

“Methods for Preparing Geometry for Mesh Generation”

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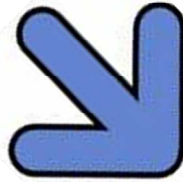
Analysis Model Preparation

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CAD Design



Many mesh generators are very sensitive to the topology in the CAD model—"Geometry-centric"



Translate
Generate Topology/Geometry
Fix Gaps
Remove Slivers
Defeature
Decompose

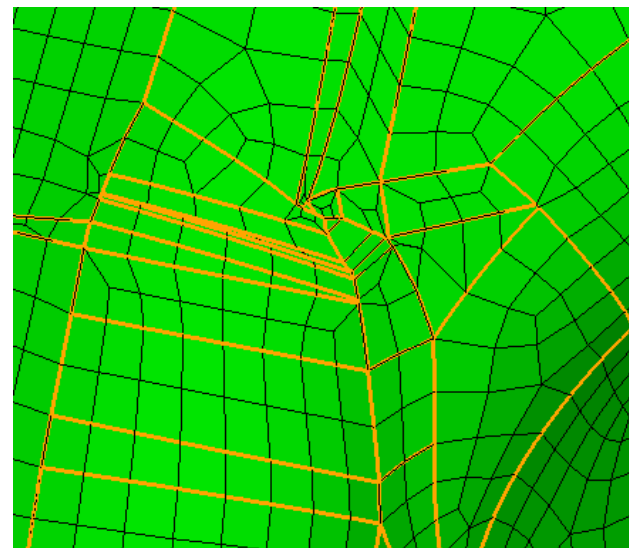
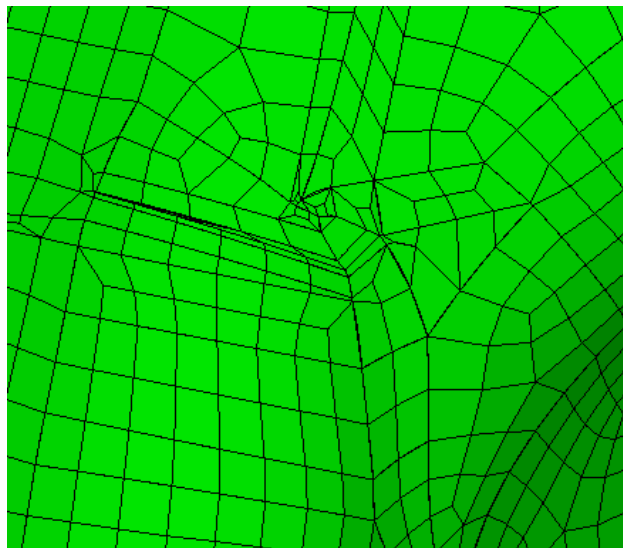
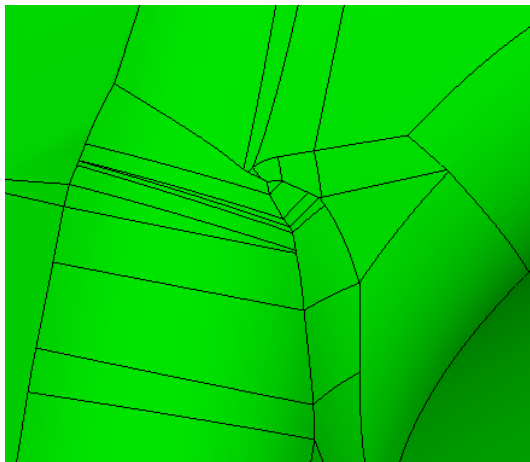


