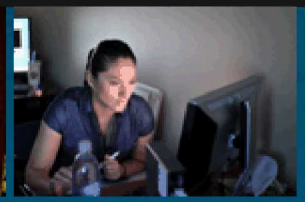
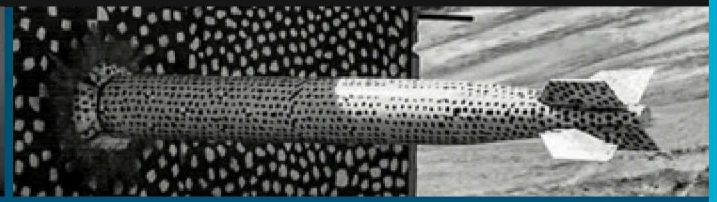
SAND2018-4136C

Converting Facets to B-Reps





PRESENTED BY

Paul R. Stallings, Ph.D.

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Statement of the Goal

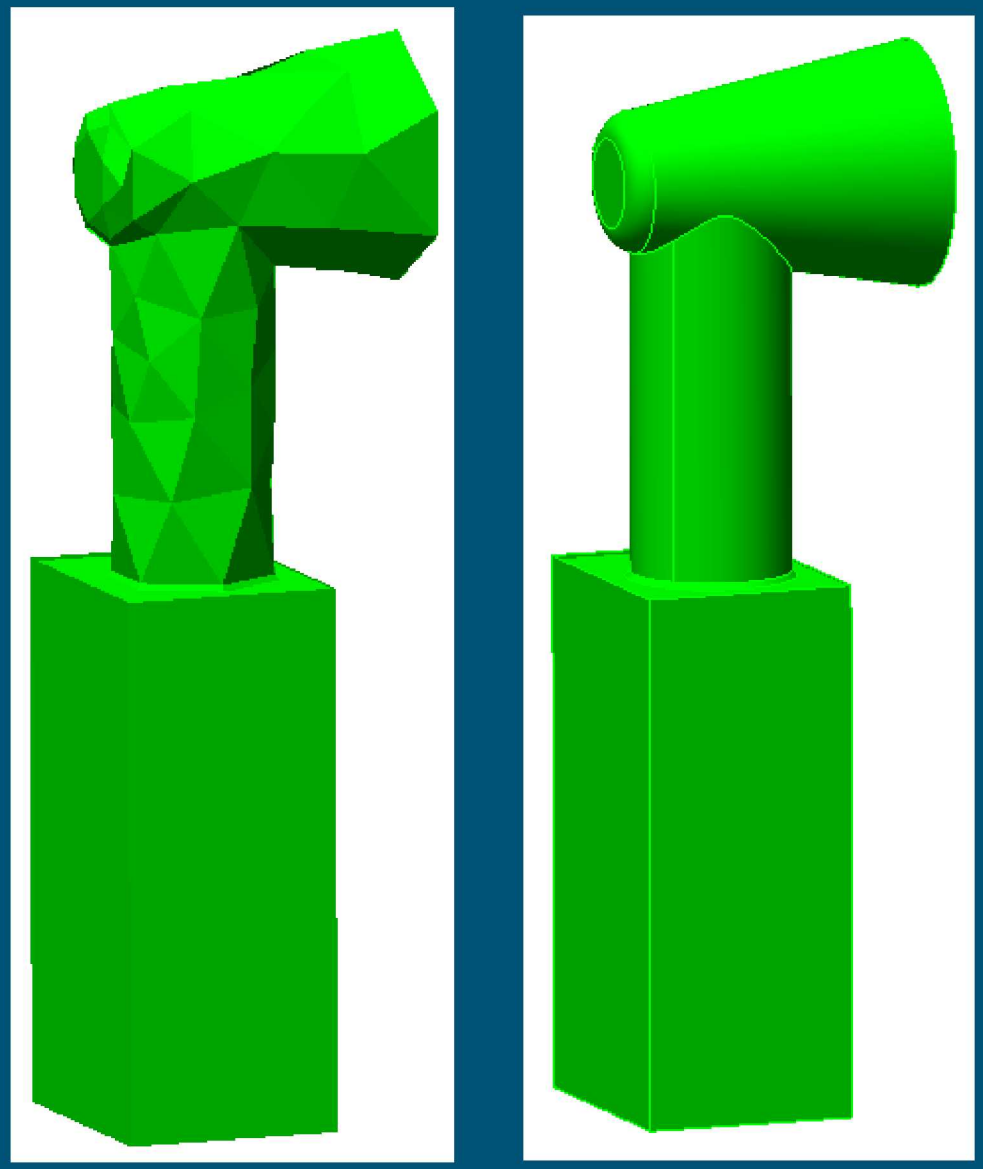
Given an STL file produce a light weight, approximating STEP file that can read into a CAD program.

```
solid Block
    facet normal 0.000000 0.000000 -1.000000
        outer loop
            vertex 0.000000 0.000000 0.000000
            vertex 0.000000 10.000000 0.000000
            vertex 10.000000 0.000000 0.000000
        endloop
    endfacet
    facet normal 0.000000 0.000000 -1.000000
        outer loop
            vertex 10.000000 0.000000 0.000000
            vertex 0.000000 10.000000 0.000000
            vertex 10.000000 10.000000 0.000000
        endloop
    endfacet
    facet normal 0.000000 0.000000 1.000000
        outer loop
            vertex 0.000000 0.000000 10.000000
            vertex 10.000000 10.000000 10.000000
            vertex 0.000000 10.000000 10.000000
        endloop
    endfacet
    facet normal 0.000000 0.000000 1.000000
        outer loop
            vertex 10.000000 10.000000 10.000000
            vertex 0.000000 0.000000 10.000000
            vertex 10.000000 0.000000 10.000000
        endloop
    endfacet
    facet normal 0.000000 -1.000000 0.000000
        outer loop
```

STL File

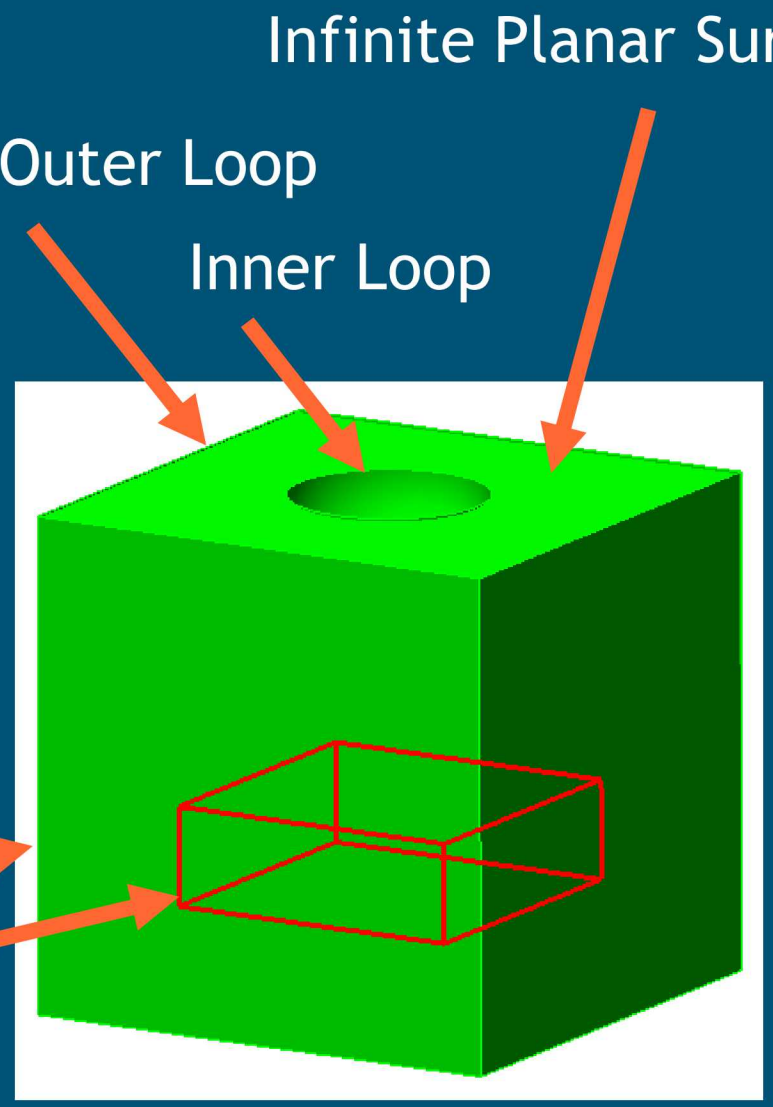
```
ISO-10303-21;
HEADER;
FILE_DESCRIPTION((' '),'1');
FILE_NAME('C:/Paul/Block.stp', '2018-02-14T00:06:43',('
FILE_SCHEMA(('AUTOMOTIVE_DESIGN'));
ENDSEC;
DATA;
#1=PRODUCT_DEFINITION_CONTEXT('',#4,'design');
#2=PRODUCT_CONTEXT('',#4,'mechanical');
#3=APPLICATION_PROTOCOL_DEFINITION('International Standa
#4=APPLICATION_CONTEXT('automotive design');
#10=DIMENSIONAL_EXPONENTS(1.0,0.0,0.0,0.0,0.0,0.0,0.0);
#11=DIMENSIONAL_EXPONENTS(0.0,0.0,0.0,0.0,0.0,0.0,0.0);
#12= (NAMED_UNIT(#10)LENGTH_UNIT()SI_UNIT(.MILLI.,.METRE
#13= (NAMED_UNIT(#11)PLANE_ANGLE_UNIT()SI_UNIT($,.RADIAN
#14= (NAMED_UNIT(#11)SOLID_ANGLE_UNIT()SI_UNIT($,.STERAD
#15=LENGTH_MEASURE_WITH_UNIT(LENGTH_MEASURE(25.4),#12);
#16= (CONVERSION_BASED_UNIT('INCH',#15)LENGTH_UNIT()NAME
#17=UNCERTAINTY_MEASURE_WITH_UNIT(LENGTH_MEASURE(1.0E-0
#18= (GEOMETRIC_REPRESENTATION_CONTEXT(3)GLOBAL_UNCERTA
#20=CARTESIAN_POINT('',(0.000000000000000,0.000000000000
#21=DIRECTION('',(0.000000000000000,0.000000000000000,1
#22=DIRECTION('',(1.00000000000000,0.000000000000000,0.0
#23=AXIS2_PLACEMENT_3D('',#20,#21,#22);
#24=CARTESIAN_POINT('',(0.000000000000000,0.000000000000
#25=VERTEX_POINT('',#24);
#26=CARTESIAN_POINT('',(10.0000000000000,0.000000000000
#27=VERTEX_POINT('',#26);
#28=CARTESIAN_POINT('',(0.000000000000000,0.000000000000
#29=DIRECTION('',(1.00000000000000,0.000000000000000,0.0
#30=VECTOR('',#29,1.00000000000000);
#31=LINE('',#28,#30);
#32=EDGE_CURVE('',#25,#27,#31,.T.);
#33=ORIENTED_EDGE('',*,*,#32,.F.);
#34=CARTESIAN_POINT('',(0.000000000000000,10.000000000000
#35=VERTEX_POINT('',#34);
```

