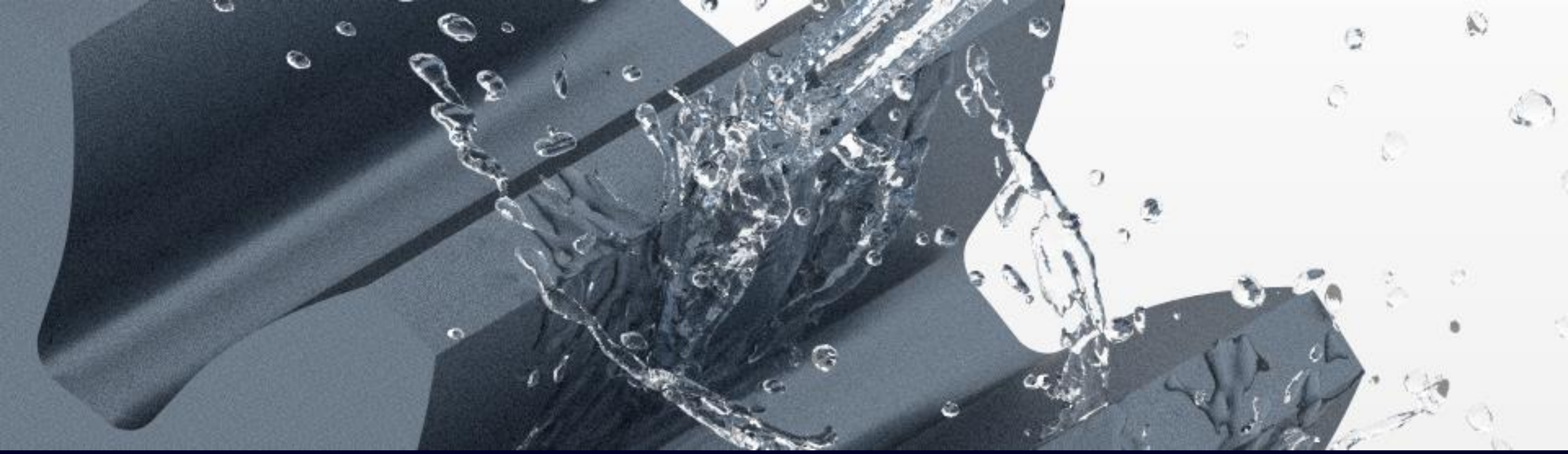

Simulation of High Speed Gears

- Geometry and Overset Setup
- Handling Small Gaps with Overset
- Motion Setup

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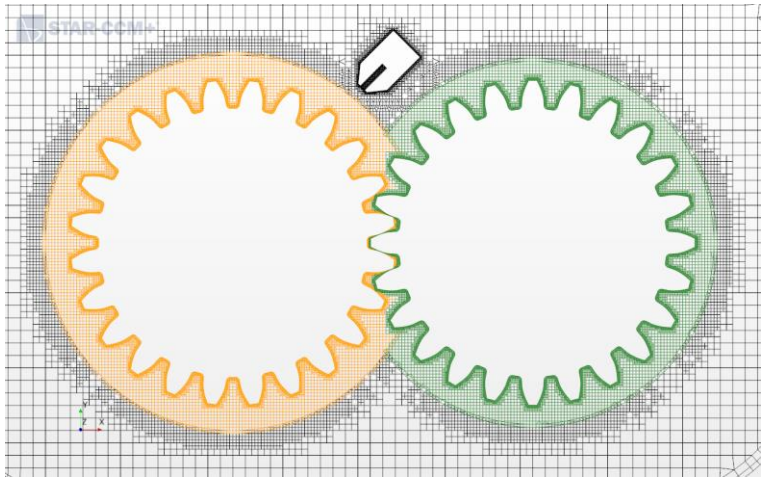
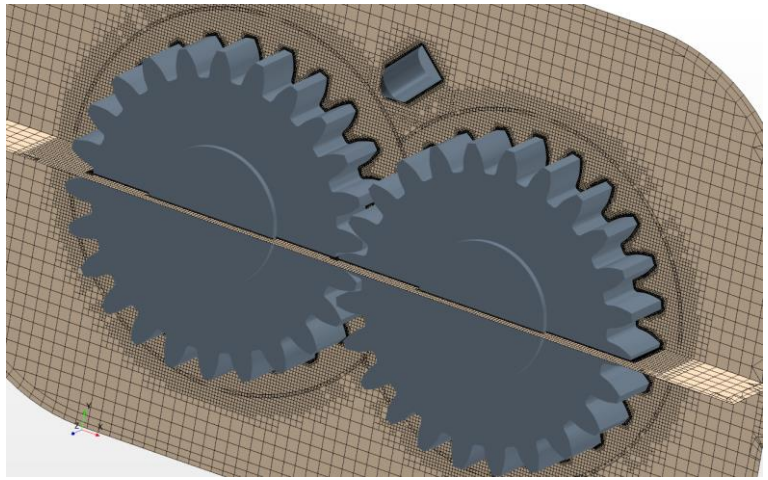
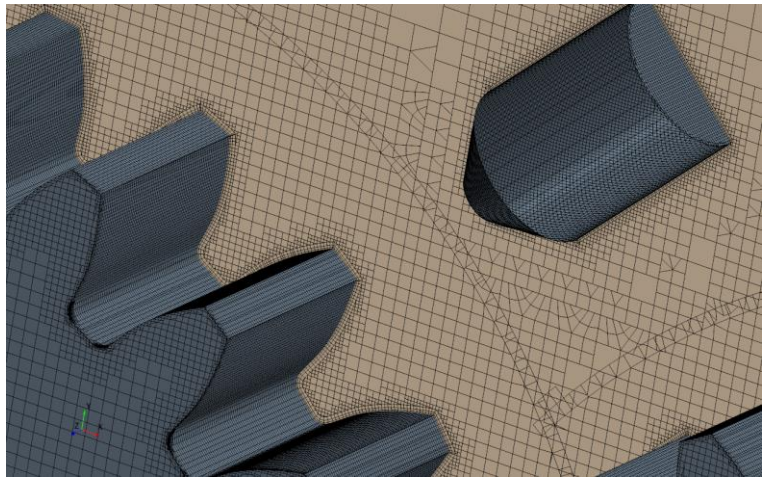
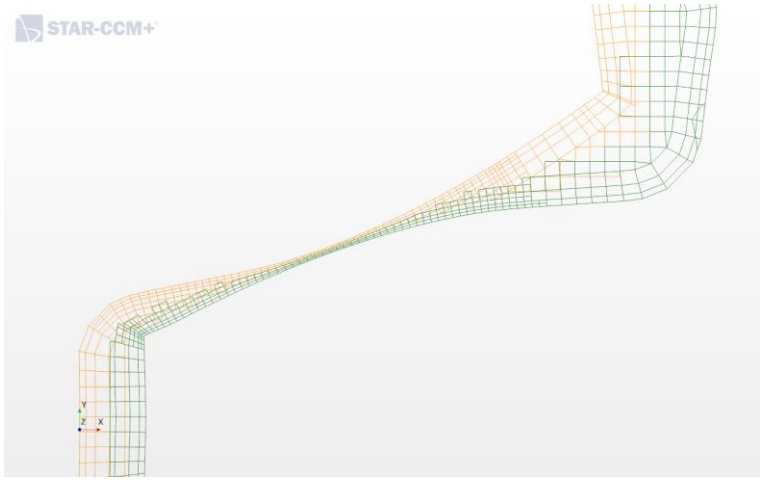
Simulating Oil Jet Lubrication of High Speed Gears
Setup Overview

