

# AeroPack User's Manual



***DARcorporation***  
Design • Analysis • Research



# AeroPack

# User's Manual

for Shark & Shark FX

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AeroPack User's Manual

2010

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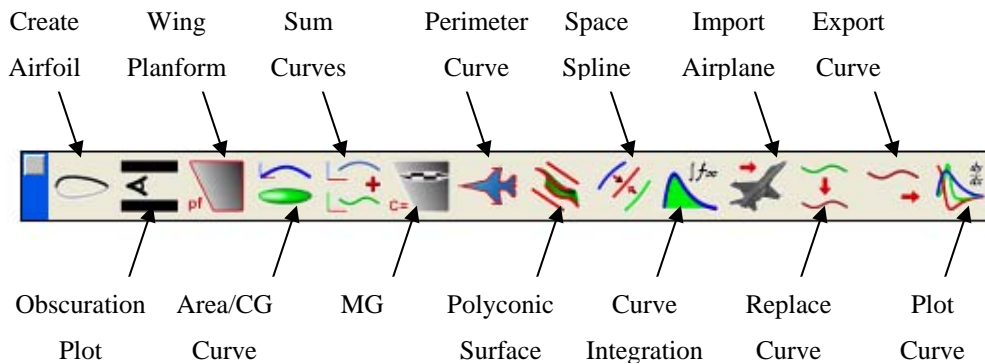
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## 1. Introduction to AeroPack

AeroPack is a collection of integrated geometry tools developed for the aerospace design communities. AeroPack includes such tools as:

- Airfoil generation (NACA equations or ASCII files)
- Wing planform generation
- Polyconic surfaces for fuselage, duct, and nacelle components
- Perimeter, area, and CG curves
- Obscuration and field of view plots
- Import airplane from Advanced Aircraft Analysis

To access the commands provided by AeroPack while in the CAD program, select the Windows: AeroPack option. The Windows option is located in the menu bar at the top of the screen. When the AeroPack option in the menu is selected, the floating tool palette window (see Figure 1.1) is displayed.



*Figure 1.1 AeroPack Options*

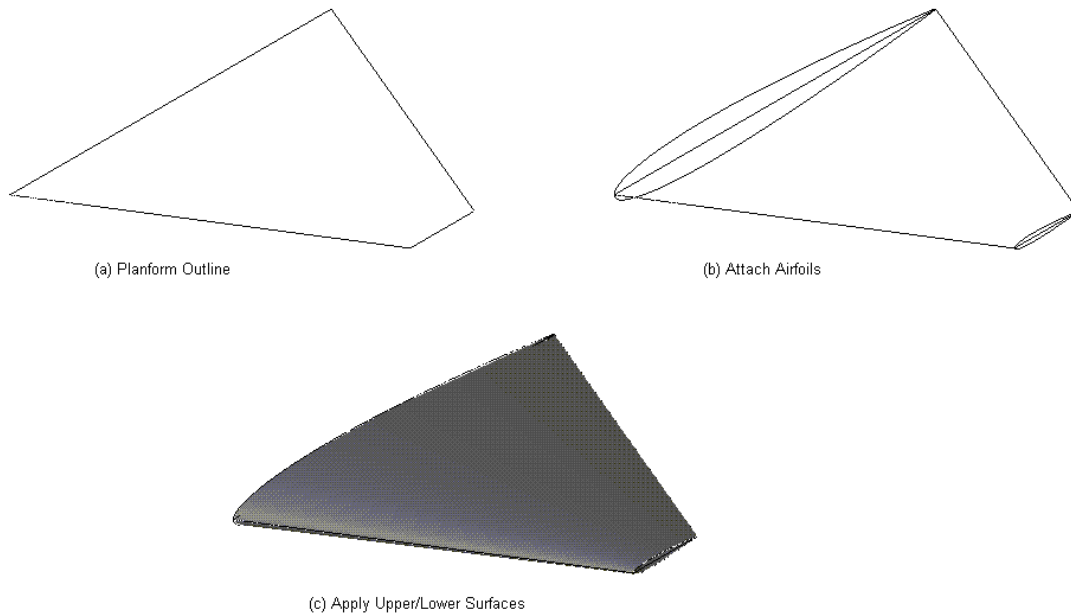
The AeroPack menu provides access to fourteen (14) commands. These commands are briefly described here:

- **Wing Planform** Given wing parameters creates wing outline (Section 2.1).
- **Create Airfoil** Creates an airfoil from a file or NACA equation (Section 2.2).
- **MGC** Calculates the mean geometric chord of lifting surfaces (Section 2.3).
- **Perimeter Curve** Creates a plot of perimeter vs fuselage station (Section 2.4).
- **Area/CG Curve** Calculates area/cg curve from surfaces/solids (Section 2.5).
- **Sum Curves** Adds two curves together (Section 2.6).
- **Curve Integration** Integrates the area under a curve. Integrating a perimeter curve yields an area value. Integrating a cross sectional area curve yields the volume (Section 2.7).
- **Obscuration Plot** Azimuth, elevation plot for determining field of view (Section 2.8)
- **Space Spline** Creates a curve that is the intersection of two projected curves. Useful for creating slope control curves for polyconic surfaces (Section 2.9).
- **Import Airplane** Allows for import of airplane geometry from the Advanced Aircraft Analysis software package (Section 2.10).
- **Polyconic Surface** Creates polyconic surfaces. Cover in detail in (Section 2.11).
- **Replace Curve** Replaces a surface boundary curve with a new boundary curve (Section 2.12).
- **Export Curve** Exports point coordinates to a \*.log file (Section 2.13).
- **Plot Curve** Plots inflection points, curvature and first derivative of a selected curve (Section 2.14).



## 2. Airfoil & Wing Generation

The generation of airfoils and wings is made possible by several utilities within AeroPack. The first utility creates a planform outline consisting of leading and trailing edges as well as root and tip chords. The second utility is the airfoil wizard, which creates airfoils on chord lines. Using the utilities together provides the designer with tools to quickly create wings as shown in Figure 2.1.



*Figure 2.1 Wing Construction*

### 2.1 Wing Planform

The wing planform tool creates half of a wing outline, in a specified plane (see Figure 2.2a), consisting of leading and trailing edges and root and tip chords.



*Figure 2.2a Wing Planform Orientation*

Figure 2.2b shows the location of the axis planes.

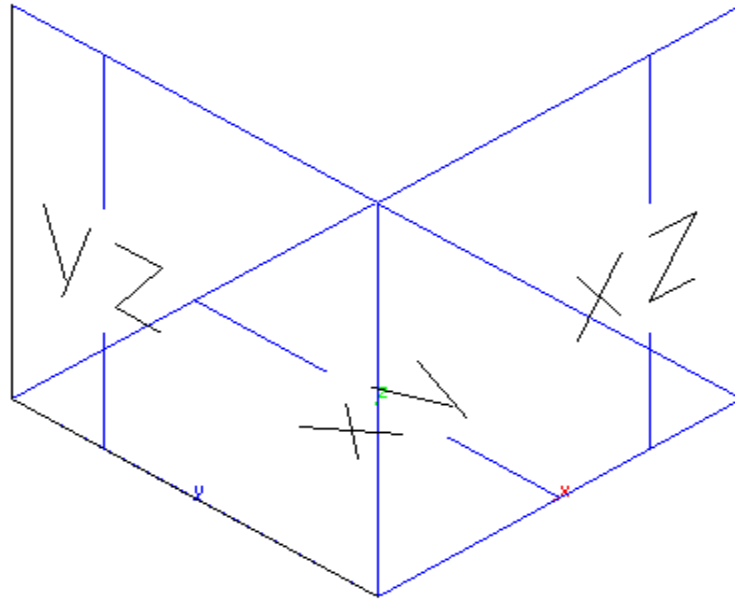


Figure 2.2b Axis System/ Work Planes

Four input methods are available (See Figure 2.3a). The default method (AR/S/Taper/SweepQC) creates a planform from the designer supplying the aspect ratio, surface area, taper ratio, and sweep of the quarter chord line (see Figure 2.3b). Click the OK button to add the planform in the drawing file.

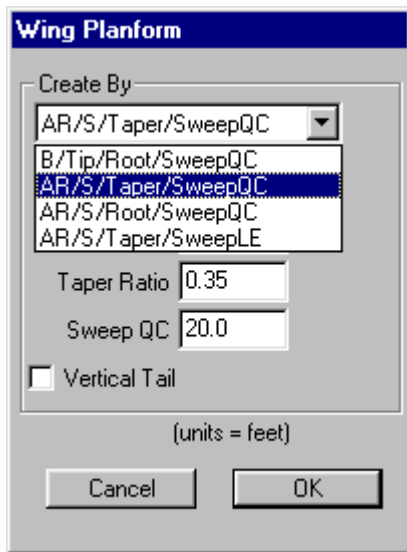


Figure 2.3a Wing Planform Options

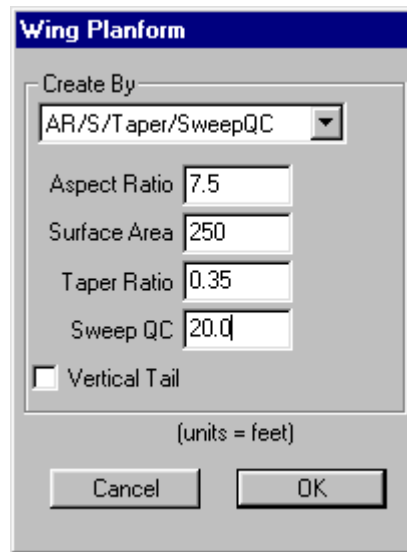


Figure 2.3b Wing Planform Dialog

By selecting from the drop down list, other input combinations can be chosen (Figure 2.3a):

- B/Tip/Root/SweepQC: Enter the surface span, tip chord length, root chord length and sweep of the quarter chord line in degrees.
- AR/S/Taper/SweepQC: Enter the aspect ratio, surface area, taper ratio and sweep of the quarter chord line in degrees.
- AR/S/Root/SweepQC: Enter the aspect ratio, surface area, root chord and sweep of the quarter chord line in degrees.
- AR/S/Taper/SweepLE: Enter the aspect ratio, surface area, taper ratio and sweep of the leading edge.

The following equations and Figure 2.4 define these input parameters.

AR = aspect ratio: aspect ratio is defined as the wing span squared divided by the wing area

$$AR = \frac{b^2}{S} \quad \text{Equation 2.1}$$

ct = tip chord: length of tip chord

cr = root chord: length of root chord

Sweep QC (c/4): sweep angle of the wing measured to the quarter chord line

Sweep LE: sweep angle of the wing measured to the leading edge

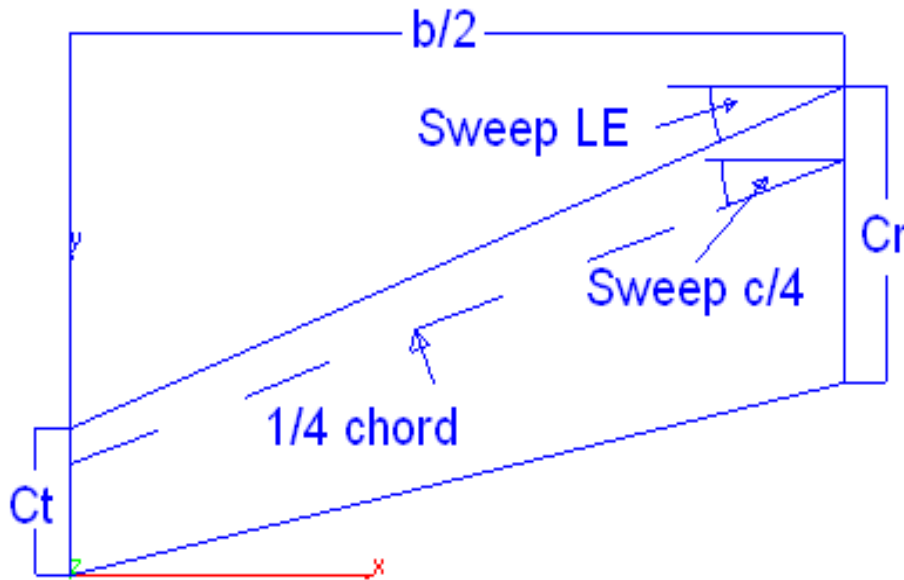
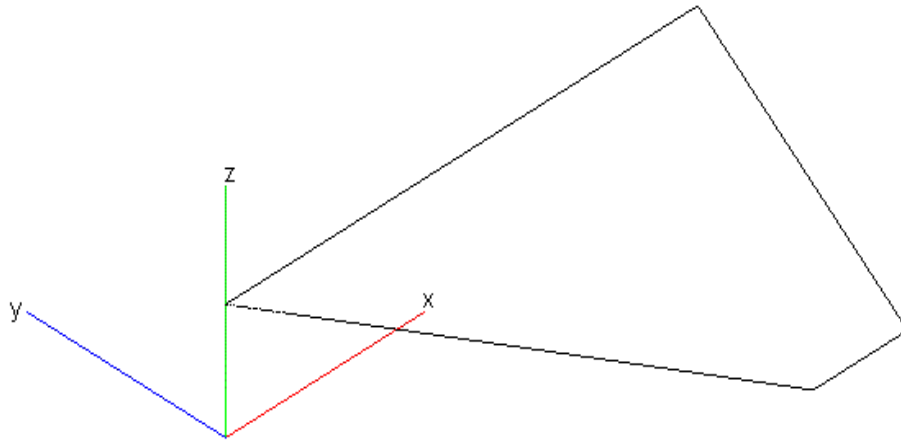


Figure 2.4 Wing Dimensions Needed For Wing Planform Tool

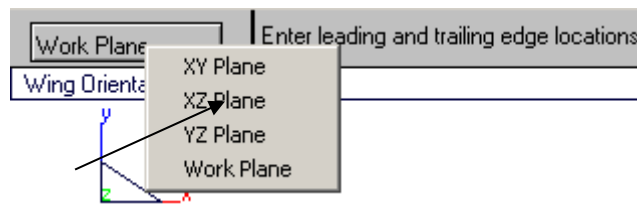
After entering the required parameters and selecting the OK button, four lines defining the half-wing edges are created (see Figure 2.5).



