Conceptual Modeling: letting designers get their hands *meshy*

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Conceptual modeling

- What is conceptual modeling?
- Why is it important?
- What is this hands “meshy” business?

Agenda

- Desirable properties of a conceptual modeler
- Existing modeling trends
- Proposed conceptual design system
- Example design tools

Conceptual design desirables

- Abstraction from underlying surface math
- Invite creative exploration
- Allow for precision and constraints
- Workflow mimics traditional design media
- Intuitive and interactive

Related work

- Interactive volumetric sculpting (Galyean & Hughes ‘91)
- Solid object design by interpreting sketches (Pugh ‘92)
- Interface for sketching 3D scenes (Zeleznik et al ‘96)
- Wires (Singh & Fiume ’98)

- Exploring interactive curve and surface manipulation using a bend and twist sensitive input strip (Balakrishnan et al ’99)
- Haptic sculpting (Sensable Technologies ’99)

- Scan data to parametric surfaces (Paraform, Geomagic ’99)
- Subdivision surfaces (Alias|wavefront ’99)
- Teddy (Igarashi ’99)

Existing Paradigms: NURBS/Solids

- Advantages
  - Smoothness
  - Precision (Analytic shapes)
  - Curves (Character, flow lines)

- Limitations
  - Patches get in the way (Patch layout, trims)
  - Editing paradigms are restricted by topology

Existing Paradigms: Polygon meshes

- Advantages
  - Smooth dense meshes are now feasible
  - No restrictions on topology
  - More flexible editing paradigms possible
  - Conversion to and from physcial data is easy

- Limitations
  - Meshes are not intrinsically “smooth”
  - Too free (no analytic shapes, hard points)
  - No concept of curves or character lines

Ideals of a conceptual modeler

- A mesh creation and sculpting paradigm that
  - Is free-form and exploratory
  - Produces smooth surfaces
  - Has constraints
  - Has curves
  - Allows flexible re-use of data
  - Facilitates hybrid modeling
- A user interface that
  - Is fast and interactive
  - Is simple and uncluttered
  - Captures domain expertise

Agenda

- Desirable properties of a conceptual modeler
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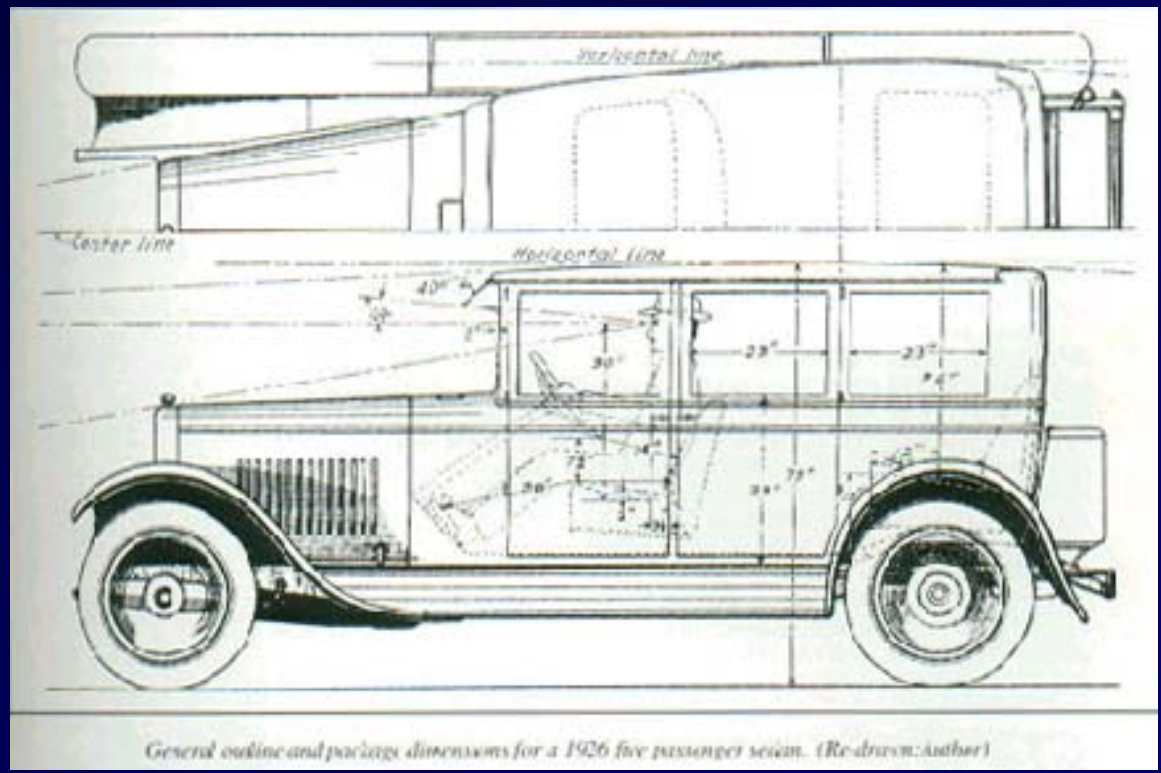
An automotive designers toolbox

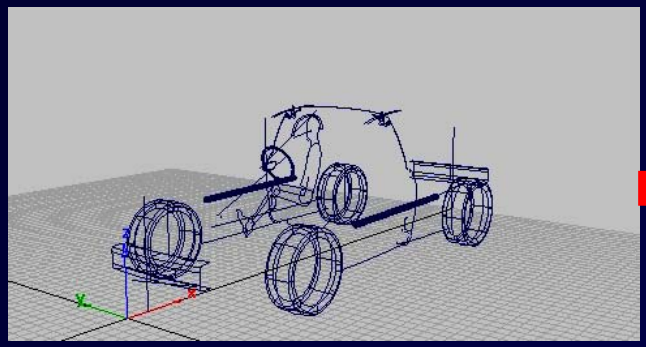
- Ideas
- Sketches
- Clay
- Engineering Criteria
- Sweeps
- Steels
- Paint box



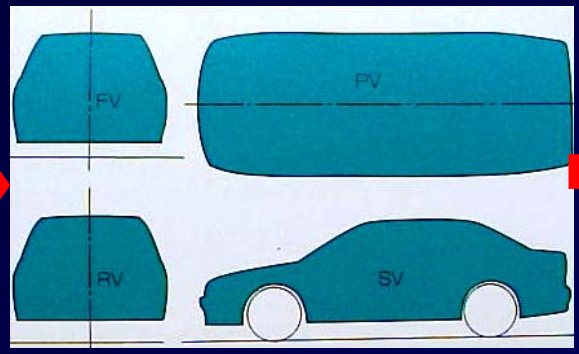
General outline and package dimensions for a 1926 five passenger sedan. (Re-drawn: Author)

