

## Workshop "HPC methods for Engineering"

# **Centaur: the meshing tool for industrial CFD**

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# The presenter

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Department of Industrial Engineering (DIEF)

*Combustion and Energy System*

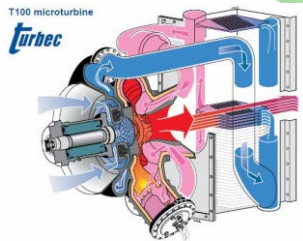
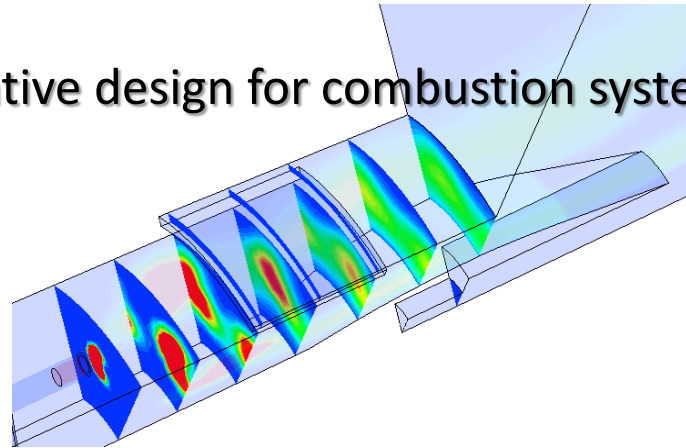
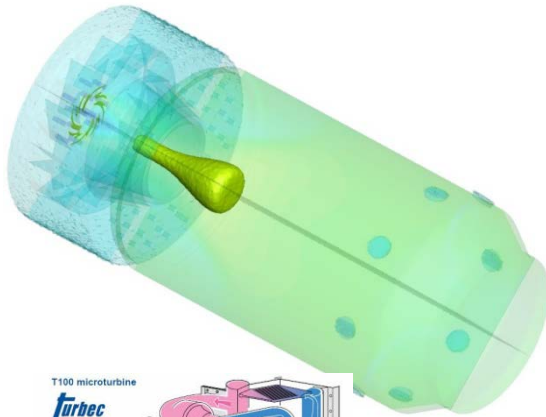
<https://www.linkedin.com/in/alexkey>



# Alternative fuels in Gas Turbine

## Hydrogen

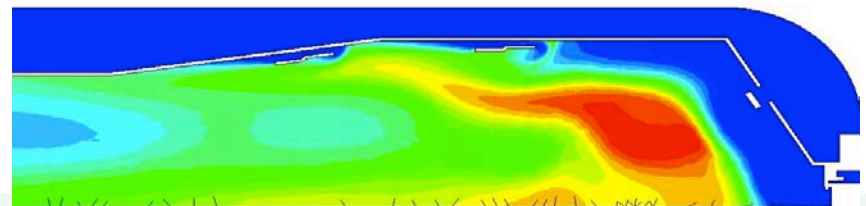
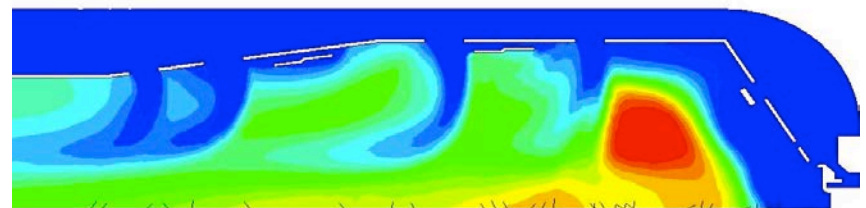
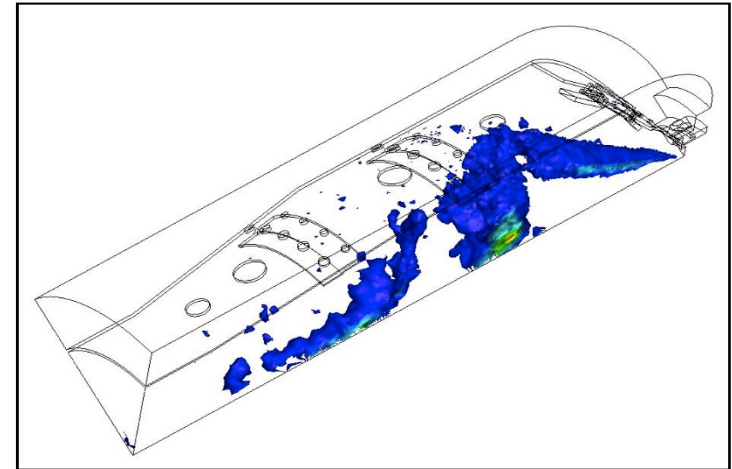
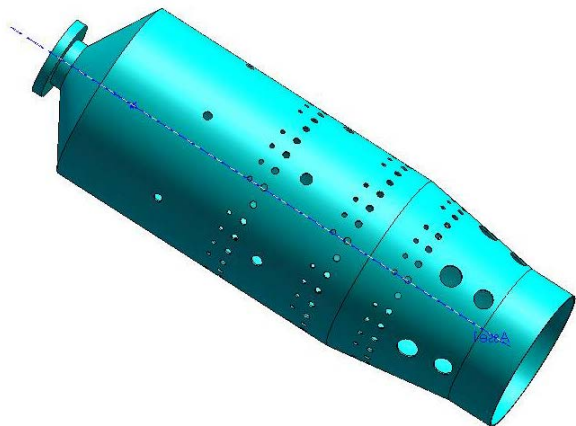
- Numerical end expertimethal studies on the H<sub>2</sub> combustion
- Development of innovative design for combustion system in MGT



# Alternative Fuels in Gas Turbines

## Bio Fuels

- Development of investigation method for analysis and design for bio-fuels using
- re-design activity on MGT combustion system



# CENTAUR

## Advanced / Unique Hybrid Grid Technology

### CentaurSoft



# Optimum Grids

- ❑ Good local resolution
- ❑ Smooth grid size variation
- ❑ Minimum number of elements
  - ❑ structured (hexahedra), semi-structured (prisms), and unstructured (tetrahedra) elements
  - ❑ Use of the unstructured and structured mesh technology where advantageous
- ❑ No grid discontinuities



# Automation

- ❑ For non-experts
- ❑ Minimum user interaction
  - ❑ No need to specify any length scales
- ❑ Local mesh adaptation
  - ❑ Refinement, Coarsening, Redistribution



## Overall Mesh Strategy

- ❑ Local use of all types of elements (2D/3D)
- ❑ Optimum boundary layer grids
- ❑ Marching mesh generation methods
- ❑ Grid quality enforced *on the fly*
- ❑ Local mesh adjustment for redesigns





# Robustness

- ❑ Complex Geometries / Flows
  - ❑ Capture Details of the Geometry
  - ❑ Capture Disparate Field Scales
- ❑ Boundary layer marching
  - ❑ Size control
  - ❑ Auto handling of special areas
- ❑ Robust tetrahedra generation



## Grid Quality

- ❑ On-the-fly imposition of grid quality constraints on the generated elements
- ❑ A grid post processor further improves user-specified quality measures
- ❑ Solver-specific quality requirements are imposed



## Structured Surface Mesh also Available

- ❑ Automatic setup
  - ❑ Mesh generator will calculate number of points
  - ❑ Matching of nearby local length scales
- ❑ User defined setup
  - ❑ Number of points / point distribution
  - ❑ Inspection of current setup
  - ❑ Auto propagation of user resolution choices

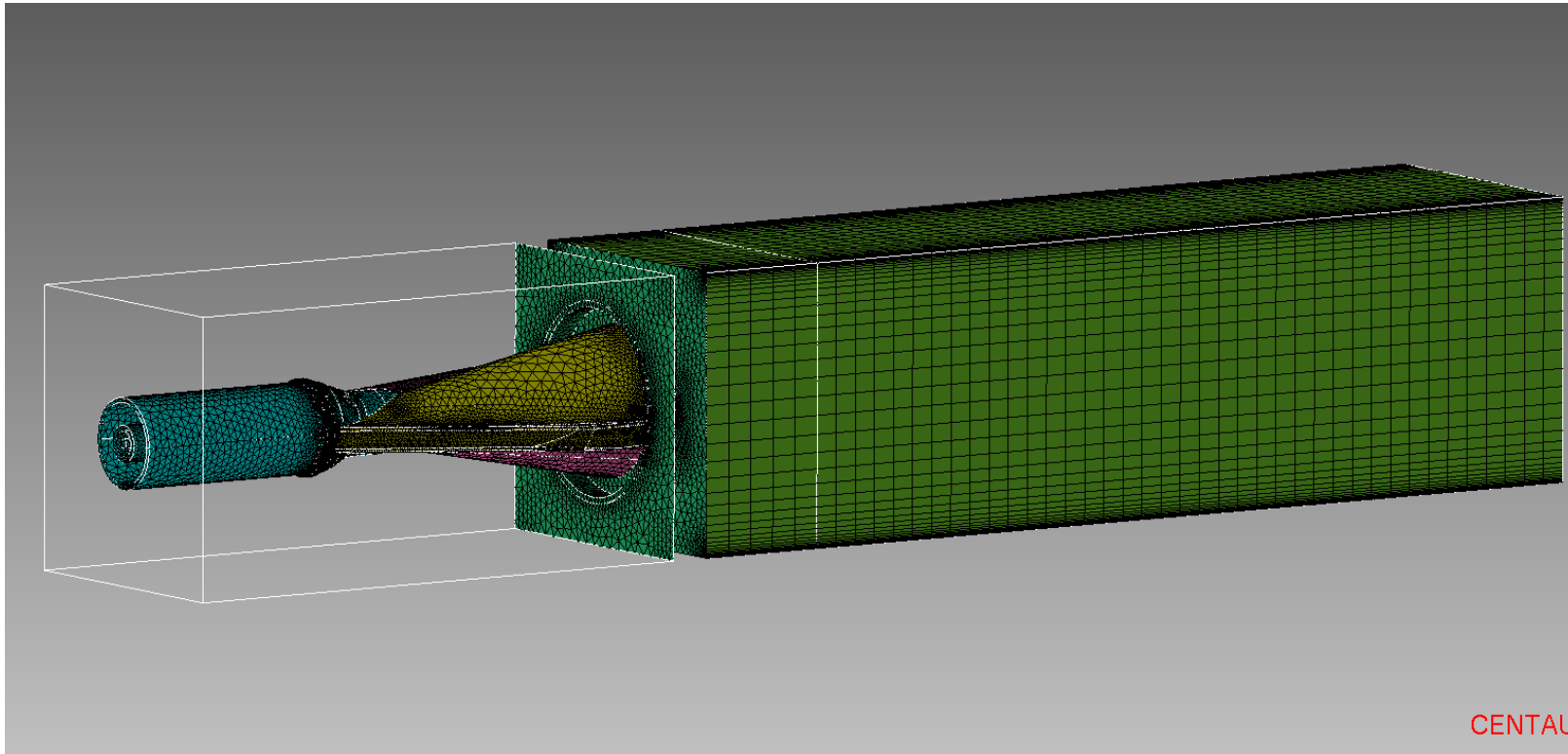


## CENTAUR Blocks

- ❑ Integrated into the hybrid mesh process
- ❑ Hex Layer Propagation
  - ❑ Extend the structured hexas of the boundary layer
  - ❑ Use the same marching techniques
  - ❑ Fill gaps between top / bottom boundary layers
- ❑ Complex Wake Blocks



