,F10.3,2F10.4,F10.5)                          HDU12340
197 FORMAT (1H1,61X,8HCONTROLS//)                                         HDU12350
198 FORMAT (4A10,5X,4A10,5X,4A10)                                         HDU12360
199 FORMAT (7A10,A7,A1,A2)                                                HDU12370
200 FORMAT (27H ERROR CONTROL IN 79 AND 80)                               HDU12380
210 FORMAT (7F10.5,A7,A1,A2)                                              HDU12390
220 FORMAT (15H GOT TO DO READ)                                           HDU12400
250 FORMAT (19H CHECKPOINT REACHED)                                       HDU12410
260 FORMAT (25H GONE TO PNEST FM 72 MAIN)                                 HDU12420
270 FORMAT (25H GONE TO PNEST FM 85 MAIN)                                 HDU12430
280 FORMAT (20H GONE TO RKG FM MAIN)                                      HDU12440
290 FORMAT (23H GONE TO SPRINT FM MAIN)                                   HDU12450
    END                                                                   HDU12460
    SUBROUTINE DER (Y,DY)                                                 HDU12470
    DIMENSION Y(16), DY(16), LE(1), QE(1), WSX(1)                         HDU12480
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      COMMON LE, FN, RK, R2TBM, RNE, D, E, LL, GO, TBMST, TBST, IST, PE,HDU12490
     1  AE, MTBST, MDI, DELTB, DETFF, XIDEL, XIMAX, IH2B, IH3B, TFUB,   HDU12500
     2  CX1, LZ1, ETB, EPB, EUB, EX1, EZ1, TSRIST, TSRBST, RS, QE, IH2, HDU12510
     3  IH3, TF, BC, SL, C, UO, SPN, IX1, IX2, IU, AZU, EU, TBM, TL, TDIHDU12520
     4  , TCB, TB, TE6, TCFF, PTB, PTFF, AZD, MTBM, MF, MTB, ISP, TSRI, HDU12530
     5  TSRB, TSCF, CGTBM, CGTB, ATBM, ATB, BTBM, LAT, AZ, TMCB, UMCB,  HDU12540
     6  PHMCE, THMCB, TI, XI, YI, ZI, WSX, WSZ, WEX, WBZ, DENSF, PRESF, HDU12550
     7  TEMPF, SLED                                                     HDU12560
      COMMON ITM(700), IMZ, IMZ1, IMZ2, NATM, J2, IDGREE(1), IROT,      HDU12570
     1  IREDLC, ITWT, IUPLEG, IUNIT, ISPRT, IRSET, ICURE, ISTIM, ISCOUT,HDU12580
     2  I3DBUF, I3DP, ISAVE6, ITONQE, IXIAYI, I5DIG, IX2N, IUN, LAM(3), HDU12590
     3  B, A, SINCE, COSCE, CSQ, IKL, GORSC, XOUT(1), YOUT, ZOUT, TOF,  HDU12600
     4  AA, IL1, AZU1, EL1, UTL, QEOUT, TEMPN, DENSN, WX, WZ, CDN, ICNN,HDU12610
     5  CENS, PA, VAS, EC, PP1, PP2, PPP1, PPP2, BTB, CONS2, CONS3, D33,HDU12620
     6  C44, CCRS, I1, I2, I3, I4, I5, I6, I7, I8, I9, NEX, ILSA, IYP,  HDU12630
     7  IEPD, CSQ, R1TB, R2TBSQ, RETB, RK12, RK2, RNESQ2, KTTE, TRCONS, HDU12640
     8  ICNP, TST, IT, ITT, ITTT, IFERR, IC1, HDX, CTS, TO, I1, I2, T3, HDU12650
     9  T4, T5, TALPH, THETA, ALPE, ALPQ1, ALPQ2, ALPQ3, CODE, D22,     HDU12660
     A  IFIRST, J1, J7, PDTCM, PMTOF, TJ(250C), LN, YP, ICODE, ICCT1,   HDU12670
     B  ICOT2, ICCT3, PHI, I6CP, R3, ALPHA, VT, V1, V2, V3, TSTAR, KDB, HDU12680
     C  KM, KL, KT, XDX, KH, DKDB, DKDBA, MACH, ISUN, SINLAT, COSLAT,   HDU12690
     D  SINAZ, COSAZ, SINC, COSD, DEL                                   HDU12700
      COMMON /ERR/ IER                                                  HDU12710
      COMMON /BDH/ REARTH, GC, AMTOMS, PO, AMTOF, FTOM, ANTOM, RTOD,    HDU12720
     1  CTOM, THCFHI, AMTCIN, AMTCKN, AMTCMH, FTOM2, CVDTOR, CVMTOR, RSQHDU12730
     2  , HA(25), TM(25), ALP(25), HEAD(169)                            HDU12740
      REAL LE, LL, IST, MDI, IH2B, IH3B, IH2, IH3, IX1, IX2, IU, MF, MTBHDU12750
     1  , ISP, LAT, LAM, MTBM, MTBST, IU1, IX2N, IUN, LZ1               HDU12760
      REAL NU1, NU2, NU3                                                HDU12770
      REAL MACH, KM, KDB, KL, KH, KF, KTA, KT, KLA, KA, KE, KFA, KMA, KSHDU12780
     1  , KTC                                                           HDU12790
      GO TO (35,1), IUSA                                                HDU12800
    1 AM=CONS2*(Y(2)-TBM)+TEMST                                         HDU12810
      WRITE (6,57)                                                      HDU12820
      CALL PNEST (1,AM,TALPH,TST)                                       HDU12830
      TR=TRCONS*TST                                                     HDU12840
      TO=Y(1)-MTB                                                       HDU12850
      R1=R1TB+RK2*TO                                                    HDU12860
      R2SQ=R2TBSQ+RK12*TO**2                                            HDU12870
      R3=TO*R1/Y(1)                                                     HDU12880
      DY(1)=-TR/ISP                                                     HDU12890
      B=BTB+(Y(1)-MTB)*R2SQ+MTB*R1**2-Y(1)*(R1-R3)**2                   HDU12900
      GO TO (2,3), I1                                                   HDU12910
    2 GO TO (34,35), I2                                                 HDU12920
    3 A=ATB+CONS3*(Y(1)-MTB)                                            HDU12930
      GO TO 2                                                           HDU12940
    4 V1=Y(7)                                                           HDU12950
      V3=Y(9)                                                           HDU12960
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    5 IF (TST.LE.0.) GO TO 12                                          HDU12970
      TSTAR=TR*TF+(PE-PA)*AE                                           HDU12980
    6 V2=Y(8)                                                          HDU12990
      VTSQ=V1**2+V2**2+V3**2                                           HDU13000
      VT=SQRT(VTSQ)                                                    HDU13010
      MACH=VT/VAS                                                      HDU13020
      IF (IODP.EQ.1) GO TO 7                                           HDU13030
      GO TO (15,19,20,13), I5                                          HDU13040
    7 VDCTX=V1*Y(14)+V2*Y(15)+V3*Y(16)                                 HDU13050
      COSA=VDCTX/VT                                                    HDU13060
      IF (ABS(COSA).LE.1.0005) GO TO 8                                 HDU13070
      WRITE (6,55) Y(2),COSA,CODE,ICCT1                                HDU13080
      GO TO IER, (56)                                                  HDU13090
    8 IF (ABS(COSA).LE.1.) GO TO 10                                    HDU13100
      IF (COSA.LT.0.) GO TO 9                                          HDU13110
      COSA=1.                                                          HDU13120
      ALPHA=0.                                                         HDU13130
      GO TO 11                                                         HDU13140
    9 COSA=-1.                                                         HDU13150
      ALPHA=3.145926535                                                HDU13160
      GO TO 11                                                         HDU13170
C     ARCCS WAS ARCCOS                                                 HDU13180
   10 ALPHA=ARCOS(COSA)                                                HDU13190
   11 ALPSQ=ALPHA**2                                                   HDU13200
      TALPH=ALPSQ                                                      HDU13210
      GO TO (15,19,20,13), I5                                          HDU13220
   12 TSTAR=0.                                                         HDU13230
      DY(1)=0                                                          HDU13240
      GO TO 6                                                          HDU13250
   13 V1=Y(7)-WSX(1)                                                   HDU13260
      V3=Y(9)-WSZ                                                      HDU13270
      GO TO 5                                                          HDU13280
   14 V1=Y(7)-WBX                                                      HDU13290
      V3=Y(9)-WBZ                                                      HDU13300
      GO TO 5                                                          HDU13310
   15 WRITE (6,57)                                                     HDU13320
      CALL PNEST (2,MACH,TALPH,KDB)                                    HDU13330
      GO TO (16,21), I6                                                HDU13340
   16 WRITE (6,57)                                                     HDU13350
      CALL PNEST (9,MACH,TALPH,F)                                      HDU13360
      F=F*FTCN                                                         HDU13370
      TO=(GC*TSTAR-DENS*D22*KDB*VTSQ)/Y(1)-GO*SINGE-F*COSGE            HDU13380
      DY(9)=0.                                                         HDU13390
      IF (TC.GT.0.) GO TO 17                                           HDU13400
      DY(7)=0.                                                         HDU13410
      DY(8)=0.                                                         HDU13420
      GO TO 18                                                         HDU13430
   17 DY(7)=TC*COSQE                                                   HDU13440
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      DY(8)=TC*SINQE                                                    HDU13450
   18 DY(4)=Y(7)                                                        HDU13460
      DY(5)=Y(8)                                                        HDU13470
