

# **Conformal Assembly Meshing with Tolerant Imprinting**

**Brett Clark**

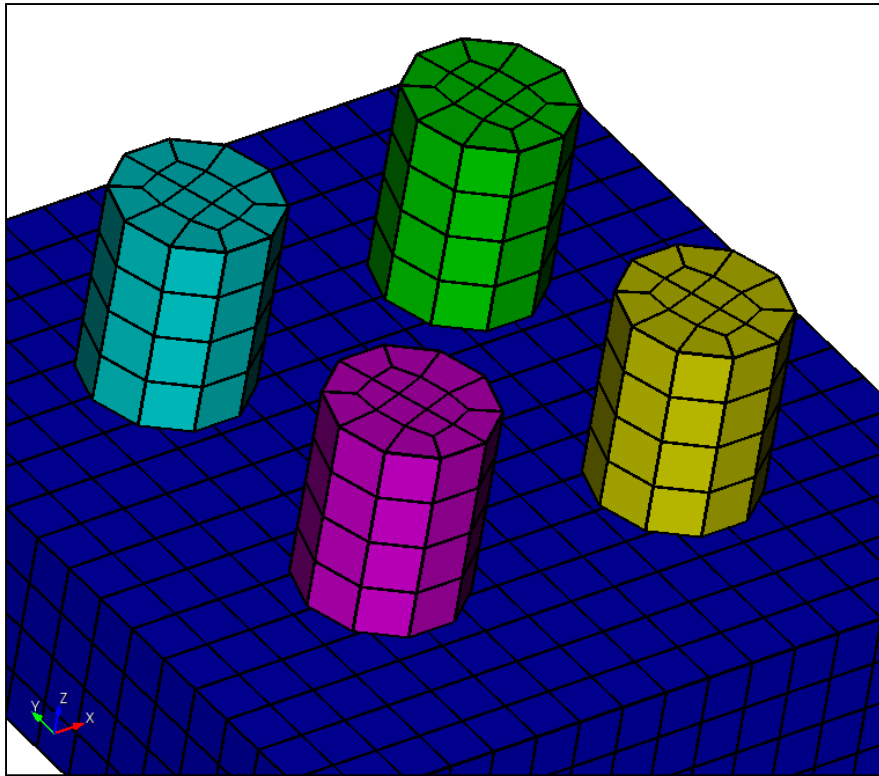
**Byron Hanks**

**Corey Ernst**

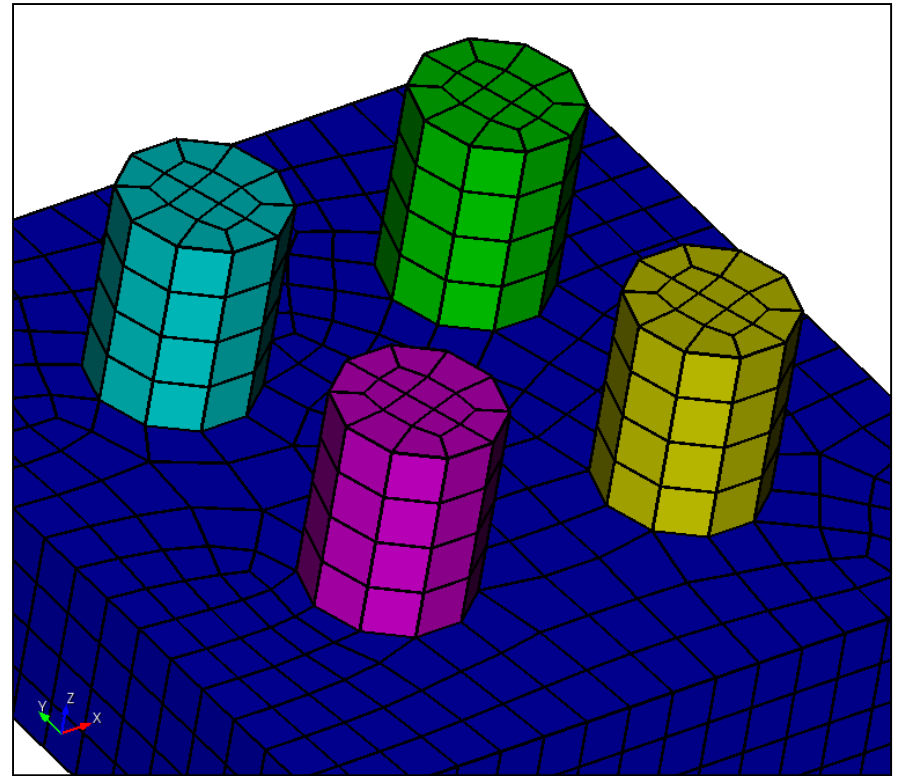
**International Meshing Roundtable 2008**