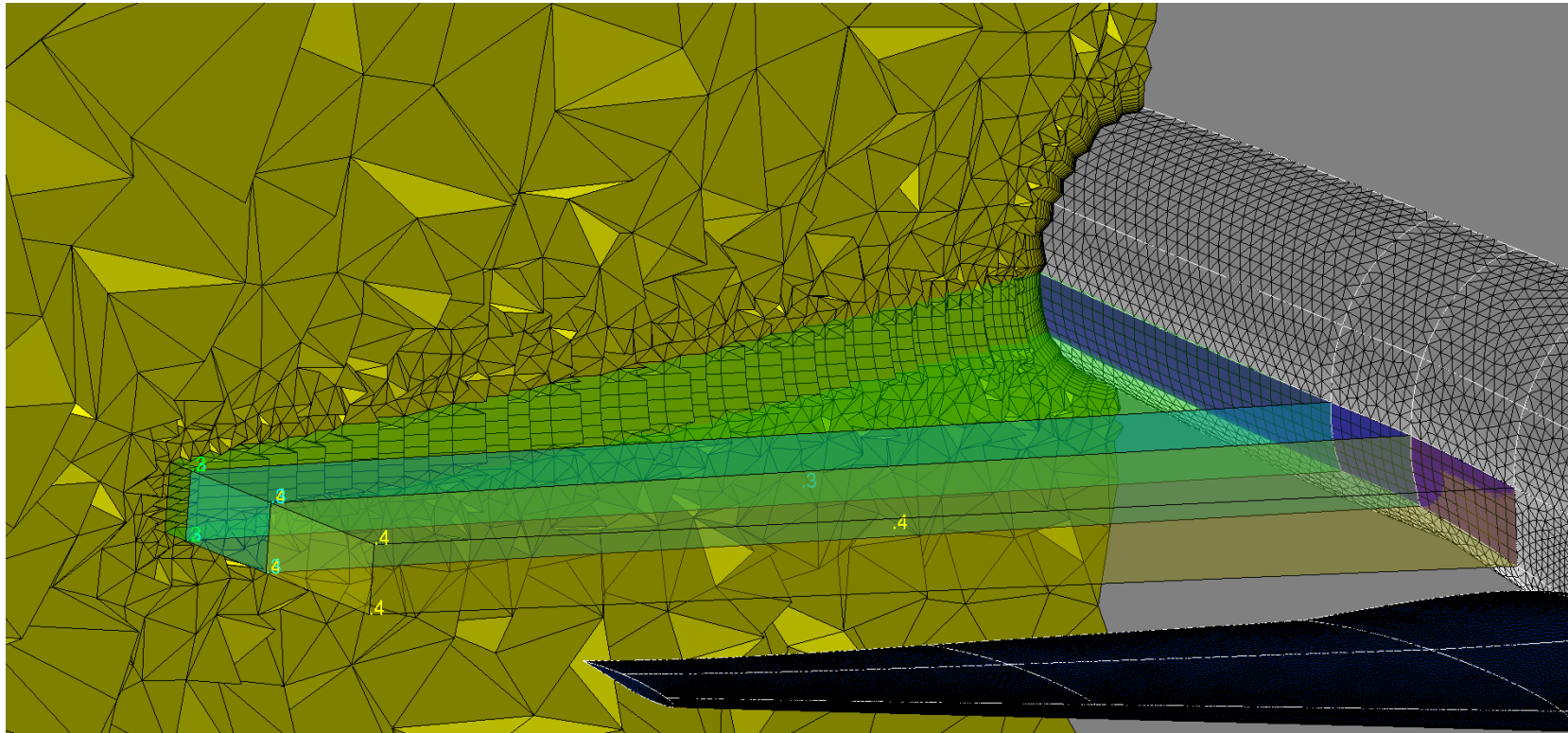
# Blocks for Simple Areas



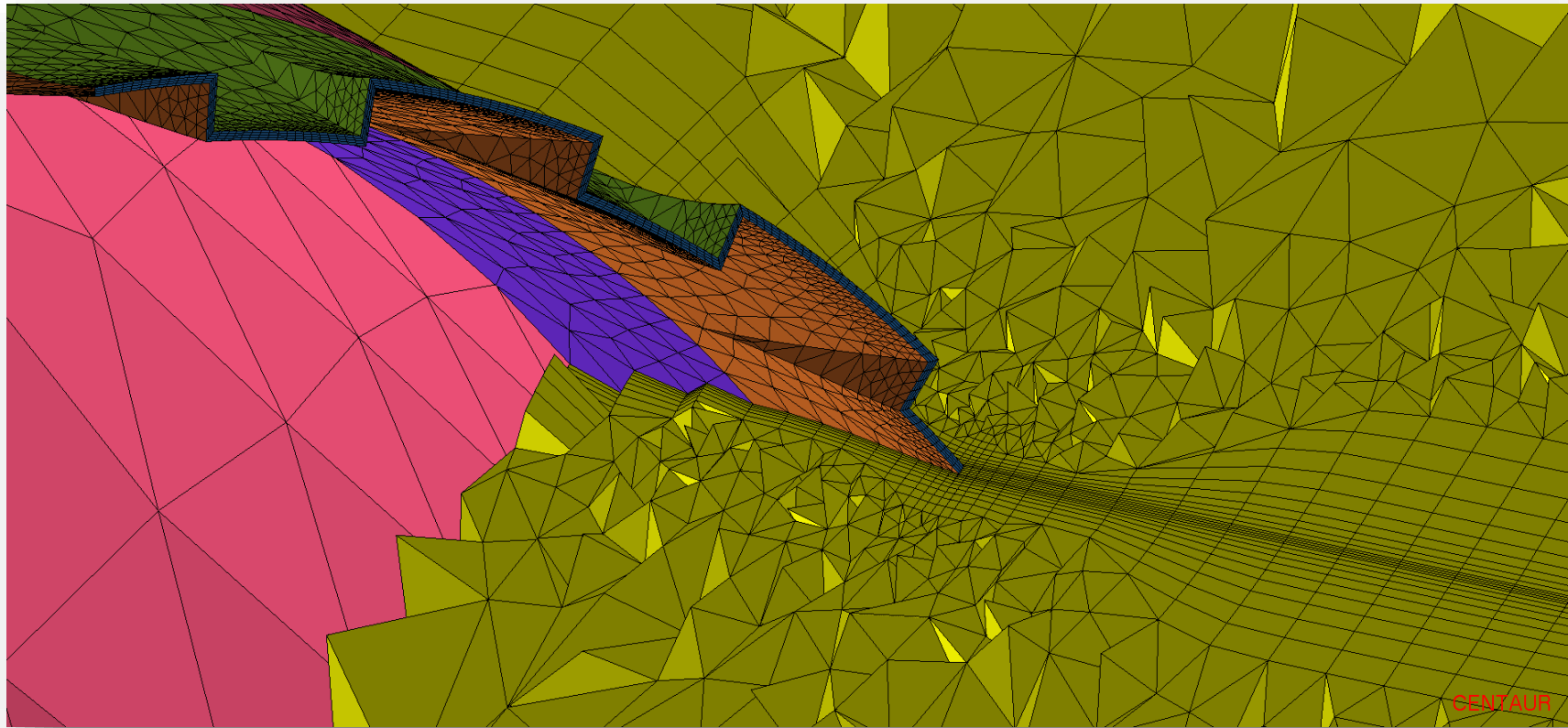
CENTAUR



# Blocks Merge into Hybrid Mesh



# Complex Wake Block from Engine Nacelle

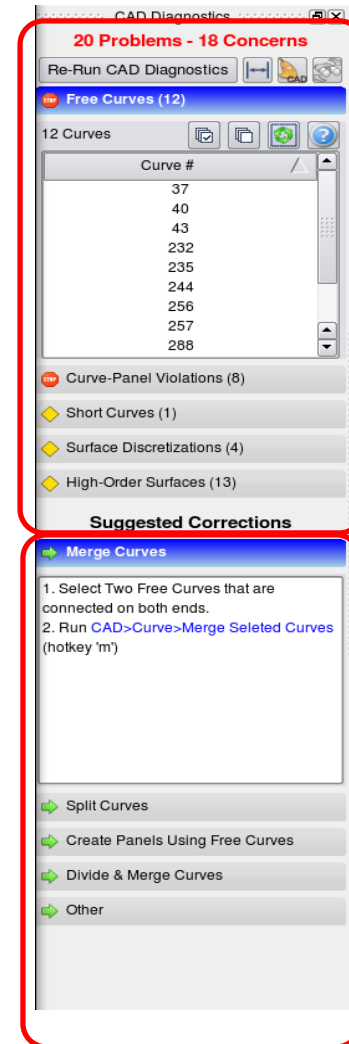


CENTAUR



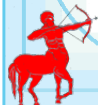
# CAD Repair Tool

- Fully Automatic
- Manual
  - Guided for complex problems
  - Full set of repair actions



← List of Problems

← List of Suggestions and Action Buttons



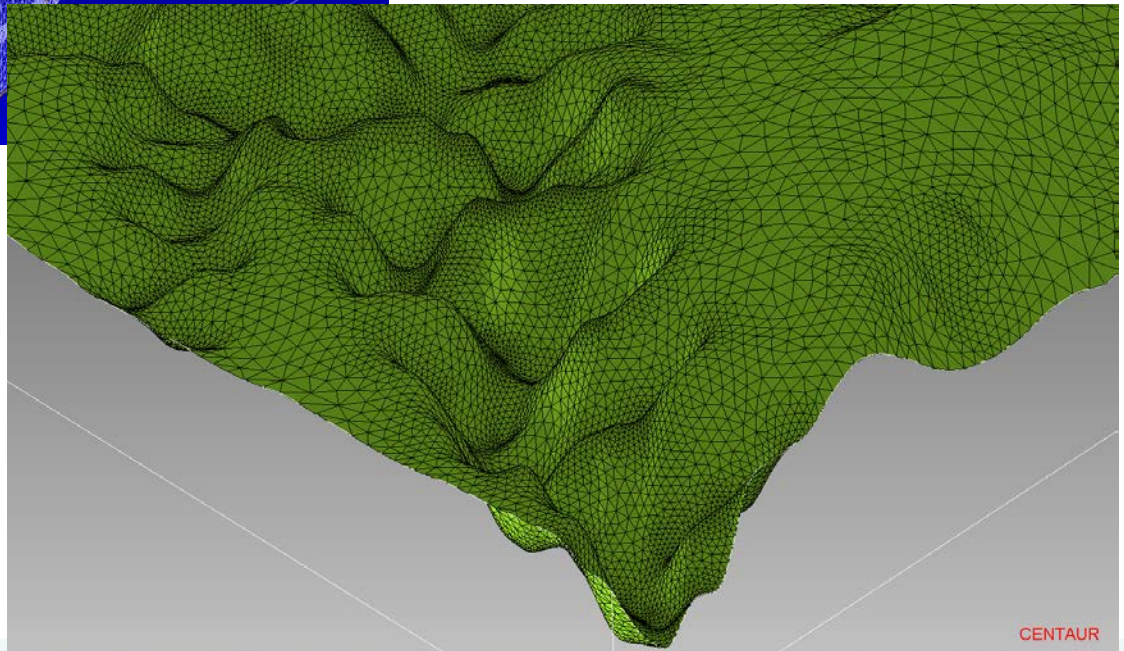
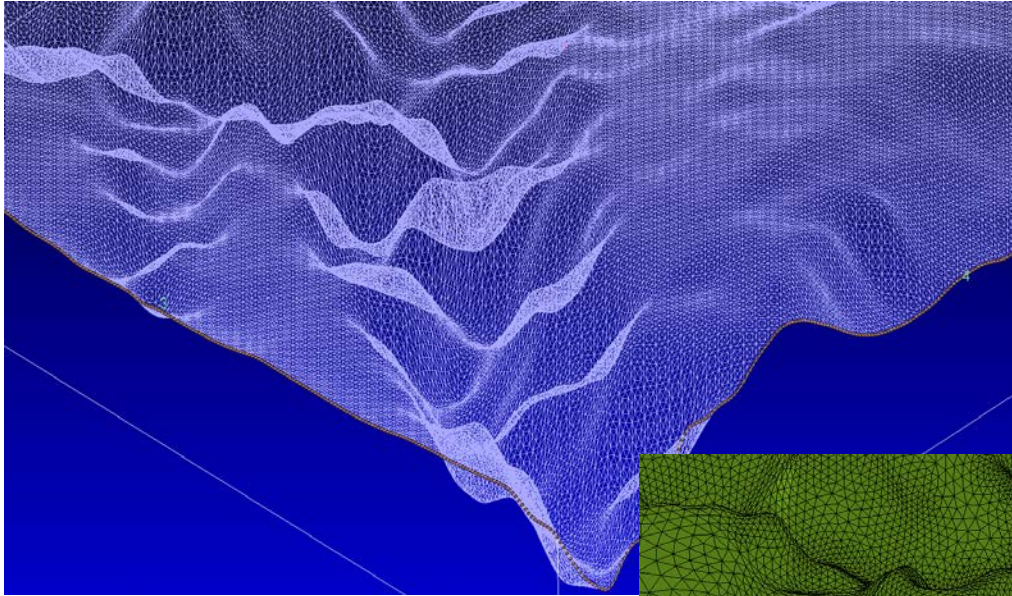


