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CALCULATION OF LATERAL-DIRECTIONAL STABILITY DERIVATIVES OF WINGS BY A NONPLANAR QUASI-VORTEX-LATTICE METHOD

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Summary

The nonplanar quasi-vortex-lattice method is applied to the calculation of lateral-directional stability derivatives of wings with and without vortex-lift effect. Results for conventional configurations and those with winglets, V-tail, etc. are compared with available data. All rolling moment derivatives are found to be accurately predicted. The prediction of side force and yawing moment derivatives for some configurations is not as accurate. Causes of the discrepancy are discussed. A user's manual for the program and the program listing are also included.

1. List of Symbols

A	aspect ratio
b	wing span
$\bar{c}$	reference chord
C	leading-edge suction parameter defined in Eqn. (21)
C_{D_i}	induced drag coefficient
C_ℓ	rolling moment coefficient
C_L	lift coefficient
C_m	pitching moment coefficient about y-axis
C_n	yawing moment coefficient
ΔC_p	lifting pressure coefficient
c_t	tip chord
C_{ℓ_β}	$= \frac{\partial C_\ell}{\partial \beta}$
C_{n_β}	$= \frac{\partial C_n}{\partial \beta}$
C_{Y_β}	$= \frac{\partial C_Y}{\partial \beta}$
C_{ℓ_p}	$= \partial C_\ell / \partial (\frac{pb}{2V_\infty})$
C_{n_p}	$= \partial C_n / \partial (\frac{pb}{2V_\infty})$
C_{Y_p}	$= \partial C_Y / \partial (\frac{pb}{2V_\infty})$
C_{ℓ_r}	$= \partial C_\ell / \partial (\frac{rb}{2V_\infty})$
C_{n_r}	$= \partial C_n / \partial (\frac{rb}{2V_\infty})$
C_{Y_r}	$= \partial C_Y / \partial (\frac{rb}{2V_\infty})$
G(x)	tip suction parameter defined in Eqn. (24)

$\vec{i}, \vec{j}, \vec{k}$ unit vectors in the positive x, y and z directions

M, M_∞ freestream Mach number

$\vec{n}_w$ unit normal vector to the wing surface

p roll rate

q pitch rate

$\bar{q}$ freestream dynamic pressure

r yaw rate

$\vec{R}$ position vector

S_{LE} sectional leading-edge suction coefficient

$\vec{v}$ induced velocity vector

v_n induced velocity normal to the wing plane

U, V, W freestream velocity components in the x, y, z directions

V_∞ freestream velocity

x, y, z rectangular coordinate system with positive x-axis pointing downstream, positive y-axis pointing to the right and positive z-axis pointing upward. See Figure 1.

$x_\ell(y)$ x-coordinate of leading edge

$z_c(x,y)$ camber surface ordinate

α angle of attack

β sideslip angle

γ_x streamwise vortex density

γ_y spanwise vortex density

Γ sectional circulation

Λ_ℓ leading-edge sweep angle

ϕ dihedral angle

λ wing taper ratio

Subscripts

a	antisymmetrical
s	symmetrical
t	tip

2. Introduction

Most existing methods for calculating lateral-directional stability derivatives are based on lifting-line type theory with or without empirical corrections (Refs. 1-5). These methods form the basis for some handbook calculations, such as in the USAF Stability and Control Datcom. Although these methods provide a reasonable estimation of lateral-directional stability derivatives for conventional configurations, they are not applicable to complex planforms of variable sweep angles, with winglets or with vertical fins, and to planforms exhibiting edge vortex separation. For these non-conventional configurations, application of a lifting-surface theory would be more appropriate.

In this report, the application of the quasi-vortex-lattice method (QVLM) of Reference 6 to calculating lateral-directional stability derivatives of arbitrary wing configurations will be described. Potential flow theory will be assumed. The effect of vortex separation along wing edges will be accounted for through Polhamus' method of suction analogy (Ref. 7). Earlier application of the present method to simple wing-body configurations at low angles of attack was reported in Reference 8.

3. Theoretical Development

It is assumed that the flow field is governed by the Prandtl-Glauert equation. Thickness effect will not be included in the formulation.

In Section 3.1, the general boundary condition to be satisfied on the wing surface will be derived. The present method is very much dependent on the accurate calculation of streamwise vortex density distribution (γ_x) and edge suction forces. These will be the subject of discussion in Section 3.2. From Sections 3.3 to 3.5, various contributions to forces and moments in lateral-directional motion will be indicated. All calculations will be done in body axes. The conversion to stability axes can be made through the use of a set of formulas to be given in Section 3.6.

3.1 Boundary Condition

It is assumed that the sideslip angle (β) is small. The freestream velocity vector ($\vec{V}_\infty$) is then given by

$$\vec{V}_\infty = U\vec{i} + V\vec{j} + W\vec{k} \tag{1}$$

where

$$U = V_\infty \cos\alpha\cos\beta \simeq V_\infty \cos\alpha \tag{2}$$

$$V = -V_\infty \beta \tag{3}$$

$$W = V_\infty \sin\alpha\cos\beta \simeq V_\infty \sin\alpha \tag{4}$$

Let $\vec{\omega}$ be the angular velocity of the wing based on the primed axes system (see Figure 1) and $\vec{R}$ be the position vector of some point on the wing. Using the conventional notation for roll rate (p), pitch rate (q) and yaw rate (r), it follows that the linear velocity ($\vec{v}'$) associated with the wing angular motion is given by

$$\vec{v}' = -(p\vec{i} + q\vec{j} + r\vec{k}) \times (x'\vec{i} + y'\vec{j} + z'\vec{k})$$
$$= -\vec{i}(qz' - y'r) + \vec{j}(pz' - x'r) - \vec{k}(py' - qx') \qquad (5)$$

To find the induced air velocity on the wing (based on xyz axes) due to $\vec{\omega}$-motion, the sign of $\vec{i}$ and $\vec{k}$-components in Eqn. (5) must be reversed and x', y', z' are to be replaced by -x, y, -z. It follows that

$$\vec{v} = \vec{i}(-qz - yr) + \vec{j}(-pz + xr) + \vec{k}(py + qx) \qquad (6)$$

The sum of $\vec{V}_\infty$ and $\vec{v}$ represents the total "freestream velocity." The latter will produce normal velocity component (v_n) to the wing plane. Before v_n can be calculated, the unit normal vector to the wing plane must be determined. Let $z_c(x,y)$ be the camber surface. Then, according to Figure 1,

$$z = z_o + z_c(x,y) + (y - y_o)\tan\phi \qquad (7)$$

Introduce a function f(x,y,z) defined by:

$$f(x,y,z) = z - z_o - z_c(x,y) - (y - y_o)\tan\phi \qquad (8)$$

Then the unit normal vector to the wing surface is given by:

$$\vec{n}_w = \frac{\nabla f}{|\nabla f|} = \frac{-\frac{\partial z_c}{\partial x}\vec{i} + (-\frac{\partial z_c}{\partial y} - \tan\phi)\vec{j} + \vec{k}}{\sqrt{1 + (\frac{\partial z_c}{\partial x})^2 + (\frac{\partial z_c}{\partial y} + \tan\phi)^2}} \qquad (9)$$

If $\frac{\partial z_c}{\partial x}$ and $\frac{\partial z_c}{\partial y}$ can be assumed to be negligible in comparison with unity and $\tan\phi$, respectively, Eqn. (9) can be simplified to be:

$$\vec{n}_w \simeq -\sin\phi\vec{j} + \cos\phi\vec{k} \qquad (10)$$

Using Eqns. (1), (6) and (9), the normal velocity component (v_n) can now be calculated as:

$$\frac{v_n}{V_\infty} = \vec{V}_\infty \cdot \vec{n}_w + \vec{v} \cdot \vec{n}_w$$

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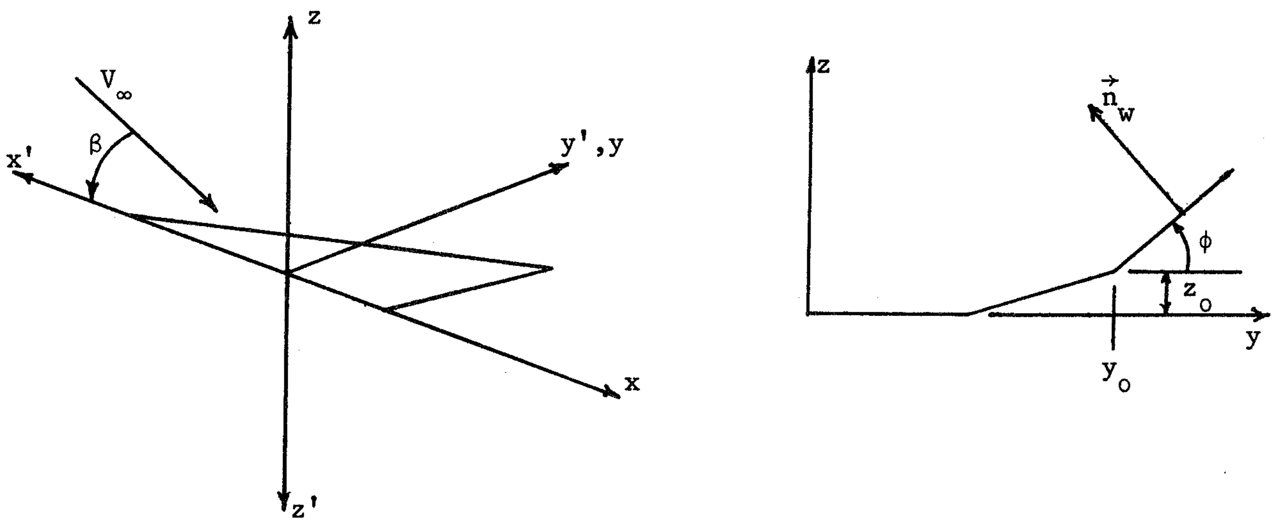


Figure 1. Definition of Axes System

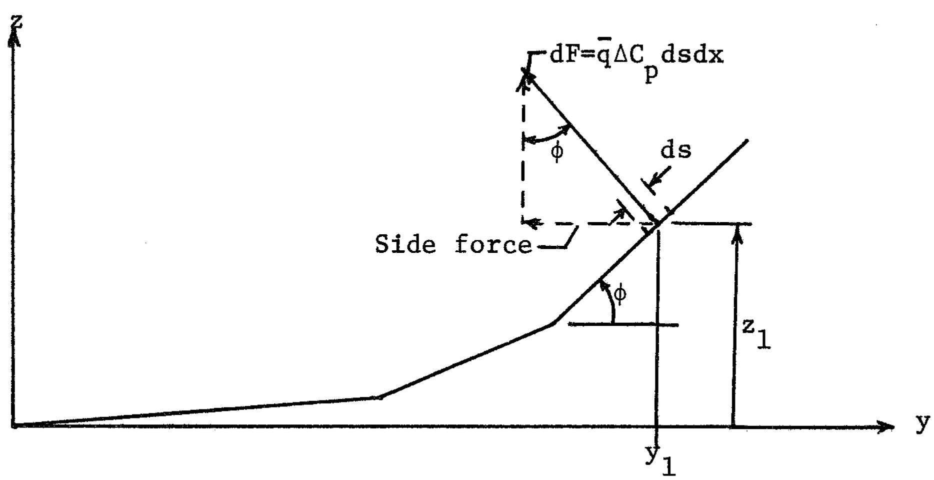


Figure 2. Decomposition of Lifting Force on a Nonplanar Wing

$$\simeq \frac{-\cos\alpha \frac{\partial z_c}{\partial x} + \sin\alpha}{\sqrt{1 + \left(\frac{\partial z_c}{\partial x}\right)^2 + \left(\frac{\partial z_c}{\partial y} + \tan\phi\right)^2}} + \beta\sin\phi + \frac{p}{V_\infty}(z\sin\phi + y\cos\phi) -$$

$$\frac{r}{V_\infty} x\sin\phi + \frac{q}{V_\infty} x\cos\phi \tag{11}$$

In Eqn. (11), $\vec{n}_w$ from Eqn. (10) is used to simplify the expression associated with angular motion. The first term in Eqn. (11) can be recognized as the boundary condition for symmetrical loading at a given angle of attack. Eqn. (11) can be written in nondimensional form:

$$\frac{v_n}{V_\infty} \simeq \frac{-\cos\alpha \frac{\partial z_c}{\partial x} + \sin\alpha}{\sqrt{1 + \left(\frac{\partial z_c}{\partial x}\right)^2 + \left(\frac{\partial z_c}{\partial y} + \tan\phi\right)^2}} + \beta\sin\phi + \bar{p}\left(\frac{z}{b/2}\sin\phi +\right.$$

$$\left.\frac{y}{b/2}\cos\phi\right) - \bar{r}\sin\phi\left(\frac{x}{b/2}\right) + \bar{q}\cos\phi\left(\frac{x}{\bar{c}/2}\right) \tag{12}$$

where

$$\bar{p} = \frac{pb}{2V_\infty}$$

$$\bar{r} = \frac{rb}{2V_\infty} \tag{13}$$

$$\bar{q} = \frac{q\bar{c}}{2V_\infty}$$

The normal velocity given by Eqn. (12) must be cancelled on the wing surface by using vortex distribution. This condition represents the boundary condition to be satisfied to find the loading.

3.2 Edge Suction and Streamwise Vortex Density Distribution (γ_x)

While the calculation of the spanwise vortex density distribution (γ_y) is the first step in determining the symmetrical loading, it is the streamwise vortex density distribution which is the basis for predicting the tip suction and the lateral-directional aerodynamic characteristics of a wing. The calculation of γ_y is made with the QVLM (Ref. 6) by satisfying the symmetrical boundary condition (the first term is Eqn. (12)) and will not be discussed here. The leading-edge suction has also been accurately predicted by the QVLM.

To determine γ_x distribution and the tip suction, the following expression for the conservation of vorticity will be used:

$$\frac{\partial \gamma_x}{\partial x} + \frac{\partial \gamma_y}{\partial y} = 0 \tag{14}$$

By integration, Eqn. (14) can be solved for γ_x (Ref. 8):

$$\gamma_x = \frac{\partial \Gamma(x,y)}{\partial y} \tag{15}$$

$$\Gamma(x,y) = -\int_{x_\ell(y)}^{x} \gamma_y(x',y)\,dx' \tag{16}$$

In Reference 8, a trigonometric interpolation formula was derived to calculate the derivative in Eqn. (15). The tip suction can also be determined accurately. For more detail, Reference 8 should be consulted.

3.3 Forces and Moments in Sideslipping Flight

The incremental ΔC_p due to sideslipping arises from the following sources:

(1) Incremental pressure force due to geometric dihedral. This contribution comes from the second term in Eqn. (12). For a flat wing, this contribution will be zero.

The predicted spanwise vortex density (γ_y) will interact with U-component of the freestream to produce a lifting pressure:

$$\Delta C_{p_1} = 2\gamma_y \cos\alpha \tag{17}$$

(2) Interaction of sideslipping velocity $(-V_\infty\beta)$ with γ_x. In nondimensional form, this will contribute to a ΔC_{p_2} amounting to

$$\Delta C_{p_2} = 2\beta\gamma_x \tag{18}$$

on the right wing in positive lift. On the left wing, ΔC_{p_2} is negative, thus creating a rolling moment.

(3) Effect of wake nonalignment with freestream. In the usual way of calculating the loading, the flat wake has been assumed to be in the positive x direction. According to Eqn. (18), the wake trailing vortices (γ_x) will then interact with the sideslipping velocity to produce positive lifting pressure on the right wake. This must be cancelled by introducing a γ_y distribution in the wake equal to $\beta\gamma_x$, where γ_x in the wake is equal to its value at the trailing edge. This is similar to the results derived by Rubbert by perturbation expansion (Ref. 9) of the governing equation.

This effect will produce downwash on the right wing, thus producing negative γ_y distribution. It will create a ΔC_p similar to that given by Eqn. (17). This refinement was not made in Reference 8.

Note that ΔC_p produced by the aforementioned sources are antisymmetrical. The resulting rolling moment, and hence the dihedral effect (C_{ℓ_β}), can be calculated in a straightforward manner. The lifting pressure (ΔC_p) is taken to be acting normal to the planform, as illustrated in Figure 2. It follows that a side force will be produced, which will also generate a yawing moment. The rolling moment due to the element can be seen to be:

$$d\mathcal{L} = -\bar{q}\Delta C_p dsdx(z_1\sin\phi + y_1\cos\phi) \tag{19}$$

where $\bar{q}$ is the freestream dynamic pressure. Integration of Eqn. (19) in the chordwise and spanwise directions will yield the total rolling moment, and hence the dihedral effect.

The side force and yawing moment due to sideslip for a wing alone are contributed from the following sources:

(a) Contribution from the incremental pressure force due to geometric dihedral, as given by Eqn. (17).

(b) Contribution from the change in the leading-edge suction. This is produced by the loading change discussed under Items (1) and (3) in this Section.

According to Reference 6, the sectional leading-edge suction coefficient for combined symmetrical and antisymmetrical loadings can be calculated as:

$$S_{LE} = \frac{\pi}{2}\sqrt{1 - M_\infty^2 \cos^2\Lambda_\ell}\ \frac{(C_s \pm C_a)^2}{\cos^2\Lambda_\ell} \tag{20}$$

where C_s is the leading-edge singularity parameter for symmetrical loading defined as (Ref. 6):

$$C_s = \lim_{x\to x_\ell} \gamma_y \sqrt{\frac{x - x_\ell}{c}} \tag{21}$$

and C_a is the corresponding parameter for antisymmetrical loading. The positive sign in Eqn. (20) is for the right wing and the negative sign is for the left wing. It follows that the effective change in leading-edge suction due to sideslip is given by:

$$\Delta S_{LE} = \frac{\pi}{2} \sqrt{1 - M_\infty^2 \cos^2\Lambda_\ell} \; \frac{(\pm 2C_s C_a)}{\cos^2\Lambda_\ell} \tag{22}$$

This suction force is normal to the leading edge, as shown in Figure 3, thus contributing to side force and yawing moment.

(c) Contribution from the change in tip suction. According to Reference 8, the local tip suction coefficient for the combined symmetrical and antisymmetrical loadings is given by

$$S_t = \frac{2\pi(G_s \pm G_a)^2}{c_t} \tag{23}$$

where G(x) is defined by

$$G(x) = \sqrt{\frac{b}{2}} \lim_{y \to \frac{b}{2}} \sqrt{1 - (\frac{y}{b/2})} \; \frac{1}{2} \frac{\partial \Gamma_t}{\partial y} \tag{24}$$

and Γ_t is the total sectional circulation. c_t in Eqn. (23) is the tip chord length. It follows that

$$\Delta S_t = \frac{2\pi(-2G_s G_a)}{c_t} \tag{25}$$

ΔS_t is also illustrated in Figure 3.

(d) Contribution from the induced drag (Page 14-3, Ref. 10)

The induced drag under symmetrical loading is assumed to act in the direction of freestream with sideslip. Hence, if C_{D_i} is the induced drag coefficient, the side force coefficient from this contribution will be

$$\Delta C_y = -C_{D_i} \; \beta \tag{26}$$

The yawing moment can be computed from the induced drag distribution.

3.4 Forces and Moments in Steady Rolling

The roll damping derivative (C_{ℓ_p}) can be computed by integrating the antisymmetrical lifting pressure induced by the roll rate (see $\bar{p}$-term in Eqn. (12)) multiplied by the spanwise moment arm. The moment arm used in Eqn. (19) is still applicable here.

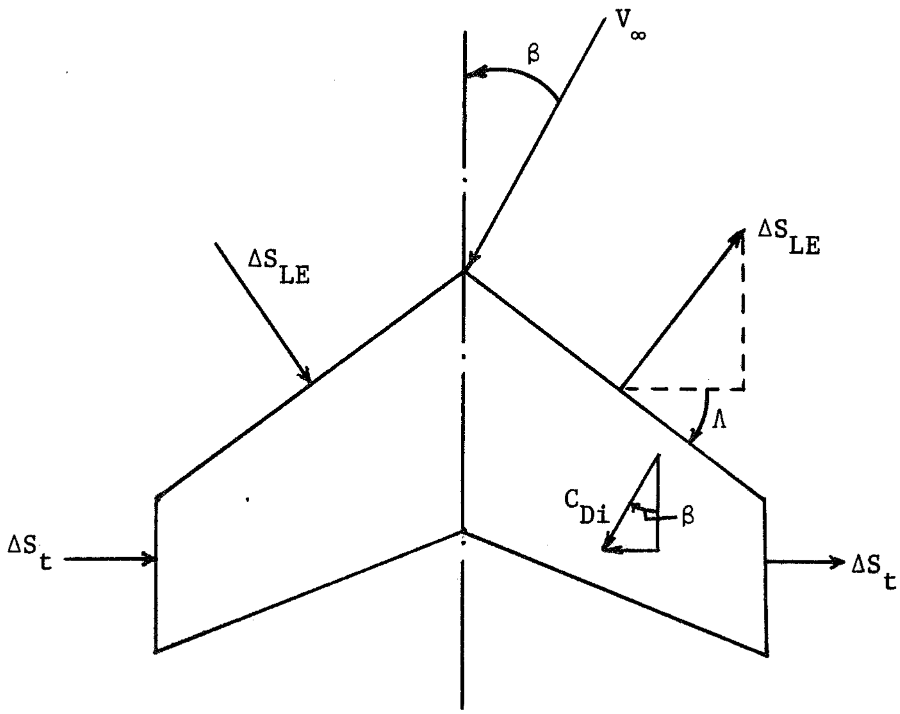


Figure 3. Change in Leading-Edge and Tip Suctions due to Lateral-Directional Motion

The side force and yawing moment due to roll rate for a wing alone are contributed from the incremental pressure force, change in the leading-edge suction and change in the tip suction, similar to those discussed in Section 3.3 for the sideslip effects.

3.5 Forces and Moments in Steady Yawing

The incremental lifting pressure due to yaw rate consists of three components:

(1) Due to yawing, a backwash ry is produced. This will interact with the symmetrical γ_y to produce a lifting pressure equal to:

$$\Delta C_{p_r} = -2 \frac{ry}{V_\infty} \gamma_y = -2(\frac{rb}{2V_\infty})\gamma_y \frac{2y}{b} \tag{27}$$

(2) Due to yawing, a sidewash $rx\cos\phi$ is produced on the wing plane. This will interact with the symmetrical γ_x to produce a lifting pressure equal to:

$$\Delta C_{p_r} = -2 \frac{rx}{V_\infty} \cos\phi\gamma_x = -2(\frac{rb}{2V_\infty})\gamma_x \frac{2x}{b} \cos\phi \tag{28}$$

(3) Incremental lifting pressure due to geometrical dihedral. This effect can be seen from the boundary condition in Eqn. (12).

Once the incremental antisymmetrical lifting pressure is obtained, the wing rolling moment due to yawing can be calculated immediately.

The calculation of side force and yawing moment due to yaw rate follows the same procedures of computing the effects due to sideslip. This is because a wing in yawing can be regarded as being subjected to "variable sideslip" effect, since the sidewash on the wing plane ($rx \cos\phi$) varies on the wing.

3.6 Conversion to Stability Axes System

Once the stability derivatives are calculated on some body axes, it is desirable to transform them to values based on stability axes. The transformation formula have been derived elsewhere (page 192, Ref. 11) and are listed below for convenience. The primed quantities in the following are based on body axes (ε in Ref. 11 is replaced with $-\alpha$).

$$C_{y_\beta} = C_{y_\beta}' \tag{29}$$

$$C_{y_p} = C_{y_p}' \cos\alpha + C_{y_r}' \sin\alpha \tag{30}$$

$$C_{y_r} = C_{y_r}' \cos\alpha - C_{y_p}' \sin\alpha \tag{31}$$

$$C_{\ell_\beta} = C_{\ell_\beta}' \cos\alpha + C_{n_\beta}' \sin\alpha \tag{32}$$

$$C_{\ell_p} = C_{\ell_p}' \cos^2\alpha + (C_{\ell_r}' + C_{n_p}')\sin\alpha\cos\alpha + C_{n_r}'\sin^2\alpha \tag{33}$$

$$C_{\ell_r} = C_{\ell_r}'\cos^2\alpha + (C_{n_r}' - C_{\ell_p}')\sin\alpha\cos\alpha - C_{n_p}'\sin^2\alpha \tag{34}$$

$$C_{n_\beta} = C_{n_\beta}' \cos\alpha - C_{\ell_\beta}' \sin\alpha \tag{35}$$

$$C_{n_p} = C_{n_p}'\cos^2\alpha + (C_{n_r}' - C_{\ell_p}')\sin\alpha\cos\alpha - C_{\ell_r} \sin^2\alpha \tag{36}$$

$$C_{n_r} = C_{n_r}'\cos^2\alpha - (C_{\ell_r}' + C_{n_p}')\sin\alpha\cos\alpha + C_{\ell_p}'\sin^2\alpha \tag{37}$$

4. Numerical Results and Discussions

Some preliminary results without the refinement for high angles of attack have been reported in Reference 8. Good agreement in roll derivatives with Garner's theoretical calculation (Ref. 12) for two wings at different Mach numbers has been demonstrated. In the following, additional results by the present refined program will be presented for conventional configurations and configurations with significant vortex-lift effect.

4.1 Conventional Configurations without Significant Vortex-Lift Effect

The experimental results for lateral-directional stability derivatives for four wings with NACA 0012 airfoil section were presented in Reference 1. The results for two wings are chosen for comparison here. Figure 4 presents the results for a rectangular wing of A = 5.16. It is seen that the present method predicts all rolling moment derivatives with good accuracy. However, C_{y_p} and C_{n_p} are not accurately predicted. To see whether this is true for other unswept configurations with different aspect ratio, the test data in Reference 5 for A = 2.61 are compared in Figure 5. Again, both C_{y_p} and C_{n_p} are overpredicted. This discrepancy indicates that both leading-edge and tip suction forces are not fully realized in the experiment, as has been assumed in the theory. This phenomenon has also been discussed by Garner in Reference 12. One possible way to solve this problem is to apply an edge suction correction factor. For the leading-edge suction, an empirical correction factor has been determined in Reference 13 as a function of airfoil geometry and Mach number. Experimental data showing the degree of leading-edge suction development can also be found in References 14 and 15. However, a systematic work on tip suction phenomena does not seem to exist.

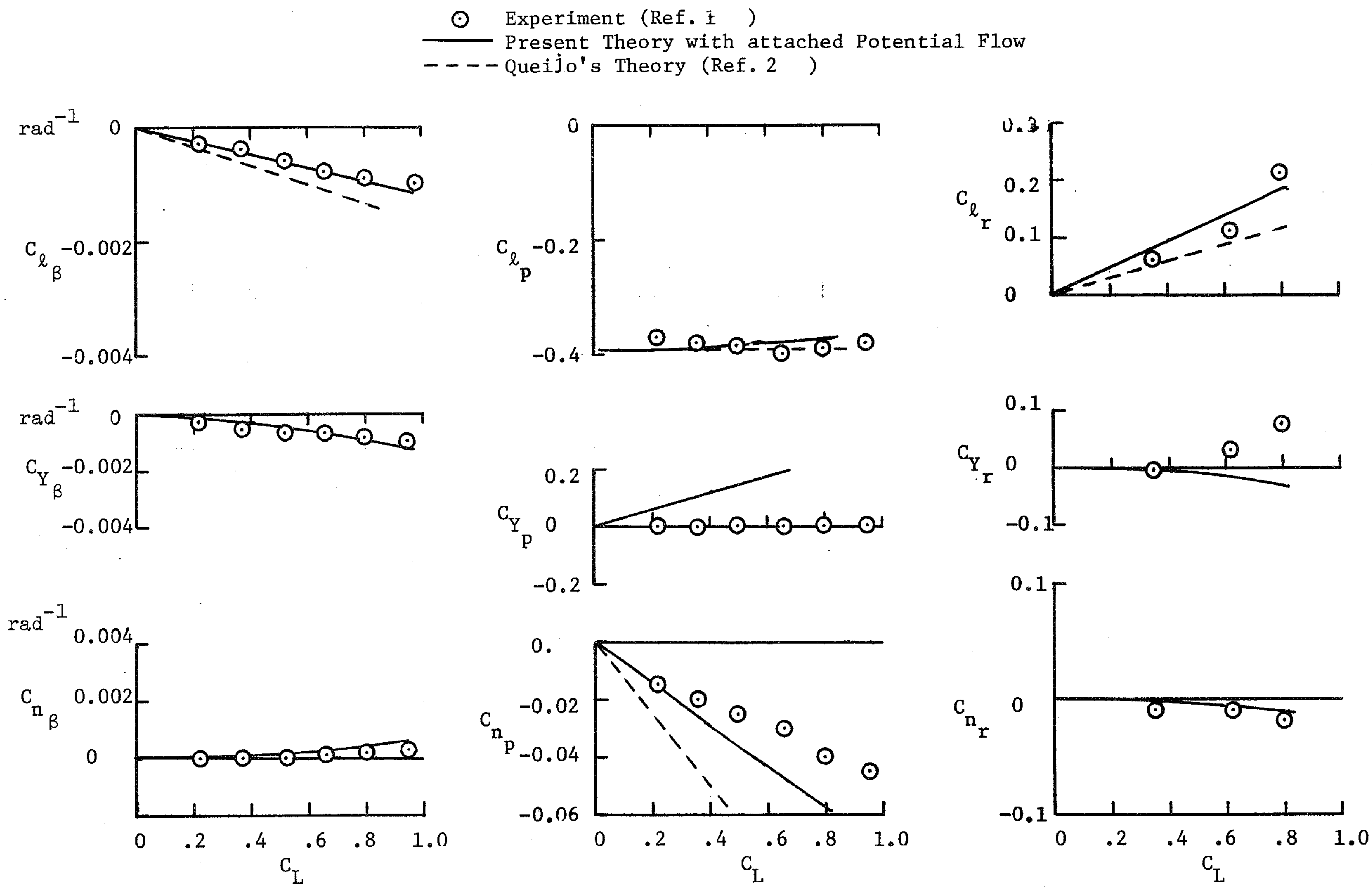


Figure 4 Comparison of Predicted Lateral-Directional Stability Derivatives with Experimental Data for an Unswept Wing at M=0. A=5.16, Λ=0, and λ=1.0

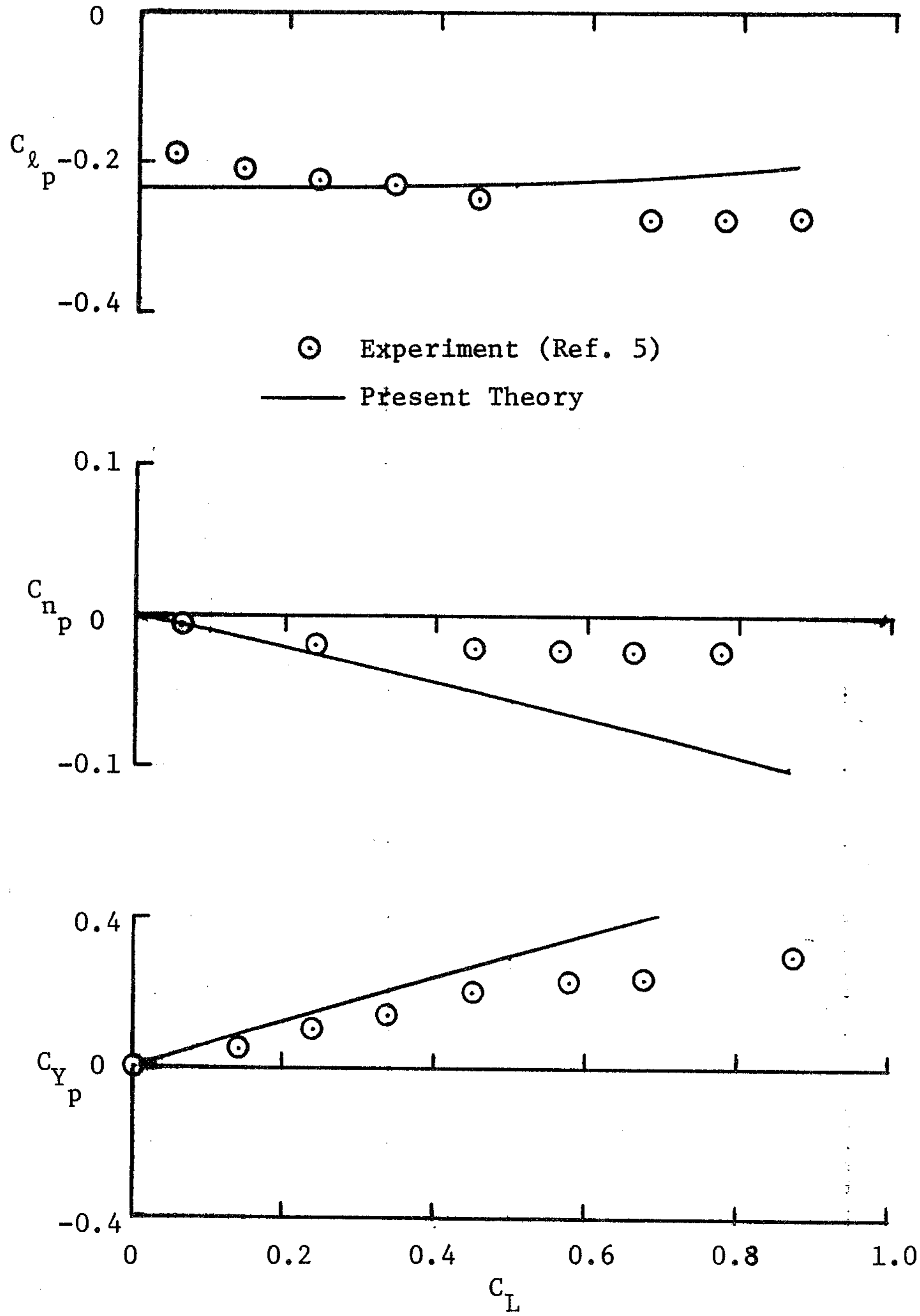


Figure 5 Comparison of Predicted Rolling Stability Derivatives with Experimental Data for a Rectangular Wing of A=2.61 at M=0

Slight increase in $|C_{\ell_p}|$ with increasing C_L in Figure 5 implies that partial vortex-lift effect may exist at the tip.

The results for a 45-degree swept wing of A = 2.61 are presented in Figure 6. In this case, the vortex lift effect is assumed to exist along the leading edge, but not along the tip chord. This is evidenced from C_{ℓ_p} variation and experimental lift curve. Again, all rolling moment derivatives are reasonably predicted, except at high lift coefficients. The prediction of side force and yawing moment due to sideslip and yaw rate is not accurate, probably because the effect of skin friction has not been included in the program. At zero C_L, the skin friction will produce negative C_{y_β}. For the other derivatives, the effect of skin friction may or may not be important, depending on the location of moment center.

Figure 7 presents the sideslip derivatives for a KC-135A wing-body model with and without winglets at different subsonic Mach numbers. The experimental results are given in Reference 16. It is seen that the dihedral effect can be accurately predicted for this nonplanar wing-body configuration below the drag-divergence Mach number. The absolute level of C_{n_β} and C_{y_β} is not correctly predicted, because the body effect has not been included. Of course, a body will contribute negative C_{n_β} and C_{y_β} to the total derivatives. However, the trend with Mach number variation and the incremental effect produced by winglets are all correctly predicted.

