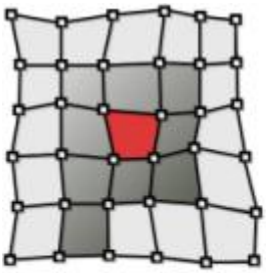


# PanelingTools

*for* Rhinoceros® 5

# Table Of Contents

# Note from the Author

PanelingTools helps designers create paneling solutions from concept to fabrication.

Development of the PanelingTools plug-in for Rhino started in 2008. PanelingTools facilitates conceptual and detailed design of paneling patterns using NURBS and mesh geometry. PanelingTools is closely integrated with the Rhinoceros environment using standard Rhino geometry. PanelingTools also extends RhinoScript, Python for completely customized paneling and Grasshopper for parametric modeling.

I hope using PanelingTools will be a fun and useful experience. I am always happy to hear from you and learn how you are using PanelingTools and how to improve it. If you have any questions or suggestions to further its development, feel free to contact me.

Rajaa Issa
Robert McNeel & Associates
Rhinoceros Development team
rajaa@mcneel.com

## Technical Support

Suggestions, bug reports, and comments are very much encouraged. Please share your stories, examples, and experiences with us. Post questions to our discussion forum http://v5.rhino3D.com/group/panelingtools/forum or e-mail us directly.

Visit http://www.rhino3D.com/support.htm for more details, or feel free to contact the developer, Rajaa Issa.

# Getting Started with PanelingTools

PanelingTools is under active development. New functionality is added frequently, and like any other McNeel product, your feedback is very important and continuously shapes and steers the development.

## Download and Install

To download PanelingTools for Rhino and Grasshopper, go to http://v5.rhino3D.com/group/panelingtools, and click on the **Download** button. All PanelingTools instructions, documentation, and discussions are available there.

## The Main Menu

When you install PanelingTools, a new **PanelingTools** menu item is added to the Rhino menu bar. You can access all of the PanelingTools commands from there.

## Toolbars

In addition to the menu, a set of toolbars is installed.

### To load the PanelingTools toolbars

1. From the **Tools** menu, click **Toolbar Layout**.
2. Under **Files**, click **PanelingTools**, and in the **Toolbars** list check **PanelingTools**.

## Overview of Paneling Elements

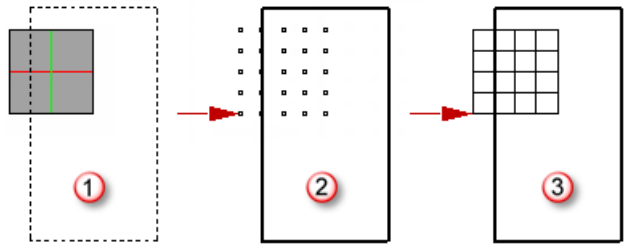
Paneling is typically done in two steps:

1. Create a grid.

   Create a rectangular paneling grid of points grouped together. Creating a paneling grid results in points that can be manipulated with any Rhino command or the PanelingTools grid utility commands.

2. Populate the grid with paneling elements.

   Populate a pattern or modules of curves, surfaces, and polysurfaces. Generating the paneling creates patterns and applies the patterns to a valid paneling grid of points. The resulting paneling is standard Rhino geometry in the form of curves, surfaces, or meshes. To further process panels (with the **Unroll**, **Offset**, **Pipe**, or **Fin** commands, for example) use paneling utility functions and other Rhino commands.



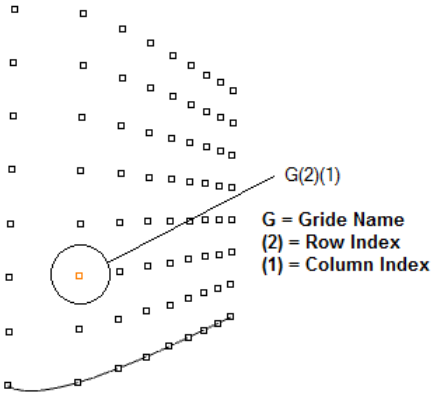

*Optional reference geometry (1), generate a grid of points (2), generate paneling (3).*

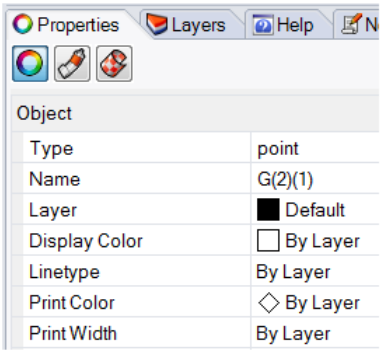
The two-step process gives more flexibility and better control over the result. Normally, the initial grid is generated interactively and is a good indicator of scale. The grid can be generated using the many grid-generating commands or with scripting. The grid can be directly edited and refined before any paneling is applied. Panels can be created using built-in patterns or user-defined free-form patterns.

## Create Paneling Grids

A paneling grid is simply an array of Rhino point objects grouped together. Each paneling point is assigned a name consisting of its row and column location in the grid.

For example:




Points have name tags S0(0)(0), S0(0)(1), .... These names are object properties. The naming convention is as follows:

S0 = paneling grid name

(first number) = row location

(second number) = column location

Since the names can be edited directly using the Rhino **Properties** command, points that are valid input for paneling can also be created using the Rhino **Points** command, and names can be assigned to reflect their locations with the **Properties** command. PanelingTools grid creation commands do the naming automatically.

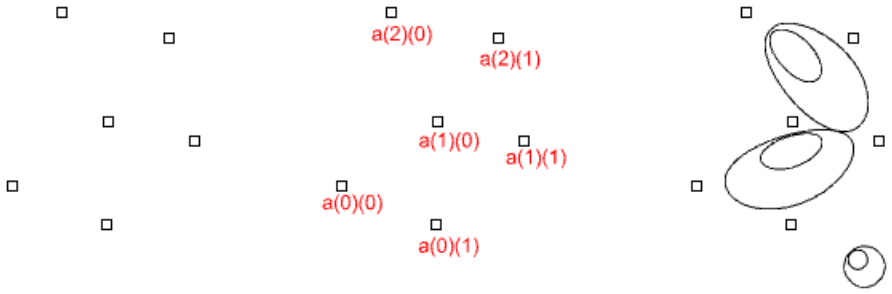
The next sections demonstrate how a grid may be created.

## Create a Grid with Point Objects

You can create points using Rhino **Points** command and then manually assign names to these points using Rhino object **Properties**. These points make a valid grid that can be paneled.

In the following example:

1. Create points using the Rhino **Points** command.
2. Apply name to each point.
3. Use one of the PanelingTools commands to populate the custom module.



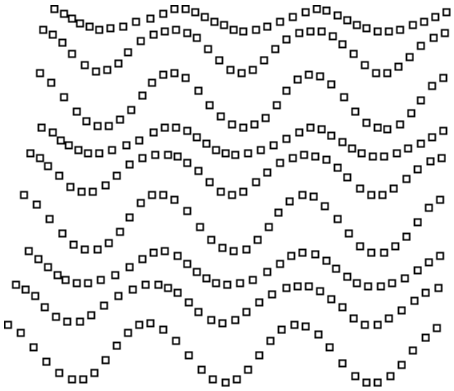

## Create a Grid with a Script

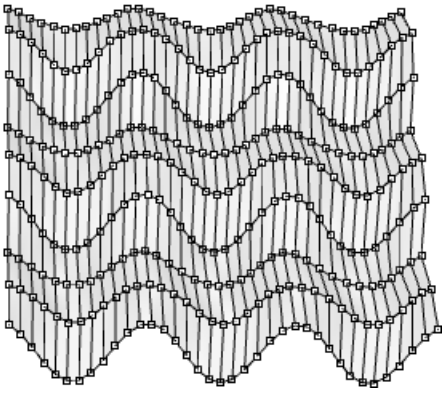
A paneling grid can be generated using RhinoScript, Python, or any other scripting language supported by Rhino. The following script creates a custom point grid by adding each point in a certain location and assigning names.

```
Sub Main()
  Dim i, j, strPt, strName
  Dim x, y, z
  Dim doubleA, doubleB, doubleStep
  doubleA = 2
  doubleB = 20
  doubleStep = 0.5

  For i = 0 To 8 Step 1
    j = 0
    For x = doubleA To doubleB Step doubleStep
      y = (2 * i) + Sin(x)
      z = Sin(y)
      strPt = Rhino.AddPoint(Array(x, y, z))

      If Not IsNull(strPt) Then
        strName = "a(" & i & ")(" & j & ")"
                Call Rhino.ObjectName(strPt, strName)
      End If
      j = j + 1
    Next
  Next
End Sub
```



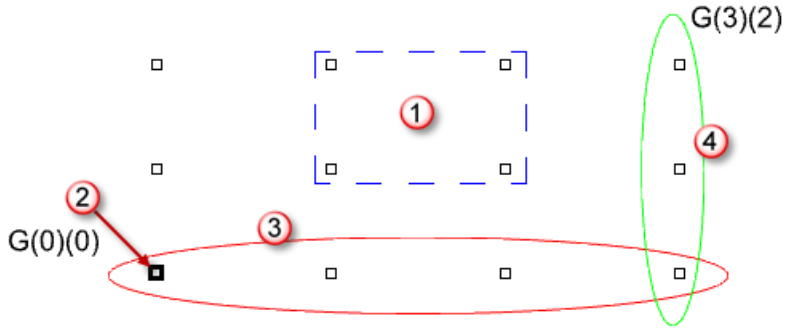


## Create a Grid with Grid Commands

The quickest way to create a valid paneling grid is to use the PanelingTools grid commands. They create all points and attach names to each point that reflects its location in the grid.

For example to create a parallel array of points, here are the steps and result:

1. Start the **ptGridArray** command.
2. Pick a base point, and press **Enter** to accept options.



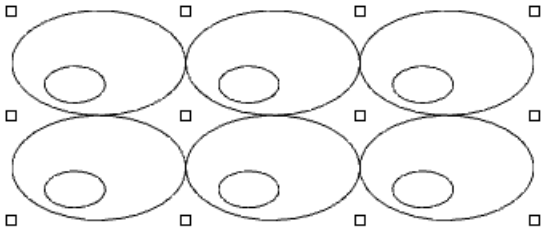

*Unit grid (1) base (2), row (3), column (4).*

The illustration above demonstrates a few concepts about the basic rectangular PanelingTools grid. Those are:

- A unit grid consists of the four points enclosing unit grid space. This is where a unit module is usually populated.
- The grid base point is the one that has the lowest row and lowest column index, in this case, (0,0).
- Each point in the grid is a native Rhino point object.
- Each point object is named to reflect its location in the grid.
- The grid has rows and columns, but the number of points does not have to be the same from one row to another or from one column to another.

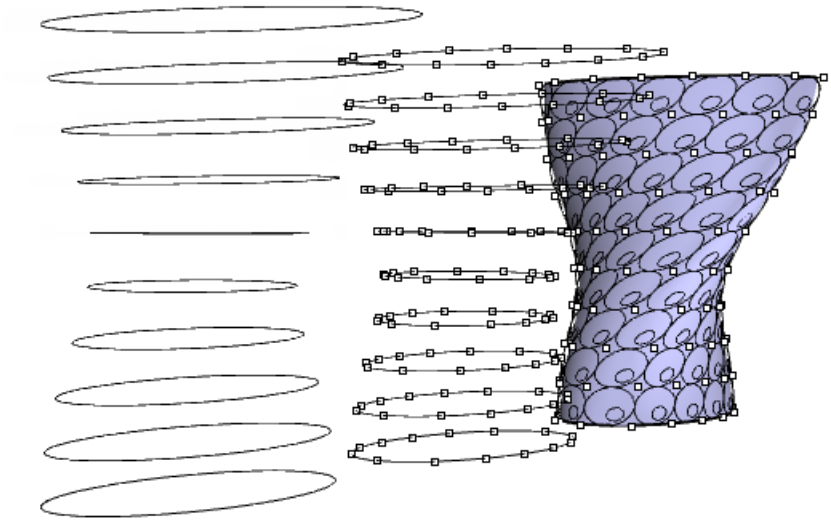
This is how the paneling looks when populating a module to the grid using **ptPanelGridCustom** command:

*Module.*



*Morphed module mapped to units of the grid.*

Grids can be derived from existing geometry such as curves and surfaces. For example, we may have an array of curves or a surface or combination of surfaces that we would like the grid to follow. The following example uses the **ptGridUCurves** command to create the grid and then populates a module using the **ptPanelGridCustom** command.



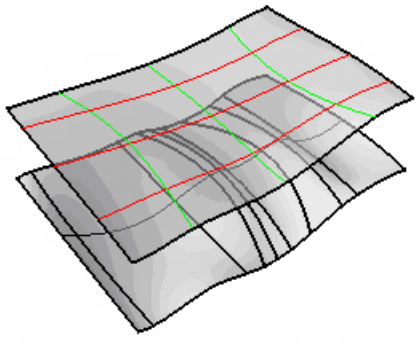
If a surface already exists and you need to rationalize the surface or populate a pattern, you can use one of the surface grid commands such as **ptGridSurfaceDomainNumber**.

It can be challenging to use polysurfaces as base geometry to populate continuous patterns. There are a number of ways to address this case and it involves some creativity, but boils down to one of two approaches.

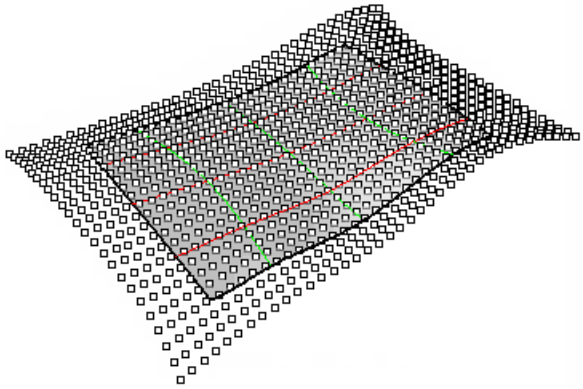
- Produce a mesh of curves that lies on the polysurface and then use intersections to create the grid.
- Create a grid on an approximate surface representation of the form then pull or project grid point to the polysurface.

**Example**

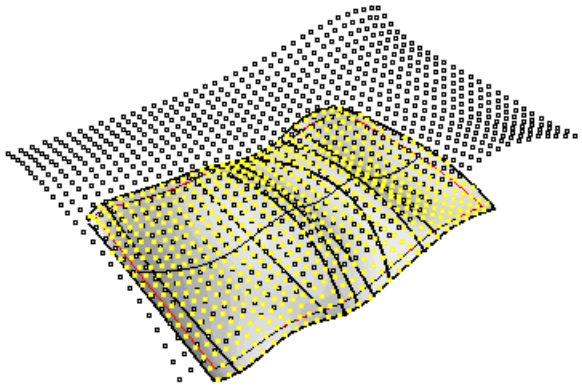
1. Create a patch using a polysurface border.



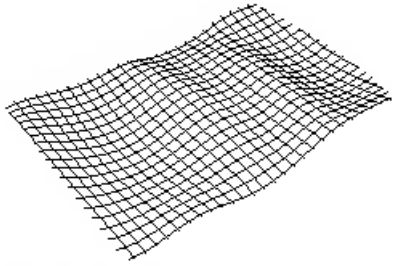
2. Grid the patch surface.



3. Extend the base and project points.



4. Use projected grid to create panels using the original base polysurface as a trimming reference.

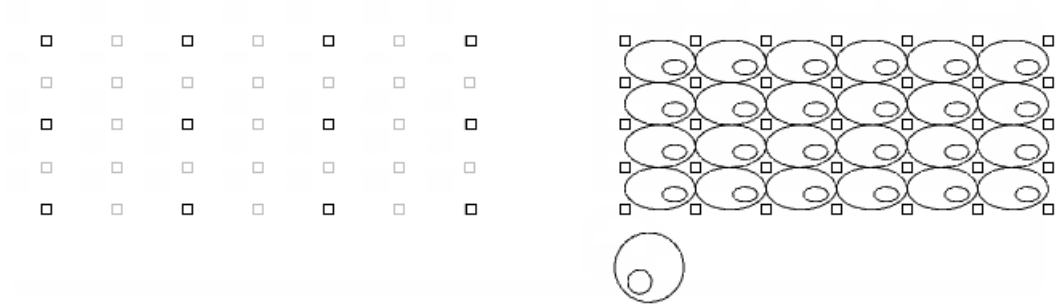


## Edit Paneling Grids

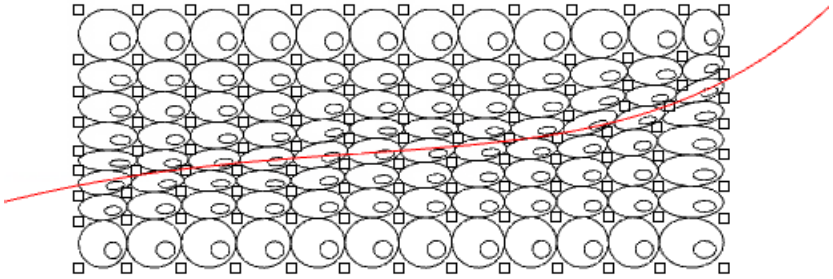
Since paneling grids are simply Rhino point objects with names, you can directly move them around, project them to some surfaces, or transform them in any way you like. All Rhino transform commands preserve objects' names and this is all you need to maintain valid grids.

PanelingTools provides commands that help manipulate the grid as a whole. For example, you may need to flip the direction of the grid, change the base point, swap row and columns, edit some row directions, close the grid in one direction, or extend in another. Many other functions are easier to handle through grid editing commands than to do manually.

Here is an example where **ptGridChangeDensity** command adds additional rows and columns to create a denser pattern.



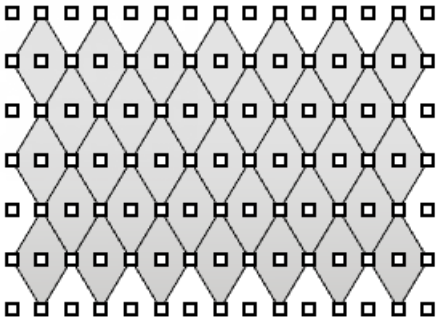
Other editing commands can weave two grids, find mean grids, or simply shuffle point locations using attractors. This comes in handy when you need to create various unit grid sizes based on some constraints. In the following case, the constraint is a curve running across the grid.



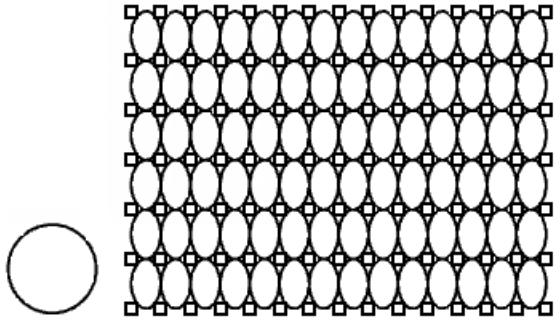
## Create Paneling Patterns

Paneling in the context of PanelingTools refers to the process of mapping geometry or modules to a rectangular ordered paneling grid. Paneling can be either along one grid to generate 2-D patterns or between two bounding grids to generate 3-D patterns. There are three main methods for paneling:

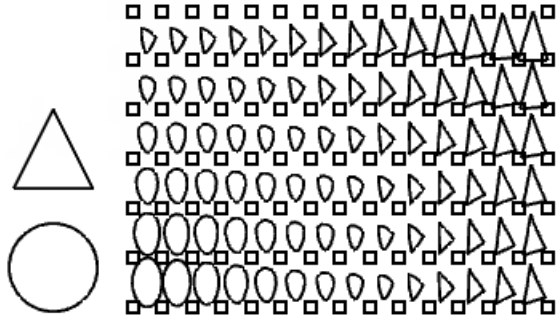
- Connect grid points to create edges, surfaces, or mesh faces of the intended pattern. This approach is the fastest and can cover a wide variety of patterns. You can also use base surfaces to pull the geometry.



- Morph a unit module and distribute it over unit paneling grid. This approach can be more time consuming, but allows for rich development of free-form patterns that do not conform to grid points.



- Morph a unit module in a variable way along the grid, depending on design constraints.

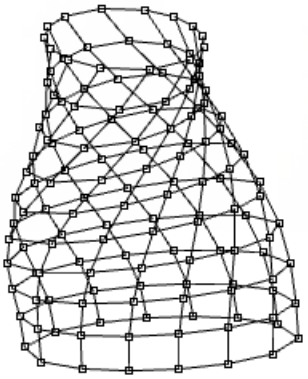


## Paneling the Grid

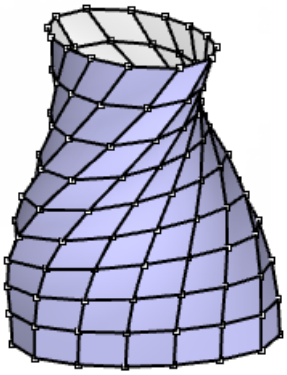
Most paneling commands support multiple output formats: edges, surfaces, planar surfaces, patch surfaces, and meshes. If a reference surface is used, panels can be pulled back to the surface. Using a base surface can trim panels to that surface. The following sections discuss paneling formats and shapes and address how panels are trimmed when using a reference surface or polysurface.

