ANSYS Fluent Mosaic Meshing for CFD Simulation

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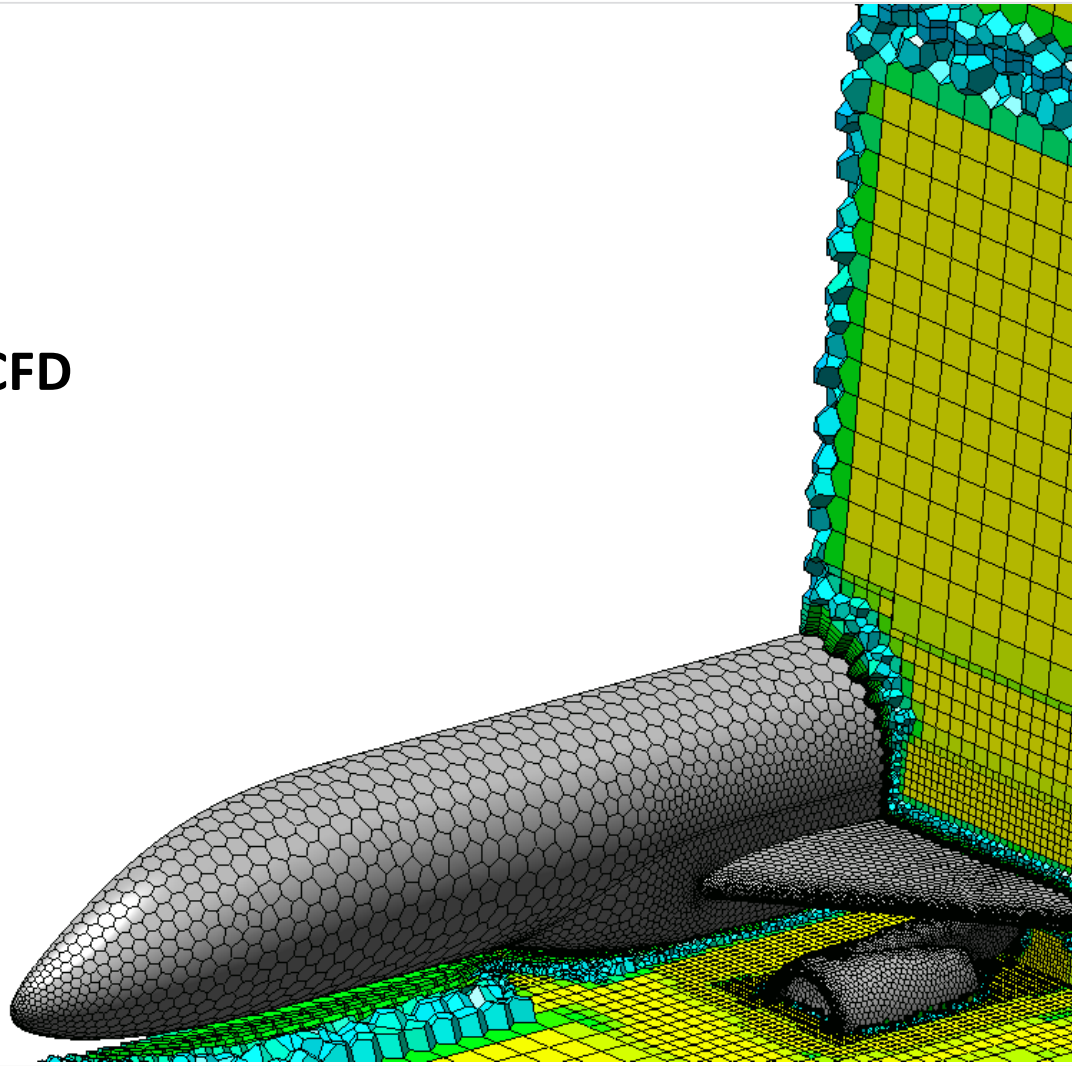
Advanced Modeling & Simulation (AMS)Seminar Series
NASA Ames Research Center, April 4, 2019

Agenda

- Introduction to ANSYS
- Mosaic Meshing Technology for CFD
- Beyond Meshing
- Discussion / Q&A



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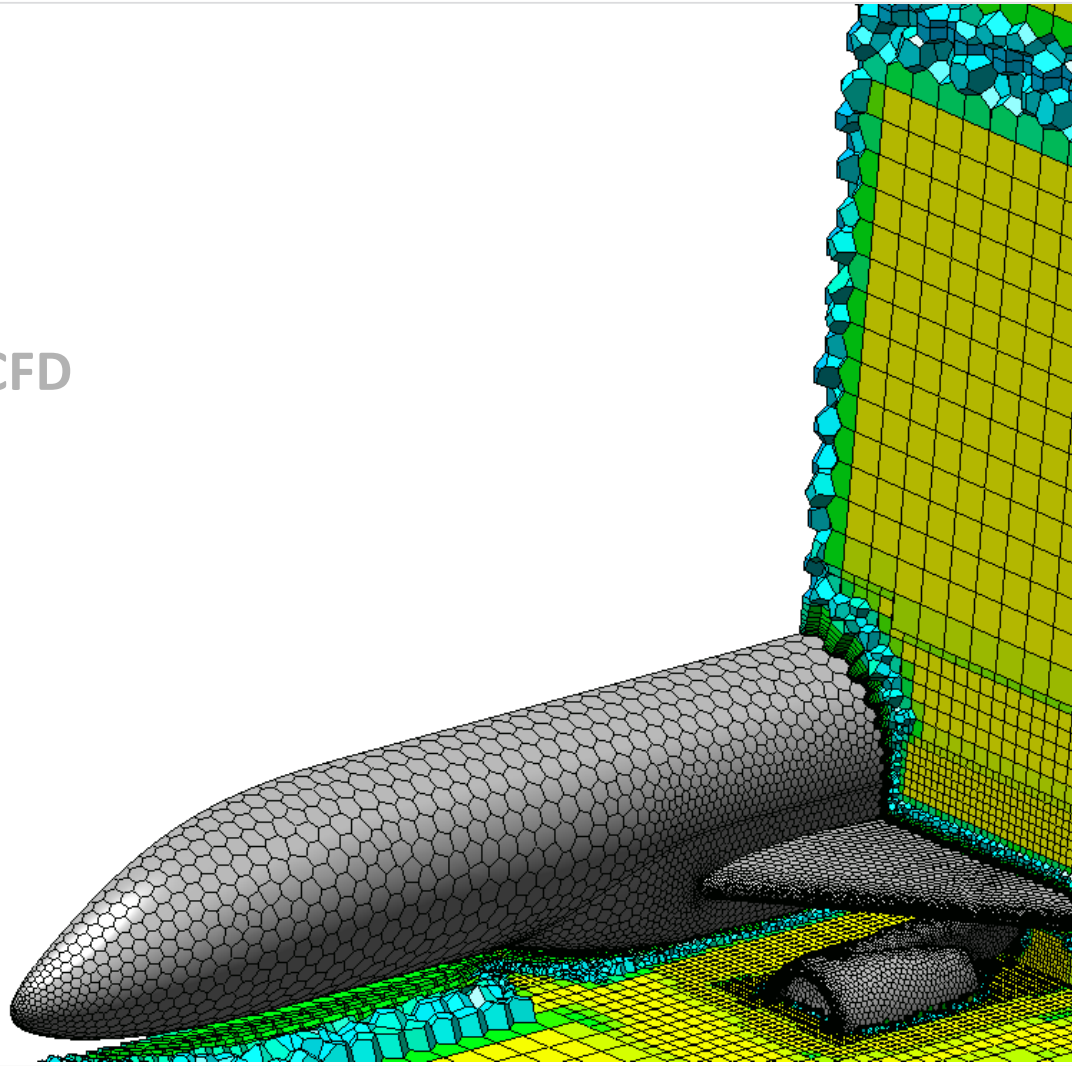


ANSYS Solutions for Multiphysics Simulation

Technical Breadth

Technical Depth

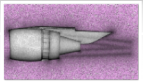
SOLIDWORKS CATIA AUTOCAD NX **CAD** SPACECLAIM PTC Pro/ENGINEER INVENTOR **ECAD**

Tet/Prism/Polyhedral
Hex/Poly Hex-Core

Structured
Unstructured

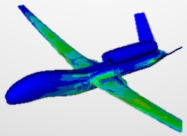
Meshing

Multi-zone
Body-fitted Cartesian

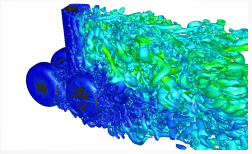


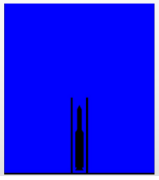
Mosaic
Patch conforming/ind.

Structures

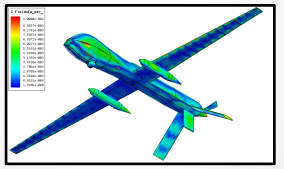


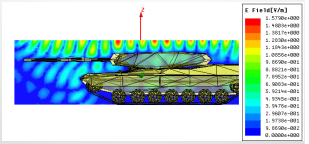
Fluids





Electromagnetics





Integrated Simulation Environment within ANSYS Workbench
Streamlined Workflow – Automation – True Multiphysics

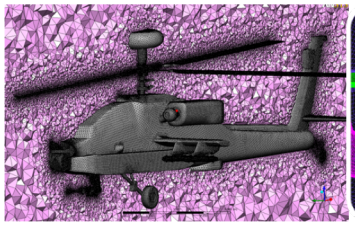
ANSYS Fluent for CFD Simulation

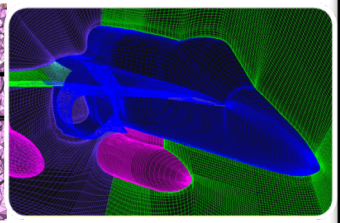
ANSYS Fluent Solver

- Navier-Stokes equations

$$\frac{\partial}{\partial t}\int_V \boldsymbol{W}\,dV + \oint [\boldsymbol{F}-\boldsymbol{G}]\cdot d\boldsymbol{A} = \int_V \boldsymbol{H}\,dV$$

- Cell-centered finite-volume formulation
- Pressure-based and density-based solvers
- RANS and SRS turbulence models
- Heat transfer, multiphase, reacting flow
- Mesh adaption, Overset and MDM
- Adjoint solver
- 6DOF solver
- HPC
- Structured and unstructured meshes

