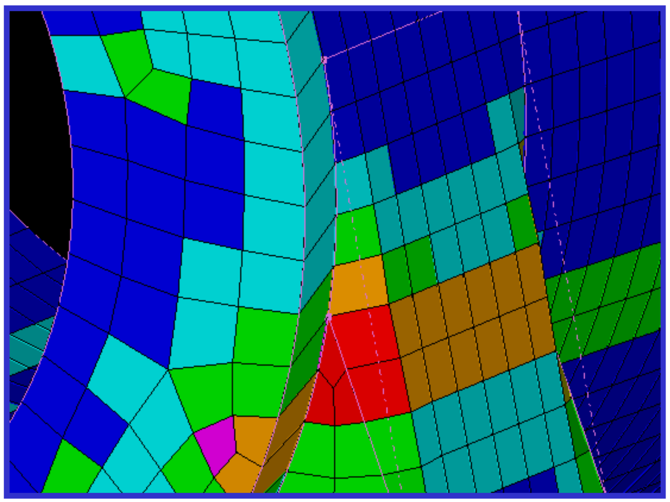
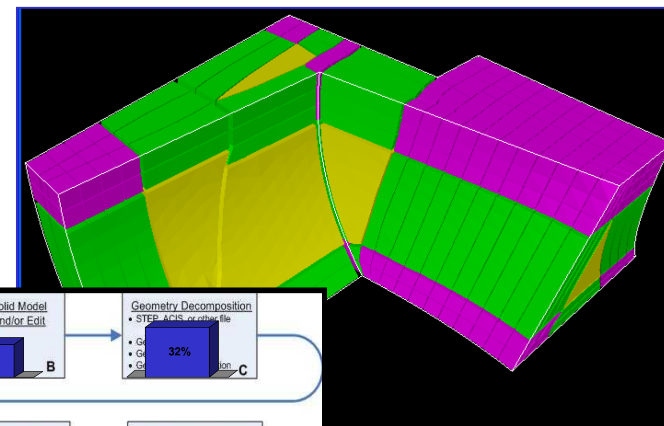
SAND2006-6830P

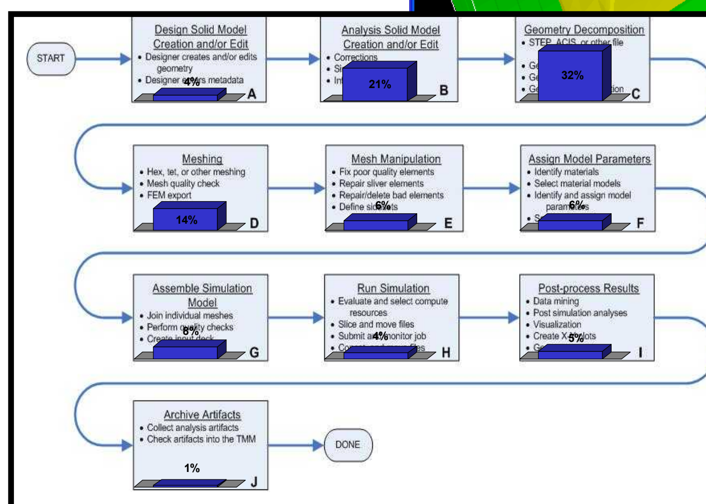
Enabling Modeling and Simulation in Complex and Diverse Environments

Ted Blacker

Sandia National Laboratories







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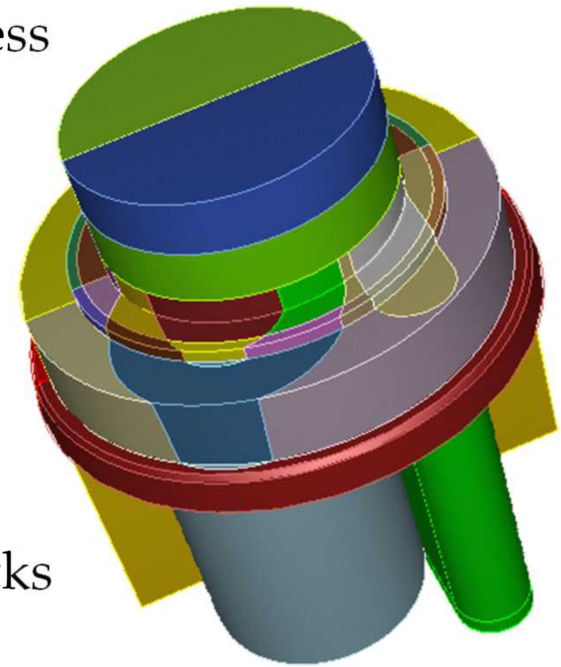
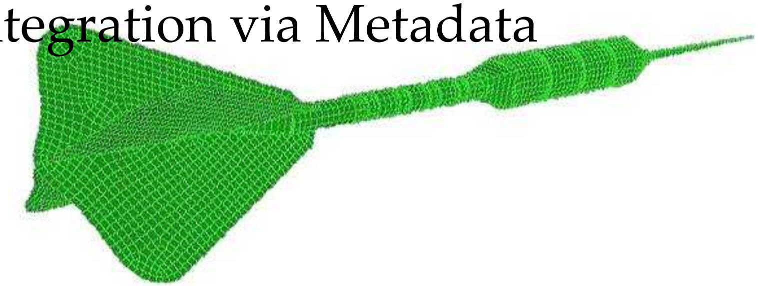
DTA (Design Through Analysis) Challenge Requires Careful Evaluation and Response

- **Problem**
  - Engineering Transformation Depends on DTA Advances
  - Responsiveness a Critical Factor for Success
- **Constraints**
  - Diverse Analyses
  - Complex Geometries
  - Plethora of Tools Required
  - Large Machines & Data Sets
- **Solution**
  - Careful Evaluation of Process & Bottlenecks
  - Core Technology Development
  - Federated Integration via Metadata



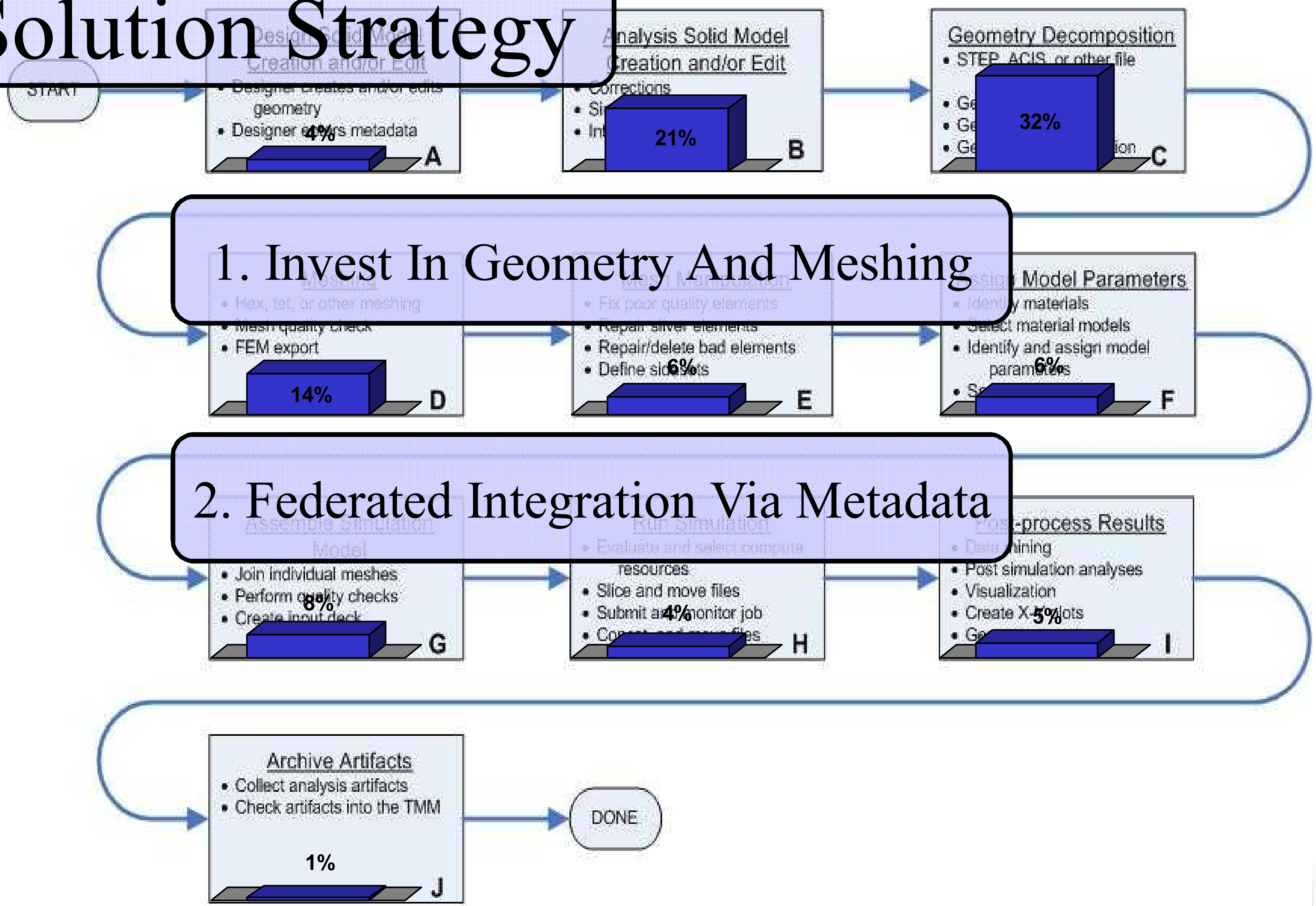


Understanding the DTA Process Allows Targeted Development & Directed Impact

Solution Strategy

1. Invest In Geometry And Meshing

2. Federated Integration Via Metadata



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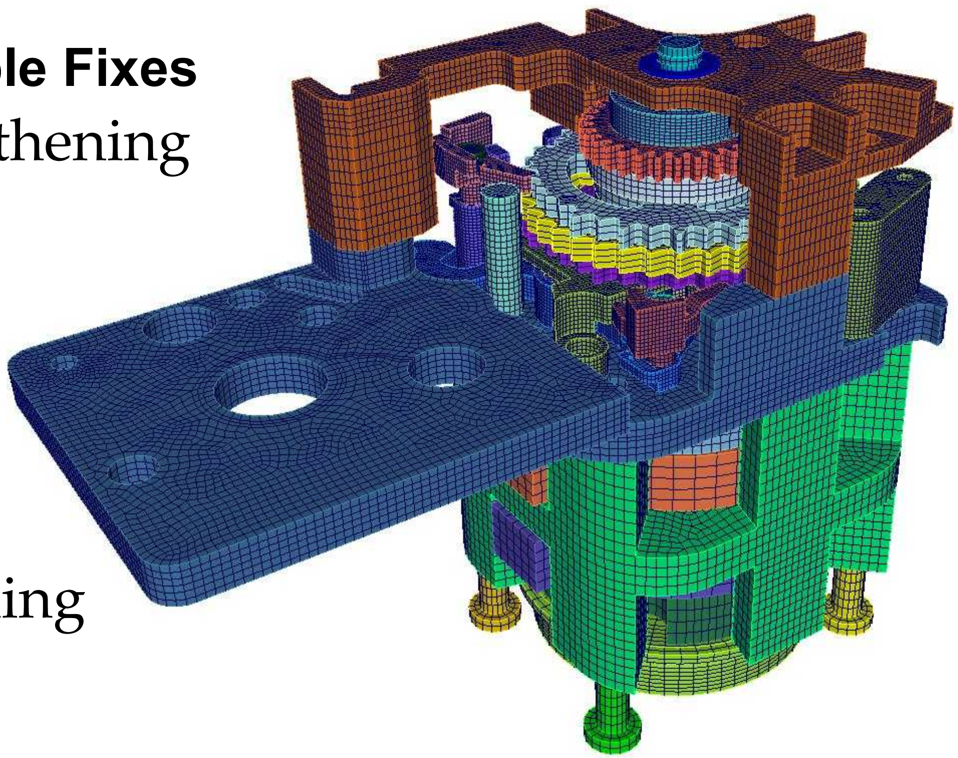
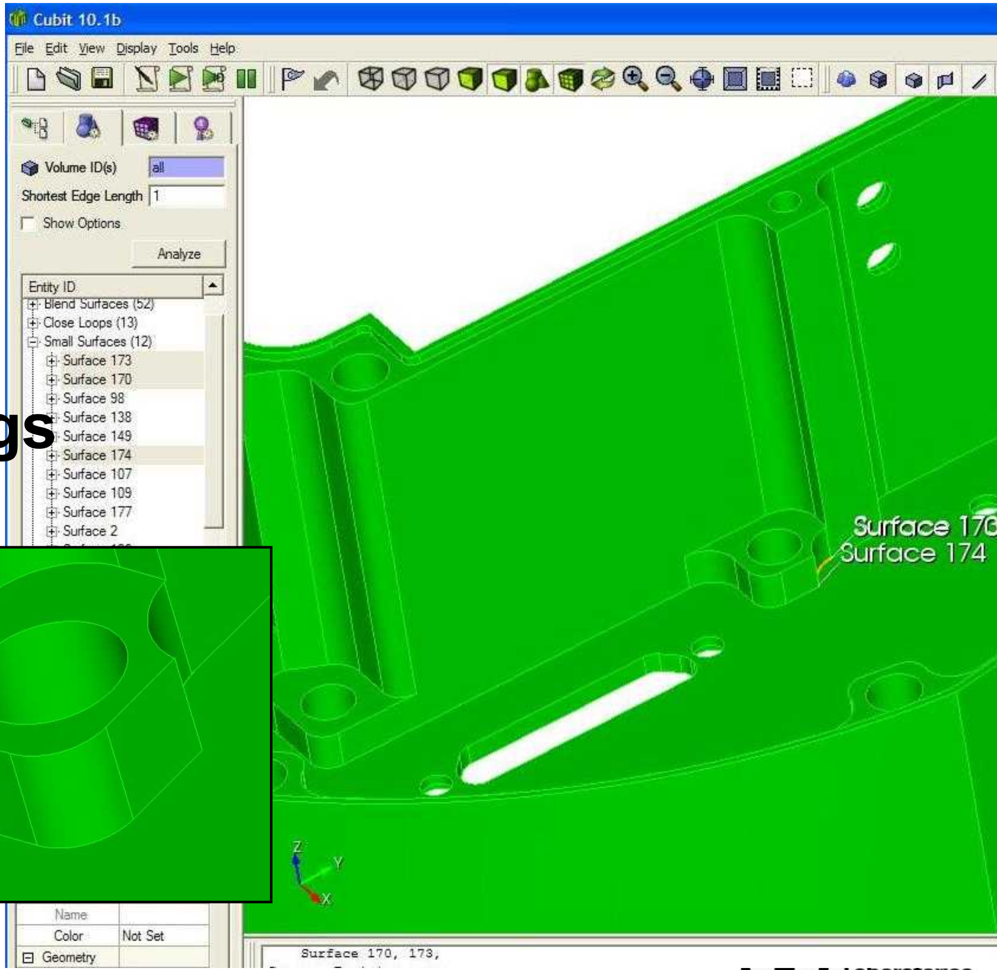
Strategy 1: Investing in Mesh and Geometry Reduces the Major Time Constraints

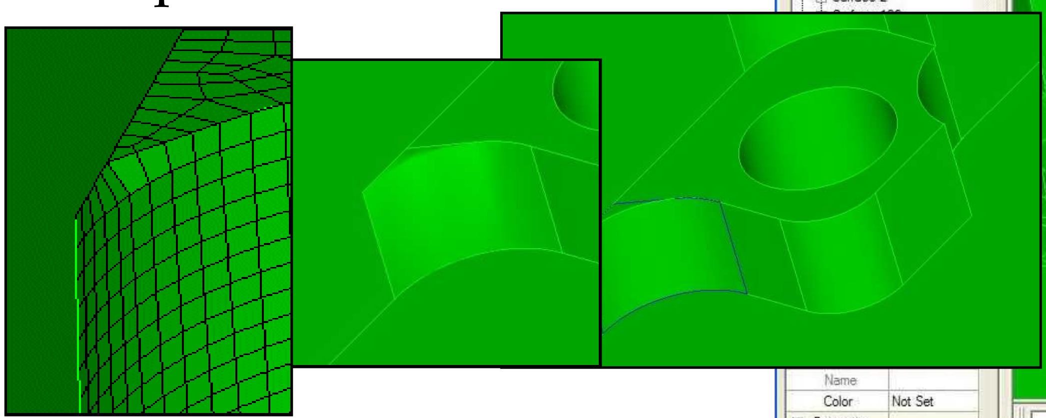
- **Geometry**
  - CAD Best Practices Cultural Change
  - Direct CAD Integration
  - Geometry Power Tool
    - **Problem Discovery**
    - **Automation of Probable Fixes**
  - Virtual Topology Strengthening
    - **Automated Cleanup**
    - **Defeaturing**
  - Dimensional Reduction
- **Meshing**
  - All-Hex Research
  - Topology Tolerant Meshing



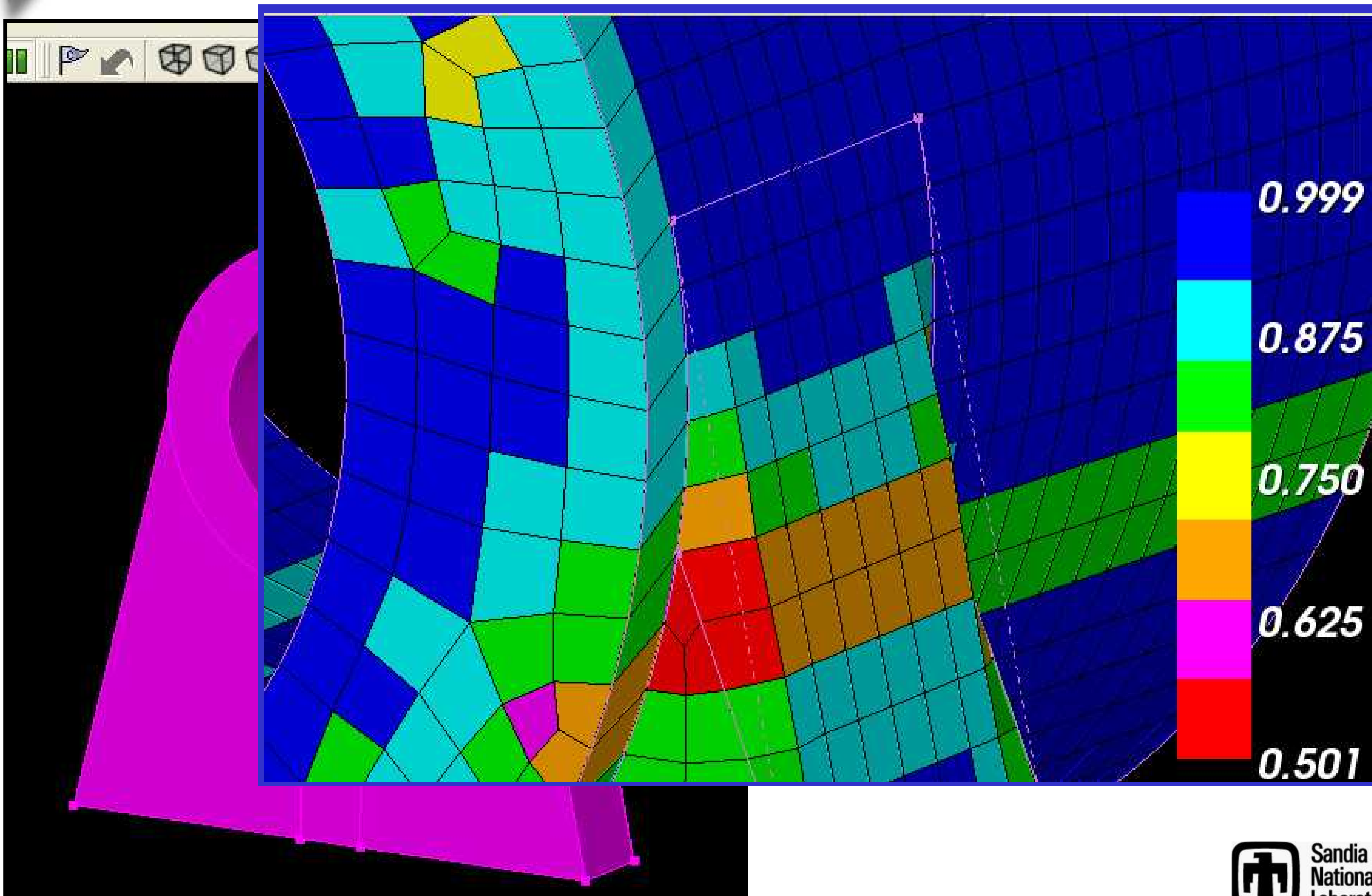
Geometry Power Tool Provides Fast Finds and Fixes

- **GUI feature focused on geometry cleanup**
  - Potential problems identified
  - Problem visualization
  - Remedies close at hand
- **New operations**
  - Collapse Small Angle
  - Split Surface
- **Substantive Time Savings**
  - Open-Ended Tests

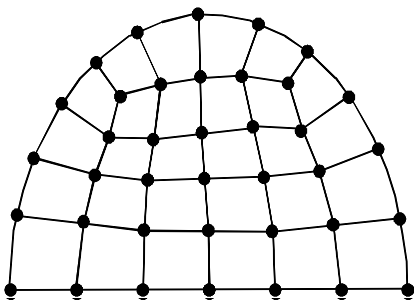




Virtual Geometry Angle Collapse Shows Power of Flexible Topology

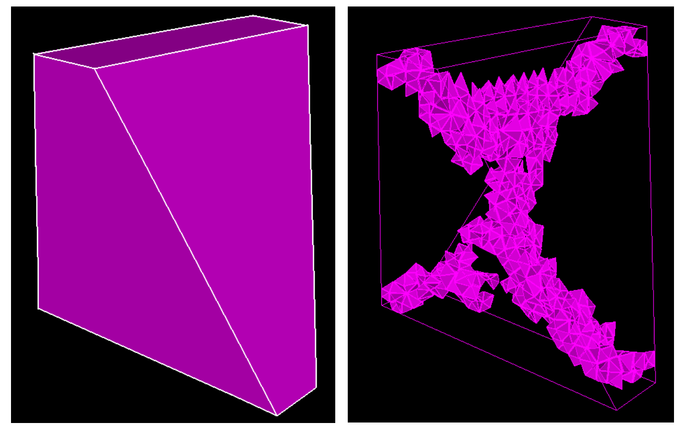


Promising Hex Research Insures Significant Impact



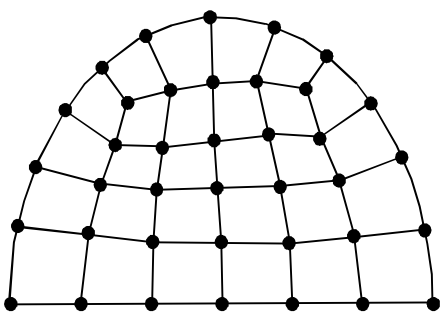
Paving - 2D (1990)

- Initial boundary nodes defined
- Advancing front by discrete elements
- Creates skewed elements in thin surfaces



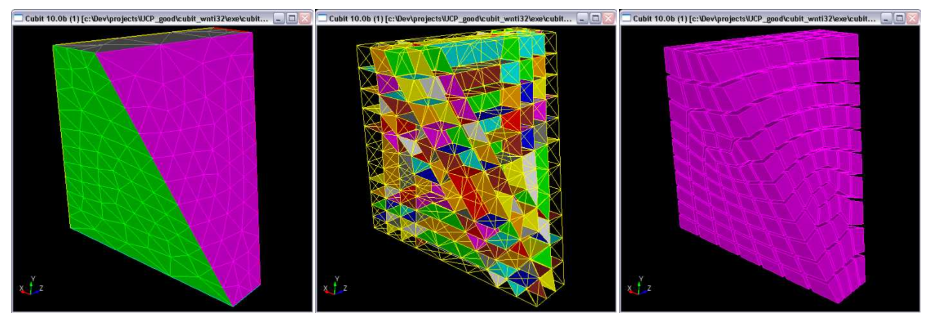
Plastering – 3D (1992)

- Initial quad boundary defined
- Advancing Front by discrete elements
- Cannot resolve interior voids



Unconstrained Paving – 2D (2005)

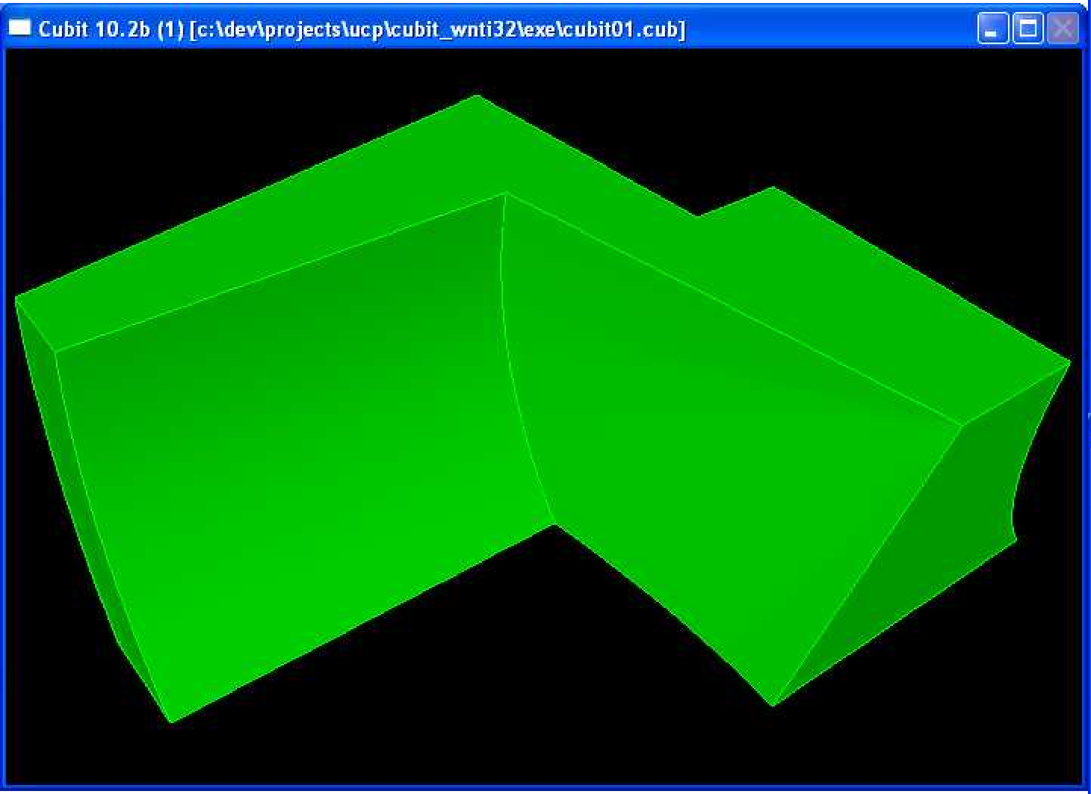
- No initial boundary nodes
- Advancing front by discrete geometric layers
- Layer-by-layer placement

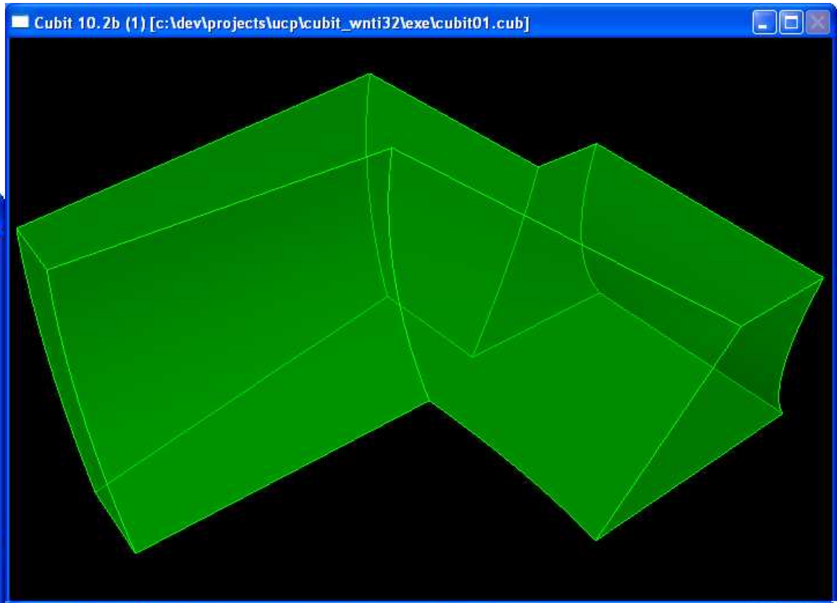


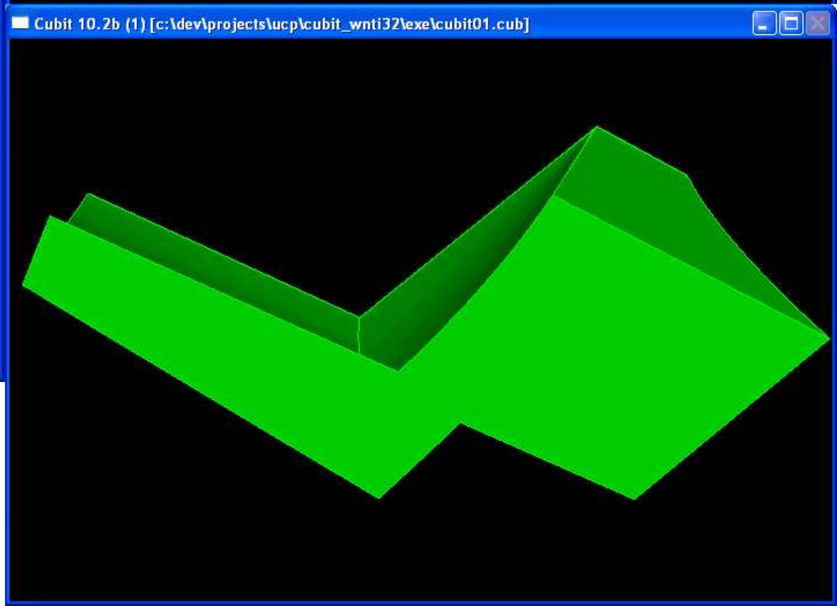
Unconstrained Plastering – 3D (2005)

- No initial boundary quad mesh
- Advancing front by discrete geometric layers
- Sheet-by-sheet placement
- Under active research and development

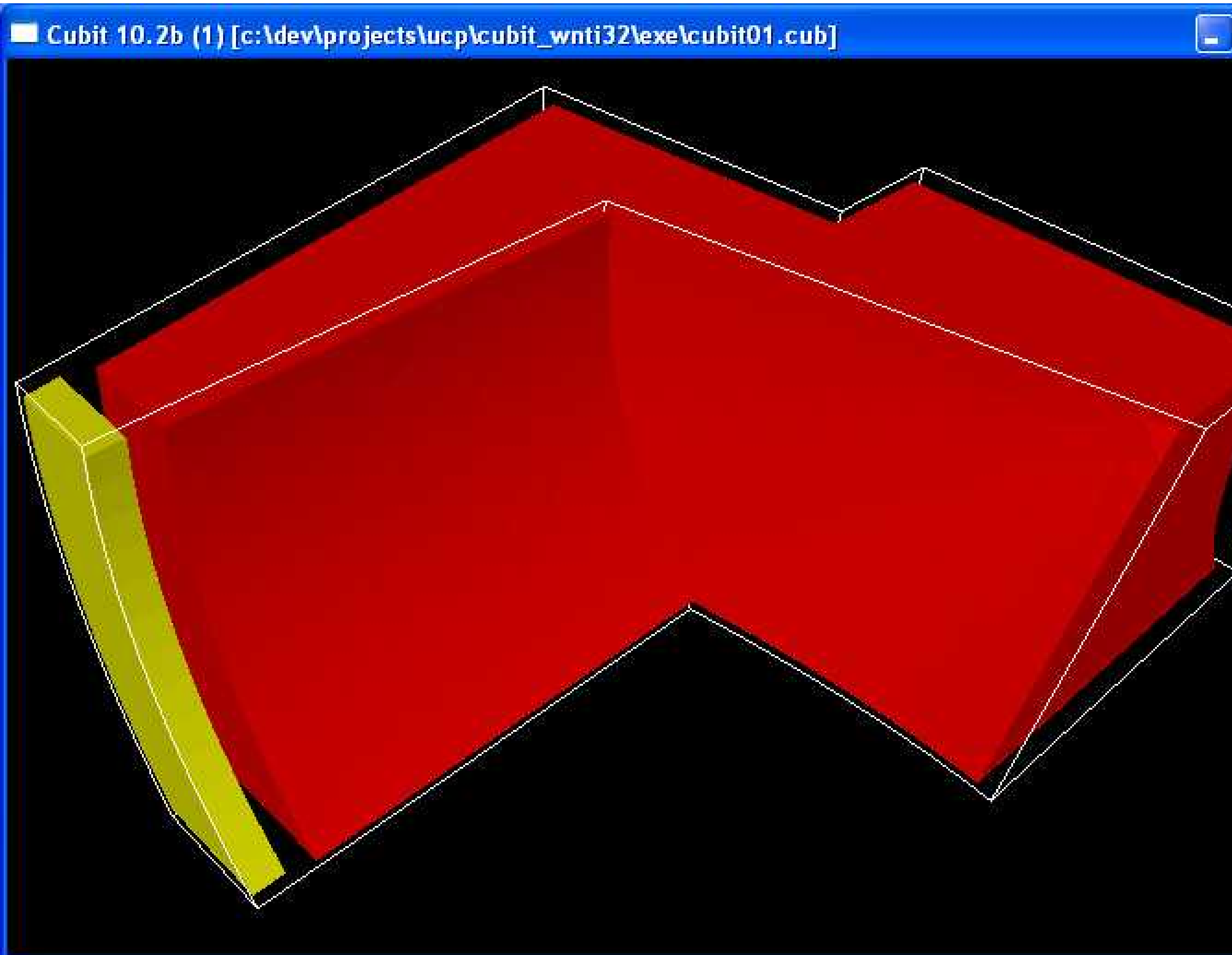
Unconstrained Plastering: Moving Forward Rapidly

