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USER'S GUIDE TO STIPPAN: A PANEL
METHOD PROGRAM FOR SLOTTED TUNNEL
INTERFERENCE PREDICTION

William B. Kemp, Jr.

THE COLLEGE OF WILLIAM AND MARY
Williamsburg, Virginia

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Hampton, Virginia 23665

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William B. Kemp, Jr.
The College of William and Mary, Williamsburg, Virginia

SUMMARY

Guidelines are presented for use of the computer program STIPPAN to simulate the subsonic flow in a slotted wind tunnel test section with a known model disturbance. Input data requirements are defined in detail and other aspects of the program usage are discussed in more general terms. The program is written for use in a CDC CYBER 200 class vector processing system.

INTRODUCTION

The computer program STIPPAN described in this paper is a slotted tunnel interference prediction program utilizing high order panel method technology as developed by Thomas (ref. 1) augmented by special wind tunnel simulation features which include a discrete finite length representation of wall slots with reentry flaps, nonlinear effects of slot inflow and outflow, and a constraint on plenum mass flow rate. In keeping with the intended use of the program for tunnel interference prediction and for later extension to tunnel interference assessment using measured wall pressures, emphasis was placed on a realistic simulation of the wind tunnel test environment in response to the disturbance of a test model represented by known singularities.

Program output describes the flow properties not only at the control points used for problem solution but also at a set of field points arbitrarily defined by the user. The flow properties calculated include the potential and velocity components of the tunnel interference perturbation as well as the total flow properties. For this purpose, the interference perturbation is defined as the total perturbation less that induced by the test model singularities. Basic capabilities of the program are discribed in ref. 2 which also presents results illustrating the significance of some of the program features. Ref. 3 gives a more detailed description of the methodology used and additional results including an accuracy comparison of several program options.

The present paper presents a description of the types of panel singularities, networks, and boundary conditions provided, gives some guidelines on assembling these elements into a wind tunnel simulation, describes the input data requirements in detail, and gives a brief discussion of computer-related aspects of the program.

SYMBOLS

B	normal velocity magnitude in Neumann boundary condition
c	reentry flap chord
d	slot spacing
f	fraction of reentry flap chord
K	nondimensional slot parameter for equivalent homogeneous wall
$\tilde{K}$	nondimensional slot parameter for discrete slot representation
m,n	index of m-line or n-line in panel network
$\vec{n}$	unit normal vector of panel
S	source line strength
u	longitudinal perturbation velocity
u_f	magnitude of reentry flap adjustment to u_p
u_p	plenum pressure expressed as an equivalent velocity perturbation
$\vec{V}$	reference velocity vector
$\vec{V}_p$	perturbation velocity vector
x,y,z	cartesian coordinates
x_o	value of x at slot origin
δ	network edge and corner control point recession in fraction of distance to local panel center
γ	local lifting vorticity on wing or tail
μ	doublet strength on panel
σ	source sheet strength on panel
ϕ	perturbation potential
$\bar{\Phi}$	perturbation potential in domain exterior to computational tunnel domain
ϕ_o	value of ϕ in tunnel flow at slot origin

NETWORK, PANEL AND BOUNDARY CONDITION OPTIONS

In the basic panel method, the bounding surface of a solution domain may be divided into one or more networks, each of which may be subdivided into panels. The geometry of each network is identified with the intersections of a set of m-lines with each of a set of n-lines. The input integers ML and NL define the number of lines in each set and the index m or n identifies a specific member in the set or m-lines of n-lines respectively. Panel corners are located at the line intersectons which are termed defining points and the boundaries of each single panel are formed by the straight line segments connecting the intersections of two adjacent m-lines with two adjacent n-lines. While the panels are quadrilateral in general, adjacent lines in either set are allowed to merge forming a triangular panel.

Within each network, m is chosen as the inner index so that the ML*NL defining points are indexed as (n-1)*ML+m and the (ML-1)*(NL-1) panels are indexed as (n-1)*(ML-1)+m. The panel index is used also as the index for other properties uniquely associated with each panel. The corners and edges of each network are also identified in order. The m and n values for each network corner are:

corner	m	n
1	1	1
2	1	NL
3	ML	NL
4	ML	1

and the edges are identified by:

edge	
1	m = 1
2	n = NL
3	m = ML
4	n = 1

A unit normal vector is calculated for each panel as the unit vector in the direction of the cross product of a panel width vector in the n-advancing direction into a panel width vector in the m-advancing direction. The sense of the unit normal vector is sensitive, therefore, to the order in which panel defining point coordinates are read into the network index grid.

Certain properties common to all panels within a network are input as network properties. These include the type and order of singularity distributions over each panel and the form of boundary condition imposed at the control points.

The form of doublet strength distribution over each panel is specified for each network by the value of IDT. The options available are given in Table I. Control points (points at which boundary conditions are

TABLE I.- PANEL DOUBLET DISTRIBUTION OPTIONS

IDT	Order of distribution	Number of unknowns
0	none	see Table II
1	constant	(ML-1)*(NL-1)
2	bilinear	(ML-1)*(NL-1)
3	biquadratic	(ML+1)*(NL+1)

imposed) are located at the panel center points for all nonzero doublet distributions. For the biquadratic distribution, additional control points are placed at the network corners and along the network edges at panel boundary midpoints. For this case (IDT = 3) the control point indices at the panel centers are given by n*(ML+1)+m. For IDT > 0 the set of unknowns for the network is the set of doublet strengths at control point locations. For IDT > 1, each coefficient of a higher order term in the bilinear or biquadratic equation for the panel singularity distribution is established as a linear combination of the singularity strengths at neighboring control points, the combining coefficients having been determined from a weighted minimization process.

The options available for panel source strength distribution are given in Table II and are selected by the value of IST. Values of 1 and 2 provide general purpose source panel networks with the source strength quantified at the panel centers. For IST = 2, the bilinear coefficients

TABLE II.- SOURCE DISTRIBUTION OPTIONS

IST	Order of distribution	Number of unknowns	Restrictions
0	none		IDT>0
1	constant	(ML-1)*(NL-1)[a]	
2	bilinear	(ML-1)*(NL-1)[a]	
8	bilinear	ML*(NL-1)	IDEFN=0, IDT=0, IBCIP=9
9	bilinear + lines	(ML-1)*(NL-2)	IDEFN=0, IDT=0, IBCIP=9 or 10
-1	constant	1 (free)	ML=NL=2, IDT=0 or 1
-2	bilinear	3 (free)	ML=NL=2, IDT=0 or 1

[a]for IDT = 0

are established by the same procedure used for the bilinear doublet distribution. The set of panel center source strengths is the set of unknowns for the network only if IDT = 0 is specified for the same network. If both IDT and IST are greater than zero, the set of unknowns is determined by IDT and the panel center source strengths are calculated from:

$$\sigma = -\vec{V}_{\infty} \cdot \vec{n} + B \tag{1}$$

where B is a constant entered into the right hand side of the matrix equation and is zero by default unless an option to read a set of B values for the network is selected.

