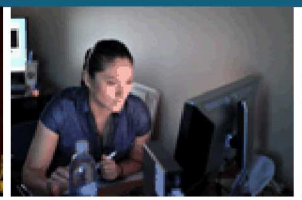
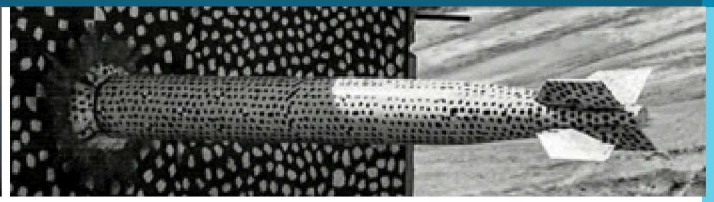
SAND2019-12356C

CUBIT - Sandia's Geometry & Meshing Toolkit



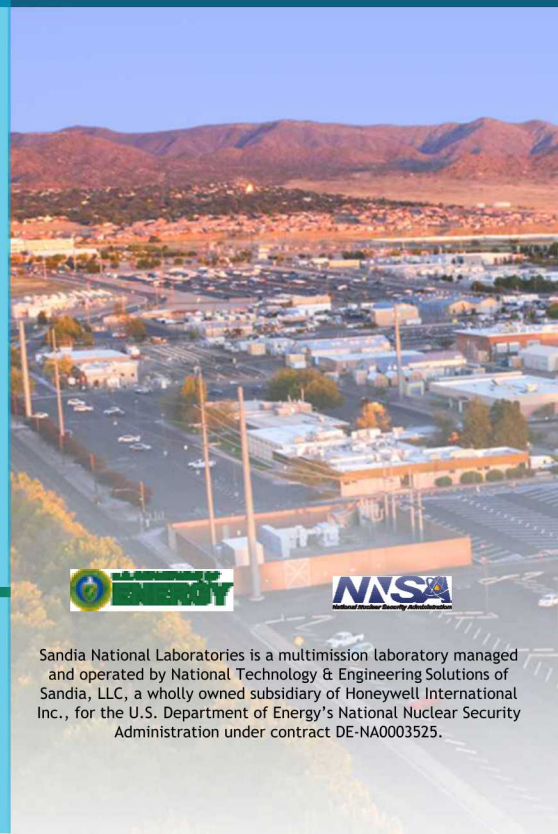


Presented by

Roshan Quadros

CUBIT Product Owner

wrquadr@sandia.gov



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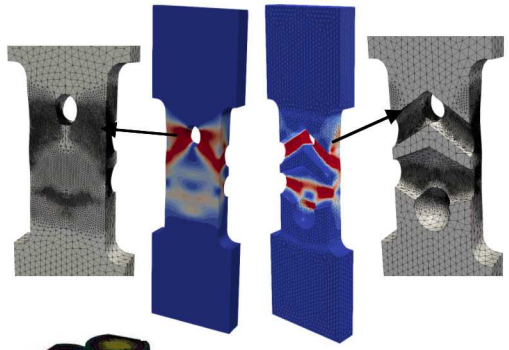
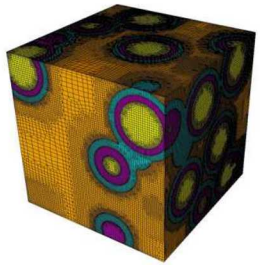
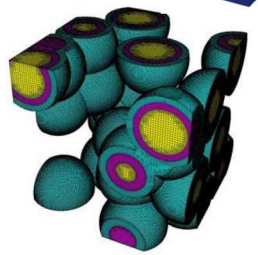
Overview of CUBIT

- Free for US Govt Use
- ~800 repeated users per month
- 70% of users are external
- ~100,000 runs every month
- CSimSoft handles Academic and Commercial licenses
- Customers:

  NASA, US Army, Navy, Air Force, USGS, DARPA, NIST, NRC, DOE, LANL, LLNL, NREL, Brookhaven, JPL, SLAC, ORNL, LBNL, FNL, NETL, APL, Kansas City National Security Campus, Y12 and CRADA/Commercial Partners (Goodyear, Caterpillar, …)

