Meshing and Geometry (MG) Project
US Naval Research Laboratory
Washington DC

CAPSTONE: Providing Geometry, Meshing and Attribution for Physics-based Analysis and Design

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Motivation

Goal

Improve efficiency of DoD acquisition engineering by reducing time, cost and risks in research, development and sustainment of weapon systems

Approach

o Develop Next-Generation Computational Solvers & Optimizers
o Insert More (Multi) Physics-Based Analysis Earlier in the Design-Cycle

Critical Hurdles

Human Effort & Calendar Time to Produce an Analyzable Representation (Model) of a Design or System

Significantly more time is often spent in 'preparing' the input data needed by solvers than is used by the solvers to solve it.

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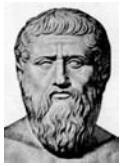
Geometry and Meshing Needs

"Let no one ignorant of geometry enter" - Plato



Geometry needs to be appropriate for analysis and meshing

- Valid
  - Dimensionally correct (1-,2-,3-D or mixed-dimension, non-manifold)
  - "Water-tight" (no gaps), non-self-intersecting
- Accurate
  - Match a shape to a given tolerance
  - Maintain the accuracy and rate of convergence of the solvers/code

Meshing needs to be appropriate for physics and discretization

What takes time and effort ?

- Geometry repair/clean-up
- De-featuring (geometry good for Physics A is not suitable for Physics B)
- Lack of automation and robustness in meshing (all-hex, complex boundary layers)
- Attribution, multi-component model preparation

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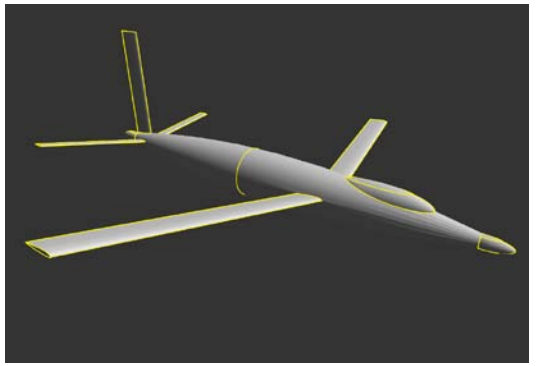
CAPSTONE – CREATE-MG Product Overview

CAPSTONE provides geometry and meshing needs for all phases of acquisition engineering (conceptual-, preliminary-, detailed-design and operational-support)

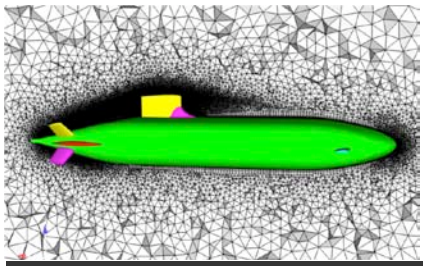


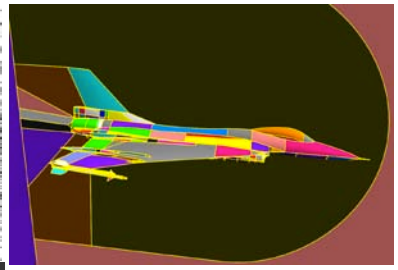
CAPSTONE: Core

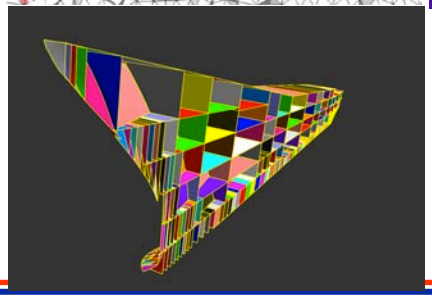
Enable parametric, associative geometry and meshes in AV:DaVinci, Ships:RDI; *geometry-based mesh adaptivity*

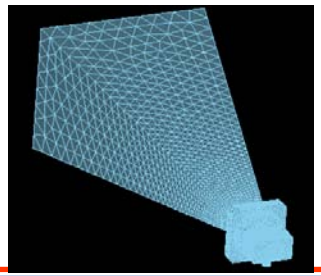
CAPSTONE: Frontend

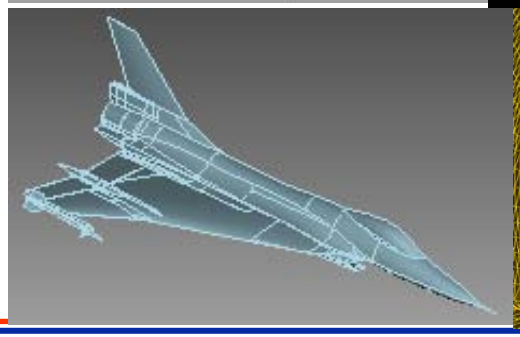
Produce analyzable representations for complex and detailed analysis