# Conformal Assembly Meshing

*Computational Modeling Sciences Department*



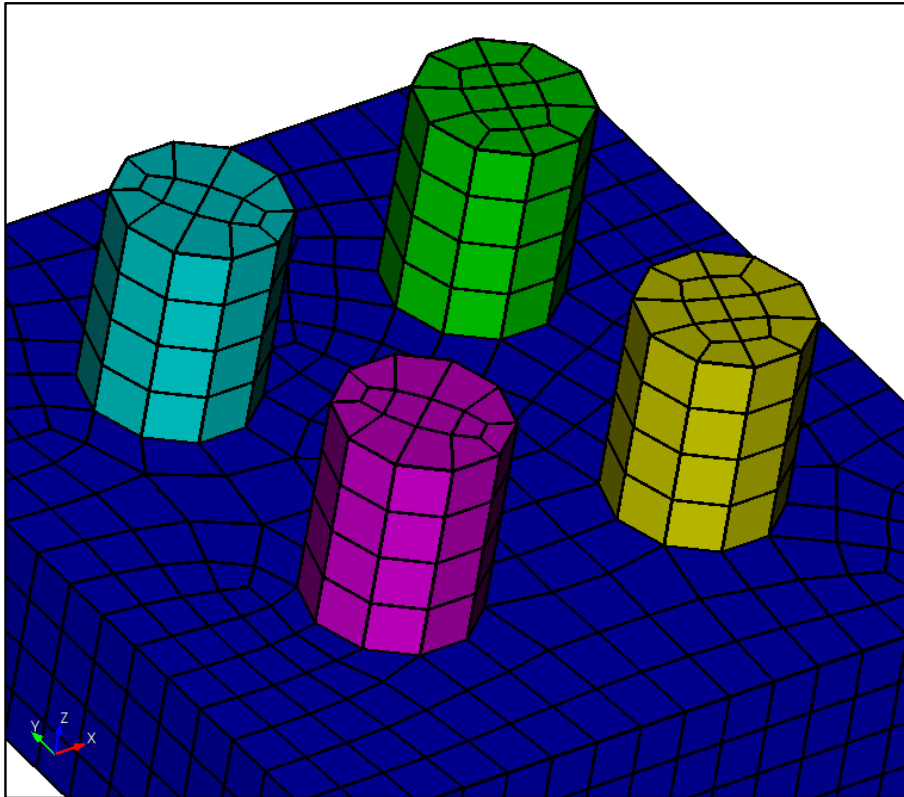
**Non-Conformal**



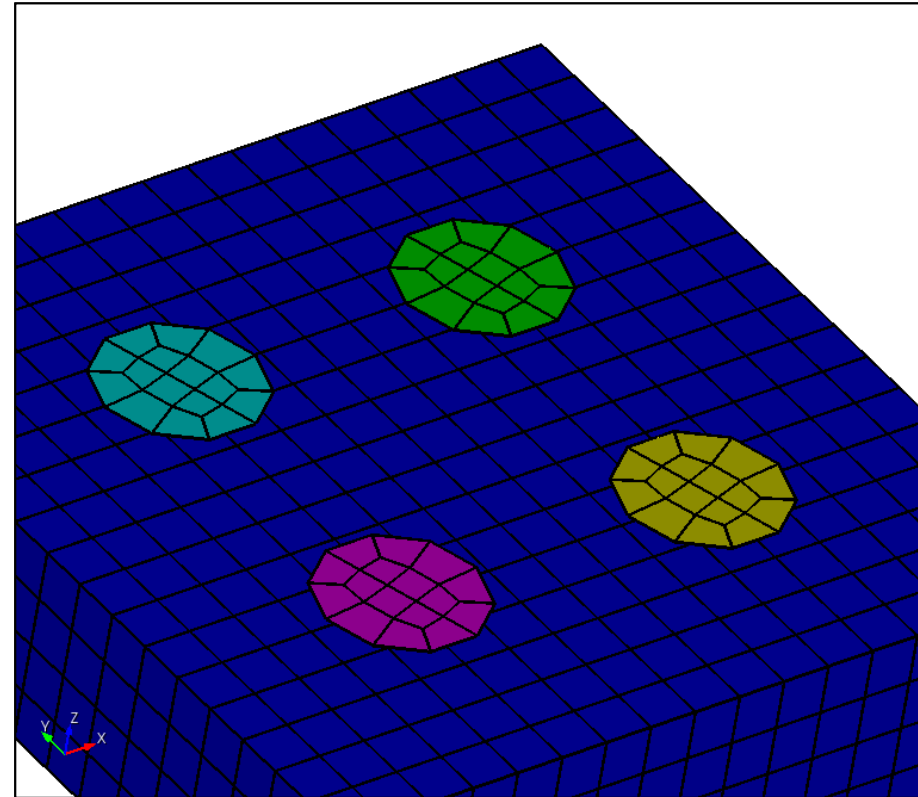
**Conformal**

# Geometry Solution vs. Mesh Solution

*Computational Modeling Sciences Department*



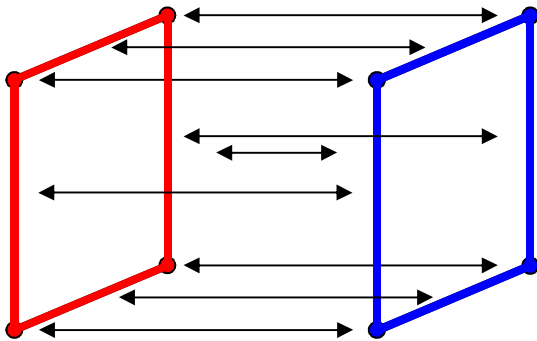
**Geometry Solution  
(Imprint/Merge)**



**Mesh Solution**

# Merging Criteria

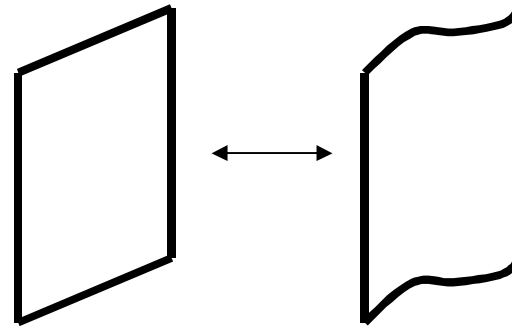
*Computational Modeling Sciences Department*



