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User's Manual for PEPSIG NASA Tip Vortex Version

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PEPSIG
PROPELLER TIP VORTEX VERSION
INPUT DESCRIPTION

Input to PEPSIG (Propeller Tip Vortex version) consists of an initial card specifying the type of calculation to perform and a title, plus three namelists. Many of the input parameters have default values and do not need to be specified by the user unless some other value is desired. The type (REAL or INTEGER) of the input parameters follows standard FORTRAN convention, unless stated otherwise. (I.e., those starting with I, J, K, L, M, or N are INTEGER, and the remainder are REAL).

TITLE CARD

MODE An integer in column 1 specifying the type of calculation to be performed, as follows:
- 3 to compute and store geometric parameters for potential flow calculation.
- 2 to perform potential flow calculation.
- 1 to perform viscous flow calculation.
- 0 to terminate run.

TITLE A descriptive title in columns 2-33 used on the printed output and in the plot file.

NAMELIST RESTRT

The parameters specified in this namelist are primarily used to control where a restart file is read and/or written. A restart file must be used when changing the polynomials used to specify the geometry, the marching step size DT, the type of output desired, etc.

IRSTIN Marching station number to be read from restart file. IRSTIN = 0 implies this is not a restart case. The default value is 0.

IRSTOT The interval for writing onto the restart file (i.e., at station IRSTIN+IRSTOT, IRSTIN+2*IRSTOT, etc.). If IRSTOT = 0 no restart file is written. The default value is 0.

NFILE The sequence number in the restart file of the station to be read. E.g., if stations 1, 5, 20, and 24 have been written onto the restart file, and a restart at station 20 is desired, then NFILE should be 3. The default value is 1.

NSAVED The number of stations in the restart file to be saved. E.g., if stations 1, 5, 20, and 24 have been written onto the restart file, and NSAVED = 3, then when a restart is next written stations 1, 5, and 20 will be saved and station 24 will be overwritten. The default value is NFILE. Note that if JRSTIN = JRSTOT (see below) and NFILE = NSAVED, the same file can be used for reading and writing restart data with destroying any previously saved data.

NOTE: In practice NFILE and NSAVED are both usually defaulted, which results in each write to the restart file overwriting the previously saved station.

JRSTIN Fortran unit number from which restart data will be read. The default value is 11.

JRSTOT Fortran unit number onto which restart data will be written. The default value is 11.

NAMELIST FLUIDS

The first group of parameters in this namelist apply to all cases, and are used to set reference conditions, initial profiles, and boundary conditions.

IUNITS
1 Dimensionless input and output.
2 SI units in input and output.
3 English units in input and output.
The default value is 1.

INPOPT Eight options are available for specifying a consistent set of reference conditions. These conditions are also used to set up the initial profiles to start the viscous marching calculation. For INPOPT = 1 to 8, the parameters to be specified by the user are summarized as follows:

NPOPT	PARAMETERS SPECIFIED				
1	CMACH	REY	YZERO	TZERO	PZERO
2	UZERO	REY	YZERO	TZERO	PZERO
3	CMACH	REY	YZERO	TZERO	RZERO
4	UZERO	REY	YZERO	TZERO	RZERO
5	CMACH	REY	YZERO	SOUND	PZERO
6	UZERO	REY	YZERO	SOUND	PZERO
7	CMACH	REY	YZERO	SOUND	RZERO
8	UZERO	REY	YZERO	SOUND	RZERO

The default value is 1.

KTURB
0 Laminar flow.
1 Turbulent flow.
The default value is 0.

CMACH Reference Mach number. The default value is 0.01.

REY Reference Reynolds number, based on RZERO, UZERO, and

UZERO Reference velocity. The default value is 1.

YZERO Reference length. The default value is 1.

TZERO	Reference static temperature. The default value is 1.
PZERO	Reference static pressure. The default value is 1.
RZERO	Reference static density. The default value is 1.
SOUND	Reference speed of sound. There is no default value.
RG	Gas constant. RG = 1716. for both IUNITS = 1 and 3. RG = 287. for IUNITS = 2
CPR	Reference value for specific heat at constant pressure, used in formula for specific heat as a function of temperature. CPR = 6006.for both IUNITS = 1 and 3. CPR = 1004.for IUNITS = 2
BLD	A 4-element array giving the initial boundary layer thicknesses on the four computational surfaces. The default values are 0., 0., 0.and 0.2.
NS1	0 Symmetry boundary condition on computational surface 1. 1 Solid wall boundary condition on computational surface 1. The default value is 0.
NS2	0 Symmetry boundary condition on computational surface 2. 1 Solid wall boundary condition on computational surface 2. The default value is 0.
NS3	0 Symmetry boundary condition on computational surface 3. 1 Solid wall boundary condition on computational surface 3. The default value is 0.
NS4	0 Symmetry boundary condition on computational surface 4. 1 Solid wall boundary condition on computational surface 4. -1 Free stream boundary condition on computational surface 4. Extrapolation of vorticity in coordinate direction. -2 Free stream boundary condition on computational surface 4. Extrapolation of vorticity normal to surface. The default value is 1.
IBFX(4)	Streamwise velocity outer boundary condition: 0 Extrapolate U at outer boundary for NS4<0. 1 Set U at outer boundary to inviscid streamwise velocity if inviscid velocity is read from potential flow, otherwise set U to freestream velocity.
ISYM	Degree of symmetry in the cross-section. set ISYM = 1. The default value is 2.
IPRD	0 On blade calculation. 3 Used to control geometry, equation writing and matrix inversion when running case off trailing edge. The default value is 0.

ILAW
- 0 Compute the laminar viscosity coefficient from Sutherland's law.
- 1 Compute the laminar viscosity coefficient by assuming it is proportional to temperature to the 0.76 power.
- 2 Hold the laminar viscosity coefficient constant at its input value (computed from YZERO, UZERO, RZERO, and REY).

The default value is 2.

IVT
- 0 Hold the specific heat at constant pressure (CP) and the ratio of specific heats (GAMMA) constant at their input values (computed from TZERO).
- 1 Treat CP and GAMMA as variable functions of temperature.

The default value is 0.

FLRFC — Flare approximation criteria for separated flow regions. If U < FLRFC*UAVG, U is reset to FLRFC*UAVG. The default value is 0.025.

The following parameters also apply to all cases, and are used to specify the distribution of grid points in the streamwise direction, and the number of grid points in the transverse directions. The distribution of grid points in the transverse directions is controlled by parameters in namelist GEOM.

T — Marching parameter, or streamwise computational coordinate. This is the independent variable used in evaluating the polynomials PCL and PGEO in namelist GEOM. The value of T must be specified at the initial station. After a restart, however, the value is taken from the restart file. There is no default value.

DTE(K) — Step size in T for marching step from station IRSTIN to IRSTIN+1. There is no default value. Up to 10 piecewise continuous sections, each beginning at TSECT(K), can be specified. (default K=1).

AP(K) — Ratio of successive step sizes in T. I.e., AP =(T(I+1)-T(I))/(T(I)-T(I-1)). The default value is 1.0, corresponding to a constant step size. Up to 10 piecewise continuous sections, each beginning at TSECT(K), can be specified. (default K=1).

APTE — For NACA 0012 type of geometry, ratio of successive step sizes after step number NXTE (namelist GEOM). Used to decrease step size when approaching trailing edge.

APWK — For NACA 0012 type of geometry, ratio of successive step sizes after step number NXWKIN+2 (namelist GEOM). Used to increase step size after marching off trailing edge.

NS — Number of last streamwise station to be computed. I.e., the code will march from station IRSTIN to station NS. There is no default value.

NEY — Number of grid points in the circumferential direction. There is no default value.

NEZ — Number of grid points in the radial direction. There is no default value.

The following parameters apply to all cases and control the type and amount of output to be printed and/or written to the plot file. (ICOEF also controls other aspects of the calculation).

ICOEF A 6x20 array containg various switches, limits, etc. See the separate write-up on ICOEF for the details.

IWSTA A 101-element array specifying station numbers at which output will be printed. This option is activated when ICOEF(2,3) < 0. The default values are all 0.

KPRT(I) An array of up to 15 elements used to specify additional printout beyond the standard printout. This is done by setting KPRT(I) equal to an integer corresponding to the variable desired. For values from 1 to MVARP (a PARAMETER equal to the number of variables in the Z array), the corresponding variable from the Z array is printed. Additional variables may also be printed. Table ? lists the variables stored in the Z array, plus the others that may be printed. For example, setting KPRT(1) = 62 and KPRT(2) = 71 results in profiles of turbulence mixing length and Mach number being printed.
The default values are all 0.

IPLOT
0 Do not write a plot file.
1 Write a file for later post-processing. The stations written into the file are controlled by the values of ICOEF(2,4), ICOEF(2,5), and IPSTA.

The default value is 1.

IPSTA A 101-element array specifying station numbers at which output will be written into the plot file. This option is activated when ICOEF(2,5) < 0. The default values are all 0.

NPLT Number of variables written into the plot file at each station. The maximum allowed is MVARP + 10. The default value is 14.

KTRSF(I) An array of NPLT elements specifying which coordinate system vector components are to be used when writing the plot file. The subscript 'I' indicated the value of KTRSF is to be applied tothe variable with the same index in the KPLT array.

Coordinate locations:
1 Orthogonal reference line coordinates
2 Computational coordinates

Velocity components:
3 Absolute Cartesian coordinates
4 local Cartesian coordinates in the computational coordinate directions.

KPLT(I) An array of NPLT elements specifying which variables are to be written into the plot file. This is done in the same way as the specification of additional printout using KPRT. The defaults for KPLT are such that the following 14 variables are stored in the plot file:

1 Reference Cartesian coordinate in x-direction. Here "reference coordinate" refers to a fixed coordinate system, as opposed to one that is perpendicular to a duct centerline, for example.

2 Reference Cartesian coordinate in z-direction.

3 Reference Cartesian coordinate in y-direction.

4 u velocity component in orthogonal reference coordinate x-direction.

5 w velocity component in orthogonal reference coordinate z-direction.

6 v velocity component in orthogonal reference coordinate y-direction.

7 Static pressure coefficient.

8 Inviscid static pressure coefficient (from potential flow file).

9 Streamwise gradient of inviscid static pressure.

10 v velocity component in orthogonal reference coordinate y-direction.

11 w velocity component in orthogonal reference coordinate z-direction.

12 u velocity component in orthogonal reference coordinate x-direction.

13 Vorticity component in the streamwise direction, non-dimensionalized by UZERO/YZERO.

14 Secondary stream function, non-dimensionalized by UZERO*YZERO.

The following parameters determine at which locations information shall be printed (suffix PR) and written to the plot file (suffix PL).

NX1PR Print initial station.

NX2PR Print final station.

NY1PR Print first y-coordinate line.

NY2PR Print last y-coordinate line.

NZ1PR Print first z-coordinate line.

NZ2PR Print last z-coordinate line.

ISKPR	Skip every ISKPR lines in the y direction in cross plane print.
JSKPR	Skip every JSKPR lines in the z direction in cross plane print.
KSKPR	Skip every KSKPR planes in the x direction between printing.
IADDPR(I)	Add these y-direction grid lines to print file.
JADDPR(I)	Add these z-direction grid lines to print file.
KADDPR(I)	Add these planes to print file.
NX1PL	Plot initial station.
NX2PL	Plot final station.
NY1PL	Plot first y-coordinate line.
NY2PL	Plot last y-coordinate line.
NZ1PL	Plot first z-coordinate line.
NZ2PL	Plot last z-coordinate line.
ISKPL	Skip every ISKPL lines in the y direction in cross plane plot.
JSKPL	Skip every JSKPL lines in the z direction in cross plane plot.
KSKPL	Skip every KSKPL planes in the x direction between plotting.
IADDPL(I)	Add these y-direction grid lines to plot file.
JADDPL(I)	Add these z-direction grid lines to plot file.
KADDPL(I)	Add these planes to plot file.

The following parameters apply to all cases, and control the starting procedure for the initial marching step, and the sequence of solution of the equations.

KSTART	0 Original PEPSIG starting procedure. 1 Iterative starting procedure. 2 Split the first marching step into substeps. The default value is 0.
DXSTRT	Initial marching parameter step size for KSTART = 1 option. The default value is T+AP*DT.
NSTART	Number of iterations in the starting sequence if KSTART = 1, or number of substeps if KSTART = 2. The default value is 1.
ISEQ	0 Original equation solving sequence in PEPSIG.

	1 Optional equation solving sequence. 2 Another optional equation solving sequence. The default value is 0.
IBETA	0 Use the small scalar approximation. 1 Use the pressure approximation. The default value is 1.

The following parameters apply only to cases involving rotating coordinate systems.

IROT	0 No rotation. 1 Rotating coordinate system. The default value is 0.
ROSBYI	Inverse of the Rosby number (i.e., 2.*OMEGA*YZERO/UZERO, where OMEGA is the angular velocity), for the rotating coordinate system. The default value is 0.
ROTAX(I,1)	Reference Cartesian coordinates giving the direction of the rotation vector (used when IROT = 1). I = 1, 2, 3 corresponds to the y, z, x directions. The default values are 0., 0., 1., corresponding to the reference Cartesian x-direction.
ROTAX(I,2)	Reference Cartesian coordinates of the center of rotation. The default values are all 0., corresponding to the reference Cartesian origin.
ALPHA	Angle of attack

NAMELIST GEOM

The following parameters specify the geometry being analyzed.

NGEOM	42 NACA 0012 airfoil section. Used when marching off the trailing edge. 51 SR3 geometry package. The default value is 2.
ARC	Centerline arc length at the start of the calculation. The default value is 0.0.
IDUCT	0 External flow case. (Requires input reference point for pressure. See ICOEF(2,16) and (2,17)). 1 Internal flow case. The default value is 1.
TSECT(K)	The geometry can be specified in up to 10 piecewise continuous sections. Section K begins at TSECT(K) (default K=1).

NXTE — For NACA 0012 type of geometry, step number where APTE (namelist FLUIDS) controls ratio of successive step sizes. Used to decrease step size when approaching trailing edge.

