NASA Contractor Report 3457

Computer Program Documentation for a Subcritical Wing Design Code Using Higher Order Far-Field Drag Minimization

John M. Kuhlman and Jin-Yea Shu

GRANT NSG-1357
SEPTEMBER 1981

NASA

NASA Contractor Report 3457

Computer Program Documentation for a Subcritical Wing Design Code Using Higher Order Far-Field Drag Minimization

John M. Kuhlman and Jin-Yea Shu
Old Dominion University Research Foundation
Norfolk, Virginia

Prepared for
Langley Research Center
under Grant NSG-1357

NASA
National Aeronautics
and Space Administration

Scientific and Technical
Information Branch

1981

SUMMARY

A subsonic, linearized aerodynamic theory, wing design program for one or two planforms has been developed which uses a vortex lattice near-field model and a higher order panel method in the far field. The theoretical development of the wake model and its implementation in the vortex lattice design code are summarized in this report and sample results are given. Detailed program usage instructions, sample input and output data, and a program listing are presented in the Appendixes.

The far-field wake model assumes a wake vortex sheet whose strength varies piecewise linearly in the spanwise direction. From this model analytical expressions for lift coefficient, induced drag coefficient, pitching moment coefficient, and bending moment coefficient have been developed. From these relationships a direct optimization scheme is used to determine the optimum wake vorticity distribution for minimum induced drag, subject to constraints on lift, and pitching or bending moment. Integration spanwise yields the bound circulation, which is interpolated in the near-field vortex lattice to obtain the design camber surface(s).

INTRODUCTION

The current computer program has been developed as a preliminary design tool for one or two interacting, subsonic lifting surfaces. Linearized aerodynamic theory is used, in the form of a vortex lattice representation of the wings in the near field, along with a piecewise linearly varying vortex sheet model of the undistorted wake. Summaries of the theoretical development and the overall code structure have been given in references 1, 2 and 3, along with some sample results. Reference 3 also describes a second design code currently under development, which includes viscous effects. In all cases, results from the current code have been compared to results for the same configuration obtained from an earlier design code (ref. 4), from which the current design program has been developed. This earlier design program, due to Lamar, uses a discrete vortex filament wake model, in contrast to the curren continuous wake vortex distribution.

A detailed development of the current far-field wake model has been given in reference 5; this theory has been developed from the model formulated by Loth and Boyle (ref. 6). A separate, stand-alone, far-field drag minimization program has been written using the current wake model, which has been documented in a user's guide (ref. 7). For completeness, a summary of this theory is given herein, including some details of the development of expressions for pitching moment and bending moment coefficients which were not given in references 1 to 3. An example of the use of the current design code in the design of a wind-tunnel model of a transport wing fitted with winglets may be found in reference 8. Again, comparison is made between the current design and the design obtained using the earlier code of reference 4.

Following the theoretical development, several sample results for configurations having one or two planforms are given. Comparison with results from the earlier code (ref. 4) generally shows a significant difference between designs only in the vicinity of a change in planform dihedral (see also refs. 1-3). Finally, the detailed user instructions, such as program limitations, input data preparation, output data, sample input and output, and the computer program listing are included in the Appendixes.

NOMENCLATURE

A	vortex lattice aerodynamic influence coefficient matrix [eq. (29)]
A_i	term in equation (14)

A_{ij}	induced drag coefficient matrix [eqs. (24) and (25)]
a	chordwise loading function parameter
b	wing span
B	bending moment
$\overline{c}$	reference wing chord
$\frac{c_\ell c}{C_L \overline{c}}$	span load
C_B	wing root bending moment coefficient
C_D	induced drag coefficient
C_L	lift coefficient
C_m	pitching moment coefficient
ΔC_p	pressure difference coefficient
G_i, $\overline{G}_i$, $\hat{G}_i$	variables containing unknown wake vortex sheet strengths, appearing in drag and bound circulation equations (3) and (10)
$I_{1_{ij}}$, $I_{2_{ij}}$, $I_{3_{ij}}$, $I_{4_{ij}}$, $I_{5_{ij}}$, $I_{6_{ij}}$	influence coefficient integrals appearing in drag equation (3)
M	Mach number
N	total number of wake panels; total number of horseshoe vortices; normal force
N_{cv}	number of chordwise rows of horseshoe vortices [eqs. (15) and (16)]
S	reference wing area
$\mathscr{s}$	local higher order wake panel coordinate
s	higher order wake panel semiwidth
U	free-stream speed
X_i	term in equation (14)
x	streamwise body axis coordinate

x_c	x-coordinate of center of pressure
Δx	shift of trim point
XP, XM	terms containing x_c in equation for C_B [eq. (19)]
y	spanwise body axis coordinate
z	vertical body axis coordinate
z_c	vertical separation between planforms
γ	wing wake vortex sheet strength
Γ	bound circulation; horeshoe vortex strength
$\Gamma_o(-S_i)$	bound circulation at outboard edge of wake panel i
ε	incidence angle
η	local fractional spanwise coordinate
Λ	wing sweep angle
λ	Lagrange multiplier
ξ	local fractional chordwise coordinate
ρ	density
ϕ	dihedral angle

THEORETICAL DEVELOPMENT OF FAR-FIELD WAKE MODEL

A summary of the theoretical development for the current code's far-field wake model is given in this section; further details may be found in references 1, 2, and 5. The wake vortex sheet strength γ is assumed to vary along the spanwise direction in a piecewise linear fashion: that is, on wake panel i,

$$\gamma(\delta_i) = \frac{\gamma_{i+1} + \gamma_i}{2} + \frac{\gamma_{i+1} - \gamma_i}{2} \frac{\delta_i}{s_i} \tag{1}$$

where s_i is the semiwidth of panel i. The wake(s) are segmented into N flat panels, having a cosine size distribution, with small panels near wing tips or changes in wing dihedral. The Biot-Savart and Kutta-Joukowski laws are applied so that the lift coefficient is a linear function of the γ values (ref. 5):

$$C_L = \frac{8}{S}\left\{\frac{1}{3}\sum_{i=1}^{N}\left[\cos\phi_i\ s_i^2\left(\frac{\gamma_{i+1}}{U} + \frac{2\gamma_i}{U}\right)\right] + \sum_{i=1}^{N}\left(\cos\phi_i\ s_i\ \frac{\Gamma_o(-s_i)}{U}\right)\right\} \tag{2}$$

where $\Gamma_o(-s_i)$ is the bound circulation at the outboard edge of wake panel i (ref. 5). The induced drag coefficient on wake panel i due to panel j and its image is quadratic in the γ_i values:

$$C_{D,ij} = \frac{1}{S}\left(G_i\overline{G}_j I_{1_{ij}} + G_i\hat{G}_j I_{2_{ij}} + \overline{G}_i\overline{G}_j I_{3_{ij}} + \overline{G}_i\hat{G}_j I_{4_{ij}} + \hat{G}_i\overline{G}_j I_{5_{ij}} + \hat{G}_i\hat{G}_j I_{6_{ij}}\right) \tag{3}$$

where the G_i, $\overline{G}_i$, and $\hat{G}_i$ are linear functions of the unknown wake vortex sheet strengths γ_i and the $(I_{1_{ij}}, I_{2_{ij}}, I_{3_{ij}}, I_{4_{ij}}, I_{5_{ij}}, I_{6_{ij}})$ are influence coefficients given in reference 5.

Expressions for the pitching moment coefficient and wing root bending moment coefficient are developed as follows. First, for the pitching moment coefficient, let M_i equal the contribution to the pitching moment due to that portion of the wing located between the inboard and outboard edges of wake panel i (see fig. 1). Then the local x-coordinate of the center of pressure may be written as

$$x_c(\mathit{s}_i) = \left\{\frac{x_{c_{i+1}} + x_{c_i}}{2}\right\} + \left\{\frac{x_{c_{i+1}} - x_{c_i}}{2}\right\}\frac{\mathit{s}_i}{s_i} \tag{4}$$

where x_{c_i} denotes the x-coordinate of the center of pressure at a y corresponding to the outboard edge of wake panel i (fig. 1). Then the contribution to C_m due to M_i equals

$$C_{m_i} = \frac{2}{\rho U^2 S\bar{c}}\int_{-s_i}^{s_i}\cos\phi_i\ x_c(\mathit{s}_i)\ N(\mathit{s}_i)\ d\mathit{s}_i \tag{5}$$

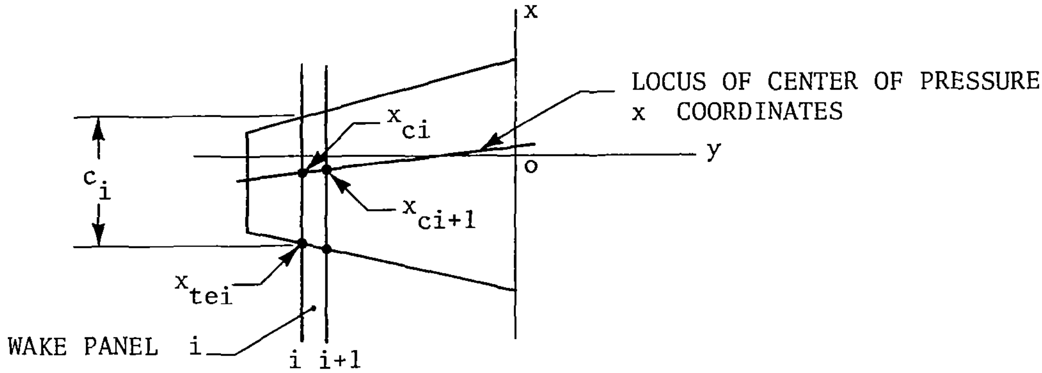


Figure 1. Geometry definition for pitching moment derivation.

where $N(s_i)$ is the local distribution of normal force. Using the Kutta Joukowski theorem results in

$$C_{m_i} = \frac{2 \cos \phi_i}{S \bar{c}} \int_{-s_i}^{s_i} \frac{\Gamma}{U} (s_i) \; x_c(s_i) \; ds_i \tag{6}$$

where $x_c(s_i)$ is written as

$$x_c(s_i) = XP_i + XM_i \frac{s_i}{s_i} \tag{7}$$

$$XP_i = \frac{x_{c_{i+1}} + x_{c_i}}{2} \tag{8}$$

$$XM_i = \frac{x_{c_{i+1}} - x_{c_i}}{2} \tag{9}$$

and from references 1, 2, and 5 :

$$\frac{\Gamma}{U} (s_i) = \frac{\Gamma_o(-s_i)}{U} + \bar{G}_i \; (s_i + s_i) + \frac{\hat{G}_i}{2s_i} (s_i^2 - s_i^2) \tag{10}$$

where

$$\bar{G}_i = \frac{\gamma_{i+1} + \gamma_i}{2 \; U}; \quad \hat{G}_i = \frac{\gamma_{i+1} - \gamma_i}{2 \; U} \tag{11}$$

and $\Gamma_o(-s_i)$ equals the value of the bound circulation at $s_i = -s_i$. Substitution of equations (7) and (10) into equation (6) and integration yield

$$C_{m_i} = \frac{2 \cos \phi_i}{S \bar{c}} \left\{ 2 \frac{\Gamma_o(-s_i)}{U} s_i \; XP_i + G_i \left(2s_i^2 \; XP_i + \frac{2}{3} s_i^2 \; XM_i \right) - \frac{2}{3} s_i^2 \; XP_i \; \hat{G}_i \right\} \tag{12}$$

or, as given in references 1 to 3, the total pitching moment coefficient is

$$C_m = \frac{2}{S\,\bar{c}} \sum_{i=1}^{N} \cos\phi_i \left\{ 2s_i\, XP_i\, \frac{\Gamma_o(-s_i)}{U} + \frac{\gamma_{i+1}}{U}\frac{s_i^2}{3}(XM_i + 2XP_i) + \frac{\gamma_i}{U}\frac{s_i^2}{3}(XM_i + 4XP_i) \right\} \tag{13}$$

The x_{c_i} values are obtained through linear interpolation from the near-field vortex lattice local chords and x values for the wing trailing edge, along with the user-specified NACA a series mean line value (ref. 4). As shown in figure 2,

$$x_{c_i} = \sum_{i=1}^{N_{cv}} A_i\, X_i \Big/ \sum_{i=1}^{N_{cv}} A_i \tag{14}$$

where

$$X_i = 1 - \left(\frac{0.75 - i}{N_{cv}}\right) \tag{15}$$

and

$$A_i = \frac{1}{N_{cv}} \text{ if } a \geq \frac{i - 0.75}{N_{cv}}$$

$$= \frac{\left(1 - \frac{i - 0.75}{N_{cv}}\right)}{N_{cv}\,(1 - a)} \text{ if } a < \frac{i - 0.75}{N_{cv}} \tag{16}$$

For the bending moment coefficient calculated about the wing root [similar to eq. (5)]

$$C_{Bi} \equiv \frac{2B_i}{Sb\rho U^2} = \frac{-2}{Sb}\int_{-s_i}^{s_i} \cos\phi_i\, \frac{\Gamma(\delta_i)}{U}\,(y_i + \delta_i \cos\phi_i)\, d\delta_i$$

$$\frac{-2}{Sb}\int_{-s_i}^{s_i} \sin\phi_i\, \frac{\Gamma(\delta_i)}{U}\,(z_i + \delta_i \sin\phi_i)\, d\delta_i \tag{17}$$

where the y_i, z_i values correspond to coordinates of the center of wake panel i. Substitution for $\Gamma(\delta_i)$ from equation (10) and integration yield

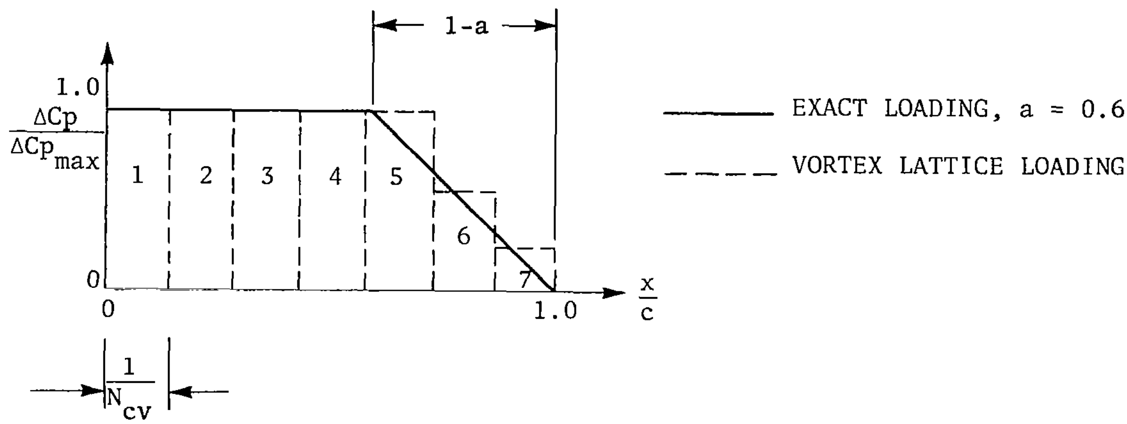


Figure 2. Example of vortex lattice representation of chordwise loading function; seven chordwise vortices.

$$C_{B_i} = \frac{2}{Sb} \left\{ (y_i \cos \phi_i + z_i \sin \phi_i) \left(2s_i \frac{\Gamma_o(-s_i)}{U} + \frac{4}{3} s_i^2 \frac{\gamma_i}{U} + \frac{2}{3} s_i^2 \frac{\gamma_{i+1}}{U} \right) + \frac{1}{3} s_i^3 \left(\frac{\gamma_{i+1}}{U} + \frac{\gamma_i}{U} \right) \right\} \tag{18}$$

Thus, the total wing root bending moment coefficient (refs. 1, 2, 3) is

$$C_B = \frac{-2}{Sb} \sum_{i=1}^{N} \left\{ \left(y_i \cos \phi_i + z_i \sin \phi_i \right) \left(2s_i \frac{\Gamma_o(-s_i)}{U} + \frac{4}{3} s_i^2 \frac{\gamma_i}{U} + \frac{2}{3} s_i^2 \frac{\gamma_{i+1}}{U} \right) + \frac{1}{3} s_i^3 \left(\frac{\gamma_{i+1} + \gamma_i}{U} \right) \right\} \tag{19}$$

It must be noted that the computer program currently can impose a bending moment constraint only for an isolated wing.

INDUCED DRAG MINIMIZATION METHOD

The minimum induced drag, subject to constraints on C_L and either C_m or C_B is obtained using Lagrange multipliers; thus the function to be minimized becomes of the form

$$C_D + \lambda_1 \left(\sum_{i=1}^{N} C_{L,i} \frac{\gamma_i}{U} - C_L \right) + \lambda_2 \left(\sum_{i=1}^{N} C_{m,i} \frac{\gamma_i}{U} - 0 \right) + \lambda_3 \left(\sum_{i=1}^{N} C_{B,i} \frac{\gamma_i}{U} - C_B \right) \tag{20}$$

The $C_{L,i}$, $C_{m,i}$, and $C_{B,i}$ denote derivatives of the respective coefficients with respect to (γ_i/U) which are (refs. 1-3):

$$C_{L,i} = \frac{8}{S} \left[\frac{2}{3} \cos \phi_i \; s_i^2 + \frac{1}{3} \cos \phi_{i-1} \; s_{i-1}^2 + \sum_{m=1}^{N-i} \cos \phi_{m+i} \; s_{m+i} \; (s_i + s_{i-1}) \right] \tag{21}$$

$$C_{m,i} = \frac{4}{S\bar{c}}\left[\frac{1}{3}\cos\phi_i\, s_i^2\,(XM_i + XP_i) + \frac{1}{3}\cos\phi_{i-1}\, s_{i-1}^2\,(XM_{i-1} + 2XP_{i-1})\right] + \frac{8}{S\bar{c}}\left[s_i\cos\phi_i\, XP_i\, s_{i-1} + (s_i + s_{i-1}) \cdot \sum_{j=i+1}^{N-1} s_j \cos\phi_j\, XP_j\right] \tag{22}$$

$$C_{B,i} = \frac{-4}{3Sb}\left[s_i^3 + s_{i-1}^3 + 4s_i^2\,(y_i\cos\phi_i + z_i\sin\phi_i) + 2s_{i-1}^2\,(y_{i-1}\cos\phi_{i-1} + z_{i-1}\sin\phi_{i-1}) + 2s_i\, s_{i-1}\,(y_i\cos\phi_i + z_i\sin\phi_i) + 2(s_i + s_{i-1})\sum_{j=i+1}^{N} s_j(y_j\cos\phi_j + z_j\sin\phi_j)\right] \tag{23}$$

The total induced drag is written as

$$C_D = 2\sum_{i=1}^{N}\sum_{j=1}^{N} C_{D,ij} = \left(\frac{\gamma}{U}\right)^T [A_{ij}] \left(\frac{\gamma}{U}\right) \tag{24}$$

where explicit expressions for elements of $[A]$ are given in references 1 to 3 and 5. A system of $N + 2$ linear equations are written for the unknown λ_i values, λ_1, and either λ_2 or λ_3. For a trimmed configuration these equations are

$$\sum_{j=1}^{N} (A_{ij} + A_{ji})\frac{\gamma_j}{U} + \lambda_1 C_{L,i} + \lambda_2 C_{m,i} = 0,\ i = 1, \ldots, N \tag{25}$$

while the remaining equations are

$$\sum_{i=1}^{N} C_{L,i}\frac{\gamma_i}{U} - C_L = 0 \tag{26}$$

$$\sum_{i=1}^{N} C_{m,i} \frac{\gamma_i}{U} = 0 \tag{27}$$

For a single planform subject to a constraint on C_B, equation (27) is replaced by

$$\sum_{i=1}^{N} C_{B,i} \frac{\gamma_i}{U} - C_B = 0 \tag{28}$$

As discussed in references 1 and 2, special treatment of these equations is necessary at the tip of each wing and in the summations containing $\Gamma_o(-s_i)$ in equations (2), (13), and (19).

MEAN CAMBER DETERMINATION

Once the far-field optimum wake vortex sheet strength distribution is obtained from equations (25) to (28), the bound circulation at the wing trailing edge is obtained from equation (10). This piecewise quadratic Γ/U distribution is linearly interpolated to obtain the chordwise sums of the Γ/U values for the near-field vortex lattice. The assumed chordwise loading value then determines the strengths of the individual horseshoe vortices. As in reference 4, this circulation distribution is related to the local surface slope by

$$\left(\frac{\partial z}{\partial x}\right) = [A] \left(\frac{\Gamma}{U}\right) \tag{29}$$

where the matrix [A] is the near-field vortex lattice aerodynamic influence coefficient matrix, as given in reference 4.

Once the surface slope array at the vortex lattice control points $\left(\frac{\partial z}{\partial x}\right)$ is obtained from equation (29), chordwise integration from the trailing edge forward is performed to obtain the nondimensional camber surface distribution z/c, which contains the combined effects of incidence, twist, and camber. This integration process uses a cubic spline interpolation between near-field slope values (ref. 4). Further details of the integration procedure and discussion of its accuracy may be found in reference 4.

SAMPLE RESULTS

In this section, results for four sample configurations are discussed (see refs. 1-3 and 8 for presentation of design results for other geometries). In most instances the current design has been compared to results obtained for the same planform using the earlier design code of reference 4. Appendix B contains an example of the computer program input data and the resultant output for one of the examples presented in the current report.

Figure 3 presents optimum induced drag coefficient values for a close-coupled wing canard configuration, as shown at the top of the figure. This planform is identical to that shown as an example, first in reference 4, and later in references 1 to 3. Solutions are shown for various vertical separations z_c, between wing and canard, and various trim points Δx. Initial results from references 1 to 3 showed that the current code (solid line) consistently yields a higher, more accurate, induced drag coefficient compared to values obtained from the original design code of reference 4 (dashed line). New results in figure 3 show that for small separations between canard and wing, $|z_c/(b/2)| < 0.169$, there is a smooth transition in the variation of C_D with the shifted pitching moment center, $\Delta x/(b/2)$, from a curve with a definite minimum C_D value at large vertical separations to a relatively straight curve at zero separation between wing and canard. Although not shown, camber surface results for the two codes (present and ref. 4) are nearly identical for this planar configuration.

As a second example, figure 4 shows the geometry of a high aspect ratio wing-strut configuration for a high-altitude reconnaissance airplane described in reference 9. Optimum spanload results are shown in figure 5 for both design codes, while wing and strut camber surface results appear in figures 6 and 7, respectively. All results shown are for a shifted moment trim point, $\Delta x = -0.9137$, at the natural trim point for the configuration. The original code (ref. 4) shows large differences in spanload and camber surfaces depending on the number of wake unknowns. Major differences between the present design and that obtained using the earlier code of reference 4 occur for this configuration largely in the wing-strut junction on the wing, and over the entire strut span. This

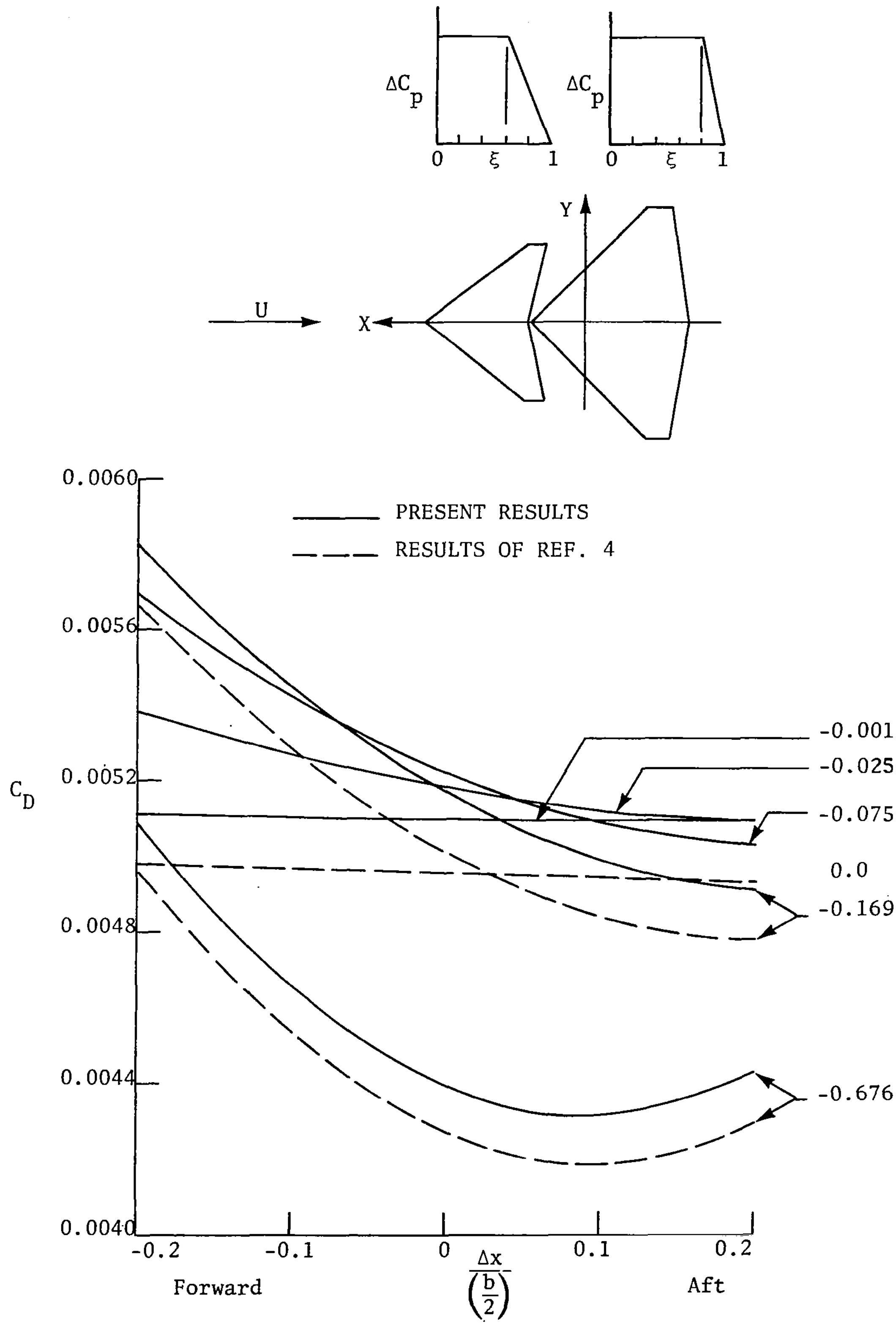


Figure 3. Optimum induced drag coefficient for a wing-canard configuration for a range of moment trim points and vertical separations for $C_L = 0.2$, $M = 0.3$.

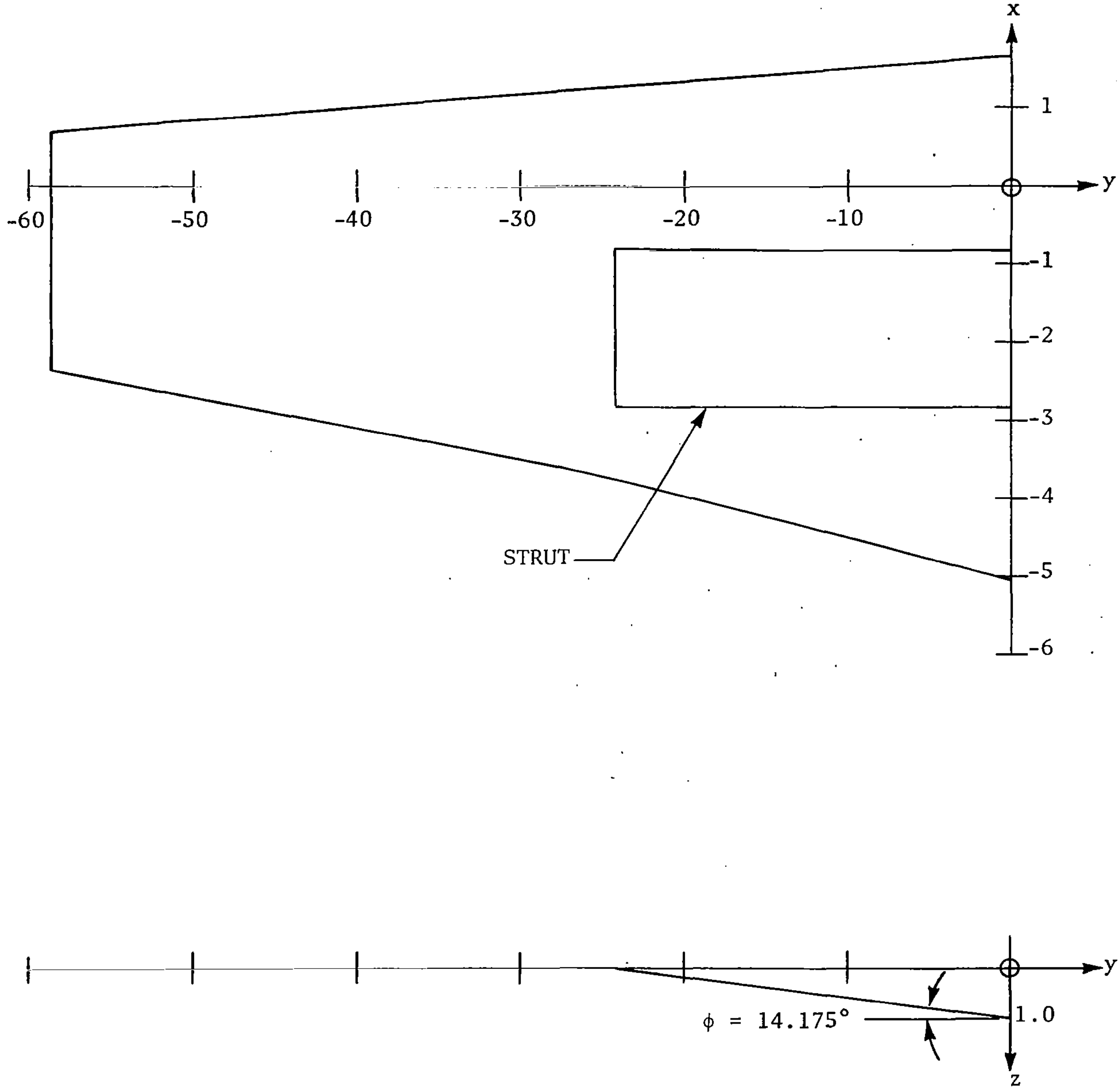


Figure 4. Wing-strut configuration geometry (note stretched x-axis).

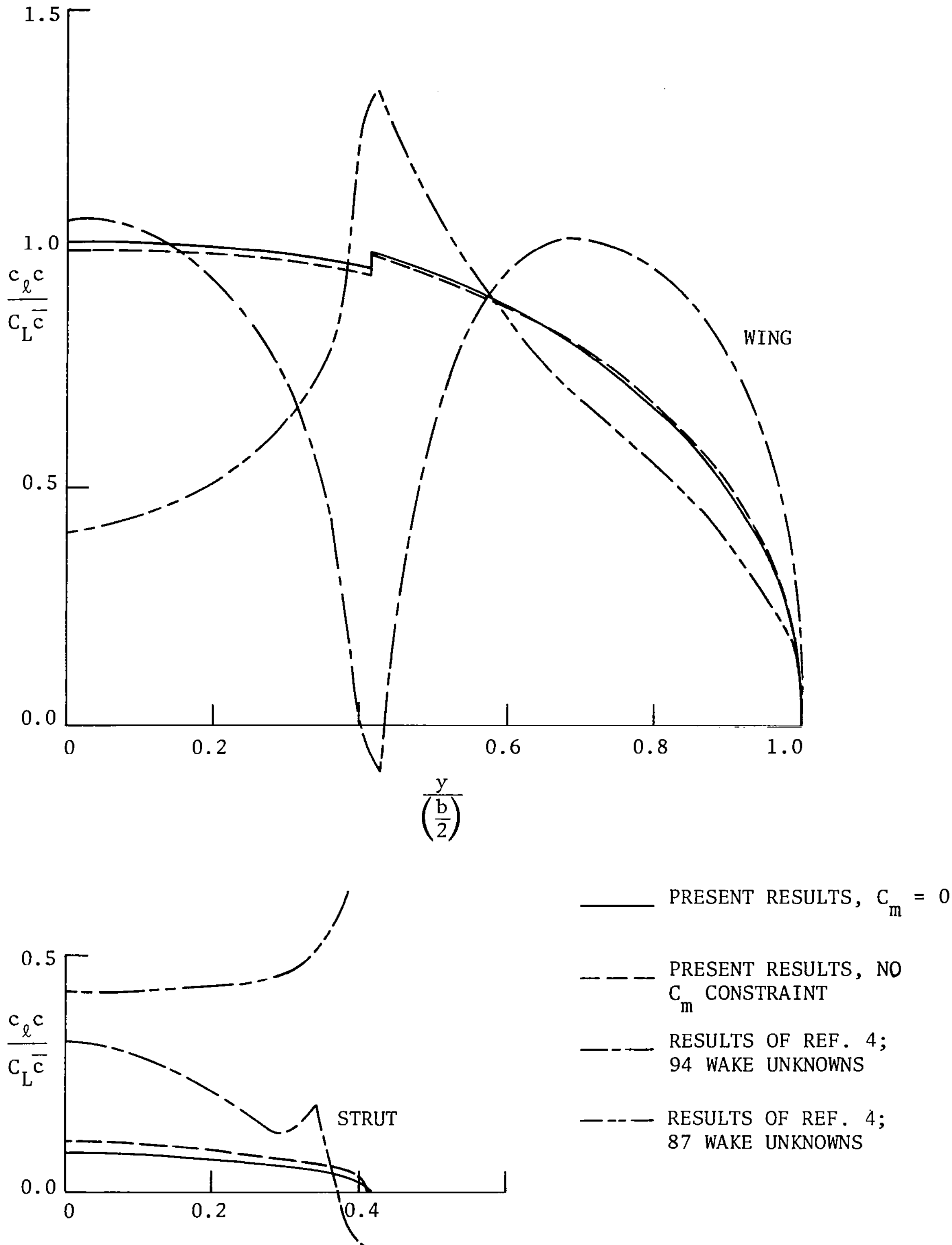


Figure 5. Optimal spanload results for a wing-strut configuration at C_L = 0.7; M = 0.65, a = 0.8, 14 × 18 vortex lattice, no gap at junction, Δx = -0.9137.

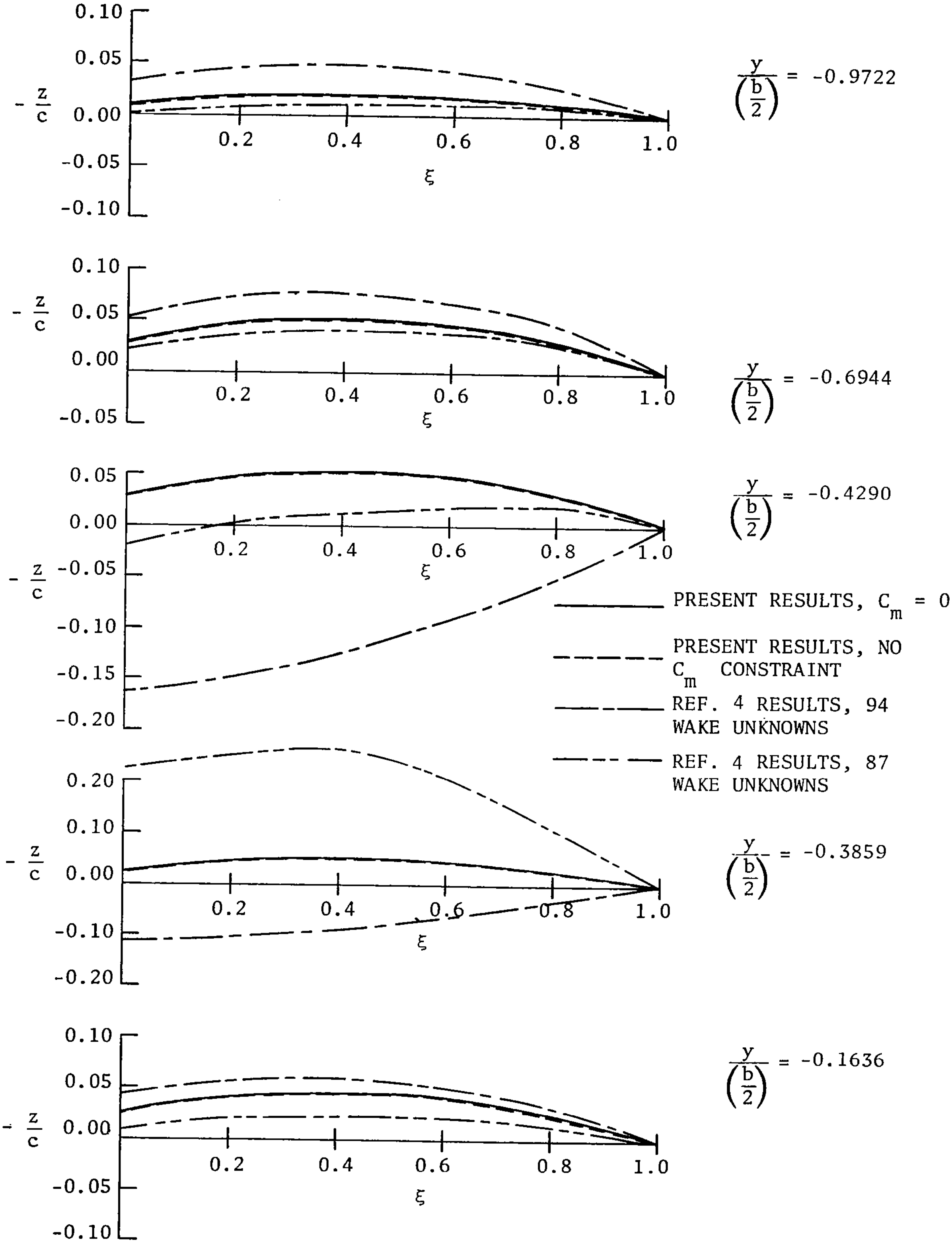


Figure 6. Optimal camber surface results for the wing of a wing-strut configuration at C_L = 0.7, M = 0.65, a = 0.8, 14 × 18 vortex lattice, no gap at junction, Δx = -0.9137.

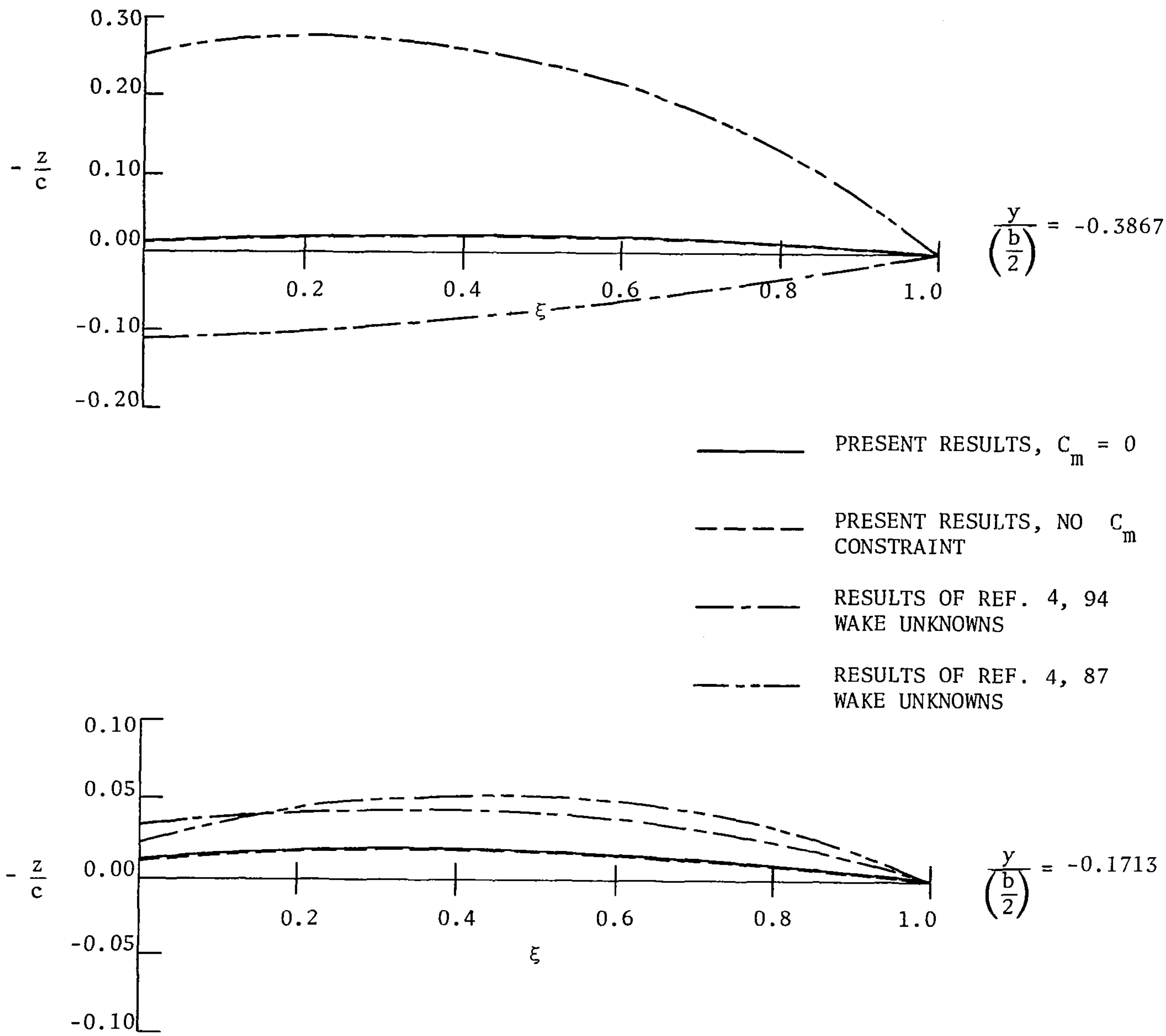


Figure 7. Optimal camber surface results for the strut of a wing-strut configuration at $C_L = 0.7$, $M = 0.65$, $a = 0.8$, 14×18 vortex lattice, no gap at junction, $\Delta x = -0.9137$.

configuration appears to be one for which the results of reference 5 are not entirely satisfactory.

Two additional 2-planform configurations are summarized in figures 8 to 11. Figures 8 and 9 show the optimal spanload and camber surface results, respectively, for a high aspect ratio joined wing (ref. 10), while figures 10 and 11 display similar results for the basic joined wing fitted with upper and lower winglets. The respective planforms are shown in figures 8 and 10. Optimal induced drag values for the joined wing are $C_D = 0.007386$ for the present results and $C_D = 0.007338$ for the code of reference 4. Differences between results of reference 4 and the current code are confined to the vicinity of the wing tips and on the winglets. A similar behavior was noted for a single transport-type wing fitted with winglets in references 1 to 3 and 8, where significant design differences were noted only on the winglet.

CONCLUSIONS

A subsonic, linear lifting surface, wing design code using a higher order panel method far-field wake model and a vortex lattice near-field model has been developed which can handle one or two planforms. A summary of the theoretical development of the far-field wake model has been given. Several sample results for a computer code which implements this wake model have been shown; these results differ from those for a code using a discrete vortex wake model in the vicinity of a wingtip, a change in planform dihedral, or near a point of intersection of the planform wakes. The spanloads and camber surface results obtained using the present code are believed to be superior to those of the original code for such complex configurations. Finally, use of the current program has been documented in a series of appendixes.