*Figure 2.5 Wing Planform Results*

## 2.2 Create Airfoil

The airfoil wizard provides a variety of methods for creating wing sections. The designer can choose from two methods that include specifying a preexisting text file, or by specifying parameters that will create an airfoil from equations. In addition to identifying the airfoil type, the designer selects the orientation and provides the leading and trailing edge locations. The orientation is defined by the pull down menu shown in Figure 2.6a. Figure 2.6b shows an airfoil drawing in the XZ plane.



*Figure 2.6a Airfoil Orientation*

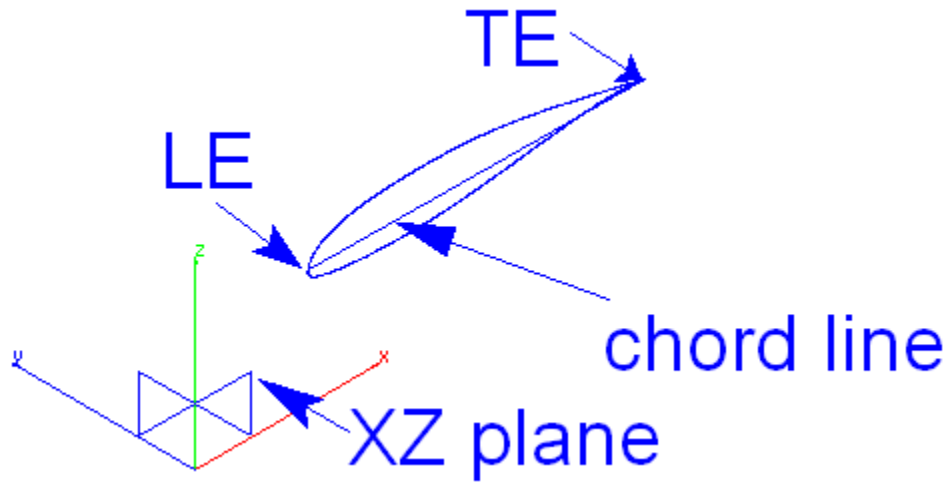


Figure 2.6b Airfoil Drawn On the XZ Work Plane

After selecting the airfoil wizard from the tool bar, the default airfoil wizard dialog box is displayed as shown in Figure 2.7. The initial dialog box displays airfoils that are read in from text files in the Airfoil Folder. When an airfoil is selected on the left hand side of the dialog box, a preview is displayed on the right hand side. Clicking on the OK button will rotate and scale the chosen airfoil to the provided plane, leading edge and trailing edge locations.

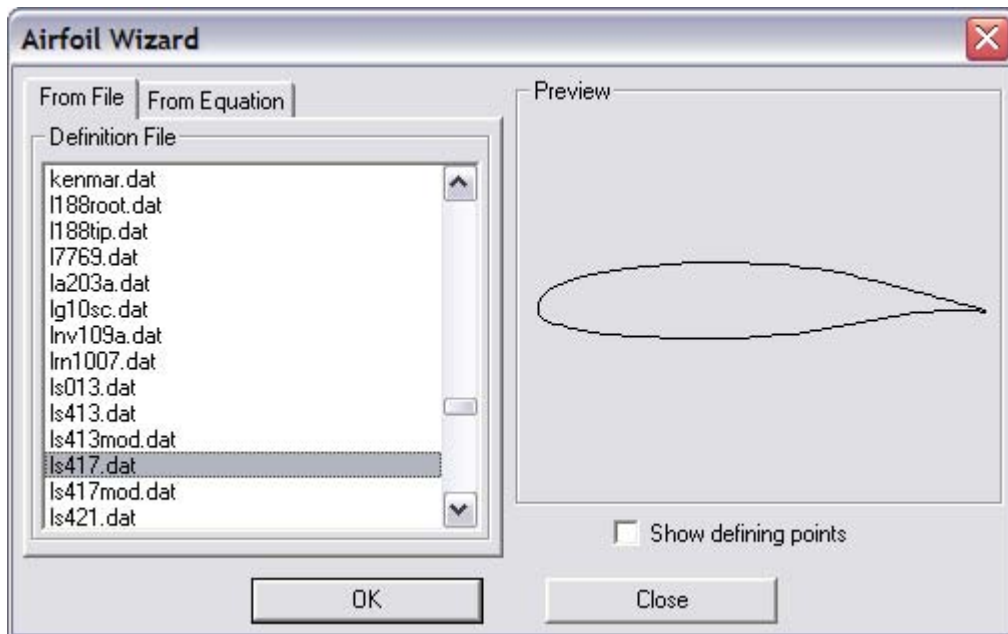


Figure 2.7 Airfoil from File

Airfoils can be added to the list by placing formatted ASCII files in to the Airfoils folder. The airfoil file formats recognized by AeroPack are listed in Appendix A. In addition to the airfoils provided, AeroPack recognizes the airfoils found in the UIUC database, which contains over 1550 airfoils. You can access these files if you have access to the web (the URL is: [http://aerospace.illinois.edu/m-selig/ads/coord\\_database.html](http://aerospace.illinois.edu/m-selig/ads/coord_database.html)).

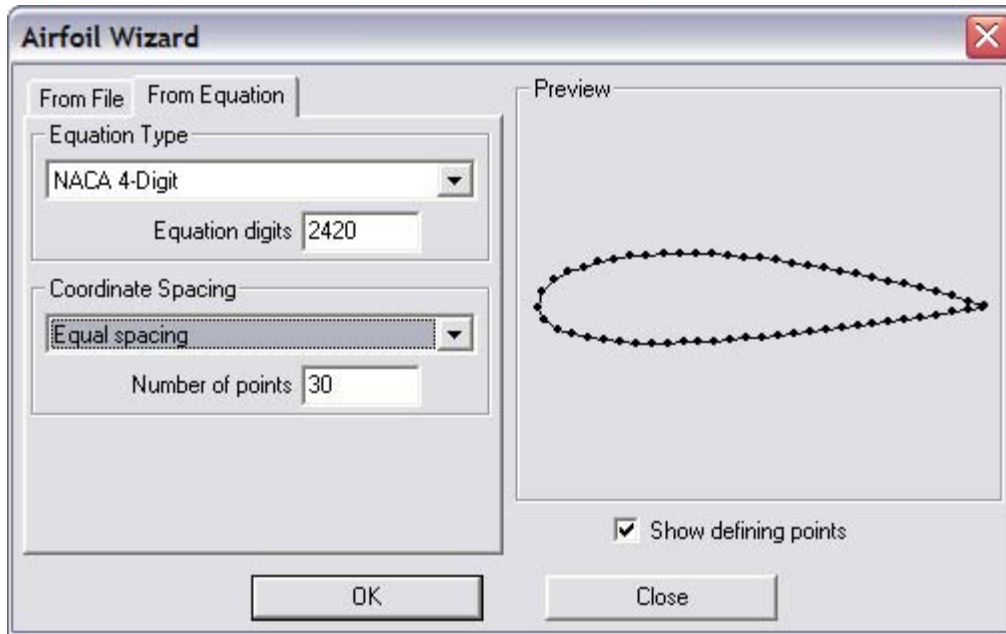
**TIP:** Remember to specify enough decimal digits when creating an airfoil file. Even though it may seem small, the values are scaled to the chord. On a large wing with a chord length of 72 inches a 0.005 deviation will result in a 0.36-inch section deviation!

### NACA Airfoils

The second method for creating airfoils is from NACA equations. When the From Equation tab (see Figure 2.8) is selected, the dialog box will reconfigure to accept input for airfoils that can be defined by equation type. The airfoil wizard supports NACA 4 Digit, NACA 5 Digit, NACA Modified 4 Digit, NACA 16 series and symmetrical biconvex airfoils. To create an airfoil by equation, select the equation type, enter the NACA digit identifier, and the preview window will display the airfoil. To see the point distribution in the preview window, select the “Show defining points” option. When the desired airfoil is obtained, click the OK button to transform the equation onto the chord. Example inputs for each equation are:

*Table 2.1 Example of NACA Airfoil Section*

NACA 4 Digit	2412	2410	0008
NACA 5 Digit	21012	22112	24212
NACA Modified 4	000812	241215	211015
NACA 16	11011	22112	21012
Symmetrical	0.08	0.10	0.15

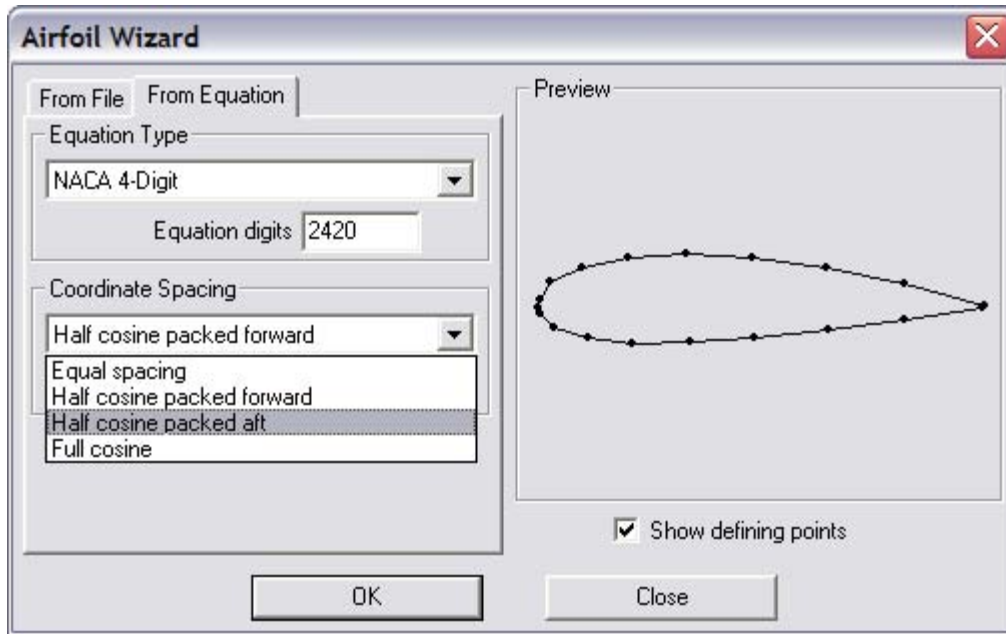


*Figure 2.8 Airfoil from Equation*

A detailed description of each airfoil numbering system can be found in *Theory of Wing Sections* by Abbott and Von Doenhoff. In particular, Chapter 6 has an excellent discussion of the history and mathematical description of the various forms of NACA airfoils.

The Coordinate spacing option allows the designer to control the point distribution for the airfoil. The coordinate spacing options are:

- |                                   |   |
|-----------------------------------|---|
| <b>Equal Spacing</b>              | Distributes points equally spaced along the chord   |
| <b>Half Cosine Packed Forward</b> | Distributes points more densely spaced near the leading edge  |
| <b>Half Cosine Packed Aft</b>     | Distributes points more densely spaced near the trailing edge                                       |
| <b>Full Cosine</b>                | Distributes points at the leading and trailing edges, leaving the middle less populated with points |



*Figure 2.9 Advanced Options*

The designer may also specify the number of points distributed on the upper and lower surfaces of the airfoil. The default of 10 will create an airfoil whose upper and lower surfaces total 20 points. Be careful when using over 20 points, since this may over constrain the spline and cause unwanted wobbles in the curve.



### **NACA 4 Digit**

The numbering system for NACA wing sections of the four digit series is based on section geometry. The first integer indicates the maximum value of the mean-line ordinate in percent of the chord. The second integer indicates the distance from the leading edge to the location of the maximum camber in tenths of chord. The last two integers indicate the section thickness in percent of the chord. For example, the NACA 2314 wing section has 2 percent camber at 0.3 of the chord from the leading edges and is 14 percent thick. Symmetrical sections are designated by two zeros (0012) in the first two digits.

### **NACA 5 Digit**

The numbering system for the wing sections of the NACA five digit series is based upon a combination of theoretical aerodynamics and geometrical characteristics. The first integer indicates the amount of camber in terms of the relative magnitude of the design lift coefficient. The design lift coefficient in tenths is therefore three-halves of the first integer. The second and third integers together indicate the distance from the leading edge to the location of the maximum camber. This distance is in percent of the chord. The NACA 23012 wing section has a design lift coefficient of 0.3, a maximum camber at 30 percent chord, and a thickness ratio of 12 percent.

### **NACA Modified 4 and 5 Digit**

The first integer following the dash indicates the relative magnitude of the leading edge radius. The normal leading edge radius is designated by 6 and a sharp leading edge by 0. The leading edge radius varies as the square of this integer except for values larger than 8. The second integer following the dash indicates the position of maximum thickness in tenths of chord. The suffix 63 indicates sections very nearly but not exactly the same as sections without the suffix. Two examples of NACA Modified 4 and 5 digit airfoils are:

NACA 0012-64

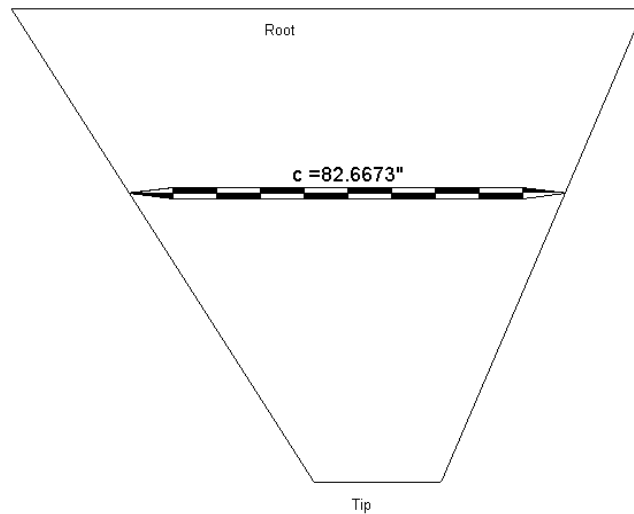
NACA 23012-64

## Symmetrical Biconvex Airfoil

Creates an airfoil that is symmetrical about the chord line.