NXWKIN — For NACA 0012 type of geometry, step number at trailing edge of blade.

DTTE — For NACA 0012 type of geometry, last Δt before trailing edge. Used to make the last step land exactly on the trailing edge.

DTWKIN — For NACA 0012 type of geometry, first Δt after trailing edge.

DTWKST — For NACA 0012 type of geometry, second Δt after trailing edge.

PCLD(I,J,K) — Used in SR3 geometry package. See SR3 input description. Coefficients, J, of polynomial in T.

PGEOD(J,1,K) — For NACA 0012 type of geometry, spanwise length of constant thickness airfoil in computational domain. Coefficients, J, of polynomial in T.

PGEOD(J,2,K) — For NACA 0012 type of geometry, distance from airfoil to outer computational surface. Coefficients, J, of polynomial in T.

PGEOD(J,3,K) — For NACA 0012 type of geometry, radius of rounded tip added to airfoil. Coefficients, J, of polynomial in T.

PGEOD(1,7,K) — For NACA 0012 type of geometry, y-direction displacement of cross section coordinate origin from inboard center of blade.

PGEOD(2,7,K) — For NACA 0012 type of geometry, z-direction displacement of cross section coordinate origin from inboard center of blade.

PGEOD(J,4,K) — For NACA 0012 type of geometry, thickness of airfoil. Coefficients, J, of polynomial in T.

EPSK(I,J) — Use in NACA 0012 input described below. Also used in SR3 geometry package. See SR3 input description.

The following parameters control the grid distribution in the cross plane for NACA 0012 type of geometries.

EPSK(I,1) — Grid index on outer boundary for 'CLPX' variable for OHGRID. (I=2,6)

EPSK(I,2) — Grid index on blade boundary for 'CLPX' variable for OHGRID. (I=2,6)

EPSK(I,3) — Grid spacing on outer boundary for 'SLOPE' variable for OHGRID. (I=2,6)

EPSK(I,4) — Grid spacing on blade boundary for 'SLOPE' variable for OHGRID. (I=2,6)

The following parameters control the grid distribution normal to the blade.

EPSK(10,1)	'SLOPE' variable for OHGRID.	
EPSK(11,1)	'ETAP' variable for OHGRID.	
EPSK(12,1)	'ALPHA' variable for OHGRID.	
EPSK(9,1)	0	Modify grid stretching normal to the blede based on boundary layer thickness.. For ICOEF(3,20)=0, use initial boundary layer, for ICOEF(3,20)=2, use local boundary layer
	1	Independent of boundary layer thickness.

PEPSIG
PROPELLER TIP VORTEX VERSION
ICOEF OPTIONS

ICOEF is a 6x20 array read in namelist FLUIDS that contains various switches, limits, etc. Some of these apply to both the potential flow (MODE=2) and viscous flow (MODE=1) calculations, some to only one or the other, and some to features in the code that are still under development. For the average user, many, if not most, of these options will have little significance. Those most likely to be needed by the typical user are marked with an asterisk. Except where noted, setting the value to 0 turns the option off. Except where noted, the default values are all zero.

ICOEF(1,n)

n	Description
1	1 Print initial station values at restart.
2	1 Momentum integral boundary layer calculation for straight pipe flow, with the correct area variation, as a basis for computing the turbulence mixing length. The default value is 1.
3	Maximum number of iterations in ADI for scalar potential solution and for Poisson pressure equation solution. The default value is 200.
4	Maximum number of iterations in ADI3D for potential flow solution. The default value is 200.
5	Maximum number of iterations in PRIMRY for computation of one-dimensional viscous pressure gradient correction. The default value is 10.
6	0 Linear interpolation on the potential flow file. 1 Potential flow pressure coefficient set equal to 0. 2 Quadratic interpolation on the potential flow file. The default value is 1.
7	Not used.
8	1 Print the Jacobian matrix at each grid point.
9	0 For SR3 geometry straight reference line. 2 For SR3 geometry helical reference line.
10	1 Print the secondary velocities in the orthogonal reference coordinates as computed during the scalar potential and coupled vorticity-stream function solutions.

11 1 Print the final computed velocities in the orthogonal reference coordinates.

12 <0 Print iteration data in ADI2X2 during the coupled vorticity-stream function solution every |ICOEF(1,12)| iterations.
0 Print namelist SCL2X2 in subroutine SCALE.
1 Same as 0, plus print of coefficients of input equations (first iteration only), plus iteration data every iteration.
2 Same as 1, plus print of coefficients of equations sent to matrix inverter each sweep, and resulting solution.
3 Same as 2, plus print from matrix inverter.
The default value is -5.

13 <0 Print iteration data in ADI during solution of scalar potential and Poisson pressure equations every |ICOEF(1,13)| iterations.
0 Print iteration data every iteration.
1 Same as 0, plus print of namelists TRMDMP, DTADI2, and DUMP in subroutine ADI.
2 Same as 1, plus print of coefficients of input equations (first iteration only).
3 Same as 2, plus print of coefficients of equations sent to matrix inverter each sweep, and resulting solution.
4 Same as 3, plus print from matrix inverter.
5 Same as 1.
The default value is -5.

14 <0 Print iteration data in ADI during solution of streamwise momentum every |ICOEF(1,13)| iterations (if ICOEF(5,5) = 0).
0 Print iteration data every iteration.
1 Print namelists TRMDMP, DTADI2, and DUMP in subroutine ADI during solution of streamwise momentum equation.
2 Same as 1, plus print of coefficients of input equations (first iteration only).
3 Same as 2, plus print of coefficients of equations sent to matrix inverter each sweep, and resulting solution.
4 Same as 3, plus print from matrix inverter.
5 Same as 1.
The default value is -5.

15 1 Print from subroutine FRAME.

16 1 Print of initial profiles from subroutine IPROF, MXPROF, or MYPROF.

17 2 Print coefficients of Laplace's equation during potential flow solution.

18 1 Print of physical coordinates, computational coordinates, and difference weights.

19 1 Print of data read from potential flow file.

20	For KSTART = 1 or 2 option, output is printed during starting procedure every ICOEF(1,20)'th iteration or sub-step.

ICOEF(2,n)

n	Description
1	Maximum number of iterations in ADI2X2 for coupled vorticity-stream function solution. The default value is 200.
2, 3	For ICOEF(2,3) greater than or equal to zero, computed profiles are printed every ICOEF(2,3)'th station starting at station ICOEF(2,2). If ICOEF(2,3) is less than zero, profiles are printed at stations specified by the array IWSTA. The defaults are 0 for ICOEF(2,2) and 1 for ICOEF(2,3).
4, 5	For ICOEF(2,5) greater than or equal to zero, computed results are written into the plot file every ICOEF(2,5)'th station starting at station ICOEF(2,4). If ICOEF(2,5) is less than zero, results are written into the plot file at stations specified by the array IPSTA. The defaults are 0 for ICOEF(2,4) and 1 for ICOEF(2,5).
6-12	Not used.
13	1 Print non-convergence message in ADI.
14	1 Non-dimensionalize all printed velocities by the average streamwise velocity at the initial station.
15	Used by the code to keep track of the number of points in separated flow regions.
16	Grid point index in the circumferential direction specifying the location of the reference pressure when using the external flow option (IDUCT = 0).
17	Grid point index in the radial direction specifying the location of the reference pressure when using the external flow option (IDUCT = 0).
18	1 Print KGRID output. 2 Print KGRID output, plus KGRID iteration data.
19	1 Print cross-plane grid point coordinates when ICOEF(2,20) = 1.
20	1 Print geometry parameters computed during a MODE = 3 calculation (geometry set-up for potential flow).

ICOEF(3,n)

n	Description
1	OHGRID dump.
2	Not used.
3	Save grid during MODE=3 run for use by potential flow code.
4	When setting up initial conditions make initial boundary layer thinner on pressure side of blade.
5	Alternate time scaling used in ADI2X2 iteration.
6	Update vorticity in START1 procedure.
7	0 Ignore phi-velocity terms when computing transverse velocity gradients as part of the computation of transverse pressure gradients in the Poisson pressure equation, and in the computation of the vorticity vector. 1 Include the phi-velocity terms. The default value is 1.
8	Compute inboard boundary condition rather than using no through flow boundary condition.
9	Print turned for ICOEF(3,8)=1 option.
10	0 Potential flow pressure coefficient from potential flow file. 1 Potential flow velocity from potential flow file. 2 Potential flow pressure coefficient and velocity from potential flow file. 3 Potential flow pressure coefficient, velocityand dP_i/dx from potential flow file. To get potential flow pressure coefficient and velocity from potential flow file. ICOEF(3,10) is automatically set equal to ICOEF(5,11) if ICOEF(5,11) = 0 or 1. If ICOEF(5,11) = 2, ICOEF(3,10) can be 0, 1, or 2.
11	Use inviscid velocities at boundaries only.
12	1 Smooth the potential flow pressure coefficient (or velocity if ICOEF(5,11) = 1) in the streamwise direction.
13	1 Print normalized arc-lengths when ICOEF(2,20) = 1.
14	1 Print absolute Cartesian coordinates when ICOEF(2,20) = 1.
15	1 Print elements of Jacobian grid transformation matrix when ICOEF(2,20) = 1.

16	Lag y-direction derivative during inboard boundary condition calculation, ICOEF(3,8)
17	Use inviscid velocity for initial streamwise velocity field.
18	Use inviscid velocity for initial cross flow velocity field.
19	Compute $\partial p/\partial s$ rather than $\partial p/\partial x$.
20	Controls grid stretching normal to the blade for NACA 0012 type cases. Also used for SR3 type geometries. See SR3 INPUT description.

ICOEF(4,n)

n	Description
1	Maximum pseudo-time step size used in ADI for solution of the scalar potential, energy, and swirl equations is divided by the factor 2**ICOEF(4,1).
2	Minimum pseudo-time step size used in ADI for solution of the scalar potential, energy, and swirl equations is divided by the factor 2**ICOEF(4,2).
3	0 BETA = 1.0 (backward streamwise differencing) in ADI. 1 BETA = 0.5 (Crank-Nicholson streamwise differencing) in ADI.
4	0 Use local minimum time step in ADI. 1 Use local maximum time step in ADI.
5	Maximum pseudo-time step size used in ADI2X2 for solution of the coupled vorticity-stream function equations is divided by the factor 2**ICOEF(4,5).
6	Minimum pseudo-time step size used in ADI2X2 for solution of the coupled vorticity-stream function equations is divided by the factor 2**ICOEF(4,6).
7	Maximum pseudo-time step size computed by SCALE for the source term in the solution of the coupled vorticity-stream function equations is divided by the factor 2**ICOEF(4,7).
8	0 BETA = 1.0 (backward streamwise differencing) in ADI2X2. 1 BETA = 0.5 (Crank-Nicholson streamwise differencing) in ADI2X2.
9	Maximum pseudo-time step size used in ADI3D for solution of the potential flow equation is divided by the factor 2**ICOEF(4,9).

10 Minimum pseudo-time step size used in ADI3D for solution of the potential flow equation is divided by the factor 2**ICOEF(4,10).

11 -1 Use local mean time step in ADI3D.
0 Use local minimum time step in ADI3D.
1 Use local maximum time step in ADI3D.
The default value is -1.

12 0 BETA = 1.0 (backward streamwise differencing) in ADI3D.
1 BETA = 0.5 (Crank-Nicholson streamwise differencing) in ADI3D.

13 Convergence criteria in ADI for scalar potential, Poisson pressure, energy, and swirl equations is multiplied by the factor 10**ICOEF(4,13).

14 Convergence criteria in ADI2X2 for the first equation (vorticity) is multiplied by the factor 10**ICOEF(4,14).

15 Convergence criteria in ADI2X2 for the second equation (stream function) is multiplied by the factor 10**ICOEF(4,15).

16 Convergence criteria in ADI3D is multiplied by the factor 10**ICOEF(4,16).

17 Number of time step cycles used in ADI3D for iterative solution of the potential flow equation. The maximum number is 3. The default value is 3.

18 1 Base the pseudo-time step for the first cycle in ADI3D on a combination of the magnitudes of the finite-difference operators in the circumferential, radial, and streamwise directions.
2 Base the time step on a combination of the circumferential and radial directions.
3 Base the time step on a combination of the radial and streamwise directions.
4 Base the time step on a combination of the circumferential and streamwise directions.
5 Base the time step on the circumferential direction.
6 Base the time step on the radial direction.
7 Base the time step on the streamwise direction.
The default value is 5.

19 Same as ICOEF(4,18), except for second cycle. The default value is 6.

20 Same as ICOEF(4,18), except for third cycle. The default value is 7.

ICOEF(5,n)

n	Description
1	1 Set the rotational part of the cross-flow velocity (computed during the coupled vorticity-stream function solution) to zero.
2	-1 Solve the Poisson pressure equation, but get the density from the potential flow pressure. 0 Solve the Poisson pressure equation, and get the density from the viscous flow pressure. 1 Skip solving the Poisson pressure equation, and get the density from the potential flow pressure. The default value is -1.
3	Used by the program in subroutine COEFVS. Do not change.
4	0 First order wall vorticity boundary condition. 1 Second order wall vorticity boundary condition.
5	0 Iterate the primary momentum equation to convergence each marching step (mainly important in separated flow regions). If used, convergence criteria (controlled by ICOEF(5,8)) should be tightened. 1 No iteration. The default value is 1.
6	Maximum pseudo-time step size used in ADI for solution of the primary momentum equation is divided by the factor 2**ICOEF(5,6). This only applies if iteration is used (ICOEF(5,5) = 0).
7	Minimum pseudo-time step size used in ADI for solution of the primary momentum equation is divided by the factor 2**ICOEF(5,7). This only applies if iteration is used (ICOEF(5,5) = 0).
8	Convergence criteria in ADI for primary momentum equation is multiplied by the factor 10**ICOEF(5,8). This only applies if iteration is used (ICOEF(5,5) = 0).
9	<0 if estimated initial velocity profiles are given as velocity components in the body-fitted computational coordinate system (instead of the centerline coordinate system).
10	0 No slip of secondary velocities. 1 Slip of secondary velocities. The default value is 0 for IBETA = 1, and 1 for IBETA = 0.
11	0 Potential flow solution from a pressure file (or to store a pressure file if MODE = 2).

