geomagic®

STUDIO®

the magic of making it simple ™

INTERACTIVE USER GUIDE

Four Basic Workflows for Studio 10

Proprietary and Restricted Rights Notice

Guide History

Date	Revision
March 2008	First Release
March 2008	Second Edition

About Geomagic Inc.

Geomagic, Inc. is a worldwide software and services company headquartered in Research Triangle Park, North Carolina (U.S.A.), with subsidiaries in Europe and Asia and distributors worldwide. Geomagic is the market leader in digital shape sampling and processing (DSSP) with a vision of mass customization, technology innovation, and business performance. Geomagic software enables customers to accelerate product development cycles and ensure quality at every step. More than 5,000 professionals use Geomagic software and services across diverse industries including automotive, aerospace, medical, and consumer products.

Contact Information

Geomagic, Inc.
P.O. Box 12219
Research Triangle Park, NC 27709 USA
Phone: +1 (800) 251-551 or +1 (919) 474-0122
Fax: +1 (919) 474-0216

Web Sites

Geomagic, Inc.	http://www.geomagic.com
Technical Support	http://support.geomagic.com
Training	http://training.geomagic.com

Email Addresses

Technical Support	support@geomagic.com
Training	training@geomagic.com
Services	servicesinfo@geomagic.com
Sales	salesinfo@geomagic.com

Table of Contents

1 GUIDE DESCRIPTION

This Guide leads an advanced beginner through four fundamental workflows of Geomagic Studio 10. The goal is to highlight the differences and expected results of each workflow, enabling you to choose the best workflow for a real-life project.

The Guide requires Geomagic Studio 10 with the Capture, Wrap, Shape, and Fashion module licenses. It's filled with live links to data files and Online Help, so it is best viewed from the Geomagic web site rather than in printed form.

1.1 Introduction

The four fundamental workflows are:

Preferred Workflow	• **Precise reproduction of underlying data with emphasis on curved regions** (data capture, cleanup, conversion to a polygon object, refinement of the polygon object, surfacing with the "Detect Contours" method in the Shape Phase, and exporting to CAD). An advantage of this technique is that the resulting CAD object has distinct faces for the curved regions, thus allowing curved regions to be further engineered in the external system if necessary. See section 2.3.1, "Shape Phase with Emphasis on Curved Regions."
	• **Precise reproduction of underlying data** ("legacy workflow") (data capture, cleanup, conversion to a polygon object, refinement of the polygon object, and surfacing with the "Detect Curvature" method in the Shape Phase). This is a legacy workflow that customers find useful in certain situations—"Precise reproduction of underlying data with emphasis on curved regions" is typically preferred over this workflow. See section 2.3.2, "Shape Phase Legacy Workflow".
Preferred Workflow	• **Optimized reproduction of underlying data with output of trimmed surfaces** (data capture, cleanup, conversion, refinement, and surfacing with the "Detect Contours" and "Create Trimmed Surfaces" method in the Fashion Phase). The purpose of this technique is to capture an object's "design intent" by generating a complete set of CAD faces (representing both the primary surfaces and the connectors between primary surfaces). See section 2.4.2, "Fashion Phase with Output of Trimmed Surfaces."
	• **Optimized reproduction of underlying data with output of untrimmed surfaces** (data capture, cleanup, conversion, refinement, and surfacing with the "Detect Contours" and "Extract Untrimmed Surfaces" method in the Fashion Phase). CAD faces reflecting "primary surfaces" are generated, but not the faces for transitions between those surfaces. The Extract Untrimmed Surfaces command and this workflow exist only as a shortcut to one of the results that can be obtained from "Create Trimmed Surfaces". See section 2.4.3, "Fashion Phase with Output of Untrimmed Surfaces."

In Geomagic Studio, an object always exists in one of several Phases:

- **Point Phase:** the state of an object when it is a collection of scanned points.
- **Polygon Phase:** the state of an object when its appearance is approximated by drawing a triangular surface between every three data points.
- **Surface Phase** (either Shape Phase or Fashion Phase): the state of an object when a reproducible surface is being applied over its underlying polygon mesh.
- **CAD Phase:** the state of an object when it is ready for trimming or for Boolean operations to be performed.

The phases and four fundamental workflows are illustrated in Figure 1.

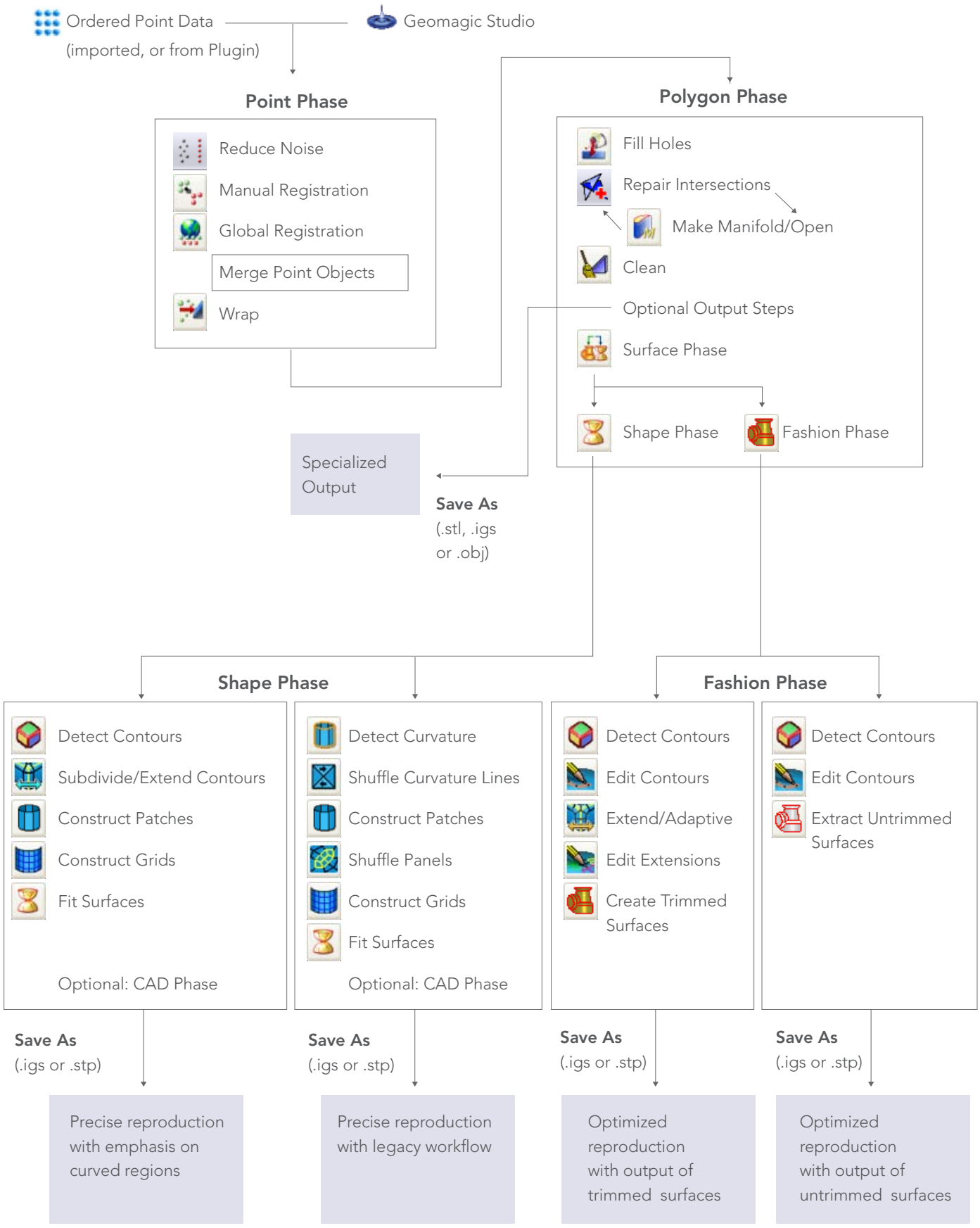


Figure 1. Phases and Four Basic Workflows of Geomagic Studio 10

2 FOUR FUNDAMENTAL WORKFLOWS

The instructions in this document use example files available from the Geomagic web site. To obtain the examples, download the data files from the web page on which you found this Guide to a directory of your choice. Double-click it to extract the example files that are referenced in this Guide, then start Geomagic Studio 10.

