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USER'S GUIDE FOR A COMPUTER PROGRAM TO ANALYZE THE LRC 16' TRANSONIC DYNAMICS TUNNEL CABLE MOUNT SYSTEM

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BETHPAGE, NY

for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FOREWARD

This report is submitted to the NASA Langley Research Center in partial fulfillment of Master Agreement Contract NAS1-10635-9. This contract involves the formulation of a digital computing program to analyze the stability of models mounted on a two-cable mount system used in the LRC 16' transonic dynamics tunnel.

Mr. R. M. Bennett of the NASA Langley Research Center is the technical monitor. Mr. Eugene Baird of the Grumman Aerospace Corporation is the master agreement program manager, and Mr. Paul Barbero of Grumman is the project manager.

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SYMBOLS

a_c	coulomb friction static force
AKR	rear cable spring constant
b	wing span (reference)
$\bar{c}$	wing chord (reference)
C_D	drag coefficient (stability axis)
CG	referenced to center of gravity
C_l	rolling moment coefficient
C_L	left coefficient (stability axis)
C_m	pitching moment coefficient
C_{m_p}	rotational damping coefficient
C_n	yawing moment coefficient
CR	referenced to equation reference center
C_x	x force coefficient (body axis)
C_y	side force coefficient
C_z	z force coefficient (body axis)
F_x, F_y, F_z	external forces on model
$\bar{g}$	acceleration due to gravity
I_{ab}	inertias with respect to axis a, b at the equation reference center
$I_{ab_{CG}}$	inertias with respect to axis a, b at the center of gravity
K_{A_z}	vertical acceleration feedback gain
K_{ϕ}	roll rate feedback gain
K_{ψ}	yaw rate feedback gain
K_{θ}	pitch rate feedback gain
m	model mass
N_p	pulley normal force
p, P	model roll rate

q, Q	model pitch rate
$\bar{q}$	dynamic pressure
r, R	model yaw rate
S	model reference wing area
T	cable tension
T_F	front cable tension
T_R	rear cable tension
V_o	tunnel velocity
W	model weight
M, N, L	external moments on model
x, y, z	displacement coordinates of model
ϕ, θ, ψ	angular rotations around x, y and z axis respectively
α	angle of attack
α_{cd}	direction cosine between flying cable c and body axis d
β	angle of sideslip
δ_{ω}	roll control deflection
δ_e	pitch control deflection
δ_r	yaw control deflection
δ_a	roll control deflection
ω	model rotational rates
ρ	tunnel density

Stability derivatives are indicated by subscript notation. For example:

$$C_{L_\alpha} = \partial C_L / \partial \alpha$$

$$C_{n_p} = \partial C_n / \partial (pb/2V_o)$$

(see section 11.1, description of array AERO)

1.0 INTRODUCTION

In accordance with the requirements set forth under NASA Master Agreement NAS1-10635, Development and Implementation of Space Shuttle Structural Dynamics Modeling Technology-Task Order Number 9, Cable Mount System Study for Space Shuttle, the following report is submitted.

Contained in this report is a discussion of the theoretical derivation of the set of equations applicable to modeling the dynamic characteristics of aeroelastically-scaled models 'flown' on the two-cable mount system in the Langley Research Center 16' transonic dynamics tunnel. Also contained herein is a description of the computer program provided for the analysis.

The program will calculate model trim conditions as well as 3 DOF longitudinal and lateral/directional dynamic conditions for various flying cable and snubber cable configurations. Sample input and output is contained in Appendix B and C.

2.0 GENERAL PROGRAM DESCRIPTION

The digital computer program described in this report is used to analyze the rigid body stability and trim characteristics of models mounted on a 'two-cable mount system' presently used in the Langley Research Center 16' Transonic Dynamics Tunnel. The program is so structured as to allow model, tunnel and cable system parameters to be varied independently in order that their effects on model stability can be analyzed.

All program options, theoretical derivations, and data input formats will be explained in the body of this report. The following items are of special interest and will be explained in detail in the report:

- The trim routine will predict model angle of attack, pitch control deflection and all cable tensions and angles for any tunnel condition of interest to the investigator.

- Stability analysis is accomplished using 2 sets of 3 DOF uncoupled longitudinal and lateral/directional perturbation equations modeling both model aerodynamic effects and cable effects.

- Included in the stability analysis is the ability to investigate the effects of automatic stabilization using model stability augmentation. The general feedback loops provided allow stabilization using pitch, roll and yaw rate feedbacks to yaw, pitch and roll moment generators in the model.

- A root locus feature is built into the program allowing for automatic variation of any input parameter, producing trim variations plus a locus of roots for the longitudinal and/or lateral/directional dynamics.

- Four general cable configurations are included in the analysis: front and rear cables vertical, front and rear cables horizontal, front cable vertical and rear cable horizontal, front cable horizontal and rear cable vertical.

- The effects of both snubbed and unsnubbed snubbers on trim and stability have been included. The general snubber arrangement is a double 'V' shown in Figure 11.3. However, proper selection of input data will convert the snubber model into any snubber configuration presently envisioned.
- Provisions have been made to include the effects of one additional cable attached anywhere on the model.
- All aerodynamic data for the model is input in stability axis as 'point data' at a given mach number or as 'table data' where all coefficients are input across the mach number range in interest.
- All cable tie-down locations and model position are input in tunnel coordinates (station, water line, butt line).
- Normal program output includes the trim condition, the roots of the characteristic equations (longitudinal and/ or lateral/directional), damped natural frequency and damping ratio for each pair of complex roots and the time to half amplitude for real roots. Additional program output ,as a user option,is included for debugging purposes.

2.1 MAJOR PROGRAM SUBROUTINES

A general flow chart of the program is shown in Figure 2.1. The following comments are made in reference to that chart.

All input data for the initial case is read in first (input format described in Section 11). If table data is to be used, it must be read in on the first pass. If root locus is to be used, the proper value of the parameter to be varied is calculated in subroutine RUTLOC. The next step is to transform the input inertia and aerodynamic data to the equation reference axis in subroutine TRAN1 (Section 3.1 and 3.2). The model is then trimmed in subroutine TRIM described in Section 4.0. After completing the trim, the aero data is transformed to body axis in subroutine TRANS described in Section 3.3. Depending on the option selected by the user either longitudinal or lateral/directional or both stability calculations are made. These calculations are contained in subroutines LONG and LAT which are discussed in Sections 6.0 and 7.0. Upon returning from these subroutines, the root locus routine is entered if a parameter variation is in progress or a new case is initiated. Input data for a new case is discussed in Section 11.0.

The subroutines formulated to handle snubber effects (SNTRM, LONGSN, LATSN) are called from within the TRIM, LONG and LAT routines and are discussed in Section 8.0.

A description of the three main subprograms, TRIM, LONG, LAT, and their supporting subprograms are presented in Sections 4 , 6, and 7 respectively. The format used is a brief description of the purpose, the theory, some pertinent equations and a functional flow diagram for each subroutine. An exception to this approach is the theoretical development of the perturbation equations and the cable influence coefficient matrix. The development of the theory and equations in generalized form are presented in Section 5.

The particular applications of these generalized equations to the longitudinal and lateral directional analysis are then discussed in Sections 6 and 7 respectively.

The axis system used throughout the study is a conventional right-handed body axis fixed to the model with the origin at a point called the center of reference (cr). The positive x axis points forward out the nose of the model and the positive y axis is out the right wing. Figure 2.2 shows the axis system and a nomenclature of the various cable constraints.

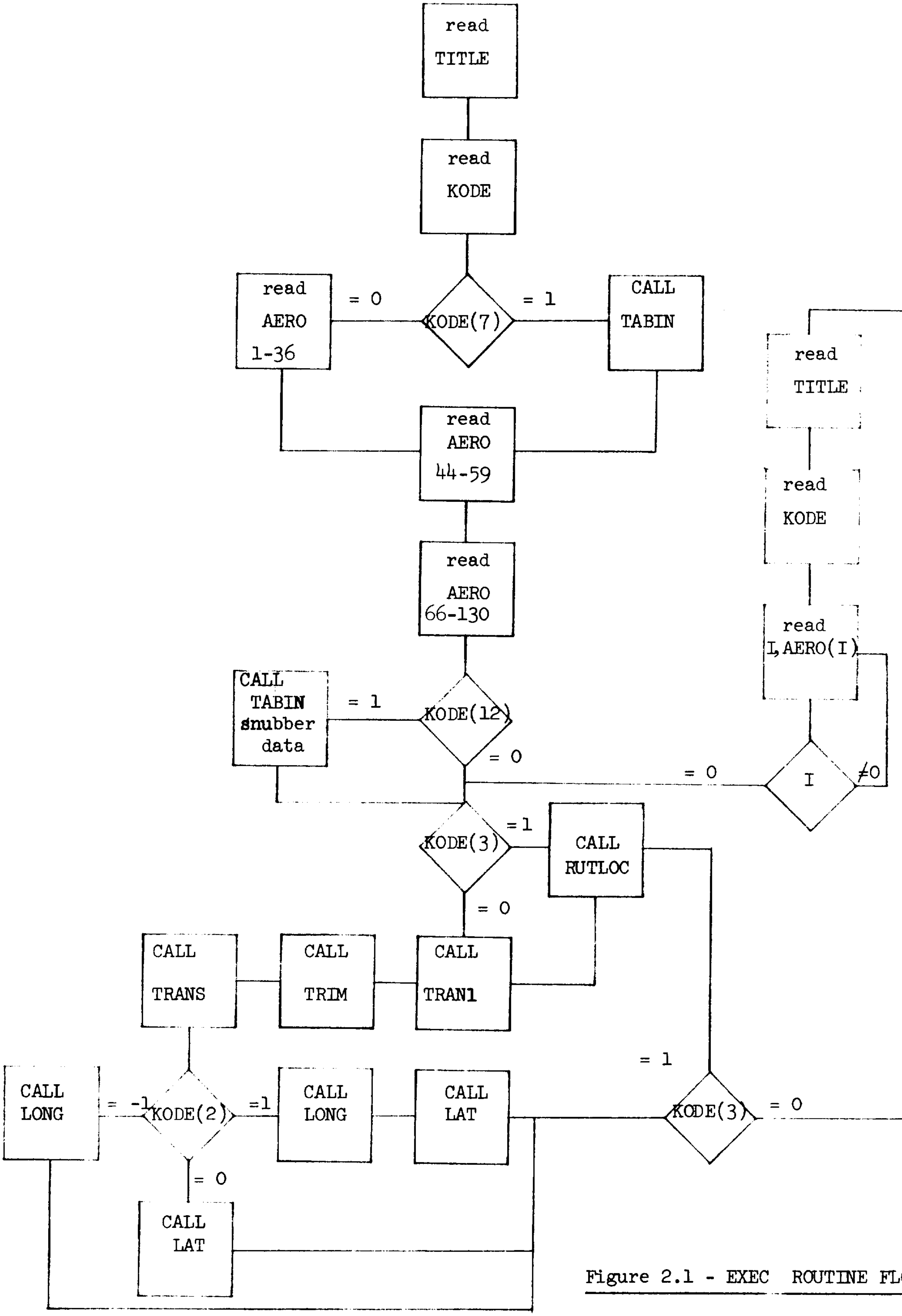
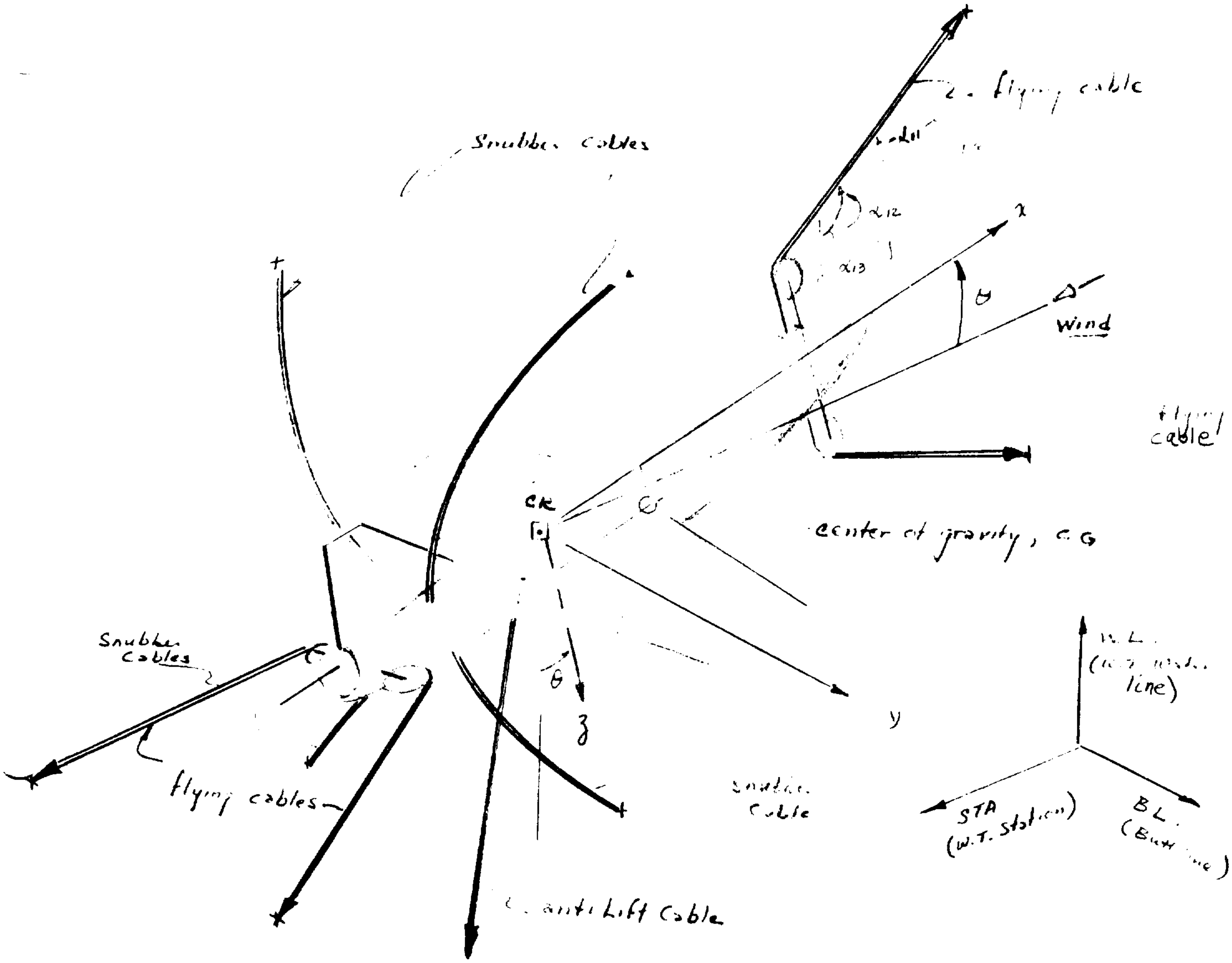


Figure 2.1 - EXEC ROUTINE FLOW CHART



STA, WL,BL - wind tunnel coordinates ~ stations (inches), water line (inches), butt line(inches)

x, y, z - body axis - fixed to the body

α (IC, J) - direction cosine angles, IC defines the cable and J defines the axis. e.g. α_{13} is the direction cosine angle from the z axis to the number 1 cable.

cr - origin of the body axis system, center of reference

C.G. - center of gravity

FIG. 2.2: AXIS AND CABLE DEFINITION

3.0 INERTIA AND AERODYNAMIC DERIVATIVE TRANSFORMATIONS

The program provides for general placement of the model mass center of gravity and the aerodynamic reference point. All force and moment equations have been written around the equation reference center which is located in terms of tunnel coordinates (STACR, WLCR, BLCR). All other reference points (center of gravity and aerodynamic reference) and pulley positions are located with respect to the reference center.

Since all equations are written with respect to the reference center, the inertias and aerodynamic data must be transformed to this center. This is done in subroutine TRAN1.

In addition to a reference center transformation, the aerodynamic derivatives must be transformed from stability to body axis. This is accomplished in subroutine TRANS.

3.1 INERTIA TRANSFORMATION

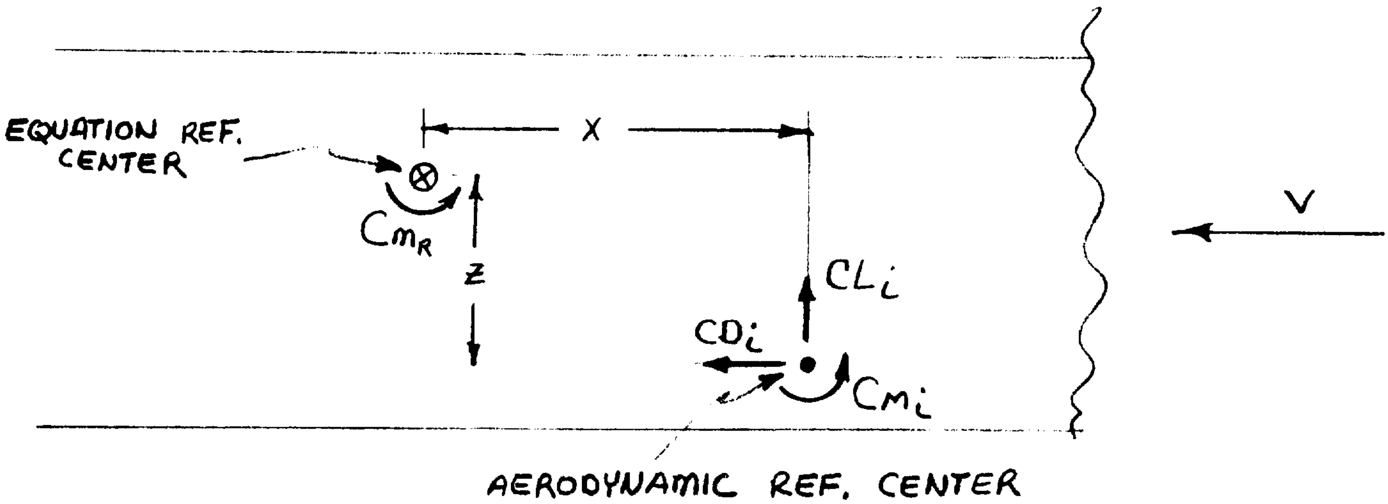
The classic inertia transformations, assuming constant model density, are used to transform mass moment of inertias from the center of gravity (inertias are input as body axis values at the center of gravity) to the equation reference center. The axis systems at the center of gravity and the equation reference center are parallel (both lie along the x-body axis) requiring only a translational transformation. It is also assumed that there is no lateral displacement between the center of gravity and the equation reference center. The resulting equations shown below are modeled in subroutine TRAN1 (Figure 3.1).

$$I_{xx} = I_{xx_{C.G.}} + x^2 m \qquad I_{zz} = I_{zz_{C.G.}} + z^2 m$$

$$I_{yy} = I_{yy_{C.G.}} + (x^2 + z^2)m \qquad I_{xz} = I_{xz_{C.G.}} - xzm$$

3.2 AERODYNAMIC REFERENCE TRANSFORMATION (Translation)

All aerodynamic moment effects must be transformed to the reference center. The following general theory is used in subroutine TRAN1 to accomplish the transformation.



Referring to the above figure:

$$Cm_R = Cm_i - \frac{z}{c} CD_i + \frac{x}{c} CL_i$$

A similar situation exists for lateral and directional moment derivatives.

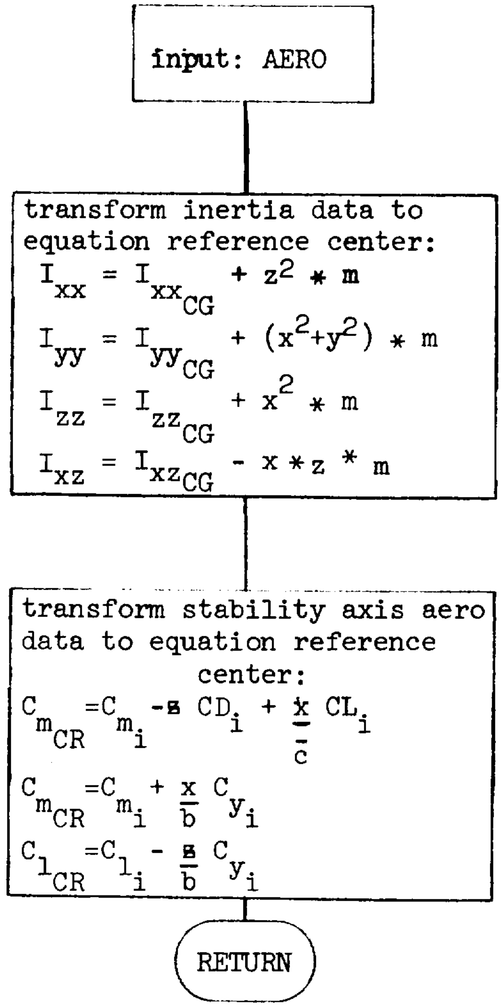
$$C_{n_R} = C_{n_i} + \frac{x}{b} C_{y_i}$$

$$C_{l_R} = C_{l_i} - \frac{z}{b} C_{y_i}$$

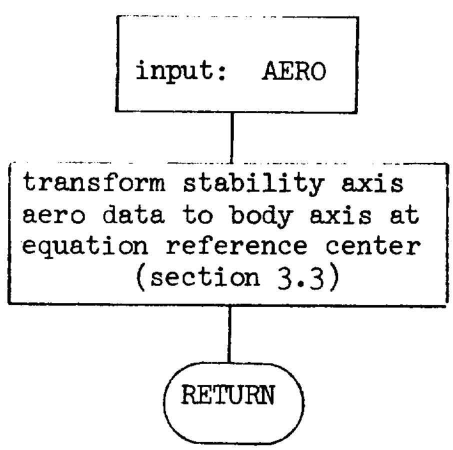
The force derivatives are not effected by a translational shift in axis systems.

3.3 AERODYNAMIC TRANSFORMATION FROM STABILITY TO BODY AXIS (Rotational)

Once the aero data is referenced to the reference center it is then transformed from the stability axis input form to the body axis form necessary for stability calculations. This is accomplished in subroutine TRANS. The transformation equations were taken directly from 'Aircraft Motion Analysis' by Thelander, pgs. 57-58. A flow chart of subroutine TRANS is shown in Figure 3.1.



SUBROUTINE TRAN1



SUBROUTINE TRANS

FIGURE 3.1 - FLOW CHART - TRAN1 AND TRANS

4.0 TRIM ANALYSIS

4.1 Subroutine TRIM

The function of this subprogram is to determine the vehicle trim attitude for a given initial rear cable tension, T_{Ro}. The outputs of the program are the trim attitude, θ, trim elevator deflection, δ_e, and the geometry and tensions of the flying and antilift cable system. The model may be trimmed at any water line and station specified. The equation reference center (STACR, WLCR) is used to position the model in the tunnel.

The subprogram defines trim as the point where the following three requirements on the longitudinal equations of motion are satisfied:

$$\begin{aligned} a_z &= \frac{1}{m}\Sigma F_z = 0 \\ a_x &= \frac{1}{m}\Sigma F_x = 0 \\ \ddot{\theta} &= \frac{1}{I_y}\Sigma M_y = 0 \end{aligned} \qquad (4.1 - 1)$$

The variables in this set of equations are θ, δ_e and T_F, the front cable tension. The T_F is a variable because the front cable is fixed in length and the tension must necessarily adjust to satisfy the constraint.

A numerical iterative technique is used to trim the system of cable and model forces. The procedure is based on the following formulation for convergence.

The forces and moments of equation 4.1-1 are expanded using the Taylor's expansion:

$$\begin{aligned} \Sigma F_z &= F_{zo} + \frac{\partial F_z}{\partial \theta}\Delta\theta + \frac{\partial F_z}{\partial \delta_e}\Delta\delta_e + \frac{\partial F_z}{\partial T_F}\Delta T_F \\ \Sigma F_x &= F_{xo} + \frac{\partial F_x}{\partial \theta}\Delta\theta + \frac{\partial F_x}{\partial \delta_e}\Delta\delta_e + \frac{\partial F_x}{\partial T_F}\Delta T_F \\ \Sigma M_y &= M_{yo} + \frac{\partial M_y}{\partial \theta}\Delta\theta + \frac{\partial M_y}{\partial \delta_e}\Delta\delta_e + \frac{\partial M_y}{\partial T_F}\Delta T_F \end{aligned} \qquad (4.1\text{-}2)$$

Equation 4.1-2 must be equated to zero to satisfy trim.

$$\begin{bmatrix} \frac{\partial F_z}{\partial \alpha} & \frac{\partial F_z}{\partial \delta_e} & \frac{\partial F_z}{\partial T_F} \\ \frac{\partial F_x}{\partial \alpha} & \frac{\partial F_x}{\partial \delta_e} & \frac{\partial F_x}{\partial T_F} \\ \frac{\partial M_y}{\partial \alpha} & \frac{\partial M_y}{\partial \delta_e} & \frac{\partial M_y}{\partial T_F} \end{bmatrix} \begin{Bmatrix} \Delta\theta \\ \Delta\delta_e \\ \Delta T_F \end{Bmatrix} = \begin{bmatrix} A \end{bmatrix} \begin{Bmatrix} \Delta\theta \\ \Delta\delta_e \\ \Delta T_F \end{Bmatrix} = \begin{Bmatrix} -F_{zo} \\ -F_{xo} \\ -M_{yo} \end{Bmatrix} \quad (4.1\text{-}3)$$

Inverting matrix A will define the required incremental change to the variables θ, δ_e, and T_F to satisfy trim. i.e.

$$\begin{Bmatrix} \Delta\theta \\ \Delta\delta_e \\ \Delta T_F \end{Bmatrix} = \begin{bmatrix} A \end{bmatrix}^{-1} \begin{Bmatrix} -F_{zo} \\ -F_{xo} \\ -M_{yo} \end{Bmatrix} \quad (4.1\text{-}4)$$

The logic in the TRIM subprogram, shown in Figure 4.1, is to compute the initial forces and moments (F_{zo}, F_{xo}, M_{yo}), and determine whether the trim requirement, is satisfied. If not, the program computes the set of partials in eq. 4.1-3 , inverts the matrix A and determines the increments $\Delta\theta$, $\Delta\delta_e$, and ΔT_F. The variables are modified and the forces and moments recomputed.

The Model is assumed to remain stationary in translation during the trim procedure. This assumption violates the constant front cable length constraint, however, the translation associated with attitude changes is negligible relative to the overall front cable length.

If the trim requirement has not been satisfied after 100 iteration cycles, the TRIM subprogram will print out a note to this effect and the last set of θ, δ_e and T_F is assumed in the continuation of the program.

4.2 Subroutine EQU

This subprogram is called by the subroutine TRIM. Its function is to generate the longitudinal forces and moments. Each time this routine is called, it establishes the cable geometry, then computes and sums the force and moment contributions due to aerodynamics, vehicle weight and the system of cables.

The input to this subprogram are the variables θ, δ_e and T_F. The basic equations are:

$$\Sigma F_z = F_{z_{aero}} + F_{z_{front\ cable}} + F_{z_{rear\ cable}} + F_{z_{\substack{anti\text{-}lift\\ cable}}} + F_{z_{snubber}} + W * \cos\theta$$

$$\Sigma F_x = F_{x_{aero}} + F_{x_{front\ cable}} + F_{x_{rear\ cable}} + F_{x_{\substack{anti\text{-}lift\\ cable}}} + F_{x_{snubber}} - W * \sin\theta \tag{4.2-1}$$

$$\Sigma M_y = M_{y_{aero}} + M_{y_{front\ cable}} + M_{y_{rear\ cable}} + M_{y_{\substack{anti\text{-}lift\\ cable}}} + M_{y_{snubber}} + M_{y_{wgt}}$$

The contribution, $M_{y_{wgt}}$, shown here is a necessary term since the moments are taken about a point other than the center of gravity location.

The aerodynamic forces and moment are determined as follow:

$$\text{Lift} = L = qS(C_{L_o} + C_{L_\alpha}\,\theta + C_{L_{\delta_e}}\,\delta_e) \tag{4.2-2}$$

$$\text{Drag} = D = qS(C_{D_o} + C_{D_\alpha}\,\theta + C_{D_{\delta_e}}\,\delta_e)$$

$$F_{z_{aero}} = -(L\cos\theta + D\sin\theta)$$

$$F_{x_{aero}} = -(D\cos - L\sin\theta)$$

$$M_{y_{aero}} = qS\bar{c}(C_{m_o} + C_{m_\alpha}\,\theta + C_{m_{\delta_e}}\,\delta_e)$$

The anti-lift cable forces and moments are determined by computing the forces in the wind tunnel axis (an axis aligned with the wind tunnel) and then transforming them to the rotated body axis. Along the wind tunnel axis, the F_{xt} and F_{zt} are computed as follows:

$$F_{zt} = FZLTT = TLFT * \cos \alpha_{ZWT}$$
$$F_{xt} = FXLTT = TLFT * \cos \alpha_{XWT} \qquad (4.2\text{-}3.1)$$

where α_{WT} are direction cosine with respect to the wind axis and TLFT is the anti-lift cable tension force defined by the equation:

$$TLFT = T\,LFTO + AKLFT\,(\ell - \ell_o) \qquad (4.2\text{-}3.2)$$

AKLFT here is the spring constant, TLFTO is the initial tension corresponding to initial cable length, ℓ_o. Converting these forces to the body axis we have:

$$F_{x_{\text{anti-lift}}} = F_{xt} \cos\theta - F_{zt} \sin\theta$$
$$F_{z_{\text{anti-lift}}} = F_{zt} \cos\theta - F_{xt} \sin\theta \qquad (4.2\text{-}4.1)$$

The anti-lift cable moment is easily obtained since the attachment point relative to the center of reference is known (ALTX, ALTZ). Thus:

$$M_{y_{\text{anti-lift}}} = F_{x_{\text{anti-lift}}} * ALTZ - F_{z_{\text{anti-lift}}} * ALTX \qquad (4.2\text{-}4.2)$$

The flying cable forces and moments along the body axis are directly computed since the direction cosines between each cable and the body axis were computed in subprograms FPLYV and RPLYH. Thus:

$$F_{X_F} = T_F\,(\cos\alpha_{11} + \cos\alpha_{21})$$
$$F_{Z_F} = T_F\,(\cos\alpha_{13} + \cos\alpha_{23}) \qquad (4.2\text{-}5.1)$$
$$F_{X_R} = T_R\,(\cos\alpha_{31} + \cos\alpha_{41})$$
$$F_{Z_R} = T_R\,(\cos\alpha_{33} + \cos\alpha_{43})$$

The subscripts of the direction cosine refer to the cable and the axis in question. The two front flying cables are designated as 1 and 2 and the two aft flying cables are designated as 3 and 4. The body axis x, y, z is referred to numerically as 1, 2, and 3. Thus Cos α_{13} is the direction cosine of the number one front cable with respect to the z-body axis. The rear tension force, T_R, is defined by the following equation.

$$T_R = T_{Ro} + AKR\ (\ell_R - \ell_{Ro}) \qquad (4.2\text{-}5.2)$$

where T_{Ro} is the initial cable tension corresponding to ℓ_{Ro}, ℓ_{Ro} being the summation of the initial lengths of cables 3 and 4. AKR and ℓ_R are respectively the rear cable spring constant and the instantaneous summed cable lengths of cables 3 and 4.

A derivation of the generalized cable force and moment is presented in Section 5.4.

The flying cable moments are obtained via the following equation:

$$M_{cable} = \sum_{i=1}^{4} \bar{x}_i * \bar{F}_i \qquad (4.2\text{-}6)$$

where $\bar{x}_i$ corresponds to the moment arm from the center of rotation to the point of action of the force $\bar{F}$. The components of $\bar{x}_i$ are computed in subroutines FPLYV and RPLYH.

Figure 4.2 presents a functional flow diagram of the subroutine EQU.

4.3 SUBROUTINE FPLYV

The function of this subroutine is to compute the geometry of a set of vertically configured flying cables.

The inputs to this program are:

1. The location of the cable attachment points to the wind tunnel wall
2. The location of the vehicle in the tunnel
3. The vehicle attitude
4. The pulley size
5. The pulley location on the model

The outputs of this program are the following geometric information for the upper and lower cables:

1. A set of direction cosine angles defining the cable orientation in space relative to the body axis (noted as ADC in the program)

2. A set of coordinates locating the point of action of the cable tension force (noted as ARM in the program)

3. The cable length (noted as XLGTH in the program)

Figure 4.3 defines the geometric nomenclature and some of the equations in the subroutine. The equations show the derivation for the cable length and the angle BETAU for the upper cable. Similar computation will define the length and the angle BETAL of the lower cable. Direction cosine angles of each of these cables can be derived from the angles BETAU, BETAL and the vehicle attitude θ. The coordinates of the point of action are also readily computed. The equations for the upper front cable are presented as an example.

Direction Cosines:

$$\begin{aligned} \alpha_{1x} &= \text{ADC}(1,1) = -\beta_u + \theta \\ \alpha_{1y} &= \text{ADC}(1,2) = \pi/2 \\ \alpha_{1z} &= \text{ADC}(1,3) = \pi/2 - \alpha_{1x} \end{aligned} \tag{4.3-1}$$

Point of Action:

$$\begin{aligned} x_p &= \text{ARM}(1, 1) = \text{EP} - \text{RAD} * \sin \alpha_{1x} \\ y_p &= \text{ARM}(1, 2) = 0 \\ z_p &= \text{ARM}(1, 3) = \text{HUU} + \text{RAD} * \cos \alpha_{1x} \end{aligned} \tag{4.3-2}$$

A functional flow diagram of this subroutine is presented in Figure 4.4.

4.4 SUBROUTINE RPLYH

The purpose of this subroutine is to define the geometry of a set of horizontally configured flying cables.

The inputs required for this subroutine are:

1. The location of the cable attachment points to the wind tunnel wall
2. The location of the model in the tunnel
3. The attitude of the model
4. The pulley size
5. The pulley location on the model

The output of this program is the following geometric information for each of the port and starboard flying cables.

1. A set of direction cosine angles defining the cable orientation with respect to the model body axis (noted as ADC in the program)
2. A set of coordinates locating the cable force point of action (noted as ARM in the program)
3. The cable length (noted as XLGTH)

Figure 4.5 defines the geometric nomenclature used in this subroutine. Figure 4.6 presents a functional flow chart of the program logic.

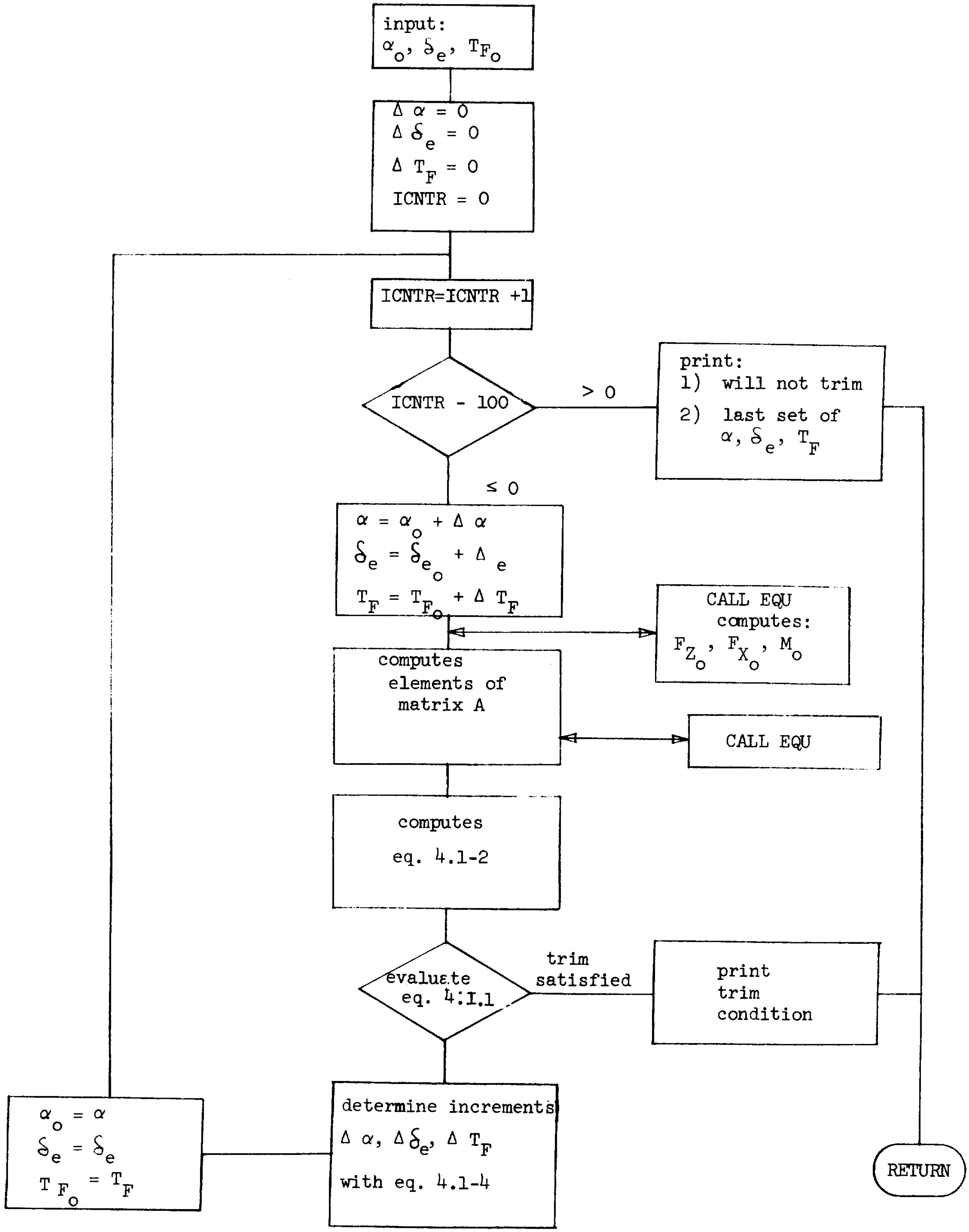


FIGURE 4.1 - FLOW CHART - SUBROUTINE TRIM

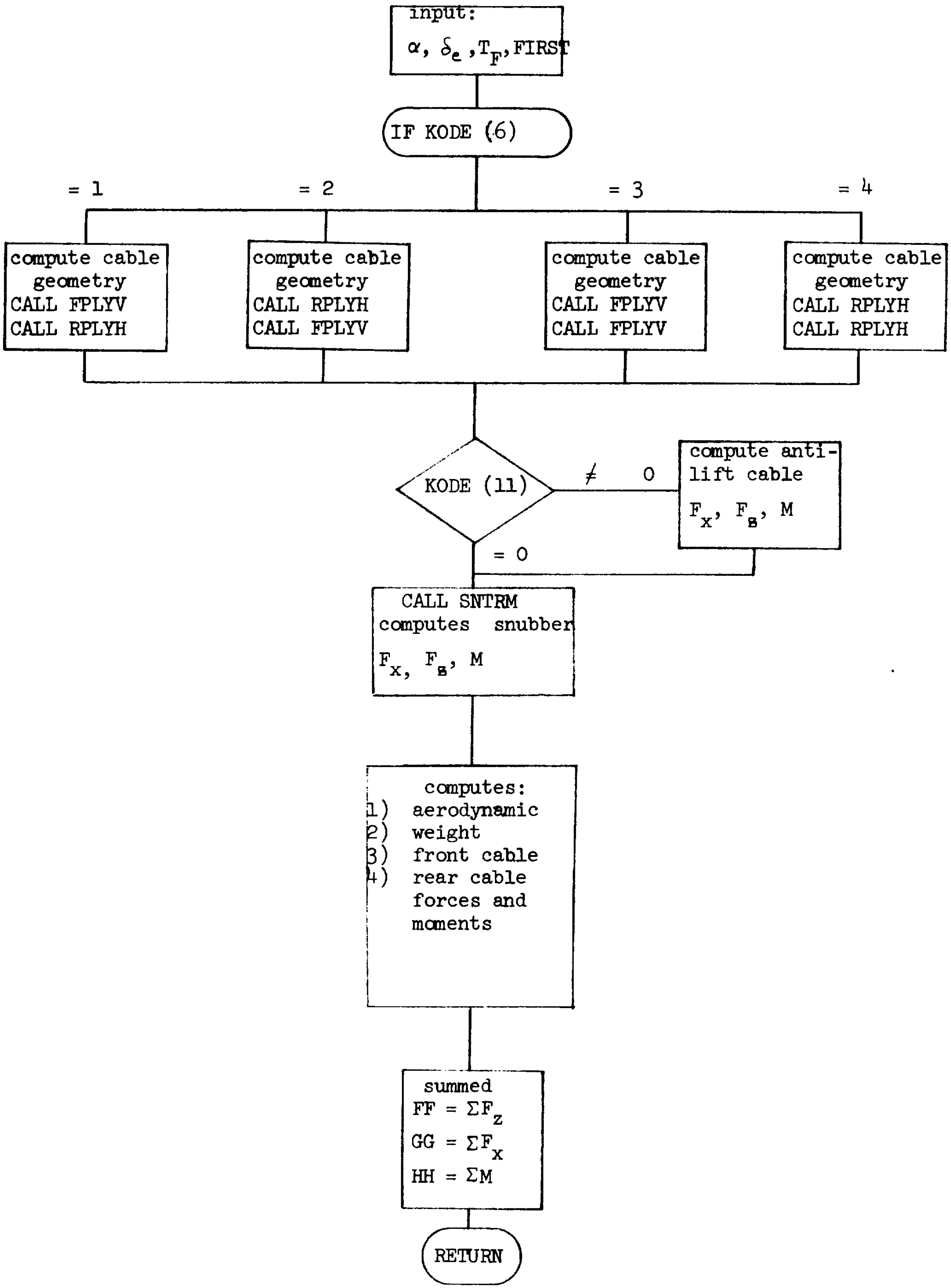
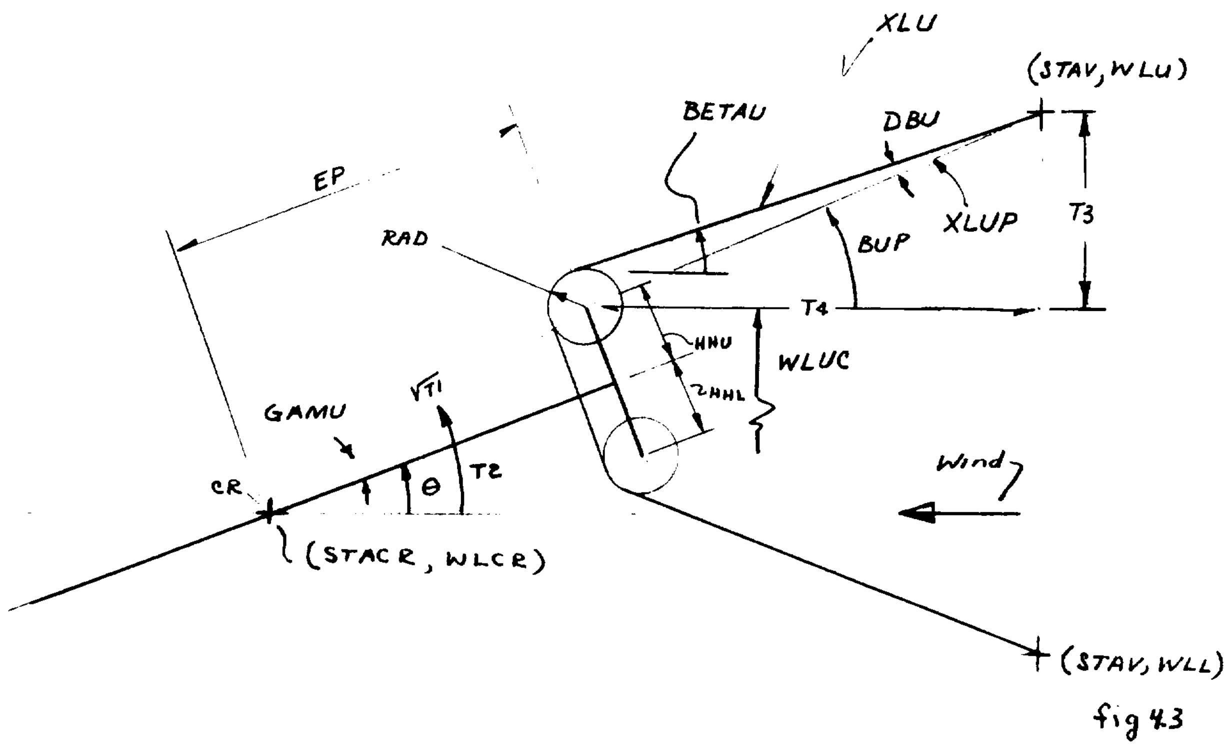


FIGURE 4.2 - FLOW CHART - SUBROUTINE EQU



$$GAMU = \tan^{-1}(HHU/EP)$$

$$T_1 = EP^2 + HHU^2$$

$$WLUC = LWCR + T_1 * SIN\,(GAMU + \theta)$$

$$T_3 = WLU - WLUC$$

$$T_4 = (STACR\text{-}STAV) - T_1 {}^* Cos\,(GAMU + \theta)$$

$$BUP = \tan^{-1}(T_3/T_4)$$

$$XLUP = (T_3{}^2 + T_4{}^2)^{1/2}$$

$$\text{Length of Cable} = XLU = (XLUP^2 - RAD^2)^{1/2}$$

$$DBU = \tan^{-1}(RAD/XLU)$$

$$BETAU = (BUP\text{-}DBU)$$

FIG. 4.3 - GEOMETRIC DEFINITIONS AND EQUATIONS

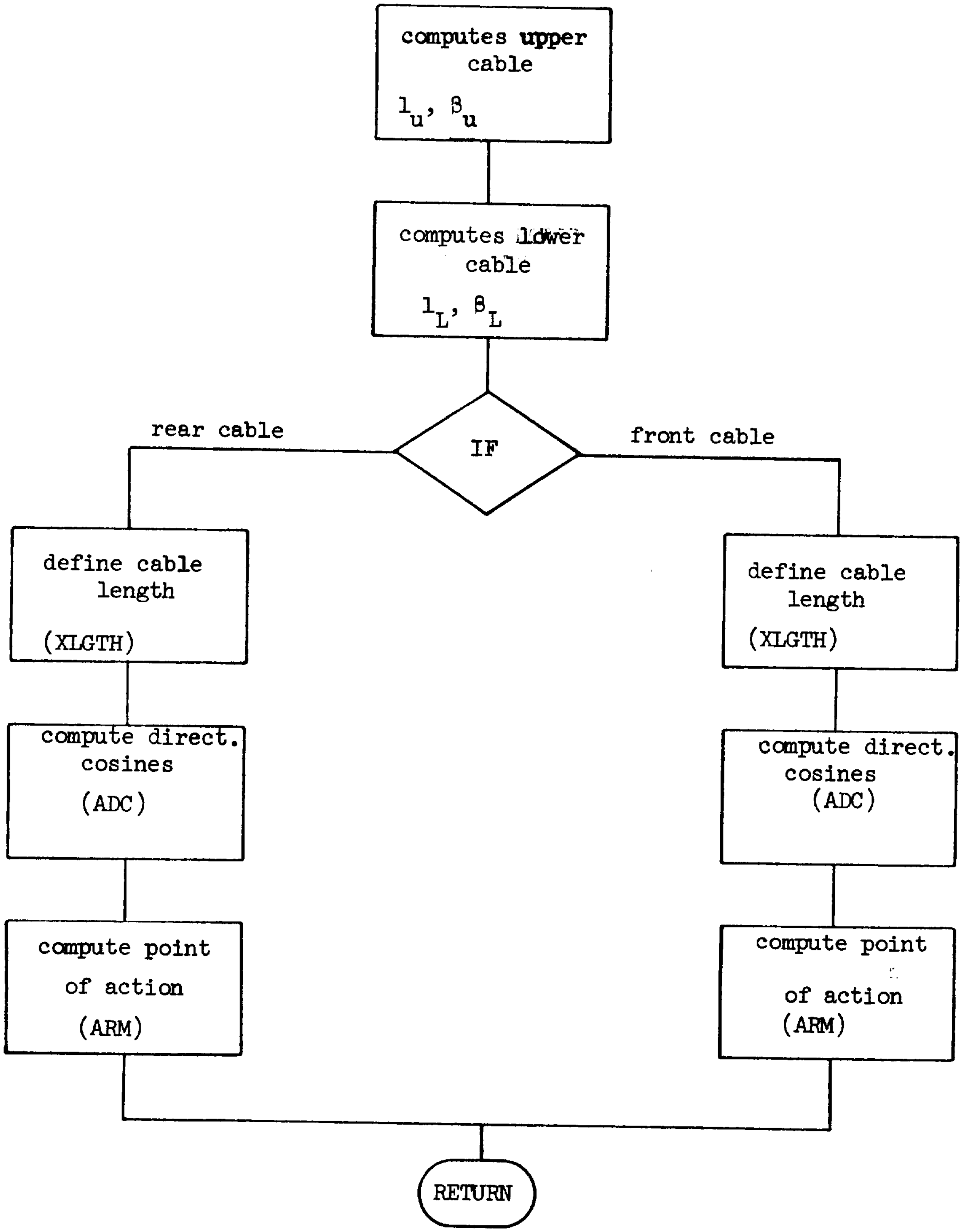
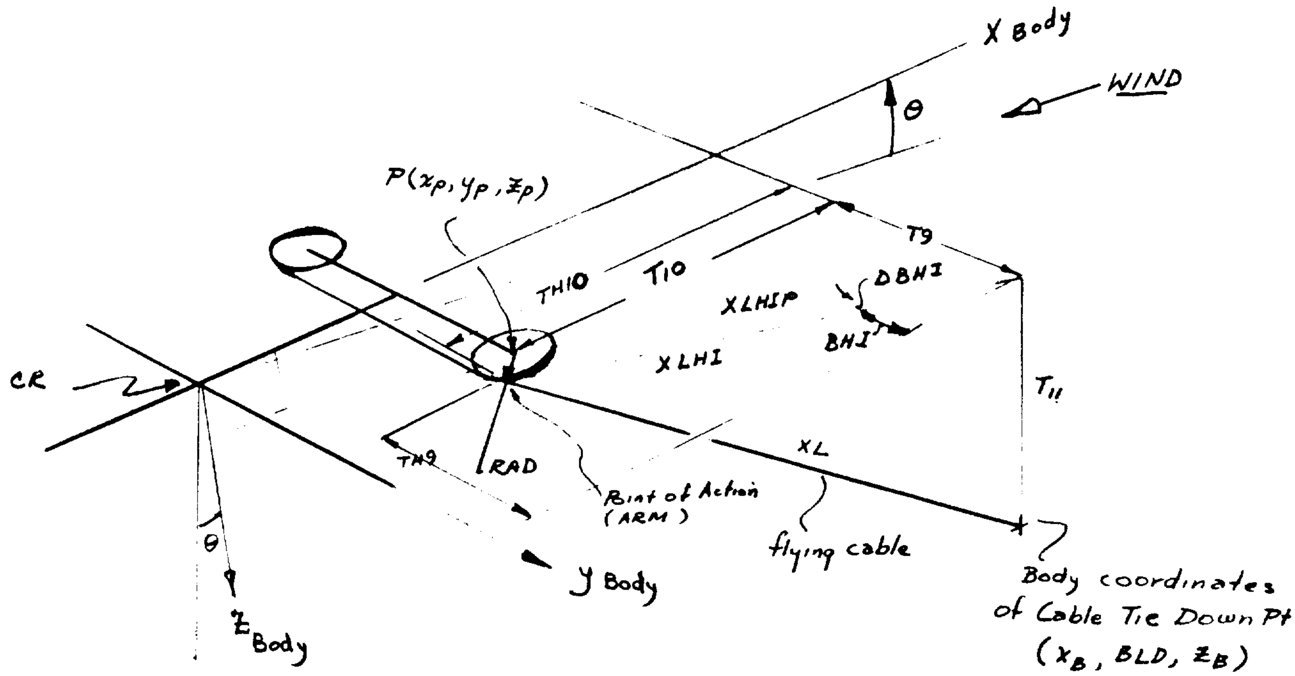


FIGURE 4.4 - FLOW CHART - SUBROUTINE FPLYV



x_p, y_p, z_p - body axis coordinates of pulley

X_B, BLD, Z_B - body axis coordinate of cable attachment point

XL - length of cable - inches

XLHI - projection of cable onto X_{body} - Y_{body} plane

RAD - pulley radius ~ inches

FIG. 4.5 - DEFINITION OF GEOMETRIC NOMENCLATURE

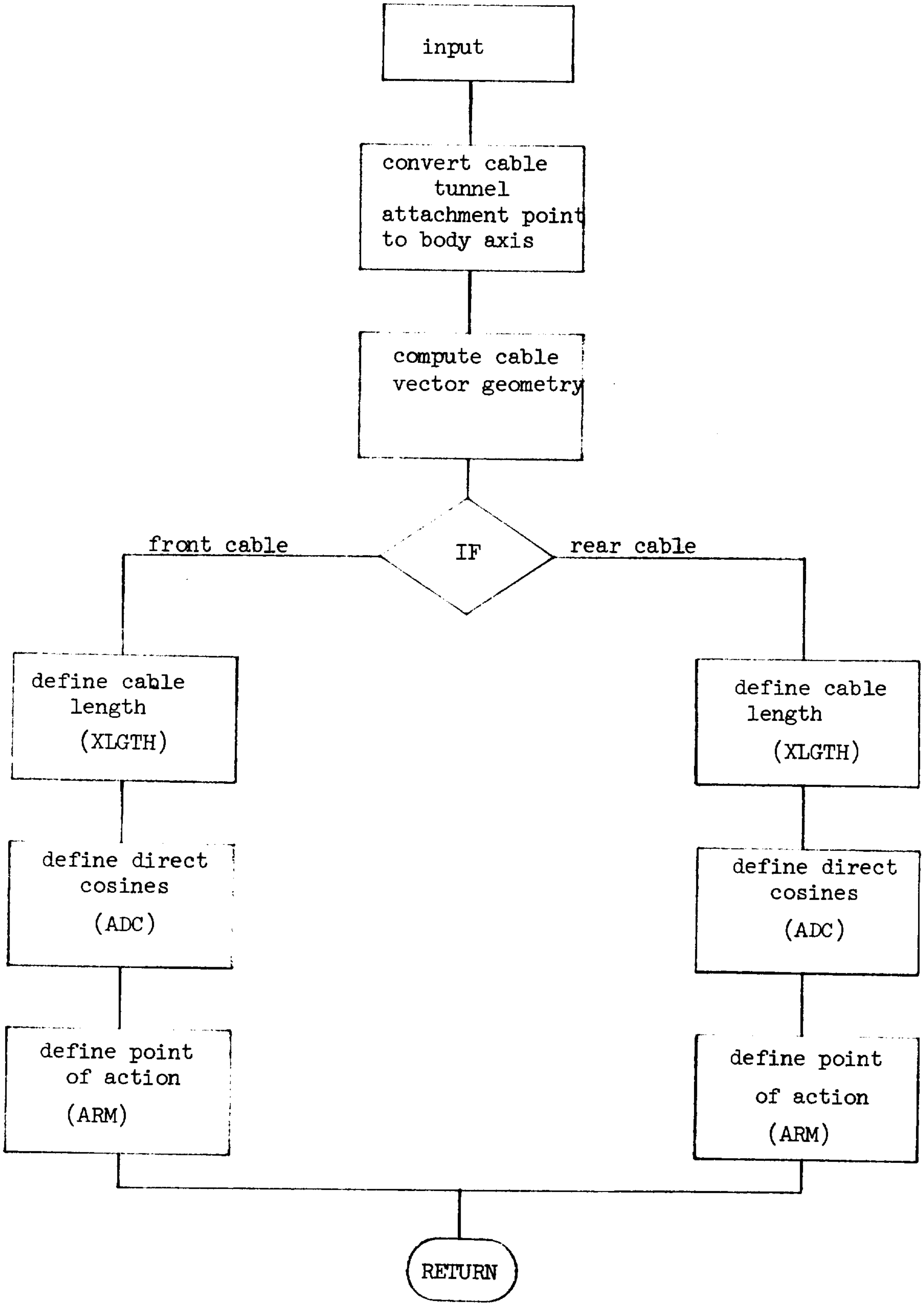


FIGURE 4.6 - FLOW CHART - SUBROUTINE RPLYH

5.0 THEORETICAL DEVELOPMENT OF THE PERTURBED EQUATIONS OF MOTION FOR A CABLE SUSPENDED MODEL IN A WIND TUNNEL

The development is divided into four sub-sections. The first section presents a derivation of the linearized equations of motion. The following sections describe the derivation of the force and moment contributions due to the vehicle weight, aerodynamics and cable forces respectively.

5.1 DERIVATION OF LINEARIZED EQUATIONS OF MOTION

The linearized equation of motion is derived about the center of reference, "CR", rather than the center of gravity. The relative location is defined by the vector, $\bar{r}$, as shown in Figure 5.1. $\bar{F}_{CR}$ and $\bar{M}_{CR}$ are the total force and moment less the weight contribution about point CR. Writing the equation of motion about the center of gravity:

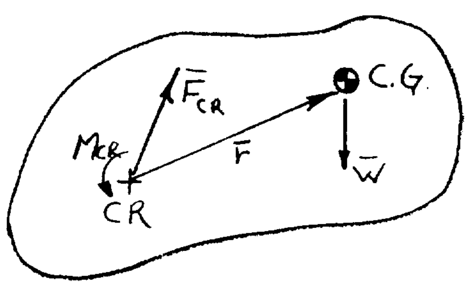


Fig. 5.1

$$\bar{F}_{CR} + m\bar{g} = m\bar{a}_{CG} \qquad (5.1\text{-}1)$$

$$\bar{M}_{CR} - \bar{r} \times \bar{F}_{CR} = \frac{d}{dt}\bar{H} \qquad (5.1\text{-}2)$$

$\bar{a}$ and $\bar{H}$ are the translational acceleration and the angular momentum vector respectively.

The following relationships are noted for a rigid body

Displacement: $\quad \bar{X}_{CG} = \bar{X}_{CR} + \bar{r} \qquad (5.1\text{-}3)$

Rate: $\quad \bar{V}_{CG} = \bar{V}_{CR} + \bar{\omega} \times \bar{r} \qquad (5.1\text{-}4)$

Acceleration: $\quad \bar{a}_{CG} = \bar{a}_{CR} + \dot{\bar{\omega}} \times \bar{r} + \bar{\omega} \times (\bar{\omega} \times \bar{r}) \qquad (5.1\text{-}5)$

$$\bar{\omega}_{CG} = \bar{\omega}_{CR}$$

where $\bar{\omega}$ is the rotation vector of the model.

Substituting equation 5.1- 5 into equation 5.1-1, we have:

$$\boxed{\bar{F}_{CR} + m\,(\bar{g} - \dot{\bar{\omega}} \times \bar{r}) - m\bar{\omega} \times (\bar{\omega} \times \bar{r}) = m\,\bar{a}_{CR}} \qquad (5.1\text{-}6)$$

noting again that

$$\bar{H}_{CR} = \bar{H}_{CG} + m\,\bar{r} \times \frac{d\bar{r}}{dt} \qquad (5.1\text{-}7)$$

or

$$\bar{H}_{CR} = \bar{H}_{CG} + m\,\bar{r} \times \cancelto{0}{\dot{\bar{r}}} + \bar{\omega} \times \bar{r} \qquad (5.1\text{-}8)$$

and

$$\frac{d\bar{H}_{CR}}{dt} = \frac{d\bar{H}_{CG}}{dt} + m\,\bar{r} \times (\dot{\bar{\omega}} \times \bar{r} + \bar{\omega} \times (\bar{\omega} \times \bar{r})) \qquad (5.1\text{-}9)$$

Equations 5.1-6 and 5.1-9 can be solved for $\bar{F}_{CR}$ and $\bar{H}_{CG}$ respectively, and the results substituted into equation 5.1-2. Cancelling like items on both sides of the equation reduces 5.1-2 to:

$$\boxed{\bar{M}_{CR} - m\;\bar{r} \times (\bar{a}_{CR} - \bar{g}) = \frac{d\bar{H}_{CR}}{dt}} \qquad (5.1\text{-}10)$$

Equations 5.1-6 and 5.1-10 represent the equation of motion about the point, "CR".

Equation 5.1-6 can further be simplified by noting that the initial rates and accelerations are zero because the vehicle is statically trimmed in the tunnel. The $\bar{\omega}$ must necessarily be a perturbation vector and $\bar{\omega} \times (\bar{\omega} \times \bar{r})$ represents a higher order term which will be ignored in the linearizing of the equation. Equations 5.1-6 and 5.1-10 can now be written in the form:

$$\bar{F}_{CR} + m(\bar{g} - \dot{\bar{\omega}} \times \bar{r}) = m\,(\dot{\bar{V}} + \bar{\omega} \times \bar{V})_{CR} \qquad (5.1\text{-}11)$$

$$M_{CR} + m[\bar{r} \times (\bar{g} - \bar{a}_{CR})] = (\dot{\bar{H}} + \bar{\omega} \times \bar{H})_{CR} \qquad (5.1\text{-}12)$$

These results show that to study perturbation motion about a point other than the center of gravity, the form of the pseudo linearized equation of motion is similar to that about the C.G. except for the gravity terms which are modified by $\dot{\bar{\omega}}$ and $\bar{a}_{CR}$.

Expanding the right hand side of equations 5.1-11 and 5.1-12 and assuming symmetry about the x-z plane, we have

$$\begin{aligned}
\Sigma F_x &= m\,(\dot{U} - RV + QW) \\
\Sigma F_y &= m\,(\dot{V} - PW + RU) \\
\Sigma F_z &= m\,(\dot{W} - QU + PV) \\
\Sigma L &= \dot{P}I_x - (\dot{R} + PQ)\,I_{xz} - QR\,(I_y - I_z) \\
\Sigma M &= \dot{Q}I_y - (R^2 - P^2)\,I_{xz} - RP\,(I_z - I_x) \\
\Sigma N &= \dot{R}\,I_z - (\dot{P} - QR)\,I_{xz} - PQ\,(I_x - I_y)
\end{aligned} \tag{5.1-13}$$

The nomenclature in Eq 5.1-13 are used in the conventional manner. If each of the variables U,V,W, and P, Q, R are replaced by a steady state term plus an increment, e.g. $X = X_o + \Delta X$: the expressions expanded and then noting that all the steady state terms are zero. 5.1-13 is simplified to

$$\begin{aligned}
\Sigma F_x &= m\dot{u} \\
\Sigma F_y &= m\dot{v} \\
\Sigma F_z &= m\dot{w} \\
\Sigma L &= \dot{p}\,I_x + \dot{r}\,I_{xz} \\
\Sigma M &= \dot{q}\,I_y \\
\Sigma N &= \dot{r}\,I_z - \dot{p}\,I_{xz}
\end{aligned} \tag{5.1-14}$$

Returning to equation 5.1-11 and expanding the left hand side of the equation

$$\overline{F}_{CR} + \Delta\overline{F}_{CR} + m\,(\overline{g}_o + \Delta\overline{g} - (\dot{\overline{\omega}}_o + \dot{\overline{\omega}}) \times \overline{r}) = m\dot{\overline{v}} \tag{5.1-15}$$

we find that due to trim

$$\overline{F}_{CR} + \overline{mg}_o = 0,\ \dot{\overline{\omega}}_o = 0 \tag{5.1-16}$$

the perturbed force equation is thus:

$$\Delta\bar{F}_{CR} + m\,(\Delta\bar{g} - \bar{\omega} \times \bar{r}) = m\,\dot{\bar{v}} \qquad (5.1\text{-}17)$$

or

$$\Delta\bar{F}_{CR} + \Delta\bar{W} = m\,\dot{\bar{v}} \qquad (5.1\text{-}18)$$

The perturbed moment equation 5.1-12 can be similarly derived:

$$\bar{M}_{CR} + \Delta\bar{M}_{CR} + m\left[\bar{r}\;x(\bar{g}_o + \Delta\bar{g} + \dot{\bar{v}})\right] = \dot{\bar{H}} \qquad (5.1\text{-}19)$$

For trim

$$\bar{M}_{CR} + m\,\bar{r} \times \bar{g}_o = 0$$

thus

$$\Delta\bar{M}_{CR} + m\,[\bar{r} \times (\Delta\bar{g} - \dot{\bar{v}})] = \dot{\bar{H}} \qquad (5.1\text{-}20)$$

or

$$\Delta\bar{M}_{CR} + \Delta\bar{M}_{wgt} = \dot{\bar{H}} \qquad (5.1\text{-}21)$$

Equation 5.1-18 and 5.1-21 can finally be written as

$$\Delta\bar{F}_{aero_{CR}} + \Delta\bar{F}_{cable_{CR}} + \Delta\bar{W} = m\,\dot{\bar{v}} \qquad (5.1\text{-}22)$$

$$\Delta\bar{M}_{aero_{CR}} + \Delta\bar{M}_{cable_{CR}} + \overline{\Delta M}_{wgt} = \dot{\bar{H}} \qquad (5.1\text{-}23)$$

The development of the weight, aerodynamic and cable terms are described in the following sections, 5.2, 5.3 and 5.4 respectively.

