NASA-CR-166,056

NASA Contractor Report 166056

NASA-CR-166056
19830010033

User's Manual for MASTER: Modeling of Aerodynamic Surfaces by Three-Dimensional Explicit Representation

S. G. Gibson

Boeing Commercial Airplane Company
Seattle, Washington

Prepared for
Langley Research Center
Under Contract NAS1-15325-10
JANUARY 1983

NASA
National Aeronautics and
Space Administration

Langley Research Center
Hampton Virginia 23665

NASA Contractor Report 166056

User's Manual for MASTER: Modeling of Aerodynamic Surfaces by Three-Dimensional Explicit Representation

S. G. Gibson

Boeing Commercial Airplane Company
Seattle, Washington

Prepared for
Langley Research Center
Under Contract NAS1-15325-10
JANUARY 1983

National Aeronautics and
Space Administration

Langley Research Center
Hampton Virginia 23665

N83-18304#

TABLE OF CONTENTS

Page

0.2 SUMMARY

This document provides user instructions for MASTER, a system used to model three-dimensional surface geometry configurations.

The first 6 sections cover the basic features of MASTER, which can model arbitrary untrimmed configurations. Section 1 presents the purpose and history of MASTER. Section 2 explains its organization: Section 2.1 describes the system capabilities; Section 2.2 names the specific procedures and data formats used to accomplish these capabilities; Section 2.3 gives the sequence of activities to use MASTER. Section 3 defines data formats: Section 3.1 gives the formats for input data; Section 3.2 explains the formats for system-produced data. Section 4 makes practical suggestions for preparing surface descriptions and other input data. Section 5 gives detailed instructions for executing the computer procedures. Section 6 shows examples of MASTER in typical usage. Section 7 presents additional features of MASTER, including a surface/surface intersector.

0.3 LIST OF ACRONYMS AND KEYWORDS

1. BEGIN
   Control statement calling a MASTER procedure (or any other CCL procedure)
2. BL
   Label for Buttock-Line (lateral coordinate)
3. CCL
   Cyber Control Language
4. CDC
   Control Data Corporation
5. CFD
   Computational Fluid Dynamics
6. CUR
   Curve data format (also file name for procedure MSHNRM intersection curves See Intersection, in the Glossary)
7. CYL
   Keyword for cylindrical coordinates (within surface description and mesh data)
8. DRAWIT
   Procedure for graphic display of surface models and intersection normals
9. DUMP
   Keyword requesting a listing of surface-modeling calculations by procedure SILSRF
10. GENTRN
    Procedure to generate coordinate-transformation data
11. INPUT
    Default file name for job-input data
12. LABELC
    Keyword to redefine the labels for cylindrical coordinates (within surface-description and mesh data)
13. LABELR
    Keyword to redefine the labels for rectangular coordinates (within surface-description and mesh data)
14. LSTOPT
    Keyword to change the level of listing from procedure MSHNRM (within mesh data)
15. MASTER
    Modeling of Aerodynamic Surfaces by Three-dimensional Explicit Representation
16. MSH
    Mesh data format (also file name for procedure MSHNRM or procedure NRMCFD input)
17. MSHNRM
    Procedure to compute mesh/surface intersection normals
18. NEWCFD
    File name for CFD-format output (from procedure NRMCFD)
19. NEWNRM
    File name for intersection-normal output (from procedure NRMREV)
20. NEWSIL
    File name for surface-description output (from procedure TRNSIL or from procedure REGSIL)
21. NOS
    Network Operating System (for CDC computers)

22. NRM
Intersection-normal data format (also file name for procedure MSHNRM output or procedure NRMCFD input)
23 NRMCFD
Procedure to format intersection normals for CFD input
24. NRMREV
Procedure for intersection-normal reversal
25 OLDCFD
File name for CFD-format input (for procedure NRMCFD)
26. OLDNRM
File name for intersection-normal input (for procedure NRMREV)
27 OLDSIL
File name for surface-description input (for procedure TRNSIL or for procedure REGSIL)
28 OPTION
File name for program-control selection input for one of the additional procedures of MASTER
29 OUT
Listing file from MASTER procedures in an interactive job
30 OUTPUT
Default file name for job output data, which contains listing from MASTER procedures in a batch job
31 RADIUS
Label for radial coordinate
32 PC
Parametric Cubic
33 REGSIL
Procedure to regulate point spacing along input surface-description curves
34 SEC
Section-curve data format (also file name for procedure SRFINT output)
35 SIL
Surface Input Language, the surface-description data format (also file name for procedure SILSRF output)
36 SILSRF
Procedure to model surfaces
37 SRF
Surface-model data format (also file name for procedure SILSRF output or procedure MSHNRM input)
38 SRFINT
Procedure for surface/surface intersection
39 STA
Label for Station (axial coordinate)
40. THETA
Label for angular coordinate
41 TOLANG
Tolerance for NRMCFD corrections to angular coordinate values (within mesh data)
42 TOLDIS
Tolerance for NRMCFD corrections to distance coordinate values (within mesh data)
43. TOLINT
Tolerance for mesh/surface intersection
44. TRN
Coordinate-transformation data format (also file name for procedure TRNSIL input)

45. TRNSIL
   Procedure for coordinate transformation within surface-description data
46. WL
   Label for Water-Line (vertical coordinate)
47. 3-D
   Three-Dimensional

0.4 GLOSSARY

1. Aborted Procedure
   An execution of a MASTER procedure that is stopped when an error is detected
2. Adaptive Spacing
   Variable spacing between points on a curve that becomes closer where the curvature is greater (This gives the most accurate interpolation for a given number of points)
3. Additional Procedure
   A MASTER procedure that is not a basic procedure (REGSIL and SRFINT are the currently implemented additional procedures)
4. Arclength
   Distance measured along a curved path

5 Basic Procedure
   A MASTER procedure required for the preparation of 3-D CFD analysis input of untrimmed configurations

6 Batch
   A mode of computer operation, where the sequence of job steps is completely input before execution begins

7 Block
   A portion of SIL input data that specifies the surface model for a region

8. Column
   A position in a line of text data, which is either blank or filled with a nonblank character

9 Comment
   A line in a data file that is ignored when reading data (It is used to add user-readable notes to a data file without affecting the data itself)

10 Configuration
   A complete shape, around which fluid flow is being analyzed

11. Coordinate Mesh
   A set of lines generated by a discrete set of values for each of the 3 coordinates (The mesh lines are grouped into 3 families Each family consists of lines with 2 coordinates constant and the other coordinate varying. Each constant coordinate value is selected from the mesh-value set for that coordinate)

12 Corner Point
   A knot within a member curve (In this context, a knot within a section curve is simply called a knot)

13. Crease
   A line where the surface bends sharply but remains connected

14 Curvature Jump
   A line where the surface suddenly changes curvature, but remains connected and not creased

15 Cut
   The calculation by procedure MSHNRM of the normals on an intersection curve where a (second) coordinate has a particular value (see Intersection, the preceding calculation step)

16. Data Line
   A line in a data file that is not recognized as a comment (One or more items of data are expected on it)

17 Elementary Rotation
   A rotation about 1 of the 3 coordinate axes

18 End Condition
   The specification that controls the direction (or curvature) of a spline-fit curve at one of its ends

19. End Direction
    A vector determining the tangent direction to a spline-fit curve at one of its ends (Extend a small line segment in the tangent direction, and resolve it along the coordinate axes, giving 3 distance components. These components are proportional to the end-direction components. The absolute values of the components are not important The signs of the values are important, and they agree with a tangent pointing from the inital end along the curve towards the final end)
20. End Slope
    (see End Direction)
21. Error Package
    A collection of all the available information generated by an aborted procedure execution
22 Field Length
    The amount of central memory used by a computing job
23. Flatness Tolerance
    The tolerance input to SRFINT that determines how closely surface SRF2 is approximated as a set of flat faces (The intersection is computed between these faces and surface SRF1.)
24. Free-Field Input
    The mode of input used to enter numeric data to MASTER (Data values are separated by blanks, rather than being read from predetermined columns.)
25 Gluing Tolerance
    The tolerance in procedure SRFINT that controls the joining of the intersections (between a patch from surface SRF1 and a set of flat faces approximating a patch from surface SRF2) to form connected intersection branches
26 Interactive
    A mode of computer operation, where the user selects job step after the previous step is completed
27. Intersection
    The calculation by procedure MSHNRM of curves within the surface, where one coordinate has a fixed value (see Cut, the following calculation step)
28 Intersection Branch
    Unit of surface-intersection data within procedure SRFINT (each connected intersection curve between a single patch of surface SRF2 and a single patch of surface SRF1 is a separate intersection branch
29 Intersection Normal
    A data line giving the position of an intersection of the surface model by a mesh line and the surface normal at that position
30 Intersections
    (see Intersection Normal)
31. Knot
    A point where the representation of a SIL input curve is divided (The part of the curve between two adjacent knots is represented by a single patch boundary)
32. Knot Flag
    A numeric value indicating whether a point on a SIL input curve is a knot or a null point
33 Lip
    A surface region located at the extreme front of an inlet
34 Listing File
    Printed summaries of MASTER procedure executions, containing any messages for the user
35. Members
    The secondary set of SIL input curves (Members are rearrangements of the section knots to form a crossing family of curves.)
36. Mesh Line
    (see Coordinate Mesh)

37. Mesh-Value Set
   (see Coordinate Mesh)
38 Normal Execution
   An execution of a MASTER procedure that is not aborted due to errors
39. Normals
   (see Intersection Normal)
40. Null Point
   A point within a SIL input curve that is not a knot
41 Option Declarations
   Data lines on an input file appearing before the body of the data (They change the program options from their default values)
42. Ordinary Point
   (see Null Point)
43. Orthogonal
   A coordinate transformation that does not change distances between points or angles between lines (A transformation matrix is orthogonal if, and only if, its transpose equals its inverse.)
44. Parameter
   An abstract variable used to locate points within a curve (or surface) modeling element (The 3 coordinates are calculated as separate polynomial functions of the parameter(s). Parameter changes tend to be proportional to the arclength between points. The element extends over a parameter range from 0 to 1)
45 Patch
   The surface-modeling element (with 2 parameters)
46. Patch Boundary
   A side of a patch, where one of the parameters is constant at either 0 or 1 (It is equivalent to a PC segment, dependent on the parameter, which is not kept constant.)
47 Patch Set
   (see Surface Model)
48 PC Segment
   The curve-modeling element (with 1 parameter)
49. Planar-Intersector Tolerance
   The tolerance used in procedure SRFINT to compute the intersection of a patch from surface SRF1 and one of the flat faces approximating a patch from surface SRF2
50. Procedure
   One of the fundamental processes within MASTER (It is executed by calling a predefined set of control statements from the procedure file, using a BEGIN statement)
51. Region
   A portion of a surface, which is modeled independently of the rest of the surface
52 Relative Spacing
   A set of values, between 0 and 1, expressing the locations of the interior points on a curve as the arclength from the beginning to each point divided by the arclength of the complete curve
53. Rigid-Object Transformation
   A coordinate transformation that changes the orientation of surfaces, but does not change their sizes or shapes (It consists of translations before and/or after a rotation)
54. Sections
   The primary set of SIL input curves describing the surface (A section contains points expressed by giving their coordinate values.)
55. Spacing Regulation
   The recalculation of points along a curve to give an adaptive spacing between the points while keeping a curve with the original shape

56. Specification
A portion of input data that describes a geometric element (e.g., section, member, or patch)

57. Spinner
The axisymmetric object at the fan face within an inlet, covering the fan hub

58. Spline
A curve made of several segments smoothly joined together

59. Standard Transformation
A predefined rigid-object coordinate transformation for use by procedure TRNSIL (e g., a rearrangement of the coordinates)

60. Surface Description
Input data that defines a surface model

61. Surface Model
A collection of patches used to represent a surface

62. Surface/Surface Intersection
The computation of the curve(s) where two surface models touch each other

63. System Account
The account where the system files for MASTER are stored (e.g., the procedure file, and sample input data files)

64 Tension
A value at points in SIL curve input, which tends to move curvature towards a point and away from the adjacent points (Normally all tension values are set to 0.)

65. Trimmed Surface
A surface that is limited to less extent than was originally defined (e g , intersecting surfaces are often defined initially to pass through each other,and later trimmed at their intersection with each other)

66 U
The parameter for surface modeling that corresponds to position along a section curve, also the parameter for curve modeling

67. Uniform Spacing
Equal-distance spacing between adjacent points on an input curve

68 V
Parameter for surface modeling that corresponds to the position along a member curve

0.5 LIST OF FIGURES

1.0 INTRODUCTION

This document is the manual for users of "Modeling of Aerodynamic Surfaces by Three-Dimensional Explicit Representation" (MASTER), a system of programs with which engineers can loft the surface geometry of configurations, with emphasis on generation of input to three-dimensional computational fluid dynamics (3-D CFD) analysis programs. This manual gives a functional description of the system (MASTER), and explains how to operate it

MASTER was developed at Boeing to prepare input for a 3-D transonic potential flow CFD code (see Reference 1). The data format for 3-D CFD input consists of a cartesian or cylindrical mesh and a set of mesh/surface intersection points with normal directions.

MASTER is a practical tool for the modeling of predefined surface configurations Its primary capabilites are surface modeling, mesh intersection and CFD input preparation. There also is a capability for coordinate transformations. The surface input is described as a set of abstract objects (i e., no assumption is made that they are components of an aerospace vehicle).

MASTER currently is operated in a CDC NOS computing environment by executing CCL procedures Some procedures are oriented for batch operation, while some are oriented for interactive operation from a timesharing terminal.

This system is a major revision of the Propulsion Bicubic Geometry System (see Reference 2), which was used to generate geometry models for engine inlet and mixer nozzle designs, and for nacelle-pylon-wing configurations.

2.0 APPLICATION

The first part of this section lists the capabilities of MASTER. The second part describes the methods to realize these capabilities The third part shows the sequence of steps to prepare input data for 3-D CFD analysis.

2.1 CAPABILITIES

This section lists the basic capabilities of MASTER. These capabilities can model untrimmed configurations and prepare their geometries for input to 3-D CFD analysis.

Additional capabilities exist to locate the intersection of two surface models and to regulate the spacing of points on input curves They are covered in Section 7

2.1.1 SURFACE-MODELING CAPABILITY

Surface models are divided into regions, typically four-sided (see Figure 2-1; all the regions shown can be unfolded to give four-sided surfaces). A tube-like region can be modeled by making corresponding points coincident on a pair of opposite sides of the region. A closed region (e g., a sphere) can be modeled similarly to a tube-like one, by also making each of the two remaining open sides consist entirely of coincident points (i e., all the points on an open side have the same location).

The surface model for a single region is divided into mathematical elements called patches (see Figure 2-2). Each patch is fundamentally four-sided, and a region typically consists of a regular arrangement of rows of patches

Surface models are smooth and continuous They have no creases when the input curves are evenly spaced. The curvature is continuous between patches unless the surface is irregularly shaped The rate of change of the curvature is discontinuous between patches. All surface properties are continuous within a patch.

Each region is input in three stages (see Figure 2-2) Points are input to form curves called sections; these points are used to form other curves called members, and patches are defined between these curves Normally a section curve does not cross other sections, nor does a member curve cross other members Member curves are oriented across sections, and they consist of a rearrangement of the same points that were input for sections, rather than containing new points Each patch is located by specifying four points from member curves to be the corners.

Separately-generated surface models can be combined by copying them to a single file.

2.1.2 COORDINATE-TRANSFORMATION CAPABILITY

Surface models can be represented in either rectangular or cylindrical coordinates. Input surface data can be automatically converted between these two types of coordinates Input surface data in rectangular coordinates can also be translated and rotated like a rigid object. The rigid-object transformations are kept on files separate from the surface data.

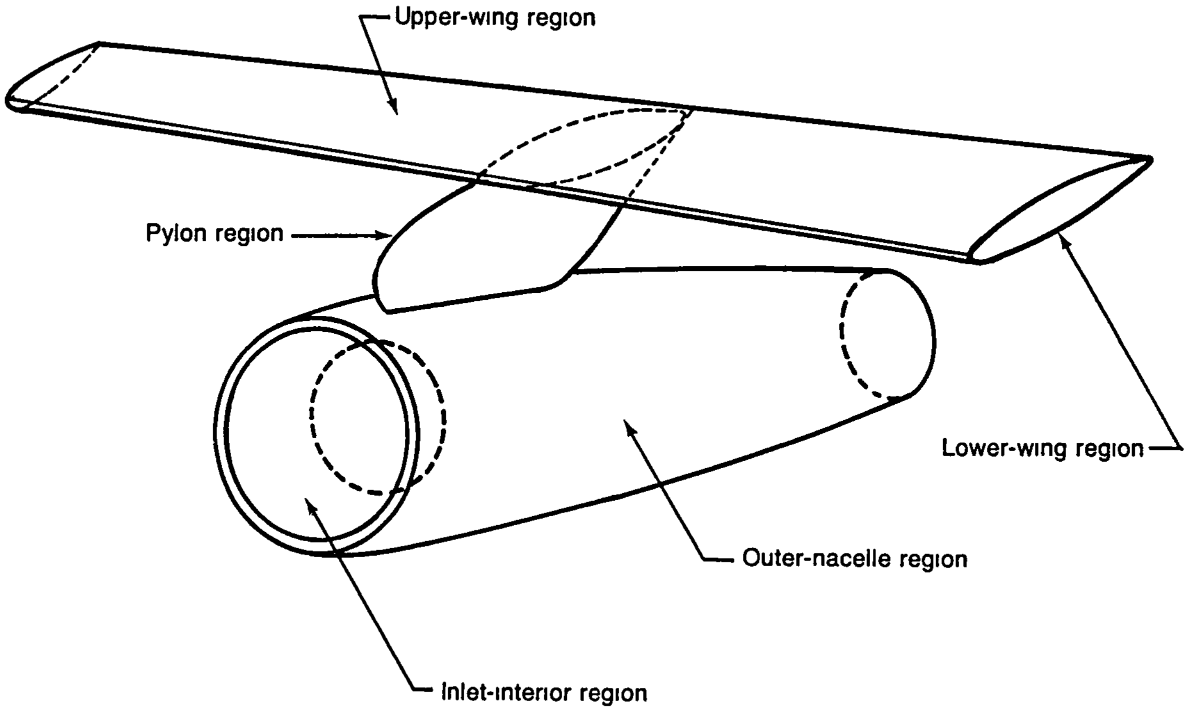


Figure 2-1. – Surface Model Divided Into Regions

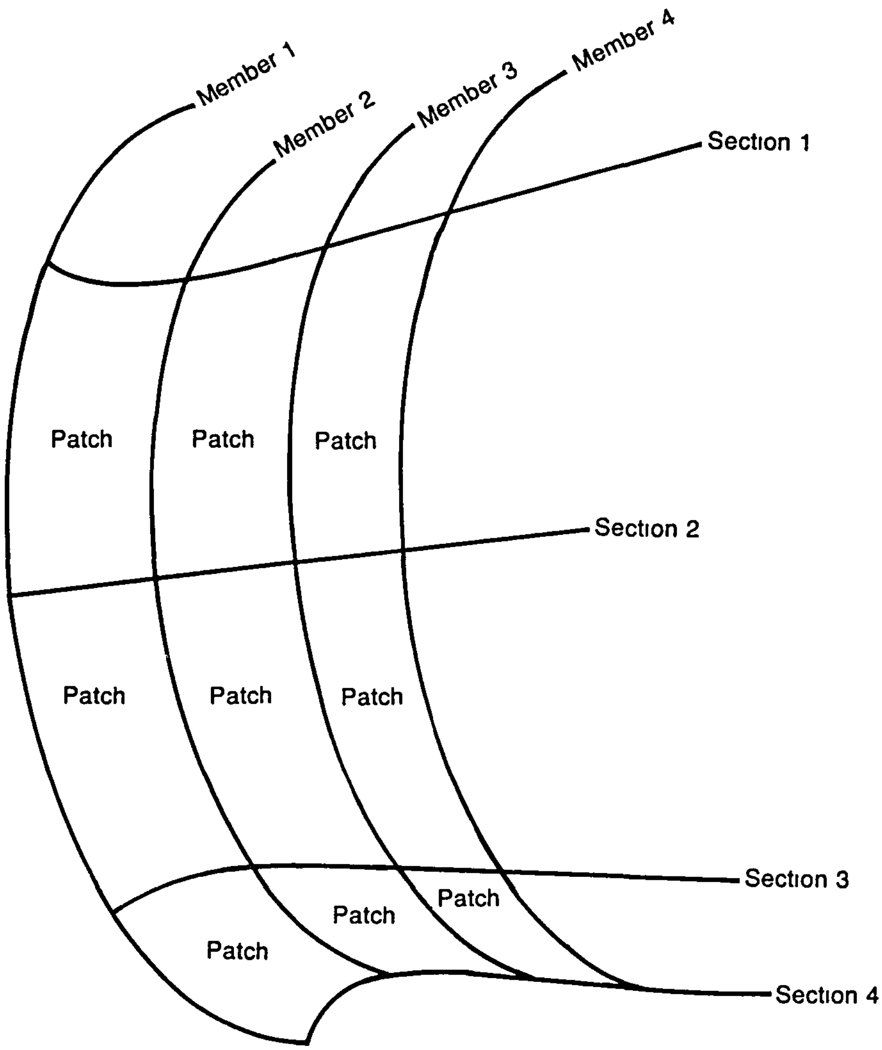


Figure 2-2. – Surface Representation by Patches

2.1.3 MESH/SURFACE INTERSECTION CAPABILITY

A surface model can be intersected with a coordinate mesh (see Figure 2-3, for clarity, only a two-dimensional mesh is shown). A coordinate mesh is specified by a set of values for each of the three coordinates. A mesh line is defined by taking values for two coordinates from their mesh-value sets and varying the third coordinate The sets of mesh lines in all three directions, defined by all possbile combinations of pairs of values, is a coordinate mesh At each intersection of a mesh line with the surface model, a location and a normal direction is calculated.* The inwards/outwards sense of the normals is consistent for each block of the surface model.

There is a capability to reverse all the normals in a set.

Separately-generated sets of intersection normals can be combined.

2.1.4 3-D CFD INPUT FORMATTING CAPABILITY

A procedure exists to sort a set of intersection-normals, to remove duplications of the same position, and to align the mesh intersections with their mesh lines. This procedure assembles a file for 3-D CFD analysis input by combining the conditioned normals, the mesh data and possibly other data.

2.2 METHODS

These methods show how the capabilities of MASTER are realized. The computer procedures and the associated data formats are named, but their details are deferred until later.

MASTER treats data files as local files; permanent storage is left to the user.

2.2.1 SURFACE-DESCRIPTION METHODS

Surface models are divided into regions. The surface should be divided into regions at any intentional gaps, creases, or curvature jumps Opposite sides of a region can be connected to form a tube or a closed surface.

The format for surface-description files is called SIL (Surface Input Language) format. Each surface region is described by a SIL block (see Section 3 1.3 for details; see Section 4 1 for practical surface-description suggestions, see Section 6 1 for an example of surface description).** Blocks consist of three parts: sections, members, and patches.

---

*Plane/surface intersection curves are produced as an intermediate step in the calculation of mesh/surface intersection points.

**A region is a subset of a surface; a block is the corresponding unit of MASTER input data.

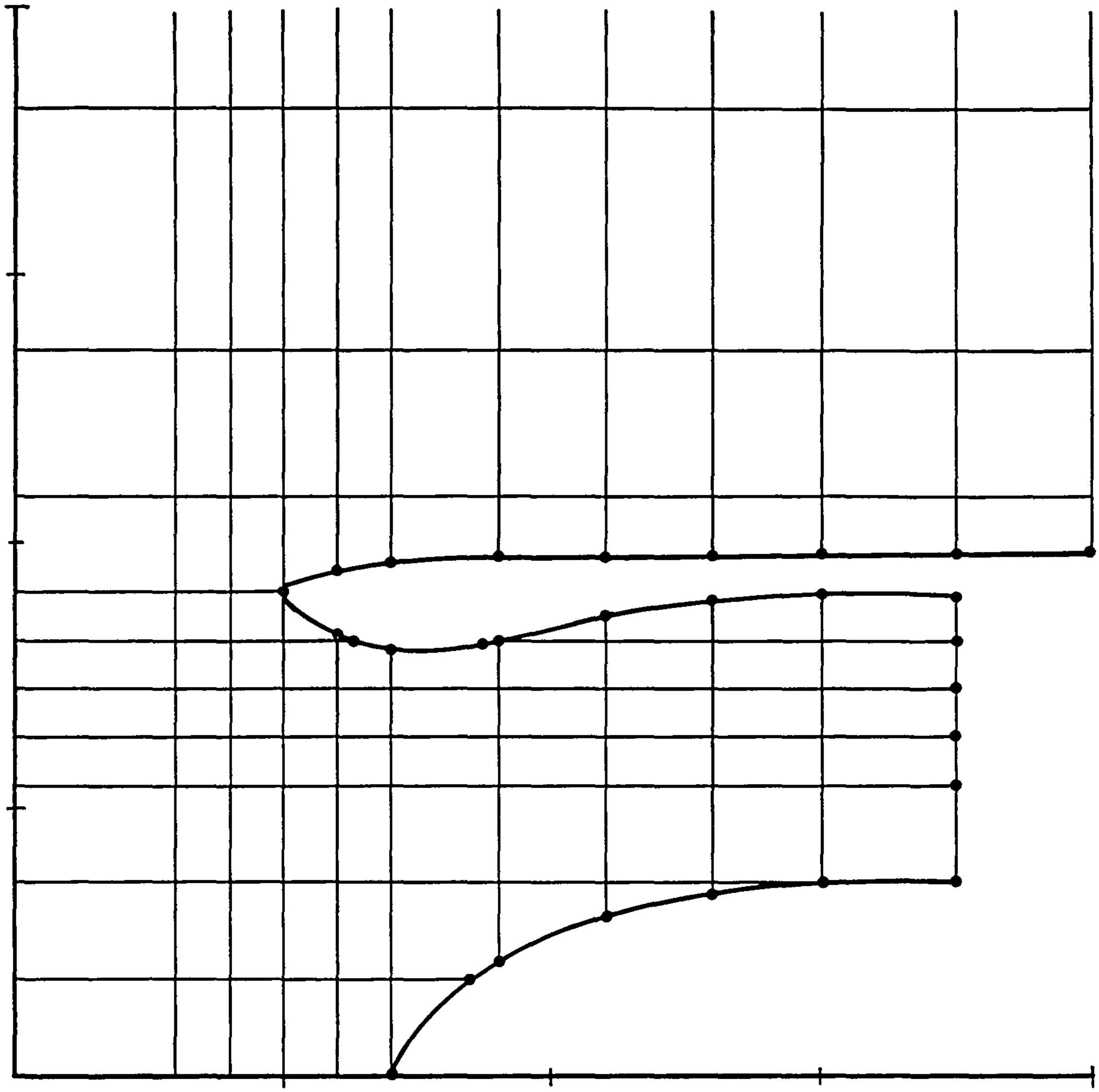


Figure 2-3 – Mesh/Surface Intersection Locations

Sections are input as an ordered set of curves. The first and last section are opposite sides of region. The beginning of each section and the the end of each section lie on the other two sides of the region. The sections should not cross and should be oriented in the same (not opposite) direction. The sections should cover the surface either with approximately even spacing or with smoothly increasing density where the surface is most curved (this is called adaptive spacing).

Each section consists of an ordered set of points, with each point expressed by three coordinate values. A boundary condition is required at the ends of a section This condition is typically expressed as tangent directions at the ends, but another option exists to connect both ends as a closed curve (without creases). Points along a section should be spaced either uniformly or adaptively.

Members are described by another set of ordered curves. The first and last members are opposite sides of the region; they are respectively the sides where the sections begin and where the sections end. The beginning of each member and the end of each member lie on the other two sides of the region; they are respectively the first and last sections. Member points are a subset of section points, and they are specified by the number for the desired section and the number for the desired knot* in this section Members should not cross each other and should run in similar, not opposite, directions. Member end conditions are specified the same way as section end conditions Member spacing is dependent on point spacing within sections. Members should be spaced either uniformly or adaptively Point spacing within a member is dependent on section spacing. Points within a member should be spaced either uniformly or adaptively.

Patches are described by specifying their corners Each corner is located at a member point and is specified by giving the number for the desired member and the number for the desired knot* within this member

Typical blocks are regularly arranged: each section has the same number of points, which are all knots; each member has the same number of points, which are all knots, the nth member contains the nth knot from each section (in the same order that the sections appear), patches cover the entire area enclosed by curves; the patches are ordered in a regular pattern of rows

A single file of SIL data can contain several blocks of sections, members, and patches.** Comments can be added to a SIL file to identify and annotate it

2.2.2 COORDINATE-TRANSFORMATION METHODS

Coordinate transformations are performed on SIL files by procedure TRNSIL (see Sections 3.1 4, and 5.3 for details; see the second part of Section 6 2 for an example of coordinate transformation) Two types of transformations are available: (1) SIL files can be converted from cylindrical to rectangular coordinates or from rectangular to cylindrical. (2) SIL files can be transformed by a

---

*A knot is a kind of point (see Section 4 1 3 2 for details)

**Blocks should be checked for consistency of the surface-normal direction between each other before they are combined on a single SIL file (see Section 4 1 2 2).

linear transformation plus additive constant, which performs rotation and translation on rectangular coordinates (as if the described geometry was moved as a rigid object). The selection of cylindrical/rectangular or rigid-object transformation is controlled by interactive user input.

Rigid-object transformations are defined prior to their use to transform coordinate data. One or more rigid-object transformations are stored as a TRN format file The selection of a particular transformation from a TRN file is controlled by interactive user input

Rigid-object transformations can be generated with the aid of procedure GENTRN (see Section 5 2 for details, see Section 4 2 for practical transformation-definition suggestions; see the first part of Section 6 2 for an example of transformation definition) This procedure interactively asks the user for translation vectors and rotations about coordinate axes

Comments can be added to TRN-format transformations to identify them

2.2.3 SURFACE-MODELING METHODS

Surface modeling is performed by procedure SILSRF (see Section 5 4 for details; see Section 6 3 for an example of surface modeling). This procedure takes surface description input from a SIL-format file and produces a SRF-format file containing the mathematical surface model. Comments can be added to the SRF files to identify surface models.

The blocks describing each surface region can be strung together as a single SIL file Alternatively, the blocks can appear as separate SIL files, which are modeled individually. SRF files can be manually merged to give a combined model *

2.2.4 MESH/SURFACE INTERSECTION METHODS

The intersections of a computational coordinate mesh with a surface model are computed by procedure MSHNRM (see Sections 3 1 5 and 5 5 for details, see Section 6.4 for an example of mesh intersection) The coordinate mesh is input as a MSH-format file. The surface model is input as a SRF-format file The mesh/surface intersection points with normal directions are output as a NRM-format file (see Section 3.2.2 for details). If the intersection-normals are found to point into the surface rather than outwards, the entire set of normals on the NRM file can be reversed by procedure NRMREV (see Section 5.6)

Comments can be added to the NRM file to identify the surface model and mesh version.

*The files should be checked for consistency of the surface-normal direction between them before they are merged (see Section 4.1 2.2).

2.2.5 FORMATTING METHODS FOR 3-D CFD ANALYSIS INPUT

A NRM file contains geometry information for 3-D CFD analysis. The analysis input is a CFD format file (see Section 3 2 3 for details), which contains the intersection normals from a NRM file, the mesh values from the corresponding MSH file, and other data. NRM data requires some conditioning before it is ready for use within a CFD file Duplicate normals can be formed at some locations;* it is also possible that the location of a normal could be calculated with a slight offset from the coordinate values for the mesh line.

NRM data conditioning and CFD formatting are done by procedure NRMCFD (see Section 5.7 for details; see Section 6 5 for an example), which reads the normals from a NRM file, sorts them by position and removes duplicates NRMCFD also reads a MSH file of coordinate values defining mesh lines If a normal is near a mesh line, it will be moved to that line. NRMCFD also reads other CFD-analysis inputs from the front of an existing CFD file and uses this other data and the mesh values with the new geometry input to automatically produce a new, complete CFD file.

2.3 USER ACTIVITIES WITH MASTER

This section explains the sequence of user activities to prepare inputs for 3-D CFD analysis. Figure 2-4 illustrates this sequence as a flow chart Figure 2-5 shows the possible data paths connecting the procedures

Start with a configuration, in the form of a design idea, a drawing, or a computational definition in some other surface-modeling system. Before creating any files, select the regions. Choose a local coordinate system for each region that takes advantage of any symmetry present (e g , describe an axisymmetric surface initially with the axis of symmetry as a cylindrical coordinate axis). A natural choice of local coordinates will make the symmetry apparent, which makes the data easier to enter and to check Then select the global coordinate system, which will generate the computational meshes for CFD analysis. All surface descriptions will be transformed to these coordinates before modeling When all coordinate systems are known, describe the transformations from each local system to the global one as TRN data (by using procedure GENTRN or by manually editing transformation equations into TRN format).

Next prepare a surface description file in local coordinates for each region (see Section 4.1 for suggestions). Add comments to these descriptions, to identify them when they are transformed to the global coordinates Do not add SIL option declarations to the files yet. Give each SIL file a preliminary pass through procedure SILSRF, it will add system comments, which make the data easier to understand, and it will spot typographical errors Correct the files and repeat procedure SILSRF until the errors are removed.

Now transform the descriptions to the global coordinates by procedure TRNSIL. Add the appropriate SIL option declarations to the transformed descriptions.

*For example, when a mesh line intersects a patch set at a patch boundary. One normal is formed from each patch, causing duplication

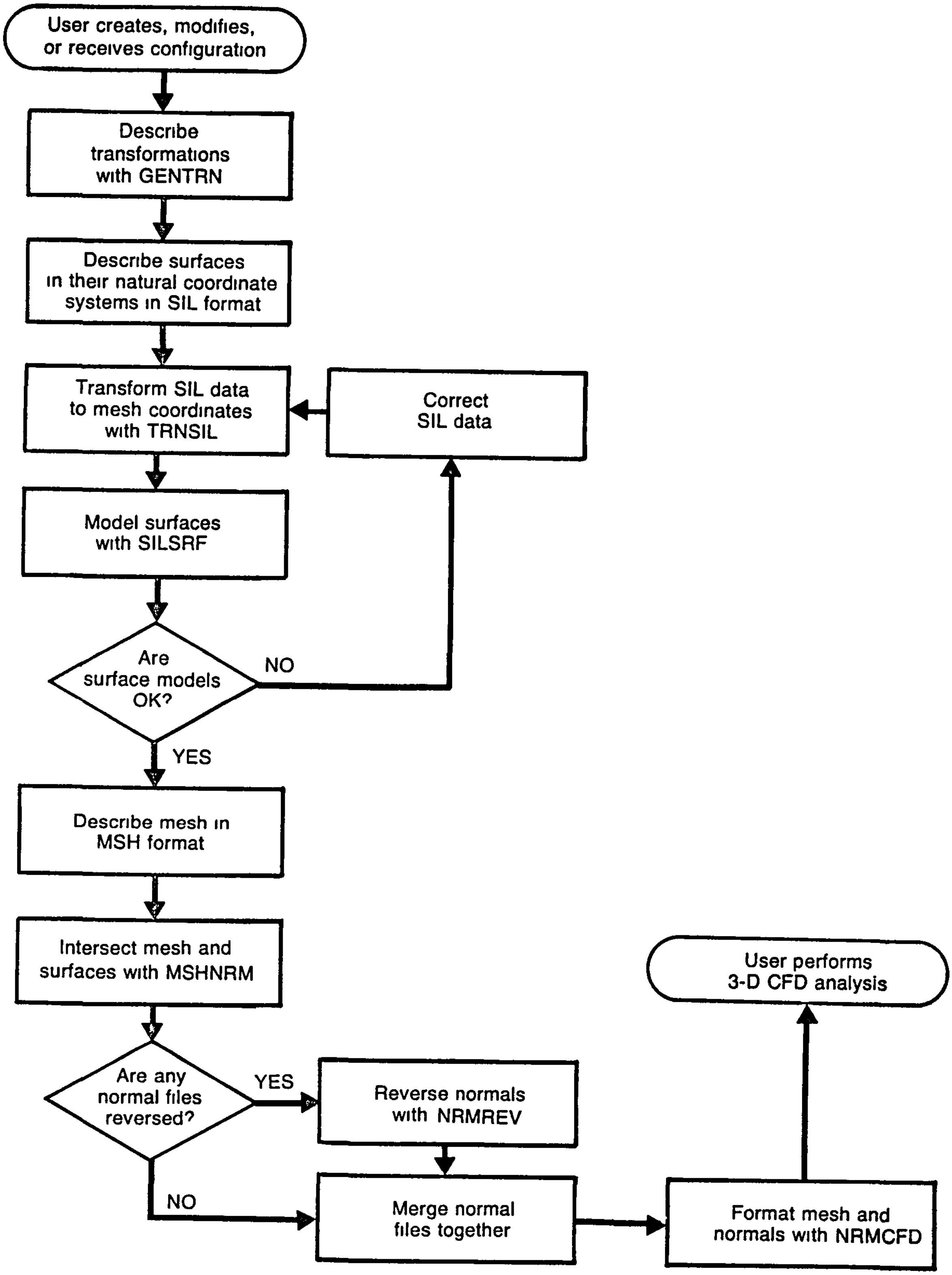


Figure 2-4. – User Activities with MASTER

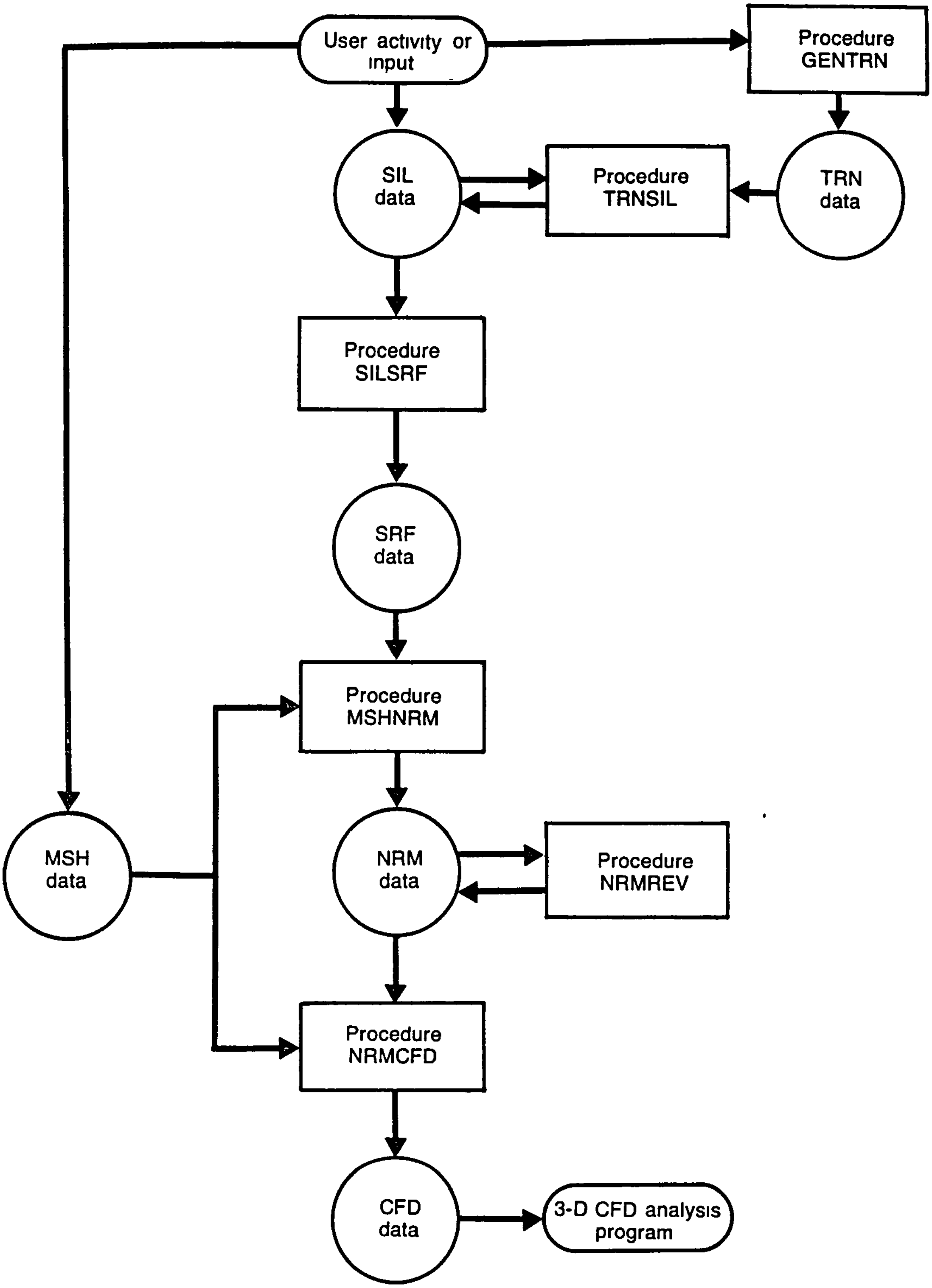


Figure 2-5. – Data and Procedure Relationships in MASTER

Now enter the surface descriptions to procedure SILSRF, to model the surface regions. Check the surface models thoroughly, using a graphical display and perhaps other methods. Where errors are detected, correct them in the local-coordinate description files. (At this stage, the system comments from the initial pass through SILSRF make it easier to find a desired line in the file.) Repeat the cycle of transformation, option insertion, modeling, and checking until the models are correct.