STEP File



Parts of a B-Rep "Boundary Represented Solid"

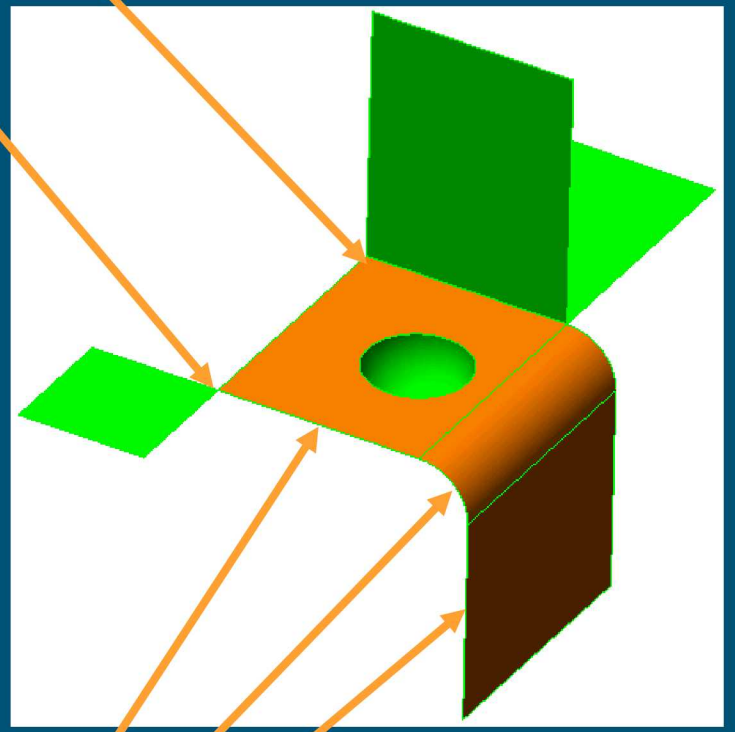
Dimension	Zero	One	Two	Three
CAD Name	Point Set	Wire Body	Sheet Body	Body
Maximal Connected	Point	Lump	Lump	Lump
Connected Boundary Part	Ø	Vertex	"Boundary Loop"	Shell
Differentiable Part	N/A	Edge	Face	N/A
Differentiable Boundary	N/A	Vertex	"Face Loop"	N/A



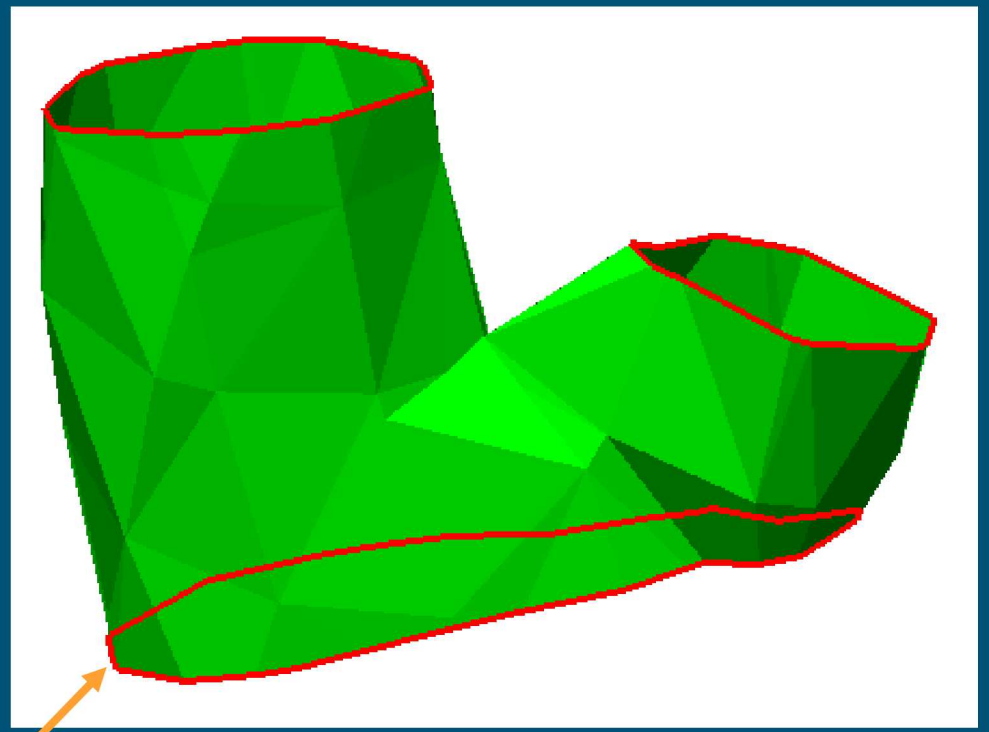
CAD Topology

Non-Manifold Vertex

Non-Manifold Edge



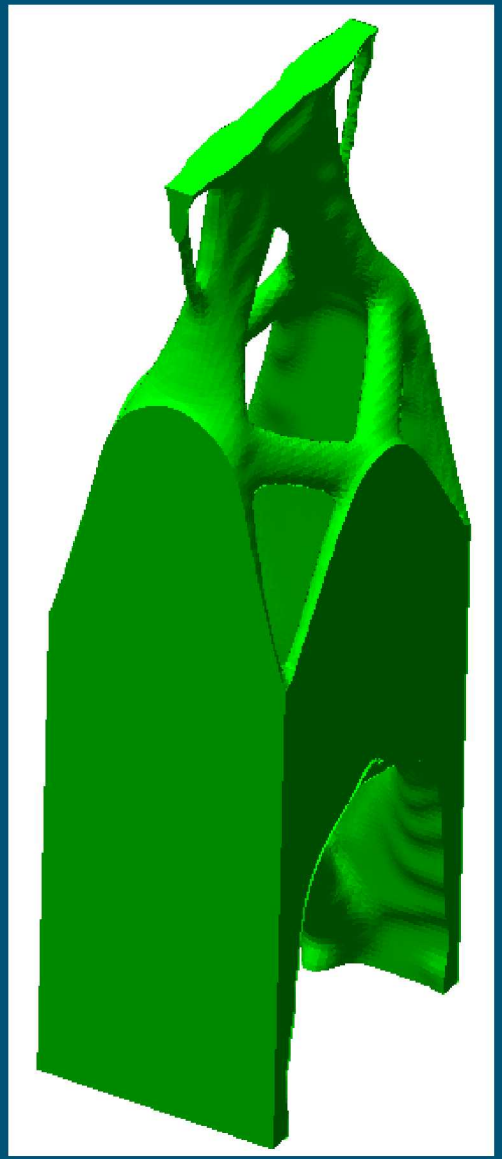
One Edge or Three ?



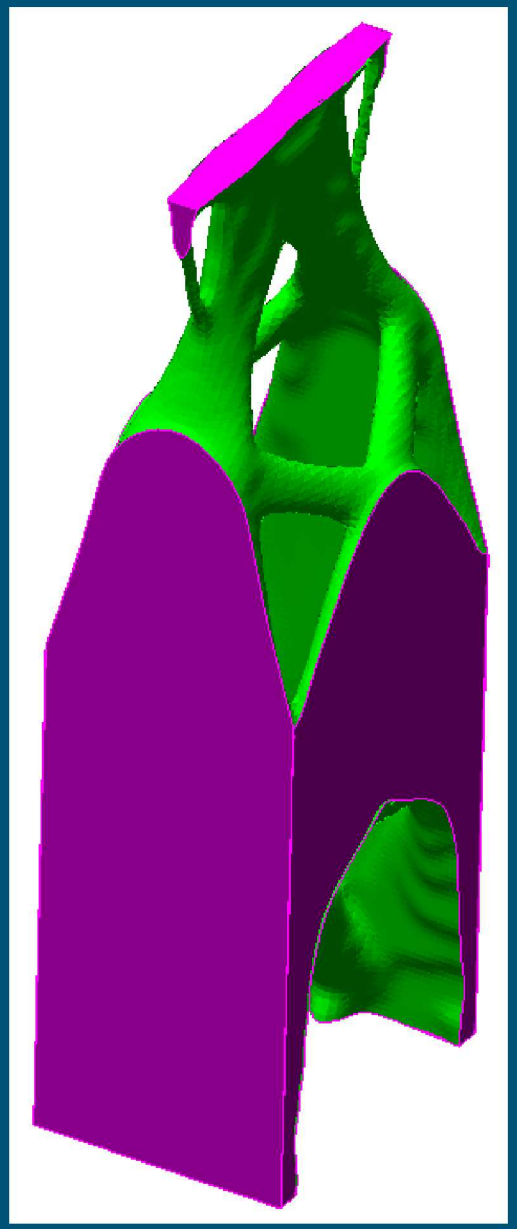
A Connected Component
of the Facet Boundary