### 2.3 MGC Symbol

The mean geometric chord (MGC) for a straight tapered surface is calculated from a root and tip chord for a given half-span. The symbol displays ten alternating black and white patterns useful for visually calculating percentages from the leading edge (see Figure 2.10). The length of the MGC is displayed as a text entity in the current unit symbol defined in the preferences dialog.



*Figure 2.10 Straight Tapered Wing Planform*

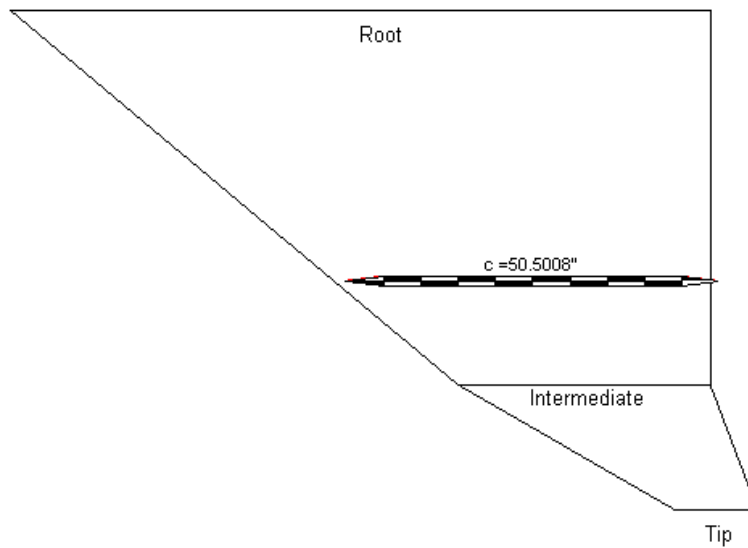
To create a MGC symbol for a straight tapered surface:

- 1) Select 'MGC' on the AeroPack tool palette
- 2) Select the root chord
- 3) Select the tip chord

To create a MGC symbol for a cranked surface:

- 1) Select 'MGC' on the AeroPack tool palette
- 2) Select the root chord
- 3) Select the intermediate chord
- 4) Select the tip chord

Notice that for a cranked wing, the MGC doesn't necessarily fall on the leading or trailing edges of the wing (Figure 2.11).



*Figure 2.11 Cranked Wing Planform*

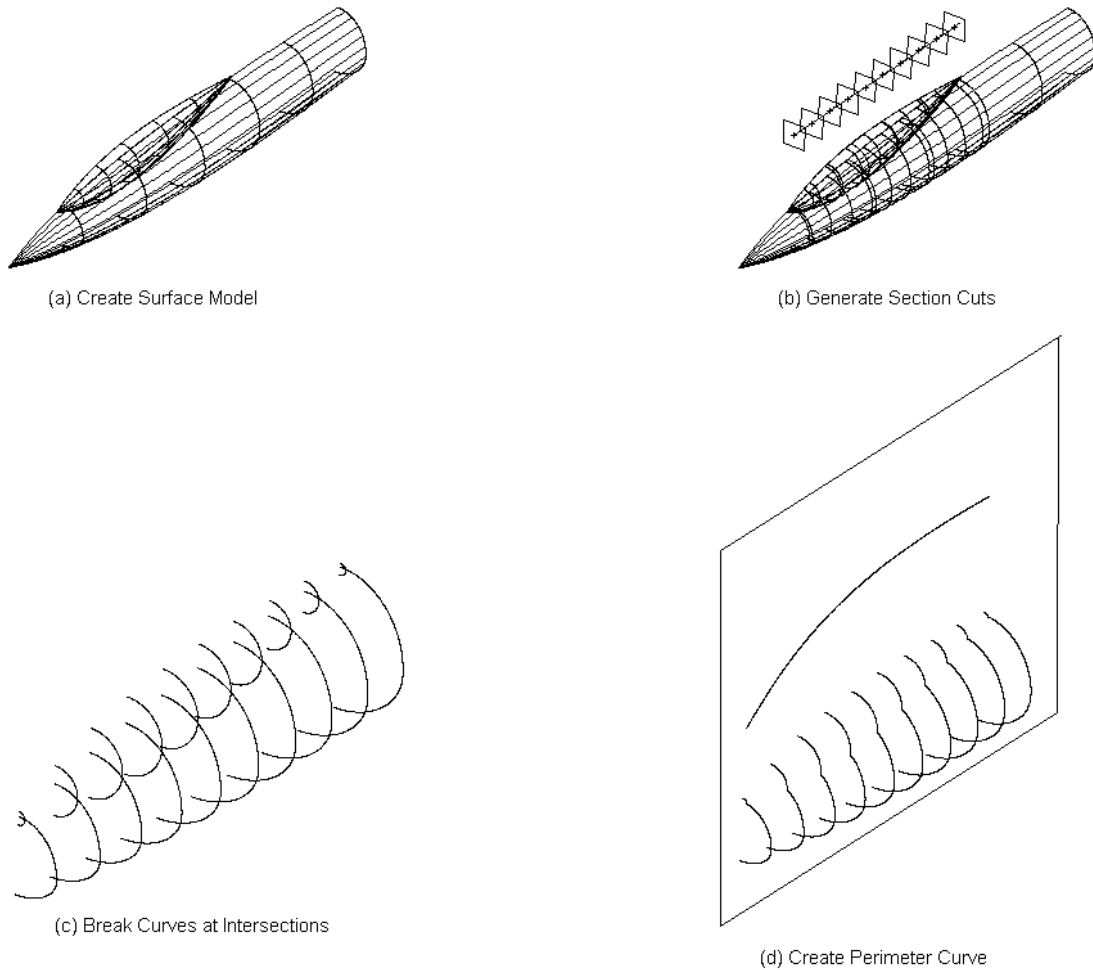
## 2.4 Perimeter Curve

A perimeter curve is a plot of wetted surface perimeters as a function of body stations. Perimeter curves are useful for calculating wetted areas of a surface. To calculate the wetted area from a perimeter curve, simply calculate the area underneath the perimeter curve. Likewise, a perimeter curve that sharply increases or decreases its slope may indicate undesirable surface characteristics.

To create a perimeter curve, select a group of fuselage station (constant x values) curves. The perimeter procedure will sort and calculate the lengths of all the curves at the same X station. Each unique set of sections will create a point on the perimeter curve (ten stations create a ten-point perimeter curve).

## Perimeter Curve Tips

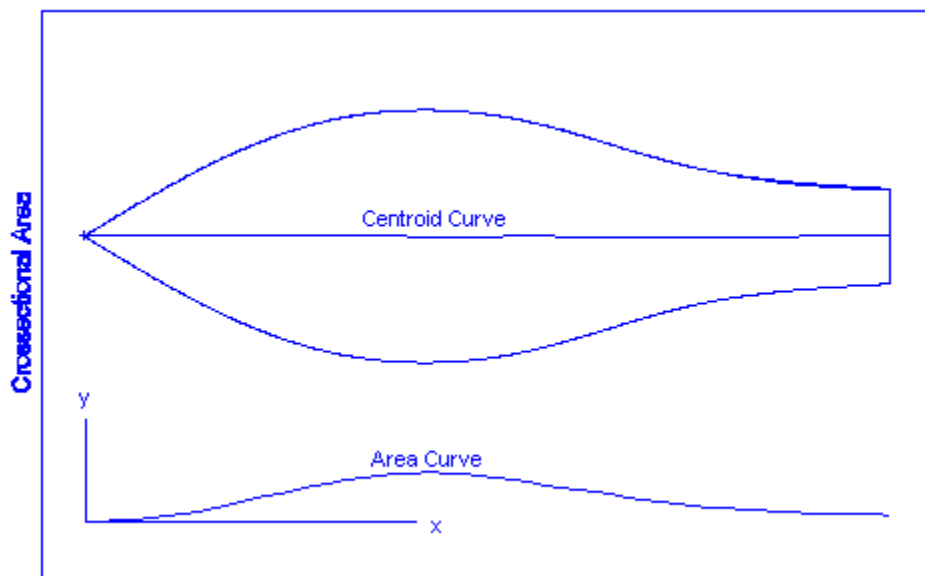
See Figure 2.12 below for tips on creating perimeter curves.



*Figure 2.12 Perimeter Curve Examples*

## 2.5 Area and Center of Gravity (CG) Curves

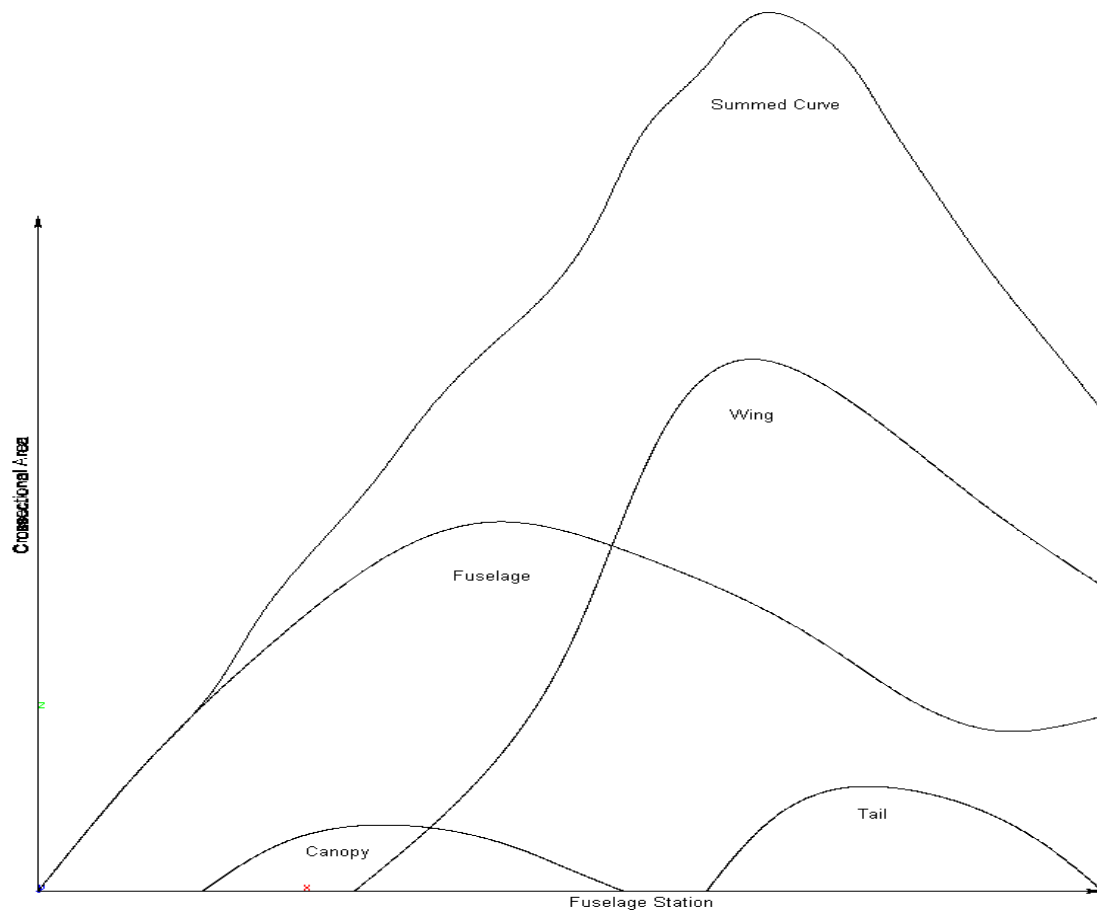
The area/CG curve tool is useful for interfacing with wave drag analysis as well as volume calculations. The designer creates an area curve by selecting a collection of trimmed surfaces. The method automatically generates fuselage section cuts, closes the section, and plots the data into a curve represented in the XZ plane. X values represent fuselage stations and Z values represent the actual cross sectional area value at that station (see Figure 2.13). Used in conjunction with the curve integration tool, the designer may calculate a volume associated with the area curve.



*Figure 2.13 Area and CG Curve*

## 2.6 Sum Curves

Associated with the area curve tool is the sum curves tool. The sum curves tool adds two curves together. The curves must lie in the XZ-plane. The sum curves tool is useful for generating summed area curve plots as shown in Figure 2.14.



