10th Symposium on Overset Composite Grids and Solution Technology

Toward Automation within OverGrid For Geometry Import and Surface Patch Definition

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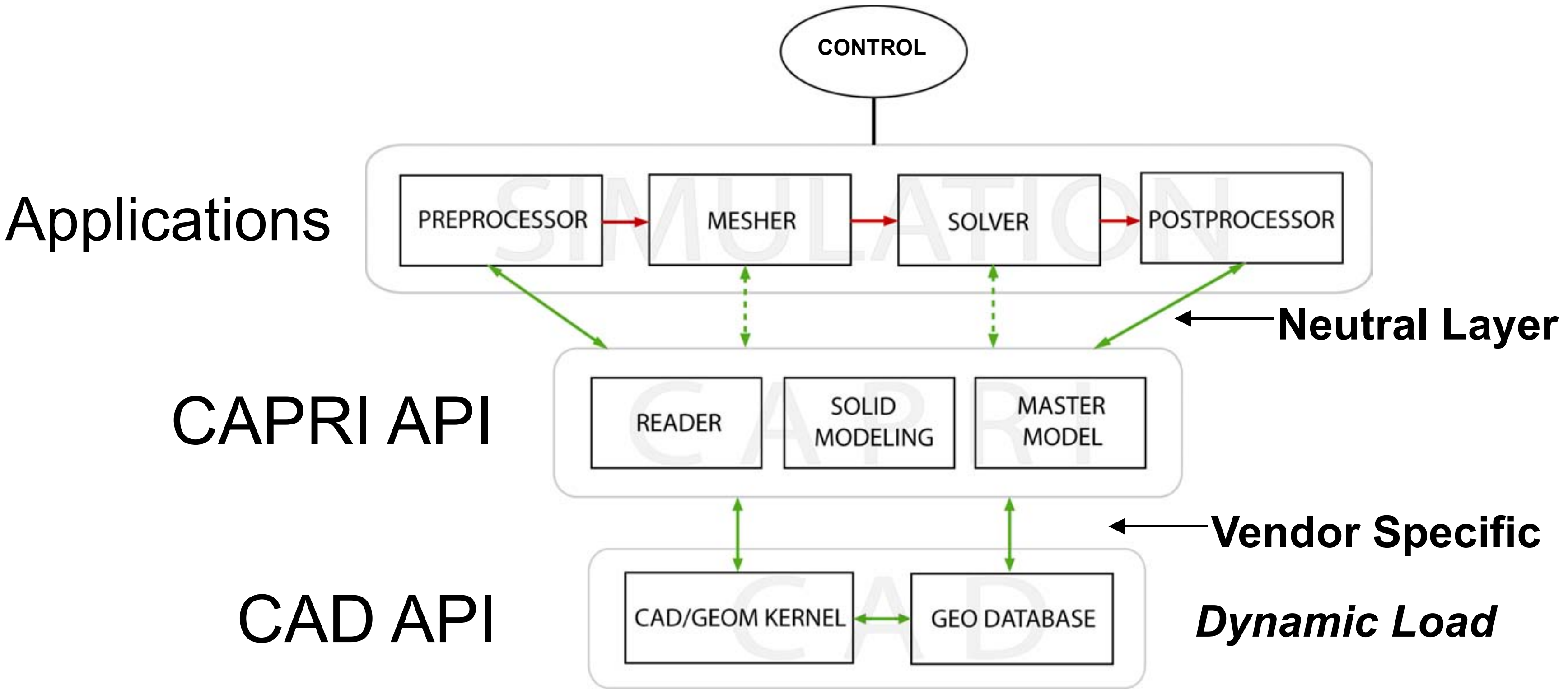
Outline

- A Uniform Direct Interface – **CAPRI**
- Automating Geometry Import
- Quilts (Engineering Reps)
- Control of BRep Topology – **vte**
- **vte** and Tcl
- OverGrid Integration
- Conclusions

Uniform Direct Interface – CAPRI

Designed as a foundation to build applications;
not just to expose the Geometry/Topology



CONTROL

Applications

SIMULATION

PREPROCESSOR

MESHER

SOLVER

POSTPROCESSOR

Neutral Layer

CAPRI API

CAPRI

READER

SOLID MODELING

MASTER MODEL

Vendor Specific

CAD API

CAD

CAD/GEOM KERNEL

GEO DATABASE

Dynamic Load

Computational **A**nalysis **PR**ogramming **I**nterface

Uniform Direct Interface – CAPRI

Solid Representation of Geometry -- BRep

Topological Entity	**Geometric Entity**	**Parameterization**
Assembly *(model)*		
Body *(volume)*		
Shell		
Face *(face)*	**surface**	(x,y,z) = **f**(u,v)
Loop		
Edge *(edge)*	**curve**	(x,y,z) = **g**(t)
Node *(node)*	**point**	

CAD Solids are open at machine precision -- tolerances

- Node points that bound Edges may not be on the curve
- Edge curves that bound the Faces (through Loops) may not be on the underlying surface