5.2 EXPANSION OF WEIGHT TERMS

The weight contribution about the point, CR, is defined by equations 5.1-18 and 5.1-21.

$$\Delta\bar{W} = m\,(\Delta\bar{g} - \dot{\bar{\omega}} \times \bar{r})$$

$$\Delta\bar{M}_{wgt} = m\,[r \times (\Delta\bar{g} - \dot{\bar{v}})] \qquad (5.2\text{-}1)$$

The $\Delta\bar{g}$ term is derived from the trim weight vector which has the following components along the trim axis:

$$gxo_t = g \operatorname{Sin} \theta_o$$

$$gyo_t = g \operatorname{Cos} \theta_o \operatorname{Cos} \phi. \qquad (5.2\text{-}2)$$

$$gzo_t = g \operatorname{Cos} \theta_o \operatorname{Cos} \phi.$$

The Eulerian Transformation matrix 'E' for small perturbations is:

$$E = \begin{vmatrix} 1 & \Psi & -\theta \\ \Psi & 1 & \phi \\ \theta & -\phi & 1 \end{vmatrix} \tag{5.2-3}$$

The total contribution of $\bar{g}$ along the instantaneous body axis is

$$\{\bar{g}_B\} = E\{gt\} \tag{5.2-4}$$

Subtracting the steady state increment gives $\Delta\bar{g}_B$

$$\{\Delta g_B\} = E\{gt\} - \{gt\} = \begin{Bmatrix} -g \text{ Cos } \theta_o \, \theta \\ g\,[\text{Sin } \theta_o \Psi + W \text{ Cos } \theta_o \, \phi] \\ g\,[-\text{Sin } \theta_o \theta - \text{Cos } \theta_o \phi] \end{Bmatrix} \tag{5.2-5}$$

The effective weight vector can now be determined if we note that:

$$\dot{\bar{\omega}} \times \bar{r} = \begin{vmatrix} \ddot{\phi} & \ddot{\theta} & \ddot{\Psi} \\ XCG & 0 & ZCG \end{vmatrix} = \begin{Bmatrix} ZCG\,\ddot{\theta} \\ XCG\,\ddot{\Psi} - ZCG\,\ddot{\phi} \\ -\,XCG\,\ddot{\theta} \end{Bmatrix} \tag{5.2-6}$$

$$\therefore \quad \boxed{\Delta\bar{W} = m \begin{Bmatrix} -g \text{ Cos } \theta_o \theta - ZCG\,\ddot{\theta} \\ g[\text{Sin } \theta_o \Psi + W \text{ Cos } \theta_o \phi] - [XCG\,\ddot{\Psi} - ZCG\,\ddot{\phi}] \\ g[-\text{Sin } \theta_o \theta - \text{Cos } \theta_o \phi] + XCG\,\ddot{\theta} \end{Bmatrix}} \tag{5.2-7}$$

The moment vector induced by the weight is determined

$$\Delta\bar{M}_{wgt} = m \begin{vmatrix} XCG & 0 & ZCG \\ \Delta g_{bx} - \ddot{x} & \Delta g_{by} - \ddot{y} & \Delta g_{bz} - \ddot{z} \end{vmatrix} \tag{5.2-8}$$

$$\Delta\overline{M}_{WGT} = m \begin{Bmatrix} -ZCG\,(\Delta g_{by} - \ddot{y}) \\ ZCG\,(\Delta g_{bx} - \ddot{x}) - XCG\,(\Delta g_{bz} - \ddot{z}) \\ XCG\,(\Delta g_{by} - \ddot{y}) \end{Bmatrix} \tag{5.2-9}$$

where Δg_{bx}, Δg_{by} and Δg_{bz} are defined by equation 5.2-5

5.3 DERIVATION OF AERODYNAMIC CONTRIBUTION TO THE FORCES AND MOMENTS

The aerodynamic forces and moments of equation 5.1-22 and 5.1-23 can be expanded as equation 5.3-1.

$$\Delta F_{x_A} = \frac{\partial F_{x_A}}{\partial\left(\frac{u}{V_o}\right)}\left(\frac{u}{V_o}\right) + \frac{\partial F_{x_A}}{\partial\left(\frac{\dot{\alpha}\bar{c}}{2V_o^2}\right)}\left(\frac{\dot{\alpha}\bar{c}}{2V_o^2}\right) + \frac{\partial F_{x_A}}{\partial\left(\frac{\dot{\theta}\bar{c}}{2V_o}\right)}\left(\frac{\dot{\theta}\bar{c}}{2V_o}\right) + \frac{\partial F_{x_A}}{\partial \delta_e}(\delta_e)$$

$$\Delta F_{y_A} = \frac{\partial F_{y_A}}{\partial\left(\frac{v}{V_o}\right)}\left(\frac{v}{V_o}\right) + \frac{\partial F_{y_A}}{\partial\left(\frac{\dot{v}}{V_o}\right)}\left(\frac{\dot{v}}{V_o}\right) + \frac{\partial F_{y_A}}{\partial\left(\frac{pb}{2V_o}\right)}\left(\frac{pb}{2V_o}\right) + \frac{\partial F_{y_A}}{\partial\left(\frac{rb}{2V_o}\right)}\left(\frac{rb}{2V_o}\right)$$

$$+ \frac{\partial F_y}{\partial \delta_R}(\delta_R) + \frac{\partial F_y}{\partial \delta_a}(\delta_a) \tag{5.3-1}$$

$$\Delta F_{z_A} = \frac{\partial F_{z_A}}{\partial\left(\frac{u}{V_o}\right)}\left(\frac{u}{V_o}\right) + \frac{\partial F_{z_A}}{\partial\left(\frac{w}{V_o}\right)}\left(\frac{w}{V_o}\right) + \frac{\partial F_{z_A}}{\partial\left(\frac{\dot{\alpha}\bar{c}}{2V_o^2}\right)}\left(\frac{\dot{\alpha}\bar{c}}{2V_o^2}\right) + \frac{\partial F_{z_A}}{\partial\left(\frac{\dot{\theta}\bar{c}}{2V_o}\right)}\left(\frac{\dot{\theta}\bar{c}}{2V_o}\right)$$

$$+ \frac{\partial F_{z_A}}{\partial \delta_e}(\delta_e)$$

$$\Delta L_A = \frac{\partial L}{\partial\left(\frac{v}{V_o}\right)}\left(\frac{v}{V_o}\right) + \frac{\partial L}{\partial\left(\frac{\dot{v}}{V_o}\right)}\left(\frac{\dot{v}}{V_o}\right) + \frac{\partial L}{\partial\left(\frac{pb}{2V_o}\right)}\left(\frac{pb}{2V_o}\right) + \frac{\partial L}{\partial\left(\frac{rb}{2V_o}\right)}\left(\frac{rb}{2V_o}\right)$$

$$+ \frac{\partial L}{\partial \delta_r}(\delta_r) + \frac{\partial L}{\partial \delta_a}(\delta_a)$$

$$\Delta M_A = \frac{\partial M}{\partial\left(\frac{u}{V_o}\right)}\left(\frac{u}{V_o}\right) + \frac{\partial M}{\partial\left(\frac{w}{V_o}\right)}\left(\frac{w}{V_o}\right) + \frac{\partial M}{\partial\left(\frac{\dot{\alpha}\bar{c}}{2V_o}\right)}\left(\frac{\dot{\alpha}\bar{c}}{2V_o}\right) + \frac{\partial M}{\partial\left(\frac{\dot{\theta}\bar{c}}{2V_o}\right)}\left(\frac{\dot{\theta}\bar{c}}{2V_o}\right)$$

$$+ \frac{\partial M}{\partial \delta_e}(\delta_e)$$

$$\Delta N_A = \frac{\partial N}{\partial\left(\frac{v}{V_o}\right)}\left(\frac{v}{V_o}\right) + \frac{\partial N}{\partial\left(\frac{\dot{v}}{2V_o}\right)}\left(\frac{\dot{v}}{2V_o}\right) + \frac{\partial N}{\partial\left(\frac{pb}{2V_o}\right)}\left(\frac{pb}{2V_o}\right) + \frac{\partial N}{\partial\left(\frac{rb}{2V_o}\right)}\left(\frac{rb}{2V_o}\right)$$

$$+ \frac{\partial N}{\partial \delta_r}(\delta_r) + \frac{\partial N}{\partial \delta_a}(\delta_a)$$

In the wind tunnel, the following relationship is true:

$$\frac{w}{V_o} = \theta + \frac{\dot{z}}{V_o}, \quad \frac{\dot{w}}{V_o} = \dot{\theta} + \frac{\ddot{z}}{V_o}$$

$$\frac{v}{V_o} = -\psi + \frac{\dot{y}}{V_o}, \quad \frac{\dot{v}}{V_o} = -\dot{\psi} + \frac{\dot{y}}{V_o} \tag{5.3-2}$$

Substituting equations 5.3-2 and 5.1-4 into equation 5.3-2 and rewriting equation5.3-2 in terms of the body axis coefficient we have:

$$\Delta F_{X_A} = \left[C_{x_w}\frac{qS}{V_o}\dot{x} + C_{x_\alpha}\frac{qS}{V_o}\dot{z} + C_{x_{\dot{\alpha}}}\frac{qS\bar{c}}{2V_o^2}\ddot{z} + C_{x_\alpha} qS\theta \right.$$

$$\left. + \left(C_{x_{\dot{\alpha}}} + C_{x_{\dot{\theta}}}\right)\frac{qS\bar{c}}{2V_o}\dot{\theta} + C_{x_{\delta_e}} qS\,\delta_e \right] \tag{5.3-3.1}$$

$$\Delta F_{y_A} = \left[C_{y_\beta}\frac{qS}{V_o}\dot{y} + C_{y_{\dot{\beta}}}\frac{qS}{V_o}\ddot{y} + C_{y_p}\frac{qSb}{2V_o}\dot{\phi} + \left(-C_{y_{\dot{\beta}}} + C_{y_r}\right)\frac{qSb}{2V_o}\dot{\Psi} \right.$$

$$\left. - C_{y_\beta} qS\Psi + C_{y_{\delta_r}} qS\delta_r + C_{y_{\delta_a}} qS\delta_a \right] \tag{5.3-3.2}$$

$$\Delta F_{Z_A} = \left[C_{z_u}\frac{qS}{V_o}\dot{x} + C_{z_\alpha}\frac{qS}{V_o}\dot{z} + C_{z_{\dot{\alpha}}}\frac{qS\bar{c}}{2V_o^2}\ddot{z} + C_{z_\alpha} qS\theta + \left(C_{z_\alpha} + C_{z_{\dot{\theta}}}\right)\frac{qS\bar{c}}{2V_o}\dot{\theta} \right.$$

$$\left. + C_{z_{\delta_e}} qS\,\delta_e \right] \tag{5.3-3.3}$$

$$\Delta L_A = \left[C_{\ell_\beta} \frac{qSb}{V_o} \dot{y} + C_{\ell_{\dot\beta}} \frac{qSb}{V_o} \ddot{y} + C_{\ell_p} \frac{qSb^2}{2V_o} \dot{\phi} + \left(C_{\ell_r} - C_{\ell_{\dot\beta}} \right) \frac{qSb^2}{2V_o} \dot{\Psi} \right.$$

$$\left. - C_{\ell_\beta} qSb\Psi + C_{\ell_{\delta_r}} qSb\delta_r + C_{\ell_{\delta_a}} qSb\,\delta_a \right] \qquad (5.3\text{-}3.4)$$

$$\Delta M_A = \left[C_{m_u} \frac{qS\bar{c}}{V_o} \dot{x} + C_{m_\alpha} \frac{qS\bar{c}}{V_o} \dot{z} + C_{m_{\dot\alpha}} \frac{qS\bar{c}^2}{2V_o} \ddot{z} + C_{m_\alpha} qS\bar{c}\theta \right.$$

$$\left. + \left(C_{m_{\dot\alpha}} + C_{m_{\dot\theta}} \right) \frac{qS\bar{c}^2}{2V_o} \theta + C_{m_{\delta_e}} qS\bar{c}\,\delta_e \right] \qquad (5.3\text{-}3.5)$$

$$\Delta N_A = \left[C_{n_\beta} \frac{qSb}{V_o} \dot{y} + C_{n_{\dot\beta}} \frac{qSb}{V_o} \ddot{y} + C_{n_p} \frac{qSb^2}{2V_o} \dot{\phi} + \left(C_{n_r} - C_{n_{\dot\beta}} \right) \frac{qSb^2}{2V_o} \dot{\Psi} \right.$$

$$\left. - C_{n_\beta} qSb\Psi + C_{n_{\delta_r}} qSb\delta_r + C_{n_{\delta_a}} qSb\delta_a \right] \qquad (5.3\text{-}3.6)$$

5.4 DERIVATION OF THE CABLE FORCES AND MOMENTS

The generalized force and moment equations for a single cable are defined. The forces and moments of the entire cable system are then obtained by the proper summation of each individual cable contribution.

For a single cable, a component of force along any trim axis can be written in terms of the tension in the cable and its direction cosine with respect to the axis. i.e.

$$F_i = T \operatorname{Cos} \alpha_i \qquad i = x,\ y \text{ or } z \qquad (5.4\text{-}1)$$

The instantaneous force component, due to changes in the cable tension and direction cosine, along the trim axis can be defined as:

$$(F_o + \Delta F)_i = (T + \Delta T) \operatorname{Cos} (\alpha + \Delta\alpha)_i \qquad (5.4\text{-}2)$$

where F_o is the steady state force component and ΔF the change in this component. Expanding this expression and linearizing, we have:

$$F_{I_i} = (F_o + \Delta F)_i = T \cos \alpha_i + \Delta T \cos \alpha_i - T\, \Delta\alpha_i \sin\alpha_i \qquad (5.4\text{-}3.1)$$

or

$$F_{o_i} = T \cos \alpha_i \qquad (5.4\text{-}3.2)$$

$$\Delta F_i = \Delta T \cos\alpha_i - T\, \Delta\alpha_i \sin\alpha_i \qquad (5.4\text{-}3.3)$$

The force, in equation 5.4-2 , is the instantaneous force along the trim body axis. The instantaneous body axis may be displaced through perturbation angles Ψ, θ and ϕ. To obtain the force along the instantaneous body axis, vector F_I , is transformed via the Eulerian transformation matrix defined in equation 5.2-2 .

$$\left\{F_I\right\}_B = \left\{F_o + \Delta F \quad B\right\} = E \left\{F_o + \Delta F\right\}_T \qquad (5.4\text{-}4)$$

Expanded, equation 5.4-4 takes the following form:

$$\left\{F_I\right\}_B = \begin{vmatrix} 1 & \Psi & -\theta \\ -\Psi & 1 & \phi \\ \theta & -\phi & 1 \end{vmatrix} \left\{F_o + \Delta F\right\}_T \qquad (5.4\text{-}5)$$

$$= \begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{vmatrix} \left\{F_o\right\}_T + \begin{vmatrix} 0 & \Psi & -\theta \\ -\Psi & 0 & \phi \\ \theta & -\phi & 0 \end{vmatrix} \left\{F_o\right\}_T$$

$$+ \begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{vmatrix} \left\{\Delta F\right\}_T + HOT$$

The first term is the steady state term, the next term is due to rotation of the body axis and the third is due to the perturbation of the steady state force. Subtracting the steady state force, the incremental change in the cable force projected on the instantaneous body axis is obtained.

$$\left\{ \Delta F_I \right\}_B = \left\{ \begin{matrix} \left[\Delta F_{T_1} + \Psi F_{To_2} - \theta F_{To_3} \right] \\ \left[\Delta F_{T_2} - \Psi F_{To_1} + \phi F_{To_3} \right] \\ \left[\Delta F_{T_3} + \theta F_{To_1} - \phi F_{To_2} \right] \end{matrix} \right\} \tag{5.4-6}$$

To determine the incremental change in moment about the instantaneous body axis, the vector notation of the generalized moment vector, $\overline{K}$, is written as:

$$\overline{K} = \left(\overline{X}_p \times \overline{F}_I \right)_B \tag{5.4-7}$$

$\overline{X}_p$ is the vector from the center of rotation to the point of action of the cable force, $\overline{F}_I$. This vector has been defined in the trim analysis. $\overline{F}_I$ is defined by the matrix in equation 5.4-5 .

Expanding the equation and subtracting the steady state moment term out, the following is obtained:

$$\{\Delta K\} = \begin{bmatrix} \Delta L \\ \Delta M \\ \Delta N \end{bmatrix}_B = \left\{ \begin{matrix} \left[y_p \Delta F_{T_3} - z_p \Delta F_{T_2} + z_p F_{To_1} \Psi - \left(y_p F_{To_2} + z_p F_{To_3} \right) \phi \right] \\ \left[z_p \Delta F_{T_1} - X_p \Delta F_{T_3} - \left(z_p T_{To_3} + x_p F_{To_1} \right) \theta \right] \\ \left[x_p \Delta F_{T_2} - y_p \Delta F_{T_1} - \left(x_p F_{To_1} + y_p F_{To_2} \right) \Psi + X_p F_{To_3} \phi \right] \end{matrix} \right\} \tag{5.4-8}$$

Equations 5.4-6 and 5.4-8 are the generalized cable forces and moments for a single cable. The force terms with a subscript zero are defined by equation 5.4-3.2. The ΔF_i increments are obtained from equation 5.4-3.3 once ΔT and $\Delta\alpha_i$ are defined. The change in tension force, ΔT, is proportional to $\Delta \ell$ via the spring constant. The $\Delta\alpha_i$ is the change in the direction cosine with respect to the trim axis.

To determine ΔT and $\Delta\alpha_i$ the vector representation of the cable at any instant of time must be defined with respect to the trim axis.

Let $\overline{X}_{WT}$ represent the vector to the cable tie-down point the tunnel wall from the center of reference in the trim axis systems and $\overline{X}_{p_B}$ the vector to the point of action in the body axis. Let $\overline{X}_{p_T}$ be the transformation of $\overline{X}_{p_B}$ onto the trim axis system. i.e.

$$\overline{X}_{p_T} = \left\{X_p\right\}_T = E^{-1} \left\{X_p\right\}_B \tag{5.4-9}$$

The cable vector is thus defined by equation 5.4-10

$$\overline{A} = \overline{X}_{W_T} - \overline{X}_{p_T} = \left\{\ell \text{ Cos } \alpha_i + \delta_i\right\}_{i = 1, 2, 3} \tag{5.4-10}$$

where δ_i is defined by the following:

$$\delta_1 = - (-y_p\Psi + z_p\Theta + x)$$

$$\delta_2 = - (x_p\Psi - z_p\phi + y)$$

$$\delta_3 = - (-x_p\theta + y_p\phi + z) \tag{5.4-11}$$

x, y, z, Ψ, θ, ϕ are perturbation variables.

The magnitude of $\overline{A}$ is the instantaneous length of the cable. Expanding and linearizing the equation gives the following:

$$\ell_o + \Delta\ell = \left| \overline{A} \right| = \ell_o + \sum_{i=1}^{3} \text{Cos } \alpha_i \ \delta_i \tag{5.4-12}$$

or

$$\boxed{\Delta\ell = \Sigma \text{ Cos } \alpha_i \ \delta_i} \tag{5.4-13}$$

The incremental change in direction cosine can be determined by defining the unit vector along $\overline{A}$ and then taking the dot product along the x, y, z axis.

$$\text{Cos } (\alpha + \Delta\alpha)_i = \left(\frac{\overline{A}}{\ell+\Delta\ell}\right) \cdot \overline{u}_i \tag{5.4-14}$$

where $\overline{u}_i$ is the unit vector along the i^{th} trim axis

Expanding and linearizing:

$$\ell \cos \alpha_i + \Delta\ell \cos \alpha_i - \Delta\alpha_i \ell \sin \alpha_i = \bar{A} \cdot \bar{u}_i$$

$$= (X_{wt} - X_{pt}) \cdot \bar{u}_i \qquad (5.4\text{-}15)$$

or $$\Delta\alpha_i = \frac{1}{\ell \sin\alpha_i} \left[\ell \cos \alpha_i + \Delta\ell \cos \alpha_i - \left(\overline{X_{w_T} - X_p} \right) \cdot \bar{u}_i \right] \qquad (5.4\text{-}16)$$

Since from equation 5.4-10 :

$$(\overline{X_{wT} - X_{pT}}) \cdot \bar{u}_i = \left(\ell \cos \alpha_i + \delta_i \right) \qquad (5.4\text{-}17)$$

Equation 5.4-16 simplifies to:

$$\boxed{\Delta\alpha_i = \frac{1}{\ell \sin \alpha_i} \cdot \left[\Delta\ell \cos \alpha_i - \delta_i \right]} \qquad (5.4\text{-}18)$$

Equations 5.4-13 and 5.4-18 are the necessary equations to define ΔF in equations 5.4-6 and 5.4-8. In Sections 6.0 and 7.0, these equations are simplified for the longitudinal and lateral directional analysis to obtain the influence coefficient matrix.

6.0 Longitudinal Stability Analysis

6.1 Subroutine LONG

This subroutine computes the perturbed forces and moments for the longitudinal perturbation equations of motion and extracts the characteristic roots for a stability analysis.

The general form of the linearized equation of motion (5.1-14) is reduced to equation 6.1-1 for the longitudinal analysis.

$$\begin{aligned} \Sigma\Delta F_x &= m\dot{u} = m\ddot{x} \\ \Sigma\Delta F_z &= m\dot{w} = m\ddot{z} \\ \Sigma\Delta M_y &= I_y\dot{q} = I_y\ddot{\theta} \end{aligned} \qquad (6.1\text{-}1)$$

x, z and θ are the longitudinal perturbation variables. $\Sigma\Delta F_x$, $\Sigma\Delta F_z$ and $\Sigma\Delta M$ are further expanded in equation 6.1-2.

$$\begin{aligned} \Sigma\Delta F_x &= \Delta F_{x_{aero}} + \Delta F_{x_{wt}} + \Delta F_{x_{cable}} + \Delta F_{x_{snubber}} \\ \Sigma\Delta F_z &= \Delta F_{z_{aero}} + \Delta F_{z_{wt}} + \Delta F_{z_{cable}} + \Delta F_{z_{snubber}} \\ \Sigma\Delta M_y &= \Delta M_{aero} + \Delta M_{wt} + \Delta M_{cable} + \Delta M_{snubber} \end{aligned} \qquad (6.1\text{-}2)$$

The aerodynamic forces and moments, $\Delta F_{x_{aero}}$, $\Delta F_{z_{aero}}$ and ΔM_{aero}, are defined by equations 5.3-3.1, 5.3-3.3 and 5.3-3.5 respectively. The weight contributions are defined by equations 5.2-7 and 5.2-9 and simplify to equation 6.1-3 with y, Ψ, ϕ = 0.

$$\begin{aligned} \Delta F_{x_{wt}} &= W \cos\theta_o\theta - Z_{CG}\, M\, \ddot{\theta} \\ \Delta F_{z_{wt}} &= W \sin\theta_o\theta = x_{CG}\, M\, \ddot{\theta} \\ \Delta M_{wt} &= z_{CG}\,(W \cos\theta_o\theta + m\ddot{x}) + x_{CG}\,(W \sin\theta_o\theta + m\ddot{z}) \end{aligned} \qquad (6.1\text{-}3)$$

The cable forces and moment are obtained from generalized equations 5.4-6 and 5.4-8 respectively.

$$\Delta F_1 = \Delta F_x = \Delta F_{T_1} - \theta F_{To_3}$$

$$\Delta F_3 = \Delta F_z = \Delta F_{T_3} + \theta F_{To_1} \qquad (6.1\text{-}4)$$

$$\Delta M_y = z_p \, \Delta F_{T_1} - x_p \, \Delta F_{T_3} - (z_p F_{To_3} + x_p \, F_{To_1}) \, \theta$$

where according to equations 5.4-3.2 and 5.4-3.3

$$F_{To_i} = T_i \text{ Cos } \alpha_i \qquad i = 1, 3$$

and (6.1-5)

$$\Delta F_{T_i} = \Delta T_i \text{ Cos } \alpha_i - T \Delta\alpha_i \text{ Sin } \alpha_i$$

The steady state direction cosine angle, α_i and cable tension, T_i are obtained from the trim analysis. The ΔT_i and $\Delta\alpha_i$ are proportional to the longitudinal perturbation variables. The ΔT_i for the rear cable is defined by equation 6.1-6 .

$$\Delta T_R = AKR \, (\Delta \ell_3 + \Delta \ell_4) \qquad (6.1\text{-}6)$$

The ΔT_F for the front cable is a variable in the analysis. The constant front cable length requirement is a constraint equation which in conjunction with the equations of motion defines a unique solution of the variables x, z, θ and ΔT_F.

The constraint equation is:

$$\Delta \ell_1 + \Delta \ell_2 = 0 \qquad (6.1\text{-}7)$$

Since:

$$\Delta \ell_1 = \frac{\partial \Delta \ell_1}{\partial x} x + \frac{\partial \Delta \ell_1}{\partial z} z + \frac{\partial \Delta \ell_1}{\partial \theta} \theta \qquad (6.1\text{-}8)$$

$$\Delta \ell_2 = \frac{\partial \Delta \ell_2}{\partial x} x + \frac{\partial \Delta \ell_2}{\partial z} z + \frac{\partial \Delta \ell_2}{\partial \theta} \theta \qquad (6.1\text{-}9)$$

The following relation of $x = f(z, \theta)$ is determined.

$$x = \frac{\left[\left(\frac{\partial \Delta \ell_1}{\partial z} + \frac{\partial \Delta \ell_2}{\partial z}\right) z + \left(\frac{\partial \Delta \ell_1}{\partial \theta} + \frac{\partial \Delta \ell_2}{\partial \theta}\right) \theta\right]}{\left(\frac{\partial \Delta \ell_1}{\partial x} + \frac{\partial \Delta \ell_2}{\partial x}\right)} \qquad (6.1\text{-}10)$$

The coefficients for $\Delta \ell_i$ are defined by subroutine DLGTH described in Section 6.3. Similarly the coefficient of $\Delta \alpha_i$ are defined in subroutine DCOSLG.

The cable forces and moment equations are reduced to functions of the basic variables x, z, θ and ΔT_F via the subroutine MASH for each individual cable. The results are then summed in the FXS array which in its final form, becomes the cable influence coefficient matrix. The initial form of the cable matrix for the front and rear flying cable are presented in Figures 6.1 and 6.2 respectively.

The stability characteristic matrix and the expanded form of the equations of motion are presented in Figure 6.3. A functional flow diagram of subroutine LONG is included as Figure 6.4.

6.2 Subroutine DLGTH

This subroutine computes the change in length of a cable for either the longitudinal or the lateral/directional perturbation stability analysis. An index, IDX, determines the mode that is being analyzed, and the correct form of $\Delta \ell$ is computed.

The variation of the cable length with respect to the longitudinal variables is defined by the partial derivatives in equation 6.2-1.

$$\Delta \ell = \frac{\partial \Delta \ell}{\partial x} x + \frac{\partial \Delta \ell}{\partial z} z + \frac{\partial \Delta \ell}{\partial \theta} \theta \qquad (6.2\text{-}1)$$

These "partials" are determined from the generalized form for $\Delta \ell$ in equations 5.4-13 and 5.4-11. Equating the lateral/directional perturbation variables, y, ϕ and Ψ to zero, the equation for $\Delta \ell$ is reduced to the following simplified form.

$$\Delta \ell = - \operatorname{Cos} \alpha_1 \, x - \operatorname{Cos} \alpha_3 \, z + \left(x_p \operatorname{Cos} \alpha_3 - z_p \operatorname{Cos} \alpha_1\right) \theta \qquad (6.2\text{-}2)$$

The subscripts 1 and 3 refer to the x and z body axis respectively. x_p and z_p corresponds to the coordinates of the cable force point of action. In the program, an added subscript, IC, is used to define the particular cable being analyzed.

In the lateral directional mode, the coefficient of the y, Ψ, and ϕ variables in the lateral directional form of $\Delta \ell$ is computed.

$$\Delta \ell = \frac{\partial \Delta \ell}{y} y + \frac{\partial \Delta \ell}{\partial \Psi} \Psi + \frac{\partial \Delta \ell}{\partial \phi} \phi \tag{6.2-3}$$

The coefficients are again obtained from equations 5.4-13 and 5.4-11, but now x, z, and θ is assumed zero. The expresssion for $\Delta \ell$ is reduced to equation 6.2-4.

$$\Delta \ell = - \text{Cos } \alpha_2 \, y + [y_p \text{ Cos } \alpha_1 - x_p \text{ Cos } \alpha_2] \Psi + [z_p \text{ Cos } \alpha_2 - y_p \text{ Cos } \alpha_3] \phi \tag{6.2-4}$$

The subscript 2 refers to the y body axis.

The expressions in equations 6.2-2 and 6.2-4 can be shown to be algebraically equivalent to their corresponding expressions in Reference 1. A functional flow diagram is included in Figure 6.3.

6.3 Subroutine DCOSLG

This subroutine computes the components of the $\Delta\alpha_1$ and $\Delta\alpha_3$ vectors required by subroutine LONG. Due to the symmetry of the longitudinal analysis, $\Delta\alpha_2$ is not required. The expressions for both $\Delta\alpha_1$ and $\Delta\alpha_3$ are obtained from equation 5.4-18. Expanding this expression and letting y, Ψ, and ϕ equal zero, the expressions for $\Delta\alpha_1$ and $\Delta\alpha_3$ are developed.

$$\Delta\alpha_1 = \left(\frac{\sin \alpha_1}{\ell}\right) x + \left(\frac{\cos \alpha_3 \cot \alpha_1}{\ell}\right) z + \left(\frac{z_p \sin \alpha_1 + x_p \cos \alpha_3}{\ell}\right) \theta$$

$$\Delta\alpha_3 = - \left(\frac{\cos \alpha_1 \cot \alpha_3}{\ell}\right) x + \left(\frac{\sin \alpha_3}{\ell}\right) z - \left(\frac{z_p \cos \alpha_1 \cot \alpha_3 + x_p \sin \alpha_3}{\ell}\right) \theta$$

The subscripts 1 or 3 again refer to the x and z axis respectively. The x_p and z_p are the x and z components of the vector from the center of reference to the point of action of the cable force.

LONGITUDINAL FRONT CABLE MATRIX

	z	θ	ΔT_F	x	$\Delta\alpha_1$	$\Delta\alpha_3$
①		$-T\cos\alpha_3$	$\cos\alpha_1$		$-T\sin\alpha_1$	
②		$T\cos\alpha_1$	$\cos\alpha_3$			$-T\sin\alpha_3$
③		$-z_p T\cos\alpha_3 - x_p T\cos\alpha_1$	$z_p\cos\alpha_1 - x_p\cos\alpha_3$		$-z_p T\sin\alpha_1$	$x_p T\sin\alpha_3$
④	$\frac{\partial x}{\partial z}$	$\frac{\partial x}{\partial \theta}$		-1		
⑤	$\Delta\alpha_{1z}$	$\Delta\alpha_{1\theta}$		$\Delta\alpha_{1x}$	-1	
⑥	$\Delta\alpha_{3z}$	$\Delta\alpha_{3\theta}$		$\Delta\alpha_{3x}$		-1

Equation:

① $\Delta F_{xc} = \Delta F_{T_1} - \theta F_{T_{03}} = (\cos\alpha_1 \Delta T_F - T_{F_0}\sin\alpha_1 \Delta\alpha_1) - T_{F_0}\cos\alpha_3\,\theta$ (eq 6.1-4)

② $\Delta F_{zc} = \Delta F_{T_3} + \theta F_{T_{01}} = (\cos\alpha_3 \Delta T_F - T_{F_0}\sin\alpha_3 \Delta\alpha_3) + T_{F_0}\cos\alpha_1\,\theta$ (eq 6.1-4)

③ $\Delta M_c = z_p \Delta F_{T_1} - x_p \Delta F_{T_3} - (z_p F_{T_{03}} + x_p F_{T_{01}})\,\theta$ (eq 6.1-4)

④ $x = \frac{\partial x}{\partial z} z + \frac{\partial x}{\partial \theta}\theta$ (eq 6.1-10)

⑤ $\Delta\alpha_1 = \Delta\alpha_{1z} z + \Delta\alpha_{1\theta}\theta + \Delta\alpha_{1x} x$ (eq 6.3-1)

⑥ $\Delta\alpha_3 = \Delta\alpha_{3z} z + \Delta\alpha_{3\theta}\theta + \Delta\alpha_{3x} x$ (eq 6.3-2)

FIG. 6.1 - MATRIX

LONGITUDINAL REAR C LE MATRIX

	z	θ	x	ΔT_R	$\Delta\alpha_1$	$\Delta\alpha_3$	$\Delta l_3 + \Delta l_4$
①		$-T_{R_0}\cos\alpha_3$		$\cos\alpha_1$	$-T_{R_0}\sin\alpha_1$		
②		$T_{R_0}\cos\alpha_1$		$\cos\alpha_3$		$-T_{R_0}\sin\alpha_3$	
③		$-z_p T_{R_0}\cos\alpha_3 - x_p T_{R_0}\cos\alpha_1$		$z_p\cos\alpha_1 - x_p\cos\alpha_3$	$-z_p T_{R_0}\sin\alpha_1$	$x_p T_{R_0}\sin\alpha_3$	
④				-1			AKR
⑤	$\Delta\alpha_{1_z}$	$\Delta\alpha_{1_T}$	$\Delta\alpha_{1_x}$		-1		
⑥	$\Delta\alpha_{3_z}$	$\Delta\alpha_{3_T}$	$\Delta\alpha_{1_x}$			-1	
⑦	$\Delta l_{3_z} + \Delta l_{4_z}$	$\Delta l_{3_\theta} + \Delta l_{4_\theta}$	$\Delta l_{3_x} + \Delta l_{4_x}$				-1

Equations

① $\Delta F_{x_c} = \Delta F_{T_1} - \theta F_{T_{03}} = (\cos\alpha_1 \Delta T_R - T_{R_0}\sin\alpha_1 \Delta\alpha_1) - T_{R_0}\cos\alpha_3\,\theta$ (eq. 6.1-4)

② $\Delta F_{z_c} = \Delta F_{T_3} + \theta F_{T_{01}} = (\cos\alpha_3 \Delta T_R - T_{R_0}\sin\alpha_3 \Delta\alpha_3) + T_{R_0}\cos\alpha_1\,\theta$ (eq. 6.1-4)

③ $\Delta M_c = z_p \Delta F_{T_1} - x_p \Delta F_{T_3} - (z_p F_{T_{03}} + x_p F_{T_{01}})\theta$ (eq. 6.1-4)

④ $\Delta T_R = AKR\,(\Delta l_3 + \Delta l_4)$ (eq. 6.1-6)

⑤ $\Delta\alpha_1 = \Delta\alpha_{1_z} z + \Delta\alpha_{1_\theta}\theta + \Delta\alpha_{1_x} x$ (eq. 6.3-1)

⑥ $\Delta\alpha_3 = \Delta\alpha_{3_z} z + \Delta\alpha_{3_\theta}\theta + \Delta\alpha_{3_x} x$ (eq. 6.3-2)

⑦ $\Delta l_3 + \Delta l_4 = (\Delta l_{3_z} + \Delta l_{4_z}) z + (\Delta l_{3_\theta} + \Delta l_{4_\theta})\theta + (\Delta l_{3_x} + \Delta l_{4_x}) x$ (eq. 6.2-1)

FIG. 6.2 - MATRIX

Longitudinal Characteristic Matrix & Equations

z	θ	ΔT_F	x
$-\left[\left(\frac{\partial X_A}{\partial \dot\alpha}\frac{1}{V_0}\right)s^2+\left(\frac{\partial X_A}{\partial \alpha}+\frac{\partial X_{SN}}{\partial \dot z}\right)s+\frac{\partial X_c}{\partial z}\right]$	$m Z_{CG} s^2-\left(\frac{\partial X_A}{\partial \dot\theta}+\frac{\partial X_A}{\partial \dot\alpha}+\frac{\partial X_{SN}}{\partial \dot\theta}\right)s+W\cos\theta_0 - \left(\frac{\partial X_c}{\partial \theta}+\frac{\partial X_A}{\partial \alpha}V_0\right)$	$-\frac{\partial X_c}{\partial \Delta T_F}$	$m s^2-\left(\frac{\partial X_A}{\partial u}+\frac{\partial X_{SN}}{\partial \dot x}\right)s-\frac{\partial X_c}{\partial x}$
$\left(m-\frac{\partial Z_A}{\partial \dot\alpha}\frac{1}{V_0}\right)s^2-\left(\frac{\partial Z_A}{\partial \alpha}+\frac{\partial Z_{SN}}{\partial \dot z}\right)s-\frac{\partial Z_c}{\partial z}$	$-m X_{CG} s^2-\left(\frac{\partial Z_A}{\partial \dot\theta}+\frac{\partial Z_A}{\partial \dot\alpha}+\frac{\partial Z_{SN}}{\partial \dot\theta}\right)s+W\sin\theta_0 - \left(\frac{\partial Z_c}{\partial \theta}+\frac{\partial Z_A}{\partial \alpha}V_0\right)$	$-\frac{\partial Z_c}{\partial \Delta T_F}$	$-\left(\frac{\partial Z_A}{\partial u}+\frac{\partial Z_{SN}}{\partial \dot x}\right)s-\frac{\partial Z_c}{\partial x}$
$-\left(\frac{1}{V_0}\frac{\partial M_{y_A}}{\partial \dot\alpha}+m X_{CG}\right)s^2-\left(\frac{1}{V_0}\frac{\partial M_{y_A}}{\partial \alpha}+\frac{\partial M_{y_{SN}}}{\partial \dot z}\right)s-\frac{\partial M_{y_c}}{\partial z}$	$I_{yy} s^2-\left(\frac{\partial M_{y_A}}{\partial \dot\theta}+\frac{\partial M_{y_A}}{\partial \dot\alpha}+\frac{\partial M_{y_{SN}}}{\partial \dot\theta}\right)s - \left(\frac{\partial M_{y_A}}{\partial \alpha}+\frac{\partial M_{y_c}}{\partial \theta}+Z_{CG}W\cos\theta_0+X_{CG}W\sin\theta_0\right)$	$-\frac{\partial M_{y_c}}{\partial \Delta T_F}$	$m Z_{CG} s^2-\left(\frac{\partial M_{y_A}}{\partial u}+\frac{\partial M_{y_{SN}}}{\partial \dot x}\right)s-\frac{\partial M_{y_c}}{\partial x}$
$-\frac{\partial x}{\partial z}$	$-\frac{\partial x}{\partial \theta}$		1

X-Force Equation:

$$m\ddot x = \underbrace{\frac{\partial X_A}{\partial u}\dot x+\frac{\partial X_A}{\partial \dot\alpha}\dot\alpha+\frac{\partial X_A}{\partial \alpha}\alpha+\frac{\partial X_A}{\partial \dot\theta}\dot\theta}_{\text{Aero}} - \underbrace{W\cos\theta_0\,\theta - m Z_{CG}\ddot\theta}_{\text{Weight}} + \underbrace{\frac{\partial X_c}{\partial x}x+\frac{\partial X_c}{\partial z}z+\frac{\partial X_c}{\partial \theta}\theta+\frac{\partial X_c}{\partial \Delta T_F}\Delta T_F}_{\text{Cable Spring Force}} + \underbrace{\frac{\partial X_{SN}}{\partial \dot x}\dot x+\frac{\partial X_{SN}}{\partial \dot z}\dot z+\frac{\partial X_{SN}}{\partial \dot\theta}\dot\theta}_{\text{Snubber Damping Force}}$$

Z-Force Equation:

$$m\ddot z = \underbrace{\frac{\partial Z_A}{\partial u}\dot x+\frac{\partial Z_A}{\partial \dot\alpha}\dot\alpha+\frac{\partial Z_A}{\partial \alpha}\alpha+\frac{\partial Z_A}{\partial \dot\theta}\dot\theta}_{\text{Aero}} - \underbrace{W\sin\theta_0\,\theta - m X_{CG}\ddot\theta}_{\text{Weight}} + \underbrace{\frac{\partial Z_c}{\partial x}x+\frac{\partial Z_c}{\partial z}z+\frac{\partial Z_c}{\partial \theta}\theta+\frac{\partial Z_c}{\partial \Delta T_F}\Delta T_F}_{\text{Cable Spring Force}} + \underbrace{\frac{\partial Z_{SN}}{\partial \dot x}\dot x+\frac{\partial Z_{SN}}{\partial \dot z}\dot z+\frac{\partial Z_{SN}}{\partial \dot\theta}\dot\theta}_{\text{Snubber Damping Force}}$$

Pitching Mom. Equation:

$$I_{yy}\ddot\theta = \underbrace{\frac{\partial M_A}{\partial u}\dot x+\frac{\partial M_A}{\partial \dot\alpha}\dot\alpha+\frac{\partial M_A}{\partial \alpha}\alpha+\frac{\partial M_A}{\partial \dot\theta}\dot\theta}_{\text{Aero Mom}} + \underbrace{(-Z_{CG}W\cos\theta_0+X_{CG}W\sin\theta_0)\theta - Z_{CG}m\ddot x + X_{CG}m\ddot z}_{\text{Weight Moment}} + \underbrace{\frac{\partial M_{y_c}}{\partial x}x+\frac{\partial M_{y_c}}{\partial z}z+\frac{\partial M_{y_c}}{\partial \theta}\theta+\frac{\partial M_{y_c}}{\partial \Delta T_F}\Delta T_F}_{\text{Cable Spring Mom}} + \underbrace{\frac{\partial M_{y_{SN}}}{\partial \dot x}\dot x+\frac{\partial M_{y_{SN}}}{\partial \dot z}\dot z+\frac{\partial M_{y_{SN}}}{\partial \dot\theta}\dot\theta}_{\text{Snubber Damping Mo}}$$

Constraint Equation:

$$x = -\frac{\partial x}{\partial z}z - \frac{\partial x}{\partial \theta}\theta$$

Auxiliary Equations:

$$\alpha = \theta + \frac{\dot z}{V_0}, \quad \dot\alpha = \dot\theta + \frac{\ddot z}{V_0}$$

FIG. 6.3 - MATRIX

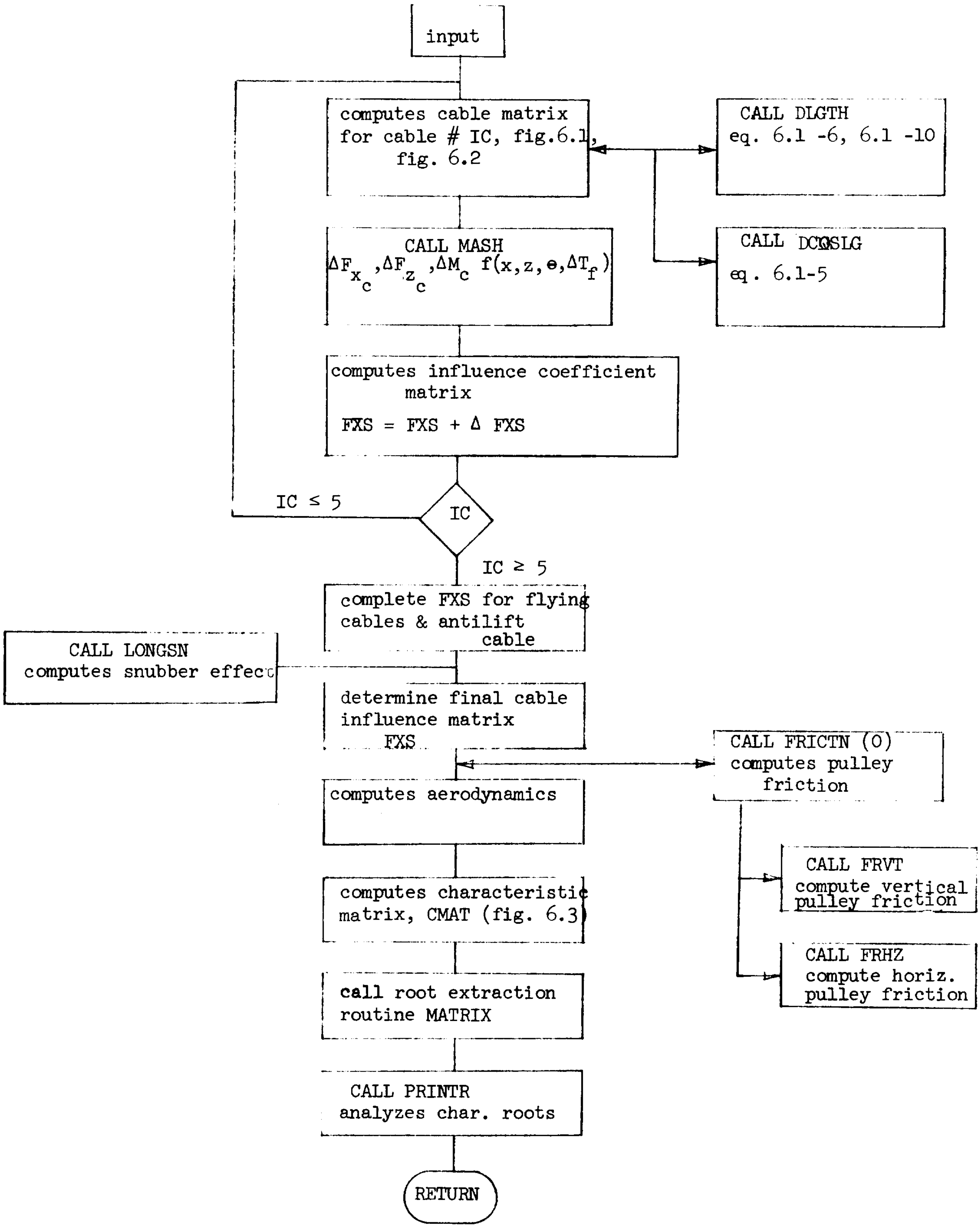
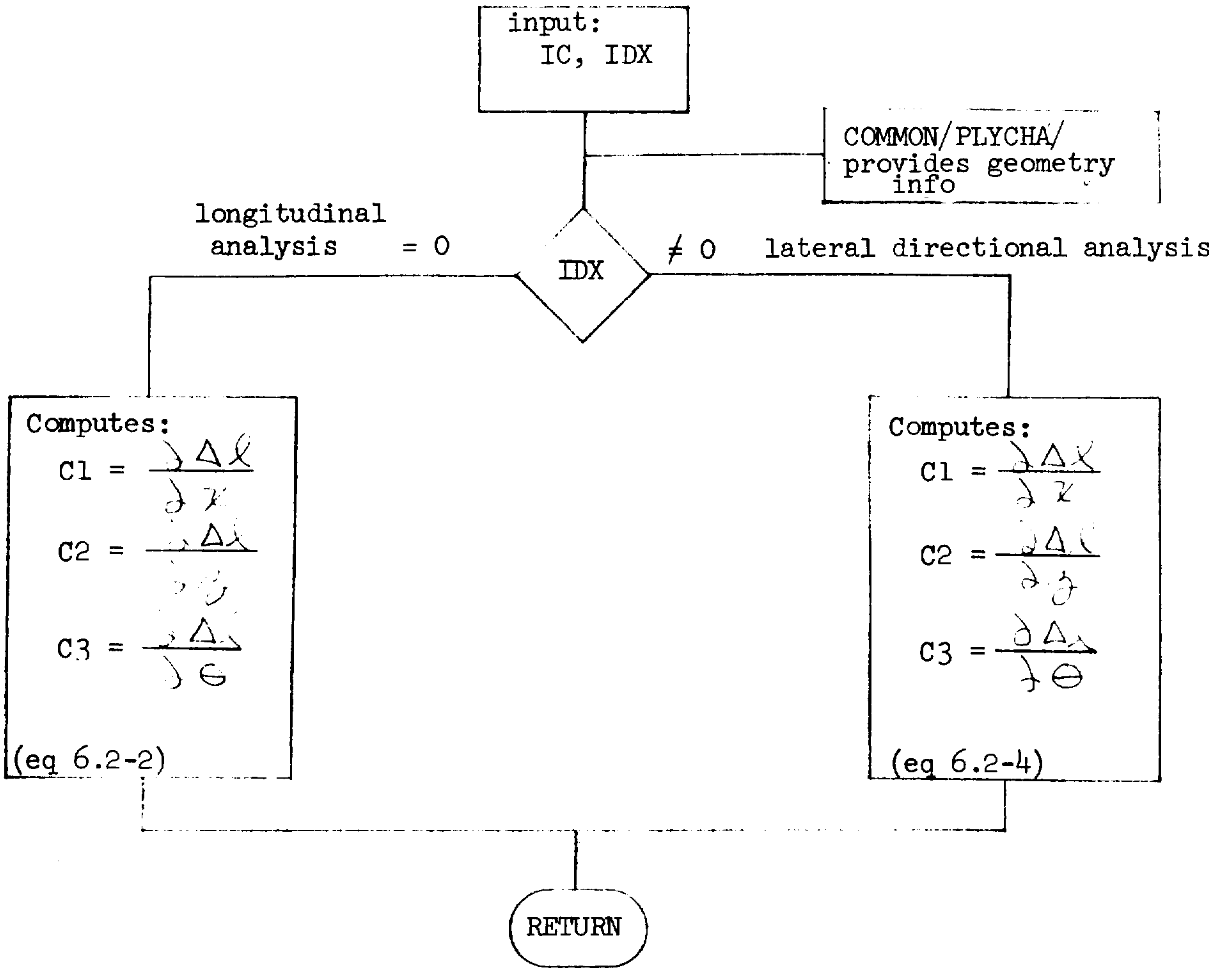


FIGURE 6.4 - FLOW CHART - SUBROUTINE LONG



IC = cable no.,

1 - front upper or front starboard pulley

2 - front lower or front port-side pulley

3 - rear upper or rear starboard pulley

4 - rear lower or rear port-side pulley

5 - anti-lift cable

FIGURE 6.5 - FLOW CHART - SUBROUTINE DLGTH

7.0 Lateral Directional Stability Analysis

7.1 Subroutine LAT

This subroutine computes the forces and moments for the perturbed lateral/directional equations of motion and extracts the characteristic roots for the stability analysis.

The equations of motion, equation 5.1-14, are reduced to 7.1-1 for the lateral/directional analysis.

$$\begin{aligned} \Sigma\Delta F_y &= m\ddot{y} \\ \Sigma\Delta M_x &= \ddot{\phi} I_x + \ddot{\Psi} I_{xz} \\ \Sigma\Delta M_z &= \ddot{\Psi} I_z - \ddot{\phi} I_{xz} \end{aligned} \tag{7.1-1}$$

where

$$\begin{aligned} \Sigma\Delta F_y &= \Delta F_{y_{aero}} + \Delta F_{y_{cable}} + \Delta W_y \\ \Sigma\Delta M_x &= \Delta L_{aero} + \Delta L_{cable} + \Delta L_{WGT} \\ \Sigma\Delta M_z &= \Delta N_{aero} + \Delta N_{cable} + \Delta L_{WGT} \end{aligned} \tag{7.1-2}$$

y, Ψ and ϕ represent lateral/directional perturbation variables:

The aerodynamic forces and moments, $\Delta F_{y_{aero}}$, ΔL_{aero} and ΔN_{aero} are defined by equations 5.3-3.2, 5.3-3.4 and 5.3-3.6 respectively. The generalized weight contributions are defined by equations 5.2-7 and 5.2-9. The expressions are simplified with x, z and $\theta = 0$.

$$\begin{aligned} \Delta W_y &= \left[W \sin\theta_o \Psi + W \cos\theta_o \phi\right] - m\left[XCG\ddot{\Psi} - ZCG\ddot{\phi}\right] \\ \Delta L_{WGT} &= -ZCG\left[(W \sin\theta_o \Psi + W \cos\theta_o \phi) - m\ddot{y}\right] \\ \Delta N_{WGT} &= XCG\left[(W \sin\theta_o \Psi + W \cos\theta_o \phi) - m\ddot{y}\right] \end{aligned} \tag{7.1-3}$$

The cable forces and moments are determined by equations 5.4-6 and 5.4-8. These equations reduce to equation 7.1-4 for x, z and θ zero.

$$\Delta F_I = \Delta F_{T_2} - \Psi F_{To_1} + \phi F_{To_3}$$

$$\Delta L_I = \left(y_p \Delta F_{T_3} - z_p \Delta F_{T_2}\right) + z_p F_{To_1} \Psi - \left(y_p F_{To_2} + z_p F_{To_3}\right) \phi \tag{7.1-4}$$

$$\Delta N_I = \left(x_p \Delta F_{T_2} - y_p \Delta F_{T_1}\right) - \left(x_p F_{To_1} + y_p F_{To_2}\right) \Psi + \left(x_p F_{To_3}\right) \phi$$

The F_{To} and ΔF_T components are defined by equations 5.4-3.2 and 5.4-3.3:

$$F_{To_i} = T \cos \alpha_i - T \Delta\alpha_i \sin \alpha_i \tag{5.4-3.2}$$

$$\Delta F_{T_i} = \Delta T_i \cos \alpha_i - T \Delta\alpha_i \sin \alpha_i \tag{5.4-3.3}$$

The steady state terms, T and α_i, are determined by the trim analysis. The perturbation terms, ΔT_i and $\Delta\alpha_i$, are proportional to y, Ψ and ϕ. In the lateral directional analysis, the rear cable tension, ΔT_{R_i}, is assumed proportional to the change in rear cable length.

$$\Delta T_{R_i} = AKR \left(\Delta \ell_3 + \Delta \ell_4\right) \tag{7.1-5}$$

The perturbed front cable tension, ΔT_{F_i}, is assumed to be zero in the analysis. The perturbed cable length, $\Delta \ell_i$, and cable direction cosine, $\Delta\alpha_i$, are computed in subroutines DLGTH and DCOSD respectively. These routines are described in Sections 6.2 and 7.2.

For each cable, the force and moment equations are reduced to functions of y, Ψ and ϕ via the subroutine MASH. The results are then summed for all cables in the FXS array. The final FXS array is the lateral/directional cable influence matrix. The form of the initial matrix prior to using MASH is shown in Figure 7.1.

Subsequent to computing the cable matrix, the lateral/directional stability characteristic matrix is generated. Figure 7.2 shows the elements of the matrix and the expanded equations of motion which it represents. A routine which reduces the matrix to a characteristic polynomial and extracts the characteristic roots is applied to the matrix at this point.

A functional flow diagram is presented in Figure 7.3.

7.2 Subroutine DCOSD.

This program computes the $\Delta\alpha$ vector components required by subroutine LAT. The vector components are derived from the generalized formulation in equation 5.4-18.

With x, z, and θ equated to zero for the lateral/directional stability analysis, equation 5.4-18 can be expanded to the following form:

$$\Delta\alpha_1 = \left(-\frac{\text{Cos }\alpha_2\text{ Cot }\alpha_1}{\ell}\right)y - \left(\frac{y_p\text{ Sin}\alpha_1 + x_p\text{ Cos }\alpha_2\text{ Cot }\alpha_1}{\ell}\right)\Psi + \left(\frac{z_p\text{ Cos }\alpha_2\text{ Cot }\alpha_1 - y_p\text{ Cos }\alpha_2\text{ Cot }\alpha_1}{\ell}\right)\phi \qquad (7.2\text{-}1)$$

$$\Delta\alpha_2 = \frac{\text{Sin }\alpha_2}{\ell}y + \left(\frac{y_p\text{ Cos }\alpha_1\text{ Cot }\alpha_2 + x_p\text{ Sin }\alpha_2}{\ell}\right)\Psi - \left(\frac{z_p\text{ Sin }\alpha_2 + y_p\text{ Cos }\alpha_3\text{ Cot }\alpha_2}{\ell}\right)\phi \qquad (7.2\text{-}2)$$

$$\Delta\alpha_3 = \left(-\frac{\text{Cos }\alpha_2\text{ Cot }\alpha_3}{\ell}\right)y + \left(\frac{y_p\text{ Cos }\alpha_1\text{ Cot }\alpha_3 - x_p\text{ Cos }\alpha_2\text{ Cot }\alpha_3}{\ell}\right)\Psi + \left(\frac{z_p\text{ Cos }\alpha_2\text{ Cot }\alpha_3 + y_p\text{ Sin }\alpha_3}{\ell}\right)\phi \qquad (7.2\text{-}3)$$

The program thus generates an array of nine elements, three elements for each of the three vectors.

LATERAL DI ECTIONAL CABLE MATRIX

	y	ψ	ϕ	ΔT	$\Delta\alpha_1$	$\Delta\alpha_2$	$\Delta\alpha_3$	Σl
①		$-T\cos\alpha_1$	$T\cos\alpha_3$	$\cos\alpha_2$		$-T\sin\alpha_2$		
②		$-x_pT\cos\alpha_1 - y_pT\cos\alpha_2$	$x_pT\cos\alpha_3$	$x_p\cos\alpha_2 - y_p\cos\alpha_1$	$y_pT\sin\alpha_1$	$-x_pT\sin\alpha_2$		
③		$z_pT\cos\alpha_1$	$-z_pT\cos\alpha_3 - y_pT\cos\alpha_2$	$y_p\cos\alpha_3 - z_p\cos\alpha_2$		$z_pT\sin\alpha_2$	$y_pT\sin\alpha_3$	
④				-1				AKR
⑤	$\Delta\alpha_{1y}$	$\Delta\alpha_{1\psi}$	$\Delta\alpha_{1\phi}$		-1			
⑥	$\Delta\alpha_{2y}$	$\Delta\alpha_{2\psi}$	$\Delta\alpha_{2\phi}$			-1		
⑦	$\Delta\alpha_{3y}$	$\Delta\alpha_{3\psi}$	$\Delta\alpha_{3\phi}$				-1	
⑧	Δl_y	Δl_ψ	Δl_ϕ					-1

EQUATIONS:

① $\Delta F_{I_2} = \Delta F_{T_2} - F_{T01}\psi + F_{T03}\phi = (\Delta T\cos\alpha_2 - \Delta\alpha_2 T\sin\alpha_2) - T\cos\alpha_1\psi + T\cos\alpha_3\phi$ (eq 7.1-4)

② $\Delta N_I = (x_p\Delta F_{T_2} - y_p\Delta F_{T_1}) - (x_pF_{T01} + y_pF_{T02})\psi + x_pF_{T03}\phi = [x_p(\Delta T\cos\alpha_2 - \Delta\alpha_2 T\sin\alpha_2) - y_p(\Delta T\cos\alpha_1 - \Delta\alpha_1 T\sin\alpha_1)]$
$- [x_pT\cos\alpha_1 + y_pT\cos\alpha_2]\psi + x_pT\cos\alpha_3\phi$ (eq 7.1-4)

③ $\Delta L_I = (y_p\Delta F_{T_3} - z_p\Delta F_{T_2}) + z_pF_{T01}\psi - (y_pF_{T02} + z_pF_{T03})\phi = [y_p(\Delta T\cos\alpha_3 - \Delta\alpha_3 T\sin\alpha_3) - z_p(\Delta T\cos\alpha_2 - \Delta\alpha_2 T\sin\alpha_2)]$
$+ z_pT\cos\alpha_1\psi - [y_pT\cos\alpha_2 + z_pT\cos\alpha_3]\phi$ (eq 7.1-4)

④ $\Delta T_F = 0$, $\Delta T_R = AKR\,(\Delta l_3 + \Delta l_4)$ (eq 7.1-5)

⑤ $\Delta\alpha_1 = \Delta\alpha_{1y}\,y + \Delta\alpha_{1\psi}\psi + \Delta\alpha_{1\phi}\phi$ (eq 7.2-1)

⑥ $\Delta\alpha_2 = \Delta\alpha_{2y}\,y + \Delta\alpha_{2\psi}\psi + \Delta\alpha_{2\phi}\phi$ (eq 7.2-2)

⑦ $\Delta\alpha_3 = \Delta\alpha_{3y}\,y + \Delta\alpha_{3\psi}\psi + \Delta\alpha_{3\phi}\phi$ (eq 7.2-3)

⑧ $\Sigma l = \Delta l_y\,y + \Delta l_\psi\psi + \Delta l_\phi\phi = (\Delta l_{3y} + \Delta l_{4y})y + (\Delta l_{3\psi} + \Delta l_{4\psi})\psi + (\Delta l_{3\phi} + \Delta l_{4\phi})\phi$ (eq 6.2-4

FIG. 7.1 - MATRIX

LATERAL DIRECTIONAL CHARACTERISTICS MATRIX & EQUATIONS

y	ψ	ϕ
$m s^2 - \left(\frac{\partial Y_A}{\partial \beta}\frac{1}{V_0} + \frac{\partial Y_{SN}}{\partial \dot y}\right)s - \frac{\partial Y_c}{\partial y}$	$m X_{CG} s^2 - \left(\frac{\partial Y_A}{\partial r} + \frac{\partial Y_{SN}}{\partial r}\right)s + \left(\frac{\partial Y_A}{\partial \beta} - \frac{\partial Y_c}{\partial \psi} - W \sin\Theta_0\right)$	$-m Z_{CG} s^2 - \left(\frac{\partial Y_A}{\partial p} + \frac{\partial Y_{SN}}{\partial \dot\phi}\right)s - \left(\frac{\partial Y_c}{\partial \phi} + W\cos\Theta_0\right)$
$m X_{CG} s^2 - \left(\frac{\partial N_A}{\partial \beta}\frac{1}{V_0} + \frac{\partial N_{SN}}{\partial \dot y}\right)s - \frac{\partial N_c}{\partial y}$	$I_{ZZ} s^2 - \left(\frac{\partial N_A}{\partial r} + \frac{\partial N_{SN}}{\partial r}\right)s + \left(\frac{\partial N_A}{\partial \beta} - \frac{\partial N_c}{\partial \psi} - X_{CG} W \sin\Theta_0\right)$	$-I_{XZ} s^2 - \left(\frac{\partial N_A}{\partial p} + \frac{\partial N_{SN}}{\partial p}\right)s - \left(\frac{\partial N_c}{\partial \phi} - X_{CG} W\cos\Theta_0\right)$
$-m Z_{CG} s^2 - \left(\frac{\partial L}{\partial \beta}\frac{1}{V_0} + \frac{\partial L_{SN}}{\partial \dot y}\right)s - \frac{\partial L_c}{\partial y}$	$-I_{XZ} s^2 - \left(\frac{\partial L_A}{\partial r} + \frac{\partial L_{SN}}{\partial r}\right)s + \left(\frac{\partial L_A}{\partial \beta} - \frac{\partial L_c}{\partial \psi} - Z_{CG} W \sin\Theta_0\right)$	$I_{XX} s^2 - \left(\frac{\partial L_A}{\partial p} + \frac{\partial L_{SN}}{\partial p}\right)s - \left(\frac{\partial L_c}{\partial \phi} + Z_{CG} W\cos\Theta_0\right)$

Y-Force Equation:

$$m\ddot y = \underbrace{\frac{\partial Y_A}{\partial \beta}\beta + \frac{\partial Y_A}{\partial r}\dot\psi + \frac{\partial Y_A}{\partial p}\dot\phi}_{\text{Aero}} + \underbrace{W\sin\Theta_0\,\psi + W\cos\Theta_0\,\phi - m X_{CG}\ddot\psi + m Z_{CG}\ddot\phi}_{\text{Weight}} + \underbrace{\frac{\partial Y_c}{\partial y}y + \frac{\partial Y_c}{\partial \psi}\psi + \frac{\partial Y_c}{\partial \phi}\phi}_{\text{Cable Spring Force}} + \underbrace{\frac{\partial Y_{SN}}{\partial \dot y}\dot y + \frac{\partial Y_{SN}}{\partial \dot\psi}\dot\psi + \frac{\partial Y_{SN}}{\partial \dot\phi}\dot\phi}_{\text{Snubber Damping Force}}$$

Yaw Moment Equation:

$$I_{ZZ}\ddot\psi - I_{XZ}\ddot\phi = \underbrace{\frac{\partial N_A}{\partial \beta}\beta + \frac{\partial N_A}{\partial r}\dot\psi + \frac{\partial N_A}{\partial p}\dot\phi}_{\text{Aero Mom}} + \underbrace{X_{CG}\left(W\sin\Theta_0 - W\cos\Theta_0\right) - m X_{CG}\ddot y}_{\text{Weight Mom}} + \underbrace{\frac{\partial N_c}{\partial y}y + \frac{\partial N_c}{\partial \psi}\psi + \frac{\partial N_c}{\partial \phi}\phi}_{\text{Cable Spring Moment}} + \underbrace{\frac{\partial N_{SN}}{\partial \dot y}\dot y + \frac{\partial N_{SN}}{\partial \dot\psi}\dot\psi + \frac{\partial N_{SN}}{\partial \dot\phi}\dot\phi}_{\text{Snubber Damping Moment}}$$

Roll Moment Equation:

$$I_{XX}\ddot\phi - I_{XZ}\ddot\psi = \underbrace{\frac{\partial L_A}{\partial \beta}\beta + \frac{\partial L_A}{\partial r}\dot\psi + \frac{\partial L_A}{\partial p}\dot\phi}_{\text{Aero Mom}} + \underbrace{Z_{CG}\left(W\cos\Theta_0 + W\sin\Theta_0\right) + m Z_{CG}\ddot y}_{\text{Weight Mom}} + \underbrace{\frac{\partial L_c}{\partial y}y + \frac{\partial L_c}{\partial \psi}\psi + \frac{\partial L_c}{\partial \phi}\phi}_{\text{Cable Spring Moment}} + \underbrace{\frac{\partial L_{SN}}{\partial \dot y}\dot y + \frac{\partial L_{SN}}{\partial \dot\psi}\dot\psi + \frac{\partial L_{SN}}{\partial \dot\phi}\dot\phi}_{\text{Snubber Damping Moment}}$$

Auxiliary Equation

$$\beta = \psi + \frac{y}{V_0} \qquad \dot\beta = \dot\psi + \frac{\dot y}{V_0}$$

FIG. 7.2 - MATRIX

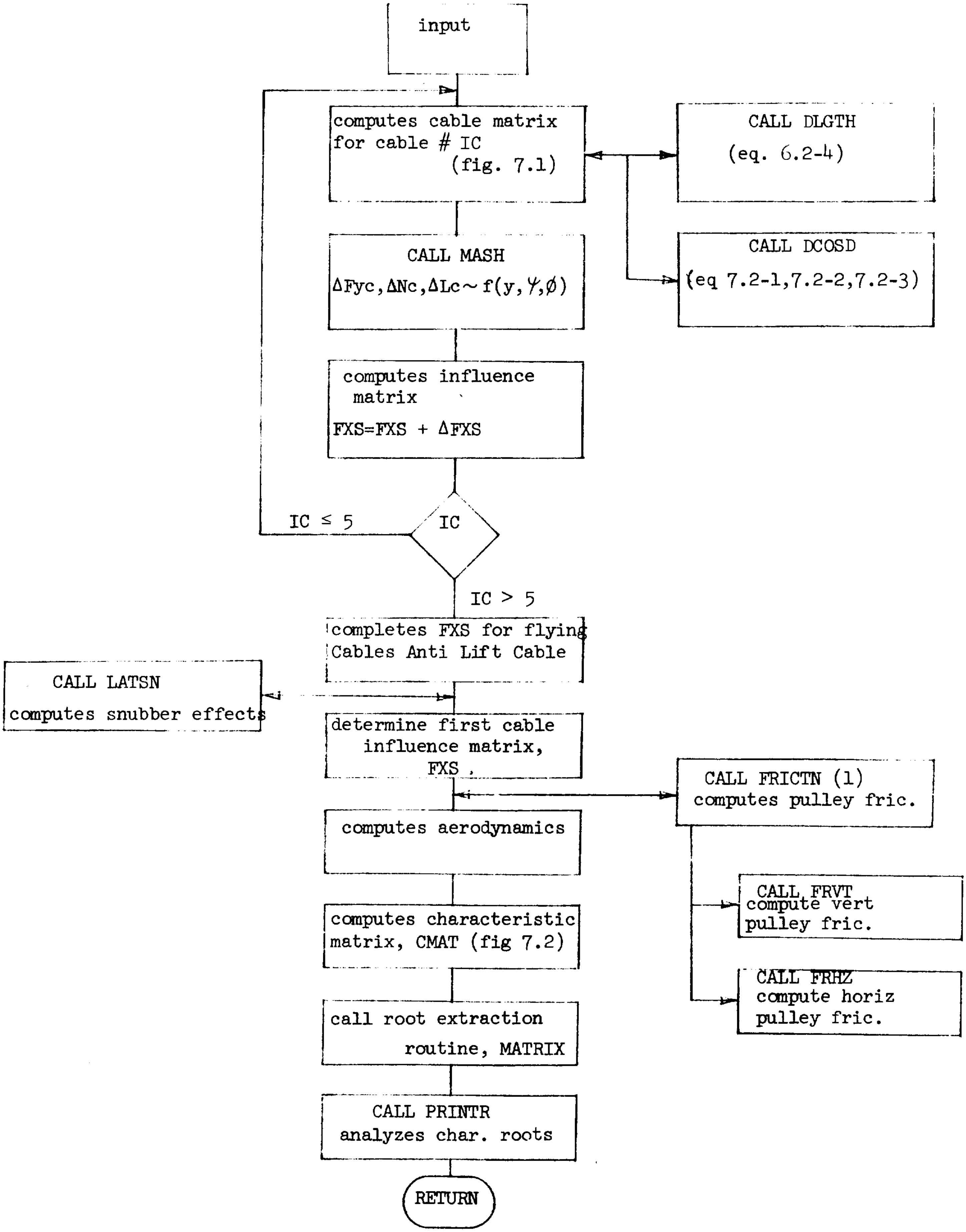


FIGURE 7.3 - FLOW CHART - SUBROUTINE LAT.