Panels can be curves, surfaces, or meshes. Each format may be desirable for a different situation. Here are few things to consider when deciding which format to use:

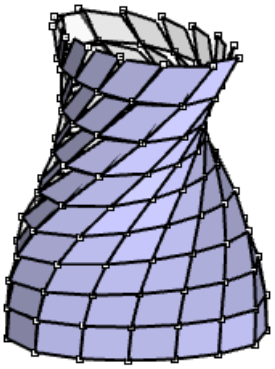
- Panels are labeled (serialized) and grouped in separate layers - one layer for each format.
- Straight edges and meshes are processed fastest.
- Creating surfaces can be time consuming, especially when they are not planar and need to be trimmed. It is best to start with edges or a mesh when exploring design ideas and to use surfaces during the final stages of design.



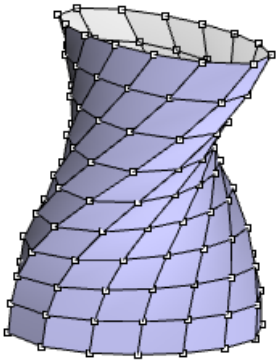
*Edges.*



*Faces.*



*FlatFaces.*



*Meshes.*

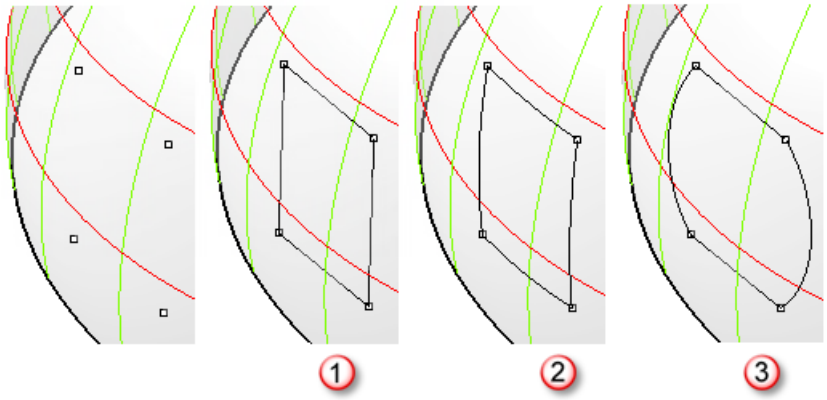
| Output Type in PanelingTools | Corresponding Rhino Geometry |
|---|---|
| Grid points | ON_3DPoint |
| Straight edges | ON_Line or ON_LineCurve |
| Straight face borders | ON_PolyLine or ON_PolylineCurve |
| Pulled edges | ON_NurbsCurve |
| Flat faces | Trimmed ON_Plane |
| Faces from straight edges | ON_NurbsSurface from an EdgeSurface |
| Faces from pulled edges | ON_NurbsSurface from a Patch |
| Mesh | ON_Mesh |

## Paneling Shapes

The paneling shape can only be straight when there is no reference surface or when the reference surface is planar. For example, edges are represented by lines connecting the paneling grid, and custom patterns are mapped to a bilinear surface connecting a unit grid. A straight shape can generate quickly and is recommended in intermediate stages of design.

If there is a reference surface for the paneling, Pulled, Iso, and Projected shapes can be used. For example, when generating a simple box pattern, line edges connecting the grid are either pulled to the base surface, made to follow its isocurves (if applicable), or are projected to the surface.

Here is an example that compares a few of the paneling shapes:



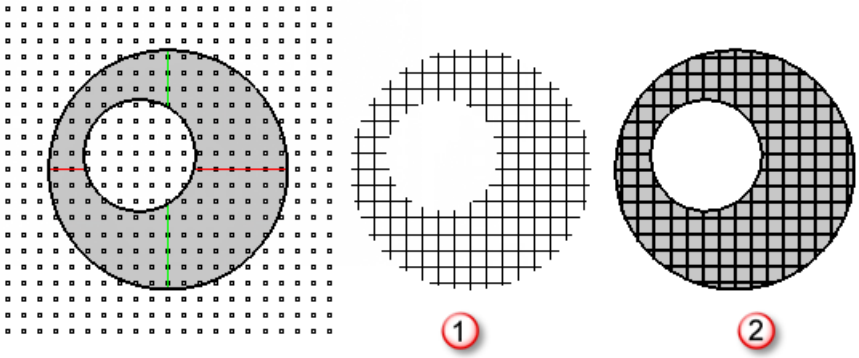

*Straight (1), Pull (2), Projected (3).*

| Panel Shapes | Description |
|---|---|
| **Straight** | A line connection between points. |
| **Pull** | Pulls a straight-line connection to the base surface. |
| **ShortPath** | The shortest path (geodesic) on the surface between points being connected. |
| **Iso** | Uses an isocurve between points if possible; otherwise pull back the straight-line curve. |
| **Projected** | Projects a line connection to the surface. |

## Trimmed Surfaces

When paneling uses a base surface or a polysurface, the panels are trimmed to the edges of that base. Selecting a base is optional in most cases, and therefore can be skipped if trimmed output is not needed.

Panels are trimmed regardless of what paneling shape is used. For example with a "straight" shape, if a line curve happens to connect two points, one within the base and the other outside it, then the line is pulled to the base and the intersection point with the boundary is used as the new second point. In some cases, this process fails to find a useful result and few panels may need to be trimmed manually.




*Trimmed edge panels (1), Trimmed face panels (2).*

## History Support

Most PanelingTools commands support history. However, history can be expensive to use. It works for smaller grids, but can be very time consuming for larger ones.

Here are few useful things to keep in mind when using history:

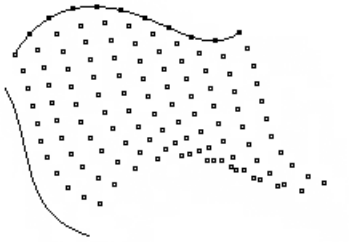
- Although history is very useful in some cases, it can be slow and counter-intuitive when dealing with a large data set.
- Rhino history is not designed to handle problems typical to paneling where there is a lot of input (grids of thousands of points) and even more output data (all those panels) that typically expands and shrinks with each update. The PanelingTools history implementation affects speed.
- The calculation can be canceled in most cases if it is taking too long.

## How does history work

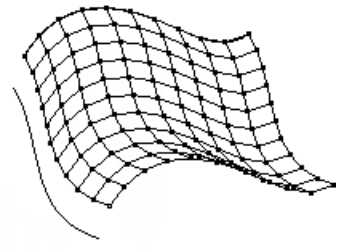
Just like other Rhino commands, you need to activate history recording before running the command you intend to record history for. When the referenced input geometry changes, the command will be replayed to update the output. Here is an example that generates a paneling grid with history.

### Example

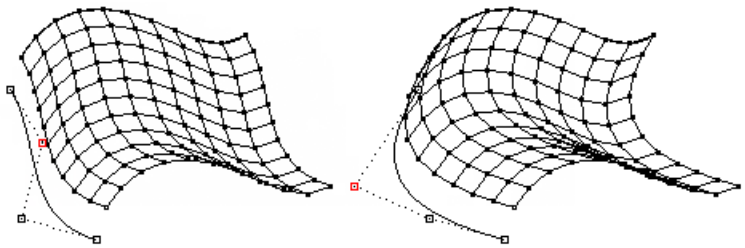
The **ptGridExtrude2** command with **Record History** on.



The **ptPanelGrid** command with **Record History** on.



Modifying the input curves updates the grid points, which in turn updates the paneling, triggering a chain update effect.

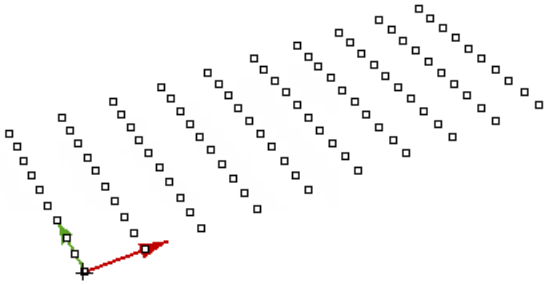


# Commands: Create Grid Directly

The **ptGridArray** and **ptGridArrayPolar** commands create a two-dimensional array of points.

## ptGridArray

The **ptGridArray** command creates an array of parallel points.



### Command flow

1. Start the command.
2. Pick a base point.
3. Press **Enter** to accept options.

### Options

**U_Number**
The number of points in the u-direction.

**U_Spacing**
The distance between points in the u-direction.

**U_direction**
Pick two points to set the u-direction.

**V_Number**
The number of points in the v-direction.

**V_Spacing**
The distance between points in the v-direction.

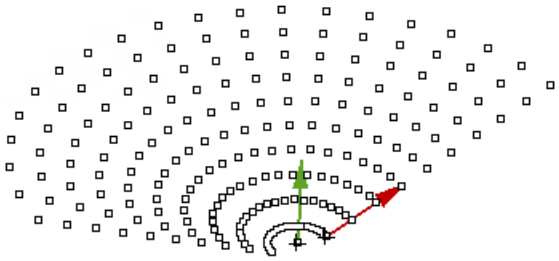
**V_Direction**
Pick two points to set the v-direction.

**Group**
If **Yes**, group the resulting points.

**NameOfGrid**
The grid name prefix attached to each point. The row and column location completes the point name.

## ptGridArrayPolar

The **ptGridArrayPolar** command creates a polar array of points.



### Command flow

1. Start the command.
2. Pick a center and first point of the rotation axis.
3. Pick a second point of the rotation axis.
   Press **Enter** to rotate normal to active construction plane.
4. Pick the base and first point of the grid direction.
5. Pick the second direction point.
   Press **Enter** if parallel to rotation axis.
6. Press **Enter** to accept options.

### Options

**U_Number**
The number of points in the u-direction.

**U_Spacing**
The distance between points in the u-direction.

**U_Direction**
Pick two points to specify a u-direction.

**V_Number**
The number of points in the v-direction (polar direction).

**V_Angle**
The angle between points in v-direction.

**Group**
If **Yes**, group the resulting points.

**NameOfGrid**
The grid name prefix attached to each point. The row and column location completes the point name.

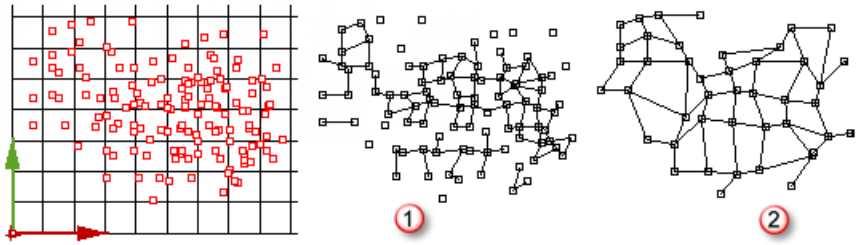
# Commands: Create Grid from Points

The **ptGridPoints** and **ptGridPointsOnSurface** commands use pre-defined sets of points to create a paneling grid or to order these points into rows and columns.

These commands define a distance tolerance to identify points that belong to one row or one column. The result may not always be desirable. It is best to define the paneling grid points using PanelingTools commands whenever possible.

## ptGridPoints

The **ptGridPoints** command uses u- and v-values from a base surface as a parallel reference grid. Input points take the row/column location from the closest reference grid point. The result may have fewer points than the input, since more than one point could be rounded to the same index. Reference spacing is critical to the result as illustrated in the image:




*Spacing = 1.0 (1), spacing = 2.0 (2).*

### Command flow

1. Start the command.
2. Pick the base point.
3. Press **Enter** to accept options.

### Options

**U_Spacing**
The reference grid spacing in the u-direction.

**V_Spacing**
The reference grid spacing in the v-direction.

**U_Direction**
Pick two points to specify a u-direction.

**V_Direction**
Pick two points to specify a v-direction.

**Group**
If **Yes**, group the resulting points.

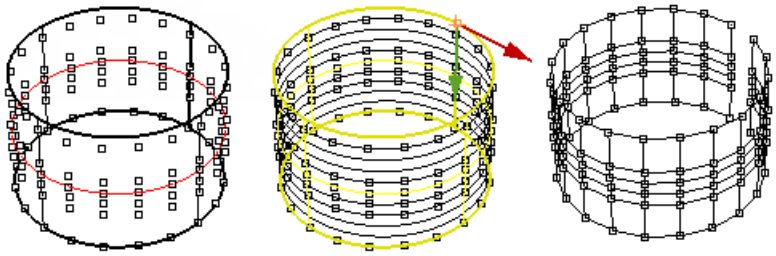
**DeleteInput**
If **Yes**, delete the input points.

**AlignPoints**
If **Yes**, shift the points to align with the reference grid.

**NameOfGrid**
The grid name prefix attached to each point. The row and column location completes the point name.

## ptGridPointsOnSurface

The **ptGridPointsOnSurface** command turns points existing on a surface into a valid grid of paneling points. The algorithm creates isocurves using twice the **Tolerance** value. Points within tolerance of any one curve are added to the grid as one row of points. Points in one row are ordered relative to their parametric location on the curve.



### Command flow

1. Start the command.
2. Select the points.
3. Select the surface.
4. Press **Enter** to accept options.

### Options

**Tolerance**

The spacing between isocurves is equal to twice this value. Points should be within tolerance from a particular row base line to be included in that row.

**Group**

If **Yes**, group the resulting points.

**DeleteInput**

If **Yes**, delete input points.

**AlignPoints**

If **Yes**, shift the points to align with the reference grid.

**NameOfGrid**

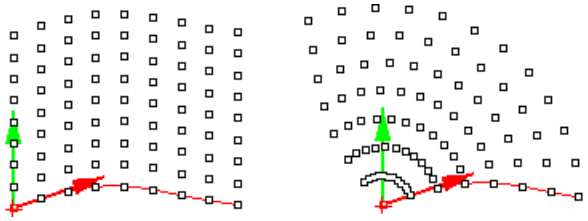
The grid name prefix attached to each point. The row and column location completes the point name.

# Commands: Create Grid from Curves

The **ptGridExtrude1**, **ptGridExtrude2**, **ptGridUCurves**, and **ptGridUVCurves** commands use input curves to create a paneling grid.

## ptGridExtrude1

The **ptGridExtrude1** command uses one curve and extrudes division points in parallel or polar directions.



*V-direction=extrusion direction (left), v-direction=rotation axis (right).*

### Command flow

1. Start the command.
2. Select the base curve.
3. Press **Enter** to accept options.

### Options

**U_Method**

The base curve division method.

**Number** — **U_NumberOfSpans**

The number of spaces between points.

**ArcLength** — **U_Length**

The along-curve distance between points.

**U_Round**

If **Yes**, round the distance up or down to fill the whole curve.

**U_RoundingMethod**

**Up**

**Down**

**ChordLength** — **U_ChordLength**

The straight-line distance between points.

**U_AddEndPoint**

If **Yes**, add a point at the end.

**V_Number**

The number of points in the extrusion v-direction.

**V_Method**

The array curve divide points in the parallel or polar direction.

**Parallel** **V_Distance**

The distance between points.

**V_Direction**

Pick two points to specify a v-direction.

**Polar** **V_Angle**

The angle between rows of points.

**V_RotationAxis**

Pick two points to specify a rotation axis.

**Group**

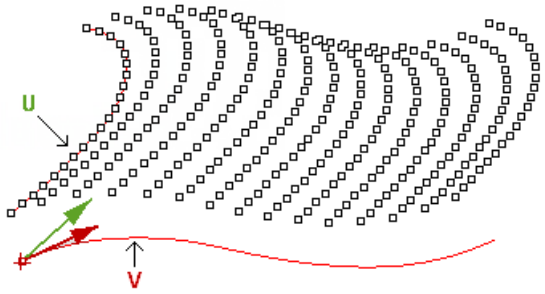
If **Yes**, group the resulting points.

**NameOfGrid**

The grid name prefix attached to each point. The row and column location completes the point name.

## ptGridExtrude2

The **ptGridExtrude2** command extrudes points of a base curve along a path curve.




### Command flow

1. Start the command.
2. Select the first curve.
3. Select the second curve.
4. Press **Enter** to accept options.

### Options

**U_Method**

The curve division method using the u-direction.

**Number** **U_NumberOfSpans**
The number of spaces between points.

**ArcLength** **U_ArcLength**
The along-curve distance between points.

**U_Round**
If **Yes**, round the distance up or down to fill the whole curve.

**U_RoundingMethod**

**Up**

**Down**

**ChordLength** **U_ChordLength**
The straight-line distance between points.

**U_AddEndPoint**
If **Yes**, add a point at the end.

**V_Method**
The curve division method using the v-direction.

**Number** **V_NumberOfSpans**
The number of spaces between points.

**ArcLength** **V_ArcLength**
The along-curve distance between points.

**V_Round**
If **Yes**, round the distance up or down to fill the whole curve.

**V_RoundingMethod**

**Up**

**Down**

**ChordLength** **V_ChordLength**
The straight-line distance between points.

**V_AddEndPoint**
If **Yes**, add a point at the end.

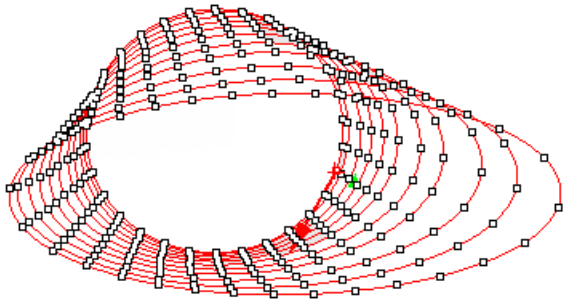
**Group**
If **Yes**, group the resulting points.

**NameOfGrid**
The grid name prefix attached to each point. The row and column location completes the point name.

**SwitchCurves**
Change which of the two curves to copy along the other curve points.

## ptGridUCurves

The **ptGridUCurves** command uses an existing array of curves to create a paneling grid. It divides the curves, which are usually parallel or non-intersecting, by a number or a distance. The option to automatically order curves and unify their direction may not yield desired result in all cases. It is best to select curves in the order of desired rows, for example, the first selected curve becomes row0.



### Command flow

1. Start the command.
2. Select the curves.
3. Press **Enter** to accept options.

### Options

**SortCurvesOrder**

If **Yes**, sort curves relative to their midpoint.

**Method**

Division method.

**NumberOfSpans**

The number of spaces between points.

**ArcLength**

The along-curve distance between points.

**Round**

If **Yes**, round the distance up or down to fill the whole curve.

**RoundingMethod**

**Up**

**Down**

**ChordLength**

The straight-line distance between points.

**AddEndPoint**

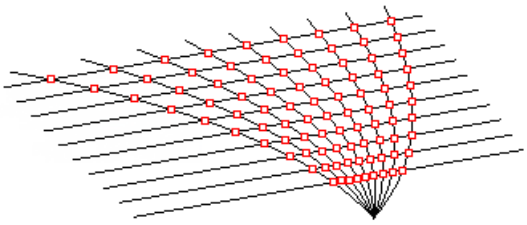
If **Yes**, add a point at the end.

**Group**

If **Yes**, group the resulting points.

## ptGridUVCurves

The **ptGridUVCurves** creates paneling points at curve intersections. Select the curves in each direction. The selection order defines the order of the rows and columns in the grid. An option sorts the order of the curves automatically.



### Command flow

1. Start the command.
2. Select the u-direction curves.
3. Select the v-direction curves.
4. Press **Enter** to accept options.

### Options

**SortCurvesOrder**

Sort curves relative to their midpoints.

**Group**

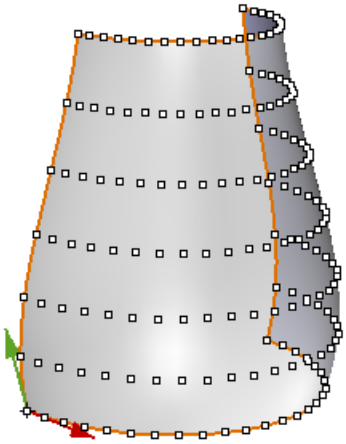
If **Yes**, group the resulting points.

# Commands: Create Grid from Surfaces

The **ptGridSurfaceDistance**, **ptGridSurfaceDomainChord**, **ptGridSurfaceDomainLength**, **ptGridSurfaceDomainNumber**, and **ptGridSurfaceDomainVariable** commands use a base NURBS surface to generate a grid.

## ptGridSurfaceDomainNumber

The **ptGridSurfaceDomainNumber** command divides a surface domain in both the u- and v-directions by a specified number of spans.



### Command flow

1. Start the command.
2. Select a surface.
3. Press **Enter** to accept options.

### Notes

- The red arrow points in the surface u-direction; the green arrow points in the surface v-direction.
- Each row and column of the resulting grid follows the isocurve directions of the surface.
- Since the grid name copies the surface name, name the input surface using the **Properties** panel before starting the command.

### Options

**U_NumberofSpans**

The number of spans in u-direction.