Now select the mesh values (see Reference 1), and edit a MSH file describing the mesh. Use procedure MSHNRM to compute the intersections of the mesh with all the surface-model files. Inspect each intersection-normal file for reversed normals, by selecting one component whose sign is known in advance for each file. Correct any reversed file of normals with procedure NRMREV. Merge the normal files together into a single file without record marks.

Now that the needed geometry information has been calculated, determine the rest of the inputs to the CFD analysis program (see Reference 1). Prepare a header file containing these inputs. Use procedure NRMCFD to combine the mesh, the complete set of intersection normals, and the other CFD inputs. The combined data is a complete CFD-analysis input file, ready for checking and execution.

3.0 DATA FORMATS

This section explains the data formats for MASTER. Input data is prepared by the user for input to MASTER. System data is created by MASTER

3.1 INPUT FORMATS

This section defines input data formats for surface description (SIL) data, coordinate-transformation definition (TRN) data, and coordinate-mesh description (MSH) data. These formats are simply the patterns of data values that are expected by the MASTER programs; Section 4 explains how to represent the desired surface, transformation, and mesh information in these formats.

All input data is stored on text files. The data is read in free-field form, where the values on a line are separated by blanks rather than being aligned in specific columns. All data after the first 80 columns of a line is ignored. Coordinates can be given any desired labels and ordering. Comments can be added to input files.

3.1.1 DEFAULT COORDINATES

This section explains the default labels and orderings for rectangular and cylindrical coordinates.

3.1.1.1 Default Rectangular Coordinates

Rectangular coordinates are named STA, BL, and WL, and this is their default order (see Figure 3-1). STA is oriented horizontally, from front to back. WL is oriented vertically, pointing upwards. BL is oriented laterally

3.1.1.2 Default Cylindrical Coordinates

Cylindrical coordinates are named STA, RADIUS, and THETA (see Figure 3-2) STA (i.e , station) is the axial coordinate. RADIUS is the radial coordinate THETA is the angular coordinate, measured in degrees.

Unlike the rectangular coordinates, the 3 cylindrical coordinates have different characters. One is axial, one radial, and one angular Because they enter differently into calculations, their order must be defined. The default order is. axial, then radial, and then angular. If the user changes their order, the coordinate labels will be rearranged to match the corresponding characters.

The STA axis is oriented horizontally, pointing from front to back STA values can be negative, depending on where along the axis the user locates the origin.

RADIUS is the radial coordinate. It can be zero or positive.

The angle THETA is defined to be zero at the 12 o'clock position Several THETA values can be used for the same position, differing from each other by multiples of 360 degrees For most MASTER operations, THETA values must be equal to be recognized as equivalent (e g., a surface description around -90 degrees will not be found to intersect a mesh value at +270 degrees). However, during the formatting of CFD data, THETA values of intersection normals are converted into equivalent values within the corresponding range of mesh values.

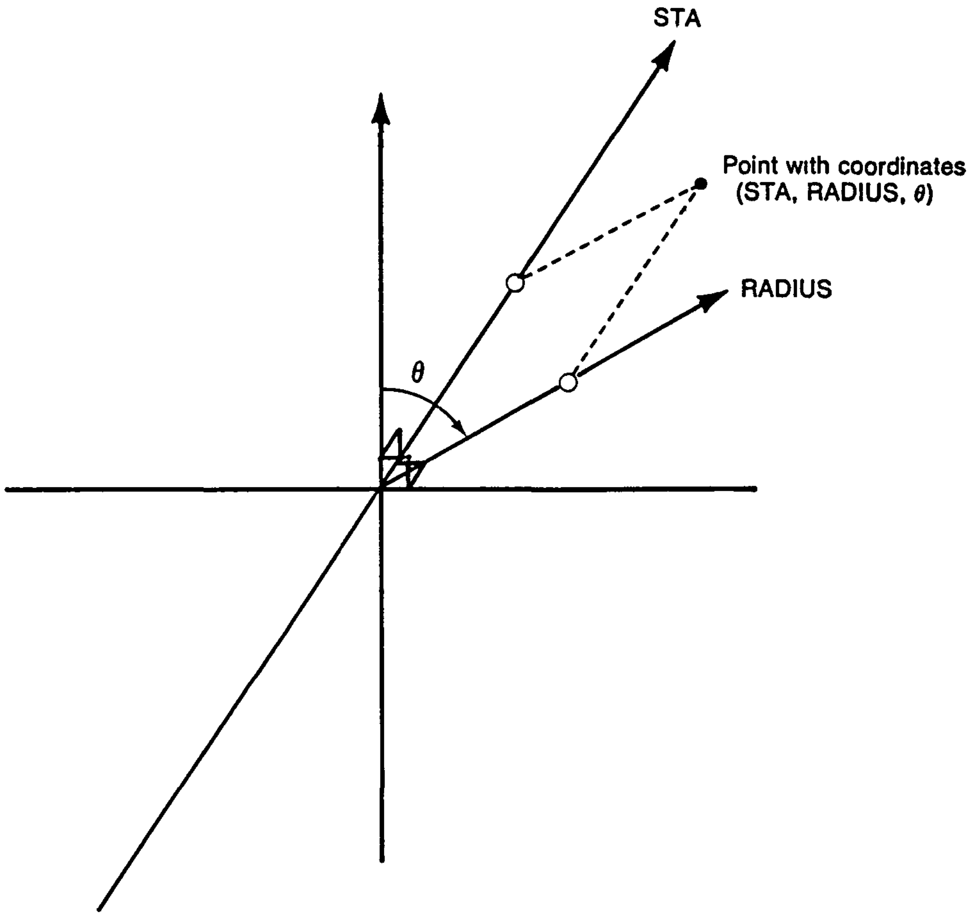


Figure 3-1 – Cylindrical Coordinates

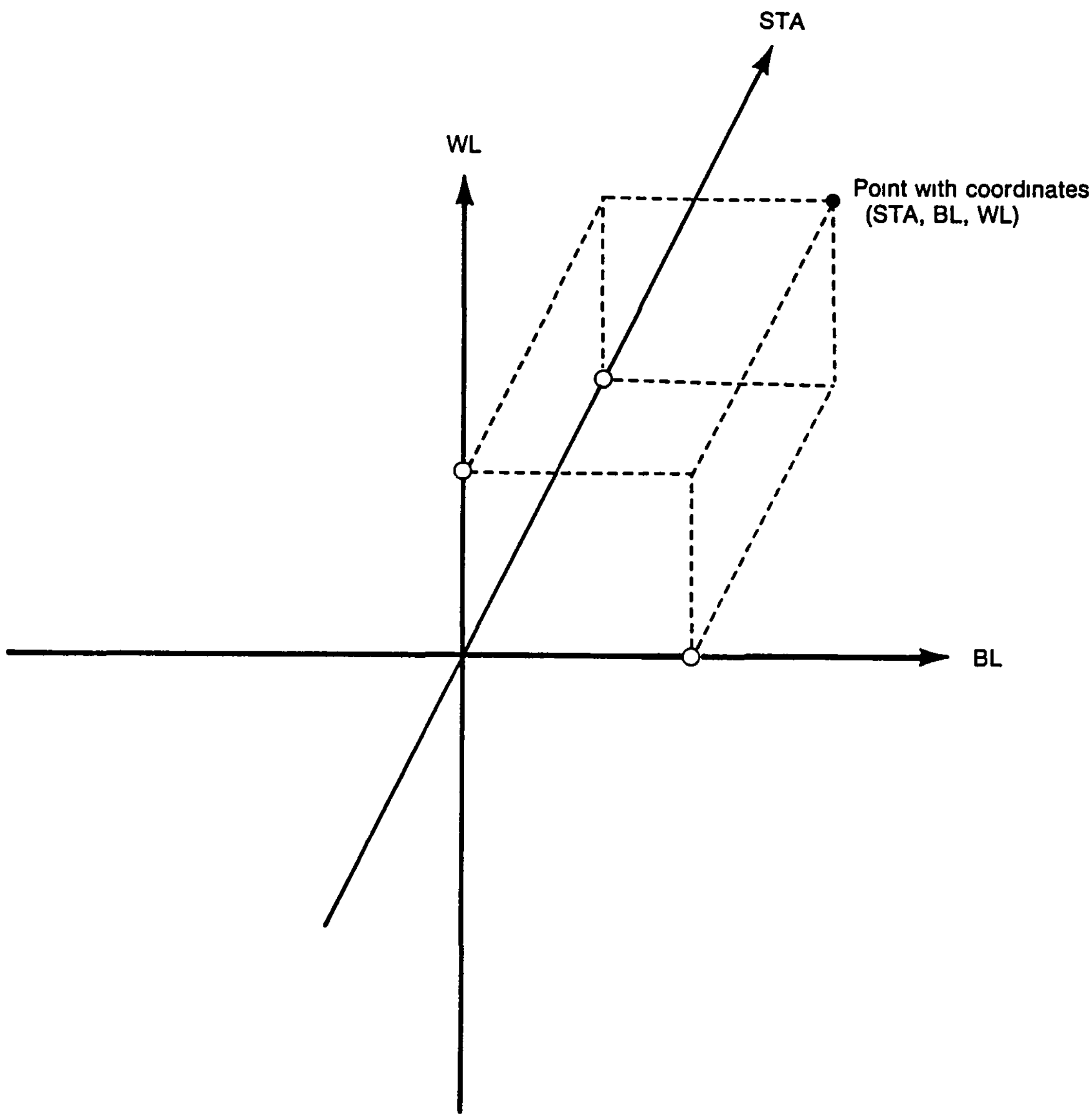


Figure 3-2 – Rectangular Coordinates

3.1.1.3 Default Rectangular/Cylindrical Coordinate Correspondence

The rectangular coordinate STA corresponds to the (axial) cylindrical coordinate, STA. The rectangular coordinate, WL, corresponds to RADIUS * cos(THETA) in cylindrical coordinates. The rectangular coordinate, BL, corresponds to RADIUS * sin(THETA).

3.1.2 INPUT COMMENT CHARACTERISTICS

The user can add comment lines to input files MASTER recognizes both system comments and user comments (see Figure 3-3). System comment lines begin with the letter C in column 1 and a blank in column 2; they are ignored. Other system comments are written on data lines after all the data values; they are also ignored. User comments begin with an asterisk (*) in column 1; they are ignored, but are copied with the data For example, user comments from input SIL files are copied to output SIL files, and user comments from input TRN or MSH files are copied to the listing file.

3.1.3 SURFACE-INPUT LANGUAGE (SIL) FORMAT

Surface Input Language (SIL) is the data format used to enter surface descriptions (Suggestions for preparing surface descriptions are made in Section 4 1; an example of surface description in SIL format is given in Section 6.1) A SIL file can begin with option declarations, or the default options can be used. Any option declarations apply to the entire SIL file. The remainder of the SIL file consists of one or more blocks (see Figure 3-4) The blocks of a SIL file are processed independently of each other. Each block describes a single surface region. The data for each block is composed of three separate parts: specifications for sections, members, and patches (see Figure 3-5).

The first part specifies an ordered set of curves, called sections Each section is expressed as initial and final end conditions and an ordered set of points in space A subset of the section points (usually all of them) is selected as knots (see Section 4 1 3 2) To refer to them in the member input, the sections are numbered in the order that they are input; the knots in a section are also numbered

The next part of data for the block rearranges these knots to form a second ordered set of curves, called members. Each member is expressed as initial and final end conditions and an ordered set of member points These points are input as knot and section numbers. A subset of the member points (usually all of them) is selected as knots (see Section 4.1.3.2) To refer to them in patch input, the members are numbered in the order that they are input; the knots in a member are also numbered.

The last part of data for the block specifies four-sided patches, bounded by two sections on opposite sides and two members between the sections. A patch is specified by naming the four corners, which are selected from the member knots. The four corners in a patch specification must appear in a particular order. These corners are input as knot and member numbers.

3.1.3.1 SIL Limitations

SIL data is used as input to two procedures. SILSRF and TRNSIL SILSRF is used to model all surfaces, while TRNSIL is used only when the coordinates in a SIL file need transformation. There currently are different limitations for SIL input to these procedures, so which limitations a particular SIL file must follow depends upon whether or not the file must have its coordinates transformed.

Case	Column 1	User input lines
(1)	C	THIS IS A SYSTEM COMMENT LINE
(2)	*	THIS IS A USER COMMENT LINE
(3)	4	(Data value without comment)
(4)	4	COMMENT FOLLOWING INPUT DATA VALUE

Case	Data value as recognized by system
(1)	(None)
(2)	(None)
(3)	4
(4)	4

Case	Column 1	System output lines
(1)		(None)
(2)	*	THIS IS A USER COMMENT LINE
(3)		4 NUMBER OF PATCHES (new comment added by program)
(4)		4 NUMBER OF PATCHES (new comment added by program)

Figure 3-3. - Comment Types

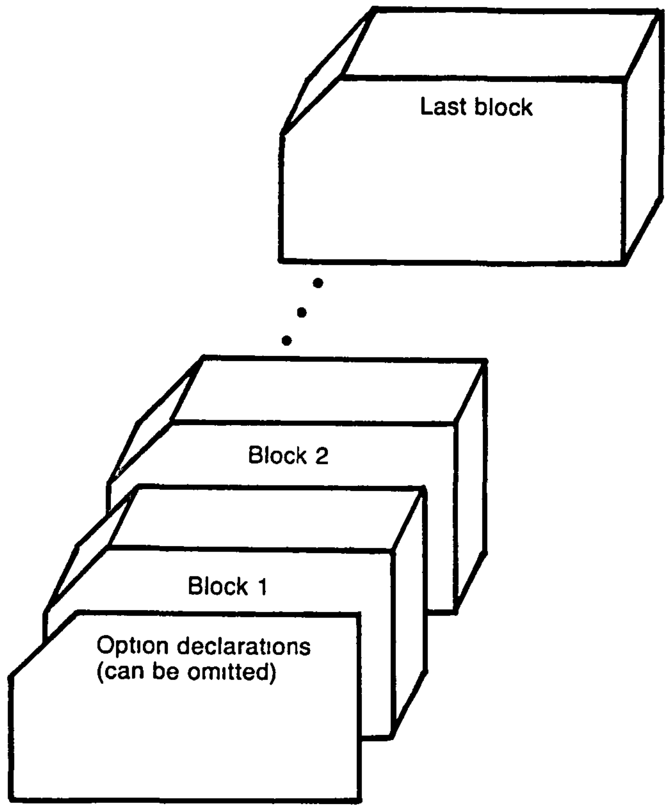


Figure 3-4 – SIL File Structure

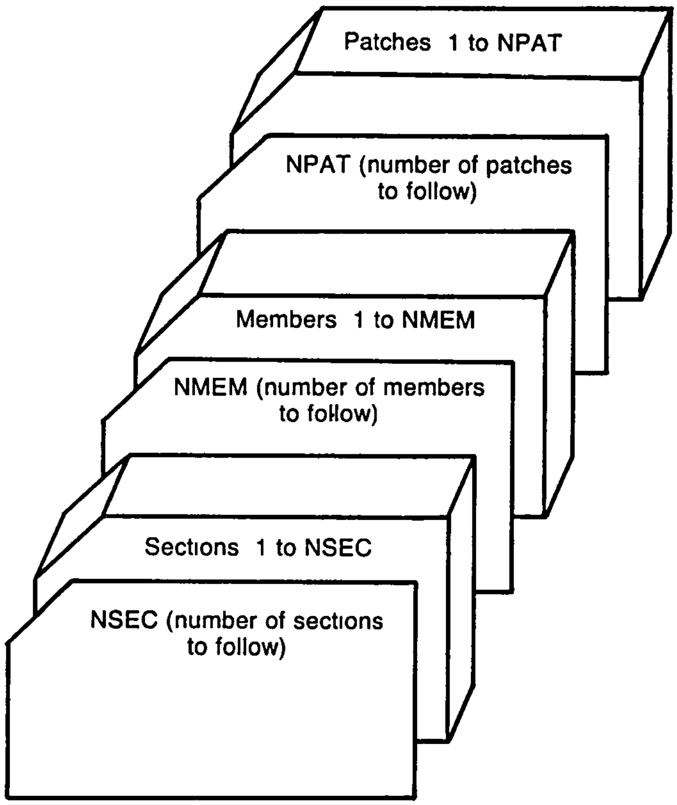


Figure 3-5. – SIL Block Format

Procedure SILSRF imposes the following limitations:

1. There can be at most 120 sections in a block.
2. Each section can contain at most 175 points.
3. There can be at most 175 members in a block.
4. Each member can contain at most 120 points.
5. There is no limitation on the number of blocks in a SIL file.

Procedure TRNSIL currently imposes the following limitations on those SIL files that must have their coordinates transformed:

1. The option declarations must be omitted.
2. The user must remember whether the coordinates are rectangular or cylindrical.
3. Cylindrical coordinates must appear in the order: axial, radial, and angular.
4. The coordinate labels are written "X", "Y", and "Z", regardless of the coordinate type.
5. Only one block can appear on a single SIL file.
6. There can be only 27 sections in a block.
7. Each section can have only 29 knots. (There can be a total of only 53 points in a section.)
8. There can be only 27 members in a block.

3.1.3.2 SIL Option Declarations

Option declarations are permissible only at the beginning of the SIL file, before any comment lines. These declarations apply to all the blocks on the file. Each declaration must appear on a separate line, which contains the corresponding keyword. When no option declarations are provided, the coordinates are recognized as rectangular, with the labels "STA", "BL", and "WL". Option declarations can: change the type of coordinates to cylindrical; change the coordinate labels, list the intermediate calculations of the procedure SILSRF, and change the ordering of cylindrical coordinates. The possible option-declaration keywords are:

1. CYLINDRICAL*

   This declaration causes the input coordinates to be recognized as cylindrical, not rectangular. It also changes the default labels to "STA", "RADIUS", and "THETA".

2. LABELR

   This declaration changes the names for rectangular coordinates from the default rectangular names ("STA", "BL", and "WL"). The names can be 10 characters long; they follow the keyword and are separated by blanks. The names are assigned to coordinates in the order that they appear.

3. LABELC

   This declaration changes the names for cylindrical coordinates from the default cylindrical names. The names can be 10 characters long; they follow the keyword and are separated by blanks. The first name is used for the axial coordinate (default "STA"); the second name is used for the radial coordinate (default "RADIUS"), and the third name is used for the angular coordinate (default "THETA"). The labels are matched in this way, even when the coordinates are reordered.

*The keyword can be abbreviated, but the letters "CYL" must appear.

4. DUMP

This declaration causes SILSRF to list its intermediate calculations. This option is intended to help MASTER consultation spot errors in SIL input. General users should ask MASTER consultation for assistance in interpreting the listing.

5. $OPTION IXAXI=?, IXRAD=?, IXANG=? $

This must be the last option declaration to appear on a SIL file. It is read as a NAMELIST.* It can have multiple lines, but the first column of each line is ignored. The user must replace the question marks with integer values. The NAMELIST ends with a dollar sign ($).

This declaration rearranges the cylindrical coordinate labels. It also changes the calculations within procedure SILSRF to correctly handle input data that has been rearranged to match the labels The three values must be 1, 2, and 3 in some ordering. They show which of the three spatial coordinates are axial (default 1st), radial (default 2nd) and angular (default 3rd), respectively.

3.1.3.3 SIL Section Set

The section-set specification (see Figure 3-5) begins with an integer, the number of sections in the set. This number appears on a separate data line. The section-curve specifications follow.

A section-curve specification (see Figure 3-6) begins with the number of points, which appears as an integer on a separate line An end-condition specification follows, in the format described in Section 3.1 3 5 The section-point specifications are the last part of the curve

Each section point is specified by a single data line consisting of three coordinate values, a spline-tension value, and a knot flag. The coordinates are decimal values. Together they locate a point in space (e.g , the origin is specified by entering "0. 0. 0.") The spline tension is a decimal value, which should be set to zero (see Sections 4.1 3.1 and 4.1.3.2). The knot flag is an integer, which can be either positive or zero A point with a positive knot flag is a knot, while a point with a zero knot flag is a null point (see Sections 4.1.3.1 and 4.1.3 2). All section points should be made knots.

3.1.3.4 SIL Member Set

A member-set specification (see Figure 3-5) begins with an integer, the number of members in the set This number appears on a separate data line. The member-curve specifications follow to complete the set.

A member-curve specification (see Figure 3-7) begins with the number of points, which appears as an integer on a separate line An end-condition specification follows, in the format described in Section 3.1.3 5. The member-points are the last part of the curve.

All member points are located at section knots. Each member point is specified by a single data line consisting of sequence numbers to identify the particular knot and section, a spline-tension value and a knot flag.

---

*A NAMELIST is a standard form of FORTRAN input. For details, check the appropriate FORTRAN manual.

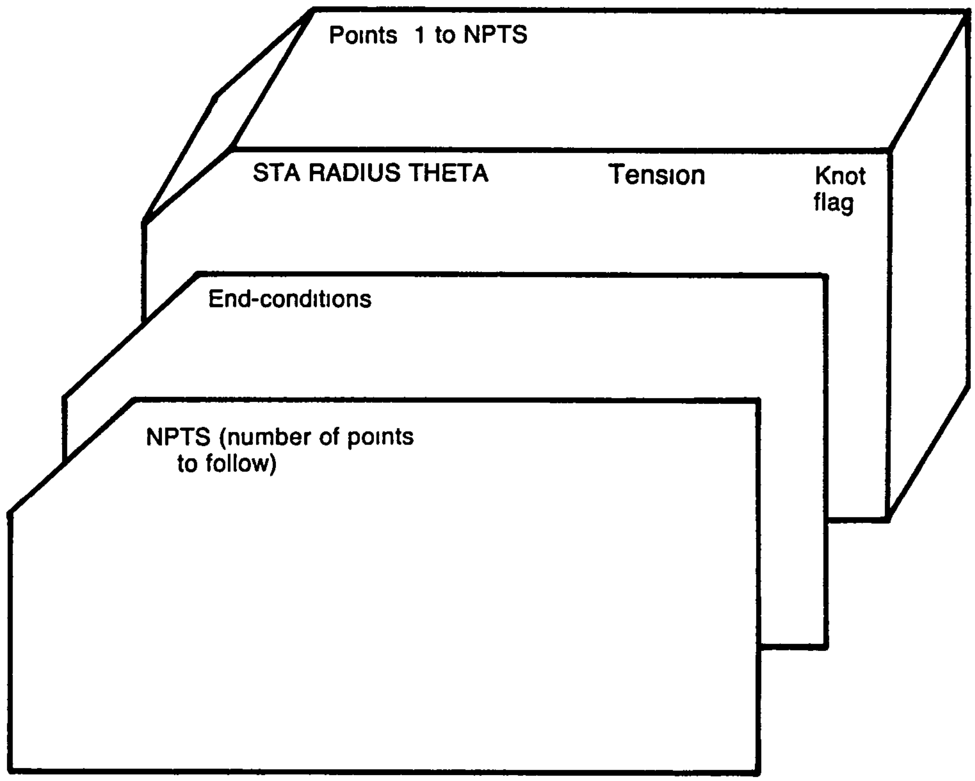


Figure 3-6. – SIL Section-Specification Format (Cylindrical Coordinates Shown)

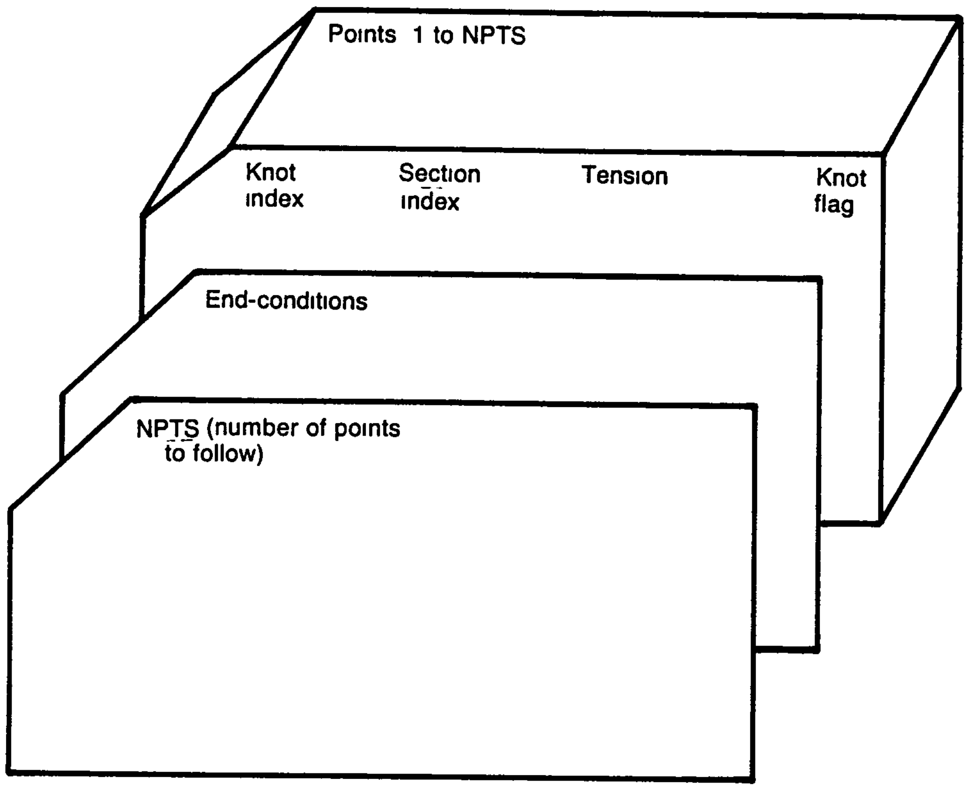


Figure 3-7. – SIL Member-Specification Format

Sequence numbers are integers· the first sequence number is the position of the desired section knot within its section (not counting any null points), the second value is the position of the desired section curve within the entire section set The spline tension is a decimal value, which should be set to zero (see Sections 4.1 3.1 and 4.1.3 2) The knot flag is an integer, which can be either positive or zero. A point with a positive knot flag is a knot, while a point with a zero knot flag is an null point (see Sections 4.1.3 1 and 4.1.3 2). All member points should be made knots.

3.1.3.5 SIL End Conditions

Sections and members require boundary conditions at the ends of each curve. The end conditions are input as a type code, which is possibly followed by end-direction values This data appears between the number of points and the set of points. The type code is an integer data value on a separate data line End-direction values are input only with certain type codes, they contain 6 decimal values (2 groups of 3) on a separate data line There are three kinds of these conditions available in MASTER (see Figure 3-8): periodic, specified-direction, and unknown (see Section 4 1 3 3 for suggestions for selecting the proper end condition).

The periodic condition will join a closed curve smoothly together. It is selected by entering "4" as a type code, no end-direction data follows

With an open curve, it is possible to specify the tangent direction at one or both ends These end conditions require the input of two end directions following the type code * Each end direction is expressed as three decimal values They are proportional to the direction cosines of the tangent direction at the end. A type code "3" specifies both ends; a type code "1" specifies just the initial end and a type code "2" specifies just the final end

End conditions for an open curve with both directions unknown is input as a type code "0". No end-direction data is required.

3.1.3.6 SIL Patch-Specification Set

The patch-specification set begins with the number of specifications, which appears as an integer on a separate line. The specifications follow to complete the set (see Figure 3-9).

Each patch is specified by a single line, in the format shown by Figure 3-10 There are four pairs of integer values. Each pair selects a member knot as one corner of the patch. The second integer in a pair is an index number for a member; the first integer in that pair is the knot index number for some knot in the selected member.

The first and second pairs must refer to adjacent knots on one member; and the third and fourth pairs must refer to adjacent knots on the next member (i.e., the member index is the same in the first and second pairs, and likewise in the third and fourth pairs)

The first and third pairs must refer to adjacent knots on one section; the second and fourth pairs must refer to adjacent knots on the next section (To check this in general, it is necessary to refer back to the member set.)

---

*Even if one of the directions is unknown, data values must be present for both ends. The unknown direction is ignored, and it can be input as three zeros

Option	Direction values follow?	Initial condition	Final condition
0	No	Unknown (no curvature)	Unknown (no curvature)
1	Yes	Direction value specified	Unknown (no curvature)
2	Yes	Unknown (no curvature)	Direction value specified
3	Yes	Direction value specified	Direction value specified
4	No	Periodic (used for a closed curve)	

Figure 3-8. – SIL End-Condition Options

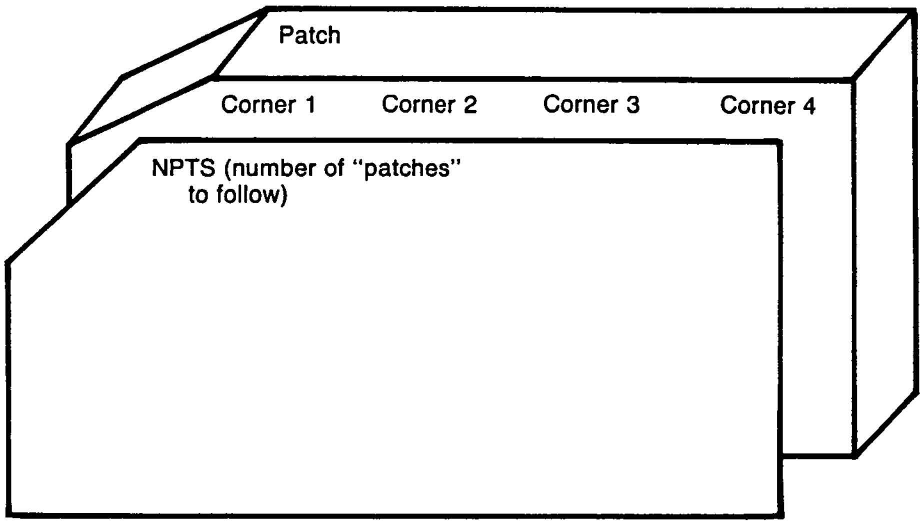


Figure 3-9. – SIL Patch-Specification Set

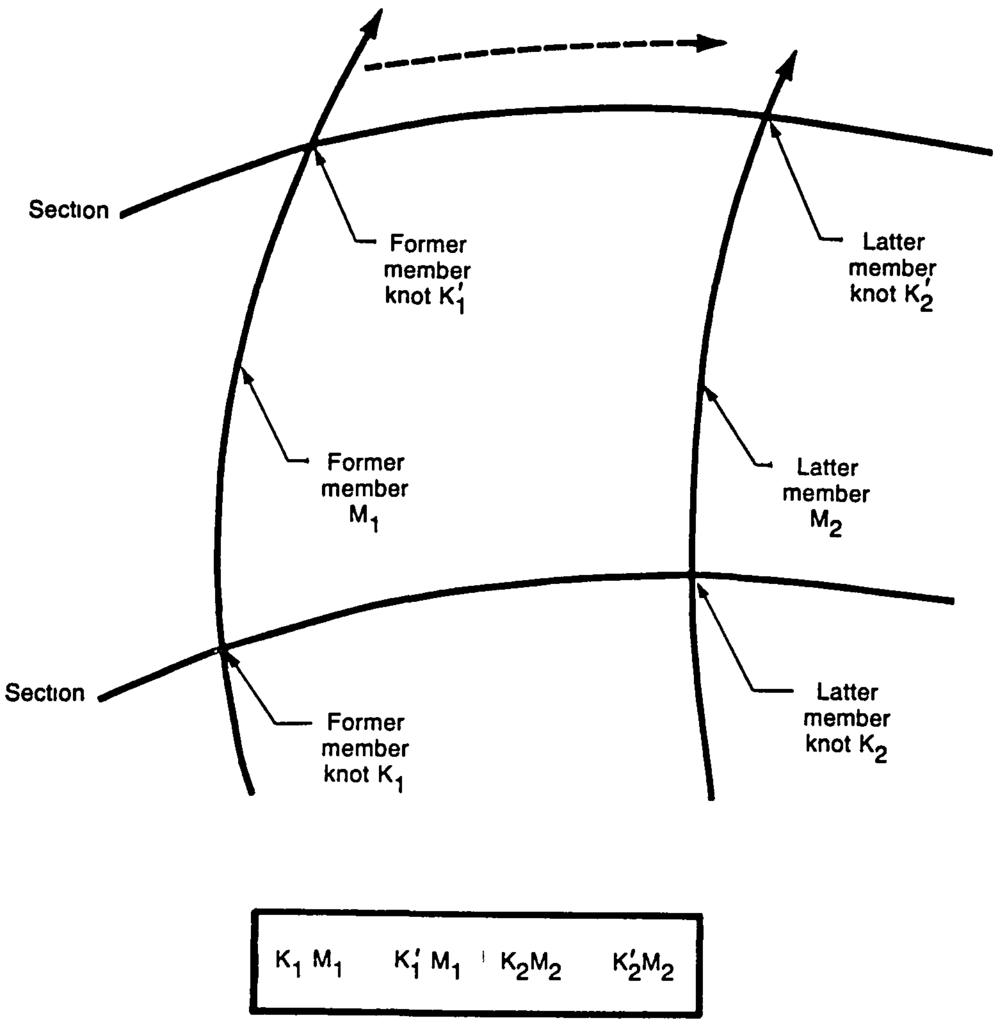


Figure 3-10 – SIL Patch Specification Details

3.1.4 COORDINATE-TRANSFORMATION (TRN) INPUT DATA FORMAT

A TRN file contains a set of rigid-object (i e , linear) coordinate transformation definitions. (Suggestions for transformation definition are given in Section 4.2, an example of transformation definition is shown in the first part of Section 6 2.) Transformations between cylindrical and rectangular coordinates do not need a TRN-format definition.

TRN data is free-field text data, which can contain comments. The first data line holds a single integer value, the number of transformation definitions to follow. The rest of the file consists of that many transformation definitions (see Figure 3-11).

Each transformation definition contains exactly five lines with three decimal values per line (see Figure 3-12) The first line is an initial translation, which is added to the input coordinates The next 3 lines are used as a rotation matrix, which multiplies the translated coordinates. The last data line is a final translation, which is added to the rotated coordinates.

The rotation matrix is input with data lines stored as columns, not rows * The matrix must be orthogonal This means that its product with its transpose must be within a tolerance of the 3 by 3 identity matrix (The tolerance is $10.^{-6}$ See Figure 3-13 for an example of verifying orthogonality.) This orthogonality requirement means that the matrix only rotates the points defining the object, but leaves the distances between them unchanged

3.1.5 MESH (MSH) FORMAT

MSH data format is used to input coordinate-mesh descriptions (An example of mesh description is shown in Section 5 4) It is also used to control the options for MSHNRM, the mesh/surface intersection procedure A MSH file can begin with option selections, or the default options can be used The remainder of the MSH file contains a list of values for each of the three coordinates (see Figure 3-14)

3.1.5.1 MSH Limitations

Each of the sets of coordinate values can contain at most 200 values

3.1.5.2 MSH Option Declarations

The option declarations in a MSH file must appear at the beginning, before any comment lines. Only one declaration can appear in a line When no options are declared, the input coordinates are recognized as rectangular, with the labels "STA", "BL", and "WL" Option declarations can change the types of coordinates for the mesh and the surface model, they can change the coordinate labels, and they can control the operation of procedure MSHNRM The possible option declarations are.

---

*To check the matrix multiplication manually, be sure to transpose the matrix before multiplying it to the front of a column vector of coordinates. (See Figure 4-6 for an example of checking matrix multiplication.)