8.0 MODELING SNUBBER EFFECTS

8.1 SNUBBER SNUBBED EFFECTS

8.1.1 TRIM EFFECTS

The effects of the snubbers on model trim are introduced as FXSN, FZSN and AMSN into the TRIM subroutine. These terms are calculated in subroutine SNTRM. The expressions for modeling these effects are identical to those used for the flying cables. The direction cosines for each snubber cable are generated in subroutine DRSCN with the resulting force and moment contributions being defined in terms of these angles.

The following derivation of one set of direction cosines for the upper right cable applies to all snubber cables. See Figure 11.3 for a definition of terms.

Calculate linear components from equation reference center to snubber tie down at the tunnel wall:

$$X_{T_1} = \text{STACR} - \text{SNUST}$$

$$Z_{T_1} = \text{WLCR} - \text{SNUWL}$$

$$Y_{T_1} = - \text{SNUBL}$$

transforming to body axis:

$$X_{B_1} = X_{T_1} \text{ Cos } \theta - Z_{T_1} \text{ Sin } \theta$$

$$Z_{B_1} = X_{T_1} \text{ Sin } \theta + Z_{T_1} \text{ Cos } \theta$$

$$Y_{B_1} = Y_{T_1}$$

Finding linear components from model tie down point to tunnel side wall:

$$X_B = X_{B_1} + SNUX$$

$$Y_B = Y_{B_1} + SNUY$$

$$Z_B = Z_{B_1} + SNUZ$$

The linear distance is then:

$$L = \sqrt{X_B^{\,2} + Y_B^{\,2} + Z_B^{\,2}}$$

The direction cosines are:

$$\gamma_x = X_B/L \qquad \gamma_y = Y_B/L \qquad \gamma_z = Z_B/L$$

resulting in the angles being:

$$\alpha_x = \mathrm{Cos}^{-1}\,\gamma_x,\ \alpha_y = \mathrm{Cos}^{-1}\,\gamma_y,\ \alpha_z = \mathrm{Cos}^{-1}\,\gamma_z$$

Assuming top and bottom cables to be symmetric with respect to the X-Z plane, the following force and moment equations define the terms necessary to determine trim.

$$F_{X_{up}} = 2\,T_{up}\,\mathrm{Cos}\,\alpha_{x_u} \qquad F_{X_{low}} = 2\,T_{low}\,\mathrm{Cos}\,\alpha_{X_l}$$

$$F_{Z_{up}} = 2\,T_{up}\,\mathrm{Cos}\,\alpha_{z_u} \qquad F_{Z_{low}} = 2\,T_{low}\,\mathrm{Cos}\,\alpha_{Z_l}$$

$$M_{up} = (-SNUZ)\,F_{X_{up}} + (SNUX)\,F_{Z_{up}} \qquad M_{low} = (SNLZ)\,F_{X_{low}} + (SNLX)\,F_{Z_{low}}$$

or:

$$F_x = F_{x_{up}} + F_{x_{low}} = FXSN$$

$$F_z = F_{z_{up}} + F_{z_{low}} = FZSN$$

$$M = M_{up} + M_{low} = AMSN$$

A flow chart of subroutine SNTRM is shown in Figure 8.1.

8.1.2 STABILITY EFFECTS

The effects of the snubbed snubbers on both longitudinal and lateral stability are modeled similar to the rear flying cables. These effects are calculated in subroutines LONGSN and LATSN and inserted into subroutines LONG and LAT as additional terms (SNU, SNUD) in the polynomial matrix describing the system. Each cable is modeled independently, the terms effecting each cable are summed up and the results, contained in the SNU array, are combined with the flying cable effects in the CMAT array. Since the theoretical derivation of these terms is similar to the rear flying cables, the derivation here will be abbreviated.

The major difference in the derivation is the calculation of the change in tension. For the rear flying cables the cable tension change was defined as:

$$\Delta T = K\Delta L$$

The snubber cables have an added damping effect resulting in the following equation:

$$\Delta T = K\Delta L + D\,\dot{\Delta L}$$

The damping term is added to the polynomial matrix CMAT through the array SNUD.

Flow charts for subroutines LONGSN and LATSN are shown in Figures 8.2 and 8.3.

8.1.2.1 LONGITUDINAL STABILITY EFFECTS

Due to symmetry the longitudinal effects of the top snubbers are modelled simultaneously and similarly the bottom cables can be modelled together. Only the top cable derivation will be presented here. See Figure 11.3 for a pictorial representation of the snubbers.

The total force and moment equations from Section 5.0 are:

$$\Sigma F_x = 2 (T + \Delta T) \text{Cos} (\alpha_x + \Delta\alpha_x) - (2T \text{Cos}\alpha_z) \theta$$

$$\Sigma F_z = 2 (T + \Delta T) \text{Cos} (\alpha_z + \Delta\alpha_z) + (2T \text{Cos}\alpha_x) \theta$$

$$\Sigma M = (\text{SNUZ}) (-F_x) + (\text{SNUX}) F_z$$

Defining perturbation terms:

$$\Delta T = K \Delta L + D \Delta\dot{L}$$

and from Section 5.0:

$$\Delta\alpha_x = \left[\frac{-\text{SNUX Sin } \alpha_x}{\text{ALU}} + \left(\frac{-\text{SNUX}}{\text{ALU}}\right)\text{Cos } \alpha_z \text{ Cot } \alpha_x\right] \theta$$

$$+ \left[\frac{\text{Sin } \alpha_x}{\text{ALU}}\right] x + \left[\frac{-\text{Cos}\alpha_z \text{ Cot}\alpha_x}{\text{ALU}}\right] z$$

$$\Delta\alpha_z = \left[\frac{\text{SNUZ Cos } \alpha_x \text{ Cot}\alpha_z}{\text{ALU}} + \left(\frac{-\text{SNUX}}{\text{ALU}}\right) \text{Sin } \alpha_z\right] \theta + \left[\frac{\text{Sin } \alpha_z}{\text{ALU}}\right] z$$

$$+ \left[\frac{-\text{Cos } \alpha_x \text{ Cot } \alpha_z}{\text{ALU}}\right] x$$

$$\Delta L = \left[-\text{Cos } \alpha_x\right] x + \Big[(- \text{SNUX} + (\text{ALU}) \text{ Cos } \alpha_x) \text{ Cos } \alpha_z$$

$$- (-\text{SNUZ} + (\text{ALU}) \text{ Cos } \alpha_z) \text{ Cos } \alpha_x \Big] \theta - \left[\text{Cos } \alpha_z\right] z$$

These equations are set in a 7 x 7 matrix with the following form:

$$\begin{bmatrix} \Sigma F_x & & & & & & \\ \Sigma F_z & & & & & & \\ \Sigma M & & & & & & \\ & & & -1 & & & \\ & & & & -1 & & \\ & & & & & -1 & \\ & & & & & & -1 \end{bmatrix} \begin{bmatrix} x \\ z \\ \theta \\ \Delta\alpha_x \\ \Delta\alpha_z \\ \Delta T \\ \Delta L \end{bmatrix} = 0$$

This matrix is reduced to a 3 x 3 matrix in x, z and θ. The first order terms are contained in the 3 x 3 array FTOP and the damping terms (second order) are contained in the array SNUD.

A similar procedure is followed for the effects of the bottom cables. The terms for each set of cables are then combined and added to the longitudinal stability matrix through the arrays SNU and SNUD.

8.1.2.2 LATERAL STABILITY EFFECTS

The lateral stability effects of the snubbers are modeled for each cable individually and the results summed up. The procedure is similar to the longitudinal case. Only the top right cable terms will be shown here. The effects for the other cables are similar.

Force and moment equations are:

$$F_y = (T + \Delta T)\ \mathrm{Cos}\ (\alpha_y + \Delta\alpha_y) - (T\ \mathrm{Cos}\ \alpha_x)\ \Psi + (T\ \mathrm{Cos}\ \alpha_z)\ \phi$$

$$\Sigma N = (-SNUX)\ F_y + (SNUY)\ F_x$$

$$\Sigma L = (-SNUY)\ F_z + (SNUZ)\ F_y$$

expanding the equations and dropping the steady state terms:

$$\Sigma\Delta F_y = \Delta T\ \mathrm{Cos}\ \alpha_y - T\ \mathrm{Sin}\ \alpha_y\ \Delta\alpha_y - \Psi T\ \mathrm{Cos}\ \alpha_x + T\ \mathrm{Cos}\ \alpha_z\ \phi$$

$$\Sigma\Delta N = (-SNUX)\ \Delta F_y + SNUY\ \left[\Delta T\ \mathrm{Cos}\ \alpha_x - T\ \mathrm{Sin}\ \alpha_x\ \Delta\ \alpha_x\right]$$

$$\Sigma\Delta L = (SNUZ)\ \Delta F_y - SNUY\ \left[\Delta T\ \mathrm{Cos}\ \alpha_z - T\ \mathrm{Sin}\ \alpha_z\ \Delta\ \alpha_z\right]$$

Defining ΔT, ΔL, $\Delta\alpha_x$, Δ_y, $\Delta\alpha_z$:

$$\Delta T = K\Delta\ell + D\ \Delta\dot{\ell}$$

From Section 5.0:

$$\Delta \ell = \left[- \text{Cos } \alpha_y \right] Y + \left[(\text{-SNUZ}) \text{ Cos } \alpha_y + (\text{SNUY}) \text{ Cos } \alpha_z \right] \phi + \left[(\text{-SNUY}) \text{ Cos } \alpha_x + (\text{SNUX}) \text{ Cos } \alpha_y \right] \Psi$$

$$\Delta \alpha_x = \left[\frac{(\text{-SNUY}) \text{ SIN } \alpha_x - (\text{SNUX}) \text{ Cos } \alpha_y \text{ Cot } \alpha_x}{\text{ALU}} \right] \Psi + \left[\frac{(\text{-SNUZ}) \text{ Cos } \alpha_y \text{ Cot } \alpha_x + \text{SNUY Cos } \alpha_z \text{ Cot } \alpha_x}{\text{ALU}} \right] \phi + \left[\frac{-\text{Cos } \alpha_y \text{ Cot } \alpha_x}{\text{ALU}} \right] y$$

$$\Delta \alpha_y = \left[\frac{(\text{-SNUY}) \text{ Cos } \alpha_y \text{ Cot } \alpha_y - (\text{SNUX}) \text{ Sin } \alpha_y}{\text{ALU}} \right] \Psi + \left[\frac{\text{Sin } \alpha_y}{\text{ALU}} \right] y - \left[\frac{(\text{-SNUZ}) \text{ Sin } \alpha_y - (\text{SNUY}) \text{ Cos } \alpha_z \text{ Cot } \alpha_y}{\text{ALU}} \right] \phi$$

$$\Delta \alpha_z = \left[\frac{(\text{-SNUY}) \text{ Cos } \alpha_x \text{ Cot } \alpha_z + (\text{SNUX}) \text{ Cos } \alpha_y \text{ Cot } \alpha_z}{\text{ALU}} \right] \Psi + \left[\frac{(\text{-SNUZ}) \text{ Cos } \alpha_y \text{ Cot } \alpha_z - (\text{SNUY}) \text{ Sin } \alpha_z}{\text{ALU}} \right] \phi - \left[\frac{\text{Cos } \alpha_y \text{ Cot } \alpha_z}{\text{ALU}} \right] y$$

These equations are set in a 8 x 8 matrix with the following form:

$$\begin{bmatrix} \Sigma F_y & & & & & & & \\ \Sigma \Delta N & & & & & & & \\ \Sigma \Delta L & & & & & & & \\ & & & -1 & & & & \\ & & & & -1 & & & \\ & & & & & -1 & & \\ & & & & & & -1 & \\ & & & & & & & -1 \end{bmatrix} \begin{bmatrix} y \\ \Psi \\ \phi \\ \Delta \alpha_x \\ \Delta \alpha_y \\ \Delta \alpha_z \\ \Delta T \\ \Delta \ell \end{bmatrix} = 0$$

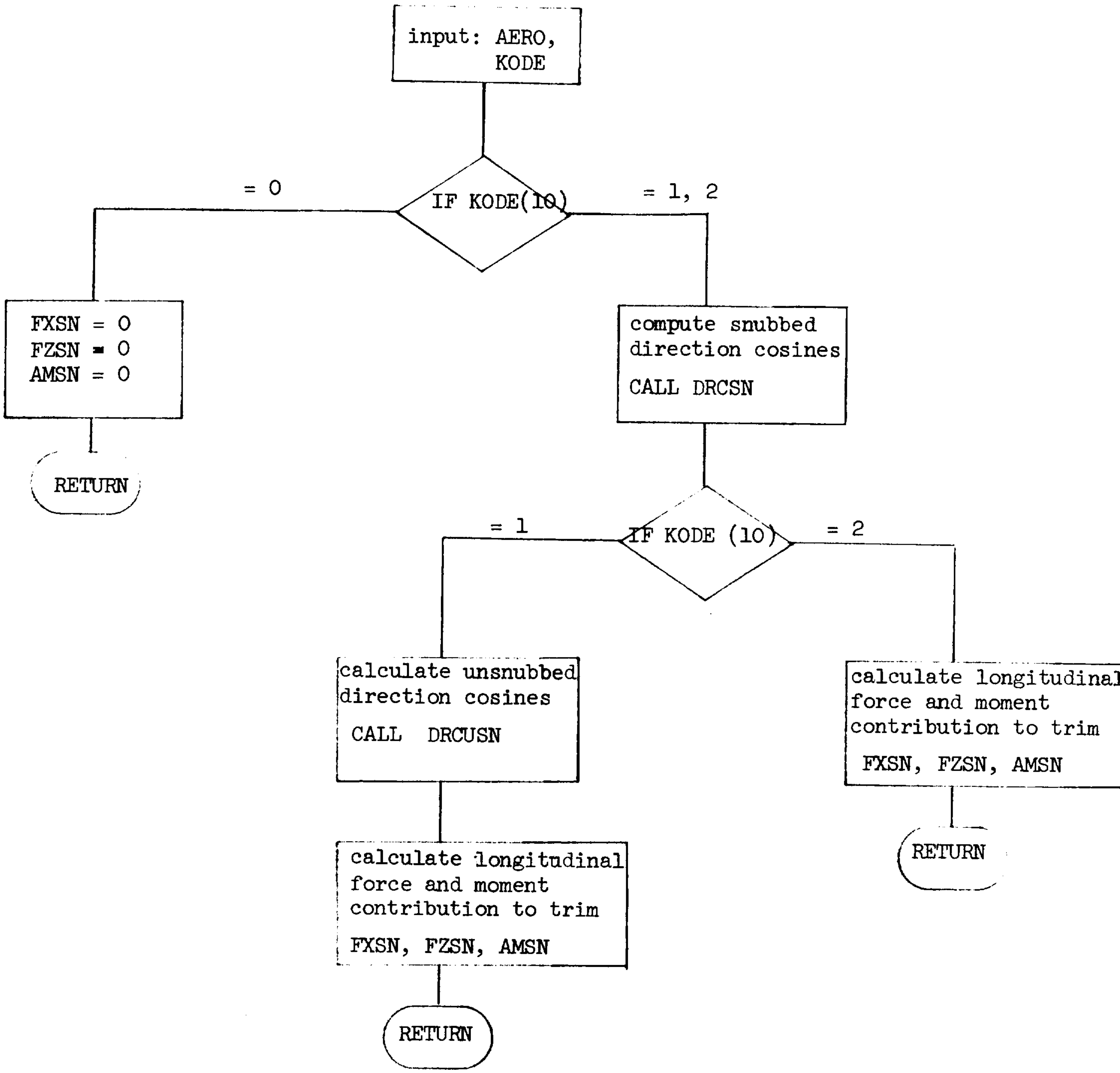


FIGURE 8.1 - FLOW CHART - SUBROUTINE SNTRM

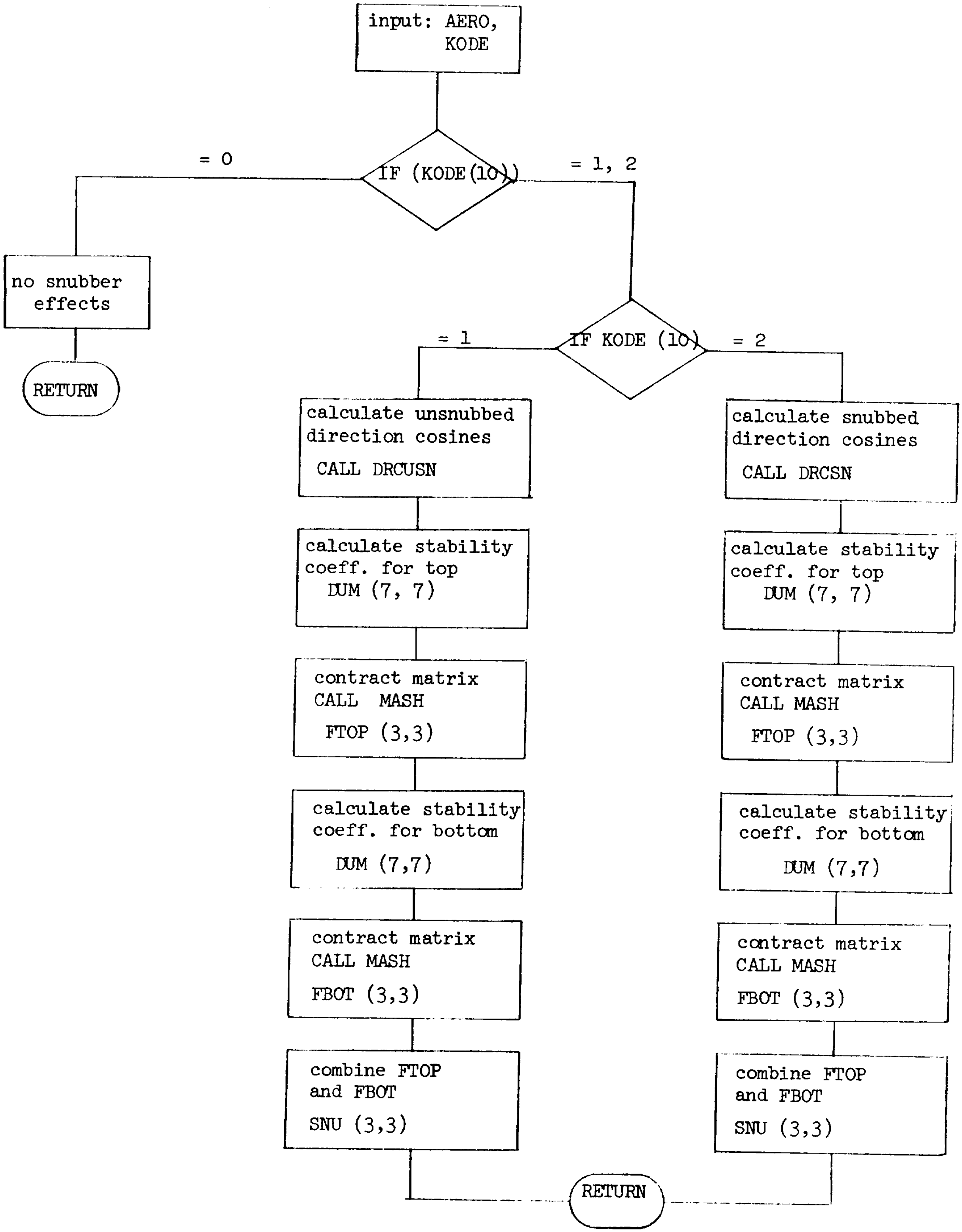


FIGURE 8.2 - FLOW CHART - SUBROUTINE LONGSN

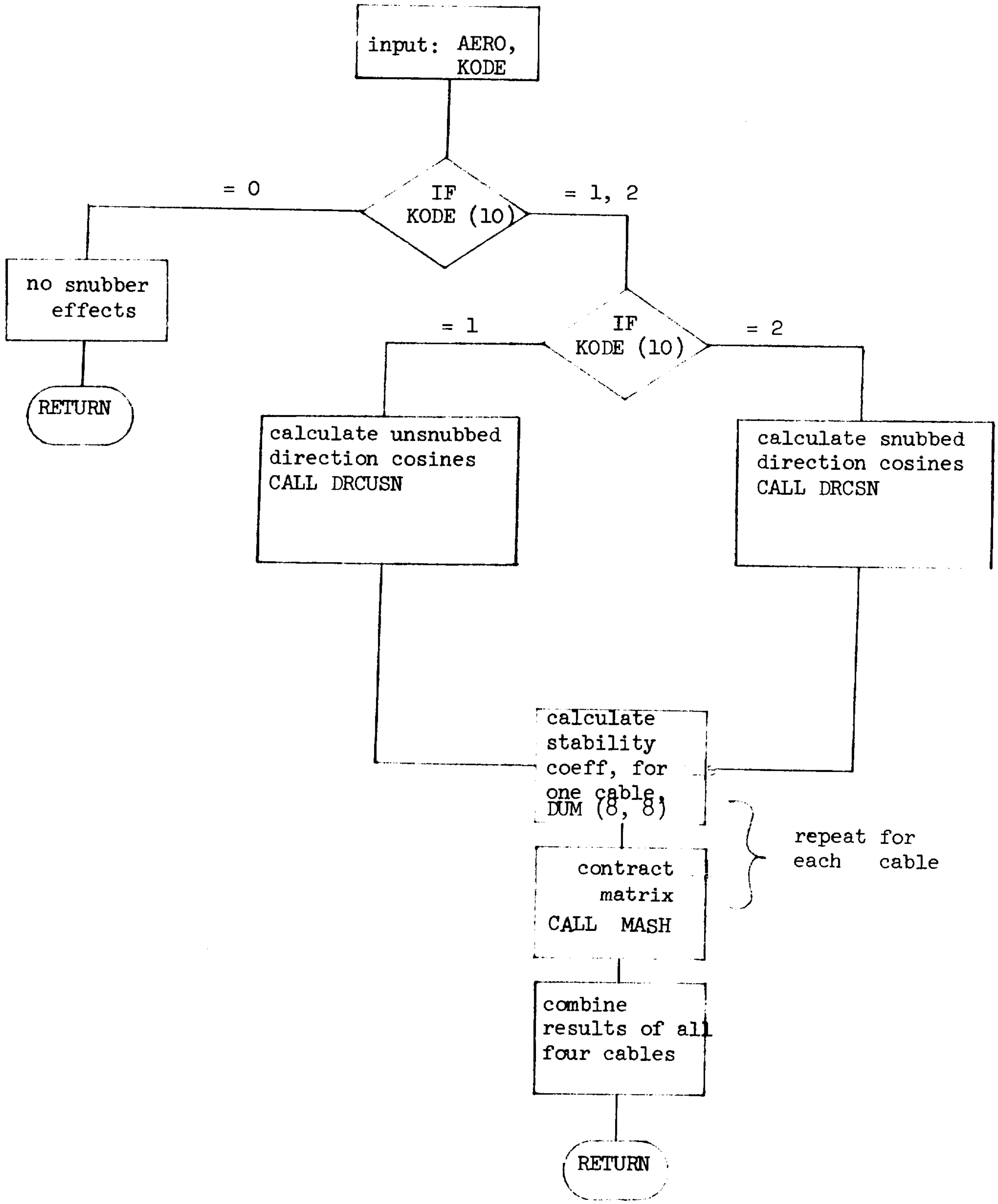


FIGURE 8.3 - FLOW CHART - SUBROUTINE LATSN

This matrix is reduced to a 3 x 3 matrix in y, Ψ and ϕ. A similar procedure is used to derive the contributions of the other three cables. The effects of all cables are added and introduced in the lateral stability matrix as SNU and SNUD.

8.2 UNSNUBBED SNUBBER EFFECTS

8.2.1 TRIM EFFECTS

The effects of the unsnubbed snubbers are modeled similar to the snubbed case except for the calculation of the direction cosines and the effective spring constant for each cable. The direction cosines for each slack cable are calculated in subroutine DRCUSN using the data from Table 1. This table contains a record of the true angle (θ_s) between the unsnubbed cable at the model tie down point and the tunnel negative X axis vs. dynamic pressure and linear distance (L_s) between model and tunnel wall tie down points. This function is shown graphically below.

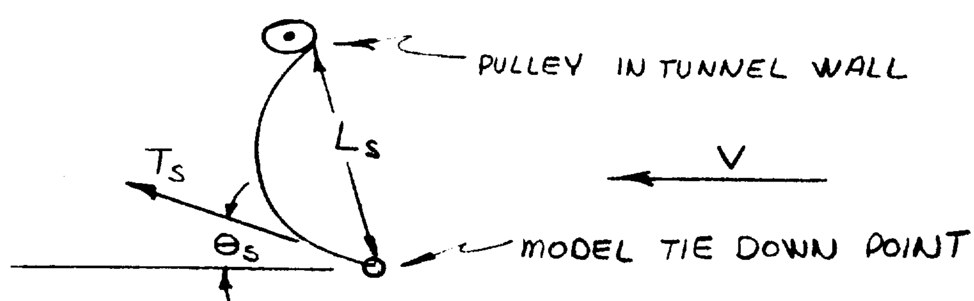


FIG. 8.4

L_s = true linear distance between the model tie-down and side wall pulley.

θ_s = angle made between the slack cable and the tunnel centerline.

T_s = tension in cable at tie-down point.

The direction cosines are derived below for the top right snubber in the unsnubbed condition. The other three cables are similarly derived. Referring to Figure 8.4, the angle the cable makes with the X-axis is:

$$\alpha_x = - \mathrm{Cos}^{-1} (\theta_s)$$

The Y and Z axis angles are derived from the theoretical length of a vector originating at the model tie-down point, intercepting the tunnel side wall and running parallel to the force vector shown below.

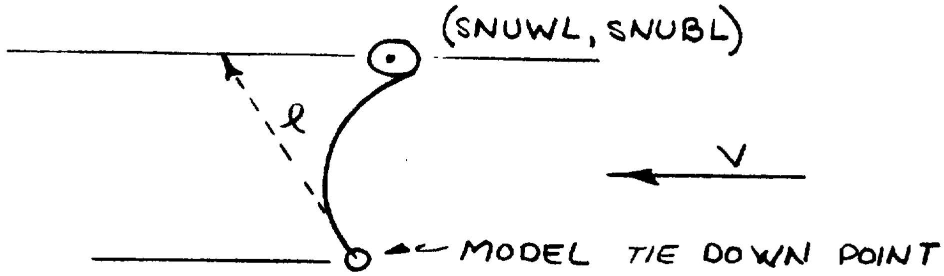


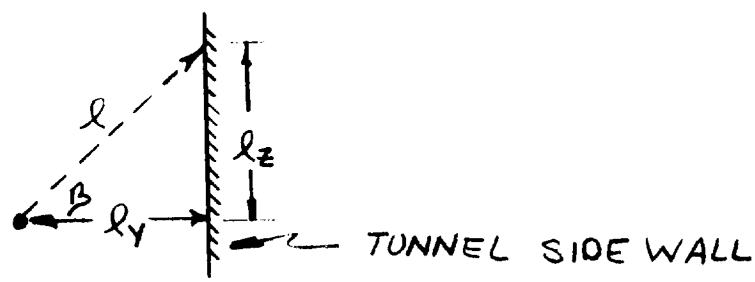
Fig. 8.5

The Y and Z components of this vector are:

$$\ell_z = SNUWL - (WLCR + SNUZ - SNUX*SIN\ \theta)$$

$$\ell_y = SNUBL - (BLCR + SNUY)$$

A front view of this vector shows:



from which: $\beta = \mathrm{Tan}^{-1}\ \ell_z/\ell_y$

The theoretical length of the vector is then:

$$\ell = \ell_y/(\mathrm{Sin}\ \theta_s)(\mathrm{Cos}\ \beta)$$

which implies the direction cosines are:

$$\gamma_y = \ell_y/_\ell \qquad \alpha_y = \mathrm{Cos}^{-1}\ \gamma_y$$

$$\gamma_z = \ell_z/_\ell \qquad \alpha_z = \mathrm{Cos}^{-1}\ \ell_z$$

These angles are in the tunnel axis system, converting to model body axis:

$$\alpha_{x_1} = \alpha_x \cos\theta - \alpha_z \sin\theta$$

$$\alpha_{y_1} = \alpha_y$$

$$\alpha_{z_1} = \alpha_z \cos\theta + \alpha_x \sin\theta$$

Since top and bottom cables are symmetric with respect to the X-Z plane, the equations shown in Section 8.1.1 can be used once again to describe the longitudinal force and moment contributions to trim.

$$F_x = 2\ T_s \cos\alpha_x$$

$$F_z = 2\ T_s \cos\alpha_z$$

$$M = (-\mathrm{SNUX})\ F_x + (\mathrm{SNUX})\ F_z$$

The tension (T_s) as a function of dynamic pressure and length (L_s) is contained in Table 2.

8.2.2 STABILITY EFFECTS

The effects of the unsnubbed snubbers on longitudinal and lateral/directional stability are modeled exactly as the snubbed case using the direction cosines derived in the previous section. The effective spring constant is calculated by obtaining the local slope of the change in tension (T_s) per change in length (L_s) obtained from Table 2.

$$\Delta T = K\ \Delta L$$

$$K = \Delta T_s / \Delta L$$

The effects on stability of the unsnubbed snubber are calculated in LONGSN and LATSN and inserted into subroutines LONG and LAT as additional terms (SNU) in the matrices describing the system.

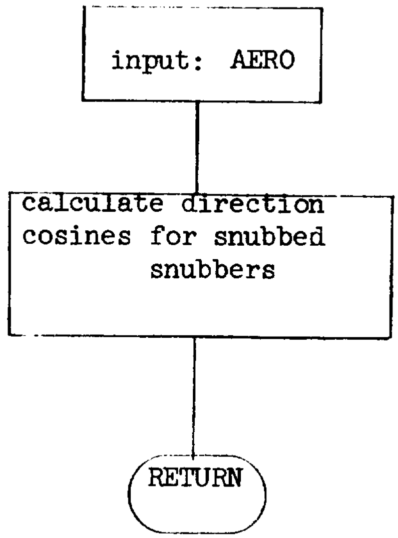
8.2.2.1 LONGITUDINAL STABILITY

Symmetry allows the top cables to be treated together and similarly the bottom cables. The equations are exactly the same as tabulated in Section 8.1.2.1. The direction cosines derived for the slack cable are used in all equations except for the ΔL equation.

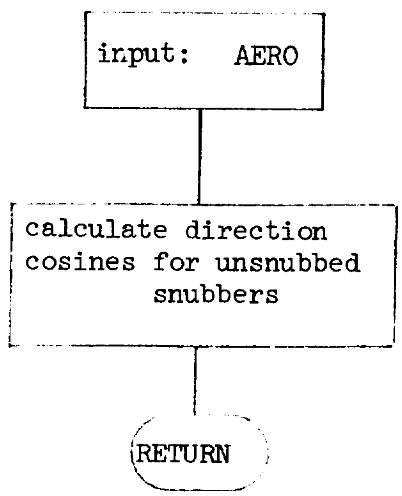
Since the spring constraint is defined in terms of a change in linear distance (L_s), the ΔL must be defined in terms of this length. Therefore the snubbed direction cosines are used for this equation. There are no damping terms ($D\ \dot{\Delta L}$) associated with the unsnubbed cable.

8.2.2.2 LATERAL STABILITY

These terms are modeled exactly the same as the snubbed case except for the changes described in the preceding section.



SUBROUTINE DRCSN



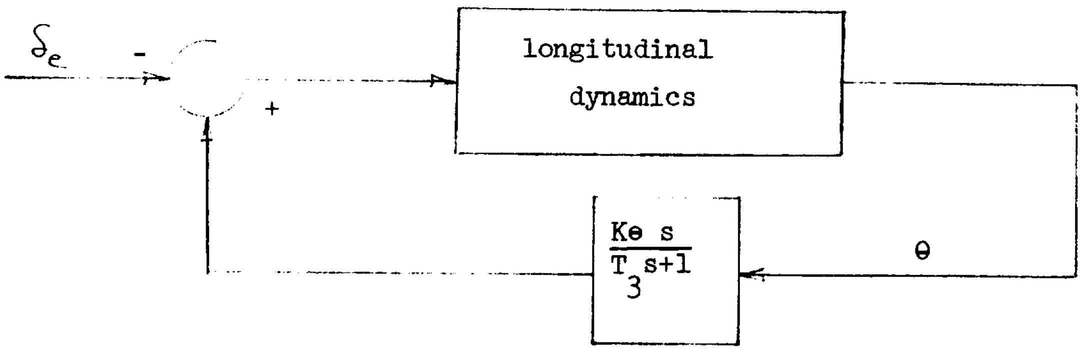
SUBROUTINE DRCUSN

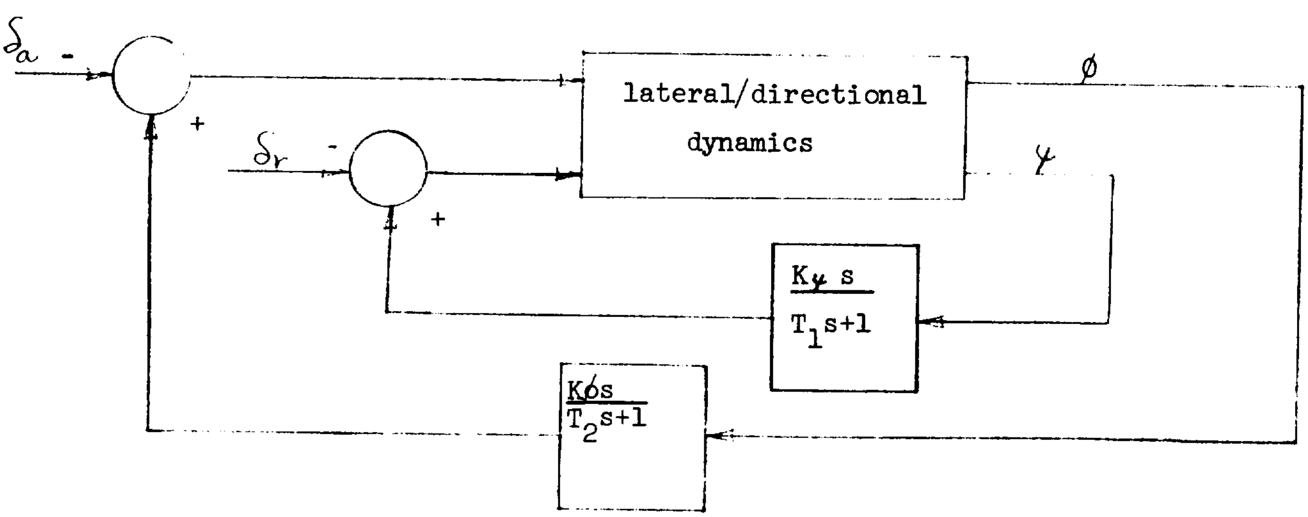
FIGURE 8.6 - FLOW CHART - SUBROUTINE DRCSN, DRCUSN

9.0 DESCRIPTION OF FEEDBACK MODELS

The feedback loops for both the longitudinal and lateral /directional stability analysis are modeled using additional rows and columns in the basic polynomial matrix representation of the dynamics.

The basic feedback elements for which provisions have been made in the program are shown below in block diagram form.





The equations describing the feedbacks are:

$$\delta_e = \frac{K_\theta S}{T_3 S+1} \theta$$

$$\delta_a = \frac{K_\theta S}{T_1 S+1} \phi, \quad \delta_r = \frac{K_\Psi S}{T_2 S+1} \Psi$$

The basic polynomial matrices are modified as follows to account for the feedback control laws.

Longitudinal:

$$\left[\begin{array}{cccc|c} & & & & -qSC_{X_{\delta_e}} \\ & \text{BASIC} & & & -qSC_{Z_{\delta_e}} \\ & \text{MATRIX} & & & -qScC_{M_{\delta_e}} \\ & & & & \\ \hline (T_3 S + 1) & (K_\theta S) & & & (T_3 S + 1) \end{array}\right] \begin{bmatrix} z \\ \theta \\ \Delta T_F \\ x \\ \delta_e \end{bmatrix} = 0$$

Lateral/Directional:

$$\left[\begin{array}{ccc|cc}
\text{BASIC} & & & -qSbC_{Y_{\delta_r}} & -qSbC_{Y_{\delta_a}} \\
\text{MATRIX} & & & -qSbC_{N_{\delta_r}} & -qSbC_{N_{\delta_a}} \\
 & & & -qSbC_{\ell_{\delta_r}} & -qSbC_{\ell_{\delta_a}} \\ \hline
K_{\Psi}S & & & -T_2S-1 & \\
 & K_{\phi}S & & & -T_1S-1
\end{array}\right]
\left[\begin{array}{c} y \\ \Psi \\ \phi \\ \delta_r \\ \delta_a \end{array}\right] = 0$$

The longitudinal control law may be evaluated by setting KODE (8) = 5.

The directional control law may be evaluated by the setting KODE (9) = 5.

The lateral plus directional control laws may be evaluated by setting KODE (9) = 6. If no directional loop is to be evaluated, set AERO (123) and AERO (127) equal to 0.

If no control loops are to be considered then KODE (8) = 4 and KODE (9) = 3.

The basic control laws provided in the program (pitch damping, roll damping and yaw damping) can be modified by manually changing the definition of the elements in the 7 x 7 array 'CMAT' which defines the linearized system dynamics. The procedure is similar to that outlined above. NOTE: The program is limited to 2nd order polynomials. Higher order terms can be handled using state vector modeling.

10.0 PULLEY FRICTION

The assumption is made that the pulley-cable friction is made up of two parts, rolling friction and coulomb friction. Both rolling and coulomb friction combine to create a change in cable tension around the pulley.

The rolling friction is treated as a linear term and the coulomb friction is linearized using a describing function technique to be described in this section. The terms are calculated in subroutine FRICT and added to the appropriate polynomial matrix through array FRIC.

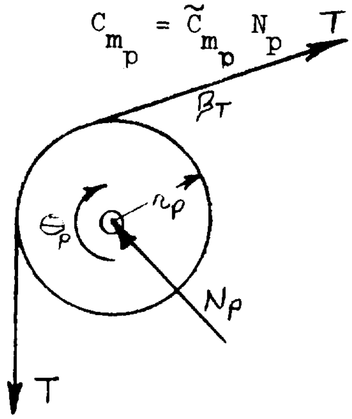
10.1 ROLLING FRICTION

Rolling friction is described by the rotational damping coefficient, C_{m_p} (ft-#/RPS). The moment transmitted to the model is then:

$$M_{P_R} = \tilde{C}_{m_p} \dot{\theta}_p N_p \tag{10.1-1}$$

where $\dot{\theta}$ is the pulley rotational speed and N_p is the total normal force acting on the pulley.

$$C_{m_p} = \tilde{C}_{m_p} N_p$$



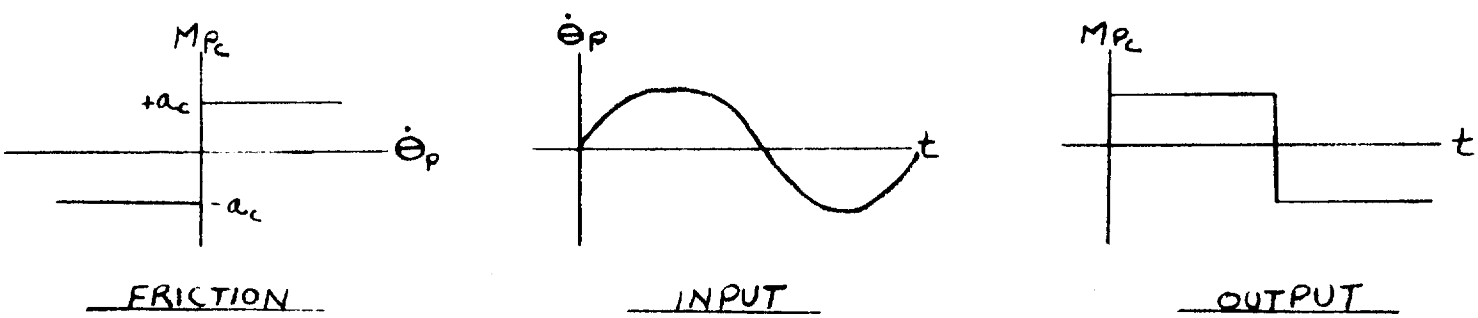
$$N_p = \sqrt{\left(T - T \text{ SIN } \beta_T\right)^2 + \left(T \text{ COS } \beta_T\right)^2}$$

$$M_{P_R} = \tilde{C}_{M_P} \sqrt{\left(T - T \text{ SIN } \beta_T\right)^2 + \left(T \text{ COS } \beta_T\right)^2} \quad \dot{\theta}_p$$

10.2 COULOMB FRICTION

Coulomb friction is by definition a non-linear effect where the friction force is of constant magnitude and is always in such a direction as to resist the relative motion. This non-linear effect can be replaced by an 'equivalent' linear effect employing the following reasoning.

First apply a sinusoidal input in $\dot{\theta}_p$ and look at the moment output due to the coulomb friction.



The input can be modeled as:

$$I(t) = \dot{\bar{\theta}}_p \text{ SIN } wt$$

The output can be modeled as a Fourier series as follows:

$$M(t) = 4a_c/\pi \left[\text{SIN } wt + 1/3 \text{ SIN } 3\ wt + 1/5 \text{ SIN } 5\ wt \ldots\ldots \right]$$

In terms of transfer functions we then have:

$$\xrightarrow{I(t)} \boxed{G(t)} \xrightarrow{M(t)}$$

or:

$$\left[\dot{\bar{\theta}}_p \text{ SIN } wt \right] G(t) = 4a_c/\pi \left[\text{SIN } wt + 1/3 \text{ SIN } 3\ wt + 1/5 \text{ SIN } 5\ wt + \ldots \right]$$

The equivalent linear transfer function is defined as the ratio of the fundamental mode of the output to the input.

$$G(t) = 4a_c/\pi \text{ SIN } wt/\dot{\bar{\theta}}_p \text{ SIN } wt = 4a_c/\pi\ \dot{\bar{\theta}}_p$$

We now have a linear equivalent of the non-linear coulomb friction which is:

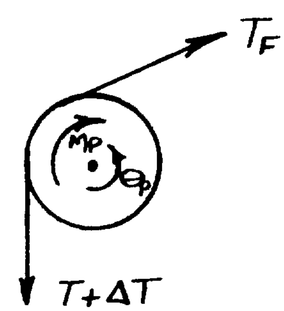
$$M_{p_c} = \frac{4a_c}{\pi} \dot{\theta}_p \qquad (10.2\text{-}1)$$

a_c is the static opposing force which is a function of wrap angle and normal force. This relationship is empirical and will not be defined in the program. a_c will be input as a constant (AERO (96)) which the user will have to determine.

Combining rolling and coulomb friction, we have the following expression for the total moment.

$$M_p = \left[\tilde{C}_{M_p} \; N_p\right] \; \dot{\theta}_p + \left[4a_c/\pi\right] \; \dot{\theta}_p \tag{10.2-2}$$

Following the reasoning presented by R. M. Bennett in his write-up, 'Comment On Mount System Damping Based On Pulley Rolling Friction,' the total moment transmitted to the model (M_p) creates an unbalance in cable tension around the pulley.



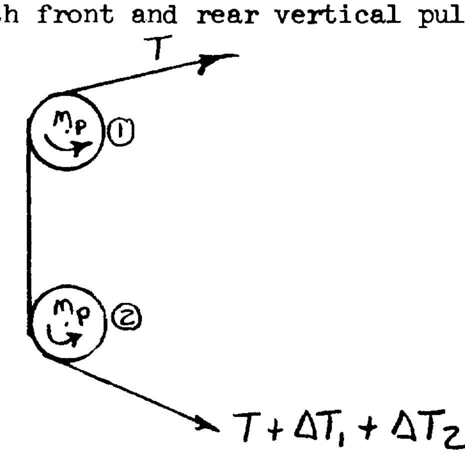
assuming pulley inertia to be negligible, a moment balance produces:

$$\Delta T = M_p/r_p = \left[\tilde{C}_{M_p} \; N_p/r_p\right] \; \dot{\theta}_p + \left[4a_c/\pi r_p\right] \; \dot{\theta}_p \tag{10.2-3}$$

The resulting forces and moments on the model can now be derived using Bennett's equations.

10.3 PULLEY FRICTION EFFECTS ON LONGITUDINAL AND LATERAL/DIRECTIONAL STABILITY

Only vertical pulleys will effect longitudinal stability. Derivations for both front and rear vertical pulleys follow.



Front Pulley

taking moments around top pulley:

$$\Sigma M = 0$$

$$\Delta T r_p + M_p = 0$$

$$\Delta T r_p - \tilde{C}_{M_p} N_p \dot{\theta}_p - (4a_c/\pi)\ \theta_p = 0$$

$$\Delta T = \left(\tilde{C}_{M_p} N_p/r_p\right) \dot{\theta}_p + \left(4a_c/\pi r_p\right) \theta_p$$

the pulley rolling in terms of cable length is:

$$\theta_{p_1} = -\Delta\ell_1/r_p \quad \therefore \quad \theta_{p_2} = -\Delta\ell_1/r_p$$

$$\theta_{p_1} = -\Delta\dot{\ell}/r_p$$

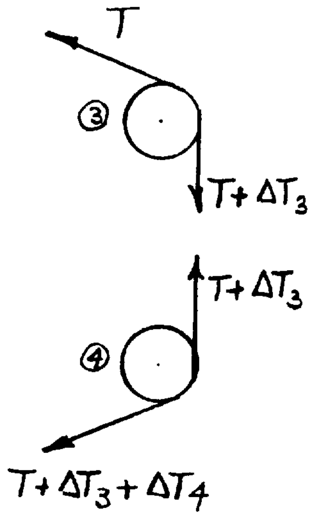
$$\Delta T_{F_1} = \left(\tilde{C}_{M_p} N_p/r_p^{\,2}\right)\left(-\Delta\ell_1\right) + \left(4a_c/\pi r_p^{\,2}\right)\left(-\Delta\ell_1\right) \qquad (10.3\text{-}1)$$

a similar approach with the bottom cables yields:

$$\Delta T_{F_2} = \left(\tilde{C}_{M_p} N_p/r_p^{\,2}\right)\left(\Delta\dot{\ell}_2\right) + \left(4a_c/\pi r_p^{\,2}\right)\left(\Delta\ell_2\right) \qquad (10.3\text{-}2)$$

$$\therefore\ \Delta T_{FRONT} = \Delta T_{F_1} + \Delta T_{F_2} = \left(C_{M_p} N_p/r_p^{\,2}\right)\left(\Delta\dot{\ell}_2 - \Delta\dot{\ell}_1\right) + \left(4a_c/\pi r_p^{\,2}\right)\left(\Delta\ell_2 - \Delta\ell_1\right) \qquad (10.3\text{-}3)$$

REAR PULLEY



$$\Sigma M = 0 \qquad -\Delta T r_p + M_p = 0$$

$$\Delta T_R = M_p/r_p = -\tilde{C}_{M_p} N_p \dot{\theta}_p/r_p - 4a_c\, \theta_p/\pi r_p$$

$$\theta_{p_3} = \Delta \ell_3/r_p \qquad \dot{\theta}_{p_3} = \Delta \dot{\ell}_3/r_p$$

$$\Delta T_3 = \left(-\tilde{C}_{M_p} N_p/r_p^{\,2}\right) \Delta \dot{\ell}_3 - \left(4a_c/\pi r_p^{\,2}\right) \Delta \ell_3 \tag{10.3-5}$$

$$\Delta T_4 = \left(\tilde{C}_{M_p} N_p/r^2_p\right) \Delta \dot{\ell}_4 + \left(4a_c/\pi f_p^{\,2}\right) \Delta \ell_4 \tag{10.3-6}$$

$$\therefore \quad \Delta T_{REAR} = \left(\tilde{C}_{M_p} N_p/r^2_p\right) \left(\Delta \dot{\ell}_4 - \Delta \dot{\ell}_3\right) + \left(4a_c/\pi r_p^{\,2}\right)\left(\Delta \ell_4 - \Delta \ell_3\right) \tag{10.3-7}$$

Since the tension ΔT_{Front}, ΔT_{Rear} is going to act at either the top or the bottom pulley (depending on the direction of motion); and since the arms and direction cosine are inherently different, the effect of these friction contributions is discontinuous about the trim for $\pm$ perturbations in x, z and θ. To eliminate the difficulty, an average arm and direction cosine in the position quadrant is assumed for the action of the forces and moments.

The average direction cosine angles for the front vertical pulleys are:

$$\alpha_x = (\alpha_{21} - \alpha_{11})/2 \qquad\qquad \alpha_z = \pi/2 - \alpha_x \tag{10.3-8}$$

The average arms for the front vertical pulleys are:

$$\ell_x = (\ell_{1x} - \ell_{1z})/2 \qquad\qquad \ell_z = (\ell_{2z} - \ell_{1z})/2 \tag{10.3-9}$$

The corresponding set for the rear vertical pulley is:

$$\alpha_x = \left(\alpha_{41} - \alpha_{31}\right)/2 \qquad \ell_x = \left(\ell_{3x} + \ell_{4x}\right)/2 \tag{10.3-10}$$

$$\alpha_z = \pi/2 - \pi_x \qquad \ell_z = \left(\ell_{4z} - \ell_{3z}\right)/2 \tag{10.3-11}$$

The friction contribution to the ΔF_x, ΔF_z and ΔM for a front and rear vertically configured pulley can be determined.

$$\Delta F_x = \Delta T_{FRONT} \cos \alpha_{x_F} + \Delta T_{REAR} \cos \alpha_{x_R} \tag{10.3-12}$$

$$\Delta F_z = \Delta R_{FRONT} \cos \alpha_{z_F} + \Delta T_{REAR} \cos \alpha_{z_F} \tag{10.3-13}$$

$$\Delta M_y = \Sigma M_p + \Delta F_x \ell_z - \Delta F_z \ell_x \tag{10.3-14}$$

$$\Sigma M_p = M_{p_F} + M_{p_R}$$

$$M_{p_F} = \left(\tilde{C}_{M_p} N_p/r_p\right)\left(\Delta\dot{\ell}_2 - \Delta\ell_1\right) + \left(4a_c/\pi r_p\right)\left(\Delta\ell_2 - \Delta\ell_1\right)$$

$$M_{p_R} = \left(\tilde{C}_{M_p} N/r_p\right)\left(\Delta\dot{\ell}_4 - \Delta\dot{\ell}_3\right) + \left(4a_c/\pi r_p\right)\left(\Delta\ell_4 - \Delta\ell_3\right)$$

If either front or rear pulleys are horizontal, there are no friction effects modeled for longitudinal analysis.

Similar expressions can be defined for the front and rear tensions for the lateral/directional analysis. In this case, however, the horizontal pulley configurations are the prime contributor to the perturbation dynamics. The horizontal pulley in the trim condition are symmetric about the x-z plane. Thus, the averaging for the direction cosine and arms process required in the longitudinal analyses are not required in the lateral analysis.

$$\Delta F_y = \Delta T_F \cos \alpha_{2_F} + \Delta T_R \cos \alpha_{2_R}$$

$$\Delta L = \Sigma \; yF_z - zF_y + L_p \qquad (10.3\text{-}15)$$

$$\Delta N = \Sigma \; xF_y - yF_x + N_p$$

where

$$L_p = \sum_{\substack{n=1 \\ F+R}}^{2} \frac{C_{m_p} N_p}{r_p^{\,2}} (\Delta\dot{\ell}_n - \Delta\dot{\ell}_{2n}) + \frac{4a_c}{\pi r_p^{\,2}} (\Delta\ell_n - \Delta\ell_{2n})$$

$$N_p = \sum_{\substack{n=1 \\ F+R}}^{2} \frac{C_{m_p} N_p}{r_p^{\,2}} (\Delta\dot{\ell}_n - \Delta\dot{\ell}_{2n}) + \frac{4a_c}{\pi r_p^{\,2}} (\Delta\ell_n - \Delta\ell_{2n})$$

Flow diagrams for subroutines FRICT, FRVT, FRHZ are shown in Figures 10.1 through 10.3. Subroutine FRKT contains the logic determining which configuration is to be analyzed while subroutines FRVT and FRHZ calculate the friction effects for vertical and horizontal configurations respectively.

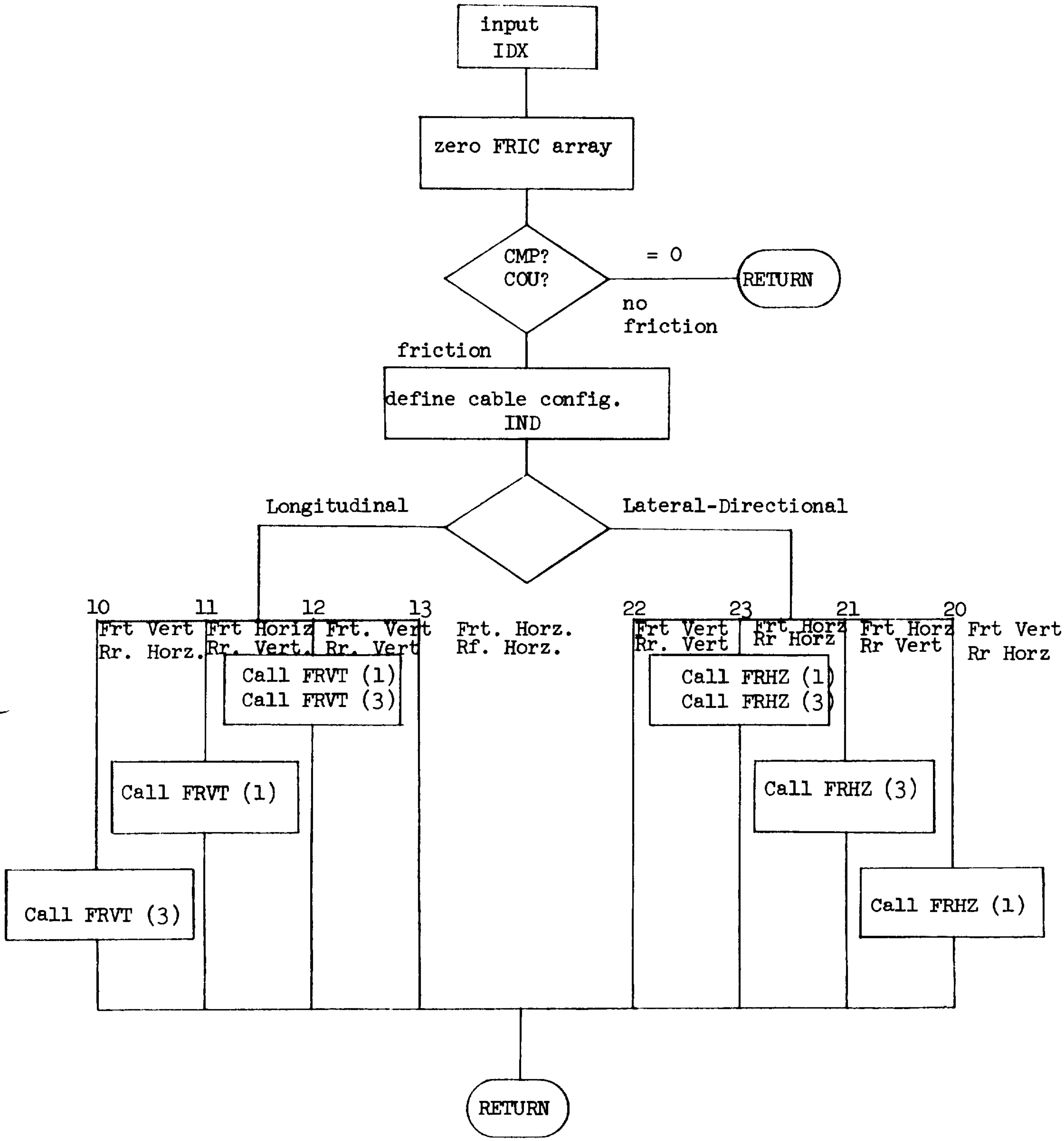


Figure 10.1 - FLOW DIAGRAM - SUBROUTINE FRICT

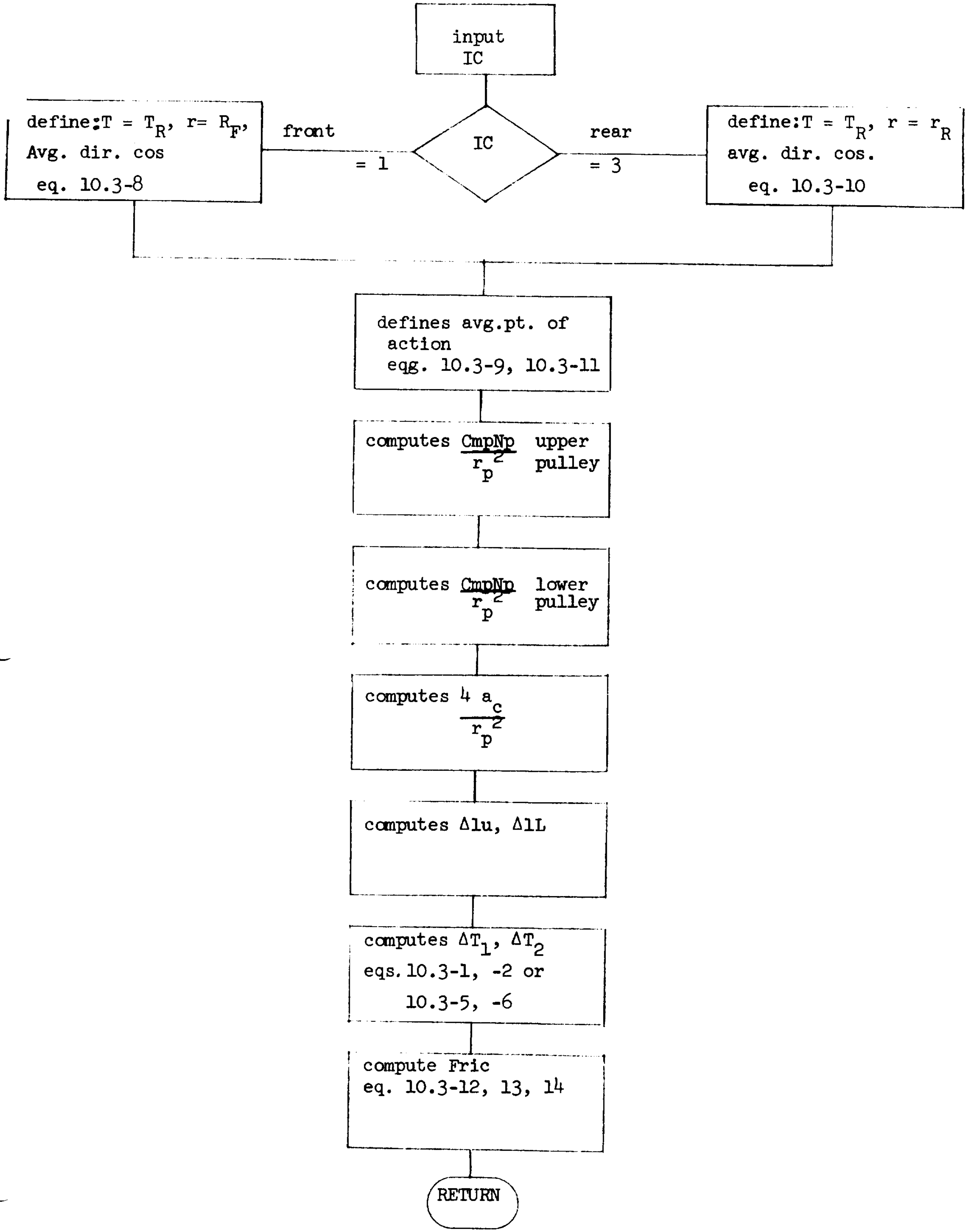


FIGURE 10.2 - FLOW CHART - SUBROUTINE FRVT

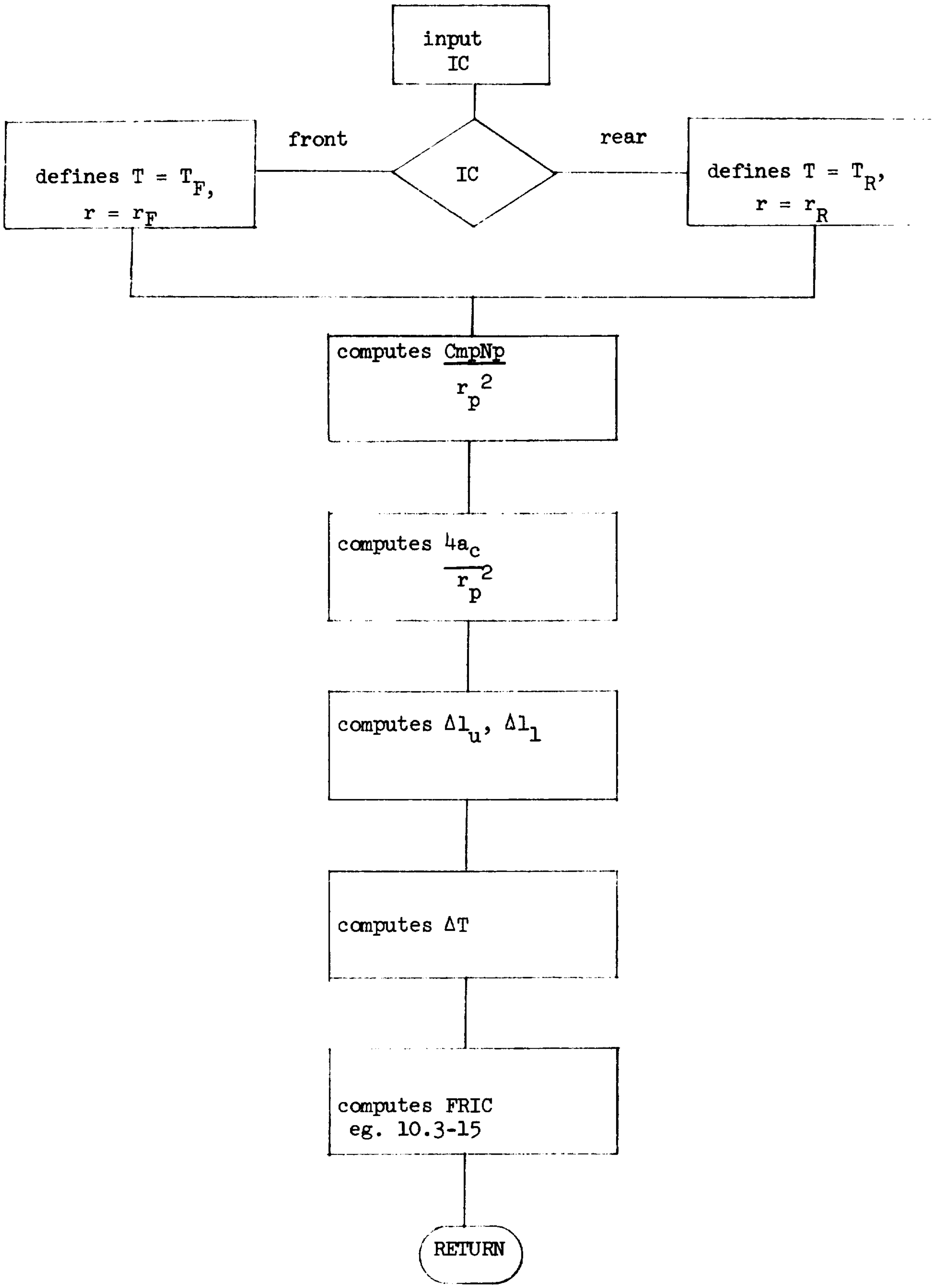


FIGURE 10.3 - FLOW DIAGRAM - SUBROUTINE FRHZ

11.0 INPUT DATA

The format for input data is most easily explained by reproducing the 'READ' statements as they appear in the program.

```
READ (IR, 1) (TITLE (I), I = 1, 20)            (1)
1 FORMAT (20A4)
READ (IR, 2) (KODE(I), I = 1, 16               (2)
2 FORMAT (15I5)
```

Then either 3A or 3B: The value of KODE (7) will determine which input to use.

```
READ (IR, 3) (AERO (I), I = 1, 36)             (3A)
CALL TABIN1 (1, 36) (See Appendix A)           (3B)
```

Continuing:

```
READ (IR, 3) (AERO (I), I = 44, 59)            (4)
READ (IR, 3) (AERO (I), I = 66, 130)           (5)
3 FORMAT (6 E12.5)
```

If unsnubbed snubber data is to be read in (determined by KODE (12)) the following statement applies.

```
CALL TABIN (1, 2)     (See Appendix A)
```

If unsnubbed data is not to be read in computations begin.

After completion of the first run the following 'READ' statements initialize another run.

```
READ (IR, 1) (TITLE (I), I = 1, 20)            (6)
READ (IR, 2) (KODE (I), I = 1, 16)             (7)
READ (IR, 3)  I, VALUE
     I = element in the 'AERO' array to be changed.
     VALUE = new value of the element
```

NOTE: If I > 1 this 'READ' statement is repeated.
If I = 0 the program begins computation.

All succeeding cases follow the same format.

A description of the aforementioned arrays follows.

ARRAY	DESCRIPTION
TITLE	Alpha-numeric array containing title describing the run to be made.
KODE	Array containing various program option parameters.
AERO	Array containing all the input data pertaining to model, mount system and tunnel conditions.