IST values of 8 and 9 identify special purpose source panel networks intended only for use on slotted-wall regions in a wind tunnel representation. IDT for these network types must be specified as zero and the boundary conditions are restricted as noted in Table II. These networks must be placed with network edge 1 at the upstream end of the slots and network edge 3 at the downstream end of the slots. The n-advancing direction must be chosen so that the panel normal vectors point to the tunnel interior. Each of these network types must be superimposed on another network having IDT > 0 and having panel boundaries in the slotted wall region which coincide with those in the source type 8 or 9 network.

The IST = 8 network provides an equivalent homogeneous representation of the slotted wall. The bilinear source distribution coefficients are established as for IST = 2 except at network edges 1 and 3 where the panel source strength is forced approximately to zero. Control points are located at all panel center points and an additional NL-1 control points are placed at the panel boundary midpoints along network edge 3. The set of unknowns includes all panel center source strengths plus NL-1 reentry flap parameters which are described later in conjunction with the slotted wall boundary conditions.

A discrete slot representation of the slotted wall is provided by the IST = 9 network. The discrete slots are represented by piecewise linear line source distributions along each n-line except those at network edges 2 and 4 and are quantified at all interior panel corners. Bilinear panel source distributions are also used but their strengths and gradients are appropriately linked to the line source strengths. One control point is located on each line source segment at a fraction of the segment length set by the input parameter ETS. The set of unknowns includes the line source strengths at all interior panel corners plus NL-2 reentry flap parameters. The control points excluding the most downstream point on each slot are indexed as (n-1)*(ML-2)+m for m ranging from 1 to ML-2 and n from 1 to NL-2. The most downstream points follow with indices of (NL-2)*(ML-2)+n.

IST values of -1 and -2 may be used only with a single panel network (ML = NL = 2) and offer the means of implementing special problem closure conditions. The unknowns consist of the one or three coefficients of the constant or bilinear source distribution over the panel. The location and other properties of the one or three control points are free to be established directly by input specifications. If IDT = 1 is specified along with a negative IST, the doublet strength unknown and the panel center control point are appended to the unknowns and control points established by the negative IST.

The types of boundary condition provided are listed in Table III. Although the boundary condition type imposed at each control point is ultimately stored in the array named IBCT, the input specification is in a different form. For each network, the type used for all panel center control points is given as IBCIP, that used at each edge of the network is taken in order from the four input values of IBCEP, and at each corner from the four input values of IBCCP. The boundary condition type for each free boundary point provided by negative IST is input directly into IBCT.

Boundary condition type 0, if specified as IBCIP, results in the elimination of all control points for the network and provides for the a priori specification of source panel strengths in a network with constant or bilinear source panels. In this case, IDT must be specified as zero.

Boundary condition type 3 provides for the direct specification of the normal component of total velocity (Neumann boundary condition) on the positive normal side of the panel. The constant B (default = 0) is the specified value of normal velocity. If IST and IDT are both greater than zero, the same value of B is used in calculating the panel source strength by equation (1). The normal component of perturbation velocity on the opposite side of the panel is thereby set to zero regardless of the value of B.

Boundary condition type 4 provides an indirect means of imposing the Neumann condition. The condition imposed directly is that the perturbation potential on the negative normal side of the panel be zero.

TABLE III.- BOUNDARY CONDITION OPTIONS

IBCT	Description	Restrictions
0	none	IDT=0, IRHSI=1
3	$\vec{V}_p \cdot \vec{n} = -\vec{V}_\infty \cdot \vec{n} + B$	
4	$\bar{\phi}_p = 0$	
5	$\mu = 0$ ($\sigma = 0$ if IDT = 0)	
9	slotted wall, eqn (2) or (3)	IDT=0, IST=8 or 9
10	slotted wall, eqn (4)	IDT=0, IST=9
12	$\partial\mu/\partial y = 0$	IBCEP or IBCCP, IDT>0

Again, if IST and IDT are both greater than zero, the source strength calculated by equation (1) produces a normal component of total velocity on the positive normal panel surface approximately equal to B.

Boundary condition types 5 and 12 are special conditions imposed directly on local doublet distribution properties rather than on flow properties. Boundary condition type 5 provides a convenient means of constraining the otherwise free constant of integration if all other boundary conditions are imposed on velocity rather than potential. Boundary condition type 12 can be imposed at a doublet network edge lying in a plane of symmetry to improve the solution continuity across the plane of symmetry.

Boundary condition types 9 and 10 provide alternative forms of the condition to be met on the slotted regions of wind tunnel walls. The previous discussion of source networks of IST type 8 or 9 is pertinent to the use of these boundary conditions. The equivalent homogeneous representation of a slotted wall region is achieved by specifying a source network with IST = 8, IDT = 0, and IBCIP = 9 in conjunction with a doublet network with IBCIP = 4. In this application, the constraint imposed by boundary condition type 9 at all control points in the IST = 8 network may be written

$$(\phi - \phi_0) - (x - x_0)u_p - \tfrac{1}{2}f^2 c u_f - Kd\sigma = 0 \tag{2}$$

Equation (2) is derived in ref. 2 and, as noted therein, states that the normal velocity through the equivalent homogeneous wall multiplied by the dimensional slotted-wall parameter Kd is equal to the local potential jump across the wall. The equivalence between σ and normal velocity depends on the coincident use of boundary condition type 4 in a doublet network. For best accuracy, the type 4 boundary condition should be applied not only in the slotted-wall regions but over the entire problem boundary. The user should note that for this homogeneous wall representation, the dimensional slotted wall parameter Kd must be entered into the same input file locations which are used for the dimensionless parameter $\tilde{K}$ in the discrete slot representations to be discussed. The unknowns u_p and u_f are discussed in the following description of the discrete slot representation.

The discrete slot representation of a slotted wall region is achieved by specifying a source network with IST = 9, IDT = 0, and IBCIP = 9 or 10 in conjunction with a doublet network with IBCIP = 3 or 4. When used with IST = 9, boundary condition type 9 is expressed as

$$(\phi - \phi_0) - (x - x_0)u_p - \tfrac{1}{2}f^2 c u_f - \tfrac{1}{2}\tilde{K}S = (\text{nonlinear terms}) \tag{3}$$

where S is the line source strength (representing the discrete slot flux) at the local control point location. With this condition, it is appropriate to place the control points at the panel corners by specifying ETS = 1.0. An alternative slot boundary condition given in difference form is provided by boundary type 10 which may be written

$$u - (u_p + fu_f) - \tfrac{1}{2}K\frac{\Delta S}{\Delta x} = \text{(nonlinear terms)} \tag{4}$$

where $\Delta S/\Delta x$ is the gradient of line source strength in the line segment containing the local control point. For this case, a value of ETS = 0.5 is appropriate.

In equations (2) to (4) the quantity u_p is an expression of the plenum pressure in the form of an equivalent longitudinal velocity perturbation and is included in the set of unknowns in any problem in which an IST specification of 8 or 9 appears. The associated constraint states that the total (inward) mass flow through all IST = 8 or 9 networks and their reflections across the plane of symmetry is equal to the input plenum flow rate PLM. The terms involving u_f introduce a plenum pressure modification simulating a reentry flap and localized to the region between the reentry flap leading edge and the downstream end of each slot. The flap leading edge location is controlled by the input quantity MRF which is the m-line index of the IST = 8 or 9 network at the flap leading edge. Reentry flap effects may be eliminated from the solution by specifying MRF $\geq$ ML-1 for the slotted wall networks.