- Whats missing? A refinable digital 3D model

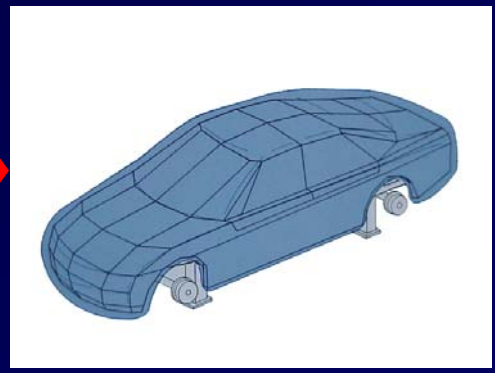
Workflow



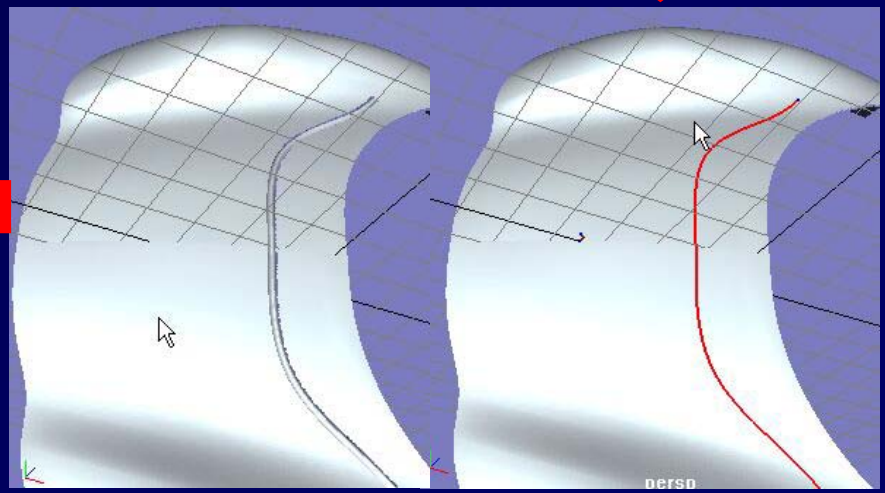
Import Engineering criteria



Orthographic Sketching



Rough mesh model



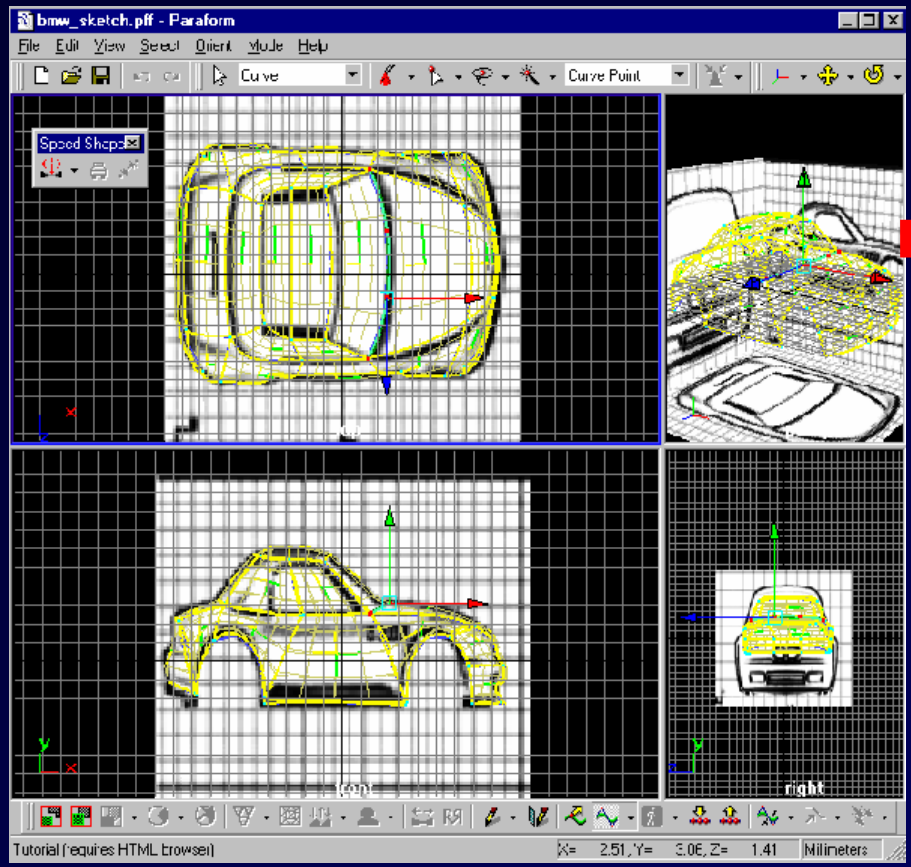
Refine mesh model

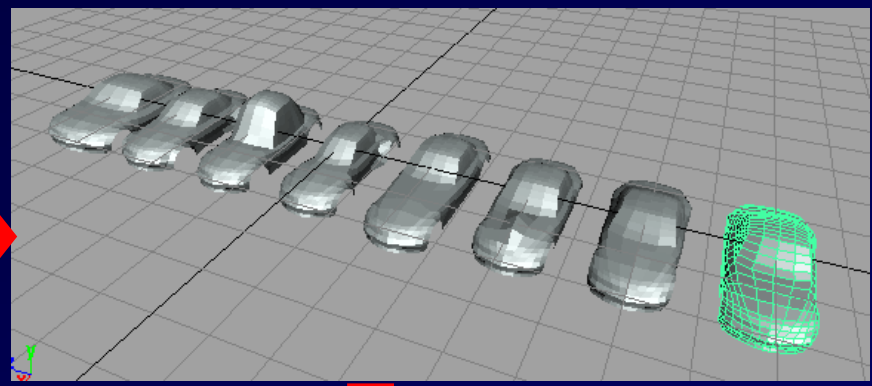
Presentation

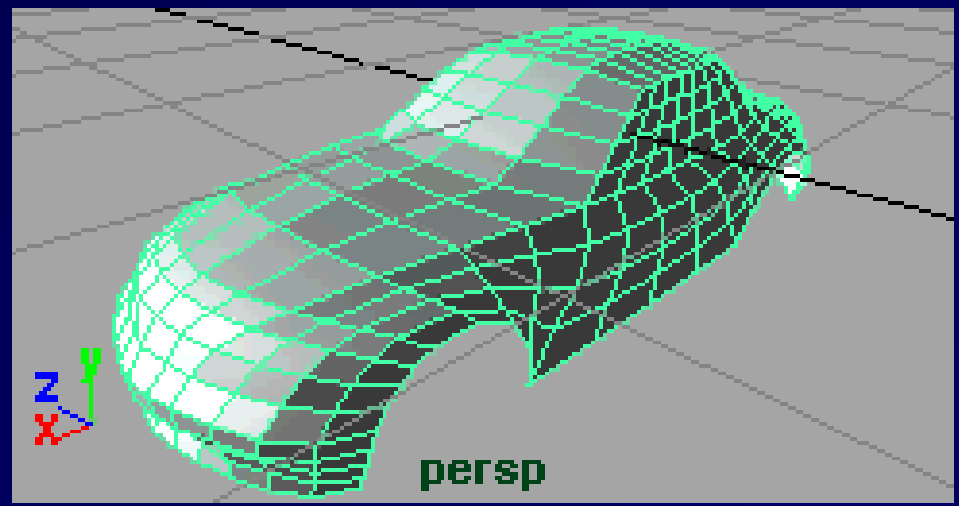
Workflow

- Speed Shape
- Shape Refinement
- Presentation

Speed Shape


bmw_sketch.pff - Paraform
File Edit View Speed Orient Mode Help
Curve
Curve Point
Speed Shape
Tutorial (requires HTML browser)
X= 2.51, Y= 3.06, Z= 1.41
Milimeters

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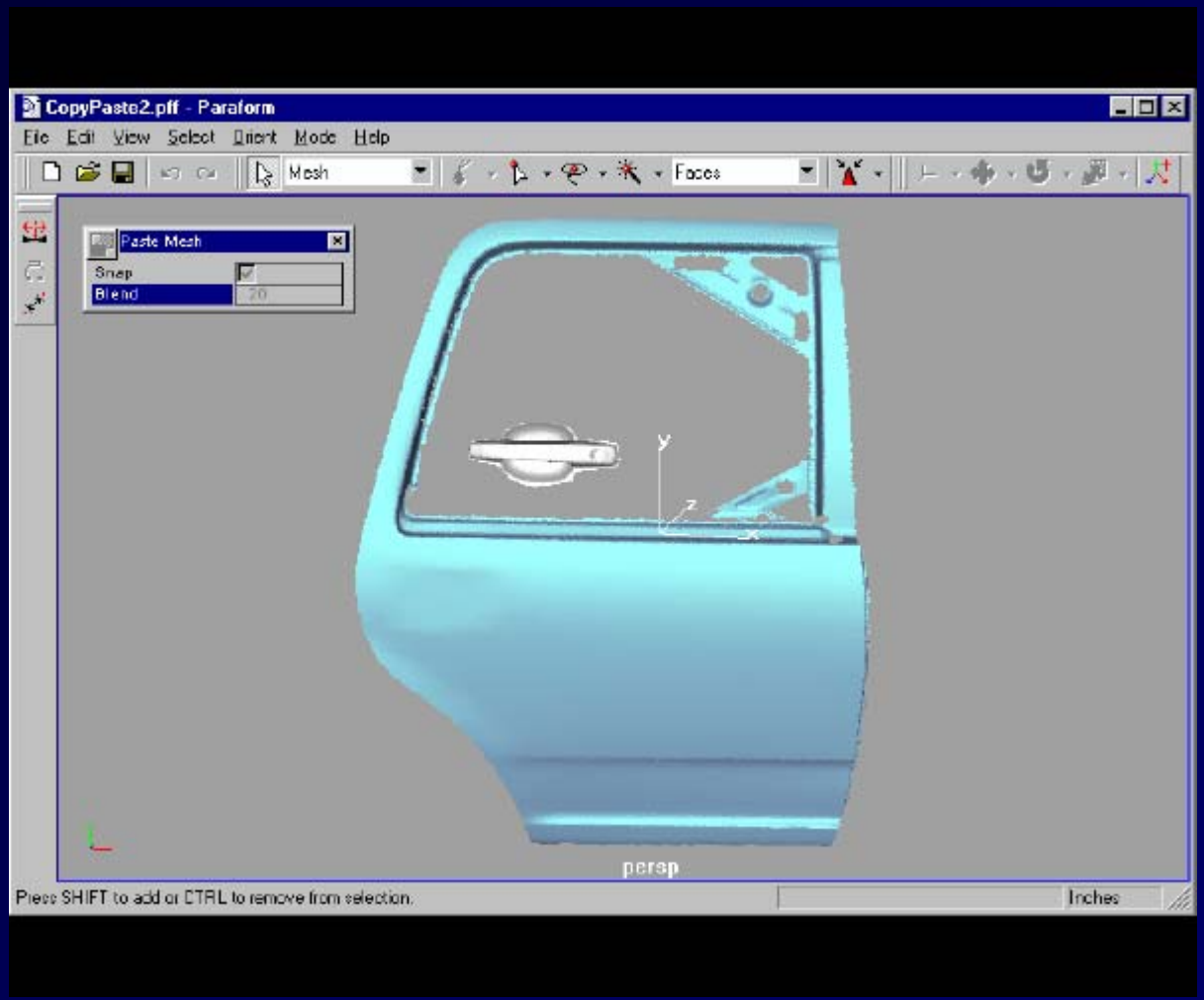
Workflow