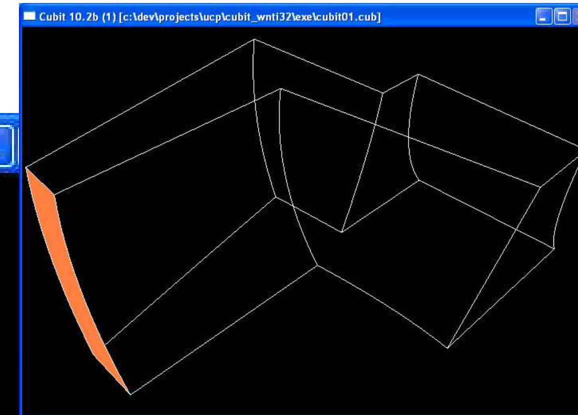






Example Model





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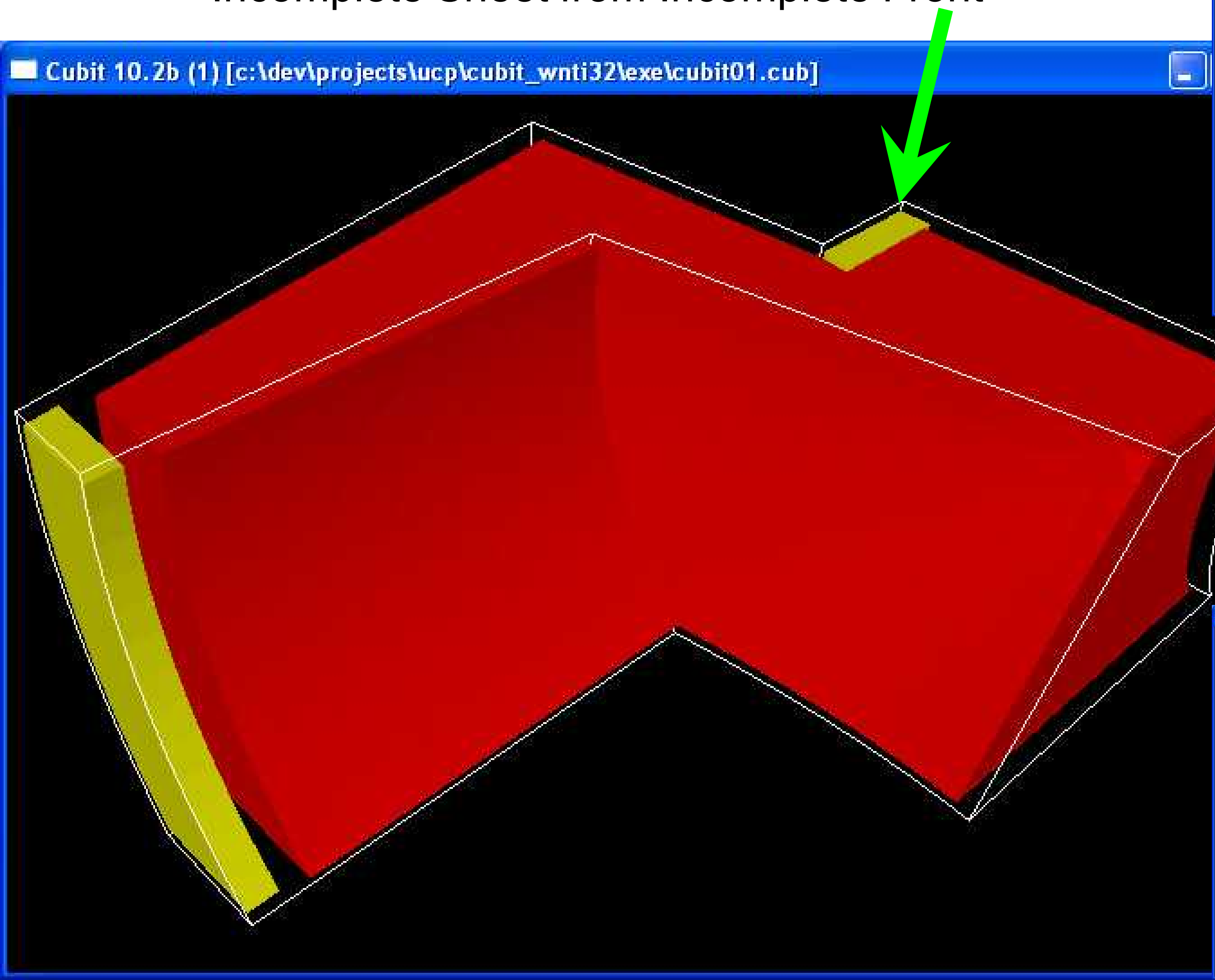
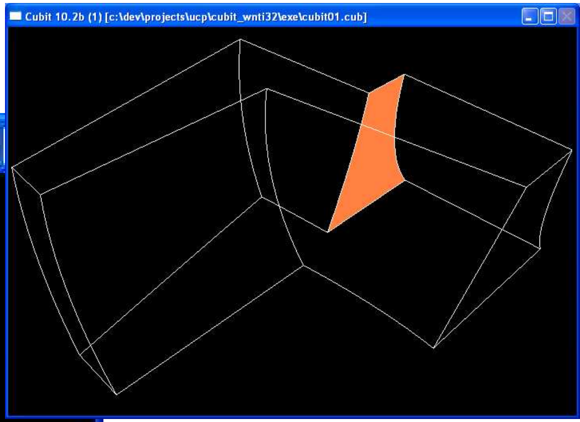
Example Model

Incomplete Sheet from Incomplete Front





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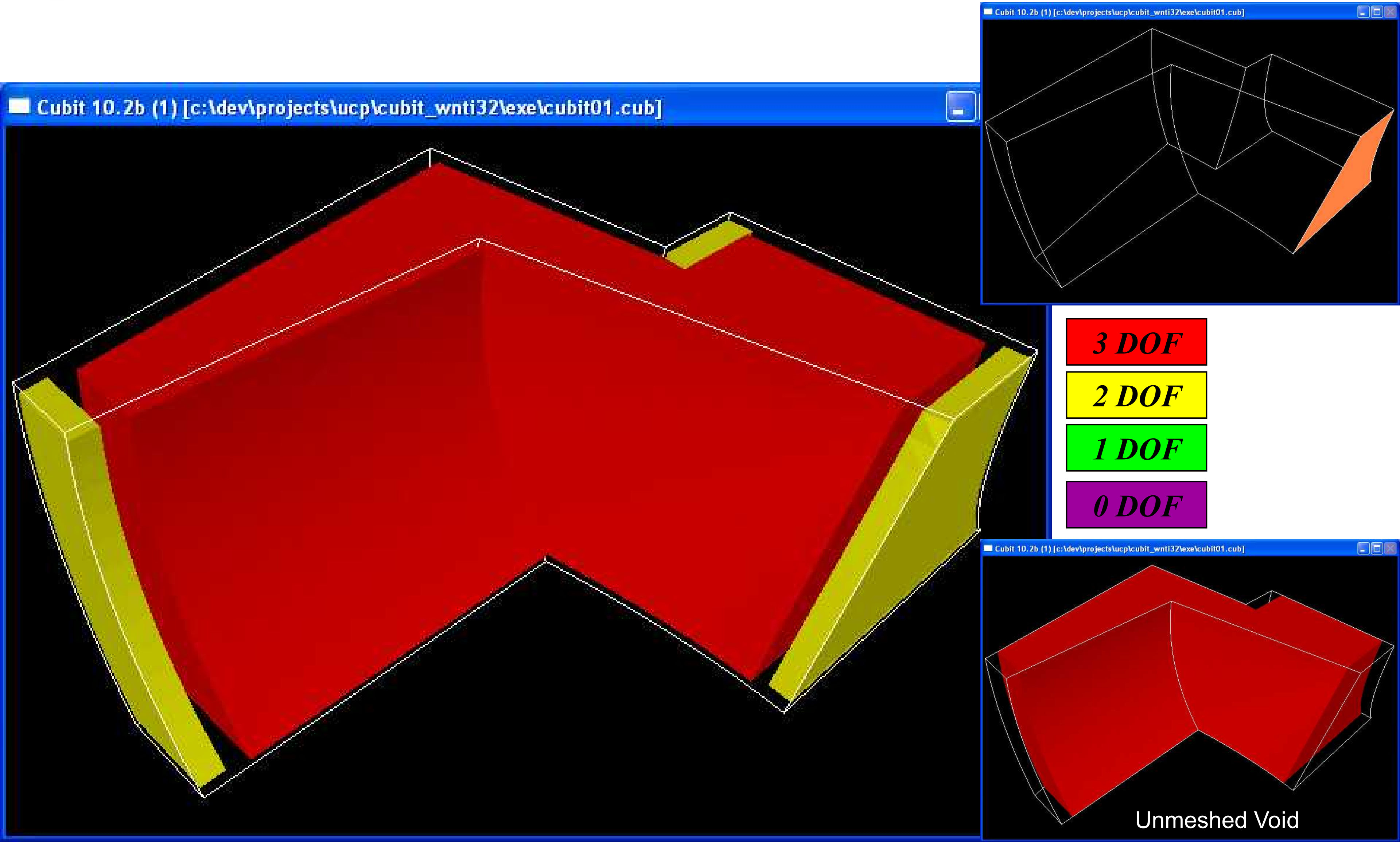

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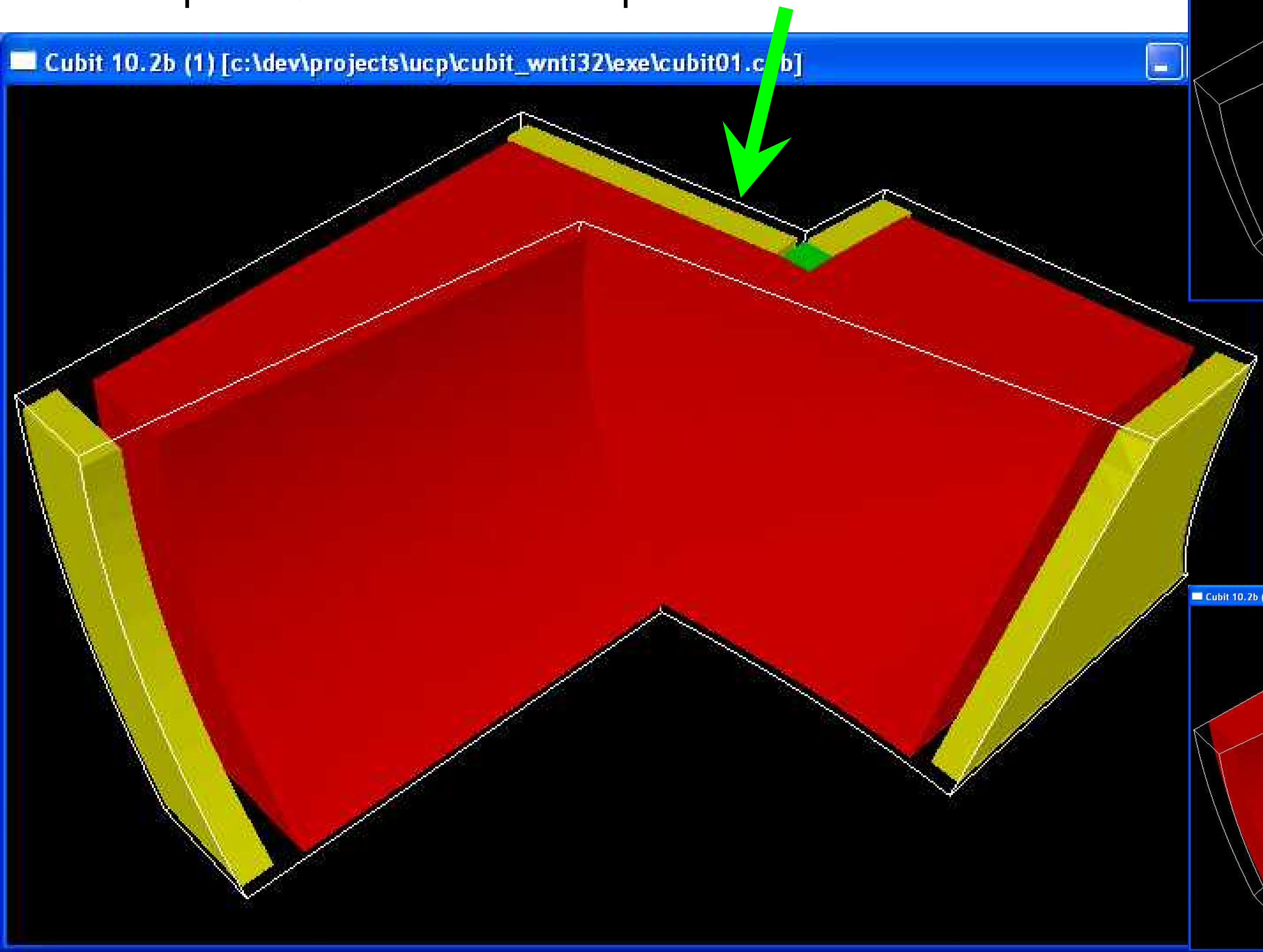

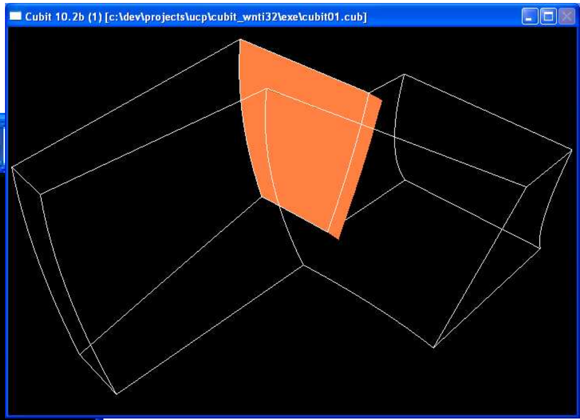

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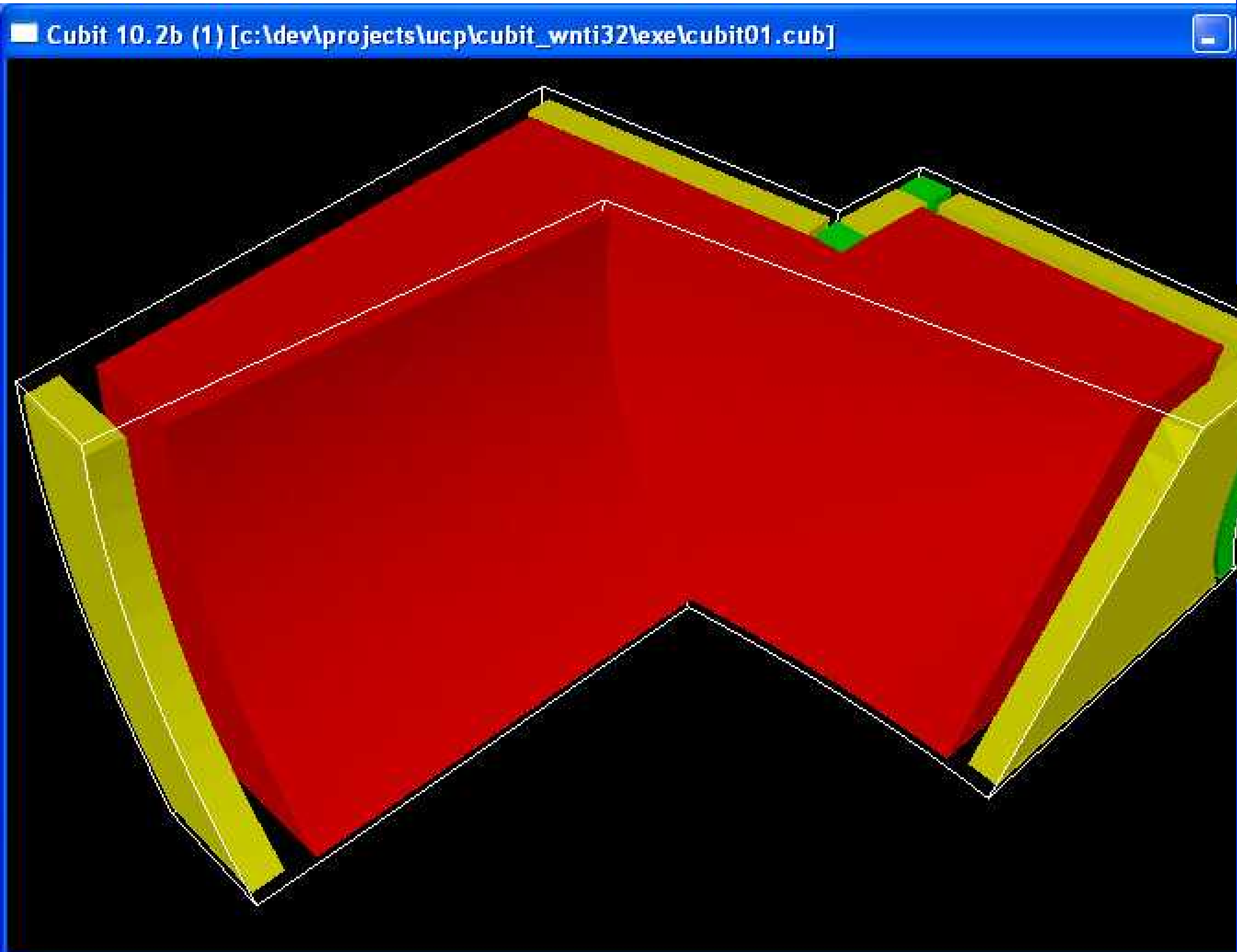

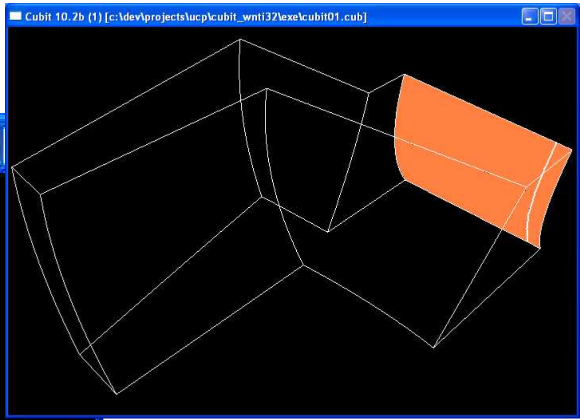

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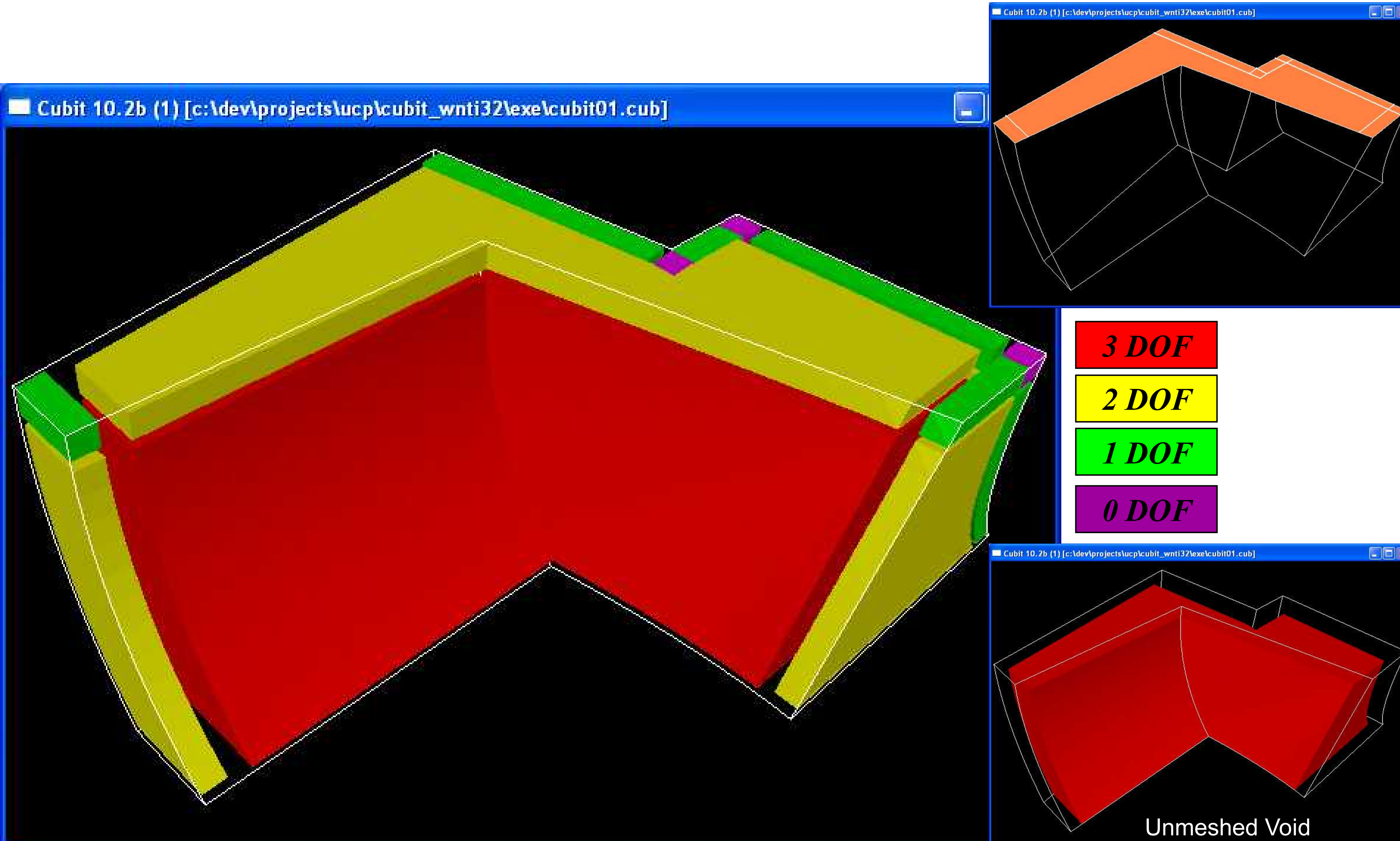

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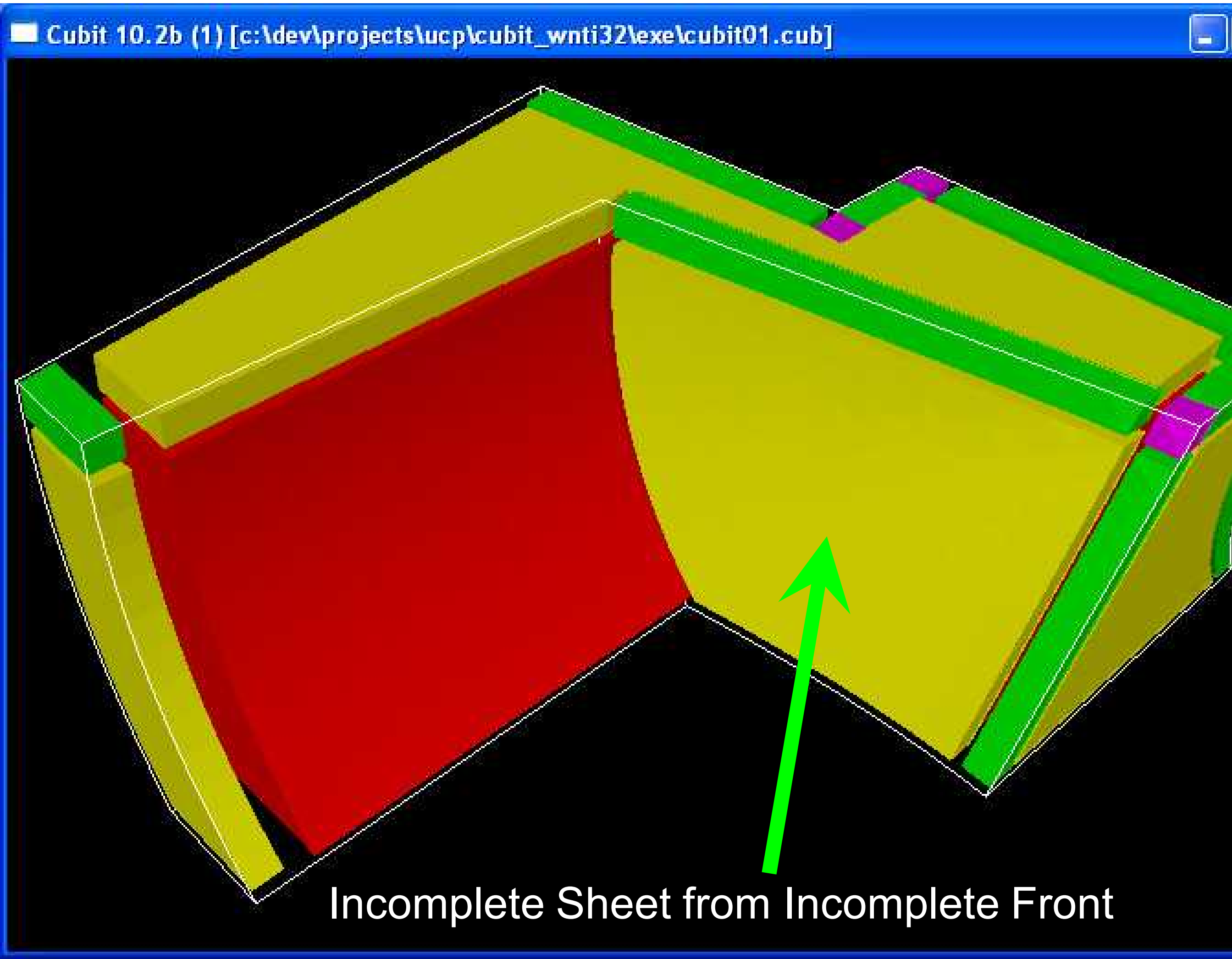

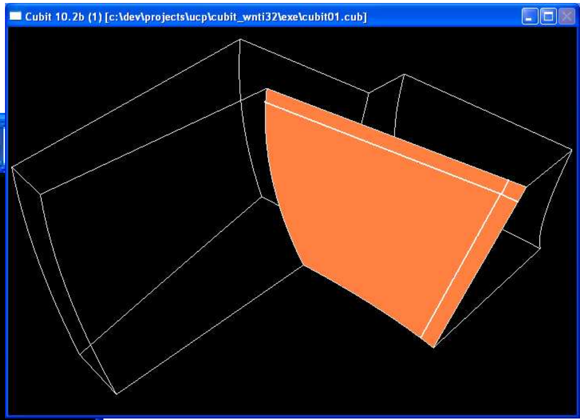

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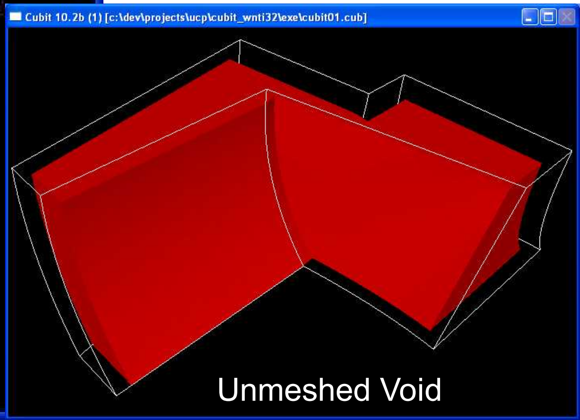

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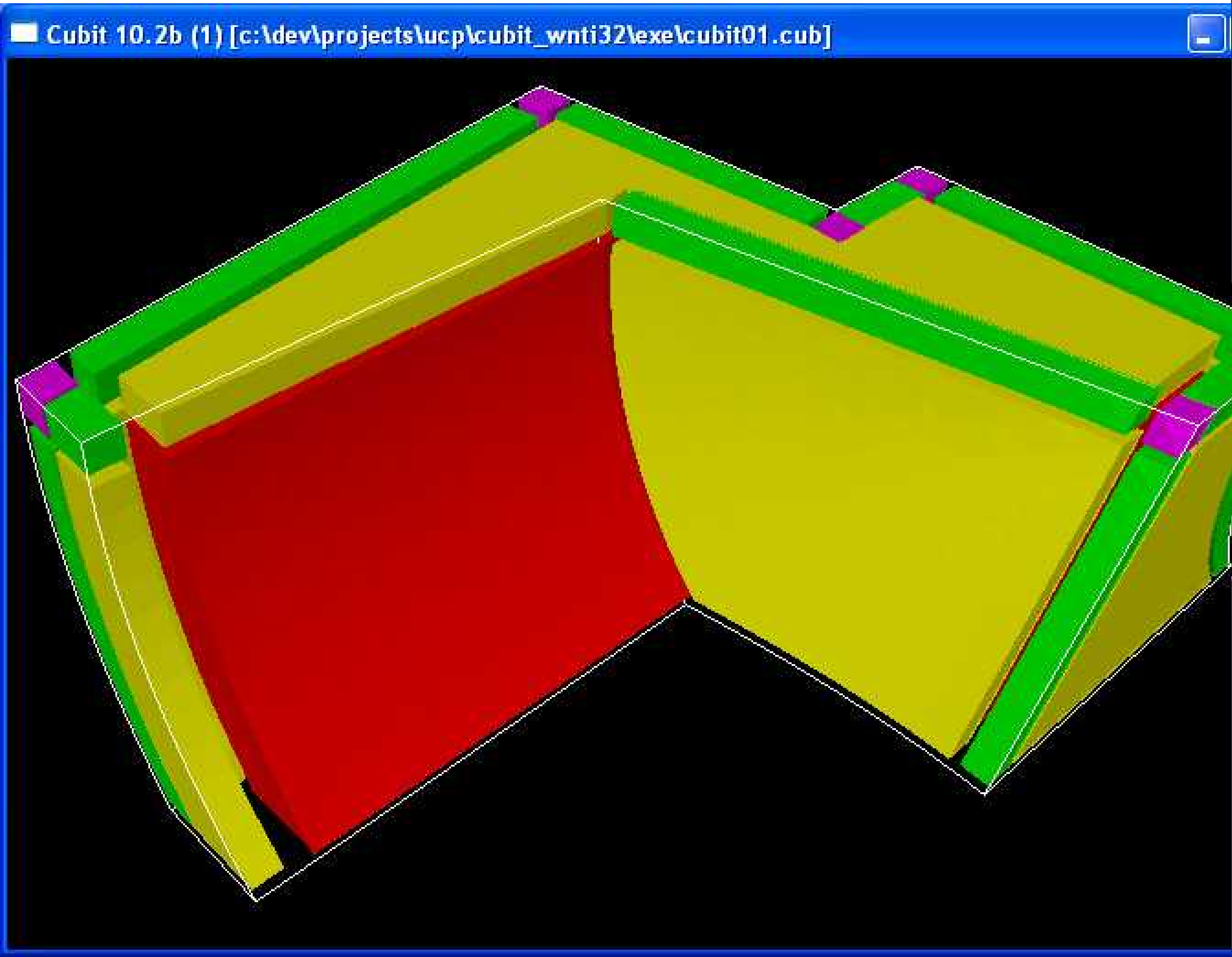