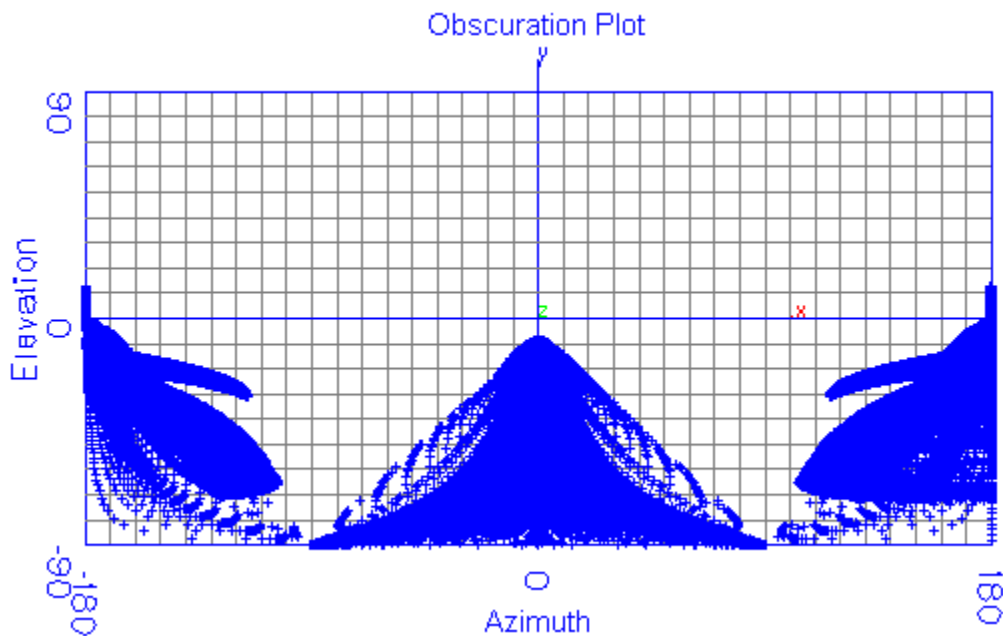
*Figure 2.14 Summed Curves*

## 2.7 Curve Integration

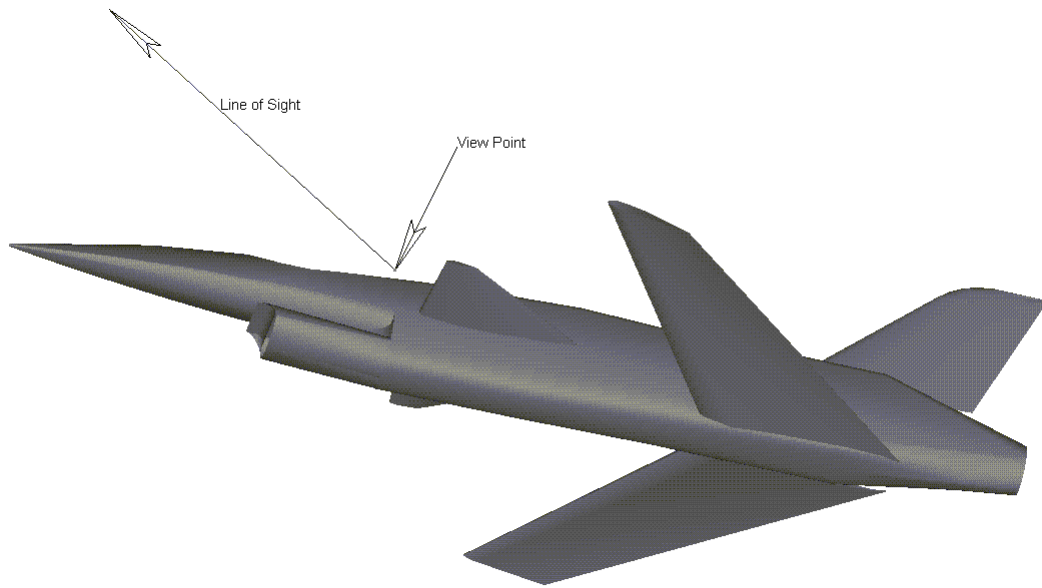
This tool integrates the area of a curve that lies in the XZ plane. Used in conjunction with the perimeter and area curves, this tool will calculate a wetted area and volume respectively, depending upon whether the curves represents an area or a perimeter. After selecting the tool, the curve can be selected for integration.

## 2.8 Obscuration/Vision Plot

Obscuration plots are used to determine the field of view for a pilot, antenna, or sensor. The designer specifies the location of interest (origin of sight). The line of sight (azimuth and elevation equal to 0.0 degrees) is taken parallel to the negative x-axis. The results are presented in a plot of points in azimuth (+/- 180 degrees) and elevation (+/- 90 degrees). The obscuration plot is created in a new layer. The points in the plot represent azimuth and elevation combinations where the line of sight is blocked by an object. Note: When creating an obscuration plot from surfaces, the density of the plot is dependent upon the resolution of the surfaces. The plot gets denser with higher resolution.



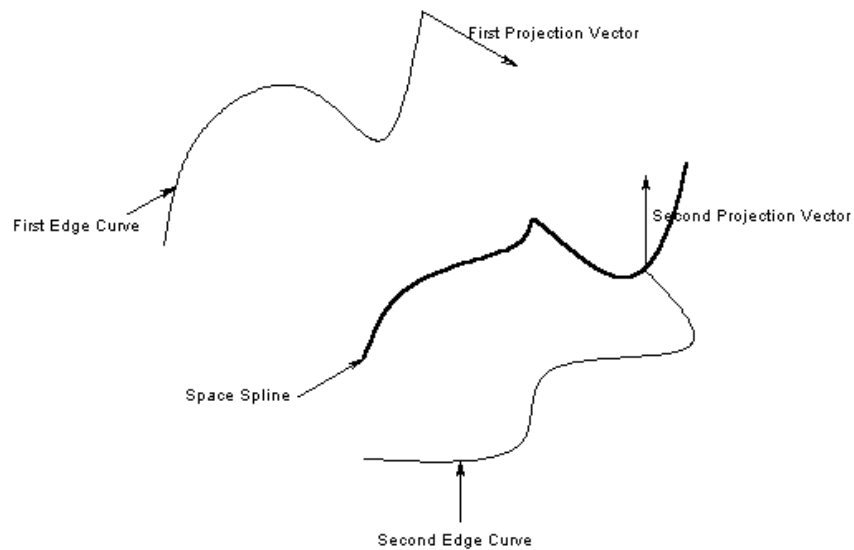
*Figure 2.15 Obscuration Plot*



*Figure 2.16 Obscuration Geometry*

## 2.9 Space Spline

The Space Spline tool on the AeroPack tool palette automates the method shown in Figure 3.2.8. The space spline tool is used by selecting the two edge curves, and then specifying a projection vector for each curve. The program then calculates the intersection of two surfaces defined by the edge curves and projection vectors (see Figure 2.17).



*Figure 2.17 Space Spline Construction*



## 2.10 Import Airplane

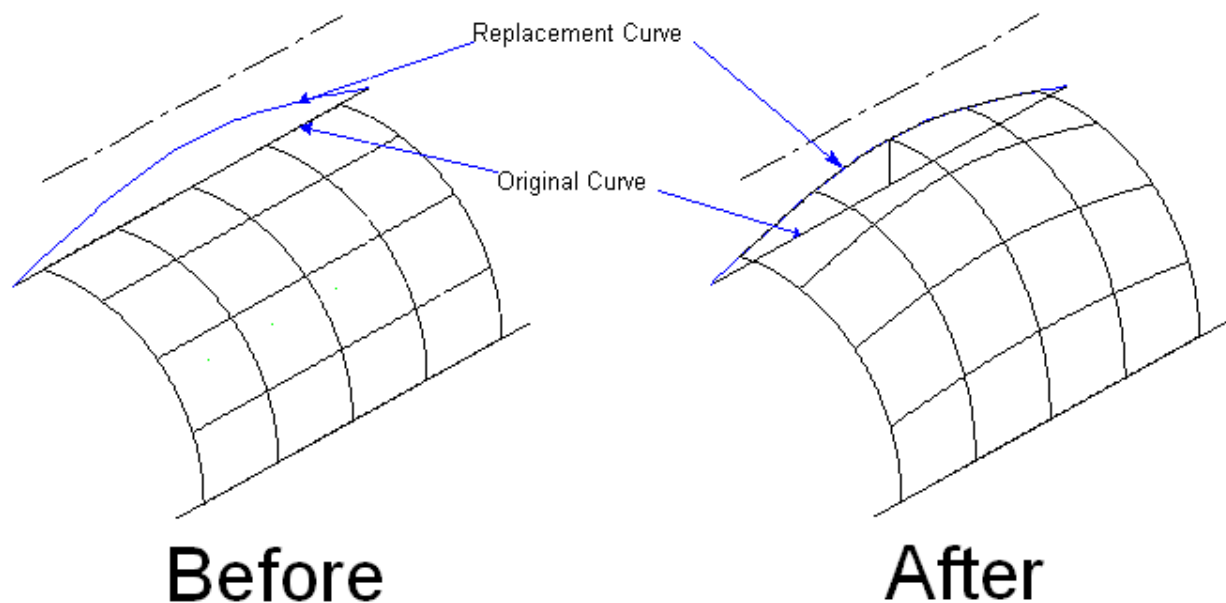
The Import Airplane option allows for the importing of airplane geometry from the Advanced Aircraft Analysis (AAA) software package. The program requires the \*.geo file created by AAA. To use this feature, open a new drawing and select Import Airplane. When airfoils are defined in the AAA software, be sure these airfoils are available on your computer.

## 2.11 Polyconic Surface

The polyconic surface tool is outlined in Chapter 3.

## 2.12 Replace Curve

The replace curve tool replaces a curve used to create a surface boundary with another curve creating a new boundary as shown in Figure 2.18.



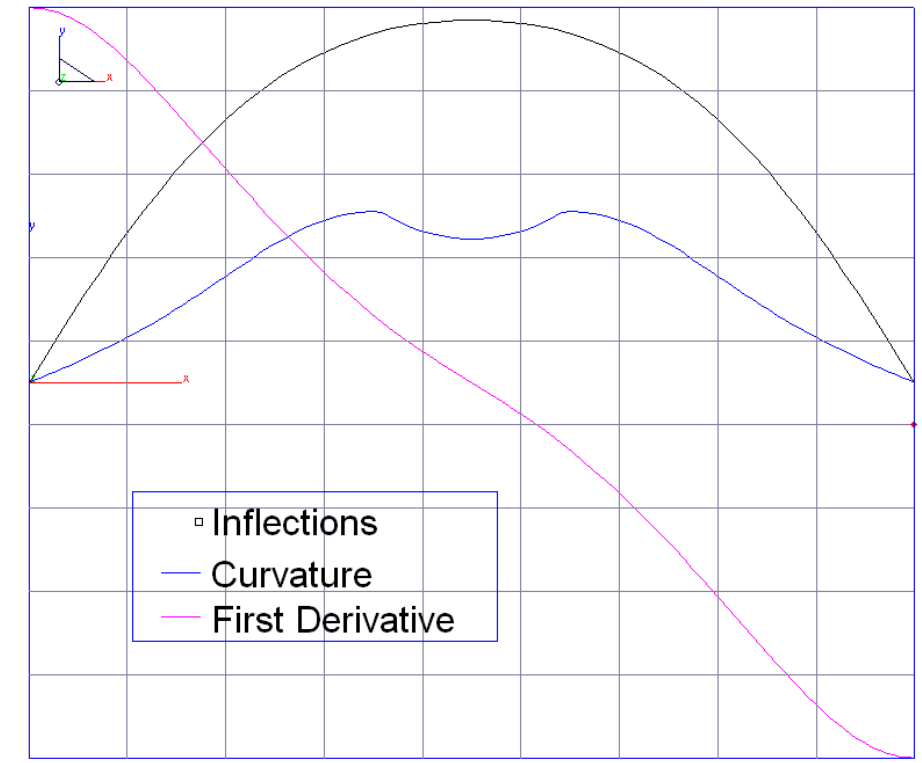
*Figure 2.18 Replace Curve Tool*

## 2.13 Export Curve

The export curve tool exports the coordinate points of a curve to a \*.log file.

## 2.14 Plot Curves

The plot curve tool plots inflection points, curvature, and the first derivative of a selected curve as shown in Figure 2.19.



*Figure 2.19 Plot Curves Tool*

### 3. Advanced Surface Modeling

This chapter introduces you to several tools for creating fuselage, nacelle and ducts, and other components of your aircraft. The tools focus on constructing surfaces based upon polyconic surfaces.

#### 3.1 Polyconic Surfaces

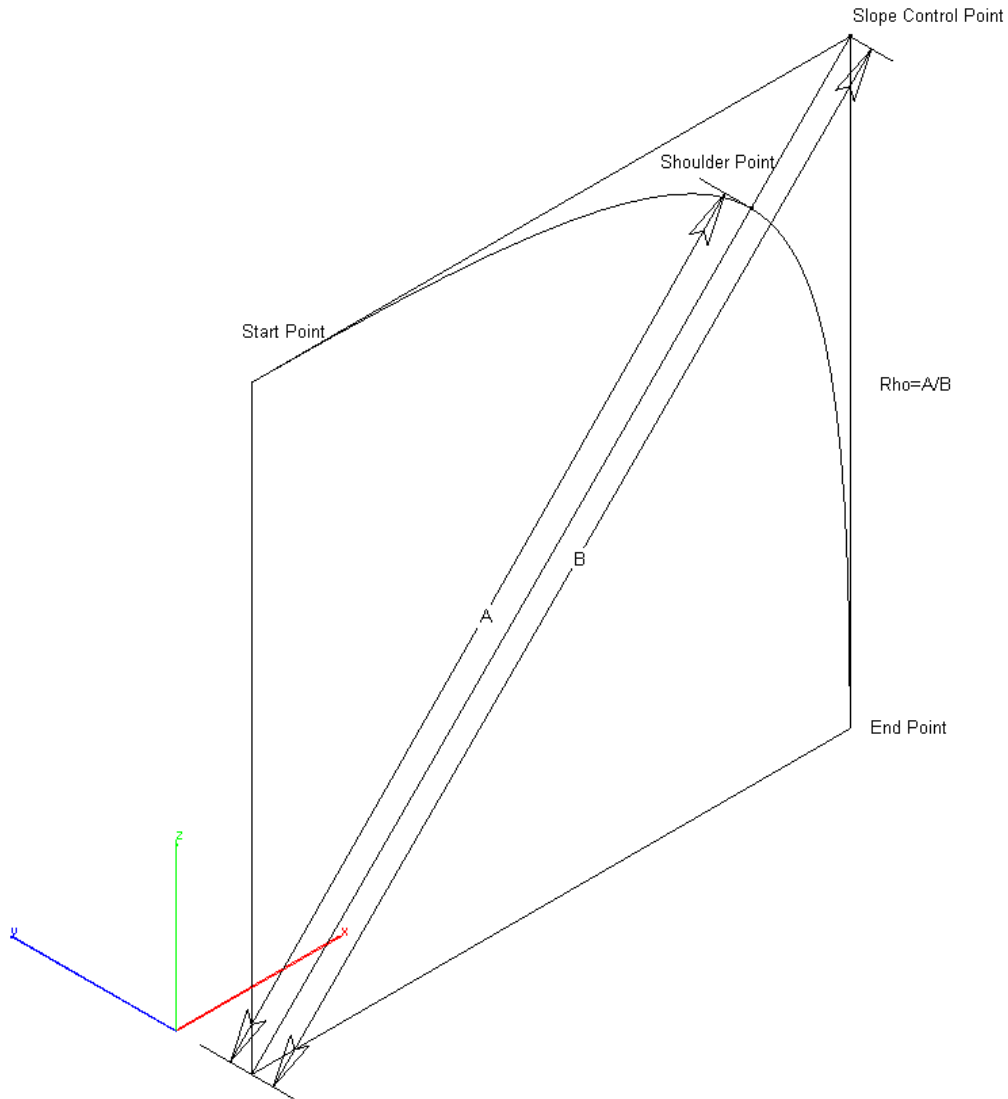
One of the first successful implementations of the polyconic surface is the fuselage design of the famous P-51 “Mustang” fighter. In light of the care being taken with the development of the P-51 airfoils, the design leadership held a firm conviction that the fuselage must be treated with similar care. The designers used smooth conic sections with key parameters controlled by longitudinal shoulder and slope control curves. The longitudinal curves defined fullness and tangency values for the conics from forward to aft of the fuselage. The P-51 designers found that this technique allowed them to accurately control sectional areas to secure the required effects for lift, drag, stability, and overall performance. There are very few resources describing polyconics, one is by Dr. Roy A. Liming in his book titled *Mathematics for Computer Graphics*.