	1	Potential flow solution from a velocity file (or to store a velocity file if MODE = 2).
	2	Potential flow solution from a file containing both pressure coefficient and velocity (but this is not currently available through PFLOW).
12	1	Include rotationality of inviscid velocity in COEFVS.
13	0	Ignore phi-velocity terms when computing streamwise velocity gradients as part of the computation of transverse pressure gradients in the Poisson pressure equation.
	1	Include the phi-velocity terms.
14		Maximum pseudo-time step size used in ADI for solution of the Poisson pressure equation is divided by the factor 2**ICOEF(5,14).
15		Minimum pseudo-time step size used in ADI for solution of the Poisson pressure equation is divided by the factor 2**ICOEF(5,15).
16-17		Not used.
18	-1	Inviscid velocity components in absolute cartesian coordinates (e.g.,Hess code)
	0	Inviscid velocity components in local cartesian coordinates along computational coordinates.
	1	Inviscid velocity components in orthogonal reference line coordinates
19	1	Update streamwise velocity and turbulent viscosity coefficient when using KSTART = 1 option.
20		Not used.

ICOEF(6,n)

1	0	No wake calculation.
	1	Wake calculation for NACA 0012 type blades.
		The default value is 0.

PEPSIG
PROPELLER TIP VORTEX VERSION
GEOMETRY INPUT DESCRIPTION

PEPSIG / SR3 INTERFACE

The corresponding values in the common block /SR3IO/ are given in parenthesis.

OUTER BOUNDARY REPRESENTATION.

The outer boundary coordinate system is determined by YB, ZB, and BETA. By assumption, YB and ZB are piecewise polynomial functions of the parameter X (consisting of a 'TIP' piece and a 'LEADING EDGE' piece), while BETA is a single polynomial function of X. X > PGEOD(7,3,1) for the 'TIP' piece, while X < PGEOD(7,3,1) for the 'LEADING EDGE' piece. The coefficients of X**(K - 1) in the polynomial expressions of YB-TIP, ZB-TIP, YB-L.E., ZB-L.E., and BETA as a function of X are stored in PGEOD(.,5-9,1). The actual values of YB, ZB, BETA, and DAB (for a given value of X) are computed in the subroutine GEOSR3. If PGEOD(6,3,1) = 0, the values of PGEOD(7,3,1) and PGEOD(.,5-9,1) are assumed to be specified on input. Otherwise, they are computed.

INPUT VARIABLES

PGEOD(1,3,1)	MAXIMUM VALUE OF DAB (I.E. THE INBOARD BOUNDARY LIES AT Z = -PGEOD(1,3,1)).
PGEOD(6,3,1)	SPECIFICATION OF THE OUTER BOUNDARY VIA PGEOD(7,3,1) AND THE POLYNOMIAL COEFFICIENTS PGEOD(.,5-9,1). = 0 : COMPUTED. = 1 : INPUT.
PGEOD(7,3,1)	VALUE OF THE PARAMETER X AT THE TIP L.E. X > PGEOD(7,3,1) : TIP. X < PGEOD(7,3,1) : L.E.
PGEOD(K,L,1)	COEFFICIENT OF X**(K - 1) IN THE POLYNOMIAL REPRESENTATION OF: L = 5 YB (TIP). L = 6 ZB (TIP). L = 7 YB (L.E.). L = 8 ZB (L.E.). L = 9 BETA (TIP AND L.E.).

GRID CLUSTERING.

EPSK(1-2,1)	CLUSTERING PARAMETERS, OUTER BOUNDARY PAR(1-2,1): MESH SPACING AT THE MID POINT.
EPSK(1-8,2)	CLUSTERING PARAMETERS, INNER BOUNDARY

	(PAR(1,2):	NUMBER OF POINTS USED TO DETERMINE THE CROSS-SECTIONAL THICKNESS,
	PAR(2,2):	MESH SPACING AT THE END POINTS,
	PAR(3-4,2):	MESH SPACING AT THE MID POINT,
	PAR(5-6,2):	PIVOT LOCATION CORRESPONDING TO THE END POINTS AND THE MID POINT,
	PAR(7-8,2):	PIVOT WIDTH)
EPSK(1-4,3)	CLUSTERING PARAMETERS, 'RADIAL' LINES	
	(PAR(1-2,3):	MESH SPACING AT THE INNER BOUNDARY,
	PAR(3-4,3):	PIVOT LOCATION AND WIDTH.)
BLD(3)	BOUNDARY LAYER THICKNESS (PAR(5,3))	
ICOEF(3,20)	POWER OF BOUNDARY LAYER THICKNESS (PAR(6,3)).	

Some of the grid clustering parameters depend on X and have to be computed at each station.

(1) THE MESH SPACING AT THE MID POINT ON THE INNER BOUNDARY IS DETERMINED BY THE PARAMETERS PAR(3-4,2),
PAR(3-4,2) = EPSK(3-4,2)*SUM (PGEOD(K,12,1)*X**(K - 1))
WHERE THE SUM IS TAKEN FROM K = 1 TO K = NP1.

(2) SIMILARLY, THE MESH SPACING AT THE INNER BOUNDARY POINT ON 'RADIAL' LINES IS DETERMINED BY THE PARAMETERS PAR(1-2,3),
(PAR(1-2,3) = EPSK(1-2,3)*SUM (PGEOD(K,13,1)*X**(K - 1)))
AND BY THE PARAMETER PAR(5,3), WHICH IS A MEASURE OF THE BOUNDARY LAYER THICKNESS.

INPUT PARAMETERS.

PGEOD(K,M,1) COEFFICIENT OF X**(K - 1) IN THE POLYNOMIAL REPRESENTATION OF THE MESH SPACING AT:
M = 12 THE MID POINT ON THE INNER BOUNDARY.
M = 13 THE INNER BOUNDARY POINT ON THE 'RADIAL' LINES.

REFERENCE LINE REPRESENTATION.

The reference line goes through the tip trailing edge (T.E.), at which point the parameter X = 0. It is straight if ICOEF(1,9) = 0, and helical (based on the tip helix for the design advance ratio) if ICOEF(1,9) = 2.

NOTATION.

ADV	ADVANCE ANGLE AT THE TIP CORRESPONDING TO THE DESIGN ADVANCE RATIO.
REFA	REFERENCE LINE 'ANGLE OF INCIDENCE' AT THE TIP T.E. SPECIFIED BY PGEOD(4,3,1) IF ICOEF(1,9) = 0, AND = ADV IF ICOEF(1,9) = 2.
REFSW	REFERENCE LINE 'SWEEP ANGLE' SPECIFIED BY PGEOD(5,3,1) IF ICOEF(1,9) = 0, AND = 0 IF ICOEF(1,9) = 2.

INPUT PARAMETERS.

ICOEF(1,9) REFERENCE LINE REPRESENTATION.
= 0 : STRAIGHT LINE.
= 2 : HELIX.

PGEOD(4,3,1)	DETERMINES REFA, THE REFERENCE LINE 'ANGLE OF INCIDENCE', I.E. THE ANGLE BETWEEN THE PROJECTION OF THE REFERENCE LINE ONTO THE ABSOLUTE CARTESIAN XY-PLANE AND THE ABSOLUTE CARTESIAN Y-AXIS. =0 REFA = TIPB. =1 REFA = ADV. =2 REFA = PI/2. <0 REFA = -PGEOD(4,3,1). NOT USED IF ICOEF(1,9) = 2.
PGEOD(5,3,1)	DETERMINES REFSW, THE REFERENCE LINE 'SWEEP ANGLE', I.E. THE ANGLE BETWEEN THE REFERENCE LINE AND THE ABSOLUTE CARTESIAN XY-PLANE. = 0 : REFSW = 0. < 0 : REFSW = -PGEOD(5,3,1). NOT USED IF ICOEF(1,9) = 2.

The following input parameters are computed from the geometry and should not be specified on input:

PCL(.,1-2)	CURVATURES OF THE STRAIGHT REFERENCE LINE, OR CURVATURE AND TORSION OF THE HELICAL REFERENCE LINE.
RFRAME(.), TFRAME(.), VFRAME(.), XFRAME	INITIAL LOCATION AND ORIENTATION OF THE REFERENCE LINE COORDINATE SYSTEM.

SR3 GOEMETRY PACKAGE

The input and output variables are read in the common block /SR3IO/

```
**************************
* COMMON BLOCK /SR3IO/   *
**************************

COMMON /SR3IO/  IXYZ,KGEOM,
                H(3,3),R(3),ISPL(6),EZPAR(6),
                NSS,NTT,NTIP,
                CP,BP,DP,MP,
                YB,ZB,BETA,DAB,DBC,NBB,PAR(8,3),
                DJ,XTIPTE,YTIPTE,ZTIPTE,TIPC,DTIPC,TIPCG,
                TIPB,TIPSW,TIPYAW,TIPANG,
                NCROSS,NTE,
                IREAD,IWRITE,IDRAW,
                IBLADE,IPROP,IWAKE,IWING,ITRAIL,ICROSS,IGRID,
                JGEOM,MPROP,MCROSS,MCLUST,MGRID
```

INPUT DATA

GEOMETRY DEFINITION:
(SUBROUTINES SR3XYZ, SR3WRT)

IXYZ — OPTION NUMBER WHICH DETERMINES THE METHOD BY WHICH THE COORDINATES ARE GENERATED. IF IXYZ < 0, THEN A CALL TO THE SUBROUTINE SR3PNL IS INCLUDED TO REGRID THE PROPELLER BLADE AFTER THE COORDINATES HAVE BEEN GENERATED.

ABS(IXYZ)	COORDINATE GENERATION METHOD
1	READ BLADE SECTION INFORMATION (AIRFOIL SECTION, CHORD, THICKNESS, TWIST ANGLE, YAW ANGLE, SWEEP ANGLE) AS A FUNCTION OF RADIUS, AND CONSTRUCT THE COORDINATES.
2	READ AIRFOIL SECTIONS AND CONSTRUCT COORDINATES FROM GIVEN CHORD, TWIST ANGLE, AND OFFSET DISTANCES.
3	READ COORDINATES.

KGEOM — OPTION NUMBER WHICH DETERMINES THE FORMAT IN WHICH THE DISK FILE IS WRITTEN THAT CONTAINS THE PROPELLER BLADE (OR WING) AND WAKE GEOMETRY.

KGEOM	FORMAT COMPATIBLE WITH
0	PANEL CODE (SUBROUTINE HESSR3).

CENTER-LINE REPRESENTATION:
(SUBROUTINE XYZROT)

H — TRANSFORMATION MATRIX (FROM ABSOLUTE CARTESIAN COORDINATES TO LOCALLY CARTESIAN CENTER-LINE COORDINATES).

R — POSITION VECTOR OF THE CENTER-LINE POINT (IN ABSOLUTE CARTESIAN COORDINATES).

SPLINE-FITS:
(SUBROUTINES CROSS0, XGRID)

ISPL(K) — TYPE OF SPLINE-FIT.

- = 0 CUBIC TAUT SPLINE.
- = 1 CUBIC SMOOTHING SPLINE THROUGH THE END POINTS, WITH CONSTANT DATA ACCURACY.

= 2	CUBIC SPLINE WITH ZERO FIRST DERIVATVES AT THE END POINTS.
= 3	CUBIC SPLINE WITH ZERO SECOND DERIVATIVES AT THE END POINTS.

EZPAR(K) SPLINE-FIT PARAMETER.
- TENSION PARAMETER IF ISPL(K) = 0.
- RELATIVE DATA ACCURACY IF ISPL(K) = 1.
- NOT USED IF ISPL(K) = 2, 3.

K	SUBROUTINE	SPLINE-FIT
1	DEFTE	T.E. LINE, X(Z), Y(Z).
2	XYFITZ	SPANWISE SECTION, X(Z), Y(Z).
3	SECT0	CHORDWISE SECTION, X(S), Y(S), Z(S).
4	WAKE0	WAKE PARAMETER, S(X).
5	WAKE0	WAKE LINE, Y(S), Z(S).
6	XPIECE	CROSS-SECTION, Y(S), Z(S).

COMPUTATION OF THE CROSS-SECTIONS: (SUBROUTINE CROSS0)

NSS — NUMBER OF SUBINTERVAL POINTS USED IN THE SEARCH FOR INTERSECTION POINTS OF A CHORDWISE LINE (A 'SECTION') AND X = 0 (SUBROUTINE SECT0).

NTT — NUMBER OF SUBINTERVAL POINTS USED IN THE SEARCH FOR INTERSECTION POINTS OF X = 0 AND THE INTERVAL (J,J+1) ON A SPANWISE LINE, GIVEN SPLINE-FITS OF THE X, Y COORDINATES ALONG THIS SPANWISE LINE AS A FUNCTION OF THE Z COORDINATE (SUBROUTINE SPAN0).

NTIP — NUMBER OF POINTS ON AN ADDED TIP (SUBROUTINE XTIP).

PARAMETRIZATION OF THE CROSS-SECTIONS: (SUBROUTINE XPIECE)

Each cross section is parameterized by a smooth curvature corrected function, S, of the arc length A.

CP — CURVATURE CORRECTION FACTOR.
S'(A) TENDS TO 1 + CP*CAPPA FOR LARGE CAPPA, WHERE CAPPA DENOTES THE ABSOLUTE VALUE OF THE CURVATURE.

BP — CORRECTION LENGTH SCALE. THE LARGER BP, THE FASTER S'(A) TENDS TO ITS ASYMPTOTIC VALUE.

DP — SMOOTHNESS PARAMETER.
A SMALLER DP MEANS MORE SMOOTHING. IF DP >> 1, THEN NO SMOOTHING TAKES PLACE.

MP — END POINT ADJUSTMENT POWER.
IF MP > 1, THEN S' = 1 AT THE END POINTS OF THE CURVE, AND THE K-TH DERIVATIVE OF S IS ZERO AT THESE POINTS (K = 2, ..., MP).