Generate
Mesh

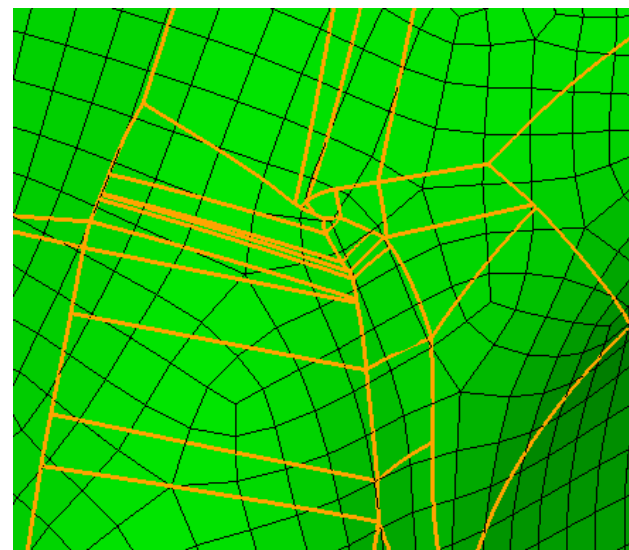
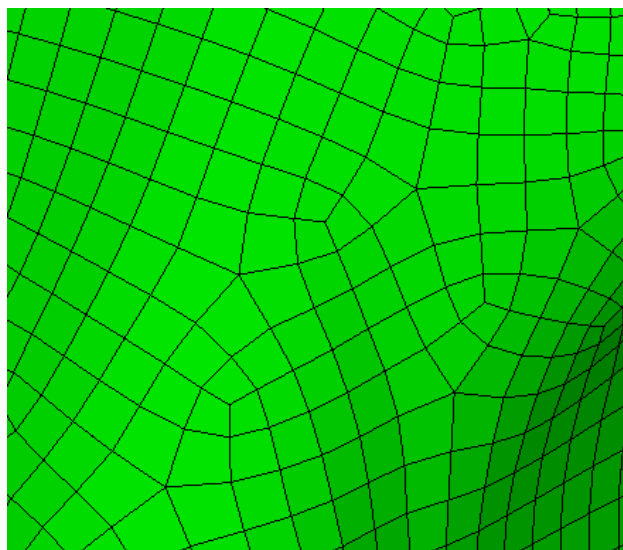
Geometry-Centric vs. Geometry-Tolerant

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Geometry-Centric



Geometry-Tolerant





Geometry-Tolerant Meshing

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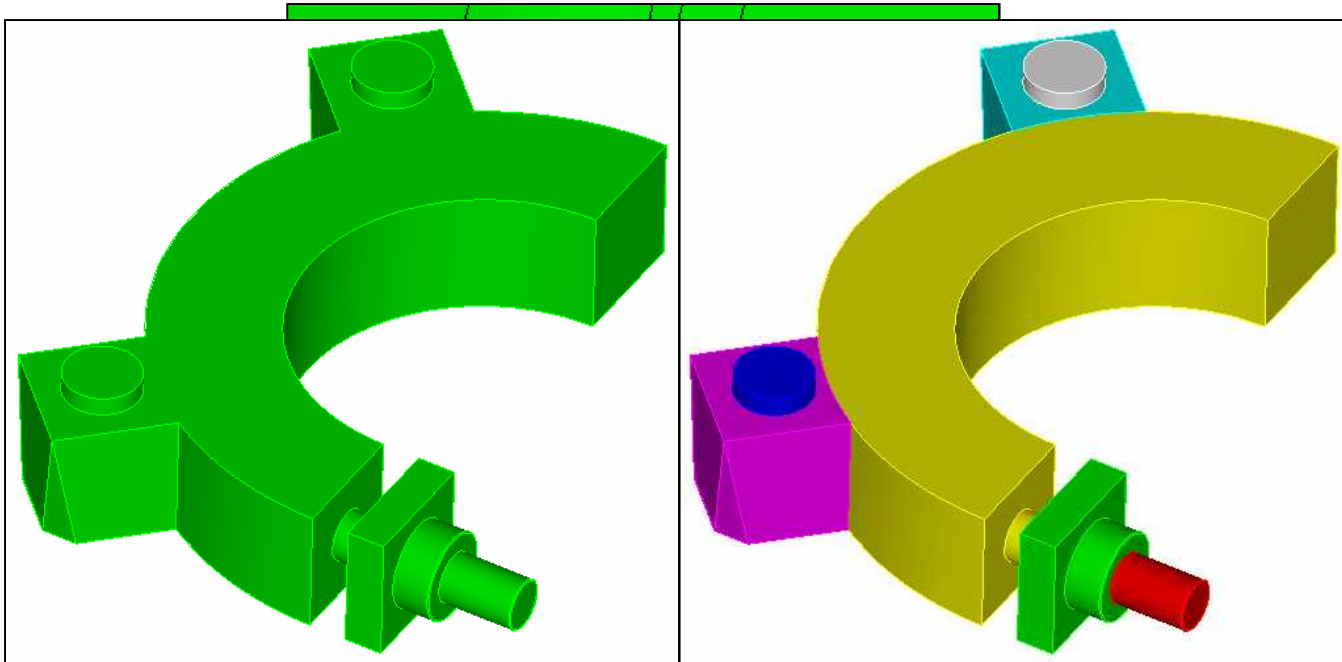
- **Push-button capabilities exist in some commercial tet meshing packages**
 - Mesh quality and connectivity problems have been observed in meshes of sloppy assemblies
 - Users have little control
 - A fair amount of geometry cleanup is still required
 - **Auto hex meshing still very geometry-centric**
 - Sweeping algorithm currently requires strong tie to CAD model topology
 - Topology modifications to a hex mesh are more global
 - Potential solutions exist in new approaches (sheet insertion algorithm-choose what topology to resolve)
- * Geometry cleanup/preparation continues to be necessary in FE model generation**