11.1 KODE, AERO Description

A description of each element in the 'KODE' and 'AERO' array follows:

NAME	VALUE	DESCRIPTION
KODE (1)		Run number
KODE (2)	-1	Calculate longitudinal stability only
	0	Calculate lateral/directional stability only
	+1	Calculate both longitudinal and lateral/directional stability
KODE (3)	0	No root locus
	+1	Do root locus
KODE (4)		Element in 'AERO' array to be varied for root locus
KODE (5)	0	Basic printout
	+1	Basic printout plus various test parameters
KODE (6)	+1	Front cable vertical - rear cable horizontal
	+2	Front cable horizontal - rear cable vertical
	+3	Front and rear cable vertical

NAME	VALUE	DESCRIPTION
	+4	Front and rear cable horizontal
KODE (7)	+1	Aero data to be input in table form
	0	Aero data to input at specific mach number
KODE (8)	+4	Longitudinal matrix with no stability augmentation
	+5	Longitudinal matrix with stability augmentation
KODE (9)	+3	Lateral/directional matrix, no stability augmentation
	+4	Lateral/directional matrix, with yaw stability augmentation
	+5	Lateral/directional matrix, with roll and yaw stability augmentation
KODE (10)	0	No snubber
	+1	Analyze snubber in unsnubbed condition
	+2	Analyze snubber in snubbed condition
KODE (11)	0	No anti-lift cable
	+1	Anti-lift cable in
KODE (12)	0	No unsnubbed snubber data input
	+1	Unsnubbed snubber data will be read in

	UNITS	LABEL	DESCRIPTION	
AERO (1)	1/ft./sec.	CDU	$\partial C_D/\partial(u/V_o)$	$\left[C_{D_u}\right]$
AERO (2)	1/ft./sec.	CLU	$\partial C_D/\partial(u/V_o)$	$\left[C_{L_u}\right]$
AERO (3)	1/ft./sec.	CMU	$\partial C_m/\partial(u/V_o)$	$\left[C_{m_u}\right]$
AERO (4)	1/rad	CDA	$\partial C_D/\partial(\alpha)$	$\left[C_{D_\alpha}\right]$
AERO (5)	1/rad	CLA	$\partial C_L/\partial(\alpha)$	$\left[C_{L_\alpha}\right]$
AERO (6)	1/rad	CMA	$\partial C_m/\partial(\alpha)$	$\left[C_{m_\alpha}\right]$
AERO (7)	1/rad/sec	CDQ	$\partial C_D/\partial(q\bar{c}/2V_o)$	$\left[C_{D_q}\right]$
AERO (8)	1/rad/sec	CLQ	$\partial C_L/\partial(q\bar{c}/2V_o)$	$\left[C_{L_q}\right]$
AERO (9)	1/rad/sec	CMQ	$\partial C_m/\partial(q\bar{c}/2V_o)$	$\left[C_{m_q}\right]$
AERO (10)	N.D.	CDO	Drag coefficient at $\alpha = 0$	$\left[C_{D_o}\right]$
AERO (11)	N.D.	CLO	Lift coefficient at $\alpha = 0$	$\left[C_{L_o}\right]$
AERO (12)	N.D.	CMO	Pitching moment at $\alpha = 0$	$\left[C_{m_o}\right]$
AERO (13)	1/rad	CDDE	$\partial C_D/\partial(\delta_e)$	$\left[C_{D_{\delta_e}}\right]$
AERO 14)	1/rad	CLDE	$\partial C_D/\partial(\delta_e)$	$\left[C_{D_{\delta_e}}\right]$
AERO (15)	1/rad	CMDE	$\partial C_m/\partial(\delta_e)$	$\left[C_{m_{\delta_e}}\right]$
AERO (16)	1/rad/sec	CDAD	$\partial C_D/\partial(\dot{\alpha}\bar{c}/2V_o)$	$\left[C_{D_{\dot\alpha}}\right]$
AERO (17)	1/rad/sec	CLAD	$\partial C_D/\partial(\dot{\alpha}\bar{c}/2V_o)$	$\left[C_{L_{\dot\alpha}}\right]$
AERO (18)	1/rad/sec	CMAD	$\partial C_m/\partial(\dot{\alpha}\bar{c}/2V_o)$	$\left[C_{m_{\dot\alpha}}\right]$
AERO (19)	1/rad/sec	CYB	$\partial C_y/\partial(\beta)$	$\left[C_{y_\beta}\right]$
AERO (20)	1/rad	CLB	$\partial C_\ell/\partial(\beta)$	$\left[C_{\ell_\beta}\right]$
AERO (21)	1/rad	CNB	$\partial C_n/\partial(\beta)$	$\left[C_{n_\beta}\right]$
AERO (22)	1/rad/sec	CYP	$\partial C_y/\partial(pb/2V_o)$	$\left[C_{y_p}\right]$
AERO (23)	1/rad/sec	CLP	$\partial C_\ell/\partial(pb/2V_o)$	$\left[C_{\ell_p}\right]$
AERO (24)	1/rad/sec	CNP	$\partial C_n/\partial(pb/2V_o)$	$\left[C_{n_p}\right]$
AERO (25)	1/rad/sec	CYR	$\partial C_y/\partial(rb/2V_o)$	$\left[C_{y_n}\right]$
AERO (26)	1/rad/sec	CLR	$\partial C_\ell/\partial(rb/2V_o)$	$\left[C_{\ell_r}\right]$

	UNITS	LABEL	DESCRIPTION	
AERO (27)	1/rad/sec	CNR	$\partial C_n/\partial(rb/2V_o)$	$[C_{n_r}]$
AERO (28)	1/rad	CYDR	$\partial C_y/\partial(\delta_r)$	$[C_{y_{\delta_r}}]$
AERO (29)	1/rad	CLDR	$\partial C_\ell/\partial(\delta_r)$	$[C_{\ell_{\delta_r}}]$
AERO (30)	1/rad	CNDR	$\partial C_n/\partial(\delta_r)$	$[C_{n_{\delta_r}}]$
AERO (31)	1/rad	CYDA	$\partial C_y/\partial(\delta_a)$	$[C_{y_{\delta_a}}]$
AERO (32)	1/rad	CLDA	$\partial C_\ell/\partial(\delta_a)$	$[C_{\ell_{\delta_a}}]$
AERO (33)	1/rad	CNDA	$\partial C_n/\partial(\delta_a)$	$[C_{n_{\delta_a}}]$
AERO (34)	1/rad	CYDS	$\partial C_y/\partial(\delta_s)$	$[C_{y_{\delta_s}}]$
AERO (35)	1/rad	CLDS	$\partial C_\ell/\partial(\delta_s)$	$[C_{\ell_{\delta_s}}]$
AERO (36)	1/rad	CNDS	$\partial C_n/\partial(\delta_s)$	$[C_{n_{\delta_s}}]$
AERO (44)	in.	XREF*	Distance from aerodynamic ref. center to the equation ref. center along the X body axis	
AERO (45)	in.	ZREF	Distance from aerodynamic ref. center to the equation ref. center along the Z body axis	
AERO (46)	in.	XCG	Distance from model mass & inertia ref. center to the equation ref. center along the X body axis	
AERO (47)	in.	ZCG	Distance from model mass & inertia ref. center to the equation ref. center along the Z body axis	
AERO (48)		AMACH	Tunnel mach number	
AERO (49)	ft/sec	VO	Tunnel velocity	
AERO (50)	slugs	AM	Model mass	
AERO (51)	$slug/ft^3$	RHO	Tunnel density	

	UNITS	LABEL	DESCRIPTION
AERO (52)	lbs	WT	Model weight
AERO (53)	ft	B	Model reference span
AERO (54)	ft	CBAR	Model reference chord
AERO (55)	ft^2	SW	Model reference wing area
AERO (56)	$slug/ft^2$	XIXZ	Model cross product of inertia (I_{XZ})
AERO (57)	$slug/ft^2$	XIXX	Model roll inertia (I_{xx}), body axis at C.G.
AERO (58)	$slug/ft^2$	YIYY	Model pitch inertia (I_{yy}), body axis at C.G.
AERO (59)	$slug/ft^2$	ZIZZ	Model yaw inertia (I_{zz}), body axis at C.G.
AERO (66)	in.	WLUF	Water line-upper front cable tie-down point (fr. vert.)
AERO (67)	in.	WLLF	Water line-lower front cable tie-down point (ft. vert.)
AERO (68)	in.	WLUR	Water line-upper rear cable tie-down point (rr. vert.)
AERO (69)	in.	WLLR	Water line-lower rear cable tie-down point (rr. vert.)
AERO (70)	in.	WLHF	Water line-horizontal front cable tie-down point (ft. hor.)
AERO (71)	in.	WLHR	Water line-horizontal rear cable tie-down point (rr. hor.)
AERO (72)	in.	STAF	Station-front cable tie-down point (fr. vert. or hor.)
AERO (73)	in	STAR	Station-rear cable tie-down point (rr. vert. or hor.)
AERO (74)	in	BLHF	Butt line-horizontal front cable tie-down point (fr. hor.)

	UNITS	LABEL	DESCRIPTION
AERO (75)	in.	BLHR	Butt line-horizontal rear cable tie-down point (rr. hor.)
AERO (76)	in.	WLCR	Water line-equation reference point
AERO (77)	in.	STACR	Station - equation reference point
AERO (78)	in.	BLCR	Butt line-equation reference point
AERO (79)	in.	EF**	Distance along X body axis from ref. center to vertical front pulley
AERO (80)	in.	ER	Distance along X body axis from ref. center to vertical rear pulley
AERO (81)	in.	AF	Distance along X body axis from ref. center to horizontal front pulley
AERO (82)	in.	AR	Distance along X body axis from ref. center to horizontal rear pulley
AERO (83)	in.	HUCF	Distance along Z body axis from ref. center to upper front pulley
AERO (84)	in.	HLCF	Distance along Z body axis from ref. center to lower front pulley
AERO (85)	in.	HUCR	Distance along Z body axis from ref. center to upper rear pulley
AERO (86)	in.	HLCR	Distance along Z body axis from ref. center to lower rear pulley
AERO (87)	in.	DCF	Distance along Y body axis from ref. center to horizontal front pulley
AERO (88)	in.	DCR	Distance along Y body axis from ref. center to horizontal rear pulley

	UNITS	LABEL	DESCRIPTION
AERO (89)		blank	
AERO (90)	in	RVF	Radius of vertical front pulley
AERO (91)	in	RHF	Radius of horizontal front pulley
AERO (92)	in	RVR	Radius of vertical rear pulley
AERO (93)	in	RHR	Radius of horizontal rear pulley
AERO (94)	lbs	TRO	Rear cable tension
AERO (95)	lbs/in	AKR	Rear cable spring constant
AERO (96)	ft-#/rad	COU	Pulley Coulomb friction (a_c)
AERO (97)	in	STLTT	Station - lift cable tie-down point
AERO (98)	in	WLLTT	Water line - lift cable tie-down point
AERO (99)	lbs	TLFTO	Lift cable tension
AERO (100)	lbs/in	AKLFT	Lift cable spring constant
AERO (101)		blank	
AERO (102)	in	ALTX*	Distance along X body axis from lift cable attachment point to the equation reference center
AERO (103)	in	ALTZ	Distance along Z body axis from lift cable attachment point to the equation reference center
AERO (104)	ft-#/RPS	CMP	Pulley rolling friction coefficient
AERO (105)	in	SNUX***	Distance along X body axis from model upper attachment point to the equation reference center
AERO (106)	in	SNUY	Distance along Y body axis from model upper snubber attachment point to the equation reference center
AERO (107)	in	SNUZ	Distance along Z body axis from model upper snubber attachment point to the equation reference center

	UNITS	LABEL	DESCRIPTION
AERO (108)	in	SNLX	Distance along X body axis from model lower snubber attachment point to the equation reference center
AERO (109)	in	SNLY	Distance along Y body axis from model lower snubber attachment point to the equation reference center
AERO (110)	in	SNLZ	Distance along Z body axis from model lower snubber attachment point to the equation reference center
AERO (111)	in	SNUST	Station - upper snubber tie-down point
AERO (112)	in	SNUWL	Water line - upper snubber tie-down point
AERO (113)	in	SNUBL	Butt line - upper snubber tie-down point
AERO (114)	in	SNLST	Station - lower snubber tie-down point
AERO (115)	in	SNLWL	Water line - lower snubber tie-down point
AERO (116)	in	SNLBL	Butt line - lower snubber tie-down point
AERO (117)	lbs	TUSNO	Upper snubber, snubbed tension
AERO (118)	lbs	TLSNO	Lower snubber, snubbed tension
AERO (119)	lbs/in	AKSNU	Upper snubber, snubbed spring constant
AERO (120)	lbs/in	AKSNL	Lower snubber, snubbed spring constant
AERO (121)	lbs/in/sec	ADSNU	Upper snubber, snubbed damping constant

	UNITS	LABEL	DESCRIPTION
AERO (122)	lbs/in/sec	ADSNL	Lower snubber, snubbed damping constant
AERO (123)	rad/rad/sec	AKSY	Feedback gain - yaw rate to rudder
AERO (124)	rad/rad/sec	AKPHI	Feedback gain - roll rate to aileron
AERO (125)	rad/rad/sec	AKTHE	Feedback gain - pitch rate to elevator
AERO (126)	blank		
AERO (127)	sec.	T1SY	Time constant for lag on yaw rate feedback
AERO (128)	sec.	T2PHI	Time constant for lag on roll rate feedback
AERO (129)	sec.	T3THE	Time constant for lag on pitch rate feedback
AERO (130)	blank		

* See Figure 11.1 for pictorial representation of various reference centers

** See Figure 11.2 for pictorial representation of pulley geometry

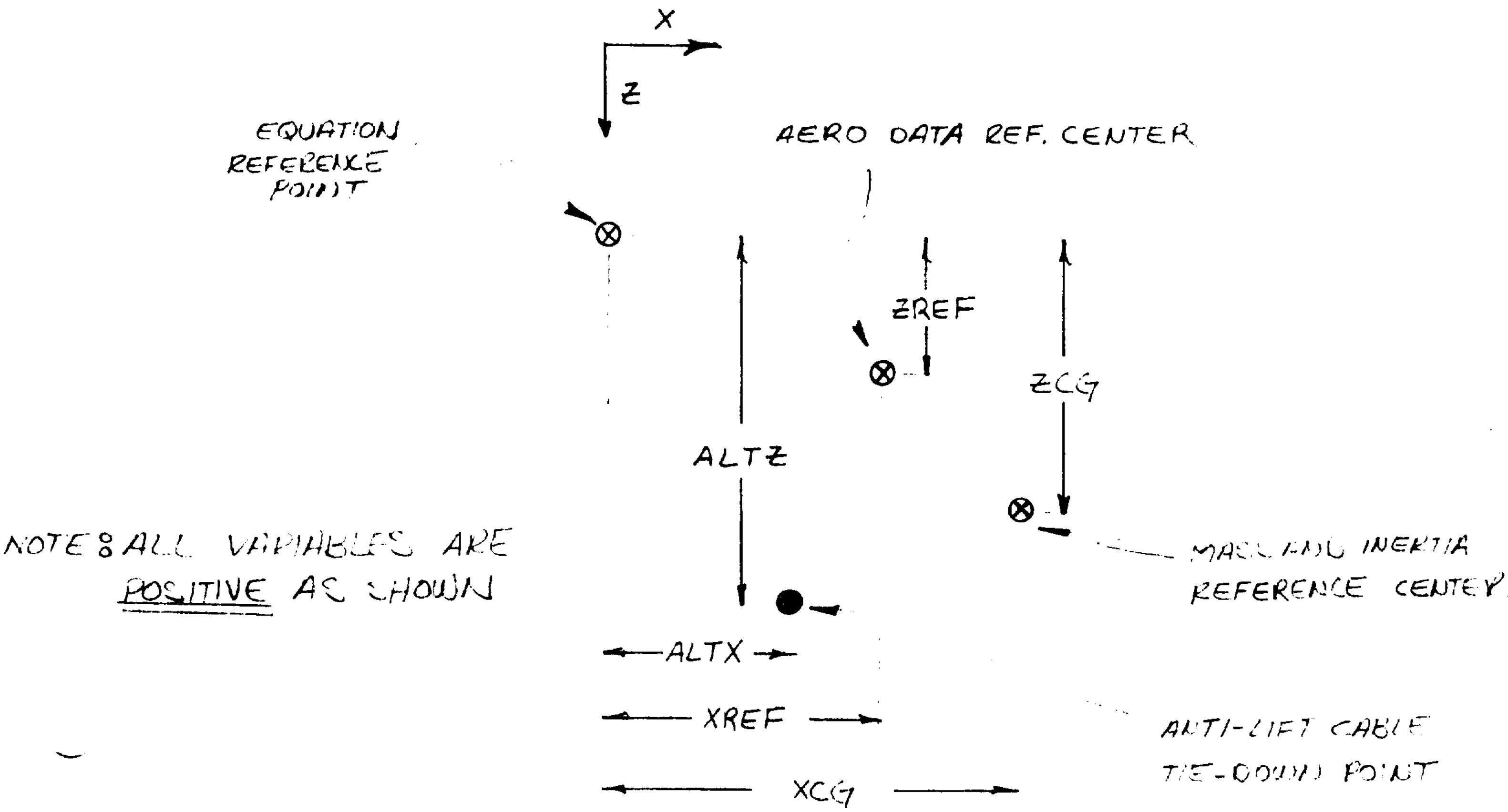
*** See Figure 11.3 for pictorial representation of snubber cable geometry

11.2 TABLE INPUT

If the aero data and snubber data are to be read in table format, the following discussion applies.

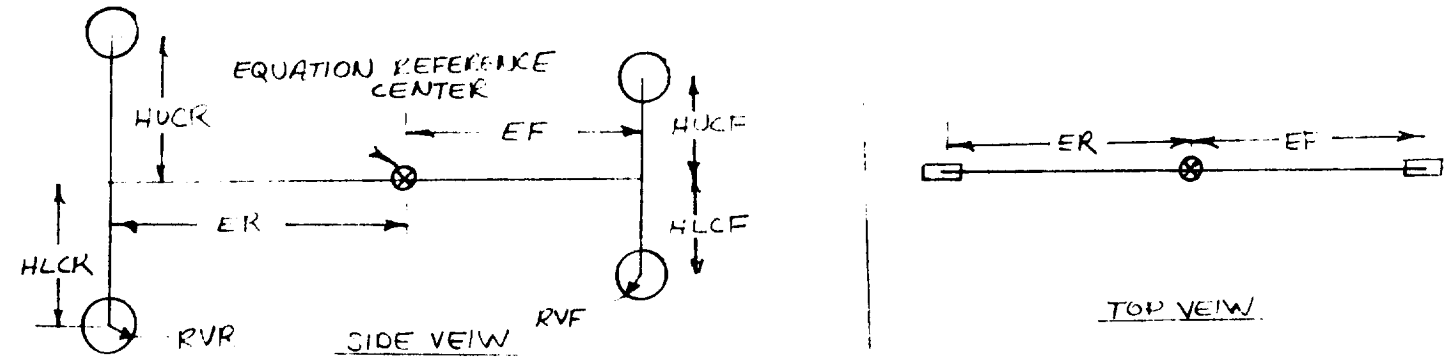
The first 36 tables contain the aero derivatives in stability axis vs. mach number. The order is the same as AERO (1) through AERO (36). The units for each derivative are also the same as AERO (1) through AERO (36). The table input format is shown in Appendix A. This data is read in under TABIN1.

The unsnubbed snubber data is contained in Tables 1 and 2. Table 1 contains cable tension (lbs) vs. dynamic pressure (psf) and linear distance (in) between model tie-down point and tunnel side wall. Table 2 contains cable angle (rad) vs. dynamic pressure (psf) and linear distance (in) between model tie-down point and tunnel side wall. The tensions and angles mentioned here are described in detail in section 8.0. The table input format is shown in Appendix A. This data is read in under TABIN.

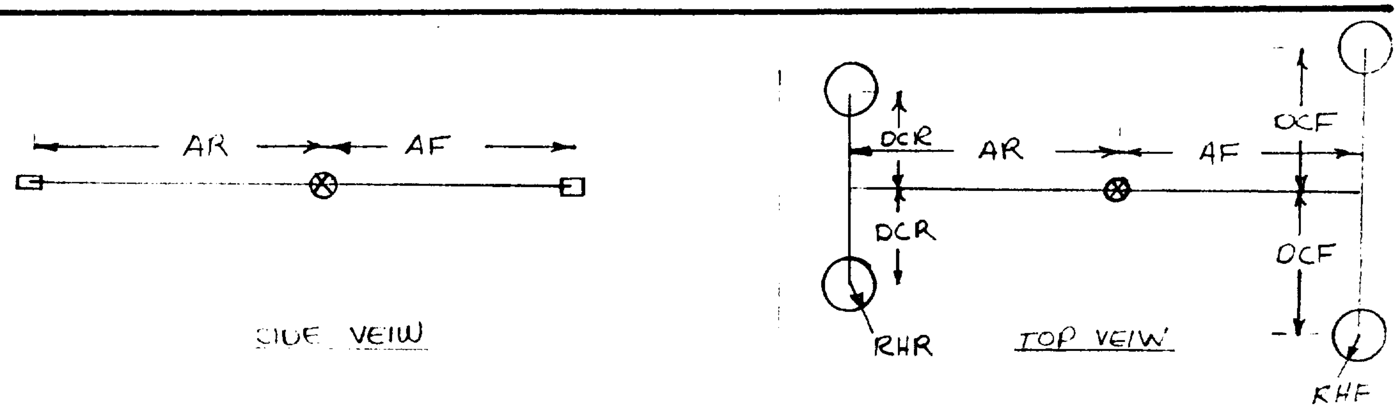


SIDE VEIW OF MODEL

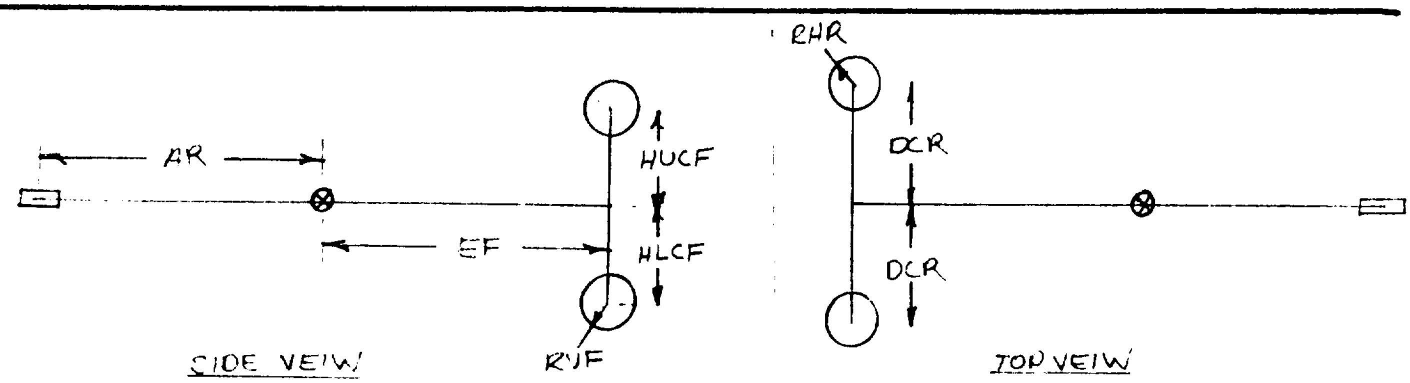
FIG. 11.1 - REFERENCE CENTER AND LIFT CABLE INPUT DATA



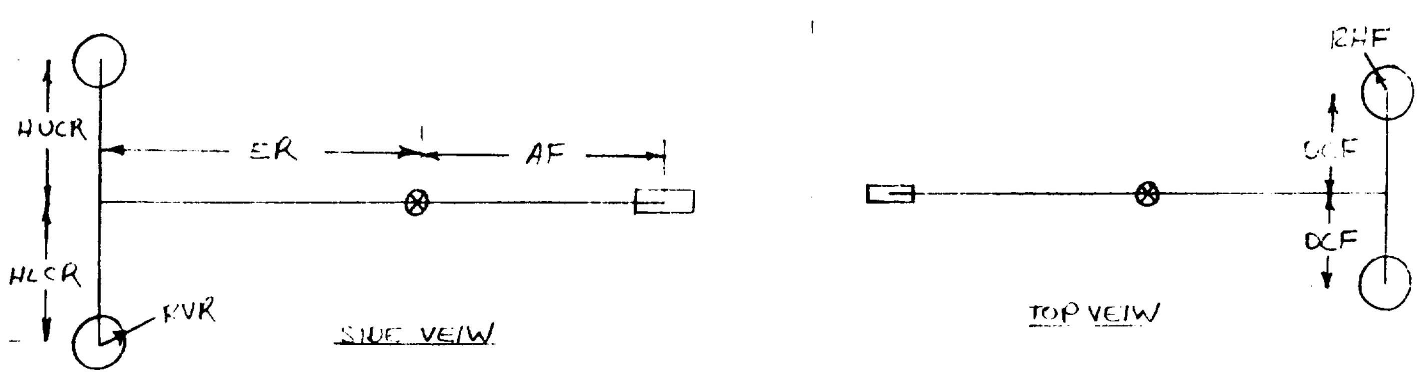
FRONT VERTICAL - REAR VERTICAL



FRONT HORIZONTAL - REAR HORIZONTAL



FRONT VERTICAL - REAR HORIZONTAL



FRONT HORIZONTAL - REAR VERTICAL

FIG. 11.2 - PULLEY GEOMETRY

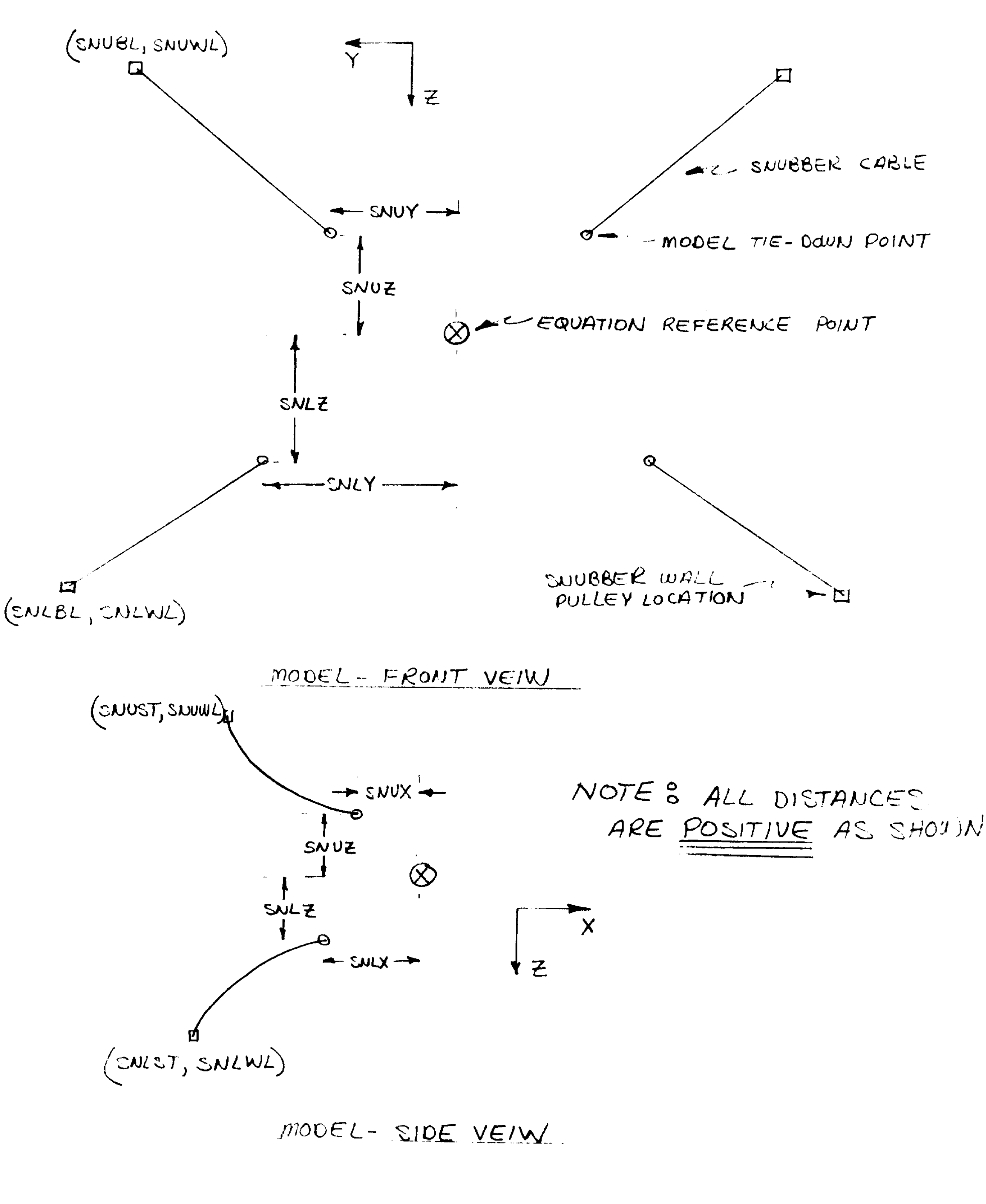


FIG. 11.2 - SNUBBER CABLE ARRANGEMENT

REFERENCES

1) Reed, Abbott - A New 'Free Flight' Mount System For High Speed Wind Tunnel Flutter Models - NASA - Langley Research Center - 9/63

2) Bennett - Comments on Mount System Damping Based on Pulley Rolling Friction

3) Thelander Aircraft Motion Analysis - FOL-TOR-64-70

4) Methods of Analysis and Synthesis of Piloted Aircraft Flight Control Systems - BU AER Report AE-61-41-3/52

5) Dynamics of the Airframe - BU AER Report AE-61-42-9/52

6) Hildebrand - Advanced Calculus for Engineers

APPENDIX A

A-1 TABIN, TABIN1

If data is to be input in table form, subroutine TABIN is used. When reading aero data the first independent variable is mach number. When reading unsnubbed snubber data the first independent variable is dynamic pressure (psf) and the second independent variable is length (L_s) in inches.

Restrictions:

1. The tabular values for the independent variables must be in algebraically increasing order.
2. The independent variables and functional values of the table must:
   a) Be single precision numbers less than 99999E9.
   b) Have a maximum of 7 significant figures if positive.
   c) Have a maximum of 6 significant figures if negative.

A maximum of 99 cards is allowed for each table.

Usage:

A. Tables are prepared according to the form on the following page. Variable noted there are:

K = table number - any positive fixed point number.

L1 = Number of tabular values of the first independent variable (x).

L2 = Number of tabular values of the second independent variable (y).

Seq. no. = sequence number of card within a table beginning with 0 for the first card, 1 for the second, etc.

Z = Value of the third independent variable (z). A separate table is needed for each tabular value of Z.

F(i,j) = functional value for x_i, y_j, and Z.

The last card for every set of tables read in MUST BE BLANK.

CARD FORMAT FOR EACH TABLE

	K	L1	L2		Seq. No.
Column	9-12	13-14	15-16		71-72

For first 9 x-values

Z	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	Seq. No.
y_1	f(1,1)	f(2,1)	f(3,1)	f(4,1)	f(5,1)	f(6,1)	f(7,1)	f(8,1)	f(9,1)	Seq. No.

⋮

y_{L2}	f(1, L2)	f(2, L2)	f(3, L2)	f(4, L2)	f(5, L2)	f(6, L2)	f(7, L2)	f(8, L2)	f(9, L2)	Seq. No.

For second 9 x-values

Z	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	x_{17}	x_{18}	Seq. No.
y	f(10, 1)	f(11, 1)	f(12, 1)	f(13, 1)	f(14, 1)	f(15, 1)	f(16, 1)	f(17, 1)	f(18, 1)	Seq. No.

⋮

y_{L2}	f(10, L2)	f(11, L2)	f(13, L2)	f(13, L2)	f(14, L2)	f(15, L2)	f(16, L2)	f(17, L2)	f(18, L2)	Seq. No.
Col. 1-7	8-14	15-21	22-28	29-35	36-42	43-49	50-56	57-63	64-70	71-72

Additional x values are similarly handled.

BLANK CARD - last in set of data read in at one time.

B. Calling sequence:

CALL TABIN (NUMTBL, IZ, NG)

NUMTBL = Number of the first table to be read in.

= 1 for the first set of tables read in on a job.

IZ = Maximum number of tables in storage at one time.

NG = error return - set equal to:

0 - tables are read in successfully

1 - error in loading tables.

C. COMMON statement to be made in the calling program:

COMMON ZZZ(n)

where ZZZ is a dummy name, n is computed as follows:

$$n = 3IZ + \sum_{i+1}^{IZ} (L1_i + 1)(L2_i + 1)$$

ZZZ must be the first array stored in blank COMMON.

A-2 STINT, STINT1

Subroutine STINT is a linear interpolation routine used to gather data from the tables.

Purpose: To look up in a table and interpolate functions of 1, 2, or 3 variables.

Restrictions:

1. CALL TABIN to read in tables (see TABIN write-up).
2. Extrapolation is not performed for arguments off the tables.

Method:*

x = ARG1	$x_o < x < x_1$	x_o, x_1	- consecutive tabular values
y = ARG2	$y_o < x < y_1$	y_o, y_1	- consecutive tabular values
z = ARG3	$z_o < z < z_1$	z_o, z_1	- tabular values for consecutive tables
f(i,j)	functional value at (x_i, y_i)		

$$A = \frac{(y_1-y)\left[(x_1-x)\ f\ (0,0) - (x_o-x)\ f\ (1,0)\right]}{(y_1-y_o)\quad(x_1-x_o)}$$

$$- \frac{(y_o-y)\left[(x_1-x)\ f\ (0,1) - (x_o-x)\ f\ (1,\ 1)\right]}{(y_1-y_o)\quad(x_1-x_o)}$$

Single table interpolation

$$FCT = f(1,0) - \frac{x_1-x}{x_1-x_o}\ (f(1,0)-f(0,0))$$

Double table interpolation

FCT = A

Triple table interpolation

A is found for the z_o table (A_o) and the z_1 table (A_1).

$$FCT = A_1 - \frac{z_1-z}{z_1-z_o}\ (A_1-A_o)$$

Usage: CALL STINT (ARG1, ARG2, ARG3, MINTBL, MAXTBL, FCT, NG)

ARG1 = floating point value used as search argument 1

ARG2 = floating point value used as search argument 2

ARG3 = floating point value used as search argument 3

MINTBL = lower bound of table position number.

MAXTBL = upper bound of table position number.

FCT = floating point variable which is returned with the result of the interpolation.

NG = Error indicator
= 1 - error in loading tables (set by TABIN)
= 2 - error in calling sequence or machine error
= 3 - argument not in domain of table
= 4 - argument(s) are within tables but function is discontinuous or non-existent.

If there is no error, the last value of NG remains in storage. NG should be interrogated after each return from STINT. If NG $\neq$ 0, set NG to 0 after taking appropriate error control action and before calling STINT again.

For single table interpolation set ARG2 = 0, and ARG3 = 0

For double table interpolation set ARG3 = 0.

For triple table interpolation

Normally at least 2 tables are needed. The tables must have consecutive position numbers. If ARG3 is exactly equal to the tabular value of z (third independent variable), only one table is needed.

A-3 MASH

Subroutine MASH is used to reduce large matrices to smaller ones. It only reduces terms of the same order.

A-4 MATRIX, PRBM1, PQFB1

Subroutines MATRIX, PRBM1, and PQFB1 are used to obtain the eigenvalues of the polynomial matrices defined in subroutines LONG and LAT. Subroutine MATRIX takes the polynomial matrix and derives the characteristic polynomial for that matrix. The roots of the characteristic polynomial are then established in subroutines PRBM1 and PQFB1. PRBM1 and PQFB1 are called from MATRIX. The dimension statements for this routine are presently set up for a 7 x 7 matrix. If in the future this is to be changed the following definitions will be necessary.

Call MATRIX (A, N, ROOTS, K4A, IER)

A: Input matrix, Dimension = (N, N, 3) the first index refers to the row, second to the column, and third to the polynomial coefficient with A (i, j, 1) = constant term, A(i, j, z) = linear term, etc.

N: The actual size of the input matrix.

ROOTS: A complex array. Dimension = 29

K4A: Equals the number of roots generated.

IER: Contains error code message. See listing of PQFB1 and PRBM1 for description.

The routine is limited to second order polynomials. That is, each polynomials represented in the A array can be no greater than second order.

APPENDIX B

A sample listing of input data is included as an example. The set of input cards listed below is the set provided with the accompanying deck.

Referring to the listing, Case 1 is one in which a root locus is done with the rear cable tension being the parameter varied. Both longitudinal and lateral stability calculations are made. The cable configuration is front vertical rear horizontal with no snubber effects. Case 2 is the same variation in rear cable tension with the unsnubbed snubber effects included. Case 3 is one in which the values for C_{L_α} and C_{m_α} are changed and only longitudinal stability effects are calculated. In Case 4, C_{L_α} and C_{m_α} are put back to their original values and the front pulleys are changed to the horizontal configuration. The output corresponding to this input data is contained in APPENDIX C.

```
  EST DATA LRC
     1     1     1    94     0     1     0     4     3     0     0     1
  0.             0.             0.            0.            6.26          -.81
  0.             0.             -8.           .018          .105          .035
  0.             .96            -1.5          0.            0.            0.
  -.73           -.035          .111          0.            -.19          -.01
  0.             .050           -.092
  0.
                                                            .8            430.
 4.35            .00039         140.          9.16          1.4           11.5
 -.11            1.8            14.           14.
 59.             -59.
 10.             285.                         80.                         175.
                 26.4                                       8.            8.4
 8.4                                                       .92
 .88                                          .88          140.           3.
                 177.           -.96
 -2.             3.             .05           2.            3.            2.
 2.              3.             2.            180.          96.           72.
 180.            -96.           72.           80.           80.           50.
 50.             0.             0.
 0
          1 4 3
  0      0      20.     100.     200.                                          1
  0      0      20.     60.      80.                                           2
 100.    0      25.     65.      85.                                           3
  30.    0      30.     70.      90.                                           4
          2 4 3
  0      0      30.     100.     200.                                          1
  0      1.57   1.20    1.00     .60                                           2
 100.    1.57   1.10    .90      .40                                           3
 200.    1.57   1.00    .80      .20                                           4
                              BLANK CARD
   TEST DATA UNSNUBBED SNUBBER
     2     1     1    94     0     1     0     4     3     1     0     0
                       BLANK CARD
   TEST DATA CHANGE CL AND CM ALPHA
     3    -1     0     0     0     1     0     4     3     0     0     0
   5    5.5
   6    -1.3
                       BLANK CARD
   TEST DATA FRONT PULLEY HORIZONTAL
     4     1     0     0     0     4     0     4     3     0     0     0
   5    6.2
   6    -.8
  70      0
  74     80.
  81     26.4
  87     8.4
  91     .88
                             BLANK CARD
```

APPENDIX C

Contained in this Appendix is the program output corresponding to the input list shown in Appendix B.

CASE NO=1 TEST DATA LRC
FRONT CABLE VERTICAL,REAR CABLE HORIZONTAL
NO SNUBBERS
NC LIFT/ANTI-LIFT CABLE
INPUT DATA AS SPECIFIED IN AERO ARRAY

AERO(1)= 0.0	AERO(2)= 0.0	AERO(3)= 0.0	AERO(4)= 0.0	AERO(5)= 6.26
AERO(6)=-0.810	AERO(7)= 0.0	AERO(8)= 0.0	AERO(9)= -8.00	AERO(10)= 0.180E-01
AERO(11)= 0.105	AERO(12)= 0.350E-01	AERO(13)= 0.0	AERO(14)= 0.960	AERO(15)= -1.50
AERO(16)= 0.0	AERO(17)= 0.0	AERO(18)= 0.0	AERO(19)=-0.730	AERO(20)=-0.350E-01
AERO(21)= 0.111	AERO(22)= 0.0	AERO(23)=-0.190	AERO(24)=-0.100E-01	AERO(25)= 0.0
AERO(26)= 0.500E-01	AERO(27)=-0.920E-01	AERO(28)= 0.0	AERO(29)= 0.0	AERO(30)= 0.0
AERO(31)= 0.0	AERO(32)= 0.0	AERO(33)= 0.0	AERO(34)= 0.0	AERO(35)= 0.0
AERO(36)= 0.0	AERO(37)= 0.0	AERO(38)= 0.0	AERO(39)= 0.0	AERO(40)= 0.0
AERO(41)= 0.0	AERO(42)= 0.0	AERO(43)= 0.0	AERO(44)= 0.0	AERO(45)= 0.0
AERO(46)= 0.0	AERO(47)= 0.0	AERO(48)= 0.800	AERO(49)= 430.	AERO(50)= 4.35
AERO(51)= 0.390E-03	AERO(52)= 140.	AERO(53)= 9.16	AERO(54)= 1.40	AERO(55)= 11.5
AERO(56)=-0.110	AERO(57)= 1.80	AERO(58)= 14.0	AERO(59)= 14.0	AERO(60)= 0.0
AERO(61)= 0.0	AERO(62)= 0.0	AERO(63)= 0.0	AERO(64)= 0.0	AERO(65)= 0.0
AERO(66)= 59.0	AERO(67)= -59.0	AERO(68)= 0.0	AERO(69)= 0.0	AERO(70)= 0.0
AERO(71)= 0.0	AERO(72)= 10.0	AERO(73)= 285.	AERO(74)= 0.0	AERO(75)= 80.0
AERO(76)= 0.0	AERO(77)= 175.	AERO(78)= 0.0	AERO(79)= 26.4	AERO(80)= 0.0
AERO(81)= 0.0	AERO(82)= 8.00	AERO(83)= 8.40	AERO(84)= 8.40	AERO(85)= 0.0
AERO(86)= 0.0	AERO(87)= 0.0	AERO(88)= 0.920	AERO(89)= 0.0	AERO(90)= 0.880
AERO(91)= 0.0	AERO(92)= 0.0	AERO(93)= 0.880	AERO(94)= 140.	AERO(95)= 3.00
AERO(96)= 0.0	AERO(97)= 177.	AERO(98)=-0.960	AERO(99)= 0.0	AERO(100)= 0.0
AERO(101)= 0.0	AERO(102)= -2.00	AERO(103)= 3.00	AERO(104)= 0.500E-01	AERO(105)= 2.00
AERO(106)= 3.00	AERO(107)= 2.00	AERO(108)= 2.00	AERO(109)= 3.00	AERO(110)= 2.00
AERO(111)= 180.	AERO(112)= 96.0	AERO(113)= 72.0	AERO(114)= 180.	AERO(115)= -96.0
AERO(116)= 72.0	AERO(117)= 80.0	AERO(118)= 80.0	AERO(119)= 50.0	AERO(120)= 50.0
AERO(121)= 5.00	AERO(122)= 5.00	AERO(123)= 0.0	AERO(124)= 0.0	AERO(125)= 0.0
AERO(126)= 0.0	AERO(127)= 0.0	AERO(128)= 0.0	AERO(129)= 0.0	AERO(130)= 0.0

>>>>> ROOT LOCUS VARYING AERO(94)

AERO(94)= 84.000

EF. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.20 DEG
DELTA = -0.39 DEG
FRT CAB. TENSION= 0.740171E 02 LBS
BR CAB. TENSION = 0.840300E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-4.1128E-01	+-4.5224E 00	1.6862E 00	5.9306E-01	1.3893E 00	7.1976E-01	7.2273E-01	9.0527E-02	8.2357E-01	5.6488E-01
-7.6359E-01	+-7.3066E 00	9.0775E-01	1.1016E 00	8.5994E-01	1.1629E 00	1.1692E 00	1.0394E-01	9.4733E-01	5.1859E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.0267E-01	+-3.2209E 00	8.6355E-01	1.1580E 00	1.9508E 00	5.1262E-01	5.2830E-01	2.4181E-01	2.2590E 00	2.0891E-01
-1.9927E 00	+-4.0231E 00	3.4784E-01	2.8749E 00	1.5618E 00	6.4029E-01	7.1453E-01	4.4386E-01	4.4900E 00	4.4501E-02
-3.9774E-01	+-8.1582E 00	1.7427E 00	5.7382E-01	7.7017E-01	1.2984E 00	1.3000E 00	4.8657E-02	4.4154E-01	7.3614E-01

AERO(94)= 98.000

EF. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.22 DEG
DELTA = -0.50 DEG
FRT CAB. TENSION= 0.856892E 02 LBS
BR CAB. TENSION = 0.980300E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-4.6201E-01	+-4.7399E 00	1.5003E 00	6.6654E-01	1.3256E 00	7.5438E-01	7.5796E-01	9.7014E-02	8.8356E-01	5.4203E-01
-7.1231E-01	+-7.6113E 00	9.7310E-01	1.0276E 00	8.2551E-01	1.2114E 00	1.2167E 00	9.3179E-02	8.4832E-01	5.5543E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.1741E-01	+-3.2566E 00	7.5555E-01	1.3235E 00	1.9294E 00	5.1830E-01	5.3847E-01	2.7116E-01	2.5536E 00	1.7033E-01
-1.8645E 00	+-4.5973E 00	3.7176E-01	2.6899E 00	1.3667E 00	7.3168E-01	7.8956E-01	3.7584E-01	3.6764E 00	7.8218E-02
-4.1133E-01	+-8.4915E 00	1.6851E 00	5.9342E-01	7.3993E-01	1.3515E 00	1.3531E 00	4.8384E-02	4.3909E-01	7.3760E-01

AERO(94)= 112.00

EF. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.24 DEG
DELTA = -0.61 DEG
FRT CAB. TENSION= 0.973730E 02 LBS
BR CAB. TENSION = 0.112031E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.0694E-01	+-4.9267E 00	1.3673E 00	7.3136E-01	1.2753E 00	7.8411E-01	7.8825E-01	1.0236E-01	9.3272E-01	5.2387E-01
-6.6702E-01	+-7.9186E 00	1.0392E 00	9.6230E-01	7.9347E-01	1.2603E 00	1.2647E 00	8.3938E-02	7.6356E-01	5.8904E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.5880E-01	+-3.3021E 00	7.2293E-01	1.3833E 00	1.9028E 00	5.2555E-01	5.4726E-01	2.7884E-01	2.6320E 00	1.6132E-01
-1.8107E 00	+-5.1177E 00	3.8261E-01	2.6123E 00	1.2277E 00	8.1450E-01	8.6398E-01	3.3355E-01	3.2072E 00	1.0828E-01
-4.2385E-01	+-8.8130E 00	1.6354E 00	6.1148E-01	7.1295E-01	1.4026E 00	1.4043E 00	4.8035E-02	4.3556E-01	7.3920E-01

AERO(94)= 126.00

EF. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.26 DEG
DELTA = -0.73 DEG
FRT CAB. TENSION= 0.109046E 03 LBS

BR CAB. TENSION = 0.126031E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.4556E-01	+-5.0902E 00	1.2705E 00	7.8707E-01	1.2344E 00	8.1013E-01	8.1477E-01	1.0657E-01	9.7154E-01	5.0996E-01
-6.2802E-01	+-8.2248E 00	1.1037E 00	9.0604E-01	7.6393E-01	1.3090E 00	1.3128E 00	7.6136E-02	6.9215E-01	6.1893E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7347E-01	+-3.3689E 00	7.1204E-01	1.4044E 00	1.8651E 00	5.3618E-01	5.5811E-01	2.7760E-01	2.6193E 00	1.6274E-01
-1.7844E 00	+-5.5806E 00	3.8844E-01	2.5744E 00	1.1259E 00	8.8817E-01	9.3247E-01	3.0457E-01	2.8985E 00	1.3411E-01
-4.3552E-01	+-9.1233E 00	1.5915E 00	6.2833E-01	6.8870E-01	1.4520E 00	1.4537E 00	4.7684E-02	4.3273E-01	7.4086E-01

AERC(94)= 140.00

BR. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.28 DEG

DELTA = -0.95 DEG

FRT CAB. TENSION= 0.120720E 03 LBS

BR CAB. TENSION = 0.140032E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.7939E-01	+-5.2364E 00	1.1994E 00	8.3443E-01	1.1999E 00	8.3340E-01	8.3847E-01	1.0979E-01	1.0012E 00	4.9957E-01
-5.9482E-01	+-8.5279E 00	1.1653E 00	8.5812E-01	7.3678E-01	1.3573E 00	1.3606E 00	6.9579E-02	6.3225E-01	6.4517E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7846E-01	+-3.4493E 00	7.0841E-01	1.4116E 00	1.8221E 00	5.4882E-01	5.7049E-01	2.7297E-01	2.5721E 00	1.6816E-01
-1.7685E 00	+-6.0008E 00	3.9193E-01	2.5514E 00	1.0471E 00	9.5506E-01	9.9568E-01	2.8269E-01	2.6715E 00	1.5696E-01
-4.4653E-01	+-9.4236E 00	1.5523E 00	6.4420E-01	6.6674E-01	1.4998E 00	1.5015E 00	4.7331E-02	4.2551E-01	7.4251E-01

AERC(94)= 154.00

BR. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.30 DEG

DELTA = -0.98 DEG

FRT CAB. TENSION= 0.132393E 03 LBS

BR CAB. TENSION = 0.154033E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.0617E-01	+-5.3696E 00	1.1435E 00	8.7451E-01	1.1701E 00	8.5460E-01	8.6003E-01	1.1218E-01	1.0233E 00	4.9199E-01
-5.6662E-01	+-8.9262E 00	1.2233E 00	8.1745E-01	7.1168E-01	1.4047E 00	1.4076E 00	6.4065E-02	5.8192E-01	6.6807E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7944E-01	+-3.5346E 00	7.0770E-01	1.4130E 00	1.7776E 00	5.6255E-01	5.8375E-01	2.6704E-01	2.5118E 00	1.7533E-01
-1.7572E 00	+-6.3888E 00	3.9447E-01	2.5351E 00	9.8346E-01	1.0168E 00	1.0546E 00	2.6519E-01	2.4931E 00	1.7762E-01
-4.5699E-01	+-9.7155E 00	1.5168E 00	6.5930E-01	6.4672E-01	1.5463E 00	1.5480E 00	4.6986E-02	4.2638E-01	7.4413E-01

AERC(94)= 168.00

BR. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.33 DEG

DELTA = -1.11 DEG

FRT CAB. TENSION= 0.144067E 03 LBS

BR CAB. TENSION = 0.168034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.2970E-01	+-5.4927E 00	1.1008E 00	9.0846E-01	1.1439E 00	8.7419E-01	8.7992E-01	1.1390E-01	1.0392E 00	4.8660E-01
-5.4266E-01	+-9.1190E 00	1.2773E 00	7.8289E-01	6.8902E-01	1.4513E 00	1.4539E 00	5.9408E-02	5.3943E-01	6.8804E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7860E-01	+-3.6243E 00	7.0831E-01	1.4118E 00	1.7336E 00	5.7683E-01	5.9749E-01	2.6067E-01	2.4475E 00	1.8332E-01
-1.7481E 00	+-6.7514E 00	3.9652E-01	2.5220E 00	9.3066E-01	1.0745E 00	1.1099E 00	2.5066E-01	2.3471E 00	1.9654E-01
-4.6701E-01	+-9.9990E 00	1.4842E 00	6.7376E-01	6.2838E-01	1.5914E 00	1.5931E 00	4.6656E-02	4.2338E-01	7.4562E-01

AERC(94)= 182.00

EH. ATT.,DEFLTN,& CABLE TENSION

THETA = 35 DEG
DELTA = 25 DEG
FRT CAB. TENSION= 0.155741E 03 LBS
RR CAB. TENSION = 0.182034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.4969E-01	+-5.6079E 00	1.0669E 00	9.3730E-01	1.1204E 00	8.9253E-01	8.9850E-01	1.1508E-01	1.0502E 00	4.8291E-01
-5.2223E-01	+-9.4059E 00	1.3273E 00	7.5341E-01	6.6801E-01	1.4970E 00	1.4993E 00	5.5437E-02	5.0329E-01	7.0550E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7690E-01	+-3.7156E 00	7.0954E-01	1.4094E 00	1.6910E 00	5.9136E-01	6.1146E-01	2.5428E-01	2.3833E 00	1.9168E-01
-1.7402E 00	+-7.0930E 00	3.9831E-01	2.5106E 00	8.8583E-01	1.1289E 00	1.1624E 00	2.3828E-01	2.2240E 00	2.1405E-01
-4.7668E-01	+-1.0275E 01	1.4541E 00	6.8771E-01	6.1149E-01	1.6354E 00	1.6371E 00	4.6343E-02	4.2053E-01	7.4715E-01

AERC(94)= 196.00

EH. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.38 DEG
DELTA = -1.40 DEG
FRT CAB. TENSION= 0.167414E 03 LBS
RR CAB. TENSION = 0.196035E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.6675E-01	+-5.7166E 00	1.0396E 00	9.6191E-01	1.0991E 00	9.0985E-01	9.1602E-01	1.1585E-01	1.0572E 00	4.8056E-01
-5.0470E-01	+-9.6866E 00	1.3734E 00	7.2813E-01	6.4865E-01	1.5417E 00	1.5438E 00	5.2034E-02	4.7230E-01	7.2081E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7482E-01	+-3.8074E 00	7.1105E-01	1.4064E 00	1.6503E 00	6.0597E-01	6.2551E-01	2.4803E-01	2.3209E 00	2.0015E-01
-1.7330E 00	+-7.4170E 00	3.9996E-01	2.5002E 00	8.4713E-01	1.1805E 00	1.2122E 00	2.2753E-01	2.1180E 00	2.3036E-01
-4.8606E-01	+-1.0545E 01	1.4260E 00	7.0124E-01	5.9587E-01	1.6782E 00	1.6800E 00	4.6047E-02	4.1785E-01	7.4854E-01

CASE NO= 2 TEST DATA UNSNUBBED SNUBBER
FRONT CABLE VERTICAL, REAR CABLE HORIZONTAL
SNUBBERS UNSNUBBED
NO LIFT/ANTI-LIFT CABLE

DATA CHANGE
C 0.0

>>>>> ROOT LOCUS VARYING AERC(94)

AERC(94)= 84.000

FF. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.26 DEG
DELTA = -0.68 DEG
FRT CAB. TENSION= 0.108811E 03 LBS
RS CAB. TENSION = 0.840315E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.0255E-01	+-5.4658E 00	1.3792E 00	7.2508E-01	1.1495E 00	8.6991E-01	8.7358E-01	9.1566E-02	8.3351E-01	5.5116E-01
-6.7106E-01	+-8.2834E 00	1.0329E 00	9.6814E-01	7.5853E-01	1.3183E 00	1.3227E 00	8.0750E-02	7.3436E-01	6.0108E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-7.7711E-01	+-4.8442E 00	8.9195E-01	1.1211E 00	1.2971E 00	7.7098E-01	7.8083E-01	1.5840E-01	1.4542E 00	3.6496E-01
-1.2905E 00	+-8.1265E 00	5.3710E-01	1.8618E 00	7.7317E-01	1.2934E 00	1.3096E 00	1.5684E-01	1.4395E 00	3.6869E-01
-1.1258E 00	+-9.4515E 00	6.1571E-01	1.6241E 00	6.6478E-01	1.5042E 00	1.5149E 00	1.1827E-01	1.0797E 00	4.7313E-01

AERC(94)= 98.000

FF. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.28 DEG
DELTA = -0.80 DEG
FRT CAB. TENSION= 0.120485E 03 LBS
RR CAB. TENSION = 0.980322E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.4112E-01	+-5.6105E 00	1.2810E 00	7.8065E-01	1.1199E 00	8.9294E-01	8.9708E-01	9.6000E-02	8.7424E-01	5.4554E-01
-6.3216E-01	+-8.5786E 00	1.0965E 00	9.1201E-01	7.3242E-01	1.3653E 00	1.3690E 00	7.3492E-02	6.6798E-01	6.2939E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.0141E-01	+-4.9230E 00	8.6491E-01	1.1562E 00	1.2763E 00	7.8352E-01	7.9383E-01	1.6068E-01	1.4756E 00	3.5957E-01
-1.2505E 00	+-8.4024E 00	5.5430E-01	1.8041E 00	7.4779E-01	1.3373E 00	1.3520E 00	1.4720E-01	1.3491E 00	3.5255E-01
-1.1416E 00	+-9.7465E 00	6.0717E-01	1.6470E 00	6.4466E-01	1.5512E 00	1.5618E 00	1.1633E-01	1.0617E 00	4.7905E-01

AERC(94)= 112.00

FR. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.30 DEG
DELTA = -0.93 DEG
FRT CAB. TENSION= 0.132159E 03 LBS
RR CAB. TENSION = 0.112033E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.7378E-01	+-5.7409E 00	1.2080E 00	8.2780E-01	1.0945E 00	9.1369E-01	9.1825E-01	9.9452E-02	9.0559E-01	5.3367E-01
-5.9907E-01	+-8.8712E 00	1.1570E 00	8.6428E-01	7.0827E-01	1.4119E 00	1.4151E 00	6.7377E-02	6.1214E-01	6.5423E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.2059E-01	+-4.9990E 00	8.4470E-01	1.1839E 00	1.2569E 00	7.9561E-01	8.0626E-01	1.6198E-01	1.4880E 00	3.5651E-01
-1.2199E 00	+-8.6700E 00	5.6820E-01	1.7600E 00	7.2470E-01	1.3799E 00	1.3935E 00	1.3933E-01	1.2754E 00	4.1310E-01
-1.1531E 00	+-1.0034E 01	6.0112E-01	1.6636E 00	6.2622E-01	1.5969E 00	1.6074E 00	1.1417E-01	1.0418E 00	4.6574E-01

AERC(94)= 126.00

FF. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.32 DEG
DELTA = -1.06 DEG
FRT CAB. TENSION= 0.143832E 03 LBS

RR CAB. TENSION = 0.126034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T F/D-SEC	1/T F/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.0143E-01	+-5.8605E 00	1.1525E 00	8.6767E-01	1.0721E 00	9.3273E-01	9.3762E-01	1.0209E-01	9.3025E-01	5.2477E-01
-5.7101E-01	+-9.1597E 00	1.2139E 00	8.2379E-01	6.8596E-01	1.4578E 00	1.4606E 00	6.2219E-02	5.6509E-01	6.7591E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.3589E-01	+-5.0730E 00	8.2923E-01	1.2059E 00	1.2386E 00	8.0739E-01	8.1827E-01	1.6258E-01	1.4936E 00	3.5512E-01
-1.1965E 00	+-8.9298E 00	5.7931E-01	1.7262E 00	7.0362E-01	1.4212E 00	1.4339E 00	1.3280E-01	1.2146E 00	4.3090E-01
-1.1613E 00	+-1.0313E 01	5.9688E-01	1.6754E 00	6.0924E-01	1.6414E 00	1.6518E 00	1.1150E-01	1.0207E 00	4.9287E-01

AERO(94)= 140.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.35 DEG
DELTA = -1.20 DEG
FRT CAB. TENSION= 0.155506E 03 LBS
RR CAB. TENSION = 0.140034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.2493E-01	+-5.9717E 00	1.1093E 00	9.0144E-01	1.0522E 00	9.5043E-01	9.5562E-01	1.0408E-01	9.4846E-01	5.1819E-01
-5.4716E-01	+-9.4432E 00	1.2668E 00	7.8939E-01	6.6536E-01	1.5029E 00	1.5055E 00	5.7846E-02	5.2523E-01	6.9455E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T F/D-SEC	1/T F/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.4823E-01	+-5.1455E 00	8.1717E-01	1.2237E 00	1.2211E 00	8.1893E-01	8.2998E-01	1.6265E-01	1.4943E 00	3.5495E-01
-1.1796E 00	+-9.1821E 00	5.8811E-01	1.7004E 00	6.8429E-01	1.4614E 00	1.4734E 00	1.2732E-01	1.1635E 00	4.4642E-01
-1.1670E 00	+-1.0586E 01	5.9398E-01	1.6836E 00	5.9354E-01	1.6848E 00	1.6950E 00	1.0957E-01	9.9926E-01	5.0026E-01

AERO(94)= 154.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.37 DEG
DELTA = -1.34 DEG
FRT CAB. TENSION= 0.167180E 03 LBS
RR CAB. TENSION = 0.154035E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T F/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.4472E-01	+-6.0764E 00	1.0751E 00	9.3014E-01	1.0340E 00	9.6709E-01	9.7251E-01	1.0551E-01	9.6180E-01	5.1342E-01
-5.2681E-01	+-9.7214E 00	1.3157E 00	7.6003E-01	6.4633E-01	1.5472E 00	1.5495E 00	5.4113E-02	4.5123E-01	7.1142E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.5829E-01	+-5.2169E 00	8.0759E-01	1.2382E 00	1.2044E 00	8.3029E-01	8.4145E-01	1.6234E-01	1.4913E 00	3.5568E-01
-1.1649E 00	+-9.4272E 00	5.9502E-01	1.6806E 00	6.6650E-01	1.5004E 00	1.5118E 00	1.2264E-01	1.1201E 00	4.6005E-01
-1.1707E 00	+-1.0853E 01	5.9208E-01	1.6890E 00	5.7896E-01	1.7272E 00	1.7373E 00	1.0725E-01	9.7784E-01	5.0774E-01

AERO(94)= 168.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.40 DEG
DELTA = -1.49 DEG
FRT CAB. TENSION= 0.178853E 03 LBS
RR CAB. TENSION = 0.166036E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.6170E-01	+-6.1757E 00	1.0475E 00	9.5464E-01	1.0174E 00	9.8290E-01	9.8853E-01	1.0654E-01	9.7124E-01	5.1007E-01
-5.0935E-01	+-9.9939E 00	1.3608E 00	7.3484E-01	6.2870E-01	1.5906E 00	1.5926E 00	5.0902E-02	4.6200E-01	7.2598E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T F/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.6656E-01	+-5.2873E 00	7.9988E-01	1.2502E 00	1.1884E 00	8.4149E-01	8.5272E-01	1.6174E-01	1.4857E 00	3.5708E-01
-1.1545E 00	+-9.6654E 00	6.0040E-01	1.6656E 00	6.5007E-01	1.5383E 00	1.5492E 00	1.1860E-01	1.0627E 00	4.7214E-01
-1.1730E 00	+-1.1113E 01	5.9093E-01	1.6922E 00	5.6537E-01	1.7687E 00	1.7786E 00	1.0496E-01	9.5675E-01	5.1522E-01

AERO(94)= 182.00

EE. ATT., DEFLTN,& CABLE TENSION

THETA = 2.42 DEG
DELTA = -1.65 DEG
FRT CAB. TENSION= 0.190527E 03 LBS
RR CAB. TENSION = 0.182037E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.7627E-01	+-6.2708E 00	1.0250E 00	9.7565E-01	1.0020E 00	9.9803E-01	1.0038E 00	1.0722E-01	9.7758E-01	5.0783E-01
-4.9429E-01	+-1.0261E 01	1.4023E 00	7.1311E-01	6.1235E-01	1.6331E 00	1.6350E 00	4.8117E-02	4.3667E-01	7.3884E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.7343E-01	+-5.3568E 00	7.9359E-01	1.2601E 00	1.1729E 00	8.5256E-01	8.6382E-01	1.6093E-01	1.4780E 00	3.5898E-01
-1.1466E 00	+-9.9972E 00	6.0453E-01	1.6542E 00	6.3484E-01	1.5752E 00	1.5857E 00	1.1508E-01	1.0501E 00	4.8292E-01
-1.1741E 00	+-1.1369E 01	5.9036E-01	1.6939E 00	5.5267E-01	1.8094E 00	1.8190E 00	1.0273E-01	9.3616E-01	5.2262E-01

AERC(94)= 196.00

EE. ATT., DEFLTN,& CABLE TENSION

THETA = 2.45 DEG
DELTA = -1.81 DEG
FRT CAB. TENSION= 0.202213E 03 LBS
RR CAB. TENSION = 0.196037E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.8885E-01	+-6.3623E 00	1.0062E 00	9.9379E-01	9.8756E-01	1.0126E 00	1.0185E 00	1.0764E-01	9.8143E-01	5.0648E-01
-4.8119E-01	+-1.0522E 01	1.4405E 00	6.9421E-01	5.9712E-01	1.6747E 00	1.6764E 00	4.5683E-02	4.1453E-01	7.5026E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.7919E-01	+-5.4256E 00	7.8839E-01	1.2684E 00	1.1581E 00	8.6351E-01	8.7478E-01	1.5996E-01	1.4689E 00	3.6126E-01
-1.1407E 00	+-1.0123E 01	6.0767E-01	1.6456E 00	6.2068E-01	1.6111E 00	1.6213E 00	1.1197E-01	1.0214E 00	4.9264E-01
-1.1744E 00	+-1.1619E 01	5.9022E-01	1.6943E 00	5.4075E-01	1.8493E 00	1.8587E 00	1.0056E-01	9.1618E-01	5.2991E-01

```
CASE NO= 3      TEST DATA CHANGE CL AND CM ALPHA
                FRONT CABLE VERTICAL,REAR CABLE HORIZONTAL
                NO SNUBBERS
                NO LIFT/ANTI-LIFT CABLE
 DATA CHANGE
   5     5.5000
   6    -1.3000
   0     0.0

EF. ATT.,DEFLTN,& CABLE TENSION
 THETA =  2.94 DEG
 DELTA = -2.78 DEG
 FRT CAB. TENSION=    0.120742E 03 LBS
 RR CAB. TENSION =    0.140053E 03 LBS
 >>>> LONGITUDINAL STABILITY <<<<
```

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-3.9605E-01	+-4.5501E 00	1.7502E 00	5.7138E-01	1.3809E 00	7.2418E-01	7.2691E-01	8.6714E-02	7.8900E-01	5.7874E-01
-6.8065E-01	+-9.9917E 00	1.0184E 00	9.8197E-01	6.2884E-01	1.5902E 00	1.5939E 00	6.7965E-02	6.1750E-01	6.5180E-01

CASE 4 TEST DATA FRONT PULLEY HORIZONTAL

BOTH CABLES HORIZONTAL

NO SNUBBERS

NO LIFT/ANTI-LIFT CABLE

DATA CHANGE

5	6.2000
6	-0.80000
70	0.0
74	80.000
81	26.400
87	8.4000
91	0.88000
0	0.0

EH. ATT.,DEPTH,& CABLE TENSION

THETA = 2.51 DEG

DELTA = -2.12 DEG

FWD CAB. TENSION= 0.126639E 03 LBS

RR CAB. TENSION = 0.140039E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-2.9475E-01	+-5.5731E 00	2.3517E 00	4.2523E-01	1.1274E 00	8.8698E-01	8.8822E-01	5.2815E-02	4.7941E-01	7.1727E-01
-6.6118E-01	+-8.0081E 00	1.0484E 00	9.5388E-01	7.8460E-01	1.2745E 00	1.2789E 00	8.2284E-02	7.4841E-01	5.9526E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-1.7860E 00	+-2.7053E 00	3.8811E-01	2.5766E 00	2.3225E 00	4.3057E-01	5.1593E-01	5.5093E-01	5.9841E 00	1.5798E-02
-1.4335E 00	+-7.2026E 00	4.8352E-01	2.0682E 00	8.7235E-01	1.1463E 00	1.1688E 00	1.9520E-01	1.8042E 00	2.8635E-01
-5.1859E-01	+-9.7303E 00	1.3366E 00	7.4816E-01	6.4573E-01	1.5486E 00	1.5508E 00	5.3222E-02	4.8311E-01	7.1543E-01

CASE NO= 1 TEST DATA LRC

FRONT CABLE VERTICAL,REAR CABLE HORIZONTAL

NO SNUBBERS

NO LIFT/ANTI-LIFT CABLE

INPUT DATA AS SPECIFIED IN AERO ARRAY

AERO(1)= 0.0	AERO(2)= 0.0	AERO(3)= 0.0	AERO(4)= 0.0	AERO(5)= 6.26
AERO(6)=-0.610	AERO(7)= 0.0	AERO(8)= 0.0	AERO(9)= -8.00	AERO(10)= 0.180E-01
AERO(11)= 0.105	AERO(12)= 0.350E-01	AERO(13)= 0.0	AERO(14)= 0.960	AERO(15)= -1.50
AERO(16)= 0.0	AERO(17)= 0.0	AERO(18)= 0.0	AERO(19)=-0.730	AERO(20)=-0.350E-01
AERO(21)= 0.111	AERO(22)= 0.0	AERO(23)=-0.190	AERO(24)=-0.100E-01	AERO(25)= 0.0
AERO(26)= 0.500E-01	AERO(27)=-0.920E-01	AERO(28)= 0.0	AERO(29)= 0.0	AERO(30)= 0.0
AERO(31)= 0.0	AERO(32)= 0.0	AERO(33)= 0.0	AERO(34)= 0.0	AERO(35)= 0.0
AERO(36)= 0.0	AERO(37)= 0.0	AERO(38)= 0.0	AERO(39)= 0.0	AERO(40)= 0.0
AERO(41)= 0.0	AERO(42)= 0.0	AERO(43)= 0.0	AERO(44)= 0.0	AERO(45)= 0.0
AERO(46)= 0.0	AERO(47)= 0.0	AERO(48)= 0.600	AERO(49)= 430.	AERO(50)= 4.35
AERO(51)= 0.390E-03	AERO(52)= 140.	AERO(53)= 9.16	AERO(54)= 1.40	AERO(55)= 11.5
AERO(56)=-0.110	AERO(57)= 1.80	AERO(58)= 14.0	AERO(59)= 14.0	AERO(60)= 0.0
AERO(61)= 0.0	AERO(62)= 0.0	AERO(63)= 0.0	AERO(64)= 0.0	AERO(65)= 0.0
AERO(66)= 59.0	AERO(67)= -59.0	AERO(68)= 0.0	AERO(69)= 0.0	AERO(70)= 0.0
AERO(71)= 0.0	AERO(72)= 10.0	AERO(73)= 285.	AERO(74)= 0.0	AERO(75)= 80.0
AERO(76)= 0.0	AERO(77)= 175.	AERO(78)= 0.0	AERO(79)= 26.4	AERO(80)= 0.0
AERO(81)= 0.0	AERO(82)= 8.00	AERO(83)= 8.40	AERO(84)= 8.40	AERO(85)= 0.0
AERO(86)= 0.0	AERO(87)= 0.0	AERO(88)= 0.920	AERO(89)= 0.0	AERO(90)= 0.880
AERO(91)= 0.0	AERO(92)= 0.0	AERO(93)= 0.880	AERO(94)= 140.	AERO(95)= 3.00
AERO(96)= 0.0	AERO(97)= 177.	AERO(98)=-0.960	AERO(99)= 0.0	AERO(100)= 0.0
AERO(101)= 0.0	AERO(102)= -2.00	AERO(103)= 3.00	AERO(104)= 0.500E-01	AERO(105)= 2.00
AERO(106)= 3.00	AERO(107)= 2.00	AERO(108)= 2.00	AERO(109)= 3.00	AERO(110)= 2.00
AERO(111)= 180.	AERO(112)= 96.0	AERO(113)= 72.0	AERO(114)= 180.	AERO(115)= -96.0
AERO(116)= 72.0	AERO(117)= 80.0	AERO(118)= 80.0	AERO(119)= 50.0	AERO(120)= 50.0
AERO(121)= 5.00	AERO(122)= 5.00	AERO(123)= 0.0	AERO(124)= 0.0	AERO(125)= 0.0
AERO(126)= 0.0	AERO(127)= 0.0	AERO(128)= 0.0	AERO(129)= 0.0	AERO(130)= 0.0