GRID GENERATION: (SUBROUTINE XGRID)

YB, ZB, BETA — THE OUTER BOUNDARY CONSISTS OF TWO PARALLEL STRAIGHT LINE SEGMENTS, CONNECTED BY A SEMI-CIRCLE. (YB, ZB) IS THE CENTER OF THE SEMI-CIRCLE, AND BETA IS THE ANGLE BETWEEN THE STRAIGHT LINE SEGMENTS AND THE Y-AXIS.

DAB — DISTANCE BETWEEN THE INBOARD BOUNDARY AND (YB,ZB), I.E. THE LENGTH OF THE OUTER BOUNDARY LINE SEGMENTS.

DBC — RADIUS OF THE OUTER BOUNDARY SEMI-CIRCLE.

NBB — NUMBER OF SUBINTERVALS USED TO DETERMINE THE INTERSECTION POINTS OF THE CROSS-SECTION WITHTHE INBOARD BOUNDARY. (CF. SUBROUTINE XBOUND).

PAR — CLUSTERING PARAMETERS.

L	K	MEANING IF PAR(K,L)
1		OUTER BOUNDARY (CF. SUBROUTINE OUTERC).
	1-2	MESH SPACING AT THE MID POINT. IF PAR(1,1) = 0, THEN PAR(2,1) MULTIPLIES THE AVERAGE MESH SPACING. IF PAR(2,1) = 0, THEN PAR(1,1) MULTIPLIES THE MESH SPACING RESULTING FROM A 5-TH ORDER POLYNOMIAL STRETCHING FUNCTION.
2		INNER BOUNDARY (CF. SUBROUTINE XCLUST).
	1	NUMBER OF POINTS USED TO DETERMINE THE CROSS-SECTIONAL THICKNESS.
	2	RELATIVE MESH SPACING AT THE END POINTS.
	3-4	MESH SPACING AT THE MID POINT. IF PAR(4,2) = 0, THEN PAR(3,2) MULTIPLIES THE AVERAGE MESH SPACING. IF PAR(3,2) = 0, THEN PAR(4,2) MULTIPLIES T TIMES THE AVERAGE MESH SPACING, WHERE T IS THE CROSS-SECTIONAL THICKNESS RELATIVE TO SOME FRACTION OF THE CROSS-SECTIONAL LENGTH. CURRENTLY, THIS FRACTION IS 1/3.
	5-6	RELATIVE PIVOT LOCATION CORRESPONDING TO THE END CLUSTER POINTS AND THE MID CLUSSTER POINT.

7-8 RELATIVE PIVOT WIDTHS.

3 RADIAL LINES (CF. SUBROUTINE RGRID).

1-2 MESH SPACING AT THE INNER BOUNDARY. IF PAR(1,3) = 0, PAR(2,3) MULTIPLIES A MESH SPACING BASED ON BOUNDARY LAYER THICKNESS; IF PAR(2,3) = 0, PAR(1,3) MULTIPLIES THE AVERAGE MESH SPACING.

3 RELATIVE PIVOT LOCATION (THE SAME FOR BOTH PIVOT POINTS).

4 RELATIVE PIVOT WIDTH (THE SAME FOR BOTH PIVOT POINTS).

5 BOUNDARY LAYER THICKNESS AT THE INNER BOUNDARY.

6 POWER TO WHICH THE SQUARE ROOT OF THE BOUNDARY LAYER THICKNESS IS TAKEN IN THE MESH SPACING RELATION.

OUTPUT VARIABLES

GEOMETRY DEFINITION:
(SUBROUTINES SR3XYZ AND TIPINF)

DJ	DESIGN ADVANCE RATIO OF THE PROPELLER.
XTIPTE, YTIPTE, ZTIPTE	COORDINATES OF THE TIP T.E. POINT.
TIPC	TIP CHORD (ACTUALLY: ITS PROJECTION ONTO THE XY-PLANE).
DTIPC	DERIVATIVE OF BLADE CHORD W.R.T. Z, AT THE TIP.
TIPCG	DISTANCE FROM TIP SECTION C.G. TO TIP SECTION L.E., NORMALIZED BY TIP CHORD.
TIPB	BLADE ANGLE AT THE TIP.
TIPSW	TANGENT OF THE T.E. SWEEP ANGLE AT THE TIP.
TIPYAW	TANGENT OF THE TIP SECTION YAW ANGLE.
TIPANG	TANGENT OF THE ANGLE BETWEEN THE PROJECTION OF THE T.E. ONTO THE PLANE NORMAL TO THE TIP CHORD LINE IN THE XY-PLANE AND THE Z-AXIS.

OUTPUT FLAGS:

NCROSS	NUMBER OF POINTS ON THE CROSS-SECTION (SUBROUTINE CROSS0).
NTE	SPANWISE GRID POINT INDEX OF THE FIRST GRID POINT ON THE BODY (THE T.E.), IF THERE IS ANY, OR OF THE INBOARD BOUNDARY OTHERWISE (SUBROUTINE XGRID). SPECIAL MEANING: = 0 NO GRID POINTS ON THE BODY. = -1 THE INBOARD BOUNDARY DOES NOT INTERSECT THE CROSS-SECTION. = -2 THERE IS NO CROSS-SECTION (NCROSS < 2).

UNIT NUMBERS

STANDARD UNIT NUMBERS:

IREAD	INPUT NAMELISTS.
IWRITE	DEFAULT PRINT OUTPUT.
IDRAW	SMALLEST PLOT FILE NUMBER MINUS ONE.

PLOT FILE UNIT NUMBERS:

IF THE I-TH PLOT FILE UNIT NUMBER IS < 0, THEN THE DEFAULT UNIT NUMBER IDRAW + I IS USED.

IBLADE	PROPELLER BLADE.
IPROP	PROPELLER (BLADES PLUS HUB).
IWAKE	PROPELLER WAKE.
IWING	WING (TRANSFORMED PROPELLER BLADE).
ITRAIL	WING WAKE (TRANSFORMED PROPELLER WAKE).
ICROSS	CROSS-SECTIONS.
IGRID	GRIDS IN TRANSVERSE COORDINATE PLANES.

DISK I/O UNIT NUMBERS:

JGEOM	PROPELLER BLADE (OR WING) AND WAKE GEOMETRY OUTPUT.

PRINT FILE UNIT NUMBERS:

IF A PRINT FILE UNIT NUMBER IS < 0, THEN THE DEFAULT UNIT NUMBER IWRITE IS USED.

MPROP	PROPELLER GEOMETRY (AIRFOIL SECTION CHARACTERISTICS, BLADE PROPERTIES, AND BLADE COORDINATES).
MCROSS	CROSS-SECTIONS.
MCLUST	CROSS-SECTIONAL PIECES AND GRID CLUSTERING.
MGRID	GRID BOUNDARIES.

NAMELISTS

Several subroutines require input variables in namelists. They should be read from unit number IREAD and are listed below in the order in which they must appear in an input file.

NAMELIST	SUBROUTINE	PURPOSE
COORD	PROP	BLADE COORDINATE PROPERTIES.
THICK	SECTN	AIRFOIL THICKNESS DISTRIBUTION.
CAMBER	SECTN	AIRFOIL MEAN LINE DISTRIBUTION.
RADIAL	BLADE	BLADE CHARACTERISTICS.
PANELS	SR3PNL	REGRIDDING ('PANELING') PARAMETERS.
WAKE	SR3WAK	WAKE CONFIGURATION.
CONFIG	PLPROP	PROPELLER CONFIGURATION.

```
+------------------------------------------------------------+
! NAMELIST   /COORD/  NS0,AS0,NT0,AR0,DBETA                 !
+------------------------------------------------------------+
```

BLADE COORDINATE PROPERTIES.

NS0	NUMBER OF POINTS ON EACH SECTION, FROM L.E. TO T.E.
AS0	STRETCHING FUNCTION PARAMETERS FOR THE DISTRIBUTION OF POINTS ON EACH SECTION (CF. SUBROUTINE STRF1). USE AS0(1) > 0 TO INCREASE THE POINT DENSITY NEAR THE L.E.; USE AS0(2) > 0 TO INCREASE THE DENSITY NEAR BOTH THE L.E. AND THE T.E.
NT0	NUMBER OF SPANWISE STATIONS, FROM HUB TO TIP.
AR0	STRETCHING FUNCTION PARAMETERS FOR THE DISTRIBUTION OF SPANWISE STATIONS (CF. SUBROUTINE STRF1). USE AR0(1) = - AR0(2) < 0 TO INCREASE THE STATION DENSITY NEAR THE TIP.
DBETA	BLADE PITCH ANGLE (IN DEGREES) RELATIVE TO THE DESIGN PITCH ANGLE.

```
+-------------------------------------------------------------------+
! 1NAMELIST   /THICK/  T,NTH,XT,YT,ISPLT,EZPART,ISPLS,EZPARS   !
+-------------------------------------------------------------------+
```

AIRFOIL THICKNESS DISTRIBUTION.

T	SECTION THICKNESS (RELATIVE TO THE CHORD LENGTH).
NTH	NUMBER OF POINTS ON THE UPPER SIDE OF THE SECTION.
XT, YT	COORDINATES OF THE THICKNESS DISTRIBUTION. IT IS ASSUMED THAT 0 = XT(1) < ... < XT(NTH) = 1.

SPLINE-FIT PARAMETERS.

LET ST BE THE ARC-LENGTH ALONG THE CURVE Y = YT(XT)/T (NORMALIZED THICKNESS DISTRIBUTION).

PARAMETERS	SPLINE-FIT
ISPLT, EZPART	XT, YT AS A FUNCTION OF ST.
ISPLS, EZPARS	ST AS A FUNCTION OF SQRT(XT).

```
+-----------------------------------------------------------+
! NAMELIST   /CAMBER/ CLI,NM,XM,YM,ISPLM,EZPARM             !
+-----------------------------------------------------------+
```

MEAN LINE DISTRIBUTION.

CLI	DESIGN SECTION LIFT COEFFICIENT.
NM	NUMBER OF POINTS ON THE MEAN LINE.
XM, YM	COORDINATES OF THE POINTS ON THE MEAN LINE. IT IS ASSUMED THAT 0 = XM(1) < ... < XM(NM) = 1.
ISPLM, EZPARM	SPLINE-FIT PARAMETERS, FOR THE SPLINE-FIT OF YM AS A FUNCTION OF THE ARC-LENGTH ALONG THE NORMALIZED THICKNESS DISTRIBUTION.

```
+----------------------------------------------------------------------+
! NAMELIST   /RADIAL/ NR,R,CHORDR,THICKR,CLDR,TWISTR,SWEEPR,           !
!.                     CONER,BETA75,DJ,ISPLR,EZPARR                     !
+----------------------------------------------------------------------+
```

BLADE CHARACTERISTICS.

NR	NUMBER OF SPANWISE STATIONS (RADIAL POINTS).
R	VALUES OF THE RADIUS AT THE SPANWISE STATIONS.IT IS ASSUMED THAT R(1) < .... < R(NR).
CHORDR	SECTION CHORD / BLADE DIAMETER AT R.
THICKR	THICKNESS RATIO AT R.
CLDR	DESIGN SECTION LIFT COEFFICIENT AT R.
TWISTR	TWIST ANGLE AT R, RELATIVE TO BLADE ANGLE AT R = 0.75.
SWEEPR	MANUFACTURED SWEEP ANGLE AT R.
CONER	SECTION INWARD 'YAW' ANGLE AT R.
BETA75	DESIGN BLADE ANGLE AT R = 0.75.
DJ	DESIGN ADVANCE RATIO.
ISPLR, EZPARR	SPLINE-FIT PARAMETERS, FOR THE SPLINE-FITS OF THE BLADE CHARACTERISTICS AS A FUNCTION OF THE PARAMETER R.

```
+----------------------------------------------------------------------+
! NAMELIST   /PANELS/ NS0,AS0,NT0,AT0,NSW0,ASW0,NTW0,ATW0,             !
!.                     ISPL0,EZPAR0,IPAR0                               !
+----------------------------------------------------------------------+
```

GRID POINT DISTRIBUTIONS.

IN THE FOLLOWING, ... STANDS FOR S, T, SW, OR TW.

S :	CHORDWISE SECTION PERIMETER.
T :	SPANWISE LINE ON THE PROPELLER BLADE.
SW :	WAKE LINE.
TW :	SPANWISE LINE ON THE WAKE.

N...0 NUMBER OF GRID POINTS. DETERMINES THE NEW VALUE OF N... (TEMPORARILY STORED IN N...1).

N...0	SPECIAL MEANING
= 0	DO NOT REDISTRIBUTE POINTS.
> 1	SET N...1 = N...0; USE THE APPROPRIATE

	STRETCHING FUNCTION.
= 1, -1	SET N...1 = N...00 (DEFAULT VALUE); USE EQUALLY SPACED POINTS.
< -1	SET N...1 = ABS(N...0); USE EQUALLY SPACED POINTS.

A...0 STRETCHING FUNCTION PARAMETERS.

A...0	STRETCHING FUNCTION
S	STRF2
T	STRF1
SW	STRF3
TW	STRF1

NO STRETCHING IF A...0(.) = 0.
SUFFICIENT CONDITIONS FOR VALID PARAMETERS:

(A) STRF1, STRF2:
- (I) A...0(1) + A...0(2) < 1
- (II) A...0(2) < 1
- (III) A...0(1)/2 + A...0(2) .GE. 0

(B) STRF3:
0 .LE. A...0 < 1

NS0	NUMBER OF GRID POINTS ON A SECTION PERIMETER (FROM THE LOWER T.E. VIA THE L.E. TO THE UPPER T.E.).
AS0	STRETCHING FUNCTION PARAMETERS (CF. SUBROUTINE STRF2). USE AS0(1) > 0 TO INCREASE THE POINT DENSITY NEAR THE L.E.; USE AS0(2) > 0 TO INCREASE THE DENSITY NEAR BOTH THE L.E. AND THE T.E.
NT0	NUMBER OF GRID POINTS ON A SPANWISE LINE (FROM HUB TO TIP).
AT0	STRETCHING FUNCTION PARAMETERS (CF. SUBROUTINE STRF1). USE AT0(1) = -AT0(2) < 0 TO INCREASE THE POINT DENSITY NEAR THE TIP.
NSW0	NUMBER OF GRID POINTS ON A WAKE LINE (FROM T.E. TO 'INFINITY').
ASW0	STRETCHING FUNCTION PARAMETER (CF. SUBROUTINE STRF3). USE ASW0 > 0 TO INCREASE THE POINT DENSITY NEAR THE T.E.
NTW0	NUMBER OF GRID POINTS ON A SPANWISE LINE ON THE WAKE (FROM 'HUB' TO 'TIP').
ATW0	STRETCHING FUNCTION PARAMETERS (CF. SUBROUTINE STRF1). USE ATW0(1) = -ATW0(2) < 0 TO INCREASE THE POINT DENSITY NEAR THE 'TIP'.