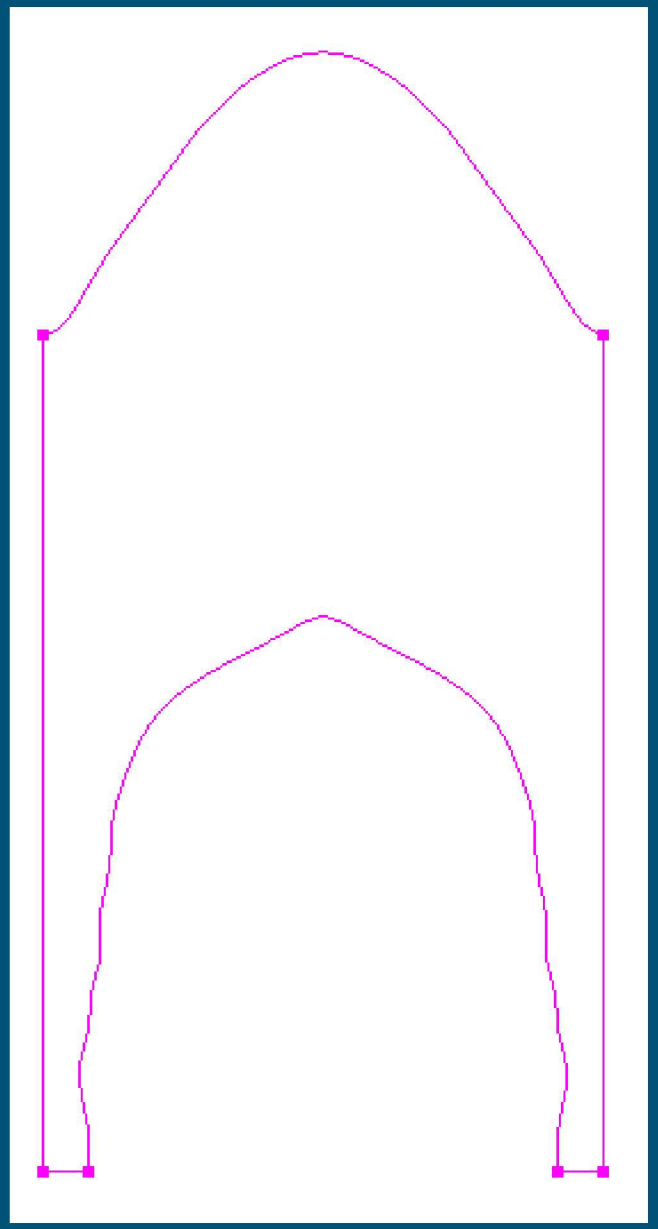
Outline of the Algorithm

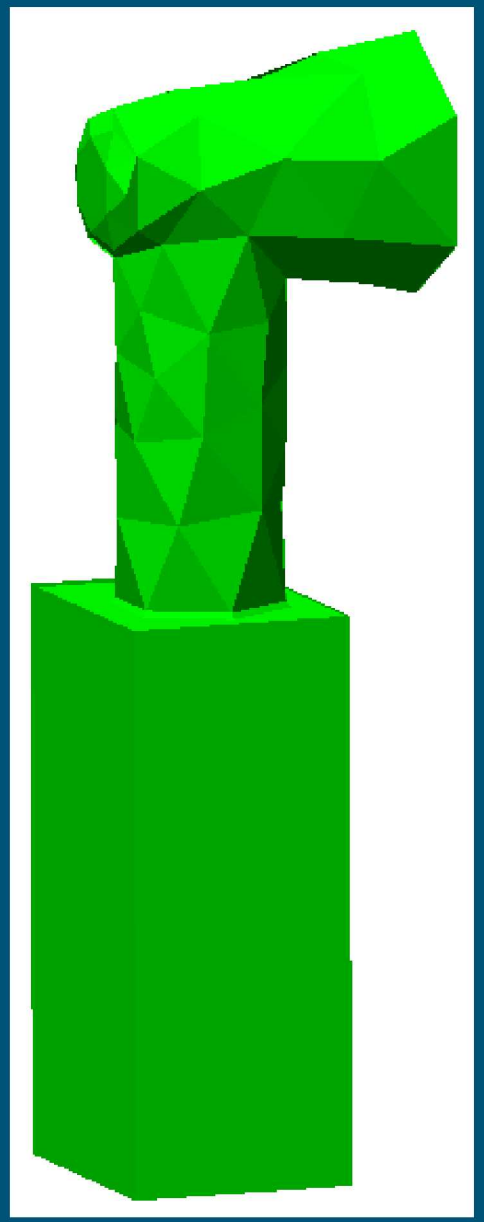
1. Read in the STL file, find connectivity and clean it up.
2. Find maximal, connected subsets of triangles that lie on the same “special” surface, i.e. Plane, Sphere, Cylinder, Revolved, Extruded, …
3. Find Edges for the subsets found in step 2.
4. Find and cut the part along plane(s) of symmetry.
5. Find and cut out tubes from the remaining part.
6. Cut the remaining joints into near differentiable single boundary parts, to which a light weight NURB can be fit with a small number, usually 4 or less, edges.
7. Stitch the faces together, enclosing a volume if possible.
8. Output the resulting B-Rep as a STEP file.