Since the P-51, the polyconic surface has evolved into a precisely fitted NURB surface used in the design of most major aircraft. Over 70 percent of the surfaces defining the F-16 and F-22 military aircraft are defined by polyconic surfaces. Although now represented as a NURB surface, the polyconic is still “fit” to a collection of conics defined by shoulder and slope control curves. With the introduction of a curved axis (a spine) for the polyconic surface, designers no longer need to limit their use to fuselages but can use them in almost all aspects of aircraft surface design.

#### *Terms and Definitions*

Polyconic surfaces are based upon collections of conics spanning the extent of the body. The conic is a smooth second order curve defined by a start, end, shoulder, and slope control point (see Figure 3.1). One of the more popular representations of the conic is replacing the shoulder point with a rho value. A rho value defines the length of the trapezoid diagonal enclosing a

conic and the position where the conic passes through the diagonal. Conics with rho values greater than 0.75 are hyperbolas, less than 0.75 are ellipses, and equal to 0.75 are parabolas. A rho value of 0.707 with equal lengths for horizontal and vertical slopes represents a circular arc. The rho value ranges from 0.501 to 0.999.



*Figure 3.1 Conic Definition*

The conic sections are defined relative to control curves. The control curves frequently used include first edge, second edge, slope control, shoulder, spine, and rho curves.

**First Edge Curve**

A curve defining the starting edge of the polyconic surface.

**Second Edge Curve**

A curve defining the ending edge of the polyconic surface.

**Spine Control Curve**

In a polyconic surface, the conic sections are oriented in a plane defined by the surface spine. The spine also defines the length of the polyconic surface as shown in Figure 3.2.1. The spine allows polyconic surfaces to describe curvy inlet lips as well as fuselage bodies.

**Slope Control Curve**

The slope control curve defines the surface tangencies. The slope control curve is the intersection of the tangents from the first and second edge curves

**Rho-Value Law Curve**

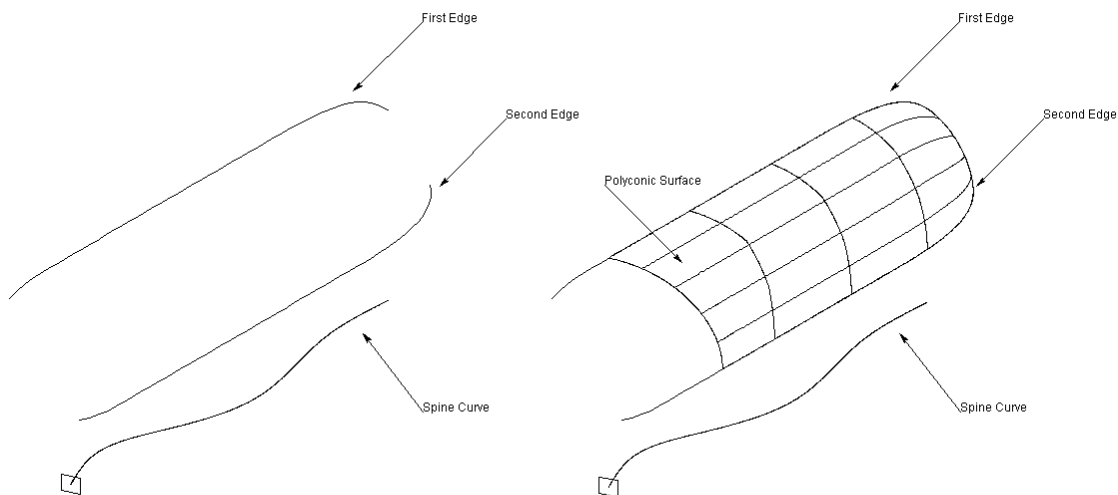
The Rho-Value Law curve defines the fullness value for the surface as a function of the spine. In other words it describes the curvature of the surface. The Rho-Value Law curve is displayed between the values of 50 and 100.

## 3.2 Polyconic Surface Control Curves

The following are some examples of how to create and use the control curves necessary in creating a polyconic surface. Section 3.3 will describe the various types of polyconic surface creation methods.

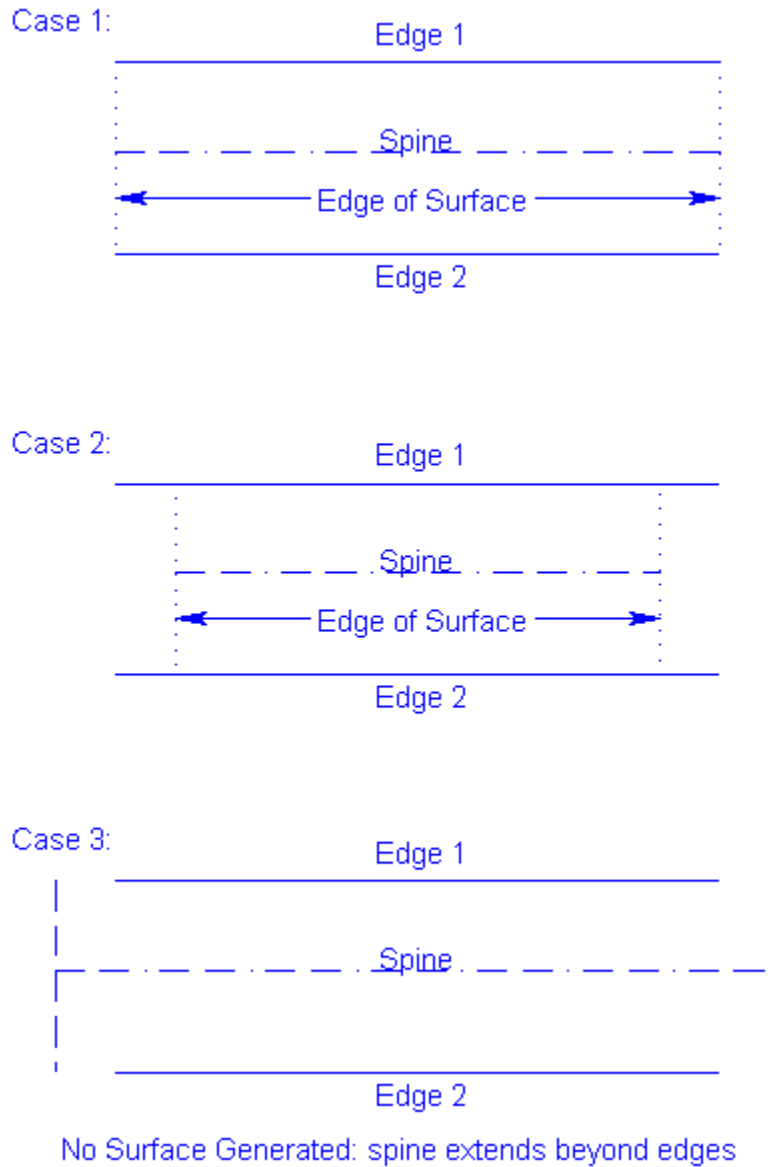
### 3.2.1 Polyconic Spines

A spine used in conjunction with a polyconic surface defines length and conic orientation. The conic orientation is defined in a plane, which is calculated perpendicular to the spine tangent.



*Figure 3.2.1 Spines*

**NOTE:** Figure 3.2.2 shows two edge curves and a series of three spine curves. The spine curve in case one will create a surface over the entire length. Case two will only create a surface as long as the spine curve itself, not as long as the edge curves. If the spine curve extends beyond the edge curves as in case three, the polyconic surface will NOT be created. Edge 2 can be greater than edge 1.



*Figure 3.2.2 Definition of Spine Curve*

### 3.2.2 Rho-Value Law Curve

To display the Rho-Value Law curve of a polyconic surface, select the surface and choose ‘Edit Objects...’ from the Edit menu or (Ctrl + I). The Rho-Value Law curve is a spline, which can be modified by adding or removing control points. Figures 3.2.3 is an example of a polyconic surface with a straight line Rho-Value Law Curve. This results in a surface that has constant conic value across the entire surface.

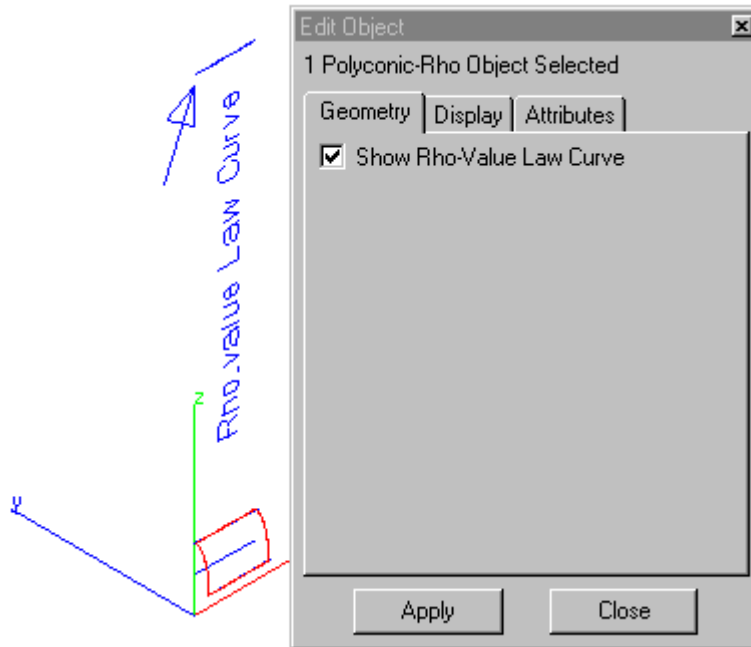


Figure 3.2.3 Edit Object Window and Rho-Value Law Curve

Figure 3.2.5 shows a polyconic surface that has been edited using the Rho-Value Law Curve. The same procedure used to create Figure 3.2.3 is used here, but the Rho-Value Law Curve has been edited to add some curvature to the surface. To create this wavy surface, three extra points had to be added to the Rho-Value Law Curve spline. This is done using the “Add control point to a spline” tool. This is the seventh tool in this window, Figure 3.2.4.



Figure 3.2.4 Spline Tear Out Window

Now we have to edit the Z coordinate of the point that we want to change. For this spline the coordinates represent the conic value at each point in the polyconic surface. If we change the 20% and 70% locations of the spline to 75 ( $0.75 \cdot 10$ ), the polyconic surface will change and will have a conic value of 0.75 at these exact locations. Changing the tangent vectors of the spline can also control the shape of the surface. This is shown later in this section of the tutorial.



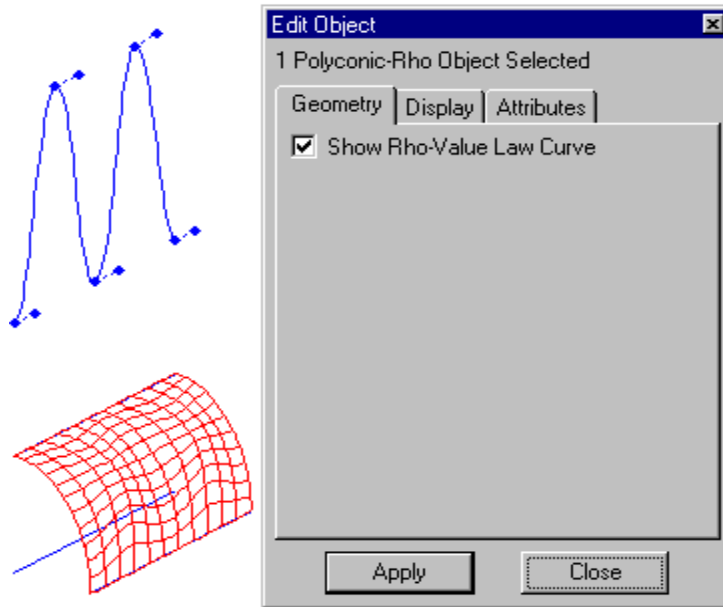


Figure 3.2.5 Rho-Value Law Curve With Additional Points

Figure 3.2.6 shows how changing the value of the Rho-Value Law curve defines the shape of the surface being defined. A Rho value of 50 represents a flat edge whereas a value of 100 represents a sharp corner. A value of 70.7 represents a circle and this can be seen above in Figure 3.2.5.