>>>>> ROOT LOCUS VARYING AERO(94)

AERO(94)= 84.000

BR. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.20 DEG
DELTA = -0.39 DEG
FRT CAB. TENSION= 0.740171E 02 LBS
RR CAB. TENSION = 0.840300E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-4.1128E-01	+-4.5224E 00	1.6862E 00	5.9306E-01	1.3893E 00	7.1976E-01	7.2273E-01	9.0527E-02	8.2357E-01	5.6488E-01
-7.6359E-01	+-7.3066E 00	9.0775E-01	1.1016E 00	8.5994E-01	1.1629E 00	1.1692E 00	1.0394E-01	9.4733E-01	5.1859E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.0267E-01	+-3.2209E 00	8.6355E-01	1.1580E 00	1.9508E 00	5.1262E-01	5.2830E-01	2.4181E-01	2.2590E 00	2.0891E-01
-1.9927E 00	+-4.0231E 00	3.4784E-01	2.8749E 00	1.5618E 00	6.4029E-01	7.1453E-01	4.4386E-01	4.4900E 00	4.4501E-02
-3.9774E-01	+-8.1582E 00	1.7427E 00	5.7382E-01	7.7017E-01	1.2984E 00	1.3000E 00	4.8657E-02	4.4154E-01	7.3614E-01

AERO(94)= 98.000

BR. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.22 DEG
DELTA = -0.50 DEG
FRT CAB. TENSION= 0.856892E 02 LBS
RR CAB. TENSION = 0.960300E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-4.6201E-01	+-4.7399E 00	1.5003E 00	6.6554E-01	1.3256E 00	7.5438E-01	7.5796E-01	9.7014E-02	8.8356E-01	5.4203E-01
-7.1231E-01	+-7.6113E 00	9.7310E-01	1.0276E 00	8.2551E-01	1.2114E 00	1.2167E 00	9.3179E-02	8.4832E-01	5.5543E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.1741E-01	+-3.2566E 00	7.5555E-01	1.3235E 00	1.9294E 00	5.1830E-01	5.3847E-01	2.7116E-01	2.5536E 00	1.7033E-01
-1.8645E 00	+-4.5973E 00	3.7176E-01	2.6899E 00	1.3667E 00	7.3168E-01	7.8956E-01	3.7584E-01	3.6764E 00	7.8218E-02
-4.1133E-01	+-8.4915E 00	1.6851E 00	5.9342E-01	7.3993E-01	1.3515E 00	1.3531E 00	4.8384E-02	4.3909E-01	7.3760E-01

AERO(94)= 112.00

BR. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.24 DEG
DELTA = -0.61 DEG
FRT CAB. TENSION= 0.972730E 02 LBS
RR CAB. TENSION = 0.112031E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.0694E-01	+-4.9267E 00	1.3673E 00	7.3136E-01	1.2753E 00	7.8411E-01	7.8825E-01	1.0236E-01	9.3272E-01	5.2387E-01
-6.6702E-01	+-7.9186E 00	1.0392E 00	9.6230E-01	7.9347E-01	1.2603E 00	1.2647E 00	8.3938E-02	7.6356E-01	5.8904E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.5880E-01	+-3.3021E 00	7.2293E-01	1.3833E 00	1.9028E 00	5.2555E-01	5.4726E-01	2.7884E-01	2.6320E 00	1.6132E-01
-1.8107E 00	+-5.1177E 00	3.8281E-01	2.6123E 00	1.2277E 00	8.1450E-01	8.6398E-01	3.3355E-01	3.2072E 00	1.0828E-01
-4.2385E-01	+-8.8130E 00	1.6354E 00	6.1148E-01	7.1295E-01	1.4026E 00	1.4043E 00	4.8035E-02	4.3556E-01	7.3920E-01

AERO(94)= 126.00

BR. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.26 DEG
DELTA = -0.73 DEG
FRT CAB. TENSION= 0.109046E 03 LBS

RR CAB. TENSION = 0.126031E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.4556E-01	+-5.0902E 00	1.2705E 00	7.8707E-01	1.2344E 00	8.1013E-01	8.1477E-01	1.0657E-01	9.7154E-01	5.0996E-01
-6.2802E-01	+-8.2248E 00	1.1037E 00	9.0604E-01	7.6393E-01	1.3090E 00	1.3128E 00	7.6136E-02	6.9215E-01	6.1893E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.7347E-01	+-3.3689E 00	7.1204E-01	1.4044E 00	1.8651E 00	5.3618E-01	5.5811E-01	2.7760E-01	2.6193E 00	1.6274E-01
-1.7844E 00	+-5.5906E 00	3.8844E-01	2.5744E 00	1.1259E 00	8.8817E-01	9.3247E-01	3.0457E-01	2.8985E 00	1.3411E-01
-4.3552E-01	+-9.1233E 00	1.5915E 00	6.2833E-01	6.8870E-01	1.4520E 00	1.4537E 00	4.7664E-02	4.3273E-01	7.4086E-01

AERO(94)= 140.00

RR. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.29 DEG

DELTA = -0.95 DEG

FRT CAB. TENSION= 0.120720E 03 LBS

RR CAB. TENSION = 0.140032E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.7835E-01	+-5.2364E 00	1.1984E 00	8.3443E-01	1.1999E 00	8.3340E-01	8.3847E-01	1.0979E-01	1.0012E 00	4.9957E-01
-5.9480E-01	+-8.5279E 00	1.1653E 00	8.5812E-01	7.3678E-01	1.3573E 00	1.3606E 00	6.9579E-02	6.3225E-01	6.4517E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7846E-01	+-3.4483E 00	7.0841E-01	1.4116E 00	1.8221E 00	5.4882E-01	5.7049E-01	2.7297E-01	2.5721E 00	1.6816E-01
-1.7685E 00	+-6.0008E 00	3.9193E-01	2.5514E 00	1.0471E 00	9.5506E-01	9.9568E-01	2.8269E-01	2.6715E 00	1.5696E-01
-4.4653E-01	+-9.4238E 00	1.5523E 00	6.4420E-01	6.6674E-01	1.4998E 00	1.5015E 00	4.7331E-02	4.2551E-01	7.4251E-01

AERO(94)= 154.00

RR. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.30 DEG

DELTA = -0.98 DEG

FRT CAB. TENSION= 0.132393E 03 LBS

RR CAB. TENSION = 0.154033E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.0617E-01	+-5.3696E 00	1.1435E 00	8.7451E-01	1.1701E 00	8.5460E-01	8.6003E-01	1.1218E-01	1.0233E 00	4.9199E-01
-5.6662E-01	+-8.8262E 00	1.2233E 00	8.1745E-01	7.1188E-01	1.4047E 00	1.4076E 00	6.4065E-02	5.8192E-01	6.6807E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7944E-01	+-3.5346E 00	7.0770E-01	1.4130E 00	1.7776E 00	5.6255E-01	5.8375E-01	2.6704E-01	2.5119E 00	1.7533E-01
-1.7572E 00	+-6.3888E 00	3.9447E-01	2.5351E 00	9.8346E-01	1.0168E 00	1.0546E 00	2.6519E-01	2.4931E 00	1.7762E-01
-4.5699E-01	+-9.7155E 00	1.5168E 00	6.5930E-01	6.4672E-01	1.5463E 00	1.5480E 00	4.6986E-02	4.2638E-01	7.4413E-01

AERO(94)= 168.00

RR. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.33 DEG

DELTA = -1.11 DEG

FRT CAB. TENSION= 0.144067E 03 LBS

RR CAB. TENSION = 0.168034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.2970E-01	+-5.4927E 00	1.1008E 00	9.0846E-01	1.1439E 00	8.7419E-01	8.7992E-01	1.1390E-01	1.0392E 00	4.8660E-01
-5.4266E-01	+-9.1190E 00	1.2773E 00	7.8289E-01	6.8902E-01	1.4513E 00	1.4539E 00	5.9404E-02	5.3543E-01	6.8804E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7860E-01	+-3.6243E 00	7.0831E-01	1.4118E 00	1.7336E 00	5.7683E-01	5.9749E-01	2.6067E-01	2.4475E 00	1.8332E-01
-1.7481E 00	+-6.7514E 00	3.9652E-01	2.5220E 00	9.3066E-01	1.0745E 00	1.1099E 00	2.5066E-01	2.3471E 00	1.9654E-01
-4.6701E-01	+-9.9990E 00	1.4842E 00	6.7376E-01	6.2838E-01	1.5914E 00	1.5931E 00	4.6656E-02	4.2338E-01	7.4568E-01

AERO(94)= 182.00

RH. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.35 DEG
DELTA = -1.25 DEG
FWD CAB. TENSION= 0.155741E 03 LBS
AFT CAB. TENSION = 0.182034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.4969E-01	+-5.6079E 00	1.0669E 00	9.3730E-01	1.1204E 00	8.9253E-01	8.9850E-01	1.1508E-01	1.0502E 00	4.8291E-01
-5.2223E-01	+-9.4059E 00	1.3273E 00	7.5341E-01	6.6801E-01	1.4970E 00	1.4993E 00	5.5437E-02	5.0329E-01	7.0550E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7690E-01	+-3.7156E 00	7.0954E-01	1.4094E 00	1.6910E 00	5.9136E-01	6.1146E-01	2.5428E-01	2.3833E 00	1.9168E-01
-1.7402E 00	+-7.0930E 00	3.9831E-01	2.5106E 00	8.8583E-01	1.1289E 00	1.1624E 00	2.3828E-01	2.2240E 00	2.1405E-01
-4.7668E-01	+-1.0275E 01	1.4541E 00	6.8771E-01	6.1149E-01	1.6354E 00	1.6371E 00	4.6343E-02	4.2053E-01	7.4715E-01

AERC(94)= 196.00

RH. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.35 DEG
DELTA = -1.40 DEG
FWD CAB. TENSION= 0.167414E 03 LBS
AFT CAB. TENSION = 0.196035E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.6675E-01	+-5.7166E 00	1.0396E 00	9.6191E-01	1.0991E 00	9.0985E-01	9.1602E-01	1.1585E-01	1.0572E 00	4.9056E-01
-5.0473E-01	+-9.6866E 00	1.3734E 00	7.2813E-01	6.4865E-01	1.5417E 00	1.5438E 00	5.2034E-02	4.7230E-01	7.2081E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7482E-01	+-3.8074E 00	7.1105E-01	1.4064E 00	1.6503E 00	6.0597E-01	6.2551E-01	2.4803E-01	2.3209E 00	2.0015E-01
-1.7330E 00	+-7.4170E 00	3.9996E-01	2.5002E 00	8.4713E-01	1.1805E 00	1.2122E 00	2.2753E-01	2.1180E 00	2.3036E-01
-4.8606E-01	+-1.0545E 01	1.4260E 00	7.0124E-01	5.9587E-01	1.6782E 00	1.6800E 00	4.6047E-02	4.1785E-01	7.4854E-01

```
CASE NO=  2        TEST DATA UNSNUBBED SNUBBER
                FRONT CABLE VERTICAL,REAR CABLE HORIZONTAL
                SNUBBERS UNSNUBBED
                NO LIFT/ANTI-LIFT CABLE
DATA CHANGE
  C     0.0
```

>>>>> ROOT LOCUS VARYING AERO(94)

AERO(94)= 84.000

RR. ATT.,DEFLIN,& CABLE TENSION
THETA = 2.26 DEG
DELTA = -0.68 DEG
FRT CAB. TENSION= 0.109811E 03 LBS
RR CAB. TENSION = 0.840315E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.0259E-01	+-5.4658E 00	1.3792E 00	7.2508E-01	1.1495E 00	8.6991E-01	8.7358E-01	9.1566E-02	8.3351E-01	5.6116E-01
-6.7106E-01	+-8.2834E 00	1.0329E 00	9.6814E-01	7.5853E-01	1.3183E 00	1.3227E 00	8.0750E-02	7.3436E-01	6.0108E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-7.7711E-01	+-4.8442E 00	8.9195E-01	1.1211E 00	1.2971E 00	7.7098E-01	7.8083E-01	1.5840E-01	1.4542E 00	3.6496E-01
-1.2905E 00	+-8.1265E 00	5.3710E-01	1.8618E 00	7.7317E-01	1.2934E 00	1.3096E 00	1.5684E-01	1.4355E 00	3.6869E-01
-1.1258E 00	+-9.4515E 00	6.1571E-01	1.6241E 00	6.6478E-01	1.5042E 00	1.5149E 00	1.1827E-01	1.0797E 00	4.7313E-01

AERO(94)= 98.000

RR. ATT.,DEFLIN,& CABLE TENSION
THETA = 2.28 DEG
DELTA = -0.80 DEG
FRT CAB. TENSION= 0.120485E 03 LBS
RR CAB. TENSION = 0.980322E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.4110E-01	+-5.6105E 00	1.2810E 00	7.8065E-01	1.1199E 00	8.9294E-01	8.9708E-01	9.6000E-02	8.7424E-01	5.4554E-01
-6.3216E-01	+-8.5786E 00	1.0965E 00	9.1201E-01	7.3242E-01	1.3653E 00	1.3690E 00	7.3492E-02	6.6758E-01	6.2939E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.0141E-01	+-4.9230E 00	8.6491E-01	1.1562E 00	1.2763E 00	7.8352E-01	7.9383E-01	1.6068E-01	1.4756E 00	3.5957E-01
-1.2505E 00	+-8.4024E 00	5.5430E-01	1.8041E 00	7.4779E-01	1.3373E 00	1.3520E 00	1.4720E-01	1.3491E 00	3.5255E-01
-1.1416E 00	+-9.7465E 00	6.0717E-01	1.6470E 00	6.4466E-01	1.5512E 00	1.5618E 00	1.1633E-01	1.0617E 00	4.7905E-01

AERO(94)= 112.00

RR. ATT.,DEFLIN,& CABLE TENSION
THETA = 2.3[illegible] DEG
DELTA = -0.93 DEG
FRT CAB. TENSION= 0.132159E 03 LBS
RR CAB. TENSION = 0.112033E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.7378E-01	+-5.7409E 00	1.2080E 00	8.2780E-01	1.0945E 00	9.1369E-01	9.1825E-01	9.9452E-02	9.0559E-01	5.3367E-01
-5.9907E-01	+-8.8712E 00	1.1570E 00	8.6428E-01	7.0827E-01	1.4119E 00	1.4151E 00	6.7377E-02	6.1214E-01	6.5423E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.2059E-01	+-4.9990E 00	8.4470E-01	1.1839E 00	1.2569E 00	7.9561E-01	8.0626E-01	1.6198E-01	1.4880E 00	3.5651E-01
-1.2199E 00	+-8.6700E 00	5.6820E-01	1.7600E 00	7.2470E-01	1.3799E 00	1.3935E 00	1.3933E-01	1.2754E 00	4.1310E-01
-1.1531E 00	+-1.0034E 01	6.0112E-01	1.6636E 00	6.2622E-01	1.5969E 00	1.6074E 00	1.1417E-01	1.0418E 00	4.8574E-01

AERO(94)= 126.00

RR. ATT.,DEFLIN,& CABLE TENSION
THETA = 2.32 DEG
DELTA = -1.06 DEG
FRT CAB. TENSION= 0.143832E 03 LBS

FR CAB. TENSION = 0.126034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T F/D-SEC	1/T F/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.0143E-01	+-5.8605E 00	1.1525E 00	8.6767E-01	1.0721E 00	9.3273E-01	9.3762E-01	1.0209E-01	9.3926E-01	5.2477E-01
-5.7101E-01	+-9.1597E 00	1.2139E 00	8.2379E-01	6.8596E-01	1.4578E 00	1.4606E 00	6.2219E-02	5.6509E-01	6.7591E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.3589E-01	+-5.0730E 00	8.2923E-01	1.2059E 00	1.2386E 00	8.0739E-01	8.1827E-01	1.6258E-01	1.4936E 00	3.5512E-01
-1.1965E 00	+-8.3298E 00	5.7931E-01	1.7262E 00	7.0362E-01	1.4212E 00	1.4339E 00	1.3280E-01	1.2146E 00	4.3090E-01
-1.1613E 00	+-1.0313E 01	5.9668E-01	1.6754E 00	6.0924E-01	1.6414E 00	1.6518E 00	1.1150E-01	1.0207E 00	4.9287E-01

AERO(94) = 140.00

EH. ATT.,DEFLIN,& CABLE TENSION
THETA = 2.35 DEG
DELTA = -1.20 DEG
FRT CAB. TENSION= 0.155506E 03 LBS
RR CAB. TENSION = 0.140034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.2493E-01	+-5.6717E 00	1.1093E 00	9.0144E-01	1.0522E 00	9.5043E-01	9.5562E-01	1.0406E-01	9.4846E-01	5.1819E-01
-5.4716E-01	+-9.4432E 00	1.2668E 00	7.8939E-01	6.6536E-01	1.5029E 00	1.5055E 00	5.7846E-02	5.2523E-01	6.9465E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T F/D-SEC	1/T F/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.4923E-01	+-5.1455E 00	8.1717E-01	1.2237E 00	1.2211E 00	8.1893E-01	8.2998E-01	1.6265E-01	1.4943E 00	3.5495E-01
-1.1786E 00	+-9.1821E 00	5.8811E-01	1.7004E 00	6.8429E-01	1.4614E 00	1.4734E 00	1.2732E-01	1.1635E 00	4.4642E-01
-1.1670E 00	+-1.0586E 01	5.9398E-01	1.6836E 00	5.9354E-01	1.6848E 00	1.6950E 00	1.0957E-01	9.9926E-01	5.0026E-01

AERO(94) = 154.00

EH. ATT.,DEFLIN,& CABLE TENSION
THETA = 2.37 DEG
DELTA = -1.34 DEG
FRT CAB. TENSION= 0.167180E 03 LBS
RR CAB. TENSION = 0.154035E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T F/D-SEC	1/T F/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.4472E-01	+-6.0764E 00	1.0751E 00	9.3014E-01	1.0340E 00	9.6709E-01	9.7251E-01	1.0551E-01	9.6180E-01	5.1342E-01
-5.2681E-01	+-9.7214E 00	1.3157E 00	7.6003E-01	6.4633E-01	1.5472E 00	1.5495E 00	5.4113E-02	4.5123E-01	7.1142E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.5829E-01	+-5.2169E 00	8.0759E-01	1.2382E 00	1.2044E 00	8.3029E-01	8.4145E-01	1.6234E-01	1.4913E 00	3.5568E-01
-1.1649E 00	+-9.4272E 00	5.9502E-01	1.6806E 00	6.6650E-01	1.5004E 00	1.5118E 00	1.2264E-01	1.1201E 00	4.6005E-01
-1.1707E 00	+-1.0853E 01	5.9208E-01	1.6890E 00	5.7896E-01	1.7272E 00	1.7373E 00	1.0725E-01	9.7784E-01	5.0774E-01

AERO(94) = 168.00

EH. ATT.,DEFLIN,& CABLE TENSION
THETA = 2.40 DEG
DELTA = -1.49 DEG
FRT CAB. TENSION= 0.178853E 03 LBS
RR CAB. TENSION = 0.166036E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.6170E-01	+-6.1757E 00	1.0475E 00	9.5464E-01	1.0174E 00	9.8290E-01	9.8853E-01	1.0654E-01	9.7124E-01	5.1007E-01
-5.0935E-01	+-9.9939E 00	1.3608E 00	7.3484E-01	6.2870E-01	1.5906E 00	1.5926E 00	5.0902E-02	4.6200E-01	7.2598E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T F/D-SEC	1/T F/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.6656E-01	+-5.2873E 00	7.9988E-01	1.2502E 00	1.1884E 00	8.4149E-01	8.5272E-01	1.6174E-01	1.4857E 00	3.5708E-01
-1.1545E 00	+-9.6654E 00	6.0040E-01	1.6656E 00	6.5007E-01	1.5383E 00	1.5492E 00	1.1860E-01	1.0627E 00	4.7214E-01
-1.1730E 00	+-1.1113E 01	5.9093E-01	1.6922E 00	5.6537E-01	1.7687E 00	1.7786E 00	1.0496E-01	9.5675E-01	5.1522E-01

AERO(94) = 182.00

EF. ATT., DEFLTN, & CABLE TENSION
THETA = 2.42 DEG
DELTA = -1.65 DEG
FRT CAB. TENSION= 0.190527E 03 LBS
RR CAB. TENSION = 0.182037E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.7627E-01	+-6.2708E 00	1.0250E 00	9.7565E-01	1.0020E 00	9.9803E-01	1.0039E 00	1.0722E-01	9.7758E-01	5.0783E-01
-4.9429E-01	+-1.0261E 01	1.4023E 00	7.1311E-01	6.1235E-01	1.6331E 00	1.6350E 00	4.8117E-02	4.3667E-01	7.3884E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.7343E-01	+-5.3568E 00	7.9359E-01	1.2601E 00	1.1729E 00	8.5256E-01	8.6382E-01	1.6093E-01	1.4780E 00	3.5898E-01
-1.1466E 00	+-9.9972E 00	6.0453E-01	1.6542E 00	6.3464E-01	1.5752E 00	1.5857E 00	1.1508E-01	1.0501E 00	4.8292E-01
-1.1741E 00	+-1.1369E 01	5.9036E-01	1.6939E 00	5.5267E-01	1.8094E 00	1.8190E 00	1.0273E-01	9.3616E-01	5.2262E-01

AERO(94)= 196.00

EF. ATT., DEFLTN, & CABLE TENSION
THETA = 2.45 DEG
DELTA = -1.81 DEG
FRT CAB. TENSION= 0.202213E 03 LBS
RR CAB. TENSION = 0.196037E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.8865E-01	+-6.3623E 00	1.0062E 00	9.9379E-01	9.8756E-01	1.0126E 00	1.0185E 00	1.0764E-01	9.8143E-01	5.0648E-01
-4.8119E-01	+-1.0522E 01	1.4405E 00	6.9421E-01	5.9712E-01	1.6747E 00	1.6764E 00	4.5683E-02	4.1453E-01	7.5026E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.7919E-01	+-5.4256E 00	7.6839E-01	1.2684E 00	1.1581E 00	8.6351E-01	8.7478E-01	1.5996E-01	1.4689E 00	3.6126E-01
-1.1407E 00	+-1.0123E 01	6.0767E-01	1.6456E 00	6.2068E-01	1.6111E 00	1.6213E 00	1.1157E-01	1.0214E 00	4.9264E-01
-1.1744E 00	+-1.1619E 01	5.9322E-01	1.6943E 00	5.4075E-01	1.8493E 00	1.8587E 00	1.0056E-01	9.1618E-01	5.2991E-01

```
CASE NO=  3        TEST DATA CHANGE CL AND CM ALPHA
                   FRONT CABLE VERTICAL,REAR CABLE HORIZONTAL
                   NO SNUBBERS
                   NO LIFT/ANTI-LIFT CABLE
 DATA CHANGE
   5      5.5000
   6     -1.3000
   9      0.0

EF. ATT.,DEFLTN,& CABLE TENSION
 THETA =  2.94 DEG
 DELTA = -2.78 DEG
 FRT CAB. TENSION=    0.120742E 03 LBS
 RR CAB. TENSION =    0.140053E 03 LBS
 >>>> LONGITUDINAL STABILITY <<<<
```

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-3.9605E-01	+-4.5501E 00	1.7502E 00	5.7138E-01	1.3809E 00	7.2418E-01	7.2691E-01	8.6714E-02	7.8900E-01	5.7874E-01
-6.8065E-01	+-9.9917E 00	1.0184E 00	5.8197E-01	6.2884E-01	1.5902E 00	1.5939E 00	6.7965E-02	6.1750E-01	6.5160E-01

CASE NO= 4 TEST DATA FRONT PULLEY HORIZONTAL
BOTH CABLES HORIZONTAL
NO SNUBBERS
NO LIFT/ANTI-LIFT CABLE

DATA CHANGE

5	6.2000
6	-0.80000
70	0.0
74	82.000
81	26.400
87	8.4000
91	0.88000
0	0.0

EQ. ATT., DEFLTN, & CABLE TENSION
THETA = 2.51 DEG
DELTA = -2.12 DEG
FRT CAB. TENSION= 0.126635E 03 LBS
RR CAB. TENSION = 0.140039E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-2.9475E-01	+-5.5731E 00	2.3517E 00	4.2523E-01	1.1274E 00	8.6699E-01	8.8822E-01	5.2815E-02	4.7941E-01	7.1727E-01
-6.6118E-01	+-8.0081E 00	1.0484E 00	9.5388E-01	7.8460E-01	1.2745E 00	1.2789E 00	8.2284E-02	7.4841E-01	5.9526E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-1.7860E 00	+-2.7053E 00	3.8811E-01	2.5766E 00	2.3225E 00	4.3057E-01	5.1593E-01	5.5093E-01	5.9841E 00	1.5798E-02
-1.4335E 00	+-7.2026E 00	4.8352E-01	2.0682E 00	8.7235E-01	1.1463E 00	1.1688E 00	1.9520E-01	1.8042E 00	2.8635E-01
-5.1855E-01	+-9.7303E 00	1.3366E 00	7.4816E-01	6.4573E-01	1.5486E 00	1.5508E 00	5.3222E-02	4.8311E-01	7.1543E-01

CASE NO- 1 TEST DATA LRC
FRONT CABLE VERTICAL,REAR CABLE HORIZONTAL
NO SNUBBERS
NO LIFT/ANTI-LIFT CABLE
INPUT DATA AS SPECIFIED IN AERO ARRAY

AERO(1)= 0.0	AERO(2)= 0.0	AERO(3)= 0.0	AERO(4)= 0.0	AERO(5)= 6.26
AERO(6)=-0.810	AERO(7)= 0.0	AERO(8)= 0.0	AERO(9)= -8.00	AERO(10)= 0.180E-01
AERO(11)= 0.105	AERO(12)= 0.350E-01	AERO(13)= 0.0	AERO(14)= 0.960	AERO(15)= -1.50
AERO(16)= 0.0	AERO(17)= 0.0	AERO(18)= 0.0	AERO(19)=-0.730	AERO(20)=-0.350E-01
AERO(21)= 0.111	AERO(22)= 0.0	AERO(23)=-0.190	AERO(24)=-0.100E-01	AERO(25)= 0.0
AERO(26)= 0.500E-01	AERO(27)=-0.920E-01	AERO(28)= 0.0	AERO(29)= 0.0	AERO(30)= 0.0
AERO(31)= 0.0	AERO(32)= 0.0	AERO(33)= 0.0	AERO(34)= 0.0	AERO(35)= 0.0
AERO(36)= 0.0	AERO(37)= 0.0	AERO(38)= 0.0	AERO(39)= 0.0	AERO(40)= 0.0
AERO(41)= 0.0	AERO(42)= 0.0	AERO(43)= 0.0	AERO(44)= 0.0	AERO(45)= 0.0
AERO(46)= 0.0	AERO(47)= 0.0	AERO(48)= 0.800	AERO(49)= 430.	AERO(50)= 4.35
AERO(51)= 0.390E-03	AERO(52)= 140.	AERO(53)= 9.16	AERO(54)= 1.40	AERO(55)= 11.5
AERO(56)=-0.110	AERO(57)= 1.80	AERO(58)= 14.0	AERO(59)= 14.0	AERO(60)= 0.0
AERO(61)= 0.0	AERO(62)= 0.0	AERO(63)= 0.0	AERO(64)= 0.0	AERO(65)= 0.0
AERO(66)= 59.0	AERO(67)= -59.0	AERO(68)= 0.0	AERO(69)= 0.0	AERO(70)= 0.0
AERO(71)= 0.0	AERO(72)= 10.0	AERO(73)= 285.	AERO(74)= 0.0	AERO(75)= 80.0
AERO(76)= 0.0	AERO(77)= 175.	AERO(78)= 0.0	AERO(79)= 26.4	AERO(80)= 0.0
AERO(81)= 0.0	AERO(82)= 8.00	AERO(83)= 8.40	AERO(84)= 8.40	AERO(85)= 0.0
AERO(86)= 0.0	AERO(87)= 0.0	AERO(88)= 0.920	AERO(89)= 0.0	AERO(90)= 0.880
AERO(91)= 0.0	AERO(92)= 0.0	AERO(93)= 0.880	AERO(94)= 140.	AERO(95)= 3.00
AERO(96)= 0.0	AERO(97)= 177.	AERO(98)=-0.960	AERO(99)= 0.0	AERO(100)= 0.0
AERO(101)= 0.0	AERO(102)= -2.00	AERO(103)= 3.00	AERO(104)= 0.500E-01	AERO(105)= 2.00
AERO(106)= 3.00	AERO(107)= 2.00	AERO(108)= 2.00	AERO(109)= 3.00	AERO(110)= 2.00
AERO(111)= 180.	AERO(112)= 96.0	AERO(113)= 72.0	AERO(114)= 180.	AERO(115)= -96.0
AERO(116)= 72.0	AERO(117)= 80.0	AERO(118)= 80.0	AERO(119)= 50.0	AERO(120)= 50.0
AERO(121)= 5.00	AERO(122)= 5.00	AERO(123)= 0.0	AERO(124)= 0.0	AERO(125)= 0.0
AERO(126)= 0.0	AERO(127)= 0.0	AERO(128)= 0.0	AERO(129)= 0.0	AERO(130)= 0.0

>>>>> ROOT LOCUS VARYING AERO(94)

AERO(94)= 84.000

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.20 DEG
DELTA = -0.39 DEG
FRT CAB. TENSION= 0.740171E 02 LBS
RR CAB. TENSION = 0.840300E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-4.1108E-01	+-4.5224E 00	1.6862E 00	5.9306E-01	1.3893E 00	7.1976E-01	7.2273E-01	9.0527E-02	8.2357E-01	5.6488E-01
-7.6359E-01	+-7.3066E 00	9.0775E-01	1.1016E 00	8.5994E-01	1.1629E 00	1.1692E 00	1.0394E-01	9.4733E-01	5.1859E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.0267E-01	+-3.2209E 00	8.6355E-01	1.1580E 00	1.9508E 00	5.1262E-01	5.2830E-01	2.4181E-01	2.2590E 00	2.0891E-01
-1.9927E 00	+-4.0231E 00	3.4784E-01	2.8749E 00	1.5618E 00	6.4029E-01	7.1453E-01	4.4386E-01	4.4900E 00	4.4501E-02
-3.9774E-01	+-8.1582E 00	1.7427E 00	5.7382E-01	7.7017E-01	1.2984E 00	1.3000E 00	4.8657E-02	4.4154E-01	7.3614E-01

AERO(94)= 98.000

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.22 DEG
DELTA = -0.50 DEG
FRT CAB. TENSION= 0.856892E 02 LBS
RR CAB. TENSION = 0.980300E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-4.6201E-01	+-4.7399E 00	1.5003E 00	6.6654E-01	1.3256E 00	7.5438E-01	7.5796E-01	9.7014E-02	8.8356E-01	5.4203E-01
-7.1231E-01	+-7.6113E 00	9.7310E-01	1.0276E 00	8.2551E-01	1.2114E 00	1.2167E 00	9.3179E-02	8.4832E-01	5.5543E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.1741E-01	+-3.2566E 00	7.5555E-01	1.3235E 00	1.9294E 00	5.1830E-01	5.3847E-01	2.7116E-01	2.5536E 00	1.7033E-01
-1.8645E 00	+-4.5973E 00	3.7176E-01	2.6899E 00	1.3667E 00	7.3168E-01	7.8956E-01	3.7584E-01	3.6764E 00	7.8218E-02
-4.1133E-01	+-8.4915E 00	1.6851E 00	5.9342E-01	7.3993E-01	1.3515E 00	1.3531E 00	4.8384E-02	4.3909E-01	7.3760E-01

AERO(94)= 112.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.24 DEG
DELTA = -0.61 DEG
FRT CAB. TENSION= 0.973730E 02 LBS
RR CAB. TENSION = 0.112031E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.0694E-01	+-4.9267E 00	1.3673E 00	7.3136E-01	1.2753E 00	7.8411E-01	7.8825E-01	1.0236E-01	9.3272E-01	5.2387E-01
-6.6702E-01	+-7.9186E 00	1.0392E 00	9.6230E-01	7.9347E-01	1.2603E 00	1.2647E 00	8.3938E-02	7.6356E-01	5.8904E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.5880E-01	+-3.3021E 00	7.2293E-01	1.3833E 00	1.9028E 00	5.2555E-01	5.4726E-01	2.7884E-01	2.6320E 00	1.6132E-01
-1.8107E 00	+-5.1177E 00	3.8281E-01	2.6123E 00	1.2277E 00	8.1450E-01	8.6398E-01	3.3355E-01	3.2072E 00	1.0828E-01
-4.2385E-01	+-8.8130E 00	1.6354E 00	6.1148E-01	7.1295E-01	1.4026E 00	1.4043E 00	4.8039E-02	4.3596E-01	7.3920E-01

AERO(94)= 126.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.26 DEG
DELTA = -0.73 DEG
FRT CAB. TENSION= 0.109046E 03 LBS

FR CAB. TENSION = 0.126031E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.4556E-	+-5.0902E 00	1.2705E 00	7.8707E-01	1.2344E 00	[illegible].1013E-01	8.1477E-01	1.0657E-01	9.7154E-01	5.0[illegible]E-01
-6.2802E-01	+-8.2248E 00	1.1037E 00	9.0604E-01	7.6393E-01	1.3090E 00	1.3128E 00	7.6136E-02	6.9215E-01	6.1893E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7347E-01	+-3.3689E 00	7.1204E-01	1.4044E 00	1.8651E 00	5.3618E-01	5.5811E-01	2.7760E-01	2.6193E 00	1.6274E-01
-1.7844E 00	+-5.5806E 00	3.8844E-01	2.5744E 00	1.1259E 00	8.8817E-01	9.3247E-01	3.0457E-01	2.8985E 00	1.3411E-01
-4.3552E-01	+-9.1233E 00	1.5915E 00	6.2833E-01	6.8870E-01	1.4520E 00	1.4537E 00	4.7684E-02	4.3273E-01	7.4086E-01

AERO(94)= 140.00

EH. ATT.,DEFLIN,& CABLE TENSION

THETA = 2.28 DEG

DELTA = -0.85 DEG

FRT CAB. TENSION= 0.120720E 03 LBS

RR CAB. TENSION = 0.140032E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.7838E-01	+-5.2364E 00	1.1984E 00	8.3443E-01	1.1999E 00	8.3340E-01	8.3847E-01	1.0979E-01	1.0012E 00	4.9957E-01
-5.9480E-01	+-8.5279E 00	1.1653E 00	8.5812E-01	7.3678E-01	1.3573E 00	1.3606E 00	6.9579E-02	6.3225E-01	6.4517E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7846E-01	+-3.4483E 00	7.0841E-01	1.4116E 00	1.8221E 00	5.4882E-01	5.7049E-01	2.7297E-01	2.5721E 00	1.6816E-01
-1.7685E 00	+-6.0008E 00	3.9193E-01	2.5514E 00	1.0471E 00	9.5506E-01	9.9568E-01	2.8269E-01	2.6715E 00	1.5696E-01
-4.4653E-01	+-9.4238E 00	1.5523E 00	6.4420E-01	6.6674E-01	1.4998E 00	1.5015E 00	4.7331E-02	4.2951E-01	7.4251E-01

AERO(94)= 154.00

EH. ATT.,DEFLIN,& CABLE TENSION

THETA = 2.30 DEG

DELTA = -0.98 DEG

FRT CAB. TENSION= 0.132393E 03 LBS

RR CAB. TENSION = 0.154033E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.0617E-01	+-5.3696E 00	1.1435E 00	8.7451E-01	1.1701E 00	8.5460E-01	8.6003E-01	1.1218E-01	1.0233E 00	4.9199E-01
-5.6662E-01	+-8.8262E 00	1.2233E 00	8.1745E-01	7.1168E-01	1.4047E 00	1.4076E 00	6.4065E-02	5.8192E-01	6.6807E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7944E-01	+-3.5346E 00	7.0770E-01	1.4130E 00	1.7776E 00	5.6255E-01	5.8375E-01	2.6704E-01	2.5118E 00	1.7533E-01
-1.7572E 00	+-6.3888E 00	3.9447E-01	2.5351E 00	9.8346E-01	1.0168E 00	1.0546E 00	2.6519E-01	2.4931E 00	1.7762E-01
-4.5699E-01	+-9.7155E 00	1.5168E 00	6.5930E-01	6.4672E-01	1.5463E 00	1.5480E 00	4.6986E-02	4.2638E-01	7.4413E-01

AERO(94)= 168.00

EH. ATT.,DEFLIN,& CABLE TENSION

THETA = 2.33 DEG

DELTA = -1.11 DEG

FRT CAB. TENSION= 0.144067E 03 LBS

RR CAB. TENSION = 0.168034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.2970E-01	+-5.4927E 00	1.1008E 00	9.0846E-01	1.1439E 00	8.7419E-01	8.7992E-01	1.1390E-01	1.0392E 00	4.8660E-01
-5.4266E-01	+-9.1190E 00	1.2773E 00	7.8289E-01	6.8902E-01	1.4513E 00	1.4539E 00	5.9404E-02	5.3943E-01	6.8804E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7860E-01	+-3.6243E 00	7.0831E-01	1.4118E 00	1.7336E 00	5.7683E-01	5.9749E-01	2.6067E-01	2.4475E 00	1.8332E-01
-1.7481E 00	+-6.7514E 00	3.9652E-01	2.5220E 00	9.3066E-01	1.0745E 00	1.1099E 00	2.5066E-01	2.3471E 00	1.9654E-01
-4.6701E-01	+-9.9990E 00	1.4842E 00	6.7376E-01	6.2838E-01	1.5914E 00	1.5931E 00	4.6656E-02	4.2338E-01	7.4568E-01

AERO(94)= 182.00

EH. ATT., LIN,& CABLE TENSION

THETA = -.35 DEG
DELTA = -1.25 DEG
FRT CAB. TENSION= 0.155741E 03 LBS
RR CAB. TENSION = 0.182034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.4969E-01	+-5.6079E 00	1.0669E 00	9.3730E-01	1.1204E 00	8.9253E-01	8.9850E-01	1.1508E-01	1.0502E 00	4.8291E-01
-5.2223E-01	+-9.4059E 00	1.3273E 00	7.5341E-01	6.6801E-01	1.4970E 00	1.4993E 00	5.5437E-02	5.0329E-01	7.0550E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7690E-01	+-3.7156E 00	7.0954E-01	1.4094E 00	1.6910E 00	5.9136E-01	6.1146E-01	2.5428E-01	2.3833E 00	1.9168E-01
-1.7402E 00	+-7.0930E 00	3.9831E-01	2.5106E 00	8.8583E-01	1.1289E 00	1.1624E 00	2.3828E-01	2.2240E 00	2.1405E-01
-4.7668E-01	+-1.0275E 01	1.4541E 00	6.8771E-01	6.1149E-01	1.6354E 00	1.6371E 00	4.6343E-02	4.2053E-01	7.4715E-01

AERO(94)= 196.00

EH. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.38 DEG
DELTA = -1.40 DEG
FRT CAB. TENSION= 0.167414E 03 LBS
RR CAB. TENSION = 0.196035E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.6675E-01	+-5.7166E 00	1.0396E 00	9.6191E-01	1.0991E 00	9.0985E-01	9.1602E-01	1.1585E-01	1.0572E 00	4.8056E-01
-5.0470E-01	+-9.6866E 00	1.3734E 00	7.2813E-01	6.4865E-01	1.5417E 00	1.5438E 00	5.2034E-02	4.7230E-01	7.2081E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7482E-01	+-3.8074E 00	7.1105E-01	1.4064E 00	1.6503E 00	6.0597E-01	6.2551E-01	2.4803E-01	2.3209E 00	2.0015E-01
-1.7330E 00	+-7.4170E 00	3.9996E-01	2.5002E 00	8.4713E-01	1.1805E 00	1.2122E 00	2.2753E-01	2.1180E 00	2.3036E-01
-4.8606E-01	+-1.0545E 01	1.4260E 00	7.0124E-01	5.9587E-01	1.6782E 00	1.6800E 00	4.6047E-02	4.1785E-01	7.4854E-01

CASE N 2 TEST DATA UNSNUBBED SNUBBER
FRONT CABLE VERTICAL, REAR CABLE HORIZONTAL
SNUBBERS UNSNUBBED
NO LIFT/ANTI-LIFT CABLE

DATA CHANGE
C 0.0

>>>>> ROOT LOCUS VARYING AERO(94)

AERO(94) = 84.000

EE. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.26 DEG
DELTA = -0.66 DEG
FRT CAB. TENSION= 0.108811E 03 LBS
RR CAB. TENSION = 0.840315E 02 LBS
>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.0259E-01	+-5.4658E 00	1.3792E 00	7.2508E-01	1.1495E 00	8.6991E-01	8.7358E-01	9.1566E-02	8.3351E-01	5.6116E-01
-6.7106E-01	+-8.2834E 00	1.0329E 00	9.6814E-01	7.5853E-01	1.3183E 00	1.3227E 00	8.0750E-02	7.3436E-01	6.0108E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-7.7711E-01	+-4.8442E 00	8.9195E-01	1.1211E 00	1.2971E 00	7.7098E-01	7.8083E-01	1.5840E-01	1.4542E 00	3.6496E-01
-1.2905E 00	+-8.1265E 00	5.3710E-01	1.8618E 00	7.7317E-01	1.2934E 00	1.3096E 00	1.5684E-01	1.4395E 00	3.6869E-01
-1.1258E 00	+-9.4515E 00	6.1571E-01	1.6241E 00	6.6478E-01	1.5042E 00	1.5149E 00	1.1827E-01	1.0797E 00	4.7313E-01

AERO(94) = 98.000

EE. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.28 DEG
DELTA = -0.80 DEG
FRT CAB. TENSION= 0.120485E 03 LBS
RR CAB. TENSION = 0.980322E 02 LBS
>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.4110E-01	+-5.6105E 00	1.2810E 00	7.8065E-01	1.1199E 00	8.9294E-01	8.9708E-01	9.6000E-02	8.7424E-01	5.4554E-01
-6.3216E-01	+-8.5786E 00	1.0965E 00	9.1201E-01	7.3242E-01	1.3653E 00	1.3690E 00	7.3492E-02	6.6798E-01	6.2939E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.0141E-01	+-4.9230E 00	8.6491E-01	1.1562E 00	1.2763E 00	7.8352E-01	7.9383E-01	1.6068E-01	1.4756E 00	3.5957E-01
-1.2505E 00	+-8.4024E 00	5.5430E-01	1.8041E 00	7.4779E-01	1.3373E 00	1.3520E 00	1.4720E-01	1.3491E 00	3.9255E-01
-1.1416E 00	+-9.7465E 00	6.0717E-01	1.6470E 00	6.4466E-01	1.5512E 00	1.5618E 00	1.1633E-01	1.0617E 00	4.7905E-01

AERO(94) = 112.00

EE. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.30 DEG
DELTA = -0.93 DEG
FRT CAB. TENSION= 0.132159E 03 LBS
RR CAB. TENSION = 0.112033E 03 LBS
>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.7378E-01	+-5.7409E 00	1.2080E 00	8.2780E-01	1.0945E 00	9.1369E-01	9.1825E-01	9.9452E-02	9.0599E-01	5.3367E-01
-5.9907E-01	+-8.8712E 00	1.1570E 00	8.6428E-01	7.0827E-01	1.4119E 00	1.4151E 00	6.7377E-02	6.1214E-01	6.5423E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.2059E-01	+-4.9990E 00	8.4470E-01	1.1839E 00	1.2569E 00	7.9561E-01	8.0626E-01	1.6198E-01	1.4880E 00	3.5651E-01
-1.2199E 00	+-9.6700E 00	5.6820E-01	1.7600E 00	7.2470E-01	1.3799E 00	1.3935E 00	1.3933E-01	1.2754E 00	4.1310E-01
-1.1531E 00	+-1.0034E 01	6.0112E-01	1.6636E 00	6.2622E-01	1.5969E 00	1.6074E 00	1.1417E-01	1.0418E 00	4.8574E-01

AERO(94) = 126.00

EE. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.32 DEG
DELTA = -1.06 DEG
FRT CAB. TENSION= 0.143832E 03 LBS

RR CAB. TENSION = [illegible].126034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.0143E-01	+-5.8605E 00	1.1525E 00	8.6767E-01	1.0721E 00	.3273E-01	9.3762E-01	1.0209E-01	9.3026E-01	5.[illegible]E-01
-5.7101E-01	+-9.1597E 00	1.2139E 00	8.2379E-01	6.8596E-01	1.4578E 00	1.4606E 00	6.2219E-02	5.6509E-01	6.7591E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.3589E-01	+-5.0730E 00	8.2923E-01	1.2059E 00	1.2386E 00	8.0739E-01	8.1827E-01	1.6258E-01	1.4936E 00	3.5512E-01
-1.1965E 00	+-8.9298E 00	5.7931E-01	1.7262E 00	7.0362E-01	1.4212E 00	1.4339E 00	1.3280E-01	1.2146E 00	4.3090E-01
-1.1613E 00	+-1.0313E 01	5.9688E-01	1.6754E 00	6.0924E-01	1.6414E 00	1.6518E 00	1.1190E-01	1.0207E 00	4.9287E-01

AERO(94)= 140.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.35 DEG
DELTA = -1.20 DEG
FRT CAB. TENSION= 0.155506E 03 LBS
RR CAB. TENSION = 0.140034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.2483E-01	+-5.9717E 00	1.1093E 00	9.0144E-01	1.0522E 00	9.5043E-01	9.5562E-01	1.0406E-01	9.4846E-01	5.1819E-01
-5.4716E-01	+-9.4432E 00	1.2668E 00	7.8939E-01	6.6536E-01	1.5029E 00	1.5055E 00	5.7846E-02	5.2523E-01	6.9485E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.4823E-01	+-5.1455E 00	8.1717E-01	1.2237E 00	1.2211E 00	8.1893E-01	8.2998E-01	1.6265E-01	1.4943E 00	3.5495E-01
-1.1786E 00	+-9.1821E 00	5.8811E-01	1.7004E 00	6.8429E-01	1.4614E 00	1.4734E 00	1.2732E-01	1.1635E 00	4.4642E-01
-1.1670E 00	+-1.0586E 01	5.9398E-01	1.6836E 00	5.9354E-01	1.6848E 00	1.6950E 00	1.0957E-01	9.9926E-01	5.0026E-01

AERO(94)= 154.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.37 DEG
DELTA = -1.34 DEG
FRT CAB. TENSION= 0.167180E 03 LBS
RR CAB. TENSION = 0.154035E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.4472E-01	+-6.0764E 00	1.0751E 00	9.3014E-01	1.0340E 00	9.6709E-01	9.7251E-01	1.0551E-01	9.6180E-01	5.1342E-01
-5.2681E-01	+-9.7214E 00	1.3157E 00	7.6003E-01	6.4633E-01	1.5472E 00	1.5495E 00	5.4113E-02	4.9123E-01	7.1142E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.5829E-01	+-5.2169E 00	8.0759E-01	1.2382E 00	1.2044E 00	8.3029E-01	8.4145E-01	1.6234E-01	1.4913E 00	3.5568E-01
-1.1649E 00	+-9.4272E 00	5.9502E-01	1.6806E 00	6.6650E-01	1.5004E 00	1.5118E 00	1.2264E-01	1.1201E 00	4.6005E-01
-1.1707E 00	+-1.0853E 01	5.9208E-01	1.6890E 00	5.7896E-01	1.7272E 00	1.7373E 00	1.0725E-01	9.7784E-01	5.0774E-01

AERO(94)= 168.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.40 DEG
DELTA = -1.49 DEG
FRT CAB. TENSION= 0.178853E 03 LBS
RR CAB. TENSION = 0.166036E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.6170E-01	+-6.1757E 00	1.0475E 00	9.5464E-01	1.0174E 00	9.8290E-01	9.8853E-01	1.0654E-01	9.7124E-01	5.1007E-01
-5.0935E-01	+-9.9939E 00	1.3608E 00	7.3484E-01	6.2870E-01	1.5906E 00	1.5926E 00	5.0902E-02	4.6200E-01	7.2598E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.6656E-01	+-5.2873E 00	7.9988E-01	1.2502E 00	1.1884E 00	8.4149E-01	8.5272E-01	1.6174E-01	1.4857E 00	3.5708E-01
-1.1545E 00	+-9.6654E 00	6.0040E-01	1.6656E 00	6.5007E-01	1.5383E 00	1.5492E 00	1.1860E-01	1.0827E 00	4.7214E-01
-1.1730E 00	+-1.1113E 01	5.9093E-01	1.6922E 00	5.6537E-01	1.7687E 00	1.7786E 00	1.0496E-01	9.5675E-01	5.1522E-01

AERO(94)= 182.00

EE. ATT., ITN,& CABLE TENSION
THETA = .42 DEG
DELTA = -1.65 DEG
FRT CAB. TENSION= 0.190527E 03 LBS
RR CAB. TENSION = 0.182037E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.7627E-01	+-6.2708E 00	1.0250E 00	9.7565E-01	1.0020E 00	9.9803E-01	1.0038E 00	1.0722E-01	9.7758E-01	5.0783E-01
-4.9429E-01	+-1.0261E 01	1.4023E 00	7.1311E-01	6.1235E-01	1.6331E 00	1.6350E 00	4.8117E-02	4.3667E-01	7.3884E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.7343E-01	+-5.3568E 00	7.9359E-01	1.2601E 00	1.1729E 00	8.5256E-01	8.6382E-01	1.6093E-01	1.4780E 00	3.5898E-01
-1.1466E 00	+-9.8972E 00	6.0453E-01	1.6542E 00	6.3484E-01	1.5752E 00	1.5857E 00	1.1508E-01	1.0501E 00	4.8292E-01
-1.1741E 00	+-1.1369E 01	5.9036E-01	1.6939E 00	5.5267E-01	1.8094E 00	1.8190E 00	1.0273E-01	9.3616E-01	5.2262E-01

AERO(94)= 196.00

EE. ATT., DEFLTN,& CABLE TENSION
THETA = 2.45 DEG
DELTA = -1.81 DEG
FRT CAB. TENSION= 0.202213E 03 LBS
RR CAB. TENSION = 0.196037E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.8885E-01	+-6.3623E 00	1.0062E 00	9.9379E-01	9.8756E-01	1.0126E 00	1.0185E 00	1.0764E-01	9.8143E-01	5.0648E-01
-4.8119E-01	+-1.0522E 01	1.4405E 00	6.9421E-01	5.9712E-01	1.6747E 00	1.6764E 00	4.5683E-02	4.1453E-01	7.5026E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.7919E-01	+-5.4256E 00	7.8839E-01	1.2684E 00	1.1581E 00	8.6351E-01	8.7478E-01	1.5996E-01	1.4689E 00	3.6126E-01
-1.1407E 00	+-1.0123E 01	6.0767E-01	1.6456E 00	6.2068E-01	1.6111E 00	1.6213E 00	1.1197E-01	1.0214E 00	4.9264E-01
-1.1744E 00	+-1.1619E 01	5.9022E-01	1.6943E 00	5.4075E-01	1.8493E 00	1.8587E 00	1.0056E-01	9.1618E-01	5.2991E-01

CASE NO 3 TEST DATA CHANGE CL AND CM ALPHA
FRONT CABLE VERTICAL,REAR CABLE HORIZONTAL
NO SNUBBERS
NO LIFT/ANTI-LIFT CABLE

DATA CHANGE

5	5.5000
6	-1.3000
0	0.0

EE. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.94 DEG
DELTA = -2.78 DEG
FRT CAB. TENSION= 0.120742E 03 LBS
RR CAB. TENSION = 0.140053E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-3.9605E-01	+-4.5501E 00	1.7502E 00	5.7138E-01	1.3809E 00	7.2418E-01	7.2691E-01	8.6714E-02	7.8900E-01	5.7874E-01
-6.8065E-01	+-9.9917E 00	1.0184E 00	9.8197E-01	6.2884E-01	1.5902E 00	1.5939E 00	6.7965E-02	6.1750E-01	6.5180E-01

CASE NO 4 TEST DATA FRONT PULLEY HORIZONTAL
BOTH CABLES HORIZONTAL
NO SNUBBERS
NO LIFT/ANTI-LIFT CABLE

DATA	CHANGE
5	6.2000
6	-0.80000
70	0.0
74	80.000
81	26.400
87	8.4000
91	0.88000
0	0.0

EH. ATT.,DEPTH,& CABLE TENSION
THETA = 2.51 DEG
DELTA = -2.12 DEG
FRT CAB. TENSION= 0.128639E 03 LBS
RR CAB. TENSION = 0.140039E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-2.9475E-01	+-5.5731E 00	2.3517E 00	4.2523E-01	1.1274E 00	8.8698E-01	8.8822E-01	5.2815E-02	4.7941E-01	7.1727E-01
-6.6118E-01	+-8.0081E 00	1.0484E 00	9.5388E-01	7.8460E-01	1.2745E 00	1.2789E 00	8.2284E-02	7.4841E-01	5.9526E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-1.7860E 00	+-2.7053E 00	3.8811E-01	2.5766E 00	2.3225E 00	4.3057E-01	5.1593E-01	5.5093E-01	5.9841E 00	1.5798E-02
-1.4335E 00	+-7.2026E 00	4.8352E-01	2.0682E 00	8.7235E-01	1.1463E 00	1.1688E 00	1.9520E-01	1.8042E 00	2.8635E-01
-5.1859E-01	+-9.7303E 00	1.3366E 00	7.4816E-01	6.4573E-01	1.5486E 00	1.5508E 00	5.3222E-02	4.8311E-01	7.1543E-01

CASE NO= 1 TEST DATA LRC
FRONT CABLE VERTICAL,REAR CABLE HORIZONTAL
NO SNUBBERS
NO LIFT/ANTI-LIFT CABLE
INPUT DATA AS SPECIFIED IN AERO ARRAY

AERO(1)= 0.0	AERO(2)= 0.0	AERO(3)= 0.0	AERO(4)= 0.0	AERO(5)= 6.26
AERO(6)=-0.810	AERO(7)= 0.0	AERO(8)= 0.0	AERO(9)= -8.00	AERO(10)= 0.180E-01
AERO(11)= 0.105	AERO(12)= 0.350E-01	AERO(13)= 0.0	AERO(14)= 0.960	AERO(15)= -1.50
AERO(16)= 0.0	AERO(17)= 0.0	AERO(18)= 0.0	AERO(19)=-0.730	AERO(20)=-0.350E-01
AERO(21)= 0.111	AERO(22)= 0.0	AERO(23)=-0.190	AERO(24)=-0.100E-01	AERO(25)= 0.0
AERO(26)= 0.500E-01	AERO(27)=-0.920E-01	AERO(28)= 0.0	AERO(29)= 0.0	AERO(30)= 0.0
AERO(31)= 0.0	AERO(32)= 0.0	AERO(33)= 0.0	AERO(34)= 0.0	AERO(35)= 0.0
AERO(36)= 0.0	AERO(37)= 0.0	AERO(38)= 0.0	AERO(39)= 0.0	AERO(40)= 0.0
AERO(41)= 0.0	AERO(42)= 0.0	AERO(43)= 0.0	AERO(44)= 0.0	AERO(45)= 0.0
AERO(46)= 0.0	AERO(47)= 0.0	AERO(48)= 0.800	AERO(49)= 430.	AERO(50)= 4.35
AERO(51)= 0.390E-03	AERO(52)= 140.	AERO(53)= 9.16	AERO(54)= 1.40	AERO(55)= 11.5
AERO(56)=-0.110	AERO(57)= 1.80	AERO(58)= 14.0	AERO(59)= 14.0	AERO(60)= 0.0
AERO(61)= 0.0	AERO(62)= 0.0	AERO(63)= 0.0	AERO(64)= 0.0	AERO(65)= 0.0
AERO(66)= 59.0	AERO(67)= -59.0	AERO(68)= 0.0	AERO(69)= 0.0	AERO(70)= 0.0
AERO(71)= 0.0	AERO(72)= 10.0	AERO(73)= 285.	AERO(74)= 0.0	AERO(75)= 90.0
AERO(76)= 0.0	AERO(77)= 175.	AERO(78)= 0.0	AERO(79)= 26.4	AERO(80)= 0.0
AERO(81)= 0.0	AERO(82)= 8.00	AERO(83)= 8.40	AERO(84)= 8.40	AERO(85)= 0.0
AERO(86)= 0.0	AERO(87)= 0.0	AERO(88)= 0.920	AERO(89)= 0.0	AERO(90)= 0.880
AERO(91)= 0.0	AERO(92)= 0.0	AERO(93)= 0.880	AERO(94)= 140.	AERO(95)= 3.00
AERO(96)= 0.0	AERO(97)= 177.	AERO(98)=-0.960	AERO(99)= 0.0	AERO(100)= 0.0
AERO(101)= 0.0	AERO(102)= -2.00	AERO(103)= 3.00	AERO(104)= 0.500E-01	AERO(105)= 2.00
AERO(106)= 3.00	AERO(107)= 2.00	AERO(108)= 2.00	AERO(109)= 3.00	AERO(110)= 2.00
AERO(111)= 180.	AERO(112)= 96.0	AERO(113)= 72.0	AERO(114)= 180.	AERO(115)= -96.0
AERO(116)= 72.0	AERO(117)= 80.0	AERO(118)= 80.0	AERO(119)= 50.0	AERO(120)= 50.0
AERO(121)= 5.00	AERO(122)= 5.00	AERO(123)= 0.0	AERO(124)= 0.0	AERO(125)= 0.0
AERO(126)= 0.0	AERO(127)= 0.0	AERO(128)= 0.0	AERO(129)= 0.0	AERO(130)= 0.0

>>>>> ROOT LOCUS VARYING AERO(94)

AERO(94)= 84.000

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.20 DEG
DELTA = -0.39 DEG
FRT CAB. TENSION= 0.740171E 02 LBS
RR CAB. TENSION = 0.840300E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-4.1108E-01	+-4.5224E 00	1.6862E 00	5.9306E-01	1.3893E 00	7.1976E-01	7.2273E-01	9.0527E-02	8.2357E-01	5.6488E-01
-7.6359E-01	+-7.3066E 00	9.0775E-01	1.1016E 00	8.5994E-01	1.1629E 00	1.1692E 00	1.0394E-01	9.4733E-01	5.1859E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.0267E-01	+-3.2209E 00	8.6355E-01	1.1580E 00	1.9508E 00	5.1262E-01	5.2830E-01	2.4181E-01	2.2590E 00	2.0891E-01
-1.9927E 00	+-4.0231E 00	3.4784E-01	2.8749E 00	1.5618E 00	6.4029E-01	7.1453E-01	4.4386E-01	4.4900E 00	4.4501E-02
-3.9774E-01	+-8.1582E 00	1.7427E 00	5.7382E-01	7.7017E-01	1.2984E 00	1.3000E 00	4.8697E-02	4.4154E-01	7.3614E-01

AERO(94)= 98.000

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.22 DEG
DELTA = -0.50 DEG
FRT CAB. TENSION= 0.956892E 02 LBS
RR CAB. TENSION = 0.990300E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-4.6201E-01	+-4.7299E 00	1.5003E 00	6.6654E-01	1.3256E 00	7.5438E-01	7.5796E-01	9.7014E-02	8.8356E-01	5.4203E-01
-7.1231E-01	+-7.6113E 00	9.7310E-01	1.0276E 00	8.2551E-01	1.2114E 00	1.2167E 00	9.3179E-02	8.4832E-01	5.5543E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.1741E-01	+-3.2566E 00	7.5555E-01	1.3235E 00	1.9294E 00	5.1830E-01	5.3847E-01	2.7116E-01	2.5536E 00	1.7033E-01
-1.8645E 00	+-4.5973E 00	3.7176E-01	2.6899E 00	1.3667E 00	7.3168E-01	7.8956E-01	3.7584E-01	3.6764E 00	7.8218E-02
-4.1133E-01	+-8.4915E 00	1.6851E 00	5.9342E-01	7.3993E-01	1.3515E 00	1.3531E 00	4.8384E-02	4.3909E-01	7.3760E-01

AERO(94)= 112.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.24 DEG
DELTA = -0.61 DEG
FRT CAB. TENSION= 0.973730E 02 LBS
RR CAB. TENSION = 0.112031E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.0694E-01	+-4.9267E 00	1.3673E 00	7.3136E-01	1.2753E 00	7.8411E-01	7.8825E-01	1.0236E-01	9.3272E-01	5.2387E-01
-6.6702E-01	+-7.9186E 00	1.0392E 00	9.6230E-01	7.9347E-01	1.2603E 00	1.2647E 00	8.3938E-02	7.6356E-01	5.8904E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.5880E-01	+-3.3021E 00	7.2293E-01	1.3833E 00	1.9028E 00	5.2555E-01	5.4726E-01	2.7884E-01	2.6320E 00	1.6132E-01
-1.8107E 00	+-5.1177E 00	3.8281E-01	2.6123E 00	1.2277E 00	8.1450E-01	8.6398E-01	3.3355E-01	3.2072E 00	1.0828E-01
-4.2385E-01	+-8.8130E 00	1.6354E 00	6.1148E-01	7.1295E-01	1.4026E 00	1.4043E 00	4.8039E-02	4.3596E-01	7.3920E-01

AERO(94)= 126.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.26 DEG
DELTA = -0.73 DEG
FRT CAB. TENSION= 0.100046E 03 LBS

FR CAB. TENSION = 0.12C03E 03 LBS
>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.4556[illegible]	+-5.[illegible]02E 00	1.2765E 00	7.8797E-01	1.2344E 00	8.1013E-01	8.1477E-01	1.0657E-01	9.7154E-01	[illegible]0996E-01
-6.2802E-01	+-8.22[illegible]E 00	1.1037E 00	9.0604E-01	7.6393E-01	1.3090E 00	1.3128E 00	7.6136E-02	6.9215E-01	.1893E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7347E-01	+-3.3689E 00	7.1204E-01	1.4044E 00	1.8651E 00	5.3618E-01	5.5811E-01	2.7760E-01	2.6193E 00	1.6274E-01
-1.7844E 00	+-5.5806E 00	3.8844E-01	2.5744E 00	1.1259E 00	8.8817E-01	9.3247E-01	3.0457E-01	2.8965E 00	1.3411E-01
-4.3552E-01	+-9.1233E 00	1.5915E 00	6.2833E-01	6.8870E-01	1.4520E 00	1.4537E 00	4.7664E-02	4.3273E-01	7.4086E-01

AERO(94)= 140.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.28 DEG
DELTA = -0.85 DEG
FRT CAB. TENSION= 0.120720E 03 LBS
RR CAB. TENSION = 0.140032E 03 LBS
>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.7839E-01	+-5.2364E 00	1.1984E 00	8.3443E-01	1.1959E 00	8.3340E-01	8.3847E-01	1.0979E-01	1.0012E 00	4.9957E-01
-5.9480E-01	+-8.5279E 00	1.1653E 00	8.5812E-01	7.3678E-01	1.3573E 00	1.3606E 00	6.9579E-02	6.3225E-01	6.4517E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7846E-01	+-3.4483E 00	7.0841E-01	1.4116E 00	1.8221E 00	5.4882E-01	5.7049E-01	2.7297E-01	2.5721E 00	1.6816E-01
-1.7685E 00	+-6.0008E 00	3.9193E-01	2.5514E 00	1.0471E 00	9.5506E-01	9.9568E-01	2.8269E-01	2.6715E 00	1.5696E-01
-4.4653E-01	+-9.4238E 00	1.5523E 00	6.4420E-01	6.6674E-01	1.4998E 00	1.5015E 00	4.7331E-02	4.2951E-01	7.4251E-01

AERO(94)= 154.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.30 DEG
DELTA = -0.98 DEG
FRT CAB. TENSION= 0.132393E 03 LBS
RR CAB. TENSION = 0.154033E 03 LBS
>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.0617E-01	+-5.3696E 00	1.1435E 00	8.7451E-01	1.1701E 00	8.5460E-01	8.6003E-01	1.1218E-01	1.0233E 00	4.9199E-01
-5.6662E-01	+-8.8262E 00	1.2233E 00	8.1745E-01	7.1188E-01	1.4047E 00	1.4076E 00	6.4065E-02	5.8192E-01	6.6807E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7944E-01	+-3.5346E 00	7.0770E-01	1.4130E 00	1.7776E 00	5.6255E-01	5.8375E-01	2.6704E-01	2.5118E 00	1.7533E-01
-1.7572E 00	+-6.3688E 00	3.9447E-01	2.5351E 00	9.8346E-01	1.0168E 00	1.0546E 00	2.6519E-01	2.4931E 00	1.7762E-01
-4.5699E-01	+-9.7155E 00	1.5168E 00	6.5930E-01	6.4672E-01	1.5463E 00	1.5480E 00	4.6986E-02	4.2638E-01	7.4413E-01

AERO(94)= 168.00

EH. ATT.,DEFLTN,& CABLE TENSION
THETA = 2.33 DEG
DELTA = -1.11 DEG
FRT CAB. TENSION= 0.144067E 03 LBS
RR CAB. TENSION = 0.168034E 03 LBS
>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.2970E-01	+-5.4927E 00	1.1008E 00	9.0846E-01	1.1439E 00	8.7419E-01	8.7992E-01	1.1390E-01	1.0392E 00	4.8660E-01
-5.4266E-01	+-9.1190E 00	1.2773E 00	7.8289E-01	6.8902E-01	1.4513E 00	1.4539E 00	5.9404E-02	5.3943E-01	6.8804E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7860E-01	+-3.6243E 00	7.0831E-01	1.4118E 00	1.7336E 00	5.7683E-01	5.9749E-01	2.6067E-01	2.4475E 00	1.8332E-01
-1.7481E 00	+-6.7514E 00	3.9652E-01	2.5220E 00	9.3066E-01	1.0745E 00	1.1099E 00	2.5066E-01	2.3471E 00	1.9654E-01
-4.6701E-01	+-9.9990E 00	1.4842E 00	6.7376E-01	6.2838E-01	1.5914E 00	1.5931E 00	4.6656E-02	4.2338E-01	7.4568E-01