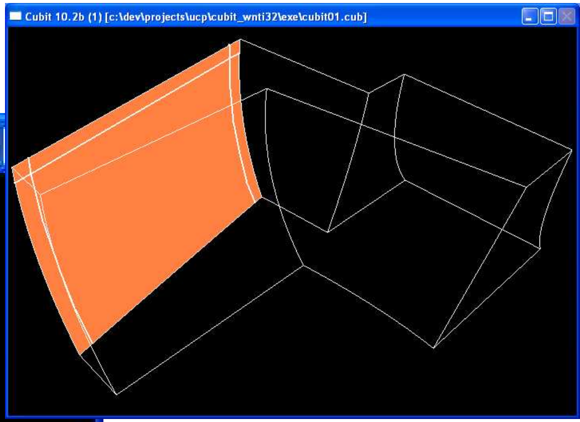

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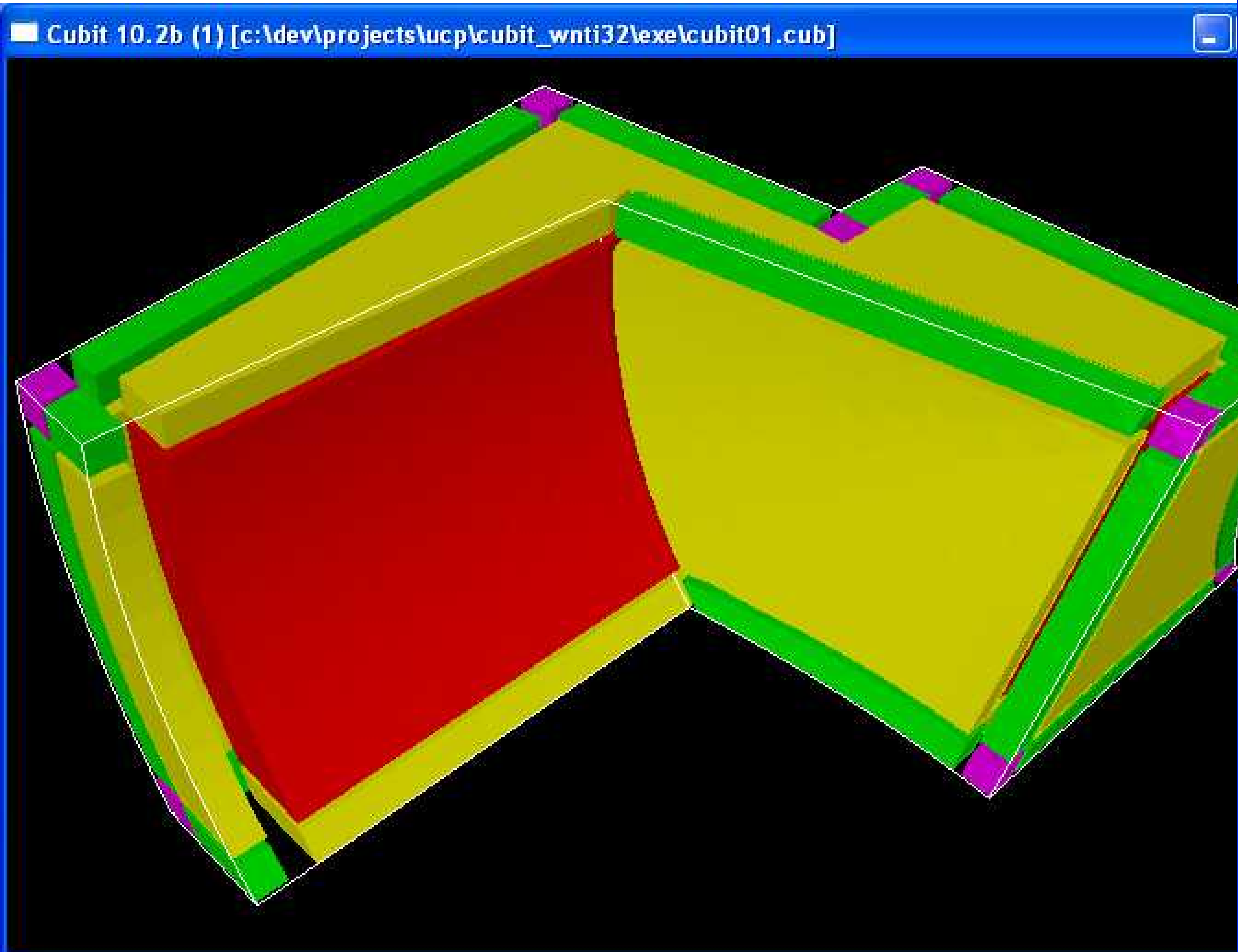
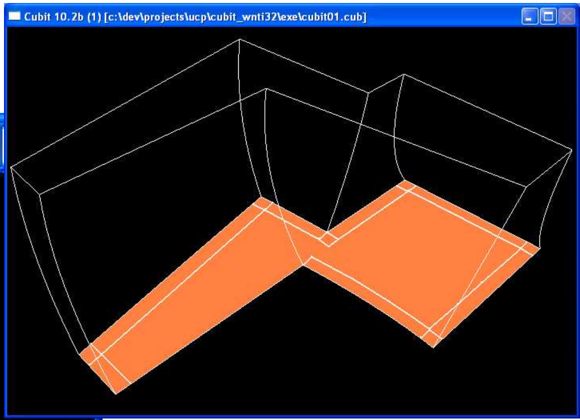
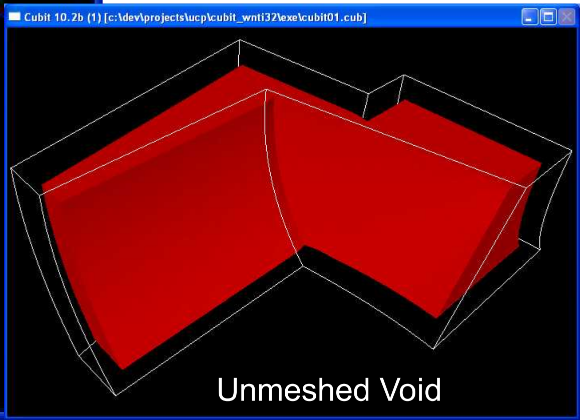




- *3 DOF*
- *2 DOF*
- *1 DOF*
- *0 DOF*



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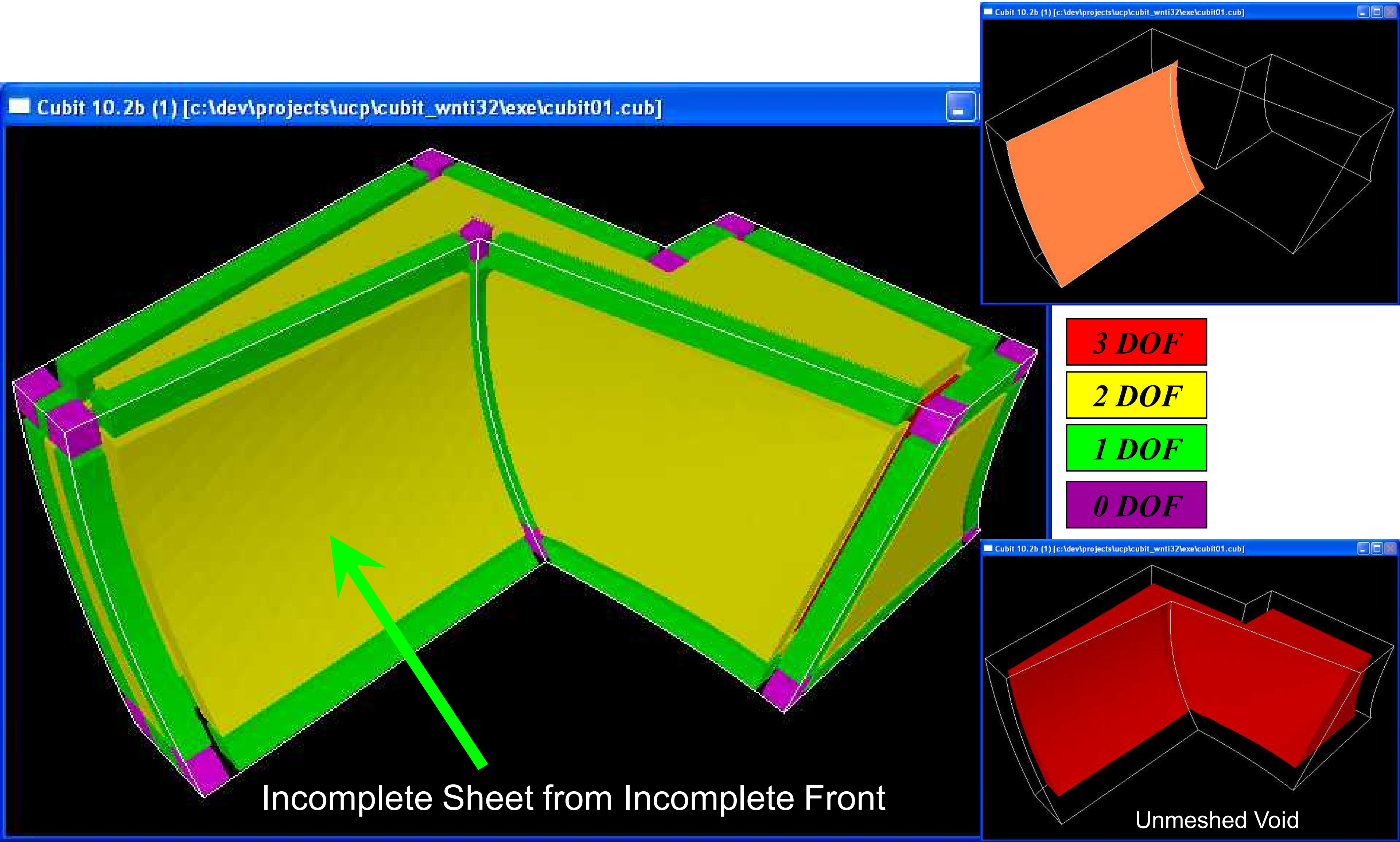

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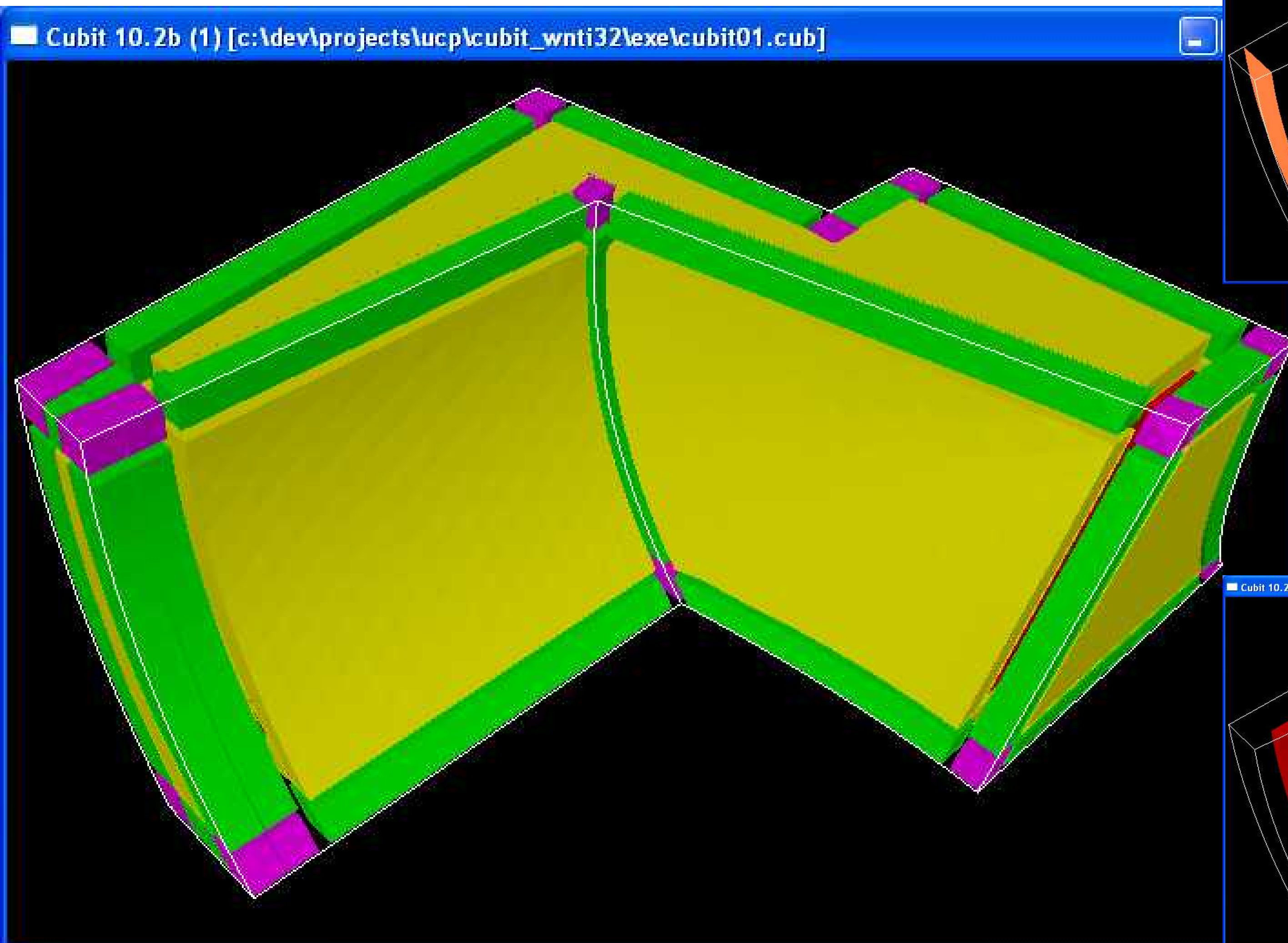

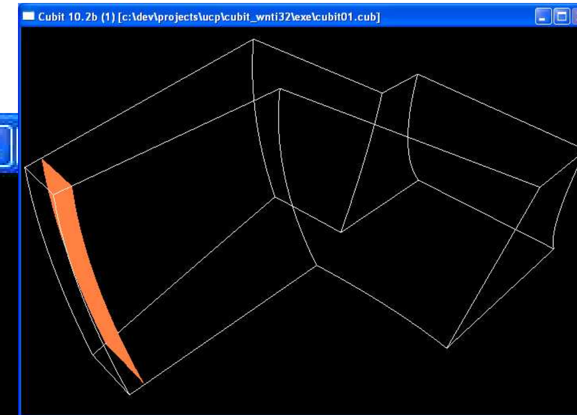

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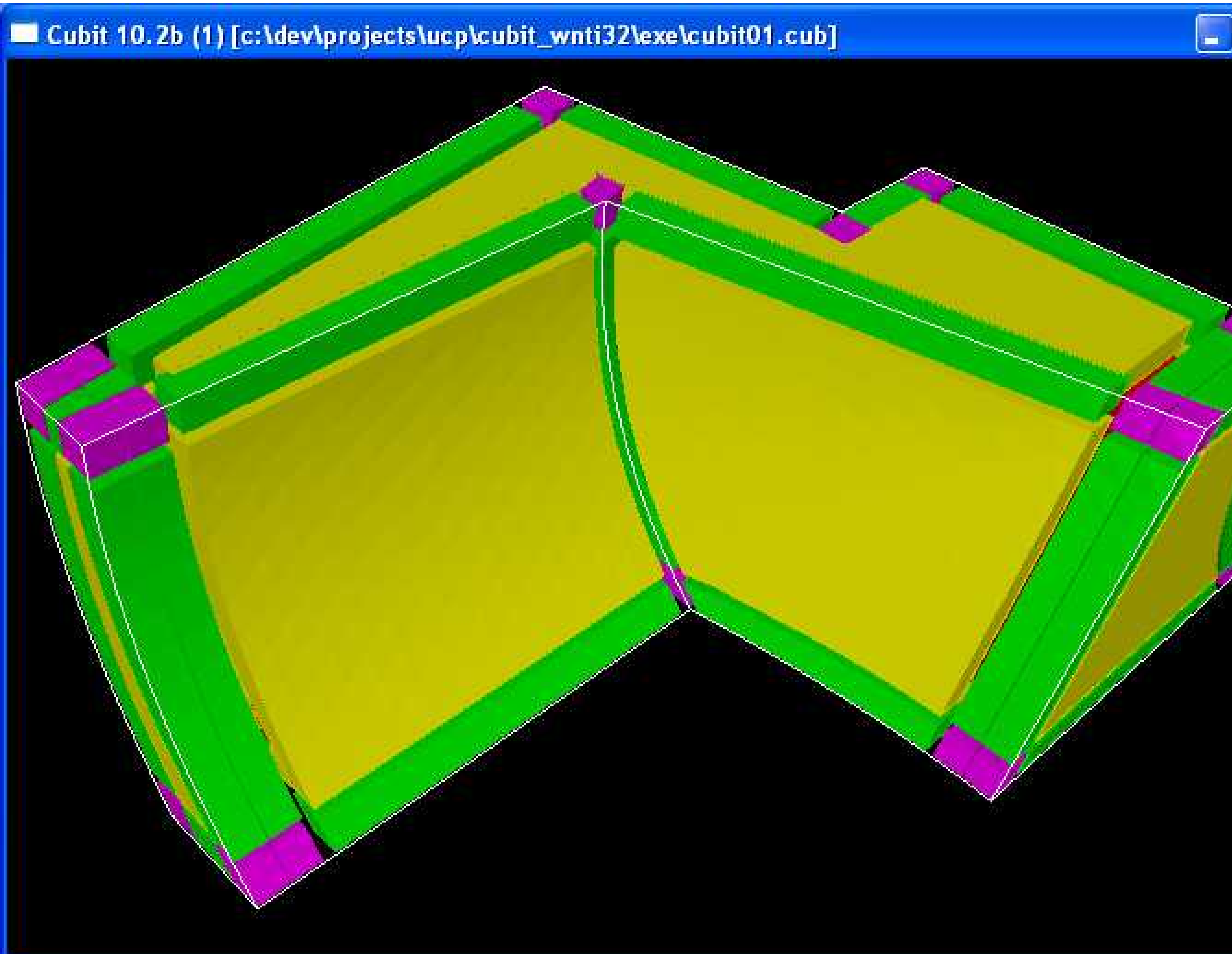

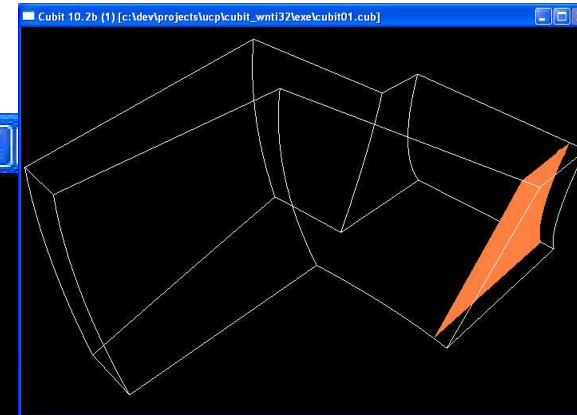

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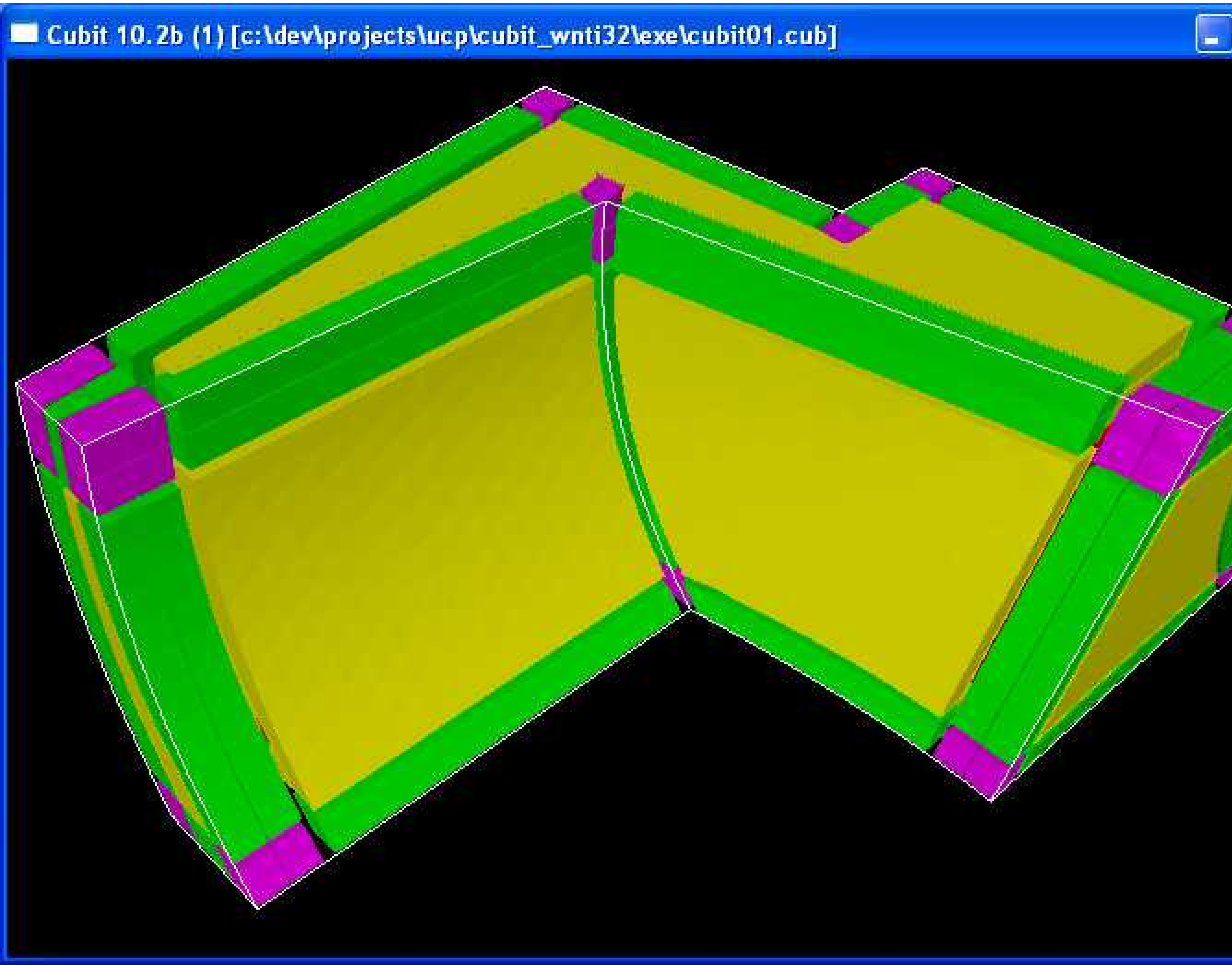

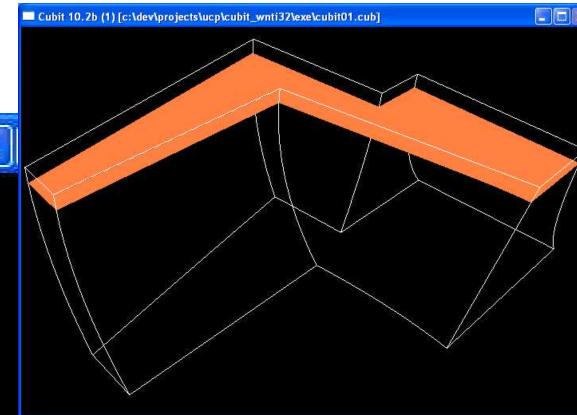

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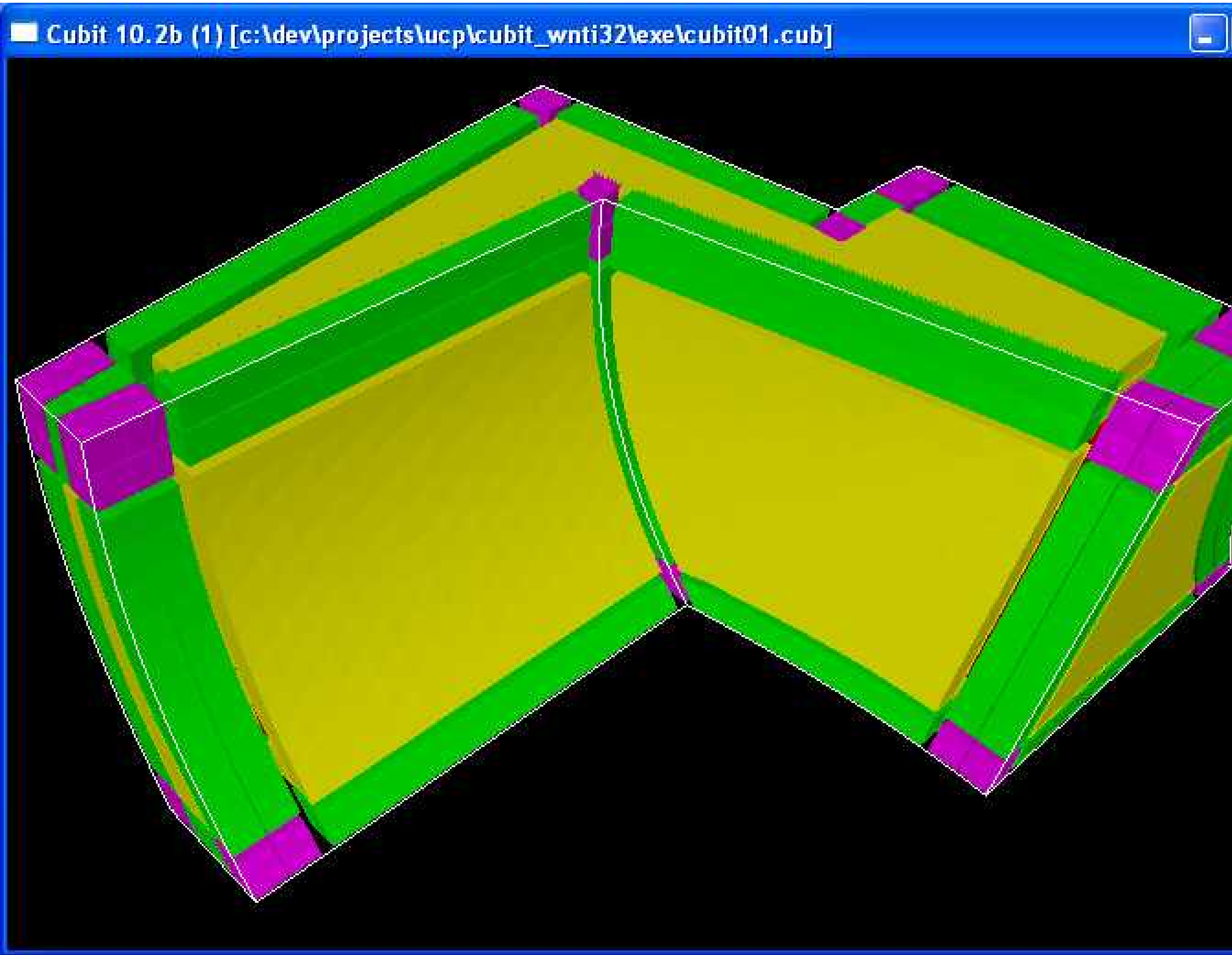

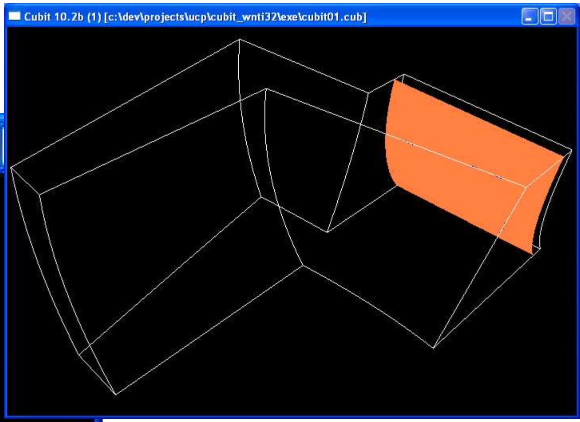

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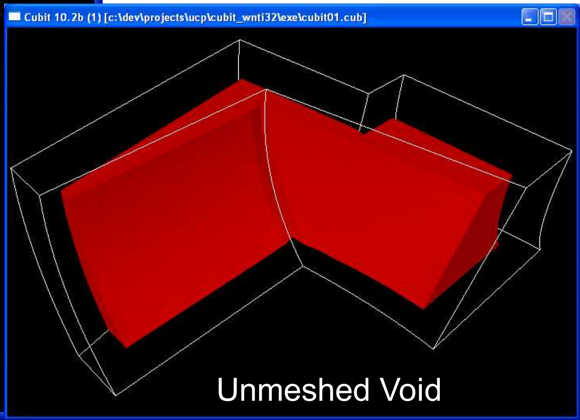

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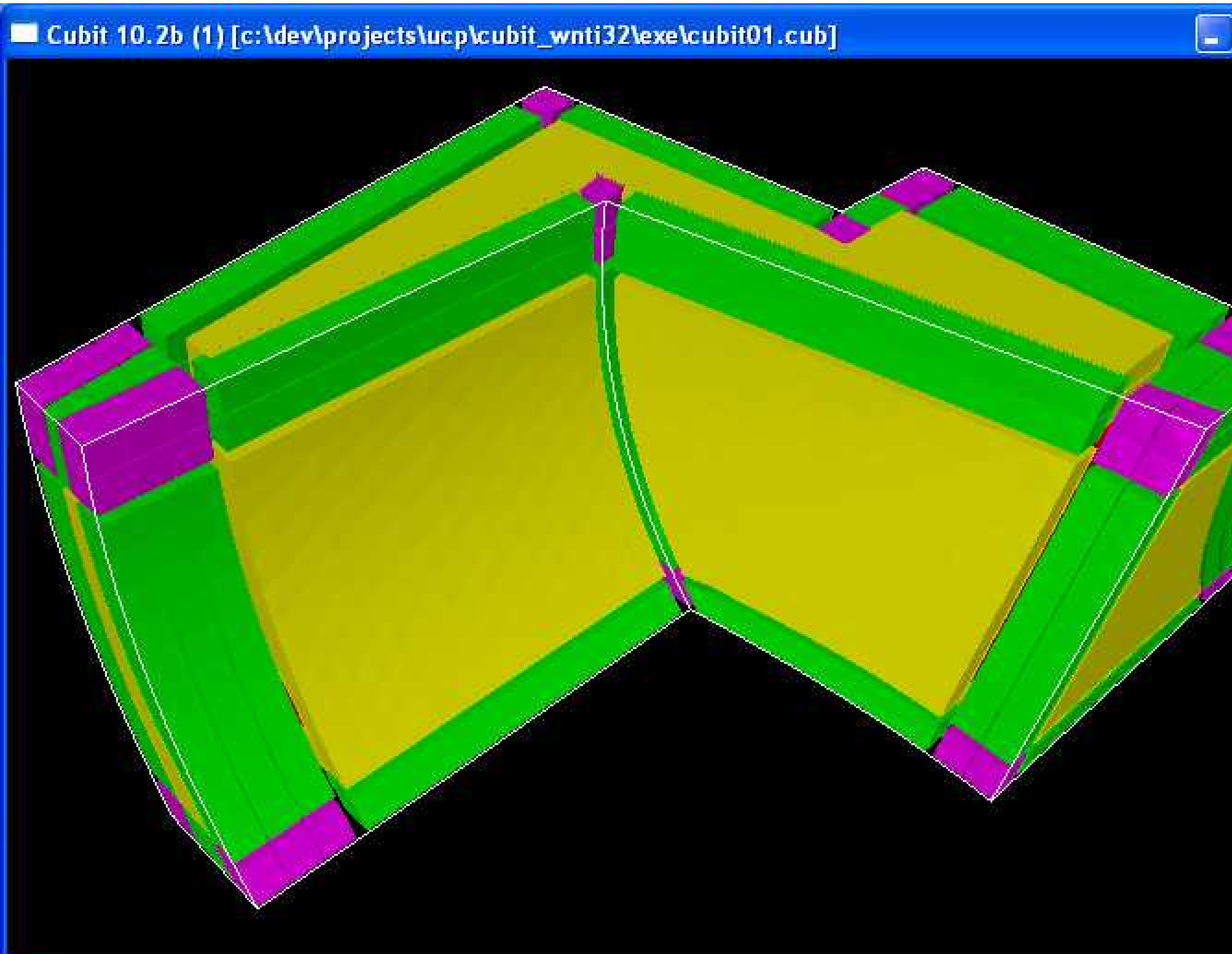

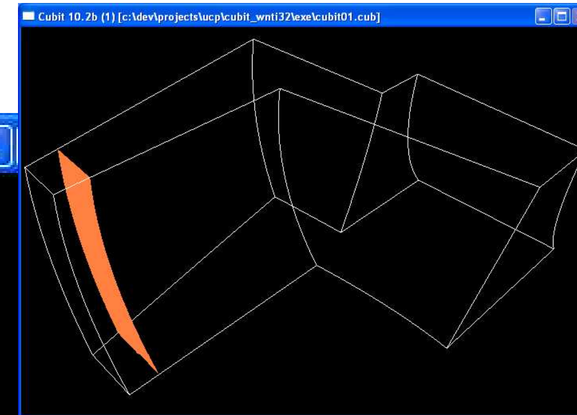

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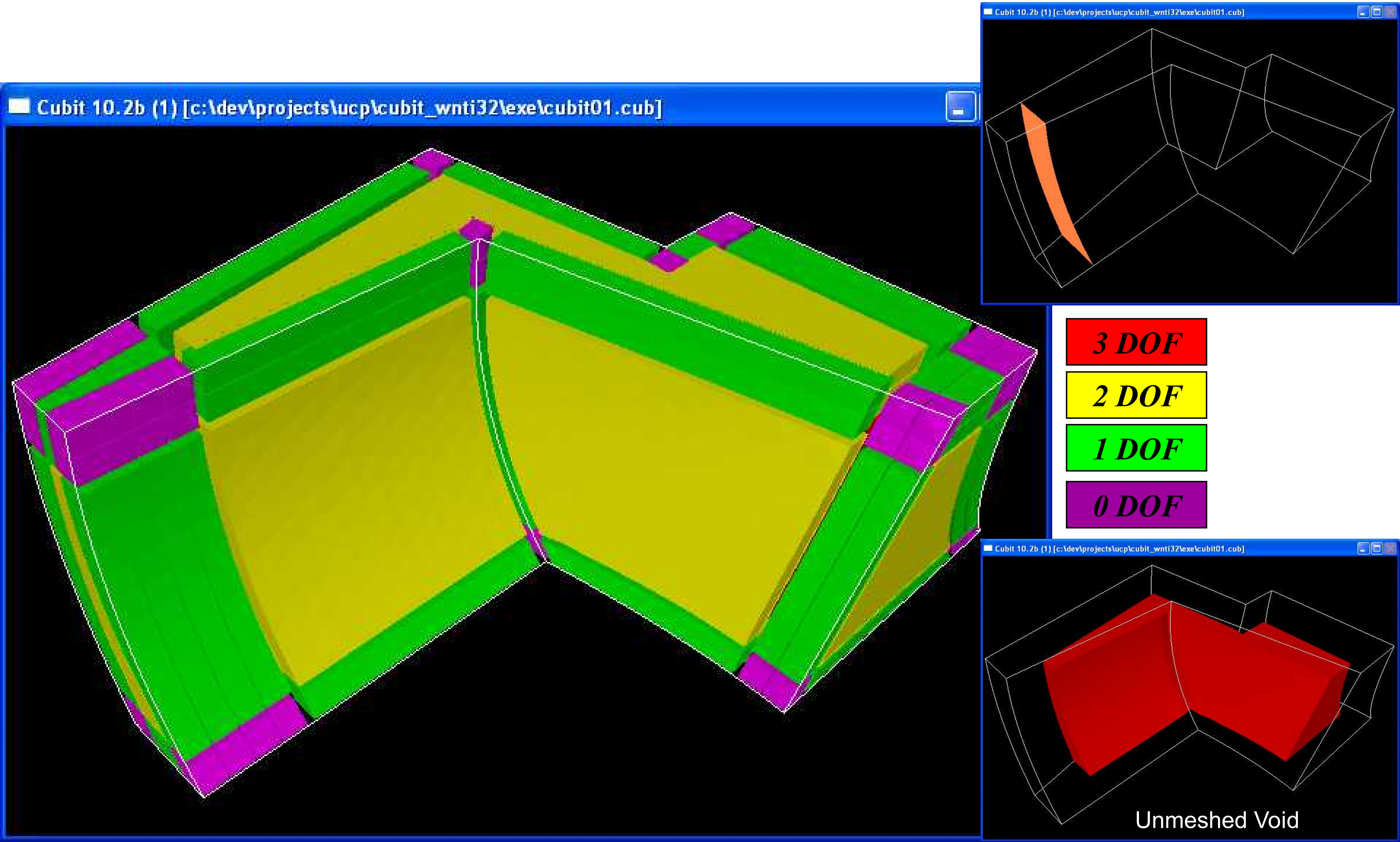

