

# ZEN & THE ART OF SOLIDWORKS SURFACING

**THINK SOLIDWORKS**

CREATE

EXPERIENCE

SPEED

GAME CHANGING

SMART DESIGN

NEXT-GEN

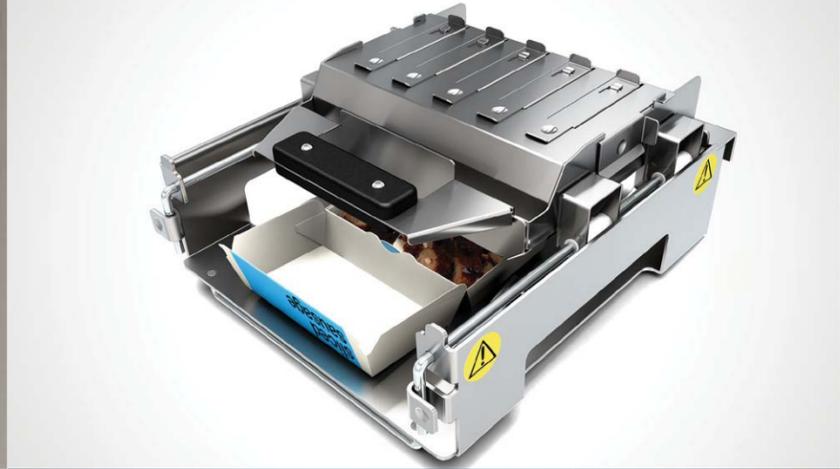
COMMUNITY-DRIVEN

EVOLVE



Andrew Lowe  
Senior Industrial Designer  
DiMonte Group Inc

**DIMONTE  
GROUP  
INC**



# **DIMONTE GROUP**

**INDUSTRIAL DESIGN  
MECHANICAL ENGINEERING**

**ELECTRICAL ENGINEERING  
SOFTWARE DEVELOPMENT**

**DIMONTEGROUP.COM**

**630.791.8074**

# And Who Am I?

Senior Industrial Designer at the DiMonte Group, collector of Mid-Century Design, builder of custom coffee tables. 7 time SOLIDWORKS World presenter.



**ARE YOU  
READY!**

# LET'S GO!

[Click here to download the example SOLIDWORKS files](#)

# SMOOTH MOVES

# If you were a limo driver, what would be a smoother ride for your passengers when making a left hand turn?

Sharply turning the steering wheel to the exact radius of the turn, holding it in the same position and then quickly straightening the wheel?

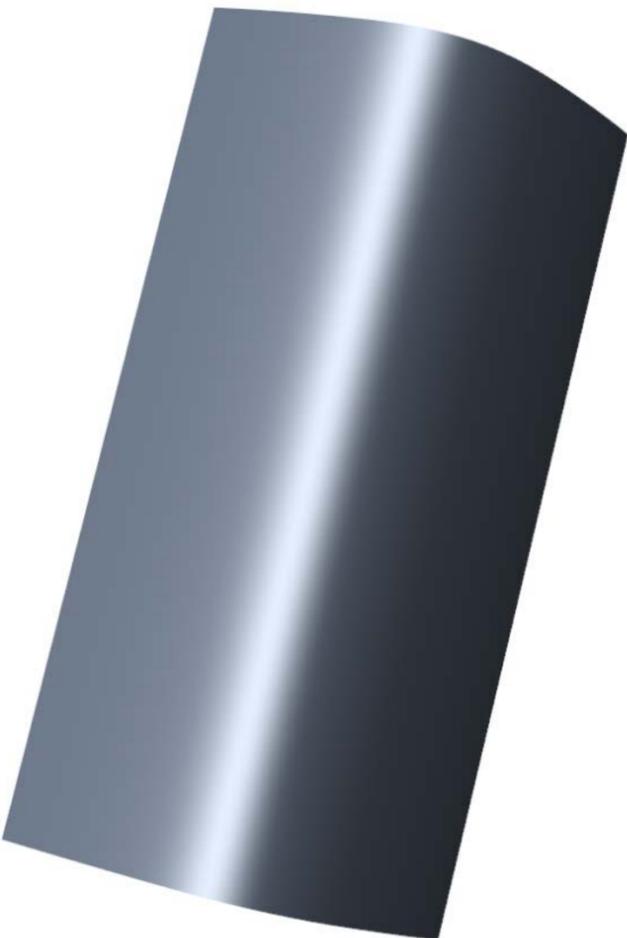
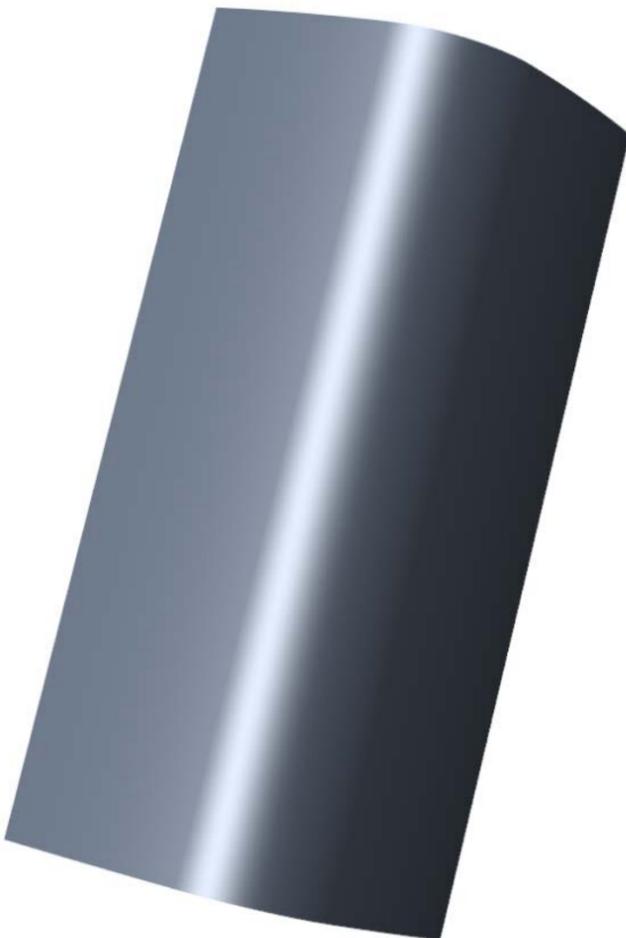


# If you were a limo driver, what would be a smoother ride for your passengers when making a left hand turn?

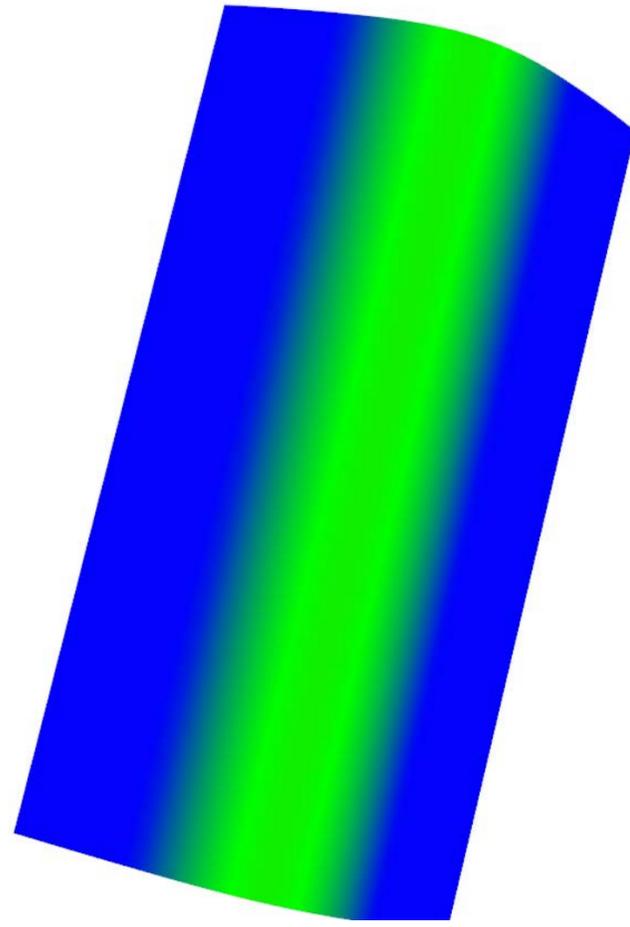
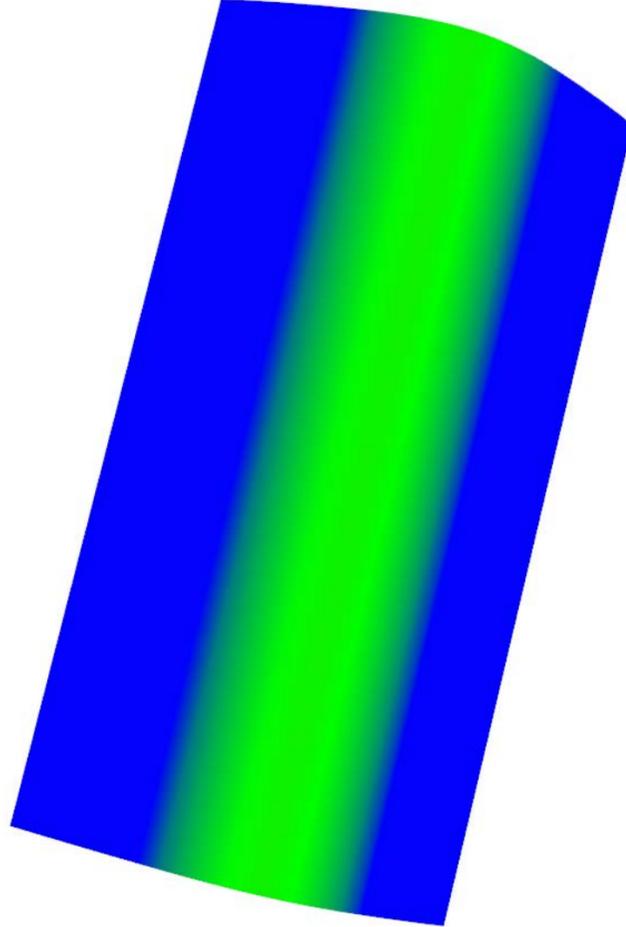
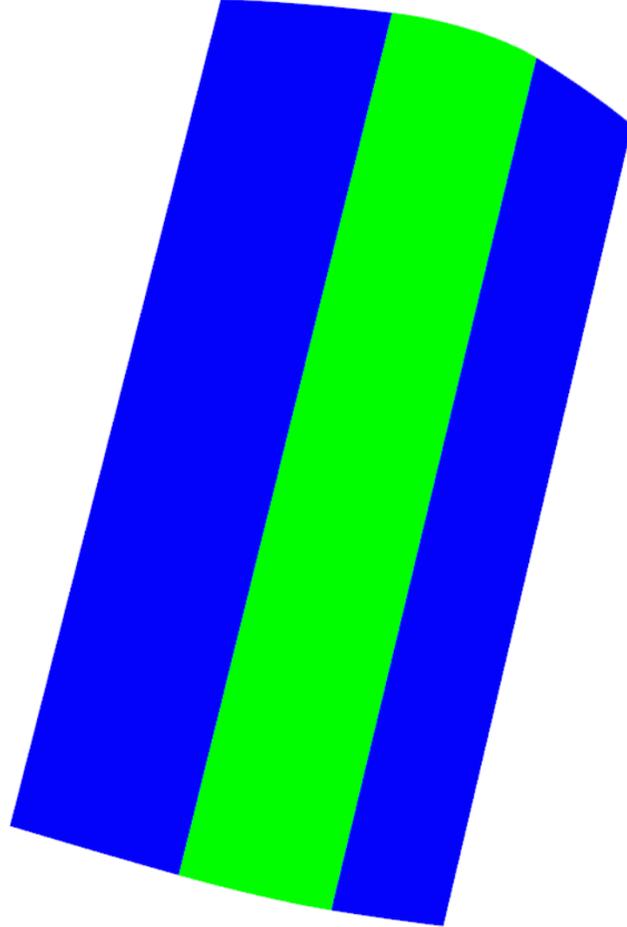
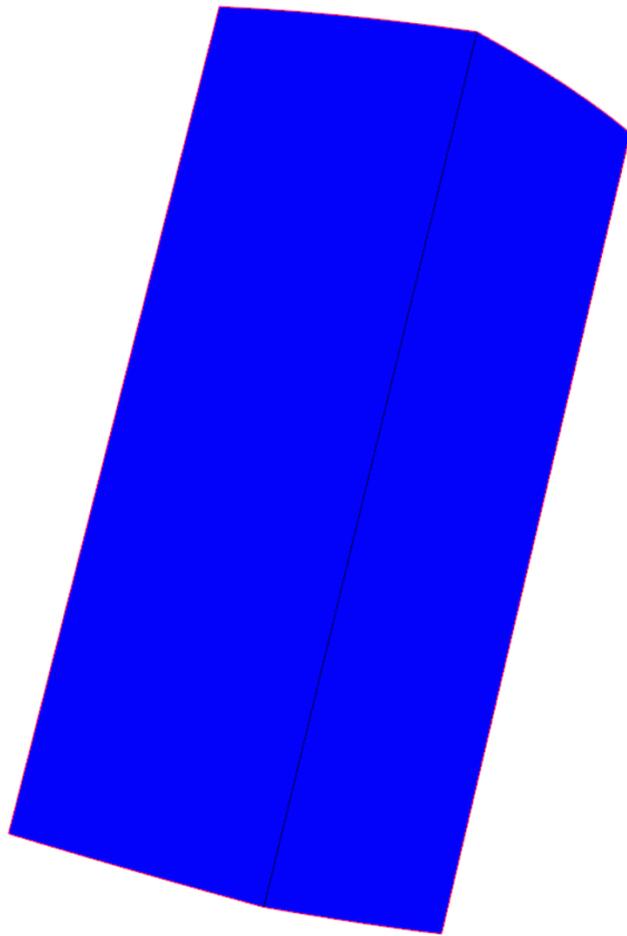
Gradually turning steering wheel until the desired position to negotiate the turn and gradually unwinding the steering wheel back to straight?



# Continuity



# Continuity



**G0**  
Contact



**G1**  
Tangent



**G2**  
Curvature



**G3**  
Curvature

**WHERE AM I  
GOING WITH  
ALL OF THIS?**

# Zen & The Art Of **SOLIDWORKS** Surfacing

High quality surface models are never made from a single surface working overtime. Instead they are carefully crafted from a network of surfaces where each surface is doing the least amount of work possible. Each surface is entirely relaxed yet fully aware of what it's neighbors are doing. Surfaces share G2 or G3 continuity with their neighbors, allowing them blend into a seamless communal whole.



# Zen & The Art Of SOLIDWORKS Surfacing

In order to build these high quality surface models, we need to understand the network that connects them. This network is often referred to as the “patch layout”. We’ll delve deeper into this later in the presentation.

**Primary Surfaces** are large and relatively flat.  
**Blend Surfaces** connect **Primary Surfaces** together.

**Transition Surfaces** complete the areas between regions of the chair.

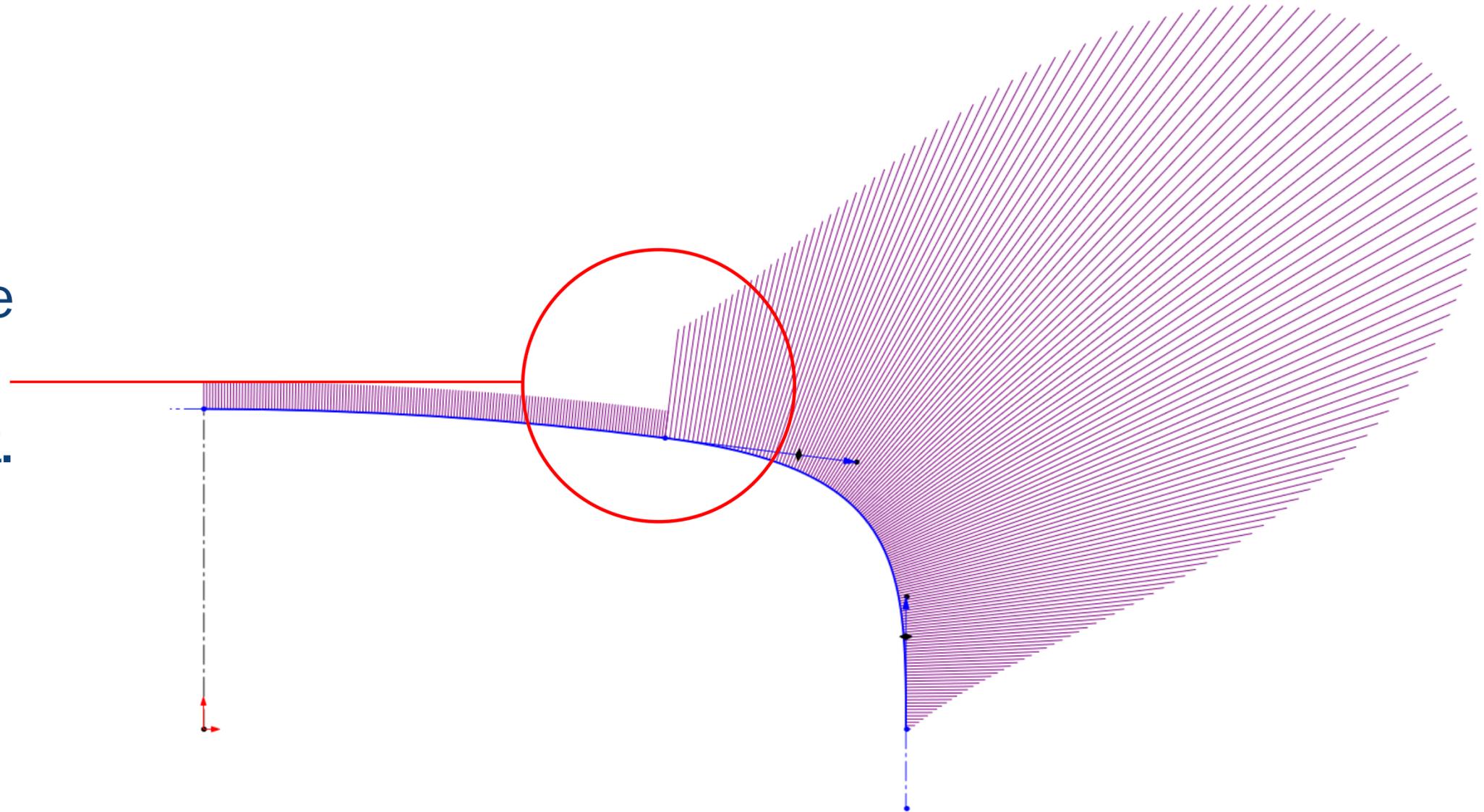


# GREAT CURVES, GREAT SURFACES

# Tangency (G1)

When two curves are G1, the angle of the two curves at the junction is equal. While there is no change in angle in the curves, the transition can visually be seen.

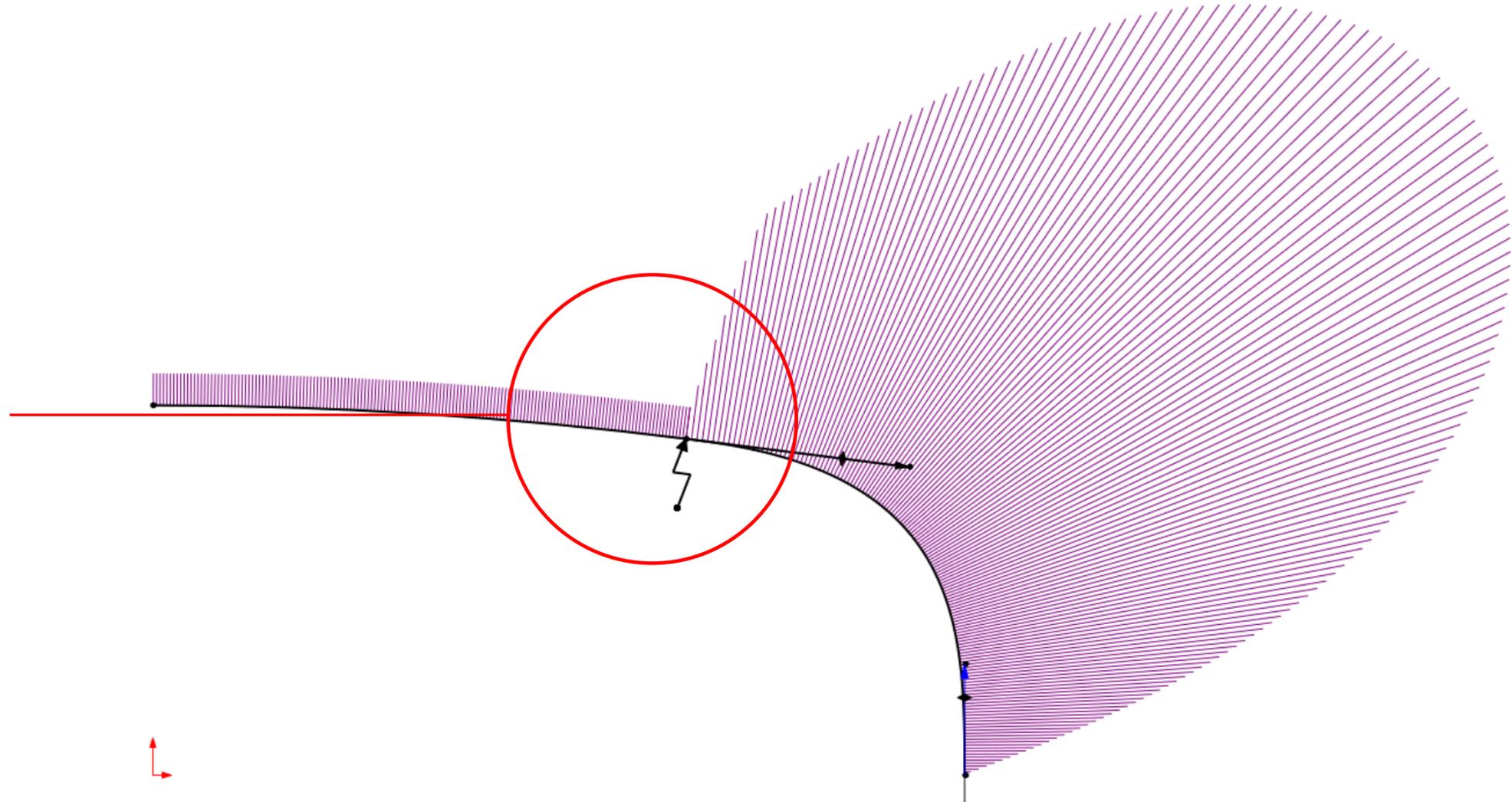
The angle of the curvature combs are equal, but the length of the curves is not.



# Curvature Continuous (G2)

When two curves are curvature continuous to each other, the radius of the two curves at the junction is equal. This is a smoother connection than G1 as there is no sudden jump in the radius between the two curves

The angle and length of the curvature combs are equal at the junction.

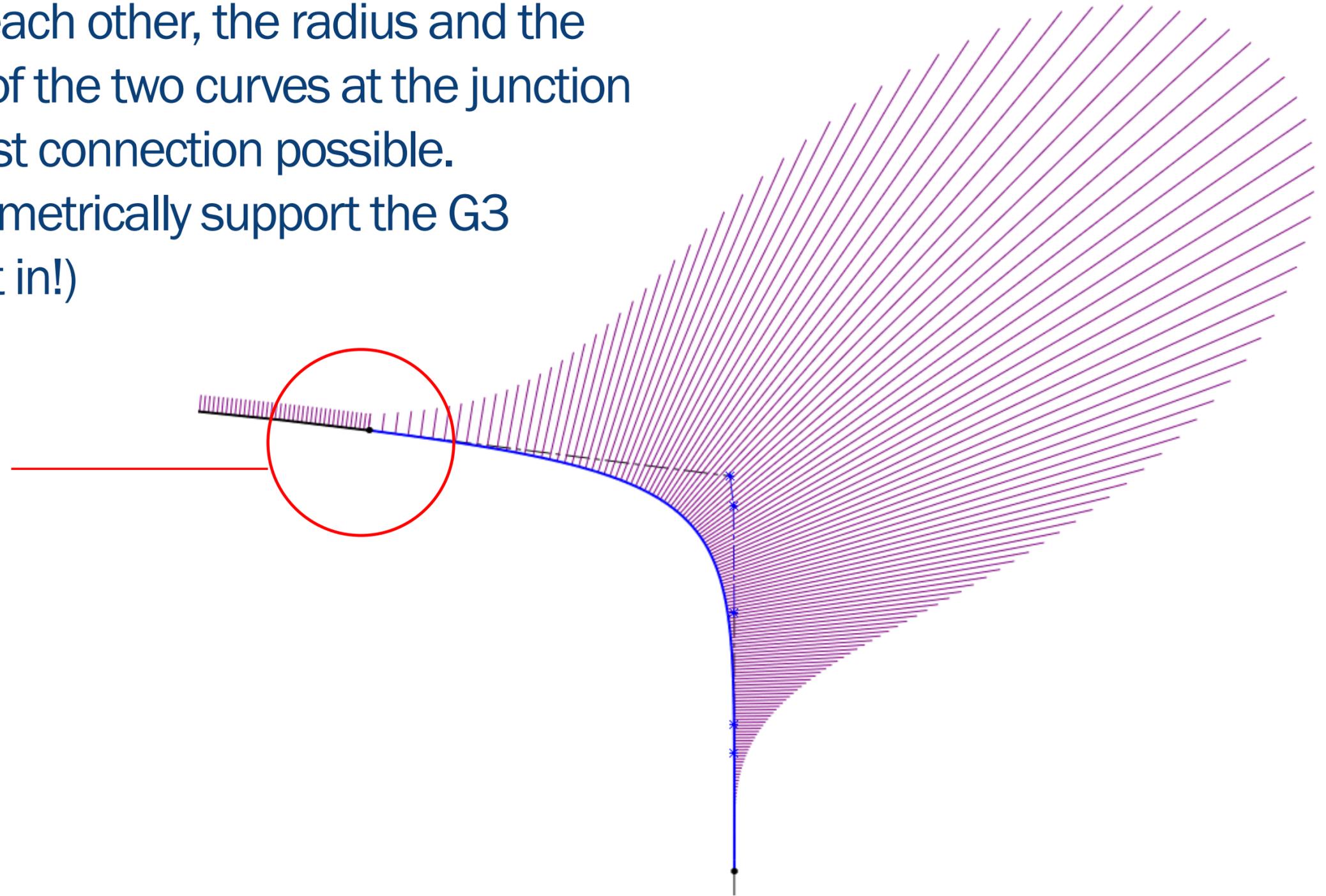


# G3 Continuous Connections

When two curves are G3 to each other, the radius and the rate of change of the radius of the two curves at the junction is equal. This is the smoothest connection possible.

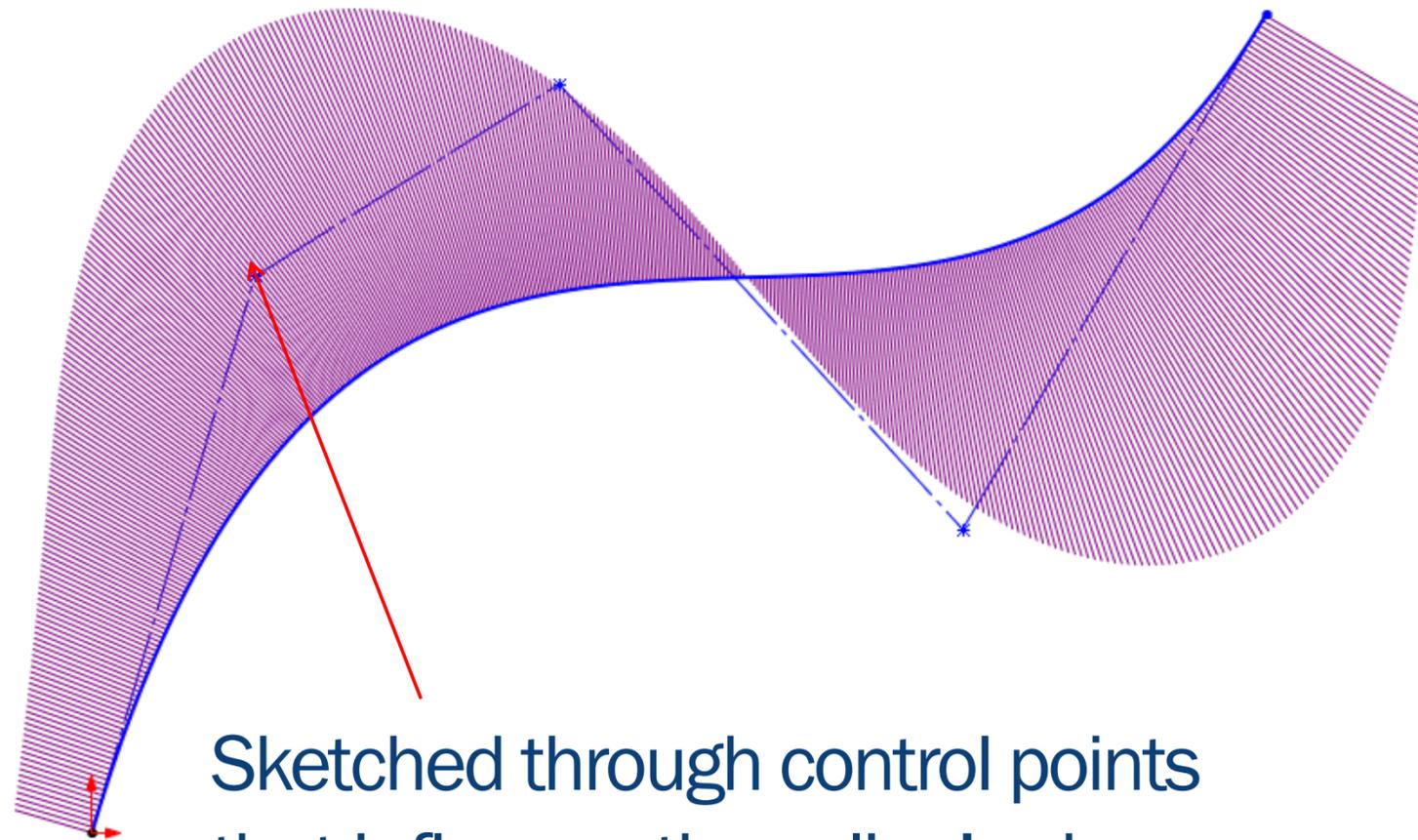
SOLIDWORKS does not parametrically support the G3 relation(\*but you can hack it in!)

Angle, Radius, and Change of Radius are equal.

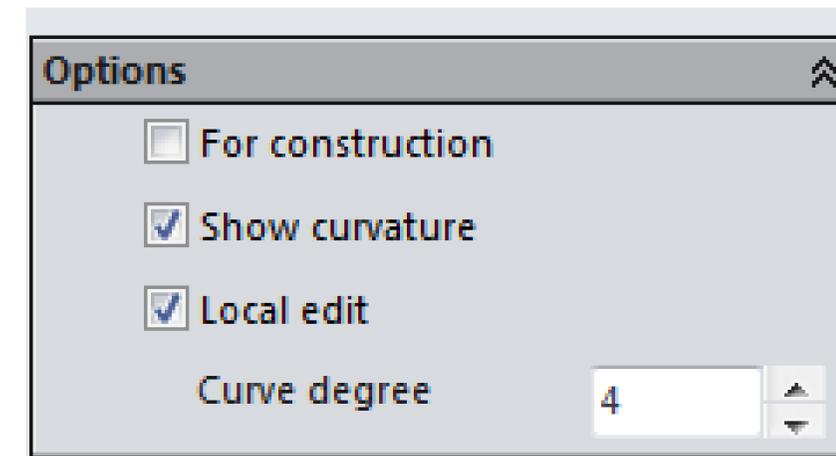


# Style Spline Tool

The Style Spline is a GAME CHANGER in surface modeling. It uses a different set of math than the interpolated spline. This means smoother curves with less spikes and dips in curvature. It is also created differently from the interpolated spline.



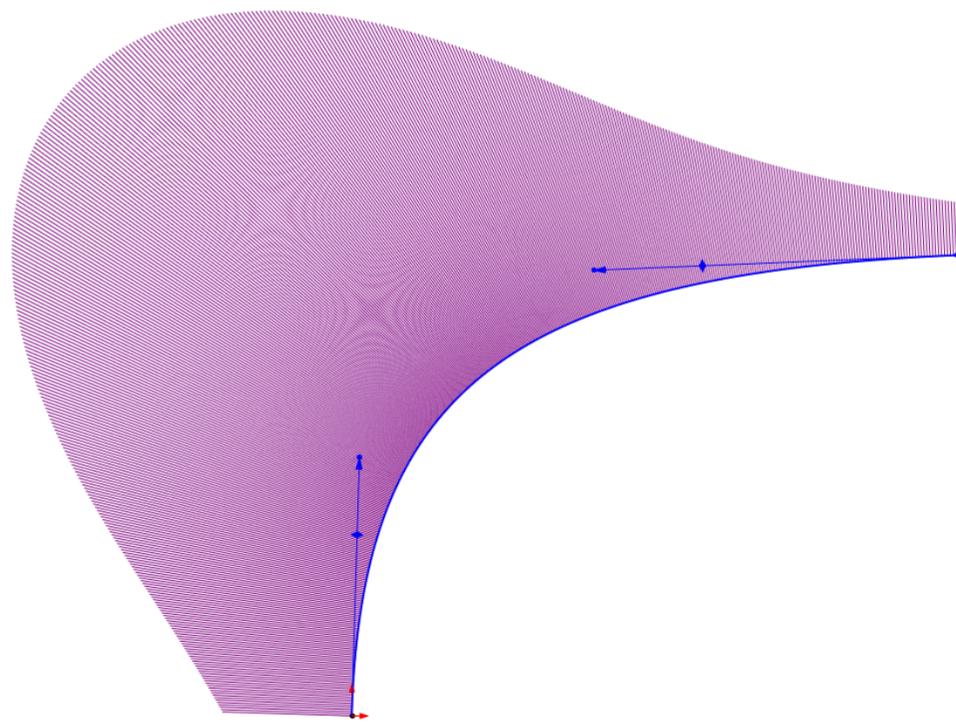
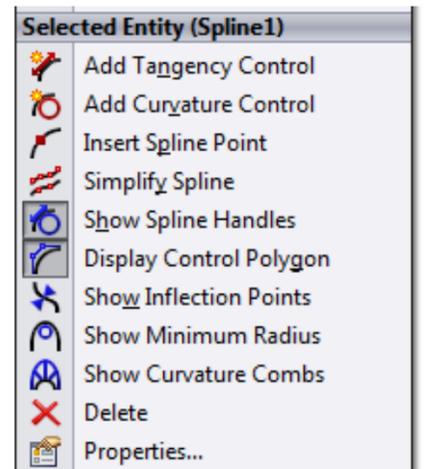
Sketched through control points that influence the spline's shape.



The curve's degree can be changed. The degree = N control points - 1. Adding more points decreases each point's influence on the curve.

# Classic Spline Tool

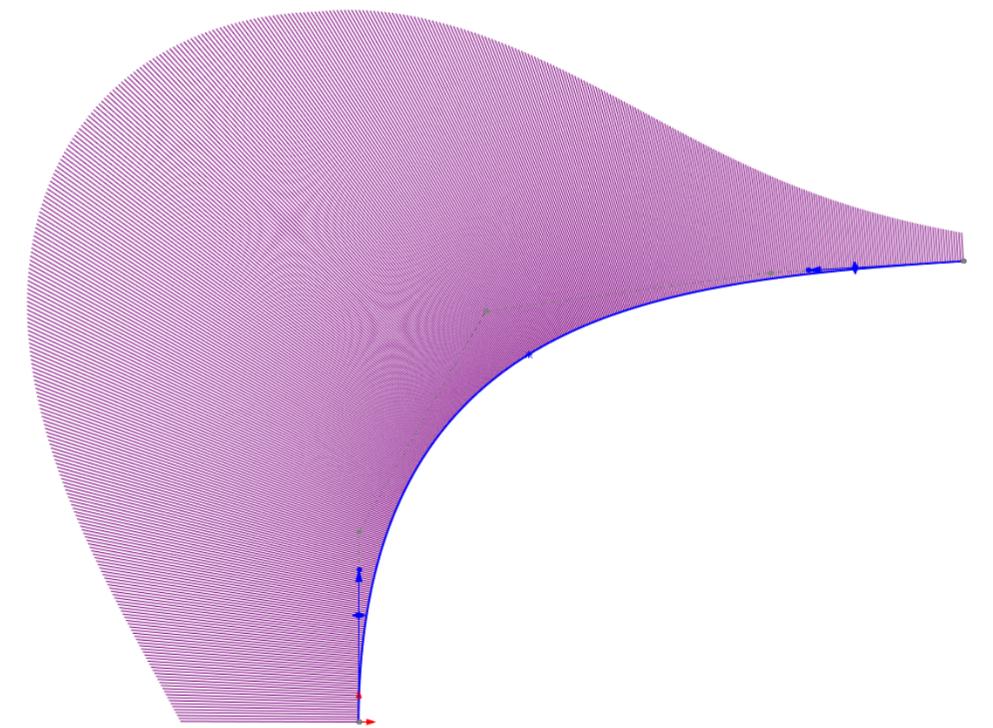
The key to using the interpolated spline tool is to use as few spline points as possible. Manipulate the spline via the end points. 2 point create the smoothest curves. If a 3<sup>rd</sup> point is required, avoid manipulating its handles. Use the control polygon instead.



2 Point Spline



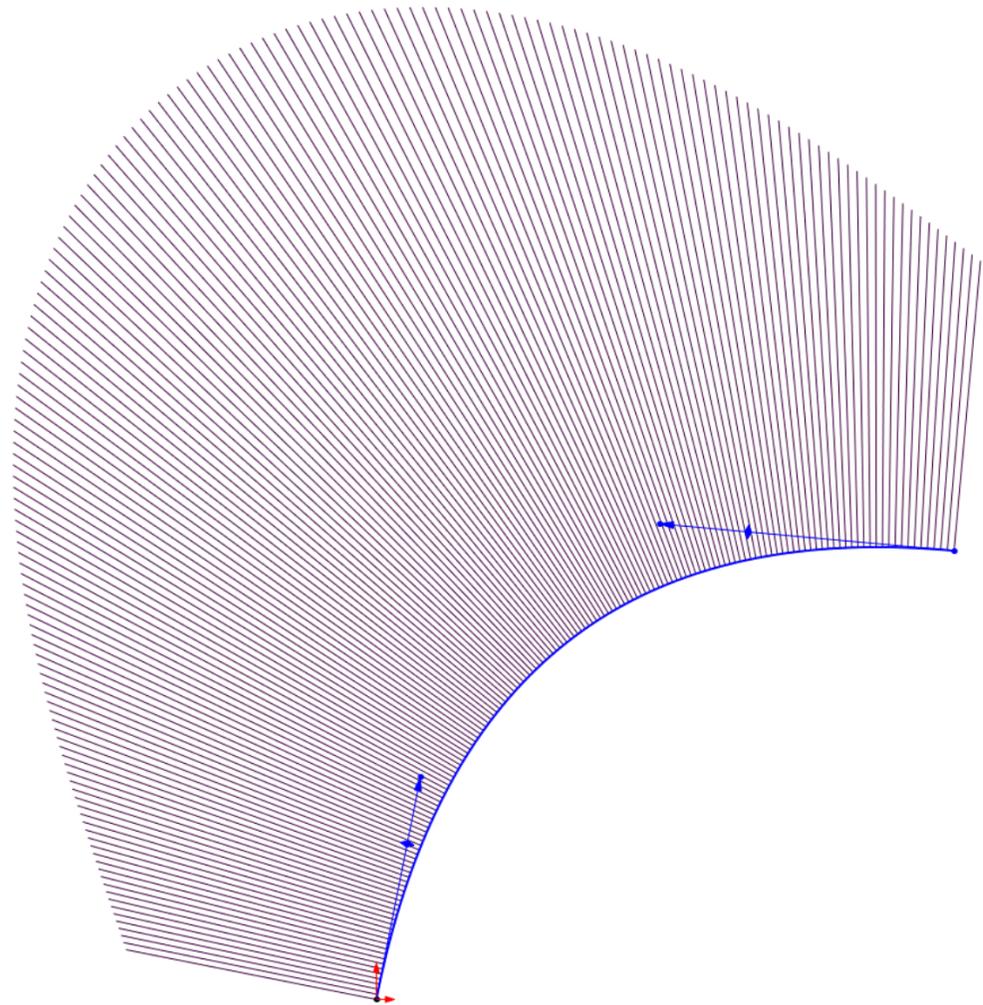
3 point, manipulated handles



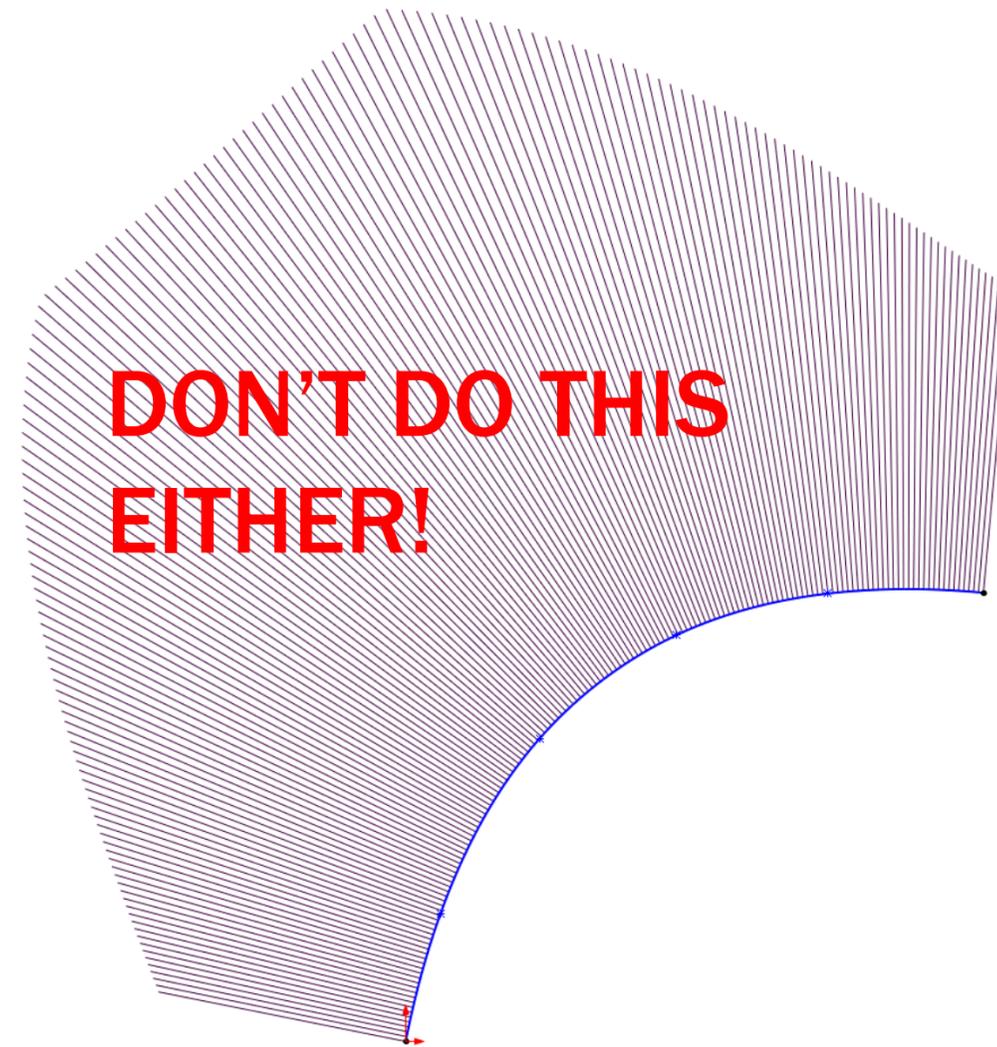
3 point, control polygon

# Classic Spline Tool

Use as few points as possible when using the classic spline tool. Manipulate the control handles to define the shape, don't sketch the spline through a bunch of points.



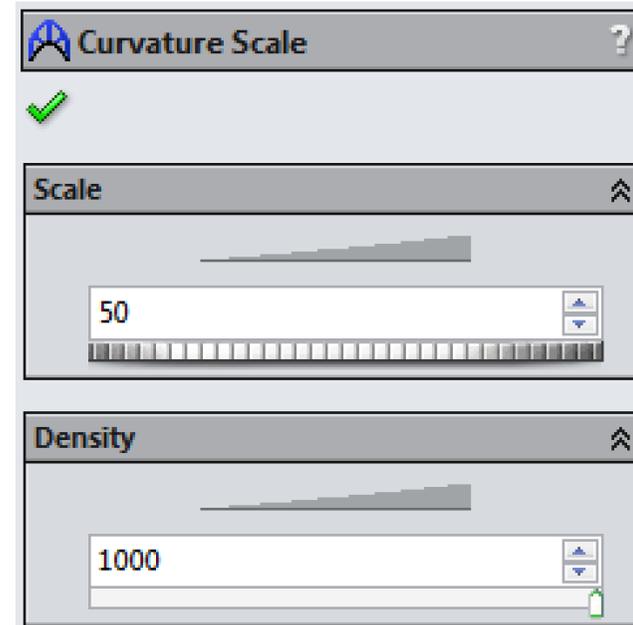
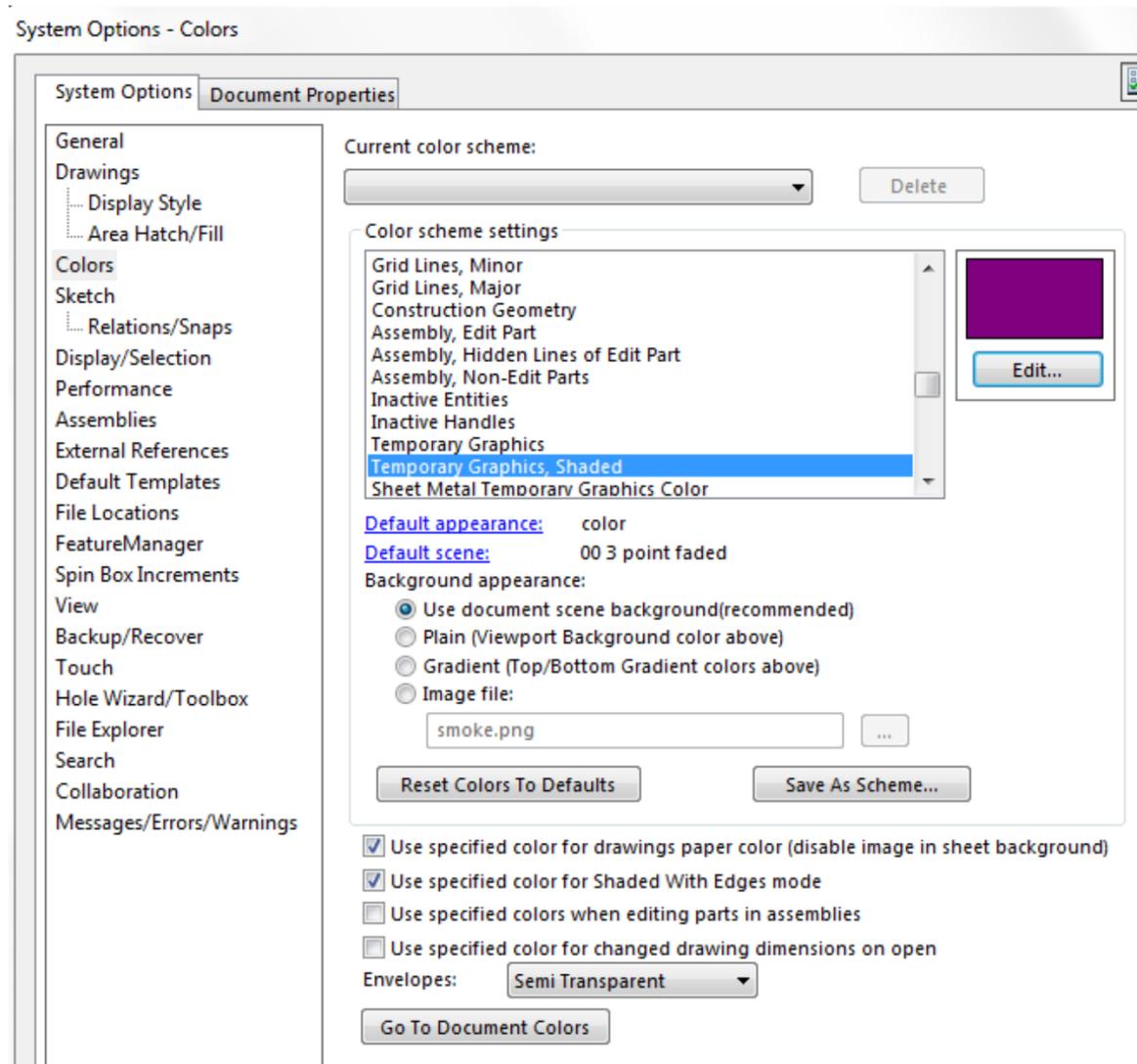
Created by manipulating spline handles



Created by adding multiple spline points

# Change the Defaults

The default yellow curvature comb color can be difficult to read. Likewise, the default curvature comb settings can be optimized.



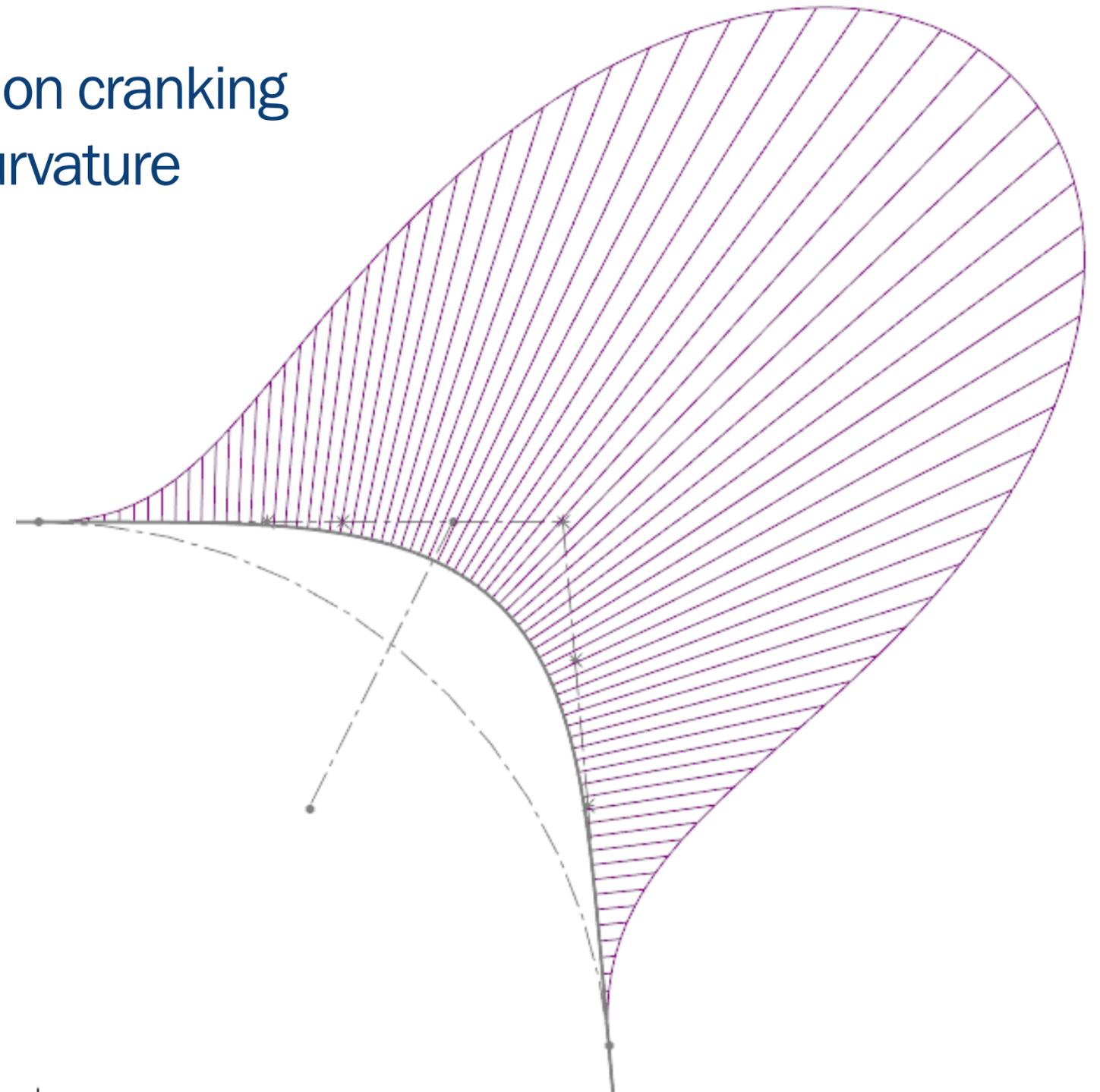
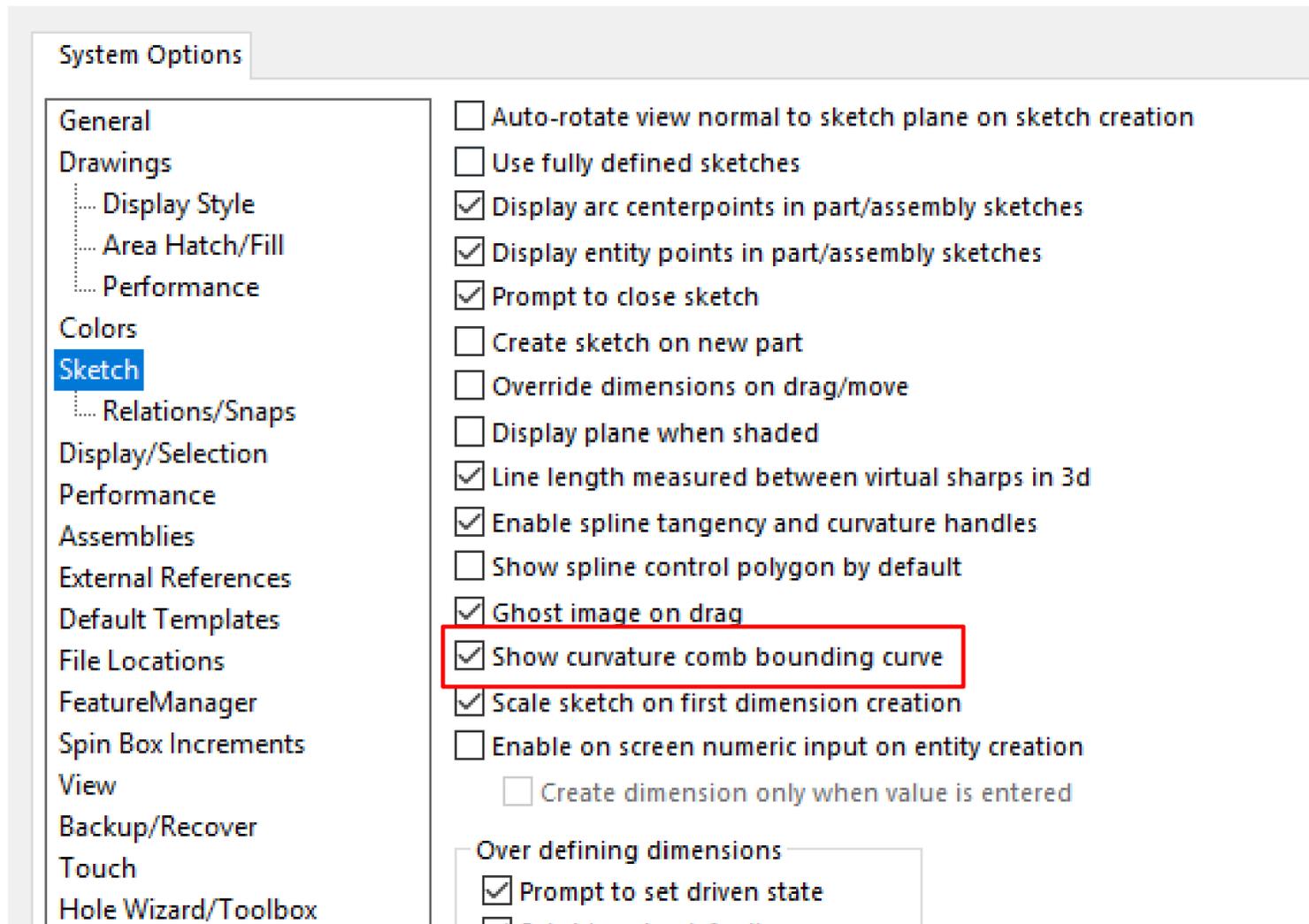
## NOTE:

The density slider cannot be dragged to 1000. It must be manually typed in.

# Change the Defaults

Before I knew about this awesome feature, I relied on cranking up the density of the curvature combs. With the Curvature Comb Bounding Curve, this is no longer required.