AERO(94)= 182.00

EH. ATT., [illegible]LTN,& CABLE TENSION
THETA = [illegible].35 DEG
DELTA = -1.25 DEG
FRT CAB. TENSION= 0.155741E 03 LBS
RR CAB. TENSION = 0.182034E 03 LBS
>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.4969E-01	+-5.6079E 00	1.0669E 00	9.3730E-01	1.1204E 00	8.9253E-01	8.9850E-01	1.1508E-01	1.0502E 00	4.8291E-01
-5.2223E-01	+-9.4059E 00	1.3273E 00	7.5341E-01	6.6801E-01	1.4970E 00	1.4993E 00	5.5437E-02	5.0329E-01	7.0550E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7690E-01	+-3.7156E 00	7.0954E-01	1.4094E 00	1.6910E 00	5.9136E-01	6.1146E-01	2.5428E-01	2.3833E 00	1.9168E-01
-1.7402E 00	+-7.0930E 00	3.9831E-01	2.5106E 00	8.8583E-01	1.1289E 00	1.1624E 00	2.3828E-01	2.2240E 00	2.1405E-01
-4.7668E-01	+-1.0275E 01	1.4541E 00	6.8771E-01	6.1149E-01	1.6354E 00	1.6371E 00	4.6343E-02	4.2053E-01	7.4715E-01

AERO(94)= 196.00

EH. ATT., DEFLTN,& CABLE TENSION
THETA = 2.38 DEG
DELTA = -1.40 DEG
FRT CAB. TENSION= 0.167414E 03 LBS
RR CAB. TENSION = 0.196035E 03 LBS
>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.6675E-01	+-5.7166E 00	1.0396E 00	9.6191E-01	1.0991E 00	9.0985E-01	9.1602E-01	1.1585E-01	1.0572E 00	4.8056E-01
-5.0470E-01	+-9.6866E 00	1.3734E 00	7.2813E-01	6.4865E-01	1.5417E 00	1.5438E 00	5.2034E-02	4.7230E-01	7.2081E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-9.7482E-01	+-3.8074E 00	7.1105E-01	1.4064E 00	1.6503E 00	6.0597E-01	6.2551E-01	2.4803E-01	2.3209E 00	2.0015E-01
-1.7330E 00	+-7.4170E 00	3.9996E-01	2.5002E 00	8.4713E-01	1.1805E 00	1.2122E 00	2.2753E-01	2.1180E 00	2.3036E-01
-4.8606E-01	+-1.0545E 01	1.4260E 00	7.0124E-01	5.9587E-01	1.6782E 00	1.6800E 00	4.6047E-02	4.1785E-01	7.4854E-01

```
CASE  = 2          TEST DATA UNSNUBBED SNUBBER
                   FRONT CABLE VERTICAL,REAR CABLE HORIZONTAL
                   SNUBBERS UNSNUBBED
                   NO LIFT/ANTI-LIFT CABLE
DATA CHANGE
  0     0.0
```

>>>>. ROOT LOCUS VARYING AERC(94)

AERC(94)= 84.000

BH. ATT.,DEFLIN,& CABLE TENSION
THETA = 2.26 DEG
DELTA = -0.68 DEG
FRT CAB. TENSION= 0.108811E 03 LBS
RR CAB. TENSION = 0.840315E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.0259E-01	+-5.4658E 00	1.3792E 00	7.2508E-01	1.1495E 00	8.6991E-01	8.7358E-01	9.1566E-02	8.3351E-01	5.5116E-01
-6.7106E-01	+-8.2834E 00	1.0329E 00	9.6814E-01	7.5853E-01	1.3183E 00	1.3227E 00	8.0750E-02	7.3436E-01	6.0108E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-7.7711E-01	+-4.8442E 00	8.9195E-01	1.1211E 00	1.2971E 00	7.7098E-01	7.8083E-01	1.5840E-01	1.4542E 00	3.6496E-01
-1.2905E 00	+-8.1265E 00	5.3710E-01	1.8618E 00	7.7317E-01	1.2934E 00	1.3096E 00	1.5684E-01	1.4395E 00	3.6869E-01
-1.1258E 00	+-9.4515E 00	6.1571E-01	1.6241E 00	6.6478E-01	1.5042E 00	1.5149E 00	1.1827E-01	1.0797E 00	4.7313E-01

AERC(94)= 98.000

BH. ATT.,DEFLIN,& CABLE TENSION
THETA = 2.28 DEG
DELTA = -0.90 DEG
FRT CAB. TENSION= 0.120485E 03 LBS
RR CAB. TENSION = 0.980322E 02 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.4110E-01	+-5.6105E 00	1.2810E 00	7.8065E-01	1.1199E 00	8.9294E-01	8.9708E-01	9.6000E-02	8.7424E-01	5.4554E-01
-6.3216E-01	+-8.5786E 00	1.0965E 00	9.1201E-01	7.3242E-01	1.3653E 00	1.3690E 00	7.3492E-02	6.6798E-01	6.2939E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.0141E-01	+-4.9230E 00	8.6491E-01	1.1562E 00	1.2763E 00	7.8352E-01	7.9383E-01	1.6068E-01	1.4756E 00	3.5957E-01
-1.2505E 00	+-8.4024E 00	5.5430E-01	1.8041E 00	7.4779E-01	1.3373E 00	1.3520E 00	1.4720E-01	1.3491E 00	3.9255E-01
-1.1416E 00	+-9.7465E 00	6.0717E-01	1.6470E 00	6.4466E-01	1.5512E 00	1.5618E 00	1.1633E-01	1.0617E 00	4.7905E-01

AERC(94)= 112.00

BH. ATT.,DEFLIN,& CABLE TENSION
THETA = 2.30 DEG
DELTA = -0.93 DEG
FRT CAB. TENSION= 0.132159E 03 LBS
RR CAB. TENSION = 0.112033E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-5.7378E-01	+-5.7409E 00	1.2080E 00	8.2780E-01	1.0945E 00	9.1369E-01	9.1825E-01	9.9452E-02	9.0599E-01	5.3367E-01
-5.9907E-01	+-8.8712E 00	1.1570E 00	8.6428E-01	7.0827E-01	1.4119E 00	1.4151E 00	6.7377E-02	6.1214E-01	6.5423E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.2059E-01	+-4.9990E 00	8.4470E-01	1.1839E 00	1.2569E 00	7.9561E-01	8.0626E-01	1.6198E-01	1.4880E 00	3.5651E-01
-1.2199E 00	+-9.6700E 00	5.6820E-01	1.7600E 00	7.2470E-01	1.3799E 00	1.3935E 00	1.3933E-01	1.2754E 00	4.1310E-01
-1.1531E 00	+-1.0034E 01	6.0112E-01	1.6636E 00	6.2622E-01	1.5969E 00	1.6074E 00	1.1417E-01	1.0418E 00	4.8574E-01

AERC(94)= 126.00

BH. ATT.,DEFLIN,& CABLE TENSION
THETA = 2.32 DEG
DELTA = -1.06 DEG
FRT CAB. TENSION= [illegible]

RR CAB. TENSION = [illegible]

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.0143E[illegible]	+-5.8605E 00	1.1525E 00	8.6767E-01	1.0721E 00	9.3273E-01	9.3762E-01	1.0209E-01	9.3026E-01	[illegible]477E-01
-5.7101E-[illegible]	+-9.1597E 00	1.2136E 00	8.2379E-01	6.8596E-01	1.4579E 00	1.4606E 00	6.2219E-02	5.6509E-01	[illegible]591E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.3569E-01	+-5.0730E 00	8.2923E-01	1.2059E 00	1.2386E 00	8.0739E-01	8.1827E-01	1.6258E-01	1.4936E 00	3.5512E-01
-1.1965E 00	+-8.9298E 00	5.7931E-01	1.7262E 00	7.0362E-01	1.4212E 00	1.4339E 00	1.3280E-01	1.2146E 00	4.3090E-01
-1.1613E 00	+-1.0313E 01	5.9688E-01	1.6754E 00	6.0924E-01	1.6414E 00	1.6518E 00	1.1150E-01	1.0207E 00	4.9287E-01

AERO(94)= 140.00

EH. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.35 DEG
DELTA = -1.20 DEG
FRT CAB. TENSION= 0.155506E 03 LBS
RR CAB. TENSION = 0.140034E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.2483E-01	+-5.9717E 00	1.1093E 00	9.0144E-01	1.0522E 00	9.5043E-01	9.5562E-01	1.0406E-01	9.4846E-01	5.1819E-01
-5.4716E-01	+-9.4432E 00	1.2668E 00	7.8939E-01	6.6536E-01	1.5029E 00	1.5055E 00	5.7846E-02	5.2523E-01	6.9465E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.4823E-01	+-5.1455E 00	8.1717E-01	1.2237E 00	1.2211E 00	8.1893E-01	8.2998E-01	1.6265E-01	1.4943E 00	3.5495E-01
-1.1786E 00	+-9.1821E 00	5.8811E-01	1.7004E 00	6.8429E-01	1.4614E 00	1.4734E 00	1.2732E-01	1.1635E 00	4.4642E-01
-1.1670E 00	+-1.0586E 01	5.9398E-01	1.6836E 00	5.9354E-01	1.6848E 00	1.6950E 00	1.0957E-01	9.9926E-01	5.0026E-01

AERO(94)= 154.00

EH. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.37 DEG
DELTA = -1.34 DEG
FRT CAB. TENSION= 0.167180E 03 LBS
RR CAB. TENSION = 0.154035E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.4472E-01	+-6.0764E 00	1.0751E 00	9.3014E-01	1.0340E 00	9.6709E-01	9.7251E-01	1.0551E-01	9.6180E-01	5.1342E-01
-5.2681E-01	+-9.7214E 00	1.3157E 00	7.6003E-01	6.4633E-01	1.5472E 00	1.5495E 00	5.4113E-02	4.9123E-01	7.1142E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.5829E-01	+-5.2169E 00	8.0759E-01	1.2382E 00	1.2044E 00	8.3029E-01	8.4145E-01	1.6234E-01	1.4913E 00	3.5568E-01
-1.1649E 00	+-9.4272E 00	5.9502E-01	1.6806E 00	6.6650E-01	1.5004E 00	1.5118E 00	1.2264E-01	1.1201E 00	4.6005E-01
-1.1707E 00	+-1.0853E 01	5.9208E-01	1.6890E 00	5.7896E-01	1.7272E 00	1.7373E 00	1.0725E-01	9.7784E-01	5.0774E-01

AERO(94)= 168.00

EH. ATT.,DEFLTN,& CABLE TENSION

THETA = 2.40 DEG
DELTA = -1.49 DEG
FRT CAB. TENSION= 0.178853E 03 LBS
RR CAB. TENSION = 0.166036E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.6170E-01	+-6.1757E 00	1.0475E 00	9.5464E-01	1.0174E 00	9.8290E-01	9.8853E-01	1.0654E-01	9.7124E-01	5.1007E-01
-5.0335E-01	+-9.9939E 00	1.3608E 00	7.3484E-01	6.2870E-01	1.5906E 00	1.5926E 00	5.0902E-02	4.6200E-01	7.2598E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.6656E-01	+-5.2873E 00	7.9988E-01	1.2502E 00	1.1884E 00	8.4149E-01	8.5272E-01	1.6174E-01	1.4857E 00	3.5708E-01
-1.1545E 00	+-9.6654E 00	6.0040E-01	1.6656E 00	6.5007E-01	1.5383E 00	1.5492E 00	1.1860E-01	1.0627E 00	4.7214E-01
-1.1730E 00	+-1.1113E 01	5.9093E-01	1.6922E 00	5.6537E-01	1.7687E 00	1.7786E 00	1.0496E-01	9.5675E-01	5.1522E-01

AERO(94)= 182.00

EF. ATT. DEFLTN,& CABLE TENSION
THETA = 2.42 DEG
DELTA = -1.65 DEG
FFT CAB. TENSION= 0.190527E 03 LBS
RR CAB. TENSION = 0.182037E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.7627E-01	+-6.2708E 00	1.0250E 00	9.7565E-01	1.0020E 00	9.9803E-01	1.0038E 00	1.0722E-01	9.7758E-01	5.0783E-01
-4.9429E-01	+-1.0261E 01	1.4023E 00	7.1311E-01	6.1235E-01	1.6331E 00	1.6350E 00	4.8117E-02	4.3667E-01	7.3884E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.7343E-01	+-5.3568E 00	7.9359E-01	1.2601E 00	1.1729E 00	8.5256E-01	8.6382E-01	1.6093E-01	1.4780E 00	3.5898E-01
-1.1466E 00	+-9.8972E 00	6.0453E-01	1.6542E 00	6.3484E-01	1.5752E 00	1.5857E 00	1.1508E-01	1.0501E 00	4.8292E-01
-1.1741E 00	+-1.1369E 01	5.9036E-01	1.6939E 00	5.5267E-01	1.8094E 00	1.8190E 00	1.0273E-01	9.3616E-01	5.2262E-01

AERC(94)= 196.00

EF. ATT., DEFLTN,& CABLE TENSION
THETA = 2.45 DEG
DELTA = -1.81 DEG
FFT CAB. TENSION= 0.202213E 03 LBS
RR CAB. TENSION = 0.196037E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-6.8885E-01	+-6.3623E 00	1.0062E 00	9.9379E-01	9.8756E-01	1.0126E 00	1.0185E 00	1.0764E-01	9.8143E-01	5.0648E-01
-4.8119E-01	+-1.0522E 01	1.4405E 00	6.9421E-01	5.9712E-01	1.6747E 00	1.6764E 00	4.5683E-02	4.1453E-01	7.5026E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-8.7919E-01	+-5.4256E 00	7.8839E-01	1.2684E 00	1.1581E 00	8.6351E-01	8.7478E-01	1.5996E-01	1.4689E 00	3.6126E-01
-1.1407E 00	+-1.0123E 01	6.0767E-01	1.6456E 00	6.2068E-01	1.6111E 00	1.6213E 00	1.1197E-01	1.0214E 00	4.9264E-01
-1.1744E 00	+-1.1619E 01	5.9022E-01	1.6943E 00	5.4075E-01	1.8493E 00	1.8587E 00	1.0056E-01	9.1618E-01	5.2951E-01

```
CASE = 3        TEST DATA CHANGE CL AND CM ALPHA
                FRONT CABLE VERTICAL,REAR CABLE HORIZONTAL
                NO SNUBBERS
                NO LIFT/ANTI-LIFT CABLE
  DATA CHANGE
     5     5.5000
     6    -1.3000
     0     0.0

EF. ATT.,DEFLTN,& CABLE TENSION
 THETA =  2.94 DEG
 DELTA = -2.78 DEG
 FRT CAB. TENSION=    0.120742E 03 LBS
 RR CAB. TENSION =    0.140053E 03 LBS
 >>>> LONGITUDINAL STABILITY <<<<
```

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-3.9605E-01	+-4.5501E 00	1.7502E 00	5.7138E-01	1.3809E 00	7.2418E-01	7.2691E-01	8.6714E-02	7.8900E-01	5.7874E-01
-6.8065E-01	+-9.9917E 00	1.0184E 00	9.8197E-01	6.2884E-01	1.5902E 00	1.5939E 00	6.7965E-02	6.1750E-01	6.5180E-01

CASE 4 TEST DATA FRONT PULLEY HORIZONTAL
BOTH CABLES HORIZONTAL
NO SNUBBERS
NO LIFT/ANTI-LIFT CABLE

DATA CHANGE

5	6.2000
6	-0.8000
70	0.0
74	30.000
81	26.400
87	8.4000
91	0.88000
0	0.0

EH. ALT.,DEFLTN,& CABLE TENSION
THETA = 2.51 DEG
DELTA = -2.12 DEG
FRT CAB. TENSION= 0.126639E 03 LBS
RR CAB. TENSION = 0.140039E 03 LBS

>>>> LONGITUDINAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-2.9475E-01	+-5.5731E 00	2.3517E 00	4.2523E-01	1.1274E 00	8.8698E-01	8.8822E-01	5.2815E-02	4.7941E-01	7.1727E-01
-6.6118E-01	+-8.0081E 00	1.0484E 00	9.5388E-01	7.8460E-01	1.2745E 00	1.2789E 00	8.2284E-02	7.4841E-01	5.9526E-01

>>>> LATERAL/DIRECTIONAL STABILITY <<<<

REAL	IMAGINARY	T H/D-SEC	1/T H/D	PERIOD-SEC	DNATF-CPS	UNDNAT-CPS	DAMP RATIO	DECAY RATIO	
-1.7860E 00	+-2.7053E 00	3.8811E-01	2.5766E 00	2.3225E 00	4.3057E-01	5.1593E-01	5.5093E-01	5.9841E 00	1.5798E-02
-1.4335E 00	+-7.2026E 00	4.8352E-01	2.0682E 00	8.7235E-01	1.1463E 00	1.1688E 00	1.9520E-01	1.8042E 00	2.8635E-01
-5.1859E-01	+-9.7303E 00	1.3366E 00	7.4816E-01	6.4573E-01	1.5486E 00	1.5508E 00	5.3222E-02	4.8311E-01	7.1543E-01

APPENDIX D

Contained in this Appendix is a program listing. The subroutines as they appear in the listing are itemized below:

EXEC ROUTINE
SUBROUTINE RUTLOC
SUBROUTINE TRANS
SUBROUTINE TRAN1
SUBROUTINE LATSN
SUBROUTINE TRIM
SUBROUTINE EQU
SUBROUTINE FPLYV
SUBROUTINE RPLYH
SUBROUTINE DLGTH
SUBROUTINE DCOSLG
SUBROUTINE LONG
SUBROUTINE PRINTR
SUBROUTINE MASH
SUBROUTINE LAT
SUBROUTINE DCOSD
SUBROUTINE SNTRM
SUBROUTINE LONGSN
SUBROUTINE DRCSN
SUBROUTINE DRCUSN
SUBROUTINE RITE
SUBROUTINE STINT
SUBROUTINE TABIN
SUBROUTINE STINT1
SUBROUTINE TABIN1
SUBROUTINE FRICT
SUBROUTINE FRVT
SUBROUTINE FRHZ
SUBROUTINE MATRIX
SUBROUTINE POLADD
SUBROUTINE POLSUB
SUBROUTINE POLMPY
SUBROUTINE MATMPY
SUBROUTINE TRACE
SUBROUTINE COMPBI

APPENDIX D (CONT.)

SUBROUTINE ENVERT

SUBROUTINE SCALER

SUBROUTINE EQUIL

SUBROUTINE PRBM1

SUBROUTINE PQFB1

SUBROUTINE ENVERT

SUBROUTINE SCALER

SUBROUTINE EQUIL

SUBROUTINE PRBM1

SUBROUTINE PQFB1

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C   EXEC ROUTINE BEGINS HERE                                            CBL00010
      COMMON/DAT/AERO(150),AEROP(50),KODE(20),LL                       CBL00020
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUC(3,3)               CBL00030
      COMMON ZZZ(200)                                                   CBL00040
      COMMON/TAB1/ZZ(800)                                               CBL00050
      COMMON/DU/DUM(10,10)                                              CBL00060
      DIMENSION TITLE(20),SAVE(50),SAVE1(150)                           CBL00070
      EQUIVALENCE(AERO(  1),  CDU),(AERO(  2),  CLU),(AERO(  3),  CMU), CBL00080
     1           (AERO(  4),  CDA),(AERO(  5),  CLA),(AERO(  6),  CMA), CBL00090
     2           (AERO(  7),  CDQ),(AERO(  8),  CLQ),(AERO(  9),  CMQ), CBL00100
     3           (AERO( 10),  CDO),(AERO( 11),  CLO),(AERO( 12),  CMO), CBL00110
     4           (AERO( 13), CDDE),(AERO( 14), CLDE),(AERO( 15), CMDE), CBL00120
     5           (AERO( 16), CDAD),(AERO( 17),CLAD),(AERO( 18),CMAD),   CBL00130
     6           (AERO( 19),  CYB),(AERO( 20),  CLB),(AERO( 21),  CNB), CBL00140
     7           (AERO( 22),  CYP),(AERO( 23),  CLP),(AERO( 24),  CNP), CBL00150
     8           (AERO( 25),  CYR),(AERO( 26),  CLR),(AERO( 27),  CNR), CBL00160
     9           (AERO( 28), CYDR),(AERO( 29), CLDR),(AERO( 30), CNDR), CBL00170
     A           (AERO( 31), CYDA),(AERO( 32), CLDA),(AERO( 33), CNDA), CBL00180
     B           (AERO( 34), CYDS),(AERO( 35), CLDS),(AERO( 36), CNDS), CBL00190
     C           (AERO( 44), XREF),(AERO( 45), ZREF),(AERO( 46),  XCG), CBL00200
     D           (AERO( 47),  ZCG)                                      CBL00210
      EQUIVALENCE(AERO (48),AMACH),(AERO (49),VC   ),(AERO (50),   AM)  CBL00220
      EQUIVALENCE(AERO (51),RHO  ),(AERO (52),   WT),(AERO (53),B    )  CBL00230
      EQUIVALENCE(AERO (54),CBAR ),(AERO (55),SW   ),(AERO (56), XIXZ)  CBL00240
      EQUIVALENCE(AERO (57),XIXX ),(AERO (58),YIYY ),(AERO (59),ZIZZ )  CBL00250
      EQUIVALENCE(AERO (60),CLT  ),(AERO (61),CDT  ),(AERO (62),CMT  ), CBL00260
     1           (AERO (63),THETA)                                      CBL00270
      EQUIVALENCE(AERO (66), WLUF),(AERO(67), WLLF),(AERO(68), WLUR),   CBL00280
     1           (AERO (69), WLLR),(AERO(70), WLHF),(AERO(71), WLHR),   CBL00290
     2           (AERO (72), STAF),(AERO(73), STAR),(AERO(74), BLHF),   CBL00300
     3           (AERO (75), BLHR),(AERO(76), WLCR),(AERO(77),STACR),   CBL00310
     4           (AERO (78), BLCR),(AERO(79),   EF),(AERO(80),   ER),   CBL00320
     5           (AERO (81),   AF),(AERO(82),   AR),(AERO(83), HUCF),   CBL00330
     6           (AERO (84), HLCF),(AERO(85), HUCR),(AERO(86), HLCR),   CBL00340
     7           (AERO (87),  DCF),(AERO(88),  DCR),                    CBL00350
     8           (AERO (90),  RVF),(AERO(91),  RHF),(AERO(92),  RVR),   CBL00360
     9           (AERO(93),   RHR),(AERO(94),  TRO),(AERO(95),  AKR),   CBL00370
     A           (AERO(96),   COU),(AERO(97),STLTT),(AERO(98),WLLTT),   CBL00380
     B           (AERO(99),TLFTO),(AERO(100),AKLFT),                    CBL00390
     C           (AERO(102),ALTX),(AERO(103), ALTZ),(AERO(104),  CMP)   CBL00400
      EQUIVALENCE(AERO(105), SNUX),(AERO(106), SNUY),(AERO(107), SNUZ), CBL00410
     1           (AERO(108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ), CBL00420
     2           (AERO(111),SNUST),(AERO(112),SNUWL),(AERO(113),SNUBL), CBL00430
     3           (AERO(114),SNLST),(AERO(115),SNLWL),(AERO(116),SNLBL), CBL00440
     4           (AERO(117),TUSNO),(AERO(118),TLSNO),(AERO(119),AKSNU), CBL00450
     5           (AERO(120),AKSNL),(AERO(121),ADSNU),(AERO(122),ADSNL), CBL00460
     6           (AERO(123), AKSY),(AERO(124),AKPHI),(AERO(125),AKTHE), CBL00470
     7           (AERO(126), AKAZ),(AERO(127), T1SY),(AERO(128),T2PHI), CBL00480
     8           (AERO(129),T3THE),(AERO(130), T4AZ)                    CBL00490
      EQUIVALENCE(AEROP( 1), CXUP),(AEROP( 2), CZUP),(AEROP( 3), CMUP), CBL00500
     1           (AEROP( 4), CXAP),(AEROP( 5), CZAP),(AEROP( 6), CMAP), CBL00510
     2           (AEROP( 7), CXQP),(AEROP( 8), CZQP),(AEROP( 9), CMQP), CBL00520
     3           (AEROP(10), CXOP),(AEROP(11), CZOP),(AEROP(12), CMOP), CBL00530
     4           (AEROP(13),CXDEP),(AEROP(14),CZDEP),(AEROP(15),CMDEP), CBL00540
     5           (AEROP(16),CXADP),(AEROP(17),CZADP),(AEROP(18),CMADP), CBL00550
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     6              (AEROP(19), CYBP),(AEROP(20), CLEF),(AEROP(21), CNBP),  CBL00560
     7              (AEROP(22), CYPP),(AEROP(23), CLFF),(AEROP(24), CNPP),  CBL00570
                    (AEROP(25), CYRP),(AEROP(26), CLRF),(AEROP(27), CNRP),  CBL00580
     9              (AEROP(28),CYDRP),(AEROP(29),CLDRP),(AEROP(30),CNDRP),  CBL00590
     A              (AEROP(31),CYDAP),(AEROP(32),CLDAF),(AEROP(33),CNDAP),  CBL00600
     B              (AEROP(34),CYDSP),(AEROP(35),CLDSF),(AEROP(36),CNDSP)   CBL00610
      EQUIVALENCE (SN( 1),  GX1),(SN( 2),  GY1),(SN( 3),  GZ1),             CBL00620
     1             (SN( 4),  GX2),(SN( 5),  GY2),(SN( 6),  GZ2),            CBL00630
     2             (SN( 7),  GX3),(SN( 8),  GY3),(SN( 9),  GZ3),            CBL00640
     3             (SN(10),  GX4),(SN(11),  GY4),(SN(12),  GZ4),            CBL00650
     4             (SN(13),  THU),(SN(14),  THL),(SN(15),  ALU),            CBL00660
     5             (SN(16),  ALL),                                          CBL00670
     6             (SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),            CBL00680
     7             (SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),            CBL00690
     8             (SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),            CBL00700
     9             (SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)             CBL00710
      KASE=0                                                                CBL00720
      IR=5                                                                  CBL00730
      IW=6                                                                  CBL00740
      L_L=0                                                                 CBL00750
      DO 11 J=1,5C                                                          CBL00760
   11 SAVE(J)=9999.                                                         CBL00770
      LL=0                                                                  CBL00780
      READ(IR,15C)(TITLE(I),I=1,20)                                         CBL00790
      READ(IR,200)(KODE(I),I=1,16)                                          CBL00800
  200 FORMAT(16I5)                                                          CBL00810
      WRITE(IW,17C) KODE(1),(TITLE(I),I=1,20)                               CBL00820
  1   FORMAT(1H1,3X,'CASE NO=',I3,4X,20A4)                                  CBL00830
      CALL RITE                                                             CBL00840
      IF(KODE(7).EQ.1) GO TO 10                                             CBL00850
      READ(IR,10C)(AERO(I),I=1,36)                                          CBL00860
      GO TO 20                                                              CBL00870
   10 CALL TABIN1(1,36,NG)                                                  CBL00880
      IF(NG.EQ.0) GO TO 20                                                  CBL00890
      WRITE(IW,300) NG                                                      CBL00900
  300 FORMAT(//,' ERROR IN READING TABLES 1-36,NG=',I2)                     CBL00910
      GO TO 500                                                             CBL00920
   20 READ(IR,10C)(AERO(I),I=44,59)                                         CBL00930
      READ(IR,100)(AERO(I),I=66,130)                                        CBL00940
  100 FORMAT(6E12.5)                                                        CBL00950
      IF(KODE(12).NE.1) GO TO 32                                            CBL00960
      CALL TABIN(1,2,NG)                                                    CBL00970
      IF(NG.EQ.0) GO TO 32                                                  CBL00980
      WRITE(IW,420) NG                                                      CBL00990
  420 FORMAT(' ERROR IN READING SNUBBER DATA TABLE,NG=',I3)                 CBL01000
      GO TO 5CC                                                             CBL01010
 1000 DO 28 I=1,150                                                         CBL01020
   28 AERO(I)=SAVE1(I)                                                      CBL01030
      READ(IR,15C)(TITLE(I),I=1,20)                                         CBL01040
  150 FORMAT(20A4)                                                          CBL01050
      KASE=1                                                                CBL01060
      DO 34 J=1,5C                                                          CBL01070
   34 SAVE(J)=9999.                                                         CBL01080
      READ(IR,20C)(KODE(I),I=1,16)                                          CBL01090
      WRITE(IW,170) KODE(1),(TITLE(I),I=1,20)                               CBL01100
```

```
      CALL RITE
      WRITE(IW,352)
 352  FORMAT(3X,'DATA CHANGE')
  26  READ(IR,350) K,VALUE
 350  FORMAT(I3,E12.5)
      WRITE(IW,351)K,VALUE
 351  FORMAT(3X,I3,3X,G12.5)
      IF(K.LT.1) GO TO 22
      AERO(K)=VALUE
      IF(K.LT.37) SAVE(K)=AERO(K)
      GO TO 26
  22  LL=0
  32  IF(KODE(7).EQ.0) GO TO 31
      DO 30 I=1,36
      CALL STINT1(AMACH,0,0,I,I,AERO(I),NG)
      IF(NG.NE.0) GO TO 40
  30  CONTINUE
      DO 36 J=1,36
  36  IF(SAVE(J).NE.9999.) AERO(J)=SAVE(J)
      GO TO 31
  40  WRITE(IW,400) I,NG
 400  FORMAT(//,' ERROR IN TABLE NO',I4,'NG=',I3)
      GO TO 500
 360  FORMAT(6E10.3)
  31  IF(KASE.EQ.1) GO TO 9
      WRITE(IW,801)
 801  FORMAT(5X,'INPUT DATA AS SPECIFIED IN AERO ARRAY')
      WRITE(IW,800)(I,AERO(I),I=1,130)
 800  FORMAT(5(2X,'AERO(',I3,')=',G10.3))
   9  DO 25 I=1,150
  25  SAVE1(I)=AERO(I)
      IF(KODE(3).EQ.0) GO TO 48
  42  DO 27 I=1,150
  27  AERO(I)=SAVE1(I)
      CALL RUTLOC
      IF(LL.EQ.0) GO TO 1000
  48  CALL TRAN1
      IF(KODE(5).EQ.0) GO TO 49
      WRITE(IW,802)
 802  FORMAT(4X,'AERO DATA IN STAB. AXIS AT EQLAT. REF. CENTER')
      WRITE(IW,800)(I,AERO(I),I=1,36)
  49  CALL TRIM
      CALL TRANS
      IF(KODE(5).EQ.0) GO TO 50
      WRITE(IW,803)
 803  FORMAT(4X,'AERO DATA IN BODY AXIS AT EQLAT. REF. CENTER')
      WRITE(IW,804)(I,AEROP(I),I=1,36)
 804  FORMAT(5(2X,'AEROP(',I3,')=',G10.3))
  50  IF(KODE(2)) 70,80,90
  70  WRITE(IW,700)
 700  FORMAT('   ++++ LONGITUDINAL STABILITY ++++')
      CALL LONG
      IF(KODE(3).EQ.1) GO TO 42
      GO TO 1000
  80  WRITE(IW,750)
```