**V_NumberOfSpans**

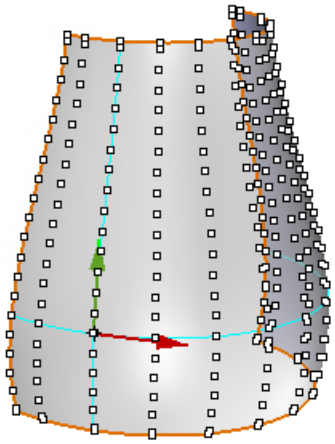
The number of spans in v-direction.

**Group**

If **Yes**, group the resulting points.

## ptGridSurfaceDomainLength

The **ptGridSurfaceDomainLength** command divides the surface domain in both the u- and v-directions by a specified length.



### Command flow

1. Start the command.
2. Select a surface.
3. Specify u- and v-lengths.
4. Press **Enter** to accept options.

### Notes

- The red arrow points in the surface u-direction; the green arrow points in the surface v-direction.
- Each row and column of the resulting grid follows the isocurve directions of the surface.
- Since the grid name copies the surface name, name the input surface using the **Properties** panel before starting the command.
- In general, the length is only exact along the two referenced u and v isocurves. If the surface curvature in both directions, the distance will vary. However, planar and extruded surfaces should maintain specified length values.

### Options

**U_Length**

The length on curve in the u-direction.

**V_Length**

The length on curve in the v-direction.

**SelectBasePoint**

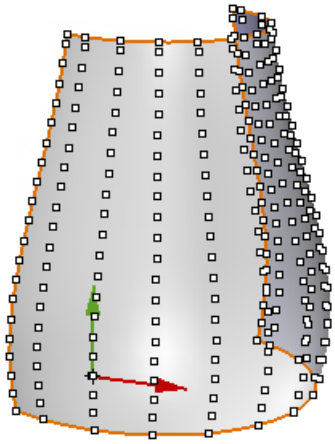
A point on surface to align grid to. If not specified, the command uses the surface base point (0,0).

**Group**

If **Yes**, group the resulting points.

## ptGridSurfaceDomainChord

The **ptGridSurfaceDomainChord** command divides a surface in both u-and v-directions by a specified distance.



### Command flow

1. Start the command.
2. Select a surface.
3. Specify the u- and v-distances.
4. Press **Enter** to accept options.

### Notes

- The red arrow points in the surface u-direction; the green arrow points in the surface v-direction.
- Each row and column of the resulting grid follows the isocurve directions of the surface.
- Since the grid name copies the surface name, name the input surface using the **Properties** panel before starting the command.
- In general, the length is only exact along the two referenced u- and v-isocurves. If the surface has curvature in both directions, the distance will vary. However, planar and extruded surfaces should maintain the specified length values.

### Options

**U_Dis**

The direct distance in the u-direction.

**V_Dis**

The direct distance in the v-direction.

**SelectBasePoint**

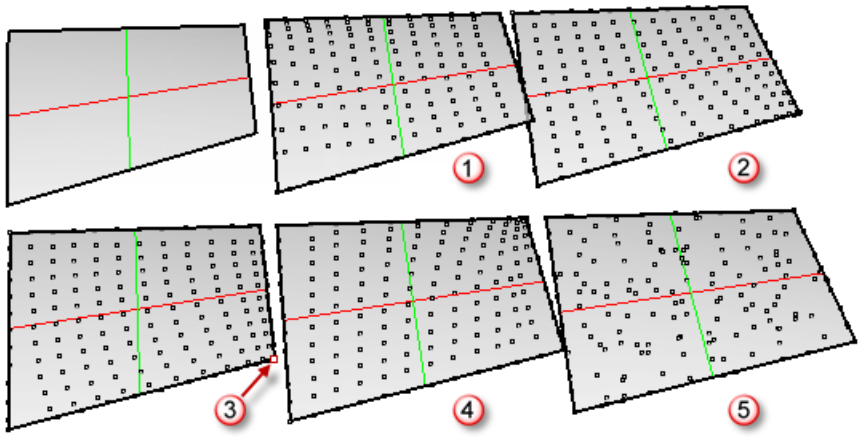
A point on the surface to align the grid to. If not specified, the command uses the surface base point (0,0).

**Group**

If **Yes**, group the resulting points.

## ptGridSurfaceDomainVariable

The **ptGridSurfaceDomainVariable** command divides a surface in both the u- and v directions by a specified number and then moves the grid points using attractors.




*Gaussian (1), Mean (2), Attractors (3), Vector (4), and Random (5).*

### Command flow

1. Start the command.
2. Select a surface.
3. Select attractor points.
4. Press **Enter** to accept options.

### Notes

- The grid in the example image is attracted towards a point (red). Points at the edges of the surface move within those edges.
- Since the grid name copies the surface name, name the input surface using the **Properties** panel before starting the command.

### Options

**U_Number**

The number of spans in the u-direction.

**V_Number**

The number of spans in the v-direction.

**DistanceMethod**

The distribution method.

**GaussianCurvature**

Uses the surface Gaussian curvature values.

**MeanCurvature**

Uses the surface mean curvature values.

**PointAttractors**

Shifts points towards or away from attractor points.

**CurveAttractors**

Shift points towards or away from attractor curves.

**Vector**

Uses a dot product between a vector and the surface normal at each point.

**Random**

Shifts points by a random amount.

**Bitmap**

Uses an image to drive the attraction.

**AttractMethod**

The direction the points are moved with respect to the attractors. If the **DistanceMethod** is **MeanCurvature** or **GaussianCurvature**, the points are attracted toward or away from the highest curvature.

**Away**

**Toward**

**Magnitude**

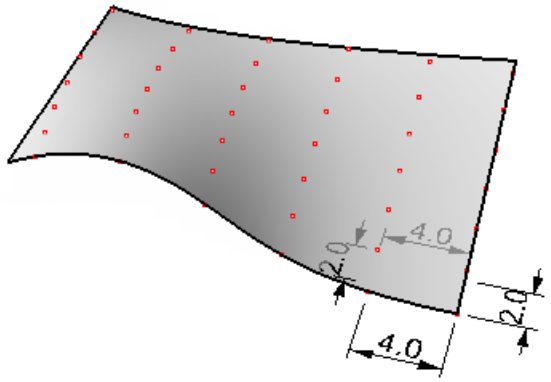
Reduces or magnifies the distance variations.

**Group**

If **Yes**, group the resulting points.

## ptGridSurfaceDistance

The **ptGridSurfaceDistance** command divides a surface by specified distances in the u- and v-directions.




### Command flow

1. Start the command.
2. Select a surface.
3. Select a base point on the surface, or press **Enter** to use the surface minimum.
4. Press **Enter** to accept options.

### The algorithm:

1. Extracts a u- and v-isocurve at the selected base point.
2. Divides the isocurves by the chord length.
3. Takes a second point on v-isocurve and  second point on u-isocurve and finds a point on the surface that is equal to the u- and v-distancex from the v and u points. If the point is valid, that new point is used with the third point on the u-isocurve to find the next point, and so on until no valid point is found.

**Note**

- Since this command uses an algorithm where every new point depends on previously created points; it may not give complete coverage. The **Extend** option may help creating better coverage.
- Since the grid name copies the surface name, name the input surface using the **Properties** panel before starting the command.
- A point on the surface can be used as a base.

**Options**

**U_Distance**

The distance in the u-direction.

**V_Distance**

The distance in the v-direction.

**Extend**

Extend the surface before dividing it to get better coverage.

**Group**

If **Yes**, group the resulting points.

# Commands: Create Grid from Projected Curves

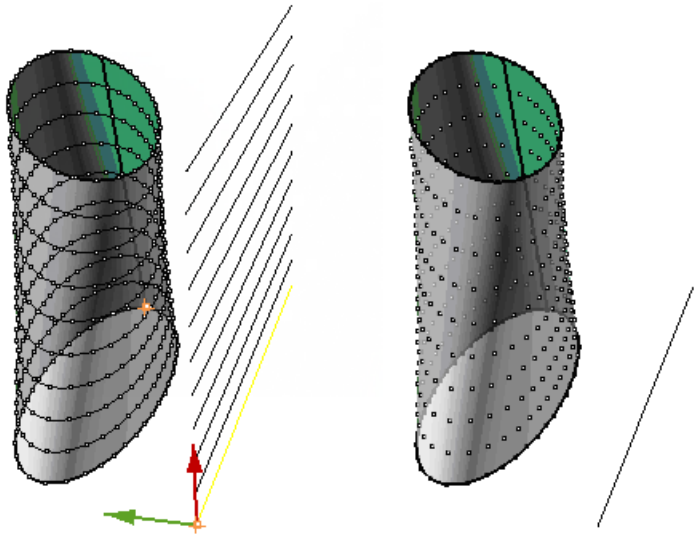
The **ptGridCurve** and **ptGridCurve2** commands create a grid a from polysurface or a surface without using its uv-directions.

The general algorithm:

- The input curve is arrayed the specified distance or angle and direction.
- The user defines the direction to project curves towards the base surface or polysurface.
- The curves are then projected and the resulting curves are joined and cleaned.
- The new curves are used to divide by the number or distance.
- If the curves are in both directions, grid points are extracted from their intersections.

## ptGridCurve (one-directional curve)

The **ptGridCurve** command generates a grid by projecting a direction curve to a surface. Curves can be open or closed. An open curve is copied in the extrusion direction by the Spacing/Angle distance. A closed curve is offset by that distance.



*Projection direction (green), extrusion direction (red).*

### Options

**Line**

Pick two points to define the direction.

**CurveOptions**

**NumberOfCuts**

The number of curves to be projected to the object.

**ExtrudeMethod**

**Parallel**

Copies the direction curve parallel.

**ExtrudeDirection**

The extrusion direction.

**Spacing**

The spacing between the curves.

**Polar**

Copies the direction curve around the object origin.

**Angle**

The angle between the curves.

**ProjectionDirection**

The direction the curves are projected.

**GridOptions**

**Method**

The curves division method.

**Number** **NumberOfSpans**

The number of spaces between points.

**ArcLength** **Length**

The along-curve distance between points.

**Round**

If **Yes**, round distances to fill the span of the curve.

**RoundingMethod**

**Up**

**Down**

**ChordLength** **Distance**

The straight-line distance between points.

**AddEndPoint**

If **Yes**, add a point at the end.

**Group**

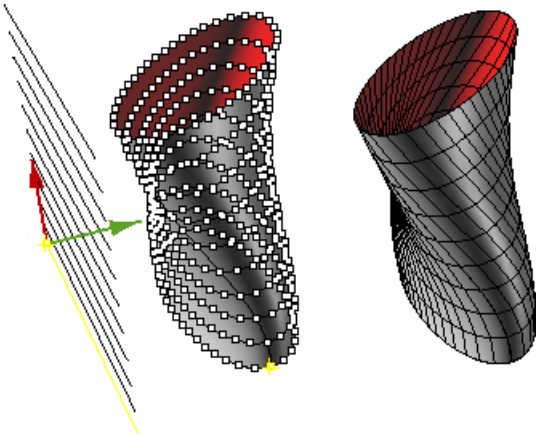
If **Yes**, group the resulting points.

**NameOfGrid**

The grid name prefix is attached to each point. The row and column location completes the point name.

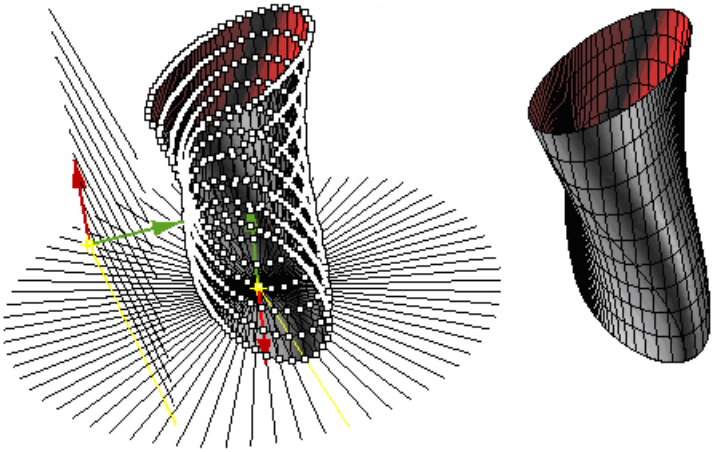
## ptGridCurve2 (two-directional curves)

The **ptGridCurve2** command generates a grid by projecting two direction curves to a surface. If there is an undesirable surface uv or surface seam, this command can apply the desired directions. In the example below, the surface has a twisted seam, this is how the paneling looks using the **ptGridCurve** command (the **ptGridSurfaceUV** command gives a similar result):



*Projection direction (green), extrusion direction (red).*

Using two direction curves, the first in the polar and the second in the parallel direction, gives desired result in this case:



*Projection direction (green), extrusion direction (red).*

### Options

**Line**

Pick two points to define the direction curve.

**FirstDirCurvesOptions / SecondDirCurvesOptions**

**NumberOfCuts**

The number of curves to be projected to the object.

**ExtrudeMethod**

**Parallel**

**ExtrudeDirection**

The extrusion direction.

**Spacing**

The distance between the curves.

**Polar**

**Angle**

The angle between the curves.

**ProjectionDirection**

The direction the curves are projected.

**Group**

If **Yes**, group the resulting points.

**NameOfGrid**

The grid name prefix is attached to each point. The row and column location completes the point name.

# Commands: 2-D Connecting Patterns

PanelingTools supports generating paneling patterns either by connecting paneling grid points or by mapping a given module to a unit grid.

Connecting paneling points is faster and does not involve time-consuming mapping or morphing.

## ptPanelGrid

Built-in connecting patterns are optimized for speed and cover many common cases. The **ptPanelGrid** command comes with built-in 2-D patterns. The **ptPanelGrid** command creates panels from an ordered grid of points. A reference surface or polysurface is optional. A list of patterns includes built-in and connecting patterns created with the **ptManage2DPatterns** command. Panels are added in the form of edges, surface borders, surfaces (**EdgeSrf** or **Patch**), flat surfaces, and a mesh.

### Command flow

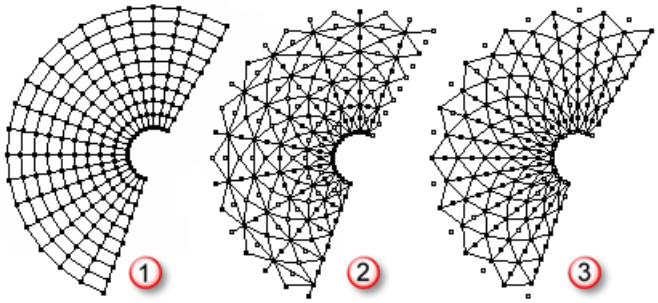
1. Start the command.
2. Select a paneling grid.
3. Select a base surface (optional).
4. Press **Enter** to accept options.

### Options

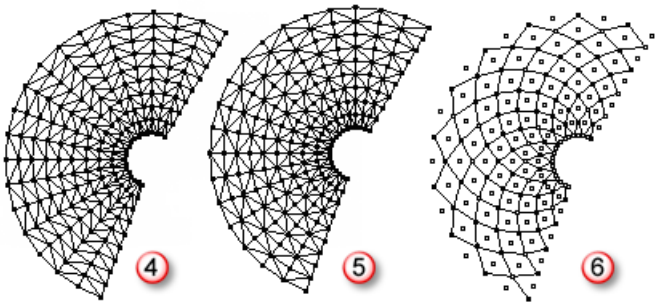
**Pattern**

The built-in 2-D patterns.

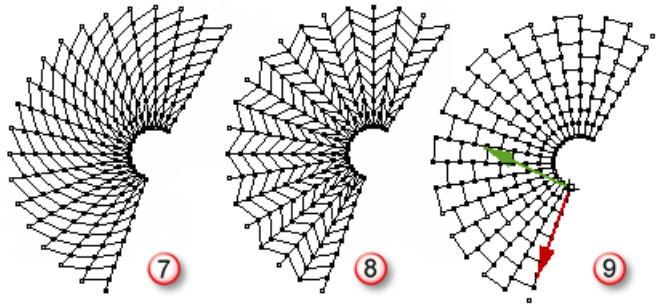
**Box** ①**, BoxX** ②**, Triangular** ③



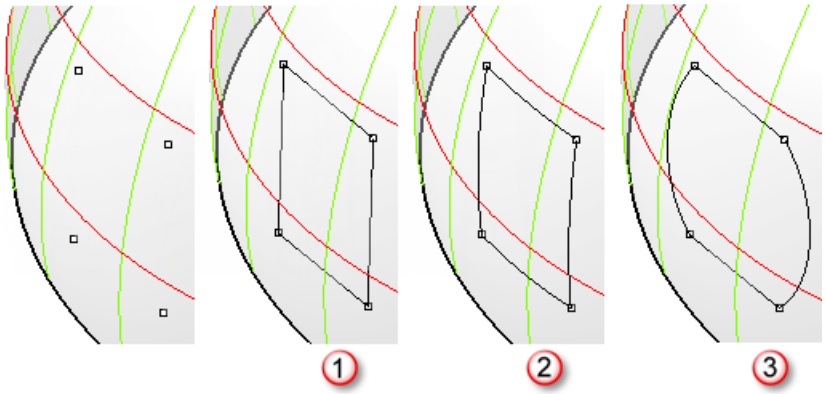

**TriBasic** ④**, Dense** ⑤**, Diamond** ⑥



**AngleBox** ⑦, **Wave** ⑧, **Brick** ⑨




**PanelShape**




**Straight** ①
A line connection between points.

**Pull** ②
Pulls the line connection to a base surface.

**ShortPath** ③
The shortest path on the surface between grid points being connected.

**Iso**
The isocurve between points if possible, otherwise the line is pulled back.

**Projected**
Projects the line connection to surface using a direction option.

**ProjectionDirection**

**Z_dir**
The projection direction = world z-axis.

**X_dir**
The projection direction = world x-axis

**Y_dir**
The projection direction = world y-axis.

**CPlaneNormal**
The projection direction = normal to active construction plane.

**PickPoints**
Pick two points to define a projection direction.

**AddEdges**

Add edge panels to a new layer. Edges are serialized.

**AddFacesBorder**

Add border curves panels to a new layer. Borders are serialized.

**AddFaces**

Add face panels (**Patch** or **EdgeSrf**) to a new layer. Faces are serialized.

**AddFlatFaces**

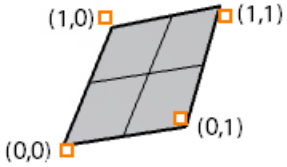
Create planar faces. Faces may not join. Faces are serialized and added to a new layer.

**FlatFaceMethod**

Specify how flat panels are calculated.

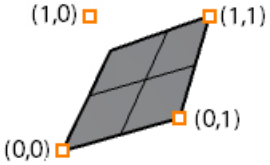
**BestFit**

The best-fit plane through all unit grid points.



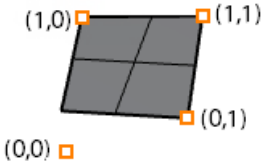

**FitBasePt0**

The best-fit plane through three of the four unit grid points starting from minimum u, minimum v and going clockwise.



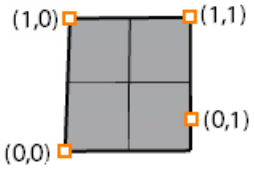

**FitBasePt1**

The best-fit plane through three of the four unit grid points starting from minimum u, maximum v and going clockwise.



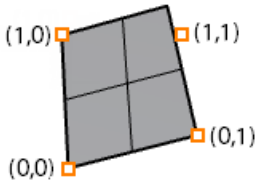

**FitBasePt2**

The best-fit plane through three of the four unit grid points starting from maximum u, maximum v and going clockwise.



**FitBasePt3**

The best-fit plane through three of the four unit grid points starting from maximum u, minimum v and going clockwise.




**TangentToCenter**

The best-tangent plane to surface center.

**AddMesh**

Add a mesh.

**Group**

If **Yes**, group the resulting points.

**Name**

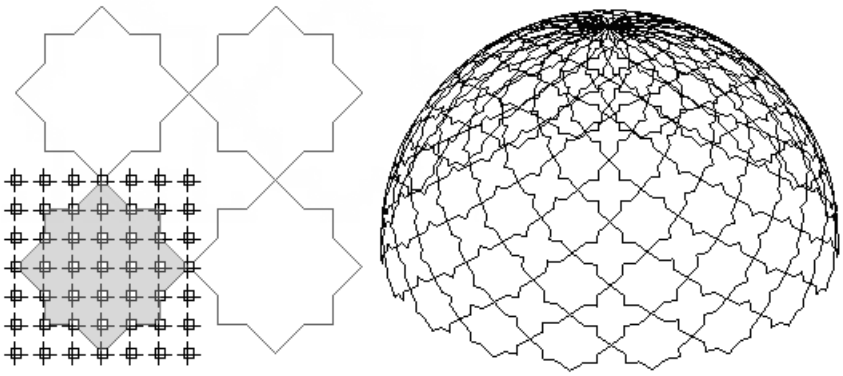
The grid name prefix is attached to each point. The row and column location completes the point name.