The control points are located as described in the foregoing discussion and are then subjected to small position adjustments. The network edge and corner control points are recessed a small fraction of the distance to the local panel center. This fraction is set by the input quantity IDEBUG(8). All control points are then shifted off of the panel surface in the positive panel normal direction except those points assigned boundary condition type 4 which are shifted in the negative panel normal direction. The distance shifted is a small constant (10^{-6} units) except for the discrete slot control points (in the IST = 9 networks) which are shifted a distance equal to the input quantity SES. Finally, during computation of the aerodynamic influence coefficients, whenever a control point is found to lie too close to the plane of any panel, even if the point is outside the panel boundaries, a diagnostic is issued and the point is assumed to lie on the positive normal side of the panel plane.

ORGANIZING THE WIND TUNNEL SIMULATION

Program STIPPAN was developed to investigate the response of the tunnel walls to a known disturbance in the tunnel interior. The test model, therefore, is simulated by specified singularities representing a known distribution of volume, lift and wake thickness. The walls are simulated by unknown distributions of source and/or doublet strength which are determined during the solution such that the boundary conditions, specified primarily at the walls, are satisfied. The primary goal is to produce a description of the wall-induced flow perturbation in the vicinity of the test model and a secondary goal is to predict, with suitable accuracy, the pressure distribution on those portions of the tunnel walls near the test model and between the wall slots.

It follows that the geometry of the computational boundary, made up of singularity panels, source lines and control points, should match closely the geometry of the tunnel walls in the tunnel region near the test model. A rule of thumb, based on experience with this and similar programs, states that the critical region for wall matching extends a full tunnel height or width upstream and downstream of the nearest point on the test model. In the case of a tunnel with slotted walls this critical region should include the entire slot length. Beyond this region, the computational boundary must provide adequate control of the velocity and uniformity of the incoming flow and allow a graceful exit of the departing flow.

In program STIPPAN, the geometry of the slotted wall networks (IST = 8 or 9) must be described in the simplified input format applicable only to flat rectangular networks in which all panel boundaries are parallel to one or another of the tunnel coordinate axes (IDEFN = 0). The slots are assumed parallel to the x-axis which is also the axis along which the unperturbed reference flow is directed with a velocity of unity. If the slotted walls in the tunnel to be simulated have a non-zero convergence or divergence angle, after accounting for boundary layer growth, the effective wall slope is represented on the computational boundary by providing for an equivalent normal velocity at the boundary.

In regions of the tunnel bounded by solid walls, the computational boundary either may reproduce the equivalent inviscid tunnel wall shape with zero normal velocity in the boundary condition, or be located on extensions of the rectangular parallelepiped used in the slotted test section with specified normal velocities derived from the local wall slope. The latter approach is more convenient with respect to preparation of the input data file and the loss in accuracy is probably insignificant.

If the downstream end of the wall slots is located sufficiently close to the test model, proper representation of this region of the computational boundary deserves special attention. Unfortunately, the equivalent inviscid distribution of tunnel cross section area downstream of the slots is particularly difficult to estimate. The sensitivity of results to changes in the wall simulation in this area can be examined by varying the specified normal velocity (or local panel source strength) in the region near the slot termination.

The upstream and downstream ends of the tunnel flow domain usually can be closed with single panel networks. In general, it is necessary to consider the relationship between the flow in the tunnel domain and the computationally definable flow in the surrounding outer domain. This is accomplished most conveniently by striving to minimize any perturbations introduced into the outer flow so that the outer velocity field will be essentially uniform with a magnitude of unity directed along the x-axis. If this is an appropriate velocity for the upstream end of the tunnel flow, the source panel may be omitted from the upstream closure. The axial velocity at the downstream end of the tunnel flow usually should be considered unknown, so a source panel is appropriate at the downstream closure. If this panel is defined with IST = -1, the associated control point is free to be located at the upstream closure (or some other velocity reference point). Of course, care must be exercised to assure that the boundary condition imposed is independent of all other boundary conditions.

The limiting far field level of the perturbation potential is established at zero implicitly through the influence coefficient formulation for all singularities. Under the concept of an unperturbed outer flow, the perturbation potential must be essentially zero everywhere outside of the computational boundary. In the tunnel flow domain, however, the perturbation potential must be free to respond to the imposed disturbances and constraints. Thus, unknown strength doublet panels are required over the entire computational boundary except for one point (or one essentially unperturbed region such as the upstream closure surface) where the potential level in the interior flow must be linked to that in the exterior flow by use of boundary condition type 5 or by omission of a doublet panel. Care should be exercised to avoid such a potential linkage between inner and outer flows anywhere else on the computational boundary.

The user is cautioned that in computing the aerodynamic influence coefficients for doublet panels, the program omits the velocity influence of the line vortices at panel edges; the potential influence, however, is fully calculated. Although this procedure is beneficial in smoothing the calculated velocity distributions over panel boundaries, it is most appropriate for the biquadratic doublet panels and can render the use of constant doublet networks completely inappropriate for many applications. It is suggested, therefore, that for wind tunnel simulation problems, biquadratic distributions should be chosen wherever doublet panels are needed except for such applications as upstream and downstream boundary closure where an adequate level of doublet continuity across panel boundaries is possible with constant doublet panels. Even there, the use of velocity boundary conditions should be examined critically.

It should be noted that an obvious violation of the concept of an unperturbed outer flow occurs with the discrete wall slot model invoked by the IST = 9 network. The perturbation arising from collecting the wall flux into discrete lines is felt with equal strength on both sides of the computational boundary. The far field behavior of this perturbation is akin to that from a line doublet segment which decays one order more rapidly with distance than that from a line source or vortex. Even in the near field of wall slots, the use of the unperturbed outer flow boundary condition (type 4) is rendered valid by a program feature which specifically omits the flux discretizing perturbation from the formulation of this condition.

THE INPUT DATA FILE

The input data file is a sequence of card image records. The following subsection entitled Input File Records describes in order all of the record types which are or might be required. The input variables, format, and repetition requirement for each record type is given and the conditional requirements are noted in comments. A following subsection lists the definitions of all input variables in the order encountered in the input file. Note that record type 1 is read only as the first line of the input file; second and succeeding cases are entered beginning with record type 2. The value of CASID is automatically incremented by unity upon completion of each case. All other record inclusion requirements are independent of the succession of cases even if the value of IDEBUG(10) causes the program to ignore the data in some records.

The appendices A, B and C give more detailed descriptions of the IDEBUG array, the network linkage provision, and the test model representation, respectively. A sample input data file is given in Appendix D for a case simulating one of the test points in the test program reported in reference 4.