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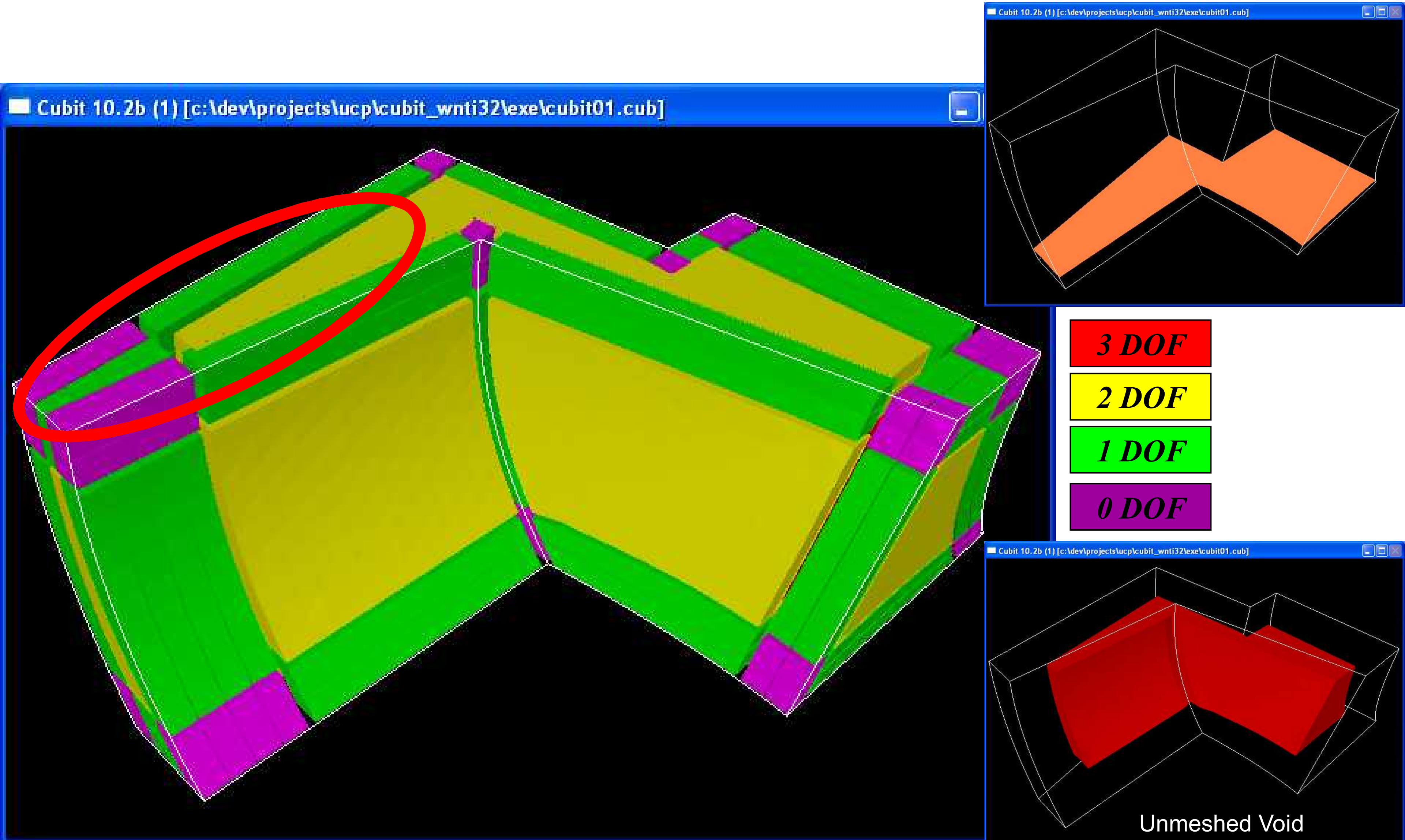

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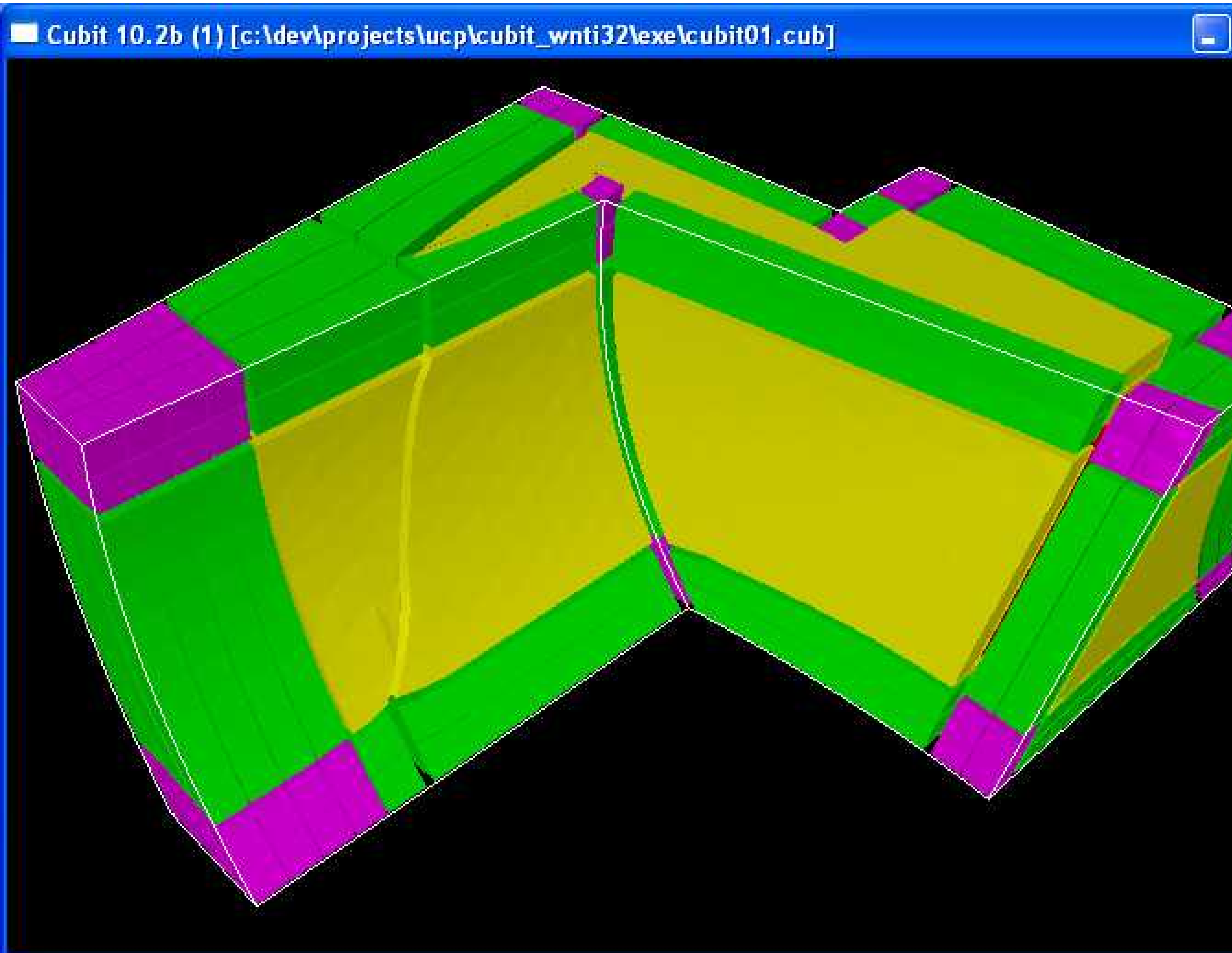

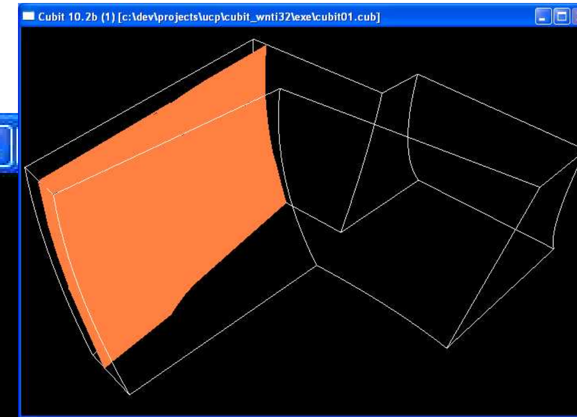

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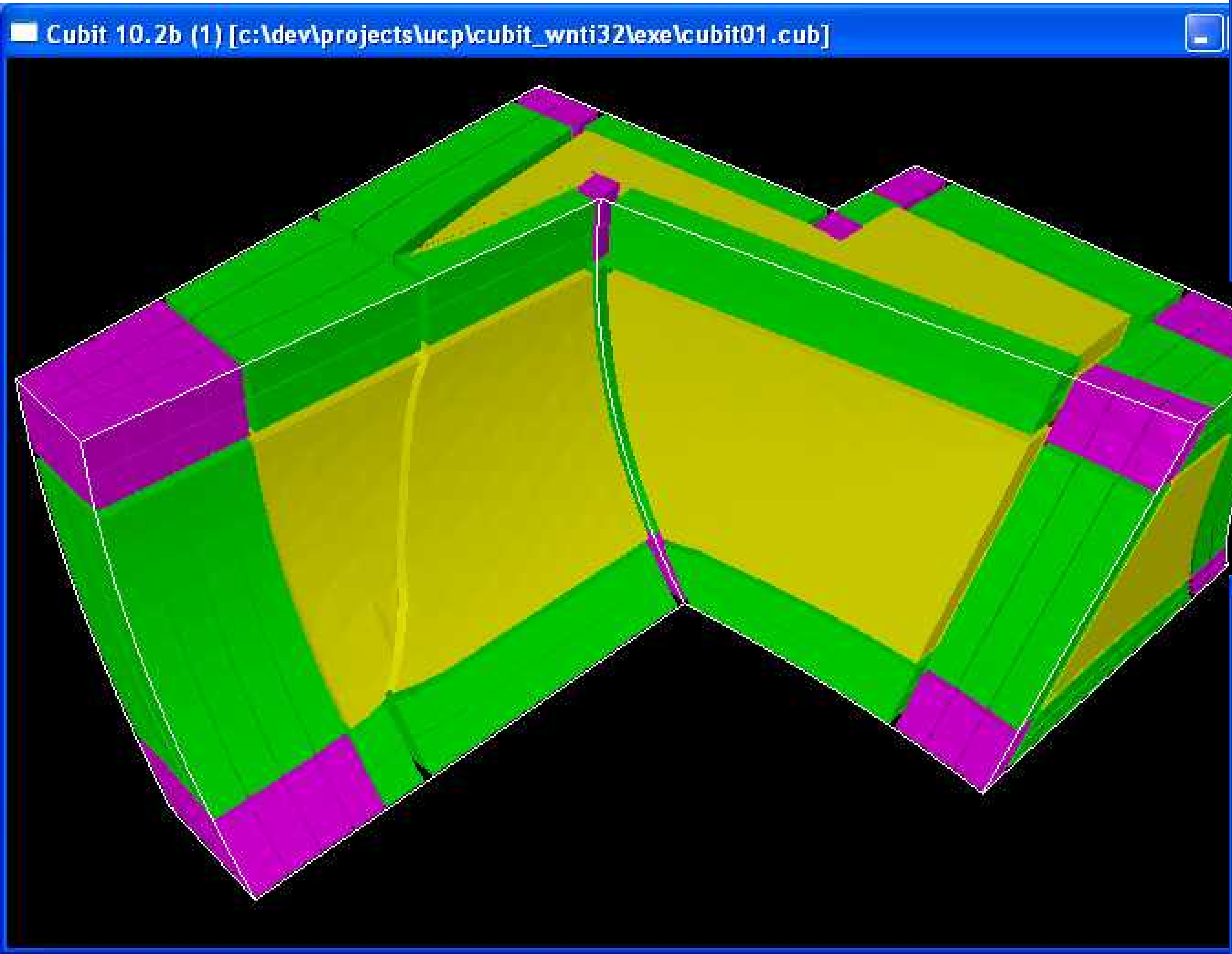

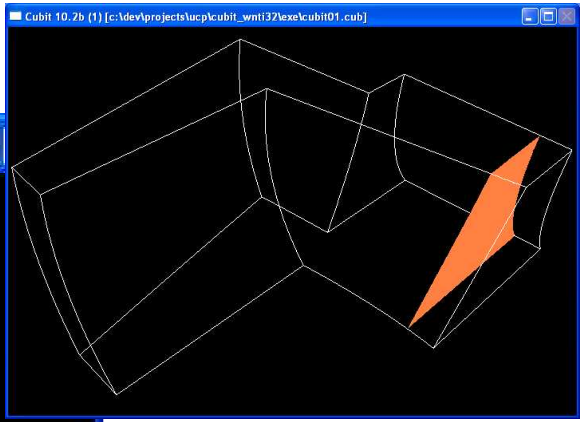

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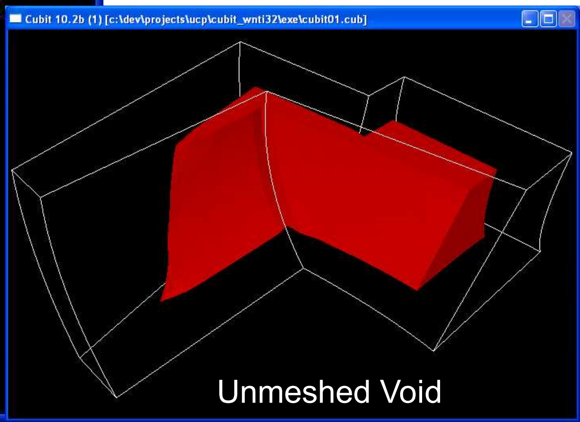

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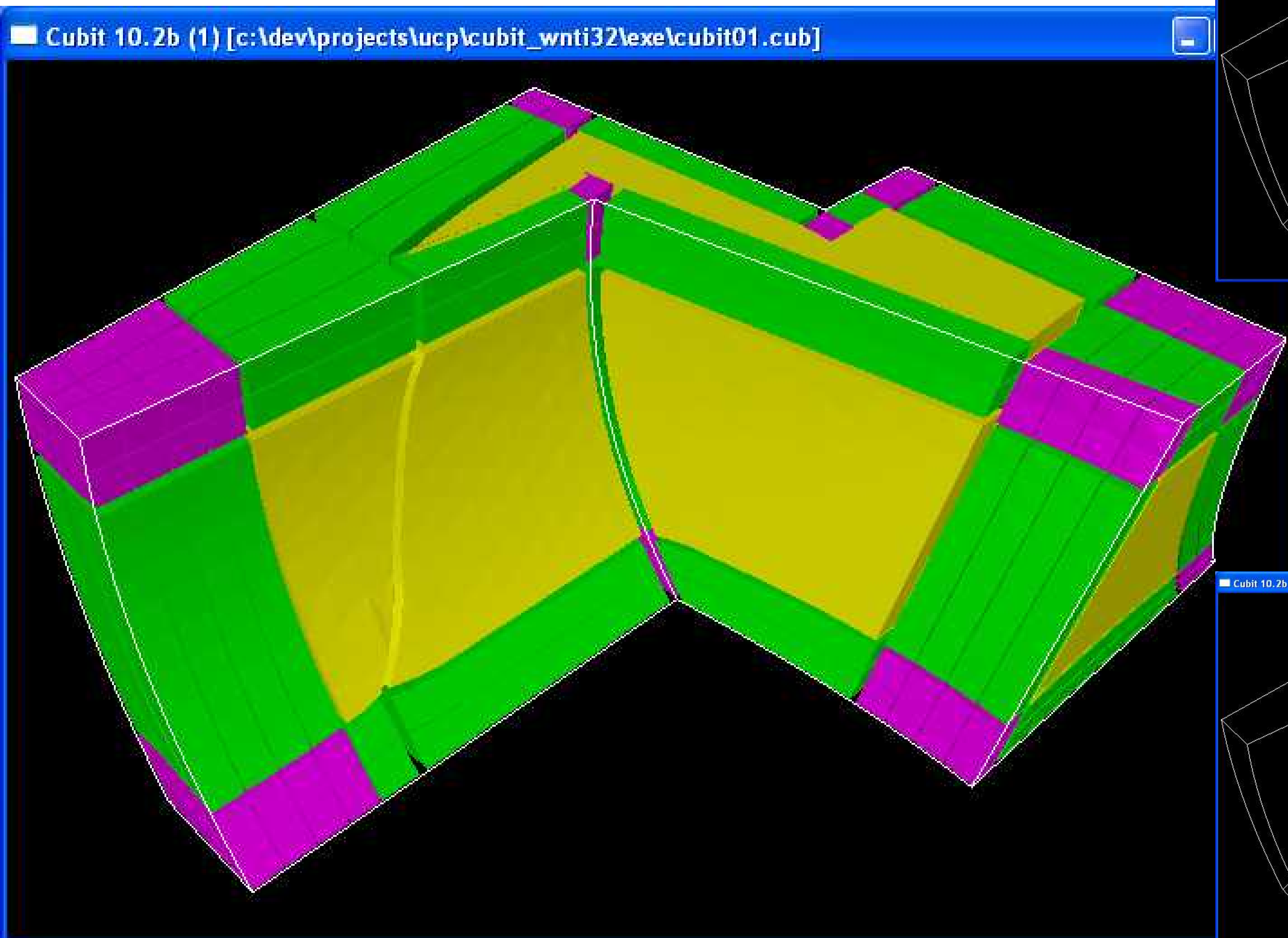

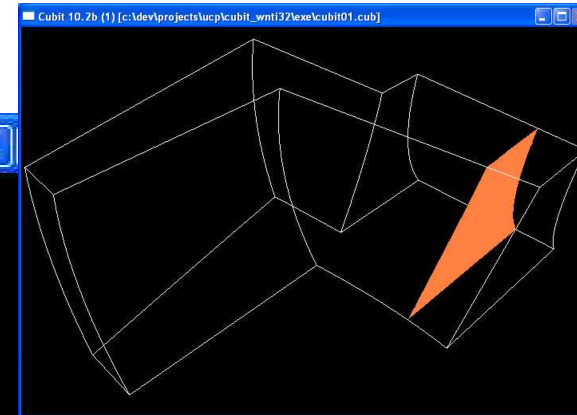

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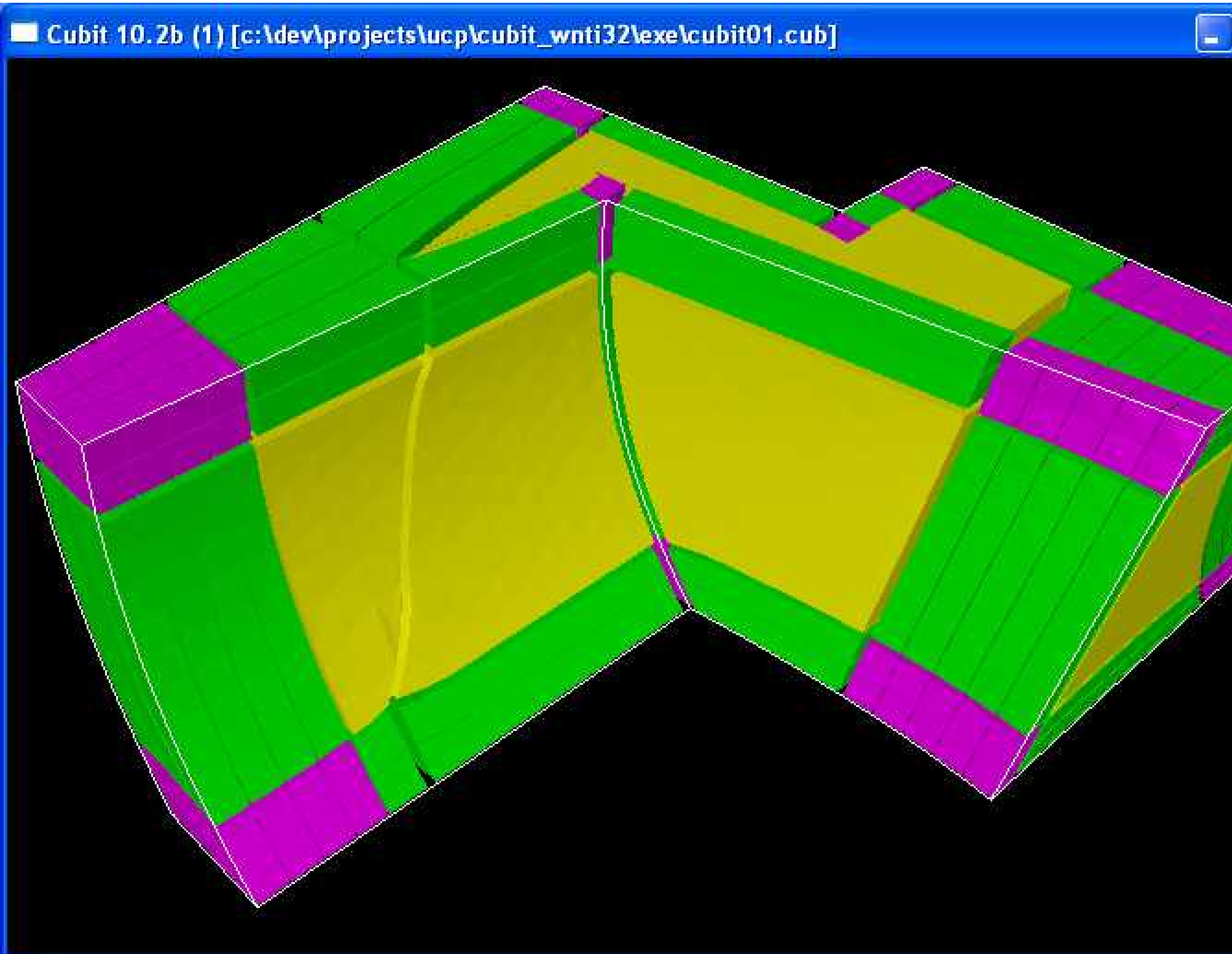

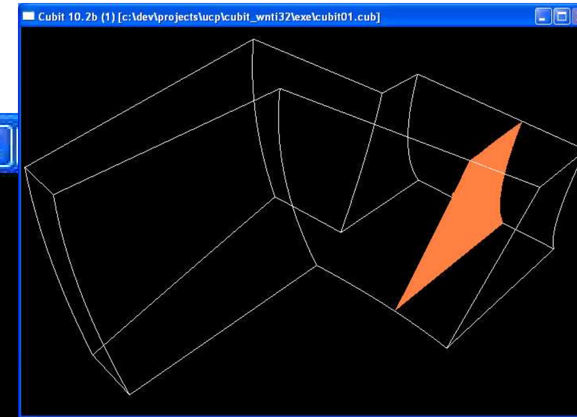

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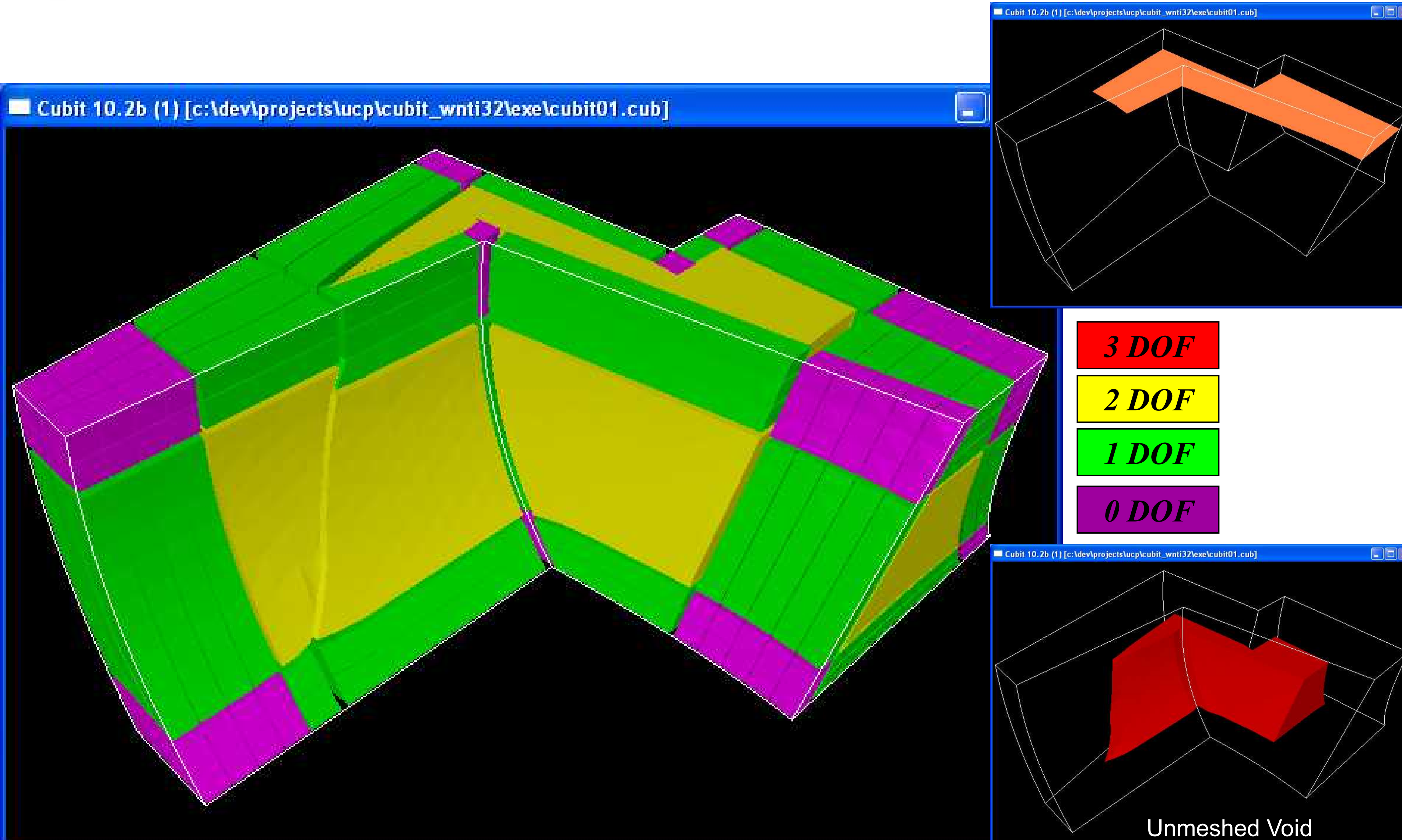

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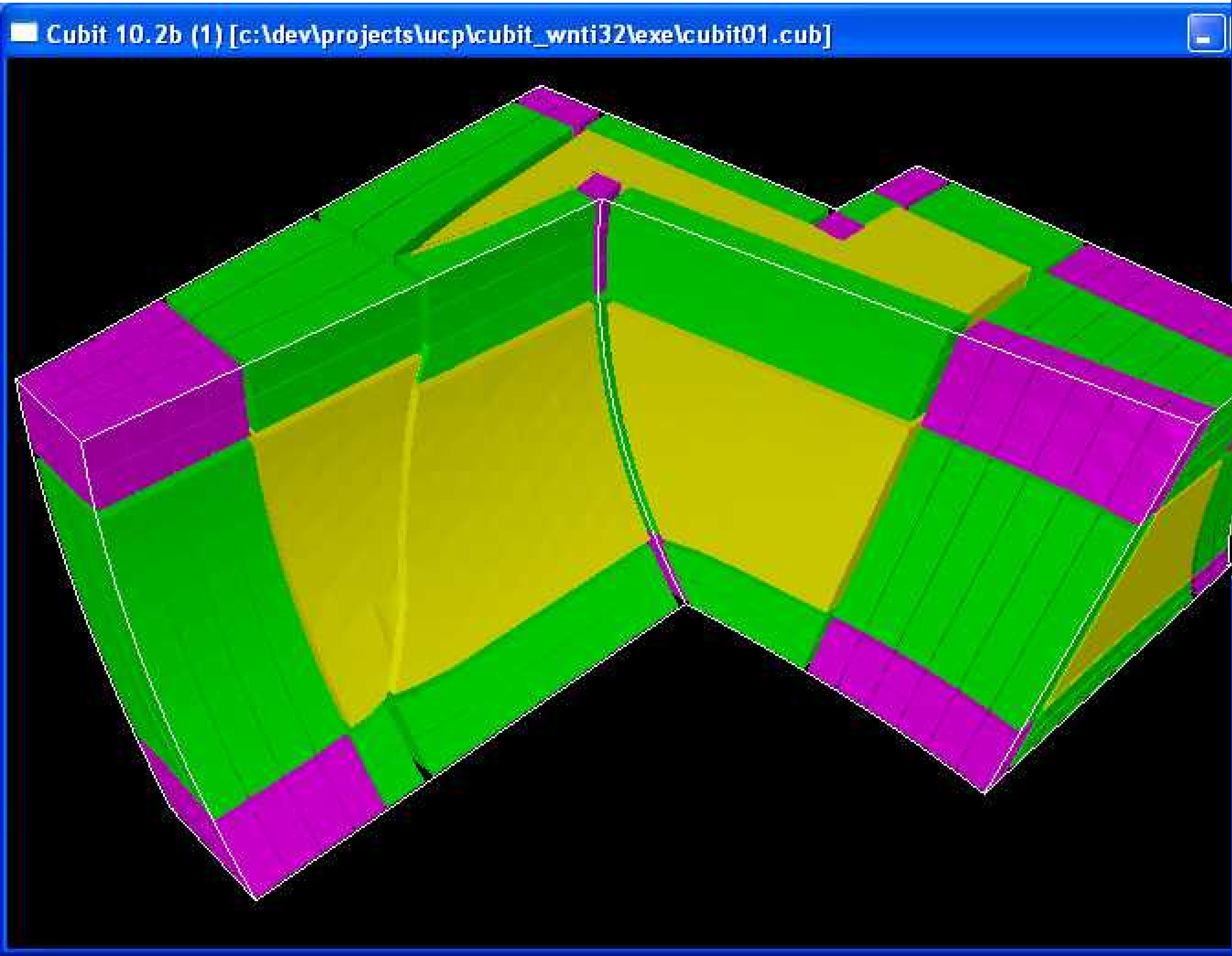

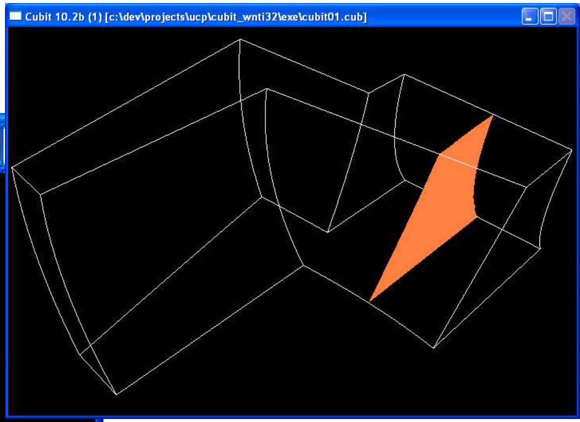

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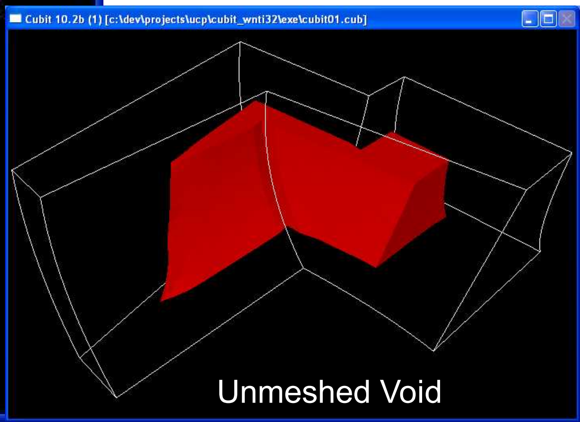