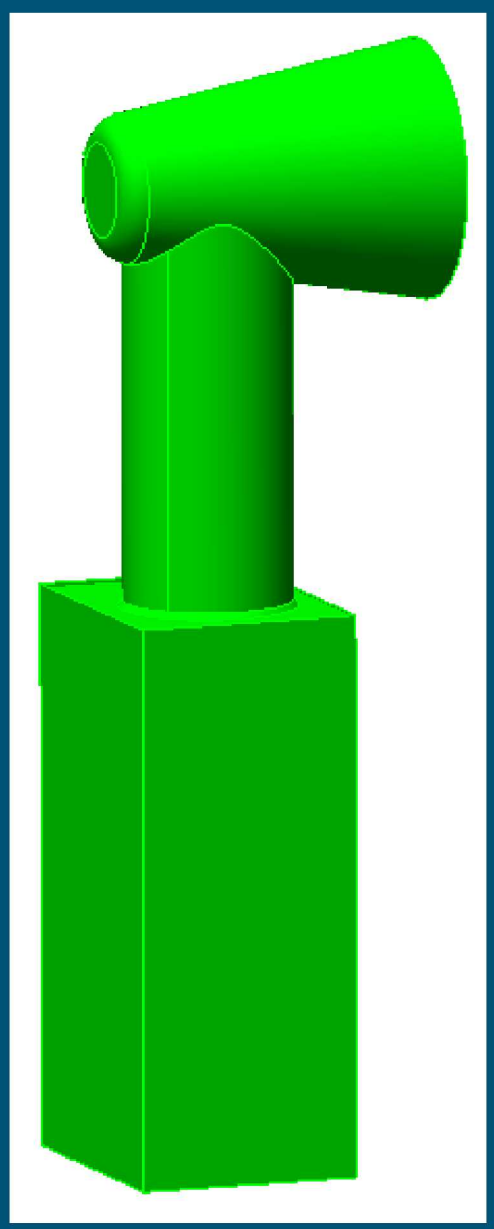


Finding “Special” Surfaces

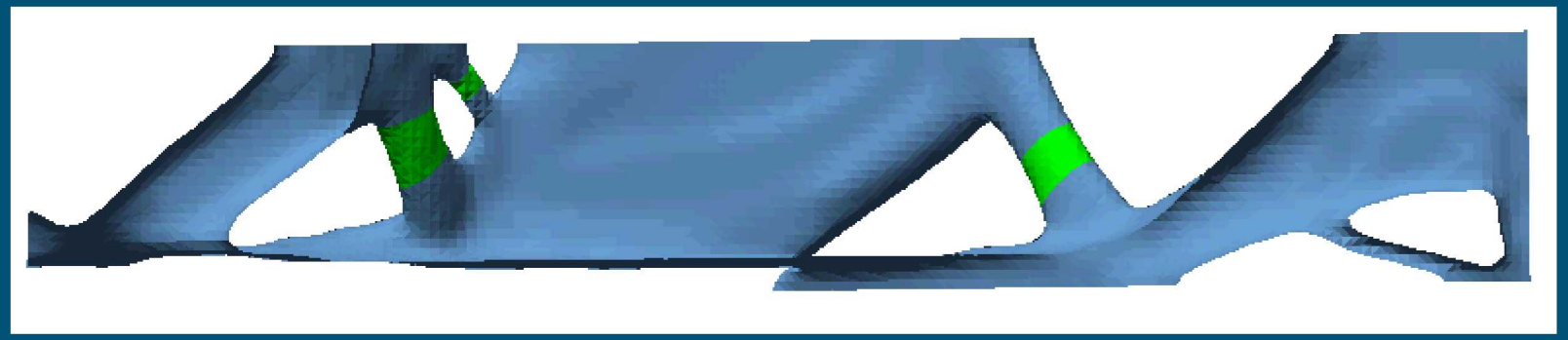


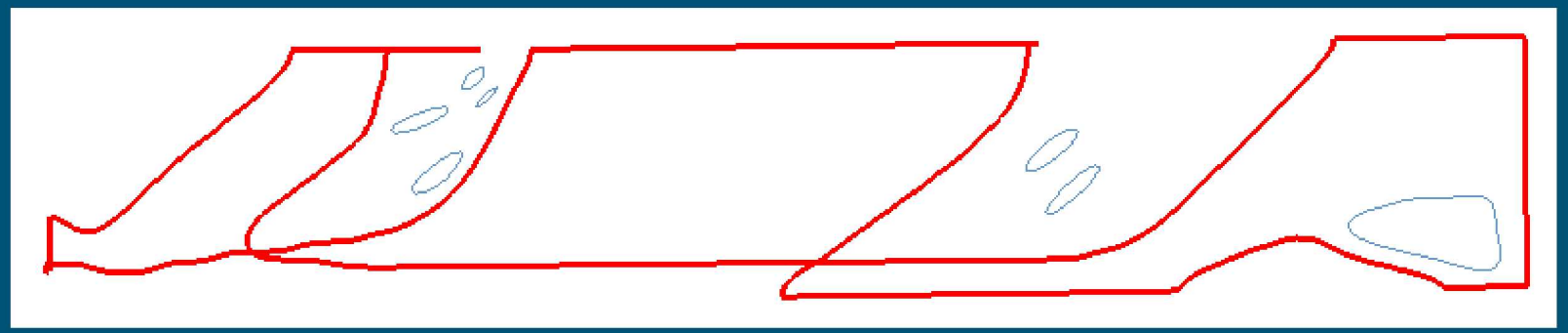






Finding Planes of Symmetry, Tubes, and Joints





Number of Triangles 15069

Number of Edges 23349

Number of Points 8266

Number of Boundary Components 8

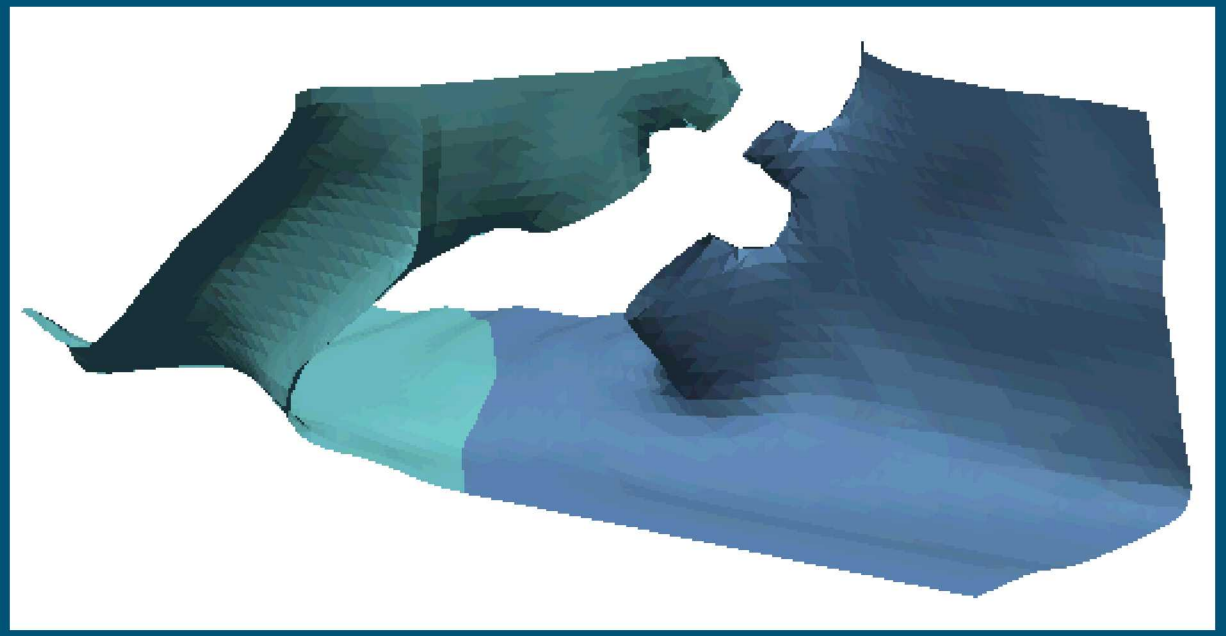
Euler Charateristic -6

Genus 0

Volume 0.000000

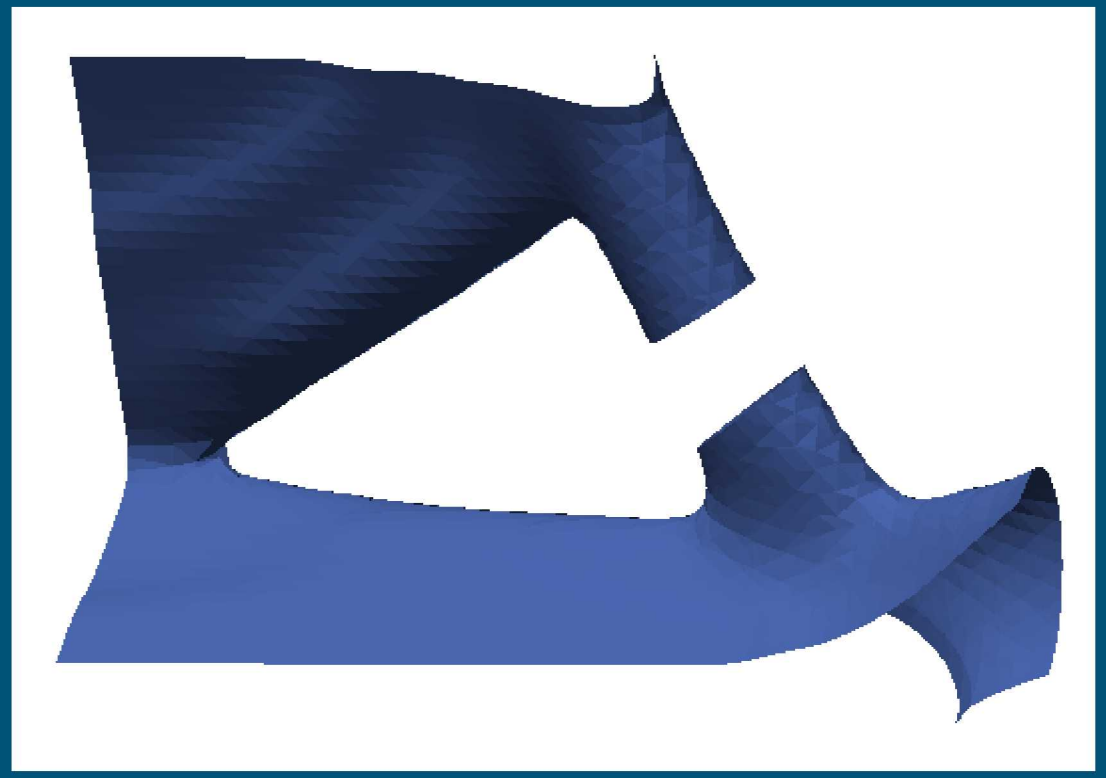
Average Facet Edge Length 0.073317

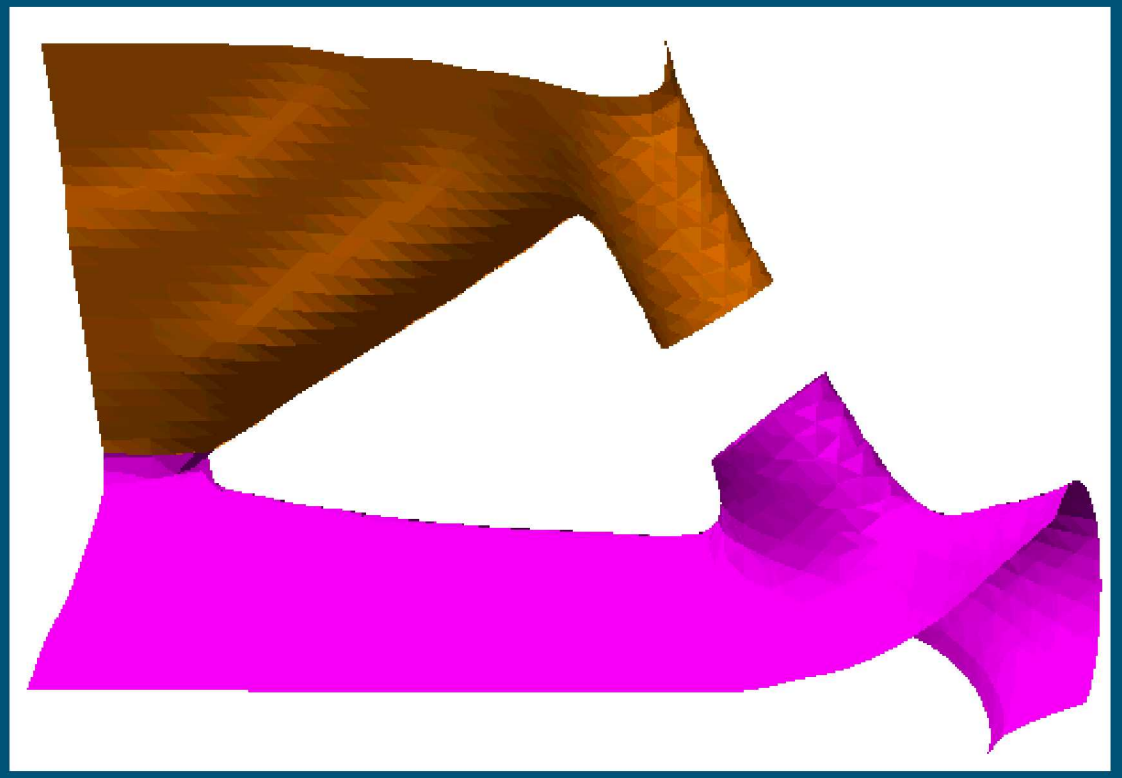
Splitting the Joints



Splitting Between
Boundary Loops

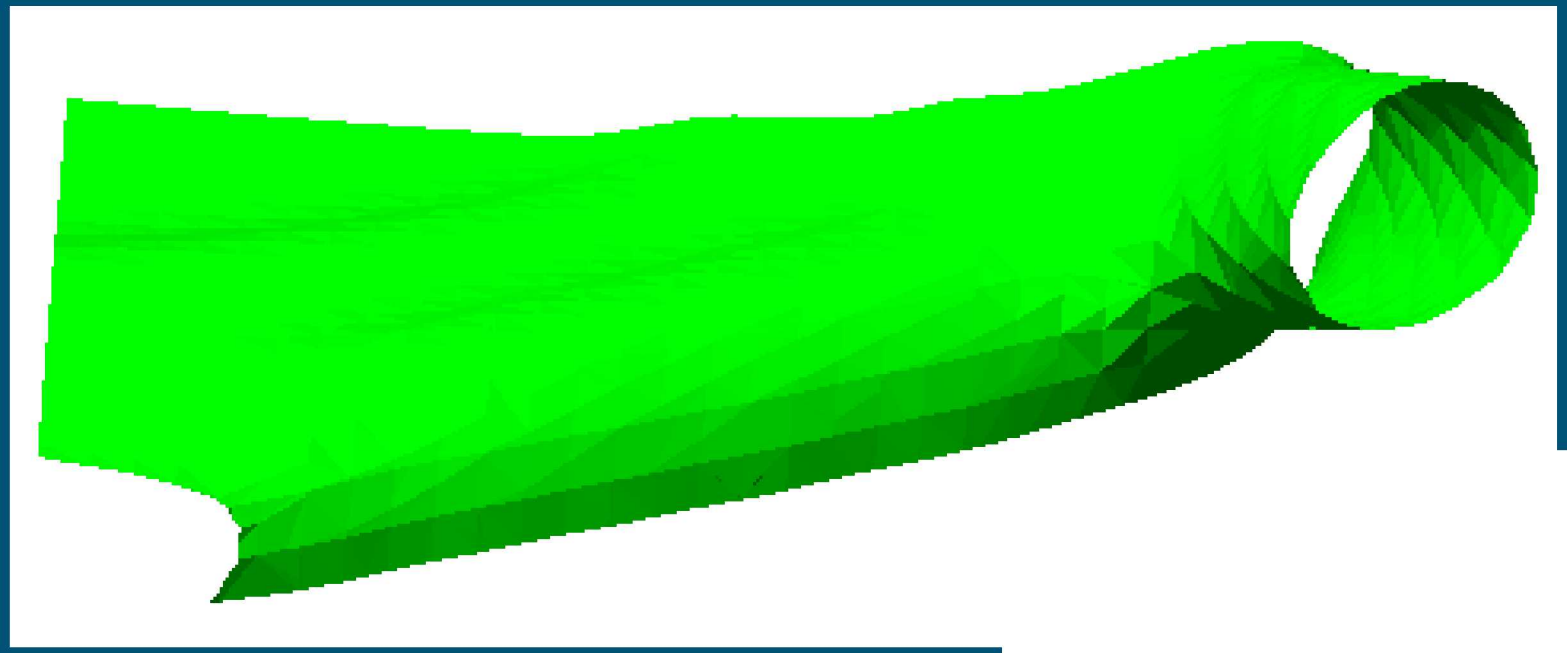
Splitting Up Parts With Three Boundary Components