What are the issues?

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- **Solid modeling kernels**

- Great for global operations (general booleans)
- Not great at local operations
- Lack composite operator! (“virtual geometry” is often used)

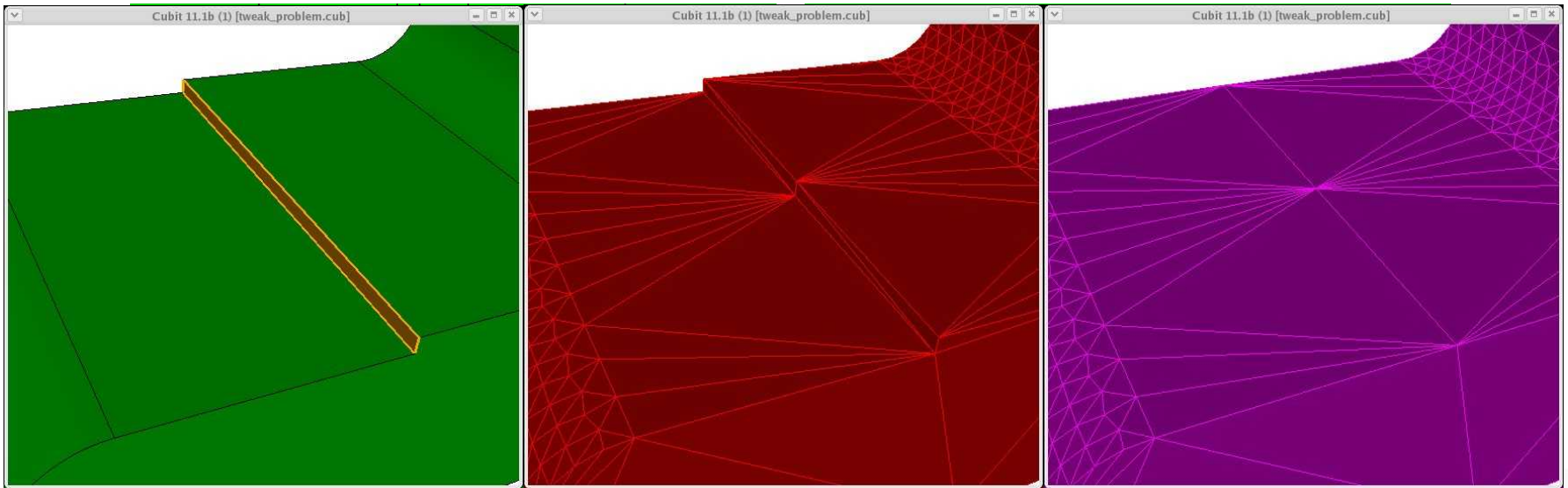


What are the issues?

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- **Virtual/Facettted Representation**

- Very good at local operations/modifications
- Composites!
- Lack of robust boolean operations (critical for decomposition for hex meshing)
- Inhibits subsequent solid-modeling (“real”) operations





What are the issues?

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- **Automation**

- It is very difficult in an algorithm to guess what the design intent is
 - **What should be considered “small”?**
 - **In an assembly with gaps/misalignments what should be connected?**



How are we addressing the issues?