# Vertices must match

# Edges must match

**Topological Match  
(Essential)**



Automatically merge if within merge tolerance

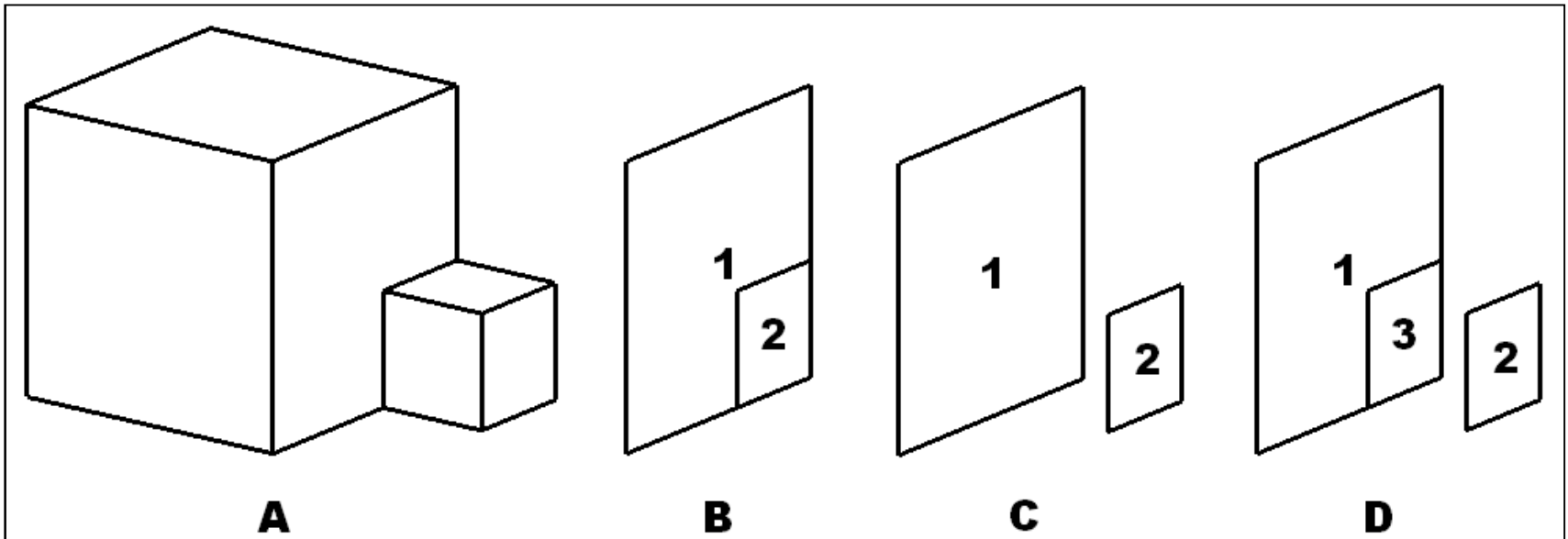
Force merge if out of merge tolerance

Different geometry affects evaluation!

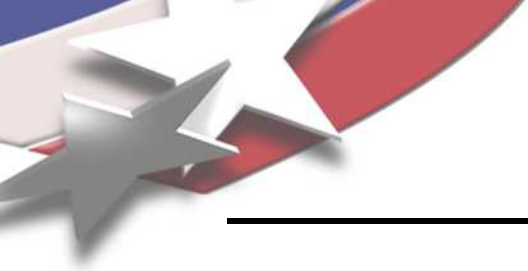
**Geometric Match  
(Optional)**

# Imprinting—Creating the Topological Match

*Computational Modeling Sciences Department*



Imprinting adjacent volumes creates the matching topology required for merging.