Automating Geometry Import

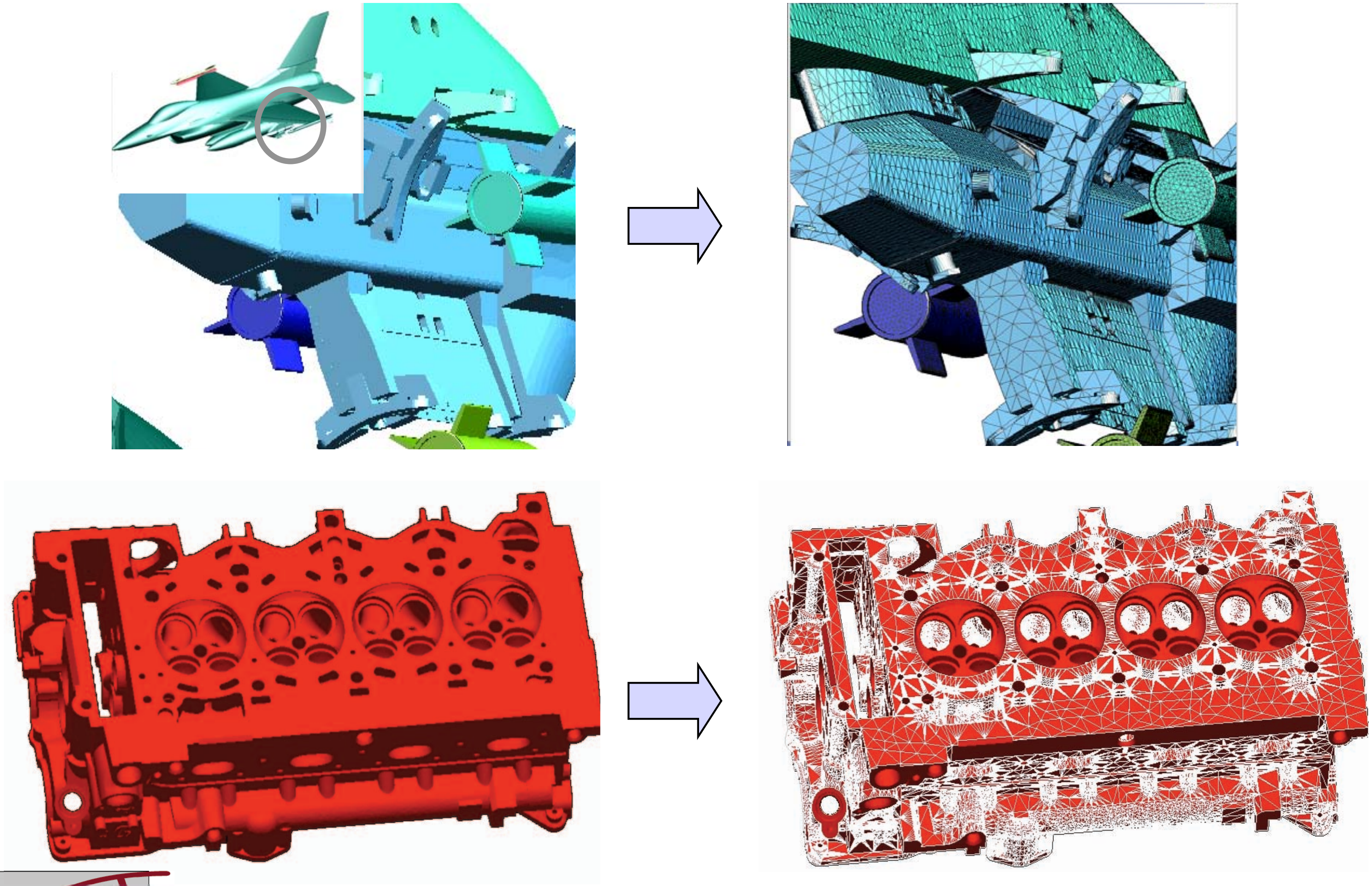
Dual View: Solid/BRep and a **Triangulation**

- **Watertight**
- **Robust**
- **Associative**
  - All vertices on geometry (with appropriate parameters)
  - Owning Face for triangles
- **Correct**
  - Logically *(u,v)*
  - Geometrically, with NO notion of physics/solver
- **Adjustable**
  - Side length, dihedral angle, chordal distance (sag)
- **CAPRI**'s *Quality* scheme:

8th ICNGG (Hawaii, 2002) – watertight tessellation

NOT just for Visualization

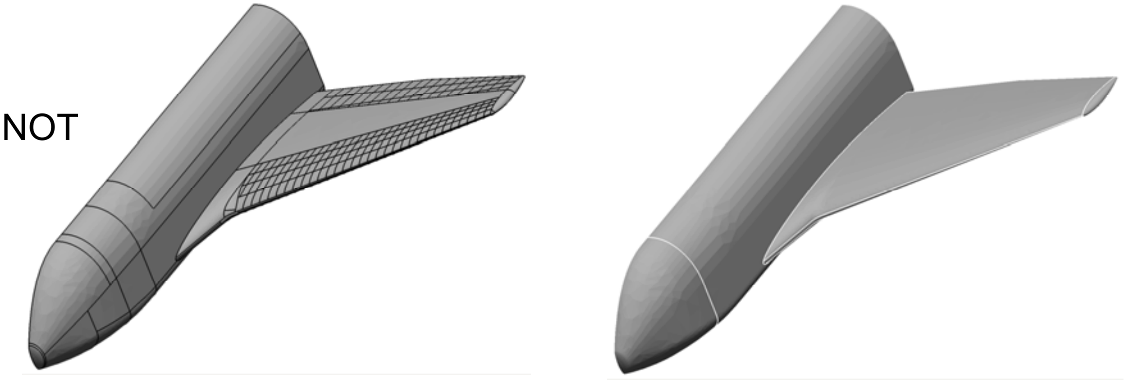
Automating Geometry Import



Tessellation Examples

Quilts (Engineering Reps)

- The BRep Topology is a result of construction **NOT** Engineering Intent
- Collect Faces to produce a *Quilt* based on Edge dihedral angles
- Associate back to ***CAPRI*** for geometry queries (that is, *Quilts* have no geometry)



Source is usually NOT Parametric CAD

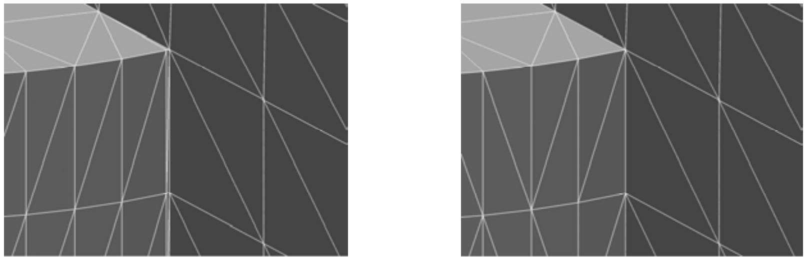
BRep containing 998 Edges and 429 Faces from ***CAPRI*** and the associated **E**ngineering **Rep**resentation containing 19 *chains* and 10 *quilts*

EReps may not be ready for Structured Block Grid Generation

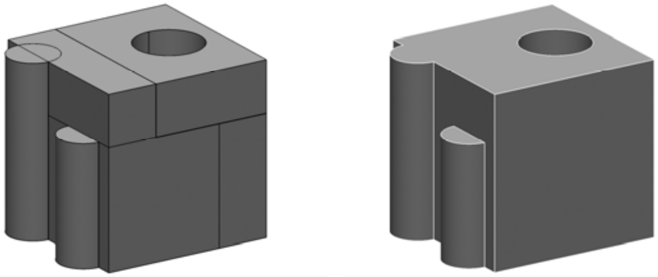
Control of BRep Topology

Need More Control Over BRep ⇨ERep Process

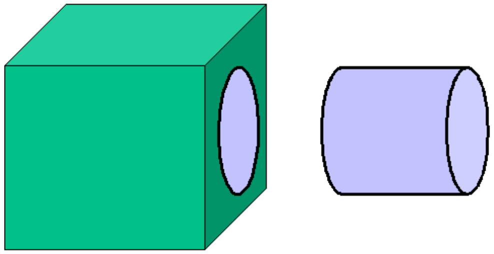
- Sliver Removal:



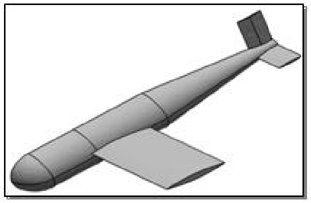
- Merging:



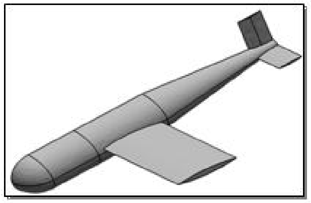
- Imprinting:



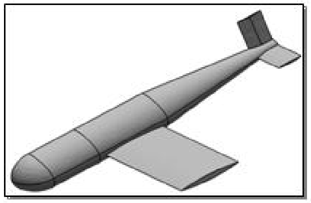
- Regeneration:



33 faces, 53 edges



31 faces, 50 edges



29 faces, 47 edges

Control of BRep Topology – vte

Virtual Topology Editor (**vte**)

- Thin Skin over the ***CAPRI*** BRep
  - Avoid the problems with translation
  - Drill down to actual geometry for accurate queries
  - Maintain ownership via a *hidden* triangulation
- Provide ***CAPRI***-like Geometric Functionality
- Dual Representation (Discrete & Analytic)
  - Need curves and surfaces not attached to topology
- Simple Topological Algebra
  - Split operator
  - Merge operator (*Quilting*)
- Facilitate Geometry Preparation of *Blocked* Meshing
  - Abutting Structured Block Grids
  - OverSet Meshes

Control of BRep Topology – vte

A “new” Solids-based Geometry Modeler

- Based on the self-contained geometry kernel from the *FLIGHT* and *FELISA* systems
  - Uses *Natural* Cubic Splines (D. Ferguson, 1986)
- Convert from any supported ***CAPRI*** CAD System and Geometry Kernel
  - Copies Topology (removes multiple outer Loops)
  - Translates Geometry
- Allows for *free-standing* geometry
- Complete ***CAPRI*** Back-end
  - Supersedes the *FELISA* port used by GridEx (Jones, LaRC)
  - Can be independently used (outside of **vte)**
  - Can always be local (no licensing, small, run on anything)

FErguson **LI**ghtweight **S**olids **A**PI – ***FELISA***

Control of BRep Topology – vte

The **vte C/C++** API

- Utility Functions
  - Operations such as object creation and destruction
- Analytic Geometry Generation
  - From points
  - From ***CAPRI*** entities
- Evaluation and Inverse Evaluation
  - Mimic the ***CAPRI*** access to geometry, but are available on temporary and created **vte** geometry
  - If the source of the geometry is a CAD model then ownership can be accessed
- High-level Functions
  - Allow the user to perform operations that change the topology of a **vte** model

Control of BRep Topology – vte

The **vte** High-Level Operators

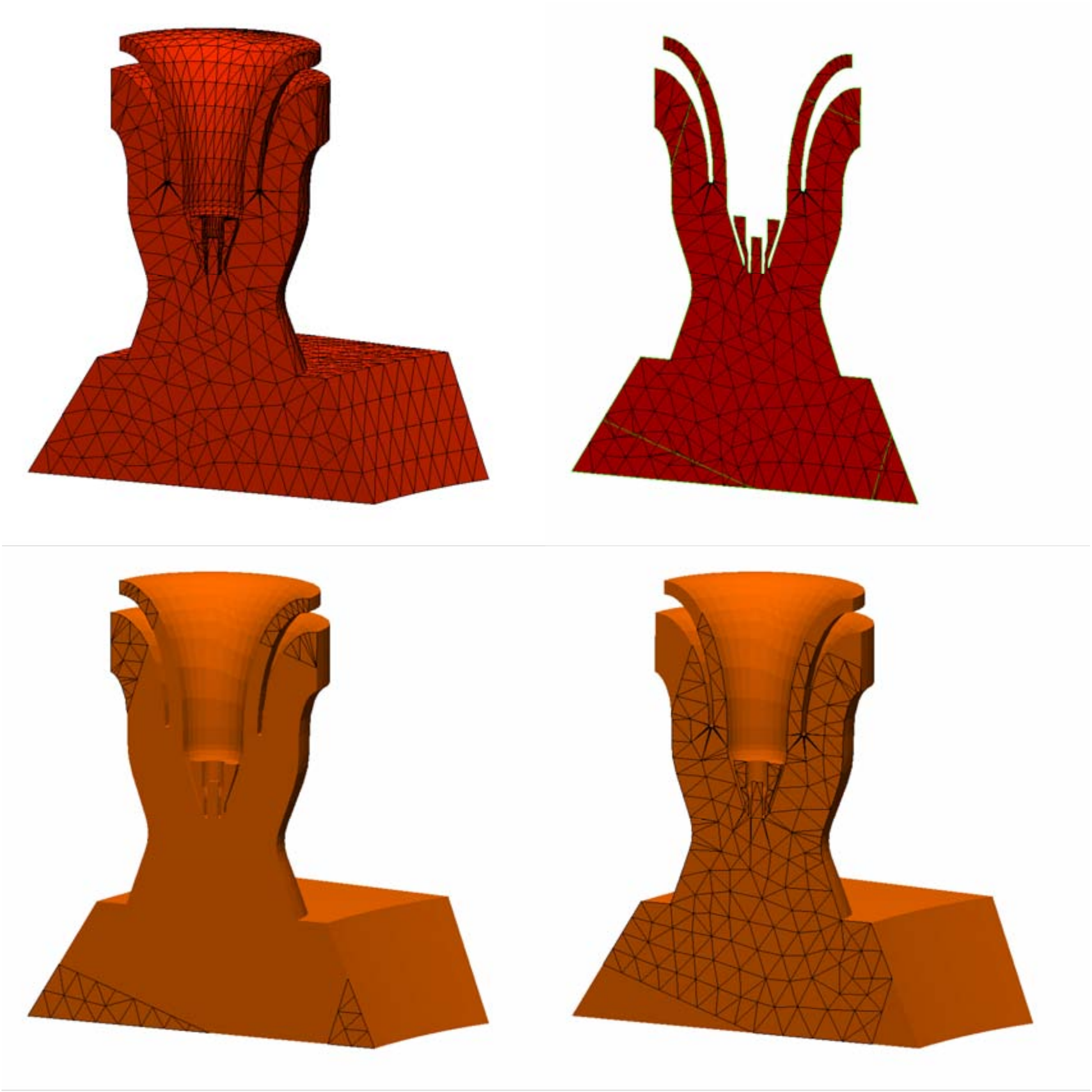
- Split (Scribe)
  - Use Curve(s) to project upon and “streamline” through the Face **vte** triangulation (used for association)
  - Split the triangulation to the resultant new Faces
  - All resultant Faces share source Analytic Geometry
  - Rebuild the Topology