## ptManage2DPatterns

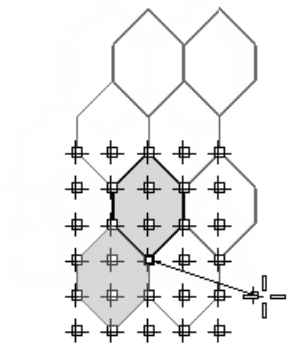
### To create custom patterns

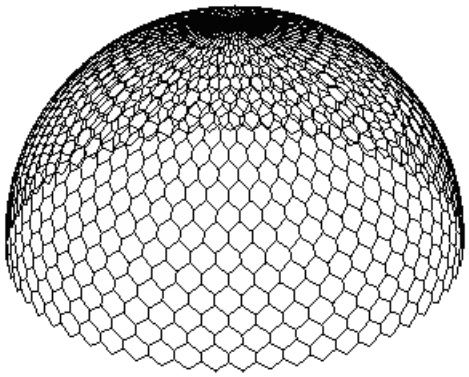
1. Specify a unit pattern with any number of grid points.
2. Draw polylines to connect the points.
3. Specify how many units the pattern shifts.
4. Specify a unique pattern name or reference in paneling command (**ptPanelGrid**).

This example uses one closed polyline with **GridWidth=7**, **GridHeight=7**, **Shift_u=6** and **Shift_v=6**.



Multiple polylines can be included in the same pattern. The following example uses two closed polylines with **GridWidth=5**, **GridHeight=6**, **Shift_u=2** and **Shift_v=4**.





## Command flow

1. Start the command.
2. Create a **New** pattern, **Edit**, or **Delete** existing patterns.
3. When selecting the **New** option, pick two points to define the scale of the preview grid.
4. Pick the grid points to define the connecting pattern.
5. Press **Enter** to define additional connections.
6. Press **Enter** to accept that pattern.
7. Press **Enter** to save the patterns and exit.

## Options

**New**

The distance in first direction.

**GridWidth**

The number of grid points in the u-direction to connect.

**GridHeight**

The number of grid points in the v-direction to connect.

**Shift_u**

The amount to shift the connecting pattern in the u-direction.

**Shift_v**

The amount to shift the connecting pattern in the v-direction.

**Reset**

Clear all connections created for the current pattern.

**Undo**

Clear all last selection points.

**Name**

The pattern name.

**Edit**

Select a pattern name from the list. The command flow and options are similar to when creating a new pattern.

**Delete**

Select the pattern name to be deleted from the list.

## Save and load custom 2-D patterns

Created 2-D patterns persist in a document and are saved with it. If you want to share patterns across files, save these patterns to an external text file.

### ptSave2DPatterns

The **ptSave2DPatterns** command creates a text file of all 2-D patterns in a document. An option appends patterns to the end of the file.

This is what the typical file with saved 2-D patterns looks like:

```
!-------------------------------------------------------------
!-- Custom 2D patterns of PanelingTools plugin for Rhinoceros
!-- Recorded on Wednesday, November 18, 2009 at 14:46:52
!-- Pattern format:
!--    Name
!--    Shift: (x_shift,y_shift)
!--    Connections: (x0,y0)(x1,y1);(x2,y2)(x3,y3)(x4,y4);...
!-------------------------------------------------------------

My_First2D
(1,1)
(0,0)(1,1)(1,0)(0,0)

My_Second2D
(2,1)
(0,0)(0,1)(1,0)(0,0);(1,0)(2,0)(2,1)(1,0)
```

#### Options

**Append**

If **Yes**, patterns are saved at the end of the file.

**SetTargetFile**

Select a target file. Accept the default path or type the path at the command line.

### ptLoad2DPatterns

The **ptLoad2DPatterns**.command loads a pattern file created with the **ptSave2DPatterns** command. If a pattern name already exists in the custom patterns list, it will be overwritten by the newly loaded pattern.

# Commands: 3-D Connecting Patterns

The **ptPanel3D** command comes with built-in 3-D patterns. The command help create edges, faces, and solids.

## ptPanel3D

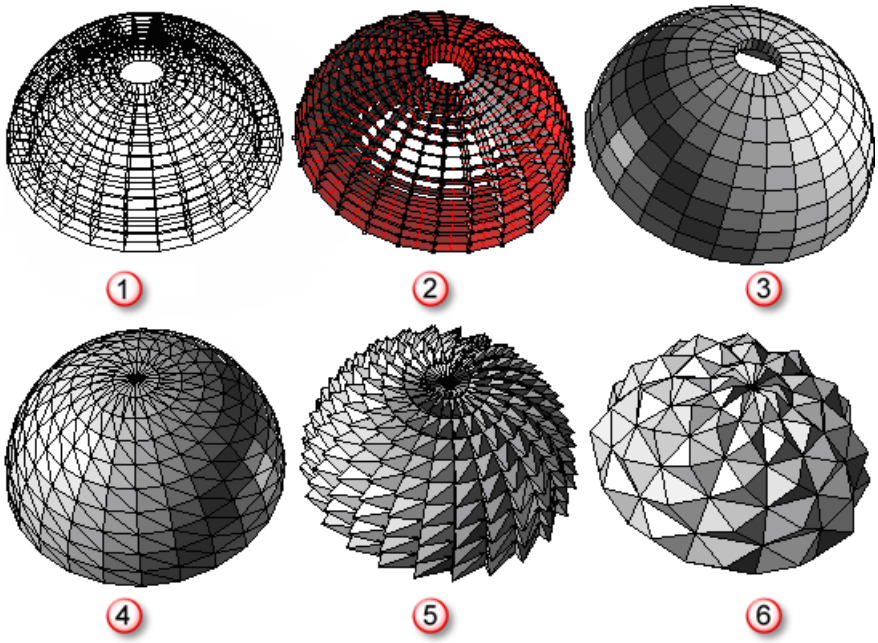
The **ptPanel3D** command creates a panel from two grids. A list of patterns includes built-in and user-defined panels. Panels are added in the form of edges, surfaces, and polysurfaces. Spacing of unit patterns depends on the grid spacing.

### Command flow

1. Start the command.
2. Select the first paneling grid. Set options for pattern in this step.
3. Select the second paneling grid.

### Options

**Pattern**




**WireBox** 1

Curves connecting grid points.

**Partition** 2

Faces generated from connecting points in the first and second bounding grids.

**Box** 3

Closed boxes connecting four points from each bounding grid.

**Wedge** 4

Closed trapezoid connecting three points from each bounding grid.

**Pyramid1** 5

Connects four points from the first grid with the corresponding minimum point from the second grid.

**Pyramid2** 6

Connect four points from the first grid that extend over two spans with the corresponding middle point in the second grid.

**User-defined**

**Group**

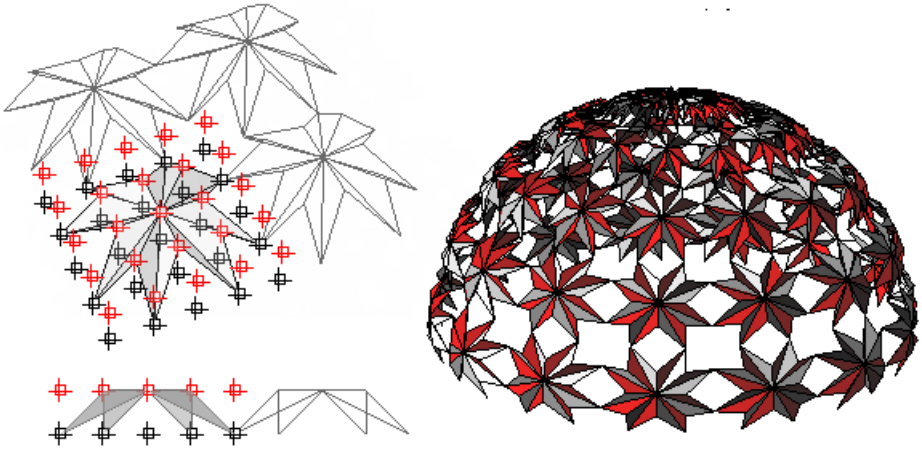
If **Yes**, group the resulting points.

**Name**

The grid name prefix attached to each point. The row and column location completes the point name.

## ptManage3DPatterns

Three-dimensional patterns require two bounding grids where a pattern is defined with polylines. Closed polylines result in faces that can be joined into a polysurface when the pattern is later applied.



### Command flow

1. Start the command.
2. Create a **New** pattern, **Edit**, or **Delete** existing patterns.
3. When selecting the **New** option, pick two points to define the scale of the preview grid.
4. Pick the grid points to define the connecting pattern. Closed polylines define faces.
5. Press **Enter** to define additional connections.
6. Press **Enter** to accept that pattern.
7. Press **Enter** to save the patterns and exit.

### Options

**New**

The distance in first direction.

**GridWidth**

The number of grid points in the u-direction to connect.

**GridHeight**

The number of grid points in the v-direction to connect.

**Shift_u**

The amount to shift the connecting pattern in the u-direction.

**Shift_v**

The amount to shift the connecting pattern in the v-direction.

**Reset**

Clear all connections created for the current pattern.

**Undo**

Clear all last selection points.

**Name**

The pattern name.

**Edit**

Select a pattern name from the list. The command flow and options are similar to when creating a new pattern.

**Delete**

Select the pattern name to be deleted from the list.

## Save and load 3-D custom patterns

Created 2-D patterns persist in a document and are saves with it, but if you want to share patterns across files, save these patterns to an external text file.

### ptSave3DPatterns

The **ptSave3DPatterns** command creates a text file of all 3-D patterns in a document. An option appends patterns to the end of the file.

This is what the typical file with saved 3-D patterns looks like:

```
!-----------------------------------------------------------------
!-- Custom 3D patterns of PanelingTools plugin for Rhinoceros
!-- Recorded on Wednesday, November 18, 2009 at 14:47:13
!-- Pattern format:
!--    Name
!--    Shift: (x_shift,y_shift)
!--    Connections: (x0,y0,z0)(x1,y1,z1);(x2,y2,z2)(x3,y3,z3);...
!-----------------------------------------------------------------

My_First3D
(1,1)
(0,0,0)(0,0,1)(1,1,1)(1,1,0)(0,0,0);(0,1,1)(1,0,1)(1,0,0)(0,1,0)(0,1,1)

My_Second3D
(1,1)
(0,0,0)(0,0,1)(0,1,1)(1,1,1)(1,1,0)(0,1,0)(0,0,0);(0,1,1)(1,0,1)(1,0,0)
```

#### Options

**Append**

If **Yes**, patterns are saved at the end of the file.

**SetTargetFile**

Select a target file. Accept the default path or type the path at the command line.

### ptLoad3DPatterns

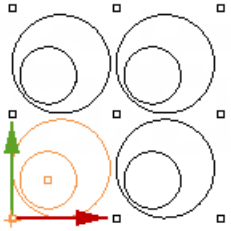
The **ptLoad3DPatterns** command loads a pattern file created with the **ptSave3DPatterns** command. If a pattern name already exists in the custom patterns list, it will be overwritten by the newly loaded pattern.

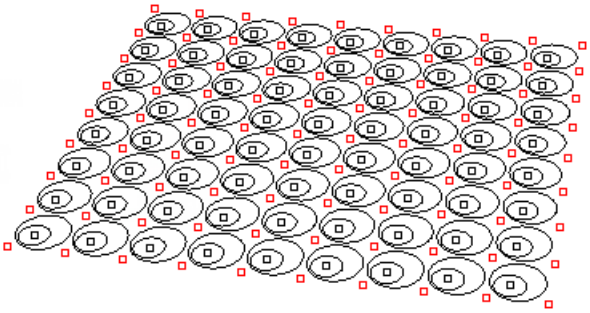
# Commands: Map to Unit Grid

The **ptPanelGridCustom**, **ptPanelGridCustomVariable**, **ptPanel3DCustom**, **ptPanel3DCustomVariable**, and **ptOrientToGrid** commands create panels from a unit grid.

## ptPanelGridCustom

The **ptPanelGridCustom** command uses a free-form pattern that cannot be represented by connecting grid points. The command scales a given pattern within a unit size then maps it to a unit grid. The **GridWidth** and **GridHeight** options scale the pattern. Other options add spacing between one unit pattern and the next in the u- and v-directions.





### Command flow

1. Start the command.
2. Select the base paneling grid.
3. Select the base surface (optional).
4. Select pattern curves and points.
5. Press **Enter** to accept options.

### Options

**GridWidth**

The unit grid width. A width that is bigger than the pattern width means that the pattern will be scaled down to fit within the same relative unit dimension.

**GridHeight**

The unit grid height.

**U_Spacing**

Set the spacing to **1** to pack the pattern.

Set the spacing to **2** to map every second paneling pattern unit grid.

**V_Spacing**

The spacing in v-direction.

**Group**

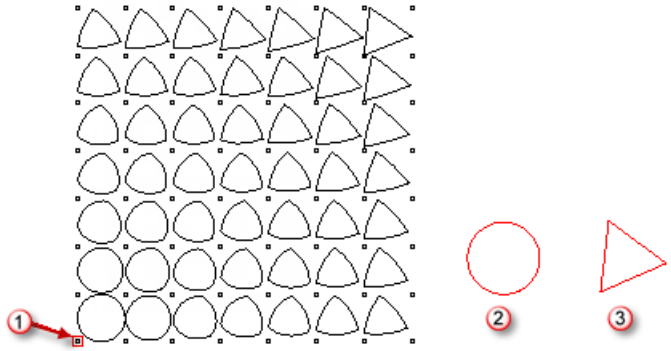
If **Yes**, group the resulting pattern.

**Name**

The name of resulting paneling. A new layer is created with this name. The name is added to the start of each paneling object name.

## ptPanelGridCustomVariable

The **ptPanelGridCustomVariable** command is similar to the **ptPanelGridCustom** command except that it allows you to scale, rotate, translate, define a list of shapes, or generate mean curves between two shapes. Variation responds to surface curvature, attractors, vector or randomly. This command supports Rhino History; so, for example, changing the location of attractor points updates the pattern.




*Attractor (1), Start (2), End (3).*

### Command flow

1. Start the command.
2. Select the base paneling grid.
3. Select the base surface (optional).
4. Press **Enter** to accept options.
5. Select the attractor points or curves (if applicable).
6. Select the pattern curves and points.
7. Select bounding objects. Press **Enter** to use a bounding box.
8. Press **Enter** to accept options.

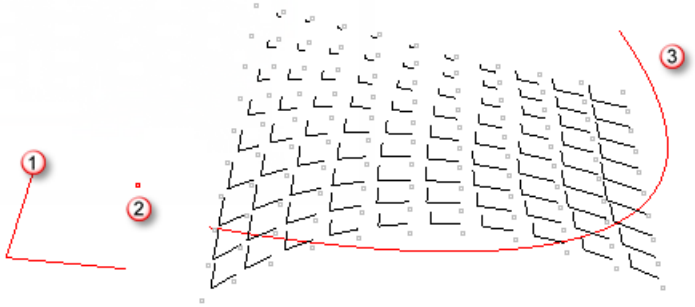
### Options

**PatternMethod**

The method for varying the input pattern.

**Scale**

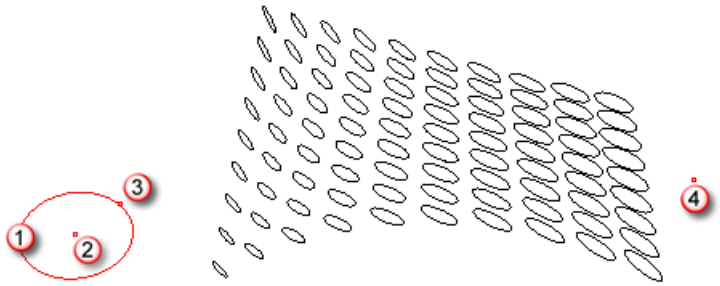
Scale input unit pattern using a base reference point and a scale factor range.




*Unit pattern (1), base point (2), attractor curve (3).*

**Scale1D**

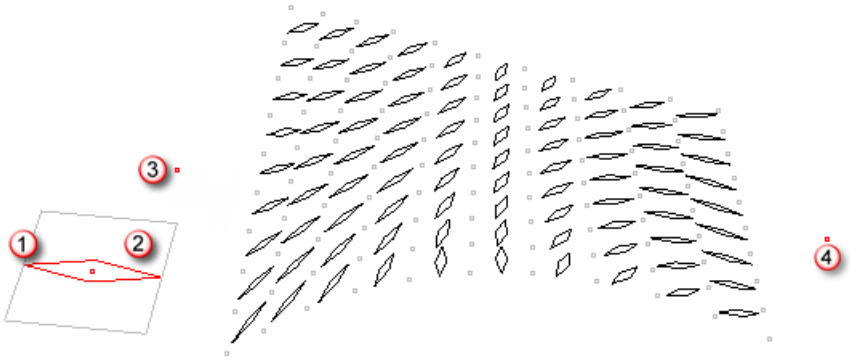
Scale input unit pattern in one direction using a base reference point, a target reference point, and a scale factor range.




*Unit pattern (1), base point (2), direction point (3), attractor (4).*

**Rotate**

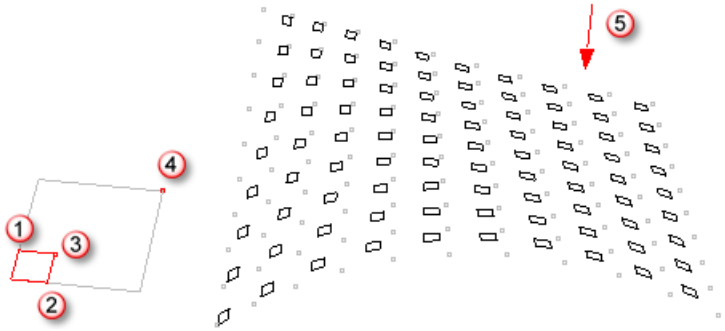
Rotate input unit pattern using a base reference point and an angle range.




*Unit pattern (1), bounding objects (2), attractor (3 and 4).*

**Translate**

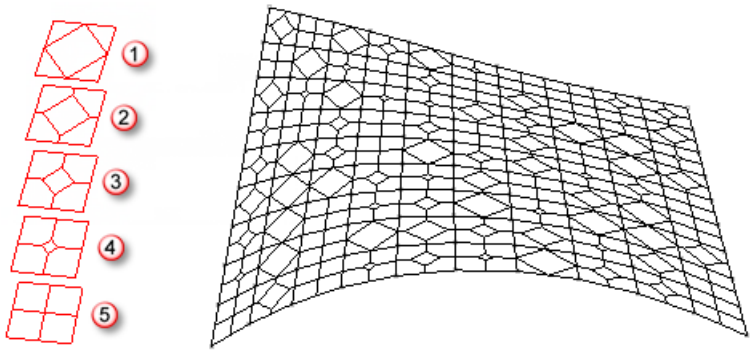
Move the selected pattern between two points.




*Unit pattern (1), bounding object (2), start point (3), end point (4), vector (5).*

**List**

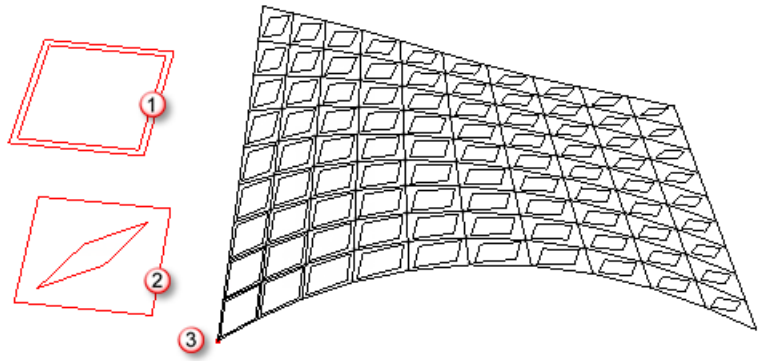
Enable selecting a list of patterns in order.




*Pattern a (1), pattern b (2), pattern c (3), pattern d (4), pattern e (5).*

**Mean**

Calculate mean curves between two sets of input curves. The first curve of the first set is matched with the first curve of the second set.



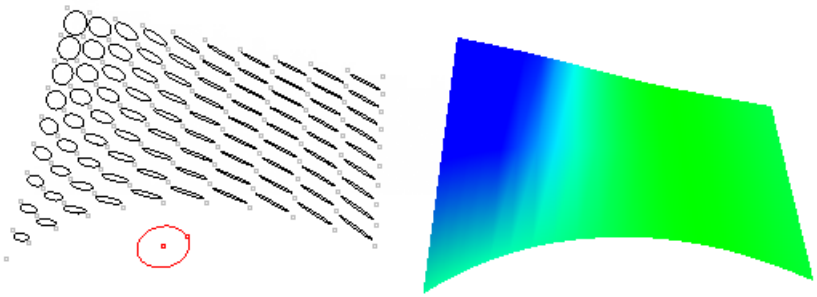

*Start pattern (1), end pattern (2), attractor (3).*

**DistributionMethod**

The method of calculating the distance factor for each square unit pattern. The distance factor is a normalized number between 0 and 1.