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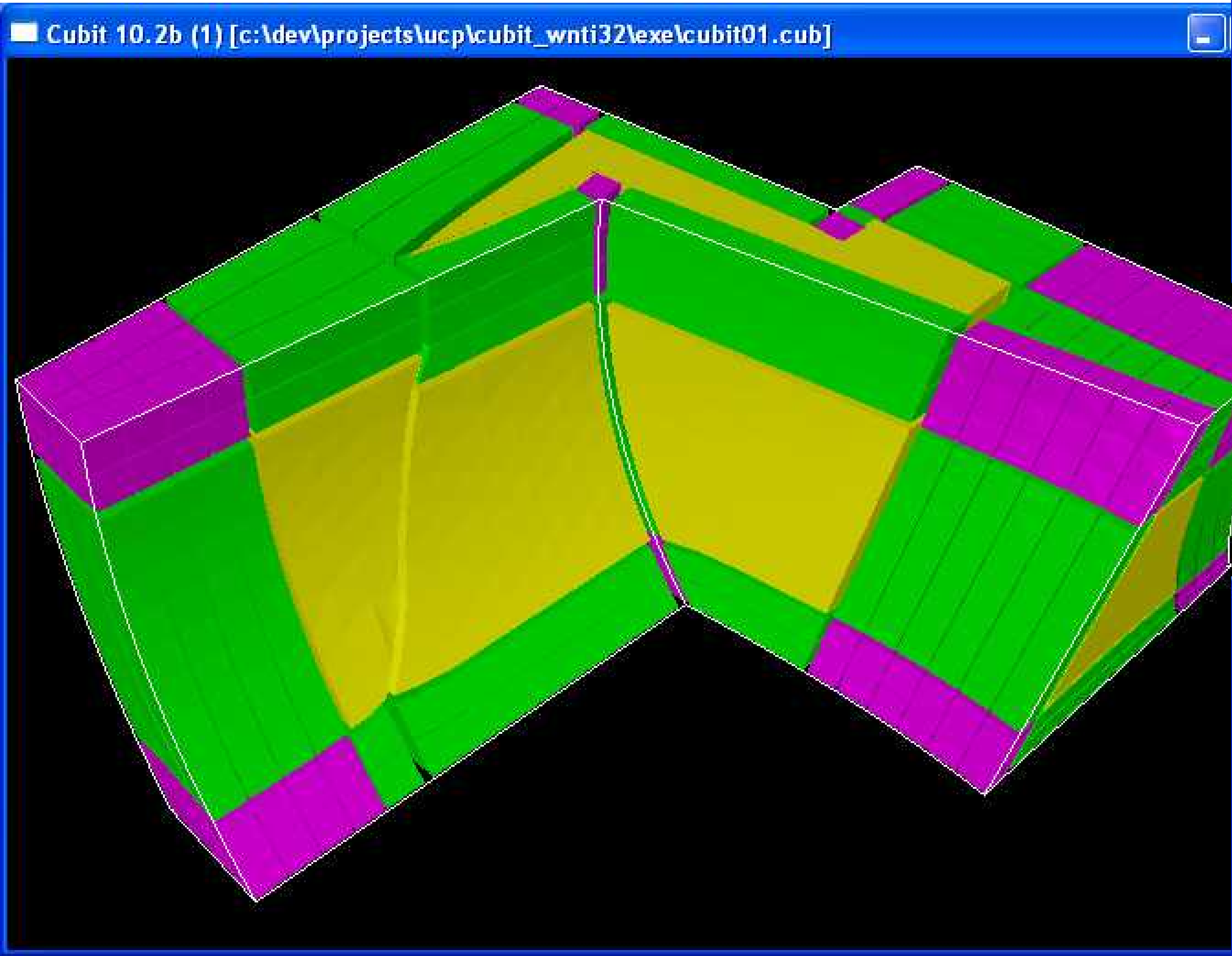

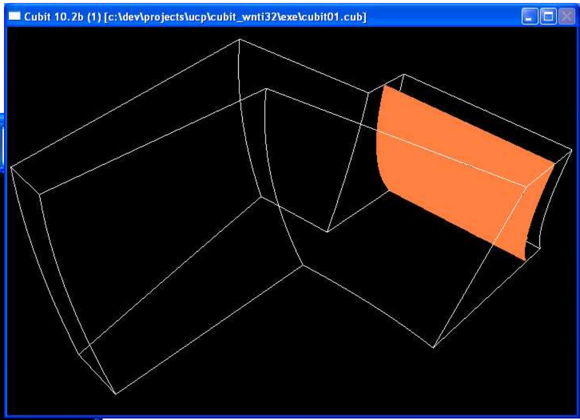

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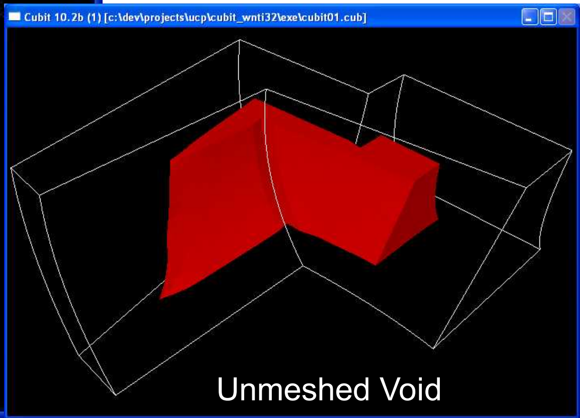

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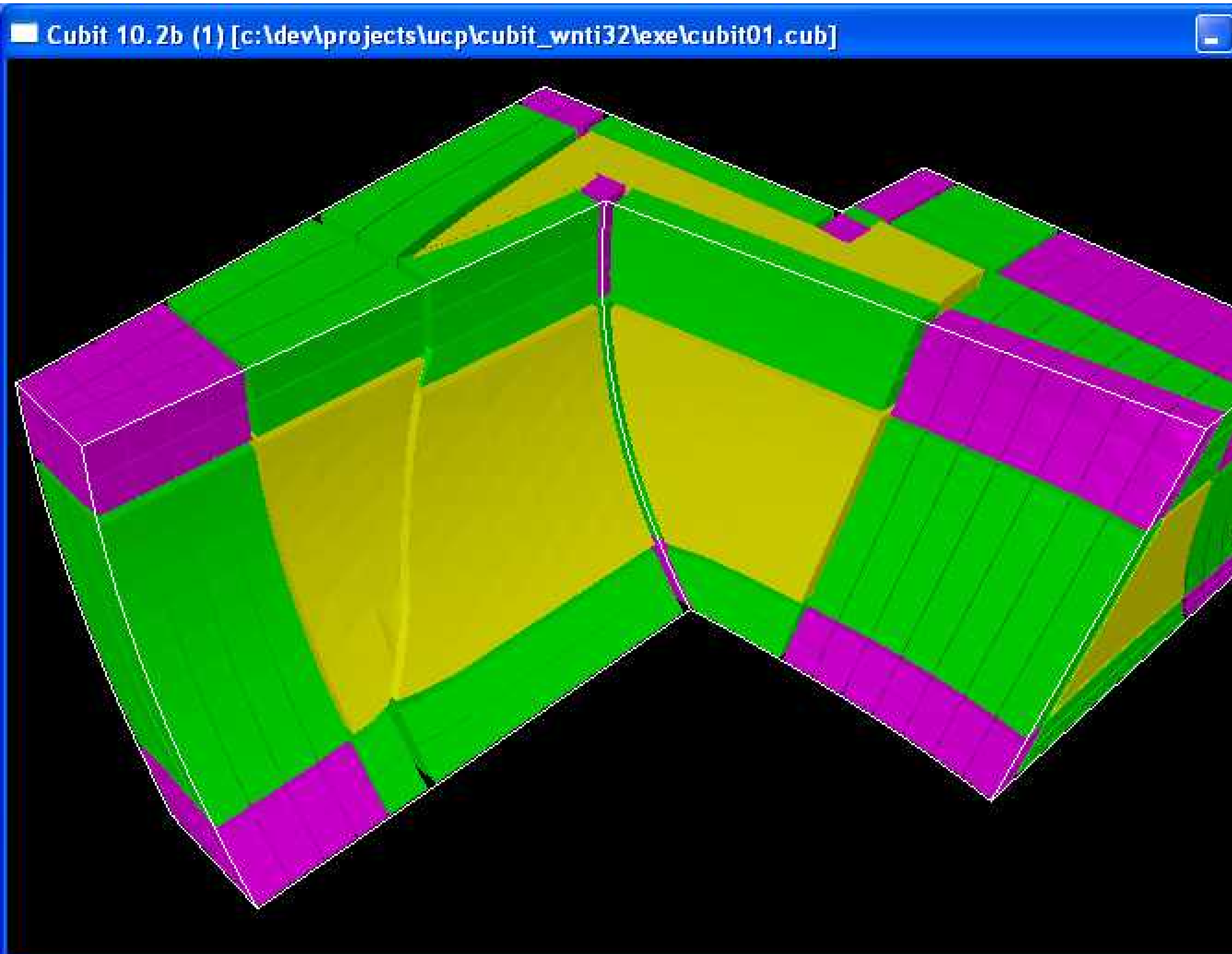

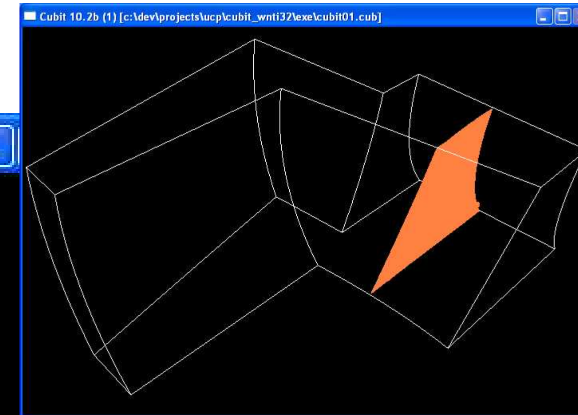

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1 DOF

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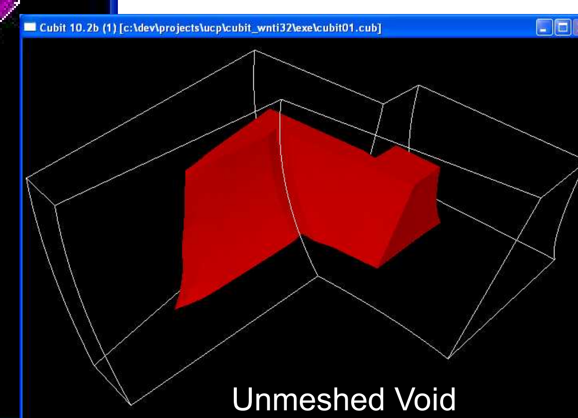
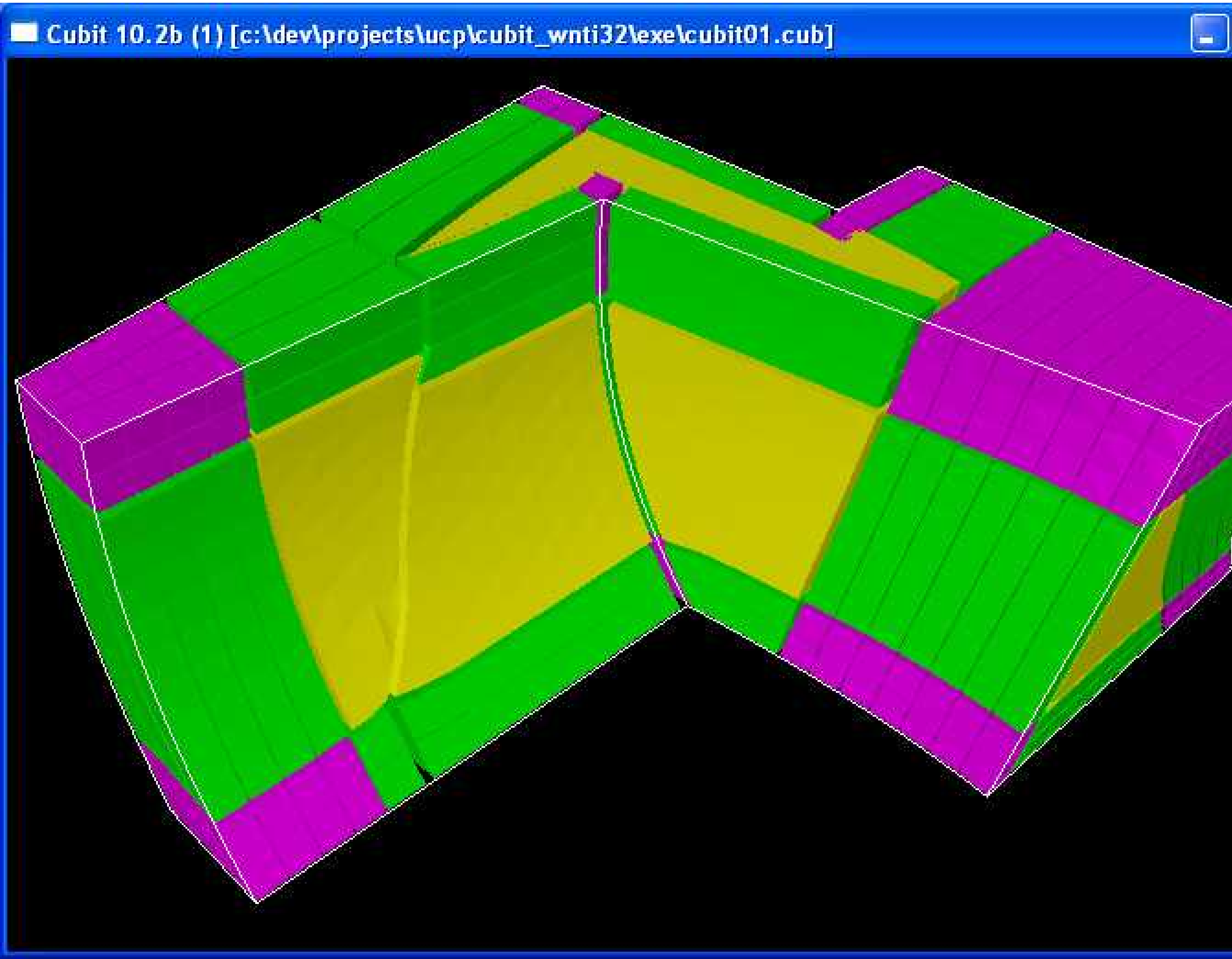
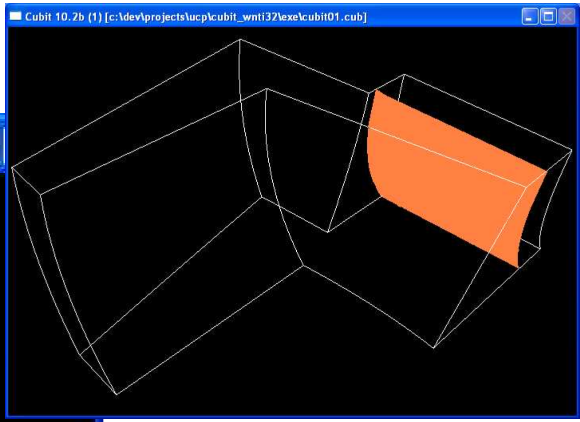


Example Model



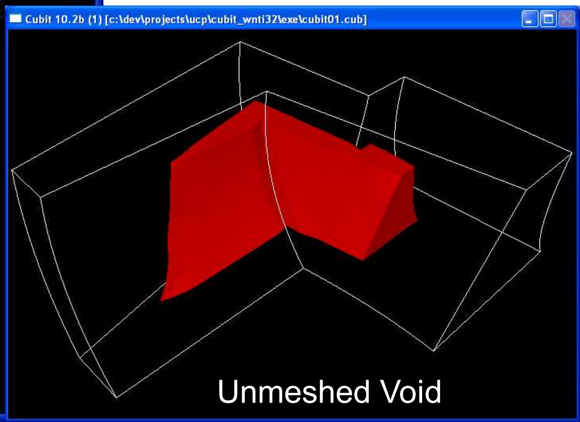


3 DOF

2 DOF

1 DOF

0 DOF



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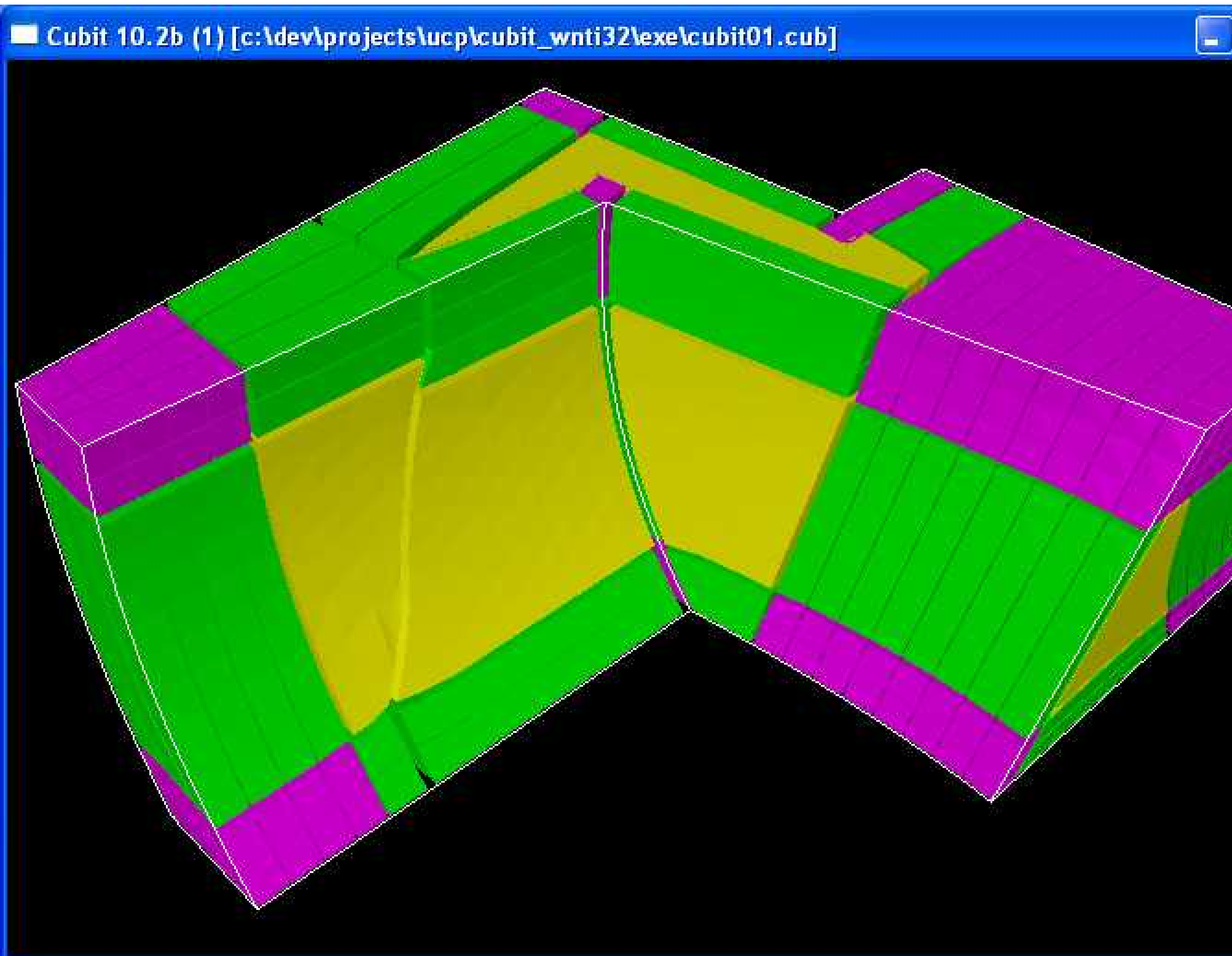

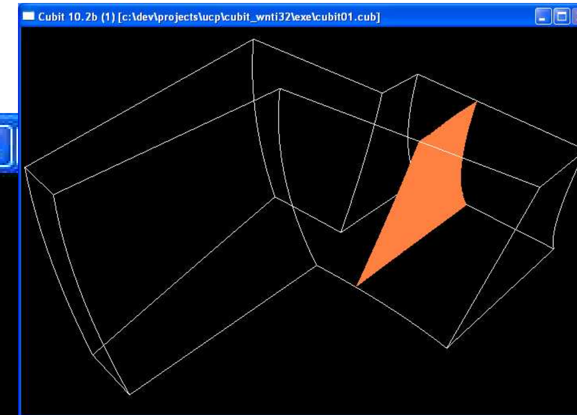

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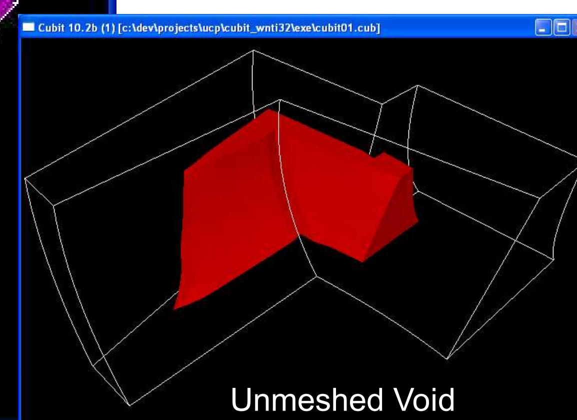
2 DOF

1 DOF

0 DOF



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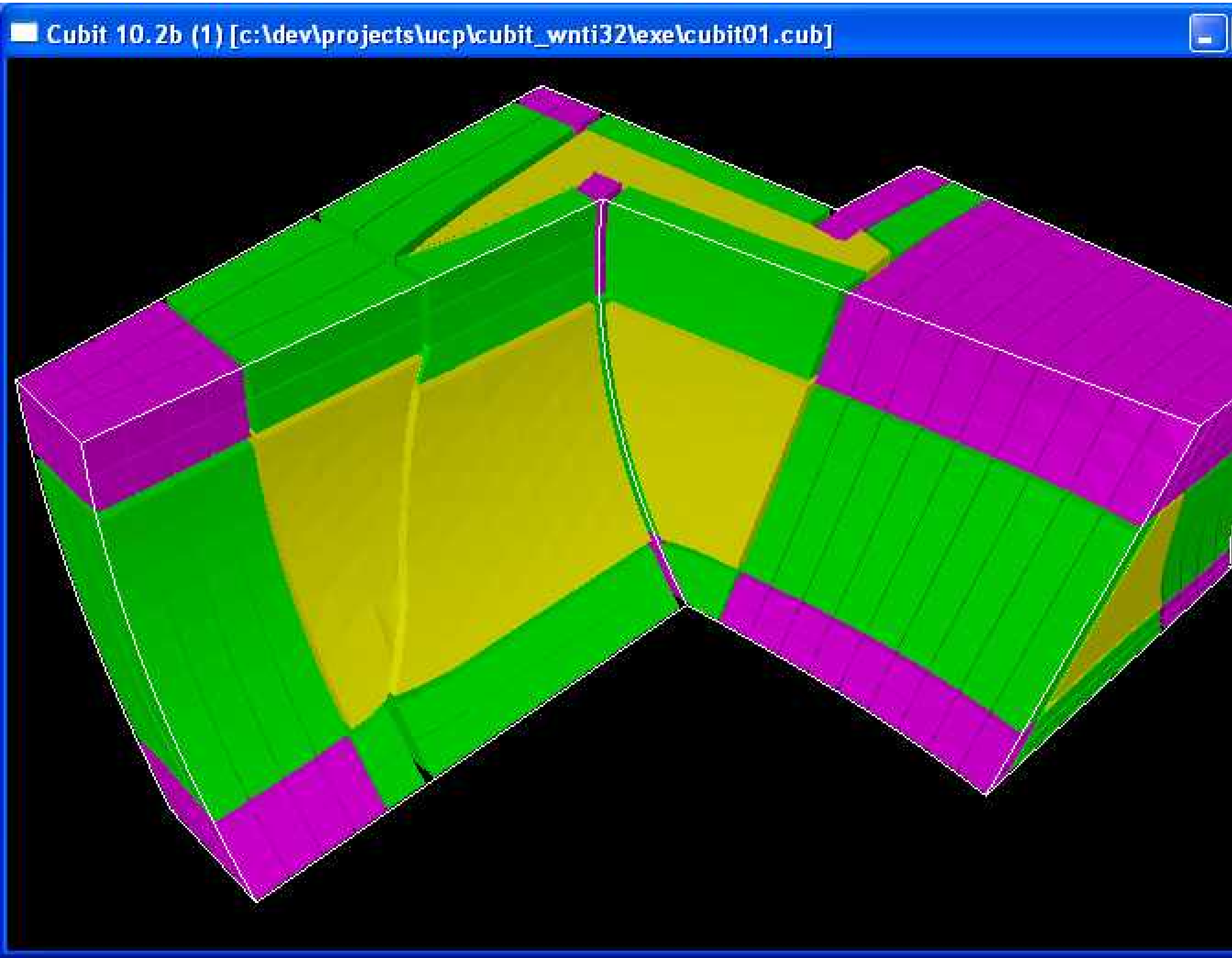

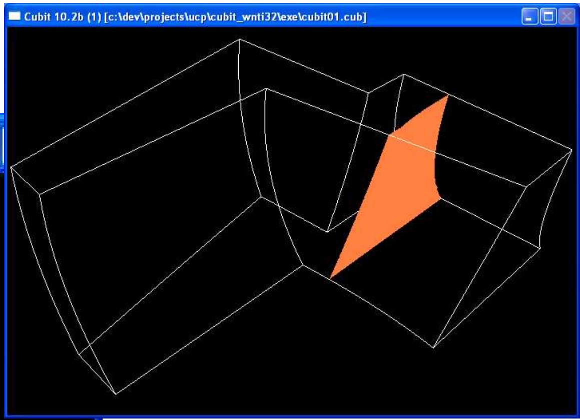

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1 DOF

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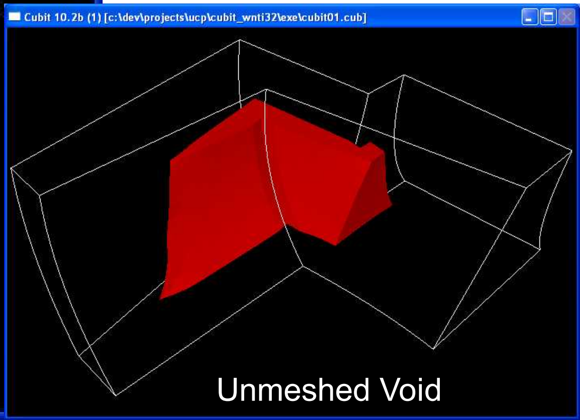
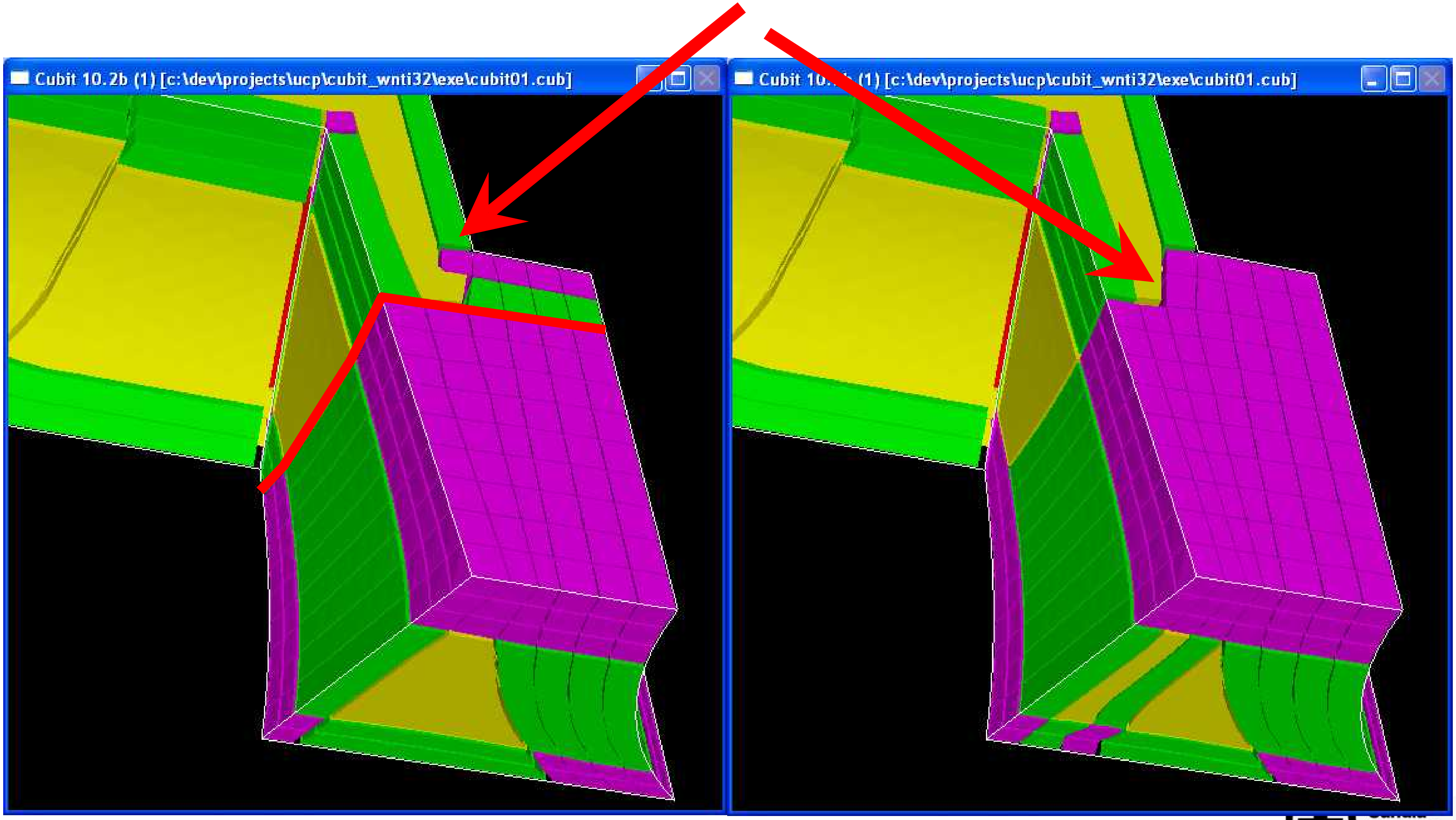
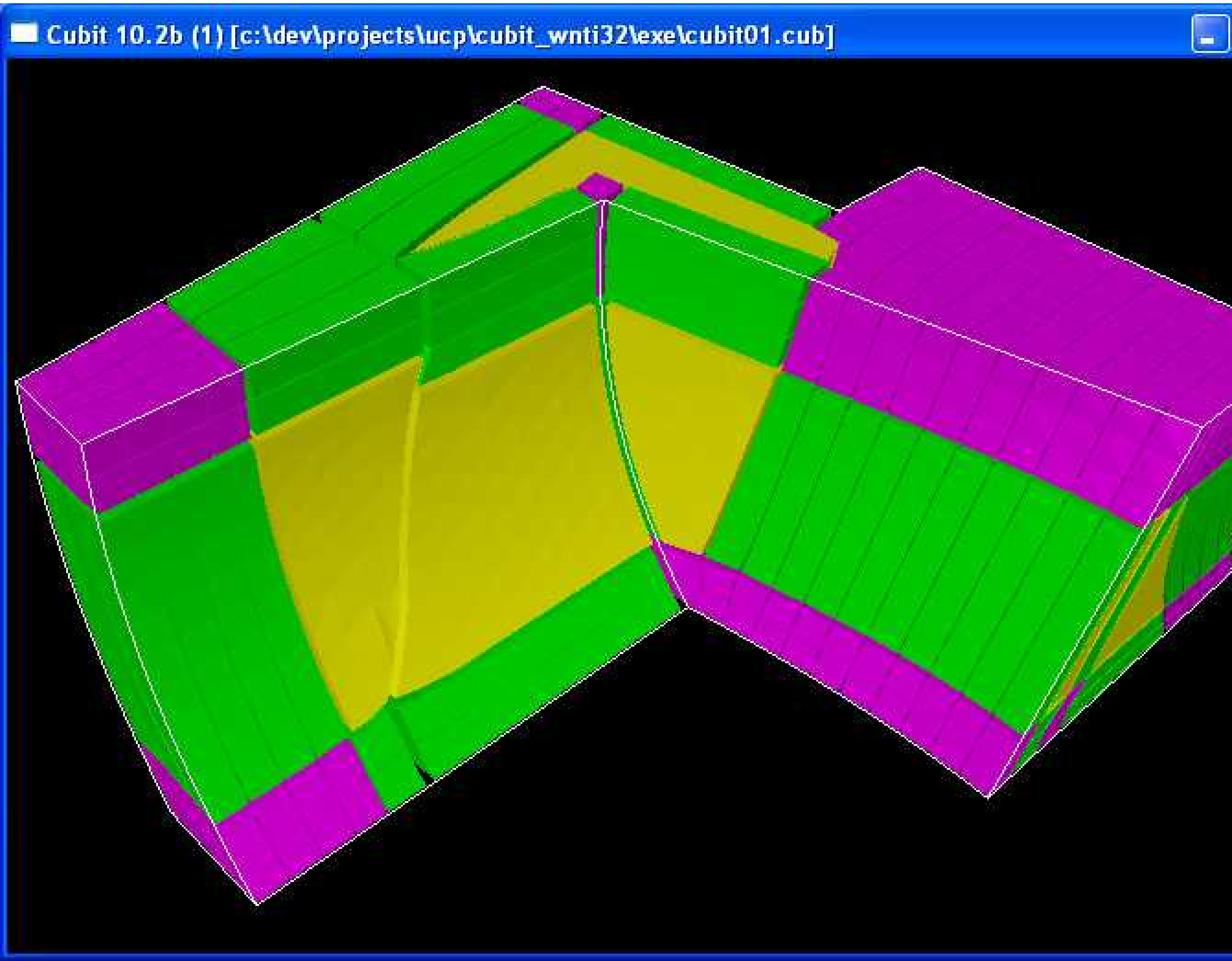