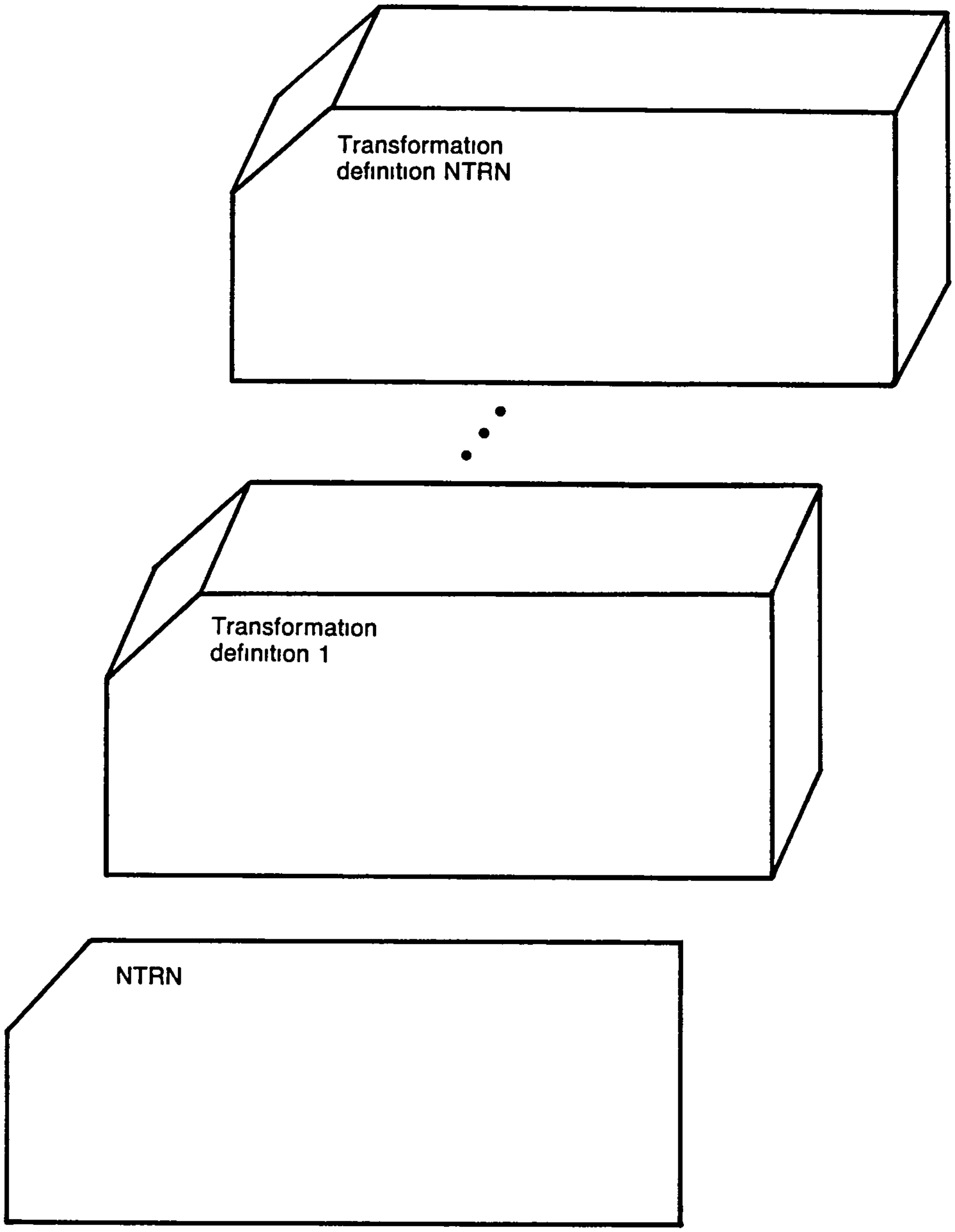


Figure 3-11. – TRN File Format

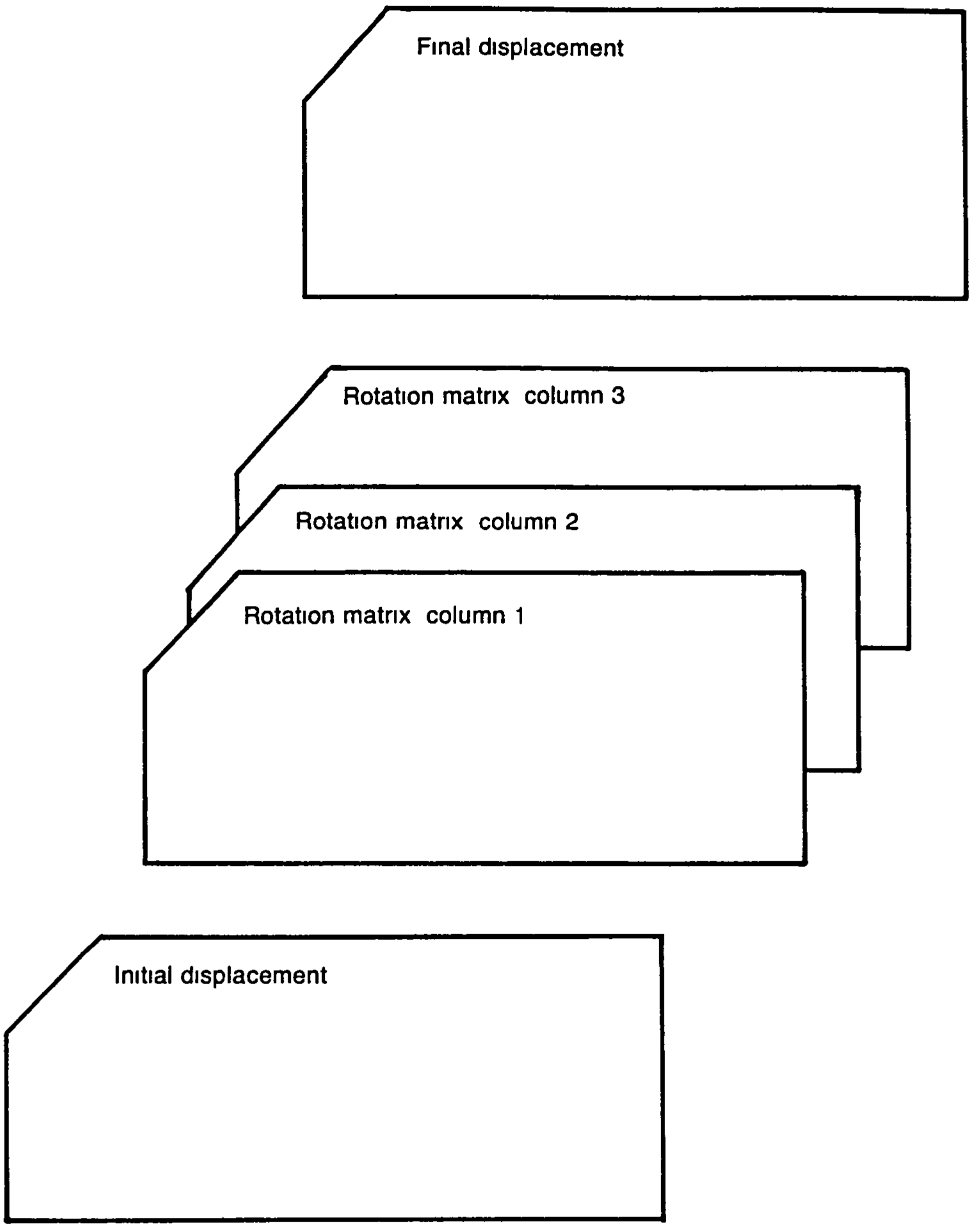


Figure 3-12 – Transformation Definition Format

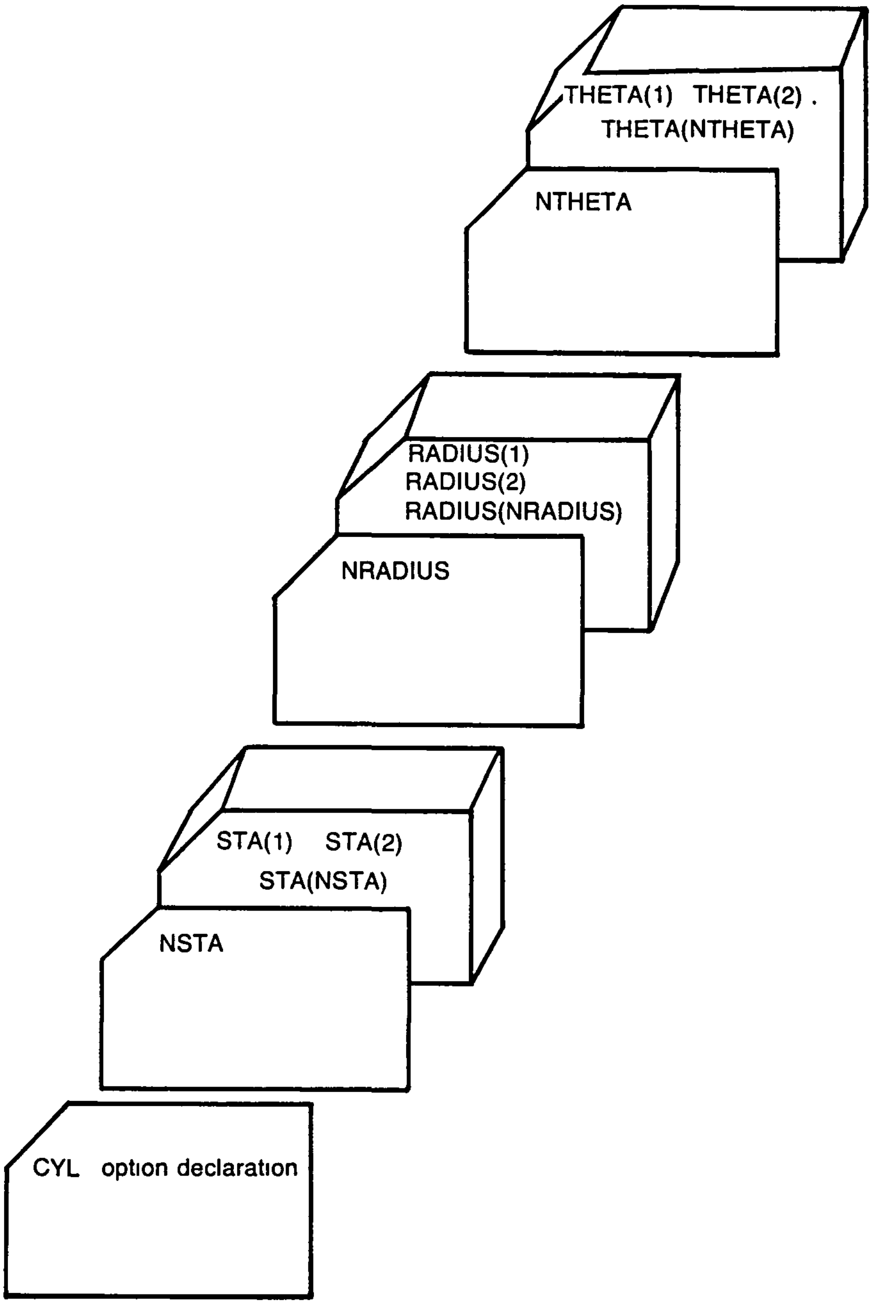
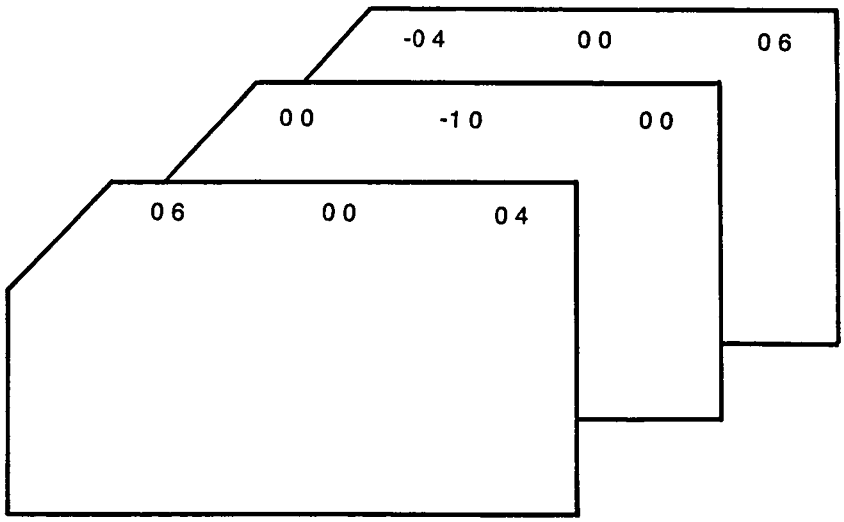


Figure 3-14. – MSH Input Format (Cylindrical Coordinates)

TRN matrıx data



Matrıx

$$\begin{bmatrix} 0\ 6 & 0\ 0 & -0\ 4 \\ 0\ 0 & 1\ 0 & 0\ 0 \\ 0\ 4 & 0\ 0 & 0\ 6 \end{bmatrix}$$

Check orthonormalıty

$$\begin{bmatrix} 0\ 6 & 0\ 0 & -0\ 4 \\ 0\ 0 & -1\ 0 & 0\ 0 \\ 0\ 4 & 0\ 0 & 0\ 6 \end{bmatrix} \begin{bmatrix} 0\ 6 & 0\ 0 & 0\ 4 \\ 0\ 0 & -1\ 0 & 0\ 0 \\ -0\ 4 & 0\ 0 & 0.6 \end{bmatrix} = \begin{bmatrix} 1\ 0 & 0\ 0 & 0\ 0 \\ 0\ 0 & 1\ 0 & 0\ 0 \\ 0\ 0 & 0\ 0 & 1\ 0 \end{bmatrix}$$

Fıgure 3-13 – Matrıx-Orthogonalıty Check

1 CYLINDRICAL*

This declaration causes both the mesh coordinates and the surface coordinates to be recognized as cylindrical, not rectangular. It also changes the default labels to "STA", "RADIUS" and "THETA".

2. LABELR

This declaration changes the names for rectangular coordinates. The names can be 10 characters long, they follow the keyword, separated by blanks. The names are assigned to coordinates in the order that they appear.

3. LABELC

This declaration changes the names for cylindrical coordinates. The names can be 10 characters long; they follow the keyword, separated by blanks. The first name is used for the axial coordinate (default "STA"); the second name is used for the radial coordinate (default "RADIUS"), and the third name is used for the angular coordinate (default "THETA"). The names are matched in this way, even when the coordinates are reordered.

4. $OPTION ... $

This declaration is used to change control variables within the MSHNRM program It must be the last option declaration to appear on a MSH file. It is read as a NAMELIST ** The NAMELIST can use multiple lines, but the first column of each line is ignored. The NAMELIST ends with a dollar sign ($). Between the keyword and the final dollar sign, the following items can appear, separated by commas:

1. IXAXIM=?, IXRADM=?, IXANGM=?

This item changes the order of cylindrical coordinate labels. It also changes the calculations within procedure MSHNRM and procedure NRMCFD to correctly handle input data that has been rearranged to match the labels. The three values to the right of the equal signs must be a rearrangement of 1, 2 and 3. They show respectively which of the three coordinates are axial (default 1st), radial (default 2nd), and angular (default 3rd).

2. LSTOPT=?

This item is used to control the listing of intermediate computations by procedure MSHNRM. The larger a value, the more details will be listed. The default value is 1, which lists the normals that were calculated. An input value of 0 will suppress the listing of the individual normals; this choice is indicated when repetitious MSHNRM executions will be made. An input value of 2 will list identify each normal as a particular root of a cut equation Larger values will list details of intermediate calculations; they are intended for use by MASTER consultation rather than general users.

---

*The keyword can be abbreviated, but the letters "CYL" must appear.

**NAMELIST is a standard form of FORTRAN input. For more details, check the appropriate FORTRAN manual.

3. NXINT=?, KXINT=?,?,?, NXCUT=?,?,?, KXCUT=?,?, ?,?, ?,?

   This item is used to control the sequence of intersection and cut (see the Glossary) operations by procedure MSHNRM. The sequence should avoid glancing intersections, where the intersection plane is nearly tangent to the surface. The default for cylindrical coordinates anticipates a slender and nearly axisymmetric body, like a nacelle. The default for rectangular coordinates anticipates a body like a horizontal wing. When computing mesh intersections with an unusually-shaped configuration, use the default settings and proceed to the CFD analysis. If the analysis program detects missing normals, contact MASTER consultation, who will explain how to specify the best alternative sequence.

4. TOLDIS=?, TOLANG=?

   This item defines the tolerances used to align intersection normals to mesh coordinate values by procedure NRMCFD. TOLDIS is the tolerance for all coordinates with distance units. TOLANG is the tolerance for the angular coordinate. The default value for TOLDIS is 0005, and the default for TOLANG is .01 degree.

3.1.5.3 MSH Mesh-Value Sets

A set of values is input for each of the 3 coordinates. The sets appear in the same order as the surface-description coordinates. Each set consists of the number of values, followed by a list of the values themselves. The number of values is an integer, appearing on a separate line. The values are decimals. They appear on one or more lines, separated by blanks.

3.2 SYSTEM DATA FORMATS

MASTER has two classes of system-generated data available for users, geometry-modeling data and mesh/surface intersections. The intersections appear both in unsorted form and prepared for input to 3-D computational fluid dynamics analysis programs.

3.2.1 GEOMETRY MODELING DATA FORMATS

MASTER uses parametric cubic representations for geometry modeling. Curves and surfaces are the kinds of geometric objects data represented A single data element consists of a range of values for the parameter(s) and 3 polynomial functions for the spatial coordinates. The polynomials use the parameter(s) as independent variables Evaluating the polynomials over the range of parameter values produces a continuous geometric element in space. The choice of coordinates is the same as for the surface-description data that created the model, and the ordering is the same

There is a single one-dimensional range of parameter values that is used for all curve-modeling elements. There is a single two-dimensional range of parameter values that is used for all surface-modeling elements. Only the polynomials are stored on data files; the range of parameter values is written into the system programs. The polynomials are represented by position vectors and derivative vectors (with respect to the parameters) at the points that bound the parameter range. Each vector appears as three decimal values on a single data line.

3.2.1.1 Curve-Model (CUR) Data

Curve-model data is described here as a preliminary step in describing surface-model data (see Reference 3, Sections 5.1.2 and 6.3.6 for details).* CUR data consists of just a sequence of PC (i.e., parametric cubic) segments in a Hermite-interpolation representation (see Section 4 1.3.1). There is no data to indicate connections between segments.

In a PC segment, there is a single parameter called "U" U stays in the parameter range [0.,1.].** As U changes from 0. to 1., the corresponding point in space moves from the beginning of the curve segment to the end.

A PC segment contains four data lines (see Figure 3-15):

1. Line 1, Position at U = 0.
2. Line 2, Position at U = 1.
3. Line 3, Derivative at U = 0.
4. Line 4, Derivative at U = 1.

The derivative vectors point tangent to the curve. They are directed from the initial position along the curve towards the final position.***

3.2.1.2 Surface-Model (SRF) Data

Surface-model data consists of a sequence of parametric bicubic patches in a Hermite-interpolation representation. (This is also called a Ferguson or Coons patch; see Reference 3, Section 6 3 4 for details.) There is no data to indicate which side of the surface is wetted by the fluid and which side is interior to the body There is no data to indicate which patches are adjacent (intersections are computed patch by patch, without the need to connect them).

A patch is a generalization of a PC curve segment, which has two parameters, called "U" and "V". For a patch, both U and V stay in the range [0, 1], so the parameter range is a unit square.

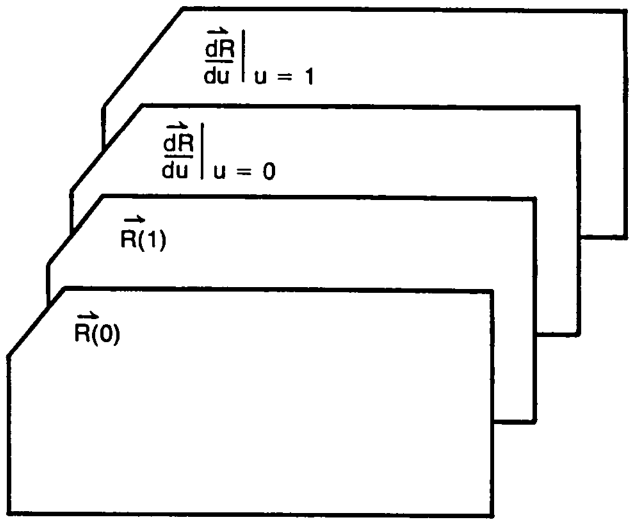
---

*CUR data is also created as an intermediate result by mesh/surface intersection

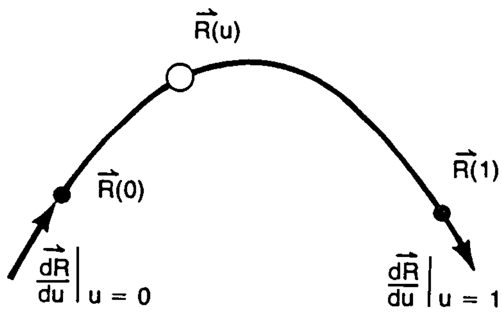
**The parameter here is linear function of the one described for SIL input curves in Section 4 1.3.1.

***The magnitude of a derivative approximately equals the length of the curve, so that equally-spaced parameter values correspond to approximately equally-spaced points along the curve. (The magnitude of a derivative vector must be expressed as the arclength derivative with respect to the parameter. For rectangular coordinates, this is the usual magnitude For cylindrical coordinates, the angular component of the derivative must be converted from degrees to distance units; this is done by dividing by 57.296 (degrees per radian) and multiplying by the radius at this location The three components in distance units are combined in the usual way)

Data format:



Graph



Formula

$$\text{If } 0 \leq u \leq 1 \text{, then } \vec{R}(u) = \vec{R}(0)\,(2u^3-3u^2+1) + \vec{R}(1)\,(-2u^3+3u^2) + \left.\frac{d\vec{R}}{du}\right|_{u=0}(u^3-2u^2+u) + \left.\frac{d\vec{R}}{du}\right|_{u=1}(u^3-u^2)$$

Figure 3-15 – PC Segment Format and Position Calculation

A patch contains 16 data lines, which contain quantities evaluated at the patch corners (see Figure 3-16) There is no mark between patches (To find the start of a patch, count 16 lines from the start of the last patch.) Each line consists of three decimal values, forming a vector. The following data lines give the locations of the patch corners·

1. Line 1 locates the corner where U=0 and V=0
2. Line 2 locates the corner where U=0 and V=1
3. Line 5 locates the corner where U=1 and V=0
4. Line 6 locates the corner where U=1 and V=1

The rest of the data for a patch consists of first derivatives with respect to U and V and cross derivatives. The U derivatives and the V derivatives are directed tangent to the surface. U derivatives point along the sections in the SIL file that generated the patches, and V derivatives point along the members The magnitudes of the first derivatives are approximately equal to the lengths of the corresponding patch boundaries. This makes the distance traveled along the patch when one parameter changes proportional to the changes in this parameter value. (The constant of proportionality is the length of the patch in this direction.) The cross derivatives are second derivatives with respect to both U and V They influence the shape of the interior of the patch, and their magnitude is expected to be smaller than either of the first derivatives

The derivatives with respect to V are:

1. Line 3, at U = 0 and V = 0
2. Line 4, at U = 0 and V = 1
3. Line 7, at U = 1 and V = 0
4. Line 8, at U = 1 and V = 1

The derivatives with respect to U are

1. Line 9, at U = 0 and V = 0
2. Line 10, at U = 0 and V = 1
3. Line 13, at U = 1 and V = 0
4. Line 14, at U = 1 and V = 1

The cross derivatives (with respect to U and V) are.

1. Line 11, at U = 0 and V = 0
2. Line 12, at U = 0 and V = 1
3. Line 15, at U = 1 and V = 0
4. Line 16, at U = 1 and V = 1

3.2.2 INTERSECTION-NORMAL (NRM) FORMAT

NRM format is used for the unsorted mesh/surface intersection normals produced by procedure MSHNRM. This data gives the locations of the intersections and the surface-normal directions at these locations. Each location appears as a single data line, with 6 decimal values separated by blanks. The first 3 values are the position coordinates They are the same coordinates as in the surface description, and appear in the same order. The last 3 values are the corresponding components of the normal direction The normal is scaled to have the sum of squared components equal to 1.

NRM data can have normals pointing out of the body (this is the desired case) or into the body. The normal direction to a patch is computed as a cross product of the U derivative before the V derivative (which is simply a cross product of the section direction before the member direction).

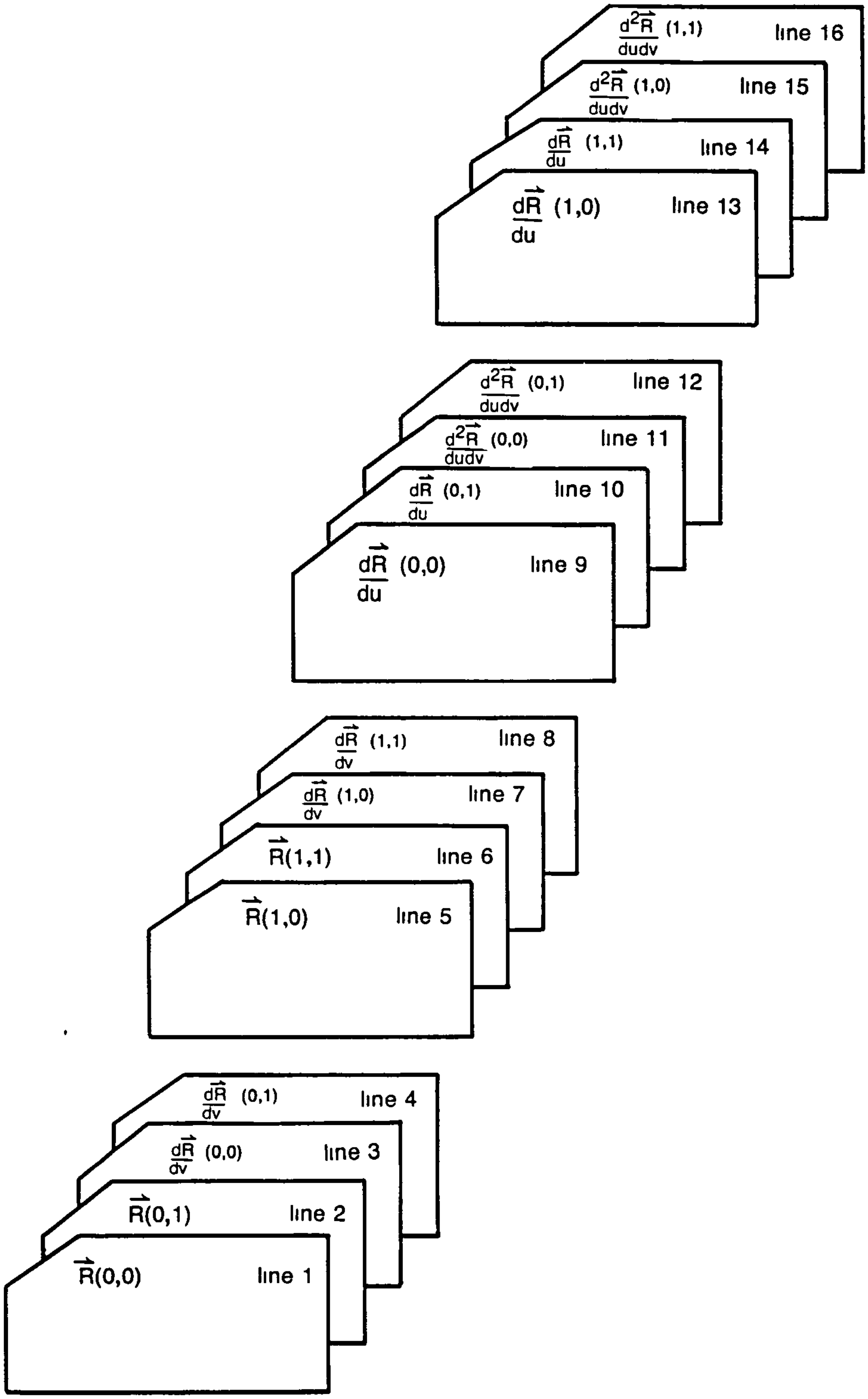


Figure 3-16 – Patch Format

This direction will be either correct over a complete surface-description region, or it will be reversed throughout the region. All the normals in a NRM file can be reversed by procedure NRMREV. (This is much easier than manually determining which normals are reversed and then changing them. Therefore, normals from different SIL blocks should be checked for reversal before combining them.)

3.2.3 THREE-DIMENSIONAL ANALYSIS INPUT (CFD) FORMAT

CFD format is the MASTER data format compatible with the input format of the 3-D transonic potential flow analysis code that MASTER was developed to support (see Figure 3-17, see Reference 1 for details). Only the features of this format that express geometry information are defined in MASTER documentation. It is the user's responsibility to define any other data required for CFD analysis. CFD-format files produced by MASTER will contain this other data as copied from an existing CFD-format file, if the existing file is available Otherwise, the other data will be omitted.

The defined part of CFD data begins when a keyword starting in column 1 is recognized, by the first four characters. The recognized keywords are "XMESH", "YMESH", "ZMESH", "RMESH", "TMESH", or "GEOMETRY".* The defined part continues to the end of data.

CFD data consists of fields 10 columns wide, with 6 fields per input line. These lines are grouped together. Each group starts with a keyword in the first field and the number of values for the group in the second field. This number is expressed as a decimal. The values start on the next line, also expressed as decimals.

The recognized part contains the mesh-value sets and then the intersection normals

The mesh-set keywords are "XMESH", "YMESH", and "ZMESH" for rectangular coordinates They are "XMESH", "RMESH", and "TMESH" for cylindrical coordinates. (Cylindrical coordinates must be ordered: axial, radial, and then angular.)**

The intersection-normal keyword is "GEOMETRY". The intersection normals appear one per line, as in NRM-format data (see Section 3.2.2). Their components appear in the same order that the preceding mesh-value sets appear.**

---

*MASTER produces CFD files with the mesh and intersection data at the bottom It assumes this is the case for input CFD files.

**Procedure NRMCFD will reorder cylindrical-coordinate data to agree with this ordering. (Rearranged input coordinates are recognized by the presence of an option declaration in the MSH input.)

```
767 INLET   APRIL 22, 1980   16 THETA PLANES
175 KNOTS   MCF=0.64   ALPHA=25.0 DEGREES   R 19   C 3
FREESTREAM
1.0         0.265       25.0        0.0
SWEEPS
800.0       100.0       50.0
1.          11.          1.
THETA LEV
16.0        16.0        116.0
SFLOW
1.0         1.0         1.0
IPRI
COMPRESSOR0.64
SCDIF       1.0
XMESH       69.0
-250.00000-218.75000-187.50000-156.25000-125.00000-108.75000
 -92.50000 -76.25000 -60.00000 -50.00000 -40.00000 -30.00000
 -20.00000 -12.50000  -5.00000   2.50000  10.00000  13.75000
  17.50000  21.25000  25.00000  27.90000  30.00000  32.50000
  35.00000  36.25000  37.50000  38.75000  40.00000  41.25000
  42.50000  43.75000  45.00000  46.25000  47.50000  48.75000
  50.00000  51.25000  52.50000  53.75000  55.00000  56.25000
  57.50000  58.75000  60.00000  61.25000  62.50000  63.75000
  65.00000  67.50000  70.00000  72.50000  75.00000  77.50000
  80.00000  82.50000  85.00000  87.50000  90.00000  92.50000
  95.44000 100.00000 105.00000 110.00000 115.00000 119.75000
 125.50000 129.25000 134.00000
RMESH       37.0
   0.00000   5.00000  10.00000  15.00000  20.00000  23.75000
  27.50000  31.25000  35.00000  37.50000  40.00000  42.50000
  45.00000  46.25000  47.50000  48.75000  50.00000  52.50000
  55.00000  57.50000  60.00000  62.50000  65.00000  67.50000
  70.00000  77.50000  85.00000  92.50000 100.00000 112.50000
 125.00000 137.50000 150.00000 175.00000 200.00000 225.00000
 250.00000
TMESH       16.0
   0.00000  22.50000  45.00000  67.50000  90.00000 112.50000
 135.00000 157.50000 180.00000 202.50000 225.00000 247.50000
 270.00000 292.50000 315.00000 337.50000
GEOMETRY  1808.
   37.9789   42.5000    0.0000  -.998896  -.046984   .000001
   38.7500   44.6861   22.5000  -.825046   .565030   .006288
   38.7500   44.6861  337.5000  -.825036   .565045  -.006288
   38.7500   44.7495    0.0000  -.752486   .658608   .000000
   38.9909   45.0000    0.0000  -.696756   .717308  -.000000
   38.9948   45.0000   22.5000  -.745554   .666445   .000735
   38.9948   45.0000  337.5000  -.745547   .666453  -.000735
   39.1819   45.0000   45.0000  -.931933   .361689   .026095
   39.1819   45.0000  315.0000  -.931928   .361704  -.026096
   40.0000   45.0000   64.4733  -.996627  -.026199   .077768
   40.0000   45.0000  295.5275  -.996627  -.026183  -.077769
   40.0000   45.7338    0.0000  -.495294   .868725  -.000000
```

Figure 3-17 – CFD Input Data

4.0 USER INPUT

This section gives suggestions for expressing user input correctly and effectively in the MASTER data formats. The first part covers SIL surface description The second part explains TRN coordinate-transformation input. The third part contains suggestions for mesh input in MSH format.

4.1 SURFACE DESCRIPTION

This section tells how to use SIL data format to describe surfaces. The first part discusses the use of comments and other aids that help avoid making mistakes The next part shows how to plan the arrangement of sections, members, and patches. The third part explains how section and member curves are fit and how to give a curve the desired shape. The last part summarizes these suggestions as a concise set of rules.

4.1.1 MEMORY AIDS

This section tells how the user can use comments and defaults to help remember details of surface description. Fewer mistakes are made when the user must remember less information, so users should take advantage of the available memory aids. MASTER provides 3 memory aids for surface description:

1. Coordinate defaults,
2 The capacity to copy user comments, and
3 System-written comments.

First, the user should keep the default coordinate ordering whenever possible. While MASTER has the capability to handle rearranged coordinates, this requires option declarations for the surface description and for all associated mesh descriptions. (The 3 cylindrical coordinates have different characters; they require a declaration to match the order of the input data, or the calculations will be incorrect The 3 rectangular coordinates have the same character, so rectangular coordinates with undeclared rearrangements can still give numerically correct results. There are still 2 possibilities for error when rectangular coordinates are rearranged. the coordinates can be arranged differently on the surface and mesh descriptions, or the user can become confused if the coordinate labels do not match the data) The simplest way to assure coordinate compatibility is to always use the defaults When creating new data, this can be done by simply entering it in the default order When editing existing data into SIL format, one can edit the data into SIL format in the given order and then immediately use TRNSIL with the standard file of transformations to rearrange the coordinates (see Section 5.3.5 and Figure 5-3)

Second, the user should identify surface descriptions with user comments A common problem with editing data is the inability to recognize the data that is being edited by the numeric values alone. This becomes a serious problem when the coordinates are transformed, changing the numeric values. MASTER has user comments available for identification purposes * Write a

*These are lines beginning with an asterisk (see Section 3.1.2). They are copied when a SIL file is read and rewritten by SILSRF or TRNSIL, so they remain with the file.

heading of user comments at the top of each block of surface description data As a minimum, this heading should identify the configuration being modeled and the region that the block represents The heading can also explain how the sections and members are arranged A reference to the original source for the data is valuable if a discrepancy in the geometry data is detected some time later (Discrepancies occur often enough to justify recording precisely where the original data was obtained) A log of any corrections made to the data can prevent errors, from either changes not made or changes made twice Also, input curves that have a special name (like the throat of an inlet) can be named on a comment just above the curve input. It may seem faster to not take time to record this information, but it is more time consuming later to guess at an unknown detail Identification that is a part of the data file is more reliable than separate records, because it can not become lost when the file name or account is changed.

Finally, the user should save surface-description files with system comments added to them These comments explain the items in the surface-description data, as MASTER recognizes them Failure to use these comments will cause errors in correcting and changing SIL data Each block of SIL input contains these sets of elements. the set of section curves, the set of member curves, the set of patch specifications; and the sets of knots that appear in each section or member curve. Each set begins with a separate integer value, the count of elements to be read. This is a potential source of error, because the count must match the number of elements present. References to sections in the member specifications and references to members in the patch specifications are made by sequence numbers (see Figure 6-5) This can cause more errors when curves or knots are added, removed, or rearranged (When a modification changes the number of curves, the references to all curves following the modification must be changed. Also, when a modification changes the number of knots on a single curve, any references to knots following the modification must be changed Finally, when curves or knots are rearranged, the references to them must be changed.) A SIL file, input to the procedure SILSRF, is rewritten with system comments containing headings above each curve and sequence numbers next to curves and knots. The rewritten data values are aligned in regular columns. The comments show counts and sequence numbers for the sets By counting the elements for the user, these comments significantly reduce the number of errors made referring to elements They should be used whenever possible.

4.1.2 PLANNING SURFACE DESCRIPTIONS

SIL input allows the same surface region to be described in many ways The availability of coordinate transformations increases the number of ways to describe a region This section shows how to choose a specific way to input a surface description The first part gives suggestions for simple ways to write a description The second part points out some problems in later operations that can be avoided, with care, during surface input

4.1.2.1 SIL Data Layout

This section considers how to simplify the description of surface regions as blocks of SIL data It covers two subjects:

1. The layout of sections, members, and patches
2. The choice of local coordinates.

The pattern of data in SIL block input should be as regular as possible, to make typographical errors easier to recognize (They stand out better against a regular pattern) Also, there are two ways a point is referenced in SIL input: member input refers to section input, and patch specification refers to member input While the independence of sections and members adds flexibility for describing trimmed (e g , one with a hole cut out of its interior), untrimmed regions can be described in a way that makes the two methods of reference look like each other The following method of layout is recommended (see Section 6.1 for an example, Figures 6-2 and 6-3 show the layout).

1 Give every section the same number of points The point spacing should be similar between sections (The number and spacing of section points must satisfy curve-description requirements, as stated in Section 4.1.3.2. The number and spacing of member points, which must satisfy similar requirements, is determined by the location of section curves) Make every section point a knot.*
2 Put exactly one point from each section on each member. Arrange the member points in the same order as the section curves Put the nth knot from each section on the nth member Make every member point a knot *
3 Arrange the patches in regular rows. Make each patch row cover the area between a pair of adjacent member curves. Arrange the patch rows to match the order of members Arrange the patches within a row to match the order of member knots

This method guarantees that the section-curve index will equal the member-knot index and the section-knot index will equal the member-curve index This method completely determines the member and patch specifications, except for the member end conditions. It is used in procedure REGSIL, which reads sections only, to complete the member and patch specifications (see Section 7 3 3)

Another way to add regularity to a surface description is by making good choices for the coordinates and for the orientation of sections and members. (These selections are related to each other)

The most natural selections for curve orientations are those which keep one of the coordinates constant over a curve ** Usually sections are oriented in this way (e g , constant-THETA sections) The corresponding members usually are oriented to keep another coordinate constant (e g , constant-STA members), which tends to make sections and members perpendicular where they intersect

A surface description is equivalent to a relation between the 3 coordinates, coordinates that satisfy this relation locate points on the surface. For a symmetric region, coordinates can be chosen such that this relation does not involve one of the coordinates (e g., an axisymmetric region can be represented in cylindrical coordinates as a relation between RADIUS and STA, by placing the coordinate axis along the axis of symmetry) In this case, sections should be oriented to keep this uninvolved coordinate constant (e.g., constant-THETA sections) The other two coordinates will have the same relation on each section The first section can be entered manually, and the others

---

*In addition to keeping the data layout regular, this is required for curve representation without curvature discontinuities, as stated in Section 4.1.3.1.

**There is an additional advantage to this choice of an orientation: coordinates that are known to be constant near the end of a curve significantly simplify the form of the end condition (see Section 4.1 3.3 for details).

can be automatically generated by editing copies of the first Corresponding points on different sections will have the same values for the other 2 coordinates, making both coordinates constant on the members This is a natural way to express the symmetry of a surface.

The suggested regular pattern for surface-description layout is useful for untrimmed regions Once a user becomes familiar with it, the references to section knots and member knots can be translated to each other without effort In other cases, the user needs help to visualize the layout of sections and of members The best way to do this is to make a sketch of the sections, and lay out the members on this sketch; then make a second sketch of the members, and lay out the patches on this sketch These sketches need to show the curve and knot numbers, but the exact shape is not required. These sketches are helpful when learning to lay out the regular SIL pattern (see Figures 6-2 and 6-3), as well as when experienced users are laying out an irregular patttern The following rules should be followed when laying out irregular surface descriptions:

1 Cover the region with sections and members so that it is divided into four-sided patches (A patch side can have zero length)
2. Do not make sections cross other sections, do not make members cross other members
3 Input sections or members in an order from one side of the region to the other.
4 Input member points in the same order used for section curves, and input member curves in the same order used for section points.
5. Make all the input points to be knots.
6 Input curves can either contain all intervals with zero length or all intervals with nonzero length; the two should not appear in the same curve
7 Two curves that coincide over more than one point must be input with exactly the same end conditions, point coordinates, tension values, and knot flags *

4.1.2.2 Avoiding Surface-Description Traps

This section warns the user about various problems that must be prevented while laying out the surface, although they are not apparent until later. These problems are:

1 Consistency of the normal direction in a multiple-block SIL file
2 Joining surface-description regions smoothly
3 The singularity of cylindrical coordinates at the axis
4 Mesh lines that miss the surface model

First, consider consistency of the normal direction. In a configuration for fluid dynamics analysis, a surface divides space into the fluid and the body. The intersection normals calculated by MASTER either can point into the body, or they can point into the fluid (this is the desired case) Consider how the normal direction is determined at given a point on a patch Let the U-derivative at this point be S, and the V-derivative be M (S points along the sections, and M points along the members). Both S and M are tangent to the surface, so the normal must be perpendicular to both of them, like their cross product Procedure MSHNRM calculates the normal direction by the cross product $S \times M$ (see Figure 4-1) This direction will point consistently to one side of the surface throughout a region, so all the normals generated from a single SIL block will have the same direction (into the fluid or into the body). Another procedure, NRMREV, can reverse the direction of all the normals on a NRM file This will easily correct any reversed (pointing into the body)

*This is required to ensure that both curves will have the same shape normals, provided that each NRM file is consistent Because each NRM file output from MSHNRM corresponds to a single input SIL file, the normal direction must be consistent over each SIL file (otherwise, the user might need to edit an entire NRM file to selectively reverse the bad normals). Unless they can consistently predict the normal direction that a SIL block will produce, users should not use multiple-block SIL files. Also, they should not merge the SRF files based upon these SIL files.

Here are some arrangements, which give the the correct normal direction:

1 Inlet surfaces with constant-THETA sections and constant-STA members with increasing THETA.
   a Sections with increasing-STA on the interior.
   b Sections with decreasing-STA on the exterior or the spinner

2 Wing surfaces with constant-BL (airfoil) sections and constant-STA members with increasing BL.
   a Sections with decreasing-STA on the upper surface.
   b. Sections with increasing-STA on the lower surface.

Next, consider joining surface-description regions smoothly. This requires that the boundary between two regions must be represented in each region by a curve with exactly the same end conditions, point coordinates, tension values, and knot flags This also requires that the crossing curves that touch this boundary must have the same end direction specified.*

Third, consider the singularity at the axis in cylindrical coordinates A cylindrical-coordinate surface model calculates STA, RADIUS, and THETA continuously. Almost everywhere this implies a smooth surface, but there are exceptions where a surface touches the coordinate axis The cylindrical coordinates themselves are not continuous at the axis (A straight line through the axis will suddenly change THETA by 180 degrees) Suppose a patch is planned with the axis in the middle of one side or at a patch corner. This makes the planned patch have a total of more than 4 sides, which is impossbile to model. The only solution is to select constant-THETA curves in the global coordinates to describe the surface. This layout makes the THETA change at the axis as one of the 4 sides of the patch, a side with zero length. No other arrangement of curves will give a correct model of the surface in the neighborhood of the axis.