      DY(6)=Y(9)                                                        HDU13480
      GO TO 33                                                          HDU13490
   19 DY(1)=MDI/(TL-TDI)                                                HDU13500
   20 WRITE (6,57)                                                      HDU13510
      CALL PNEST (4,MACH,TALPH,KDB)                                     HDU13520
   21 TO=Y(5)+REARTH                                                    HDU13530
      R=SQRT(Y(4)**2+TO**2+Y(6)**2)                                     HDU13540
      T1=GORSC/R**3                                                     HDU13550
      G1=T1*Y(4)                                                        HDU13560
      G2=T1*TO                                                          HDU13570
      G3=T1*Y(6)                                                        HDU13580
      NU1=-LAM(1)*Y(8)-LAM(2)*Y(9)                                      HDU13590
      NU2=LAM(1)*Y(7)+LAM(3)*Y(9)                                       HDU13600
      NU3=LAM(2)*Y(7)-LAM(3)*Y(8)                                       HDU13610
      T4=GC*TSTAR                                                       HDU13620
      GO TO (22,27), I7                                                 HDU13630
   22 WRITE (6,57)                                                      HDU13640
      CALL PNEST (3,MACH,TALPH,DKDB)                                    HDU13650
      DKDBA=DKDB*ALPSQ                                                  HDU13660
      T1=DENS*D22                                                       HDU13670
      T10=DENS*D33                                                      HDU13680
      T2=DENS*DSQ                                                       HDU13690
      WRITE (6,57)                                                      HDU13700
      CALL PNEST (IKL,MACH,TALPH,KL)                                    HDU13710
      CALL PNEST (10,MACH,TALPH,KM)                                     HDU13720
      RE=RETE-R3                                                        HDU13730
      XCG=LE(1)-RE                                                      HDU13740
      TO=(CGTE-XCG)/D                                                   HDU13750
      KM=KM-TO*(KL+KDB)                                                 HDU13760
      GO TO (23,27), I5                                                 HDU13770
   23 T1=-T1*(KDB+DKDBA)*VT                                             HDU13780
      WRITE (6,57)                                                      HDU13790
      CALL PNEST (6,MACH,TALPH,KS)                                      HDU13800
      T3=T10*KS*VT/B                                                    HDU13810
      X1CH1=Y(15)*Y(13)-Y(16)*Y(12)                                     HDU13820
      X2CH2=Y(16)*Y(11)-Y(14)*Y(13)                                     HDU13830
      X3CH3=Y(14)*Y(12)-Y(15)*Y(11)                                     HDU13840
      RT=RTTE-R3                                                        HDU13850
      CALL PNEST (8,MACH,TALPH,KH)                                      HDU13860
      T11=DENS*D44                                                      HDU13870
      T7=-DY(1)*RE*RT                                                   HDU13880
      DY(10)=0.                                                         HDU13890
      HDX=0.                                                            HDU13900
      V1CX1=V2*Y(16)-V3*Y(15)                                           HDU13910
      V2CX2=V3*Y(14)-V1*Y(16)                                           HDU13920
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      V3CX3=V1*Y(15)-V2*Y(14)                                           HDU13930
      DO 24 I=7,9                                                       HDU13940
      DY(I)=C.                                                          HDU13950
   24 CY(I+4)=0.                                                        HDU13960
      XDX=Y(14)**2+Y(15)**2+Y(16)**2                                    HDU13970
      IF (XDX.LE.1.0005) GO TO (25,26,28,30), I8                        HDU13980
      WRITE (6,54) Y(2),XDX,CCDE,ICOT1                                  HDU13990
      GO TO IER, (56)                                                   HDU14000
   25 T2=T2*KL*SL6D                                                     HDU14010
      T5=T10*KM*VT                                                      HDU14020
      T6=T11*KH*VT                                                      HDU14030
      DY(7)=(T1*V1+T2*(VTSQ*Y(14)-VDOTX*V1)+T3*X1CH1+T4*Y(14))/Y(1)-G1  HDU14040
     1  +NU1+DY(7)                                                      HDU14050
      DY(8)=(T1*V2+T2*(VTSQ*Y(15)-VDCTX*V2)+T3*X2CH2+T4*Y(15))/Y(1)-G2  HDU14060
     1  +NU2+DY(8)                                                      HDU14070
      DY(9)=(T1*V3+T2*(VTSQ*Y(16)-VDCTX*V3)+T3*X3CH3+T4*Y(16))/Y(1)-G3  HDU14080
     1  +NU3+DY(9)                                                      HDU14090
      DY(4)=Y(7)                                                        HDU14100
      DY(5)=Y(8)                                                        HDU14110
      DY(6)=Y(9)                                                        HDU14120
      HDXX1=HDX*Y(14)                                                   HDU14130
      HDXX2=HDX*Y(15)                                                   HDU14140
      HDXX3=HDX*Y(16)                                                   HDU14150
      DY(11)=T5*V1CX1+(T6*(HDXX1-Y(11))-T7*(Y(11)-HDXX1))/B+DY(11)      HDU14160
      DY(12)=T5*V2CX2+(T6*(HDXX2-Y(12))-T7*(Y(12)-HDXX2))/B+DY(12)      HDU14170
      DY(13)=T5*V3CX3+(T6*(HDXX3-Y(13))-T7*(Y(13)-HDXX3))/B+DY(13)      HDU14180
      DY(14)=-X1CH1/B                                                   HDU14190
      DY(15)=-X2CH2/B                                                   HDU14200
      DY(16)=-X3CH3/B                                                   HDU14210
      GO TO 33                                                          HDU14220
   26 HDX=Y(11)*Y(14)+Y(12)*Y(15)+Y(13)*Y(16)                           HDU14230
      T9=HDX/A                                                          HDU14240
      WRITE (6,57)                                                      HDU14250
      CALL PNEST (13,MACH,TALPH,KF)                                     HDU14260
      KF=KF*T10*T9/Y(1)                                                 HDU14270
      CALL PNEST (44,MACH,TALPH,KTA)                                    HDU14280
      KTA=KTA*ALPSQ                                                     HDU14290
      CALL PNEST (15,MACH,TALPH,KT)                                     HDU14300
      KT=KT+KTA                                                         HDU14310
      TK=T11*T9*KT                                                      HDU14320
      CALL PNEST (41,MACH,TALPH,KLA)                                    HDU14330
      KLA=KLA*ALPSQ                                                     HDU14340
      KL=KL+KLA                                                         HDU14350
      CALL PNEST (42,MACH,TALPH,KMA)                                    HDU14360
      KMA=KMA*ALPSQ                                                     HDU14370
      KM=KM+KMA                                                         HDU14380
      CALL PNEST (43,MACH,TALPH,KHA)                                    HDU14390
      KHA=KHA*ALPSQ                                                     HDU14400
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      KH=KH+KHA                                                         HDU14410
      CALL PNEST (17,MACH,TALPH,KA)                                     HDU14420
      KA=KA*T11*VT*T9                                                   HDU14430
      CALL PNEST (24,MACH,TALPH,KE)                                     HDU14440
      KE=KE*T10*E*VTSQ                                                  HDU14450
      AM=(Y(2)-TSRI)*CTS+TSRIST                                         HDU14460
      CALL PNEST (25,AM,TALPH,TS)                                       HDU14470
      TS=TS*CTS*TSCF*CCRS                                               HDU14480
      TO=-KA+KE+TS                                                      HDU14490
      T12=DY(1)*RNESQ2*TS                                               HDU14500
      DY(7)=-KF*V1CX1                                                   HDU14510
      DY(8)=-KF*V2CX2                                                   HDU14520
      DY(9)=-KF*V3CX3                                                   HDU14530
      TOT12=TC+T12                                                      HDU14540
      DY(11)=TK*(VDOTX*Y(14)-V1)+Y(14)*TOT12                            HDU14550
      DY(12)=TK*(VDOTX*Y(15)-V2)+Y(15)*TOT12                            HDU14560
      DY(13)=TK*(VDOTX*Y(16)-V3)+Y(16)*TOT12                            HDU14570
      GO TO 25                                                          HDU14580
   27 GO TO (25,26,28,30), I8                                           HDU14590
   28 DKDB=0.                                                           HDU14600