- Volume of Fluid (VOF) with liquid oil and air
- Overset regions with prism layer shrinkage
- Gear velocity and oil jet velocity ~ 50m/s
- Time step 0.25µs (12000 time steps per revolution @ 20000rpm)
- ~6M cells after solution init









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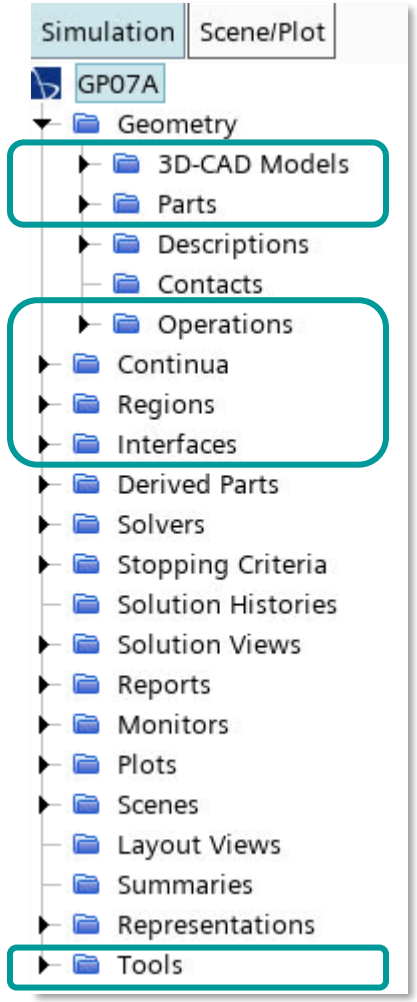
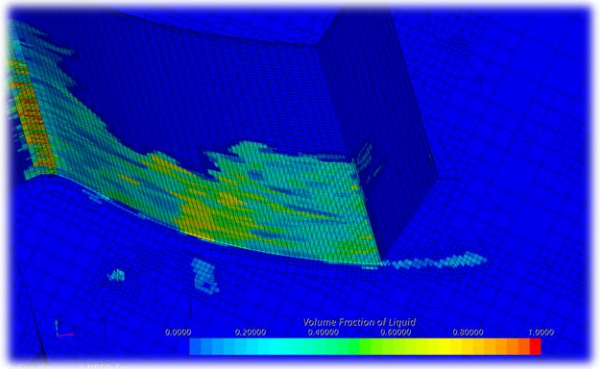
The Simulation Tree