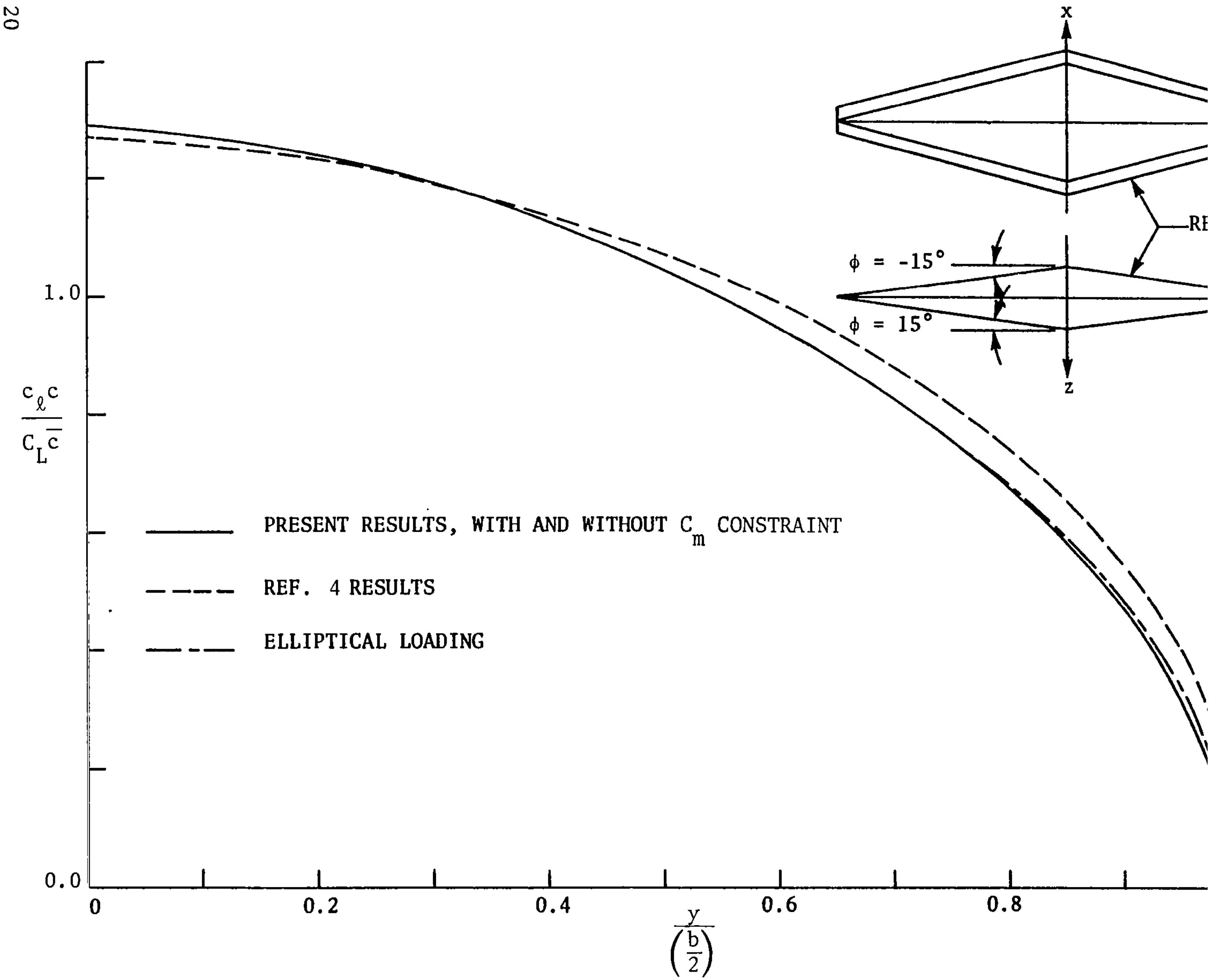


Figure 8. Optimal spanload results for a joined wing configuration of aspect
for C_L = 0.5, M = 0.8, a = 1.0, front or rear wing, 14 × 14 vortex

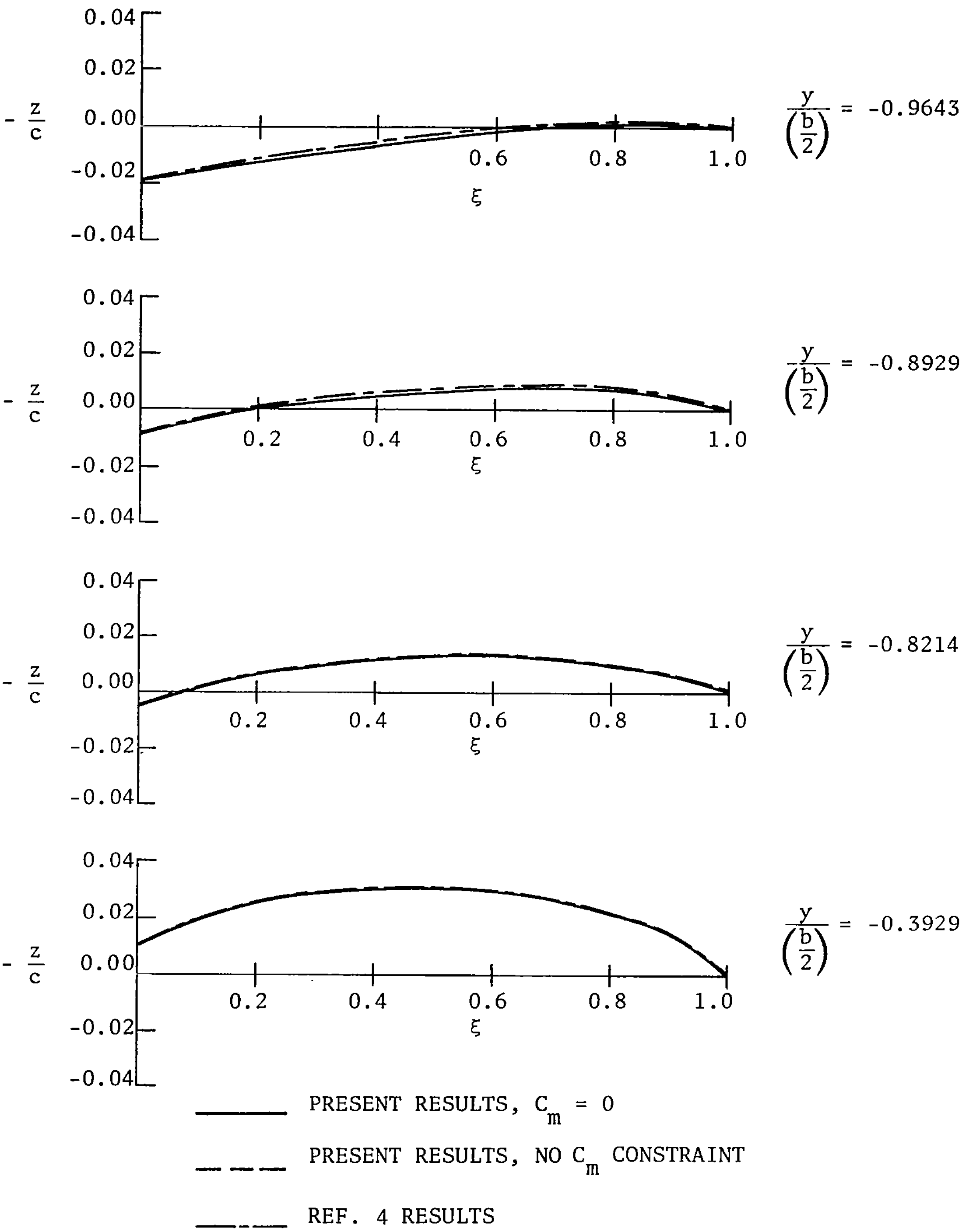


Figure 9(a). Optimal camber surface results for a joined wing configuration of aspect ratio 10.0 for C_L = 0.5, M = 0.8, a = 1.0, front wing, 14 × 14 vortex lattice.

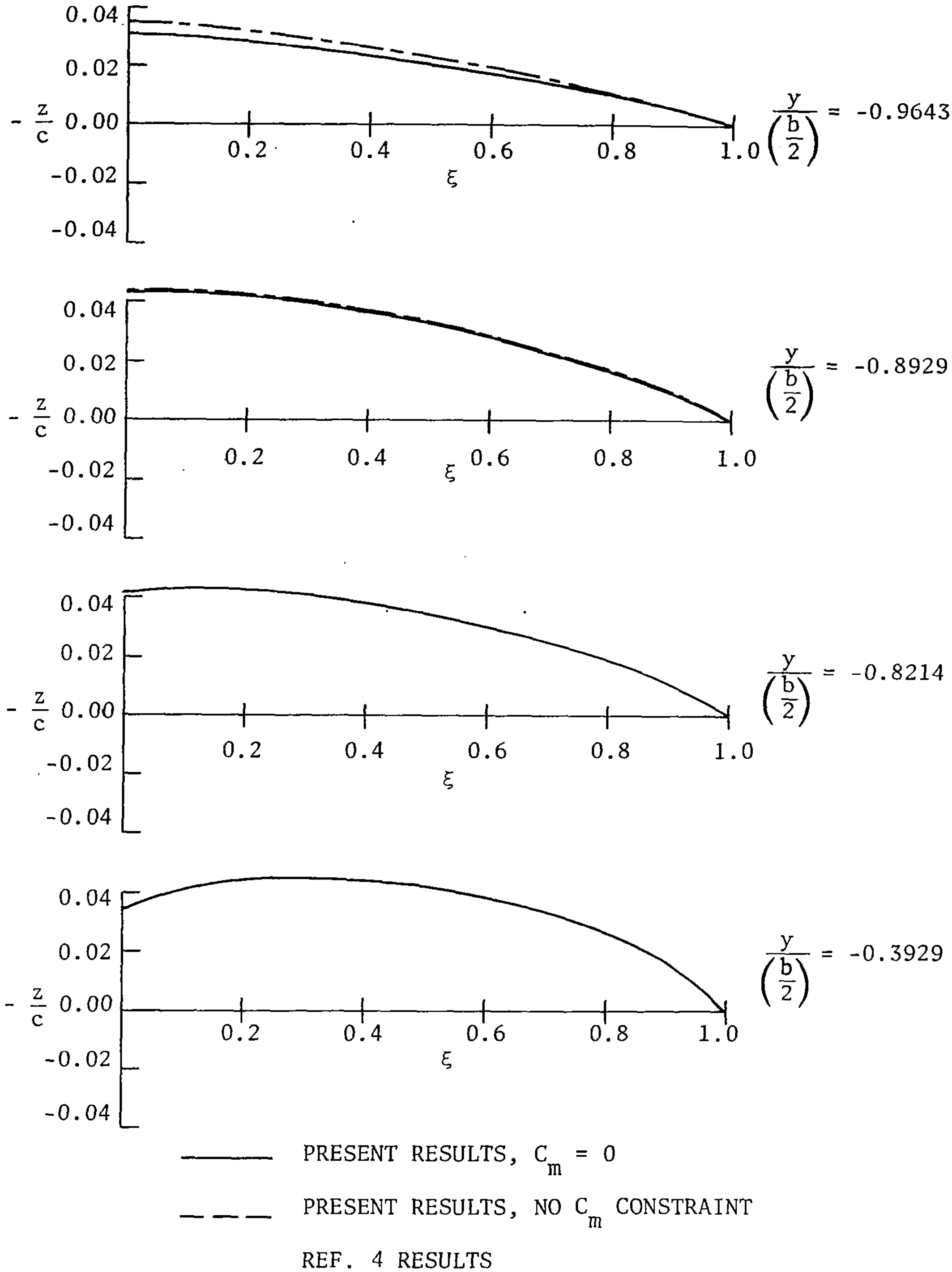


Figure 9(b). Optimal camber surface results for a joined wing configuration of aspect ratio 10.0 for C_L = 0.5, M = 0.8, a = 1.0, rear wing, 14 × 14 vortex lattice.

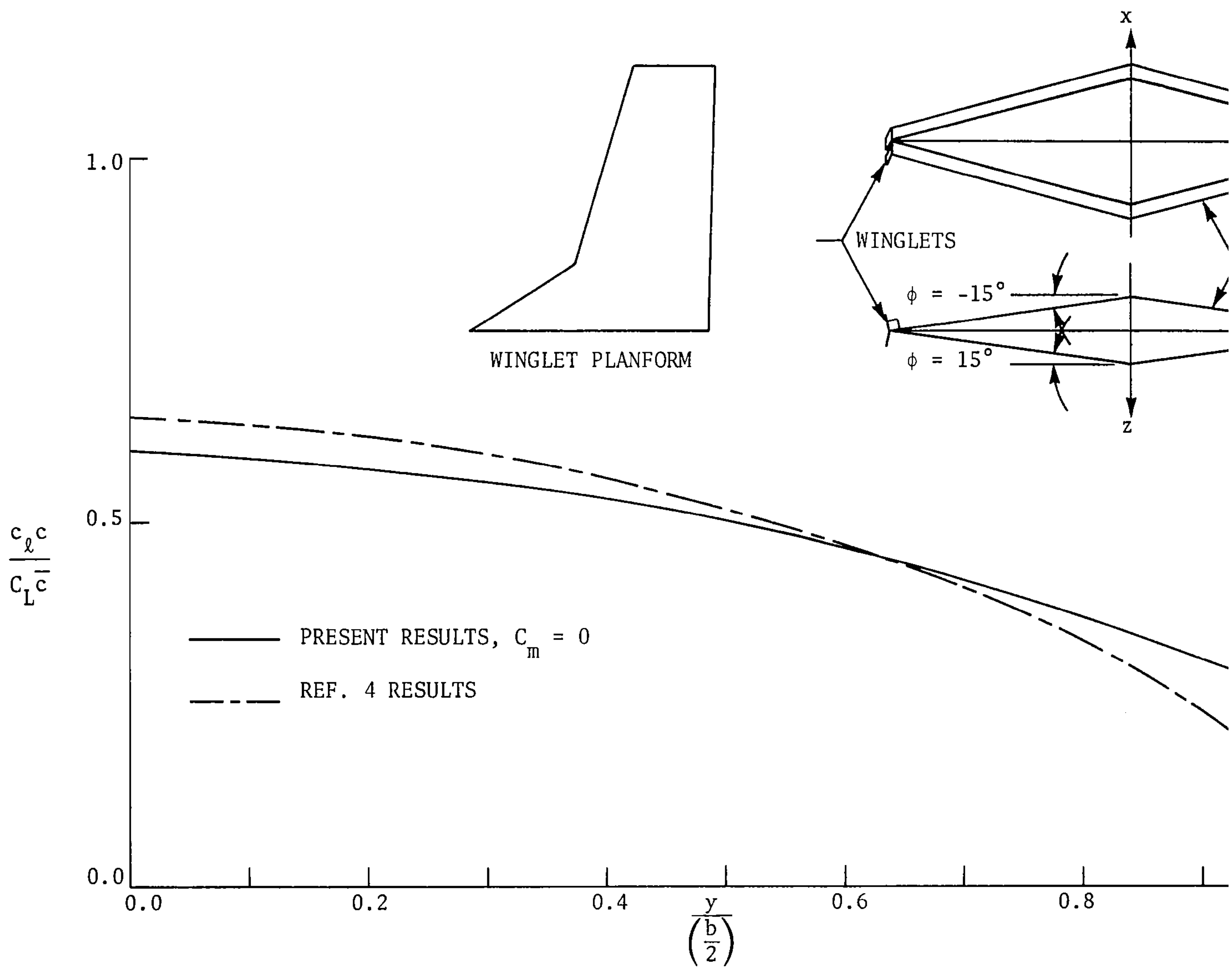


Figure 10. Optimal spanload results for a joined wing configuration with upper a
winglets for C_L = 0.3, M = 0.75, a = 1.0, front or rear planform, 14
vortex lattice.

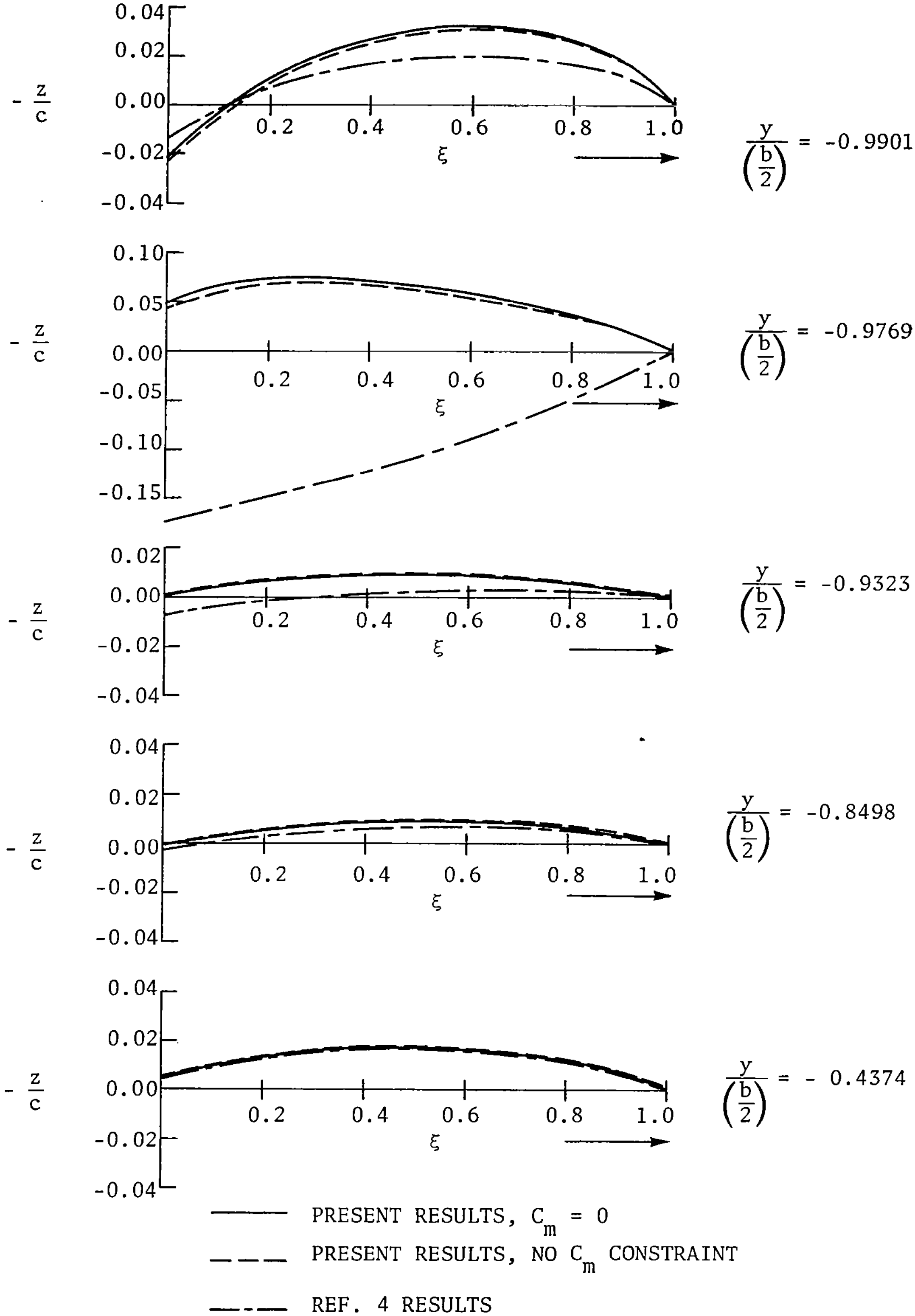


Figure 11(a). Optimal camber surface results for a joined wing configuration with upper and lower winglets for $C_L = 0.3$, $M = 0.8$, $a = 1.0$, front planform, 14 × 14 vortex lattice.

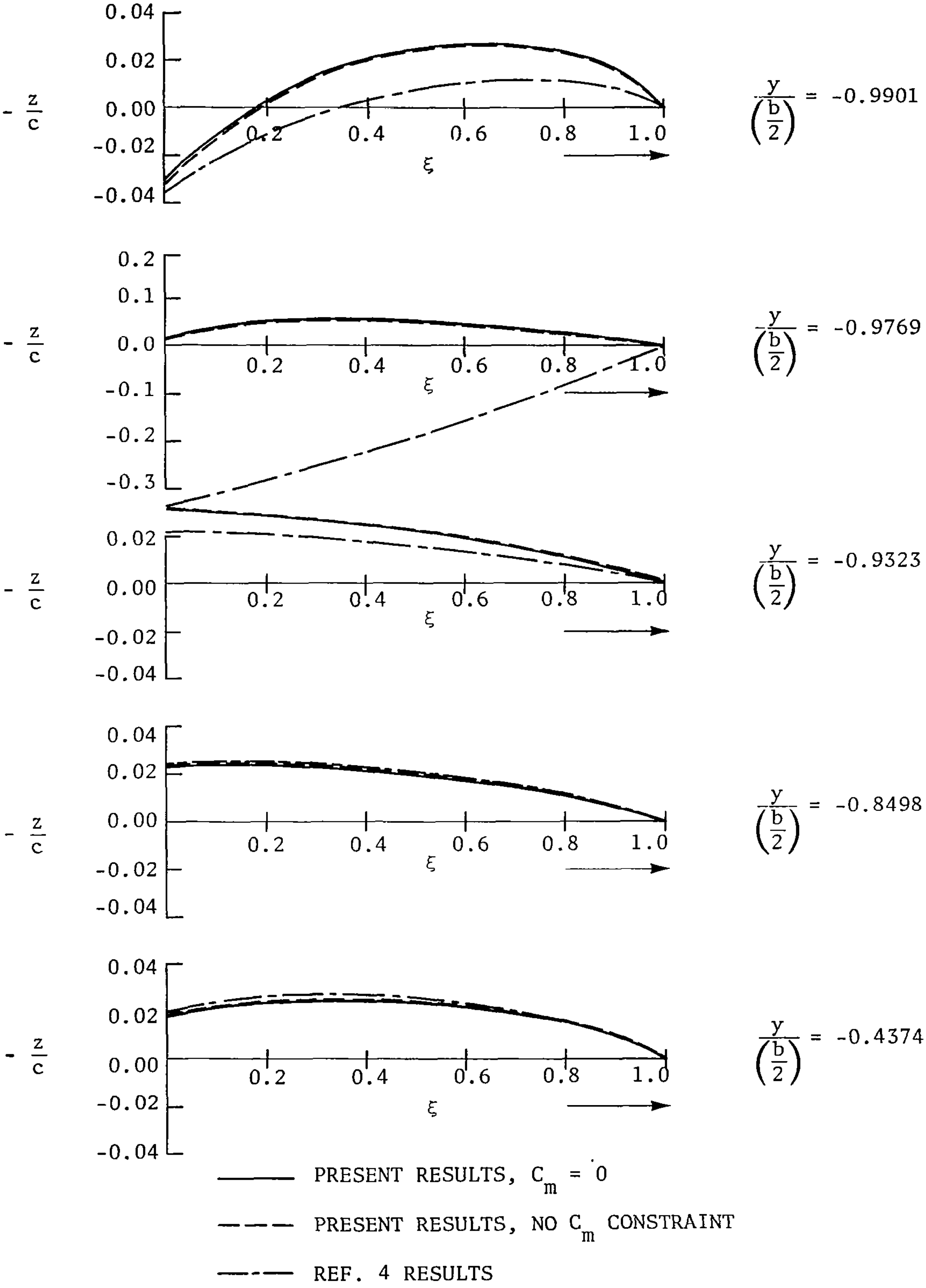


Figure 11(b). Optimal camber surface results for a joined wing configuration with upper and lower winglets for C_L = 0.3, M = 0.8, a = 1.0, rear planform, 14 × 14 vortex lattice.

APPENDIX A

COMPUTER PROGRAM DESCRIPTION AND LIMITATIONS

This appendix briefly describes the organization of the computer program written to implement the theory described in the main body of the report: known program limitations are also discussed. Input and output data are described in Appendix B and Appendix C, respectively, while a sample input deck and output are given in Appendix D. A complete listing of the program appears in Appendix E.

This computer program has been written in FORTRAN IV and is currently operational on a Cyber 173 computer at the NASA/Langley Research Center (LaRC). This computer uses approximately 15 decimal digits in all computations. As a result, some modifications to the code may be necessary to ensure correct execution on a computer system which uses a significantly different number of decimal digits. Specifically, tolerances set in the program in subroutines SNTAN and LOGS and in programs GEOMTRY and ZOCDETM may have to be changed. Further, double precision arithmetic in program WINGAL through subroutine LOGS will be required for machines using eight decimal digits. This would entail adding implicit double precision (A-H, O-Z) statements in the main programs and all subroutines, as well as using double precision for all special functions such as DCOS, DSIN, DLOG, DATAN, DATAN2, DSQRT, DABS, DMIN1, and DMAX1. Finally, some variable names should be changed in subroutines CCAL and CONCAL to be consistent with the implicit double precision statements. Use of double precision arithmetic seems to be of particular importance in the far-field drag minimization section of the code (program CIRCUL2).

The computer program consists of two separate job steps: First, program GEOMTRY is compiled and executed, and vortex lattice geometry results are written on a disk file designated TAPE25. Program GEOMTRY is nearly identical to the first portion of the program described in reference 4. It is in this program that all configuration data are read from the input file. This program uses 51000 octal storage locations. Once the geometry has been defined and stored on disk, a second program written using three overlays is compiled. The zero overlay consists of a controlling program WINGAL, and interpolation and linear equation solver subroutines. WINGAL calls overlay 1 (program CIRCUL2) where the far-field drag minimization is performed followed by a call to overlay 2 (program

ZOCDETM) to determine the optimum mean camber surface. The program CIRCUL2 and subroutines GAMCAL, DRACAL, CCAL, CONCAL, SNTAN, and LOGS are similar in many respects to the direct optimization program described in reference 7. However, the earlier program was not written to allow solution by direct optimization for the minimum drag for the two planform case. To allow the inclusion of constraints on pitching moment or wing root bending moment, as described in the main body of this report, required the direct optimization method implemented in CIRCUL2. The program ZOCDETM uses circulation strengths computed in CIRCUL2 to determine vortex lattice control point slopes, from which the optimal camber surfaces are determined by integration, using a cubic spline curve fit of the slopes between control points. This portion of the code also is essentially unchanged from that of reference 4, with the exception of additional output data, as discussed in Appendix C. (See reference 4 for some discussion of the accuracy of this integration process.)

The known limitations of the program are now described. First, the program will not correctly execute with a wing dihedral value of exactly 90°. Instead, it is necessary to use a dihedral near 90° (say $\phi \simeq 87\text{-}88°$) to approximate the effect of an endplate on the design. This same limitation also exists in both the original design code (ref. 4), and in the stand alone drag minimization code (ref. 7).

Next, the current limitations on the number of unknowns are described. The total (both planforms) number of horseshoe vortices must be no greater than 400, while the total number of far-field wake panels must be no more than 50. This number of unknowns leads to accuracy comparable to that obtained using 200 to 250 discrete vortex unknowns (see ref. 5). The user must also determine the chordwise number of horseshoe vortices and the spanwise numbers of both horseshoe vortices and wake panels which yield the best solution. Reference 4 discusses the recommended near-field lattice arrangement. The wake paneling is automatically done using a cosine size distribution, but the user must determine how many wake panels to assign to each planform and to each spanwise portion of a wing having constant ϕ. (See Appendix B for more details of input data preparation.)

Third, the code currently uses NASA/LaRC system subroutines such as INFOPLT for plotting which are not generally available outside the NASA computing system. Hence, plotting of the optimal camber surfaces or airfoils is not generally available. (See Appendix B for a description of the available plotting options.)

Finally, as discussed in Appendix A of reference 7, for configurations with two planforms, or for configurations having wake shapes comprised of smoothly curved surfaces which are to be approximated by a series of flat wake panels, the following restrictions hold. The wakes cannot cross one another unless such wake crossing points occur at (to machine accuracy) edges of wake panels. The code automatically searches for such wake breakpoints having equal span (y) stations with z-coordinates within 10^{-4} of one another. The z-coordinate of the wake on the second planform is then adjusted to be equal to the corresponding z-coordinate on the first planform to insure exact intersection. However, other logic in program GEOMTRY necessitates that there be a slight change in planform dihedral on a planform across such wake intersections, as for example in the wing-strut-configuration discussed in this report. (See Appendix B for further discussion of preparation of input data.) If there are intersections of wakes away from wake panel edges, the statement "80 ENTERED" appears on the program output file; design results for such computer runs are of questionable accuracy and should not be utilized. This is because there is an apparent midrange singularity which occurs in the far-field influence coefficients which is not currently dealt with adequately (ref. 7). It must also be mentioned that this singularity may occur for curved wakes, even when there are no physical wake crossings, whenever the projection of the plane containing one wake panel intersects another wake panel away from the edges of the panel. Such projection intersection points must be calculated to machine accuracy by the user, and input as planform breakpoints (see Appendix B), across which there is a slight change in planform dihedral.

APPENDIX B

INPUT DATA PREPARATION

Introduction

In this appendix instructions are given for the preparation of an input deck to use the computer program listed in Appendix E. An example input deck and the resultant output are given in Appendix D. Almost all user-supplied input, with the exception of those cards dealing with the wake paneling, is identical to input required for the original design code (discrete wake) described in reference 4. Thus, much of what follows is identical to the instructions given in reference 4. The required input data are broken into three groups: groups one and two are identical to input for the code described in reference 4, while group three contains input for the higher order wake model.

Group One

First the planform(s) geometry and reference values are input. All coordinates and sweep angles should be for the left half of the wing planform (negative y). The axis system used is shown in the planform sketch of figure 3. Any consistent set of input units is acceptable; output will be in terms of the user-chosen input units. The x-axis is in the symmetry plane and points into the wind. The y-axis is positive pointing along the right wing, while the z-axis is positive downwards. All input cards in group one use a format of 8F10.6.

Data on the first card are for the five named variables below, supplied in the following order:

PLAN	number of planforms for the configuration; use either 1. or 2.; this sets the maximum value of the variable IT;
TOTAL	specify 1. for this field;
CREF	reference chord of the configuration; this chord is used to nondimensionalize the pitching moment terms and must be greater than zero;
SREF	reference area of the configuration; this area is used to nondimensionalize the lift, drag, pitching moment, and root bending moment terms and must be greater than zero; and

XLOCTN — location of pitching moment reference point (trim point), if shifted from zero of coordinate system.

The data required to define each planform are next provided by a set of cards. The initial card in each set contains the following data, for planform IT:

AAN(IT) — number of straight line segments used to define the left half of a wing planform excluding the root chord; a maximum of 24 line segments may be used;

XS(IT) — x-location of the pivot for a variable sweep wing; use 0. for a fixed wing; the axis system used is shown in the inset to figure 3;

YS(IT) — y-location of the pivot; use 0. for a fixed wing; and

RTCDHT(IT) — vertical coordinate of the root chord of the particular planform being defined.

The rest of this data set to define a planform requires one data card for each straight line segment used to define the left half of the planform [variable AAN(IT)]. Note that, as discussed in Appendix A, if there are wake intersections it will be necessary to break a straight portion of a planform leading or trailing edge into two pieces by adding a planform breakpoint at the y-coordinate of the wake intersection. All data described below are required on all except the last card of this set; the last card uses only the first two variables in the following set:

XREG(I,IT) — x-location of the Ith breakpoint; the first breakpoint is located at the intersection of the left wing leading edge with the root chord; the breakpoints are numbered in increasing order, for each intersection of lines, in a counterclockwise direction;

YREG(I,IT) — y-location of the Ith breakpoint;

DIH(I,IT) — dihedral angle (in degrees) in Y-Z plane of line from breakpoint I to breakpoint I+1, positive upward; along a streamwise line the dihedral angle is not defined, so use 0. for these lines; the dihedral angle must have the same sign and magnitude along the leading and trailing edges of a planform over the same spanwise extent; note also that there must be a slight change in dihedral across a planform breakpoint corresponding to the intersection of wakes as discussed in Appendix A; and

AMCD — move code; this number indicates whether the line segment is on the movable panel of a variable-sweep wing; use 1. for a line which is fixed or 2. for a line which is movable.

Group Two

Two sections of data form the group two data. The first section is a single card which gives the details of the particular configuration for which the mean camber surface is to be found. This card requires a format of 5F5.1, 2F10.4. The second section is used to specify the fractional chord locations where the chord load changes from a constant to a linearly decreasing value. This card uses a format of 2F10.4.

Section one data are to be supplied in the following order:

CONFIG — arbitrary configuration number which may include up to four digits;

SCW — number of chordwise horseshoe vortices to be used to represent the wing; a maximum of 20 may be used; do not set equal to zero;

VIC — nominal number of spanwise rows at which chordwise rows of horseshoe vortices will be located; the variable VIC must not result in more than 50 chordwise rows of vortices to be used by the program to describe the left half of the configuration; in addition, the product of SCW and SSW (the actual number of spanwise rows) must not exceed 400;

MACH — Mach number; this value should be less than the critical Mach number; if a value other zero is specified, the Prandtl-Glauert correction factor will be applied to all x-coordinates;

CLDES — design lift coefficient for the lifting system;

SA(1) — variable sweep angle of the first planform; specify leading edge sweep angle (in degrees) for the first movable line adjacent to the fixed portion of the planform; for a fixed planform this quantity may be omitted; and

SA(2) variable sweep angle for the second planform.

Section two data consist of two quantities:

XCFW fractional chord location where the chord load changes from a constant value to a linearly varying value toward zero at the trailing edge of the first planform; this is the same as the symbol a used in the body of this report;

XCFT fractional chord location where the chord load changes from a constant value to a linearly varying value, decreasing to zero at the trailing edge of the second planform; if only one planform is present, the variable XCFT should be omitted from the input data.

Group Three

Two sections of data form the group three data. The first section sets various control flags to define what constraints are desired, to specify whether thickness data is to be used to obtain airfoil coordinates, and to control various plot and card punch options. The second section determines the wake panel spacing and defines the desired bending moment coefficient or thickness distribution, if required. Both sections of data are in 10F5.0 format, except for the thickness data, which is in 6F10.0 format.

Section one data consists of a single card; values are to be supplied in the following order:

FJFLAG flag to set the type of constraints to be imposed on the minimum drag design, as discussed in the theoretical development section of this report; the following values may be chosen:

0. the configuration is to be constrained only as to the total lift generated;

1. in addition to the constraint as to the total lift, the configuration is to be trimmed;

2. in addition to the constraint as to the total lift, the configuration is to have a specified wing root bending moment coef- fient, as input in section two; this option is available for a single planform only; and

FJCTL — flag to determine whether or not thickness data is to be input in section two, and to determine which plotting option is to be used; the following values may be specified:

0. no thickness data is to be specified; no plotting is to be performed;

1. no thickness data is to be specified; optimal chordwise mean line results at the centers of each chordwise row of horseshoe vortices will be plotted using NASA/LaRC computer system subroutine INFOPLT;

2. thickness data is to be specified; optimal airfoil results obtained as the addition of the optimal mean camber surface results plus or minus the specified thickness distribution will be plotted using NASA/LaRC computer system subroutine INFOPLT.

FSLP — flag to determine whether or not a deck of optimal design control point slopes is to be punched; use 1. here to obtain a deck or 0. if no deck is desired.

Section two data determines the wake panel spacing for each planform, as well as determining the wing root bending moment coefficient and thickness distribution, if required. The initial card contains the following data for planform IT:

BRK(IT) — number of breakpoints for the wake of planform IT; equal to number of flat portions of the wake of planform IT plus one; and

TOT(IT) — total number of wake panels for the wake of planform IT; this value connot exceed 50; for configurations having 2 planforms, the sum of TOT(IT) values for both planforms cannot exceed 50.

The second card determines the distribution of the TOT(IT) wake panels among the BRK(IT)-1 flat portions of the wake of planform IT; it consists of BRK(IT)-1 values; for planform IT:

SEGG(I) — number of cosine-spaced wake panels on Ith flat portion of wake of planform IT; first value specified will be the number of wake panels on the inboard portion of the wake; the sum of all SEGG(I) values on planform IT must equal TOT(IT).

The above data must be specified separately for both planforms for a two-planform configuration. Next, if FJFLAG=2., a single card follows to determine the required wing root bending moment:

CRBM — desired ratio of the design wing root bending moment coefficient, divided by the wing root bending moment coefficient of an elliptically loaded planar wing having the same span and lift coefficient as the designed configuration.

Finally, if FJCTL=2., thickness data are to be specified beginning with a single card to fix the number of thickness values:

FNZS — number of specified percent chord and thickness values; the value specified must not exceed 50.

Following the definition of FNZS are a series of cards to specify, first, the fractional chord stations where thickness data are to be given, followed by the fractional thickness values; only a single thickness distribution, valid for both planforms, may be specified. Thus, the first set of cards contains FNZS values, in 6F10.0 format:

PCTX(I) — fractional chordwise locations at which thickness data are specified; values must be specified in increasing order and must begin with 0.0 and end with 1.0.

A set of FNZS thickness data values are given as the last set of cards:

PCTZ(I) — fractional airfoil thickness at corresponding PCTX(I) chord station.

A sample input deck, as well as the resulting output appears in Appendix D. It is recommended that a minimum of 10 spanwise and 10 chordwise rows of horseshoe vortices be used (ref. 4). Use of at least 25 wake panels is also recommended. Further, some sensitivity studies as to the effects of vortex lattice arrangement and wake panel spacing are advisable (see refs. 4 and 5 for further discussion).

APPENDIX C

OUTPUT DATA DESCRIPTION

Introduction

The printed results of this computer program appear in three sections: geometry data, aerodynamic data, and local elevation data. The geometry data follows the output format of the program of reference 4, while portions of the aerodynamic and local elevation data differ in format from those of reference 4.

Geometric and Aerodynamic Data

The geometry data are described in the order that they appear on the printout. The first group of data describes the planform(s), stating the number of straight line segments used to describe the planform perimeter(s), the root-chord height, and the pivot position, followed by the breakpoints, sweep and dihedral angles and move codes. These listed data are all input data except for the sweep angles.

The second group of data describes the particular planform for which the local elevation data are being computed. Included are the configuration number, the sweep position, a listing of the breakpoints of the wing planform (x, y, z) values, sweep and dihedral angles and move codes. These data are listed primarily for variable-sweep wings to provide a definition of the planform where the outer panel sweep differs from that of the reference planform. Also listed is information about the number of horseshoe vortices and the shift of the coordinate system origin, if any.

The third group of data describes the wake geometry and far-field optimum drag solution. The wake breakpoint coordinates are listed, followed by the numbers of wake panels on each flat wake segment. Next the individual wake panel center coordinates (y, z, ϕ) and wake panel semiwidth values are printed. Following the wake geometry data, the calculated induced velocities at the wake panel centers, followed by the optimal wake vortex sheet strength and bound circulation solution values and optimal induced drag are listed.

The fourth group of data presents a detailed description of the vortex lattice used to represent the configuration. These data are listed in eight columns, where each line describes one elemental horseshoe vortex. The following information is presented for each panel or horseshoe vortex:

X C/4	x-location of quarter-chord at midspan of horseshoe vortex
X 3C/4	x-location of three-quarter-chord at midspan of horseshoe vortex; this is the x-location of the control point
Y	y-location of the midspan of the horseshoe vortex
Z	z-location of the midspan of the horseshoe vortex
S	semiwidth of the horseshoe vortex
C/4 SWEEP ANGLE	sweep angle of the quarter-chord
DIHEDRAL ANGLE	dihedral angle of the elemental panel
GAMMA/U AT CLDES	Γ/U value at the design C_L

The fifth group of data lists the following configuration reference data:

REF. CHORD	reference chord
C AVERAGE	average chord; equal to true planform area divided by true span
TRUE AREA	true planform area
REF. AREA	reference area
B/2	largest true semispan of the planforms listed in the second group of geometry data
REF. AR	reference aspect ratio computed from reference planform area and true span
TRUE AR	true aspect ratio computed from true planform area and true span
MACH NUMBER	Mach number

The sixth group of data gives aerodynamic results:

A1	fractional chord location where chord load changes from a constant value to triangular on the first planform; this is the same as the symbol a used in the body of this paper
A2	fractional chord location where chord load changes from a constant value to triangular on the second planform; this is the same as the symbol a used in the body of this paper

CL*C	$c_\ell c$, span loading
CL DESIGN	C_{Ld}, design lift coefficient
CL COMPUTED	total C_L actually developed from the interpolated spanwise bound circulations
CM COMPUTED	total C_m actually developed from the interpolated spanwise bound circulations
CD V	C_D vortex drag coefficient based on the higher order far-field solution at C_{Ld}

Local Elevation Data

This section presents the optimal local elevation solutions at varying spanwise stations, for up to two planforms. An explanation of the variables listed follows:

Y	spanwise location
Y/B/2	2y/b, fractional spanwise location based on semi-span of larger planform
CHORD	physical chord at y, projected into wing reference plane
DZ/DX	slope of local elevation curves along the chord

These data are followed by the angle of attack of the local chord line with respect to the x-axis in the X-Z plane, followed by the following elevation data, for configurations where no thickness data have been specified:

X/C	fractional chordwise distance measured from the leading edge, positive aft
Z/C	z/c, local elevation normalized by the chord measured with respect to elevation of the local trailing edge, positive down
(Z/C) COS(DIH)	z/c cos (ϕ), local elevation normalized by the chord times cosine of the local dihedral angle; equal to local normalized elevation with respect to wing reference plane, positive down
DELTA X	(x/c) (chord)
DELTA Z	(z/c) (chord)
(DLT Z) COS(DIH)	(z/c) (chord) (cos ϕ)

If thickness data have been specified, columns of the above data will also contain the following:

Z/C US COS(DIH)	upper surface local elevation normalized by the chord times cosine of the local dihedral angle; equal to local normalized wing upper surface coordinate with respect to wing reference plane, positive down
Z/C LS COS(DIH)	lower surface local elevation normalized by the chord times cosine of the local dihedral angle; equal to local normalized wing lower surface coordinate with respect to wing reference plane, positive down
Z US COS(DIH)	(z/c) (chord) (cos ϕ) upper surface
Z LS COS(DIH)	(z/c) (chord) (cos ϕ) lower surface

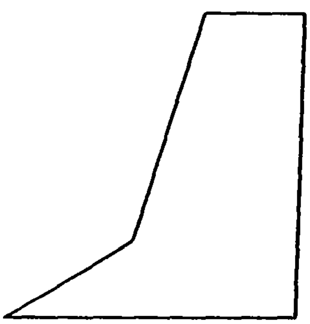
APPENDIX D

EXAMPLE OF INPUT AND OUTPUT DATA

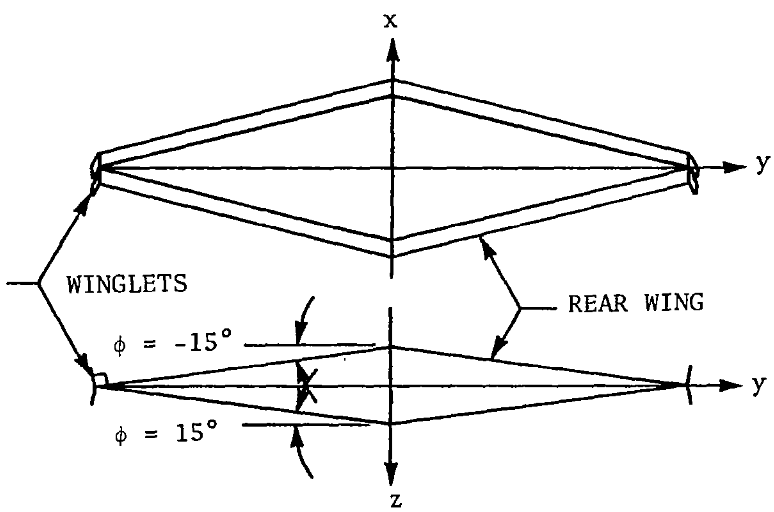
Sample input and output data are presented for the joined wing with winglet configuration presented in figures 10 and 11 of this report. Input data and a sketch of the input planform and wake shape appear on page 46, while the output data begins on page 47.

INPUT DATA FOR JOINED WING FITTED WITH WINGLETS

```
2.         1.         2.         160.       0.
6.         0.         0.         5.3589839
12.        0.         15.        1.
2.         -20.       -75.       1.
1.0551885  -20.13588  -75.       1.
.3207539   -20.54352  0.         1.
-.3292461  -20.54352  -75.       1.
0.         -20.       15.        1.
10.        0.
6.         0.         0.         -5.3589839
-10.       0.         -15.       1.
0.         -20.       75.        1.
-0.9448115-20.13588   75.        1.
-1.6792461-20.54352   0.         1.
-2.3292461-20.54352   75.        1.
-2.        -20.       -15.       1.
-12.       0.
2.    14.  13.   .75  .3
1.         1.
0.    1.
    3    25
   15    10
    3    25
   15    10
```



WINGLET PLANFORM



PROGRAM OUTPUT DATA FOR JOINED WING FITTED WITH WINGLETS

GEOMETRY DATA

FIRST REFERENCE PLANFORM HAS 6 CURVES

ROOT CHORD HEIGHT = 5.35898390 VARIABLE SWEEP PIVOT POSITION X(S) = 0.00000 Y(S) =

BREAK POINTS FOR THE REFERENCE PLANFORM

POINT	X REF	Y REF	SWEEP ANGLE	DIHEDRAL ANGLE	MOVE CODE
1	12.00000	0.00000	26.56505	15.00000	1
2	2.00000	-20.00000	81.81601	-75.00000	1
3	1.05519	-20.13588	60.96801	-75.00000	1
4	.32075	-20.54352	90.00000	0.00000	1
5	-.32925	-20.54352	31.20607	-75.00000	1
6	0.00000	-20.00000	26.56505	15.00000	1
7	10.00000	0.00000			

SECOND REFERENCE PLANFORM HAS 6 CURVES

ROOT CHORD HEIGHT = -5.35898390 VARIABLE SWEEP PIVOT POSITION X(S) = 0.00000 Y(S) =

BREAK POINTS FOR THE REFERENCE PLANFORM

POINT	X REF	Y REF	SWEEP ANGLE	DIHEDRAL ANGLE	MOVE CODE
1	-10.00000	0.00000	-26.56505	-15.00000	1
2	0.00000	-20.00000	81.81601	75.00000	1
3	-.94481	-20.13588	60.96801	75.00000	1
4	-1.67925	-20.54352	90.00000	0.00000	1
5	-2.32925	-20.54352	31.20607	75.00000	1
6	-2.00000	-20.00000	-26.56505	-15.00000	1
7	-12.00000	0.00000			

CONFIGURATION NO. 2.