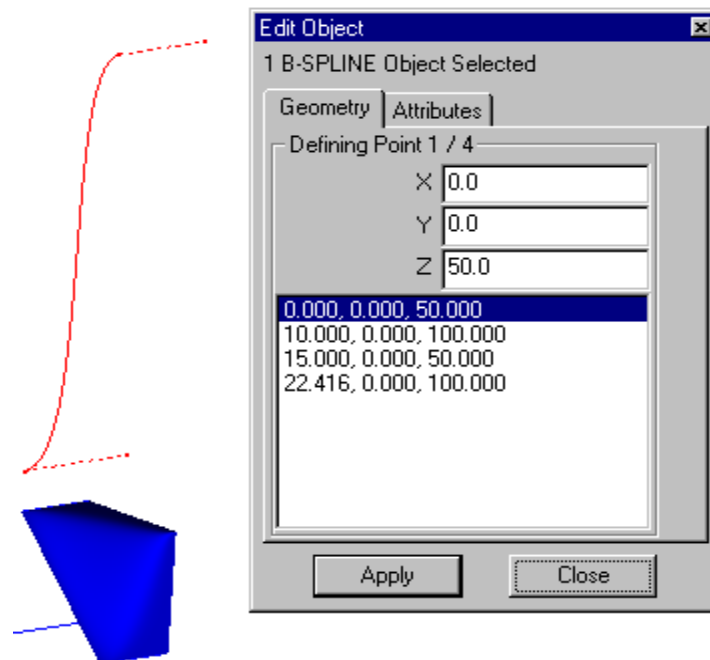


Figure 3.2.6 Example Of How Rho Value Effects Surface Contour

### 3.2.3 Shoulder Curve

Like the Rho-Value Law curve, the shoulder curve defines the fullness value of the surface. It is the designer's option whether to use a rho or shoulder curve to define the fullness of the surface. Figure 3.2.7a shows an example of a shoulder curve. By putting a spline through the midpoints of five conics (dashed lines) the shoulder curve is generated. The shoulder curve works well when you do not know what the conic values of a constructed surface are, such as a drawing from another CAD package. The shoulder curve would then just be a line that has been projected onto the surface. In most cases when starting from scratch this tool is not used due to the capabilities of the other tools. Figure 3.2.7b is another example, but with the conic definition points and tangency vectors shown. The dotted lines in Figure 3.2.7b DO NOT have to be perpendicular to each other as shown.

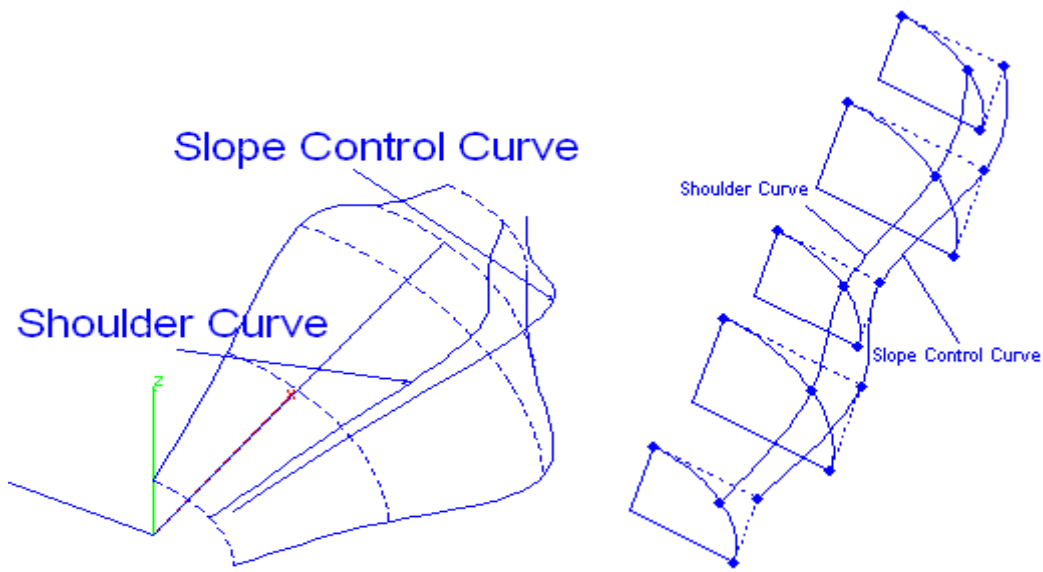
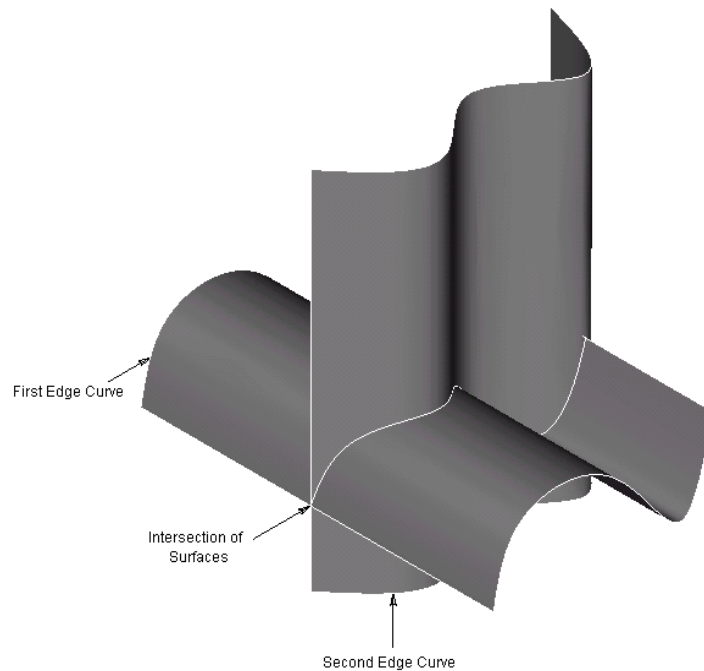


Figure 3.2.7a Example of a Shoulder Curve Figure 3.2.7b Example 2

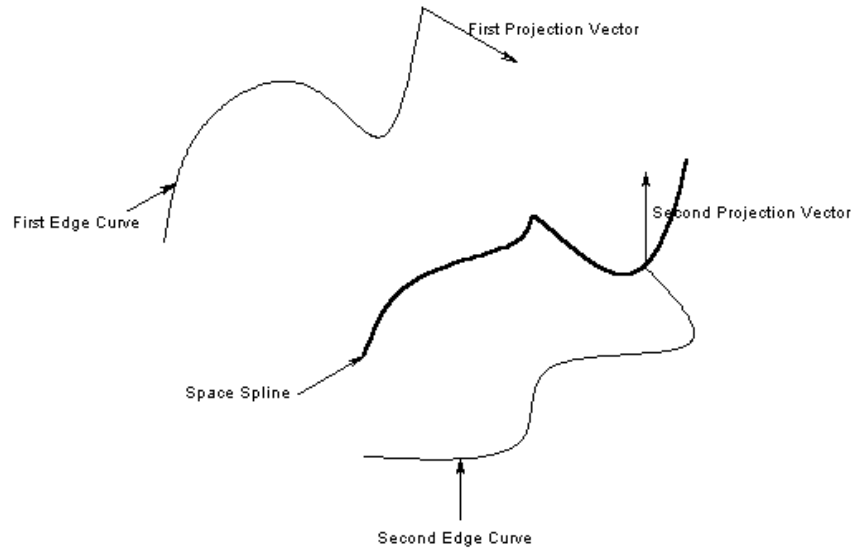
### 3.2.4 Constructing Slope Control Curves Using the Space Spline Tool

The polyconic slope control curve (see Section 3.1) is used to control the edge tangencies of the surface. To create a slope control curve, two options exist. The first option is to create two surfaces from the edge curves and intersect them. This technique is shown in Figure 3.2.8.



*Figure 3.2.8 Creating Slope Control Curve Using Intersecting Surfaces*

The Space Spline tool on the AeroPack tool palette automates the method shown above. The space spline tool is used by selecting the two edge curves, and then specifying a projection vector for each curve. The program then calculates the intersection of two surfaces defined by the edge curves and projection vectors (see Figure 3.2.9).



*Figure 3.2.9 Creating Slope Control Curve Using a Space Spline*

NOTE: Figures 3.2.10 and 3.2.11 show how the slope control curve defines surface tangency. Figure 3.2.10 shows the edge curves, spine curve, and the slope control curve. Notice that in this case the slope control curve is created at a 90-degree angle to the two edge curves. The edge curves can be the edges of other surfaces as shown in Figure 3.2.11. Notice in Figure 3.2.11 that the polyconic surface is tangent to the other cross-hatched surfaces. The slope control curve has no effect on the Rho-Value Law Curve; it only defines the tangency that the polyconic surface will sustain. The Slope Control Curve in this example is made, so that a 90-degree angle exists between the two surfaces that the polyconic is going to join. The slope control curve is created using the Space Spline tool in the AeroPack menu. Edge one is projected along the  $-y$ -axis and edge 2 is projected along the  $+z$  axis.

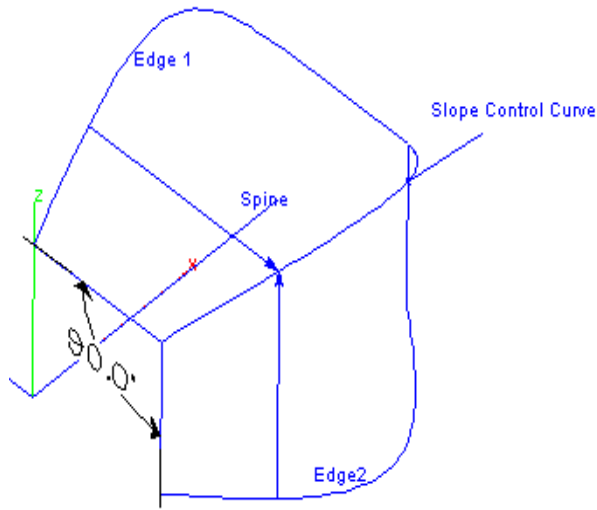


Figure 3.2.10 Slope Control Curve

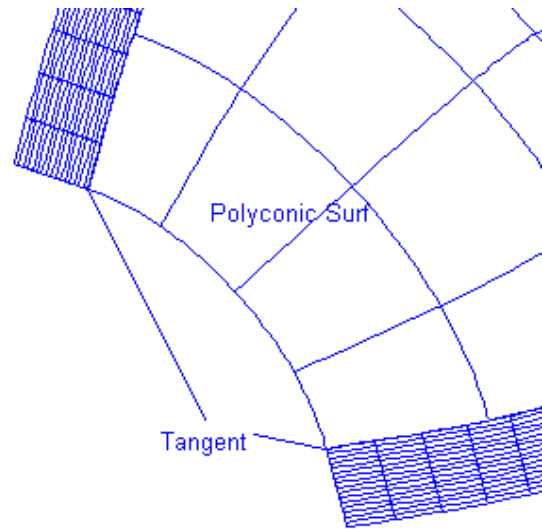


Figure 3.2.11 Tangent Surface

**NOTE:** Figure 3.2.12 below gives three examples as to how the slope control curve defines the surface tangency when created to join another surface. What we are looking for when we define this tangent surface is that the dashed lines are tangent to the object they requiring tangency, as shown in Figure 3.2.11.

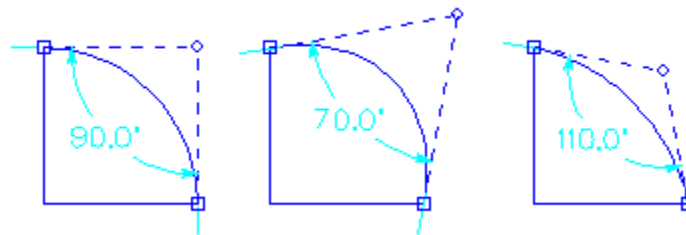
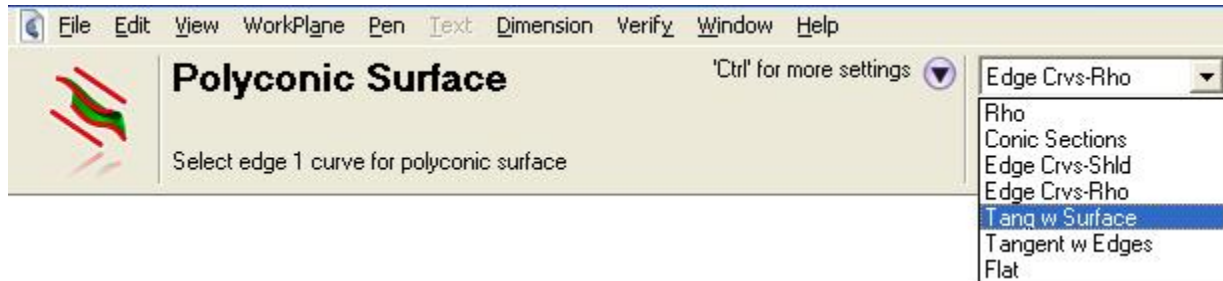


Figure 3.2.12 Example of Slope Control Curve Definition

### 3.3 Polyconic Surface Types

The designer can choose one of seven construction methods for polyconic surfaces (see Figure 3.3.1).



*Figure 3.3.1 Polyconic Surface Options*

- 1) Rho (First Edge, Second Edge, Rho)
- 2) Conic Sections (First Edge, Second Edge, Sections)
- 3) Edge Crvs-Rho (First Edge, Second Edge, Slope Control, Rho)
- 4) Edge Crvs-Shld (First Edge, Second Edge, Slope Control, Shoulder)
- 5) Tang w Surface
- 6) Tangent w Edges
- 7) Flat

#### 3.3.1 Rho (First Edge, Second Edge, Rho)

This option creates a polyconic surface given two edge curves. The resulting surface uses a horizontal slope for the first edge and a vertical slope for the second edge (With respect to a conic in the YZ plane). The initial surface uses a default rho of 0.707. Display the rho curve to change the shaping across the surface.