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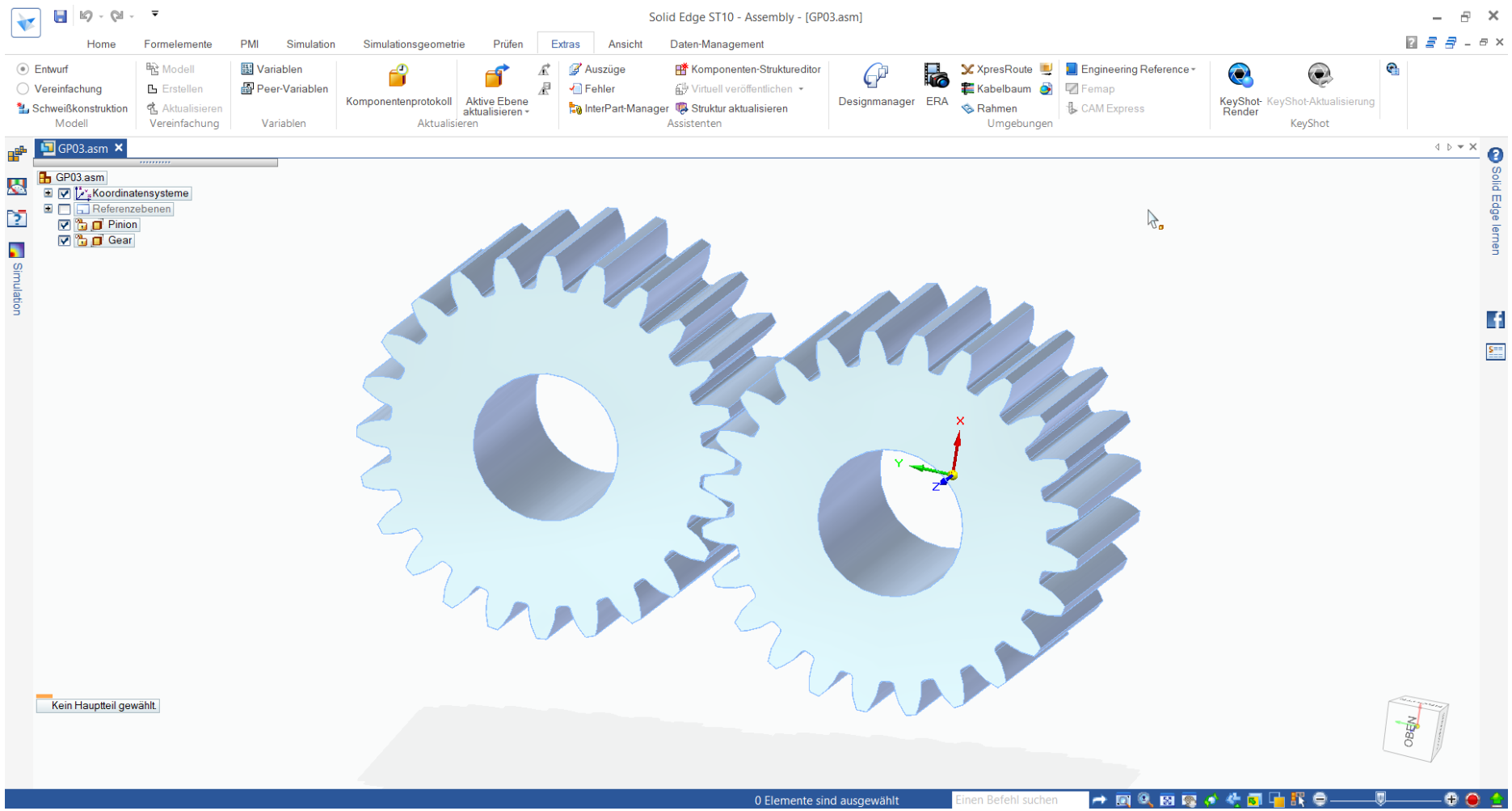
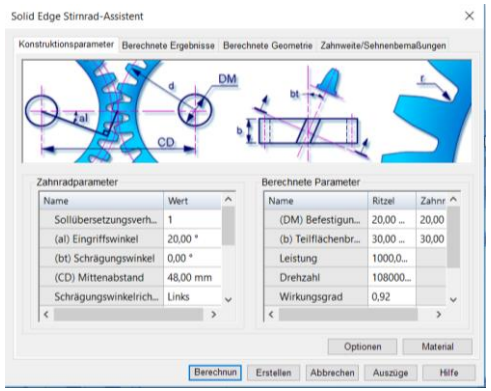
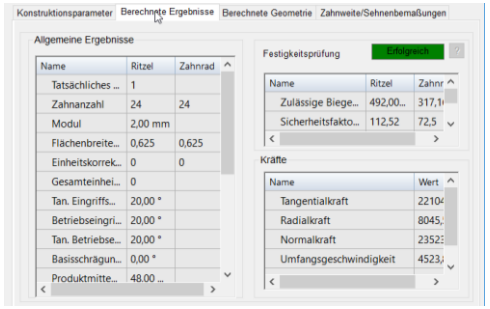
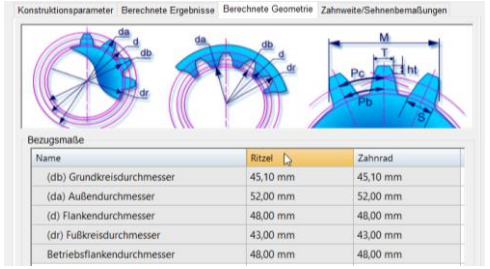
Simulating Oil Jet Lubrication of High Speed Gears