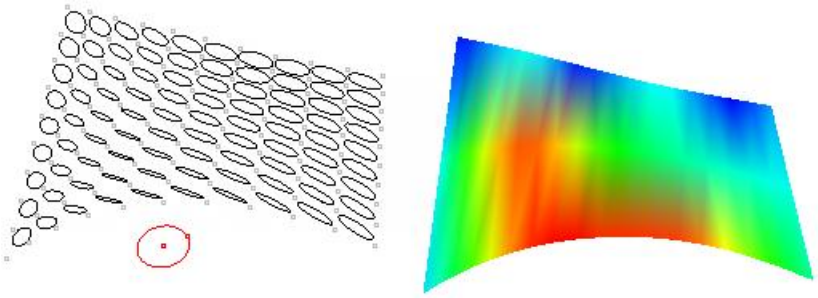
**GaussCurvature**

Use normalized surface (or grid) Gaussian curvature to define a factor between 0.0 and 1.0 for each square grid unit.



**MeanCurvature**

Use normalized surface (or grid) mean curvature to define a factor between 0.0 and 1.0 for each square grid unit.



**PointAttractors**

The factor is based on the normalized distance from a set of points.

**CurveAttractors**

The factor is based on the normalized distance from a set of curves.

**Vector**

The factor is based on the normalized angle with the input vector.

**Random**

Randomly assign a factor between 0.0 and 1.0 for each square grid unit.

**PullCurves**

Pull the resulting pattern curves to the base surface (if available).

**Group**

If **Yes**, group the resulting pattern.

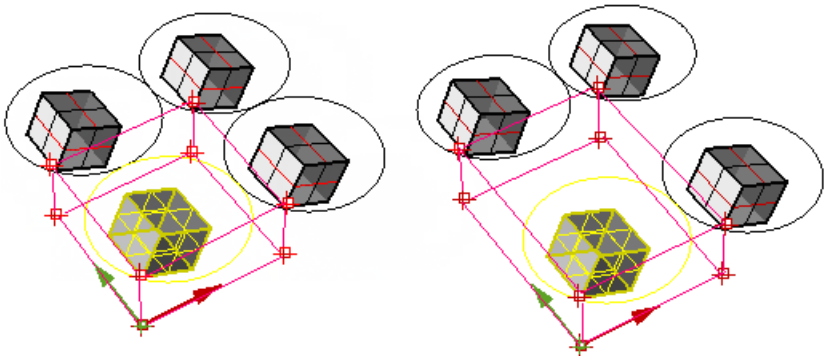
**Name**

The name of resulting paneling. A new layer is created with this name. The name is added to the start of each paneling object name.

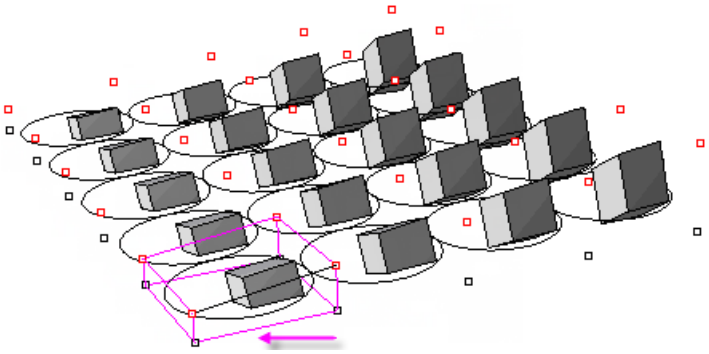
## ptPanel3DCustom

The **ptPanel3DCustom** command scales a given 3-D pattern bounding box to a unit grid box. (A unit grid is a box bounded by four points from the first bounding grid and four points from the second bounding grid.) Options scale the pattern and add spacing between each unit pattern and the next in u and v directions.

The following example uses two bounding grids and maps the bounding box of the 3-D module to each of the one-unit grid boxes.



*Default (left); increase length in the y-direction (right).*



*Unit grid box.*

## Command flow

1. Start the command.
2. Select the first bounding paneling grid.
3. Select the second bounding paneling grid.
4. Select two bounding surfaces (optional).
5. Select a 3-D pattern (any type of object).
6. Press **Enter** to accept options.

## Options

**Base_x**

The starting grid index in the u-direction. If set to **0**, start at minimum x.

**Base_y**

The starting grid index in the v-direction. If set to **0**, start at minimum y.

**Shift_x**

Set the spacing to **1** to pack the pattern.

Set the spacing to **2** to map every second paneling pattern unit grid.

**X_Length**

The module x-length. If increased, the pattern is scaled down in the x-direction.

**Y_Length**

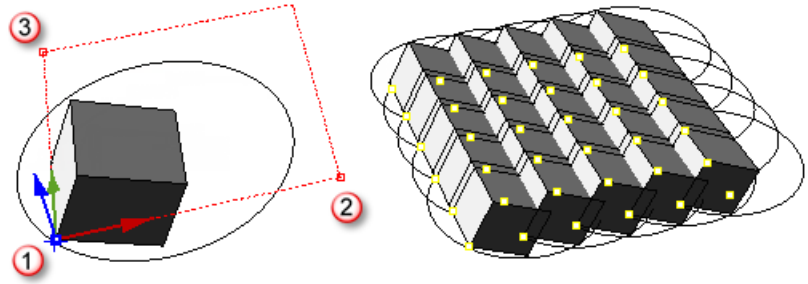
The module y-length.

**Z_Length**

The unit grid z-length.

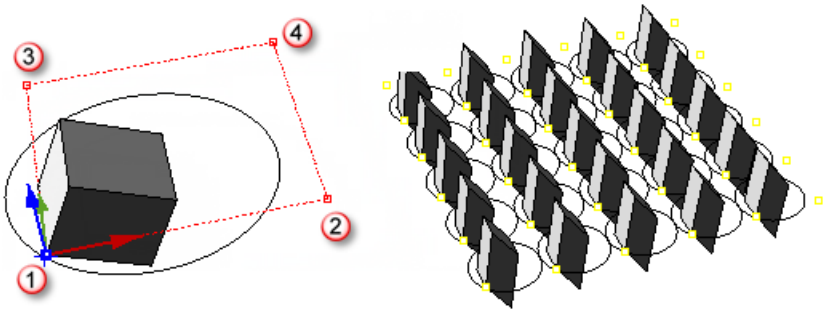
## ptOrientToGrid

The **ptOrientToGrid** command populates 3-D pattern objects to one paneling grid. This command gives additional control to define the input pattern base point, scale, and whether the mapping is rigid or deformed. The following example is a rigid transform that uses three reference points.




*Base point (1), x-reference (2), y-reference (3).*

If a fourth reference point is set, the object will be deformed when populating the grid.




*Base point (1), x_ref (2), y_ref (3), 4th ref point (4).*

### Command flow

1. Start the command.
2. Select the module objects. Press **Enter** when done.
3. Select the module base point, x-reference point and y-reference point.
4. If the module needs to maintain its size, press **Enter**.
   Or select al fourth point if the module should be deformed.
5. Select the paneling grid.
6. Press **Enter** to accept options.

### Options

**Base_x**

The starting grid index in the u-direction. If set to **0**, start at minimum x.

**Base_y**

The starting grid index in the v-direction. If set to **0**, start at minimum y.

**Shift_x**

Set the spacing to **1** to pack the pattern.

Set the spacing to **2** to map every second paneling pattern unit grid.

**Shift_y**

The shift amount in the y-direction.

**X_Length**

The number of x grid points to stretch along.

**Y_Length**

The unit grid y-length.

## ptPanel3DCustomVariable

The **ptPanel3DCustomVariable** command is similar to the **ptPanel3DCustom** command except that it allows defining a list of objects or generating mean surfaces between two input surfaces. The variation responds to surface curvature, attractors, vector, or randomly.

### Command flow

1. Start the command.
2. Select bounding paneling grids (the second one is optional).
3. Press **Enter** to accept options.
4. Select attractor points or curves (if applicable).
5. Select a list of patterns (or a start and end surface for the **Mean** option).
6. Press **Enter** to accept options.

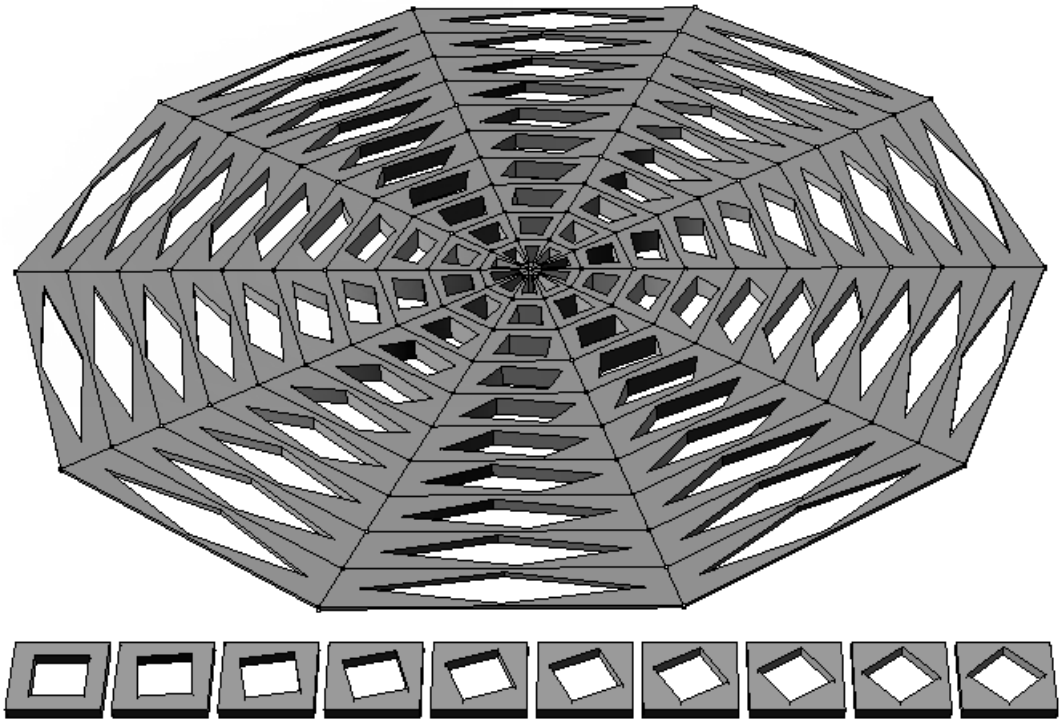
### Options

**PatternMethod**

The method for varying the input pattern.

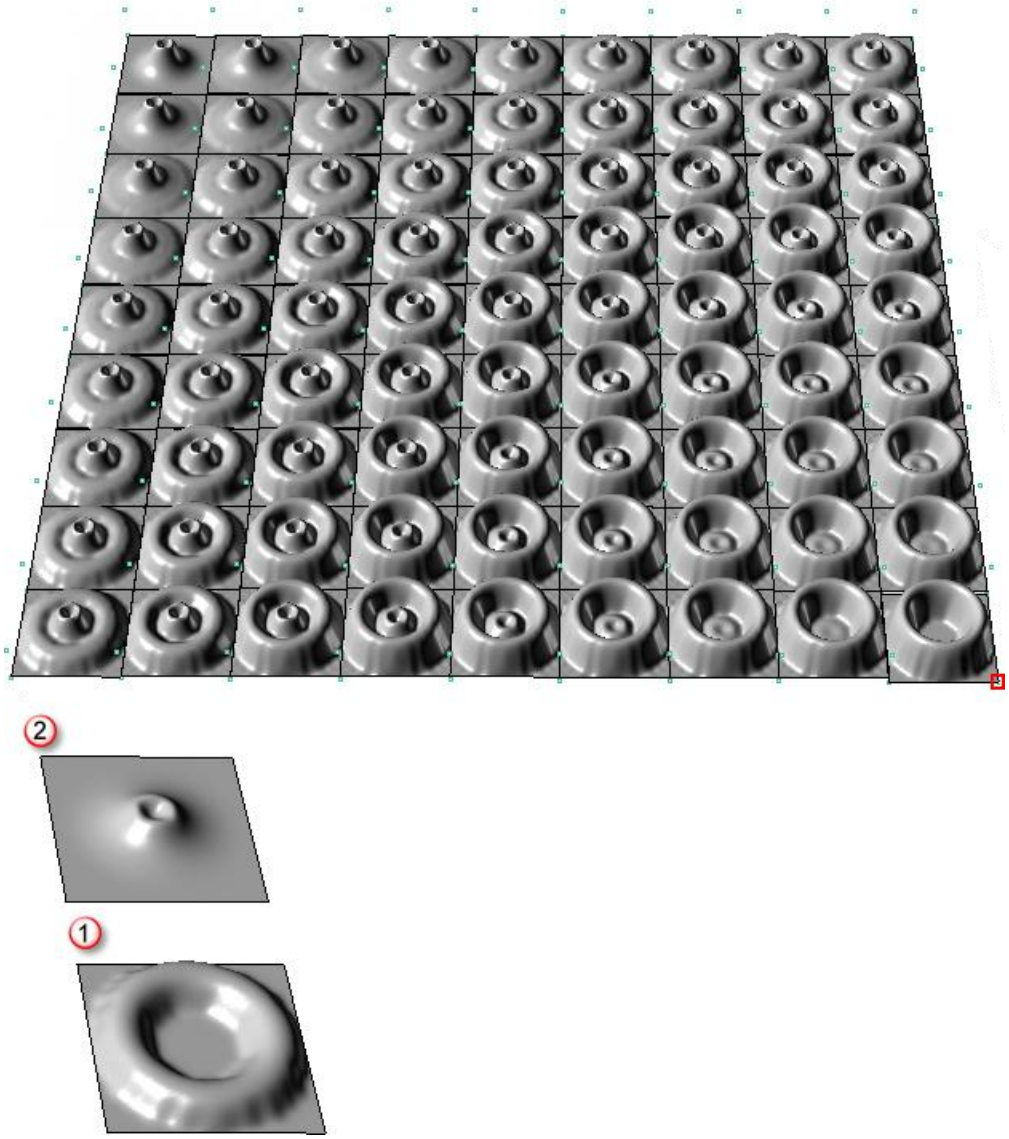
**List**

Enable selecting a list of patterns in order.



**Mean**

Calculates mean curves between two input surfaces. Surfaces must be untrimmed and pre-matched. Mean surfaces are generated similar to the **ptMeanSurfaces** command.




*Start pattern (1), end pattern (2).*

**DistributionMethod**

The method of calculating the distance factor for each square unit pattern. The distance factor is a normalized number between 0 and 1.

**GaussCurvature**

Use normalized surface (or grid) Gaussian curvature to define a factor between 0.0 and 1.0 for each square grid unit.

**MeanCurvature**

Use normalized surface (or grid) mean curvature to define a factor between 0.0 and 1.0 for each square grid unit.

**PointAttractors**

The factor is based on the normalized distance from a set of points.

**CurveAttractors**

The factor is based on the normalized distance from a set of curves.

**Vector**

The factor is based on the normalized angle with the input vector.

**Random**

Randomly assign a factor between 0.0 and 1.0 for each square grid unit.

**Group**

If **Yes**, group the resulting pattern.

**Name**

The name of resulting paneling. A new layer is created with this name. The name is added to the start of each paneling object name.

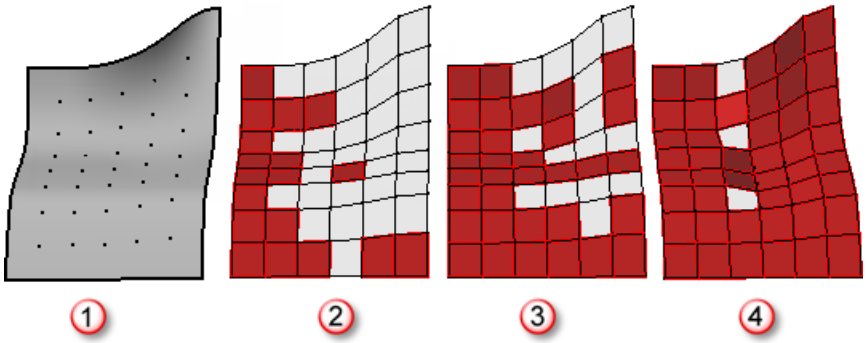
# Paneling Planar Quadrangles

Creating planar panels from a free-form base surface is an active area of research. The **ptPanelGridQuads** command provides very basic functionality to approximate an input paneling grid to maximize number of planar quadrangular panels. Following is the details of the command that supports this functionality.

## ptPanelGridQuads

The **ptPanelGridQuads** command adjusts paneling grid to create maximum number of quads within tolerance.

One way to have better quadrangle coverage is to increase the maximum deviation, but that increases distortion. Another way is to use a dense grid.




*Original grid - one surface (1), Deviation = 0.01 (2), Deviation = 0.1 (3), Deviation = 1.0 (4).*

### Command flow

1. Start the command.
2. Select paneling grid.
3. Select base surface or polysurface.
4. Press **Enter** to accept options.

### Options

**MaxDeviation**

Deviation from base grid. Higher deviation means better coverage and more distortion.

**Triangulate**

If **Yes**, quadrangles that are not made planar are split into two triangles.

**Group**

If **Yes**, group the resulting points.

**Name**

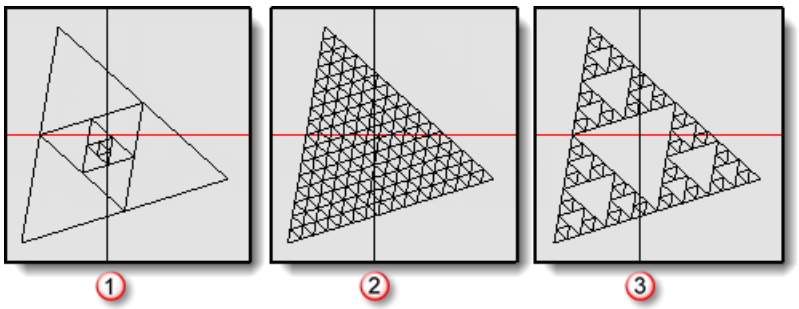
Grid name prefix attached to each point. The row and column location complete the point name.

# Commands: Paneling without a Grid

The **ptPanelSubDivide**, **ptPanelRandomPoints**, and **ptTriangulatePoints** commands do not create a base grid, but use either polylines or points on surface as an input to panel.

## ptPanelSubDivide

The **ptPanelSubDivide** command recursively subdivides any number of polylines on a base surface. Each new polyline connects the midpoints of the parent polyline segments.




*Main only (1), All (2), SubOnly (3).*

### Command flow

1. Start the command.
2. Select a base surface.
3. Select polylines.
4. Press **Enter** when done.

### Options

**Degree**

The number of subdividing steps.

**Method**

If **Yes**, group the resulting points.

**All**

Subdivide all resulting sub-polylines.

**SubOnly**

Subdivide sub-curves only.

**Main Only**

Subdivide the main curve only.

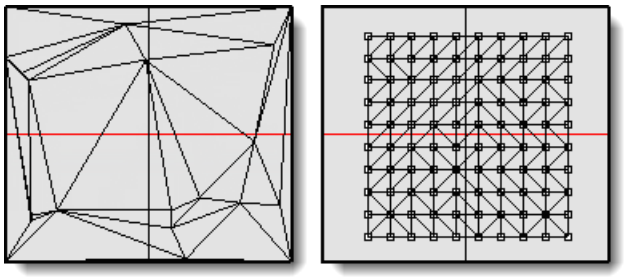
**PanelShape**

**Straight**

**Pull**

## ptPanelRandomPoints

The **ptPanelRandomPoints** command triangulates points on a base surface. You can select any number of points on a surface or let the command generate random points. The command solves triangulation of points on surface and solves for the shortest distance. It can be time consuming for a large set of points.



### Command flow

1. Start the command.
2. Select the base surface.
3. Select points on the surface.
4. Press **Enter** when done.

### Options

**GenerateRandomly**

If **Yes**, internally generate random points.

**PointCount**

The number of points to be generated.

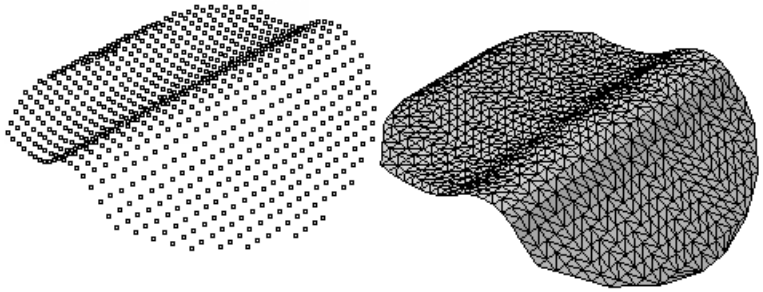
**PanelShape**

**Straight**

**Pull**

## ptTriangulatePoints

The **ptTriangulatePoints** command uses Delaunay triangulation to create a mesh from points. The command generates planar surfaces as an output. The **ptTriangulatePoints** command is appropriate for a large data set.