Finally, another nonplanar configuration - a V-tail is analyzed in Figure 8. The experimental data can be found in Reference 17. The lateral stability derivatives are presented as a function of geometric

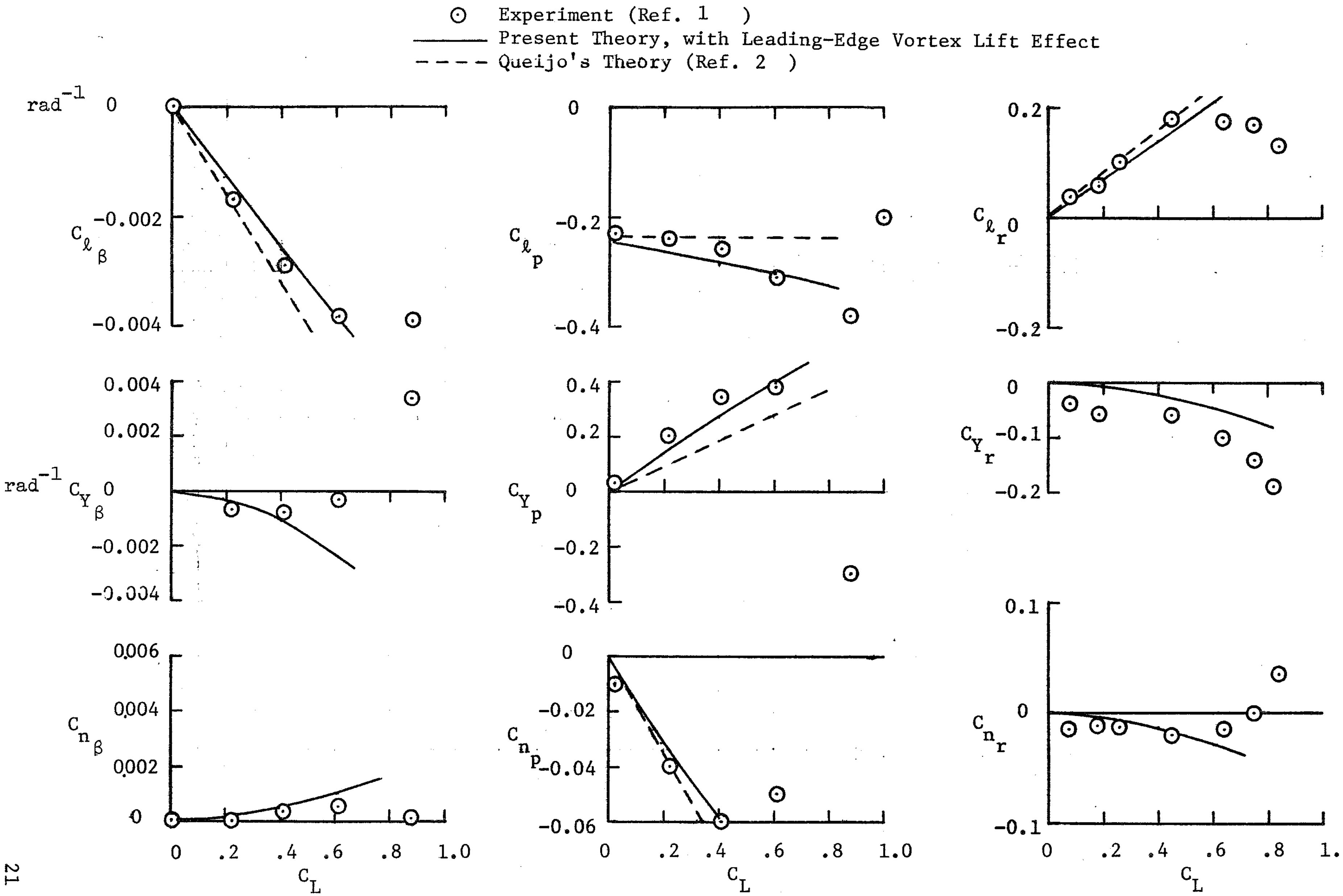


Figure 6 Comparison of Predicted Lateral-Directional Stability Derivatives with Experimental Data for a Swept Wing at M=0. A=2.61, Λ=45° and λ=1.0

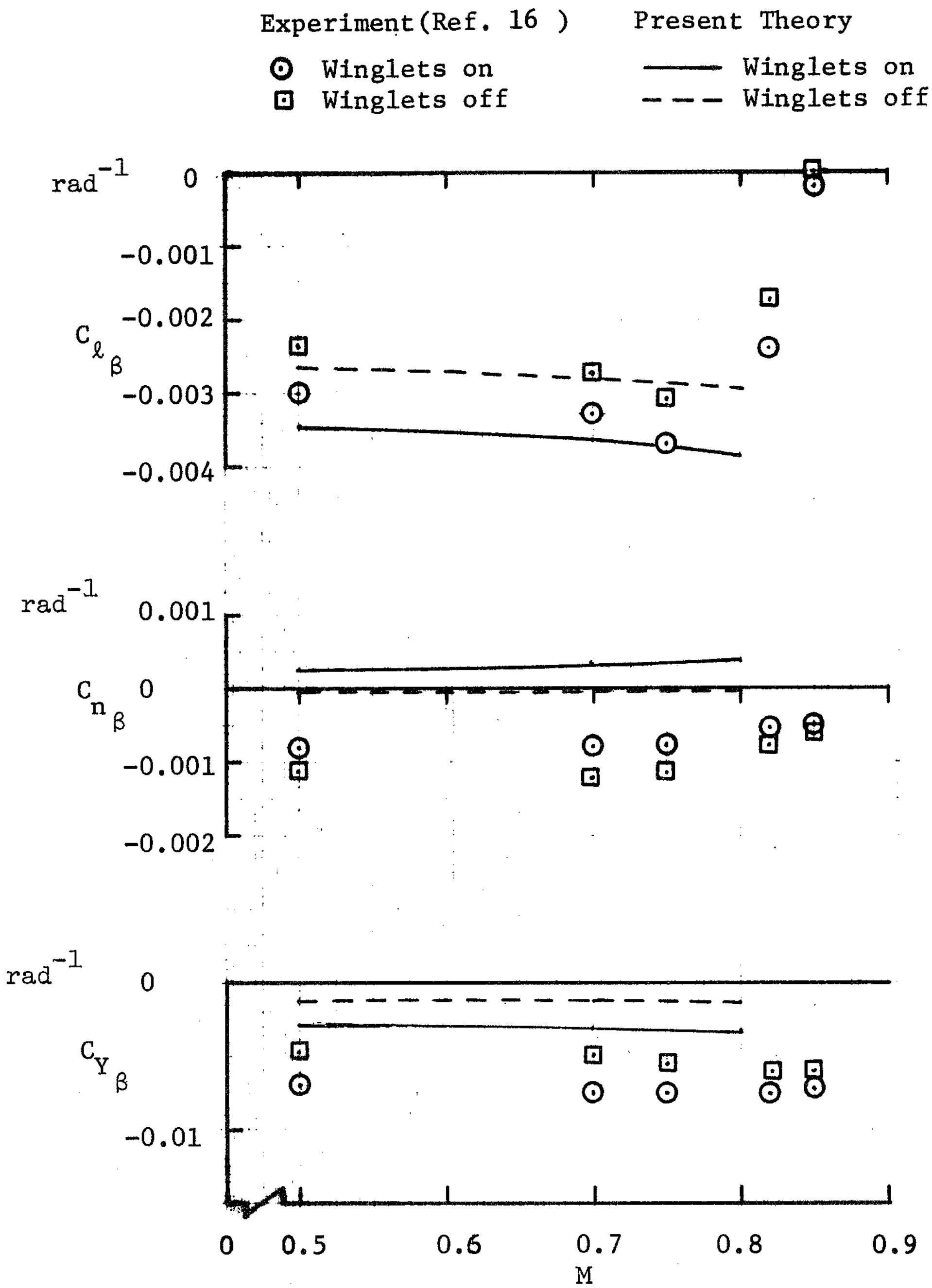


Figure 7 Comparison of Predicted Lateral Stability Derivatives with Experimental Data for a KC-135A Model at C_L=0.44

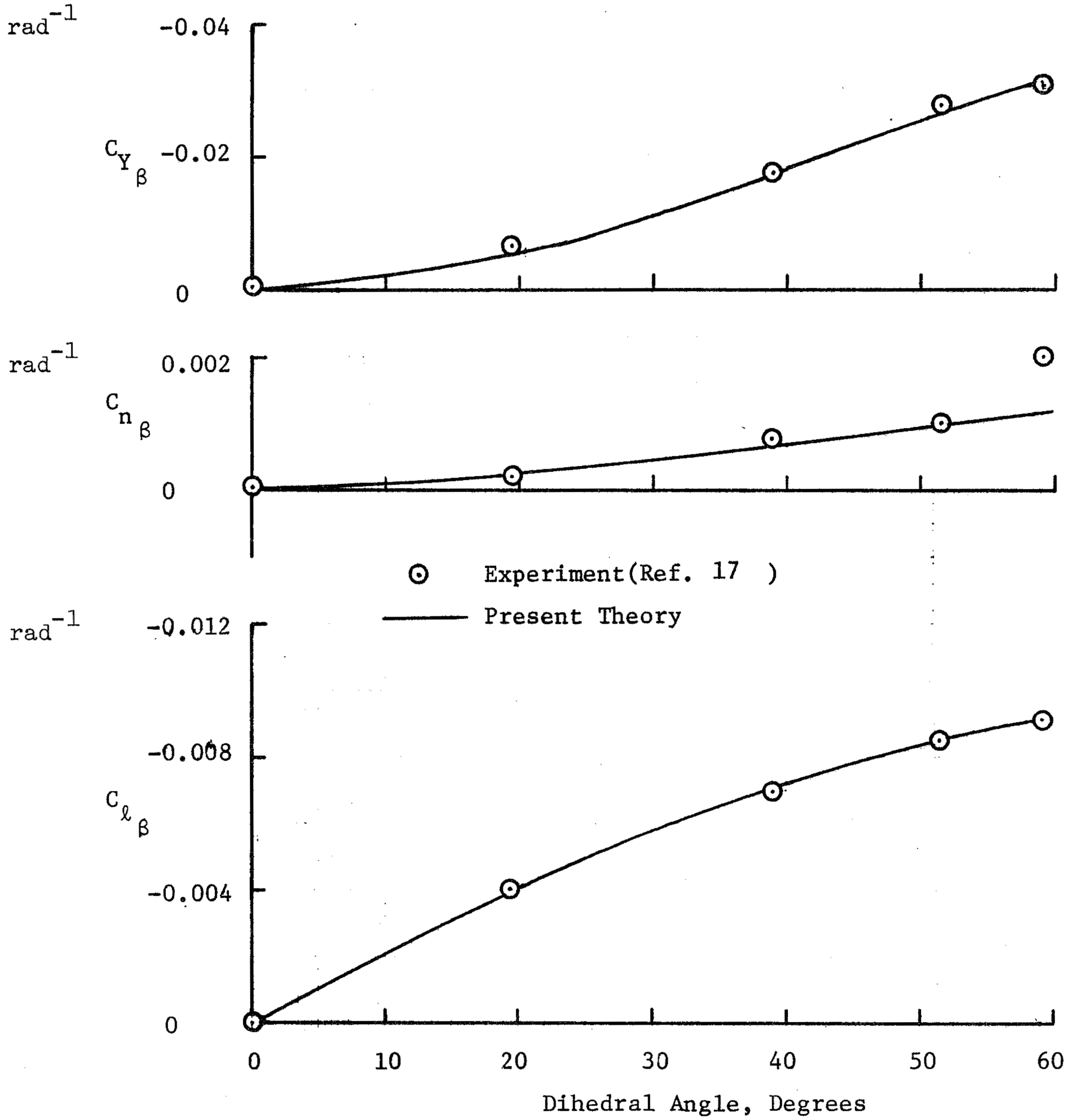


Figure 8 Comparison of Predicted Lateral Stability Derivatives with Experimental Data at $\alpha=0°$ and M=0 for a V-Tail of Aspect Ratio of 5.55

dihedral angles. All predicted β-derivatives are seen to agree quite well with experimental data.

4.2 Configurations with Significant Vortex-Lift Effect

When edge vortex separation is present, its effect can be predicted by Polhamus' suction analogy (Ref. 7). In this method, the predicted leading-edge and tip suctions are assumed to be acting normal to the wing at the edges.

A delta wing of A = 1.147 with sharp edges was tested and reported in Reference 18. The longitudinal aerodynamic characteristics are presented in Figure 9 together with the predicted results. As can be seen, the method of suction analogy works quite well for this wing. The sideslip derivatives are compared in Figure 10. Again, C_{ℓ_β} is reasonably well predicted. As for C_{y_β}, the effect of skin friction may explain the discrepancy. At high angles of attack, C_{y_β} reverses in sign. This may be due to the fact that at high angles of attack in sideslip, the windward leading-edge vortex is large and is pushed more inboard to affect a larger wing area on the right side as compared with the left vortex effect. Since the right side leading-edge vortex generates positive sidewash on the wing surface, the resulting positive side force will make C_{y_β} more positive as angle of attack is increased. This effect is not included in the present method.

A more complicated configuration is illustrated in Figure 11. Test results of this configuration were reported in Reference 19. The longitudinal and lateral aerodynamic characteristics are presented in Figures 12 and 13, respectively. In the present calculation, the outboard portion of wing which has a lower sweep angle and has dihedral is assumed

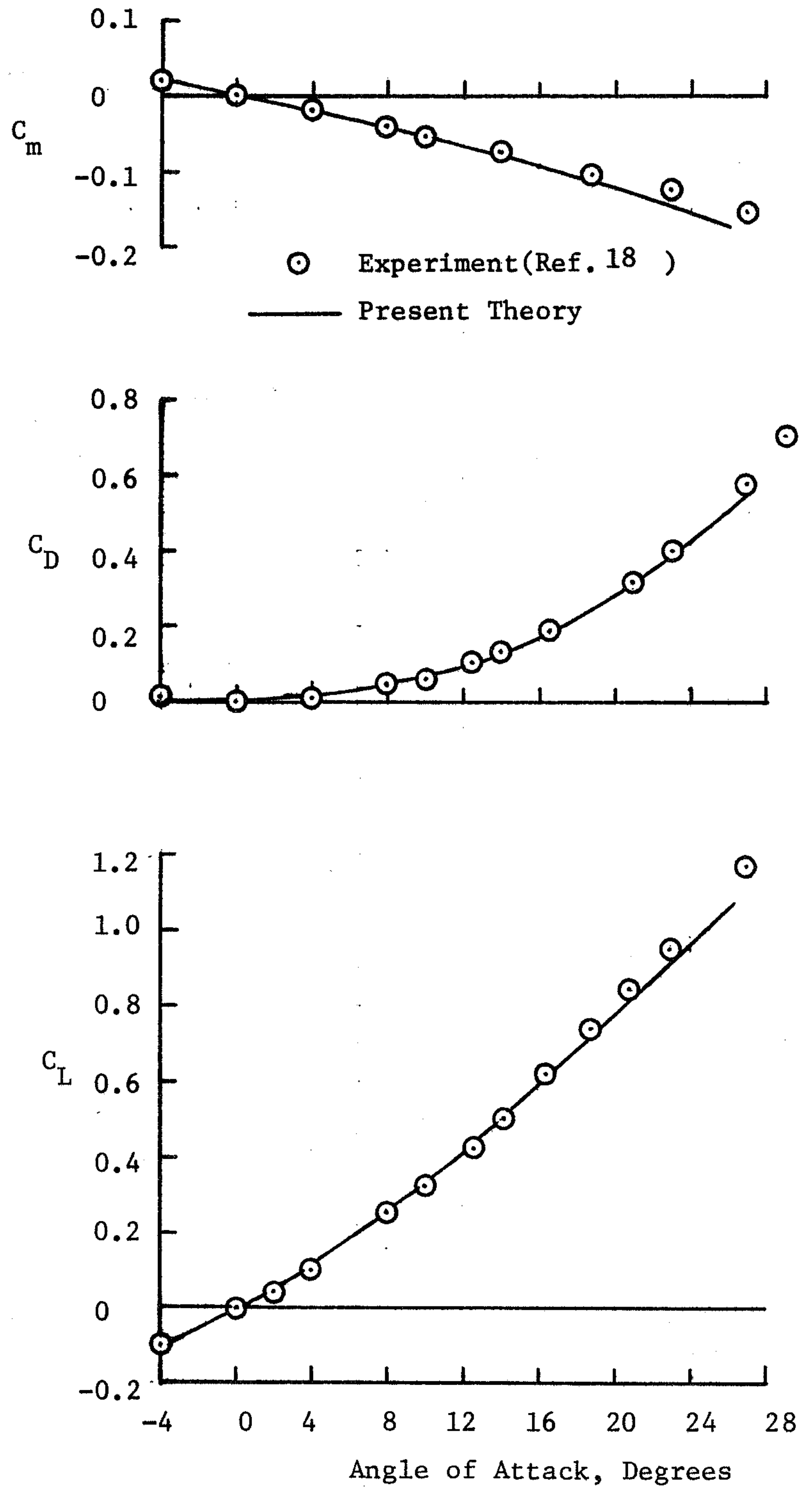


Figure 9 Comparison of Predicted Longitudinal Aerodynamic Characteristics with Experimental Data for a Delta Wing of A=1.147 at M=0.2

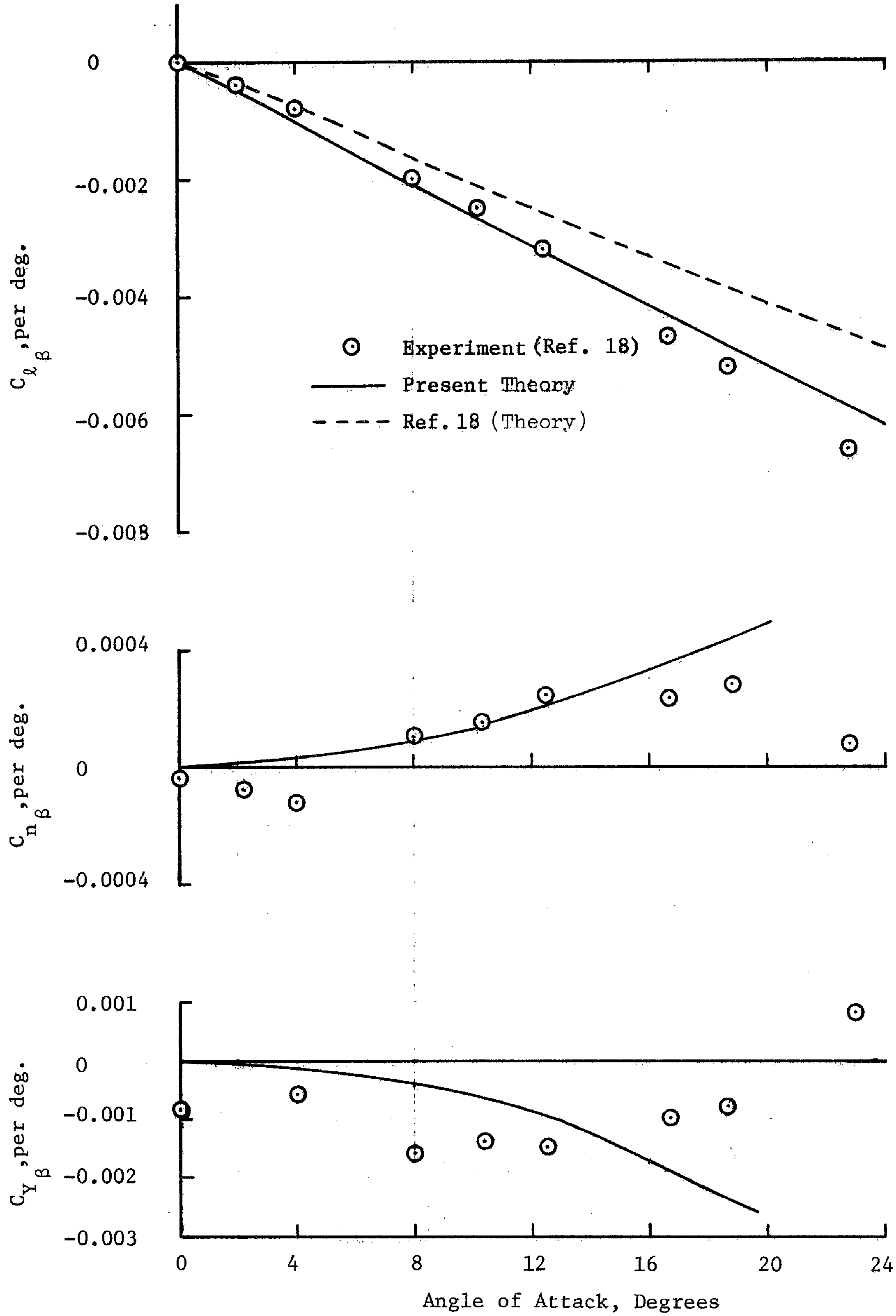


Figure 10 Comparison of Predicted Lateral Stability Derivatives with Experimental Data for a Delta Wing of A=1.147 at M=0.2

All dimensions are in cm.(in.)

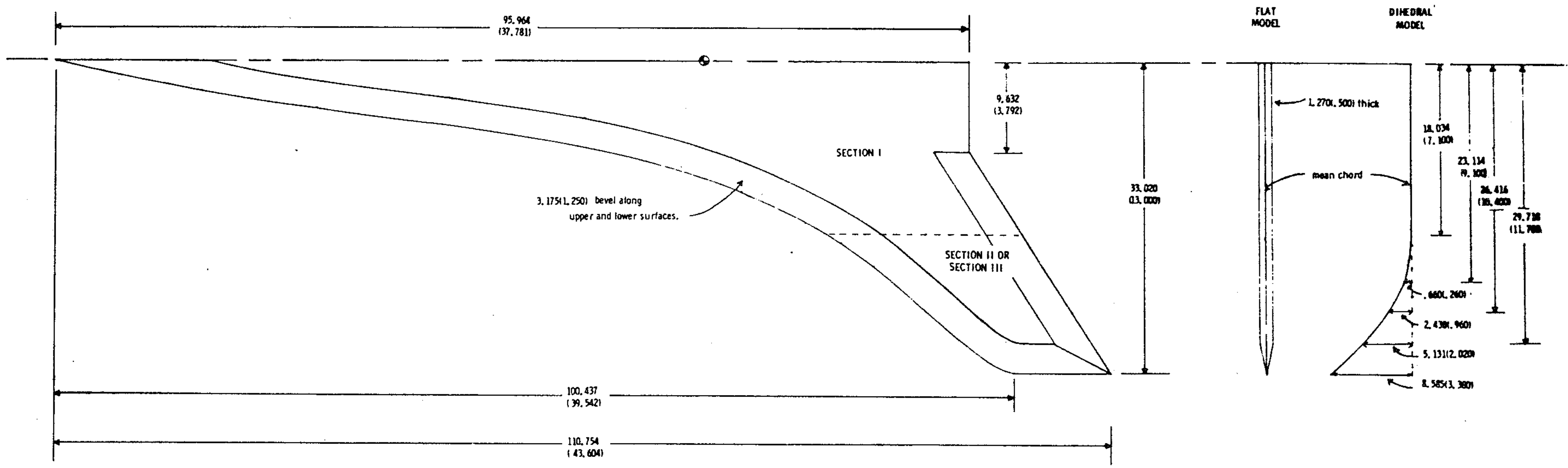


Figure 11 Geometry for a Test Model of Supersonic Cruise Configuration

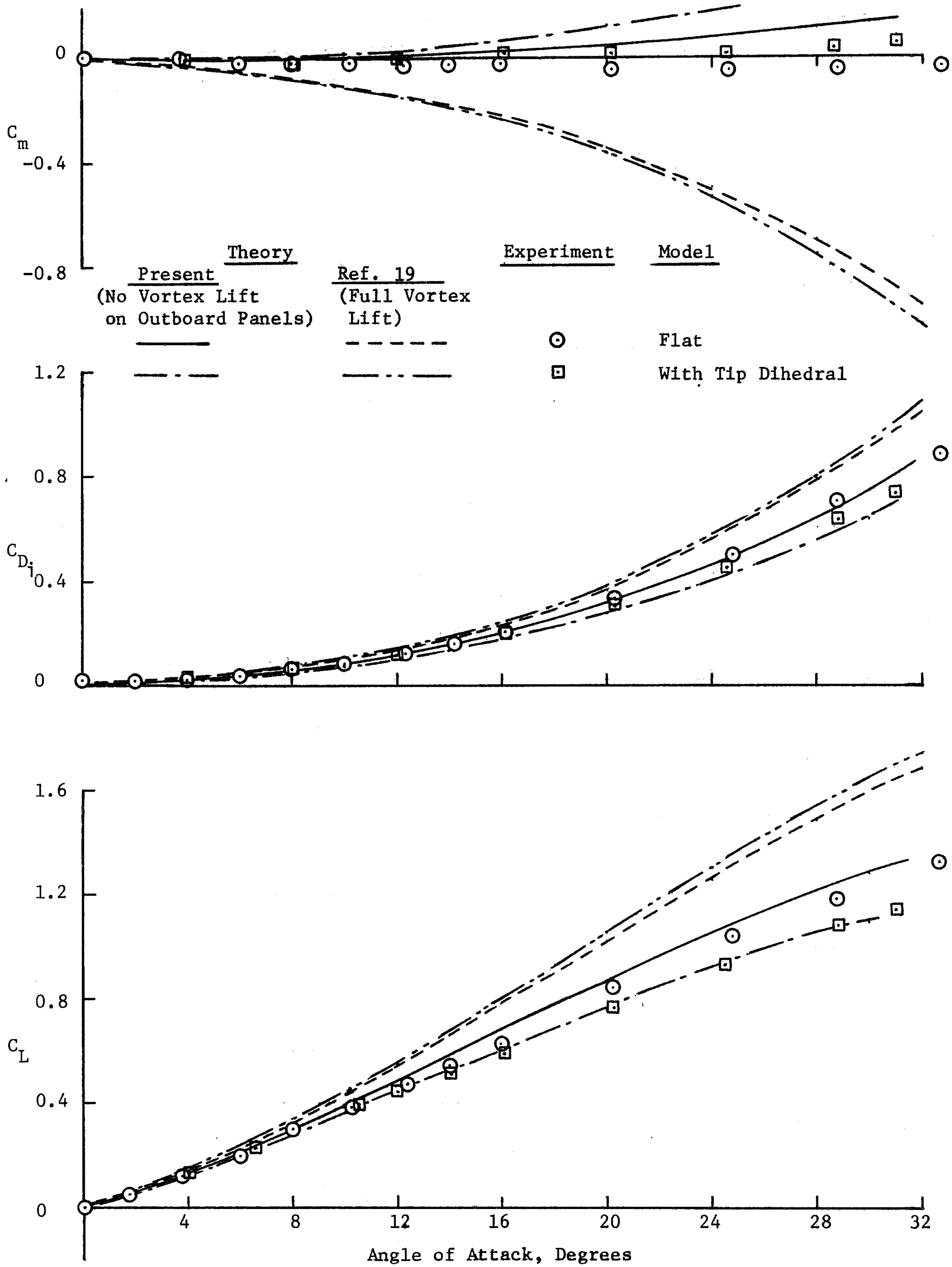


Figure 12 Comparison of Predicted Longitudinal Aerodynamic Characteristics of a Supersonic Cruise Configuration with Experimental Data at M=0.165

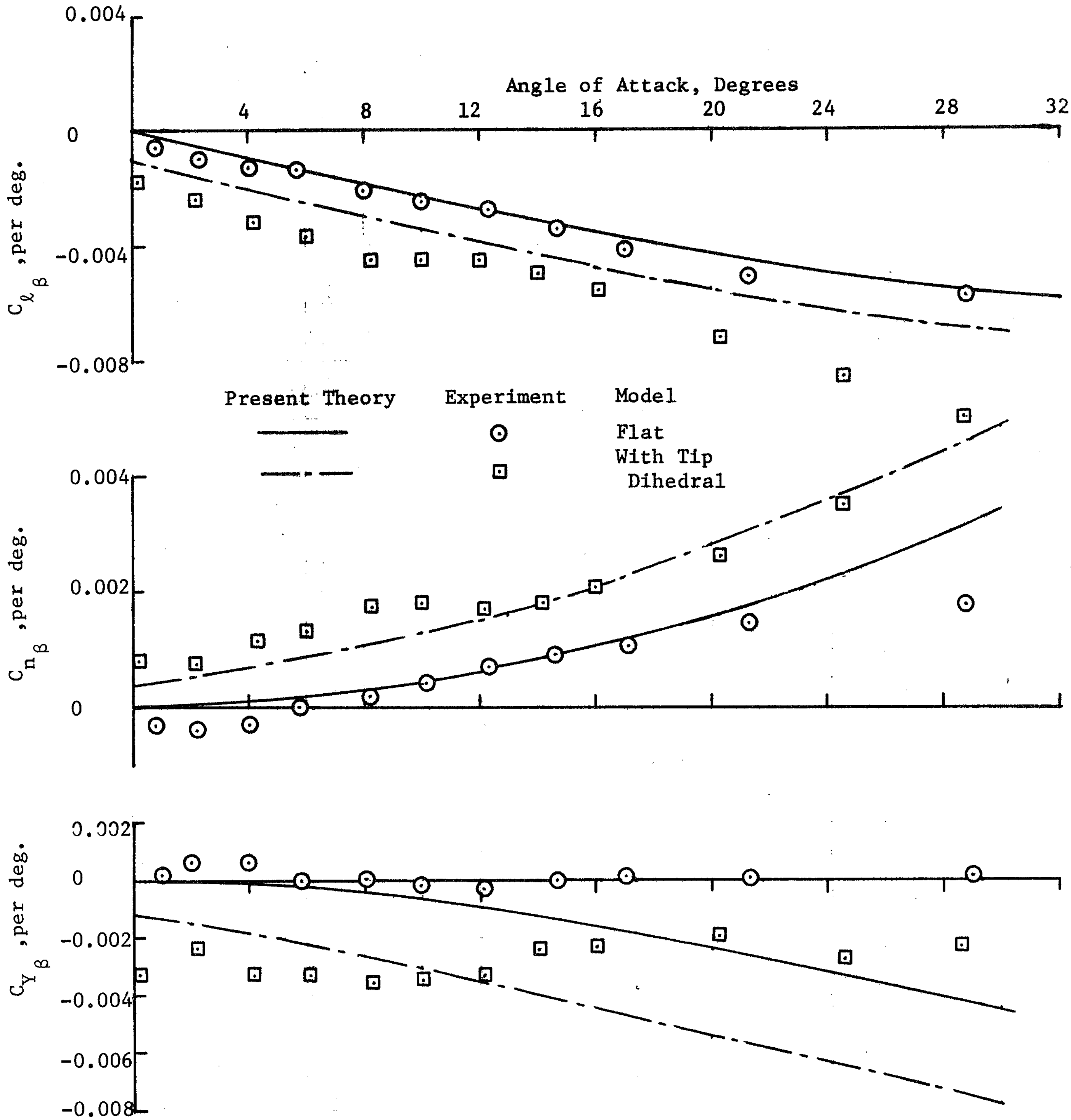


Figure 13 Comparison of Predicted Lateral Stability Derivatives for a Supersonic Cruise Configuration with Experimental Data at M = 0.165

not to develop vortex lift and has zero leading-edge suction. This assumption is plausible judged from the surface oil flow data in Reference 19. Figure 12 shows that the present method predicts the longitudinal characteristics quite well, in particular, the trend with tip dihedral being correctly predicted. The theoretical method used in Reference 19 is the conventional vortex-lattice method (Ref. 20).

5. Concluding Remarks

The present nonplanar quasi-vortex-lattice method predicts quite well all rolling moment derivatives, which are, of course, contributed mainly by the wing in a complete configuration. To improve the prediction of other lateral-directional stability derivatives, the following refinements are needed:

(1) to include the fuselage effect.

(2) to include the effect of skin friction so that the prediction of C_{y_β}, C_{n_β}, C_{y_r} and C_{n_r} can be improved.

(3) to incorporate empirical correction factors for the degree of development of edge suction forces.

6. References

(1) Toll, T. A. and Queijo, M. J., "Approximate Relations and Charts for Low-Speed Stability Derivatives of Swept Wings," NACA TN 1581, 1948.

(2) Queijo, M. J., "Theory for Computing Span Loads and Stability Derivatives due to Sideslip, Yawing, and Rolling for Wings in Subsonic Compressible Flow," NASA TN D-4929, December 1968.

(3) Queijo, M. J., "Theoretical Span Load Distributions and Rolling Moments for Sideslipping Wings of Arbitrary Plan Form in Incompressible Flow," NACA Report 1269, 1955.

(4) Polhamus, E. C. and Sleeman, W. C., Jr., "The Rolling Moment due to Sideslip of Swept Wings at Subsonic and Transonic Speeds," NASA TN D-209, February 1960.

(5) Goodman, A. and Fisher, L. R., "Investigation at Low Speeds of the Effect of Aspect Ratio and Sweep on Rolling Stability Derivatives of Untapered Wings," NACA Report 968, 1950.

(6) Lan, C. E., "A Quasi-Vortex-Lattice Method in Thin Wing Theory," Journal of Aircraft, Vol. 11, No. 9, Sept. 1974, pp. 518-527.

(7) Polhamus, E. C., "A Concept of the Vortex Lift of Sharp-Edge Delta Wings Based on a Leading-Edge-Suction Analogy," NASA TN D-3767, December 1966.

(8) Lan, C. E., "Calculation of Lateral-Directional Stability Derivatives for Wing-Body Combinations with and without Jet-Interaction Effects," NASA CR-145251, August 1977.

(9) Rubbert, P.E., "Sideslip of Wing-Body Combinations," NASA CR-114716, October 1972.

(10) Hoerner, S. F. and Borst, H. V., "Fluid-Dynamic Lift," published by Hoerner Fluid Dynamics, P.O. Box 342, Brick Town, N.J. 08723, 1975.

(11) Etkin, B., "Dynamics of Atmospheric Flight," John Wiley and Son, Inc., 1972.

(12) "On the Application of Subsonic Linearized Wing Theory to Second-Order Forces and Moments," ARC R & M No. 3758, 1975.
Part I General Principles and Mathematical Models, by G. J. Hancock.
Part II Edge Forces and Roll-Rate Derivatives, by H. C. Garner.

(13) Carlson, H. W. and Mack, R. J., "Studies of Leading-Edge Thrust Phenomena," AIAA Paper No. 80-0325, Jan. 1980.

(14) Henderson, W. P., "Studies of Various Factors Affecting Drag Due to Lift at Subsonic Speeds," NASA TN D-3584, October 1966.

(15) Henderson, W. P., "Effects of Wing Leading-Edge Radius and Reynolds Number on Longitudinal Aerodynamic Characteristics of Highly Swept Wing-Body Configurations at Subsonic Speeds," NASA TN D-8361, December 1976.

(16) Jacobs, P. F., "Effect of Winglets on a First-Generation Jet Transport Wing. V-Stability Characteristics of a Full-Span Wing with a Generalized Fuselage at High Subsonic Speeds," NASA TP-1163, March, 1978.

(17) Schade, R. O., "Effect of Geometric Dihedral on the Aerodynamic Characteristics of Two Isolated Vee-Tail Surfaces," NACA TN-1369, July 1947.

(18) Davenport, E. E. and Huffman, J. K., "Experimental and Analytical Investigation of Subsonic Longitudinal and Lateral Aerodynamic Characteristics of Slender Sharp-Edge 74° Swept Wings," NASA TN D-6344, July 1971.

(19) Washburn, K. E.and Gloss, B. B., "Effect of Wing-Tip Dihedral on the Longitudinal and Lateral Aerodynamic Characteristics of a Supersonic Cruise Configuration at Subsonic Speeds," NASA TM X-72693, August 1976.

(20) Lamar, J. E. and Gloss, B. B., "Subsonic Aerodynamic Characteristics of Interacting Lifting Surfaces with Separated Flow Around Sharp Edges Predicted by a Vortex-Lattice Method," NASA TN D-7921, September 1975.

Appendix A

Instruction on the Usage of the Nonplanar QVLM Program and Sample Input Data

A.1 PROGRAM CAPABILITIES

This program has the following main features:

(1) It is applicable to nonplanar wing configurations, such as wing-winglet, wing-vertical fin combinations, etc. It can also analyze wing-tail or wing-canard configurations. However, the wake is assumed flat.

(2) Up to five flap spans with different flap angles, including ailerons, can be analyzed.

(3) Arbitrary camber shapes defined at three spanwise stations or less are used in the program through cubic spline interpolation.

(4) The program can calculate the symmetrical loading, the rolling moment coefficient due to aileron deflections (for attached potential flow only) and lateral-directional stability derivatives. For the first two conditions, the bending moment distribution is also calculated.

(5) The vortex-lift effect is calculated through the use of Polhamus' suction analogy.

(6) Ground effect analysis is made by the image vortex method. However, the ground effect on lateral-directional stability derivatives has not been correlated with the experimental data.

A.2 INPUT DATA FORMAT

Group 1 Format (6X, I4), 1 card

ICASE Number of cases to be run

Group 2 Format 2(6X, I4), 1 card

NCASE User's case number

NGRD = 1 if the wing is in ground effect; = 0 otherwise.

Group 3 Format (13A6), 1 card

TITLE (I) (I = 1, 13) Any words describing the case to be run.

Group 4 Format 8(6X, I4), 1 card

NC Number of spanwise sections on the right wing (to be divided according to points of discontinuities in geometry, such as edges of flap spans). Limited to 7. (Avoid dividing planforms into too many sections).

M1(I),I=1, NC Numbers of vortex strips in each section plus one. There are NC numbers. Minimum value is 3. Maximum total number of vortex strips is 48.

IWING = Last wing vortex strip number if a tail is present, = 0, otherwise.

NWING = The numerical order of the last wing spanwise section, numbered from inboard sections.

IWGLT = 1 if a winglet to be represented by a tail is present. = 2 if the winglet (vertical fin) is placed inboard of wing tip. = 0 otherwise.

Group 5 Format 8(6X, I4), 1 card

NFP Number of flap spans. Limited to 5.

NJW(I),I=1,NFP Numerical orders of flap spans among the spanwise sections. For clean or full-span flap configurations, set NFP = 1, NJW(I) = 1.

NVRTX The vortex strip number at and outboard of which the leading-edge vortex-lift effect is not included. If it is zero, total vortex-lift is assumed.

Group 6 Format 8(6X, I4), 1 card

NW(1) Numbers of vortex elements in chordwise sections,

NW(2) divided along flap hinge line or winglet leading edge, as illustrated in sample input.

ICAM = 1 if camber ordinates are to be read in,

= 0 if camber slopes are defined manually in subprograms ZCR(X), ZCI(X), ZCT(X). The default is for a noncambered wing.

IM Number of camber ordinates to be read in (limited to 12); arbitrary if ICAM = 0.

IST Number of stations at which camber ordinates are read in. Limited to 3. Station 2 must be consistent with the intermediate station defining twist (see Group 13).

ICAMT = 1 if the tail, winglet or vertical fin has camber. In this case, camber ordinates at wing root, wing tip and tail should be all read in.

= 0, otherwise.

---

*Omit group 7 if ICAM = 0 *

Group 7 Format 8F10.6

XT(I,J) X-coordinates at which camber ordinates are read in. Nondimensionalized with chord length. All X-coordinates are read in first.

ZC(I,J) Camber ordinates at the corresponding X-locations. Nondimensionalized with chord length.

The above are to be repeated IST times. Input root chord first.

Group 8 Format 2(6X, I4), 1 card

LAT = 0 for symmetrical loading only

= -1 for computing C_ℓ with aileron deflection.

= 1 for computing lateral-directional stability derivatives. (Symmetrical loading is always calculated).

NAL Numerical order of aileron span among the flap spans. (= 0 if LAT ≠ -1)

Group 9 Format 8F10.6

Corner-point coordinates of a spanwise section.

XXL(1) L.E. X-coordinate of the inboard chord.

XXT(1) T.E. X-coordinate of the inboard chord.

YL(1) Y-coordinate of the inboard chord.

XXL(2) L.E. X-coordinate of the outboard chord.

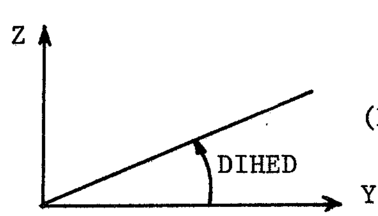
XXT(2) T.E. X-coordinate of the outboard chord.

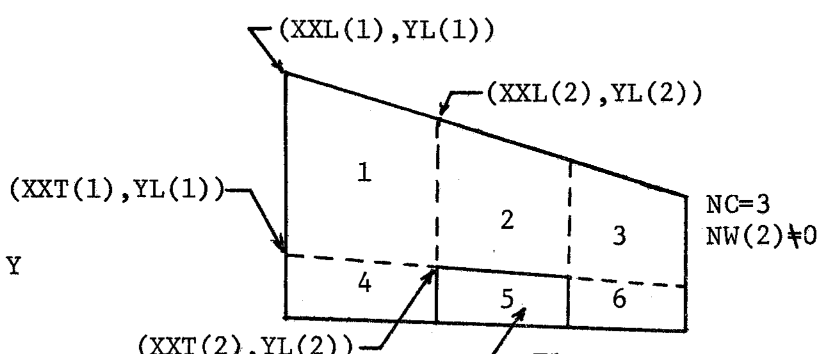
YL(2) Y-coordinate of the outboard chord.

ZS elevation of the spanwise section.

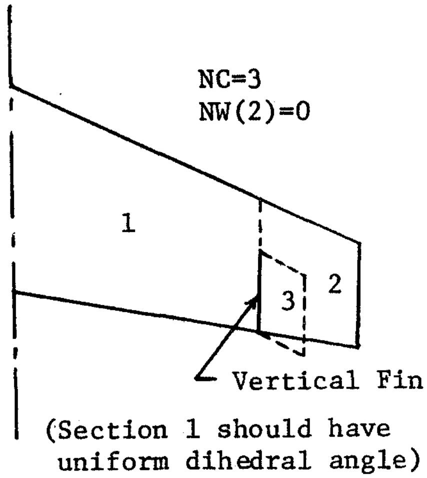
DIHED dihedral angle in degrees for the section.

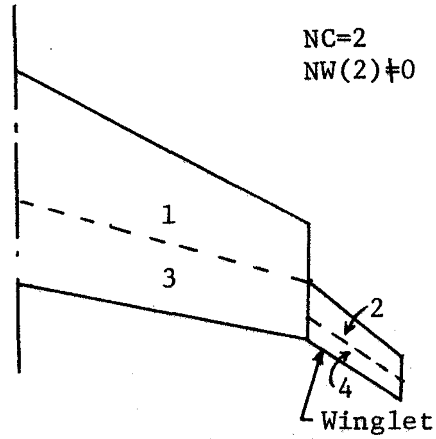
Note. Group 9 is to be repeated NC times. With flaps or winglet, another NC cards are needed to describe the flap and the associated regions. The order of input is illustrated below. Panels with dihedral must be rotated to X-Y plane for geometric description.

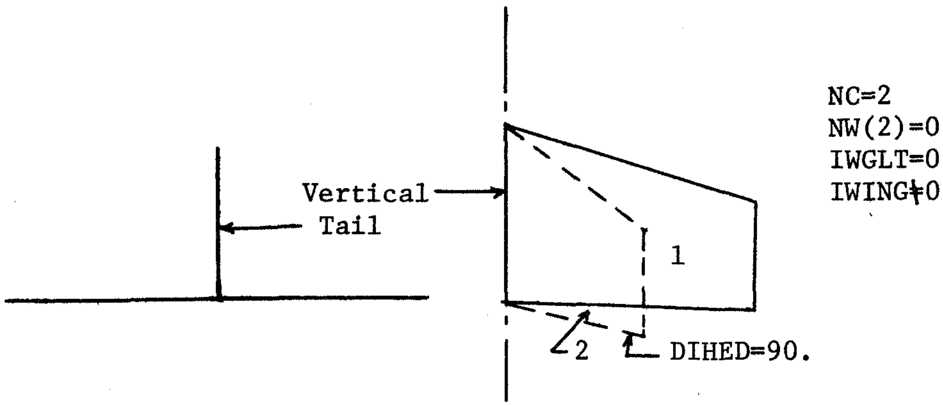




Numbers inside panels denote input order.