Gear pair created with Solid Edge ST10









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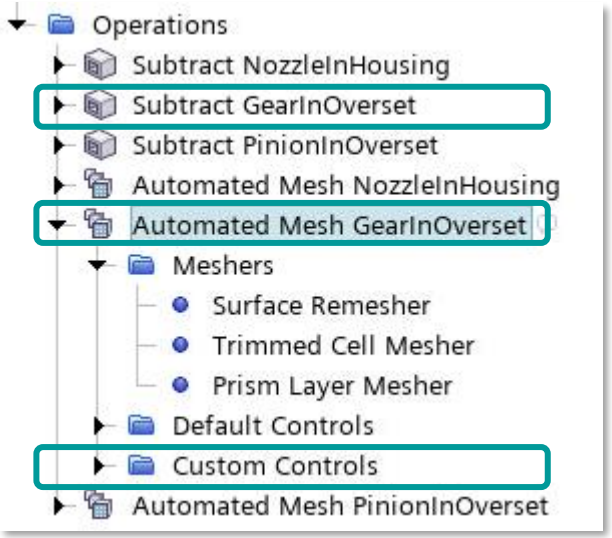
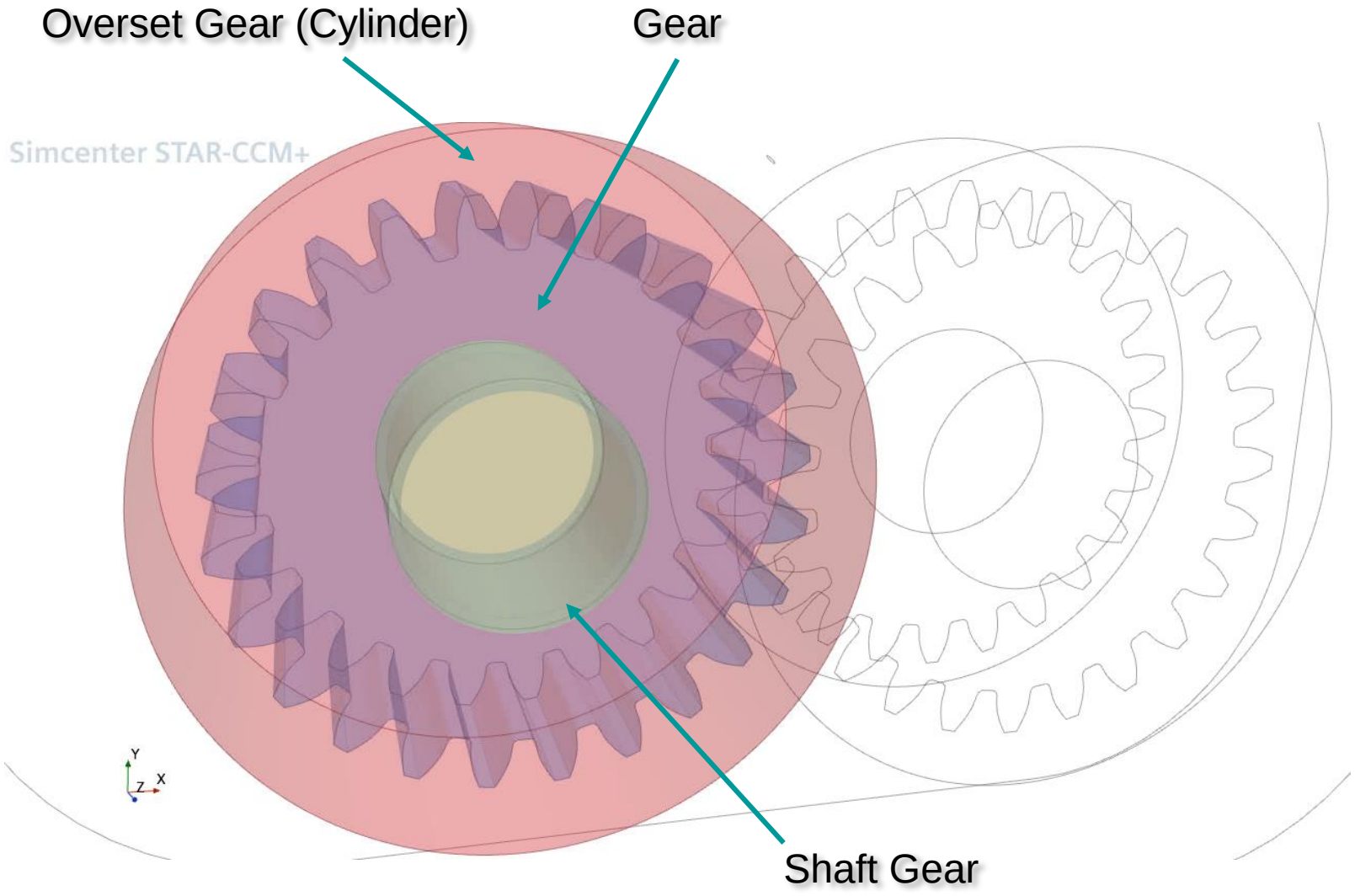
Geometry Parts & Mesher