- Merge
  - Agglomerate Face triangulations
  - Individual triangles of the collected tessellation are not merged (unless fragments from an earlier split can be coalesced)
  - Reparameterize the *Quilt-like* (Super)Face sensitive to the underlying curvature
  - Build an Analytic Surface from the Reparameterization
  - Rebuild the Topology

Control of BRep Topology (Splitting)

CAPRI tessellation of a converted 1/2 nozzle (from Parasolid) into the FELISA modeler (orange). 4 isocline fragments with the Face bounds make up a Loop (green). The triangulation is cut accordingly (in red). Note the isoclines intersect the symmetry plane in a complex manner.

The two ochre plots show the new faces generated with a tessellation that reflects this splitting. In this case the single Face was split into 7 Faces due to the complexity of the Loop/Face intersection.

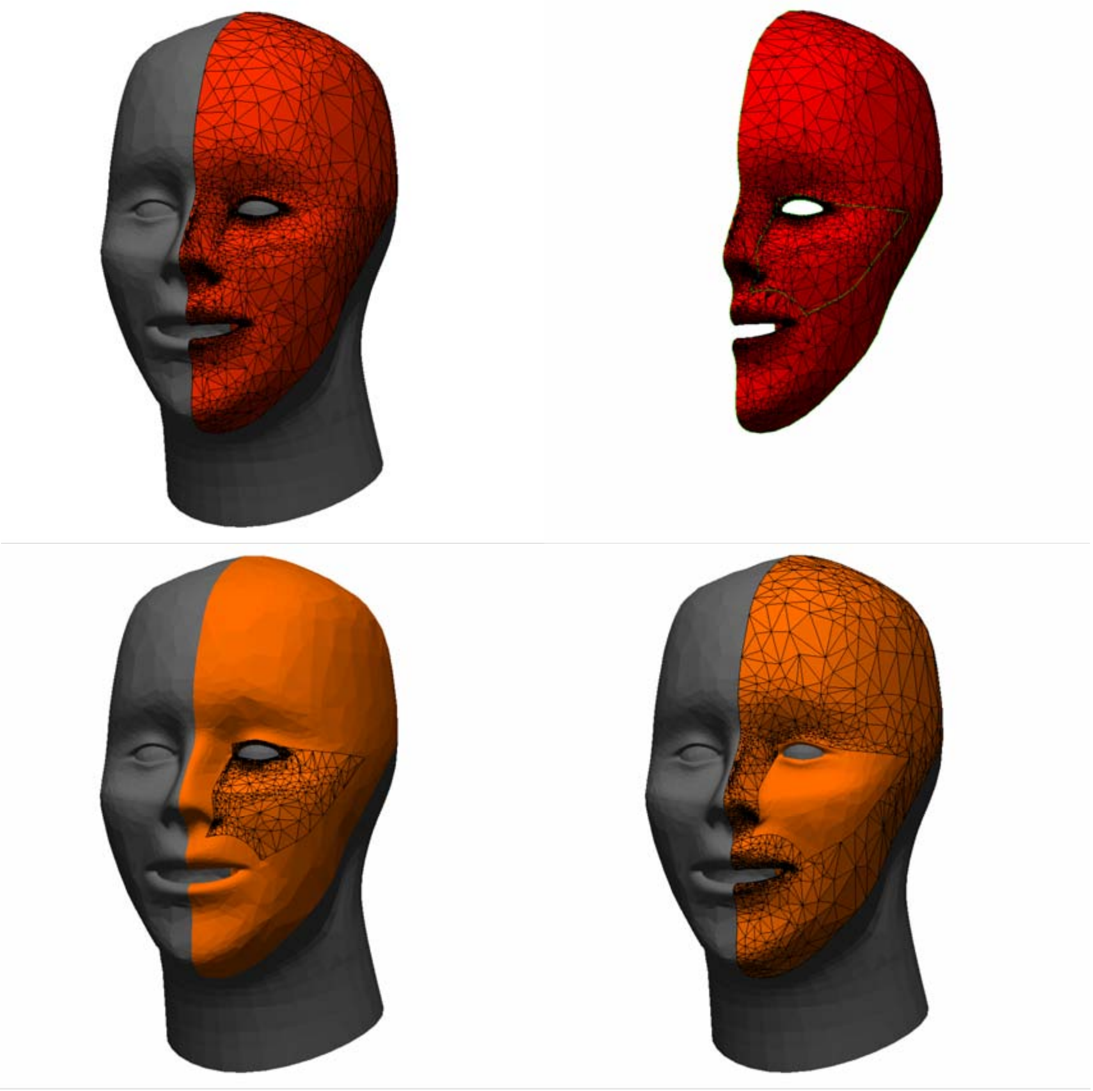


Control of BRep Topology (Splitting)

CAPRI tessellation of a converted head (from Parasolid) into the FELISA modeler (orange). 4 isoclines making up a Loop (green) with the triangulation cut accordingly (in red). It should be noted that this single surface is quite complex in shape and displays 2 degenerate poles (in the mouth and the top of the head) in the *[u,v]* mapping (a morphed spherical surface).