Input File Records

Record Type	No. of Records	Format	Variables or comments
1	1	F10.0	CASID -- First line only, do not repeat for multiple case input files.
2	1	10A8	TITLE
3	1	2I5,5F10.0	ISYM, NNET, AMREF, XROT, ZROT, SMOD, THETS
4	1	10I4	IDEBUG(1-10)
5	NNET	17I4	NL, ML, NLR, IDEFN, IST, IDT, IRHSI, IAICP, IBCIP, IBCEP(1-4), IBCCP(1-4)
			Include record types 6 and 7 only if one or more networks have IST = 8 or 9.
6	1	3F10.0	PLM, ETS, SES
7	1	I10,4F10.0	ITMX, CNVQ, RLX, WFS, FLN
			For each network, taken in order from 1 to NNET, include either a group of type 8 through 12 records if IDEFN=0, or the required number of type 13 records if IDEFN=1.
8	1	4I5,F10.0	MRF, NDIR, MDIR, NORM, XNO

9	NL/8	8F10.0	XND(I)
10	ML/8	8F10.0	XMD(I)
			Include record types 11 and 12 only for networks having IST=8 or 9.
11	(ML-1)/8	8F10.0	AK(I)
12	(ML-1)/8	8F10.0	SLTW(I)
13	NL*ML	3F10.0	PDEFP(I)
			Include the required number of type 14 records for each network having IRHSI=1.
14	(NL-1)* (ML-1)/8	8F10.0	BCENP
			NFBP is total number of free boundary points. Count 1 for each IST=-1 network and 3 for each IST=-2 network.
15	NFBP	2I5,7F10.0	IPOINT, IBCT, PCONP[(1-3), SCONP(1-3), BCONP
			Include records of type 16 through 25 only if IDEBUG(5)=4.
16	1	5I5	NBS, NWS, NTS, NSEB, ISEB
17	1	5F10.0	XMROT, ZMROT, DTHET, ZWING, ZTAIL
			Include types 18 through 21 only if NBS$\geq$2, omitting type 21 if NSEB=0.
18	NBS/8	8F10.0	XBS(I)
19	NBS/8	8F10.0	ZBS(I)
20	(NBS-1)/8	8F10.0	QBV(I)
21	NSEB/8	8F10.0	WKW(I)
			Include types 22 and 23 only if NWS$\geq$2.
22	NWS	6F10.0	YWG, XCW, QS0, QS1, QS2, QS3
23	NWS	4F10.0	QG0, QG1, QG2, QG3
			Include types 24 and 25 only if NTS$\geq$2.
24	NTS	6F10.0	YTS, XCT, QS0T, QS1T, QS2T, QS3T

25	NTS	4F10.0	QG0T, QG1T, QG2T, QG3T
			Type 26 required for all cases.
26	1	3I5	NST, NSEP, ISEP
			Include types 27 through 30 only if NST$\geq$2, omitting type 30 if NSEP=0.
27	NST/8	8F10.0	XSS
28	NST/8	8F10.0	ZSS
29	(NST-1)/8	8F10.0	QSV
30	NSEP/8	8F10.0	WKW
			Include types 31 and 32 only if IDEBUG(7)=2.
31	1	2I10,F10.0	NROW, NSTR, DELS
32	NROW	I10,6F10.0	NPROW, X1, Y1, Z1, X2, Y2, Z2

Definition of Input Variables

CASID — Case identification number to be recorded on SIF file. Should have integer value for proper SIF file usage. Value of 0.0 causes no SIF file to be written.

TITLE — 80 character case identification label.

ISYM — Symmetry flag
- = 0 for no symmetry
- = 1 for problem symmetric about y = 0 plane. Items not reflected are point disturbance model, full model body, sting, and PLM.

NNET — Total number of networks.

AMREF — Reference Mach number.

XROT,ZROT — x- and z- coordinates of center of rotation of sting support system.

SMOD — Model strength. Strength of point doublet, source or lift system if IDEBUG(5) = 1, 2 or 3. If IDEBUG(5) = 4, multiplying factor for wing lift only.

THETS — Pitch angle setting of sting support system, degrees.

IDEBUG — A 10-element integer array for program control (see Appendix A).

NL,ML Number of n-lines and m-lines for a network.

NLR Receiving network number for linked output (see Appendix B).

IDEFN Panel geometry input flag.
- = 0 for simplified orthogonal network input form.
- = 1 for input listing of panel corner point coordinates.
- = 2 for IBCIP = 9 network downstream of a similar network on the same wall and sharing same plenum, input form same as IDEFN = 0.

IST Source distribution type (see Table II).

IDT Doublet distribution type (see Table I).

IRHSI Right hand side constant input flag.
- = 0 for B = 0.
- = 1 for B read from record type 14.

IAICP Output calculation flag.
- = 1 Velocity at control points calculated from aerodynamic influence coefficients.
- = 4 Both forms of velocity calculation.
- = 5 Velocity at control points calculated from panel singularities assuming unperturbed velocity on negative normal side.

IBCIP Boundary condition type at network interior control points (see Table III).

IBCEP(I) Boundary condition type at control points on network edge I (see Table III).

IBCCP(I) Boundary condition type at control points at network corner I (see Table III).

PLM Total mass flow rate from plenum through slots into tunnel.

ETS x-location of discrete slot control points in fraction of slot line segment length.

SES Recession distance of discrete slot control points into tunnel interior.

ITMX Maximum number of iterations allowed for solution of problem with nonlinear slot boundary conditions.

CNVQ Convergence criterion for maximum residual of nonlinear slot boundary conditions.

RLX Relaxation factor for update of nonlinear slot boundary conditions.

WFS Longitudinal smoothing factor for slot flux used in evaluating slot inflow nonlinearity .

FLN — Scaling factor used in setting boundary condition for slot inflow separation bubble.

MRF — Index of m-line to be identified as slot reentry flap leading edge.

NDIR, MDIR, NORM — Coordinate direction of advancing n-index, advancing m-index and network normal respectively. Use 1, 2, 3 for x, y, z.

XNO — Value of NORM coordinate at network plane.

XND(I) — Array of n-line coordinates in NDIR direction (I=1 to NL).

XMD(I) — Array of m-line coordinates in MDIR direction (I=1 to ML).

AK(I) — Array of slot parameter values at control points on a slot representative of the network (I=1 to ML-1). Enter nondimensional parameter $\widetilde{K}$ for IST=9, dimensional parameter Kd for IST=8.

SLTW(I) — Array of slot width at m-line locations on a slot representative of the network (I=1 to ML-1). Input values are used only to evaluate slot outflow nonlinearity.

PDEFP(I) — Coordinates of panel corner points in network (I=1, 2, 3 for x, y, z).

BCENP — Array of right hand side constant B for all panel center points in network.

IPOINT — Panel index number to define panel normal recession direction of free boundary point.

IBCT — Boundary condition type.

PCONP(I) — Free boundary point coordinates (I=1, 2, 3 for x, y, z).

SCONP(I) — Components of unit normal vector used for boundary condition type 3 (I=1, 2, 3 for x, y, z).

BCONP — Right hand side constant B.

NBS — Number of body stations.

NWS — Number of wing stations.

NTS — Number of tail stations.

NSEB — Number of consecutive body segments having separated flow.

ISEB Index of initial body segment having separated flow.

XMROT, ZMROT x- and z-coordinates of center of rotation in model coordinate system.