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- **Model Representation**

- Allow both “real” (solid modeling kernel) and “virtual” (faceted) representations
- Both are needed because of their strengths

- **Modification Operators**

- Add to the set of real operators
- Provide interoperability between real and virtual operations

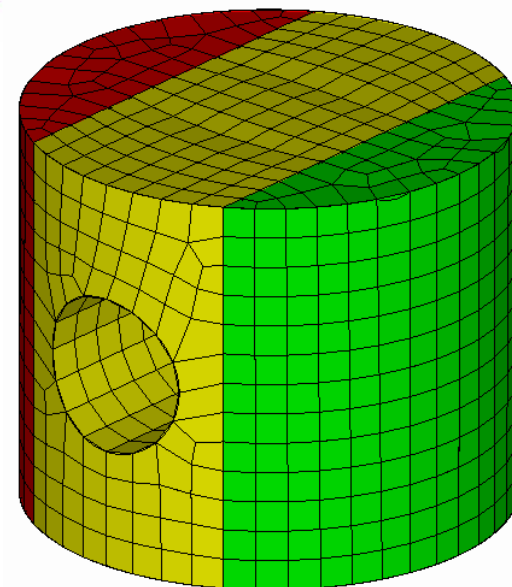
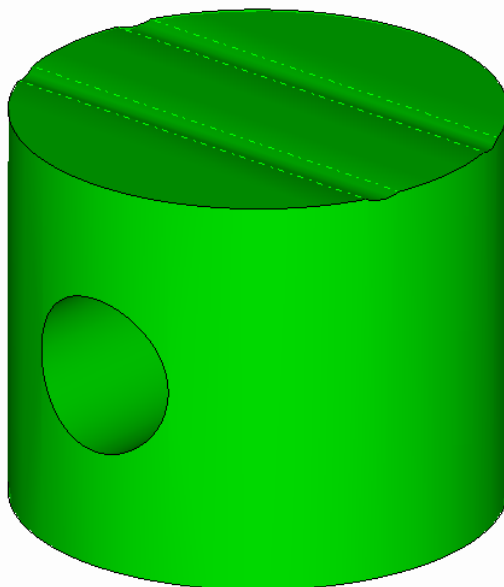
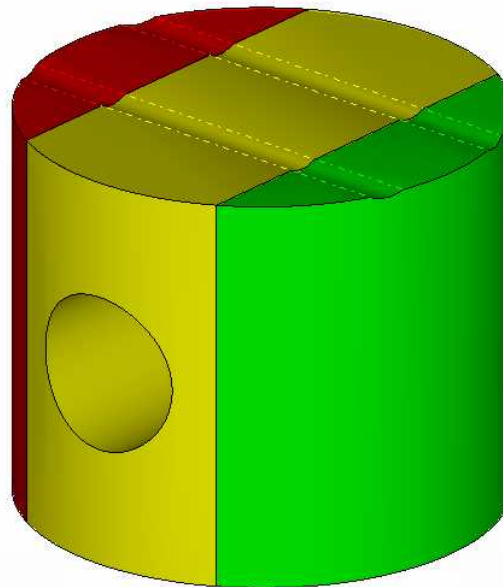
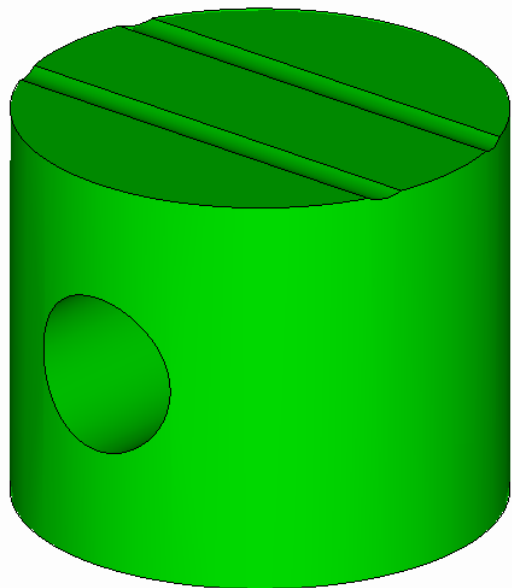
- **Automation**


- Semi-automated Diagnostic/Solution approach in the ITEM user interface to facilitate geometry modification
- Research in geometry-tolerant meshing algorithms