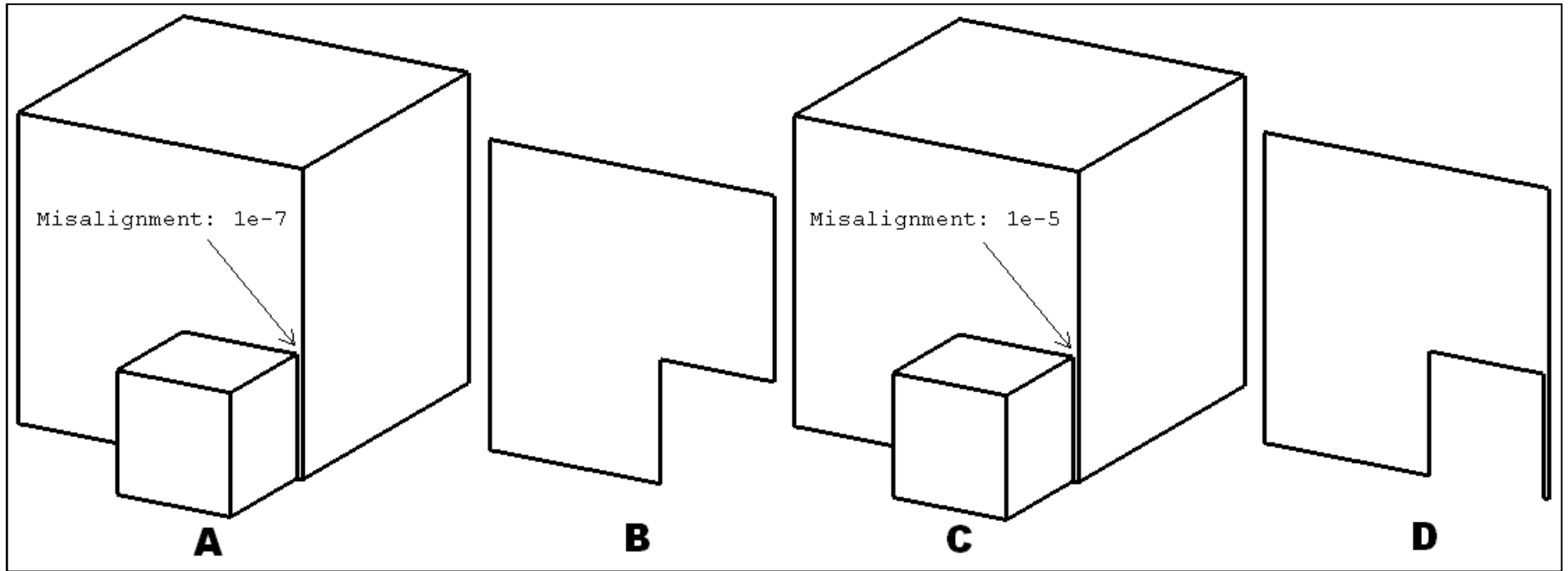
# Imprinting Tolerance

*Computational Modeling Sciences Department*

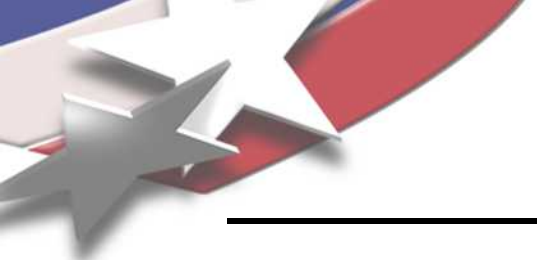
- **Imprinting is a solid modeling kernel operation**
- **Tolerance is defined by solid modeling kernel**
- **Tolerance is generally not user-modifiable**
- **2 Properties of imprinting**
  - Only entities within tolerance will imprint
  - No slivers smaller than tolerance will be introduced
- **Part adjacencies within an assembly must be cleanly defined within the imprinting tolerance or**
  - Imprint won't occur
  - Slivers will be introduced

# Sliver Example

*Computational Modeling Sciences Department*



- Imprinting tolerance is  $1e-6$  (solid modeling kernel value)
- Results differ based on alignment of parts in assembly
- CAD systems differ in assembly constraint tolerances!



# Tolerant Imprinting

---

*Computational Modeling Sciences Department*

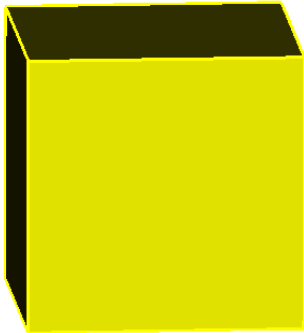
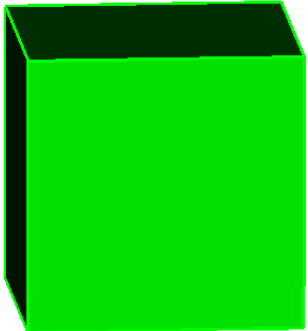
- Same as imprinting from user's point of view
- 2 Properties still hold
  - Only entities within tolerance will imprint
  - No slivers smaller than tolerance will be introduced
- User can modify the imprinting tolerance
- Modifiable Imprinting tolerance = Merge tolerance