DTHET Pitch angle of model coordinate system relative to sting, degrees.

ZWING, ZTAIL z-coordinate of wing reference plane or tail reference plane respectively in model coordinate system.

XBS(I) Array of x-coordinates of body stations in order of increasing x in model coordinate system (I=1 to NBS).

ZBS(I) Array of z-coordinates of body stations in model coordinate system (I=1 to NBS).

QBV(I) Volume of body segment between stations I and I+1 (I=1 to NBS-1).

WKW(I) Array of wake widths behind body segments with separated flow (I=1 to NSEB).

YWG(I) Array of y-coordinates of wing stations in order of increasing y (I=1 to NWS).

XCW(I) Array of x-coordinates of wing station mid-chord points in model coordinate system (I=1 to NWS).

QS0(I), QS1(I), QS2(I), QS3(I) Coefficients of multipole representation of wing section thickness distribution at wing station I (see Appendix C).

QG0(I), QG1(I), QG2(I), QG3(I) Coefficients of multipole representation of wing chordwise circulation distribution at wing station I (see Appendix C).

YTL(I) Array of tail station y-coordinates in increasing order (I=1 to NTS).

XCT(I) x-coordinate of mid-chord point at tail station I in model coordinate system (I=1 to NTS).

QS0T(I), QS1T(I), QS2T(I), QS3T(I) Coefficients of multipole representation of tail section thickness distribution at tail station I (see Appendix C).

QG0T(I), QG1T(I), QG2T(I), QG3T(I) Coefficients of multipole representation of tail chordwise circulation distribution at tail station I (see Appendix C).

NST Number of sting stations.

NSEP	Number of consecutive sting segments having separated flow.
ISEP	Index of initial sting segment having separated flow.
XSS(I)	Array of sting station x-coordinates at THETS=0 relative to center of rotation in increasing order (I=1 to NST).
ZSS(I)	Array of sting station z-coordinates at THETS=0 relative to center of rotation (I=1 to NST).
QSV(I)	Volume of sting segment between stations I and I+1 (I=1 to NST-1).
WKW(I)	Separated flow wake width behind sting segment between stations I+ISEP-1 and I+ISEP (I=1 to NSEP).
NROW	Number of rows of initial flow survey points.
NSTR	Number of points along a streamline through each initial flow survey point.
DELS	Distance increment between flow survey points along a streamline.
NPROW	Number of points in a row of initial flow survey points.
X1, Y1, Z1	Coordinates of first point in a row of initial flow survey points.
X2, Y2, Z2	Coordinates of last point in a row of initial flow survey points.

Array Size Limitations

Program dimensions limit the maximum values of certain input variables and combinations thereof as follows:

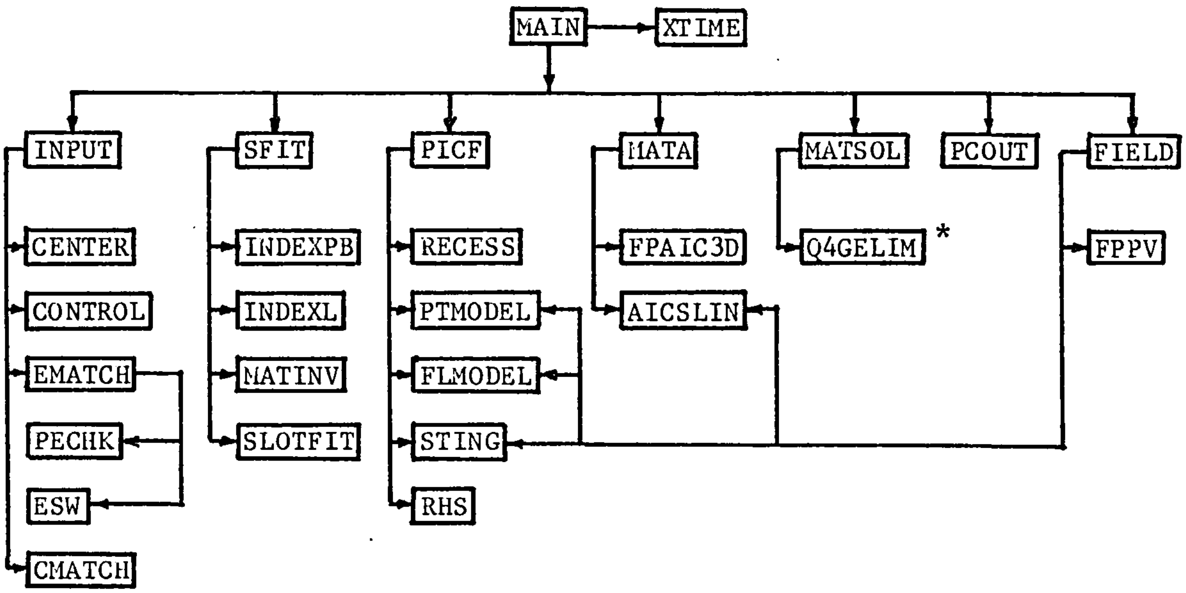
Quantity	Name	Maximum
Total number of networks,	NNET	12
Number of IST=8 and IST=9 networks.		3
Number of panel defining points, $\sum^{NNET}$ (NL*ML)		1200

Number of unknowns, $\sum\limits^{IDT=3} (NL+1)*(ML+1) + \sum\limits^{IDT<3} (NL-1)*(ML-1) + \sum\limits^{IST=8} (NL-1) - \sum\limits^{IST=9} (ML-1)$		600
Number of influenced points = number of unknowns (above) $+ \sum\limits^{IBCIP=0} (NL-1)*(ML-1) + \sum\limits^{IST=8,IDEFN=0} (NL-1) + \sum\limits^{IST=9,IDEFN=0} (NL-2)$		660
NL for each IST=9 network		8
NL for each IDEFN=0 network		20
ML for each IDEFN=0 network		25
Number of body stations	NBS	50
Number of wing stations	NWS	20
Number of tail stations	NTS	20
Number of sting stations	NTS	50
Number of field survey points $\sum\limits^{NROW} NPROW$		660

PROGRAM ORGANIZATION, OUTPUT AND COMPUTER INTERFACE

Program STIPPAN is written in CDC CYBER 200 FORTRAN Version 1.4 and is compatible with the CDC CYBER 200 FORTRAN Version 2 compiler and the CDC VSOS Version 2.1.5 operating system. The program is made up of 28 code modules linked by the calling paths shown in Figure 1. Program dimensions allow 16 networks and are geared to a maximum problem size of 600 unknowns.