      DY(7)=0.                                                          HDU14610
      DY(8)=0.                                                          HDU14620
      DY(9)=0.                                                          HDU14630
   29 TO=-DENS*C22*(KDB+DKDB)*VT                                        HDU14640
      COSAE=COS(SQRT(ALPE))                                             HDU14650
      COSAVT=COSAE/VT                                                   HDU14660
      ALP1=T4*(V1*COSAVT+ALPQ1)                                         HDU14670
      ALP2=T4*(V2*COSAVT+ALPQ2)                                         HDU14680
      ALP3=T4*(V3*COSAVT+ALPQ3)                                         HDU14690
      DY(7)=(ALP1+TO*V1)/Y(1)-G1+NU1+DY(7)                              HDU14700
      DY(8)=(ALP2+TO*V2)/Y(1)-G2+NU2+DY(8)                              HDU14710
      DY(9)=(ALP3+TO*V3)/Y(1)-G3+NU3+DY(9)                              HDU14720
      DY(4)=Y(7)                                                        HDU14730
      DY(5)=Y(8)                                                        HDU14740
      DY(6)=Y(9)                                                        HDU14750
      GO TO 33                                                          HDU14760
   30 WRITE (6,57)                                                      HDU14770
      CALL PNEST (13,MACH,TALPH,KF)                                     HDU14780
      CALL PNEST (15,MACH,TALPH,KT)                                     HDU14790
      CALL PNEST (44,MACH,TALPH,KTO)                                    HDU14800
      KT=KT+KTC*ALPE                                                    HDU14810
      CALL PNEST (42,MACH,TALPH,KMA)                                    HDU14820
      KM=KM+KMA*ALPE                                                    HDU14830
      CALL PNEST (41,MACH,TALPH,KLA)                                    HDU14840
      KL=KL+KLA*ALPE                                                    HDU14850
      CALL PNEST (43,MACH,TALPH,KHA)                                    HDU14860
      CALL PNEST (8,MACH,TALPH,KH)                                      HDU14870
      KH=KH+KHA*ALPE                                                    HDU14880
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      TO=KL*KF*VTSQ/Y(10)                                               HDU14890
      TO=TO+DSQ*KF*KT*Y(10)                                             HDU14900
      TO=T10*VTSQ*TO                                                    HDU14910
      ALPA=A*KL/TO                                                      HDU14920
      ALPB=Y(1)*DSQ*KT/TO                                               HDU14930
      T1=ALPB-ALPA                                                      HDU14940
      T2=T2*KL                                                          HDU14950
      IF (IKL.EQ.12) GO TO 31                                           HDU14960
      ALPQ1=T1*(V2*DY(9)-V3*DY(8))+ALPB*(V2*G3-V3*G2)                   HDU14970
      ALPQ2=T1*(V3*DY(7)-V1*DY(9))+ALPB*(V3*G1-V1*G3)                   HDU14980
      ALPQ3=T1*(V1*DY(8)-V2*DY(7))+ALPB*(V1*G2-V2*G1)                   HDU14990
      GO TO 32                                                          HDU15000
   31 ALPQ1=V2*V1/VTSQ                                                  HDU15010
      ALPQ2=-1.+V2**2/VTSQ                                              HDU15020
      ALPQ3=V2*V3/VTSQ                                                  HDU15030
   32 ALPE=ALPQ1**2+ALPQ2**2+ALPQ3**2                                   HDU15040
      DKDB=DKDB*ALPE*DSQ                                                HDU15050
      T1=T2*SL*VTSQ                                                     HDU15060
      T2=T10*KF*Y(10)*Q                                                 HDU15070
      TALPH=ALPE                                                        HDU15080
      ALPE1=ALPQ2*V3-ALPQ3*V2                                           HDU15090
      ALPE2=ALPQ3*V1-ALPQ1*V3                                           HDU15100
      ALPE3=ALPQ1*V2-ALPQ2*V1                                           HDU15110
      RMASS=1./Y(1)                                                     HDU15120
      DY(7)=(T1*ALPQ1+T2*ALPE1)*RMASS                                   HDU15130
      DY(8)=(T1*ALPQ2+T2*ALPE2)*RMASS                                   HDU15140
      DY(9)=(T1*ALPQ3+T2*ALPE3)*RMASS                                   HDU15150
      CALL PNEST (17,MACH,TALPH,KA)                                     HDU15160
      DY(10)=-T10*D*KA*VT*Y(10)/A                                       HDU15170
      GO TO 29                                                          HDU15180
   33 IEPD=5                                                            HDU15190
      IF (IFIRST.EQ.1) CALL SPRINT (Y,DY,1)                             HDU15200
   34 RETURN                                                            HDU15210
   35 TO=SQRT(RSQ-Y(4)**2)                                              HDU15220
      EC=Y(5)+REARTH-TO                                                 HDU15230
      GO TO (36,43), J2                                                 HDU15240
   36 T1=Y(8)+(Y(7)*Y(4)/TO)                                            HDU15250
      T2=REARTH+EC                                                      HDU15260
      GPH=REARTH*EC/T2                                                  HDU15270
      IF (EC.GT.90000.) GO TO 41                                        HDU15280
      IF (GPH.LE.HA(1)) GO TO 42                                        HDU15290
   37 IF (GPH.LE.HA(IMZ+2)) GO TO 38                                    HDU15300
      IMZ=IMZ+1                                                         HDU15310
      GO TO 37                                                          HDU15320
   38 IF (GPH.GE.HA(IMZ+1)) GO TO 39                                    HDU15330
      IMZ=IMZ-1                                                         HDU15340
      GO TO 38                                                          HDU15350
   39 TEMP=TM(IMZ+1)+ALM(IMZ+1)*(GPH-HA(IMZ+1))                         HDU15360
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      DY(3)=(-.0341631 5474*Y(3)*RSQ*T1)/(TEMP*T2**2)                   HDU15370
      PA=Y(3)*22.4808 5431*PRESF                                        HDU15380
      TO=EC                                                             HDU15390
      DENS=(Y(3)/TEMP)*.7680191702*DENSF                                HDU15400
      TEMP=TEMP*TEMPF                                                   HDU15410
   40 VAS=20.0468 0276*SQRT(TEMP)                                       HDU15420
      GO TO (4,13,14), I4                                               HDU15430
   41 GPH=EC                                                            HDU15440
      GO TO 37                                                          HDU15450
   42 IMZ=0                                                             HDU15460
      GO TO 39                                                          HDU15470
   43 TO=EC*AMTOF                                                       HDU15480
      IF (TO.LE.0.) GO TO 46                                            HDU15490
   44 IF (TO.LE.ATM(IMZ1+8)) GO TO 45                                   HDU15500
      IMZ1=IMZ1+7                                                       HDU15510
      IF (IMZ1.LT.NATM) GO TO 44                                        HDU15520
      WRITE (6,52)                                                      HDU15530
      GO TO IER, (56)                                                   HDU15540
   45 IF (TO.GE.ATM(IMZ1+1)) GO TO 47                                   HDU15550
      IMZ1=IMZ1-7                                                       HDU15560
      GO TO 45                                                          HDU15570
   46 IMZ1=0                                                            HDU15580
   47 T1=(TO-ATM(IMZ1+1))/(ATM(IMZ1+8)-ATM(IMZ1+1))                     HDU15590
      WBX=ATM(IMZ1+2)+T1*(ATM(IMZ1+9)-ATM(IMZ1+2))                      HDU15600
      WSX(1)=WBX                                                        HDU15610
      WSZ=ATM(IMZ1+3)+T1*(ATM(IMZ1+10)-ATM(IMZ1+3))                     HDU15620
      WBZ=WSZ                                                           HDU15630
      IF (TO.LE.0.) GO TO 50                                            HDU15640
   48 IF (TO.LE.ATM(IMZ2+11)) GO TO 49                                  HDU15650
      IMZ2=IMZ2+7                                                       HDU15660
      IF (IMZ2.LT.NATM) GO TO 48                                        HDU15670
      WRITE (6,53)                                                      HDU15680
      GO TO IER, (56)                                                   HDU15690
   49 IF (TO.GE.ATM(IMZ2+4)) GO TO 51                                   HDU15700
      IMZ2=IMZ2-7                                                       HDU15710
      GO TO 49                                                          HDU15720
   50 IMZ2=0                                                            HDU15730
   51 T1=(TO-ATM(IMZ2+4))/(ATM(IMZ2+11)-ATM(IMZ2+4))                    HDU15740