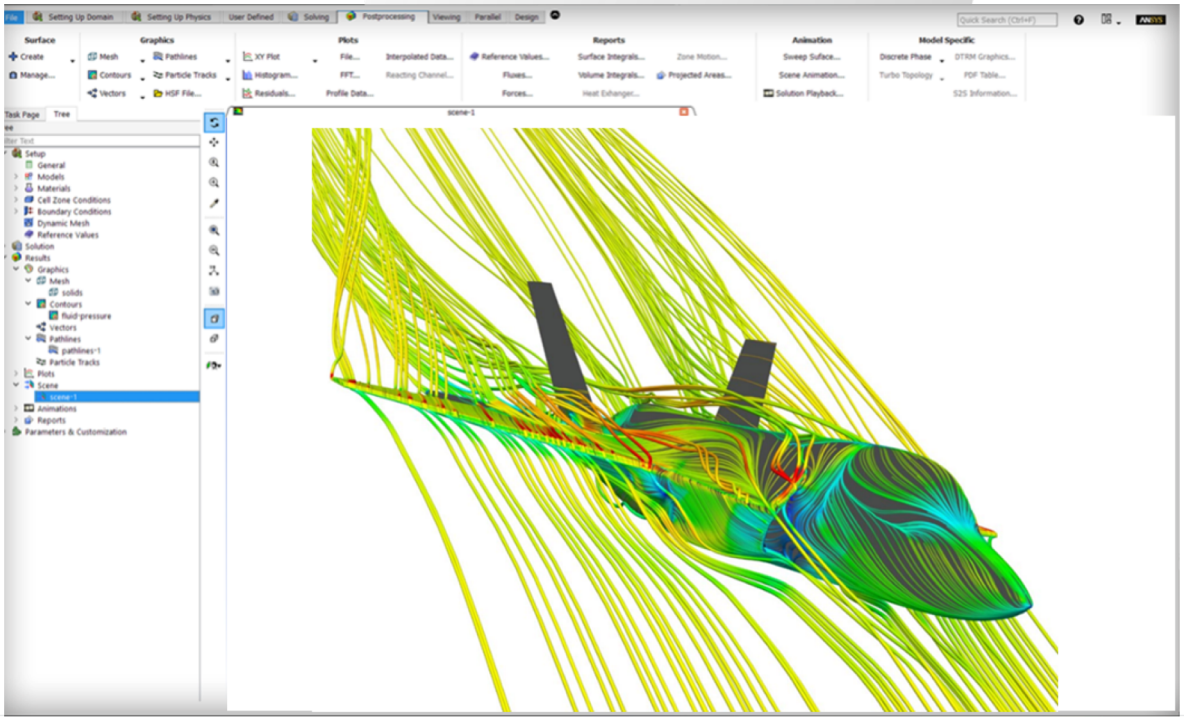




ANSYS Fluent

A New Fluent Experience

ANSYS 19.2: Single-window, task-based workflow with Mosaic-enabled Meshing



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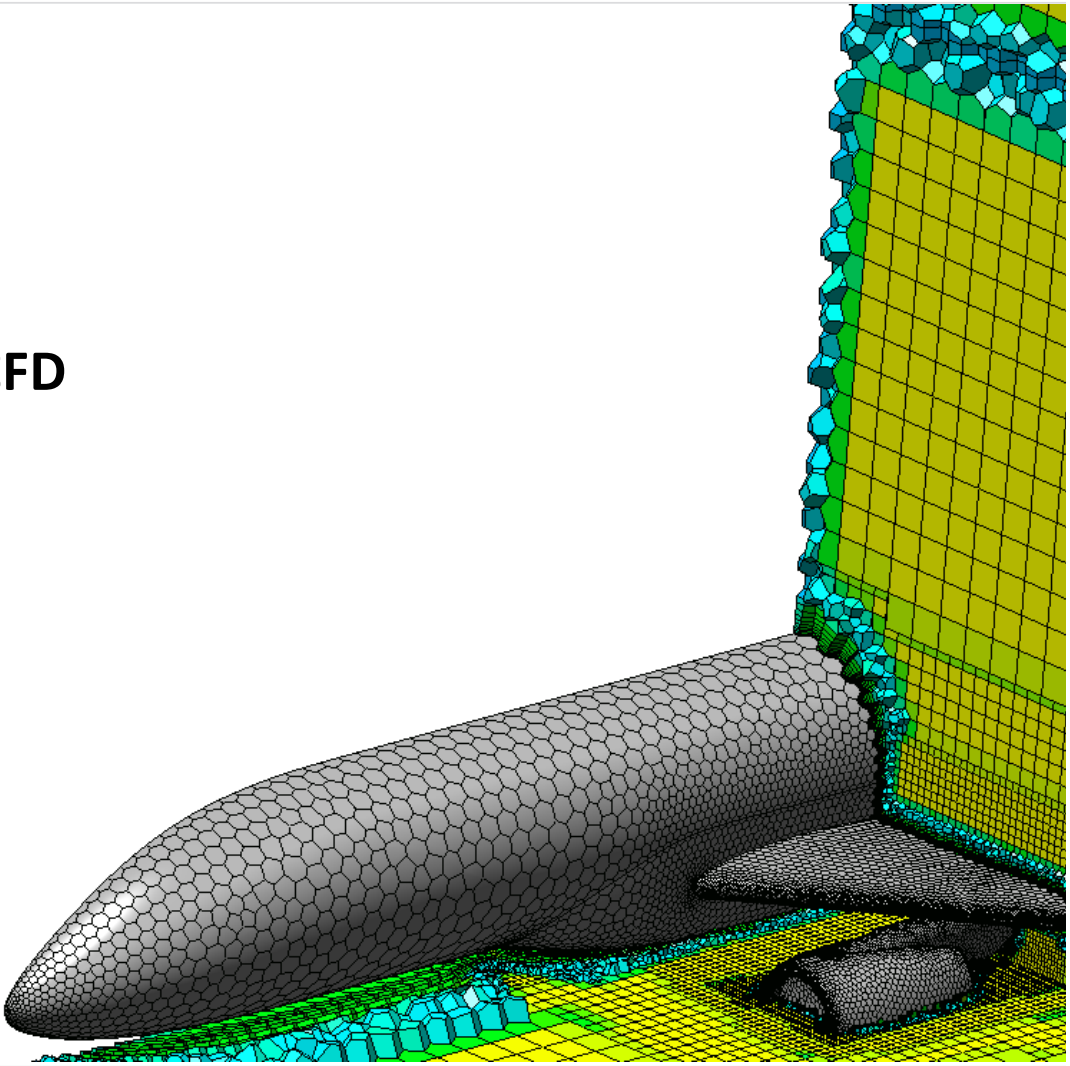
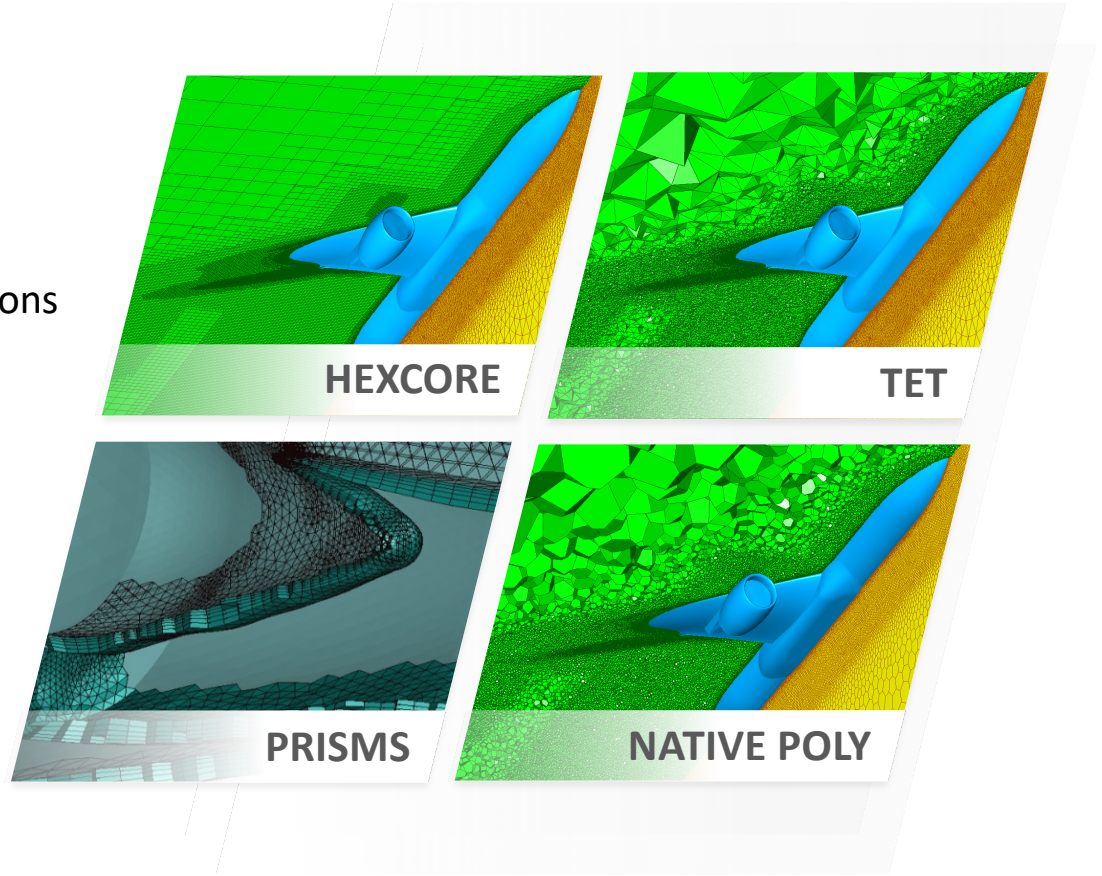


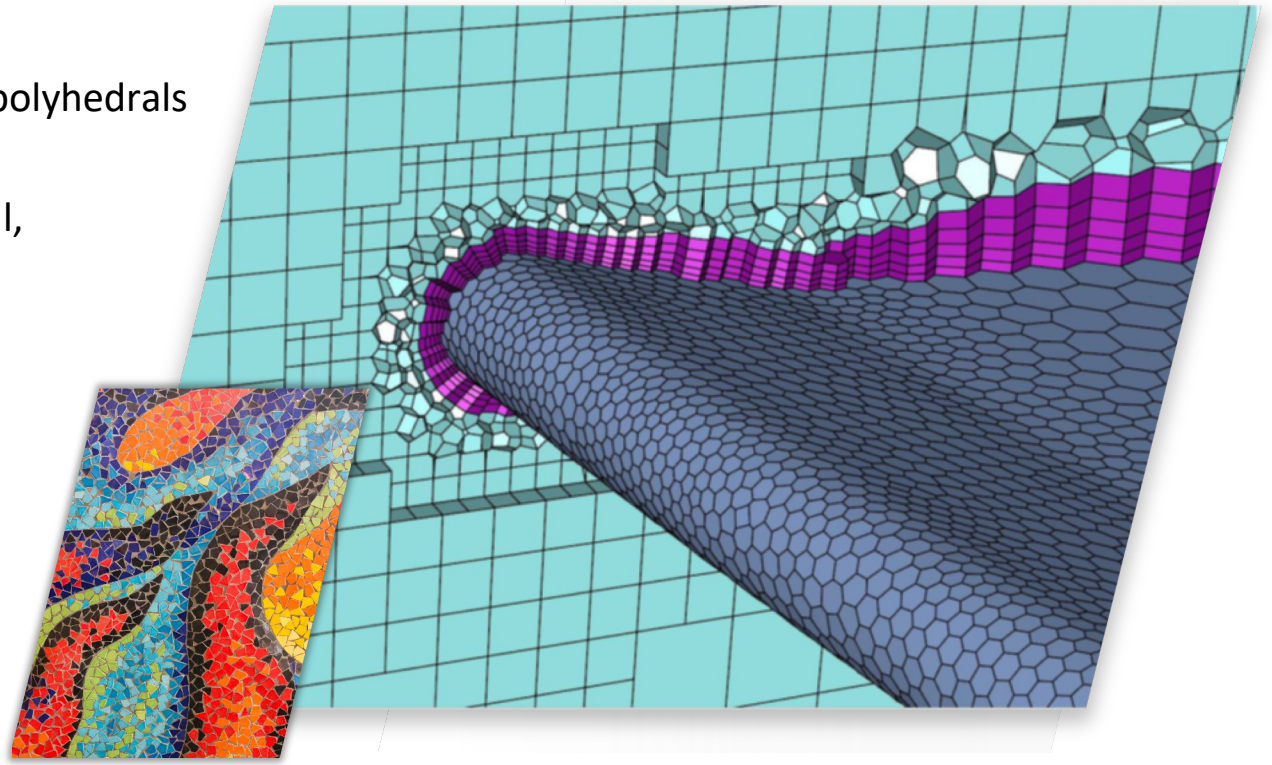
Accuracy and solution time are highly dependent on the mesh

- Various geometries and flow regimes require different meshes
- But there's no good solution for mesh transitions
  - Reduced mesh quality
  - Excessive cell counts
- Forced to compromise on a common element type to minimize mesh transitions



Mosaic™ technology automatically combines disparate meshes with polyhedral elements for fast, accurate flow resolution

- Connects all element types using polyhedrals
  - Surface: triangle, quad, polygon
  - Volume: hexahedral, tetrahedral, pyramid, prism
- Always a conformal connection
- Patent pending