The MAIN program is a simple executive routine which calls the seven major groups of subroutines in sequence and records the CPU time utilized in each. The INPUT group of subroutines reads the panel network input data and deals with panel and control point geometry. The SFIT group produces data relating the higher order coefficients of the singularity distribution on each panel to the singularity strengths at neighboring control points. These data are written panel by panel to a scratch file identified as TAPE1 which is accessed in the MATA, PCOUT and FIELD subroutines. The PICF group performs final adjustments to the control point locations and generates most of the problem forcing data accumulated on the right hand side of the matrix equation. In the MATA group, the aerodynamic influence coefficients for all panels and source lines are calculated, accumulated according to the higher order singularity coefficients, stored for subsequent use and assembled according to boundary condition type into the primary coefficient matrix. All of these operations are performed in a single network loop to minimize data paging



*Q4GELIM is a library subroutine

Figure 1.- STIPPAN program routines and calling paths.

into and out of core. The basic influence coefficient storage array has a dimension of 1,440,000 and is accessed again in subroutine PCOUT. The matrix equation is solved in the MATSOL group. If a nonlinear slot boundary condition is specified, the solution is iterated with updates to the right hand side. The gaussian elimination subroutine used is a Langley math library routine which factors the linear coefficient matrix only for the first solution and simply performs a back substitution for subsequent solutions. The PCOUT subroutine prepares the basic solution output data at the panel network control points. The FIELD group uses the singularity strengths defined by the solution to produce a flow survey at new field points arbitrarily specified by the user. This requires the calculation of new aerodynamic influence coefficients but data handling is minimized by accumulating the results directly in the output arrays.

Five files are named in the program statement. TAPE1 is a binary file which, as previously noted, is a scratch file written and read by the program. The remaining files are coded files. The input data file is identified as TAPE5, and TAPE6 is the print file used as the primary output file. TAPE25 contains solution and field survey results in a condensed form and is intended to be accessible for a quick look at results. TAPE2 contains solution and field survey results in a special coded format designed for easy conversion to the CYBER 170 binary format of a Standard Interface File (SIF) as described in Ref. 5. The SIF file

```
      PROGRAM WSIFT (TAPE2,TAPE6)
      DIMENSION DATA(100)
      REWIND 2
      REWIND 6
      READ(2,50,END=999) KEY,N,(DATA(I),I=1,N)
   50 FORMAT( A10,I4,(8(A10,3X)))
      GO TO 2
    1 READ(2,100,END=999) KEY,N,(DATA(I),I=1,N)
  100 FORMAT(A10,I4,(8E13.6))
    2 WRITE(6) KEY,N,(DATA(I),I=1,N)
      GO TO 1
  999 STOP
      END
```

Figure 2.- Fortran program to convert file TAPE2 to the SIF format.

is intended for postprocessing by one of the graphics utility programs in the Langley Research Center system of data processing utilities. The SIF file could not be written directly by program STIPPAN because the VSOS operating system has no provision for converting alphanumeric data to the CYBER 170 binary format. The FORTRAN program listing given as Figure 2 can be used to convert TAPE2 to a SIF file. The following information is needed for plotting from the SIF file. The names in the SIF file NAMES record are:

CASE, NETWORK, ROW	Heirarchial data identifiers
XLOC, YLOC, ZLOC	Point coordinates
VXTOT, VYTOT, VZTOT	Components of total velocity
VXINT, VYINT, VZINT	Components of interference velocity
PCOEF	Value of pressure coefficient
PHI	Perturbation potential

The value in CASE starts with CASID from record 1 of the input data file and is incremented by unity for subsequent cases in a multi-case run. NETWORK values from 1 to NNET give data at panel center control points at ROW values from 1 to NL-1. Generating networks in a linkage set are omitted unless IST=9. Data given for an IST=9 network are at slot comtrol points at ROW values from 1 to NL-2 and interference velocity components are not given; instead, VXINT contains the x location of the line segment end where S is quantified and VZINT contains the line source strength normalized to an equivalent normal velocity, -S/2d. Data from FIELD survey rows are identified by a NETWORK value of NNET+1.

APPENDIX A
THE IDEBUG ARRAY

IDEBUG is a 10-element integer array used for program control. The available options for each element are listed below.

IDEBUG(1)	= 0	Execute complete program
	= 1	Stop after INPUT routines
	= 2	Stop after SFIT routines
	= 3	Stop after PICF routines
	= 4	Stop after MATA routines
	= 5	End this case after MATSOL routine
IDEBUG(2)	= 0	Normal panel data output
	= 1	More detailed panel data output
IDEBUG(3)	= 0	Normal control point output
	= 1	More detailed control point output
IDEBUG(4)	= 0	Normal singularity fit output
	= 1	Add panel and index output
	= 2	Add panel orientation and AH matrix output
IDEBUG(5)	= 0	No wind tunnel test model
	= 1	Point doublet model
	= 2	Point source model
	= 3	Point lift model
	= 4	Distributed singularity model
IDEBUG(6)	= 0	Linear slot boundary condition
	= 1	Include outflow dynamic pressure nonlinearity
	= 2	Include outflow and inflow nonlinearities
IDEBUG(7)	= 0	Omit FIELD routines
	= 2	Call FIELD routine
IDEBUG(8)	= 0	Normal solution output
	= 1	Add perturbation output at all control points and source panel output for IST=9 and IBCIP=0 networks
IDEBUG(9)	> 0	δ = .1*IDEBUG(9)
	< 0	δ = 10.**IDEBUG(9)
IDEBUG(10)	= 0	Execute full program
	$\geq$ 1	Suppress listing of geometry details
	$\geq$ 2	Use singularity fit from previous case
	$\geq$ 3	Use aerodynamic influence coefficients from previous case
	$\geq$ 4	Use factored matrix from previous case

Significant savings in volume of output and computer time can be achieved by executing multiple cases in a single job submission with judicious use of IDEBUG(10). Constraints on the allowable use of IDEBUG(10) are given below.

IDEBUG(10) =0 or 1 must be used for:

a. First case in input file
b. Changed number of networks or number of panels or control points in any network
c. Changed panel geometry in a network with (IST or IDT)>1
d. Changed singularity type involving (IST or IDT)>1
e. Changed Mach number if any network has (IST or IDT)>1

IDEBUG(10) ≤ 2 must be used for:

a. Changes in panel or control point geometry, singularity type or Mach number not noted above
b. Changed boundary condition type to or from type 4

IDEBUG(10) ≤ 3 must be used for:

a. Changed slot K
b. Changed boundary condition type not involving type 4

IDEBUG(10) = 4 may be used for:

a. Changed right hand side constants
b. Changed slot width or nonlinearity specification (K unchanged)
c. Any change in model or sting specification
d. Any change in FIELD survey specification

APPENDIX B
NETWORK OUTPUT LINKAGE

A basic part of the solution output listing is a comprehensive listing of panel singularity strengths and gradients and flow characteristics on the positive normal side of the panel at the center point of each panel in each network. If IBCIP=4 was specified for the network, the panel center control point is located on the opposite side of the panel, and if IAICP=1 or 4 was specified, the aerodynamic influence coefficients are used to calculate the flow potential and velocity components at the control point. The local doublet strength and gradients and source strength are then used to transfer the flow potential and velocity components to the positive normal side of the panel. Network output linkage provides the capability to merge this output computation and listing within each group of coplanar networks.

The program assigns a network number NNE in sequence from one to NNET in the same order in which the networks are defined by the type 5 records of the input data file. Groundrules for the use of linkage are listed below.

1. Linkage occurs in groups with one receiver network and one or more generator networks in each group.

2. Doublet panels may exist only in the receiver network and must not exist in the generator networks.

3. The network number of each generator network in a linkage group must be higher than that of the receiver network for that group and lower than that of the receiver network for the next group. Non-linked networks may be interspersed at will.