Finally, consider the amount of the configuration that is modeled. This must be large enough to contain any possible intersections of mesh lines with the surface Due to the approximate nature of mesh/surface intersection, a mesh intersection that lies on the edge of the surface model could be missed, so the surface model should extend past the range of distance-coordinate values for the mesh. (However, the range for THETA values does not need extension.)

*The actual requirement is that the cross product of the 2 curve directions at each boundary knot must be the same in both regions. The crossing-curve direction can differ between the regions, but the difference must lie in the plane of the surface.

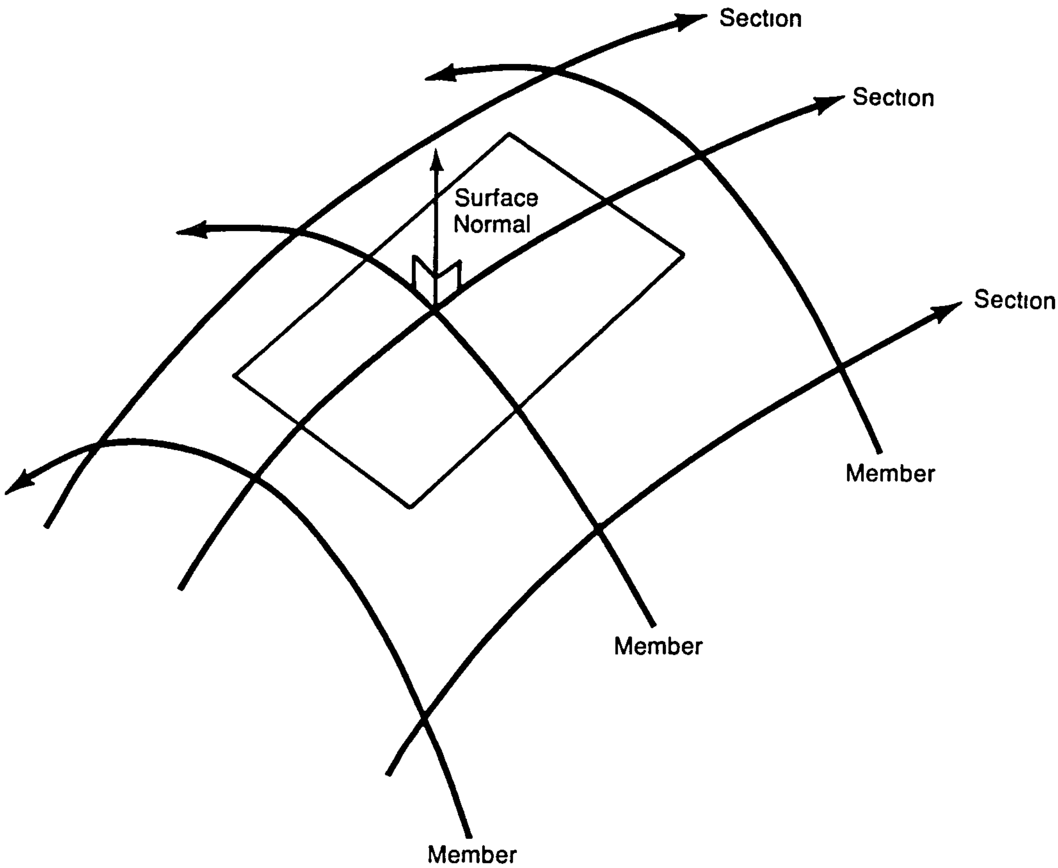


Figure 4-1 – Determination of Surface-Normal Direction

4.1.3 CURVE DESCRIPTION

After the surface description has been planned and the curves are located, these curves must be described with the desired shapes. This section covers the curve-description problem. The first part is an explanation of the mathematical steps performed to represent a curve from SIL input (It gives the motivations for the suggestions made in the other parts.) The next part explains how to select points to represent a curve. The third part tells how to choose end conditions.

4.1.3.1 Mathematical Ideas of Curve Representation

This section explains how curve representations are calculated in MASTER. This explanation gives the reasons that motivate the rules for curve description in the next 2 sections Curves are represented in 3 steps: parameter calculation by an accumulated chord-length method; tangent calculation by a parametric cubic spline fit, with Nielson's tension modification; and a Hermite-interpolation representation for the segments of the curve.

First, parameter values are assigned to the input points. Interpolated points on the curve will be calculated as functions of the parameter (see Reference 3, Section 4 1 1). The parameter is defined to range from 0 at the beginning of the curve to 1 at the end The parameter should not depend on the orientation of the input coordinates, so a distance-based formula is used To control tangent magnitudes (see the spline fit description below), the parameter values should be proportional to the arclength along the interpolation curve. This is not possible, because the shape of the interpolated curve is not yet known, so the parameter values at the input points are made proportional to the accumulated chord length (see Figure 4-2 and Reference 3, Section 6 3.4) Straight-line distances are measured from point to point; the total length of the curve is calculated, and the accumulated distance from the beginning to each point is divided by the chord length of the entire curve, giving the parameter value at that point The quality of this chord approximation affects the quality of the final interpolation This is a good approximation when the input points are spaced closely enough to make the arcs between adjacent points almost straight, the input points are close enough, if the spacing between points is small compared to the local radius of curvature along the curve

Next, the derivatives of the coordinates (with respect to the parameter) are calculated at all the input points. This calculation is called a spline fit. The spline fit defines cubic interpolation functions for each coordinate between adjacent input points so that the they have continuous value, first derivative, and second derivative at the input points (see Reference 3, Section 6 2 2) Continuous first derivatives for the coordinate interpolation makes the direction of the three-dimensional curve continuous, while continuous second (and first) derivatives makes the three-dimensional curvature continuous. The derivatives at each input point can be grouped as a vector, which is tangent to the interpolated curve The size of this vector should agree with the length of the curve segments next to the point * The length of the tangent, multiplied by the parameter difference across the segment, should give the length of the segment. This is accomplished when the parameter values approximately are proportional to the segment lengths (which is attempted above), and the tangent lengths equal the total length of the curve**.

---

*If the tangent is too large, a loop will appear in the curve If the tangent is too small, the curve will resemble a straight line between its ends In either case, the shape of the curve will become distorted. Note that this condition requires that adjacent segments of the curve must have approximately the same length.

**In general, the tangent length should equal the physical length of the curve divided by the parametric length, which is 1 here.

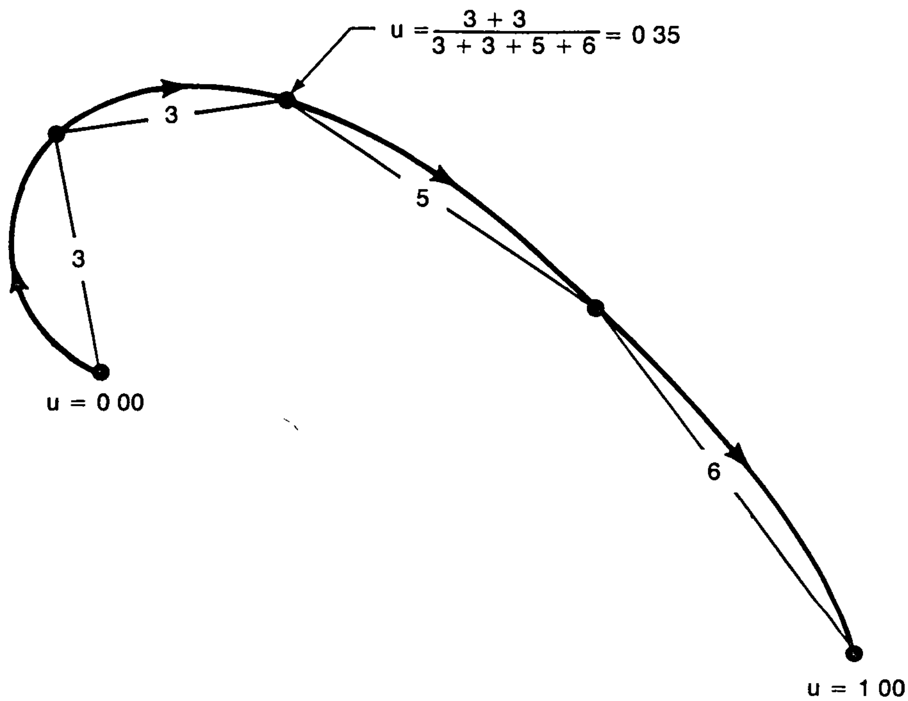


Figure 4-2. – Accumulated Chord-Length Parametrization (Lengths Shown for Each Chord)

The spline fit for each coordinate requires two additional values to be specified, usually the derivative values at each end are specified. This is the purpose of the end-condition input When an end direction is specified, it is scaled to have the length of the entire curve and then used as the end derivative vector. The spline fit with this end condition is very reliable, and it makes all the derivative vectors have approximately the same length Periodic end conditions leave the derivatives at each end unspecified, but they force the first and second derivatives at the beginning to match those at the end. Unknown end conditions set the curvatures at the ends to zero. They will give reasonable shapes if the end of the curve is straight for some distance, but they can be unreliable in other cases.

Tension is an extension to the spline fit (see Reference 4). The tension spline requires the user to input a tension value at each point. When all tension values are zero (this is the usual case) the spline fit is made with a uniform distribution of curvature. A positive tension value at a point would make the interpolation more curved near that point and less curved near the middle of the adjacent segments. Thus tension would control the shape of the curve, by making these segments look more like straight lines.

After the parameter and tangent values are calculated, the curve is stored in the format described in Section 3 2.1.1. This is a Hermite-interpolation representation, which defines a segment by the position and derivative values its ends. A new parameter range is used, from 0 to 1 The derivatives are adjusted to this parameter change by multiplying them by the change in the old parameter over the interval (see Reference 3, Section 6.3 6).

Until now, knots and null points have been treated the same. The output curve segments are located between adjacent knots; the position and derivative values at any null points are omitted from the final results Because both segments touching a knot use the same first-derivative vector, the tangent to the curve remains continuous. However the omission of null points changes the second derivative at adjacent knots, so the curvature becomes discontinuous between segments

4.1.3.2 Point Input

This section explains the input of SIL curves, except for the end conditions (which are covered in the next section) Discontinuities within the curve are discussed The principles of point selection are presented. Finally, the avoidance of tension and null points is urged.

The spline fit forces the interpolated curve to have a continuous tangent and curvature If the desired curve has sudden changes of direction or curvature, the spline fit will not match the desired shape. Such a desired shape must be broken into pieces wherever there is a discontinuity of either type, and the pieces must be input as separate curves.

The input points must be spaced closely enough for the chord-length parametrization to approximate arclength. This means that the distance between adjacent points must be small compared to the radius of curvature of the desired curve between these points (see Figure 4-3) For a curve whose shape is critical, use at least 10 segments (11 input points) to represent a 90-degree arc (e g , the inner or outer portion of an inlet lip). The number of points can be reduced where the exact shape is not critical, but the curve should not change direction more than 45 degrees over any segment.

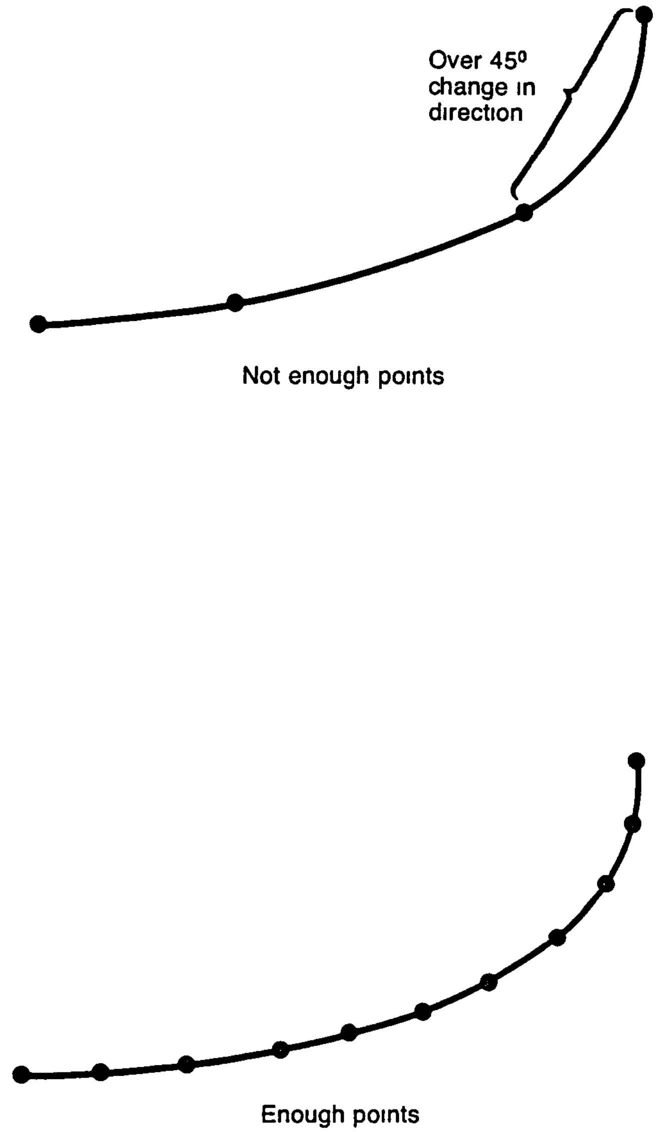


Figure 4-3. – Required Point Density

The limited complexity of the shape of an output PC segment also imposes a point-spacing requirement This requirement is based upon the variation of curvature, rather than the curvature values themselves. The portion of a curve which a single PC segment represents should have at most one inflection (i.e , change in the direction of curvature) Also, rapid changes in curvature can require a closer spacing of input points However the curvature-based requirement alone will typically produce an adequate spacing, provided that the input points are all knots (which makes the output segments no longer than the spacing of input points). The exceptional cases where more points are required are indicated by the presence of ripples when the surface model is displayed graphically. If it is not clear where the extra points should be added, increase the density throughout the curve and use procedure REGSIL to identify and remove the unneeded points (see Section 7).

There is a requirement that the spacing between input points must not change suddenly (see Figure 4-4) The ratio of lengths between the 2 intervals around an input point must not exceed 2.

Two practical methods are recommended for selecting enough points and avoiding sudden changes in spacing: uniform and adaptive spacing (see Figure 4-4). Uniform spacing keeps the distance between the points constant The separation is determined from the largest curvature found on the set of curves which must have the same spacing This method often uses more input points than are needed, but it is easy to understand and use. Adaptive spacing is a general class of methods which make the distance between points vary similarly to the local radius of curvature (see Reference 2, Section 5.1 for an example of adaptive spacing on an elliptical curve). This does not need to be an exact proportion; the key point is that any variations from uniform spacing should tend to group the points where they are most needed. If several methods for locating points on a particular region have been determined, the adaptive-spacing principle should be used as a guide to select the best of them Adaptive spacings are more complicated to lay out, but they reduce the amount of data required to represent surfaces.

Null points should not be used. They are an old feature of SIL data (when fewer knots were permitted on input curves, null points were needed to input more points and improve the parametrization) Null points are kept in SIL format now only to preserve compatibility with old data files Their use will cause curvature discontinuity*.

The input tension value should be zero at every point Tension is another old feature of SIL data, which was used to control the shape of curves. The preferred way to control curve shapes is the correct location of input points. The proper use of tension would require a repetitive cycle of adjusting tension values and checking the smoothness of the curve fit.

4.1.3.3 End-Condition Input

This section tells how to choose the proper end condition. End-direction input is explained

The periodic end condition is the correct choice for a closed curve (i e , one with both ends at the same location). A closed curve in cylindrical coordinates which loops around the axis will have initial and final points at the same position, but their THETA coordinates will differ by 360 degrees.

---

*This discontinuity does not influence the spline-fit stage, it does not enable curves with sudden changes in the desired curvature to be represented better

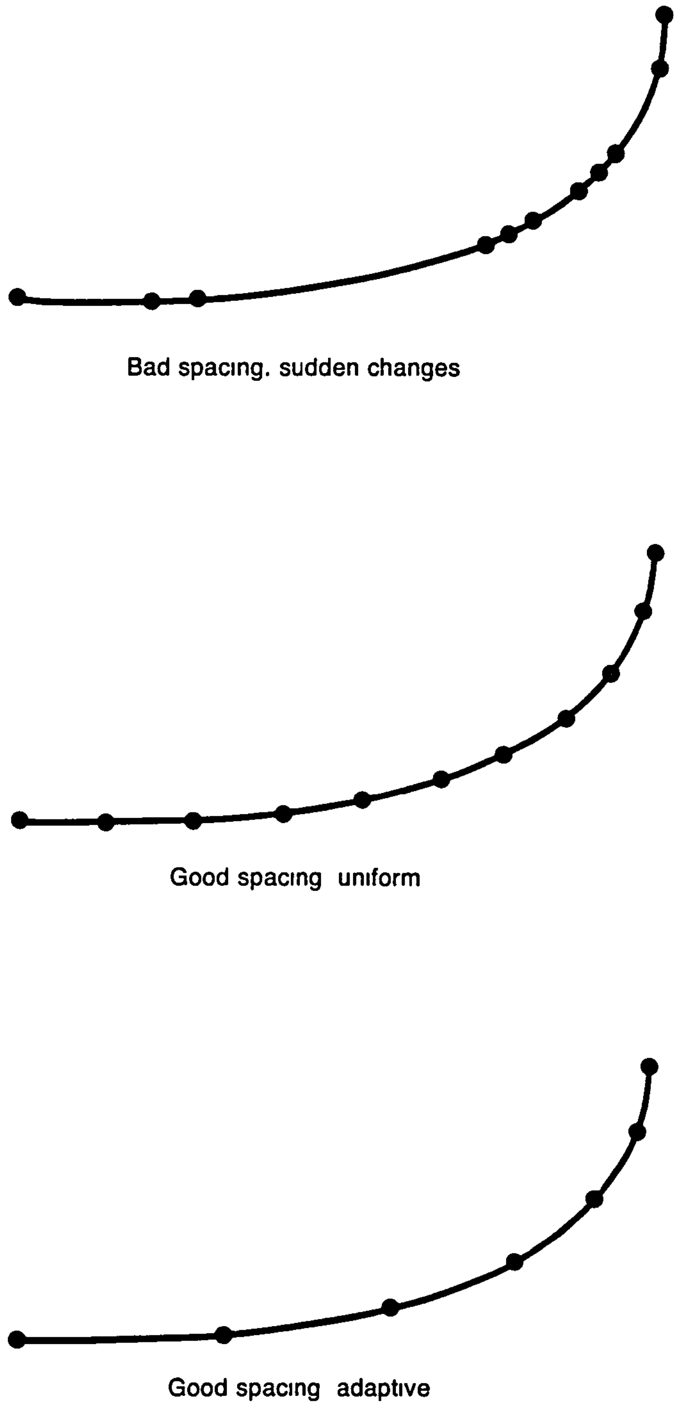


Figure 4-4 – Variations in Point Density

The unknown end condition is a poor choice, which should be avoided unless the end directions for an open curve are not known. It tends to introduce ripples to the spline fit (which will be visible on a graphical display of the surface model) unless the curve is very straight near the affected end. When this condition is used, the surface must be graphically checked for ripples with particular care

Specified end directions are the best condition for an open curve. An end direction consists of 3 decimal values, which correspond to the coordinates. If a coordiate is constant in the neighborhood of an end, the corresponding end-direction component is zero The components corresponding to distance coordinates are proportional to the rate of change of that coordinate (see Figure 4-5). The component corresponding to THETA is proportional to the change in distance implied by the change in THETA. The change in THETA is multiplied by the RADIUS value at the end and then divided by 57 296 (degrees per radians).* The overall size of the end-direction components is not important, because they are scaled within MASTER; the proportion between the components is the significant input. The signs of the components are significant; they show the direction of change for each coordinate. The initial end direction points from the end along the curve, the final end direction points along the curve to the end.

For example, consider the inital end direction for a constant-THETA curve where d RADIUS / d STA is 0 1. The end direction can be input as:

1 0 0 1 0 0

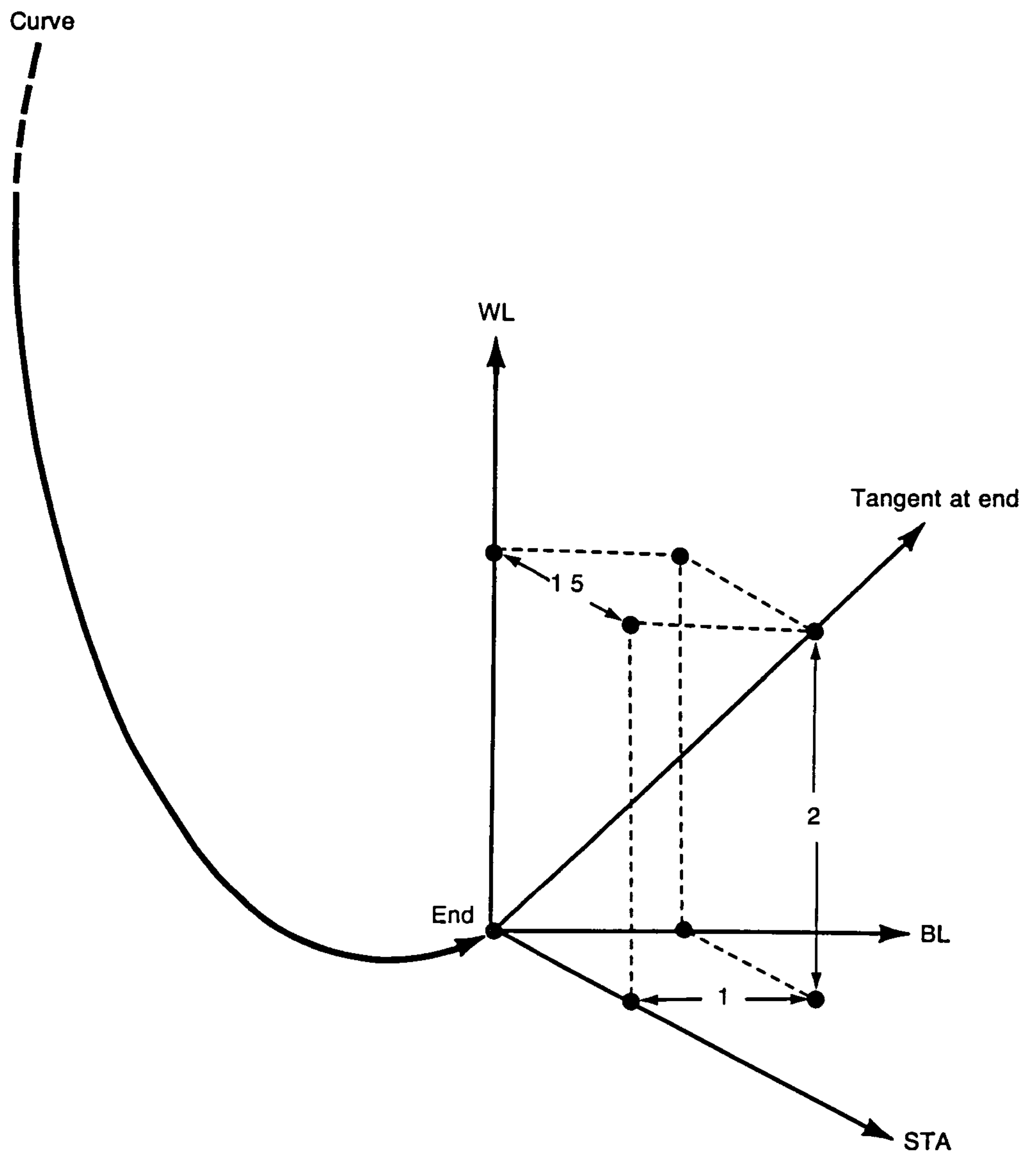
4.1.4 RULES FOR SURFACE DESCRIPTION

This section lists concise rules based upon the surface-description suggestions which have been stated in detail throughout Section 4.1.

1. Use the available memory aids
   a. Enter cylindrical coordinates in the default order.
   b Write a heading of user comments to identify each block.
   c Store descriptions in the rewritten form, with the system comments from SILSRF.
2. Lay out the sections and members regularly:
   a. Describe each region in local coordinates which emphasize the symmetry of the region. Use constant-coordinate curves
   b. Choose the more complicated curves as sections, not members. Every section should have the same number of knots. Every section point should be a knot.
   c. The nth member should have the nth knot from every section The section knots should appear in a member in the same order that the section curves appear. Every member point should be a knot
   d Group the patches into rows which cover the areas between pairs of adjacent members
3 Choose the directions of section and member curves so that the normal direction points in the correct direction. The normal direction is calculated by the cross product of tangents:
   Section X Member
4 When a surface touches the (global) cylindrical-coordinate axis, arrange either the sections or the members radially in the neighborhood of the axis.
5. Extend the surface description past the limits of the intended mesh.

---

*End-direction components to all have the same dimensional units (i e., distance), so they form vectors which can be rotated by multiplication by a rotation matrix.



End dırectıon 1 5 1 0 2 0

Figure 4-5 – End-Dırectıon Input

6 . Follow these rules for point input:
   a . Use uniform spacing or an adaptive spacing.
   b . Keep the spacing smaller than the radius of curvature.
   c . Break curves into separate sections and members at slope or curvature breaks.
   d . ***Do not use null points.***
   e . ***Do not use tension.***
6 . End a closed curve at the location where it begins (THETA usually will differ by 360 degrees).
7 . Specify the correct end conditions:
   a . Use a periodic condition for closed curves.
   b . Specify both the end directions for open curves. End directions are vectors which point tangent to the curve. The components are proportional to the rates of change of the coordinates (The angular component is converted to distance units.) The signs of the components matter, but the overall scaling is not important.

4.2 TRANSFORMATION DEFINITION

Be careful to get the rotation axis correctly placed. The rotation by matrix multiplication will keep the origin (0. , 0. , 0.) fixed, so the initial translation should move the desired rotation axis to pass through the origin. The initial translation should be the negatives of the coordinates of a point on the rotation axis. The final translation should equal the transformed coordinates for the same point.

Carefully check each rotation matrix. This can either be done by transforming SIL files and checking a few points whose transformed coordinates are known, or by manually testing the rotation. To check the correctness of a rotation matrix, use it to rotate some vectors, as shown in Section 3 1.4.1 and Figure 4-6. (Note that the rotation matrix is transposed from the input data before it is multiplied) The unit vectors in the 3 coordinate directions are a good choice for test data.

The best way to create the rotation matrix for a transformation is to use the procedure GENTRN. This procedure uses interactive input to set up matrix factors as rotations by a given angle about a given coordinate axis. It also will multiply the factors to give a combined rotation matrix and will accept translations

To create a transformation to undo what a given transformation does (i.e., an inverse transformation): (1) exchange the inital and final translations; (2) negate each number in both translations; and (3) transpose the rotation matrix.

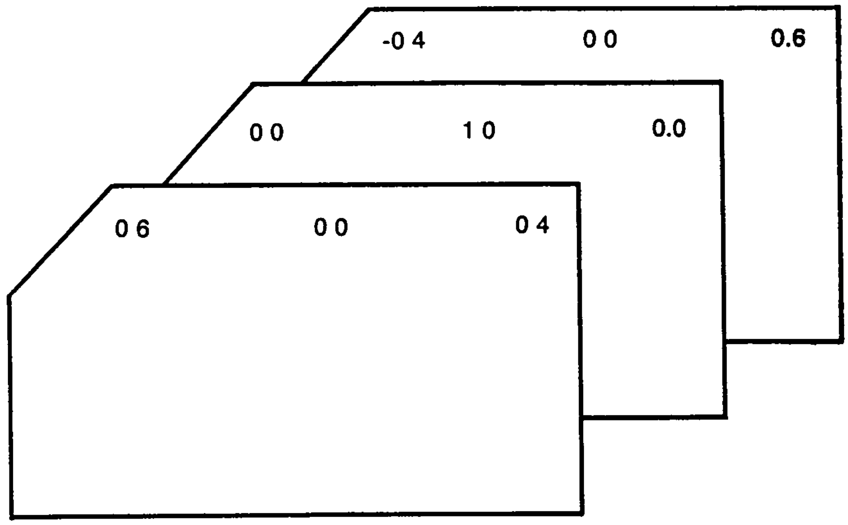
4.3 MESH DESCRIPTION

The selection of mesh values is dependent on the requirements of the CFD analysis program.

Use the IXAXIM, IXRADM, and IXANGM items of the $OPTION namelist to match any reordering of cylindrical coordinates in surface models from the default ordering.

Except for coordinate reordering, execute MSHNRM and NRMCFD without $OPTION namelist declarations. If experience shows that the other defaults need changing, ask MASTER consultation for assistance.

TRN matrix data



Matrix (transposed from TRN data)

$$\begin{bmatrix} 0.6 & 0.0 & -0.4 \\ 0.0 & 1.0 & 0.0 \\ 0.4 & 0.0 & 0.6 \end{bmatrix}$$

Check multiplication

$$\begin{bmatrix} 0.6 & 0.0 & -0.4 \\ 0.0 & 1.0 & 0.0 \\ 0.4 & 0.0 & 0.6 \end{bmatrix} \begin{bmatrix} 1.0 \\ 0.0 \\ 0.0 \end{bmatrix} = \begin{bmatrix} 0.6 \\ 0.0 \\ 0.4 \end{bmatrix}$$

$$\begin{bmatrix} 0.6 & 0.0 & -0.4 \\ 0.0 & 1.0 & 0.0 \\ 0.4 & 0.0 & 0.6 \end{bmatrix} \begin{bmatrix} 0.0 \\ 1.0 \\ 0.0 \end{bmatrix} = \begin{bmatrix} 0.0 \\ 1.0 \\ 0.0 \end{bmatrix}$$

$$\begin{bmatrix} 0.6 & 0.0 & -0.4 \\ 0.0 & 1.0 & 0.0 \\ 0.4 & 0.0 & 0.6 \end{bmatrix} \begin{bmatrix} 0.0 \\ 0.0 \\ 1.0 \end{bmatrix} = \begin{bmatrix} -0.4 \\ 0.0 \\ 0.6 \end{bmatrix}$$

Figure 4-6. – Matrix-Multiplication Check

When a mesh line will intersect the boundary of a configuration (and the surface description could not be extended, as suggested in Item 5 of Section 4.1.2.2), make separate MSH files for procedures MSHNRM and NRMCFD. For NRMCFD, keep the mesh value at the intended value. For MSHNRM, move the value towards the interior of the configuration by a distance less than TOLDIS (e.g., with the default of .0005 for TOLDIS, move the value by .0004). The MSHNRM intersection will be reliably calculated from the interior of the configuration. Procedure NRMCFD will then move the normal back to the edge.

5.0 OPERATION

MASTER is operated by executing procedures. These procedures are the control statements to use the MASTER computer programs.

5.1 GENERAL CHARACTERISTICS

MASTER procedures are implemented in a CDC NOS computing environment. The procedures (see Figures 2-4 and 2-5) are:

1 GENTRN
   This procedure generates coordinate transformations, which are TRN data.
2. TRNSIL
   This procedure transforms coordinates in SIL data. It reads TRN data; it both reads and writes SIL data.
3 SILSRF
   This procedure takes SIL surface-description data and produces a SRF surface-model file.
4 MSHNRM
   This procedure takes SRF surface-model data and MSH mesh-description data and produces NRM intersection-normal data.*
5 NRMREV
   This procedure takes a NRM file and reverses the direction of all the normals.
6 NRMCFD
   This procedure takes a MSH file and a NRM file. It sorts and conditions the intersection normals for use in CFD input. It combines the mesh and the intersections, giving a file in CFD format.
7 DRAWIT
   This procedure produces interactive-graphic displays of surface models. It is the program which is described in Section 4.3 of Reference 2, as DRAW6.

5.1.1 ACCESS

Separate from this manual, there is an access-summary sheet for each MASTER installation. This sheet describes the available versions of MASTER and names a procedure file for each one. It names the system account, where these files are found. It also locates MASTER consultation, where assistance beyond this manual is available.

Before executing a procedure, the user must get a local copy of the procedure file. This is done by the control statement.

"GET,PROCFIL=version/UN=system."

Replace "version" with the procedure file name and "system" with the system account name (PROCFIL is used below as the default name for the local procedure file, but a different name can be used).

---

*CUR curve-model data is produced as an intermediate result during MSHNRM execution and is made available to help diagnose deficiencies in mesh-intersection results, when the CFD analysis program detects geometry problems.

MASTER procedures are written in CCL procedure language, which is described in the operating-system manual for each installation. A procedure is called by entering a BEGIN statement. Each procedure has an order-dependent list of data files (see Figure 5-1 for a summary). There are default names for the procedure file and the data files, but the user can specify different names.

For example, consider procedure TRNSIL, with the following list of default file names:

"TRN,OLDSIL,NEWSIL,OUT."

The simplest way to call TRNSIL is:

"BEGIN,TRNSIL."

This is equivalent to·

"BEGIN,TRNSIL,PROCFIL,TRN,OLDSIL,NEWSIL,OUT."

Data files are changed from their default names by entering the new name in the list in its proper place, as illustrated by.

BEGIN,TRNSIL,,,INTSIL1,INTSIL2."

This statement is equivalent to.

"BEGIN,TRNSIL,PROCFIL,TRN, ***INTSIL1,INTSIL2,*** OUT."

The procedure file name can also be changed from the default, as illustrated by:

"GET,NEWPROC=version/UN=system."

"BEGIN,TRNSIL,NEWPROC."

This begin statement is equivalent to:

"BEGIN,TRNSIL, ***NEWPROC,*** TRN,OLDSIL,NEWSIL,OUT."

5.1.2 FILE RELATIONSHIPS

Each MASTER procedure has a set of input files and a set of output files. The file names used in this manual are the default names, which are used unless a substitution is given in the begin-procedure statement. The input and output files are listed in the sections on file relationships for individual procedures. (Figure 5-1 summarizes these lists.) This listing gives the file ordering used in the begin-procedure statement. If a list of file names follows "PROCFIL" (the name of the local file containing the procedures), the listed names are matched with the default names.* All the listed names are substituted for the corresponding default names.

MASTER treats all data files as local files, permanent storage is left to the user.

If an input file is absolutely necessary, MASTER will check that a file with that name exists before beginning execution; this offers some protection against misspelled file names. Most data files which can include comments may not be input from a time-sharing terminal; when this limitation applies, MASTER will check for it.

Each procedure produces a listing file, which is formatted for a line printer. If the procedure is being executed in a batch job, the listing file is OUTPUT. If the procedure is being executed by a time-sharing job, the listing file is a local file with (default) name OUT.

---

*A default name is used where adjacent commas in the list indicate an empty place in the list. (See Section 6 2 for an example.)

Basic procedures

BEGIN, GENTRN, PROCFIL, INPUT, TRN, OUT
BEGIN, TRNSIL, PROCFIL, TRN, OLDSIL, NEWSIL, INPUT, OUT.
BEGIN, SILSRF, PROCFIL, SIL, SRF, OUT
BEGIN, MSHNRM, PROCFIL, MSH, SRF, NRM, CUR, OUT
BEGIN, NRMREV, PROCFIL, OLDNRM, NEWNRM, OUT.
BEGIN, NRMCFD, PROCFIL, MSH, NRM, OLDCFD, NEWCFD, OUT.

Additional procedures

BEGIN, REGSIL, PROCFIL, OPTION, OLDSIL, NEWSIL
BEGIN, SRFINT, PROCFIL, SRF1, SRF2, SEC, OPTION, OUT
BEGIN, DRAWIT, PROCFIL, OUT

Figure 5-1. – File Lists for MASTER Procedures

All the input data files, except INPUT, are rewound before and after execution. All the output data files are returned before execution and are rewound after execution. The files INPUT and OUTPUT are not rewound or returned, so the procedures will fit naturally into a batch job. The listing file OUT is not rewound or returned, so a time-sharing job will not lose listing information from one procedure when a later procedure is executed.**

5.1.3 ERROR CONDITIONS

There are two possible paths of job flow after a procedure is executed. Either the procedure executes normally, or it is aborted. A normal procedure execution causes the job flow to continue with the next control statement. An aborted procedure execution acts like a regular control statement which caused an error; a batch job will skip to the next "EXIT" statement.

An aborted procedure execution leaves a message in the dayfile describing the type of failure (e.g., a required input file was missing; a program error occurred; or the job's field length was too short). Often this message will be enough to correct the problem (e.g., when the field length is too short, the message will be of the form: "124000 FIELD LENGTH REQUIRED"). If more information could help solve the problem, additional information is added to make the listing file a complete error package. A list of local files, dayfile, catalogs and listings of all the data files and temporary data files, a load map for the program, and catalogs of the binary files are included. A copy of this error package is automatically kept by the system for use by MASTER consultation.

5.1.4 PRACTICAL SUGGESTIONS

1. If possible, execute procedures GENTRN and TRNSIL interactively. Execute procedures SILSRF, MSHNRM, and NRMCFD only from batch jobs.
2. Check surface models carefully before proceeding to compute mesh intersections. A graphical display of the model is essential, such as the displays from DRAWIT. (This program is documented in Reference 2, Section 4.3.)

**It is the user's responsibility to send the listing information to the printer before logging off.

5.2 GENTRN - PROCEDURE TO GENERATE COORDINATE-TRANSFORMATION DATA

GENTRN defines coordinate transformation data Either it creates a new TRN file or it adds transformations to an existing file. The transformations are formed from rotations about coordinate axes and from translation vectors. GENTRN is oriented for interactive use.

5.2.1 PURPOSE

GENTRN is used to form elementary rotation matrices, to multiply them, and to combine them with translation vectors in TRN format.

5.2.2 LIMITATIONS

There are no significant limitations to data size

GENTRN will execute from an interactive timesharing job. It requires a field length of 50000 (octal).

GENTRN assumes that the elementary rotations are each oriented about a coordinate axis

5.2.3 ACCESS

BEGIN,GENTRN,PROCFIL,INPUT,TRN,OUT

5.2.4 FILE RELATIONSHIPS

GENTRN reads input data from file INPUT

GENTRN write TRN output to file TRN GENTRN can read transformation definitions from file TRN, when this file is present before execution

GENTRN uses file OUTPUT to request the user inputs. GENTRN uses the listing file (OUT or OUTPUT) for printer output

See Figure 5-2 for a diagram of GENTRN file relationships

5.2.5 INPUT DATA

An existing file TRN can be input This file is in TRN format, as described in Section 3.1.4 Any new transformations will be added after the existing ones. An input TRN file is optional.

File INPUT is used to enter data items * All input is preceded by an output message, which tells the interactive user what to enter. The data items are read in free-field format, they are separated by blanks and do not need to be in any particular columns

---

*MASTER does not check that file INPUT exists before executing GENTRN (Such a check would not accept input from a timesharing terminal.) An empty INPUT file will produce an output TRN file with no new transformations.

BEGIN, GENTRN, MASTER, INPUT, TRN, OUT

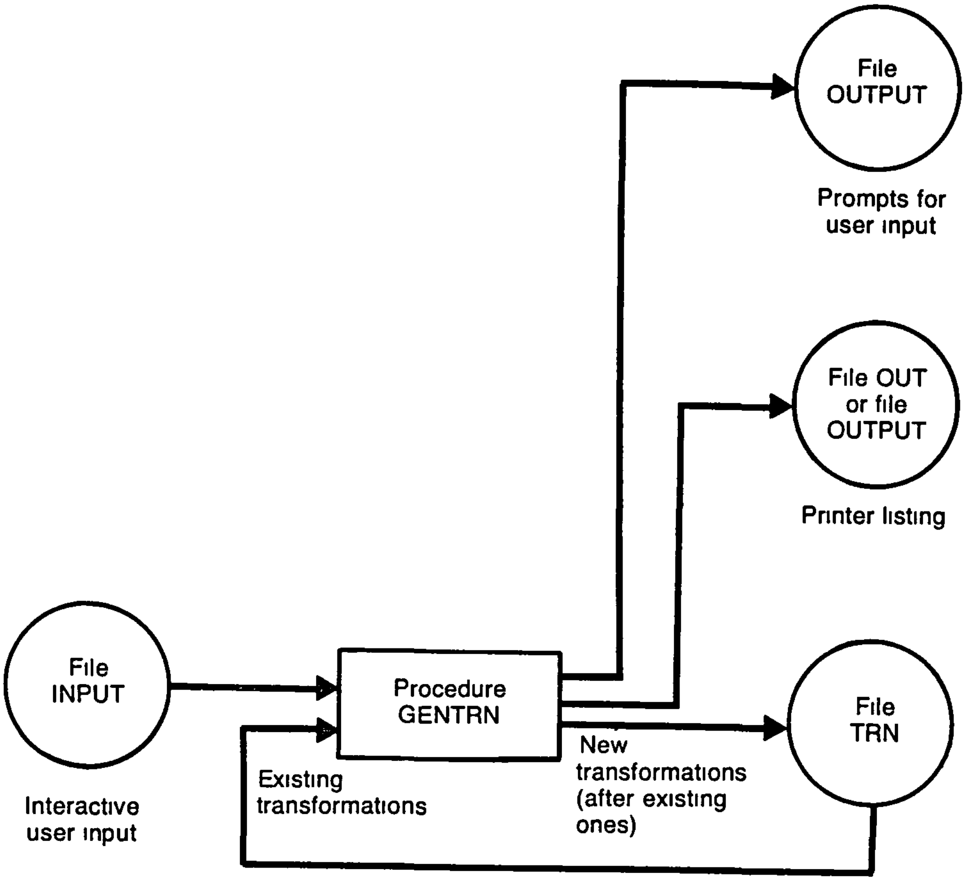


Figure 5-2 – Procedure GENTRN File Relationships

The program requests data until a line consisting of only a carriage return is entered. (If the last transformation definition is incomplete, it is completed with a null translation and possibly a null (i e , identity) rotation matrix)

Each transformation is defined by an initial translation, then a set of rotations, and finally another translation.*

The translations are vectors, expressed as three decimal values on a single data line.