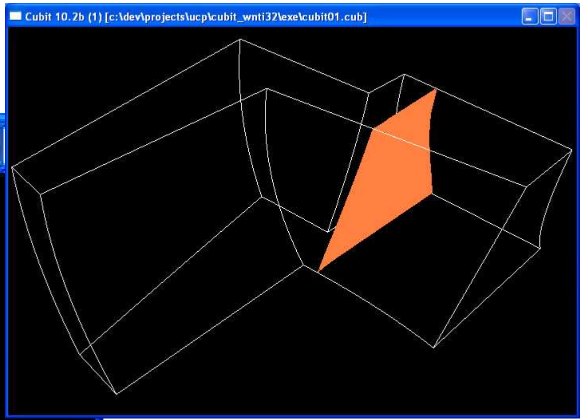
Example Model

Incomplete Sheet is completed by proximity resolution during sheet advance



Example Model



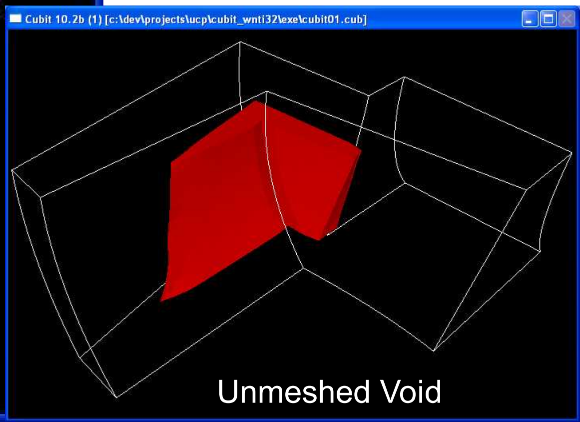


3 DOF

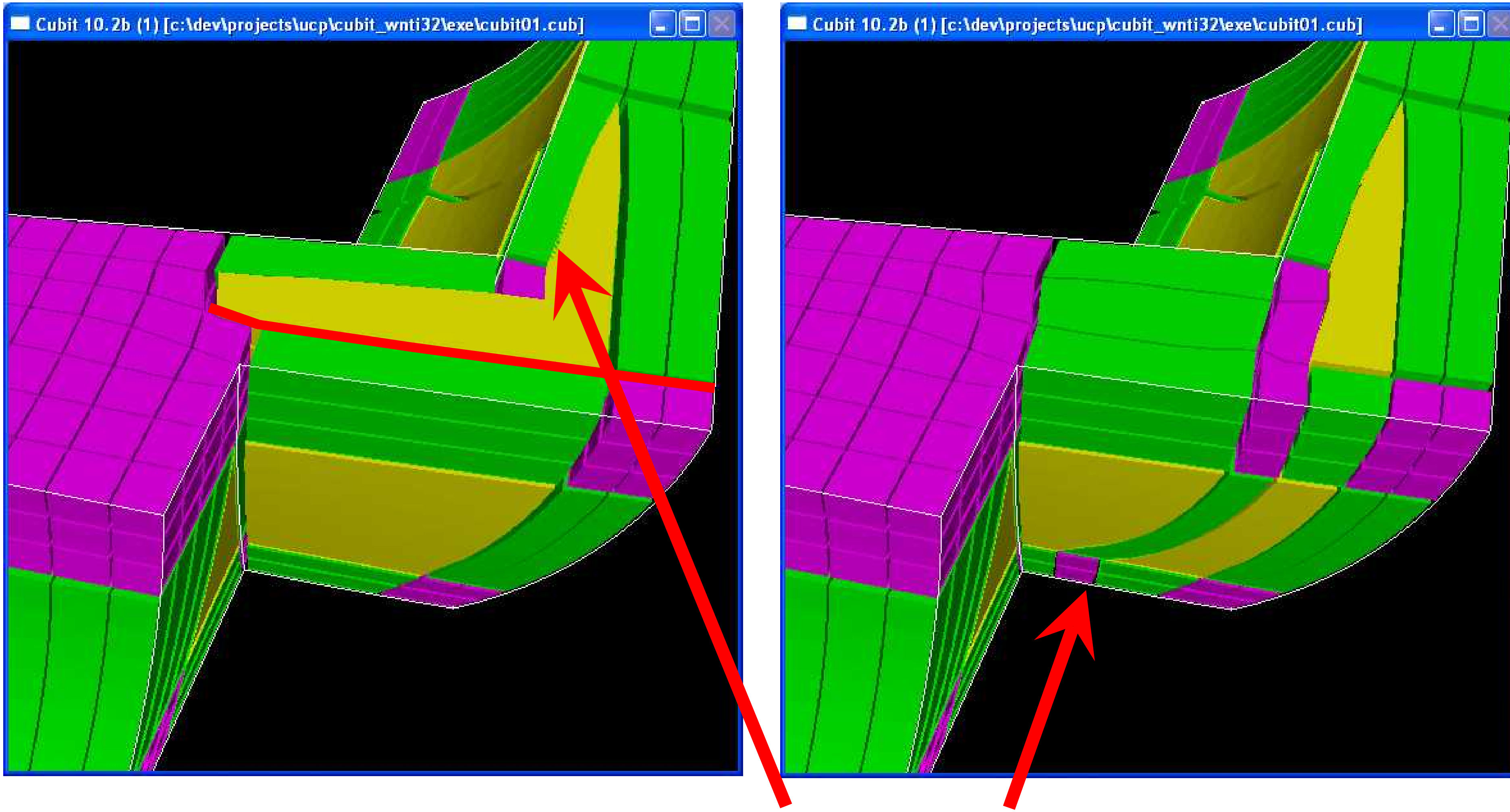
2 DOF

1 DOF

0 DOF

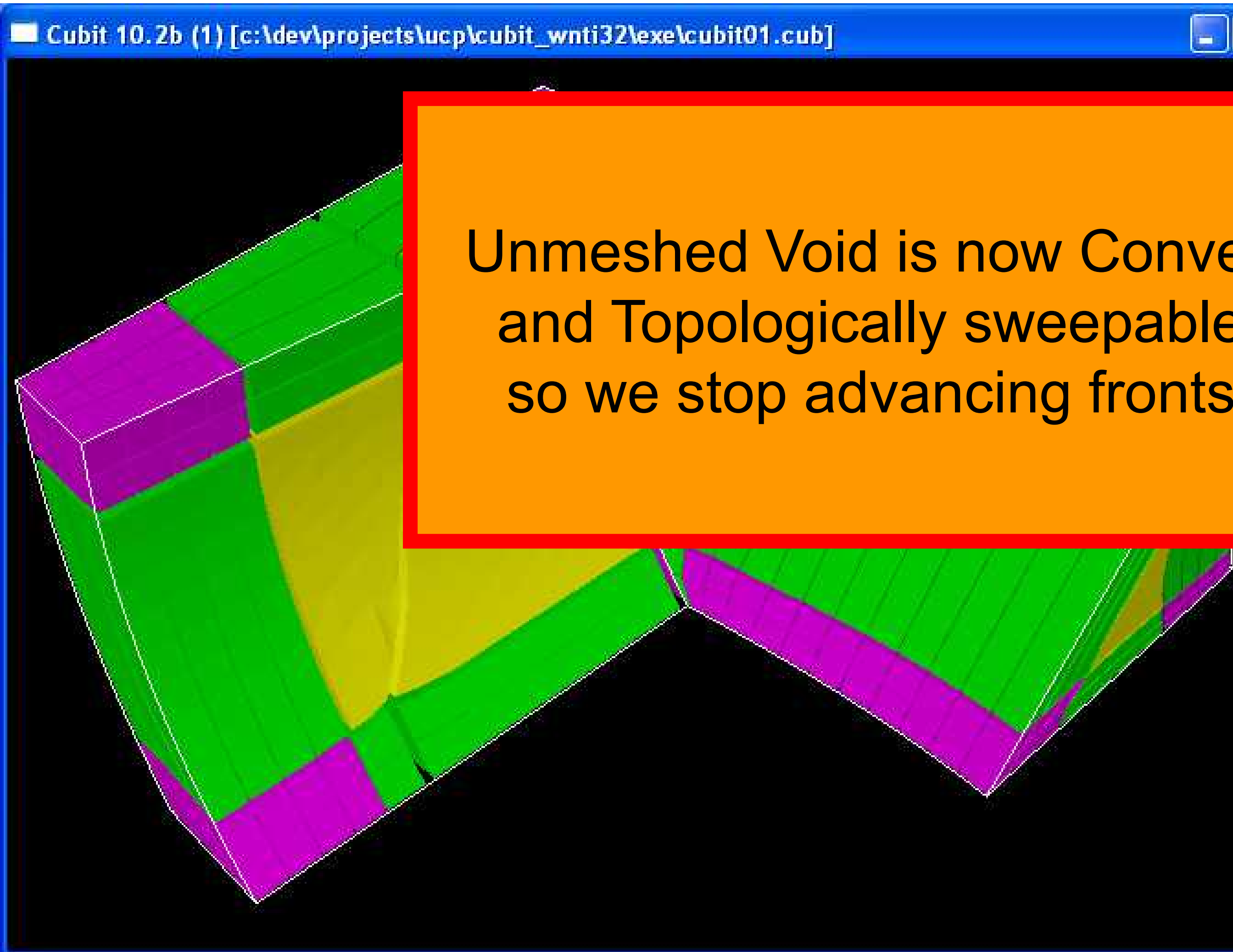


Example Model

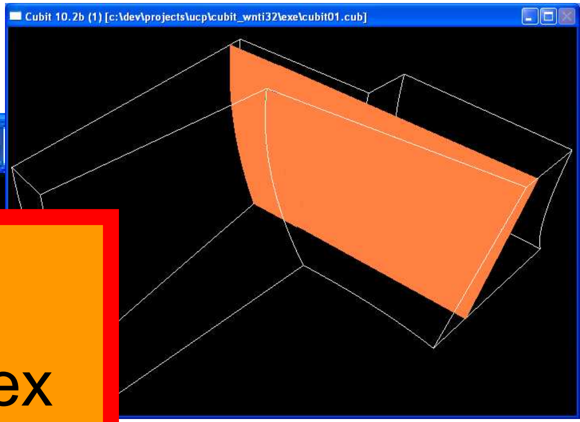


Incomplete Sheet is completed by proximity resolution during sheet advance

Example Model



Unmeshed Void is now Convex and Topologically sweepable so we stop advancing fronts