- Speed Shape
- Shape Refinement
- Presentation

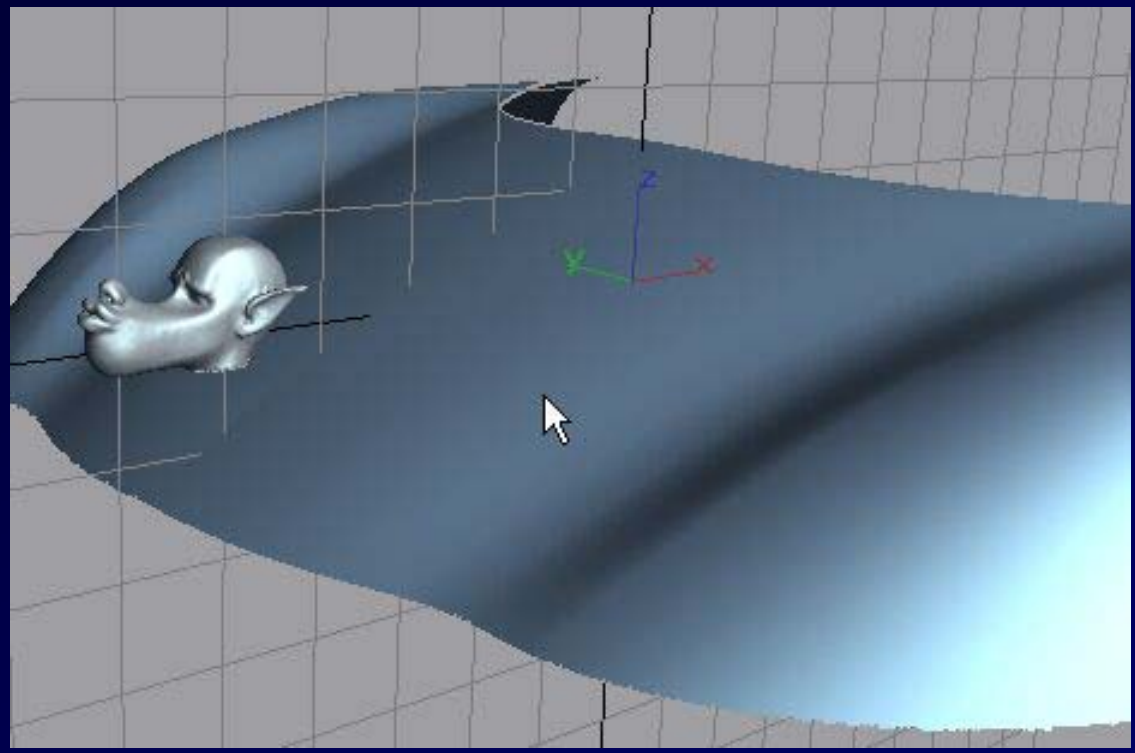
Shape Refinement

- Cut, copy and paste geometry
- Deformation
- Constraints

Cut, copy and paste geometry

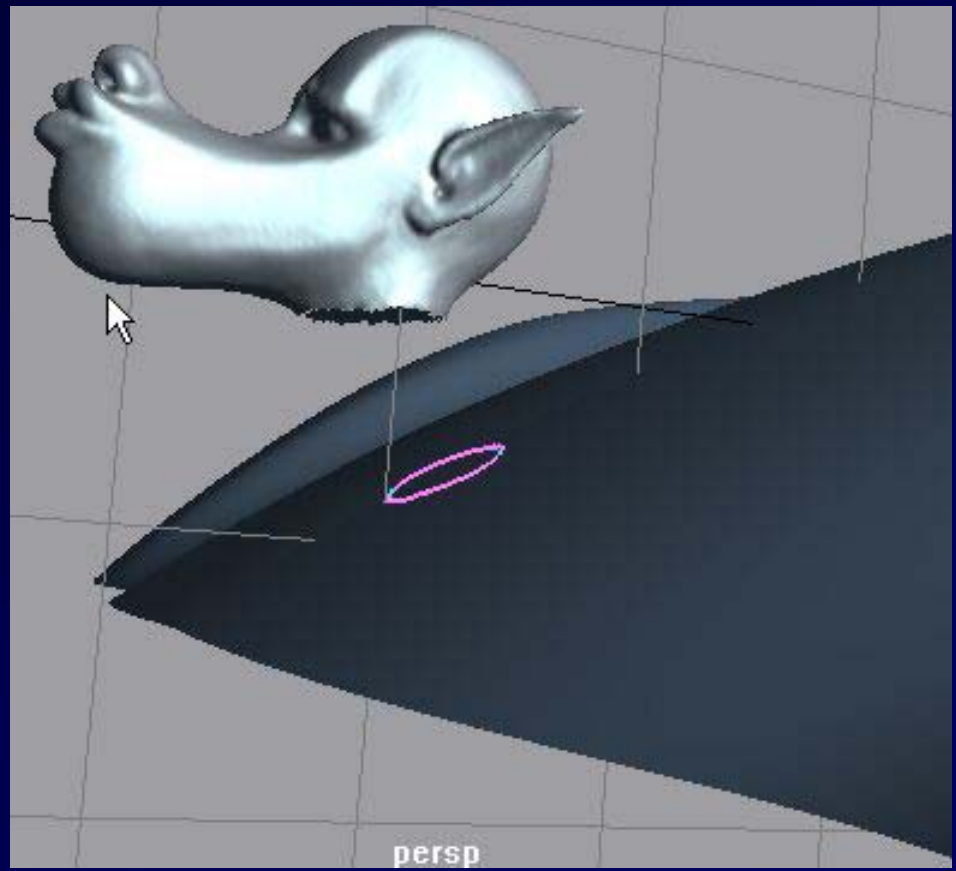


Paste



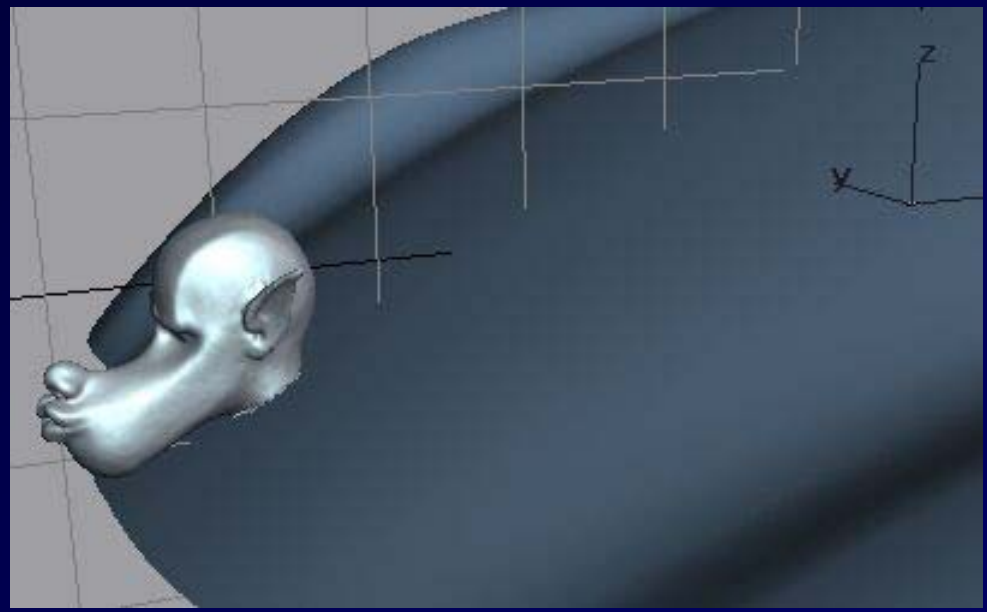
Hood ornament to be pasted, roughly placed