      TEMP=ATM(IMZ2+7)+T1*(ATM(IMZ2+14)-ATM(IMZ2+7))                    HDU15750
      TEMP=TEMP+273.15                                                  HDU15760
      DENS=(ATM(IMZ2+5)+T1*(ATM(IMZ2+12)-ATM(IMZ2+5)))*.0022046222622   HDU15770
      PA=(ATM(IMZ2+6)+T1*(ATM(IMZ2+13)-ATM(IMZ2+6)))*22.48085431        HDU15780
      GO TO 40                                                          HDU15790
   52 FORMAT (24H EXCEEDS METRO FOR WINDS)                              HDU15800
   53 FORMAT (42H ERROR METRC EXCEEDED FOR DENSITY AND TEMP)            HDU15810
   54 FORMAT (15H ROUND TUMELED ,2F10.3,A5,I5)                          HDU15820
   55 FORMAT (27H ALPHA VDX GREATER THAN VT ,2F10.3,A5,I5)              HDU15830
   57 FORMAT (21H GONE TC PNEST FM DER)                                 HDU15840
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5C RETURN                                                               FDU15850
   END                                                                  FDU15860
   SUBROUTINE SPRINT (Y,DY,INEST)                                       FDU15870
   DIMENSION Y(16), DY(16), LE(1), QE(1), WSX(1)                        FDU15880
   COMMON LE, RN, RK, R2TBM, RNE, C, E, LL, GO, TBMST, TBST, IST, PE,FDU15890
  1  AE, MTBST, MDI, DELTB, DETFF, XICEL, XIMAX, IH2B, IH3B, TFUB,     FDU15900
  2  CX1, LZ1, ETB, EPB, EUB, EX1, EZ1, TSRIST, TSRBST, RS, QE, IH2,   FDU15910
  3  IH3, TF, BC, SL, C, UO, SPN, IX1, IX2, IU, AZU, EU, TBM, TL, TDIFDU15920
  4  , TCB, TB, TE6, TCFF, PTB, PTFF, AZD, MTBF, MF, MTB, ISP, TSRI,   FDU15930
  5  TSRB, TSCF, CGTBM, CGTB, ATBM, ATB, BTBM, LAT, AZ, TMCB, UMCB,    FDU15940
  6  PHMCB, THMCB, TI, XI, YI, ZI, WSX, WSZ, WEX, WBZ, DENSF, PRESF,   FDU15950
  7  TEMPF, SL6D                                                       FDU15960
   COMMON ATM(700), IMZ, IMZ1, IMZ2, NATM, J2, IDGREE(1), IROT,         FDU15970
  1  IREDUC, ITWT, IUPLEG, IUNIT, ISPRT, IRSET, ICURE, ISTIM, ISCOUT,FDU15980
  2  I3DBUF, I3DP, ISAVE6, ITONQE, IXIAYI, I5DIG, IX2N, IUN, LAM(3),   FDU15990
  3  B, A, SINCE, COSCE, CSQ, IKL, GORSQ, XOUT(1), YOUT, ZOUT, TOF,    FDU16000
  4  AA, IL1, AZU1, EL1, LTL, QEOUT, TEMPN, DENSN, WX, WZ, CON, ICNN,FDU16010
  5  CENS, PA, VAS, EC, PP1, PP2, PPP1, PPP2, BTB, CONS2, CONS3, D33,FDU16020
  6  D44, GCRS, I1, I2, I3, I4, I5, I6, I7, I8, I9, NEX, ILSA, IYP,    FDU16030
  7  IEPD, CSQ, R1TB, R2TBSQ, RETB, RK12, RK2, RNESQ2, RTTE, TRCONS,   FDU16040
  8  ICNP, TST, IT, ITT, ITTT, IFERR, IC1, HDX, CTS, TO, T1, T2, T3,   FDU16050
  9  T4, T5, TALPH, THETA, ALPE, ALPQ1, ALPQ2, ALPQ3, CODE, D22,       FDU16060
  A  IFIRST, J1, J7, PDTCM, PMTOF, TJ(2900), UN, YP, ICODE, ICCT1,     FDU16070
  B  ICOT2, ICCT3, PHI, I6CP, R3, ALPHA, VT, V1, V2, V3, TSTAR, KDB,   FDU16080
  C  KM, KL, KT, XDX, KH, DKDB, DKDBA, MACH, ISUN, SINLAT, COSLAT,     FDU16090
  D  SINAZ, COSAZ, SINC, COSD, DEL                                      FDU16100
   COMMON /ERR/ IER                                                     FDU16110
   COMMON /BCH/ REARTH, GC, AMTOMS, PC, AMTOF, FTOM, ANTOM, RTOD,       FDU16120
  1  DTOM, TWOPHI, AMTCIN, AMTOKN, AMTCMH, FTOM2, CVDTOR, CVMTOR, RSQFDU16130
  2  , HA(23), TM(23), ALM(22), HEAD(169)                               FDU16140
   REAL IH2B, IH3B, IH2, IH3, IU, IU1, IUN, IST, ISP, IX1, IX2, IX2N,FDU16150
  1  KDB, LAM, LAT, LE, LL, LZ1, MDI, MF, MTB, MTBM, MTBST, MACH,      FDU16160
  2     KM, KL, KT, KH                                                 FDU16170
   DATA PI,PI2 /3.141592654, 1.570796327/                               FDU16180
   GO TO (1,51), INEST                                                  FDU16190
 1 GO TO (49,52,51,292,2), IEPD                                         FDU16200
 2 IF IRST=C                                                            FDU16210
   UN=SQRT(Y(7)**2+Y(8)**2+Y(9)**2)                                     FDU16220
C  ARSIN WAS ARCSIN                                                     FDU16230
   PHI=PDTCM*RTOD*ARSIN(Y(8)/UN)                                        FDU16240
   THETA=PDTOM*RTOD*ATAN(Y(9)/Y(7))                                     FDU16250
   YP=EC                                                                FDU16260
   IF (IYP.EQ.C) YP=Y(5)                                                FDU16270
   UN=PMTCF*UN                                                          FDU16280
   IF (I6CP.EQ.1) GO TO 3                                               FDU16290
   T1=Y(1C)/TWOPHI                                                      FDU16300
   T2=RTOD*SQRT(ALPE)                                                   FDU16310
   AE1=ALPQ1                                                            FDU16320
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      AE2=ALPG2                                                         HDU16330
      AE3=ALPG3                                                         HDU16340
      GO TO 4                                                           HDU16350
    3 T1=0.                                                             HDU16360
      IF (A.GT.0.) T1=HDX/(TWOPHI*A)                                    HDU16370
      T2=RTOD*ALPHA                                                     HDU16380
      AE1=Y(14)                                                         HDU16390
      AE2=Y(15)                                                         HDU16400
      AE3=Y(16)                                                         HDU16410
    4 IF (T2.GT.0.) GO TO 5                                             HDU16420
      PSI=0.                                                            HDU16430
      GO TO 6                                                           HDU16440
    5 T3=(V1*AE3-V3*AE1)*VT                                             HDU16450
      T4=V1*(V1*AE2-V2*AE1)-V3*(V2*AE3-V3*AE2)                          HDU16460
      IF (T3.NE.0..OR.T4.NE.0.) GO TO 500                               HDU16470
      PSI=0.                                                            HDU16480
      GO TO 6                                                           HDU16490
  500 PSI=ATAN2(T3,T4)                                                  HDU16500
      IF (PSI.GE.0.) GO TO 6                                            HDU16510
      PSI=TWOPHI+PSI                                                    HDU16520
    6 PSI=RTOD*PSI                                                      HDU16530
      IF (IGOF.EQ.1) GO TO 7                                            HDU16540
      T3=KDB+DKDB                                                       HDU16550
      GO TO 8                                                           HDU16560
    7 T3=KDB+DKDBA                                                      HDU16570
    8 IF (T1.GT.20.) GO TO 9                                            HDU16580
      TJ(IT+11)=0.0                                                     HDU16590
      TJ(IT+12)=0.0                                                     HDU16600
      GO TO 15                                                          HDU16610
    9 T6=DENS*D33/Y(1)                                                  HDU16620
      T4=T6*(KL-KT*(Y(1)*D22/A))                                        HDU16630
      T5=T6*(KL-T3+KH*(Y(1)*D22/B))                                     HDU16640
      T6=KM*DENS*D22*D33/B                                              HDU16650
      T7=TWOPHI*T1*D*A/(B*VT)                                           HDU16660
      SDY=2.*T4/T5                                                      HDU16670
      SGY=T7**2/(4.*T6)                                                 HDU16680
      IDY=0                                                             HDU16690
      IGY=0                                                             HDU16700
      IF (1./SGY.LT.1.) GO TO 10                                        HDU16710
      IGY=1                                                             HDU16720
      IDY=1                                                             HDU16730
      GO TO 11                                                          HDU16740
   10 IF (1./SGY.LE.SDY*(2.-SDY)) GO TO 11                              HDU16750
      IDY=1                                                             HDU16760
   11 IF (IGY.EQ.1) GO TO 12                                            HDU16770
      SGY=TJ(IT+11)                                                     HDU16780
C     ENCODE (10,58,TJ(IT+11) )SGY                                      HDU16790
      GO TO 13                                                          HDU16800
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   12 SGY=TJ(IT+11)                                                     HDU16810
C  12 ENCODE (10,59,TJ(IT+11) )SGY                                      HDU16820
   13 IF (ICY.EQ.1) GO TO 14                                            HDU16830
      SDY=TJ(IT+12)                                                     HDU16840
C     ENCODE (10,58,TJ(IT+12) )SDY                                      HDU16850
      GO TO 15                                                          HDU16860
   14 SDY=TJ(IT+12)                                                     HDU16870