SPLINE-FITS.

ISPL0(K) PARAMETER THAT DETERMINES WHICH SPLINE-FIT ROUTINE IS USED.
- K = 1: CHORDWISE SECTIONS ON THE PROPELLER BLADE.
- K = 2: SPANWISE LINES ON THE BLADE.
- K = 3: WAKE LINES.
- K = 4: SPANWISE LINES ON THE WAKE.

EZPAR0(K) SPLINE PARAMETER.

IPAR0(K) PARAMETER THAT DETERMINES WHICH PROPERTY IS USED TO PARAMETRIZE THE SPLINE-FIT.

CURRENTLY USED ONLY FOR K = 2, 4.
= 0: ARC-LENGTH.
= 1: RADIAL (Z-) DISTANCE.

```
+-----------------------------------------------------------+
! NAMELIST   /WAKE/   NSW0,ASW0,WL,WP,IWP                   !
+-----------------------------------------------------------+
```

WAKE CONFIGURATION.

NSW0	NUMBER OF POINTS IN THE WAKE FOR EACH SPANWISE STATION. SPECIAL MEANING: NSW0 > 1 : NSW = NSW0; USE STRETCHING FUNCTION FOR POINT DISTRIBUTION. -2 < NSW0 < 2 : NSW IS EQUAL TO ITS DEFAULT VALUE; POINTS ARE EQUALLY SPACED. NSW0 < -2 : NSW = ABS(NSW0); POINTS ARE EQUALLY SPACED.
ASW0	STRETCHING FUNCTION PARAMETER USED IN THE DISTRIBUTION OF POINTS ON EACH WAKE LINE (CF. SUBROUTINE STRF3). USE ASW0 > 0 TO INCREASE THE POINT DENSITY NEAR THE T.E.
WL	EXTENT OF THE WAKE IN NUMBER OF REVOLUTIONS OF THE LOCAL T.E. HELIX.
WP	WAKE SHAPE PARAMETER. THE LARGER WP, THE FASTER A WAKE LINE TENDS TO A HELIX.
IWP	WAKE SCALE PARAMETER. THE WAKE SHAPE PARAMETER IS SCALED W.R.T. ARC LENGTH ALONG THE T.E. HELIX IF IWP = 0, AZIMUTHAL ANGLE ALONG THE T.E. HELIX IF IWP = 1, NUMBER OF REVOLUTIONS OF THE T.E. HELIX IF IWP = 2.

```
+-----------------------------------------------------------+
! NAMELIST   /CONFIG/ DBETA,ISK,JSK,NBLADE,NHUB             !
+-----------------------------------------------------------+
```

PROPELLER CONFIGURATION (FOR PLOTTING PURPOSES ONLY).

DBETA	BLADE ANGLE ADJUSTMENT.
ISK, JSK	NUMBER OF CHORDWISE AND SPANWISE DATA POINTS SKIPPED BETWEEN POINTS PLOTTED.
NBLADE	NUMBER OF BLADES. IF NBLADE = 0, ONE BLADE IS PLOTTED WITHOUT A HUB.
NHUB	NUMBER OF POINTS IN CIRCUMFERENTIAL DIRECTION ON HUB BETWEEN TWO BLADES.

SUBROUTINE OHGRID (Z,NCLUST,CLPX,CLPY,SLOPE,ETAP ,ALPHA,ISKIP,W,NDGRID)

Maps an arbitrary physical coordinate distribution into a desired computational coordinate with uniform grid distribution. The transformation function and its higher derivatives are differentiable.

FEATURES:

(1) PRECISE CONTROL OF GRID SIZES.
(2) MORE THAN ONE LOCATION OF CLUSTERED GRIDS.
(3) EXACT POSITIONING OF PARTICULAR COMPUTATIONAL NODES IN THE PHYSICAL DOMAIN.

NOTE: The subroutine OHGRID calls the matrix inversion subroutine MINV and the printer-plot subroutine EZGRAF (which calls the scaling routine AXSCL0 and the general printer-plot subroutine PRGRAF).

ADAPTED FROM:

OH, Y.H. (1978), 'AN ANALYTICAL TRANSFORMATION TECHNIQUE FOR GENERATING UNIFORMLY SPACED COMPUTATIONAL MESH', FINAL REPORT, NASA-LANGLEY RESEARCH GRANT NSG 1087
(SEE ALSO NASA CP-2166, 'NUMERICAL GRID GENERATION TECHNIQUES', PP. 385 - 398).

INPUT VARIABLES:

Z	COORDINATES OF THE GRID POINTS IN THE PHYSICAL DOMAIN.
NCLUST	NUMBER OF INTERNAL CLUSTER POINTS. THE CLUSTER POINTS NEED NOT COINCIDE WITH NODALPOINTS.
CLPX	SEQUENCE OF COMPUTATIONAL COORDINATES CORRESPONDING TO THE CLUSTER POINTS. THE 2 BOUNDARY POINTS ARE ALWAYS CLUSTER POINTS, SO THE TOTAL NUMBER OF CLUSTER POINTS IS NCLUST + 2. CLPX(NCLUST+2) - CLPX(1) + 1 IS THE TOTAL NUMBER OF GRID POINTS.
CLPY	SEQUENCE OF PHYSICAL COORDINATES CORRESPONDING TO THE CLUSTER POINTS.
SLOPE	VALUES OF D(CLPY)/D(CLPX) AT THE CLUSTER POINTS. IF A NEGATIVE VALUE IS INPUT AT THE FIRST OR LAST CLUSTER POINT, NO SLOPE CONSTRAINT WILL BE ENFORCED AT THIS LOCATION.
ETAP	GRID POINT LOCATIONS OF THE PIVOT POINTS. TWO PIVOT POINTS ARE ASSOCIATED WITH EACH INTERIOR CLUSTER POINT, AND ONE PIVOT POINT IS ASSOCIATED WITH EACH END CLUSTER POINT. THUS, THE TOTAL NUMBER OF PIVOT POINTS IS 2*NCLUST + 2.
ALPHA	WIDTH SPACINGS CORRESPONDING TO THE PIVOT POINTS. THE WIDTH SPACING IS THE NUMBER OF GRID POINTS IN WHICH 90 PERCENT OF THE CHANGE OF GRID SPACING TAKES PLACE AROUND A PIVOT POINT.

ISKIP	PRINT CONTROL. EXTENSIVE OUTPUT IS DUMPED TO UNIT ISKIP IF ISKIP > 0.
W	WORK SPACE, SIZE 3*NGRID, NEEDED ONLY IF ISKIP > 0.
NDGRID	NUMBER OF GRID POINTS USED IN THE DIMENSIONING OF Z AND W.

METHOD:

Let Y be the coordinate in the physical domain, and let ETA be the coordinate in the computational domain. By assumption, the grid points are uniformly spaced in the computational domain, i.e. ETA(.+1) - ETA(.) = 1. Then the transformation is composed of a series of complimentary error functions:

Y'(ETA) = BETA(0) + 0.5*SUM (BETA(J)*(ERFC(XI(J)) - (1 + SIGN(ALPHA(J)))))

where the sum is taken from J = 1 TO J = NPIVOT (the number of pivot points), and where

XI(J) = GAMMA*(ETA - ETAP(J))/ALPHA(J)

GAMMA is a convenient constant for scaling ALPHA(J), chosen such that ERFC(GAMMA/2) = 0.1 (LEADING TO GAMMA = 2.326), and the BETA(J) are the step heights for the pivots which decide the ratio between the sizes of node spacings in Y on both sides of the pivots.
Note that the sign of BETA(J) depends on the sign of ALPHA(J). Therefore, the sign of ALPHA(J) is irrevelant. Integration of the expressiion for Y'(ETA) yields

Y(ETA) = Y(ETAMIN) + BETA(0)*(ETA - ETAMIN)
+ 0.5*SUM (BETA(J)*((THETA(J) - THETAM(J))* ALPHA(J)/GAMMA
- (1 + SIGN(ALPHA(J))* (ETA - ETAMIN)))

where

THETA(J) = XI(J)*ERFC(XI(J)) - EXP(-XI(J)**2)/SQRT(PI)

and where THETAM denotes THETA at ETA = ETAMIN. To determine Y(ETA), the NPIVOT + 1 values of BETA(J) in the expression for Y(ETA) have to be computed. By constraining the values of the physical coordinates at the interior and end cluster points, and by constraining the values of the slopes Y'(ETA) at these points, 2*NCLUST + 3 = NPIVOT + 1 linear independant equations are obtained for the BETA(J) (plus a value for Y(ETAMIN)).

PEPSIG
PROPELLER TIP VORTEX VERSION
"Z" ARRAY
(PRINTOUT AVAILABLE WITH KPRT OPTION)

This table lists the variables that may be printed and/or written into the plot file using the KPRT and KPLT arrays. Variable numbers 1 through 70 are stored in the Z array. Those above 70 are additional variables that may be printed and/or written into the plot file. In this table, "n" refers to the upstream station, and "n+1" refers to the station most recently computed.

No.	VARIABLE	MNEMONIC NAME	DESCRIPTION
1	u	NUN	Streamwise velocity at n
2	u	NU	Streamwise velocity at n+1
3	v	NVN	Velocity at n in relative Cartesian y-direction
4	v	NV	Velocity at n+1 in relative Cartesian y-direction
5	w	NWN	Velocity at n in relative Cartesian z-direction
6	w	NW	Velocity at n+1 in relative Cartesian z-direction
7	ρ	NRHON	Static density at n
8	ρ	NRHO	Static density at n+1
9	Ω	NVORN	Streamwise vorticity at n
10	Ω	NVOR	Streamwise vorticity at n+1
11	c_p	NCPIN	Inviscid pressure coefficient at n
12	c_p	NCPI	Inviscid pressure coefficient at n+1
13	μ	MUN	Laminar viscosity coefficient at n
14	μ	MU	Laminar viscosity coefficient at n+1
15	μ_t	MUTN	Turbulent viscosity coefficient at n
16	μ_t	MUT	Turbulent viscosity coefficient at n+1
17	p	NPRESN	Static pressure at n from Poisson pressure equation

18	p	NPRES	Static pressure at n+1 from Poisson pressure equation
19	v	NVPHN	Scalar potential velocity in relative Cartesian y-direction at n
20	v	NVPH	Scalar potential velocity in relativ Cartesian y-direction at n+1
21	w	NWPHN	Scalar potential velocity in relative Cartesian z-direction at n
22	w	NWPH	Scalar potential velocity in relative Cartesian z-direction at n+1
23	y	NXYZA	Reference Cartesian coordinate in y-direction
24	z	NXYZA+1	Reference Cartesian coordinate in z-direction
25	x	NXYZA+2	Reference Cartesian coordinate in x-direction
26-34		NEI11+	Elements of Jacobian matrix at n+1
35-43		NEN11+	Elements of Jacobian matrix at n
44	2D:D	NDD	Dissipation function
45	h	NHN	Orthogonal metric scale factor at n
46	h	NH	Orthogonal metric scale factor at n+1
47	v_i	NVIN	Inviscid velocity at n in relative Cartesian y-direction
48	v_i	NVI	Inviscid velocity at n+1 in relative Cartesian y-direction
49	w_i	NWIN	Inviscid velocity at n in relative Cartesian z-direction
50	w_i	NWI	Inviscid velocity at n+1 in relative Cartesian z-direction
51		NPX1	y-component of the transverse pressure gradient
52		NPX2	z-component of the transverse pressure gradient
53		NRAD1	x-component of the distance vector to the center of rotation

54		NRAD2	y-component of the distance vector to the center of rotation
55		NRAD3	z-component of the distance vector to the center of rotation
56	v	NVPSN	Vector potential velocity in relative Cartesian y-direction at n
57	v	NVPS	Vector potential velocity in relative Cartesian y-direction at n+1
58	w	NWPSN	Vector potential velocity in relative Cartesian z-direction at n
59	w	NWPS	Vector potential velocity in relative Cartesian z-direction at n+1
60	u_i	NUIN	Inviscid streamwise velocity at n
61	u_i	NUI	Inviscid streamwise velocity at n+1
62	l	NLEN	Turbulence mixing length
63	ψ	NPSI	Secondary flow stream function
64	ϕ	NPHI	Secondary flow scalar potential
65	T	NTEMN	Static temperature at n
66	T	NTEM	Static temperature at n+1
67	E^0	NEON	Total enthalpy at n
68	E^0	NEO	Total enthalpy at n+1
69		NDPIDX	Inviscid streamwise pressure gradient
70			
71	M_n	NLOCMA	Mach number
72	P	NDSTPR	Static pressure
73	P_t	NDTOPR	Total pressure
74	ρ	NDRHO	Static density
75	c_p	NDCP	Static pressure coefficient
76	T_t	NDTOTM	Total temperature

PEPSIG
PROPELLER TIP VORTEX VERSION
PARAMETERS

In PEPSIG, the sizes of the dimensioned arrays, and hence the storage required for the program, are set using PARAMETERs. These PARAMETERs themselves are set in COMDECK CPARAM. Larger or smaller dimensions can be set for the entire program simply by changing the appropriate PARAMETERs in COMDECK CPARAM, and then recompiling the program. The basic PARAMETERs are defined as follows:

NDYP - Maximum number of grid points in the circumferential direction for the viscous flow calculation. Currently setequal to 55.