Interoperability of Virtual Composites

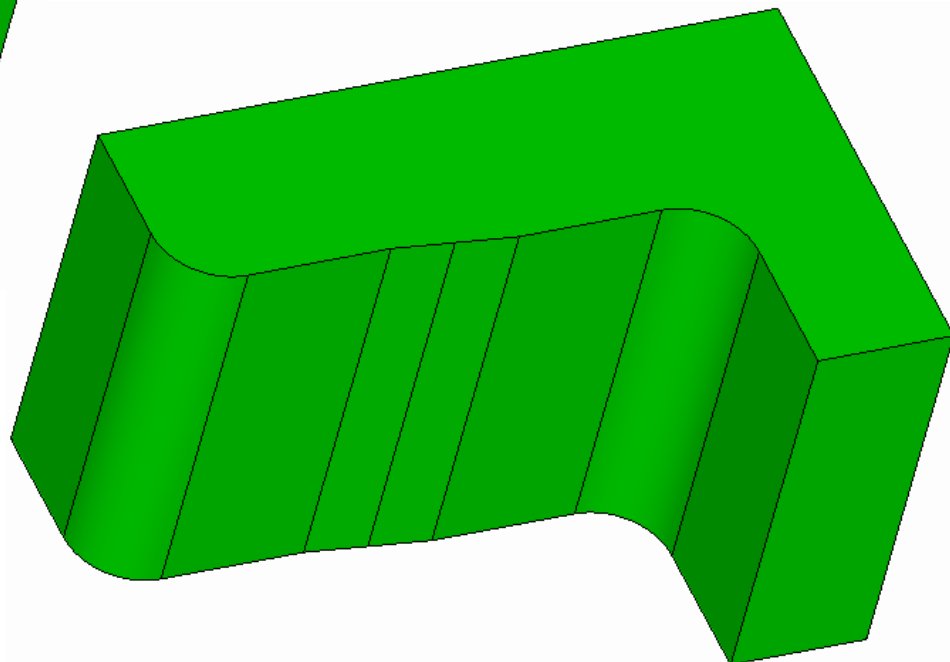
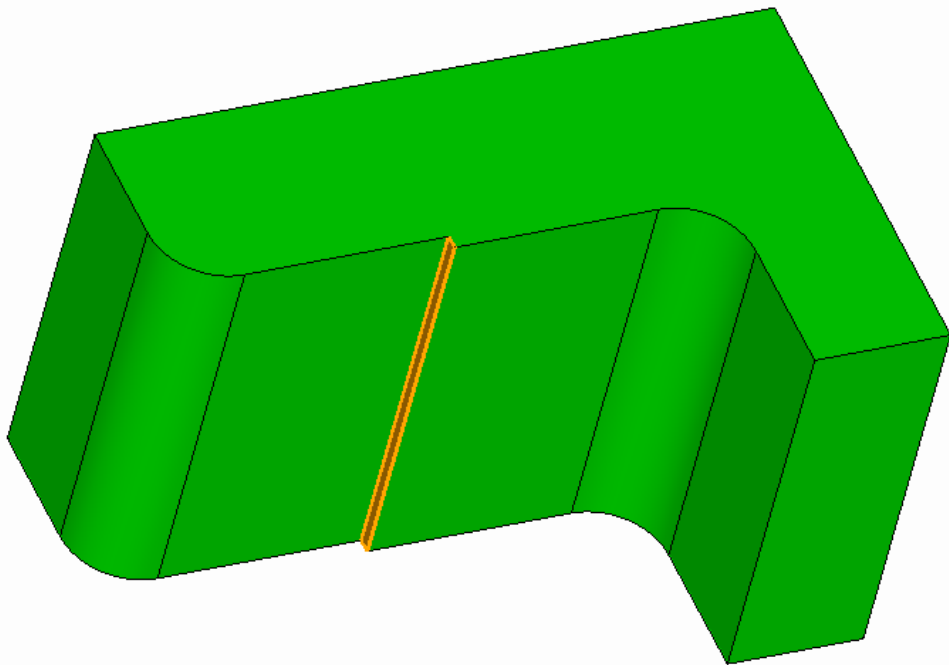
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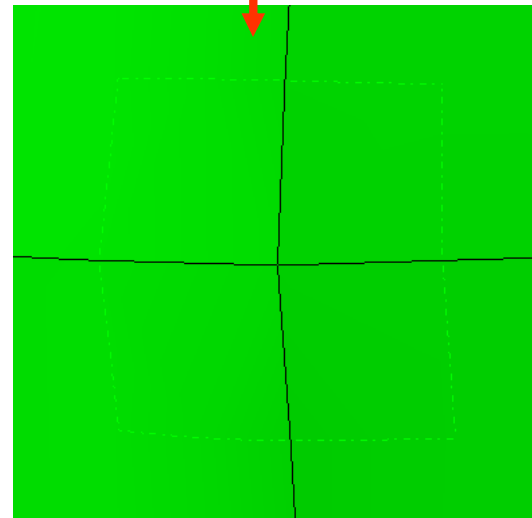
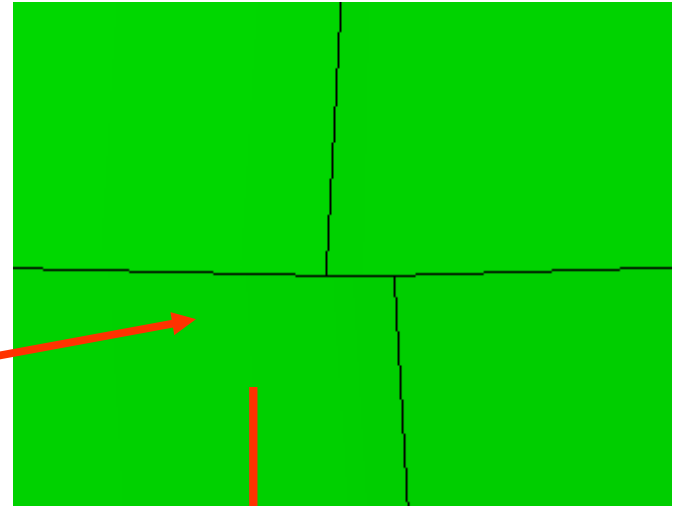
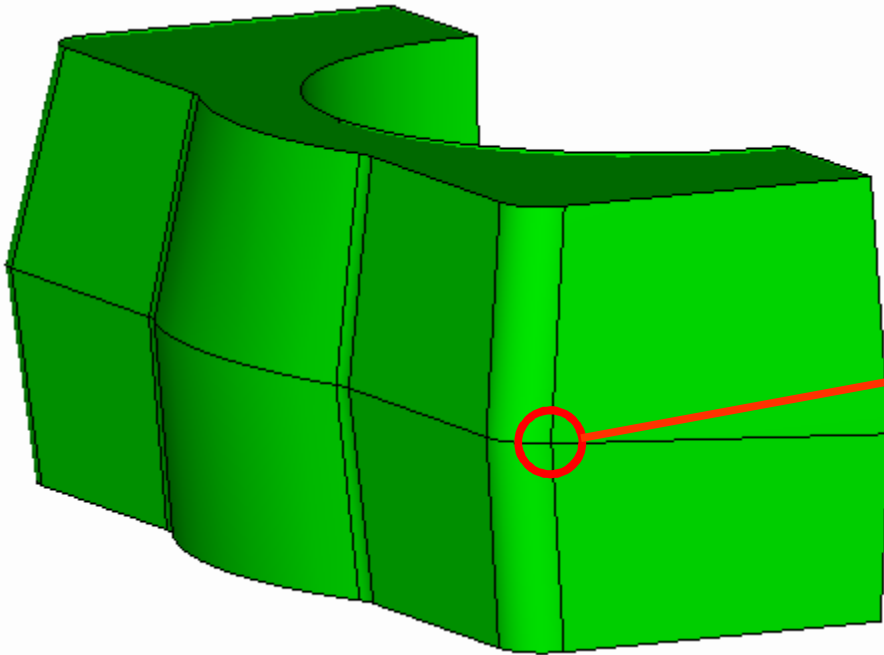
Custom Kernel (“real”) Operator