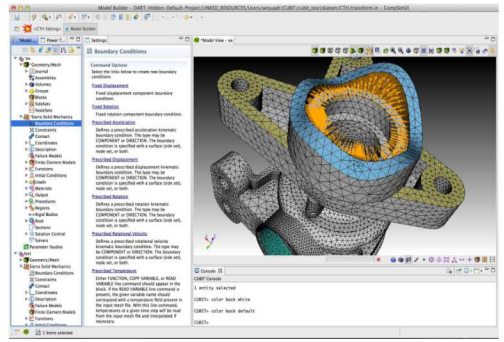




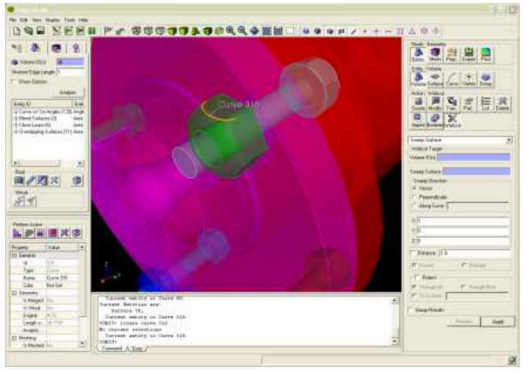


Advanced Meshing Algorithms

Mesh Quality

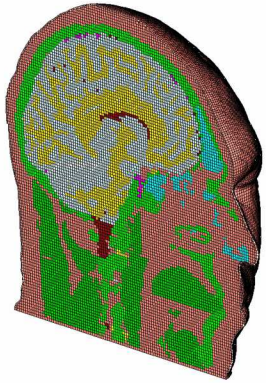


Model Attribution

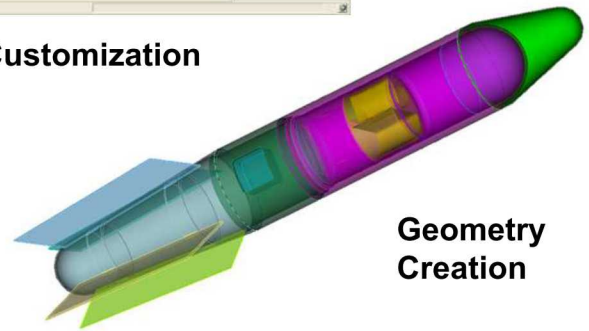


GUI and Customization

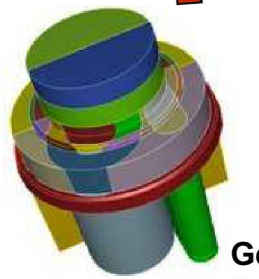
CUBIT



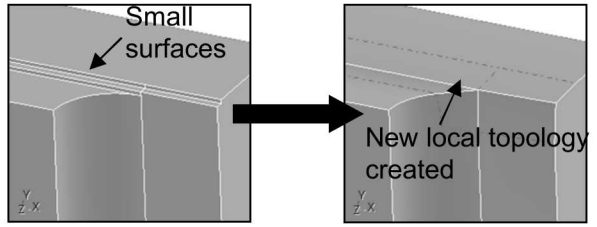
Parallel Meshing: Tet & Hex



Geometry Creation

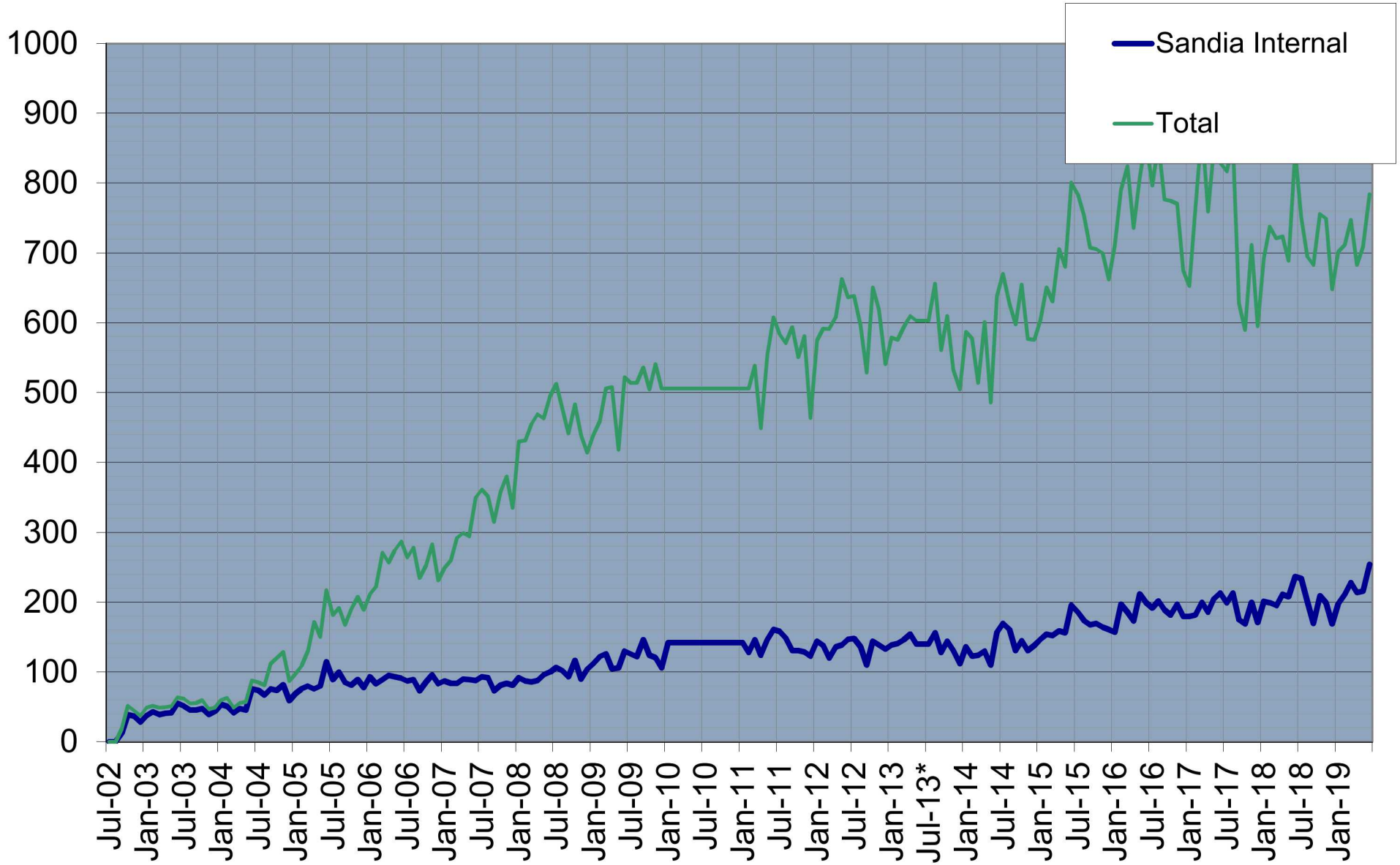


Geometry Decomposition

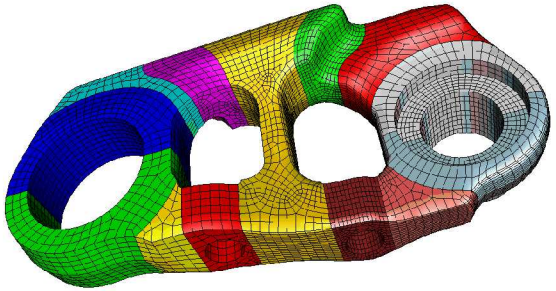


Geometry Defeaturing

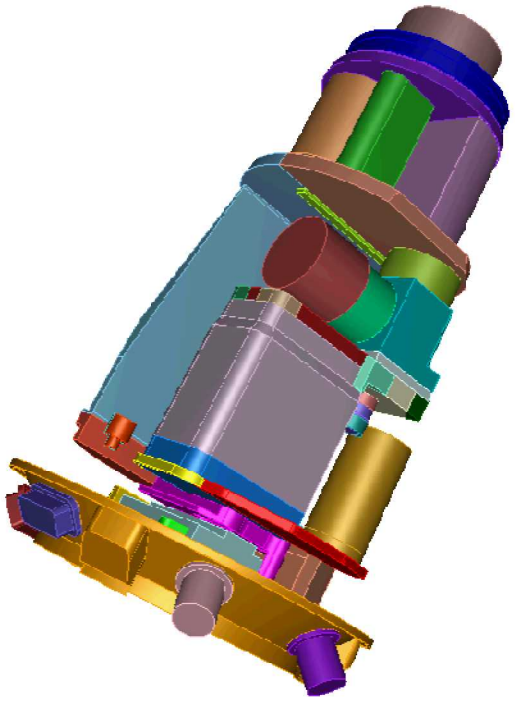
Repeated Users Per Month (17 Years: 2002 to 2019)