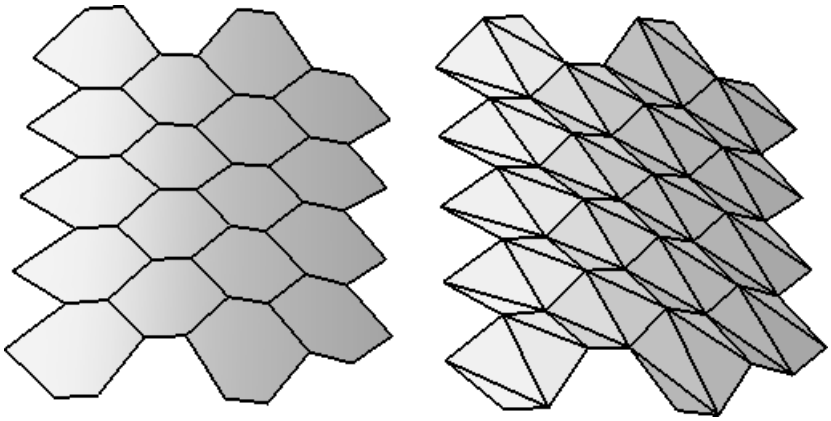


### Command flow

1. Start the command.
2. Select points.
3. Press **Enter** when done.

## ptTriangulateFaces

The **ptTriangulateFaces** command turns faces in the polysurfaces into triangular faces with straight edges. This helps when you need to approximate panels to unfold.



### Command flow

1. Start the command.
2. Select the input faces or a polysurface.
3. Press **Enter**.

### Options

**DeleteInput**

Deletes the input faces.

**Join**

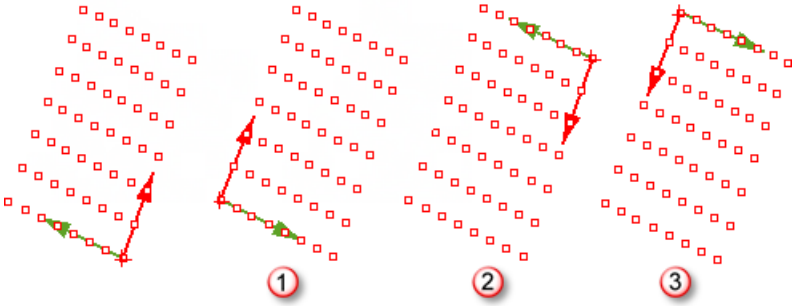
Joins the result.

# Commands: Grid Utilities

The paneling grid can be modified directly using Rhino commands to project a grid on a surface, pull back, delete parts of it, or transform it such as **Move**, **Scale**, **Rotate**, **SoftMove**. In general, any modification that does not change names of the grid of points is acceptable. Utility commands **ptDirection**, **ptRowsDirection**, **ptCompactGrid**, **ptCloseGrid**, **ptGridSeam**, **ptCleanOverlap**, **ptTrimGrid**, **ptOffsetPoints**, **ptChangeGridDensity**, **ptExtendGrid**, and **ptShiftGrid** help manipulate the paneling grid.

## ptDirection

The **ptDirection** command flips the u- and v-directions of the grid. This changes the names of points in the grid.




*VReverse=Yes (1), UReverse=Yes (2), U and V Reverse=Yes (3).*

### Command flow

1. Start the command.
2. Select a grid.
3. Press **Enter** to accept options.

### Options

**UReverse**

If **Yes**, reverse the u-direction of the grid.

**VReverse**

If **Yes**, reverse the v-direction of the grid.

**Group**

If **Yes**, group the resulting points.

**NameOfGrid**

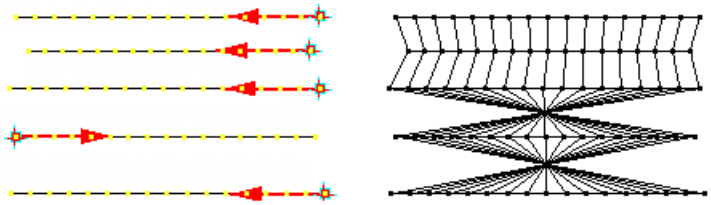
The name of paneling grid. Defaults to name of the selected grid point.

## ptSwapGridUV

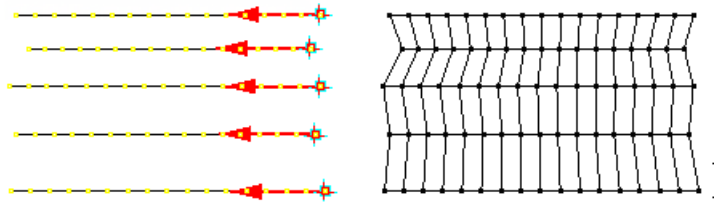
The **ptSwapGridUV** command swaps the u- and v-direction of a point grid.

## ptRowsDirection

The **ptRowsDirection** command reverses the direction of selected rows in a paneling grid.



*Flipped row directions cause twisted paneling.*



*The reversed row directions.*

### Command flow

1. Start the command.
2. Select a grid.
3. Select a row base point to flip its direction.

### Options

**Group**

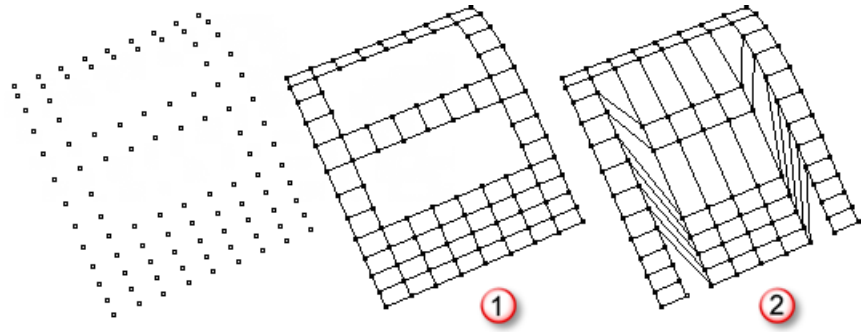
If **Yes**, group the resulting points.

**NameOfGrid**

The name of paneling grid. Defaults to name of the selected grid point.

## ptCompactGrid

The **ptCompactGrid** command removes holes in the selected grid. The command compacts rows and columns of points.



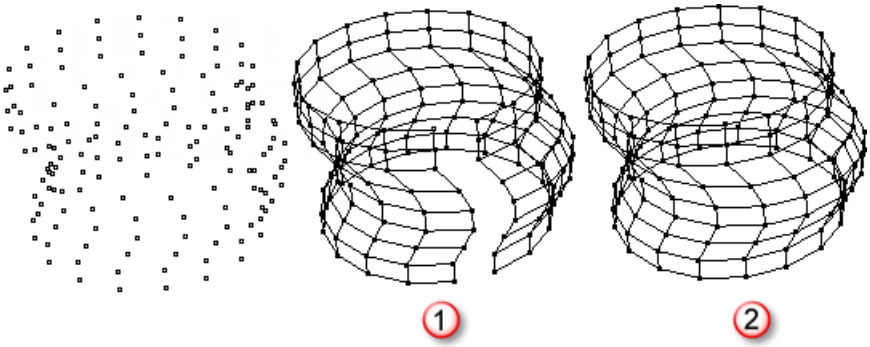

*Before compacting (1), after compacting (2).*

### Command flow

1. Start the command.
2. Select a grid.
3. Press **Enter** to accept.

## ptCloseGrid

The **ptCloseGrid** command closes selected grid in u-, v-, or both directions.




Before closing (1), after closing (2).

### Command flow

1. Start the command.
2. Select a grid.
3. Press **Enter** to accept.

### Options

**Direction**

Close in u-, v-, or both directions

**Group**

If **Yes**, group the resulting points.

**NameOfGrid**

The name of paneling grid. Defaults to name of the selected grid point.

**Overlap**

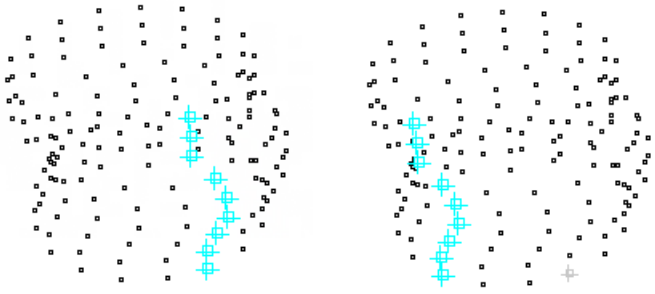
The number of rows or columns to overlap.

**StartIndex**

The index of the first row or column to overlap.

## ptGridSeam

The **ptGridSeam** command moves the grid seam in a closed paneling grid. This command is useful when seam points do not align.



*Shift=3, All=Yes to move all seam points three steps.*

### Command flow

1. Start the command.
2. Select a grid.
3. Select seam points to shift.
4. Press **Enter** when done

### Options

**Direction (U/V)**
Appears when the grid is closed in two directions.

**Shift**
Represents the number of steps a selected seam point moves by. It can be a positive or negative number.

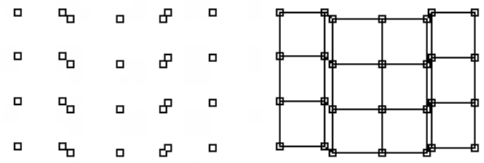
**All**
Moves all seam points together.

**Group**
If **Yes**, group the resulting points.

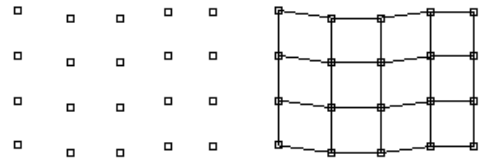
**NameOfGrid**
The name of paneling grid. Defaults to name of the selected grid point.

## ptCleanOverlap

The **ptCleanOverlap** command removes overlapped points in a paneling grid or merges them within tolerance. The command behaves differently if points to be merged are in one row versus in one column. The command deletes grid points that are within tolerance in the u-direction. It moves points within tolerance in the v-direction to overlap.



*Grid and panels before merging near grid points.*



*Grid and panels after merging.*

### Command flow

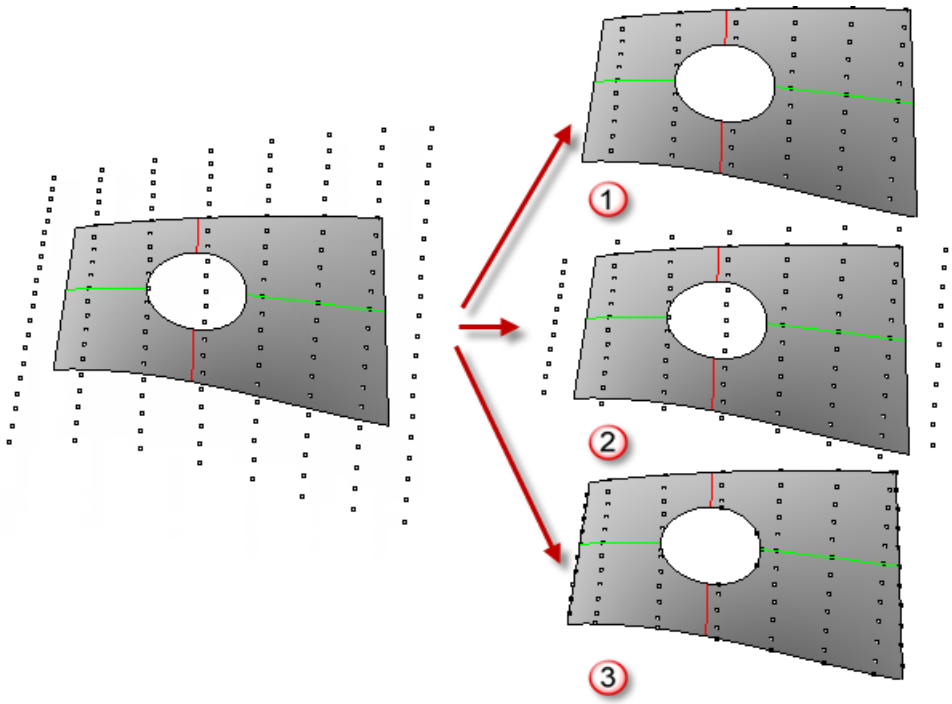
1. Start the command.
2. Select a grid.
3. Press **Enter** to accept the tolerance option.

### Options

**Tolerance**
The maximum distance between points to be merged.

## ptTrimGrid

The **ptTrimGrid** command trims a grid to a base surface or polysurface. It is possible to keep inside points, inside and points immediately outside, or move outside points to the closest points on the edge.




*Inside (1), Outside (2), Edge (3).*

### Command flow

1. Start the command.
2. Select a grid and select options.
3. Select a base surface or polysurface.

### Options

**Mode**

**Inside**
Select only inside points.

**Outside**
Select inside points and points immediately outside.

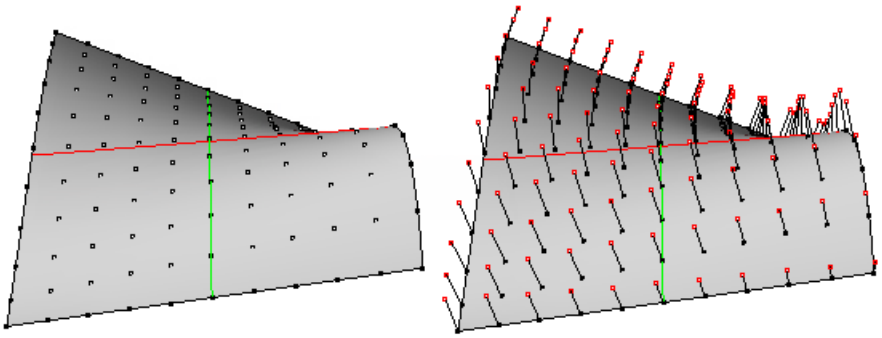
**Edge**
Move the nearest outside points to the closest edge.

**Group**
If **Yes**, group the resulting points.

**NameOfGrid**
The name of paneling grid. Defaults to name of the selected grid point.

## ptOffsetPoints

The **ptOffsetPoints** command offsets points on a surface or polysurface by a specified amount normal to that surface. An option connects input points with offset points.



### Command flow

1. Start the command.
2. Select a grid and options.
3. Select a base surface or polysurface.

### Options

**DistanceMethod**

**Fixed**
Offset with fixed distance

**GaussianCurvature**
Use the surface Gaussian curvature values.

**MeanCurvature**
Use the surface mean curvature values.

**AttractorPoints**
Shift towards attractor points

**SunVector**
Use tthe dot product between a vector and normal on surface at each point.

**Random**
Shift points by a random amount

**Distance (when DistanceMethod=fixed)**
The offset distance.

**MinDistance (when DistanceMethod is not fixed)**
The minimum offset distance.

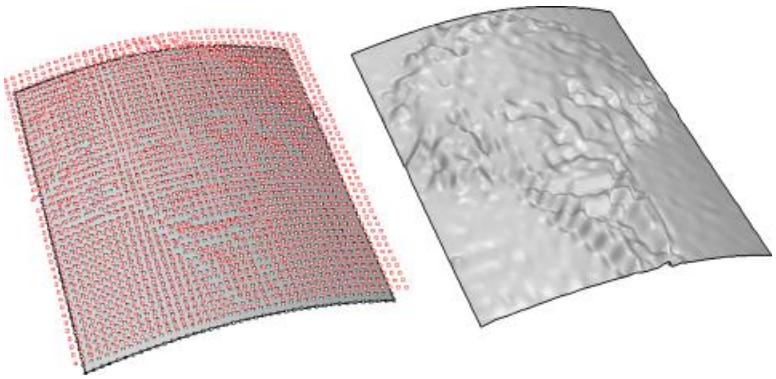
**MaxDistance (when DistanceMethod is not fixed)**
The maximum offset distance.

**Group**
If **Yes**, group the resulting points.

**Connect**
Draw lines between points and their corresponding offset points.

## ptOffsetGridByHeightfield

The **ptOffsetGridBtHeightfield** command offsets points on surface or polysurface by a variable distance normal to the surface using a base bitmap image.



### Command flow

1. Start the command.
2. Select a grid to offset.
3. Select a base surface or polysurface and set options.
4. Select an image.

### Options

**MinDistance**

The minimum offset distance.

**MaxDistance**

The maximum offset distance.

**CreateSurface**

Use offset grid to create new NURBS surface.

**Group**

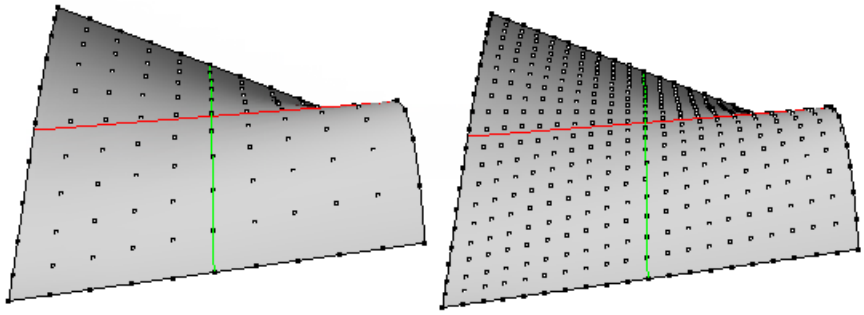
If **Yes**, group the resulting points.

**DeleteInput**

If **Yes**, the delete input grid.

## ptChangeGridDensity

The **ptChangeGridDensity** command increases or decreases grid density by adding or removing points in the u-, v- or both directions. It is also possible to keep the same density in either direction.



### Command flow

1. Start the command.
2. Select a grid and options.
3. Select a base surface or polysurface.

### Options

**UDensity**

The u-direction density mode.

**Increase**

**Decrease**

**Same**

**UNumber**

Number of points to add or remove between each two original grid points.

**VDensity**

The v-direction density mode.

**Increase**

**Decrease**

**Same**

**VNumber**

The number of points to add or remove between each two original grid points.

**DeleteInput**

Delete input grid.

**Group**

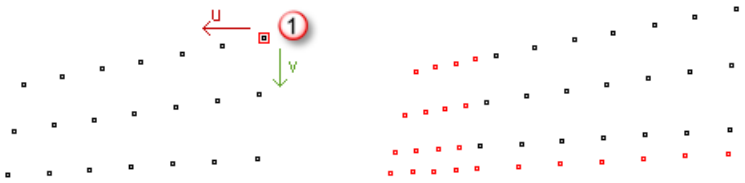
If **Yes**, group the resulting points.

**NameOfGrid**

The name of paneling grid. Defaults to name of the selected grid point.

## ptExtendGrid

The **ptExtendGrid** command adds grid points in the u-, v-, or both directions at a specified distance. The extension direction is calculated relative to the direction between the last two points in a row or column.




*Base point (1).*

### Command flow

1. Start the command.
2. Select a grid.
3. Press **Enter** to accept options.

### Options

**UExtend**

If **Yes**, extend the grid in the u-direction.

**UNumber**

The number of points to extend in the u-direction.

**UDistance**

The distance between points extended in the u-direction.

**VExtend**

If **Yes**, extend the grid in the v-direction.

**VNumber**

The number of points to extend in the v-direction.

**VDistance**

The distance between points extended in the v-direction.

**Group**

If **Yes**, group the resulting points.

**NameOfGrid**

The name of paneling grid. Defaults to name of the selected grid point.

## ptShiftGrid

The **ptShiftGrid** command shifts the index of the selected grid points by a specified amount. This helps space out a grid and create holes. It is also useful for combining existing grids.

*Shift in u-direction by 1.*

### Command flow

1. Start the command.
2. Select a grid.
3. Press **Enter** to accept options.

### Options

**RowShift**

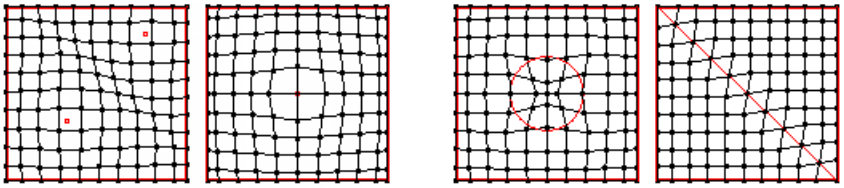
The number of steps shifted in the u-direction.

**ColShift**

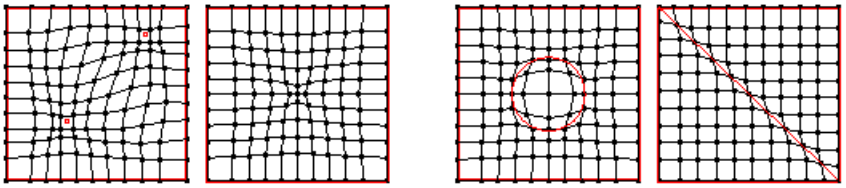
The number of steps shifted in the v-direction.