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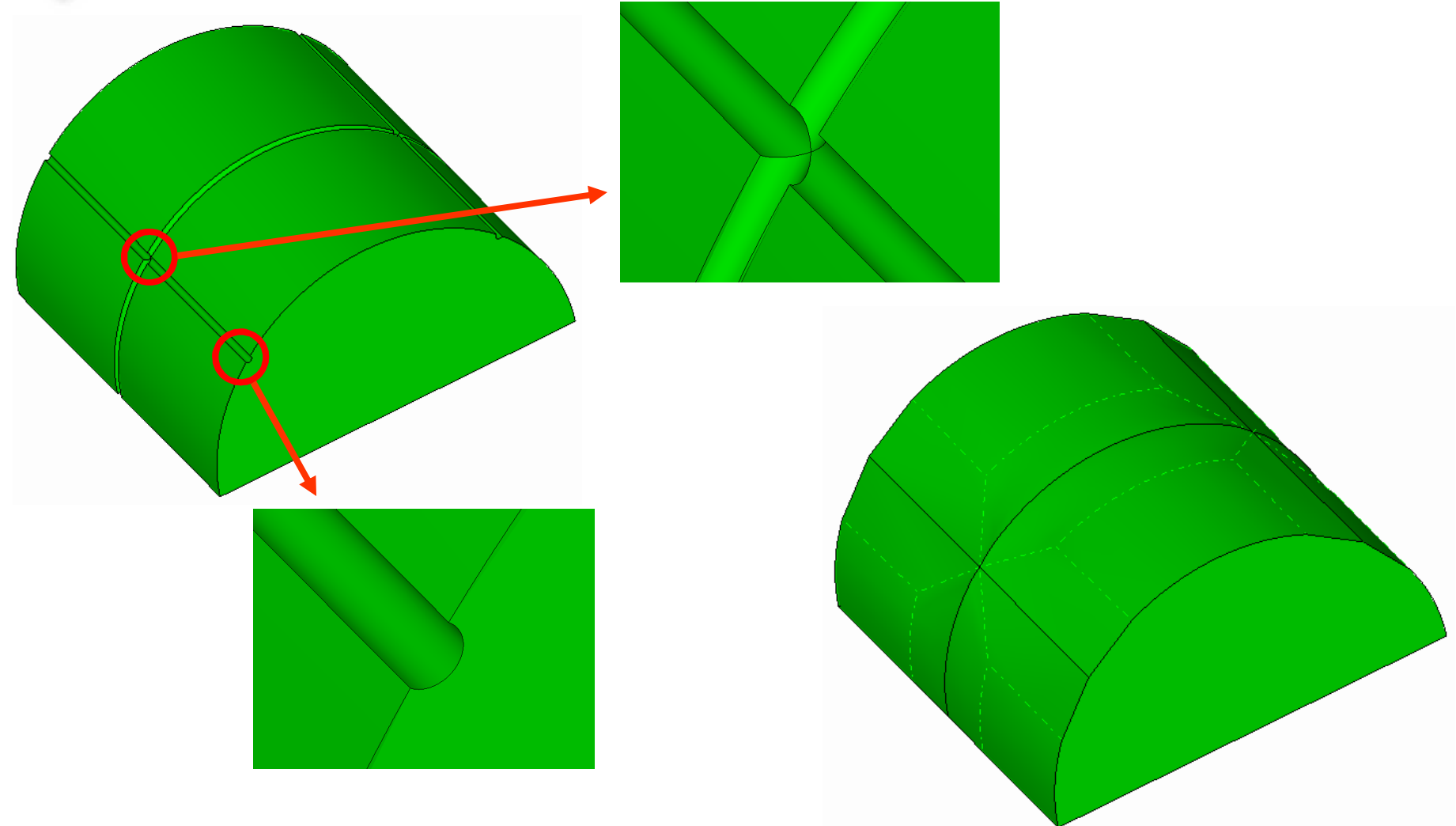
Custom Kernel (“real”) Operator