Sandia Problems

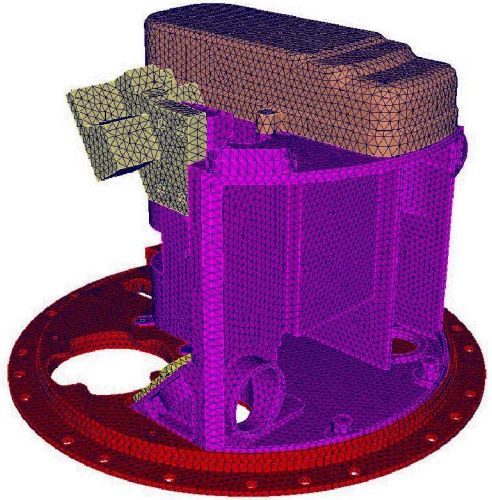


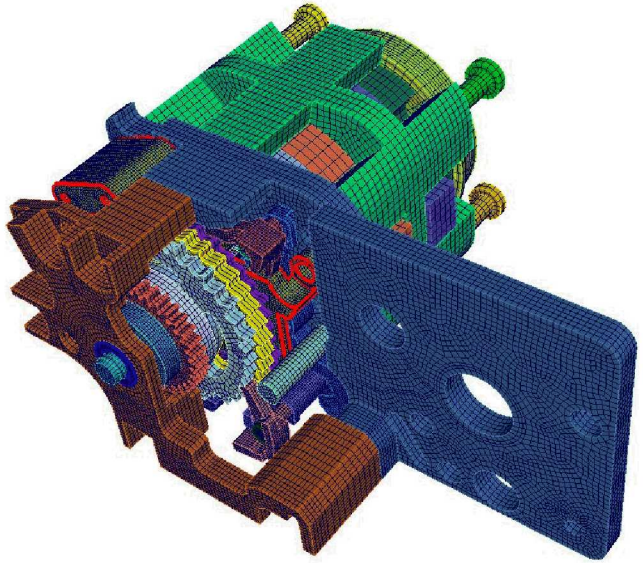
Large Assemblies



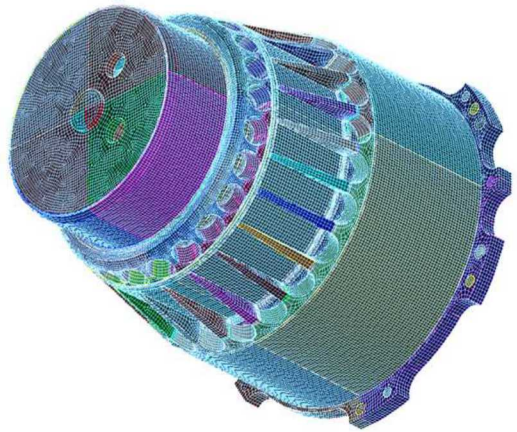
Mis-alignments, Unwanted features, …

Lots of Part Interactions





High-Quality Mesh



History

1990: Paving (Ted Blacker et al.)

1991: CUBIT (Ted Blacker et al.)

1992: 1st IMR (Ted Blacker et al.)

1995: Hex Meshing Research

2000: Common Geometry Module - ACIS, Facets, …

2000: Licensed GHS3D (now MeshGems with Distene)

2003: Added Qt-based GUI

2007: CATIA Integration

2009: Sculpt - all-hex mesh generator

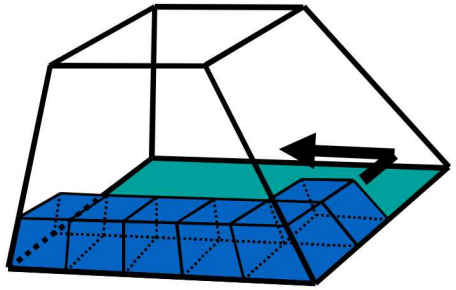
2016: Parallel mesh modification

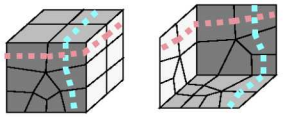
2019: CUBIT part of NGS (Project Lead: Roshan Quadros, Project Manager: Mike Skroch)

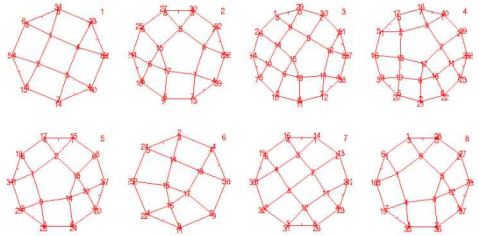
CUBIT Meshing

1995

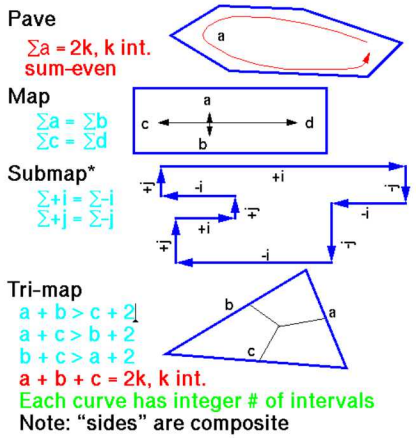
Plastering: Advancing front hex meshing







1996 Whisker Weaving: Dual-based advancing front hex meshing

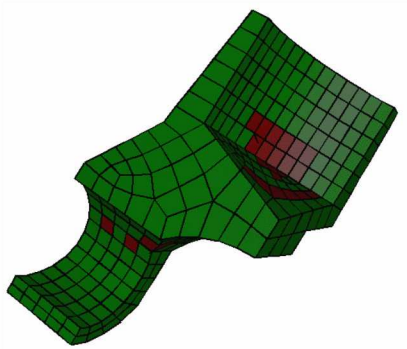


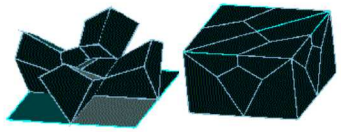
1997

Interval Matching: Automatically determine mesh intervals based on selected meshing algorithm

1998

Hex-Tet: Plastering on boundary with tetrahedra on interior

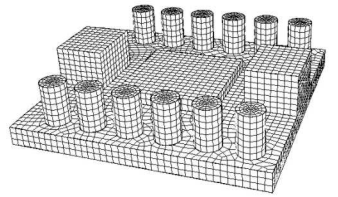




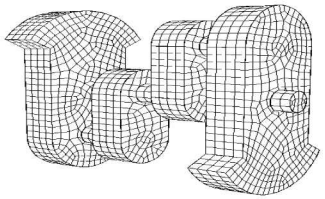
1999

Geode: Transition template to facilitate all hex mesh with hex-tet algorithm.

One-to-One Sweep



Many-to-One Sweep

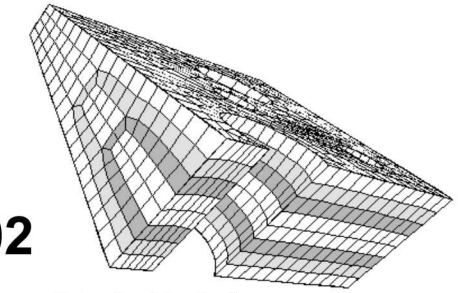


Multisweeping

1998-2001

Sweeping Algorithms: Hex meshing tools for sweeping a geometry-conforming quad mesh

CUBIT Meshing

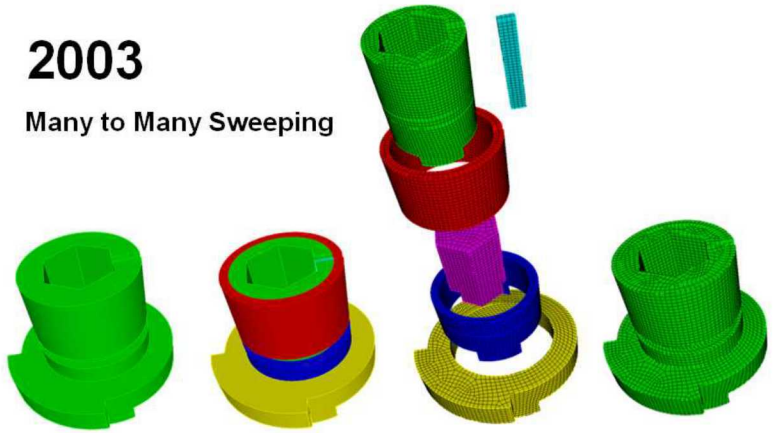


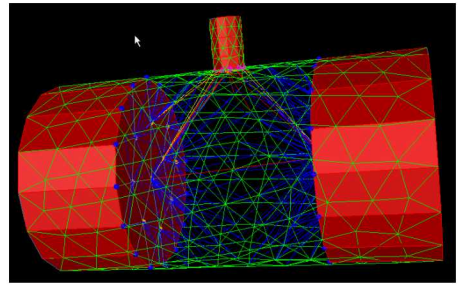
2002

Dual-based Tools: Tools for coarsening and refinement using dual-based operations