# STL / Foreign Surface Mesh

- ❑ Support for faceted data
  - ❑ Foreign surface mesh
  - ❑ Scanned data
  - ❑ Biomedical geometries
  - ❑ Terrain mapping
  
- ❑ Automatic / Manual ridge identification



# STL Terrain



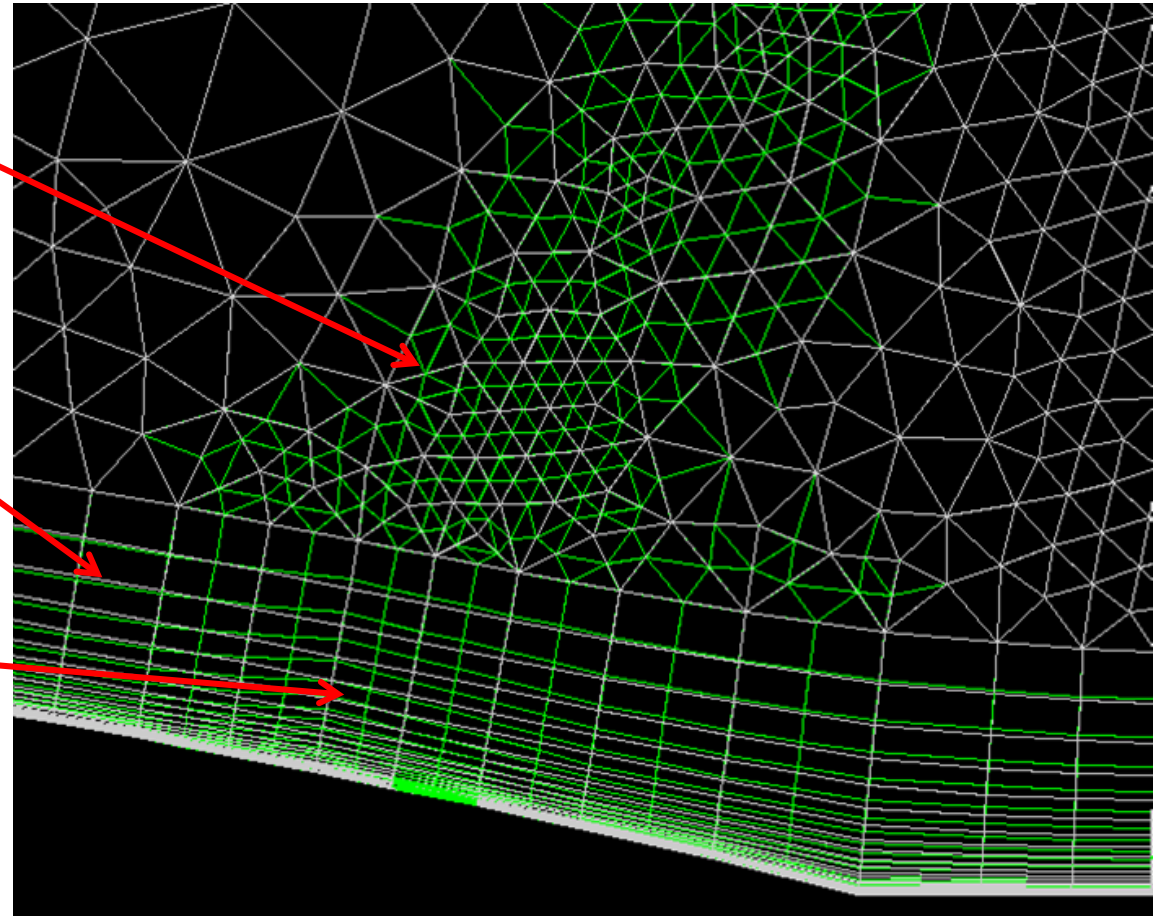
# Dual Hybrid Mesh Adaptation

Shock refinement

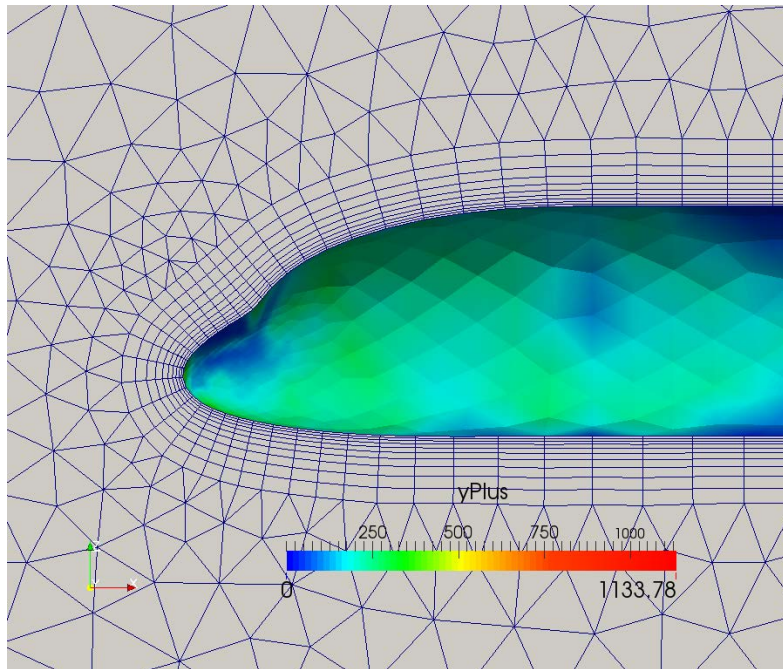
Boundary layer  
directional refinement

Boundary layer  
redistribution

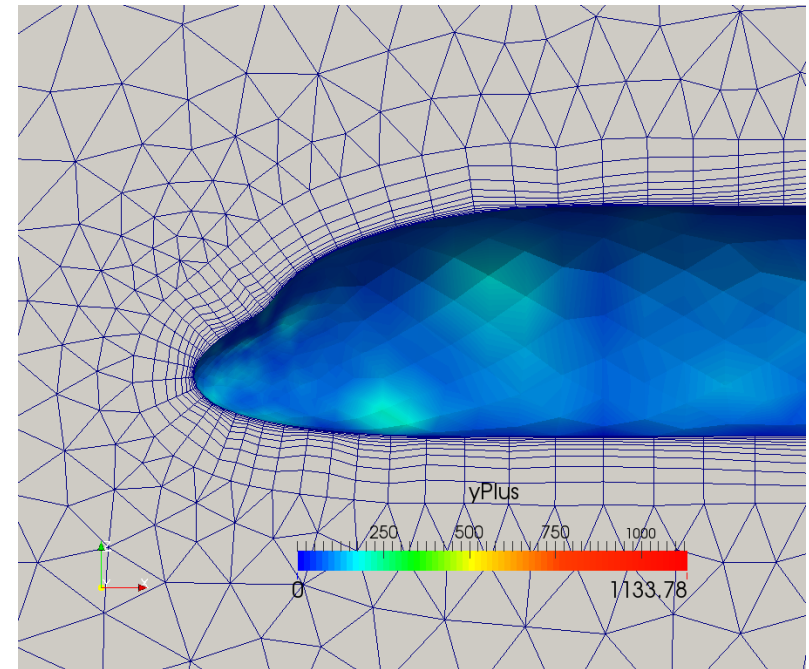
Real Geometry  
preservation



# Boundary Layer $Y^+$ Redistribution on Aircraft



Before Redistribution



After Redistribution



# Other Important Features



# Mega Grids for LES

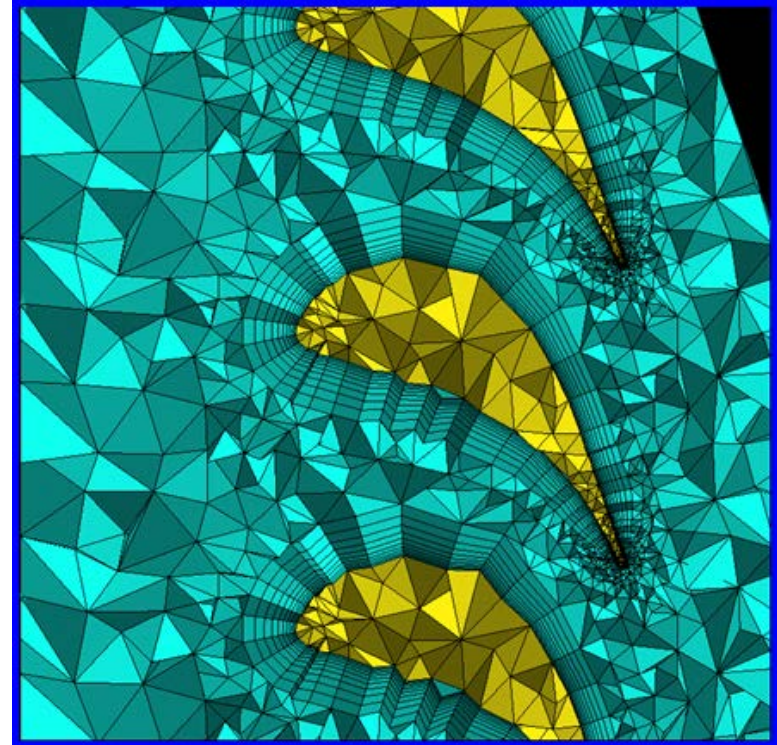
- ❑ Very large meshes are facilitated via:
  - ❑ Multi-zone mesh generation
  - ❑ Parallel and/or multi-core mesh generation
  - ❑ Partial *Exascale* support

*Grids with over 800 million elements*



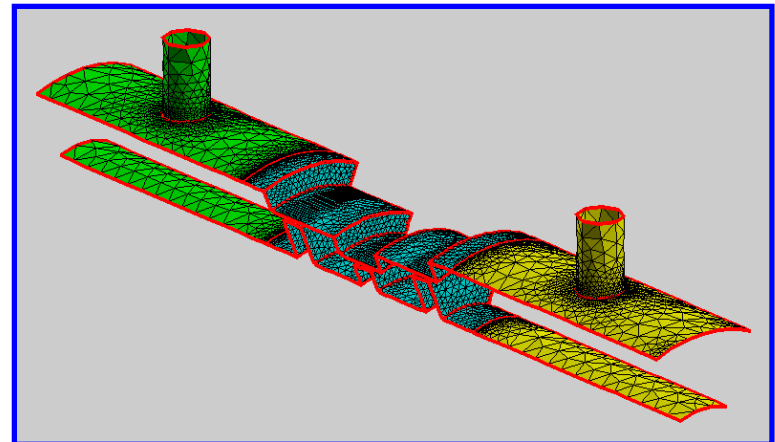
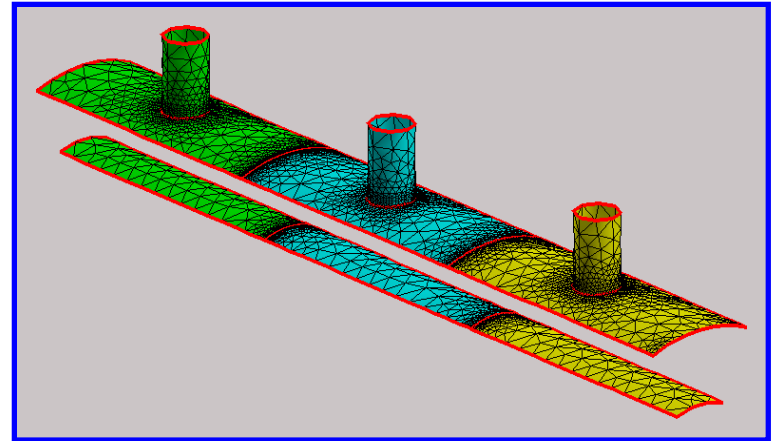
# Multi-Zone / Multi-Physics Meshes