Paste



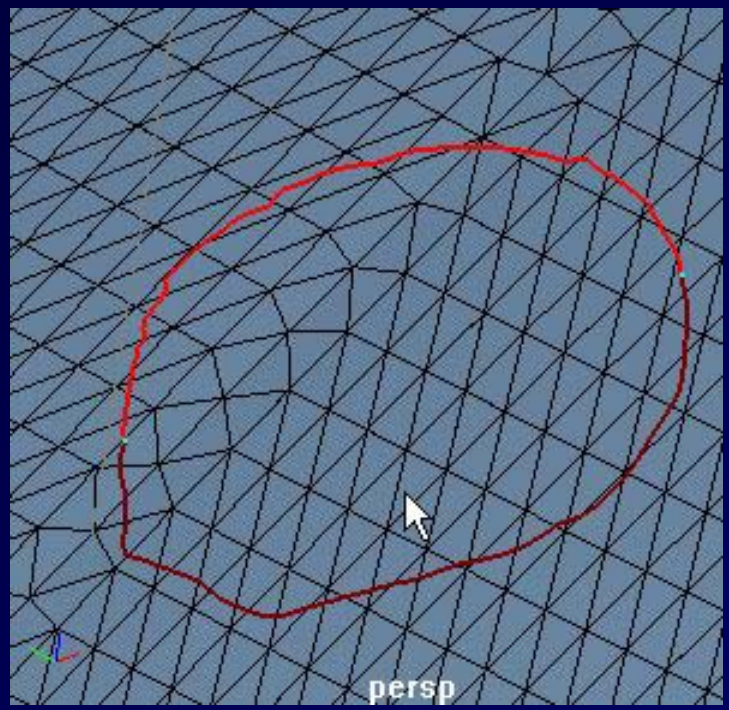
Hole projected onto hood

Paste



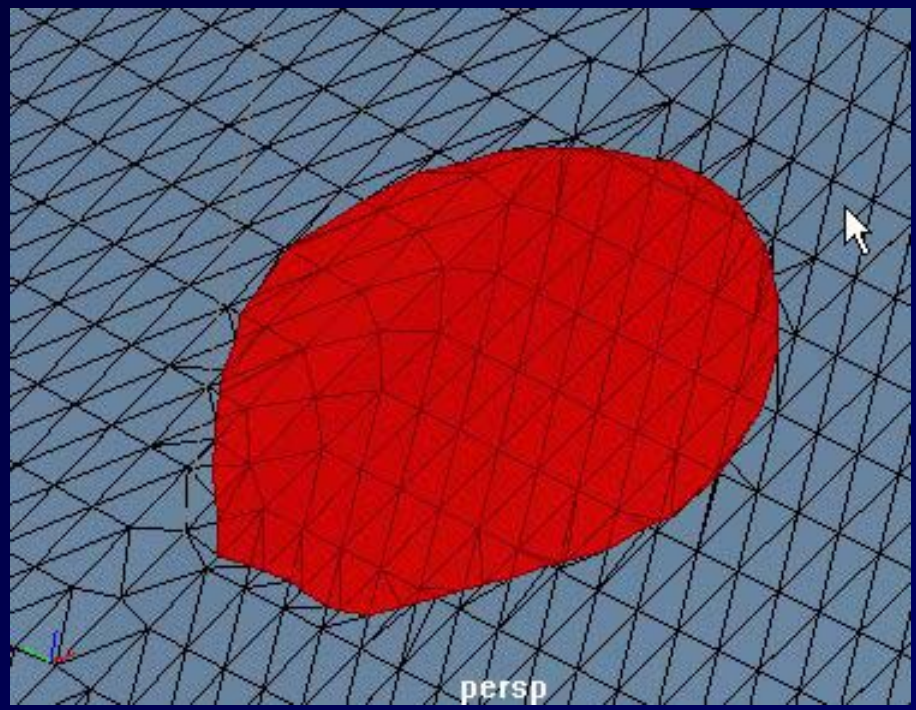
Hole aligned with projected hole

Paste



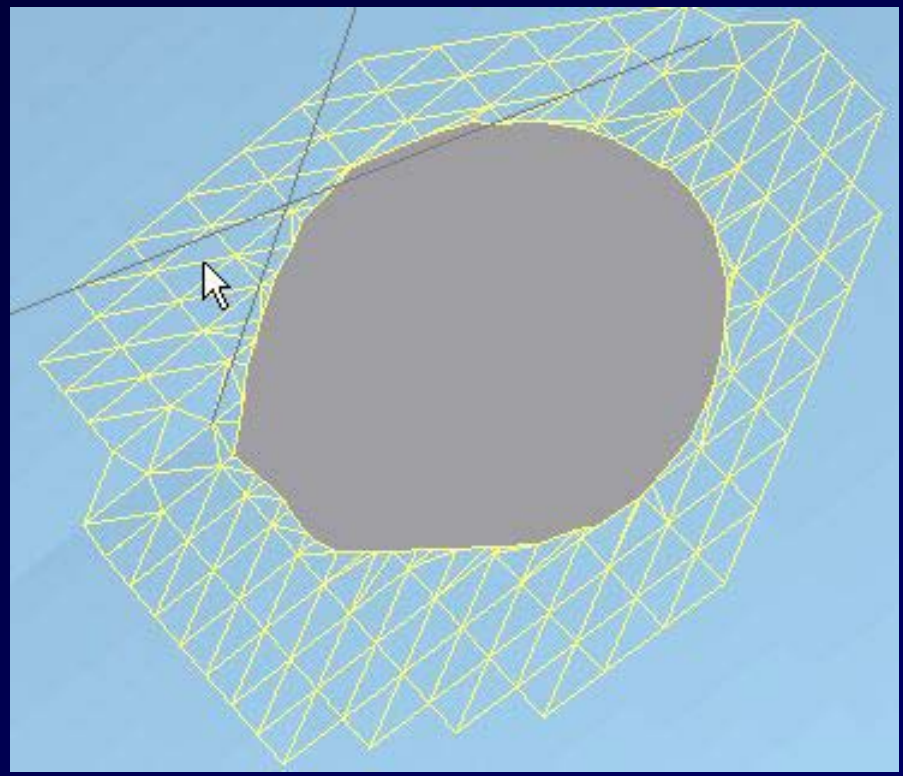
Aligned hole reprojected on hood

Paste



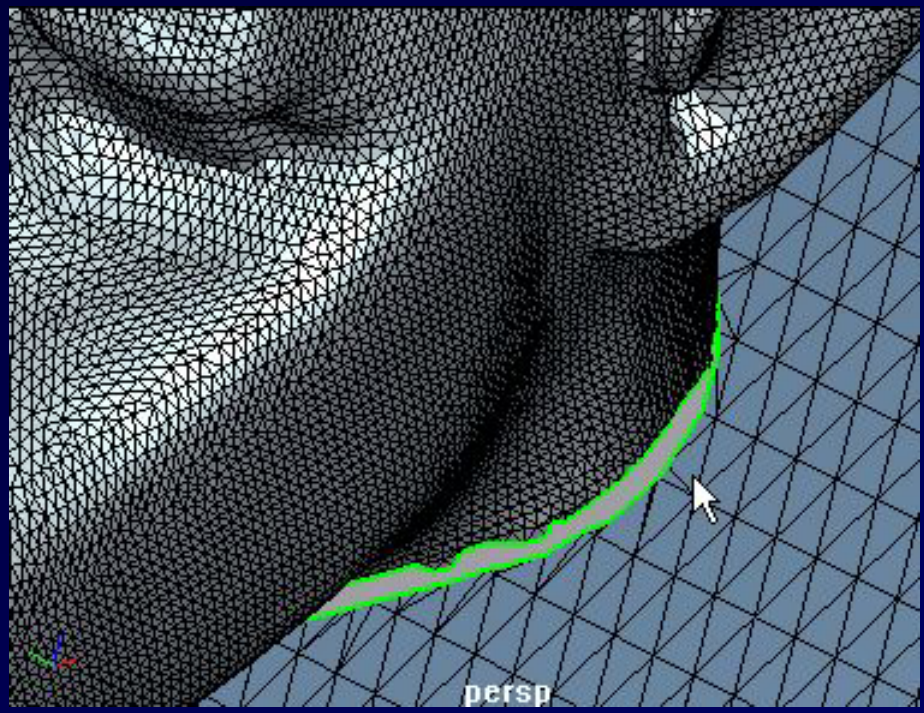
Sectioned hood

Paste