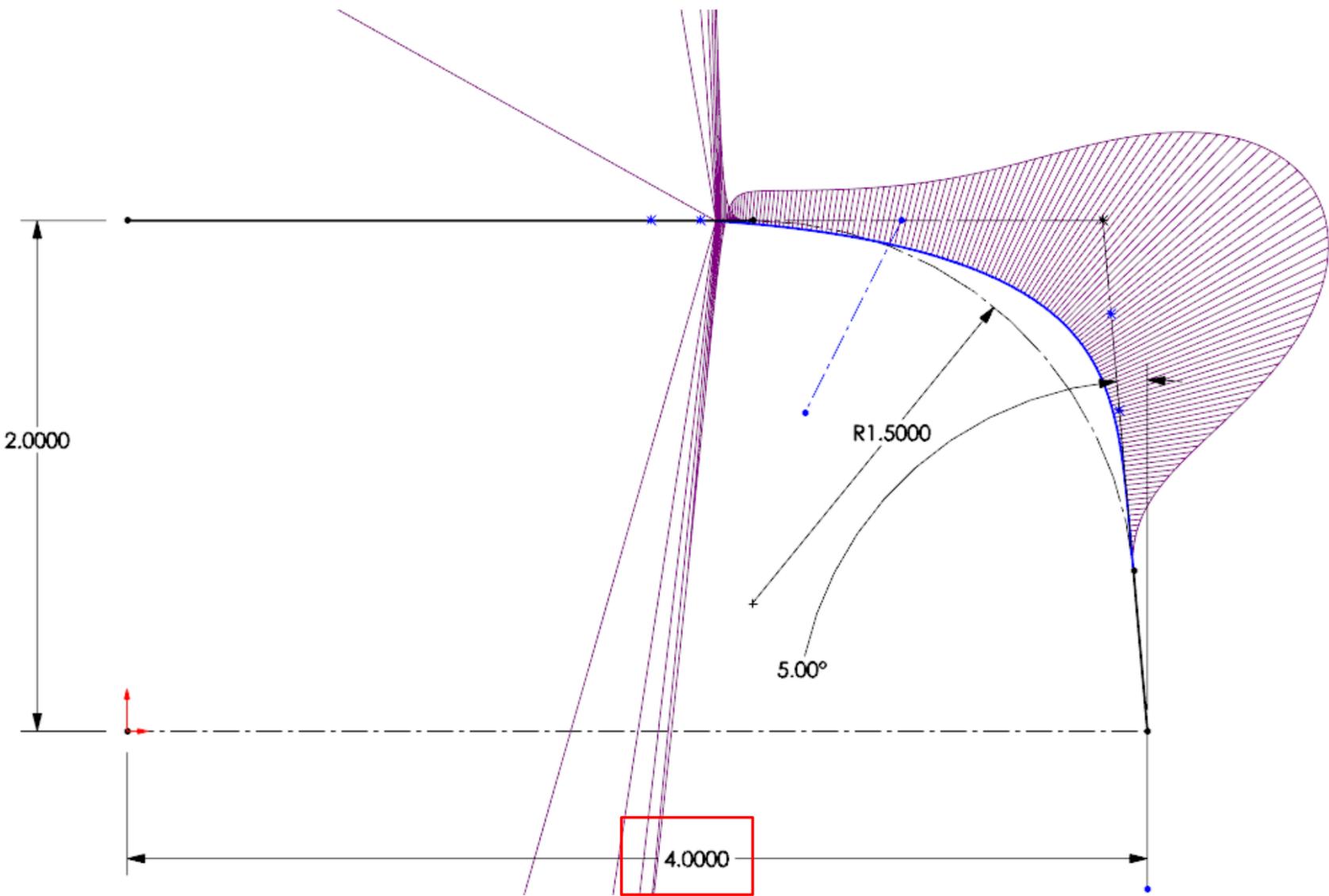
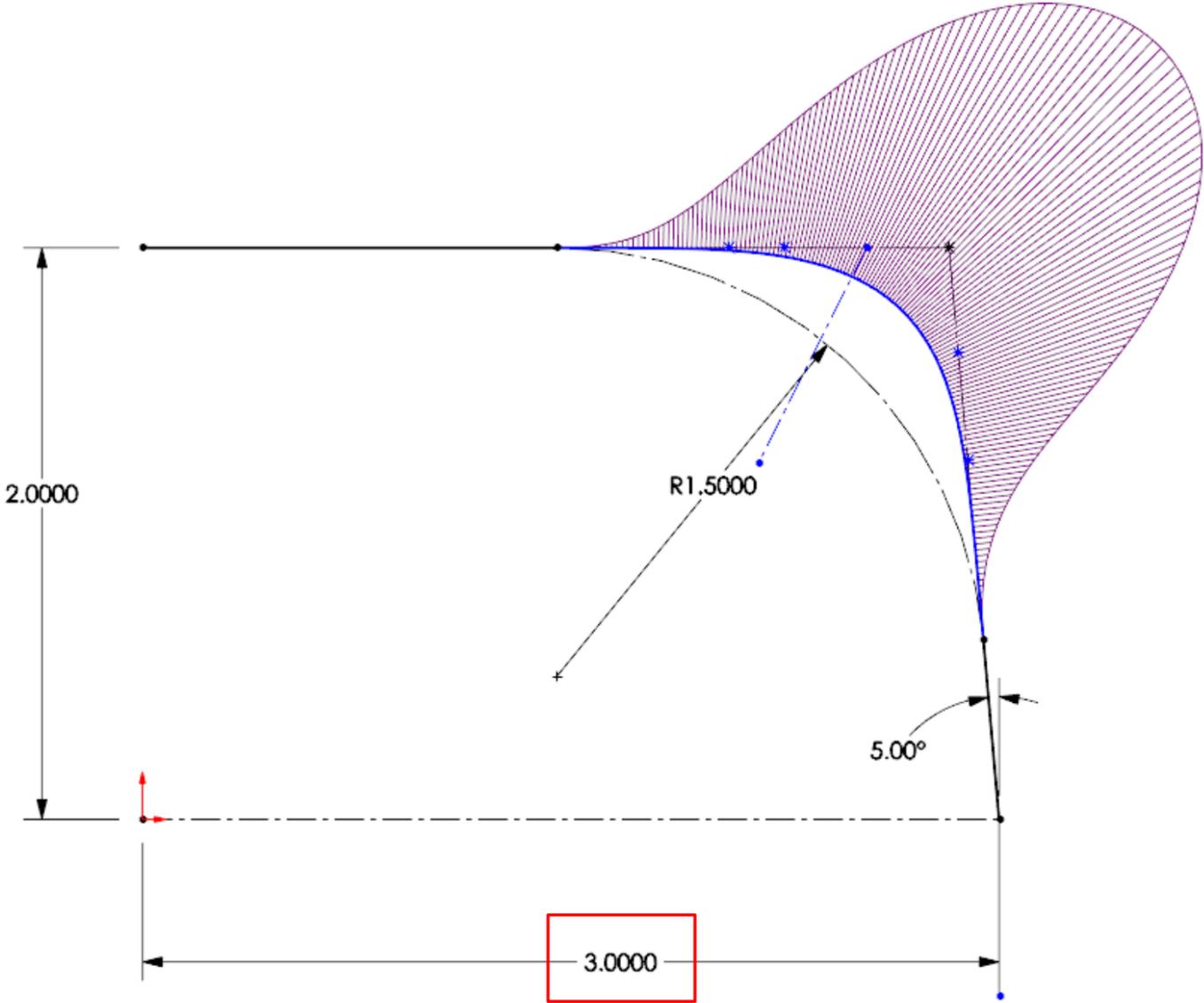
System Options - Sketch



# PARAMETRIC G3 CONNECTIONS!

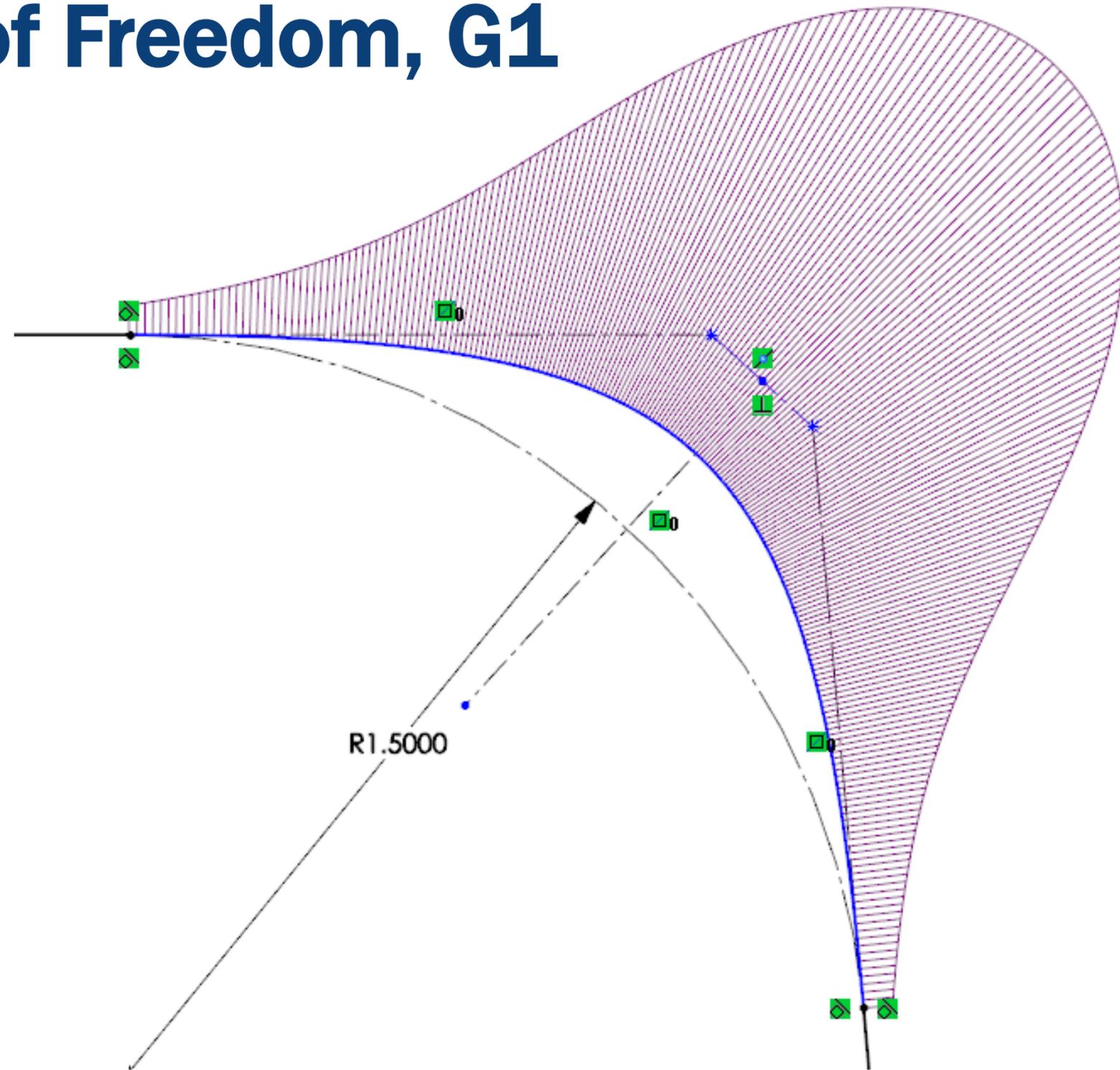
# Parametric G3 Connections

SOLIDWORKS doesn't have a G3 relation. Spline control points can be adjusted to be G3, but don't move in relation to other model changes.



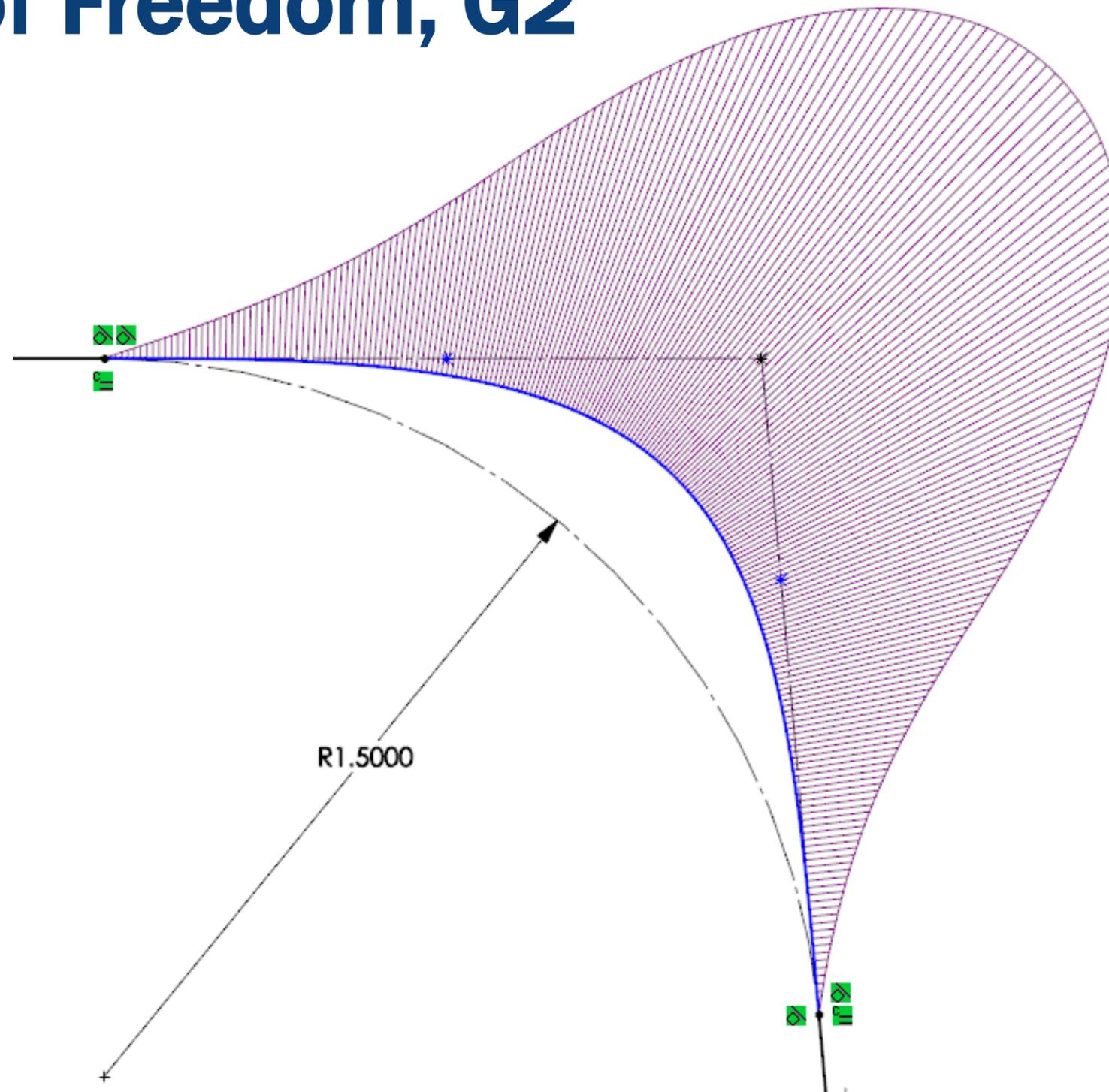
# Controlling Degrees of Freedom, G1

Adding the tangent relation to a style spline fully defines the first control segment in each direction. The control segment is also made co-linear to the existing line segments.



# Controlling Degrees of Freedom, G2

Adding the equal curvature relation to a style spline fully defines the first two control segments in each direction. The control segments are also made co-linear to the existing line segments.



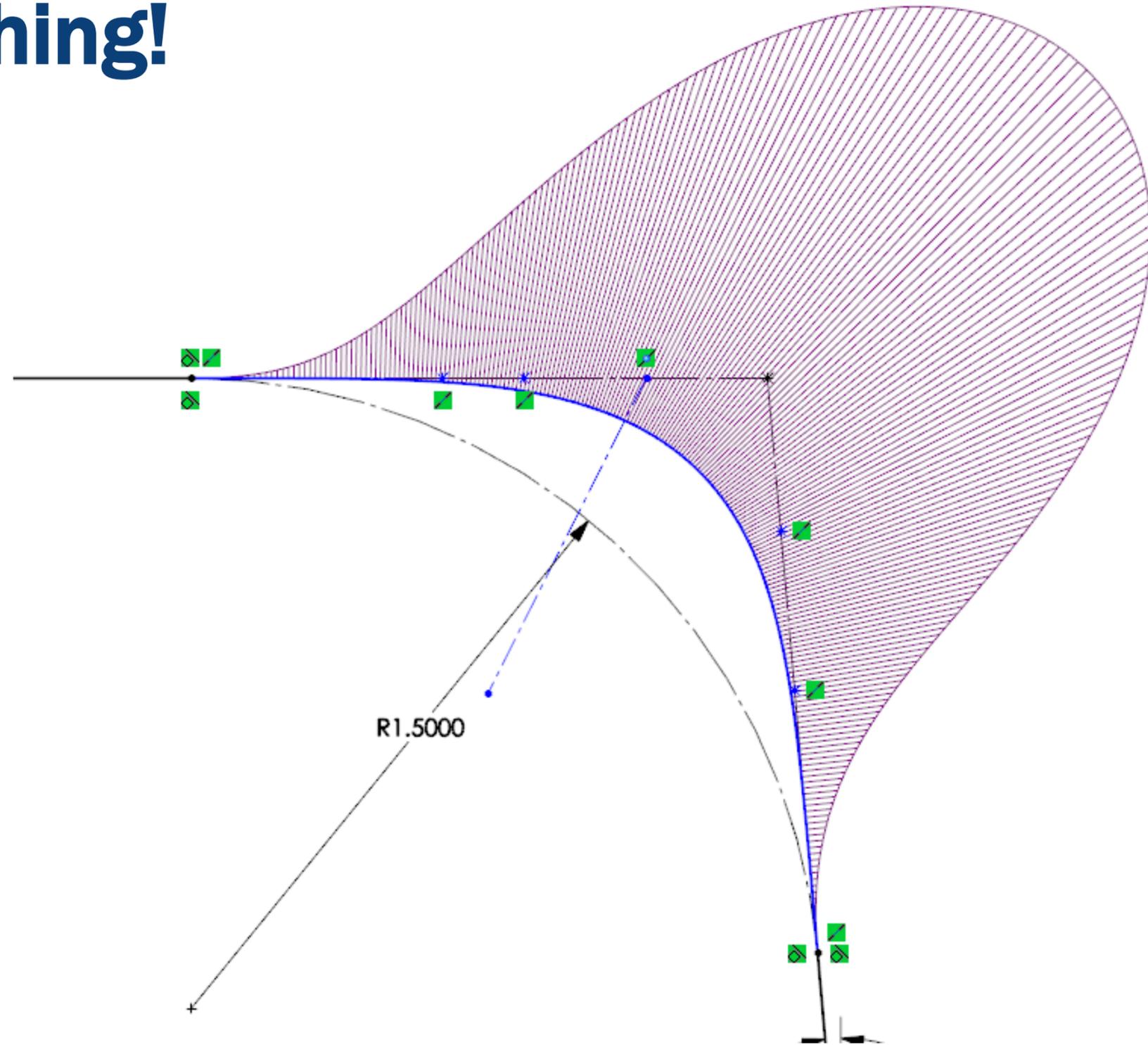
If the tangent relation fully defines the first control segment, and the equal curvature relation fully defines the second control segment, what happens if we added a third control segment using a degree six style spline and made all 3 control segments collinear to the input line segment?

# We're On To Something!

A perfect G3 connection!

Using a degree 6 style spline with half of the control segments made collinear to each respective line segment.

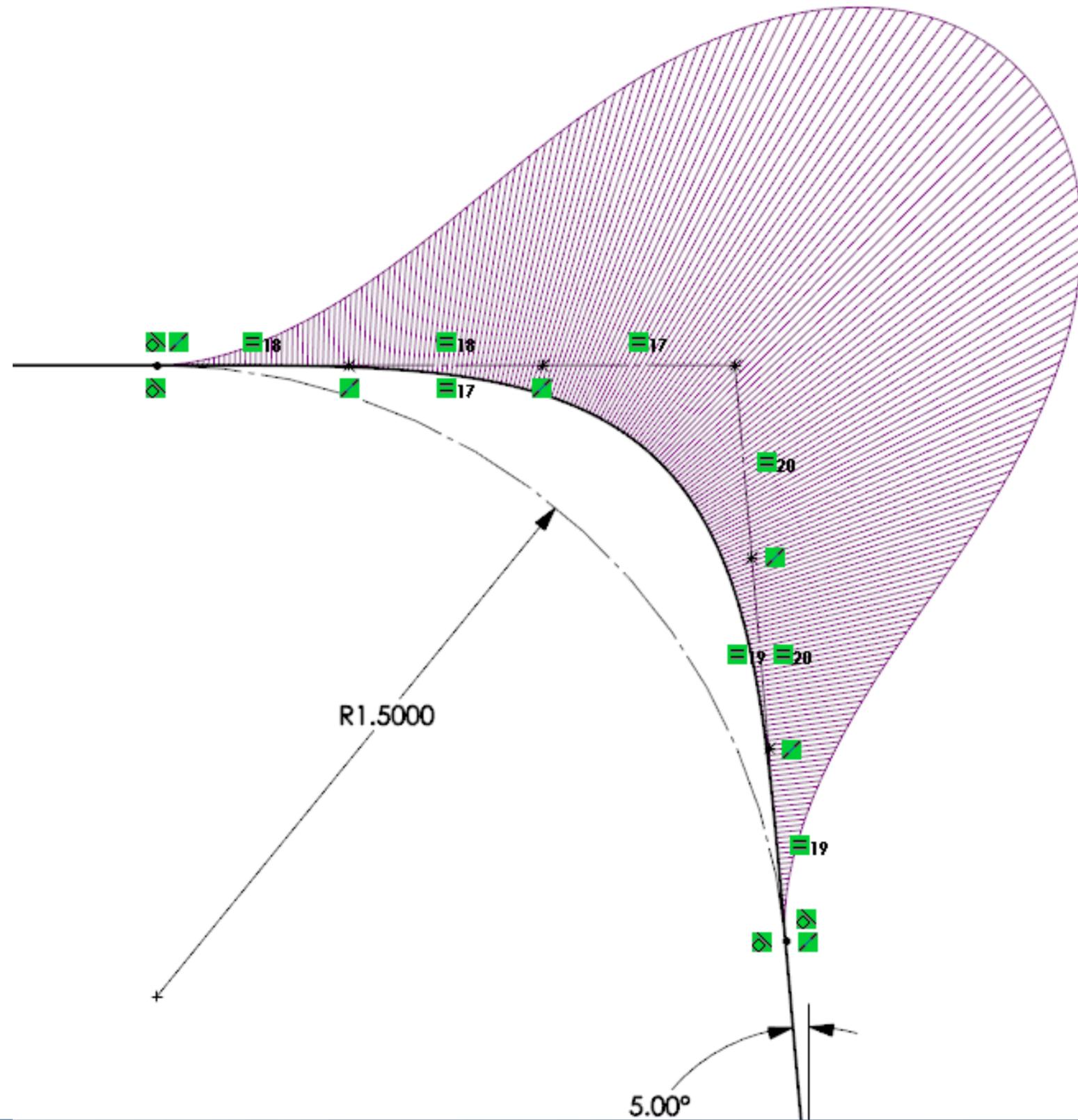
Now how does this become parametric?



# EUREKA!

In order for the G3 style spline to be parametric, the points need to move when the spline moves. Setting the control segments on each spline equal to each other solves the problem!

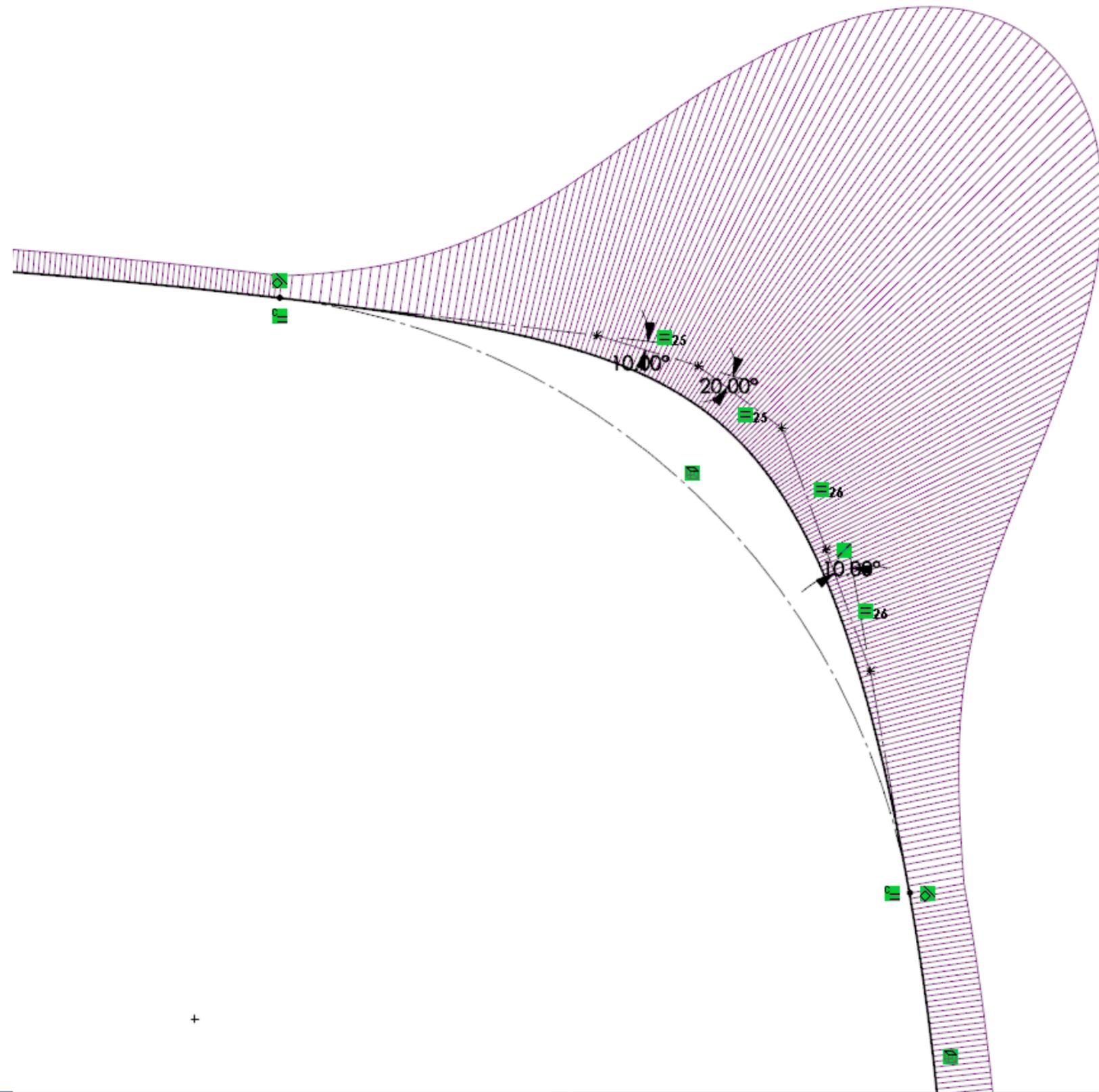
A black, fully defined parametric G3 spline!



# And Now With Arcs!

Start with a degree 6 Bezier style spline. Add the equal curvature relation to both ends of the spline.

Adjust the spline so that it's G3 continuous to the adjacent arcs. Add relations (no dimensions, angles are fine) to fully define the shape of the spline.

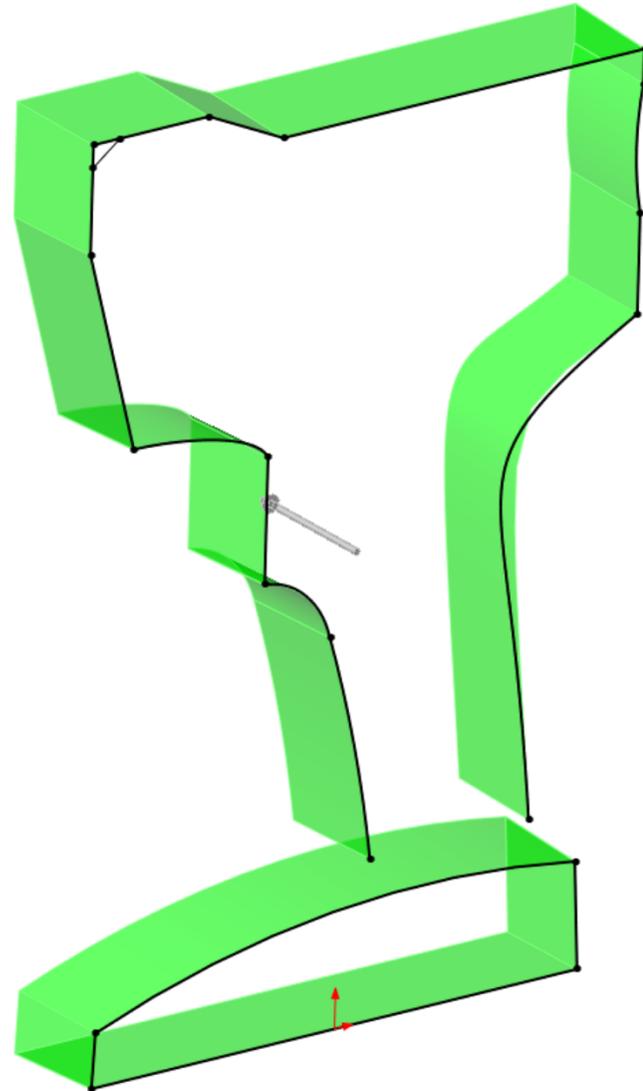
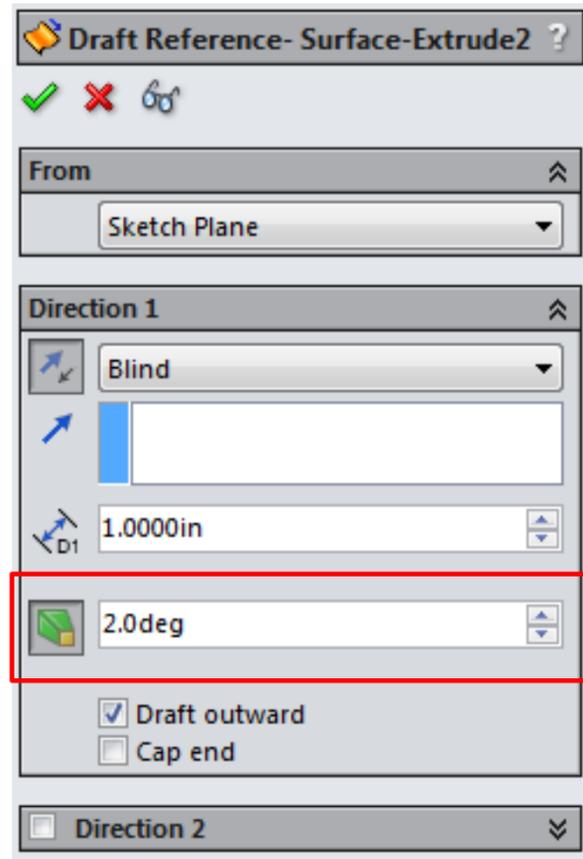


# NOW FEATURING: SURFACES



# Surface Extrude

Surface-Extrude works the same as solid extrudes. They are critical for creating reference geometry that will be used to define the shape of more complicated surfaces.



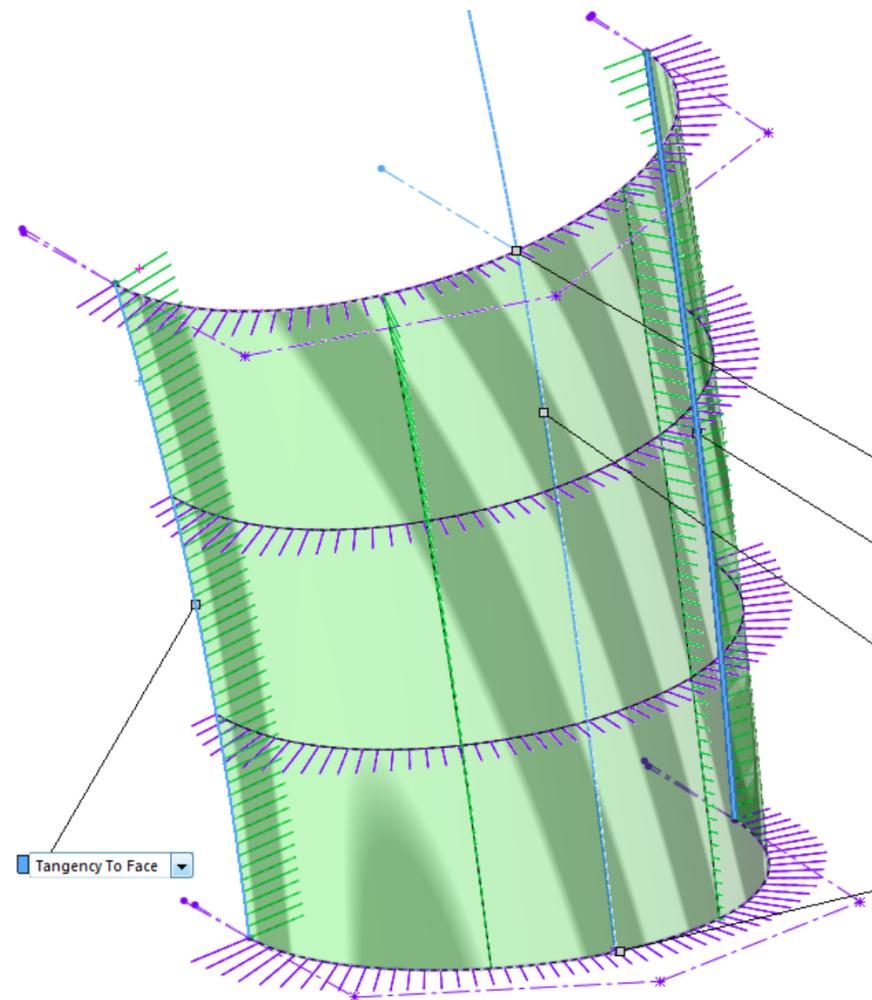
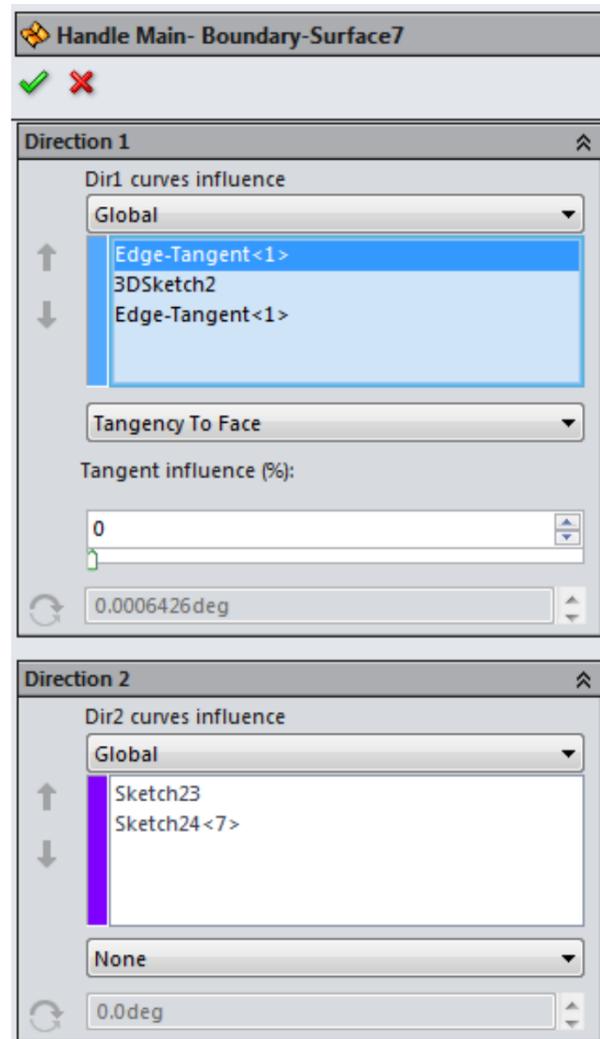
Reference surfaces have two major functions.

1. Creating draft reference surfaces. These ensure surface features have the correct draft at the parting line.
2. Creating tangency reference surfaces. These are used to ensure a flat surface along a mirror plane when creating symmetric parts.



# Boundary Surface

The Boundary Surface is the workhorse of my surface modeling in SOLIDWORKS. It generates new surfaces from a selection of profiles in either one or two directions. It supports G1 & G2 continuity in both directions.



## BEST PRACTICE:

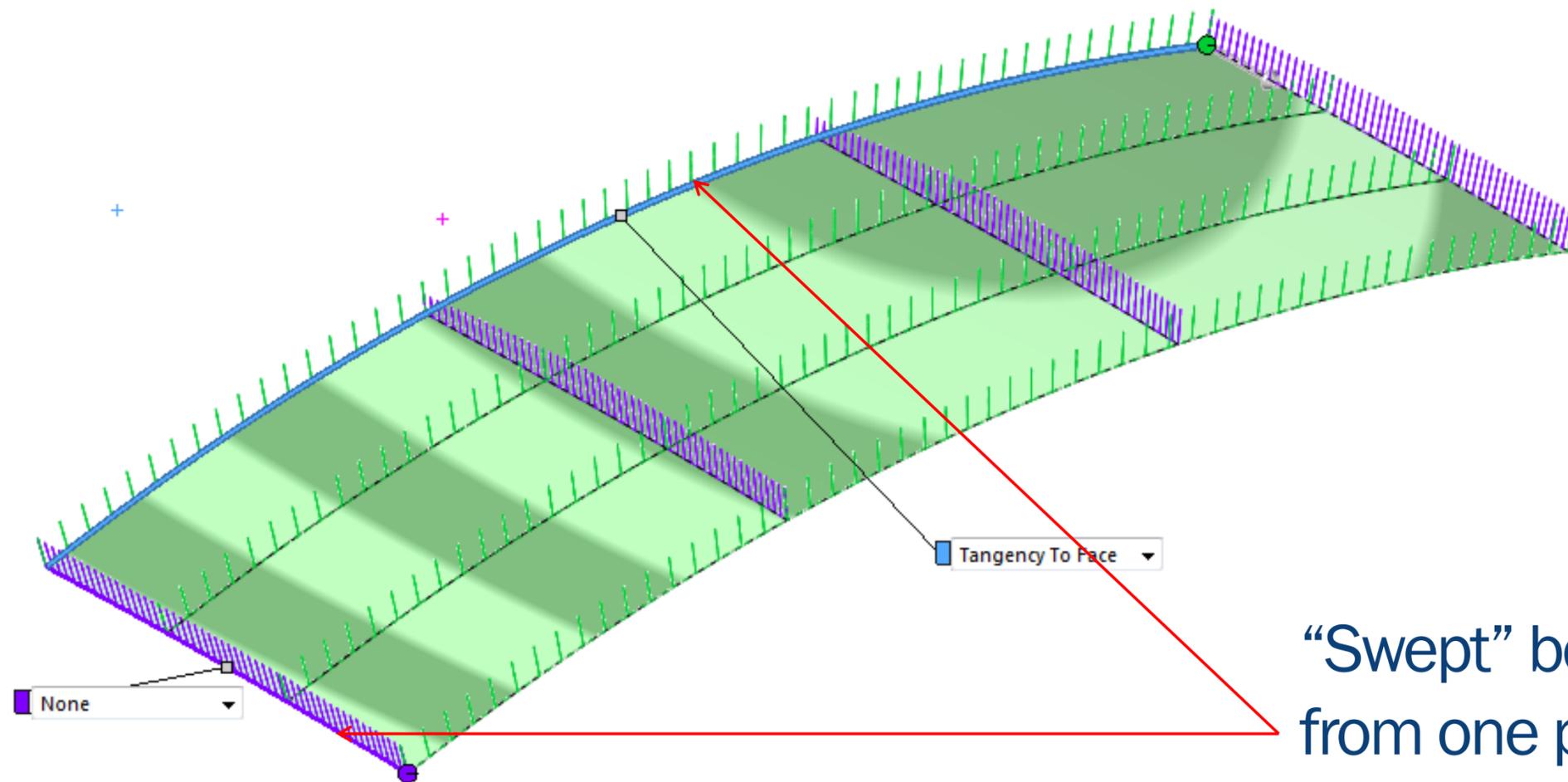
Always create Boundary Surfaces that have 4 sides. 3-sided Boundary Surfaces introduce a “degenerate point” where the two edges of the surface converge in a single vertex.

Degenerate points cause issues with Shells, Fillets, Surface Offsets and can corrupt downstream operations.



# Boundary Surface

The Boundary Surface can create surfaces from a number of profiles.

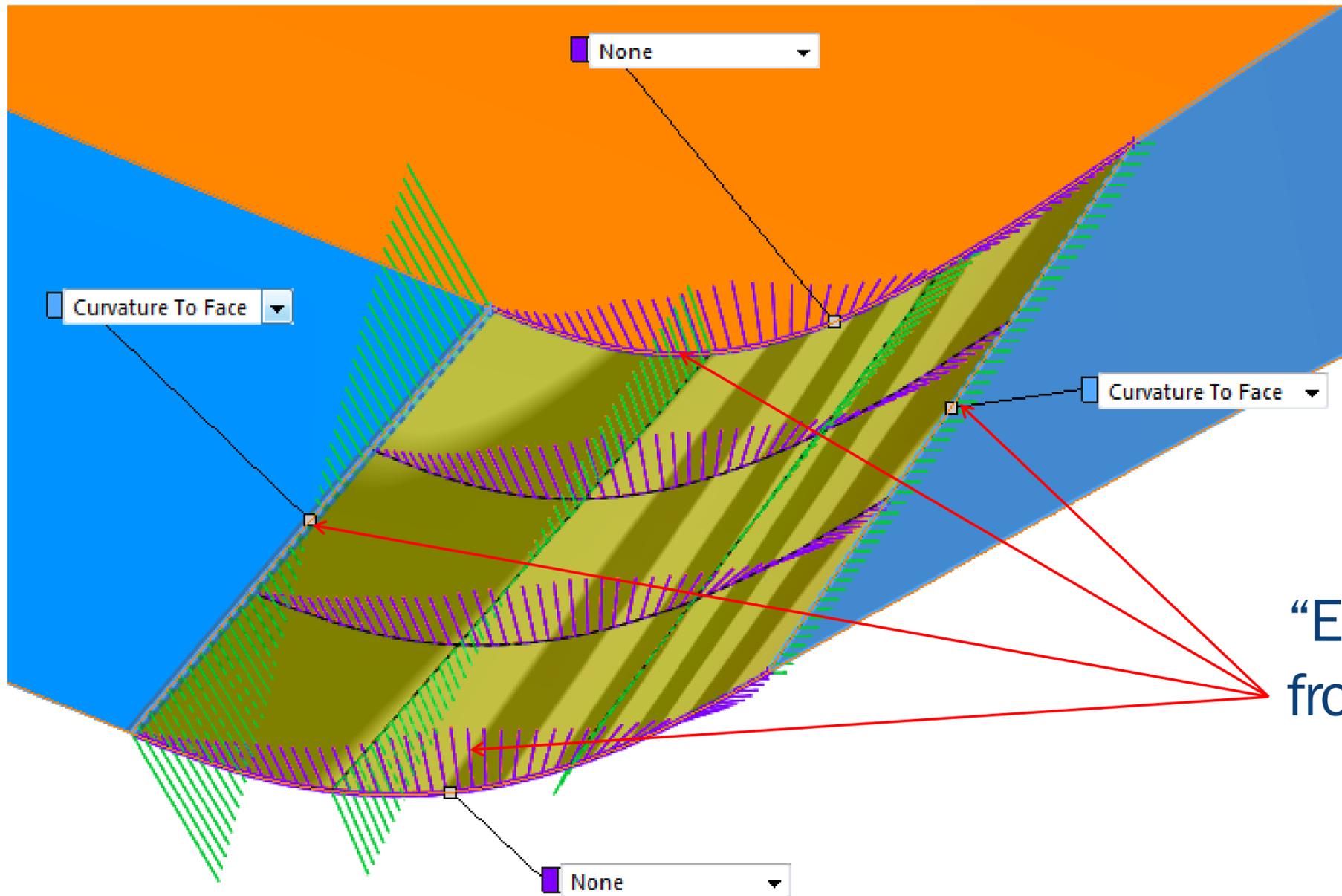


“Swept” boundary surface created from one profile in each direction.



# Boundary Surface

The Boundary Surface can create surfaces from a number of profiles.

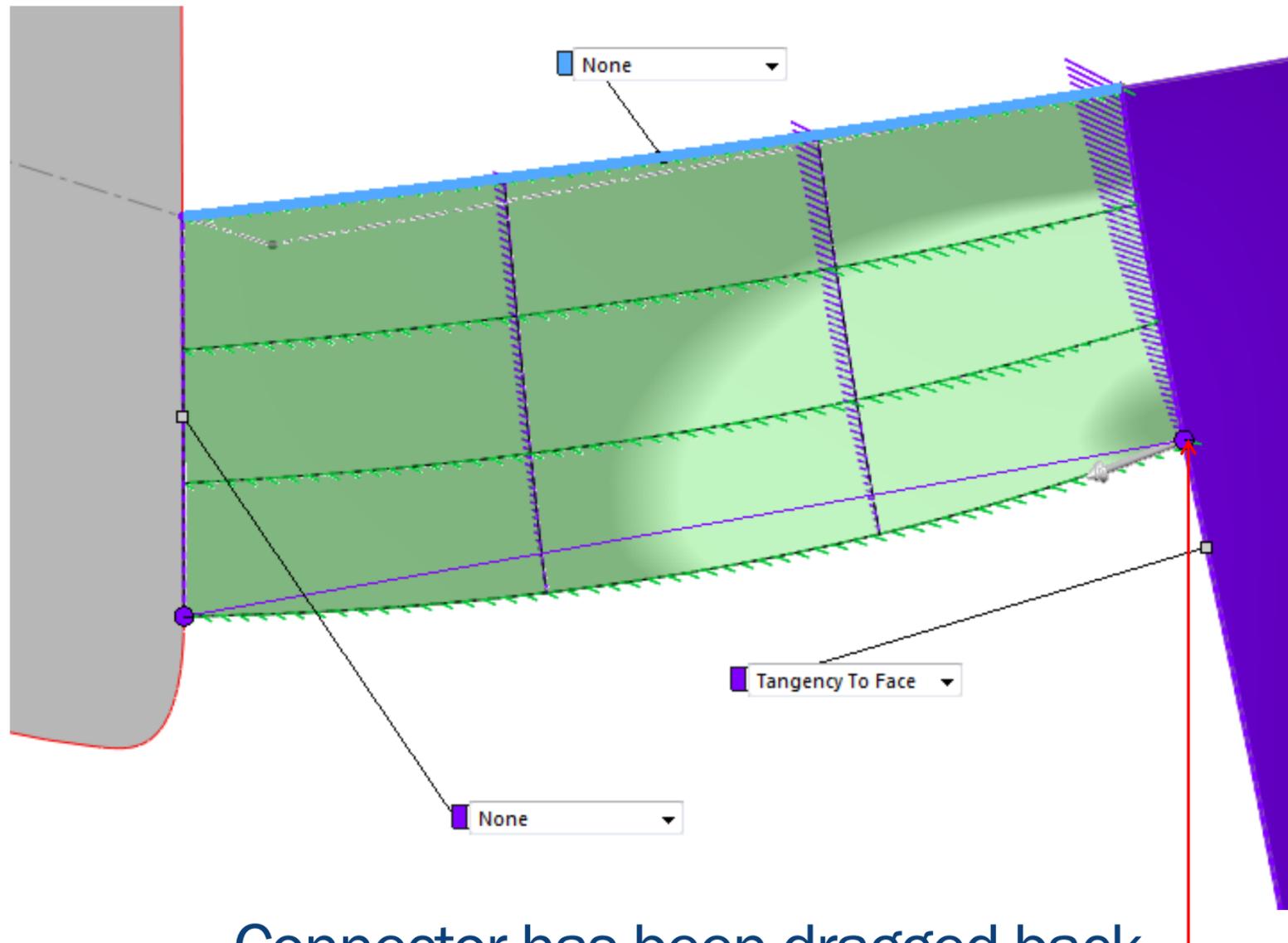


“Enclosed” Boundary Surface created from a 4 sided perimeter.



# Boundary Surface

The Boundary Surface can create surfaces from a number of profiles.



Connector has been dragged back

“Short edge” Boundary Surface where a connector has been dragged back forming new, partial edge.

The ability to adjust the start and end of a boundary profile is one its of greatest strengths.

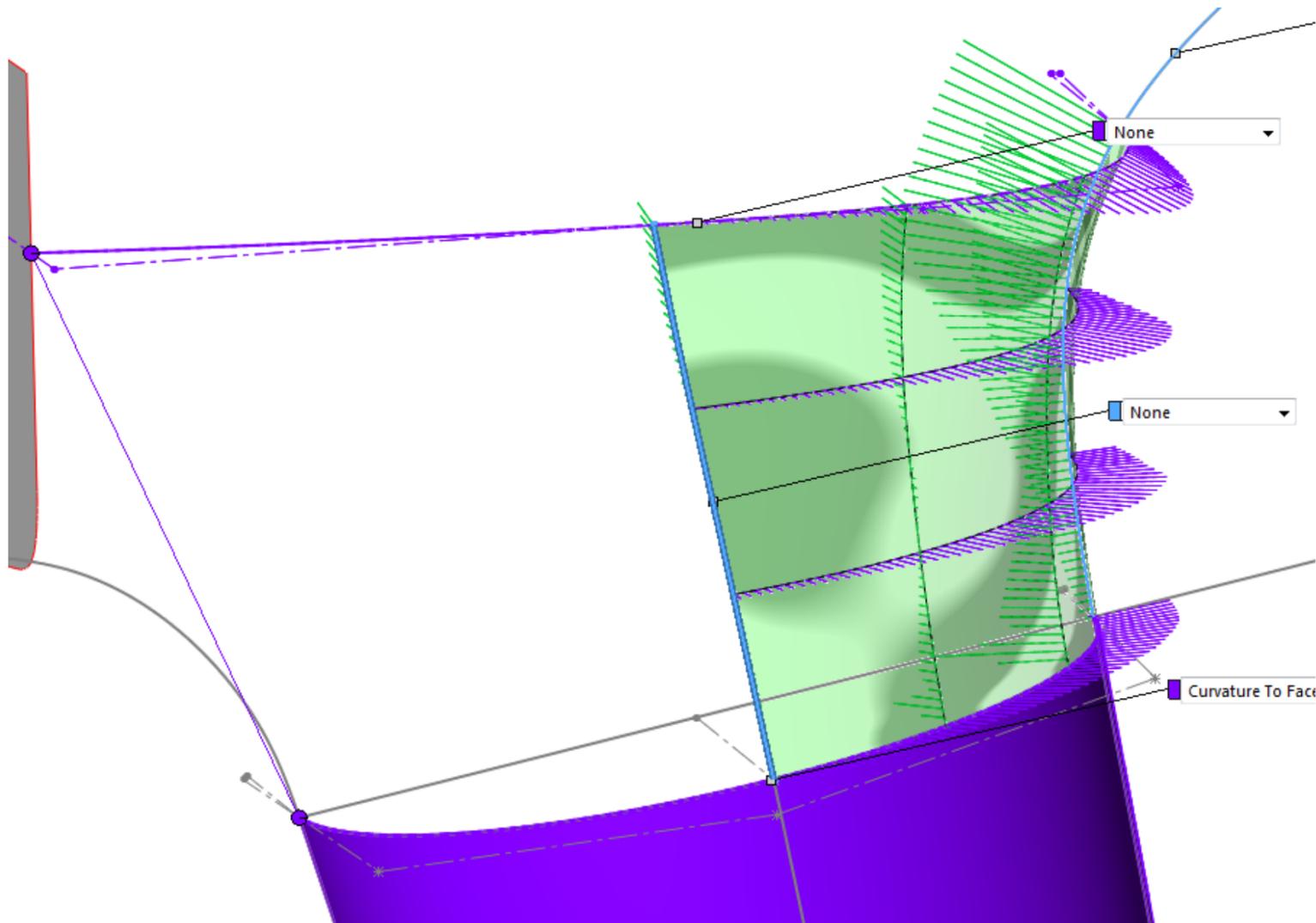
## NOTE:

Connector edits are NOT parametric and may revert to original positions on major design changes.

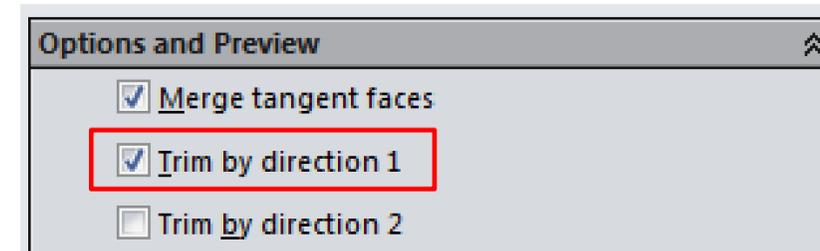


# Boundary Surface

The Boundary Surface can create surfaces from a number of profiles.



“Trimmed” Boundary Surface where the profiles in one direction extend past the profiles used. The Boundary surface is then trimmed back.

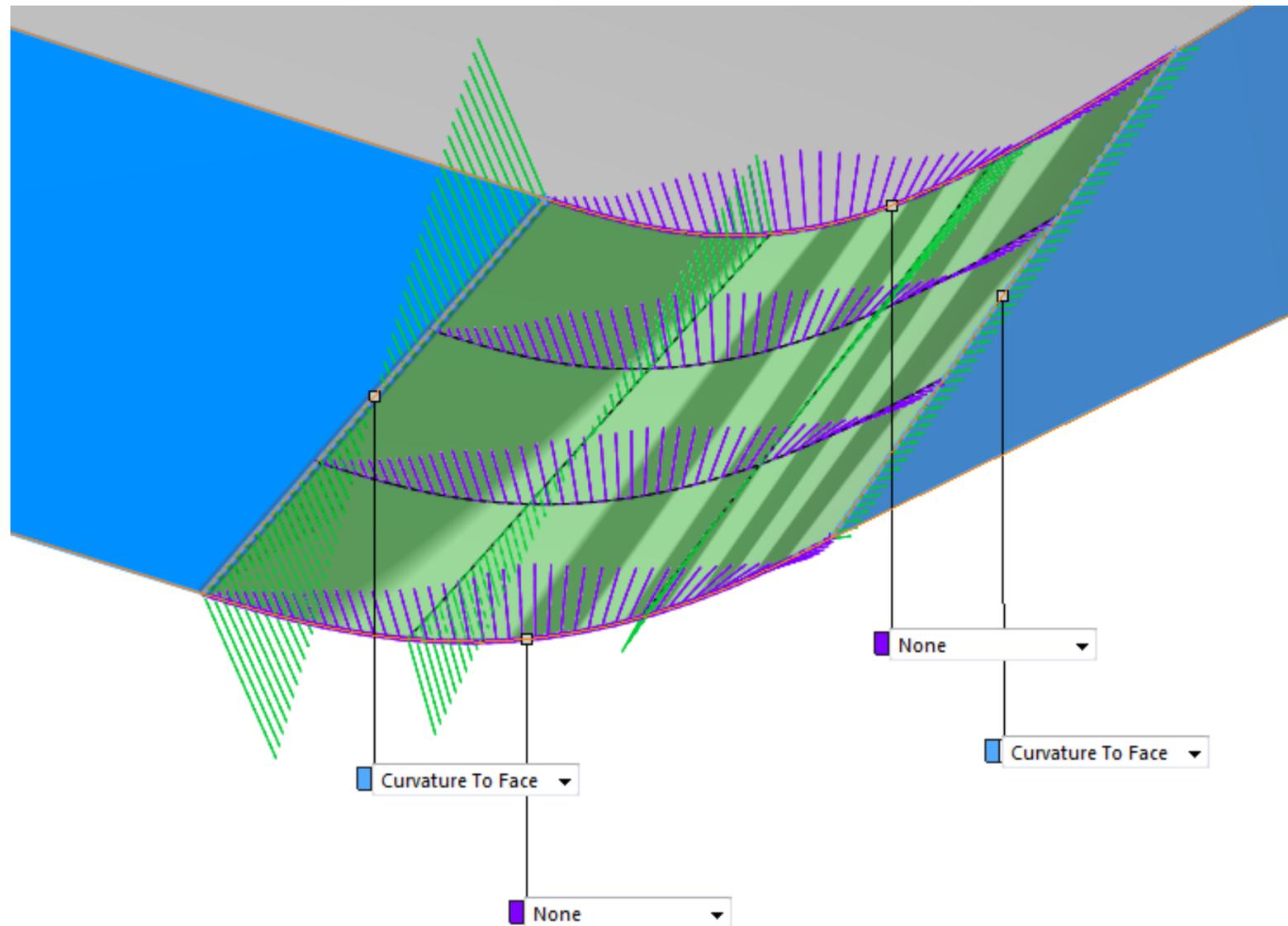


Direction 2 (PURPLE) extends past the profiles in Direction 1 (BLUE). Enabling “Trim by direction 1” allows the larger profile to be used.

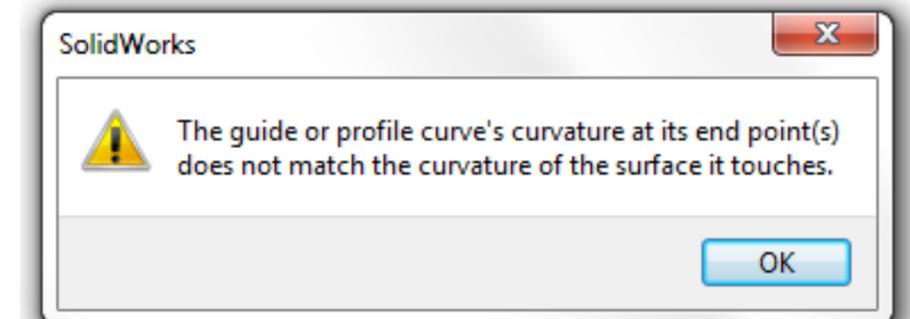


# Boundary Surface

The Boundary Surface supports tangent and curvature continuity in both directions.



Curvature continuity has been applied to the profiles in direction 1. This ensures the resultant surface is G2 to the adjacent faces.



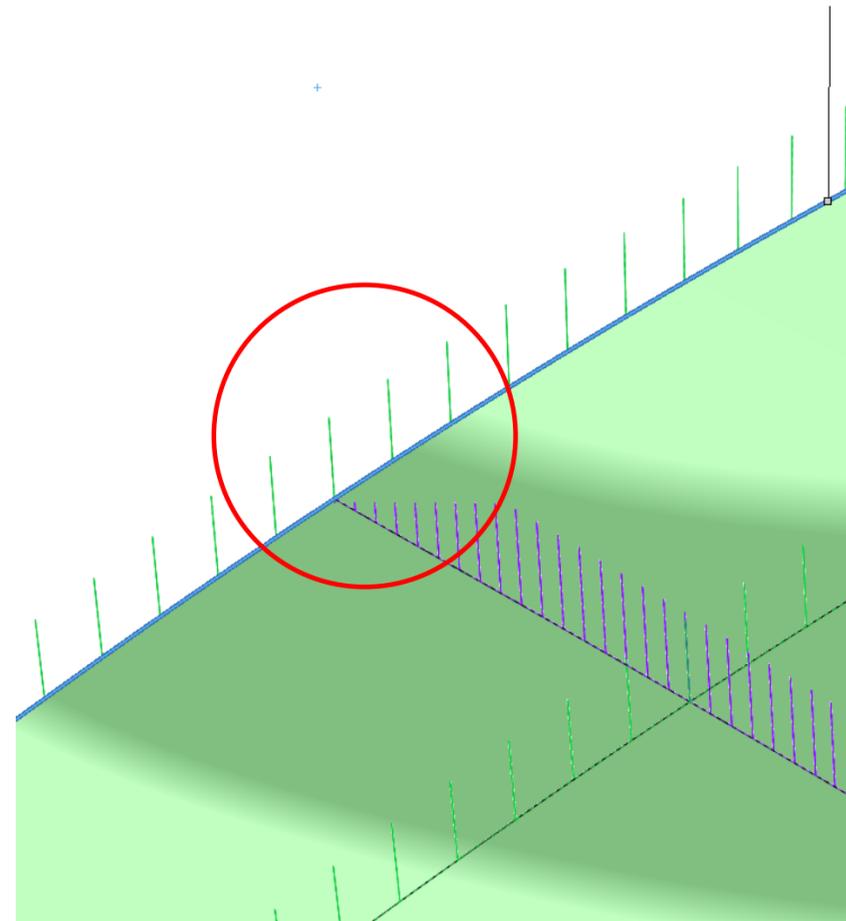
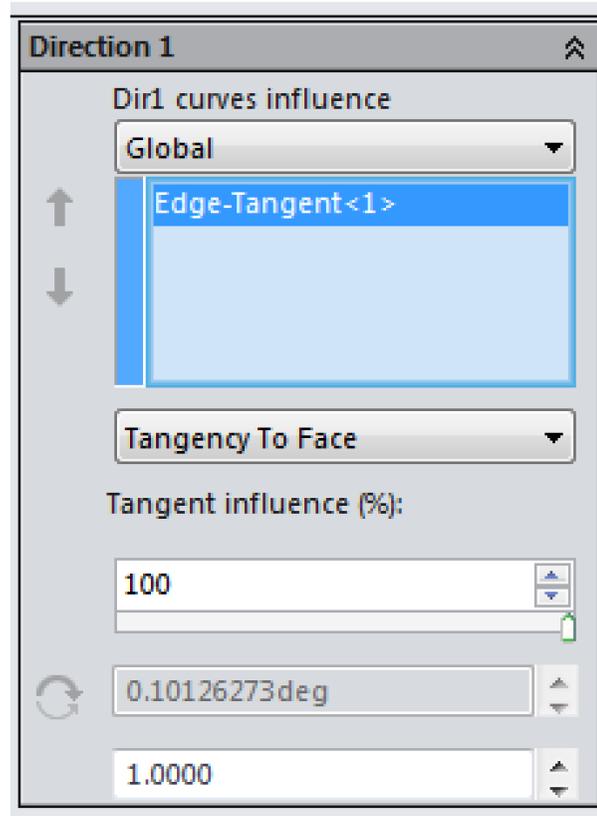
## NOTE:

This error message frequently pops up when adding the curvature relation. It is caused by slight mismatches in the adjacent faces, normally due to knitting tolerances. It can be ignored.

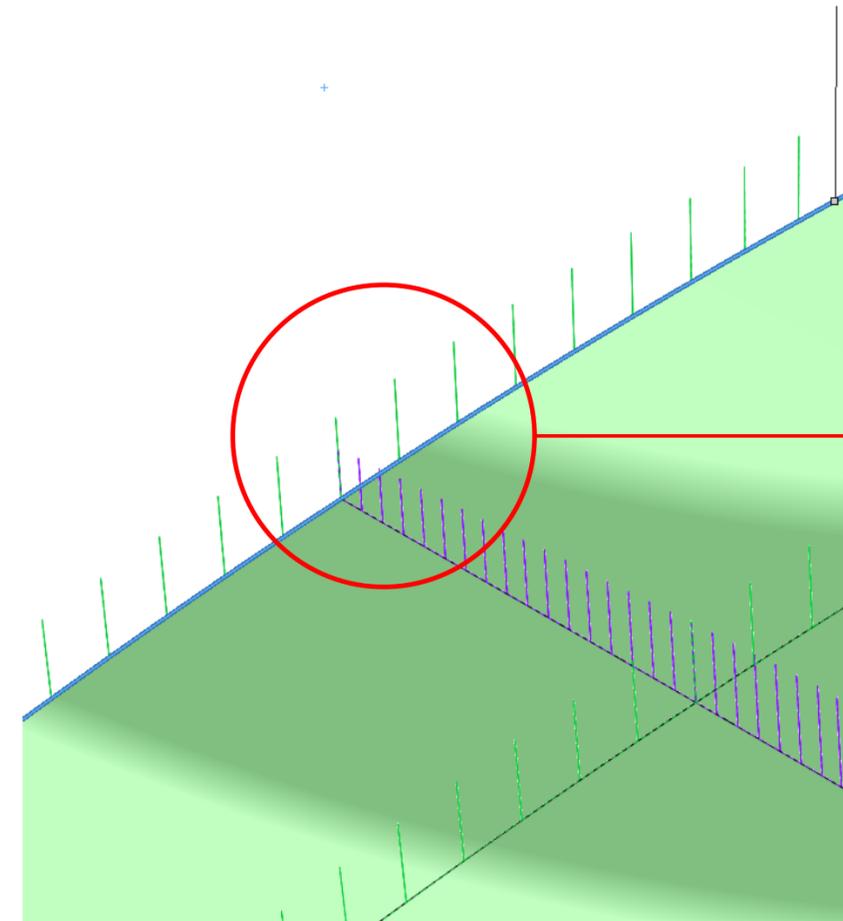


# Boundary Surface

The tangent influence slider is used to allow one profile to affect the shape of the boundary more than other profiles. It can be used to help “inflate” the shape of the surface.