- ❑ Re-use of existing mesh
- ❑ Multi-physics grids
  - ❑ Conjugate Heat Transfer
  - ❑ Fluid Structure Interaction



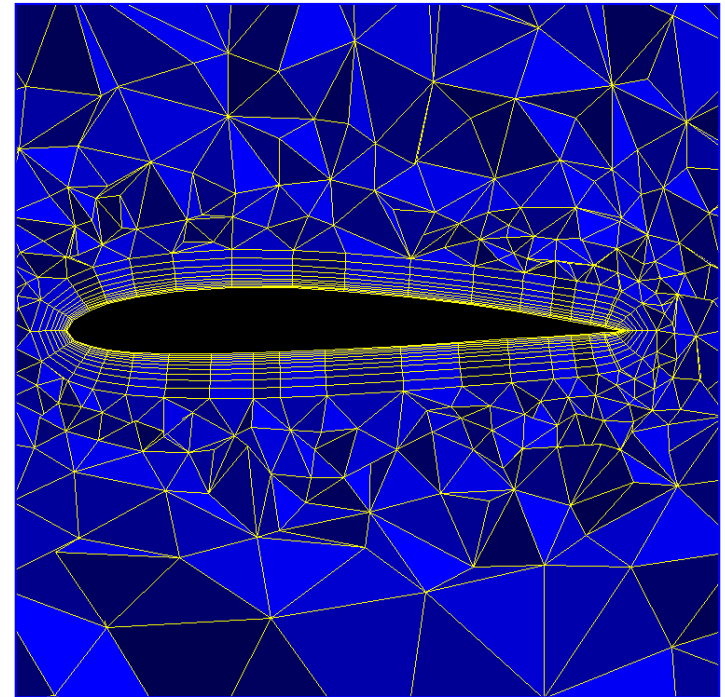
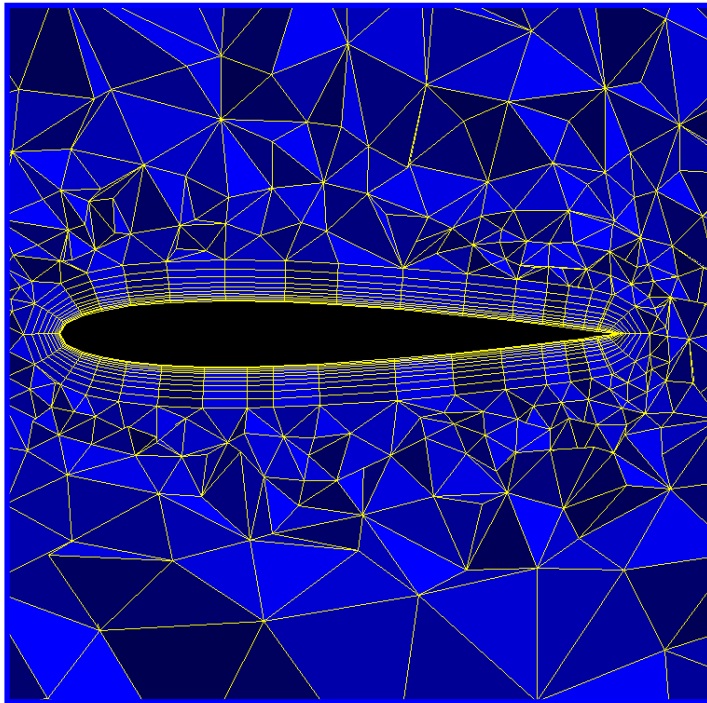
# Modular Mesh Generation

- ❑ Redesign part of the geometry
- ❑ Use the old grid
- ❑ Generate grid only for new part



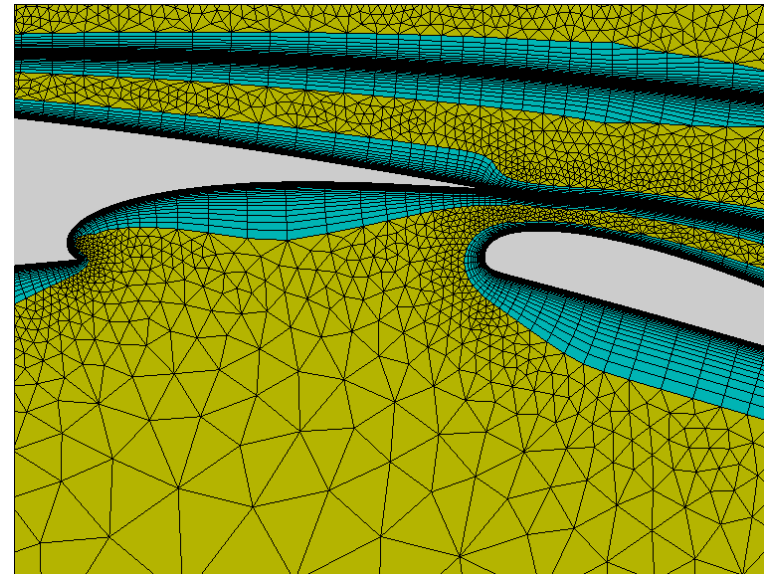
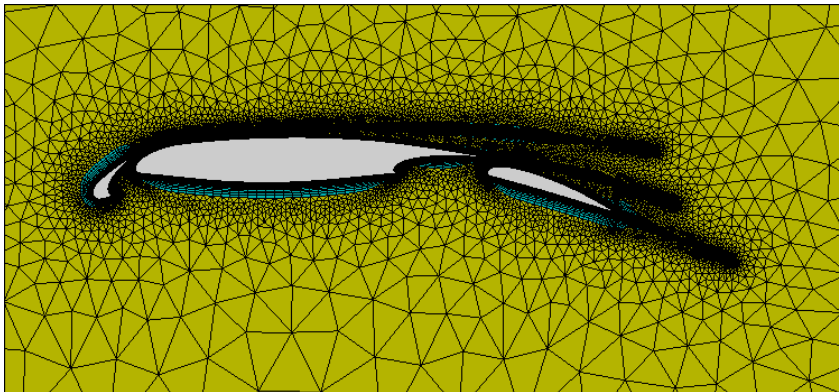


# Moving Grid for Geometry Shape Change

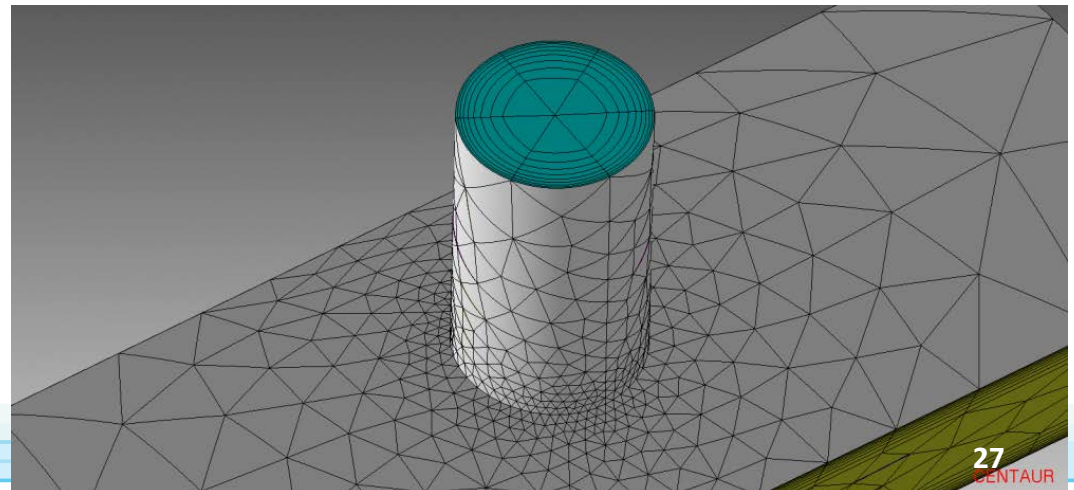
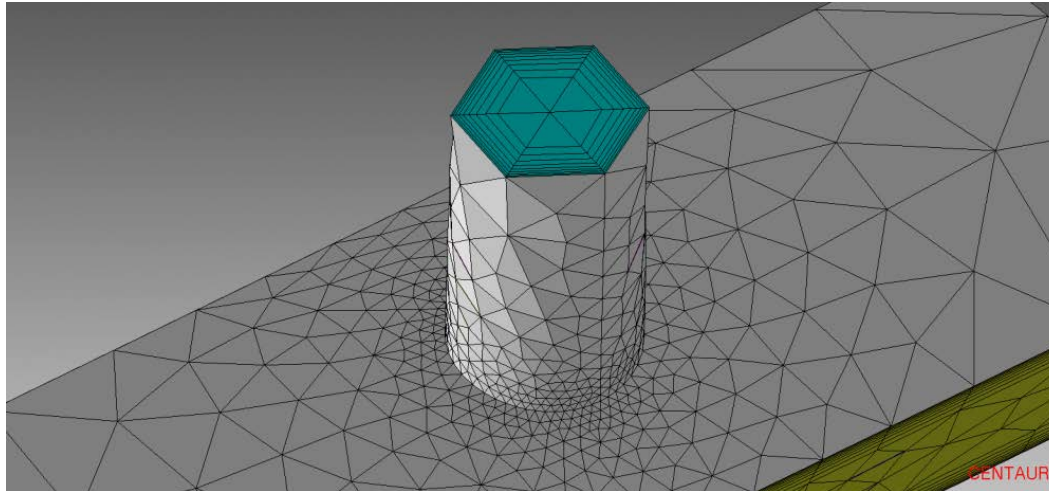


# True 2-D Mesh Generator

- ❑ Independent from the 3D mesh generator
- ❑ Combines both quadrilaterals and triangles
- ❑ Same interface and capabilities as the 3D generator