```
  750 FORMAT('  ++++ LATERAL/DIRECTIONAL STABILITY ++++')
      CALL LAT
      IF(KODE(3).EQ.1) GO TO 42
      GO TO 1000
   90 WRITE( IW,700)
      CALL LONG
      WRITE( IW,750)
      CALL LAT
      IF(KODE(3).EQ.1) GO TO 42
      GO TO 1000
  500 STOP
      END
      SUBROUTINE RUTLOC
      COMMON /DAT/AERO(150),AEROP(50),KODE(20),LL
      IW=6
      IF(LL.GT.0) GO TO 42
      II=KODE( 4)
      VARY= ABS(AERO(II)*.1)
      ANOM= AERO(II)
      L=0
      LL=1
      WRITE( IW ,600) II
  600 FORMAT(      1H1,3X,'  ROOT LOCUS VARYING AERO(',I3,')')
   42 L=L+1
      II=KODE( 4)
      AERO( II)=ANOM-5.*VARY+L*VARY
      IF(L.GT.9) GO TO 44
      WRITE( IW,150) KODE(4),AERO(II)
  150 FORMAT(/2X,5HAERO(,I3,2H)=,G12.5)
      RETURN
   44 AERO( II)=ANOM
      LL=0
      RETURN
      END
      SUBROUTINE TRANS
C  THIS ROUTINE CALCULATES BODY AXIS AERO DATA AT CR FROM STAB.
C  AXIS AERO DATA AT CR
      COMMON /DAT/ AERO(150),AEROP(50),KODE(20),LL
      EQUIVALENCE(AERO( 1),  CDU),(AERO( 2),  CLU),(AERO( 3),  CMU),
     1            (AERO( 4),  CDA),(AERO( 5),  CLA),(AERO( 6),  CMA),
     2            (AERO( 7),  CDQ),(AERO( 8),  CLQ),(AERO( 9),  CMQ),
     3            (AERO(10),  CDO),(AERO(11),  CLO),(AERO(12),  CMO),
     4            (AERO(13), CDDE),(AERO(14), CLDE),(AERO(15), CMDE),
     5            (AERO(16), CDAD),(AERO(17),CLAD),(AERO(18),CMAD),
     6            (AERO(19),  CYB),(AERO(20),  CLB),(AERO(21),  CNB),
     7            (AERO(22),  CYP),(AERO(23),  CLP),(AERO(24),  CNP),
     8            (AERO(25),  CYR),(AERO(26),  CLR),(AERO(27),  CNR),
     9            (AERO(28), CYDR),(AERO(29), CLDR),(AERO(30), CNDR),
     A            (AERO(31), CYDA),(AERO(32), CLDA),(AERO(33), CNDA),
     B            (AERO(34), CYDS),(AERO(35), CLDS),(AERO(36), CNDS),
     C            (AERO(44), XREF),(AERO(45), ZREF),(AERO(46),  XCG),
     D            (AERO(47),  ZCG),(AERO(63),THETA)
      EQUIVALENCE(AEROP( 1), CXUP),(AEROP( 2), CZUP),(AEROP( 3), CMUP),
     1            (AEROP( 4), CXAP),(AEROP( 5), CZAP),(AEROP( 6), CMAP),
     2            (AEROP( 7), CXQP),(AEROP( 8), CZQP),(AEROP( 9), CMQP),
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     3          (AEROP(10), CXQP),(AEROP(11), CZQP),(AEROP(12), CMQP), CBL02210
     4          (AEROP(13),CXDEP),(AEROP(14),CZDEP),(AEROP(15),CMDEP), CBL02220
     5          (AEROP(16),CXADP),(AEROP(17),CZADP),(AEROP(18),CMADP), CBL02230
     6          (AEROP(19), CYBP),(AEROP(20), CLBP),(AEROP(21), CNBP), CBL02240
     7          (AEROP(22), CYPP),(AEROP(23), CLPP),(AEROP(24), CNPP), CBL02250
     8          (AEROP(25), CYRP),(AEROP(26), CLRP),(AEROP(27), CNRP), CBL02260
     9          (AEROP(28),CYDRP),(AEROP(29),CLDRP),(AEROP(30),CNDRP), CBL02270
     A          (AEROP(31),CYDAP),(AEROP(32),CLDAP),(AEROP(33),CNDAP), CBL02280
     B          (AEROP(34),CYDSP),(AEROP(35),CLDSP),(AEROP(36),CNDSP)  CBL02290
      IW=6                                                             CBL02300
      ALPHA=THETA                                                      CBL02310
      SNALF= SIN(ALPHA)                                                CBL02320
      COALF= COS(ALPHA)                                                CBL02330
      SNSQ = SNALF**2                                                  CBL02340
      COSQ = COALF**2                                                  CBL02350
      SNCO = SNALF*COALF                                               CBL02360
      CDU=CDU+2.*(CDO+CDA*THETA)                                       CBL02370
      CLU=CLU+2.*(CLO+CLA*THETA)                                       CBL02380
      CDA=CDA-(CLO+CLA*THETA)                                          CBL02390
      CLA=CLA+CDO+CDA*THETA                                            CBL02400
      CXUP=-CLA*SNSQ-CDU*COSQ+(CDA+CLU)*SNCO                           CBL02410
      CZUP= CDA*SNSQ-CLU*COSQ+(CLA-CDU)*SNCO                           CBL02420
      CMUP= -CMA *SNALF+ CMU *COALF                                    CBL02430
      CXAP= CLU*SNSQ-CDA*COSQ+(CLA-CDU)*SNCO                           CBL02440
      CZAP=-CDU*SNSQ-CLA*COSQ-(CDA+CLU)*SNCO                           CBL02450
      CMAP=  CMU *SNALF+ CMA *COALF                                    CBL02460
      CXQP= CLQ*SNALF-CDQ*COALF                                        CBL02470
      CZQP=-(CDQ*SNALF+CLQ*COALF)                                      CBL02480
      CMQP= CMQ                                                        CBL02490
      CZADP=-CLAD*COALF+CDAD*SNALF                                     CBL02500
      CXADP=-CDAD*COALF-CLAD*SNALF                                     CBL02510
      CMADP= CMAD                                                      CBL02520
      CXDEP= CLDE*SNALF-CDDE*COALF                                     CBL02530
      CZDEP=-CDDE*SNALF-CLDE*COALF                                     CBL02540
      CMDEP= CMDE                                                      CBL02550
      CYBP= CYB                                                        CBL02560
      CNBP=  CLB *SNALF+ CNB *COALF                                    CBL02570
      CLBP= -CNB *SNALF+ CLB *COALF                                    CBL02580
      CYPP= (-CYR*SNALF+ CYP*COALF)                                    CBL02590
      CNPP=(-CLR*SNSQ+ CNP*COSQ+ (CLP- CNR)*SNCO)                      CBL02600
      CLPP=( CNR*SNSQ+ CLP*COSQ- (CLR+ CNP)*SNCO)                      CBL02610
      CYRP= ( CYP*SNALF+ CYR*COALF)                                    CBL02620
      CNRP=( CLP*SNSQ+ CNR*COSQ+ (CLR+ CNP)*SNCO)                      CBL02630
      CLRP=(-CNP*SNSQ+ CLR*COSQ+ (CLP- CNR)*SNCO)                      CBL02640
      CYDAP= CYDA                                                      CBL02650
      CNDAP= CLDA*SNALF+ CNDA*COALF                                    CBL02660
      CLDAP= -CNDA*SNALF+ CLDA*COALF                                   CBL02670
      CYDRP= CYDR                                                      CBL02680
      CNDRP= CLDR*SNALF+ CNDR*COALF                                    CBL02690
      CLDRP=-CNDR*SNALF+ CLDR*COALF                                    CBL02700
      CYDSP= CYDS                                                      CBL02710
      CLDSP=-CNDS*SNALF+ CLDS*COALF                                    CBL02720
      CNDSP= CLDS*SNALF+ CNDS*COALF                                    CBL02730
      RETURN                                                           CBL02740
      END                                                              CBL02750
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```
      SUBROUTINE TRAN1
C  THIS ROUTINE TRANSFORMS INERTIA DATA & STABILITY AXIS AERO DATA
C     THE EQUATION REFERENCE CENTER
      COMMON /DAT/AERO(150),AEROP(50),KODE(20),LL
      EQUIVALENCE(AERO( 1),  CDU),(AERO( 2),  CLU),(AERO( 3),  CMU),
     1           (AERO( 4),  CDA),(AERO( 5),  CLA),(AERO( 6),  CMA),
     2           (AERO( 7),  CDQ),(AERO( 8),  CLQ),(AERO( 9),  CMQ),
     3           (AERO(10),  CDO),(AERO(11),  CLO),(AERO(12),  CMO),
     4           (AERO(13), CDDE),(AERO(14), CLDE),(AERO(15), CMDE),
     5           (AERO(16), CDAD),(AERO(17),CLAD),(AERO(18),CMAD),
     6           (AERO(19),  CYB),(AERO(20),  CLB),(AERO(21),  CNB),
     7           (AERO(22),  CYP),(AERO(23),  CLP),(AERO(24),  CNP),
     8           (AERO(25),  CYR),(AERO(26),  CLR),(AERO(27),  CNR),
     9           (AERO(28), CYDR),(AERO(29), CLDR),(AERO(30), CNDR),
     A           (AERO(31), CYDA),(AERO(32), CLDA),(AERO(33), CNDA),
     B           (AERO(34), CYDS),(AERO(35), CLDS),(AERO(36), CNDS),
     C           (AERO(44), XREF),(AERO(45), ZREF),(AERO(46),  XCG),
     D           (AERO(47),  ZCG),(AERO(63),THETA)
      EQUIVALENCE(AERO (48),AMACH),(AERO (49),VC   ),(AERO (50),   AM)
      EQUIVALENCE(AERO (51),RHO  ),(AERO (52),   WT),(AERO (53),B    )
      EQUIVALENCE(AERO (54),CBAR ),(AERO (55),SW   ),(AERO (56), XIXZ)
      EQUIVALENCE(AERO (57),XIXX ),(AERO (58),YIYY ),(AERO (59),ZIZZ )
      EQUIVALENCE(AERO (60),CLT  ),(AERO (61),CDT  ),(AERO (62),CMT  )
C  INERTIA TRANSFORMATIONS
      X=XCG/12.
      Z=ZCG/12.
      XIXX=XIXX+AM*(Z**2)
      YIYY=YIYY+AM*(X**2)+AM*(Z**2)
      ZIZZ=ZIZZ+AM*(X**2)
      XIXZ=XIXZ-AM*X*Z
C  AERO DATA TRANSFORMATIONS
      X=XREF/(12.*CBAR)
      Z=ZREF/(12.*CBAR)
      CMO=CMO-Z*CDO+X*CLO
      CMA=CMA-Z*CDA+X*CLA
      CMQ=CMQ-Z*CDQ+X*CLQ
      CMDE=CMDE-Z*CDDE+X*CLDE
      X=XCG/(12.*B)
      Z=ZCG/(12.*B)
      CNB=CNB+X*CYB
      CNR=CNR+X*CYR
      CNP=CNP+X*CYP
      CNDR=CNDR+X*CYDR
      CNDA=CNDA+X*CYDA
      CNDS=CNDS+X*CYDS
      CLB=CLB-Z*CYB
      CLR=CLR-Z*CYR
      CLP=CLP-Z*CYP
      CLDR=CLDR-Z*CYDR
      CLDA=CLDA-Z*CYDA
      CLDS=CLDS-Z*CYDS
      RETURN
      END
      SUBROUTINE LATSN
      COMMON /DAT/AERO(150),AEROP(50),KODE(20),LL
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```
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUD(3,3)
      COMMON ZZZ(200)
      COMMON/DU/DUM(10,10)
      COMMON/TAB1/ZZ(800)
      EQUIVALENCE(AERO(105), SNUX),(AERO(106), SNUY),(AERO(107), SNUZ),
     1(AERO( 108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ),
     2(AERO( 111),SNUST),(AERO(112),SNUWL),(AERO(113),SNUBL),
     3(AERO( 114),SNLST),(AERO(115),SNLWL),(AERO(116),SNLBL),
     4(AERO( 117),TUSNO),(AERO(118),TLSNO),(AERO(119),AKSNU),
     5(AERO( 120),AKSNL),(AERO(49),    VO),(AERO(51),   FHC),
     6(AERO(63),THETA),(AERO(121),ADSNU),(AERO(122),ADSNL)
      EQUIVALENCE (SN( 1),  GX1),(SN( 2),  GY1),(SN( 3),  GZ1),
     1(SN( 4),   GX2),(SN( 5),   GY2),(SN( 6),   GZ2),
     2(SN( 7),   GX3),(SN( 8),   GY3),(SN( 9),   GZ3),
     3(SN( 10),  GX4),(SN(11),   GY4),(SN(12),   GZ4),
     4(SN( 13),  THU),(SN(14),   THL),(SN(15),   ALL),
     5(SN( 16),  ALL),
     6(SN( 19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),
     7(SN( 22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),
     8(SN( 25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),
     9(SN( 28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)
      DIMENSION TOPR(3,3),TOPL(3,3),BOTR(3,3),BOTL(3,3)
      COT(BBB)=1./TAN(BBB)
      GXY(A,AA,C)              = (-A*COT(AA)/C)*12.
      GXSY(A,AA,C,D,E,F)       = -(A*SIN(AA)+C*D*COT(E))/F
      GXPHI(A,AA,C,D,E,F,G)    = (A*AA*COT(C)-D*E*COT(F))/G
      GYY(A,AA)                = (SIN(A)/AA)*12.
      GYSY(A,AA,C,D,E,F)       = (A*AA*COT(C)+D*SIN(E))/F
      GYPHI(A,AA,C,D,E,F)      = -(A*SIN(AA)+C*D*COT(E))/F
      GZY(A,AA,C)              = (-A*COT(AA)/C)*12.
      GZSY(A,AA,C,D,E,F,G)     = (A*AA*COT(C)-D*E*COT(F))/G
      GZPHI(A,AA,C,D,E,F)      = (A*AA*COT(C)+D*SIN(E))/F
      ALY(A)                  = -A
      ALSY(A,AA,C,D)           =  (A*AA-C*D)/12.
      ALPHI(A,AA,C,D)          =  (A*AA-C*D)/12.
      IW=6
      DO 1005 I=1,3
      DO 1005 J=1,3
      SNU(I,J)=0
 1005 SNUD(I,J)=0
      DO 1006 I=1,10
      DO 1006 J=1,10
 1006 DUM(I,J)=0
      IF(KODE(10).EQ.0) GO TO 1002
C  TERMS FOR SNUBBER EFFECTS (LAT)
      CALL DRCSN(THETA)
      IF(KODE(10).EQ.1) CALL DRCUSN(THETA)
      DUM(1,2) = -TUSNO*GX1
      DUM(1,3) =  TUSNO*GZ1
      DUM(1,5) =  -TUSNO*SIN(THGY1)
      DUM(1,7) =  GY1
      DUM(2,2) =  SNUX*TUSNO*GX1/12.+SNUY*TUSNO*GY1/12.
      DUM(2,3) =  -SNUX*TUSNO*GZ1/12.
      DUM(2,4) =  -SNUY*TUSNO*SIN(THGX1)/12.
      DUM(2,5) =  SNUX*TUSNO*SIN(THGY1)/12.
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      DUM(2,7) =  (-SNUX*GY1+SNUY*GX1)/12.                             CBL03860
      DUM(3,2) =  -SNUZ*TUSNO*GX1/12.                                  CBL03870
      DUM(3,3) =   SNUZ*TUSNO*GZ1/12.+SNUY*TUSNO*GY1/12.              CBL03880
      DUM(3,5) =  -SNUZ*TUSNO*SIN(THGY1)/12.                           CBL03890
      DUM(3,6) =   SNUY*TUSNO*SIN(THGZ1)/12.                           CBL03900
      DUM(3,7) =  (-SNUY*GZ1+SNUZ*GY1)/12.                             CBL03910
      DUM(4,1) =   GXY(GY1,THGX1,ALU)                                  CBL03920
      DUM(4,2) =   GXSY(-SNUY,THGX1,-SNUX,GY1,THGX1,ALU)              CBL03930
      DUM(4,3) =   GXPHI(-SNUZ,GY1,THGX1,-SNUY,GZ1,THGX1,ALU)         CBL03940
      DUM(4,4) =  -1.                                                  CBL03950
      DUM(5,1) =   GYY(THGY1,ALU)                                      CBL03960
      DUM(5,2) =   GYSY(-SNUY,GX1,THGY1,-SNUX,THGY1,ALU)              CBL03970
      DUM(5,3) =   GYPHI(-SNUZ,THGY1,-SNUY,GZ1,THGY1,ALU)             CBL03980
      DUM(5,5) =  -1.                                                  CBL03990
      DUM(6,1) =   GZY(GY1,THGZ1,ALU)                                  CBL04000
      DUM(6,2) =   GZSY(-SNUY,GX1,THGZ1,-SNUX,GY1,THGZ1,ALU)          CBL04010
      DUM(6,3) =   GZPHI(-SNUZ,GY1,THGZ1,-SNUY,THGZ1,ALU)             CBL04020
      DUM(6,6) =  -1.                                                  CBL04030
      IF(KODE(10).EQ.2) GO TO 1010                                     CBL04040
      CALL DRCSN(THETA)                                                CBL04050
      Q=.5*RHO*VO*VO                                                   CBL04060
      ALU1=ALU+1.                                                      CBL04070
       CALL STINT(Q,ALU1,0,1,1,TUSN1,NG)                               CBL04080
      IF(NG.NE.0) GO TO 5000                                           CBL04090
      ALU2=ALU-1.                                                      CBL04100
      CALL STINT(Q,ALU2,0,1,1,TUSN2,NG)                                CBL04110
      IF(NG.NE.0) GO TO 5000                                           CBL04120
      GO TO 5001                                                       CBL04130
 5000 WRITE(IW,5002) NG,ALU,ALU,G                                      CBL04140
 5002 FORMAT('ERROR IN SNUBBER TABLE 1,NG=',I2,3XE10.3)                CBL04150
      RETURN                                                           CBL04160
 5001 CONTINUE                                                         CBL04170
      AKTU=(TUSN1-TUSN2)/2.                                            CBL04180
      AKSNU=AKTU                                                       CBL04190
 1010 CONTINUE                                                         CBL04200
      DUM(7,7) =  -1.                                                  CBL04210
      DUM(7,8) =   AKSNU*12.                                           CBL04220
      DUM(8,1) =   ALY(GY1)                                            CBL04230
      DUM(8,2) =   ALSY(-SNUY,GX1,-SNUX,GY1)                           CBL04240
      DUM(8,3) =   ALPHI(-SNUZ,GY1,-SNUY,GZ1)                          CBL04250
      DUM(8,8) =  -1.                                                  CBL04260
      IF(KODE(10).EQ.1) GO TO 1015                                     CBL04270
      DO 1016 I=1,3                                                    CBL04280
      DO 1016 J=1,3                                                    CBL04290
 1016 SNUD(I,J)=DUM(I,7)*ADSNU*DUM(8,J)*12.                            CBL04300
 1015 CALL MASH(3,8)                                                   CBL04310
      DO 1050 I=1,3                                                    CBL04320
      DO 1050 J=1,3                                                    CBL04330
 1050 TOPR(I,J)= DUM(I,J)                                              CBL04340
      IF(KODE(10).EQ.1) CALL DRCUSN(THETA)                             CBL04350
      DUM(1,2) =  -TUSNO*GX2                                           CBL04360
      DUM(1,3) =   TUSNO*GZ1                                           CBL04370
      DUM(1,5) =  -TUSNO*SIN(THGY2)                                    CBL04380
      DUM(1,7) =   GY2                                                 CBL04390
      DUM(2,2) =   SNUX*TUSNO*GX2/12.-SNUY*TUSNO*GY2/12.              CBL04400
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      DUM(2,3) = -SNUX*TUSNO*GZ2/12.
      DUM(2,4) =  SNUY*TUSNO*SIN(THGX2)/12.
      DUM(2,5) =  SNUX*TUSNO*SIN(THGY2)/12.
      DUM(2,7) = (-SNUX*GY2-SNUY*GX2)/12.
      DUM(3,2) = -SNUZ*TUSNO*GX2/12.
      DUM(3,3) =  SNUZ*TUSNO*GZ2/12.-SNUY*TUSNO*GY2/12.
      DUM(3,5) = -SNUZ*TUSNO*SIN(THGY2)/12.
      DUM(3,6) = -SNUY*TUSNO*SIN(THGZ2)/12.
      DUM(3,7) = (SNUY*GZ2+SNUZ*GY2)/12.
      DUM(4,1) =  GXY(GY2,THGX2,ALU)
      DUM(4,2) =  GXSY(SNUY,THGX2,-SNUX,GY2,THGX2,ALU)
      DUM(4,3) =  GXPHI(-SNUZ,GY2,THGX2,SNUY,GZ2,THGX2,ALU)
      DUM(4,4) = -1.
      DUM(5,1) =  GYY(THGY2,ALU)
      DUM(5,2) =  GYSY(SNUY,GX2,THGY2,-SNUX,THGY2,ALU)
      DUM(5,3) =  GYPHI(-SNUZ,THGY2,SNUY,GZ2,THGY2,ALU)
      DUM(5,5) = -1.
      DUM(6,1) =  GZY(GY2,THGZ2,ALU)
      DUM(6,2) =  GZSY(SNUY,GX2,THGZ2,-SNUX,GY2,THGZ2,ALU)
      DUM(6,3) =  GZPHI(-SNUZ,GY2,THGZ2,SNUY,THGZ2,ALU)
      DUM(6,6) = -1.
      IF(KODE(10).EQ.2) GO TO 1020
      CALL DRCSN(THETA)
      ALU1=ALU+1.
       CALL STINT(Q,ALU1,0,1,1,TUSN1,NG)
      IF(NG.NE.0) GO TO 5000
      ALU2=ALU-1.
      CALL STINT(Q,ALU2,0,1,1,TUSN2,NG)
      IF(NG.NE.0) GO TO 5000
      AKTU=(TUSN1-TUSN2)/2.
      AKSNU=AKTU
 1020 CONTINUE
      DUM(7,7) = -1.
      DUM(7,8) =  AKSNU*12.
      DUM(8,1) =  ALY(GY2)
      DUM(8,2) =  ALSY(SNUY,GX2,-SNUX,GY2)
      DUM(8,3) =  ALPHI(-SNUZ,GY2,SNUY,GZ2)
      DUM(8,8) = -1.
      IF(KODE(10).EQ.1) GO TO 1025
      DO 1026 I=1,3
      DO 1026 J 1,3
 1026 SNUD(I,J) =SNUD(I,J)+DUM(I,7)*ADSNU*DUM(8,J)*12.
 1025 CALL MASH(3,8)
      DO 1060 I=1,3
      DO 1060 J=1,3
 1060 TOPL(I,J)= DUM(I,J)
      IF(KODE(10).EQ.1) CALL DRCUSN(THETA)
      DUM(1,2) = -TLSNO*GX3
      DUM(1,3) =  TLSNO*GZ3
      DUM(1,5) = -TLSNO*SIN(THGY3)
      DUM(1,7) =  GY3
      DUM(2,2) =  SNLX*TLSNO*GX3/12.-SNLY*TLSNO*GY3/12.
      DUM(2,3) = -SNLX*TLSNO*GZ3/12.
      DUM(2,4) =  SNLY*TLSNO*SIN(THGX3)/12.
      DUM(2,5) =  SNLX*TLSNO*SIN(THGY3)/12.
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      DUM(2,7) =  (-SNLX*GY3-SNLY*GX3)/12.                              CBL04960
      DUM(3,2) =   SNLZ*TLSNO*GX3/12.                                   CBL04970
      DUM(3,3) =  -SNLZ*TLSNO*GZ3/12.-SNLY*TLSNC*GY3/12.                CBL04980
      DUM(3,5) =   SNLZ*TLSNO*SIN(THGY3)/12.                            CBL04990
      DUM(3,6) =  -SNLY*TLSNO*SIN(THGZ3)/12.                            CBL05000
      DUM(3,7) =   (SNLY*GZ3-SNLZ*GY3)/12.                              CBL05010
      DUM(4,1) =   GXY(GY3,THGX3,ALL)                                   CBL05020
      DUM(4,2) =   GXSY(SNLY,THGX3,-SNLX,GY3,THGX3,ALL)                 CBL05030
      DUM(4,3) =   GXPHI(SNLZ,GY3,THGX3,SNLY,GZ3,THGX3,ALL)             CBL05040
      DUM(4,4) =  -1.                                                   CBL05050
      DUM(5,1) =   GYY(THGY3,ALL)                                       CBL05060
      DUM(5,2) =   GYSY(SNLY,GX3,THGY3,-SNLX,THGY3,ALL)                 CBL05070
      DUM(5,3) =   GYPHI(SNLZ,THGY3,SNLY,GZ3,THGY3,ALL)                 CBL05080
      DUM(5,5) =  -1.                                                   CBL05090
      DUM(6,1) =   GZY(GY3,THGZ3,ALL)                                   CBL05100
      DUM(6,2) =   GZSY(SNLY,GX3,THGZ3,-SNLX,GY3,THGZ3,ALL)             CBL05110
      DUM(6,3) =   GZPHI(SNLZ,GY3,THGZ3,SNLY,THGZ3,ALL)                 CBL05120
      DUM(6,6) =  -1.                                                   CBL05130
      IF(KODE(10).EQ.2) GO TO 1030                                      CBL05140
      CALL DRCSN(THETA)                                                 CBL05150
      ALL1=ALL+1.                                                       CBL05160
      CALL STINT(Q,ALL1,0,1,1,TLSN1,NG)                                 CBL05170
      IF(NG.NE.0) GO TO 5000                                            CBL05180
      ALL2=ALL-1.                                                       CBL05190
      CALL STINT(Q,ALL2,0,1,1,TLSN2,NG)                                 CBL05200
      IF(NG.NE.0) GO TO 5000                                            CBL05210
       AKTL=(TLSN1-TLSN2)/2.                                            CBL05220
      AKSNL=AKTL                                                        CBL05230
 1030 CONTINUE                                                          CBL05240
      DUM(7,7) =  -1.                                                   CBL05250
      DUM(7,8) =   AKSNL*12.                                            CBL05260
      DUM(8,1) =   ALY(GY3)                                             CBL05270
      DUM(8,2) =   ALSY(SNLY,GX3,-SNLX,GY3)                             CBL05280
      DUM(8,3) =   ALPHI(SNLZ,GY3,SNLY,GZ3)                             CBL05290
      DUM(8,8) =  -1.                                                   CBL05300
      IF(KODE(10).EQ.1) GO TO 1035                                      CBL05310
      DO 1036 I=1,3                                                     CBL05320
      DO 1036 J=1,3                                                     CBL05330
 1036 SNUD(I,J)=SNUD(I,J)+DUM(I,7)*ADSNL*DUM(8,J)*12.                   CBL05340
 1035 CALL MASH(3,8)                                                    CBL05350
      DO 1070 I=1,3                                                     CBL05360
      DO 1070 J=1,3                                                     CBL05370
 1070 BOTL(I,J)= DUM(I,J)                                               CBL05380
      IF(KODE(10).EQ.1) CALL DRCUSN(THETA)                              CBL05390
      DUM(1,2) =  -TLSNO*GX4                                            CBL05400
      DUM(1,3) =  TLSNO*GZ4                                             CBL05410
      DUM(1,5) =  -TLSNO*SIN(THGY4)                                     CBL05420
      DUM(1,7) =  GY4                                                   CBL05430
      DUM(2,2) =   SNLX*TLSNO*GX4/12.+SNLY*TLSNC*GY4/12.                CBL05440
      DUM(2,3) =  -SNLX*TLSNO*GZ4/12.                                   CBL05450
      DUM(2,4) =  -SNLY*TLSNO*SIN(THGX4)/12.                            CBL05460
      DUM(2,5) =   SNLX*TLSNO*SIN(THGY4)/12.                            CBL05470
      DUM(2,7) =  (-SNLX*GY3+SNLY*GX4)/12.                              CBL05480
      DUM(3,2) =   SNLZ*TLSNO*GX4/12.                                   CBL05490
      DUM(3,3) =  -SNLZ*TLSNO*GZ4/12.+SNLY*TLSNC*GY4/12.                CBL05500
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      DUM(3,5) =   SNLZ*TLSNO*SIN(THGY4)/12.
      DUM(3,6) =   SNLY*TLSNO*SIN(THGZ4)/12.
      DUM(3,7) =  (-SNLY*GZ4-SNLZ*GY4)/12.
      DUM(4,1) =   GXY(GY4,THGX4,ALL)
      DUM(4,2) =   GXSY(-SNLY,THGX4,-SNLX,GY4,THGX4,ALL)
      DUM(4,3) =   GXPHI(SNLZ,GY4,THGX4,-SNLY,GZ4,THGX4,ALL)
      DUM(4,4) =  -1.
      DUM(5,1) =   GYY(THGY4,ALL)
      DUM(5,2) =   GYSY(-SNLY,GX4,THGY4,-SNLX,THGY4,ALL)
      DUM(5,3) =   GYPHI(SNLZ,THGY4,-SNLY,GZ4,THGY4,ALL)
      DUM(5,5) =  -1.
      DUM(6,1) =   GZY(GY4,THGZ4,ALL)
      DUM(6,2) =   GZSY(-SNLY,GX4,THGZ4,-SNLX,GY4,THGZ4,ALL)
      DUM(6,3) =   GZPHI(SNLZ,GY4,THGZ4,-SNLY,THGZ4,ALL)
      DUM(6,6) =  -1.
      IF(KODE(10).EQ.2) GO TO 1040
      CALL DRCSN(THETA)
      ALL1=ALL+1.
      CALL STINT(Q,ALL1,0,1,1,TLSN1,NG)
      IF(NG.NE.0) GO TO 5000
      ALL2=ALL-1.
      CALL STINT(Q,ALL2,0,1,1,TLSN2,NG)
      IF(NG.NE.0) GO TO 5000
       AKTL=(TLSN1-TLSN2)/2.
      AKSNL=AKTL
 1040 CONTINUE
      DUM(7,7) =  -1.
      DUM(7,8) =   AKSNL*12.
      DUM(8,1) =   ALY(GY4)
      DUM(8,2) =   ALSY(-SNLY,GX4,-SNLX,GY4)
      DUM(8,3) =   ALPHI(SNLZ,GY4,-SNLY,GZ4)
      DUM(8,8) =  -1.
      IF(KODE(10).EQ.1) GO TO 1045
      DO 1046 I=1,3
      DO 1046 J=1,3
 1046  SNUD(I,J)=SNUD(I,J)+DUM(I,7)*ADSNL*DUM(8,J)*12.
 1045 CALL MASH(3,8)
      DO 1080 I=1,3
      DO 1080 J=1,3
 1080 BOTR(I,J)= DUM(I,J)
      DO 1090 I=1,3
      DO 1090 J=1,3
 1090 SNU (I,J)= TOPR(I,J)+TOPL(I,J)+BOTL(I,J)+BOTR(I,J)
      IF(KODE(10).EQ.2) RETURN
      DO 1095 I=1,3
      DO 1095 J=1,3
 1095 SNUD(I,J)=0
      RETURN
 1002 DO 1004 I=1,3
      DO 1004 J=1,3
      SNUD(I,J)=0
 1004 SNU(I,J)=0
      RETURN
      END
      SUBROUTINE TRIM
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C        CABLE  SUSPENSION  SYSTEM  TRIM  ROUTINE
      COMMON /DAT/ AERO(150),AEROP(50),KCDE(20),LL
      COMMON / PLYCHA/RTD,XLGTH(5),ADC(5,3),AFN(5,3),TR,TLFT,TF
      DIMENSION ANG(5,3)
      EQUIVALENCE(AERO( 1),  CDU),(AERO( 2),  CLU),(AERO( 3),  CMU),
     1            (AERO( 4),  CDA),(AERO( 5),  CLA),(AERO( 6),  CMA),
     2            (AERO( 7),  CDQ),(AERO( 8),  CLQ),(AERO( 9),  CMQ),
     3            (AERO(10),  CDO),(AERO(11),  CLO),(AERO(12),  CMO),
     4            (AERO(13), CDDE),(AERO(14), CLDE),(AERO(15), CMDE),
     5            (AERO(16), CDAD),(AERO(17),CLAD),(AERO(18),CMAD),
     6            (AERO(19),  CYB),(AERO(20),  CLB),(AERO(21),  CNB),
     7            (AERO(22),  CYP),(AERO(23),  CLP),(AERO(24),  CNP),
     8            (AERO(25),  CYR),(AERO(26),  CLR),(AERO(27),  CNR),
     9            (AERO(28), CYDR),(AERO(29), CLDR),(AERO(30), CNDR),
     A            (AERO(31), CYDA),(AERO(32), CLDA),(AERO(33), CNDA),
     B            (AERO(34), CYDS),(AERO(35), CLDS),(AERO(36), CNDS)
      EQUIVALENCE(AERO(46),XCG),(AERO(47),ZCG)
      EQUIVALENCE(AERO (48),AMACH),(AERO (49),VC   ),(AERO (50),   AM)
      EQUIVALENCE(AERO (51),RHO  ),(AERO (52),   WT),(AERO (53),B    )
      EQUIVALENCE(AERO (54),CBAR ),(AERO (55),SW   ),(AERO (56), XIXZ)
      EQUIVALENCE(AERO (57),XIXX ),(AERO (58),YIYY ),(AERO (59),ZIZZ )
      EQUIVALENCE(AERO (60),CLT  ),(AERO (61),CDT  ),(AERO (62),CMT  ),
     1(AERO(63),THETA)
      EQUIVALENCE(AERO (66), WLUF),(AERO(67), WLLF),(AERO(68), WLUR),
     1            (AERO (69), WLLR),(AERO(70), WLHF),(AERO(71), WLHR),
     2            (AERO (72), STAF),(AERO(73), STAR),(AERO(74), BLHF),
     3            (AERO (75), BLHR),(AERO(76), WLCR),(AERO(77),STACR),
     4            (AERO (78), BLCR),(AERO(79),   EF),(AERO(80),   ER),
     5            (AERO (81),   AF),(AERO(82),   AR),(AERO(83), HUCF),
     6            (AERO (84), HLCF),(AERO(85), HUCR),(AERO(86), HLCR),
     7            (AERO (87),  DCF),(AERO(88),  DCR),(AERO(89),  ALF),
     8            (AERO (90),  RVF),(AERO(91),  RHF),(AERO(92),  RVR),
     9            (AERO(93),   RHR),(AERO(94),  TFO),(AERO(95),  AKR),
     A            (AERO(96), ALRC),(AERO(97),STLTT),(AERO(98),WLLTT),
     B            (AERO(99),TLFTO),(AERO(100),AKLFT),(AERO(101),ALLTO),
     C            (AERO(102),ALTX),(AERO(103),ALTZ)
      EQUIVALENCE(AEROP( 1), CXUP),(AEROP( 2), CZUP),(AEROP( 3), CMUP),
     1            (AEROP( 4), CXAP),(AEROP( 5), CZAP),(AEROP( 6), CMAP),
     2            (AEROP( 7), CXQP),(AEROP( 8), CZQP),(AEROP( 9), CMQP),
     3            (AEROP(10), CXOP),(AEROP(11), CZOP),(AEROP(12), CMOP),
     4            (AEROP(13),CXDEP),(AEROP(14),CZDEP),(AEROP(15),CMDEP),
     5            (AEROP(16),CXADP),(AEROP(17),CZADP),(AEROP(18),CMADP),
     6            (AEROP(19), CYBP),(AEROP(20), CLBP),(AEROP(21), CNBP),
     7            (AEROP(22), CYPP),(AEROP(23), CLPP),(AEROP(24), CNPP),
     8            (AEROP(25), CYRP),(AEROP(26), CLRP),(AEROP(27), CNRP),
     9            (AEROP(28),CYDRP),(AEROP(29),CLDRP),(AEROP(30),CNDRP),
     A            (AEROP(31),CYDAP),(AEROP(32),CLDAP),(AEROP(33),CNDAP),
     B            (AEROP(34),CYDSP),(AEROP(35),CLDSP),(AEROP(36),CNDSP)
      RTD=57.2958
      THETA=0.
      DELALF=.001
      DTF=.1
      DALFAW=0.0
      DDELTE=0.0
      DTHRST=0.0
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      ICNTR=0
      FIRST=0.
      THINT=0.
      ALFINT=THETA
      DELINT=0.
      THRSTO=THINT
      ALFAWO=ALFINT
      DELTEO=DELINT
      QS=RHO*VO*VO*.5*SW
  209 THRSTI=THRSTO+DTHRST
      ALFAWI=ALFAWO+DALFAW
      DELTEI=DELTEO+DDELTE
      ICNTR=ICNTR+1
      IF(ICNTR.GT.100)GO TO 520
      VAL1=ALFAWI*RTD
      VAL2=DELTEI*RTD
      VAL3=THRSTI
      CALL EQU(ALFAWI,DELTEI,THRSTI,F0,G0,H0,FIRST)
      IF(FIRST.NE.1.)FIRST=1.
C  COMPUTES PARTIALS
      ALFAWI=ALFAWI+DELALF*0.5
      CALL EQU(ALFAWI,DELTEI,THRSTI,F1,G1,H1,1.)
      ALFAWI=ALFAWI-DELALF
      CALL EQU(ALFAWI,DELTEI,THRSTI,F2,G2,H2,1.)
      ALFAWI=ALFAWI+DELALF*0.5
      FALFWO=(F1-F2)/DELALF
      GALFWO=(G1-G2)/DELALF
      HALFWO=(H1-H2)/DELALF
      FDELEO=-QS*(CLDE*COS(ALFAWI)+CDDE*SIN(ALFAWI))
      GDELEO=QS*(CLDE*SIN(ALFAWI)-CDDE*COS(ALFAWI))
      HDELEO=QS*CBAR*CMDE
      THRSTI=THRSTI+DTF
      CALL EQU(ALFAWI,DELTEI,THRSTI,F1,G1,H1,1.)
      THRSTI=THRSTI-2.*DTF
      CALL EQU(ALFAWI,DELTEI,THRSTI,F2,G2,H2,1.)
      THRSTI=THRSTI+DTF
      FTHSTO=(F1-F2)/DTF
      GTHSTO=(G1-G2)/DTF
      HTHSTO=(H1-H2)/DTF
C     SET UP ITERATION EQUATIONS
      FI=F0+FALFWO*DALFAW+FDELEO*DDELTE+FTHSTO*DTHRST
      GI=G0+GALFWO*DALFAW+GDELEO*DDELTE+GTHSTO*DTHRST
      HI=H0+HALFWO*DALFAW+HDELEO*DDELTE+HTHSTO*DTHRST
      ACCZ=FI/AM
      ACCX=GI/AM
      THEDOT=HI/YIYY
      IF(ABS(ACCZ).LT..01)GO TO 1005
      GO TO 1100
 1005 IF(ABS(ACCX).LT..01)GO TO 1007
      GO TO 1100
 1007 IF(ABS(THEDOT).LE.0.001)GO TO 42
C     NOW COMPUTE PARAMETER INCREMENTS FROM MATRIX EQUATIONS
 1100 DETRM=FALFWO*GDELEO*HTHSTO+FDELEO*GTHSTO*HALFWO+FTHSTO*GALFWO*
     1HDELEO-FTHSTO*GDELEO*HALFWO-FALFWO*GTHSTO*HDELEO-FDELEO*GALFWO*
     2HTHSTO
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      DALFAW=(-(GDELEO*HTHSTO-GTHSTO*HDELEO)*FC+(FDELEO*HTHSTO-FTHSTO
     1*HDELEO)*GO-(FDELEO*GTHSTO-FTHSTO*GDELEO)*HC)/DETRM
      DDELTE=(+(GALFWO*HTHSTO-GTHSTO*HALFWO)*FC-(FALFWO*HTHSTO-HALFWO
     1*FTHSTO)*GO+(FALFWO*GTHSTO-FTHSTO*GALFWO)*HC)/DETRM
      DTHRST=(-(GALFWO*HDELEO-GDELEO*HALFWO)*FC+(FALFWO*HDELEO-FDELEO
     1*HALFWO)*GO-(FALFWO*GDELEO-FDELEO*GALFWO)*HC)/DETRM
      THRSTO=THRSTI
      ALFAWO=ALFAWI
      DELTEO=DELTEI
      GO TO 209
  520 WRITE(6,521)
  521 FORMAT('   TRIM ITERATION EXCEEDS LIMITS')
      GO TO 522
   42 CALL EQU(ALFAWI,DELTEI,THRSTI,FC,GC,HC,1.)
  522 DO 523 IZZ=1,4
      DO 523 IZK=1,3
      ANG(IZZ,IZK)=ADC(IZZ,IZK)*RTD
  523 CONTINUE
      THETA=ALFAWI
      DE=DELTEI
      TF=THRSTI
      THETD=THETA*RTD
      DED=DE*RTD
      DO 524 IZZ=1,4
      IF(KODE(5).EQ.0) GO TO 528
      WRITE(6,525)IZZ,XLGTH(IZZ),(ANG(IZZ,IZK),ARM(IZZ,IZK),IZK=1,3)
  525 FORMAT(' CABLE GEOMETRY-CABLE NO.',I2,5X,'CABLE LENGTH=',E15.6,
     1' IN',/,3X,'  DIR. COS.=DEG    ARM-IN',/,(3(3X,2E15.6,/)),//)
  524 CONTINUE
      WRITE(6,526)ICNTR,ACCZ,ACCX,THEDOT
  526 FORMAT(' ITERATION PARAMETER =',I5,/,2X,'ACCZ  =',E15.8,
     1/,2X,'ACCX  =',E15.8,/,2X,'THEDOT=',E15.8,' RAD/SEC')
  528 WRITE(6,527)THETD,DED,TF,TR
  527 FORMAT(//,'VEH. ATT.,DEFLTN.& CABLE TENSION',/,
     12X,'THETA  =',F6.2,' DEG',/,2X,'DELTA  =',F6.2,' DEG',/,2X
     2,'FRT CAB. TENSION=',E15.6,' LBS',/,
     32X,'RR CAB. TENSION =',E15.6,' LBS')
      RETURN
      END
      SUBROUTINE EQU(THETA,DE,TF,FF,GG,HH,FIRST)
C        CABLE  SUSPENSION  SYSTEM  TRIM  EQUATIONS
      COMMON /DAT/ AERO(150),AEROP(50),KODE(20),LL
      COMMON / PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,DUMMY
      REAL*8 XNM1,XNM2,YNM1,YNM2
      EQUIVALENCE(AERO( 1),  CDU),(AERO( 2),  CLU),(AERO( 3),  CMU),
     1           (AERO( 4),  CDA),(AERO( 5),  CLA),(AERO( 6),  CMA),
     2           (AERO( 7),  CDQ),(AERO( 8),  CLQ),(AERO( 9),  CMQ),
     3           (AERO(10),  CDO),(AERO(11),  CLO),(AERO(12),  CMO),
     4           (AERO(13), CDDE),(AERO(14), CLDE),(AERO(15), CMDE),
     5           (AERO(16), CDAD),(AERO(17),CLAD),(AERO(18),CMAD),
     6           (AERO(19),  CYB),(AERO(20),  CLB),(AERO(21),  CNB),
     7           (AERO(22),  CYP),(AERO(23),  CLP),(AERO(24),  CNP),
     8           (AERO(25),  CYR),(AERO(26),  CLR),(AERO(27),  CNR),
     9           (AERO(28), CYDR),(AERO(29), CLDR),(AERO(30), CNDR),
     A           (AERO(31), CYDA),(AERO(32), CLDA),(AERO(33), CNDA),
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     B          (AERO(34), CYDS),(AERO(35), CLDS),(AERO(36), CNDS)
      EQUIVALENCE(AERO(46),XCG) ,(AERO(47),ZCG)
      EQUIVALENCE(AERO (48),AMACH),(AERO (49),VC   ),(AERO (50),   AM)
      EQUIVALENCE(AERO (51),RHO  ),(AERO (52),   WT),(AERO (53),B    )
      EQUIVALENCE(AERO (54),CBAR ),(AERO (55),SW   ),(AERO (56), XIXZ)
      EQUIVALENCE(AERO (57),XIXX ),(AERO (58),YIYY ),(AERO (59),ZIZZ )
      EQUIVALENCE(AERO (60),CLT  ),(AERO (61),CCT  ),(AERO (62),CMT  )
      EQUIVALENCE(AERO (66), WLUF),(AERO(67), WLLF),(AERO(68), WLUR),
     1          (AERO (69), WLLR),(AERO(70), WLHF),(AERO(71), WLHR),
     2          (AERO (72), STAF),(AERO(73), STAR),(AERO(74), BLHF),
     3          (AERO (75), BLHR),(AERO(76), WLCR),(AERO(77),STACR),
     4          (AERO (78), BLCR),(AERO(79),   EF),(AERO(80),   ER),
     5          (AERO (81),   AF),(AERO(82),   AR),(AERO(83), HUCF),
     6          (AERO (84), HLCF),(AERO(85), HUCR),(AERO(86), HLCR),
     7          (AERO (87),  DCF),(AERO(88),  DCR),(AERO(89),  ALF),
     8          (AERO (90),  RVF),(AERO(91),  RHF),(AERO(92),  RVR),
     9          (AERO(93),  RHR),(AERO(94),  TFO),(AERO(95),  AKR),
     A          (AERO(96), ALRO),(AERO(97),STLTT),(AERO(98),WLLTT),
     B          (AERO(99),TLFTO),(AERO(100),AKLFT),(AERO(101),ALLTO),
     C          (AERO(102),ALTX),(AERO(103),ALTZ)
      DATA XNM1,XNM2 /'VERTICAL','HORIZNTL'/
      RTD=57.2958
      VAL1=THETA
      Q = RHO*VO*VO/2.0
   64 IND=KODE(6)
      GO TO (501,502,503,504),IND
  501 YNM1=XNM1
      YNM2=XNM2
      CALL FPLYV(STAF,WLUF,WLLF,HUCF,HLCF,EF,FVF,THETA,1)
      CALL RPLYH(STAR,BLHR,WLHR,-AR,DCR,0.,RHF,THETA,3)
      GO TO 505
  502 YNM1=XNM2
      YNM2=XNM1
      CALL RPLYH(STAF,BLHF,WLHF,AF,DCF,0.,RHF,THETA,1)
      CALL FPLYV(STAR,WLUR,WLLR,HUCR,HLCR,ER,FVF,THETA,3)
      GO TO 505
  503 YNM1=XNM1
      YNM2=XNM1
      CALL FPLYV(STAF,WLUF,WLLF,HUCF,HLCF,EF,FVF,THETA,1)
      CALL FPLYV(STAR,WLUR,WLLR,HUCR,HLCR,ER,FVF,THETA,3)
      GO TO 505
  504 YNM1=XNM2
      YNM2=XNM2
      CALL RPLYH(STAF,BLHF,WLHF,AF,DCF,0.,RHF,THETA,1)
      CALL RPLYH(STAR,BLHR,WLHR,-AR,DCR,0.,RHF,THETA,3)
  505 IF(KODE(11))506,507,506
  506 WLLT = WLCR + ALTX*SIN(THETA) - ALTZ*COS(THETA)
      STALT = STACR - ALTX*COS(THETA) - ALTZ*SIN(THETA)
      XLGTH(5) = SQRT((WLLTT - WLLT)**2 + (STLTT - STALT)**2)
      IF(FIRST.NE.0.)GO TO 12
      ELLO=XLGTH(5)
   12 ELL=XLGTH(5)
      TLFT = TLFTO+AKLFT*(ELL-ELLO)
      ARM(5,1)=ALTX
      ARM(5,2)=0
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      ARM(5,3)=ALTZ                                                     CBL08260
      FXLTT = (TLFT*(STALT - STLTT))/XLGTH(5)                           CBL08270
      FZLTT = (TLFT*(WLLT - WLLTT))/XLGTH(5)                            CBL08280
      FXLTB = FXLTT*COS(THETA) - FZLTT*SIN(THETA)                       CBL08290
      FZLTB = FZLTT*COS(THETA) + FXLTT*SIN(THETA)                       CBL08300
      YMLFT =( FXLTB*ALTZ - FZLTB*ALTX)/12.                             CBL08310
      ADC(5,1)=ARCOS(FXLTB/TLFT)                                        CBL08320
      ADC(5,2)=3.14159/2.                                               CBL08330
      ADC(5,3)=ARCOS(FZLTB/TLFT)                                        CBL08340
      GO TO 508                                                         CBL08350
  507 FXLTB=0.                                                          CBL08360
      FZLTB=0.                                                          CBL08370
      YMLFT=0.                                                          CBL08380
      TLFT=0                                                            CBL08390
      XLGTH(5)=0.                                                       CBL08400
      DO 13 IA=1,3                                                      CBL08410
      ARM(5,IA)=0.                                                      CBL08420
      ADC(5,IA)=0.                                                      CBL08430
   13 CONTINUE                                                          CBL08440
  508 CALL SNTRM(FXSN,FZSN,EMSN,THETA)                                  CBL08450
      IF (FIRST.NE.0.)GO TO 510                                         CBL08460
      IF(KODE(5).EQ.0) GO TO 512                                        CBL08470
      WRITE(6,509)YNM1,YNM2                                             CBL08480
  509 FORMAT(' CABLE CONFIGURATION ON MODEL',/,                         CBL08490
     1' FRONT CABLE IS ',A8,' AND REAR CABLE IS ',A8)                   CBL08500
  512 EL0=XLGTH(3)+XLGTH(4)                                             CBL08510
  510 EL =XLGTH(3)+XLGTH(4)                                             CBL08520
      TR=TR0+AKR*(EL-EL0)                                               CBL08530
      ELIFT=Q*SW*(CL0+CLA*THETA+CLDE*DE)                                CBL08540
      ADRAG=Q*SW*(CD0+CDA*THETA+CDDE*DE)                                CBL08550
      FXAIR=-ADRAG*COS(THETA)+ELIFT*SIN(THETA)                          CBL08560
      FZAIR=-ADRAG*SIN(THETA)-ELIFT*COS(THETA)                          CBL08570
      WGTX=-32.2*AM*SIN(THETA)                                          CBL08580
      WGTZ=32.2*AM*COS(THETA)                                           CBL08590
      EMWGT=(ZCG*WGTX-XCG*WGTZ)/12.                                     CBL08600
      FXCR=TR*(COS(ADC(3,1))+COS(ADC(4,1)))                             CBL08610
      FZCR=TR*(COS(ADC(3,3))+COS(ADC(4,3)))                             CBL08620
      FXCFF=TF*(COS(ADC(1,1))+COS(ADC(2,1)))                            CBL08630
      FZCFF=TF*(COS(ADC(1,3))+COS(ADC(2,3)))                            CBL08640
      EMOC=0.                                                           CBL08650
      DO 511 I=1,4                                                      CBL08660
      TENS=TF                                                           CBL08670
      IF(I.GT.2)TENS=TR                                                 CBL08680
      EMOC=EMOC+TENS*(COS(ADC(I,1))*ARM(I,3)-COS(ADC(I,3))*ARM(I,1))    CBL08690
  511 CONTINUE                                                          CBL08700
      EMOC=EMOC/12.                                                     CBL08710
      AEROM=Q*SW*CBAR*(CM0+CMA*THETA+CMDE*DE)                           CBL08720
      FF=FZCFF+FZCR+FZLTB+FZSN+WGTZ+FZAIR                               CBL08730
      GG=FXCFF+FXCR+FXLTB+FXSN+WGTX+FXAIR                               CBL08740
      HH=EMOC+YMLFT+EMSN+EMWGT+AEROM                                    CBL08750
      RETURN                                                            CBL08760
      END                                                               CBL08770
      SUBROUTINE FPLYV(STAV,WLU,WLL,HHU,HHL,EF,FAC,THETA,IF)            CBL08780
      COMMON /DAT/AERO(150),AEROP(50),KODE(20),LL                       CBL08790
      COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TF,TLFT,TF          CBL08800
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```
      EQUIVALENCE (AERO(76),WLCR),(AERO(77),STACR),(AERO(78),BLCR)
      PI=3.14159
      GAMU= ATAN(HHU/EP)
      T1= EP*EP +HHU*HHU
      T2= THETA +GAMU
      IF( IF.EQ.3) T2=GAMU-THETA
      WLUC= WLCR +SQRT(T1)*SIN(T2)
      T3= WLU -WLUC
      T4= ABS(STACR -STAV) -SQRT(T1)*COS(T2)
      XLUP= SQRT(T3*T3+T4*T4)
      XLU= SQRT(XLUP*XLUP -RAD*RAD)
      BUP= ATAN(T3/T4)
      DBU= ATAN(RAD/XLU)
      BETAU=(BUP -DBU)*RTD
      GAML= ATAN(HHL/EP)
      T5= EP*EP +HHL*HHL
      T6= THETA -GAML
      IF( IF.EQ.3) T6=-(THETA+GAML)
      WLLC= WLCR +SQRT(T5)*SIN(T6)
      T7= WLLC -WLL
      T8= ABS(STACR -STAV) -SQRT(T5)*COS(T6)
      XLLP= SQRT(T7*T7 +T8*T8)
      XLL= SQRT(XLLP*XLLP -RAD*RAD)
      BLP= ATAN(T7/T8)
      DBL= ATAN(RAD/XLL)
      BETAL= (BLP -DBL)*RTD
      IF( IF.EQ.1)GO TO 1
      XLGTH( 3)=XLU
      XLGTH( 4)=XLL
      ADC( 3, 1)=BETAU/RTD-THETA+PI
      ADC( 3, 2)=-PI/2.
      ADC( 3, 3)=PI/2.-ADC(3,1)
      ADC( 4, 1)=PI-(BETAL/RTD-THETA)
      ADC( 4, 2)=-PI/2
      ADC( 4, 3)=PI/2-ADC(4,1)
      ARM( 3, 1)=-EP+RAD*SIN(ADC(3,1))
      ARM( 3, 2)=0.
      ARM( 3, 3)=-HHU+RAD*COS(ADC(3,1))
      ARM( 4, 1)=-EP-RAD*SIN(ADC(4,1))
      ARM( 4, 2)=0.
      ARM( 4, 3)=HHL-RAD*COS(ADC(4,1))
      RETURN
    1 XLGTH( 1)=XLU
      XLGTH( 2)=XLL
      ADC( 1, 1)=-BETAU/RTD+THETA
      ADC( 1, 2)=PI/2.
      ADC( 1, 3)=PI/2.-ADC(1,1)
      ADC( 2, 1)=BETAL/RTD+THETA
      ADC( 2, 2)=PI/2.
      ADC( 2, 3)=PI/2.-ADC(2,1)
      ARM( 1, 1)=EP+RAD*SIN(ADC(1,1))
      ARM( 1, 2)=0.
      ARM( 1, 3)=-HHU-RAD*COS(ADC(1,1))
      ARM( 2, 1)=EP-RAD*SIN(ADC(2,1))
      ARM( 2, 2)=0.
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      ARM(2,3)=HHL+RAD*COS(ADC(2,1))
      RETURN
      END
      SUBROUTINE RPLYH(STAD,BLD,WLD,XP,YP,ZP,FAC,THETA,IF)
      COMMON /DAT/AERO(150),AEROP(50),KODE(20),LL
      COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TF,TLFT,TF
      EQUIVALENCE(AERO(76),WLCR),(AERO(77),STACR),(AERO(78),BLCR)
      PI=3.14159
      XWT=STACR-STAD
      ZWT=WLCR-WLD
      XB=XWT*COS(THETA)-ZWT*SIN(THETA)
      ZB=XWT*SIN(THETA)+ZWT*COS(THETA)
      T9= BLD -YP
      T10=XB-XP
      XLHIP= SQRT(T9*T9 +T10*T10)
      BHIP= ATAN2(T9,T10)
      XLHI= SQRT(XLHIP*XLHIP -RAD*RAD)
      DBHI= ATAN(RAD/XLHI)
      BHI= BHIP -DBHI
      T11=ZB-ZP
      XL=SQRT(XLHI*XLHI+T11*T11)
      TH10=T10-RAD*COS(BHI)
      TH9=T9-RAD*SIN(BHI)
      IF(IF.EQ.3)GO TO 3
      XLGTH(1)=XL
      XLGTH(2)=XL
      ADC(1,1)=ARCOS(TH10/XL)
      ADC(1,2)=ARCOS(TH9/XL)
      ADC(1,3)=ARCOS(T11/XL)
      ADC(2,1)=-ADC(1,1)
      ADC(2,2)=PI-ADC(1,2)
      ADC(2,3)=ADC(1,3)
      ARM(1,1)=XP-RAD*SIN(BHI)
      ARM(1,2)=YP+RAD*COS(BHI)
      ARM(1,3)=0.
      ARM(2,1)=ARM(1,1)
      ARM(2,2)=-ARM(1,2)
      ARM(2,3)=0.
      RETURN
    3 XLGTH(3)=XL
      XLGTH(4)=XL
      ADC(3,1)=ARCOS(TH10/XL)
      ADC(3,2)=ARCOS(TH9/XL)
      ADC(3,3)=ARCOS(T11/XL)
      ADC(4,1)=-ADC(3,1)
      ADC(4,2)=PI-ADC(3,2)
      ADC(4,3)=ADC(3,3)
      ARM(3,1)=XP+RAD*SIN(BHI)
      ARM(3,2)=YP-RAD*COS(BHI)
      ARM(3,3)=0.
      ARM(4,1)=ARM(3,1)
      ARM(4,2)=-ARM(3,2)
      ARM(4,3)=0.
      RETURN
      END
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      SUBROUTINE DLGTH(C1,C2,C3,IC,IDX)                                 CBL09910
C   COMPUTES DEL-LGTH EQ FOR X-Z-THETA OR Y-PSI-PHI COEFF               CBL09920
      COMMON/PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TF,TLFT,TF           CBL09930
      IF( IDX .NE. 0)GO TO 1                                            CBL09940
      C1=-COS(ADC(IC,1))                                                CBL09950
      C2=-COS(ADC(IC,3))                                                CBL09960
      C3=( ARM( IC, 1)*COS(ADC(IC,3))-ARM(IC,3)*COS(ADC(IC,1)))/12.     CBL09970
      RETURN                                                            CBL09980
    1 C1=-COS(ADC(IC,2))                                                CBL09990
      C2=( ARM( IC,2)*COS(ADC(IC,1))-ARM(IC,1)*COS(ADC(IC,2)))/12.      CBL10000
      C3=( ARM( IC,3)*COS(ADC(IC,2))-ARM(IC,2)*COS(ADC(IC,3)))/12.      CBL10010
      RETURN                                                            CBL10020
      END                                                               CBL10030
      SUBROUTINE DCOSLG(IC,CX1,CZ1,CT1,CX3,CZ3,CT3)                     CBL10040
C   COMPUTES D-DIR COS EQS FOR X-Z-THETA COEFF.                         CBL10050
      COMMON/PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TF,TLFT,TF           CBL10060
      CX1=SIN(ADC( IC, 1))/XLGTH(IC)*12.                                CBL10070
      CZ1=-COS(ADC( IC,3))*COTAN(ADC(IC,1))/XLGTH(IC)*12.               CBL10080
      XWT=ARM( IC, 1)                                                   CBL10090
      ZWT=ARM( IC, 3)                                                   CBL10100
      CT1=(ZWT*SIN(ADC( IC,1))+XWT*COS(ADC(IC,3))*COTAN(ADC(IC,1)))/    CBL10110
     1XLGTH( IC)                                                        CBL10120
      CX3=-COS(ADC( IC, 1))*COTAN(ADC(IC,3))/XLGTH(IC)*12.              CBL10130
      CZ3=SIN(ADC( IC,3))/XLGTH(IC)*12.                                 CBL10140
      CT3=-( ZWT*COS(ADC(IC,1))*COTAN(ADC(IC,3))+XWT*SIN(ADC(IC,3)))    CBL10150
     1/XLGTH( IC)                                                       CBL10160
      RETURN                                                            CBL10170
      END                                                               CBL10180
C   THIS IS A SINGLE PRECISION VERSION OF CABLE4 TO BE USED             CBL10190
C   WITH THE LRC MATRIX REDUCTION AND IBM ROOT                          CBL10200
C   FINDING ROUTINE                                                     CBL10210
      SUBROUTINE LONG                                                   CBL10220
      COMMON /DAT/ AERO(150),AEROP(50),KODE(20),LL                      CBL10230
      COMMON / PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TF,TLFT,TF         CBL10240
      COMMON /DU/DUM(10,10)                                             CBL10250
      EQUIVALENCE(AERO(46),   XCG),(AERO(47),   ZCG)                    CBL10260
      EQUIVALENCE(AERO (63),THETA),(AERO (49),VO   ),(AERO (50),    AM) CBL10270
      EQUIVALENCE(AERO (51),RHO  ),(AERO (52),    WT),(AERO (53),B    ) CBL10280
      EQUIVALENCE(AERO (54),CBAR ),(AERO (55),SW   ),(AERO (56), XIXZ)  CBL10290
      EQUIVALENCE(AERO (57),XIXX ),(AERO (58),YIYY ),(AERO (56),ZIZZ ), CBL10300
     1            (AERO(95),AKR),(AERO(100),AKLFT)                      CBL10310
      EQUIVALENCE(AERO(123), AKSY),(AERO(124),AKPHI),(AERO(125),AKTHE), CBL10320
     1            (AERO(126), AKAZ),(AERO(127), T1SY),(AERO(128),T2PHI), CBL10330
     2            (AERO(129),T3THE),(AERO(130), T4AZ)                   CBL10340
      EQUIVALENCE(AEROP( 1), CXUP),(AEROP( 2), CZUP),(AEROP( 3), CMUP), CBL10350
     1            (AEROP( 4), CXAP),(AEROP( 5), CZAP),(AEROP( 6), CMAP), CBL10360
     2            (AEROP( 7), CXQP),(AEROP( 8), CZQP),(AEROP( 9), CMQP), CBL10370
     3            (AEROP(10), CXOP),(AEROP(11), CZOP),(AEROP(12), CMOP), CBL10380
     4            (AEROP(13),CXDEP),(AEROP(14),CZDEP),(AEROP(15),CMDEP), CBL10390
     5            (AEROP(16),CXADP),(AEROP(17),CZADP),(AEROP(18),CMADP), CBL10400
     6            (AEROP(19), CYBP),(AEROP(20), CLBP),(AEROP(21), CNBP), CBL10410
     7            (AEROP(22), CYPP),(AEROP(23), CLPP),(AEROP(24), CNPP), CBL10420
     8            (AEROP(25), CYRP),(AEROP(26), CLRP),(AEROP(27), CNRP), CBL10430
     9            (AEROP(28),CYDRP),(AEROP(29),CLDRP),(AEROP(30),CNDRP), CBL10440
     A            (AEROP(31),CYDAP),(AEROP(32),CLDAP),(AEROP(33),CNDAP), CBL10450
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    8               (AEROP(34),CYDSP),(AEROP(35),CLCSF),(AEROP(36),CNDSP)
      DIMENSION CMAT(7,7,3)
      COMPLEX ROOTS(29)
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUD(3,3)
      COMMON /ROUGH/FRIC(3,6)
      DIMENSION FXS(3,4)
      DO 10 J=1,3
      DO 10 K=1,4
   10 FXS(J,K)=0.
      DO 1 IC=1,5
      DO 3 J=1,10
      DO 3 K=1,10
    3 DUM(J,K)=0.
      TENS=TF
      IF( IC.GT.2) TENS=TR
      IF( IC.GT.4) TENS=TLFT
      DUM( 1, 2)= - TENS * COS(ADC(IC,3))
      DUM( 1, 5)= - TENS * SIN (ADC(IC,1))
      DUM( 2, 2)= TENS * COS(ADC(IC,1))
      DUM( 2, 6)= - TENS * SIN(ADC(IC,3))
      DUM( 3, 2)=( ARM(IC,3)*DUM(1,2)-ARM(IC,1)*DUM(2,2))/12.
      DUM( 3, 5)= ARM( IC,3)*DUM(1,5)/12.
      DUM( 3, 6)=-ARM( IC,1)*DUM(2,6)/12.
      IF( IC.GT.2) GO TO 2
      DUM( 1, 3)=COS(ADC(IC,1))
      DUM( 2, 3)=COS(ADC( IC,3))
      DUM( 3, 3)=(ARM( IC,3)*DUM(1,3)-ARM(IC,1)*DUM(2,3))/12.
      CALL DLGTH (CX,CZ,CT,1,0)
      CALL DLGTH (CXP,CZP,CTP,2,0)
      CX = CX + CXP
      XPZ =-(CZ+CZP)/CX
      DUM( 4, 1) =XPZ
      XPT =-(CT+CTP)/CX
      DUM( 4, 2)=XPT
      DUM( 4, 4)= -1
      CALL DCOSLG ( IC,DUM(5,4),DUM(5,1),DUM(5,2),DUM(6,4),
     1DUM( 6, 1),DUM( 6, 2))
      DUM( 5, 5)=-1
      DUM( 6, 6)=-1
      CALL MASH( 3,6)
      DO 4 J=1,3
      DO 4 K=1,3
    4 FXS(J,K)=FXS( J,K)+DUM(J,K)
      GO TO 1
    2 IF( IC.GT.4)GO TO 5
      DUM( 1, 4)=COS(ADC( IC,1))
      DUM( 2, 4)=COS(ADC( IC,3))
      DUM( 3, 4)=(ARM( IC,3)*DUM(1,4)-ARM(IC,1)*DUM(2,4))/12.
      CALL DLGTH(CX,CZ,CT,3,0)
      CALL DLGTH(CXP,CZP,CTP,4,0)
      DUM( 7, 1)=CZ+CZP
      DUM( 7, 2)=CT+CTP
      DUM( 7, 3)=CX+CXP
      DUM( 4, 7)=AKR*12.
    8 CALL DCOSLG( IC,DUM(5,3),DUM(5,1),DUM(5,2),DUM(6,3),DUM(6,1),DUM
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     1(6,2))
      DUM(4,4)=-1
      DUM(5,5)=-1
      DUM(6,6)=-1
      DUM(7,7)=-1
      CALL MASH(3,7)
      DO 6 J=1,3
      DO 6 K=1,3
      IF(K.NE.3)FXS(J,K)=FXS(J,K)+DUM(J,K)
    6 IF(K.EQ.3)FXS(J,4)=FXS(J,4)+DUM(J,K)
      GO TO 1
    5 IF(KODE(11).EQ.0)GO TO 1
      CALL DLGTH(DUM(7,3),DUM(7,1),DUM(7,2),5,0)
      DUM(4,7)=AKLFT*12.
      GO TO 8
    1 CONTINUE
C  ADD SNUBBER INCREMENTS
      CALL LONGSN
      DO 7 J=1,3
      FXS(J,1)=FXS(J,1)+SNU(J,2)
      FXS(J,2)=FXS(J,2)+SNU(J,3)
    7 FXS(J,4)=FXS(J,4)+SNU(J,1)
      CALL FRICT(0)
C  THE CABLE FORCES/MOMENTS PARTIALS ARE COMPLETED
C  AERO. DATA IS NOW COMPUTED
      Q=RHO*VO*VO/2.
      QS=Q*SW
      QSV=QS/VO
      XU=CXUP*QSV
      ZU=CZUP*QSV
      EMU=CMUP*QSV*CBAR
      XA=CXAP*QSV
      ZA=CZAP*QSV
      EMA=CMAP*QSV*CBAR
      XQ=CXQP*QSV*CBAR/(VO*2.)
      ZQ=CZQP*QSV*CBAR/(VO*2.)
      EMQ=CMQP*QSV*CBAR/2.
      XDE=CXDEP*QS
      ZDE=CZDEP*QS
      EMDE=CMDEP*QS*CBAR
      XAD=CXADP*QSV*CBAR/(VO*2.)
      ZAD=CZADP*QSV*CBAR/(VO*2.)
      EMAD=CMADP*QSV*CBAR/(2.*VO)
      IROW=7
      ICOL=7
      IORDER=3
      DO 20 I=1,IROW
      DO 20 J=1,ICOL
      DO 20 K=1,IORDER
   20 CMAT(I,J,K)=0.
C  FX EQUATION
      CMAT(1,1,1)=-FXS(1,1)
      CMAT(1,1,2)=-XA-SNUD(1,2)-FRIC(1,5)-FRIC(1,2)
      CMAT(1,1,3)=-XAD
      CMAT(1,2,1)=-FXS(1,2)+WT*COS(THETA)-XA*VC
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      CMAT(1,2,2)=-XQ-XAD*VO-SNUD(1,3)-FRIC(1,6)-FRIC(1,3)
      CMAT(1,2,3)=ZCG*AM/12.
      CMAT(1,3,1)=-FXS(1,3)
      CMAT(1,4,1)=-FXS(1,4)
      CMAT(1,4,2)=-XL-SNUD(1,1)-FRIC(1,4)-FRIC(1,1)
      CMAT(1,4,3)=AM
      CMAT(1,5,1)=-XDE
C  FZ EQUATION
      CMAT(2,1,1)=-FXS(2,1)
      CMAT(2,1,2)=-ZA-SNUD(2,2)-FRIC(2,5)-FRIC(2,2)
      CMAT(2,1,3)=AM-ZAD
      CMAT(2,2,1)=-FXS(2,2)+WT*SIN(THETA)-ZA*VO
      CMAT(2,2,2)=-ZQ-ZAD*VO-SNUD(2,3)-FRIC(2,6)-FRIC(2,3)
      CMAT(2,2,3)=-XCG*AM/12.
      CMAT(2,3,1)=-FXS(2,3)
      CMAT(2,4,1)=-FXS(2,4)
      CMAT(2,4,2)=-ZL-SNUD(2,1)-FRIC(2,4)-FRIC(2,1)
      CMAT(2,5,1)=-ZDE
C  MOMENT EQUATION
      CMAT(3,1,1)=-FXS(3,1)
      CMAT(3,1,2)=-EMA-SNUD(3,2)-FRIC(3,5)-FRIC(3,2)
      CMAT(3,1,3)=-EMAD*CBAR+XCG*AM/12.
      CMAT(3,2,1)=-FXS(3,2)-EMA*VO+ZCG*WT*COS(THETA)/12.
     1-XCG*WT*SIN(THETA)/12.
      CMAT(3,2,2)=(-EMQ-EMAD*VO)*CBAR-SNUD(3,3)-FRIC(3,6)-FRIC(3,3)
      CMAT(3,2,3)=YIYY
      CMAT(3,3,1)=-FXS(3,3)
      CMAT(3,4,1)=-FXS(3,4)
      CMAT(3,4,2)=-EML-SNUD(3,1)-FRIC(3,4)-FRIC(3,1)
      CMAT(3,4,3)=ZCG*AM/12.
      CMAT(3,5,1)=-EMDE
C  CONSTRAINT EQUATION
      CMAT(4,1,1)=-XPZ
      CMAT(4,2,1)=-XPT
      CMAT(4,4,1)=1
C  FEEDBACK LOOP EQUATION
      CMAT(5,2,2)=AKTHE
      CMAT(5,5,2)=-T4THE
      CMAT(5,5,1)=-1.
      IW=6
      N=KODE(8)
      CALL MATRIX(CMAT,N,ROOTS,K4A,IER)
      IF(KODE(5).NE.0) WRITE(IW,100) IER
  100 FORMAT(2X,'IER=',I3,3X,'SEE SUBR. PCFB AND FREM FOR ERROR CODE')
C  THE ROOTS OF THE CHARAC. EQUAT. ARE IN THE COMPLEX ARRAY 'ROOTS'
C  AND THE NUMBER OF ROOTS IS 'K4A'
      CALL PRINTR(IW,ROOTS,K4A)
      RETURN
      END
      SUBROUTINE PRINTR (LOUT,RT,NROOT)
      DIMENSION RT(2,1)
COMMENT   PRINTS PERTINENT INFORMATION ABOUT CHARACTERISTIC ROOTS
      WRITE(LOUT,507)
  507 FORMAT(    '     REAL          IMAGINARY       T H/D-SEC      1/T H/',
     1           'D      PERIOD-SEC     DNATF-CPS     UNDNAT-CPS     DAMP ',
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     2                'RATIO      DECAY RATIC '                         )CBL 12110
      NEXT=1                                                            CBL 12120
      DO 530 I=1,NROOT                                                  CBL 12130
      IF(NEXT.EQ.2) GO TO 777                                           CBL 12140
      SIG=RT(1,I)                                                       CBL 12150
      ASIG=ABS(SIG)                                                     CBL 12160
      AWD=ABS(RT(2,I))                                                  CBL 12170
      THDI= ASIG*1.442695                                               CBL 12180
      THD= 99999.                                                       CBL 12190
      IF(THDI.GT.1.E-5) THD= 1./THDI                                    CBL 12200
      IF(AWD.EQ.0.) GO TO 531                                           CBL 12210
      NEXT=2                                                            CBL 12220
      WD=-AWD                                                           CBL 12230
      DNAT= AWD * .159155                                               CBL 12240
      PER= 99999.                                                       CBL 12250
      IF(DNAT.GT.1.E-5) PER= 1./DNAT                                    CBL 12260
      UNDNAT= SQRT(ASIG**2+AWD**2) *.1591550                            CBL 12270
      DAMPR= 0.                                                         CBL 12280
      IF( AWD - 1.E15 * ASIG ) 503,504,504                              CBL 12290
  503 DAMPR= SIGN ( COS( ATAN ( AWD/ASIG ) ), -SIG )                    CBL 12300
  504 CHDI= THDI*PER                                                    CBL 12310
      DECR= 99999.                                                      CBL 12320
      ARG= SIG * PER                                                    CBL 12330
      IF(ARG.LT.174.6) DECR= EXP (ARG)                                  CBL 12340
      WRITE(LOUT,529) SIG,WD,THD,THDI,PER,DNAT,UNDNAT,DAMPR,CHDI,DECR   CBL 12350
  529 FORMAT( 1PE12.4,2X,1H+,1PE11.4,1P8E13.4)                          CBL 12360
      GO TO 530                                                         CBL 12370
  5   WRITE(LOUT,532) SIG,THD,THDI                                      CBL 12380
  532 FORMAT( 1PE12.4,14X,2E13.4)                                       CBL 12390
      GO TO 530                                                         CBL 12400
  777 NEXT=1                                                            CBL 12410
  530 CONTINUE                                                          CBL 12420
      RETURN                                                            CBL 12430
      END                                                               CBL 12440
      SUBROUTINE MASH (NN,N)                                            CBL 12450
      COMMON /DU/DUM(10,10)                                             CBL 12460
C   NN = FINAL MATRIX SIZE                                              CBL 12470
C   N =  ORIGINAL MATRIX SIZE                                           CBL 12480
      INN=N-NN                                                          CBL 12490
      DO 1001 LL=1,INN                                                  CBL 12500
      L=N+1-LL                                                          CBL 12510
      II=L-1                                                            CBL 12520
      JJ=L-1                                                            CBL 12530
      DO 1001 I=1,II                                                    CBL 12540
      DO 1001 J=1,JJ                                                    CBL 12550
 1001 DUM(I,J)= DUM(I,J)+DUM(L,J)*DUM(I,L)/(-DUM(L,L))                  CBL 12560
      RETURN                                                            CBL 12570
      END                                                               CBL 12580
      SUBROUTINE LAT                                                    CBL 12590
      COMMON /DAT/ AERO(150),AEROP(50),KODE(20),LL                      CBL 12600
      COMMON / PLYCHA/RTD,XLGTH(5),ADC(5,3),AFN(5,3),TR,TLFT,TF         CBL 12610
      COMMON /DU/DUM(10,10)                                             CBL 12620
      EQUIVALENCE(AERO( 46),   XCG),(AERO(47),   ZCG)                   CBL 12630
      EQUIVALENCE(AERO (63),THETA),(AERO (49),VC    ),(AERO (50),   AM) CBL 12640
      EQUIVALENCE(AERO (51),RHO   ),(AERO (52),    WT),(AERO (53),B   ) CBL 12650
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      EQUIVALENCE(AERO (54),CBAR ),(AERO (55),SW   ),(AERO (56), XIXZ)  CBL 12660
      EQUIVALENCE(AERO (57),XIXX ),(AERO (58),YIYY ),(AERO (59),ZIZZ ), CBL 12670
     1           (AERO(95),AKR),(AERO(100),AKLFT)                       CBL 12680
      EQUIVALENCE(AERO(123), AKSY),(AERO(124),AKPHI),(AERO(125),AKTHE), CBL 12690
     1           (AERO(126), AKAZ),(AERO(127), T1SY),(AERO(128),T2PHI), CBL 12700
     2           (AERO(129),T3THE),(AERO(130), T4AZ)                    CBL 12710
      EQUIVALENCE(AEROP( 1), CXUP),(AEROP( 2), CZUP),(AEROP( 3), CMUP), CBL 12720
     1           (AEROP( 4), CXAP),(AEROP( 5), CZAP),(AEROP( 6), CMAP), CBL 12730
     2           (AEROP( 7), CXQP),(AEROP( 8), CZQP),(AEROP( 9), CMQP), CBL 12740
     3           (AEROP(10), CXOP),(AEROP(11), CZOP),(AEROP(12), CMOP), CBL 12750
     4           (AEROP(13),CXDEP),(AEROP(14),CZDEP),(AEROP(15),CMDEP), CBL 12760
     5           (AEROP(16),CXADP),(AEROP(17),CZADP),(AEROP(18),CMADP), CBL 12770
     6           (AEROP(19), CYBP),(AEROP(20), CLBP),(AEROP(21), CNBP), CBL 12780
     7           (AEROP(22), CYPP),(AEROP(23), CLPP),(AEROP(24), CNPP), CBL 12790
     8           (AEROP(25), CYRP),(AEROP(26), CLRP),(AEROP(27), CNRP), CBL 12800
     9           (AEROP(28),CYDRP),(AEROP(29),CLDRP),(AEROP(30),CNDRP), CBL 12810
     A           (AEROP(31),CYDAP),(AEROP(32),CLDAP),(AEROP(33),CNDAP), CBL 12820
     B           (AEROP(34),CYDSP),(AEROP(35),CLDSP),(AEROP(36),CNDSP)  CBL 12830
      DIMENSION CMAT(7,7,3)                                             CBL 12840
      COMPLEX ROOTS(29)                                                 CBL 12850
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUC(3,3)                CBL 12860
      COMMON /ROUGH/FRIC(3,6)                                           CBL 12870
      DIMENSION FXS(3,3)                                                CBL 12880
      DO 10 J=1,3                                                       CBL 12890
      DO 10 K=1,3                                                       CBL 12900
   10 FXS(J,K)=0.                                                       CBL 12910
      DO 111 IC=1,5                                                     CBL 12920
      IF(KODE(11).EQ.0.AND.IC.EQ.5)GO TO 1                              CBL 12930
      DO 3 J=1,8                                                        CBL 12940
      DO 3 K=1,8                                                        CBL 12950
    3 DUM(J,K)=0.                                                       CBL 12960
      TENS=TF                                                           CBL 12970
      IF(IC.GT.2)TENS=TR                                                CBL 12980
      IF(IC.GT.4)TENS=TLFT                                              CBL 12990
      CA1=COS(ADC(IC,1))                                                CBL 13000
      CA2=COS(ADC(IC,2))                                                CBL 13010
      CA3=COS(ADC(IC,3))                                                CBL 13020
      IF(ABS(CA1).LT..0001) CA1=0.                                      CBL 13030
      IF(ABS(CA2).LT..0001) CA2=0.                                      CBL 13040
      IF(ABS(CA3).LT..0001) CA3=0.                                      CBL 13050
      DUM(1,2)=-TENS*CA1                                                CBL 13060
      DUM(1,3)=TENS*CA3                                                 CBL 13070
      DUM(1,4)=CA2                                                      CBL 13080
      DUM(1,6)=-TENS*SIN(ADC(IC,2))                                     CBL 13090
      DUM(2,2)=( ARM(IC,1)*DUM(1,2)-ARM(IC,2)*TENS*CA2)/12.             CBL 13100
      DUM(2,3)= ARM(IC,1)*DUM(1,3)/12.                                  CBL 13110
      DUM(2,4)=(ARM(IC,1)*CA2-ARM(IC,2)*CA1)/12.                        CBL 13120
      DUM(2,5)= ARM(IC,2)*TENS*SIN(ADC(IC,1))/12.                       CBL 13130
      DUM(2,6)= ARM(IC,1)*DUM(1,6)/12.                                  CBL 13140
      DUM(4,4)=-1.                                                      CBL 13150
      DUM(4,8)=0.                                                       CBL 13160
      IF(IC.GT.2)DUM(4,8)=AKR*12.                                       CBL 13170
      IF(IC.GT.4)DUM(4,8)=AKLFT*12.                                     CBL 13180
      DUM(3,2)=-ARM(IC,3)*DUM(1,2)/12.                                  CBL 13190
      DUM(3,3)=(-ARM(IC,3)*DUM(1,3)-ARM(IC,2)*TENS*CA2)/12.             CBL 13200
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```
      DUM(3,4)=(ARM(IC,2)*CA3-ARM(IC,3)*CA2)/12.
      DUM(3,7)=-ARM(IC,2)*TENS*SIN(ADC(IC,1))/12.
      DUM(3,6)=-ARM(IC,3)*DUM(1,6)/12.
      CALL DCOSD(IC,DUM(5,1),DUM(5,2),DUM(5,3),DUM(6,1),DUM(6,2),DUM(
     16,3),DUM(7,1),DUM(7,2),DUM(7,3))
      DUM(5,5)=-1.
      DUM(6,6)=-1.
      DUM(7,7)=-1.
      IF(IC.GT.2)GO TO 2
      CALL MASH(3,7)
    6 DO 4 J=1,3
      DO 4 K=1,3
    4 FXS(J,K)=FXS(J,K)+DUM(J,K)
      GO TO 1
    2 IF(IC.GT.4)GO TO 5
      CALL DLGTH(CY,CPS,CPH,3,1)
      CALL DLGTH(CYP,CPSP,CPHP,4,1)
      DUM(8,1)=CY+CYP
      DUM(8,2)=CPS+CPSP
      DUM(8,3)=CPH+CPHP
      DUM(8,8)=-1.
      CALL MASH(3,8)
      GO TO 6
    5 IF(KODE(11).EQ.0)GO TO 1
      CALL DLGTH(DUM(8,1),DUM(8,2),DUM(8,3),5,1)
      DUM(8,8)=-1.
      GO TO 6
      CONTINUE
    1 CONTINUE
C   COMPLETE SUMMATION OF CABLE FORCES & MOMENTS
C   ADD SNUBBER INCREMENTS
  112 CALL LATSN
      DO 8 J=1,3
      DO 8 K=1,3
    8 FXS(J,K)=FXS(J,K)+SNU(J,K)
      CALL FRICT(1)
C   ADD AERO INCREMENTS
      Q=.5*RHO*VO*VO
      QS=Q*SW
      QSV=QS/VO
      BOV=B/(2.*VO)
      YV=CYBP*QSV
      ELV=CLBP*QSV*B
      ENV=CNBP*QSV*B
      YP=CYPP*QS*BOV
      ELP=CLPP*BOV*QS*B
      ENP=CNPP*BOV*QS*B
      YR=CYRP*QS*BOV
      ELR=CLRP*BOV*QS*B
      ENR=CNRP*BOV*QS*B
      YDR=CYDRP*QS
      ENDR=CNDRP*QS*B
      ELDR=CLDRP*QS*B
      YDA=CYDAP*QS
      ENDA=CNDAP*QS*B
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      ELDA=CLDAP*QS*B
      YDS=CYDSP*QS
      ENDS=CNDSP*QS*B
      ELDS=CLDSP*QS*B
      DO 113 I=1,7
      DO 113 J=1,7
      DO 113 K=1,3
  113 CMAT(I,J,K)=0.
C   Y FORCE EQUATION
      CMAT(1,1,1)=-FXS(1,1)
      CMAT(1,1,2)=-YV-SNUD(1,1)-FRIC(1,4)-FRIC(1,1)
      CMAT(1,1,3)=AM
      CMAT(1,2,1)=-FXS(1,2)+YV*VO-WT*SIN(THETA)
      CMAT(1,2,2)=-YR-SNUD(1,2)-FRIC(1,5)-FRIC(1,2)
      CMAT(1,2,3)=AM*XCG/12.
      CMAT(1,3,1)=-FXS(1,3)-WT*COS(THETA)
      CMAT(1,3,2)=-YP-SNUD(1,3)-FRIC(1,6)-FRIC(1,3)
      CMAT(1,3,3)=-AM*ZCG/12.
      CMAT(1,4,1)=-QS*CYDRP
      CMAT(1,5,1)=-QS*CYDAP
C   YAW EQUATION
      CMAT(2,1,1)=-FXS(2,1)
      CMAT(2,1,2)=-ENV-SNUD(2,1)-FRIC(2,4)-FRIC(2,1)
      CMAT(2,1,3)=AM*XCG/12.
      CMAT(2,2,1)=-FXS(2,2)+ENV*VO-XCG*WT*SIN(THETA)/12.
      CMAT(2,2,2)=-ENR-SNUD(2,2)-FRIC(2,5)-FRIC(2,2)
      CMAT(2,2,3)=ZIZZ
      CMAT(2,3,1)=-FXS(2,3)+XCG*WT*COS(THETA)/12.
      CMAT(2,3,2)=-ENP-SNUD(2,3)-FRIC(2,6)-FRIC(2,3)
      CMAT(2,3,3)=-XIXZ
      CMAT(2,4,1)=-QS*B*CNDRP
      CMAT(2,5,1)=-QS*B*CNDAP
C   ROLL EQUATION
      CMAT(3,1,1)=-FXS(3,1)
      CMAT(3,1,2)=-ELV-SNUD(3,1)-FRIC(3,4)-FRIC(3,1)
      CMAT(3,1,3)=-AM*ZCG/12.
      CMAT(3,2,1)=-FXS(3,2)+ELV*VO-ZCG*WT*SIN(THETA)/12.
      CMAT(3,2,2)=-ELR-SNUD(3,2)-FRIC(3,5)-FRIC(3,2)
      CMAT(3,2,3)=-XIXZ
      CMAT(3,3,1)=-FXS(3,3)-ZCG*WT*COS(THETA)/12.
      CMAT(3,3,2)=-ELP-SNUD(3,3)-FRIC(3,6)-FRIC(3,3)
      CMAT(3,3,3)=XIXX
      CMAT(3,4,1)=-QS*B*CLDRP
      CMAT(3,5,1)=-QS*B*CLDAP
C   RUDDER FEEDBACK LOOP
      CMAT(4,2,2)=AKSY
      CMAT(4,4,2)=-T2SY
      CMAT(4,4,1)=-1.
C   AILERON FEEDBACK LOOP
      CMAT(5,3,2)=AKPHI
      CMAT(5,5,2)=-T2PHI
      CMAT(5,5,1)=-1.
      IW=6
      N=KODE(9)
      CALL MATRIX(CMAT,N,ROOTS,K4A,IER)
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```
      IF(KODE(5).NE.0) WRITE(IW,100) IER
  100 FORMAT(2X,'IER=',I3,3X,'SEE SUBR. PQFB AND FREN FOR ERROR CODE')
C     HE ROOTS OF THE CHARACTERISTIC EQUAT. ARE IN THE COMPLEX ARRAY
C     'ROOTS' AND THE NUMBER OF ROOTS IS 'K4A'
      CALL PRINTR(IW,ROOTS,K4A)
      RETURN
      END
      SUBROUTINE DCOSD(IC,CY1,CPSI1,CPHI1,CY2,CPSI2,CPHI2,CY3,CPSI3,
     1CPHI3)
      COMMON /PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF
      XWT=ARM(IC,1)
      YWT=ARM(IC,2)
      ZWT=ARM(IC,3)
      CY1=-COS(ADC(IC,2))*COTAN(ADC(IC,1))/XLGTH(IC)*12.
      CPSI1=-(YWT*SIN(ADC(IC,1))+XWT*COS(ADC(IC,2))*COTAN(ADC(IC,1)))
     1/XLGTH(IC)
      CPHI1=(ZWT*COS(ADC(IC,2))*COTAN(ADC(IC,1))-YWT*COS(ADC(IC,3))*
     1COTAN(ADC(IC,1)))/XLGTH(IC)
      CY2=SIN(ADC(IC,2))/XLGTH(IC)*12.
      CPSI2=(YWT*COS(ADC(IC,1))*COTAN(ADC(IC,2))+XWT*SIN(ADC(IC,2)))/
     1XLGTH(IC)
      CPHI2=-(ZWT*SIN(ADC(IC,2))+YWT*COS(ADC(IC,3))*COTAN(ADC(IC,2)))
     1/XLGTH(IC)
      CY3=-COS(ADC(IC,2))*COTAN(ADC(IC,3))/XLGTH(IC)*12.
      CPSI3=(YWT*COS(ADC(IC,1))*COTAN(ADC(IC,3))-XWT*COS(ADC(IC,2))*
     1COTAN(ADC(IC,3)))/XLGTH(IC)
      CPHI3=(ZWT*COS(ADC(IC,2))*COTAN(ADC(IC,3))+YWT*SIN(ADC(IC,3)))
     1/XLGTH(IC)
      RETURN
      END
      SUBROUTINE SNTRM (FXSN,FZSN,AMSN,THETA)
      COMMON/DAT/AERO(150),AEROP(50),KODE(20),LL
      COMMON ZZZ(200)
      COMMON/TAB1/ZZ(800)
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUC(3,3)
      EQUIVALENCE((AERO(105), SNUX),(AERO(106), SNUY),(AERO(107), SNUZ),
     1            (AERO(108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ),
     2            (AERO(111),SNUST),(AERO(112),SNUWL),(AERO(113),SNUBL),
     3            (AERO(114),SNLST),(AERO(115),SNLWL),(AERO(116),SNLBL),
     4            (AERO(117),TUSNO),(AERO(118),TLSNO),(AERO(119),AKSNU),
     5            (AERO(120),AKSNL),(AERO(49),    VO),(AERO(51),   RHO),
     6            (AERO(76),WLCR),(AERO(77),STACF),
     7            (AERO(78),BLCR)
      EQUIVALENCE (SN( 1),  GX1),(SN( 2),  GY1),(SN( 3),  GZ1),
     1            (SN( 4),  GX2),(SN( 5),  GY2),(SN( 6),  GZ2),
     2            (SN( 7),  GX3),(SN( 8),  GY3),(SN( 9),  GZ3),
     3            (SN(10),  GX4),(SN(11),  GY4),(SN(12),  GZ4),
     4            (SN(13),  THU),(SN(14),  THL),(SN(15),  ALU),
     5            (SN(16),  ALL),
     6            (SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),
     7            (SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),
     8            (SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),
     9            (SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)
      IW=6
      IF(KODE(10).EQ.0) GO TO 5005
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      CALL DRCSN(THETA)
      IF(KODE(10).NE.1) GO TO 5003