Tangent Influence 0%

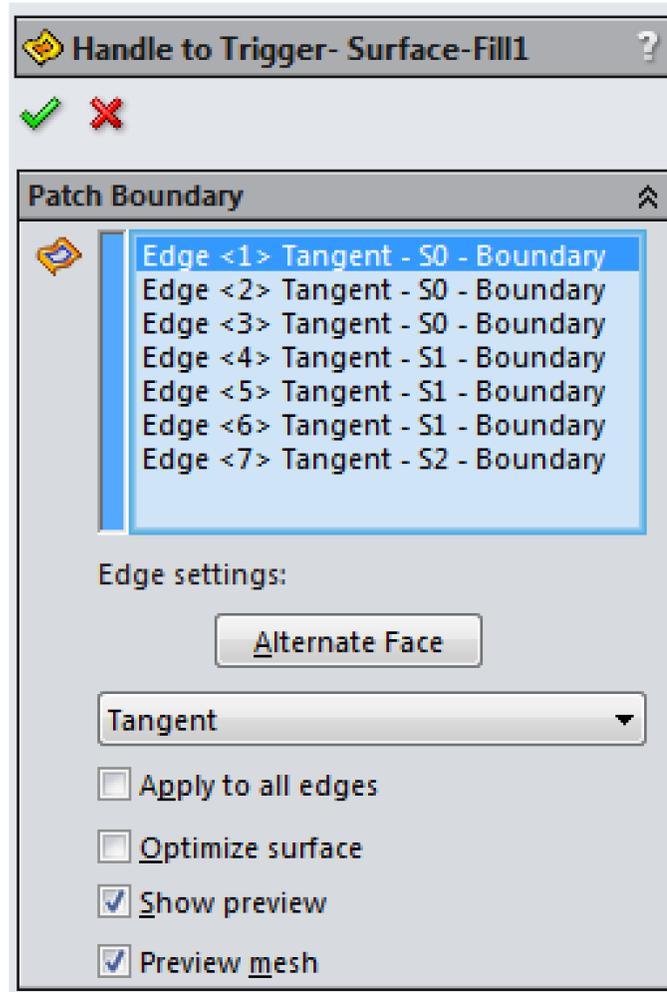


Tangent Influence 100%

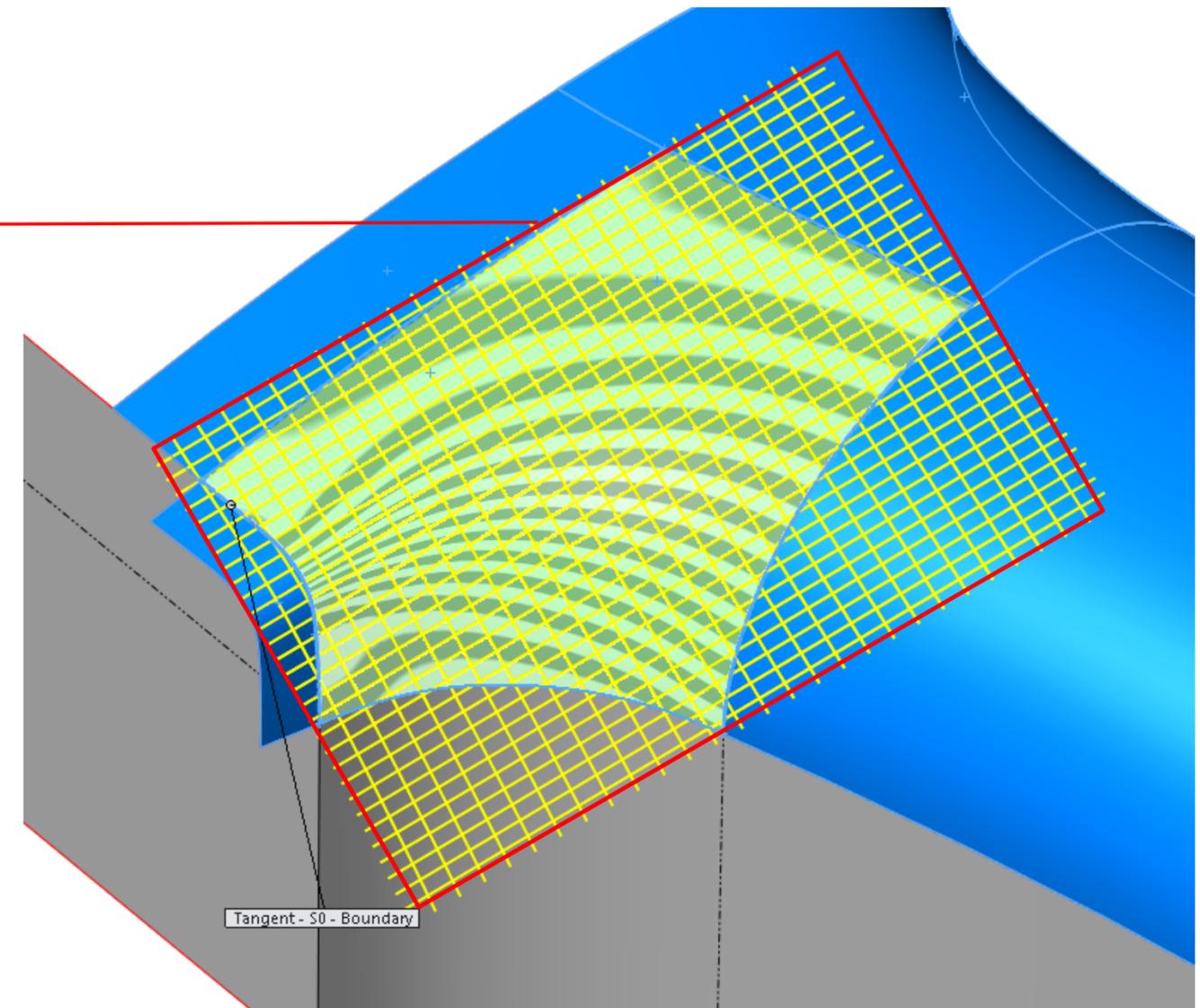
100% tangent influence corrects dip in curvature.

# Surface Fill

Surface Fill is one of the most powerful features in SOLIDWORKS. Surface Fill has the ability to create a patch within N number of surface edges. Tangent and curvature relations can also be added to the edges.



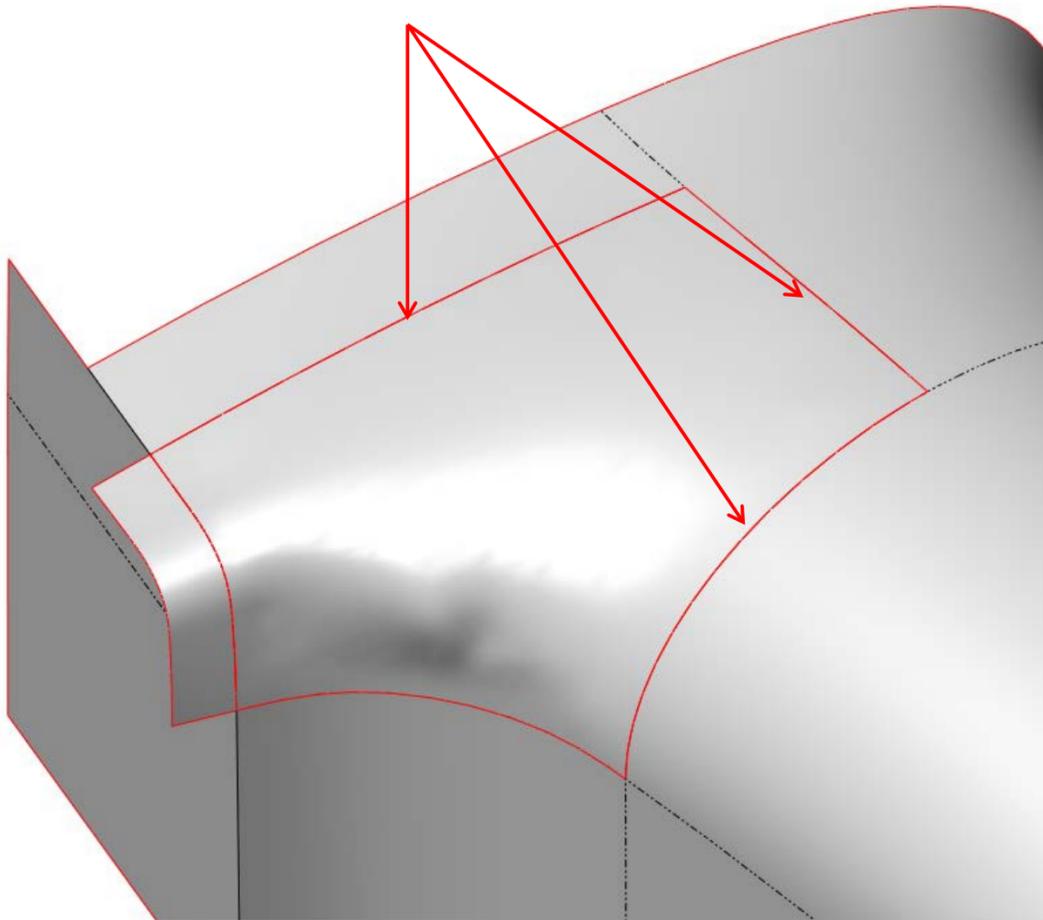
Surface Fill generates a 4-sided surface and trims it to fit within the patch boundary. This gives it the power to patch N sided boundaries.



# Surface Fill

While it may make sense to use the Curvature relation on all required edges, it can actually produce detrimental results.

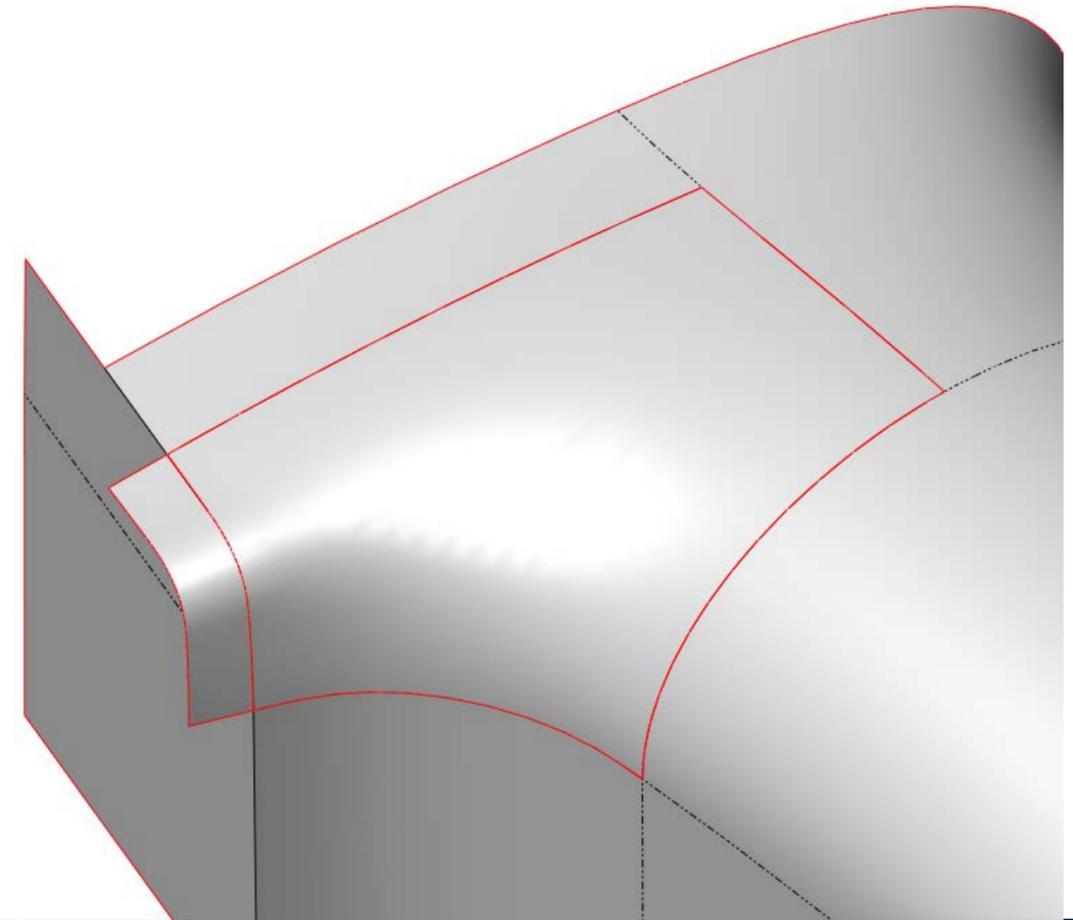
Curvature on these edges,  
Tangency on remaining edges



## Best Practice:

Apply tangency to all required edges.  
Evaluate the surface.  
Add curvature only as required.

Tangency on all edges



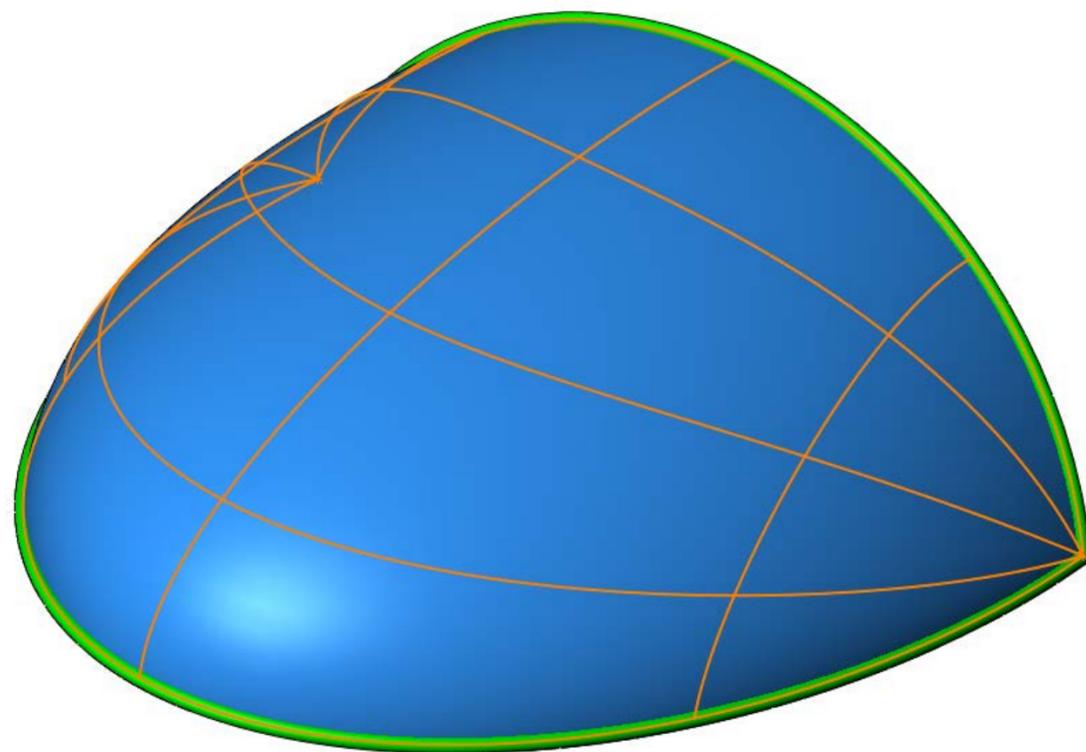
# Boundary Surface



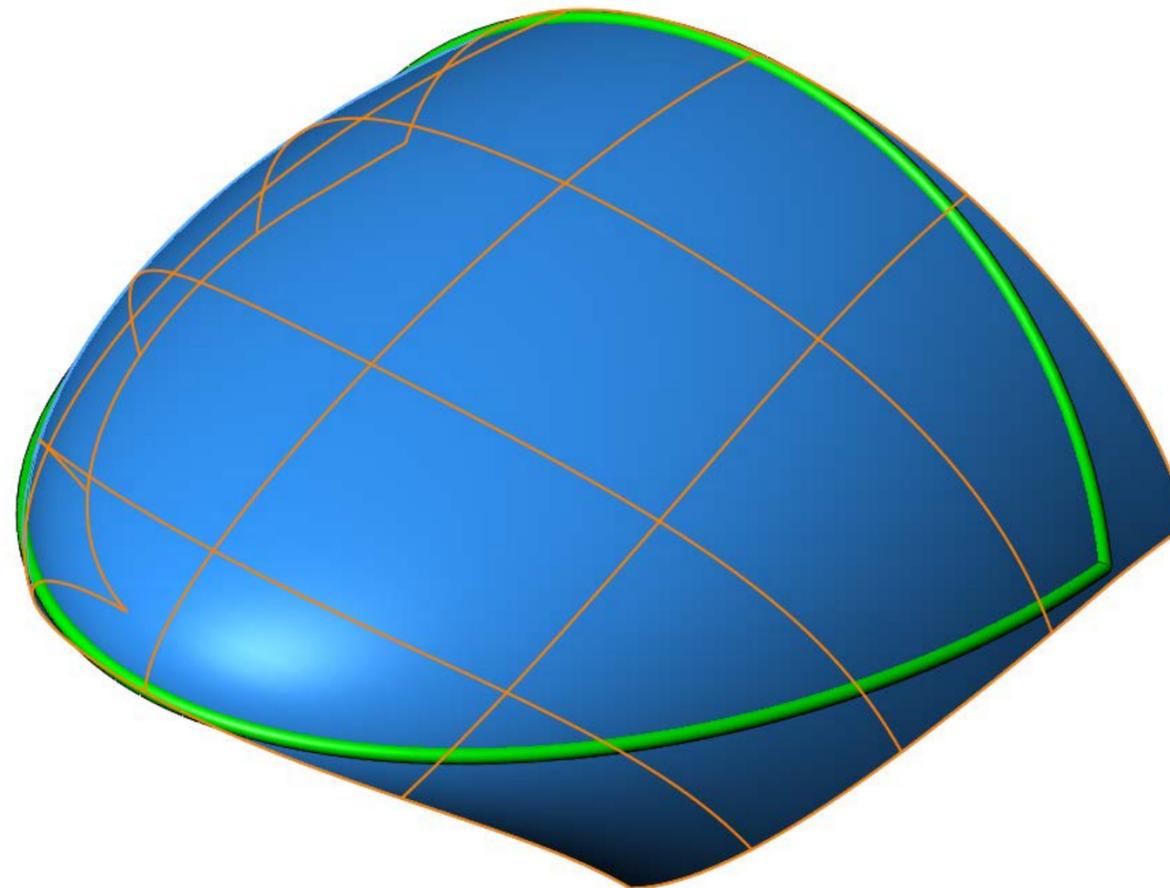
# vs Surface Fill



Imagine the outline of the patch as a frame with a rectangular tarp stretched over. The tarp can be any shape and size, but always starts with 4 sides.



Trying to fit the tarp over this shape results in bunched up corners.



Draping the tarp over the frame and then trimming prevents the corners from bunching.

# Boundary Surface



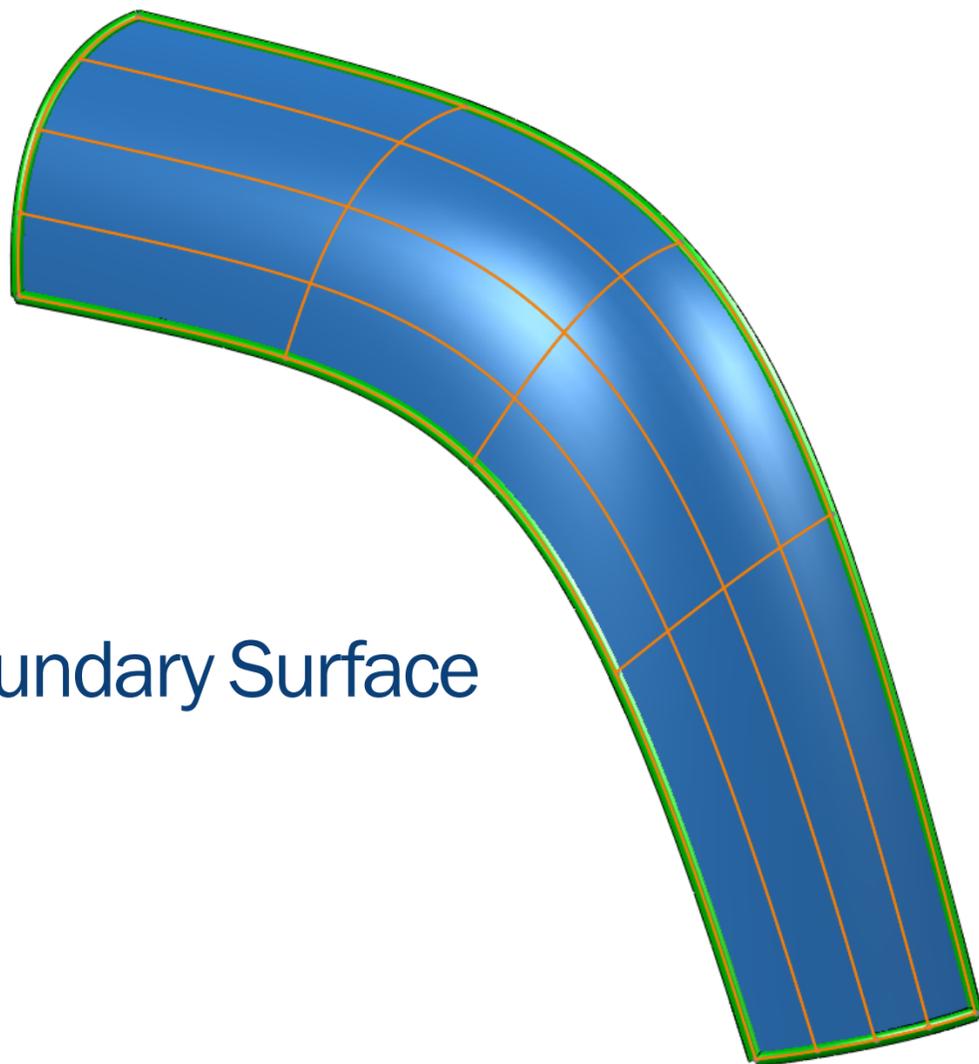
# vs Surface Fill



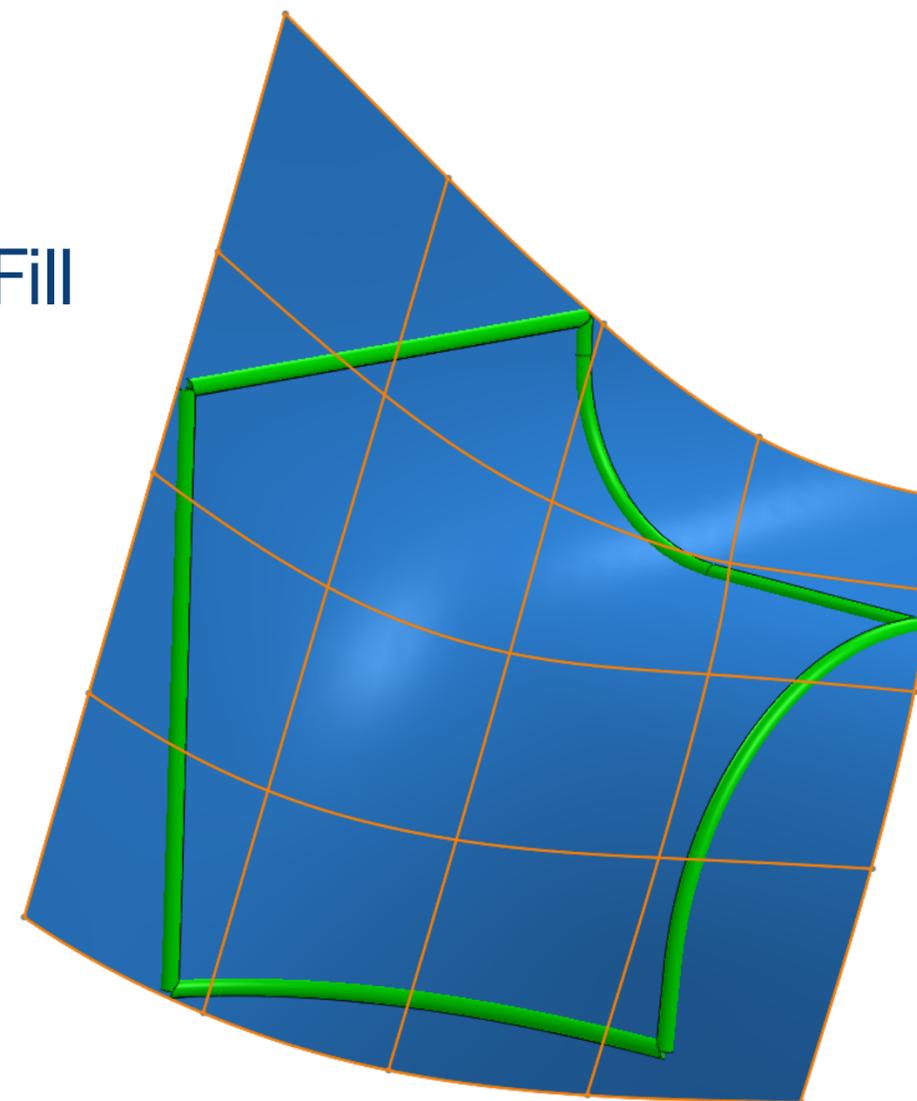
When the surface to be created is 4 sided, use Boundary Surface for more control.

When the surface to be created is 2,3 or 5+ sided, use Surface Fill due to its ability to trim back.

Boundary Surface



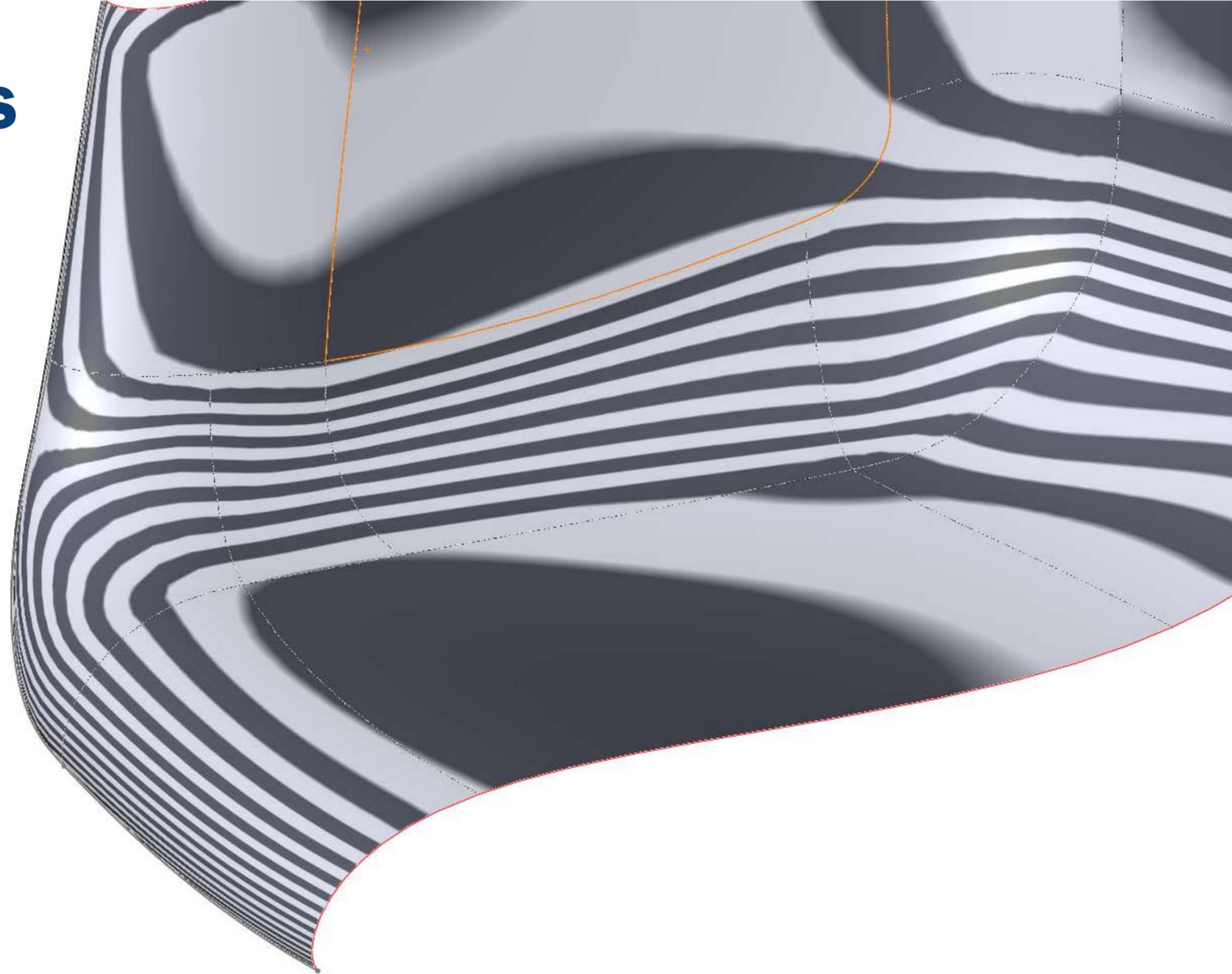
Surface Fill



# Evaluating Connections Zebra Stripes

Evaluate the flow of light over the various surfaces with Zebra Stripes.

There should be no break in the zebra stripe over a surface edge. The connection should be perfectly smooth. A hard edge indicates dissimilar radii at the junction.

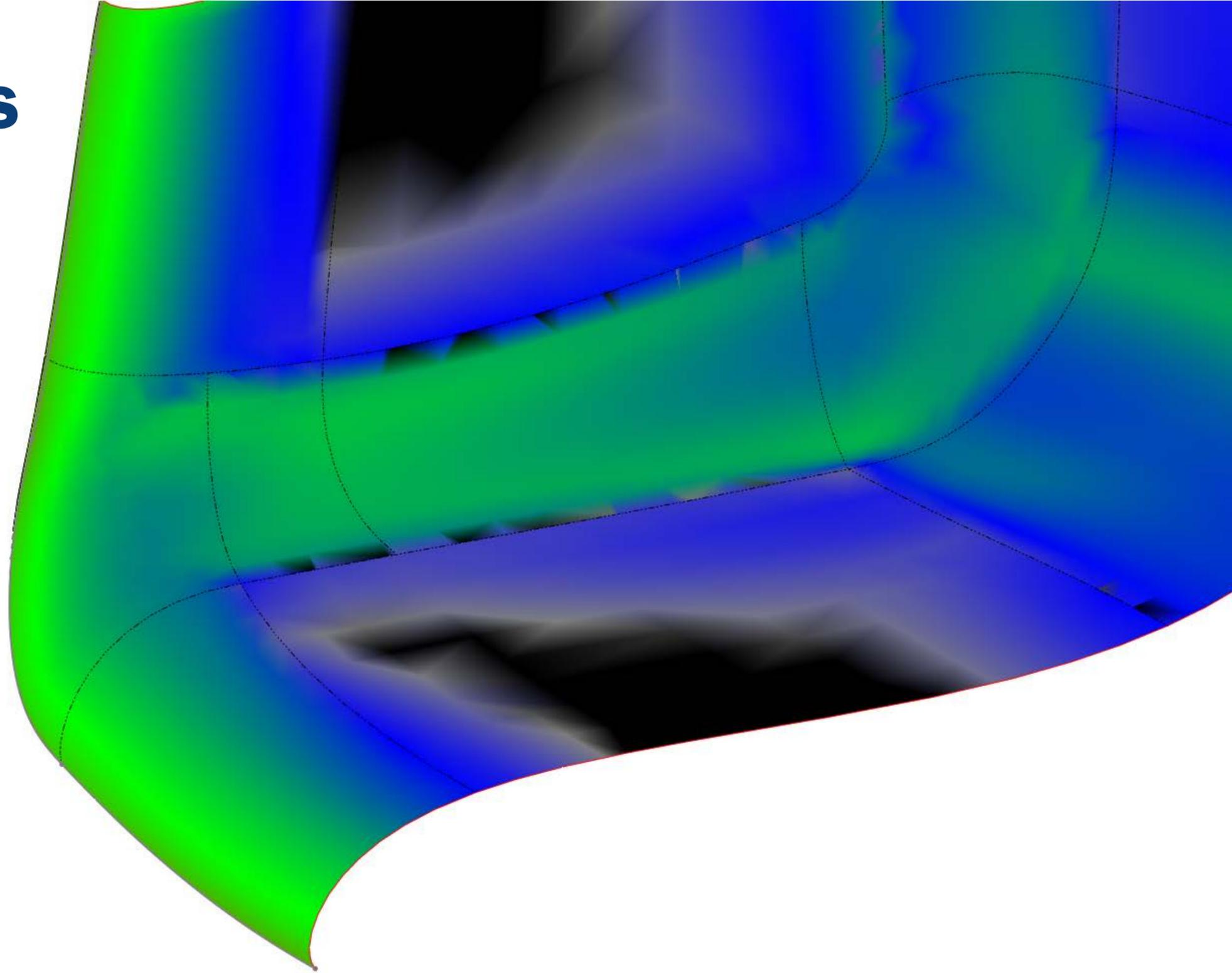


# Evaluating Connections

## Curvature Display

Evaluate the flow change of curvature with curvature display.

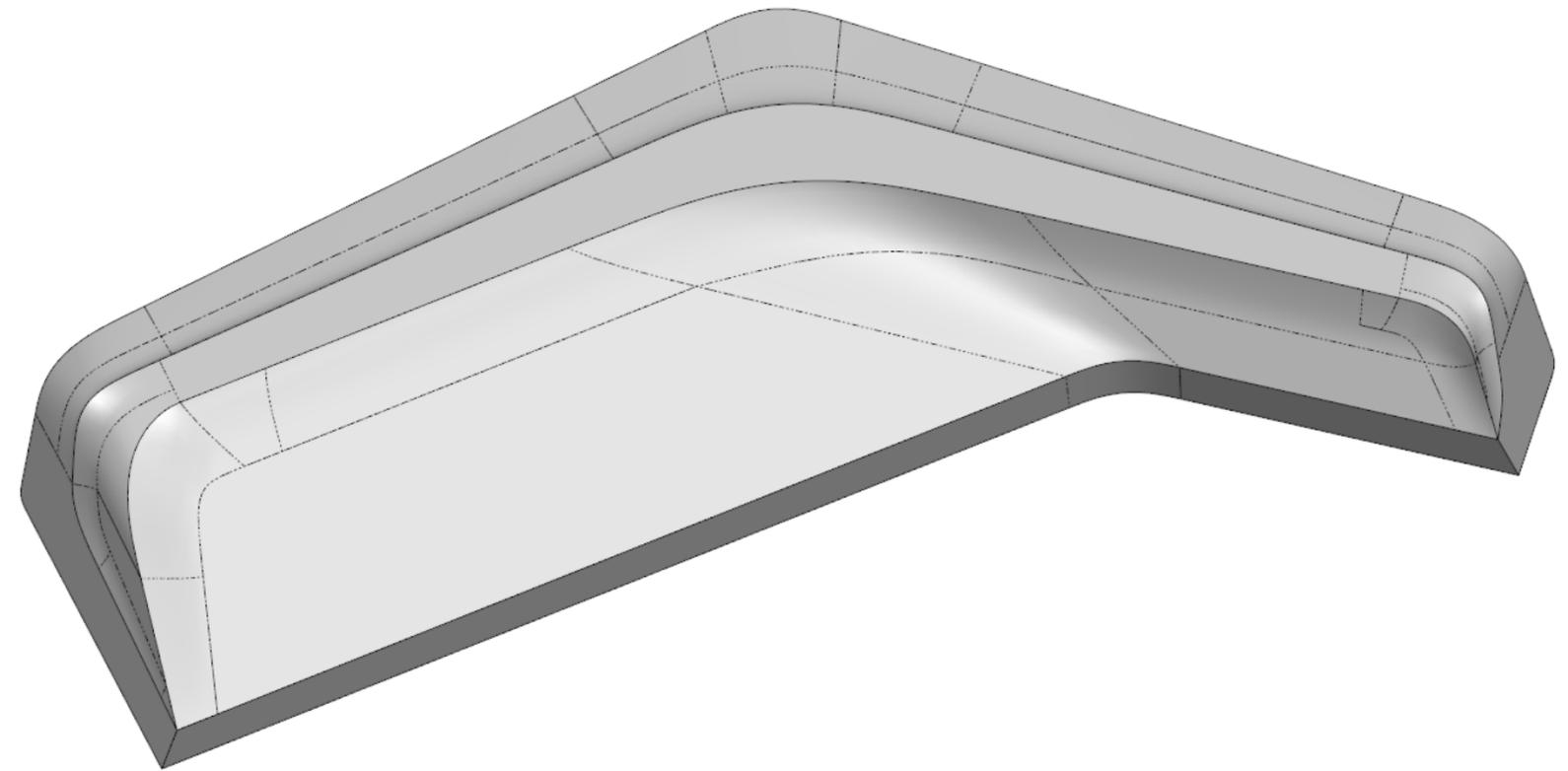
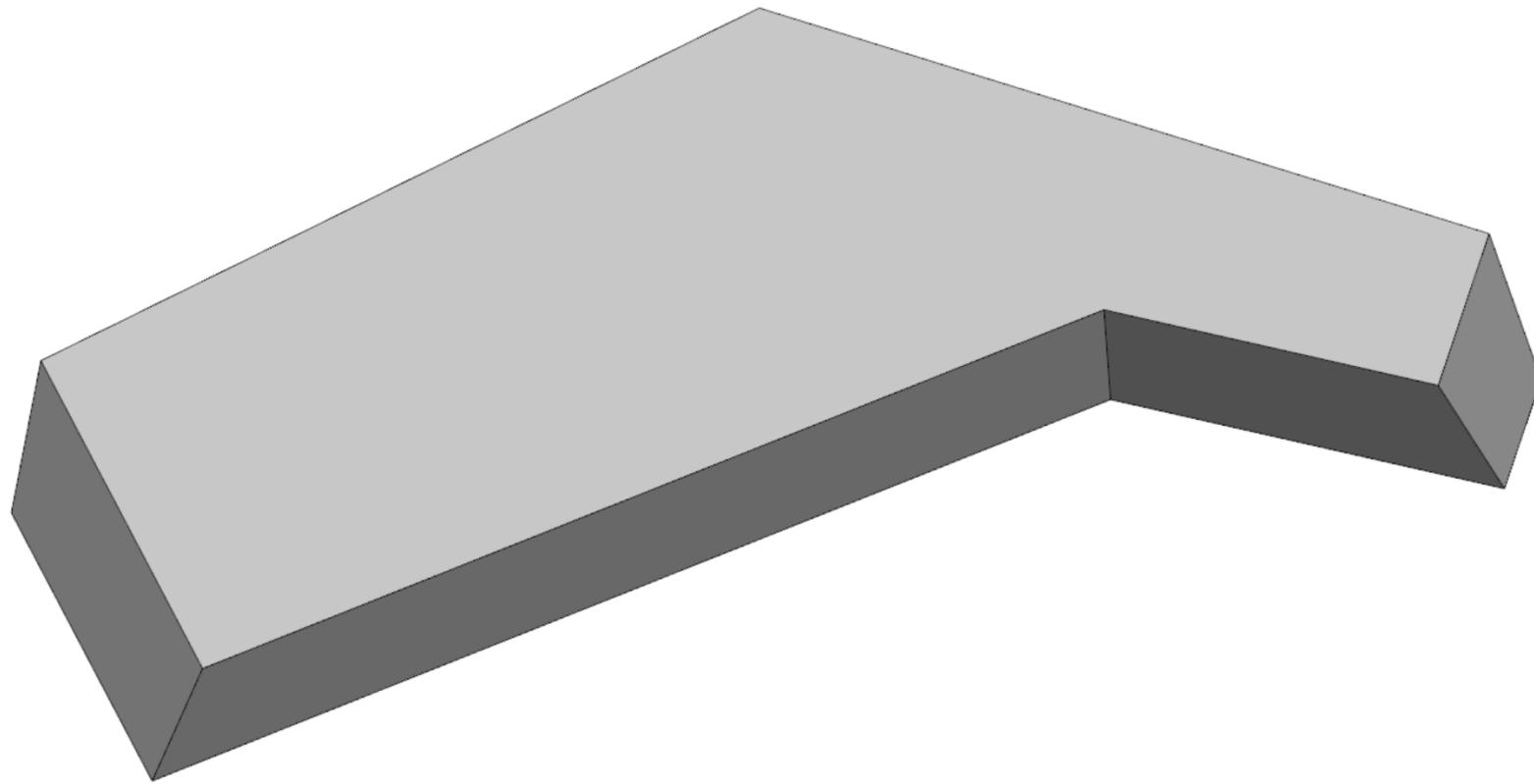
A gradual gradient indicates smooth change in curvature. A sharp color break between two surfaces indicates two different radii at the junction.



# SOLID SCUPLTING

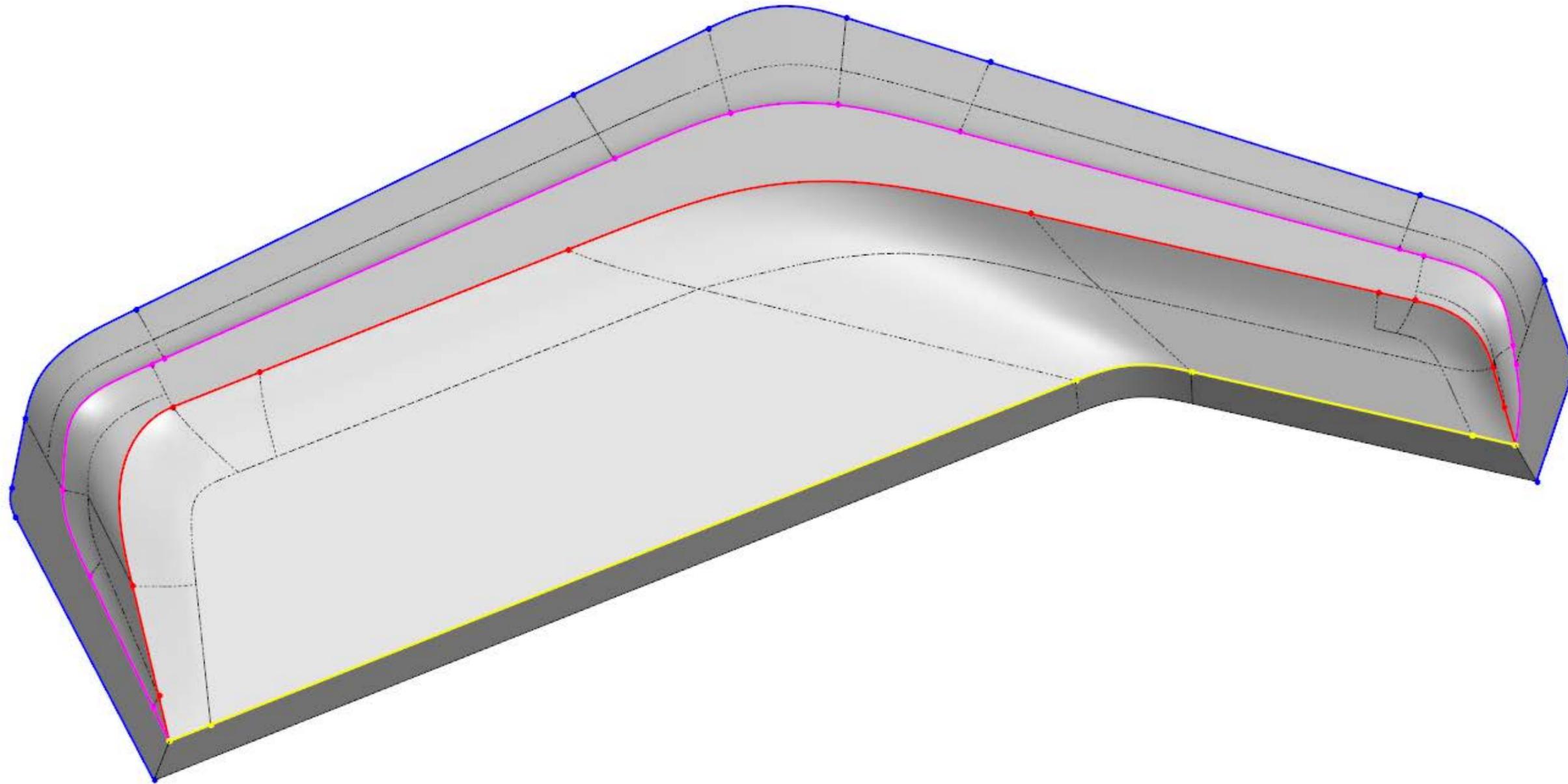
# “Subtractive” Surfacing

The smooth, organically shaped handle will be constructed entirely with surface features.



# Identify Character Lines

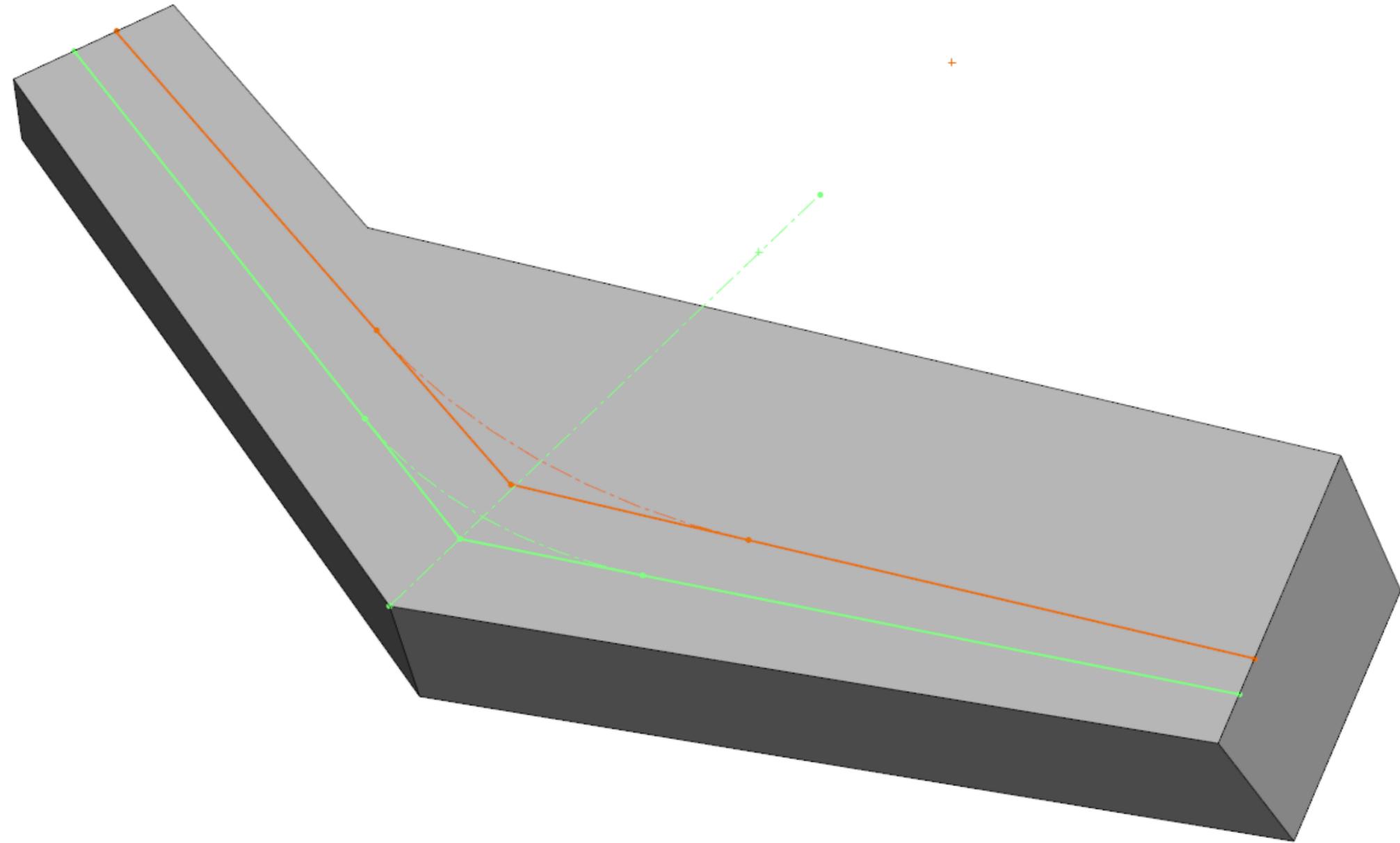
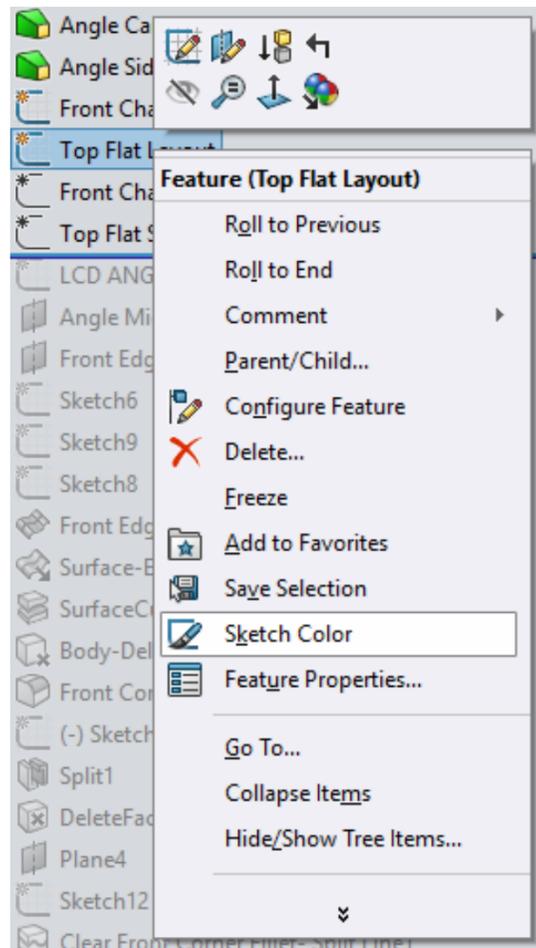
The smooth, organically shaped handle will be constructed entirely with surface features.



# Identify Character Lines

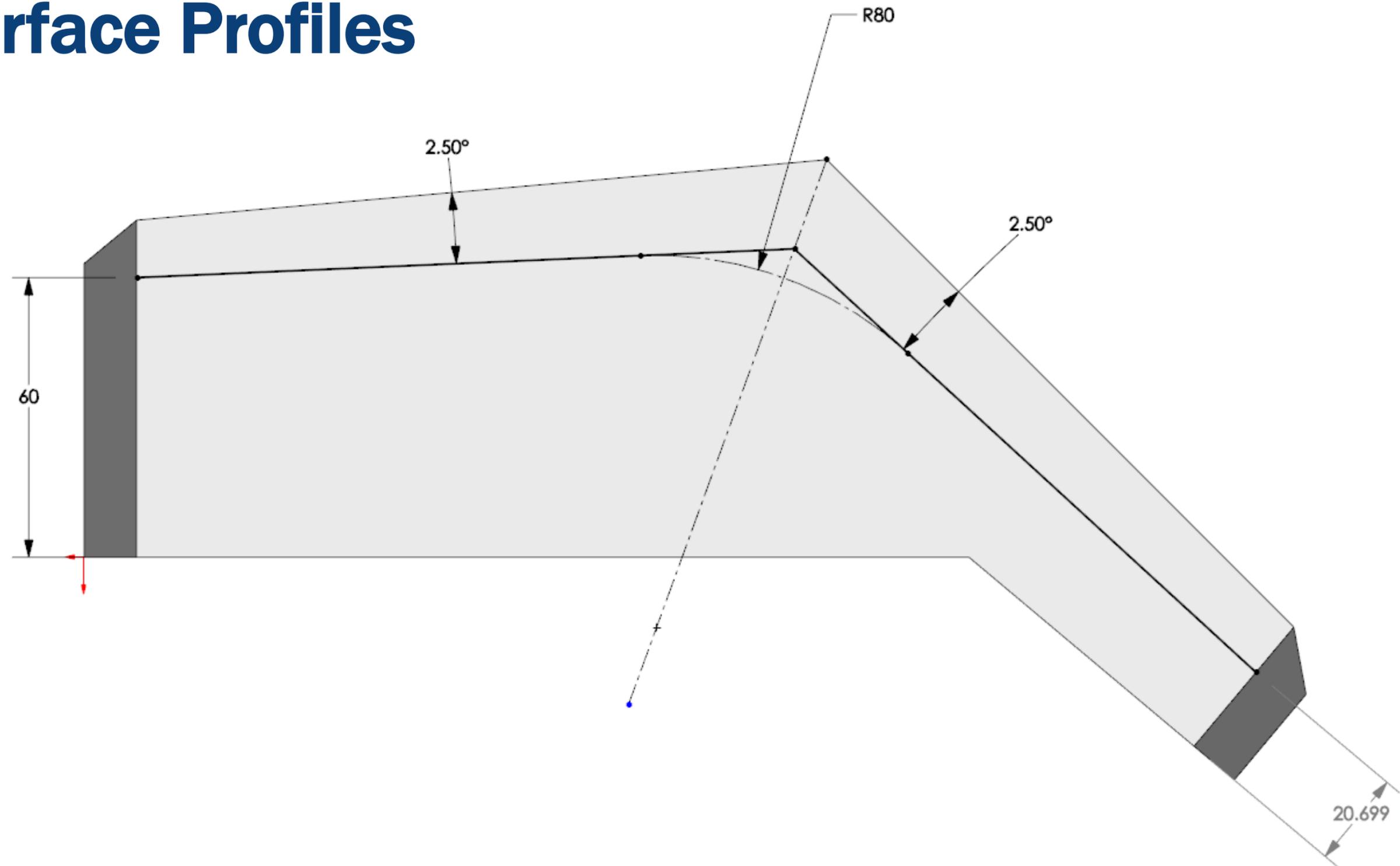
The smooth, organically shaped handle will be constructed entirely with surface features.

**TIP:** Color your layout sketches! They stand out against all the grey!



# Sketch the Surface Profiles

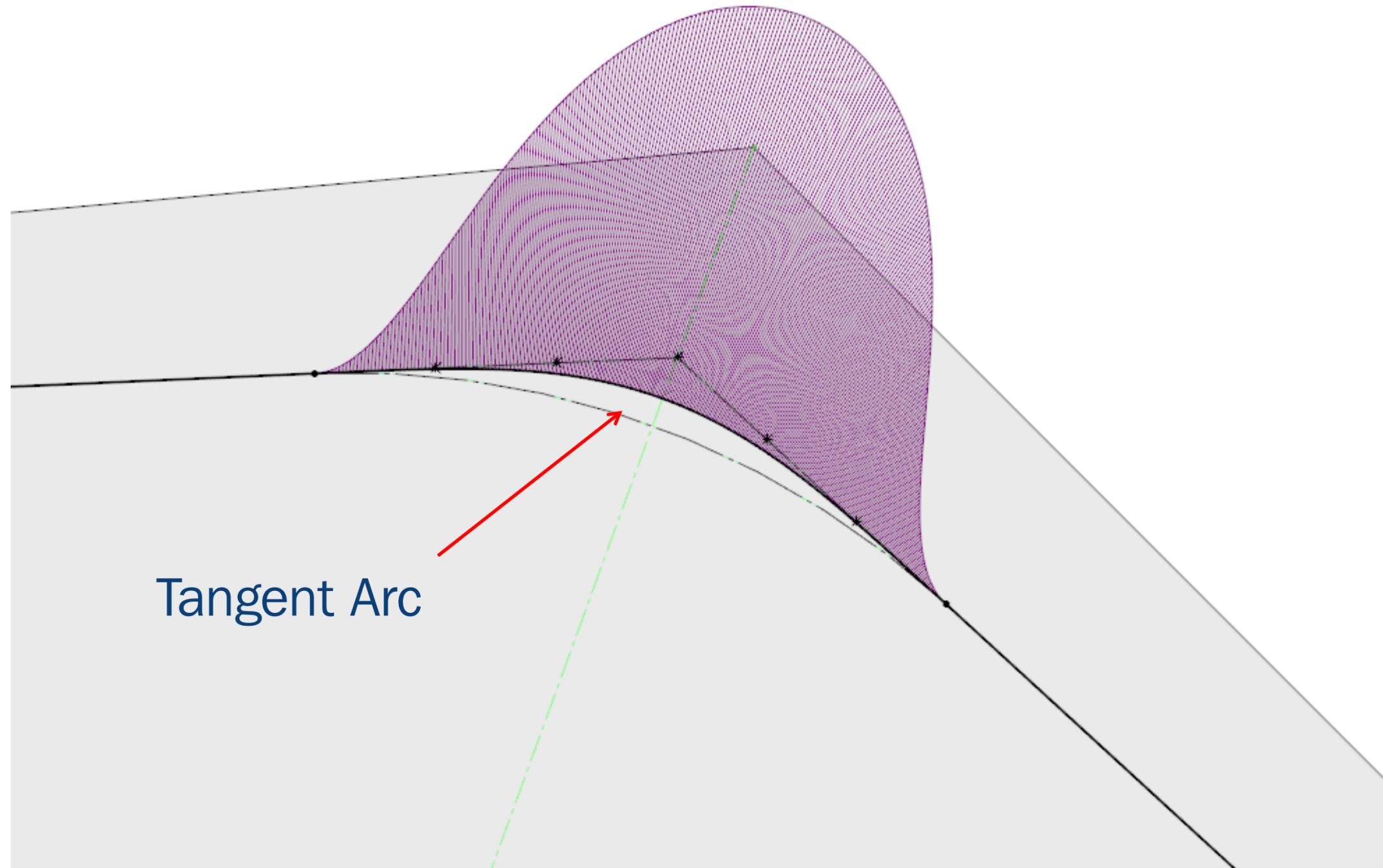
The smooth, organically shaped handle will be constructed entirely with surface features.



# Smother Connections Look Smaller

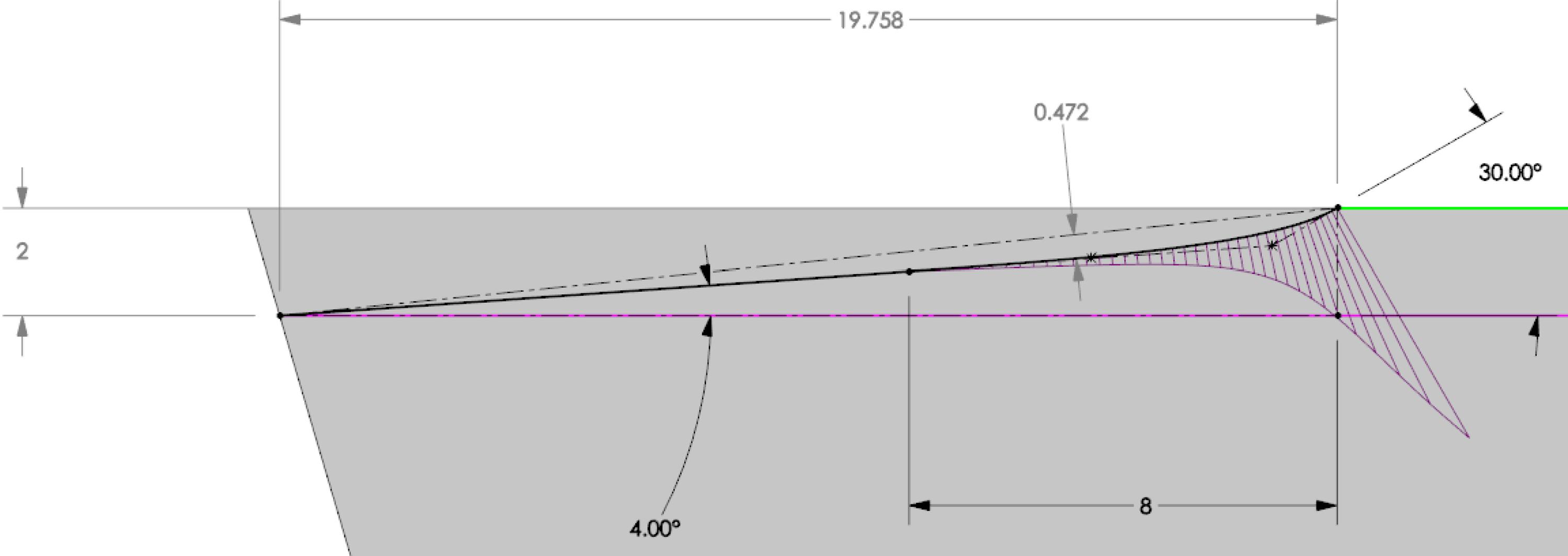
The higher the degree of the transition, the visually smaller the transition will look.

The G3 Style Spline visually appears smaller than the G1 tangent arc.