C  14 ENCODE (10,59,TJ(IT+12) )SDY                                      HDU16880
   15 TJ(IT+1)=Y(2)                                                     HDU16890
      TJ(IT+2)=PMTOF*Y(4)                                               HDU16900
      TJ(IT+3)=PMTOF*YP                                                 HDU16910
      JAH=0                                                             HDU16920
      TJ(IT+4)=PMTOF*Y(6)                                               HDU16930
      TJ(IT+5)=LN                                                       HDU16940
      TJ(IT+6)=PHI                                                      HDU16950
      TJ(IT+7)=THETA                                                    HDU16960
      TJ(IT+8)=T1                                                       HDU16970
      TJ(IT+9)=T2                                                       HDU16980
      TJ(IT+14)=ICOT1                                                   HDU16990
      TJ(IT+10)=PSI                                                     HDU17000
      TJ(IT+13)=CODE                                                    HDU17010
      IT=IT+14                                                          HDU17020
      IF (IGDP.EQ.0) GO TO 25                                           HDU17030
      TJ(ITT+841)=Y(2)                                                  HDU17040
      IF (ISUN.EQ.1) GO TO 16                                           HDU17050
      TJ(ITT+842)=0.                                                    HDU17060
      GO TO 22                                                          HDU17070
   16 TLHA=DEL+7.27220521E-5*Y(2)+(Y(4)*SINAZ+Y(6)*COSAZ)/(REARTH*COSLAT HDU17080
     1 )                                                                HDU17090
      IF (TLHA-PI.GE.0.) GO TO 17                                       HDU17100
      TMERID=TLHA                                                       HDU17110
      GO TO 19                                                          HDU17120
   17 IF (TLHA-TWOPHI.GE.0.) GO TO 18                                   HDU17130
      TMERID=TWOPHI-TLHA                                                HDU17140
      GO TO 19                                                          HDU17150
   18 TMERID=TLHA-TWOPHI                                                HDU17160
   19 SINH=SINLAT*SIND+COSLAT*COSD*COS(TMERID)                          HDU17170
      H=ASIN(SINH)                                                      HDU17180
      Z=ARCOS((SIND-SINLAT*SINH)/(COSLAT*COS(H)))                       HDU17190
      IF (TLHA-PI.LT.0.) GO TO 20                                       HDU17200
      IF (TLHA-TWOPHI.GE.0.) GO TO 20                                   HDU17210
      THE=PI2-Z                                                         HDU17220
      GO TO 21                                                          HDU17230
   20 THE=Z-PI-PI2                                                      HDU17240
   21 PH=PI2-H                                                          HDU17250
C     CALL SINCOS (PH,SINPH,COSPH)                                      HDU17260
      SINPH=SIN(PH)                                                     HDU17270
      COSPH=COS(PH)                                                     HDU17280
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C     CALL SINCOS (THE,SINTH,COSTH)                                    HDU17290
      SINTH=SIN(TH)                                                    HDU17300
      COSTH=COS(TH)                                                    HDU17310
      S1=COSAZ*SINPH*SINTH+SINAZ*SINPH*COSTH                           HDU17320
      S2=COSPH                                                         HDU17330
      S3=COSAZ*SINPH*COSTH-SINAZ*SINPH*SINTH                           HDU17340
      TJ(ITT+842)=RTOD*ASIN(S1*Y(14)+S2*Y(15)+S3*Y(16))                HDU17350
   22 T1=Y(14)                                                         HDU17360
      T2=Y(16)                                                         HDU17370
      TJ(ITT+844)=RTOD*ATAN2(T2,T1)                                    HDU17380
      T1=SQRT(T1**2+T2**2)                                             HDU17390
      T2=Y(15)                                                         HDU17400
      TJ(ITT+843)=RTOD*ATAN2(T2,T1)                                    HDU17410
      IF (PP1.NE.10000.) GO TO 23                                      HDU17420
      GO TO 24                                                         HDU17430
   23 T1=-(T5*PP1-T7*T4+PPP1)/(2.*PP1-T7)*1000.                        HDU17440
      T2=-(T5*PP2-T7*T4+PPP2)/(2.*PP2-T7)*1000.                        HDU17450
C     ENCODE (40,60,TJ(ITT+845) )T1,T2,PP1,PP2                         HDU17460
      TJ(ITT+845)=T1                                                   HDU17470
      TJ(ITT+846)=T2                                                   HDU17480
      TJ(ITT+847)=PP1                                                  HDU17490
      TJ(ITT+848)=PP2                                                  HDU17500
   24 TJ(ITT+849)=TSTAR                                                HDU17510
      TJ(ITT+850)=Y(1)                                                 HDU17520
      TJ(ITT+851)=B/FTOM2                                              HDU17530
      TJ(ITT+852)=XDX                                                  HDU17540
      TJ(ITT+853)=CODE                                                 HDU17550
      TJ(ITT+854)=ICOT2                                                HDU17560
      ITT=ITT+14                                                       HDU17570
   25 IF (ISPRT.EQ.0) GO TO 26                                         HDU17580
      TJ(IT+1667)=Y(2)                                                 HDU17590
      TJ(IT+1668)=PMTOF*Y(7)                                           HDU17600
      TJ(IT+1669)=PMTOF*Y(8)                                           HDU17610
      TJ(IT+1670)=PMTOF*Y(9)                                           HDU17620
      TJ(IT+1671)=PMTOF*DY(7)                                          HDU17630
      TJ(IT+1672)=PMTOF*DY(8)                                          HDU17640
      TJ(IT+1673)=PMTOF*DY(9)                                          HDU17650
      TJ(IT+1674)=2.546475089*T3                                       HDU17660
      TJ(IT+1675)=MACH                                                 HDU17670
      TJ(IT+1676)=Y(1)                                                 HDU17680
      TJ(IT+1677)=PMTOF*VT                                             HDU17690
      TJ(IT+1678)=CODE                                                 HDU17700
      TJ(IT+1679)=ICCT3                                                HDU17710
   26 IF (ISDIG.EQ.1) GO TO 54                                         HDU17720
   27 IF (ICCT1.EQ.IC1) GO TO 28                                       HDU17730
      IC1=ICCT1                                                        HDU17740
      ICNP=ICNP+1                                                      HDU17750
   28 IF (ICNP.GE.56) GO TO 291                                        HDU17760
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      GO TO (292,29), J7                                                HDU17770
   29 ICNP=ICNP+1                                                       HDU17780
      GO TO (57,57,57,46,57), NEX                                       HDU17790
  291 JAH=1                                                             HDU17800
      GOTO 30                                                           HDU17810
  292 IF(JAH.EQ.1)GO TO 45                                              HDU17820
   30 K=27                                                              HDU17830
      IF (PMTCF.EQ.1.) K=14                                             HDU17840
      II=0                                                              HDU17850
      J=2                                                               HDU17860
      KI=K                                                              HDU17870
      KII=KI+12                                                         HDU17880
      IF (IYF.EQ.0) GO TO 31                                            HDU17890
      WRITE (6,61) (HEAD(I),I=1,13)                                     HDU17900
      GO TO 32                                                          HDU17910
   31 WRITE (6,61) (HEAD(I),I=157,169)                                  HDU17920
   32 WRITE (6,62) (HEAD(I),I=KI,KII)                                   HDU17930
   33 WRITE (6,63)                                                      HDU17940
      J=J+1                                                             HDU17950
   34 KI=II+1                                                           HDU17960
      KII=KI+13                                                         HDU17970
      WRITE (6,64) (TJ(I),I=KI,KII)                                     HDU17980
      J=J+1                                                             HDU17990
      IF (J.EQ.58) GO TO 36                                             HDU18000
      IF (ITT.EQ.II+14) GO TO 35                                        HDU18010
      II=II+14                                                          HDU18020