# Gap Example

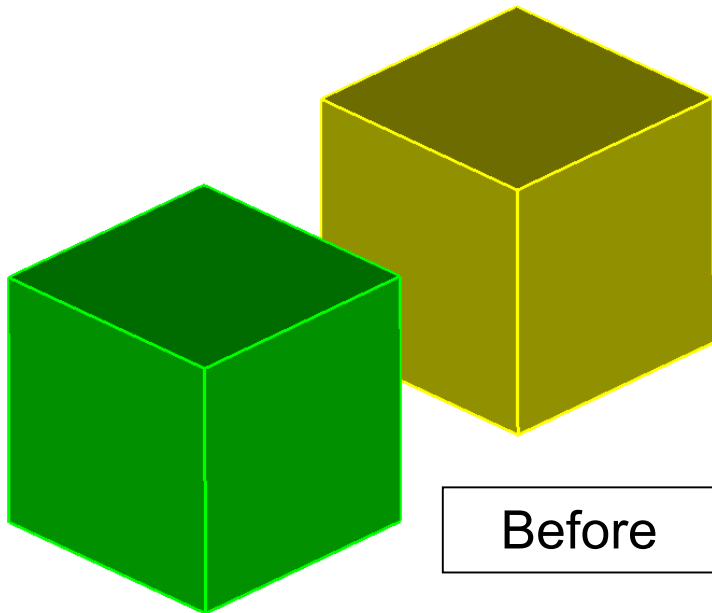
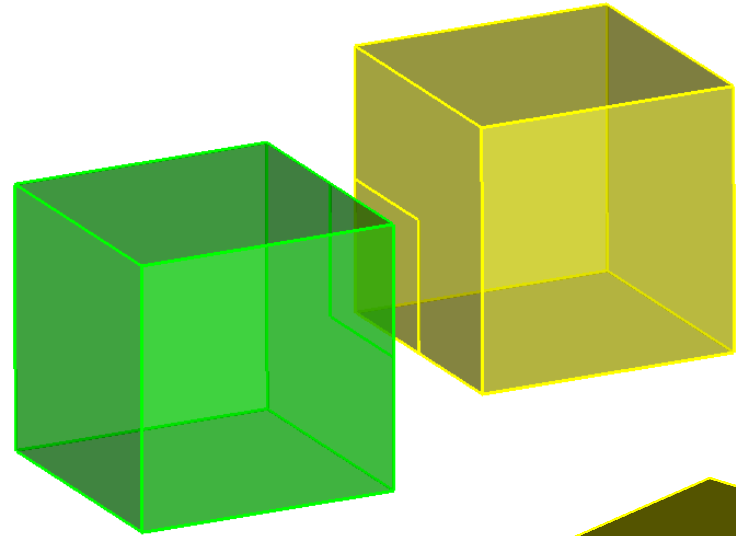
*Computational Modeling Sciences Department*

Side = 1.0

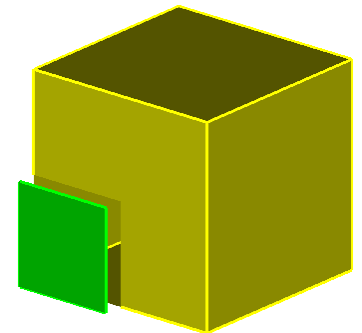
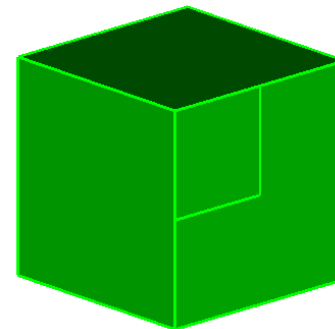