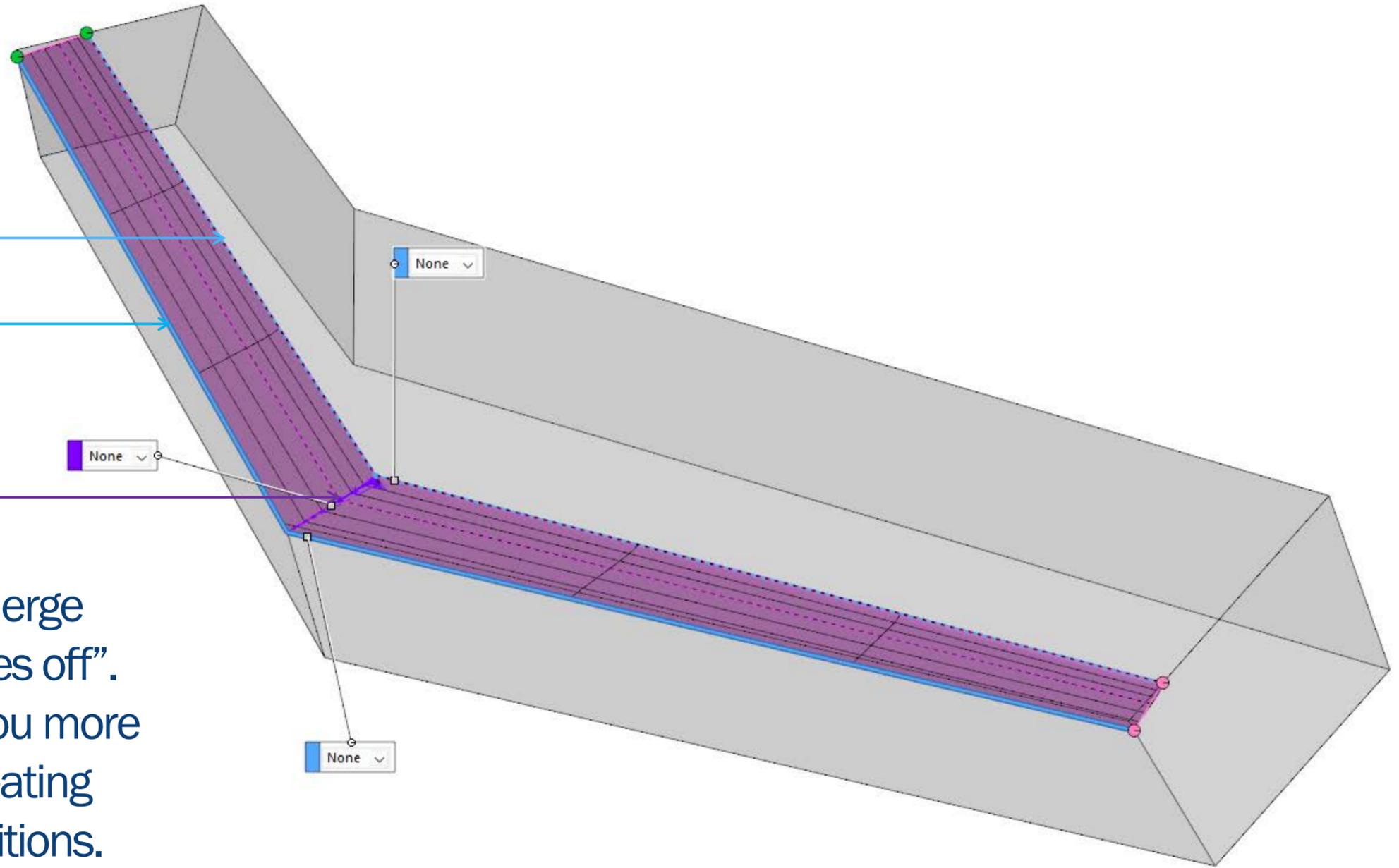
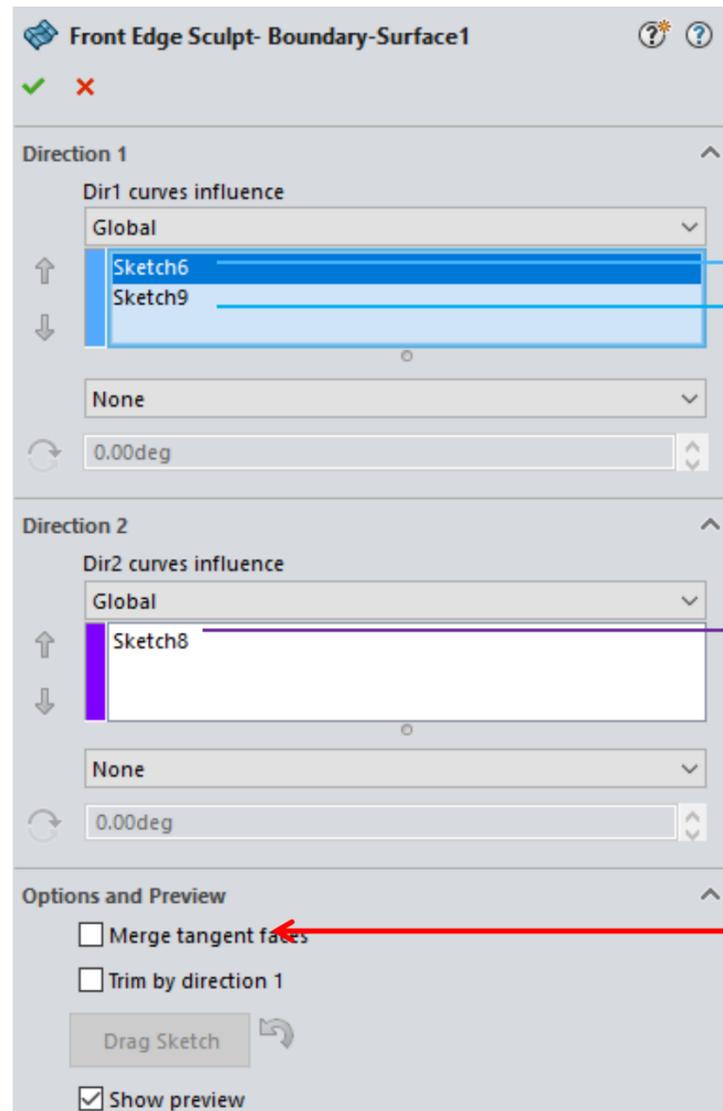
# Emphasize Character Lines

Use curves that increase in curvature at the character to emphasize the line. The physical difference is small, the perceive difference is huge.



# Build The Sculpting Surface

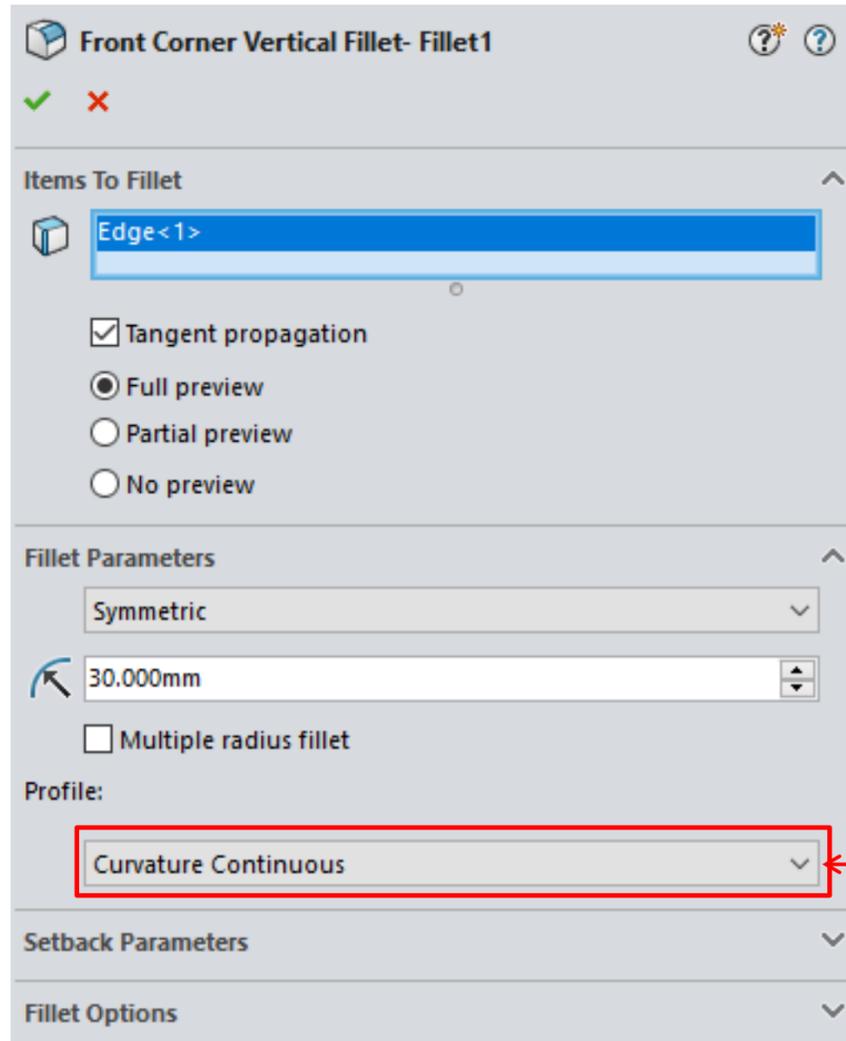
Boundary Surface is used to generate the surface from 2 profiles in Direction 1 and a single profile in Direction 2.



**TIP:** Turn “Merge tangent faces off”. This gives you more flexibility creating future transitions.

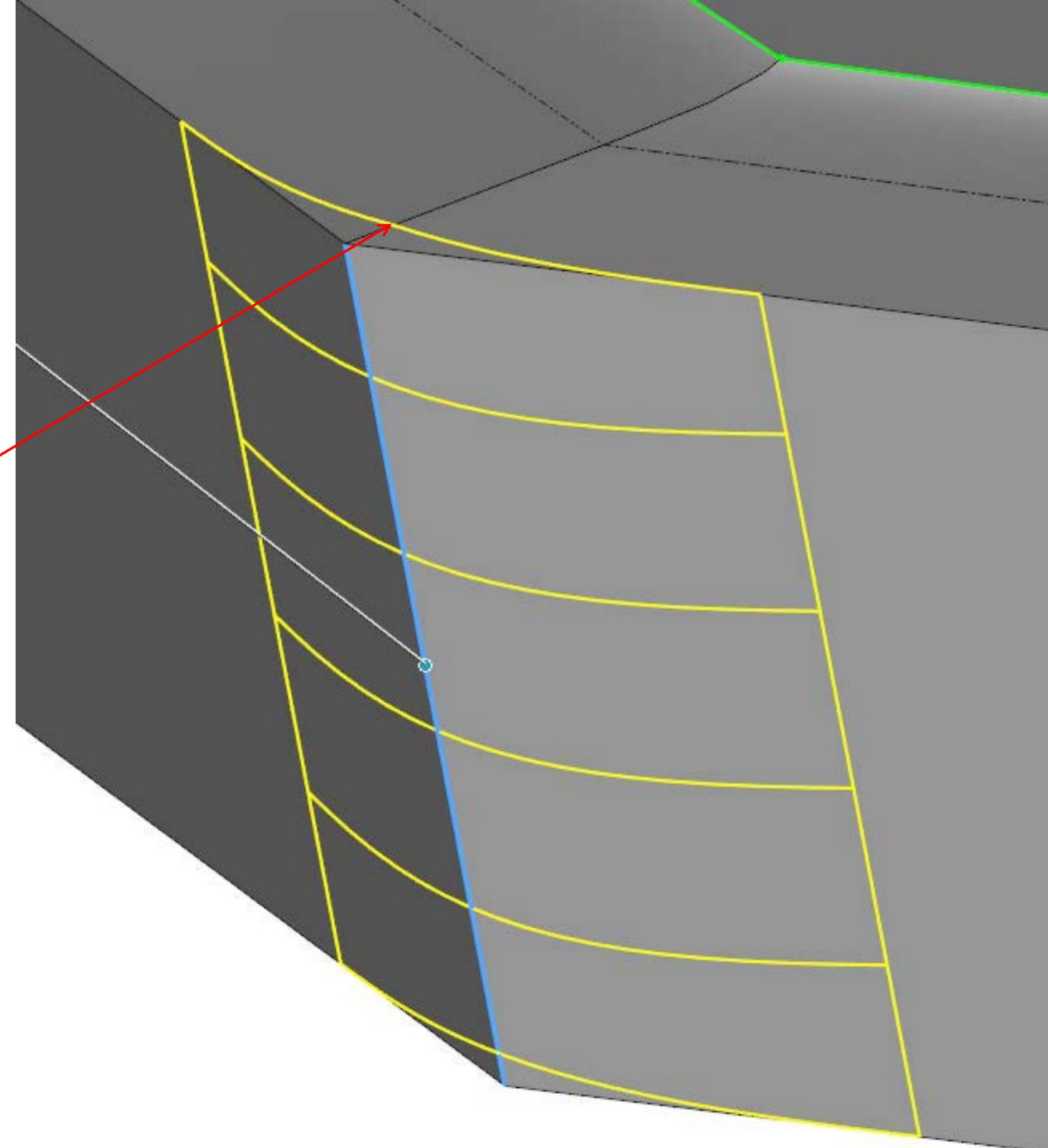
# Create the Corner Transition

Adding the Curvature Continuous corner fillet causes the sculpted surface to kick up. This needs to be adjusted manually.



This edge kicks up with the application of the fillet

New in SW2016, Curvature Continuous Edge Fillets!



# Split Out The Transition Region.

Splitting, surfacing and combining is far more stable than using the Split Line feature.

Split1

Message

Double-click a body file name or select a body callout in the graphics area to assign the body to an existing or new file.

Trim Tools

Sketch11

Cut Part

Resulting Bodies

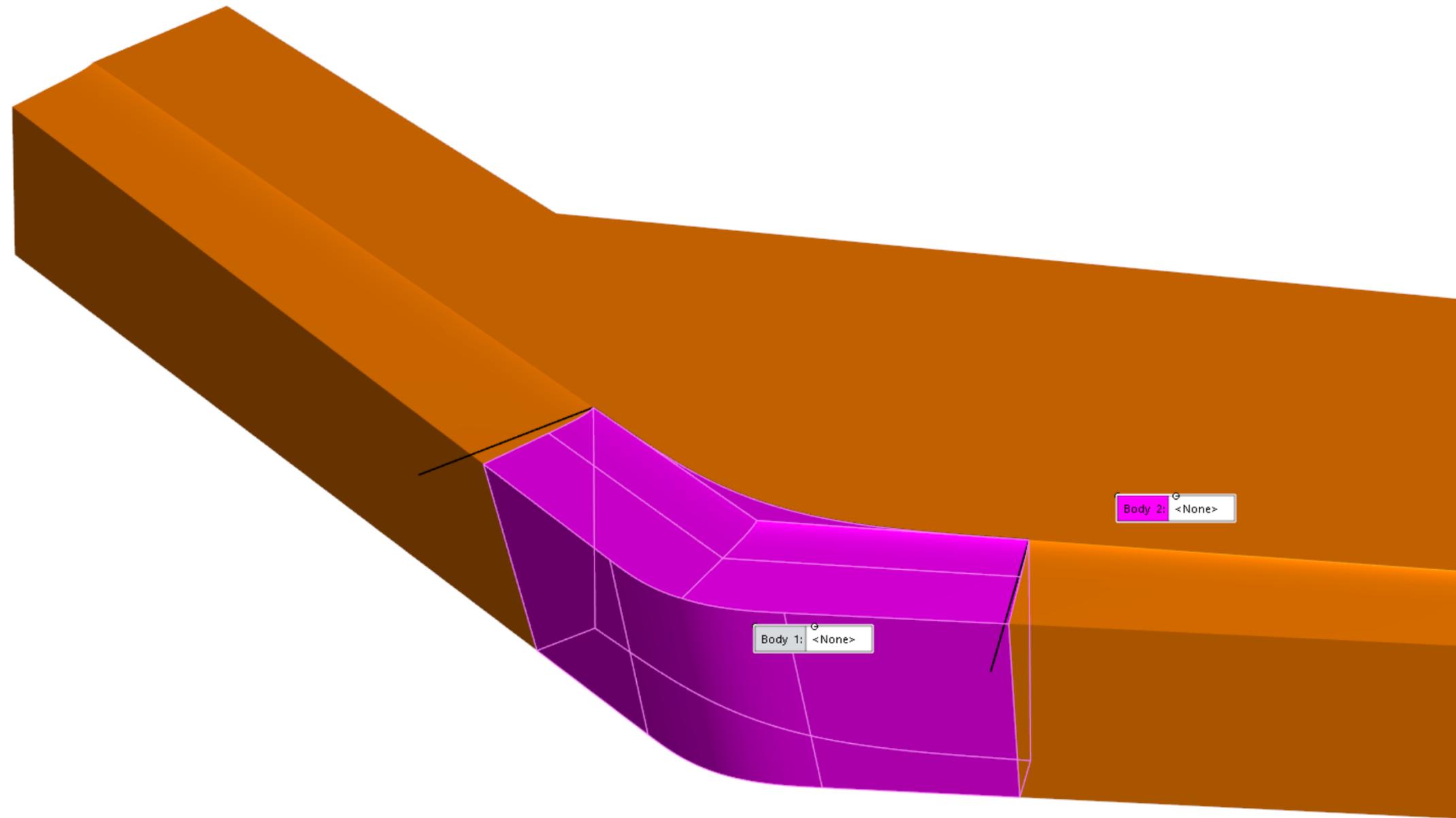
	✓	File
1	<input checked="" type="checkbox"/>	<None>
2	<input type="checkbox"/>	<None>

Auto-assign Names

Consume cut bodies

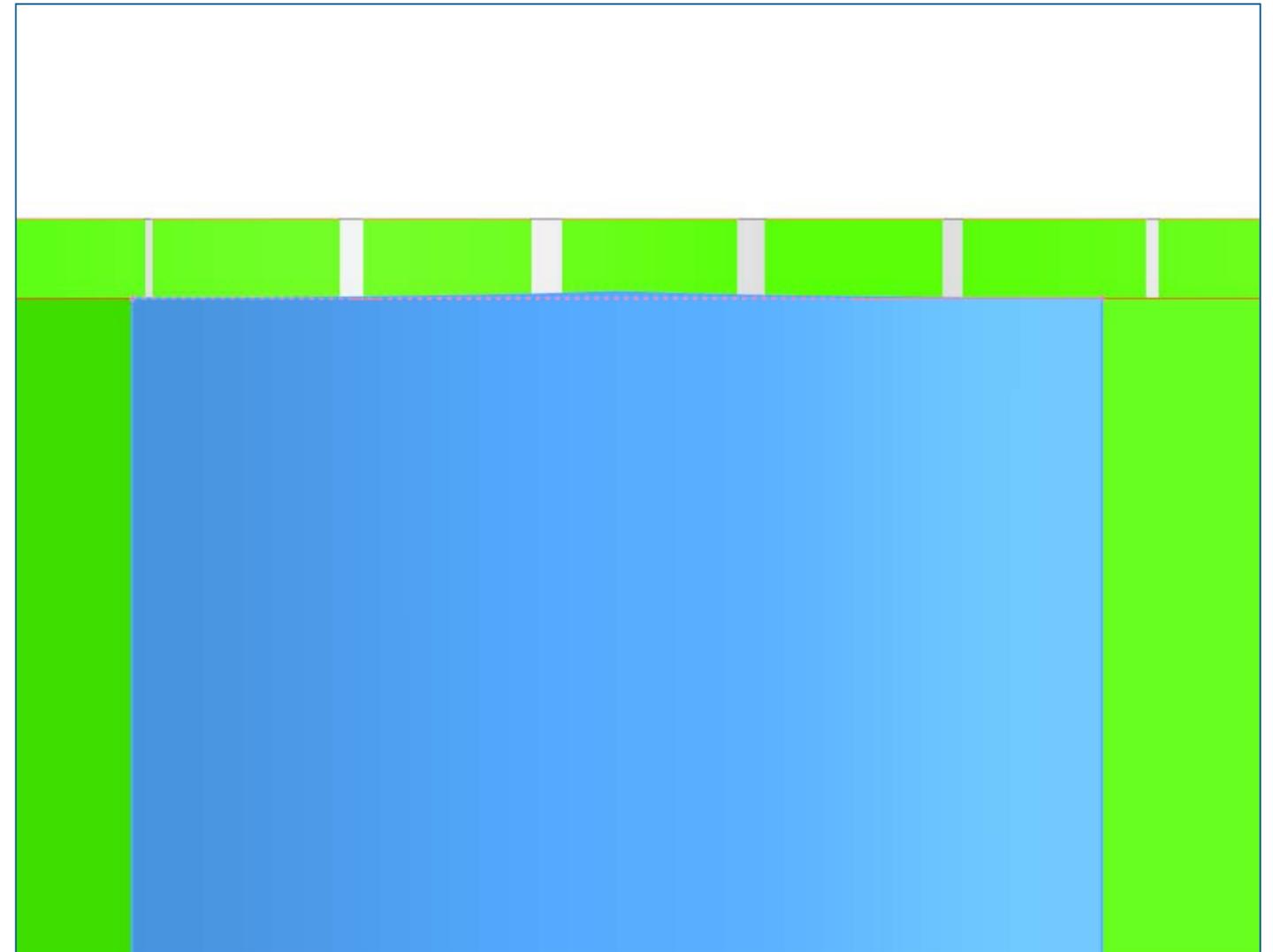
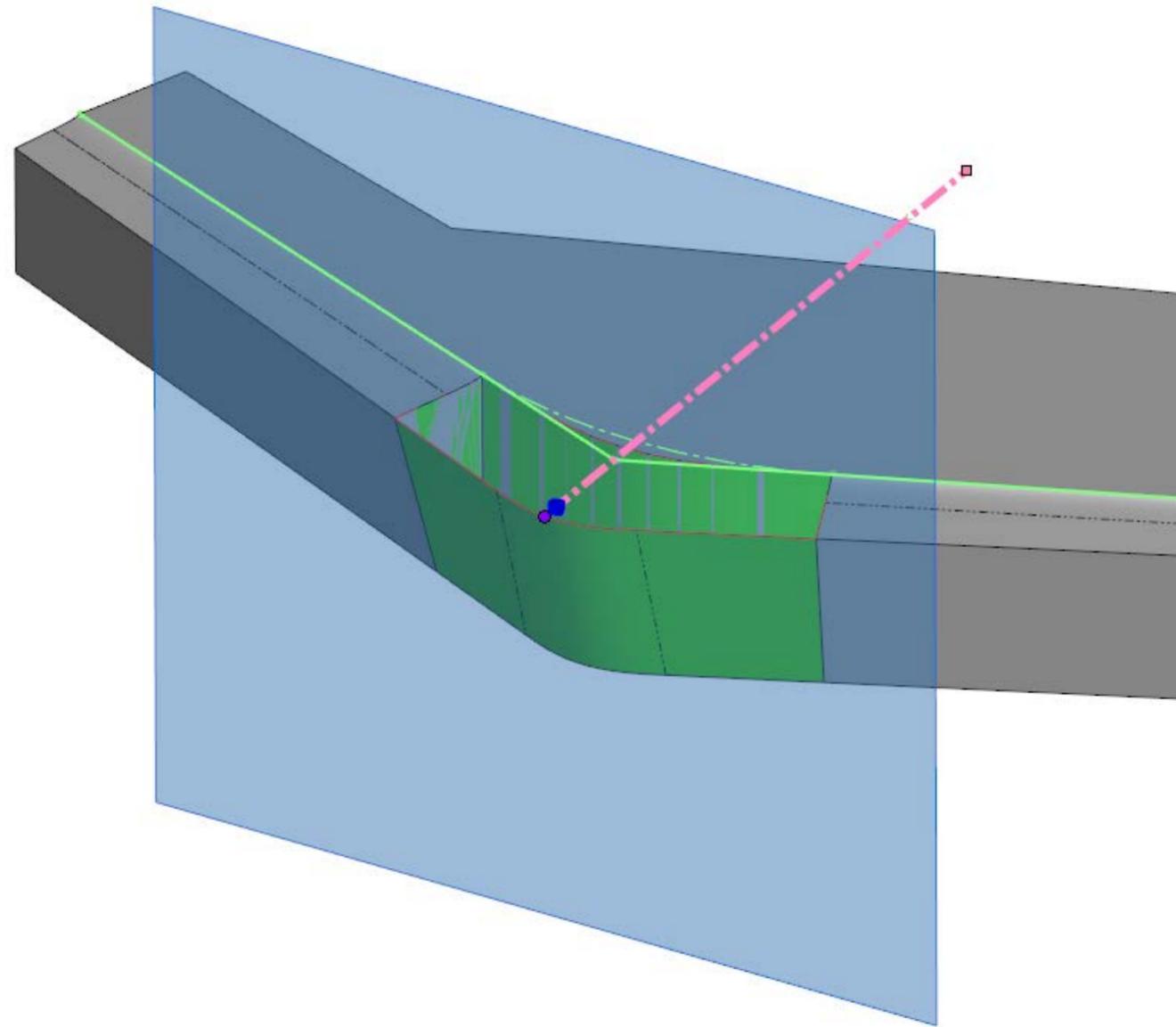
Propagate visual properties

Copy custom properties to new parts



# Clean Up the Corner

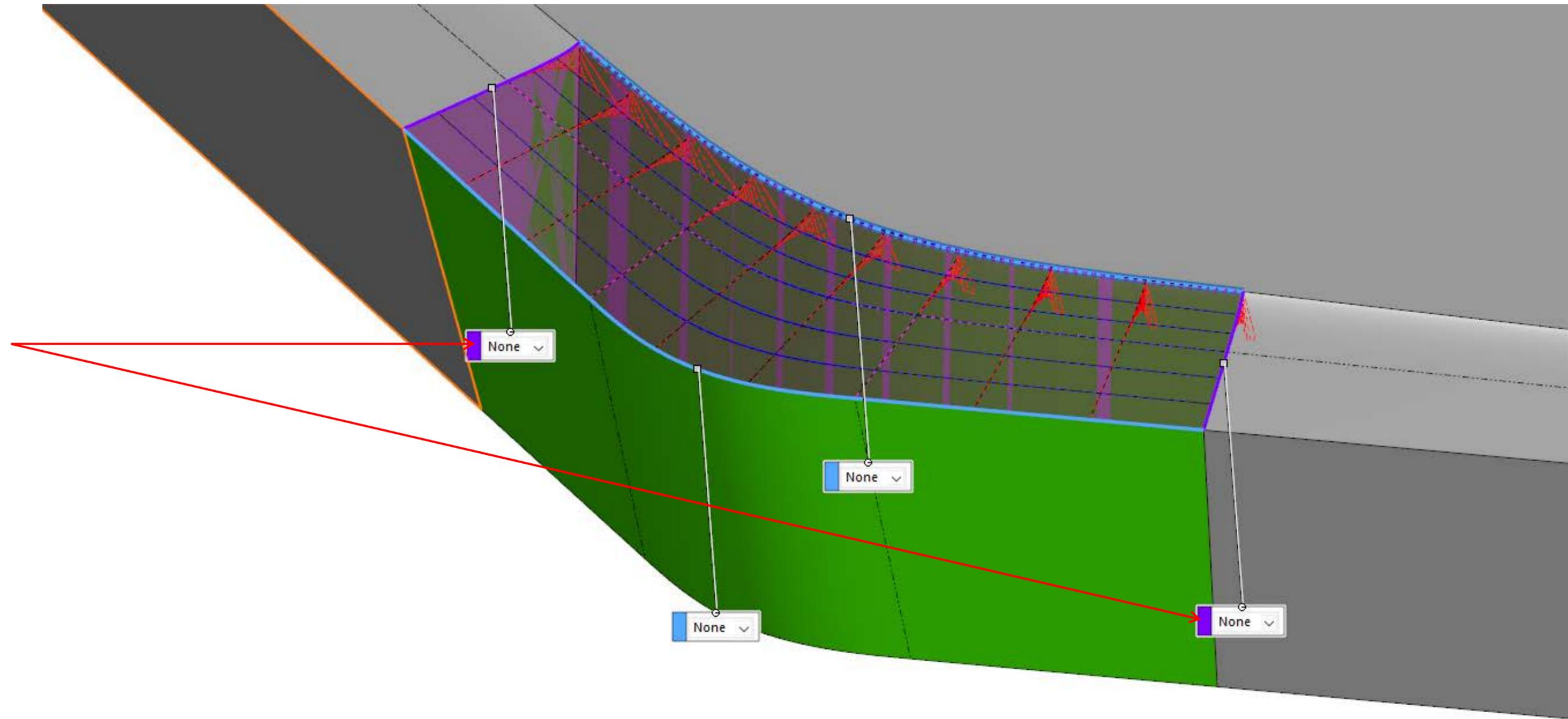
A new Plane is created normal to the corner fillet. The Split Line and Delete Face features are used to clean up the corner for the final surface.



# Complete the Corner Transition

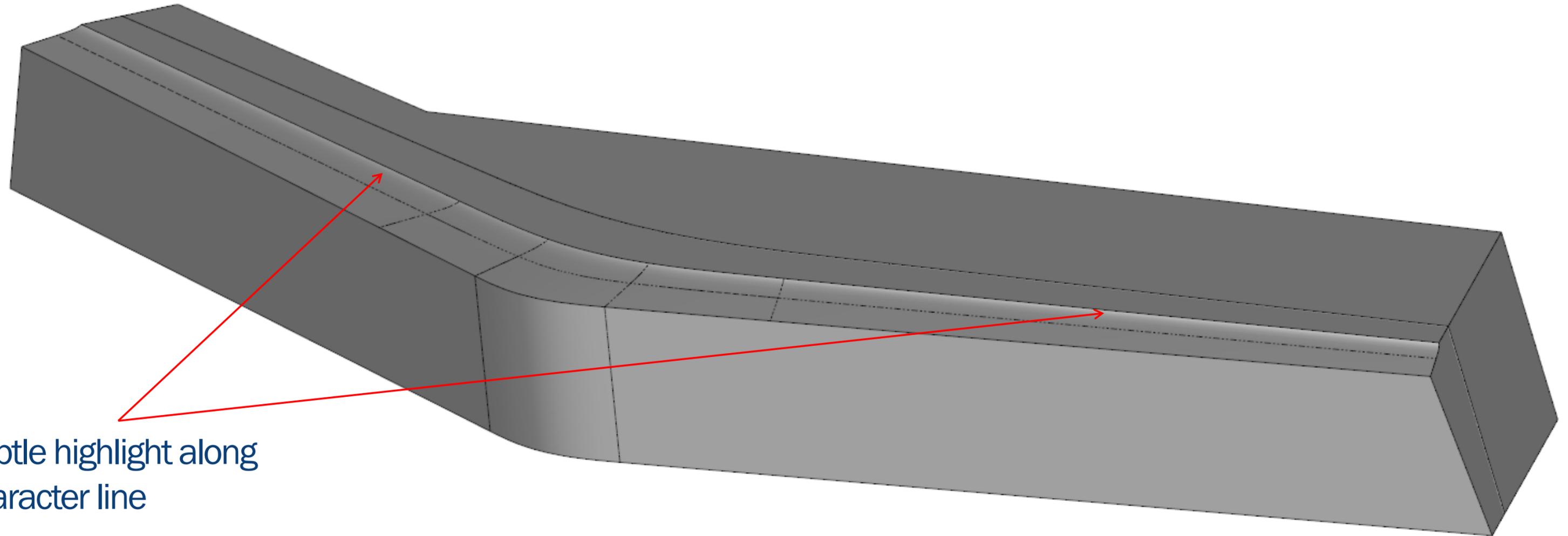
A second Boundary Surface complete the transition of the sculpted surface. Because the profiles used are inherently Curvature Continuous, end conditions are set in the Boundary Surface.

End conditions are not used in Direction 2.



# Completed Sculpted Character Line

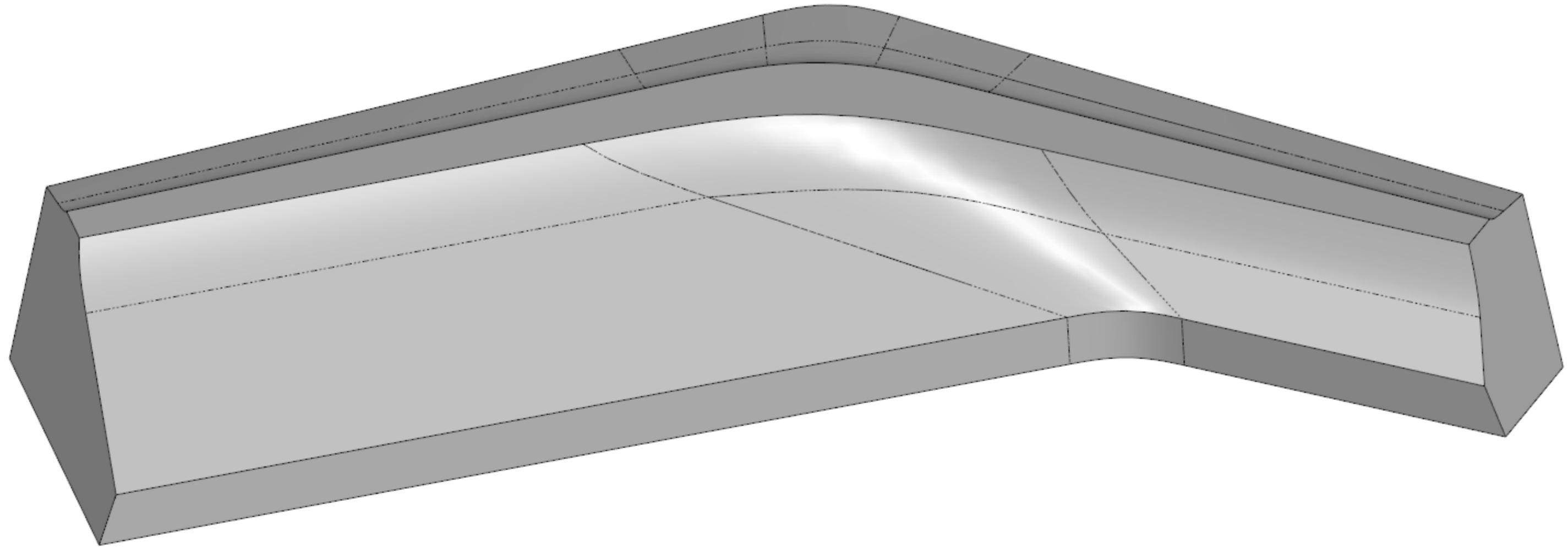
The subtle kick up of the sculpted surface causes a highlight along the character line, emphasizing the form.



Subtle highlight along character line

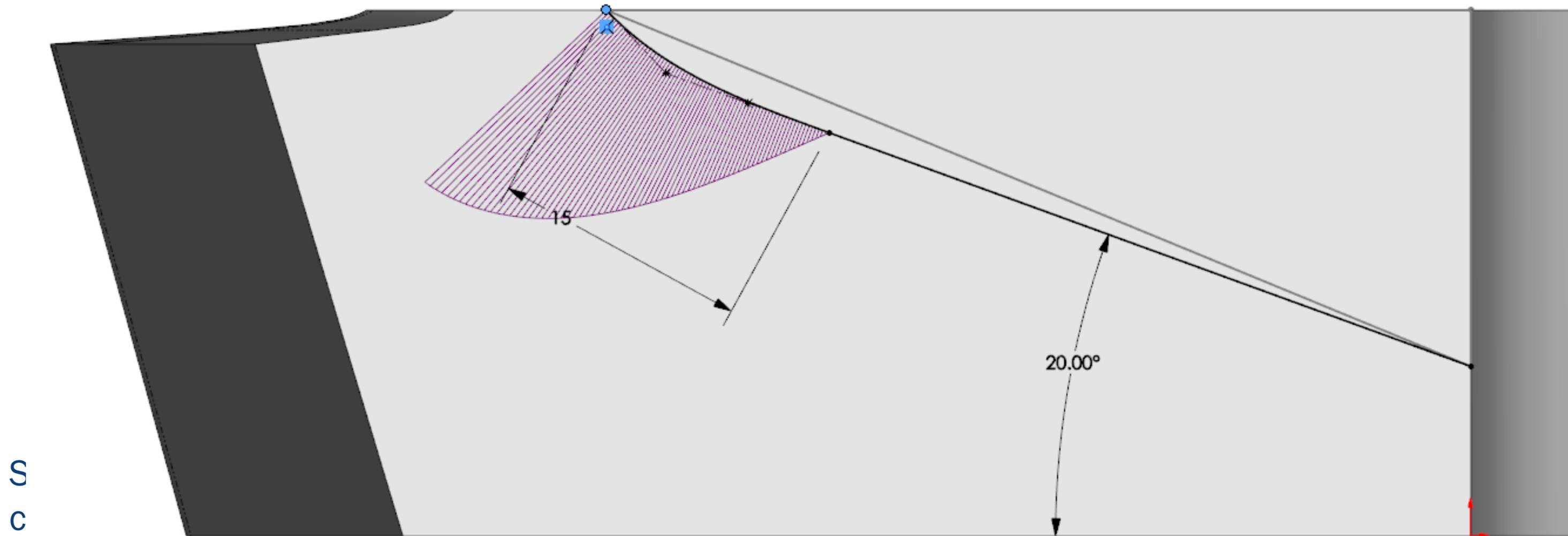
# Sculpted Angled Rear Surface

Like the sculpted front surface, the rear surface has a subtle kick towards the character line.



# Create Functional Surfaces As Required

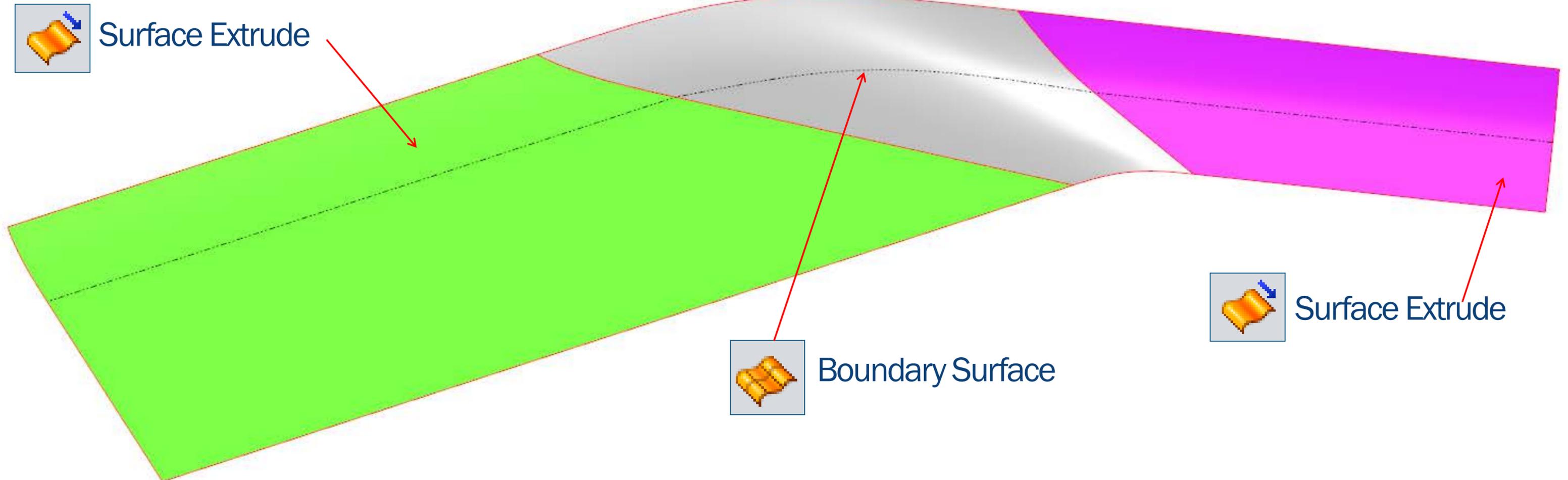
Due to internal components of this housing, a planar face at an angle was required.



S  
C

# Surface Construction

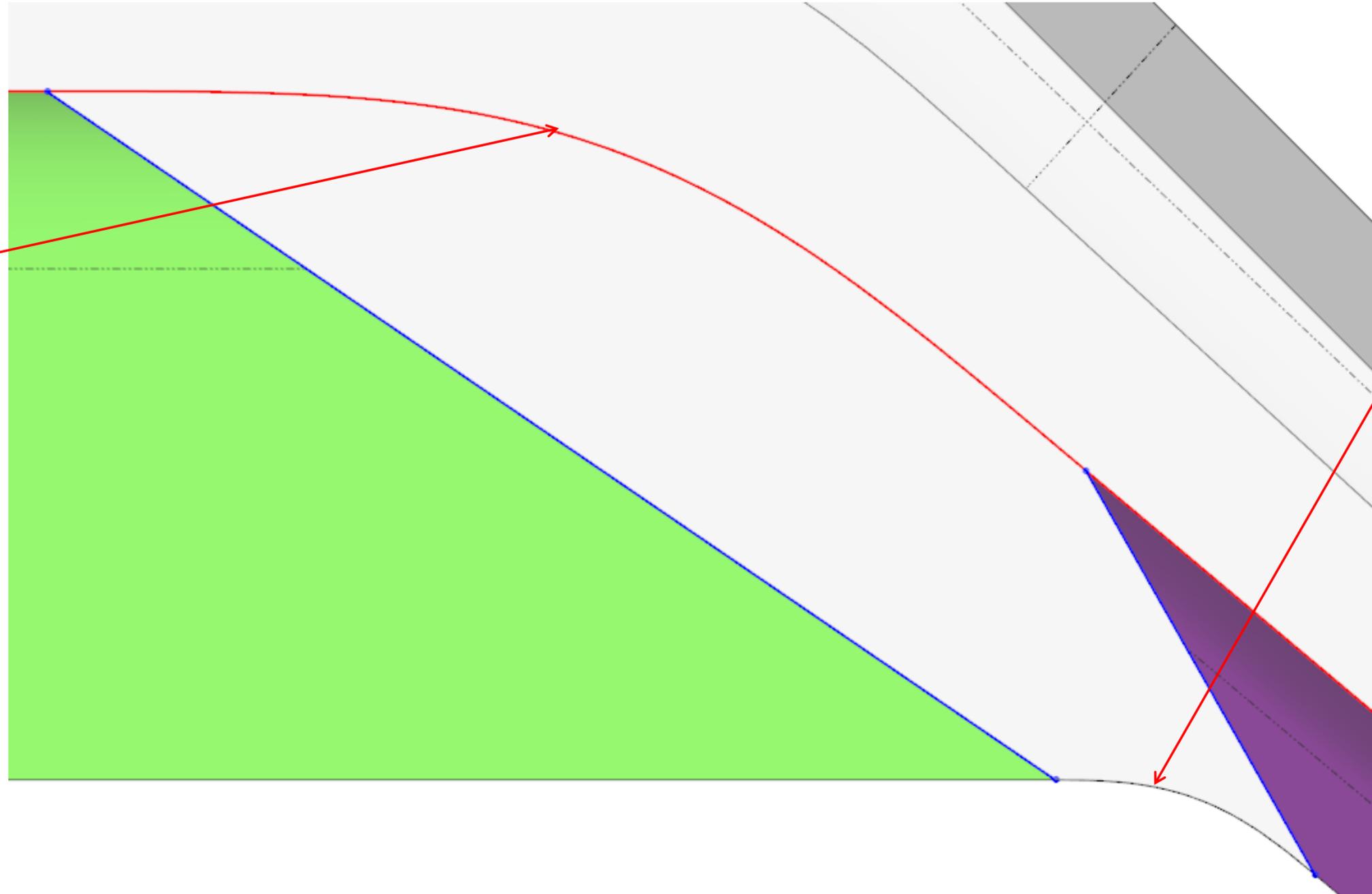
These surfaces are created with two Surface Extrude features with a blend between them. Laying out where the blend starts and stops is the key to a high quality transition.



# Shaping the Blend

The size of the spline defining the blend was critical to ensuring the smoothness of the transition.

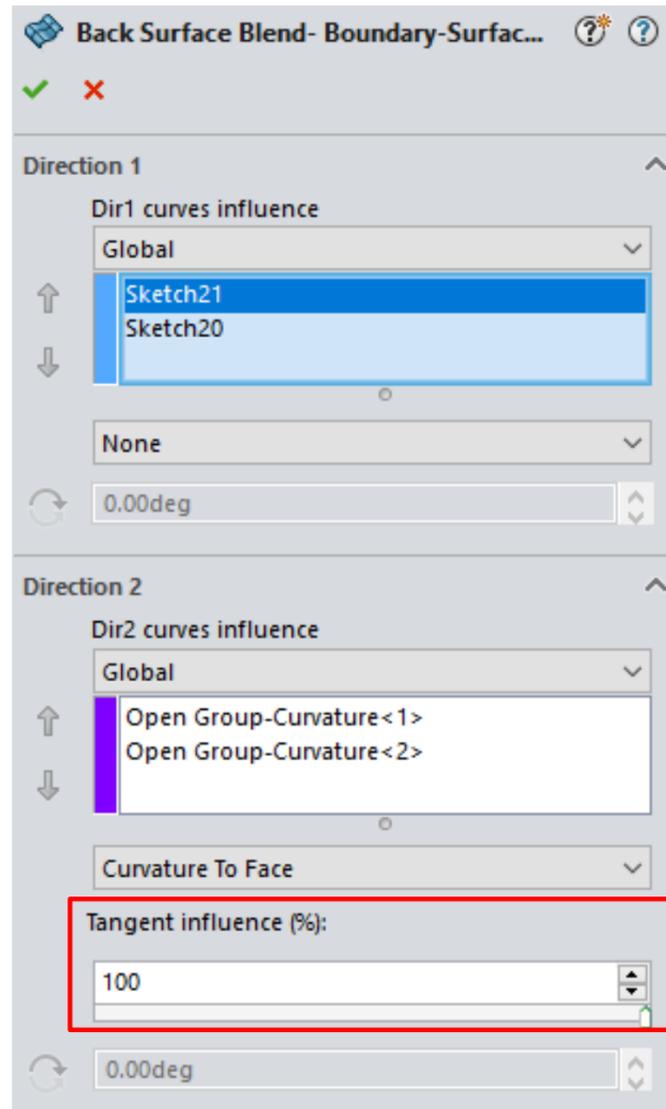
The exact size of this transition was dialed in to have the blend look optimal



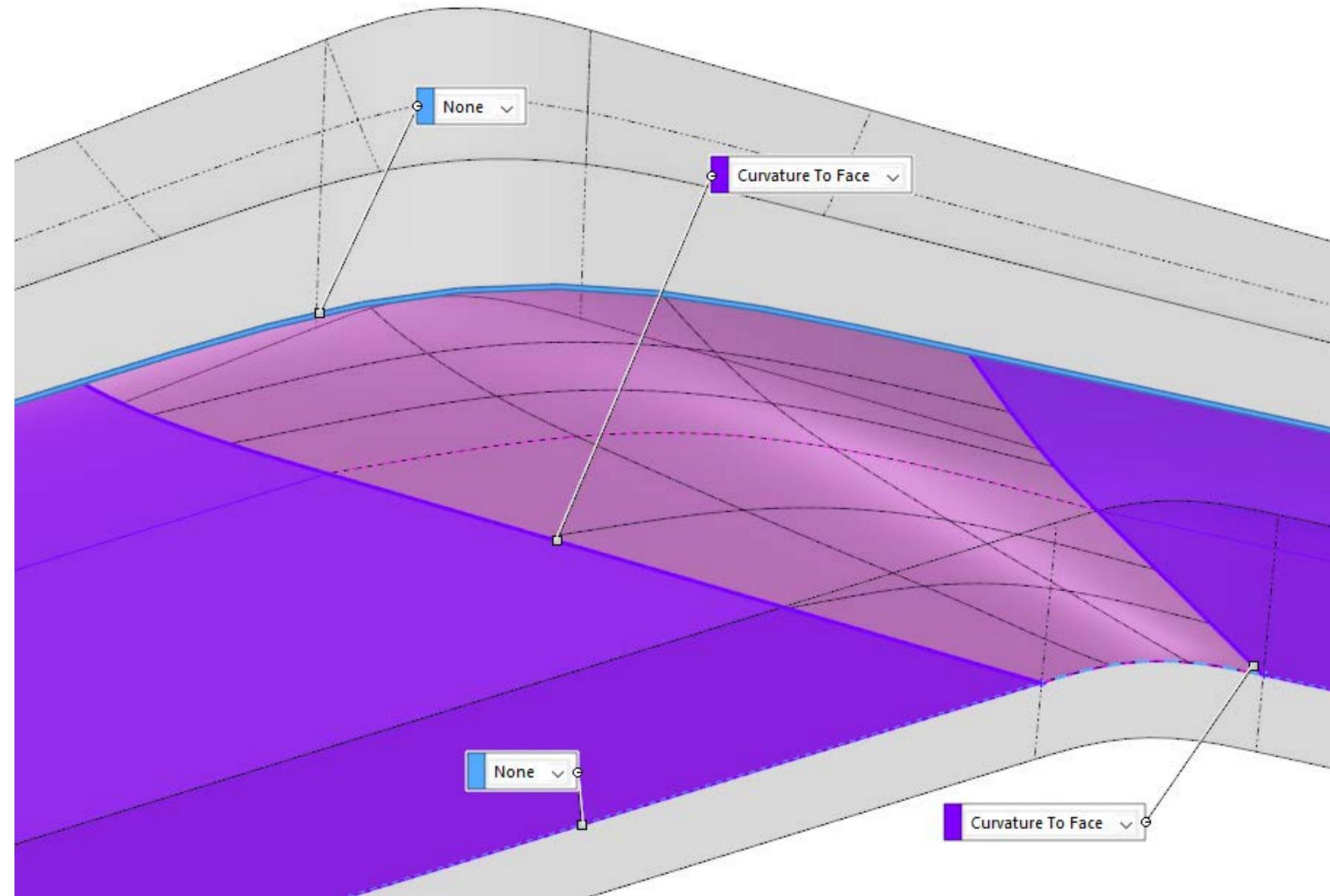
The location of this fillet was dictated by external factors.

# Shaping The Blend

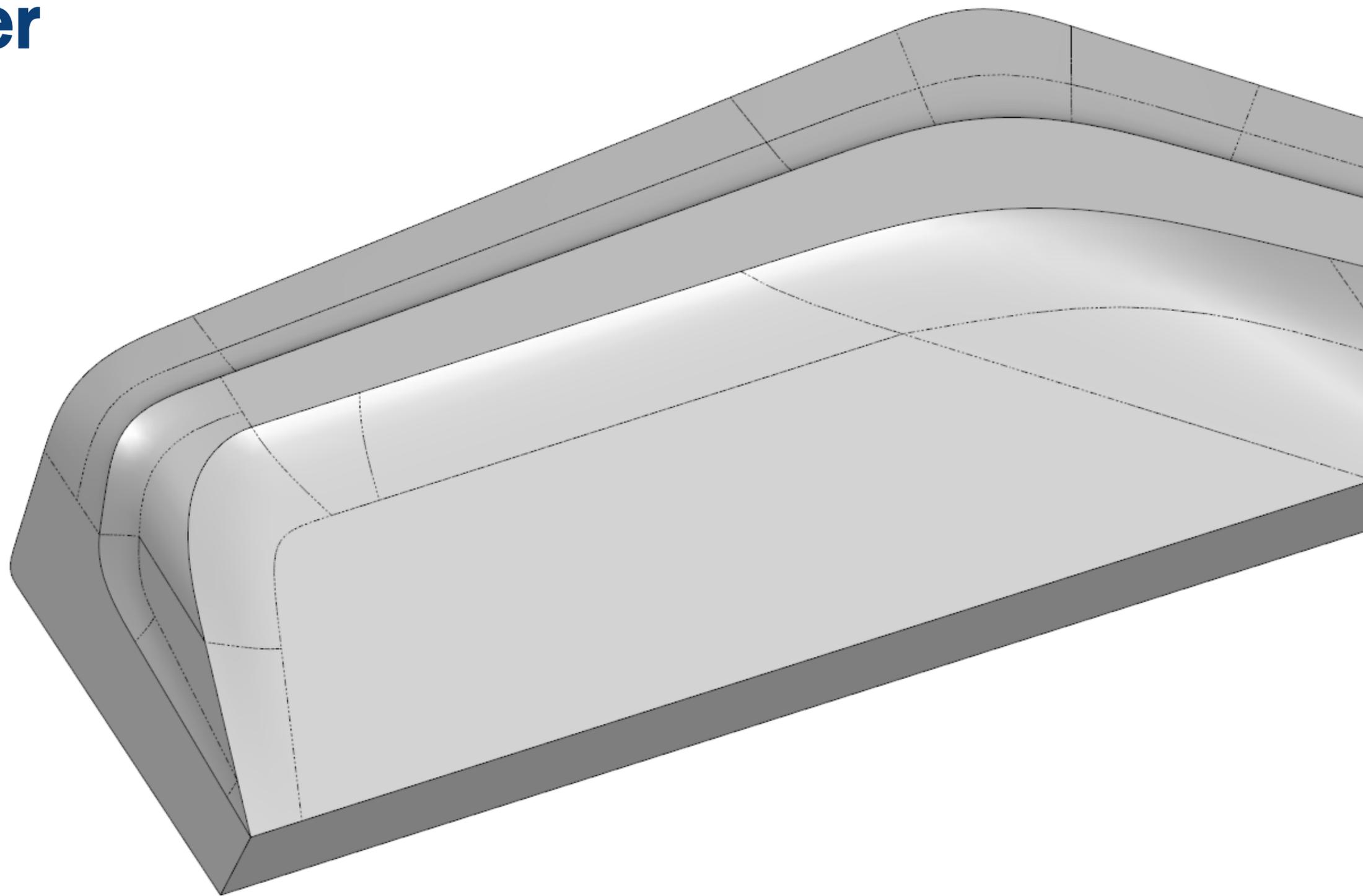
The blend surface is created with a Boundary Surface. Curvature to Face is used to ensure a seamless connection. Note that the profiles being used also need to be curvature continuous.



The tangent influence is increased to 100% to give preference to the shape of Direction 2 profiles and “pump up” the surface.

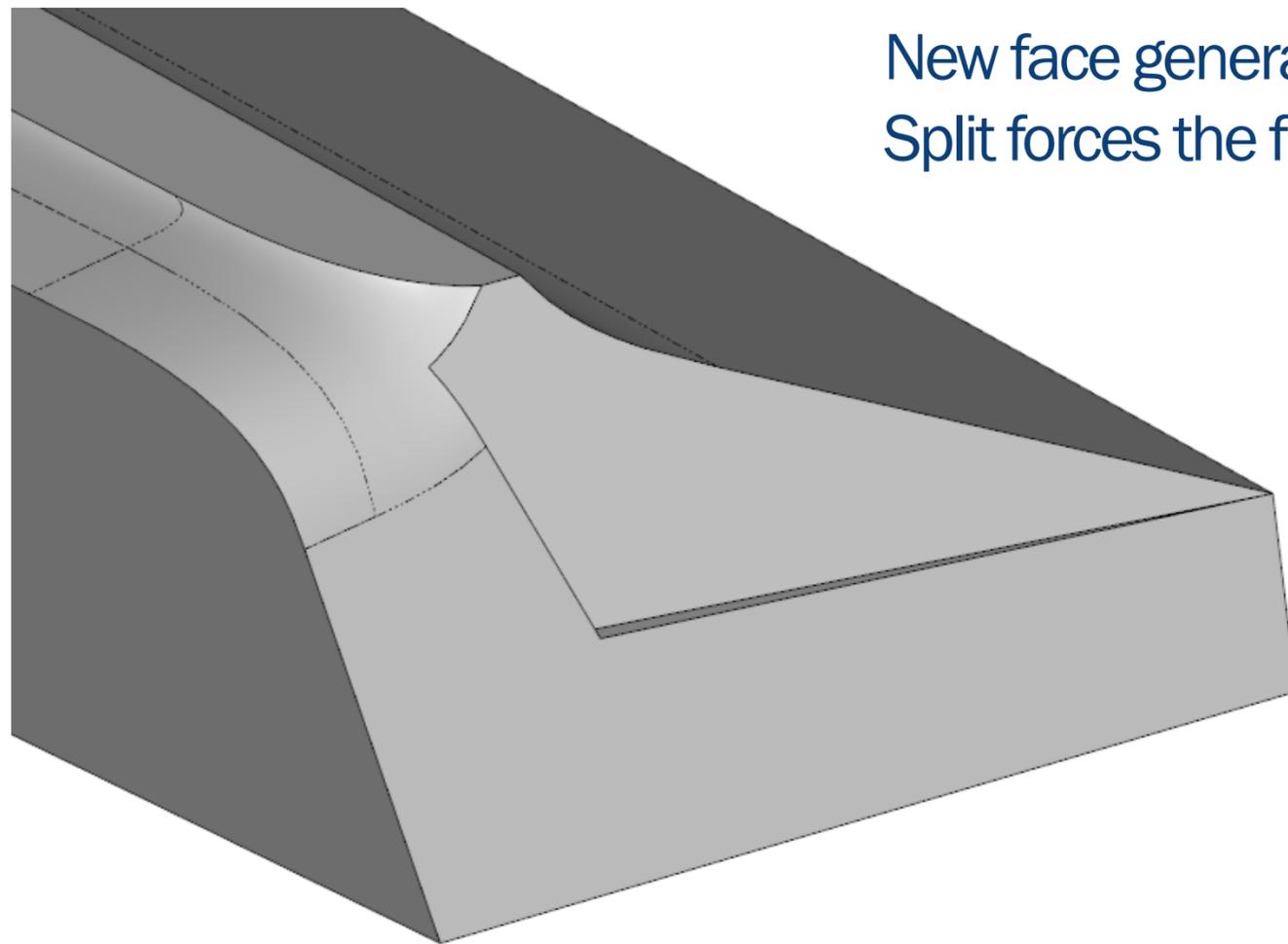


# Building The Corner

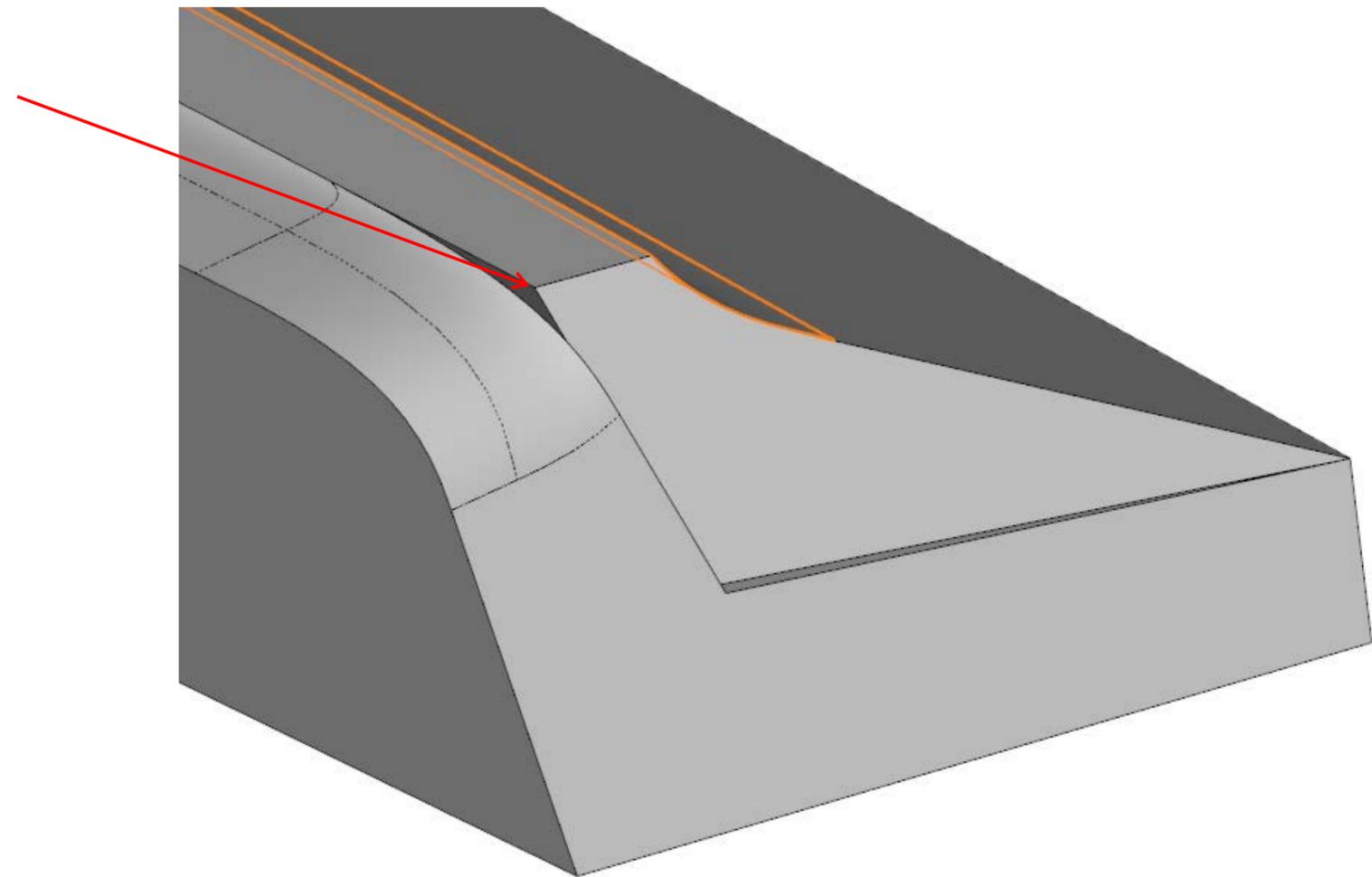


# Stop The Fillets!

Using the Split Feature to cut the model up into multiple bodies generates new faces which allow for fillets to stop precisely where intended.