CURVE 1 IS SWEPT 26.56505 DEGREES ON PLANFORM 1

CURVE 1 IS SWEPT -26.56505 DEGREES ON PLANFORM 2

BREAK POINTS FOR THIS CONFIGURATION

POINT	X	Y	Z	SWEEP ANGLE	DIHEDRAL ANGLE	MOVE CODE
1	12.00000	0.00000	5.35898	26.56505	15.00000	1
2	2.00000	-20.00000	.00000	81.81601	-75.00000	1
3	1.05519	-20.13588	.50711	60.96801	-75.00000	1
4	.32075	-20.54352	2.02844	90.00000	0.00000	1
5	-.32925	-20.54352	2.02844	31.20607	-75.00000	1
6	0.00000	-20.00000	.00000	26.56505	15.00000	1
7	10.00000	0.00000	5.35898			

SECOND PLANFORM BREAK POINTS

POINT	X	Y	Z	SWEEP ANGLE	DIHEDRAL ANGLE	MOVE CODE
1	-10.00000	0.00000	-5.35898	-26.56505	-15.00000	1
2	0.00000	-20.00000	-.00000	81.81601	75.00000	1
3	-.94481	-20.13588	-.50711	60.96801	75.00000	1
4	-1.67925	-20.54352	-2.02844	90.00000	0.00000	1
5	-2.32925	-20.54352	-2.02844	31.20607	75.00000	1
6	-2.00000	-20.00000	-.00000	-26.56505	-15.00000	1
7	-12.00000	0.00000	-5.35898			

392 HORSESHOE VORTICES USED ON THE LEFT HALF OF THE CONFIGURATION

PLANFORM	TOTAL	SPANWISE
1	196	14
2	196	14

14. HORSESHOE VORTICES IN EACH CHORDWISE ROW

X SHIFT OF ORIGIN = 0.0000 UNITS

MINIMUM FIELD LENGTH = 63000

PLANFORM 1

WAKE GEOMETRY

Y	Z	PHI
0.00000	5.35898	15.00000
-20.00000	.00000	-75.00000
-20.54352	2.02844	0.00000

NO OF WAKE VORTICITY SEGMENTS = 25

WAKE VORTICITY SEGS ON WING SEGMENT NO 1= 15

WAKE VORTICITY SEGS ON WING SEGMENT NO 2= 10

TOTAL PLANFORM PERIPHERAL LENGTH= 22.80552

PLANFORM 2

WAKE GEOMETRY

Y	Z	PHI
0.00000	-5.35898	-15.00000
-20.00000	.00000	75.00000
-20.54352	-2.02844	0.00000

NO OF WAKE VORTICITY SEGMENTS = 25

WAKE VORTICITY SEGS ON WING SEGMENT NO 5= 15

WAKE VORTICITY SEGS ON WING SEGMENT NO 6= 10

TOTAL PLANFORM PERIPHERAL LENGTH= 22.80552

SEGMT NO	Y	Z	PHI
1	-20.536870	2.003625	-1.308997
2	-20.510919	1.906775	-1.308997
3	-20.461557	1.722556	-1.308997
4	-20.393617	1.469001	-1.308997
5	-20.313749	1.170928	-1.308997
6	-20.229771	.857516	-1.308997
7	-20.149903	.559444	-1.308997
8	-20.081963	.305888	-1.308997
9	-20.032601	.121669	-1.308997
10	-20.006650	.024820	-1.308997

(cont'd)

PLANFORM 2

WAKE GEOMETRY (Continued)

SEGMENT NO.	Y	Z	PHT
11	-19.945219	.014679	.261799
12	-19.726695	.073232	.261799
13	-19.292041	.189697	.261799
14	-18.646020	.362798	.261799
15	-17.795709	.590638	.261799
16	-16.750424	.870721	.261799
17	-15.521618	1.199979	.261799
18	-14.122754	1.574803	.261799
19	-12.569159	1.991088	.261799
20	-10.877853	2.444272	.261799
21	-9.067366	2.929390	.261799
22	-7.157536	3.441128	.261799
23	-5.169287	3.973878	.261799
24	-3.124402	4.521803	.261799
25	-1.045285	5.078901	.261799
26	-20.536870	-2.003625	1.308997
27	-20.510919	-1.906775	1.308997
28	-20.461557	-1.722556	1.308997
29	-20.393617	-1.469000	1.308997
30	-20.313749	-1.170928	1.308997
31	-20.229771	-.857516	1.308997
32	-20.149902	-.559444	1.308997
33	-20.081962	-.305888	1.308997
34	-20.032601	-.121669	1.308997
35	-20.006650	-.024820	1.308997
36	-19.945219	-.014678	-.261799
37	-19.726695	-.073232	-.261799
38	-19.292041	-.189697	-.261799
39	-18.646020	-.362798	-.261799
40	-17.795709	-.590638	-.261799
41	-16.750424	-.870721	-.261799
42	-15.521618	-1.199979	-.261799
43	-14.122754	-1.574803	-.261799
44	-12.569159	-1.991088	-.261799
45	-10.877852	-2.444272	-.261799
46	-9.067366	-2.929390	-.261799
47	-7.157536	-3.441128	-.261799
48	-5.169287	-3.973878	-.261799
49	-3.124401	-4.521803	-.261799
50	-1.045285	-5.078901	-.261799

I	SNN(I)
1	.02570
2	.07457
3	.11615
4	.14635
5	.16223
6	.16223
7	.14635
8	.11615
9	.07457
10	.02570
11	.05671
12	.16952
13	.28047
14	.38834
15	.49196
16	.59019
17	.68196
18	.76625
19	.84215
20	.90882
21	.96553
22	1.01167
23	1.04672
24	1.07030
25	1.08216
26	.02570
27	.07457
28	.11615
29	.14635
30	.16223
31	.16223
32	.14635
33	.11615
34	.07457
35	.02570
36	.05671
37	.16952
38	.28047
39	.38834
40	.49196
41	.59019
42	.68196
43	.76625
44	.84215
45	.90882
46	.96553
47	1.01167
48	1.04672
49	1.07030
50	1.08216

I	DOWNWASH	W/COS(PHI)
1	.26354E-02	.10182E-01
2	.42277E-03	.16335E-02
3	.20471E-02	.79092E-02
4	.18115E-02	.69990E-02
5	.19528E-02	.75450E-02
6	.18834E-02	.72770E-02
7	.20239E-02	.78199E-02
8	.16775E-02	.64814E-02
9	.19696E-02	.76099E-02
10	.23813E-02	.92005E-02
11	.42885E-02	.44397E-02
12	.74524E-02	.77153E-02
13	.72964E-02	.75538E-02
14	.71862E-02	.74397E-02
15	.72206E-02	.74753E-02
16	.72209E-02	.74756E-02
17	.72197E-02	.74743E-02
18	.72173E-02	.74719E-02
19	.72166E-02	.74711E-02
20	.72159E-02	.74705E-02
21	.72160E-02	.74706E-02
22	.72151E-02	.74696E-02
23	.72167E-02	.74713E-02
24	.72095E-02	.74638E-02
25	.72408E-02	.74963E-02
26	.25909E-02	.10010E-01
27	.42875E-03	.16565E-02
28	.20391E-02	.78784E-02
29	.18250E-02	.70514E-02
30	.19174E-02	.74083E-02
31	.19672E-02	.76009E-02
32	.17630E-02	.68117E-02
33	.24998E-02	.96587E-02
34	-.85679E-03	-.33104E-02
35	.25199E-01	.97360E-01
36	-.84587E-03	-.87571E-03
37	.81431E-02	.84303E-02
38	.70199E-02	.72675E-02
39	.72548E-02	.75107E-02
40	.72021E-02	.74562E-02
41	.72270E-02	.74819E-02
42	.72181E-02	.74728E-02
43	.72181E-02	.74727E-02
44	.72164E-02	.74710E-02
45	.72160E-02	.74706E-02
46	.72161E-02	.74707E-02
47	.72150E-02	.74695E-02
48	.72170E-02	.74716E-02
49	.72090E-02	.74633E-02
50	.72413E-02	.74967E-02

SEGMT	ROUND CIRC	SHED STRTH	ETA
1	0.	.97090E+00	.10000E+01
2	.31154E-01	.24155E+00	.99935E+00
3	.60112E-01	.14678E+00	.99747E+00
4	.88570E-01	.98235E-01	.99455E+00
5	.11406E+00	.75912E-01	.99086E+00
6	.13622E+00	.60708E-01	.98677E+00
7	.15430E+00	.50696E-01	.98268E+00
8	.16767E+00	.40692E-01	.97900E+00
9	.17638E+00	.34269E-01	.97607E+00
10	.18042E+00	.19976E-01	.97419E+00
11	.18416E+00	.12560E+00	.97354E+00
12	.19136E+00	.12458E-02	.96821E+00
13	.19249E+00	.54515E-02	.95227E+00
14	.19675E+00	.97408E-02	.92589E+00
15	.20601E+00	.14101E-01	.88938E+00
16	.22068E+00	.15718E-01	.84311E+00
17	.23913E+00	.15546E-01	.78761E+00
18	.25958E+00	.14436E-01	.72348E+00
19	.28057E+00	.12958E-01	.65143E+00
20	.30105E+00	.11357E-01	.57223E+00
21	.32022E+00	.97358E-02	.48677E+00
22	.33745E+00	.81115E-02	.39598E+00
23	.35221E+00	.64832E-02	.30084E+00
24	.36398E+00	.47619E-02	.20241E+00
25	.37230E+00	.30113E-02	.10176E+00
26	0.	.97300E+00	.10000E+01
27	.31228E-01	.24230E+00	.99935E+00
28	.60270E-01	.14716E+00	.99747E+00
29	.88819E-01	.98639E-01	.99455E+00
30	.11440E+00	.76128E-01	.99086E+00
31	.13671E+00	.61428E-01	.98677E+00
32	.15485E+00	.50356E-01	.98268E+00
33	.16872E+00	.44426E-01	.97900E+00
34	.17691E+00	.26073E-01	.97607E+00
35	.18486E+00	.80547E-01	.97419E+00
36	.18227E+00	-.18143E+00	.97354E+00
37	.17274E+00	.13398E-01	.96821E+00
38	.17531E+00	.17682E-02	.95227E+00
39	.17874E+00	.10474E-01	.92589E+00
40	.18818E+00	.13832E-01	.88938E+00
41	.20273E+00	.15752E-01	.84311E+00
42	.22119E+00	.15511E-01	.78761E+00
43	.24161E+00	.14433E-01	.72348E+00
44	.26259E+00	.12950E-01	.65143E+00
45	.28306E+00	.11354E-01	.57223E+00
46	.30222E+00	.97334E-02	.48677E+00
47	.31945E+00	.81094E-02	.39598E+00
48	.33421E+00	.64830E-02	.30084E+00
49	.34598E+00	.47594E-02	.20241E+00
50	.35430E+00	.30137E-02	.10176E+00
51	.35756E+00	0.	0.

CD CALCULATED USING DIRECT OPTIMIZATION LINEAR SHSHEET DIST = .22412E-02

FIRST PLANFORM

HORSESHOE VORTEX DESCRIPTIONS

X C/4	X 30/4	Y	Z	S	C/4 SWEEP ANGLE	DIHEDRAL ANGLE	GAMMA/U AT CLDES= .3000
.67201	.64009	-20.33970	1.26778	.78750	60.67720	-75.00000	.00845
.60817	.57625	-20.33970	1.26778	.78750	59.45913	-75.00000	.00845
.54433	.51241	-20.33970	1.26778	.78750	58.14646	-75.00000	.00845
.48049	.44857	-20.33970	1.26778	.78750	56.72931	-75.00000	.00845
.41665	.38473	-20.33970	1.26778	.78750	55.19663	-75.00000	.00845
.35281	.32090	-20.33970	1.26778	.78750	53.53619	-75.00000	.00845
.28898	.25706	-20.33970	1.26778	.78750	51.73447	-75.00000	.00845
.22514	.19322	-20.33970	1.26778	.78750	49.77671	-75.00000	.00845
.16130	.12938	-20.33970	1.26778	.78750	47.64693	-75.00000	.00845
.09746	.06554	-20.33970	1.26778	.78750	45.32815	-75.00000	.00845
.03362	.00170	-20.33970	1.26778	.78750	42.80274	-75.00000	.00845
-.03022	-.06214	-20.33970	1.26778	.78750	40.05299	-75.00000	.00845
-.09406	-.12598	-20.33970	1.26778	.78750	37.06210	-75.00000	.00845
-.15790	-.18982	-20.33970	1.26778	.78750	33.81547	-75.00000	.00845
1.49958	1.44355	-20.06794	.25356	.26250	81.68227	-75.00000	.01243
1.38753	1.33150	-20.06794	.25356	.26250	81.10092	-75.00000	.01243
1.27547	1.21945	-20.06794	.25356	.26250	80.43301	-75.00000	.01243
1.16342	1.10739	-20.06794	.25356	.26250	79.65789	-75.00000	.01243
1.05137	.99534	-20.06794	.25356	.26250	78.74785	-75.00000	.01243
.93931	.88329	-20.06794	.25356	.26250	77.66492	-75.00000	.01243
.82726	.77123	-20.06794	.25356	.26250	76.35571	-75.00000	.01243
.71521	.65918	-20.06794	.25356	.26250	74.74293	-75.00000	.01243
.60315	.54713	-20.06794	.25356	.26250	72.71089	-75.00000	.01243
.49110	.43507	-20.06794	.25356	.26250	70.07951	-75.00000	.01243
.37905	.32302	-20.06794	.25356	.26250	66.55590	-75.00000	.01243
.26699	.21096	-20.06794	.25356	.26250	61.64062	-75.00000	.01243
.15494	.09891	-20.06794	.25356	.26250	54.44693	-75.00000	.01243
.04288	-.01314	-20.06794	.25356	.26250	43.40480	-75.00000	.01243
2.38791	2.31648	-19.15275	.22702	.87714	26.56505	15.00000	.01398
2.24505	2.17362	-19.15275	.22702	.87714	26.56505	15.00000	.01398
2.10220	2.03077	-19.15275	.22702	.87714	26.56505	15.00000	.01398
1.95934	1.88791	-19.15275	.22702	.87714	26.56505	15.00000	.01398
1.81648	1.74505	-19.15275	.22702	.87714	26.56505	15.00000	.01398
1.67362	1.60220	-19.15275	.22702	.87714	26.56505	15.00000	.01398
1.53077	1.45934	-19.15275	.22702	.87714	26.56505	15.00000	.01398
1.38791	1.31648	-19.15275	.22702	.87714	26.56505	15.00000	.01398
1.24505	1.17362	-19.15275	.22702	.87714	26.56505	15.00000	.01398
1.10220	1.03077	-19.15275	.22702	.87714	26.56505	15.00000	.01398
.95934	.88791	-19.15275	.22702	.87714	26.56505	15.00000	.01398
.81648	.74505	-19.15275	.22702	.87714	26.56505	15.00000	.01398
.67362	.60220	-19.15275	.22702	.87714	26.56505	15.00000	.01398
.53077	.45934	-19.15275	.22702	.87714	26.56505	15.00000	.01398
3.23516	3.16373	-17.45826	.68106	.87714	26.56505	15.00000	.01561

(cont'd)

FIRST PLANFORM

HORSESHOE VORTEX DESCRIPTIONS (Continued)

X C/4	X 3C/4	Y	Z	S	C/4 SWEEP ANGLE	DIHEDRAL ANGLE	GAMMA/U AT CLDES = 0.3000
3.09230	3.02087	-17.45826	.68106	.87714	26.56505	15.00000	.01561
2.94944	2.87801	-17.45826	.68106	.87714	26.56505	15.00000	.01561
2.80659	2.73516	-17.45826	.68106	.87714	26.56505	15.00000	.01561
2.66373	2.59230	-17.45826	.68106	.87714	26.56505	15.00000	.01561
2.52087	2.44944	-17.45826	.68106	.87714	26.56505	15.00000	.01561
2.37801	2.30659	-17.45826	.68106	.87714	26.56505	15.00000	.01561
2.23516	2.16373	-17.45826	.68106	.87714	26.56505	15.00000	.01561
2.09230	2.02087	-17.45826	.68106	.87714	26.56505	15.00000	.01561
1.94944	1.87801	-17.45826	.68106	.87714	26.56505	15.00000	.01561
1.80659	1.73516	-17.45826	.68106	.87714	26.56505	15.00000	.01561
1.66373	1.59230	-17.45826	.68106	.87714	26.56505	15.00000	.01561
1.52087	1.44944	-17.45826	.68106	.87714	26.56505	15.00000	.01561
1.37801	1.30659	-17.45826	.68106	.87714	26.56505	15.00000	.01561
4.08241	4.01098	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
3.93955	3.86812	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
3.79669	3.72526	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
3.65383	3.58241	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
3.51098	3.43955	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
3.36812	3.29669	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
3.22526	3.15383	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
3.08241	3.01098	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
2.93955	2.86812	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
2.79669	2.72526	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
2.65383	2.58241	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
2.51098	2.43955	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
2.36812	2.29669	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
2.22526	2.15383	-15.76376	1.13510	.87714	26.56505	15.00000	.01754
4.92965	4.85822	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
4.78680	4.71537	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
4.64394	4.57251	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
4.50108	4.42965	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
4.35822	4.28680	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
4.21537	4.14394	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
4.07251	4.00108	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
3.92965	3.85822	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
3.78680	3.71537	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
3.64394	3.57251	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
3.50108	3.42965	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
3.35822	3.28680	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
3.21537	3.14394	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
3.07251	3.00108	-14.06927	1.58914	.87714	26.56505	15.00000	.01935
5.77690	5.70547	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
5.63404	5.56262	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
5.49119	5.41976	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
5.34833	5.27690	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
5.20547	5.13404	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
5.06262	4.99119	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
4.91976	4.84833	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
4.77690	4.70547	-12.37477	2.04317	.87714	26.56505	15.00000	.02095

FIRST PLANFORM

HORSESHOE VORTEX DESCRIPTIONS (Continued)

X C/4	X 3C/4	Y	Z	S	C/4 SWEEP ANGLE	DIHEDRAL ANGLE	GAMMA/U AT CLDES = 0.3000
4.63404	4.56262	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
4.49119	4.41976	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
4.34833	4.27690	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
4.20547	4.13404	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
4.06262	3.99119	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
3.91976	3.84833	-12.37477	2.04317	.87714	26.56505	15.00000	.02095
6.62415	6.55272	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
6.48129	6.40986	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
6.33843	6.26701	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
6.19558	6.12415	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
6.05272	5.98129	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
5.90986	5.83843	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
5.76701	5.69558	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
5.62415	5.55272	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
5.48129	5.40986	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
5.33843	5.26701	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
5.19558	5.12415	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
5.05272	4.98129	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
4.90986	4.83843	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
4.76701	4.69558	-10.68027	2.49721	.87714	26.56505	15.00000	.02234
7.47140	7.39997	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
7.32854	7.25711	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
7.18568	7.11425	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
7.04283	6.97140	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
6.89997	6.82854	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
6.75711	6.68568	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
6.61425	6.54283	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
6.47140	6.39997	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
6.32854	6.25711	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
6.18568	6.11425	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
6.04283	5.97140	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
5.89997	5.82854	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
5.75711	5.68568	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
5.61425	5.54283	-8.98578	2.95125	.87714	26.56505	15.00000	.02354
8.31864	8.24722	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
8.17579	8.10436	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
8.03293	7.96150	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
7.89007	7.81864	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
7.74722	7.67579	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
7.60436	7.53293	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
7.46150	7.39007	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
7.31864	7.24722	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
7.17579	7.10436	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
7.03293	6.96150	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
6.89007	6.81864	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
6.74722	6.67579	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
6.60436	6.53293	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
6.46150	6.39007	-7.29128	3.40529	.87714	26.56505	15.00000	.02456
9.16589	9.09446	-5.59679	3.85933	.87714	26.56505	15.00000	.02540

FIRST PLANFORM

HORSESHOE VORTEX DESCRIPTIONS (Concluded)

C/4	X 3C/4	Y	Z	S	C/4 SWEEP ANGLE	DIHEDRAL ANGLE	GAMMA/U AT CLDES =0.3000
9.02304	8.95161	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
8.88018	8.80875	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
8.73732	8.66589	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
8.59446	8.52304	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
8.45161	8.38018	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
8.30875	8.23732	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
8.16589	8.09446	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
8.02304	7.95161	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
7.88018	7.80875	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
7.73732	7.66589	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
7.59446	7.52304	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
7.45161	7.38018	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
7.30875	7.23732	-5.59679	3.85933	.87714	26.56505	15.00000	.02540
10.01314	9.94171	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
9.87028	9.79885	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
9.72743	9.65600	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
9.58457	9.51314	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
9.44171	9.37028	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
9.29885	9.22743	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
9.15600	9.08457	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
9.01314	8.94171	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
8.87028	8.79885	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
8.72743	8.65600	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
8.58457	8.51314	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
8.44171	8.37028	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
8.29885	8.22743	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
8.15600	8.08457	-3.90229	4.31337	.87714	26.56505	15.00000	.02607
10.86039	10.78896	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
10.71753	10.64610	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
10.57467	10.50325	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
10.43182	10.36039	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
10.28896	10.21753	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
10.14610	10.07467	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
10.00325	9.93182	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
9.86039	9.78896	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
9.71753	9.64610	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
9.57467	9.50325	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
9.43182	9.36039	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
9.28896	9.21753	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
9.14610	9.07467	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
9.00325	8.93182	-2.20780	4.76741	.87714	26.56505	15.00000	.02656
11.62415	11.55272	-.68027	5.17671	.70427	26.56505	15.00000	.02675
11.48129	11.40986	-.68027	5.17671	.70427	26.56505	15.00000	.02675
11.33843	11.26701	-.68027	5.17671	.70427	26.56505	15.00000	.02675
11.19558	11.12415	-.68027	5.17671	.70427	26.56505	15.00000	.02675
11.05272	10.98129	-.68027	5.17671	.70427	26.56505	15.00000	.02675
10.90986	10.83843	-.68027	5.17671	.70427	26.56505	15.00000	.02675
10.76701	10.69558	-.68027	5.17671	.70427	26.56505	15.00000	.02675
10.62415	10.55272	-.68027	5.17671	.70427	26.56505	15.00000	.02675
10.48129	10.40986	-.68027	5.17671	.70427	26.56505	15.00000	.02675
10.33843	10.26701	-.68027	5.17671	.70427	26.56505	15.00000	.02675
10.19558	10.12415	-.68027	5.17671	.70427	26.56505	15.00000	.02675
10.05272	9.98129	-.68027	5.17671	.70427	26.56505	15.00000	.02675
9.90986	9.83843	-.68027	5.17671	.70427	26.56505	15.00000	.02675
9.76701	9.69558	-.68027	5.17671	.70427	26.56505	15.00000	.02675

SECOND PLANFORM HORSESHOE VORTEX DESCRIPTIONS

-1.32799	-1.35991	-20.33970	-1.26778	.78750	60.67720	75.00000	.00848
-1.39183	-1.42375	-20.33970	-1.26778	.78750	59.45913	75.00000	.00848
-1.45567	-1.48759	-20.33970	-1.26778	.78750	58.14646	75.00000	.00848
-1.51951	-1.55143	-20.33970	-1.26778	.78750	56.72931	75.00000	.00848
-1.58335	-1.61527	-20.33970	-1.26778	.78750	55.19663	75.00000	.00848
-1.64719	-1.67910	-20.33970	-1.26778	.78750	53.53619	75.00000	.00848
-1.71102	-1.74294	-20.33970	-1.26778	.78750	51.73447	75.00000	.00848
-1.77486	-1.80678	-20.33970	-1.26778	.78750	49.77671	75.00000	.00848
-1.83870	-1.87062	-20.33970	-1.26778	.78750	47.64693	75.00000	.00848
-1.90254	-1.93446	-20.33970	-1.26778	.78750	45.32815	75.00000	.00848
-1.96638	-1.99830	-20.33970	-1.26778	.78750	42.80274	75.00000	.00848
-2.03022	-2.06214	-20.33970	-1.26778	.78750	40.05299	75.00000	.00848
-2.09406	-2.12598	-20.33970	-1.26778	.78750	37.06210	75.00000	.00848
-2.15790	-2.18982	-20.33970	-1.26778	.78750	33.81547	75.00000	.00848
-.50042	-.55645	-20.06794	-.25356	.26250	81.68227	75.00000	.01248
-.61247	-.66850	-20.06794	-.25356	.26250	81.10092	75.00000	.01248
-.72453	-.78055	-20.06794	-.25356	.26250	80.43301	75.00000	.01248
-.83658	-.89261	-20.06794	-.25356	.26250	79.65789	75.00000	.01248
-.94863	-1.00466	-20.06794	-.25356	.26250	78.74785	75.00000	.01248
-1.06069	-1.11671	-20.06794	-.25356	.26250	77.66492	75.00000	.01248
-1.17274	-1.22877	-20.06794	-.25356	.26250	76.35571	75.00000	.01248
-1.28479	-1.34082	-20.06794	-.25356	.26250	74.74293	75.00000	.01248
-1.39685	-1.45287	-20.06794	-.25356	.26250	72.71089	75.00000	.01248
-1.50890	-1.56493	-20.06794	-.25356	.26250	70.07951	75.00000	.01248
-1.62095	-1.67698	-20.06794	-.25356	.26250	66.55590	75.00000	.01248
-1.73301	-1.78904	-20.06794	-.25356	.26250	61.64062	75.00000	.01248
-1.84506	-1.90109	-20.06794	-.25356	.26250	54.44693	75.00000	.01248
-1.95712	-2.01314	-20.06794	-.25356	.26250	43.40480	75.00000	.01248
-.45934	-.53077	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-.60220	-.67362	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-.74505	-.81648	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-.88791	-.95934	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-1.03077	-1.10220	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-1.17362	-1.24505	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-1.31648	-1.38791	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-1.45934	-1.53077	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-1.60220	-1.67362	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-1.74505	-1.81648	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-1.88791	-1.95934	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-2.03077	-2.10220	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271

(cont'd)

SECOND PLANFORM HORSESHOE

VORTEX DESCRIPTIONS

(Continued)

-2.17362	-2.24505	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-2.31648	-2.38791	-19.15275	-.22702	.87714	-26.56505	-15.00000	.01271
-1.30659	-1.37801	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-1.44944	-1.52087	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-1.59230	-1.66373	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-1.73516	-1.80659	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-1.87801	-1.94944	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-2.02087	-2.09230	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-2.16373	-2.23516	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-2.30659	-2.37801	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-2.44944	-2.52087	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-2.59230	-2.66373	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-2.73516	-2.80659	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-2.87801	-2.94944	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-3.02087	-3.09230	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-3.16373	-3.23516	-17.45826	-.68106	.87714	-26.56505	-15.00000	.01433
-2.15383	-2.22526	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-2.29669	-2.36812	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-2.43955	-2.51098	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-2.58241	-2.65383	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-2.72526	-2.79669	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-2.86812	-2.93955	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-3.01098	-3.08241	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-3.15383	-3.22526	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-3.29669	-3.86812	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-3.43955	-3.51098	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-3.58241	-3.65383	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-3.72526	-3.79669	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-3.86812	-3.93955	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-4.01098	-4.08241	-15.76376	-1.13510	.87714	-26.56505	-15.00000	.01626
-3.00108	-3.07251	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-3.14394	-3.21537	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-3.28680	-3.35822	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-3.42965	-3.50108	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-3.57251	-3.64394	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-3.71537	-3.78680	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-3.85822	-3.92965	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-4.00108	-4.07251	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-4.14394	-4.21537	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-4.28680	-4.35822	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-4.42965	-4.50108	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-4.57251	-4.64394	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-4.71537	-4.78680	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-4.85822	-4.92965	-14.06927	-1.58914	.87714	-26.56505	-15.00000	.01806
-3.84833	-3.91976	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-3.99119	-4.06262	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-4.13404	-4.20547	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-4.27690	-4.34833	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-4.41976	-4.49119	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966

SECOND PLANFORM HORSESHOE

VORTEX DESCRIPTION

(Continued)

-4.56262	-4.63404	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-4.70547	-4.77690	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-4.84833	-4.91976	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-4.99119	-5.06262	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-5.13404	-5.20547	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-5.27690	-5.34833	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-5.41976	-5.49119	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-5.56262	-5.63404	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-5.70547	-5.77690	-12.37477	-2.04317	.87714	-26.56505	-15.00000	.01966
-4.69558	-4.76701	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-4.83843	-4.90986	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-4.98129	-5.05272	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-5.12415	-5.19558	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-5.26701	-5.33843	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-5.40986	-5.48129	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-5.55272	-5.62415	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-5.69558	-5.76701	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-5.83843	-5.90986	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-5.98129	-6.05272	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-6.12415	-6.19558	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-6.26701	-6.33843	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-6.40986	-6.48129	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-6.55272	-6.62415	-10.68027	-2.49721	.87714	-26.56505	-15.00000	.02106
-5.54283	-5.61425	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-5.68568	-5.75711	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-5.82854	-5.89997	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-5.97140	-6.04283	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-6.11425	-6.18568	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-6.25711	-6.32854	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-6.39997	-6.47140	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-6.54283	-6.61425	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-6.68568	-6.75711	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-6.82854	-6.89997	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-6.97140	-7.04283	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-7.11425	-7.18568	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-7.25711	-7.32854	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-7.39997	-7.47140	-8.98578	-2.95125	.87714	-26.56505	-15.00000	.02226
-6.39007	-6.46150	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-6.53293	-6.60436	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-6.67579	-6.74722	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-6.81864	-6.89007	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-6.96150	-7.03293	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-7.10436	-7.17579	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-7.24722	-7.31864	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-7.39007	-7.46150	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-7.53293	-7.60436	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-7.67579	-7.74722	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-7.81864	-7.89007	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-7.96150	-8.03293	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327

SECOND PLANFORM HORSESHOE

VORTEX DESCRIPTIONS

(Continued)

-8.10436	-8.17579	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-8.24722	-8.31864	-7.29128	-3.40529	.87714	-26.56505	-15.00000	.02327
-7.23732	-7.30875	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-7.38018	-7.45161	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-7.52304	-7.59446	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-7.66589	-7.73732	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-7.80875	-7.88018	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-7.95161	-8.02304	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-8.09446	-8.16589	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-8.23732	-8.30875	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-8.38018	-8.45161	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-8.52304	-8.59446	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-8.66589	-8.73732	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-8.80875	-8.88018	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-8.95161	-9.02304	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-9.09446	-9.16589	-5.59679	-3.85933	.87714	-26.56505	-15.00000	.02411
-8.08457	-8.15600	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-8.22743	-8.29885	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-8.37028	-8.44171	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-8.51314	-8.58457	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-8.65600	-8.72743	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-8.79885	-8.87028	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-8.94171	-9.01314	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-9.08457	-9.15600	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-9.22743	-9.29885	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-9.37028	-9.44171	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-9.51314	-9.58457	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-9.65600	-9.72743	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-9.79885	-9.87028	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-9.94171	-10.01314	-3.90229	-4.31337	.87714	-26.56505	-15.00000	.02479
-8.93182	-9.00325	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-9.07467	-9.14610	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-9.21753	-9.28896	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-9.36039	-9.43182	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-9.50325	-9.57467	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-9.64610	-9.71753	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-9.78896	-9.86039	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-9.93182	-10.00325	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-10.07467	-10.14610	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-10.21753	-10.28896	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-10.36039	-10.43182	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-10.50325	-10.57467	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-10.64610	-10.71753	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-10.78896	-10.86039	-2.20780	-4.76741	.87714	-26.56505	-15.00000	.02527
-9.69558	-9.76701	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546
-9.83843	-9.90986	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546
-9.98129	-10.05272	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546
-10.12415	-10.19558	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546
-10.26701	-10.33843	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546

SECOND PLANFORM HORSESHOE

VORTEX DESCRIPTIONS

(Concluded)

-10.40986	-10.48129	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546
-10.55272	-10.62415	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546
-10.69558	-10.76701	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546
-10.83843	-10.90986	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546
-10.98129	-11.05272	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546
-11.12415	-11.19558	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546
-11.26701	-11.33843	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546
-11.40986	-11.48129	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546
-11.55272	-11.62415	-.68027	-5.17671	.70427	-26.56505	-15.00000	.02546

REF. CHORD	C AVERAGE	TRUE AREA	REFERENCE AREA	B/2	REF. AR	TRUE AR	MACH NUMBER
2.00000	3.95039	162.30996	160.00000	20.54352	10.55091	10.40075	.75000

A1 = 1.00000

A2 = 1.00000

F I R S T   P L A N F O R M   S P A N   L O A D I N G

Y	CL*C
-20.33970	.06123
-20.06794	.09010
-19.15275	.37810
-17.45826	.42221
-15.76376	.47446
-14.06927	.52321
-12.37477	.56652
-10.68027	.60426
-8.98578	.63671
-7.29128	.66421
-5.59679	.68699
-3.90229	.70515
-2.20780	.71832
-.68027	.72348

CL DEVELOPED ON THIS PLANFORM=   .154441

CM DEVELOPED ON THIS PLANFORM=   .502438

S E C O N D   P L A N F O R M   S P A N   L O A D I N G

Y	CL*C
-20.33970	.06142
-20.06794	.09044
-19.15275	.34369
-17.45826	.38758
-15.76376	.43977
-14.06927	.48848
-12.37477	.53178
-10.68027	.56950
-8.98578	.60195
-7.29128	.62944
-5.59679	.65221
-3.90229	.67037
-2.20780	.68354
-.68027	.68871

CL DEVELOPED ON THIS PLANFORM= .145462
CM DEVELOPED ON THIS PLANFORM= -.471198

CL DESIGN = .300000   CL COMPUTED= .299904   CM COMPUTED= .312E-01   CD V= .002241

LOCAL ELEVATION DATA

Y= -20.3397 Y/P/2= -.9901 CHORD= .8938

SLOPES.DZ/DX.AT SLOPE POINTS.FROM FRONT TO REAR

.1996 .1494 .1169 .0918 .0704 .0511 .0328 .0147-.0039-.0238-.0466-.0751-.1177-.2332

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= 1.3739DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
.0000	.0240	.0062	.0000	.0214	.0055
.0250	.0190	.0049	.0223	.0170	.0044
.0500	.0139	.0036	.0447	.0124	.0032
.0750	.0090	.0023	.0670	.0081	.0021
.1000	.0046	.0012	.0894	.0041	.0011
.1250	.0006	.0001	.1117	.0005	.0001
.1500	-.0030	-.0008	.1341	-.0027	-.0007
.1750	-.0062	-.0016	.1564	-.0055	-.0014
.2000	-.0092	-.0024	.1788	-.0082	-.0021
.2250	-.0120	-.0031	.2011	-.0107	-.0028
.2500	-.0145	-.0038	.2234	-.0130	-.0034
.2750	-.0169	-.0044	.2458	-.0151	-.0039
.3000	-.0190	-.0049	.2681	-.0170	-.0044
.3250	-.0210	-.0054	.2905	-.0187	-.0049
.3500	-.0227	-.0059	.3128	-.0203	-.0053
.3750	-.0243	-.0063	.3352	-.0218	-.0056
.4000	-.0258	-.0067	.3575	-.0230	-.0060
.4250	-.0270	-.0070	.3798	-.0242	-.0063
.4500	-.0281	-.0073	.4022	-.0252	-.0065
.4750	-.0291	-.0075	.4245	-.0260	-.0067
.5000	-.0299	-.0077	.4469	-.0267	-.0069
.5250	-.0305	-.0079	.4692	-.0273	-.0071
.5500	-.0310	-.0080	.4916	-.0277	-.0072
.5750	-.0313	-.0081	.5139	-.0280	-.0072
.6000	-.0314	-.0081	.5363	-.0281	-.0073
.6250	-.0314	-.0081	.5586	-.0281	-.0073
.6500	-.0312	-.0081	.5809	-.0279	-.0072
.6750	-.0309	-.0080	.6033	-.0276	-.0071
.7000	-.0303	-.0079	.6256	-.0271	-.0070
.7250	-.0296	-.0077	.6480	-.0265	-.0069
.7500	-.0287	-.0074	.6703	-.0257	-.0066
.7750	-.0276	-.0071	.6927	-.0247	-.0064
.8000	-.0262	-.0068	.7150	-.0235	-.0061
.8250	-.0246	-.0064	.7373	-.0220	-.0057
.8500	-.0227	-.0059	.7597	-.0203	-.0053
.8750	-.0207	-.0054	.7820	-.0185	-.0048
.9000	-.0184	-.0048	.8044	-.0164	-.0043
.9250	-.0154	-.0040	.8267	-.0137	-.0036
.9500	-.0112	-.0029	.8491	-.0100	-.0026
.9750	-.0058	-.0015	.8714	-.0052	-.0013
1.0000	0.0000	0.0000	.8938	0.0000	0.0000

Y= -20.0679 Y/B/2= -.9769 CHORD= 1.5688

SLOPES.DZ/DX.AT SLOPE POINTS.FROM FRONT TO REAR

.1936 .0976 .0419 .0049-.0208-.0397-.0549-.0681-.0807-.0939-.1093-.1301-.1647-.2609

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -2.3371DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
.0000	-.0408	-.0106	.0000	-.0640	-.0166
.0250	-.0457	-.0118	.0392	-.0717	-.0186
.0500	-.0506	-.0131	.0784	-.0794	-.0206
.0750	-.0553	-.0143	.1177	-.0867	-.0224
.1000	-.0592	-.0153	.1569	-.0928	-.0240
.1250	-.0620	-.0161	.1961	-.0973	-.0252
.1500	-.0641	-.0166	.2353	-.1006	-.0260
.1750	-.0657	-.0170	.2745	-.1030	-.0267
.2000	-.0668	-.0173	.3138	-.1049	-.0271
.2250	-.0677	-.0175	.3530	-.1062	-.0275
.2500	-.0682	-.0176	.3922	-.1069	-.0277
.2750	-.0684	-.0177	.4314	-.1072	-.0278
.3000	-.0683	-.0177	.4706	-.1071	-.0277
.3250	-.0680	-.0176	.5098	-.1066	-.0276
.3500	-.0675	-.0175	.5491	-.1058	-.0274
.3750	-.0668	-.0173	.5883	-.1048	-.0271
.4000	-.0659	-.0171	.6275	-.1034	-.0268
.4250	-.0649	-.0168	.6667	-.1018	-.0264
.4500	-.0638	-.0165	.7059	-.1000	-.0259
.4750	-.0625	-.0162	.7452	-.0980	-.0254
.5000	-.0611	-.0158	.7844	-.0959	-.0248
.5250	-.0596	-.0154	.8236	-.0935	-.0242
.5500	-.0580	-.0150	.8628	-.0909	-.0235
.5750	-.0562	-.0145	.9020	-.0882	-.0228
.6000	-.0544	-.0141	.9413	-.0853	-.0221
.6250	-.0524	-.0136	.9805	-.0822	-.0213
.6500	-.0503	-.0130	1.0197	-.0789	-.0204
.6750	-.0481	-.0125	1.0589	-.0755	-.0195
.7000	-.0458	-.0119	1.0981	-.0719	-.0186
.7250	-.0434	-.0112	1.1373	-.0681	-.0176
.7500	-.0409	-.0106	1.1766	-.0641	-.0166
.7750	-.0382	-.0099	1.2158	-.0599	-.0155
.8000	-.0353	-.0091	1.2550	-.0553	-.0143
.8250	-.0322	-.0083	1.2942	-.0505	-.0131
.8500	-.0290	-.0075	1.3334	-.0454	-.0118
.8750	-.0256	-.0066	1.3727	-.0401	-.0104
.9000	-.0220	-.0057	1.4119	-.0345	-.0089
.9250	-.0178	-.0046	1.4511	-.0279	-.0072
.9500	-.0126	-.0033	1.4903	-.0198	-.0051
.9750	-.0065	-.0017	1.5295	-.0102	-.0026
1.0000	0.0000	0.0000	1.5688	0.0000	0.0000

Y= -19.1528 Y/B/2= -.9323 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0353 .0253 .0186 .0133 .0086 .0043 .0002-.0038-.0078-.0120-.0166-.0224-.0313-.0576

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.0925DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
.0000	-.0016	-.0016	.0000	-.0032	-.0031
.0250	-.0025	-.0024	.0500	-.0050	-.0048
.0500	-.0034	-.0033	.1000	-.0068	-.0066
.0750	-.0043	-.0041	.1500	-.0085	-.0082
.1000	-.0050	-.0049	.2000	-.0101	-.0097
.1250	-.0057	-.0055	.2500	-.0114	-.0111
.1500	-.0063	-.0061	.3000	-.0126	-.0122
.1750	-.0068	-.0066	.3500	-.0137	-.0132
.2000	-.0073	-.0071	.4000	-.0147	-.0142
.2250	-.0078	-.0075	.4500	-.0155	-.0150
.2500	-.0082	-.0079	.5000	-.0163	-.0157
.2750	-.0085	-.0082	.5500	-.0170	-.0164
.3000	-.0088	-.0085	.6000	-.0176	-.0170
.3250	-.0090	-.0087	.6500	-.0181	-.0175
.3500	-.0093	-.0089	.7000	-.0185	-.0179
.3750	-.0094	-.0091	.7500	-.0189	-.0182
.4000	-.0096	-.0093	.8000	-.0192	-.0185
.4250	-.0097	-.0094	.8500	-.0194	-.0187
.4500	-.0098	-.0094	.9000	-.0195	-.0188
.4750	-.0098	-.0095	.9500	-.0196	-.0189
.5000	-.0098	-.0095	1.0000	-.0196	-.0189
.5250	-.0097	-.0094	1.0500	-.0195	-.0188
.5500	-.0097	-.0093	1.1000	-.0193	-.0187
.5750	-.0096	-.0092	1.1500	-.0191	-.0185
.6000	-.0094	-.0091	1.2000	-.0188	-.0182
.6250	-.0092	-.0089	1.2500	-.0185	-.0179
.6500	-.0090	-.0087	1.3000	-.0181	-.0174
.6750	-.0088	-.0085	1.3500	-.0176	-.0170
.7000	-.0085	-.0082	1.4000	-.0170	-.0164
.7250	-.0082	-.0079	1.4500	-.0163	-.0158
.7500	-.0078	-.0075	1.5000	-.0156	-.0151
.7750	-.0074	-.0071	1.5500	-.0148	-.0143
.8000	-.0069	-.0067	1.6000	-.0139	-.0134
.8250	-.0064	-.0062	1.6500	-.0129	-.0124
.8500	-.0059	-.0057	1.7000	-.0117	-.0113
.8750	-.0053	-.0051	1.7500	-.0106	-.0102
.9000	-.0046	-.0045	1.8000	-.0093	-.0090
.9250	-.0038	-.0037	1.8500	-.0077	-.0074
.9500	-.0028	-.0027	1.9000	-.0055	-.0053
.9750	-.0014	-.0014	1.9500	-.0029	-.0028
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -17.4583 Y/B/2= -.8498 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0404 .0295 .0225 .0170 .0122 .0079 .0037-.0005-.0050-.0098-.0155-.0227-.0338-.0644

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= .0328DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
.0000	.0006	.0006	.0000	.0011	.0011
.0250	-.0004	-.0004	.0500	-.0009	-.0009
.0500	-.0015	-.0014	.1000	-.0029	-.0028
.0750	-.0025	-.0024	.1500	-.0049	-.0047
.1000	-.0034	-.0032	.2000	-.0067	-.0065
.1250	-.0041	-.0040	.2500	-.0083	-.0080
.1500	-.0048	-.0047	.3000	-.0097	-.0093
.1750	-.0055	-.0053	.3500	-.0109	-.0106
.2000	-.0060	-.0058	.4000	-.0121	-.0117
.2250	-.0066	-.0064	.4500	-.0132	-.0127
.2500	-.0071	-.0068	.5000	-.0141	-.0136
.2750	-.0075	-.0072	.5500	-.0150	-.0145
.3000	-.0079	-.0076	.6000	-.0158	-.0152
.3250	-.0082	-.0080	.6500	-.0165	-.0159
.3500	-.0085	-.0082	.7000	-.0171	-.0165
.3750	-.0088	-.0085	.7500	-.0176	-.0170
.4000	-.0090	-.0087	.8000	-.0181	-.0175
.4250	-.0092	-.0089	.8500	-.0185	-.0178
.4500	-.0094	-.0091	.9000	-.0188	-.0181
.4750	-.0095	-.0092	.9500	-.0190	-.0184
.5000	-.0096	-.0093	1.0000	-.0192	-.0185
.5250	-.0096	-.0093	1.0500	-.0193	-.0186
.5500	-.0097	-.0093	1.1000	-.0193	-.0187
.5750	-.0096	-.0093	1.1500	-.0193	-.0186
.6000	-.0096	-.0092	1.2000	-.0191	-.0185
.6250	-.0095	-.0091	1.2500	-.0189	-.0183
.6500	-.0093	-.0090	1.3000	-.0186	-.0180
.6750	-.0091	-.0088	1.3500	-.0183	-.0176
.7000	-.0089	-.0086	1.4000	-.0178	-.0172
.7250	-.0086	-.0083	1.4500	-.0173	-.0167
.7500	-.0083	-.0080	1.5000	-.0166	-.0160
.7750	-.0079	-.0077	1.5500	-.0159	-.0153
.8000	-.0075	-.0072	1.6000	-.0150	-.0145
.8250	-.0070	-.0067	1.6500	-.0140	-.0135
.8500	-.0064	-.0062	1.7000	-.0128	-.0124
.8750	-.0058	-.0056	1.7500	-.0116	-.0112
.9000	-.0051	-.0050	1.8000	-.0103	-.0099
.9250	-.0043	-.0041	1.8500	-.0085	-.0082
.9500	-.0031	-.0030	1.9000	-.0062	-.0060
.9750	-.0016	-.0016	1.9500	-.0032	-.0031
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -15.7638 Y/B/2= -.7673 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

[illegible] .0320 .0241 .0179 .0125 .0076 .0029-.0019-.0069-.0124-.0188-.0270-.0395-.0740

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.0378DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
0.0000	-.0007	-.0006	0.0000	-.0013	-.0013
.0250	-.0018	-.0017	.0500	-.0035	-.0034
.0500	-.0029	-.0028	.1000	-.0058	-.0056
.0750	-.0040	-.0038	.1500	-.0079	-.0077
.1000	-.0050	-.0048	.2000	-.0099	-.0096
.1250	-.0058	-.0056	.2500	-.0116	-.0112
.1500	-.0066	-.0063	.3000	-.0131	-.0127
.1750	-.0073	-.0070	.3500	-.0145	-.0140
.2000	-.0079	-.0076	.4000	-.0157	-.0152
.2250	-.0084	-.0082	.4500	-.0169	-.0163
.2500	-.0090	-.0086	.5000	-.0179	-.0173
.2750	-.0094	-.0091	.5500	-.0188	-.0182
.3000	-.0098	-.0095	.6000	-.0196	-.0190
.3250	-.0102	-.0098	.6500	-.0204	-.0197
.3500	-.0105	-.0101	.7000	-.0210	-.0203
.3750	-.0108	-.0104	.7500	-.0215	-.0208
.4000	-.0110	-.0106	.8000	-.0220	-.0212
.4250	-.0112	-.0108	.8500	-.0224	-.0216
.4500	-.0113	-.0109	.9000	-.0227	-.0219
.4750	-.0114	-.0110	.9500	-.0229	-.0221
.5000	-.0115	-.0111	1.0000	-.0230	-.0222
.5250	-.0115	-.0111	1.0500	-.0230	-.0222
.5500	-.0115	-.0111	1.1000	-.0230	-.0222
.5750	-.0114	-.0110	1.1500	-.0229	-.0221
.6000	-.0113	-.0109	1.2000	-.0227	-.0219
.6250	-.0112	-.0108	1.2500	-.0224	-.0216
.6500	-.0110	-.0106	1.3000	-.0220	-.0212
.6750	-.0107	-.0104	1.3500	-.0215	-.0207
.7000	-.0104	-.0101	1.4000	-.0209	-.0202
.7250	-.0101	-.0098	1.4500	-.0202	-.0195
.7500	-.0097	-.0094	1.5000	-.0194	-.0188
.7750	-.0093	-.0089	1.5500	-.0185	-.0179
.8000	-.0087	-.0084	1.6000	-.0174	-.0169
.8250	-.0081	-.0078	1.6500	-.0162	-.0157
.8500	-.0074	-.0072	1.7000	-.0149	-.0144
.8750	-.0067	-.0065	1.7500	-.0135	-.0130
.9000	-.0059	-.0057	1.8000	-.0118	-.0114
.9250	-.0049	-.0047	1.8500	-.0098	-.0095
.9500	-.0035	-.0034	1.9000	-.0071	-.0069
.9750	-.0018	-.0018	1.9500	-.0037	-.0036
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -14.0693 Y/P/2= -.6849 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0477 .0342 .0254 .0185 .0125 .0071 .0019-.0034-.0089-.0150-.0221-.0311-.0448-.0829

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.1143DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
.0000	-.0020	-.0019	.0000	-.0040	-.0039
.0250	-.0032	-.0031	.0500	-.0064	-.0062
.0500	-.0044	-.0043	.1000	-.0088	-.0085
.0750	-.0056	-.0054	.1500	-.0111	-.0108
.1000	-.0066	-.0064	.2000	-.0132	-.0128
.1250	-.0075	-.0073	.2500	-.0151	-.0146
.1500	-.0083	-.0081	.3000	-.0167	-.0161
.1750	-.0091	-.0088	.3500	-.0181	-.0175
.2000	-.0097	-.0094	.4000	-.0194	-.0188
.2250	-.0103	-.0100	.4500	-.0206	-.0199
.2500	-.0108	-.0105	.5000	-.0217	-.0210
.2750	-.0113	-.0109	.5500	-.0226	-.0219
.3000	-.0117	-.0113	.6000	-.0235	-.0227
.3250	-.0121	-.0117	.6500	-.0242	-.0234
.3500	-.0124	-.0120	.7000	-.0248	-.0240
.3750	-.0127	-.0123	.7500	-.0254	-.0245
.4000	-.0129	-.0125	.8000	-.0258	-.0249
.4250	-.0131	-.0126	.8500	-.0262	-.0253
.4500	-.0132	-.0128	.9000	-.0264	-.0255
.4750	-.0133	-.0128	.9500	-.0266	-.0257
.5000	-.0133	-.0129	1.0000	-.0267	-.0258
.5250	-.0133	-.0129	1.0500	-.0267	-.0257
.5500	-.0133	-.0128	1.1000	-.0265	-.0256
.5750	-.0132	-.0127	1.1500	-.0263	-.0254
.6000	-.0130	-.0126	1.2000	-.0260	-.0251
.6250	-.0128	-.0124	1.2500	-.0256	-.0248
.6500	-.0126	-.0121	1.3000	-.0251	-.0243
.6750	-.0123	-.0119	1.3500	-.0245	-.0237
.7000	-.0119	-.0115	1.4000	-.0238	-.0230
.7250	-.0115	-.0111	1.4500	-.0230	-.0222
.7500	-.0110	-.0107	1.5000	-.0221	-.0213
.7750	-.0105	-.0101	1.5500	-.0210	-.0203
.8000	-.0099	-.0095	1.6000	-.0198	-.0191
.8250	-.0092	-.0089	1.6500	-.0184	-.0177
.8500	-.0084	-.0081	1.7000	-.0168	-.0162
.8750	-.0076	-.0073	1.7500	-.0152	-.0147
.9000	-.0067	-.0064	1.8000	-.0133	-.0129
.9250	-.0055	-.0053	1.8500	-.0110	-.0106
.9500	-.0040	-.0038	1.9000	-.0080	-.0077
.9750	-.0021	-.0020	1.9500	-.0041	-.0040
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -12.3748 Y/B/2= -.6024 CHORD= 2.0000