Each rotation in the set is input by an axis selection, followed by an angle The axis selection is a single integer value on a data line The selection can be 1, 2, or 3. The angle is a single decimal value on a data line. The angle is in units of degrees. The set of rotations is ended by entering a zero value instead of a positive value for an axis selection.

5.2.6 OUTPUT DATA

A TRN-format file is output. This file is in TRN format, as described in Section 3.1.4. All created transformations appear in the order they were input Any previous transformations which were input on file TRN are kept at the beginning, in the same order

A header message on file OUTPUT introduces GENTRN. Before each line of input is read, a message is written to OUTPUT to request the data.

5.2.7 ERROR CONDITIONS

Errors can occur only while entering user input; the user will be prompted again for the same data item

5.2.8 PRACTICAL SUGGESTIONS

Refer to Section 4 2, for practical suggestions about expressing transformations in TRN format.

See the first part of Section 6 2 for an example of GENTRN execution.

*This sequence of translations and rotations corresponds to the TRN data format, as defined in Section 3.1 4.

5.3 TRNSIL - PROCEDURE TO TRANSFORM COORDINATES IN SIL DATA

5.3.1 PURPOSE

TRNSIL is used either to convert a surface description from cylindrical coordinates to rectangular coordinates, or to rotate and translate a surface description in rectangular coordinates as if it was a rigid object; or to convert a surface description from rectangular coordinates to cylindrical coordinates.

5.3.2 LIMITATIONS

Procedure TRNSIL currently imposes the following limitations on a SIL file which is to be transformed·

1 The option declarations must be omitted.
2 The user must keep track of whether the coordinates are rectangular or cylindrical.
3 Cylindrical coordinates must appear in this order: axial, radial, and angular.
4 Only one block can appear on a single SIL file.
5 There can be only 27 sections in a block.
6. Each section can have only 29 knots.
7. There can be only 27 members in a block.

These are more severe limits than those for SILSRF. (Up to 120 sections, member points, and member knots are allowed in SILSRF Up to 175 members, section points, and section knots are allowed there.)

TRNSIL will execute from an interactive timesharing job. It requires a field length of 40000 (octal)

TRNSIL will not change the size or shape of a surface.

Surface descriptions in cylindrical coordinates which touch the coordinate axis can give incorrect surface models (see Section 4.1.2.2), but they can be transformed correctly to other coordinates.

When transforming from rectangular to cylindrical coordinates, THETA is ambiguous at points on the cylindrical-coordinate axis The THETA values and end slopes at such points should be checked for consistency with the rest of the input curve.

5.3.3 ACCESS

BEGIN,TRNSIL,PROCFIL,TRN,OLDSIL,NEWSIL,INPUT,OUT.

5.3.4 FILE RELATIONSHIPS

See Figure 5-3 for a diagram of TRNSIL file relationships

If a rigid-object transformation is selected, TRNSIL reads the transformation definition from file TRN.

TRNSIL reads SIL input from file OLDSIL.

TRNSIL reads the transformation selection from file INPUT.

BEGIN, TRNSIL, MASTER, TRN, OLDSIL, NEWSIL, INPUT, OUT.

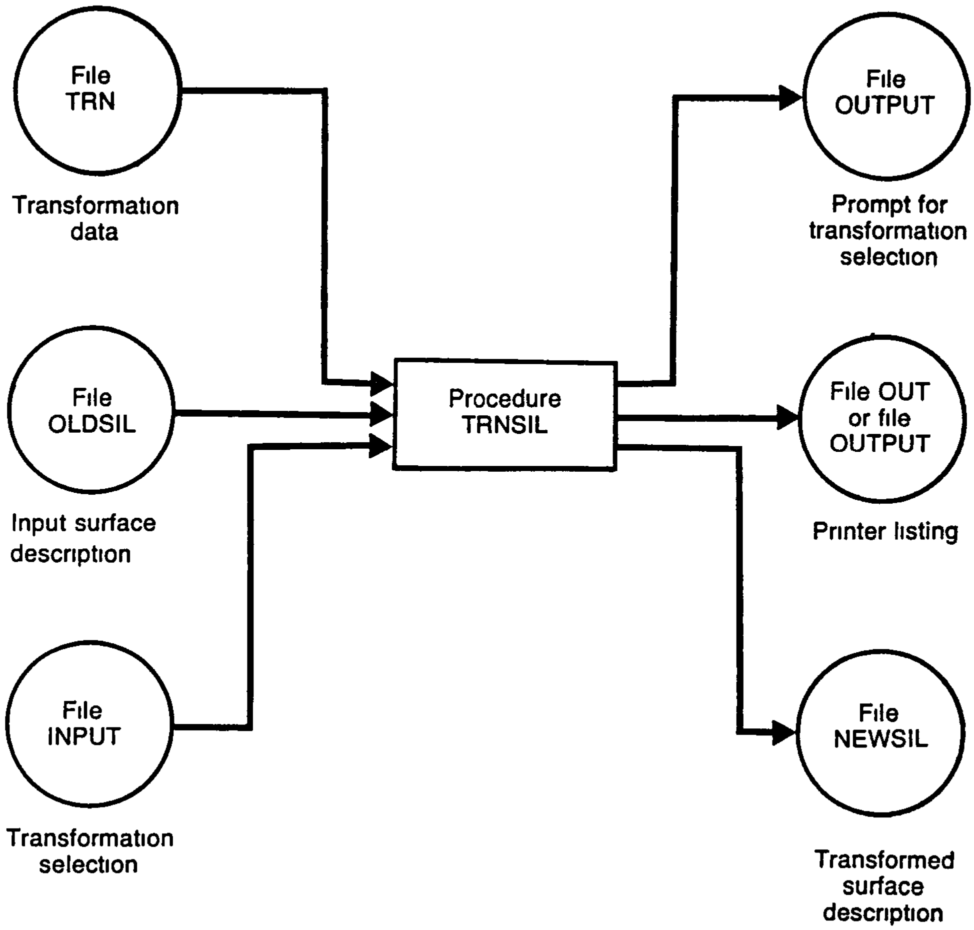


Figure 5-3. – Procedure TRNSIL File Relationships

TRNSIL writes SIL output to file NEWSIL.

TRNSIL writes listing information to the listing file (OUT or OUTPUT).

TRNSIL uses file OUTPUT to request the transformation selection.

5.3.5 INPUT DATA

File TRN is input in TRN format, as described in Section 3.1.4. There is a set of standard transformations available as file STDTRN on the system account. The standard transformations include 90-degree and 180-degree rotations, mirror reflections, and coordinate rearrangements. (See Figure 5-4 for a list.)

File OLDSIL is input in SIL format, as described in Section 3.1.3. The file must meet the second set of limitations described in Section 3.1.3.1.

File INPUT is used to select a transformation, by entering one or two numbers. To select a transformation defined on TRN input, enter the sequence number for that transformation. To select conversion between rectangular and cylindrical coordinates, first enter "0", then either "1" to convert from cylindrical to rectangular or "0" to convert from rectangular to cylindrical. The selection is input free-field; it does not need to be in any particular column.

5.3.6 OUTPUT DATA

File NEWSIL is output in SIL format, as described in Section 3.1.3.

Before the transformation selection is read, a message is written to file OUTPUT to request the data.

The transformed surface description from file NEWSIL appears on the listing file (OUT or OUTPUT)

5.3.7 ERROR CONDITIONS

Error conditions cause a message to be written on the listing file and the procedure is aborted.

5.3.8 PRACTICAL SUGGESTIONS

Set up the transformations for a configuration before preparing any other data. Check these transformations carefully before using them.

Remember to remove any option declarations before coordinate transformation and to restore the declarations after transformation

Remember to convert from cylindrical to rectangular coordinates before doing a rigid-object transformation. Also, remember to convert back to cylindrical coordinates after the rigid-object transformation. See the second part of Section 6 2 for an example.

```
 1:  X1 -> X2 -> X3 -> X1 (CYCLIC PERMUTATION)
 2:  X1 -> X3 -> X2 -> X1 (CYCLIC PERMUTATION)
 3:  X1 <-> X2 (EXCHANGED)
 4:  X2 <-> X3 (EXCHANGED)
 5:  X1 <-> X3 (EXCHANGED)
 6:  X1 REVERSED
 7:  X2 REVERSED
 8:  X3 REVERSED
 9:  180-DEGREE ROTATION ABOUT X1-AXIS
10:  180-DEGREE ROTATION ABOUT X2-AXIS
11:  180-DEGREE ROTATION ABOUT X3-AXIS
12:  90-DEGREE ROTATION ABOUT X1-AXIS
13:  90-DEGREE ROTATION ABOUT X2-AXIS
14:  90-DEGREE ROTATION ABOUT X3-AXIS
15:  NEGATIVE 90-DEGREE ROTATION ABOUT X1-AXIS
16:  NEGATIVE 90-DEGREE ROTATION ABOUT X2-AXIS
17:  NEGATIVE 90-DEGREE ROTATION ABOUT X3-AXIS
18:  5-DEGREE DROOP (ROTATION ABOUT X2-AXIS)
19:  INVERSE TO 5-DEGREE DROOP
```

Figure 5-4 – List of Standard Transformations

Transformations between cylindrical and rectangular coordinates require the input coordinates to be in the default order, as shown in Section 3.1.1. Also, the output coordinates will be in the default order. If this is not the desired order, standard transformations 1 through 5 can rearrange the coordinates.*

Scan the listing file for possible errors.

The second part of Section 6.2 shows an example of TRNSIL execution.

---

*Standard transformation 1 will rearrange cylindrical-coordinates from the IGS ordering (see Reference 2) to the MASTER default ordering; standard transformation 2 will rearrange them from the MASTER default ordering to the IGS ordering.

5.4 SILSRF — PROCEDURE TO MODEL SURFACES

SILSRF generates SRF data. It reads SIL data.

5.4.1 PURPOSE

SILSRF is used to model surfaces

5.4.2 LIMITATIONS

There are minor limitations to data size, as described in Section 3.1.3.1. Typical models easily fit these limitations.

SILSRF should be executed from a batch job It requires a field length of 144000 (octal)

Surface models in cylindrical coordinates can fail to represent the parts where a surface meets the coordinate axis. This problem is described in Section 4 1.2.2.

5.4.3 ACCESS

BEGIN,SILSRF,PROCFIL,SIL,SRF,OUT.

5.4.4 FILE RELATIONSHIPS

See Figure 5-5 for a diagram of SILSRF file relationships.

SILSRF reads input from file SIL, and it rewrites the same data to file SIL with system comments added

SILSRF writes output data to file SRF.

5.4.5 INPUT DATA

File SIL is input in SIL format, as described in Section 3.1.3.

5.4.6 OUTPUT DATA

File SRF is output in SRF format. This format is shown in Section 3.2.1.2.

File SIL is rewritten with the values aligned, but it contains the same data as was input. The rewritten form contains several headings, written as system comments. There are headings for each block, for each group within a set, for each curve within a section set, and for the end conditions within each curve. The alignment and the comments improve the readability of the SIL file significantly

The listing file (OUT or OUTPUT) shows the revised form of the SIL data If a "DUMP" option was selected, the listing also shows details of the computations within SILSRF.

5.4.7 ERROR CONDITIONS

Error conditions cause a message to be written on the listing file, then the procedure is aborted.

5.4.8 PRACTICAL SUGGESTIONS

Refer to Section 4.1 for practical suggestions for surface description.

Scan the printer listing for possible error messages.

Check surface models carefully before proceeding to compute mesh intersections. A graphical display of the model is essential, such as the displays from DRAWIT (this program is documented in Reference 2, Section 4.3).

Section 6.3 shows an example of SILSRF execution.

5.5 MSHNRM — PROCEDURE TO CREATE MESH/SURFACE INTERSECTION NORMALS

5.5.1 PURPOSE

MSHNRM is used to intersect a coordinate mesh with a surface model.

5.5.2 LIMITATIONS

There can be only 200 coordinate values in any of the three sets of mesh values.

MSHNRM should be executed from a batch job. It requires a field length of 160000 (octal).

The mesh and the surface model must be expressed in the same coordinates.

5.5.3 ACCESS

BEGIN,MSHNRM,PROCFIL,MSH,SRF,NRM,CUR,OUT.

5.5.4 FILE RELATIONSHIPS

See Figure 5-6 for a diagram of MSHNRM file relationships.

MSHNRM reads the mesh data from file MSH.

MSHNRM reads the surface-model data from file SRF.

MSHNRM writes the intersection-normal data to file NRM *

MSHNRM writes printer information to the listing file (OUT or OUTPUT).

5.5.5 INPUT DATA

File MSH is in MSH format, as described in Section 3.1 5.

File SRF is in SRF format, as produced from procedure SILSRF.

5.5.6 OUTPUT DATA

File NRM is in NRM format, as described in Section 3 2 2

The listing file contains descriptions of the input data and the output intersection normals.

5.5.7 ERROR CONDITIONS

Error conditions cause a message to be written on the listing file. If possible, execution will continue.

---

*MSHNRM calculates intersection curves as an intermediate step in normal calculation. These curves are written to file CUR for checking MSHNRM problems graphically. The curves are in CUR format as described in Section 3.2.1.1.

BEGIN,SILSRF,MASTER,SIL,SRF,OUT

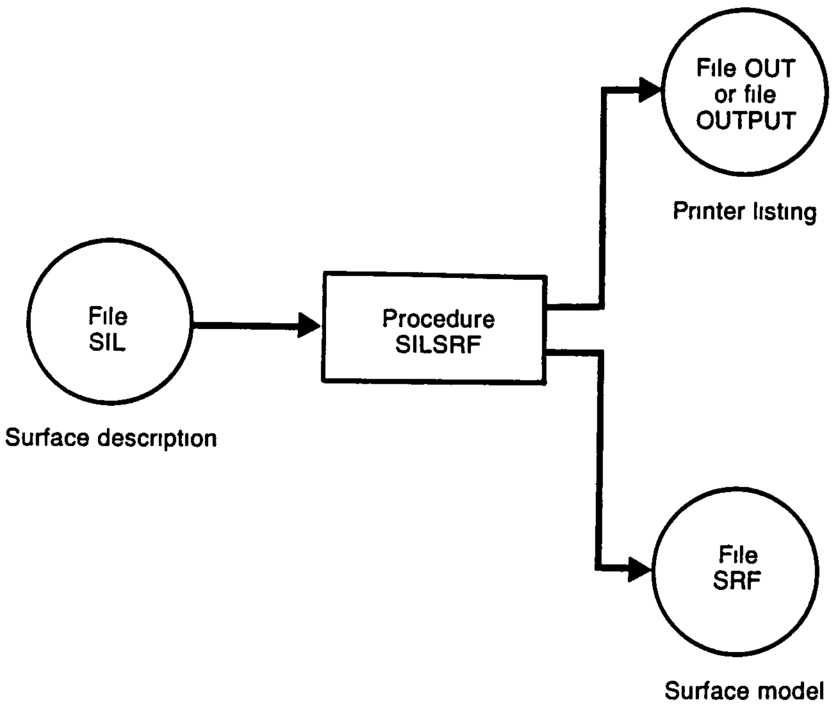


Figure 5-5. – Procedure SILSRF File Relationships

BEGIN,MSHNRM,MASTER,MSH,SRF,NRM,CUR,OUT.

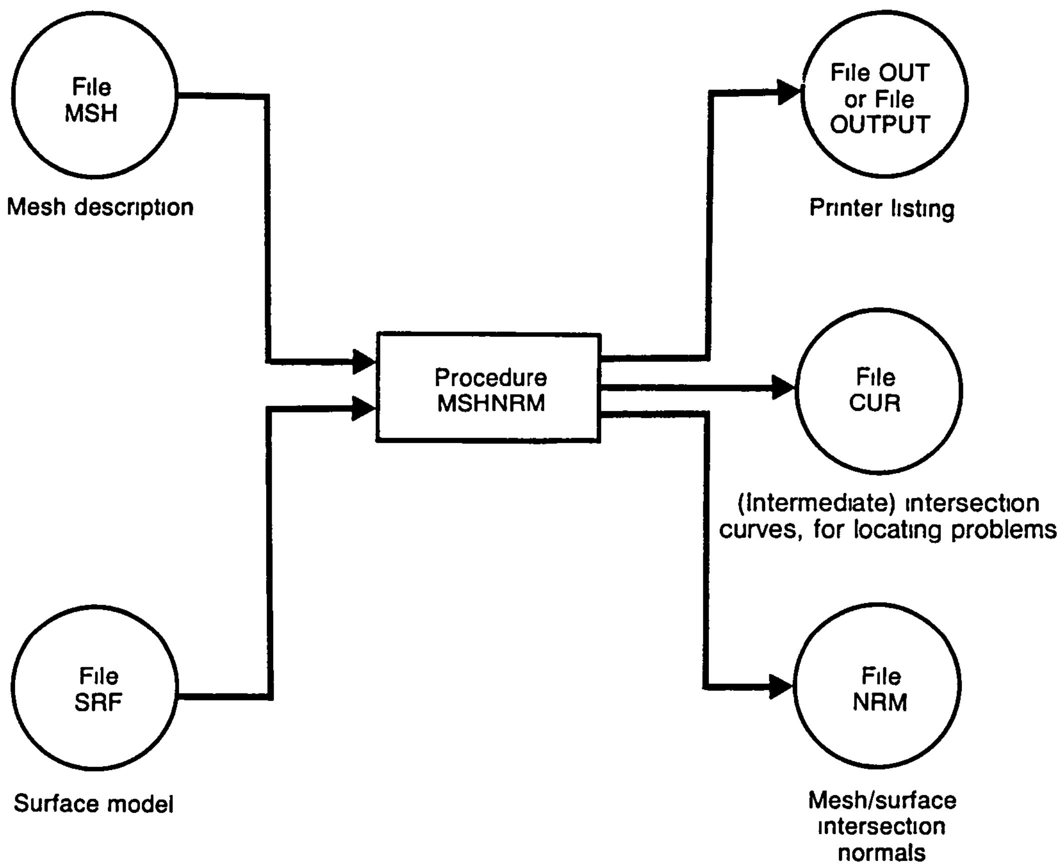


Figure 5-6. –Procedure MSHNRM File Relationships

Some conditions are noted as possible errors. They indicate that some intersections may be missing or incorrect The user should check the results near the location shown.

5.5.8 PRACTICAL SUGGESTIONS

Refer to Section 4.3 for practical suggestions for mesh description.

Be sure that the order of the coordinates agrees between the MSH and SRF input files.

Scan the listing file to check for error messages.

Reduce costs by making a reduced MSH file for each SRF file. Include only the mesh values expected to intersect the surface, plus one value on each side to ensure that the mesh bounds the surface

Section 6.4 shows an example of MSHNRM execution.

5.6 NRMREV — PROCEDURE TO REVERSE NORMALS

5.6.1 PURPOSE

NRMREV is used to reverse the direction of all the normals on a file.

5.6.2 LIMITATIONS

NRMREV requires a field length of 20000 (octal).

5.6.3 ACCESS

BEGIN,NRMREV,PROCFIL,OLDNRM,NEWNRM,OUT.

5.6.4 FILE RELATIONSHIPS

See Figure 5-7 for a diagram of NRMREV file relationships

NRMREV reads reversed normals from file OLDNRM and writes corrected normals to file NEWNRM.

The listing file is used only when an error package is returned from an aborted NRMREV execution.

5.6.5 INPUT DATA

File OLDNRM is in NRM format, as described in Section 3 2 2.

5.6.6 OUTPUT DATA

File NEWNRM is in NRM format, as described in Section 3.2.2.

5.6.7 ERROR CONDITIONS

None.

5.6.8 PRACTICAL SUGGESTIONS

Scan the listing file to check that the correct input data was used.

Section 6.4 shows an example of NRMREV execution.

BEGIN,NRMREV,MASTER,OLDNRM,NEWNRM,OUT

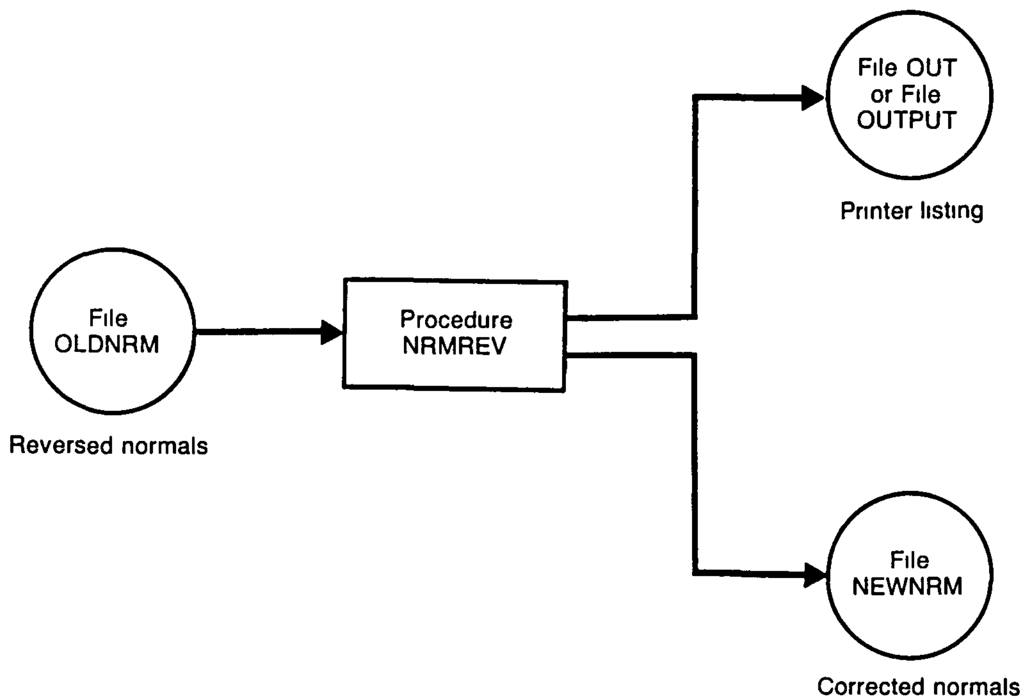


Figure 5-7 – Procedure NRMREV File Relationships

5.7 NRMCFD — PROCEDURE TO CONDITION NORMALS AND FORMAT CFD OUTPUT

5.7.1 PURPOSE

NRMCFD is used to combine the complete set of normals and the complete coordinate mesh for a configuration, giving a CFD analysis input file.

5.7.2 LIMITATIONS

NRMCFD should be executed from a batch job It requires a field length of 124000 (octal).

5.7.3 ACCESS

BEGIN,NRMCFD,PROCFIL,MSH,NRM,OLDCFD,NEWCFD,OUT

5.7.4 FILE RELATIONSHIPS

See Figure 5-8 for a diagram of NRMCFD file relationships.

NRMCFD reads mesh input from file MSH.

NRMCFD reads intersection-normal data from file NRM.

NRMCFD can read CFD header data from file OLDCFD, but this data is not needed for NRMCFD execution

NRMCFD writes CFD data to file NEWCFD

NRMCFD writes a copy of the output CFD data to the listing file.

5.7.5 INPUT DATA

File MSH is in MSH format, as described in Section 3 1 5 The mesh must include all coordinate values for input to CFD analysis

File NRM is in NRM format, as described in Section 3 2 2 The intersection-normals must include all the intersections of the complete configuration with the complete mesh. The input used from file OLDCFD, if present, is the unspecified header data in CFD format as described in Section 3.2 3.

5.7.6 OUTPUT DATA

File NEWCFD is in CFD format, as described in Section 3 2 3 The unspecified header data is simply the data copied from file OLDCFD, if present Cylindrical coordinates are output in the order: STA, RADIUS, and then THETA.

The listing file (OUT or OUTPUT) contains a copy of the output CFD data from file NEWCFD.

5.7.7 ERROR CONDITIONS

Error conditions cause a message to be written on the listing file, then the procecure is aborted.

BEGIN,NRMCFD,MASTER,MSH,NRM,OLDCFD,NEWCFD,OUT

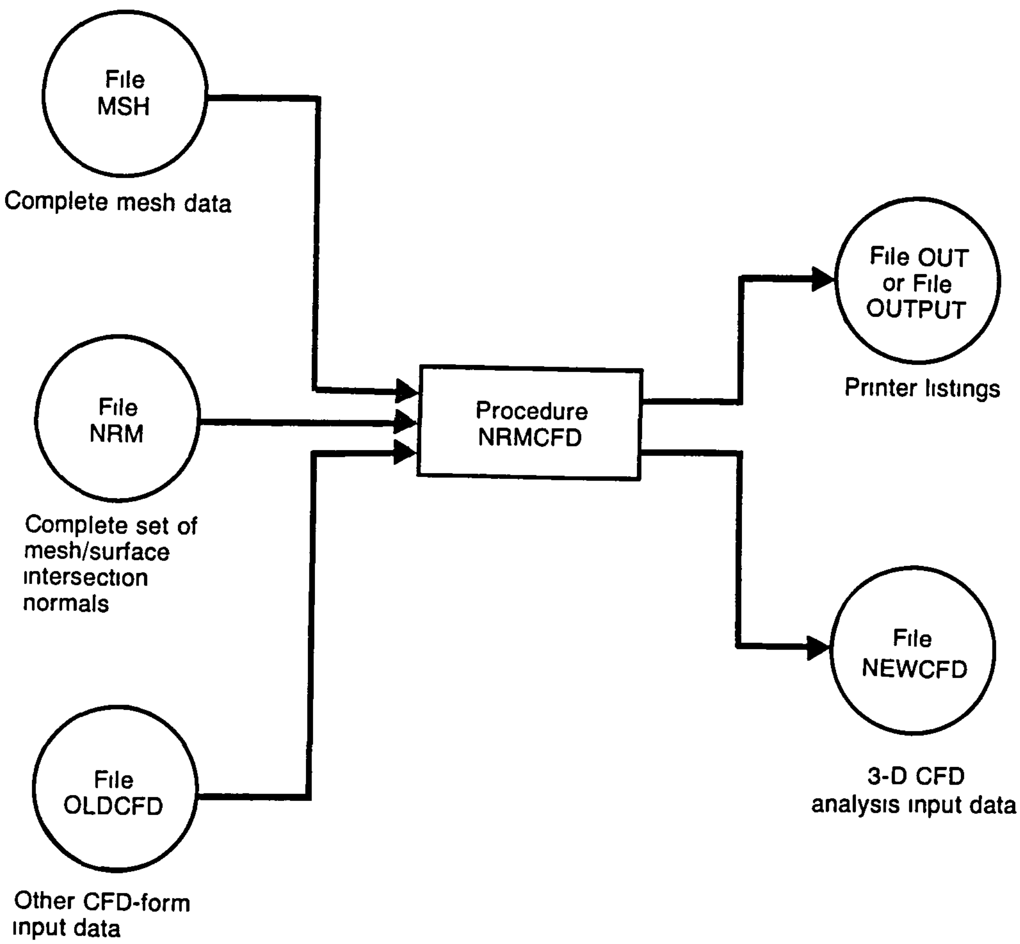


Figure 5-8 – Procedure NRMCFD File Relationships

5.7.8 PRACTICAL SUGGESTIONS

Use the $OPTION declaration to indicate in the MSH file any rearrangement of cylindrical coordinates.

Provide an old version of the CFD file to OLDCFD when changing the geometry. This will copy the nongeometric CFD input automatically.

Scan the listing file for error conditions.

Section 6.5 shows an example of NRMCFD execution.

6.0 EXAMPLES

These examples illustrate the operation of MASTER. Section 6.1 shows how to describe a surface by preparing a SIL-format input file. Section 6 2 illustrates the transformation of coordinate data in SIL files; it also shows how to rename input or output files away from their default names Section 6 3 models a surface. Section 6.4 illustrates mesh/surface intersection. Section 6 5 shows how to format a mesh and intersection normals as CFD-format data

6.1 SURFACE-DESCRIPTION EXAMPLE

This example illustrates surface description by SIL-format input. For simplicity, the numbers of curves, points, and patches have been reduced below the requirements for accurate modeling Also, the surface region has been reduced in extent; it is not a complete configuration for 3-D CFD analysis

A portion of an axisymmetric inlet lip is described in cylindrical coordinates, extending from THETA = 0 degrees to THETA = 90 degrees; the axis of symmetry is used as the coordinate axis. (Figure 6-1 shows the lip configuration) The lip is defined from an inner boundary at STA = 0 25 and RADIUS = 0.9, through a highlight at STA = 0 00 and RADIUS = 1 0, to an outer boundary at STA = 0 25 and RADIUS = 1 1 (The surface normal points radially at both boundaries and parallel to the axis at the highlight)

Constant-THETA sections are input They start at the outer boundary, pass through the highlight, and end at the inner boundary. The sections have both end directions specified, with a type-3 end code. (The tangent to a section is parallel to the axis at both boundaries STA is increasing along a section at the inner boundary, and it is decreasing along a section at the outer boundary.) All the section points are knots. There are 5 sections, from THETA = 0 to THETA = 360 degrees, with a 90-degree spacing

Circular members are input. A sketch of the section curves, shown in Figure 6-2, is used to find the section and knot index values which name the input member points. The members have periodic end conditions, with a type-4 end code. There are 3 members:

1. At the outer boundary,
2. At the highlight,
3. At the inner boundary

Patch specifications are input to cover the area between the first 2 sections. A sketch of the member curves, shown in Figure 6-3, is used to find the member knot-and-curve index values which name the patch corners There are 2 patches:

1. From the inner boundary to the highlight, and
2. From the highlight to the outer boundary

The surface-description file is shown in Figure 6-4. The option declaration for cylindrical coordinates is the first line User comments at the top identify the surface region. Figure 6-14 shows the file after being rewritten by procedure SILSRF, with headings on system-comment lines. This file is available in this form on the MASTER system account, on file SIL. Note that the comments make the data easier to understand. Figure 6-5 illustrates references to section knots in member specifications and references to member knots in patch specifications

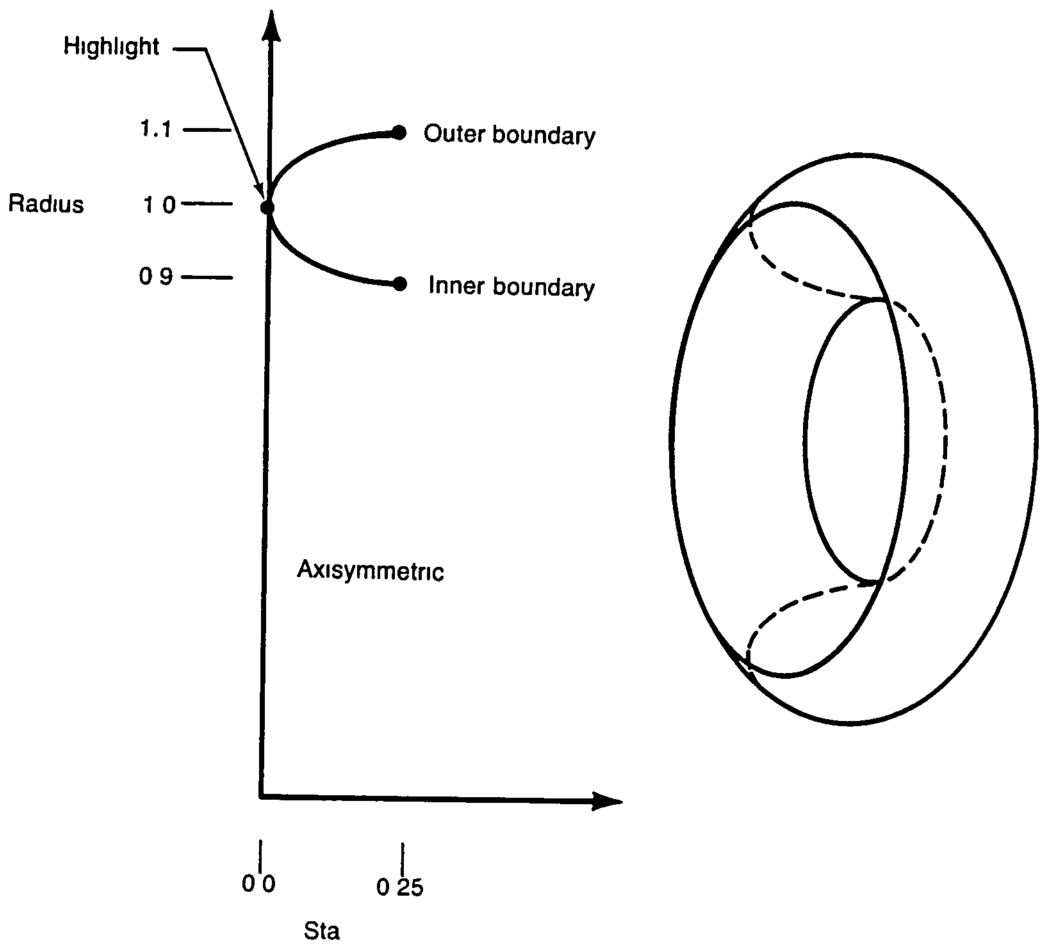


Figure 6-1 – Axisymmetric Inlet Lip Configuration

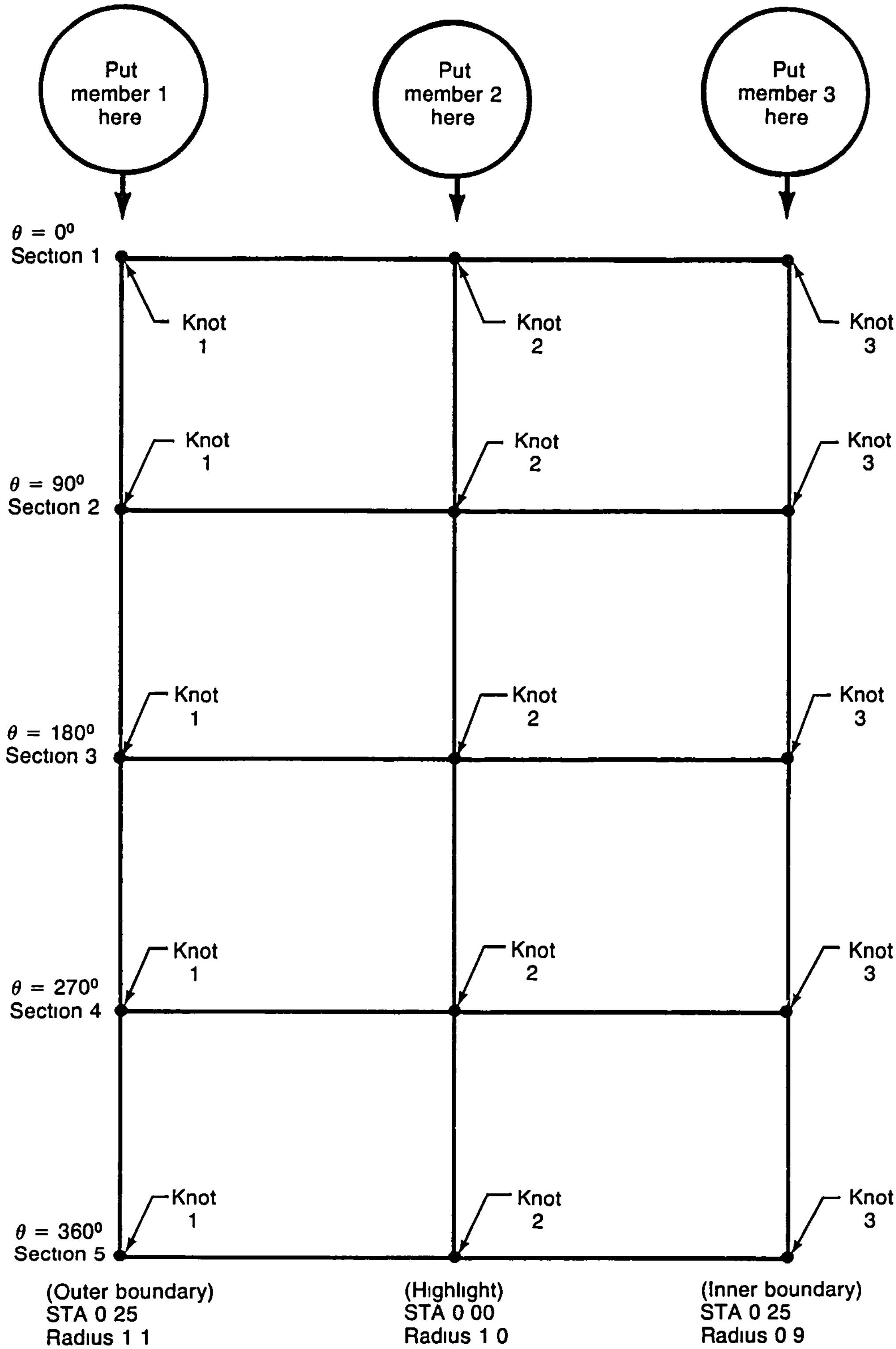


Figure 6-2. – Sketch of Sections

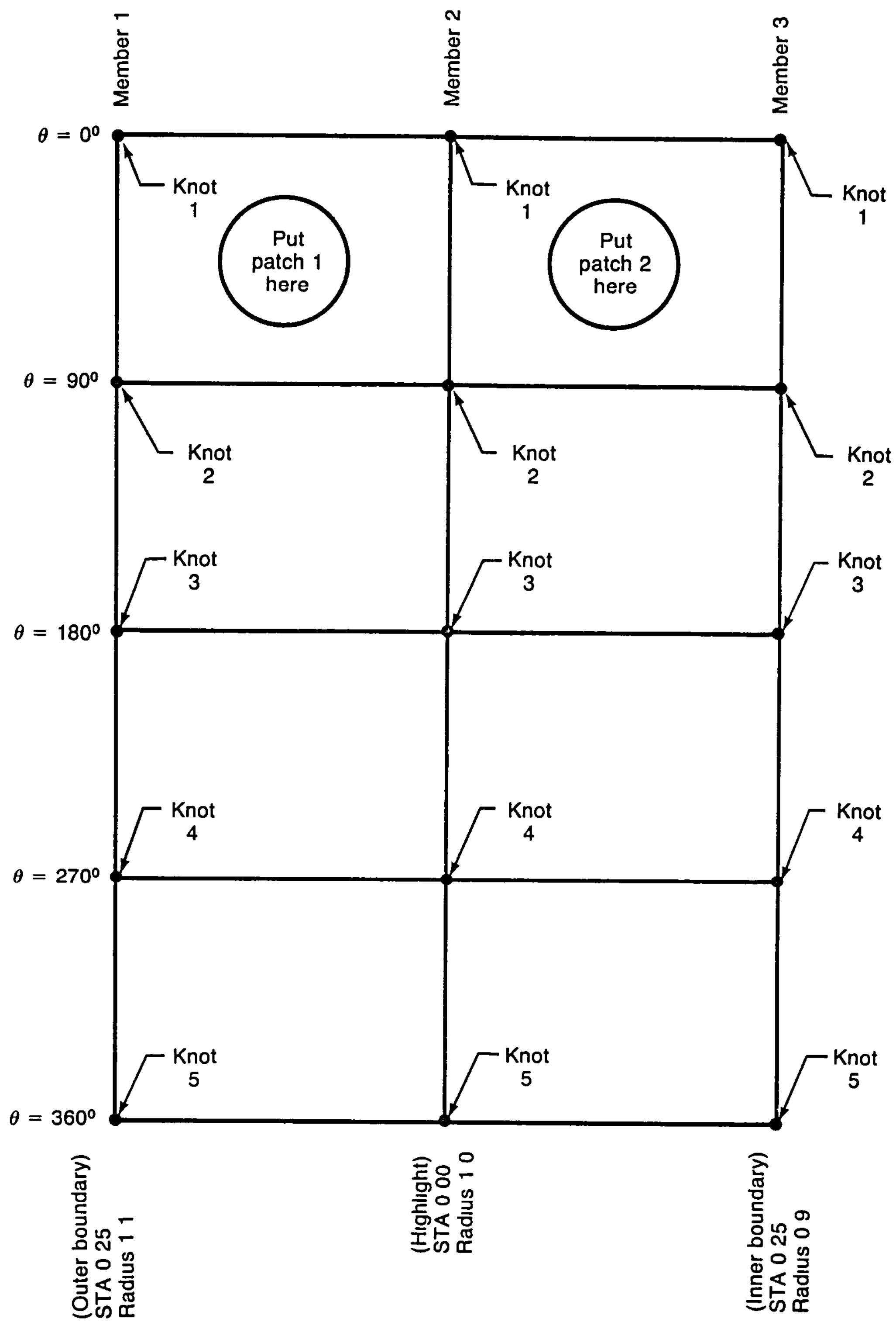


Figure 6-3. – Sketch of Members

```
CYL
* MASTER:  MODELING OF AERODYNAMIC SURFACES
*          BY THREE-DIMENSIONAL EXPLICIT REPRESENTATION
* SURFACE DESCRIPTION EXAMPLE
* PREPARED 29 JAN 1982.
* SIMPLIFIED INLET LIP
5
3
3
-1. 0. 0.     1. 0. 0.      3
.25 1.1   0.     0. 9       5
.00 1.0   0.     0. 9       4
.25 0.9   0.     0. 9       1 1               0. 9
3                           1 2               0. 9
3                           1 3               0. 9
-1. 0. 0.     1. 0. 0.      1 4               0. 9
.25 1.1  90.     0. 9       1 5               0. 9
.00 1.0  90.     0. 9       5
.25 0.9  90.     0. 9       4
3                           2 1               0. 9
3                           2 2               0. 9
-1. 0. 0.     1. 0. 0.      2 3               0. 9
.25 1.1 180.     0. 9       2 4               0. 9
.00 1.0 180.     0. 9       2 5               0. 9
.25 0.9 180.     0. 9       5
3                           4
3                           3 1               0. 9
-1. 0. 0.     1. 0. 0.      3 2               0. 9
.25 1.1 270.     0. 9       3 3               0. 9
.00 1.0 270.     0. 9       3 4               0. 9
.25 0.9 270.     0. 9       3 5               0. 9
3                           2
3                           1 1     2 1       1 2     2 2
-1. 0. 0.     1. 0. 0.      1 2     2 2       1 3     2 3
.25 1.1 360.     0. 9
.00 1.0 360.     0. 9
.25 0.9 360.     0. 9
```