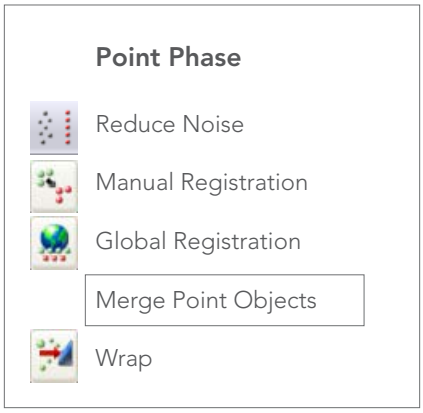
It is possible to open the first file, follow the instructions carefully, and complete a workflow without opening another file. But each step also mentions a specific file name that provides a new starting point. For example, the result of steps applied to **Handle1.wrp** in Step 1 can be checked by opening **Handle2.wrp**.

2.1 Point Phase

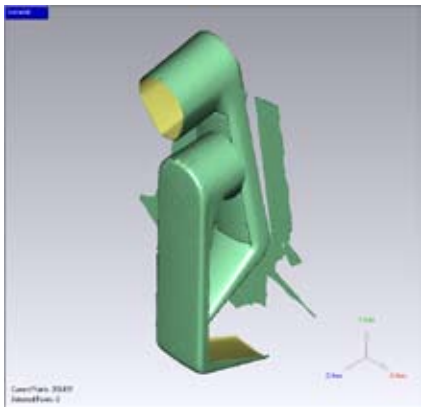
The Point Phase procedure explains how to register and merge two point objects into a single object, and represent that object as a polygon object.

The typical way to begin is to obtain one or more Point objects, either by creating them with a scanner plugin or by opening an existing Point object file. The Guide Dog gets you started by offering an existing Point object file.

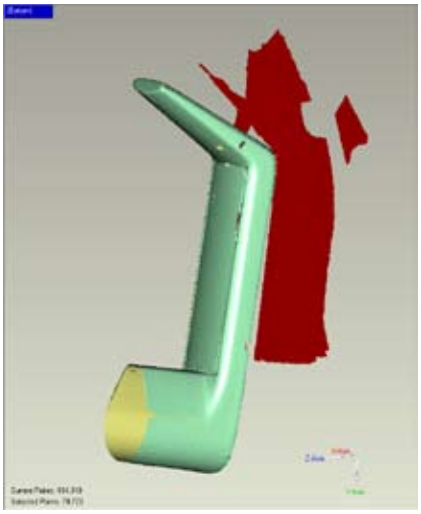
These steps are common to all four workflows described in this document.



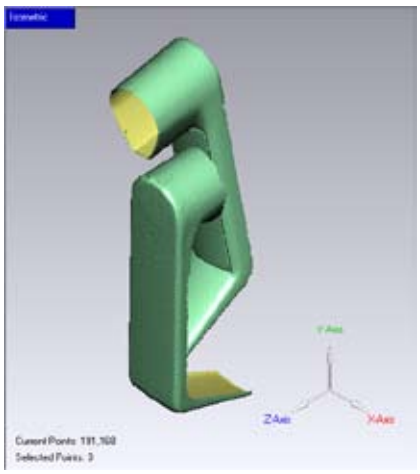
Step 1. Open Handle1.wrp in Geomagic Studio 10. This object contains two scans: Underside and Topside.



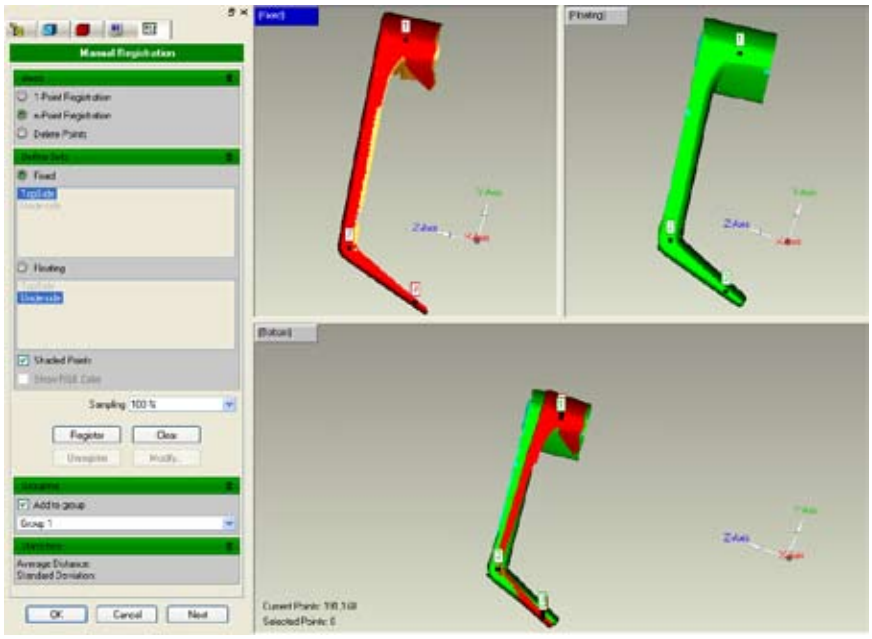
Step 2. Select the Underside scan in the Model Manager. Use the selection tools to highlight (in red) and delete the tabletop from Underside.



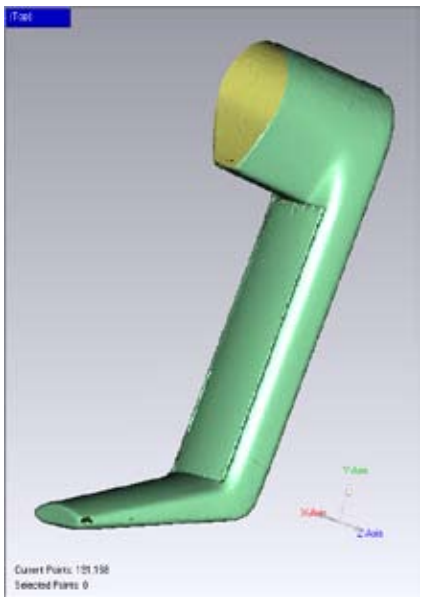
Step 3. Select the Underside and Topside scans in the Model Manager. These objects contain extraneous data points, so use Points > Reduce Noise with "Prismatic Shape" selected to reduce noise on both objects. To perform the reduction, simply press **Apply** and then **OK.** It is often necessary to use **Edit > Select > Outliers** and then delete the outliers.