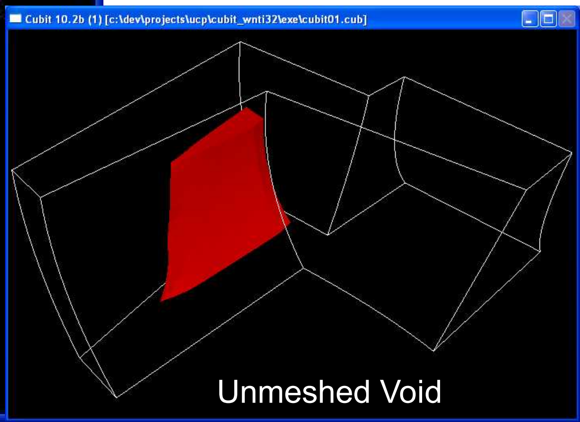


3 DOF

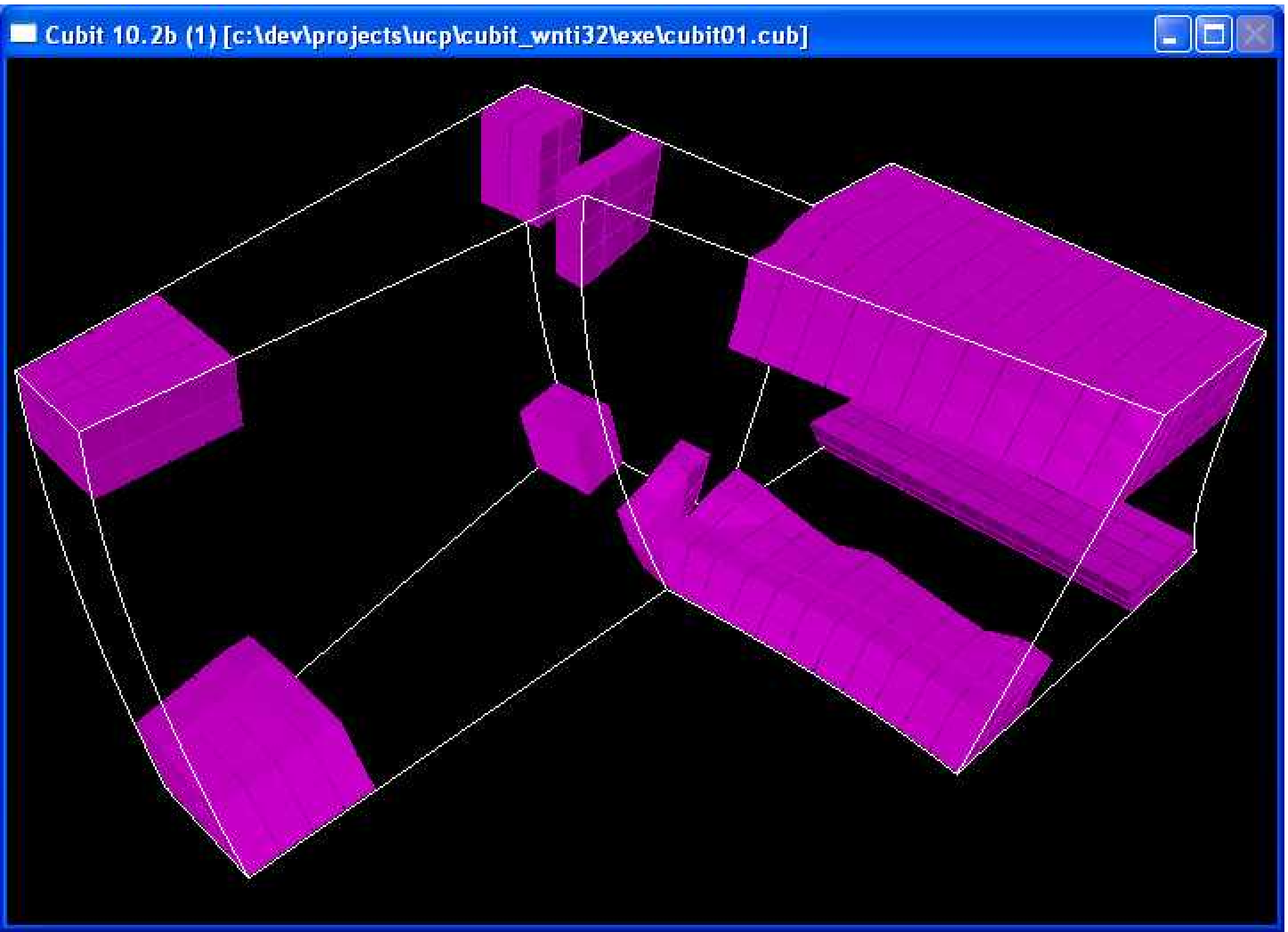
2 DOF

1 DOF

0 DOF



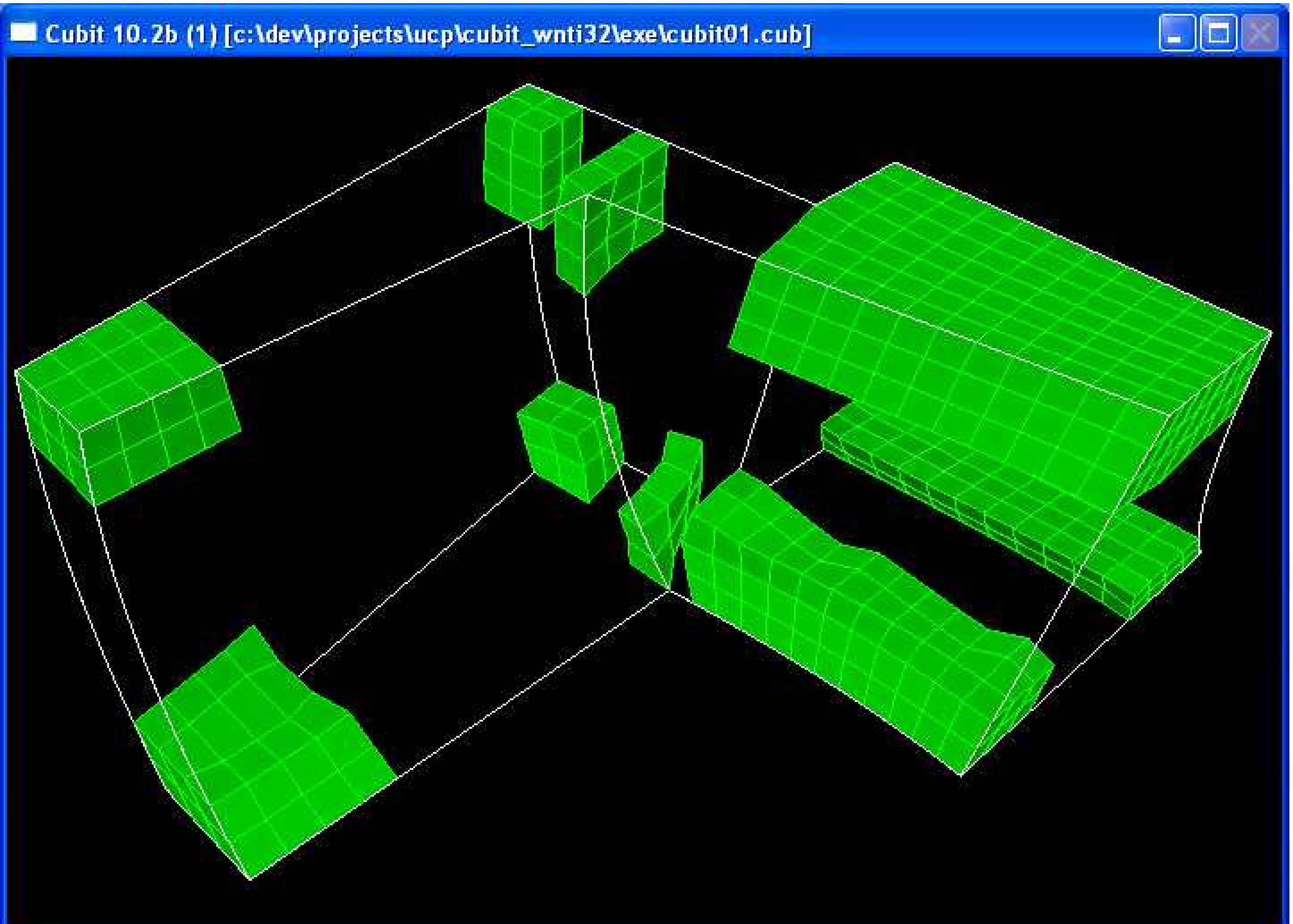
Example Model



Defined Hexes
0 DOF

Converted 1-1
To Hexahedral
Elements

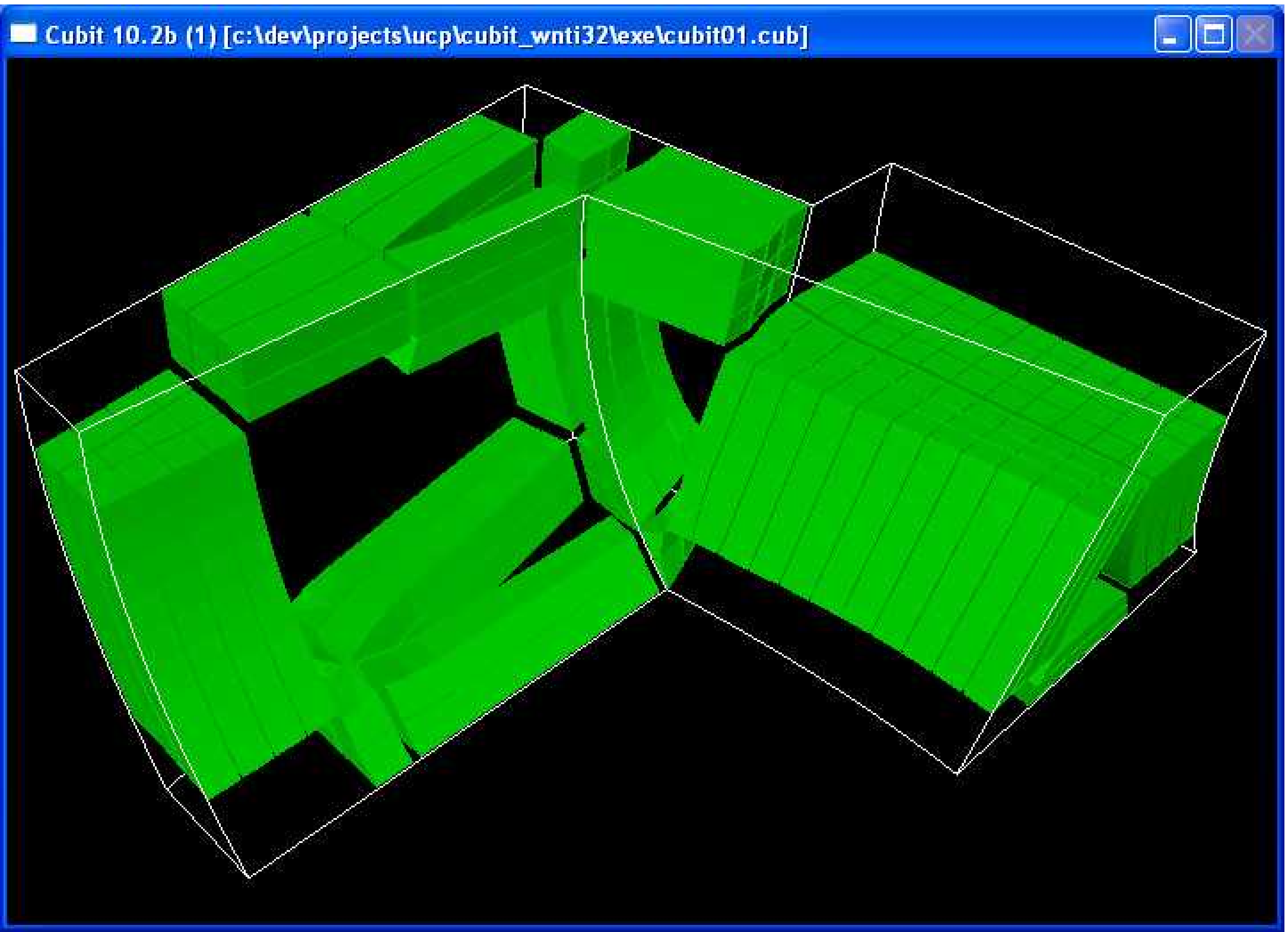
Example Model



Defined Hexes
0 DOF

Converted 1-1
To Hexahedral
Elements

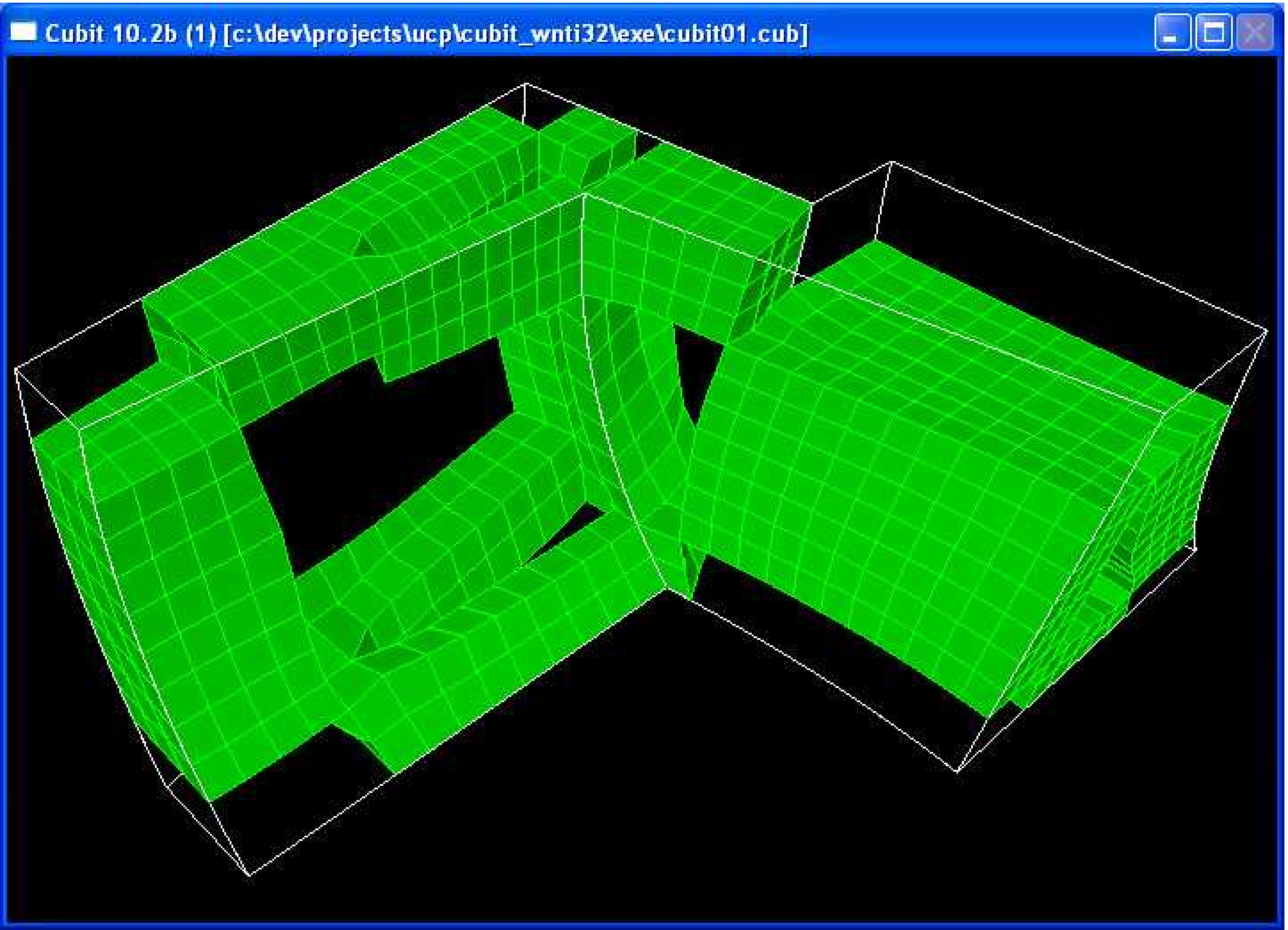
Example Model



Connecting Webs
1 DOF

Converted to Stack of Hexahedral Elements

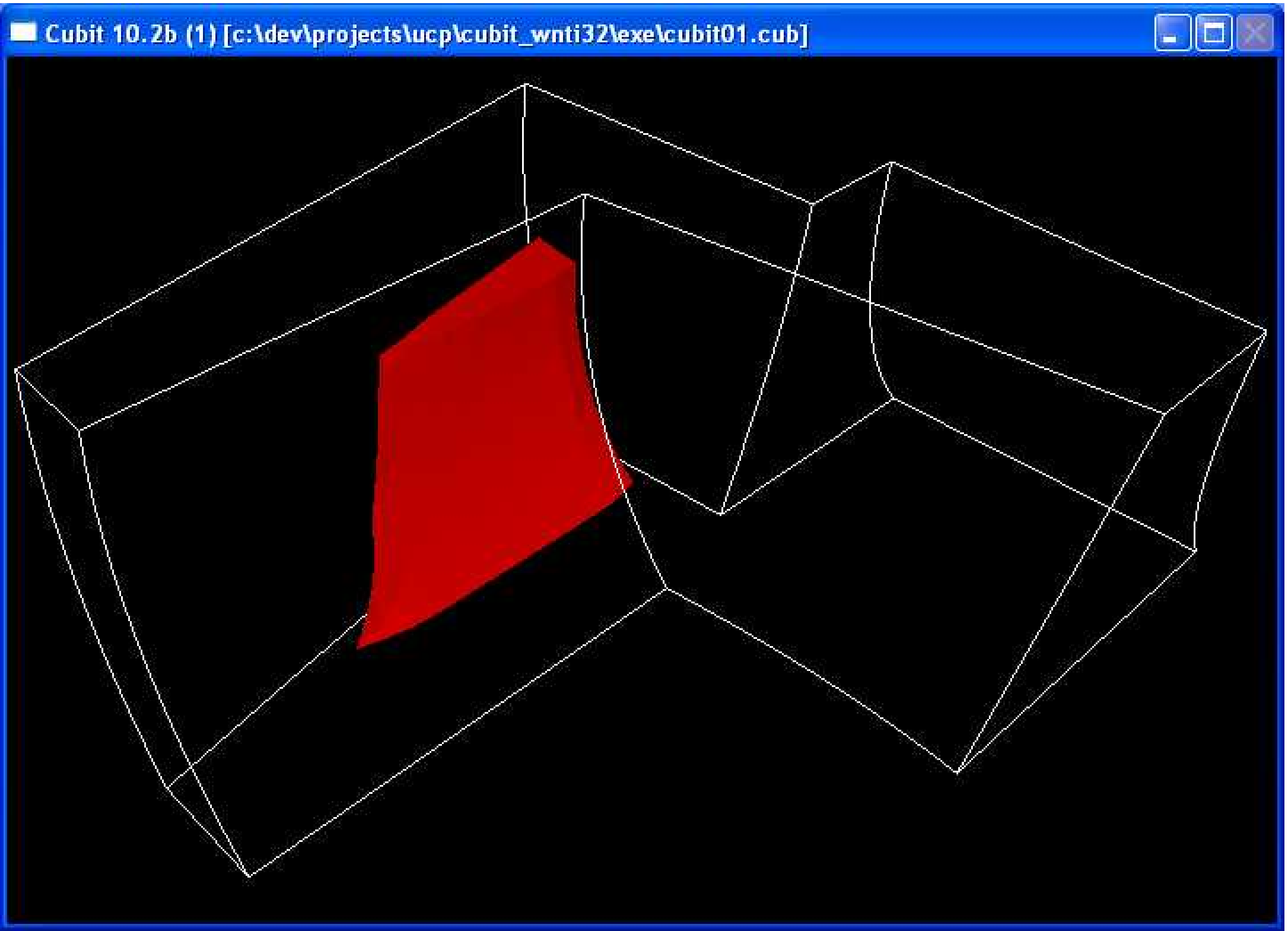
Example Model



Connecting Webs
1 DOF

Converted to
Stack of
Hexahedral
Elements

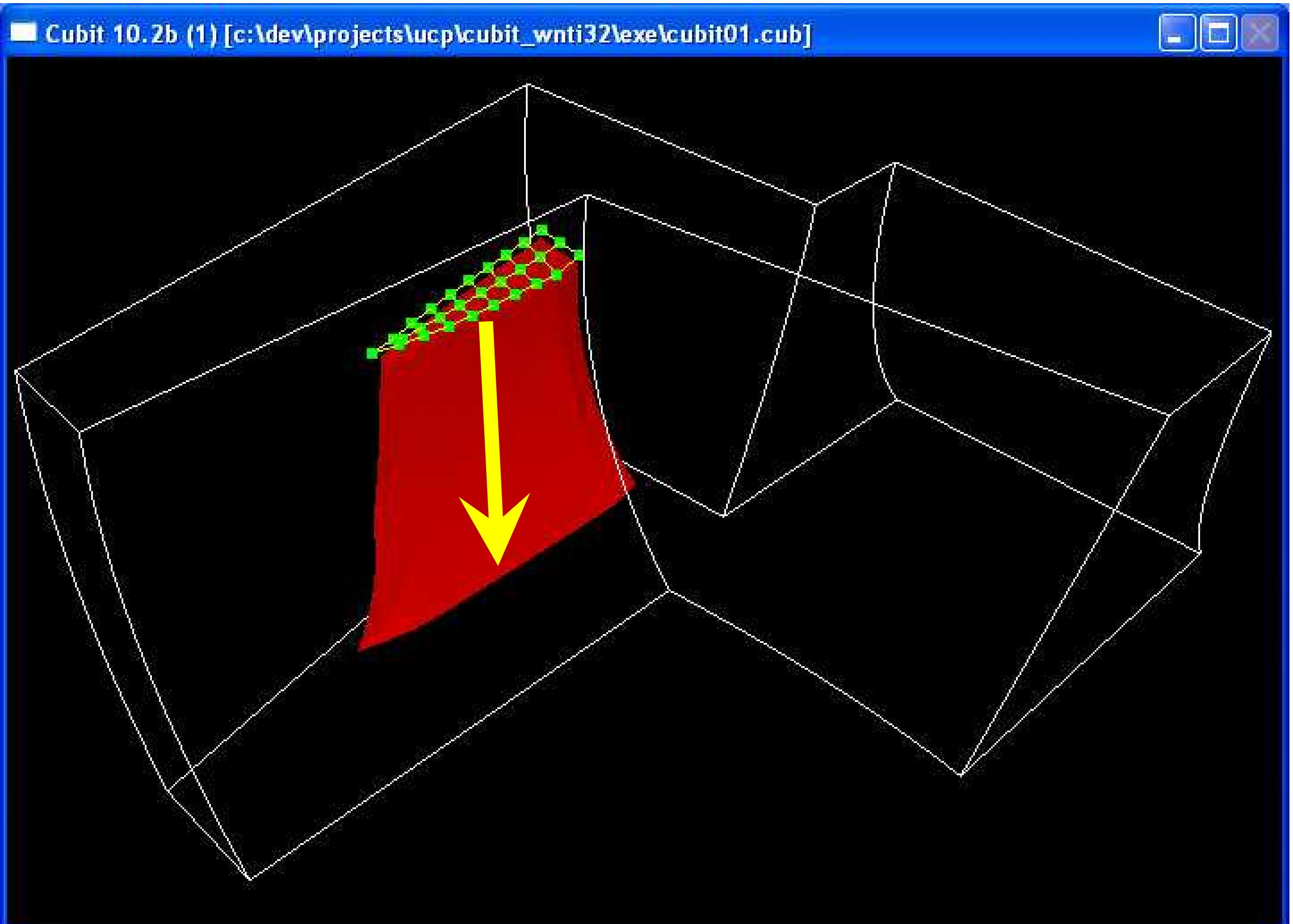
Example Model



Unmeshed Void
3 DOF

Meshed with either midpoint subdivision, sweeping, or mapping

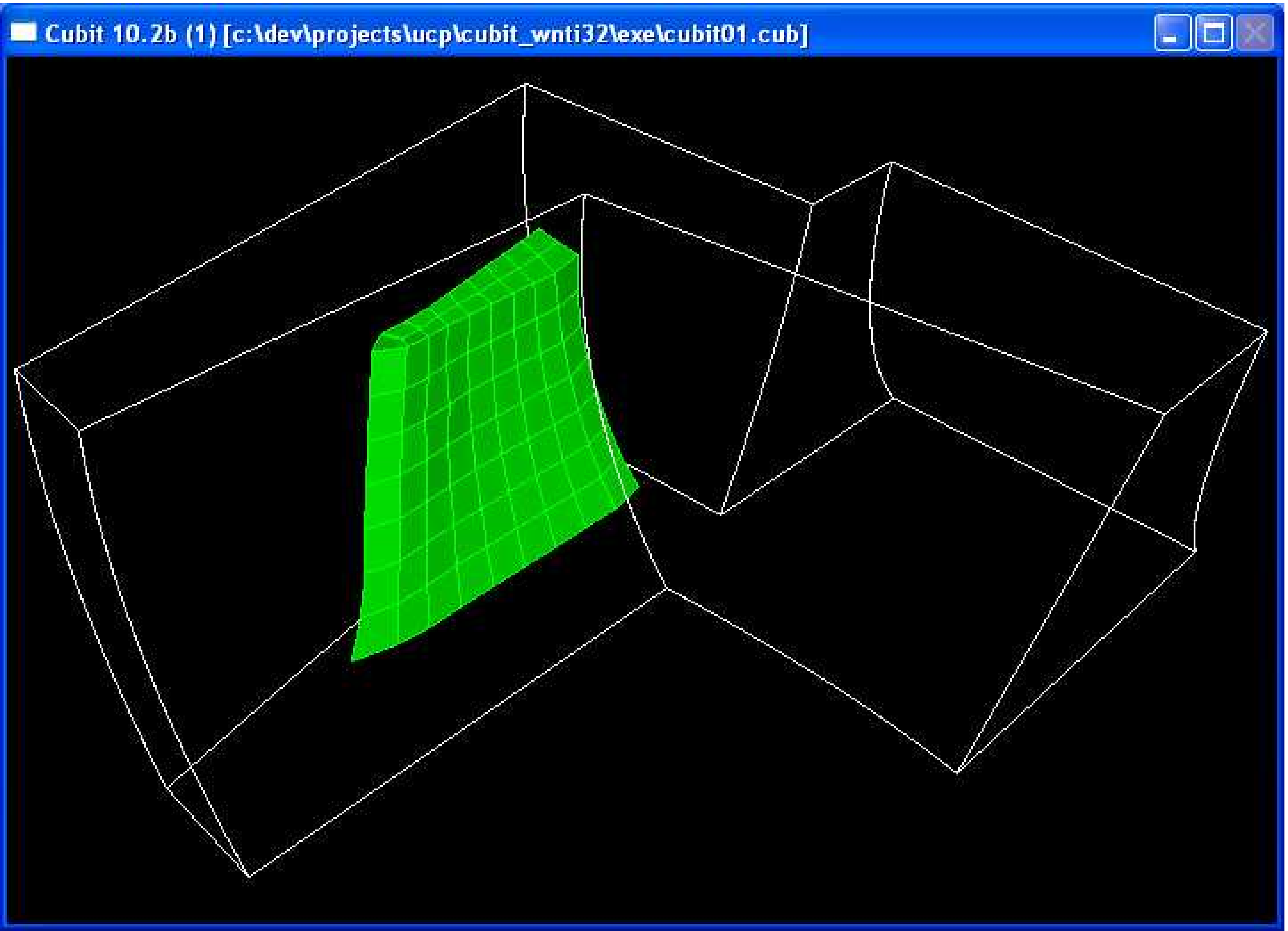
Example Model



Unmeshed Void
3 DOF

Meshed with
either midpoint
subdivision,
sweeping,
or mapping

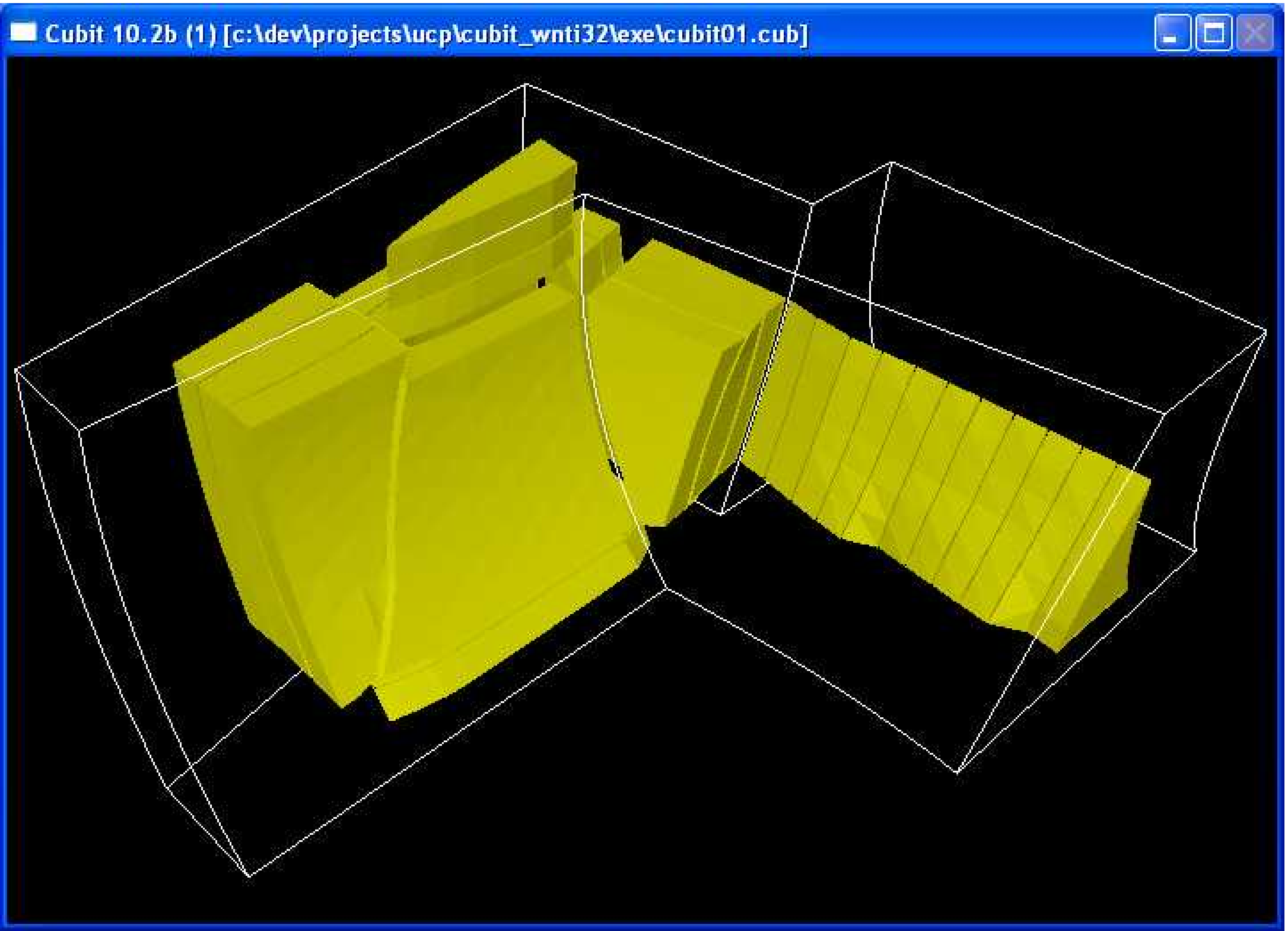
Example Model



Unmeshed Void
3 DOF

Meshed with
either midpoint
subdivision,
sweeping,
or mapping

Example Model

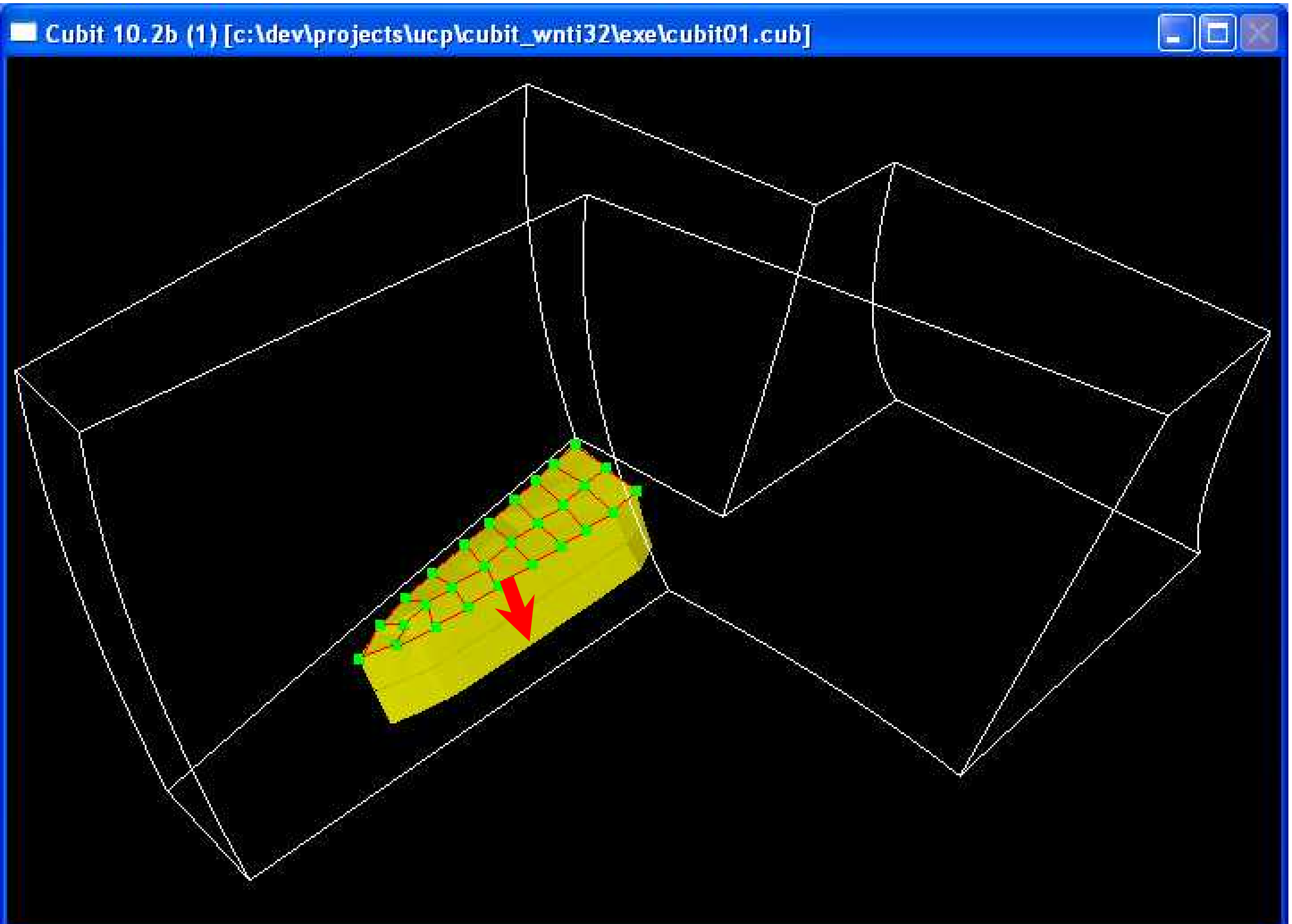


Connecting Tubes
2 DOF

Converted to Swept Layers of Hexahedral Elements

If connected to unmeshed void, source mesh is from corresponding surface on unmeshed void

Example Model

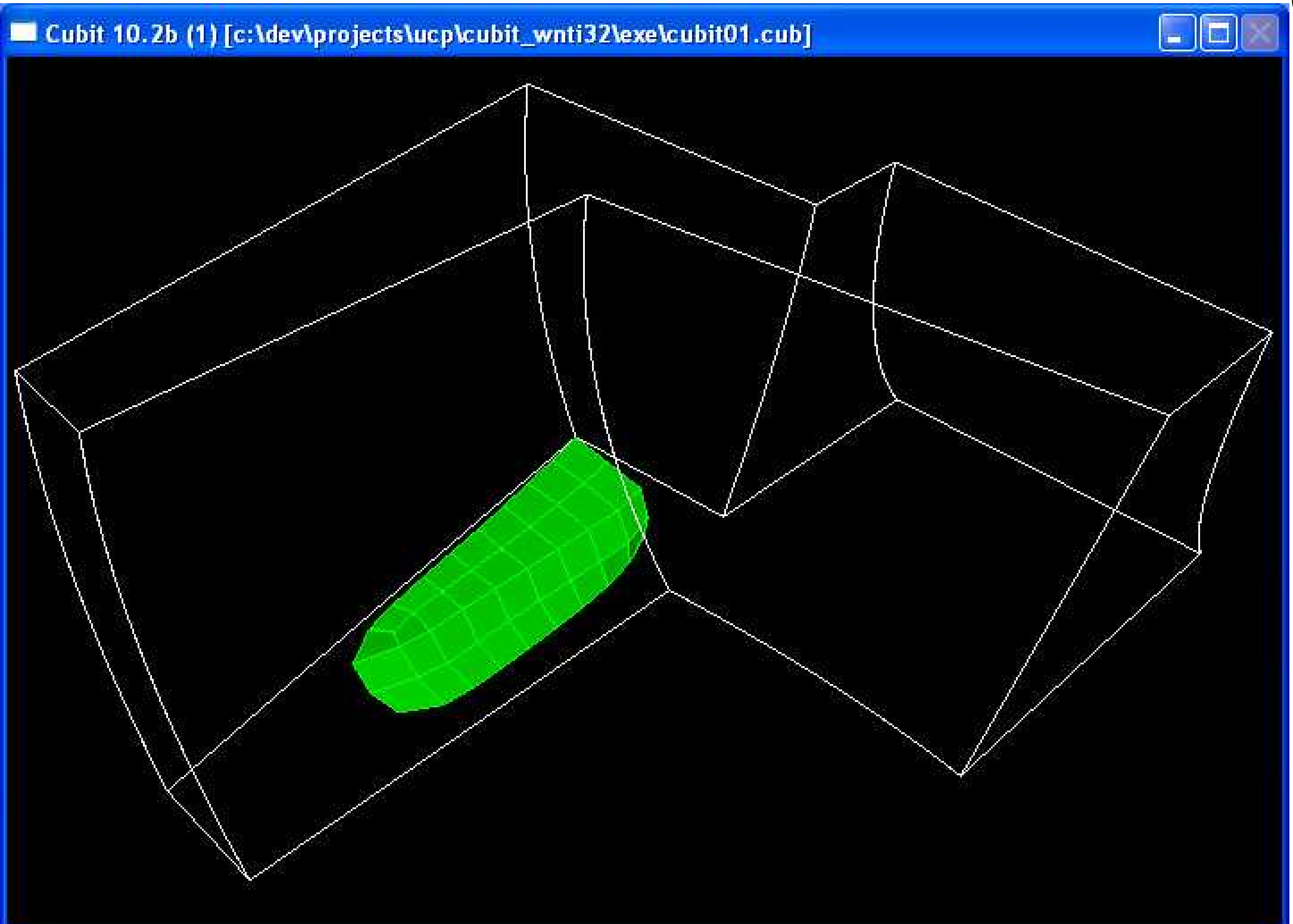


Connecting Tubes
2 DOF

Converted to Swept Layers of Hexahedral Elements

If connected to unmeshed void, source mesh is from corresponding surface on unmeshed void

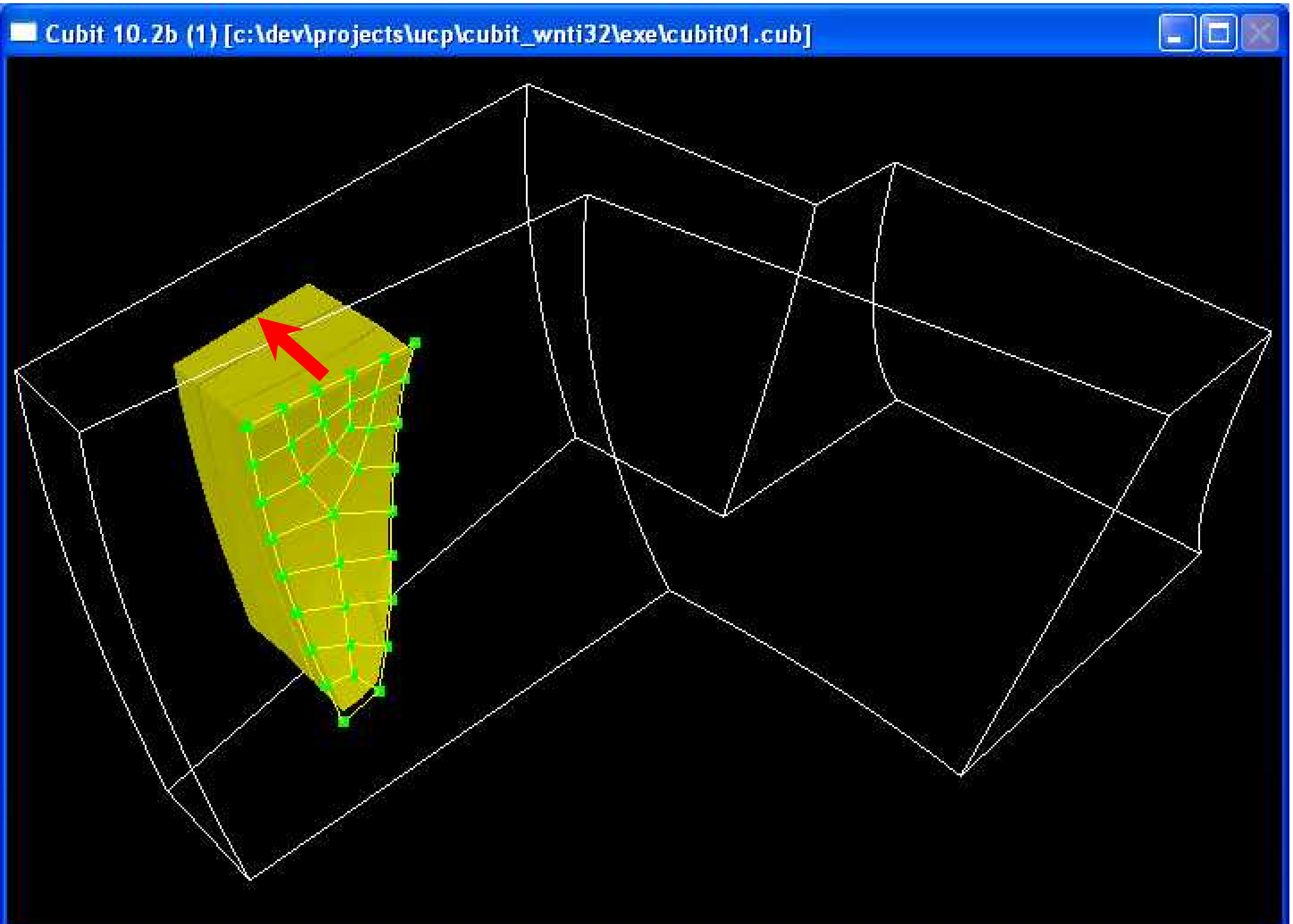
Example Model



Connecting Tubes
2 DOF

Converted to Swept Layers of Hexahedral Elements

Example Model



Connecting Tubes
2 DOF

Converted to Swept Layers of Hexahedral Elements

If not connected to unmeshed void, source mesh is paved.

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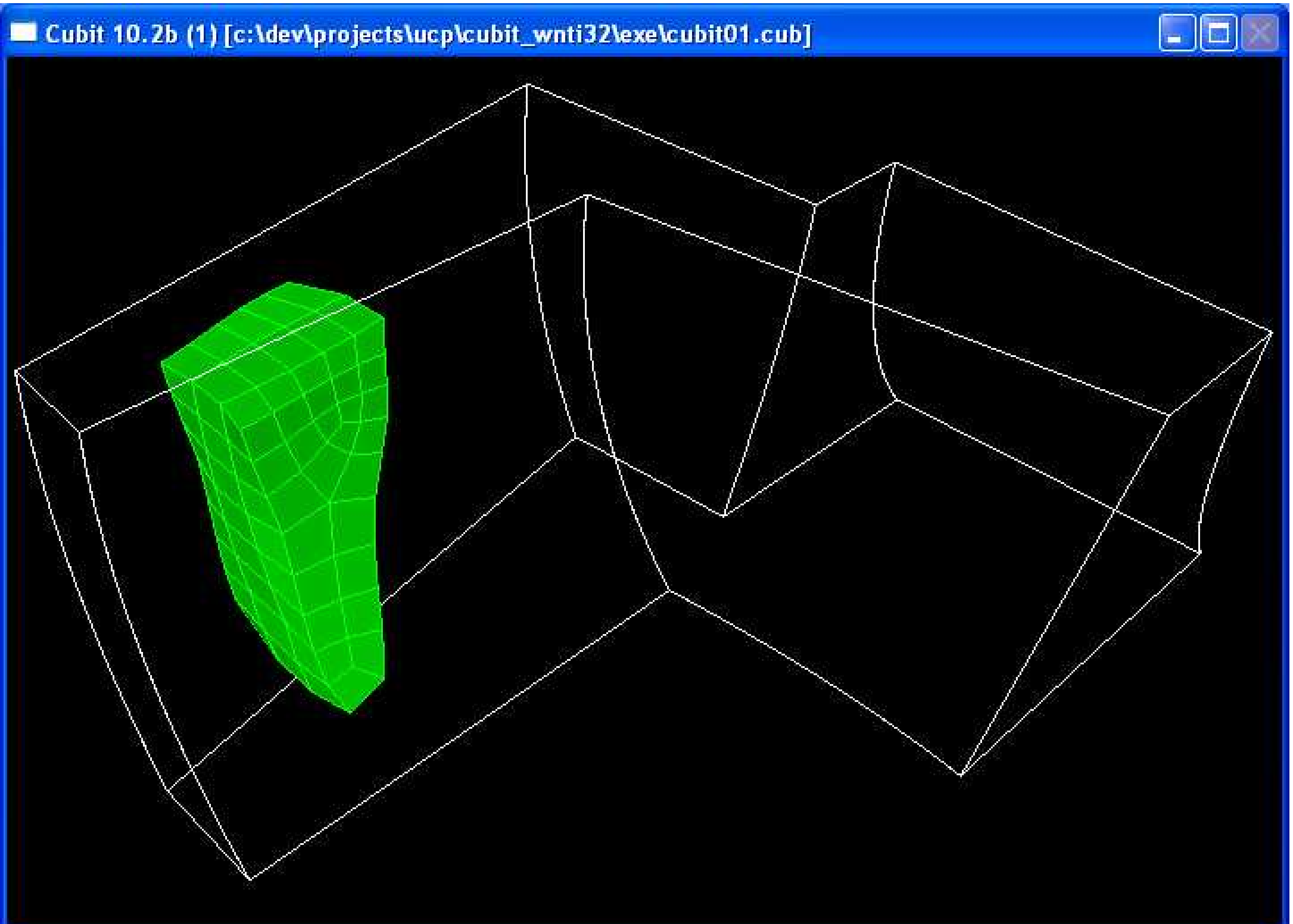
Example Model

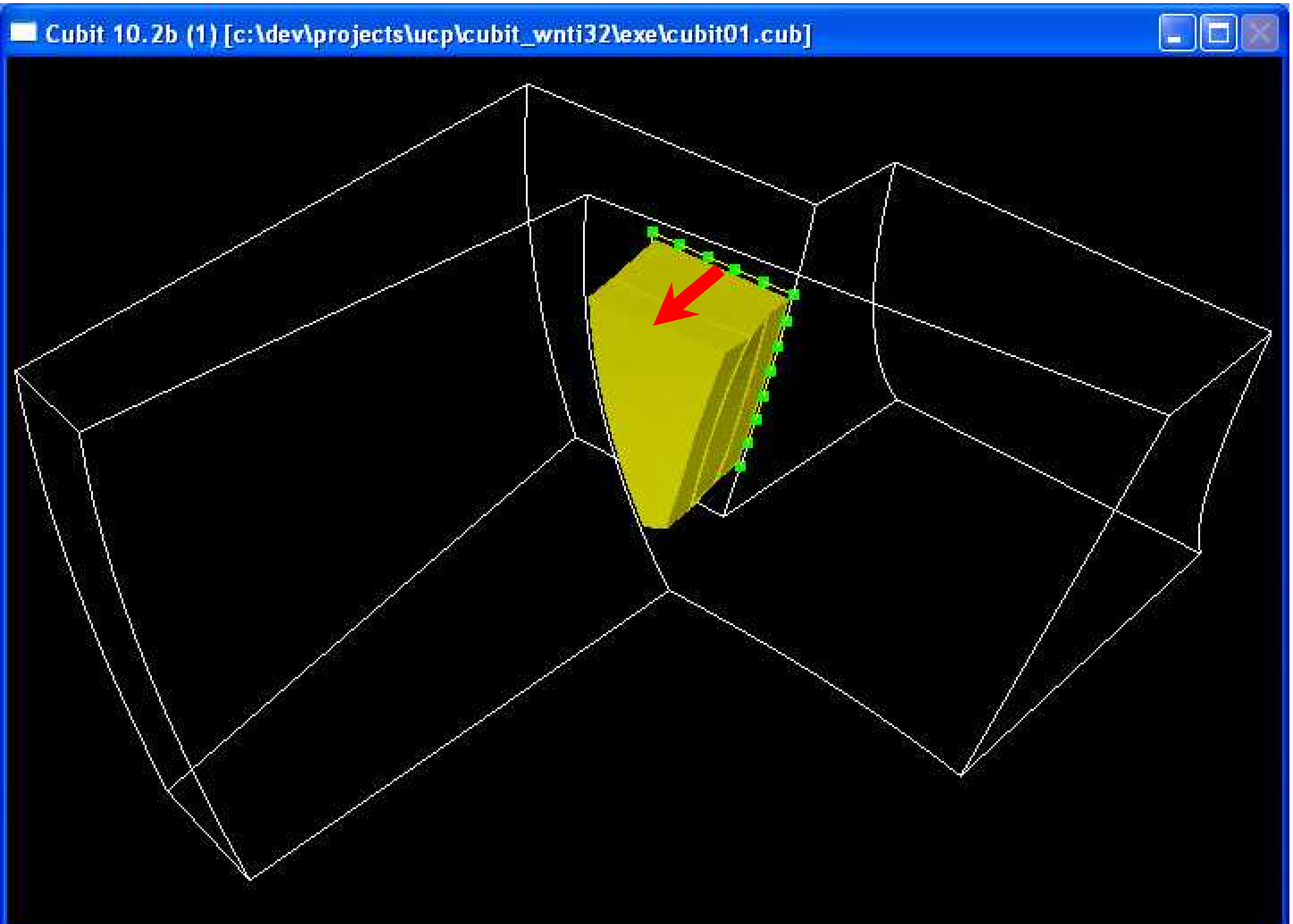


Connecting Tubes
2 DOF

Converted to Swept Layers of Hexahedral Elements

If not connected to unmeshed void, source mesh is paved.

Example Model

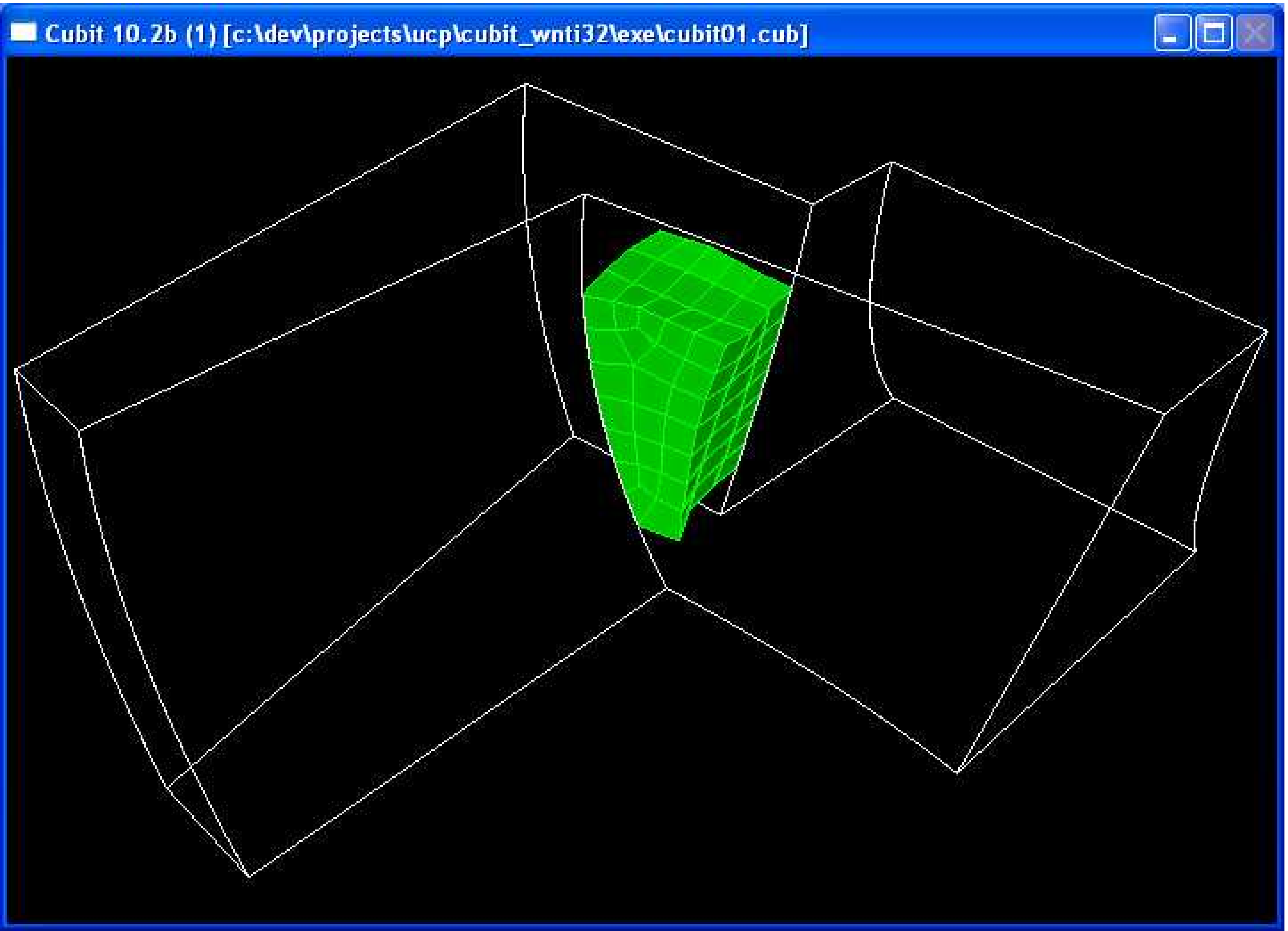


Connecting Tubes
2 DOF

Converted to Swept Layers of Hexahedral Elements

If not connected to unmeshed void, source mesh is paved.

Example Model



Connecting Tubes
2 DOF

Converted to Swept Layers of Hexahedral Elements

If not connected to unmeshed void, source mesh is paved.

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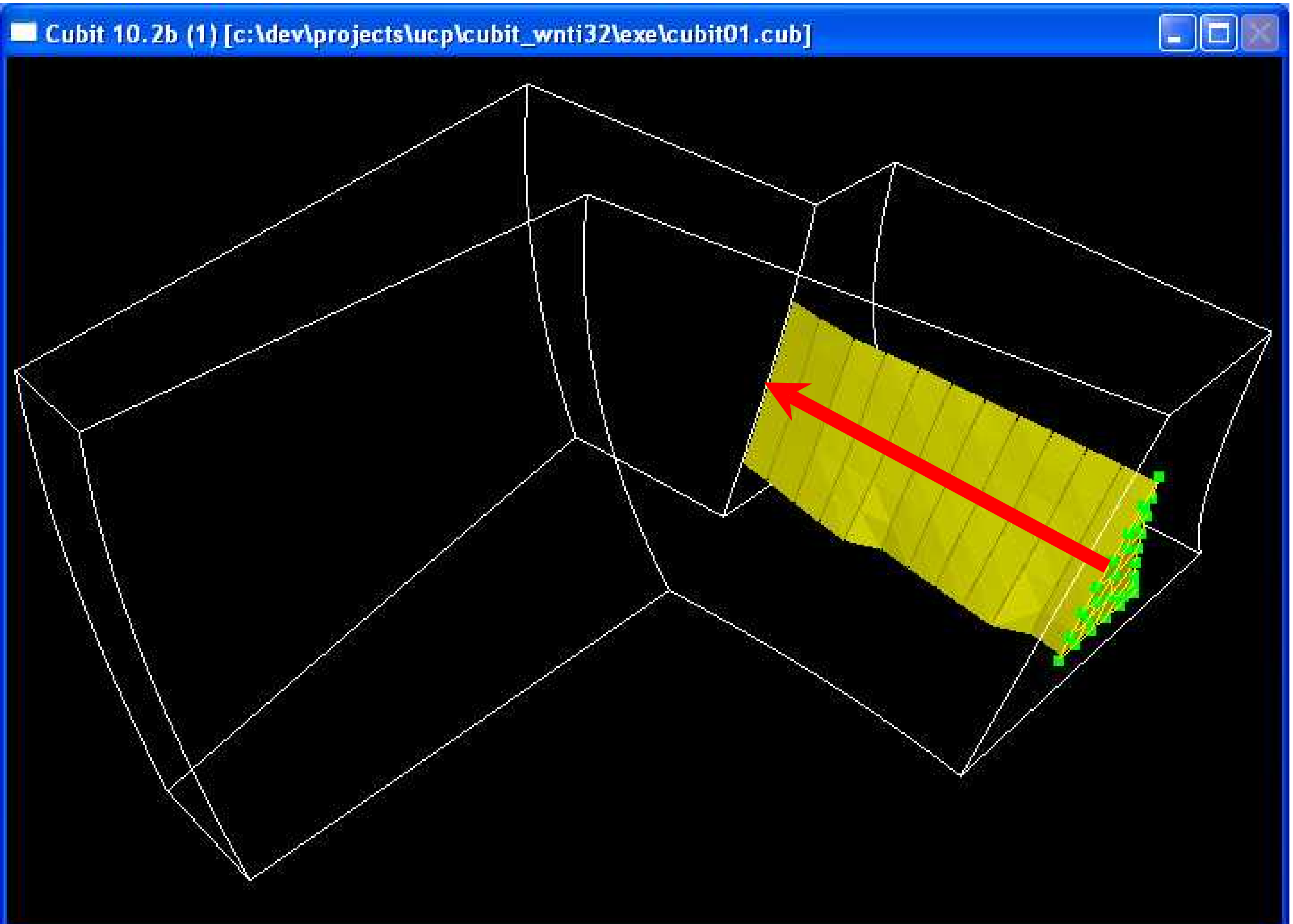
Example Model



Connecting Tubes
2 DOF

Converted to Swept Layers of Hexahedral Elements

If not connected to unmeshed void, source mesh is paved.