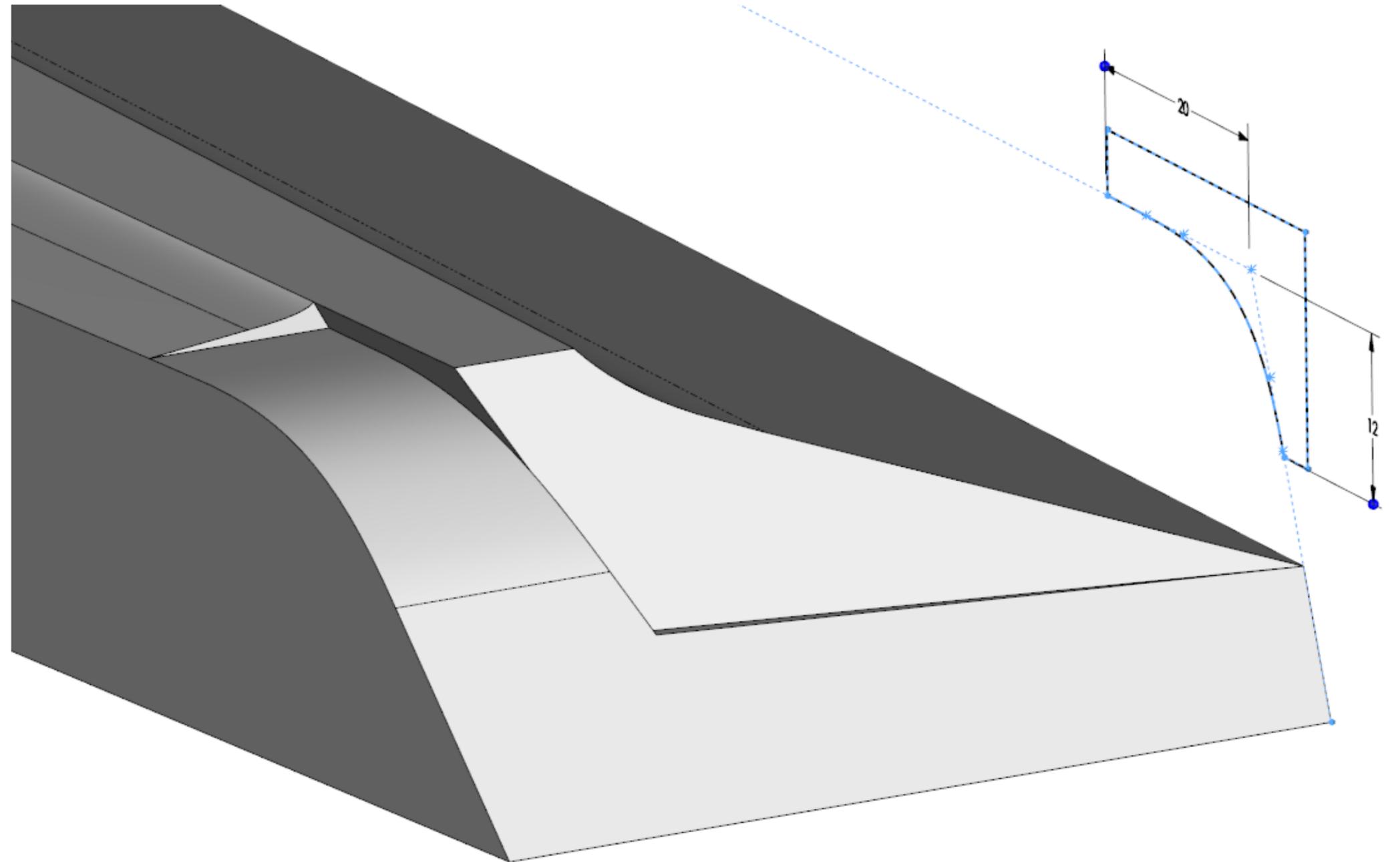


New face generated by the Split forces the fillet to stop.



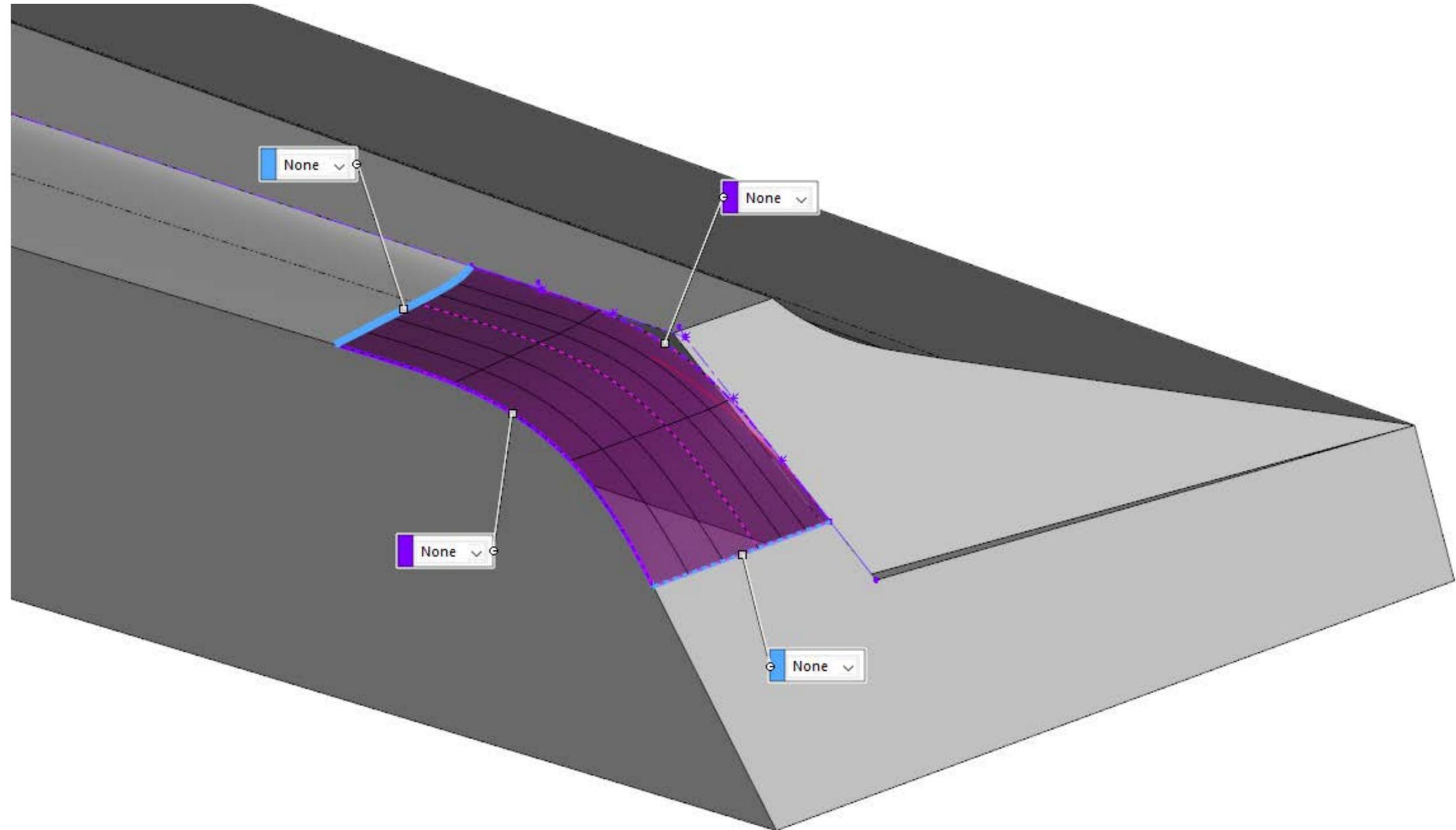
# Setting Up The Blend

The kicked out surface emphasizing the character line will be blended out in the corner transition. Instead of relying on the curvature continuous fillet tool, a simple cut extrude is used to shape the corner.

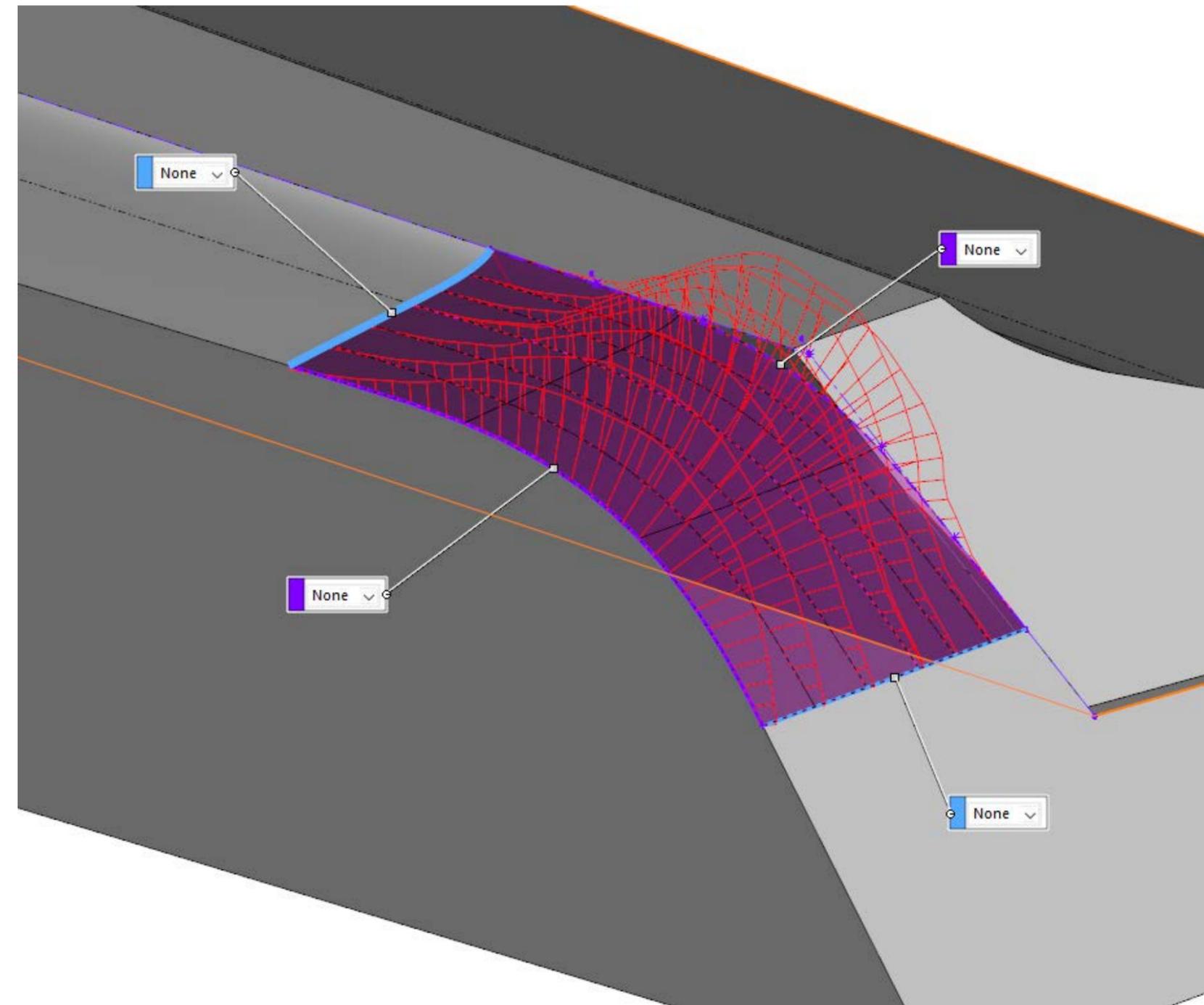
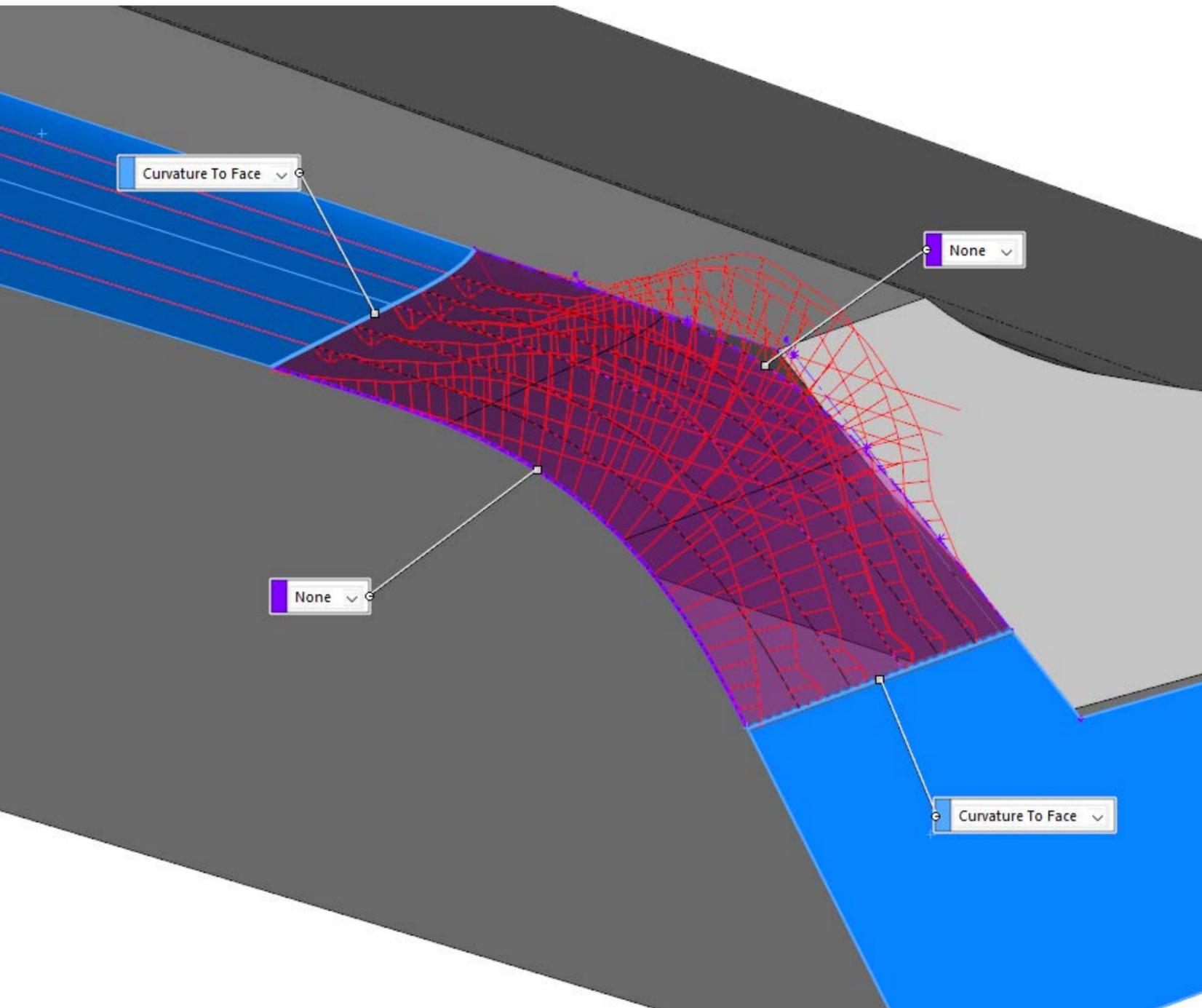


# Using the Right End Conditions

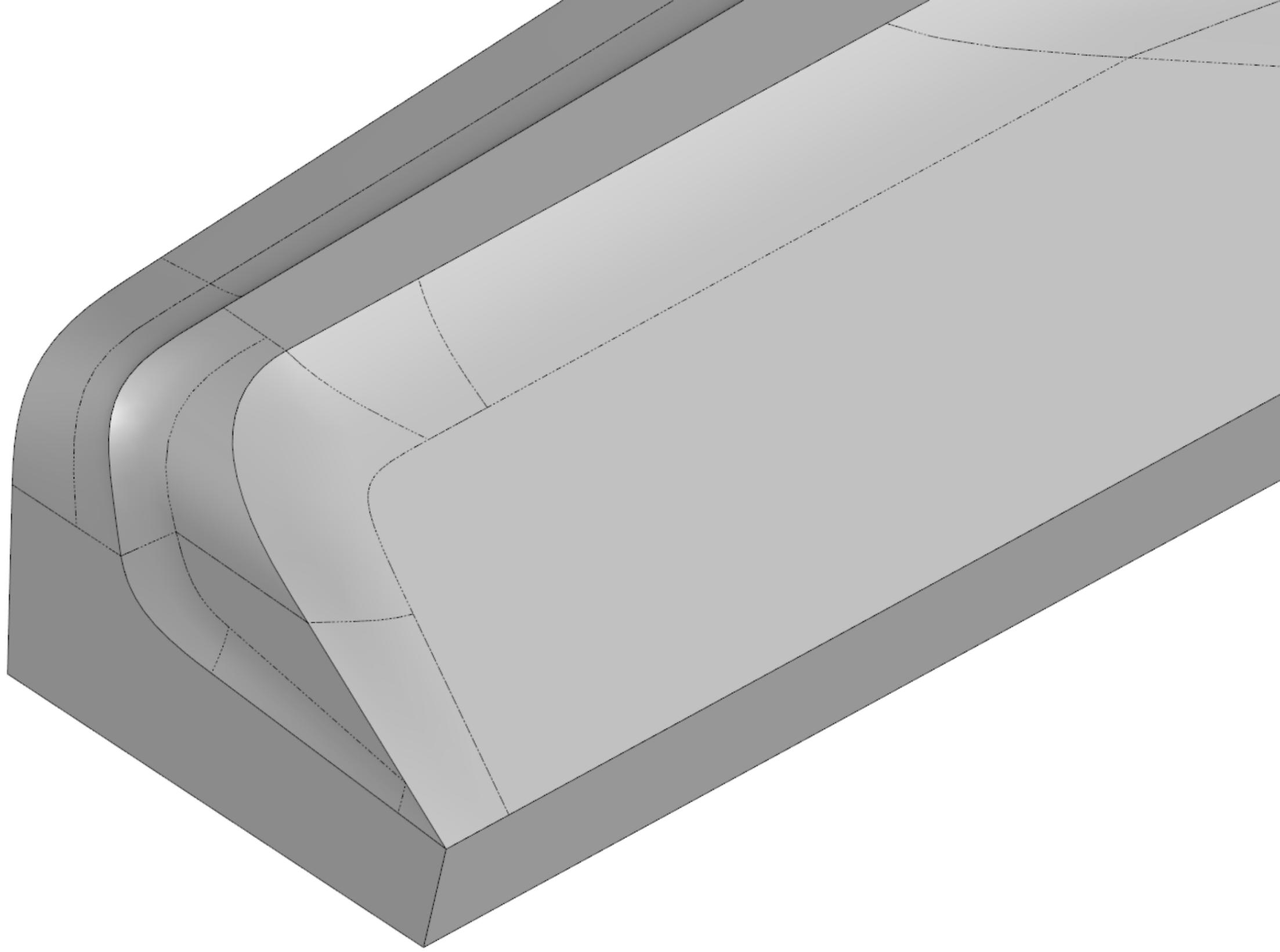
Because the two style splines are G3 continuous to the adjacent surfaces, there is no need to use the Curvature To Face end condition. This results in a better surface by not forcing the geometry.



# See The Difference?

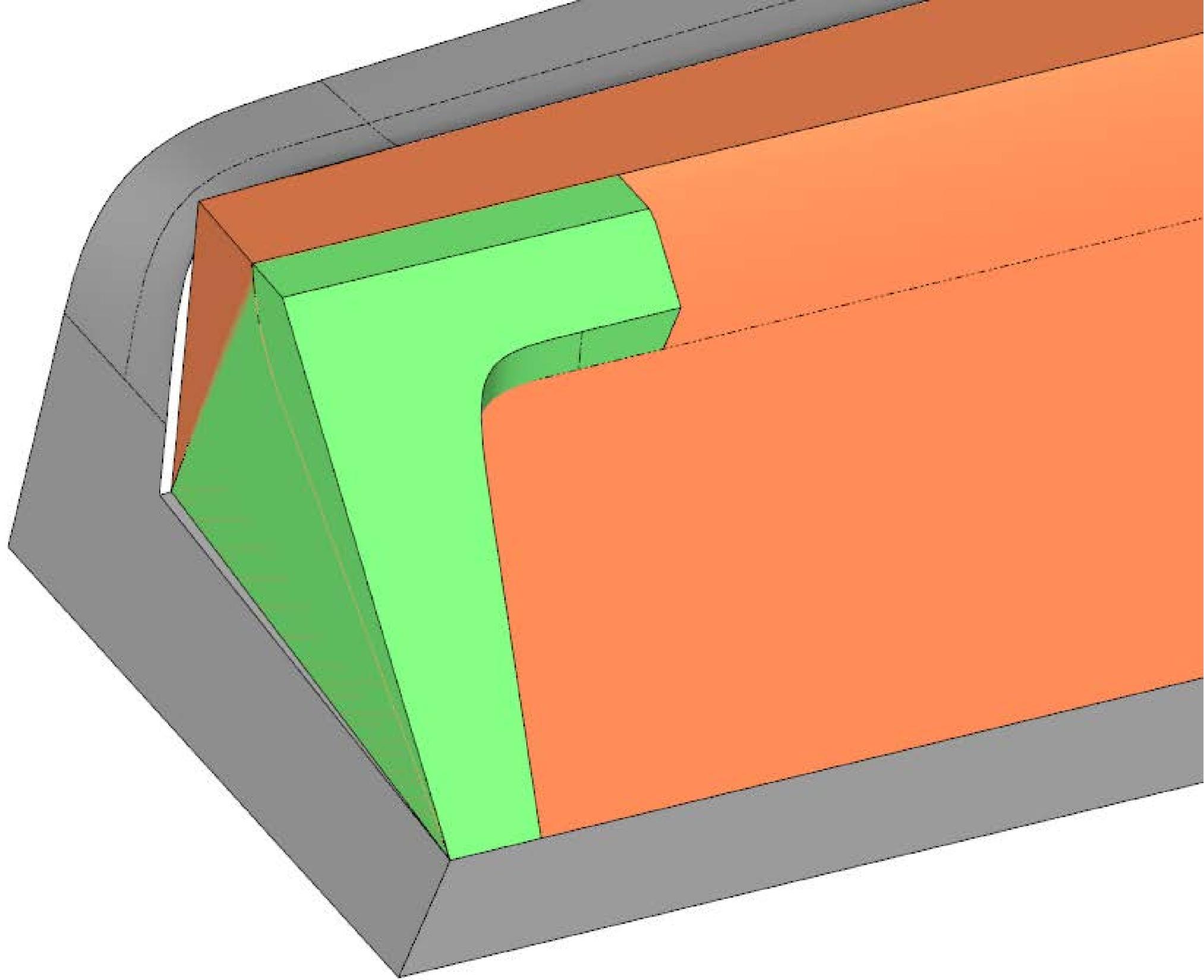


# Final Sculpting



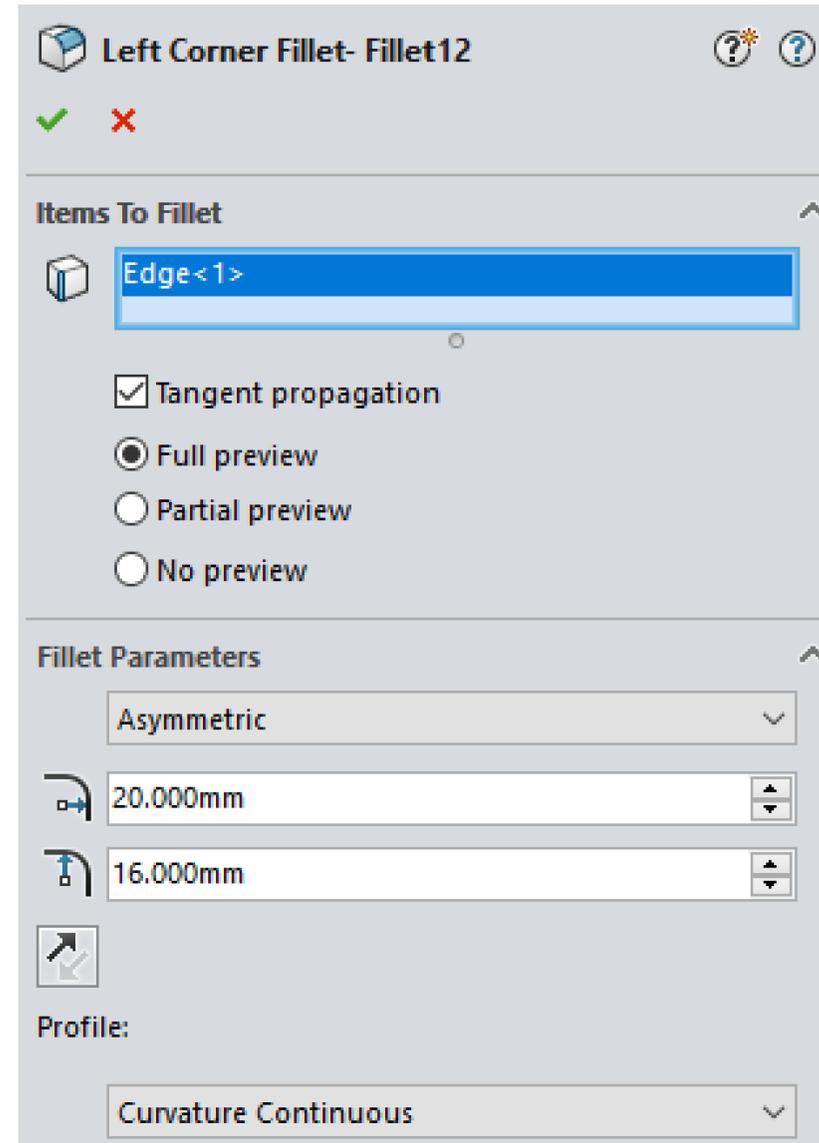
# Add Material

Using solid features is a quick way to generate new edges for surfacing.

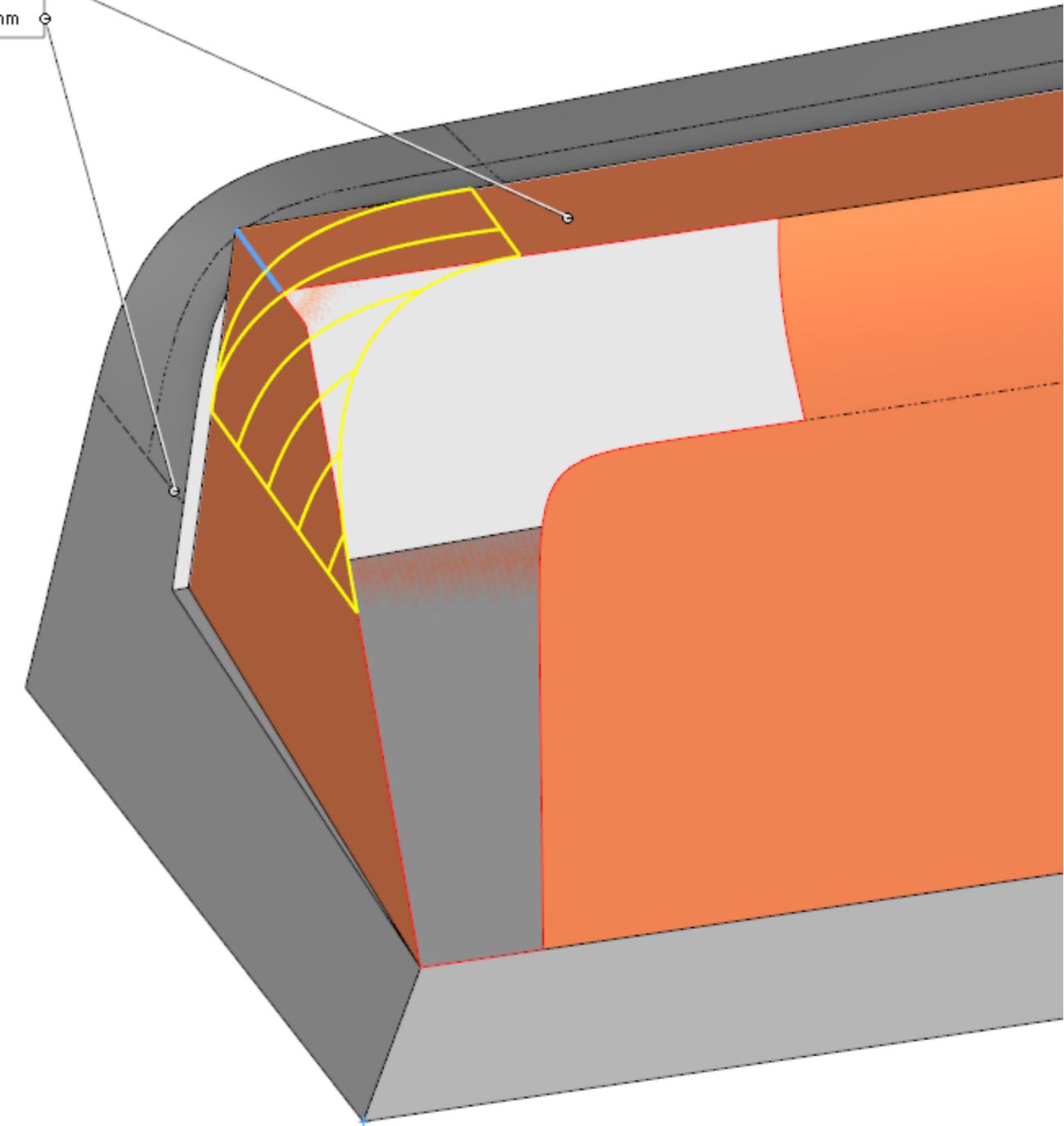


# Asymmetric Fillets

New in SW2016, the asymmetric fillet tool is a great way to great blended shapes, especially when utilizing the curvature continuous option.

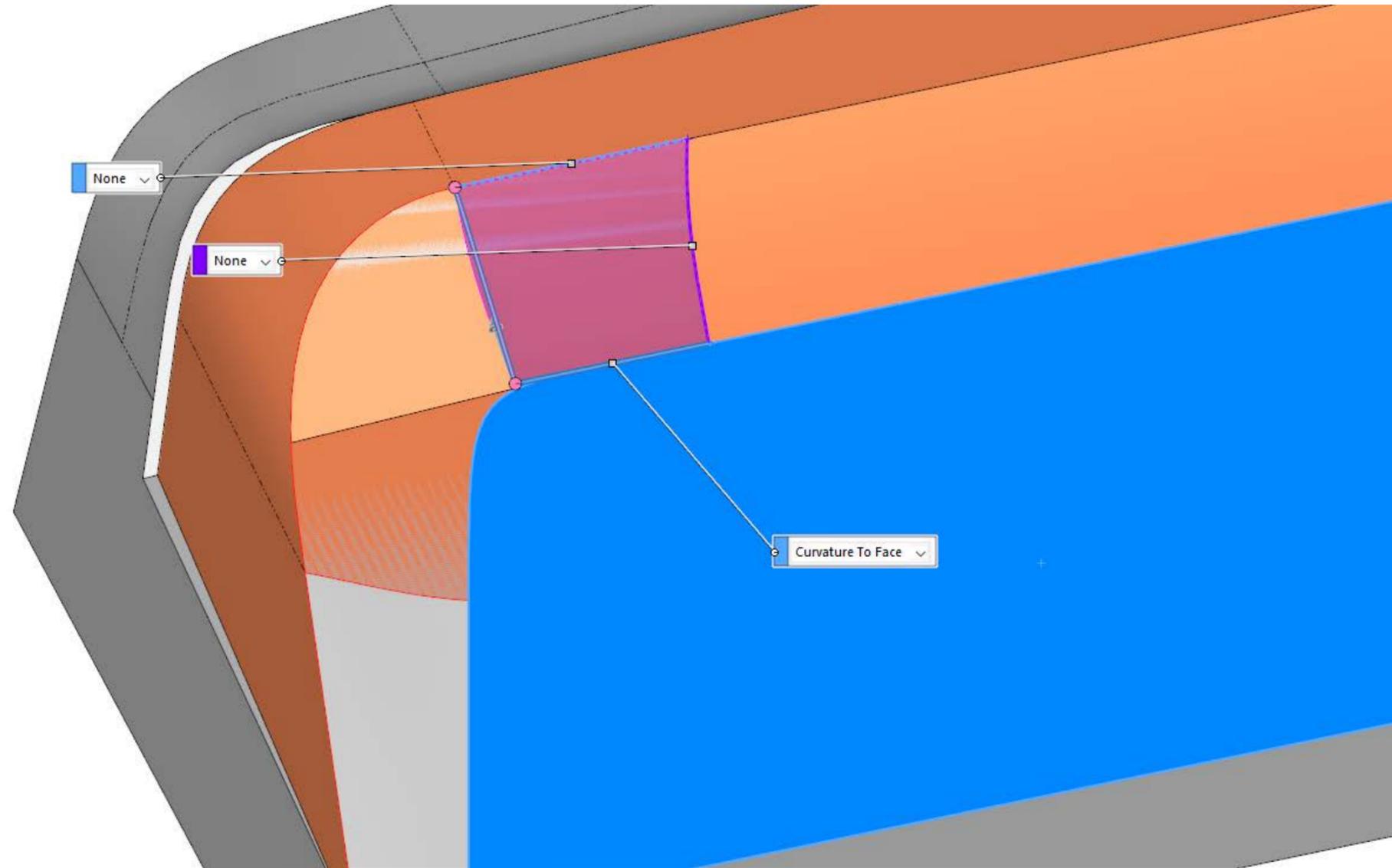
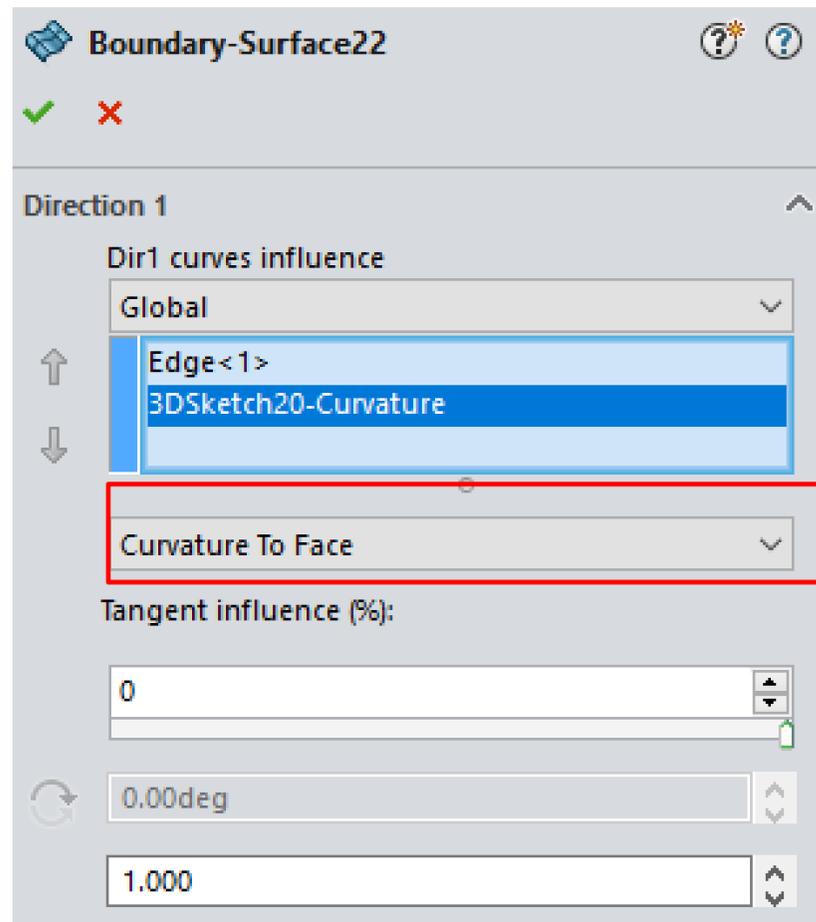


Radius 1: 20mm  
Radius 2: 16mm



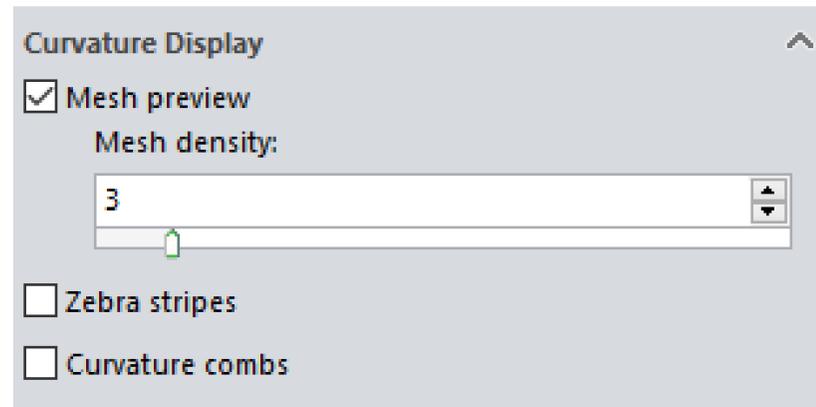
# 3D Sketches & Boundary Surface

Using a 3D sketch converted from a model edge still allows the use of tangent and curvature end conditions on the Boundary Surface. Here the 3D Sketch line segment is dragged longer to prevent the odd shape of the surface. It will be trimmed back later.

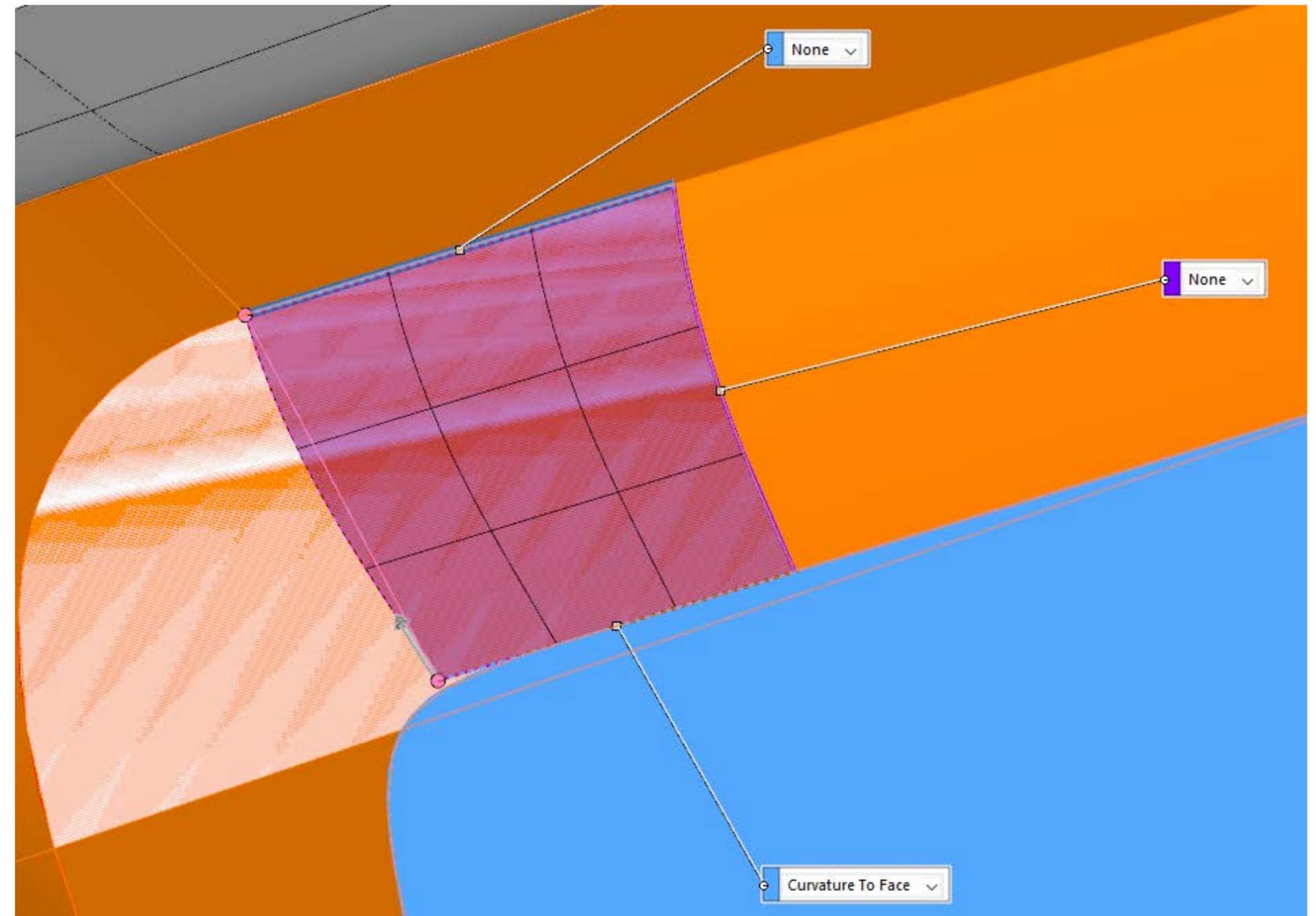


# Why? Because UV Curves

The UV curves a surface are the underlying math that defines the shape of the surface. Think of them as a series of lines in Direction 1 and 2 of the surface. Always aim for a relatively uniform series of lines.

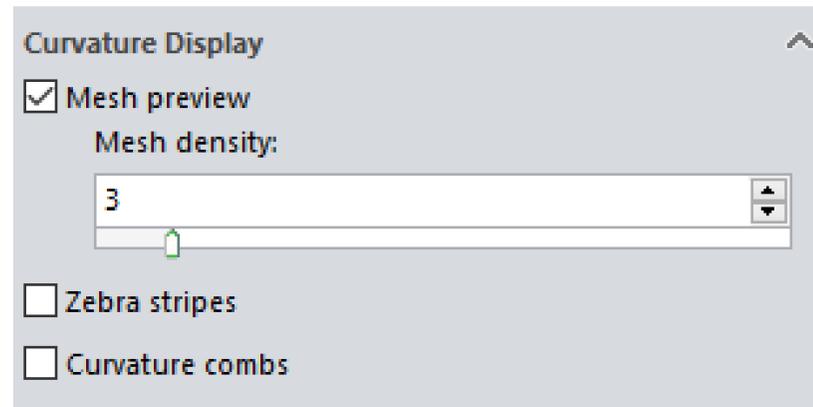


Turning Mesh Previous on will show how the surface is shaped.

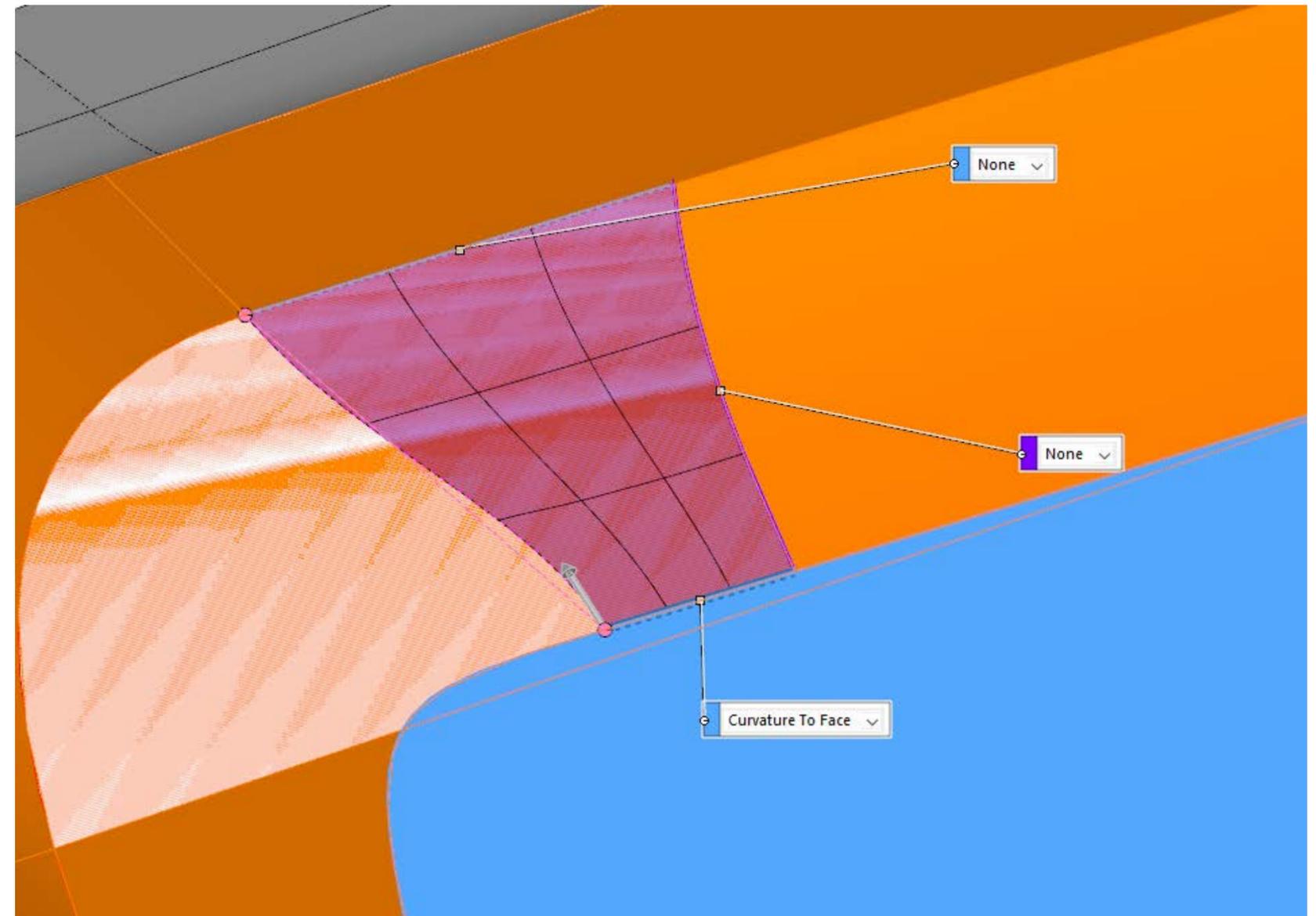


# Why? Because UV Curves

Because the edges are different lengths, and Curvature to Face is being used, the underlying UV curves take on the shape of the adjacent surfaces.



Turning Mesh Preview on will show how the surface is shaped.



# FREEFORM SURFACING

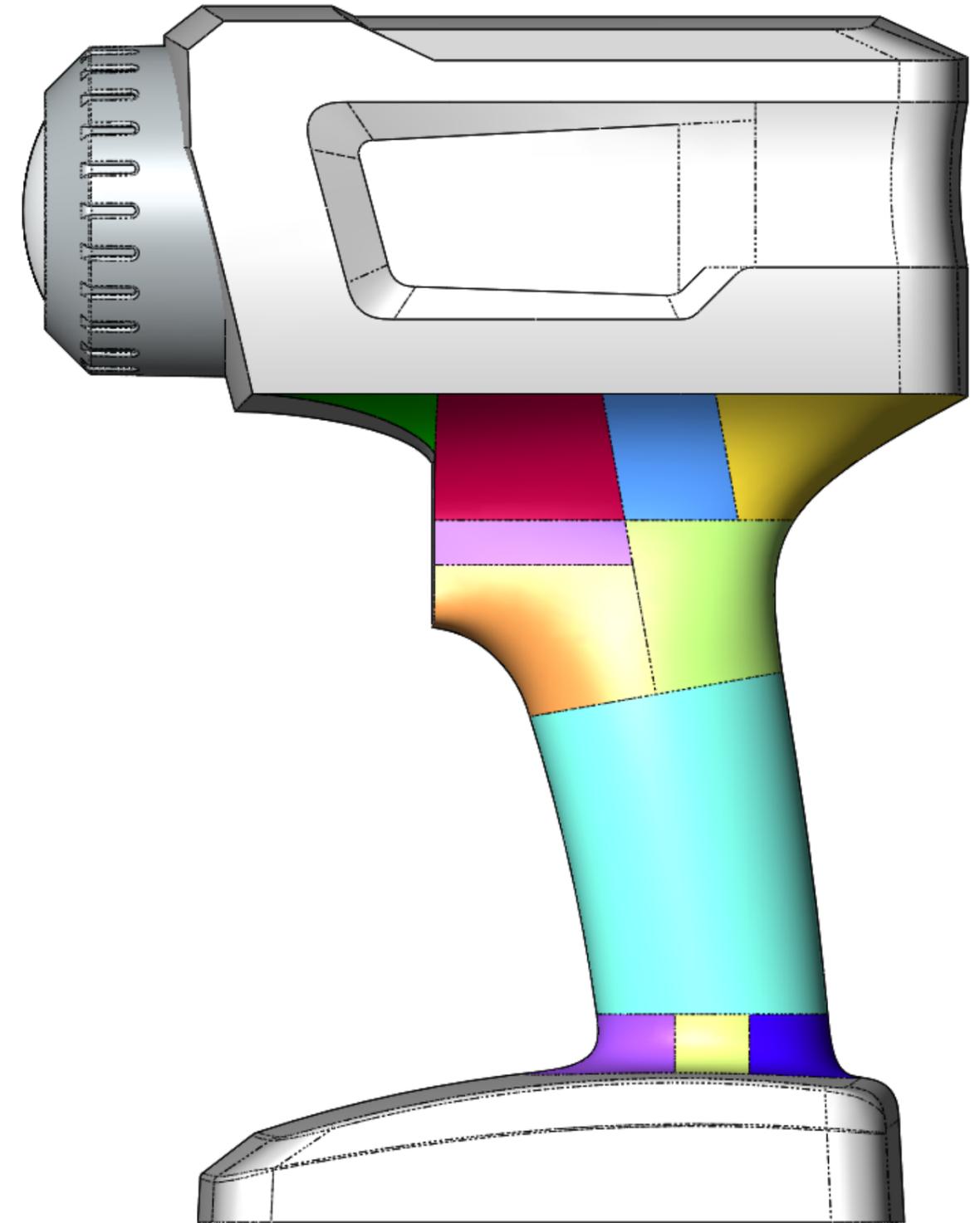
# Patch Layout

Before starting to model, layout the surfaces you'll use to construct the shape. The strategy you use will dictate where planes, sketches and projected curves/ 3D sketches will be positioned.

It is ALWAYS better to break patches into smaller surfaces. Don't try to do too much with one surface.

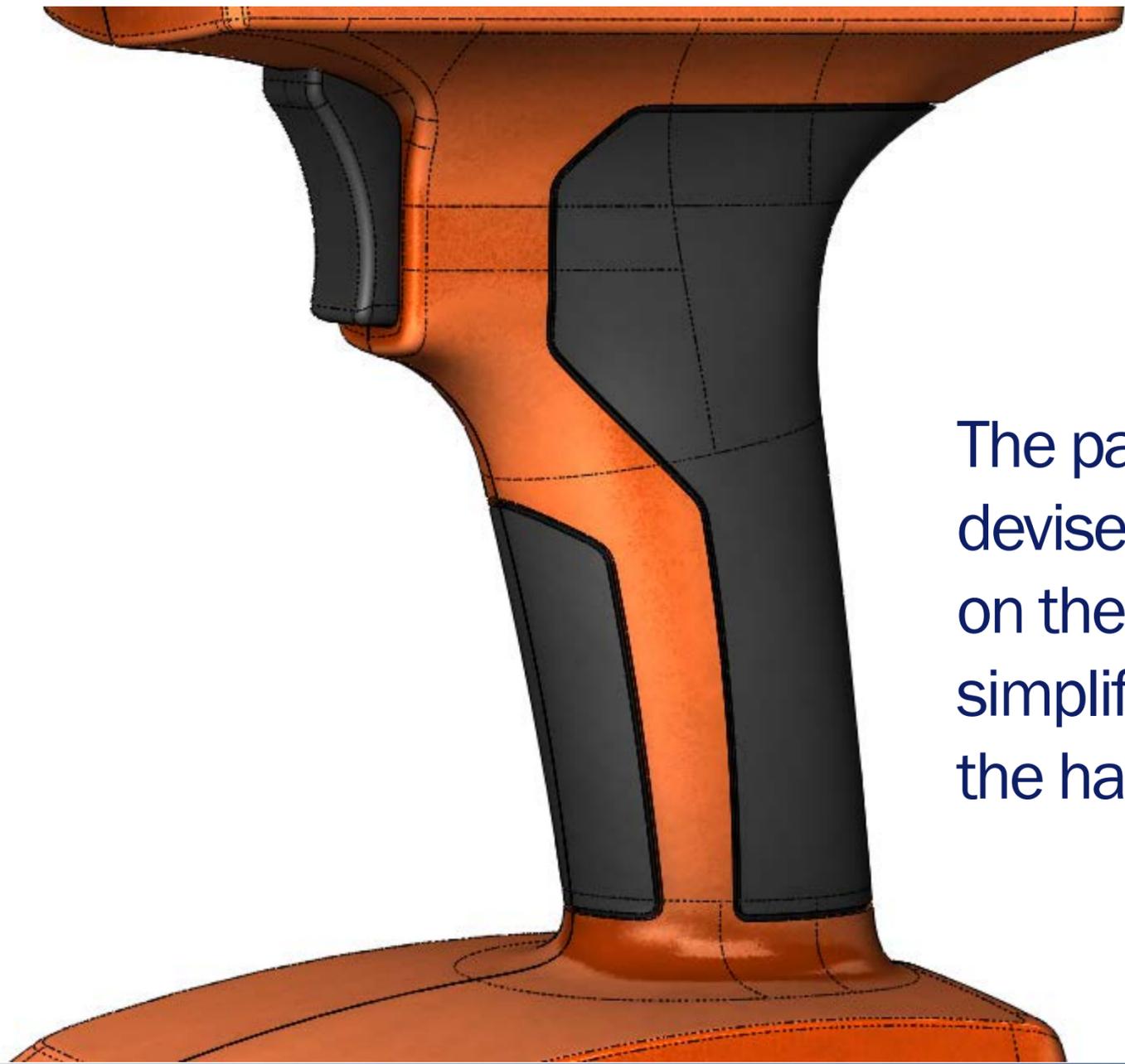
Break the shape into as many 4 sided patches as required. These will become Boundary Surfaces.

The remaining N-sided patches will be completed with Surface Fills.

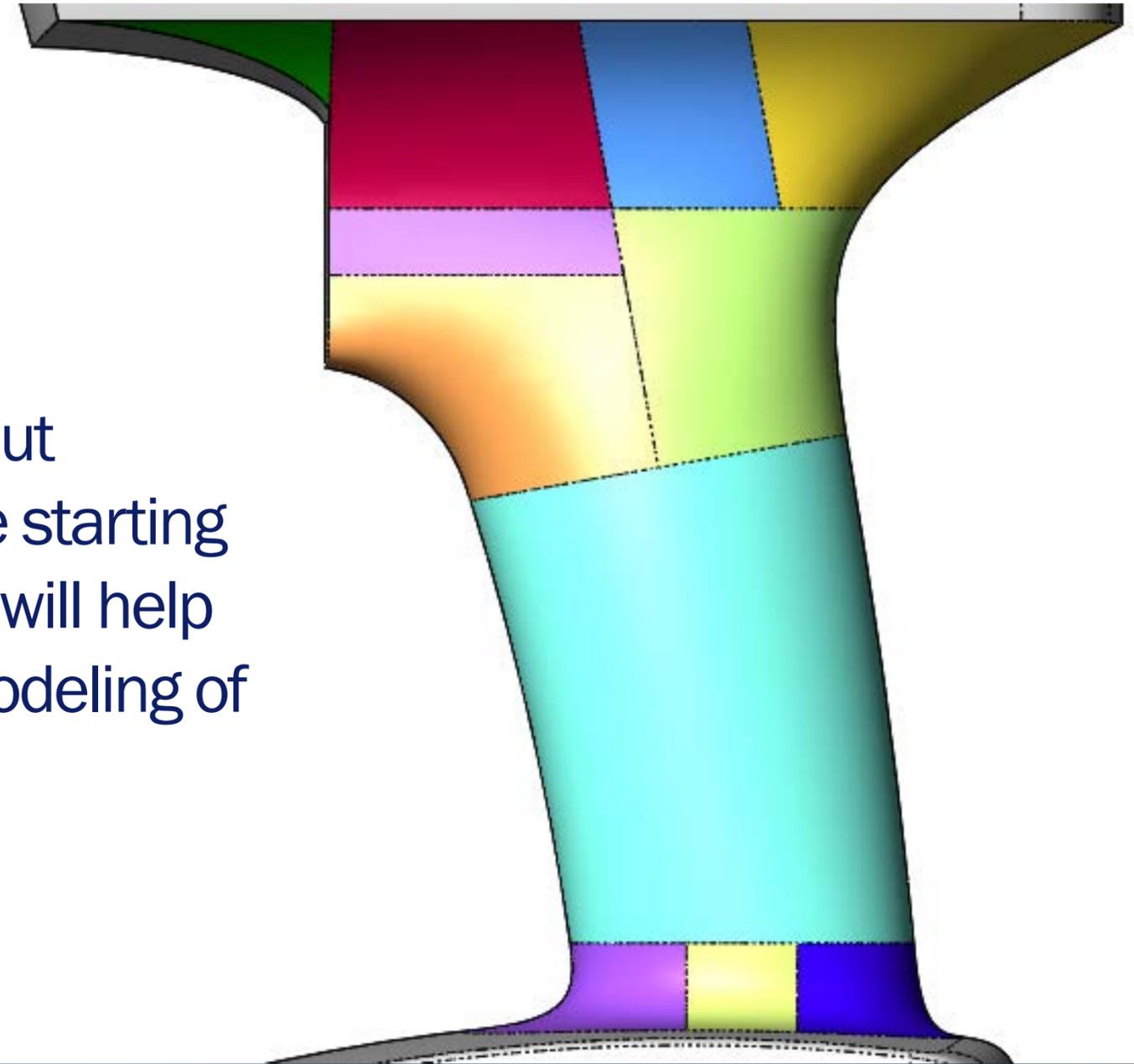


# Construct The Handle

The smooth, organically shaped handle will be constructed entirely with surface features.

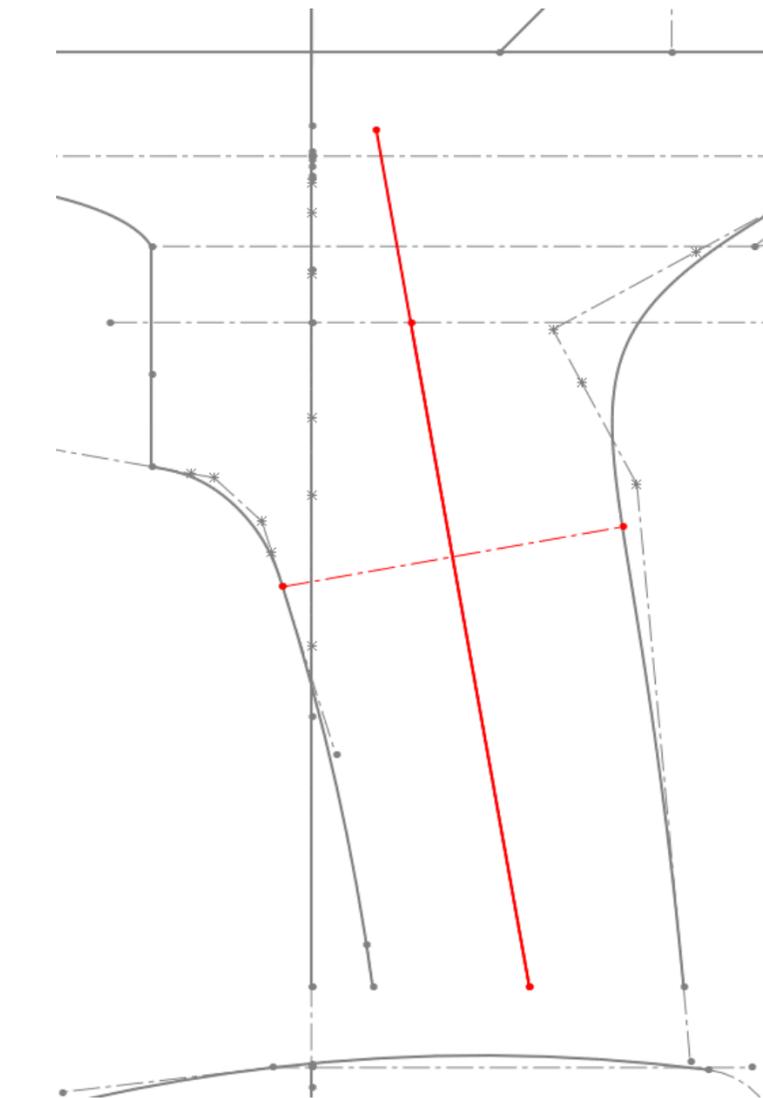


The patch layout devised before starting on the handle will help simplify the modeling of the handle.