Group 10 Format 8F10.6, 1 card

AM	Freestream Mach number. AM < 1.
HALFSW	Reference half wing area.
CREF	Reference chord.
ALPCON	An indicator (= 1. if C_{L_α} and C_{m_α} are to be computed. In this case, put flap angles to zero. = 0. otherwise).
DF(I), I=1,NFP	flap angles in degrees, inboard flap span first.

Group 11 Format 3F10.6, 1 card

ALNM	Number of angles of attack to be processed for the same configuration at the same Mach number.
ALPI	Initial angle of attack in degrees.

ALPINC Incremental angle of attack in degrees.

Note. The above variables in Group 11 should be all zero if ALPCON = 1.0

Group 12 Format 2F10.6, 1 card

HEIGHT Ground height of 3/4 chord point of M.A.C., or other reference point. = 0. if NGRD = 0.

ATT pitch attitude angle in degrees. = 0. if NGRD = 0.

Group 13 must be omitted if ALPCON = 1.

Group 13 Format 7F10.6, 1 card

TWIST1 twist in degrees from root chord to an intermediate station, negative for washout. If TWIST1 >99., the twist distribution and camber slope defined in Functions TWST & ZCDX will be used.

TWIST2 twist in degrees from an intermediate station to tip chord, referenced to the intermediate station. = 0. if the intermediate station is the tip.

YTW Y-coordinate of the intermediate station.

RINC root chord incidence angle in degrees.

CAMLE1 L.E. camber slope at the root chord.

CAMLE2 L.E. camber slope at the intermediate station

CAMLE3 L.E. camber slope at the tip chord.

(CAMLE1, CAMLE2, CAMLE3: arbitrary if ICAM = 1)

---

*Group 14 must be omitted if IWING = 0

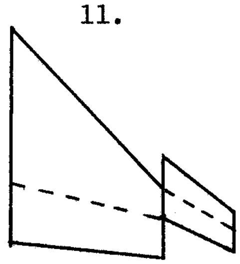
Group 14 Format 3F10.6, 1 card

TINC Tail incidence angle in degrees.

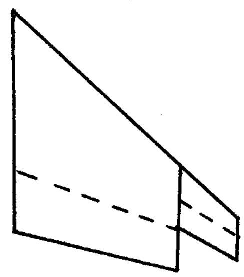
HALFSH Tail half area. If the tail is to represent the winglet at the tip, put HALFSH = HALFSW. If the tail is a vertical fin inboard of wing tip, put HALFSH = fin area.

POS Winglet position indicator. Its numerical value is based on whether the winglet is attached to the wing first or second chordwise section, respectively. It is indicated below. If there is no winglet, it should be 0.

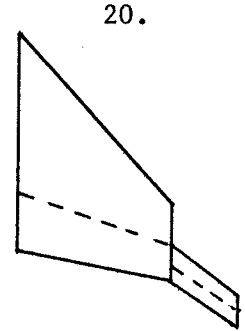
POS = 11.



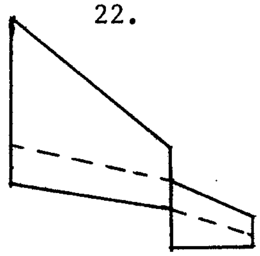
10.



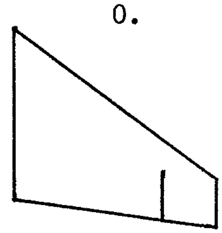
20.



POS = 22.



0.



If ICASE > 1, repeat Groups 2-14.

<u>Remarks</u>:

(1) With the existing dimension for the array DQ(I,J) in the main program, a total of 140 vortex elements can be used. The minimum memory for execution is 55K (decimal).

(2) Three working disk files are needed in execution. They are designated as (01), (02) and (03).

A.3 OUTPUT DATA FORMAT

(1) First, the input data will be printed.

HALFSW half wing area

CREF reference chord

(2) Vortex Element Endpoint Coordinates:

(X_1,Y_1,Z_1) coordinates of the inboard endpoint of a bound vortex element

(X_2,Y_2,Z_2) coordinates of the corresponding outboard endpoint of a bound vortex element

(3) Control Point Coordinates:

One set of (XCP, YCP, ZCP) defines a control point location.

(4) Sectional Pressure and Force Data

XV	percent chordwise location
YV	percent spanwise location (referred to half span)
CP	ΔC_p (with aileron deflections, ΔC_p on both left and right wings will be printed).
Y/S	the nondimensional y-coordinate of the spanwise station (referred to half span)
CL	Sectional lift coefficient
CM	sectional pitching moment coefficient about the y-axis
CT	sectional leading-edge thrust coefficient
CDI	sectional induced drag coefficient

(5) The next group of output variables is for the attached potential flow. If ALPCON = 1, the lift and pitching moment coefficients will be C_{L_α} and C_{m_α}.

(6) The results to be used in the method of suction analogy are printed next. If ALPCON = 1, the variables printed are used for a noncambered wing in the following formulas:

$$C_L = K_p \sin\alpha \cos^2\alpha + (K_{v,\ell e} + K_{v,se}) \sin^2\alpha \cos\alpha$$

$$C_{D_i} = C_L \tan\alpha$$

$$C_m = K_p \sin\alpha \cos\alpha \frac{\bar{x}_p}{C_{ref}} + K_{v,\ell e} \sin^2\alpha \frac{\bar{x}_{\ell e}}{C_{ref}} + K_{v,se} \sin^2\alpha \frac{\bar{x}_{se}}{C_{ref}}$$

(7) If lateral-directional stability derivatives are calculated, results for both attached potential flow and vortex-separated flow will be printed, based on body and stability axes. The sideslip derivatives are in per radian.

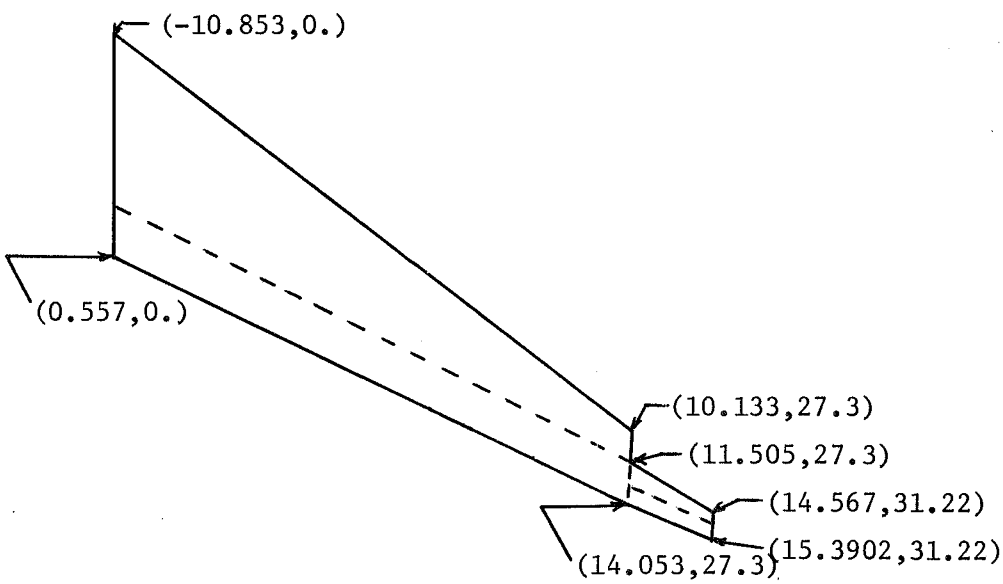
(8) If rolling moment coefficient due to aileron deflection is calculated, it will be printed here.

(9) The last group of results is the bending moment distribution and the bending moment coefficient at the root chord.

A.4 Sample Test Case No. 1

Input Data :

```
         1
        10          0
NASA TP-1163, KC-135A WITH WINGLFT
         2         14          6          13          1          1
         1          1          0
         3          3          1          11          3          1
0.          0.1         0.2         0.3         0.4         0.5         0.6         0.7
0.8         0.9         1.
0.          0.0145      0.01878     0.01947     0.01946     0.01855     0.01744     0.01458
0.01022     0.00582     0.
0.          0.1         0.2         0.3         0.4         0.5         0.6         0.7
0.8         0.9         1.
0.          0.0145      0.01878     0.01947     0.01946     0.01855     0.01744     0.01458
0.01022     0.00582     0.
0.          0.1         0.2         0.3         0.4         0.5         0.6         0.7
0.8         0.9         1.
0.          0.01505     0.019       0.02145     0.023       0.0237      0.0241      0.0233
 0.0199     0.01215     -0.00435
         1          0
-10.853     -3.4365     0.          10.133      11.505      27.3        0.          7.
11.505      13.161      27.3         14.567     15.102      31.22       0.          75.
-3.4365     0.557       0.           11.505     14.053      27.3        0.          7.
13.161      14.053      27.3         15.102     15.3902     31.22       0.          75.
0.5         209.25      8.275       0.          0.
1.          1.51        0.
0.          0.
0.          0.          27.3        2.          0.          0.          0.
-4.         209.25      20.
```



```
        1

 *****************************************
CASE NUMBER =10

 *****************************************

 *****************************************
  NASA TP-1163, KC-135A WITH WINGLET

 *****************************************

 INPUT DATA
         2         14          6         13          1          1
         1          1          0
         3          3          1         11          3          1
         1          0
-10.853000 -3.436500  0.        10.133000 11.505000 27.300000  0.         7.000000
 11.505000 13.161000 27.300000 14.567000 15.102000 31.220000  0.        75.000000
 -3.436500  0.557000  0.        11.505000 14.053000 27.300000  0.         7.000000
 13.161000 14.053000 27.300000 15.102000 15.390200 31.220000  0.        75.000000
  0.500000209.250000  8.275000  0.         0.
  1.000000  1.510000  0.
  0.        0.
  0.        0.        27.300000  2.000000  0.         0.         0.
 -4.000000209.250000 20.000000
          HALF SW= 0.20925E 03          CREF= 0.82750E 01
*** CAMBER ORDINATES FOR THE ROOT SECTION ***

       X/C    0.          0.10000   0.20000   0.30000   0.40000   0.50000   0.60000

       Z/C    0.          0.01450   0.01878   0.01947   0.01946   0.01855   0.01744

              0.70000     0.80000   0.90000   1.00000

              0.01458     0.01022   0.00582   0.

*** CAMBER ORDINATES FOR THE INTERMEDIATE SECTION ***

       X/C    0.          0.10000   0.20000   0.30000   0.40000   0.50000   0.60000

       Z/C    0.          0.01450   0.01878   0.01947   0.01946   0.01855   0.01744

              0.70000     0.80000   0.90000   1.00000

              0.01458     0.01022   0.00582   0.
*** CAMBER ORDINATES FOR THE TIP SECTION ***

       X/C    0.          0.10000   0.20000   0.30000   0.40000   0.50000   0.60000

       Z/C    0.          0.01505   0.01900   0.02145   0.02300   0.02370   0.02410

              0.70000     0.80000   0.90000   1.00000

              0.02330     0.01990   0.01215  -0.00435
```

VORTEX ELEMENT ENDPOINT COORDINATES=

X1	X2	Y1	Y2	Z1	Z2
-10.35619	-9.77872	0.	0.76599	0.	0.
-7.14475	-6.64072	0.	0.76599	0.	0.
-3.93331	-3.50272	0.	0.76599	0.	0.
-9.77872	-8.77890	0.76599	2.09221	0.	0.
-6.64072	-5.76805	0.76599	2.09221	0.	0.
-3.50272	-2.75720	0.76599	2.09221	0.	0.
-8.77890	-7.34216	2.09221	3.99799	0.	0.
-5.76805	-4.51402	2.09221	3.99799	0.	0.
-2.75720	-1.68588	2.09221	3.99799	0.	0.
-7.34216	-5.54054	3.99799	6.38776	0.	0.
-4.51402	-2.94152	3.99799	6.38776	0.	0.
-1.68588	-0.34250	3.99799	6.38776	0.	0.
-5.54054	-3.46439	6.38776	9.14169	0.	0.
-2.94152	-1.12940	6.38776	9.14169	0.	0.
-0.34250	1.20559	6.38776	9.14169	0.	0.
-3.46439	-1.21782	9.14169	12.12168	0.	0.
-1.12940	0.83147	9.14169	12.12168	0.	0.
1.20559	2.88076	9.14169	12.12168	0.	0.
-1.21782	1.08653	12.12168	15.17831	0.	0.
0.83147	2.84278	12.12168	15.17831	0.	0.
2.88076	4.59902	12.12168	15.17831	0.	0.
1.08653	3.33311	15.17831	18.15831	0.	0.
2.84278	4.80365	15.17831	18.15831	0.	0.
4.59902	6.27419	15.17831	18.15831	0.	0.
3.33311	5.40926	18.15831	20.91224	0.	0.
4.80365	6.61577	18.15831	20.91224	0.	0.
6.27419	7.82228	18.15831	20.91224	0.	0.
5.40926	7.21087	20.91224	23.30201	0.	0.
6.61577	8.18827	20.91224	23.30201	0.	0.
7.82228	9.16566	20.91224	23.30201	0.	0.
7.21087	8.64761	23.30201	25.20778	0.	0.
8.18827	9.44230	23.30201	25.20778	0.	0.
9.16566	10.23698	23.30201	25.20778	0.	0.
8.64761	9.64744	25.20778	26.53401	0.	0.
9.44230	10.31497	25.20778	26.53401	0.	0.
10.23698	10.98250	25.20778	26.53401	0.	0.
9.64744	10.22491	26.53401	27.30000	0.	0.
10.31497	10.81900	26.53401	27.30000	0.	0.
10.98250	11.41309	26.53401	27.30000	0.	0.
11.61593	12.05335	27.30000	27.87407	0.	0.
12.33300	12.69934	27.30000	27.87407	0.	0.
13.05007	13.34532	27.30000	27.87407	0.	0.
12.05335	12.72285	27.87407	28.75271	0.	0.
12.69934	13.26003	27.87407	28.75271	0.	0.
13.34532	13.79721	27.87407	28.75271	0.	0.
12.72285	13.49592	28.75271	29.76729	0.	0.
13.26003	13.90747	28.75271	29.76729	0.	0.
13.79721	14.31902	28.75271	29.76729	0.	0.
13.49592	14.16542	29.76729	30.64593	0.	0.
13.90747	14.46816	29.76729	30.64593	0.	0.
14.31902	14.77091	29.76729	30.64593	0.	0.
14.16542	14.55195	30.64593	31.15321	0.	0.
14.46816	14.79188	30.64593	31.15321	0.	0.
14.77091	15.03181	30.64593	31.15321	0.	0.
-3.16899	-2.75247	0.	0.76599	0.	0.
-1.43975	-1.04080	0.	0.76599	0.	0.
0.28949	0.67088	0.	0.76599	0.	0.
-2.75247	-2.03132	0.76599	2.09221	0.	0.
-1.04080	-0.35005	0.76599	2.09221	0.	0.
0.67088	1.33121	0.76599	2.09221	0.	0.
-2.03132	-0.99503	2.09221	3.99799	0.	0.
-0.35005	0.64254	2.09221	3.99799	0.	0.
1.33121	2.28011	2.09221	3.99799	0.	0.
-0.99503	0.30443	3.99799	6.38776	0.	0.
0.64254	1.88721	3.99799	6.38776	0.	0.
2.28011	3.46999	3.99799	6.38776	0.	0.
0.30443	1.80191	6.38776	9.14169	0.	0.
1.88721	3.32155	6.38776	9.14169	0.	0.
3.46999	4.84119	6.38776	9.14169	0.	0.

1.80191	3.42231	9.14169	12.12168	0.	0.
3.32155	4.87363	9.14169	12.12168	0.	0.
4.84119	6.32494	9.14169	12.12168	0.	0.
3.42231	5.08439	12.12168	15.17831	0.	0.
4.87363	6.46562	12.12168	15.17831	0.	0.
6.32494	7.84686	12.12168	15.17831	0.	0.
5.08439	6.70479	15.17831	18.15831	0.	0.
6.46562	8.01770	15.17831	18.15831	0.	0.
7.84686	9.33061	15.17831	18.15831	0.	0.
6.70479	8.20227	18.15831	20.91224	0.	0.
8.01770	9.45204	18.15831	20.91224	0.	0.
9.33061	10.70181	18.15831	20.91224	0.	0.
8.20227	9.50173	20.91224	23.30201	0.	0.
9.45204	10.69671	20.91224	23.30201	0.	0.
10.70181	11.89169	20.91224	23.30201	0.	0.
9.50173	10.53802	23.30201	25.20778	0.	0.
10.69671	11.68930	23.30201	25.20778	0.	0.
11.89169	12.84059	23.30201	25.20778	0.	0.
10.53802	11.25917	25.20778	26.53401	0.	0.
11.68930	12.38005	25.20778	26.53401	0.	0.
12.84059	13.50092	25.20778	26.53401	0.	0.
11.25917	11.67568	26.53401	27.30000	0.	0.
12.38005	12.77900	26.53401	27.30000	0.	0.
13.50092	13.88232	26.53401	27.30000	0.	0.
13.22075	13.49908	27.30000	27.87407	0.	0.
13.60700	13.84704	27.30000	27.87407	0.	0.
13.99325	14.19500	27.30000	27.87407	0.	0.
13.49908	13.92508	27.87407	28.75271	0.	0.
13.84704	14.21443	27.87407	28.75271	0.	0.
14.19500	14.50379	27.87407	28.75271	0.	0.
13.92508	14.41698	28.75271	29.76729	0.	0.
14.21443	14.63867	28.75271	29.76729	0.	0.
14.50379	14.86035	28.75271	29.76729	0.	0.
14.41698	14.84298	29.76729	30.64593	0.	0.
14.63867	15.00606	29.76729	30.64593	0.	0.
14.86035	15.16914	29.76729	30.64593	0.	0.
14.84298	15.08893	30.64593	31.15321	0.	0.
15.00606	15.21817	30.64593	31.15321	0.	0.
15.16914	15.34742	30.64593	31.15321	0.	0.

CONTROL POINT COORDINATES=

XCP	YCP	ZCP	XCP	YCP	ZCP
-8.75474	0.34223	0.	-5.08437	0.34223	0.
-3.24919	0.34223	0.	-8.03457	1.35177	0.
-4.47596	1.35177	0.	-2.69666	1.35177	0.
-6.87447	2.97800	0.	-3.49590	2.97800	0.
-1.80662	2.97800	0.	-5.33263	5.13936	0.
-2.19333	5.13936	0.	-0.62369	5.13936	0.
-3.48635	7.72749	0.	-0.63358	7.72749	0.
0.79281	7.72749	0.	-1.42822	10.61259	0.
1.10516	10.61259	0.	2.37185	10.61259	0.
0.73856	13.65000	0.	2.93569	13.65000	0.
4.03425	13.65000	0.	2.90535	16.68741	0.
4.76621	16.68741	0.	5.69665	16.68741	0.
4.96348	19.57251	0.	6.50495	19.57251	0.
7.27569	19.57251	0.	6.80976	22.16064	0.
8.06471	22.16064	0.	8.69219	22.16064	0.
8.35160	24.32200	0.	9.36728	24.32200	0.
9.87512	24.32200	0.	9.51169	25.94822	0.

10.34734	25.94822	0.	10.76516	25.94822	0.
10.23186	26.95777	0.	10.95575	26.95777	0.
11.31769	26.95777	0.	12.10534	27.56259	0.
12.89580	27.56259	0.	13.29102	27.56259	0.
12.61444	28.28000	0.	13.30231	28.28000	0.
13.64625	28.28000	0.	13.30988	29.26000	0.
13.85763	29.26000	0.	14.13150	29.26000	0.
14.00531	30.24000	0.	14.41294	30.24000	0.
14.61675	30.24000	0.	14.51441	30.95741	0.
14.81945	30.95741	0.	14.97198	30.95741	0.
-2.25535	0.34223	0.	-0.26766	0.34223	0.
0.72619	0.34223	0.	-1.71618	1.35177	0.
0.24478	1.35177	0.	1.22526	1.35177	0.
-0.84766	2.97800	0.	1.07025	2.97800	0.
2.02920	2.97800	0.	0.30666	5.13936	0.
2.16735	5.13936	0.	3.09769	5.13936	0.
1.68890	7.72749	0.	3.43107	7.72749	0.
4.37715	7.72749	0.	3.22975	10.61259	0.
4.94553	10.61259	0.	5.80343	10.61259	0.
4.85194	13.65000	0.	6.48731	13.65000	0.
7.30500	13.65000	0.	6.47413	16.68741	0.
8.02909	16.68741	0.	8.80657	16.68741	0.
8.01498	19.57251	0.	9.49356	19.57251	0.
10.23285	19.57251	0.	9.39722	22.16064	0.
10.80728	22.16064	0.	11.51231	22.16064	0.
10.55154	24.32200	0.	11.90438	24.32200	0.
12.58080	24.32200	0.	11.42006	25.94822	0.
12.72984	25.94822	0.	13.38474	25.94822	0.
11.95922	26.95777	0.	13.24228	26.95777	0.
13.88381	26.95777	0.	13.50391	27.56259	0.
13.92969	27.56259	0.	14.14258	27.56259	0.
13.83151	28.28000	0.	14.20204	28.28000	0.
14.38730	28.28000	0.	14.27902	29.26000	0.
14.57407	29.26000	0.	14.72160	29.26000	0.
14.72654	30.24000	0.	14.94611	30.24000	0.
15.05590	30.24000	0.	15.05414	30.95741	0.
15.21846	30.95741	0.	15.30062	30.95741	0.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

PRESSURE DISTRIBUTION AT ALPHA = 1.510 DEG.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

VORTEX	XV	YV	CP
1	0.04345	0.01254	0.44793
2	0.32435	0.01254	0.38576
3	0.60524	0.01254	0.32569
4	0.67223	0.01254	0.30430
5	0.82435	0.01254	0.24915
6	0.97647	0.01254	0.13859
7	0.04319	0.04952	0.51146
8	0.32236	0.04952	0.39793
9	0.60154	0.04952	0.34470
10	0.66852	0.04952	0.28451
11	0.82236	0.04952	0.23705
12	0.97620	0.04952	0.13022
13	0.04273	0.10908	0.61962
14	0.31894	0.10908	0.41677
15	0.59516	0.10908	0.34324
16	0.66215	0.10908	0.28332
17	0.81894	0.10908	0.22449
18	0.97574	0.10908	0.12415
19	0.04206	0.13826	0.73317
20	0.31393	0.18826	0.44271
21	0.58580	0.18826	0.34170
22	0.65279	0.18826	0.28761
23	0.81393	0.18826	0.22183
24	0.97507	0.18826	0.12341
25	0.04114	0.28306	0.83924
26	0.30708	0.28306	0.47327
27	0.57303	0.28306	0.34552
28	0.64001	0.28306	0.29913
29	0.80708	0.28306	0.22708
30	0.97415	0.28306	0.12514
31	0.03994	0.38874	0.93525

32	0.29810	0.38874	0.50727
33	0.55627	0.38874	0.35338
34	0.62326	0.38874	0.31709
35	0.79810	0.38874	0.23901
36	0.97295	0.38874	0.12950
37	0.03840	0.50000	1.02196
38	0.28664	0.50000	0.54353
39	0.53488	0.50000	0.36461
40	0.60187	0.50000	0.33801
41	0.78664	0.50000	0.25459
42	0.97142	0.50000	0.13431
43	0.03649	0.61126	1.09970
44	0.27239	0.61126	0.58078
45	0.50828	0.61126	0.38022
46	0.57527	0.61126	0.35992
47	0.77239	0.61126	0.27372
48	0.96951	0.61126	0.14072
49	0.03419	0.71694	1.16713
50	0.25521	0.71694	0.61809
51	0.47622	0.71694	0.40000
52	0.54321	0.71694	0.37765
53	0.75521	0.71694	0.29265
54	0.96720	0.71694	0.14530
55	0.03154	0.81174	1.22098
56	0.23545	0.81174	0.65585
57	0.43936	0.81174	0.41463
58	0.50634	0.81174	0.38701
59	0.73545	0.81174	0.30991
60	0.96456	0.81174	0.14991
61	0.02873	0.89092	1.24769
62	0.21441	0.89092	0.68390
63	0.40010	0.89092	0.40675
64	0.46709	0.89092	0.38537
65	0.71441	0.89092	0.31304
66	0.96174	0.89092	0.14774
67	0.02609	0.95048	1.20932
68	0.19475	0.95048	0.66992
69	0.36341	0.95048	0.35915
70	0.43040	0.95048	0.36456
71	0.69475	0.95048	0.32383
72	0.95910	0.95048	0.16032
73	0.02416	0.98746	1.01572
74	0.18035	0.98746	0.51482
75	0.33653	0.98746	0.28470
76	0.40352	0.98746	0.37978
77	0.68035	0.98746	0.36652
78	0.95717	0.98746	0.15582
79	0.04354	1.00962	1.63960
80	0.32496	1.00962	0.54866
81	0.60638	1.00962	0.30345
82	0.67337	1.00962	0.22973
83	0.82496	1.00962	0.27614
84	0.97655	1.00962	0.15960
85	0.04354	1.03590	1.37233
86	0.32496	1.03590	0.48631
87	0.60638	1.03590	0.32067
88	0.67337	1.03590	0.25103
89	0.82496	1.03590	0.27775
90	0.97655	1.03590	0.15470
91	0.04354	1.07179	1.19007
92	0.32496	1.07179	0.43811
93	0.60638	1.07179	0.30323
94	0.67337	1.07179	0.23858
95	0.82496	1.07179	0.26857
96	0.97655	1.07179	0.14981
97	0.04354	1.10769	1.06233
98	0.32496	1.10769	0.38888
99	0.60638	1.10769	0.27029
100	0.67336	1.10769	0.21341
101	0.82496	1.10769	0.24611
102	0.97655	1.10769	0.14150
103	0.04354	1.13397	0.87051
104	0.32495	1.13397	0.26300
105	0.60637	1.13397	0.17610
106	0.67336	1.13397	0.14406
107	0.82495	1.13397	0.18574
108	0.97655	1.13397	0.12581

Y/S	CL(RIGHT)	CL(LEFT)	CM	CT	CDI
0.01254	0.34518	0.34518	0.24092	0.00019	0.01417
0.04952	0.35762	0.35762	0.22875	0.00006	0.01331
0.10908	0.37702	0.37702	0.20357	0.00056	0.01116
0.18826	0.40089	0.40089	0.15610	0.00162	0.00860
0.28306	0.42631	0.42631	0.08314	0.00306	0.00660
0.38874	0.45157	0.45157	-0.01396	0.00469	0.00476
0.50000	0.47470	0.47470	-0.12994	0.00635	0.00326
0.61126	0.49492	0.49492	-0.25730	0.00791	0.00224
0.71694	0.50951	0.50951	-0.38461	0.00921	0.00166
0.81174	0.51620	0.51620	-0.49878	0.01008	0.00153
0.89092	0.50534	0.50534	-0.57692	0.01018	0.00133
0.95048	0.47718	0.47718	-0.61040	0.00894	0.00261
0.98746	0.42661	0.42661	-0.58830	0.00574	0.00747
THE FOLLOWING ARE THE WINGLET CHARACTERISTICS					
1.00962	0.14184	0.14184	-0.23425	0.04885	-0.06425
1.03590	0.13154	0.13154	-0.21894	0.02880	-0.04238
1.07179	0.11994	0.11994	-0.20718	0.02093	-0.03293
1.10769	0.10802	0.10802	-0.19401	0.01629	-0.02706
1.13397	0.08108	0.08108	-0.14953	0.01083	-0.01932

*** THE FOLLOWING ARE ATTACHED POTENTIAL FLOW RESULTS ***

TOTAL LIFT COEFFICIENT = 0.44493

TOTAL INDUCED DRAG COEFFICIENT = 0.00474

THE INDUCED DRAG PARAMETER = 0.02394

TOTAL PITCHING MOMENT COEFFICIENT = -0.08550

THE WING LIFT COEFFICIENT = 0.44115

THE WING INDUCED DRAG COEFFICIENT = 0.00596

THE WING PITCHING MOMENT COEFFICIENT = -0.07904

THE TAIL LIFT COEFFICIENT = 0.00378(BASED ON WING AREA), = 0.00378(BASED ON TAIL AREA)

THE TAIL PITCHING MOMENT COEFFICIENT BASED ON REFERENCE WING AREA
AND MEAN WING CHORD, AND REFERRED TO THE Y-AXIS = -0.00646

(NOTE. THE INDUCED DRAG COMPUTATION IS FOR SYMMETRICAL LOADING ONLY)

****

THE FOLLOWING PARAMETERS ARE USED IN THE METHOD OF SUCTION ANALOGY

CLP = 0.44591 CLVLE = 0.00620 CLVSE = 0.00109

CDP = 0.01027 CDVLE = -0.00100 CDVSE = 0.00007

CMP = -0.08550 CMVLE = -0.00178 CMVSE = -0.00149

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*STABILITY DERIVATIVES BY POTENTIAL FLOW THEORY*
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***STABILITY DERIVATIVES EVALUATED AT ALPHA =   1.510  DEGREES
   AND AT MACH NO.= 0.50,BASED ON BODY AXES(IN PER RADIAN)***

   CYB =  -0.1691180  CLB =  -0.1986322  CNB =   0.0151494
   CYP =  -0.1860291  CLP =  -0.4867214  CNP =  -0.0144590
   CYR =   0.1008180  CLR =   0.1168240  CNR =  -0.0159456

***STABILITY DERIVATIVES BASED ON STABILITY AXES***

   CYB =  -0.1691180  CLB =  -0.1981640  CNB =   0.0203784
   CYP =  -0.1833078  CLP =  -0.4836980  CNP =  -0.0021287
   CYR =   0.1056851  CLR =   0.1291542  CNR =  -0.0189690
****************************************
*STABILITY DERIVATIVES WITH EDGE VORTEX SEPARATION*
****************************************

***STABILITY DERIVATIVES EVALUATED AT ALPHA =   1.510  DEGREES
   AND AT MACH NO.= 0.50,BASED ON BODY AXES(IN PER RADIAN)***

   **INCLUDING THE EFFECT OF LE AND SE VORTEX LIFT*

   CYB =  -0.2169768  CLB =  -0.2115922  CNB =   0.0348294
   CYP =  -0.3323266  CLP =  -0.5473992  CNP =   0.0466965
   CYR =   0.1118237  CLR =   0.1198273  CNR =  -0.0225003

***STABILITY DERIVATIVES BASED ON STABILITY AXES***

   CYB =  -0.2169768  CLB =  -0.2106009  CNB =   0.0403930
   CYP =  -0.3292644  CLP =  -0.5426481  CNP =   0.0604079
   CYR =   0.1205421  CLR =   0.1335387  CNR =  -0.0272514

***STABILITY DERIVATIVES EVALUATED AT ALPHA =   1.510  DEGREES
   AND AT MACH NO.= 0.50,BASED ON BODY AXES(IN PER RADIAN)***

   *INCLUDING THE EFFECT OF LE VORTEX LIFT*

   CYB =  -0.2106318  CLB =  -0.2102347  CNB =   0.0333645
   CYP =  -0.3059744  CLP =  -0.5369804  CNP =   0.0411909
   CYR =   0.1091325  CLR =   0.1193995  CNR =  -0.0218611

***STABILITY DERIVATIVES BASED ON STABILITY AXES***

   CYB =  -0.2106318  CLB =  -0.2092825  CNB =   0.0388929
   CYP =  -0.3029924  CLP =  -0.5323923  CNP =   0.0546488
   CYR =   0.1171575  CLR =   0.1328574  CNR =  -0.0264491
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THE FOLLOWING BENDING MOMENT COEFFICIENT IS BASED ON Q*S*(B/2),
WHERE S = 418.50000 AND B/2 = 27.30000
(FOR ATTACHED POTENTIAL FLOW ONLY)

Y/S	BM(RIGHT)	BM(LEFT)
0.01254	0.10333	0.10333
0.04952	0.09516	0.09516
0.10908	0.08275	0.08275
0.18826	0.06770	0.06770
0.28306	0.05186	0.05186
0.38874	0.03694	0.03694
0.50000	0.02429	0.02429
0.61126	0.01459	0.01459
0.71694	0.00794	0.00794
0.81174	0.00389	0.00389
0.89092	0.00177	0.00177
0.95048	0.00083	0.00083
0.98746	0.00050	0.00050

THE FOLLOWING ARE THE WINGLET CHARACTERISTICS BASED ON WING GEOMETRY
WHERE S = 418.50000 AND B/2 = 27.30000

1.00962	0.00035	0.00035
1.03590	0.00020	0.00020
1.07179	0.00007	0.00007
1.10769	0.00001	0.00001
1.13397	0.00000	0.00000

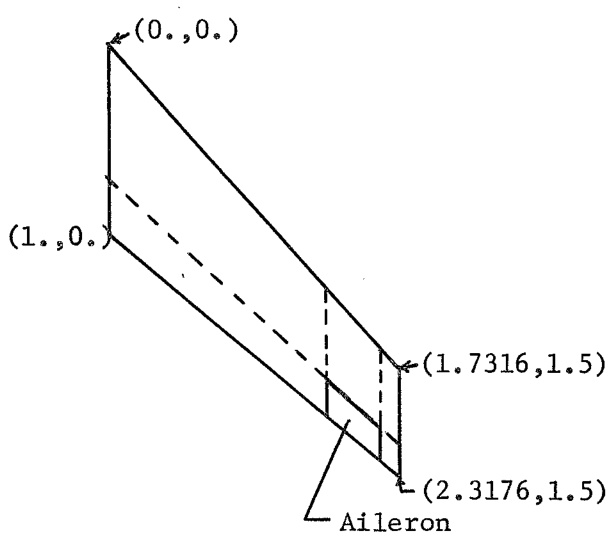
THE BENDING MOMENT COEFFICIENT BASED ON WING HALF SPAN AND WING AREA
AT THE WING ROOT = 0.106180 (RIGHT), = 0.106180 (LEFT)

THE BENDING MOMENT COEFFICIENT BASED ON WING HALF SPAN AND WING AREA
AT THE WINGLET ROOT = 0.000420 (RIGHT), = 0.000420 (LEFT)

A.5 Sample Test Case No.2

Input Data:

```
          1
         10         0
 A CONFIGURATION WITH ANTISYMMETRICAL AILERON DEFLECTIONS
          3        11         6         3         0         3         0
          1         2         0
          3         2         0         0         0         0
         -1         1
0.        0.7       0.        1.2987    1.7814    1.125     0.        0.
1.2987    1.7814    1.125     1.645     2.0697    1.425     0.        0.
1.645     2.0697    1.425     1.7316    2.1418    1.5       0.        0.
0.7       1.        0.        1.7814    1.9882    1.125     0.        0.
1.7814    1.9882    1.125     2.0697    2.2517    1.425     0.        0.
2.0697    2.2517    1.425     2.1418    2.3176    1.5       0.        0.
0.4       1.1895    0.811     0.        -15.
1.        5.        0.
0.        0.
0.        0.        1.5       0.        0.        0.        0.
```



1

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 ****************************************
CASE NUMBER =10