4. Linkage is invoked by setting NLR for each generator network in one group equal to the receiver network number for the same group. NLR for each receiver or non-linked network should be set to zero.

5. All networks involved in linkage must be defined with IDEFN=0 or 2 and those in each group must have identical values of NDIR, MDIR, NORM and XNOR. (Only flat, orthogonally oriented, coplanar networks may be linked together.)

APPENDIX C
MODEL AND STING REPRESENTATION

In program STIPPAN, the wind tunnel test model may be represented either by a point disturbance or by a distributed system of singularities. The selection is made through the value of IDEBUG(5) as described in Appendix A.

Point Disturbance Model

The point disturbance is located at the center of rotation specified by the input values of XROT and ZROT and the disturbance strength is specified by SMOD. The strength is generally interpreted as model volume in the case of a point doublet, wake displacement cross section area for a point source, and lift coefficient multiplied by half the model reference area in the case of a point lifting system. The three types of point disturbance may not be combined in a single case.

Distributed Singularity Model

The distributed singularity representation of the test model is evolved from that used in program LINCOR by Rizk and Smithmeyer (Ref. 6) and is described more fully in Ref. 3. The model consists of three components, body, wing and tail. Each component is defined by input data given at a specified number of stations. If the number of stations specified for any component is less than two, no further input data is read for that component and it makes no contribution to the model perturbation. For convenience of geometry input, separate reference coordinate systems are used for the model and for the sting. These two systems, together with the wind tunnel coordinate system share a common plane of symmetry at y=0. The center of sting rotation is located by the coordinates XMROT and ZMROT in the model reference system. The angle DTHET is the pitch orientation of the model reference system relative to the sting axis. The model and sting are then located in the tunnel by the sting rotation center coordinates XROT and ZROT in the tunnel coordinate system and the sting pitch angle THETS.

<u>The Model Body</u>.- The body is represented by use of inclined slender body principles in which a point source represents a change in cross section area scaled by cosine of angle of attack, and a line doublet segment represents the local cross section area scaled by sine of angle of attack. The present program applies this concept segment by segment to accommodate an irregular body camber shape. The body axis is located in the y=0 plane. Body input data should describe the full body rather than a half body because body influence computations are independent of the input value of ISYM. The input quantities NBS, XBS and ZBS give the number and coordinates of stations along the body axis and the volume of each segment between stations is input into QBV. A separated wake is presumed to trail from the blunt base of the last body segment. The wake

displacement is the cross section area of the last segment scaled by cosine of the segment angle of attack. This wake may be eliminated by appending a dummy segment having zero volume to the end of the body. Integration of the body with a sting is discussed in the subsequent section describing the sting representation.

Capability is provided to represent additional wake blockage due to flow separation from an inclined body. NSEB is the number of consecutive body segments generating a wake, ISEB is the segment number of the first segment in the separated series and the wake width behind each separated segment is read into WKW. The equivalent wake cross section area behind each segment is the wake width WKW multiplied by the projected length of the body segment axis on the tunnel z axis.

The Model Wing.- The wing lies in the z=ZWING plane in the model coordinate system and is described by input data at the number of wing stations specified by NWS. The YWS array gives the y coordinate of each station. If the symmetry option is selected (ISYM=1) the first and last stations should be at y=0 and at the wing tip. The far field perturbations due to wing thickness and lift are approximated by representing the chordwise distributions of thickness and lift at each wing station by the first four terms of a multipole series located at the half-chord point at the wing station. The x locations of the half-chord points are read into the XCW array.

The multipole coefficients required to complete the wing input data at each wing station may be evaluated as follows. Let X_1=x-XCW, the thickness distribution t(x) and the lift distribution $\gamma(x)$ be defined from the section leading edge $X_1=-c/2$ to the trailing edge $X_1=c/2$. Further, express the thickness gradient as $\sigma=\partial t/\partial x$. Then the thickness multipole coefficients are given by:

$$QS0 = \int_{-c/2}^{c/2} \sigma dX_1 = t_{TE}$$

$$QS1 = \int_{-c/2}^{c/2} \sigma X_1 dX_1 = t_{TE}\left(\frac{c}{2}\right) - \int_{-c/2}^{c/2} t dX_1$$

$$QS2 = \int_{-c/2}^{c/2} \sigma X_1^2 dX_1 = t_{TE}\left(\frac{c}{2}\right)^2 - 2\int_{-c/2}^{c/2} t X_1 dX_1$$

$$QS3 = \int_{-c/2}^{c/2} \sigma X_1^3 dX_1 = t_{TE}\left(\frac{c}{2}\right)^3 - 3\int_{-c/2}^{c/2} t X_1^2 dX_1$$

Note that the integrals of the form $\int tX_1{}^n dX_1$ are the thickness coefficients of the series used by Rizk and Smithmeyer (Ref. 6) which is applicable only for zero trailing-edge thickness. The present series can be evaluated from an "equivalent inviscid" thickness distribution in which t_{TE} represents the wake displacement thickness giving rise to wake blockage.

The lift multipole coefficients are given by:

$$QG0 = \int_{-c/2}^{c/2} \gamma dX_1$$

$$QG1 = \int_{-c/2}^{c/2} \gamma X_1 dX_1$$

$$QG2 = \int_{-c/2}^{c/2} \gamma X_1{}^2 dX_1$$

$$QG3 = \int_{-c/2}^{c/2} \gamma X_1{}^3 dX_1$$

which are identical to those used in Ref. 6. In the present program, the wing section lift multipole coefficients are multiplied by the input value of SMOD so if the multipole coefficients are evaluated for an overall wing lift coefficient of unity, the actual wing lift coefficient for a given case may be input into SMOD.

The Model Tail.- The tail input quantities are evaluated in a manner completely analogous to that described above for the wing except that the tail lift multipole coefficients are not scaled by any other input factor.

Sting Representation

The input data form for the sting is analogous to that described for the model body in a preceding section with two exceptions. First, record type 26 giving the three integer values NST, NSEP and ISEP is required in the input data file for all cases even if no sting is to be represented. If the value of NST is less than 2, no following sting data records are read. Second, the sting station coordinates XSS and ZSS are expressed in the sting coordinate system having its origin at the sting center of rotation and oriented at a pitch angle THETS relative to the tunnel coordinate system.

The sting is represented as a segmented inclined slender body by use of point sources and line doublets as described for the model body. In the case of the sting, however, the first point source, which would represent the growth in cross section area from zero to that of the first sting segment, is omitted. With this arrangement, a sting emerging from the blunt base of a model body may be described with the first sting station located at the last body station. The combined representation is then equivalent to a sting immersed in the wake behind the blunt body. If the nose of the sting is exposed to the unshielded tunnel flow, the sting should be described with a dummy zero-volume segment placed ahead of the actual sting nose.

It should be noted that the location of the model-sting interface is significant in that the interference perturbation at any point is calculated as the perturbation summed over all singularities except those included in the model representation.