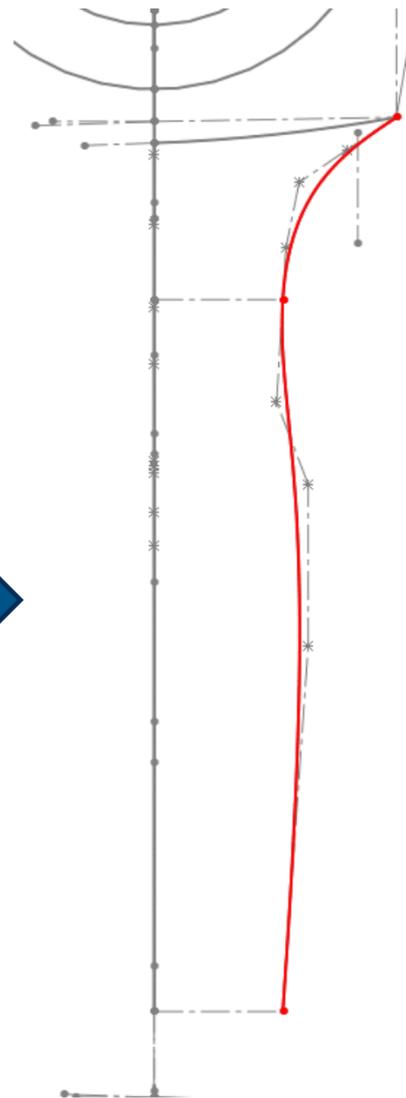
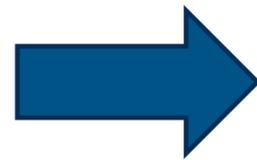


# Begin Laying Out Curves and Sketches

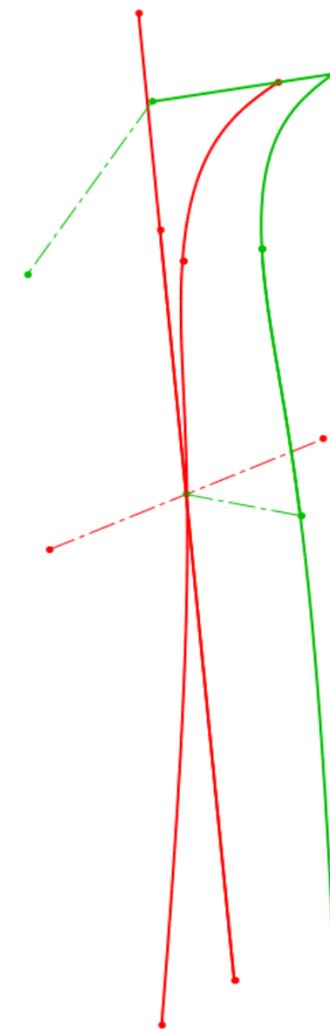
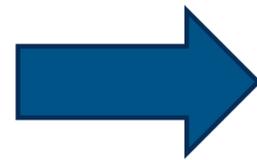
The handle surfaces will be built from curves and sketches. The front profile of the handle is projected onto a sketch on the right plane creating the main profile of the handle.



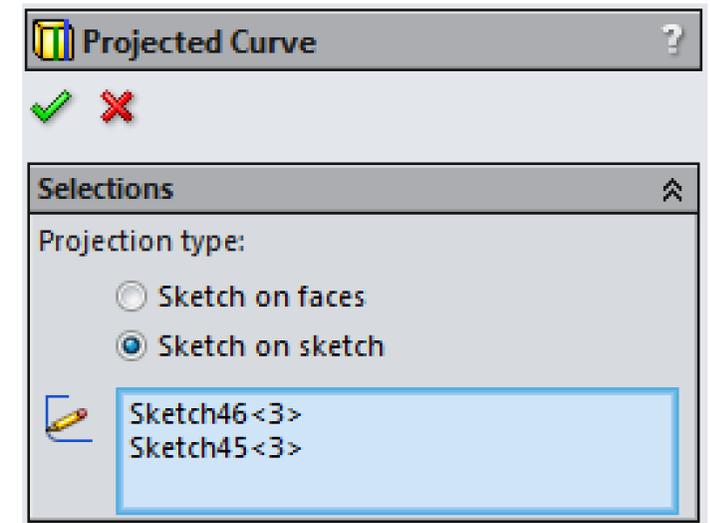
2D Sketch Right Plane



2D Sketch Front Plane



3D Projected Curve

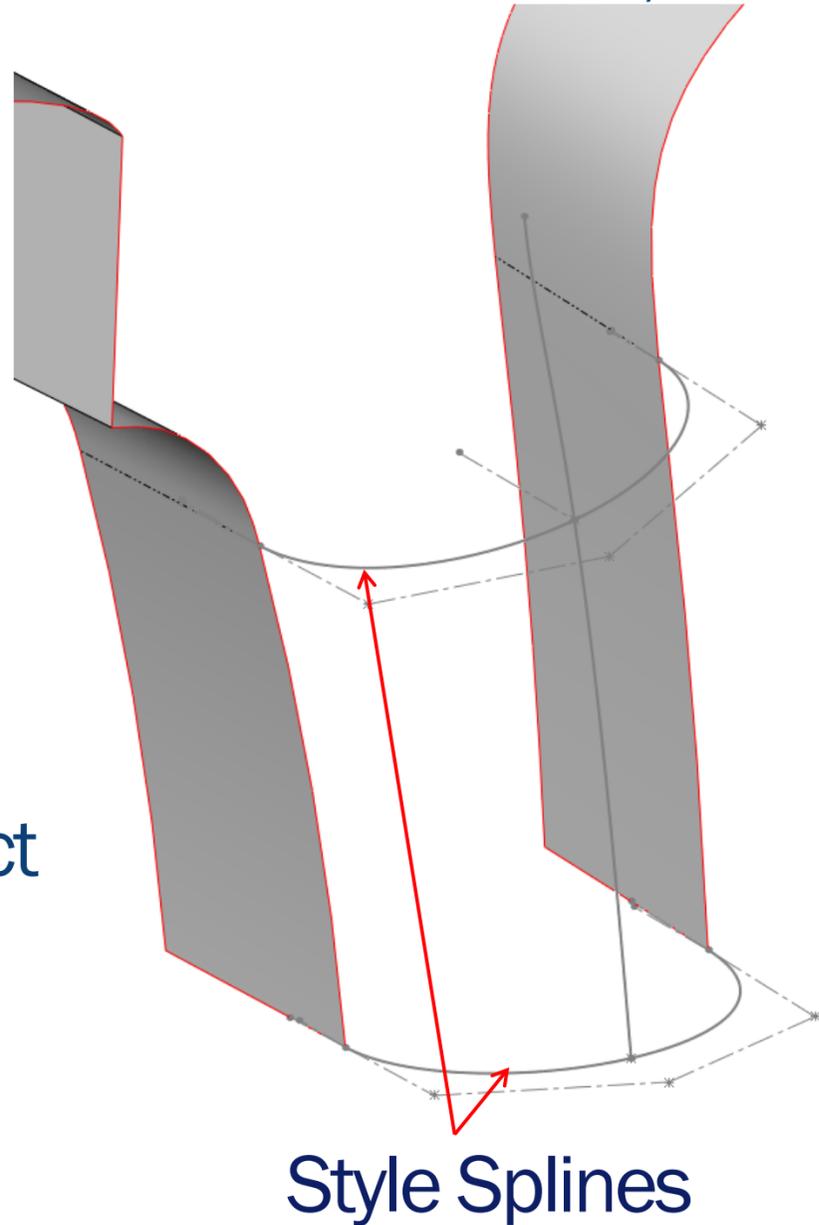


**TIP:** Convert the Projected Curve into a 3D sketch.

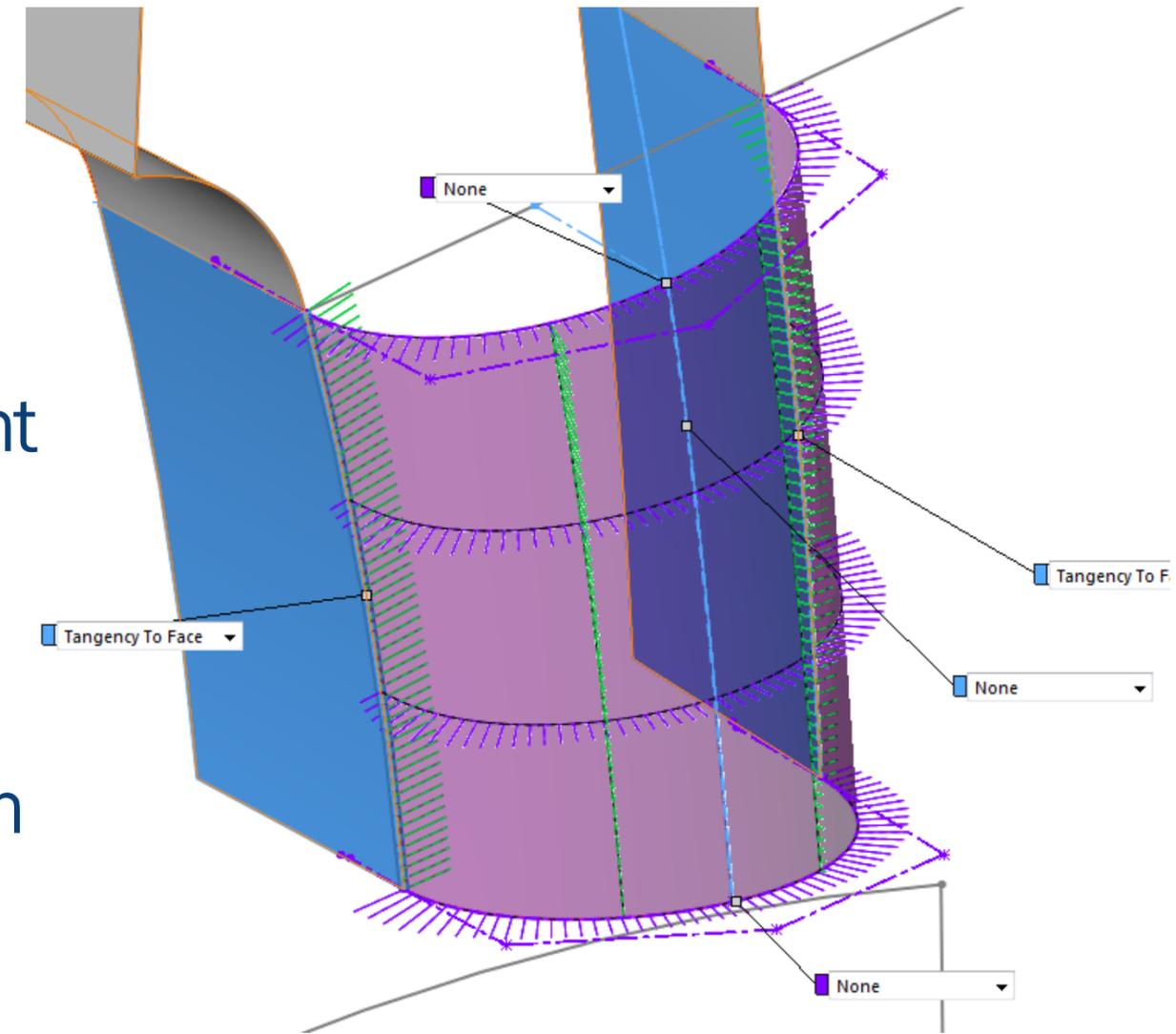
# Create Surfaces from the Curves

Style Splines are sketched on a series of planes to further define the shape of the handle. Once a perimeter is established, a Boundary Surface can be created.

Use the tangent face relation to ensure correct draft at parting line.

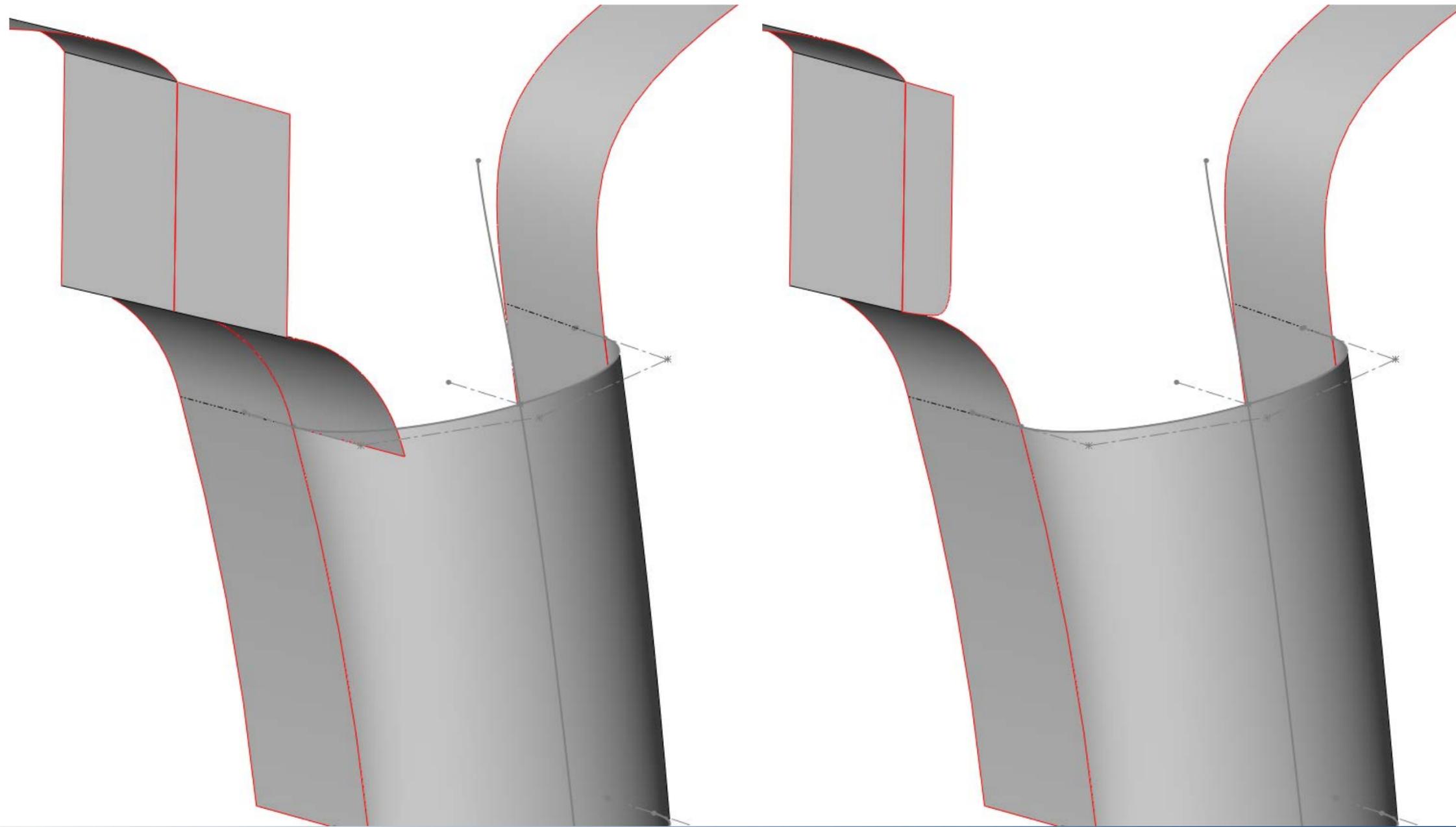


**TIP:** Evaluate the curvature combs of the surface before changing the tangent influence. In this example, changing from 0% only introduces a ripple in D2.



# Create The Trigger Flat

A Surface Extrude with draft and a Trim complete the flat trigger area. Fillets will be added later.



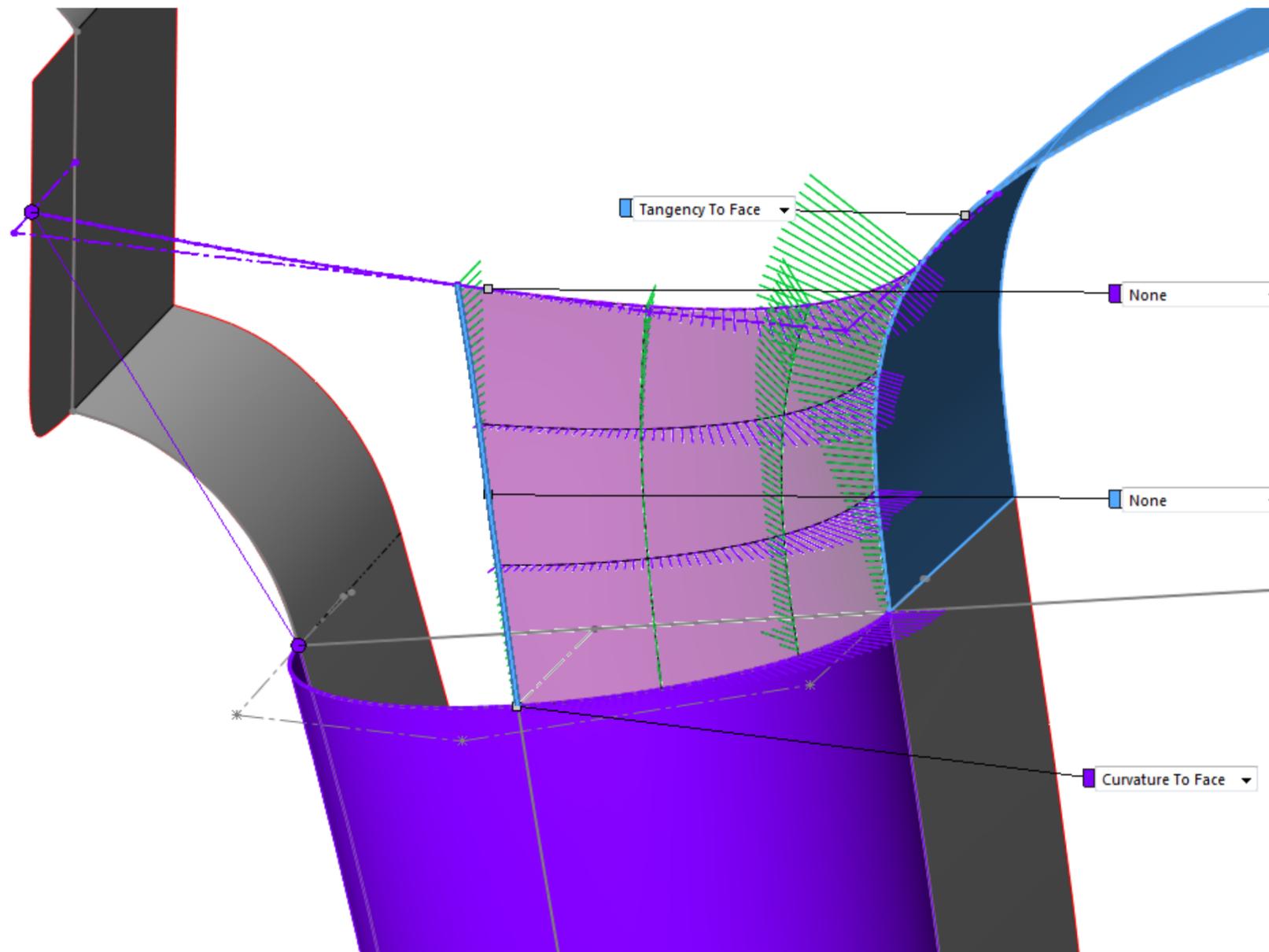
## TIP:

Overbuild surfaces to virtual sharps and add fillets later.

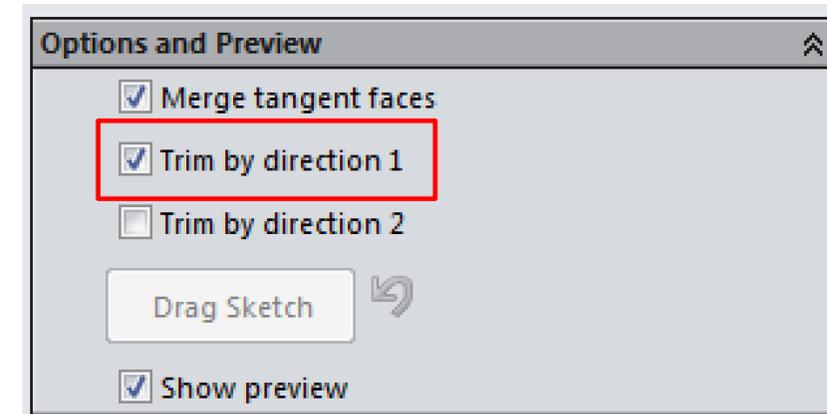
Trying to build fillet features into surfaces can be unwieldy.

# Continue Building 4 Sided Surfaces

Additional Boundary Surfaces are created between existing model edges and 2D style splines sketched on planes.

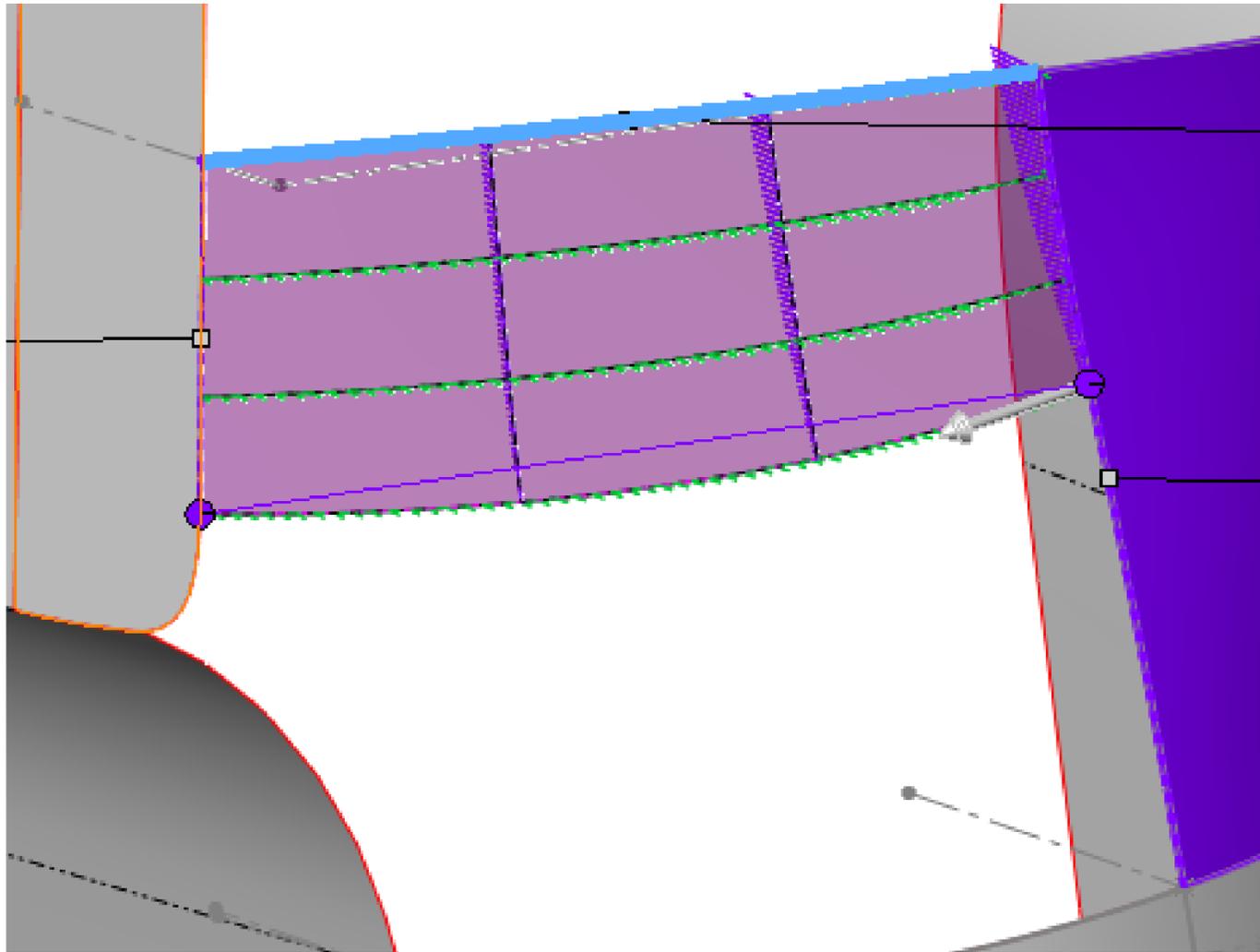


Note that the profiles in D2 extend past the first profile in D1. Enabling “Trim by Direction 1” causes the surfaces to be built only between the two profiles in D1.

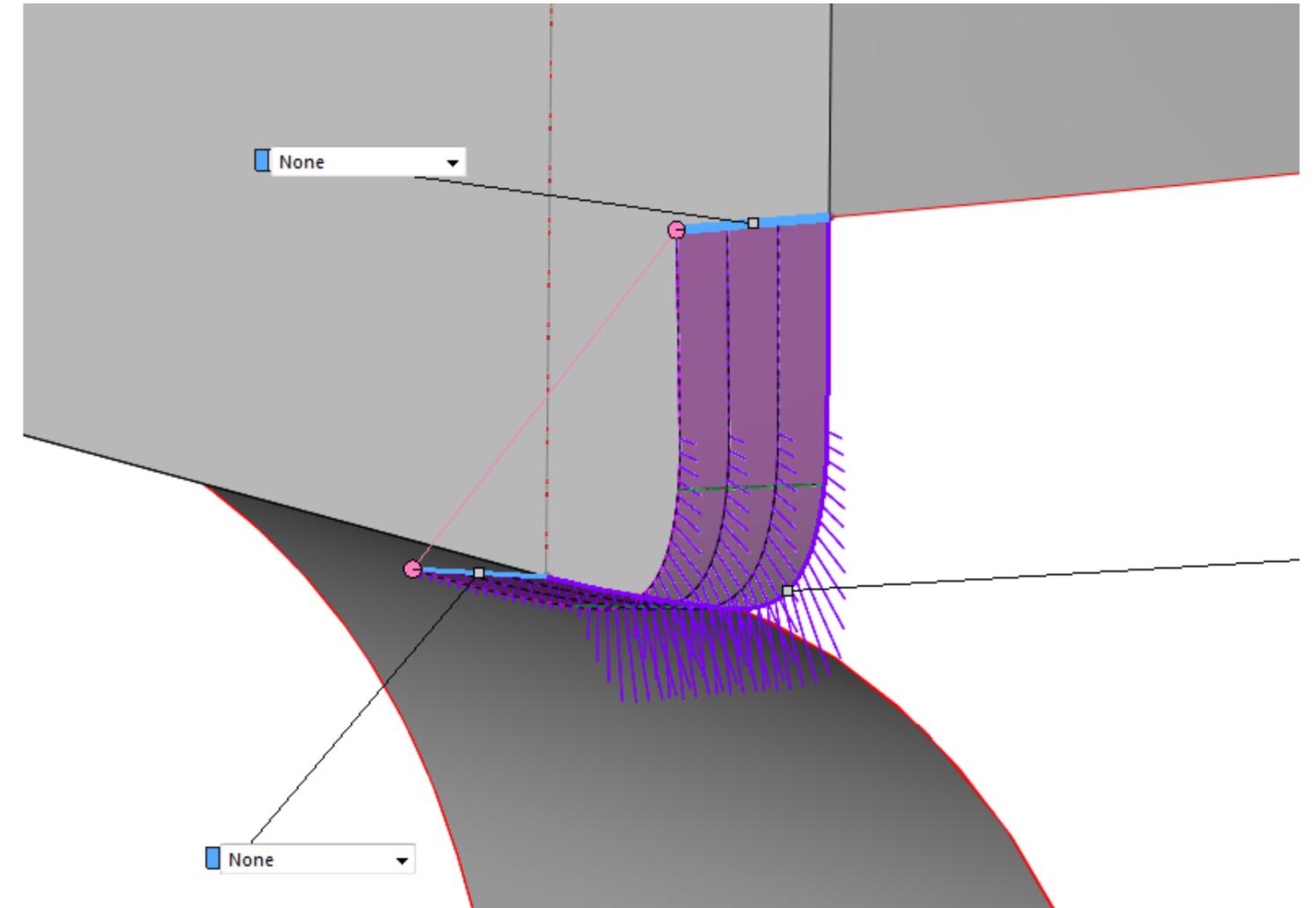


# Create Guides for Surface Fill

Surface Fill works best when it can be shaped with the tangent constraint to adjacent faces.



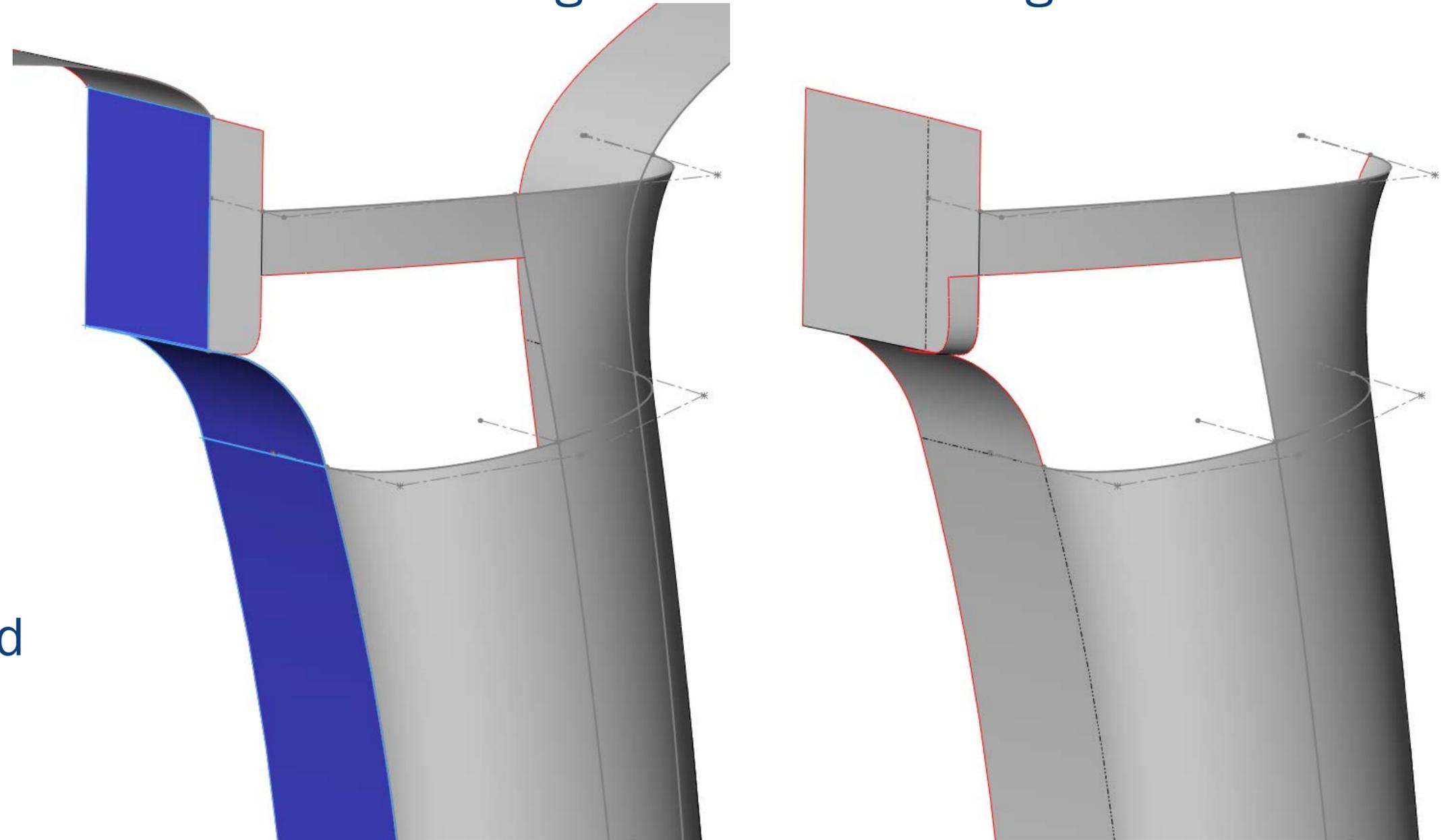
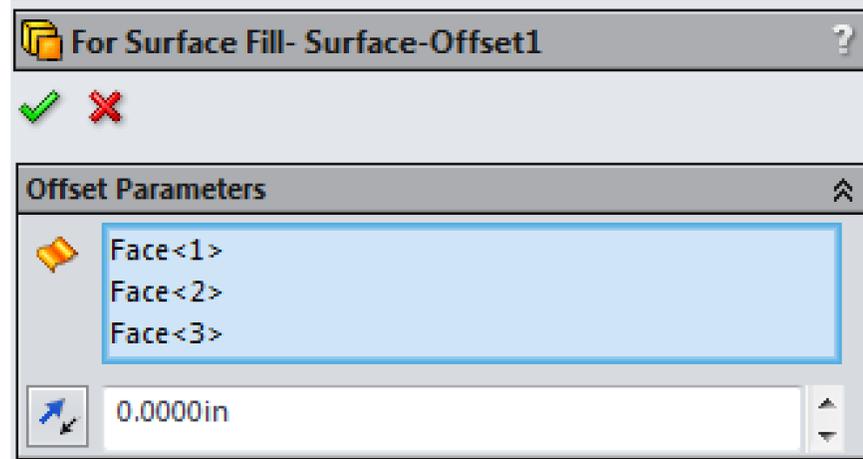
Boundary Surface is overbuilt and then trimmed back for clean curvature.



A helper surface is built from two line segments made tangent to geometry in a 3D sketch.

# Create A Closed Perimeter

Surface Fill works best when it has a closed set of edges. While it will work with sets of open edges, tangency and curvature constraints can sometimes be ignored on non-knit edges.



Draft Reference surfaces are copied with a 0 distance surface offset, then knit into the model. They will be deleted after the Surface Fill.

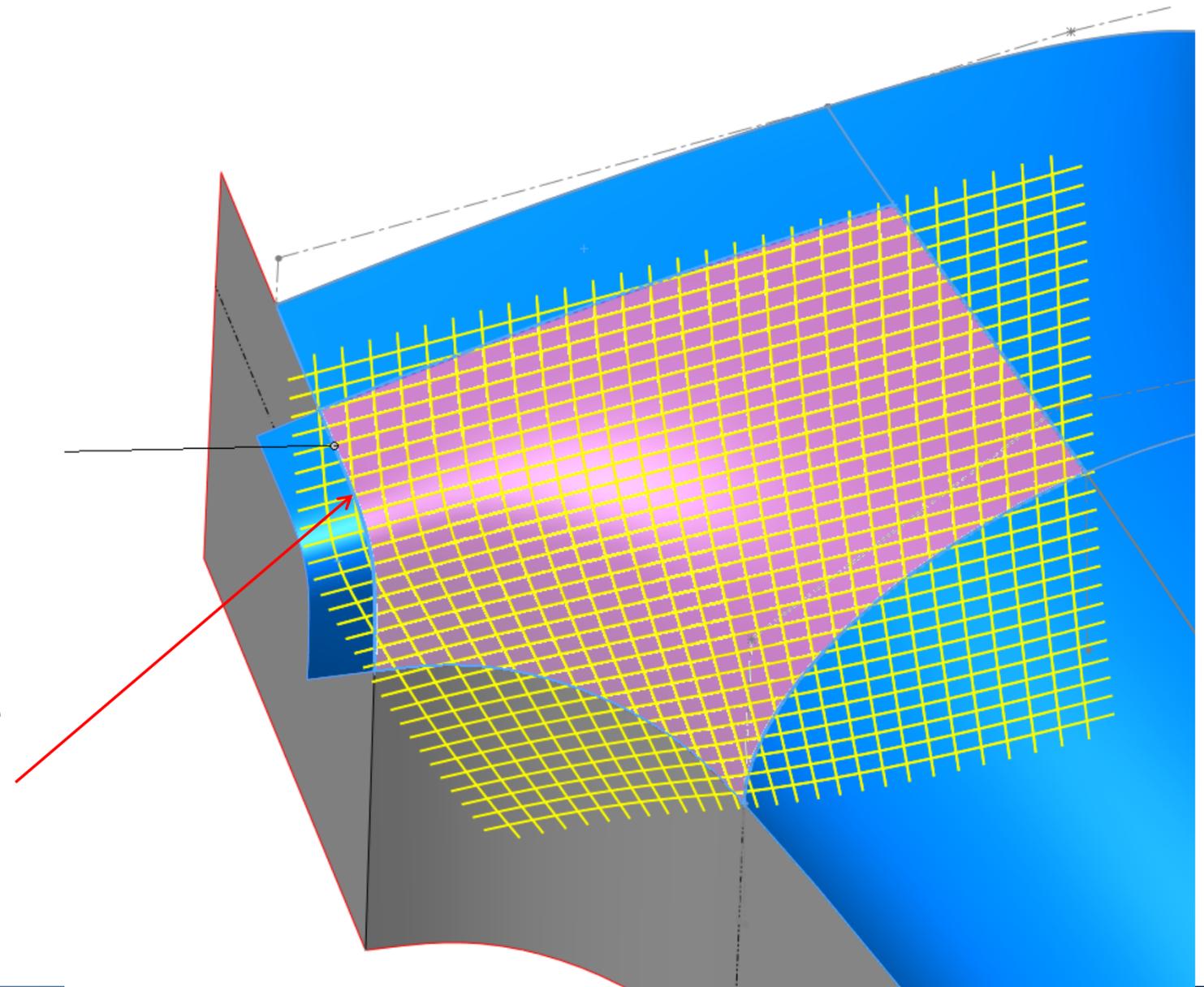
# Create the Surface Fill

This 5 sided patch would be difficult to close with Boundary Surfaces. However, this area was specifically constructed to harness the power of Surface Fill.

## TIP:

Start with tangency on all edges. Use zebra stripes to evaluate flow of surface. If required, add curvature. This example produces inferior results when curvature is applied to the 3 main edges.

Helper surface guides the shape of the Surface fill. The fill uses tangency on all edges. Contact on the front edge causes an undesirable dip.



# REALLY FREEFORM SURFACING

**“Getting the most of the best to  
the greatest number of people  
for the least.”**

**-Charles Eames**

# Eames Fiberglass Shell Chair



# Eames Fiberglass Shell Chair

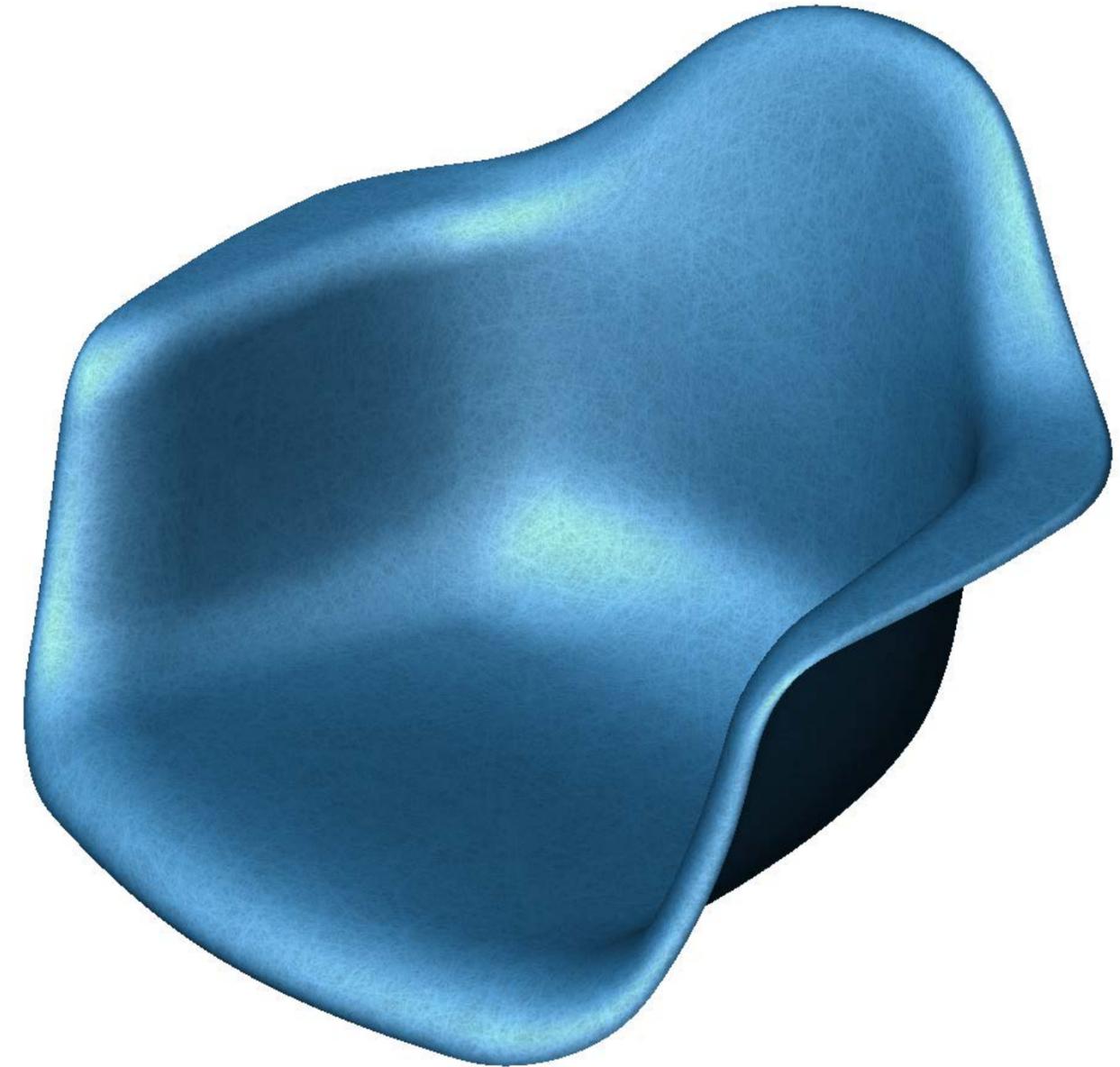


# Eames Fiberglass Shell Chair

The Eames' strove to design modern, functional and reasonably priced furniture. Their Fiberglass Shell Chairs arguably come closest to achieving this vision.

First manufactured in glass fiber reinforced polyester in 1950, the chair was the first one piece plastic chair not covered in upholstery. Instead, the chopped glass fibers contribute to the look and authenticity of the chair .

The chairs were produced by impregnating a glass fiber mat with resin and then forming in a core-cavity steel mold mounted in a hydraulic press.



# Patch Layout II

Break up the form of the chair into 3 types of surfaces. This forms the basis for the Patch Layout that will dictate where surface sections and 3D curves are generated.

**Primary Surfaces** are large and relatively flat.

**Blend Surfaces** connect **Primary Surfaces** together.

**Transition Surfaces** complete the areas between regions of the chair.

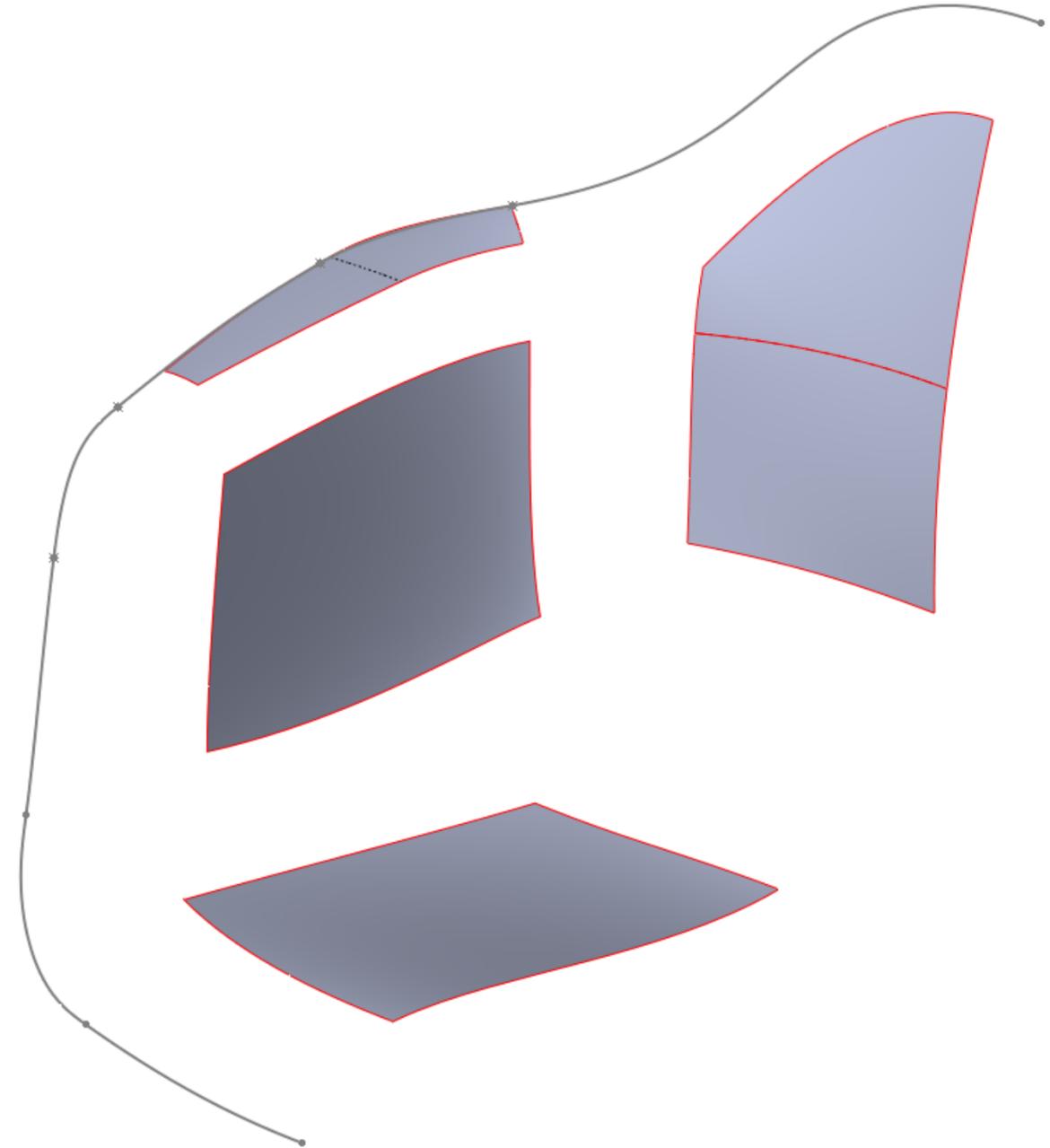


# Primary Surfaces

Primary Surfaces consist of 4 sided Boundary Surfaces constructed from 2D sketches, 3D sketches and Project Curves.

Section surfaces will be used to help trace sketches over the scan data.

Because the chair is symmetric, one half will be modeled and then mirrored.

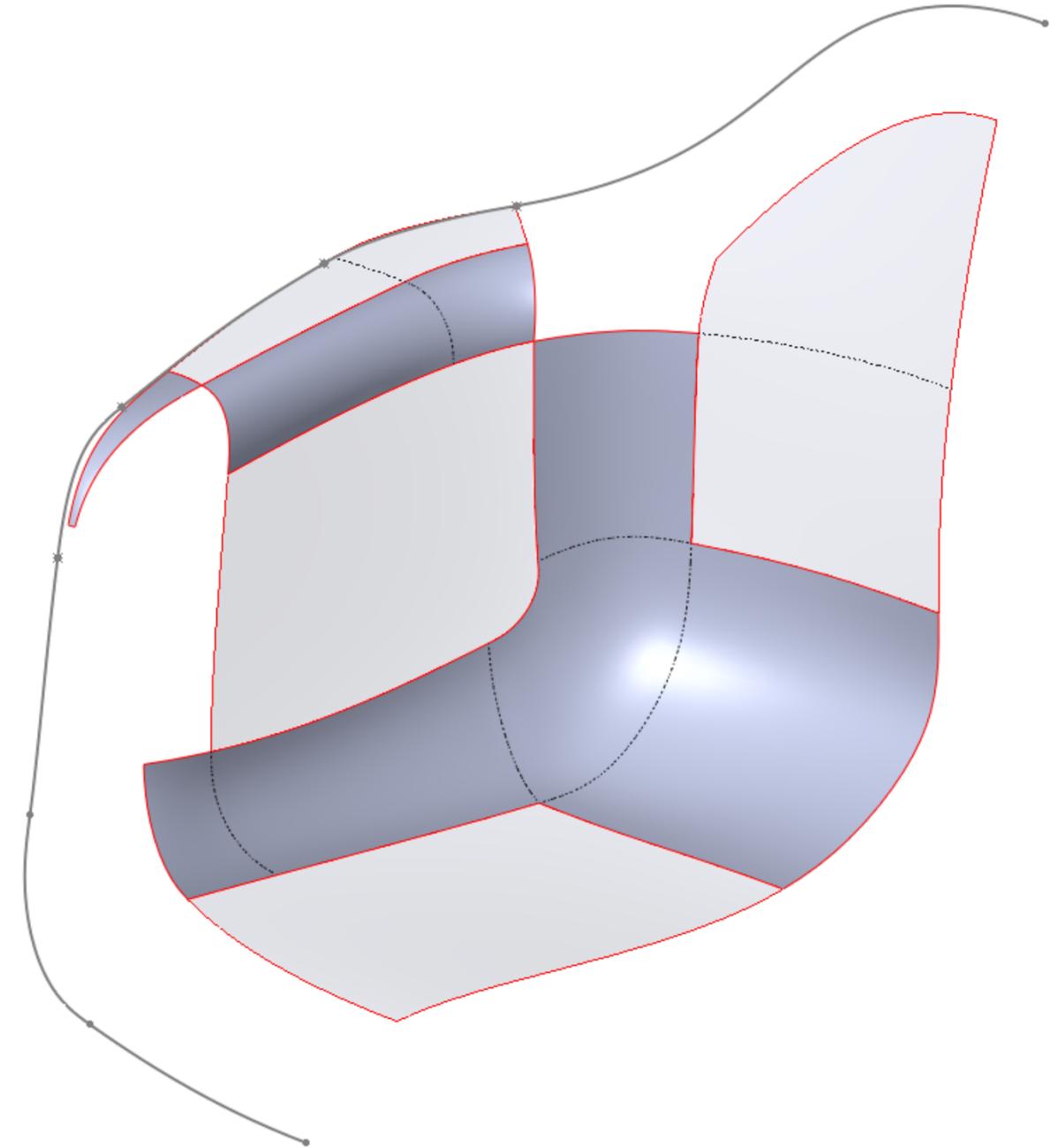


# Blend Surfaces

Blend surfaces consist of 4 sided Boundary Surfaces constructed from existing model edges with 2D sketches or 3D sketches defining the blend between two Primary Surfaces.

Blend Surfaces differ from Fillets as the shape is precisely defined by the operator instead of the software.

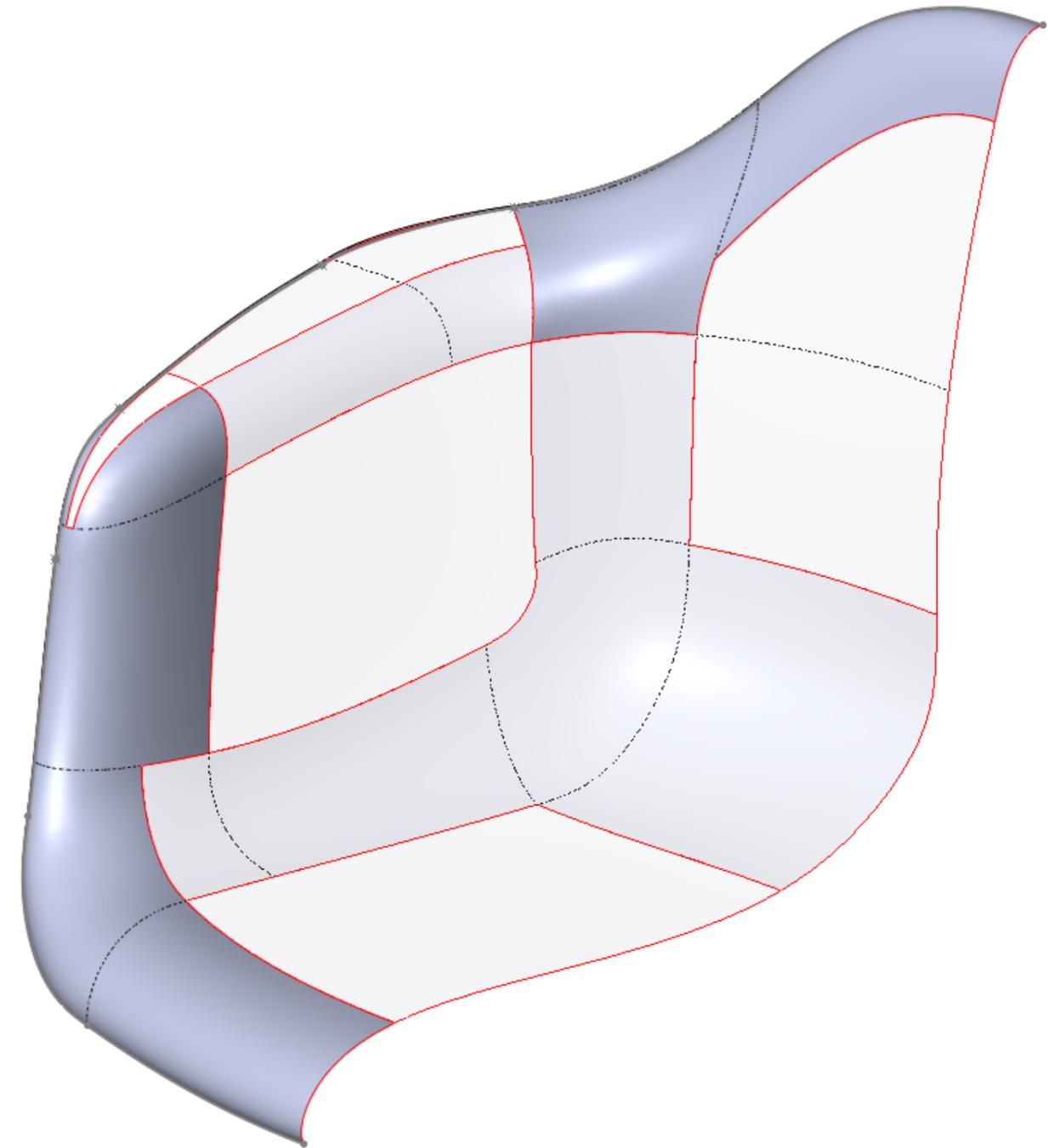
Hand sculpting each surface mimics the way the original form was sculpted by hand. It allows precise matching of the scan data.



# Transition Surfaces

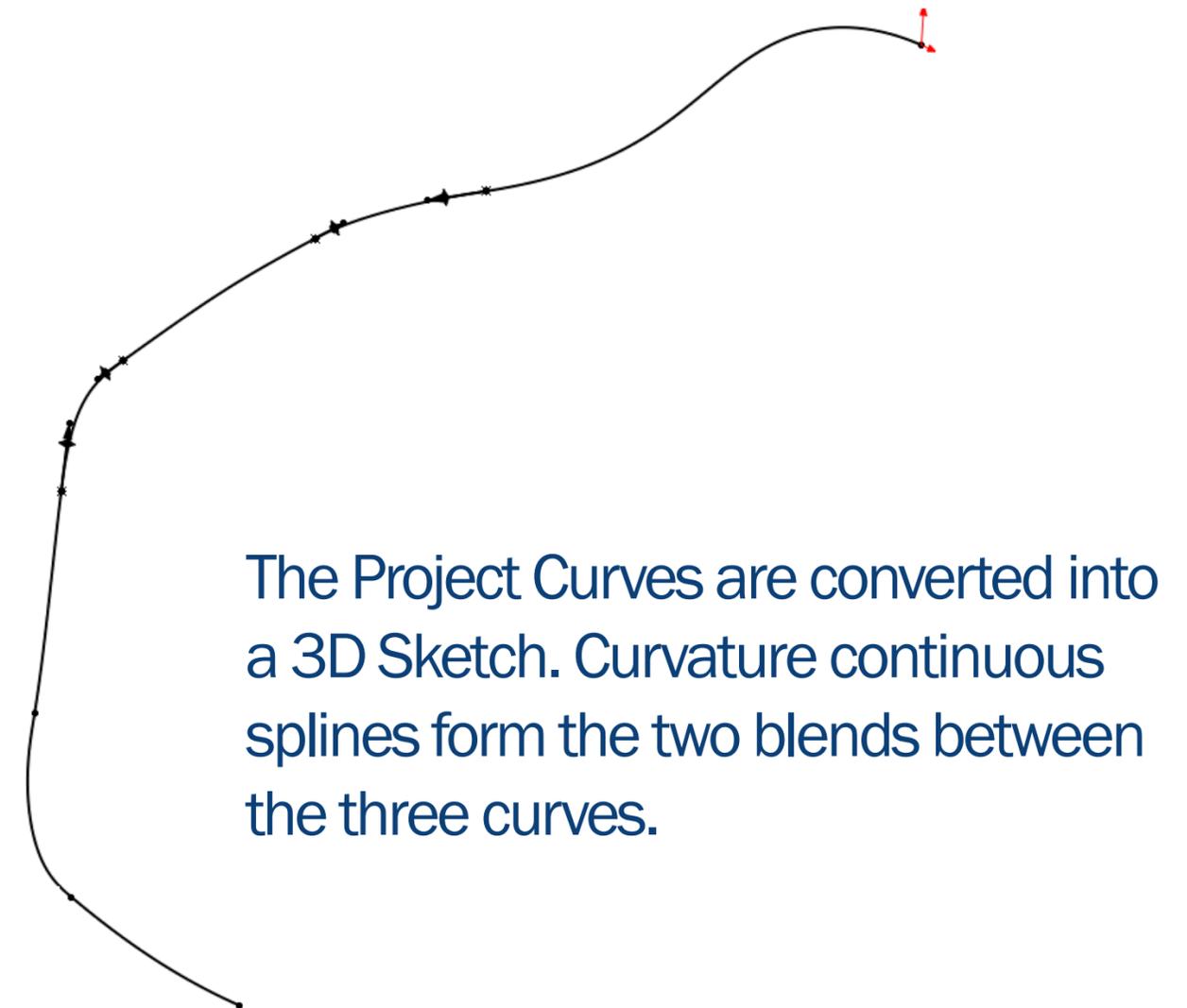
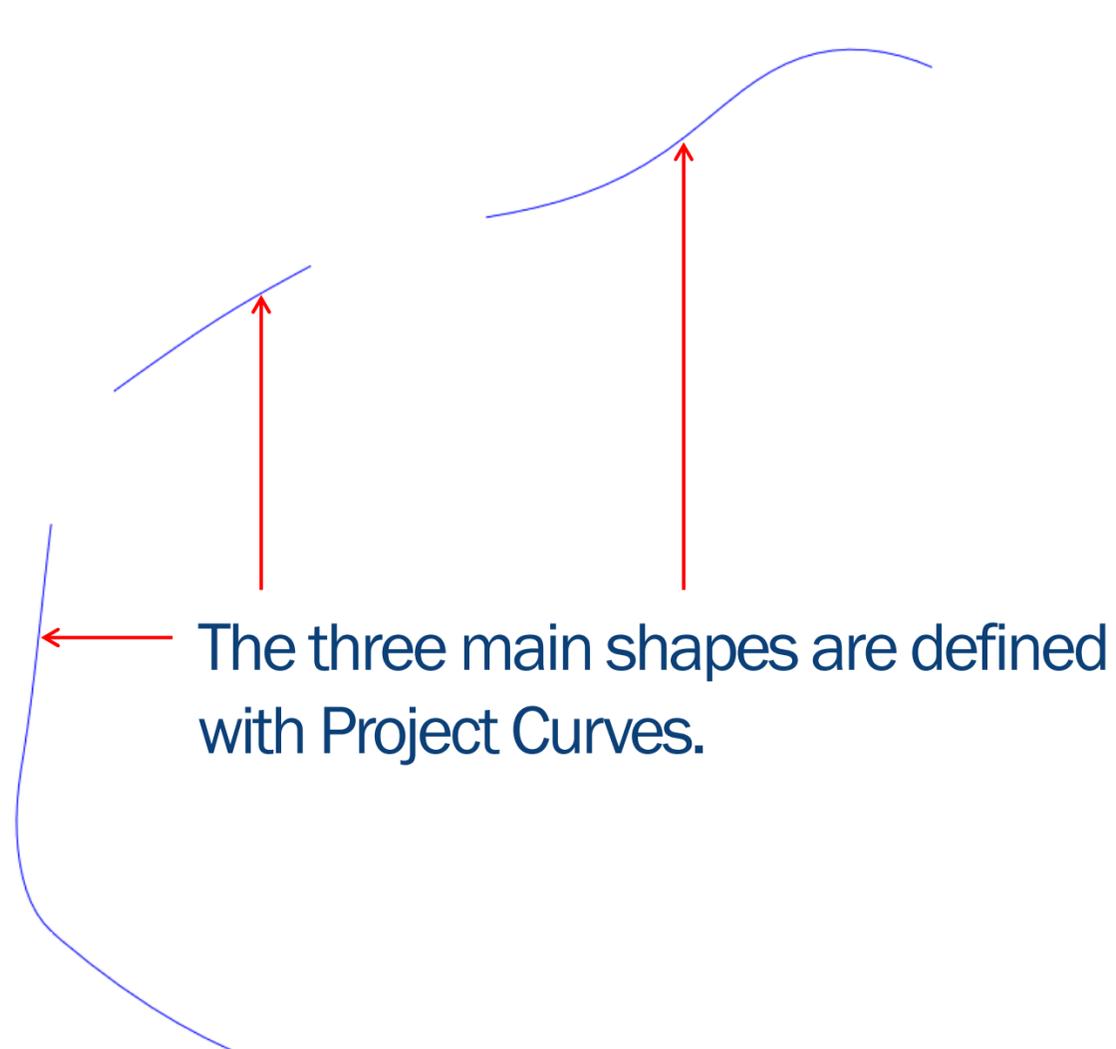
Transition Surfaces are 4 sided Boundary Surfaces or 3, 5 or more sided Surface Fills. They are constructed from 2D sketches, Project Curves, 3D sketches and existing model edges.