Gap = 0.1

Merge Tolerance = 0.11



Before

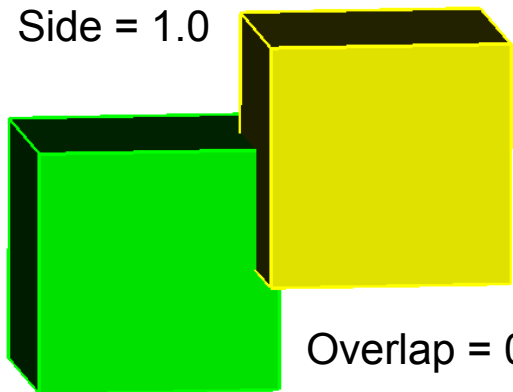


After

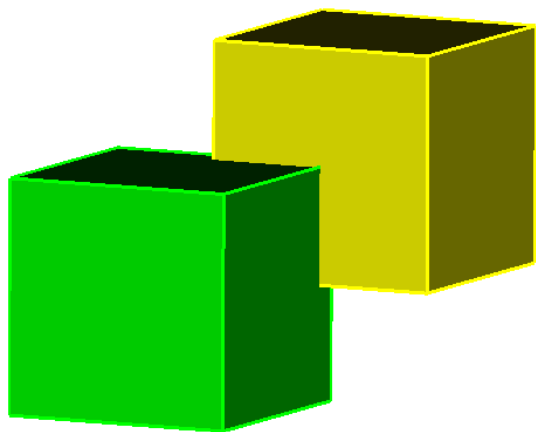
# Overlap Example

*Computational Modeling Sciences Department*

Side = 1.0

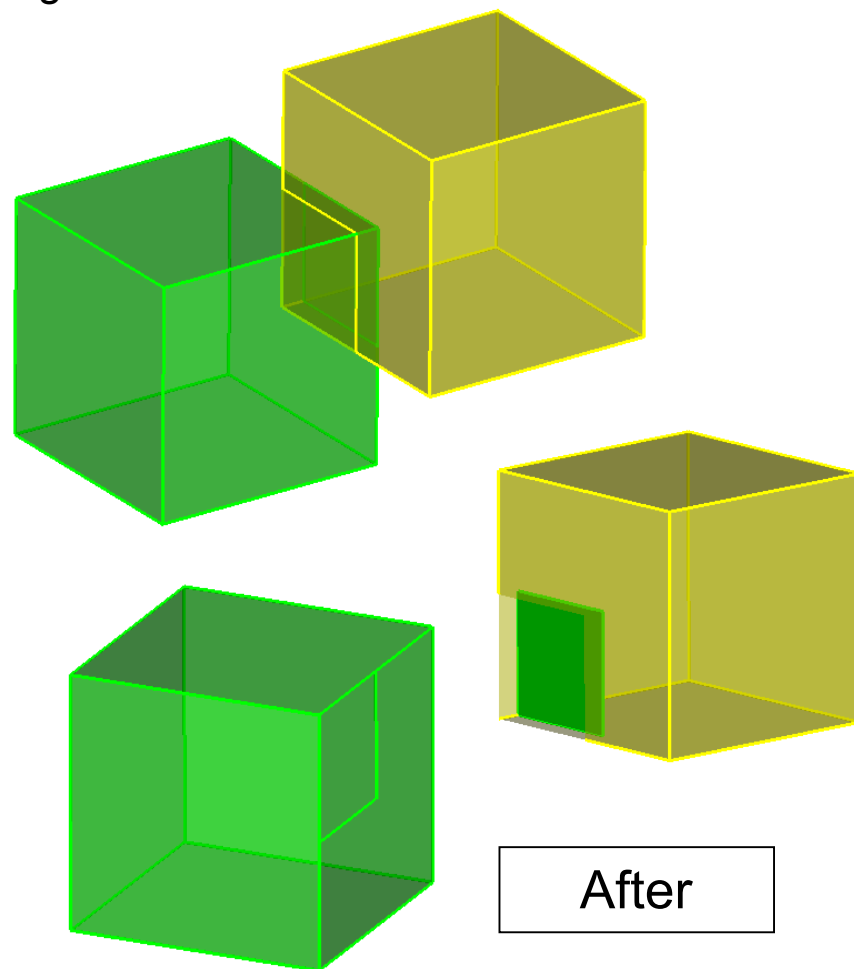


Overlap = 0.1



Before

Merge Tolerance = 0.11

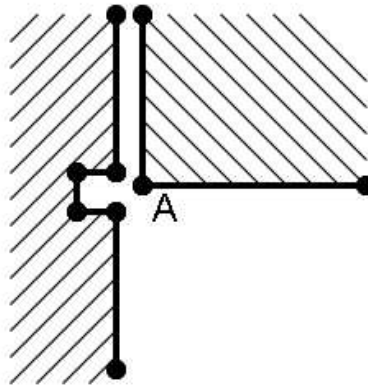


After

# Determining Merge Tolerance

*Computational Modeling Sciences Department*

- **Must be smaller than the smallest feature**



- **Must be larger than the largest gap, misalignment, or overlap**

# Smallest Feature

Computational Modeling Sciences Department

**Prepare Geometry**

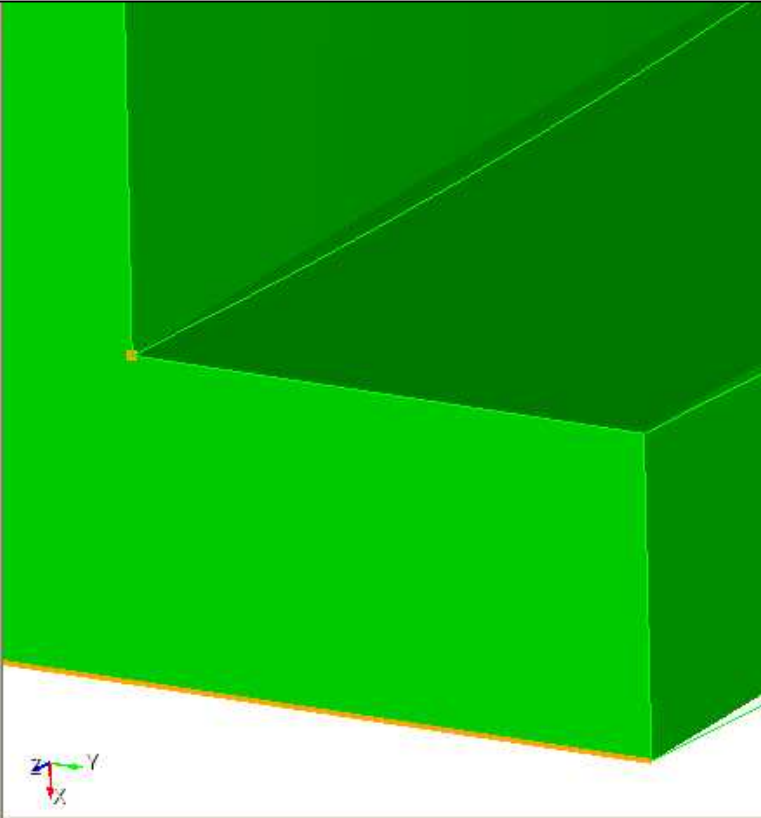
**Determine Smallest Feature Size**  
Search for the smallest features in your model.  
This will help you decide what the smallest feature is that you want to resolve in the mesh and which features should be removed. After analyzing the results set the smallest feature size to be used in later diagnostics.