APPENDIX D
SAMPLE CASE INPUT DATA FILE

The following input data file simulates one of the test points in the test program reported in reference 4. The tunnel is a facility providing a reduced-scale representation of the National Transonic Facility and the test model is the larger of the two delta-wing models used in the test program. Eleven panel networks are used to simulate the tunnel. Networks 1 and 11 provide the upstream and downstream closures respectively, networks 2, 3, 7 and 8 simulate the bottom and top slotted walls and networks 4 and 9 provide the effective area increase (set to zero herein) associated with a step at the slot ends. Networks 5 and 6 represent the solid sidewall with a contoured region opposite the sting support sector, and the sector itself is approximated as a wedge-nosed plate by network 10.

The model is inverted and the sting center of rotation is somewhat below the tunnel axis. It may be noted that the actual model had a vertical tail but no horizontal tail. The numerical description in the sample input data incorporates a very short span tail having a thickness description tailored to reproduce the cross section area distribution of the actual vertical tail, and a lift description to reproduce the zero-lift pitching moment of the actual model. The wing lift description corresponds to a wing lift coefficient of negative unity with a moment center matching the experimental aerodynamic center. Thus, the experimental lift and pitching moment are both matched if the value of SMOD is set at the experimental lift coefficient reduced by the contribution of the numerical representation of the tail.

Illustrative results from this sample case are shown in reference 3 as the "Basic DFA simulation".

```
 1.
 LARGE HST MODEL IN DFA, RUN 5, PT 9.
    1   11 .5873     3.3995     -.08357   .1233      -3.226
   0   0   0   0   4   2   2   0  -2   0
   2   2   0   0   1   0   0   1   4
   5  20   0   0   0   3   0   1   4   4  12   4   4   4   4   4   4
   5  15   2   0   9   0   0   1   9
   2   2   2   0   1   0   1   1   0
   6  20   0   0   0   3   0   1   4   4   4   4   4   4   4   4   4
   2   5   5   0   1   0   1   1   0
   5  20   0   0   0   3   0   1   4   4   4   4  12   4   4   4   4
   5  15   7   0   9   0   0   1   9
   2   2   7   0   1   0   1   1   0
   2   2   0   0   1   0   1   1   0
   2   2   0   0  -1   1   0   1   4
0.        1.        .005128
       200 .000001  1.        .03       .3
    0    3    2    1 -2.
-1.       1.
```

```
1.        0.
    0    2    1    3 -1.
1.        .83333    .5        .16667    0.
-2.       0.        .8        1.5       2.        2.4       2.75      3.1
3.45      3.8       4.15      4.5       4.9192    5.3       5.7       6.13777
6.6       7.3       8.        8.7671
   12    2    1    3 -1.
1.        .83333    .5        .16667    0.
0.        .8        1.5       2.        2.4       2.75      3.1       3.45
3.8       4.15      4.5       4.9192    5.3       5.7       6.1377
1.67      2.2       2.97      2.3       2.263     2.263     2.263     2.263
2.263     2.263     2.263     2.263     2.263     2.263
.0305     .0203     .0117     .0198     .02       .02       .02       .02
.02       .02       .05       .07       .09       .1
    0    2    1    3 -1.
1.        0.
4.9192    6.1377
    0    3    1    2 1.
1.        .716      .142      -.142     -.716     -1.
-2.       0.        .8        1.5       2.        2.4       2.75      3.1
3.45      3.8       4.15      4.5       4.9192    5.3       5.7       6.13777
6.6       7.3       8.        8.7671
    0    3    1    2 1.
1.        -1.
6.1377    6.6       7.3       8.        8.7671
    0    2    1    3 1.
0.        .16667    .5        .83333    1.
-2.       0.        .8        1.5       2.        2.4       2.75      3.1
3.45      3.8       4.15      4.5       4.9192    5.3       5.7       6.13777
6.6       7.3       8.        8.7671
   12    2    1    3 1.
0.        .16667    .5        .83333    1.
0.        .8        1.5       2.        2.4       2.75      3.1       3.45
3.8       4.15      4.5       4.9192    5.3       5.7       6.1377
1.67      2.2       2.97      2.3       2.263     2.263     2.263     2.263
2.263     2.263     2.263     2.263     2.263     2.263
.0305     .0203     .0117     .0198     .02       .02       .02       .02
.02       .02       .05       .07       .09       .1
    0    2    1    3 1.
0.        1.
4.9192    6.1377
    0    3    1    2 0.
1.        -1.
6.8157    7.1057
    0    3    2    1 8.7671
1.        -1.
1.        0.
0.
-.06623   -.08753   -.0123    -.00639
0.
.18889
    1    3 -2.0     .5        0.        1.        0.        0.        1.
```

10	5	4	0	0			
1.3239	0.	0.	0.	-.1424			
0.	.21911	.43822	.65733	.87644	1.09555	1.31467	1.53378
1.75289	2.00704						
0.	-.01	-.014	-.016	-.017	-.018	-.018	-.018
-.017	-.016						
.000295	.001517	.002711	.003204	.003156	.003103	.003366	.003945
.002821							
0.	1.15946	-.0072	-.02011	-.00148	-.00272		
.10956	1.27386	-.00539	-.01127	-.00062	-.00086		
.21911	1.38826	-.00358	-.00504	-.00019	-.00017		
.32867	1.50267	-.00177	-.00122	-.00002	-.00001		
.42223	1.60037	-.00022	-.00002	0.	0.		
-.95842	0.	-.06198	0.				
-.83707	.10435	-.05019	.01591				
-.5957	.07532	-.01905	.00762				
-.29454	.01841	-.0023	.00092				
-.03735	.0003	0.	0.				
0.	1.87884	0.	-.078	-.0036	-.0041		
.00548	1.93604	0.	-.0504	-.0019	-.0017		
.01643	2.05045	0.	-.0122	-.0002	-.0001		
.02579	2.14815	0.	-.0002	0.	0.		
-.1627	0.	0.	0.				
-.1353	0.	0.	0.				
-.0669	0.	0.	0.				
-.0085	0.	0.	0.				
23	0	0					
.6832	.7762	.8603	.9623	1.0553	1.1483	1.2414	1.3344
1.5241	1.7317	1.9304	2.2005	2.5005	2.8005	3.1005	3.4005
3.7005	4.0005	4.3005	4.6005	4.9005	5.2005	5.3676	
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	
.0007708	.0007708	.0007708	.0007708	.0007708	.0007708	.0007708	.003601
.009683	.0178	.03119	.03464	.03464	.03464	.03464	.03464
.02204	.02204	.02204	.02204	.02204	.01228		
	4	11.					
	210.	0.	-.083	4.	0.	-.083	
	410.	.2	-.083	8.	.2	-.083	
	410.	.4	-.083	8.	.4	-.083	
	410.	.6	-.083	8.	.6	-.083	

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William B. Kemp, Jr.

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Williamsburg, Virginia 23185

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16. Abstract
Guidelines are presented for use of the computer program STIPPAN to simulate the subsonic flow in a slotted wind tunnel test section with a known model disturbance. Input data requirements are defined in detail and other aspects of the program usage are discussed in more general terms. The program is written for use in a CDC CYBER 200 class vector processing system.

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