Step 4. With **Handle2.wrp**, use Tools > Registration > Manual Registration to achieve a rough registration of the two halves. Pick "Topside" as the Fixed object, and "Underside" as the Floating object. Use "n-Point Registration" and pick at least three points on the Fixed and the same three points on the Floating, then press **Register** and **OK.** The parts become aligned.



Step 5. Select Tools > Registration > Global Registration to lock the two halves tightly. After you press **Apply** and **OK**, the halves are well registered but remain as separate objects (as shown to the right). At this stage, the object appears to be a smooth surface—increasing the magnification on the object still reveals the points.

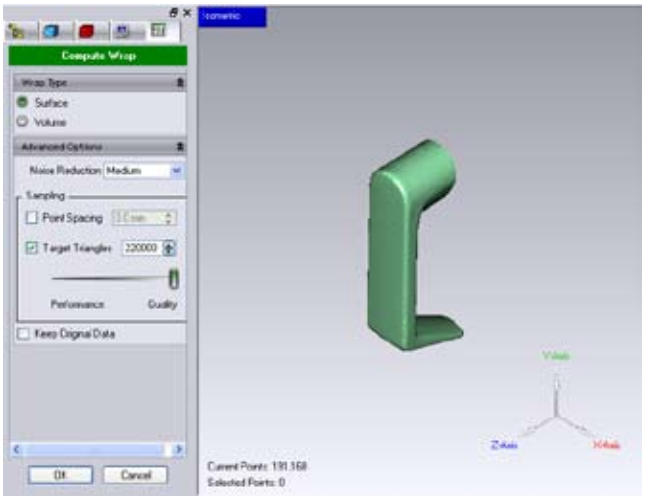


The two halves are locked tightly together after registration.

Step 6. With **Handle3.wrp**, use Points > Merge Point Objects to create a single point object that represents the whole door handle. When prompted, name the single object "WholeHandle".

Step 7. With **Handle4.wrp**, use Points > Uniform Sample to create an evenly dense point cloud. Accept the default settings, then press **Apply** and **OK.**

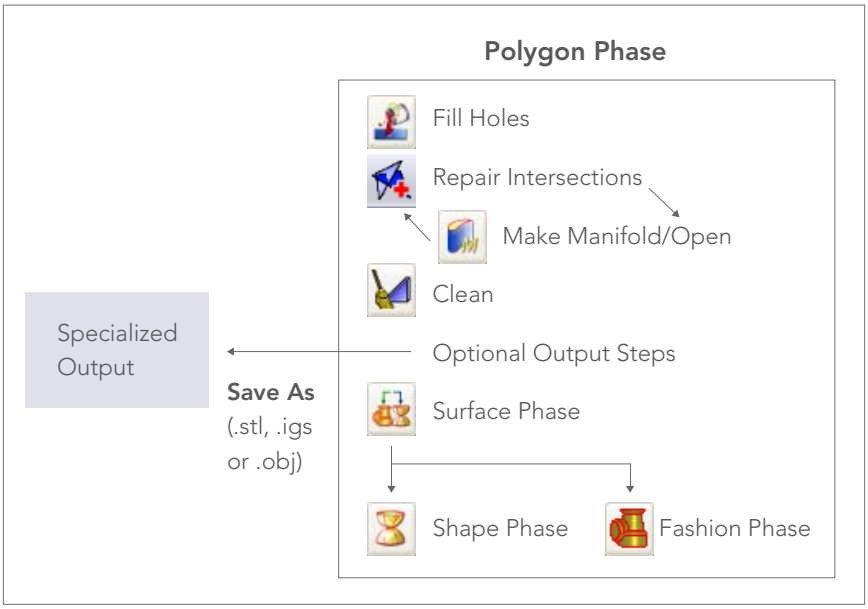
Step 8. Create a polygon object by using Points > Wrap. Use a "Surface Wrap", set the "Target Triangles" to 220,000, and set "Noise Reduction" to Medium. (This noise reduction supplements the reduction performed earlier.) To minimize the amount of data in the Model Manager, uncheck "Keep Original Data."



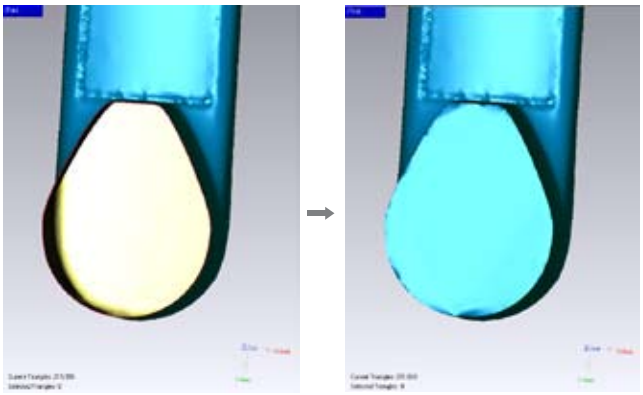
The Point Phase is now complete. The object has become a Polygon object.

2.2 Polygon Phase

The steps in the Polygon Phase walk you through cleaning up the polygon object in preparation for moving to the Surface Phase or for exporting specialized outputs.



Step 1. With **Handle5.wrp**, use Polygons > Fill Holes to intelligently fill the gaps in the polygon surface. For best results, start by filling the largest hole individually by clicking on its border and use "Flat Filling".



*Before **Fill Holes** (left) and after fill (right)*

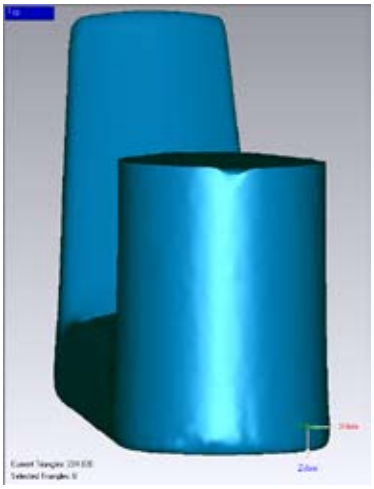
Step 2. All remaining holes, even tiny and unnoticeable ones, can be filled simultaneously by pressing **Fill All** with "Curvature-Based Filling".

Step 3. Use Polygons > Clean to "clean up" the polygon further. For additional cleanup tools, see the Help for the Polygons Menu.

Step 4. With **Handle6.wrp**, use Polygons > Repair Intersections in "Defeature" mode to delete and replace disorganized triangles that are remnants of the hole-filling process.

Step 5. Use Polygons > Make Manifold Open to force all triangles to be connected on all three sides. Now use Repair Intersections in the Clean/Relax mode (which tends to flatten the array or triangles), then Make Manifold Open again. Repeat **Polygons > Repair Intersections** in "Defeature" mode. Verify that **Repair Intersections** has detected Zero bad intersections and then use **Polygons > Make Manifold Open** for the last time.

Step 6. With **Handle7.wrp**, use Polygons > Clean and check the **Smooth** checkbox. (There's no fixed set of commands that must be performed on all Polygon objects—subsequent steps on this door handle are optimized by this smoothing step.)



The object is now a highly refined Polygon object that is ready to be taken to one of the Surface Phases (Shape Phase or Fashion Phase) or to be exported using one of the optional output steps.