Volume List

Find the  smallest features

Find Small Features

| Entity Pair        | Distance   |
|--------------------|------------|
| Vert 37 - Curve 57 | 0.25400000 |
| Vert 39 - Vert 38  | 0.25400000 |
| Vert 41 - Vert 40  | 0.25400000 |
| Vert 42 - Curve 57 | 0.25400000 |
| Vert 38 - Vert 37  | 0.44450000 |
| Vert 42 - Vert 41  | 0.44450000 |
| Vert 39 - Vert 37  | 0.51195337 |
| Vert 42 - Vert 40  | 0.51195337 |
| Vert 15 - Vert 14  | 0.63500000 |
| Vert 36 - Vert 1   | 0.63500000 |
| Vert 23 - Vert 22  | 0.73036047 |
| Vert 29 - Vert 28  | 0.73036047 |
| Vert 45 - Vert 44  | 1.17284148 |
| Vert 52 - Vert 51  | 1.17284148 |
| Vert 68 - Vert 66  | 1.17284148 |



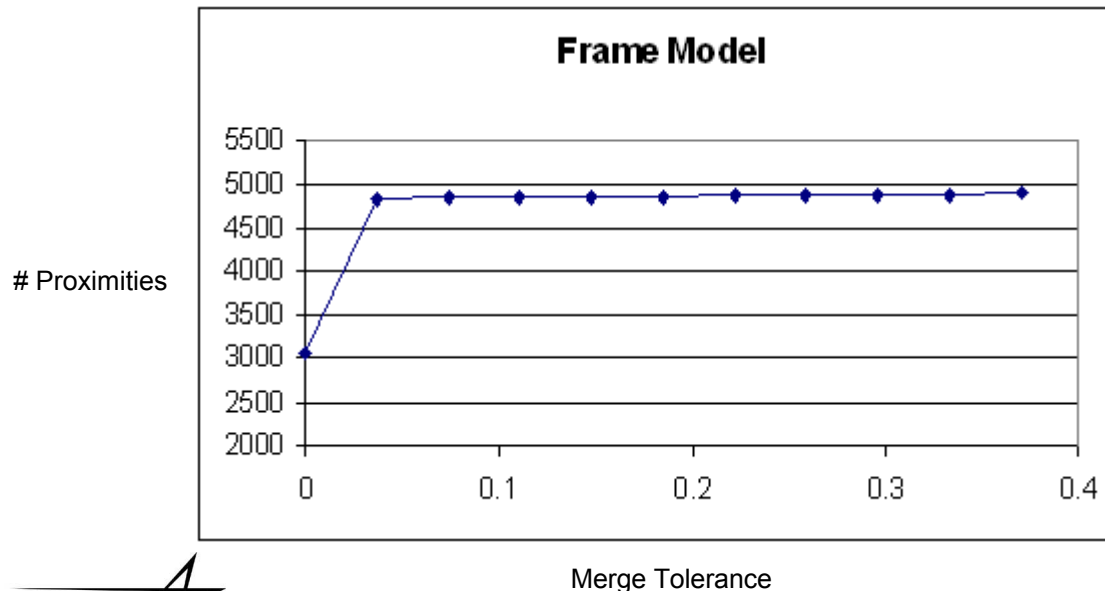
```
CUBIT> import acis "C:/Models/L2Problems/Problem2/Problem2.s
" attributes_on separate_bodies
Geometry engine set to: ACIS Version 17.0.2.0
Read 3 ACIS Entities from the input file
```