      IF (TJ(II).EQ.TJ(II+14)) GO TO 34                                 HDU18030
      GO TO 33                                                          HDU18040
   35 WRITE (6,63)                                                      HDU18050
   36 GO TO (37,41), J7                                                 HDU18060
   37 IF (TJ(853).EQ.0.) GO TO 40                                       HDU18070
      IF (J.NE.58) WRITE (6,63)                                         HDU18080
      II=841                                                            HDU18090
      J=2                                                               HDU18100
      KI=K+39                                                           HDU18110
      KII=KI+12                                                         HDU18120
      WRITE (6,61) (HEAD(I),I=40,52)                                    HDU18130
      WRITE (6,62) (HEAD(I),I=KI,KII)                                   HDU18140
   38 WRITE (6,63)                                                      HDU18150
      J=J+1                                                             HDU18160
   39 KII=II+13                                                         HDU18170
      WRITE (6,65) (TJ(I),I=II,KII)                                     HDU18180
      J=J+1                                                             HDU18190
      IF (J.EQ.58) GO TO 40                                             HDU18200
      IF (ITT.EQ.II-827) GO TO 40                                       HDU18210
      II=II+14                                                          HDU18220
      IF (TJ(II-1).EQ.TJ(II+13)) GO TO 39                               HDU18230
      GO TO 38                                                          HDU18240
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40 ITT=0                                                          HDU18250
   GO TO 42                                                       HDU18260
41 IF (Y(2).LT.TE6) GO TO 37                                      HDU18270
   IF (IGDF.EQ.1) GO TO 37                                        HDU18280
42 IF (ISFRT.EQ.0) GO TO 45                                       HDU18290
   IF (J.NE.58) WRITE (6,63)                                      HDU18300
   II=1681                                                        HDU18310
   J=2                                                            HDU18320
   K=105                                                          HDU18330
   IF (PMTCF.EQ.1.) K=92                                          HDU18340
   KII=K+12                                                       HDU18350
   WRITE (6,61) (HEAD(I),I=79,91)                                 HDU18360
   WRITE (6,62) (HEAD(I),I=K,KII)                                 HDU18370
43 WRITE (6,63)                                                   HDU18380
   J=J+1                                                          HDU18390
   IF (TJ(1652).EQ.0.) GO TO 45                                   HDU18400
44 KII=II+12                                                      HDU18410
   WRITE (6,66) (TJ(I),I=II,KII)                                  HDU18420
   J=J+1                                                          HDU18430
   IF (J.EQ.58) GO TO 45                                          HDU18440
   IF (ITT.EQ.II-1667) GO TO 45                                   HDU18450
   II=II+14                                                       HDU18460
   IF (TJ(II-1).EQ.TJ(II+13)) GO TO 44                            HDU18470
   GO TO 43                                                       HDU18480
45 IT=0                                                           HDU18490
   ICNP=3                                                         HDU18500
   J7=2                                                           HDU18510
   GO TO (57,57,57,46,57), NEX                                    HDU18520
46 WRITE (6,63)                                                   HDU18530
   II=2700                                                        HDU18540
   J=2                                                            HDU18550
   KI=144                                                         HDU18560
   IF (PMTCF.EQ.1.) KI=131                                        HDU18570
   KII=KI+12                                                      HDU18580
   WRITE (6,61) (HEAD(I),I=118,130)                               HDU18590
   WRITE (6,62) (HEAD(I),I=KI,KII)                                HDU18600
47 WRITE (6,63)                                                   HDU18610
   J=J+1                                                          HDU18620
   IF (TJ(2709).EQ.0.) GO TO 49                                   HDU18630
48 KII=II+9                                                       HDU18640
   WRITE (6,67) (TJ(I),I=II,KII)                                  HDU18650
   J=J+1                                                          HDU18660
   IF (ITTT.EQ.0) GO TO 49                                        HDU18670
   IF (ITTT.EQ.II-2690) GO TO 49                                  HDU18680
   II=II+10                                                       HDU18690
   IF (TJ(II-1).EQ.TJ(II+9)) GO TO 48                             HDU18700
   GO TO 47                                                       HDU18710
49 ITTT=0                                                         HDU18720
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      DO 50 I=1,2700                                                    HDU18730
   50 TJ(I)=0.                                                          HDU18740
      GO TO 53                                                          HDU18750
   51 J7=1                                                              HDU18760
      NEX=4                                                             HDU18770
      GO TO 2                                                           HDU18780
   52 J7=1                                                              HDU18790
      NEX=4                                                             HDU18800
      GO TO 30                                                          HDU18810
   53 IF (ISCOUT.EQ.0) GO TO 56                                         HDU18820
   54 XOUT(1)=Y(4)                                                      HDU18830
      YOUT=Y(5)                                                         HDU18840
      ZOUT=Y(6)                                                         HDU18850
      TOF=Y(2)                                                          HDU18860
      AA=IX2*AMTOF                                                      HDU18870
      IU1=IU*AMTOKN                                                     HDU18880
      AZU1=AZU                                                          HDU18890
      EU1=EU                                                            HDU18900
      UTL=UO*AMTOF                                                      HDU18910
      CECUT=CE(1)                                                       HDU18920
      TEMPN=TEMPF                                                       HDU18930
      DENSN=DENSF                                                       HDU18940
      WX=WBX*AMTOMH                                                     HDU18950
      WZ=WBZ*AMTOMH                                                     HDU18960
      CDN=CODE                                                          HDU18970
      IDNN=ICODE                                                        HDU18980
      IF (ISDIG.EQ.0) GO TO 56                                          HDU18990
      GO TO 27                                                          HDU19000
   56 CONTINUE                                                          HDU19010
   57 RETURN                                                            HDU19020
   58 FORMAT (F10.6)                                                    HDU19030
   59 FORMAT (F8.4,2H *)                                                HDU19040
   60 FORMAT (4F10.7)                                                   HDU19050
   61 FORMAT (1H1,13A10)                                                HDU19060
   62 FORMAT (13A10)                                                    HDU19070
   63 FORMAT (1H )                                                      HDU19080
   64 FORMAT (F10.5,3F10.3,4F10.4,2F10.5,2A10,1X,A5,F5.0)               HDU19090
   65 FORMAT (4F10.5,4A10,F10.2,F10.3,F10.2,F10.7,1X,A5,F5.0)           HDU19100
   66 FORMAT (F10.5,6F10.4,F10.7,F10.6,F10.3,F10.4,11X,A5,F5.0)         HDU19110
   67 FORMAT (3X,F10.4,5X,6(F10.6,5X),F10.4,2X,A5,F5.0)                 HDU19120
      END                                                               HDU19130
      SUBROUTINE AERCH                                                  HDU19140
      DIMENSION B(16600), C(7), A(8), IND(45), MULTI(45)                HDU19150
      REAL MULTI                                                        HDU19160
      COMMON /AERCB/ B                                                  HDU19170
      DATA IND /1, 2, 3, 4, 5, 6, 24, 7, 8, 9, 10, 11, 11               HDU19180
     1, 12, 12, 13, 13, 13, 14, 26, 15, 16, 17, 18, 25, 27, 28, 29, 19, HDU19190