Mosaic Meshing Technology

Poly Prism

✓ High quality

✓ Significantly fewer cells than tri-prisms

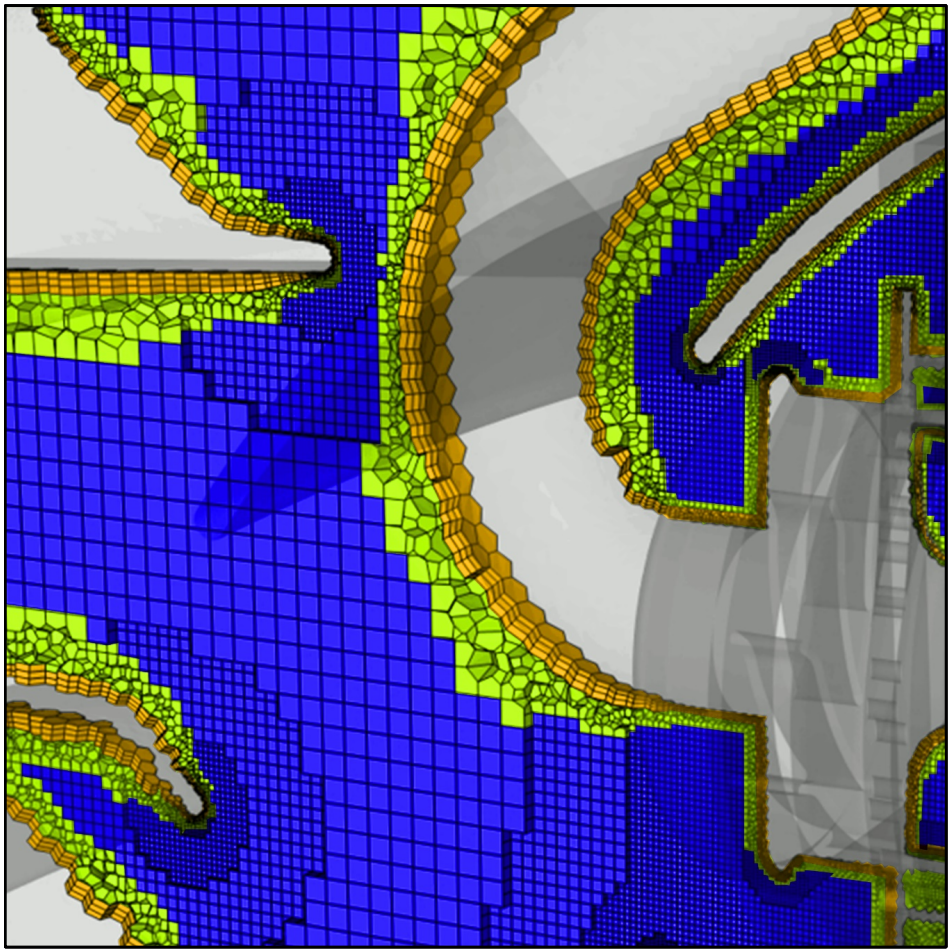
Hexcore

✓ High quality

✓ Fast solve time

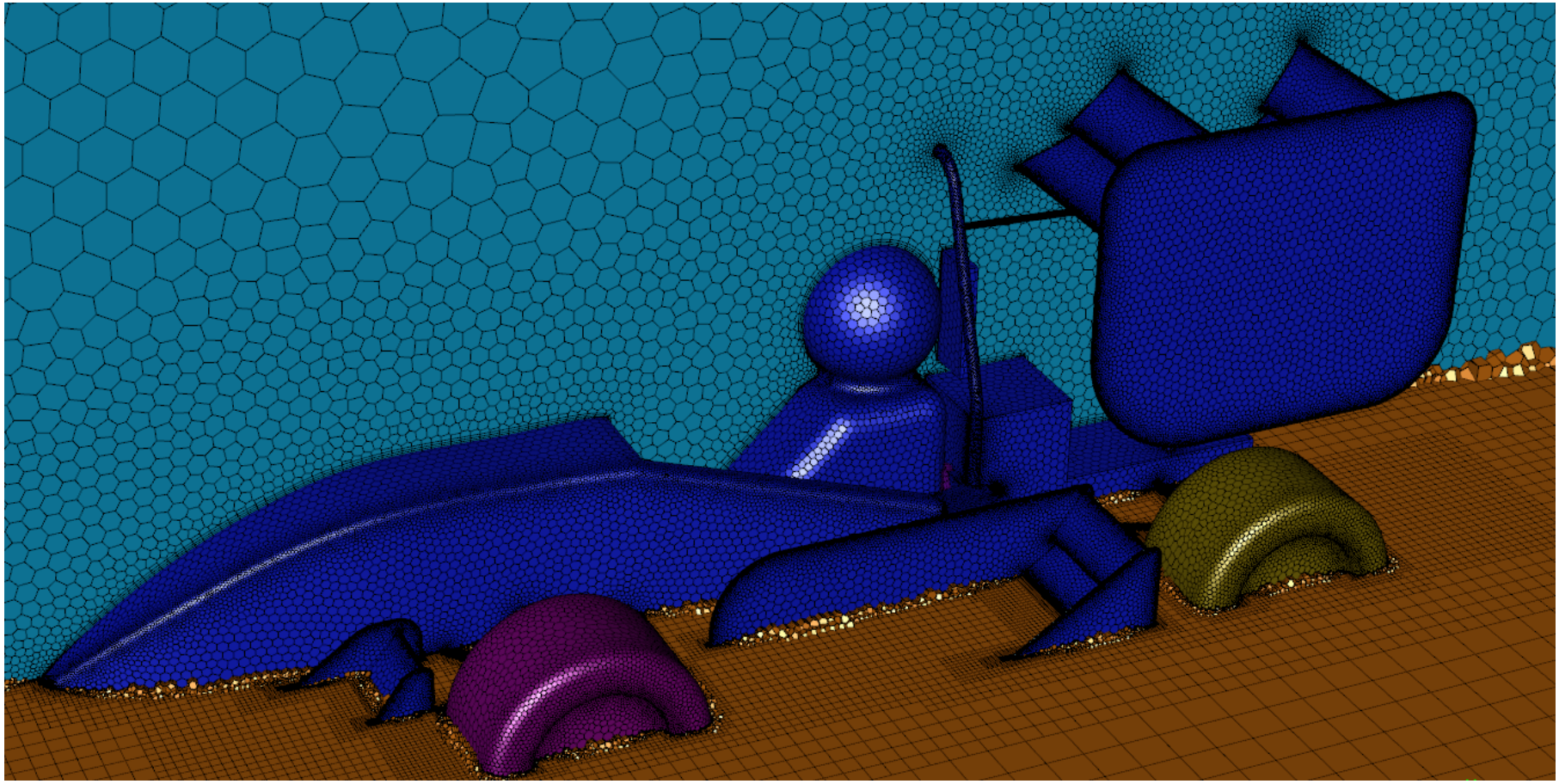
***New:* Mosaic Technology**

✓ *Conformally connects poly prisms to hexcore*

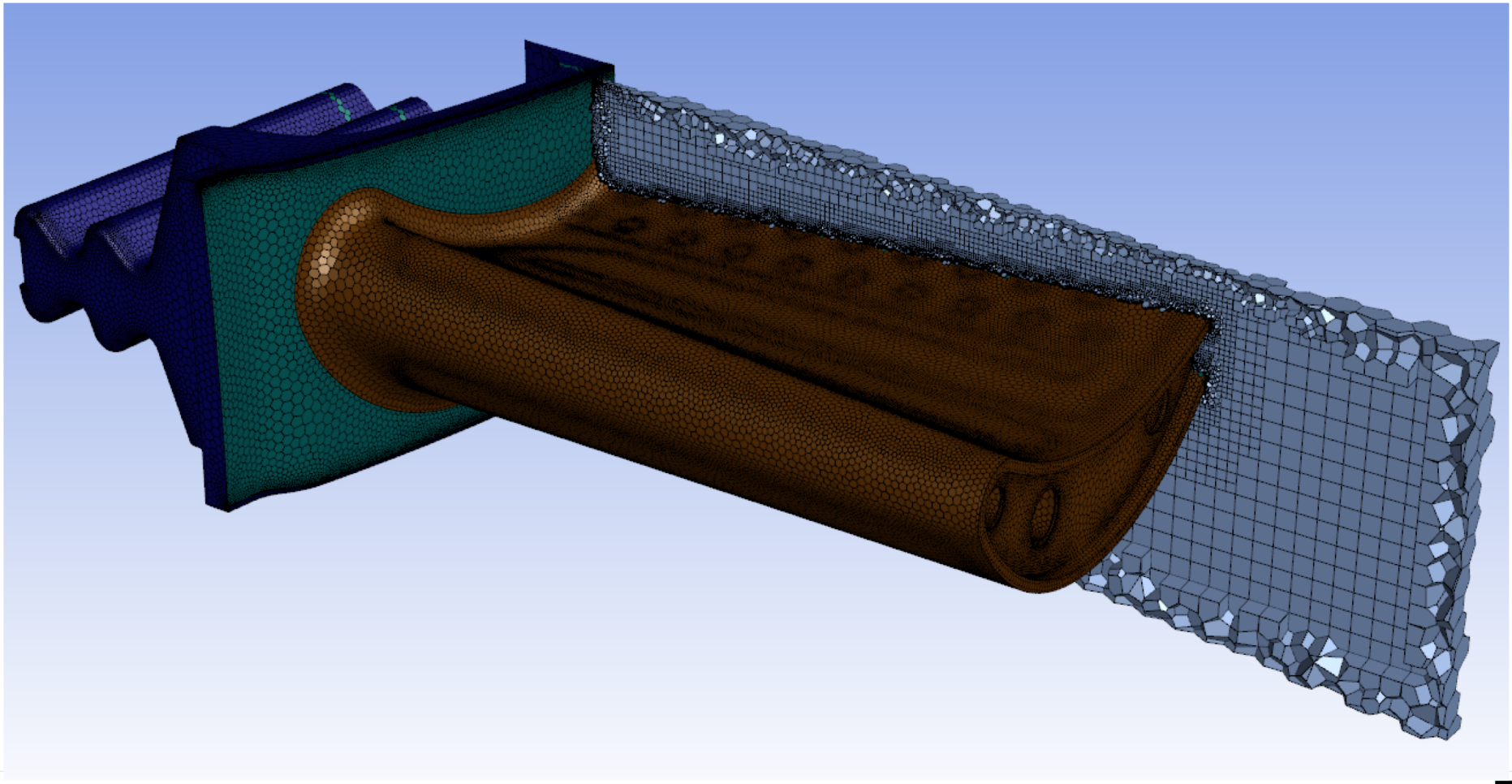


….also full tet-mesh, hexcore-mesh or poly-mesh with or without boundary-layer prisms