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Custom Kernel (“real”) Operator

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Diagnostic/Solution Paradigm using ITEM

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Cubit 11.1b

File Edit View Display Tools Help

Prepare Geometry

Remove Small Features
Small features can over-constrain your mesh and result in poor elements. First enter a size below which helps Cubit identify small features.

Small Curve Length: .3

☒ Auto Update **Detect Small Features**

Consider correcting small features listed below. Select a small feature to view the possible solutions.

Small Features

Entity ID	Entity Data
Small Surfaces (15) Area	
Surface 17	0.03017080
Surface 16	0.03680391
Surface 19	0.06413326
Surface 30	0.06413326
Surface 21	0.07218750
Surface 28	0.07218750
Surface 26	0.12826653
Surface 23	0.14437500
Surface 27	0.20000000

Solutions

Possible Solutions

- Composite with Surface 5
- Composite with Surface 26
- Composite with Surface 29
- Composite with Surface 31
- Rebuild Topology

Execute

Cubit 11.1b

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Small Features

Entity ID	Entity Data
Narrow Surfaces (0) Area	
Small Curves (0) Length	
Small Surfaces (0) Area	

Solutions

Possible Solutions

- Select an entity to see potential solutions

Execute

Diagnostic/Solution Paradigm using ITEM

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The image displays three sequential screenshots of the Cubit 11.1b software interface, illustrating the diagnostic and solution paradigm for a 3D model of a mechanical part. The model is a yellow, C-shaped component with a green cylindrical feature on the right side.