 ****************************************

 ****************************************
   A CONFIGURATION WITH ANTISYMMETRICAL AILERON DEFLECTIONS

 ****************************************

 INPUT DATA
        3          11          6          3          0          3          0
        1           2          0
        3           2          0          0          0          0
       -1           1
 0.         0.700000   0.         1.298700   1.781400   1.125000   0.         0.
 1.298700   1.781400   1.125000   1.645000   2.069700   1.425000   0.         0.
 1.645000   2.069700   1.425000   1.731600   2.141800   1.500000   0.         0.
 0.700000   1.000000   0.         1.781400   1.988200   1.125000   0.         0.
 1.781400   1.988200   1.125000   2.069700   2.251700   1.425000   0.         0.
 2.069700   2.251700   1.425000   2.141800   2.317600   1.500000   0.         0.
 0.400000   1.189500   0.811000   0.       -15.000000
 1.000000   5.000000   0.
 0.         0.
 0.         0.         1.500000   0.         0.         0.         0.
        HALF SW= 0.11895E 01          CREF= 0.81100E 00
```

VORTEX ELEMENT ENDPOINT COORDINATES=

X1	X2	Y1	Y2	Z1	Z2
0.04689	0.10491	0.	0.05083	0.	0.
0.35000	0.40377	0.	0.05083	0.	0.
0.65311	0.70263	0.	0.05083	0.	0.
0.10491	0.20372	0.05083	0.13739	0.	0.
0.40377	0.49534	0.05083	0.13739	0.	0.
0.70263	0.78695	0.05083	0.13739	0.	0.
0.20372	0.34183	0.13739	0.25839	0.	0.
0.49534	0.62333	0.13739	0.25839	0.	0.
0.78695	0.90483	0.13739	0.25839	0.	0.
0.34183	0.50807	0.25839	0.40403	0.	0.
0.62333	0.77739	0.25839	0.40403	0.	0.
0.90483	1.04670	0.25839	0.40403	0.	0.
0.50807	0.68896	0.40403	0.56250	0.	0.
0.77739	0.94502	0.40403	0.56250	0.	0.
1.04670	1.20109	0.40403	0.56250	0.	0.
0.68896	0.86986	0.56250	0.72097	0.	0.
0.94502	1.11266	0.56250	0.72097	0.	0.
1.20109	1.35547	0.56250	0.72097	0.	0.
0.86986	1.03609	0.72097	0.86661	0.	0.
1.11266	1.26672	0.72097	0.86661	0.	0.
1.35547	1.49735	0.72097	0.86661	0.	0.
1.03609	1.17421	0.86661	0.98761	0.	0.
1.26672	1.39471	0.86661	0.98761	0.	0.
1.49735	1.61522	0.86661	0.98761	0.	0.
1.17421	1.27301	0.98761	1.07417	0.	0.
1.39471	1.48628	0.98761	1.07417	0.	0.
1.61522	1.69955	0.98761	1.07417	0.	0.
1.27301	1.33103	1.07417	1.12500	0.	0.
1.48628	1.54005	1.07417	1.12500	0.	0.
1.69955	1.74907	1.07417	1.12500	0.	0.
1.33103	1.38118	1.12500	1.16893	0.	0.
1.54005	1.58652	1.12500	1.16893	0.	0.
1.74907	1.79185	1.12500	1.16893	0.	0.
1.38118	1.45793	1.16893	1.23618	0.	0.
1.58652	1.65764	1.16893	1.23618	0.	0.
1.79185	1.85735	1.16893	1.23618	0.	0.
1.45793	1.54655	1.23618	1.31382	0.	0.
1.65764	1.73976	1.23618	1.31382	0.	0.
1.85735	1.93297	1.23618	1.31382	0.	0.
1.54655	1.62330	1.31382	1.38107	0.	0.
1.73976	1.81088	1.31382	1.38107	0.	0.
1.93297	1.99846	1.31382	1.38107	0.	0.

1.62330	1.67345	1.38107	1.42500	0.	0.
1.81088	1.85735	1.38107	1.42500	0.	0.
1.99846	2.04125	1.38107	1.42500	0.	0.
1.67345	1.71626	1.42500	1.46250	0.	0.
1.85735	1.89702	1.42500	1.46250	0.	0.
2.04125	2.07779	1.42500	1.46250	0.	0.
1.71626	1.75334	1.46250	1.49498	0.	0.
1.89702	1.93138	1.46250	1.49498	0.	0.
2.07779	2.10943	1.46250	1.49498	0.	0.
0.74393	0.79218	0.	0.05083	0.	0.
0.95607	1.00133	0.	0.05083	0.	0.
0.79218	0.87433	0.05083	0.13739	0.	0.
1.00133	1.07842	0.05083	0.13739	0.	0.
0.87433	0.98917	0.13739	0.25839	0.	0.
1.07842	1.18617	0.13739	0.25839	0.	0.
0.98917	1.12740	0.25839	0.40403	0.	0.
1.18617	1.31586	0.25839	0.40403	0.	0.
1.12740	1.27781	0.40403	0.56250	0.	0.
1.31586	1.45699	0.40403	0.56250	0.	0.
1.27781	1.42822	0.56250	0.72097	0.	0.
1.45699	1.59812	0.56250	0.72097	0.	0.
1.42822	1.56644	0.72097	0.86661	0.	0.
1.59812	1.72781	0.72097	0.86661	0.	0.
1.56644	1.68129	0.86661	0.98761	0.	0.
1.72781	1.83556	0.86661	0.98761	0.	0.
1.68129	1.76344	0.98761	1.07417	0.	0.
1.83556	1.91265	0.98761	1.07417	0.	0.
1.76344	1.81169	1.07417	1.12500	0.	0.
1.91265	1.95791	1.07417	1.12500	0.	0.
1.81169	1.85337	1.12500	1.16893	0.	0.
1.95791	1.99704	1.12500	1.16893	0.	0.
1.85337	1.91718	1.16893	1.23618	0.	0.
1.99704	2.05691	1.16893	1.23618	0.	0.
1.91718	1.99086	1.23618	1.31382	0.	0.
2.05691	2.12605	1.23618	1.31382	0.	0.
1.99086	2.05466	1.31382	1.38107	0.	0.
2.12605	2.18593	1.31382	1.38107	0.	0.
2.05466	2.09635	1.38107	1.42500	0.	0.
2.18593	2.22505	1.38107	1.42500	0.	0.
2.09635	2.13195	1.42500	1.46250	0.	0.
2.22505	2.25845	1.42500	1.46250	0.	0.
2.13195	2.16278	1.46250	1.49498	0.	0.
2.25845	2.28738	1.46250	1.49498	0.	0.

CONTROL POINT COORDINATES=

XCP	YCP	ZCP
0.20020	0.02279	0.
0.72190	0.02279	0.
0.61515	0.08929	0.
0.38974	0.19414	0.
0.88662	0.19414	0.
0.85696	0.32883	0.
0.70864	0.48245	0.
1.16375	0.48245	0.
1.17368	0.64255	0.
1.05565	0.79617	0.
1.46531	0.79617	0.
1.46473	0.93086	0.
1.32060	1.03571	0.
1.69557	1.03571	0.
1.63772	1.10221	0.
1.44160	1.14510	0.
1.80071	1.14510	0.
1.73642	1.20000	0.
1.58527	1.27500	0.
1.92555	1.27500	0.
1.88782	1.35000	0.
1.72895	1.40490	0.
2.05039	1.40490	0.
1.98246	1.44375	0.
1.81341	1.48125	0.
2.12378	1.48125	0.
1.02001	0.02279	0.
1.07844	0.08929	0.
1.17053	0.19414	0.
1.28884	0.32883	0.
1.42378	0.48245	0.
1.56442	0.64255	0.
1.69936	0.79617	0.
1.81767	0.93086	0.
1.90976	1.03571	0.
1.96819	1.10221	0.
2.00585	1.14510	0.
2.05408	1.20000	0.
2.11995	1.27500	0.
2.18583	1.35000	0.
2.23405	1.40490	0.
2.26818	1.44375	0.
2.30113	1.48125	0.

XCP	YCP	ZCP
0.54800	0.02279	0.
0.27377	0.08929	0.
0.78583	0.08929	0.
0.72099	0.19414	0.
0.53872	0.32883	0.
1.01609	0.32883	0.
1.01205	0.48245	0.
0.88573	0.64255	0.
1.31765	0.64255	0.
1.32876	0.79617	0.
1.20463	0.93086	0.
1.59478	0.93086	0.
1.57058	1.03571	0.
1.39417	1.10221	0.
1.75950	1.10221	0.
1.68101	1.14510	0.
1.50232	1.20000	0.
1.85348	1.20000	0.
1.81212	1.27500	0.
1.66822	1.35000	0.
1.99762	1.35000	0.
1.94324	1.40490	0.
1.77192	1.44375	0.
2.08773	1.44375	0.
2.02032	1.48125	0.
0.87096	0.02279	0.
0.93214	0.08929	0.
1.02858	0.19414	0.
1.15246	0.32883	0.
1.29377	0.48245	0.
1.44103	0.64255	0.
1.58234	0.79617	0.
1.70622	0.93086	0.
1.80266	1.03571	0.
1.86384	1.10221	0.
1.90328	1.14510	0.
1.95378	1.20000	0.
2.02275	1.27500	0.
2.09172	1.35000	0.
2.14222	1.40490	0.
2.17795	1.44375	0.
2.21245	1.48125	0.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

PRESSURE DISTRIBUTION AT ALPHA = 5.000 DEG.

AND AILERON ANGLE = -15.000 DEG.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

VORTEX	XV	YV	CP(LEFT)	CP(RIGHT)
1	0.04689	0.01519	0.49270	0.49261
2	0.35000	0.01519	0.23912	0.23897
3	0.65311	0.01519	0.13056	0.13042
4	0.74393	0.01519	0.14866	0.14835
5	0.95607	0.01519	0.05956	0.05941
6	0.04689	0.05953	0.54355	0.54316
7	0.35000	0.05953	0.23920	0.23855
8	0.65311	0.05953	0.14605	0.14530
9	0.74394	0.05953	0.12413	0.12299
10	0.95607	0.05953	0.05468	0.05399
11	0.04689	0.12943	0.62831	0.62708
12	0.35000	0.12943	0.24049	0.23878
13	0.65312	0.12943	0.13995	0.13782
14	0.74394	0.12943	0.11321	0.11070
15	0.95607	0.12943	0.04806	0.04645
16	0.04689	0.21922	0.71018	0.70695
17	0.35001	0.21922	0.24636	0.24259
18	0.65312	0.21922	0.13386	0.12928
19	0.74395	0.21922	0.10798	0.10307
20	0.95607	0.21922	0.04505	0.04193
21	0.04689	0.32163	0.77842	0.77106
22	0.35001	0.32163	0.25523	0.24761
23	0.65313	0.32163	0.13328	0.12432
24	0.74396	0.32163	0.10753	0.09822
25	0.95607	0.32163	0.04481	0.03892
26	0.04689	0.42837	0.83337	0.81819
27	0.35002	0.42837	0.26585	0.25107
28	0.65314	0.42837	0.13691	0.11953
29	0.74396	0.42837	0.11079	0.09272
30	0.95607	0.42837	0.04658	0.03500
31	0.04689	0.53078	0.87752	0.84875
32	0.35002	0.53078	0.27755	0.24944
33	0.65315	0.53078	0.14434	0.10967
34	0.74397	0.53078	0.11836	0.08108
35	0.95607	0.53078	0.05150	0.02668
36	0.04689	0.62057	0.91292	0.86269
37	0.35003	0.62057	0.29053	0.23871
38	0.65316	0.62057	0.15917	0.08719
39	0.74398	0.62057	0.13722	0.05263
40	0.95607	0.62057	0.06517	0.00685
41	0.04690	0.69047	0.94000	0.86146
42	0.35003	0.69047	0.30511	0.21735
43	0.65317	0.69047	0.19263	0.04043
44	0.74399	0.69047	0.19223	-0.01819
45	0.95608	0.69047	0.09522	-0.03155
46	0.04690	0.73481	0.95748	0.85295
47	0.35004	0.73481	0.31835	0.19295
48	0.65317	0.73481	0.25917	-0.03940

49	0.74399	0.73481	0.31258	-0.15485
50	0.95608	0.73481	0.12057	-0.06401
51	0.04690	0.76340	0.96868	0.84340
52	0.35003	0.76340	0.32895	0.17099
53	0.65317	0.76340	0.43862	-0.23096
54	0.74399	0.76340	0.50386	-0.35861
55	0.95608	0.76340	0.13092	-0.07971
56	0.04690	0.80000	0.98205	0.82405
57	0.35003	0.80000	0.34413	0.13339
58	0.65316	0.80000	0.55599	-0.37039
59	0.74399	0.80000	0.56498	-0.43773
60	0.95607	0.80000	0.13501	-0.09206
61	0.04689	0.85000	0.99379	0.78111
62	0.35002	0.85000	0.35288	0.07270
63	0.65315	0.85000	0.59571	-0.44949
64	0.74397	0.85000	0.56704	-0.47037
65	0.95607	0.85000	0.12161	-0.09063
66	0.04689	0.90000	0.97710	0.71149
67	0.35002	0.90000	0.31927	0.01538
68	0.65314	0.90000	0.55888	-0.45870
69	0.74396	0.90000	0.49888	-0.43630
70	0.95607	0.90000	0.08490	-0.06504
71	0.04689	0.93660	0.90648	0.62689
72	0.35001	0.93660	0.25458	-0.01798
73	0.65313	0.93660	0.47104	-0.40289
74	0.74395	0.93660	0.35365	-0.31471
75	0.95607	0.93660	0.04964	-0.03657
76	0.04689	0.96250	0.78308	0.52504
77	0.35001	0.96250	0.18737	-0.03162
78	0.65312	0.96250	0.25811	-0.21131
79	0.74394	0.96250	0.12904	-0.10482
80	0.95607	0.96250	0.02938	-0.02045
81	0.04689	0.98750	0.50500	0.33050
82	0.35000	0.98750	0.10005	-0.02656
83	0.65311	0.98750	0.11979	-0.09439
84	0.74394	0.98750	0.04110	-0.03106
85	0.95607	0.98750	0.01409	-0.00905

Y/S	CL(RIGHT)	CL(LEFT)	CM	CT	CDI
0.01519	0.23574	0.23592	-0.10373	0.00305	0.01757
0.05953	0.24281	0.24356	-0.12321	0.00749	0.01375
0.12943	0.25384	0.25576	-0.15697	0.01062	0.01163
0.21922	0.26651	0.27066	-0.20770	0.01389	0.00955
0.32163	0.27809	0.28641	-0.27238	0.01686	0.00777
0.42837	0.28573	0.30205	-0.34406	0.01930	0.00633
0.53078	0.28573	0.31801	-0.41348	0.02120	0.00513
0.62057	0.27230	0.33750	-0.47057	0.02253	0.00405
0.69047	0.23757	0.36819	-0.50779	0.02335	0.00306
0.73481	0.18432	0.41277	-0.52527	0.02377	0.00226
0.76340	0.10288	0.48521	-0.53283	0.02391	0.00173
0.80000	0.04478	0.52562	-0.53560	0.02386	0.00100
0.85000	-0.00500	0.53641	-0.52201	0.02340	-0.00024
0.90000	-0.03051	0.49681	-0.47710	0.02210	-0.00179
0.93660	-0.02304	0.41397	-0.41095	0.02023	-0.00320
0.96250	0.02598	0.28682	-0.33477	0.01759	-0.00397
0.98750	0.02764	0.16116	-0.20527	0.01317	-0.00496

*** THE FOLLOWING ARE ATTACHED POTENTIAL FLOW RESULTS ***

TOTAL LIFT COEFFICIENT = 0.26716

TOTAL INDUCED DRAG COEFFICIENT = 0.00624

THE INDUCED DRAG PARAMETER = 0.08738

TOTAL PITCHING MOMENT COEFFICIENT = -0.32568

FAR-FIELD INDUCED DRAG= 0.00636

FAR-FIELD INDUCED DRAG PARAMETER= 0.08905

(NOTE. THE INDUCED DRAG COMPUTATION IS FOR SYMMETRICAL LOADING ONLY)

****

THE FOLLOWING PARAMETERS ARE USED IN THE METHOD OF SUCTION ANALOGY

CLP =	0.26567	CLVLE =	0.02597	CLVSE =	0.00729
CDP =	0.02324	CDVLE =	0.00227	CDVSE =	0.00064
CMP =	-0.32568	CMVLE =	-0.02963	CMVSE =	-0.01871

****

THE ROLLING MOMENT COEFFICIENT = 0.0220 DUE TO AILERON DEFLECTION OF -15.000 DEG. AT M = 0.400

THE FOLLOWING BENDING MOMENT COEFFICIENT IS BASED ON Q*S*(B/2),
WHERE S = 2.37900 AND B/2 = 1.50000
(FOR ATTACHED POTENTIAL FLOW ONLY)

Y/S	BM(RIGHT)	BM(LEFT)
0.01519	0.03796	0.11287
0.05953	0.03340	0.10402
0.12943	0.02682	0.09067
0.21922	0.01945	0.07461
0.32163	0.01254	0.05782
0.42837	0.00703	0.04207
0.53078	0.00334	0.02864
0.62057	0.00131	0.01821
0.69047	0.00044	0.01097
0.73481	0.00017	0.00680
0.76340	0.00009	0.00483
0.80000	0.00006	0.00330
0.85000	0.00006	0.00171
0.90000	0.00005	0.00065
0.93660	0.00002	0.00019
0.96250	0.00001	0.00004
0.98750	0.00000	0.00000

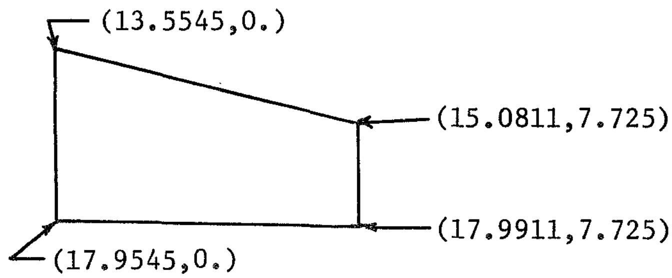
THE BENDING MOMENT COEFFICIENT BASED ON WING HALF SPAN AND WING AREA
AT THE WING ROOT = 0.039589 (RIGHT), = 0.115973 (LEFT)

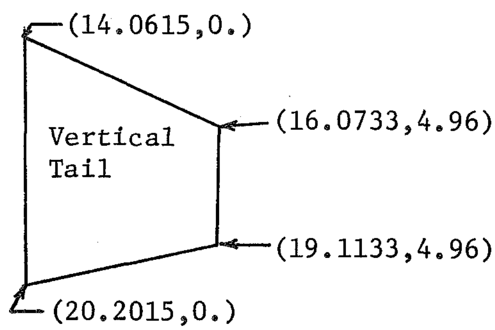
A.6 Sample Test Case No.3

Input Data:

```
  1
 10               0
THRUSH-HORIZONTAL AND VERTICAL TAIL COMBINATION AT 7800 LBS
 2               11         6          10        1        0
 1                1         0
 5                0
 1                0
13.5545   17.9545   0.     15.0811    17.9911   7.725    2.708    0.
14.0615   20.2015   0.      16.0733   19.1133   4.96     2.708    90.
0.        163.3     7.5    0.         0.
3.        -2.       6.
0.       0.
0.        0.        7.725  0.         0.        0.       0.
0.        11.385   0.
```

NOTE. The calculated derivatives in this case will be based on the span of the horizontal tail (b_H). To convert them to those based on wing geometry, C_{ℓ_β}, C_{n_β}, C_{Y_p} and C_{Y_r} should be multiplied by b_H/b_w, and all others except C_{Y_β} should be multiplied by $(b_H/b_w)^2$.





```
         1
 ****************************************
CASE NUMBER =10

 ****************************************

 ****************************************
  THRUSH-HORIZONTAL AND VERTICAL TAIL COMBINATION AT 7800 LBS

 ****************************************

 INPUT DATA
         2          11           6          10           1           0
         1           1           0
         5           0           0           0           0           0
         1           0
13.554500 17.954500  0.        15.081100 17.991100  7.725000  2.708000  0.
14.061500 20.201500  0.        16.073300 19.113300  4.960000  2.708000 90.000
 0.       163.299999  7.500000  0.         0.
 3.000000 -2.000000  6.000000
 0.        0.
 0.        0.        7.725000  0.         0.         0.         0.
 0.       11.385000  0.
        HALF SW= 0.16330E 03           CREF= 0.75000E 01

 VORTEX ELEMENT ENDPOINT COORDINATES=
```

X1	X2	Y1	Y2	Z1	Z2
13.66218	13.72951	0.	0.34905	2.70800	2.70800
14.46137	14.51647	0.	0.34905	2.70800	2.70800
15.75450	15.78982	0.	0.34905	2.70800	2.70800
17.04763	17.06316	0.	0.34905	2.70800	2.70800
17.84682	17.85013	0.	0.34905	2.70800	2.70800
13.72951	13.84416	0.34905	0.94342	2.70800	2.70800
14.51647	14.61030	0.34905	0.94342	2.70800	2.70800
15.78982	15.84995	0.34905	0.94342	2.70800	2.70800
17.06316	17.08960	0.34905	0.94342	2.70800	2.70800
17.85013	17.85575	0.34905	0.94342	2.70800	2.70800
13.84416	14.00443	0.94342	1.77427	2.70800	2.70800
14.61030	14.74147	0.94342	1.77427	2.70800	2.70800
15.84995	15.93402	0.94342	1.77427	2.70800	2.70800
17.08960	17.12657	0.94342	1.77427	2.70800	2.70800
17.85575	17.86361	0.94342	1.77427	2.70800	2.70800
14.00443	14.19733	1.77427	2.77431	2.70800	2.70800
14.74147	14.89934	1.77427	2.77431	2.70800	2.70800
15.93402	16.03520	1.77427	2.77431	2.70800	2.70800
17.12657	17.17106	1.77427	2.77431	2.70800	2.70800
17.86361	17.87306	1.77427	2.77431	2.70800	2.70800
14.19733	14.40724	2.77431	3.86250	2.70800	2.70800
14.89934	15.07112	2.77431	3.86250	2.70800	2.70800
16.03520	16.14530	2.77431	3.86250	2.70800	2.70800
17.17106	17.21948	2.77431	3.86250	2.70800	2.70800
17.87306	17.88336	2.77431	3.86250	2.70800	2.70800
14.40724	14.61715	3.86250	4.95069	2.70800	2.70800
15.07112	15.24291	3.86250	4.95069	2.70800	2.70800
16.14530	16.25540	3.86250	4.95069	2.70800	2.70800
17.21948	17.26789	3.86250	4.95069	2.70800	2.70800

17.88336	17.89365	3.86250	4.95069	2.70800	2.70800
14.61715	14.81006	4.95069	5.95073	2.70800	2.70800
15.24291	15.40078	4.95069	5.95073	2.70800	2.70800
16.25540	16.35658	4.95069	5.95073	2.70800	2.70800
17.26789	17.31239	4.95069	5.95073	2.70800	2.70800
17.89365	17.90311	4.95069	5.95073	2.70800	2.70800
14.81006	14.97033	5.95073	6.78158	2.70800	2.70800
15.40078	15.53194	5.95073	6.78158	2.70800	2.70800
16.35658	16.44065	5.95073	6.78158	2.70800	2.70800
17.31239	17.34935	5.95073	6.78158	2.70800	2.70800
17.90311	17.91096	5.95073	6.78158	2.70800	2.70800
14.97033	15.08498	6.78158	7.37595	2.70800	2.70800
15.53194	15.62577	6.78158	7.37595	2.70800	2.70800
16.44065	16.50078	6.78158	7.37595	2.70800	2.70800
17.34935	17.37580	6.78158	7.37595	2.70800	2.70800
17.91096	17.91659	6.78158	7.37595	2.70800	2.70800
15.08498	15.14473	7.37595	7.68569	2.70800	2.70800
15.62577	15.67467	7.37595	7.68569	2.70800	2.70800
16.50078	16.53212	7.37595	7.68569	2.70800	2.70800
17.37580	17.38958	7.37595	7.68569	2.70800	2.70800
17.91659	17.91952	7.37595	7.68569	2.70800	2.70800
14.21176	14.49527	0.	0.72638	2.70800	2.70800
15.32700	15.52805	0.	0.72638	2.70800	2.70800
17.13150	17.19913	0.	0.72638	2.70800	2.70800
18.93600	18.87021	0.	0.72638	2.70800	2.70800
20.05124	19.90299	0.	0.72638	2.70800	2.70800
14.49527	14.92920	0.72638	1.83813	2.70800	2.70800
15.52805	15.83577	0.72638	1.83813	2.70800	2.70800
17.19913	17.30264	0.72638	1.83813	2.70800	2.70800
18.87021	18.76951	0.72638	1.83813	2.70800	2.70800
19.90299	19.67608	0.72638	1.83813	2.70800	2.70800
14.92920	15.43025	1.83813	3.12187	2.70800	2.70800
15.83577	16.19109	1.83813	3.12187	2.70800	2.70800
17.30264	17.42216	1.83813	3.12187	2.70800	2.70800
18.76951	18.65323	1.83813	3.12187	2.70800	2.70800
19.67608	19.41407	1.83813	3.12187	2.70800	2.70800
15.43025	15.86418	3.12187	4.23362	2.70800	2.70800
16.19109	16.49881	3.12187	4.23362	2.70800	2.70800
17.42216	17.52567	3.12187	4.23362	2.70800	2.70800
18.65323	18.55253	3.12187	4.23362	2.70800	2.70800
19.41407	19.18716	3.12187	4.23362	2.70800	2.70800
15.86418	16.11471	4.23362	4.87550	2.70800	2.70800
16.49881	16.67648	4.23362	4.87550	2.70800	2.70800
17.52567	17.58543	4.23362	4.87550	2.70800	2.70800
18.55253	18.49439	4.23362	4.87550	2.70800	2.70800
19.18716	19.05615	4.23362	4.87550	2.70800	2.70800

CONTROL POINT COORDINATES=

XCP	YCP	ZCP	XCP	YCP	ZCP
14.00270	0.15646	2.70800	15.09516	0.15646	2.70800
16.44550	0.15646	2.70800	17.53796	0.15646	2.70800
17.95524	0.15646	2.70800	14.08454	0.61316	2.70800
15.15497	0.61316	2.70800	16.47810	0.61316	2.70800
17.54854	0.61316	2.70800	17.95740	0.61316	2.70800
14.21355	1.33310	2.70800	15.24927	1.33310	2.70800
16.52949	1.33310	2.70800	17.56521	1.33310	2.70800
17.96082	1.33310	2.70800	14.37929	2.25796	2.70800
15.37041	2.25796	2.70800	16.59550	2.25796	2.70800
17.58662	2.25796	2.70800	17.96520	2.25796	2.70800

14.56832	3.31281	2.70800	15.50857	3.31281	2.70800
16.67079	3.31281	2.70800	17.61105	3.31281	2.70800
17.97020	3.31281	2.70800	14.76533	4.41219	2.70800
15.65257	4.41219	2.70800	16.74926	4.41219	2.70800
17.63651	4.41219	2.70800	17.97540	4.41219	2.70800
14.95435	5.46704	2.70800	15.79073	5.46704	2.70800
16.82455	5.46704	2.70800	17.66093	5.46704	2.70800
17.98040	5.46704	2.70800	15.12009	6.39190	2.70800
15.91187	6.39190	2.70800	16.89057	6.39190	2.70800
17.68235	6.39190	2.70800	17.98478	6.39190	2.70800
15.24910	7.11184	2.70800	16.00617	7.11184	2.70800
16.94195	7.11184	2.70800	17.69902	7.11184	2.70800
17.98820	7.11184	2.70800	15.33094	7.56854	2.70800
16.06599	7.56854	2.70800	16.97455	7.56854	2.70800
17.70960	7.56854	2.70800	17.99036	7.56854	2.70800
14.76275	0.33226	2.70800	16.24584	0.33226	2.70800
18.07903	0.33226	2.70800	19.56212	0.33226	2.70800
20.12860	0.33226	2.70800	15.07676	1.24000	2.70800
16.41801	1.24000	2.70800	18.07589	1.24000	2.70800
19.41714	1.24000	2.70800	19.92945	1.24000	2.70800
15.50571	2.48000	2.70800	16.65321	2.48000	2.70800
18.07159	2.48000	2.70800	19.21909	2.48000	2.70800
19.65740	2.48000	2.70800	15.93465	3.72000	2.70800
16.88840	3.72000	2.70800	18.06730	3.72000	2.70800
19.02105	3.72000	2.70800	19.38535	3.72000	2.70800
16.24866	4.62774	2.70800	17.06057	4.62774	2.70800
18.06416	4.62774	2.70800	18.87607	4.62774	2.70800
19.18620	4.62774	2.70800			

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

PRESSURE DISTRIBUTION AT ALPHA = -2.000 DEG.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

VORTEX	XV	YV	CP
1	0.02447	0.02025	-0.53002
2	0.20611	0.02025	-0.17444
3	0.50000	0.02025	-0.08830
4	0.79389	0.02025	-0.04403
5	0.97553	0.02025	-0.01357
6	0.02447	0.07937	-0.55666
7	0.20611	0.07937	-0.17422
8	0.50000	0.07937	-0.08819
9	0.79389	0.07937	-0.04399
10	0.97553	0.07937	-0.01347
11	0.02447	0.17257	-0.58248
12	0.20611	0.17257	-0.17730
13	0.50000	0.17257	-0.08814
14	0.79389	0.17257	-0.04373
15	0.97553	0.17257	-0.01337
16	0.02447	0.29229	-0.60058
17	0.20611	0.29229	-0.18106
18	0.50000	0.29229	-0.08838
19	0.79389	0.29229	-0.04341
20	0.97553	0.29229	-0.01323
21	0.02447	0.42884	-0.60922
22	0.20611	0.42884	-0.18241
23	0.50000	0.42884	-0.08764
24	0.79389	0.42884	-0.04252

25	0.97553	0.42884	-0.01291
26	0.02447	0.57116	-0.60504
27	0.20611	0.57116	-0.17894
28	0.50000	0.57116	-0.08408
29	0.79389	0.57116	-0.04015
30	0.97553	0.57116	-0.01212
31	0.02447	0.70771	-0.58248
32	0.20611	0.70771	-0.16761
33	0.50000	0.70771	-0.07563
34	0.79389	0.70771	-0.03530
35	0.97553	0.70771	-0.01060
36	0.02447	0.82743	-0.53309
37	0.20611	0.82743	-0.14375
38	0.50000	0.82743	-0.06040
39	0.79389	0.82743	-0.02759
40	0.97553	0.82743	-0.00831
41	0.02447	0.92063	-0.44247
42	0.20611	0.92063	-0.10137
43	0.50000	0.92063	-0.03939
44	0.79389	0.92063	-0.01820
45	0.97553	0.92063	-0.00566
46	0.02447	0.97975	-0.27469
47	0.20611	0.97975	-0.04556
48	0.50000	0.97975	-0.01841
49	0.79389	0.97975	-0.00894
50	0.97553	0.97975	-0.00320
51	0.02447	0.06699	-0.00000
52	0.20611	0.06699	-0.00000
53	0.50000	0.06699	-0.00000
54	0.79389	0.06699	-0.00000
55	0.97553	0.06699	0.00000
56	0.02447	0.25000	-0.00000
57	0.20611	0.25000	-0.00000
58	0.50000	0.25000	-0.00000
59	0.79389	0.25000	-0.00000
60	0.97553	0.25000	-0.00000
61	0.02447	0.50000	-0.00000
62	0.20611	0.50000	-0.00000
63	0.50000	0.50000	-0.00000
64	0.79389	0.50000	-0.00000
65	0.97553	0.50000	-0.00000
66	0.02447	0.75000	-0.00000
67	0.20611	0.75000	-0.00000
68	0.50000	0.75000	-0.00000
69	0.79389	0.75000	-0.00000
70	0.97553	0.75000	-0.00000
71	0.02447	0.93301	-0.00000
72	0.20611	0.93301	-0.00000
73	0.50000	0.93301	-0.00000
74	0.79389	0.93301	-0.00000
75	0.97553	0.93301	-0.00000

Y/S	CL(RIGHT)	CL(LEFT)	CM	CT	CDI
0.02025	-0.13605	-0.13605	0.26648	0.00271	0.00205
0.07937	-0.13854	-0.13854	0.27224	0.00313	0.00171
0.17257	-0.14175	-0.14175	0.28021	0.00344	0.00151
0.29229	-0.14444	-0.14444	0.28797	0.00366	0.00139
0.42884	-0.14514	-0.14514	0.29223	0.00377	0.00130
0.57116	-0.14206	-0.14206	0.28891	0.00372	0.00124
0.70771	-0.13295	-0.13295	0.27280	0.00347	0.00117
0.82743	-0.11511	-0.11511	0.23777	0.00295	0.00106
0.92063	-0.08629	-0.08629	0.17885	0.00213	0.00068
0.97975	-0.04662	-0.04662	0.09669	0.00107	0.00056
THE FOLLOWING ARE THE TAIL CHARACTERISTICS					
0.06699	-0.00000	-0.00000	0.00000	0.00000	0.00000
0.25000	-0.00000	-0.00000	0.00000	0.00000	0.00000
0.50000	-0.00000	-0.00000	0.00000	0.00000	0.00000
0.75000	-0.00000	-0.00000	0.00000	0.00000	0.00000
0.93301	-0.00000	-0.00000	0.00000	0.00000	0.00000

*** THE FOLLOWING ARE ATTACHED POTENTIAL FLOW RESULTS ***

TOTAL LIFT COEFFICIENT = -0.02265

TOTAL INDUCED DRAG COEFFICIENT = 0.00023

THE INDUCED DRAG PARAMETER = 0.43964

TOTAL PITCHING MOMENT COEFFICIENT = 0.04559

THE WING LIFT COEFFICIENT = -0.02265

THE WING INDUCED DRAG COEFFICIENT = 0.00023

THE WING PITCHING MOMENT COEFFICIENT = 0.04559

THE TAIL LIFT COEFFICIENT = 0. (BASED ON WING AREA), = 0. (BASED ON TAIL AREA)

THE TAIL PITCHING MOMENT COEFFICIENT BASED ON REFERENCE WING AREA AND MEAN WING CHORD, AND REFERRED TO THE Y-AXIS = 0.

(NOTE. THE INDUCED DRAG COMPUTATION IS FOR SYMMETRICAL LOADING ONLY)

****

THE FOLLOWING PARAMETERS ARE USED IN THE METHOD OF SUCTION ANALOGY

CLP = -0.02263 CLVLE = -0.00058 CLVSE = -0.00016

CDP = 0.00079 CDVLE = 0.00002 CDVSE = 0.00001

CMP = 0.04559 CMVLE = 0.00109 CMVSE = -0.00036

****

STABILITY DERIVATIVES BY POTENTIAL FLOW THEORY

****

STABILITY DERIVATIVES EVALUATED AT ALPHA = -2.000 DEGREES AND AT MACH NO.= 0. ,BASED ON BODY AXES(IN PER RADIAN)

CYB =	-0.1692203	CLB =	-0.0379778	CNB =	0.1747360
CYP =	-0.0769056	CLP =	-0.0760935	CNP =	0.0825351
CYR =	0.4059052	CLR =	0.0921547	CNR =	-0.4236924

STABILITY DERIVATIVES BASED ON STABILITY AXES

CYB =	-0.1692203	CLB =	-0.0440529	CNB =	0.1733041
CYP =	-0.0910246	CLP =	-0.0826097	CNP =	0.0944460
CYR =	0.4029740	CLR =	0.1040656	CNR =	-0.4171761

****

STABILITY DERIVATIVES WITH EDGE VORTEX SEPARATION

****

STABILITY DERIVATIVES EVALUATED AT ALPHA = -2.000 DEGREES AND AT MACH NO.= 0. ,BASED ON BODY AXES(IN PER RADIAN)

**INCLUDING THE EFFECT OF LE AND SE VORTEX LIFT*

CYB =	-0.1704073	CLB =	-0.0384587	CNB =	0.1762162
CYP =	-0.0685944	CLP =	-0.0696868	CNP =	0.0707230
CYR =	0.4066442	CLR =	0.0931148	CNR =	-0.4250563

STABILITY DERIVATIVES BASED ON STABILITY AXES

CYB =	-0.1704073	CLB =	-0.0445851	CNB =	0.1747666
CYP =	-0.0827443	CLP =	-0.0758340	CNP =	0.0829181
CYR =	0.4040026	CLR =	0.1053099	CNR =	-0.4189091

STABILITY DERIVATIVES EVALUATED AT ALPHA = -2.000 DEGREES AND AT MACH NO.= 0. ,BASED ON BODY AXES(IN PER RADIAN)

INCLUDING THE EFFECT OF LE VORTEX LIFT

CYB =	-0.1701461	CLB =	-0.0383281	CNB =	0.1759301
CYP =	-0.0749457	CLP =	-0.0728624	CNP =	0.0776267
CYR =	0.4061316	CLR =	0.0928586	CNR =	-0.4244940

STABILITY DERIVATIVES BASED ON STABILITY AXES

CYB =	-0.1701461	CLB =	-0.0444446	CNB =	0.1744853
CYP =	-0.0890738	CLP =	-0.0792370	CNP =	0.0896834
CYR =	0.4032687	CLR =	0.1049152	CNR =	-0.4181195

THE FOLLOWING BENDING MOMENT COEFFICIENT IS BASED ON Q*S*(B/2),
WHERE S = 326.60000 AND B/2 = 7.72500
(FOR ATTACHED POTENTIAL FLOW ONLY)

Y/S	BM(RIGHT)	BM(LEFT)
0.02025	-0.00469	-0.00469
0.07937	-0.00406	-0.00406
0.17257	-0.00317	-0.00317
0.29229	-0.00219	-0.00219
0.42884	-0.00132	-0.00132
0.57116	-0.00066	-0.00066
0.70771	-0.00026	-0.00026
0.82743	-0.00007	-0.00007
0.92063	-0.00001	-0.00001
0.97975	-0.00000	-0.00000

THE FOLLOWING ARE THE TAIL CHARACTERISTICS BASED ON TAIL GEOMETRY,
WHERE S = 22.77000 AND B/2 = 4.96000

0.06699	-0.00000	-0.00000
0.25000	-0.00000	-0.00000
0.50000	-0.00000	-0.00000
0.75000	-0.00000	-0.00000
0.93301	-0.00000	-0.00000

THE BENDING MOMENT COEFFICIENT BASED ON WING HALF SPAN AND WING AREA
AT THE WING ROOT = -0.004920 (RIGHT), = -0.004920 (LEFT)

THE BENDING MOMENT COEFFICIENT BASED ON TAIL HALF SPAN AND TAIL AREA
AT THE TAIL ROOT = -0.000000 (RIGHT), = -0.000000 (LEFT)

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

PRESSURE DISTRIBUTION AT ALPHA = 4.000 DEG.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

VORTEX	XV	YV	CP
1	0.02447	0.02025	1.05746
2	0.20611	0.02025	0.34803
3	0.50000	0.02025	0.17616
4	0.79389	0.02025	0.08784
5	0.97553	0.02025	0.02708
6	0.02447	0.07937	1.11062
7	0.20611	0.07937	0.34759
8	0.50000	0.07937	0.17594
9	0.79389	0.07937	0.08777
10	0.97553	0.07937	0.02688
11	0.02447	0.17257	1.16212
12	0.20611	0.17257	0.35374
13	0.50000	0.17257	0.17584
14	0.79389	0.17257	0.08726
15	0.97553	0.17257	0.02667
16	0.02447	0.29229	1.19824
17	0.20611	0.29229	0.36124
18	0.50000	0.29229	0.17632
19	0.79389	0.29229	0.08661
20	0.97553	0.29229	0.02640
21	0.02447	0.42884	1.21547
22	0.20611	0.42884	0.36394
23	0.50000	0.42884	0.17485
24	0.79389	0.42884	0.08484
25	0.97553	0.42884	0.02575
26	0.02447	0.57116	1.20713
27	0.20611	0.57116	0.35701
28	0.50000	0.57116	0.16776
29	0.79389	0.57116	0.08009
30	0.97553	0.57116	0.02418
31	0.02447	0.70771	1.16212
32	0.20611	0.70771	0.33441
33	0.50000	0.70771	0.15089
34	0.79389	0.70771	0.07042
35	0.97553	0.70771	0.02116
36	0.02447	0.82743	1.06358
37	0.20611	0.82743	0.28680
38	0.50000	0.82743	0.12050
39	0.79389	0.82743	0.05504
40	0.97553	0.82743	0.01658
41	0.02447	0.92063	0.88278
42	0.20611	0.92063	0.20225
43	0.50000	0.92063	0.07859
44	0.79389	0.92063	0.03632
45	0.97553	0.92063	0.01129
46	0.02447	0.97975	0.54804
47	0.20611	0.97975	0.09090
48	0.50000	0.97975	0.03673
49	0.79389	0.97975	0.01784
50	0.97553	0.97975	0.00638
51	0.02447	0.06699	0.00000
52	0.20611	0.06699	0.00000
53	0.50000	0.06699	0.00000
54	0.79389	0.06699	0.00000
55	0.97553	0.06699	-0.00000
56	0.02447	0.25000	0.00000
57	0.20611	0.25000	0.00000
58	0.50000	0.25000	0.00000
59	0.79389	0.25000	0.00000
60	0.97553	0.25000	0.00000
61	0.02447	0.50000	0.00000
62	0.20611	0.50000	0.00000
63	0.50000	0.50000	0.00000
64	0.79389	0.50000	0.00000
65	0.97553	0.50000	0.00000
66	0.02447	0.75000	0.00000
67	0.20611	0.75000	0.00000
68	0.50000	0.75000	0.00000
69	0.79389	0.75000	0.00000
70	0.97553	0.75000	0.00000
71	0.02447	0.93301	0.00000
72	0.20611	0.93301	0.00000
73	0.50000	0.93301	0.00000
74	0.79389	0.93301	-0.00000
75	0.97553	0.93301	-0.00000

Y/S	CL(RIGHT)	CL(LEFT)	CM	CT	CDI
0.02025	0.27151	0.27151	-0.53167	0.01085	0.00811
0.07937	0.27655	0.27655	-0.54315	0.01251	0.00680
0.17257	0.28300	0.28300	-0.55905	0.01373	0.00603
0.29229	0.28842	0.28842	-0.57453	0.01461	0.00553
0.42884	0.28983	0.28983	-0.58304	0.01504	0.00519
0.57116	0.28368	0.28368	-0.57640	0.01488	0.00493
0.70771	0.26549	0.26549	-0.54427	0.01387	0.00466
0.82743	0.22986	0.22986	-0.47437	0.01180	0.00425
0.92063	0.17229	0.17229	-0.35682	0.00851	0.00352
0.97975	0.09307	0.09307	-0.19291	0.00427	0.00223

THE FOLLOWING ARE THE TAIL CHARACTERISTICS

0.06699	0.00000	0.00000	-0.00000	0.00000	0.00000
0.25000	0.00000	0.00000	-0.00000	0.00000	0.00000
0.50000	0.00000	0.00000	-0.00000	0.00000	0.00000
0.75000	0.00000	0.00000	-0.00000	0.00000	0.00000
0.93301	0.00000	0.00000	-0.00000	0.00000	0.00000

*** THE FOLLOWING ARE ATTACHED POTENTIAL FLOW RESULTS ***

TOTAL LIFT COEFFICIENT = 0.04522

TOTAL INDUCED DRAG COEFFICIENT = 0.00090

THE INDUCED DRAG PARAMETER = 0.43975

TOTAL PITCHING MOMENT COEFFICIENT = -0.09096

THE WING LIFT COEFFICIENT = 0.04522

THE WING INDUCED DRAG COEFFICIENT = 0.00090

THE WING PITCHING MOMENT COEFFICIENT = -0.09096

THE TAIL LIFT COEFFICIENT = 0. (BASED ON WING AREA), = 0. (BASED ON TAIL AREA)

THE TAIL PITCHING MOMENT COEFFICIENT BASED ON REFERENCE WING AREA

AND MEAN WING CHORD, AND REFERRED TO THE Y-AXIS = 0.

(NOTE. THE INDUCED DRAG COMPUTATION IS FOR SYMMETRICAL LOADING ONLY)

****

THE FOLLOWING PARAMETERS ARE USED IN THE METHOD OF SUCTION ANALOGY

CLP = 0.04506 CLVLE = 0.00230 CLVSE = 0.00064

CDP = 0.00315 CDVLE = 0.00016 CDVSE = 0.00004

CMP = -0.09096 CMVLE = -0.00437 CMVSE = -0.00143

****

****

STABILITY DERIVATIVES BY POTENTIAL FLOW THEORY

****

STABILITY DERIVATIVES EVALUATED AT ALPHA = 4.000 DEGREES AND AT MACH NO.= 0. ,BASED ON BODY AXES(IN PER RADIAN)

CYB =	-0.1652173	CLB =	-0.0361644	CNB =	0.1704872
CYP =	-0.0518568	CLP =	-0.0799039	CNP =	0.0469839
CYR =	0.4002541	CLR =	0.0860504	CNR =	-0.4173858

STABILITY DERIVATIVES BASED ON STABILITY AXES

CYB =	-0.1652173	CLB =	-0.0241837	CNB =	0.1725946
CYP =	-0.0238102	CLP =	-0.0722887	CNP =	0.0228523
CYR =	0.4028964	CLR =	0.0619189	CNR =	-0.4250011

****

STABILITY DERIVATIVES WITH EDGE VORTEX SEPARATION

****

STABILITY DERIVATIVES EVALUATED AT ALPHA = 4.000 DEGREES AND AT MACH NO.= 0. ,BASED ON BODY AXES(IN PER RADIAN)

**INCLUDING THE EFFECT OF LE AND SE VORTEX LIFT*

CYB =	-0.1643711	CLB =	-0.0337119	CNB =	0.1678057
CYP =	-0.0684690	CLP =	-0.0920946	CNP =	0.0705937
CYR =	0.3897360	CLR =	0.0793132	CNR =	-0.4021554

STABILITY DERIVATIVES BASED ON STABILITY AXES

CYB =	-0.1643711	CLB =	-0.0219242	CNB =	0.1697485
CYP =	-0.0411156	CLP =	-0.0831718	CNP =	0.0482882
CYR =	0.3935628	CLR =	0.0570077	CNR =	-0.4110781

STABILITY DERIVATIVES EVALUATED AT ALPHA = 4.000 DEGREES AND AT MACH NO.= 0. ,BASED ON BODY AXES(IN PER RADIAN)

INCLUDING THE EFFECT OF LE VORTEX LIFT

CYB =	-0.1659218	CLB =	-0.0344873	CNB =	0.1694948
CYP =	-0.0557742	CLP =	-0.0857472	CNP =	0.0567947
CYR =	0.3941712	CLR =	0.0815308	CNR =	-0.4069859

STABILITY DERIVATIVES BASED ON STABILITY AXES

CYB =	-0.1659218	CLB =	-0.0225799	CNB =	0.1714876
CYP =	-0.0281423	CLP =	-0.0776847	CNP =	0.0337677
CYR =	0.3971017	CLR =	0.0585039	CNR =	-0.4150484

THE FOLLOWING BENDING MOMENT COEFFICIENT IS BASED ON Q*S*(B/2),
WHERE S = 326.60000 AND B/2 = 7.72500
(FOR ATTACHED POTENTIAL FLOW ONLY)

Y/S	BM(RIGHT)	BM(LEFT)
0.02025	0.00937	0.00937
0.07937	0.00811	0.00811
0.17257	0.00632	0.00632
0.29229	0.00438	0.00438
0.42884	0.00264	0.00264
0.57116	0.00133	0.00133
0.70771	0.00053	0.00053
0.82743	0.00014	0.00014
0.92063	0.00002	0.00002
0.97975	0.00000	0.00000

THE FOLLOWING ARE THE TAIL CHARACTERISTICS BASED ON TAIL GEOMETRY,
WHERE S = 22.77000 AND B/2 = 4.96000

0.06699	0.00000	0.00000
0.25000	0.00000	0.00000
0.50000	0.00000	0.00000
0.75000	0.00000	0.00000
0.93301	0.00000	0.00000

THE BENDING MOMENT COEFFICIENT BASED ON WING HALF SPAN AND WING AREA
AT THE WING ROOT = 0.009824 (RIGHT), = 0.009824 (LEFT)

THE BENDING MOMENT COEFFICIENT BASED ON TAIL HALF SPAN AND TAIL AREA
AT THE TAIL ROOT = 0.000000 (RIGHT), = 0.000000 (LEFT)

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

PRESSURE DISTRIBUTION AT ALPHA = 10.000 DEG.

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

VORTEX	XV	YV	CP
1	0.02447	0.02025	2.59872
2	0.20611	0.02025	0.85530
3	0.50000	0.02025	0.43293
4	0.79389	0.02025	0.21587
5	0.97553	0.02025	0.06654
6	0.02447	0.07937	2.72936
7	0.20611	0.07937	0.85421
8	0.50000	0.07937	0.43238
9	0.79389	0.07937	0.21569
10	0.97553	0.07937	0.06606
11	0.02447	0.17257	2.85593
12	0.20611	0.17257	0.86933
13	0.50000	0.17257	0.43214
14	0.79389	0.17257	0.21443
15	0.97553	0.17257	0.06554
16	0.02447	0.29229	2.94470
17	0.20611	0.29229	0.88775
18	0.50000	0.29229	0.43332
19	0.79389	0.29229	0.21284
20	0.97553	0.29229	0.06487
21	0.02447	0.42884	2.98704
22	0.20611	0.42884	0.89438
23	0.50000	0.42884	0.42969
24	0.79389	0.42884	0.20849
25	0.97553	0.42884	0.06328
26	0.02447	0.57116	2.96654
27	0.20611	0.57116	0.87735
28	0.50000	0.57116	0.41227
29	0.79389	0.57116	0.19683
30	0.97553	0.57116	0.05943
31	0.02447	0.70771	2.85593
32	0.20611	0.70771	0.82182
33	0.50000	0.70771	0.37080
34	0.79389	0.70771	0.17305
35	0.97553	0.70771	0.05199
36	0.02447	0.82743	2.61377
37	0.20611	0.82743	0.70481
38	0.50000	0.82743	0.29612
39	0.79389	0.82743	0.13526
40	0.97553	0.82743	0.04074
41	0.02447	0.92063	2.16946
42	0.20611	0.92063	0.49702
43	0.50000	0.92063	0.19314
44	0.79389	0.92063	0.08925
45	0.97553	0.92063	0.02774
46	0.02447	0.97975	1.34682
47	0.20611	0.97975	0.22338
48	0.50000	0.97975	0.09027
49	0.79389	0.97975	0.04384
50	0.97553	0.97975	0.01568
51	0.02447	0.06699	0.00000
52	0.20611	0.06699	0.00000
53	0.50000	0.06699	0.00000
54	0.79389	0.06699	0.00000
55	0.97553	0.06699	-0.00000
56	0.02447	0.25000	0.00000
57	0.20611	0.25000	0.00000
58	0.50000	0.25000	0.00000
59	0.79389	0.25000	0.00000
60	0.97553	0.25000	0.00000
61	0.02447	0.50000	0.00000
62	0.20611	0.50000	0.00000
63	0.50000	0.50000	0.00000
64	0.79389	0.50000	0.00000
65	0.97553	0.50000	0.00000
66	0.02447	0.75000	0.00000
67	0.20611	0.75000	0.00000
68	0.50000	0.75000	0.00000
69	0.79389	0.75000	0.00000
70	0.97553	0.75000	0.00000
71	0.02447	0.93301	0.00000
72	0.20611	0.93301	0.00000
73	0.50000	0.93301	-0.00000
74	0.79389	0.93301	-0.00000
75	0.97553	0.93301	-0.00000

Y/S	CL(RIGHT)	CL(LEFT)	CM	CT	CDI
0.02025	0.66854	0.66854	-1.30658	0.06721	0.04963
0.07937	0.68228	0.68228	-1.33481	0.07750	0.04161
0.17257	0.69905	0.69905	-1.37387	0.08508	0.03686
0.29229	0.71299	0.71299	-1.41192	0.09051	0.03381
0.42884	0.71680	0.71680	-1.43283	0.09322	0.03173
0.57116	0.70172	0.70172	-1.41652	0.09218	0.03013
0.70771	0.65668	0.65668	-1.33756	0.08597	0.02850
0.82743	0.56837	0.56837	-1.16578	0.07311	0.02598
0.92063	0.42572	0.42572	-0.87689	0.05275	0.02151
0.97975	0.22967	0.22967	-0.47408	0.02645	0.01364
THE FOLLOWING ARE THE TAIL CHARACTERISTICS					
0.06699	0.00000	0.00000	-0.00000	0.00000	0.00000
0.25000	0.00000	0.00000	-0.00000	0.00000	0.00000
0.50000	0.00000	0.00000	-0.00000	0.00000	0.00000
0.75000	0.00000	0.00000	-0.00000	0.00000	0.00000
0.93301	0.00000	0.00000	-0.00000	0.00000	-0.00000

*** THE FOLLOWING ARE ATTACHED POTENTIAL FLOW RESULTS ***

TOTAL LIFT COEFFICIENT = 0.11174

TOTAL INDUCED DRAG COEFFICIENT = 0.00550

THE INDUCED DRAG PARAMETER = 0.44047

TOTAL PITCHING MOMENT COEFFICIENT = -0.22354

THE WING LIFT COEFFICIENT = 0.11174

THE WING INDUCED DRAG COEFFICIENT = 0.00550

THE WING PITCHING MOMENT COEFFICIENT = -0.22354

THE TAIL LIFT COEFFICIENT = 0. (BASED ON WING AREA), = 0. (BASED ON TAIL AREA)

THE TAIL PITCHING MOMENT COEFFICIENT BASED ON REFERENCE WING AREA AND MEAN WING CHORD, AND REFERRED TO THE Y-AXIS = 0.

(NOTE. THE INDUCED DRAG COMPUTATION IS FOR SYMMETRICAL LOADING ONLY)

****

THE FOLLOWING PARAMETERS ARE USED IN THE METHOD OF SUCTION ANALOGY

CLP = 0.10932 CLVLE = 0.01404 CLVSE = 0.00389

CDP = 0.01928 CDVLE = 0.00248 CDVSE = 0.00069

CMP = -0.22354 CMVLE = -0.02706 CMVSE = -0.00886

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*****************************************
 *STABILITY DERIVATIVES BY POTENTIAL FLOW THEORY*
*****************************************

 ***STABILITY DERIVATIVES EVALUATED AT ALPHA =  10.000  DEGREES
    AND AT MACH NO.= 0.  ,BASED ON BODY AXES(IN PER RADIAN)***

    CYB =  -0.1736853  CLB =  -0.0309358  CNB =   0.1831156
    CYP =  -0.0262398  CLP =  -0.0828390  CNP =   0.0109179
    CYR =   0.4509616  CLR =   0.0618147  CNR =  -0.4841812

 ***STABILITY DERIVATIVES BASED ON STABILITY AXES***
    CYB =  -0.1736853  CLB =   0.0013319  CNB =   0.1857056
    CYP =   0.0524675  CLP =  -0.0825029  CNP =  -0.0599088
    CYR =   0.4486670  CLR =  -0.0090120  CNR =  -0.4845172
*****************************************
 *STABILITY DERIVATIVES WITH EDGE VORTEX SEPARATION*
*****************************************

 ***STABILITY DERIVATIVES EVALUATED AT ALPHA =  10.000  DEGREES
    AND AT MACH NO.= 0.  ,BASED ON BODY AXES(IN PER RADIAN)***
    **INCLUDING THE EFFECT OF LE AND SE VORTEX LIFT*
    CYB =  -0.1727723  CLB =  -0.0192611  CNB =   0.1733771
    CYP =  -0.0675935  CLP =  -0.1116661  CNP =   0.0696910
    CYR =   0.3892940  CLR =   0.0227515  CNR =  -0.3957882

 ***STABILITY DERIVATIVES BASED ON STABILITY AXES***
    CYB =  -0.1727723  CLB =   0.0111382  CNB =   0.1740878
    CYP =   0.0010336  CLP =  -0.1044248  CNP =   0.0183158
    CYR =   0.3951172  CLR =  -0.0286237  CNR =  -0.4030295

 ***STABILITY DERIVATIVES EVALUATED AT ALPHA =  10.000  DEGREES
    AND AT MACH NO.= 0.  ,BASED ON BODY AXES(IN PER RADIAN)***
    *INCLUDING THE EFFECT OF LE VORTEX LIFT*
    CYB =  -0.1806514  CLB =  -0.0232006  CNB =   0.1819484
    CYP =  -0.0359916  CLP =  -0.0958652  CNP =   0.0353404
    CYR =   0.4171407  CLR =   0.0366749  CNR =  -0.4260917

 ***STABILITY DERIVATIVES BASED ON STABILITY AXES***
    CYB =  -0.1806514  CLB =   0.0087469  CNB =   0.1832129
    CYP =   0.0369909  CLP =  -0.0935074  CNP =  -0.0233032
    CYR =   0.4170532  CLR =  -0.0219687  CNR =  -0.4284495
```