# Merge Tolerance Estimator

*Computational Modeling Sciences Department*

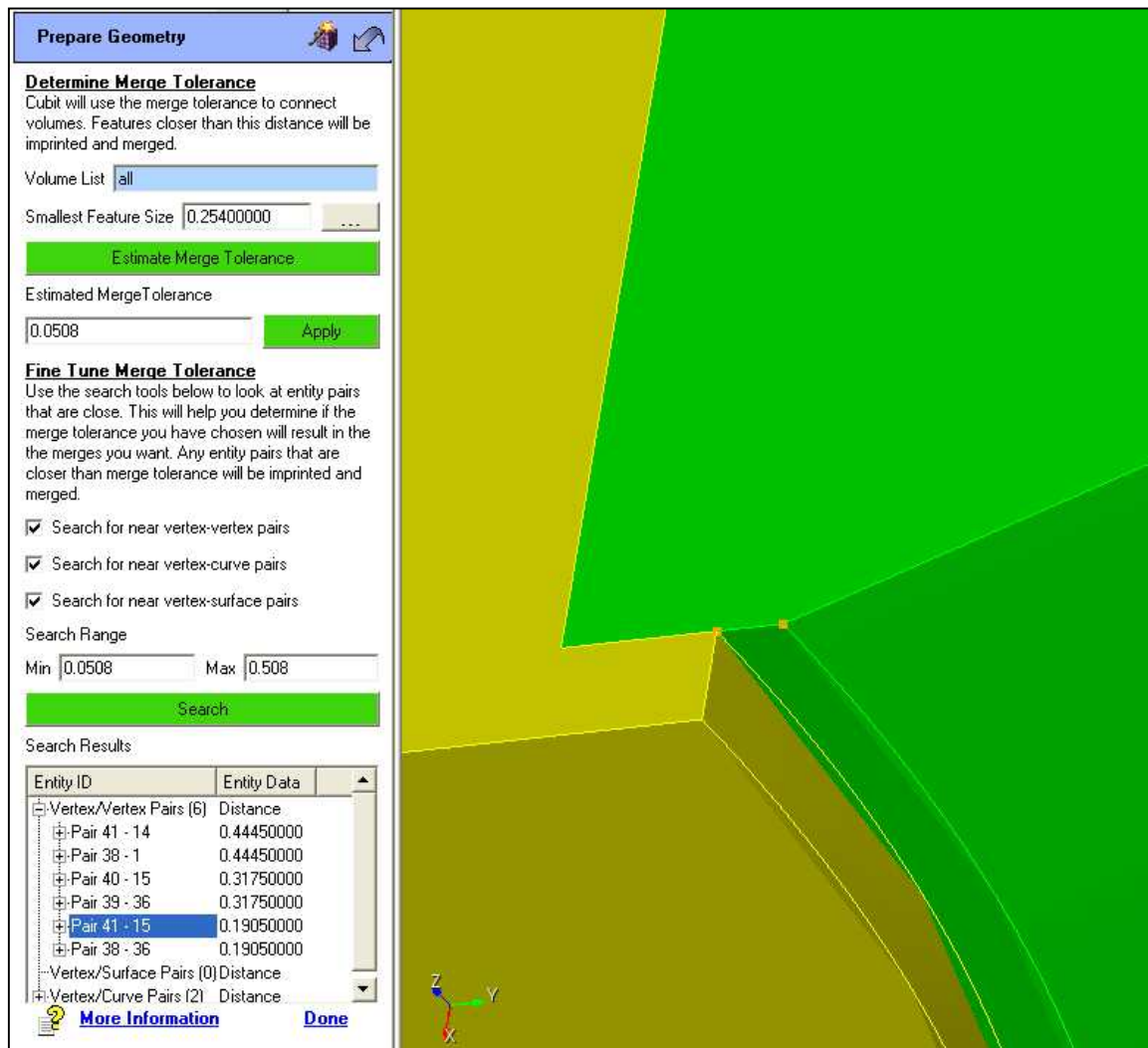
- Examine range from 0 to smallest feature size
- At different values in the range find the # of proximities
- Plot current value vs. # of proximities
- Pick off point where the plot starts to level off

Model with ~900 volumes



# Volume-Volume Proximities

Computational Modeling Sciences Department



**Prepare Geometry**

**Determine Merge Tolerance**  
Cubit will use the merge tolerance to connect volumes. Features closer than this distance will be imprinted and merged.

Volume List: all

Smallest Feature Size: 0.25400000

Estimate Merge Tolerance

Estimated MergeTolerance: 0.0508

Apply

**Fine Tune Merge Tolerance**  
Use the search tools below to look at entity pairs that are close. This will help you determine if the merge tolerance you have chosen will result in the merges you want. Any entity pairs that are closer than merge tolerance will be imprinted and merged.

☒ Search for near vertex-vertex pairs  
☒ Search for near vertex-curve pairs  
☒ Search for near vertex-surface pairs

Search Range  
Min: 0.0508 Max: 0.508

Search

Search Results

| Entity ID                         | Entity Data |
|-----------------------------------|-------------|
| Vertex/Vertex Pairs (6) Distance  |             |
| Pair 41 - 14                      | 0.44450000  |
| Pair 38 - 1                       | 0.44450000  |
| Pair 40 - 15                      | 0.31750000  |
| Pair 39 - 36                      | 0.31750000  |
| Pair 41 - 15                      | 0.19050000  |
| Pair 38 - 36                      | 0.19050000  |
| Vertex/Surface Pairs (0) Distance |             |
| Vertex/Curve Pairs (2) Distance   |             |

[More Information](#) [Done](#)

The 3D model on the right shows a yellow volume and a green volume. A small orange square highlights the proximity between the two volumes. A coordinate system (X, Y, Z) is visible in the bottom left corner of the 3D view.



# Impact on Real Model

*Computational Modeling Sciences Department*

- **AF&F (arming, fusing, and firing) model**
- **~240 volumes**
- **Dense model with many volume-volume interfaces**
- **“Sloppy” volume-volume interfaces**

|                     | Time (min) | # Overlapping Surface Pairs |
|---------------------|------------|-----------------------------|
| Regular Imprinting  | 3.5        | 169                         |
| Tolerant Imprinting | 56         | 2                           |



# Conclusions

---

*Computational Modeling Sciences Department*

- **Tolerant imprinting will significantly reduce geometry modification time on sloppy assemblies**
- **Determining merge tolerance must be done carefully**
- **Need to continue to try to automate conformal meshing of sloppy assemblies**