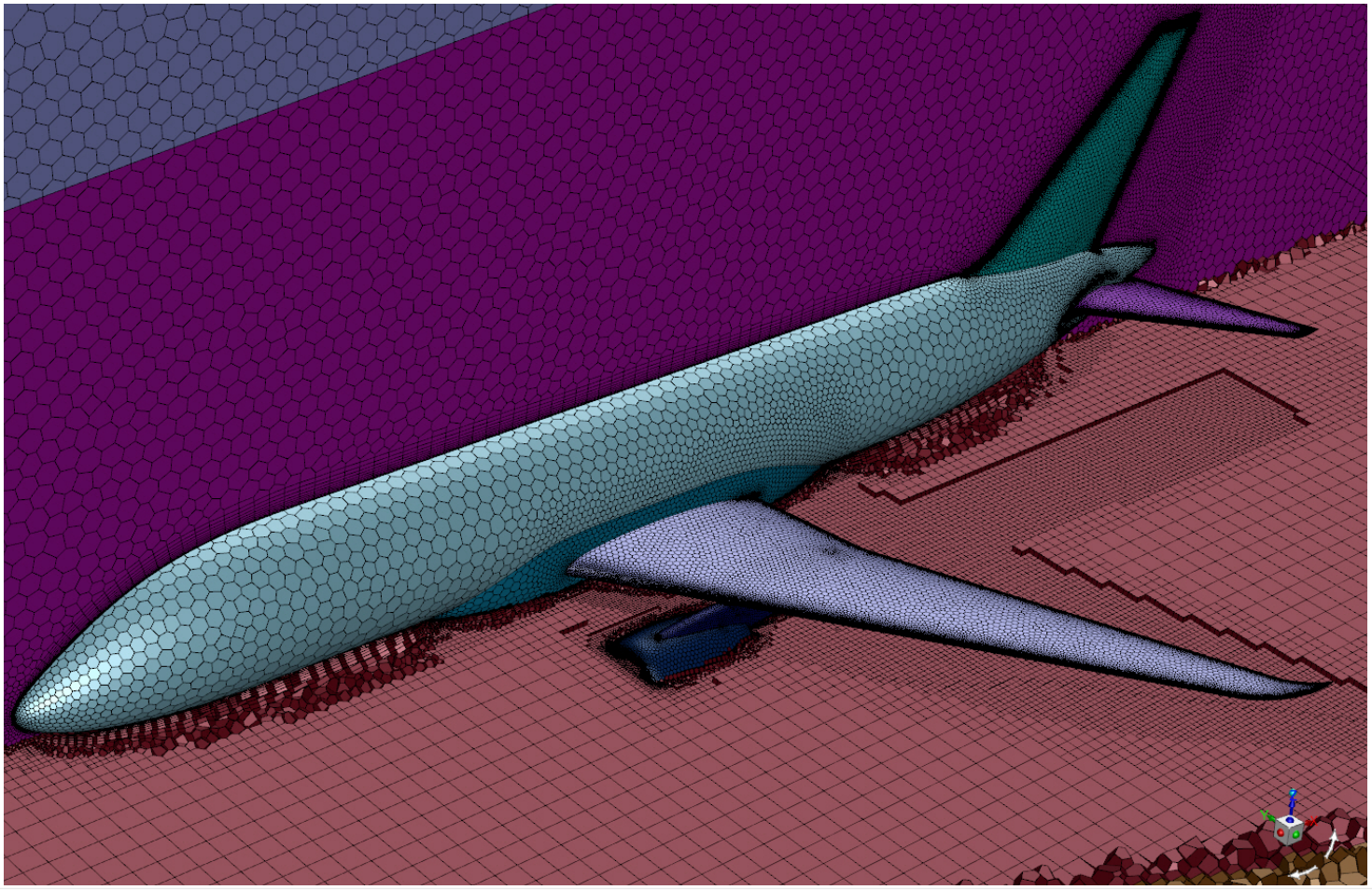
Example: Race Cart



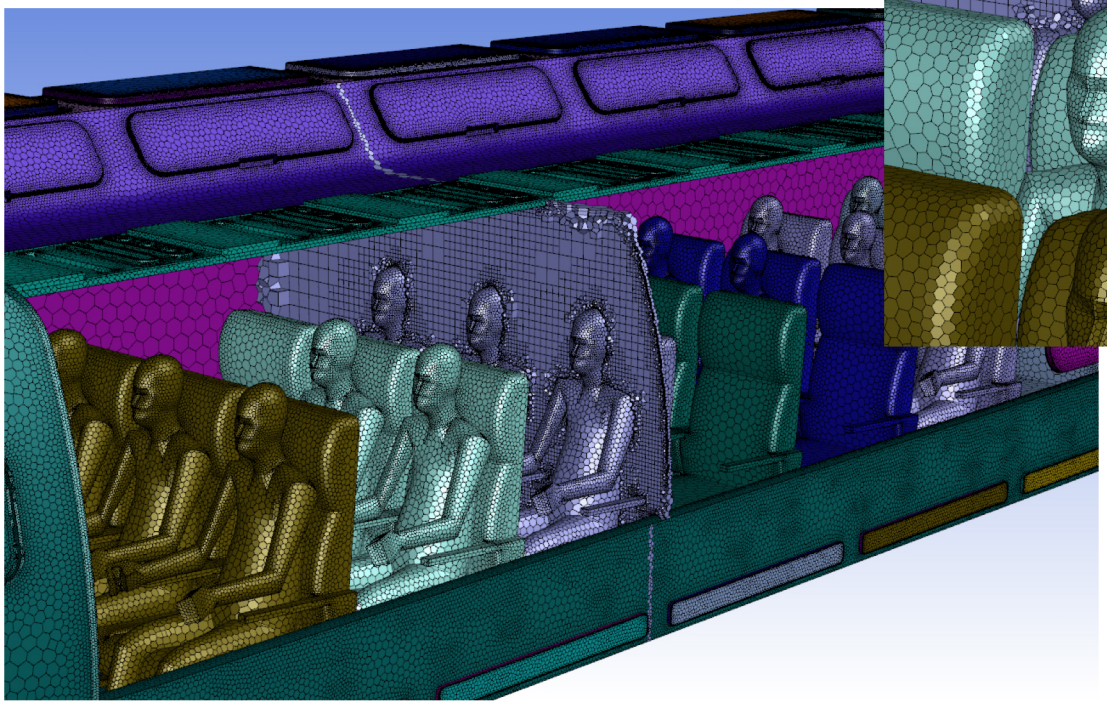
Example: Turbine Blade

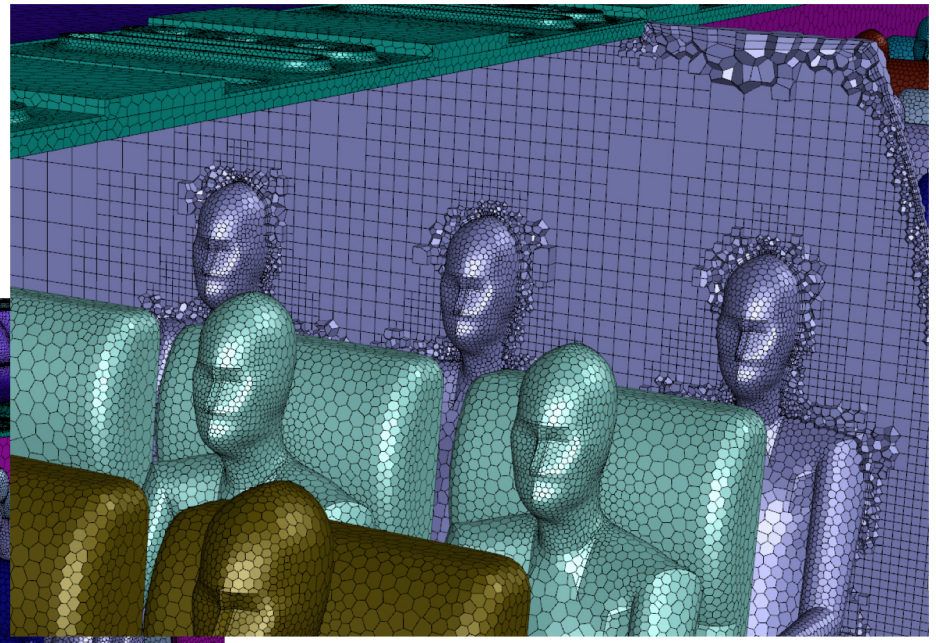


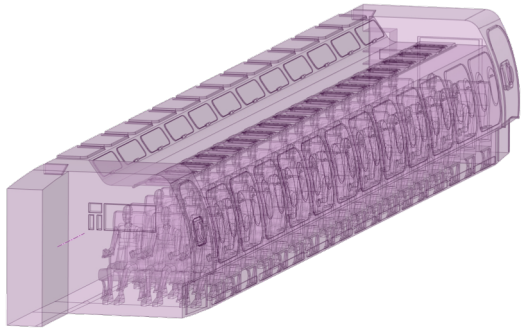
Example: Aircraft



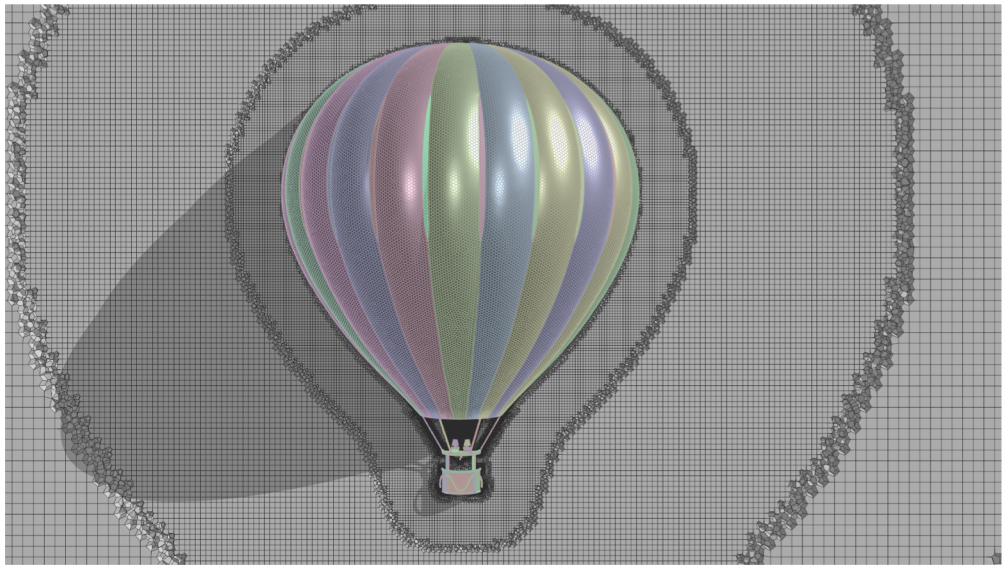
Example: Aircraft Cabin



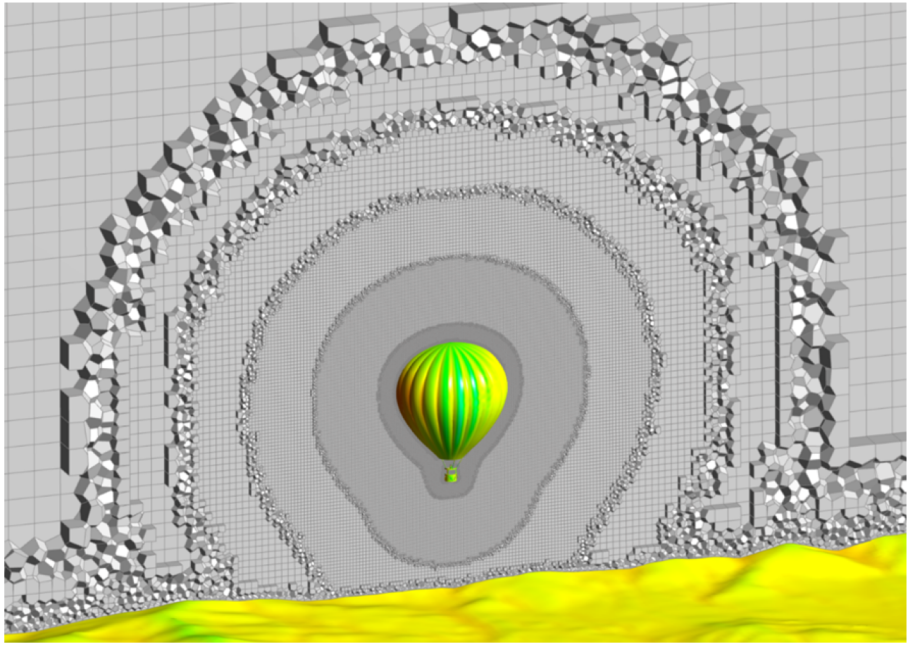




Example: Hot Air Balloon

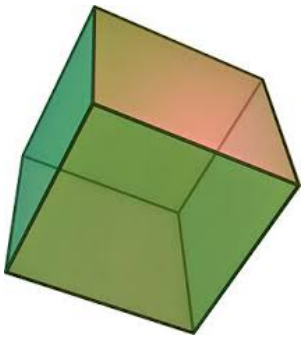


Mosaic Conformally Connects 1:8 Hexcore Mesh

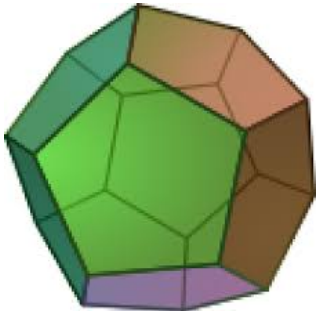


Why Does Element Type Matter?