NDZP - Maximum number of grid points in the radial direction for the viscous flow calculation. Currently set equal to 50.

NDXPA - Maximum number of grid points in the streamwise direction for the potential flow calculation. Currently set equal to 50.

NDYPA - Maximum number of grid points in the circumferential direction for the potential flow calculation. Currently set equal to 20.

NDZPA - Maximum number of grid points in the radial direction for the potential flow calculation. Currently set equal to 20.

MVARP - Total number of variables stored in the Z array. Currently set equal to 70.

Several additional PARAMETERs are defined in COMDECK CPARAM as functions of those listed above. The following PARAMETERs are used in various common blocks, DIMENSION statements, and EQUIVALENCE statements:

NDP	=	Maximum of NDYP, NDZP, NDYPA, and NDZPA.
NDYNDZ	=	NDYP*NDZP.
NDP2	=	NDP**2
NDPM2	=	NDP - 2
NDZP1	=	NDZP + 1
NDPA	=	Maximum of NDYP, NDZP, NDXPA, NDYPA, NDZPA.
NPFA	=	18*NDXPA*NDYPA*NDZPA

NPF	=	18*NDXPA*NDYPA*NDZPA - 15*NDYP*NDZP - 35*NDYP*NDZP -18*NDP**2 - MVARP*NDYP*NDZP

The PARAMETER NPF may require some explanation. The total amount of storage required in the C array (common block BLKMM) for the potential flow calculation is 18*NDXPA*NDYPA*NDZPA. However, the total amount required in common block BLKMM for the viscous calculation is only 15*NDYP*NDZP (for array C), plus 35*NDYP*NDZP + 18*NDP**2 (for array CQVQ1), plus MVARP*NDYP*NDZP (for array Z). The array CPFLOW(NPF) is therefore added to common block BLKMM to make it large enough for the potential flow calculation. If BLKMM is already large enough, NPF is equal to 1.

In addition to the above PARAMETERs, the following are used in the BLOCK DATA routine:

NDC	= 15*NDYP*NDZP
NZV	= MVARP*NDYP*NDZP
MVARP1	= MVARP + 1
MVARP2	= MVARP + 2
MVARP3	= MVARP + 3
MVARP4	= MVARP + 4
MVARP5	= MVARP + 5
MVARP6	= MVARP + 6
MVARP7	= MVARP + 7
MVARP8	= MVARP + 8
MVARP9	= MVARP + 9
MVAR4	= MVARP - 4
MVAR69	= MVARP - 69
NDANG	= 4*NDYPA
NDRAD	= 4*NDZPA
NDCPI	= 4*NDYPA*NDZPA

```
JOB,JN=N0012,MFL=700000,T=1200.
ACCOUNT,AC=TOSRA2,APW=XXXXX.
ACCESSTM,DN=PGC4SB,ID=TOSRA2,YOURID=TOSRA2.
ACCESSTM,DN=UTIL,PDN=LIB*UTILB,ID=TOSRA2,YOURID=TOSRA2.
TASSIGN,DN=PLOT,A=FT08.
ASSIGN,DN=TAPE09,A=FT09.
ASSIGN,DN=GRID,A=FT10.
ASSIGN,DN=REST,A=FT11.
ASSIGN,DN=PFLOW,A=FT13.
LDR,DN=PGC4SB,LIB=UTIL,MAP=PART.
DISPOSE,DN=PLOT,SDN=TPLOT,DF=BB,DC=ST,MF=,TID=,TEXT=.
SAVETMP,DN=REST,PDN=N12TB,ID=TOSRA2,UQ,YOURID=TOSRA2.
ERASETMP,PDN=N12TB,ID=TOSRA2,ED=-1,YOURID=TOSRA2.
AUDITMP,ID=TOSRA2,YOURID=TOSRA2.
EXIT.
/EOF
1TIP FLOW
 &RESTRT
 &END
 &FLUIDS
 IPLOT=1,
 REY=10000.,
 CMACH=0.24,
 KTURB =1,
 NEY=57,NEZ=40,NS=132,
 T=.204,DTE=.01,
 AP=1.02,APWK=1.02,APTE=.97,
 BLD(3)=.01,
 NS1=0
 NS2=0,
 NS3=1,
 NS4=-1,IBFX(4)=1,
 ALPHA=6.18,
 ISEQ=0,KSTART=0,
 DXSTRT=-0.1,
 ICOEF(1,1)=1,ICOEF(1,3)=500,ICOEF(1,6)=1,ICOEF(1,8)=0,
 ICOEF(1,12)=-100,
 ICOEF(1,13)=-100,
 ICOEF(1,14)=-100,
 ICOEF(2,1)=500,
 ICOEF(2,3)=0,ICOEF(2,2)=1,NX1PR=1,
 KADDPR  =1,10,20,30,40,50,60,69,70,80,100,120,132,
 ICOEF(2,5)=0,ICOEF(2,4)=1,NX1PL=1,
 KADDPL  =1,10,20,30,40,50,60,69,70,80,100,120,132,
 NY1PR=1,NY2PR=57,ISKPR=0,
 IADDPR=0,
 NZ1PR=1,NZ2PR=40,JSKPR=0,
 JADDPR=0,
 NPLT          = 14,
 ICOEF(2,16)=57,
 ICOEF(2,17)=40,ICOEF(2,19)=1,ICOEF(2,20)=1,
 ICOEF(3,7)=1,ICOEF(3,8)=1,
 ICOEF(3,10)=2,ICOEF(3,11)=1,ICOEF(3,12)=1,ICOEF(3,17)=1,
 ICOEF(3,19)=1,
 ICOEF(4,1)=2,ICOEF(4,2)=2,
 ICOEF(4,5)=1,ICOEF(4,6)=1,
 ICOEF(4,13)=-1,ICOEF(4,13)=-2,
 ICOEF(5,2)=1,
```

```
ICOEF(5,10)=0,ICOEF(5,11)=2,
IPRD=3,
&GEOM
NGEOM=42,
IDUCT=0,
PGEOD(1,1,1)=.6,10*0.,
PGEOD(1,2,1)=.75,10*0.,
PGEOD(1,3,1) = 0.12, 1.4845, -0.00633333,-0.63, -1.758, 1.4215, -0.5075,
PGEOD(1,4,1) = 0.12, 1.4845, -0.00633333,-0.63, -1.758, 1.4215, -0.5075,
PGEOD(1,5,1)=11*0.,
PGEOD(1,6,1)=1,10*0.,
PGEOD(1,7,1)=2*0.,1.,8*0.,
PGEOD(1,8,1)=0.,10*0.,
NXTE=31,
NXWKIN=69,DTTE=.002169,DTWKIN=.005,DTWKST=.017676,
EPSK(1,1)=0.,1.,21.,29.,37.,57.,0.,
EPSK(1,2)=0.,1.,23.,29.,35.,57.,0.,
EPSK(1,3)=0.,-1.,.075,.1,.075,-1.,0.,
EPSK(1,4)=0.,-1.,.00003,.00001,.00003,-1.,0.,
EPSK(9,1)=0.,2*.75,.5,
EPSK(10,1)=.005,
&END
STOP
/EOF
```

```
JOB,JN=SR3PNL,MFL=1500000,T=60.
ACCOUNT,AC=TOSRA2,APW=XXXXX.
TASSIGN,DN=PLOT,A=FT08.
ASSIGN,DN=GRD,A=FT10.
ASSIGN,DN=REST,A=FT11.
ASSIGN,DN=PFLOW,A=FT13.
ASSIGN,DN=DPDX,A=FT18.
ASSIGN,DN=TAPE32,A=FT32.
ASSIGN,DN=BLADE,A=FT21.
ASSIGN,DN=PROP,A=FT22.
ASSIGN,DN=WAKE,A=FT23.
ASSIGN,DN=PNL,A=FT31.
ACCESSTM,DN=SR3,PDN=LIB*SR3MB,ID=TOSRA2,YOURID=TOSRA2.
ACCESSTM,DN=UTIL,PDN=LIB*UTILB,ID=TOSRA2,YOURID=TOSRA2.
ACCESSTM,DN=PGB,PDN=PGC4MB,ID=TOSRA2,YOURID=TOSRA2.
LDR,DN=PGB,LIB=SR3:UTIL.
DISPOSE,DN=PLOT,SDN='GRID',DF=BB,DC=ST.
SAVETMP,DN=PNL,PDN=SR3*PNL,ID=TOSRA2,YOURID=TOSRA2.
ERASETMP,PDN=SR3*PNL,ID=TOSRA2,ED=-1,YOURID=TOSRA2.
SAVETMP,DN=GRD,PDN=SR3*GRD,ID=TOSRA2,YOURID=TOSRA2.
ERASETMP,PDN=SR3*GRD,ID=TOSRA2,ED=-1,YOURID=TOSRA2.
EXIT.
*/
*/ RUNS PEPSIG (VERSION C4R) WITH THE SR3 LIBRARIES.
*/
/EOF
3 SR3  PROP BLADE GEOMETRY

 &RESTRT
 &END

 &FLUIDS
 ;GRID.
 ISYM            = 1,
 NEY=20,NEZ=10,
 NS=30,
 T=-.31,DTE=.01,
 AP=1.,
 ;BOUNDARY LAYER THICKNESS (ALSO USED IN GRID GENERATION).
 BLD(3)=.002,
 ICOEF(3,3)=1,
 ;INITIAL BLD THINNER ON PRESSURE SURFACE (1 IS YES - 0 IS NO)
 ICOEF(3,4)=1,
 ICOEF(3,20)     = 1,
 ;REFERENCE LINE, STRAIGHT (0) OR HELICAL (2).
 ICOEF(1,9)      = 0,
 ;FLOW PROPERTIES.
 CMACH           = 0.24,
 REY=3.E+05,
 KTURB           = 0,
 ALPHA=0.,
 ;BOUNDARIES.
 NS1             = 0,
 NS2             = 0,
 NS3             = 1,
 NS4             = -2,
 ;SKIP STARTING PROCEDURE
 KSTART=2,NSTART=-1,
```

```
;UPDATE U AND TURBULENCE IN START.
ICOEF(5,19)      = 1,
;UPDATE STREAMWISE GRADIENTS IN START1.
ICOEF(3,6)       = 1,
;EQUATION SEQUENCE.
ISEQ             = 0,
;P AND RHO  COMPUTATION.
ICOEF(5,2)       = -1,
;PHI-TERMS IN TRANSVERSE PRESSURE GRADIENT.
ICOEF(3,7) =0,
ICOEF(5,13)      = 0,
;COMPUTE DP/DS INSTEAD OF DP/DX.
ICOEF(3,19)=0,
;WALL VORTICITY B.C.
ICOEF(5,4)       = 1,
;COUPLED INBOARD B.C.'S.
ICOEF(3,8)       = 1,
ICOEF(3,9)       = 0,
ICOEF(3,16)      = 0,

;INVISCID FIELD.
ICOEF(1,6)       =0,
;INTERPOLATION.
ICOEF(3,10)      = 2,
;INTERIOR OR BOUNDARY ONLY.
ICOEF(3,11)      = 0,
;SMOOTHING.
ICOEF(3,12)      = 1,
;USE INVISCID V FOR INITIAL PROFILE.
ICOEF(3,17)      = 1,
ICOEF(3,18)      = 0,
;DATA FILE.
ICOEF(5,11)      = 2,
;ROTATIONALITY OF INVISCID V.
ICOEF(5,12)      = 1,
;OUTPUT FORMAT (MODE = 3 ONLY).
ICOEF(5,20)      = 1,
;ITERATION PARAMETERS.
;OUTPUT.
;PRINT STATIONS.
NX1PR            = 1,
ICOEF(2,3)       = 0,
KADDPR=1,15,30,
 IADDPR=2,
 JADDPR=2,
;2-D OUTPUT
ISKPR=1,JSKPR=1,
ISKPL=1,JSKPL=1,
;PLOT STATIONS.
IPLOT            = 1,
NX1PL            = 1,
ICOEF(2,5)       = 1,
NPLT=7,
;PRINT CROSS-SECTION AND GRID CLUSTERING INFORMATION.
ICOEF(3,1)       = 0,
;PRINT GRID PROPERTIES (IF MODE = 3).
ICOEF(2,19)      = 1,
ICOEF(2,20)      = 1,
```

```
&END

&GEOM
;SR3-LIKE GEOMETRY.
NGEOM              = 51,
;PANEL DUMP (KGEOM, JGEOM, IXYZ < 0).
NCTRK(1)=0,31,1,
;EXTERNAL FLOW.
IDUCT              = 0,
;ROTATION VECTOR.
ROTAX(1,1)         = 1., 0., 0.,
;CENTER OF ROTATION.
ROTAX(1,2)         = 0., 0., 0.,

;PROPELLER BLADE (0) OR WING (1).
PGEOD(1,1,1)     = 1.,
;PGEOD(1,1,1)      = 0.,
;COMPUTATION OF THE CROSS-SECTION (NSS, NTT, NTIP).
PGEOD(2,1,1)      = 21.,
PGEOD(3,1,1)      = 21.,
PGEOD(4,1,1)      = 11.,

;PARAMETRIZATION OF THE CROSS-SECTION (CP, BP, DP, MP).
PGEOD(1,2,1)      = 0.,
PGEOD(2,2,1)      = 10.,
PGEOD(3,2,1)      = 4.,
PGEOD(4,2,1)      = 2.,

;OUTER AND INBOARD BOUNDARY (DAB, DBC, NBB).
PGEOD(1,3,1)      = 0.2,
PGEOD(2,3,1)      = 0.20,
PGEOD(3,3,1)      = 21.,

;STRAIGHT REFERENCE LINE OPTIONS (REFA, REFSW).
PGEOD(4,3,1)    = 0.,
PGEOD(5,3,1)    = 0.,

;OUTER BOUNDARY SPECIFICATION.
PGEOD(6,3,1)    = 0.,

;STANDARD UNIT NUMBERS (IREAD, IWRITE, IDRAW).
PGEOD(1,4,1)      = 5.,
PGEOD(2,4,1)      = 6.,
PGEOD(3,4,1)      = 20.,

;PLOT FILE UNIT NUMBERS (IBLADE, IPROP, IWAKE, IWING, ITRAIL,
;ICROSS, IGRID).
;PGEOD(4,4,1)      = 0.,
;PGEOD(5,4,1)      = 0.,
;PGEOD(6,4,1)      = 0.,
;PGEOD(7,4,1)      = 0.,
;PGEOD(8,4,1)      = 0.,
;PGEOD(9,4,1)      = 0.,
;PGEOD(10,4,1)     = 0.,
;PGEOD(4,4,1)     =-1.,
;PGEOD(5,4,1)     =0.,
;PGEOD(6,4,1)     =-1.,
```

```
;PGEOD(7,4,1)    =-1.,
;PGEOD(8,4,1)    =-1.,
;PGEOD(9,4,1)    =-1.,
;PGEOD(10,4,1)   =-1.,

;PROPELLER PRINT FILE UNIT NUMBER (MPROP).
;PGEOD(11,4,1)    = 0.,
PGEOD(11,4,1)    = -1.,

;SPLINE-FIT PARAMETERS
;(ISPL(K), EZSPL(K), K = 1, ..., 6,
; K = 1 :   T.E. LINE,
; K = 2 :   SPANWISE SECTION,
; K = 3 :   CHORDWISE SECTION,
; K = 4 :   WAKE PARAMETER,
; K = 5 :   WAKE LINE,
; K = 6 :   CROSS-SECTION).
PGEOD(1,10,1)    = 0.,
PGEOD(2,10,1)    = 0.,
PGEOD(3,10,1)    = 0.,
PGEOD(4,10,1)    = 0.,
PGEOD(5,10,1)    = 0.,
PGEOD(6,10,1)    = 3.,
PGEOD(1,11,1)    = 2.5,
PGEOD(2,11,1)    = 2.5,
PGEOD(3,11,1)    = 2.5,
PGEOD(4,11,1)    = 2.5,
PGEOD(5,11,1)    = 2.5,
PGEOD(6,11,1)    = 2.5,

;POLYNOMIAL VARIATION OF CLUSTERING PARAMETERS
;(PGEO(K,12) :   MESH SPACING AT INNER BOUNDARY MID POINT,
; PGEO(K,13) :   MESH SPACING AT RADIAL LINE BOUNDARY POINT).
PGEOD(1,12,1)    = 1., 10*0.,
PGEOD(1,13,1)    = 1., 10*0.,

;CLUSTERING PARAMETERS, OUTER BOUNDARY
;(PAR(1-2,1) :   MESH SPACING AT THE MID POINT).
;EPSK(1,1)        = 0.75, 0.,
EPSK(1,1)        = 1.5, 0.,

;CLUSTERING PARAMETERS, INNER BOUNDARY
;(PAR(1,2) :     NTHICK,
; PAR(2,2) :     MESH SPACING AT THE END POINTS,
; PAR(3-4,2) :   MESH SPACING AT THE MID POINT,
; PAR(5-6,2) :   PIVOT LOCATIONS FOR END POINTS AND MID POINT,
; PAR(7-8,2) :   PIVOT WIDTHS).
EPSK(1,2)        = 21.,
EPSK(2,2)        = 2.,
EPSK(3,2)        = 0., 0.5,
EPSK(5,2)        = 0.25,
EPSK(6,2)        = 0.50,
EPSK(7,2)        = 0.75,
EPSK(8,2)        = 0.50,

;CLUSTERING PARAMETERS, RADIAL LINES
;(PAR(1-2,3) :   MESH SPACING AT THE INNER BOUNDARY,
; PAR(3-4,3) :   PIVOT LOCATION AND WIDTH).
```

```
;COARSE GRID
EPSK(1,3)=0.65,0.,
EPSK(3,3)       = 0.75,
EPSK(4,3)       = 0.50,
&END

&COORD
;PARAMETER DISTRIBUTION.
NS0        = 21,
NT0        = 21,
&END

&THICK
;THICKNESS DISTRIBUTION OF THE NACA 16-021 AIRFOIL SECTION
;(ABBOTT AND VON DOENHOFF, P. 333)
T          = 0.21,
NTH        = 17,
XT         = 0.0000, 0.0125, 0.0250, 0.0500, 0.0750,
             0.1000, 0.1500, 0.2000, 0.3000, 0.4000,
             0.5000, 0.6000, 0.7000, 0.8000, 0.9000,
             0.9500, 1.0000,
YT         = 0.00000, 0.02261, 0.03159, 0.04391, 0.05306,
             0.06050, 0.07236, 0.08162, 0.09480, 0.10246,
             0.10500, 0.10211, 0.09221, 0.07348, 0.04405,
             0.02476, 0.00210,
ISPLT      = 0,
EZPART     = 2.5,
ISPLS      = 0,
EZPARS     = 2.5,
&END

&CAMBER
;MEAN LINE DISTRIBUTION FOR NACA 1-SERIES
;(ABBOTT AND VON DOENHOFF, P. 405)
CLI        = 1.0,
NM         = 26,
XM         = 0.0000, 0.0050, 0.0075, 0.0125, 0.0250,
             0.0500, 0.0750, 0.1000, 0.1500, 0.2000,
             0.2500, 0.3000, 0.3500, 0.4000, 0.4500,
             0.5000, 0.5500, 0.6000, 0.6500, 0.7000,
             0.7500, 0.8000, 0.8500, 0.9000, 0.9500,
             1.0000,
YM         = 0.00000, 0.00250, 0.00350, 0.00535, 0.00930,
             0.01580, 0.02120, 0.02585, 0.03365, 0.03980,
             0.04475, 0.04860, 0.05150, 0.05355, 0.05475,
             0.05515, 0.05475, 0.05355, 0.05150, 0.04860,
             0.04475, 0.03980, 0.03365, 0.02585, 0.01580,
             0.00000,
ISPLM      = 0,
EZPARM     = 2.5,
&END

&RADIAL
;BLADE CHARACTERISTICS FOR THE SR-3 BLADE
;(NASA CR-3505, PP. 52-53)
BETA75     = 56.93,
DJ         = 3.06,
NR         = 9,
```

```
R         = 0.24, 0.30, 0.40, 0.50, 0.60,
            0.70, 0.80, 0.90, 1.00,
CHORDR    = 0.163, 0.171, 0.189, 0.202, 0.202,
            0.192, 0.170, 0.132, 0.072,
THICKR    = 0.240, 0.101, 0.060, 0.044, 0.034,
            0.027, 0.022, 0.020, 0.020,
THICKR    = 0.060, 0.060, 0.060, 0.060, 0.060,
            0.060, 0.060, 0.060, 0.060,
CLDR      = -0.360, -0.125,  0.080,  0.150,  0.190,
             0.220,  0.240,  0.230,  0.200,
TWISTR    = 24.00, 20.00, 14.75, 10.00,  5.75,
             1.75, -1.75, -4.75, -7.50,
SWEEPR    = -25.0, -22.0,  -7.5,   7.5,  21.5,
             31.0,  38.5,  44.0,  45.0,
CONER     = 14.0, 13.5,  9.5,  6.5,  5.0,
             4.5,  3.5,  2.0,  0.0,
ISPLR     = 0,
EZPARR    = 2.5,
&END
&PANELS
;REDISTRIBUTION OF GRID POINTS ('PANELING').
NS0=81,
AS0=0.,0.,
ISPL0(1)=0,
EZPAR0(1)=2.5,
IPAR0(1)=0,
NT0=17,
AT0=-1.6,0.8,
ISPL0(2)=0,
EZPAR0(2)=2.5,
IPAR0(2)=1,
&END
&WAKE
;WAKE CONFIGURATION.
NSW0=21,ASW0=0.9,
WL        = 0.1,
WP        = 1.,
&END

&CONFIG
;PROPELLER CONFIGURATION.
DBETA     = 0.,
ISK       = 0,
JSK       = 0,
NBLADE    = 8,
NHUB      = 5,
&END

/EOF
```

```
JOB,JN=SR3HES,MFL=1500000,T=1200.
ACCOUNT,AC=TOSRA2,APW=XXXXXX.
ACCESSTM,DN=GRD,PDN=SR3*GRD,ID=TOSRA2,YOURID=TOSRA2.
ACCESSTM,DN=PNL,PDN=SR3*PNL,ID=TOSRA2,YOURID=TOSRA2.
ASSIGN,DN=TAPE03,A=FT03.
ASSIGN,DN=TAPE04,A=FT04.
ASSIGN,DN=TAPE08,A=FT08.
ASSIGN,DN=TAPE09,A=FT09.
ASSIGN,DN=TAPE10,A=FT10.
ASSIGN,DN=TAPE11,A=FT11.
ASSIGN,DN=TAPE12,A=FT12.
ASSIGN,DN=TAPE13,A=FT13.
ASSIGN,DN=TAPE14,A=FT14.