Figure 6-4 – Surface Description (SIL) File

```
 CYLINDRICAL COORDINATES
C
C ----------------------------------------------------------------------
C
* MASTER:  MODELING OF AERODYNAMIC SURFACES
*          BY THREE-DIMENSIONAL EXPLICIT REPRESENTATION
* SURFACE DESCRIPTION EXAMPLE
* PREPARED 29 JAN 1982.
* SIMPLIFIED INLET LIP
C     **** BLOCK NUMBER  1 ****
C
C     ****  SECTION INPUT  ****
C
   5   NUMBER OF SECTIONS
C
C     ****SECTION NUMBER  1 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000             1.00000   0.00000   0.00000
C        STA        RADIUS        THETA  TENSION    KNOT
       .25000       1.10000       0.00000 0.            1     POINT  1
      0.00000       1.00000       0.00000 0.            2     POINT  2
       .25000        .90000       0.00000 0.            3     POINT  3
C
C     ****SECTION NUMBER  2 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000             1.00000   0.00000   0.00000
C        STA        RADIUS        THETA  TENSION    KNOT
       .25000       1.10000      90.00000 0.            1     POINT  1
      0.00000       1.00000      90.00000 0.            2     POINT  2
       .25000        .90000      90.00000 0.            3     POINT  3
C
C     ****SECTION NUMBER  3 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000             1.00000   0.00000   0.00000
C        STA        RADIUS        THETA  TENSION    KNOT
       .25000       1.10000     180.00000 0.            1     POINT  1
      0.00000       1.00000     180.00000 0.            2     POINT  2
       .25000        .90000     180.00000 0.            3     POINT  3
C
C     ****SECTION NUMBER  4 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000             1.00000   0.00000   0.00000
C        STA        RADIUS        THETA  TENSION    KNOT
       .25000       1.10000     270.00000 0.            1     POINT  1
      0.00000       1.00000     270.00000 0.            2     POINT  2
       .25000        .90000     270.00000 0.            3     POINT  3
```

(Continued from Below)

Figure 6-5 – SIL Cross-References

(Continued from Above)

```
C
C     ****  MEMBER INPUT  ****
C
   3   NUMBER OF MEMBERS
C
C     ****MEMBER NUMBER  1 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER     SECTION NUMBER    TENSION      CORNER PT
           1                  1  0.                   1     POINT  1
           1                  2  0.                   2     POINT  2
           1                  3  0.                   3     POINT  3
           1                  4  0.                   4     POINT  4
           1                  5  0.                   5     POINT  5
C
C     ****MEMBER NUMBER  2 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER     SECTION NUMBER    TENSION      CORNER PT
           2                  1  0.                   1     POINT  1
           2                  2  0.                   2     POINT  2
           2                  3  0.                   3     POINT  3
           2                  4  0.                   4     POINT  4
           2                  5  0.                   5     POINT  5
C
C     ****MEMBER NUMBER  3 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER     SECTION NUMBER    TENSION      CORNER PT
           3                  1  0.                   1     POINT  1
           3                  2  0.                   2     POINT  2
           3                  3  0.                   3     POINT  3
           3                  4  0.                   4     POINT  4
           3                  5  0.                   5     POINT  5
C
C     ****  PATCH INPUT  ****
C
   2   NUMBER OF PATCHES
C  U0V0      U0V1      U1V0      U1V1     EACH PAIR:  CORNER PT, MEMBER
    1   1     2   1     1   2     2   2                   PATCH  1
    1   2     2   2     1   3     2   3                   PATCH  2
C
C -----------------------------------------------------------------------
C
```

Figure 6-5 – SIL Cross-References (concluded)

6.2 COORDINATE-TRANSFORMATION EXAMPLE

This example illustrates coordinate-transformation description and the transformation of surface-description coordinates. It also illustrates how to change file names from their defaults. Procedure GENTRN aids the user in coordinate-transformation description. Surface-description coordinates are transformed by procedure TRNSIL.

The axisymmetric inlet lip from Section 6 1 provides the input surface description. The input coordinates are cylindrical, with the inlet axis of symmetry as the coordinate axis The output coordinates are also cylindrical, with a 5-degree droop rotation.* The rotation is about an axis located at STA = 1 0, RADIUS = 1.0, and THETA = 180 degrees The transformed coordinates for its location are also STA = 1 0, RADIUS = 1.0, and THETA = 180 degrees Figure 6-6 illustrates the input and output coordinate systems Note that the transformation will make the highlight more forwards on the top than on the bottom

Surface-description coordinates are in cylindrical coordinates, and a rigid-object transformation is desired This requires a sequence of 3 executions of TRNSIL

1 Conversion to rectangular coordinates,
2 . Transformation in rectangular coordinates,
3 Conversion to cylindrical coordinates.

One transformation description is required, for the second TRNSIL execution a (negative) 5-degree rotation about an axis through STA = 1.0 and WL = -1.0, parallel to the BL coordinate-axis

Procedure GENTRN is used to produce a TRN file with the one transformation description The initial translation is (-1 0 , 0 0 , 1 0), it moves the rotation axis to the origin. The rotation is -5 degrees about the second (BL) coordinate axis The final translation moves the rotation axis to its new coordinate values Figure 6-7 shows the interactive terminal session for transformation description The transformation description is on file TRN and is shown in Figure 6-8. A copy of this file is available on the MASTER system account

Figure 6-9 shows the terminal session for transforming surface-description coordinates, which illustrates the file-renaming feature of the CCL begin-procedure statement. (See Sections 5.1.1 and 5.1 2) The input surface description is on file OLDSIL,** the 2 intermediate surface descriptions are on files INTSIL1 and INTSIL2, and the output surface description is on file NEWSIL Copies of these files are available on the MASTER system account OLDSIL is the default name for SIL input, and NEWSIL is the default name for SIL output The intermediate SIL files are connected to the procedure by adding their names at the correct places in the BEGIN statements. Files INTSIL1, INTSIL2, and NEWSIL are shown in Figures 6-10, 6-11, and 6-12

In file NEWSIL, STA values at the highlight are less at the top than at the bottom This means that the top is more forwards than the bottom, as noted from Figure 6-6. This check confirms that the correct sign has been chosen for the 5-degree rotation.

---

*A droop rotation is about an axis parallel to a THETA = 90 degrees radial line It tends to lower the forward end of the object, where the STA-values are the lowest.

**The cylindrical-coordinate option declaration line has been removed from the surface-description. Procedure TRNSIL will not accept SIL option declarations. (See Section 3.1 3 1)

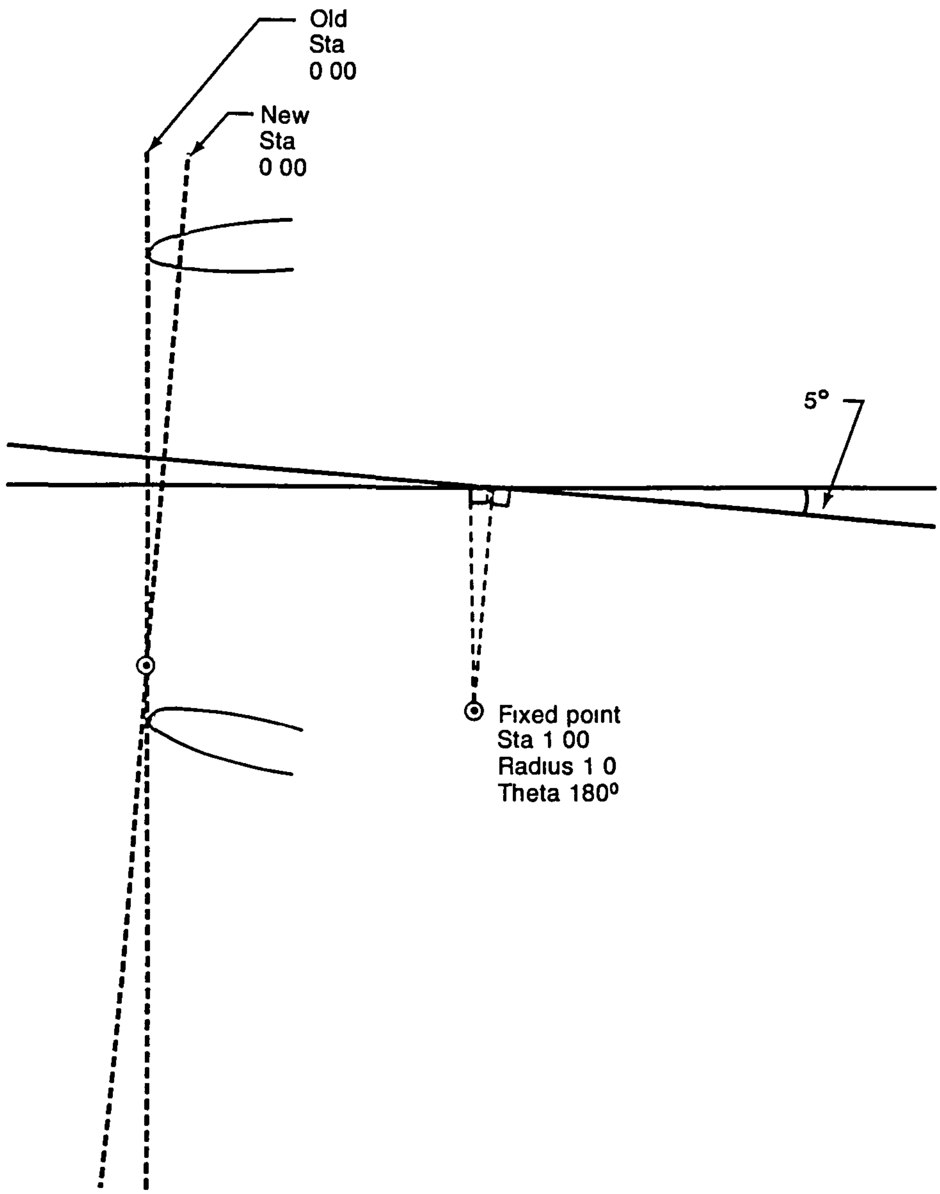


Figure 6-6 – Illustration of Coordinate Systems

```
C>GET,PROCFIL=<version>/UN=<account>.
C>BEGIN,GENTRN.
 17.00.28.            *** GENTRN ***
 17.00.28.       (GENERATE TRANSFORMATION)
 17.00.32.     *** CREATING NEW TRN FILE ***
 17.00.35.        *** EXECUTING GENTRN ***
1
 ---------------------------------------------------------------------
 I                                                                   I
 I   SYSTEM:  MASTER                                                 I
 I            (MODELING OF AERODYNAMIC SURFACES                      I
 I             -          -            -                             I
 I             BY THREE-DIMENSIONAL EXPLICIT REPRESENTATION          I
 I                -                -        -                        I
 I                                                                   I
 I  PROGRAM:  GENTRN                                                 I
 I            GENERATION OF COORDINATE-TRANSFORMATION DATA           I
 I            ---                        -- -                        I
 I            INTERACTIVELY FROM USER INPUT                          I
 I                                                                   I
 I JOB NAME:  DRBA010 82/02/24.  17.00.37.                           I
 I  USER ID:                                                         I
 I                                                                   I
 ---------------------------------------------------------------------


 INPUT INITAL TRANSLATION:  3 DECIMALS
 OR <CR> TO STOP
I>* TRANSFORMATION-DESCRIPTION EXAMPLE
I>* DROOP TRANSFORMATION
I>-1. 0. 1.
 ELEMENTARY ROTATIONS ARE NOW REQUESTED:
 THE POSSIBLE ROTATION CODES ARE (INTEGER) 0, 1, 2 AND 3
 0 IS THE CODE TO STOP ROTATION INPUT
 1, 2 AND 3 ARE AXIS-IDENTIFIERS
 INPUT ROTATIONS IN THE ORDER OF THEIR APPLICATION.
 INPUT ROTATION CODE
I>2
 INPUT AMOUNT OF ROTATION, DEGREES (DECIMAL)
I>-5.
 INPUT ROTATION CODE
I>0
 INPUT FINAL TRANSLATION:  3 DECIMALS
I>1. 0. -1.
 INPUT INITAL TRANSLATION:  3 DECIMALS
 OR <CR> TO STOP
I>
 17.02.20.       *** ENDED  EXECUTION ***
 17.02.21.     *** LISTING  ON FILE OUT ***
 17.02.22.       *** GENTRN COMPLETED ***


C>SAVE,TRN.
```

Figure 6-7. – Terminal Session for Transformation Description

```
 1
* TRANSFORMATION-DESCRIPTION EXAMPLE:
* DROOP TRANSFORMATION
  -1.000000000000E+00     0.                          1.000000000000E+00
   9.961946980917E-01     0.                          8.715574274766E-02
   0.                     1.000000000000E+00          0.
  -8.715574274766E-02     0.                          9.961946980917E-01
   1.000000000000E+00     0.                         -1.000000000000E+00
```

Figure 6-8. – Transformation Description (TRN) File

```
C>GET,PROCFIL=<version>/UN=<account>.
C>GET,OLDSIL,TRN.
C>BEGIN,TRNSIL,,,,INTSIL1.      NEWSIL is renamed to INTSIL1
 17.06.39.           *** TRNSIL ***
 17.06.39.(TRANFORM COORDINATES IN SIL DATA)
 17.06.46.      *** EXECUTING TRNSIL ***
 ------------------------------------------------------------------
 I                                                                I
 I   SYSTEM:  MASTER                                              I
 I            (MODELING OF AERODYNAMIC SURFACES                   I
 I             -          -          -                            I
 I             BY THREE-DIMENSIONAL EXPLICIT REPRESENTATION       I
 I                -            -       -                          I
 I                                                                I
 I  PROGRAM:  TRNSIL:                                             I
 I            TRANSFORMATION OF SURFACE INPUT LANGUAGE DATA       I
 I            -- -           -      -     -                       I
      TIME.  82/02/24. 17.06.47.                                  I
 I                                                                I
 ------------------------------------------------------------------

 INPUT TRANSFORM ID CODE ( 0 FOR RECT. TO/FROM CYL.).
I>0
 INPUT 0 FOR RECTANGULAR-TO-CYLINDRICAL
       1 FOR CYLINDRICAL-TO-RECTANGULAR.
I>1
 PATCH TRANSFORMATION COMPLETE.
 17.07.26.      *** ENDED  EXECUTION ***
 17.07.27.   *** LISTING  ON FILE OUT ***
 17.07.27.      *** TRNSIL COMPLETED ***
C>BEGIN,TRNSIL,,,INTSIL1,INTSIL2.      OLDSIL & NEWSIL renamed to INTSIL 1 & 2
 17.08.44.           *** TRNSIL ***
 17.08.44.(TRANFORM COORDINATES IN SIL DATA)
 17.08.50.      *** EXECUTING TRNSIL ***
 ------------------------------------------------------------------
 I                                                                I
 I   SYSTEM:  MASTER                                              I
 I            (MODELING OF AERODYNAMIC SURFACES                   I
 I             -          -          -                            I
 I             BY THREE-DIMENSIONAL EXPLICIT REPRESENTATION       I
 I                -            -       -                          I
 I                                                                I
 I  PROGRAM:  TRNSIL:                                             I
 I            TRANSFORMATION OF SURFACE INPUT LANGUAGE DATA       I
 I            -- -           -      -     -                       I
      TIME.  82/02/24. 17.08.51.                                  I
 I                                                                I
 ------------------------------------------------------------------

 INPUT TRANSFORM ID CODE ( 0 FOR RECT. TO/FROM CYL.).
I>1
* TRANSFORMATION-DESCRIPTION EXAMPLE:
* DROOP TRANSFORMATION
 PATCH TRANSFORMATION COMPLETE.
 17.09.24.      *** ENDED  EXECUTION ***
 17.09.25.   *** LISTING  ON FILE OUT ***
 17.09.25.      *** TRNSIL COMPLETED ***
C>BEGIN,TRNSIL,,,INTSIL2.      OLDSIL is renamed to INTSIL2
 17.10.03.           *** TRNSIL ***
 17.10.03.(TRANFORM COORDINATES IN SIL DATA)
 17.10.09.      *** EXECUTING TRNSIL ***
 ------------------------------------------------------------------
 I                                                                I
 I   SYSTEM:  MASTER                                              I
 I            (MODELING OF AERODYNAMIC SURFACES                   I
 I             -          -          -                            I
 I             BY THREE-DIMENSIONAL EXPLICIT REPRESENTATION       I
 I                -            -       -                          I
 I                                                                I
 I  PROGRAM:  TRNSIL:                                             I
 I            TRANSFORMATION OF SURFACE INPUT LANGUAGE DATA       I
 I            -- -           -      -     -                       I
      TIME:  82/02/24. 17.10.10.                                  I
 I                                                                I
 ------------------------------------------------------------------

 INPUT TRANSFORM ID CODE ( 0 FOR RECT. TO/FROM CYL.).
I>0
 INPUT 0 FOR RECTANGULAR-TO-CYLINDRICAL
       1 FOR CYLINDRICAL-TO-RECTANGULAR.
I>0
 PATCH TRANSFORMATION COMPLETE.
 17.10.34.      *** ENDED  EXECUTION ***
 17.10.36.   *** LISTING  ON FILE OUT ***
 17.10.36.      *** TRNSIL COMPLETED ***

C>SAVE,NEWSIL.
```

Figure 6-9 – Terminal Session for Coordinate Transformation

```
* MASTER:  MODELING OF AERODYNAMIC SURFACES
*          BY THREE-DIMENSIONAL EXPLICIT REPRESENTATION
* SURFACE DESCRIPTION EXAMPLE
* PREPARED 29 JAN 1982.
* SIMPLIFIED INLET LIP
C
C     ****  SECTION INPUT  ****
C
   5   NUMBER OF SECTIONS
C
C     ****SECTION NUMBER  1 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000              1.00000   0.00000   0.00000
C     X            Y            Z        TENSION    KNOT
      .25000      0.00000      1.10000 0.             1      POINT  1
     0.00000      0.00000      1.00000 0.             2      POINT  2
      .25000      0.00000       .90000 0.             3      POINT  3
C
C     ****SECTION NUMBER  2 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000              1.00000   0.00000   0.00000
C     X            Y            Z        TENSION    KNOT
      .25000      1.10000      -.00000 0.             1      POINT  1
     0.00000      1.00000      -.00000 0.             2      POINT  2
      .25000       .90000      -.00000 0.             3      POINT  3
C
C     ****SECTION NUMBER  3 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000              1.00000   0.00000   0.00000
C     X            Y            Z        TENSION    KNOT
      .25000      -.00000     -1.10000 0.             1      POINT  1
     0.00000      -.00000     -1.00000 0.             2      POINT  2
      .25000      -.00000      -.90000 0.             3      POINT  3
C
C     ****SECTION NUMBER  4 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000              1.00000   0.00000   0.00000
C     X            Y            Z        TENSION    KNOT
      .25000     -1.10000       .00000 0.             1      POINT  1
     0.00000     -1.00000       .00000 0.             2      POINT  2
      .25000      -.90000       .00000 0.             3      POINT  3
```

Figure 6-10 – First Intermediate SIL File. INTSIL1

```
C
C     ****SECTION NUMBER  5 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    Ø NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000  0.00000  0.00000            1.00000  0.00000  0.00000
C     X            Y            Z       TENSION    KNOT
      .25000       .00000       1.10000 0.           1      POINT  1
     0.00000       .00000       1.00000 0.           2      POINT  2
      .25000       .00000        .90000 0.           3      POINT  3
C
C     ****  MEMBER INPUT  ****
C
   3   NUMBER OF MEMBERS
C
C     ****MEMBER NUMBER  1 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG    Ø NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER    SECTION NUMBER    TENSION      CORNER PT
          1                 1  Ø.                    1     POINT  1
          1                 2  Ø.                    2     POINT  2
          1                 3  Ø.                    3     POINT  3
          1                 4  Ø.                    4     POINT  4
          1                 5  Ø.                    5     POINT  5
C
C     ****MEMBER NUMBER  2 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG    Ø NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER    SECTION NUMBER    TENSION      CORNER PT
          2                 1  Ø.                    1     POINT  1
          2                 2  Ø.                    2     POINT  2
          2                 3  Ø.                    3     POINT  3
          2                 4  Ø.                    4     POINT  4
          2                 5  Ø.                    5     POINT  5
C
C     ****MEMBER NUMBER  3 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG    Ø NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER    SECTION NUMBER    TENSION      CORNER PT
          3                 1  Ø.                    1     POINT  1
          3                 2  Ø.                    2     POINT  2
          3                 3  Ø.                    3     POINT  3
          3                 4  Ø.                    4     POINT  4
          3                 5  Ø.                    5     POINT  5
C
C     ****  PATCH INPUT  ****
C
   2   NUMBER OF PATCHES
C  UØVØ      UØV1      U1VØ      U1V1     EACH PAIR: CORNER PT, MEMBER
   1   1     2   1     1   2     2   2                   PATCH  1
   1   2     2   2     1   3     2   3                   PATCH  2
```

Figure 6-10 – First Intermediate SIL File INTSIL1 (concluded)

```
* MASTER:  MODELING OF AERODYNAMIC SURFACES
*          BY THREE-DIMENSIONAL EXPLICIT REPRESENTATION
* SURFACE DESCRIPTION EXAMPLE
* PREPARED 29 JAN 1982.
* SIMPLIFIED INLET LIP
C
C     ****  SECTION INPUT  ****
C
   5   NUMBER OF SECTIONS
C
C     ****SECTION NUMBER  1 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -.99619   0.00000   -.08716                 .99619   0.00000    .08716
C     X              Y              Z          TENSION    KNOT
       .06983        0.00000        1.02664 0.              1       POINT  1
      -.17051        0.00000         .90523 0.              2       POINT  2
       .08726        0.00000         .82740 0.              3       POINT  3
C
C     ****SECTION NUMBER  2 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -.99619   0.00000   -.08716                 .99619   0.00000    .08716
C     X              Y              Z          TENSION    KNOT
       .16570        1.10000        -.06917 0.              1       POINT  1
      -.08335        1.00000        -.09096 0.              2       POINT  2
       .16570         .90000        -.06917 0.              3       POINT  3
C
C     ****SECTION NUMBER  3 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -.99619   0.00000   -.08716                 .99619   0.00000    .08716
C     X              Y              Z          TENSION    KNOT
       .26157        0.00000       -1.16499 0.              1       POINT  1
       .00381        0.00000       -1.08716 0.              2       POINT  2
       .24414        0.00000        -.96575 0.              3       POINT  3
C
C     ****SECTION NUMBER  4 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -.99619   0.00000   -.08716                 .99619   0.00000    .08716
C     X              Y              Z          TENSION    KNOT
       .16570       -1.10000        -.06917 0.              1       POINT  1
      -.08335       -1.00000        -.09096 0.              2       POINT  2
       .16570        -.90000        -.06917 0.              3       POINT  3
```

Figure 6-11. – Second Intermediate SIL File. INTSIL2

```
C
C     ****SECTION NUMBER  5 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -.99619   0.00000   -.08716                 .99619   0.00000    .08716
C     X            Y              Z          TENSION    KNOT
      .06983       0.00000        1.02664 0.             1      POINT  1
     -.17051       0.00000         .90523 0.             2      POINT  2
      .08726       0.00000         .82740 0.             3      POINT  3
C
C     ****  MEMBER INPUT  ****
C
   3   NUMBER OF MEMBERS
C
C     ****MEMBER NUMBER  1 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER    SECTION NUMBER    TENSION        CORNER PT
          1                    1  0.                 1     POINT  1
          1                    2  0.                 2     POINT  2
          1                    3  0.                 3     POINT  3
          1                    4  0.                 4     POINT  4
          1                    5  0.                 5     POINT  5
C
C     ****MEMBER NUMBER  2 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER    SECTION NUMBER    TENSION        CORNER PT
          2                    1  0.                 1     POINT  1
          2                    2  0.                 2     POINT  2
          2                    3  0.                 3     POINT  3
          2                    4  0.                 4     POINT  4
          2                    5  0.                 5     POINT  5
C
C     ****MEMBER NUMBER  3 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER    SECTION NUMBER    TENSION        CORNER PT
          3                    1  0.                 1     POINT  1
          3                    2  0.                 2     POINT  2
          3                    3  0.                 3     POINT  3
          3                    4  0.                 4     POINT  4
          3                    5  0.                 5     POINT  5
C
C     ****  PATCH INPUT  ****
C
   2   NUMBER OF PATCHES
C  U0V0       U0V1       U1V0       U1V1      EACH PAIR: CORNER PT, MEMBER
   1  1.      2  1       1  2       2  2                      PATCH  1
   1  2       2  2       1  3       2  3                      PATCH  2
```

Figure 6-11 – Second Intermediate SIL File: INTSIL2 (concluded)

```
* MASTER:  MODELING OF AERODYNAMIC SURFACES
*          BY THREE-DIMENSIONAL EXPLICIT REPRESENTATION
* SURFACE DESCRIPTION EXAMPLE
* PREPARED 29 JAN 1982.
* SIMPLIFIED INLET LIP
C
C     ****  SECTION INPUT  ****
C
   5   NUMBER OF SECTIONS
C
C     ****SECTION NUMBER  1 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -.99619    -.08716    0.00000               .99619    .08716    0.00000
C      X            Y             Z          TENSION     KNOT
       .06983      1.02664      0.00000 0.               1      POINT  1
      -.17051       .90523      0.00000 0.               2      POINT  2
       .08726       .82740      0.00000 0.               3      POINT  3
C
C     ****SECTION NUMBER  2 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -.99619    .00547    .08699                 .99619    -.00668    -.08690
C      X            Y             Z          TENSION     KNOT
       .16570      1.10217      93.59813 0.              1      POINT  1
      -.08335      1.00413      95.19732 0.              2      POINT  2
       .16570       .90265      94.39486 0.              3      POINT  3
C
C     ****SECTION NUMBER  3 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -.99619    .08716    -.00000                .99619    -.08716     .00000
C      X            Y             Z          TENSION     KNOT
       .26157      1.16499     180.00000 0.              1      POINT  1
       .00381      1.08716     180.00000 0.              2      POINT  2
       .24414       .96575     180.00000 0.              3      POINT  3
C
C     ****SECTION NUMBER  4 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -.99619    .00547    -.08699                .99619    -.00668     .08690
C      X            Y             Z          TENSION     KNOT
       .16570      1.10217     266.40187 0.              1      POINT  1
      -.08335      1.00413     264.80268 0.              2      POINT  2
       .16570       .90265     265.60514 0.              3      POINT  3
```

Figure 6-12. – Transformed Surface Description File

```
C
C     ****SECTION NUMBER  5 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -.99619   -.08716   0.00000             .99619    .08716   0.00000
C     X            Y            Z         TENSION    KNOT
      .06983       1.02664     360.00000 0.               1     POINT  1
     -.17051        .90523     360.00000 0.               2     POINT  2
      .08726        .82740     360.00000 0.               3     POINT  3
C
C     ****  MEMBER INPUT  ****
C
   3   NUMBER OF MEMBERS
C
C     ****MEMBER NUMBER  1 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER    SECTION NUMBER    TENSION       CORNER PT
           1                 1   0.                     1   POINT  1
           1                 2   0.                     2   POINT  2
           1                 3   0.                     3   POINT  3
           1                 4   0.                     4   POINT  4
           1                 5   0.                     5   POINT  5
C
C     ****MEMBER NUMBER  2 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER    SECTION NUMBER    TENSION       CORNER PT
           2                 1   0.                     1   POINT  1
           2                 2   0.                     2   POINT  2
           2                 3   0.                     3   POINT  3
           2                 4   0.                     4   POINT  4
           2                 5   0.                     5   POINT  5
C
C     ****MEMBER NUMBER  3 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER    SECTION NUMBER    TENSION       CORNER PT
           3                 1   0.                     1   POINT  1
           3                 2   0.                     2   POINT  2
           3                 3   0.                     3   POINT  3
           3                 4   0.                     4   POINT  4
           3                 5   0.                     5   POINT  5
C
C     ****  PATCH INPUT  ****
C
   2   NUMBER OF PATCHES
C  U0V0       U0V1       U1V0       U1V1     EACH PAIR:  CORNER PT, MEMBER
    1   1     2   1     1   2     2   2                     PATCH  1
    1   2     2   2     1   3     2   3                     PATCH  2
```

Figure 6-12. – Transformed Surface Description File (concluded)

6.3 SURFACE-MODELING EXAMPLE

This example illustrates the use of SILSRF to model surfaces. The axisymmetric inlet lip from Section 6.1 provides the input surface description, which is on file SIL. Figure 6-13 shows the terminal session illustrating this example. (For surface models of a practical size, SILSRF should be executed from a batch job.) Figure 6-14 shows the system comments added to SIL when it is rewritten by SILSRF. The resulting surface model is on file SRF. Files SIL and SRF are available on the MASTER system account.

6.4 MESH/SURFACE INTERSECTION EXAMPLE

This example illustrates the use of MSHNRM to compute mesh/surface intersections. The axisymmetric inlet lip from Sections 6.1 and 6.3 provides the input surface model. The mesh description is on file MSH, which is shown in Figure 6-15. The coordinate mesh is in cylindrical coordinates, with 3 mesh values each for STATION, RADIUS, and THETA. Figure 6-16 shows the terminal session illustrating this example. (For cases of practical size, MSHNRM should be executed from a batch job.) The MSHNRM printer listing is shown in Figure 6-17. The intersection-normal output is on file NRM, which is shown in Figure 6-18. Files MSH, SRF, and NRM are available on the MASTER system account.

The intersection normals are oriented into the fluid, as desired. This is dependent on a cross-product of section and member directions, which are defined during surface description. If the normals point into the body, they must be reversed by executing procedure NRMREV. Figure 6-19 shows a terminal session to reverse normals. The input reversed normals are on file OLDNRM, and the output corrected normals are on file NEWNRM.

6.5 3-D CFD INPUT PREPARATION EXAMPLE

This example illustrates the use of procedure NRMCFD to condition intersection normals and to format mesh and intersection data as 3-D CFD input The input mesh and the output intersection normals from Section 6.4 provide the geometry inputs. The mesh is on file MSH, which is shown in Figure 6-15. The intersections are on file NRM, which is shown in Figure 6-18. The CFD header data, which is placed before the geometry data, is represented here by the contents of file OLDCFD,* which is shown in Figure 6-20.

Figure 6-21 shows a terminal session illustrating NRMCFD execution. (For cases of practical size, NRMCFD should be executed from a batch job.) The assembled and conditioned data is output on file NEWCFD, which is shown in Figure 6-22. Files OLDCFD, MSH, NRM, and NEWCFD are available on the MASTER system account.

---

*File OLDCFD is a typical input header to the analysis program in Reference 1. Consult the reference for details of the header format.

```
C>GET,SIL.
C>GET,PROCFIL=<version>/UN=<account>.
C>BEGIN,SILSRF.
 17.12.33.          *** SILSRF ***
 17.12.33.         (SURFACE MODELING)
 17.12.38.      *** EXECUTING SILSRF ***
 17.12.50.      *** ENDED  EXECUTION ***
 17.12.51.    *** LISTING  ON FILE OUT ***
 17.12.51.      *** SILSRF COMPLETED ***
C>REPLACE,SIL.
C>SAVE,SRF.
```

Figure 6-13. – Terminal Session for Surface Modeling

```
 CYLINDRICAL COORDINATES
C
C ----------------------------------------------------------------------
C
* MASTER:  MODELING OF AERODYNAMIC SURFACES
*          BY THREE-DIMENSIONAL EXPLICIT REPRESENTATION
* SURFACE DESCRIPTION EXAMPLE
* PREPARED 29 JAN 1982.
* SIMPLIFIED INLET LIP
C      **** BLOCK NUMBER  1 ****
C
C      ****  SECTION INPUT  ****
C
   5   NUMBER OF SECTIONS
C
C      ****SECTION NUMBER  1 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000             1.00000   0.00000   0.00000
C        STA        RADIUS         THETA  TENSION    KNOT
       .25000       1.10000       0.00000 0.           1      POINT  1
      0.00000       1.00000       0.00000 0.           2      POINT  2
       .25000        .90000       0.00000 0.           3      POINT  3
C
C      ****SECTION NUMBER  2 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000             1.00000   0.00000   0.00000
C        STA        RADIUS         THETA  TENSION    KNOT
       .25000       1.10000      90.00000 0.           1      POINT  1
      0.00000       1.00000      90.00000 0.           2      POINT  2
       .25000        .90000      90.00000 0.           3      POINT  3
C
C      ****SECTION NUMBER  3 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000             1.00000   0.00000   0.00000
C        STA        RADIUS         THETA  TENSION    KNOT
       .25000       1.10000     180.00000 0.           1      POINT  1
      0.00000       1.00000     180.00000 0.           2      POINT  2
       .25000        .90000     180.00000 0.           3      POINT  3
C
C      ****SECTION NUMBER  4 ****
C
   3   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT, 2 NAT,SLP  3 2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000             1.00000   0.00000   0.00000
C        STA        RADIUS         THETA  TENSION    KNOT
       .25000       1.10000     270.00000 0.           1      POINT  1
      0.00000       1.00000     270.00000 0.           2      POINT  2
       .25000        .90000     270.00000 0.           3      POINT  3
```

Figure 6-14. – Rewritten SIL File

```
C
C     ****  MEMBER INPUT  ****
C
   3   NUMBER OF MEMBERS
C
C     ****MEMBER NUMBER  1 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG    Ø NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER    SECTION NUMBER    TENSION      CORNER PT
           1                1  Ø.                      1     POINT  1
           1                2  Ø.                      2     POINT  2
           1                3  Ø.                      3     POINT  3
           1                4  Ø.                      4     POINT  4
           1                5  Ø.                      5     POINT  5
C
C     ****MEMBER NUMBER  2 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG    Ø NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER    SECTION NUMBER    TENSION      CORNER PT
           2                1  Ø.                      1     POINT  1
           2                2  Ø.                      2     POINT  2
           2                3  Ø.                      3     POINT  3
           2                4  Ø.                      4     POINT  4
           2                5  Ø.                      5     POINT  5
C
C     ****MEMBER NUMBER  3 ****
C
   5   NUMBER OF POINTS IN MEMBER
   4   END FLAG    Ø NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER    SECTION NUMBER    TENSION      CORNER PT
           3                1  Ø.                      1     POINT  1
           3                2  Ø.                      2     POINT  2
           3                3  Ø.                      3     POINT  3
           3                4  Ø.                      4     POINT  4
           3                5  Ø.                      5     POINT  5
C
C     ****  PATCH INPUT  ****
C
   2   NUMBER OF PATCHES
C  UØVØ      UØV1      U1VØ      U1V1     EACH PAIR:  CORNER PT, MEMBER
   1  1      2  1      1  2      2  2                      PATCH  1
   1  2      2  2      1  3      2  3                      PATCH  2
C
C -----------------------------------------------------------------
C
```

Figure 6-14 – Rewritten SIL File (concluded)

```
 CYLINDRICAL
* MESH DESCRIPTION FOR MSHNRM EXAMPLE
3
.01 .1 .2
3
0. 1. 2.
3
0. 90. 180.
```

Figure 6-15 – Mesh Description (MSH) File

```
C>GET,MSH,SRF.
C>GET,PROCFIL=<version>/UN=<account>.
C>BEGIN,MSHNRM.
 11.16.54.          *** MSHNRM ***
 11.16.54.    ( MESH/SURFACE INTERSECTION )
 11.17.02.      *** EXECUTING MSHNRM ***
 11.17.08.      *** ENDED  EXECUTION ***
 11.17.09.    *** LISTING  ON FILE OUT ***
 11.17.10.      *** MSHNRM COMPLETED ***
C>SAVE,NRM.
```

Figure 6-16. – Terminal Session for Mesh/Surface Intersection

```
-----------------------------------------------------------------
I                                                               I
I   SYSTEM:  MASTER                                             I
I            (MODELING OF AERODYNAMIC SURFACES                  I
I             -           -           -                         I
I             BY THREE-DIMENSIONAL EXPLICIT REPRESESNTATION     I
I                -           -         -                        I
I                                                               I
I  PROGRAM:  MSHNRM                                             I
I            COORDINATE MESH / SURFACE MODEL INTERSECTION       I
I                       - --                                    I
I            GIVING POINTS WITH NORMALS                         I
I                              - --                             I
I                                                               I
I    TIME:   82/04/16. 15.35.08.                                I
I                                                               I
-----------------------------------------------------------------


 MESH DESCRIPTION FOR MSHNRM EXAMPLE

 CYLINDRICAL SURFACE COORDINATES.
SURFACE LABELS:  STA RADIUS THETA


 CYLINDRICAL MESH COORDINATES.
   MESH LABELS:  STA RADIUS THETA


 INPUT MESH DATA:
  MESH DESCRIPTION FOR MSHNRM EXAMPLE

 STA-MESH HAS   3 VALUES:
     1        1.0000000E-02
     2        1.0000000E-01
     3        2.0000000E-01

 RADIUS-MESH HAS   3 VALUES:
     1        0.
     2        1.0000000E+00
     3        2.0000000E+00

 THETA-MESH HAS   3 VALUES:
     1        0.
     2        9.0000000E+01
     3        1.8000000E+02
```