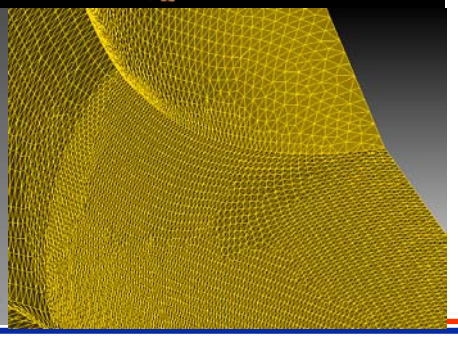












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CAPSTONE User Types

User Type

- Analysis Data Modeler
  - End-user who creates analysis-suitable mesh from geometry which may be
    - imported from existing (legacy) description
    - created from scratch
  - Not expected to be a developer (programmer)
  - Typical example- bench-engineer (analyst) doing
    - analysis of existing aircrafts for specific maneuvers
    - analysis of shock damage for a ship configuration
    - analysis of complex antenna systems

- Design Tool Creator
  - Users (team) producing a tool (environment) for rapid evaluation of conceptual/early designs
  - Expected to be developers (programmers)
  - Typical examples would be AV-DaVinci and Ships-RDI team

- Analysis Code Developer
  - Developers of physics-based CBE analysis tools
  - Expected to be developers (programmers)
  - Typical uses- geometry-based a-posteriori adaptive-analysis

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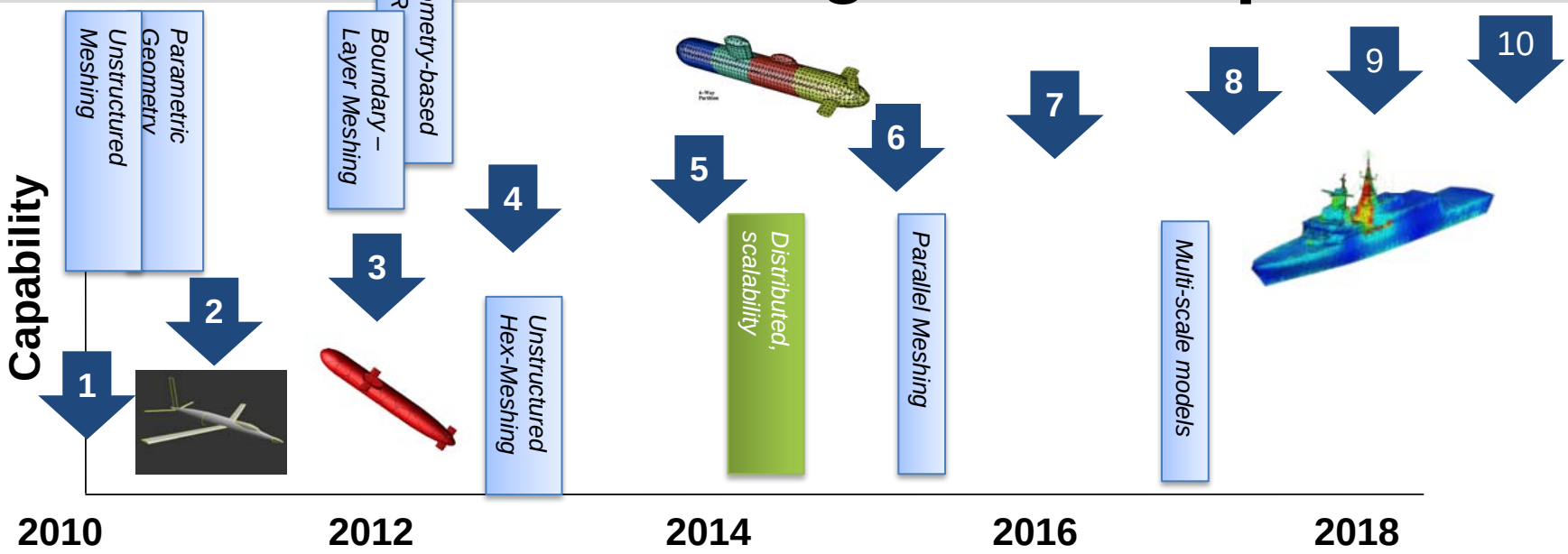
CAPSTONE
Four Stage Roadmap