THE FOLLOWING BENDING MOMENT COEFFICIENT IS BASED ON Q*S*(B/2),
WHERE S = 326.60000 AND B/2 = 7.72500
(FOR ATTACHED POTENTIAL FLOW ONLY)

Y/S	BM(RIGHT)	BM(LEFT)
0.02025	0.02317	0.02317
0.07937	0.02005	0.02005
0.17257	0.01564	0.01564
0.29229	0.01083	0.01083
0.42884	0.00652	0.00652
0.57116	0.00328	0.00328
0.70771	0.00130	0.00130
0.82743	0.00036	0.00036
0.92063	0.00005	0.00005
0.97975	0.00000	0.00000

THE FOLLOWING ARE THE TAIL CHARACTERISTICS BASED ON TAIL GEOMETRY,
WHERE S = 22.77000 AND B/2 = 4.96000

0.06699	0.00000	0.00000
0.25000	0.00000	0.00000
0.50000	0.00000	0.00000
0.75000	0.00000	0.00000
0.93301	0.00000	0.00000

THE BENDING MOMENT COEFFICIENT BASED ON WING HALF SPAN AND WING AREA
AT THE WING ROOT = 0.024290 (RIGHT), = 0.024290 (LEFT)

THE BENDING MOMENT COEFFICIENT BASED ON TAIL HALF SPAN AND TAIL AREA
AT THE TAIL ROOT = 0.000000 (RIGHT), = 0.000000 (LEFT)