2.2.1 Optional Output Steps

Typically, users will continue directly to one of the Surface Phases. There are at least two commonly used files which are exported at this point: saving the polygon object as-is as a .stl or .obj file and exporting a section from a polygon object.

2.2.1.1 Saving the Polygon Object for use by Other Apps

Many external software packages accept an .stl or .obj representation of a polygon object. To create one now, right-click the WholeHandle object in the Model Manager, then select **Save**, and Save As **Type** .stl or .obj.

2.2.1.2 Exporting a Profile from a Polygon Object

A two-dimensional section of the Polygon object can also be exported now so that a 3D solid can be reconstructed in an external CAD system. This is a common "side usage" of Geomagic Studio.

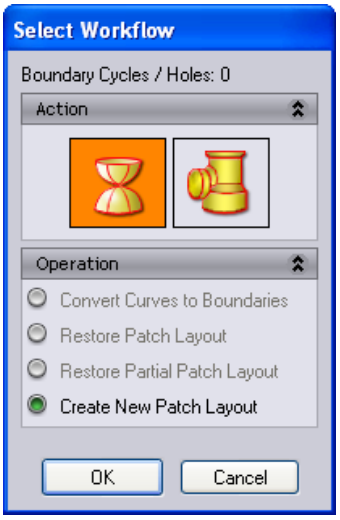
Step 1. Start by creating a section using Polygons > Curves by Section. Pressing **Compute** and **OK** generates a "Curves" object in the Model Manager.

Step 2. Right-click the object in the Model Manager and save it with a file type of .obj or .igs.

2.2.2 Choosing the Next Phase

Once the Polygon Phase has been completed, the next step is to move to either the Shape or Fashion Phase.

Step 1. Open **Handle8.wrp** and press the **Surface Phase** icon. Depending on the intended workflow, click the **Shape Phase** or **Fashion Phase** icon. In either case, pick "Create New Patch Layout", and press **OK.**



For the **Shape Phase** ("with Emphasis on Curved Regions" or "Legacy Workflow"), continue at section 2.3.

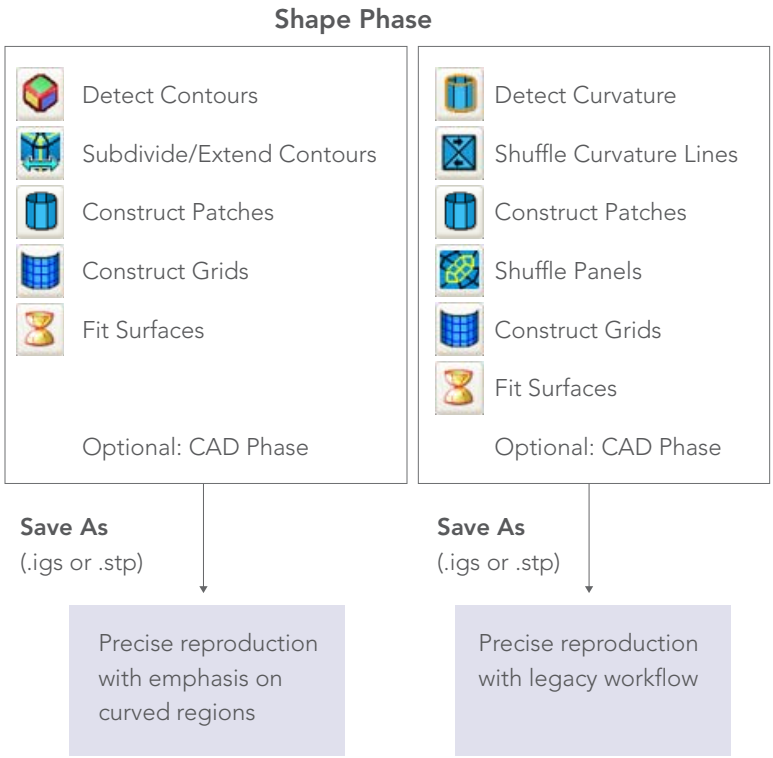
For the **Fashion Phase** (with "Output of Trimmed" or "Output of Untrimmed"), continue at section 2.4.

2.3 Shape Phase

Producing a "good" surface during Shape Phase requires creating an object with a good patch structure with regularly shaped patches (i.e., rectangular shaped without severe or multiple-curvature changes) that fill spaces efficiently.

The basic steps for Shape Phase are illustrated in the flowchart on the next page. The first column depicts steps to produce a precise reproduction of an object with the emphasis on curved regions. The second set of steps places no emphasis on curved regions.

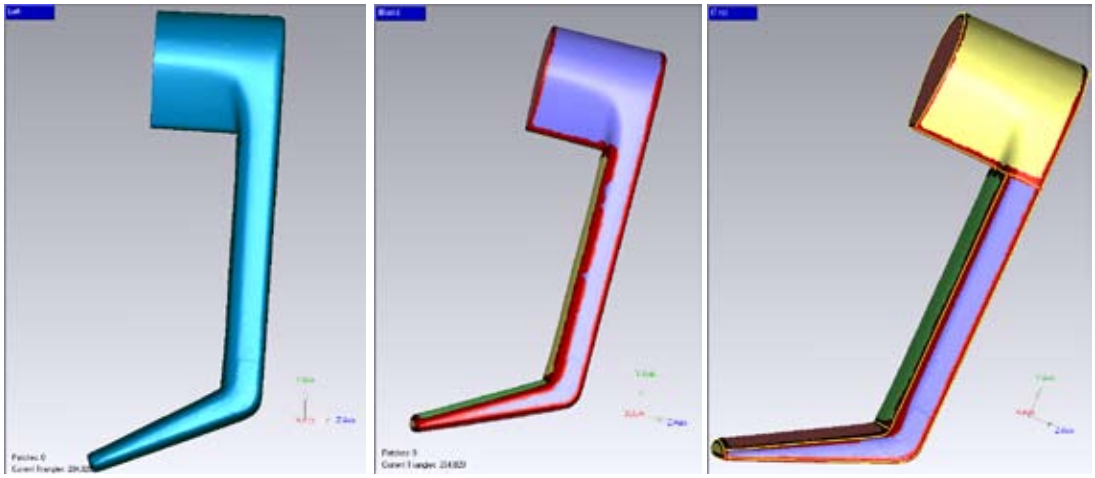
- For the "Shape Phase with Emphasis on Curved Regions," start at section 2.3.1.
- For the "Shape Phase Legacy Workflow," start at section 2.3.2.



2.3.1 Shape Phase with Emphasis on Curved Regions

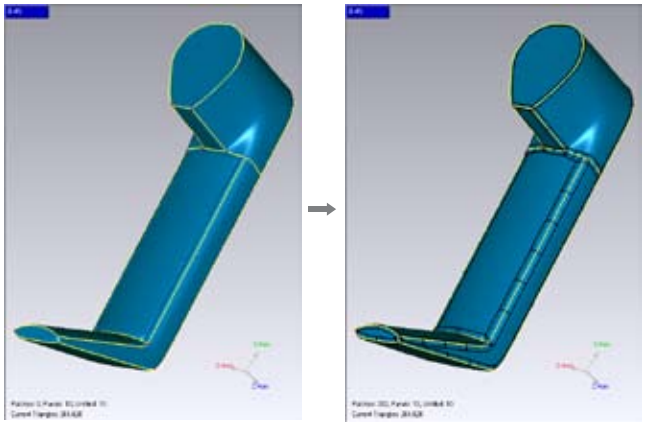
The steps in this section produce a precise reproduction of the original object with emphasis on the precision of the curvy parts.