2003

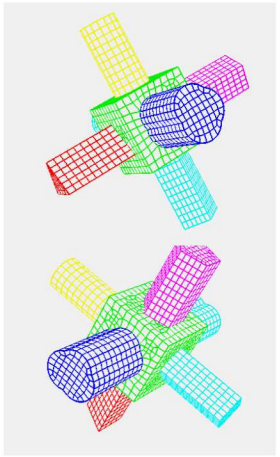
Many to Many Sweeping





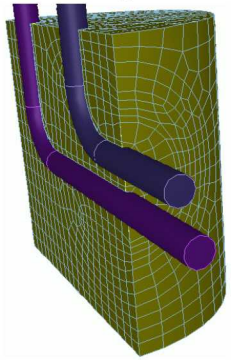
2005

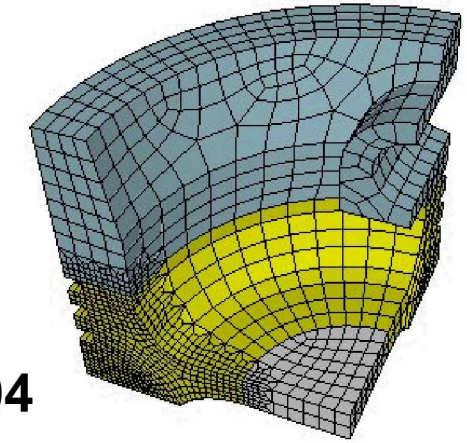
Cable Weaving and Unconstrained Plastering: Ongoing research to define all-hex mesh for arbitrary volumes