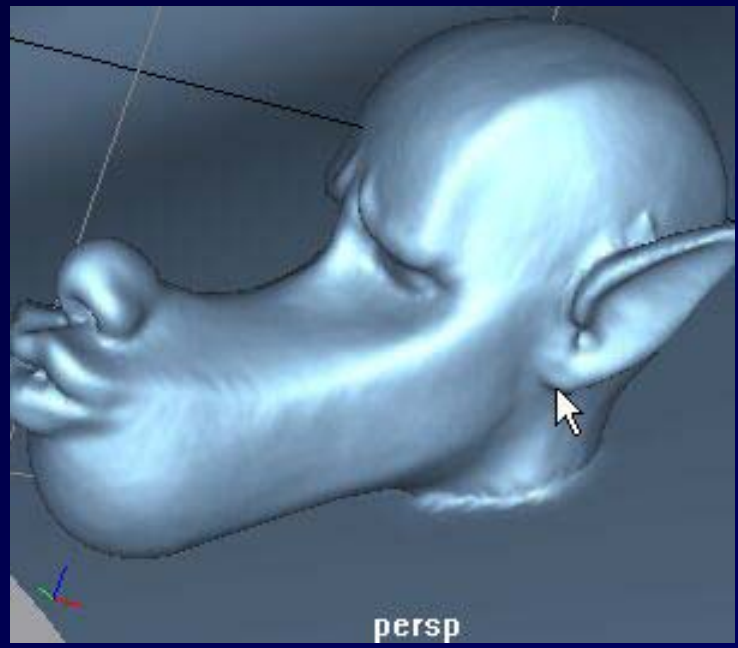
Hood cutout, blend region highlighted

Paste



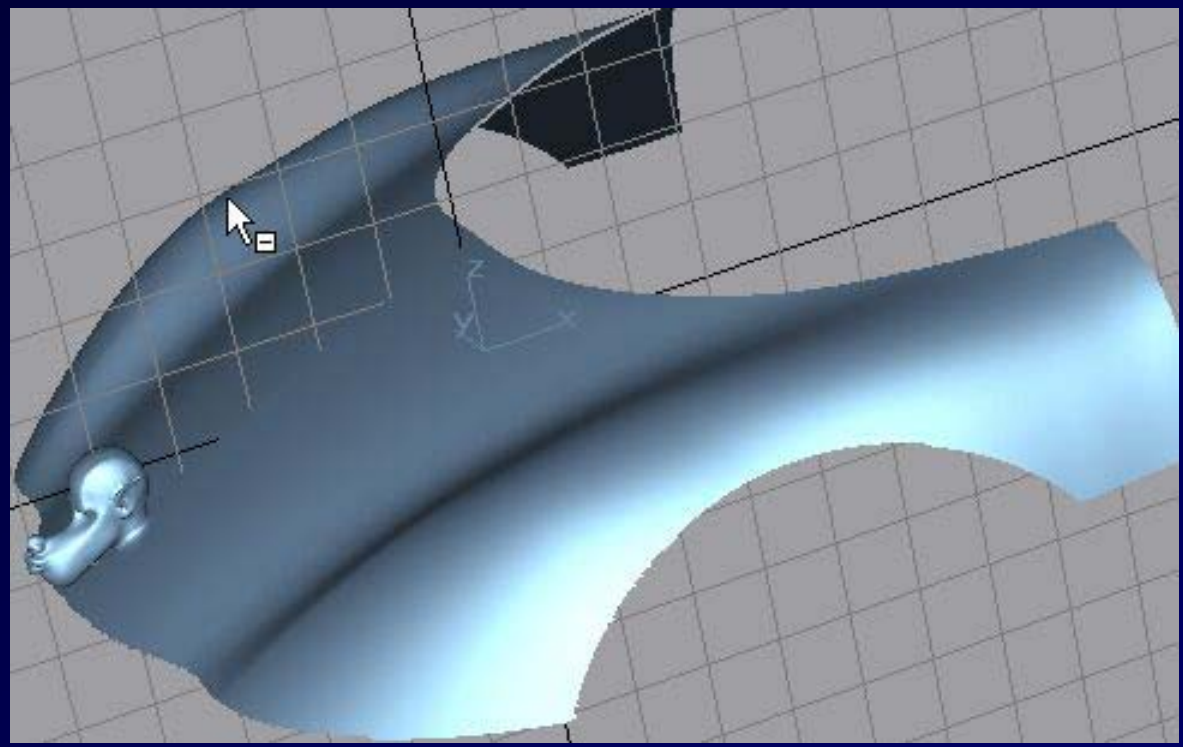
Holes prior to being stitched

Paste



Pasted hood ornament

Paste



Pasted hood ornament

Shape Refinement

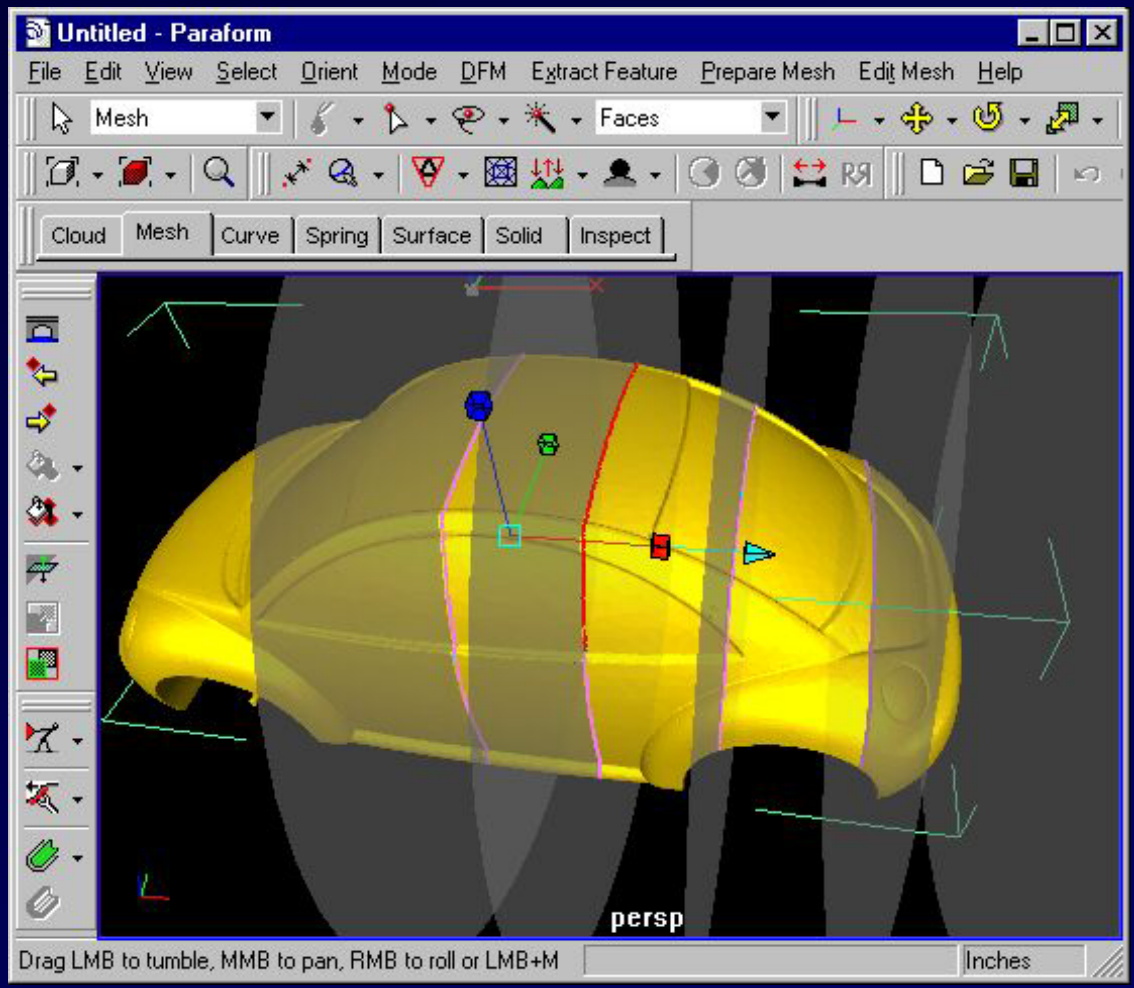
- Cut, copy and paste geometry
- Deformation
- Constraints