Start up

FY08 – ICD, planning, team formation

FY09 – Evaluate legacy tools; early prototype

Initial Capability For AV, RF and Ships

FY10 – v1.0; Foundational capabilities, mesh implant

FY11 – v2.0; BL meshing, repair, complex parametric geometry

FY12 – v3.0; geometry-based AMR, advanced repair, complex BL, Improved rendering

FY13 – v4.0; ultra-large distributed mesh representation, hex meshing; scripting interface

Scaling Improvement

FY14 – v5.0; Re-factor/optimize for distributed scalability

FY15 – v6.0; Parallel meshing

FY16 – v7.0; Multi-scale representations

Full-scale Deployment

FY17 – v8.0; Improved robustness for large-scale problems

FY18 – v9.0; Support multi-physics, multi-disciplinary models

FY19 – v10.0; Improve robustness

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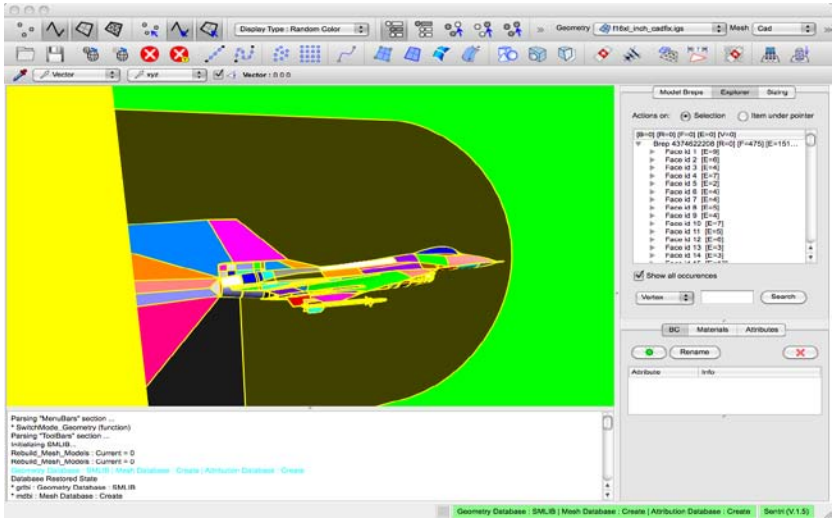
CAPSTONE 1.0 Capabilities (FY10)

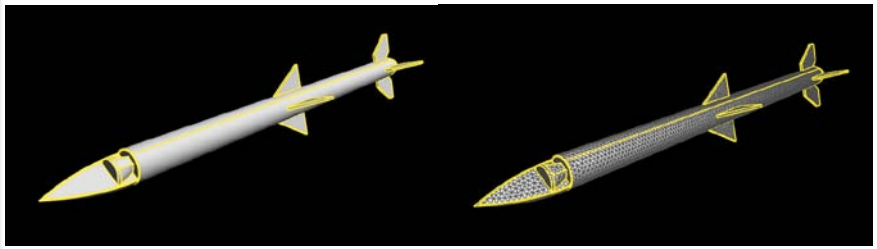
Geometry Module

- CAD-Neutral
- Create geometry from scratch
- Import existing IGES, STEP format
- Repair, clean-up



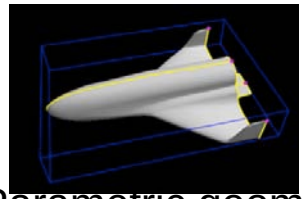
Mesh Module

- Automated unstructured surface and volume mesh generation
- Mesh quality optimization
- Automated implant of components

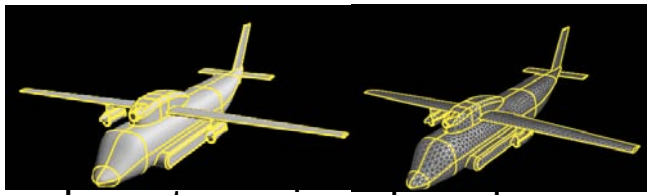


Attribution Module

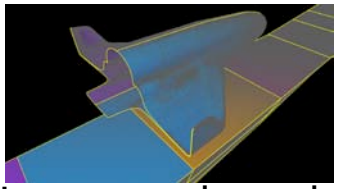
- Mesh sizing based on sources, curvature, topology and proximity
- Geometry-associative attribution of analysis properties