SLOPES.DZ/DX.AT SLOPE POINTS.FROM FRONT TO REAR

.0506 .0360 .0264 .0189 .0125 .0066 .0009-.0048-.0108-.0174-.0250-.0347-.0496-.0908

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.1860DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DTH)	DELTA X	DELTA Z	(DLT Z)COS(DTH)
.0000	-.0032	-.0031	.0000	-.0065	-.0063
.0250	-.0045	-.0044	.0500	-.0090	-.0087
.0500	-.0058	-.0056	.1000	-.0116	-.0112
.0750	-.0070	-.0068	.1500	-.0141	-.0136
.1000	-.0082	-.0079	.2000	-.0163	-.0158
.1250	-.0091	-.0088	.2500	-.0182	-.0176
.1500	-.0100	-.0096	.3000	-.0199	-.0193
.1750	-.0107	-.0104	.3500	-.0214	-.0207
.2000	-.0114	-.0110	.4000	-.0228	-.0220
.2250	-.0120	-.0116	.4500	-.0240	-.0232
.2500	-.0126	-.0121	.5000	-.0251	-.0243
.2750	-.0131	-.0126	.5500	-.0261	-.0252
.3000	-.0135	-.0130	.6000	-.0270	-.0260
.3250	-.0139	-.0134	.6500	-.0277	-.0268
.3500	-.0142	-.0137	.7000	-.0283	-.0274
.3750	-.0144	-.0139	.7500	-.0289	-.0279
.4000	-.0146	-.0141	.8000	-.0293	-.0283
.4250	-.0148	-.0143	.8500	-.0296	-.0286
.4500	-.0149	-.0144	.9000	-.0298	-.0288
.4750	-.0150	-.0145	.9500	-.0300	-.0289
.5000	-.0150	-.0145	1.0000	-.0300	-.0290
.5250	-.0149	-.0144	1.0500	-.0299	-.0289
.5500	-.0149	-.0144	1.1000	-.0297	-.0287
.5750	-.0147	-.0142	1.1500	-.0294	-.0284
.6000	-.0145	-.0140	1.2000	-.0291	-.0281
.6250	-.0143	-.0138	1.2500	-.0286	-.0276
.6500	-.0140	-.0135	1.3000	-.0280	-.0270
.6750	-.0136	-.0132	1.3500	-.0273	-.0263
.7000	-.0132	-.0128	1.4000	-.0264	-.0255
.7250	-.0128	-.0123	1.4500	-.0255	-.0246
.7500	-.0122	-.0118	1.5000	-.0244	-.0236
.7750	-.0116	-.0112	1.5500	-.0232	-.0224
.8000	-.0109	-.0105	1.6000	-.0218	-.0211
.8250	-.0101	-.0098	1.6500	-.0203	-.0196
.8500	-.0093	-.0089	1.7000	-.0185	-.0179
.8750	-.0083	-.0081	1.7500	-.0167	-.0161
.9000	-.0073	-.0071	1.8000	-.0146	-.0141
.9250	-.0060	-.0058	1.8500	-.0121	-.0117
.9500	-.0044	-.0042	1.9000	-.0087	-.0084
.9750	-.0023	-.0022	1.9500	-.0045	-.0044
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -10.6803 Y/B/2= -.5199 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0531 .0374 .0272 .0192 .0123 .0060-.0000-.0061-.0125-.0195-.0276-.0380-.0538-.0977

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.2532DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA Y	DELTA Z	(DLT Z)COS(DIH)
.0000	-.0044	-.0043	.0000	-.0088	-.0085
.0250	-.0058	-.0056	.0500	-.0115	-.0111
.0500	-.0071	-.0069	.1000	-.0142	-.0137
.0750	-.0084	-.0081	.1500	-.0168	-.0162
.1000	-.0096	-.0092	.2000	-.0191	-.0185
.1250	-.0106	-.0102	.2500	-.0211	-.0204
.1500	-.0114	-.0111	.3000	-.0229	-.0221
.1750	-.0122	-.0118	.3500	-.0245	-.0236
.2000	-.0129	-.0125	.4000	-.0259	-.0250
.2250	-.0136	-.0131	.4500	-.0271	-.0262
.2500	-.0141	-.0136	.5000	-.0283	-.0273
.2750	-.0146	-.0141	.5500	-.0292	-.0283
.3000	-.0151	-.0145	.6000	-.0301	-.0291
.3250	-.0154	-.0149	.6500	-.0308	-.0298
.3500	-.0157	-.0152	.7000	-.0315	-.0304
.3750	-.0160	-.0154	.7500	-.0320	-.0309
.4000	-.0162	-.0156	.8000	-.0324	-.0313
.4250	-.0163	-.0158	.8500	-.0327	-.0316
.4500	-.0164	-.0159	.9000	-.0329	-.0317
.4750	-.0165	-.0159	.9500	-.0329	-.0318
.5000	-.0165	-.0159	1.0000	-.0329	-.0318
.5250	-.0164	-.0158	1.0500	-.0328	-.0317
.5500	-.0163	-.0157	1.1000	-.0326	-.0314
.5750	-.0161	-.0156	1.1500	-.0322	-.0311
.6000	-.0159	-.0153	1.2000	-.0318	-.0307
.6250	-.0156	-.0151	1.2500	-.0312	-.0301
.6500	-.0153	-.0147	1.3000	-.0305	-.0295
.6750	-.0148	-.0143	1.3500	-.0297	-.0287
.7000	-.0144	-.0139	1.4000	-.0288	-.0278
.7250	-.0139	-.0134	1.4500	-.0277	-.0268
.7500	-.0133	-.0128	1.5000	-.0265	-.0256
.7750	-.0126	-.0122	1.5500	-.0252	-.0243
.8000	-.0118	-.0114	1.6000	-.0237	-.0228
.8250	-.0110	-.0106	1.6500	-.0219	-.0212
.8500	-.0100	-.0097	1.7000	-.0200	-.0194
.8750	-.0090	-.0087	1.7500	-.0180	-.0174
.9000	-.0079	-.0076	1.8000	-.0158	-.0153
.9250	-.0065	-.0063	1.8500	-.0130	-.0126
.9500	-.0047	-.0045	1.9000	-.0094	-.0091
.9750	-.0024	-.0024	1.9500	-.0049	-.0047
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -8.9858 Y/B/2= -.4374 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0551 .0385 .0277 .0193 .0121 .0054-.0010-.0074-.0141-.0214-.0300-.0409-.0576-.1038

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.3189DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
0.0000	-.0056	-.0054	0.0000	-.0111	-.0108
.0250	-.0070	-.0067	.0500	-.0139	-.0134
.0500	-.0083	-.0081	.1000	-.0167	-.0161
.0750	-.0097	-.0094	.1500	-.0194	-.0187
.1000	-.0109	-.0105	.2000	-.0218	-.0211
.1250	-.0119	-.0115	.2500	-.0239	-.0231
.1500	-.0128	-.0124	.3000	-.0257	-.0248
.1750	-.0136	-.0132	.3500	-.0273	-.0263
.2000	-.0144	-.0139	.4000	-.0287	-.0277
.2250	-.0150	-.0145	.4500	-.0300	-.0290
.2500	-.0156	-.0150	.5000	-.0311	-.0301
.2750	-.0161	-.0155	.5500	-.0321	-.0310
.3000	-.0165	-.0159	.6000	-.0330	-.0319
.3250	-.0169	-.0163	.6500	-.0337	-.0326
.3500	-.0172	-.0166	.7000	-.0343	-.0332
.3750	-.0174	-.0168	.7500	-.0348	-.0336
.4000	-.0176	-.0170	.8000	-.0352	-.0340
.4250	-.0177	-.0171	.8500	-.0355	-.0343
.4500	-.0178	-.0172	.9000	-.0356	-.0344
.4750	-.0178	-.0172	.9500	-.0357	-.0344
.5000	-.0178	-.0172	1.0000	-.0356	-.0344
.5250	-.0177	-.0171	1.0500	-.0354	-.0342
.5500	-.0176	-.0170	1.1000	-.0351	-.0339
.5750	-.0173	-.0168	1.1500	-.0347	-.0335
.6000	-.0171	-.0165	1.2000	-.0342	-.0330
.6250	-.0168	-.0162	1.2500	-.0335	-.0324
.6500	-.0164	-.0158	1.3000	-.0328	-.0316
.6750	-.0159	-.0154	1.3500	-.0319	-.0308
.7000	-.0154	-.0149	1.4000	-.0308	-.0298
.7250	-.0148	-.0143	1.4500	-.0297	-.0287
.7500	-.0142	-.0137	1.5000	-.0284	-.0274
.7750	-.0135	-.0130	1.5500	-.0269	-.0260
.8000	-.0126	-.0122	1.6000	-.0253	-.0244
.8250	-.0117	-.0113	1.6500	-.0234	-.0226
.8500	-.0107	-.0103	1.7000	-.0214	-.0206
.8750	-.0096	-.0093	1.7500	-.0192	-.0186
.9000	-.0084	-.0081	1.8000	-.0168	-.0162
.9250	-.0069	-.0067	1.8500	-.0139	-.0134
.9500	-.0050	-.0048	1.9000	-.0100	-.0096
.9750	-.0026	-.0025	1.9500	-.0052	-.0050
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -7.2913 Y/B/2= -.3549 CHORD= 2.0000

SLOPES.DZ/DX.AT SLOPE POINTS.FROM FRONT TO REAR

.0565 .0392 .0280 .0192 .0116 .0046-.0020-.0087-.0157-.0233-.0322-.0436-.0610-.1092

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.3878DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
.0000	-.0068	-.0065	.0000	-.0135	-.0131
.0250	-.0082	-.0079	.0500	-.0164	-.0158
.0500	-.0096	-.0093	.1000	-.0192	-.0186
.0750	-.0110	-.0106	.1500	-.0220	-.0212
.1000	-.0122	-.0118	.2000	-.0245	-.0236
.1250	-.0133	-.0128	.2500	-.0266	-.0257
.1500	-.0142	-.0137	.3000	-.0284	-.0274
.1750	-.0150	-.0145	.3500	-.0300	-.0290
.2000	-.0157	-.0152	.4000	-.0315	-.0304
.2250	-.0164	-.0158	.4500	-.0328	-.0317
.2500	-.0170	-.0164	.5000	-.0339	-.0328
.2750	-.0175	-.0169	.5500	-.0349	-.0337
.3000	-.0179	-.0173	.6000	-.0358	-.0345
.3250	-.0182	-.0176	.6500	-.0365	-.0352
.3500	-.0185	-.0179	.7000	-.0371	-.0358
.3750	-.0188	-.0181	.7500	-.0375	-.0362
.4000	-.0189	-.0183	.8000	-.0379	-.0366
.4250	-.0190	-.0184	.8500	-.0381	-.0368
.4500	-.0191	-.0185	.9000	-.0382	-.0369
.4750	-.0191	-.0184	.9500	-.0382	-.0369
.5000	-.0190	-.0184	1.0000	-.0381	-.0368
.5250	-.0189	-.0183	1.0500	-.0378	-.0365
.5500	-.0187	-.0181	1.1000	-.0375	-.0362
.5750	-.0185	-.0179	1.1500	-.0370	-.0357
.6000	-.0182	-.0176	1.2000	-.0364	-.0351
.6250	-.0178	-.0172	1.2500	-.0357	-.0345
.6500	-.0174	-.0168	1.3000	-.0348	-.0336
.6750	-.0169	-.0163	1.3500	-.0338	-.0327
.7000	-.0164	-.0158	1.4000	-.0327	-.0316
.7250	-.0157	-.0152	1.4500	-.0315	-.0304
.7500	-.0150	-.0145	1.5000	-.0301	-.0290
.7750	-.0142	-.0138	1.5500	-.0285	-.0275
.8000	-.0134	-.0129	1.6000	-.0267	-.0258
.8250	-.0124	-.0119	1.6500	-.0247	-.0239
.8500	-.0113	-.0109	1.7000	-.0226	-.0218
.8750	-.0101	-.0098	1.7500	-.0203	-.0196
.9000	-.0089	-.0086	1.8000	-.0177	-.0171
.9250	-.0073	-.0070	1.8500	-.0146	-.0141
.9500	-.0052	-.0051	1.9000	-.0105	-.0101
.9750	-.0027	-.0026	1.9500	-.0055	-.0053
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -5.5968 Y/B/2= -.2724 CHORD= 2.0000

SLOPES.DZ/DX.AT SLOPE POINTS.FROM FRONT TO REAR

.0572 .0393 .0277 .0186 .0108 .0036-.0033-.0102-.0174-.0253-.0345-.0462-.0641-.1140

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.4682DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
.0000	-.0082	-.0079	.0000	-.0163	-.0158
.0250	-.0096	-.0093	.0500	-.0192	-.0186
.0500	-.0111	-.0107	.1000	-.0221	-.0214
.0750	-.0125	-.0120	.1500	-.0249	-.0241
.1000	-.0137	-.0132	.2000	-.0274	-.0265
.1250	-.0148	-.0143	.2500	-.0295	-.0285
.1500	-.0157	-.0152	.3000	-.0314	-.0303
.1750	-.0165	-.0159	.3500	-.0330	-.0319
.2000	-.0172	-.0166	.4000	-.0344	-.0332
.2250	-.0179	-.0172	.4500	-.0357	-.0345
.2500	-.0184	-.0178	.5000	-.0368	-.0356
.2750	-.0189	-.0182	.5500	-.0378	-.0365
.3000	-.0193	-.0186	.6000	-.0386	-.0373
.3250	-.0196	-.0190	.6500	-.0393	-.0379
.3500	-.0199	-.0192	.7000	-.0398	-.0385
.3750	-.0201	-.0194	.7500	-.0402	-.0389
.4000	-.0203	-.0196	.8000	-.0405	-.0392
.4250	-.0204	-.0197	.8500	-.0407	-.0393
.4500	-.0204	-.0197	.9000	-.0408	-.0394
.4750	-.0203	-.0197	.9500	-.0407	-.0393
.5000	-.0202	-.0196	1.0000	-.0405	-.0391
.5250	-.0201	-.0194	1.0500	-.0402	-.0388
.5500	-.0199	-.0192	1.1000	-.0398	-.0384
.5750	-.0196	-.0189	1.1500	-.0392	-.0379
.6000	-.0193	-.0186	1.2000	-.0385	-.0372
.6250	-.0189	-.0182	1.2500	-.0377	-.0364
.6500	-.0184	-.0178	1.3000	-.0368	-.0355
.6750	-.0179	-.0172	1.3500	-.0357	-.0345
.7000	-.0172	-.0167	1.4000	-.0345	-.0333
.7250	-.0166	-.0160	1.4500	-.0331	-.0320
.7500	-.0158	-.0153	1.5000	-.0316	-.0306
.7750	-.0150	-.0145	1.5500	-.0300	-.0289
.8000	-.0140	-.0136	1.6000	-.0281	-.0271
.8250	-.0130	-.0125	1.6500	-.0259	-.0251
.8500	-.0118	-.0114	1.7000	-.0237	-.0228
.8750	-.0106	-.0103	1.7500	-.0212	-.0205
.9000	-.0093	-.0090	1.8000	-.0185	-.0179
.9250	-.0076	-.0074	1.8500	-.0152	-.0147
.9500	-.0055	-.0053	1.9000	-.0110	-.0106
.9750	-.0028	-.0027	1.9500	-.0057	-.0055
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -3.9023 Y/B/2= -.1900 CHORD= 2.0000

SLOPES.DZ/DX.AT SLOPE POINTS.FROM FRONT TO REAR

.0568 .0385 .0265 .0172 .0092 .0019-.0052-.0122-.0196-.0276-.0370-.0490-.0674-.1185

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .8107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.5818DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DTH)	DELTA X	DELTA Z	(DLT Z)COS(DTH)
.0000	-.0102	-.0098	.0000	-.0203	-.0196
.0250	-.0116	-.0112	.0500	-.0232	-.0224
.0500	-.0130	-.0126	.1000	-.0260	-.0252
.0750	-.0144	-.0139	.1500	-.0288	-.0278
.1000	-.0156	-.0151	.2000	-.0313	-.0302
.1250	-.0167	-.0161	.2500	-.0334	-.0322
.1500	-.0176	-.0170	.3000	-.0352	-.0340
.1750	-.0184	-.0177	.3500	-.0367	-.0355
.2000	-.0191	-.0184	.4000	-.0381	-.0368
.2250	-.0197	-.0190	.4500	-.0393	-.0380
.2500	-.0202	-.0195	.5000	-.0404	-.0390
.2750	-.0206	-.0199	.5500	-.0413	-.0399
.3000	-.0210	-.0203	.6000	-.0420	-.0406
.3250	-.0213	-.0206	.6500	-.0426	-.0412
.3500	-.0215	-.0208	.7000	-.0431	-.0416
.3750	-.0217	-.0210	.7500	-.0434	-.0420
.4000	-.0218	-.0211	.8000	-.0436	-.0422
.4250	-.0219	-.0211	.8500	-.0437	-.0422
.4500	-.0218	-.0211	.9000	-.0437	-.0422
.4750	-.0218	-.0210	.9500	-.0435	-.0420
.5000	-.0216	-.0209	1.0000	-.0432	-.0418
.5250	-.0214	-.0207	1.0500	-.0428	-.0414
.5500	-.0211	-.0204	1.1000	-.0423	-.0409
.5750	-.0208	-.0201	1.1500	-.0416	-.0402
.6000	-.0204	-.0197	1.2000	-.0409	-.0395
.6250	-.0200	-.0193	1.2500	-.0399	-.0386
.6500	-.0194	-.0188	1.3000	-.0389	-.0376
.6750	-.0189	-.0182	1.3500	-.0377	-.0364
.7000	-.0182	-.0176	1.4000	-.0364	-.0351
.7250	-.0175	-.0169	1.4500	-.0349	-.0337
.7500	-.0166	-.0161	1.5000	-.0333	-.0321
.7750	-.0157	-.0152	1.5500	-.0315	-.0304
.8000	-.0147	-.0142	1.6000	-.0294	-.0284
.8250	-.0136	-.0131	1.6500	-.0272	-.0263
.8500	-.0124	-.0120	1.7000	-.0247	-.0239
.8750	-.0111	-.0107	1.7500	-.0222	-.0214
.9000	-.0097	-.0093	1.8000	-.0193	-.0187
.9250	-.0079	-.0077	1.8500	-.0159	-.0153
.9500	-.0057	-.0055	1.9000	-.0114	-.0110
.9750	-.0030	-.0029	1.9500	-.0059	-.0057
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -2.2078 Y/B/2= -.1075 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0536 .0350 .0228 .0134 .0053-.0021-.0092-.0162-.0236-.0317-.0411-.0532-.0718-.1237

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.8085DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
0.0000	-.0141	-.0136	0.0000	-.0282	-.0273
.0250	-.0155	-.0149	.0500	-.0309	-.0299
.0500	-.0168	-.0162	.1000	-.0336	-.0325
.0750	-.0181	-.0175	.1500	-.0363	-.0350
.1000	-.0193	-.0186	.2000	-.0386	-.0372
.1250	-.0202	-.0196	.2500	-.0405	-.0391
.1500	-.0210	-.0203	.3000	-.0421	-.0407
.1750	-.0217	-.0210	.3500	-.0435	-.0420
.2000	-.0223	-.0216	.4000	-.0447	-.0431
.2250	-.0229	-.0221	.4500	-.0457	-.0441
.2500	-.0233	-.0225	.5000	-.0466	-.0450
.2750	-.0236	-.0228	.5500	-.0473	-.0457
.3000	-.0239	-.0231	.6000	-.0478	-.0462
.3250	-.0241	-.0233	.6500	-.0482	-.0466
.3500	-.0243	-.0234	.7000	-.0485	-.0469
.3750	-.0243	-.0235	.7500	-.0487	-.0470
.4000	-.0243	-.0235	.8000	-.0487	-.0470
.4250	-.0243	-.0234	.8500	-.0486	-.0469
.4500	-.0242	-.0233	.9000	-.0483	-.0467
.4750	-.0240	-.0232	.9500	-.0480	-.0463
.5000	-.0237	-.0229	1.0000	-.0475	-.0458
.5250	-.0234	-.0226	1.0500	-.0469	-.0453
.5500	-.0231	-.0223	1.1000	-.0461	-.0446
.5750	-.0226	-.0219	1.1500	-.0453	-.0437
.6000	-.0221	-.0214	1.2000	-.0443	-.0428
.6250	-.0216	-.0209	1.2500	-.0432	-.0417
.6500	-.0210	-.0202	1.3000	-.0419	-.0405
.6750	-.0203	-.0196	1.3500	-.0405	-.0392
.7000	-.0195	-.0188	1.4000	-.0390	-.0377
.7250	-.0187	-.0180	1.4500	-.0373	-.0361
.7500	-.0177	-.0171	1.5000	-.0355	-.0343
.7750	-.0167	-.0162	1.5500	-.0335	-.0323
.8000	-.0156	-.0151	1.6000	-.0312	-.0302
.8250	-.0144	-.0139	1.6500	-.0288	-.0278
.8500	-.0131	-.0126	1.7000	-.0261	-.0252
.8750	-.0117	-.0113	1.7500	-.0234	-.0226
.9000	-.0102	-.0098	1.8000	-.0203	-.0196
.9250	-.0083	-.0080	1.8500	-.0166	-.0161
.9500	-.0060	-.0058	1.9000	-.0119	-.0115
.9750	-.0031	-.0030	1.9500	-.0062	-.0060
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -.6803 Y/P/2= -.0331 CHORD= 2.0000

SLOPES.DZ/DX.AT SLOPE POINTS.FROM FRONT TO REAR

.0396 .0201 .0075-.0023-.0105-.0178-.0246-.0311-.0378-.0450-.0534-.0644-.0819-.1331

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -1.6002DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
.0000	-.0279	-.0270	.0000	-.0559	-.0540
.0250	-.0289	-.0279	.0500	-.0579	-.0559
.0500	-.0299	-.0289	.1000	-.0599	-.0578
.0750	-.0309	-.0298	.1500	-.0618	-.0597
.1000	-.0317	-.0306	.2000	-.0634	-.0612
.1250	-.0323	-.0312	.2500	-.0646	-.0624
.1500	-.0327	-.0316	.3000	-.0654	-.0632
.1750	-.0330	-.0319	.3500	-.0660	-.0638
.2000	-.0332	-.0321	.4000	-.0665	-.0642
.2250	-.0334	-.0322	.4500	-.0667	-.0645
.2500	-.0334	-.0323	.5000	-.0668	-.0645
.2750	-.0334	-.0322	.5500	-.0667	-.0645
.3000	-.0333	-.0321	.6000	-.0665	-.0642
.3250	-.0331	-.0319	.6500	-.0661	-.0639
.3500	-.0328	-.0317	.7000	-.0656	-.0634
.3750	-.0325	-.0314	.7500	-.0650	-.0628
.4000	-.0321	-.0310	.8000	-.0642	-.0620
.4250	-.0316	-.0306	.8500	-.0633	-.0611
.4500	-.0311	-.0301	.9000	-.0623	-.0602
.4750	-.0306	-.0295	.9500	-.0611	-.0591
.5000	-.0299	-.0289	1.0000	-.0599	-.0578
.5250	-.0293	-.0283	1.0500	-.0585	-.0565
.5500	-.0285	-.0275	1.1000	-.0570	-.0551
.5750	-.0277	-.0268	1.1500	-.0554	-.0536
.6000	-.0269	-.0259	1.2000	-.0537	-.0519
.6250	-.0259	-.0251	1.2500	-.0519	-.0501
.6500	-.0250	-.0241	1.3000	-.0499	-.0482
.6750	-.0239	-.0231	1.3500	-.0479	-.0462
.7000	-.0228	-.0221	1.4000	-.0457	-.0441
.7250	-.0217	-.0209	1.4500	-.0433	-.0419
.7500	-.0204	-.0197	1.5000	-.0409	-.0395
.7750	-.0191	-.0185	1.5500	-.0382	-.0369
.8000	-.0177	-.0171	1.6000	-.0354	-.0342
.8250	-.0162	-.0156	1.6500	-.0324	-.0313
.8500	-.0146	-.0141	1.7000	-.0291	-.0282
.8750	-.0129	-.0125	1.7500	-.0258	-.0249
.9000	-.0111	-.0107	1.8000	-.0223	-.0215
.9250	-.0090	-.0087	1.8500	-.0181	-.0175
.9500	-.0064	-.0062	1.9000	-.0129	-.0124
.9750	-.0033	-.0032	1.9500	-.0067	-.0064
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -20.3397 Y/B/2= -.9901 CHORD= .8938

SLOPES.DZ/DX.AT SLOPE POINTS.FROM FRONT TO REAR

.2050 .1550 .1229 .0982 .0774 .0587 .0412 .0239 .0061-.0130-.0349-.0626-.1044-.2194

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= 1.8866DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
0.0000	.0329	.0085	0.0000	.0294	.0076
.0250	.0278	.0072	.0223	.0248	.0064
.0500	.0226	.0059	.0447	.0202	.0052
.0750	.0176	.0046	.0670	.0157	.0041
.1000	.0130	.0034	.0894	.0116	.0030
.1250	.0089	.0023	.1117	.0079	.0020
.1500	.0052	.0013	.1341	.0046	.0012
.1750	.0018	.0005	.1564	.0016	.0004
.2000	-.0013	-.0003	.1788	-.0012	-.0003
.2250	-.0043	-.0011	.2011	-.0038	-.0010
.2500	-.0070	-.0018	.2234	-.0063	-.0016
.2750	-.0095	-.0025	.2458	-.0085	-.0022
.3000	-.0118	-.0031	.2681	-.0105	-.0027
.3250	-.0139	-.0036	.2905	-.0124	-.0032
.3500	-.0159	-.0041	.3128	-.0142	-.0037
.3750	-.0176	-.0046	.3352	-.0158	-.0041
.4000	-.0193	-.0050	.3575	-.0172	-.0045
.4250	-.0207	-.0054	.3798	-.0185	-.0048
.4500	-.0220	-.0057	.4022	-.0197	-.0051
.4750	-.0232	-.0060	.4245	-.0207	-.0054
.5000	-.0242	-.0063	.4469	-.0216	-.0056
.5250	-.0250	-.0065	.4692	-.0224	-.0058
.5500	-.0257	-.0067	.4916	-.0230	-.0059
.5750	-.0262	-.0068	.5139	-.0235	-.0061
.6000	-.0266	-.0069	.5363	-.0238	-.0062
.6250	-.0269	-.0070	.5586	-.0240	-.0062
.6500	-.0269	-.0070	.5809	-.0241	-.0062
.6750	-.0268	-.0069	.6033	-.0240	-.0062
.7000	-.0266	-.0069	.6256	-.0238	-.0061
.7250	-.0261	-.0068	.6480	-.0234	-.0060
.7500	-.0255	-.0066	.6703	-.0228	-.0059
.7750	-.0247	-.0064	.6927	-.0221	-.0057
.8000	-.0236	-.0061	.7150	-.0211	-.0055
.8250	-.0223	-.0058	.7373	-.0199	-.0052
.8500	-.0207	-.0054	.7597	-.0185	-.0048
.8750	-.0190	-.0049	.7820	-.0170	-.0044
.9000	-.0170	-.0044	.8044	-.0152	-.0039
.9250	-.0143	-.0037	.8267	-.0128	-.0033
.9500	-.0105	-.0027	.8491	-.0094	-.0024
.9750	-.0055	-.0014	.8714	-.0049	-.0013
1.0000	0.0000	0.0000	.8938	0.0000	0.0000

Y= -20.0679 Y/B/2= -.9769 CHORD= 1.5688

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.2386 .1376 .0775 .0368 .0079-.0139-.0315-.0467-.0607-.0743-.0888-.1063-.1333-.2197

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.6625DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
0.0000	-.0116	-.0030	0.0000	-.0181	-.0047
.0250	-.0176	-.0046	.0392	-.0276	-.0071
.0500	-.0237	-.0061	.0784	-.0371	-.0096
.0750	-.0294	-.0076	.1177	-.0462	-.0119
.1000	-.0344	-.0089	.1569	-.0539	-.0140
.1250	-.0383	-.0099	.1961	-.0601	-.0155
.1500	-.0414	-.0107	.2353	-.0649	-.0168
.1750	-.0438	-.0113	.2745	-.0688	-.0178
.2000	-.0459	-.0119	.3138	-.0720	-.0186
.2250	-.0476	-.0123	.3530	-.0747	-.0193
.2500	-.0489	-.0127	.3922	-.0768	-.0199
.2750	-.0499	-.0129	.4314	-.0783	-.0203
.3000	-.0506	-.0131	.4706	-.0794	-.0206
.3250	-.0511	-.0132	.5098	-.0801	-.0207
.3500	-.0513	-.0133	.5491	-.0804	-.0208
.3750	-.0513	-.0133	.5883	-.0804	-.0208
.4000	-.0511	-.0132	.6275	-.0802	-.0207
.4250	-.0507	-.0131	.6667	-.0796	-.0206
.4500	-.0502	-.0130	.7059	-.0788	-.0204
.4750	-.0495	-.0128	.7452	-.0777	-.0201
.5000	-.0487	-.0126	.7844	-.0764	-.0198
.5250	-.0478	-.0124	.8236	-.0749	-.0194
.5500	-.0467	-.0121	.8628	-.0732	-.0190
.5750	-.0455	-.0118	.9020	-.0713	-.0185
.6000	-.0441	-.0114	.9413	-.0693	-.0179
.6250	-.0427	-.0110	.9805	-.0670	-.0173
.6500	-.0411	-.0106	1.0197	-.0645	-.0167
.6750	-.0394	-.0102	1.0589	-.0618	-.0160
.7000	-.0376	-.0097	1.0981	-.0590	-.0153
.7250	-.0357	-.0092	1.1373	-.0559	-.0145
.7500	-.0336	-.0087	1.1766	-.0527	-.0136
.7750	-.0314	-.0081	1.2158	-.0493	-.0128
.8000	-.0291	-.0075	1.2550	-.0456	-.0118
.8250	-.0265	-.0069	1.2942	-.0416	-.0108
.8500	-.0239	-.0062	1.3334	-.0375	-.0097
.8750	-.0212	-.0055	1.3727	-.0332	-.0086
.9000	-.0183	-.0047	1.4119	-.0287	-.0074
.9250	-.0149	-.0038	1.4511	-.0233	-.0060
.9500	-.0106	-.0027	1.4903	-.0166	-.0043
.9750	-.0055	-.0014	1.5295	-.0086	-.0022
1.0000	0.0000	0.0000	1.5688	0.0000	0.0000

Y= -19.1528 Y/B/2= -.9323 CHORD= 2.0000

SLOPES.DZ/DX.AT SLOPE POINTS.FROM FRONT TO REAR

-.0034-.0121-.0176-.0217-.0249-.0276-.0299-.0320-.0342-.0367-.0400-.0447-.0527-.0769

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -1.7818DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
0.0000	-.0311	-.0300	0.0000	-.0622	-.0601
.0250	-.0310	-.0300	.0500	-.0621	-.0599
.0500	-.0310	-.0299	.1000	-.0619	-.0598
.0750	-.0309	-.0298	.1500	-.0617	-.0596
.1000	-.0307	-.0296	.2000	-.0614	-.0593
.1250	-.0304	-.0294	.2500	-.0608	-.0588
.1500	-.0301	-.0291	.3000	-.0602	-.0581
.1750	-.0297	-.0287	.3500	-.0594	-.0574
.2000	-.0293	-.0283	.4000	-.0585	-.0565
.2250	-.0288	-.0278	.4500	-.0576	-.0557
.2500	-.0283	-.0273	.5000	-.0566	-.0547
.2750	-.0278	-.0268	.5500	-.0555	-.0537
.3000	-.0272	-.0263	.6000	-.0544	-.0526
.3250	-.0266	-.0257	.6500	-.0532	-.0514
.3500	-.0260	-.0251	.7000	-.0520	-.0502
.3750	-.0253	-.0245	.7500	-.0507	-.0490
.4000	-.0247	-.0238	.8000	-.0494	-.0477
.4250	-.0240	-.0232	.8500	-.0480	-.0463
.4500	-.0233	-.0225	.9000	-.0466	-.0450
.4750	-.0225	-.0218	.9500	-.0451	-.0436
.5000	-.0218	-.0211	1.0000	-.0436	-.0421
.5250	-.0210	-.0203	1.0500	-.0421	-.0406
.5500	-.0202	-.0195	1.1000	-.0405	-.0391
.5750	-.0194	-.0188	1.1500	-.0389	-.0375
.6000	-.0186	-.0180	1.2000	-.0372	-.0359
.6250	-.0178	-.0172	1.2500	-.0355	-.0343
.6500	-.0169	-.0163	1.3000	-.0338	-.0326
.6750	-.0160	-.0155	1.3500	-.0320	-.0309
.7000	-.0151	-.0146	1.4000	-.0302	-.0292
.7250	-.0142	-.0137	1.4500	-.0283	-.0274
.7500	-.0132	-.0128	1.5000	-.0264	-.0255
.7750	-.0122	-.0118	1.5500	-.0244	-.0236
.8000	-.0112	-.0108	1.6000	-.0224	-.0216
.8250	-.0101	-.0098	1.6500	-.0202	-.0195
.8500	-.0090	-.0087	1.7000	-.0180	-.0174
.8750	-.0078	-.0076	1.7500	-.0157	-.0152
.9000	-.0067	-.0064	1.8000	-.0133	-.0129
.9250	-.0053	-.0051	1.8500	-.0106	-.0103
.9500	-.0037	-.0036	1.9000	-.0075	-.0072
.9750	-.0019	-.0019	1.9500	-.0038	-.0037
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -17.4583 Y/B/2= -.8498 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0138 .0038-.0026-.0078-.0121-.0160-.0198-.0235-.0273-.0316-.0365-.0429-.0528-.0806

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -1.2775DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
0.0000	-.0223	-.0215	0.0000	-.0446	-.0431
.0250	-.0227	-.0219	.0500	-.0453	-.0438
.0500	-.0230	-.0222	.1000	-.0460	-.0444
.0750	-.0233	-.0225	.1500	-.0467	-.0451
.1000	-.0236	-.0228	.2000	-.0471	-.0455
.1250	-.0237	-.0229	.2500	-.0474	-.0458
.1500	-.0238	-.0230	.3000	-.0475	-.0459
.1750	-.0238	-.0230	.3500	-.0475	-.0459
.2000	-.0237	-.0229	.4000	-.0474	-.0458
.2250	-.0236	-.0228	.4500	-.0472	-.0456
.2500	-.0235	-.0227	.5000	-.0469	-.0453
.2750	-.0233	-.0225	.5500	-.0466	-.0450
.3000	-.0231	-.0223	.6000	-.0461	-.0445
.3250	-.0228	-.0220	.6500	-.0456	-.0440
.3500	-.0225	-.0217	.7000	-.0450	-.0435
.3750	-.0222	-.0214	.7500	-.0443	-.0428
.4000	-.0218	-.0210	.8000	-.0436	-.0421
.4250	-.0214	-.0207	.8500	-.0428	-.0413
.4500	-.0210	-.0202	.9000	-.0419	-.0405
.4750	-.0205	-.0198	.9500	-.0410	-.0396
.5000	-.0200	-.0193	1.0000	-.0400	-.0386
.5250	-.0194	-.0188	1.0500	-.0389	-.0376
.5500	-.0189	-.0182	1.1000	-.0378	-.0365
.5750	-.0183	-.0177	1.1500	-.0366	-.0353
.6000	-.0177	-.0171	1.2000	-.0353	-.0341
.6250	-.0170	-.0164	1.2500	-.0340	-.0328
.6500	-.0163	-.0157	1.3000	-.0326	-.0315
.6750	-.0155	-.0150	1.3500	-.0311	-.0300
.7000	-.0148	-.0143	1.4000	-.0295	-.0285
.7250	-.0140	-.0135	1.4500	-.0279	-.0270
.7500	-.0131	-.0127	1.5000	-.0262	-.0253
.7750	-.0122	-.0118	1.5500	-.0244	-.0236
.8000	-.0112	-.0109	1.6000	-.0225	-.0217
.8250	-.0102	-.0099	1.6500	-.0204	-.0197
.8500	-.0092	-.0088	1.7000	-.0183	-.0177
.8750	-.0080	-.0078	1.7500	-.0161	-.0155
.9000	-.0069	-.0066	1.8000	-.0137	-.0133
.9250	-.0055	-.0053	1.8500	-.0111	-.0107
.9500	-.0039	-.0038	1.9000	-.0078	-.0076
.9750	-.0020	-.0019	1.9500	-.0040	-.0039
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -15.7638 Y/B/2= -.7673 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0210 .0095 .0019-.0040-.0091-.0137-.0181-.0224-.0270-.0319-.0376-.0450-.0563-.0880

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -1.1987DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA Y	DELTA Z	(DLT Z)COS(DIH)
0.0000	-.0209	-.0202	0.0000	-.0418	-.0404
.0250	-.0215	-.0207	.0500	-.0429	-.0415
.0500	-.0220	-.0212	.1000	-.0440	-.0425
.0750	-.0225	-.0217	.1500	-.0450	-.0435
.1000	-.0229	-.0221	.2000	-.0458	-.0443
.1250	-.0232	-.0224	.2500	-.0464	-.0448
.1500	-.0234	-.0226	.3000	-.0468	-.0452
.1750	-.0235	-.0227	.3500	-.0470	-.0454
.2000	-.0236	-.0228	.4000	-.0472	-.0455
.2250	-.0236	-.0228	.4500	-.0472	-.0456
.2500	-.0236	-.0228	.5000	-.0471	-.0455
.2750	-.0235	-.0227	.5500	-.0469	-.0453
.3000	-.0233	-.0225	.6000	-.0467	-.0451
.3250	-.0231	-.0224	.6500	-.0463	-.0447
.3500	-.0229	-.0221	.7000	-.0458	-.0443
.3750	-.0227	-.0219	.7500	-.0453	-.0438
.4000	-.0224	-.0216	.8000	-.0447	-.0432
.4250	-.0220	-.0213	.8500	-.0440	-.0425
.4500	-.0216	-.0209	.9000	-.0433	-.0418
.4750	-.0212	-.0205	.9500	-.0424	-.0410
.5000	-.0207	-.0200	1.0000	-.0415	-.0401
.5250	-.0202	-.0196	1.0500	-.0405	-.0391
.5500	-.0197	-.0190	1.1000	-.0394	-.0381
.5750	-.0191	-.0185	1.1500	-.0383	-.0370
.6000	-.0185	-.0179	1.2000	-.0370	-.0358
.6250	-.0179	-.0173	1.2500	-.0357	-.0345
.6500	-.0172	-.0166	1.3000	-.0344	-.0332
.6750	-.0164	-.0159	1.3500	-.0329	-.0318
.7000	-.0157	-.0151	1.4000	-.0313	-.0302
.7250	-.0148	-.0143	1.4500	-.0297	-.0286
.7500	-.0140	-.0135	1.5000	-.0279	-.0270
.7750	-.0130	-.0126	1.5500	-.0261	-.0252
.8000	-.0120	-.0116	1.6000	-.0241	-.0232
.8250	-.0110	-.0106	1.6500	-.0219	-.0212
.8500	-.0098	-.0095	1.7000	-.0197	-.0190
.8750	-.0087	-.0084	1.7500	-.0174	-.0168
.9000	-.0074	-.0072	1.8000	-.0149	-.0144
.9250	-.0060	-.0058	1.8500	-.0120	-.0116
.9500	-.0043	-.0041	1.9000	-.0085	-.0082
.9750	-.0022	-.0021	1.9500	-.0044	-.0042
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -14.0693 Y/B/2= -.6849 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0266 .0137 .0053-.0012-.0069-.0120-.0170-.0219-.0269-.0325-.0389-.0471-.0597-.0949

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -1.1561DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA Y	DELTA Z	(DLT Z)COS(DIH)
0.0000	-.0202	-.0195	0.0000	-.0404	-.0390
.0250	-.0209	-.0201	.0500	-.0417	-.0403
.0500	-.0215	-.0208	.1000	-.0431	-.0416
.0750	-.0222	-.0214	.1500	-.0443	-.0428
.1000	-.0227	-.0219	.2000	-.0454	-.0439
.1250	-.0231	-.0223	.2500	-.0462	-.0446
.1500	-.0234	-.0226	.3000	-.0468	-.0452
.1750	-.0236	-.0228	.3500	-.0472	-.0456
.2000	-.0238	-.0230	.4000	-.0475	-.0459
.2250	-.0239	-.0231	.4500	-.0477	-.0461
.2500	-.0239	-.0231	.5000	-.0478	-.0462
.2750	-.0239	-.0231	.5500	-.0478	-.0461
.3000	-.0238	-.0230	.6000	-.0476	-.0460
.3250	-.0237	-.0229	.6500	-.0474	-.0458
.3500	-.0235	-.0227	.7000	-.0470	-.0454
.3750	-.0233	-.0225	.7500	-.0466	-.0450
.4000	-.0230	-.0223	.8000	-.0461	-.0445
.4250	-.0227	-.0220	.8500	-.0455	-.0439
.4500	-.0224	-.0216	.9000	-.0448	-.0433
.4750	-.0220	-.0213	.9500	-.0440	-.0425
.5000	-.0216	-.0208	1.0000	-.0431	-.0417
.5250	-.0211	-.0204	1.0500	-.0422	-.0408
.5500	-.0206	-.0199	1.1000	-.0412	-.0398
.5750	-.0200	-.0193	1.1500	-.0400	-.0387
.6000	-.0194	-.0187	1.2000	-.0388	-.0375
.6250	-.0188	-.0181	1.2500	-.0375	-.0362
.6500	-.0181	-.0174	1.3000	-.0361	-.0349
.6750	-.0173	-.0167	1.3500	-.0346	-.0335
.7000	-.0165	-.0160	1.4000	-.0331	-.0319
.7250	-.0157	-.0151	1.4500	-.0314	-.0303
.7500	-.0148	-.0143	1.5000	-.0296	-.0286
.7750	-.0138	-.0134	1.5500	-.0277	-.0267
.8000	-.0128	-.0124	1.6000	-.0256	-.0247
.8250	-.0117	-.0113	1.6500	-.0234	-.0226
.8500	-.0105	-.0102	1.7000	-.0210	-.0203
.8750	-.0093	-.0090	1.7500	-.0186	-.0180
.9000	-.0080	-.0077	1.8000	-.0160	-.0154
.9250	-.0065	-.0062	1.8500	-.0129	-.0125
.9500	-.0046	-.0044	1.9000	-.0092	-.0089
.9750	-.0024	-.0023	1.9500	-.0047	-.0046
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -12.3748 Y/B/2= -.6024 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0314 .0174 .0083 .0011-.0050-.0106-.0160-.0213-.0269-.0329-.0399-.0489-.0627-.1011

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -1.1193DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DTH)	DELTA X	DELTA Z	(DLT Z)COS(DTH)
0.0000	-.0195	-.0189	0.0000	-.0391	-.0377
.0250	-.0203	-.0196	.0500	-.0407	-.0393
.0500	-.0211	-.0204	.1000	-.0423	-.0408
.0750	-.0219	-.0211	.1500	-.0438	-.0423
.1000	-.0225	-.0218	.2000	-.0451	-.0435
.1250	-.0230	-.0223	.2500	-.0461	-.0445
.1500	-.0234	-.0226	.3000	-.0468	-.0452
.1750	-.0237	-.0229	.3500	-.0474	-.0458
.2000	-.0239	-.0231	.4000	-.0479	-.0462
.2250	-.0241	-.0233	.4500	-.0482	-.0466
.2500	-.0242	-.0234	.5000	-.0484	-.0468
.2750	-.0243	-.0234	.5500	-.0485	-.0469
.3000	-.0242	-.0234	.6000	-.0485	-.0468
.3250	-.0242	-.0233	.6500	-.0483	-.0467
.3500	-.0240	-.0232	.7000	-.0481	-.0464
.3750	-.0239	-.0231	.7500	-.0477	-.0461
.4000	-.0236	-.0228	.8000	-.0473	-.0457
.4250	-.0234	-.0226	.8500	-.0468	-.0452
.4500	-.0231	-.0223	.9000	-.0461	-.0446
.4750	-.0227	-.0219	.9500	-.0454	-.0439
.5000	-.0223	-.0215	1.0000	-.0446	-.0431
.5250	-.0218	-.0211	1.0500	-.0437	-.0422
.5500	-.0213	-.0206	1.1000	-.0427	-.0412
.5750	-.0208	-.0201	1.1500	-.0416	-.0401
.6000	-.0202	-.0195	1.2000	-.0404	-.0390
.6250	-.0195	-.0189	1.2500	-.0391	-.0377
.6500	-.0188	-.0182	1.3000	-.0377	-.0364
.6750	-.0181	-.0175	1.3500	-.0362	-.0349
.7000	-.0173	-.0167	1.4000	-.0346	-.0334
.7250	-.0164	-.0159	1.4500	-.0329	-.0317
.7500	-.0155	-.0150	1.5000	-.0310	-.0300
.7750	-.0145	-.0140	1.5500	-.0291	-.0281
.8000	-.0135	-.0130	1.6000	-.0269	-.0260
.8250	-.0123	-.0119	1.6500	-.0246	-.0238
.8500	-.0111	-.0107	1.7000	-.0222	-.0214
.8750	-.0098	-.0095	1.7500	-.0197	-.0190
.9000	-.0085	-.0082	1.8000	-.0169	-.0164
.9250	-.0069	-.0066	1.8500	-.0137	-.0133
.9500	-.0049	-.0047	1.9000	-.0098	-.0094
.9750	-.0025	-.0024	1.9500	-.0050	-.0049
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -10.6803 Y/P/2= -.5199 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0356 .0207 .0109 .0032-.0033-.0093-.0151-.0208-.0267-.0332-.0407-.0504-.0651-.1063