Step 1. With **HandleShape1.wrp,** use Contours > Detect Contours. For the purpose of this Guide, ignore the warning by pressing **Yes**. Press the **Compute Regions** button. The red separator bands represent the software's estimate of the location of curved regions. Drag and Ctrl-drag the mouse to paint the separators as pictured in the third figure—the goal being to put red separator bands where you would expect to see seams on an upholstered chair. Press the **Extract** button to generate yellow contour lines.



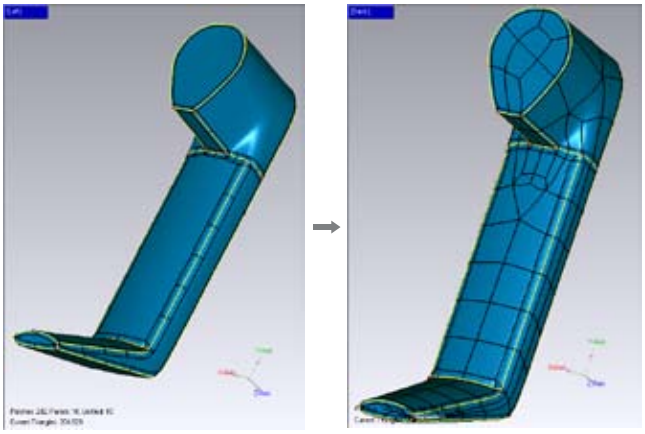
At this point, yellow contour lines are present on the centerlines of the estimated curved regions.

Step 2. Now that yellow contour lines appear on the centerlines of estimated curved regions, the "estimated" location of curved regions need to be converted into "actual" locations of curved regions. With **HandleShape2.wrp**, use Contours > Subdivide/Extend to lay "contour patches" on the curved regions. Put the command in "Extension" mode (not "Subdivision" mode) and press **OK**. Contour patches define where the surface will be reproduced with the greatest precision.



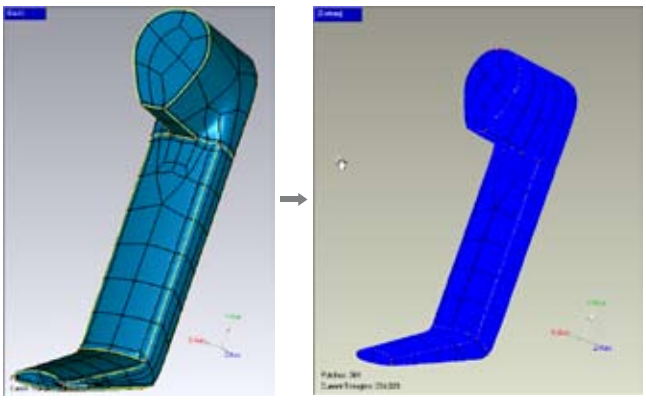
*Before **Subdivide/Extend** (left) and after (right)*

Step 3. With **HandleShape3.wrp**, use the **Fill Empty Panels** button of Patches > Shuffle > Panels to fill the spaces between the contour patches. Press **OK**.



*Before **Shuffle Panels** (left) and after (right)*

Step 4. With **HandleShape4.wrp**, use Grids > Construct Grids. Press **Apply**. If the resulting grids are tangled and therefore are displayed in red rather than blue, reduce the **Resolution** to about 17 and try again. Press **OK**. The grids serve as a "bed" for the NURBS surface that will be generated in the next step.



*Before **Construct Grids** (left) and after (right)*

Step 5. Use NURBS > Fit Surfaces. Accept the default settings, then press **Apply** and **OK**.

Step 6. Use NURBS > To CAD Phase.

Step 7. Save CAD the object as .igs or .stp for further processing by an external system.

The "Shape Phase with emphasis on curved regions" objective is complete.

2.3.2 Shape Phase with Legacy Workflow

The steps in this section produce a precise reproduction of the original object with no particular emphasis on curved regions.

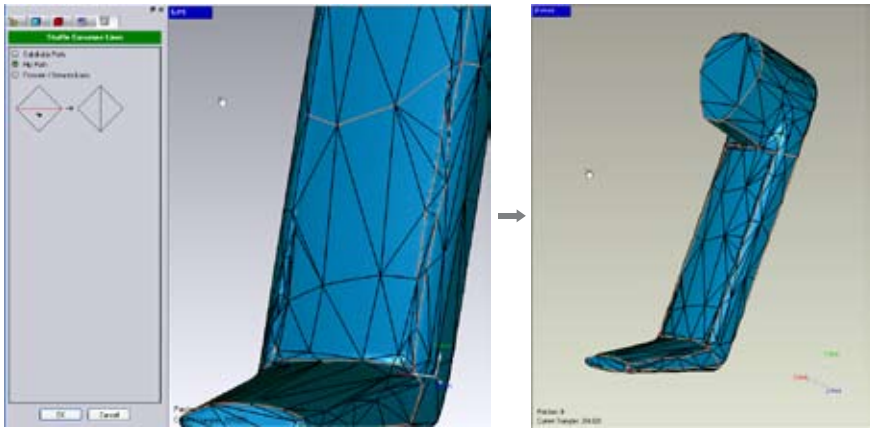
Step 1. Make sure you performed Step 1 of Section 2.2.2.

Step 2. Still with Handle8.wrp, use Contours > Detect Curvature. Set the **Target** to 500 curvature lines and **Curvature Level** to 0.25. Press **Apply** and **OK**. The resulting black lines represent candidates for promotion to orange panel demarcation lines in the next step.

Step 3. With **HandleShapeA.wrp,** use Contours > Shuffle Curvature Lines to achieve an optimal set of orange panel demarcation lines. "Optimal" orange lines resemble the seams on a furniture slip-cover. The art of shuffling curvature lines is to convert certain black lines to orange so that the resulting set of orange lines resembles the seams on a slip-cover.

- In "Promote/Demote" mode, promote some black lines to orange by clicking them (and Ctrl-Click to make some orange lines black).
- In "Flip Path" mode, change the direction of existing black lines so they become more likely candidates for promotion to orange.

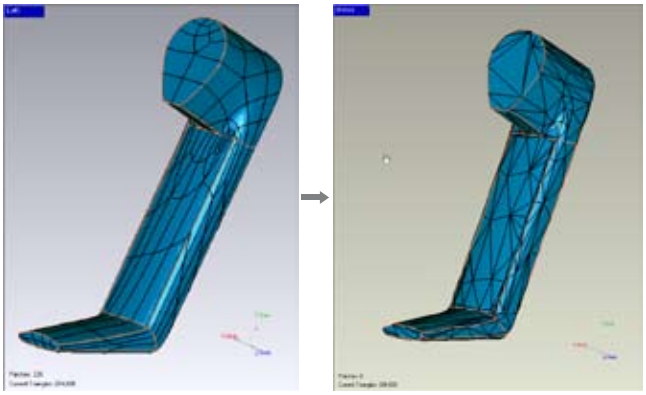
When complete, press **OK**.



*Before **Shuffle Curvature Lines** (left) and after (right)*

Step 4. With **HandleShapeB**, use Patches > Construct Patches. Set the "Target Patch Count" to 100.