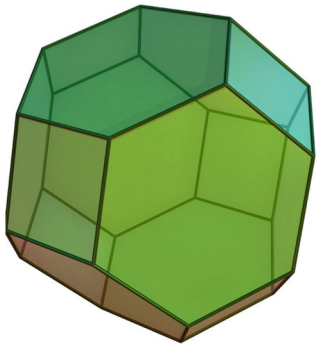
- Hex element has 6 faces, Poly element has 12 faces
  - Fluent solver scales with the number of faces so runs faster on Poly-Hexcore mesh compared to all Poly mesh
- Hex elements are aligned with x/y/z axis, resulting in higher solver efficiency and accuracy
- Up to 2x solution time speedup with Poly-Hexcore mesh compared to all Poly mesh



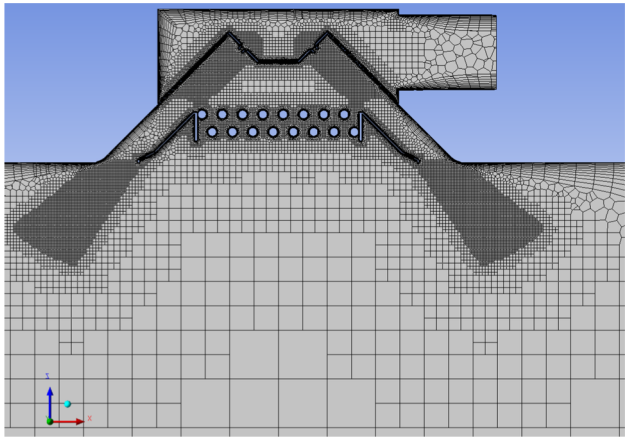
Hex – 6 faces



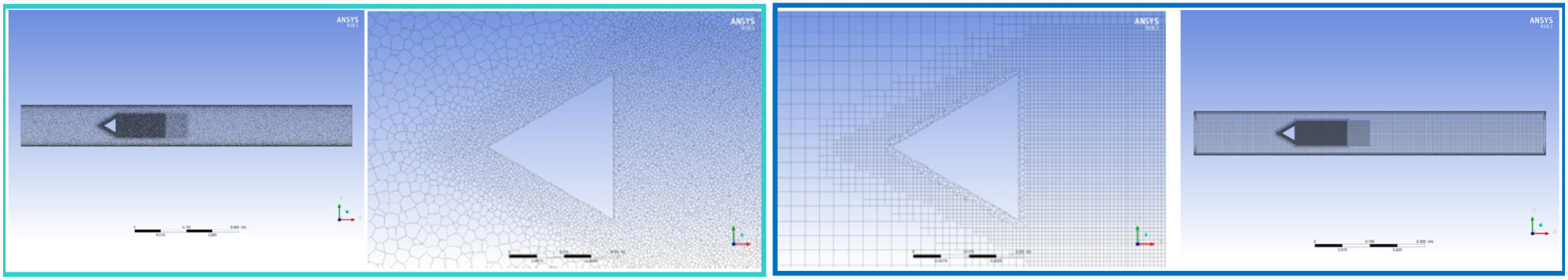
Polyhedra – 12 faces



Octahedra – 14 faces

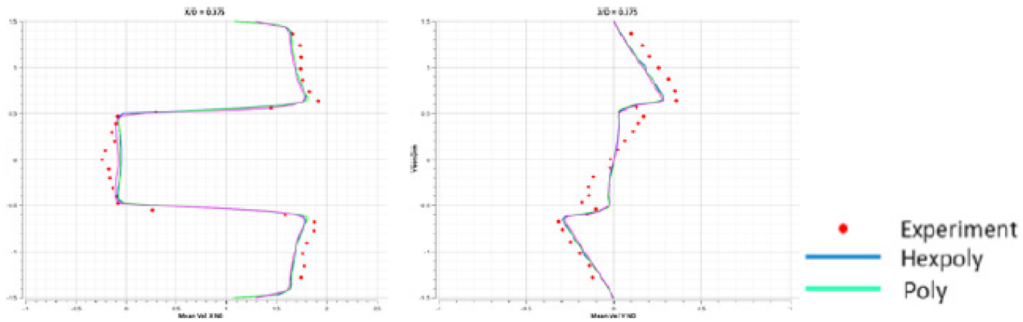


Mosaic Poly-Hexcore Mesh Benchmark: Volvo Flameholder



All polyhedral mesh (left) and Poly-Hexcore mesh (right)

"Sjunnesson A, Nelsson C, and Max E, LDA Measurements of Velocities and Turbulence in a Bluff Body Stabilized Flame, 4th International Conference on Laser Anemometry – Advances and Applications, ASME, Cleverland, August 1991"



Mean X velocity (left) and mean Y velocity (right) for all polyhedral and Poly-Hexcore simulations versus physical experiments

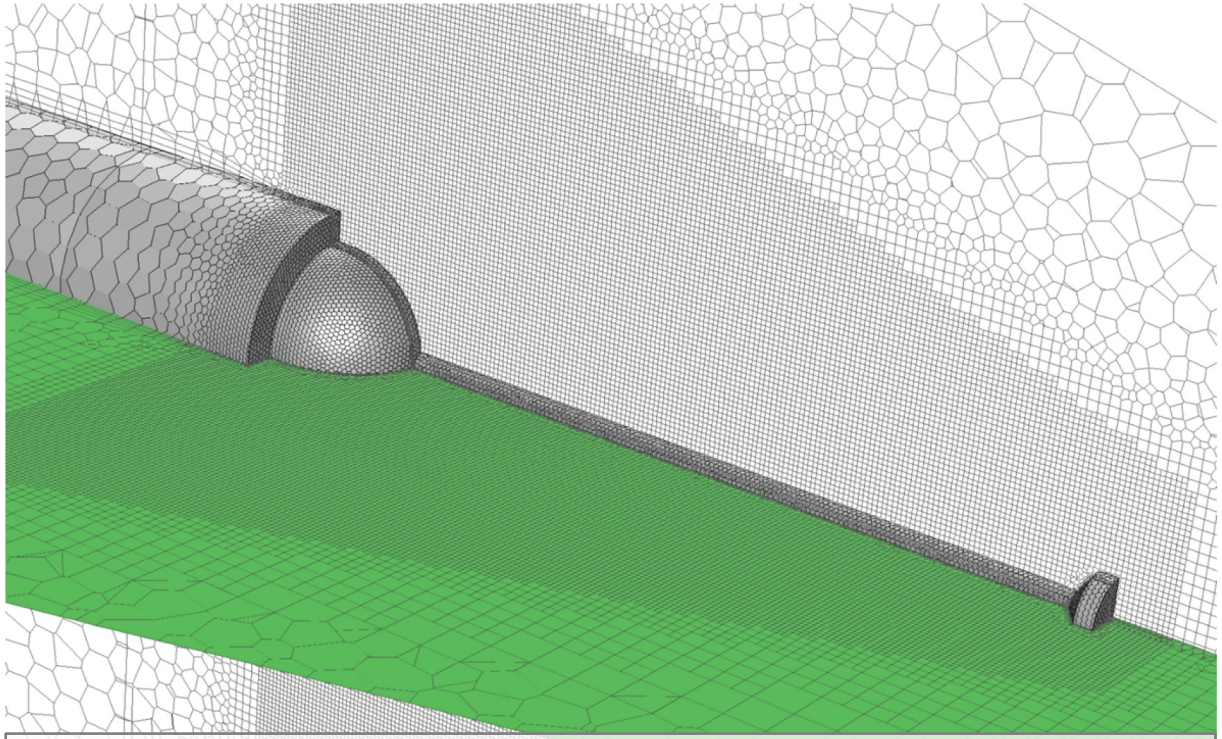
Adiabatic Premixed Combustion – Propane-Air

Mesh type	Number of cores	Number of cells	Memory (GB)	Wall clock (s)
All polyhedral	120	7,641,636	63.5668	489,617
Poly-Hexcore	120	6,191,657	41.7829	259,043

35% Less Memory

90% Faster Solution

Case Study: Hypersonic Aerospike Simulation



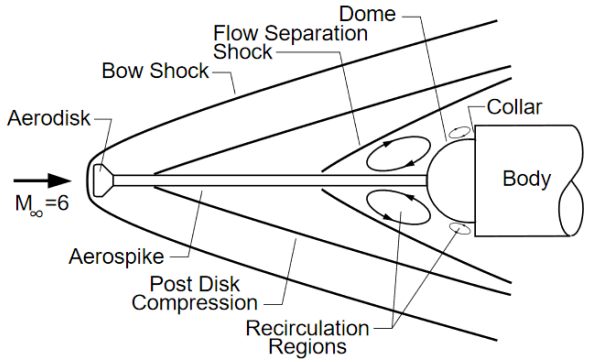
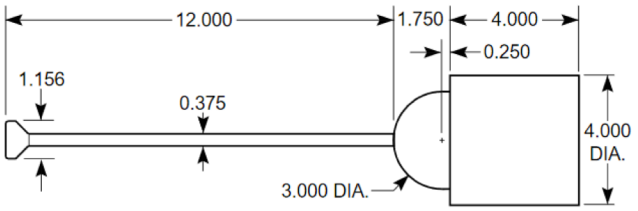


Fig. 1. Schematic of aerospike-induced flowfield.



Publication: AIAA 95-0737 “Experimental Results on the Feasibility of an Aerospike for Hypersonic Missiles” by Lawrence Huebner (NASA Langley, Hampton VA), Anthony Mitchell and Ellis Boudreaux (USAF Wright Lab, Eglin AFB, FL)

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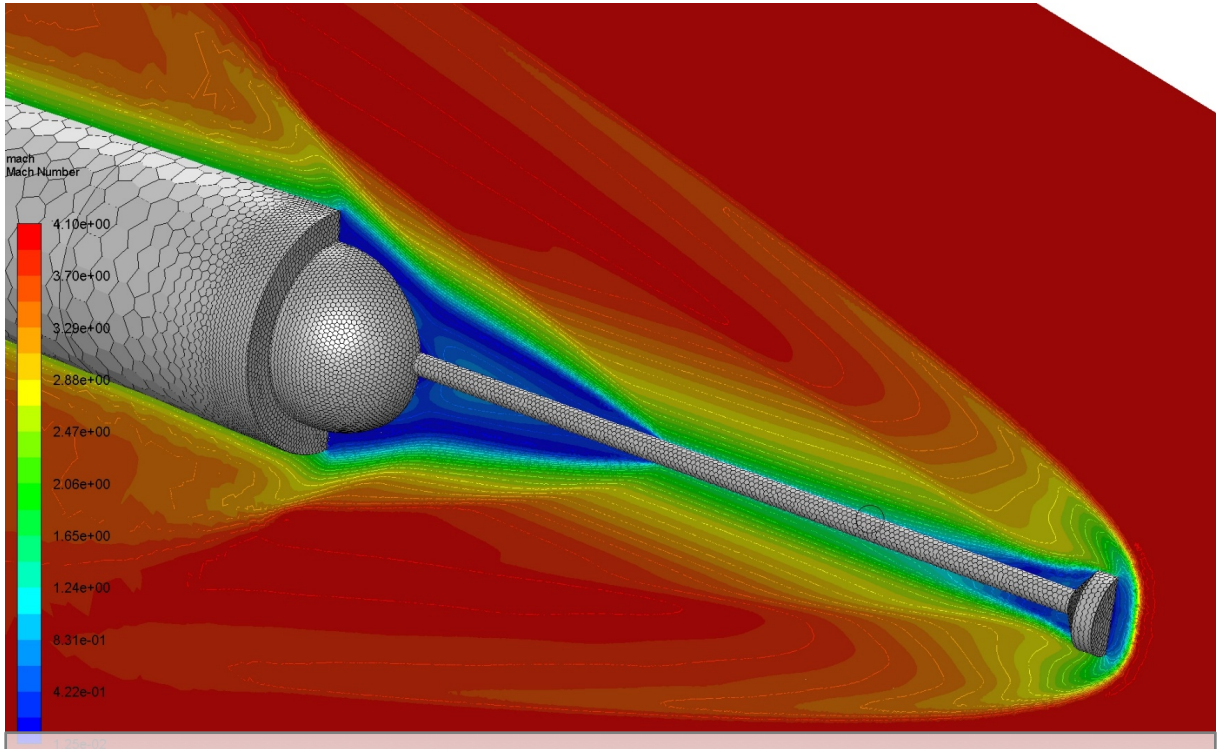