ASSIGN,DN=TAPE15,A=FT15.
ASSIGN,DN=TAPE16,A=FT16.
ASSIGN,DN=TAPE17,A=FT17.
ASSIGN,DN=GRD,A=FT19.
ASSIGN,DN=ALG,A=FT20.
ASSIGN,DN=OFFB,A=FT21.
ASSIGN,DN=ONB,A=FT22.
ASSIGN,DN=WING,A=FT23.
ASSIGN,DN=TIP,A=FT24.
ASSIGN,DN=PNL,A=FT31.
ACCESS,DN=HESS,PDN=HESSB,ID=FDJ,OWN=PSSRAWT.
ACCESS,DN=RWW,PDN=LIB*RWWB,ID=FDJ,OWN=PSSRAWT.
ACCESSTM,DN=UTIL,PDN=LIB*UTILB,ID=TOSRA2,YOURID=TOSRA2.
LDR,DN=HESS,LIB=RWW:UTIL.
SAVETMP,DN=OFFB,PDN=SR3H,ID=TOSRA2,YOURID=TOSRA2.
ERASETMP,PDN=SR3H,ED=-1,ID=TOSRA2,YOURID=TOSRA2.
EXIT.
/EOF
 &BEGIN
 TITLE='SR3-','LIKE',' PRO','PELL','ER B','LADE',
       ', FL','AT T','IP ,',
 &END
 &PARAMS
 CASE='SR3',
 LIST=0,
 IOFF(1)=1,0,0,1,0,1,0,
 MOMENT=0,
 IATACK=1,
 ISAVE=1,
 RHO1SQ=16.,
 RHO2SQ=6.,
 SYM1=0.,
 SYM2=0.,
 LASWAK=0,
 &END
 &ALPHAS
 IALPHA=1,
 PITCH(1)=0.,
 YAW(1)=-1.,
 &END
 &CENTER
 ORIGNX=0.25,
 ORIGNY=0.,
 ORIGNZ=0.,
 &END
```

```
 &HSR3
 ISR3=31,
 NBODST=1,
 NRATIO=4,
 A2=2*0.,
 &END
/EOF
```

```
JOB,JN=SR3INT,MFL=699000,T=10.
ACCOUNT,AC=TOSRA2,APW=XXXXX.
ACCESSTM,DN=OFFB,PDN=SR3H,ID=TOSRA2,YOURID=TOSRA2.
ASSIGN,DN=OFFB,A=FT13.
ASSIGN,DN=FINE,A=FT14.
ASSIGN,DN=PFLOW,A=FT15.
ASSIGN,DN=PLOT,A=FT16.
ASSIGN,DN=ONB,A=FT22.
ACCESS,DN=INTB,PDN=INT3DB,ID=FDJ,OWN=PSSRAWT.
ACCESS,DN=INT,PDN=LIB*INTB,ID=PSSRAWT,OWN=PSSRAWT.
ACCESSTM,DN=UTIL,PDN=LIB*UTILB,ID=TOSRA2,YOURID=TOSRA2.
LDR,DN=INTB,LIB=INT:UTIL.
SAVETMP,DN=PFLOW,PDN=SR3*INV,ID=TOSRA2,YOURID=TOSRA2.
ERASETMP,PDN=SR3*INV,ID=TOSRA2,YOURID=TOSRA2,ED=-1.
AUDITMP,ID=TOSRA2.
EXIT.
/EOF
INTERPOLATION DATA
 &INTERP
 METHOD=1,
 IBOUND=2,
 IWALL=1,
 IPRINT=1,0,
 IPLOT=1,0,
 IDUMP=1,0,
 &END
/EOF
```

```
JOB,JN=SR3T,MFL=1990000,T=18000.
ACCOUNT,AC=TOSRA2,APW=XXXXX.
ACCESSTMP,DN=PFLOW,PDN=SR3*INV,ID=TOSRA2,YOURID=TOSRA2.
TASSIGN,DN=PLOT,A=FT08.
ASSIGN,DN=GRID,A=FT10.
ASSIGN,DN=REST,A=FT11.
ASSIGN,DN=PFLOW,A=FT13.
ASSIGN,DN=DPDX,A=FT18.
ACCESSTMP,DN=SR3,PDN=LIB*SR3UB,ID=TOSRA2,YOURID=TOSRA2.
ACCESSTMP,DN=UTIL,PDN=LIB*UTILB,ID=TOSRA2,YOURID=TOSRA2.
ACCESSTMP,DN=PGB,PDN=PGC4UB,ID=TOSRA2,YOURID=TOSRA2.
COPYD.
REWIND,DN=$IN.
LDR,DN=PGB,LIB=SR3:UTIL.
DISPOSE,DN=PLOT,SDN='TPLOT',DF=BB,DC=ST.
SAVETMP,DN=REST,PDN=SR3T1,YOURID=TOSRA2,ID=TOSRA2.
ERASETMP,PDN=SR3T1,YOURID=TOSRA2,ED=-1,ID=TOSRA2.
EXIT.
*/
*/ RUNS PEPSIG (VERSION C4R) WITH THE SR3 LIBRARIES.
*/
/EOF
1 SR3  AL=8 - R.SR3T

 &RESTRT
 &END

 &FLUIDS
 ;GRID.
 ISYM             = 1,
 NEY              = 95,
 NEZ              = 95,
 NS               = 300,
 T                = -0.30,
 DTE              = 0.0010,
 AP               = 1.00,
 ;BOUNDARY LAYER THICKNESS (ALSO USED IN GRID GENERATION).
 BLD(3)=.002,
 ;INITIAL BLD THINNER ON PRESSURE SURFACE (1 IS YES - 0 IS NO)
 ICOEF(3,4)=1,ICOEF(3,5)=0,
 ICOEF(3,20)      = 1,
 ;REFERENCE LINE, STRAIGHT (0) OR HELICAL (2).
 ICOEF(1,9)       = 0,

 ;FLOW PROPERTIES.
 CMACH            = 0.30,
 REY              = 3.E+05,
 KTURB            = 1,
 ALPHA=0.,

 ;BOUNDARIES.
 NS1              = 0,
 NS2              = 0,
 NS3              = 1,
 NS4              = -2,IBFX(4)=1,

 ;STARTING PROCEDURE.
 KSTART           = 1,
```

```
NSTART           = 5,
DXSTRT           = 0.0002,
ICOEF(5,18)=-1,
;UPDATE U AND TURBULENCE IN START.
ICOEF(5,19)      = 1,
;UPDATE STREAMWISE GRADIENTS IN START1.
ICOEF(3,6)       = 1,
;EQUATION SEQUENCE.
ISEQ             = 0,
;P AND RHO  COMPUTATION.
ICOEF(5,2)=1,
;PHI-TERMS IN TRANSVERSE PRESSURE GRADIENT.
ICOEF(3,7)=1,
ICOEF(5,13)=0,
;COMPUTE DP/DS INSTEAD OF DP/DX.
ICOEF(3,19)=0,
;WALL VORTICITY B.C.
ICOEF(5,4)       = 1,
;COUPLED INBOARD B.C.'S.
ICOEF(3,8)    =1,
ICOEF(3,9)    =0,
ICOEF(3,16)   =1,

;INVISCID FIELD.
ICOEF(1,6)       =0,
;PRESSURE REFERENCE POINT.
ICOEF(2,16)      = 1,
ICOEF(2,17)      = 95,
;INTERPOLATION.
ICOEF(3,10)      = 2,
;INTERIOR OR BOUNDARY ONLY.
ICOEF(3,11)      = 0,
;SMOOTHING.
ICOEF(3,12)      = 1,
;USE INVISCID V FOR INITIAL PROFILE.
ICOEF(3,17)      = 1,
ICOEF(3,18)      = 0,
;DATA FILE.
ICOEF(5,11)      = 2,
;ROTATIONALITY OF INVISCID V.
ICOEF(5,12)      = 1,
;OUTPUT FORMAT (MODE = 3 ONLY).
ICOEF(5,20)      = 1,

;ITERATION PARAMETERS.
;ADI ITERATIONS, PHI- AND P-EQUATION.
ICOEF(1,3)       = 10000,
;ADI2X2 OUTPUT.
ICOEF(1,12)      = -100,
;ADI OUTPUT, PHI- AND P-EQUATION.
ICOEF(1,13)      = -100,
;ADI OUTPUT, U-EQUATION.
ICOEF(1,14)      = -100,
;ADI2X2 ITERATIONS.
ICOEF(2,1)       = 10000,
;ADI TIME STEPS, PHI-EQUATION.
ICOEF(4,1)       = 3,
ICOEF(4,2)       = 3,
```

```
;ADI2X2 TIME STEPS.
ICOEF(4,5)       = 2,
ICOEF(4,6)       = 2,
ICOEF(4,7)       = 0,
;ADI CONVERGENCE CRITERION, PHI-EQUATION.
ICOEF(4,13)      = -1,
;ADI2X2 CONVERGENCE CRITERION, OMEGA- AND PSI-EQUATION.
ICOEF(4,14)      = 0,
ICOEF(4,15)      = 0,
;ITERATION ON U-EQUATION.
ICOEF(5,5)       = 1,

;OUTPUT.
;PRINT REFERENCE LINE INFORMATION.
ICOEF(1,15)      = 1,
;PRINT STATIONS.
NX1PR            = 1,
ICOEF(2,3)       = 0,
KADDPR         =10,50,100,150,200,250,300,
 IADDPR=2,95,IADDPL=95,
 JADDPR=2,95,JADDPL=95,
;2-D OUTPUT
ICOEF(1,11)=1,
ISKPR=2,JSKPR=2,
ISKPL=2,JSKPL=2,
;PLOT STATIONS.
IPLOT            = 1,
NX1PL            = 1,
ICOEF(2,5)       = 15,
NPLT             = 14,
KPLT             = 23, 24, 25, 4, 6, 2,
;PRINT CROSS-SECTION AND GRID CLUSTERING INFORMATION.
ICOEF(3,1)       = 0,
;PRINT GRID PROPERTIES (IF MODE = 3).
ICOEF(2,19)      = 1,
ICOEF(2,20)      = 1,

&END

&GEOM
;SR3-LIKE GEOMETRY.
NGEOM            = 51,
;EXTERNAL FLOW.
IDUCT            = 0,
;ROTATION VECTOR.
ROTAX(1,1)       = 1., 0., 0.,
;CENTER OF ROTATION.
ROTAX(1,2)       = 0., 0., 0.,

;PROPELLER BLADE (0) OR WING (1).
PGEOD(1,1,1)     = 1.,

;COMPUTATION OF THE CROSS-SECTION (NSS, NTT, NTIP).
PGEOD(2,1,1)     = 21.,
PGEOD(3,1,1)     = 21.,
PGEOD(4,1,1)     = 11.,

;PARAMETRIZATION OF THE CROSS-SECTION (CP, BP, DP, MP).
```

```
PGEOD(1,2,1)     = 0.,
PGEOD(2,2,1)     = 10.,
PGEOD(3,2,1)     = 4.,
PGEOD(4,2,1)     = 2.,

;OUTER AND INBOARD BOUNDARY (DAB, DBC, NBB).
PGEOD(1,3,1)     = 0.2,
PGEOD(2,3,1)     = 0.20,
PGEOD(3,3,1)     = 21.,

;STRAIGHT REFERENCE LINE OPTIONS (REFA, REFSW).
PGEOD(4,3,1)    = 0.,
PGEOD(5,3,1)    = 0.,

;OUTER BOUNDARY SPECIFICATION.
PGEOD(6,3,1)    = 0.,

;STANDARD UNIT NUMBERS (IREAD, IWRITE, IDRAW).
PGEOD(1,4,1)     = 5.,
PGEOD(2,4,1)     = 6.,
PGEOD(3,4,1)     = 20.,

;PLOT FILE UNIT NUMBERS (IBLADE, IPROP, IWAKE, IWING, ITRAIL,
;ICROSS, IGRID).
PGEOD(4,4,1)     = 0.,
PGEOD(5,4,1)     = 0.,
PGEOD(6,4,1)     = 0.,
PGEOD(7,4,1)     = 0.,
PGEOD(8,4,1)     = 0.,
PGEOD(9,4,1)     = 0.,
PGEOD(10,4,1)    = 0.,

;PROPELLER PRINT FILE UNIT NUMBER (MPROP).
PGEOD(11,4,1)    = 0.,

;SPLINE-FIT PARAMETERS
;(ISPL(K), EZSPL(K), K = 1, ..., 6,
; K = 1 :   T.E. LINE,
; K = 2 :   SPANWISE SECTION,
; K = 3 :   CHORDWISE SECTION,
; K = 4 :   WAKE PARAMETER,
; K = 5 :   WAKE LINE,
; K = 6 :   CROSS-SECTION).
PGEOD(1,10,1)    = 0.,
PGEOD(2,10,1)    = 0.,
PGEOD(3,10,1)    = 0.,
PGEOD(4,10,1)    = 0.,
PGEOD(5,10,1)    = 0.,
PGEOD(6,10,1)    = 3.,
PGEOD(1,11,1)    = 2.5,
PGEOD(2,11,1)    = 2.5,
PGEOD(3,11,1)    = 2.5,
PGEOD(4,11,1)    = 2.5,
PGEOD(5,11,1)    = 2.5,
PGEOD(6,11,1)    = 2.5,

;POLYNOMIAL VARIATION OF CLUSTERING PARAMETERS
;(PGEO(K,12) :   MESH SPACING AT INNER BOUNDARY MID POINT,
```

```
; PGEO(K,13) :    MESH SPACING AT RADIAL LINE BOUNDARY POINT).
PGEOD(1,12,1)    = 1., 10*0.,
PGEOD(1,13,1)    = 1., 10*0.,

;CLUSTERING PARAMETERS, OUTER BOUNDARY
;(PAR(1-2,1) :    MESH SPACING AT THE MID POINT).
EPSK(1,1)        = 0.75, 0.,

;CLUSTERING PARAMETERS, INNER BOUNDARY
;(PAR(1,2) :      NTHICK,
; PAR(2,2) :      MESH SPACING AT THE END POINTS,
; PAR(3-4,2) :    MESH SPACING AT THE MID POINT,
; PAR(5-6,2) :    PIVOT LOCATIONS FOR END POINTS AND MID POINT,
; PAR(7-8,2) :    PIVOT WIDTHS).
EPSK(1,2)        = 21.,
EPSK(2,2)        = 2.,
EPSK(3,2)        = 0., 0.020,
EPSK(5,2)        = 0.25,
EPSK(6,2)        = 0.50,
EPSK(7,2)        = 0.75,
EPSK(8,2)        = 0.50,

;CLUSTERING PARAMETERS, RADIAL LINES
;(PAR(1-2,3) :    MESH SPACING AT THE INNER BOUNDARY,
; PAR(3-4,3) :    PIVOT LOCATION AND WIDTH).
EPSK(1,3)        = 0., 0.10,
EPSK(3,3)        = 0.75,
EPSK(4,3)        = 0.50,
&END

&COORD
;PARAMETER DISTRIBUTION.
NS0         = 21,
NT0         = 21,
&END

&THICK
;THICKNESS DISTRIBUTION OF THE NACA 16-021 AIRFOIL SECTION
;(ABBOTT AND VON DOENHOFF, P. 333)
T          = 0.21,
NTH        = 17,
XT         = 0.0000, 0.0125, 0.0250, 0.0500, 0.0750,
             0.1000, 0.1500, 0.2000, 0.3000, 0.4000,
             0.5000, 0.6000, 0.7000, 0.8000, 0.9000,
             0.9500, 1.0000,
YT         = 0.00000, 0.02261, 0.03159, 0.04391, 0.05306,
             0.06050, 0.07236, 0.08162, 0.09480, 0.10246,
             0.10500, 0.10211, 0.09221, 0.07348, 0.04405,
             0.02476, 0.00210,
ISPLT      = 0,
EZPART     = 2.5,
ISPLS      = 0,
EZPARS     = 2.5,
&END

&CAMBER
;MEAN LINE DISTRIBUTION FOR NACA 1-SERIES
;(ABBOTT AND VON DOENHOFF, P. 405)
```

```
CLI       = 1.0,
NM        = 26,
XM        = 0.0000, 0.0050, 0.0075, 0.0125, 0.0250,
            0.0500, 0.0750, 0.1000, 0.1500, 0.2000,
            0.2500, 0.3000, 0.3500, 0.4000, 0.4500,
            0.5000, 0.5500, 0.6000, 0.6500, 0.7000,
            0.7500, 0.8000, 0.8500, 0.9000, 0.9500,
            1.0000,
YM        = 0.00000, 0.00250, 0.00350, 0.00535, 0.00930,
            0.01580, 0.02120, 0.02585, 0.03365, 0.03980,
            0.04475, 0.04860, 0.05150, 0.05355, 0.05475,
            0.05515, 0.05475, 0.05355, 0.05150, 0.04860,
            0.04475, 0.03980, 0.03365, 0.02585, 0.01580,
            0.00000,
ISPLM     = 0,
EZPARM    = 2.5,
&END

&RADIAL
;BLADE CHARACTERISTICS FOR THE SR-3 BLADE
;(NASA CR-3505, PP. 52-53)
BETA75    = 56.93,
DJ        = 3.06,
NR        = 9,
R         = 0.24, 0.30, 0.40, 0.50, 0.60,
            0.70, 0.80, 0.90, 1.00,
CHORDR    = 0.163, 0.171, 0.189, 0.202, 0.202,
            0.192, 0.170, 0.132, 0.072,
THICKR    = 0.240, 0.101, 0.060, 0.044, 0.034,
            0.027, 0.022, 0.020, 0.020,
THICKR    = 0.060, 0.060, 0.060, 0.060, 0.060,
            0.060, 0.060, 0.060, 0.060,
CLDR      = -0.360, -0.125,  0.080,  0.150,  0.190,
              0.220,  0.240,  0.230,  0.200,
TWISTR    = 24.00, 20.00, 14.75, 10.00,  5.75,
             1.75, -1.75, -4.75, -7.50,
SWEEPR    = -25.0, -22.0,  -7.5,   7.5,  21.5,
             31.0,  38.5,  44.0,  45.0,
CONER     = 14.0, 13.5,  9.5,  6.5,  5.0,
             4.5,  3.5,  2.0,  0.0,
ISPLR     = 0,
EZPARR    = 2.5,
&END

&WAKE
;WAKE CONFIGURATION.
NSW0   = 21,
WL        = 0.1,
WP        = 1.,
&END

&CONFIG
;PROPELLER CONFIGURATION.
DBETA     = 0.,
ISK       = 0,
JSK       = 0,
NBLADE    = 8,
NHUB      = 5,
```

```
 &END
/EOF
```

NASA
National Aeronautics and Space Administration

Report Documentation Page

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15. Supplementary Notes

Project Manager, Christopher J. Miller,

Propeller and Acoustics Technology Branch, NASA Lewis Research Center

16. Abstract

The tip vortex flowfield plays a significant role in the performance of advanced aircraft propellers. The flowfield in the tip region is complex, three-dimensional and viscous with large secondary velocities. A computer code was developed to predict the tip vortex flowfield of advanced aircraft propellers. This document is the User's manual. The analysis and a series of test cases are presented in NASA CR-182179.

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