The two ochre plots show the new Faces generated with a tessellation that

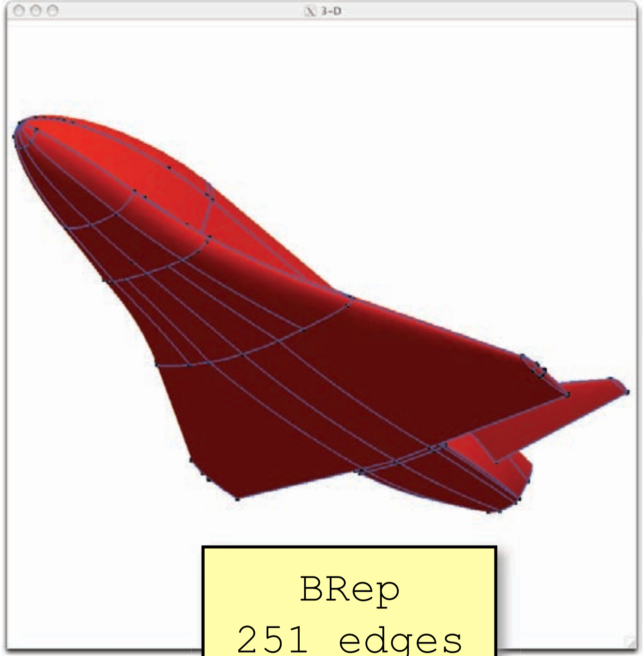
reflects this splitting.



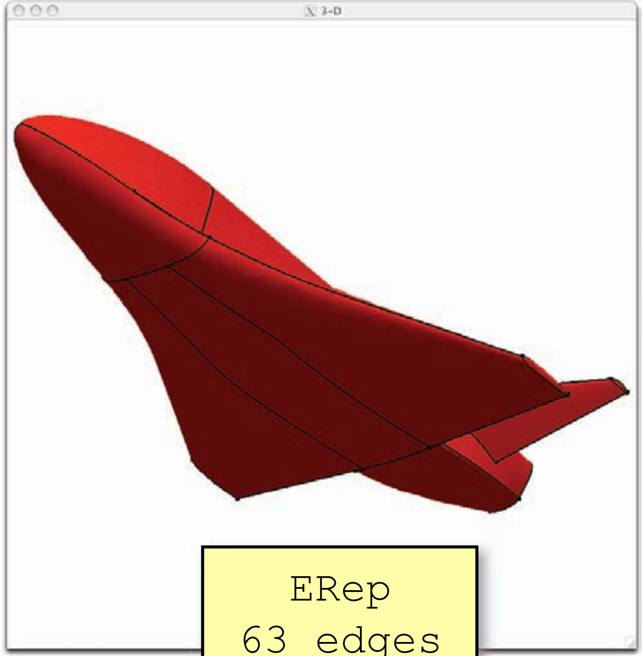
Control of BRep Topology (Merging)

Automatically generate an ERep from a BRep

- Edges classified based upon dihedral angles
- User can modify classifications based upon Engineering knowledge



BRep
251 edges
87 faces



ERep
63 edges
27 faces

vte and Tcl

vte Interpreter

- Abutting *vs* Overset Structured Block Meshing
  - Rules are very different
  - Need the flexibility to easily build, test and then adjust the blocking procedures
- Tcl Selected
  - Consistent with *OverGrid* & Pointwise's Glyph
  - Simple and natural Tcl *Object-Oriented* language constructed that encompasses the **C/C++** API
- **vteTcl** Execution
  - Can use *tclsh* or *wish* in standalone mode
  - **vteTcl** is a dynamically loaded module which automatically loads and initializes ***CAPRI***
  - Optional graphics/user interaction is available via ***CAPRI***'s gv (Geometry Viewer) also as a dynamically loaded module

vte and Tcl

```
vte       start
vte       load             $modeler $part
vte       stop

vteBrep CAPRIinit     $vol  ?$angle $maxedg $sag?  ⇨ newBrep
vteBrep destroy       $brep  ?$keepVol?
vteBrep edgeAttrib    $brep $edge  ?$attrib?  ?$value?
vteBrep edgeEval      $brep $edge $t ⇨ x y z
vteBrep faceAttrib    $brep $face  ?$attrib?  ?$value?
vteBrep faceEval      $brep $face $uv ⇨ x y z
vteBrep removeEdges   $brep $edgeList  ?$removeNodes?  ⇨ newBrep
vteBrep splitFace     $brep $face $curveList $tol ⇨ newBrep
vteBrep save          $brep $name
             :

vteSurf  attrib       $surf  ?$attrib?  ?$value?
vteSurf  eval         $surf $uv ⇨ x y z
vteSurf  fromPts      arrayName $periodic ⇨ newSurf
vteSurf  make         $brep $face ⇨ newSurf
             :
```

vte and Tcl

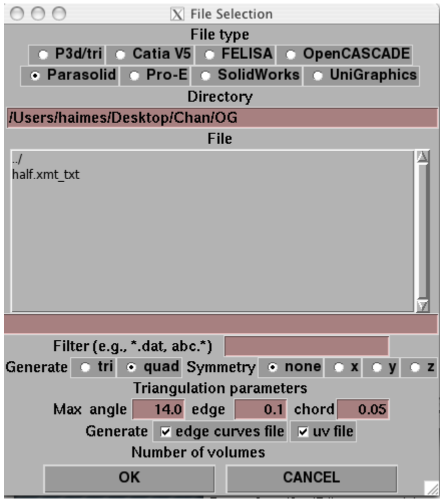
```
vteCurv   attrib    $curv  ?$attrib?  ?$value?
vteCurv   eval      $curv $t ⇨ x y z
vteCurv   fit       arrayName $tol ⇨ newCurv
vteCurv   fromPts   arrayName $periodic ⇨ newCurv
vteCurv   isoU      $brep $face $value ⇨ newCurv
vteCurv   isoV      $brep $face $value ⇨ newCurv
vteCurv   isoX      $brep $face $value ⇨ newCurv
vteCurv   isoY      $brep $face $value ⇨ newCurv
vteCurv   isoZ      $brep $face $value ⇨ newCurv
vteCurv   make      $brep $edge ⇨ newCurv
            :

gv        bind      $type ?$command?
gv        start
gv        stop
gv        update
```

Integration with OverGrid

Coupled at the Tcl level -- **vte** loaded at run time

- No source changes to *OverGrid* (Tcl scripts modified)
- Updates without new *OverGrid* Releases
  - New **vte** releases
  - **CAPRI** releases or support for new CAD Revs



File Selection

File type

○ P3d/tri ○ Catia V5 ○ FELISA ○ OpenCASCADE
● Parasolid ○ Pro-E ○ SolidWorks ○ UniGraphics

Directory

/Users/haimes/Desktop/Chan/OG

File

../
half.xmt_txt

Filter (e.g., *.dat, abc.*)