Deformation: Global

- Stretch planes and cross section curves
- Inverse Templates

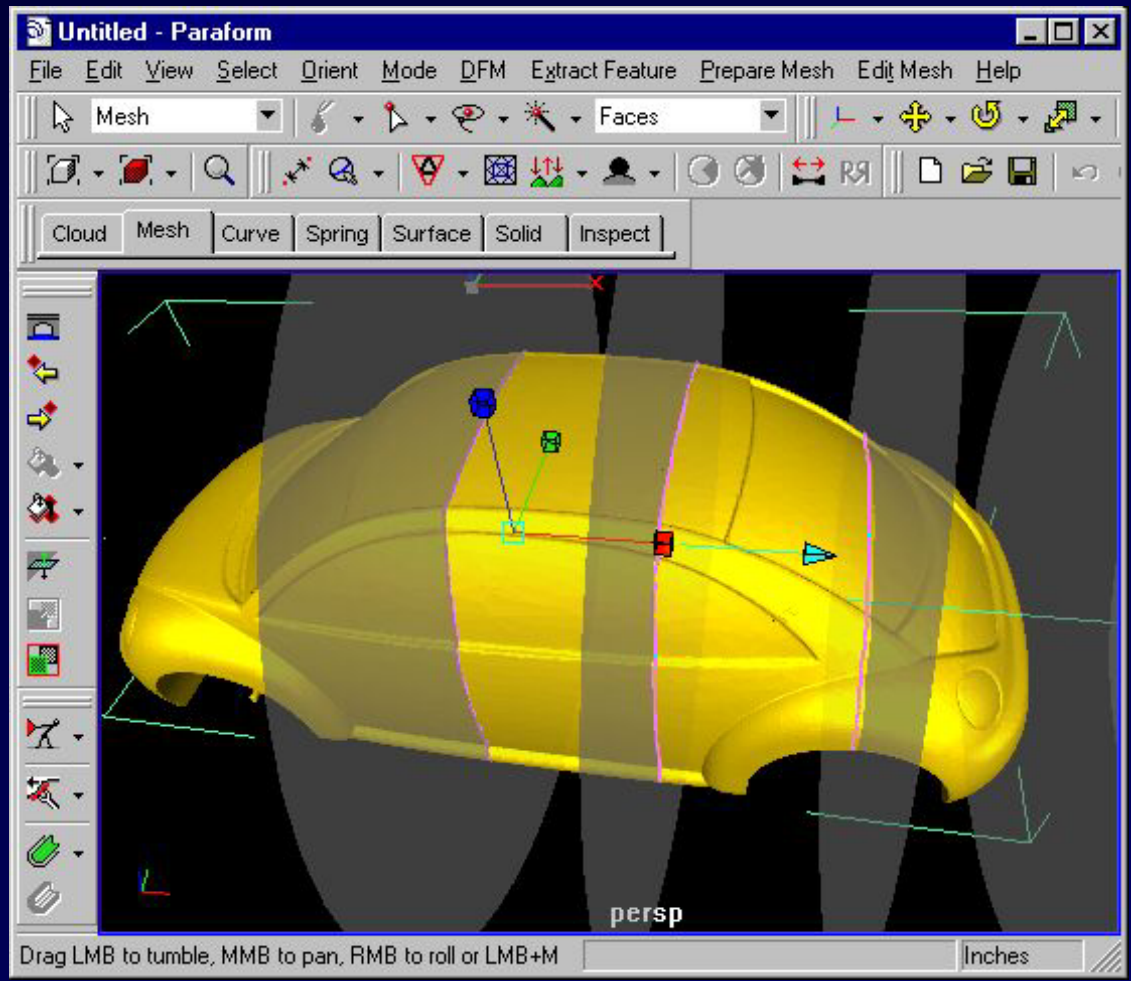
Deformation: Global

Stretch planes and cross section curves



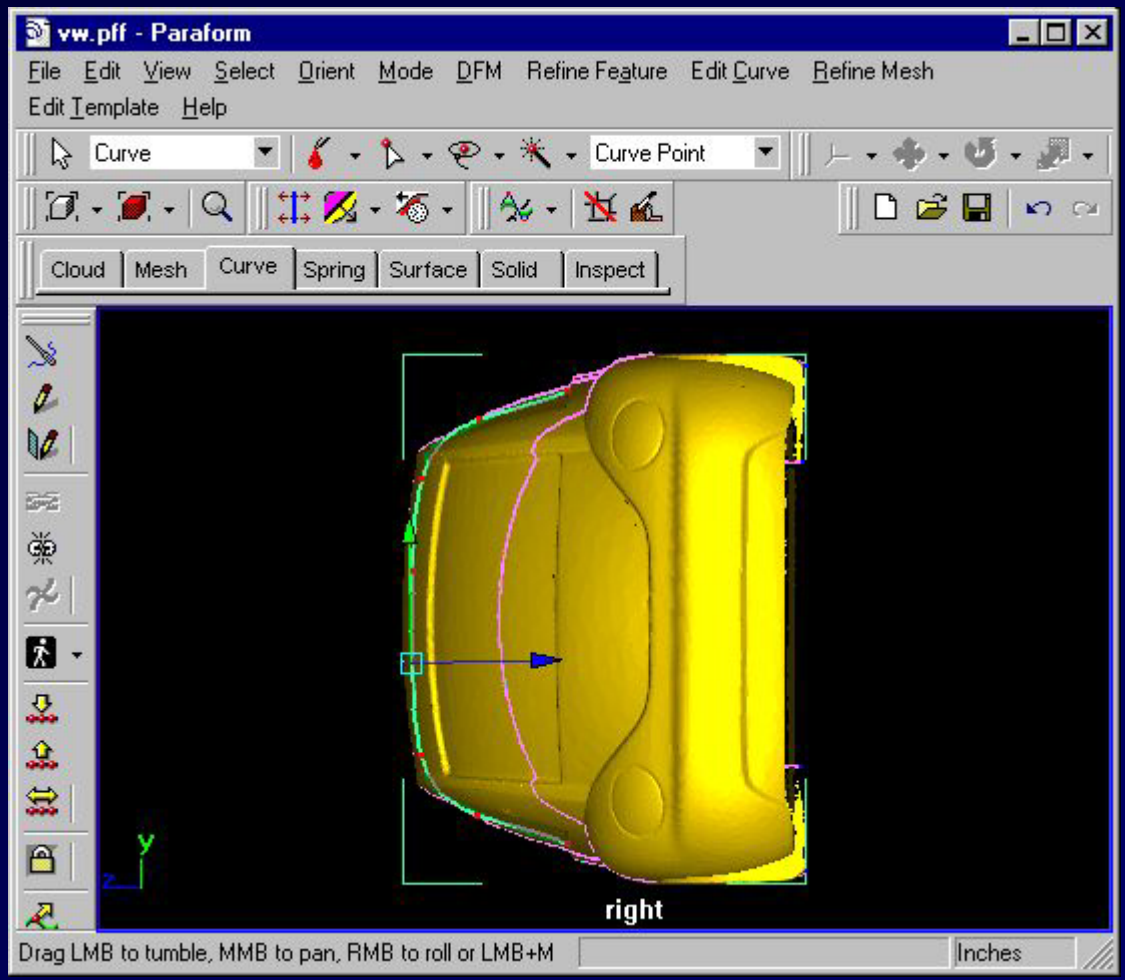
Deformation: Global

A stretch operation



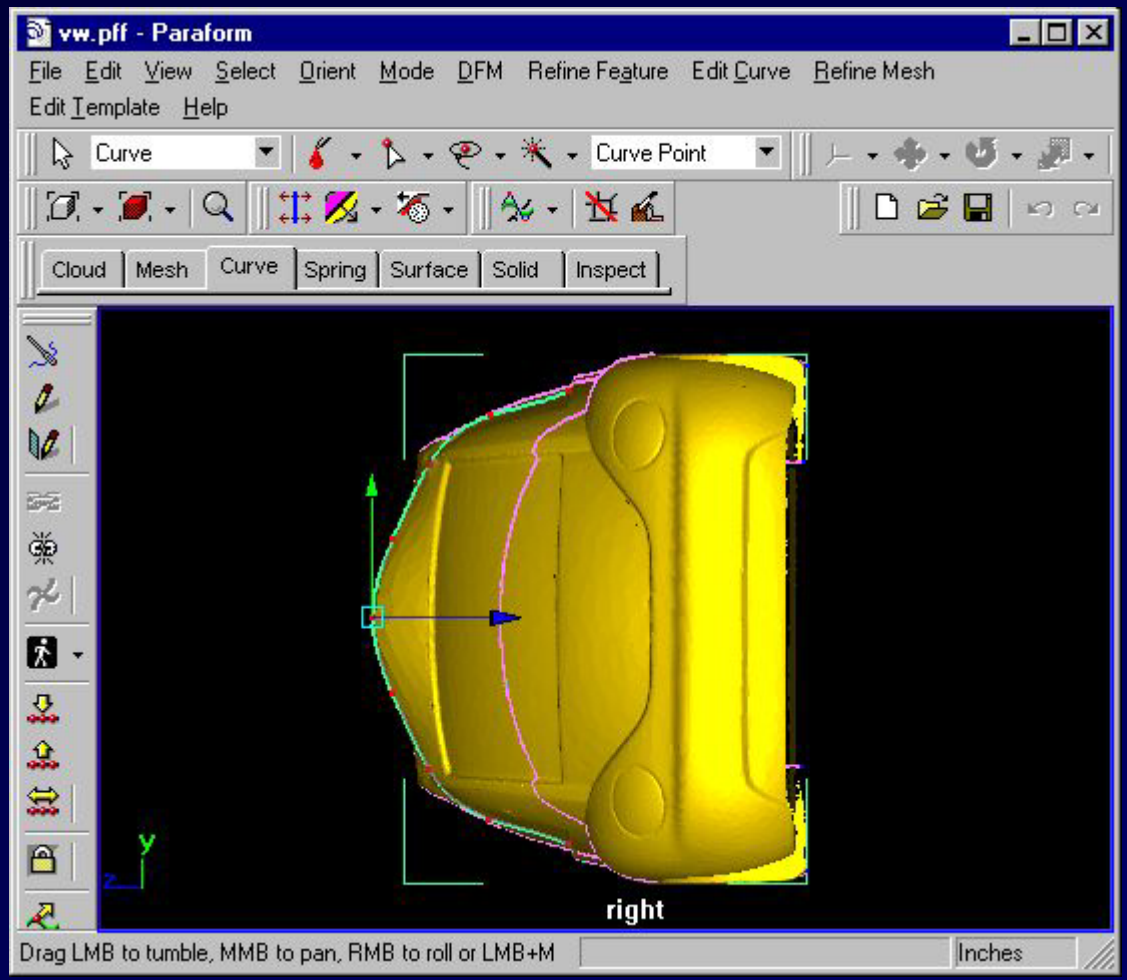
Deformation: Global

Curve based editing: before



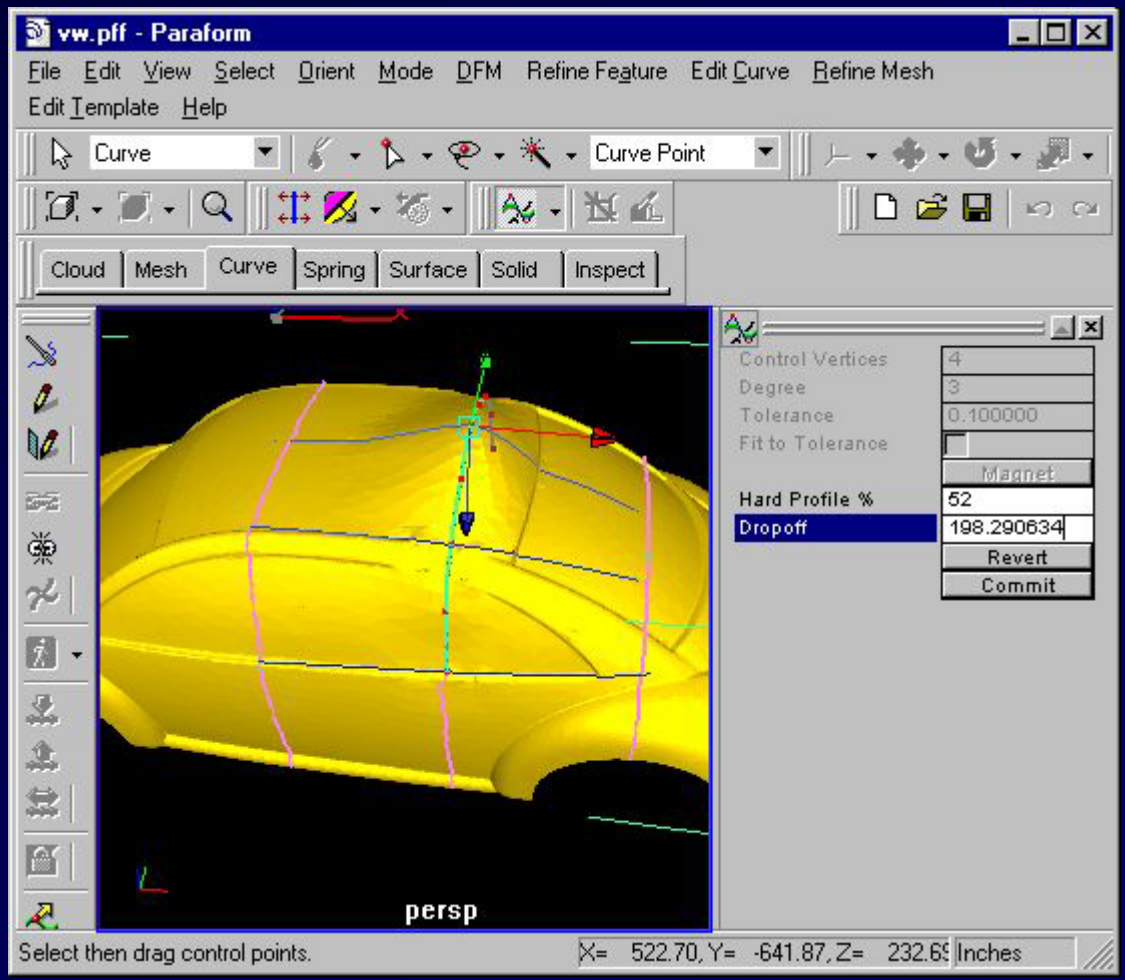
Deformation: Global

Curve based editing: after

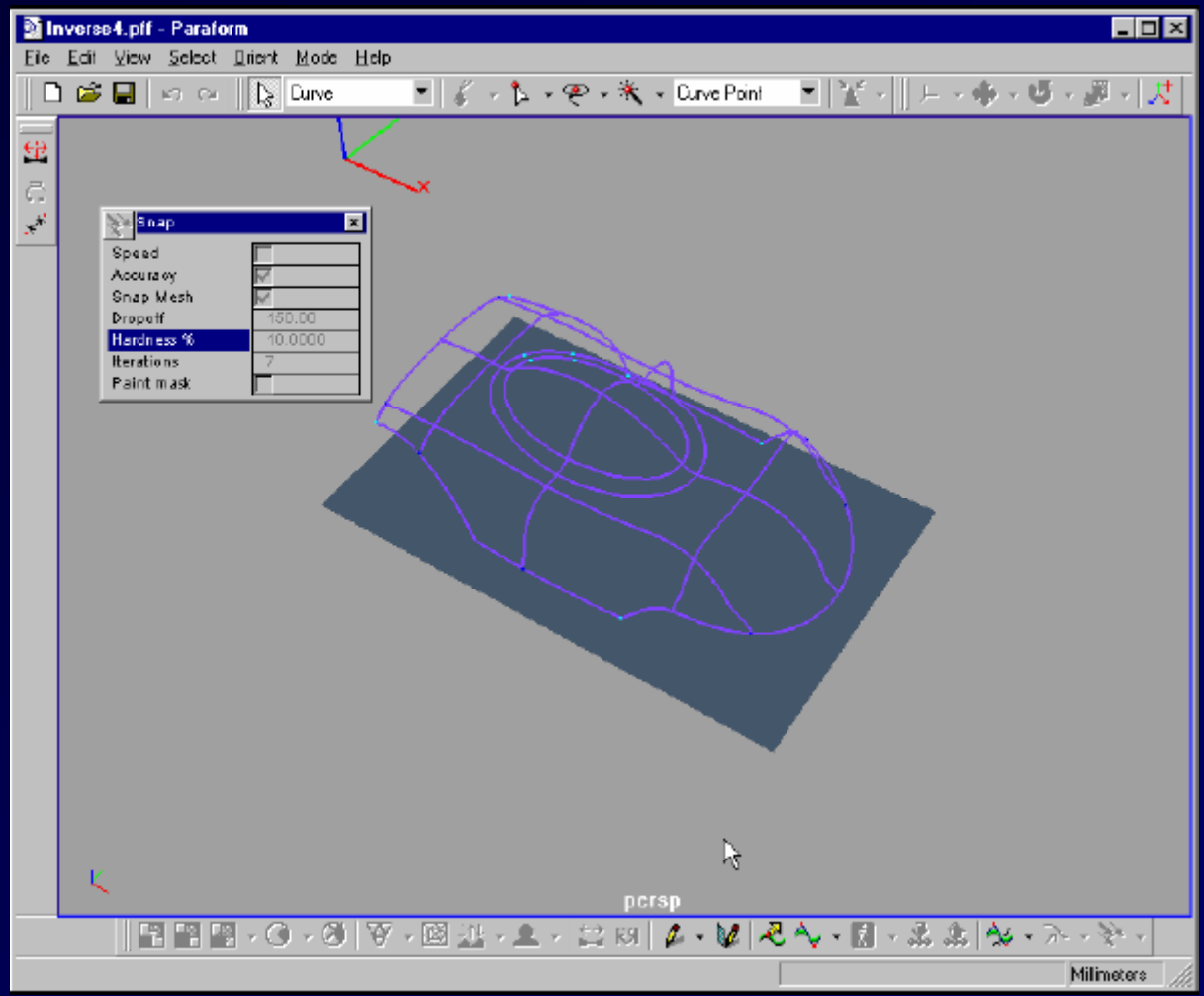