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -1.0825DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
-.0000	-.0189	-.0183	-.0000	-.0378	-.0365
.0250	-.0198	-.0191	.0500	-.0396	-.0382
.0500	-.0207	-.0200	.1000	-.0414	-.0400
.0750	-.0216	-.0208	.1500	-.0431	-.0417
.1000	-.0223	-.0215	.2000	-.0446	-.0431
.1250	-.0229	-.0221	.2500	-.0458	-.0442
.1500	-.0234	-.0226	.3000	-.0467	-.0451
.1750	-.0237	-.0229	.3500	-.0474	-.0458
.2000	-.0240	-.0232	.4000	-.0480	-.0464
.2250	-.0242	-.0234	.4500	-.0485	-.0468
.2500	-.0244	-.0236	.5000	-.0488	-.0471
.2750	-.0245	-.0237	.5500	-.0490	-.0473
.3000	-.0245	-.0237	.6000	-.0491	-.0474
.3250	-.0245	-.0237	.6500	-.0490	-.0473
.3500	-.0244	-.0236	.7000	-.0489	-.0472
.3750	-.0243	-.0235	.7500	-.0486	-.0469
.4000	-.0241	-.0233	.8000	-.0482	-.0466
.4250	-.0239	-.0231	.8500	-.0477	-.0461
.4500	-.0236	-.0228	.9000	-.0472	-.0456
.4750	-.0232	-.0225	.9500	-.0465	-.0449
.5000	-.0229	-.0221	1.0000	-.0457	-.0442
.5250	-.0224	-.0217	1.0500	-.0448	-.0433
.5500	-.0219	-.0212	1.1000	-.0439	-.0424
.5750	-.0214	-.0207	1.1500	-.0428	-.0413
.6000	-.0208	-.0201	1.2000	-.0416	-.0402
.6250	-.0202	-.0195	1.2500	-.0403	-.0390
.6500	-.0195	-.0188	1.3000	-.0389	-.0376
.6750	-.0187	-.0181	1.3500	-.0374	-.0362
.7000	-.0179	-.0173	1.4000	-.0358	-.0346
.7250	-.0170	-.0165	1.4500	-.0341	-.0329
.7500	-.0161	-.0156	1.5000	-.0322	-.0311
.7750	-.0151	-.0146	1.5500	-.0302	-.0292
.8000	-.0140	-.0135	1.6000	-.0280	-.0271
.8250	-.0128	-.0124	1.6500	-.0257	-.0248
.8500	-.0116	-.0112	1.7000	-.0232	-.0224
.8750	-.0103	-.0099	1.7500	-.0206	-.0199
.9000	-.0089	-.0086	1.8000	-.0177	-.0171
.9250	-.0072	-.0070	1.8500	-.0144	-.0139
.9500	-.0051	-.0050	1.9000	-.0103	-.0099
.9750	-.0027	-.0026	1.9500	-.0053	-.0051
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -8.9858 Y/B/2= -.4374 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0394 .0236 .0133 .0052-.0017-.0081-.0141-.0202-.0265-.0333-.0413-.0515-.0671-.1106

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -1.0427DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
0.0000	-.0182	-.0176	0.0000	-.0364	-.0352
.0250	-.0192	-.0185	.0500	-.0384	-.0371
.0500	-.0202	-.0195	.1000	-.0404	-.0390
.0750	-.0211	-.0204	.1500	-.0423	-.0409
.1000	-.0220	-.0212	.2000	-.0439	-.0424
.1250	-.0226	-.0219	.2500	-.0453	-.0437
.1500	-.0232	-.0224	.3000	-.0463	-.0448
.1750	-.0236	-.0228	.3500	-.0472	-.0456
.2000	-.0240	-.0231	.4000	-.0479	-.0463
.2250	-.0242	-.0234	.4500	-.0485	-.0468
.2500	-.0245	-.0236	.5000	-.0489	-.0473
.2750	-.0246	-.0238	.5500	-.0492	-.0475
.3000	-.0247	-.0238	.6000	-.0494	-.0477
.3250	-.0247	-.0239	.6500	-.0494	-.0477
.3500	-.0247	-.0238	.7000	-.0493	-.0476
.3750	-.0246	-.0237	.7500	-.0491	-.0475
.4000	-.0244	-.0236	.8000	-.0488	-.0472
.4250	-.0242	-.0234	.8500	-.0484	-.0468
.4500	-.0240	-.0231	.9000	-.0479	-.0463
.4750	-.0236	-.0228	.9500	-.0473	-.0457
.5000	-.0233	-.0225	1.0000	-.0466	-.0450
.5250	-.0229	-.0221	1.0500	-.0457	-.0442
.5500	-.0224	-.0216	1.1000	-.0448	-.0433
.5750	-.0219	-.0211	1.1500	-.0437	-.0422
.6000	-.0213	-.0206	1.2000	-.0426	-.0411
.6250	-.0207	-.0200	1.2500	-.0413	-.0399
.6500	-.0200	-.0193	1.3000	-.0399	-.0386
.6750	-.0192	-.0186	1.3500	-.0384	-.0371
.7000	-.0184	-.0178	1.4000	-.0368	-.0356
.7250	-.0175	-.0169	1.4500	-.0351	-.0339
.7500	-.0166	-.0160	1.5000	-.0332	-.0321
.7750	-.0156	-.0150	1.5500	-.0312	-.0301
.8000	-.0145	-.0140	1.6000	-.0289	-.0280
.8250	-.0133	-.0128	1.6500	-.0265	-.0256
.8500	-.0120	-.0116	1.7000	-.0240	-.0232
.8750	-.0107	-.0103	1.7500	-.0213	-.0206
.9000	-.0092	-.0089	1.8000	-.0184	-.0178
.9250	-.0075	-.0072	1.8500	-.0150	-.0145
.9500	-.0053	-.0052	1.9000	-.0107	-.0103
.9750	-.0029	-.0027	1.9500	-.0055	-.0053
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -7.2913 Y/B/2= -.3549 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0428 .0263 .0155 .0071-.0002-.0068-.0131-.0194-.0260-.0332-.0415-.0522-.0685-.1140

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.9962DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
-.0000	-.0174	-.0168	-.0000	-.0348	-.0336
.0250	-.0185	-.0178	.0500	-.0369	-.0357
.0500	-.0196	-.0189	.1000	-.0391	-.0378
.0750	-.0206	-.0199	.1500	-.0412	-.0398
.1000	-.0215	-.0208	.2000	-.0430	-.0415
.1250	-.0222	-.0215	.2500	-.0445	-.0429
.1500	-.0228	-.0220	.3000	-.0456	-.0441
.1750	-.0233	-.0225	.3500	-.0466	-.0450
.2000	-.0237	-.0229	.4000	-.0475	-.0458
.2250	-.0241	-.0232	.4500	-.0481	-.0465
.2500	-.0243	-.0235	.5000	-.0487	-.0470
.2750	-.0245	-.0237	.5500	-.0491	-.0474
.3000	-.0247	-.0238	.6000	-.0493	-.0476
.3250	-.0247	-.0239	.6500	-.0494	-.0477
.3500	-.0247	-.0239	.7000	-.0494	-.0477
.3750	-.0247	-.0238	.7500	-.0493	-.0476
.4000	-.0245	-.0237	.8000	-.0491	-.0474
.4250	-.0244	-.0235	.8500	-.0487	-.0471
.4500	-.0241	-.0233	.9000	-.0483	-.0466
.4750	-.0239	-.0230	.9500	-.0477	-.0461
.5000	-.0235	-.0227	1.0000	-.0470	-.0454
.5250	-.0231	-.0223	1.0500	-.0462	-.0447
.5500	-.0227	-.0219	1.1000	-.0453	-.0438
.5750	-.0222	-.0214	1.1500	-.0443	-.0428
.6000	-.0216	-.0209	1.2000	-.0432	-.0417
.6250	-.0210	-.0203	1.2500	-.0420	-.0405
.6500	-.0203	-.0196	1.3000	-.0406	-.0392
.6750	-.0196	-.0189	1.3500	-.0391	-.0378
.7000	-.0188	-.0181	1.4000	-.0375	-.0362
.7250	-.0179	-.0173	1.4500	-.0358	-.0345
.7500	-.0169	-.0164	1.5000	-.0339	-.0327
.7750	-.0159	-.0154	1.5500	-.0318	-.0308
.8000	-.0148	-.0143	1.6000	-.0296	-.0286
.8250	-.0136	-.0131	1.6500	-.0272	-.0263
.8500	-.0123	-.0119	1.7000	-.0246	-.0237
.8750	-.0109	-.0106	1.7500	-.0219	-.0211
.9000	-.0095	-.0091	1.8000	-.0189	-.0183
.9250	-.0077	-.0074	1.8500	-.0154	-.0149
.9500	-.0055	-.0053	1.9000	-.0110	-.0106
.9750	-.0028	-.0028	1.9500	-.0057	-.0055
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -5.5968 Y/B/2= -.2724 CHORD= 2.0000

SLOPES.DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0459 .0289 .0177 .0090 .0015-.0053-.0119-.0184-.0252-.0326-.0413-.0523-.0693-.1165

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.9355DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DTH)	DELTA X	DELTA Z	(DLT Z)COS(DTH)
-.0000	-.0163	-.0158	-.0000	-.0327	-.0315
.0250	-.0175	-.0169	.0500	-.0350	-.0338
.0500	-.0187	-.0180	.1000	-.0373	-.0360
.0750	-.0198	-.0191	.1500	-.0395	-.0382
.1000	-.0207	-.0200	.2000	-.0415	-.0401
.1250	-.0215	-.0208	.2500	-.0431	-.0416
.1500	-.0222	-.0214	.3000	-.0444	-.0429
.1750	-.0228	-.0220	.3500	-.0455	-.0440
.2000	-.0232	-.0224	.4000	-.0464	-.0448
.2250	-.0236	-.0228	.4500	-.0472	-.0456
.2500	-.0239	-.0231	.5000	-.0479	-.0462
.2750	-.0242	-.0233	.5500	-.0483	-.0467
.3000	-.0243	-.0235	.6000	-.0487	-.0470
.3250	-.0244	-.0236	.6500	-.0489	-.0472
.3500	-.0245	-.0237	.7000	-.0490	-.0473
.3750	-.0245	-.0236	.7500	-.0489	-.0473
.4000	-.0244	-.0236	.8000	-.0488	-.0471
.4250	-.0243	-.0234	.8500	-.0485	-.0469
.4500	-.0241	-.0232	.9000	-.0481	-.0465
.4750	-.0238	-.0230	.9500	-.0476	-.0460
.5000	-.0235	-.0227	1.0000	-.0470	-.0454
.5250	-.0231	-.0223	1.0500	-.0463	-.0447
.5500	-.0227	-.0219	1.1000	-.0454	-.0439
.5750	-.0222	-.0215	1.1500	-.0445	-.0429
.6000	-.0217	-.0210	1.2000	-.0434	-.0419
.6250	-.0211	-.0204	1.2500	-.0422	-.0407
.6500	-.0204	-.0197	1.3000	-.0409	-.0395
.6750	-.0197	-.0190	1.3500	-.0394	-.0381
.7000	-.0189	-.0183	1.4000	-.0378	-.0365
.7250	-.0181	-.0174	1.4500	-.0361	-.0349
.7500	-.0171	-.0165	1.5000	-.0343	-.0331
.7750	-.0161	-.0156	1.5500	-.0322	-.0311
.8000	-.0150	-.0145	1.6000	-.0300	-.0290
.8250	-.0138	-.0133	1.6500	-.0276	-.0266
.8500	-.0125	-.0121	1.7000	-.0250	-.0241
.8750	-.0111	-.0107	1.7500	-.0222	-.0215
.9000	-.0096	-.0093	1.8000	-.0193	-.0186
.9250	-.0079	-.0076	1.8500	-.0157	-.0152
.9500	-.0056	-.0054	1.9000	-.0112	-.0109
.9750	-.0029	-.0028	1.9500	-.0058	-.0056
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -3.9023 Y/B/2= -.1900 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0491 .0316 .0202 .0113 .0036-.0034-.0101-.0168-.0237-.0314-.0402-.0516-.0690-.1175

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= -.8419DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DTH)	DELTA X	DELTA Z	(DLT Z)COS(DTH)
-.0000	-.0147	-.0142	-.0000	-.0294	-.0284
.0250	-.0159	-.0154	.0500	-.0319	-.0308
.0500	-.0172	-.0166	.1000	-.0344	-.0332
.0750	-.0184	-.0177	.1500	-.0367	-.0355
.1000	-.0194	-.0188	.2000	-.0388	-.0375
.1250	-.0203	-.0196	.2500	-.0406	-.0392
.1500	-.0210	-.0203	.3000	-.0420	-.0406
.1750	-.0216	-.0209	.3500	-.0433	-.0418
.2000	-.0222	-.0214	.4000	-.0443	-.0428
.2250	-.0226	-.0218	.4500	-.0452	-.0437
.2500	-.0230	-.0222	.5000	-.0460	-.0444
.2750	-.0233	-.0225	.5500	-.0466	-.0450
.3000	-.0235	-.0227	.6000	-.0470	-.0454
.3250	-.0237	-.0229	.6500	-.0474	-.0457
.3500	-.0238	-.0230	.7000	-.0475	-.0459
.3750	-.0238	-.0230	.7500	-.0476	-.0460
.4000	-.0238	-.0230	.8000	-.0476	-.0459
.4250	-.0237	-.0229	.8500	-.0474	-.0458
.4500	-.0235	-.0227	.9000	-.0471	-.0455
.4750	-.0233	-.0225	.9500	-.0467	-.0451
.5000	-.0231	-.0223	1.0000	-.0461	-.0446
.5250	-.0227	-.0220	1.0500	-.0455	-.0439
.5500	-.0224	-.0216	1.1000	-.0447	-.0432
.5750	-.0219	-.0212	1.1500	-.0438	-.0424
.6000	-.0214	-.0207	1.2000	-.0428	-.0414
.6250	-.0209	-.0201	1.2500	-.0417	-.0403
.6500	-.0202	-.0195	1.3000	-.0405	-.0391
.6750	-.0195	-.0189	1.3500	-.0391	-.0378
.7000	-.0188	-.0181	1.4000	-.0376	-.0363
.7250	-.0180	-.0173	1.4500	-.0359	-.0347
.7500	-.0171	-.0165	1.5000	-.0341	-.0329
.7750	-.0161	-.0155	1.5500	-.0321	-.0310
.8000	-.0150	-.0145	1.6000	-.0300	-.0289
.8250	-.0138	-.0133	1.6500	-.0276	-.0266
.8500	-.0125	-.0121	1.7000	-.0250	-.0241
.8750	-.0112	-.0108	1.7500	-.0223	-.0215
.9000	-.0097	-.0094	1.8000	-.0194	-.0187
.9250	-.0079	-.0076	1.8500	-.0158	-.0153
.9500	-.0057	-.0055	1.9000	-.0113	-.0109
.9750	-.0029	-.0028	1.9500	-.0059	-.0057
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -2.2078 Y/B/2= -.1075 CHORD= 2.0000

SLOPES.DZ/DY.AT SLOPE POINTS.FROM FRONT TO REAR

.0532 .0355 .0240 .0150 .0073 .0003-.0064-.0131-.0202-.0279-.0369-.0484-.0662-.1157

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN Y-Z PLANE= -.6409DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA Y	DELTA Z	(DLT Z)COS(DIH)
-.0000	-.0112	-.0108	-.0000	-.0224	-.0216
.0250	-.0125	-.0121	.0500	-.0250	-.0242
.0500	-.0139	-.0134	.1000	-.0277	-.0268
.0750	-.0152	-.0146	.1500	-.0303	-.0293
.1000	-.0163	-.0158	.2000	-.0326	-.0315
.1250	-.0173	-.0167	.2500	-.0346	-.0334
.1500	-.0181	-.0175	.3000	-.0362	-.0350
.1750	-.0188	-.0182	.3500	-.0376	-.0364
.2000	-.0194	-.0188	.4000	-.0389	-.0376
.2250	-.0200	-.0193	.4500	-.0400	-.0386
.2500	-.0205	-.0198	.5000	-.0409	-.0395
.2750	-.0209	-.0201	.5500	-.0417	-.0403
.3000	-.0212	-.0205	.6000	-.0424	-.0409
.3250	-.0214	-.0207	.6500	-.0429	-.0414
.3500	-.0216	-.0209	.7000	-.0432	-.0418
.3750	-.0217	-.0210	.7500	-.0435	-.0420
.4000	-.0218	-.0211	.8000	-.0436	-.0421
.4250	-.0218	-.0211	.8500	-.0436	-.0421
.4500	-.0218	-.0210	.9000	-.0435	-.0420
.4750	-.0216	-.0209	.9500	-.0433	-.0418
.5000	-.0215	-.0207	1.0000	-.0429	-.0415
.5250	-.0212	-.0205	1.0500	-.0425	-.0410
.5500	-.0209	-.0202	1.1000	-.0419	-.0405
.5750	-.0206	-.0199	1.1500	-.0412	-.0398
.6000	-.0202	-.0195	1.2000	-.0404	-.0390
.6250	-.0197	-.0190	1.2500	-.0394	-.0381
.6500	-.0192	-.0185	1.3000	-.0384	-.0370
.6750	-.0186	-.0179	1.3500	-.0371	-.0359
.7000	-.0179	-.0173	1.4000	-.0358	-.0346
.7250	-.0172	-.0166	1.4500	-.0343	-.0332
.7500	-.0163	-.0158	1.5000	-.0327	-.0316
.7750	-.0154	-.0149	1.5500	-.0309	-.0298
.8000	-.0144	-.0139	1.6000	-.0289	-.0279
.8250	-.0133	-.0129	1.6500	-.0266	-.0257
.8500	-.0121	-.0117	1.7000	-.0242	-.0234
.8750	-.0108	-.0105	1.7500	-.0217	-.0210
.9000	-.0095	-.0091	1.8000	-.0189	-.0183
.9250	-.0078	-.0075	1.8500	-.0155	-.0150
.9500	-.0056	-.0054	1.9000	-.0111	-.0108
.9750	-.0029	-.0028	1.9500	-.0058	-.0056
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

Y= -.6803 Y/B/2= -.0331 CHORD= 2.0000

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0632 .0465 .0360 .0280 .0212 .0148 .0086 .0021-.0048-.0126-.0219-.0340-.0525-.1031

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0536 .1250 .1964 .2679 .3393 .4107 .4821 .5536 .6250 .6964 .7679 .8393 .9107 .9821

CHORD ANGLE OF ATTACK IN X-Z PLANE= .1380DEGREES

LOCAL ELEVATION

X/C	Z/C	(Z/C)COS(DIH)	DELTA X	DELTA Z	(DLT Z)COS(DIH)
-.0000	.0024	.0023	-.0000	.0048	.0047
.0250	.0008	.0008	.0500	.0016	.0016
.0500	-.0008	-.0007	.1000	-.0016	-.0015
.0750	-.0023	-.0022	.1500	-.0046	-.0045
.1000	-.0037	-.0036	.2000	-.0075	-.0072
.1250	-.0050	-.0048	.2500	-.0100	-.0096
.1500	-.0061	-.0059	.3000	-.0122	-.0117
.1750	-.0071	-.0068	.3500	-.0141	-.0137
.2000	-.0080	-.0077	.4000	-.0160	-.0155
.2250	-.0088	-.0086	.4500	-.0177	-.0171
.2500	-.0096	-.0093	.5000	-.0193	-.0186
.2750	-.0104	-.0100	.5500	-.0207	-.0200
.3000	-.0110	-.0106	.6000	-.0220	-.0213
.3250	-.0116	-.0112	.6500	-.0232	-.0224
.3500	-.0121	-.0117	.7000	-.0243	-.0234
.3750	-.0126	-.0122	.7500	-.0252	-.0244
.4000	-.0130	-.0126	.8000	-.0261	-.0252
.4250	-.0134	-.0129	.8500	-.0268	-.0259
.4500	-.0137	-.0132	.9000	-.0274	-.0265
.4750	-.0140	-.0135	.9500	-.0279	-.0270
.5000	-.0142	-.0137	1.0000	-.0283	-.0274
.5250	-.0143	-.0138	1.0500	-.0286	-.0277
.5500	-.0144	-.0139	1.1000	-.0288	-.0278
.5750	-.0144	-.0139	1.1500	-.0289	-.0279
.6000	-.0144	-.0139	1.2000	-.0288	-.0278
.6250	-.0143	-.0138	1.2500	-.0287	-.0277
.6500	-.0142	-.0137	1.3000	-.0283	-.0274
.6750	-.0140	-.0135	1.3500	-.0279	-.0270
.7000	-.0137	-.0132	1.4000	-.0273	-.0264
.7250	-.0133	-.0128	1.4500	-.0266	-.0257
.7500	-.0129	-.0124	1.5000	-.0257	-.0248
.7750	-.0123	-.0119	1.5500	-.0247	-.0238
.8000	-.0117	-.0113	1.6000	-.0234	-.0226
.8250	-.0109	-.0106	1.6500	-.0219	-.0211
.8500	-.0101	-.0098	1.7000	-.0202	-.0195
.8750	-.0092	-.0089	1.7500	-.0184	-.0178
.9000	-.0082	-.0079	1.8000	-.0163	-.0157
.9250	-.0068	-.0066	1.8500	-.0136	-.0131
.9500	-.0049	-.0048	1.9000	-.0099	-.0095
.9750	-.0026	-.0025	1.9500	-.0052	-.0050
1.0000	0.0000	0.0000	2.0000	0.0000	0.0000

APPENDIX E

COMPUTER PROGRAM LISTING

This program has been written in FORTRAN IV language for the CDC Cyber 173 computer system with NOS 1.3 operating system. The program is briefly described in Appendix A of this report. Minor modifications to the program may be necessary to achieve successful execution on other computers, as discussed in Appendix A. The following table is an index to the computer program listing:

This program is stored under user number 496125E on the NASA/LaRC computer system, with program GEOMTRY stored in permanent file WDES, and all other programs and subroutines stored in permanent WDEM. An example of the necessary control cards for execution of this program appears on the following page.

EXAMPLE OF CONTROL CARDS FOR EXECUTION OF CURRENT COMPUTER CODE AT NASA/LaRC

```
KUHL,T677,CM135000.                                   91212        WDESWDEM(KUHL)
USER,
CHARGE,
GET,WDES.
RFL,64000.
COPY,INPUT,TAPE5.
REWIND,TAPE5.
COPYSBF,TAPE5,OUTPUT.
REWIND,TAPE5.
FTN,I=WDES,STATIC.
LDSET,PRESET=INDEF.
LGO,TAPE5.
REWIND(TAPE50)
RFL,135000.
GET,WDEM.
ATTACH,FTNMLIB/UN=LIBRARY.
ATTACH,LRCGOSF/UN=LIBRARY.
FTN,I=WDEM,B=GLO,STATIC.
LDSET,LIB=LRCGOSF/FTNMLIB,PRESET=INDEF.
GLO.
EXIT.
```

PROGRAM LISTING

PROGRAM GEOMTRY

```
PROGRAM GEOMTRY     74/74    OPT=1 STATIC                    FTN 4.7+485         81/01/27. 13.

      PROGRAM  GEOMTRY(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE25,TAPE
     150)
      DIMENSION  XREF(25), YREF(25), SAR(25), A(25), RSAR(25), X(25), Y(
     125), ROTSV(2), SA(2), VRORD(51), SPY(50,2), KEX(2), IYL(50,2), IYT
     2(50,2)
      DIMENSION  LSEG(10), Z(10), YJ(10), PJ(10)
      DIMENSION  PCTX(50), PCTZ(50)
      DIMENSION  NTOT(2), NBRK(2), TOT(2), BRK(2), SEGG(10)
      COMMON  /ALL/ ROT,M,BETA,PTEST,QTEST,TPLSCW(50),Q(400),PN(400),PV(
     1400),S(400),PSI(400),PHI(50),ZH(50),NSSW
      COMMON  /MAINONE/ ICODEOF,TOTAL,AAN(2),XS(2),YS(2),KFCTS(2),XREG(2
     15,2),YREG(25,2),AREG(25,2),DIH(25,2),MCD(25,2),XX(25,2),YY(25,2),A
     2S(25,2),TTWD(25,2),MMCD(25,2),AN(2),ZZ(25,2),IFLAG
      COMMON  /ONETHRE/ TWIST(2),CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,RT
     1CDHT(2),CONFIG,NSSWSV(2),MSV(2),KBOT,PLAN,IPLAN,MACH,SSWWA(50)
      COMMON  /CCRRDD/ CHORD(50),XTE(50),KRIT,TSPAN,TSPANA
      REAL  MACH
      REWIND 50
C
C     THIS PROGRAM IS A SLIGHT REVISION OF THE GEOMETRY PROGRAM
C     DESCRIBED IN NASA TN D-8090, BY JOHN E. LAMAR
C     PROGRAM CIRCUL2 CONTAINS THE TREFFTZ PLANE OPTIMIZATION
C     USING THE 2-D ADVANCED PANEL THEORY OF NASA CP-3154, BY
C     JOHN M. KUHLMAN. FURTHER REFERENCES AND A DESCRIPTION
C     OF THE THEORY ARE GIVEN AS COMMENTS IN PROGRAM CIRCUL2.
C     PROGRAM ZOCDETM FOLLOWS THE MEAN CAMBER INTEGRATION PRO-
C     GRAM OF TN D-8090
C
C
C       PART ONE - GEOMETRY COMPUTATION
C
C                    SECTION ONE - INPUT OF REFERENCE WING POSITION
C
C
      ICODEOF = 0
      TOTAL = 0.
      PTEST = 0.
      QTEST = 0.
      TWIST(1) = 0.
      TWIST(2) = 0.
C     IF (TOTAL.EQ.0.) RTCDHT(1)=RTCDHT(2)=0.
      YTOL = 1.E - 10
```

(cont'd)

```
      AZY = 1.E + 13
      PITTT = 4. * ATAN(1.)
      PIT = PITTT / 2.
      RAD = 180. / PITTT
      IF (TOTAL .GT. 0.) GO TO 70
      RTCDHT(1) = 0.
      RTCDHT(2) = RTCDHT(1)
C
C
C     SET PLAN EQUAL TO 1. FOR A WING ALONE COMPUTAION - EVEN FOR A
C     VARIABLE SWEEP WING
C     SET PLAN EQUAL TO 2. FOR A WING - TAIL COMBINATION
C
C     SET TOTAL EQUAL TO THE NUMBER OF SETS
C       OF GROUP TWO DATA PROVIDED
C
      READ (5,1080) PLAN,TOTAL,CREF,SREF,XPREF
      IF (EOF(5)) 980,10
   10 IPLAN = PLAN
C
C
C     SET AAN(IT) EQUAL TO THE MAXIMUM NUMBER OF CURVES REQUIRED TO
C     DEFINE THE PLANFORM PERIMETER OF THE (IT) PLANFORM.
C
C     SET RTCDHT(IT) EQUAL TO THE ROOT CHORD HEIGHT OF THE LIFTING
C     SURFACE (IT),WHOSE PERIMETER POINTS ARE BEING READ IN, WITH
C     RESPECT TO THE WING ROOT CHORD HEIGHT
C
      WRITE (6,1060)
      DO 60 IT = 1,IPLAN
      READ (5,1010) AAN(IT),XS(IT),YS(IT),RTCDHT(IT)
      N = AAN(IT)
      N1 = N + 1
      MAK = 0
      IF (IPLAN .EQ. 1) PRTCON = 10H
      IF (IPLAN .EQ. 2 .AND. IT .EQ. 1) PRTCON = 10H    FIRST
      IF (IPLAN .EQ. 2 .AND. IT .EQ. 2) PRTCON = 10H   SECOND
      WRITE (6,1070) PRTCON,N,RTCDHT(IT),XS(IT),YS(IT)
      WRITE (6,1190)
      DO 50 I = 1,N1
      READ (5,1080) XREG(I,IT),YREG(I,IT),DIH(I,IT),AMCD
      XREG(I,IT) = XREG(I,IT) - XPREF
```

```
      MCD(I,IT) = AMCD
      IF (I .EQ. 1) GO TO 50
      IF (MAK .NE. 0 .OR. MCD(I - 1,IT) .NE. 2) GO TO 20
      MAK = I - 1
   20 IF (ABS(YREG(I - 1,IT) - YREG(I,IT)) .LT. YTOL) GO TO 30
      AREG(I - 1,IT) = (XREG(I - 1,IT) - XREG(I,IT)) / (YREG(I - 1,IT) -
     1 YREG(I,IT))
      ASWP = ATAN(AREG(I - 1,IT)) * RAD
      GO TO 40
   30 YREG(I,IT) = YREG(I - 1,IT)
      AREG(I - 1,IT) = AZY
      ASWP = 90.
   40 J = I - 1
C
C     WRITE PLANFORM PERIMETER POINTS AND ANGLES
C
      WRITE (6,1160) J,XREG(J,IT),YREG(J,IT),ASWP,DIH(J,IT),MCD(J,IT)
      DIH(J,IT) = TAN(DIH(J,IT) / RAD)
   50 CONTINUE
      KFCTS(IT) = MAK
      WRITE (6,1160) N1,XREG(N1,IT),YREG(N1,IT)
   60 CONTINUE
C
C                               PART 1 - SECTION 2
C            READ GROUP 2 DATA AND COMPUTE DESIRED WING POSITION
C
C
C     SET SA(1),SA(2) EQUAL TO THE SWEEP ANGLE,IN DEGREES, FOR THE FIRST
C     CURVE(S) THAT CAN CHANGE SWEEP FOR EACH PLANFORM
C
   70 READ (5,1150) CONFIG,SCW,VIC,MACH,CLDES,SA(1),SA(2)
C
      WRITE (6,1090) CONFIG
      IF (EOF(5)) 980,80
   80 IF (PTEST .NE. 0. .AND. QTEST .NE. 0.) GO TO 1000
      IF (SCW .EQ. 0.) GO TO 100
      DO 90 I = 1,50
   90 TBLSCW(I) = SCW
      GO TO 110
  100 READ (5,1080) STA
      NSTA = STA
      READ (5,1080) (TBLSCW(I),TBLSCW(I + 1),TBLSCW(I + 2),TBLSCW(I + 3)
```

```
     1,TBLSCW(I + 4),TBLSCW(I + 5),TBLSCW(I + 6),TBLSCW(I + 7),I = 1,NST
     2A,8)
  110 DO 360 IT = 1,IPLAN
      N = AAN(IT)
      N1 = N + 1
      DO 120 I = 1,N
      XREF(I) = XREG(I,IT)
      YREF(I) = YREG(I,IT)
      A(I) = AREG(I,IT)
      RSAR(I) = ATAN(A(I))
      IF (A(I) .EQ. AZY) RSAR(I) = PIT
  120 CONTINUE
      XREF(N1) = XREG(N1,IT)
      YREF(N1) = YREG(N1,IT)
      IF (KFCTS(IT) .GT. 0) GO TO 130
      K = 1
      SA(IT) = RSAR(1) * RAD
      GO TO 140
  130 K = KFCTS(IT)
  140 WRITE (6,1120) K,SA(IT),IT
      SB = SA(IT) / RAD
      IF (ABS(SB - RSAR(K)) .GT. (.1 / RAD)) GO TO 170
C     REFERENCE PLANFORM COORDINATES ARE STORED UNCHANGED FOR WINGS
C            WITHOUT CHANGE IN SWEEP
      DO 160 I = 1,N
      X(I) = XREF(I)
      Y(I) = YREF(I)
      IF (RSAR(I) .EQ. PIT) GO TO 150
      A(I) = TAN(RSAR(I))
      GO TO 160
  150 A(I) = AZY
  160 SAR(I) = RSAR(I)
      X(N1) = XREF(N1)
      Y(N1) = YREF(N1)
      GO TO 340
C
C     CHANGES IN WING SWEEP ARE MADE HERE
C
  170 IF (MOD(K,IT) .NE. 2) GO TO 990
      KA = K - 1
      DO 180 I = 1,KA
      X(I) = XREF(I)
```

```
PROGRAM GEOMTRY    74/74    OPT=1 STATIC                FTN 4.7+485         81/01/27. 13.35.39        PAGE      5

              Y(I) = YREF(I)
          180 SAR(I) = RSAR(I)
      C       DETERMINE LEADING EDGE INTERSECTION BETWEEN FIXED AND VARIABLE
      C              SWEEP WING SECTIONS
              SAR(K) = SB
              A(K) = TAN(SB)
              SAI = SB - RSAR(K)
              X(K + 1) = XS(IT) + (XREF(K + 1) - XS(IT)) * COS(SAI) + (YREF(K +
             11) - YS(IT)) * SIN(SAI)
              Y(K + 1) = YS(IT) + (YREF(K + 1) - YS(IT)) * COS(SAI) - (XREF(K +
             11) - XS(IT)) * SIN(SAI)
              IF (ABS(SB - SAR(K - 1)) .LT. (.1 / RAD)) GO TO 190
              Y(K) = X(K + 1) - X(K - 1) - A(K) * Y(K + 1) + A(K - 1) * Y(K - 1)
              Y(K) = Y(K) / (A(K - 1) - A(K))
              X(K) = A(K) * X(K - 1) - A(K - 1) * X(K + 1) + A(K - 1) * A(K) * (
             1Y(K + 1) - Y(K - 1))
              X(K) = X(K) / (A(K) - A(K - 1))
              GO TO 200
      C       ELIMINATE EXTRANEOUS BREAKPOINTS
          190 X(K) = XREF(K - 1)
              Y(K) = YREF(K - 1)
              SAR(K) = SAR(K - 1)
          200 K = K + 1
      C       SWEEP THE BREAKPOINTS ON THE VARIABLE SWEEP PANEL
      C           (IT ALSO KEEPS SWEEP ANGLES IN FIRST OR FOURTH QUADRANTS)
          210 K = K + 1
              SAR(K - 1) = SAI + RSAR(K - 1)
          220 IF (SAR(K - 1) .LE. PIT) GO TO 230
              SAR(K - 1) = SAR(K - 1) - 3.1415927
              GO TO 220
          230 IF (SAR(K - 1) .GE. ( - PIT)) GO TO 240
              SAR(K - 1) = SAR(K - 1) + 3.1415927
              GO TO 230
          240 IF ((SAR(K - 1)) .LT. .0) GO TO 250
              IF (SAR(K - 1) - PIT) 280,260,260
          250 IF (SAR(K - 1) + PIT) 270,270,280
          260 A(K - 1) = AZY
              GO TO 290
          270 A(K - 1) = -AZY
              GO TO 290
          280 A(K - 1) = TAN(SAR(K - 1))
          290 KK = MOD(K,IT)
```

```
      IF (KK .EQ. 1) GO TO 300
      Y(K) = YS(IT) + (YREF(K) - YS(IT)) * COS(SAI) - (XREF(K) - XS(IT))
     1 * SIN(SAI)
      X(K) = XS(IT) + (XREF(K) - XS(IT)) * COS(SAI) + (YREF(K) - YS(IT))
     1 * SIN(SAI)
      GO TO 210
C     DETERMINE THE TRAILING EDGE INTERSECTION
C        BETWEEN FIXED AND VARIABLE SWEEP WING SECTIONS
  300 IF (ABS(RSAR(K) - SAR(K - 1)) .LT. (.1 / RAD)) GO TO 310
      Y(K) = XREF(K + 1) - X(K - 1) - A(K) * YREF(K + 1) + A(K - 1) * Y(
     1K - 1)
      Y(K) = Y(K) / (A(K - 1) - A(K))
      X(K) = A(K) * X(K - 1) - A(K - 1) * XREF(K + 1) + A(K - 1) * A(K)
     1* (YREF(K + 1) - Y(K - 1))
      X(K) = X(K) / (A(K) - A(K - 1))
      GO TO 320
  310 X(K) = XREF(K + 1)
      Y(K) = YREF(K + 1)
  320 K = K + 1
C     STORE REFERENCE PLANFORM COORDINATES ON INBOARD FIXED TRAILING
C     EDGE
      DO 330 I = K,N1
      X(I) = XREF(I)
      Y(I) = YREF(I)
  330 SAR(I - 1) = RSAR(I - 1)
  340 DO 350 I = 1,N
      XX(I,IT) = X(I)
      YY(I,IT) = Y(I)
      MMCD(I,IT) = MCD(I,IT)
      TTWD(I,IT) = DIH(I,IT)
  350 AS(I,IT) = A(I)
      XX(N1,IT) = X(N1)
      YY(N1,IT) = Y(N1)
      AN(IT) = AAN(IT)
  360 CONTINUE
C
C       LINE UP BREAKPOINTS AMONG PLANFORMS
C
      BOTSV(1) = 0.
      BOTSV(2) = 0.
      WRITE (6,1180)
      DO 480 IT = 1,IPLAN
```

```
            NIT = AN(IT) + 1
            DO 420 ITT = 1,IPLAN
            IF (ITT .EQ. IT) GO TO 420
            NITT = AN(ITT) + 1
            DO 410 I = 1,NITT
            JPSV = 0
            DO 370 JP = 1,NIT
            IF (YY(JP,IT) .EQ. YY(I,ITT)) GO TO 410
        370 CONTINUE
            DO 380 JP = 1,NIT
            IF (YY(JP,IT) .LT. YY(I,ITT)) GO TO 390
        380 CONTINUE
            GO TO 410
        390 IF (JP .EQ. 1) GO TO 410
            JPSV = JP
            IND = NIT - (JPSV - 1)
            DO 400 JP = 1,IND
            K2 = NIT - JP + 2
            K1 = NIT - JP + 1
            XX(K2,IT) = XX(K1,IT)
            YY(K2,IT) = YY(K1,IT)
            MMCD(K2,IT) = MMCD(K1,IT)
            AS(K2,IT) = AS(K1,IT)
        400 TTWD(K2,IT) = TTWD(K1,IT)
            YY(JPSV,IT) = YY(I,ITT)
            AS(JPSV,IT) = AS(JPSV - 1,IT)
            TTWD(JPSV,IT) = TTWD(JPSV - 1,IT)
            XX(JPSV,IT) = (YY(JPSV,IT) - YY(JPSV - 1,IT)) * AS(JPSV - 1,IT) +
           1XX(JPSV - 1,IT)
            MMCD(JPSV,IT) = MMCD(JPSV - 1,IT)
            AN(IT) = AN(IT) + 1.
            NIT = NIT + 1
        410 CONTINUE
        420 CONTINUE
      C
      C     SEQUENCE WING COORDINATES FROM TIP TO ROOT
      C
            N1 = AN(IT) + 1.
            DO 430 I = 1,N1
        430 Q(I) = YY(I,IT)
            DO 470 J = 1,N1
            HIGH = 1.
```

```
            DO 440 I = 1,N1
            IF ((Q(I) - HIGH) .GE. 0.) GO TO 440
            HIGH = Q(I)
            IH = I
        440 CONTINUE
            IF (J .NE. 1) GO TO 450
            BOTSV(IT) = HIGH
            KFX(IT) = IH
        450 Q(IH) = 1.
            SPY(J,IT) = HIGH
            IF (IH .GT. KFX(IT)) GO TO 460
            IYL(J,IT) = 1
            IYT(J,IT) = 0
            GO TO 470
        460 IYL(J,IT) = 0
            IYT(J,IT) = 1
        470 CONTINUE
        480 CONTINUE
      C
      C     SELECT MAXIMUM B/2 AS THE WING SEMISPAN.   IF BOTH FIRST AND
      C     SECOND PLANFORMS HAVE SAME SEMISPAN THEN THE SECOND PLANFORM IS
      C     TAKEN TO BE THE WING.
      C
            KBOT = 1
            IF (BOTSV(1) .GE. BOTSV(2)) KBOT = 2
            BOT = BOTSV(KBOT)
      C
      C     COMPUTE NOMINAL HORSESHOE VORTEX WIDTH ALONG WING SURFACE
      C
            TSPAN = 0
            ISAVE = KFX(KBOT) - 1
            I = KFX(KBOT) - 2
        490 IF (I .EQ. 0) GO TO 500
            IF (TTWD(I,KBOT) .EQ. TTWD(ISAVE,KBOT)) GO TO 510
        500 CTWD = COS(ATAN(TTWD(ISAVE,KBOT)))
            TLGTH = (YY(ISAVE + 1,KBOT) - YY(I + 1,KBOT)) / CTWD
            TSPAN = TSPAN + TLGTH
            IF (I .EQ. 0) GO TO 520
            ISAVE = I
        510 I = I - 1
            GO TO 490
        520 VI = TSPAN / VIC
```

```
      VSTOL = VI / 2
C
      TSPANA = 0.
      KPIT = 2
      IF (IPLAN .EQ. 1) GO TO 560
      IF (KBOT .EQ. 2) KBIT = 1
      ISAVEA = KFX(KPIT) - 1
      IA = KFX(KBIT) - 2
  530 IF (IA .EQ. 0) GO TO 540
      IF (TTWD(IA,KPIT) .EQ. TTWD(ISAVEA,KBIT)) GO TO 550
  540 CTWDA = COS(ATAN(TTWD(ISAVEA,KBIT)))
      TLGTHA = (YY(ISAVEA + 1,KPIT) - YY(IA + 1,KBIT)) / CTWDA
      TSPANA = TSPANA + TLGTHA
      IF (IA .EQ. 0) GO TO 560
      ISAVEA = IA
  550 IA = IA - 1
      GO TO 530
  560 CONTINUE
C     ELIMINATE PLANFORM BREAKPOINTS WHICH ARE WITHIN (B/2)/2000 UNITS
C     LATERALLY
C
      DO 580 IT = 1,IPLAN
      N = AN(IT)
      N1 = N + 1
      DO 580 J = 1,N
      AA = ABS(SPY(J,IT) - SPY(J + 1,IT))
      IF (AA .EQ. 0. .OR. AA .GT. ABS(TSPAN / 2000.)) GO TO 580
      IF (AA .GT. YTOL) WRITE (6,1210) SPY(J + 1,IT),SPY(J,IT)
      DO 570 I = 1,N1
      IF (YY(I,IT) .NE. SPY(J + 1,IT)) GO TO 570
      YY(I,IT) = SPY(J,IT)
  570 CONTINUE
      SPY(J + 1,IT) = SPY(J,IT)
  580 CONTINUE
C
C     COMPUTE Z COORDINATES
C
      DO 620 IT = 1,IPLAN
      JM = N1 = AN(IT) + 1.
      DO 590 JZ = 1,N1
  590 ZZ(JZ,IT) = RTCDHT(IT)
      JZ = 1
```

```
      600 JZ = JZ + 1
          IF (JZ .GT. KEX(IT)) GO TO 610
          ZZ(JZ,IT) = ZZ(JZ - 1,IT) + (YY(JZ,IT) - YY(JZ - 1,IT)) * TTWD(JZ
         1- 1,IT)
          GO TO 600
      610 JM = JM - 1
          IF (JM .EQ. KEX(IT)) GO TO 620
          ZZ(JM,IT) = ZZ(JM + 1,IT) + (YY(JM,IT) - YY(JM + 1,IT)) * TTWD(JM,
         1IT)
          GO TO 610
      620 CONTINUE
C
C         WRITE PLANFORM PERIMETER POINTS ACTUALLY USED IN THE COMPUTATIONS
C
          WRITE (6,1100)
          DO 640 IT = 1,IPLAN
          N = AN(IT)
          N1 = N + 1
          IF (IT .EQ. 2) WRITE (6,1200)
          DO 630 KK = 1,N
          TOUT = ATAN(TTWD(KK,IT)) * RAD
          AOUT = ATAN(AS(KK,IT)) * RAD
          IF (AS(KK,IT) .EQ. AZY) AOUT = 90.
          WRITE (6,1110) KK,XX(KK,IT),YY(KK,IT),ZZ(KK,IT),AOUT,TOUT,MMCD(KK,
         1IT)
      630 CONTINUE
          WRITE (6,1110) N1,XX(N1,IT),YY(N1,IT),ZZ(N1,IT)
      640 CONTINUE
C
C         SELECT WAKE BREAKPOINTS FOR USE IN CIRCUL2
C         NOTE THAT WAKE INTERSECTIONS MUST BE INCLUDED
C         AS WAKE BREAKPOINTS
C
C         THIS REQUIRES A SLIGHT CHANGE IN DIHEDRAL ACROSS
C         THE INTERSECTION POINT ON BOTH PLANFORMS
C
          IT = 1
          JKT = 1
      650 J1 = JKT + 1
          YJ(JKT) = YY(1,IT)
          Z(JKT) = ZZ(1,IT)
          PJ(JKT) = ATAN(TTWD(1,IT)) * RAD
```

```
          YJ(J1) = YY(2,IT)                                                   A 421
          Z(J1) = ZZ(2,IT)                                                    A 422
          PJ(J1) = ATAN(TTWD(2,IT)) * RAD                                     A 423
          N = AN(IT)                                                          A 424
          JKT = J1 + 1                                                        A 425
          N1 = N - 1                                                          A 426
          YMINT = 0.                                                          A 427
          DO 660 J = 1,N                                                      A 428
      660 YMINT = AMIN1(YMINT,YY(J,IT))                                       A 429
          DO 690 KK = 2,N1                                                    A 430
          K1 = KK + 1                                                         A 431
          JM = JKT - 1                                                        A 432
          JM2 = JKT - 2                                                       A 433
          K2 = KK + 2                                                         A 434
          IF (YY(KK,IT) .EQ. YMINT) GO TO 700                                 A 435
          IF (YY(K1,IT) .EQ. YY(KK,IT) .AND. YY(K2,IT) .GT. YY(K1,IT)) GO TO  A 436
         1 700                                                                A 437
          IF (YY(K1,IT) .GT. YY(KK,IT) .AND. YY(K2,IT) .GT. YY(K1,IT)) GO TO  A 438
         1 700                                                                A 439
          TOUT = ATAN(TTWD(KK,IT)) * RAD                                      A 440
          IF (YY(KK,IT) .NE. YY(K1,IT)) GO TO 670                             A 441
          PJ(JKT - 1) = ATAN(TTWD(K1,IT)) * RAD                               A 442
          GO TO 690                                                           A 443
      670 YJ(JKT) = YY(K1,IT)                                                 A 444
          Z(JKT) = ZZ(K1,IT)                                                  A 445
          PJ(JKT) = ATAN(TTWD(K1,IT)) * RAD                                   A 446
          IF (PJ(JM2) .NE. PJ(JM)) GO TO 680                                  A 447
          YJ(JM) = YJ(JKT)                                                    A 448
          Z(JM) = Z(JKT)                                                      A 449
          PJ(JM) = PJ(JKT)                                                    A 450
          JKT = JM                                                            A 451
      680 CONTINUE                                                            A 452
          JKT = JKT + 1                                                       A 453
      690 CONTINUE                                                            A 454
          JKT = JKT + 1                                                       A 455
      700 CONTINUE                                                            A 456
          IF (IT .EQ. IPLAN) GO TO 710                                        A 457
          IT = IT + 1                                                         A 458
          GO TO 650                                                           A 459
      710 CONTINUE                                                            A 460
C                                                                             A 461
C         MOVE PLANFORM TWO BREAKPOINTS VERTICALLY TO COINCIDE                A 462
```

```
      PROGRAM GEOMTRY    74/74    OPT=1 STATIC              FTN 4.7+485        81/01/27. 13.35.39        PAGE    12

C     WITH POINT AT SAME Y ON PLANFORM ONE IF Y VALUES SAME
C     AND ABS DIFF Z VALUES,LESS THAN TOLERANCE, DIFZ
C
      IF (IPLAN .EQ. 1) GO TO 730
      DIFY = 1.E - 07
      DIFZ = 1.E - 04
      JKT1 = JKT - 1
      DO 720 IC = 1,JKT1
      YCOMP = YJ(IC)
      ZCOMP = Z(IC)
      DO 720 JC = 1,JKT1
      IF (ABS(YJ(JC) - YCOMP) .LT. DIFY .AND. ABS(Z(JC) - ZCOMP) .LT. DI
     1FZ) Z(JC) = ZCOMP
  720 CONTINUE
  730 CONTINUE
C
C     PART ONE - SECTION THREE - LAY OUT YAWED HORSESHOE VORTICES
C
      STRUE = 0.
      NSSWSV(1) = 0
      NSSWSV(2) = 0
      MSV(1) = 0
      MSV(2) = 0
      DO 820 IT = 1,IPLAN
      N1 = AN(IT) + 1.
      I = 0
      J = 1
      YIN = BOTSV(IT)
      ILE = KFX(IT)
      ITE = KFX(IT)
C     DETERMINE SPANWISE BORDERS OF HORSESHOE VORTICES
  740 IXL = 0
      IXT = 0
      I = I + 1
      CPHI = COS(ATAN(TTWD(ILE,IT)))
      IF (YIN .GE. (SPY(J,IT) + VSTOL * CPHI)) GO TO 750
C     BORDER IS WITHIN VORTEX SPACING TOLERANCE (VSTOL) OF BREAKPOINT
C     THEREFORE USE THE NEXT BREAKPOINT INBOARD FOR THE BORDER
      VBORD(I) = YIN
      GO TO 780
C     USE NOMINAL VORTEX SPACING TO DETERMINE THE BORDER
  750 VBORD(I) = SPY(J,IT)
```

```
      C     COMPUTE SUBSCRIPTS ILE AND ITE TO INDICATE WHICH
      C     BREAKPOINTS ARE ADJACENT AND WHETHER THEY ARE ON THE WING LEADING
      C       EDGE OR THE TRAILING EDGE
        760 IF (J .GE. N1) GO TO 770
            IF (SPY(J,IT) .NE. SPY(J + 1,IT)) GO TO 770
            IXL = IXL + IYL(J,IT)
            IXT = IXT + IYT(J,IT)
            J = J + 1
            GO TO 760
        770 YIN = SPY(J,IT)
            IXL = IXL + IYL(J,IT)
            IXT = IXT + IYT(J,IT)
            J = J + 1
        780 CONTINUE
            IPHI = ILE - IXL
            IF (J .GE. N1) IPHI = 1
            YIN = YIN - VI * COS(ATAN(TTWD(IPHI,IT)))
            IF (I .NE. 1) GO TO 800
        790 ILE = ILE - IXL
            ITE = ITE + IXT
            GO TO 740
      C     COMPUTE COORDINATES FOR CHORDWISE ROW OF HORSESHOE VORTICES
        800 YQ = (VBORD(I - 1) + VBORD(I)) / 2.
            HW = (VBORD(I) - VBORD(I - 1)) / 2.
            IM1 = I - 1 + NSSWSV(1)
            ZH(IM1) = ZZ(ILE,IT) + (YQ - YY(ILE,IT)) * TTWD(ILE,IT)
            PHI(IM1) = TTWD(ILE,IT)
            SSWWA(IM1) = AS(ILE,IT)
            XLE = XX(ILE,IT) + AS(ILE,IT) * (YQ - YY(ILE,IT))
            XET = XX(ITE,IT) + AS(ITE,IT) * (YQ - YY(ITE,IT))
            XLOCAL = (XLE - XET) / TBLSCW(IM1)
      C
      C     COMPUTE WING AREA PROJECTED TO THE X - Y PLANE
      C
            STRUE = STRUE + XLOCAL * TBLSCW(IM1) * (HW * 2.) * 2.
      C
            NSCW = TBLSCW(IM1)
            DO 810 JCW = 1,NSCW
            AJCW = JCW - 1
            XLEL = XLE - AJCW * XLOCAL
            NTS = JCW + MSV(1) + MSV(2)
            PN(NTS) = XLEL - .25 * XLOCAL
```

```
            PV(NTS) = XLEL - .75 * XLOCAL
            PSI(NTS) = ((XLE - PN(NTS)) * AS(ITE,IT) + (PN(NTS) - XET) * AS(IL
           1E,IT)) / (XLE - XET)
            S(NTS) = HW / CPHI
            Q(NTS) = YO
        810 CONTINUE
            MSV(IT) = MSV(IT) + NSCW
      C
      C     TEST TO DETERMINE WHEN WING ROOT IS REACHED
            IF (YBORD(I) .LT. YREG(1,IT)) GO TO 790
      C
            NSSWSV(IT) = I - 1
        820 CONTINUE
            M = MSV(1) + MSV(2)
      C
      C     COMPUTE ASPECT RATIO  AND  AVERAGE CHORD
      C
            BOT = -BOT
            AR = 4. * BOT * BOT / SREF
            ARTRUE = 4. * BOT * BOT / STRUE
            CAVE = STRUE / (2. * BOT)
            BETA = (1. - MACH * MACH) ** .5
            WRITE (6,1240) M
            WRITE (6,1250) (IT,MSV(IT),NSSWSV(IT),IT = 1,IPLAN)
            IF (SCW .NE. 0.) WRITE (6,1220) SCW
            SCWJK = SCW
            IF (SCW .EQ. 0.) WRITE (6,1230) (TBLSCW(I),I = 1,NSTA)
      C
      C     APPLY PRANDTL-GLAUERT CORRECTION
      C
            DO 830 NV = 1,M
            PSI(NV) = ATAN(PSI(NV) / BETA)
            PN(NV) = PN(NV) / BETA
        830 PV(NV) = PV(NV) / BETA
            NSSW = NSSWSV(1) + NSSWSV(2)
            JN = 0
            DO 850 JSSW = 1,NSSW
            CHORD(JSSW) = 0.
            NSCW = TBLSCW(JSSW)
            DO 840 JSCW = 1,NSCW
            JN = JN + 1
            CHORD(JSSW) = CHORD(JSSW) - 2. * (PV(JN) - PN(JN)) * BETA
```

```
    840 CONTINUE
    850 XTE(JSSW) = (PV(JN) + (PV(JN) - PN(JN)) / 2.) * BETA
        PHISUM = 0.
        DO 860 IKY = 1,NSSW
        PHISUM = PHISUM + PHI(IKY)
    860 CONTINUE
C
C       FORCE USE OF PROGRAM CIRCUL2
C
        IFLAG = 2
C
C       READ CHORD LOAD SHAPES TO BE USED IN NEXT OVERLAY
C
        READ (5,1300) XCFW,XCFT
C
C       READ TREFFTZ PLANE DRAG ANALYSIS DATA FOR NEXT OVERLAY
C
C       NLLINE=NO OF LIFTING LINES
C
C       FJFLAG=0. FOR CL CONSTRAINT ONLY
C       FJFLAG=1. FOR CL,CM CONSTRAINTS
C       FJFLAG=2. FOR CL,CB CONSTRAINTS
C       FJCTL=0. FOR NO THICKNESS OR PLOTS
C       FJCTL=1. FOR NO THICKNESS; PLOT MEAN CAMBERS
C       FJCTL=2. FOR THICKNESS; PLOT AIRFOIL SHAPES
C
C
C       FSLP=1. FOR PUNCHED OUTPUT OF SURFACE SLOPES(SEE PROG 70CDETM)
C       FSLP=0. FOR NO PUNCHED OUTPUT OF SURFACE SLOPES
C
        NLLINE = IPLAN
        JFLAG = 0
        READ (5,1020) FJFLAG,FJCTL,FSLP
        JCTL = IFIX(FJCTL)
        JFLAG = IFIX(FJFLAG)
        JSLP = IFIX(FSLP)
        ICT = 0
        INC = 0
        IST = 1
        ISP = 0
        JST = 1
        JSP = 0
```

```
      JNC = 0
  870 CONTINUE
      ICT = ICT + 1
      IF (ICT .GT. NLLINE) GO TO 890
      READ (5,1020) BRK(ICT),TOT(ICT)
      NBRK(ICT) = IFIX(BRK(ICT))
      NTOT(ICT) = IFIX(TOT(ICT))
      ISP = ISP + NBRK(ICT)
      IST = IST + INC
      NBRJ = NBRK(ICT) - 1
      JSP = JSP + NBRJ
      JST = JST + JNC
      READ (5,1020) (SEGG(I),I = JST,JSP)
      DO 880 I = JST,JSP
  880 LSEG(I) = IFIX(SEGG(I))
      INC = NBRK(ICT)
      JNC = NBRJ
      GO TO 870
  890 CONTINUE
      CRBM = 0.
      IF (JFLAG .EQ. 0 .OR. JFLAG .EQ. 1) GO TO 900
      READ (5,1030) CRBM
  900 CONTINUE
      WRITE (6,1050) XPREF
C
C     READ THICKNESS DISTRIBUTION FOR USE IN ZOCDETM
C     THIS DATA MUST BE SPECIFIED ONLY IF JCTL IS NOT ZERO
C     SPECIFY PERCENT X/C TABLE ,FOLLOWED BY T/2C TABLE
C
C     IF JCTL IS NOT ZERO, THEN LANGLEY PLOTTING SUBROUTINE
C     INFOPLOT IS USED TO PLOT THE DESIGNED AIRFOIL SECTIONS
C     IN PLANES NORMAL TO THE WING PLANE, OR THE CAMBER SURFACE
C
C     ONLY ONE THICKNESS DIST FOR ALL SPAN STATIONS MAY
C     BE SPECIFIED
C
C     NZS IS NO OF PCTX,PCTZ VALUES SPECIFIED, WHERE PCTZ
C     IS ONE HALF OF TOTAL MAX THICKNESS OVER LOCAL WING
C     CHORD
C
C     NZS MUST BE LESS THAN 51
C
```

```
      IF (JCTL .EQ. 0) GO TO 910
      IF (JCTL .EQ. 1) GO TO 910
      READ (5,1020) FNZS
      NZS = IFIX(FNZS)
      READ (5,1040) (PCTX(I),I = 1,NZS)
      READ (5,1040) (PCTZ(I),I = 1,NZS)
  910 CONTINUE
      IF (M .GT. 400) GO TO 940
      NSW = NSSWSV(1) + NSSWSV(2)
      IF (NSW .GT. 50) GO TO 930
      ITSV = 0
      DO 920 IT = 1,IPLAN
      IF (AN(IT) .LE. 25.) GO TO 920
      WRITE (6,1280) IT,AN(IT)
      ITSV = 1
  920 CONTINUE
      IF (ITSV .GT. 0) GO TO 960
      GO TO 950
  930 WRITE (6,1270) NSW
      GO TO 960
  940 WRITE (6,1260) M
      GO TO 960
  950 REWIND 25
      WRITE (25) BOT,M,BETA,PTEST,QTEST,TBLSCW,Q,PN,PV,S,PSI,PHI,ZH,NSSW
     1,TWIST,CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,RTCDHT,CONFIG,NSSWSV,M
     2SV,KBOT,PLAN,IPLAN,MACH,SSWWA,CHORD,XTE,KBIT,TSPAN,TSPANA,XCFW,XCF
     3T,IFLAG,YREG(1,1),YREG(1,2),ALLINF,NTOT,NBRK,LSEG,YJ,Z,PJ,SCWJK,JF
     4LAG,CRBM,VBORD,XPREF,PCTX,PCTZ,NZS,JCTL,JSLP
      END FILE 25
      WRITE (6,1290)
      WRITE (50,1310)
      GO TO 970
  960 TOTAL = TOTAL - 1.
      WRITE (50,1320)
  970 CONTINUE
      END FILE 50
      STOP
  980 ICODEOF = 1
      WRITE (6,1130) CONFIG
      GO TO 960
  990 ICODEOF = 2
      WRITE (6,1140) K,IT
```