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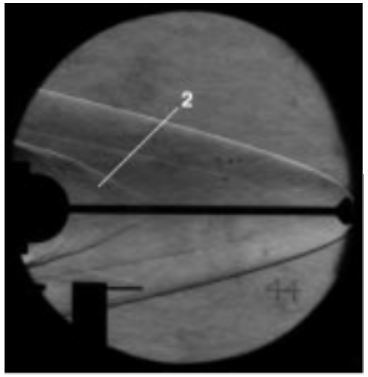
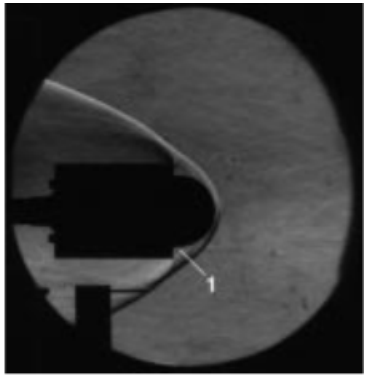
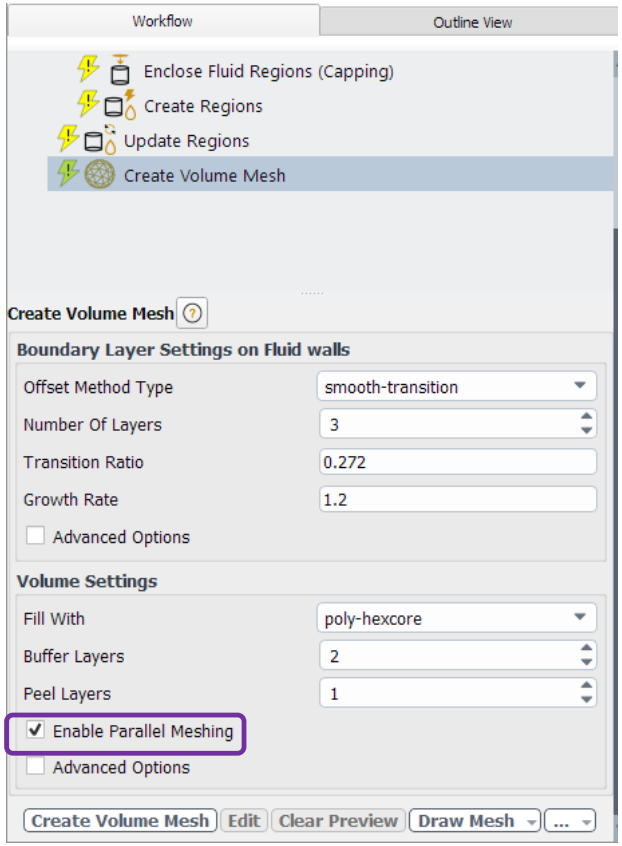




KEY
1 - collar-induced separation region
2 - aerospike-induced separation region

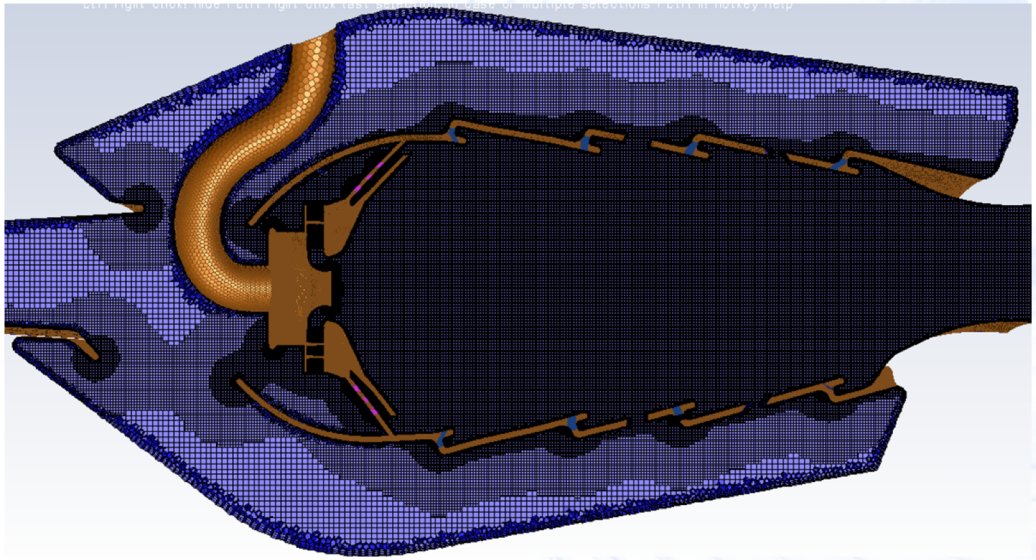
Parallel Poly-Hexcore Volume Meshing

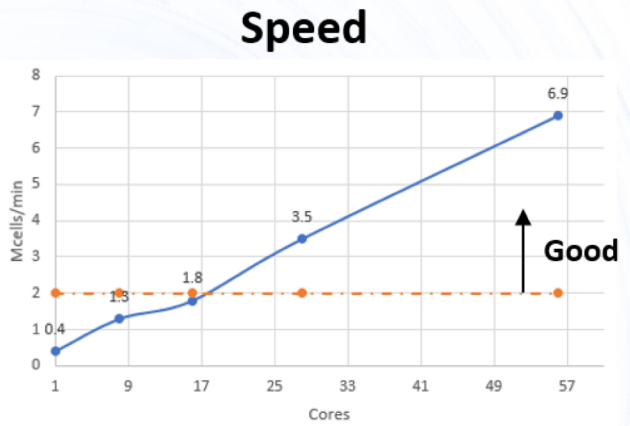
- Particular benefit for meshes larger than 10-20 million cells
- Up to 2.5 million cells/min with 16-way parallel
- Typical memory requirement: ~3GB / million cells

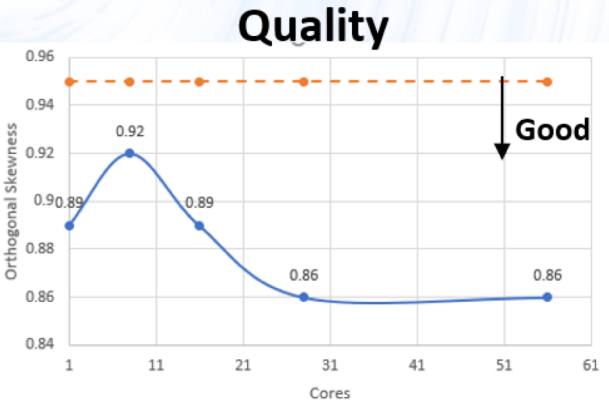


Parallel Poly-Hexcore Volume Meshing – Generic Combustor

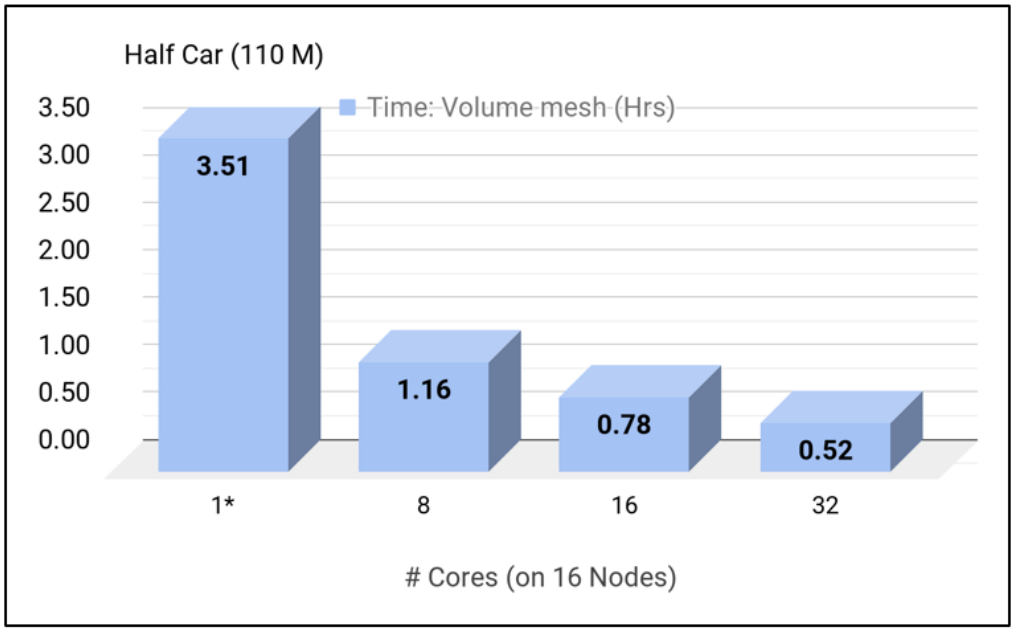
- **Total Mesh Count ~38M cells**
  - 3 inflation layers on all walls
- **Volumetric Growth rate – 1.05**