     219, 19, 19, 19, 19, 19, 19, 19, 19, 19, 20, 21, 22, 23, 23/       HDU19200
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      DATA MLLTI /1., .3926990816, .3926990816, .3926990816,            HDU19210
     1 .3926990816, -.3926990816, 1., -.3926990816, 1., .3926990816, 1.,HDU19220
     2 .3926990816, -.3926990816, 1., -.3926990816, 1., -.3926990816, 1.HDU19230
     3, 1., 1., 1., 1., 1., .3926990816, 1., 1., 1., 1., 1., 1., 1., 1.,HDU19240
     4 1., 1., 1., 1., 1., 1., 1., 1., .3926990816,  .3926990816, -.3926HDU19250
     5990816,-.3926990816, 1./                                          HDU19260
      DO 1 I=1,16600                                                    HDU19270
    1 B(I)=0.                                                           HDU19280
      WRITE (6,24)                                                      HDU19290
    2 READ (5,28) C,JCBCCD,ICNT,MCNT,ICCD,ITYPE                         HDU19300
      WRITE (6,28) C,JCBCCD,ICNT,MCNT,ICCD,ITYPE                        HDU19310
      IF (ITYPE.EQ.0) GO TO 19                                          HDU19320
      IF (ITYPE.EQ.2.OR.ITYPE.EQ.6) GO TO 9                             HDU19330
C     AEROPACK OPTION SET AT 6                                          HDU19340
      IF (ITYPE.EQ.1.OR.ITYPE.EQ.5) GO TO 3                             HDU19350
      WRITE (6,27) ITYPE                                                HDU19360
      STOP                                                              HDU19370
C   3 DECODE (79,21,A(1) )(C(I),I=1,6)                                  HDU19380
C     IF (ITYPE.EQ.1) GO TO 5                                           HDU19390
    3 DO 4 I=1,5                                                        HDU19400
    4 C(I)=MLLTI(ICOD)*C(I)                                             HDU19410
    5 I=(INC(ICOD)-1)*572+1                                             HDU19420
      B(I)=1.                                                           HDU19430
      B(I+1)=B(I+1)+6.                                                  HDU19440
      J=B(I+1)+1.+FLOAT(I)                                              HDU19450
      IF (B(I+1).EQ.6.) GO TO 6                                         HDU19460
      IF (C(6).GT.B(J-6)) GO TO 6                                       HDU19470
      WRITE (6,25) ICCD,C(6)                                            HDU19480
      STOP                                                              HDU19490
    6 K=J-5                                                             HDU19500
    7 II=1                                                              HDU19510
      DO 8 I=K,J                                                        HDU19520
      B(I)=C(II)                                                        HDU19530
    8 II=II+1                                                           HDU19540
      GO TO 2                                                           HDU19550
C     THIS OPTION USED ONLY                                             HDU19560
C   9 DECODE (79,22,A(1) )C,ICNT                                        HDU19570
C     IF (ITYPE.EQ.2) GO TO 11                                          HDU19580
    9 DO 10 J=1,6,2                                                     HDU19590
   10 C(J)=C(J)*MLLTI(ICCD)                                             HDU19600
   11 DO 12 J=2,6,2                                                     HDU19610
   12 C(J)=.CC030461742*C(J)                                            HDU19620
      I=(INC(ICOD)-1)*572+1                                             HDU19630
      B(I)=2.                                                           HDU19640
      J=I+39                                                            HDU19650
      IF (B(I+1).EQ.0.) J=J-19                                          HDU19660
   13 IF (B(J).EQ.0.) GO TO 14                                          HDU19670
      J=J+19                                                            HDU19680
```

```
      GO TO 13                                                          HDU19690
   14 IF (ICNT.EQ.1) GO TO 16                                           HDU19700
      IF (C(7).EQ.B(J-19)) GO TO 15                                     HDU19710
      WRITE (6,26) ICOD,C(7),B(J-19)                                    HDU19720
      WRITE (6,30)                                                      HDU19730
      STOP                                                              HDU19740
   15 IF (ICNT.EQ.3) GO TO 18                                           HDU19750
      K=J-31                                                            HDU19760
      J=J-26                                                            HDU19770
      GO TO 7                                                           HDU19780
   16 IF (B(I+1).EQ.0.) GO TO 17                                        HDU19790
      IF (C(7).GT.B(J-19)) GO TO 17                                     HDU19800
      WRITE (6,25) ICOD,C(7)                                            HDU19810
      WRITE (6,31)                                                      HDU19820
      STOP                                                              HDU19830
   17 B(J)=C(7)                                                         HDU19840
      B(I+1)=B(I+1)+19.                                                 HDU19850
      K=J-18                                                            HDU19860
      J=J-13                                                            HDU19870
      GO TO 7                                                           HDU19880
   18 K=J-25                                                            HDU19890
      J=J-20                                                            HDU19900
      GO TO 7                                                           HDU19910
   19 WRITE (6,29)                                                      HDU19920
      RETURN                                                            HDU19930
   20 FORMAT (7A10,A7,I2,I1)                                            HDU19940
   21 FORMAT (6E12.8,5X,I2)                                             HDU19950
   22 FORMAT (7E10.5,3X,I2,2X,I2)                                       HDU19960
   23 FORMAT (25X,7A10,A7,I2,I1)                                        HDU19970
   24 FORMAT (1H1,55X,19HAERODYNAMIC PACKAGE//)                         HDU19980
   25 FORMAT (27H AERO IS OUT OF ORDER  CODE,I4,12H BREAK POINT,E15.7)  HDU19990
   26 FORMAT (48H TYPE 2 OR 6 AERO SECOND OR THIRD CARD MACH NO. ,6HWRONHDU20000
     1G ,I4,9H FOR MACH,E15.7,9H AND MACH,E15.7)                        HDU20010
   27 FORMAT (31H ERROR COLUMN 80 OF AERO WAS A ,I2,23H INSTEAD OF A 1,2HDU20020
     1,5,OR6)                                                           HDU20030
   28 FORMAT (7F10.4,I3,I2,I2,I2,I1)                                    HDU20040
   29 FORMAT (16H LEAVING AEROSUB)                                      HDU20050
   30 FORMAT (19H STOPPED AT AERO 14)                                   HDU20060
   31 FORMAT (19H STOPPED AT AERO 16)                                   HDU20070
      END                                                               HDU20080
      SUBROUTINE PNEST (II,AM,ALPHA,R)                                  HDU20090
      DIMENSION B(16600), RA(2), IND(45)                                HDU20100
      COMMON /AEROB/ B                                                  HDU20110
      COMMON /ERR/ IER                                                  HDU20120
      DATA IND /1, 2, 3, 4, 5, 6, 24, 7, 8, 9, 9, 10, 11, 11            HDU20130
     1, 12, 12, 13, 13, 13, 14, 26, 15, 16, 17, 18, 25, 27, 28, 29, 19, HDU20140
     219, 19, 19, 19, 19, 19, 19, 19, 19, 19, 20, 21, 22, 23, 23/       HDU20150
      I=(IND(II)-1)*572+1                                               HDU20160
```

```
      N=I+7                                                             HDU2C170
      BR=AM                                                             HDU2C180
      K=B(I+1)+1.+FLOAT(I)                                              HDU2C190
      IF (B(I).EQ.2.) GO TO 4                                           HDU20200
      DO 1 J=N,K,6                                                      HDU20210
      IF (BR.LE.B(J)) GO TO 3                                           HDU2C220
    1 CONTINUE                                                          HDU20230
    2 WRITE (6,11) II,BR                                                HDU2C240
      J=J-11                                                            HDU2C250
      IF (B(I+1).EQ.2.) J=J-15                                          HDU20260
      WRITE (6,10) (B(I),I=J,K)                                         HDU2C270
      GO TO IER,(167)                                                   HDU20280
    3 R=B(J-5)+BR*(B(J-4)+BR*(B(J-3)+BR*(B(J-2)+BR*B(J-1))))            HDU20290
      RETURN                                                            HDU2C300
    4 A2=ALPHA                                                          HDU20310
      N=N+13                                                            HDU2C320
      K=K-15                                                            HDU2C330