PROGRAM GEOMTRY (Continued)


```
            GO TO 960
       1000 ICODEOF = 3
            WRITE (6,1170) PTEST,QTEST
            GO TO 960
C
C
C
       1010 FORMAT (3F10.4,F10.7)
       1020 FORMAT (10F5.0)
       1030 FORMAT (3F10.0)
       1040 FORMAT (6F10.0)
       1050 FORMAT (/45X,20HX SHIFT OF ORIGIN = ,F10.4,6H UNITS/)
       1060 FORMAT (1H1//63X,13HGEOMETRY DATA)
       1070 FORMAT (///45X,A10,22HREFERENCE PLANFORM HAS,I3,7H CURVES//12X,19H
           1ROOT CHORD HEIGHT =,F14.8,4X,29HVARIABLE SWEEP PIVOT POSITION,4X,6
           2HX(S) =,F12.5,5X,6HY(S) =,F12.5//46X,40HBREAK POINTS FOR THE REFER
           3ENCE PLANFORM /)
       1080 FORMAT (8F10.4)
       1090 FORMAT (1H1//47X,17HCONFIGURATION NO.,F8.0/)
       1100 FORMAT (22X,5HPOINT,6X,1HX,11X,1HY,11X,1HZ,10X,5HSWEEP,7X,8HDIHEDR
           1AL,4X,4HMOVE/68X,5HANGLE,8X,5HANGLE,6X,4HCODE/)
       1110 FORMAT (20X,I5,3F12.5,2F14.5,I6)
       1120 FORMAT (/40X,5HCURVE,I3,9H IS SWEPT,F12.5,20H DEGREES ON PLANFORM,
           1I3)
       1130 FORMAT (1H1///41X,43HEND OF FILE ENCOUNTERED AFTER CONFIGURATION,F
           17.0)
       1140 FORMAT (1H1///18X,45HTHE FIRST VARIABLE SWEEP CURVE SPECIFIED (K =
           1,I3,44H ) DOES NOT HAVE AN M CODE OF 2 FOR PLANFORM,I4)
       1150 FORMAT (5F5.1,2F10.4)
       1160 FORMAT (26X,I5,2F12.5,2F16.5,4X,I4)
       1170 FORMAT (1H1///1X,38HERROR - PROGRAM CANNOT PROCESS PTEST =,F5.1,12
           1H AND QTEST =,F5.1)
       1180 FORMAT (//48X,35HBREAK POINTS FOR THIS CONFIGURATION//)
       1190 FORMAT (28X,5HPOINT,6X,1HX,11X,1HY,11X,5HSWEEP,10X,8HDIHEDRAL,7X,4
           1HMOVE/38X,3HREF,9X,3HREF,10X,5HANGLE,11X,5HANGLE,9X,4HCODE/)
       1200 FORMAT (/52X,28HSECOND PLANFORM BREAK POINTS/)
       1210 FORMAT (////25X,34HTHE BREAKPOINT LOCATED SPANWISE AT,F11.5,3X,20H
           1HAS BEEN ADJUSTED TO,F9.5////)
       1220 FORMAT (/43X,F5.0,41H HORSESHOE VORTICES IN EACH CHORDWISE ROW)
       1230 FORMAT (/23X,98HTABLE OF HORSESHOE VORTICES IN EACH CHORDWISE ROW
           1(FROM TIP TO ROOT BEGINNING WITH FIRST PLANFORM)//25F5.0/25F5.0)
       1240 FORMAT (///33XI5,62H HORSESHOE VORTICES USED ON THE LEFT HALF OF T
```

PROGRAM GEOMTRY (Concluded)


```
        1HE CONFIGURATION//50X,36HPLANFORM       TOTAL        SPANWISE/)      A 757
   1250 FORMAT (52X,I4,10X,I3,11X,I4)                                         A 758
   1260 FORMAT (1H1//10X,I6,93HHORSESHOE VORTICES LAIDOUT, THIS IS MORE TH    A 759
        1AN THE 400 MAXIMUM. THIS CONFIGURATION IS ABORTED.)                  A 760
   1270 FORMAT (1H1//10X,I6,101H ROWS OF HORSESHOE VORTICES LAIDOUT. THIS     A 761
        1IS MORE THAN THE 50 MAXIMUM. THIS CONFIGURATION IS ABORTED.)         A 762
   1280 FORMAT (1H1//10X,8HPLANFORM,I6,4H HAS,I6,74H BREAKPOINTS. THE MAXI    A 763
        1MUM DIMENSIONED IS 25. THE CONFIGURATION IS ABORTED.)                A 764
   1290 FORMAT (///45X,28HMINIMUM FIELD LENGTH = 63000)                       A 765
   1300 FORMAT (6F10.4)                                                       A 766
   1310 FORMAT (35H*COMPILE VLMCDRAGS,VLMCCIR2,VLMCZOC)                       A 767
   1320 FORMAT (18H*COMPILE VLMCDUMMY)                                        A 768
        END                                                                   A 769-
```

PROGRAM WINGAL

```
PROGRAM WINGAL      74/74    OPT=1 STATIC                FTN 4.7+485        81/01/27. 13.38.34        PAGE     1

            OVERLAY (WINGTL,0,0)
            PROGRAM  WINGAL(OUTPUT,TAPE6=OUTPUT,TAPE10,TAPE20,TAPE25,PUNCH)
            COMMON  /ALL/ ROT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(400),PN(400),PV(
           1400),S(400),PSI(400),PHI(50),ZH(50),NSSW
            COMMON  /ONETHRE/ TWIST(2),CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,RT
           1CDHT(2),CONFIG,NSSWSV(2),MSV(2),KBOT,PLAN,IPLAN,MACH,SSWWA(50),XCF
           2W,XCFT,YREG(1,2),CRBM,VBORD(51),XPREF
            COMMON  /TOTHRE/ CIR(400)
            COMMON  /CCPRDD/ CHORD(50),XTE(50),KBIT,TSPAN,TSPANA
            COMMON  /JMK/ NTOT(2),NBRK(2),LSEG(10),YJ(10),Z(10),PJ(10),SCWJK
            COMMON  /JK2/ PCTX(50),PCTZ(50),NZS,JCTL,JSLP
            COMMON  /FEN/ NSPT(4),NLLINE,JFLAG
            REAL  MACH
      C
      C
      C        VORTEX LATTICE AERODYNAMIC COMPUTATION
      C
            REWIND 25
            READ (25) ROT,M,BETA,PTEST,QTEST,TBLSCW,Q,PN,PV,S,PSI,PHI,ZH,NSSW,
           1TWIST,CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,RTCDHT,CONFIG,NSSWSV,MS
           2V,KBOT,PLAN,IPLAN,MACH,SSWWA,CHORD,XTE,KBIT,TSPAN,TSPANA,XCFW,XCFT
           3,IFLAG,YREG(1,1),YREG(1,2),NLLINE,NTOT,NBRK,LSEG,YJ,Z,PJ,SCWJK,JFL
           4AG,CRBM,VBORD,XPREF,PCTX,PCTZ,NZS,JCTL,JSLP
      C
      C
            WINGTL = 6LWINGTL
            RECALL = 6HRECALL
      C
      C
            CALL OVERLAY (WINGTL,1,0,RECALL)
      C
            CALL OVERLAY (WINGTL,2,0,RECALL)
            STOP
            READ (5)
            READ (5,10)
            WRITE (6,10)
      C
         10 FORMAT (1X)
            END
```

SUBROUTINE FILUP

```
SUBROUTINE FTLUP      74/74    OPT=1 STATIC                    FTN 4.7+485        81/01/27. 13.38.34        PAGE     1

                SUBROUTINE FTLUP (X,Y,M,N,VARI,VARD)
          C     ***DOCUMENT DATE 09-12-69     SUBROUTINE REVISED 07-07-69 *********
          C        MODIFICATION OF LIBRARY INTERPOLATION SUBROUTINE  FTLUP
                DIMENSION  VARI(1), VARD(1), V(3), YY(2)
                DIMENSION  II(43)
          C
          C      INITIALIZE ALL INTERVAL POINTERS TO -1.0   FOR MONOTONICITY CHECK
                DATA  (II(J),J=1,43)/43*-1/
                MA = IABS(M)
          C
          C             ASSIGN INTERVAL POINTER FOR GIVEN VARI TABLE
          C      THE SAME POINTER WILL BE USED ON A GIVEN VARI TABLE EVERY TIME
                LI = MOD(LOCF(VARI(1)),43) + 1
                I = II(LI)
                IF (I .GE. 0) GO TO 60
                IF (N .LT. 2) GO TO 60
          C
          C     MONOTONICITY CHECK
                IF (VARI(2) - VARI(1)) 20,20,40
          C     ERROR IN MONOTONICITY
             10 K = LOCF(VARI(1))
                PRINT 170, J,K,(VARI(J),J = 1,N),(VARD(J),J = 1,N)
                STOP
          C     MONOTONIC DECREASING
             20 DO 30 J = 2,N
                IF (VARI(J) - VARI(J - 1)) 30,10,10
             30 CONTINUE
                GO TO 60
          C     MONOTONIC INCREASING
             40 DO 50 J = 2,N
                IF (VARI(J) - VARI(J - 1)) 10,10,50
             50 CONTINUE
          C
          C     INTERPOLATION
             60 IF (I .LE. 0) I = 1
                IF (I .GE. N) I = N - 1
                IF (N .LE. 1) GO TO 70
                IF (MA .NE. 0) GO TO 80
          C     ZERO ORDER
             70 Y = VARD(1)
                GO TO 160
          C     LOCATE I INTERVAL  (X(I).LE.X.LT.X(I+1))
```

(cont'd)

SUBROUTINE FILUP (Concluded)

```
SUBROUTINE FILUP       74/74    OPT=1 STATIC                  FTN 4.7+485        81/01/27. 13.38.34        PAGE     2

            80 IF ((VARI(I) - X) * (VARI(I + 1) - X)) 110,110,90
         C     IN GIVES DIRECTION FOR SEARCH OF INTERVALS
            90 IN = SIGN(1.0,(VARI(I + 1) - VARI(I)) * (X - VARI(I)))
         C     IF X OUTSIDE ENDPOINTS, EXTRAPOLATE FROM END INTERVAL
           100 IF ((I + IN) .LE. 0) GO TO 110
               IF ((I + IN) .GE. N) GO TO 110
               I = I + IN
               IF ((VARI(I) - X) * (VARI(I + 1) - X)) 110,110,100
           110 IF (MA .EQ. 2) GO TO 120
         C
         C     FIRST ORDER
               Y = (VARD(I) * (VARI(I + 1) - X) - VARD(I + 1) * (VARI(I) - X)) /
              1(VARI(I + 1) - VARI(I))
               GO TO 160
         C
         C     SECOND ORDER
           120 IF (N .EQ. 2) GO TO 10
               IF (I .EQ. (N - 1)) GO TO 140
               IF (I .EQ. 1) GO TO 130
         C     PICK THIRD POINT
               SK = VARI(I + 1) - VARI(I)
               IF ((SK * (X - VARI(I - 1))) .LT. (SK * (VARI(I + 2) - X))) GO TO
              1140
           130 L = I
               GO TO 150
           140 L = I - 1
           150 V(1) = VARI(L) - X
               V(2) = VARI(L + 1) - X
               V(3) = VARI(L + 2) - X
               YY(1) = (VARD(L) * V(2) - VARD(L + 1) * V(1)) / (VARI(L + 1) - VAR
              1I(L))
               YY(2) = (VARD(L + 1) * V(3) - VARD(L + 2) * V(2)) / (VARI(L + 2) -
              1 VARI(L + 1))
               Y = (YY(1) * V(3) - YY(2) * V(1)) / (VARI(L + 2) - VARI(L))
           160 II(LI) = I
               RETURN
         C
         C
         C
           170 FORMAT (1H1,50H TABLE BELOW OUT OF ORDER FOR FTLUP  AT POSITION  ,
              1I5,/31H X TABLE IS STORED IN LOCATION ,O6,//(8G15.8))
               END
```

(Cont'd)

SUBROUTINE SIMEQ


```
      SUBROUTINE SIMEQ (A,N,B,M,DETERM,IPIVOT,NMAX,ISCALE)
C     SOLUTION OF SIMULTANEOUS LINEAR.EQUATIONS
C     *** DOCUMENT DATE 08-01-68   SUBROUTINE REVISED 08-01-68 *********
C
      DIMENSION  IPIVOT(N), A(NMAX,N), B(NMAX,M)
      EQUIVALENCE (IROW,JROW), (ICOLUM,JCOLUM), (AMAX,T,SWAP)
C
C     INITIALIZATION
C
   10 ISCALE = 0
      R1 = 10.0 ** 100
      R2 = 1.0 / R1
      DETERM = 1.0
      DO 20 J = 1,N
   20 IPIVOT(J) = 0
      DO 380 I = 1,N
C
C     SEARCH FOR PIVOT ELEMENT
C
      AMAX = 0.0
      DO 70 J = 1,N
      IF (IPIVOT(J) - 1) 30,70,30
   30 DO 60 K = 1,N
      IF (IPIVOT(K) - 1) 40,60,390
   40 IF (ABS(AMAX) - ABS(A(J,K))) 50,60,60
   50 IROW = J
      ICOLUM = K
      AMAX = A(J,K)
   60 CONTINUE
   70 CONTINUE
      IF (AMAX) 90,80,90
   80 DETERM = 0.0
      ISCALE = 0
      GO TO 390
   90 IPIVOT(ICOLUM) = IPIVOT(ICOLUM) + 1
C
C     INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL
C
      IF (IROW - ICOLUM) 100,140,100
  100 DETERM = -DETERM
      DO 110 L = 1,N
      SWAP = A(IROW,L)
```

(Cont'd)

SUBROUTINE SIMEQ (Continued)

```
SUBROUTINE SIMEQ      74/74   OPT=1 STATIC                  FTN 4.7+485        81/01/27. 13.38.34        PAGE      2

                  A(IROW,L) = A(ICOLUM,L)
              110 A(ICOLUM,L) = SWAP
                  IF (M) 140,140,120
              120 DO 130 L = 1,M
                  SWAP = B(IROW,L)
                  B(IROW,L) = B(ICOLUM,L)
              130 B(ICOLUM,L) = SWAP
              140 PIVOT = A(ICOLUM,ICOLUM)
                  IF (PIVOT) 150,80,150
            C
            C     SCALE THE DETERMINANT
            C
              150 PIVOTI = PIVOT
                  IF (ABS(DETERM) - R1) 180,160,160
              160 DETERM = DETERM / R1
                  ISCALE = ISCALE + 1
                  IF (ABS(DETERM) - R1) 210,170,170
              170 DETERM = DETERM / R1
                  ISCALE = ISCALE + 1
                  GO TO 210
              180 IF (ABS(DETERM) - R2) 190,190,210
              190 DETERM = DETERM * R1
                  ISCALE = ISCALE - 1
                  IF (ABS(DETERM) - R2) 200,200,210
              200 DETERM = DETERM * R1
                  ISCALE = ISCALE - 1
              210 IF (ABS(PIVOTI) - R1) 240,220,220
              220 PIVOTI = PIVOTI / R1
                  ISCALE = ISCALE + 1
                  IF (ABS(PIVOTI) - R1) 270,230,230
              230 PIVOTI = PIVOTI / R1
                  ISCALE = ISCALE + 1
                  GO TO 270
              240 IF (ABS(PIVOTI) - R2) 250,250,270
              250 PIVOTI = PIVOTI * R1
                  ISCALE = ISCALE - 1
                  IF (ABS(PIVOTI) - R2) 260,260,270
              260 PIVOTI = PIVOTI * R1
                  ISCALE = ISCALE - 1
              270 DETERM = DETERM * PIVOTI
            C
            C     DIVIDE PIVOT ROW BY PIVOT ELEMENT
```

SUBROUTINE SIMEQ (Concluded)

```
      SUBROUTINE SIMEQ      74/74    OPT=1 STATIC          FTN 4.7+485        81/01/27. 13.38.34        PAGE      3

      C
            DO 290 L = 1,N
            IF (IPIVOT(L) - 1) 280,290,390
        280 A(ICOLUM,L) = A(ICOLUM,L) / PIVOT
        290 CONTINUE
            IF (M) 320,320,300
        300 DO 310 L = 1,M
        310 B(ICOLUM,L) = B(ICOLUM,L) / PIVOT
      C
      C     REDUCE NON-PIVOT ROWS
      C
        320 DO 380 L1 = 1,N
            IF (L1 - ICOLUM) 330,380,330
        330 T = A(L1,ICOLUM)
            DO 350 L = 1,N
            IF (IPIVOT(L) - 1) 340,350,390
        340 A(L1,L) = A(L1,L) - A(ICOLUM,L) * T
        350 CONTINUE
            IF (M) 380,380,360
        360 DO 370 L = 1,M
        370 B(L1,L) = B(L1,L) - B(ICOLUM,L) * T
        380 CONTINUE
        390 RETURN
            END
```

```
PROGRAM CIRCUL2     74/74    OPT=1 STATIC                   FTN 4.7+485         81/01/27. 13.38.34         PAGE       1

            OVERLAY (WINGTL,1,0)
            PROGRAM  CIRCUL2
            DIMENSION  A(53,53), CDRAG(53), IPIVOT(53), NMA(2), PPP(50), ZZH(5
           11), YB(50), YC(50), T1(53,53), T2(53,53), T3(53,53), T4(53,53), T5
           2(53,53), T6(53,53), PKK(50), XTT(51)
            DIMENSION  YINT1(50), YINT2(50), CORD1(50), CORD2(50), XT1(50), XT
           12(50), WN(2), YY(2)
            DIMENSION  CKP(51), CKM(51), CBI(50)
            DIMENSION  PERIF(10), YJK(50), ZJK(50), PJK(50), DTHETA(10), BGAM(
           151), AINT(6)
            DIMENSION  PP1(400,1), YCTR(100)
            DIMENSION CBD(53)
            COMMON  /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(400),PN(400),PV(
           1400),S(400),PSI(400),PHI(50),ZH(50),NSSW
            COMMON  /ONETHRE/ TWIST(2),CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,PT
           1CDHT(2),CONFIG,NSSWSV(2),MSV(2),KBOT,PLAN,IPLAN,MACH,SSWWA(50),XCF
           2W,XCFT,YREG(1,2),CRPM,VBORD(51),XPREF
            COMMON  /TOTHRE/ CIR(400)
            COMMON  /CCRBDD/ CHORD(50),XTE(50),KBIT,TSPAN,TSPANA
            COMMON  /COR/ CORSUM
            COMMON  /JMK/ NTOT(2),NBPK(2),LSEG(10),YJ(10),Z(10),PJ(10),SCWJK
            COMMON  /TEL/ TOL,TOL2
            COMMON  /SEG/ SJK(50)
            COMMON  /FEN/ NSPT(4),NLLINE,JFLAG
      C     THIS PROGRAM PERFORMS A TREFFTZ PLANE OPTIMIZATION
      C     TO COMPUTE THE BOUND CIRCULATION DISTRIBUTION FOR
      C     MINIMUM INDUCED DRAG FOR ONE OR TWO SYMMETRIC, INTER-
      C     ACTING SUBSONIC PLANFORMS.  AN ADVANCED-PANEL THEORY
      C     DEVELOPED IN NASA CR-3154, JUNE, 1979, IS USED.
      C
      C     THIS PROGRAM HAS BEEN WRITTEN BY DR. JOHN M. KUHLMAN,
      C     DEPT. OF MECHANICAL ENGRNG. &MECHANICS, OLD DOMINION
      C     UNIVERSITY, NORFOLK, VA. 23508.
      C     UNDER NASA GRANT NSG-1357, DR. JOHN E. LAMAR, TECH-
      C     NICAL MONITOR.
      C
      C     AN OPTIMIZATION CODE ORIGINALLY WRITTEN TO IMPLEMENT THIS
      C     THEORY HAS BEEN DESCRIBED IN A USER'S MANUAL, ODU RESEARCH
      C     FOUNDATION TECHNICAL PROGRESS REPORT DATED NOVEMBER,1979,
      C     GRANT NSG-1357 (FEDD DOC.) MODIFICATIONS AND ADDITIONS TO THIS
      C     THEORY TO ALLOW IMPLEMENTATION IN THE CURRENT DESIGN CODE
      C     HAVE BEEN DESCRIBED IN A PAPER BY J. KUHLMAN PUBLISHED
```

(cont'd)

```
PROGRAM CIRCUL2    74/74    OPT=1 STATIC                FTN 4.7+485        81/01/27. 13.38.34        PAGE      2

      C     IN THE AIAA JOURNAL OF AIRCRAFT, VOL 17, NO 9, SEPT. 1980,
      C     PP 648-655.  SIMILAR MATERIAL IS ALSO DESCRIBED IN
      C     IN ASME BOOK NUMBER G00147, TITLED "AERODYNAMICS OF TRANS-
      C     PORTATION", JUNE, 1979.
      C     A USERS MANUAL FOR THIS CODE HAS BEEN WRITTEN AND WILL BE AVAIL-
      C     ABLE SOMETIME IN THE SPRING, 1981.
      C
      C     THE THEORY ASSUMES THE UNDISTORTED WAKES TO BE BROKEN UP INTO
      C     A NUMBER OF FLAT, FINITE PANELS.  THE WAKE VORTEX SHEET
      C     STRENGTHS ARE ASSUMED TO VARY IN A PIECEWISE LINEAR FASHION
      C     ON EACH OF THESE WAKE PANELS.  ANALYTICAL EXPRESSIONS ARE
      C     DEVELOPED FOR THE INDUCED NORMAL VELOCITIES AT ANY POINT ON
      C     THE WAKE USING THE BIOT-SAVART LAW.  THESE ARE THEN USED TO
      C     WRITE AN ANALYTICAL EXPRESSION FOR THE INDUCED DRAG COEFFICIENT
      C     AND THE LIFT , PITCHING MOMENT AND WING ROOT BENDING MOMENT
      C     COEFFICIENTS.   FINALLY, ANALYTIC EXRESSIONS FOR DERIVATIVES
      C     OF EACH OF THE COEFFICIENTS IN TERMS OF THE UNKNOWN WAKE
      C     VORTEX SHEET STRENGTHS ARE USED TO OBTAIN BY A DIRECT METHOD
      C     THE WAKE VORTEX SHEET STRENGTHS FOR MINIMUM INDUCED DRAG
      C     SUBJECT TO LIFT AND EITHER A PITCHING MOMENT OR A BENDING
      C     MOMENT CONSTRAINT.  THESE WAKE STRENGTHS ARE THEN INTEGRATED
      C     TO OBTAIN THE OPTIMUM BOUND CIRCULATION, WHICH IS THEN
      C     USED IN PROGRAM 70CDETM( TAKEN FROM NASA TN D-8090) TO
      C     COMPUTE THE OPTIMUM CAMBER SHAPE AT THE DESIGN POINT.
      C
            JE = 0
            NTOTT = 0
            DO 10 I = 1,NLLINE
            JE = JE + NBRK(I)
            NTOTT = NTOTT + NTOT(I)
         10 CONTINUE
            NSV = NSSWSV(1) + NSSWSV(2)
            IF (NTOTT .LE. 50) GO TO 20
            WRITE (6,1400)
            STOP
         20 CONTINUE
            NSCWJK = IFIX(SCWJK)
      C
      C
            TOLC = (BOT * 15.E - 05) ** 2
      C
      C
```

PROGRAM CIRCUL2 (Continued)


```
      NMA(1) = NMA(2) = 0
      PI = 4. * ATAN(1.)
      RAD = 180. / PI
      BOTL = ABS(TSPAN)
      BOL = ABS(TSPANA)
      DO 30 I = 1,NSV
      KI = (I - 1) * NSCWJK + 1
      YCTR(I) = Q(KI)
   30 CONTINUE
      NTOT1 = NTOTT + 1
      NTOT3 = NTOTT + 3
      IL = NTOT1
      DO 40 I = 1,NTOT3
      CDRAG(I) = 0.
      DO 40 J = 1,NTOT3
   40 A(I,J) = 0.
      SCWMIN = 20.
      DO 50 I = 1,NSSW
   50 SCWMIN = AMIN1(SCWMIN,TPLSCW(I))
      NSCWMIN = SCWMIN
      II = 1
      NSV1 = NSSWSV(1)
      NSV2 = NSSWSV(2)
      DO 90 I = 1,IPLAN
      NSVI = NSSWSV(I)
      IC = MSV(1) + (I - 1) * MSV(2)
      ID = IC + I
      I7 = NSV1 + (I - 1) * NSV2
      YCAT = YREG(1,I)
      DO 70 J = 1,NSVI
      JJ = J + (I - 1) * NSVI
      II = II + TBLSCW(JJ)
      IE = NSVI - J + 1
      ITL = TBLSCW(I7)
      ID = ID - ITL
      IA = ID + ITL
      IF (IA .GT. IC) YCAT = YCAT - S(ID)
      IF (IA .GT. IC) GO TO 60
      YCAT = YCAT - S(ID) - S(IA)
   60 I7 = I7 - 1
      YB(IE) = YCAT
   70 CONTINUE
```

PROGRAM CIRCUL2 (Continued)


```
      DO 80 J = 1,NSV1
      JJ = J + (I - 1) * NSV1
      YC(JJ) = YB(J)
   80 CONTINUE
   90 CONTINUE
      NSPT(1) = 1
      ICT = 0
      JST = 1
      JSP = 0
      INC = 0
      ISP = 0
      NADD = 1
      NTOLD = 0
  100 CONTINUE
      ICT = ICT + 1
      IF (ICT .GT. NLLINE) GO TO 260
      NB = NBRK(ICT)
      ICP = ICT + 1
      NSPT(ICP) = NTOT(ICT) + NADD
      WRITE (6,1430) ICT
      WRITE (6,1410)
      IST = INC + 1
      ISP = ISP + NB
      DO 110 I = IST,ISP
  110 WRITE (6,1420) YJ(I),Z(I),PJ(I)
      WRITE (6,1440) NTOT(ICT)
      NBR = NBRK(ICT) - 1
      JSP = JST + NBR - 1
      DO 120 I = JST,JSP
      ITEM = JST - 1 + I
  120 WRITE (6,1450) ITEM,LSEG(I)
      DO 130 J = 1,NBR
      I = IST + J - 1
  130 PERIF(J) = SQRT((Z(I + 1) - Z(I)) ** 2 + (YJ(I + 1) - YJ(I)) ** 2)
      DTOT = 0.
      DO 140 I = 1,NBR
  140 DTOT = DTOT + PERIF(I)
      WRITE (6,1460) DTOT
      DO 170 I = 1,NBR
      IF (I .EQ. NBR) GO TO 150
      DTHETA(I) = PI / (FLOAT(LSEG(NBRK(ICT) - I - 1 + JST)))
      GO TO 160
```

PROGRAM CIRCUL2 (Continued)


```
  150 CONTINUE
      DTHETA(I) = PI / (2. * FLOAT(LSEG(NBRK(ICT) - I - 1 + JST)))
  160 CONTINUE
  170 CONTINUE
      CONST = 1. / RAD
      NBRJ = NBRK(ICT)
      DO 180 I = 1,NBRJ
      J = IST - 1 + I
  180 PJ(J) = CONST * PJ(J)
      BH = 0.5 * PERIF(NBR)
      I = NSPT(ICT)
      IF (NBR .NE. 1) GO TO 190
      SJK(I) = 0.5 * PERIF(1) * (1. - COS(DTHETA(1)))
      GO TO 200
  190 SJK(I) = 0.5 * BH * (1. - COS(DTHETA(1)))
  200 PJK(I) = PJ(ISP - 1)
      NN = 0 + NTOLD
      DO 240 I = 1,NBR
      NN = NN + LSEG(JSP + 1 - I)
      IF (I .EQ. NBR) GO TO 210
      BH = 0.5 * PERIF(NBRK(ICT) - I)
      GO TO 220
  210 CONTINUE
      BH = PERIF(NBRK(ICT) - I)
  220 CONTINUE
      LL = LSEG(JSP + 1 - I)
      DO 230 J = 1,LL
      IF (I .EQ. 1 .AND. J .EQ. 1) GO TO 230
      NM = NN - LL + J
      PJK(NM) = PJ(NBR + 1 - I + INC)
      SJK(NM) = 0.50 * BH * (COS(FLOAT(J) * DTHETA(I)) - COS(FLOAT(J - 1
     1) * DTHETA(I)))
      SJK(NM) = ABS(SJK(NM))
  230 CONTINUE
  240 CONTINUE
      NST = NSPT(ICT)
      YJK(NST) = YJ(ISP) + SJK(NST) * COS(PJK(NST))
      ZJK(NST) = Z(ISP) + SJK(NST) * SIN(PJK(NST))
      NSEG = NTOT(ICT) + NTOLD
      NST = NSPT(ICT) + 1
      DO 250 I = NST,NSEG
      YJK(I) = YJK(I - 1) + SJK(I - 1) * COS(PJK(I - 1)) + SJK(I) * COS(
```

```
     1PJK(I))
      ZJK(I) = ZJK(I - 1) + SJK(I - 1) * SIN(PJK(I - 1)) + SJK(I) * SIN(
     1PJK(I))
  250 CONTINUE
      NTOLD = NTOT(ICT)
      INC = NB
      NADD = NSPT(ICP)
      JST = JSP + 1
      GO TO 100
  260 CONTINUE
      WRITE (6,1470)
      WRITE (6,1480) (I,YJK(I),ZJK(I),PJK(I),I = 1,NTOTT)
      WRITE (6,1490)
      BSAVE = 0.
      DO 270 J = 1,JF
      BCOM = 2. * ABS(YJ(J))
      BSAVE = AMAX1(BSAVE,BCOM)
  270 CONTINUE
      WRITE (6,1500) (I,SJK(I),I = 1,NTOTT)
C     TOLERANCES SET HERE ARE FOR SINGULARITIES IN INTEGRALS
C     TOL IS TOLERANCE FOR ATAN INTEGRALS
C     TOL2 IS TOLERANCE FOR LOG INTEGRALS
      SMIN = SJK(1)
      DO 280 I = 1,NTOTT
      STEM = SJK(I)
  280 SMIN = AMIN1(SMIN,STEM)
      TOL = 5.E - 05 * SMIN * NSPT(2)
      TOL2 = TOL
      DO 290 I = 1,NTOT3
      DO 290 J = 1,NTOT3
      T1(I,J) = 0.
      T2(I,J) = 0.
      T3(I,J) = 0.
      T4(I,J) = 0.
      T5(I,J) = 0.
      T6(I,J) = 0.
  290 CONTINUE
      DO 300 I = 1,NTOTT
      I1 = I + 1
      DO 300 J = 1,NTOTT
      J1 = J + 1
      CALL DRACAL (I,J,YJK,ZJK,PJK,AINT)
```

```
      T1(I1,J1) = AINT(1)                                               D 253
      T2(I1,J1) = AINT(2)                                               D 254
      T3(I1,J1) = AINT(3)                                               D 255
      T4(I1,J1) = AINT(4)                                               D 256
      T5(I1,J1) = AINT(5)                                               D 257
      T6(I1,J1) = AINT(6)                                               D 258
  300 CONTINUE                                                          D 259
      DO 420 I = 1,NTOTT                                                D 260
      I1 = I + 1                                                        D 261
      DO 420 J = 1,NTOTT                                                D 262
      J1 = J + 1                                                        D 263
      A(I,J) = T3(I1,J1) - T4(I1,J1) - T5(I1,J1) + T6(I1,J1)            D 264
      DO 310 K = 1,NLLINE                                               D 265
      IC = NSPT(K)                                                      D 266
      IF (I .EQ. IC) GO TO 330                                          D 267
  310 CONTINUE                                                          D 268
      A(I,J) = A(I,J) + T3(I1 - 1,J1) - T4(I1 - 1,J1) + T5(I1 - 1,J1) - D 269
     1T6(I1 - 1,J1)                                                     D 270
      DO 320 K = 1,NLLINE                                               D 271
      JC = NSPT(K)                                                      D 272
      IF (J .EQ. JC) GO TO 350                                          D 273
  320 CONTINUE                                                          D 274
      A(I,J) = A(I,J) + T3(I1 - 1,J1 - 1) + T4(I1 - 1,J1 - 1) + T5(I1 - D 275
     1I1,J1 - 1) + T6(I1 - 1,J1 - 1)                                    D 276
  330 CONTINUE                                                          D 277
      DO 340 K = 1,NLLINE                                               D 278
      JC = NSPT(K)                                                      D 279
      IF (J .EQ. JC) GO TO 350                                          D 280
  340 CONTINUE                                                          D 281
      A(I,J) = A(I,J) + T3(I1,J1 - 1) + T4(I1,J1 - 1) - T5(I1,J1 - 1) - D 282
     1T6(I1,J1 - 1)                                                     D 283
  350 CONTINUE                                                          D 284
      A(I,J) = A(I,J) + 1.5 * SJK(I) * (T1(I1,J1) - T2(I1,J1))          D 285
      DO 360 K = 1,NLLINE                                               D 286
      JC = NSPT(K)                                                      D 287
      IF (J .EQ. JC) GO TO 370                                          D 288
  360 CONTINUE                                                          D 289
      A(I,J) = A(I,J) + 1.5 * SJK(I) * (T1(I1,J1 - 1) + T2(I1,J1 - 1))  D 290
  370 CONTINUE                                                          D 291
      DO 380 K = 1,NLLINE                                               D 292
      IC = NSPT(K)                                                      D 293
      IF (I .EQ. IC) GO TO 410                                          D 294
```

PROGRAM CIRCUL2 (Continued)


```
  380 CONTINUE
      A(I,J) = A(I,J) + .5 * SJK(I - 1) * (T1(I1 - 1,J1) - T2(I1 - 1,J1)
     1)
      DO 390 K = 1,NLLINE
      JC = NSPT(K)
      IF (J .EQ. JC) GO TO 400
  390 CONTINUE
      A(I,J) = A(I,J) + .5 * SJK(I - 1) * (T1(I1 - 1,J1 - 1) + T2(I1 - 1
     1,J1 - 1))
  400 CONTINUE
  410 CONTINUE
      A(I,J) = A(I,J) * 0.25
  420 CONTINUE
      DO 560 I = 1,NTOTT
      I1 = I + 1
      DO 430 K = 1,NLLINE
      IC = NSPT(K)
      ISP = NSPT(K + 1) - 1
      IF (I .EQ. IC) GO TO 500
  430 CONTINUE
      SCON = 0.5 * (SJK(I) + SJK(I - 1))
      TEMP = 0.
      NST = NSPT(1)
      NSTP = NSPT(2) - 1
      IF (I .LE. NSTP) GO TO 440
      NST = NSTP + 1
      NSTP = NSPT(3) - 1
  440 CONTINUE
      LL = NSPT(2)
      DO 490 J = 1,NTOTT
      J1 = J + 1
      AT = T1(I1,J1 - 1) + T2(I1,J1 - 1)
      IF (J .EQ. 1) AT = 0.0
      IF (J .EQ. LL) AT = 0.0
      TEMP = .5 * SJK(I - 1) * (T1(I1,J1) - T2(I1,J1) + AT)
      IF (I .EQ. NSTP) GO TO 480
      IS = I + 1
      DO 470 IP = IS,NSTP
      IP1 = IP + 1
      AT = 0.0
      DO 450 K = 1,NLLINE
      JC = NSPT(K)
```