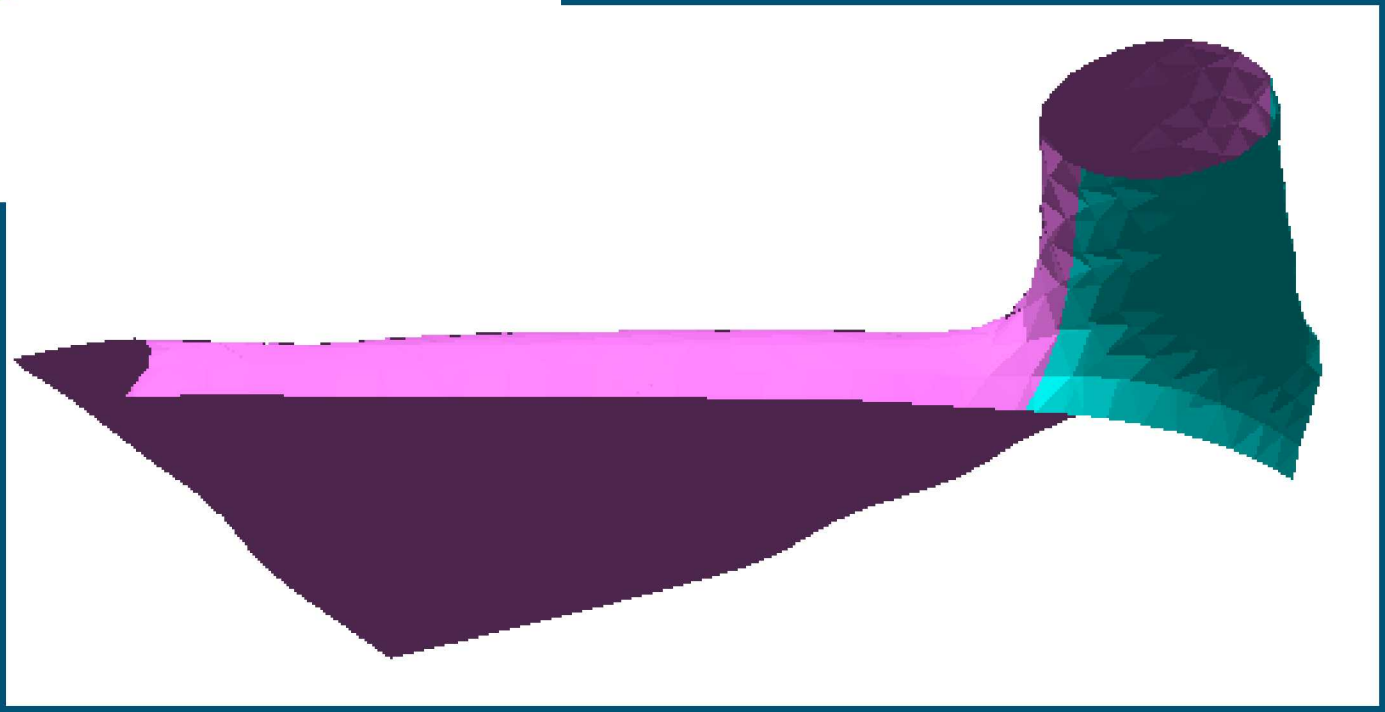


Pinched Boundary Split

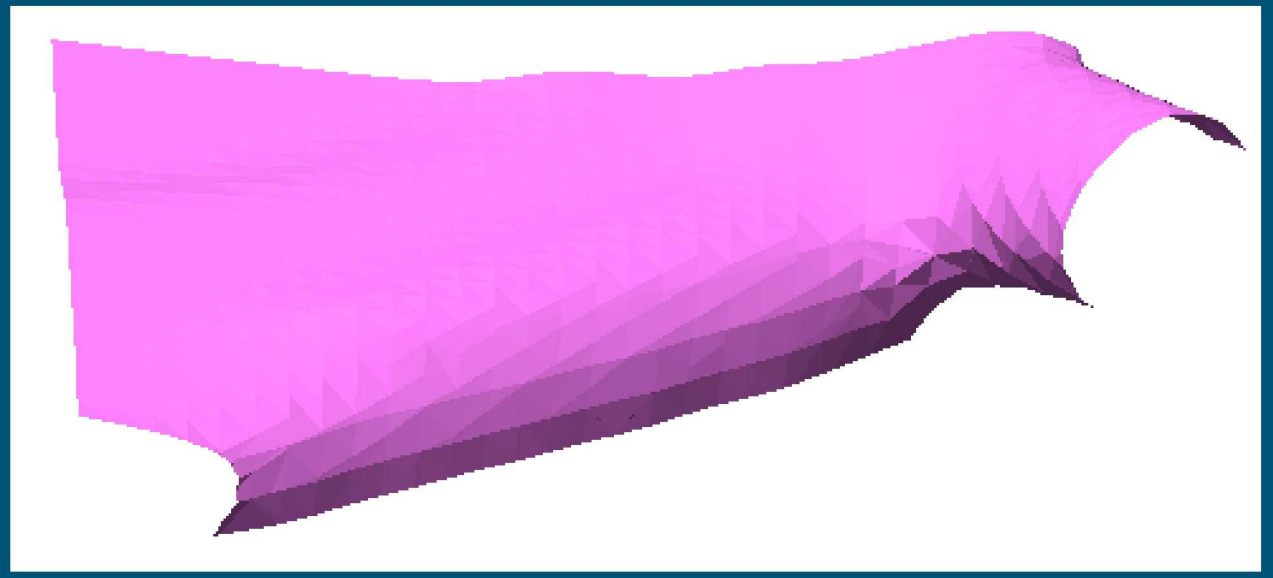
Splitting Up Parts With Two Boundary Componets

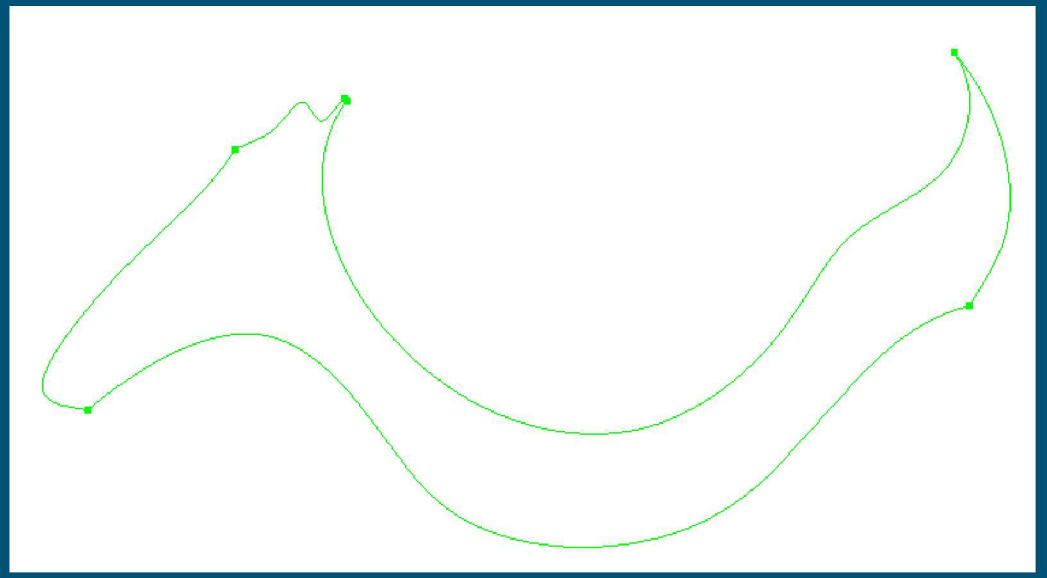


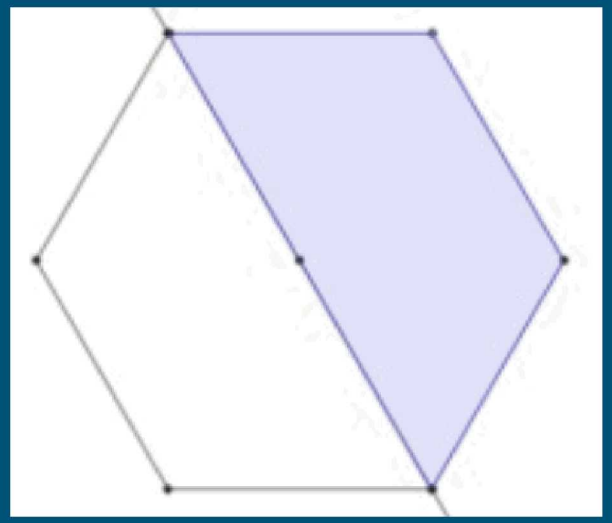
Two Cuts Between The Boundary Components