## ptShuffleGrid

The **ptShuffleGrid** command uses a reference surface and some parameters to redistribute a grid. If a surface is not available, then one is created from the input grid on the fly, and its parametric space is used to shuffle the grid. If you use a reference surface make sure that its u- and v-directions match the grid you are shuffling. If not, you can use commands like **ptDirection** or **ptSwapGridUV** to adjust the grid.



*Variable distribution away from attractor points and curves.*



*Variable distribution toward attractor points and curves.*

### Command flow

1. Start the command.
2. Select a grid.
3. Select a surface, or press **Enter** to accept options.
4. If using attractor points or curves, select reference points or curves.

### Options

**DistanceMethod**

**GaussianCurvature**

Use surface Gaussian curvature values.

**MeanCurvature**

Use surface mean curvature values.

**AttractorPoints**

Shift towards or away from attractor points.

**AttractorCurves**

Shift towards or away from attractor curves.

**SunVector**

Use the dot product between a vector and normal on the surface at each point.

**Random**

Shift points by a random amount.

**AttractMethod**

Either away or towards attractor points or curves. If the **DistanceMethod** is **Mean** or **Gaussian**, attract towards or away from the highest curvature.

**Magnitude**

Increasing the magnitude exaggerates the effect.

**Group**

If **Yes**, group the resulting grid.

**DeleteInput**

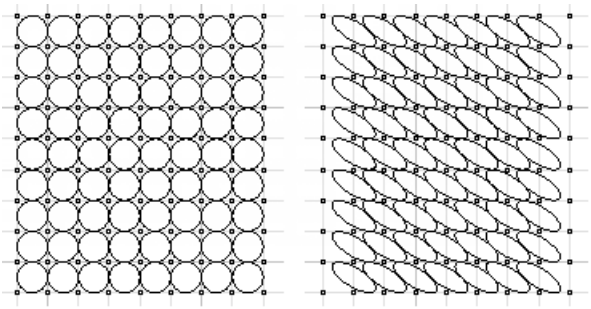
If **Yes**, deletes input grid.

## ptConvertToDiagonalGrid

The **ptConvertToDiagonalGrid** command converts a rectangular paneling grid into a diagonal grid. This is useful when populating patterns that need to go in a specific direction other than rectangular.

**Note**: The resulting grid does not necessarily follow the surface u- and v-directions, and therefore you may not be able to properly modify them with commands like **ptShuffleGrid**.

In the following example, a circle is populated using the **ptPanelGridCustom** command on a rectangular diagonal grids.



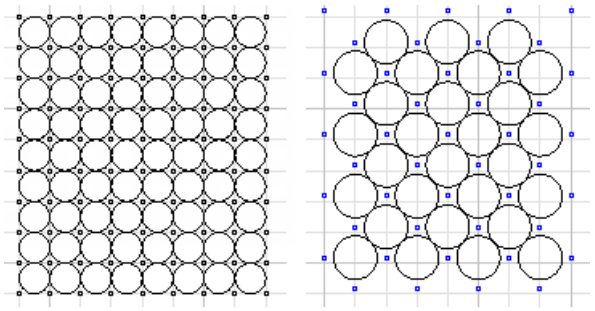
*Rectangular (left) and diagonal (right).*

## ptConvertToDiamondGrid

The **ptConvertToDiamondGrid** command converts a rectangular paneling grid into a diamond grid. This is useful when populating patterns that need to go in a specific direction other than rectangular.

**Note**: The resulting grid does not necessarily follow the surface u- and v-directions and therefore you may not be able to properly modify them with commands like **ptShuffleGrid**.

In the following example, a circle is populated using the **ptPanelGridCustom** command on a rectangular and diamond grid.



*Rectangular (left) and diamond (right).*

## ptWeaveGrids

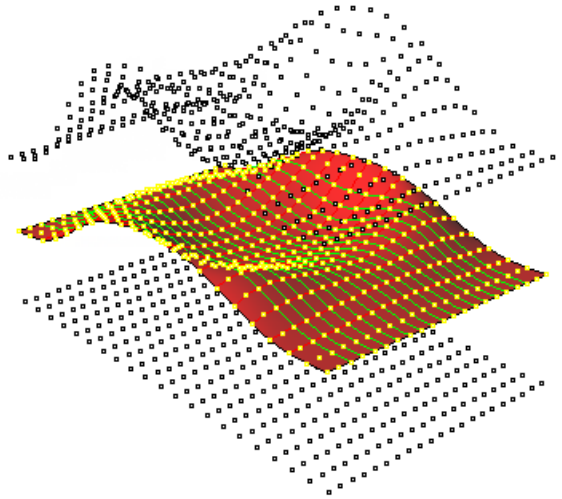
The **ptWeaveGrids** command creates a new grid by weaving rows from two input grids.

## ptExtractCenterGrid

The **ptExtractCenterGrid** command extracts the center point grid of the input grid. Center points are relevant to each four grid unit. An option allows selecting a base surface to pull center points to.

## ptMeanGrid

The **ptMeanGrid** command makes intermediate surfaces between two input grids. The command does not align seam location for closed surfaces or match the u- and v-direction or parameterization.



### Command flow

1. Start the command.
2. Select a starting grid.
3. Select an ending grid.
4. Set number of intermediate grids, or press **Enter** to accept default number.

### Options

**NumberOfGrids**

The number of mean grids.

**CreateSrf**

Use intermediate grid to create a surface

**Group**

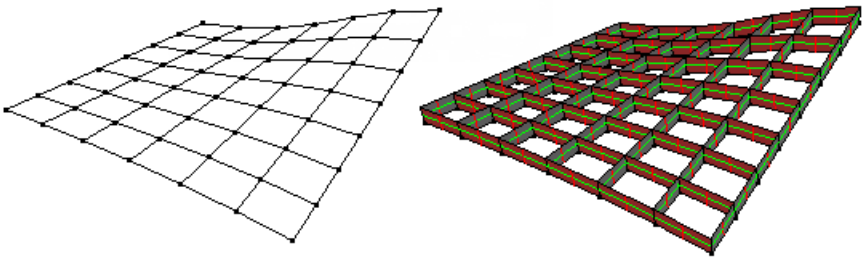
If **Yes**, group the resulting grid.

# Commands: Paneling Utilities

Panels generated with paneling commands are standard Rhino geometry. They can be curves, surfaces, polysurfaces, or meshes. Any Rhino command can be used to manipulate them. In addition, **ptExtrudeEdges**, **ptOffsetEdges**, **ptFinEdges**, **ptUnifyFacesDirection**, **ptAnalyzeFlatFaces**, **ptGroupSimilarPanels**, **ptUnrollFaces**, **ptUnrollEdges**, **ptUnrollPoints**, **ptOffsetBorder**, and **ptPlanarLips** commands can help special situations.

## ptExtrudeEdges

The **ptExtrudeEdges** command extrudes paneling edges normal to a base surface or in a specified direction.



### Command flow

1. Start the command.
2. Select curve panels.
3. Select base surface (optional), or pick two points for direction.

### Options

**HeightMethod**

**Fixed**
Extrude with fixed distance

**GaussianCurvature**
Use surface Gaussian curvature values

**MeanCurvature**
Use surface mean curvature values.

**AttractorPoints**
Shift towards attractor points

**SunVector**
Use dot product between a vector and normal on surface at each point.

**Random**
Shift points by random amount

**Height *(when HeightMethod=fixed)***
Extrude distance.

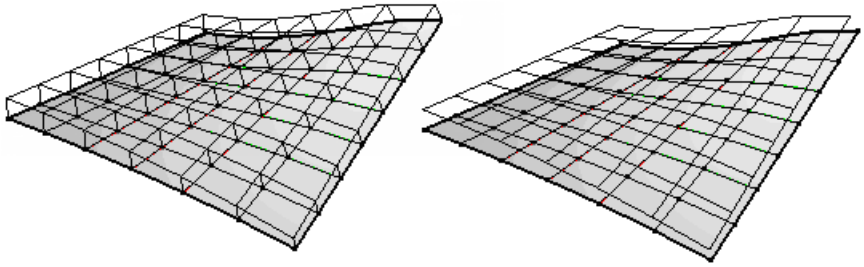
**MinHeight *(when HeightMethod is not fixed)***
Minimum extrude distance.

**MaxHeight *(when HeightMethod is not fixed)***
Maximum extrude distance.

**NameEnding**
Suffix added to edge name to serialize extruded parts.

## ptOffsetEdges

The **ptOffsetEdges** command offsets paneling edges using base surface. If no base is available, use **ptSurfaceFromGridOfEditPoints** command to create one.



*Connect=Yes (left), Connect=No (right).*

### Command flow

1. Start the command.
2. Select curve panels.
3. Select base surface.

### Options

**DistanceMethod**

**Fixed**
Offset with fixed distance

**GaussianCurvature**
Use surface Gaussian curvature values

**MeanCurvature**
Use surface mean curvature values.

**AttractorPoints**
Sift towards attractor points

**SunVector**
Use dot product between a vector and normal on surface at each point.

**Random**
Shift points by random amount

**Distance *(when DistanceMethod=fixed)***
Offset distance.

**MinDistance *(when DistanceMethod is not fixed)***
Minimum offset distance.

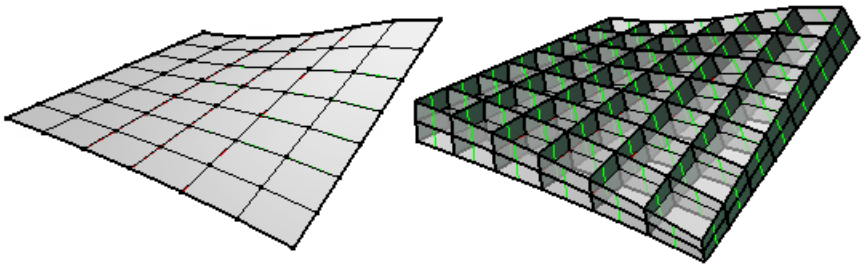
**MaxDistance *(when DistanceMethod is not fixed)***
Maximum offset distance.

**Connect**
If **Yes**, connect offset edges with input edges.

**NameEnding**
Prefix added to edge name to serialize extruded parts.

## ptFinEdges

The **ptFinEdges** command extrudes paneling edges using a base surface. The fin can be on one or both sides.



### Command flow

1. Start the command.
2. Select curve panels.
3. Select base surface.

### Options

**DistanceMethod**

**Fixed**
Offset with fixed distance

**GaussianCurvature**
Use surface Gaussian curvature values

**MeanCurvature**
Use surface mean curvature values.

**AttractorPoints**
Sift towards attractor points

**SunVector**
Use dot product between a vector and normal on surface at each point.

**Random**
Shift points by random amount

**Distance *(when DistanceMethod is fixed)***
Offset distance.

**MinDistance *(when DistanceMethod is not fixed)***
Minimum offset distance.

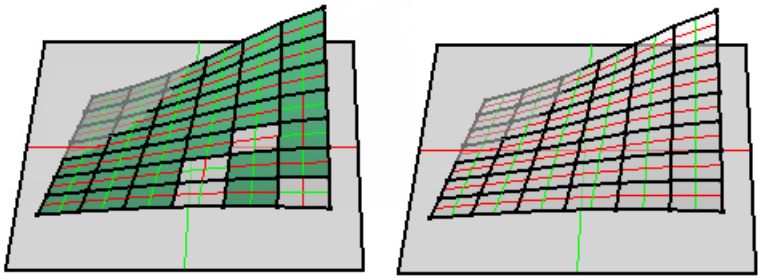
**MaxDistance *(when DistanceMethod is not fixed)***
Maximum offset distance.

**NameEnding**
Suffix added to edge name to serialize extruded parts.

**BothSides**
If **Yes**, fin both sides.

## ptUnifyFacesDirection

The **ptUnifyFacesDirection** command orients u-, v-, and normal directions of the input faces relative to a base surface.



*A few input faces have flipped normal and swapped uv compared to a base surface.*

### Command flow

1. Start the command.
2. Select input faces.
3. Select base surface to use its u-, v-, and normal direction as a reference.

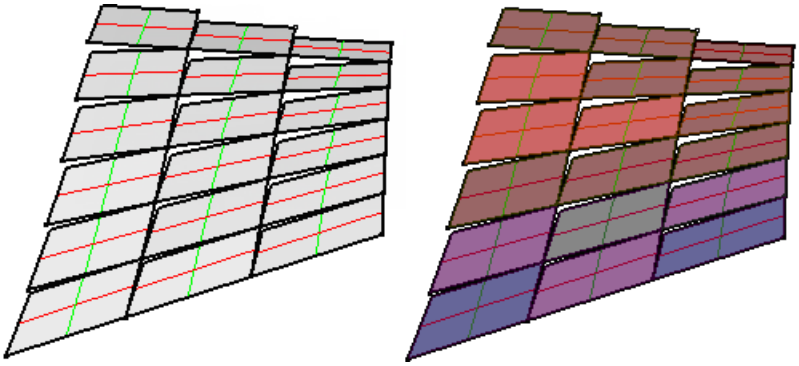
### Options

**UnifyUV**

Match reference surface u- and v-directions.

## ptAnalyzeFlatFaces

The **ptAnalyzeFlatFaces** command creates an analysis mesh to show the amount of deviation of flat surfaces from their base surface. When creating flat surfaces with the **ptPanelGrid** command, the deviation amount is saved as user data on each surface. This information is used to create the analysis mesh.

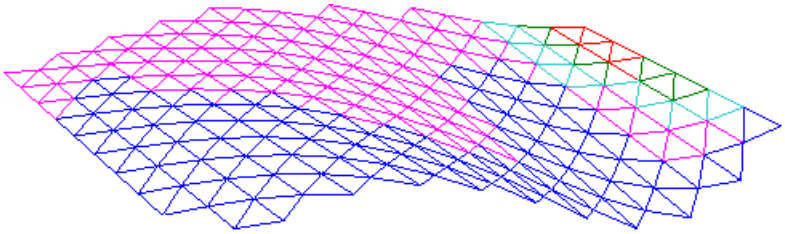


### Command flow

1. Start the command.
2. Select flat faces (faces created with **ptPanelGrid** **> FlatFaces** option).
3. Press **Enter** when finished.

## ptGroupSimilarPanels

The **ptGroupSimilarPanels** command groups similar curves together within a given tolerance. Similar curves have similar edge length within tolerance.



### Command flow

1. Start the command.
2. Select input paneling curves.
3. Press **Enter** to complete.

### Options

**Tolerance**

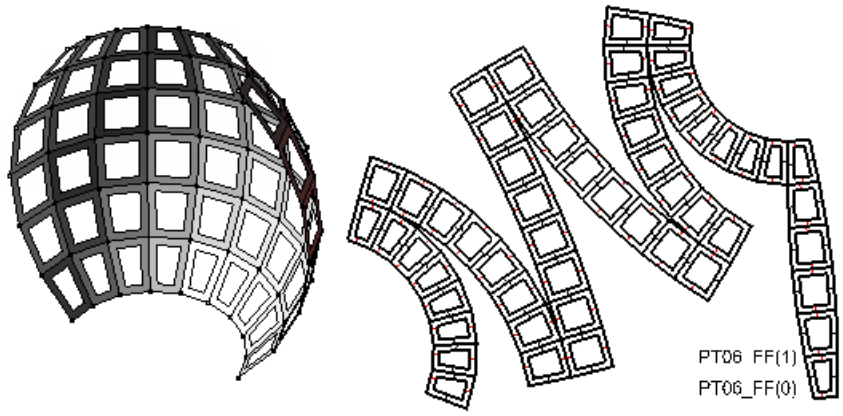
Difference in edge length allowed for panels to be considered similar.

## ptUnrollFaces

The **ptUnrollFaces** command unrolls surfaces into one polysurface and keeps input surface attributes (name, user-data, etc.).

### Command flow

1. Start the command.
2. Select faces.
3. Press **Enter** to complete.




### Options

**Explode**

If **Yes**, explode the unrolled faces.

**Label**

Places matching numbered dots on the edges of the original polysurface and the flattened surfaces.

**Layer**

**Current**

Add unrolled faces to current layer.

**NewSubLayer**

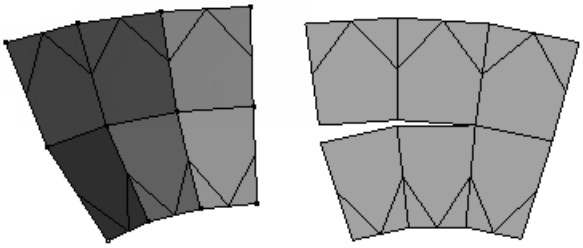
Add unrolled faces to a new sub layer.

**SubLayerName**

Name of the sub layer.

## ptUnrollEdges

The **ptUnrollEdges** command unrolls edges using a base surface or polysurface. Attributes of input edges are passed to unrolled ones.



### Command flow

1. Start the command.
2. Select curves on a surface or a polysurface.
3. Select the base surface or polysurface.

### Options

**Layer**

**Current**

Add unrolled edges to current layer.

**NewSubLayer**

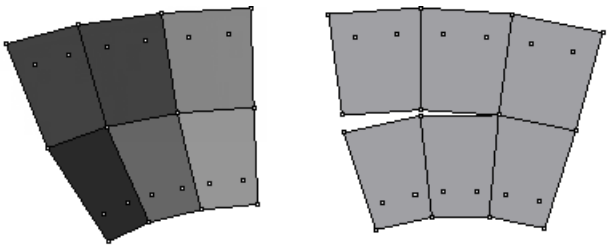
Add unrolled edges to a new sub layer.

**SubLayerName**

Name of the sub layer.

## ptUnrollPoints

The **ptUnrollPoints** command unrolls points using a base surface or polysurface. Attributes of input points are passed to unrolled ones.



### Command flow

1. Start the command.
2. Select points on a surface or a polysurface.
3. Select the base surface or polysurface.

### Options

**Layer**

**Current**
Add unrolled points to current layer.

**NewSubLayer**
Add unrolled points to a new sub layer.

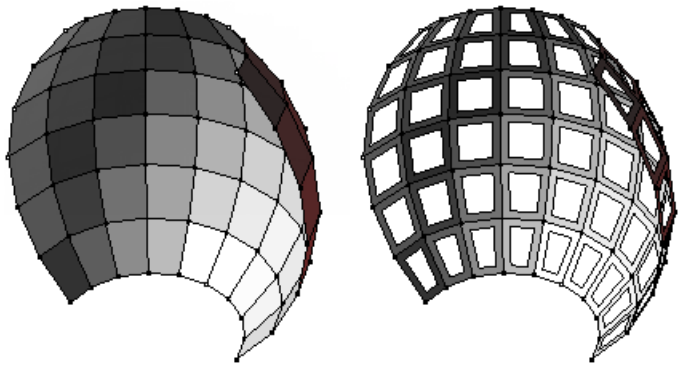
**SubLayerName**
Name of the sub layer.

## ptOffsetBorder

The **ptOffsetBorder** command offsets face borders inwards with an option to create a hole.

### Command flow

1. Start the command.
2. Select paneling faces.
3. Press **Enter** to accept.



### Options

**DistanceMethod**

**Fixed**
Offset with fixed distance

**GaussianCurvature**
Use surface Gaussian curvature values

**MeanCurvature**
Use surface mean curvature values.

**AttractorPoints**
Sift towards attractor points

**SunVector**

Use dot product between a vector and normal on surface at each point.

**Random**

Shift points by random amount

**Distance *(when DistanceMethod is fixed)***

Offset distance on surface.

**MinDistance *(when DistanceMethod is not fixed*)**

Minimum offset distance.

**MaxDistance *(when DistanceMethod is not fixed)***

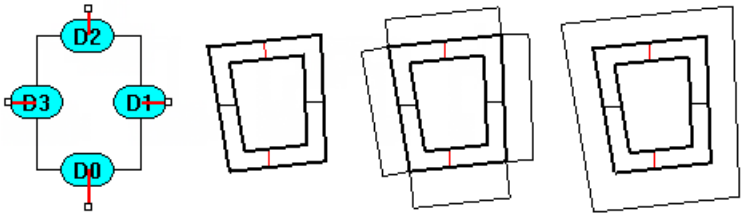
Maximum offset distance.

**MakeHole**

If **Yes**, use offset curve to drill a hole in the face.

## ptPlanarLips

The **ptPlanarLips** command adds edge extrusions (lips) to a planar surfaces. This is useful for unrolled faces that will be used for fabrication. The command uses a reference polyline to define the offset directions and the offset distance for each direction.




### Command flow

1. Start the command.
2. Select a polyline to use its edges as a direction reference.
3. Select faces to add lips.
4. Press **Enter** to accept.

### Options

**Output**

Output format.

**Curve**

**Surface**

**ConnectEdges**

If **Yes**, extend and connect offset edges of input face.

**TypeOfDistance**

**Uniform**

Distance is the same is all directions.

**Variable**

Each direction can be set to a different offset distance.

**DeleteInput**

If **Yes**, delete input faces.