Transition surfaces connect the different regions of the chair together. They are the last step in surface modeling the chair.



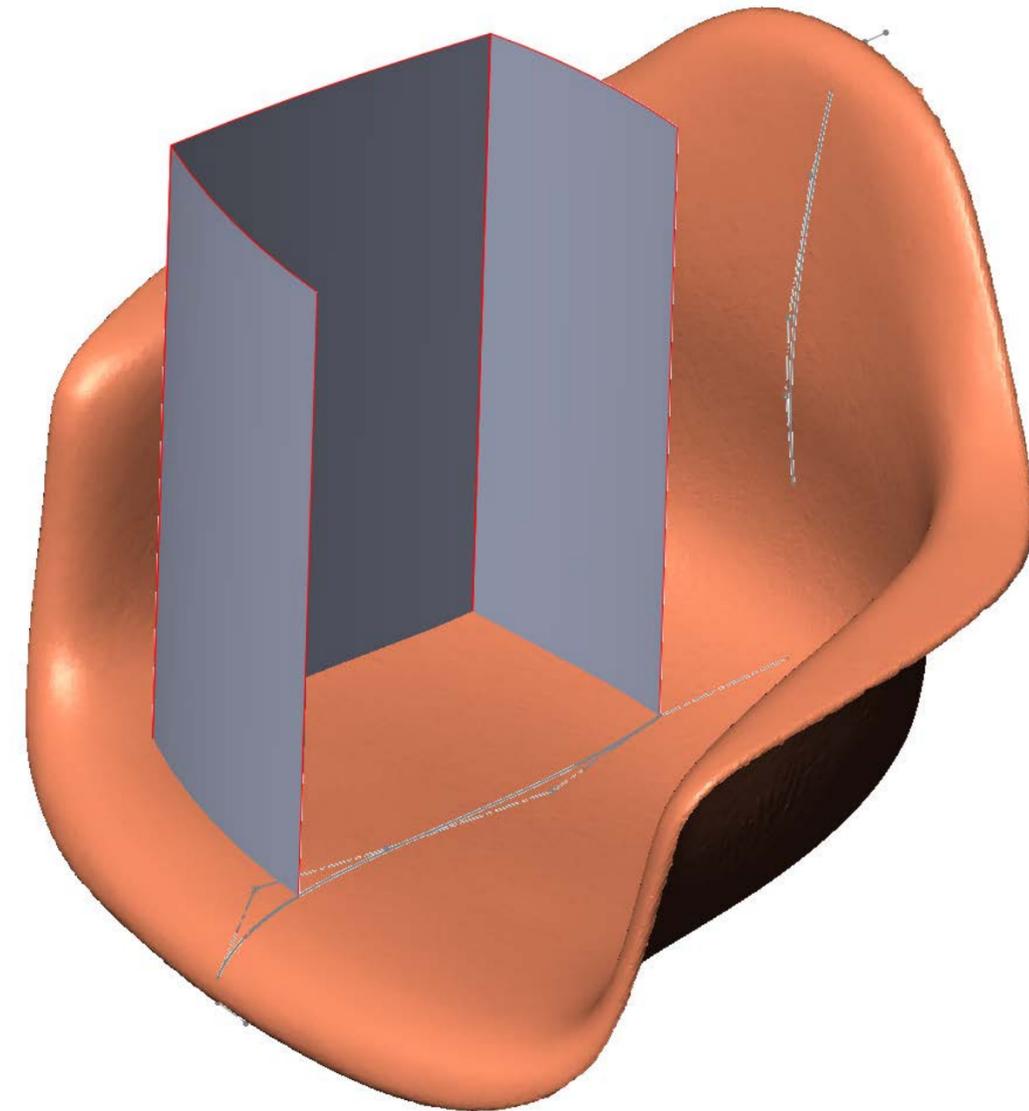
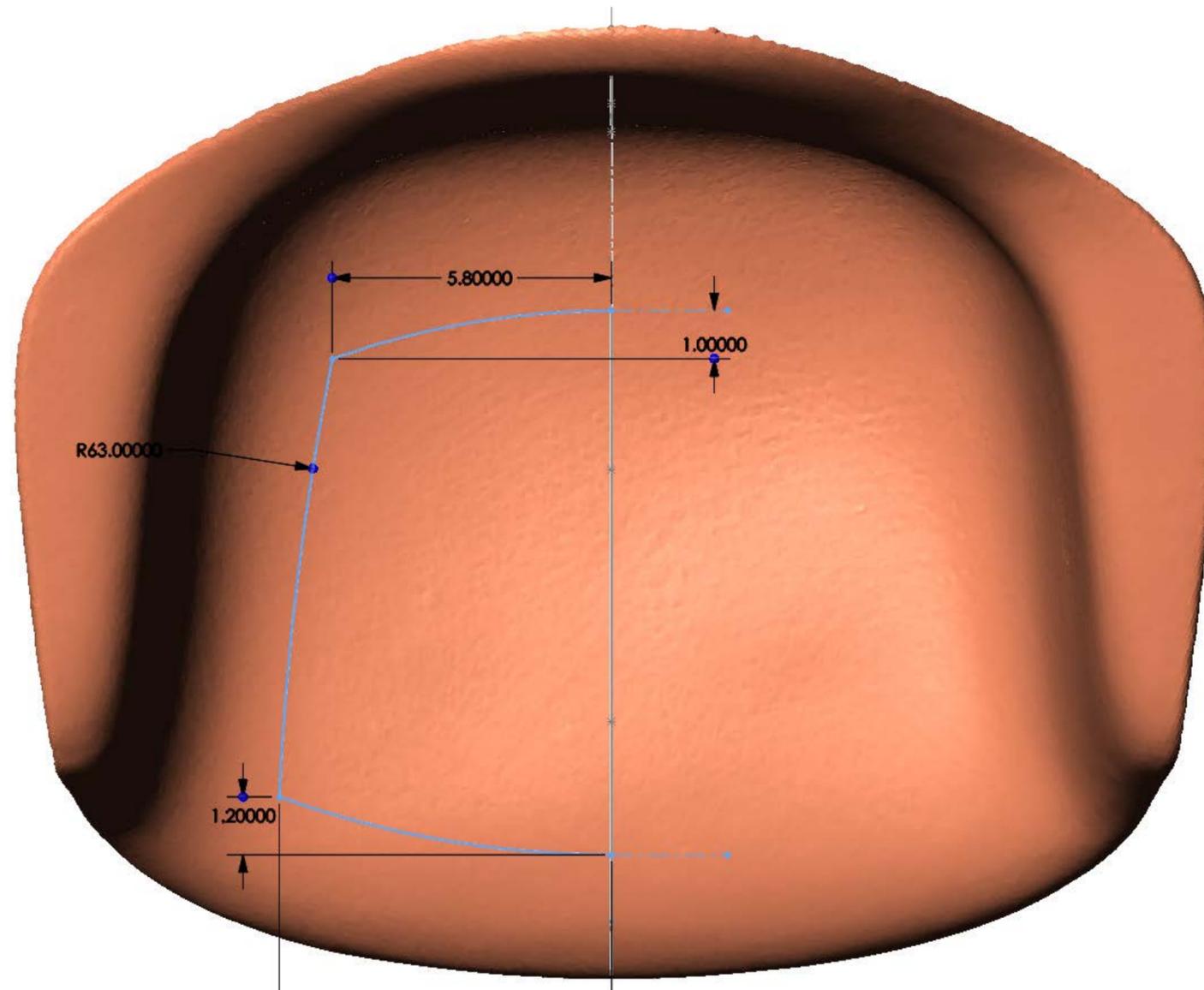
# Define the Perimeter

The perimeter of the chair sweeps up and down, in and out. It would be difficult to define in a single 3D Sketch or Project Curve. Instead the shape is broken down into component parts and defined with multiple Project Curves and 3D sketches.



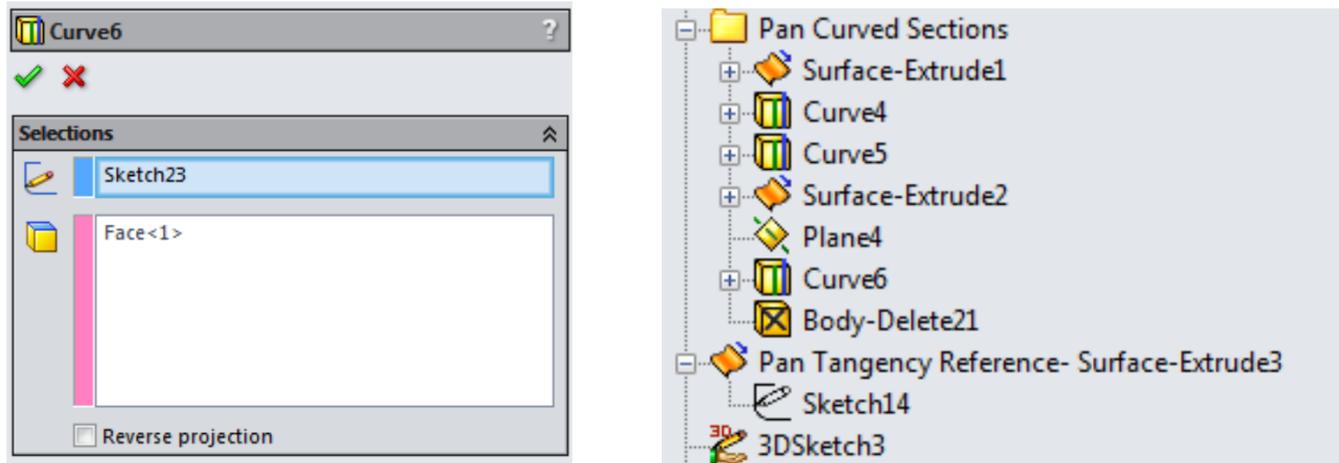
# Section Surfaces

Section surfaces are created from sketches on the default planes. The sketch approximates the start of the blend surfaces. Dimensions adjust the sketch after creation to match the scan.



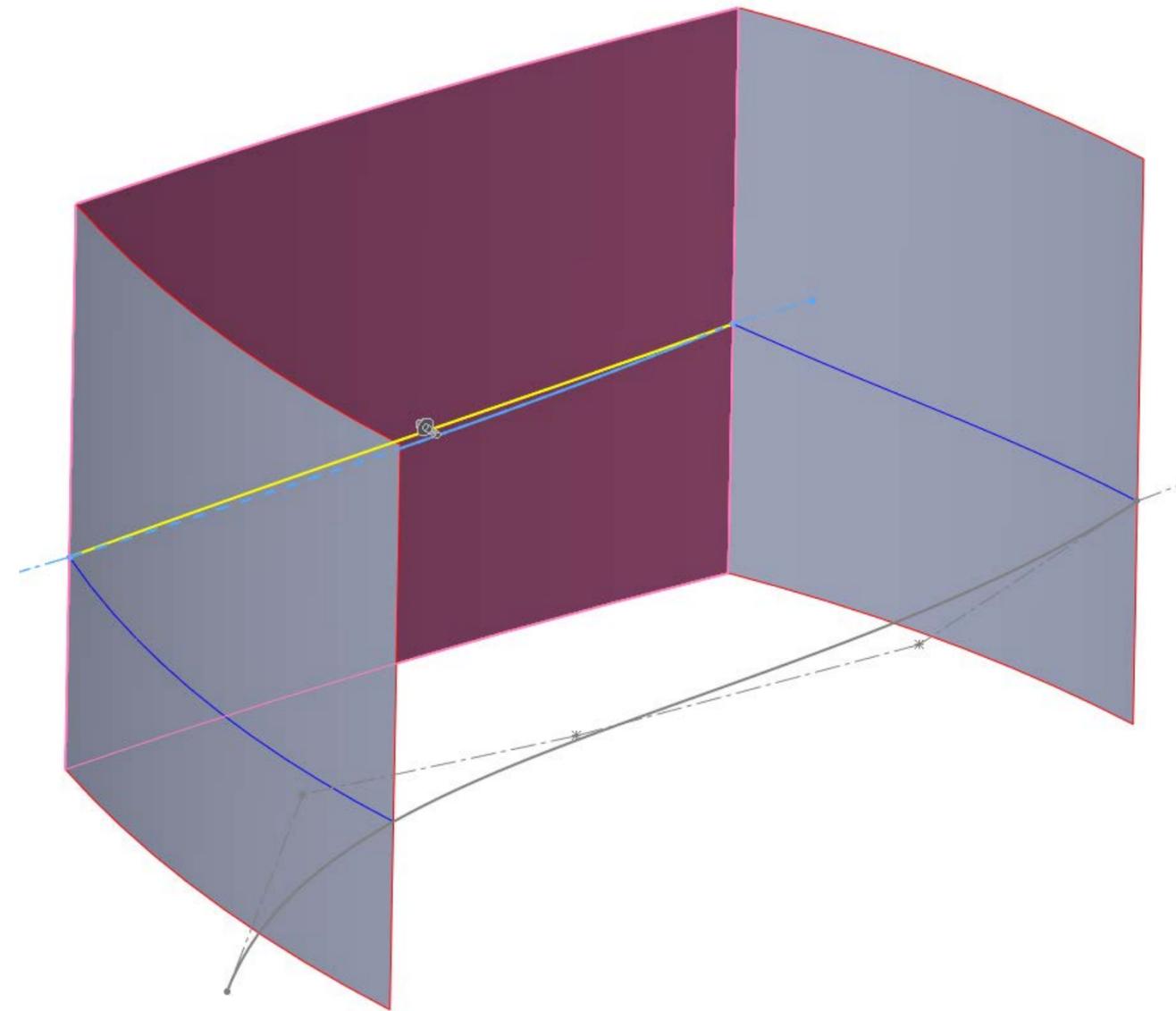
# Project Curves

The sketches are projected onto section planes to create 3D curve that will form the profiles of the Boundary Surface creating the seat pan.



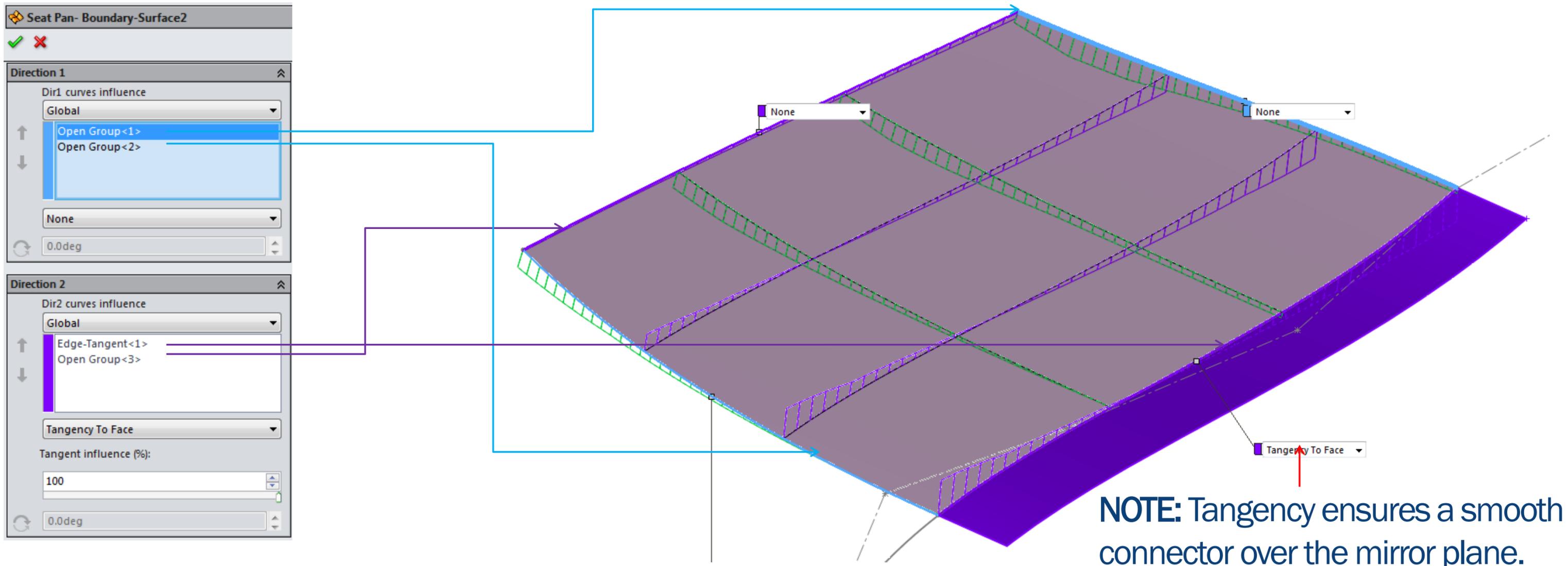
**TIP:** Until SW2016, absorbed curve features were not selectable in the graphics window and could not be used more than once. Work around this by converting the curves into a 3D sketch.

This has the added benefit of keeping a cleaner Feature Tree as Section Surfaces and Curves can be placed in a folder after creation. Remove un-needed Section Surfaces with a Body Delete feature.



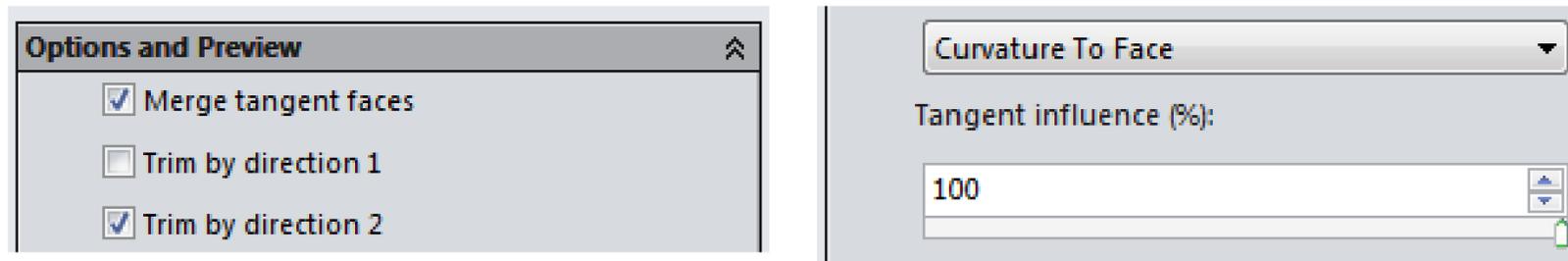
# Seat Pan Boundary Surface

Boundary Surface creates the seat through Project Curves. A surface extrude is created from a profile on the right plane; the boundary is made tangent for correct mirroring.



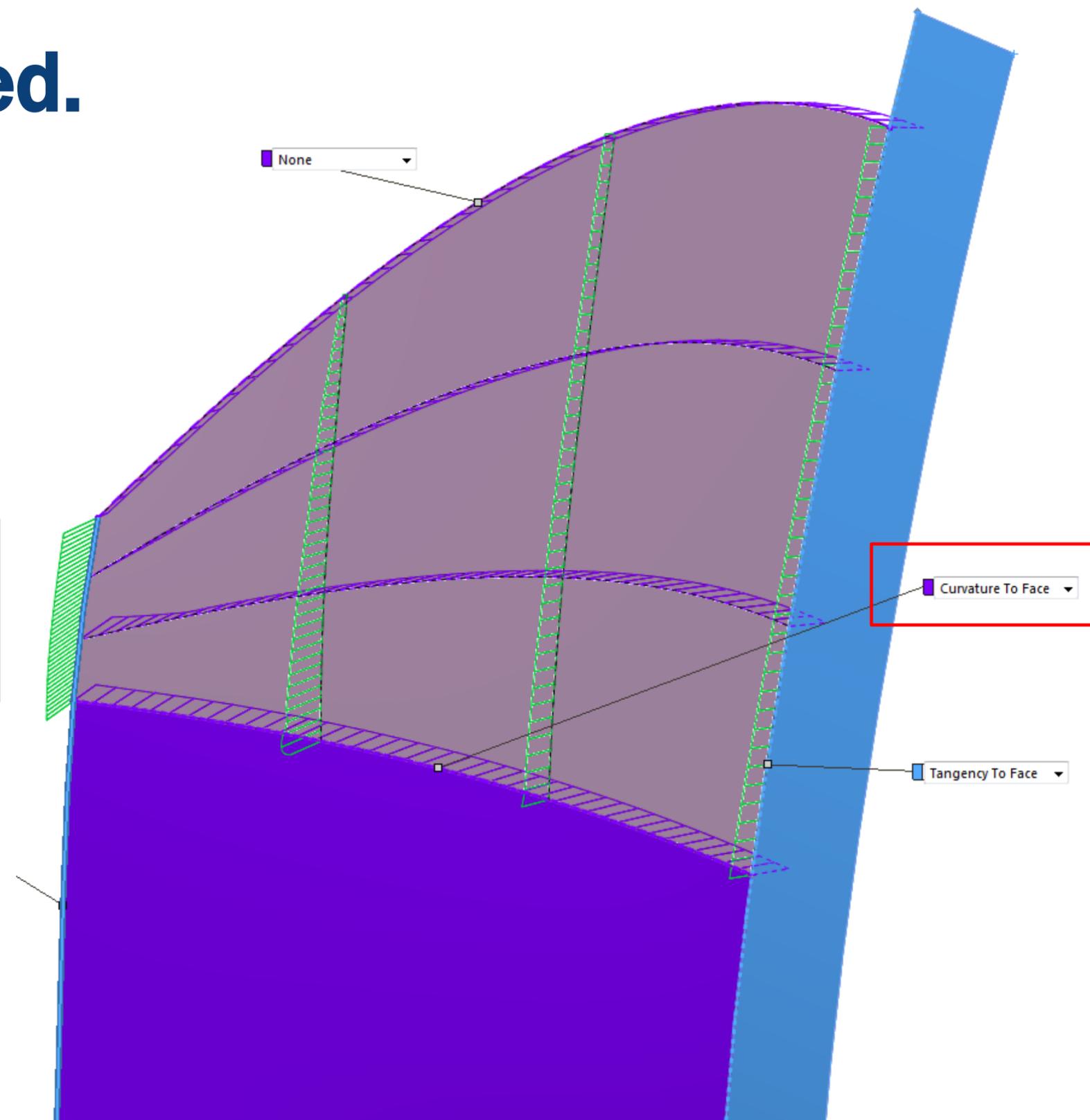
# Break Up Surfaces As Required.

It is better to break up an area into multiple boundary surfaces each with only 4 profiles instead of adding additional profiles to try and define a shape. Connect the surfaces with the Curvature option.



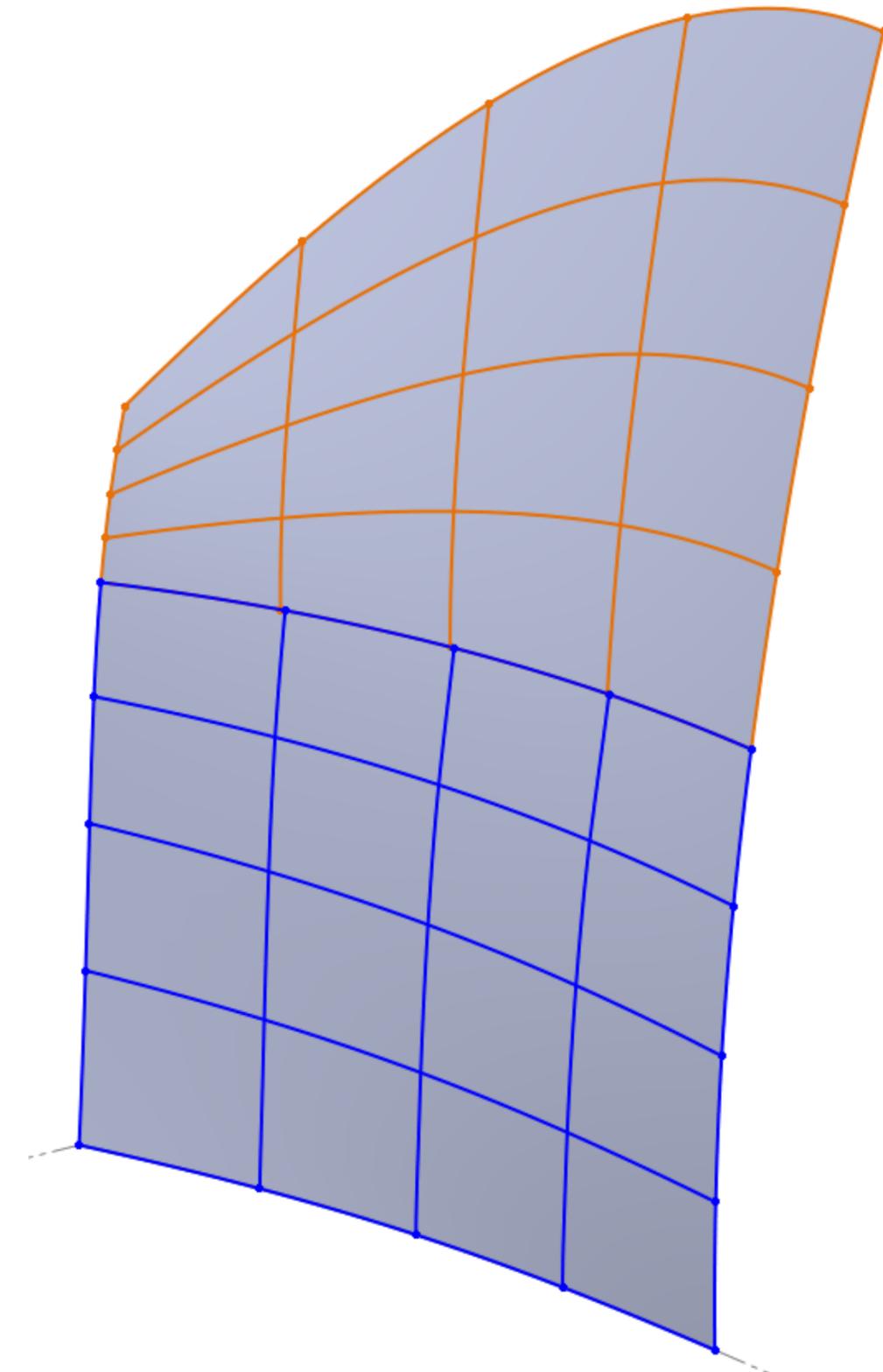
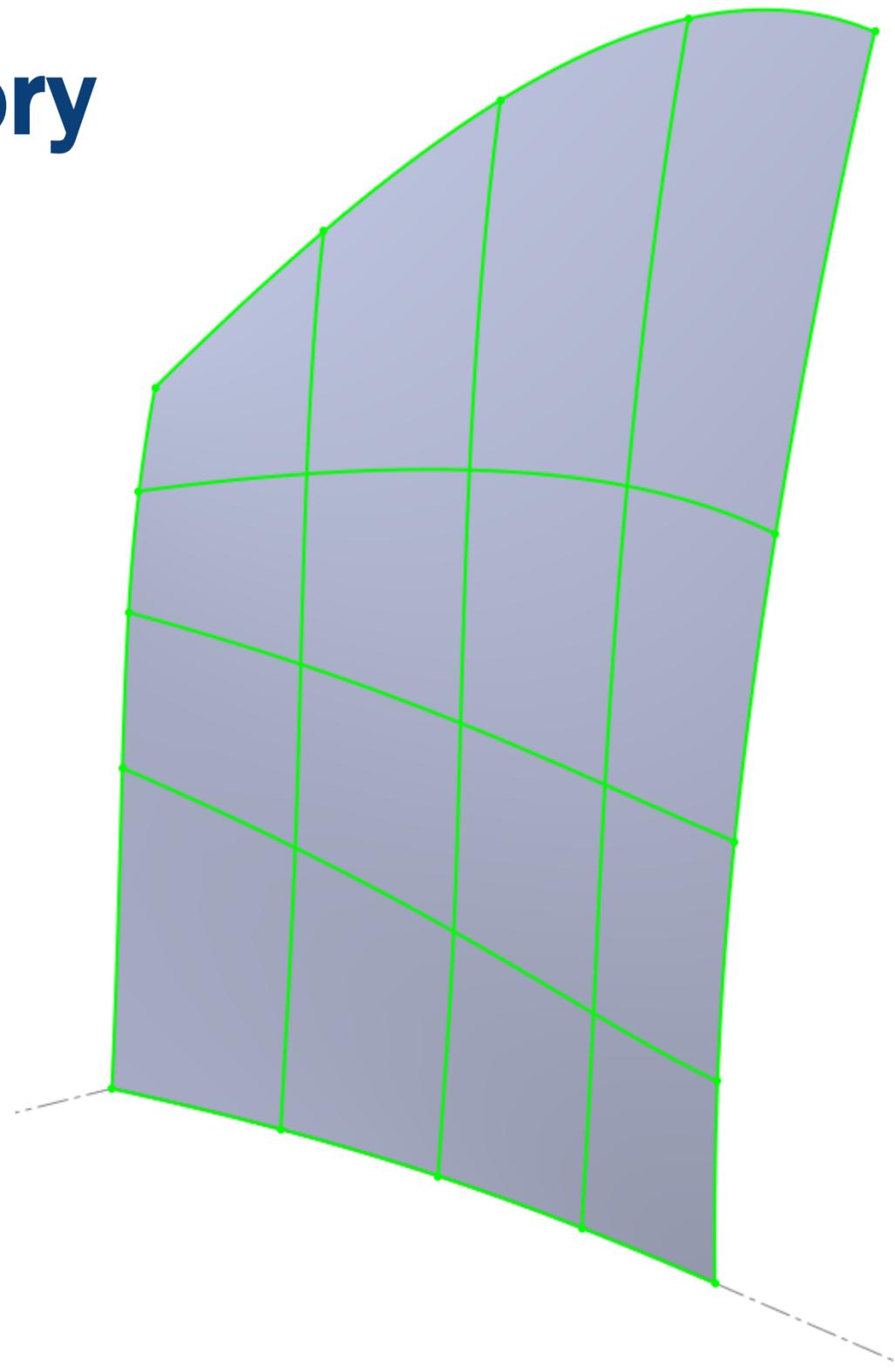
**TIP:** Enable the Trim by Direction option to build the curve only through the profiles in Direction 2, and not continuing the full length of Direction 1.

**TIP:** Increase the tangent influence slider to give more preference to the shape of set of profiles. It can be used to tame errant curvature combs.



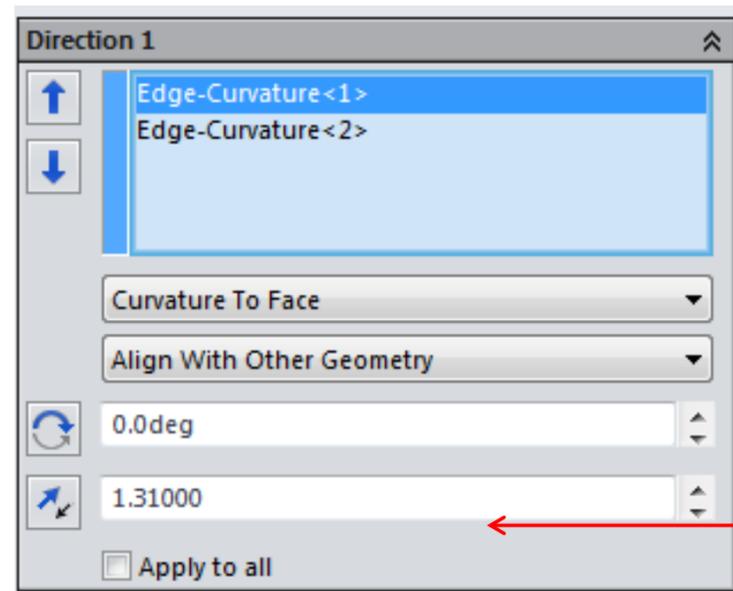
# Surface Layout Theory

By splitting the surface up, the UV curves (the underlying math of the surface) can better be controlled. Ideally, the UV curves should match the natural flow of the surface.



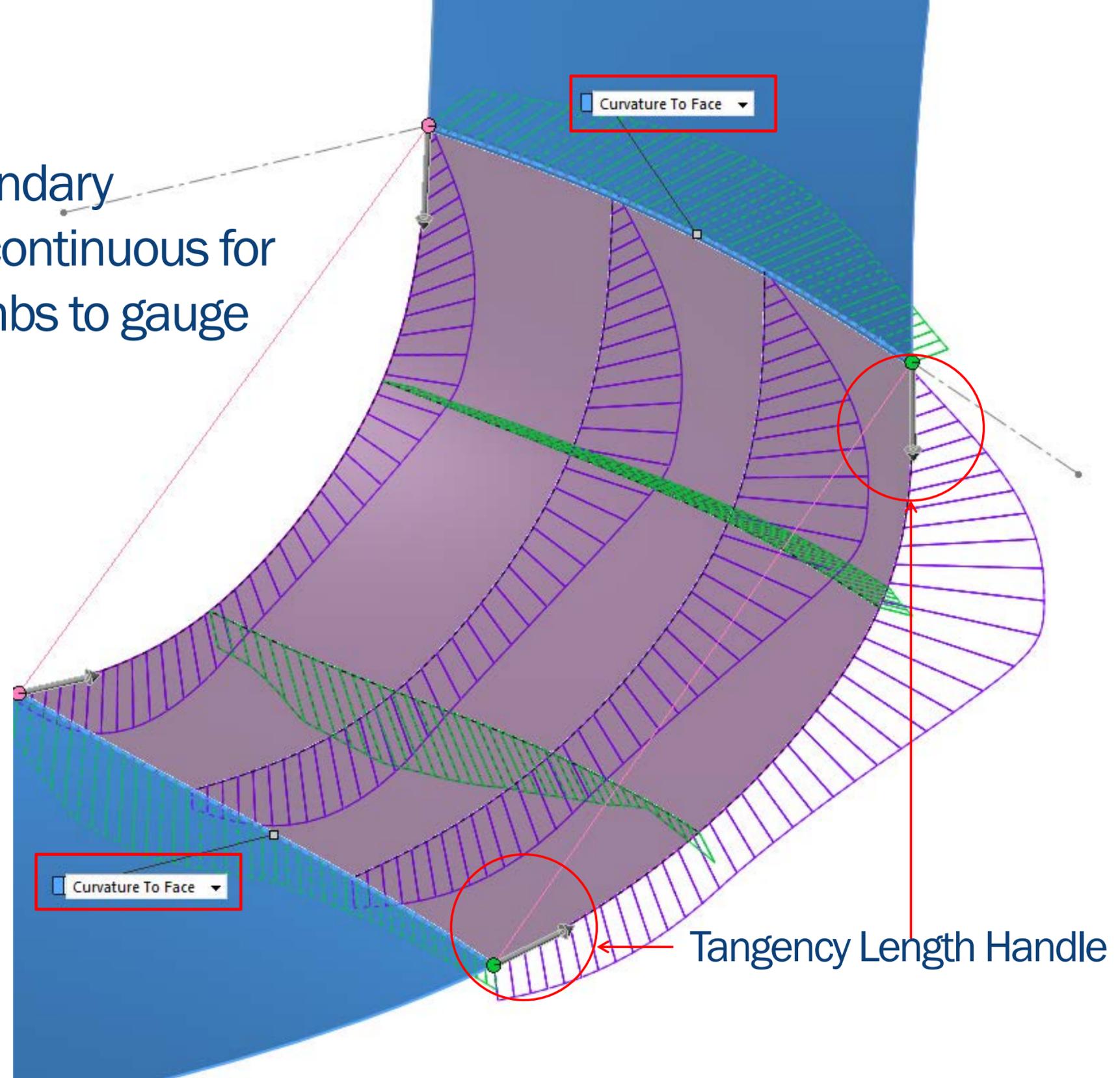
# Blend Surfaces

Connect Primary Surfaces together with Boundary Surfaces. Connections are made curvature continuous for a smooth connection. Use the curvature combs to gauge the quality of the blend.



Tangency Length

**TIP:** Shape the blend surface by manipulating the tangency length. The handles can also be directly manipulated in the graphics window.

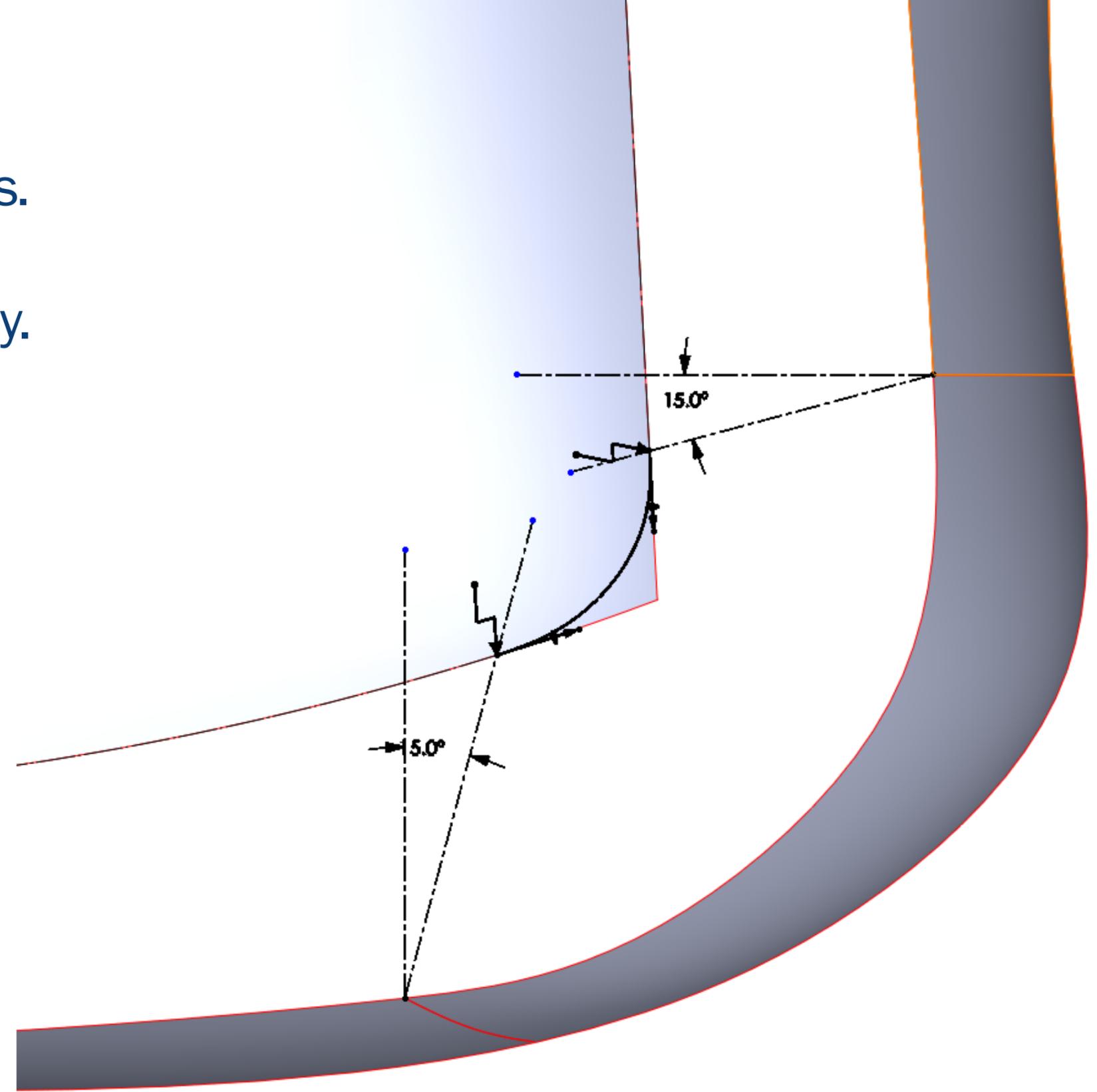


Tangency Length Handle

# Trim as Required

Boundary Surfaces should always have 4 sides. To create the corner blend surface, trim the sharp of the edge of the seat side surface away. Add construction lines to connect the trim spline to the existing model edges.

**TIP:** The trim spline should be smaller than the edge it is being blended with. Angles can quickly alter the size of the spline to dial in the exact trim shape.



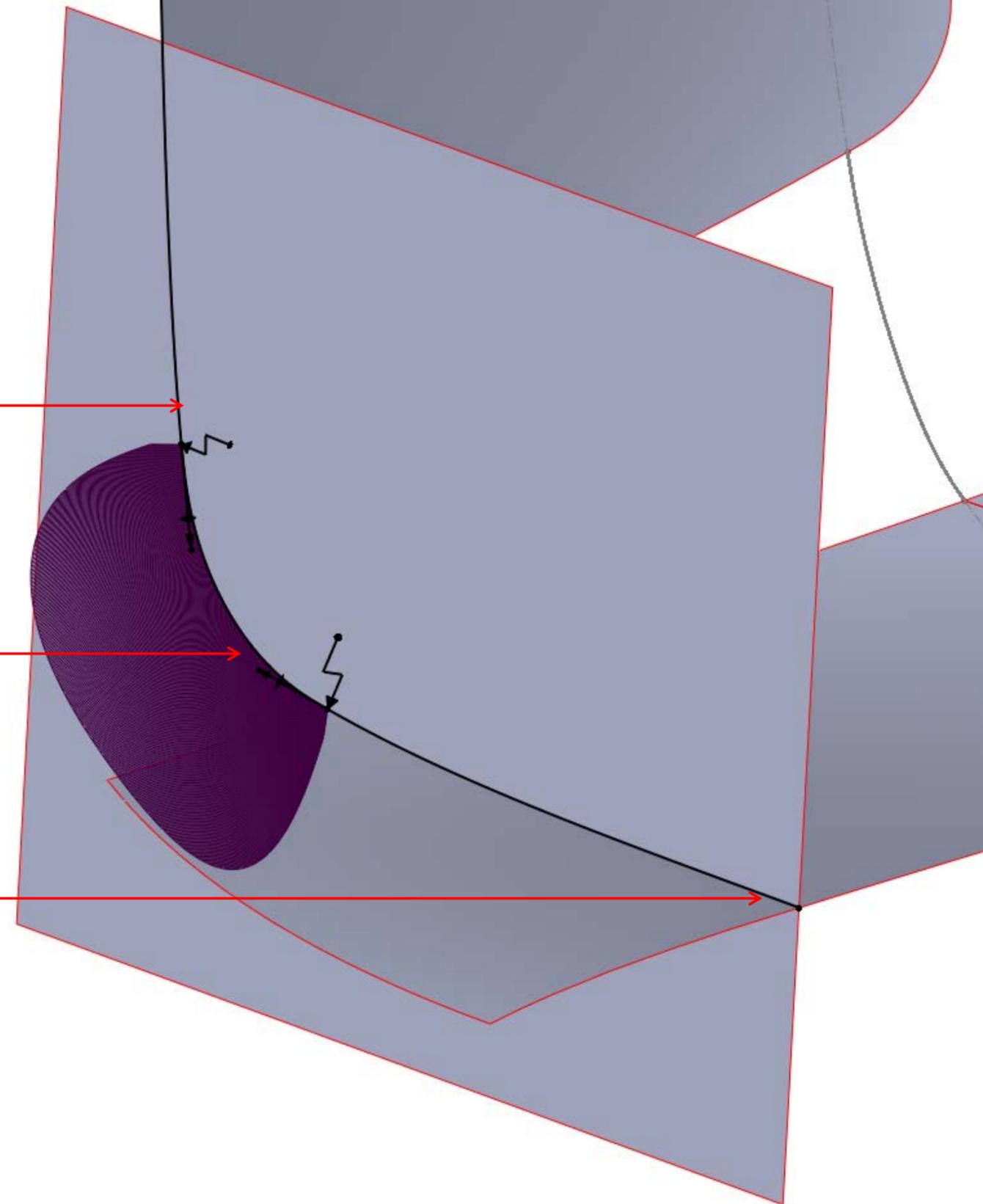
# Create Blend Profiles

For more exact control of Blend Surfaces, create additional profiles on sketch planes.

**TIP:** Do not connect splines to model edges. Convert the edge into the sketch and then connect with the equal curvature relation.

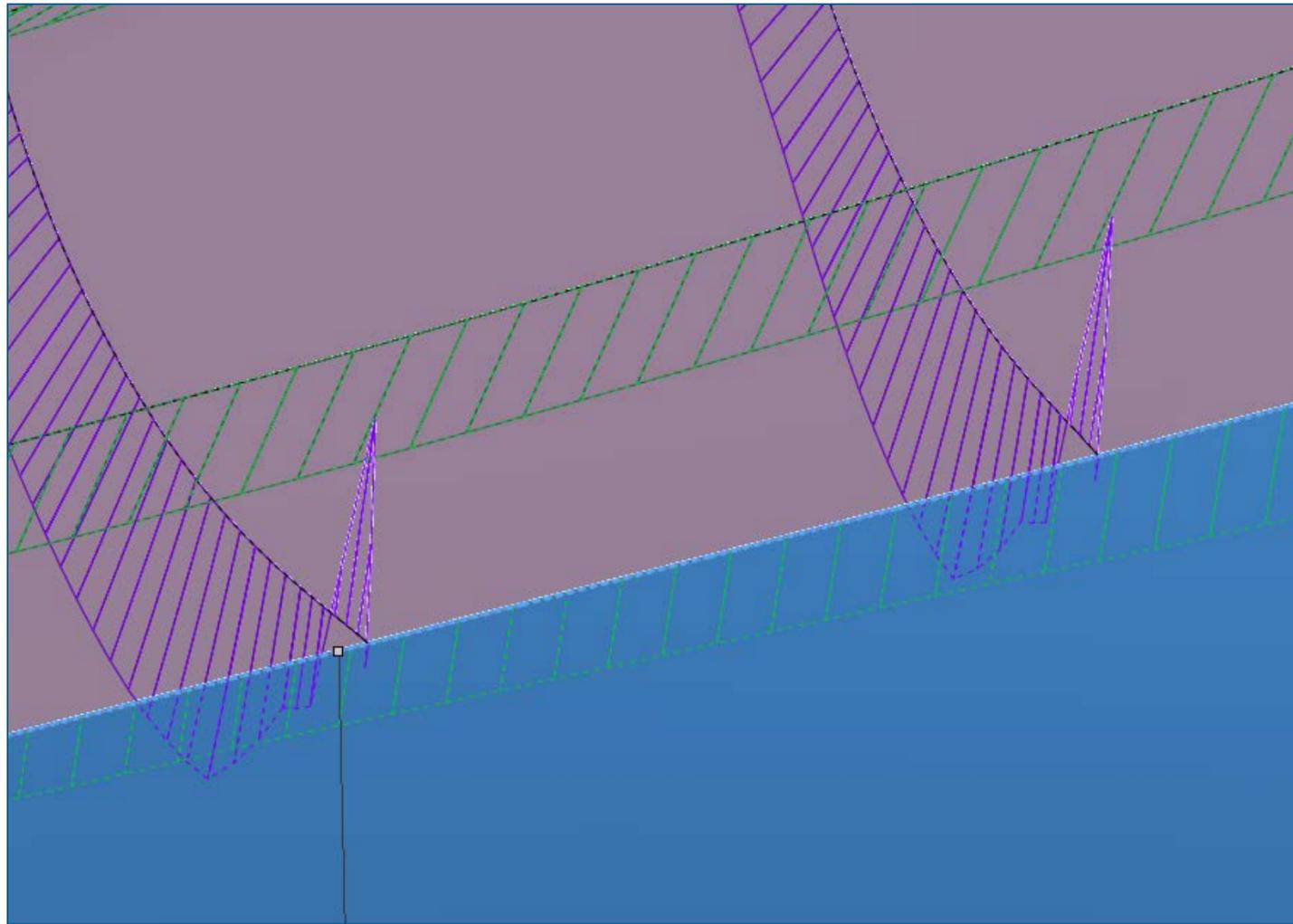
**TIP:** Adjust spline handles and evaluate the changes with the curvature combs. Try for the smoothest possible shape that matches the scan as closely as possible.

**TIP:** Add intersection curves to add the equal curvature relation where there is no model edge.

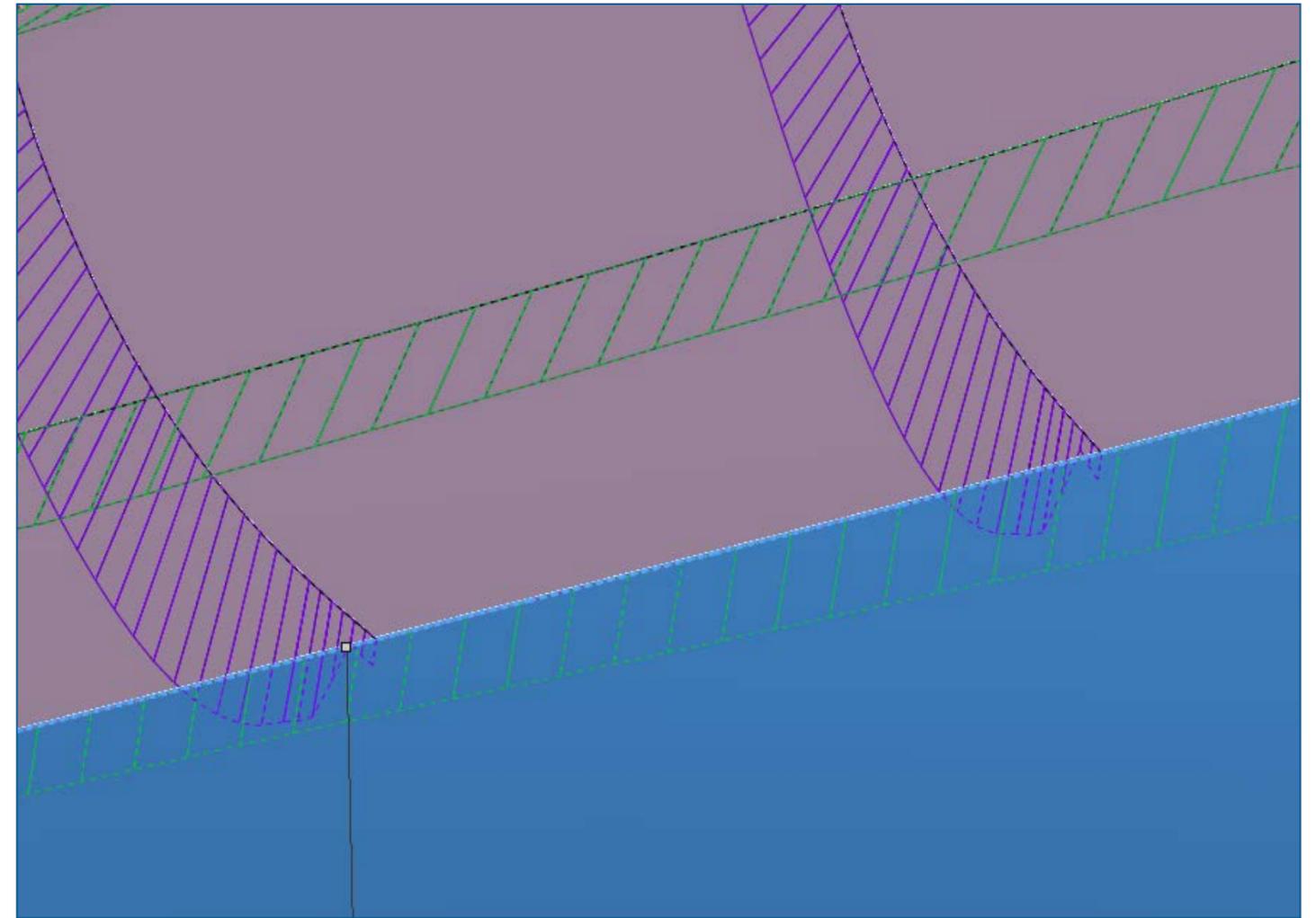


# Tangent Influence

When there are profiles in both directions, use the tangent influence slider to give more preference to the shape of the Primary Surfaces. This can correct curvature spikes.



0% Tangent Influence

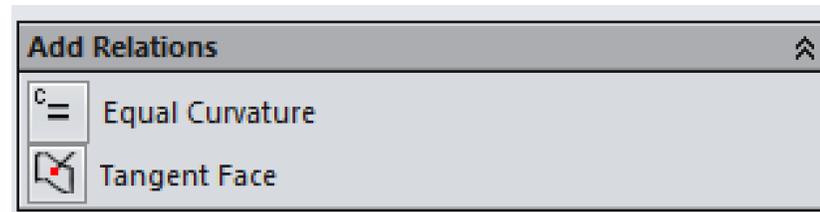


100% Tangent Influence

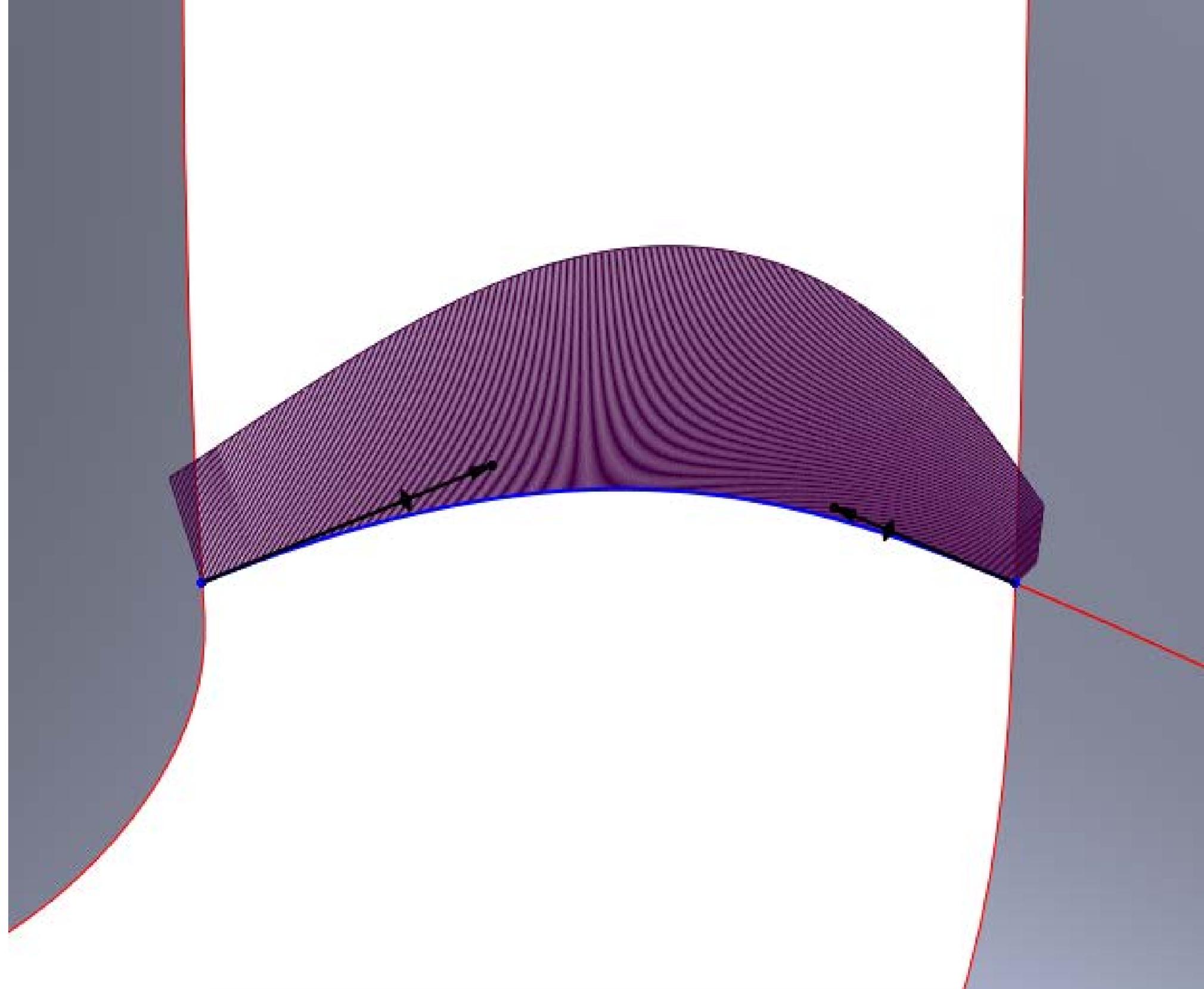
# 3D Sketches

Blend profiles can also be created with 3D sketches.

**TIP:** Add an equal curvature relation to a 3D sketch by using the Equal Curvature Face relation.

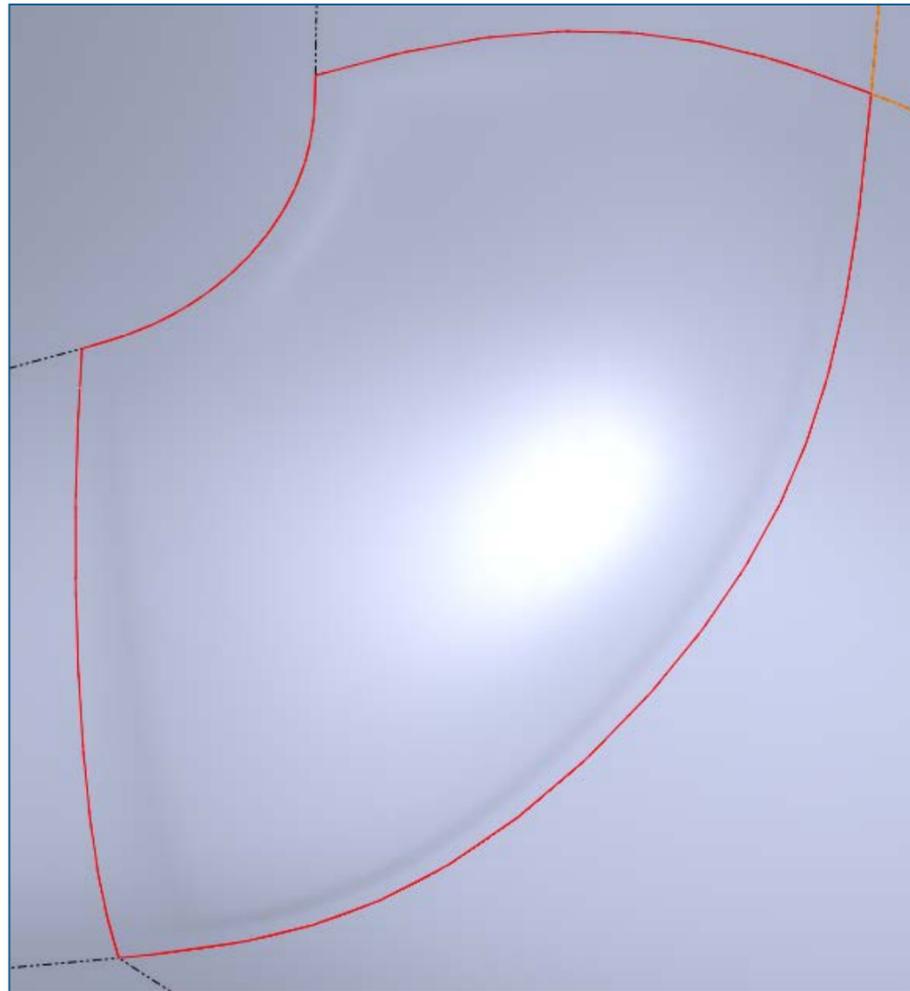


Select the sketch entity, model edge and face.