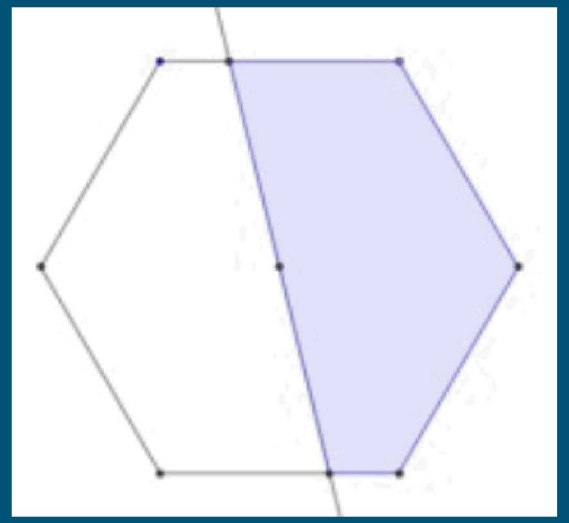


Splitting Up Parts With One Boundary Component

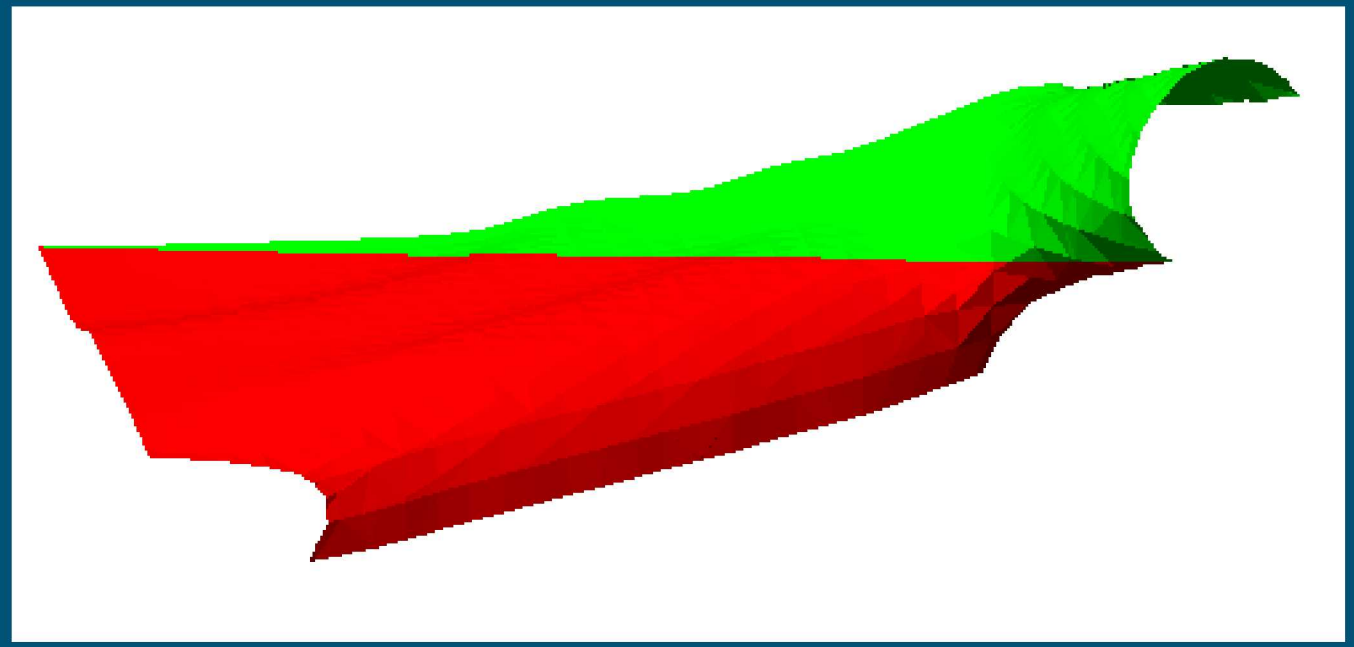




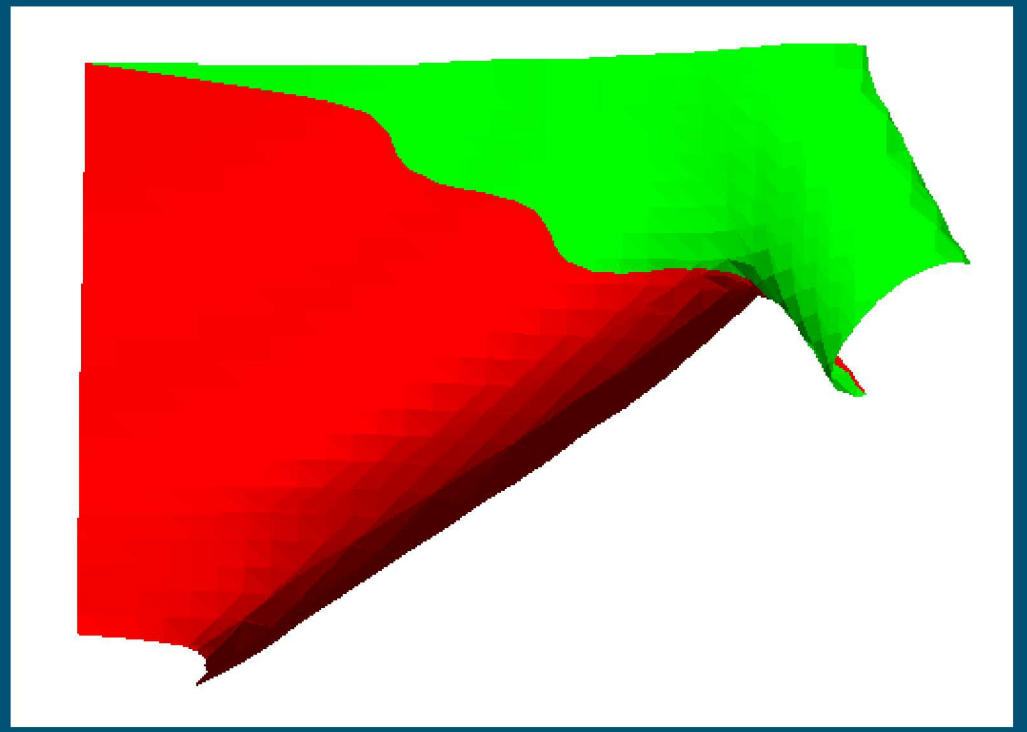




How NOT to Split the Part

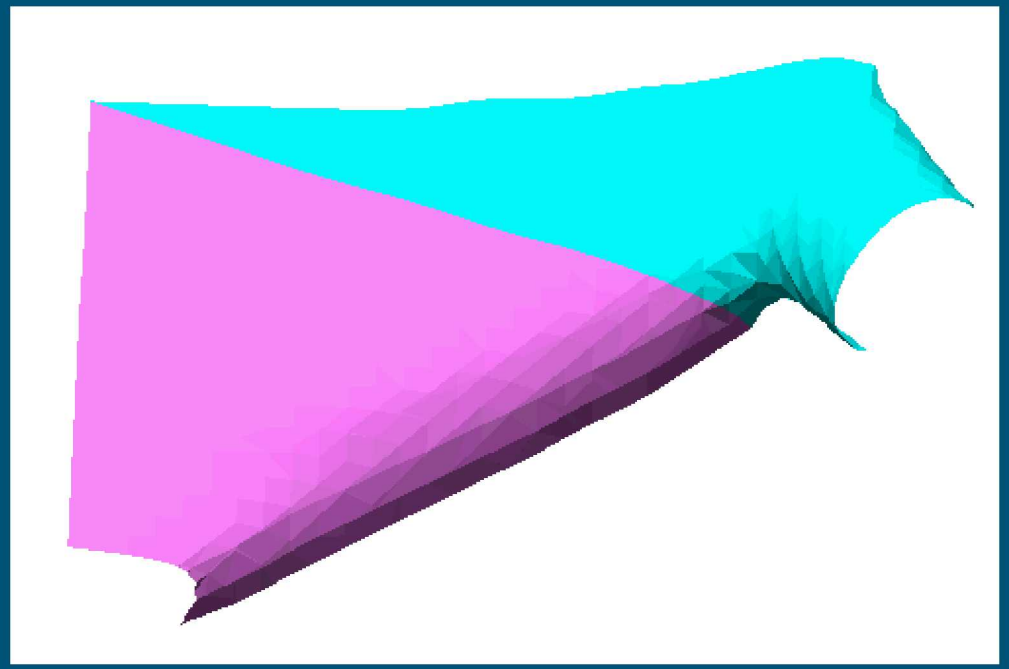


Sharp Corners
"Slivers"