2002-2003

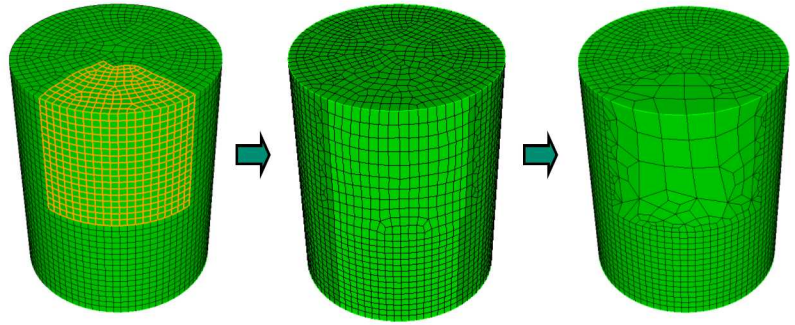
Mesh Cutting and Grafting





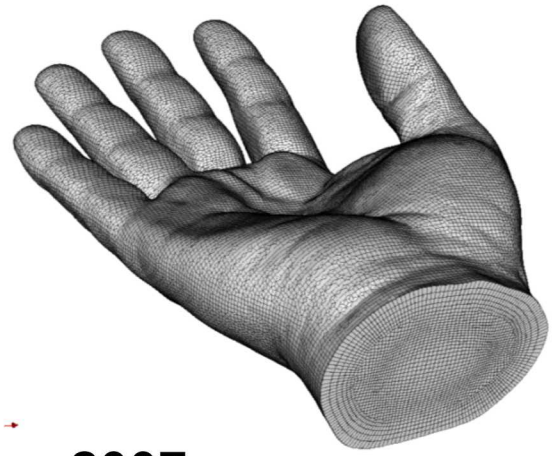
2004

Conformal Hex Refinement

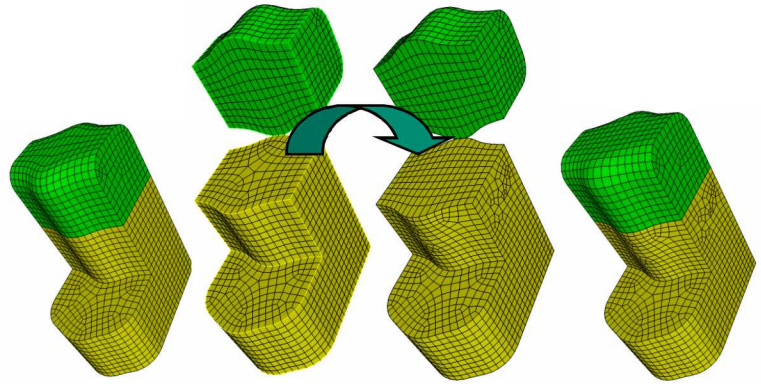


2008 **Conformal Hex Coarsening**

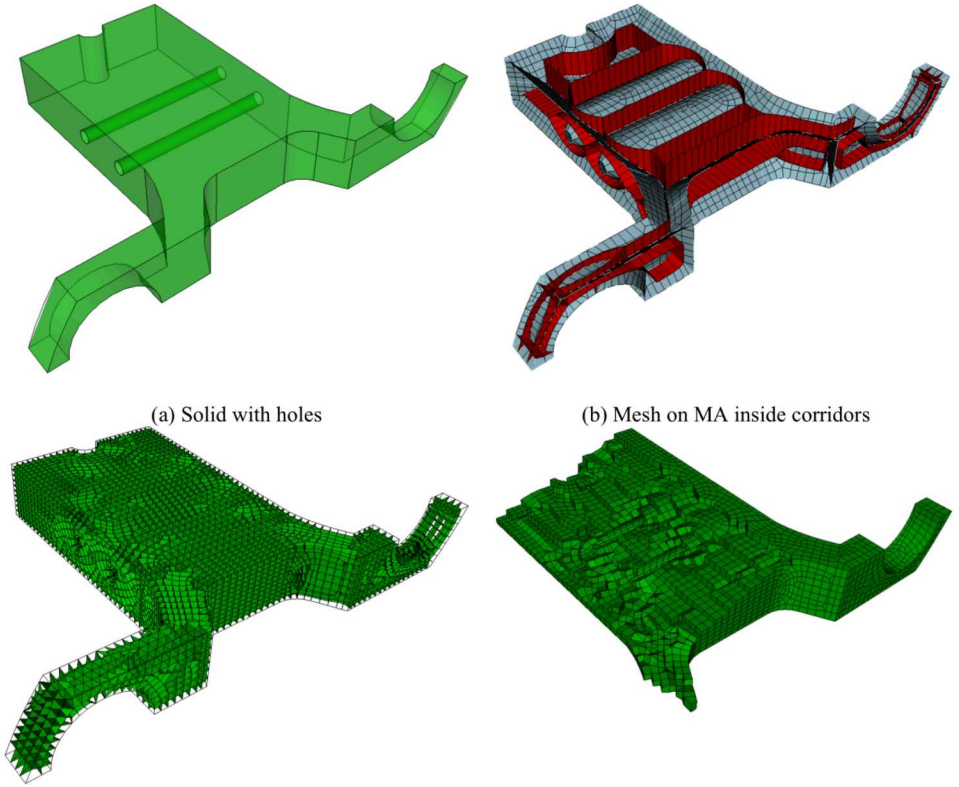
CUBIT Meshing



2007
Sheet Insertion



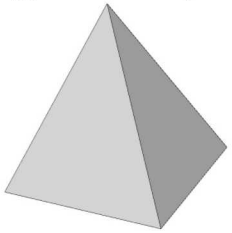
2008
Mesh matching



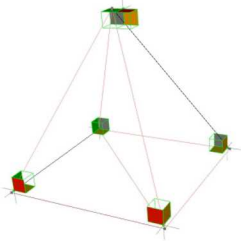
LayTracks3D: Hex Meshing via Medial Object
2014