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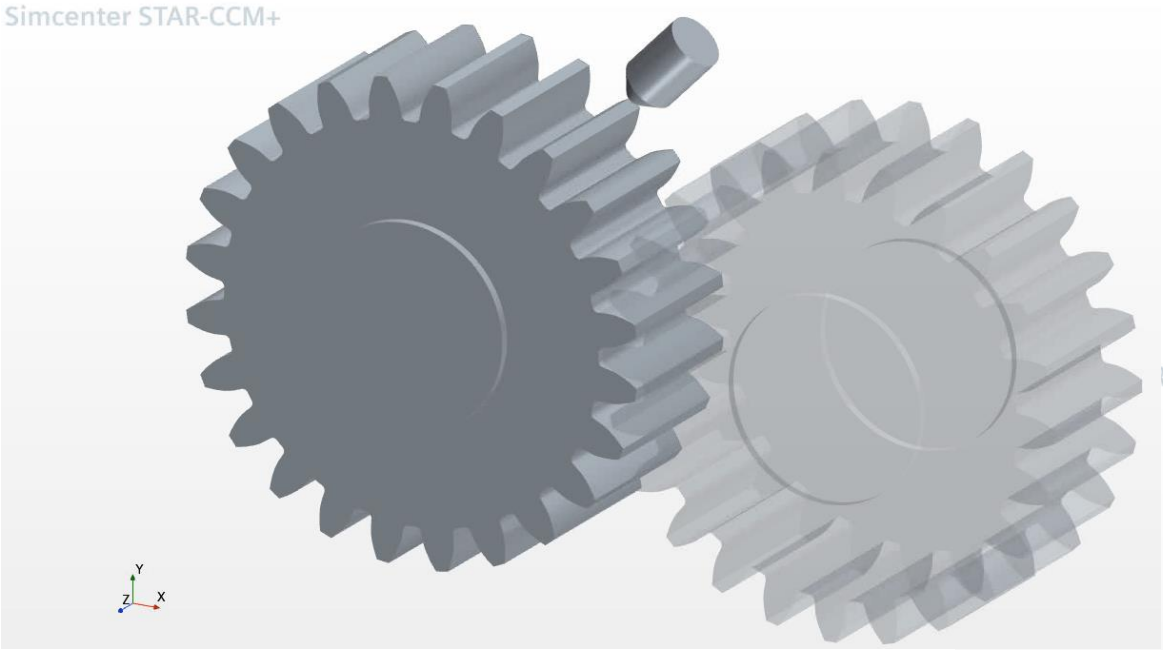
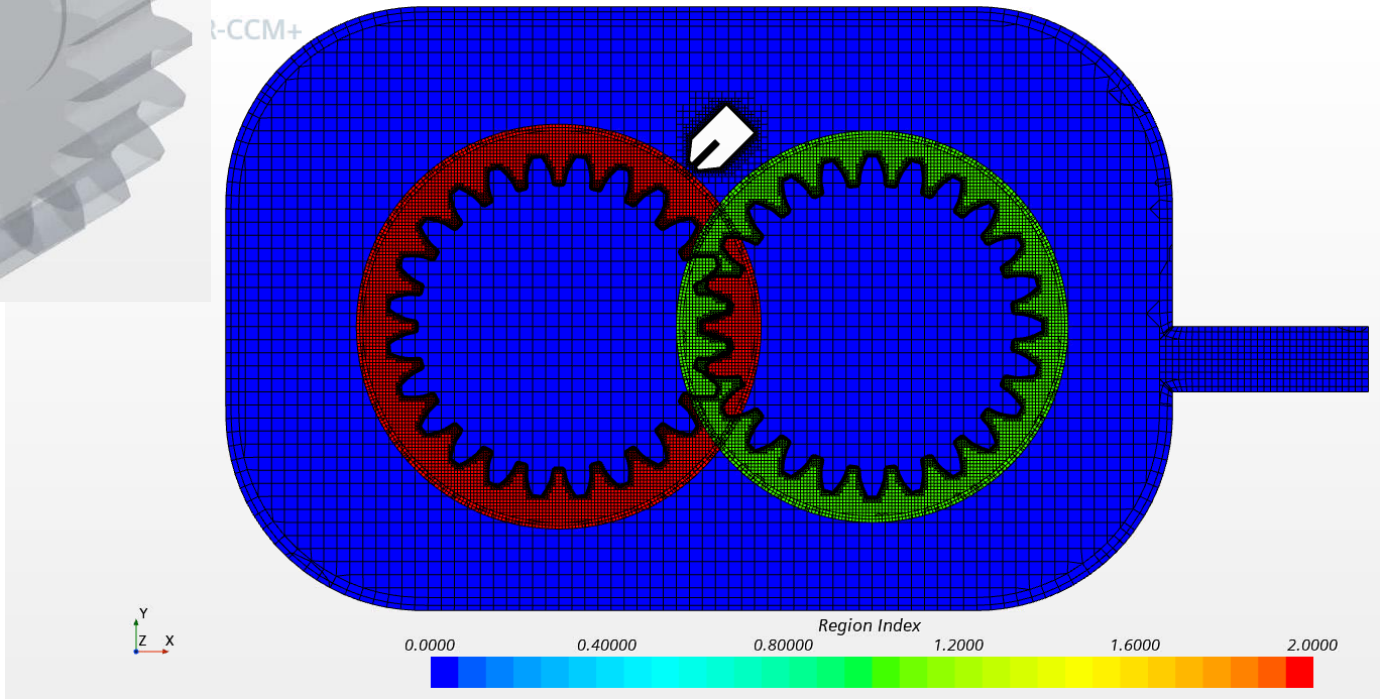
Subtracted Geometry & Meshed Geometry





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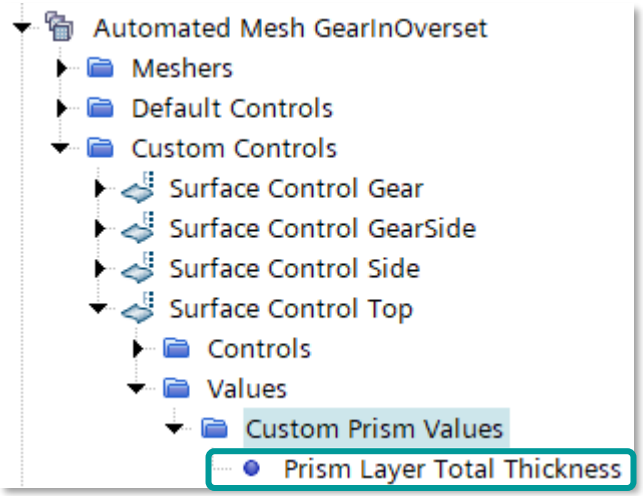
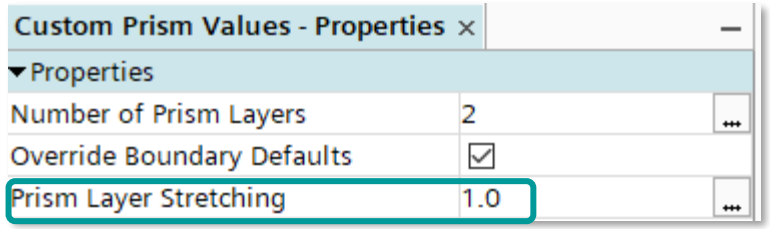
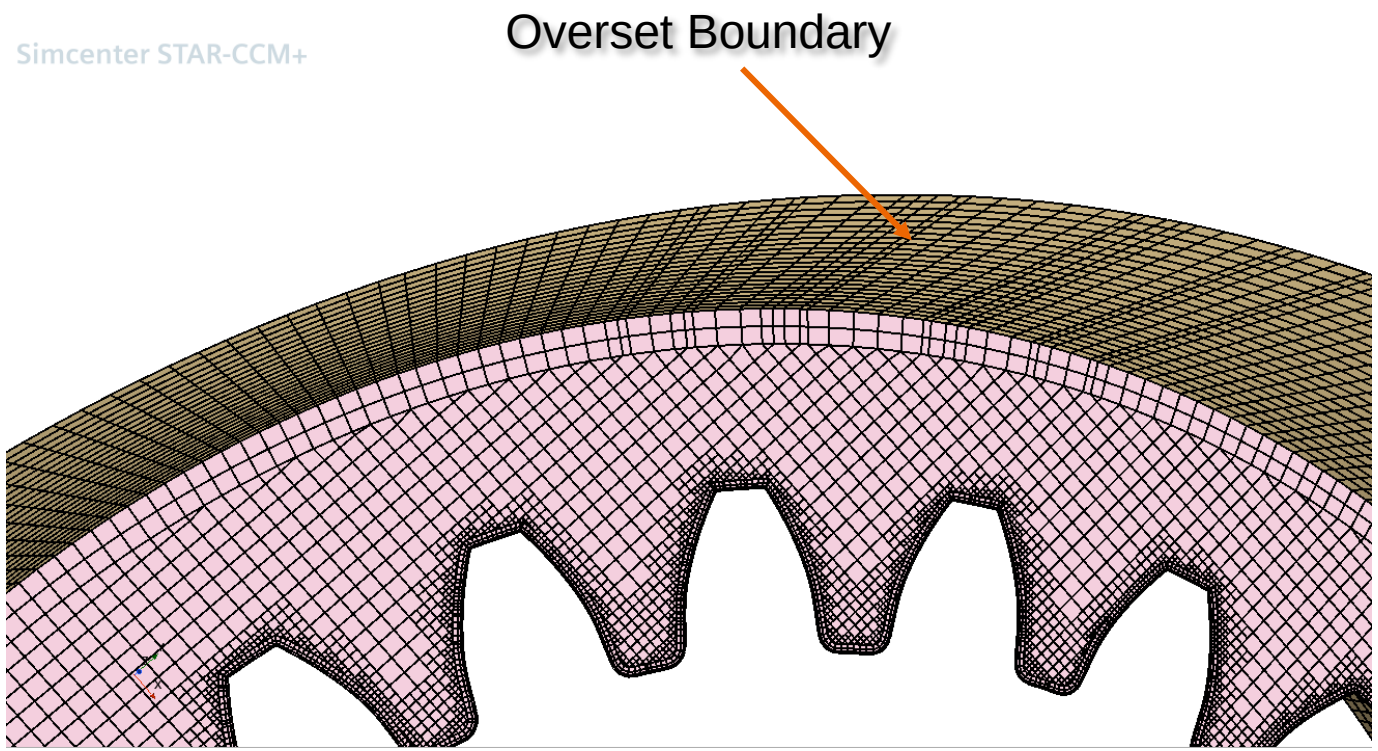
Customized Meshing at the Overset Boundaries