Appendix B

Program Listing

This Program is operational on the Honeywell 66/60 computer system at the University of Kansas.

```
C QVLM
C
C   THIS PROGRAM IS BASED ON THE QUASI VORTEX LATTICE METHOD BY
C     C. EDWARD LAN OF UNIVERSITY OF KANSAS
C
C     REFERENCE   JOURNAL OF AIRCRAFT VOL. 11, NO. 9, SEPT. 1974, PP.518
C     -527
C
C  *** GAMMA MUST BE DIMENSIONED TO HAVE AT LEAST (N+1)**2/4 ELEMENTS,
C      WHERE N IS THE SIZE OF THE MATRIX ***
C
      DIMENSION GAMMA(19600)
C    * IP SHOULD BE CONSISTENT WITH MATRIX SIZE. IF IP IS INCREASED,
C      DIMENSION FOR GAMMA SHOULD ALSO BE INCREASED.
      PARAMETER IP=140
      DIMENSION DQ(IP,IP)
      EQUIVALENCE  (DQ(1,1),GAMMA(1))
C
      DIMENSION CP(200), AW(201), CA(201), DMM(200)
      DIMENSION XXL(2), YL(2), XXT(2), CPCWL(15), CPSWL(31), YBREAK(10)
      DIMENSION ALPH(50), SNALP(50), CLS(50), DCOS(7), DSIN(7), CLY(50),
     1 CNALP(50)
      DIMENSION BREAK(10), SWP(10,15), CHORDT(4), TFLP(5), CTP(2)
      DIMENSION BMR(50), BML(50), DF(5), TITLE(13), CSU(50), YCN(6)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(100),YLE(100),
     1XTE(100),PSI(30),CH(100),XV(200),YV(200),SN(10,3),XN(200,2),YN(200
     2,2),ZN(200,2),WIDTH(7),YCON(51),SWEEP(100),HALFB,SJ(31,7)
      COMMON /AERO/ AM,B,CL(50),CT(50),CD(50),CM(50)
      COMMON /CONST/ NCS,NCW,M1(7),MJW1(2,5),MJW2(2,5),NJW(5),NFP,NW(2)
      COMMON /CAMB/ ICAM,IM,XT(3,12),ZC(3,12),AAM(3,11),BBM(3,11),CCM(3,
     111),DDM(3,11)
      COMMON /EXTRA/ CAMLE1,CAMLE2,CAMLE3,YTW,IST,TINP,NGRD,HEIGHT,ATT,N
     1C,NWING,HALFBH,IPOS,IALP
      COMMON /BETA/ GMAX(50),XTG(50),YTG(50),ZTG(50),B2,NCG,CTG(15),STG(
     115),DIST
      DIMENSION GAMP(200), GAMX(200), GAMB(200), GAMR(200)
      EQUIVALENCE  (GAMP(1),GAMMA(201)), (GAMB(1),GAMMA(401)), (GAMX(1),
     1   GAMMA(601)), (GAMR(1),GAMMA(801))
      PI=3.14159265
      DO 221 I=1,10
  221 BREAK(I)=0.
      PIS=PI*2.
C
C  ***NUMBER OF CASES TO BE RUN ***
C
      READ (5, 148) ICASE
      WRITE (6, 148) ICASE
      NCON=1
      IWGLT=0
 1    CONTINUE
C
C  *** USER'S CASE NUMBER ***
C     NGRD=1 IF THE WING IS IN GROUND EFFECT, =0 OTHERWISE
C
      READ (5, 148) NCASE,NGRD
      WRITE (6, 152)
```

```
      WRITE (6, 150) NCASE
      WRITE (6, 152)
C   *** CASE TITLE ***
      READ (5, 163) (TITLE(I),I=1,13)
      WRITE (6, 152)
      WRITE (6, 163) (TITLE(I),I=1,13)
      WRITE (6, 152)
      NCS=0
      IPANEL=1
      WRITE (6, 153)
C
C   ***TOTAL NUMBER OF SPANWISE SECTIONS, AND THE NUMBER OF VORTEX STRIPS
C      IN EACH SECTION PLUS ONE ***
C
C
C      IWING=LAST WING VORTEX STRIP NUMBER IF A TAIL IS PRESENT, =0
C      OTHERWISE.
C   ***NWING = THE NUMERICAL ORDER OF LAST WING SPANWISE SECTION ***
C   ** IWGLT=1 IF A WINGLET TO BE REPRESENTED BY A TAIL IS PRESENT **
C    ** IWGLT=2 IF THE WINGLET IS AT A LOCATION AWAY FROM THE WING TIP **
C
      READ (5, 148) NC,(M1(I),I=1,NC),IWING,NWING,IWGLT
      WRITE (6, 148) NC,(M1(I),I=1,NC),IWING,NWING,IWGLT
C
C   ***NFP=NUMBER OF FLAP SPANS.
C      NJW=NUMERICAL ORDERS OF FLAP SPANS AMONG THE SPANWISE SECTIONS*
C   *  NOTE. THE NUMBER OF FLAP SPANS IS LIMITED TO FIVE *
C      FOR A CLEAN OR FULL-SPAN FLAP CONFIGURATION, PUT NFP=NJW(1)=1
C    * NVRTX=VORTEX STRIP NUMBER AT AND OUTBOARD OF WHICH THE L.E. VORTEX
C      LIFT EFFECT IS NOT INCLUDED. IF IT IS ZERO, TOTAL VORTEX LIFT
C      EFFECT IS ASSUMED.
C
      READ (5, 148) NFP,(NJW(I),I=1,NFP),NVRTX
      WRITE (6, 148) NFP,(NJW(I),I=1,NFP),NVRTX
C
C   *** NUMBER OF CHORDWISE VORTEX ELEMENTS IN CHORDWISE SECTIONS, CAMBER
C      CODE (=1 IF CAMBER ORDINATES ARE TO BE READ IN, =0 IF THE CAMBER
C      FUNCTIONS ARE DEFINED BY CLOSED-FORM EXPRESSIONS MANUALLY IN
C      SUBPROGRAMS ZCR(X),ZCI(X) AND ZCT(X)), AND THE NUMBER OF CAMBER
C      ORDINATES TO BE READ IN (ARBITRARY IF ICAM=0), AND NUMBER OF
C      STATIONS AT WHICH CAMBER ORDINATES ARE READ IN (=2 AT MOST IF
C      THERE IS NO CHANGE IN TWIST AT AN INTERMEDIATE STATION) ***
C      ICAMT=1 IF THE TAIL, WINGLET OR VERTICAL FIN HAS CAMBER. IN THIS
C      CASE, CAMBER ORDINATES AT WING ROOT, WING TIP (REGARDED AS INTER-
C      MEDIATE STATION) AND TAIL SHOULD BE ALL READ IN. =0 OTHERWISE.
C
      READ (5, 148) (NW(I),I=1,2),ICAM,IM,IST,ICAMT
      WRITE (6, 148) (NW(I),I=1,2),ICAM,IM,IST,ICAMT
C
C   *** IF  ICAM=1, READ IN THE X-COORDINATES AND THE CAMBER ORDINATES
C      FOR THE ROOT SECTION, THE INTERMEDIATE SECTION AND THE TIP SECTION
C      SUCCESSIVELY ***
C   * NOTE. THE MAXIMUM NUMBER OF CAMBER ORDINATES ALLOWED IS 11 *
C
      IF  (ICAM .NE. 1) GO TO  3
      DO  2 I=1,IST
      READ (5, 147) (XT(I,J),J=1,IM)
 2    READ (5, 147) (ZC(I,J),J=1,IM)
```

```
      CALL SPLINE (IM,XT,ZC,AAM,BBM,CCM,DDM,1,IST)
 3    CONTINUE
      IF  (ICAM .EQ. 0) IST=1
C
C  *** LATERAL MODE SELECTOR (=-1 IF THE ROLLING MOMENT COEFFICIENT AT A
C     GIVEN AILERON ANGLE IS DESIRED, =0 FOR NO LATERAL MODE OF MOTION,
C     AND =1 IF LATERAL-DIRECTIONAL DERIVATIVES ARE TO BE COMPUTED) ***
C
C  *** NAL=NUMERICAL ORDER OF AILERON SPAN (=0 IF LAT=0) ***
C
      READ (5, 148) LAT,NAL
      WRITE (6, 148) LAT,NAL
      NCW=NW(1)
      L=1
      CHORDT(2)=0.
      CHORDT(3)=0.
      CHORDT(4)=0.
      IV=0
      IDIH=0
      B2=0.
      DIST=0.
 4    CONTINUE
      LL=1
      FN=NCW
      DO   5 I=1,NCW
      FI=I
      CPCWL(I)=0.5*(1.-COS((2.*FI-1.)*PI/(2.*FN)))
      SN(I,L)=2.*SQRT(CPCWL(I)*(1.-CPCWL(I)))
 5    CPCWL(I)=CPCWL(I)*100.
      DO   12 KK=1,NC
C
C  *** COORDINATES OF BREAK CHORDS BOUNDING SPANWISE SECTIONS, FROM
C      ROOT TO TIP ON THE RIGHT WING ***
C  *  DIHED=THE DIHEDRAL ANGLE IN DEGREES FOR THE SECTION *
C
      READ (5, 147) ((XXL(I),XXT(I),YL(I),I=1,2),ZS,DIHED)
      WRITE (6, 147) ((XXL(I),XXT(I),YL(I),I=1,2),ZS,DIHED)
      YBREAK(KK)=YL(2)
      FM=M1(KK)
      NSW=M1(KK)
      IF  (KK.EQ.1) DIST=DIST+XXT(1)-XXL(1)
      DO   6 J=1,NSW
      FJ=J
      CPSWL(J)=0.5*(1.-COS((2.*FJ-1.)*PI/(2.*FM)))*100.
      YCON(J)=0.5*(1.-COS(FJ*PI/FM))
      SJ(J,KK)=SIN(FJ*PI/FM)
 6    CONTINUE
      IF  (DIHED .GT. 5.) IDIH=1
      DCOS(KK)=COS(DIHED    *PI/180.)
      DSIN(KK)=SIN(DIHED    *PI/180.)
      IF  (IWING .NE. 0 .AND. DCOS(KK) .LE. 0.001) IV=1
      IF  (KK .EQ. NC) GO TO  7
      IF  (IWING .NE. 0 .AND. KK .EQ. NWINC) GO TO  7
      CPSWL(1)=0.
      CPSWL(NSW)=100.
      GO TO  8
 7    CPSWL(1)=0.
```

```
      IF  (IWGLT .EQ. 1 .AND. KK .EQ. NWING) CPSWL(NSW)=100.
 8    IF  (KK .EQ. NJW(LL)) MJW1(L,LL)=IPANEL
      LR=(L-1)*NC+KK
      CALL PANEL (XXL,YL,XXT,CPCWL,CPSWL,NSW,IPANEL,LPANEL,SWP,LR,ZS,L)
      IPANEL=LPANEL+1
      NCS=NCS+NSW-1
      B2=B2+FLOAT(NSW)-1.
      WIDTH(KK)=YL(2)-YL(1)
      BREAK(KK)=YL(1)
      IF  (KK .EQ. NJW(LL)) MJW2(L,LL)=LPANEL
      IF  (IWING .NE. 0 .AND. KK .EQ. NWING) GO TO  9
      IF  (KK .NE. NC) GO TO  11
 9    IF  (KK .EQ. NC .AND. IWING .NE. 0) GO TO  10
      CHORDT(L)=XXT(2)-XXL(2)
      HALFB=YL(2)
      YCN(L) = XXL(2)
      GO TO  11
 10   CHORDT(L+2)=XXT(2)-XXL(2)
      HALFBH=YL(2)
      YCN(L+2) = XXL(2)
 11   IF  (KK .EQ. NJW(LL)) LL=LL+1
 12   CONTINUE
      IF  (L .EQ. 2) GO TO  15
      LPAN1=LPANEL
      IF  (NW(2) .EQ. 0) GO TO  13
      L=2
      NCW=NW(2)
      B2=0.
      GO TO  4
 13   DO  14 I=1,NFP
      MJW1(2,I)=0
 14   MJW2(2,I)=0
      NCS=NCS*2
 15   CONTINUE
      NCS=NCS/2
      NCW=NW(1)+NW(2)
      IF  (NVRTX.EQ.0) NVRTX=NCS+1
      DO 220 I=1,5
      DF(I)=0.
  220 TFLP(I)=0.
      IF  (IWGLT .NE. 0) IV=0
C
C   *** MACH NUMBER, REFERENCE HALF WING AREA,
C       CONTROL INPUT FOR LARGE ALPHA COMPUTATION (=1. IF ALPHA=1. RADIAN
C       (IN THIS CASE, PUT ALP=DF(I)=0.) AND =0., OTHERWISE), AND FLAP
C       ANGLES IN DEG. ***
C       CREF=REFERENCE CHORD
C
      READ (5, 147) AM,HALFSW,CREF,ALPCON,(DF(I),I=1,NFP)
      WRITE (6, 147) AM,HALFSW,CREF,ALPCON,(DF(I),I=1,NFP)
C
C   *** THE FOLLOWING DATA SHOULD BE ALL 0. IF ALPCON=1.
C       ALNM=NUMBER OF ALPHA TO BE EVALUATED.
C       ALPI=INITIAL ALPHA IN DEGREES
C       ALPINC=INCREMENTAL ALPHA IN DEGREES
C
      READ (5, 147) ALNM,ALPI,ALPINC
      WRITE (6, 147) ALNM,ALPI,ALPINC
```

```
      NALP=ALNM
      IF (NALP.EQ.0) NALP=1
      ALPI=ALPI*PI/180.
      ALPINC=ALPINC*PI/180.
      ALP=ALPI
      ALQ=ALP
C
C   *** HEIGHT=HEIGHT OF 3/4 CHORD POINT OF M.A.C. FROM GROUND IF NGRD=1,
C       =0. OTHERWISE.   ATT=PITCH ATTITUDE OF WING IN DEGREES,
C       =0. IF NGRD=0.
C
      READ (5, 147) HEIGHT,ATT
      WRITE (6, 147) HEIGHT,ATT
      ATT=SIN(ATT*PI/180.)
      DO  16 I=1,NFP
      DF(I)=DF(I)*PI/180.
 16   TFLP(I)=-DF(I)
      CAMLE1=0.
      CAMLE2=0.
      CAMLE3=0.
      YTW=HALFB
      TINC=0.
      IALP=ALPCON
      POS=0.
      TWIST1=0.
      ITWST=0
      HALFSH=0.
C
C   ***THE FOLLOWING INPUT DATA ARE NOT NEEDED IF ALPCON=1. ***
C   ***TWIST IN DEG. FOR SECTION 1 AND 2(NEGATIVE FOR WASHOUT), Y-STATION
C       AT WHICH THE TWIST IS CHANGED (=HALFB FOR NO INTERMEDIATE TWIST),
C       ROOT CHORD INCIDENCE IN DEG.,L.E. CAMBER SLOPE AT ROOT CHORD, YTW
C       AND TIP ***
C     * IF TWIST1 .GT. 99., THE TWIST DISTRIBUTION DEFINED IN FUNCTION
C       SUBPROGRAM TWST IS TO BE USED. IN THIS CASE, THE CAMBER SLOPE WILL
C       BE TAKEN FROM FUNCTION SUBPROGRAM ZCDX *
C
C   * IF CAMBER ORDINATES ARE TO BE READ IN, THE L.E. CAMBER SLOPES TO BE
C       READ IN BELOW MAY BE ARBITRARY NUMBERS *
C
      IF  (IALP .EQ. 1) GO TO  17
      READ (5, 147) TWIST1,TWIST2,YTW,RINC,CAMLE1,CAMLE2,CAMLE3
      WRITE (6, 147) TWIST1,TWIST2,YTW,RINC,CAMLE1,CAMLE2,CAMLE3
C
C   ***IF A TAIL IS PRESENT, READ IN THE INCIDENCE ANGLE IN DEG., AND
C       HALF TAIL AREA. OTHERWISE, THIS CARD SHOULD BE OMITTED ***
C   ** IF THE TAIL IS TO REPRESENT THE WINGLET, PUT HALFSH=HALFSW **
C   ** HOWEVER, IF THE WINGLET IS INBOARD OF THE WING TIP, PUT HALFSH=
C       WINGLET AREA ***
C       POS IS THE WINGLET POSITION INDICATOR WITH RESPECT TO WING TIP.
C       FOR DETAIL, SEE INSTRUCTIONS .
C
 17   CONTINUE
      IF  (TWIST1 .GT. 99.) ITWST=1
      IF  (IWING .EQ. 0) GO TO  18
      READ (5, 147) TINC,HALFSH,POS
      WRITE (6, 147) TINC,HALFSH,POS
 18   CONTINUE
```

```
      IPOS=POS
      TWIST1=TWIST1*PI/180.
      TWIST2=TWIST2*PI/180.
      RINC=RINC*PI/180.
      TINC=TINC*PI/180.
      WRITE (6, 149) HALFSW,CREF
      JWING=IWING
      CM(50)=IV
      CM(49)=ICAMT
      IF  (ICAM .NE. 1) GO TO  19
      WRITE (6, 156)
      WRITE (6, 158)  (XT(1,I),I=1,IM)
      WRITE (6, 159)  (ZC(1,I),I=1,IM)
      CAMLE1=ZCR(0.)
      CAMLE2=CAMLE1
      CAMLE3=CAMLE2
      IF  (IST .EQ. 1) GO TO  19
      WRITE (6, 157)
      WRITE (6, 158)  (XT(2,I),I=1,IM)
      WRITE (6, 159)  (ZC(2,I),I=1,IM)
      CAMLE2=ZCI(0.)
      CAMLE3=CAMLE2
      IF  (IST .EQ. 2) GO TO  19
      WRITE (6, 160)
      WRITE (6, 158)  (XT(3,I),I=1,IM)
      WRITE (6, 159)  (ZC(3,I),I=1,IM)
      CAMLE3=ZCT(0.)
19    CONTINUE
      WRITE (6, 154)
      WRITE (6, 162)
      WRITE (6, 151)  (XN(I,1),XN(I,2),YN(I,1),YN(I,2),ZN(I,1),ZN(I,2),I=
     11,LPANEL)
      WRITE (6, 155)
      WRITE (6, 161)
      WRITE (6, 151)  (XCP(I),YCP(I),ZCP(I),I=1,LPANEL)
      J1=LPANEL+1
      B1=1.-AM*AM
      B2=B1
      ALZ=ALP*180./PI
      REWIND 01
      REWIND 02
      NPP=NALP
      DO  146 KP=1,NALP
      IF (IALP.EQ.1) GO TO  24
      TINP=TINC+ALP
      DO  23 I=1,NCS
      IF (IWING.NE.0.AND.I.GT.IWING) GO TO  21
      IF (ITWST.EQ.1) GO TO  22
      IF (YLE(I).GT.YTW) GO TO  20
      ALPH(I)=ALP+RINC+TWIST1*YLE(I)/YTW
      SNALP(I)=SIN(ALPH(I))
      CNALP(I)=COS(ALPH(I))
      GO TO  23
20    ALPH(I)=ALP+RINC+TWIST1+TWIST2*(YLE(I)-YTW)/(HALFB-YTW)
      SNALP(I)=SIN(ALPH(I))
      CNALP(I)=COS(ALPH(I))
      GO TO  23
```

```
21    ALPH(I)=TINP
      SNALP(I)=SIN(ALPH(I))
      CNALP(I)=COS(ALPH(I))
      GO TO  23
22    YC=YLE(I)/HALFB
      ALPH(I)=ALP+RINC+TWST(YC)
      SNALP(I)=SIN(ALPH(I))
      CNALP(I)=COS(ALPH(I))
23    CONTINUE
24    CONTINUE
      MM=NW(1)
      NN=NW(1)
      IZ=1
      B=B1
      IPN=1
      IF  (NW(2) .EQ. 0) GO TO  25
      II=1+NCS
      CHORD=CH(1)+CH(II)
      GO TO  26
25    CHORD=CH(1)
26    CONTINUE
      CSD=DCOS(1)
      SSD=DSIN(1)
      ZB=0.
      YB=0.
      YBB=0.
      IF (KP.NE.1) GO TO  27
      CALL WING (AW,LPANEL,1 ,B,LPAN1,LAT,NGRD,HEIGHT,ATT,CSD,SSD,YBREAK
     1,DCOS,DSIN,IWING,ZB,YB,YBB,IWSLT,NC)
27    CONTINUE
      XC=(XCP(1)-XLE(IZ))/CHORD
      IF  (ITWST .EQ. 1) GO TO  28
      YX=YTW
      IF  (IST .LE. 2) YX=HALFB
      ZR=ZCR(XC)
      ZI=ZR
      IF  (IST .NE. 1) ZI=ZCI(XC)
      CAM=ZR-(ZR-ZI)*YCP(1)/YX
      GO TO  29
28    YC=YLE(IZ)/HALFB
      CAM=ZCDX(XC,YC)
29    CONTINUE
      IF  (IALP .EQ. 1) ALPT=1.
      IF  (IALP .NE. 1) ALPT=SNALP(IZ)
      IF  (IALP .EQ. 1) CAM=0.
      AW(J1)=(ALPT-CAM)*CSD
      IF (NALP.GT.1) CA(1)=AW(J1)
      IF (NALP.GT.1) GO TO  31
      DO  30 I=1,LPANEL
30    GAMMA(I)=-AW(I+1)/AW(1)
31    CONTINUE
      IJ=2
      NJ=LPANEL-1
      LL=1
32    CONTINUE
      IF (KP.NE.1) GO TO  33
      CALL WING (AW,LPANEL,IJ,B,LPAN1,LAT,NGRD,HEIGHT,ATT,CSD,SSD,YBREAK
```

```
     1,DCOS,DSIN,IWING,ZB,YB,YBB,IWGLT,NC)
33    CONTINUE
      IF  (NW(2) .EQ. 0) GO TO  34
      II=IZ+NCS
      CHORD=CH(IZ)+CH(II)
      GO TO  35
34    CHORD=CH(IZ)
35    CONTINUE
      XC=(XCP(IJ)-XLE(IZ))/CHORD
      IF (IZ.GT.JWING.AND.JWING.NE.0) GO TO  51
      LCAM=0
      IF  (IALP .EQ. 1) GO TO  40
      IF  (ITWST .EQ. 1) GO TO  41
      IF  (YCP(IJ) .GT. YTW) GO TO  36
      ZR=ZCR(XC)
      YX=YTW
      ZI=ZR
      IF  (IST .NE. 1) ZI=ZCI(XC)
      IF  (IST .LE. 2) YX=HALFB
      CAM=ZR-(ZR-ZI)*YCP(IJ)/YX
      GO TO  42
36    IF  (IST .EQ. 1) GO TO  37
      IF  (IST .EQ. 2) GO TO  38
      ZI=ZCI(XC)
      ZT=ZCT(XC)
      YX=YTW
      GO TO  39
37    ZI=ZCR(XC)
      ZT=ZI
      YX=0.
      GO TO  39
38    ZI=ZCR(XC)
      ZT=ZCI(XC)
      YX=0.
39    CONTINUE
      CAM1=ZI-(ZI-ZT)*(YCP(IJ)-YX)/(HALFB-YX)
      IF  (LCAM .EQ. 1) GO TO  48
      CAM=CAM1
      GO TO  42
40    CAM=0.
      GO TO  50
41    YC=YLE(IZ)/HALFB
      CAM=ZCDX(XC,YC)
42    CONTINUE
      IF  (IJ .GE. MJW1(2,LL) .AND. IJ .LE. MJW2(2,LL)) GO TO  43
      GO TO  44
43    IF  (LL .EQ. NAL) GO TO  50
      CAM=TFLP(LL)+CAM
      GO TO  50
44    IF  (NW(2) .EQ. 0) GO TO  50
      IF  (NC .GT. 1) GO TO  45
      IF  (IJ .EQ. MM) CAM=CAM+0.5*TFLP(LL)
      GO TO  50
45    IF  (IJ .GE. MJW1(1,LL) .AND. IJ .LE. MJW2(1,LL)) GO TO  49
      IF  (IJ .GT. LPAN1) GO TO  50
      IF  (IJ .NE. MM) GO TO  50
      NCM=IJ+(NCS-IZ)*NW(1)+(IZ-1)*NW(2)+1
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```
      XC=(XCP(NCM)-XLE(IZ))/CHORD
      IF  (ITWST .EQ. 1) GO TO  46
      IF  (YCP(IJ) .GT. YTW) GO TO  47
      ZR=ZCR(XC)
      YX=YTW
      IF  (IST .LE. 2) YX=HALFB
      ZI=ZR
      IF  (IST .NE. 1) ZI=ZCI(XC)
      CAM1=ZR-(ZR-ZI)*YCP(IJ)/YX
      GO TO  48
46    CAM1=ZCDX(XC,YC)
      GO TO  48
47    LCAM=1
      GO TO  36
48    CONTINUE
      CAM=0.5*(CAM+CAM1)
      GO TO  50
49    IF  (LL .EQ. NAL) GO TO  50
      IF  (IJ .EQ. MM) CAM=CAM+0.5*TFLP(LL)
50    CONTINUE
      IF  (IALP .NE. 1) ALPT=SNALP(IZ)
      IF  (IALP .EQ. 1) ALPT=1.
      GO TO  53
51    ALPT=SNALP(IZ)
      IF  (IALP .EQ. 1) ALPT=1.
      CAM=0.
      IF (IALP.EQ.1) GO TO  53
      IF (ICAMT.EQ.0) GO TO  52
      CAM=ZCT(XC)
      IF (IJ.GT.LPAN1) GO TO  52
      IF (IJ.NE.MM) GO TO  52
      NCM=IJ+(NCS-IZ)*NW(1)+(IZ-1)*NW(2)+1
      XC=(XCP(NCM)-XLE(IZ))/CHORD
      CAM1=ZCT(XC)
      CAM=0.5*(CAM+CAM1)
52    CONTINUE
      IF (IJ.EQ.MM) CAM=CAM+0.5*TFLP(LL)
      IF (IJ.GT.LPAN1) CAM=CAM+TFLP(LL)
53    CONTINUE
      AW(J1)=(ALPT-CAM)*CSD
      IF (NALP.GT.1) CA(IJ)=AW(J1)
      IF (NALP.GT.1) GO TO  54
      CALL VMSEQN (NJ,IJ,AW,GAMMA,CA)
54    CONTINUE
      IF  (IJ .GE. LPAN1 .AND. IJ .LT. LPANEL) GO TO  55
      IF  (IJ .EQ. MJW2(1,LL)) LL=LL+1
      GO TO  56
55    NN=NW(2)
      IF  (IJ .EQ. MJW2(2,LL)) LL=LL+1
56    CONTINUE
      IF  (IJ .LT. MM) GO TO  63
      IF (NW(2).EQ.0) GO TO  57
      IF (IJ.LE.LPAN1) GO TO  58
57    ZTG(IZ+1)=ZTG(IZ+1)+ZB+(YTG(IZ+1)-YB)*SSD
      YTG(IZ+1)=YBB+(YTG(IZ+1)-YB)*CSD
      XLL(IZ)=SSD
      XTT(IZ)=CSD
```

```
58    CONTINUE
      IZ=IZ+1
      MM=MM+NN
      IF  (IWING .NE. 0 .AND. IZ .EQ. (IWING+1)) GO TO  59
      IF (IZ.EQ.(NCS+1)) GO TO  61
      IF  (YLE(IZ) .LT. YBREAK(IPN)) GO TO  63
59    CONTINUE
      ZB=ZB+(YBREAK(IPN)-YB)*SSD
      YBB=YBB+(YBREAK(IPN)-YB)*CSD
      YB=YBREAK(IPN)
      IF  (IWING .NE. 0 .AND. IZ .EQ. (IWING+1)) GO TO  60
      GO TO  62
60    IF (IWGLT .EQ. 1) GO TO  62
61    ZB=0.
      YB=0.
      YBB=0.
      IF (IZ .EQ. (NCS+1)) GO TO  62
      IF  (IWGLT .NE. 2) GO TO  62
      ZB=YBREAK(NC-2)*DSIN(1)
      YBB=YBREAK(NC-2)*DCOS(1)
      YB=YBREAK(NC-2)
62    CONTINUE
      IPN=IPN+1
      IF  (IJ .EQ. LPAN1 .OR. IJ .EQ. LPANEL) IPN=1
      CSD=DCOS(IPN)
      SSD=DSIN(IPN)
63    IF  (IJ .EQ. LPAN1) IZ=1
      IF  (IJ .EQ. LPAN1) LL=1
      IJ=IJ+1
      NJ=NJ-1
      IF  (IJ .LE. LPANEL) GO TO  32
      DO  64 I=1,LPANEL
64    DMM(I)=GAMMA(I)
      IF (KP.EQ.1) CALL INVN (DQ,CP,AW,LAT,NPP,LPANEL,IP)
      DO  65 I=1,LPANEL
65    GAMMA(I)=DMM(I)
      REWIND 02
      IF (NALP.EQ.1) GO TO  67
      DO  66 I=1,LPANEL
      GAMMA(I)=0.
      READ (02) (AW(K),K=1,LPANEL)
      DO  66 J=1,LPANEL
66    GAMMA(I)=GAMMA(I)-AW(J)*CA(J)
67    CONTINUE
      CM(1)=ITWST
      CALL THRUST (LPANEL,GAMMA,SNALP,IALP,LPAN1,CAMLE1,CAMLE2,CAMLE3,YT
     1W,IST,IWING,TINP,NGRD,HEIGHT,ATT,YBREAK,DCOS,DSIN,CSU,JWING,IWGLT,
     2NC,0,0.,0.,0.,CNALP)
      DO  68 I=1,NCS
68    Y(1,I)=CD(I)
      DO  69 I=1,LPANEL
69    CP(I)=GAMMA(I)
      CALL GAMAX (AW,CA,LPAN1,LPANEL,CP,NC,BREAK,SWP,CHORDT,IWING,NWING,
     1 HALFBH,YCN,CTP,CTX,IWGLT,IPOS,0)
      DO  70 I=1,LPANEL
70    GAMX(I)=CA(I)
      DO  71 I=1,NCW
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      Y(2,I)=CL(I)
   71 IF (IWING.NE.0) Y(3,I)=CM(I)
      CTIP=CTP(1)*DCOS(NWING)
      IF  (IWGLT .NE. 0) CTIP=CTIP+CTP(2)*DCOS(NWING+1)
      IF (LAT.NE.0) CALL LATERL (GAMMA,AW,CA,LAT,LPANEL,LPAN1,DF,NAL,YBR
     1EAK,DSIN,DCOS,IWING,IWGLT,NPP,ALP,GAMP,GAMB,GAMR,CP,GAMX,BREAK,SWP
     2, CHORDT,YCN,SNALP,CNALP)
      IF (LAT.EQ.(-1)) GO TO  73
      DO  72 I=1,LPANEL
   72 GAMMA(I)=0.
   73 CONTINUE
      P=0.1
      RL=0.1
      BK=0.1
      COSA=COS(ALP)
      SINA=SIN(ALP)
      CLPP=0.
      CDPP=0.
      CDVL=0.
      CLT=0.
      CMT=0.
      CDT=0.
      CLL=0.
      CLW=0.
      CMW=0.
      CDW=0.
      CY=0.
      CNB=0.
      CLB=0.
      CLP=0.
      CYP=0.
      CNP=0.
      CYR=0.
      CLRR=0.
      CNR=0.
      CYBV=0.
      CYBVSE=0.
      CNBV=0.
      CNBVSE=0.
      CLBV=0.
      CLBVSE=0.
      CYPV=0.
      CYPVSE=0.
      CNPV=0.
      CNPVSE=0.
      CLPV=0.
      CLPVSE=0.
      CYRV=0.
      CYRSE=0.
      CLRRV=0.
      CLRVSE=0.
      CNRV=0.
      CNRVSE=0.
      CSL = 0.
      CSXL = 0.
      KC=1
      NCOL=M1(1)
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      KLL=0
      MM=0
      NCW1=NCW+1
      NL=1
      IPN=1
      COD=DCOS(1)
      SOD=DSIN(1)
      ZB=0.
      YB=0.
      YBB=0.
      NCSS=NCS
      COW=1.
      SOW=0.
      DO  110 I=1,NCS
      FATR=1.
      IF(IV.EQ.1.AND.I.GT.JWING) FATR=0.5
      IF  (NW(2) .EQ. 0) GO TO  74
      I1=I+NCS
      CHORD=CH(I)+CH(I1)
      GO TO  75
74    CHORD=CH(I)
75    CONTINUE
      CML=0.
      CLS(I)=0.
      CL(I)=0.
      CD(I)=0.
      CYS=0.
      CNS=0.
      CLBS=0.
      CLPS=0.
      CLPVS=0.
      CYPS=0.
      CNPS=0.
      CYRS=0.
      CLRS=0.
      CNRS=0.
      CNB1=0.
      CYR1=0.
      CNR1=0.
      CLY(I)=0.
      DO  93 J=1,NCW
      NN=J+MM
      IF  (NW(2) .EQ. 0) GO TO  76
      IF  (J .LE. NW(1)) GO TO  76
      LL=LPAN1-NW(1)*I+NN+NW(2)*(I-1)
      IL=I1
      JLL=J-NW(1)
      L=2
      FN=NW(2)
      GO TO  77
76    LL=NN
      IL=I
      JLL=J
      L=1
      FN=NW(1)
77    CONTINUE
      XC=(XV(LL)-XLE(I))/CHORD
      IF (JWING.NE.0.AND.I.GT.JWING) GO TO  86
      X1=ZCR(XC)
```

```
      X2=X1
      X3=X1
      IF  (IST .EQ. 1) GO TO  78
      X2=ZCI(XC)
      X3=X2
      IF  (IST .EQ. 2) GO TO  78
      X3=ZCT(XC)
78    CONTINUE
      IF  (IALP .EQ. 1) GO TO  88
      IF  (LL .GE. MJW1(2,NL) .AND. LL .LE. MJW2(2,NL)) GO TO  82
      IF  (ITWST .EQ. 1) GO TO  80
      IF  (YLE(I) .GT. YTW) GO TO  79
      YX=YTW
      IF  (IST .LE. 2) YX=HALFB
      CAM=X1-(X1-X2)*YLE(I)/YX
      GO TO  81
79    YX=YTW
      IF  (IST .LE. 2) YX=0.
      CAM=X2-(X2-X3)*(YLE(I)-YX)/(HALFB-YX)
      GO TO  81
80    YC=YLE(I)/HALFB
      CAM=ZCDX(XC,YC)
81    EP=ALPH(I)
      CS=COS(EP)
      SS=SIN(EP)
      GO TO  89
82    IF  (NL .EQ. NAL) EP=ALPH(I)
      IF  (NL .NE. NAL) EP=ALPH(I)-TFLP(NL)
      IF  (ITWST .EQ. 1) GO TO  84
      IF  (YLE(I) .GT. YTW) GO TO  83
      YX=YTW
      IF  (IST .LE. 2) YX=HALFB
      CAM=X1-(X1-X2)*YLE(I)/YX
      GO TO  85
83    YX=YTW
      IF  (IST .LE. 2) YX=0.
      CAM=X2-(X2-X3)*(YLE(I)-YX)/(HALFB-YX)
      GO TO  85
84    YC=YLE(I)/HALFB
      CAM=ZCDX(XC,YC)
85    CONTINUE
      CS=COS(EP)
      SS=SIN(EP)
      GO TO  89
86    IF  (IALP .EQ. 1) GO TO  88
      IF  (LL .GT. LPAN1) GO TO  87
      CS=COS(TINP)
      SS=SIN(TINP)
      CAM=0.
      IF (ICAMT.NE.0) CAM=ZCT(XC)
      GO TO  89
87    CS=COS(TINP-TFLP(NL))
      SS=SIN(TINP-TFLP(NL))
      CAM=0.
      IF (ICAMT.NE.0) CAM=ZCT(XC)
      GO TO  89
88    CS=1.
```

```
      SS=1.
      CAM=0.
   89 CONTINUE
      U1=0.
      U2=0.
      V1=0.
      V2=0.
      IF  (NGRD .EQ. 0) GO TO  90
      ZCW=-2.*(ZN(LL,1)+ZB+(YCP(LL)-YB)*SOD+HEIGHT)+ZN(LL,1)+ZB+(YCP(LL)
     1-YB)*SOD
      CALL BACKWH (XV(LL),YV(LL),ZCW,LPANEL,B,LPAN1,NW,CP,U1,LAT,COD,SOD
     1,YBREAK,DCOS,DSIN,V1,IWING,ZB,YB,YBB,NCSS,IWGLT,NC)
      IF (LAT.NE.(-1)) GO TO  90
      CALL BACKWH (XV(LL),YV(LL),ZCW,LPANEL,B,LPAN1,NW,GAMMA,U2,LAT,COD,
     1 SOD,YBREAK,DCOS,DSIN,V2,IWING,ZB,YB,YBB,NCSS,IWGLT,NC)
   90 CONTINUE
      IF  (IALP .EQ. 0) GO TO  91
      GAK=CP(LL)*(1.+U1*ALP)+CP(LL)*ALP*U1-GAMX(LL)*(V1*ALP+SOD*ALP)*2.
      GBK=GAMMA(LL)
      CP(LL)=GAK
      GO TO  92
   91 GAK=CP(LL)*(1.+U1)*CS-GAMX(LL)*(V1+SOD*SNALP(I))
      GBK=GAMMA(LL)*(1.+U1+U2)*CS-GAMX(LL)*(V2+V1)
      CP(LL)=GAK
      GAMMA(LL)=GBK
   92 CONTINUE
      GBS=GAK*SN(JLL,L)*CH(IL)/FN
      WBS=GBK*SN(JLL,L)*CH(IL)/FN
      WAS=0.
      FT=SQRT(1.+CAM*CAM*COD*COD)
      CL(I)=CL(I)+GBS*(CAM*SS+CS)*COD/FT
      CML=CML-GBS*XV(LL)*COD/FT
      CD(I)=CD(I)+GBS*(-CAM*CS+SS)*COD/FT
      CLS(I)=CLS(I)+WBS
      CLY(I)=CLY(I)+GBS*CS
      IF (LAT.NE.1) GO TO  93
      FZ=SN(JLL,L)*CH(IL)/FN
      WP=GAMP(LL)*FZ*(1.+U1)
      WB=GAMB(LL)*FZ*(1.+U1)
      WR=GAMR(LL)*FZ*(1.+U1)
      YCV=SOD*XV(LL)
      ZCV=SOD*(ZCP(LL)+ZB+(YCP(LL)-YB)*SOD)+COD*(YBB+(YCP(LL)-YB)*COD)
      CYS=CYS-WB*SOD-GBS*(-CAM*CS+SS)*COD/FT*BK*COSA
      CNS=CNS+WB*YCV+GBS*(-CAM*CS+SS)*COD/FT*BK*XV(LL)*COSA
      CLBS=CLBS-WB*ZCV
      CYPS=CYPS-WP*SOD
      CLPS=CLPS-WP*ZCV
      CNPS=CNPS+WP*YCV
      CYRS=CYRS-WR*SOD+GBS*SS*XV(LL)/HALFB*COD/FT*RL
      CLRS=CLRS-WR*ZCV
      CNRS=CNRS+WR*YCV-GBS*SS*XV(LL)/HALFB*COD/FT*RL*XV(LL)
      CLPVS=CLPVS-(WP-GBS/CS*P*ZCV*SINA/HALFB)*ZCV
      CNB1=CNB1+WB*YCV
      CYR1=CYR1-WR*SOD
      CNR1=CNR1+WR*YCV
      CNB1=CNB1+GBS*(-CAM*CS+SS)*COD/FT*BK*XV(LL)*COSA
   93 CONTINUE
```

```
      IF  (IALP .EQ. 1) GO TO  97
      IF  (JWING .NE. 0 .AND. I .GT. JWING) GO TO  98
      IF  (ITWST .EQ. 1) GO TO  95
      IF  (YLE(I) .GT. YTW) GO TO  94
      YX=YTW
      IF  (IST .LE. 2) YX=HALFB
      CAMLE=CAMLE1-(CAMLE1-CAMLE2)*YLE(I)/YX
      GO TO  96
   94 YX=YTW
      IF  (IST .LE. 2) YX=0.
      CAMLE=CAMLE2-(CAMLE2-CAMLE3)*(YLE(I)-YX)/(HALFB-YX)
      GO TO  96
   95 YC=YLE(I)/HALFB
      CAMLE=ZCDX(0.,YC)
   96 EP=ALPH(I)
      XCS=COS(EP)
      XSS=SIN(EP)
      GO TO  99
   97 XCS=1.
      XSS=0.
      CAMLE=0.
      GO TO  99
   98 XCS=COS(TINP)
      XSS=SIN(TINP)
      CAMLE=0.
      IF (ICAMT.NE.0) CAMLE=CAMLE3
   99 CONTINUE
      FS=COS(SWEEP(I))
      SSN=SIN(SWEEP(I))
      TAN=SSN/FS
      FTAN=TAN
      F1=SQRT(COD*COD*(1.+CAMLE**2)+SOD*SOD)
      F2=SQRT((1.+FTAN*FTAN)*COD*COD+(CAMLE*FTAN*COD+SOD)**2)
      F12=F1*F2
      F3=1.+COD*SOD*CAMLE*FTAN
      F4=-CAMLE*COD*COD+SOD*COD*FTAN
      F5=F12/SQRT(F3*F3+F4*F4)
      FT=SQRT(1.+CAMLE**2)
      FL=XSS-XCS*CAMLE
      FD=-XCS-XSS*CAMLE
      CSU(I)=CSU(I)*F5
      CLPPS=CL(I)*PI/CHORD
      CL(I)=CL(I)*PI/CHORD+CT(I)*FL/FT
      CM(I)=CML*PI/(CREF*CHORD)
      CDPPS=CD(I)*PI/CHORD
      CD(I)=CD(I)*PI/CHORD+CT(I)*FD/FT
      CLS(I)=CLS(I)*PI/CHORD
      CLY(I)=CLY(I)*PI/CHORD+CT(I)*FL/FT
      IF  (LAT.NE.1) GO TO  102
      CONST=PI/CHORD
      CTH=PI/2.*SQRT(1.-AM*AM*FS*FS)/FS
      CYS=CYS*CONST
      CNS=CNS*CONST
      CLBS=CLBS*CONST
      CYPS=CYPS*CONST
      CNPS=CNPS*CONST
      CLPS=CLPS*CONST
```

```
      CYRS=CYRS*CONST
      CNRS=CNRS*CONST
      CLRS=CLRS*CONST
      CLPVS=CLPVS*CONST
      CNB1=CNB1*CONST
      CYR1=CYR1*CONST
      CNR1=CNR1*CONST
      SIDE=CTH*2.*Y(1,I)*Y(4,I)*F5
      SIDEB=CTH*2.*Y(1,I)*Y(7,I)*F5
      SIDER=CTH*2.*Y(1,I)*Y(10,I)*F5
      YE=YBB+(YLE(I)-YB)*COD
      KA=1+(I-1)*NW(1)
      ZYE=SOD*(ZCP(KA)+ZB+(YLE(I)-YB)*SOD)+COD*(YBB+(YLE(I)-YB)*COD)
      F6=(CAMLE*COD*(CAMLE*TAN*COD+SOD)+TAN*COD*COD)/F12
      FD=FD*COD
      CYB1=CYS-SIDEB*SOD/F1
      CNB1=CNB1+SIDEB*SOD*XLE(I)
      CLB1=CLBS-SIDEB*ZYE/F1
      CYP1=CYPS-SIDE*SOD/F1
      CNP1=CNPS+SIDE*SOD*XLE(I)
      CYR1=CYR1-SIDER*SOD/F1
      CNR1=CNR1+SIDER*SOD*XLE(I)
      CLR1=CLRS-SIDER*ZYE/F1
      CYPS=CYPS+SIDE*F6
      CNPS=CNPS-SIDE*YE*F3/F12
      CNPS=CNPS-SIDE*XLE(I)*F6
      CLPS=CLPS-SIDE*ZYE*F4/F12
      CYS=CYS+SIDEB*F6-CT(I)*FD/FT*BK
      CNS=CNS-SIDEB*YE*F3/F12+CT(I)*FD/FT*BK*XLE(I)
      CNS=CNS-SIDEB*XLE(I)*F6
      CLBS=CLBS-SIDEB*ZYE*F4/F12
      CYRS=CYRS+SIDER*F6+CT(I)*FD/FT*XLE(I)/HALFB*RL
      CNRS=CNRS-SIDER*YE*F3/F12-CT(I)*FD/FT*XLE(I)/HALFB*RL*XLE(I)
      CNRS=CNRS-SIDER*XLE(I)*F6
      CLRS=CLRS-SIDER*ZYE*F4/F12
      CLPVS=CLPVS-SIDE*ZYE/F1
      IF (I.GE.NVRTX) GO TO  100
      GO TO  101
100   CYB1=CYS
      CNB1=CNS
      CLB1=CLBS
      CYP1=CYPS
      CNP1=CNPS
      CLPVS=CLPS
      CYR1=CYRS
      CNR1=CNRS
      CLR1=CLRS
101   CONTINUE
102   CONTINUE
      IF  (I .LT. NCOL) GO TO  103
      KLL=NCOL-1
      KC=KC+1
      NCOL=NCOL+M1(KC)-1
103   KL=I-KLL
      FM=M1(KC)
      AA=CHORD*SJ(KL,KC)*WIDTH(KC)/FM
```

```
      AA=AA*FATR
      CLT=CLT+CL(I)*AA
      CMT=CMT+CM(I)*AA
      CDT=CDT+CD(I)*AA
      CLL=CLL+CLS(I)*AA*YLE(I)
      CLPP=CLPP+CLPPS*AA
      CDPP=CDPP+CDPPS*AA
      IF (I.GE.NVRTX) GO TO  104
      CDVL=CDVL+CSU(I)*(-CAMLE*XCS+XSS)/FT*COD*AA
      CSL=CSL+CSU(I)*(CAMLE*XSS+XCS)/FT*COD*AA
      CSXL=CSXL-CSU(I)*XLE(I)*AA*COD
104   CONTINUE
      IF (LAT.NE.1) GO TO  105
      CY=CY+CYS*AA
      CNB=CNB+CNS*AA
      CLB=CLB+CLBS*AA
      CYP=CYP+CYPS*AA
      CNP=CNP+CNPS*AA
      CLP=CLP+CLPS*AA
      CYR=CYR+CYRS*AA
      CNR=CNR+CNRS*AA
      CLRR=CLRR+CLRS*AA
      CLPV=CLPV+CLPVS*AA
      CYPV=CYPV+CYP1*AA
      CNPV=CNPV+CNP1*AA
      CYRV=CYRV+CYR1*AA
      CNRV=CNRV+CNR1*AA
      CLRRV=CLRRV+CLR1*AA
      CYBV=CYBV+CYB1*AA
      CNBV=CNBV+CNB1*AA
      CLBV=CLBV+CLB1*AA
105   CONTINUE
      MM=(NCW-NW(2))*I
      IF  (IWING .NE. 0 .AND. I .EQ.IWING) GO TO  106
      IF  (I .EQ. NCS) GO TO  109
      IF  (YLE(I+1) .LT. YBREAK(IPN)) GO TO  109
106   CONTINUE
      ZB=ZB+(YBREAK(IPN)-YB)*SOD
      YBB=YBB+(YBREAK(IPN)-YB)*COD
      YB=YBREAK(IPN)
      IF  (IWING .NE. 0 .AND. I .EQ. IWING) GO TO  107
      GO TO  108
107   SOW=SOD
      COW=COD
      YPRW=YBB
      YRW=YB
      ZPRW=ZB
      YBKW=YBREAK(IPN)
      IF (IWGLT.EQ.1) GO TO  108
      ZB=0.
      YB=0.
      YBB=0.
      IF  (IWGLT .NE. 2) GO TO  108
      ZB=YBREAK(NC-2)*DSIN(1)
      YBB=YBREAK(NC-2)*DCOS(1)
      YB=YBREAK(NC-2)
      YPRW=YBB
      YRW=YB
      ZPRW=ZB
```

```
 108   CONTINUE
       IPN=IPN+1
       COD=DCOS(IPN)
       SOD=DSIN(IPN)
 109   CONTINUE
       IF  (LL .EQ. MJW2(2,NL)) NL=NL+1
       IF  (IWING .EQ. 0) GO TO  110
       IF  (I .NE. JWING) GO TO  110
       CLW=CLT
       CMW=CMT
       CDW=CDT
 110   CONTINUE
       IF (LAT.NE.1) GO TO  116
       CYBVSE=CYBV
       CNBVSE=CNBV
       CLBVSE=CLBV
       CYPVSE=CYPV
       CNPVSE=CNPV
       CLPVSE=CLPV
       CYRSE=CYRV
       CNRVSE=CNRV
       CLRVSE=CLRRV
       NCNT=1
       IF (IWING.NE.0) NCNT=2
       DO  115 KK=1,NCNT
       FATR=1.
       IF(IV.EQ.1.AND.KK.EQ.2) FATR=0.5
       K1=KK
       KA=1+(NCS-1)*NW(1)
       IF (IWING.EQ.0) GO TO  111
       IF (KK.EQ.2) GO TO  111
       KA=1+(IWING-1)*NW(1)
       SS=SOW
       CS=COW
       YB2=YPRW
       YB1=YRW
       ZB1=ZPRW
       YKP=YBKW
       IF (KK.EQ.1) GO TO  112
 111   CONTINUE
       IF (KK.EQ.2) K1=KK+1
       SS=SOD
       CS=COD
       YB2=YBB
       YB1=YB
       ZB1=ZB
       YKP=YBREAK(IPN)
 112   ISN=1
       FN=NW(1)
       DO  114 J=1,NCW
       JJ=J
       IF (J.LE.NW(1)) GO TO  113
       ISN=2
       FN=NW(2)
       JJ=J-NW(1)
       K1=KK+1
       IF(KK.EQ.2) K1=KK+2
 113   FJJ=JJ
       ZCV=CS*(ZB1+(YKP-YB1)*SS)-SS*(YB2+(YKP-YB1)*CS)
       YCV=SS*(ZB1+(YKP-YB1)*SS)+CS*(YB2+(YKP-YB1)*CS)
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```
      XQ=YCN(K1)+0.5*CHORDT(K1)*(1.-COS((2.*FJJ-1.)*PI/(2.*FN)))        A1027
      CK=CHORDT(K1)*2.*Y(KK+1,J)*Y(KK+4,J)*SN(JJ,ISN)/FN                A1028
      CK2=CHORDT(K1)*2.*Y(KK+1,J)*Y(KK+7,J)*SN(JJ,ISN)/FN               A1029
      CK3=CHORDT(K1)*2.*Y(KK+1,J)*XL(KK,J)*SN(JJ,ISN)/FN                A1030
      CK=CK*FATR
      CK2=CK2*FATR
      CK3=CK3*FATR
      CK=CK*CS                                                          A1031
      CK2=CK2*CS                                                        A1032
      CK3=CK3*CS                                                        A1033
      CY=CY+CK2*PIS                                                     A1034
      CNB=CNB-CK2*XQ*PIS                                                A1035
      CLB=CLB+CK2/CS*ZCV*PIS                                            A1036
      CYP=CYP+CK*PIS                                                    A1037
      CNP=CNP-CK*XQ*PIS                                                 A1038
      CLP=CLP+CK/CS*ZCV*PIS                                             A1039
      CYR=CYR+CK3*PIS                                                   A1040
      CNR=CNR-CK3*XQ*PIS                                                A1041
      CLRR=CLRR+CK3/CS*ZCV*PIS                                          A1042
      CYBVSE=CYBVSE+CK2*PIS                                             A1043
      CNBVSE=CNBVSE-CK2*XQ*PIS                                          A1044
      CLBVSE=CLBVSE+CK2/CS*ZCV*PIS                                      A1045
      CYPVSE=CYPVSE+CK*PIS                                              A1046
      CNPVSE=CNPVSE-CK*PIS*XQ                                           A1047
      CLPVSE=CLPVSE+CK/CS*ZCV*PIS                                       A1048
      CYRSE=CYRSE+CK3*PIS                                               A1049
      CNRVSE=CNRVSE-CK3*PIS*XQ                                          A1050
      CLRVSE=CLRVSE+CK3/CS*ZCV*PIS                                      A1051
      CYBV=CYBV-CK2/CS*SS*PIS                                           A1052
      CNBV=CNBV+CK2/CS*SS*PIS*XQ                                        A1053
      CLBV=CLBV-CK2/CS*YCV*PIS                                          A1054
      CYPV=CYPV-CK/CS*SS*PIS                                            A1055
      CNPV=CNPV+CK/CS*SS*PIS*XQ                                         A1056
      CYRV=CYRV-CK3/CS*SS*PIS                                           A1057
      CNRV=CNRV+CK3/CS*SS*PIS*XQ                                        A1058
      CLRRV=CLRRV-CK3/CS*YCV*PIS                                        A1059
  114 CLPV=CLPV-CK/CS*YCV*PIS                                           A1060
  115 CONTINUE                                                          A1061
  116 CONTINUE                                                          A1062
      IF (ABS(CSL).GT.0.0001) XLEBAR=CSXL/CSL                           A1063
      CLT=CLT*PI/(2.*HALFSW)                                            A1064
      CMT=CMT*PI/(2.*HALFSW)                                            A1065
      CDT=CDT*PI/(2.*HALFSW)                                            A1066
      CLL=-CLL*PI/(4.*HALFSW*HALFB)                                     A1067
      CLW=CLW*PI/(2.*HALFSW)                                            A1068
      CMW=CMW*PI/(2.*HALFSW)                                            A1069
      CDW=CDW*PI/(2.*HALFSW)                                            A1070
      CLPP=CLPP*PI/(2.*HALFSW)                                          A1071
      CDPP=CDPP*PI/(2.*HALFSW)                                          A1072
      CDVL=CDVL*PI/(2.*HALFSW)                                          A1073
      CSL=CSL*PI/(2.*HALFSW)                                            A1074
      CSXL=CSXL*PI/(2.*HALFSW*CREF)                                     A1075
      IF (ABS(CLT).GT.0.0001) XBP=CMT/CLT*CREF                          A1076
      IF (IALP .EQ. 1) GO TO  117                                       A1077
      KK=NCS                                                            A1078
      IF (IWING .NE. 0) KK=IWING                                        A1079
      CDVS=CTIP*SNALP(KK)*2.                                            A1080
      CLVS=CTIP*COS(ALPH(KK))*2.                                        A1081
      CMVS=CTIP*CTX*2./CREF                                             A1082
  117 CONTINUE                                                          A1083
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```
      CDCL2=0.
      IF (LAT.NE.1) GO TO  118
      CONST=PI/(2.*HALFSW)
      CONTB=CONST/(2.*HALFB)
      CY=CY*CONST/BK
      CNB=CNB*CONTB/BK
      CLB=CLB*CONTB/BK
      CYP=CYP*CONST/P
      CNP=CNP*CONTB/P
      CLP=CLP*CONTB/P
      CYR=CYR*CONST/RL
      CNR=CNR*CONTB/RL
      CLRR=CLRR*CONTB/RL
      CLPV=CLPV*CONTB/P
      CYBV=CYBV*CONST/BK
      CYBVSE=CYBVSE*CONST/BK
      CNBV=CNBV*CONTB/BK
      CNBVSE=CNBVSE*CONTB/BK
      CLBV=CLBV*CONTB/BK
      CLBVSE=CLBVSE*CONTB/BK
      CYPV=CYPV*CONST/P
      CYPVSE=CYPVSE*CONST/P
      CNPV=CNPV*CONTB/P
      CNPVSE=CNPVSE*CONTB/P
      CLPVSE=CLPVSE*CONTB/P
      CYRV=CYRV*CONST/RL
      CYRSE=CYRSE*CONST/RL
      CLRRV=CLRRV*CONTB/RL
      CLRVSE=CLRVSE*CONTB/RL
      CNRV=CNRV*CONTB/RL
      CNRVSE=CNRVSE*CONTB/RL
 118  CONTINUE
      IF  (ABS(CLT) .LE. 0.001) GO TO  119
      CDCL2=CDT/(CLT*CLT)
 119  CONTINUE
      IF (LAT.EQ.(-1)) GO TO  121
      CALL BENDIN (NC,CLY,BMR,IWING,BREAK,CBMR,CBTR,NWING,HALFSH,HALFBH,
     1DCOS,DSIN,IWGLT,FTL)
      IF (IWGLT.EQ.2) CBMR=CBMR+FTL*(SOD*ZPRW+COD*YPRW)/HALFB+CBTR
      CBML=CBMR
      CBTL=CBTR
      DO  120 I=1,NCS
 120  BML(I)=BMR(I)
      GO TO  124
 121  IF (LAT.EQ.1) GO TO  124
      DO  122 I=1,NCS
 122  YCON(I)=CLY(I)+CLS(I)
      CALL BENDIN (NC,YCON,BMR,IWING,BREAK,CBMR,CBTR,NWING,HALFSH,HALFBH
     1,DCOS,DSIN,IWGLT,FTL)
      IF (IWGLT.EQ.2) CBMR=CBMR+FTL*(SOD*ZPRW+COD*YPRW)/HALFB+CBTR
      DO  123 I=1,NCS
 123  YCON(I)=CLY(I)-CLS(I)
      CALL BENDIN (NC,YCON,BML,IWING,BREAK,CBML,CBTL,NWING,HALFSH,HALFBH
     1,DCOS,DSIN,IWGLT,FTL)
      IF (IWGLT.EQ.2) CBML=CBML+FTL*(SOD*ZPRW+COD*YPRW)/HALFB+CBTL
 124  CONTINUE
      ALP=ALP*180./PI
```

```
      WRITE (6, 165)
      IF  (IALP .EQ. 1) WRITE (6, 167)
      IF(IALP.EQ.1) GO TO 125
      WRITE(6,166) ALP
      IF(NAL.NE.0) AF=DF(NAL)*180./PI
      IF(NAL.EQ.0) AF=0.
      IF (LAT .EQ. (-1)) WRITE (6, 164) AF
  125 CONTINUE
      WRITE (6, 165)
      IF (LAT.NE.(-1)) WRITE (6, 168)
      IF (LAT.EQ.(-1)) WRITE (6, 169)
      K1=0
      JJ1=0
      HAB=HALFB
      IF (IWGLT .EQ. 1) IWING=NCS
      DO  132 I=1,NCS
      IF  (I .GT. IWING .AND. IWING .NE. 0) HAB=HALFBH
      IF  (I .GT. IWING .AND. IWGLT .EQ. 2) HAB=HALFB
      IF  (NW(2) .EQ. 0) GO TO  126
      I1=I+NCS
      CHORD=CH(I)+CH(I1)
      GO TO  127
  126 CHORD=CH(I)
  127 CONTINUE
      DO  131 J=1,NCW
      JJ=JJ1+J
      KK=K1+J
      IF  (NW(2) .EQ. 0) GO TO  128
      IF  (J .LE. NW(1)) GO TO  128
      LL=LPAN1-NW(1)*I+JJ+NW(2)*(I-1)
      GO TO  129
  128 LL=JJ
  129 CONTINUE
      XI=(XV(LL)-XLE(I))/CHORD
      ETA=YV(LL)/HAB
      IF (LAT.NE.(-1)) GO TO  130
      CPR=(CP(LL)+GAMMA(LL))*2.
      CPL=(CP(LL)-GAMMA(LL))*2.
      WRITE (6, 170) KK,XI,ETA,CPL,CPR
      GO TO  131
  130 CPK=2.*CP(LL)
      WRITE (6, 170) KK,XI,ETA,CPK
  131 CONTINUE
      JJ1=(NCW-NW(2))*I
      K1=K1+NCW
  132 CONTINUE
      WRITE (6, 171)
      HAB=HALFB
      DO  135 I=1,NCS
      IF  (IWGLT .EQ. 0) GO TO  133
      IF  (I .EQ. (JWING+1)) WRITE (6, 173)
      GO TO  134
  133 CONTINUE
      IF  (JWING .NE. 0 .AND. I .EQ. (JWING+1)) WRITE (6, 172)
  134 CONTINUE
      IF  (IWING .NE. 0 .AND. I .GT. IWING) HAB=HALFBH
      IF  (I .GT. IWING .AND. IWGLT .EQ. 2) HAB=HALFB
      YE=YLE(I)/HAB
```

```
      TEM=CLS(I)
      IF (LAT.NE.(-1)) TEM=0.
      CLRT=CL(I)+TEM
      CLLT=CL(I)-TEM
  135 WRITE (6, 174) YE,CLRT,CLLT,CM(I),CT(I),CD(I)
      WRITE (6, 175)
      WRITE (6, 176) CLT
      WRITE (6, 177) CDT
      WRITE (6, 178) CDCL2
      WRITE (6, 179) CMT
      IF (IWING.NE.0) GO TO  136
      IF (ABS(CLT).LE.0.001) GO TO  137
      IF (NGRD.NE.0) GO TO  137
      IF (IDIH.NE.0) GO TO  137
      CALL DRAG (CLT,YBREAK,NC,TFLP,NAL)
      GO TO  137
  136 WRITE (6, 186) CLW
      WRITE (6, 187) CDW
      WRITE (6, 188) CMW
      CLTLW=CLT-CLW
      CLTLH=CLTLW*HALFSW/HALFSH
      CMTAIL=CMT-CMW
      WRITE (6, 189) CLTLW,CLTLH
      WRITE (6, 190)
      WRITE (6, 191) CMTAIL
  137 CONTINUE
      WRITE (6, 192)
      IF  (IALP .EQ. 0) GO TO  138
      WRITE (6, 152)
      CTIP = CTIP*2
      WRITE (6, 182)
      WRITE (6, 180) CLT,CSL,CTIP
      WRITE (6, 181) XBP,XLEBAR,CTX
      WRITE (6, 152)
      GO TO  139
  138 CONTINUE
      WRITE (6, 152)
      WRITE (6, 182)
      WRITE (6, 183) CLPP,CSL,CLVS
      WRITE (6, 184) CDPP,CDVL,CDVS
      WRITE (6, 185) CMT,CSXL,CMVS
      WRITE (6, 152)
  139 CONTINUE
      HW=2.*HALFSW
      HSH=2.*HALFSH
      IF  (LAT .EQ. 0) GO TO  142
      IF(NAL.EQ.0) GO TO 225
      DF(NAL)=DF(NAL)*180./PI
      IF  (LAT .EQ. (-1)) WRITE (6, 203) CLL,DF(NAL),AM
  225 CONTINUE
      IF (LAT.NE.1) GO TO  142
      WRITE (6, 152)
      WRITE (6, 193)
      WRITE (6, 152)
      KA=1
  140 CONTINUE
      IF (KA.GT.3) GO TO  142
      WRITE (6, 195) ALZ
      WRITE (6, 196) AM
```

```
      IF (KA.EQ.2) WRITE (6, 201)
      IF (KA.EQ.3) WRITE (6, 202)
      WRITE (6, 197) CY,CLB,CNB
      WRITE (6, 198) CYP,CLP,CNP
      WRITE (6, 199) CYR,CLRR,CNR
      WRITE (6, 200)
      CYBB=CY
      CLBB=CLB*COSA+CNB*SINA
      CNBB=CNB*COSA-CLB*SINA
      CYPP=CYP*COSA+CYR*SINA
      CLPP=CLP*COSA*COSA+(CLRR+CNP)*COSA*SINA+CNR*SINA*SINA
      CNPP=CNP*COSA*COSA+(CNR-CLP)*COSA*SINA-CLRR*SINA*SINA
      CYRR=CYR*COSA-CYP*SINA
      CLRL=CLRR*COSA*COSA+(CNR-CLP)*SINA*COSA-CNP*SINA*SINA
      CNRR=CNR*COSA*COSA-(CLRR+CNP)*SINA*COSA+CLP*SINA*SINA
      WRITE (6, 197) CYBB,CLBB,CNBB
      WRITE (6, 198) CYPP,CLPP,CNPP
      WRITE (6, 199) CYRR,CLRL,CNRR
      IF (KA.EQ.1) WRITE (6, 152)
      IF (KA.EQ.1) WRITE (6, 194)
      IF (KA.EQ.1) WRITE (6, 152)
      IF (KA.GT.2) GO TO  142
      KA=KA+1
      IF (KA.EQ.2) GO TO  141
      CY=CYBVSE
      CNB=CNBVSE
      CLB=CLBVSE
      CYP=CYPVSE
      CLP=CLPVSE
      CNP=CNPVSE
      CYR=CYRSE
      CLRR=CLRVSE
      CNR=CNRVSE
      GO TO  140
  141 CY=CYBV
      CNB=CNBV
      CLB=CLBV
      CYP=CYPV
      CLP=CLPV
      CNP=CNPV
      CYR=CYRV
      CLRR=CLRRV
      CNR=CNRV
      GO TO  140
  142 CONTINUE
      WRITE (6, 204) HW,HALFB
      WRITE (6, 205)
      WRITE (6, 206)
      HAB=HALFB
      DO  145 I=1,NCS
      IF  (IWGLT .EQ. 0) GO TO  143
      IF  (I .EQ. (JWING+1)) WRITE (6, 208) HW,HALFB
      GO TO  144
  143 CONTINUE
      IF  (JWING .NE. 0 .AND. I .EQ. (JWING+1)) WRITE (6, 207) HSH,HALFB
     1H
  144 CONTINUE
```

```
      IF  (JWING .NE. 0 .AND. I .EQ. (JWING+1)) WRITE (6, 209)
      IF  (IWING .NE. 0 .AND. I .GT. IWING) HAB=HALFBH
      IF  (I .GT. IWING .AND. IWGLT .EQ. 2) HAB=HALFB
      YE=YLE(I)/HAB
  145 WRITE (6, 174) YE,BMR(I),BML(I)
      WRITE (6, 209)
      WRITE (6, 210) CBMR,CBML
      WRITE (6, 209)
      IF (IWING .NE. 0 .AND. IWGLT .NE. 1) WRITE (6, 211) CBTR,CBTL
      IF  (IWGLT .EQ. 1) WRITE (6, 212) CBTR,CBTL
      ALP=ALQ+ALPINC
      ALQ=ALP
      ALZ=ALQ*180./PI
      IF(IWGLT.EQ.1) IWING=JWING
  146 CONTINUE
      NCON=NCON+1
      IF  (NCON .LE. ICASE) GO TO  1
      STOP
C
  147 FORMAT (8F10.6)
  148 FORMAT (8(6X,I4))
  149 FORMAT (10X,8HHALF SW=,E12.5,10X,5HCREF=,E12.5)
  150 FORMAT (13HCASE NUMBER =,I2)
  151 FORMAT (6F10.5)
  152 FORMAT (1H0,40H****************************************)
  153 FORMAT (1H0,10HINPUT DATA)
  154 FORMAT (1H0,36HVORTEX ELEMENT ENDPOINT COORDINATES=)
  155 FORMAT (1H0,26HCONTROL POINT COORDINATES=)
  156 FORMAT (/45H*** CAMBER ORDINATES FOR THE ROOT SECTION ***)
  157 FORMAT (/53H*** CAMBER ORDINATES FOR THE INTERMEDIATE SECTION ***)
  158 FORMAT (/7X,3HX/C,11F10.5)
  159 FORMAT (/7X,3HZ/C,11F10.5)
  160 FORMAT (/44H*** CAMBER ORDINATES FOR THE TIP SECTION ***)
  161 FORMAT (/4X,3HXCP,7X,3HYCP,7X,3HZCP,7X,3HXCP,7X,3HYCP,7X,3HZCP)
  162 FORMAT (/4X,2HX1,8X,2HX2,8X,2HY1,8X,2HY2,8X,2HZ1,6X,2HZ2)
  163 FORMAT (13A6)
  164 FORMAT (/20X,19HAND AILERON ANGLE =,F8.3,2X,4HDEG.)
  165 FORMAT (/20X,42HXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX)
  166 FORMAT (/20X,32HPRESSURE DISTRIBUTION AT ALPHA =,F8.3,2X,4HDEG.)
  167 FORMAT (/20X,43HPRESSURE DISTRIBUTION AT ALPHA = 1.0 RADIAN)
  168 FORMAT (/3X,6HVORTEX,14X,2HXV,17X,2HYV,19X,2HCP)
  169 FORMAT (/3X,6HVORTEX,14X,2HXV,17X,2HYV,17X,8HCP(LEFT),12X, 9HCP(RI
     1GHT))
  170 FORMAT (6X,I3,4(10X,F10.5))
  171 FORMAT (/9X,3HY/S,11X,9HCL(RIGHT),6X,8HCL(LEFT),10X,2HCM,12X,2HCT,
     1 13X,3HCDI)
  172 FORMAT (/4X,42HTHE FOLLOWING ARE THE TAIL CHARACTERISTICS)
  173 FORMAT (/4X,45HTHE FOLLOWING ARE THE WINGLET CHARACTERISTICS)
  174 FORMAT (8(5X,F10.5))
  175 FORMAT (/2X,57H*** THE FOLLOWING ARE ATTACHED POTENTIAL FLOW RESUL
     1TS ***)
  176 FORMAT (/24HTOTAL LIFT COEFFICIENT =,F10.5)
  177 FORMAT (/2X,32HTOTAL INDUCED DRAG COEFFICIENT =,F10.5)
  178 FORMAT (/2X,28HTHE INDUCED DRAG PARAMETER =,F10.5)
  179 FORMAT (/2X,35HTOTAL PITCHING MOMENT COEFFICIENT =,F10.5)
  180 FORMAT (/2X,4HKP =,F10.5,3X,6HKVLE =,F10.5,3X,6HKVSE =,F10.5)
  181 FORMAT (/2X,5HXBP =,F10.5,3X,6HXBLE =,F10.5,3X,6HXBSE =,F10.5)
  182 FORMAT (/66HTHE FOLLOWING PARAMETERS ARE USED IN THE METHOD OF SUC
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     1TION ANALOGY)
183   FORMAT (/2X,5HCLP =,F10.5,3X,7HCLVLE =,F10.5,3X,7HCLVSE =,F10.5)
184   FORMAT (/2X,5HCDP =,F10.5,3X,7HCDVLE =,F10.5,3X,7HCDVSE =,F10.5)
185   FORMAT (/2X,5HCMP =,F10.5,3X,7HCMVLE =,F10.5,3X,7HCMVSE =,F10.5)
186   FORMAT (/5X,27HTHE WING LIFT COEFFICIENT =,F10.5)
187   FORMAT (/5X,35HTHE WING INDUCED DRAG COEFFICIENT =,F10.5)
188   FORMAT (/5X,38HTHE WING PITCHING MOMENT COEFFICIENT =,F10.5)
189   FORMAT (/5X,27HTHE TAIL LIFT COEFFICIENT =,F10.5,21H(BASED ON WING
     1 AREA),,2X,1H=,F10.5,20H(BASED ON TAIL AREA))
190   FORMAT (/5X,65HTHE TAIL PITCHING MOMENT COEFFICIENT BASED ON REFER
     1ENCE WING AREA)
191   FORMAT (/10X,49HAND MEAN WING CHORD, AND REFERRED TO THE Y-AXIS =,
     1 F10.5)
192   FORMAT (/5X,68H(NOTE. THE INDUCED DRAG COMPUTATION IS FOR SYMMETRI
     1CAL LOADING ONLY))
193   FORMAT (/2X,48H*STABILITY DERIVATIVES BY POTENTIAL FLOW THEORY*)
194   FORMAT (/2X,51H*STABILITY DERIVATIVES WITH EDGE VORTEX SEPARATION*
     1)
195   FORMAT (//2X,45H***STABILITY DERIVATIVES EVALUATED AT ALPHA =,F6.3
     1,2X,7HDEGREES)
196   FORMAT (5X,16HAND AT MACH NO.=,F5.2,37H,BASED ON BODY AXES(IN PER
     1RADIAN)***)
197   FORMAT (/5X,5HCYB =,F12.7,2X,5HCLB =,F12.7,2X,5HCNB =,F12.7)
198   FORMAT (/5X,5HCYP =,F12.7,2X,5HCLP =,F12.7,2X,5HCNP =,F12.7)
199   FORMAT (/5X,5HCYR =,F12.7,2X,5HCLR =,F12.7,2X,5HCNR =,F12.7)
200   FORMAT (//2X,51H***STABILITY DERIVATIVES BASED ON STABILITY AXES**
     1*)
201   FORMAT (/5X,48H**INCLUDING THE EFFECT OF LE AND SE VORTEX LIFT*)
202   FORMAT (/5X,40H*INCLUDING THE EFFECT OF LE VORTEX LIFT*)
203   FORMAT (/2X,32HTHE ROLLING MOMENT COEFFICIENT =,F7.4,2X,28HDUE TO
     1AILERON DEFLECTION OF,F8.3,2X,4HDEG.,2X,6HAT M =,F8.3)
204   FORMAT (//63HTHE FOLLOWING BENDING MOMENT COEFFICIENT IS BASED ON
     1Q*S*(B/2),,/15X,9HWHERE S =,F10.5,2X,9HAND B/2 =,F10.5)
205   FORMAT (10X,34H(FOR ATTACHED POTENTIAL FLOW ONLY))
206   FORMAT (/9X,3HY/S,11X,9HBM(RIGHT),6X,8HBM(LEFT))
207   FORMAT (/4X,66HTHE FOLLOWING ARE THE TAIL CHARACTERISTICS BASED ON
     1 TAIL GEOMETRY,,/10X,9HWHERE S =,F10.5,2X,9HAND B/2 =,F10.5)
208   FORMAT (/4X,68HTHE FOLLOWING ARE THE WINGLET CHARACTERISTICS BASED
     1 ON WING GEOMETRY,/10X,9HWHERE S =,F10.5,2X,9HAND B/2 =,F10.5)
209   FORMAT (1H0)
210   FORMAT (68HTHE BENDING MOMENT COEFFICIENT BASED ON WING HALF SPAN
     1AND WING AREA, /15X,18HAT THE WING ROOT =,F10.6,2X,8H(RIGHT),,2X,1
     2H=,F10.6,2X,6H(LEFT))
211   FORMAT (68HTHE BENDING MOMENT COEFFICIENT BASED ON TAIL HALF SPAN
     1AND TAIL AREA,/15X,18HAT THE TAIL ROOT =,F10.6,2X,8H(RIGHT),,2X,1H
     2=,F10.6,2X,6H(LEFT))
212   FORMAT (2X,68HTHE BENDING MOMENT COEFFICIENT BASED ON WING HALF SP
     1AN AND WING AREA/10X,21HAT THE WINGLET ROOT =,F10.6,2X,8H(RIGHT),,
     2 2X,1H=,F10.6,2X,6H(LEFT))
      END
```

```
      FUNCTION ZCDX (X,Y)
C     DEFINE THE CAMBER SLOPE AT ANY X,Y IN CLOSED FORM, WHERE X IS
C     THE NON-DIMENSIONAL CHORDWISE LOCATION W.R.T. L.E. AND Y IS NON-
C     DIMENSIONALIZED W.R.T. HALF SPAN.
C
      A=0.11*(1.-2.*Y)+0.03
      B=-0.0825*(1.-2.*Y)-TWST(Y)-0.101
      C=0.0275*(1.-2.*Y)+0.0075-A-B
      ZCDX=3.*A*X*X+2.*B*X+C
      RETURN
      END
```

```
      FUNCTION TWST (Y)
C     DEFINE THE TWIST DISTRIBUTION IN RADIAN AS A FUNCTION OF NONDIMEN-
C     SIONAL Y.
C
      TWST=-0.05041+3.61004*Y-36.98046*Y*Y+37.79204*Y**3+5.54321*Y**4
     1-15.46932*Y**5-0.00085*Y**6+0.00441*Y**7
      TWST=TWST*3.14159265/180.
      RETURN
      END
```

```
      FUNCTION ZCAM (I,X)
      COMMON /CAMB/ ICAM,IM,XT(3,12),ZC(3,12),AAM(3,11),BBM(3,11),CCM(3,
     111),DDM(3,11)
      K=1
1     IF  (X .GE. XT(I,K) .AND. X .LT. XT(I,K+1)) GO TO  2
      K=K+1
      IF  (K .GE. IM) GO TO  3
      GO TO  1
2     SM=X-XT(I,K)
      ZCAM=3.*AAM(I,K)*SM**2+2.*BBM(I,K)*SM+CCM(I,K)
      GO TO  5
3     IF  (X .LT. XT(I,1)) GO TO  4
      K=IM-1
      GO TO  2
4     K=1
      GO TO  2
5     RETURN
      END
```

```
      FUNCTION ZCR (X)
      COMMON /CAMB/ ICAM,IM,XT(3,12),ZC(3,12),AAM(3,11),B3M(3,11),CCM(3,
     111),DDM(3,11)
      IF  (ICAM .EQ. 1) GO TO  1
C
C   *** CAMBER FUNCTION AT THE ROOT IS DEFINED HERE ***
C
      ZCR=0.
      GO TO  2
 1    ZCR=ZCAM(1,X)
 2    RETURN
      END
```

```
      FUNCTION ZCI (X)
      COMMON /CAMB/ ICAM,IM,XT(3,12),ZC(3,12),AAM(3,11),B3M(3,11),CCM(3,
     111),DDM(3,11)
      IF  (ICAM .EQ. 1) GO TO  1
C
C   *** CAMBER FUNCTION AT THE INTERMEDIATE STATION IS DEFINED HERE ***
C
      ZCI=ZCR(X)
      GO TO  2
 1    ZCI=ZCAM(2,X)
 2    RETURN
      END
```

```
      FUNCTION ZCT (X)
      COMMON /CAMB/ ICAM,IM,XT(3,12),ZC(3,12),AAM(3,11),B3M(3,11),CCM(3,
     111),DDM(3,11)
      IF  (ICAM .EQ. 1) GO TO  1
C
C   *** CAMBER FUNCTION AT THE TIP IS DEFINED HERE ***
C
      ZCT=ZCR(X)
      GO TO  2
 1    ZCT=ZCAM(3,X)
 2    RETURN
      END
```

```
      SUBROUTINE INVN (DQ,CP,AW,LAT,NALP,N,IP)
      DIMENSION DQ(IP,IP), CP(1), AW(1)
C
C     SETDIM IS TO SET UP ARRAY TABLE FOR MATRIX INVERSION, AND MAY NOT
C     BE NEEDED IF OTHER INVERSION ROUTINES ARE USED.
C
      IA=IP
      CALL SETDIM (DQ,IA,IA)
      IF (NALP.EQ.1) GO TO  3
      REWIND 01
      DO  1 I=1,N
      READ (01) (AW(K),K=1,N)
      READ (01) (CP(K),K=1,N)
      DO  1 J=1,N
    1 DQ(I,J)=AW(J)
C
C     DQ IS THE MATRIX TO BE INVERTED. AW IS A WORKING ARRAY. THE
C     INVERTED MATRIX IS RETURNED IN DQ.
C
      CALL HEMINV (DQ,N,AW)
      DO  2 I=1,N
    2 WRITE (02) (DQ(I,K),K=1,N)
    3 IF (LAT.NE.1) GO TO  6
      REWIND 01
      DO  4 I=1,N
      READ (01) (AW(K),K=1,N)
      READ (01) (CP(K),K=1,N)
      DO  4 J=1,N
    4 DQ(I,J)=CP(J)
      CALL HEMINV (DQ,N,AW)
      DO  5 I=1,N
    5 WRITE (02) (DQ(I,K),K=1,N)
    6 RETURN
      END
```

```
      SUBROUTINE THRUST (LPANEL,GAMMA,SNALP,IALP,LPAN1,CAMLE1,CAMLE2,CAM
     1LE3,YTW,IST,IWING,TINP,NGRD,HEIGHT,ATT,YK,DC,DS,CSU,JWING,IWGLT,NC
     2,KZ,P,BK,RL,CNALP)
      DIMENSION GAMMA(1), SNALP(1), YK(1), DC(1), DS(1), CSU(1)
      DIMENSION CNALP(1)
      TAN(X)=SIN(X)/COS(X)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(100),YLE(100),
     1XTE(100),PSI(30),CH(100),XV(200),YV(200),SN(10,3),XN(200,2),YN(200
     2,2),ZN(200,2),WIDTH(7),YCON(51),SWEEP(100),HALFB,SJ(31,7)
      COMMON /AERO/ AM,B,CL(50),CT(50),CD(50),CM(50)
      COMMON /CONST/ NCS,NCW,M1(7),MJW1(2,5),MJW2(2,5),NJW(5),NFP,NW(2)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      LG=1
      NS=NCS
      IF  (NGRD .EQ. 1) LG=2
      ITWST=CM(1)
      IV=CM(50)
      ICAMT=CM(49)
      B1=B
      PI=3.14159265
      CN=NW(1)
      CS=DC(1)
      SS=DS(1)
      ZB=0.
      YB=0.
      YBB=0.
      IPM=1
      DO  29 I=1,NCS
      FCOS=COS(SWEEP(I))
      FTAN=TAN(SWEEP(I))
      CST=CS
      IF  (NW(2) .EQ. 0) GO TO  1
      I1=I+NCS
      CHL=CH(I)+CH(I1)
      GO TO  2
    1 CHL=CH(I)
    2 CONTINUE
      SRT=SQRT(CH(I)/CHL)
      BB=B
      IZ=1
      IW=1
      MM=0
      ISN=1
      NM=NW(1)
      NL=NW(1)
      A=0.
      KP=1+(I-1)*NW(1)
      COSD=DC(1)
      SIND=DS(1)
      ZA=0.
      YA=0.
      YAA=0.
      IPN=1
      DO  17 NN=1,LPANEL
      L=NN
      J=NN-MM
```

```
      FN=NL
      IF  (NN .GE. LPAN1 .AND. NN .LT. LPANEL) GO TO  3
      GO TO  4
3     NL=NW(2)
      IF  (NN .GT. LPAN1 .AND. NN .LE. LPANFL) ISN=2
4     CONTINUE
      X1=XN(NN,1)-XLE(I)
      X2=XN(NN,2)-XLE(I)
      X12=XN(NN,2)-XN(NN,1)
      ISM=2
      FC=1.
      IF  (IV .EQ. 1 .AND. IZ .GT. IWING) ISM=1
      DO  12 K=1,ISM
      IF (KZ.EQ.1.AND.K.EQ.2) FC=-1.
      IF  (K .EQ. 1) GO TO  5
      N1=1
      GO TO  6
5     N1=2
6     CONTINUE
      DO  12 KK=1,LG
      IF (ABS(CS-COSD).GT.0.001) GO TO  7
      IF  (K .EQ. 1 .AND. KK .EQ. 1) GO TO  8
7     CONTINUE
      PS=SIND
      PC=COSD
      QS=SS
      QC=CS
      GO TO  9
8     PS=0.
      PC=1.
      QS=0.
      QC=1.
9     CONTINUE
      Y12=YN(NN,2)-YN(NN,1)
      Z12=ZN(NN,2)-ZN(NN,1)+Y12*PS
      Y12=Y12*PC
      YC=(-1.)**N1*(YBB+(YLE(I)-YB)*QC)
      Y1=YAA+(YN(NN,1)-YA)*PC-YC
      Y2=YAA+(YN(NN,2)-YA)*PC-YC
      XYK=X1*Y12-Y1*X12
      IF  (KK .EQ. 1) GO TO  10
      ZC=-2.*(ZCP(KP)+ZB+(YLE(I)-YB)*QS+HEIGHT)+ZCP(KP)+Z3+(YLE(I)-YB)*W
     1S
      GE=-1.
      FCON=1.
      GO TO  11
10    ZC=ZCP(KP)+ZB+(YLE(I)-YB)*QS
      GE=1.
      FCON=0.
11    Z1=ZN(NN,1)-ZC+ZA+(YN(NN,1)-YA)*PS
      Z2=ZN(NN,2)-ZC+ZA+(YN(NN,2)-YA)*PS
      XZJ=X1*Z12-Z1*X12
      UCOM=-Z1*Y12*(-ATT)*FCON
      YZI=Y1*Z12-Z1*Y12
      ALB1=XYK*XYK+XZJ*XZJ+B1*YZI*YZI
      R1B1=SQRT(X1*X1+B1*Y1*Y1+B1*Z1*Z1)
      R2B1=SQRT(X2*X2+B1*Y2*Y2+B1*Z2*Z2)
```

```
      UUB1=(X2*X12+B1*Y2*Y12+B1*Z2*Z12)/R2B1-(X1*X12+B1*Y1*Y12+B1*Z1*Z12
     1)/R1B1
      G1B1=(1.-X1/R1B1)/(Y1*Y1+Z1*Z1)
      G2B1=(1.-X2/R2B1)/(Y2*Y2+Z2*Z2)
      F1=UUB1*(UCOM+XYK)*GE/ALB1
      F2=(-Y2*G2B1+Y1*G1B1)*GE
      F3=-XZJ*UUB1/ALB1*(-1.)**N1
      F4=(Z2*G2B1-Z1*G1B1)*(-1.)**N1
   12 A=A+((F1+F2)*QC-(F3+F4)*QS)*SN(J,ISN)*GAMMA(NN)*CH(IZ)/FN
     1*FC
      IF  (NN .LT. NM .OR. NN .EQ. LPANEL) GO TO  17
      IW=IW+1
      IZ=IZ+1
      MM=NM
      NM=NM+NL
      IF  (IWING .NE. 0 .AND. IW .EQ. (IWING+1)) GO TO  13
      IF (IW .EQ. (NCS+1)) GO TO  15
      IF  (YLE(IZ) .LT. YK(IPN)) GO TO  17
   13 CONTINUE
      ZA=ZA+(YK(IPN)-YA)*SIND
      YAA=YAA+(YK(IPN)-YA)*COSD
      YA=YK(IPN)
      IF  (IWING .NE. 0 .AND. IW .EQ. (IWING+1)) GO TO  14
      GO TO  16
   14 IF (IWGLT .EQ. 1) GO TO  16
   15 ZA=0.
      YA=0.
      YAA=0.
      IF (IZ .EQ. (NCS+1)) GO TO  16
      IF  (IWGLT .NE. 2) GO TO  16
      ZA=YK(NC-2)*DS(1)
      YAA=YK(NC-2)*DC(1)
      YA=YK(NC-2)
   16 CONTINUE
      IPN=IPN+1
      IF (NN .EQ. LPAN1) IW=1
      IF  (NN .EQ. LPAN1 .OR. NN .EQ. LPANEL) IPN=1
      COSD=DC(IPN)
      SIND=DS(IPN)
   17 CONTINUE
      IF (KZ.EQ.1) GO TO  23
      IF  (IALP .EQ. 1) GO TO  21
      IF  (JWING .NE. 0 .AND. I .GT. JWING) GO TO  22
      IF  (ITWST .EQ. 1) GO TO  19
      IF  (YLE(I) .GT. YTW) GO TO  18
      YX=YTW
      IF  (IST .LE. 2) YX=HALFB
      CAM=CAMLE1-(CAMLE1-CAMLE2)*YLE(I)/YX
      GO TO  20
   18 YX=YTW
      IF  (IST .LE. 2) YX=0.
      CAM=CAMLE2-(CAMLE2-CAMLE3)*(YLE(I)-YX)/(HALFB-YX)
      GO TO  20
   19 YC=YLE(I)/HALFB
      CAM=ZCDX(0.,YC)
   20 ALPT=SNALP(I)
      GO TO  24
```

```
21    CAM=0.
      ALPT=1.
      GO TO  24
22    CAM=0.
      ALPT=SNALP(I)
      IF (ICAMT.EQ.0) GO TO  24
      CAM=CAMLE3
      GO TO  24
23    ZC=ZCP(KP)+ZB+(YLE(I)-YB)*DS(IPM)
      YC=YBB+(YLE(I)-YB)*DC(IPM)
      XC=XLE(I)
      DSS=DS(IPM)
      DCC=DC(IPM)
      WBT=0.
      IF (BK.GT.0.001 .OR. RL.GT.0.001) CALL WBETA (XC,YC,ZC,WBT,DSS,DCC
     1, BK,RL,HALFB,XLL,XTT,NS,IV,IWING,NGRD,HEIGHT,ATT,YK,IWGLT,NC)
      ALPT=P*(ZC*DS(IPM)+YC*DC(IPM))/HALFB+BK*DS(IPM)-RL*XLE(I)/HALFB
     1*DS(IPM)+WBT
      CAM=0.
      CST=1.
24    CONTINUE
      A=A/8.+(ALPT-CAM)*CST
      A=A*SRT
      THRT1=A/(CN*SQRT(FTAN*FTAN+BB))
      CD(I)=THRT1
      IF (KZ.NE.0) GO TO  25
      CT(I)=(PI/2.)*SQRT(1.-AM*AM*FCOS*FCOS)*THRT1*THRT1/FCOS
      FCR=1.
      IF (THRT1.LT.0.) FCR=-1.
      CSU(I)=CT(I)*FCR
25    CONTINUE
      IF  (IWING .NE. 0 .AND. I .EQ. IWING) GO TO  26
      IF  (I .EQ. NCS) GO TO  29
      IF  (YLE(I+1) .LT. YK(IPM)) GO TO  29
26    CONTINUE
      ZB=ZB+(YK(IPM)-YB)*SS
      YBB=YBB+(YK(IPM)-YB)*CS
      YB=YK(IPM)
      IF  (IWING .NE. 0 .AND. I .EQ. IWING) GO TO  27
      GO TO  28
27    IF (IWGLT .EQ. 1) GO TO  28
      ZB=0.
      YB=0.
      YBB=0.
      IF  (IWGLT .NE. 2) GO TO  28
      ZB=YK(NC-2)*DS(1)
      YBB=YK(NC-2)*DC(1)
      YB=YK(NC-2)
28    CONTINUE
      IPM=IPM+1
      CS=DC(IPM)
      SS=DS(IPM)
29    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE BENDIN (NC,CL,BM,IWING,BREAK,SUMM,SUMT,NWING,HALFSH,HAL
     1FBH,DC,DS,IWGLT,FTL)
      DIMENSION A(30), BM(1), H(30), PHI(30), BREAK(1), CL(1)
      DIMENSION DC(1), DS(1)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(100),YLE(100),
     1XTE(100),PSI(30),CH(100),XV(200),YV(200),SN(10,3),XN(200,2),YN(200
     2,2),ZN(200,2),WIDTH(7),YCON(51),SWEEP(100),HALFB,SJ(31,7)
      COMMON /CONST/ NCS,NCW,M1(7),MJW1(2,5),MJW2(2,5),NJW(5),NFP,NW(2)
      PI=3.14159265
      NST=NCS-M1(NC)+1
      SUMF=0.
      SUMM=0.
      SUMS=0.
      FTL=0.
      AREA=HALFSH
      HAB=HALFBH
      IF  (IWGLT .EQ. 1) HAB=HALFB
      IF  (IWGLT .EQ. 2) AREA=HALFSW
      IF  (IWGLT .EQ. 2) HAB=HALFB
      DO  10 I=1,NC
      M=NC-I+1
      IF  (I.NE.NC) DIHEFC=DC(M)*DC(M-1)+DS(M)*DS(M-1)
      IF (I.NE.NC) DIHEFS=DS(M)*DC(M-1)-DC(M)*DS(M-1)
      IF  (I .EQ. NC) DIHEFC=1.
      IF  (I .EQ. NC) DIHEFS=0.
      WSPAN=WIDTH(M)*0.5
      MM=M1(M)-1
      MM1=M1(M)
      FM=MM1
      IF  (M .EQ. NWING) AREA=HALFSW
      IF  (M .EQ. NWING) HAB=HALFB
      DO  1 J=1,MM
      FJ=J
      JJ=NST+J
      CHORD=CH(JJ)
      IF  (NW(2) .NE. 0) CHORD=CHORD+CH(JJ+NCS)
      PHI(J)=FJ*PI/FM
      H(J)=CL(JJ)*CHORD*SJ(J,M)
1     CONTINUE
      DO  3 J=1,MM1
      A(J)=0.
      FJ=J
      DO  2 K=1,MM
2     A(J)=A(J)+H(K)*COS((FJ-1.)*PHI(K))
      IF  (J .EQ. 1) A(J)=A(J)/FM
      IF  (J .NE. 1) A(J)=A(J)*2./FM
3     CONTINUE
      DO  6 K=1,MM1
      JK=MM1-K
      KK=JK+NST
      BSPAN=BREAK(M)-YLE(KK)+WSPAN
      IF  (K .EQ. MM1) GO TO  5
      SUM=A(1)*((PI-PHI(JK))*BSPAN+SIN(PHI(JK))*WSPAN)-0.5*A(2)*WSPAN*(
     1PI-PHI(JK)-SIN(2.*PHI(JK))/2.)-A(2)*SIN(PHI(JK))*BSPAN
      DO  4 J=2,MM
      FJ=J
4     SUM=SUM-BSPAN*A(J+1)*SIN(FJ*PHI(JK))/FJ+WSPAN*0.5*A(J+1)*(SIN((FJ+
```

```
     11.)*PHI(JK))/(FJ+1.)+SIN((FJ-1.)*PHI(JK))/(FJ-1.))
      BM(KK)=WSPAN*SUM/(2.*AREA*HAB)     +SUMM+SUMF*(BREAK(M+1)-YLE(KK))
      GO TO  6
    5 BSPAN=WSPAN
      SUM=(A(1)*BSPAN-0.5*A(2)*WSPAN)*PI
      SUMM=WSPAN*SUM/(2.*AREA*HAB)     +SUMM+SUMF*(BREAK(M+1)-BREAK(M))
    6 CONTINUE

      P1=A(1)*PI*WSPAN/(2.*AREA*HAB)
      SUMF=(SUMF+P1)*DIHEFC-SUMS*DIHEFS
      SUMS=(SUMF+P1)*DIHEFS+SUMS*DIHEFC
      IF  (M .EQ. (NWING+1) .AND. IWING .NE. 0) GO TO  7
      GO TO  8
    7 SUMI=SUMM
      FTL=SUMF
      IF  (IWGLT .EQ. 1) GO TO  8
      SUMM=0.
      SUMF=0.
    8 CONTINUE
      IF  (I .EQ. NC) GO TO  9
      NST=NST-M1(M-1)+1
      GO TO  10
    9 NST=0
   10 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE WING (AW,LPANEL,I,BB,LPAN1,LAT,NGRD,HEIGHT,ATT,CS,SS,YK
     1,DC,DS,IWING,ZB,YB,YBB,IWGLT,NC)
      DIMENSION AW(1)
      DIMENSION BW(200)
      DIMENSION W(2), W1(2), YK(1), DC(1), DS(1), V(2), V1(2)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(100),YLE(100),
     1XTE(100),PSI(30),CH(100),XV(200),YV(200),SN(10,3),XN(200,2),YN(200
     2,2),ZN(200,2),WIDTH(7),YCON(51),SWEEP(100),HALFB,SJ(31,7)
      COMMON /AERO/ AM,B,CL(50),CT(50),CD(50),CM(50)
      COMMON /CONST/ NCS,NCW,M1(7),MJW1(2,5),MJW2(2,5),NJW(5),NFP,NW(2)
      LG=1
      IF  (NGRD .EQ. 1) LG=2
      IV=CM(50)
      W1(1)=0.
      V1(1)=0.
      IPN=1
      B1=BB
      IZ=1
      IW=1
      IFF=1
      ISN=1
      NL=NW(1)
      NN=NW(1)
      COSD=DC(1)
      SIND=DS(1)
      ZA=0.
      YA=0.
      YAA=0.
      DO  16 J=1,LPANEL
      V1(2)=0.
      W1(2)=0.
      W(2)=0.
      V(2)=0.
      MI=J-IFF+1
      FN=NL
      IF  (J .GT. LPAN1 .AND. J .LE. LPANEL) ISN=2
      IF  (J .GE. LPAN1 .AND. J .LT. LPANEL) GO TO  1
      GO TO  2
    1 NL=NW(2)
    2 CONTINUE
      X1=XN(J,1)-XCP(I)
      X2=XN(J,2)-XCP(I)
      X12=XN(J,2)-XN(J,1)
      ISM=2
      IF  (IV .EQ. 1 .AND. IZ .GT. IWING) ISM=1
      DO  11 II=1,ISM
      IF  (II.EQ.1) GO TO  3
      N=1
      GO TO  4
    3 N=2
    4 CONTINUE
      DO  11 KK=1,LG
      IF (ABS(CS-COSD).GT.0.001) GO TO  5
      IF  (II .EQ. 1 .AND. KK .EQ. 1) GO TO  6
    5 CONTINUE
      PS=SIND
      PC=COSD
```

```
      QS=SS
      QC=CS
      GO TO  7
6     PS=0.
      PC=1.
      QS=0.
      QC=1.
7     CONTINUE
      Y12=YN(J,2)-YN(J,1)
      Z12=ZN(J,2)-ZN(J,1)+Y12*PS
      Y12=Y12*PC
      YC=(-1.)**N*(YBB+(YCP(I)-YB)*QC)
      Y1=YAA+(YN(J,1)-YA)*PC-YC
      Y2=YAA+(YN(J,2)-YA)*PC-YC
      XYK=X1*Y12-Y1*X12
      IF  (KK .EQ. 1) GO TO  8
      ZC=-2.*(ZCP(I)+ZB+(YCP(I)-YB)*QS+HEIGHT)+ZCP(I)+ZB+(YCP(I)-YB)*QS
      FCON=1.
      GO TO  9
8     ZC=ZCP(I)+ZB+(YCP(I)-YB)*QS
      FCON=0.
9     CONTINUE
      Z1=ZN(J,1)-ZC+ZA+(YN(J,1)-YA)*PS
      Z2=ZN(J,2)-ZC+ZA+(YN(J,2)-YA)*PS
      XZJ=X1*Z12-Z1*X12
      UCOM=-Z1*Y12*(-ATT)*FCON
      YZI=Y1*Z12-Z1*Y12
      ALB1=XYK*XYK+XZJ*XZJ+B1*YZI*YZI
      R1B1=SQRT(X1*X1+B1*Y1*Y1+B1*Z1*Z1)
      R2B1=SQRT(X2*X2+B1*Y2*Y2+B1*Z2*Z2)
      UUB1=(X2*X12+B1*Y2*Y12+B1*Z2*Z12)/R2B1-(X1*X12+B1*Y1*Y12+B1*Z1*Z12
     1)/R1B1
      G1B1=(1.-X1/R1B1)/(Y1*Y1+Z1*Z1)
      G2B1=(1.-X2/R2B1)/(Y2*Y2+Z2*Z2)
      F1=UUB1*(UCOM+XYK)/ALB1
      F2=-Y2*G2B1+Y1*G1B1
      F3=-XZJ*UUB1/ALB1
      F4=Z2*G2B1-Z1*G1B1
      IF  (KK .EQ. 2) GO TO  10
      W(II)=(F1+F2)*CH(IZ)*SN(MI,ISN)/(8.*FN)
      V(II)=(F3+F4)*CH(IZ)*SN(MI,ISN)/(8.*FN)
      W(II)=W(II)*QC
      V(II)=V(II)*QS
      GO TO  11
10    W1(II)=(F1+F2)*CH(IZ)*SN(MI,ISN)/(8.*FN)
      V1(II)=(F3+F4)*CH(IZ)*SN(MI,ISN)/(8.*FN)
      W1(II)=W1(II)*QC
      V1(II)=V1(II)*QS
11    CONTINUE
      AW(J)=W(1)+W(2)-W1(1)-W1(2)-(V(1)-V(2)+V1(1)-V1(2))
      BW(J)=W(1)-W(2)-W1(1)+W1(2)-(V(1)+V(2)+V1(1)+V1(2))
      IF  (J .LT. NN .OR. J .EQ. LPANEL) GO TO  16
      IZ=IZ+1
      IW=IW+1
      IFF=NN+1
      NN=NN+NL
      IF  (IWING .NE. 0 .AND. IW .EQ. (IWING+1)) GO TO  12
```

```
      IF (IW .EQ. (NCS+1)) GO TO  14
      IF  (YLE(IZ) .LT. YK(IPN)) GO TO  16
12    CONTINUE
      ZA=ZA+(YK(IPN)-YA)*SIND
      YAA=YAA+(YK(IPN)-YA)*COSD
      YA=YK(IPN)
      IF  (IWING .NE. 0 .AND. IW .EQ. (IWING+1)) GO TO  13
      GO TO  15
13    IF (IWGLT .EQ. 1) GO TO  15
14    ZA=0.
      YA=0.
      YAA=0.
      IF (IW .EQ. (NCS+1)) GO TO  15
      IF  (IWGLT .NE. 2) GO TO  15
      ZA=YK(NC-2)*DS(1)
      YAA=YK(NC-2)*DC(1)
      YA=YK(NC-2)
15    CONTINUE
      IPN=IPN+1
      IF  (J .EQ. LPAN1 .OR. J .EQ. LPANEL) IPN=1
      COSD=DC(IPN)
      SIND=DS(IPN)
16    IF  (J .EQ. LPAN1 .OR. J .EQ. LPANEL) IW=1
      WRITE (01) (AW(J),J=1,LPANEL)
      WRITE (01) (BW(J),J=1,LPANEL)
      RETURN
      END
```

```
      SUBROUTINE LATERL (GAMMA,AW,CA,LAT,LPANEL,LPAN1,DF,NAL,YK,DS,DC,IW
     1ING,IWGLT,NALP,ALP,GAMP,GAMB,GAMR,CP,GAMX,BREAK,SWP,CHORDT,YCN,
     2 SNALP,CNALP)
      DIMENSION GAMMA(1), AW(1), CA(1), DF(1), YK(1), DS(1)
      DIMENSION DC(1), GAMP(1), GAMB(1), GAMR(1), CP(1), GAMX(1), BREAK(
     11), SWP(10,15), CHORDT(1), YCN(1), SNALP(1), CNALP(1)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(100),YLE(100),
     1XTE(100),PSI(30),CH(100),XV(200),YV(200),SN(10,3),XN(200,2),YN(200
     2,2),ZN(200,2),WIDTH(7),YCON(51),SWEEP(100),HALFB,SJ(31,7)
      COMMON /CONST/ NCS,NCW,M1(7),MJW1(2,5),MJW2(2,5),NJW(5),NFP,NW(2)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      COMMON /AERO/ AM,B,CL(50),CT(50),CD(50),CM(50)
      COMMON /EXTRA/ CAMLE1,CAMLE2,CAMLE3,YTW,ISP,TINP,NGRD,HEIGHT,ATT,N
     1C,NWING,HALFBH,IPOS,IALP
      COMMON /BETA/ GMAX(50),XTG(50),YTG(50),ZTG(50),B2,NCG,CTG(15),STG(
     115),DIST
      DIMENSION DUM(200), DUMY(200), DUMZ(200), DUMS(200), DUMC(200)
      L1=LPANEL+1
      IV=CM(50)
      PI=3.14159265
      IF (LAT.EQ.1) GO TO  5
      REWIND 01
      READ (01) (DUM(I),I=1,LPANEL)
      READ (01) (AW(I),I=1,LPANEL)
      AW(L1)=0.
      DO  1 I=1,LPANEL
    1 GAMMA(I)=-AW(I+1)/AW(1)
      NJ=LPANEL-1
      MM=NW(1)
      NN=NW(1)
      DO  4 IJ=2,LPANEL
      READ (01) (DUM(K),K=1,LPANEL)
      READ (01) (AW(K),K=1,LPANEL)
      AW(L1)=0.
      IF  (IJ .GE. MJW1(1,NAL) .AND. IJ .LE. MJW2(1,NAL)) GO TO  2
      IF  (IJ .GE. MJW1(2,NAL) .AND. IJ .LE. MJW2(2,NAL)) AW(L1)=DF(NAL)
      GO TO  3
    2 IF  (IJ .EQ. MM) AW(L1)=0.5*DF(NAL)
    3 IK=IJ
      CALL VMSEQN (NJ,IK,AW,GAMMA,CA)
      NJ=NJ-1
      IF (IJ.GE.LPAN1.AND.IJ.LT.LPANEL) NN=NW(2)
      IF (IJ.LT.MM) GO TO  4
      MM=MM+NN
    4 CONTINUE
      RETURN
    5 KZ=1
      BK=0.
      P=0.1
      RL=0.
      NWW=NW(1)
      IST=0
      IF (NW(2).NE.0) NWW=NW(2)
      IF (NW(2).NE.0) IST=LPAN1
      DO  8 I=1,NCS
      GMAX(I)=0.
```

```
      MK=IST+(I-1)*NWW
      IK=I
      IF (NW(2).NE.0) IK=I+NCS
      DO  7 LQ=1,NWW
      LP=MK+LQ
      AA=1.
      DO  6 LS=1,NWW
      LN=MK+LS
      IF (LS.EQ.LQ) GO TO  6
      AA=AA*(XTE(IK)-XV(LN))/(XV(LP)-XV(LN))
    6 CONTINUE
    7 GMAX(I)=GMAX(I)+AA*GAMX(LP)
    8 CONTINUE
      NCG=8
      FN=NCG
      DIST=DIST*2.
      DO  9 I=1,NCG
      FI=I
      AG=(2.*FI-1.)*PI/(2.*FN)
      CTG(I)=COS(AG)
    9 STG(I)=SIN(AG)
      DO  33 I=1,3
      MM=NW(1)
      NN=NW(1)
      IPN=1
      IPM=0
      IZ=1
      IW=1
      YB=0.
      ZB=0.
      YBB=0.
      IF (I.NE.1) REWIND 03
      DO  15 IJ=1,LPANEL
      YC=YBB+(YCP(IJ)-YB)*DC(IPN)
      ZC=ZCP(IJ)+ZB+(YCP(IJ)-YB)*DS(IPN)
      XC=XCP(IJ)
      WBT=0.
      DSS=DS(IPN)
      DCC=DC(IPN)
      IZ=IW
      IF (I.NE.1) CALL WBETA (XC,YC,ZC,WBT,DSS,DCC,BK,RL,HALFB,XLL,XTT,N
     1CS,IV,IWING,NGRD,HEIGHT,ATT,YK,IWGLT,NC)
      CA(IJ)=P*(ZC*DS(IPN)+YC*DC(IPV))/HALFB+BK*DS(IPN)- RL*XCP(IJ)/
     1HALFB*DS(IPN)+WBT
      IF (I.NE.1) GO TO  10
      DUM(IJ)=DC(IPN)
      DUMS(IJ)=DS(IPN)
      DUMC(IJ)=CNALP(IZ)
      DUMY(IJ)=YC
      DUMZ(IJ)=ZC
   10 CONTINUE
      IF  (IJ .GE. LPAN1 .AND. IJ .LT. LPANEL) NN=NW(2)
      IF  (IJ .LT. MM) GO TO  15
      MM=MM+NN
      IZ=IZ+1
      IW=IW+1
      IF  (IWING .NE. 0 .AND. IW .EQ. (IWING+1)) GO TO  11
      IF (IW.EQ.(NCS+1)) GO TO  13
```