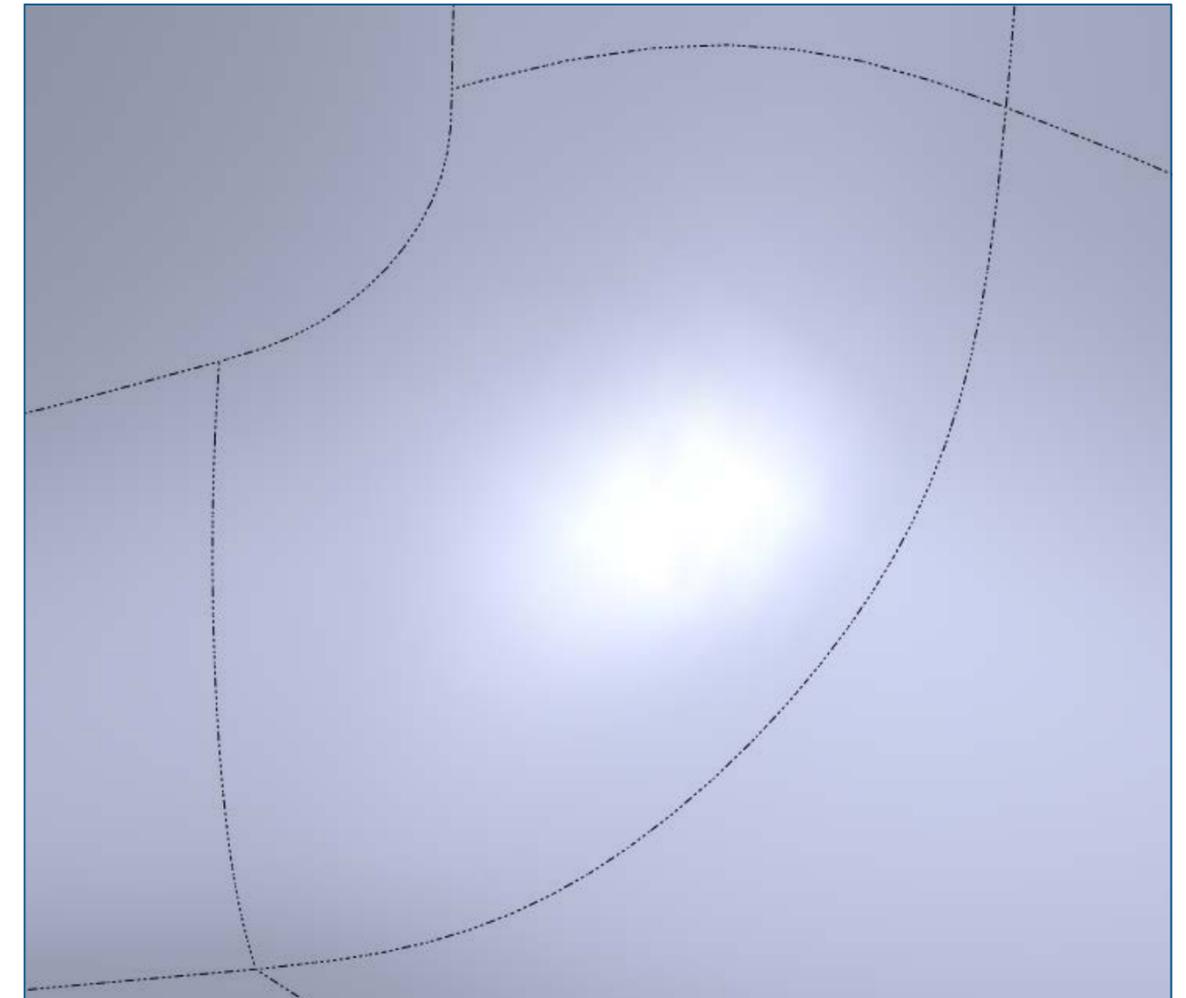
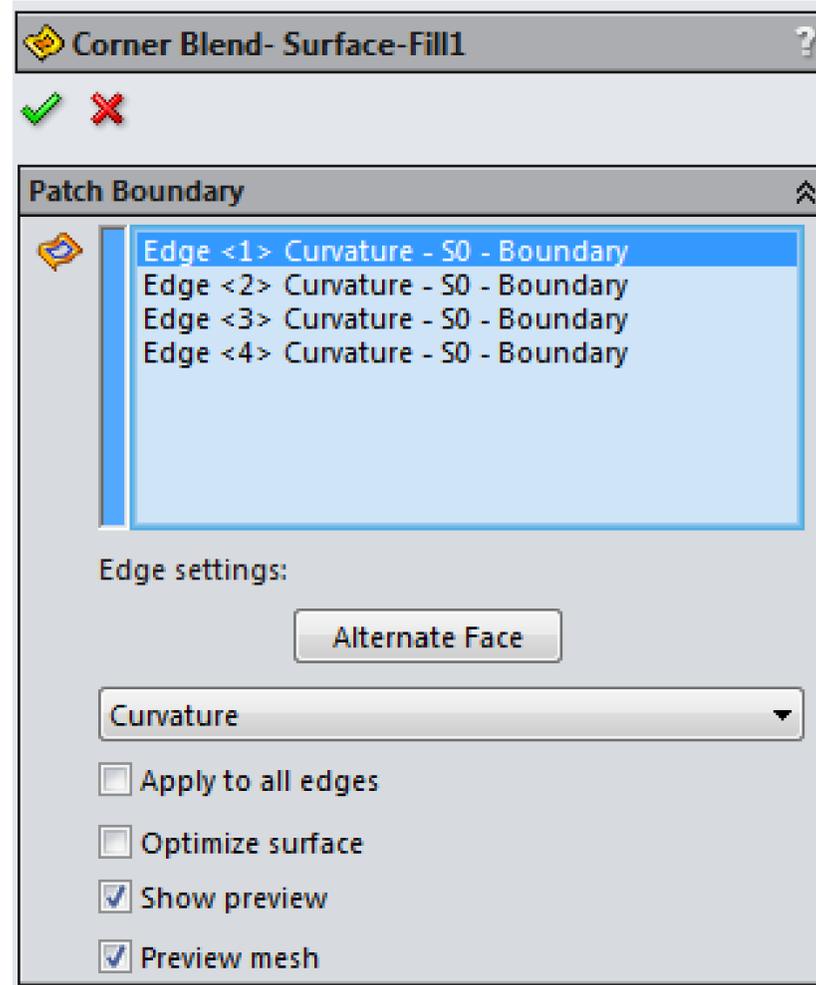


# Complete Corner Blends

Occasionally, Boundary Surface produces a surface with ripples, creases or kinks that cannot be ironed out (or made worse) by using the tangency influence slider. Try Surface Fill Instead.



Boundary Surface



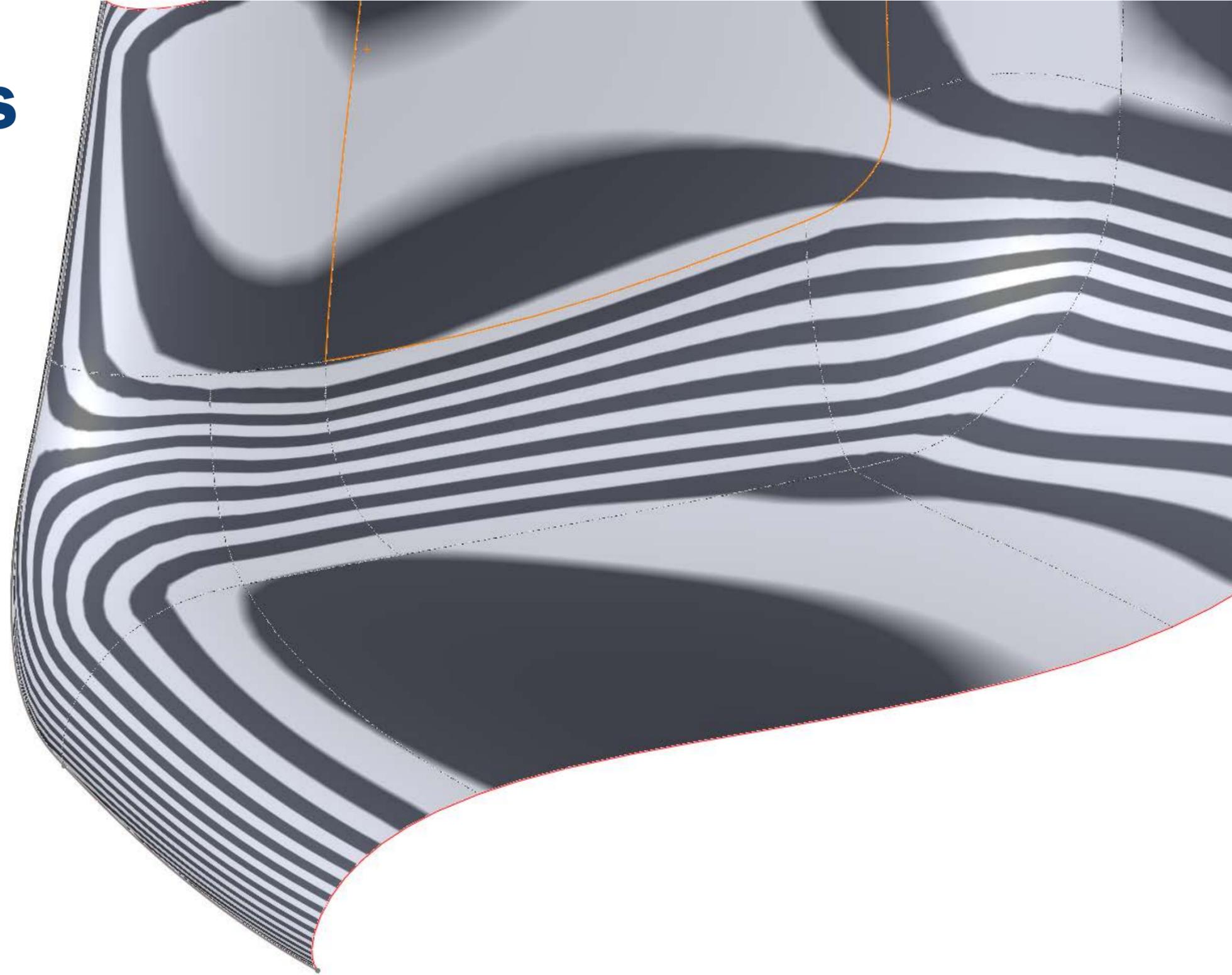
Surface Fill

# Evaluating Connections

## Zebra Stripes

Evaluate the flow of light over the various surfaces with Zebra Stripes.

There should be no break in the zebra stripe over a surface edge. The connection should be perfectly smooth. A hard edge indicates dissimilar radii at the junction.

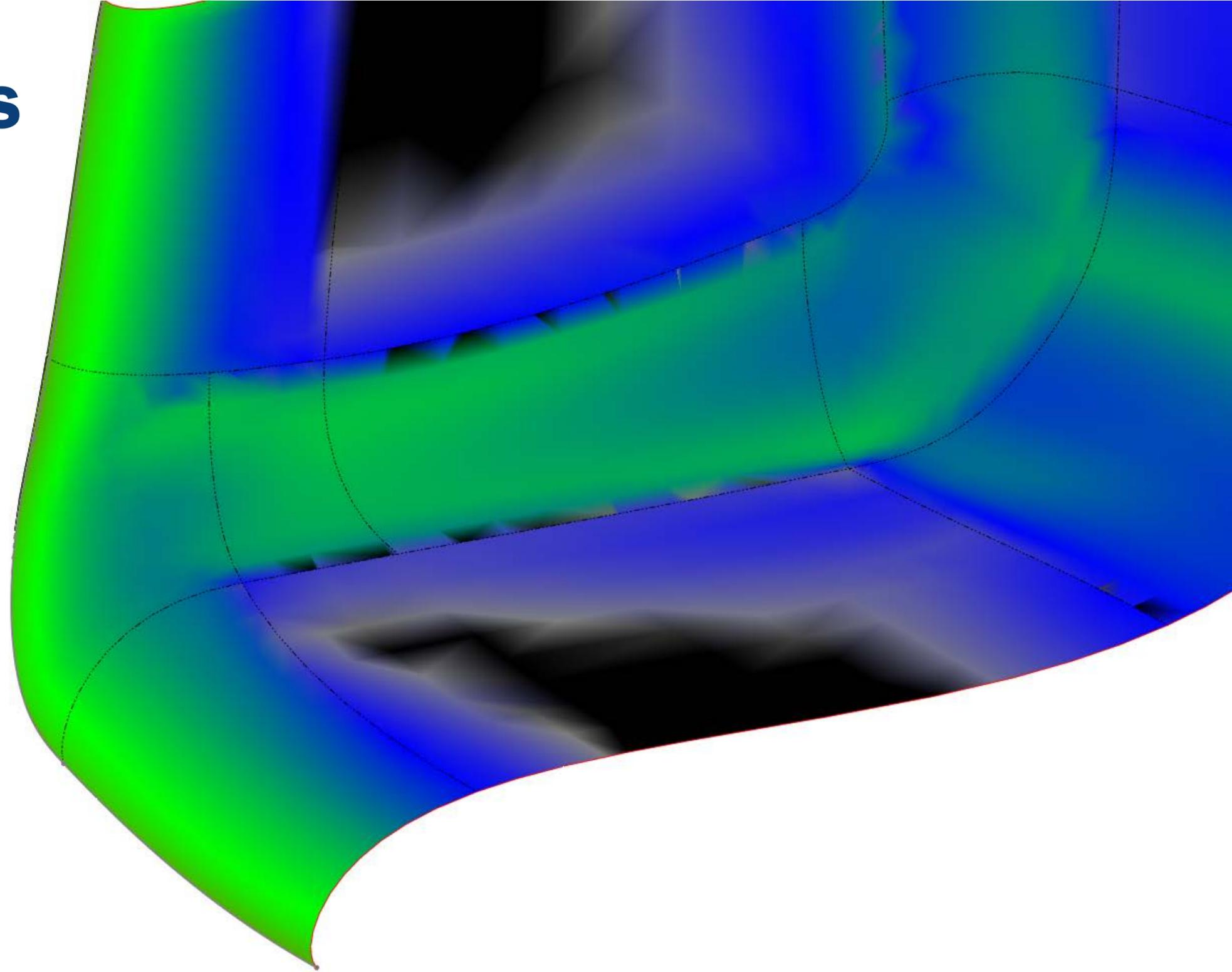


# Evaluating Connections

## Curvature Display

Evaluate the flow change of curvature with curvature display.

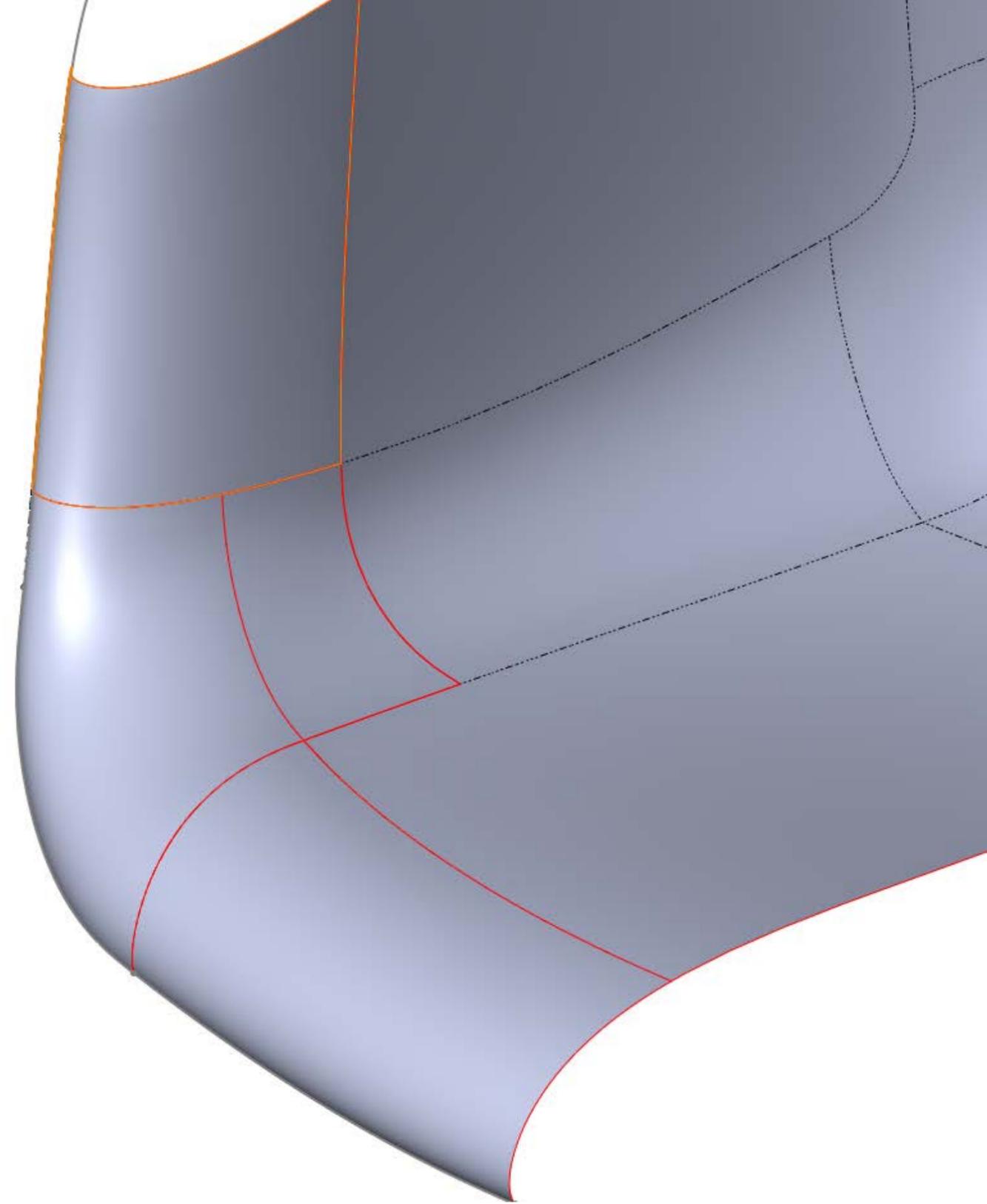
A gradual gradient indicates smooth change in curvature. A sharp color break between two surfaces indicates two different radii at the junction.



# Build Transition Surfaces

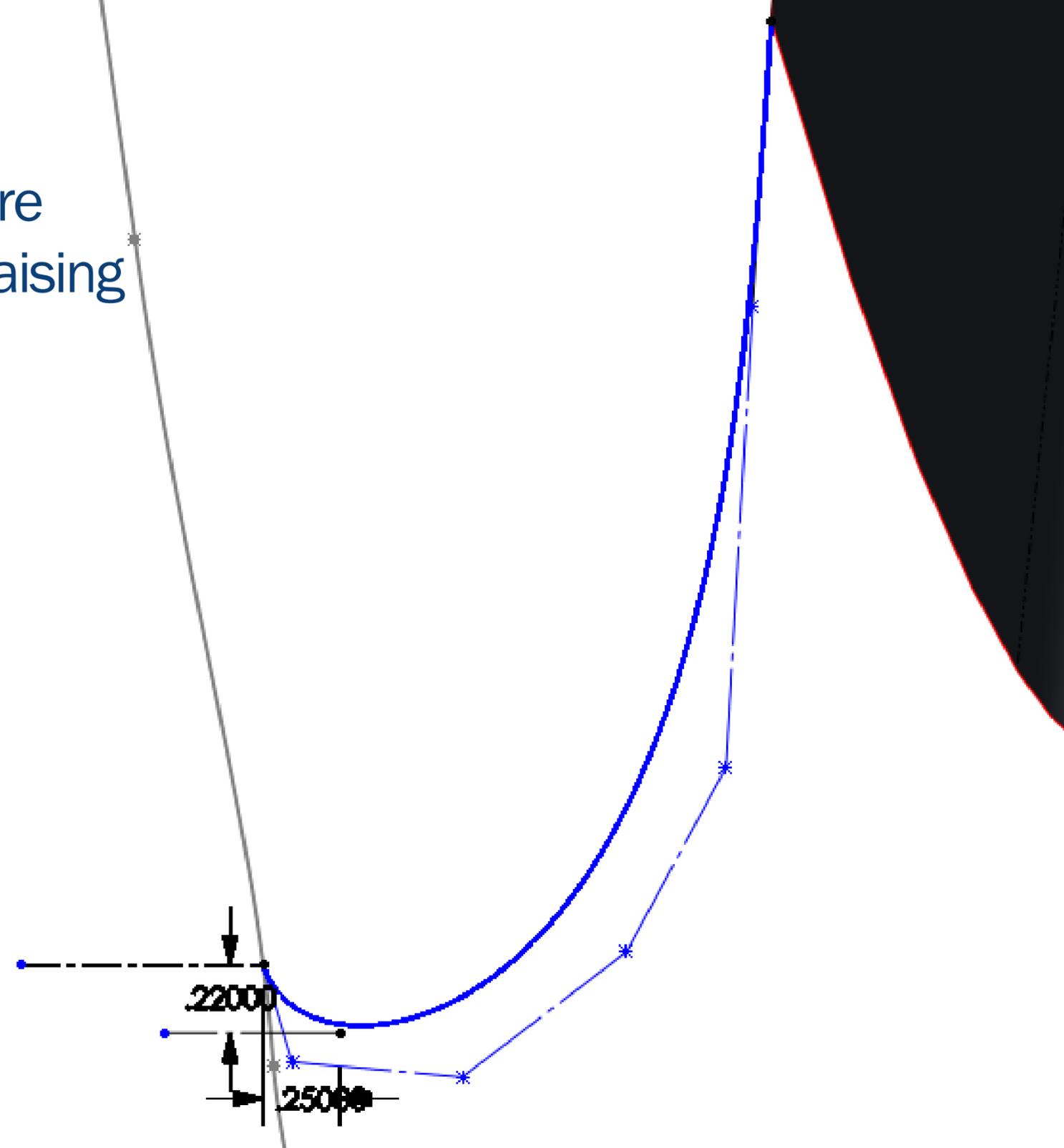
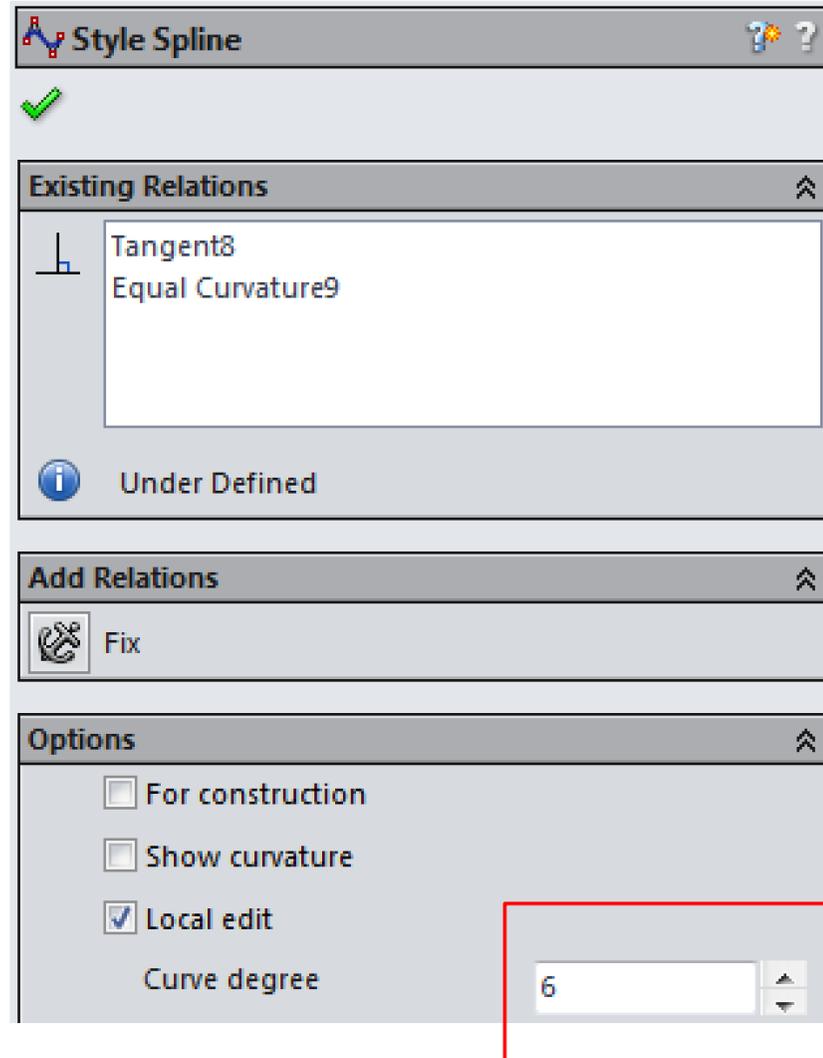
Continue to define the shape by creating section surfaces and sketching profiles on them. Create Boundary Surfaces between the existing model edges and the perimeter 3D sketch.

**TIP:** Convert segments of the perimeter 3D sketch. This allows the perimeter 3D sketch to stay at the top of the Feature Tree instead of being absorbed into a feature.



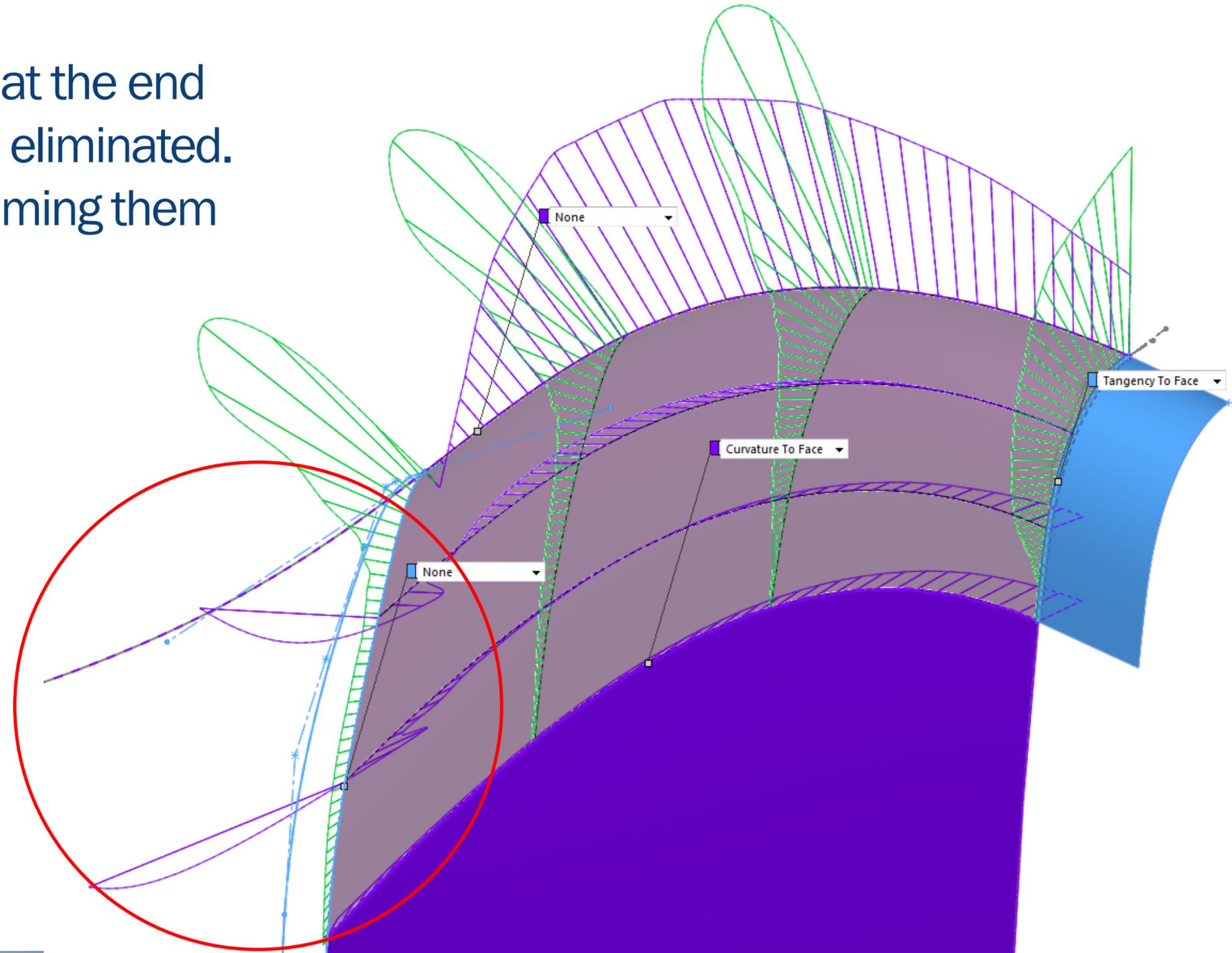
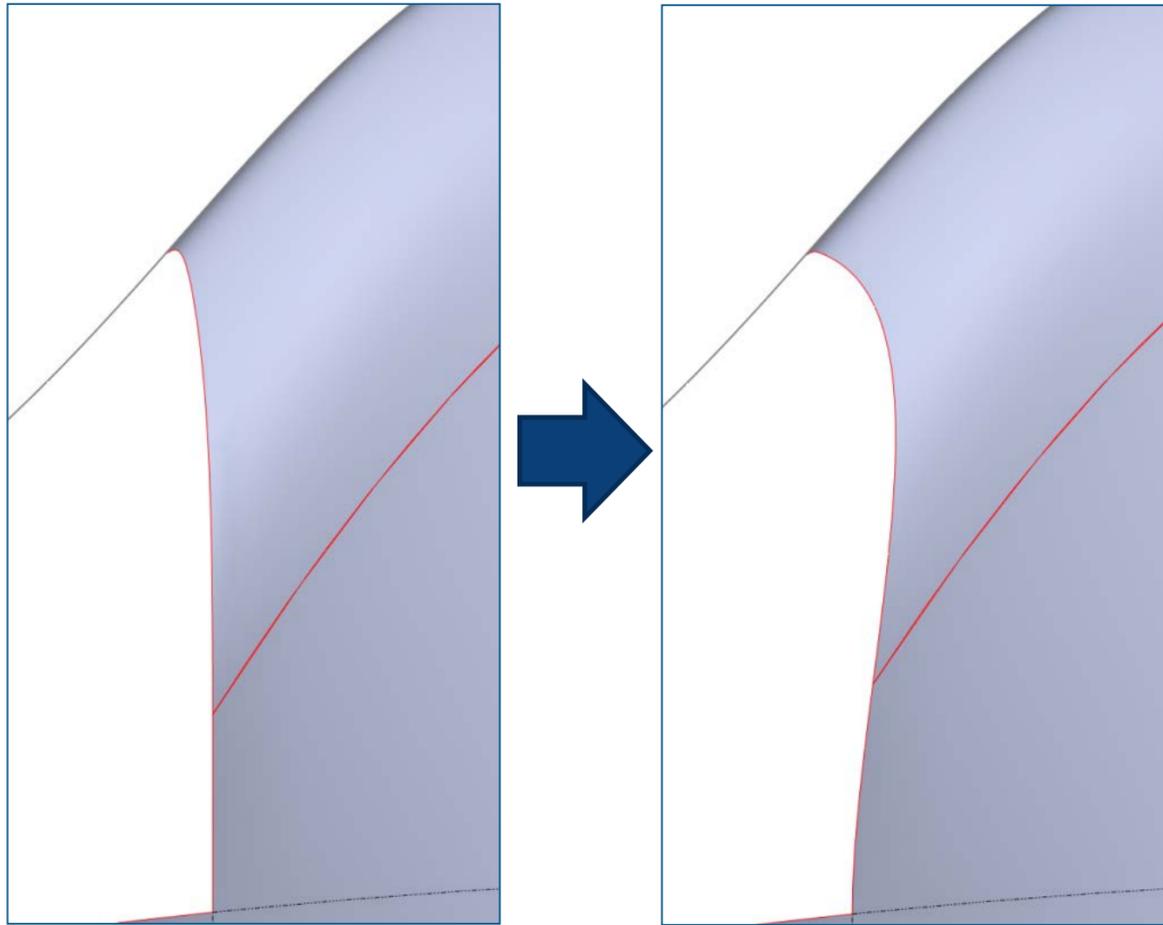
# Style Splines

Use Style Splines when the spline changes shape more than once. Gain additional control over the spline by raising the degree of the spline.



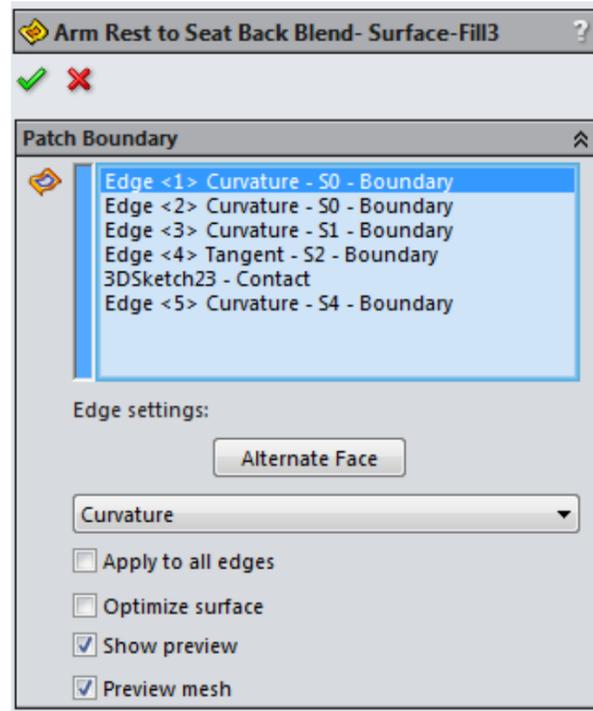
# Curvature Spikes

Sometimes curvature spikes appear at the end of Boundary Surfaces and cannot be eliminated. Remove these problem areas by trimming them from the model.

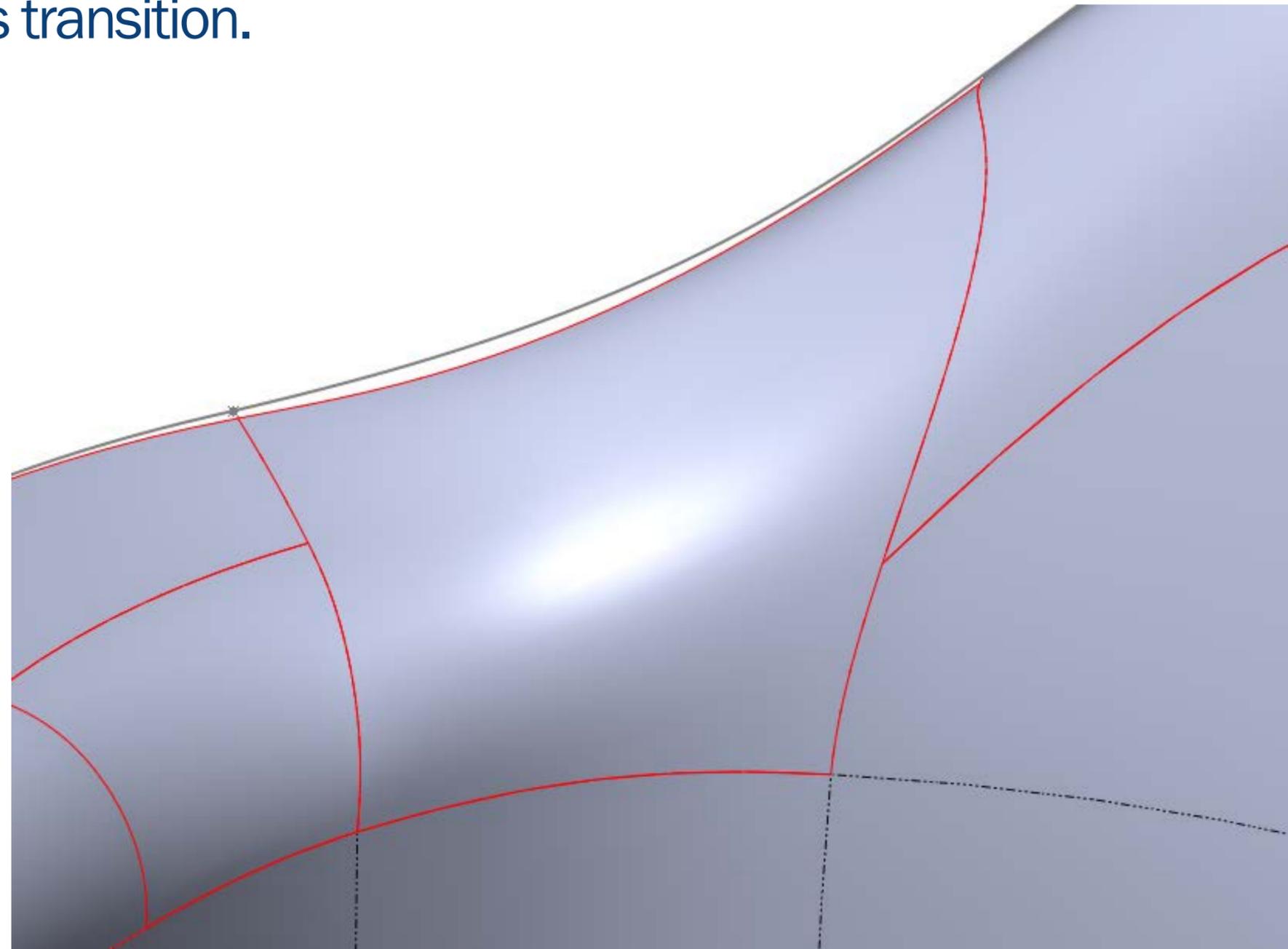


# Challenging Transitions

The connection from the armrest to the seat back has differing shapes smoothly flowing into each other. Surface Fill is best at tackling this transition.

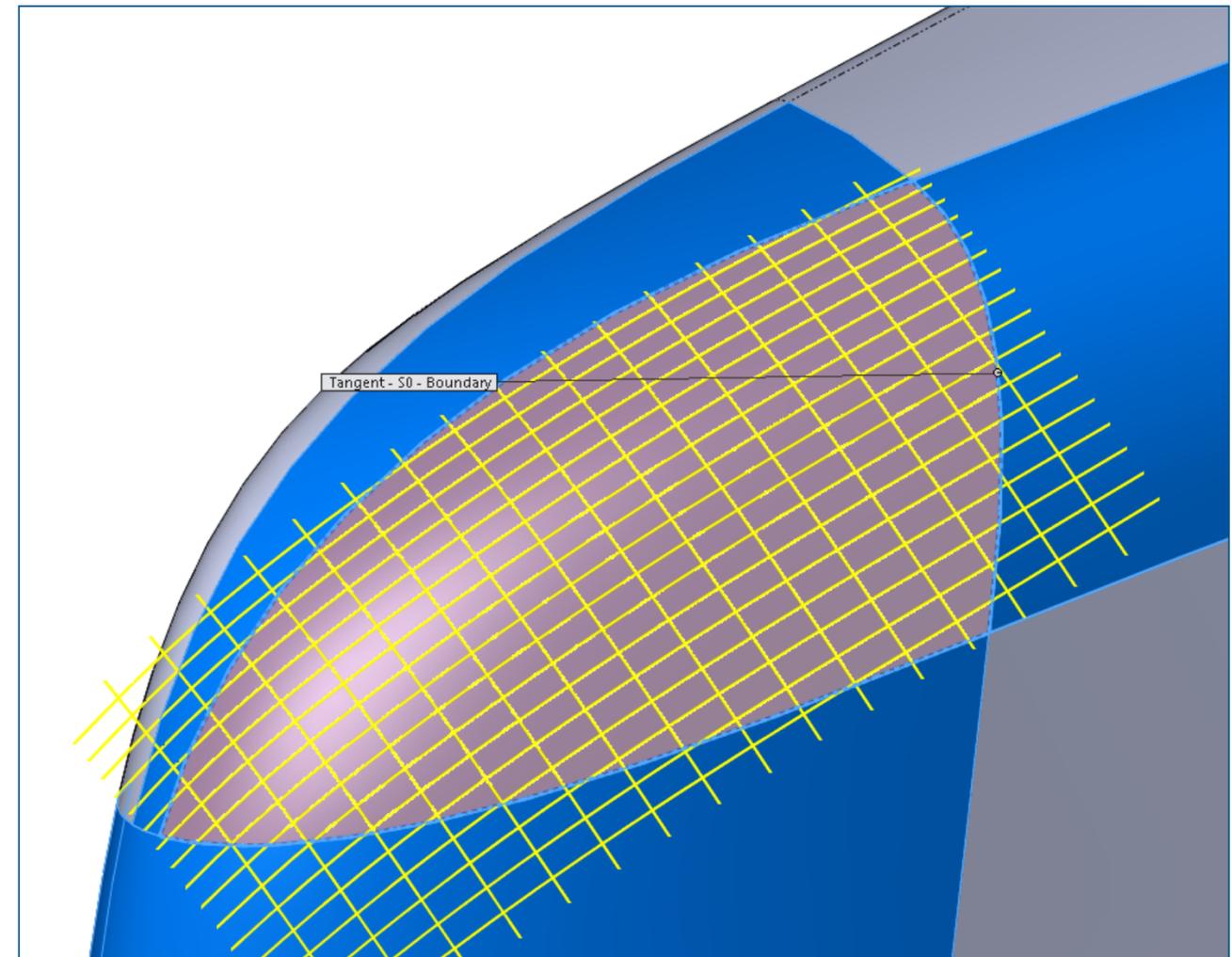
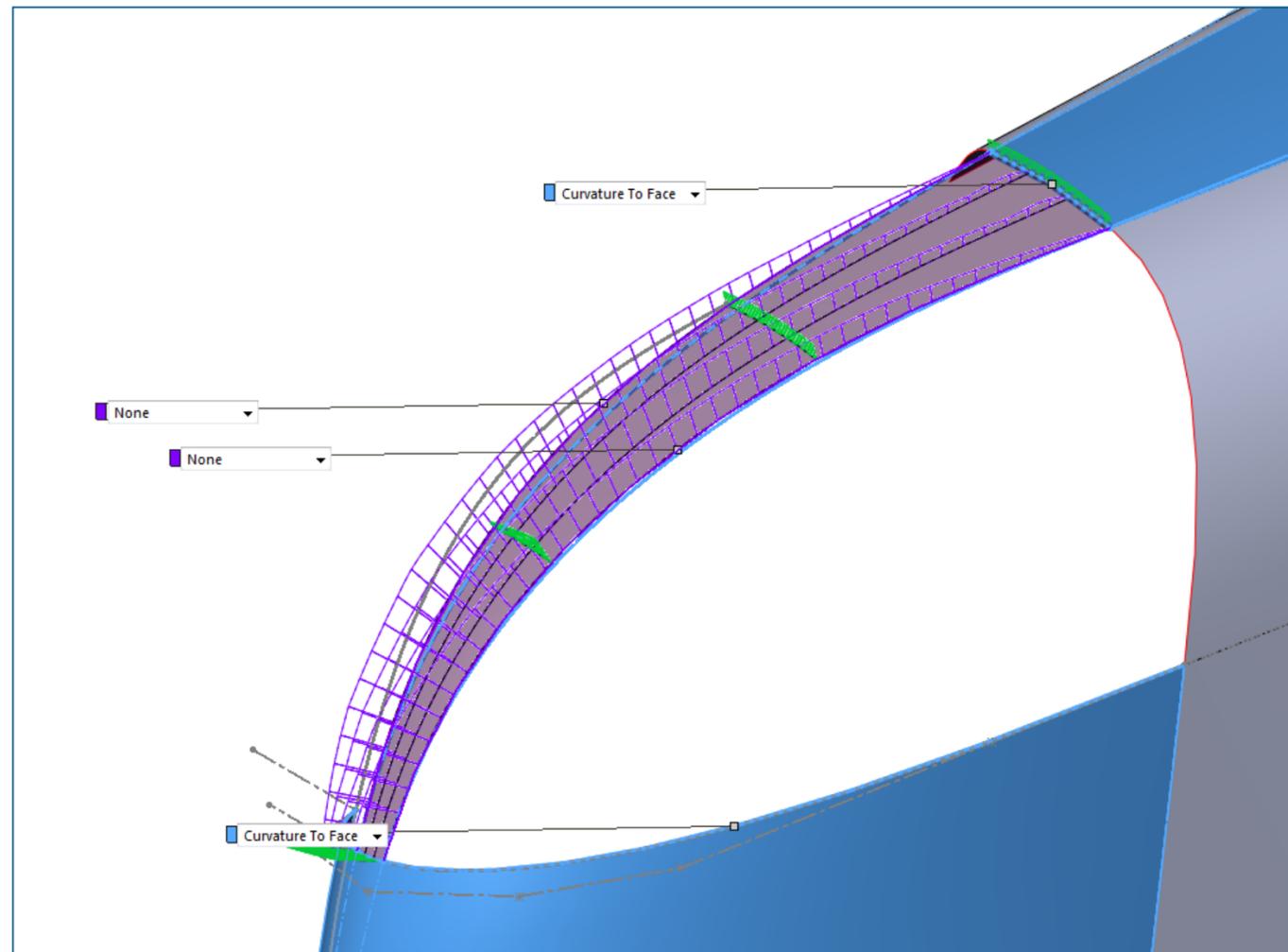


**TIP:** Do not default to curvature on all edges. Start with all edges on tangent and evaluate with zebra stripes and curvature display. Add curvature as required.



# Guide With Boundary Surface

Instead of trying to use Surface Fill on the entire challenging front corner, guide the shape with a Boundary Surface. This will give direction to the Surface Fill that will complete the transition.

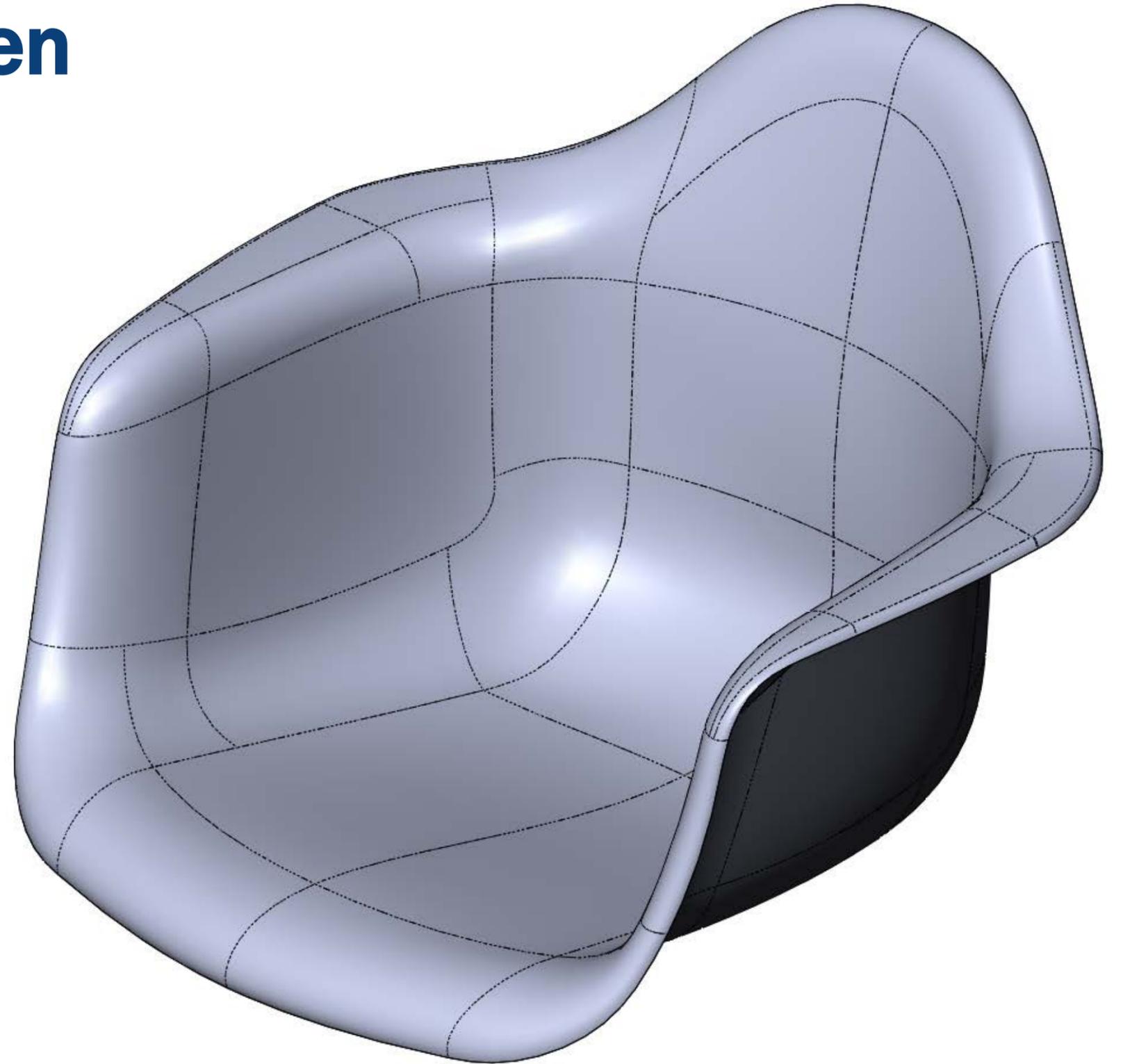


**TIP:** Surface Fill is excellent at patching 3 and 5 sides surfaces. It over builds a four side surface and trims back to fit.

# Convert to Solid With Thicken

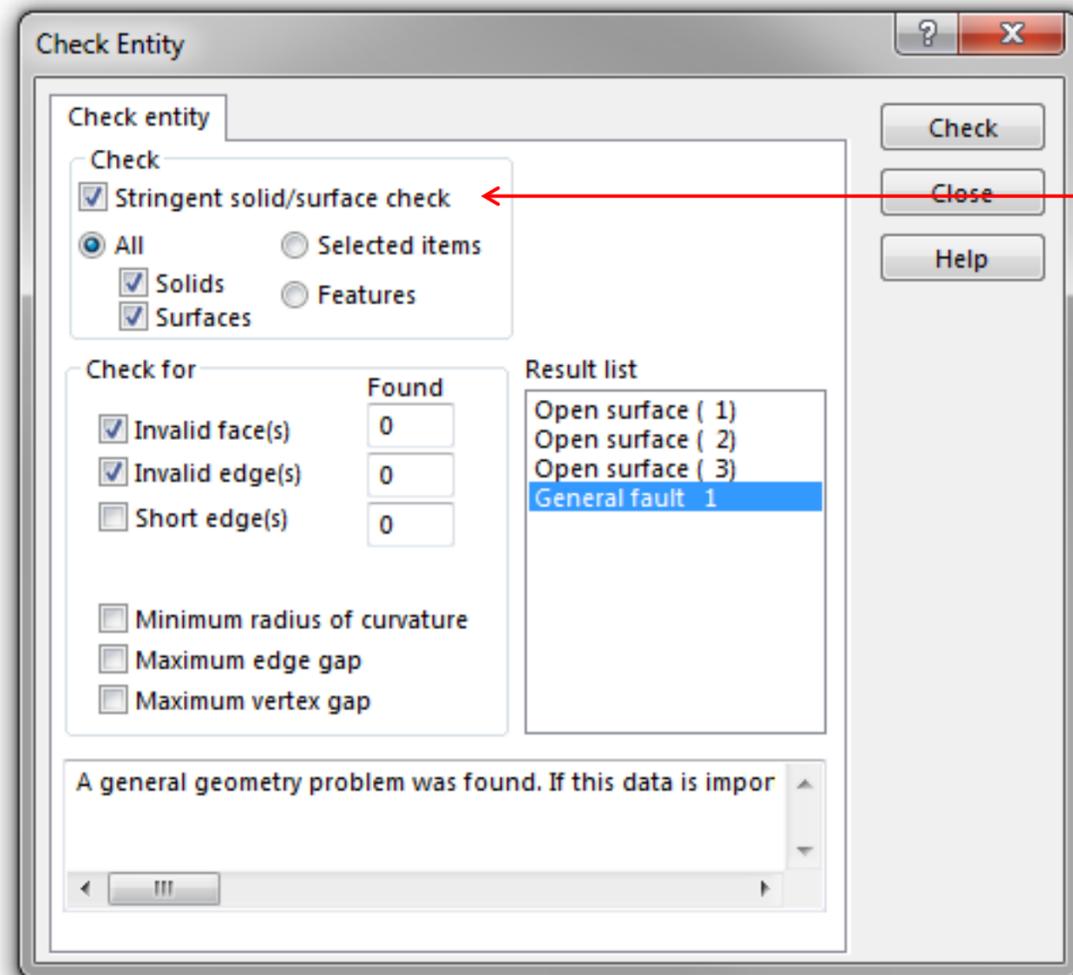
Once the chair surfaces are complete, mirror about the right plane. Use the Thicken feature to convert the surface body into a solid body.

**TIP:** Thicken rarely creates a planar surface on the symmetry plane. Avoid this by mirroring first, thickening and then using Surface Cut with the Right Plane



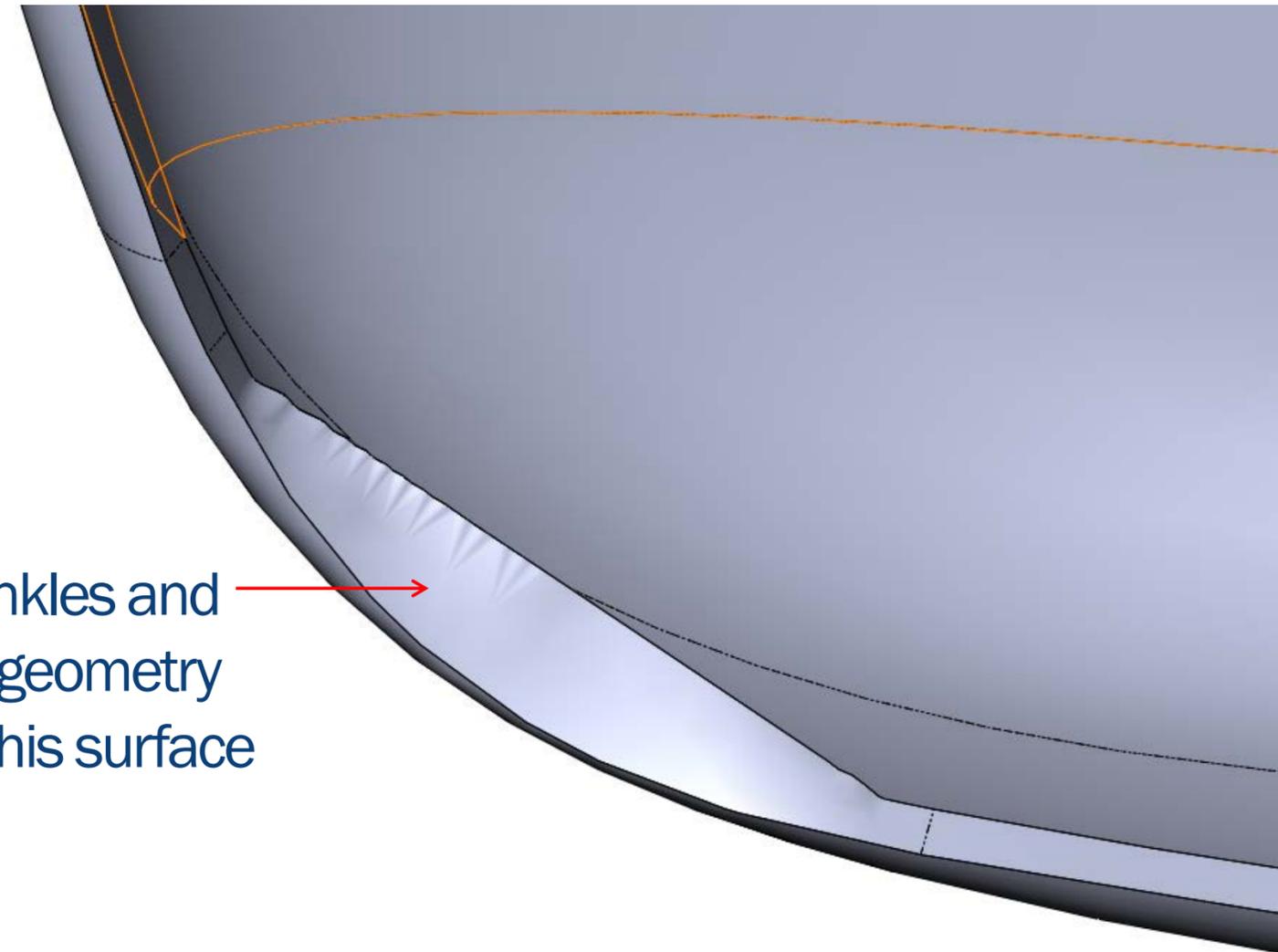
# Geometry Check

A best practice after using Thicken or Shell features is to perform a geometry check. These features can create invalid geometry that can cause down stream features to fail.



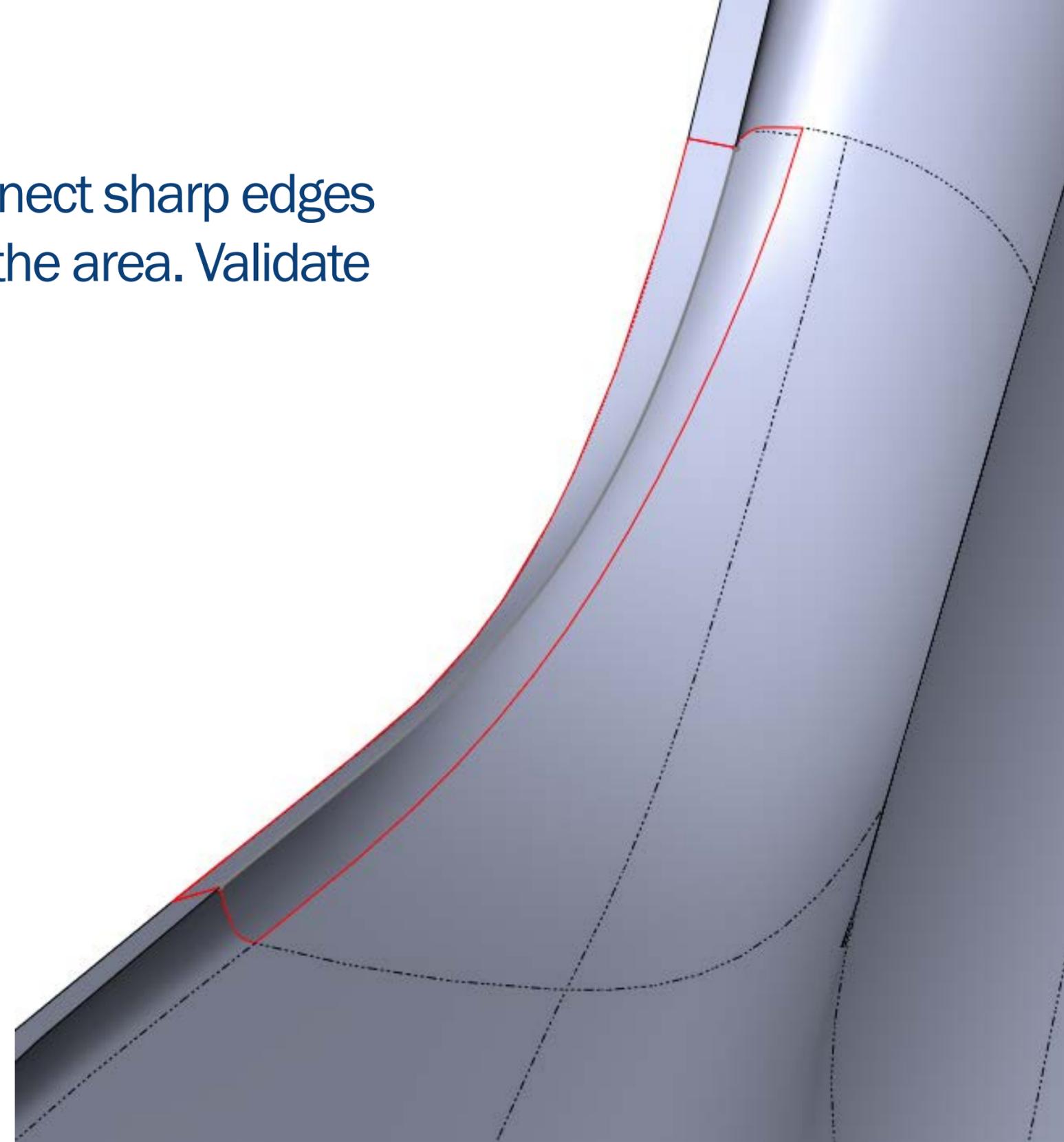
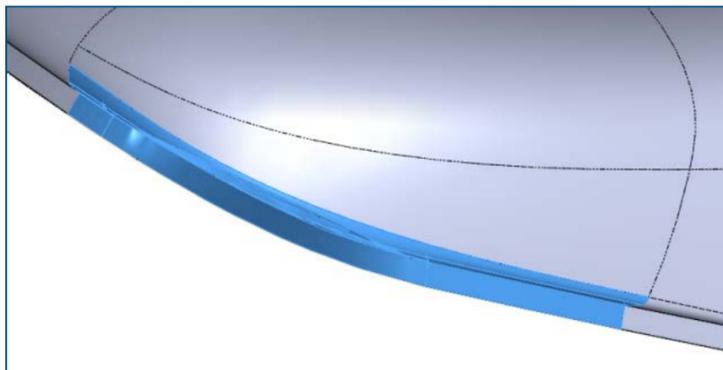
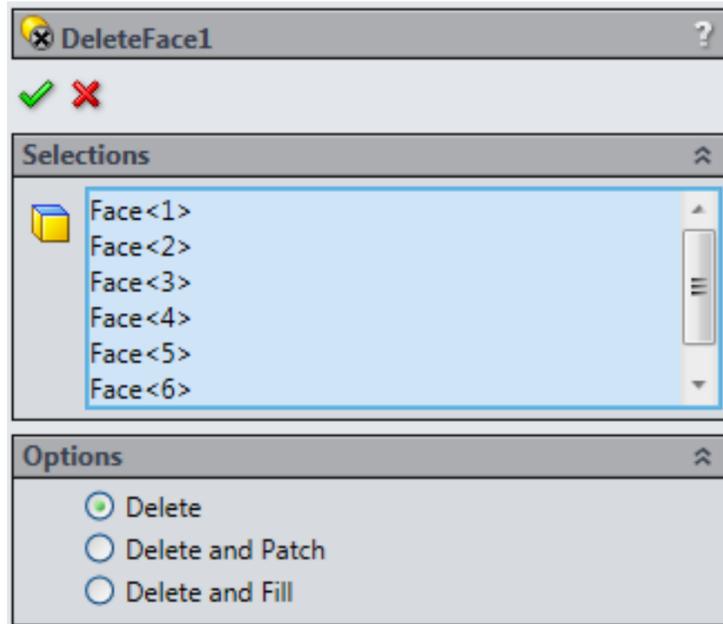
Stringent check avoids the re-use of previous check results.

Faces with squiggles, wrinkles and odd curves may indicate geometry problems. The shape of this surface is also undesirable.



# Geometry Repair

Delete the offending geometry from the model. Connect sharp edges with a 3D sketch spline. Use surface tools to repair the area. Validate geometry with Check.



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