**Distance**

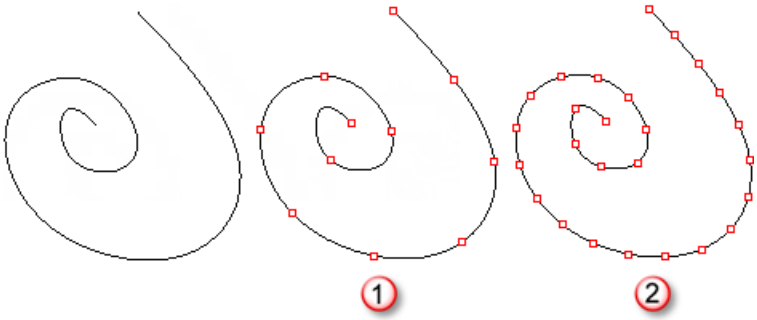
Offset distance. If **TypeOfDistance**=***Variable***, each tagged edge will have a separate distance value to set (D1, D2, etc.)

# Commands: General Utilities

The utility commands **ptDivideCurveSpan**, **ptDivideCurveByChordLength**, and **ptSurfaceFromGridOfControlPoints** divide curves, create NURBS surfaces from a paneling grid, and label data.

## ptDivideCurveSpan

The **ptDivideCurveSpan** command finds curve division points by a number or the distance along curve.




*Number=10 (1) , Distance=1.0 (2).*

### Command flow

1. Start the command.
2. Select curves.
3. Press **Enter** to accept options.

### Options

**Method**

**Number** **NumberOfSpans**

The number of spaces between division point.

**ArcLength** **Length**

The along-curve distance between division points.

**Round**

If **Yes**, round the distance up or down to fill the whole curve.

**RoundingMethod**

**Up**

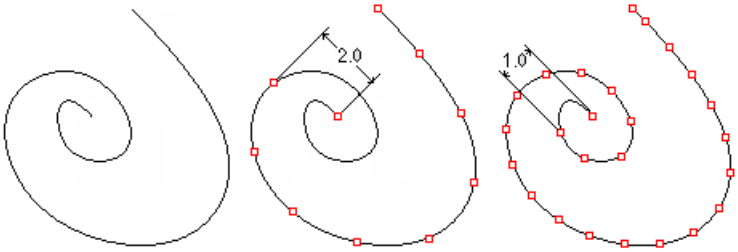
**Down**

**Group**

If **Yes**, group resulting points.

## ptDivideCurveByChordLength

The **ptDivideCurveByChordLength** command finds curve division points by chord length (straight-line distance) between points. The algorithm uses sphere intersections with the curve to find points.




### Command flow

1. Start the command.
2. Select curves.
3. Press **Enter** to accept options.

### Options

**Distance**

The straight-line distance between points.

**AddEndPoint**

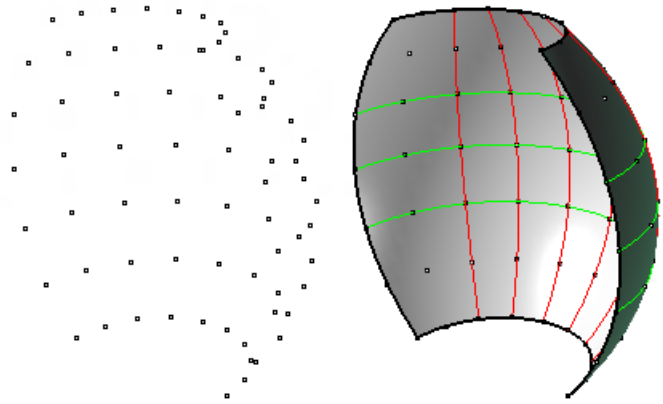
If **Yes**, add a point to the end of the curve.

**Group**

If **Yes**, group resulting points.

## ptSurfaceFromGridOfEditPoints

The **ptSurfaceFromGridOfEditPoints** command creates a NURBS surface through the grid points using the grid points as the surface edit points.

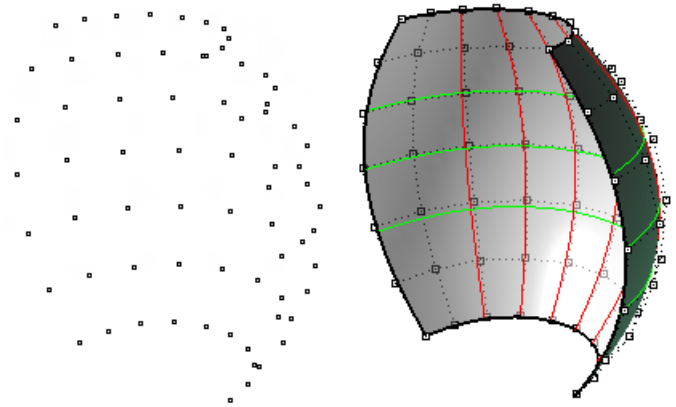


### Command flow

1. Start the command.
2. Select grid points.
3. Press **Enter** to complete.

## ptSurfaceFromGridOfControlPoints

The **ptSurfaceFromGridOfControlPoints** command creates a NURBS surface using the point grid as the surface control points.

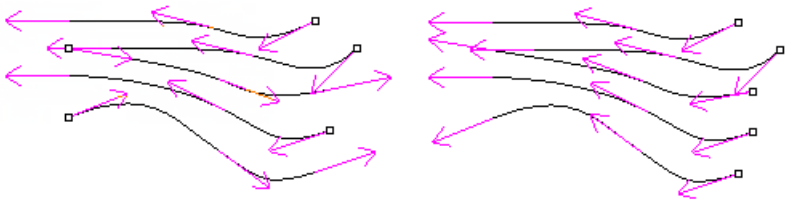


### Command flow

1. Start the command.
2. Select grid points.
3. press **Enter** to complete.

## ptUnifyCurvesDirection

The **ptUnifyCurvesDirection** command changes the direction of curves to point in the same general direction.



## ptTagObjects

The **ptTagObjects** command tags objects with their names as text or dots.


*Tag with Dot (1), Tag with text (2).*

### Options

**TagMode**

**Dot**

Tag with dots.

**Text**

Tag with text.

**Height**

The text height.

## ptSerializeObjectsName

The **ptSerializeObjectsName** command adds a serialized name to objects (points, curves, and surfaces).

### Options

**SortMethod**

Sort order method.

**OrderOfSelection**

Use the selection order.

**Coordinates**

Use world coordinate values.

**Direction**

Pick two points to specify a direction.

**Surface**

Use a reference surface.

**Prefix**

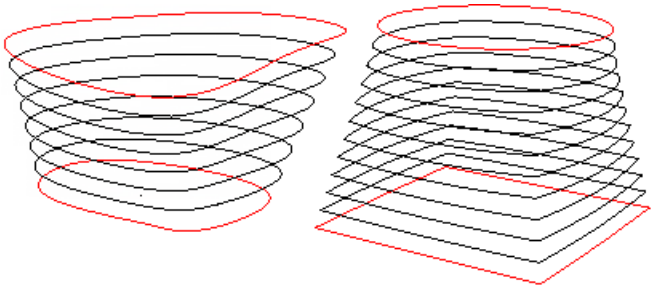
The name prefixed to the serial number.

**StartIndex**

The starting number.

## ptMeanCurves

The **ptMeanCurves** command makes intermediate curves between two input curves. The command does not align the seam locations for closed curves. Use the **CrvSeam** command to check and align seam locations.

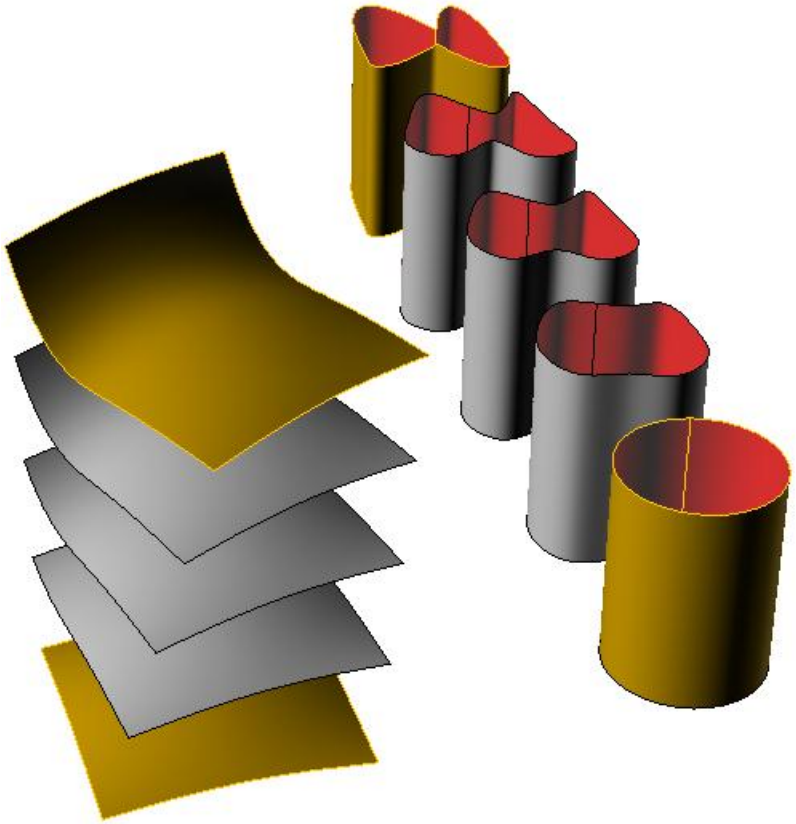


### Command flow

1. Start the command.
2. Select the start curve.
3. Select the end curve.
4. Specify the number of intermediate curves, or press **Enter** to accept the default number.

## ptMeanSurfaces

The **ptMeanSurfaces** command makes intermediate surfaces between two input surfaces. The command does not align seam locations for closed surfaces or match u- and v-directions or parameterization. The command works best if a starting surface is created and then copied and edited to create the end surface. An option generates a surface with a distance factor between the two surfaces.



### Command flow

1. Start the command.
3. Select an untrimmed starting surface.
4. Select an untrimmed ending surface.
5. Specify a number of intermediate surfaces, or press **Enter** to accept default number.

### Options

**Method**

Sort using one of the following methods.

**ByNumber**

Specify the number of mean surfaces.

**ByDisFactor**

Specify a distance between the surfaces. The factor must be between 0 and 1.

**CreateSrf**

Use intermediate grid to create a surface.

**Group**

If **Yes**, group the output surfaces.

## ptRemoveOverlappedPoints

The **ptRemoveOverlappedPoints** command is a cleaning function that removes overlapped points. It can be used before calling one of the serialize commands to avoid duplicates.

# Commands: Serializing for FE analysis

The **ptSerializeEdges**, **ptSerializePoints**, **ptTagSerializedData**, **ptExportEdgesSerializeData**, and **ptExportPointsSerializeData** commands add user data to serialize and store information on points and edges and to label geometry and export formatted text to a file.

## ptSerializePoints

The **ptSerializedPoints** command serializes a set of points relative to coordinates and adds serial numbers with a user string to the point object. The **ptTagSerializedData** command can then be used to visualize the data in Rhino.

### Options

**DataString**

Stores data associated with the selected points. The string is set to "null" if no data is available.

**StartIndex**

The starting index for serial numbers.

## ptSerializeEdges

The **ptSerializeEdges** command serializes a set of edges relative to coordinates and adds serial numbers with a user string to the point object. The **ptTagSerializedData** command can be used to visualize the data in Rhino.

This command should be called after serializing end points of the edges using the **ptSerializePoints** command. The information about serial numbers of end points is also stored on the edges as user data. If end points are not serialized, the command will serialize them first.

### Options

**DataString**

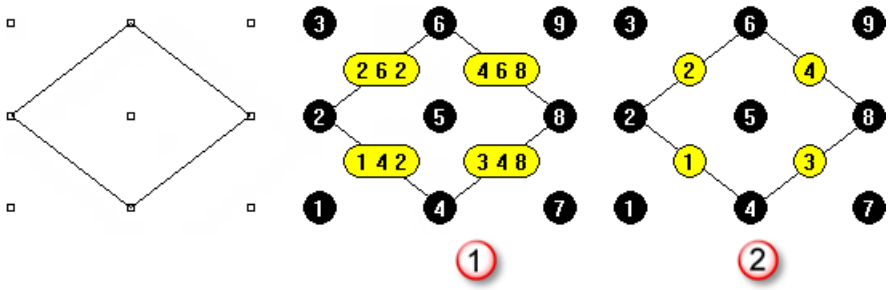
Store data associated with the selected edges. The string is set to "null" if no data is available.

**StartIndex**

The starting index for serial numbers.

## ptTagSerializedData

The **ptTagSerializedData** command tags points and edges with the user data created with the **ptSerializePoints** and **ptSerializeEdges** commands.




*DisplaySerialOnly=No (1), DisplaySerialOnly=Yes (2).*

### Options

**TagMode**

**Dot**

Tag with dots.

**Text**

Tag with text.

**Height**

The text height.

**DisplaySerialOnly**

If **Yes**, ignores the edge end point serial numbers and the point and edge data strings.

## ptExportPointsSerializeData

The **ptExportPointsSerializeData** command creates a text file with serialized data created with the **ptSerializePoints** command.

### Command flow

1. Start the command.
2. Select points and select options.
3. Specify a target file

### Options

**AddPointsCoordinates**

Output points coordinates (x, y and z).

**Description**

Specify a title for the file. This is set to "null" if none is available.

**StartString**

The prefix string to be added before each point datum.

**EndString**

The suffix string to be added after each point datum.

**NewLine**

If **Yes**, separate points output by a new line.

**PrintPointSerial**

If **No**, the serial number will not display.

**Append**

Append the data to an existing file.

**SetTargetFile**

Specify the file.

## ptExportEdgesSerializeData

The **ptExportEdgesSerializeData** command creates a text file with serialize data created with the **ptSerializeEdges** command.

### Command flow

1. Start the command.
2. Select points and set options.
3. Set target file.

### Options

**Description**
Specify a title for the file. This is set to "null" if none is available.

**StartString**
The prefix string to be added before each edge datum.

**EndString**
The prefix string to be added before each edge datum.

**NewLine**
If **Yes**, separate edges output by a new line.

**PrintEdgeSerial**
If **No**, the serial number will not display.

**Append**
Append to an existing file.

**SetTargetFile**
Specify the file.

# Command List


**ptAnalyzeFlatFaces**
Creates an analysis mesh to show amount of deviation of flat surfaces from their base surface.


**ptChangeGridDensity**
Increases or decreases grid density.


**ptCleanOverlap**
Removes overlapped points in a paneling grid or merges them within tolerance.


**ptCompactGrid**
Removes holes in the selected grid.


**ptCloseGrid**
Closes selected grid in u-, v-, or both directions.


**ptConvertToDiagonalGrid**
Converts a rectangular paneling grid into a diagonal grid.


**ptConvertToDiamondGrid**
Converts a rectangular paneling grid into a diamond grid.


**ptDirection**
Flips the u- and v-directions of the grid.


**ptDivideCurveByChordLength**
Finds curve divide points by chord length (straight-line distance) between points.


**ptDivideCurveSpan**
Finds curve division points by number or distance along curve.


**ptExportEdgesSerializeData**
Creates a text file with serialize data created with the **ptSerializeEdges** command.


**ptExportPointsSerializeData**
Creates a text file with serialize data created with the **ptSerializePoints** command.


**ptExtendGrid**
Adds grid points in u-, v- or both directions at the specified distance.


**ptExtractCenterGrid**
Extracts center point grid of the input grid.


**ptExtrudeEdges**
Extrudes paneling edges normal to a base surface or a specified direction.


**ptFinEdges**
Extrudes paneling edges using base surface.


**ptGridArray**
Creates an array of parallel points.


**ptGridArrayPolar**

Creates a polar array of points.


**ptGridCurve**

Generates a grid by projecting a direction curve to a surface


**ptGridCurve2**

Generates a grid by projecting two direction curves to a surface.


**ptGridExtrude1**

Uses one curve and extrudes division points in parallel or polar directions.


**ptGridExtrude2**

Extrudes points of a base curve along a path curve.


**ptGridPoints**

Uses u- and v-values from a base surface as a parallel reference grid.


**ptGridPointsOnSurface**

Turns points existing on a surface into a valid grid of paneling points.


**ptGridSeam**

Changes the grid seam in a closed paneling grid.


**ptGridSurfaceDistance**

Divides a surface by specified distances in the u- and v-directions.


**ptGridSurfaceDomainChord**

Divides a surface in both u-and v-directions by a specified distance.


**ptGridSurfaceDomainLength**

Divides the surface domain in both u- and v-directions by a specified length.


**ptGridSurfaceDomainNumber**

Divides surface domain in both u- and v-directions by a specified number of spans.


**ptGridSurfaceDomainVariable**

Divides a surface in both u- and v directions by a specified number and then moves the grid points using attractors.


**ptGridUCurves**

Uses an existing array of curves to create a paneling grid.


**ptGridUVCurves**

Creates paneling points at u and v curve intersections.


**ptGroupSimilarPanels**

Groups similar curves together within a given tolerance.


**ptLoad2DPatterns**

Imports a pattern file created with the **ptSave2DPatterns** command.


**ptLoad3DPatterns**

Loads a pattern file created with the **ptSave3DPatterns** command.


**ptManage2DPatterns**

Creates, edits, and deletes custom 2-D patterns.


**ptManage3DPatterns**

Creates, edits, and deletes custom 3-D patterns.


**ptMeanCurves**

Makes intermediate curves between two input curves.


**ptMeanGrid**

Makes intermediate surfaces between two input grids.


**ptMeanSurfaces**

Makes intermediate surfaces between two input surfaces.


**ptOffsetBorder**

Offsets faces borders inwards with an option to create a hole.


**ptOffsetEdges**

Offsets paneling edges using base surface.


**ptOffsetGridBtHeightfield**

Offsets points on surface or polysurface by a variable distance normal to the surface using a base bitmap image.


**ptOffsetPoints**

Offsets points on surface or polysurface by a specified amount normal to that surface.


**ptOrientToGrid**

Populates 3-D pattern objects to one paneling grid.


**ptPanel3D**

Creates 3-D paneling.


**ptPanel3DCustom**

Scales a 3-D-pattern bounding box to a unit grid box.


**ptPanelGridCustomVariable**

Scales, rotates, translates, and defines a list of shapes, or generates mean curves between two shapes.


**ptPanelGrid**

Generates 2-D patterns from a base grid and allows access to pre-defined connecting patterns and user-defined patterns.


**ptPanelGridCustom**

Uses a free-form pattern that cannot be represented by connecting grid points.


**ptPanel3DCustomVariable**

Scales, rotates, translates, and defines a list of shapes, or generates mean curves between two shapes, defines a list of objects, or generates mean surfaces between two input surfaces.

**ptPanelGridQuads**

Adjusts paneling grid to create maximum number of quadrangles within tolerance.

**ptPanelRandomPoints**

Triangulates points on a base surface. Select any number of points on surface or generates random points.

**ptPanelSubDivide**

Recursively subdivides any number of polylines on a base surface. Each new polyline connects the midpoints of parent polyline segments.

**ptPlanarLips**

Generates edge extrusions (lips) to planar surfaces.

**ptRemoveOverlappedPoints**

Removes overlapped points.

**ptRowsDirection**

Reverses the direction of selected rows in a paneling grid.

**ptSave2DPatterns**

Saves custom 2-D patterns

**ptSave3DPatterns**

Saves 3-D patterns.

**ptSerializeEdges**

Serializes a set of edges relative to coordinates and adds serial numbers with user string to the point object.

**ptSerializeObjectsName**

Adds a serialized name to objects.

**ptSerializePoints**

Serializes a set of points relative to coordinates and adds serial numbers with a user string to the point object.

**ptShiftGrid**

Shifts the index of selected grid points by the specified amount.

**ptShuffleGrid**

Uses reference surface and some parameters to redistribute a given grid.

**ptSurfaceFromGridOfControlPoints**

Creates a NURBS surface using the point grid as surface control points.

**ptSurfaceFromGridOfEditPoints**

Creates a NURBS surface through the grid points using the grid points as surface edit points.

**ptSwapGridUV**

Swaps the u- and v-direction of a point grid.

**ptTagObjects**

Tags objects with their names as text or dots.

**ptTagSerializedData**

Tags objects (points and edges) with the user data created with the **ptSerializePoints** and **ptSerializeEdges** commands.

**ptTriangulateFaces**

Turns faces in the polysurfaces into triangular faces with straight edges.

**ptTriangulatePoints**

Uses Delaunay triangulation to create a mesh from points. The command generates planar surfaces as an output.

**ptTrimGrid**

Trims a grid to a base surface or polysurface.

**ptUnifyCurvesDirection**

Unifies the direction of curves to point in the same general direction.

**ptUnifyFacesDirection**

Orients u-, v-, and normal directions of the input faces relative to a base surface.

**ptUnrollEdges**

Unrolls edges using a base surface or polysurface.

**ptUnrollFaces**

Unrolls surfaces that do not have to be joined in one polysurface

**ptUnrollPoints**

Unrolls points using a base surface or polysurface.

**ptWeaveGrids**

Creates a new grid by weaving rows from two input grids.