PROGRAM CIRCUL2 (Continued)

```
PROGRAM CIRCUL2    74/74    OPT=1 STATIC                  FTN 4.7+485        81/01/27. 13.38.34        PAGE     9

              IF (J .EQ. JC) GO TO 460                                            D 337
          450 CONTINUE                                                            D 338
              AT = T1(IP1,J1 - 1) + T2(IP1,J1 - 1)                                D 339
          460 CONTINUE                                                            D 340
          470 TEMP = TEMP + SCON * (T1(IP1,J1) - T2(IP1,J1) + AT)                 D 341
          480 CONTINUE                                                            D 342
              A(I,J) = A(I,J) + TEMP                                              D 343
              A(I,J) = A(I,J) / SREF                                              D 344
          490 CONTINUE                                                            D 345
              GO TO 550                                                           D 346
          500 CONTINUE                                                            D 347
              SCON = .5 * SJK(I)                                                  D 348
              DO 540 J = 1,NTOTT                                                  D 349
              J1 = J + 1                                                          D 350
              TEMP = 0.                                                           D 351
              DO 530 IP = I1,ISP                                                  D 352
              IP1 = IP + 1                                                        D 353
              AT = 0.0                                                            D 354
              DO 510 K = 1,NLLINE                                                 D 355
              JC = NSPT(K)                                                        D 356
              IF (J .EQ. JC) GO TO 520                                            D 357
          510 CONTINUE                                                            D 358
              AT = T1(IP1,J1 - 1) + T2(IP1,J1 - 1)                                D 359
          520 CONTINUE                                                            D 360
              TEMP = TEMP + SCON * (T1(IP1,J1) - T2(IP1,J1) + AT)                 D 361
          530 CONTINUE                                                            D 362
              A(I,J) = A(I,J) + TEMP                                              D 363
              A(I,J) = A(I,J) / SREF                                              D 364
          540 CONTINUE                                                            D 365
          550 CONTINUE                                                            D 366
          560 CONTINUE                                                            D 367
              DO 570 I = 1,NTOTT                                                  D 368
              DO 570 J = 1,NTOTT                                                  D 369
          570 T1(I,J) = 2. * A(I,J)                                               D 370
              DO 580 I = 1,NTOTT                                                  D 371
              DO 580 J = 1,NTOTT                                                  D 372
              A(I,J) = 2. * A(I,J) + T1(J,I)                                      D 373
          580 CONTINUE                                                            D 374
        C                                                                         D 375
        C     T1(I,J) NOW HAS A MATRIX FOR CDI CALCULATION                        D 376
        C                                                                         D 377
              A(IL,IL) = 0.0                                                      D 378
```

PROGRAM CIRCUL2 (Continued)


```
          DO 610 I = 1,NTOTT                                                     D 379
          AT = 0.0                                                               D 380
          DO 590 K = 1,NLLINE                                                    D 381
          IC = NSPT(K)                                                           D 382
          IF (I .EQ. IC) GO TO 600                                               D 383
  590     CONTINUE                                                               D 384
          AT = COS(PJK(I - 1)) * SJK(I - 1) ** 2                                 D 385
  600     CONTINUE                                                               D 386
          A(IL,I) = (2. * COS(PJK(I)) * SJK(I) ** 2 + AT) * 4. / (3. * SREF)     D 387
  610     CONTINUE                                                               D 388
          ICT = 1                                                                D 389
          NST = 2                                                                D 390
          NSP = NSPT(2) - 1                                                      D 391
  620     CONTINUE                                                               D 392
          IF (ICT .GT. NLLINE) GO TO 670                                         D 393
          SUMX = 0.0                                                             D 394
          L = NSPT(ICT)                                                          D 395
          DO 630 I = NST,NSP                                                     D 396
          SUMX = SUMX + COS(PJK(I)) * SJK(I)                                     D 397
  630     CONTINUE                                                               D 398
          A(IL,L) = A(IL,L) + (4. / SREF) * SJK(L) * SUMX                        D 399
          DO 660 I = NST,NSP                                                     D 400
          SUMX = COS(PJK(I)) * SJK(I) * SJK(I - 1)                               D 401
          I1 = I + 1                                                             D 402
          IF (I .EQ. NSP) GO TO 650                                              D 403
          DO 640 J = I1,NSP                                                      D 404
          SUMX = SUMX + COS(PJK(J)) * SJK(J) * (SJK(I) + SJK(I - 1))             D 405
  640     CONTINUE                                                               D 406
  650     CONTINUE                                                               D 407
          A(IL,I) = A(IL,I) + 4. / SREF * SUMX                                   D 408
  660     CONTINUE                                                               D 409
          IF (ICT .EQ. 2) GO TO 670                                              D 410
          NST = NSP + 2                                                          D 411
          NSP = NSPT(3) - 1                                                      D 412
          ICT = ICT + 1                                                          D 413
          GO TO 620                                                              D 414
  670     CONTINUE                                                               D 415
          DO 680 I = 1,NTOTT                                                     D 416
          A(IL,I) = 2. * A(IL,I)                                                 D 417
          A(I,IL) = A(IL,I)                                                      D 418
  680     CONTINUE                                                               D 419
          CDRAG(IL) = CLDES                                                      D 420
```

```
C
C     NOW CALCULATE PITCH AND BENDING MOMENT CONSTRAINTS
C
      JCT = IL
      IF (JFLAG .EQ. 0 .OR. JFLAG .EQ. 2) GO TO 890
      JCT = JCT + 1
C
C     PITCH CONSTRAINT
C
      WRITE (6,1510)
      DO 690 J = 1,NSV1
      YINT1(J) = YCTR(J)
      XT1(J) = XTE(J)
      CORD1(J) = CHORD(J)
  690 CONTINUE
      DO 700 J = 1,NSV2
      JJ = J + NSV1
      YINT2(J) = YCTR(JJ)
      XT2(J) = XTE(JJ)
      CORD2(J) = CHORD(JJ)
  700 CONTINUE
      NSPM = NSPT(2) - 1
      DO 780 J = 1,NTOTT
      IF (J .GE. NSPT(2)) GO TO 720
      YKJ = YJK(J) - SJK(J) * COS(PJK(J))
      CALL FTLUP (YKJ,CRL, + 1,NSV1,YINT1,CORD1)
      CALL FTLUP (YKJ,XTL, + 1,NSV1,YINT1,XT1)
      NSM = NSV1 - 1
      DY = YINT1(NSV1) - YINT1(NSM)
      SLP = (XT1(NSV1) - XT1(NSM)) / DY
      SLP2 = (CORD1(NSV1) - CORD1(NSM)) / DY
      XTP = XT1(NSV1) + SLP * ABS(YINT1(NSV1))
      CRP = CORD1(NSV1) + SLP2 * ABS(YINT1(NSV1))
      IF (J .EQ. NSPM) GO TO 710
      YKJ = YJK(J) + SJK(J) * COS(PJK(J))
      CALL FTLUP (YKJ,CRP, + 1,NSV1,YINT1,CORD1)
      CALL FTLUP (YKJ,XTP, + 1,NSV1,YINT1,XT1)
  710 CONTINUE
      GO TO 740
  720 CONTINUE
      YKJ = YJK(J) - SJK(J) * COS(PJK(J))
      CALL FTLUP (YKJ,XTL, + 1,NSV2,YINT2,XT2)
```

```
      PROGRAM CIRCUL2    74/74   OPT=1 STATIC          FTN 4.7+485       81/01/27. 13.38.34       PAGE    12

            CALL FTLUP (YKJ,CRL, + 1,NSV2,YINT2,CORD2)
            NSM = NSV2 - 1
            DY = YINT2(NSV2) - YINT2(NSM)
            SLP = (XT2(NSV2) - XT2(NSM)) / DY
            SLP2 = (CORD2(NSV2) - CORD2(NSM)) / DY
            XTP = XT2(NSV2) + SLP * ABS(YINT2(NSV2))
            CRP = CORD2(NSV2) + SLP2 * ABS(YINT2(NSV2))
            IF (J .EQ. NTOTT) GO TO 730
            YKJ = YJK(J) + SJK(J) * COS(PJK(J))
            CALL FTLUP (YKJ,CRP, + 1,NSV2,YINT2,CORD2)
            CALL FTLUP (YKJ,XTP, + 1,NSV2,YINT2,XT2)
        730 CONTINUE
        740 CONTINUE
            XTEM = XCFW
            JCK = NSPT(2)
            IF (J .GE. JCK) XTEM = XCFT
            IF (XTEM .EQ. 1.) GO TO 760
            AXSUM = 0.0
            ASUM = 0.0
            DO 750 K = 1,NSCWJK
            XCK = (K - 0.75) / SCWJK
            AI = (1. - XCK) / SCWJK / (1. - XTEM)
            XI = 1. + (0.75 - K) / SCWJK
            IF (XCK .LE. XTEM) AI = 1. / SCWJK
            ASUM = ASUM + AI
            AXSUM = AXSUM + AI * XI
        750 CONTINUE
            CON = AXSUM / ASUM
            GO TO 770
        760 CONTINUE
            CON = 0.5
        770 CONTINUE
            XCP = XTP + CRP * CON
            XCL = XTL + CRL * CON
            CKP(J) = (XCL + XCP) * 0.5
            CKM(J) = (XCP - XCL) * 0.5
        780 CONTINUE
            DO 810 J = 1,NTOTT
            A(JCT,J) = SJK(J) ** 2 * (CKM(J) + 4. * CKP(J)) * COS(PJK(J)) / 3
            DO 790 K = 1,NLLINE
            JCK = NSPT(K)
            IF (J .EQ. JCK) GO TO 800
```

PROGRAM CIRCUL2 (Continued)


```
  790 CONTINUE
      A(JCT,J) = A(JCT,J) + SJK(J - 1) ** 2 * (CKM(J - 1) + 2. * CKP(J -
     1 1)) * COS(PJK(J - 1)) / 3
  800 CONTINUE
  810 CONTINUE
      STEM = 0.0
      DO 870 J = 1,NTOTT
      DO 820 K = 1,NLLINE
      JCK = NSPT(K)
      IF (J .EQ. JCK) GO TO 830
  820 CONTINUE
      STEM = SJK(J) + SJK(J - 1)
      A(JCT,J) = A(JCT,J) + 2. * COS(PJK(J)) * SJK(J) * SJK(J - 1) * CKP
     1(J)
      GO TO 840
  830 CONTINUE
      STEM = SJK(J)
  840 CONTINUE
      TEMP = 0.0
      IST = J + 1
      ISP = NTOTT
      IF (J .LE. NSPM) ISP = NSPM
      IF (J .EQ. ISP) GO TO 860
      DO 850 I = IST,ISP
      TEMP = TEMP + 2. * STEM * CKP(I) * SJK(I) * COS(PJK(I))
  850 CONTINUE
      A(JCT,J) = A(JCT,J) + TEMP
  860 CONTINUE
  870 CONTINUE
      SUMATT = 0.
      DO 880 J = 1,NTOTT
      A(JCT,J) = 4. * A(JCT,J) / (SREF * CREF)
      A(J,JCT) = A(JCT,J)
      CBD(J) = A(JCT,J)
  880 CONTINUE
      CDRAG(JCT) = 0.
  890 CONTINUE
      IF (JFLAG .EQ. 0 .OR. JFLAG .EQ. 1) GO TO 1020
      JCT = JCT + 1
C
C     ROOT BENDING CONSTRAINT
C
```

```
      DO 900 I = 1,NTOTT
      PKK(I) = PJK(I)
      PJK(I) = 0.0
  900 CONTINUE
C
      WRITE (6,1520)
      DO 960 J = 1,NTOTT
      NSTP = NTOTT
      IF (J .GE. NSPT(2)) GO TO 910
      NSTP = NSPT(2) - 1
  910 CONTINUE
      A(JCT,J) = 0.
      DO 920 K = 1,NLLINE
      JCHK = NSPT(K)
      IF (J .EQ. JCHK) GO TO 940
  920 CONTINUE
      DL = YJK(J) * COS(PJK(J)) + ZJK(J) * SIN(PJK(J))
      A(JCT,J) = 2. * SJK(J) * SJK(J - 1) * DL
      IF (J .EQ. NSTP) GO TO 960
      JJ = J + 1
      DO 930 K = JJ,NSTP
      DL = YJK(K) * COS(PJK(K)) + ZJK(K) * SIN(PJK(K))
      A(JCT,J) = A(JCT,J) + 2. * SJK(K) * DL * (SJK(J) + SJK(J - 1))
  930 CONTINUE
      GO TO 960
  940 CONTINUE
      J1 = JCHK + 1
      DL = YJK(J1) * COS(PJK(J1)) + ZJK(J1) * SIN(PJK(J1))
      A(JCT,J) = 2. * SJK(J1) * DL * SJK(JCHK)
      DO 950 K = 3,NSTP
      DL = YJK(K) * COS(PJK(K)) + ZJK(K) * SIN(PJK(K))
      A(JCT,1) = A(JCT,1) + SJK(1) * 2. * DL * SJK(K)
  950 CONTINUE
  960 CONTINUE
      DO 990 J = 1,NTOTT
      DL = YJK(J) * COS(PJK(J)) + ZJK(J) * SIN(PJK(J))
      A(JCT,J) = A(JCT,J) + SJK(J) ** 3 / 3. + 4. * SJK(J) ** 2 * DL / 3
     1.
      DO 970 K = 1,NLLINE
      JCHK = NSPT(K)
      IF (J .EQ. JCHK) GO TO 980
  970 CONTINUE
```

```
      DLM = YJK(J - 1) * COS(PJK(J - 1)) + ZJK(J - 1) * SIN(PJK(J - 1))
      A(JCT,J) = A(JCT,J) + SJK(J - 1) ** 3 / 3. + 2. * SJK(J - 1) ** 2
     1* DLM / 3.
  980 CONTINUE
      A(JCT,J) = -A(JCT,J) * 2. / (SREF * BSAVE / 2.)
  990 CONTINUE
      DO 1000 L = 1,NTOTT
 1000 CRI(L) = A(JCT,L)
      CRBM = CRBM * CLDES * 0.5 * 0.424413
      CDRAG(JCT) = CRBM
C
      DO 1010 I = 1,NTOTT
 1010 PJK(I) = PKK(I)
C
 1020 CONTINUE
      CALL SIMEQ (A,JCT,CDRAG,1,DETERM,IPIVOT,53,ISCALE)
      CDRAG(IL) = 0.
      WRITE (6,1530)
      DO 1100 I = 1,NTOTT
      WNORM = 0.
      DO 1090 J = 1,NTOTT
      SS = SJK(J)
      CALL CCAL (I,J,YJK,ZJK,PJK,SS,AA,BB,DD,FF,GG,EE,AJ,AK,RR,TT,UU,WW)
      CALL CONCAL (AA,BB,FF,GG,SS,A1,B,C,DI,F,G,CJ,CK,CL,CM,CN,CO,CP)
      IF (RR .EQ. 0.) GO TO 1030
      P = 2. * (ATAN(C / ABS(RR)) - ATAN(DI / ABS(RR))) / ABS(RR)
      GO TO 1040
 1030 CONTINUE
      P = 2. / (FF - 2. * SS) - 2. / (FF + 2. * SS)
 1040 CONTINUE
      IF (UU .EQ. 0.) GO TO 1050
      QQ = 2. * (ATAN((AJ + 2. * SS) / ABS(UU)) - ATAN((AJ - 2. * SS) /
     1ABS(UU))) / ABS(UU)
      GO TO 1060
 1050 CONTINUE
      QQ = 2. / (AJ - 2. * SS) - 2. / (AJ + 2. * SS)
 1060 CONTINUE
      Z1 = (SS * SS + FF * SS + GG) / (SS * SS - FF * SS + GG)
      Z2 = (SS * SS + AJ * SS + AK) / (SS * SS - AJ * SS + AK)
      A1IJ = (P * A1 + 0.5 * BB * ALOG(Z1)) / (2. * PI)
      A3IJ = (CL * P + 2. * BB * SS + CO * ALOG(Z1)) / (2. * SS * PI)
      CALL CONCAL (DD,EE,AJ,AK,SS,A2,B,C,DI,F,G,CJ,CK,CL,CM,CN,CO,CP)
```

```
      A2IJ = -(QQ * A2 + 0.5 * FE * ALOG(Z2)) / (2. * PI)
      A4IJ = -(CL * QQ + 2. * FE * SS + CO * ALOG(Z2)) / (2. * SS * PI)
      DO 1070 K = 1,NLLINE
      KK = K + 1
      KCHK = NSPT(KK) - 1
      IF (J .EQ. KCHK) GO TO 1080
 1070 CONTINUE
      WNORM = WNORM + .5 * (CDRAG(J + 1) + CDRAG(J)) * (A1IJ + A2IJ) + 0
     1.5 * (CDRAG(J + 1) - CDRAG(J)) * (A3IJ + A4IJ)
      GO TO 1090
 1080 CONTINUE
      WNORM = WNORM + 0.5 * CDRAG(J) * (A1IJ + A2IJ - A3IJ - A4IJ)
 1090 CONTINUE
C     WASH AT WING IS 0.5 WASH AT MINUS INFINITY
      WNORM = WNORM / 2.
      WOP = WNORM / COS(PJK(I))
      WRITE (6,1540) I,WNORM,WOP
 1100 CONTINUE
      DO 1110 I = 1,NTOTT
      CALL GAMCAL (I,IL,SJK,CDRAG,BGAMO)
      BGAM(I) = BGAMO
 1110 CONTINUE
      BGAM(IL) = BGAM(NTOTT) + CDRAG(NTOTT) * SJK(NTOTT)
      WRITE (6,1560)
      DO 1140 I = 1,IL
      IF (I .EQ. IL) GO TO 1120
      ETA = 2. * ( - YJK(I) + SJK(I) * COS(PJK(I))) / BSAVE
      GO TO 1130
 1120 CONTINUE
      ETA = 0.
 1130 CONTINUE
      WRITE (6,1550) I,BGAM(I),CDRAG(I),ETA
 1140 CONTINUE
C
C     COMPUTE FARFIELD CM
C
      IF (JFLAG .NE. 1) GO TO 1160
      SUMATT = 0.
      DO 1150 J = 1,NTOTT
      SUMATT = SUMATT + CRD(J) * CDRAG(J)
 1150 CONTINUE
 1160 CONTINUE
```

```
      CD = 0.
C
C     CALCULATE CDI USING T1, WHICH IS DRAG MATRIX
C
      DO 1180 I = 1,NTOTT
      CDI = 0.0
      DO 1170 J = 1,NTOTT
      CDI = CDI + T1(I,J) * CDRAG(J)
 1170 CONTINUE
      CD = CD + CDI * CDRAG(I)
 1180 CONTINUE
      WRITE (6,1570) CD
      IF (JFLAG .NE. 2) GO TO 1200
      CB = 0.
      DO 1190 J = 1,NTOTT
 1190 CB = CB + CBI(J) * CDRAG(J)
      WRITE (6,1580) CB
 1200 CONTINUE
C
C     NOW MUST INTERPOLATE TO GET BOUND CIRCLATIONS FOR VLM GEOM
C
      PJK(IL) = PJK(NTOTT)
      JS = 0
C     WRITE (6,159)
      DO 1290 I = 1,IPLAN
      NTO = NTOT(I)
      NTO1 = NTO + 1
      XTEM = XCFW
      IF (I .EQ. 2) XTEM = XCFT
      ASUM = 0.
      IF (XTEM .EQ. 1.) GO TO 1220
      DO 1210 K = 1,NSCWJK
      XCK = (K - .75) / SCWJK
      AI = (1. - XCK) / (SCWJK * (1. - XTEM))
      IF (XCK .LE. XTEM) AI = 1. / SCWJK
      ASUM = ASUM + AI
 1210 CONTINUE
      GO TO 1230
 1220 CONTINUE
      ASUM = 1.
 1230 CONTINUE
      DO 1240 L = 1,NTO
```

```
              J = L + JS
              ZZH(L) = YJK(J) - SJK(J) * COS(PJK(J))
              XTT(L) = RGAM(J) / SCWJK
         1240 CONTINUE
              IF (I .EQ. 1) GO TO 1250
              ZZH(NTO1) = 0.
              XTT(NTO1) = RGAM(IL) / SCWJK
C             WRITE (6,161)
              GO TO 1260
         1250 CONTINUE
              ZZH(NTO1) = 0.0
              XTT(NTO1) = (RGAM(NTO) + CDRAG(NTO) * SJK(NTO)) / SCWJK
         1260 CONTINUE
              DO 1270 K = 1,NTO1
C             WRITE (6,163) K,ZZH(K),XTT(K)
         1270 CONTINUE
              NSVI = NSSWSV(I)
              DO 1280 J = 1,NSVI
              JJ = J + (I - 1) * NSSWSV(1)
              JK = 1 + (JJ - 1) * (IFIX(SCWJK))
              CALL FTLUP (Q(JK),PP1(JJ,1), + 1,NTO1,ZZH,XTT)
              PPP(JJ) = PP1(JJ,1) / ASUM
         1280 CONTINUE
              JS = NTO1 - 1
         1290 CONTINUE
              JK = 0
C
C             CALCULATIONS OF NORMAL WASH AND NWSH/COS(PHI)
C
              NSVTOT = NSV1 + NSV2
              DO 1300 I = 1,NSVTOT
              K = 1 + (I - 1) * NSCWJK
         1300 CONTINUE
C             WRITE(6,153)
              DO 1340 I = 1,NSVTOT
              WNORM = 0.
              K = 1 + (I - 1) * NSCWJK
              RPHI = ATAN(PHI(I))
              DO 1330 J = 1,NSVTOT
              L = 1 + (J - 1) * NSCWJK
              SPHI = ATAN(PHI(J))
              YY(1) = Q(K) - Q(L)
```

```
      YY(2) = Q(K) + Q(L)
      ZZ = ZH(I) - ZH(J)
      SNN = S(L)
      DO 1320 KK = 1,2
      DSIGN = 1.
      FSIGN = 1.
      IF (KK .EQ. 2) GO TO 1310
      IF (YY(1) .LT. TOLC) FSIGN = -1.
      IF (YY(1) .LT. ( - TOLC)) DSIGN = -1.
 1310 YYY = YY(KK)
      CALL DRAGSUB (RPHI,SPHI,YYY,ZZ,SNN,DSIGN,FSIGN,WNK)
      WN(KK) = WNK
      SPHI = -SPHI
 1320 CONTINUE
      WNORM = WNORM + PP1(J,1) * (WN(1) - WN(2)) * SCWJK
 1330 CONTINUE
      WNORM = WNORM / (2. * PI) / 2.
      WOP = WNORM / (COS(RPHI))
C     WRITE (6,154) I,WNORM,WOP
 1340 CONTINUE
      DO 1360 I = 1,IPLAN
      KA = 1 + (I - 1) * NSSWSV(1)
      KB = NSSWSV(1) + (I - 1) * NSSWSV(2)
      D = XCFW
      IF (I .EQ. 2) D = XCFT
      DO 1350 J = KA,KB
      NSCW = TBLSCW(J)
      AI = NSCW * D + 0.75
      IMAX = INT(AI)
      DO 1350 K = 1,NSCW
      JK = JK + 1
      E = 1.
      IF (K .GT. IMAX) E = (1. - (K - .75) / NSCW) / (1. - D)
      CIR(JK) = PPP(J) * E
 1350 CONTINUE
 1360 CONTINUE
      WRITE (6,1630) CLDES
      NR = 0
      DO 1370 NV = 1,NSSW
      NSCW = TBLSCW(NV)
      NP = NR + 1
      NR = NR + NSCW
```

```
      PHIPR = ATAN(PHI(NV)) * RAD
      IF (NV .EQ. (NSSWSV(1) + 1)) WRITE (6,1640)
      DO 1370 I = NP,NR
      PNPR = PN(I) * BETA
      PVPR = PV(I) * BETA
      PSIPR = ATAN(BETA * TAN(PSI(I))) * RAD
      WRITE (6,1650) PNPR,PVPR,Q(I),ZH(NV),S(I),PSIPR,PHIPR,CIR(I)
 1370 CONTINUE
      WRITE (6,1610)
      WRITE (6,1620) CREF,CAVE,STRUE,SREF,BOT,AR,ARTRUE,MACH
      WRITE (6,1590) XCFW
      WRITE (6,1600) XCFT
      CLTOT = CMTOT = 0.
      DO 1390 I = 1,NSSW
      IF (I .EQ. 1) WRITE (6,1670)
      IF (I .EQ. (NSSWSV(1) + 1)) WRITE (6,1680)
      SPANLD = 0.
      DO 1380 IJ = 1,NSCWMIN
      IK = (I - 1) * NSCWMIN + IJ
      SPANLD = SPANLD + 2. * CIR(IK) * COS(ATAN(PHI(I)))
      CLTOT = CLTOT + 8. * S(IK) * CIR(IK) / SREF * COS(ATAN(PHI(I)))
      CMTOT = CMTOT + 8. * S(IK) * CIR(IK) * PN(IK) * BETA * COS(ATAN(PH
     1I(I))) / (SREF * CREF)
 1380 CONTINUE
      WRITE (6,1700) Q(IK),SPANLD
      IF (I .EQ. NSSWSV(1)) CL1 = CLTOT
      IF (I .EQ. NSSWSV(1)) CM1 = CMTOT
      IF (I .EQ. NSSWSV(1)) WRITE (6,1690) CL1,CM1
      IF (I .EQ. NSSW .AND. IPLAN .EQ. 2) CL2 = CLTOT - CL1
      IF (I .EQ. NSSW .AND. IPLAN .EQ. 2) CM2 = CMTOT - CM1
      IF (I .EQ. NSSW .AND. IPLAN .EQ. 2) WRITE (6,1690) CL2,CM2
 1390 CONTINUE
C
      IF (JFLAG .EQ. 1.) CMTOT = SUMATT
      WRITE (6,1660) CLDES,CLTOT,CMTOT,CD
C
C     162 FORMAT(35X,46HDATA USED TO INTERPOLATE BACK TO VLMC GEOMETRY//2
C     5X, 1HY,10X,5HGAMMA/)
C
 1400 FORMAT (//25X,39HTOTAL NO WAKE SEGMENTS ABOVE MAX OF 50/)
 1410 FORMAT (///35X,13HWAKE GEOMETRY///32X,1HY,12X,1HZ,10X,3HPHI//)
 1420 FORMAT (28X,3F11.5)
```

PROGRAM CIRCUL2 (Concluded)

```
PROGRAM CIRCUL2    74/74    OPT=1 STATIC                    FTN 4.7+485        81/01/27. 13.38.34        PAGE    21

      1430 FORMAT (35X,8HPLANFORM,I4)
      1440 FORMAT (//25X,33H NO OF WAKE VORTICITY SEGMENTS = ,I5/)
      1450 FORMAT (25X,30HWAKE VORTICITY SEGS ON WING SEGMENT NO,I5,1H=,I5/)
      1460 FORMAT (30X,33HTOTAL PLANFORM PERIPHERAL LENGTH=,F15.5/)
      1470 FORMAT (/20X,8HSEGMT NO,10X,1HY,15X,1HZ,15X,3HPHI/)
      1480 FORMAT (25X,I5,3F15.6)
      1490 FORMAT (/25X,1HI,5X,6HSNN(I)/)
      1500 FORMAT (25X,I5,F12.5)
      1510 FORMAT (/25X,23HPITCH CONSTRAINT ACTIVE/)
      1520 FORMAT (/25X,32HBENDING MOMENT CONSTRAINT ACTIVE)
      1530 FORMAT (//33X,1HI,7X,8HDOWNWASH,7X,10HW/COS(PHI)/)
      1540 FORMAT (30X,I5,2F15.5)
      1550 FORMAT (20X,I5,4E13.5)
      1560 FORMAT (//21X,5HSEGMT,3X,10HBOUND CIRC,2X,10HSHED STRTH,7X,3HETA//
     1)
      1570 FORMAT (///25X,63HCD CALCULATED USING DIRECT OPTIMIZATION LINEAR S
     1HSHEET DIST =  ,F15.5/)
      1580 FORMAT (//25X,66HCB CALAULATED USING DIRECT OPTIMIZATION LINEAR SH
     1 ED SHEET DIST = ,E15.5/)
      1590 FORMAT (///70X,5HA1 = ,F10.5/)
      1600 FORMAT (//70X,5HA2 = ,F10.5/)
      1610 FORMAT (////4X,11H REF. CHORD,6X,25HC AVERAGE      TRUE AREA  ,2X,1
     14HREFERENCE AREA,9X,3HB/2,8X,7HREF. AR,8X,7HTRUE AR,4X,11HMACH NUM
     2BER/)
      1620 FORMAT (8F15.5)
      1630 FORMAT (1H1,///25X,1HX11X,1HX,11X,1HY,11X,1HZ,12X,1HS,5X,9HC/4 SWE
     1EP,4X,8HDIHEDRAL,3X,10HGAMMA/U AT/24X,3HC/4,9X,4H3C/4,42X,5HANGLE,
     27X,5HANGLE,4X,6HCLDES=,F7.4/)
      1640 FORMAT (/45X,45HSECOND PLANFORM HORSESHOE VORTEX DESCRIPTIONS/)
      1650 FORMAT (17X,8F12.5)
      1660 FORMAT (/////15X,11HCL DESIGN =,F10.6,5X,12HCL COMPUTED=,F10.6,5X,
     112HCM COMPUTED=,E10.3,5X,5HCD V=,F10.6)
      1670 FORMAT (////40X,56HF I R S T    P L A N F O R M    S P A N    L O
     1A D I N G//60X,1HY,11X,4HCL*C)
      1680 FORMAT (////40X,58HS E C O N D    P L A N F O R M    S P A N    L
     1O A D I N G//60X,1HY,11X,4HCL*C)
      1690 FORMAT (//50X,30HCL DEVELOPED ON THIS PLANFORM=,F10.6/50X,30HCM DE
     1VELOPED ON THIS PLANFORM=,F10.6)
      1700 FORMAT (55XF10.5,3XF10.5)
           END
```

SUBROUTINE GAMCAL


```
      SUBROUTINE GAMCAL (I,IL,SNN,AOPT,BGAM0)
C
C     CALCULATE BOUND CIRCULATION AT LEFT END PT OF SEGMENT I,BGAM
C     AOPT LAST COLUMN CONTAINS ARRAY OF OPTIMIZED SHED SHEET STRENGTHS
C
      COMMON  /FEN/ NSPT(4),NLLINE
      DIMENSION  SNN(1), AOPT(1)
      BGAM0 = 0.
      DO 10 K = 1,NLLINE
      KK = NLLINE - K + 1
      KCHK = NSPT(KK)
      IF (I .EQ. KCHK) GO TO 40
      IF (I .GT. KCHK) GO TO 20
   10 CONTINUE
   20 CONTINUE
      BGAM0 = AOPT(KCHK) * SNN(KCHK) + AOPT(I) * SNN(I - 1)
      KCHK1 = KCHK + 1
      IF (I .EQ. KCHK1) GO TO 50
      IM = I - 1
      IP = KCHK + 1
      DO 30 J = IP,IM
      BGAM0 = BGAM0 + AOPT(J) * (SNN(J - 1) + SNN(J))
   30 CONTINUE
      GO TO 50
   40 BGAM0 = 0.
   50 CONTINUE
      RETURN
      END
```

SUBROUTINE DRAGSUB

```
SUBROUTINE DRAGSUB    74/74   OPT=1 STATIC            FTN 4.7+485        81/01/27. 13.38.34        PAGE     1

      SUBROUTINE DRAGSUB (R,A,Y,Z,S,IS,JS,WNK)
      REAL  IS,JS
      ZP = Z + S * SIN(A)
      YP = Y + S * COS(A)
      ZM = Z - SIN(A) * S
      YM = Y - S * COS(A)
      RL = SQRT(ZP ** 2 + YP ** 2)
      RR = SQRT(ZM ** 2 + YM ** 2)
      ZPOYP = ZP / YP
      ZMOYM = ZM / YM
      PHILTLJ = ATAN(ZPOYP)
      PHIRTLJ = ATAN(ZMOYM)
      PLMPI = PHILTLJ - R
      PRMPI = PHIRTLJ - R
      COSPLI = COS(PLMPI)
      COSPRI = COS(PRMPI)
      WNK = IS * COSPLI / RL - JS * COSPRI / RR
      RETURN
      END
```

SUBROUTINE DRACAL

```
SUBROUTINE DRACAL      74/74    OPT=1 STATIC                 FTN 4.7+485        81/01/27. 13.38.34        PAGE      1

                    SUBROUTINE DRACAL (I,J,YHH,ZHH,PPP,AINT)
              C
              C     SUBROUTINE DRACAL
              C
              C     TREFFTZ PLANE DRAG ANALYSIS ASSUMES PIECEWISE LINEARLY VARYING
              C     SHED VORTICITY SHEET STRENGTH
              C
              C     CALCULATE INTEGRALS A THROUGH F FOR DRAG COEF CALCULATION
              C
              C     CALLS SUBROUTINES LOGS,SNTAN,CCAL,CONCAL
              C
                    DIMENSION  AINT(6)
                    DIMENSION  YHH(1), ZHH(1), PPP(1)
                    COMMON  /SEG/ SNN(50)
                    PI = 4. * ATAN(1.)
                    S = SNN(J)
                    CALL CCAL (I,J,YHH,ZHH,PPP,S,AA,BB,DD,FF,GG,EE,AJ,AK,RR,TT,UU,WW)
                    CALL CONCAL (AA,BB,FF,GG,S,A,B,C,D,F,G,CJ,CK,CL,CM,CN,CO,CP,1)
                    S = SNN(I)
                    CALL LOGS (S,CJ,F,RELN,RESLN,RES2LN,RES3LN)
                    CALL SNTAN (S,C,BB,RR,TT,RTAN,RSTAN,RS2TAN,RS3TAN,RS4TAN)
                    AAAAAA = A * RTAN + B * RSTAN + BB * RELN / 4
                    BBBBBB = 2. * (CL * RTAN + CM * RSTAN + CN * RS2TAN) + CO * RELN +
                   1 CP * RESLN
                    CCCCCC = A * RSTAN + B * RS2TAN + BB * RESLN / 4
                    DDDDDD = 2. * (CL * RSTAN + CM * RS2TAN + CN * RS3TAN) + CO * RESL
                   1N + CP * RES2LN
                    EEEEEE = A * RS2TAN + B * RS3TAN + BB * RES2LN / 4
                    FFFFFF = 2. * (CL * RS2TAN + CM * RS3TAN + CN * RS4TAN) + CO * RES
                   12LN + CP * RES3LN
                    CALL LOGS (S,CK,G,RELN,RESLN,RES2LN,RES3LN)
                    CALL SNTAN (S,D,BB,RR,TT,RTAN,RSTAN,RS2TAN,RS3TAN,RS4TAN)
                    AAAAAA = AAAAAA - A * RTAN - B * RSTAN - BB * RELN / 4
                    BBBBBB = BBBBBB - 2. * (CL * RTAN + CM * RSTAN + CN * RS2TAN) - CO
                   1 * RELN -.CP * RESLN
                    CCCCCC = CCCCCC - A * RSTAN - B * RS2TAN - BB * RESLN / 4
                    DDDDDD = DDDDDD - 2. * (CL * RSTAN + CM * RS2TAN + CN * RS3TAN) -
                   1CO * RESLN - CP * RES2LN
                    EEEEEE = EEEEEE - A * RS2TAN - B * RS3TAN - BB * RES2LN / 4
                    FFFFFF = FFFFFF - 2. * (CL * RS2TAN + CM * RS3TAN + CN * RS4TAN) -
                   1 CO * RES2LN - CP * RES3LN
                    S = SNN(J)
```

(cont'd)

SUBROUTINE DRACAL (Concluded)


```
      CALL CONCAL (DD,EE,AJ,AK,S,A,B,C,D,F,G,CJ,CK,CL,CM,CN,CO,CP,2)       G  43
      S = SNN(I)                                                           G  44
      CALL LOGS (S,CJ,F,RELN,RESLN,RES2LN,RES3LN)                          G  45
      CALL SNTAN (S,C,FE,UU,WW,RTAN,RSTAN,RS2TAN,RS3TAN,RS4TAN)            G  46
      AAAAAA = AAAAAA - A * RTAN - B * RSTAN - EE * RELN / 4               G  47
      BBBBBB = BBBBBB - 2. * (CL * RTAN + CM * RSTAN + CN * RS2TAN) - CO   G  48
     1 * RELN - CP * RESLN                                                 G  49
      CCCCCC = CCCCCC - A * RSTAN - B * RS2TAN - EE * RESLN / 4            G  50
      DDDDDD = DDDDDD - 2. * (CL * RSTAN + CM * RS2TAN + CN * RS3TAN) -    G  51
     1CO * RESLN - CP * RES2LN                                             G  52
      EEEEEE = EEEEEE - A * RS2TAN - B * RS3TAN - EE * RES2LN / 4          G  53
      FFFFFF = FFFFFF - 2. * (CL * RS2TAN + CM * RS3TAN + CN * RS4TAN) -   G  54
     1 CO * RES2LN - CP * RES3LN                                           G  55
      CALL LOGS (S,CK,G,RELN,RESLN,RES2LN,RES3LN)                          G  56
      CALL SNTAN (S,D,FE,UU,WW,RTAN,RSTAN,RS2TAN,RS3TAN,RS4TAN)            G  57
      AAAAAA = AAAAAA + A * RTAN + B * RSTAN + EE * RELN / 4               G  58
      BBBBBB = BBBBBB + 2. * (CL * RTAN + CM * RSTAN + CN * RS2TAN) + CO   G  59
     1 * RELN + CP * RESLN                                                 G  60
      CCCCCC = CCCCCC + A * RSTAN + B * RS2TAN + EE * RESLN / 4            G  61
      DDDDDD = DDDDDD + 2. * (CL * RSTAN + CM * RS2TAN + CN * RS3TAN) +    G  62
     1CO * RESLN + CP * RES2LN                                             G  63
      EEEEEE = EEEEEE + A * RS2TAN + B * RS3TAN + EE * RES2LN / 4          G  64
      FFFFFF = FFFFFF + 2. * (CL * RS2TAN + CM * RS3TAN + CN * RS4TAN) +   G  65
     1 CO * RES2LN + CP * RES3LN                                           G  66
      SK = SNN(J)                                                          G  67
      AAAAAA = AAAAAA / PI                                                 G  68
      BBBBBB = BBBBBB / (2. * PI * SK) + (2. * S / PI) * (BB - EE)         G  69
      CCCCCC = CCCCCC / PI                                                 G  70
      DDDDDD = DDDDDD / (2. * PI * SK)                                     G  71
      EEEEEE = EEEEEE / (2 * PI * S)                                       G  72
      FFFFFF = FFFFFF / (4. * PI * S * SK) + (BB - EE) * S * S / (3 * PI   G  73
     1)                                                                    G  74
      AINT(1) = AAAAAA                                                     G  75
      AINT(2) = BBBBBB                                                     G  76
      AINT(3) = CCCCCC                                                     G  77
      AINT(4) = DDDDDD                                                     G  78
      AINT(5) = EEEEEE                                                     G  79
      AINT(6) = FFFFFF                                                     G  80
      RETURN                                                               G  81
      END                                                                  G  82-
```

SUBROUTINE CCAL


```
      SUBROUTINE CCAL (I,J,YHH,ZHH,PPP,S,AA,BB,DD,FF,GG,EE,JJ,KK,RR,TT,U
     1U,WW)
C
C     SUBROUTINE CCAL
C
C     CALCULATES GEOMETRICAL CONSTANTS NEEDED IN EVALUATION OF INTEGRALS
C     FOR VARYING I AND J VALUES
C
      REAL  JJ,KK
      DIMENSION  YHH(1), ZHH(1), PPP(1)
      DYIJ = YHH(I) - YHH(J)
      DZIJ = ZHH(I) - ZHH(J)
      COI = COS(PPP(I))
      SII = SIN(PPP(I))
      COJ = COS(PPP(J))
      SIJ = SIN(PPP(J))
      AA = DYIJ * COI + DZIJ * SII
      BB = -COS(PPP(J) - PPP(I))
      FF = -2 * (DYIJ * COJ + DZIJ * SIJ)
      GG = DYIJ * DYIJ + DZIJ * DZIJ
      DYIJP = YHH(I) + YHH(J)
      DZIJP = DZIJ
      DD = DYIJP * COI + DZIJP * SII
      EE = COS(PPP(J) + PPP(I))
      JJ = 2. * (DYIJP * COJ - DZIJP * SIJ)
      KK = DYIJP * DYIJP + DZIJP * DZIJP
      RR = 2 * (DYIJ * SIJ - DZIJ * COJ)
      TT = 2 * SIN(PPP(J) - PPP(I))
      UU = 2. * (DYIJP * SIJ + DZIJP * COJ)
      WW = 2. * SIN(PPP(J) + PPP(I))
      RETURN
      END
```

SUBROUTINE CONCAL

```
SUBROUTINE CONCAL      74/74    OPT=1 STATIC                    FTN 4.7+485        81/01/27. 13.38.34        PAGE      1

      SUBROUTINE CONCAL (AA,BB,FF,GG,S,A,B,C,D,F,G,J,K,L,M,N,O,P)
C
C     SUBROUTINE CONCAL
C
C     CALCULATES GEOMETRICAL CONSTANTS NEEDED IN EVALUATION OF INTEGRALS
C
      REAL  J,K,L,M,N
      A = AA - 0.5 * BB * FF
      B = 1. - BB * BB
      C = FF + 2. * S
      D = FF - 2. * S
      F = S * S + S * FF + GG
      G = S * S - S * FF + GG
      J = 2. * (AA + S * BB)
      K = 2. * (AA - S * BB)
      L = 0.5 * (BB * FF * FF - AA * FF - 2. * BB * GG)
      M = 0.5 * ( - FF - 6. * AA * BB + 4. * FF * BB * BB)
      N = 2. * (BB * BB - 1.) * BB
      O = 0.5 * (AA - FF * BB)
      P = 0.5 * (1. - 2. * BB * BB)
      RETURN
      END
```

SUBROUTINE SNTAN


```
      SUBROUTINE SNTAN (S,C,BB,RR,TT,RTAN,RSTAN,RS2TAN,RS3TAN,RS4TAN)
C
C     SUBROUTINE SNTAN
C
C     EVALUATES INTEGRALS OF THE FORM S**N*ATAN((C+2*BB*S)/(RR+S*TT))
C     ALL DIVIDED BY (RR+S*TT)
C     WITH RESPECT TO S BETWEEN LIMITS OF -S AND S FOR N=0,1,2,3.
C
C     ATAN PART OF INTEGRAND APPROXIMATED AS A QUADRATIC IN S WHICH IS
C     FORCED THROUGH ATAN VALUES AT -S,0,AND S.
C
C     A,C ARE CALCULATED IN SUBROUTINE CONCAL
C     BB,RR,TT ARE CALCULATED IN SUBROUTINE CCAL
C
C     RESULTS ARE RTAN,RSTAN,RS2TAN,RS3TAN
C     APPROXIMATE INTEGRAL EVALUATED USING MACSYMA PROGRAM OF MIT PROJ.
C     EVALUATION OF INTEGRALS FOR TT=0. BEGIND AT AT LABEL 10
C     SINGULAR INTEGRALS EVALUATED AT APPROXIMATE ENDPOINTS,+-SAWAY
C     MIDRANGE SINGULARITIES EXCLUDED,ATAN PART OF INT APPROX-
C     IMATED AS 2 QUADRATICS
C
      COMMON  /TEL/ TOL,TOL2
      DIMENSION  AA1(3,3), AA(3), IPIVOT(3)
      RRR = RR
      SSS = S
      CCC = C
      RTAN = 0.0
      RSTAN = 0.0
      RS2TAN = 0.0
      RS3TAN = 0.0
      RS4TAN = 0.0
      IF (TT .EQ. 0.0 .AND. ABS(RR) .LT. 1E - 08) GO TO 70
      IF (TT .EQ. 0.0 .AND. RR .EQ. 0.0) GO TO 70
      IF (TT .EQ. 0.0) GO TO 40
C
C     FIRST, CHECK FOR MIDRANGE SINGULARITIES,EXCLUDING ANY FOUND
C
      SZERO = -RR / TT
      IF (ABS(ABS(SZERO) - S) .LT. 1E - 04 .AND. ABS(SZERO) .LE. S) GO T
     1O 30
      IF (SZERO .GE. 0.0 .AND. SZERO .LT. S) GO TO 160
      IF (SZERO .LT. 0.0 .AND. SZERO .GT. -S) GO TO 160
```

(Cont'd)

```
      10 CONTINUE
         C = ATAN2(CCC,ABS(RR))
         C1 = .5 * (ATAN2((CCC + 2. * RR * S),ABS(RR + TT * S)) + ATAN2((CC
        1C - 2. * RR * S),ABS(RR - TT * S))) - C
         C1 = C1 / (S * S)
         C2 = (ATAN2((CCC + 2. * RR * S),ABS(RR + TT * S))) / S - C / S - C
        11 * S
C
C        INTEGRAND NOW IS (C1*S*S+C2*S+C)*S**N/(RR+TT*S))
C
         CLOGR = ALOG(ABS((RR + TT * S) / (RR - TT * S)))
         CON0 = (C * TT * TT - C2 * RR * TT + C1 * RR * RR) / (TT ** 3)
         CON1 = (C2 * TT - C1 * RR) / (TT * TT)
         RTAN = CON0 * CLOGR + 2. * S * CON1
         CON2 = (C * TT * TT - C2 * RR * TT + C1 * RR * RR) / (TT ** 3)
         CON3 = (C * RR * TT * TT - C2 * RR * RR * TT + C1 * RR ** 3) / (TT
        1 ** 4)
         RSTAN = 2. * S * CON2 - CON3 * CLOGR + 2. * C1 * TT * TT * S ** 3
        1/ (3 * TT ** 3)
         CON4 = (C * RR * RR * TT * TT - C2 * RR ** 3 * TT + C1 * RR ** 4)
        1/ (TT ** 5)
         CON5 = 4. * C2 * TT ** 3 - 4. * C1 * RR * TT ** 2
         CON5 = CON5 / (12 * TT ** 4)
         CON6 = ( - C * RR * TT * TT + C2 * RR * RR * TT - C1 * RR ** 3) /
        1(TT ** 4)
         RS2TAN = CON4 * CLOGR + 2. * CON5 * S ** 3 + 2. * S * CON6
         CON8 = 20. * (C * TT ** 4 - C2 * RR * TT ** 3 + C1 * RR ** 2 * TT
        1** 2) / (60 * TT ** 5)
         CON9 = (C * RR ** 2 * TT ** 2 - C2 * RR ** 3 * TT + C1 * RR ** 4)
        1/ (TT ** 5)
         CON10 = C * RR ** 3 * TT ** 2 - C2 * RR ** 4 * TT + C1 * RR ** 5
         CON10 = CON10 / (TT ** 6)
         RS3TAN = 2. * CON8 * S ** 3 + 2. * CON9 * S - CON10 * CLOGR + 24.
        1* C1 * TT ** 4 * S ** 5 / (60 * TT ** 5)
         CONA = (C * RR ** 4 * TT ** 2 - C2 * RR ** 5 * TT + C1 * RR ** 6)
        1/ (TT ** 7)
         CONB = (C2 * TT - C1 * RR) / (5 * TT ** 2)
         CONC = ( - C * RR * TT ** 2 + C2 * RR ** 2 * TT - C1 * RR ** 3) /
        1(3 * TT ** 4)
         COND = CONC * RR ** 2 / (TT ** 2 / 3)
         RS4TAN = CONA * CLOGR + CONB * 2 * S ** 5 + CONC * 2 * S ** 3 + CO
        1ND * 2 * S
```