Step 5. With **HandleShapeC**, use Patches > Shuffle > Panels to make the patches more orderly.



*Before **Shuffle Panels** (left) and after (right)*

The figures below are close-ups of a panel during the **Shuffle Panels** command.

Figure A is of the panel after clicking it to activate it for subsequent actions.

Figure B is of the panel after clicking the left end in **Add/Del 2 Paths** mode. Note that each pair of opposing sides now has an equal number of "path" lines (even though they are tangled).

Figure C is of the panel after setting the **Type** to "Grid" and pressing **Execute**.

The goal is to make all panels more orderly by this technique.

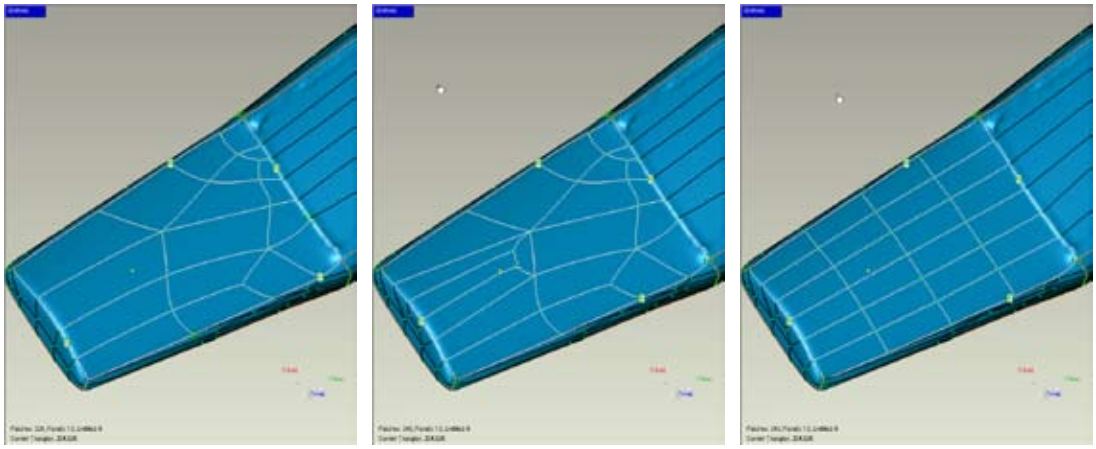
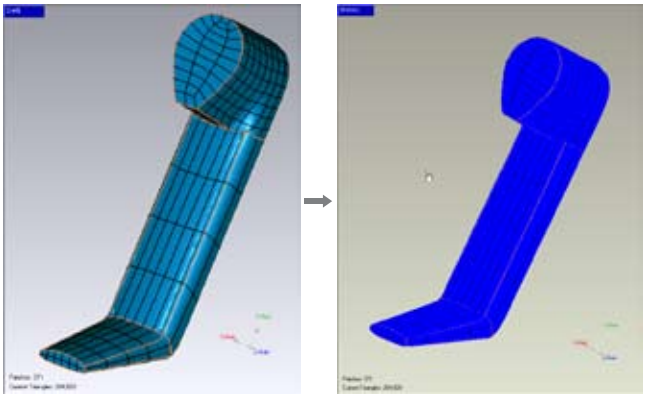


Figure A *Figure B* *Figure C*

Step 6. With **HandleShapeD**, use Grids > Construct Grids with **Resolution** of 20. The grids serve as a "bed" for the NURBS surface that will be generated in the next step.



*Before **Construct Grids** (left) and after (right)*

Step 7. Use NURBS > Fit Surfaces with Adaptive fitting.

Step 8. Optionally, use NURBS > To CAD Phase to perform additional work on the CAD object.

Step 9. Save the CAD object as .igs or .stp for further processing by an external system. This object is an accurate reproduction of the scanned data.

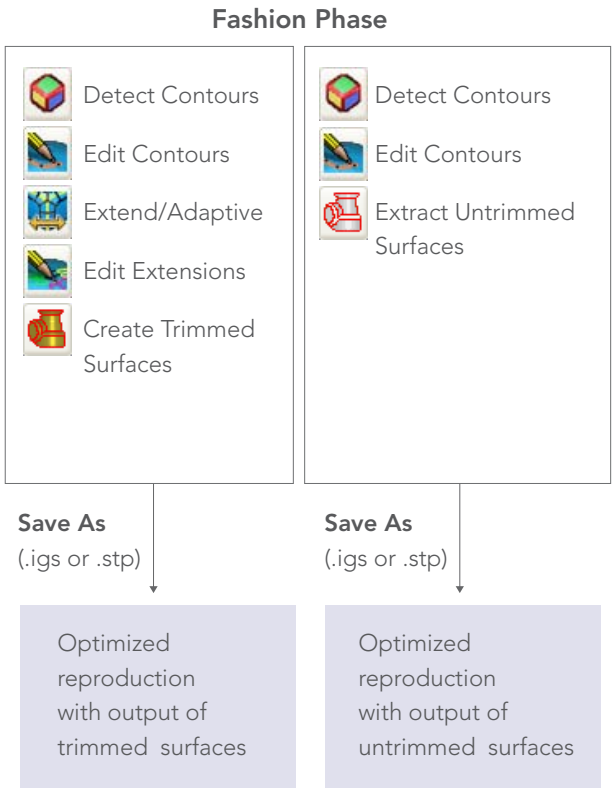
The Shape Phase Legacy Workflow is complete.

2.4 Fashion Phase

The Fashion Phase lets you extract CAD-like surfaces. The procedures illustrated in this section produce two different outcomes:

- optimized reproduction with output of trimmed surfaces (see section 2.4.2) and
- optimized reproduction with output of untrimmed surfaces (see section 2.4.3).

The initial steps in Fashion Phase are common to both work flows. Follow the steps below and then continue the appropriate section.

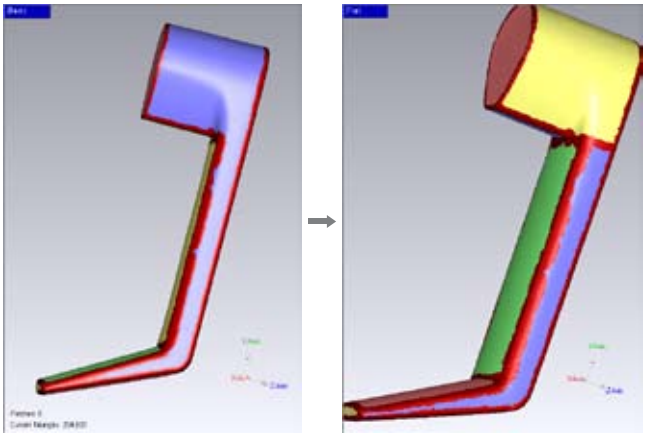


2.4.1 Initial Steps

Once in Fashion Phase, the icon on the WholeHandle object in the Model Manager has changed to the Fashion Phase icon.