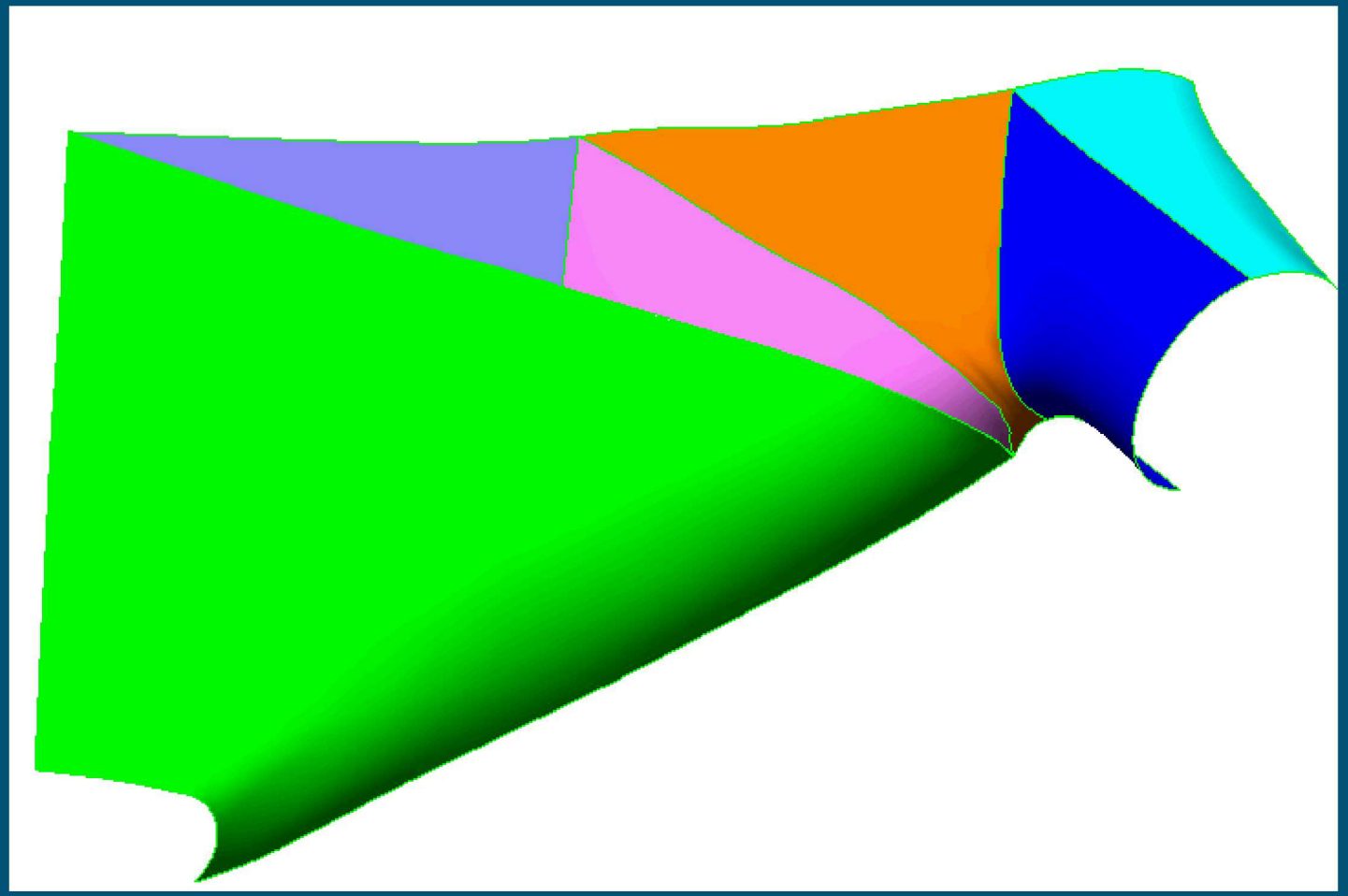


The Cut Plane is Near
Parallel to the Surface

Two Four Sided Parts, and the NURBs that Fit Them

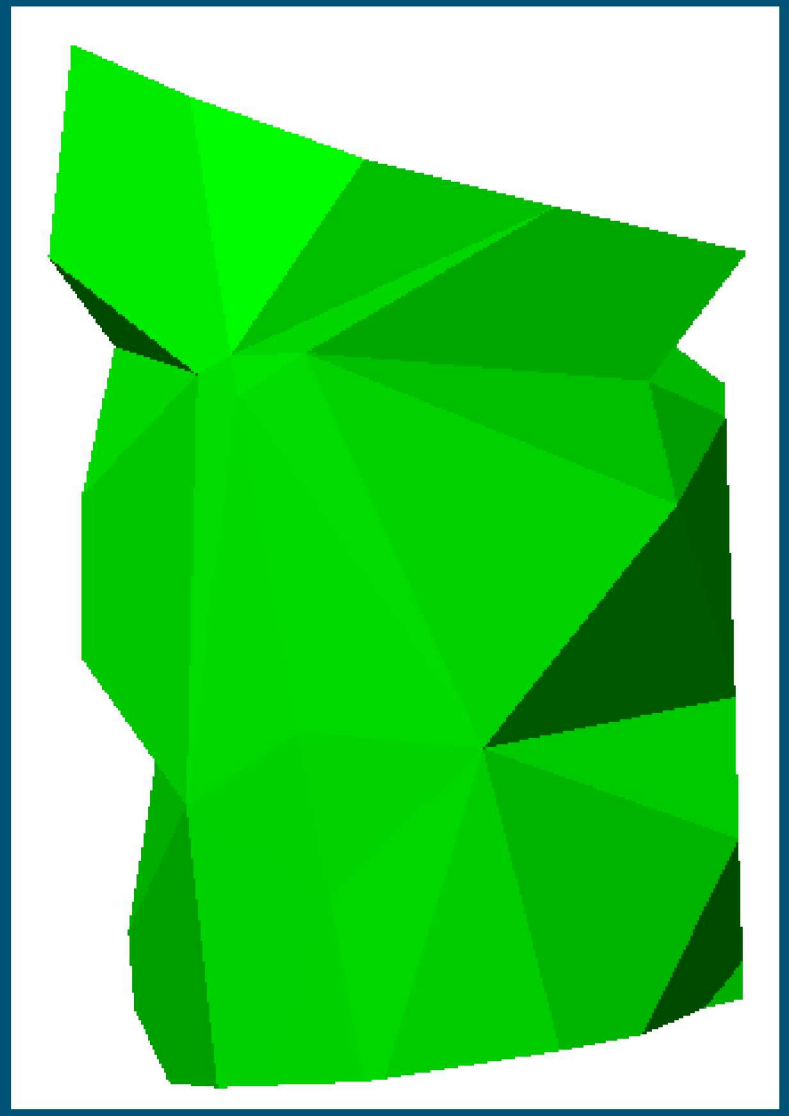


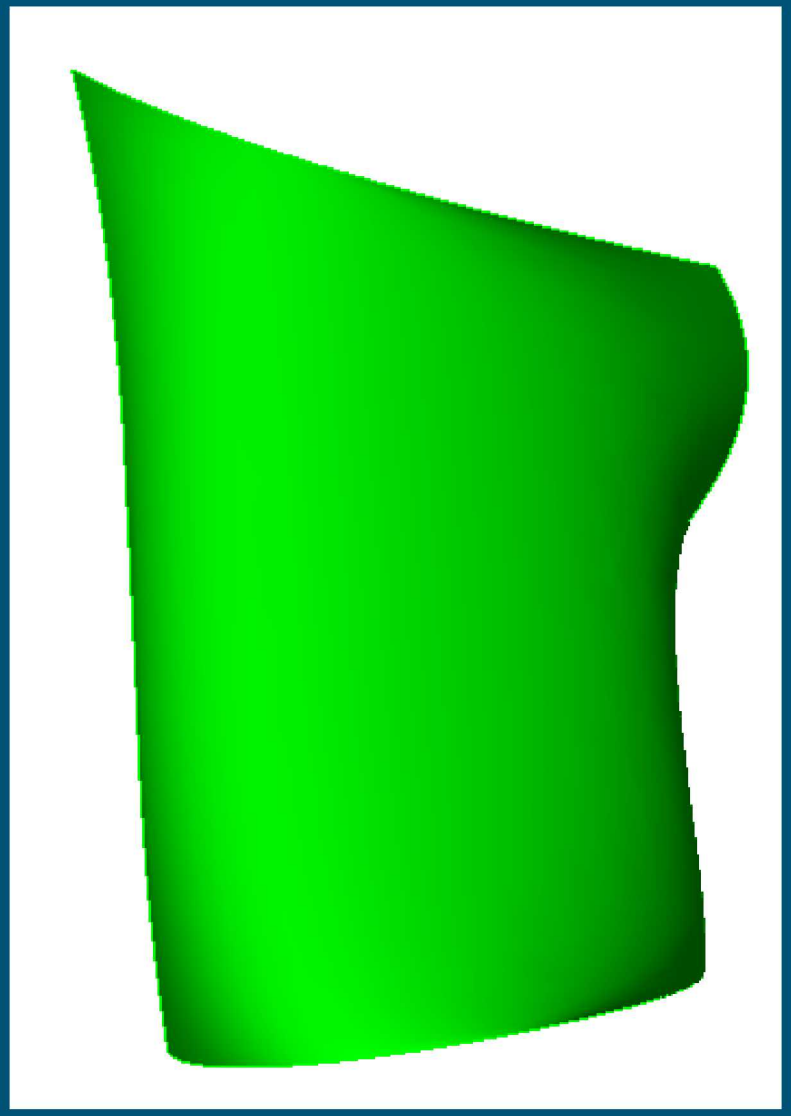
Clean Cut Part

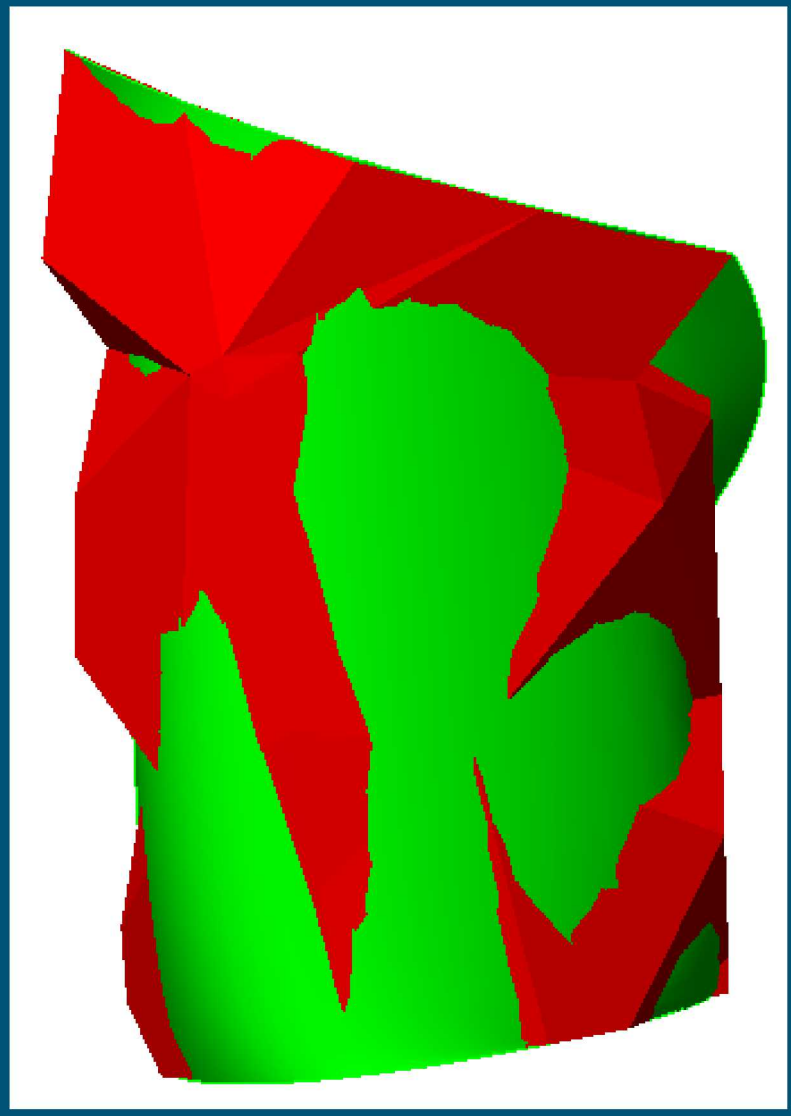


Final Result Fit With NURBS

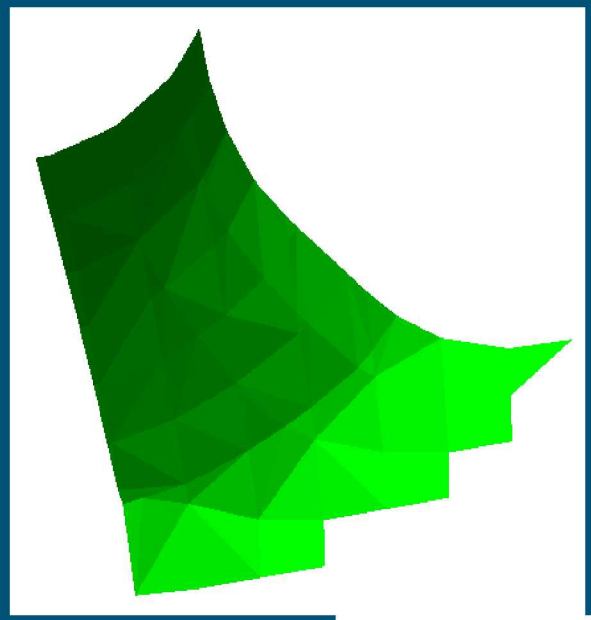
Smoothing Out the Garbage

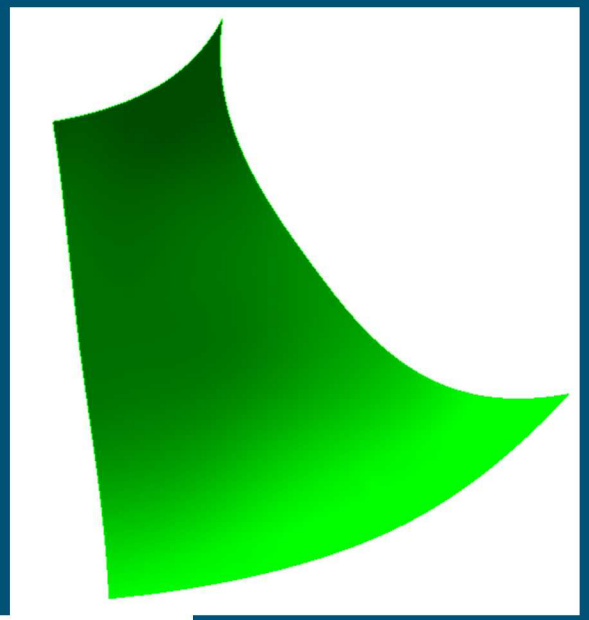


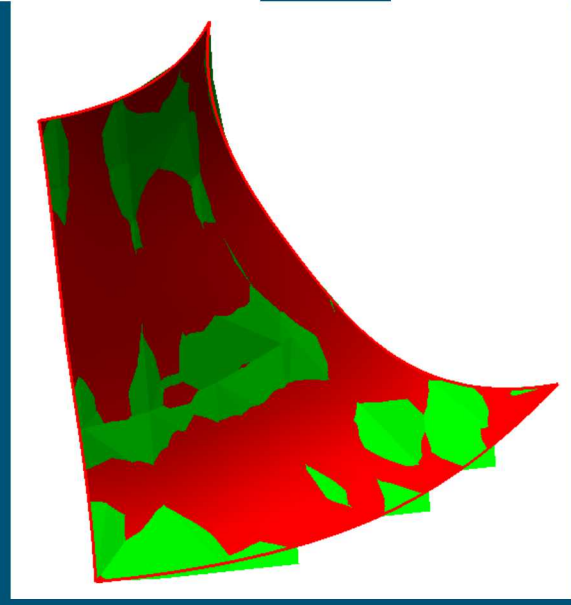


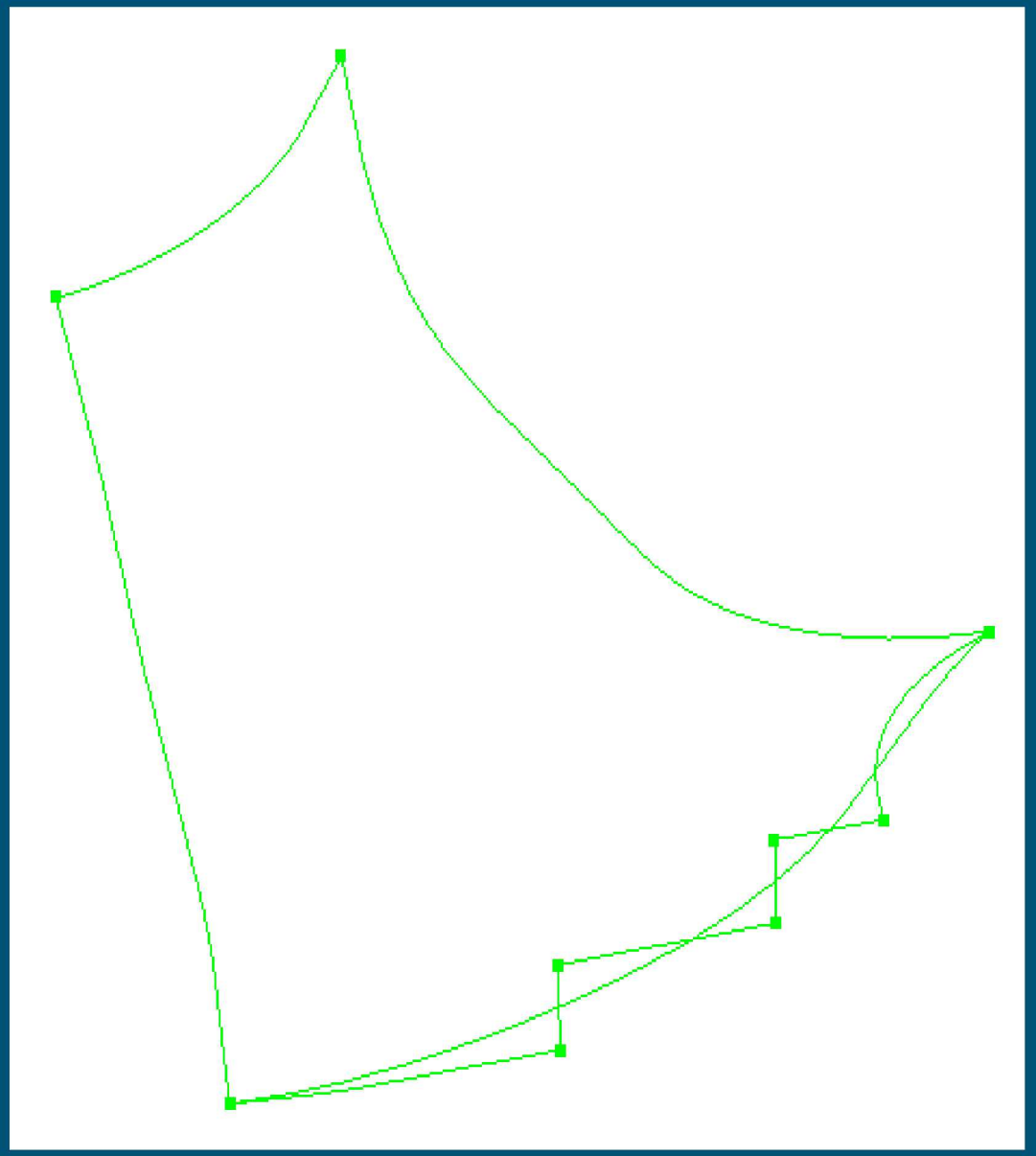