      DO 5 J=N,K,19                                                     HDU20340
      IF (BR.GE.B(J).AND.BR.LE.B(J+19)) GO TO 6                         HDU2C350
    5 CONTINUE                                                          HDU20360
      GO TO 2                                                           HDU20370
    6 JS=J-3                                                            HDU2C380
      DO 9 I=1,2                                                        HDU2C390
      K=JS                                                              HDU20400
      KK=K-14                                                           HDU2C410
      DO 7 L=KK,K,2                                                     HDU2C420
      IF (A2.GE.B(L).AND.A2.LE.B(L+2)) GO TO 8                          HDU20430
    7 CONTINUE                                                          HDU2C440
      WRITE (6,12) A2,II,BR                                             HDU20450
      GO TO 2                                                           HDU2C460
    8 RA(I)=B(L+1)+(B(L-1)-B(L+1))*(A2-B(L+2))/(B(L)-B(L+2))            HDU2C470
    9 JS=JS+15                                                          HDU2C480
      R=RA(2)+(BR-B(J+19))*(RA(1)-RA(2))/(B(J)-B(J+19))                 HDU2C490
      RETURN                                                            HDU20500
   10 FORMAT (6E15.8)                                                   HDU2C510
   11 FORMAT (20H AERO EXCEEDED CODE=,I4,12H BREAK POINT,E15.8)         HDU20520
   12 FORMAT (10H ALPHA2 OF,E15.8,9H FOR TYPE,I4,12H BREAK POINT,E15.8) HDU2C530
  167 RETURN                                                            HDU2C540
      END                                                               HDU20550
      SUBROUTINE COA (PY,DPY)                                           HDU2C560
      DIMENSION PY(2), DPY(2)                                           HDU2C570
      COMMON /BDH/ REARTH, GC, AMTOMS, PO, AMTOF, FTOM, ANTOM, RTOD,    HDU20580
     1  CTOM, THCPHI, AMTOIN, AMTOKN, AMTOMH, FTOM2, CVDTOR, CVMTOR, RSQHDU2C590
     2  , HA(25), TM(25), ALP(25), HEAD(169)                            HDU20600
      J=2                                                               HDU20610
      T2=REARTH+PY(1)                                                   HDU2C620
      GPH=REARTH*PY(1)/T2                                               HDU20630
    1 IF (GPH.LE.HA(J)) GO TO 2                                         HDU20640
```

```
      J=J+1                                                             HDU2C650
      GO TO 1                                                           HDU20660
    2 J=J-1                                                             HDU2C670
      TEMP=TM(J)+ALM(J)*(GPH-HA(J))                                     HDU2C680
      DPY(2)=-.03416319474*PY(2)*RSQ/(TEMP*T2**2)                       HDU2C690
      RETURN                                                            HDU2C700
      END                                                               HDU20710
      BLCCK DATA                                                        HDU2C720
      COMMCN /BDH/ REARTH, GC, AMTOMS, PO, AMTOF, FTOM, ANTOM, RTOD,    HDU2C730
     1  DTOM, TWOPHI, AMTOIN, AMTOKN, AMTCMH, FTOM2, CVDTCR, CVMTCR, RSQHDU20740
     2  , HA(23), TM(23), ALM(22), HEAD(169)                            HDU2C750
      DATA REARTH, GC, AMTOMS, PO, AMTOF, FTCM, ANTOM, RTCD, DTOM, TWOPHHDU2C760
     1I, AMTCIN, AMTOKN, AMTCMH, FTOM2 /6.356766EC6, 9.80665, .44704, 1.HDU20770
     201325EC3, 3.280839895, .3048, .0254, 57.2957795, 17.7777778, 6.283HDU2C780
     3185307, 39.37007874, 1.943844492, 2.2365362S, .09290304/          HDU2C790
      DATA CVDTCR, CVMTOR /.01745329252, .0009817477044/                HDU2C800
      DATA RSC /4.0408473978756E13/                                     HDU2C810
      DATA HA /0., .11E5, .2E5, .32E5, .47E5, .52E5, .61E5,             HDU2C820
     1.79E5, .88743E5, .9E5, .1E6, .11E6, .12E6, .15E6, .16E6, .17E6, .1HDU2C830
     2SE6, .23E6, .3E6, .4E6, .5E6, .6E6, .7E6/                         HDU20840
      DATA TM /288.15, 216.65, 216.65, 228.65, 270.65, 270.65,          HDU20850
     1252.65, 180.65, 180.65, 180.65, 210.65, 260.65, 360.65, 960.65,   HDU2C860
     2 1110.65, 1210.65, 1350.65, 1550.65, 1830.65, 2160.65, 2426.65, 25HDU20870
     390.65, 2700.65/                                                   HDU2C880
      DATA ALM /-.0065, .C, .001, .0028, 0., -.002, -.004, 0.,          HDU2C890
     10., .003, .005, .01, .02, .015, .01, .007, .005, .004, .0033,     HDU20900
     2.0026, .0017, .0011/                                              HDU2C910
      DATA HEAD/169*4H    /                                             HDU2C920
C     DATA HEAD /7H   TIME, 6H    E1, 6H    E2, 6H    E3, 6             HDU2C930
C    1H     L, 8H  GAMMAV, 8H  GAMMAH, 7H   SPIN, 8H  ALPHAR, 10HPHI ALPHDU2C940
C    2HAR, 10H GYROSCOPI, 9HC DYNAMIC, 7H   CCDE, 7H    SEC, 6H     M, 6HDU2C950
C    3H     M, 6H     M, 8H   M/SEC, 7H    MIL, 7H    MIL, 9H  REV/SEC, HDU2C960
C    47H    DEG, 7H    DEG, 10H STABILITY, 10H STABILITY, 1H , 7H    SECHDU20970
C    5, 6H    FT, 6H    FT, 6H    FT, 8H  FT/SEC, 7H    DEG, 7H    DEG, HDU2C980
C    69H  REV/SEC, 7H    DEG, 7H    DEG, 10H STABILITY, 10H STABILITY, 1HDU2C990
C    7H , 7H   TIME, 10H  SIGMA N , 8H   EULEL, 8H   EULAZ, 9H  LAMBDAN,HDU21000
C    8 9H  LAMBDAP, 9H NLT RATE, 10H PREC RATE, 8H  THRUST, 8H  WEIGHT, HDU21010
C    96H    IX, 7H    X.X, 7H   CCDE, 7H    SEC, 7H    DEG, 7H    DEG, 7HDU21020
C    AH    DEG, 1CH 10**3/CAL, 1CH 10**3/CAL, 9H  RAD/CAL, 9H  RAD/CAL, HDU21030
C    B6H    LE, 6H    LB, 8H  LB-FT2, 1H , 1H , 7H    SEC, 7H    DEG, 7HHDU21040
C    C    DEG, 7H    DEG, 10H 10**3/CAL, 10H 10**3/CAL, 9H  RAD/CAL, 9H HDU21050
C    D RAD/CAL, 6H    LB, 6H    LB, 8H  LB-FT2, 1H , 1H , 7H   TIME, 6H HDU21060
C    E   U1, 6H    U2, 6H    U3, 8H  UDOT1, 8H  UDOT2, 8H  UDOT3, 10HHDU21070
C    F DRAG CCEF, 7H   MACH, 8H  WEIGHT, 6H    V, 1H , 7H   CODE, 7H   HDU21080
C    G SEC, 8H   M/SEC, 8H   M/SEC, 8H   M/SEC, 8H  M/SEC2, 8H  M/SEC2, HDU21090
C    H8H  M/SEC2, 6H    CD, 8H  NUMBER, 6H    LB, 8H   M/SEC, 1H , 1H / HDU21100
C     DATA HEAD /7H    SEC, 8H  FT/SEC, 8H  FT/SEC, 8H  F               HDU21110
C    1T/SEC, 8H FT/SEC2, 8H FT/SEC2, 8H FT/SEC2, 6H    CD, 8H  NUMBER, 6HDU21120
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C     2H    LB, 8H  FT/SEC, 1H , 1H , 5H        QE, 10H          O, 7HMEGAYHDU21130
C     3 O, 10H    CMEGAZ, 2H O, 6HTHRUST, 8H        C, 1H , 3H  L, 8H      HDU21140
C     4  C, 1H , 4H  UO, 7H   CODE, 10H        MIL, 1H , 7HRAD/SEC, 10H    HDU21150
C     5  RAD/S, 2HEC, 6HFACTOR, 10H    LB/IN2, 1H , 1H , 1H , 1H , 6H M/SHDU21160
C     6EC, 1H , 10H        MIL, 1H , 7HRAD/SEC, 10H     RAD/S, 2HEC, 6HFACHDU21170
C     7TOR, 10H    LB/IN2, 1H , 1H , 1H , 1H , 6HFT/SEC, 1H , 7H   TIME, HDU21180
C     86H    X1, 6H    X2, 6H    X3, 6H    U, 8H  GAMMAV, 8H  GAMMAH, 7HHDU21190
C     9   SPIN, 8H  ALPHAR, 10HPHI ALPHAR, 10H GYRCSCOPI, 9HC DYNAMIC, 7HHDU21200
C     A   CODE/                                                          HDU21210
      ENC                                                                HDU21220
      SUBROUTINE RKG (DELTA,N,DERIV,Y,DY,Q,J)                            HDU21230
      DIMENSION Y(N), DY(N), Q(N), C1(4), C2(4), C3(4)                   HDU21240
      IF (J-1) 3,1,3                                                     HDU21250
    1 DO 2 I=1,N                                                         HDU21260
    2 Q(I)=0.0                                                           HDU21270
      WRITE (6,200)                                                      HDU21280
      CALL DERIV (Y,DY)                                                  HDU21290
      RETURN                                                             HDU21300
    3 DO 5 I=1,4                                                         HDU21310
      DO 4 K=1,N                                                         HDU21320
      R=C1(I)*(DY(K)-C2(I)*Q(K))                                         HDU21330
      Y(K)=Y(K)+DELTA*R                                                  HDU21340
    4 Q(K)=Q(K)+3.0*R-C3(I)*DY(K)                                        HDU21350
      WRITE (6,200)                                                      HDU21360
      CALL DERIV (Y,DY)                                                  HDU21370
    5 CONTINUE                                                           HDU21380
  200 FORMAT (21H GONE TO DERIV FM RKG)                                  HDU21390
      RETURN                                                             HDU21400
      DATA C1(1), C1(2), C1(3), C1(4) /.5, .29289321881345 25, 1.70710678HDU21410
     1118654 12, .16666666666666667/                                     HDU21420
      DATA C2(1), C2(2), C2(3), C2(4) /2.0, 1.0, 1.0, 2.0/               HDU21430
      DATA C3(1), C3(2), C3(3), C3(4) /.5, .29289321881345 25, 1.70710678HDU21440
     1118654 12, .5/                                                     HDU21450
      END                                                                HDU21460
```

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