Generate ○ tri ● quad Symmetry ● none ○ x ○ y ○ z

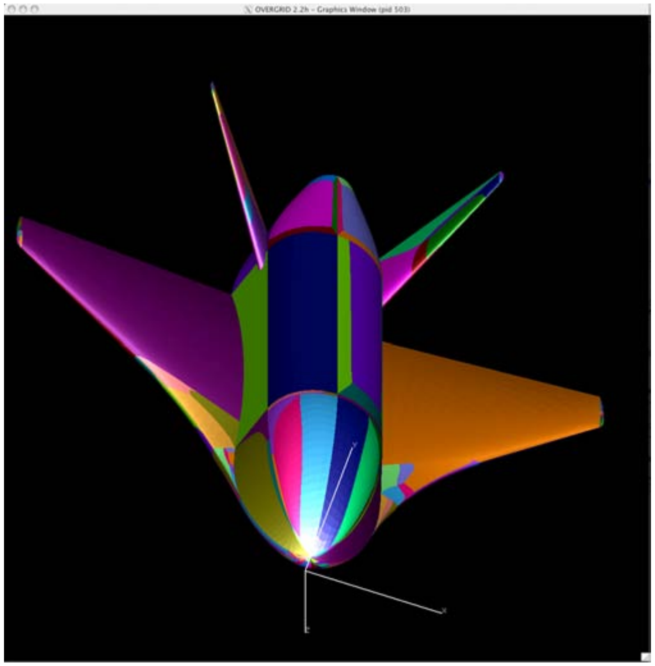
Triangulation parameters

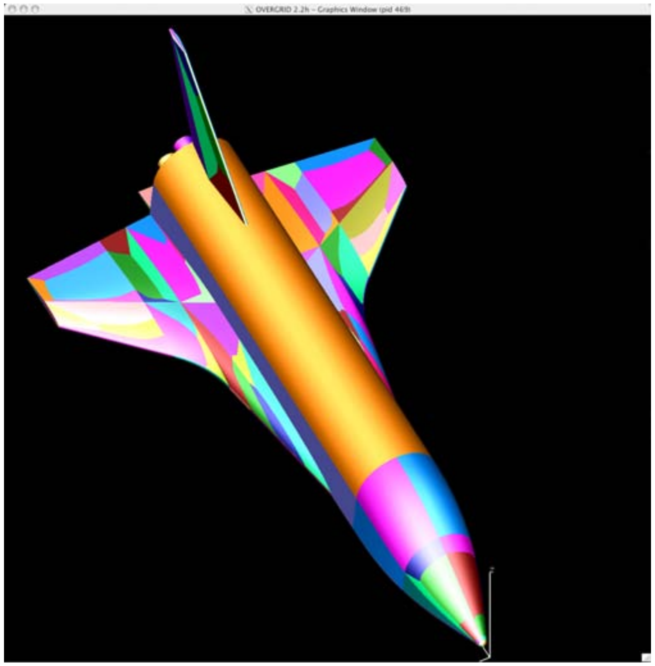
Max angle 14.0 edge 0.1 chord 0.05

Generate ☑ edge curves file ☑ uv file

Number of volumes

OK CANCEL

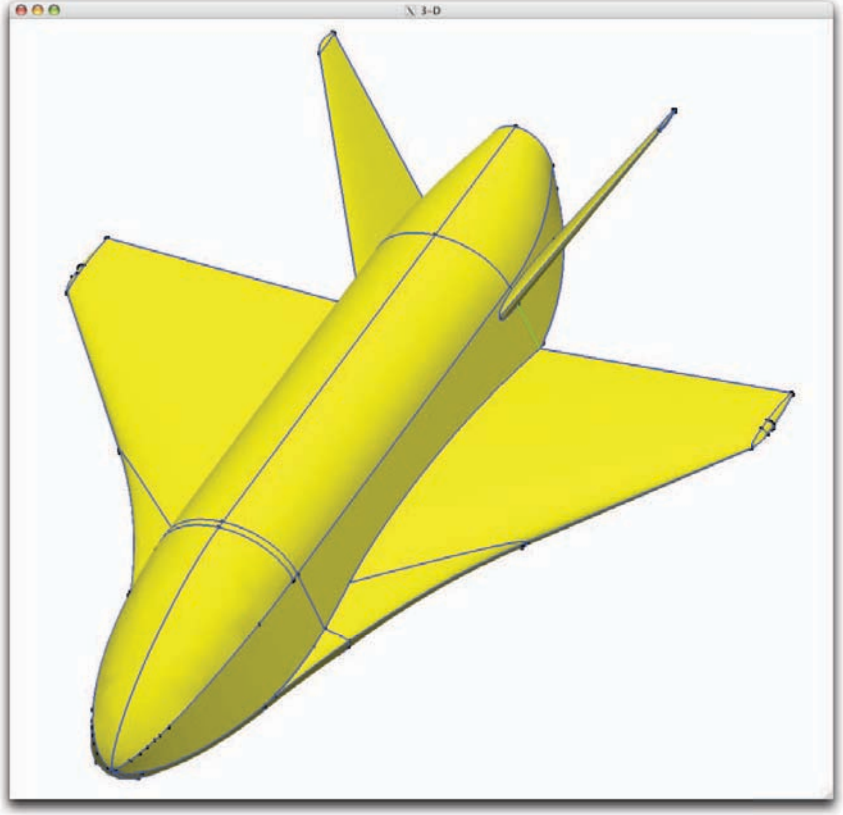


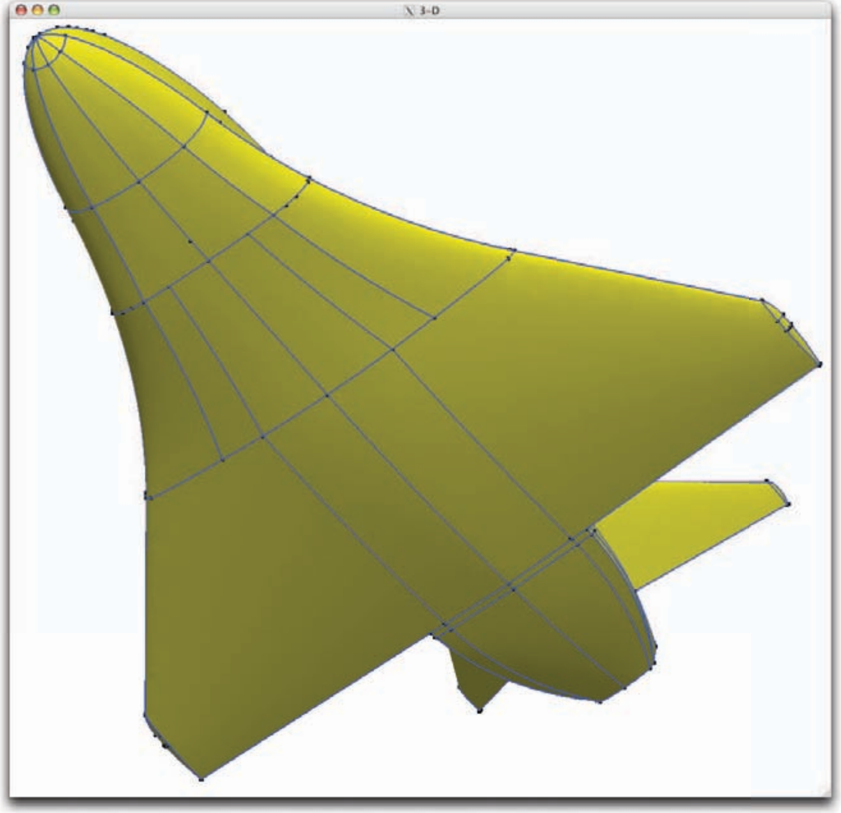


Optionally available with the resent release of *OverGrid*

Integration with OverGrid

- Shuttle-like Configuration
- Pro/Engineer Solid



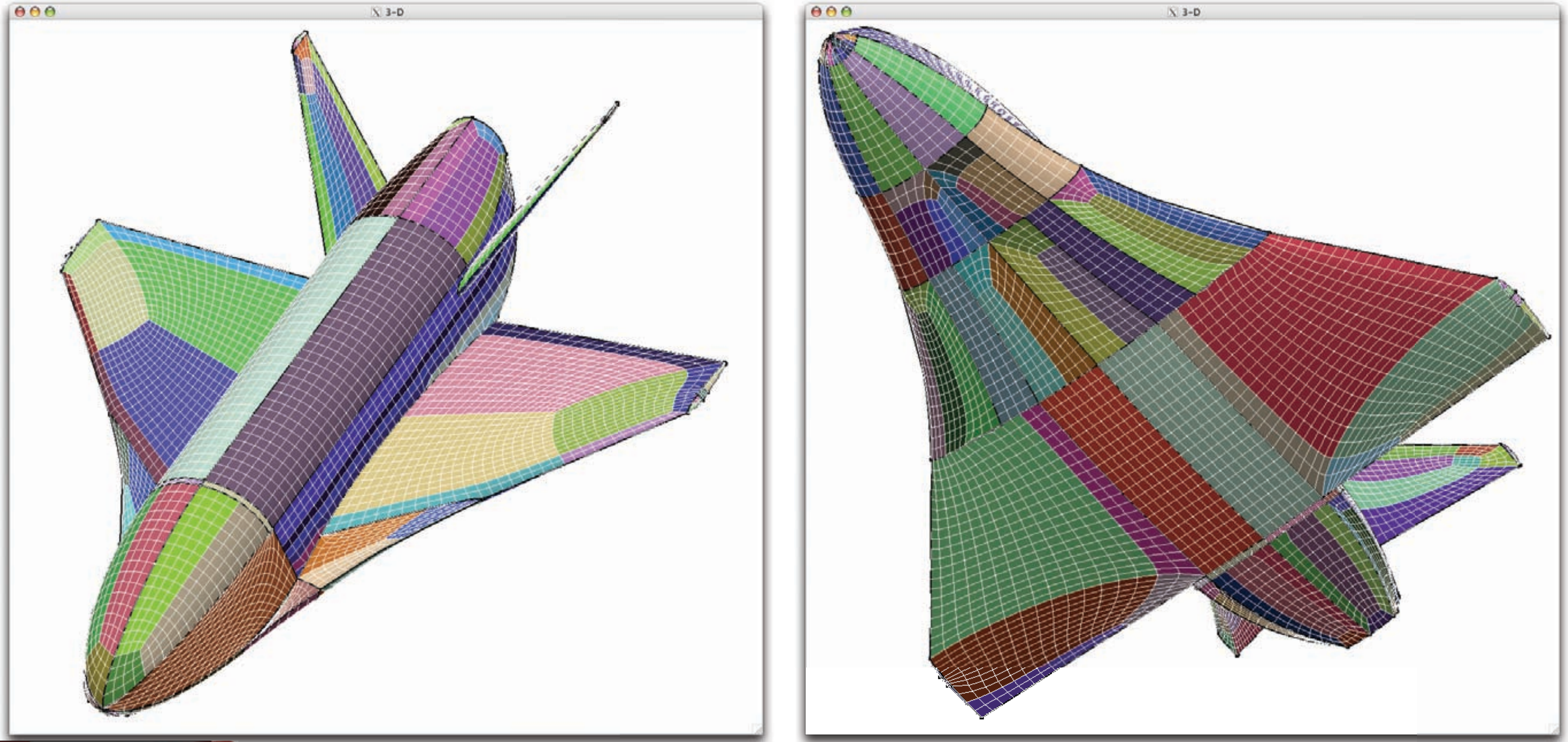


251 Edges   87 Faces

Integration with OverGrid

Automatically-generated Quadrilaterals

- Completely watertight
- Each BRep Face Quadded via the use of Templates