2009
Sculpt Research

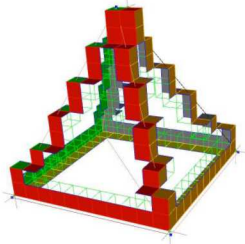
Original geometry



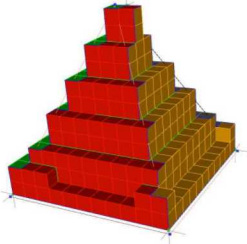
Vertices embedded



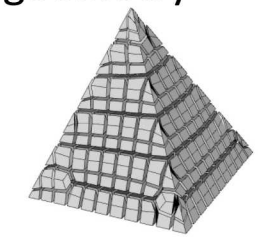
Curves embedded



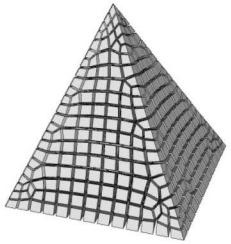
Surfaces/Volumes embedded



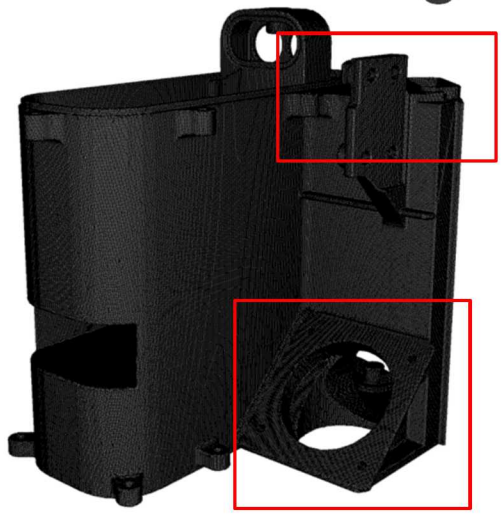
Smooth to geometry



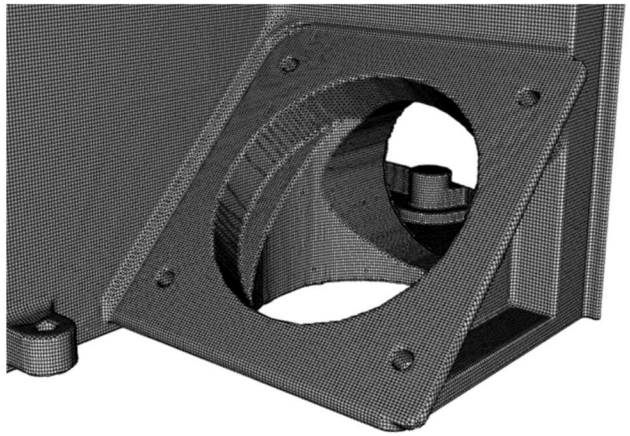
Sheets Inserted

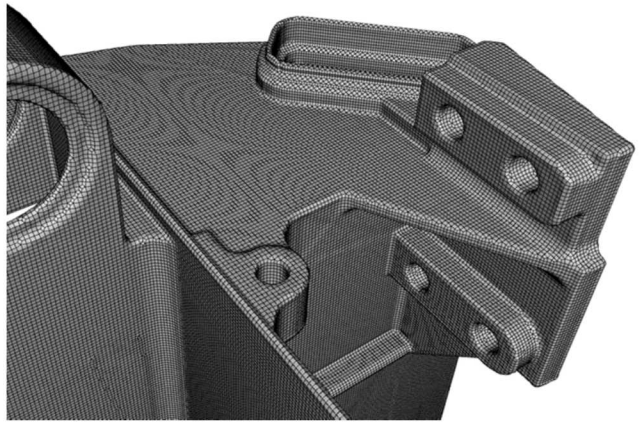


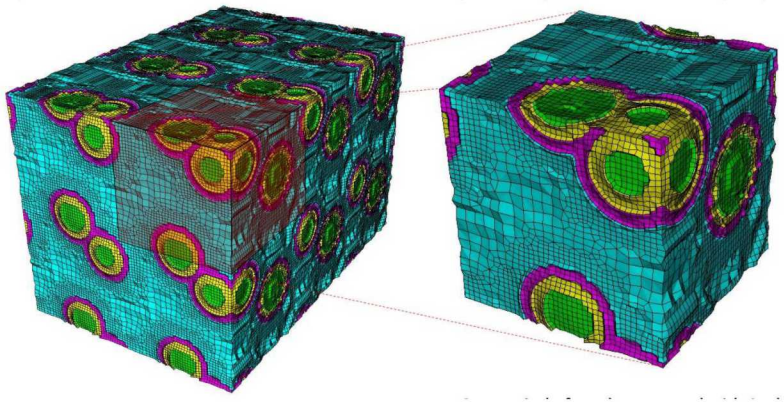
CUBIT Meshing



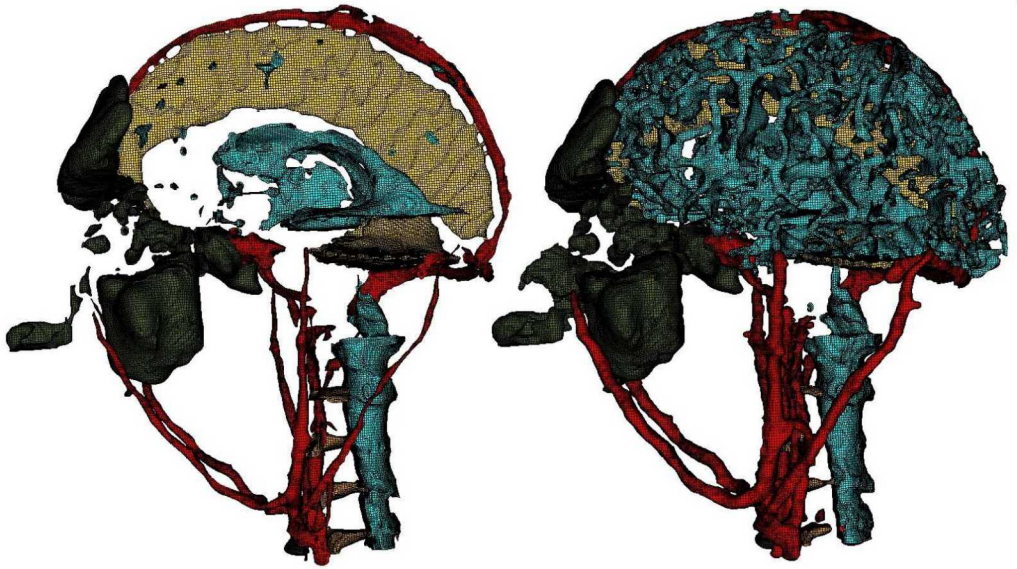
Mechanical Parts



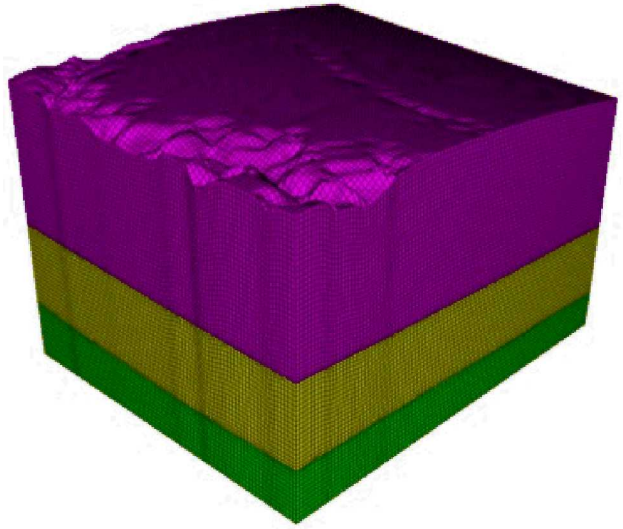




Molecular Modeling



Medical Imaging

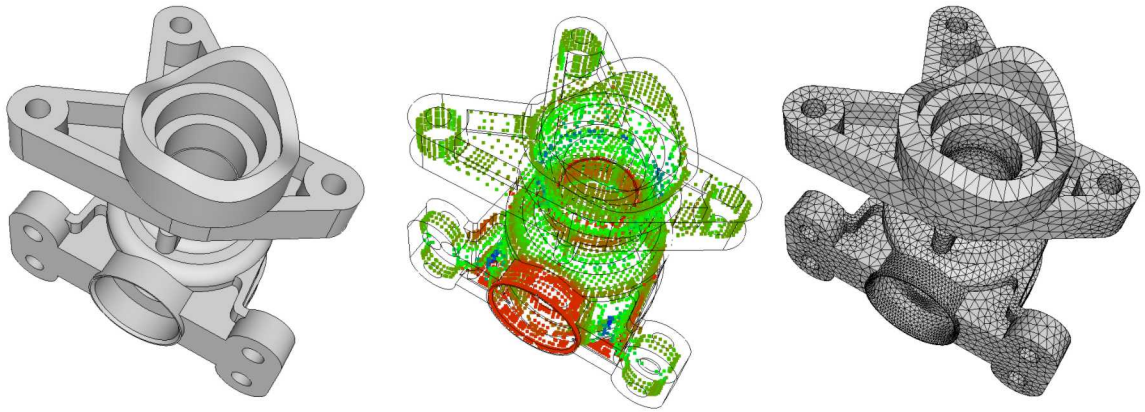


Geological models

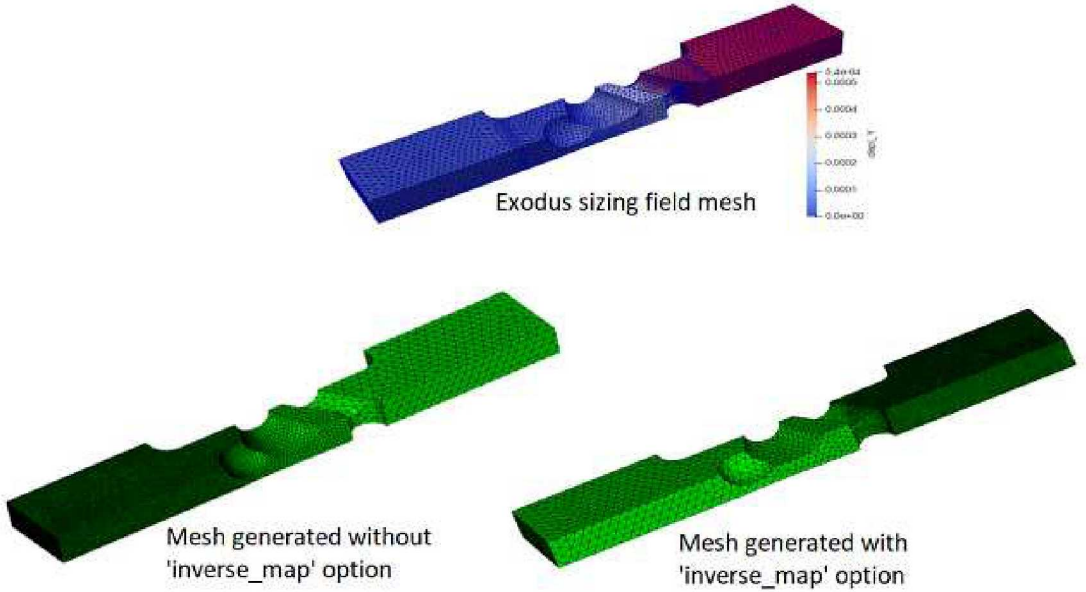
2009-2019

Sculpt – Parallel All-Hex Inline Mesh Generator