Figure 6-17 - Procedure MSHNRM Printer Listing

```
INTERSECTING THE SURFACE AT CONSTANT STA VALUES:


INTERSECTION AT STA =        .0100:
  2 CURVE SEGMENTS, NUMBERED   1 TO   2.
*                   P O S I T I O N                       *            N O R M A L          *   I N D E X   *
*         STA                RADIUS            THETA       *STA         RADIUS     THETA     * PAT  CUR  NRM *
            .0100                .9777          0.0000   -.752310   -.658810  0.000000     1    1    1
            .0100               1.0223          0.0000   -.752310    .658810  0.000000     2    2    2
            .0100                .9777         90.0000   -.752310   -.658810  0.000000     1    1    3
            .0100               1.0223         90.0000   -.752310    .658810  0.000000     2    2    4

INTERSECTION AT STA =        .1000:
  2 CURVE SEGMENTS, NUMBERED   3 TO   4.
*                   P O S I T I O N                       *            N O R M A L          *   I N D E X   *
*         STA                RADIUS            THETA       *STA         RADIUS     THETA     * PAT  CUR  NRM *
            .1000                .9282          0.0000   -.325220   -.945638  0.000000     1    3    5
            .1000               1.0718          0.0000   -.325220    .945638  0.000000     2    4    6
            .1000                .9282         90.0000   -.325220   -.945638  0.000000     1    3    7
            .1000               1.0718         90.0000   -.325220    .945638  0.000000     2    4    8

INTERSECTION AT STA =        .2000:
  2 CURVE SEGMENTS, NUMBERED   5 TO   6.
*                   P O S I T I O N                       *            N O R M A L          *   I N D E X   *
*         STA                RADIUS            THETA       *STA         RADIUS     THETA     * PAT  CUR  NRM *
            .2000                .9040          0.0000   -.142179   -.989841  0.000000     1    5    9
            .2000               1.0960          0.0000   -.142179    .989841  0.000000     2    6   10
            .2000                .9040         90.0000   -.142179   -.989841  0.000000     1    5   11
            .2000               1.0960         90.0000   -.142179    .989841  0.000000     2    6   12

INTERSECTION AT CONSTANT STA VALUES:
   6 CURVE SEGMENTS, NUMBERED    1 TO    6
AND   12 NORMAL VECTORS, NUMBERED    1 TO   12.

INTERSECTING THE SURFACE AT CONSTANT THETA VALUES:


INTERSECTION AT THETA =      0.0000:
  2 CURVE SEGMENTS, NUMBERED   7 TO   8.
*                   P O S I T I O N                       *            N O R M A L          *   I N D E X   *
*         STA                RADIUS            THETA       *STA         RADIUS     THETA     * PAT  CUR  NRM *
           0.0000               1.0000          0.0000  -1.000000   -.000000  0.000000     1    7   13
           0.0000               1.0000          0.0000  -1.000000   0.000000  0.000000     2    8   14

INTERSECTION AT THETA =     90.0000:
  2 CURVE SEGMENTS, NUMBERED   9 TO  10.
*                   P O S I T I O N                       *            N O R M A L          *   I N D E X   *
*         STA                RADIUS            THETA       *STA         RADIUS     THETA     * PAT  CUR  NRM *
           0.0000               1.0000         90.0000  -1.000000   -.000000  0.000000     1    9   15
           0.0000               1.0000         90.0000  -1.000000   0.000000  0.000000     2   10   16

INTERSECTION AT THETA =    180.0000:
NO INTERSECTION FOUND.

INTERSECTION AT CONSTANT THETA VALUES:
   4 CURVE SEGMENTS, NUMBERED    7 TO   10
AND    4 NORMAL VECTORS, NUMBERED   13 TO   16.



10 CURVE SEGMENTS ON INTERSECTION FILE
16 NORMAL VECTORS    ON NORMAL        FILE
```

Figure 6-17. – Procedure MSHNRM Printer Listing (concluded)

1.0000000E-02	9.7770985E-01	0.	-.752310	-.658810	0.000000
1.0000000E-02	1.0222901E+00	0.	-.752310	.658810	0.000000
1.0000000E-02	9.7770985E-01	9.0000000E+01	-.752310	-.658810	0.000000
1.0000000E-02	1.0222901E+00	9.0000000E+01	-.752310	.658810	0.000000
1.0000000E-01	9.2817545E-01	0.	-.325220	-.945638	0.000000
1.0000000E-01	1.0718245E+00	0.	-.325220	.945638	0.000000
1.0000000E-01	9.2817545E-01	8.9999997E+01	-.325220	-.945638	0.000000
1.0000000E-01	1.0718245E+00	9.0000000E+01	-.325220	.945638	0.000000
2.0000000E-01	9.0397900E-01	0.	-.142179	-.989841	0.000000
2.0000000E-01	1.0960210E+00	0.	-.142179	.989841	0.000000
2.0000000E-01	9.0397900E-01	8.9999997E+01	-.142179	-.989841	0.000000
2.0000000E-01	1.0960210E+00	9.0000000E+01	-.142179	.989841	0.000000
0.	1.0000000E+00	0.	-1.000000	-.000000	0.000000
0.	1.0000000E+00	0.	-1.000000	0.000000	0.000000
0.	1.0000000E+00	9.0000000E+01	-1.000000	-.000000	0.000000
0.	1.0000000E+00	9.0000000E+01	-1.000000	0.000000	0.000000

Figure 6-18. - Mesh/Surface Intersection Normal (NRM) File

```
C>GET,OLDNRM.
C>GET,PROCFIL=<version>/UN=<account>.
C>BEGIN,NRMREV.
 11.23.23.           *** NRMREV ***
 11.23.23.         (NORMAL  REVERSAL)
 11.23.30.      *** EXECUTING NRMREV ***
 11.23.33.      *** ENDED  EXECUTION ***
 11.23.34.    *** LISTING  ON FILE OUT ***
 11.23.36       *** NRMREV COMPLETED ***
C>SAVE,NEWNRM.
```

Figure 6-19 – Terminal Session for Normal Reversal

```
P465 TYPICAL HEADER DATA   1982 MARCH 3    16 THETA PLANES
175 KNOTS   MCF=0.64   ALPHA=25.0 DEGREES
FREESTREAM
1.0         0.265      25.0       0.0
SWEEPS
800.0       100.0      50.0
1.          11.         1.
THETA LEV
16.0        16.0       116.0
SFLOW
1.0         1.0        1.0
IPRI
COMPRESSOR0.64
SCDIF       1.0
```

Figure 6-20 – Input CFD-Header File: OLDCFD

```
C>GET,OLDCFD,MSH,NRM.
C>GET,PROCFIL=<version>/UN=<account>.
C>BEGIN,NRMCFD.
 11.35.38.          *** NRMCFD ***
 11.35.38.        (PREPARE  CFD INPUT)
 11.35.46.      *** EXECUTING NRMCFD ***
 11.35.49.      *** ENDED  EXECUTION ***
 11.35.50.    *** LISTING  ON FILE OUT ***
 11.35.50.      *** NRMCFD COMPLETED ***
C>SAVE,NEWCFD.
```

Figure 6-21 – Terminal Session for CFD Input Formatting

```
P465 TYPICAL HEADER DATA   1982 MARCH 3    16 THETA PLANES
175 KNOTS   MCF=0.64   ALPHA=25.0 DEGREES
FREESTREAM
1.0        0.265      25.0       0.0
SWEEPS
800.0      100.0      50.0
1.         11.         1.
THETA LEV
16.0       16.0       116.0
SFLOW
1.0        1.0        1.0
IPRI
COMPRESSOR0.64
SCDIF      1.0
XMESH               3.
     .0100      .1000      .2000
RMESH               3.
   0.0000    1.0000     2.0000
TMESH               3.
   0.0000   90.0000   180.0000
GEOMETRY           14.
   0.0000    1.0000     0.0000 -1.000000   0.000000   0.000000
   0.0000    1.0000    90.0000 -1.000000   0.000000   0.000000
    .1000     .9282     0.0000  -.325220   -.945638   0.000000
    .1000    1.0718     0.0000  -.325220    .945638   0.000000
    .1000    1.0718    45.0000  -.325220    .945638   0.000000
    .1000     .9282    45.0000  -.325220   -.945638   0.000000
    .1000     .9282    90.0000  -.325220   -.945638   0.000000
    .1000    1.0718    90.0000  -.325220    .945638   0.000000
    .2000     .9040     0.0000  -.142179   -.989841   0.000000
    .2000    1.0960     0.0000  -.142179    .989841   0.000000
    .2000    1.0960    45.0000  -.142179    .989841   0.000000
    .2000     .9040    45.0000  -.142179   -.989841   0.000000
    .2000     .9040    90.0000  -.142179   -.989841   0.000000
    .2000    1.0960    90.0000  -.142179    .989841   0.000000
```

Figure 6-22. – Generated File for CFD-Analysis Input: NEWCFD

7.0 ADDITIONAL FEATURES

In addition to the basic procedures described in Section 5, MASTER has the following additional procedures:

1. Procedure REGSIL, which regulates the spacing of points on curves in SIL input
2. Procedure SRFINT, which computes the intersection of a pair of surface models.

7.1 INTRODUCTION

This section presents the additional MASTER procedures. It is organized similarly to Sections 1, 2, 3, 5, and 6: the capabilities and methods are described in Section 7.2, Section 7 3 introduces the data formats, which differ only slightly from those given in Section 3; Section 7.4 shows how to operate the additional procedures; and Section 7.5 gives examples of additional procedure execution.

These procedures are likely to be changed as experience with their usage grows. The user is recommended to contact MASTER consultation before using them.

7.2 APPLICATION

This section lists the additional capabilities of MASTER and describes how to use them. The user can regulate the spacing of points on section curves in SIL input. The intersection of two surface models can be determined.

7.2.1 SPACING REGULATION

The preparation of surface descriptions in SIL format is the most time-consuming activity for typical MASTER usage. The user must plan explicitly where each patch corner will be located This requires the input points on adjacent sections to line up somewhat evenly, to define members. For surfaces defined by a mathematical formula, the surface description can be generated by a simple user-written program which uses this formula. However, a surface extracted from another surface-modeling system typically is given as a set of cross-section curves without correspondence between points on adjacent curves These externally extracted curves often contain many more points than should be used as patch corners.

REGSIL, the spacing-regulation procedure for SIL section curves, will read curves in a simplified format, a subset of the the section-specification format used within a SIL block It can compute new points along these curves which line up between the curves, with the least number of points needed to preserve a user-specified accuracy These points are adaptively spaced. The computed curves are used to output a complete SIL block in the proper format. The user can input end conditions, or REGSIL can estimate the end direction

This automatic spacing determination is very expensive to compute, expecially when it is determined from a set of many curves There is an option for the user to avoid this cost by specifying the spacing as relative divisions of the curve parameter (approximately proportional to arclength) starting at 0.0 and ending at 1 0 The user can reduce overall costs by determining an optimal spacing for the most critical single curve and then entering this spacing to a second REGSIL execution, which creates a SIL block with revised spacing

7.2.2 SURFACE/SURFACE INTERSECTION

In multiple-component configurations (e.g., a nacelle/pylon/wing combination) surfaces are initally defined beyond their actual extent and later trimmed by their intersections with other surfaces. Such configurations are represented in MASTER by this process:

1. The surfaces are initally modeled extending past where they meet each other.
2. Their intersection curve is computed.
3. This curve is added to the SIL files for each surface.*
4. The patch specifications on the other side of the intersection are removed from each SIL file.
5. Trimmed surfaces are modeled, from the new SIL files.

The intersection curve is computed by procedure SRFINT, which computes section-format curves along the intersections of a pair of surface models. These curves should be processed by procedure REGSIL for spacing regulation.

7.3 MODIFIED DATA FORMATS

REGSIL and SRFINT, the additional procedures, use some modifications of the SIL data format defined in Section 3 The intersection curves from procedure SRFINT are written like a section-specification set for a SIL block** The input curves for REGSIL are read in a simplified format which is compatible with the section-specification set of a SIL block. The SIL output from REGSIL makes some simple assumptions to produce member and patch specifications matching the output section specifications. (See Section 4.1.2.1.)

Some irregularities can appear in the SRFINT output curves. The points in a curve can appear out of order. Also, a connected intersection can appear broken into more than one curve These difficulties are found only occasionally, and they are corrected by manually editing the output curves.

7.3.1 SRFINT INTERSECTION-CURVE OUTPUT

The surface intersection curves from procedure SRFINT are intended to be added to SIL files. They are each output in the form of SIL section-curve specifications, with comments to label them. The set of intersection curves is preceded by the number of curves, to take the form of a section-set specification. However these curves are not related to each other like a set of sections are; they should be used one at a time

Output curves contain many points, close to each other. There are more points than patch corners. The user should reduce the number of points, by procedure REGSIL or some other method.

*There is no clear method to perform this. (An intersection curve typically crosses both sections and members in the untrimmed surface description. When such a curve cuts across the corner of a 4-sided patch, it divides it into a 3-sided piece and a 5-sided one. Either of these pieces must be expressed differently, as one or more 4-sided patches.) For assistance, contact MASTER consultation.

**These curves should be used independently of each other, although they are output as a set.

7.3.2 REGSIL INPUT CURVES

The input for REGSIL is an ordered set of curves, like sections. The curves are basically formatted like SIL section specifications, but the points need not have tension values and knot flags. Option declarations can come before the curves, as in SIL data.

The minimum required input is the number of curves, followed by the curves. Each curve must contain the number of points, an SIL end-condition specification, followed by the points. Each point can be input as just a location, expressed as 3 decimal values on a single data line. The tension values and knot flags are not needed

7.3.3 REGSIL SURFACE-DESCRIPTION OUTPUT

The output of procedure REGSIL is a single block of SIL format data. Any option conditions from the input will be copied before the block. The SIL block contains the same number of sections as were input. The sections have the same end conditions as were input. The section points are located at different places, but they define a curve with the same shape (within a tolerance) as was input. There are fewer section points output than are input. Each section contains the same number of points, and they are all knots. The knot spacing is similar on each section, an adaptive spacing.

The SIL output block is completed with a member-specification set and a patch-specification set. The members connect corresponding knots on each section. If rectangular coordinates are used, the member end conditions are of the unknown type. If cylindrical coordinates are declared, the member end conditions are of the periodic type. In many cases the user will need to determine an appropriate member end condition manually. The patches are specified in a regular pattern of rows, bounded by the members.

7.4 ADDITIONAL PROCEDURE OPERATION

The additional procedures are implemented in the same way as the procedures in Section 5. They are accessed from the same procedure files and according to the same rules, from Section 5.1.

The user should contact MASTER consultation before using these procedures. They could be changed, as further experience using them is accumulated.

7.4.1 REGSIL — PROCEDURE TO REGULATE THE POINT SPACING ALONG INPUT CURVES

REGSIL regulates the point spacing within input curves. It reads a simplified SIL section specification set. It writes a complete SIL file.

7.4.1.1 Purpose

REGSIL is used to automatically regulate the spacing of points on input curves.

There is an option to use a user-specified relative spacing. This avoids the great cost of automatically determining the spacing within REGSIL.

7.4.1.2 Limitations

REGSIL can handle input sets of up to 17 curves. The input curves can each have up to 175 points. The number of points on each output curve is limited to at most 52.

REGSIL is expensive to execute, if the point spacing is not specified in the user input The procedure will only execute in a batch job. REGSIL requires a field length of 160000 (octal) to execute.

REGSIL regulates the spacing of points along input sections, but not along input members. For this reason, the profile with the largest variation of curvature should be selected for representation as sections.

REGSIL assumes that the input curves have similar lengths and shapes. Using this assumption, it attempts to locate corresponding knots at similar places on each section. The output knots on each section have the same relative spacing with respect to arclength along the curves.

7.4.1.3 Access

BEGIN,REGSIL,PROCFIL,OPTION,OLDSIL,NEWSIL.

7.4.1.4 File Relationships

See Figure 7-1 for a diagram of REGSIL file relationships.

REGSIL reads program control selections from file OPTION.

REGSIL reads input curves from file OLDSIL.

REGSIL writes SIL output to file NEWSIL.

REGSIL writes listing information to the listing file, OUTPUT.

BEGIN,REGSIL,MASTER,OPTION,OLDSIL,NEWSIL.

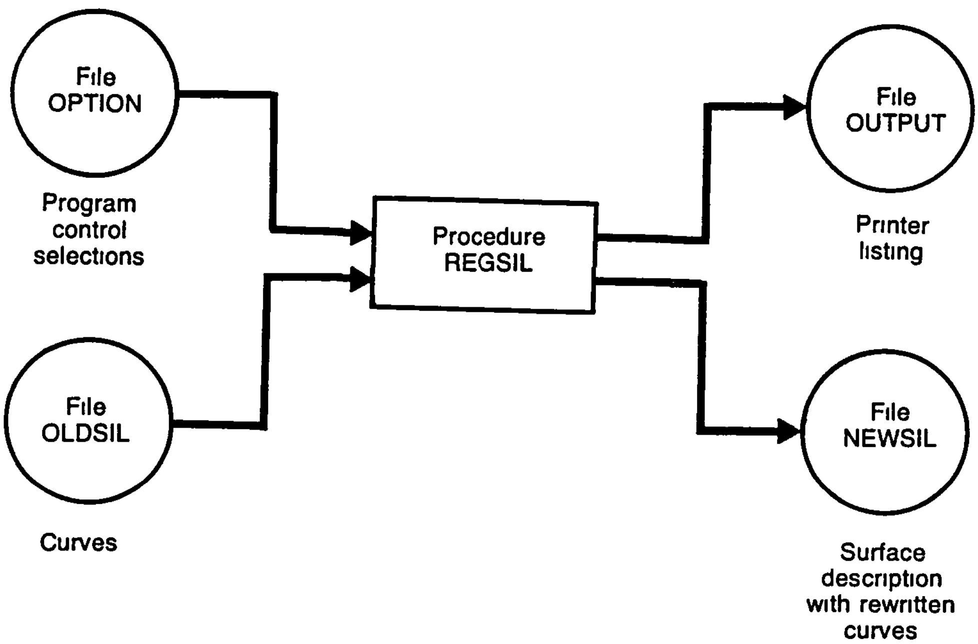


Figure 7-1. – Procedure REGSIL File Relationships

7.4.1.5 Input Data

The curves are input on file OLDSIL, in the format described in Section 7.3.2.

The user must select an option, either automatic determination of the optimal relative spacing or user input of a previously-determined relative spacing. This option selection and other controlling input is read from file OPTION. All data values on OPTION are read free field. The first line selects the option: enter "0" for automatic spacing determination, and enter "1" to read the spacing.

For the automatic-spacing option, two more data lines follow. The second data line contains a tolerance value. (This should be at least .01) The tighter the tolerance, the more closely the output curves follow the input curves (which forces REGSIL to use more knots). Execution costs increase sharply as the tolerance is tightened. The third line contains the minimum number of knots to attempt to place to satisfy the tolerance. (This should be at least 2 and at most 10.) REGSIL will output at least this number of knots on each curve. The number of knots per curve will be greater than this if the tolerance cannot be satisfied with the minumum number, optimally placed. By not attempting to fit the curve within the tolerance with fewer points than are known to be required, the costs of the unsuccessful attempts at knot placement are avoided.

For the input-spacing option, the remaining data on file OPTION contains the relative locations of the interior knots. The number of data values following the option-selection line determines the number of interior knots used. (Two more knots are used at the ends of the curves.) From 1 to 50 interior-knot locations can be input. The locations are input as parameter values on the curve (See Section 4.1.3 1.) They are decimal values strictly between 0 and 1. (The start of the curve corresponds to 0, while the end corresponds to 1.) Points are located on each output curve at distances (along the curve, from the initial end) equal to the input values times the total length of the curve.

7.4.1.6 Output Data

File NEWSIL contains the SIL output. The data format is described in Section 7 3.3 The output is a complete SIL block, but the user may need to correct the member end conditions manually.

7.4.1.7 Error Conditions

Error conditions cause a message to be written on the listing file. Severe errors cause the procedure to be aborted.

7.4.1.8 Practical Suggestions

Contact MASTER consultation for assistance before using procedure REGSIL. Effective operation requires experienced advice, as well as these instructions. This program also will be improved later, so the operation instructions are subject to changes.

Reduce costs by using only the most critical curve (or handful of curves) to automatically determine an arclength spacing. Use a second REGSIL execution to rewrite the complete set of curves, entering the spacing on file OPTION.

Check the results carefully for reasonableness and accuracy.

Check the member end conditions. If they are not appropriate, replace them.

Section 7.5.1 shows an example of REGSIL execution.

7.4.2 SRFINT - PROCEDURE FOR SURFACE/SURFACE INTERSECTION

Procedure SRFINT computes the intersection of two surface models. It reads two SRF data files and writes a file of SIL section specifications.

7.4.2.1 Purpose

SRFINT is used to generate a section describing the curve of intersection of two surface models, for use in trimming the models at their mutual intersection.

7.4.2.2 Limitations

A single patch from one surface can intersect a single patch from the other surface at up to 12 intersection branches.* There can be a total of up to 200 intersection branches.

Each intersection branch can contain up to 100 points. (This is controlled by the input tolerances.)

SRFINT should be executed from a batch job. It requires a field length of 160000 (octal).

SRFINT is sensitive to the choice of input tolerance values. This can affect the recognition of valid intersections, the generation of spurious intersections, the cost of execution, and the proper connection of the pieces of an intersection curve.

7.4.2.3 Access

BEGIN,SRFINT,PROCFIL,SRF1,SRF2,SEC,OPTION,OUT.

7.4.2.4 File Relationships

See Figure 7-2 for a diagram of SRFINT file relationships.

SRFINT reads the two surface models from files SRF1 and SRF2. The computed intersection curve will be exactly on SRF1, and it will be almost exactly on SRF2.**

SRFINT reads tolerance values from file OPTION, if there is data there.

SRFINT writes the intersection curves to file SEC.

SRFINT write listing information to the listing file, OUTPUT.

---

*An intersection branch is a connected segment of an intersection curve which is contained within a single patch of each surface. The output curves are formed in two steps: computation of intersection branches and joining them together.

**The patches of SRF2 which possibly intersect a patch of SRF1 are recursively divided, until the SRF2 subpatches are within a flatness tolerance of being planar. The intersections of these planar regions with the SRF1 patch are computed. Thus the intersection is computed to be exactly on SRF1 but only approximately on SRF2.

BEGIN,SRFINT,MASTER,SRF1,SRF2,SEC,OPTION,OUT

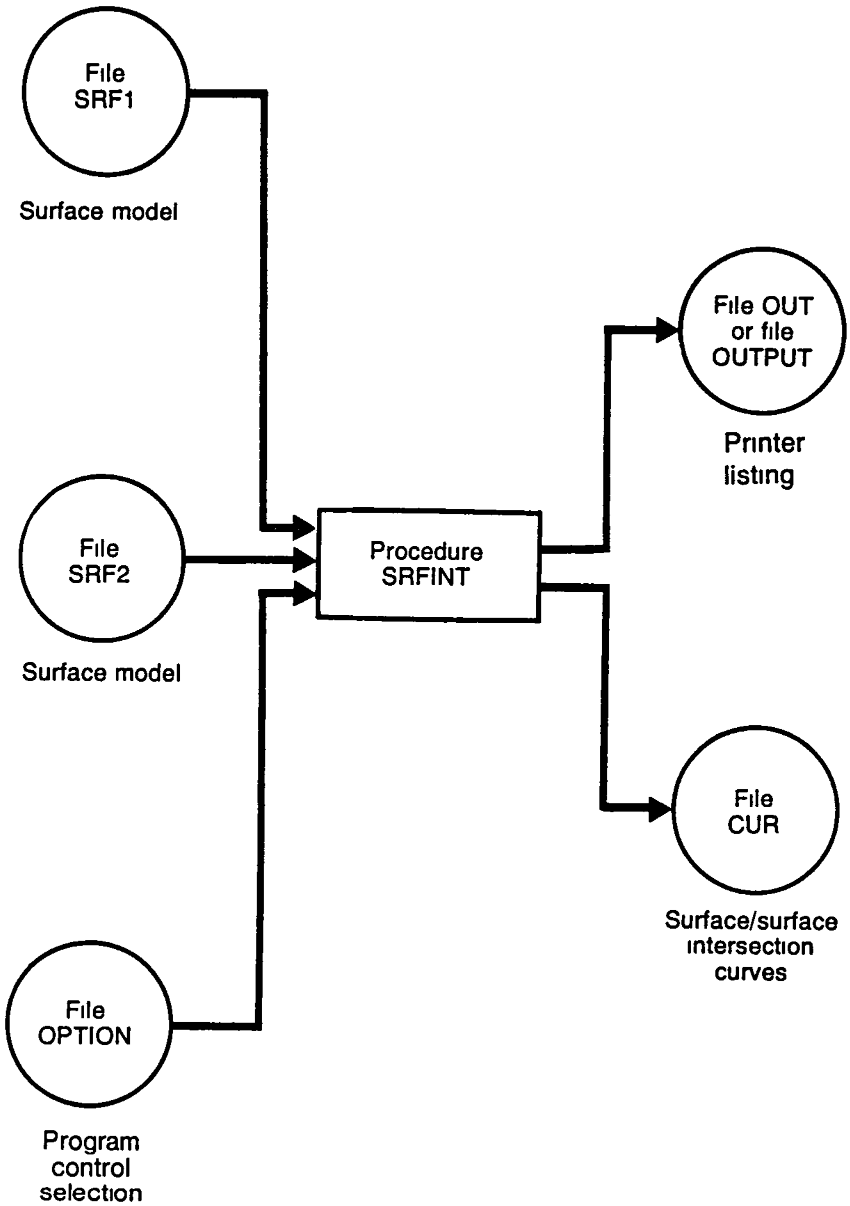


Figure 7-2. – Procedure SRFINT File Relationships

7.4.2.5 Input Data

Files SRF1 and SRF2 are in SRF format, as output from procedure SILSRF.

If file OPTION is empty, the tolerances are set to their default values; otherwise they are read from OPTION. Tolerance input consists of two data lines, each of which contains 3 decimal values. The second line contains the tolerances used when computing the intersections. The tolerances in the first line are used to connect the various branches into curves.

Three intersection tolerances are needed. They are input in this order: gluing, flatness, and planar-intersector. The gluing tolerance affects the number of branches found. Tightening this tolerance will result in more and shorter branches containing the same points. The default gluing tolerance is $10.^{-2}$ The flatness tolerance affects curve length, the total number of points, and the closeness of the computed intersection to the second surface; as the flatness tolerance is tightened, more data is generated and the accuracy is improved, but the execution cost increases sharply. The default flatness tolerance is $10.^{-3}$. The planar-intersector tolerance affects the total number of points computed and the accuracy of the intersection (provided the flatness tolerance is sufficiently tight); as this tolerance is tightened, the density of points increases on the intersections. The default planar-intersector tolerance value is $10.^{-5}$.

The 3 branch-connection tolerances correspond to the spatial coordinates. A pair of branches can be connected to each other if their ends have not yet been connected elsewhere, and if the absolute difference between each of the components of their end locations is within the corresponding tolerance. The default value for each of these tolerances is 1.

7.4.2.6 Output Data

File SEC is in the SIL section format, as described in Section 7.3.1.

The listing file starts with the tolerance values used, followed by any diagnostic messages from the computation of the intersection branches Next comes a table of the intersection branches. This table shows for each branch. the locations of the ends, the number of points, and the connections recognized to other branches. Finally the output curves appear, as on file SEC.

7.4.2.7 Error Conditions

Error conditions cause a message to be written on the listing file If possible, execution will continue.

Some conditions are noted as possible errors. They indicate that some intersections may be inaccurate or missing. The user should check the results near the named location.

7.4.2.8 Practical Suggestions

Contact MASTER consultation before using SRFINT to model intersecting surfaces. Effective operation requires experienced advice, as well as these instructions. This program also might be improved later, so the operating instructions are subject to changes.

Test cases should be run with the flatness (second) tolerance loosened to about 10^{-2} and the planar-intersector (third) tolerance loosened to about 10^{-3}. The gluing (first) tolerance should be looser than the flatness tolerance, and the flatness tolerance should be looser than the planar-intersector tolerance.

Avoid too tight a flatness tolerance, which sharply increases execution costs. (Do not input a tighter value than 10^{-3}, the default) Recommended tolerance values are each about 1% of the range in the corresponding coordinate (over the expected intersection curve, or else over the input surface models). The connecting-tolerance values do not affect the points computed, but only the degree that they are connected together. The user must edit the intersection curve output later, to make those connections which are apparent to the user but exceed these tolerances. The 3 branch-joining tolerances can be adjusted, as desired. However, if just a few branch junctions were missed, join them by editing the output.

Scan the listing file to check for error messages

Costs are somewhat reduced by making a pair of reduced SRF files for each SRFINT execution. Take a temporary copy of the associated surface descriptions and remove the patch specifications for any patches which are known to miss the other surface. (Do not change the sections or members. Remember to change the count of patch specifications.) Use SILSRF with the reduced surface descriptions to make the reduced SRF files.

Section 7.5.2 shows an example of SRFINT execution.

7.5 ADDITIONAL EXAMPLES

These examples illustrate MASTER additional-procedure operation. Section 7.5.1 shows how to regulate the spacing of points on input curves Section 7.5.2 shows how to intersect two surface models.

These examples illustrate how to use these additional programs. The programs are still being improved, and the results could change from those given in this manual.

7.5.1 EXAMPLE OF SPACING REGULATION

This example illustrates the use of REGSIL to regulate the spacing of points along a curve. The method of using 2 REGSIL executions with multiple curves, as suggested in Section 7 4.1 8, is shown. For simplicity there are only 2 curves in this example, but this method can be used with up to 17 curves. (This is enough for THETA cuts every 22 5 degrees over a full circle or for THETA cuts every 11.25 degrees over a half circle) Curves of densely-spaced points are given for an inlet interior configuration. A SIL file is desired which will model the surface within an accuracy of at least 0.1 inch The SIL file is formed in two steps: (1) the point-spacing is determined from a typical curve, and (2) each curve of the set is rewritten with this point spacing The overall cost for this process is reduced by such a 2-step method, because only one curve must be used for automatic spacing calculation (which is the expensive step). Figure 7-3 is a listing of the input curves. These curves are constant-THETA sections in cylindrical coordinates

The first curve (the crown section, at THETA = 0 degrees) is selected as the typical input curve to compute point spacing. Figure 7-4 lists the OLDSIL file containing this curve. The OPTION file starts with an integer value of zero, to select the automatic-spacing option, followed by the required tolerance (0 1 inch) and the number of points for the initial attempt to fit the curve. (Three interior points are initially used. Including the 2 end points gives a total of 5 points.) Figure 7-5 shows the OPTION input. Figure 7-6 shows a job deck for this REGSIL execution The execution used 8.3 CPU seconds, for job cost of about $3.10. (The job was run at priority 02 on EKS, executing on a Cyber 760, during a typical nighttime system load.) Figure 7-7 shows highlights of

```
 CYLINDRICAL
DUMP
 SOPTION   IXAXI=3,  IXRAD=1,  IXANG=2  $
2
50
3
-1. 0. 0. -.1102 0.0 .9939
 42.3383   0.0       0.0000
 41.9866   0.0        .0540
 41.4440   0.0        .2323
 40.9189   0.0        .5272
 40.4163   0.0        .9433
 40.2949   0.0       1.0671
 39.5080   0.0       2.1674
 39.0343   0.0       3.2213
 38.7265   0.0       4.2323
 38.5441   0.0       5.0964
 38.4083   0.0       6.0580
 38.3237   0.0       7.1273
 38.2950   0.0       8.3281
 38.3097   0.0       9.2200
 38.3548   0.0      10.2188
 38.4357   0.0      11.3884
 38.4941   0.0      12.0954
 38.6237   0.0      13.5800
 38.6756   0.0      14.1732
 38.7653   0.0      15.0697
 38.8916   0.0      16.0758
 39.0592   0.0      17.1850
 39.2641   0.0      18.3497
 39.5150   0.0      19.6102
 39.6583   0.0      20.2754
 39.9847   0.0      21.6905
 40.1738   0.0      22.4626
 40.3786   0.0      23.2708
 40.6070   0.0      24.1439
 40.8619   0.0      25.0914
 41.1432   0.0      26.1122
 41.4810   0.0      27.3132
 41.8650   0.0      28.6562
 42.3589   0.0      30.3653
 43.1151   0.0      32.9740
 43.6147   0.0      34.7027
 43.8632   0.0      35.5672
 44.1101   0.0      36.4321
 44.3347   0.0      37.2258
 44.6982   0.0      38.5309
 44.8543   0.0      39.1021
 45.4943   0.0      41.5486
 45.8840   0.0      43.1703
 46.3470   0.0      45.3269
 46.6887   0.0      47.2209
 46.9940   0.0      49.4646
 47.1593   0.0      51.5059
 47.2089   0.0      53.0533
 47.1330   0.0      55.1786
 46.8800   0.0      57.4603
```

Figure 7-3. – Input Curve Data for REGSIL Example (File OLDSIL for Second Execution)

```
50
3
-1. 0.0 0.0 -.1102 0.0 .9939
 51.7404  180.0          8.2308
 51.4205  180.0          8.2260
 50.9074  180.0          8.3127
 50.3777  180.0          8.5211
 49.8274  180.0          8.8650
 49.2557  180.0          9.3630
 48.8153  180.0          9.8495
 48.6657  180.0         10.0361
 47.9194  180.0         11.1463
 47.3285  180.0         12.2668
 46.9005  180.0         13.2441
 46.4943  180.0         14.3356
 46.2397  180.0         15.1234
 45.8882  180.0         16.3879
 45.6779  180.0         17.2797
 45.4894  180.0         18.2046
 45.3247  180.0         19.1570
 45.1858  180.0         20.1301
 45.0739  180.0         21.1180
 44.9647  180.0         22.5026
 44.9369  180.0         23.0267
 44.9002  180.0         24.1190
 44.8900  180.0         25.2821
 44.9077  180.0         26.5274
 44.9277  180.0         27.1903
 44.9915  180.0         28.5928
 45.0365  180.0         29.3508
 45.0913  180.0         30.1561
 45.2330  180.0         31.9273
 45.3226  180.0         32.9189
 45.4287  180.0         34.0215
 45.5588  180.0         35.3046
 45.7129  180.0         36.7677
 45.9236  180.0         38.7242
 46.0997  180.0         40.3547
 46.2752  180.0         41.9852
 46.4645  180.0         43.7741
 46.5568  180.0         44.6686
 46.6466  180.0         45.5632
 46.7079  180.0         46.1927
 46.8189  180.0         47.3900
 46.9348  180.0         48.7663
 46.9685  180.0         49.2205
 47.0287  180.0         50.0668
 47.0967  180.0         51.2716
 47.1353  180.0         52.2847
 47.1505  180.0         53.1354
 47.1488  180.0         54.1611
 47.1242  180.0         55.1445
 46.8800  180.0         57.4603
```

Figure 7-3. – Input Curve Data for REGSIL Example (File OLDSIL for Second Execution) (concluded)

```
 CYLINDRICAL
DUMP
 $OPTION    IXAXI=3,  IXRAD=1,  IXANG=2  $
 1
 50
 3
-1. 0. 0. -.1102 0. .9939
 42.3383     0.0       0.0000  0         1
 41.9866     0.0        .0540  0         1
 41.4440     0.0        .2323  0         1
 40.9189     0.0        .5272  0         1
 40.4163     0.0        .9433  0         1
 40.2949     0.0       1.0671  0         1
 39.5080     0.0       2.1674  0         1
 39.0343     0.0       3.2213  0         1
 38.7265     0.0       4.2323  0         1
 38.5441     0.0       5.0964  0         1
 38.4083     0.0       6.0580  0         1
 38.3237     0.0       7.1273  0         1
 38.2950     0.0       8.3281  0         1
 38.3097     0.0       9.2200  0         1
 38.3548     0.0      10.2188  0         1
 38.4357     0.0      11.3884  0         1
 38.4941     0.0      12.0954  0         1
 38.6237     0.0      13.5800  0         1
 38.6756     0.0      14.1732  0         1
 38.7653     0.0      15.0697  0         1
 38.8916     0.0      16.0758  0         1
 39.0592     0.0      17.1850  0         1
 39.2641     0.0      18.3497  0         1
 39.5150     0.0      19.6102  0         1
 39.6583     0.0      20.2754  0         1
 39.9847     0.0      21.6905  0         1
 40.1738     0.0      22.4626  0         1
 40.3786     0.0      23.2708  0         1
 40.6070     0.0      24.1439  0         1
 40.8619     0.0      25.0914  0         1
 41.1432     0.0      26.1122  0         1
 41.4810     0.0      27.3132  0         1
 41.8650     0.0      28.6562  0         1
 42.3589     0.0      30.3653  0         1
 43.1151     0.0      32.9740  0         1
 43.6147     0.0      34.7027  0         1
 43.8632     0.0      35.5672  0         1
 44.1101     0.0      36.4321  0         1
 44.3347     0.0      37.2258  0         1
 44.6982     0.0      38.5309  0         1
 44.8543     0.0      39.1021  0         1
 45.4943     0.0      41.5486  0         1
 45.8840     0.0      43.1703  0         1
 46.3470     0.0      45.3269  0         1
 46.6887     0.0      47.2209  0         1
 46.9940     0.0      49.4646  0         1
 47.1593     0.0      51.5059  0         1
 47.2089     0.0      53.0533  0         1
 47.1330     0.0      55.1786  0         1
 46.8800     0.0      57.4603  0         1
```

Figure 7-4. – Input Curve (OLDSIL) Data for First REGSIL Execution

```
0
.1
3
```

Figure 7-5. - Program Control Selection (OPTION) Input for First REGSIL Execution

```
REGSIL1,CM160000,T30.  FIRST STEP OF REGSIL EXAMPLE
USER,<userno>,<password>. <name> / <phone> / <mailstop>
CHARGE,<cwa>,<project>.
GET,PROCFIL=<version>/UN=<system>.
GET,OLDSIL=OLDSIL2,OPTION=OPTION2.
BEGIN,REGSIL,,OPTION,OLDSIL,NEWSIL.
SAVE,NEWSIL=NEWSIL2.
```

Figure 7-6. – Job Deck for First REGSIL Execution

```
TOL =      .1000000000  NBEG =  3
  42.33830   0.00000   0.00000
  41.98660   0.00000    .05400
  41.44400   0.00000    .23230
  40.91890   0.00000    .52720
  40.41630   0.00000    .94330
  40.29490   0.00000   1.06710
  39.50800   0.00000   2.16740
  39.03430   0.00000   3.22130
  38.72650   0.00000   4.23230
  38.54410   0.00000   5.09640
  38.40830   0.00000   6.05800
  38.32370   0.00000   7.12730
  38.29500   0.00000   8.32810
  38.30970   0.00000   9.22000
  38.35480   0.00000  10.21880
  38.43570   0.00000  11.38840
  38.49410   0.00000  12.09540
  38.62370   0.00000  13.58000
  38.67560   0.00000  14.17320
  38.76530   0.00000  15.06970
  38.89160   0.00000  16.07580
  39.05920   0.00000  17.18500
  39.26410   0.00000  18.34970
  39.51500   0.00000  19.61020
  39.65830   0.00000  20.27540
  39.98470   0.00000  21.69050
  40.17380   0.00000  22.46260
  40.37860   0.00000  23.27080
  40.60700   0.00000  24.14390
  40.86190   0.00000  25.09140
  41.14320   0.00000  26.11220
  41.48100   0.00000  27.31320
  41.86500   0.00000  28.65620
  42.35890   0.00000  30.36530
  43.11510   0.00000  32.97400
  43.61470   0.00000  34.70270
  43.86320   0.00000  35.56720
  44.11010   0.00000  36.43210
  44.33470   0.00000  37.22580
  44.69820   0.00000  38.53090
  44.85430   0.00000  39.10210
  45.49430   0.00000  41.54860
  45.88400   0.00000  43.17030
  46.34700   0.00000  45.32690
  46.68870   0.00000  47.22090
  46.99400   0.00000  49.46460
  47.15930   0.00000  51.50590
  47.20890   0.00000  53.05330
  47.13300   0.00000  55.17860
  46.88000   0.00000  57.46030
MAXIMUM NUMBER OF KNOTS ALLOWED:    8
NOB=  50  NDIMC=  50
 INITIAL ERROR      .2018367423E+01
```