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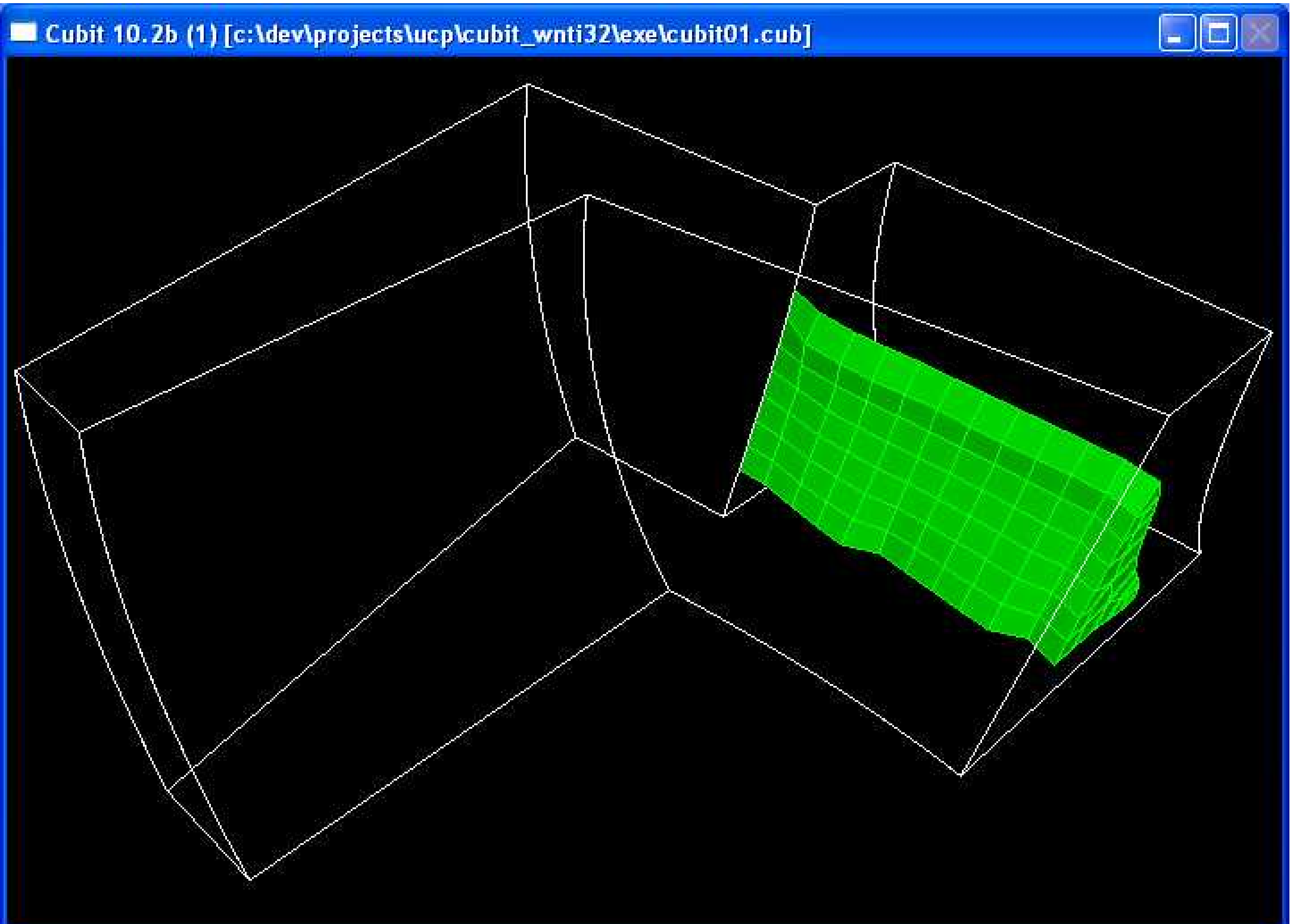
Example Model

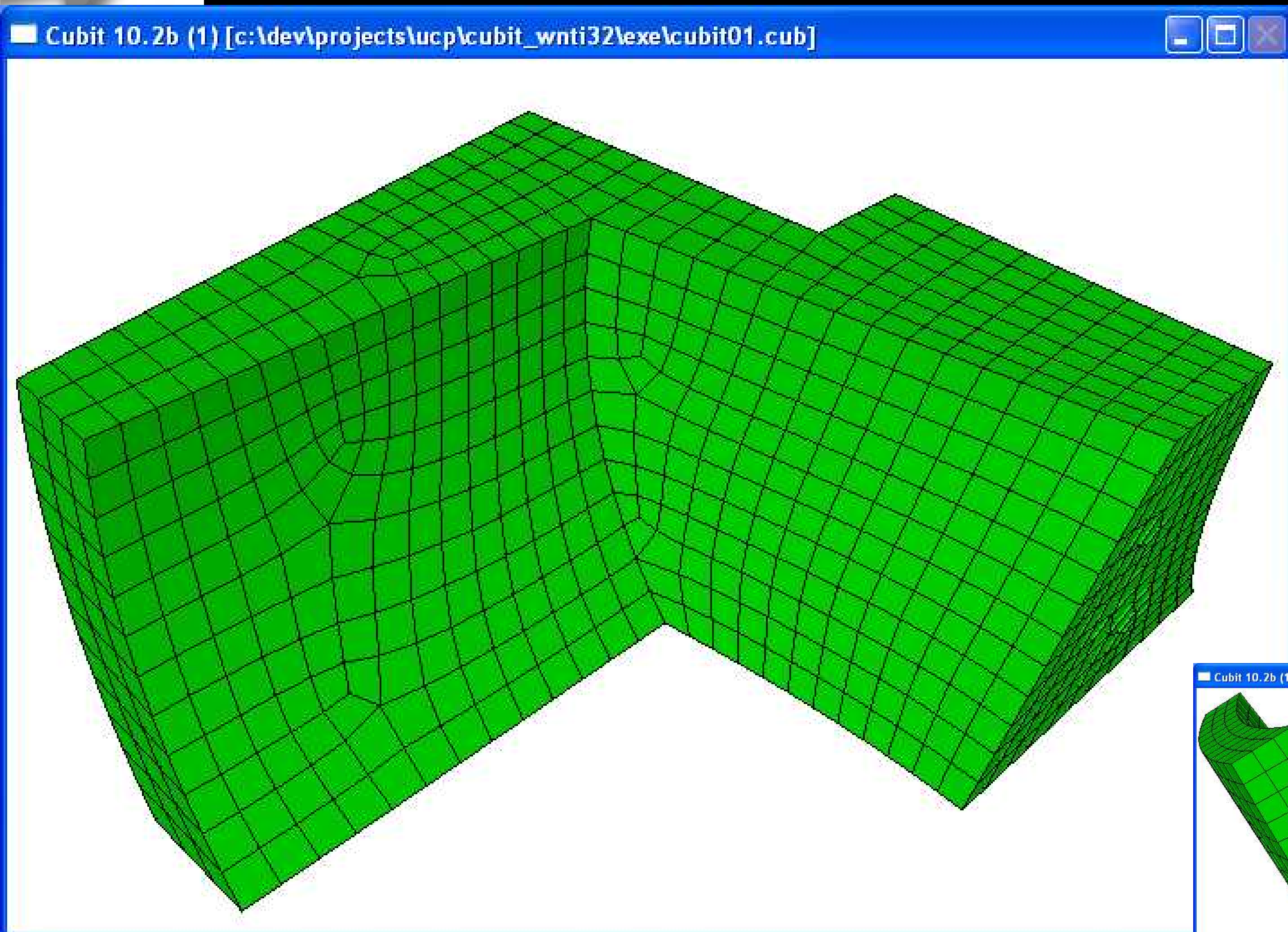


Connecting Tubes
2 DOF

Converted to Swept Layers of Hexahedral Elements

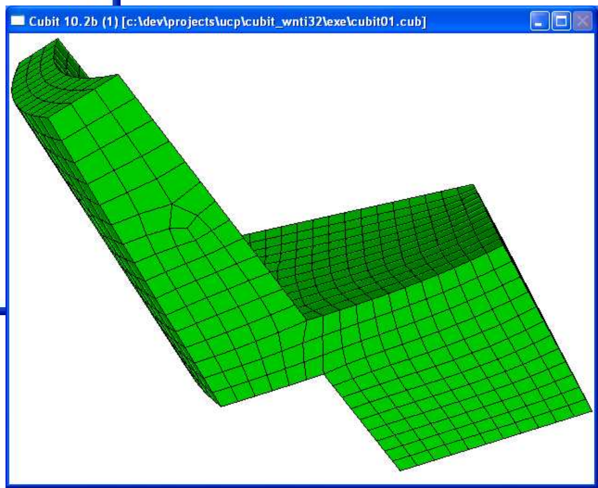
If not connected to unmeshed void, source mesh is paved.

Unconstrained Plastering
No manual decomposition

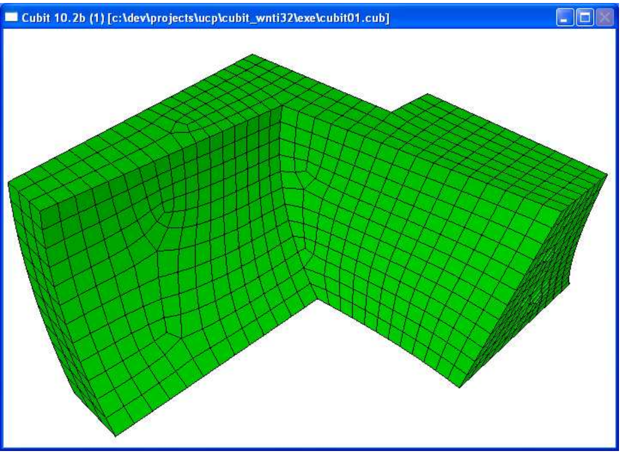


Minimum Scaled Jacobian: 0.578

1 User Command



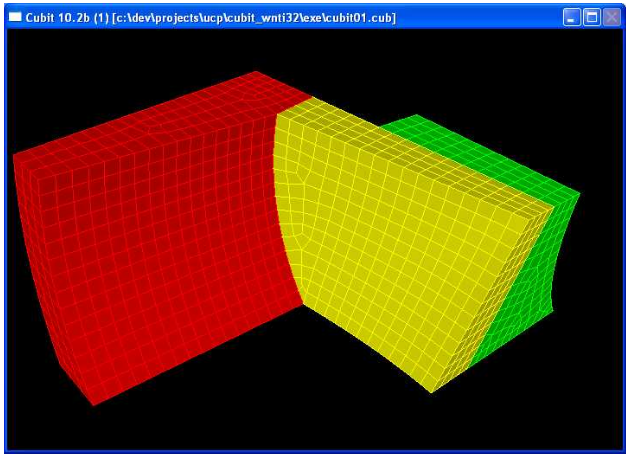
Example Model - Summary



Unconstrained Plastering:

Minimum Scaled Jacobian: 0.578

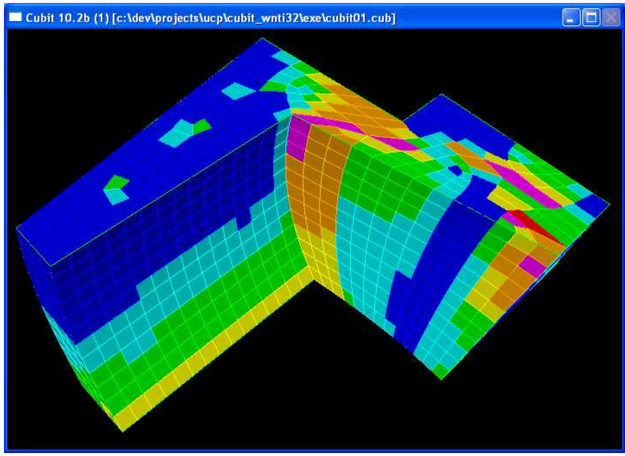
1 User Command



Partition-and-Sweep:

Minimum Scaled Jacobian: 0.503

7 User Commands



Single Sweep:

Minimum Scaled Jacobian: 0.276

1 User Command

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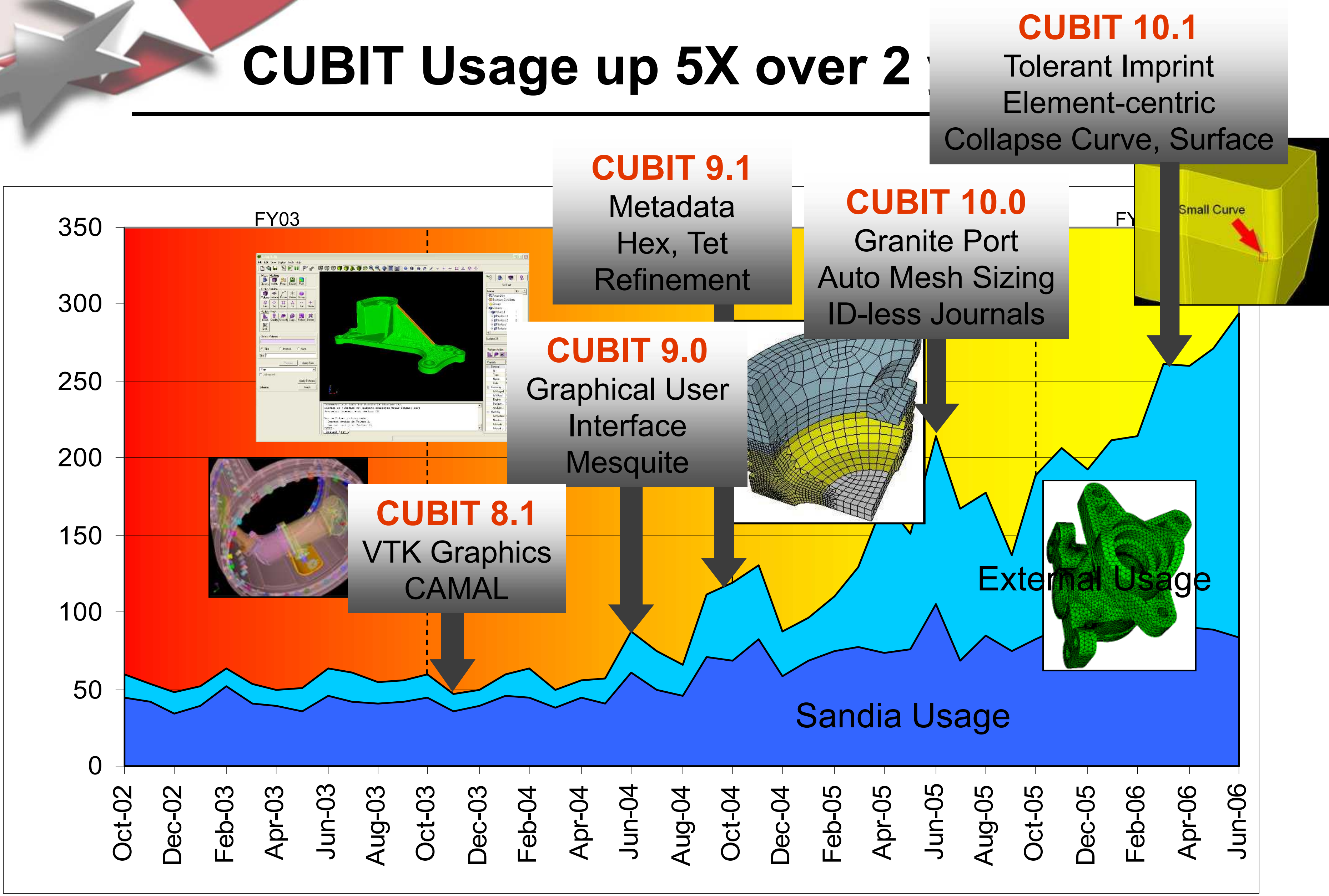
CUBIT Usage up 5X over 2



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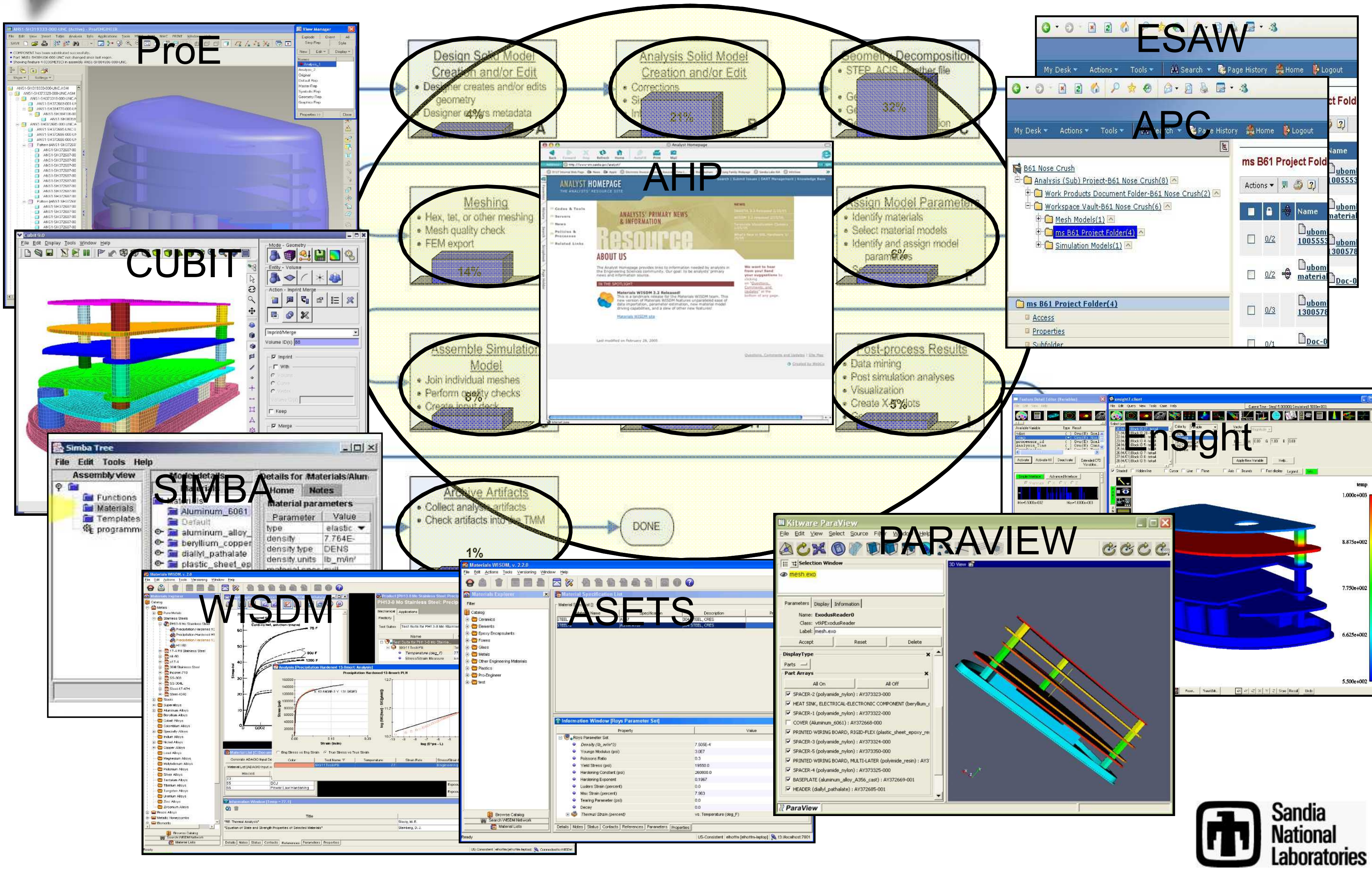
Strategy 2: Federated Integration Via Metadata Provides Connectivity at Minimal Cost



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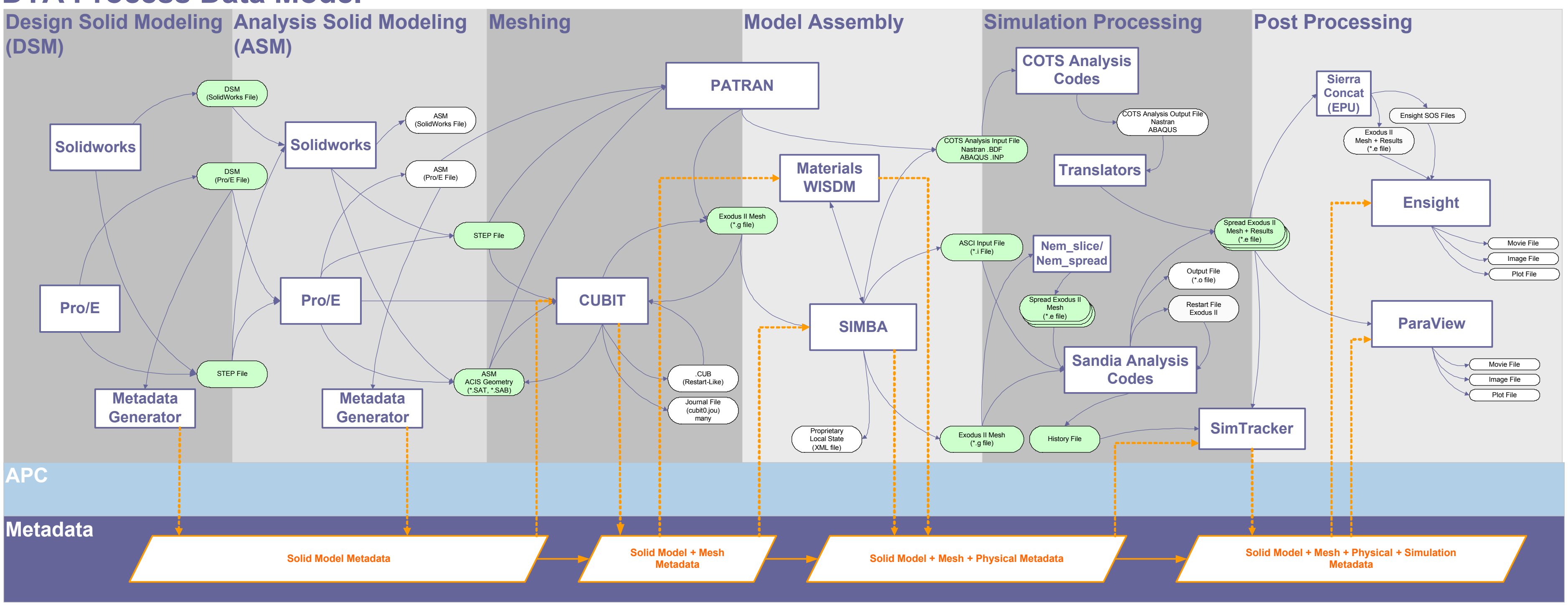
APC and Metadata Layers Provide Needed Connectivity

Open Architecture: A software architecture based on well defined interfaces between the core (generalized) software components.

DTA Process Data Model



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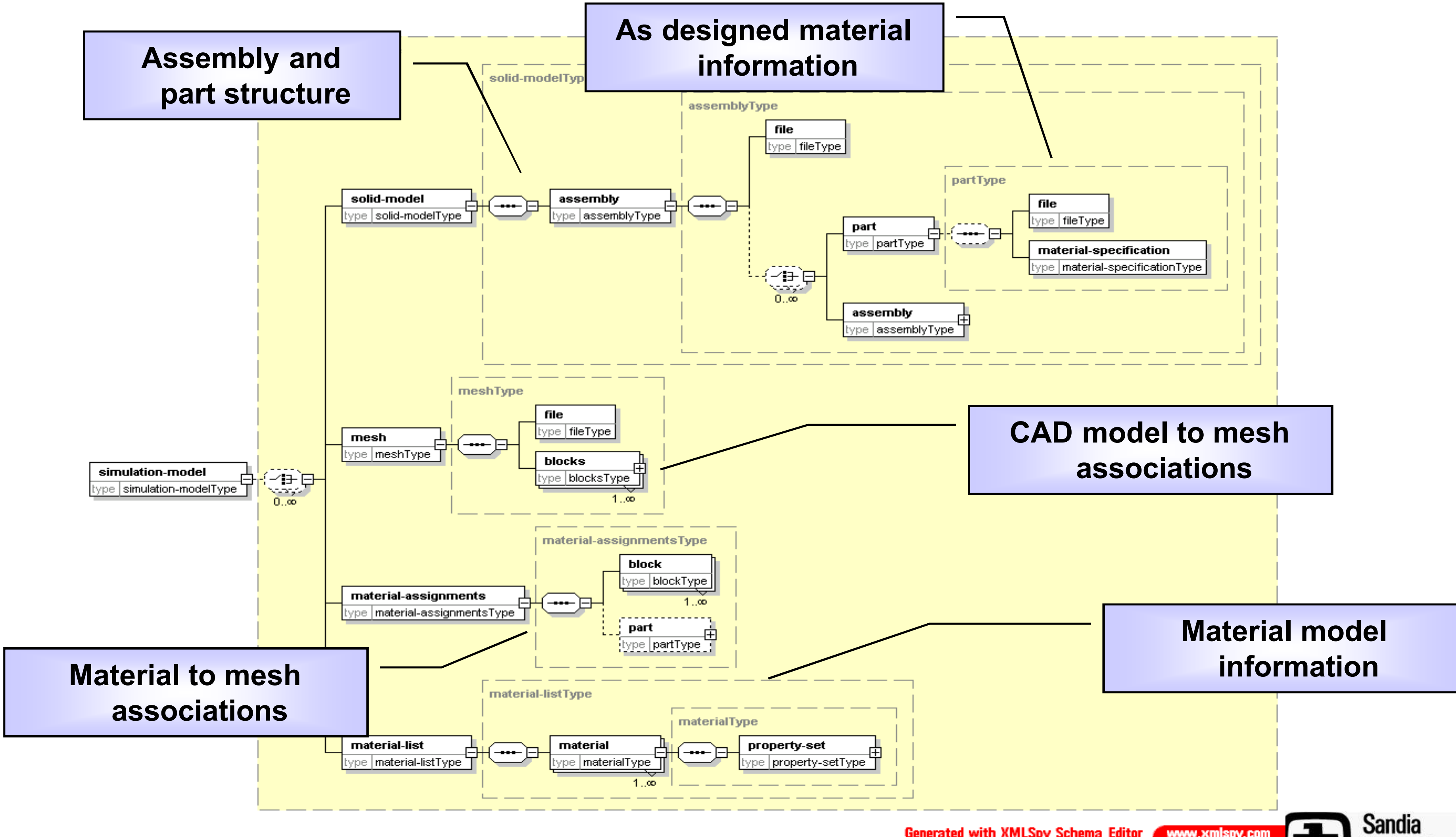
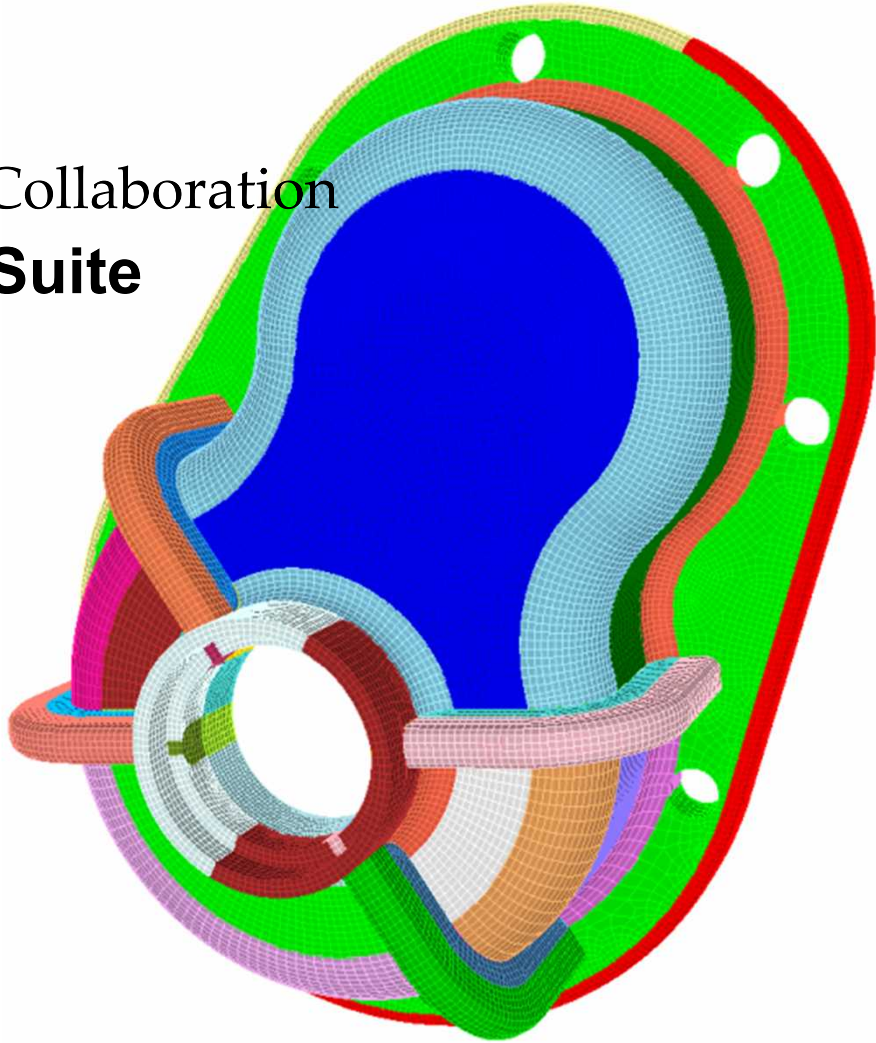
XML Metadata Schema Allows Flexibility and Agility While Maintaining Interconnections



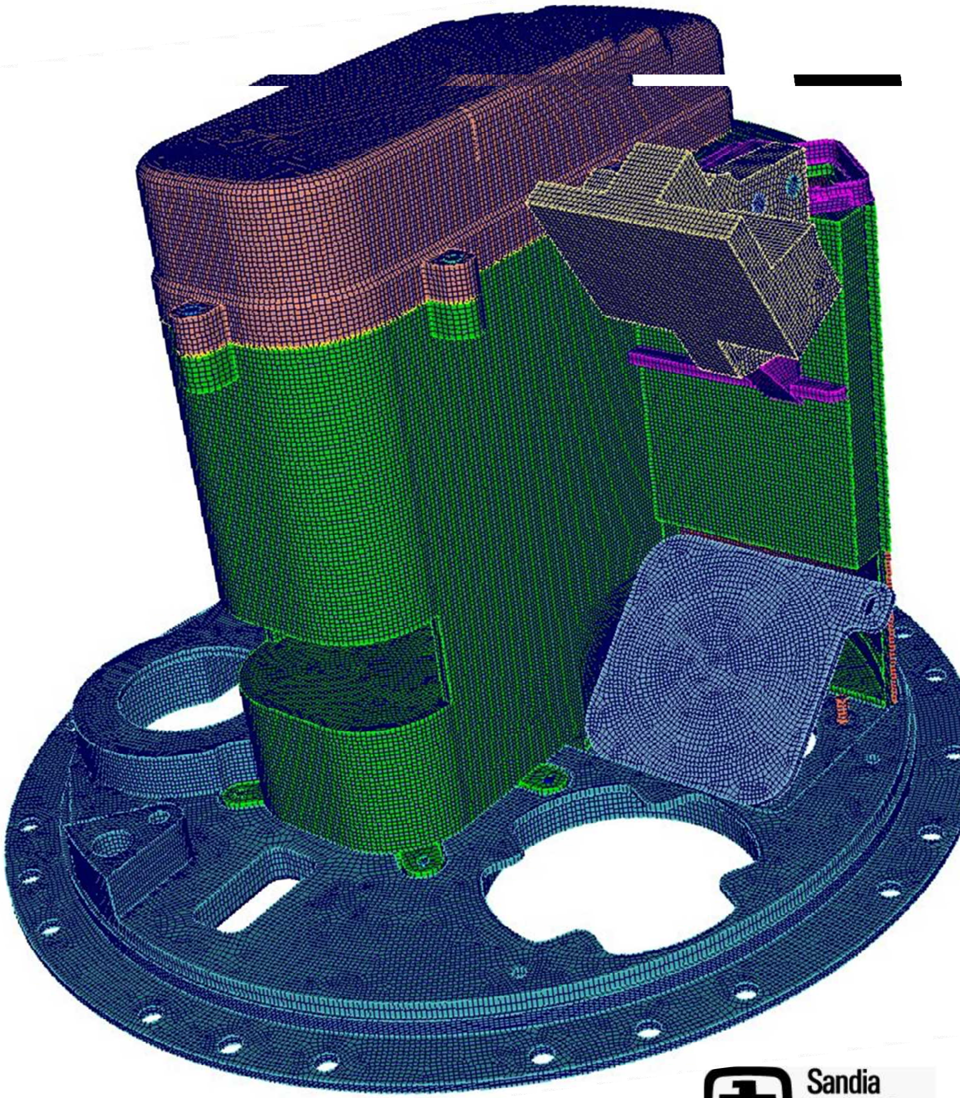
Massive Customization May Provide Needed Automation with Minimal Investment

- **Highly Customized**
  - Vertically Integrated
  - Expert Analysts & Designer Collaboration
- **Cloaked Complex Physics Suite**
  - Hidden Complexity
  - Carefully Exposed Options
- **Rapid Local Development**
  - Analyst Owned
  - Requires No Release Cycle
  - Run-Time Customizable
  - Plug-In Philosophy
- **Industry Tool Suite**
  - VGL / QT / Python



Summary Points

- Analysis Throughput Critical to M&S Success
- Strengthening Core Tools (Geometry and Meshing) Reduces Major Bottlenecks
- Federated Environment Provides Integration While Minimizing Costs



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