Cubit Meshing



Geometry Adaptive Mesh Sizing

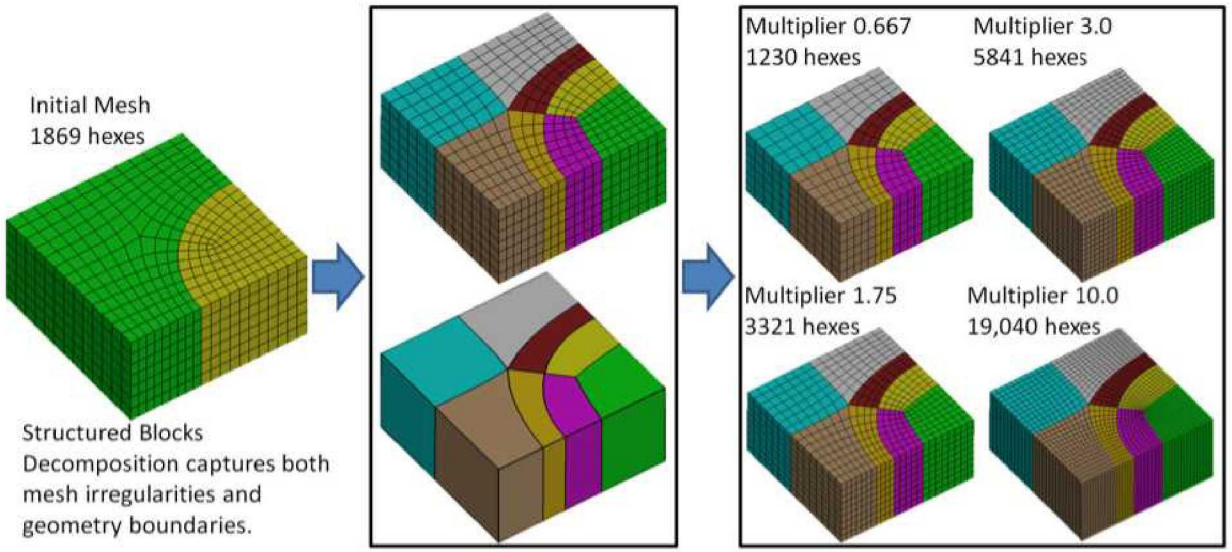


Physics-based Adaptive Remeshing

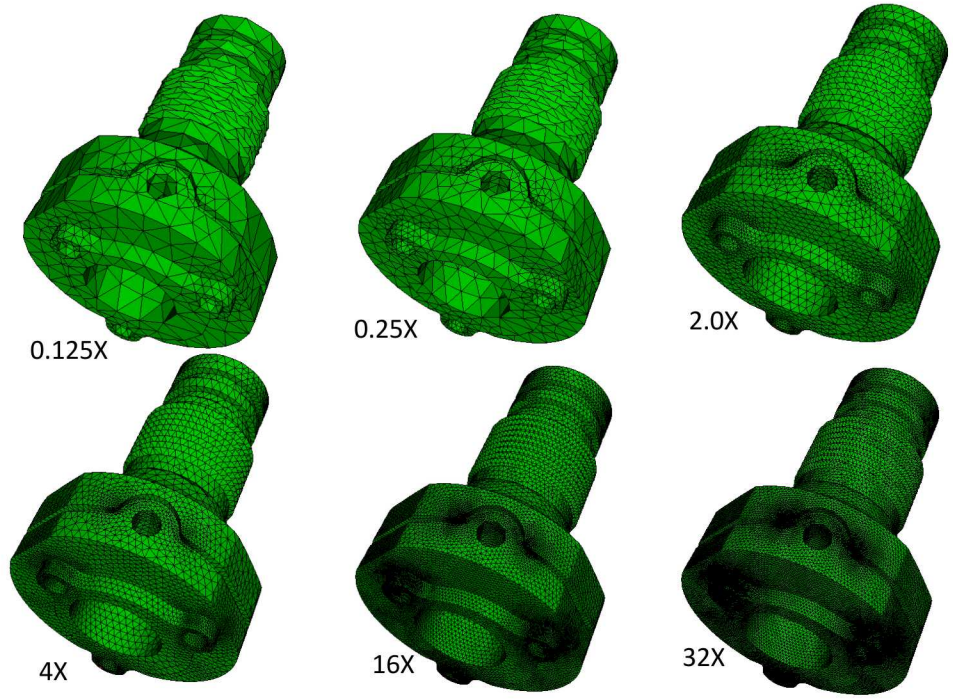
2005 – 2018

Mesh Sizing Framework

CUBIT Meshing

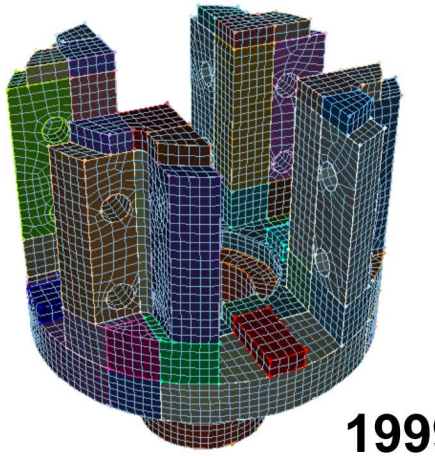


2016
Hex Mesh Scaling



2017
Tet Mesh Scaling

CUBIT Geometry

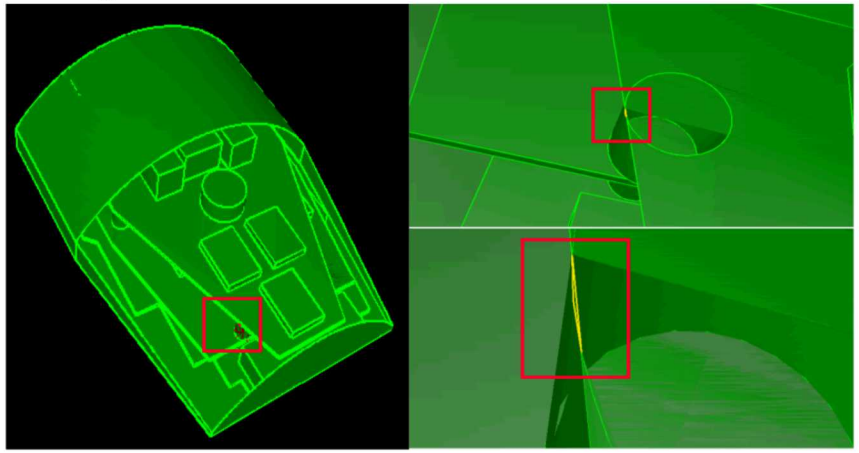


1999

Automatic Decomposition: Detects and decomposes geometry into sweepable parts

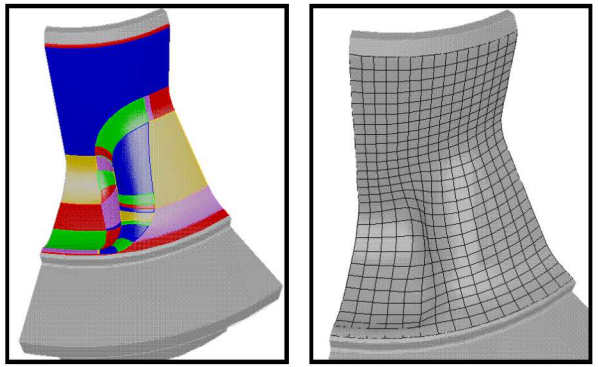
2000

Automatic Detail Suppression: An approach to detecting and removing small features in a CAD model



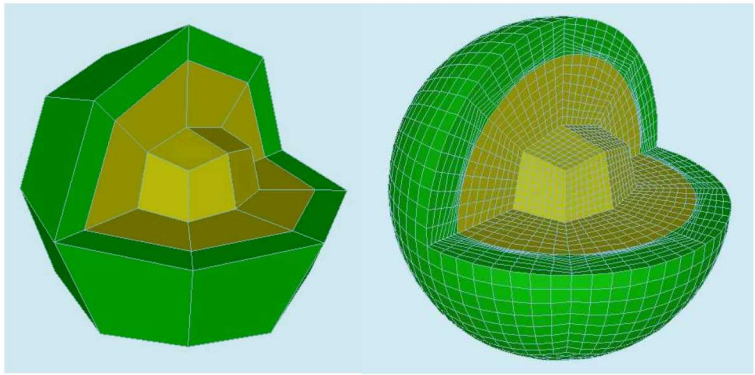
2002

Mesh-based Geometry: Creates a geometric model from a finite element mesh. Enables mesh improvement and design changes without CAD geometry