# High-Order Grids for Curved Boundaries



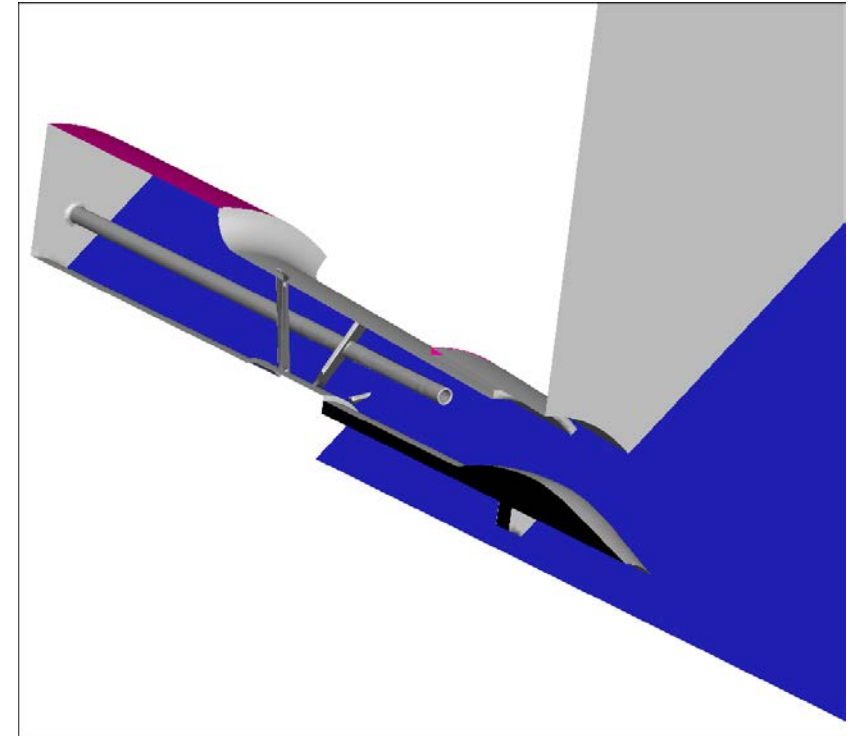
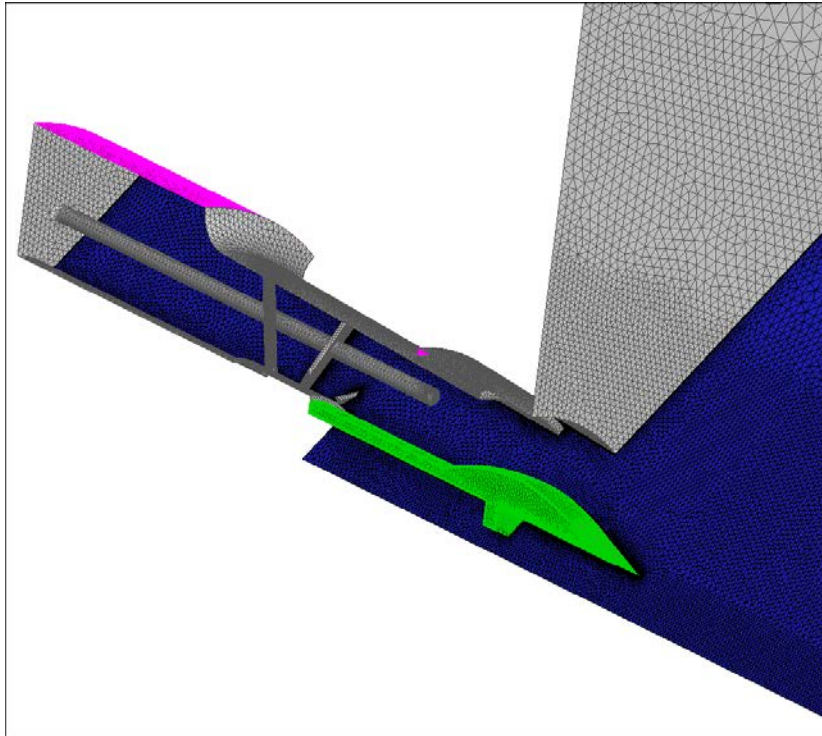
# CENTAUR

Application on Industrial Geometry

The Experience of UNIFI



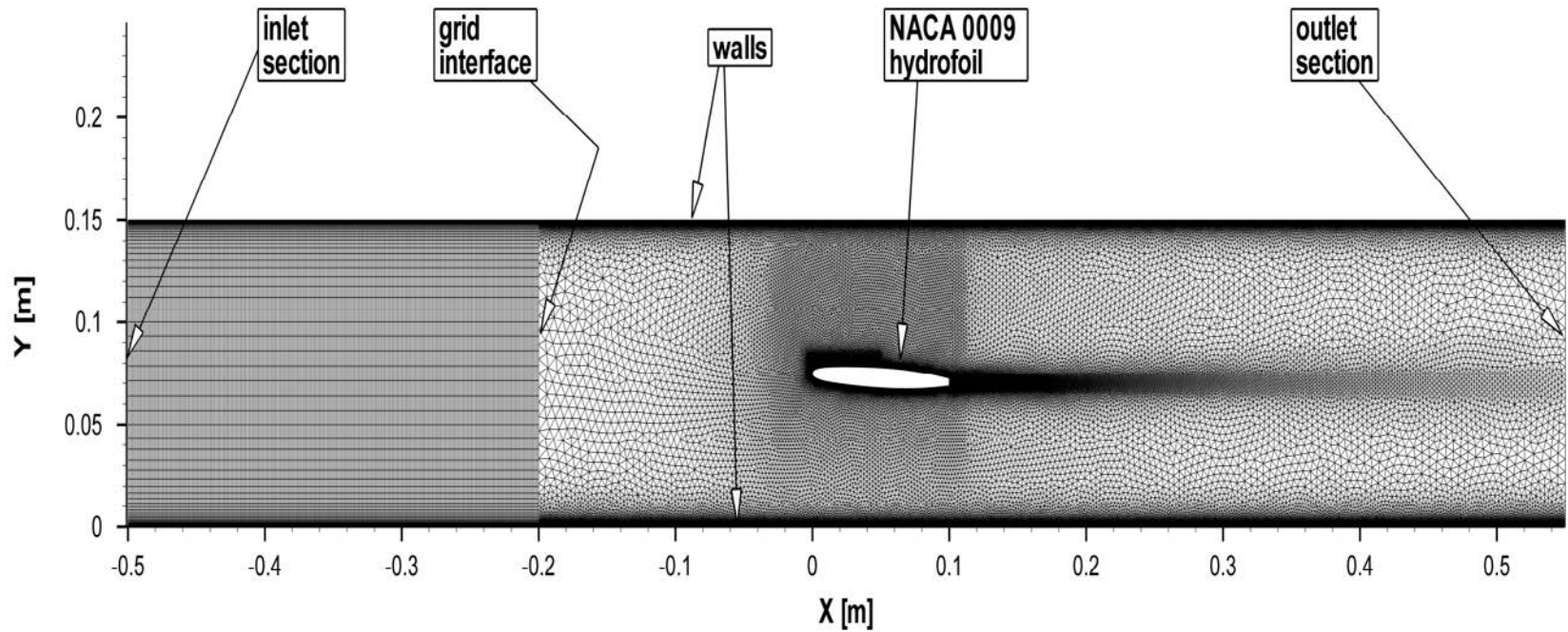
# Prototype of a Premixer for H<sub>2</sub> Fueling



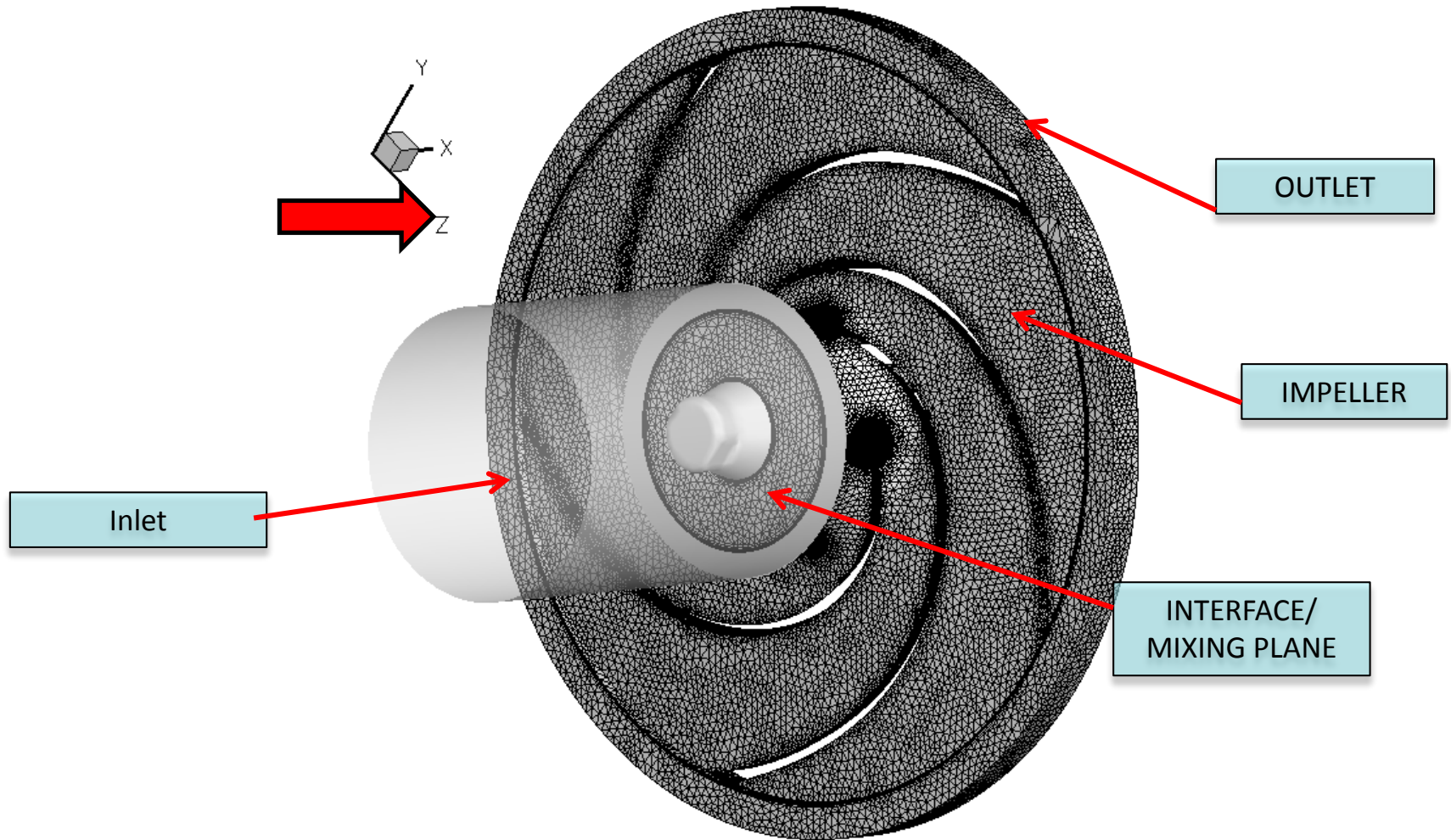
- Pink: Inlets
- Green: Metal Solid
- Blue: Periodic
- Grey: solid wall