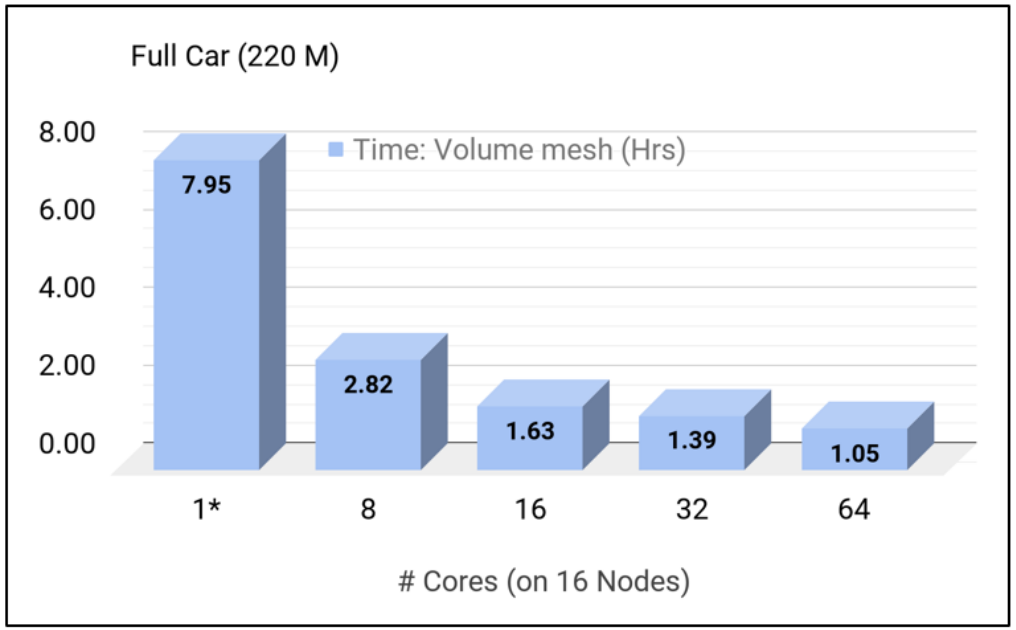






Poly-Hexcore Mesh Benefits: Parallel Meshing



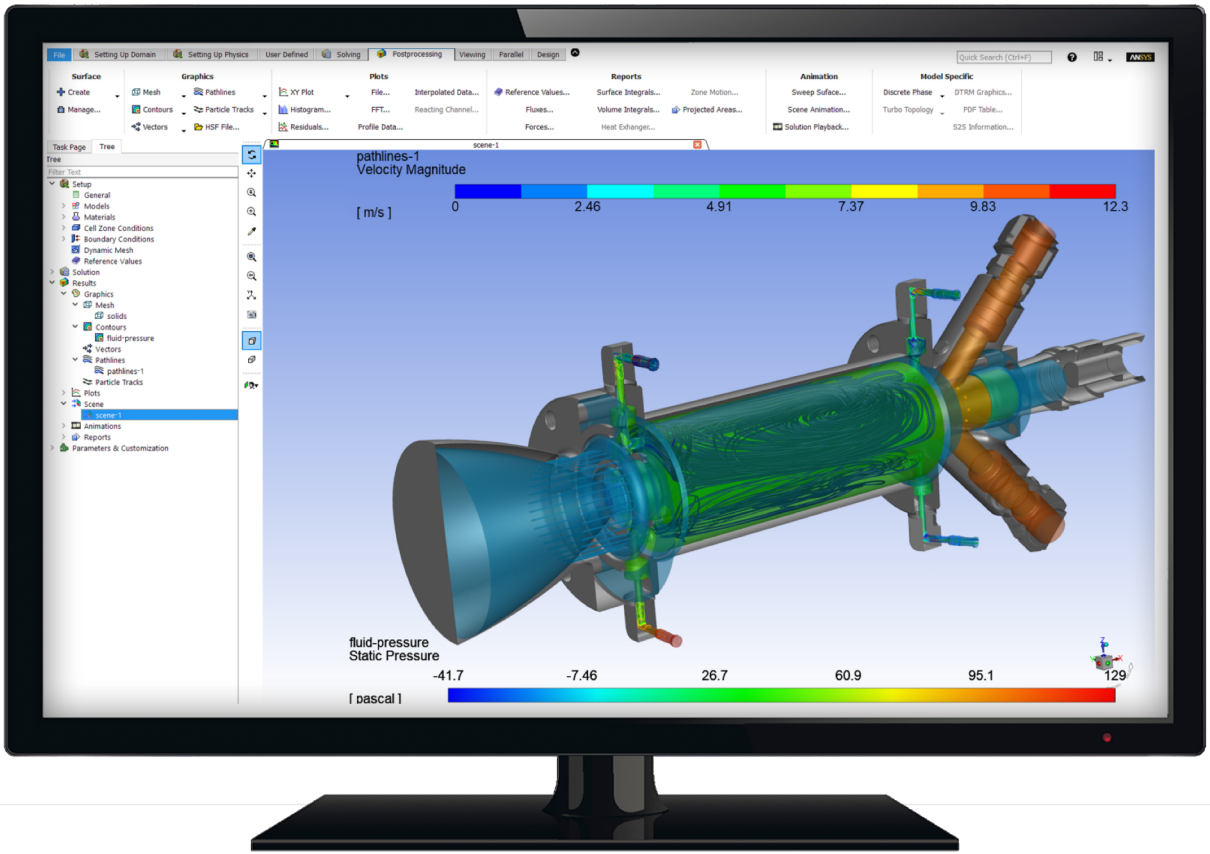


Open Wheel F1 Race Car

1* machine with 512 GB RAM

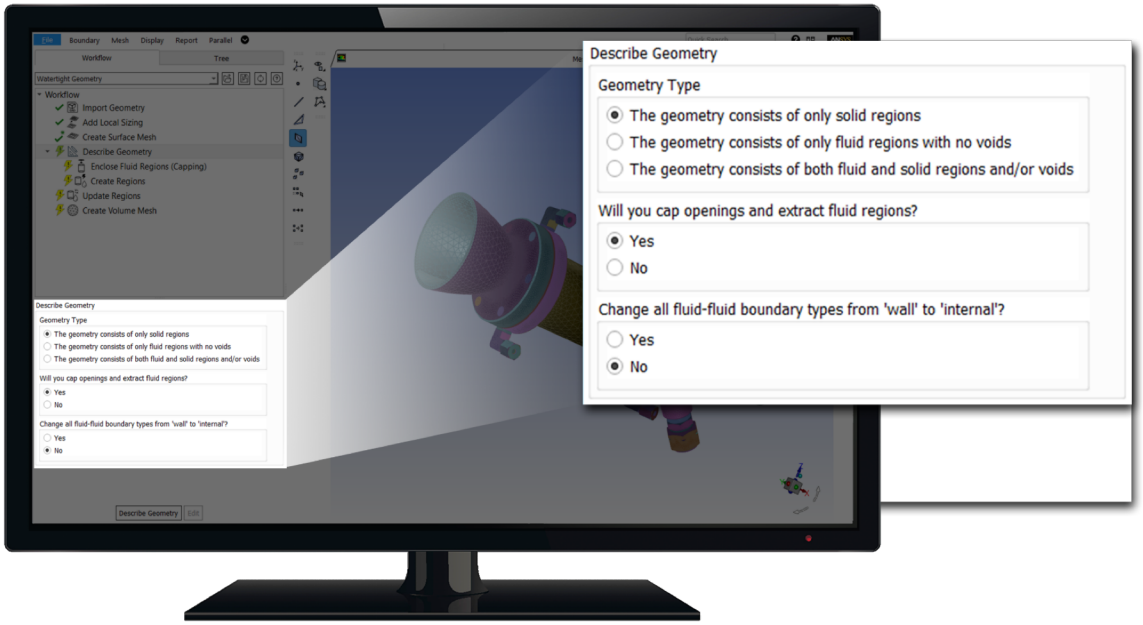
All Encapsulated in Single-Window CFD Workflow

Import Geometry	Surface Mesh	Region Extract	Volume Mesh	Setup/Solve	Post



Task-Based Water-Tight Meshing Workflow

…reliably meshes water tight clean CAD
…handles large length scales, curvature, high face counts



Guides the user by focusing on meaningful tasks
Presents tasks as simple inputs and choices

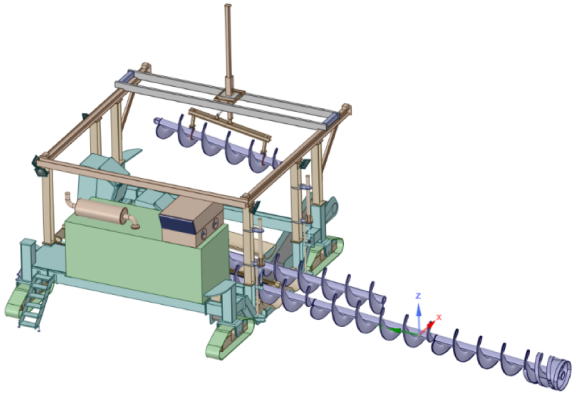
Indicates status and warnings with graphics
Minimizes user intervention with intelligence and behind the scenes automation
Creates custom workflows by modifying the task-list

Records and replays the workflows
Processes upstream changes robustly

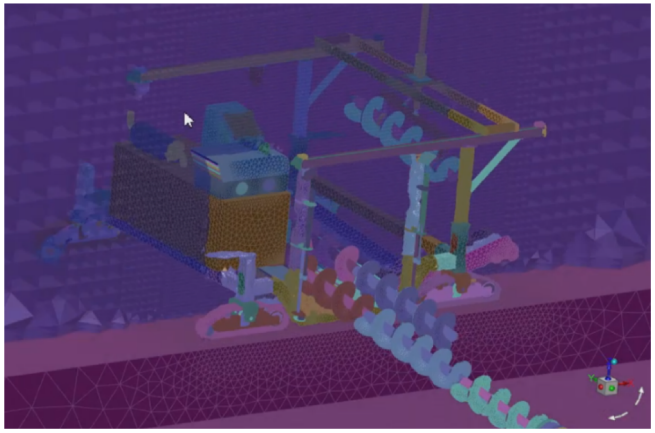
70% faster with
50% less hands-on time
compared to the standard Tree Workflow

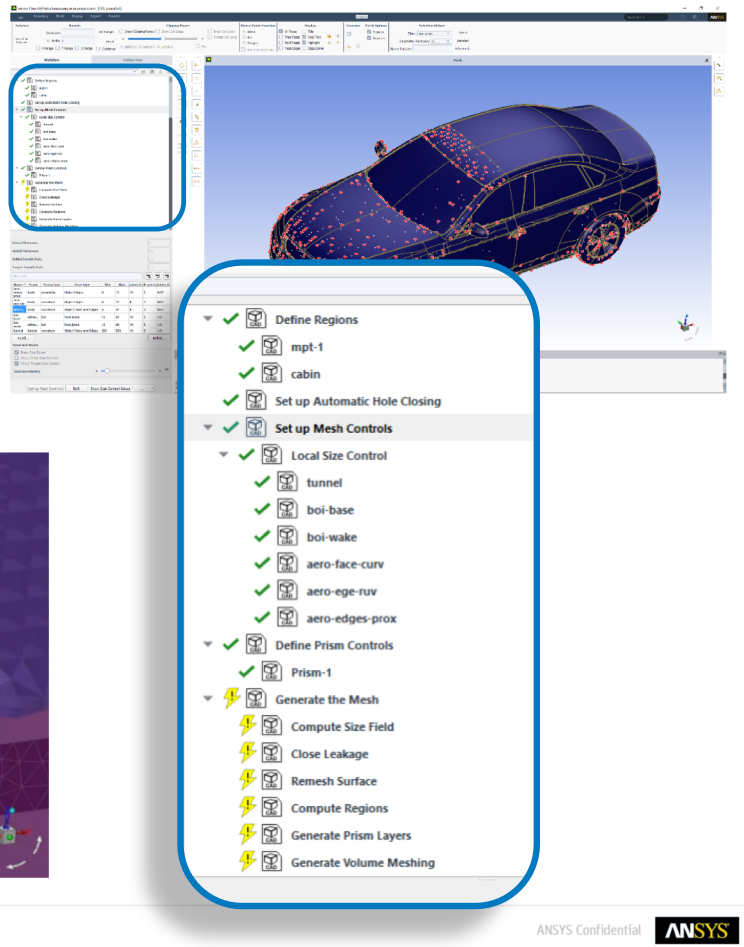
Task-Based Fault-Tolerant Meshing Workflow

- New task-based CAD -> Mesh workflow **for dirty geometry** (holes, intersecting surfaces, etc.) **using wrapper**