Deformation: Global

Control over deformation profile

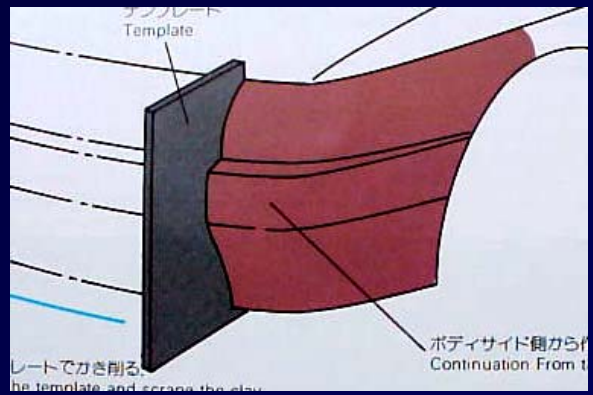


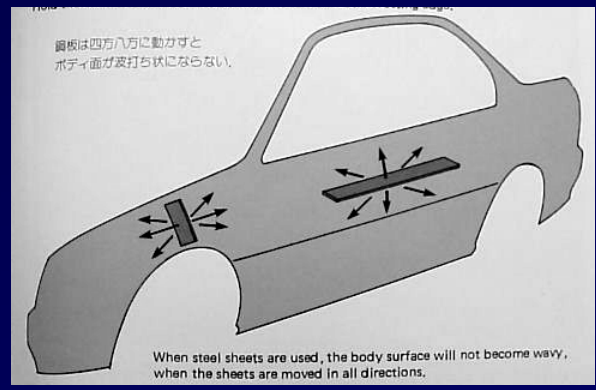
Deformation: Inverse Templates

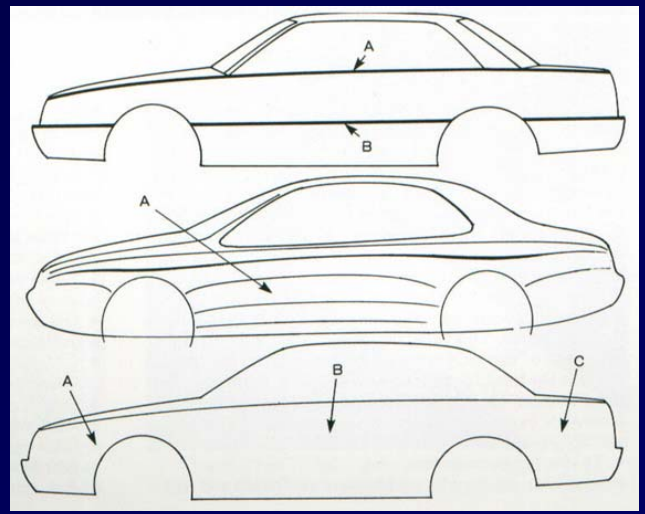


Deformation: Local

Sculpt based 3D output w/ digital “clay” tools

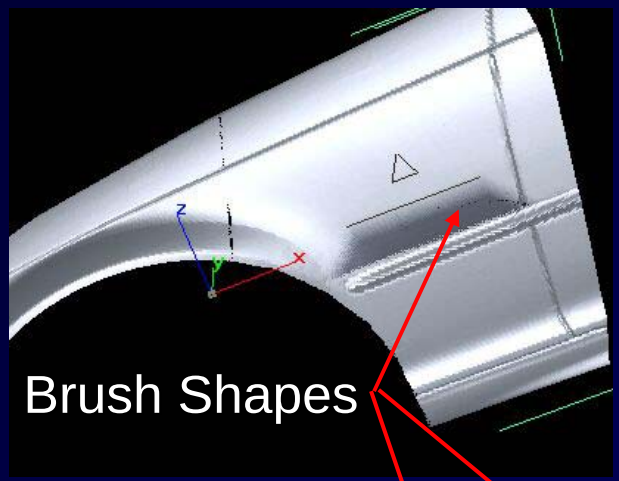


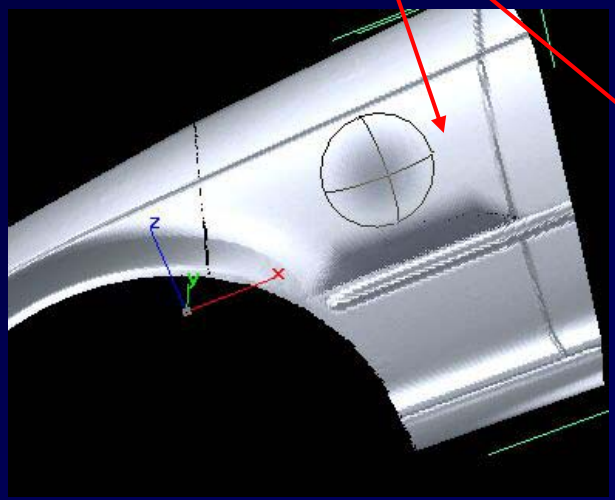


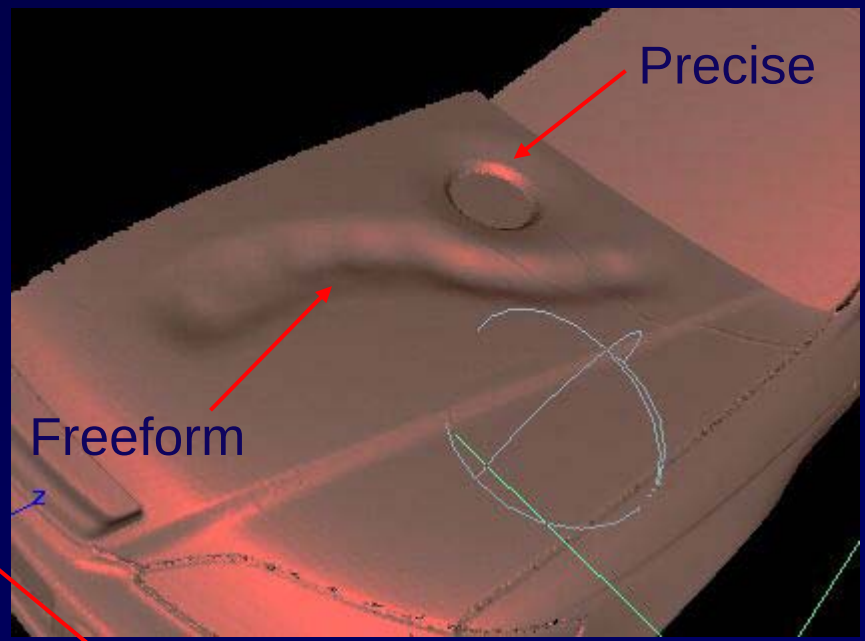


Deformation: Local

Brush based sculpting, smoothing.