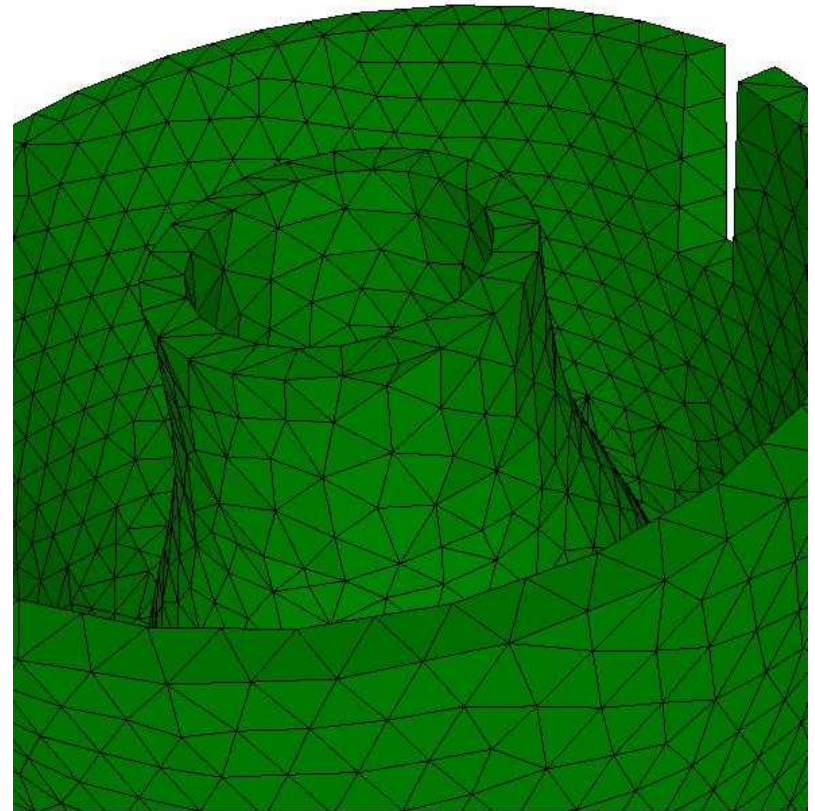
Left Screenshot: The 'Prepare Geometry' panel is active. The 'Decompose Volume' section shows 'Volume 1' selected. The 'Solutions' panel lists possible solutions for decomposition, including 'webcut volume from Surface 8 to Surface 22' and 'merge include...'. The 'Execute' button is visible.

Middle Screenshot: The 'Prepare Geometry' panel is active. The 'Decompose Volume' section shows 'Volume 1' selected. The 'Solutions' panel lists possible solutions for decomposition, including 'webcut volume from Surface 31 to Surface 34' and 'merge include...'. The 'Execute' button is visible.

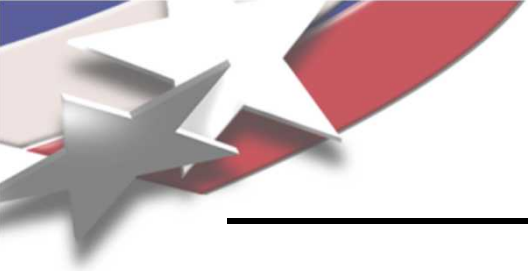
Right Screenshot: The 'Prepare Geometry' panel is active. The 'Decompose Volume' section shows 'Volume 1' and 'Volume 2' selected. The 'Solutions' panel lists possible solutions for decomposition, including 'webcut volume from Surface 21 to Surface 32' and 'merge include...'. The 'Execute' button is visible.

Geometry-tolerant Meshing

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- **Initial work in tet meshing**
 - Similar to approach by Shephard et al. [1].



Summary

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- **At Sandia we are working both the geometry cleanup problem and the geometry-tolerant meshing problem**
- **Open Issues**
 - Input CAD model is usually not generated with analysis in mind
 - There is not one CAD representation that provides all of the necessary geometry operators



References

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- **M S Shephard, M W Beall, and R M O'Bara.**
Revisiting the elimination of the adverse effects of small model features in automatically generated meshes. Proceedings of the 7th International Meshing Roundtable, pages 119-132, 1998.