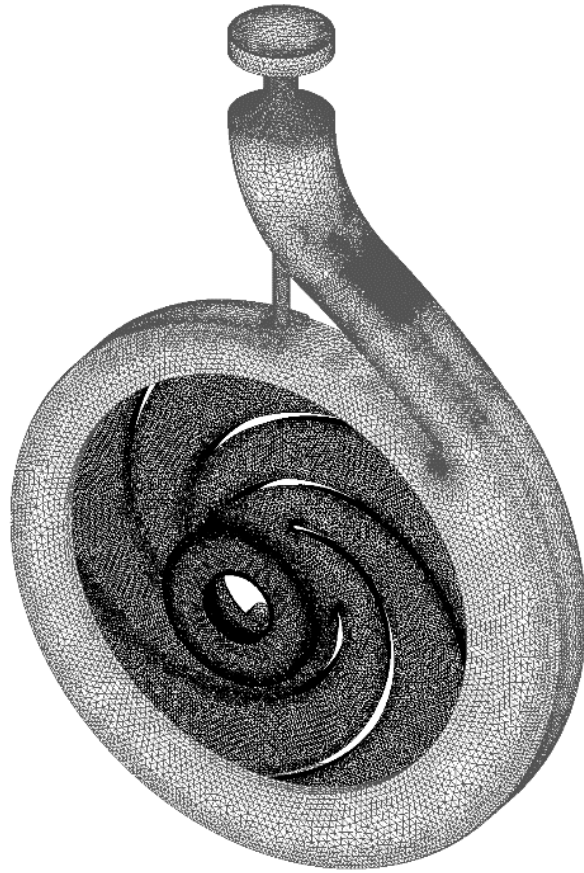
# 2D NACA Profiles



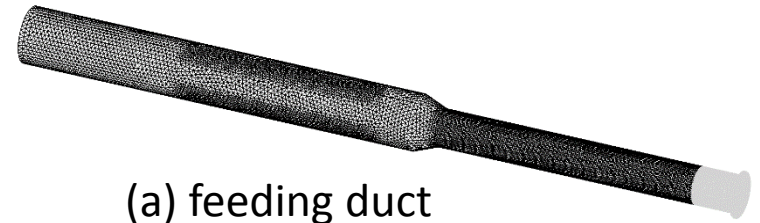
# ANALYSIS OF PUMP



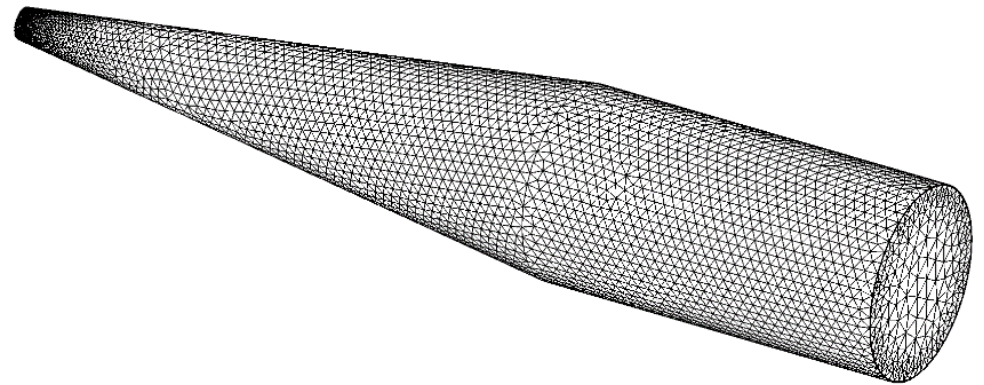
## ANALYSIS OF PUMP



(b) impeller and volute



(a) feeding duct

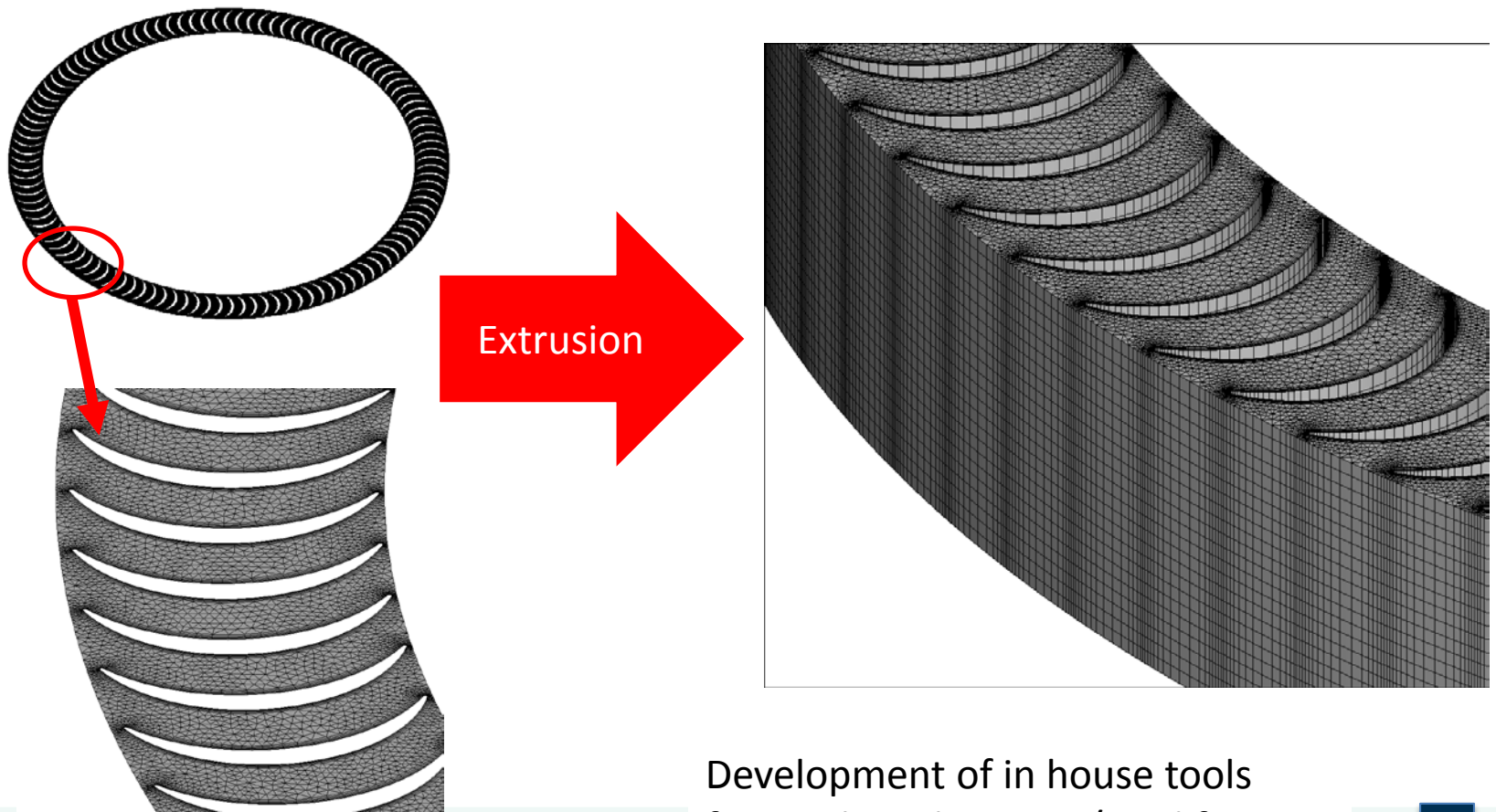


(c) discharge duct





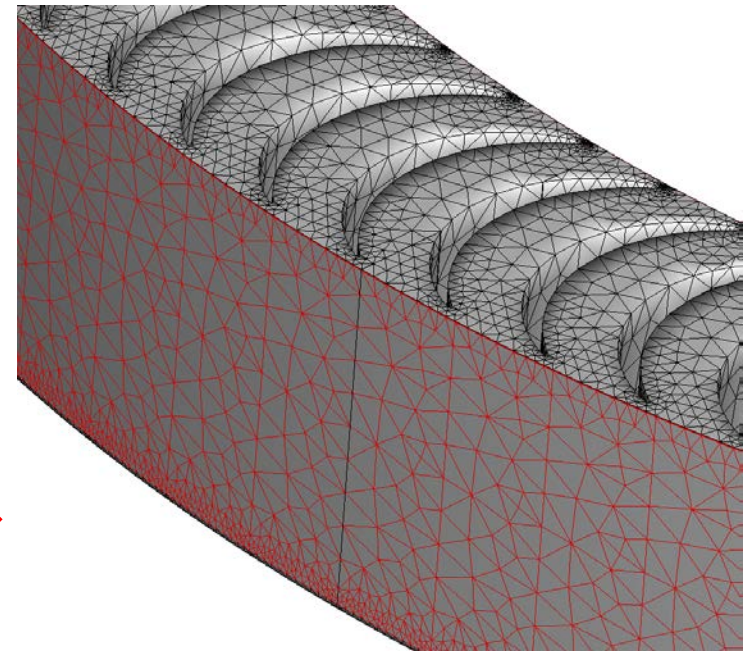
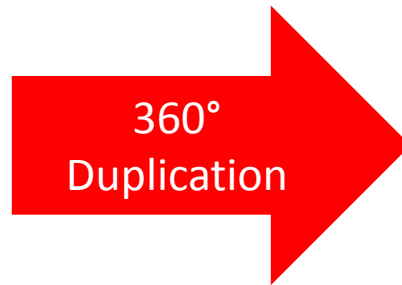
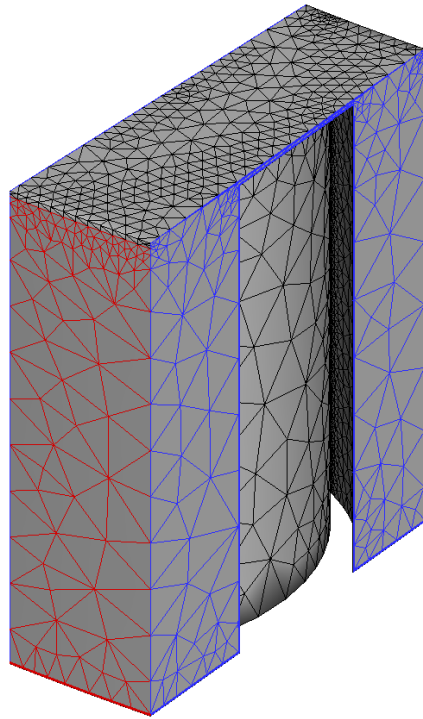
## Rotor of Regenerative compressor



Development of in house tools  
for meshes alteration/modification



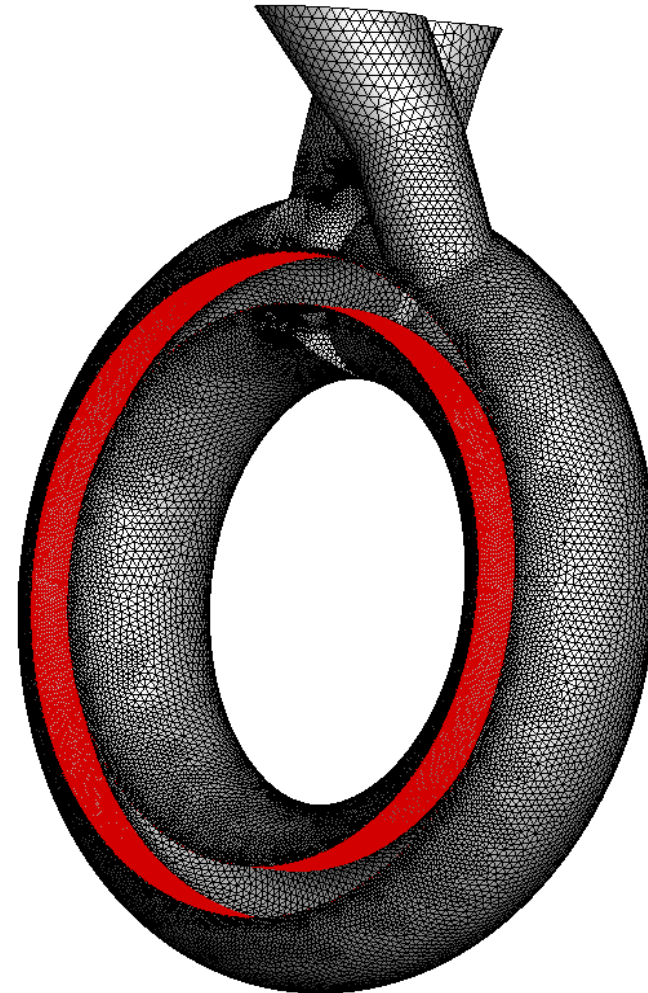
## Rotor of Regenerative compressor



- Blue: Periodic
- Red: Interface Rotor-stator
- Black: Vane (Fluid )