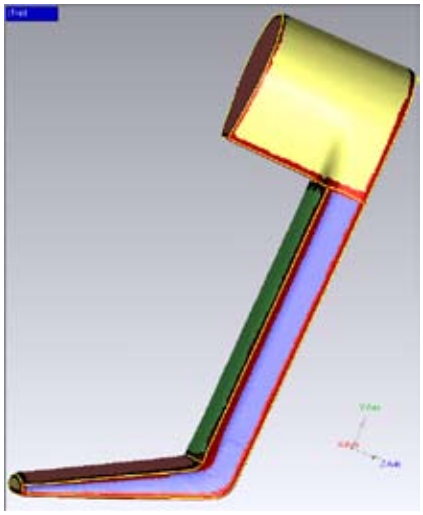
Step 1. With **Handle8.wrp**, run Contours > Detect Contours. For the purpose of this Guide, ignore the warning by pressing **Yes.** Compute the regions. Red separators appear on the model. The red separators represent the estimated position of future connection surfaces. A wide red separator indicates that the future connection surface is wide, and a narrow red separator indicates that a future connection surface is narrow. Adjust the width of red separators to reflect the intended future width of connection surfaces.

Step 2. (Press Ctrl-V to ensure the application is in "Select Visible" mode). Ctrl-Left-Click and drag the mouse to make the red separators more distinct in the wedge areas, and Shift-Left-Click and drag the mouse to add separators near the barrel as shown. Make the red separators as clean as possible.



Before adding the additional separators (left) and after (right)

Step 3. Make sure "Detect Sharp Contours" is not checked, and press the **Extract** button to lay yellow contour lines in the middle of the red separator bands. These represent the center-lines of the estimayed position of connection surfaces. Close the dialog by pressing **OK.**



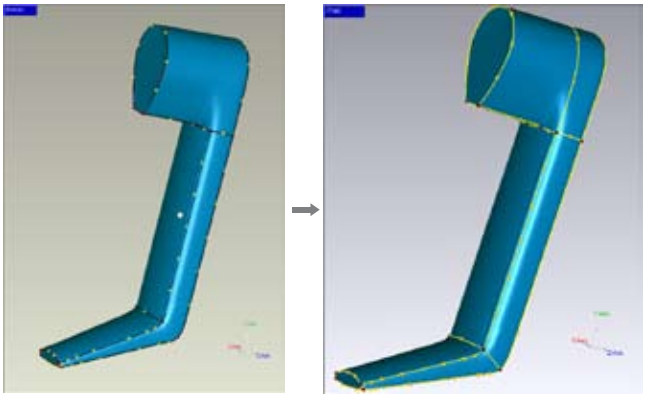
Step 4. Go to the appropriate section:

- For the Fashion Phase with Output of Trimmed Surfaces, continue at section 2.4.2.
- For the Fashion Phase with Output of Untrimmed Surfaces, continue at section 2.4.3.

2.4.2 Fashion Phase with Output of Trimmed Surfaces

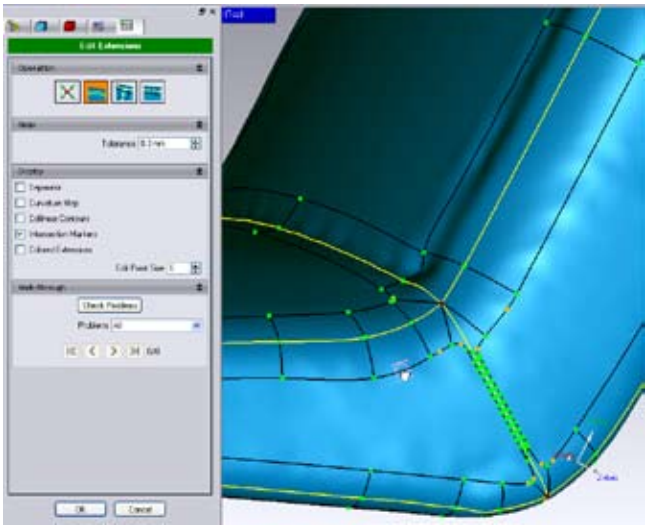
Once in Fashion Phase, the icon on the WholeHandle object in the Model Manager has changed to the Fashion Phase icon.

Step 1. With **Handle9.wrp**, use Contours > Edit Contours to add contour lines that may have been "missed" by Contours > Detect Contours. (The first time an object is loaded into **Edit Contours**, it's necessary to press **Subdivide** and **Accept** before continuing.) Add contour lines to match those in **Handle10.wrp**. The goal is to divide the overall surface into distinct regions, as if designing the slipcover for chair.



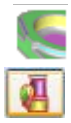
During the editing of contours (left) and after (right)

Step 2. With **Handle10.wrp**, use Contours > Extend > Adaptive to create extensions. Do not use **Extend > Uniform** in the Fashion Phase. The illustration in the next step shows a close-up of the extension lines.

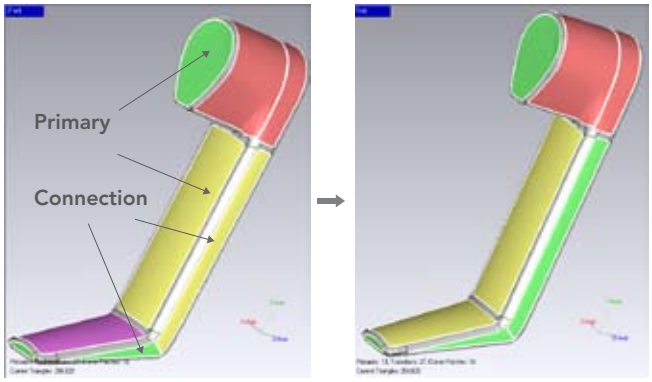


Step 3. With **Handle11.wrp**, use Contours > Edit Extensions. For the purpose of this Guide, ignore the warning by pressing Yes. Relax yellow contour lines and black extension lines to get a precise delineation between fillets and flats. Use other operations of this command as necessary.

Step 4. With **Handle12.wrp**, use Surfaces > Create Trimmed Surfaces. Primaries are "main" surfaces that determine the overall shape of an object. Connections are narrow surfaces that join two or more Primaries and lie on the "extensions" that were carefully laid out in previous steps.



Use the Classify operation with "AutoDetect" to discover whether each Primary most closely resembles a plane, cylinder, cone, sphere, extrusion, drafted extrusion, or freeform. If necessary, override classifications as in **Handle13.wrp.** (In this example, every surface should be a plane (light green), except the two freeforms (salmon) on the cam-shaped area, and the two cylindricals (yellow) on the inside of the handle.)



Before overriding classifications (left) and after (right)

Step 5. Use the Fit Primaries operation and press **Fit All** to produce results similar to the example illustrated in Figure 2.

Step 6. Now use Fit Connections operation and **Fit All** connections to produce results similar to the example illustrated in Figure 3.

Step 7. Use the Trim/Stitch operation and click **Preview** to view the stitched object. The object should appear similar to the one illustrated in Figure 4.