2001

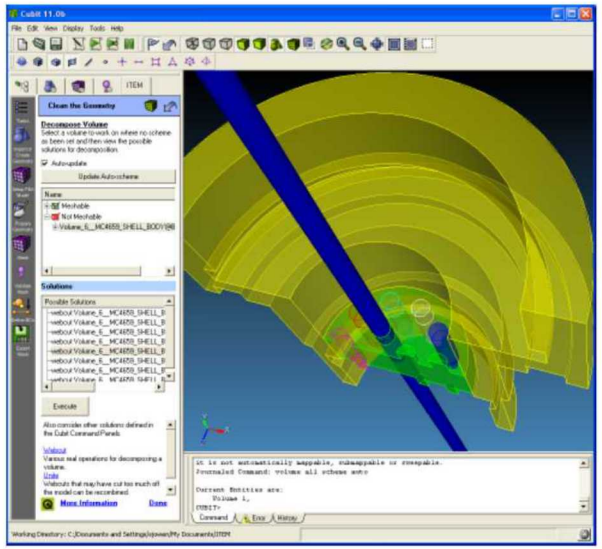
Virtual Geometry: Enables Composite and partitioned geometry to simplify mesh generation

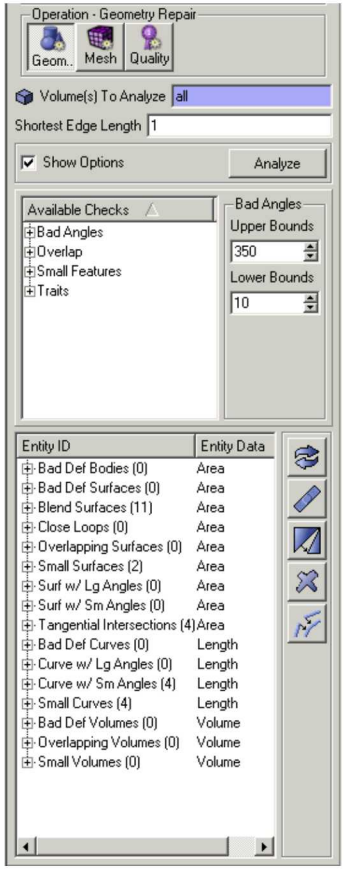


CUBIT Geometry

2005 & 2007

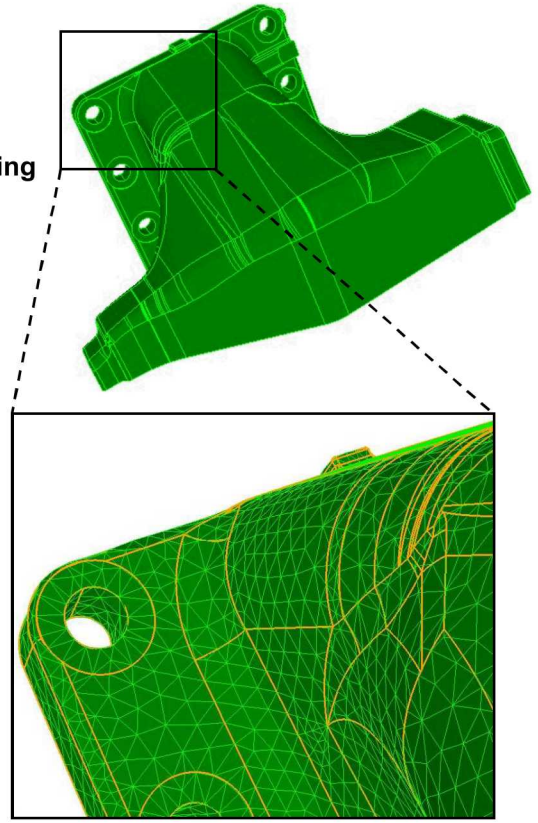
Geometry Power Tool & Immersive Topology Environment for Meshing (ITEM)





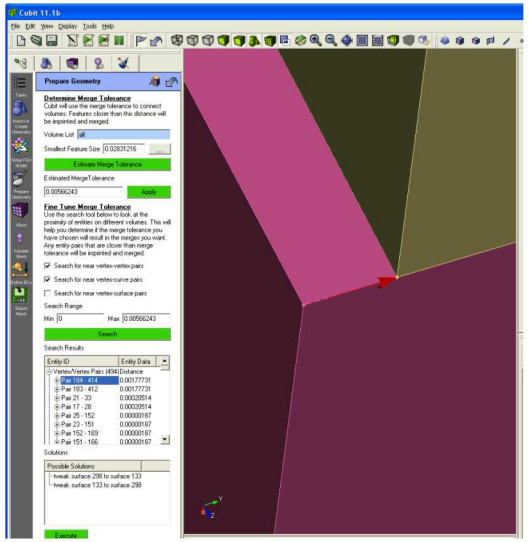
2009

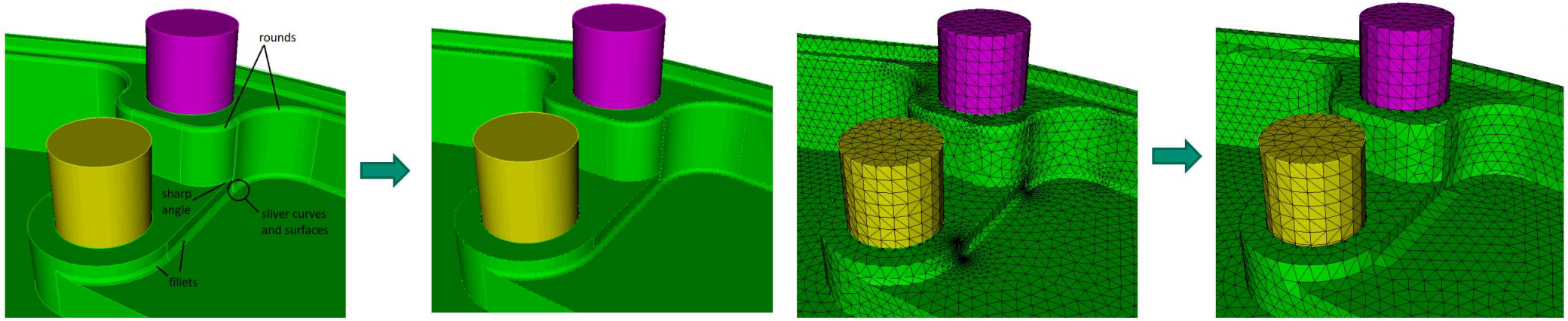
Geometry Tolerant Meshing



2006 & 2008

Tolerant Imprinting and User Tools





2018

Automatic Defeaturing via Massive Compositing

Outlook at Sandia

- Parallel Meshing for NGP
  - Morph parallel tetmesher in NGS
  - Sculpt enhancements
  - MeshGems parallel tetmesher Tetra-HPC
  - Lightweight uniform mesh refinement
- Address Geometry Issues
  - Scalable Geometric Modeler (SGM) - Open source geometric kernel
- Componentize to support Next Generation Simulation (NGS)