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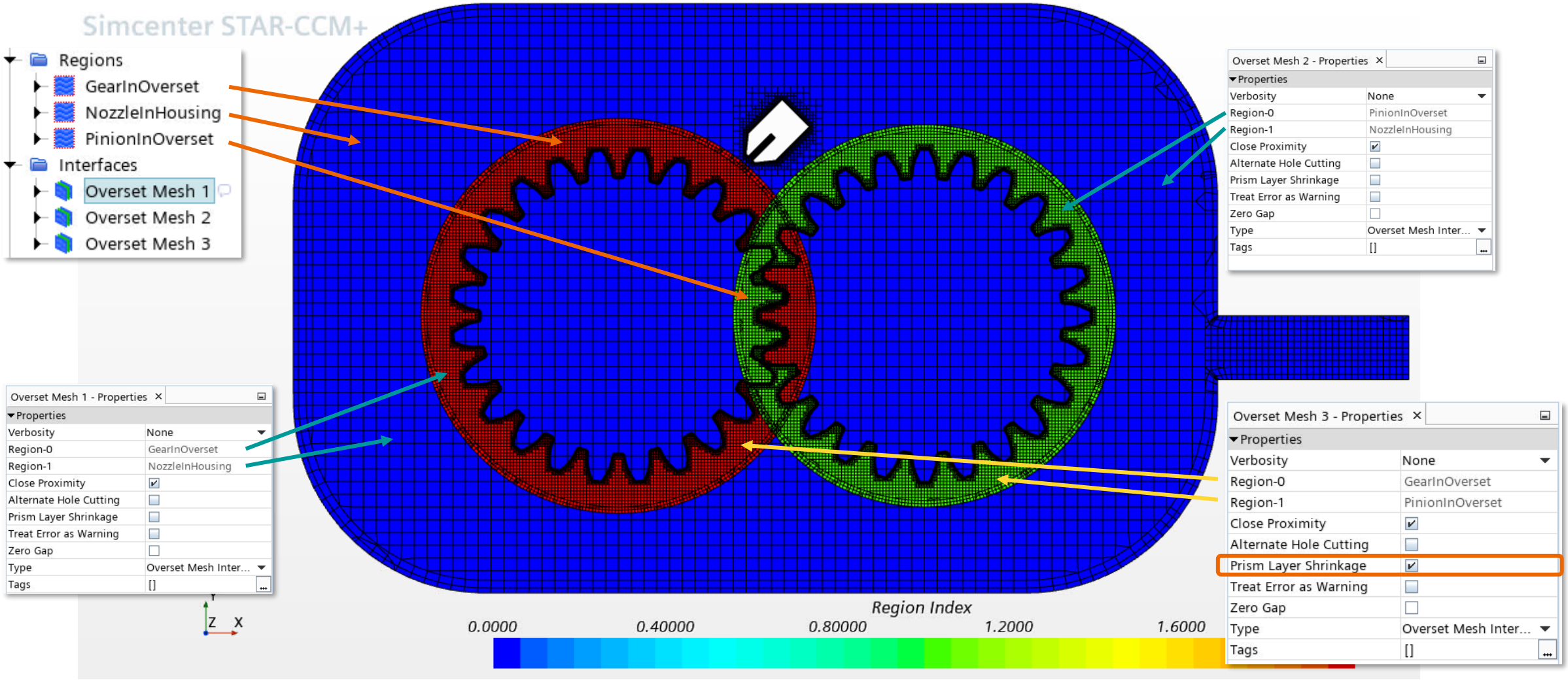
Regions and Overset Interfaces