SUBROUTINE SNTAN (Continued)


```
      IF (RR .GT. 0.) GO TO 20
      RTAN = -RTAN
      RSTAN = -RSTAN
      RS2TAN = -RS2TAN
      RS3TAN = -RS3TAN
      RS4TAN = -RS4TAN
   20 CONTINUE
      GO TO 130
   30 CONTINUE
      SAWAY = S - TOL
      S = SAWAY
      GO TO 10
C
C     FOR CASE OF RR NOT ZERO,TT=0.0
C
   40 CONTINUE
      RR = ABS(RR)
      ALNNUM = (2 * BB) ** 2 * S ** 2 + 4 * C * BB * S + RR ** 2 + C **
     12
      ALNDEN = (2 * BB) ** 2 * S ** 2 - 4 * C * BB * S + RR ** 2 + C **
     12
      IF (ALNNUM .EQ. 0.0 .OR. ALNDEN .EQ. 0.0) GO TO 50
      GO TO 60
   50 CONTINUE
      S = S - TOL
      ALNNUM = (2 * BB) ** 2 * S ** 2 + 4 * C * BB * S + RR ** 2 + C **
     12
      ALNDEN = (2 * BB) ** 2 * S ** 2 - 4 * C * BB * S + RR ** 2 + C **
     12
   60 RATLN = ALOG(ALNNUM / ALNDEN)
      TNDIF = ATAN2((C + 2. * BB * S),RR) - ATAN2((C - 2. * BB * S),RR)
      TNSUM = ATAN2((C + 2. * BB * S),RR) + ATAN2((C - 2. * BB * S),RR)
      RTAN = -(.25 * RR / BB) * RATLN + 0.5 * C * TNDIF / BB
      RTAN = RTAN / RR + S * TNSUM / RR
      RSTAN = 0.5 * (S * S + (RR * RR - C * C) / (2 * BB) ** 2) * TNDIF
     1- .5 * RR * S / BB + ((.5 * C * RR) / (2 * BB) ** 2) * RATLN
      RSTAN = RSTAN / RR
      RS2TAN = (S ** 3 / 3) * TNSUM + ((RR ** 3 - 3 * C ** 2 * RR) / (48
     1 * BB ** 3)) * RATLN + C * RR * S / (3 * BB ** 2) - ((6 * C * RR *
     2* 2 - 2 * C ** 3) / (6 * (2 * BB) ** 3)) * TNDIF
      RS2TAN = RS2TAN / RR
      RS3TAN = (S ** 4 / 4) * TNDIF - ((C * RR ** 3 - C ** 3 * RR) / (32
```

```
         1 * BB ** 4)) * RATLN - TNDIF * (RR ** 4 - 6 * C ** 2 * RR ** 2 + C
         2 ** 4) / (64 * BB ** 4) - RR * S ** 3 / (12 * BB) - S * (9 * C **
         32 * RR ** 2 - 3 * RR ** 4) / (48 * RR * BB ** 3)
          RS3TAN = RS3TAN / RR
          RS4TAN = (S ** 5 / (5 * BB)) * TNSUM + TNDIF * (5 * C * RR ** 6 -
         110 * C ** 3 * RR ** 4 + C ** 5 * RR ** 2) / (160 * BB ** 5 * RR **
         2 3) - RATLN * (RR ** 6 - 10 * C ** 2 * RR ** 4 + 5 * C ** 4 * RR *
         3* 2) / (320 * RR ** 2 * BB ** 5) + C * S ** 3 / (15 * BB ** 2) + S
         4 * (C ** 3 - C * RR ** 2) / (10 * BB ** 4)
          GO TO 130
C
C         FOR CASE OF RR=TT=0.0, IF I=J
C
       70 TOP = C + 2. * BB * S
          BOT = C - 2. * BB * S
          IF (C .EQ. 0.0 .AND. BB .EQ. 0.0) GO TO 130
          SBAD = -C / (2. * BB)
          SBADAB = ABS(SBAD)
          IF (SBADAB .LT. S) GO TO 80
          GO TO 90
       80 CONTINUE
          SUL = SBAD - TOL
          SLL = SBAD + TOL
          CLOGR1 = ALOG(TOP / (C + 2. * BB * SLL))
          CLOGR2 = ALOG((C + 2. * BB * SUL) / BOT)
          CLOGR = CLOGR1 + CLOGR2
          RTAN = -(.5 / BB) * CLOGR
          RSTAN = (.25 * C / BB ** 2) * CLOGR - (.5 / BB) * (2. * S - SLL +
         1SUL)
          RS2TAN = -(C ** 2 / (8. * BB ** 3)) * CLOGR + (C / (4. * BB ** 2))
         1 * (2. * S - SLL + SUL) - (.25 / BB) * (SUL * SUL - SLL * SLL)
          RS3TAN = (C ** 3 / (16. * BB ** 4)) * CLOGR - (2. * S ** 3 - SLL *
         1* 3 + SUL ** 3) / (6. * BB) - (C * C / (8. * BB ** 3)) * (2. * S -
         2 SLL + SUL) + (C / (8. * BB * BB)) * (SUL * SUL - SLL * SLL)
          RS4TAN = -(C ** 4 / (32. * BB ** 5)) * CLOGR - (SUL ** 4 - SLL **
         14) / (8. * BB) + (C / (12. * BB * BB)) * (2. * S ** 3 - SLL ** 3 +
         2 SUL ** 3) - C ** 2 * (SUL ** 2 - SLL * SLL) / (16. * BB ** 3) + C
         3 ** 3 * (2. * S - SLL + SUL) / (16. * BB ** 4)
          GO TO 130
       90 CONTINUE
          IF (ABS(TOP) .LT. 1E - 9 .OR. ABS(BOT) .LT. 1E - 9) GO TO 120
          IF (TOP .LE. 0.0) GO TO 110
```

SUBROUTINE SNTAN (Continued)


```
      IF (BOT .LE. 0.0) GO TO 110
  100 CLOGR = ALOG(TOP / BOT)
      RTAN = -(1 / BB) * CLOGR
      RTAN = RTAN / 2
      RSTAN = (.25 * C / BB ** 2) * CLOGR - S / BB
      RS2TAN = -(C ** 2 / (8 * BB ** 3)) * CLOGR + C * S / (2. * BB ** 2
     1)
      RS3TAN = (C ** 3 / (16. * BB ** 4)) * CLOGR - S ** 3 / (3. * BB) -
     1 S * C ** 2 / (4. * BB ** 3)
      RS4TAN = -(C ** 4 / (32 * BB ** 5)) * CLOGR + 2. * C * S ** 3 / (1
     12 * BB ** 2) + 2. * S * C ** 3 / (16 * BB ** 4)
      GO TO 130
  110 TPDBBT = TOP / BOT
      IF (TPDBBT .GT. 0.0) GO TO 100
      IF (TOP .LT. 0.0) GO TO 140
      IF (BOT .LT. 0.0) GO TO 140
  120 CONTINUE
      SAWAY = S - TOL
      TOP = C + 2. * BB * SAWAY
      BOT = C - 2. * BB * SAWAY
      CLOGR = ALOG(TOP / BOT)
      RTAN = -(1 / BB) * CLOGR
      RTAN = RTAN / 2
      RSTAN = (.25 * C / BB ** 2) * CLOGR - S / BB
      RS2TAN = -(C ** 2 / (8 * BB ** 3)) * CLOGR + C * S / (2. * BB ** 2
     1)
      RS3TAN = (C ** 3 / (16. * BB ** 4)) * CLOGR - S ** 3 / (3. * BB) -
     1 S * C ** 2 / (4. * BB ** 3)
      RS4TAN = -(C ** 4 / (32 * BB ** 5)) * CLOGR + 2. * C * S ** 3 / (1
     12 * BB ** 2) + 2. * S * C ** 3 / (16 * BB ** 4)
      GO TO 130
  130 CONTINUE
C
C     WRITE STATEMENTS GO HERE IF NEEDED
C
      GO TO 150
  140 WRITE (6,240)
  150 CONTINUE
      GO TO 230
C
C     FOR CASE OF BB,TT NOT ZERO, BUT WITH MIDRANGE SINGULARITY
C
```

```
  160 CONTINUE
      WRITE (6,250)
      SUL = SZERO - TOL
      SLL = SZERO + TOL
      SMID1 = S - 0.5 * ABS(S - SLL)
      SMID2 = -S + 0.5 * ABS( - S - SUL)
      ANG1 = ATAN2((C + 2. * BB * S),ABS(RR + TT * S))
      ANG2 = ATAN2((C + 2. * BB * SMID1),ABS(RR + TT * SMID1))
      ANG3P = ATAN2((C + 2. * BB * SLL),ABS(RR + TT * SLL))
      ANG3 = ATAN2((C - 2. * BB * S),ABS(RR - TT * S))
      ANG4 = ATAN2((C + 2. * BB * SMID2),ABS(RR + TT * SMID2))
      ANG5 = ATAN2((C + 2. * BB * SUL),ABS(RR + TT * SUL))
      DO 220 I = 1,2
      IF (I .EQ. 2) GO TO 170
      AA1(1,1) = SUL * SUL
      AA1(1,2) = SUL
      AA1(1,3) = 1.
      AA1(2,3) = 1.
      AA1(3,3) = 1.
      AA1(2,1) = SMID2 * SMID2
      AA1(2,2) = SMID2
      AA1(3,1) = S * S
      AA1(3,2) = -S
      AA(1) = ANG5
      AA(2) = ANG4
      AA(3) = ANG3
      CLOGP = ALOG((RR + TT * SUL) / (RR - TT * S))
      SUSE = SMID2
      DELS = SUL + S
      DELS2 = SUL ** 2 - S ** 2
      DELS3 = SUL ** 3 + S ** 3
      DELS4 = SUL ** 4 - S ** 4
      DELS5 = SUL ** 5 + S ** 5
      DELS6 = SUL ** 6 - S ** 6
      GO TO 180
  170 CONTINUE
      AA1(1,1) = S * S
      AA1(1,2) = S
      AA1(1,3) = 1.
      AA1(2,3) = 1.
      AA1(3,3) = 1.
      AA1(2,1) = SMID1 * SMID1
```

SUBROUTINE SNTAN (Continued)


```
      AA1(2,2) = SMID1
      AA1(3,1) = SLL * SLL
      AA1(3,2) = SLL
      AA(1) = ANG1
      AA(2) = ANG2
      AA(3) = ANG3P
      CLOGR = ALOG(ABS((RR + TT * S) / (RR + TT * SLL)))
      SUSF = SMID1
      DELS = S - SLL
      DELS2 = S ** 2 - SLL ** 2
      DELS3 = S ** 3 - SLL ** 3
      DELS4 = S ** 4 - SLL ** 4
      DELS5 = S ** 5 - SLL ** 5
      DELS6 = S ** 6 - SLL ** 6
  180 CONTINUE
      CALL SIMEQ (AA1,3,AA,1,DETERM,IPIVOT,3,ISCALE)
      C1 = AA(1)
      C2 = AA(2)
      C = AA(3)
      CON0 = (C * TT * TT - C2 * RR * TT + C1 * RR * RR) / (TT ** 3)
      CON1 = (C2 * TT - C1 * RR) / (TT * TT)
      CON11 = 0.5 * C1 / TT
      CON2 = (C * TT * TT - C2 * RR * TT + C1 * RR * RR) / (TT ** 3)
      CON3 = (C * RR * TT * TT - C2 * RR * RR * TT + C1 * RR ** 3) / (TT
     1 ** 4)
      CON21 = C2 / (2 * TT) - C1 * RR / (2 * TT * TT)
      CON4 = (C * RR * RR * TT * TT - C2 * RR ** 3 * TT + C1 * RR ** 4)
     1/ (TT ** 5)
      CON5 = 4. * C2 * TT ** 3 - 4. * C1 * RR * TT ** 2
      CON5 = CON5 / (12 * TT ** 4)
      CON6 = ( - C * RR * TT * TT + C2 * RR * RR * TT - C1 * RR ** 3) /
     1(TT ** 4)
      CON31 = (C * TT ** 3 - C2 * RR * TT ** 2 + C1 * RR ** 2 * TT) / (2
     1 * TT ** 4)
      CON32 = C1 / (4 * TT)
      CON8 = 20. * (C * TT ** 4 - C2 * RR * TT ** 3 + C1 * RR ** 2 * TT
     1** 2) / (60 * TT ** 5)
      CON9 = (C * RR ** 2 * TT ** 2 - C2 * RR ** 3 * TT + C1 * RR ** 4)
     1/ (TT ** 5)
      CON10 = C * RR ** 3 * TT ** 2 - C2 * RR ** 4 * TT + C1 * RR ** 5
      CON10 = CON10 / (TT ** 6)
      CON41 = (C2 * TT - C1 * RR) / (4 * TT ** 2)
```

SUBROUTINE SNTAN (Continued)


```
      CON42 = ( - C * RR * TT ** 2 + C2 * RR ** 2 * TT - C1 * RR ** 3) /
     1 (2 * TT ** 4)
      CONA = (C * RR ** 4 * TT ** 2 - C2 * RR ** 5 * TT + C1 * RR ** 6)
     1/ (TT ** 7)
      CONB = (C2 * TT - C1 * RR) / (5 * TT ** 2)
      CONC = ( - C * RR * TT ** 2 + C2 * RR ** 2 * TT - C1 * RR ** 3) /
     1(3 * TT ** 4)
      COND = CONC * RR ** 2 / (TT ** 2 / 3)
      CONE = (C * TT ** 2 - C2 * RR * TT + C1 * RR ** 2) / (4 * TT ** 3)
      CONF = C1 / (6 * TT)
      CONG = CONE * RR ** 2 * 2 / (TT ** 2)
      IF (I .EQ. 1) GO TO 190
      IF (I .EQ. 2 .AND. (RR + TT * SUSE) .GT. 0.) GO TO 190
      RTAN = RTAN - CON0 * CLOGR + CON1 * DELS + CON11 * DELS2
      RSTAN = RSTAN - CON21 * DELS2 + CON2 * DELS - CON3 * CLOGR + C1 *
     1DELS3 / (3 * TT)
      RS2TAN = RS2TAN - CON4 * CLOGR + CON5 * DELS3 + CON31 * DELS2 + CO
     1N32 * DELS4 + CON6 * DELS
      RS3TAN = RS3TAN - CON41 * DELS4 + CON8 * DELS3 + CON42 * DELS2 + C
     1ON9 * DELS - CON10 * CLOGR + C1 * DELS5 / (5 * TT)
      RS4TAN = RS4TAN - CONA * CLOGR + CONB * DELS5 + CONE * DELS4 + CON
     1F * DELS6 + CONC * DELS3 + CONG * DELS2 + COND * DELS
      GO TO 200
  190 CONTINUE
      RTAN = RTAN + CON0 * CLOGR + CON1 * DELS + CON11 * DELS2
      RSTAN = RSTAN + CON21 * DELS2 + CON2 * DELS - CON3 * CLOGR + C1 *
     1DELS3 / (3 * TT)
      RS2TAN = RS2TAN + CON4 * CLOGR + CON5 * DELS3 + CON31 * DELS2 + CO
     1N32 * DELS4 + CON6 * DELS
      RS3TAN = RS3TAN + CON41 * DELS4 + CON8 * DELS3 + CON42 * DELS2 + C
     1ON9 * DELS - CON10 * CLOGR + C1 * DELS5 / (5 * TT)
      RS4TAN = RS4TAN + CONA * CLOGR + CONB * DELS5 + CONE * DELS4 + CON
     1F * DELS6 + CONC * DELS3 + CONG * DELS2 + COND * DELS
  200 CONTINUE
      IF (I .EQ. 2) GO TO 210
      IF (I .EQ. 1 .AND. (RR - TT * S) .GT. 0.) GO TO 210
      RTAN = -RTAN
      RSTAN = -RSTAN
      RS2TAN = -RS2TAN
      RS3TAN = -RS3TAN
      RS4TAN = -RS4TAN
  210 CONTINUE
```

SUBROUTINE SNTAN (Concluded)

```
SUBROUTINE SNTAN      74/74    OPT=1 STATIC                    FTN 4.7+485        81/01/27. 13.38.34       PAGE      9

          220 CONTINUE                                                            J 337
              GO TO 130                                                           J 338
          230 CONTINUE                                                            J 339
              RR = RRR                                                            J 340
              S = SSS                                                             J 341
              C = CCC                                                             J 342
              RETURN                                                              J 343
        C                                                                         J 344
          240 FORMAT (30X,43HONE OF THE ENDPOINTS HAS A NEGATIVE LOG ARG)         J 345
          250 FORMAT (30X,11H 80 ENTERED)                                         J 346
              END                                                                 J 347-
```

SUBROUTINE LOGS

```
SUBROUTINE LOGS       74/74    OPT=1 STATIC              FTN 4.7+485         81/01/27. 13.38.34        PAGE      1

          SUBROUTINE LOGS (S,E,D,RELN,RESLN,RES2LN,RES3LN)
C
C         SUBROUTINE LOGS
C
C         CALCULATES INTEGRALS OF FORM S**N*ALOG(S*S+E*S+D) WITH
C         RESPECT TO S OVER LIMITS OF -S TO S FOR N=0,1,2,3.
C
C         S= PANEL SEGMENT HALFWIDTH
C         E,D ARE CALCULATED IN SUBROUTINE CONCAL
C         INTEGRAL RESULTS ARE RELN,RESLN,RES2LN,RES3LN
C
C         EVALUATION OF INTEGRALS PERFORMED USING MACSYMA ALGEBRAIC
C         MANIPULATION PROGRAM OF MIT PROJECT MAC
C         IF I=J INTEGRAL EVALUALTED AT APPROXIMATE ENDPOINTS,+-SAWAY
C
          COMMON  /TEL/ DUM,TOL2
          REAL  LATB,LADB,L1,L2,L3,L4
          TOL = TOL2
          RELN = 0.0
          RESLN = 0.0
          RES2LN = 0.0
          RES3LN = 0.0
          SS = S
          A = S * S + E * S + D
          B = S * S - E * S + D
          A = ABS(A)
          B = ABS(B)
          AA = ABS(A)
          BB = ABS(B)
          IF (AA .LE. 0.000000001) GO TO 60
          IF (BB .LE. 0.000000001) GO TO 60
       10 DISC = E * E - 4 * D
          DISQ = SQRT(ABS(DISC))
          DIS = E * E - 2. * D
          DIS3 = E ** 3 - 3. * D * E
          DIS4 = (E * E - 4. * D) * (E * E - D)
          DIS44 = E ** 4 - 4. * D * E * E + 2. * D * D
          DIS5 = E ** 5 - 6. * D * E ** 3 + 8. * E * D ** 2
          LATB = ALOG(A * B)
          LADB = ALOG(A / B)
          IF (AA .LE. 0.000000001) S = SAWAY
          IF (BB .LE. 0.000000001) S = SAWAY
```


(Cont'd)

SUBROUTINE LOGS (Continued)


```
      RE = S * LATB + 0.5 * E * LADB
      ESP = E + 2 * S
      ESM = E - 2 * S
      IF (DISC) 40,30,20
   20 CONTINUE
      L1 = E - DISQ + 2 * S
      L2 = E + DISQ + 2 * S
      L3 = E - DISQ - 2 * S
      L4 = E + DISQ - 2 * S
      DIFFLN = ALOG(L1 * L4 / L2 / L3)
      RELN = RE - 4 * S - 0.5 * DISQ * DIFFLN
      RESLN = 0.5 * LADB * S ** 2 + (0.25 * E * DISC / DISQ) * DIFFLN
      RESLN = RESLN - 0.25 * DIS * LADB + E * S
      RES2LN = (S ** 3 / 3) * LATB - DIS4 / (6 * DISQ) * DIFFLN + LADB *
     1 (DIS3 / 6) - 4 * S ** 3 / 9 - 6 * DIS * S / 9
      RES3LN = 0.25 * S ** 4 * LADB + DIS5 / (8 * DISQ) * DIFFLN - LADB
     1* (DIS44 / 8) + E * S ** 3 / 6 + 0.5 * S * DIS3
      GO TO 50
   30 CLOGRT = ALOG(ABS(ESP / ESM))
      RELN = S * LATB - 4 * S + E * CLOGRT
      RESLN = 0.5 * S ** 2 * LADB - 0.5 * DIS * CLOGRT + E * S
      RES2LN = (S ** 3 * LATB + DIS3 * CLOGRT + (DIS4) * ((1 / ESP) - (1
     1 / ESM)) - 2 * S * DIS) / 3 - 4 * (S ** 3) / 9
      RES3LN = 0.25 * S ** 4 * LADB - DIS44 * 0.25 * CLOGRT - .25 * DIS5
     1 * (1 / ESP - 1 / ESM) + E * S ** 3 / 6 + 0.5 * S * DIS3
      GO TO 50
   40 TNRAT = ATAN2(ESP,DISQ) - ATAN2(ESM,DISQ)
      RELN = RE - 4 * S - (DISC / DISQ) * TNRAT
      RESLN = 0.5 * (S ** 2 - 0.5 * DIS) * LADB + 0.5 * E * DISC / DISQ
     1* TNRAT + E * S
      RES2LN = S ** 3 / 3 * LATB + (DIS3 / 6) * LADB - (DIS4 / (3 * DISQ
     1)) * TNRAT - 4 * S ** 3 / 9 - 2 * S * DIS / 3
      RES3LN = (0.25 * S ** 4 - DIS44 / 8) * LADB + 0.25 * DIS5 / DISQ *
     1 TNRAT + E * S ** 3 / 6 + S * DIS3 / 2
   50 CONTINUE
      GO TO 70
   60 CONTINUE
      SAWAY = S - TOL
      A = SAWAY * SAWAY + E * SAWAY + D
      B = SAWAY * SAWAY - E * SAWAY + D
      A = ABS(A)
      B = ABS(B)
```

SUBROUTINE LOGS (Concluded)

```
SUBROUTINE LOGS        74/74    OPT=1 STATIC                FTN 4.7+485        81/01/27. 13.38.34       PAGE     3

             GO TO 10                                                                K  85
          70 CONTINUE                                                                K  86
             S = SS                                                                  K  87
             RETURN                                                                  K  88
             END                                                                     K  89-
```

PROGRAM ZOCDETM

```
PROGRAM ZOCDETM     74/74    OPT=1 STATIC                    FTN 4.7+485        81/01/27. 13.38.34         PAGE     1

              OVERLAY (WINGTL,2,0)
              PROGRAM  ZOCDETM
              DIMENSION  YY(2), FV(2), FW(2), DZDX(400), XXCC(20), WOU(20)
              DIMENSION  X3C4(22), ALOC(22,1), T(41), SS(41,1), SS1(41,1), SS2(4
             11,1), S2(22,1), S3(22,1), DELY(22,1), H(22), PSUM(41,1)
              DIMENSION  ZOCM(41), ZOCK(30), PDUM(41,1)
              DIMENSION  ZUPA(41), ZLOA(41), PTX(41), ZMC(41)
              DIMENSION  WK(455)
              COMMON  /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(400),PN(400),PV(
             1400),S(400),PSI(400),PHI(50),ZH(50),NSSW
              COMMON  /TOTHRF/ CIR(400)
              COMMON  /CCRRDD/ CHORD(50),XTE(50),KBIT,TSPAN,TSPANA
              COMMON  /INSUB23/ APSI,APHI,XX,YYY,ZZ,SNN,TOLC
              COMMON  /JK2/ PCTX(50),PCTZ(50),NZS,JCTL,JSLP
        C
        C
        C     PART 3 - COMPUTE Z/C VERSUS X/C
        C
        C
        C     THE TOLERANCE SET AT THIS POINT IN THE PROGRAM MAY NEED TO BE
        C     CHANGED FOR COMPUTERS OTHER THAN THE CDC 6000 SERIES
        C
        C
              WRITE (6,280)
              TOLC = (BOT * 15.E - 05) ** 2
              PI = 4. * ATAN(1.)
              RAD = 180. / PI
              IZZ = 1
              NNV = TBLSCW(IZZ)
              DO 30 NV = 1,M
              DZDX(NV) = 0.
              IZ = 1
              NNN = TBLSCW(IZ)
              DO 20 NN = 1,M
              APHI = ATAN(PHI(IZ))
              APSI = PSI(NN)
              XX = PV(NV) - PN(NN)
              YY(1) = Q(NV) - Q(NN)
              YY(2) = Q(NV) + Q(NN)
              ZZ = ZH(IZZ) - ZH(IZ)
              SNN = S(NN)
              DO 10 I = 1,2
```

(Cont'd)

PROGRAM ZOCDETM (Continued)

```
PROGRAM ZOCDETM    74/74   OPT=1 STATIC                    FTN 4.7+485        81/01/27. 13.38.34        PAGE     2

               YYY = YY(I)
               CALL INFSUB (ROT,FV(I),FW(I))
               APHI = -APHI
               APSI = -APSI
            10 CONTINUE
               FVN = FW(1) + FW(2) - (FV(1) + FV(2)) * PHI(IZZ)
               DZDX(NV) = DZDX(NV) + FVN * CIR(NN) / 12.5663704
               IF (NN .LT. NNN .OR. NN .EQ. M) GO TO 20
               IZ = IZ + 1
               NNN = NNN + TBLSCW(IZ)
            20 CONTINUE
               IF (NV .LT. NNV .OR. NV .EQ. M) GO TO 30
               IZZ = IZZ + 1
               NNV = NNV + TBLSCW(IZZ)
            30 CONTINUE
      C
      C
      C          INTEGRATE DZ/DX TO OBTAIN Z/C VERSUS X/C AT THE VARIOUS Y LOCATI
      C
      C
               IF (JSLP .NE. 1) GO TO 40
               PUNCH 240, (DZDX(NN),NN = 1,M)
            40 CONTINUE
               REWIND 10
               IF (JCTL .EQ. 0) GO TO 50
               CALL PSEUDO
            50 CONTINUE
               LA = 1
               LB = 0
               DO 230 I = 1,NSSW
               IN = TBLSCW(I)
               CPHI = COS(ATAN(PHI(I)))
               IF (I .EQ. 1) GO TO 60
               LA = LA + TBLSCW(I - 1)
            60 LB = LB + TBLSCW(I)
               DO 70 J = LA,LB
               N = J - LA + 1
               WOU(N) = -DZDX(J)
               XXCC(N) = (N - 0.25) / IN
               K = IN + 1 + LA - J
               X3C4(K) = PV(J) * BETA
            70 ALOC(K) = -DZDX(J)
```

PROGRAM ZOCDETM (Continued)


```
          Y = Q(LA) / BOT
          WRITE (6,250) Q(LA),Y,CHORD(I)
          WRITE (6,290)
          WRITE (6,360) (WOU(IJ),IJ = 1,IN)
          WRITE (6,300)
          WRITE (6,360) (XXCC(IJ),IJ = 1,IN)
          K1 = IN + 2
          K2 = IN + 1
          ALOC(1) = ALOC(2)
          ALOC(K1) = ALOC(K2)
          X3C4(1) = XTE(I)
          X3C4(K1) = XTE(I) + CHORD(I)
          D1 = 0.
          D2 = 0.
          DO 80 L = 1,41
       80 T(L) = XTE(I) + CHORD(I) * (L - 1) * .025
          IW = 0
          CALL SPLINE (22,1,41,K1,1,41,X3C4,ALOC,T,A,SS,SS1,SS2,S2,S3,DELY,H
         1,IW,D1,D2,1,PSUM)
          DO 90 L = 1,40
          K = 42 - L
          J = 41 - L
       90 PSUM(K) = PSUM(J)
          PSUM(1) = 0.
          ALPIN = ATAN(PSUM(41) / CHORD(I)) * RAD
          WRITE (6,330) ALPIN
          WRITE (6,310)
          IF (JCTL .EQ. 2) GO TO 100
          WRITE (6,320)
          GO TO 110
      100 CONTINUE
          WRITE (6,350)
      110 CONTINUE
          DO 150 L = 1,41
          K = 42 - L
          XOC = 1. + (XTE(I) - T(K)) / CHORD(I)
          ZOC = PSUM(K) / CHORD(I)
          ZOCM(L) = -ZOC
          X = XOC * CHORD(I)
          ZOCPP = ZOC * CPHI
          ZMC(L) = -ZOCPP
          DLTZPP = PSUM(K) * CPHI
```

```
      IF (JCTL .NE. 2) GO TO 120
      CALL CSIUNI (50,NZS,1,1,1,PCTX,PCTZ,XOC,THK, - 1,WK)
      ZOCU = ZOCPR - THK
      ZOCL = ZOCPR + THK
      ZUP = ZOCU * CHORD(I)
      ZLO = ZOCL * CHORD(I)
      ZUPA(L) = ZOCU
      ZLOA(L) = ZOCL
  120 CONTINUE
      IF (JCTL .EQ. 2) GO TO 130
      WRITE (6,260) XOC,ZOC,ZOCPR,X,PSUM(K),DLTZPR
      GO TO 140
  130 CONTINUE
      WRITE (6,340) XOC,ZOC,ZOCPR,ZOCU,ZOCL,X,PSUM(K),DLTZPR,ZUP,ZLO
  140 CONTINUE
  150 CONTINUE
      WRITE (6,370)
      DO 160 L = 1,19
      ZOCK(L) = ZOCM(L)
  160 CONTINUE
      DO 170 L = 20,30
      LL = 2 * L - 19
      ZOCK(L) = ZOCM(LL)
  170 CONTINUE
      IF (JCTL .NE. 2) GO TO 200
      DO 180 L = 1,21
      LL = 1 + (L - 1) * 2
      ZUPA(L) = ZUPA(LL)
      ZLOA(L) = ZLOA(LL)
  180 PTX(L) = 0.05 * (FLOAT(L - 1))
      WRITE (10,270) (PTX(L),L = 1,21)
      WRITE (10,270) (ZUPA(L),L = 1,21)
      WRITE (10,270) (ZLOA(L),L = 1,21)
      DO 190 L = 1,21
      ZUPA(L) = -ZUPA(L)
  190 ZLOA(L) = -ZLOA(L)
      CALL TMFOPLT (0,21,PTX,1,ZUPA,1,0.,1., - .5,0.5,0,0,3,3HX/C,12,12H
     1Z/C COS(PHI),0)
      THET = 0.
      XL = 5.5
      YL = 8.
      HT = 0.3
```

```
      CALL NOTATE (XL,YL,HT,6HCHORD=,THET,6)
      YL = 7.
      CALL NOTATE (XL,YL,HT,6HY/B/2=,THET,6)
      XL = 8.
      YL = 8.
      CALL NUMBER (XL,YL,HT,CHORD(I),THET,3)
      YL = 7.
      CALL NUMBER (XL,YL,HT,Y,THET,4)
      CALL INFOPLT (1,21,PTX,1,ZLOA,1,0.,1., - .5,0.5,0.0,3,3HX/C,12,12H
     1Z/C COS(PHI),0)
  200 CONTINUE
      IF (JCTL .NE. 1) GO TO 220
      DO 210 L = 1,41
  210 PTX(L) = 0.025 * FLOAT(L - 1)
      CALL INFOPLT (1,41,PTX,1,ZMC,1,0.,1., - .5,0.5,0.0,3,3HX/C,12,12HZ
     1/C COS(PHI),0)
      THET = 0.
      XL = 5.5
      YL = 8.
      HT = 0.3
      CALL NOTATE (XL,YL,HT,6HCHORD=,THET,6)
      YL = 7.
      CALL NOTATE (XL,YL,HT,6HY/B/2=,THET,6)
      XL = 8.
      YL = 8.
      CALL NUMBER (XL,YL,HT,CHORD(I),THET,3)
      YL = 7.
      CALL NUMBER (XL,YL,HT,Y,THET,4)
  220 CONTINUE
      WRITE (10,270) (ZOCK(L),L = 1,30)
  230 CONTINUE
      END FILE 10
      REWIND 10
C
  240 FORMAT (8F10.6)
  250 FORMAT (35X,2HY=,F10.4,11X,6HY/B/2=,F10.4,11X,6HCHORD=,F10.4//)
  260 FORMAT (23X,F9.4,5(5XF9.4))
  270 FORMAT (7F10.6)
  280 FORMAT (1H1,55X,20HLOCAL ELEVATION DATA///)
  290 FORMAT (41X,47HSLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR/)
  300 FORMAT (42X,46HCORRESPONDING X/C LOCATIONS FROM FRONT TO REAR/)
  310 FORMAT (////49X,15HLOCAL ELEVATION//)
```

PROGRAM ZOCDETM (Concluded)


```
      320 FORMAT (29X,3HX/C,11X,3HZ/C,5X,13H(Z/C)COS(DIH),5X,7HDELTA X,7X,7H  L 211
         1DELTA Z,3X,15H(DLT Z)COS(DIH)/)                                     L 212
      330 FORMAT (///34X,35HCHORD ANGLE OF ATTACK IN X-Z PLANE=,F9.4,7HDEGRE  L 213
         1ES)                                                                 L 214
      340 FORMAT (4X,F9.4,9(4X,F9.4))                                         L 215
      350 FORMAT (8X,3HX/C,9X,3HZ/C,4X,12HZ/C COS(DIH),1X,15HZ/C US COS(DIH)  L 216
         1,1X,15HZ/C LS COS(DIH),1X,7HDELTA X,4X,7HDELTA Z,1X,15H(DLT Z)COS(  L 217
         2DIH),1X,13HZ US COS(DIH),1X,13HZ LS COS(DIH)/)                      L 218
      360 FORMAT (5X,20F6.4)                                                  L 219
      370 FORMAT (1H1)                                                        L 220
          END                                                                 L 221
```

SUBROUTINE INFSUB


```
      SUBROUTINE INFSUB (BOT,FVI,FWI)
      COMMON  /INSUP23/ PSII,APHII,XXX,YYY,ZZZ,SNN,TOLRNC
      FC = COS(PSII)
      FS = SIN(PSII)
      FT = FS / FC
      FPC = COS(APHII)
      FPS = SIN(APHII)
      FPT = FPS / FPC
      F1 = XXX + SNN * FT * FPC
      F2 = YYY + SNN * FPC
      F3 = ZZZ + SNN * FPS
      F4 = XXX - SNN * FT * FPC
      F5 = YYY - SNN * FPC
      F6 = ZZZ - SNN * FPS
      FFA = (XXX ** 2 + (YYY * FPS) ** 2 + FPC ** 2 * ((YYY * FT) ** 2 +
     1 (ZZZ / FC) ** 2 - 2. * XXX * YYY * FT) - 2. * ZZZ * FPC * (YYY *
     2FPS + XXX * FT * FPS))
      FFB = (F1 * F1 + F2 * F2 + F3 * F3) ** .5
      FFC = (F4 * F4 + F5 * F5 + F6 * F6) ** .5
      FFD = F5 * F5 + F6 * F6
      FFE = F2 * F2 + F3 * F3
      FFF = (F1 * FPC * FT + F2 * FPC + F3 * FPS) / FFB - (F4 * FPC * FT
     1 + F5 * FPC + F6 * FPS) / FFC
C
C
C     THE TOLERANCE SET AT THIS POINT IN THE PROGRAM MAY NEED TO BE
C     CHANGED FOR COMPUTERS OTHER THAN THE CDC 6000 SERIES
C
C
      IF (ABS(FFA) .LT. (BOT * 15.E - 5) ** 2) GO TO 10
      FVONE = (XXX * FPS - ZZZ * FT * FPC) * FFF / FFA
      FWONE = (YYY * FT - XXX) * FFF / FFA * FPC
      GO TO 20
   10 FVONE = 0.
      FWONE = 0.
C
   20 IF (ABS(FFD) .LT. TOLRNC) GO TO 30
      FVTWO = F6 * (1. - F4 / FFC) / FFD
      FWTWO = -F5 * (1. - F4 / FFC) / FFD
      GO TO 40
   30 FVTWO = 0.
      FWTWO = 0.
```

(Cont'd)

```
SUBROUTINE INFSUB      74/74    OPT=1 STATIC                    FTN 4.7+485       81/01/27. 13.38.34        PAGE     2

          C
            40 IF (ABS(FFE) .LT. TOLRNC) GO TO 50
               FVTHRE = -F3 * (1. - F1 / FFR) / FFE
               FWTHRE = F2 * (1. - F1 / FFR) / FFE
               GO TO 60
            50 FVTHRE = 0.
               FWTHRE = 0.
          C
            60 FVI = FVONE + FVTWO + FVTHRE
               FWI = FWONE + FWTWO + FWTHRE
               RETURN
               END
```

SUBROUTINE SPLINE


```
      SUBROUTINE SPLINE (MNPTS,MNCVS,MMAX,N,NCVS,M,X,Y,T,PROXIN,SS,SS1,S
     1S2,S2,S3,DELY,H,IW,D1,D2,KAB,PSUM)
      DIMENSION  TH(50), DFLH(50,1), CT(50), TH2(50), DFLSQH(50), ST2(50
     1,1)
      DIMENSION  PSUM(MMAX,MNCVS)
      DIMENSION  X(MNPTS), Y(MNPTS,MNCVS), T(MMAX), DELY(MNPTS,MNCVS), S
     12(MNPTS,MNCVS), S3(MNPTS,MNCVS), SS1(MMAX,MNCVS), SS(MMAX,MNCVS),
     2H(MNPTS), SS2(MMAX,MNCVS), PROXIN(MNCVS), DELSQY(50), H2(50), C(50
     3), D(50)
      DIMENSION  D1(NCVS), D2(NCVS), KAB(NCVS)
      IF (IW) 90,10,90
   10 N1 = N - 1
      IW = 2
      DO 80 K = 1,NCVS
      DO 20 I = 1,N1
      H(I) = X(I + 1) - X(I)
      II = I + 1
      DELY(I,K) = (Y(II,K) - Y(I,K)) / H(I)
   20 C(I) = H(I)
      DO 30 I = 2,N1
      H2(I) = (H(I - 1) + H(I)) * 2.
      DELSQY(I) = (DELY(I,K) - DELY(I - 1,K)) * 6.
   30 CONTINUE
      IF (KAB(K) .EQ. 0) GO TO 40
      H2(1) = 2. * H(1)
      H2(N) = 2. * H(N1)
      DELSQY(1) = 6. * (DELY(1,K) - D1(K))
      DELSQY(N) = (D2(K) - DELY(N1,K)) * 6.
      GO TO 50
   40 H2(1) = 1.0
      H2(N) = 1.0
      C(1) = 0.0
      H(N1) = 0.0
      DELSQY(1) = 0.0
      DELSQY(N) = 0.0
   50 CALL TRIMAT (H,H2,C,DELSQY,D,N)
      DO 60 I = 1,N
   60 S2(I,K) = D(I)
      H(N1) = C(N1)
      DO 70 I = 1,N1
      II = I + 1
   70 S3(I,K) = (S2(II,K) - S2(I,K)) / H(I)
```

SUBROUTINE SPLINE (Continued)


```
   80 CONTINUE
   90 CONTINUE
      J = 0
  100 J = J + 1
      I = 1
      IF (T(J) - X(1)) 140,170,110
  110 IF (T(J) - X(N)) 130,150,140
  120 IF (T(J) - X(I)) 160,170,130
  130 I = I + 1
      GO TO 120
  140 CONTINUE
      PRINT 250, J
      PRINT 260, (X(I),I = 1,N)
      PRINT 260, (Y(I,1),I = 1,N)
      GO TO 190
  150 I = N
  160 CONTINUE
      IW = -I
      I = I - 1
  170 DO 180 K = 1,NCVS
      HT1 = T(J) - X(I)
      II = I + 1
      HT2 = T(J) - X(II)
      PROD = HT1 * HT2
      SS2(J,K) = S2(I,K) + HT1 * S3(I,K)
      DELSQS = (S2(I,K) + S2(II,K) + SS2(J,K)) / 6.
      SS(J,K) = Y(I,K) + HT1 * DELY(I,K) + PROD * DELSQS
      SS1(J,K) = DELY(I,K) + (HT1 + HT2) * DELSQS + PROD * S3(I,K) / 6.0
  180 CONTINUE
  190 CONTINUE
      IF (J .LT. M) GO TO 100
      M1 = M - 1
      DO 240 K = 1,NCVS
      DO 200 I = 1,M1
      TH(I) = T(I + 1) - T(I)
      II = I + 1
      DELH(I,K) = (SS(II,K) - SS(I,K)) / TH(I)
      CT(I) = TH(I)
  200 CONTINUE
      DO 210 I = 2,M1
      TH2(I) = (TH(I - 1) + TH(I)) * 2.
      DELSQH(I) = (DELH(I,K) - DELH(I - 1,K)) * 6.
```

SUBROUTINE SPLINE (Concluded)

```
SUBROUTINE SPLINE      74/74    OPT=1 STATIC                FTN 4.7+485        81/01/27. 13.38.34        PAGE      3

      210 CONTINUE
          TH2(1) = TH2(M) = 1.
          CT(1) = 0
          TH(M1) = 0
          DELSQH(1) = DELSQH(M) = 0.
          CALL TRIMAT (TH,TH2,CT,DELSQH,D,M)
          DO 220 I = 1,M
          ST2(I,K) = D(I)
      220 CONTINUE
          TH(M1) = CT(M1)
          PROXIN(K) = 0.0
          DO 230 I = 1,M1
          II = I + 1
          PROXIN(K) = PROXIN(K) + .5 * TH(I) * (SS(I,K) + SS(II,K)) - TH(I)
         1** 3 * (ST2(I,K) + ST2(II,K)) / 24.
          PSUM(I,K) = PROXIN(K)
      230 CONTINUE
      240 CONTINUE
          RETURN
C
C
      250 FORMAT (I4,24HTH ARGUMENT OUT OF RANGE)
      260 FORMAT (10F10.3)
          END
```

SUBROUTINE TRIMAT

```
SUBROUTINE TRIMAT      74/74    OPT=1 STATIC                    FTN 4.7+485        81/01/27. 13.38.34        PAGE      1

              SUBROUTINE TRIMAT (A,B,C,D,T,N)
              DIMENSION  A(1), B(1), C(1), D(1), T(1), W(50), SV(50), G(50)
        C
        C     THIS ROUTINE SOLVES THE TRIDIAGONAL (EXCEPT TWO ELEMENTS)   MATRIX
        C
              W(1) = B(1)
              SV(1) = C(1) / B(1)
              G(1) = D(1) / W(1)
              NM1 = N - 1
              DO 20 K = 2,N
              KM1 = K - 1
              W(K) = B(K) - A(KM1) * SV(KM1)
              IF (K .EQ. N) GO TO 10
              SV(K) = C(K) / W(K)
           10 G(K) = (D(K) - A(KM1) * G(KM1)) / W(K)
           20 CONTINUE
              T(N) = G(N)
              DO 30 K = 1,NM1
              KK = N - K
              T(KK) = G(KK) - SV(KK) * T(KK + 1)
           30 CONTINUE
              RETURN
              END
```

REFERENCES

1. Kuhlman, J.M.: Higher Order Farfield Drag Minimization for a Subcritical Wing Design Code. J. Aircraft, Vol. 17, No. 9, Sept. 1980, pp. 648-655; also AIAA reprint 80-4094.

2. Kuhlman, J.M.: Integration of Advanced Panel Trefftz Plane Drag Minimization Technique in Vortex Lattice Wing Design Code. Published in ASME Book No. G00147, 1979, pp. 201-210. Presented at ASME/AIAA/SAE Joint Symposium on Aerodynamics of Transportation (Niagara Falls, N.Y.), June 18-20, 1979.

3. Kuhlman, J.M.; and Felarca, V.M.: Optimal Aerodynamic Design of Subcritical Transport Type Wings. Presented at ASME ETC Century Two Aerospace Conference (San Francisco, Calif.), Aug. 13-15, 1980.

4. Lamar, John E.: A Vortex-Lattice Method for the Mean Camber Shapes of Trimmed Noncoplanar Planforms with Minimum Vortex Drag. NASA TN D-8090, June 1976.

5. Kuhlman, J.M.: Numerical Optimization Techniques for Bound Circulation Distribution for Minimum Induced Drag of Nonplanar Wings: Basic Formulations. NASA CR-3154, June 1979.

6. Loth, John L.; and Boyle, Robert E.: Optimum Loading on Nonplanar Wings at Minimum Induced Drag. Aerospace Engineering TR-19, (Contract N00014-68-A-1512), West Virginia Univ., Aug. 1969. (Available from DTIC as AD 704 502.)

7. Kuhlman, J.M.; and Ku, T.J.: Numerical Optimization Techniques for Bound Circulation Distribution for Minimum Induced Drag of Nonplanar Wings: Computer Program Documentation, NASA CR-3458, 1981.

8. Kuhlman, J.M.: Optimized Aerodynamic Design Process for Subsonic Transport Wing Fitted with Winglets. NASA CR-159180, Dec. 1979.

9. Smith, P.E.; DeYoung, J.; Lovell, W.A.; Price, J.E.; and Washburn, G.F.: A Study of High-Altitude Manned Research Aircraft Employing Strut-Braced Wings of High-Aspect-Ratio. NASA CR-159262, Feb. 1981.

10. Wolkovitch, Julian : Joined Wing Aircraft. U.S. Patent No. 3,942,747, issue date March 9, 1976. Other patents pending.

1. Report No. NASA CR-3457	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle COMPUTER PROGRAM DOCUMENTATION FOR A SUBCRITICAL WING DESIGN CODE USING HIGHER ORDER FAR-FIELD DRAG MINIMIZATION		5. Report Date September 1981
		6. Performing Organization Code
7. Author(s) John M. Kuhlman, Principal Investigator, and Jin-Yea Shu		8. Performing Organization Report No.
9. Performing Organization Name and Address Old Dominion University Research Foundation P.O. Box 6369 Norfolk, Virginia 23508		10. Work Unit No.
		11. Contract or Grant No. NSG-1357
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546		13. Type of Report and Period Covered Contractor Report 9/1/79 - 8/31/80
		14. Sponsoring Agency Code

15. Supplementary Notes

Langley Technical Monitors: John B. Peterson, Jr., and John E. Lamar
Topical Report

16. Abstract

A subsonic, linearized aerodynamic theory, wing design program for one or two planforms has been developed which uses a vortex lattice near-field model and a higher order panel method in the far field. The theoretical development of the wake model and its implementation in the vortex lattice design code are summarized in this report and sample results are given. Detailed program usage instructions, sample input and output data, and a program listing are presented in the Appendixes.

The far-field wake model assumes a wake vortex sheet whose strength varies piecewise linearly in the spanwise direction. From this model analytical expressions for lift coefficient, induced drag coefficient, pitching moment coefficient, and bending moment coefficient have been developed. From these relationships a direct optimization scheme is used to determine the optimum wake vorticity distribution for minimum induced drag, subject to constraints on lift, and pitching or bending moment. Integration spanwise yields the bound circulation, which is interpolated in the near-field vortex lattice to obtain the design camber surface(s).

17. Key Words (Suggested by Author(s)) Subsonic Aerodynamic Design Induced Drag Minimization Nonplanar Configurations FORTRAN Computer Program Users Manual		18. Distribution Statement FEDD Distribution Subject Category 02	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 176	22. Price

Available: NASA's Industrial Applications Centers