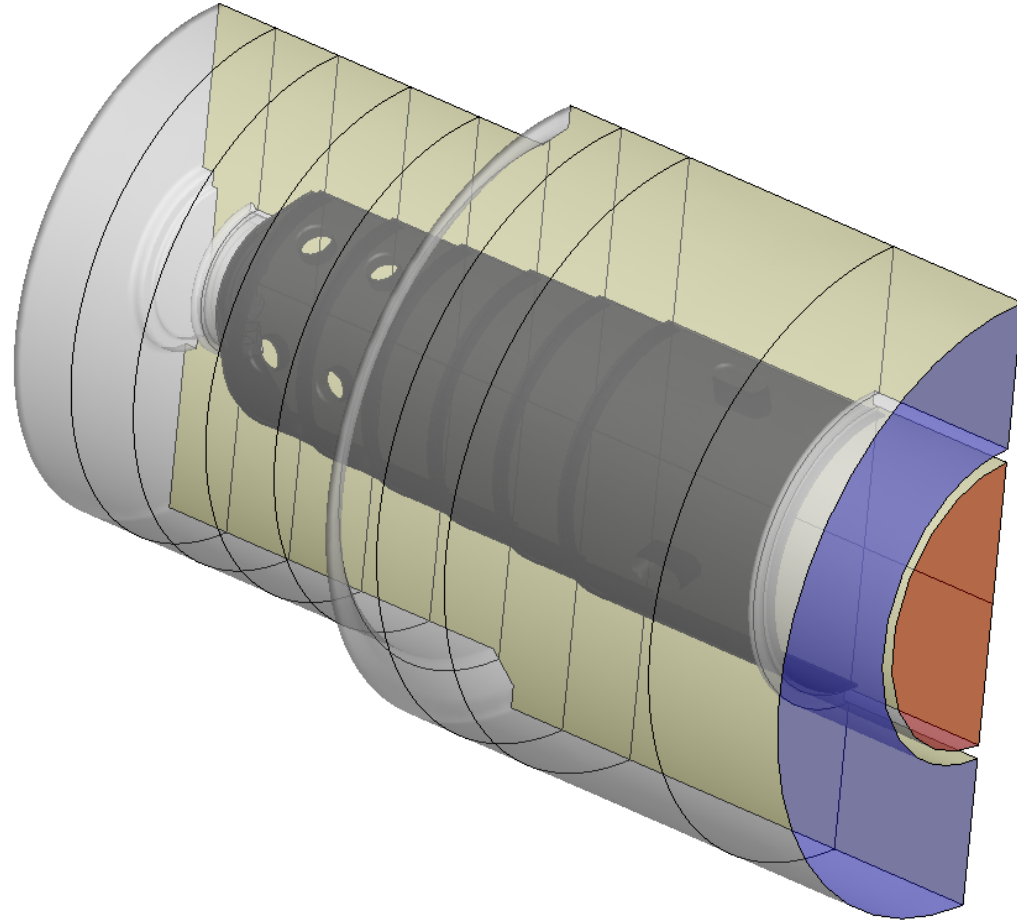
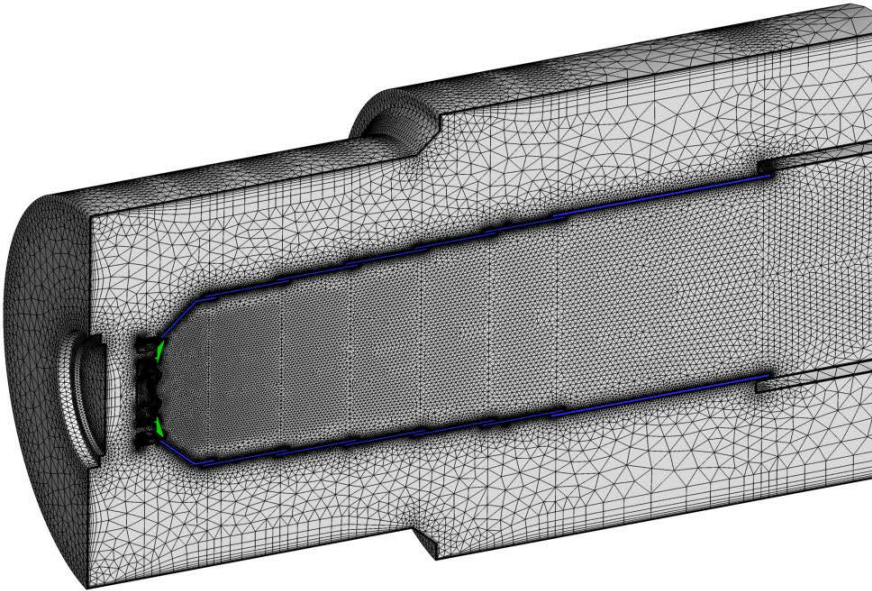
## Stator of Regenerative compressor



- Blue: Periodic
- Red: Interface Rotor-stator
- Black: Vane (Fluid )

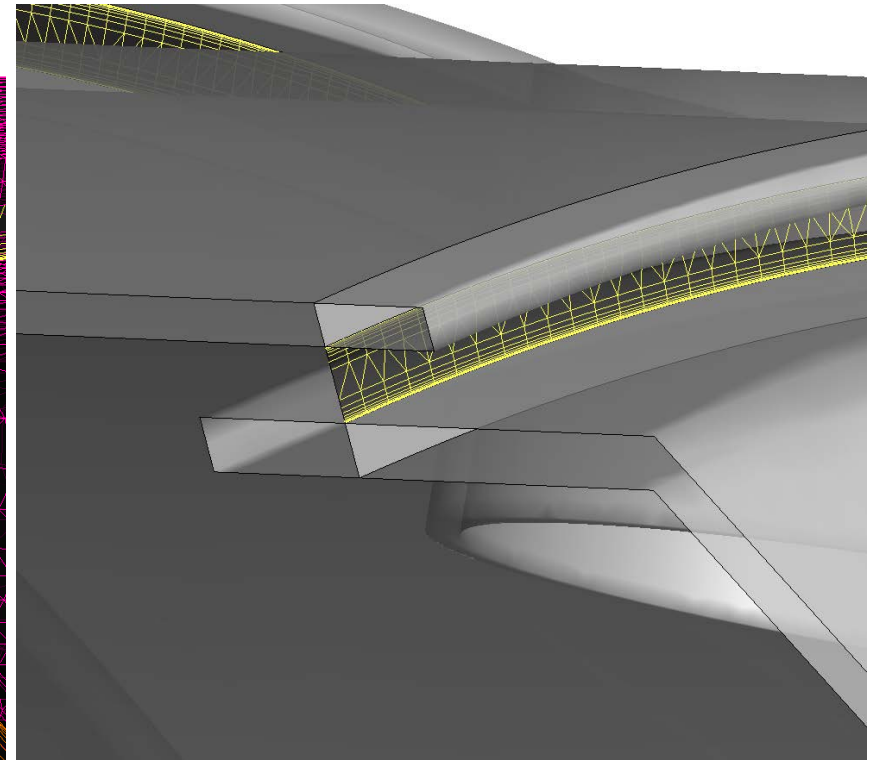
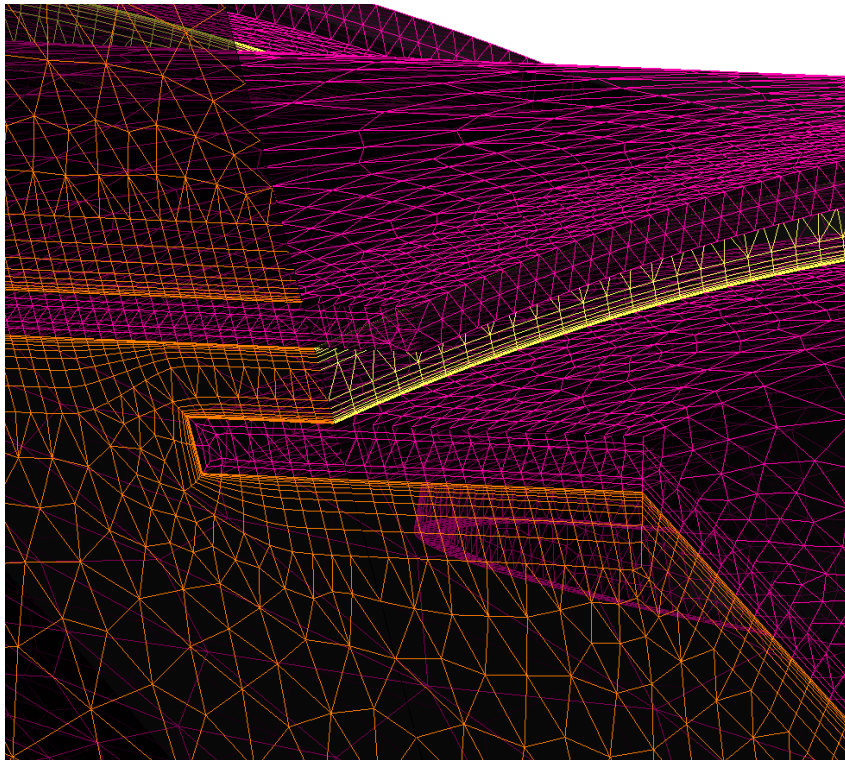


# CHT Cases: GT Combustor 1



- Metal
- Fluid
- Porous jump (surface) -> Cooling Slot
- Porous media (volume) -> Swirler
  - More 20 volume zones
  - 210 Surface zones (wall, interface, boundary condition)
  - All interface are conformed

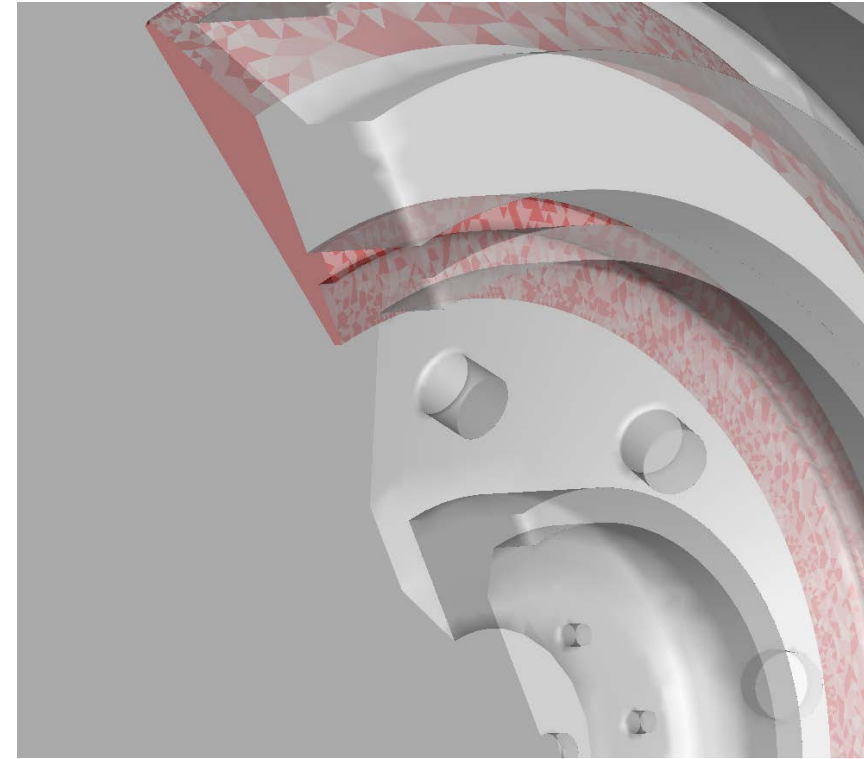
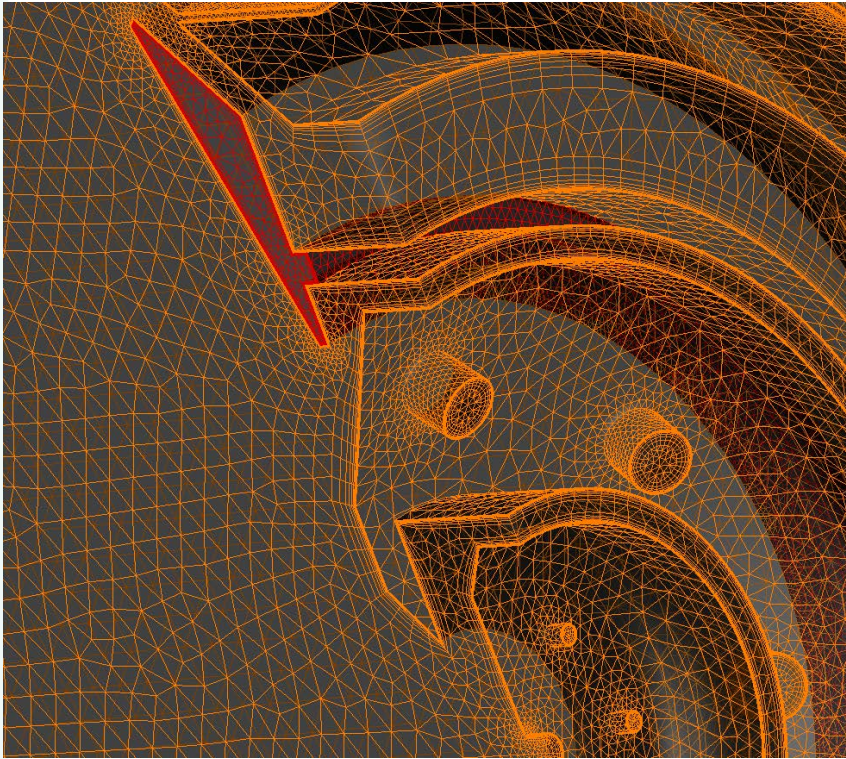
# CHT Cases: GT Combustor 2