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      IF  (YLE(IZ) .LT. YK(IPN)) GO TO  15
11    CONTINUE
      ZB=ZB+(YK(IPN)-YB)*DS(IPN)
      YBB=YBB+(YK(IPN)-YB)*DC(IPN)
      YB=YK(IPN)
      IF (IWING.NE.0.AND.IW.EQ.(IWING+1)) GO TO  12
      GO TO  14
12    IF (IWGLT.EQ.1) GO TO  14
13    ZB=0.
      YB=0.
      YBB=0.
      IF (IW.EQ.(NCS+1)) GO TO  14
      IF (IWGLT.NE.2) GO TO  14
      ZB=YK(NC-2)*DS(1)
      YBB=YK(NC-2)*DC(1)
      YB=YK(NC-2)
14    CONTINUE
      IPN=IPN+1
      IF  (IJ .EQ. LPAN1 .OR. IJ .EQ. LPANEL) IPN=1
15    IF  (IJ .EQ. LPAN1 .OR. IJ .EQ. LPANEL) IW=1
      IF (I.EQ.1) GO TO  17
      REWIND 02
      IF (NALP.EQ.1) GO TO  17
      DO  16 K=1,LPANEL
16    READ (02) (AW(J),J=1,LPANEL)
17    DO  19 J=1,LPANEL
      GAMMA(J)=0.
      READ (02) (AW(K),K=1,LPANEL)
      DO  18 K=1,LPANEL
18    GAMMA(J)=GAMMA(J)-AW(K)*CA(K)
19    CONTINUE
      CALL THRUST (LPANEL,GAMMA,SNALP,IALP,LPAN1,CAMLE1,CAMLE2,CAMLE3,YT
     1W,ISP,IWING,TINP,NGRD,HEIGHT,ATT,YK,DC,DS,CA,IWING,IWGLT,NC,KZ,
     2 P,BK,RL,CNALP)
      CALL GAMAX (AW,CA,LPAN1,LPANEL,GAMMA,NC,BREAK,SWP,CHORDT,IWING,
     1 NWING,HALFBH,YCN,SLOPE,CTX,IWGLT,IPOS,KZ)
      IF (I.EQ.1) GO TO  23
      IF (I.EQ.2) GO TO  27
      DO  20 K=1,LPANEL
20    GAMR(K)=GAMMA(K)*DUMC(K)-YV(K)/HALFB*CP(K)*RL-XV(K)/HALFB
     1*GAMX(K)*RL*DUM(K)
      DO  21 K=1,NCS
21    Y(10,K)=CD(K)
      DO  22 K=1,NCW
      XL(1,K)=CL(K)
22    IF (IWING.NE.0) XL(2,K)=CM(K)
      GO TO  31
23    DO  24 K=1,LPANEL
24    GAMP(K)=GAMMA(K)*DUMC(K)+DUM(K)*P*DUMZ(K)/HALFB*GAMX(K)-DUMS(K)*P
     1*DUMY(K)/HALFB*GAMX(K)
      DO  25 K=1,NCS
25    Y(4,K)=CD(K)
      DO  26 K=1,NCW
      Y(5,K)=CL(K)
26    IF (IWING.NE.0) Y(6,K)=CM(K)
      GO TO  31
27    DO  28 K=1,LPANEL
```