C    RMS TO MODEL SNUBBER EFFECTS (MODEL UNSNUBBED)
      Q=.5*RHO*VO*VO
      CALL STINT(Q,ALU,C,1,1,TUSN,NG)
      IF(NG.NE.0) GO TO 5000
      CALL STINT(Q,ALL,0,1,1,TLSN,NG)
      IF(NG.NE.0) GO TO 5000
      CALL STINT(Q,ALU,C,2,2,THUSN,NG)
      IF(NG.NE.0) GO TO 5000
      CALL STINT(Q,ALL,0,2,2,THLSN,NG)
      IF(NG.EQ.0) GO TO 5001
 5000 WRITE(IW,5002) NG,ALL,ALU,Q
 5002 FORMAT(2X,'ERROR IN SNUBBER TABLE 1-2   , NG=',I3,3E10.3)
      RETURN
 5001 CONTINUE
C       CALCULATING FORCE AND MOMENT EFFECTS
      CALL DRCUSN(THETA)
      FXUSN= 2.*TUSN*GX1
      FZUSN= 2.*TUSN*GZ1
      AMUSN= -FXUSN*SNUZ+SNUX*FZUSN
      FXLSN= 2.*TLSN*GX3
      FZLSN= 2.*TLSN*GZ3
      AMLSN= FXLSN*SNLZ+FZLSN*SNLX
      FXSN  = FXUSN+FXLSN
      FZSN  = FZUSN+FZLSN
      AMSN  =(AMUSN+AMLSN)/12.
      RETURN
 5003 CONTINUE
C  TERMS TO MODEL SNUBBER EFFECTS (MODEL SNUBBED)
      FXUSN= 2.*TUSNO*GX1
      FZUSN= 2.*TUSNO*GZ1
      AMUSN =-FXUSN*SNUZ+FZUSN*SNUX
      FXLSN= 2.*TLSNO*GX3
      FZLSN= 2.*TLSNO*GZ3
      AMLSN  = FXLSN*SNLZ+FZLSN*SNLX
      FXSN  = FXUSN+FXLSN
      FZSN  = FZUSN+FZLSN
      AMSN  =(AMUSN+AMLSN)/12.
      RETURN
 5005 FXSN=0
      FZSN=0
      AMSN=0
      RETURN
      END
      SUBROUTINE LONGSN
      COMMON/DAT/AERO(150),AEROP(50),KODE(20),LL
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUD(3,3)
      COMMON ZZZ(200)
      COMMON/TAB1/ZZ(600)
      COMMON/DU/DUM(10,10)
      EQUIVALENCE(AERO(105), SNUX),(AERO(106), SNUY),(AERO(107), SNUZ),
     1            (AERO(108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ),
     2            (AERO(111),SNUST),(AERO(112),SNUWL),(AERO(113),SNUBL),
     3            (AERO(114),SNLST),(AERO(115),SNLWL),(AERO(116),SNLBL),
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     4              (AERO(117),TUSNO),(AERO(118),TLSNO),(AERO(119),AKSNU),
     5              (AERO(120),AKSNL),(AERO(49),    VO),(AERO(51),    RHO),
     6              (AERO(63),THETA),(AERO(121),ACSNU),(AERO(122),ACSNL)
      EQUIVALENCE (SN( 1),  GX1),(SN( 2),  GY1),(SN( 3),  GZ1),
     1              (SN( 4),  GX2),(SN( 5),  GY2),(SN( 6),  GZ2),
     2              (SN( 7),  GX3),(SN( 8),  GY3),(SN( 9),  GZ3),
     3              (SN(10),  GX4),(SN(11),  GY4),(SN(12),  GZ4),
     4              (SN(13),  THU),(SN(14),  THL),(SN(15),  ALU),
     5              (SN(16),  ALL),
     6              (SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),
     7              (SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),
     8              (SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),
     9              (SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)
      DIMENSION FTOP(3,3),FBOT(3,3)
      COT(A)=1./TAN(A)
      IW =6
      DO 1001 I=1,3
      DO 1001 J=1,3
      SNU(I,J)=0
 1001 SNUD(I,J)=0
      DO 5102 I=1,10
      DO 5102 J=1,10
 5102 DUM(I,J)=0
      IF(KODE(10).NE.1) GO TO 1000
C  TERMS FOR UNSNUBBED SNUBBER EFFECTS (LONG)
      DO 1004 I=1,7
      DO 1004 J=1,7
 1004 DUM(I,J)=0
      CALL DRCUSN(THETA)
      DUM(1,3)= -2.*TUSNO*GZ1
      DUM(1,4)= -2.*TUSNO*SIN(THGX1)
      DUM(1,6)=  2.*GX1
      DUM(2,3)=  2.*TUSNO*GX1
      DUM(2,5)= -2.*TUSNO*SIN(THGZ1)
      DUM(2,6)=  2.*GZ1
      DUM(3,3)= (-SNUZ*DUM(1,3)+SNUX*DUM(2,3))/12.
      DUM(3,4)= -SNUZ*DUM(1,4)/12.
      DUM(3,5)=  SNUX*DUM(2,5)/12.
      DUM(3,6)= (-SNUZ*DUM(1,6)+SNUX*DUM(2,6))/12.
      DUM(4,1)=(SIN(THGX1)/ALU)*12.
      DUM(4,2)= (-GZ1*COT(THGX1)/ALU)*12.
      DUM(4,3)= -SNUZ*SIN(THGX1)/ALU-SNUX*GZ1*COT(THGX1)/ALU
      DUM(4,4)=  -1.
      DUM(5,1)= (-GX1*COT(THGZ1)/ALU)*12.
      DUM(5,2)=  (SIN(THGZ1)/ALU)*12.
      DUM(5,3)=  SNUZ*GX1*COT(THGZ1)/ALU + SNUX*SIN(THGZ1)/ALU
      DUM(5,5)= -1.
      CALL DRCSN(THETA)
      Q= .5*RHO*VO*VO
      ALU1=ALU+1.
      CALL STINT(Q,ALU1,0,1,1,TUSN1,NG)
      IF(NG.NE.0) GO TO 5000
      ALU2=ALU-1.
      CALL STINT(Q,ALU2,0,1,1,TUSN2,NG)
      IF(NG.EQ.0) GO TO 5001
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 5000 WRITE( IW,5C02) NG,ALL,ALU,Q
 5002 FORMAT( 'ERROR IN TABLE 1-2,NG=',I2,3XE10.3)
      RETURN
 5001 CONTINUE
      AKTU=( TUSN1-TUSN2)/2.
      DUM( 6, 6)= -1.
      DUM( 6, 7)= AKTU*12.
      DUM( 7, 1)= -GX1
      DUM( 7, 2)= -GZ1
      DUM( 7, 3)=( (-SNLX+ALU*GX1)*GZ1-(-SNU2+ALL*GZ1)*GX1)/12.
      DUM( 7, 7)= -1.
      CALL MASH( 3,7)
      DO 1005 I=1,3
      DO 1005 J=1,3
 1005 FTOP( I,J )=DUM( I,J)
      CALL DRCUSN( THETA)
      DUM( 1, 3)= -2.*TLSNO*GZ3
      DUM( 1, 4)= -2.*TLSNO*SIN(THGX3)
      DUM( 1, 6)=  2.*GX3
      DUM( 2, 3)=  2.*TLSNO*GX3
      DUM( 2, 5)= -2.*TLSNO*SIN(THGZ3)
      DUM( 2, 6)=  2.*GZ3
      DUM( 3, 3)=  (SNLZ*DUM(1,3)+SNLX*DUM(2,3))/12.
      DUM( 3, 4)=  SNLZ*DUM(1,4)/12.
      DUM( 3, 5)=  SNLX*DUM(2,5)/12.
      DUM( 3, 6)=  (SNLZ*DUM(1,6)+SNLX*DUM(2,6))/12.
      DUM( 4, 1)=  (SIN( THGX3)/ALL)*12.
      DUM( 4, 2)= (-GZ3*COT(THGX3)/ALL)*12.
      DUM( 4, 3)=  SNLZ*SIN(THGX3)/ALL - SNLX*GZ3*COT(THGX3)/ALL
      DUM( 4, 4)=  -1.
      DUM( 5, 1)=  (-GX3*COT( THGZ3)/ALL)*12.
      DUM( 5, 2)=  (SIN( THGZ3)/ALL)*12.
      DUM( 5, 3)=  -SNLZ*GX3*COT( THGZ3)/ALL + SNLX*SIN(THGZ3)/ALL
      DUM( 5, 5)=  -1.
      CALL DRCSN( THETA)
      ALL1=ALL+1.
      CALL STINT(Q,ALL1,0,1,1,TLSN1,NG)
      IF(NG.NE.0) GO TO 5003
      ALL2=ALL-1.
      CALL STINT(Q,ALL2,0,1,1,TLSN2,NG)
      IF(NG.EQ.0) GO TO 5004
 5003 WRITE( IW,5C02) NG,ALL,ALU,Q
      RETURN
 5004 CONTINUE
      AKTL=( TLSN1-TLSN2)/2.
      DUM( 6, 6)=  -1.
      DUM( 6, 7)=  AKTL*12.
      DUM( 7, 1)=  -GX3
      DUM( 7, 2)=  -GZ3
      DUM( 7, 3)=( (-SNLX+ALL*GX3)*GZ3-(SNLZ+ALL*GZ3)*GX3)/12.
      DUM( 7, 7)=  -1.
      CALL MASH( 3,7)
      DO 1008 I=1,3
      DO 1008 J=1,3
 1008 FBOT( I,J )=DUM( I,J)
```

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      DO 1009 I=1,3                                                     CBL 16510
      DO 1009 J=1,3                                                     CBL 16520
      SNUD(I,J)=0                                                       CBL 16530
 1009 SNU(I,J)= FTOP(I,J)+FBOT(I,J)                                     CBL 16540
      RETURN                                                            CBL 16550
 1000 IF(KODE(10).EQ.0) GO TO 1002                                      CBL 16560
C     TERMS FOR SNUBBED SNUBBER EFFECTS(LONG)                           CBL 16570
      CALL DRCSN(THETA)                                                 CBL 16580
      DO 1006 I=1,7                                                     CBL 16590
      DO 1006 J=1,7                                                     CBL 16600
 1006 DUM(I,J)=0                                                        CBL 16610
      DUM(1,3)= -2.*TUSNO*GZ1                                           CBL 16620
      DUM(1,4)= -2.*TUSNO*SIN(THGX1)                                    CBL 16630
      DUM(1,6)=  2.*GX1                                                 CBL 16640
      DUM(2,3)=  2.*TUSNO*GX1                                           CBL 16650
      DUM(2,5)= -2.*TUSNO*SIN(THGZ1)                                    CBL 16660
      DUM(2,6)=  2.*GZ1                                                 CBL 16670
      DUM(3,3)= (-SNUZ*DUM(1,3)+SNUX*DUM(2,3))/12.                      CBL 16680
      DUM(3,4)= -SNUZ*DUM(1,4)/12.                                      CBL 16690
      DUM(3,5)=  SNUX*DUM(2,5)/12.                                      CBL 16700
      DUM(3,6)= (-SNUZ*DUM(1,6)+SNUX*DUM(2,6))/12.                      CBL 16710
      DUM(4,1)=  (SIN(THGX1)/ALU)*12.                                   CBL 16720
      DUM(4,2)= (-GZ1*COT(THGX1)/ALU)*12.                               CBL 16730
      DUM(4,3)= -SNUZ*SIN(THGX1)/ALU-SNUX*GZ1*COT(THGX1)/ALU            CBL 16740
      DUM(4,4)=  -1.                                                    CBL 16750
      DUM(5,1)= (-GX1*COT(THGZ1)/ALU)*12.                               CBL 16760
      DUM(5,2)=  (SIN(THGZ1)/ALU)*12.                                   CBL 16770
      DUM(5,3)=  SNUZ*GX1*COT(THGZ1)/ALU + SNUX*SIN(THGZ1)/ALU          CBL 16780
      DUM(5,5)= -1.                                                     CBL 16790
      DUM(6,6)= -1.                                                     CBL 16800
      DUM(6,7)= AKSNU*12.                                               CBL 16810
      DUM(7,1)= -GX1                                                    CBL 16820
      DUM(7,2)= -GZ1                                                    CBL 16830
      DUM(7,3)= ((-SNUX+ALU*GX1)*GZ1-(-SNUZ+ALU*GZ1)*GX1)/12.           CBL 16840
      DUM(7,7)= -1.                                                     CBL 16850
      DO 10 I=1,3                                                       CBL 16860
      DO 10 J=1,3                                                       CBL 16870
   10 SNUD(I,J)=DUM(I,6)*ADSNU*DUM(7,J)*12.                             CBL 16880
      CALL MASH(3,7)                                                    CBL 16890
      DO 1007 I=1,3                                                     CBL 16900
      DO 1007 J=1,3                                                     CBL 16910
 1007 FTOP(I,J)=DUM(I,J)                                                CBL 16920
      DUM(1,3)= -2.*TLSNO*GZ3                                           CBL 16930
      DUM(1,4)= -2.*TLSNO*SIN(THGX3)                                    CBL 16940
      DUM(1,6)=  2.*GX3                                                 CBL 16950
      DUM(2,3)=  2.*TLSNO*GX3                                           CBL 16960
      DUM(2,5)= -2.*TLSNO*SIN(THGZ3)                                    CBL 16970
      DUM(2,6)=  2.*GZ3                                                 CBL 16980
      DUM(3,3)=  (SNLZ*DUM(1,3)+SNLX*DUM(2,3))/12.                      CBL 16990
      DUM(3,4)=  SNLZ*DUM(1,4)/12.                                      CBL 17000
      DUM(3,5)=  SNLX*DUM(2,5)/12.                                      CBL 17010
      DUM(3,6)=  (SNLZ*DUM(1,6)+SNLX*DUM(2,6))/12.                      CBL 17020
      DUM(4,1)=  (SIN(THGX3)/ALL)*12.                                   CBL 17030
      DUM(4,2)= (-GZ3*COT(THGX3)/ALL)*12.                               CBL 17040
      DUM(4,3)=  SNLZ*SIN(THGX3)/ALL - SNLX*GZ3*COT(THGX3)/ALL          CBL 17050
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```
      DUM(4,4)=  -1.
      DUM(5,1)=  (-GX3*COT(THGZ3)/ALL)*12.
      DUM(5,2)=  (SIN(THGZ3)/ALL)*12.
      DUM(5,3)=  -SNLZ*GX3*COT(THGZ3)/ALL + SNLX*SIN(THGZ3)/ALL
      DUM(5,5)=  -1.
      DUM(6,6)=  -1.
      DUM(6,7)=  AKSNL*12.
      DUM(7,1)=  -GX3
      DUM(7,2)=  -GZ3
      DUM(7,3)= ((-SNLX+ALL*GX3)*GZ3 -(SNLZ+ALL*GZ3)*GX3)/12.
      DUM(7,7)=  -1.
      DO 20 I=1,3
      DO 20 J=1,3
   20 SNUD(I,J)=SNUD(I,J)+DUM(I,6)*ADSNL*DUM(7,J)*12.
      CALL MASH(3,7)
      DO 1010 I=1,3
      DO 1010 J=1,3
 1010 FBOT(I,J)=DUM(I,J)
      DO 1011 I=1,3
      DO 1011 J=1,3
 1011 SNU(I,J)= FTOP(I,J)+FBOT(I,J)
      RETURN
 1002 DO 1003 I=1,3
      DO 1003 J=1,3
      SNUD(I,J)=0
 1003 SNU(I,J)=0
      RETURN
      END
      SUBROUTINE DRCSN(THETA)
      COMMON /DAT/AERO(150),AEROP(50),KODE(20),LL
      COMMON /SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNUD(3,3)
      EQUIVALENCE(AERO(105), SNUX),(AERO(106), SNUY),(AERO(107), SNUZ),
     1            (AERO(108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ),
     2            (AERO(111),SNUST),(AERO(112),SNUWL),(AERO(113),SNUBL),
     3            (AERO(114),SNLST),(AERO(115),SNLWL),(AERO(116),SNLBL),
     4            (AERO(117),TUSNO),(AERO(118),TLSNO),(AERO(119),AKSNU),
     5            (AERO(120),AKSNL),
     6            (AERO(76),WLCR),(AERO(77),STACR),(AERO(78),BLCR)
      EQUIVALENCE (SN( 1), GX1),(SN( 2), GY1),(SN( 3), GZ1),
     1            (SN( 4), GX2),(SN( 5), GY2),(SN( 6), GZ2),
     2            (SN( 7), GX3),(SN( 8), GY3),(SN( 9), GZ3),
     3            (SN(10), GX4),(SN(11), GY4),(SN(12), GZ4),
     4            (SN(13), THU),(SN(14), THL),(SN(15), ALU),
     5            (SN(16), ALL),
     6            (SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),
     7            (SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),
     8            (SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),
     9            (SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)
C  CALCULATION OF SNUBBER CABLE DIRECTION COSINES
      XB1= (STACR-SNUST)*COS(THETA)-(WLCR-SNUWL)*SIN(THETA)
      ZB1= (WLCR-SNUWL)*COS(THETA)+(STACR-SNUST)*SIN(THETA)
      XB2= XB1
      ZB2= ZB1
      XB3= (STACR-SNLST)*COS(THETA)-(WLCR-SNLWL)*SIN(THETA)
      ZB3= (WLCR-SNLWL)*COS(THETA)+(STACR-SNLST)*SIN(THETA)
```

```
      XB4= XB3
      ZB4=ZB3
      DX1= XB1+SNUX
      DY1= -SNUBL+SNUY
      DZ1= ZB1+SNUZ
      DX2= DX1
      DY2= SNUBL-SNUY
      DZ2= DZ1
      DX3= XB3+SNLX
      DY3= SNLBL-SNLY
      DZ3= ZB3-SNLZ
      DX4= DX3
      DY4= -SNLBL+SNLY
      DZ4= DZ3
      ALUSQ=  DX1**2 + DY1**2 + DZ1**2
      ALU  = SQRT(ALUSQ)
      ALLSQ  = DX3**2 + DY3**2 + DZ3**2
      ALL  = SQRT(ALLSQ)
      GX1  = DX1/ALU
      GY1  = DY1/ALU
      GZ1  = DZ1/ALU
      GX2  = DX2/ALU
      GY2  = DY2/ALU
      GZ2  = DZ2/ALU
      GX3  = DX3/ALL
      GY3  = DY3/ALL
      GZ3  = DZ3/ALL
      GX4  = DX4/ALL
      GY4  = DY4/ALL
      GZ4  = DZ4/ALL
      DO 1 I=19,30
      J=I-18
    1 SN(I)=ARCOS(SN(J))
      RETURN
      END
      SUBROUTINE ORCLSN(THETA)
      COMMON/DAT/AERO(150),AEROP(50),KODE(20),LL
      COMMON/SNUBB/SNU(3,3),SN(30),THUSN,THLSN,SNLC(3,3)
      EQUIVALENCE(AERO(105), SNUX),(AERO(106), SNUY),(AERO(107), SNUZ),
     1            (AERO(108), SNLX),(AERO(109), SNLY),(AERO(110), SNLZ),
     2            (AERO(111),SNUST),(AERO(112),SNUWL),(AERO(113),SNUBL),
     3            (AERO(114),SNLST),(AERO(115),SNLWL),(AERO(116),SNLBL),
     4            (AERO(117),TUSNO),(AERO(118),TLSNO),(AERO(119),AKSNU),
     5            (AERO(120),AKSNL),
     6            (AERO(76),WLCR),(AERO(77),STACF),(AERO(78),BLCR)
      EQUIVALENCE (SN( 1),  GX1),(SN( 2),  GY1),(SN( 3),  GZ1),
     1            (SN( 4),  GX2),(SN( 5),  GY2),(SN( 6),  GZ2),
     2            (SN( 7),  GX3),(SN( 8),  GY3),(SN( 9),  GZ3),
     3            (SN(10),  GX4),(SN(11),  GY4),(SN(12),  GZ4),
     4            (SN(13),  THU),(SN(14),  THL),(SN(15),  ALU),
     5            (SN(16),  ALL),
     6            (SN(19),THGX1),(SN(20),THGY1),(SN(21),THGZ1),
     7            (SN(22),THGX2),(SN(23),THGY2),(SN(24),THGZ2),
     8            (SN(25),THGX3),(SN(26),THGY3),(SN(27),THGZ3),
     9            (SN(28),THGX4),(SN(29),THGY4),(SN(30),THGZ4)
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C     CALCULATION FOR EFFECTIVE DIRECTION COSINES FOR UNSNUBBED CASE
       AYL  =  SNLBL-(BLCR+SNLY)
       AZL  =-SNLWL-(WLCR+SNLZ+SNLX*SIN(THETA))
       AYU  =  SNUBL-(BLCR+SNUY)
       AZU  =  SNUWL-(WLCR+SNUZ-SNUX*SIN(THETA))
       THU= ATAN(AZU/AYU)
       THL= ATAN(AZL/AYL)
       ALU=AYU/(SIN(THUSN)*COS(THU))
       GX1S= -COS(THUSN)
       GY1S= -AYU/ALU
       GZ1S= -AZU/ALU
       GX1  =  GX1S*COS(THETA)-GZ1S*SIN(THETA)
       GY1  =  GY1S
       GZ1  =  GZ1S*COS(THETA)+GX1S*SIN(THETA)
       GX2  =  GX1
       GY2  =-GY1
       GZ2  =  GZ1
       ALL=AYL/(SIN(THLSN)*COS(THL))
       GX3S= -COS(THLSN)
       GY3S=  AYL/ALL
       GZ3S=  AZL/ALL
       GX3  =  GX3S*COS(THETA)-GZ3S*SIN(THETA)
       GY3  =  GY3S
       GZ3  =  GZ3S*COS(THETA)+GX3S*SIN(THETA)
       GX4  =  GX3
       GY4  =-GY3
       GZ4  =  GZ3
      DO  1  I=19,30
      J=I-18
    1 SN(I)=ARCOS(SN(J))
      RETURN
      END
      SUBROUTINE RITE
      COMMON/DAT/AERO(150),AEROP(50),KODE(20),LL
      IW=6
      IF(KODE(6).GT.1) GO TO 1
      WRITE(IW,100)
  100 FORMAT(15X,'FRONT CABLE VERTICAL,REAR CABLE HORIZONTAL')
      GO TO 4
    1 IF(KODE(6).GT.2) GO TO 2
      WRITE(IW,200)
  200 FORMAT(15X,'FRONT CABLE HORIZONTAL,REAR CABLE VERTICAL')
      GO TO 4
    2 IF(KODE(6).GT.3) GO TO 3
      WRITE(IW,300)
  300 FORMAT(15X,'BOTH CABLES VERTICAL')
      GO TO 4
    3 WRITE(IW,400)
  400 FORMAT(15X,'BOTH CABLES HORIZONTAL')
    4 CONTINUE
      IF(KODE(10).EQ.0) GO TO 5
      IF(KODE(10).EQ.1) GO TO 6
      WRITE(IW,500)
  500 FORMAT(15X,'SNUBBERS SNUBBED')
      GO TO 7
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    5 WRITE(IW,600)
    0 FORMAT(15X,'NO SNUBBERS')
      GO TO 7
    6 WRITE(IW,700)
  700 FORMAT(15X,'SNUBBERS UNSNUBBED')
    7 CONTINUE
      IF(KODE(11).EQ.0) GO TO 8
      WRITE(IW,800)
  800 FORMAT(15X,'LIFT/ANTI-LIFT CABLE IN')
      GO TO 9
    8 WRITE(IW,900)
  900 FORMAT(15X,'NO LIFT/ANTI-LIFT CABLE')
    9 CONTINUE
      RETURN
      END
      SUBROUTINE STINT(A1,A2,A3,MINTBL,MAXTBL,FCT,NG)
      EQUIVALENCE (X(1),NUMPTS(1))
      COMMON NUMPTS(1)
      DIMENSION X(1)
      IZ =NUMPTS(1)/3
70    IF(MINTBL-MAXTBL)71,71,110
   71 DO 73 II=MINTBL,MAXTBL
      NJ=NUMPTS(II)+1
      IF(A3-X(NJ))72,74,73
   72 IF(II-MINTBL) 110,112,75
   73 CONTINUE
      GO TO 112
    5 IK = 1
      IL =2
      NM=NJ
  101 DO 97 IF=IK,IL
      NJ =NUMPTS(II)+1
      NI = IZ+II
      IO =NUMPTS(NI)
      IP =IO+NJ
      DO 77 IQ=1,IO
      NN= NJ+IQ
      IF (A1-X(NN))76,78,77
   76 IF(IQ-1) 110,112,79
   77 CONTINUE
      GO TO 112
   78 IG =-1
      GO TO 80
   79 IG =+1
   80 NI=NI+IZ
      IB = NUMPTS(NI)
      DO 82 IA=1,IB
      NS=IP+IA
      IF (A2-X(NS))81,83,82
   81 IF(IA-1) 110,112,84
   82 CONTINUE
      GO TO 112
    3 IH =-1
      GO TO 85
   84 IH =+1
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   85 NE=IP+IB+IQ+IO*IA-IO                                            CBL 19260
      NR=NE-IO                                                        CBL 19270
      IF( IG+IH) 86,88,91                                             CBL 19280
   86 IF (X(NE)-99998.5E9)87,113,113                                  CBL 19290
   87 FCT = X(NE)                                                     CBL 19300
      GO TO 99                                                        CBL 19310
   88 IF( IG) 89,110,93                                               CBL 19320
   89 IF(AMAX1(X(NE),X(NR))-99998.5E9)90,113,113                      CBL 19330
   90 FCT =X(NE)-(X(NS)-A2)*(X(NE)-X(NR))/(X(NS)-X(NS-1))             CBL 19340
      GO TO 99                                                        CBL 19350
   91 IF(AMAX1(X(NE),X(NR),X(NE-1),X(NR-1))-99998.5E9)92,113,113      CBL 19360
   92 FCT = ((X(NS)-A2)*((X(NN)-A1)*X(NR-1)-(X(NN-1)-A1)*X(NR)        CBL 19370
     1)-(X(NS-1)-A2)*((X(NN)-A1)*X(NE-1)-(X(NN-1)-A1)*X(NE)))         CBL 19380
     2/((X(NS)-X(NS-1))*(X(NN)-X(NN-1)))                              CBL 19390
      GO TO 99                                                        CBL 19400
   93 IF(AMAX1(   X(NE),   X(NE-1))-99998.5E9) 94,113,113             CBL 19410
   94 FCT =   X(NE)-(   X(NN)-A1)*(   X(NE)-   X(NE-1))/(   X(NN)-   X(NN-1)) CBL 19420
   95 GO TO (96,98,99),IF                                             CBL 19430
   96 DUMSTG =FCT                                                     CBL 19440
   97 II =II-1                                                        CBL 19450
   98 FCT =DUMSTG-(   X(NM)-A3)*(DUMSTG-FCT)/(   X(NM)-   X(NJ))      CBL 19460
   99 RETURN                                                          CBL 19470
   74 IK =3                                                           CBL 19480
      IL =3                                                           CBL 19490
      GO TO 101                                                       CBL 19500
  110 NG =2                                                           CBL 19510
      GO TO 99                                                        CBL 19520
    2 NG =3                                                           CBL 19530
      GO TO 99                                                        CBL 19540
  113 NG =4                                                           CBL 19550
      GO TO 99                                                        CBL 19560
      END                                                             CBL 19570
      SUBROUTINE TABIN(NUMTBL,NZ,NG)                                  CBL 19580
      COMMON NUMPTS(1)                                                CBL 19590
      COMMON /TABOUT/ NIMTBL,ISOQ                                     CBL 19600
      DIMENSION XUMPTS(1)                                             CBL 19610
      INTEGER*2 LABEL(27)                                             CBL 19620
      EQUIVALENCE (XUMPTS(1),NUMPTS(1)),(DUMMY(1),NUMMY)              CBL 19630
      DIMENSION DUMMY(10)                                             CBL 19640
      MCR=0                                                           CBL 19650
   10 IZ =IABS(NZ)                                                    CBL 19660
      NUNIT=5                                                         CBL 19670
      IF(NZ.LT.0) NUNIT=8                                             CBL 19680
      NIMTBL = NUMTBL                                                 CBL 19690
      NG=0                                                            CBL 19700
      NUMPTS(1)=IZ+IZ+IZ                                              CBL 19710
  102 READ(NUNIT,57) K, L1N, L2N, LABEL, ISEC                         CBL 19720
      IF(MCR.EQ.0) GO TO 3                                            CBL 19730
    4 WRITE(6,1) K,L1N,L2N,LABEL,ISEQ                                 CBL 19740
    1 FORMAT(3I5, 10X,27A2,I46)                                       CBL 19750
   57 FORMAT(8XI4,2I2,27A2,I2)                                        CBL 19760
    3 IF( ISEQ) 69,58,69                                              CBL 19770
   58 IF(K) 99, 99, 59                                                CBL 19780
   59 M = IZ + NIMTBL                                                 CBL 19790
      NUMPTS(M) = L1N                                                 CBL 19800
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      M = M + IZ
      NUMPTS(M) = L2N
      IF(NUMTBL-NIMTBL)17,70,17
   17 NUMPTS(NIMTBL) = MUMMY
   70 N1 = (L1N-1) / 9 + 1
      DO 68 IS = 1,N1
      L3 = (IS-1) * 9 + 1
      IF (IS-N1) 60, 61, 60
   60 L4 = L3 + 8
      GO TO 62
   61 L4 = L1N
   62 L5 = NUMPTS(NIMTBL) + 1
      L6 = L5 + L3
      L7 = L5 + L4
      JJ = 0
      LM = L5 + L1N
      LN = LM + L2N
   63 READ(NUNIT,64) (DUMMY(K),K=1,10), ISEQ
   64 FORMAT (10E7.0,I2)
      IF(MCP.EQ.0) GO TO 5
    6 WRITE(6,2)DUMMY,ISEQ
    2 FORMAT(10E12.4,I5)
    5 XUMPTS(L5)= DUMMY(1)
      K = 2
      DO 65 J = L6,L7
      XUMPTS(J) = DUMMY(K)
   65 K = K+1
      ISOQ=(IS-1)*(L2N+1)+JJ+1
      IF(ISEQ-ISOQ) 69,66,69
   66 L6 = LN + L3
      L7 = LN + L4
      L5 = LM + 1 + JJ
      IF (JJ-L2N) 67, 68, 69
   67 JJ = JJ + 1
      LN = LN + L1N
      GO TO 63
   68 CONTINUE
  109 MUMMY = NUMPTS(NIMTBL) + (L1N+1) * (L2N+1)
  108 NIMTBL = NIMTBL + 1
      GO TO 102
   69 NG = 1
   99 RETURN
      END
      SUBROUTINE STINT1(A1,A2,A3,MINTBL,MAXTBL,FCT,NG)
      EQUIVALENCE (X(1),NUMPTS(1))
      COMMON/TAB1/NUMPTS(1)
      DIMENSION X(1)
      IZ =NUMPTS(1)/3
70    IF(MINTBL-MAXTBL)71,71,110
   71 DO 73 II=MINTBL,MAXTBL
      NJ =NUMPTS(II)+1
      IF(A3-X(NJ))72,74,73
   72 IF(II-MINTBL) 110,112,75
    3 CONTINUE
      GO TO 112
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   75 IK = 1                                                              CBL20360
      IL =2                                                               CBL20370
      NM=NJ                                                               CBL20380
  101 DO 97 IF=IK,IL                                                      CBL20390
      NJ =NUMPTS(II)+1                                                    CBL20400
      NI = IZ+II                                                          CBL20410
      IO =NUMPTS(NI)                                                      CBL20420
      IP =IO +NJ                                                          CBL20430
      DO 77 IQ=1,IO                                                       CBL20440
      NN= NJ+IQ                                                           CBL20450
      IF (A1-X(NN))76,78,77                                               CBL20460
   76 IF(IQ-1) 110,112,79                                                 CBL20470
   77 CONTINUE                                                            CBL20480
      GO TO 112                                                           CBL20490
   78 IG =-1                                                              CBL20500
      GO TO 80                                                            CBL20510
   79 IG =+1                                                              CBL20520
   80 NI=NI+IZ                                                            CBL20530
      IB = NUMPTS(NI)                                                     CBL20540
      DO 82 IA=1,IB                                                       CBL20550
      NS=IP+IA                                                            CBL20560
      IF (A2-X(NS))81,83,82                                               CBL20570
   81 IF(IA-1) 110,112,84                                                 CBL20580
   82 CONTINUE                                                            CBL20590
      GO TO 112                                                           CBL20600
   83 IH =-1                                                              CBL20610
      GO TO 85                                                            CBL20620
    4 IH =+1                                                              CBL20630
   85 NE=IP+IB+IQ+IO*IA-IO                                                CBL20640
      NR=NE-IO                                                            CBL20650
      IF(IG+IH) 86,88,91                                                  CBL20660
   86 IF (X(NE)-99998.5E9)87,113,113                                      CBL20670
   87 FCT = X(NE)                                                         CBL20680
      GO TO 95                                                            CBL20690
   88 IF(IG) 89,110,93                                                    CBL20700
   89 IF(AMAX1(X(NE),X(NR))-99998.5E9)90,113,113                          CBL20710
   90 FCT =X(NE)-(X(NS)-A2)*(X(NE)-X(NR))/(X(NS)-X(NS-1))                 CBL20720
      GO TO 95                                                            CBL20730
   91 IF(AMAX1(X(NE),X(NR),X(NE-1),X(NR-1))-99998.5E9)92,113,113          CBL20740
   92 FCT = ((X(NS)-A2)*((X(NN)-A1)*X(NR-1)-(X(NN-1)-A1)*X(NR)            CBL20750
     1)-(X(NS-1)-A2)*((X(NN)-A1)*X(NE-1)-(X(NN-1)-A1)*X(NE)))             CBL20760
     2/((X(NS)-X(NS-1))*(X(NN)-X(NN-1)))                                  CBL20770
      GO TO 95                                                            CBL20780
   93 IF(AMAX1(  X(NE),  X(NE-1))-99998.5E9) 94,113,113                   CBL20790
   94 FCT =  X(NE)-(  X(NN)-A1)*(  X(NE)-  X(NE-1))/(  X(NN)-  X(NN-1))   CBL20800
   95 GO TO (96,98,99),IF                                                 CBL20810
   96 DUMSTG =FCT                                                         CBL20820
   97 II =II-1                                                            CBL20830
   98 FCT =DUMSTG-(  X(NM)-A3)*(DUMSTG-FCT)/(  X(NM)-  X(NJ))             CBL20840
   99 RETURN                                                              CBL20850
   74 IK =3                                                               CBL20860
      IL =3                                                               CBL20870
      GO TO 101                                                           CBL20880
    0 NG =2                                                               CBL20890
      GO TO 99                                                            CBL20900
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```
  112 NG =3                                                          CBL 20910
      GO TO 99                                                       CBL 20920
    3 NG =4                                                          CBL 20930
      GO TO 99                                                       CBL 20940
      END                                                            CBL 20950
      SUBROUTINE TABIN1(NUMTBL,NZ,NG)                                CBL 20960
      COMMON/TAB1/NUMPTS(1)                                          CBL 20970
      COMMON /TABOU1/ NIMTBL,ISOQ                                    CBL 20980
      DIMENSION XUMPTS(1)                                            CBL 20990
      INTEGER*2 LABEL(27)                                            CBL 21000
      EQUIVALENCE (XUMPTS(1),NUMPTS(1)),(DUMMY(1),MUMMY)             CBL 21010
      DIMENSION DUMMY(10)                                            CBL 21020
      MCR=0                                                          CBL 21030
   10 IZ=IABS(NZ)                                                    CBL 21040
      NUNIT=5                                                        CBL 21050
      IF(NZ.LT.0) NUNIT=8                                            CBL 21060
      NIMTBL = NUMTBL                                                CBL 21070
      NG=0                                                           CBL 21080
      NUMPTS(1)=IZ+IZ+IZ                                             CBL 21090
  102 READ(NUNIT,57) K, L1N, L2N, LABEL, ISEQ                        CBL 21100
      IF(MCR.EQ.0) GO TO 3                                           CBL 21110
    4 WRITE(6,1) K,L1N,L2N,LABEL,ISEQ                                CBL 21120
    1 FORMAT(3I5, 10X,27A2,I46)                                      CBL 21130
   57 FORMAT(8XI4,2I2,27A2,I2)                                       CBL 21140
    3 IF(ISEQ) 69,58,69                                              CBL 21150
   58 IF(K) 99, 99, 59                                               CBL 21160
   59 M = IZ + NIMTBL                                                CBL 21170
      NUMPTS(M) = L1N                                                CBL 21180
      M = M + IZ                                                     CBL 21190
      NUMPTS(M) = L2N                                                CBL 21200
      IF(NUMTBL-NIMTBL)17,70,17                                      CBL 21210
   17 NUMPTS(NIMTBL) = MUMMY                                         CBL 21220
   70 N1 = (L1N-1) / 9 + 1                                           CBL 21230
      DO 68 IS = 1,N1                                                CBL 21240
      L3 = (IS-1) * 9 + 1                                            CBL 21250
      IF (IS-N1) 60, 61, 60                                          CBL 21260
   60 L4 = L3 + 8                                                    CBL 21270
      GO TO 62                                                       CBL 21280
   61 L4 = L1N                                                       CBL 21290
   62 L5 = NUMPTS(NIMTBL) + 1                                        CBL 21300
      L6 = L5 + L3                                                   CBL 21310
      L7 = L5 + L4                                                   CBL 21320
      JJ = 0                                                         CBL 21330
      LM = L5 + L1N                                                  CBL 21340
      LN = LM + L2N                                                  CBL 21350
   63 READ(NUNIT,64) (DUMMY(K),K=1,10), ISEQ                         CBL 21360
   64 FORMAT (10E7.0,I2)                                             CBL 21370
      IF(MCR.EQ.0) GO TO 5                                           CBL 21380
    6 WRITE(6,2)DUMMY,ISEQ                                           CBL 21390
    2 FORMAT(10E12.4,I5)                                             CBL 21400
    5 XUMPTS(L5)= DUMMY(1)                                           CBL 21410
      K = 2                                                          CBL 21420
      DO 65 J = L6,L7                                                CBL 21430
      XUMPTS(J) = DUMMY(K)                                           CBL 21440
   65 K = K+1                                                        CBL 21450
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```
      ISOQ=( IS-1)*(L2N+1)+JJ+1                                        CBL21460
      IF( ISEQ-ISOQ) 69,66,69                                          CBL21470
      L6 = LN + L3                                                     CBL21480
      L7 = LN + L4                                                     CBL21490
      L5 = LM + 1 + JJ                                                 CBL21500
      IF (JJ-L2N) 67, 68, 69                                           CBL21510
   67 JJ = JJ + 1                                                      CBL21520
      LN = LN + L1N                                                    CBL21530
      GO TO 63                                                         CBL21540
   68 CONTINUE                                                         CBL21550
  109 MUMMY = NUMPTS(NIMTBL) + (L1N+1) * (L2N+1)                       CBL21560
  108 NIMTBL = NIMTBL + 1                                              CBL21570
      GO TO 102                                                        CBL21580
   69 NG = 1                                                           CBL21590
   99 RETURN                                                           CBL21600
      END                                                              CBL21610
      SUBROUTINE FRICT(IDX)                                            CBL21620
      COMMON/DAT/AERO(150),AEROP(50),KODE(20)                          CBL21630
      COMMON/ROUGH/FRIC(3,6)                                           CBL21640
      EQUIVALENCE (AERO(96),COU),(AERO(104),CMF)                       CBL21650
      DO 1 I=1,3                                                       CBL21660
      DO 1 J=1,6                                                       CBL21670
    1 FRIC(I,J)=C.                                                     CBL21680
      IF(CMP.EQ.0..AND.COU.EQ.0.)RETURN                                CBL21690
      IND=KODE(6)                                                      CBL21700
      IF( IDX.NE.0)GO TO 2                                             CBL21710
C   LONGITUDINAL PULLEY FRICTION COMPUTATION                           CBL21720
      GO TO( 10,11,12,13),IND                                          CBL21730
   10 CALL FRVT(1)                                                     CBL21740
      RETURN                                                           CBL21750
   11 CALL FRVT(3)                                                     CBL21760
      RETURN                                                           CBL21770
   12 CALL FRVT(1)                                                     CBL21780
      CALL FRVT(3)                                                     CBL21790
   13 RETURN                                                           CBL21800
C   LATERAL DIRECTIONAL FRICTION COMPUTATION                           CBL21810
    2 GO TO( 20,21,22,23),IND                                          CBL21820
   20 CALL FRHZ(3)                                                     CBL21830
      RETURN                                                           CBL21840
   21 CALL FRHZ(1)                                                     CBL21850
   22 RETURN                                                           CBL21860
   23 CALL FRHZ(1)                                                     CBL21870
      CALL FRHZ(3)                                                     CBL21880
      RETURN                                                           CBL21890
      END                                                              CBL21900
      SUBROUTINE FRVT(IC)                                              CBL21910
C   COMPUTES THE FRICT. EFFECT OF THE VERT PULLEYS ON THE LONG. DYN.   CBL21920
      COMMON/DAT/AERO(150),AEROP(50),KODE(20)                          CBL21930
      COMMON/PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TF,TLFT,TF          CBL21940
      COMMON/ROUGH/FRIC(3,6)                                           CBL21950
      EQUIVALENCE (AERO(90),RVF),(AERO(92),RVF),(AERO(96),COU),        CBL21960
     1(AERO(104),CMP)                                                  CBL21970
      DIMENSION DT1(3),DT2(3)                                          CBL21980
      IF( IC.EQ.3)GO TO 1                                              CBL21990
      TENS=TF                                                          CBL22000
```

```
      RAD=RVF/12.                                                       CBL22010
      AVX=(ADC(2,1)-ADC(1,1))/2.                                        CBL22020
      CAX=COS(AVX)                                                      CBL22030
      CAZ=SIN(AVX)                                                      CBL22040
      GO TO 2                                                           CBL22050
    1 TENS=TR                                                           CBL22060
      RAD=RVR/12.                                                       CBL22070
      AVX=3.14159+(ADC(4,1)-ADC(3,1))/2.                                CBL22080
      CAX=COS(AVX)                                                      CBL22090
      CAZ=SIN(AVX)                                                      CBL22100
    2 ARMX=(ARM(IC,1)+ARM(IC+1,1))/24.                                  CBL22110
      ARMZ=(ARM(IC+1,3)-ARM(IC,3))/24.                                  CBL22120
      ENORX=TENS*COS(ADC(IC,1))                                         CBL22130
      ENORZ=TENS*(1.+COS(ADC(IC,3)))                                    CBL22140
      ENORM=SQRT(ENORX**2+ENORZ**2)                                     CBL22150
      CMPP=CMP/ENORM                                                    CBL22160
      FACU=CMPP*ENORM/RAD**2                                            CBL22170
      ENORX=TENS*COS(ADC(IC+1,1))                                       CBL22180
      ENORZ=TENS*(1.+COS(ADC(IC+1,3)))                                  CBL22190
      ENORM=SQRT(ENORX**2+ENORZ**2)                                     CBL22200
      CMPP=CMP/ENORM                                                    CBL22210
      FACL=CMPP*ENORM/RAD**2                                            CBL22220
      FACT=4.*COU/(3.14159*RAD**2)                                      CBL22230
      CALL DLGTH(CX,CZ,CT,IC,0)                                         CBL22240
      CALL DLGTH(CXP,CZP,CTP,IC+1,0)                                    CBL22250
      DT1(1)=FACT *(CXP-CX)                                             CBL22260
      DT1(2)=FACT *(CZP-CZ)                                             CBL22270
      DT1(3)=FACT *(CTP-CT)                                             CBL22280
      DT2(1)=FACL*CXP-FACU*CX                                           CBL22290
      DT2(2)=FACL*CZP-FACU*CZ                                           CBL22300
      DT2(3)=FACL*CTP-FACU*CT                                           CBL22310
      DO 3 I=1,3                                                        CBL22320
      FRIC(1,I)=FRIC(1,I)+DT1(I)*CAX                                    CBL22330
      FRIC(1,I+3)=FRIC(1,I+3)+DT2(I)*CAX                                CBL22340
      FRIC(2,I)=FRIC(2,I)+DT1(I)*CAZ                                    CBL22350
      FRIC(2,I+3)=FRIC(2,I+3)+DT2(I)*CAZ                                CBL22360
      FRIC(3,I)=FRIC(3,I)+DT1(I)*RAD+DT1(I)*CAX*ARMZ-DT1(I)*CAZ*ARMX    CBL22370
      FRIC(3,I+3)=FRIC(3,I+3)+DT2(I)*RAD+DT2(I)*CAX*ARMZ-DT2(I)*CAZ*ARMX CBL22380
    3 CONTINUE                                                          CBL22390
      RETURN                                                            CBL22400
      END                                                               CBL22410
      SUBROUTINE FRHZ(IC)                                               CBL22420
C  COMPUTES THE FRICT. EFFECT OF THE HORZ PULLEYS ON THE LAT. DIR. DYN. CBL22430
      COMMON/DAT/AERO(150),AEROP(50),KODE(20)                           CBL22440
      COMMON/PLYCHA/RTD,XLGTH(5),ADC(5,3),ARM(5,3),TR,TLFT,TF           CBL22450
      COMMON/ROUGH/FRIC(3,6)                                            CBL22460
      EQUIVALENCE (AERO(91),RHF),(AERO(93),RHR),(AERO(96),COU),         CBL22470
     1(AERO(104),CMP)                                                   CBL22480
      DIMENSION DT1(3),DT2(3)                                           CBL22490
      IF(IC.EQ.3)GO TO 1                                                CBL22500
      TENS=TF                                                           CBL22510
      RAD=RHF/12.                                                       CBL22520
      GO TO 2                                                           CBL22530
    1 TENS=TR                                                           CBL22540
      RAD=RHR/12.                                                       CBL22550
```

```
    2 ENORX=TENS*COS(ADC(IC,1))
      ENORY=TENS*(1.+COS(ADC(IC,2)))
      ENORM=SQRT(ENORY*ENORY+ENORX+ENORX)
      CMPP=CMP/ENORM
      FACL=CMPP*ENORM/RAD**2
      FACT=4.*COL/(3.14159*RAD**2)
      CALL DLGTH(CY,CPSI,CPHI,IC,1)
      CALL DLGTH(CYP,CPSIP,CPHIP,IC+1,1)
      DT1(1)=FACT*(CY-CYP)
      DT1(2)=FACT*(CPSI-CPSIP)
      DT1(3)=FACT*(CPHI-CPHIP)
      DT2(1)=FACL*(CY-CYP)
      DT2(2)=FACL*(CPSI-CPSIP)
      DT2(3)=FACL*(CPHI-CPHIP)
      DO 3 I=1,3
      FRIC(1,I)=FRIC(1,I)+DT1(I)*COS(ADC(IC,2))
      FRIC(1,I+3)=FRIC(1,I+3)+DT2(I)*COS(ADC(IC,2))
      FRIC(2,I)=FRIC(2,I)+DT1(I)*RAD-DT1(I)*COS(ADC(IC,1))*ARM(IC,2)
     1/12.+DT1(I)*COS(ADC(IC,2))*ARM(IC,1)/12.
      FRIC(2,I+3)=FRIC(2,I+3)+DT2(I)*RAD-DT2(I)*COS(ADC(IC,1))*ARM(IC,2)
     1/12.+DT2(I)*COS(ADC(IC,2))*ARM(IC,1)/12.
      FRIC(3,I)=FRIC(3,I)+DT1(I)*RAD+DT1(I)*COS(ADC(IC,3))*ARM(IC,2)
     1/12.-ARM(IC,3)/12.*DT1(I)*COS(ADC(IC,2))
      FRIC(3,I+3)=FRIC(3,I+3)+DT2(I)*RAD+DT2(I)*COS(ADC(IC,3))*ARM(IC,2)
     1/12.-ARM(IC,3)/12.*DT2(I)*COS(ADC(IC,2))
    3 CONTINUE
      RETURN
      END
C THIS IS A SINGLE PRECISION VERSION OF THE LRC MATRIX
C  MATRIX REDUCTION AND THE IBM ROOT FINDING ROUTINE
      SUBROUTINE MATRIX(A,N,ROOTS,K4A,IER)
      COMPLEX ROOTS(1)
      DIMENSION A(7,7,3),ATILDA(7,7,15),ADET(29),
     1                    G(7,7,15)
      DIMENSION COEF(29),EQ(29),RR(29),RC(29),FCL(29)
      COMMON/DAT/AERO(150),AEROP(50),KODE(20),LL
      DO 501 I=1,29
  501 ADET(I)=0
      ISWCK=1
      IW=6
      K=2
         KP1 = K + 1
      IF(KODE(5).EQ.0) GO TO 26
      DO 25 I = 1, N
      DO 25 J = 1, N
      WRITE( IW, 39) I, J
   25 WRITE( IW, 50) (A(I,J,K1), K1 = 1, KP1)
   26 CALL SCALER (A,1.,N,N,KP1)
      CALL EQUIL (A,N,N,KP1,EQ,DDET)
      CALL ENVERT(N, A, K, G, ATILDA, ADET)
      DO 301 I=1,29
  301 COEF(I)=ADET(I)
      DO 27 I=1,29
   27 IF(ABS(COEF(I)).LT.1.E-08) COEF(I)=0.
      IF(KODE(5).EQ.0) GO TO 305
```

```
      WRITE(IW,401)
  401 FORMAT(2X,'COEFFICIENTS OF CHARACTERISTIC POLYNOMIAL
     1 ORDERED FROM LOW TO HIGH')
      WRITE(IW,400)(COEF(I),I=1,29)
  400 FORMAT(6(2X,E10.3))
  305 CONTINUE
      CALL PRBM1(COEF,29,RR,RC,POL,IRT,IER,50)
      DO 300 I=1,IRT
  300 ROOTS(I)=CMPLX(RR(I),RC(I))
      K4A=IRT
      RETURN
   39 FORMAT(25X, 3HA (, I2, 1H,, I2, 1H))
   50  FORMAT (6E19.8)
         END

      SUBROUTINE POLADD(N1,V1,N2,V2,N3,V3)
C SUM OF TWO POLYNOMIALS
C
C     N1= DEGREE OF P1 (FIRST POLYNOMIAL)
C     N2= DEGREE OF P2
C     N3= DEGRE  OF OUTPUT POLYNOMIAL
C
C     V1= BASE ADDRESS OF COEFFICIENTS OF P1
C     V2= BASE ADDRESS OF COEFFICIENTS OF P2
C     V3= BASE ADDRESS OF OUTPUT VECTOR.
C
C     THIS ROUTINE WILL HANDLE A POLYNOMIAL OF DEGREE 50
      DIMENSION V1(51),V2(51),V3(51)
C     PERFORM ADD --ADD COEFFICIENTS OF LIKE POWERS
      IC3=N2+1
      IC1=N1+1
      IC2=N2+2
      IC4=N1+2
      IF (N2-N1) 1,8,2
 1    DO 4 I=IC2,IC1
 4    V3(I)=V1(I)
 8    N3= N1
      DO 5 I=1,IC3
 5    V3(I)= V1(I)+V2(I)
      RETURN
 2    N3 = N2
      DO 6 I=1,IC1
      V3(I)=V1(I)+V2(I)
 6    CONTINUE
      DO 7 J=IC4,IC3
      V3(J)=V2(J)
 7    CONTINUE
      RETURN
      END
      SUBROUTINE POLSUB (N1,V1,N2,V2,N3,V3)
C
C SUBTRACT P2 FROM P1 AND STORE IN P3
C
C     SEE NOTES ON ADD
      DIMENSION V1(51),V2(51),V3(51)
```

```
      IC1=N1+1
      IC2=N2+1
      IC3=N2+2
      IC4=N1+2
      IF (N2-N1) 1,8,2
 1    DO 4 I= IC3,IC1
 4    V3(I) = V1(I)
 8    N3=N1
      DO 5 I=1,IC2
 5    V3(I)=V1(I)-V2(I)
      RETURN
 2    N3=N2
      DO 6 I=1,IC1
      V3(I)=V1(I)-V2(I)
 6    CONTINUE
      DO 7 J=IC4,IC2
      V3(J)=-V2(J)
 7    CONTINUE
      RETURN
      END

      SUBROUTINE POLMPY(N1,START1,N2,START2,N3,START3)
C MULTIPLY TWO POLYNOMIALS
C       N1 = DEGREE OF P1 (THE FIRST POLYNOMIAL)
C       N2 = DEGREE OF P2
C       N3 = THE LOCATION (INT.) WHERE THE DEGREE OF THE OUTPUT
C            POLYNOMIAL WILL BE STORED.
C       START1 = THE FIRST LOCATION OF THE COEFFICIENTS OF P1 . CONSTANT
C                TERM IS FIRST
C       START2 = THE FIRST LOCATION OF THE COEFFICIENTS OF P2
C
C       START3 = THE BASE LOCATION OF THE OUTPUT POLYNOMIAL
C
C       THE ROUTINE WILL HANDLE POLYNOMIALS OF 50TH DEGREE
      DIMENSION START1(55),START2(55),START3(55),WORK(51)
C
C  START MULTIPLY --  ZERO OUTPUT VECTOR
C
      N4=N1+N2+1
      DO 1 I=1,N4
      WORK(I) = 0.0
 1    CONTINUE
C
C  CARRY THROUGH MULTIPLICATION PROCESS
C
      IC1 = N1+1
      IC2 = N2+1
      DO 3 I=1,IC1
      DO 2 J=1,IC2
      WORK (I+J-1) =(START1(I)*START2(J))+WORK(I+J-1)
 2    CONTINUE
 3    CONTINUE
      DO 4 I=1,N4
 4    START3(I) = WORK(I)
      N3=N4-1
```

```
      RETURN
      END

      SUBROUTINE MATMPY(A, N, IADEG, B, M, IBDEG, C, NA, NB, NC)
      DIMENSION A(7,7,NA),B(7,7,NB),C(7,7,NC),VA(29),VB(29),VC(29)
     1          ,VD(29)
      IADEG1 = IADEG + 1
      IBDEG1 = IBDEG + 1
      ICDEG1 = IADEG + IBDEG + 1
      DO 10 I = 1, N
      DO 10 J = 1, M
      DO 50 K = 1, ICDEG1
   50 VD(K) = 0.0
      DO 20 JJ = 1, N
      DO 30 K = 1, IADEG1
   30 VA(K) = A(I,JJ,K)
      DO 40 K = 1, IBDEG1
   40 VB(K) = B(JJ,J,K)
      CALL POLMPY(IADEG, VA, IBDEG, VB, ICDEG, VC)
   20 CALL POLADD(ICDEG, VC, ICDEG, VD, ICDEG, VD)
      DO 60 K = 1, ICDEG1
   60 C( I,J,K) = VD(K)
   10 CONTINUE
      RETURN
      END

      SUBROUTINE TRACE(N, AI, IADEG, RL, P)
      DIMENSION AI(7,7,15),P(27),VA(27),VB(27)
      IADEG1 = IADEG + 1
      DO 50 K = 1, IADEG1
   50 VB(K) = 0.0
      DO 10 I = 1, N
      DO 20 K = 1, IADEG1
   20 VA(K) = AI(I,I,K)
   10 CALL POLADD(IADEG, VA, IADEG, VB, IADEG, VB)
      DO 30 K = 1, IADEG1
   30 P(K) = VB(K) / RL
      RETURN
      END

      SUBROUTINE COMPBI(N, IADEG, AI, P, BI)
      DIMENSION AI(7,7,15),BI(7,7,15),P(27),VA(27),VB(27)
      IADEG1 = IADEG + 1
      DO 10 I = 1, N
      DO 10 J = 1, N
      IF (I .NE. J) GO TO 20
      DO 50 K = 1, IADEG1
   50 VA(K) = AI(I,J,K)
      CALL POLSUB(IADEG, VA, IADEG, P, IADEG, VB)
      DO 51 K = 1, IADEG1
   51 BI(I,J,K) = VB(K)
      GO TO 10
   20 DO 52 K = 1, IADEG1
   52 BI(I,J,K) = AI(I,J,K)
   10 CONTINUE
```

```
      RETURN
      END

      SUBROUTINE ENVERT(N, A, IADEG, AI, BI, F)
      DIMENSION A(7,7,3),AI(7,7,15),BI(7,7,15),F(27)
      IADEG1 = IADEG + 1
      DO 50 I = 1, N
      DO 50 J = 1, N
      DO 50 K = 1, IADEG1
   50 AI(I,J,K) = A(I,J,K)
      IBDEG = 0
      DO 10 L = 1, N
      IF (L .EQ. 1) GO TO 20
      CALL MATMPY (A,N,IADEG,BI,N,IBDEG,AI,3,7,7)
   20 IBDEG = IBDEG + IADEG
      RL = L
      CALL TRACE(N, AI, IBDEG, RL, P)
      IF (L .EQ. N) GO TO 30
   10 CALL COMPRI(N, IBDEG, AI, P, BI)
   30 CONTINUE
      RETURN
      END

      SUBROUTINE SCALER (C,SCALE,M,N,NC)
      DIMENSION C(7,7,NC)
      IF(NC.LE.1) RETURN
      DO 1 I=1,M
      DO 1 J=1,N
      DO 1 K=2,NC
    1 C(I,J,K)=C(I,J,K)*SCALE**(K-1)
      RETURN
      END

      SUBROUTINE EQUIL (C,M,N,NC,EQ,DDET)
      DIMENSION C(7,7,NC),EQ(M)
      DDET=1.0
      DO 1 I=1,M
      AMAX=0.0D0
      DO 2 J=1,N
      DO 2 K=1,NC
      CC=ABS(C(I,J,K))
      IF (CC.GT.AMAX) AMAX=CC
    2 CONTINUE
      EQ(I)=10./AMAX
      DO 3 J=1,N
      DO 3 K=1,NC
    3 C(I,J,K)=C(I,J,K)*EQ(I)
    1 DDET=DDET*EQ(I)
      DDET=DDET*(-1)**(M-1)
      RETURN
      END
C
C     ..................................................................
C
C        SUBROUTINE PRBM1
```

```
C
C        PURPOSE
C           TO CALCULATE ALL REAL AND COMPLEX ROOTS OF A GIVEN
C           POLYNOMIAL WITH REAL COEFFICIENTS.
C
C        USAGE
C           CALL PRBM1 (C,IC,RR,RC,POL,IR,IER,LIM)
C
C        DESCRIPTION OF PARAMETERS
C           C      - INPUT VECTOR CONTAINING THE COEFFICIENTS OF THE
C                    GIVEN POLYNOMIAL. COEFFICIENTS ARE ORDERED FROM
C                    LOW TO HIGH. ON RETURN COEFFICIENTS ARE DIVIDED
C                    BY THE LAST NONZERO TERM.
C           IC     - DIMENSION OF VECTORS C, RR, RC, AND POL.
C           RR     - RESULTANT VECTOR OF REAL PARTS OF THE ROOTS.
C           RC     - RESULTANT VECTOR OF COMPLEX PARTS OF THE ROOTS.
C           POL    - RESULTANT VECTOR OF COEFFICIENTS OF THE POLYNOMIAL
C                    WITH CALCULATED ROOTS. COEFFICIENTS ARE ORDERED
C                    FROM LOW TO HIGH (SEE REMARK 4).
C           IR     - OUTPUT VALUE SPECIFYING THE NUMBER OF CALCULATED
C                    ROOTS. NORMALLY IR IS EQUAL TO IC-1.
C           IER    - RESULTANT ERROR PARAMETER CODED AS FOLLOWS
C                     IER=0  - NO ERROR.
C                     IER=1  - SUBROUTINE PQFB RECORDS POOR CONVERGENCE
C                              AT SOME QUADRATIC FACTORIZATION WITHIN
C                              50 ITERATION STEPS.
C                     IER=2  - POLYNOMIAL IS DEGENERATE, I.E. ZERO OR
C                              CONSTANT,
C                              OR OVERFLOW IN NORMALIZATION OF GIVEN
C                              POLYNOMIAL,
C                     IER=3  - THE SUBROUTINE IS BYPASSED DUE TO
C                              SUCCESSIVE ZERO DIVISORS OR OVERFLOWS
C                              IN QUADRATIC FACTORIZATION OR DUE TO
C                              COMPLETELY UNSATISFACTORY ACCURACY.
C                     IER=-1 - CALCULATED COEFFICIENT VECTOR HAS LESS
C                              THAN THREE CORRECT SIGNIFICANT DIGITS.
C                              THIS REVEALS POOR ACCURACY OF CALCULATED
C                              ROOTS.
C          LIM     - NUMBER OF ITERATION STEPS, NOMINAL 50.
C        REMARKS
C           (1) REAL PARTS OF THE ROOTS ARE STORED IN RR(1) UP TO RR(IR)
C               AND CORRESPONDING COMPLEX PARTS IN RC(1) UP TO RC(IR).
C           (2) ERROR MESSAGE IER=1 INDICATES POOR CONVERGENCE WITHIN
C               50 ITERATION STEPS AT SOME QUADRATIC FACTORIZATION
C               PERFORMED BY SUBROUTINE PQFB.
C           (3) NO ACTION BESIDES ERROR MESSAGE IER=2 IN CASE OF A ZERO
C               OR CONSTANT POLYNOMIAL. THE SAME ERROR MESSAGE IS GIVEN
C               IN CASE OF AN OVERFLOW IN NORMALIZATION OF GIVEN
C               POLYNOMIAL.
C           (4) ERROR MESSAGE IER=3 INDICATES SUCCESSIVE ZERO DIVISORS
C               OR OVERFLOWS OR COMPLETELY UNSATISFACTORY ACCURACY AT
C               ANY QUADRATIC FACTORIZATION PERFORMED BY
C               SUBROUTINE PQFB. IN THIS CASE CALCULATION IS BYPASSED.
C               IR RECORDS THE NUMBER OF CALCULATED ROOTS.
C               POL(1),...,POL(J-IR) ARE THE COEFFICIENTS OF THE
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C                REMAINING POLYNOMIAL, WHERE J IS THE ACTUAL NUMBER OF
C                COEFFICIENTS IN VECTOR C (NORMALLY J=IC).
C            (5) IF CALCULATED COEFFICIENT VECTOR HAS LESS THAN THREE
C                CORRECT SIGNIFICANT DIGITS THOUGH ALL QUADRATIC
C                FACTORIZATIONS SHOWED SATISFACTORY ACCURACY, THE ERROR
C                MESSAGE IER=-1 IS GIVEN.
C            (6) THE FINAL COMPARISON BETWEEN GIVEN AND CALCULATED
C                COEFFICIENT VECTOR IS PERFORMED ONLY IF ALL ROOTS HAVE
C                BEEN CALCULATED. IN THIS CASE THE NUMBER OF ROOTS IR IS
C                EQUAL TO THE ACTUAL DEGREE OF THE POLYNOMIAL (NORMALLY
C                IR=IC-1). THE MAXIMAL RELATIVE ERROR OF THE COEFFICIENT
C                VECTOR IS RECORDED IN RR(IR+1).
C
C        SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
C           SUBROUTINE PQFB      QUADRATIC FACTORIZATION OF A POLYNOMIAL
C                                BY BAIRSTOW ITERATION.
C
C        METHOD
C           THE ROOTS OF THE POLYNOMIAL ARE CALCULATED BY MEANS OF
C           SUCCESSIVE QUADRATIC FACTORIZATION PERFORMED BY BAIRSTOW
C           ITERATION. X**2 IS USED AS INITIAL GUESS FOR THE FIRST
C           QUADRATIC FACTOR, AND FURTHER EACH CALCULATED QUADRATIC
C           FACTOR IS USED AS INITIAL GUESS FOR THE NEXT ONE. AFTER
C           COMPUTATION OF ALL ROOTS THE COEFFICIENT VECTOR IS
C           CALCULATED AND COMPARED WITH THE GIVEN ONE.
C           FOR REFERENCE, SEE J. H. WILKINSON, THE EVALUATION OF THE
C           ZEROS OF ILL-CONDITIONED POLYNOMIALS (PART ONE AND TWO),
C           NUMERISCHE MATHEMATIK, VOL.1 (1959), PP.150-180.
C
C     ..................................................................
C
      SUBROUTINE PRBM1(C,IC,RR,RC,POL,IR,IER,LIM)
C
C
      DIMENSION C(1),RR(1),RC(1),POL(1),Q(4)
      TEST=1.E+70
C
C        TEST ON LEADING ZERO COEFFICIENTS
      EPS=1.E-3
C             LIM=KK*LIM WHERE KK=1 OR 2 AND LIM=50.
      IR=IC+1
    1 IR=IR-1
      IF(IR-1)42,42,2
    2 IF(C(IR))3,1,3
C
C        WORK UP ZERO ROOTS AND NORMALIZE REMAINING POLYNOMIAL
    3 IER=0
      J=IR
      L=0
      A=C(IR)
      DO 8 I=1,IR
      IF(L)4,4,7
    4 IF(C(I))6,5,6
    5 RR(I)=0.
      RC(I)=0.
```

```
      POL(J)=0.
      J=J-1
      GO TO 8
    6 L=1
      IST=I
      J=0
    7 J=J+1
      C(I)=C(I)/A
      POL(J)=C(I)
      IF(POL(J).GT.TEST) GO TO 42
    8 CONTINUE
C
C        START BAIRSTOW ITERATION
      Q1=0.
      Q2=0.
    9 IF(J-2)33,10,14
C
C        DEGREE OF RESTPOLYNOMIAL IS EQUAL TO ONE
   10 A=POL(1)
      RR(IST)=-A
      RC(IST)=0.
      IR=IR-1
      Q2=0.
      IF(IR-1)13,13,11
   11 DO 12 I=2,IR
      Q1=Q2
      Q2=POL(I+1)
   12 POL(I)=A*Q2+Q1
   13 POL(IR+1)=A+Q2
      GO TO 34
C        THIS IS BRANCH TO COMPARISON OF COEFFICIENT VECTORS C AND POL
C
C        DEGREE OF RESTPOLYNOMIAL IS GREATER THAN ONE
   14 DO 22 L=1,10
      N=1
   15 Q(1)=Q1
      Q(2)=Q2
      CALL PQFB1(POL,J,Q,LIM,I)
      IF(I)16,24,23
   16 IF(Q1)18,17,18
   17 IF(Q2)18,21,18
   18 GO TO (19,20,19,21),N
   19 Q1=-Q1
      N=N+1
      GO TO 15
   20 Q2=-Q2
      N=N+1
      GO TO 15
   21 Q1=1.+Q1
   22 Q2=1.-Q2
C
C        ERROR EXIT DUE TO UNSATISFACTORY RESULTS OF FACTORIZATION
      IER=3
      IR=IR-J
      RETURN
```

```
C
C         WORK UP RESULTS OF QUADRATIC FACTORIZATION
   23 IER=1
   24 Q1=Q(1)
      Q2=Q(2)
C
C         PERFORM DIVISION OF FACTORIZED POLYNOMIAL BY QUADRATIC FACTOR
      B=0.
      A=0.
      I=J
   25 H=-Q1*B-Q2*A+POL(I)
      POL(I)=B
      B=A
      A=H
      I=I-1
      IF(I-2)26,26,25
   26 POL(2)=B
      POL(1)=A
C
C         MULTIPLY POLYNOMIAL WITH CALCULATED ROOTS BY QUADRATIC FACTOR
      L=IR-1
      IF(J-L)27,27,29
   27 DO 28 I=J,L
   28 POL(I-1)=POL(I-1)+POL(I)*Q2+POL(I+1)*Q1
   29 POL(L)=POL(L)+POL(L+1)*Q2+Q1
      POL(IR)=POL(IR)+Q2
C
C         CALCULATE ROOT-PAIR FROM QUADRATIC FACTOR X*X+Q2*X+Q1
      H=-.5*Q2
      A=H*H-Q1
      B=SQRT(ABS(A))
      IF(A)30,30,31
   30 RR(IST)=H
      RC(IST)=B
      IST=IST+1
      RR(IST)=H
      RC(IST)=-B
      GO TO 32
   31 B=H+SIGN(B,H)
      RR(IST)=Q1/B
      RC(IST)=0.
      IST=IST+1
      RR(IST)=B
      RC(IST)=0.
   32 IST=IST+1
      J=J-2
      GO TO 9
C
C         SHIFT BACK ELEMENTS OF POL BY 1 AND COMPARE VECTORS POL AND C
   33 IR=IR-1
   34 A=0.
      DO 38 I=1,IR
      Q1=C(I)
      Q2=POL(I+1)
      POL(I)=Q2
```

```
      IF(Q1)35,36,35
   35 Q2=(Q1-Q2)/Q1
   36 Q2=ABS(Q2)
      IF(Q2-A)38,38,37
   37 A=Q2
   38 CONTINUE
      I=IR+1
      POL(I)=1.
      RR(I)=A
      RC(I)=0.
      IF(IER)39,39,41
   39 IF(A-EPS)41,41,40
C
C        WARNING DUE TO POOR ACCURACY OF CALCULATED COEFFICIENT VECTOR
   40 IER=-1
   41 RETURN
C
C        ERROR EXIT DUE TO DEGENERATE POLYNOMIAL OR OVERFLOW IN
C        NORMALIZATION
   42 IER=2
      IR=0
      RETURN
      END

C
C     ..................................................................
C
C        SUBROUTINE PQFB1
C
C        PURPOSE
C           TO FIND AN APPROXIMATION Q(X)=Q1+Q2*X+X*X TO A QUADRATIC
C           FACTOR OF A GIVEN POLYNOMIAL P(X) WITH REAL COEFFICIENTS.
C
C        USAGE
C           CALL PQFB1(C,IC,Q,LIM,IER)
C
C        DESCRIPTION OF PARAMETERS
C           C     - INPUT VECTOR CONTAINING THE COEFFICIENTS OF P(X) -
C                   C(1) IS THE CONSTANT TERM (DIMENSION IC)
C           IC    - DIMENSION OF C
C           Q     - VECTOR OF DIMENSION 4 - ON INPUT Q(1) AND Q(2) MUST
C                   CONTAIN INITIAL GUESSES FOR Q1 AND Q2 - ON RETURN Q(1)
C                   AND Q(2) CONTAIN THE REFINED COEFFICIENTS Q1 AND Q2 OF
C                   Q(X), WHILE Q(3) AND Q(4) CONTAIN THE COEFFICIENTS A
C                   AND B OF A+B*X, WHICH IS THE REMAINDER OF THE QUOTIENT
C                   OF P(X) BY Q(X)
C           LIM   - INPUT VALUE SPECIFYING THE MAXIMUM NUMBER OF
C                   ITERATIONS TO BE PERFORMED
C           IER   - RESULTING ERROR PARAMETER (SEE REMARKS)
C                   IER= 0 - NO ERROR
C                   IER= 1 - NO CONVERGENCE WITHIN LIM ITERATIONS
C                   IER=-1 - THE POLYNOMIAL P(X) IS CONSTANT OR UNDEFINED
C                          - OR OVERFLOW OCCURRED IN NORMALIZING P(X)
C                   IER=-2 - THE POLYNOMIAL P(X) IS OF DEGREE 1
C                   IER=-3 - NO FURTHER REFINEMENT OF THE APPROXIMATION TO
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C                     A QUADRATIC FACTOR IS FEASIBLE, DUE TO EITHER
C                     DIVISION BY 0, OVERFLOW OF AN INITIAL GUESS
C                     THAT IS NOT SUFFICIENTLY CLOSE TO A FACTOR OF
C                     P(X)
C
C     REMARKS
C        (1)  IF IER=-1 THERE IS NO COMPUTATION OTHER THAN THE
C             POSSIBLE NORMALIZATION OF C.
C        (2)  IF IER=-2 THERE IS NO COMPUTATION OTHER THAN THE
C             NORMALIZATION OF C.
C        (3)  IF IER =-3  IT IS SUGGESTED THAT A NEW INITIAL GUESS BE
C             MADE FOR A QUADRATIC FACTOR.  C, HOWEVER, WILL CONTAIN
C             THE VALUES ASSOCIATED WITH THE ITERATION THAT YIELDED
C             THE SMALLEST NORM OF THE MODIFIED LINEAR REMAINDER.
C        (4)  IF IER=1, THEN, ALTHOUGH THE NUMBER OF ITERATIONS LIM
C             WAS TOO SMALL TO INDICATE CONVERGENCE, NO OTHER PROB-
C             LEMS HAVE BEEN DETECTED, AND C WILL CONTAIN THE VALUES
C             ASSOCIATED WITH THE ITERATION THAT YIELDED THE SMALLEST
C             NORM OF THE MODIFIED LINEAR REMAINDER.
C        (5)  FOR COMPLETE DETAIL SEE THE DOCUMENTATION FOR
C             SUBROUTINES PQFB AND DPQFB.
C
C     SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
C        NONE
C
C     METHOD
C        COMPUTATION IS BASED ON BAIRSTOW S ITERATIVE METHOD.  (SEE
C        WILKINSON, J.H., THE EVALUATION OF THE ZEROS OF ILL-CON-
C        DITIONED POLYNOMIALS (PART ONE AND TWO), NUMERISCHE MATHE-
C        MATIK, VOL.1 (1959), PP. 150-180, OR HILDEBRAND, F.B.,
C        INTRODUCTION TO NUMERICAL ANALYSIS, MC GRAW-HILL, NEW YORK/
C        TORONTO/LONDON, 1956, PP. 472-476.)
C
C     ..................................................................
C
      SUBROUTINE PQFB1(C,IC,Q,LIM,IER)
C
C
      DIMENSION C(4),Q(4)
C
C        TEST ON LEADING ZERO COEFFICIENTS
      IER=0
      TEST=1.E+70
      J=IC+1
    1 J=J-1
      IF(J-1)40,40,2
    2 IF(C(J))3,1,3
C
C        NORMALIZATION OF REMAINING COEFFICIENTS
    3 A=C(J)
      IF(A-1.)4,6,4
    4 DO 5 I=1,J
      C(I)=C(I)/A
      IF(C(I).GT.TEST) GO TO 40
    5 CONTINUE
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C                                                                       CBL28610
C         TEST ON NECESSITY OF BAIRSTOW ITERATION                       CBL28620
    6 IF(J-3)41,38,7                                                    CBL28630
C                                                                       CBL28640
C         PREPARE BAIRSTOW ITERATION                                    CBL28650
    7 EPS =  1.E-4                                                      CBL28660
      EPS1=  1.E-2                                                      CBL28670
      L=0                                                               CBL28680
      LL=0                                                              CBL28690
      Q1=Q(1)                                                           CBL28700
      Q2=Q(2)                                                           CBL28710
      QQ1=0.                                                            CBL28720
      QQ2=0.                                                            CBL28730
      AA=C(1)                                                           CBL28740
      BB=C(2)                                                           CBL28750
      CB=ABS(AA)                                                        CBL28760
      CA=ABS(BB)                                                        CBL28770
      IF(CB-CA)8,9,10                                                   CBL28780
    8 CC=CB+CB                                                          CBL28790
      CB=CB/CA                                                          CBL28800
      CA=1.                                                             CBL28810
      GO TO 11                                                          CBL28820
    9 CC=CA+CA                                                          CBL28830
      CA=1.                                                             CBL28840
      CB=1.                                                             CBL28850
      GO TO 11                                                          CBL28860
   10 CC=CA+CA                                                          CBL28870
      CA=CA/CB                                                          CBL28880
      CB=1.                                                             CBL28890
   11 CD=CC*.1                                                          CBL28900
C                                                                       CBL28910
C         START BAIRSTOW ITERATION                                      CBL28920
C         PREPARE NESTED MULTIPLICATION                                 CBL28930
   12 A=0.                                                              CBL28940
      B=A                                                               CBL28950
      A1=A                                                              CBL28960
      B1=A                                                              CBL28970
      I=J                                                               CBL28980
      QQQ1=Q1                                                           CBL28990
      QQQ2=Q2                                                           CBL29000
      DQ1=HH                                                            CBL29010
      DQ2=H                                                             CBL29020
C                                                                       CBL29030
C         START NESTED MULTIPLICATION                                   CBL29040
   13 H=-Q1*B-Q2*A+C(I)                                                 CBL29050
      IF(H.GT.TEST) GO TO 42                                            CBL29060
      B=A                                                               CBL29070
      A=H                                                               CBL29080
      I=I-1                                                             CBL29090
      IF(I-1)18,15,16                                                   CBL29100
   15 H=0.                                                              CBL29110
   16 H=-Q1*B1-Q2*A1+H                                                  CBL29120
      IF(H.GT.TEST) GO TO 42                                            CBL29130
      C1=B1                                                             CBL29140
      B1=A1                                                             CBL29150
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      A1=H
      GO TO 13
C        END OF NESTED MULTIPLICATION
C
C        TEST ON SATISFACTORY ACCURACY
   18 H=CA*ABS(A)+CB*ABS(B)
      IF(LL)19,19,39
   19 L=L+1
      IF(ABS(A)-EPS*ABS(C(1)))20,20,21
   20 IF(ABS(B)-EPS*ABS(C(2)))39,39,21
C
C        TEST ON LINEAR REMAINDER OF MINIMUM NORM
   21 IF(H-CC)22,22,23
   22 AA=A
      BB=B
      CC=H
      QQ1=Q1
      QQ2=Q2
C
C        TEST ON LAST ITERATION STEP
   23 IF(L-LIM)28,28,24
C
C        TEST ON RESTART OF BAIRSTOW ITERATION WITH ZERO INITIAL GUESS
   24 IF(H-CD)43,43,25
   25 IF(Q(1))27,26,27
   26 IF(Q(2))27,42,27
   27 Q(1)=0.
      Q(2)=0.
      GO TO 7
C
C        PERFORM ITERATION STEP
   28 H1=ABS(A1)
      H2=ABS(B1)
      IF(H1-H2)45,46,46
   45 H1=ABS(C1)
      IF(H1-H2)47,48,48
   46 H2=ABS(C1)
      IF(H1-H2)48,49,49
   47 HH=ABS(B1)
      GO TO 50
   48 HH=ABS(C1)
      GO TO 50
   49 HH=ABS(A1)
   50 IF(HH)42,42,29
   29 A1=A1/HH
      B1=B1/HH
      C1=C1/HH
      H=A1*C1-B1*B1
      IF(H)30,42,30
   30 A=A/HH
      B=B/HH
      HH=(B*A1-A*B1)/H
      H=(A*C1-B*B1)/H
      Q1=Q1+HH
      Q2=Q2+H
```

```
C          END OF ITERATION STEP
C
C          TEST ON SATISFACTORY RELATIVE ERROR OF ITERATED VALUES
      IF(ABS(HH)-EPS*ABS(Q1))31,31,33
   31 IF(ABS(H)-EPS*ABS(Q2))32,32,33
   32 LL=1
      GO TO 12
C
C          TEST ON DECREASING RELATIVE ERRORS
   33 IF(L-1)12,12,34
   34 IF(ABS(HH)-EPS1*ABS(Q1))35,35,12
   35 IF(ABS(H)-EPS1*ABS(Q2))36,36,12
   36 IF(ABS(QQQ1*HH)-ABS(Q1*DQ1))37,44,44
   37 IF(ABS(QQQ2*H)-ABS(Q2*DQ2))12,44,44
C          END OF BAIRSTOW ITERATION
C
C          EXIT IN CASE OF QUADRATIC POLYNOMIAL
   38 Q(1)=C(1)
      Q(2)=C(2)
      Q(3)=0.
      Q(4)=0.
      RETURN
C
C          EXIT IN CASE OF SUFFICIENT ACCURACY
   39 Q(1)=Q1
      Q(2)=Q2
      Q(3)=A
      Q(4)=B
      RETURN
C
C          ERROR EXIT IN CASE OF ZERO OR CONSTANT POLYNOMIAL
   40 IER=-1
      RETURN
C
C          ERROR EXIT IN CASE OF LINEAR POLYNOMIAL
   41 IER=-2
      RETURN
C
C          ERROR EXIT IN CASE OF NONREFINED QUADRATIC FACTOR
   42 IER=-3
      GO TO 44
C
C          ERROR EXIT IN CASE OF UNSATISFACTORY ACCURACY
   43 IER=1
   44 Q(1)=QQ1
      Q(2)=QQ2
      Q(3)=AA
      Q(4)=BB
      RETURN
      END
```