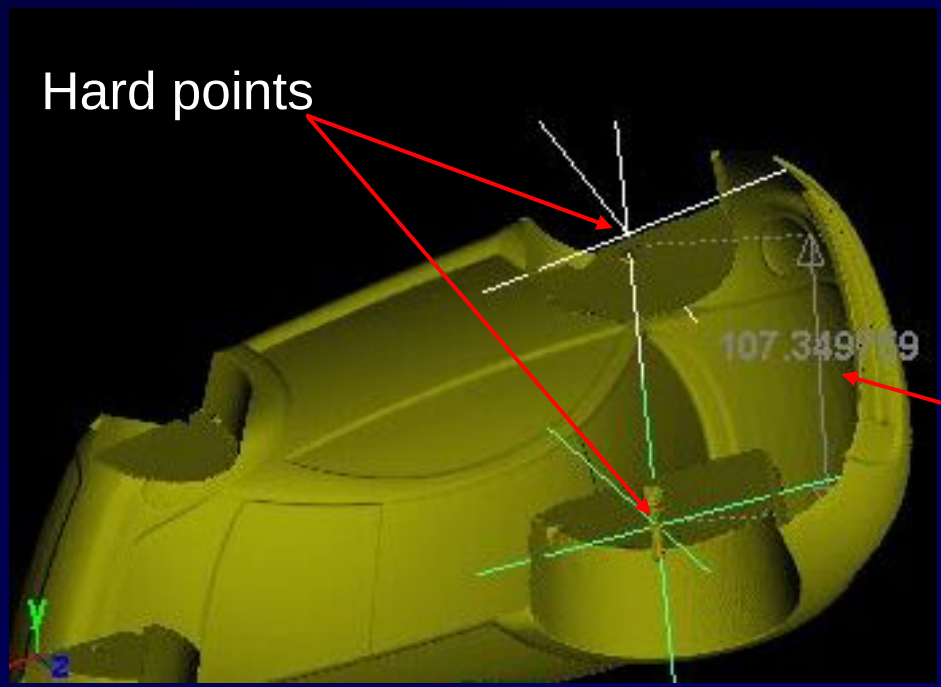


Shape Refinement

- Cut, copy and paste geometry
- Deformation
- Constraints

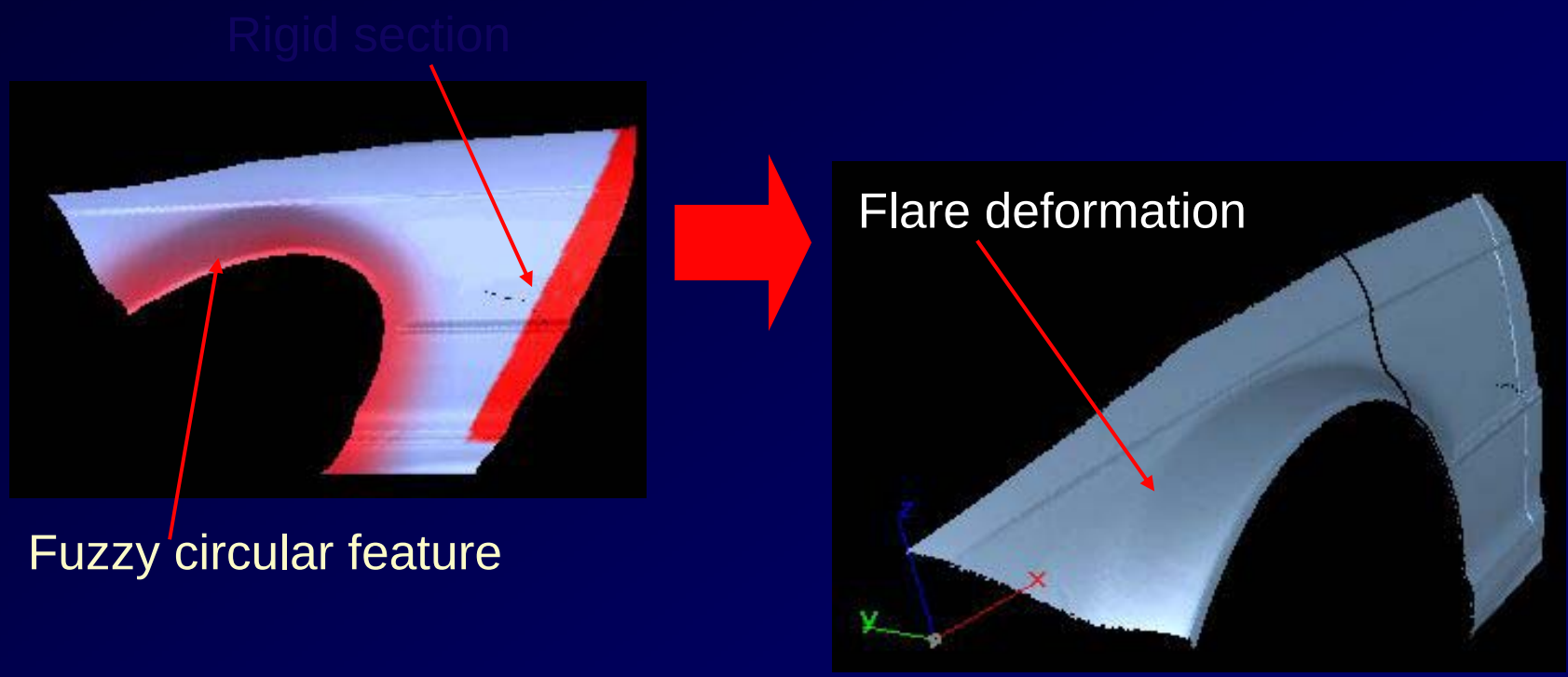
Constraints: Spatial

- Reference frames



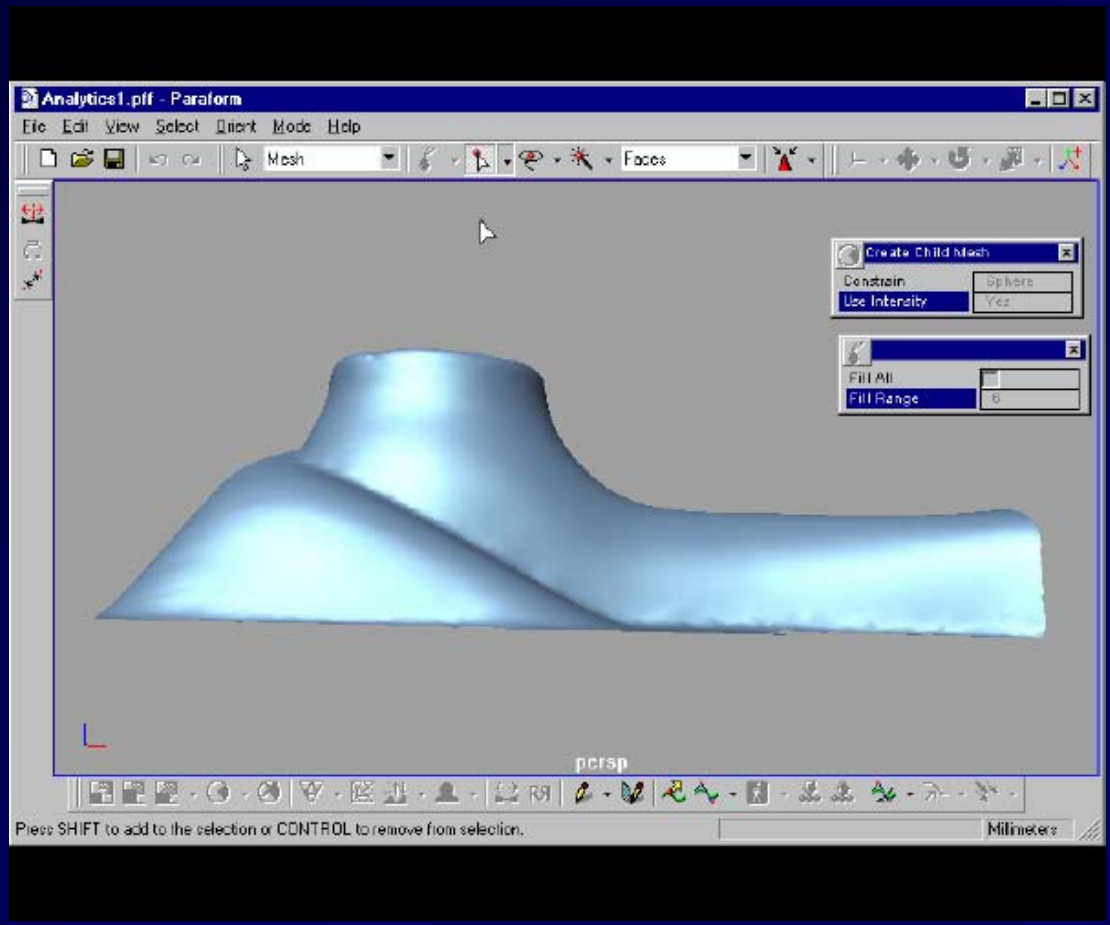
Constraints: Surface based

- Surface features based on a fuzzy selection (rigid, planar, cylindrical, spherical)



Constraints: Surface based

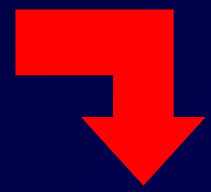
Analytic fitting and deformation



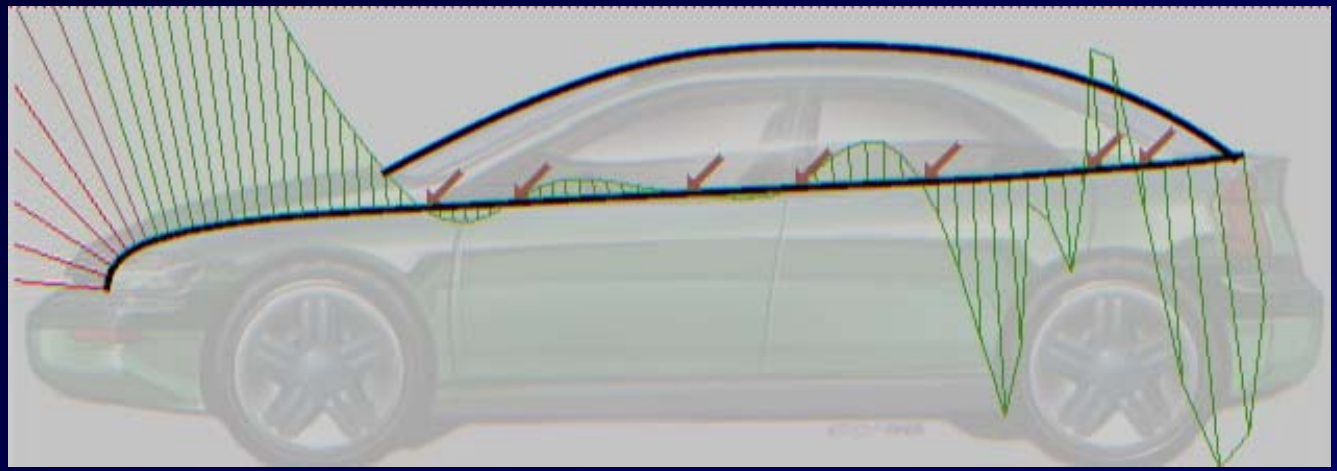
Workflow

- Speed Shape
- Shape Refinement
- Presentation

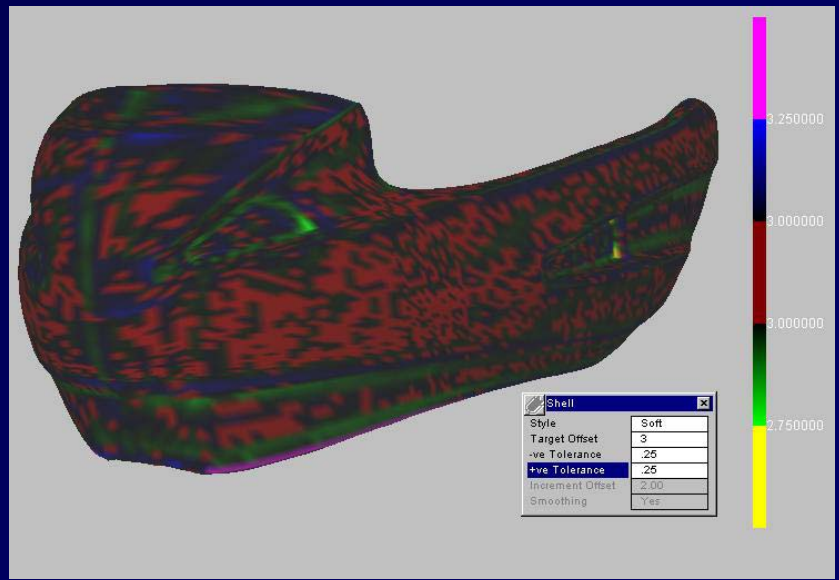
Environments and dynamic maps



Evaluation

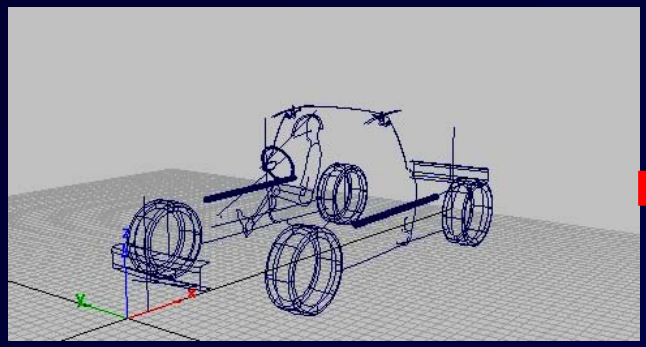


- Curvature plots
- Zebra maps
- Reflection lines



Presentation

Summary



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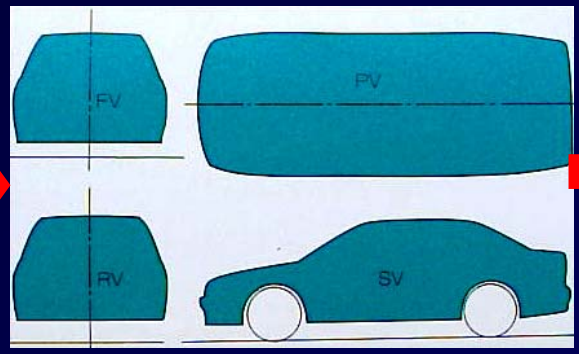

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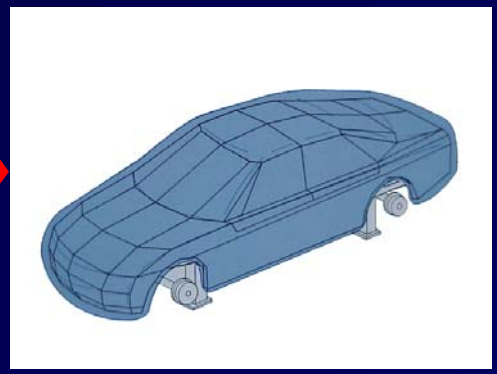
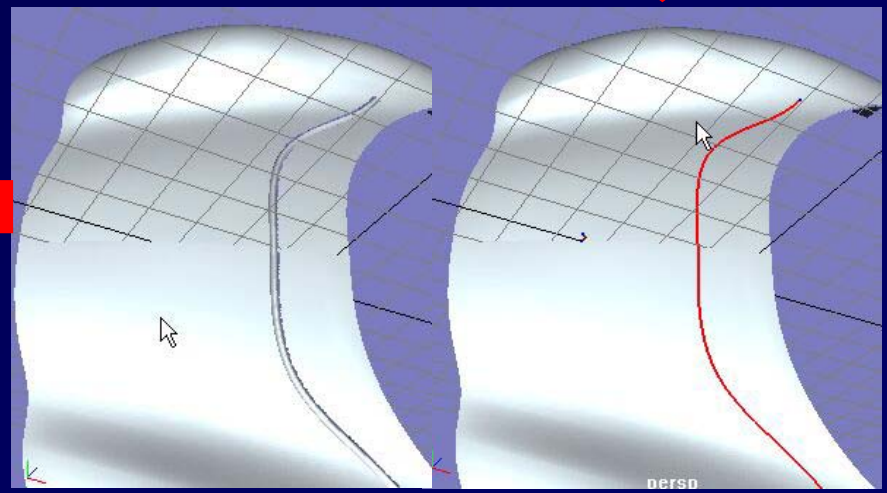


Rough mesh model



Refine mesh model

Presentation