```
28    GAMB(K)=GAMMA(K)*DUMC(K)+BK*GAMX(K)*DUM(K)
      DO  29 K=1,NCS
29    Y(7,K)=CD(K)
      DO  30 K=1,NCW
      Y(8,K)=CL(K)
30    IF (IWING.NE.0) Y(9,K)=CM(K)
31    IF (I.EQ.1) GO TO  32
      IF (I.EQ.3) GO TO  33
      RL=0.1
      BK=0.
      GO TO  33
32    BK=0.1
      P=0.
33    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE WBETA (X,Y,Z,WN,DSS,DCC,BK,RL,HALFB,DS,DC,NCS,IV,IWING,
     1 NGRD,HEIGHT,ATT,YK,IWGLT,NC)
      DIMENSION DS(1), DC(1), CON(2), W(2), V(2), YK(1)
      COMMON /BETA/ GMAX(50),XTG(50),YTG(50),ZTG(50),B2,NCG,CTG(15),STG(
     115),DIST
      DATA CON/1.,-1./
      DIST2=0.5*DIST
      FN=NCG
      WW=0.
      VV=0.
      LG=1
      IF (NGRD.EQ.1) LG=2
      ZA=0.
      YA=0.
      YAA=0.
      IPN=1
      DO  13 I=1,NCS
      IF (BK.GT.0.01) PR=BK*DC(I)
      ISM=2
      IF (IV.EQ.1.AND.I.GT.IWING) ISM=1
C     J=2 FOR LEFT WING EFFECT
      DO  8 J=1,ISM
      W(J)=0.
      V(J)=0.
      DO  8 K=1,NCG
      DO  8 KK=1,LG
      YC=Y*CON(J)
      QX1=XTG(I)+DIST2*(1.-CTG(K))
      QX2=XTG(I+1)+DIST2*(1.-CTG(K))
      IF (RL.GT.0.01) PR=-RL*0.5*(QX1+QX2)/HALFB
      IF (RL.GT.0.01) GO TO  6
      X1=QX1-X
      X2=QX2-X
      X12=QX2-QX1
      IF (ABS(DCC-DC(I)).GT.0.001) GO TO  1
      IF (J.EQ.1.AND.KK.EQ.1) GO TO  2
    1 PS=DS(I)
      PC=DC(I)
      GO TO  3
    2 PS=0.
      PC=1.
    3 CONTINUE
      Y12=YTG(I+1)-YTG(I)
      Z12=ZTG(I+1)-ZTG(I)+Y12*PS
      Y12=Y12*PC
      Y1=YAA+(YTG(I)-YA)*PC-YC
      Y2=YAA+(YTG(I+1)-YA)*PC-YC
      XYK=X1*Y12-Y1*X12
      IF (KK.EQ.1) GO TO  4
      ZC=-2.*(Z+HEIGHT)+Z
      GE=-1.
      FCON=1.
      GO TO  5
    4 ZC=Z
      GE=1.
      FCON=0.
    5 Z1=ZTG(I)-ZC+ZA+(YTG(I)-YA)*PS
```

```
      Z2=ZTG(I+1)-ZC+ZA+(YTG(I+1)-YA)*PS
      XZJ=X1*Z12-Z1*X12
      UCOM=-Z1*Y12*(-ATT)*FCON
      YZI=Y1*Z12-Z1*Y12
      ALB1=XYK*XYK+XZJ*XZJ+B2*YZI*YZI
      RB1=SQRT(X1*X1+B2*Y1*Y1+B2*Z1*Z1)
      RB2=SQRT(X2*X2+B2*Y2*Y2+B2*Z2*Z2)
      UB=(X2*X12+B2*Y2*Y12+B2*Z2*Z12)/RB2-(X1*X12+B2*Y1*Y12+B2*Z1*Z12)/
     1RB1
      GB1=(1.-X1/RB1)/(Y1*Y1+Z1*Z1)
      GB2=(1.-X2/RB2)/(Y2*Y2+Z2*Z2)
      F1=UB*(UCOM+XYK)*GE/ALB1
      F2=(-Y2*GB2+Y1*GB1)*GE
      F3=-XZJ*UB/ALB1*CON(J)
      F4=(Z2*GB2-Z1*GB1)*CON(J)
      P1=-(F3+F4)*STG(K)*GMAX(I)*DIST/FN
      P2=-(F1+F2)*STG(K)*GMAX(I)*DIST/FN
      WRITE (03) P1,P2
      GO TO  7
    6 READ (03) P1,P2
    7 V(J)=V(J)+P1*PR
    8 W(J)=W(J)+P2*PR
      IF (RL.GT.0.01) GO TO  12
      IF (IWING.NE.0.AND.I.EQ.IWING) GO TO  9
      IF (YTG(I+1).LT.YK(IPN)) GO TO  12
    9 ZA=ZA+(YK(IPN)-YA)*DS(I)
      YAA=YAA+(YK(IPN)-YA)*DC(I)
      YA=YK(IPN)
      IF (IWING.NE.0 .AND. I.EQ.IWING) GO TO  10
      GO TO  11
   10 IF (IWGLT.EQ.1) GO TO  11
      ZA=0.
      YA=0.
      YAA=0.
      IF (IWGLT.NE.2) GO TO  11
      ZA=YK(NC-2)*DS(1)
      YAA=YK(NC-2)*DC(1)
      YA=YK(NC-2)
   11 IPN=IPN+1
   12 CONTINUE
      WW=WW+(W(1)-W(2))/8.
      VV=VV+(V(1)-V(2))/8.
   13 CONTINUE
      WN=WW*DCC-VV*DSS
      RETURN
      END
```

```
      SUBROUTINE BACKWH (X,Y,Z,LPANEL,B,LPAN1,NW,GAMMA,VX,LAT,CD,SD,YK,
     1DC,DS,VT,IWING,ZB,YB,YBB,NCS,IWGLT,NC)
      DIMENSION NW(1), GAMMA(1), U(2), YK(1), DC(1), DS(1)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(100),YLE(100),
     1XTE(100),PSI(30),CH(100),XV(200),YV(200),SN(10,3),XN(200,2),YN(200
     2,2),ZN(200,2),WIDTH(7),YCON(51),SWEEP(100),HALFB,SJ(31,7)
      B1=B
      IZ=1
      IFF=1
      ISN=1
      IPN=1
      IW=1
      COSD=DC(1)
      SIND=DS(1)
      ZA=0.
      YA=0.
      YAA=0.
      MM=NW(1)
      NN=NW(1)
      VX=0.
      VT=0.
      DO  6  J=1,LPANEL
      JJ=J
      MI=J-IFF+1
      FN=NN
      IF  (J .GT. LPAN1 .AND. J .LE. LPANEL) ISN=2
      IF  (J .GE. LPAN1 .AND. J .LT. LPANEL) NN=NW(2)
      X1=XN(J,1)-X
      X2=XN(J,2)-X
      X12=XN(J,2)-XN(J,1)
      Y12=YN(J,2)-YN(J,1)
      Z12=ZN(J,2)-ZN(J,1)+Y12*SIND
      Y12=Y12*COSD
      Z1=ZN(J,1)-(Z+ZB+(Y-YB)*SD)+ZA+(YN(J,1)-YA)*SIND
      Z2=ZN(J,2)-(Z+ZB+(Y-YB)*SD)+ZA+(YN(J,2)-YA)*SIND
      XZJ=X1*Z12-Z1*X12
      DO  1  II=1,2
      FCP=1.
      IF  (II .EQ. 2) FCP=-1.
      YC=FCP*(YBB+(Y-YB)*CD)
      Y1=YAA+(YN(J,1)-YA)*COSD-YC
      Y2=YAA+(YN(J,2)-YA)*COSD-YC
      XYK=X1*Y12-Y1*X12
      YZI=Y1*Z12-Z1*Y12
      ALB1=XYK*XYK+XZJ*XZJ+B1*YZI*YZI
      R1B1=SQRT(X1*X1+B1*Y1*Y1+B1*Z1*Z1)
      R2B1=SQRT(X2*X2+B1*Y2*Y2+B1*Z2*Z2)
      UUB1=(X2*X12+B1*Y2*Y12+B1*Z2*Z12)/R2B1-(X1*X12+B1*Y1*Y12+B1*Z1*Z12
     1)/R1B1
      G1=(1.-X1/R1B1)/(Y1*Y1+Z1*Z1)
      G2=(1.-X2/R2B1)/(Y2*Y2+Z2*Z2)
      F1=UUB1*XYK/ALB1
      F2=-Y2*G2+Y1*G1
      F4=-XZJ*UUB1/ALB1
      F5=Z2*G2-Z1*G1
      F12=-(F1+F2)
      F45=F4+F5
```

```
      IF  (LAT .EQ. 0) F45=F45*FCP
      IF  (LAT .NE. 0) F12=F12*FCP
      F3=UUB1*YZI/ALB1
      IF  (LAT .NE. 0) F3=F3*FCP
      U(II)=F3*CH(IZ)*SN(MI,ISN)*GAMMA(JJ)/(8.*FN)
      VT=VT+(F12*SD+F45*CD)*CH(IZ)*SN(MI,ISN)*GAMMA(JJ)/(8.*FN)
1     CONTINUE
      VX=U(1)+U(2)+VX
      IF  (J .LT. MM) GO TO  6
      IZ=IZ+1
      IW=IW+1
      IFF=MM+1
      MM=MM+NN
      IF  (IWING .NE. 0 .AND. IW .EQ. (IWING+1)) GO TO  2
      IF (IW .EQ. (NCS+1)) GO TO  4
      IF  (YLE(IZ) .LT. YK(IPN)) GO TO  6
2     CONTINUE
      ZA=ZA+(YK(IPN)-YA)*SIND
      YAA=YAA+(YK(IPN)-YA)*COSD
      YA=YK(IPN)
      IF  (IWING .NE. 0 .AND. IW .EQ. (IWING+1)) GO TO  3
      GO TO  5
3     IF (IWGLT .EQ. 1) GO TO  5
4     ZA=0.
      YA=0.
      YAA=0.
      IF (IW .EQ. (NCS+1)) GO TO  5
      IF  (IWGLT .NE. 2) GO TO  5
      ZA=YK(NC-2)*DS(1)
      YAA=YK(NC-2)*DC(1)
      YA=YK(NC-2)
5     CONTINUE
      IPN=IPN+1
      IF  (J .EQ. LPAN1 .OR. J .EQ. LPANEL) IPN=1
      COSD=DC(IPN)
      SIND=DS(IPN)
6     IF  (J .EQ. LPAN1 .OR. J .EQ. LPANEL) IW=1
      RETURN
      END
```

```
      SUBROUTINE PANEL (XXL,YL,XXT,CPCWL,CPSWL,NSW,IPANEL,LPANEL,SWP,LR,
     1 ZS,L)
      DIMENSION XXL(1), YL(1), XXT(1), CPCWL(1), CPSWL(1)
      DIMENSION SWP(10,15)
      COMMON /SCHEME/ C(2),X(10,41),Y(10,41),SLOPE(15),XL(2,15),XTT(41),
     1XLL(41)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(100),YLE(100),
     1XTE(100),PSI(30),CH(100),XV(200),YV(200),SN(10,3),XN(200,2),YN(200
     2,2),ZN(200,2),WIDTH(7),YCON(51),SWEEP(100),HALFB,SJ(31,7)
      COMMON /CONST/ NCS,NCW,M1(7),MJW1(2,5),MJW2(2,5),NJW(5),NFP,NW(2)
      COMMON /BETA/ GMAX(50),XTG(50),YTG(50),ZTG(50),B2,NCG,CTG(15),STG(
     115),DIST
      PI=3.14159265
      NSW1=NSW-1
      NR=B2
      DO  1 I=1,2
      C(I)=XXT(I)-XXL(I)
      DO  1 J=1,NCW
    1 XL(I,J)=XXL(I)+CPCWL(J)*C(I)/100.
      SPAN=YL(2)-YL(1)
      DO  2 J=1,NCW
      PSI(J)=0.5*(1.-COS(FLOAT(J)*PI/FLOAT(NCW)))
      SLOPE(J)=(XL(2,J)-XL(1,J))/SPAN
    2 SWP(J,LR)=ATAN(SLOPE(J))
      SPN=(XXT(2)-XXT(1))/SPAN
      DO  5 K=1,NSW
      YK=CPSWL(K)*SPAN/100.
      IF (NW(2).EQ.0) GO TO  3
      IF (L.EQ.1) GO TO  4
    3 KK=NR+K
      YTG(KK)=YL(1)+YK
      XTG(KK)=XXT(1)+SPN*(YTG(KK)-YL(1))
      ZTG(KK)=ZS
    4 CONTINUE
      DO  5 J=1,NCW
      Y(J,K)=YK+YL(1)
      X(J,K)=XL(1,J)+SLOPE(J)*(Y(J,K)-YL(1))
    5 CONTINUE
      XLL(1)=XXL(1)
      XTT(1)=XXT(1)
      DO  6 I=2,NSW
      XLL(I)=XLL(I-1)+(XXL(2)-XXL(1))*(Y(1,I)-Y(1,I-1))/SPAN
    6 XTT(I)=XTT(I-1)+(XXT(2)-XXT(1))*(Y(1,I)-Y(1,I-1))/SPAN
      DO  8 K=1,NSW1
      KK=NCS+K
      YLE(KK)=YCON(K)*SPAN+YL(1)
      XLE(KK)=XLL(K)+(XLL(K+1)-XLL(K))*(YLE(KK)-Y(1,K))/(Y(1,K+1)-Y(1,K)
     1)
      XTE(KK)=XTT(K)+(XTT(K+1)-XTT(K))*(YLE(KK)-Y(1,K))/(Y(1,K+1)-Y(1,K)
     1)
      CH(KK)=XTE(KK)-XLE(KK)
      SWEEP(KK)=ATAN((XXL(2)-XXL(1))/SPAN)
      DO  8 J=1,NCW
      NPANEL=(K-1)*NCW +J-1+IPANEL
      DO  7 I=1,2
      KI1=K+I-1
      XN(NPANEL,I)=X(J,KI1)
```

```
      YN(NPANEL,I)=Y(J,KI1)
      ZN(NPANEL,I)=ZS
 7    CONTINUE
      XCP(NPANEL)=XLE(KK)+PSI(J)*CH(KK)
      YCP(NPANEL)=YLE(KK)
      ZCP(NPANEL)=ZS
      XV(NPANEL)=XLE(KK)+CPCWL(J)*CH(KK)/100.
      YV(NPANEL)=YLE(KK)
 8    CONTINUE
      LPANEL=NPANEL
      RETURN
      END
```

```
      SUBROUTINE DRAG (CLT,YBREAK,NC,TFLP,NAL)
      DIMENSION ALPHI(50), YBREAK(1), TFLP(1), XK(50), YK(50)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(100),YLE(100),
     1XTE(100),PSI(30),CH(100),XV(200),YV(200),SN(10,3),XN(200,2),YN(200
     2,2),ZN(200,2),WIDTH(7),YCON(51),SWEEP(100),HALFB,SJ(31,7)
      COMMON /AERO/ AM,B,CL(50),CT(50),CD(50),CM(50)
      COMMON /CONST/ NCS,NCW,M1(7),MJW1(2,5),MJW2(2,5),NJW(5),NFP,NW(2)
      M=41
      PI=3.14159265
      NS=(M+1)/2-1
      MM1=M-1
      FM=M
      DO  1 I=1,NS
      FI=I
      J=M-I
      XK(I)=SIN(FI*PI/FM)
      XK(J)=XK(I)
      YK(I)=-COS(FI*PI/FM)
    1 YK(J)=-YK(I)
      DO  2 I=1,NCS
    2 CM(I)=SQRT(1.-(YLE(I)/HALFB)**2)
      IC=1
      BREAK=YBREAK(1)
      MST=1
      MEND=M1(1)-1
      DO  8 I=1,NS
      YCON(I)=0.
      CD(I)=0.
      II=NS+I
      BB=YK(II)*HALFB
      IF  (BB .LE. BREAK) GO TO  3
      NK=M1(IC)-1
      IC=IC+1
      NQ=M1(IC)-1
      BREAK=YBREAK(IC)
      MST=MST+NK
      MEND=MEND+NQ
    3 CONTINUE
      DO  7 J=MST,MEND
      IF  (NW(2) .EQ. 0) GO TO  4
      J1=J+NCS
      CHORD=CH(J)+CH(J1)
      GO TO  5
    4 CHORD=CH(J)
    5 CONTINUE
      A=1.
      DO  6 K=MST,MEND
      IF  (K .EQ. J) GO TO  6
      A=A*(BB-YLE(K))/(YLE(J)-YLE(K))
    6 CONTINUE
      CD(I)=CD(I)+A*CL(J)*CM(J)
    7 YCON(I)=YCON(I)+A*CHORD
      CD(I)=CD(I)/SQRT(1.-YK(II)**2)
    8 CONTINUE
      DO  14 I=1,NS
      ALPHI(I)=0.
      IN=NS+I
```

```
      DO  13 J=1,MM1
      IF  (J .EQ. IN) GO TO  9
      INDEX=IABS(J-IN)
      FACTOR=2.*((-1.)**INDEX-1.)*XK(J)/(FM*(YK(J)-YK(IN))**2)
      GO TO  10
9     FACTOR=FM/XK(J)
10    IF  (J .GT. NS) GO TO  11
      JJ=M-J-NS
      GO TO  12
11    JJ=J-NS
12    ALPHI(I)=ALPHI(I)+CD(JJ)*YCON(JJ)*FACTOR
13    CONTINUE
      ALPHI(I)=ALPHI(I)/(16.*HALFB)
14    CONTINUE
      CDI=0.
      DO  15 I=1,NS
      IN=NS+I
15    CDI=CDI+CD(I)*YCON(I)*ALPHI(I)*XK(IN)
      CDI=CDI*HALFB*PI/(HALFSW*FM)
      CDL2=CDI/(CLT*CLT)
      WRITE (6, 16) CDI
      WRITE (6, 17) CDL2
      RETURN
C
16    FORMAT (/2X,23HFAR-FIELD INDUCED DRAG=,F10.5)
17    FORMAT (/2X,33HFAR-FIELD INDUCED DRAG PARAMETER=,F10.5)
      END
```

```
      SUBROUTINE VMSEQN (NC1,K,AA,A,CA)
      DIMENSION AA(1), CA(1), A(1)
      NC=K*NC1
      SUM1=0.
      K1=K-1
      JJ=1
      DO  1 J=1,K1
      SUM1=SUM1+AA(J)*A(JJ)
 1    JJ=JJ+NC1+1
      SUM1=SUM1+AA(K)
      DO  3 I=1,NC1
      SUM2=0.
      JJ=I+1
      DO  2 J=1,K1
      SUM2=SUM2+AA(J)*A(JJ)
 2    JJ=JJ+NC1+1
      KK=K+I
      SUM2=SUM2+AA(KK)
 3    CA(I)=-SUM2/SUM1
      M=1
      L=0
      KNC=(K-1)*NC1
      DO  6 I=1,NC
      IF  (I.GT.KNC) GO TO  5
      MM=(M-1)*NC1+1
      IF  (I.EQ.MM) GO TO  7
 4    KK=KK+1
      IL=I+L
      A(I)=CA(KK)*BASE+A(IL)
      GO TO  6
 5    II=I-KNC
      A(I)=CA(II)
 6    CONTINUE
      GO TO  8
 7    II=MM+M-1
      BASE=A(II)
      KK=0
      L=L+1
      M=M+1
      GO TO  4
 8    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE GAMAX (AW,CA,LPAN1,LPANEL,GAMMA,NC,BREAK,SWP,CHORDT,IWI
     1NG,NWING,HALFBH,YCN,CTIP,CTX,IWGLT,IPOS,KZ)
      DIMENSION AW(1), CA(1), GAMMA(1), BREAK(1)
      DIMENSION SWP(10,15), CTIP(1)
      DIMENSION G(10,2), CHORDT(1), YCN(1)
      DIMENSION A(15), F(15), THETA(15)
      COMMON /GEOM/ HALFSW,XCP(200),YCP(200),ZCP(200),XLE(100),YLE(100),
     1XTE(100),PSI(30),CH(100),XV(200),YV(200),SN(10,3),XN(200,2),YN(200
     2,2),ZN(200,2),WIDTH(7),YCON(51),SWEEP(100),HALFB,SJ(31,7)
      COMMON /AERO/ AM,B,CL(50),CT(50),CD(50),CM(50)
      COMMON /CONST/ NCS,NCW,M1(7),MJW1(2,5),MJW2(2,5),NJW(5),NFP,NW(2)
      PI=3.14159265
      IPS1=IPOS/10
      IPS2=IPOS-IPS1*10
      NK=0
      MK=LPAN1
      DO  8 I=1,NCS
      NA=1
      SUMI=0.
      NWW=NW(1)
      ISN=1
      FN=NW(1)
    1 N1=NWW+1
      DO  2 J=1,NWW
      KK=NK+J
      IF  (NA .EQ. 2) KK=MK+J
      FJ=J
      THETA(J)=(2.*FJ-1.)*PI/(2.*FN)
      F(J)=GAMMA(KK)*SN(J,ISN)
    2 CONTINUE
      THETA(N1)=PI
      DO  4 J=1,N1
      A(J)=0.
      FJ=J
      DO  3 K=1,NWW
    3 A(J)=A(J)+F(K)*COS((FJ-1.)*THETA(K))
      IF  (J .EQ. 1) A(J)=A(J)/FN
      IF  (J .NE. 1) A(J)=A(J)*2./FN
    4 CONTINUE
      DO  6 K=1,N1
      KK=NK+K
      IF  (NA .EQ. 2) KK=MK+K
      SUM=A(1)*THETA(K)
      DO  5 J=1,NWW
      FJ=J
    5 SUM=SUM+A(J+1)*SIN(FJ*THETA(K))/FJ
      IZ=I
      IF  (NA .EQ. 2) IZ=I+NCS
      SUM=-0.5*CH(IZ)*SUM+SUMI
      IF  (NA .EQ. 1 .AND. K .EQ. N1) GO TO  6
      AW(KK)=SUM
    6 CONTINUE
      IF  (NA .EQ. 2) GO TO  7
      IF  (NCW .EQ. NW(1)) GO TO  7
      NWW=NW(2)
      NA=NA+1
      ISN=ISN+1
```

```
      FN=NWW
      SUMI=SUM
      GO TO  1
 7    CONTINUE
      NK=NK+NW(1)
 8    MK=MK+NW(2)
      NK1=0
      NK2=LPAN1
      DO  38 I=1,NC
      M=M1(I)
      FM=M
      MM=M-1
      DO  37 J=1,NCW
      IF  (IWING .NE. 0 .AND. I .EQ. NWING) GO TO  9
      IF  (I .EQ. NC) GO TO  9
      GO TO  10
 9    CONTINUE
      IW=1
      IPZ=1
      IF  (I .GT. NWING) IW=2
      IF  (I .GT. NWING) IPZ=3
      G(J,IW)=0.
10    CONTINUE
      IK=0
      IS=0
      HAB=HALFB
      AA=-1.
      BB=1.
      FT=1.
      BR=BREAK(I)
      IF  (J .GT. NW(1)) GO TO  15
      NK=NK1
      LK=0
      IR1=I
      JJ=J
      MK=NW(1)
      IF  (I .GT. NWING) GO TO  11
      IF  (IPS1 .EQ. 2) IS=1
      IF  (IPS1 .EQ. 1) GO TO  12
      IF  (IPS1 .EQ. 2) GO TO  13
      GO TO  17
11    IF  (IPS2 .EQ. 1) GO TO  14
12    HAB=HALFBH
      IF  (IWGLT .EQ. 2) HAB=WIDTH(I)
      IF  (IWGLT .EQ. 2) BR=0.
      GO TO  17
13    HAB=HALFB
      GO TO  17
14    HC=HALFBH-HALFB
      AA=HALFB/HC
      BB=HALFBH/HC
      HAB=HC
      IK=1
      FT=2.
      GO TO  17
15    NK=NK2
      MK=NW(2)
```

```
      LK=NW(1)
      IR1=I+NC
      JJ=J-NW(1)
      IF  (I .GT. NWING) GO TO  16
      IF  (IPS1 .EQ. 1) IS=1
      IF  (IPS1 .EQ. 1) GO TO  13
      IF  (IPS1 .EQ. 2) GO TO  12
      GO TO  17
16    IF  (IPS2 .EQ. 2) GO TO  14
      GO TO  12
17    IF  (J .EQ. 1 .OR. J .EQ. (NW(1)+1)) GO TO  18
      GO TO  20
18    CONTINUE
      DO  19 JP=1,MM
      FJ=JP
      YCON(JP)=COS(FJ*PI/FM)
      Y=0.5*WIDTH(I)*(1.-YCON(JP))+BR
19    PSI(JP)=SQRT((BB-Y/HAB)*(Y/HAB-AA))*FT
20    CONTINUE
      L1=NK+J-LK
      L2=L1+MK
      L3=L2+MK
      SP=SWP(JJ,IR1)
      CS=COS(SP)
      TAN=SIN(SP)/CS
      SM=0.
      IF  (IK .EQ. 1) GO TO  23
      DO  22 LQ=1,MM
      LP=L1+(LQ-1)*MK
      AA=1.
      DO  21 LS=1,MM
      LN=L1+(LS-1)*MK
      IF  (LS .EQ. LQ) GO TO  21
      AA=AA*(BREAK(I)-YCP(LN))/(YCP(LP)-YCP(LN))
21    CONTINUE
22    SM=SM+AA*AW(LP)*PSI(LQ)
      GAMAO=SM
      GO TO  24
23    GAMAO=0.
24    CONTINUE
      IF  (IS .EQ. 1) GO TO  27
      IF  (IWING .NE. 0 .AND. I .EQ. NWING) GO TO  27
      IF  (I .EQ. NC) GO TO  27
      SM=0.
      DO  26 LQ=1,MM
      LP=L1+(LQ-1)*MK
      AA=1.
      DO  25 LS=1,MM
      LN=L1+(LS-1)*MK
      IF  (LS .EQ. LQ) GO TO  25
      AA=AA*(BREAK(I+1)-YCP(LN))/(YCP(LP)-YCP(LN))
25    CONTINUE
26    SM=SM+AA*AW(LP)*PSI(LQ)
      GAMAN=SM
      GO TO  28
27    GAMAN=0.
28    DO  32 K=1,MM
```

```
      LL=NK+(K-1)*MK+J-LK
      CA(LL)=0.
      DO   30 KK=1,MM
      LI=NK+(KK-1)*MK+J-LK
      IF   (KK .EQ. K)  GO TO   29
      CA(LL)=CA(LL)+2.*(-1.)**(K+KK)*    AW(LI)*PSI(KK)/(WIDTH(I)*(YCON(K
     1K)-YCON(K)))
      GO TO   30
29    CA(LL)=CA(LL)+    AW(LL)*PSI(K)*YCON(K)/(WIDTH(I)*SJ(K,I)*SJ(K,I))
30    CONTINUE
      IF   (IK .EQ. 0)  FK=YCP(LL)/(HAB*HAB)
      IF   (IK .EQ. 1)  FK=-(1.-2.*(YCP(LL)-HALFB)/HAB)/(0.5*HAB)
      CA(LL)=CA(LL)+GAMAO*(-1.)**K/(1.-YCON(K))/WIDTH(I)-GAMAN*(-1.)**(M
     1+K)/(1.+YCON(K))/WIDTH(I)+AW(LL)*FK/PSI(K)
      CA(LL)=CA(LL)/PSI(K)
      IF   (IWING .NE. 0 .AND. I .EQ. NWING) GO TO   31
      IF   (I .EQ. NC)  GO TO   31
      GO TO   32
31    CONTINUE
      IF   (CHORDT(IPZ) .LE. 0.001) GO TO   32
      G(J,IW)=G(J,IW)+AW(LL)*PSI(K)*(-1.)**(K+M)/(1.+YCON(K))
32    CA(LL)=TAN*GAMMA(LL)+CA(LL)
      IF   (J .EQ. NW(1))  NK1=LL
      IF   (I .EQ. NC)  GO TO   33
      IF (IWING.NE.0 .AND. I.EQ.NWING) GO TO 33
      GO TO 37
33    CONTINUE
      IF (CHORDT(IPZ) .LE. 0.001) GO TO 37
      G(J,IW)=2./WIDTH(I)*G(J,IW)+0.5*(-1.)**M*GAMAO/WIDTH(I)
      IF   (IK .EQ. 0)  G(J,IW)=G(J,IW)*SQRT(HAB)/2.828427124
      IF   (IK .EQ. 1)  G(J,IW)=G(J,IW)*SQRT(HAB)/4.
      IF (IW.EQ.2)  CM(J)=G(J,IW)
      IF (IW.EQ.2)  GO TO   37
      IF (IWING.NE.0)  GO TO   35
34    CL(J)=G(J,IW)
      GO TO   37
35    IF (IPS1.EQ.2.AND.J.GT.NW(1))  GO TO   36
      IF (IPS1.EQ.1)  GO TO   36
      GO TO   34
36    CL(J)=0.
37    CONTINUE
      NK2=LL
38    CONTINUE
      IF (KZ.EQ.1)  RETURN
      CTP=0.
      CTX = 0.
      SUMM = 0.
      DO   42 K=1,IW
      CTIP(K)=0.
      IPZ=1
      IF   (K .EQ. 2)  IPZ=3
      IF   (CHORDT(IPZ) .LE. 0.001) GO TO   42
      SUM=0.
      ISN=1
      FN=NW(1)
      CHD=CHORDT(IPZ)
      DO   41 I=1,NCW
      FCR=1.
```

```
      IF (G(I,K).LT.0.) FCR=-1.
      J=I
      X1=YCN(IPZ)
      IF  (K .EQ. 2) GO TO  39
      IF  (IPS1 .EQ. 2 .AND. I .GT. NW(1)) GO TO  41
      IF  (IPS1 .EQ. 1) GO TO  41
   39 CONTINUE
      IF  (I .LE. NW(1)) GO TO  40
      ISN=2
      FN=NW(2)
      J=I-NW(1)
      X1=YCN(IPZ+1)
      CHD=CHORDT(IPZ+1)
   40 FJ = J
      XM = X1 + 0.5*CHD*(1.-COS((2.*FJ - 1.)*PI/(2.*FN)))
      SUM=SUM+CHD*G(I,K)*G(I,K)*SN(J,ISN)*FCR/FN
      SUMM=SUMM+CHD*XM*G(I,K)*G(I,K)*SN(J,ISN)*FCR/FN
   41 CONTINUE
      CTX=SUM+CTX
      CTIP(K)=SUM*PI*PI/(2.*HALFSW)
      CTP=CTP+CTIP(K)
   42 CONTINUE
      IF (ABS(CTX).LE.0.00001) GO TO  43
      IF (CHORDT(1).GT. 0.001 .OR. CHORDT(3).GT. 0.001) CTX=SUMM/CTX
   43 CONTINUE
      CTX=-CTX
      RETURN
C
      END
```

```
      SUBROUTINE SPLINE (N,X,Y,A,B,C,D,LM,NT)
      DIMENSION S(43), H(13), CA(12), X(3,12), Y(3,12)
      DIMENSION A(3,11), B(3,11), C(3,11), D(3,11)
      L=LM
      DO  9 NN=1,NT
      I=1
      NI=N+1
      N1=N-1
      H(NI)=0.
      H(1)=X(L,3)-X(L,2)
      H(2)=-X(L,3)+X(L,1)
      H(3)=X(L,2)-X(L,1)
      DO  1 K=4,N
    1 H(K)=0.
      DO  2 K=1,N
    2 S(K)=-H(K+1)/H(1)
      NJ=N-1
      DO  7 I=2,N
      IF  (I .EQ. N) GO TO  3
      H(NI)=-6.*((Y(L,I+1)-Y(L,I))/(X(L,I+1)-X(L,I))-(Y(L,I)-Y(L,I-1))/
     1(X(L,I)-X(L,I-1)))
      GO TO  4
    3 H(NI)=0.
    4 DO  6 J=1,N
      H(J)=0.
      IF  (I .EQ. N) GO TO  5
      IF  (J .LT. (I-1) .OR. J .GT. (I+1)) GO TO  6
      H(I-1)=X(L,I)-X(L,I-1)
      H(I)=2.*(X(L,I+1)-X(L,I-1))
      H(I+1)=X(L,I+1)-X(L,I)
      GO TO  6
    5 H(N-2)=X(L,N)-X(L,N-1)
      H(N-1)=-X(L,N)+X(L,N-2)
      H(N)=X(L,N-1)-X(L,N-2)
    6 CONTINUE
      II=I
      CALL VMSEQN (NJ,II,H,S,CA)
      NJ=NJ-1
    7 CONTINUE
      DO  8 I=1,N1
      A(L,I)=(S(I+1)-S(I))/(6.*(X(L,I+1)-X(L,I)))
      B(L,I)=S(I)/2.
      C(L,I)=(Y(L,I+1)-Y(L,I))/(X(L,I+1)-X(L,I))-(X(L,I+1)-X(L,I))*(2.*
     1S(I)+S(I+1))/6.
    8 D(L,I)=Y(L,I)
    9 L=L+1
      RETURN
      END
```

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16. Abstract

The nonplanar quasi-vortex-lattice method is applied to the calculation of lateral-directional stability derivatives of wings with and without vortex-lift effect. Results for conventional configurations and those with winglets, V-tail, etc. are compared with available data. All rolling moment derivatives are found to be accurately predicted. The prediction of side force and yawing moment derivatives for some configurations is not as accurate. Causes of the discrepancy are discussed. A user's manual for the program and the program listing are also included.

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