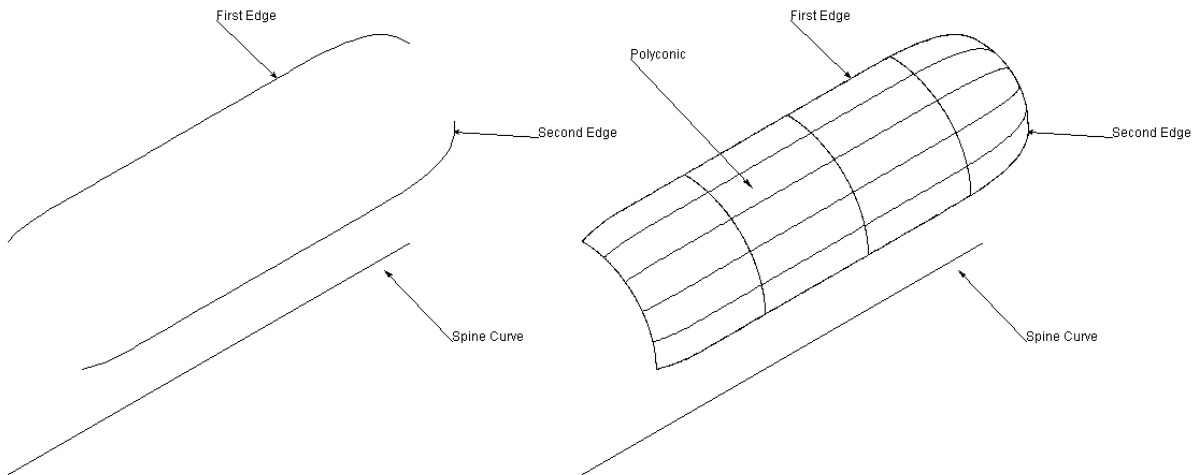


Figure 3.3.2 Edge, Edge, Rho

### 3.3.2 Conic Sections (First Edge, Second Edge, Sections)

Creates a polyconic surface from an upper and lower profile curve, and a collection of conic sections. From the given conics a rho and slope control curve is calculated.

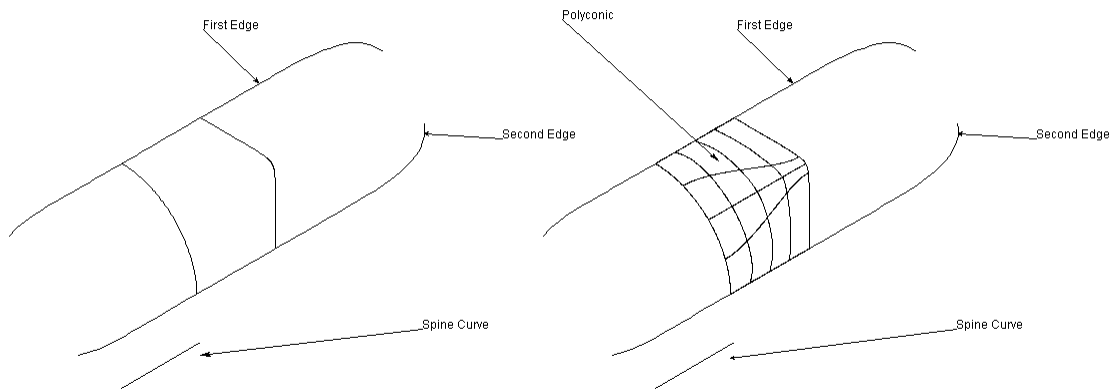
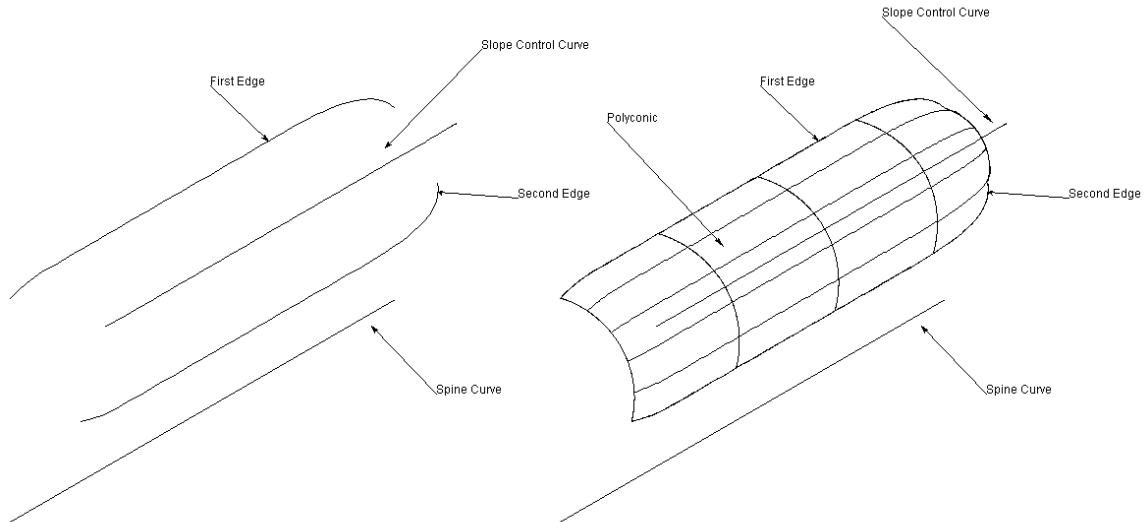


Figure 3.3.3 Edge, Edge, Sections

### 3.3.3 Edge Crvs-Rho (First Edge, Second Edge, Slope Control, Rho)

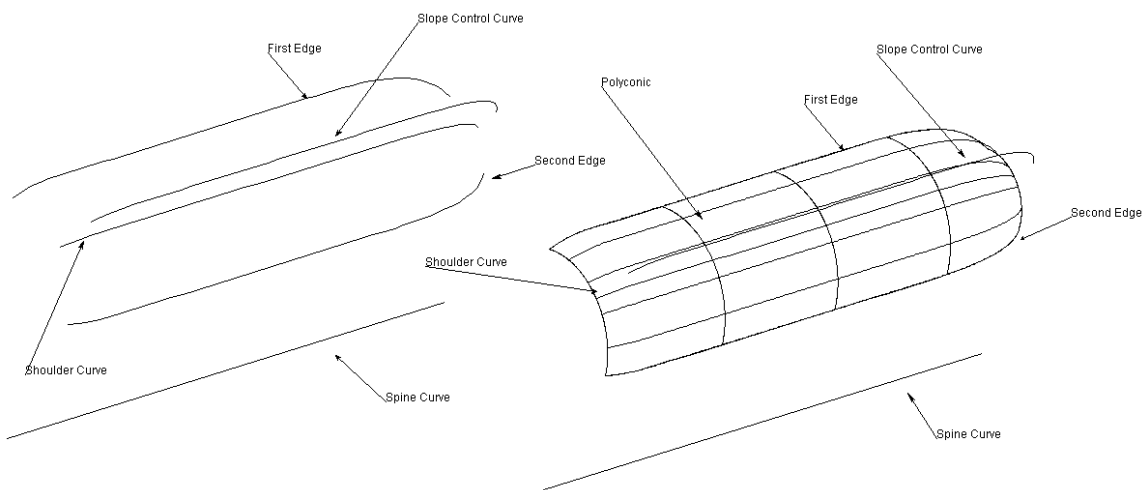
Creates a polyconic surface from an upper and lower profile curve, slope control, and a rho curve.



*Figure 3.3.4 Edge, Edge, Slope Control, Rho*

### 3.3.4 Edge Crvs-Shld (First Edge, Second Edge, Slope Control, Shoulder)

Creates a polyconic surface from an upper and lower profile curve, slope control, and shoulder curve.

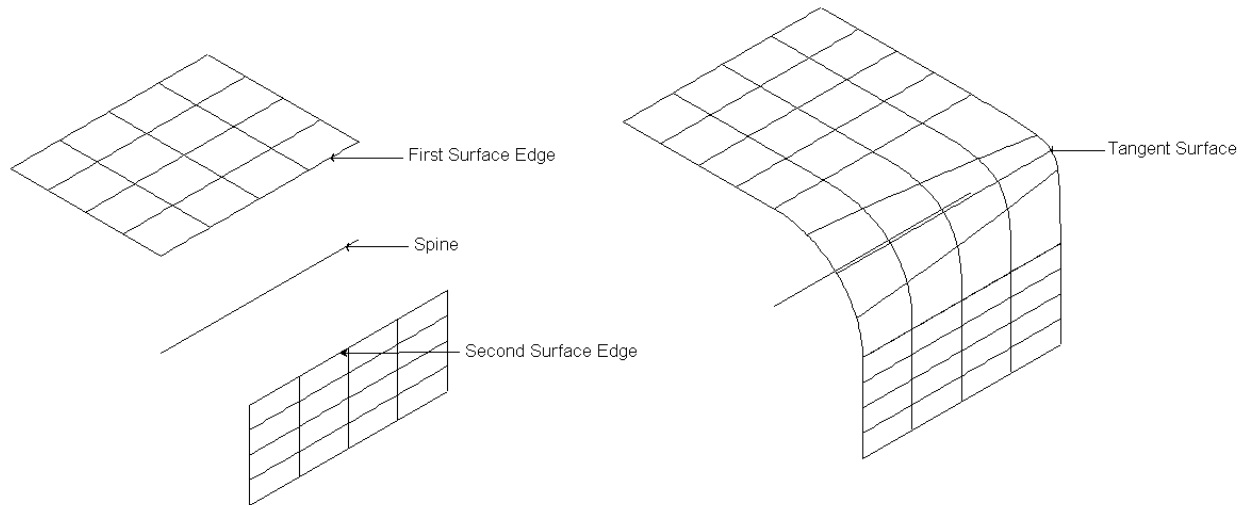


*Figure 3.3.5 Edge, Edge, Slope Control, Shoulder*



### 3.3.5 Tangent with Surface

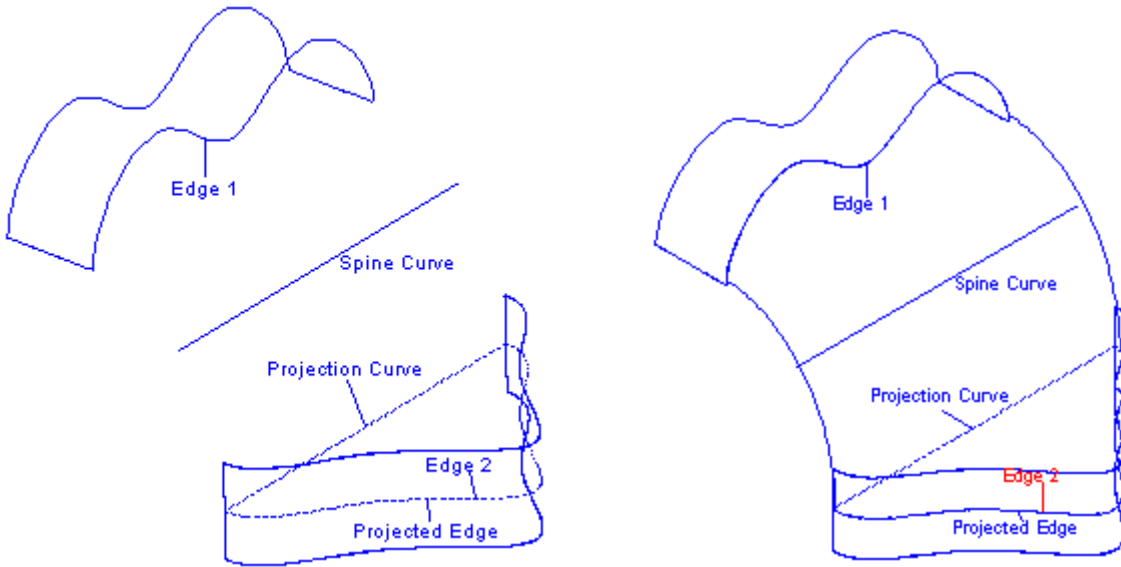
Creates a polyconic surface tangent to two surface edges. The rho curve of the tangent surface can be modified.



*Figure 3.3.6 Tangent Surface*

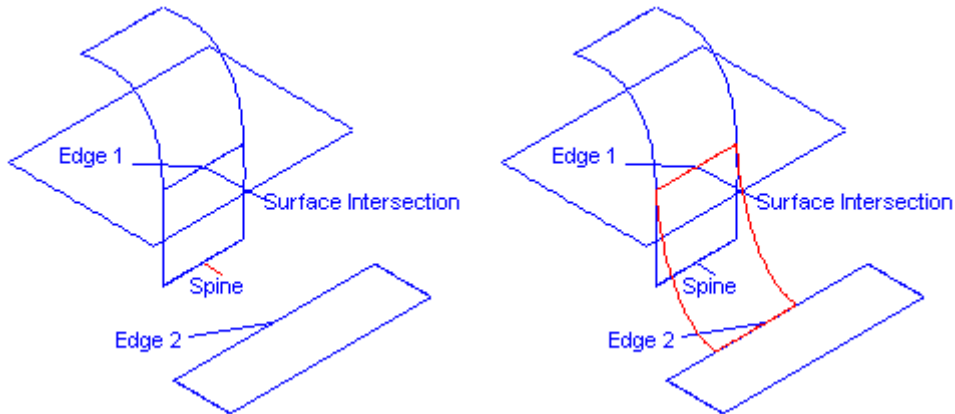
### 3.3.6 Tangent with Edge

Creates a polyconic surface tangent to two surface but the edge can be a curve projected onto the surface or it could also be a surface intersection. The Rho curve of the tangent surface can be modified. Figures 3.3.7a and 3.3.7b show a projected curve onto a surface.



*Figure 3.3.7a Tangent with Edge Geometry Figure 3.3.7b Tangent Surface at Edge*

Figures 3.3.8a and 3.3.8b show an example of how to use a surface intersection to define a tangent edge polyconic surface. In this case the horizontal surface will not work as surface one because it is parallel to surface two. The definition of a conic needs to be considered when defining this type of surface.



*Figure 3.3.8a Surface Intersection*

*Figure 3.3.8b Tangent Edge Polyconic*

### 3.3.7 Flat

Creates a polyconic surface which is flat. The spine curve determines the location of the flat surface along the edges.