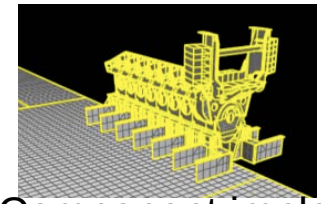
Parametric geometry



Import, repair and meshing



Large mesh models



Component implant

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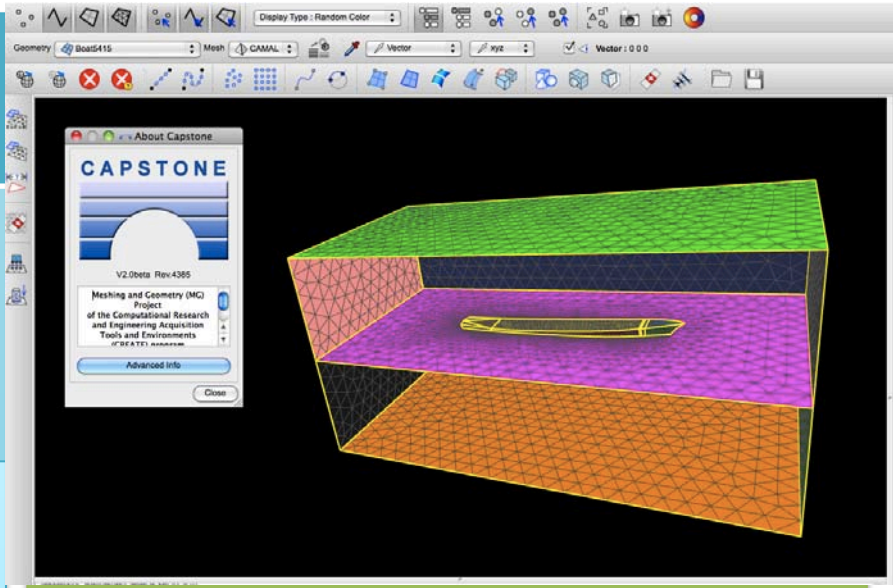
CAPSTONE 2.0 Capabilities

Geometry Module
- **Native support for Parasolid kernel**
- **Improved geometry repair and clean-up**

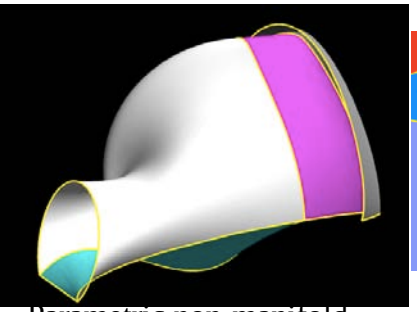
Mesh Module
- Automated boundary layer meshing
- Periodic and curvilinear meshes
- Local mesh optimizations
- Automated implant of components

Attribution Module
- Mesh sizing based on sources, curvature, topology and proximity
- Geometry-associative attribution of analysis properties
- Export to CREATE AV, RF and Ships solvers

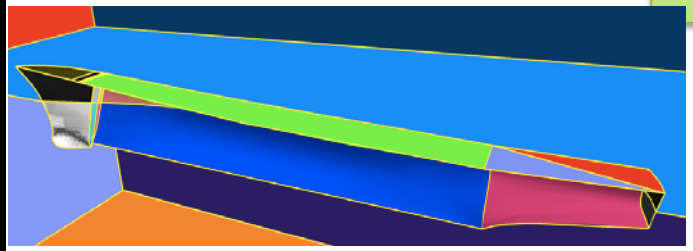


CAPSTONE 2.0 planned release Oct 15, 2011

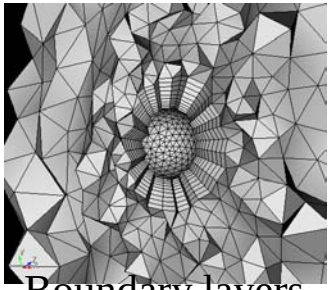
https://portal.create.hpc.mil/mg/index.php



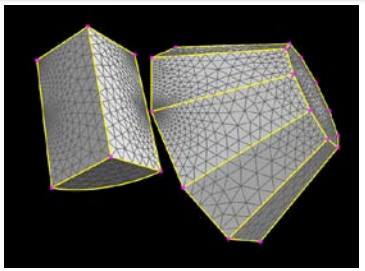
Parametric non-manifold geometry



Improved repair and cleanup



Boundary layers



Periodic Meshing

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