- Pink: Metal
- Orange: Fluid
- Yellow: Porous jump



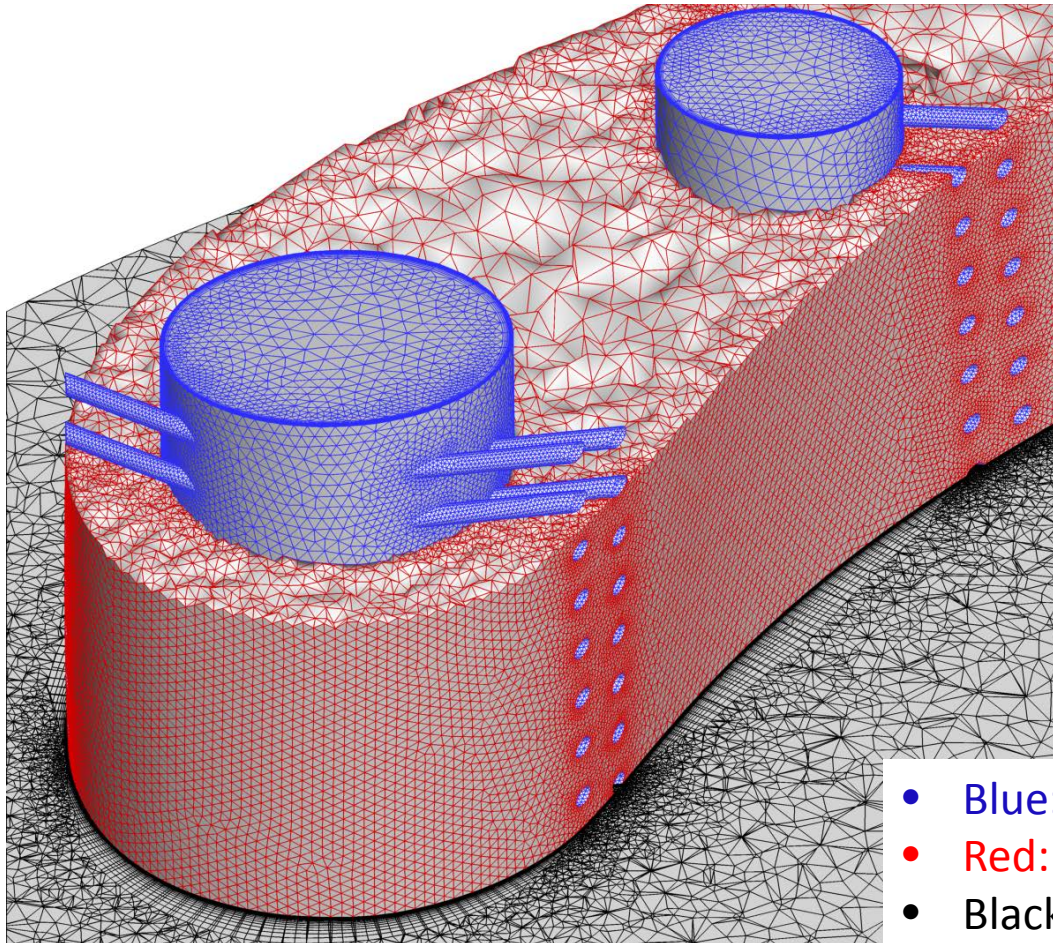
# CHT Cases: GT Combustor 2



- Pink: Metal
- Orange: Fluid
- Yellow: Porous jump
- Red: Porous media



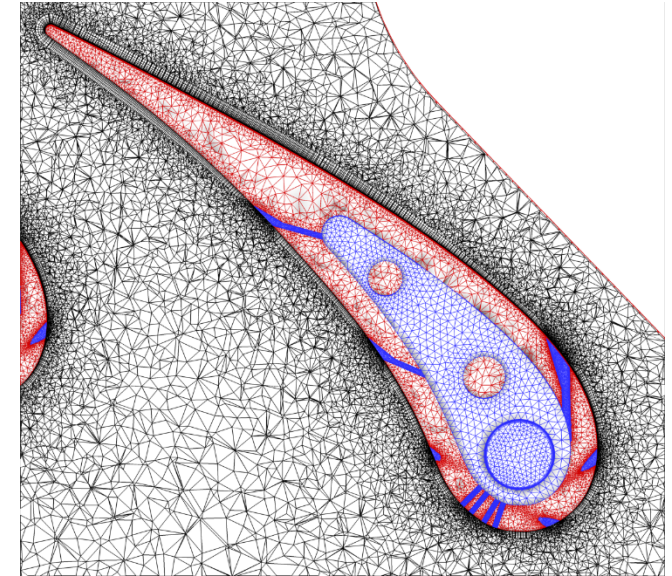
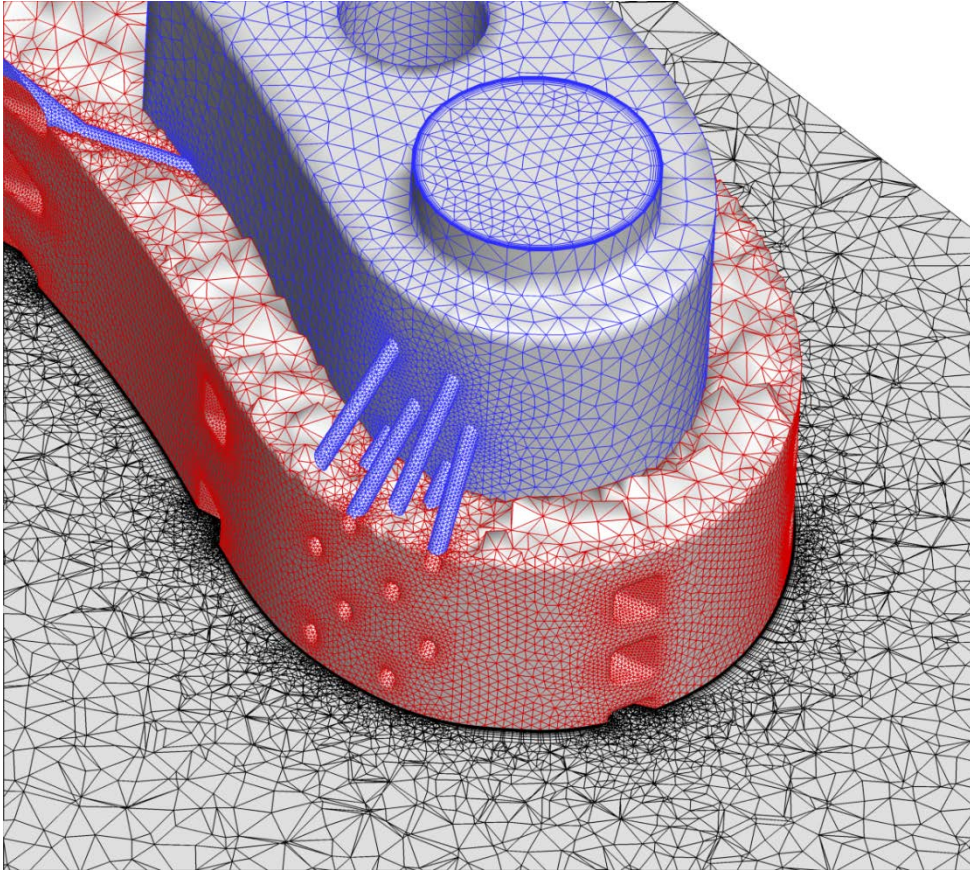
## CHT GT Stator Vane Simplified Geometry



- Blue: Cooling Channel (Fluid)
- Red: Blade (Metal)
- Black: Vane (Fluid)



## CHT GT Stator Vane Realistic Geometry

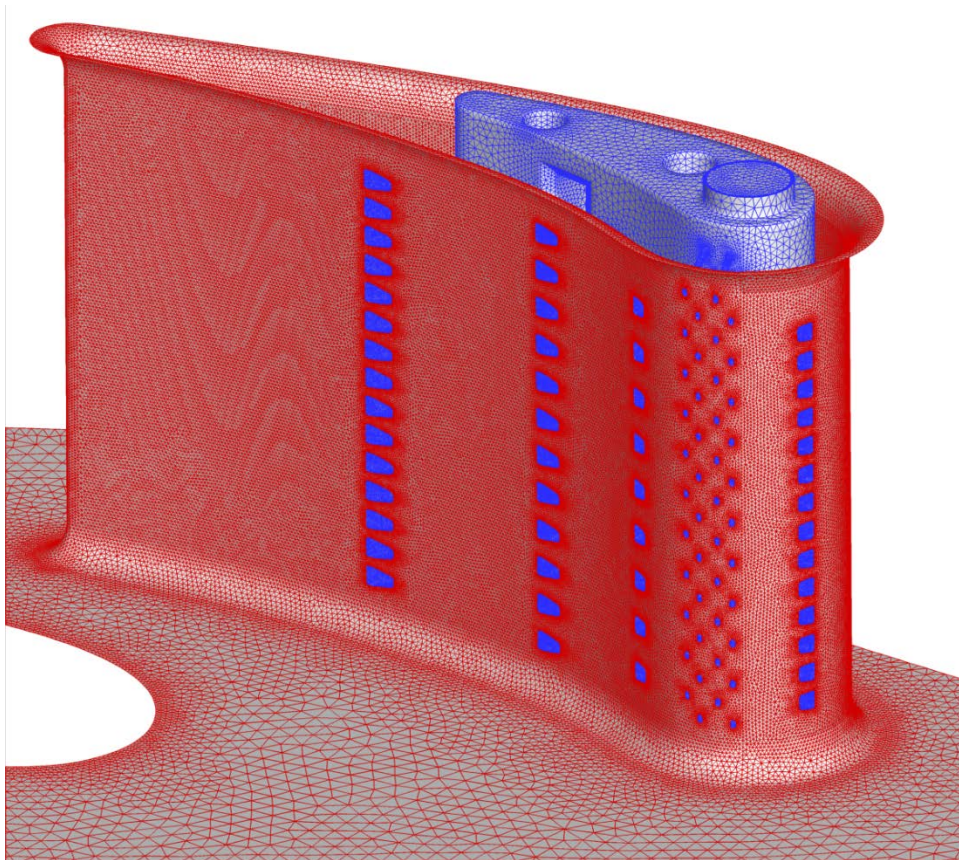


- Blue: Cooling Channel (Fluid)
- Red: Blade (Metal)
- Black: Vane (Fluid )





## CHT GT Stator Vane Realistic Geometry



- Blue: Cooling Channel (Fluid)
- Red: Blade (Metal)
- Black: Vane (Fluid )



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## **Thank You for your attention**

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