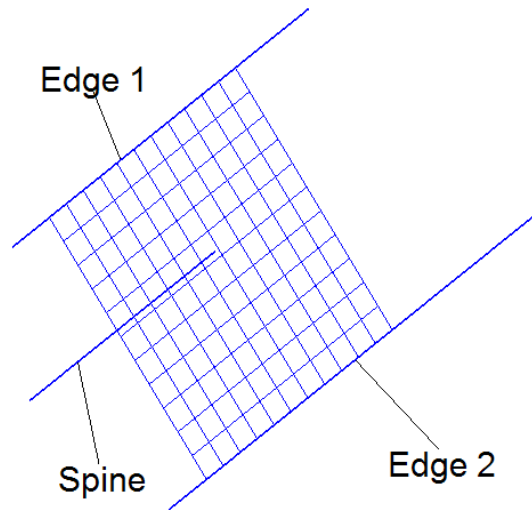


Figure 3.3.9 Flat Polyconic

### 3.3.8 Polyconic Surface Example

Figure 4.1 shows the top, bottom, and side profile of a fuselage. The canopy must join the fuselage at a 45-degree angle.



Figure 4.1 Profile Of Example Fuselage

Figure 4.2 shows two spine curves for two surfaces on the top half of the fuse. Also notice the 45-degree line, the two splines meet at the endpoint of this line and are perpendicular to it. This makes sure that the two surfaces will meet at the same angle with no discontinuities.

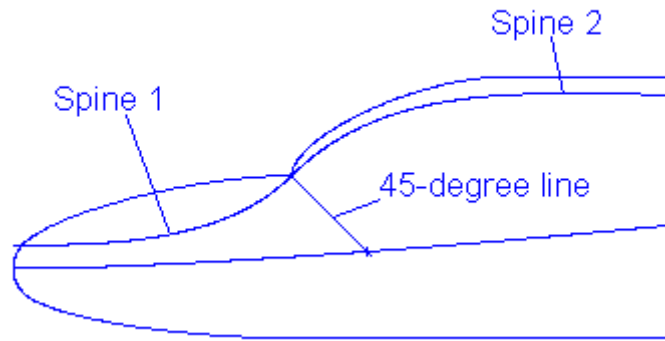


Figure 4.2 Spine Curves For Demo Fuse

The placement of the spine curves in a situation like this is very important and will be addressed next. The spine curve generates cross sections; say ten cross sections per spine curve. The problem arises because these cross sections cannot cross each other when generating a polyconic surface. The following two figures illustrate this discussion.

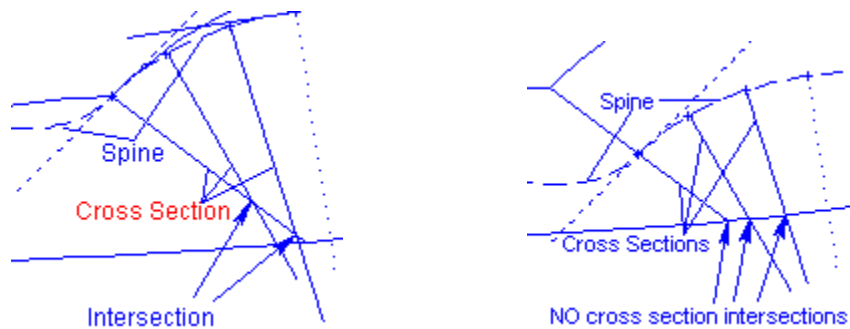


Figure 3.10a Incorrect Construction Figure 3.10b Correct Construction

In Figure 3.10a there are two cross section curves that intersect the first cross section curve (45-degree line). This will not allow creation of a polyconic surface because the surface will have to overlap itself and this is not allowed. Figure 3.10b shows the correct construction method necessary for this kind of polyconic surface. The only difference between the two methods is that in Figure 3.10b the spine curve has been moved to the midpoint of the 45-degree line. Also, the cross section lines still intersect, but this intersection occurs beyond the edge of the surface, which is acceptable. Some trial and error may be required to get this kind of surface to work, but just remember that the spine cross sections may not intersect.

There is one more example that needs to be looked at regarding the Rho-Value Law Curve. In the example above, two polyconics were created to join at a 45-degree angle with each other. Figures 3.11a and 3.11b depict a mismatch in conic values at the joint between two surfaces. Figure 3.11c shows how a good joint looks when rendered.

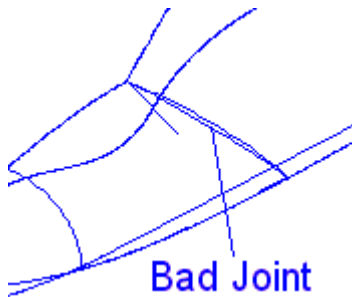


Figure 3.11a Bad Joint

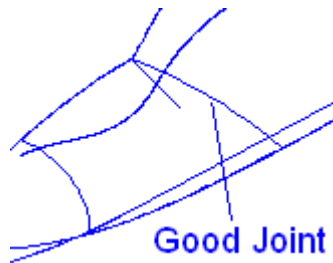


Figure 3.11b Good Joint

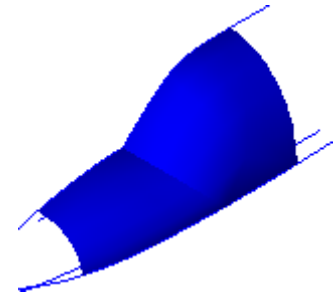


Figure 3.11c Good Surface

Figures 3.12a and 3.12b show an example of how a set of Rho-Value Law Curves looks. Notice in Figure 3.12a that there has been four independent conic values assigned to both surfaces. The edge between the two surfaces is set at 0.707 for both surfaces. The other two edges are set to 0.8 and 0.65 as shown. Notice the difference between the three edges. The first edge is slightly flat, the second edge is circular, and the last edge has a hyperbolic trend. NOTE: both of these figures are in isometric view.

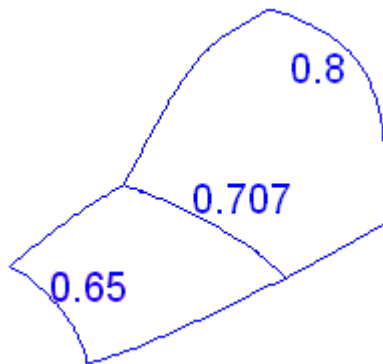


Figure 3.12a Fuselage Surfaces

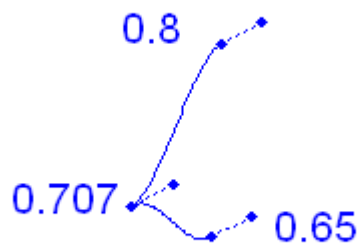


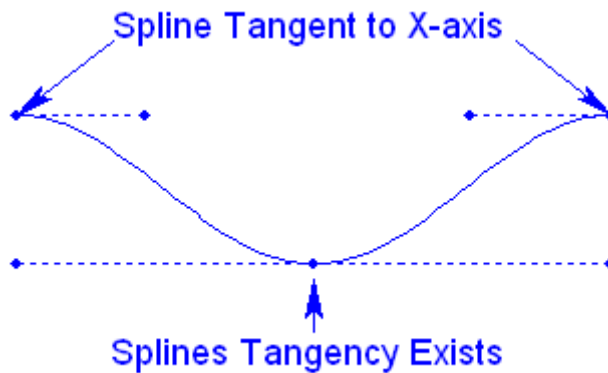
Figure 3.12b Rho-Value Law Curve for Figure 3.12

Figure 3.12b shows the Rho-Value Law Curves for Figure 3.12a. Notice that the values for the Rho-Value Law Curve are the same as Figure 3.12a. Also notice that the two splines meet at the same point of 0.707. These values would be multiplied by a factor of 100 for scaling. One other

thing that needs to be mentioned here is the fact that tangency is maintained in the Rho-Value Law Curve. The dashed lines between the points are the tangency vectors. For the 0.707 point the end tangency vectors for both splines are parallel to each other. This maintains tangency from one surface to the next. In this example all of the tangency vectors are in the + x-axis direction.

NOTE: When talking about tangency in this example, tangency is not necessarily a smooth transition from one surface to the next. There should be a smooth transition in conic values. In most cases this does mean a smooth edge, but in the example above there is a discontinuity in the surface smoothness because of the way the nose top edge and canopy top edge meet at a point.

NOTE: To create tangent surface intersections make sure all construction lines are tangent to each other as shown in Figure 3.7. The tangency vectors can be shown by selecting the curve and hitting Ctrl +D or by going to Layout in the menu and selecting Show Points.



*Figure 3.7 Spline Tangency Examples*

## Appendix A: Airfoil File Formats

### A.1 UIUC Airfoil Data Site

The UIUC Airfoil Data Site is a World Wide Web Site containing coordinates for over 1150 airfoils. The site is sponsored by the University of Illinois at Urbana-Champaign. The site can be accessed at [http://www.uiuc.edu/ph/www/m-selig/ads/coord\\_database.html](http://www.uiuc.edu/ph/www/m-selig/ads/coord_database.html). Airfoil coordinates can be downloaded from the site.

### A.2 Symmetrical Airfoil Format

This format consists of station locations on the left and associated ordinate heights on the right. The station locations are in percent chord length.

- Line 1: Must contain the string "Format 1" to identify a symmetrical airfoil
- Line 2: Description Line
- Line X: X and Y for upper surface from leading edge to trailing edge. If Z is included, it will be set to 0.0

An example of the symmetrical airfoil file format is shown in Figure 1.

```

FORMAT 1
Symmetrical Airfoil
00.0000 00.0000 0.0
01.2500 01.9500 0.0
02.5000 02.8910 0.0
05.0000 04.2410 0.0
07.5000 05.2220 0.0
10.0000 06.0130 0.0
15.0000 07.1550 0.0
20.0000 07.9560 0.0
30.0000 08.8590 0.0
40.0000 09.1420 0.0
50.0000 08.8650 0.0
60.0000 08.0980 0.0
70.0000 06.8810 0.0
80.0000 05.1940 0.0
90.0000 02.9970 0.0
95.0000 01.6380 0.0
100.000 00.1400 0.0

```

*Figure 1 Symmetrical Airfoil File Format*

### A.3 Asymmetrical Airfoil Leading to Trailing Edge File Format

This format consists of a number of station locations defining the upper and lower surfaces of the airfoil. An example of this file format is shown in Figure 2. A description is presented here:

- Line 1: Description Line
- Line 2: number of upper points, number of lower points
- Line 3: blank line
- Line X: X and Y for upper surface from leading edge to trailing edge. If Z is included, it will be set to 0.0
- Line Y: X and Y for lower surface from leading edge to trailing edge. If Z is included, it will be set to 0.0

Note: The number of points on the upper surface must be greater than or equal to the number of points on the lower surface. The leading edge point is defined for both upper and lower surface.



```
Clark V Airfoil
17 17

0.000000 0.000000 0.0
0.012500 0.019500 0.0
0.025000 0.028910 0.0
0.050000 0.042410 0.0
0.075000 0.052220 0.0
0.100000 0.060130 0.0
0.150000 0.071550 0.0
0.200000 0.079560 0.0
0.300000 0.088590 0.0
0.400000 0.091420 0.0
0.500000 0.088650 0.0
0.600000 0.080980 0.0
0.700000 0.068810 0.0
0.800000 0.051940 0.0
0.900000 0.029970 0.0
0.950000 0.016380 0.0
1.000000 0.001400 0.0
0.000000 0.000000 0.0
0.012500 -.013800 0.0
0.025000 -.018290 0.0
0.050000 -.023090 0.0
0.075000 -.025580 0.0
0.100000 -.027370 0.0
0.150000 -.028950 0.0
0.200000 -.029440 0.0
0.300000 -.027810 0.0
0.400000 -.024180 0.0
0.500000 -.020150 0.0
0.600000 -.016120 0.0
0.700000 -.012090 0.0
0.800000 -.008060 0.0
0.900000 -.004030 0.0
0.950000 -.002010 0.0
1.000000 0.000000 0.0
```

*Figure 2 Asymmetrical Airfoil Leading to Trailing Edge File Format*

#### A.4 Asymmetrical Airfoil Trailing to Leading to Trailing Edge File Format

This format consists of a number of station locations defining the upper and lower surfaces of the airfoil. The stations begin at the trailing edge of the upper surface, progress to the leading edge along the upper surface, and then to the trailing edge along the bottom surface. An example of this file format is shown in Figure 3. A description is presented here:

Line 1: Description Line

Line X: X and Y for upper surface from trailing edge to leading edge. If Z is included, it will be set to 0.0

Line Y: X and Y for lower surface from leading edge to trailing edge. If Z is included, it will be set to 0.0

Note: The leading edge point is defined only once in this format.

```
Clark K Airfoil
1.000000 0.000600 0.0
0.899080 0.023420 0.0
0.798280 0.043650 0.0
0.697600 0.060990 0.0
0.597040 0.075020 0.0
0.496660 0.084670 0.0
0.396470 0.089620 0.0
0.296510 0.088680 0.0
0.196830 0.080550 0.0
0.097610 0.060650 0.0
0.072950 0.052070 0.0
0.048370 0.041410 0.0
0.023920 0.027340 0.0
0.000000 0.000000 0.0
0.025950 -.024180 0.0
0.051050 -.026590 0.0
0.076110 -.028200 0.0
0.101220 -.031010 0.0
0.201250 -.031770 0.0
0.301110 -.028140 0.0
0.400950 -.024200 0.0
0.500800 -.020270 0.0
0.600640 -.016330 0.0
0.700490 -.012400 0.0
0.800330 -.008470 0.0
0.900180 -.004530 0.0
1.000000 -.000600 0.0
```

Figure 3 Asymmetrical Airfoil Trailing to Leading to Trailing Edge File Format



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[www.airplanedesign.aero](http://www.airplanedesign.aero)