- 795 bodies
- 1 fluid cell zone
- Hexcore, 18.2M elements





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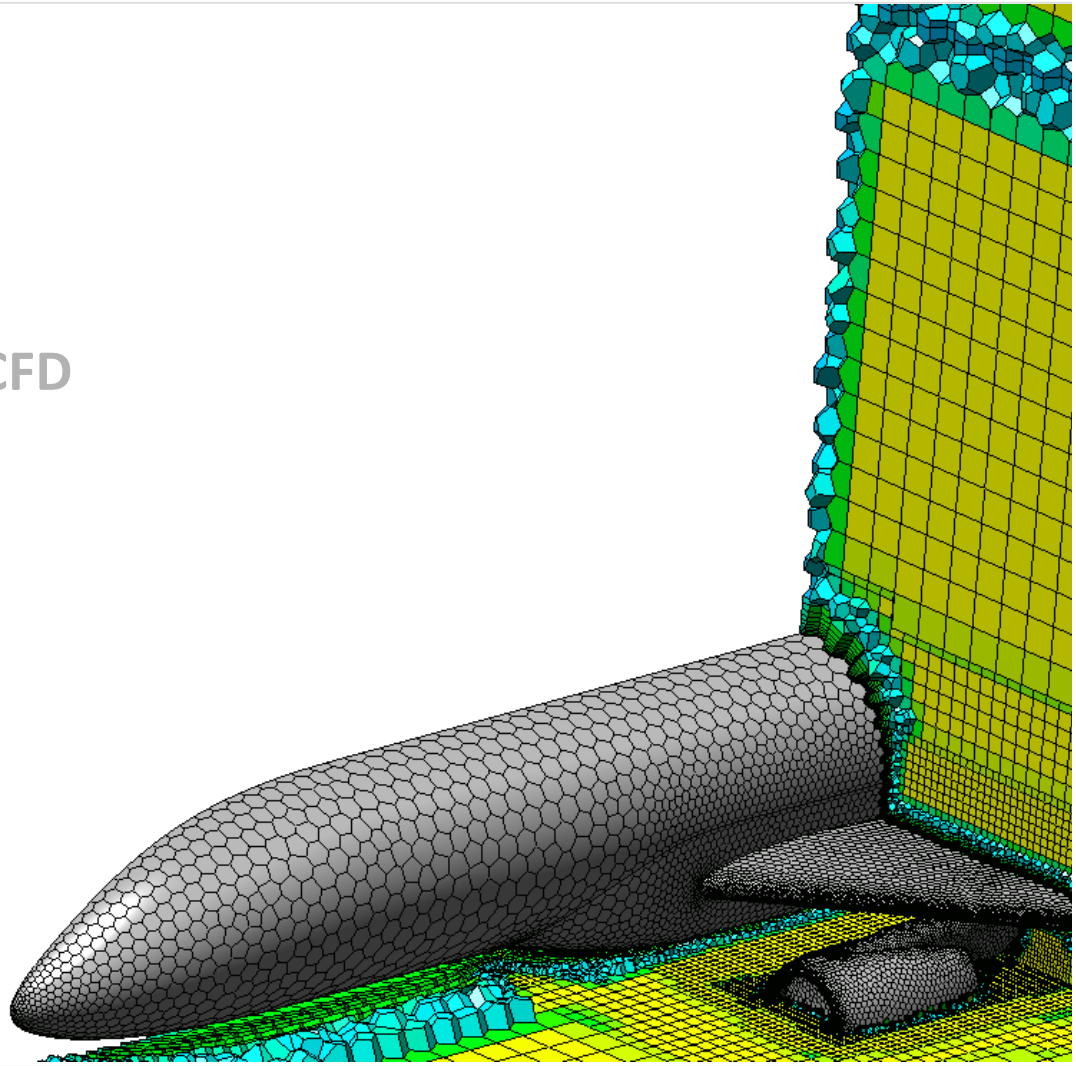
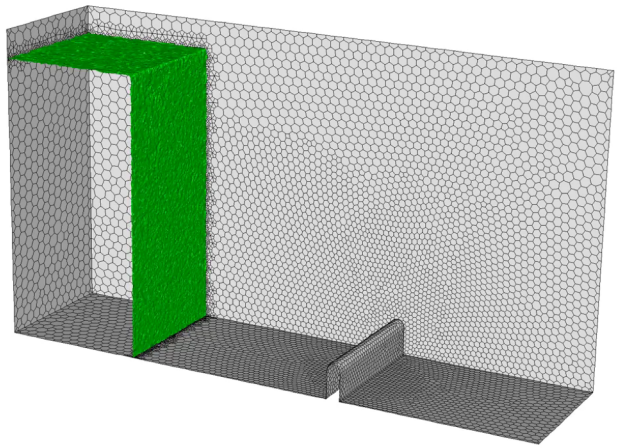
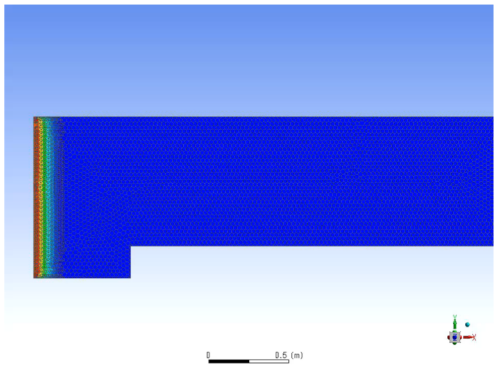


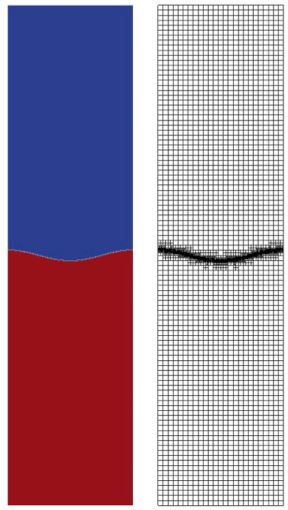
PUMA: Polyhedral Unstructured Mesh Adaption



Transient free-surface capture

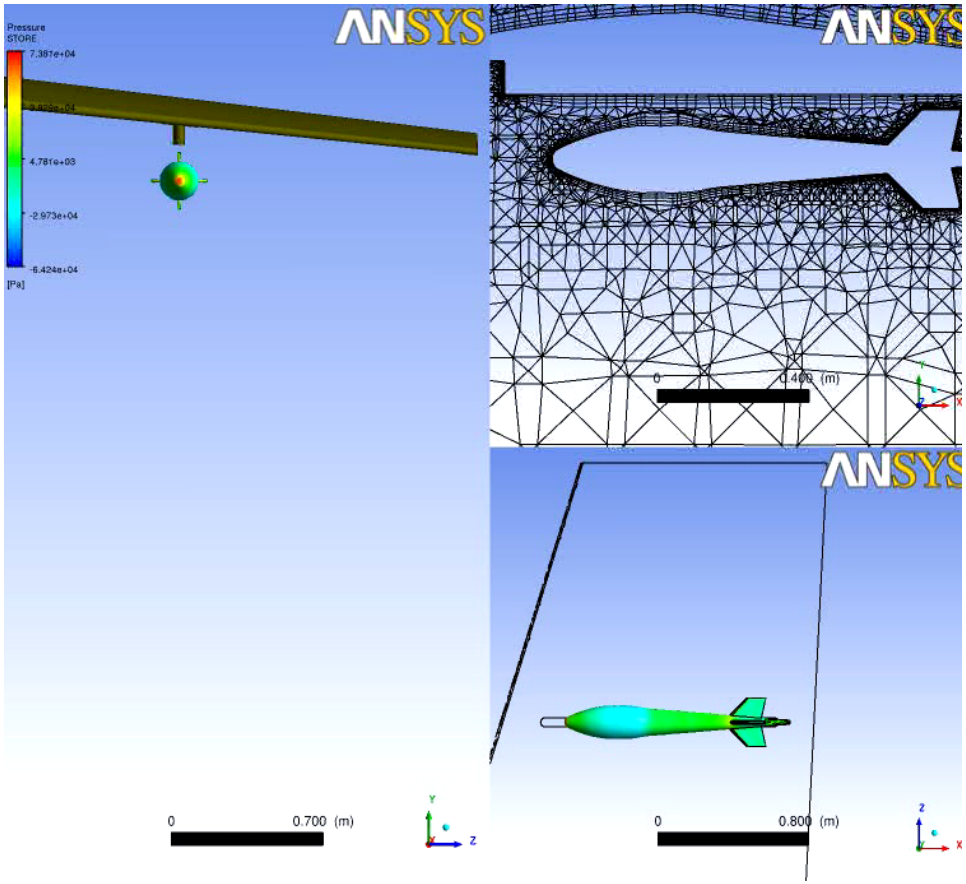


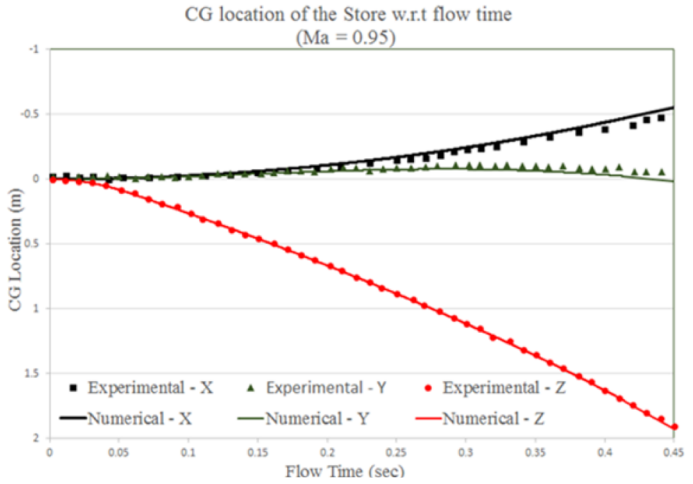
Moving shock wave capture

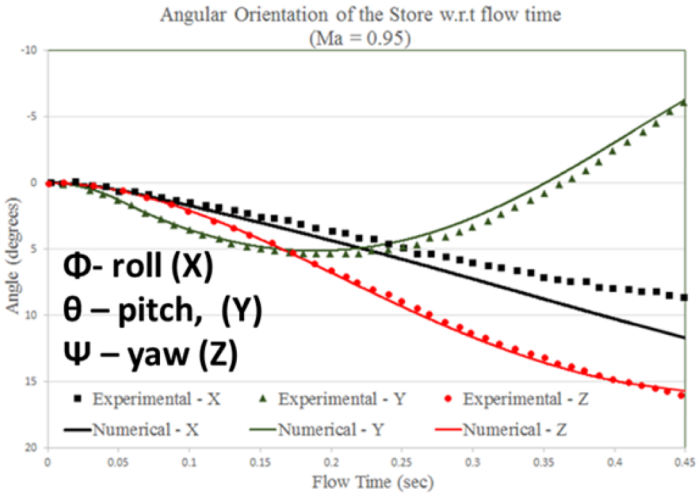


Fluid mixing interface capture

Moving Deforming Mesh (MDM)



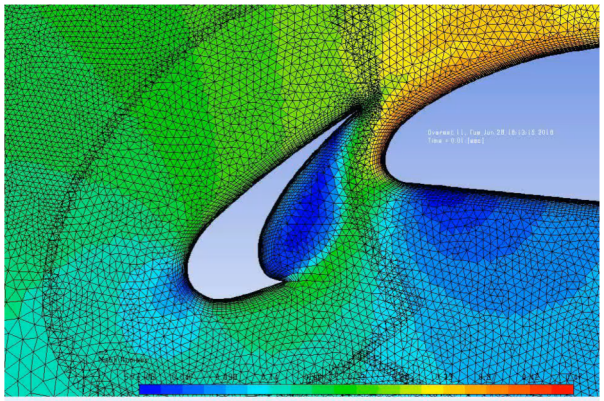


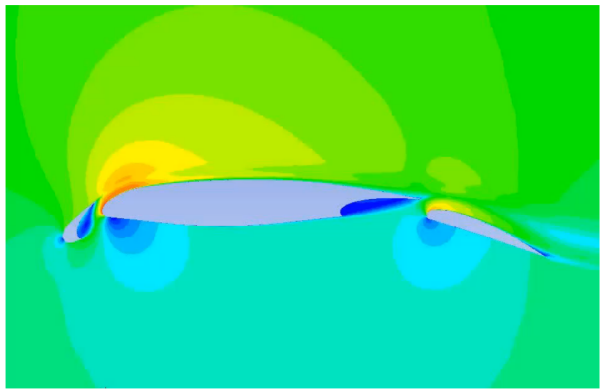


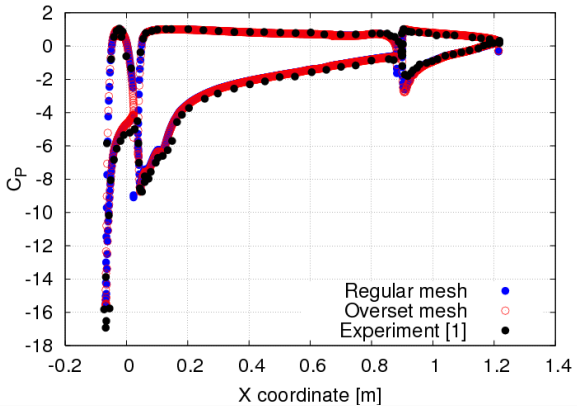
Transonic Store Separation (Ma = 0.95)

Overset Mesh

- Handle moving parts without complex remeshing
- Useful for part replacement, only re-mesh the part being replaced
- Compatible with
  - Density and pressure-based solvers, 6-DOF solver
  - Conjugate heat transfer
  - MRF zone, dynamic and sliding mesh
  - Multiphase models with cavitation, evaporation, condensation
  - Species transport, user-defined scalars







Agenda

- Introduction to ANSYS
- Mosaic Meshing Technology for CFD
- Beyond Meshing
- **Discussion / Q&A**