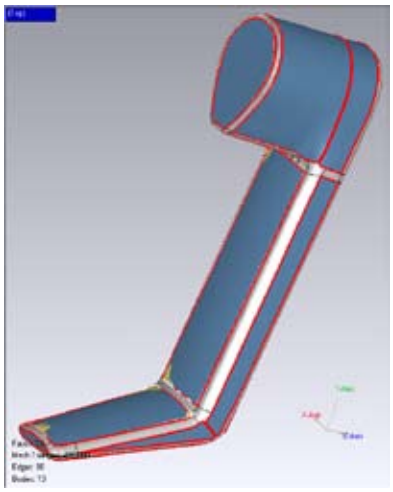


Figure 2. Fit Primaries > Fit All

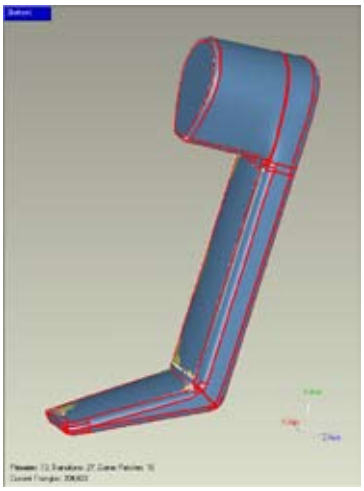
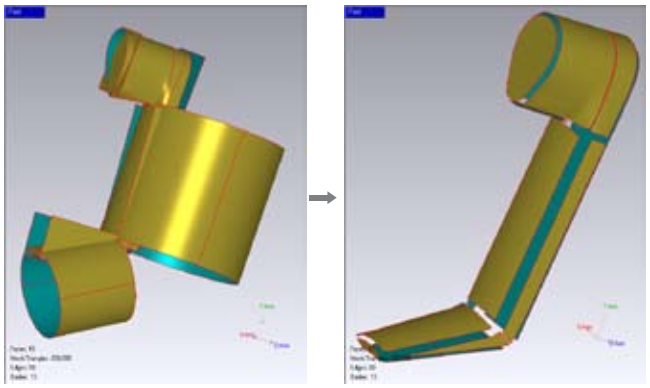


Figure 3. Fit Connections > Fit All

Figure 4. Trim/Stitch Preview

Step 8. Preview the untrimmed primaries and trimmed primaries.



Untrimmed primaries (left) and trimmed primaries (right) previews.

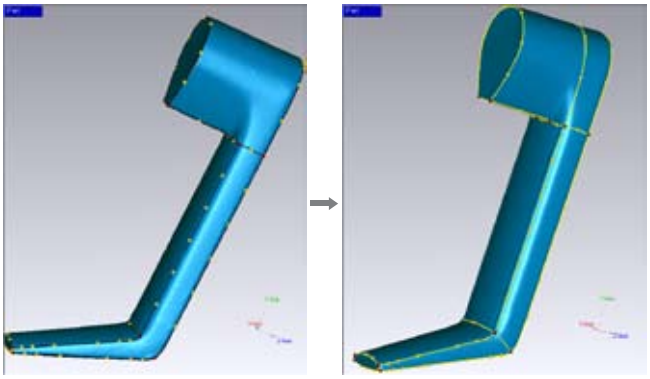
Step 9. Create either kind of object by setting a radio button and pressing **Create.** Export the "Stitched Model" from the Model Manager to an external CAD system for further processing (by right-clicking the object in the Model Manager and saving it as .igs or .stp).

The Fashion Phase with Output of Trimmed Surfaces is complete.

2.4.3 Fashion Phase with Output of Untrimmed Surfaces

The goal of this workflow is to generate a set of untrimmed primary surfaces, but not the connection surfaces, so the steps related to calculating the position of connectors are not necessary. Namely, it is not necessary to extend the yellow contour lines.

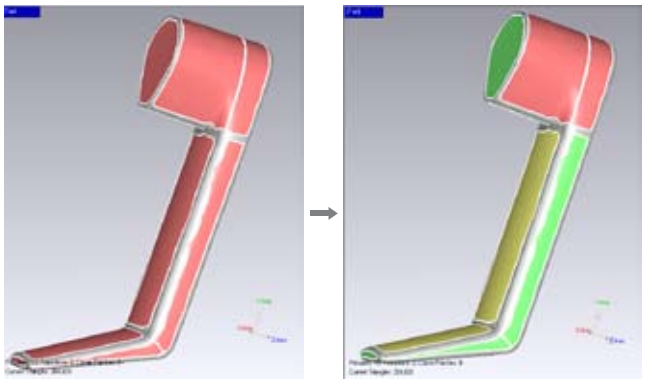
Step 1. With **Handle9.wrp**, use Contours > Edit Contours to add contour lines that may have been "missed" by Contours > Detect Contours. (The first time an object is loaded into **Edit Contours**, it's necessary to press **Subdivide** and **Accept** before continuing.) Add contour lines to match those in **Handle10.wrp**. The goal is to divide the overall surface into distinct regions, as if designing the slipcover for chair.



Before editing contours (left), and after adding contour lines (right).

Step 2. With **Handle10.wrp**, use Surfaces > Extract Untrimmed Surfaces. Create Trimmed Surfaces deals with connectors, while **Extract Untrimmed Surfaces** does not, so it does not have the Fit Connectors or Trim & Stitch operations.

Step 3. Use the Classify operation with "Autodetect". If necessary, override classifications as pictured in **Handle10B.wrp**. (All regions should be defined as planes except the two free-forms on the cam-shaped part, and the two yellow cylindricals on the inside of the handle.)

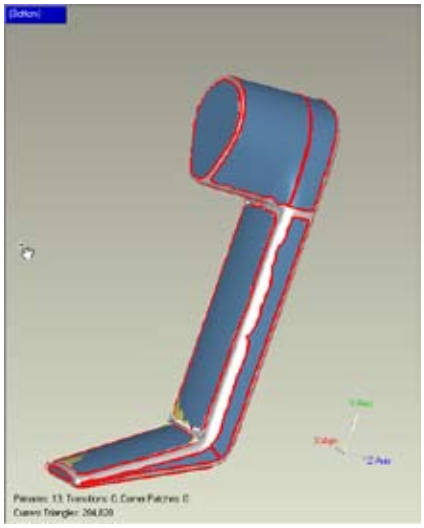


Before the Classify operation (left) and after completing the classification (right)

Press Ctrl-A to select surfaces for the next step.

Step 4. Use the Fit Primaries operation and press **Fit All**. The model will change to something similar to the one pictured here.

Carefully compare this screen shot to Step 5 of section 2.4.2. This example does not have connectors: connectors are irrelevant to the purpose of Surfaces > Extract Untrimmed Surfaces.

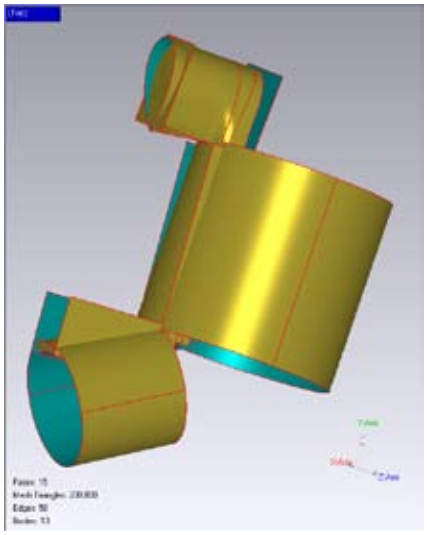


Step 5. Use the Create Object operation to Preview the Untrimmed Primaries, as shown here.

The result of Surfaces > Extract Untrimmed Surfaces is the same as that from Surfaces > Create Trimmed Surfaces with the Untrimmed Surfaces option, but the advantage of the **Extract Untrimmed Surfaces** workflow is that it offers a number of shortcuts.

Step 6. Press **Create** to put the untrimmed object into the Model Manager.

Step 7. Right-click the object in the Model Manager to save it as an .igs or .stp file for use in an external CAD system.



The Fashion Phase with Output of Untrimmed Surfaces objective is complete.