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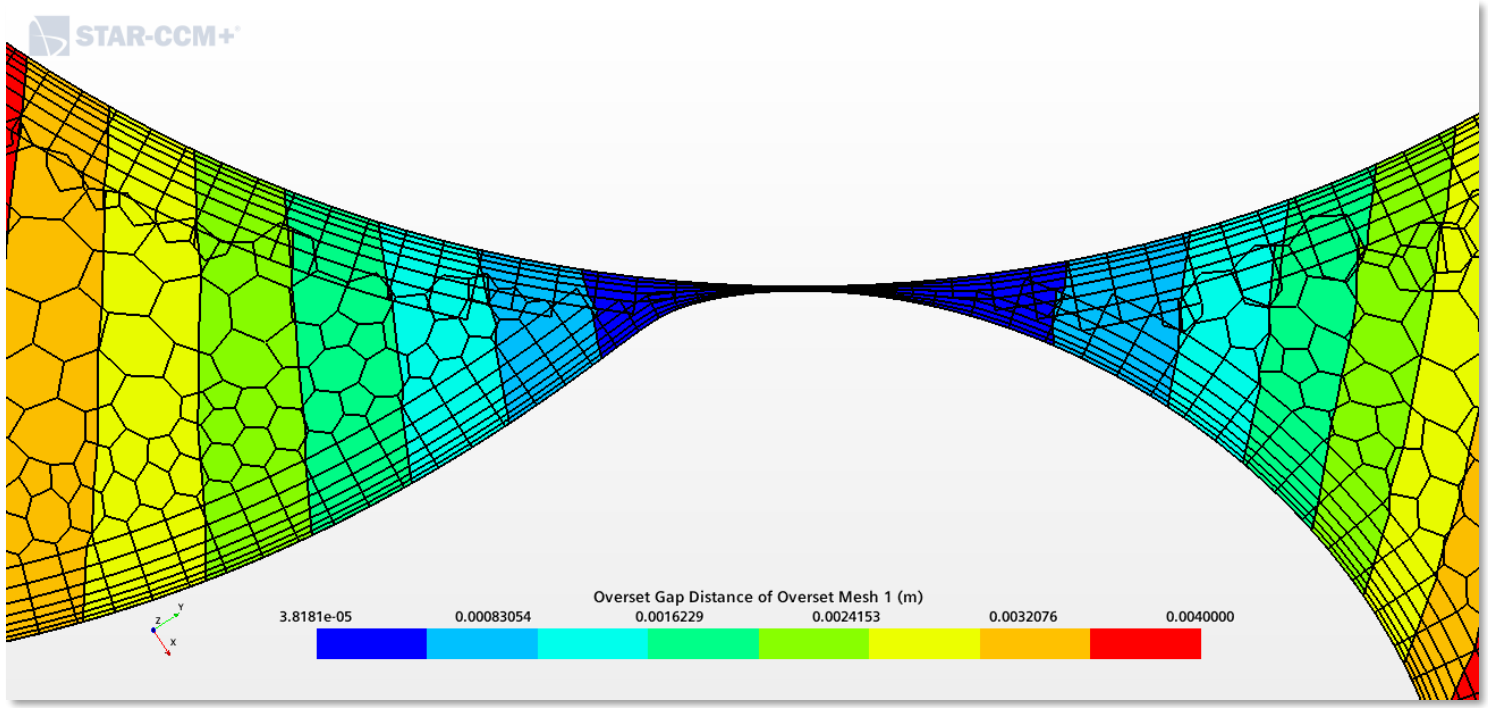
Overset Small Gap Modeling

Overset Prism Layer Shrinkage

- Moving previously inactive prism layer cells into the gap ("specialized morphing")
- Anisotropic refinement
- Cheap (no additional cells)

Adaptive Mesh Refinement

- Refining cells inside the gap
- Isotropic refinement
- No prism layers required



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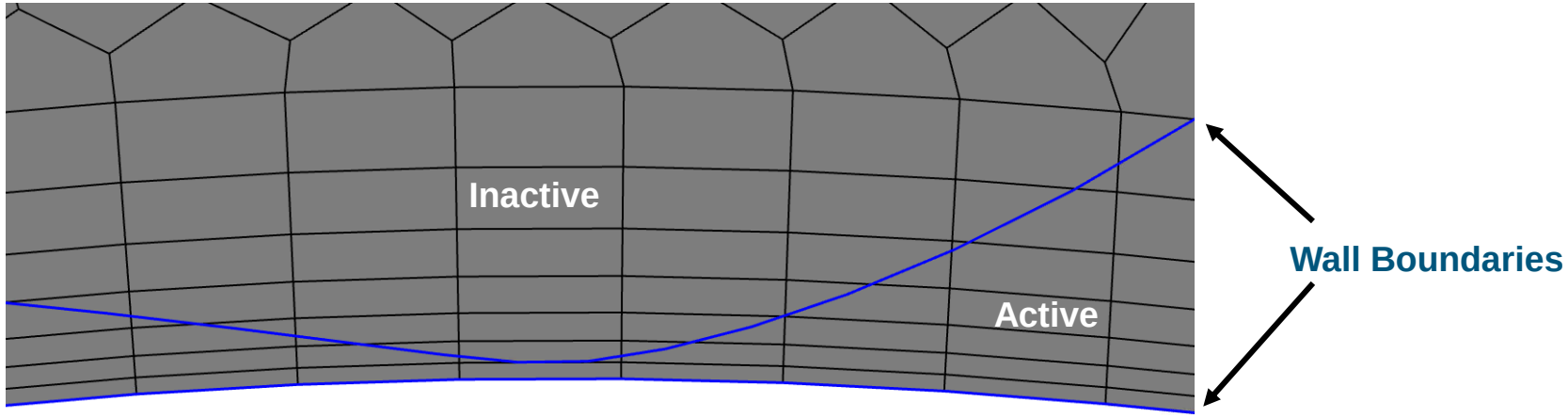
Overset Prism Layer Shrinking