Figure 7-7. – Procedure REGSIL (First Execution) Printer Listing

```
ENTRY TO NW021

ITERATIONS      0   CALLS TO RESID      1

RESIDUAL SUM-OF-SQUARES      .109885756180083E+02
X =
   .224489795918837E+00    .469387755102040E+00    .714285714285720E+00

ITERATIONS      2   CALLS TO RESID      4

RESIDUAL SUM-OF-SQUARES      .661042911620060E+00
X =
   .130563000154473E+00    .706100697742520E+00    .684068497216560E+00

KF =      0
  ERRMAX AND NP,IER    .53459E+00         3         0
 PKNOT     .13056     .70610     .68407
 INITIAL ERROR       .8167963482E+00


ENTRY TO NW021

ITERATIONS      0   CALLS TO RESID      1

RESIDUAL SUM-OF-SQUARES      .183800369791460E+01
X =
   .183673469387760E+00    .387755102040820E+00    .591836734693880E+00    .795918367346940E+00

ITERATIONS      1   CALLS TO RESID      2

RESIDUAL SUM-OF-SQUARES      .998916754010920E+00
X =
   .141410926027730E+00    .442061360576500E+00    .563113560086020E+00    .786184206865930E+00

KF =      0
  ERRMAX AND NP,IER    .59163E+00         4         0
 PKNOT     .14141     .44206     .56311     .78618
 INITIAL ERROR       .6755189662E+00
                                        •
                                        •
                                        •
```

Figure 7-7 – Procedure REGSIL (First Execution) Printer Listing (continued)

```
ENTRY TO NW021

ITERATIONS      0   CALLS TO RESID      1

RESIDUAL SUM-OF-SQUARES      .544559325257806E-01
X =
   .408163265306120E-01     .102040816326530E+00     .163265306122450E+00     .224489795918370E+00     .285714285714290E+00
   .346938775510210E+00     .408163265306120E+00     .469387755102040E+00     .530612244897960E+00     .591836734693800E+00
   .653061224489800E+00     .714285714285720E+00     .775510204081630E+00     .836734693877550E+00

ITERATIONS      1   CALLS TO RESID      2

RESIDUAL SUM-OF-SQUARES      .544556264566850E-01
X =
   .222286333115310E-01     .102040807011230E+00     .163265230710350E+00     .224489712219140E+00     .285714173488060E+00
   .346938753082180E+00     .408163229052470E+00     .469387779045760E+00     .530612290046430E+00     .591836949378080E+00
   .653061264179340E+00     .714285843412180E+00     .775510132732310E+00     .836734640969090E+00

KF =       0
  ERRMAX AND NP,IER    .14408E+00          14         0
 PKNOT      .02223     .10204     .16327     .22449     .28571
 PKNOT      .34694     .40816     .46939     .53061     .59184
 PKNOT      .65306     .71429     .77551     .83673
 INITIAL ERROR       .9012424390E-01


ENTRY TO NW021

ITERATIONS      0   CALLS TO RESID      1

RESIDUAL SUM-OF-SQUARES      .295677991413630E-01
X =
   .408163265306120E-01     .102040816326530E+00     .163265306122450E+00     .224489795918370E+00     .285714285714290E+00
   .346938775510210E+00     .408163265306120E+00     .469387755102040E+00     .530612244897960E+00     .591836734693800E+00
   .653061224489800E+00     .714285714285720E+00     .775510204081630E+00     .836734693877550E+00     .897959183673470E+00

ITERATIONS      1   CALLS TO RESID      2

RESIDUAL SUM-OF-SQUARES      .295676257011810E-01
X =
   .304676426076020E-01     .102040806586380E+00     .163265227268250E+00     .224489708514910E+00     .285714168605780E+00
   .346938752028300E+00     .408163226917650E+00     .469387779675540E+00     .530612286784450E+00     .591836829972990E+00
   .653061238432350E+00     .714285721688880E+00     .775510203306910E+00     .836734666542420E+00     .897959134322260E+00

KF =       0
  ERRMAX AND NP,IER    .90124E-01          15         0
 PKNOT      .03047     .10204     .16327     .22449     .28571
 PKNOT      .34694     .40816     .46939     .53061     .59184
 PKNOT      .65306     .71429     .77551     .83673     .89796

INTERIOR KNOTS :

PKNOT( 1)=     .03047
PKNOT( 2)=     .10204
PKNOT( 3)=     .16327
PKNOT( 4)=     .22449
PKNOT( 5)=     .28571
PKNOT( 6)=     .34694
PKNOT( 7)=     .40816
PKNOT( 8)=     .46939
PKNOT( 9)=     .53061
PKNOT(10)=     .59184
PKNOT(11)=     .65306
PKNOT(12)=     .71429
PKNOT(13)=     .77551
PKNOT(14)=     .83673
PKNOT(15)=     .89796
```

Figure 7-7. – Procedure REGSIL (First Execution) Printer Listing (continued)

```
      CATALOG OF NEWSIL         FILE     1                                82/04/15. 13.05.10.      PAGE      1
REC   NAME      TYPE        LENGTH     CKSUM      DATE       COMMENTS

  1    CYLIND    TEXT          1476       5176

      * EOI *       SUM =      1476        5176


CYLINDRICAL COORDINATES
DUMP OF SURFACE-MODELING COMPUTATIONS REQUESTED
1$OPTION
$IXAXI    = 3,
$IXRAD    = 1,
$IXANG    = 2,
$$END
C
C      ****  SECTION INPUT  ****
C
   1    NUMBER OF SECTIONS
C
C      ****SECTION NUMBER   1 ****
C
  17    NUMBER OF POINTS IN SECTION
   3    END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3  2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000                 -.11020   0.00000    .99390
C        RADIUS           THETA           STA  TENSION     KNOT
       42.33030        0.00000       0.00000 0.            1       POINT  1
       41.93347        0.00000        .06749 0.            2       POINT  2
       40.98237        0.00000        .40430 0.            3       POINT  3
       40.16007        0.00000       1.20609 0.            4       POINT  4
       39.35553        0.00000       2.45566 0.            5       POINT  5
       38.54165        0.00000       5.11220 0.            6       POINT  6
       38.86009        0.00000      15.05062 0.            7       POINT  7
       39.67419        0.00000      20.34726 0.            8       POINT  8
       40.48758        0.00000      23.69072 0.            9       POINT  9
       41.30102        0.00000      26.67615 0.           10       POINT 10
       42.11455        0.00000      29.52128 0.           11       POINT 11
       42.92816        0.00000      32.32803 0.           12       POINT 12
       43.74172        0.00000      35.14400 0.           13       POINT 13
       44.55516        0.00000      38.01366 0.           14       POINT 14
       45.36871        0.00000      41.05263 0.           15       POINT 15
       46.18292        0.00000      44.54179 0.           16       POINT 16
       46.00000        0.00000      57.46030 0.           17       POINT 17
C
C      ****  MEMBER INPUT  ****
C
  17    NUMBER OF MEMBERS
C
C      ****MEMBER NUMBER  1 ****
C
   1    NUMBER OF POINTS IN MEMBER
   4    END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER     SECTION NUMBER    TENSION       CORNER PT
           1                  1  0.                       1      POINT  1
C
C      ****MEMBER NUMBER  2 ****
C
   1    NUMBER OF POINTS IN MEMBER
   4    END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER     SECTION NUMBER    TENSION       CORNER PT
           2                  1  0.                       1      POINT  1
C
C      ****MEMBER NUMBER  3 ****
C
   1    NUMBER OF POINTS IN MEMBER
   4    END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER     SECTION NUMBER    TENSION       CORNER PT
           3                  1  0.                       1      POINT  1
C
C      ****MEMBER NUMBER  4 ****

   .
   .
   .
   .
```

Figure 7-7. – Procedure REGSIL (First Execution) Printer Listing (concluded) the printer listing from REGSIL. (The option input is listed first. Successive attempts to fit the curve follow for the inital number of knots and then increasing by one at a time. Finally, the output spacing is computed) A total of 15 interior points are required The input and output files for the first step are available on the MASTER system account Their permanent-file names have "2" appended to make them unique; they are OLDSIL2, OPTION2, and NEWSIL2

Now that a relative spacing is determined, it is applied to all the input curves (both curves in this example), by executing REGSIL again Figure 7-8 shows the OPTION input This file starts with an integer value of 1, to select the input-spacing option, followed by the relative locations of the interior points. (These locations are decimal values, between 0 0 and 1 0, and strictly increasing.) Note that this spacing has been transferred from the printer listing from the first REGSIL execution. The OLDSIL file is listed in Figure 7-3. The job deck for this second execution is shown in Figure 7-9 This execution required 0 27 CPU seconds and cost less than $1 00, executing on a Cyber 760 in the EKS system, at priority 02 during a typical nighttime system load Figure 7-10 shows highlights of the printer listing from REGSIL. Figure 7-11 shows the NEWSIL output, which is in SIL format and is completely ready for input to SILSRF. This surface description will produce a model with 16 patches, compared with 49 patches which would be produced if every input point were used as a patch corner This implies a cost reduction of about ⅔ during the TRNSIL, SILSRF, and MSHNRM executions which will follow In addition, the time and effort required to form the SIL file is less than would be needed to form a description by directly editing the input curves. The input and output files for the second step are available on the MASTER system account. Their permanent-filenames have "3" appended to make them unique, they are OLDSIL3, OPTION3, and NEWSIL3

Note that the relative spacing input to the second step is changed slightly from that output by the first step. The changes were made by MASTER consultation, to correct a local problem in the curve fit resulting from the first-step results. Such manual editing was typically needed when this example was written, but this difficulty could be removed by later program enhancements. Contact MASTER consultation for current details when you plan to use REGSIL.

7.5.2 SURFACE-INTERSECTION EXAMPLE

This example illustrates the use of SRFINT to compute the curve of intersection of a pair of surface models The surface models are input as files SRF1 and SRF2. The models respectively represent a nacelle surface and a pylon surface, in rectangular coordinates These models are reduced, as suggested in Section 7.4.2 8, to just those patches which could possibly contribute to the intersection. SRF1 contains 18 patches, in 9 pairs. (The patches in each pair lie on the outboard and inboard sides of the pylon respectively. The pairs run aft from the leading edge. SRF2 contains 18 patches, in 6 rows of 3. (Each row runs vertically upwards The rows run from the outboard side, forward to the leading edge, and then aft to the inboard side.) Figure 7-12 shows the patches of SRF1 and SRF2 as separate surface models, and then superimposed. Figure 7-13 shows the trimmed surfaces, which can be described later, using the intersection curve The control input is on file OPTION, which is listed in Figure 7-14. Figure 7-15 shows a job deck for this example. The example used 28 3 CPU seconds, for a job cost of about $11 25 (The job was run at priority P02, executing on a Cyber 760, during a typical nighttime system load) Figure 7-16 shows the printer listing from SRFINT. (The option input is listed first. The diagnostic messages from attempting to intersect pairs of single patches follow The branches of the intersection are shown next, by listing their endpoints and the connections between them. Finally, the intersection-curve output is listed) Note that some of the connections between branches were missed or were not made symmetrically This behavior is typical of current SRFINT results, but could be changed by later program enhancements. Contact MASTER consultation when you plan to use SRFINT, for current details. Figure 7-17 shows the SEC output.

```
1
.10204
.12023
.16327
.22449
.28571
.3044
.3150
.34694
.40816
.46939
.53061
.59184
.65306
.71429
.77551
.83673
.89796
.9760
```

Figure 7-8. – Program Control Selection (OPTION) Input for Second REGSIL Execution

```
REGSIL2,CM160000,T2.  SECOND STEP OF REGSIL EXAMPLE
USER,<userno>,<password>. <name> / <phone> / <mailstop>
CHARGE,<cwa>,<project>.
GET,MASTER=<version>/UN=<system>.
GET,OLDSIL=OLDSIL3,OPTION=OPTION3.
BEGIN,REGSIL,,OPTION,OLDSIL,NEWSIL.
SAVE,NEWSIL=NEWSIL3.
```

Figure 7-9 – Job Deck for Second REGSIL Execution

```
INTERIOR KNOTS :

PKNOT( 1)=     .10204
PKNOT( 2)=     .12023
PKNOT( 3)=     .16327
PKNOT( 4)=     .22449
PKNOT( 5)=     .28571
PKNOT( 6)=     .30440
PKNOT( 7)=     .31500
PKNOT( 8)=     .34694
PKNOT( 9)=     .40816
PKNOT(10)=     .46939
PKNOT(11)=     .53061
PKNOT(12)=     .59184
PKNOT(13)=     .65306
PKNOT(14)=     .71429
PKNOT(15)=     .77551
PKNOT(16)=     .83673
PKNOT(17)=     .89796
PKNOT(18)=     .97600
```

Figure 7-10. – Procedure REGSIL (Second Execution) Printer Listing

```
 CYLINDRICAL COORDINATES
 DUMP OF SURFACE-MODELING COMPUTATIONS REQUESTED
1SOPTION
0IXAXI   = 3,
0IXRAD   = 1,
0IXANG   = 2,
0SEND
C
C      ****  SECTION INPUT  ****
C
   2   NUMBER OF SECTIONS
C
C      ****SECTION NUMBER   1 ****
C
  20   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3  2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000              -.11020   0.00000    .99390
C       RADIUS        THETA          STA  TENSION    KNOT
     42.33830      0.00000      0.00000 0.             1      POINT  1
     40.98238      0.00000       .48437 0.             2      POINT  2
     40.74062      0.00000       .65844 0.             3      POINT  3
     40.16881      0.00000      1.20696 0.             4      POINT  4
     39.35553      0.00000      2.45566 0.             5      POINT  5
     38.54171      0.00000      5.11182 0.             6      POINT  6
     38.29552      0.00000      8.40410 0.             7      POINT  7
     38.43689      0.00000     11.40512 0.             8      POINT  8
     38.86090      0.00000     15.85074 0.             9      POINT  9
     39.67415      0.00000     20.34707 0.            10      POINT 10
     40.48761      0.00000     23.69083 0.            11      POINT 11
     41.30099      0.00000     26.67604 0.            12      POINT 12
     42.11459      0.00000     29.52142 0.            13      POINT 13
     42.92814      0.00000     32.32877 0.            14      POINT 14
     43.74178      0.00000     35.14420 0.            15      POINT 15
     44.55516      0.00000     38.01365 0.            16      POINT 16
     45.36865      0.00000     41.05239 0.            17      POINT 17
     46.18293      0.00000     44.54185 0.            18      POINT 18
     47.20880      0.00000     53.37326 0.            19      POINT 19
     46.88000      0.00000     57.46030 0.            20      POINT 20
C
C      ****SECTION NUMBER   2 ****
C
  20   NUMBER OF POINTS IN SECTION
   3   END FLAG    0 NAT  1 SLP,NAT  2 NAT,SLP  3  2SLP  4 PER
C XYZ COORDS OF SLOPE AT ENDS IF FLAG=1,2,3 (BOTH SLOPES REQUIRED.)
  -1.00000   0.00000   0.00000              -.11020   0.00000    .99390
C       RADIUS        THETA          STA  TENSION    KNOT
     51.74040    180.00000      8.23080 0.             1      POINT  1
     47.04842    180.00000     12.88830 0.             2      POINT  2
     46.69083    180.00000     13.78482 0.             3      POINT  3
     46.01274    180.00000     15.91209 0.             4      POINT  4
     45.35864    180.00000     18.94630 0.             5      POINT  5
     44.99922    180.00000     21.98554 0.             6      POINT  6
     44.94230    180.00000     22.91389 0.             7      POINT  7
                                    .
                                    .
                                    .
```

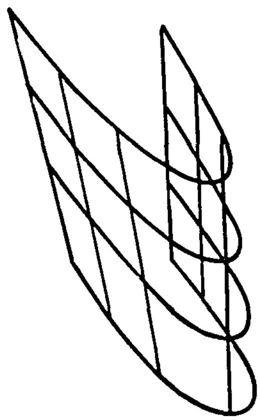
Figure 7-11. – Output Data from REGSIL Example (File NEWSIL from Second Execution)

```
C
C     ****  MEMBER INPUT  ****
C
  20   NUMBER OF MEMBERS
C
C     ****MEMBER NUMBER  1 ****
C
   2   NUMBER OF POINTS IN MEMBER
   4   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER     SECTION NUMBER    TENSION       CORNER PT
          1                 1   0.                    1     POINT  1
          1                 2   0.                    2     POINT  2
C
C     ****MEMBER NUMBER  2 ****
C
   2   NUMBER OF POINTS IN MEMBER
   4   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER     SECTION NUMBER    TENSION       CORNER PT
          2                 1   0.                    1     POINT  1
          2                 2   0.                    2     POINT  2
C
C     ****MEMBER NUMBER  3 ****
C
   2   NUMBER OF POINTS IN MEMBER
   4   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER     SECTION NUMBER    TENSION       CORNER PT
          3                 1   0.                    1     POINT  1
          3                 2   0.                    2     POINT  2
C
C     ****MEMBER NUMBER  4 ****
C
   2   NUMBER OF POINTS IN MEMBER
   4   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER     SECTION NUMBER    TENSION       CORNER PT
          4                 1   0.                    1     POINT  1
          4                 2   0.                    2     POINT  2
C
C     ****MEMBER NUMBER  5 ****
C
   2   NUMBER OF POINTS IN MEMBER
   4   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER     SECTION NUMBER    TENSION       CORNER PT
          5                 1   0.                    1     POINT  1
          5                 2   0.                    2     POINT  2
C
C     ****MEMBER NUMBER  6 ****
C
   2   NUMBER OF POINTS IN MEMBER
   4   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C KNOT NUMBER     SECTION NUMBER    TENSION       CORNER PT
          6                 1   0.                    1     POINT  1
                              .
                              .
                              .
```

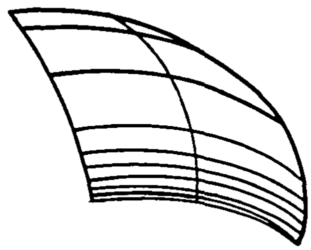
Figure 7-11 – Output Data from REGSIL Example (File NEWSIL from Second Execution) (continued)

```
C
C     ****  PATCH INPUT  ****
C
  19   NUMBER OF PATCHES
C  U0V0         U0V1        U1V0        U1V1       EACH PAIR:  CORNER PT, MEMBER
    1   1       2   1       1   2       2   2                         PATCH  1
    1   2       2   2       1   3       2   3                         PATCH  2
    1   3       2   3       1   4       2   4                         PATCH  3
    1   4       2   4       1   5       2   5                         PATCH  4
    1   5       2   5       1   6       2   6                         PATCH  5
    1   6       2   6       1   7       2   7                         PATCH  6
    1   7       2   7       1   8       2   8                         PATCH  7
    1   8       2   8       1   9       2   9                         PATCH  8
    1   9       2   9       1  10       2  10                         PATCH  9
    1  10       2  10       1  11       2  11                         PATCH 10
    1  11       2  11       1  12       2  12                         PATCH 11
    1  12       2  12       1  13       2  13                         PATCH 12
    1  13       2  13       1  14       2  14                         PATCH 13
    1  14       2  14       1  15       2  15                         PATCH 14
    1  15       2  15       1  16       2  16                         PATCH 15
    1  16       2  16       1  17       2  17                         PATCH 16
    1  17       2  17       1  18       2  18                         PATCH 17
    1  18       2  18       1  19       2  19                         PATCH 18
    1  19       2  19       1  20       2  20                         PATCH 19
```

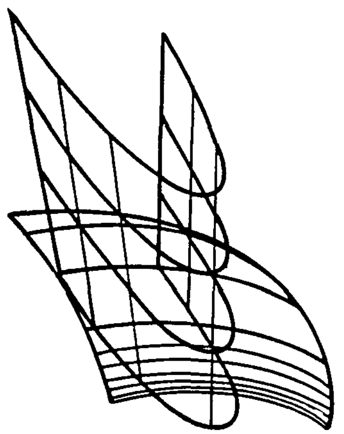
Figure 7-11. – Output Data from REGSIL Example (File NEWSIL from Second Execution) (concluded)



(a) PYLON

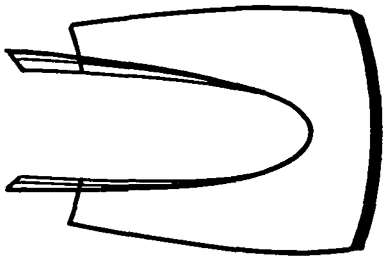


(b) NACELLE

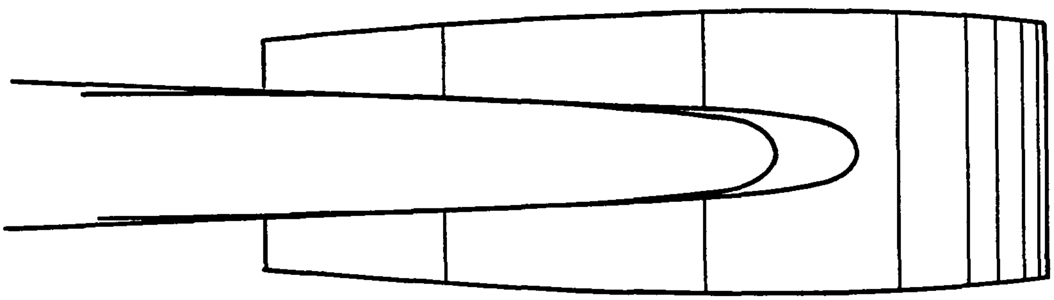


(c) NACELLE AND PYLON

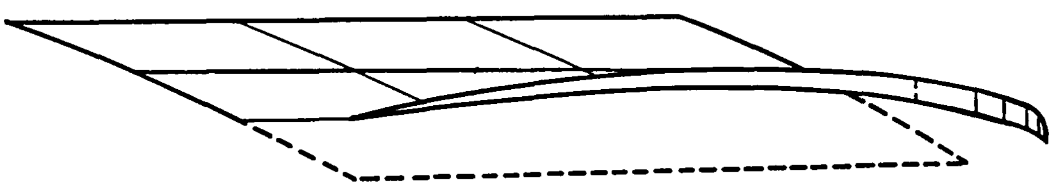
Figure 7-12. – Intersection of Nacelle and Pylon



(a) INCLINED TOP VIEW, ALONG PYLON LE



(b) TOP VIEW



(c) SIDE VIEW

Figure 7-13. – Nacelle and Pylon, Trimmed at Intersection

```
2.0  1.0  1.5
0.01 0.01 0.00001
```

Figure 7-14. - Program Control Selection (OPTION) Input for SRFINT Example

```
SRFINT,CM160000,T30.  SRFINT EXAMPLE
USER,<userno>,<password>. <name> / <phone> / <mailstop>
CHARGE,<cwa>,<project>.
GET,PROCFIL=<version>/UN=<system>.
GET,SRF1,SRF2,OPTION.
BEGIN,SRFINT,,SRF1,SRF2,SEC,OPTION,.
SAVE,SEC.
```

Figure 7-15. – Job Deck for SRFINT Example

```
SURFACE INTERSECTION PROGRAM

 DEFINED TOLERANCES
             CURVE CONNECTION       X=  2.00000   Y=  1.00000   Z=  1.50000
             SURINT TOLERANCES           .01000        .01000        .00001


IER =  7     SURFACE 1 PATCH 13     SURFACE 2 PATCH  8
WARNING ... WARNING ... WARNING
THE STEPSIZE NECESSARY TO FOLLOW THE CURVE IS LESS THAN TOL(2) =   .1000E-01

IER =  7     SURFACE 1 PATCH 14     SURFACE 2 PATCH 11
WARNING ... WARNING ... WARNING
THE STEPSIZE NECESSARY TO FOLLOW THE CURVE IS LESS THAN TOL(2) =   .1000E-01

IER =  7     SURFACE 1 PATCH 15     SURFACE 2 PATCH  8
WARNING ... WARNING ... WARNING
THE STEPSIZE NECESSARY TO FOLLOW THE CURVE IS LESS THAN TOL(2) =   .1000E-01

IER =  7     SURFACE 1 PATCH 16     SURFACE 2 PATCH 11
WARNING ... WARNING ... WARNING
THE STEPSIZE NECESSARY TO FOLLOW THE CURVE IS LESS THAN TOL(2) =   .1000E-01
```

Figure 7-16. – Printer Listing for SRFINT Example

END POINT TABLE

NO	X	Y	Z	IP1	IP2	IBR	OTHER END	CONNECT TO	NO. OF POINTS
1	79.32228	.53751	51.39687	13	8	1	2	0	27
2	88.51835	4.90289	51.57550	13	8	1	1	10	27
3	81.62685	-2.80624	51.45808	14	11	2	4	4	3
4	82.42095	-3.18302	51.47444	14	11	2	3	3	3
5	88.51835	-4.90292	51.57550	14	11	3	6	11	21
6	79.87158	-1.52612	51.41002	14	11	3	5	0	21
7	113.82662	7.38803	50.65196	15	5	1	8	9	12
8	126.23921	8.03119	49.31106	15	5	1	7	17	12
9	113.82662	7.38803	50.65196	15	8	1	10	7	24
10	88.94175	4.98928	51.57663	15	8	1	9	2	24
11	88.51835	-4.90292	51.57550	16	11	1	12	5	27
12	113.82662	-7.38803	50.65196	16	11	1	11	13	27
13	113.82662	-7.38803	50.65196	16	14	1	14	12	12
14	126.23921	-8.03017	49.31123	16	14	1	13	19	12
15	142.67864	8.52320	47.10333	17	2	2	16	18	10
16	152.13448	8.67636	45.58937	17	2	2	15	0	10
17	126.23921	8.03119	49.31106	17	5	1	18	8	15
18	142.67862	8.52319	47.10333	17	5	1	17	15	15
19	126.23921	-8.03017	49.31123	18	14	2	20	14	16
20	142.67845	-8.52321	47.10324	18	14	2	19	21	16
21	142.67852	-8.52321	47.10327	18	17	1	22	20	10
22	152.13448	-8.67609	45.58942	18	17	1	21	0	10

Figure 7-16 – Printer Listing for SRFINT Example (continued)

```
 ****  SECTION OUTPUT  ****

 3   NUMBER OF SECTIONS

 ****SECTION NUMBER  1 ****

85   NUMBER OF POINTS IN SECTION
 0   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
       STA           BL            WL  TENSION    KNOT
    79.32220       .53751      51.39687     0.000      1        POINT   1
    79.27118       .27244      51.39669     0.000      1        POINT   2
    79.25849       .00000      51.39897     0.000      1        POINT   3
    79.32216       .53752      51.39681     0.000      1        POINT   4
    79.41056       .79530      51.39928     0.000      1        POINT   5
    79.68969      1.28943      51.40777     0.000      1        POINT   6
    79.61116      1.16002      51.40753     0.000      1        POINT   7
    79.53566      1.04587      51.40413     0.000      1        POINT   8
    79.87623      1.52602      51.41243     0.000      1        POINT   9
    80.08647      1.75593      51.41399     0.000      1        POINT  10
    79.96236      1.61318      51.41629     0.000      1        POINT  11
    80.34013      1.97892      51.42283     0.000      1        POINT  12
    80.67397      2.21620      51.43510     0.000      1        POINT  13
    80.92645      2.40530      51.43847     0.000      1        POINT  14
    81.29355      2.61285      51.45070     0.000      1        POINT  15
    81.62699      2.80618      51.45817     0.000      1        POINT  16
    81.65176      2.81760      51.45900     0.000      1        POINT  17
    83.32103      3.53609      51.49712     0.000      1        POINT  18
    83.31871      3.53615      51.49592     0.000      1        POINT  19
    84.30060      3.86719      51.51568     0.000      1        POINT  20
    85.24733      4.14339      51.53277     0.000      1        POINT  21
    85.36090      4.17703      51.53402     0.000      1        POINT  22
    86.07210      4.35752      51.54714     0.000      1        POINT  23
    86.49474      4.46666      51.55160     0.000      1        POINT  24
    87.63426      4.72360      51.56674     0.000      1        POINT  25
    87.69321      4.73705      51.56718     0.000      1        POINT  26
    88.51835      4.90289      51.57550     0.000      1        POINT  27
    88.94188      4.98928      51.57670     0.000      1        POINT  28
    90.24039      5.22409      51.58318     0.000      1        POINT  29
    90.64418      5.28939      51.58597     0.000      1        POINT  30
    91.57493      5.44244      51.58286     0.000      1        POINT  31
    92.77013      5.61870      51.58105     0.000      1        POINT  32
    92.94560      5.64505      51.57902     0.000      1        POINT  33
    94.33342      5.83278      51.56535     0.000      1        POINT  34
    94.89604      5.90163      51.56062     0.000      1        POINT  35
    95.73907      6.00629      51.54540     0.000      1        POINT  36
    96.62388      6.10148      51.53117     0.000      1        POINT  37
    97.02174      6.14428      51.52475     0.000      1        POINT  38
    98.57590      6.31358      51.48509     0.000      1        POINT  39
    99.14711      6.36575      51.47174     0.000      1        POINT  40
   101.27201      6.56086      51.40258     0.000      1        POINT  41
   101.40283      6.57267      51.39717     0.000      1        POINT  42
   103.39633      6.73033      51.31759     0.000      1        POINT  43
   104.16546      6.78949      51.28026     0.000      1        POINT  44
   105.51995      6.88106      51.21621     0.000      1        POINT  45
   107.64278      7.01631      51.09827     0.000      1        POINT  46
   108.30839      7.05893      51.05545     0.000      1        POINT  47
   109.35357      7.12518      50.98831     0.000      1        POINT  48
   109.76472      7.14977      50.96210     0.000      1        POINT  49
   111.88568      7.27699      50.80848     0.000      1        POINT  50
   113.82662      7.38803      50.65196     0.000      1        POINT  51
   114.00555      7.39889      50.63744     0.000      1        POINT  52
   116.12426      7.52683      50.44745     0.000      1        POINT  53
   117.61751      7.61580      50.30101     0.000      1        POINT  54
   118.24172      7.64974      50.24029     0.000      1        POINT  55
   119.67715      7.72589      50.08885     0.000      1        POINT  56
   120.35788      7.76174      50.01707     0.000      1        POINT  57
   121.32641      7.81211      49.90697     0.000      1        POINT  58
                                  .
                                  .
                                  .
```

Figure 7-16 – Printer Listing for SRFINT Example (concluded)

```
C
C     ****  SECTION INPUT  ****
C
   3   NUMBER OF SECTIONS
C
C     ****SECTION NUMBER  1 ****
C
  85   NUMBER OF POINTS IN SECTION
   0   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C          STA            BL             WL  TENSION    KNOT
      79.32220        .53751      51.39687     0.000      1       POINT   1
      79.27118        .27244      51.39669     0.000      1       POINT   2
      79.25849        .00000      51.39897     0.000      1       POINT   3
      79.32216        .53752      51.39681     0.000      1       POINT   4
      79.41056        .79530      51.39928     0.000      1       POINT   5
      79.60969       1.28943      51.40777     0.000      1       POINT   6
      79.61116       1.16002      51.40753     0.000      1       POINT   7
      79.53566       1.04587      51.40413     0.000      1       POINT   8
      79.87623       1.52602      51.41243     0.000      1       POINT   9
      80.08647       1.75593      51.41399     0.000      1       POINT  10
      79.96236       1.61318      51.41629     0.000      1       POINT  11
      80.34013       1.97892      51.42283     0.000      1       POINT  12
      80.67397       2.21620      51.43510     0.000      1       POINT  13
      80.92645       2.40530      51.43847     0.000      1       POINT  14
      81.29355       2.61285      51.45070     0.000      1       POINT  15
      81.62699       2.80618      51.45817     0.000      1       POINT  16
      81.65176       2.81760      51.45900     0.000      1       POINT  17
      83.32103       3.53609      51.49712     0.000      1       POINT  18
      83.31871       3.53615      51.49592     0.000      1       POINT  19
      84.30060       3.86719      51.51560     0.000      1       POINT  20
      85.24733       4.14339      51.53277     0.000      1       POINT  21
      85.36090       4.17703      51.53402     0.000      1       POINT  22
      86.07210       4.35752      51.54714     0.000      1       POINT  23
      86.49474       4.46666      51.55160     0.000      1       POINT  24
      87.63426       4.72360      51.56674     0.000      1       POINT  25
      87.69321       4.73705      51.56718     0.000      1       POINT  26
      88.51835       4.90289      51.57550     0.000      1       POINT  27
      88.94180       4.98928      51.57670     0.000      1       POINT  28
      90.24039       5.22409      51.58318     0.000      1       POINT  29
      90.64418       5.28939      51.58597     0.000      1       POINT  30
      91.57493       5.44244      51.58286     0.000      1       POINT  31
      92.77013       5.61870      51.58105     0.000      1       POINT  32
      92.94560       5.64505      51.57902     0.000      1       POINT  33
      94.33342       5.83278      51.56535     0.000      1       POINT  34
      94.89604       5.90163      51.56062     0.000      1       POINT  35
      95.73907       6.00629      51.54540     0.000      1       POINT  36
      96.62380       6.10148      51.53117     0.000      1       POINT  37
      97.02174       6.14428      51.52475     0.000      1       POINT  38
          :             :             :          :        :               :
          :             :             :          :        :               :
          :             :             :          :        :               :
     139.49521       8.44773      47.55805     0.000      1       POINT  73
     141.06974       8.48591      47.33605     0.000      1       POINT  74
     142.52543       8.51968      47.12600     0.000      1       POINT  75
     142.67862       8.52319      47.10333     0.000      1       POINT  76
     142.83403       8.52626      47.08089     0.000      1       POINT  77
     144.28887       8.55446      46.86531     0.000      1       POINT  78
     145.83821       8.58321      46.62924     0.000      1       POINT  79
     147.29147       8.60090      46.40118     0.000      1       POINT  80
     148.74391       8.63398      46.16614     0.000      1       POINT  81
     149.34362       8.64407      46.06594     0.000      1       POINT  82
     150.60138       8.65995      45.84185     0.000      1       POINT  83
     152.13175       8.67633      45.58985     0.000      1       POINT  84
     152.13440       8.67636      45.58937     0.000      1       POINT  85
```

Figure 7-17. – Output Data (File SEC) from SRFINT Example

```
C
C     ****SECTION NUMBER  2 ****
C
  82   NUMBER OF POINTS IN SECTION
   0   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C          STA          BL            WL  TENSION    KNOT
     79.87158    -1.52612    51.41002    0.000     1      POINT   1
     79.60582    -1.28949    51.40576    0.000     1      POINT   2
     79.47201     -.90811    51.40411    0.000     1      POINT   3
     79.53532    -1.04508    51.40396    0.000     1      POINT   4
     79.41506     -.79526    51.40160    0.000     1      POINT   5
     79.25849      .00000    51.39897    0.000     1      POINT   6
     79.32516     -.53749    51.39836    0.000     1      POINT   7
     79.68612    -1.28949    51.40591    0.000     1      POINT   8
     80.33255    -1.97910    51.41891    0.000     1      POINT   9
     80.67156    -2.21515    51.43500    0.000     1      POINT  10
     80.92600    -2.40535    51.43822    0.000     1      POINT  11
     81.29079    -2.61171    51.45061    0.000     1      POINT  12
     81.62261    -2.80635    51.45590    0.000     1      POINT  13
     83.31152    -3.53240    51.49693    0.000     1      POINT  14
     83.32096    -3.53620    51.49706    0.000     1      POINT  15
     84.30027    -3.86733    51.51548    0.000     1      POINT  16
     85.24923    -4.14411    51.53277    0.000     1      POINT  17
     86.05708    -4.35382    51.54691    0.000     1      POINT  18
     86.49476    -4.46686    51.55157    0.000     1      POINT  19
     87.69319    -4.73728    51.56714    0.000     1      POINT  20
     88.51835    -4.90292    51.57550    0.000     1      POINT  21
     88.94177    -4.98953    51.57661    0.000     1      POINT  22
     90.24041    -5.22438    51.58315    0.000     1      POINT  23
     90.64418    -5.28933    51.58598    0.000     1      POINT  24
     91.57493    -5.44275    51.58283    0.000     1      POINT  25
     92.77013    -5.61880    51.58104    0.000     1      POINT  26
     92.94560    -5.64539    51.57899    0.000     1      POINT  27
     94.33341    -5.83313    51.56531    0.000     1      POINT  28
     94.89604    -5.90175    51.56060    0.000     1      POINT  29
     95.73905    -6.00666    51.54535    0.000     1      POINT  30
     96.58949    -6.10244    51.53117    0.000     1      POINT  31
     97.02174    -6.15106    51.52395    0.000     1      POINT  32
     97.15873    -6.16673    51.52036    0.000     1      POINT  33
     98.57561    -6.31398    51.48505    0.000     1      POINT  34
     99.14711    -6.36507    51.47182    0.000     1      POINT  35
    101.27201    -6.56085    51.40259    0.000     1      POINT  36
    101.40281    -6.57306    51.39712    0.000     1      POINT  37
    103.39633    -6.72840    51.31784    0.000     1      POINT  38
        .           .           .          .       .               .
        .           .           .          .       .               .
        .           .           .          .       .               .
    148.70205    -8.63337    46.17300    0.000     1      POINT  78
    149.34346    -8.64449    46.06587    0.000     1      POINT  79
    149.49653    -8.64638    46.04082    0.000     1      POINT  80
    150.71558    -8.66046    45.83598    0.000     1      POINT  81
    152.13448    -8.67609    45.58942    0.000     1      POINT  82
C
C     ****SECTION NUMBER  3 ****
C
   3   NUMBER OF POINTS IN SECTION
   4   END FLAG     0 NAT  1 SLP,NAT  2 NAT,SLP  3 2SLP  4 PER
C          STA          BL            WL  TENSION    KNOT
     81.62685    -2.80624    51.45808    0.000     1      POINT   1
     81.66452    -2.82365    51.45934    0.000     1      POINT   2
     82.42095    -3.10302    51.47444    0.000     1      POINT   3
```

Figure 7-17 – Output Data (File SEC) from SRFINT Example (concluded)

8.0 REFERENCES

1. Reyhner, T.A., "Computation of Transonic Potential Flow About Three-Dimensional Inlets, Ducts and Bodies," NASA CR-3514, March 1982.
2. Gibson, S.G., "User's Manual for the Propulsion Bicubic Geometry System (IGS & DRAW6)," D6-48968, Rev. A, Boeing Commercial Airplane Co., Seattle WA, 1980.
3. Faux, I D. and Pratt, M.J., ***Computational Geometry for Design and Manufacture,*** Ellis Horwood Ltd., Chichester, West Sussex, England, 1979.
4. Nielson, G M., "Some Piecewise Polynomial Alternatives to Splines in Tension," in ***Computer-Aided Geometric Design*** (eds. Barnhill, R.E. and Reisenfeld, R.F.), Academic Press, New York, NY, 1974.

1 Report No	2 Government Accession No	3 Recipient's Catalog No
NASA CR- 166056		

4 Title and Subtitle	5 Report Date / 6 Performing Organization Code
User's Manual for Master: Modeling of Aerodynamic Surfaces by Three-Dimensional Explicit Representation	5 Report Date: January 1983 6 Performing Organization Code: B-8406
7 Author(s) S. G. Gibson	8 Performing Organization Report No D6-51088
9 Performing Organization Name and Address Boeing Commercial Airplane Company P.O. Box 3707 Seattle, WA 98124	10 Work Unit No 4.3.3 11 Contract or Grant No NAS1-15325-10
12 Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546	13 Type of Report and Period Covered Contractor Report 14 Sponsoring Agency Code

15 Supplementary Notes

Technical Monitor David E. Reubush
Final Report

16 Abstract

A system of computer programs has been developed to model general three-dimensional surfaces. Surfaces are modeled as sets of parametric bicubic patches. There are also capabilities to transform coordinates, to compute mesh/surface intersection normals, and to format input data for a transonic potential flow analysis (NASA CR-3534). A graphical display of surface models and intersection normals is available. There are additional capabilities to regulate point spacing on input curves and to compute surface/surface intersection curves

Input and output data formats are described; detailed suggestions are given for user input. Instructions for execution are given, and examples are shown.

17 Key Words		18 Distribution Statement
bicubic patch	parametric	Unclassified - Unlimited
intersection normals	surface model	
mesh	three-dimensional	Subject Category 61

19 Security Classif (of this report)	20 Security Classif (of this page)	21 No of Pages	22 Price
Unclassified	Unclassified	162	A08

For sale by the National Technical Information Service, Springfield, Virginia 22161

End of Document