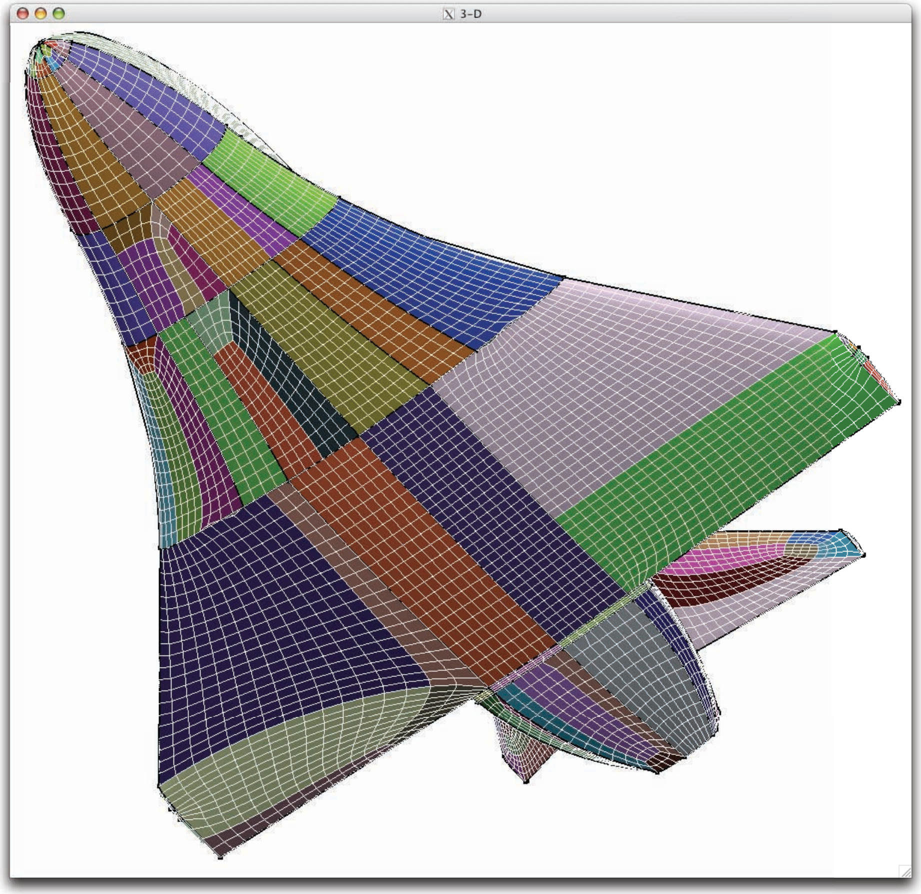


Edge point counts from Input panel -- 247 Quad surface patches

Integration with OverGrid

Quadrilaterals with Modified Point Counts

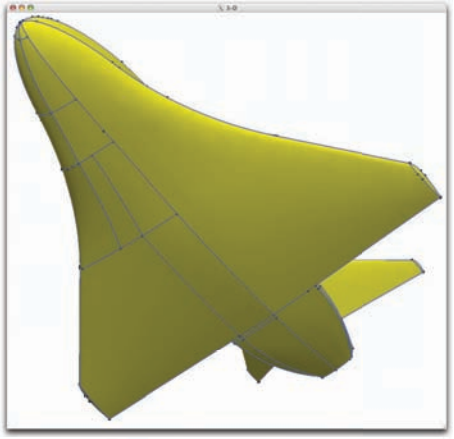
- Modified point counts on port side of configuration
- Not watertight along selected Edges
- Point counts changed on Edges to remove loops
- Same Face topology
- 10 Edges modified

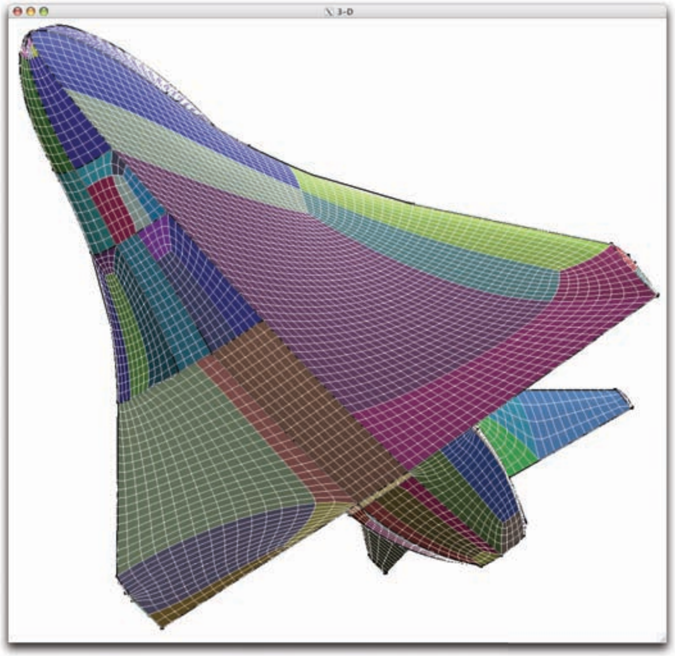


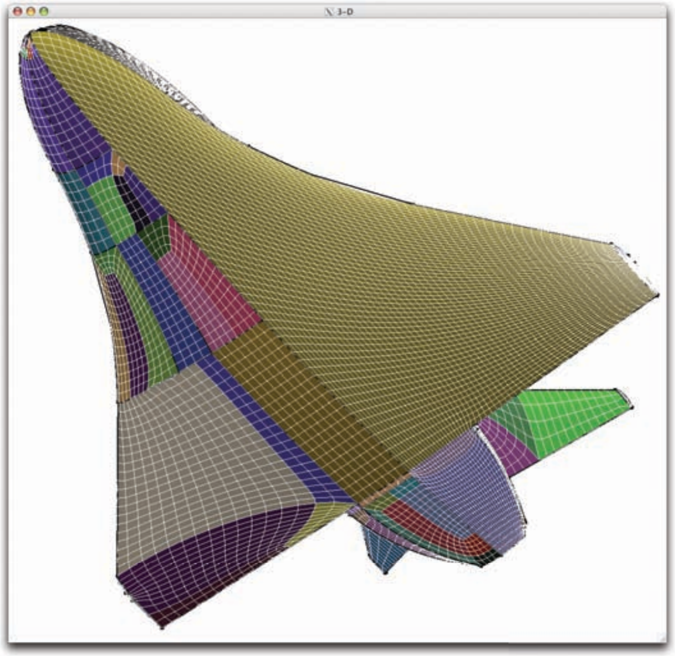
Integration with OverGrid

BRep Modified Through vte Merges

- Merges applied to port side of lower surface
- 18 faces ⇨ 3 faces







Automatic Quadrilaterals

Modified counts -- not watertight

Conclusions

Automatically Import Quadrilateral Patches

- Current state of *OverGrid*/**vte**
  - Start from ***CAPRI*** BRep
  - Quad Faces
- Quad Patches also used as Geometry Import

Framework Exists for *Easy* Tcl-based Enhancements

- Merges
- Splits
- Point count adjustments and (Re)Quadding
- Some automatic “collar” grid support

Acknowledgments

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Bob Meakin was the Technical Monitor.

The bulk of **vte** effort described here was then funded by the NASA Fundamental Aeronautics Program (supersonics) under Cooperative Agreement NNX07AV29A.
May-Fun Liou (NASA GRC) is the Technical Monitor.