Garbage Edges

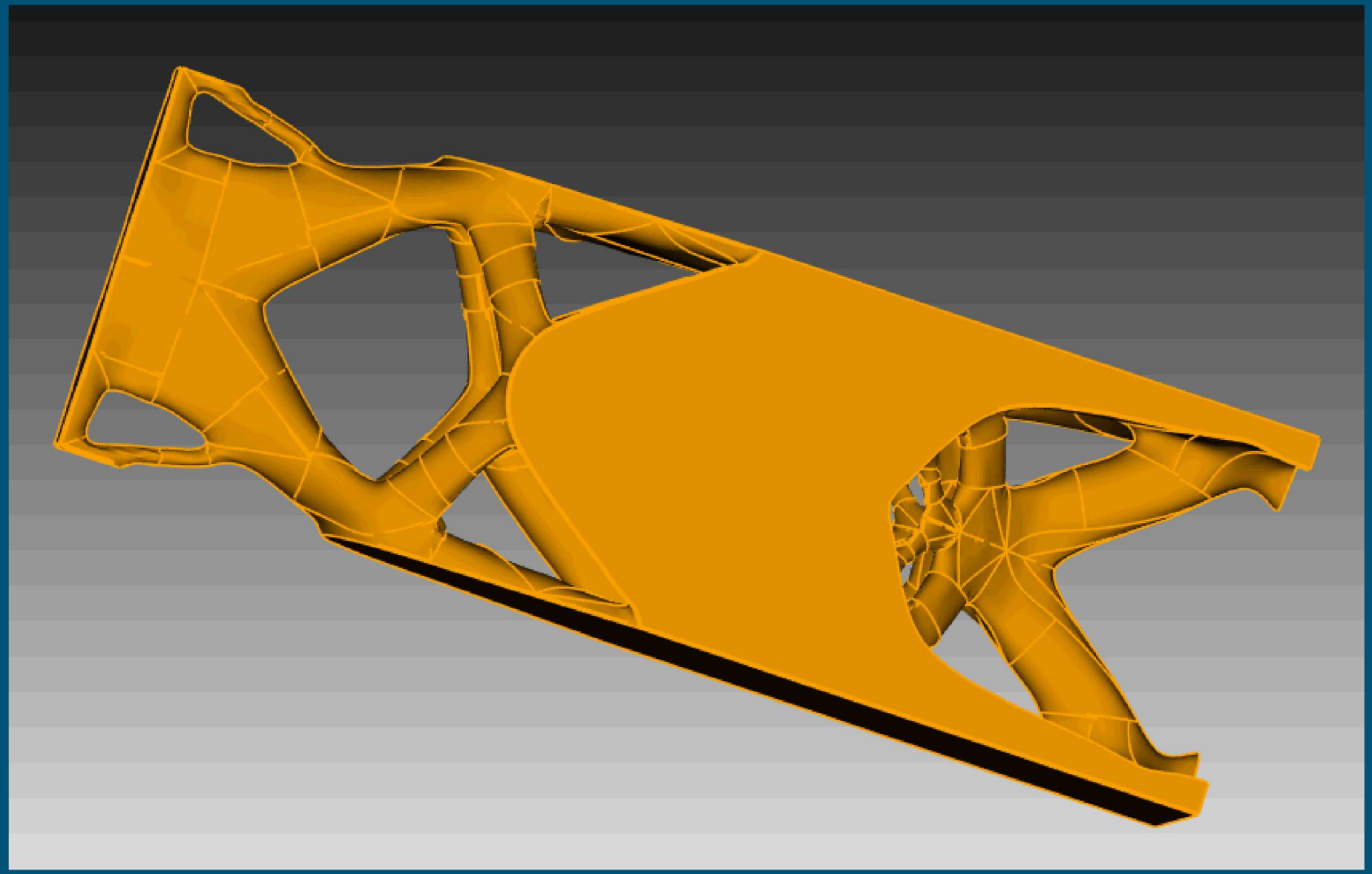








The Final Result Read in as a STEP File to Cubit



277 CAD Faces

Faceted Volume 27.5223

CAD Volume 27.4382

0.305 Percent Difference

Future Work

1. Merge adjacent faces when possible.
2. Smooth surfaces and / or reduce the weight of the surfaces.
3. Make near tangent edges exactly tangent.
4. Replace sequential method calling with multiple method calling.
5. Make it run on multiple processers.
6. Find internal edges.
7. Expand the test suite.