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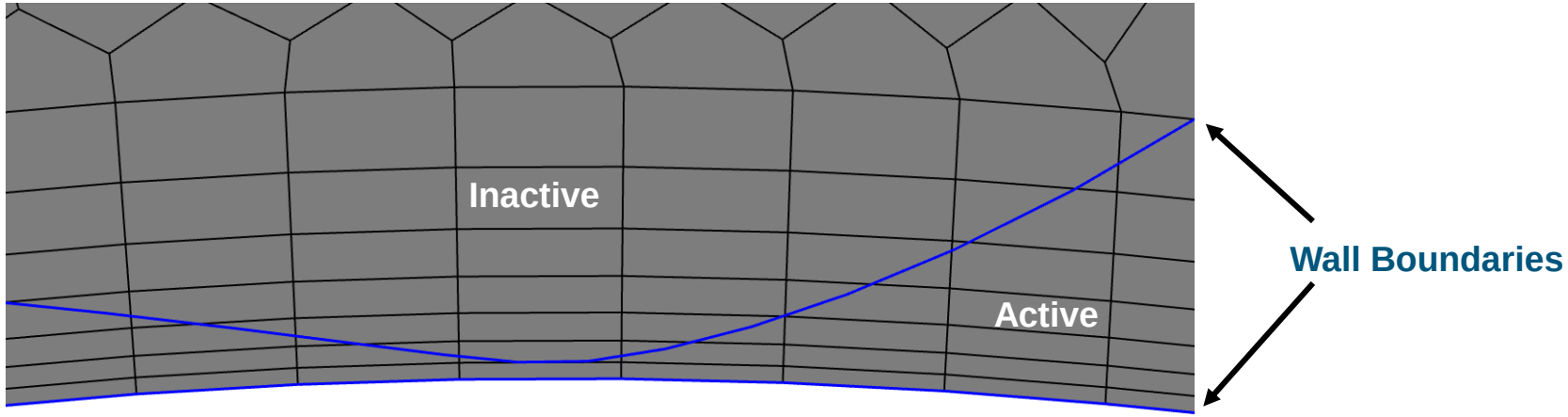
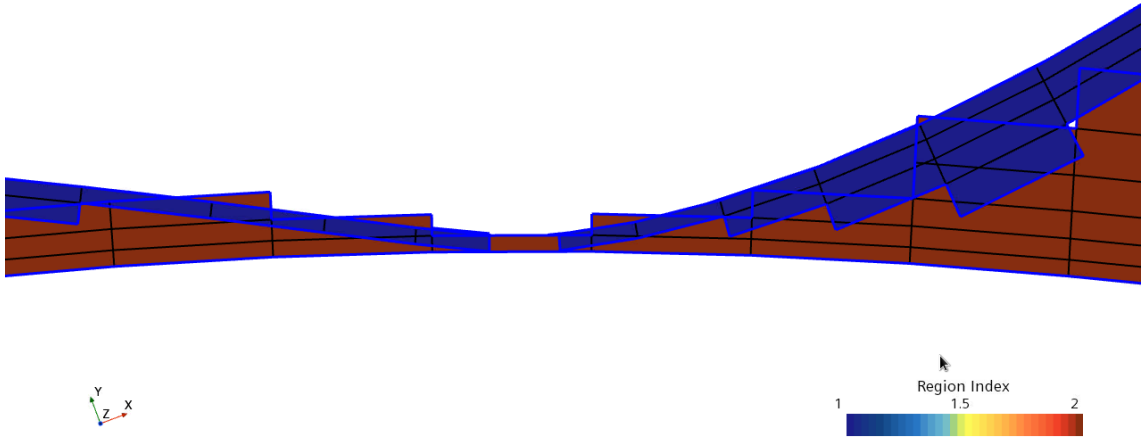
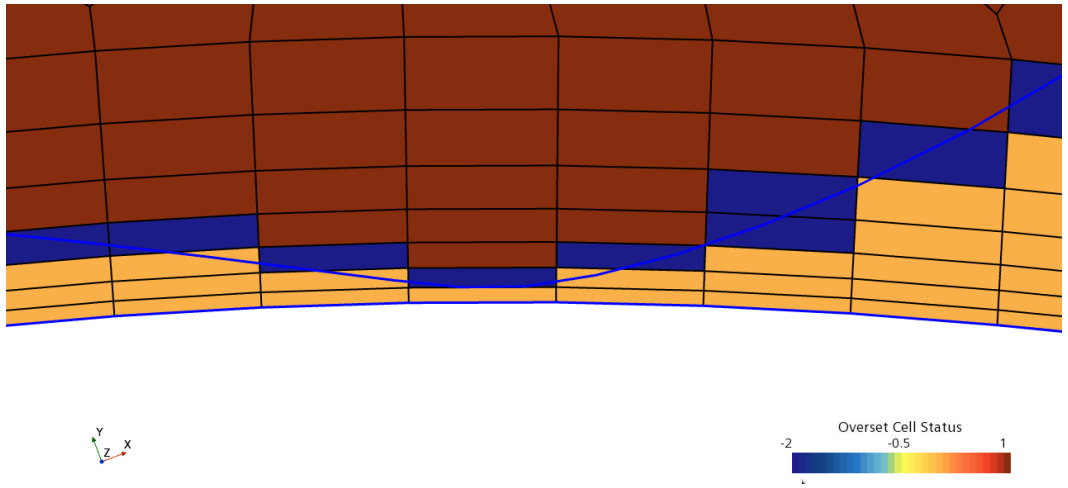
Overset Prism Layer Shrinking







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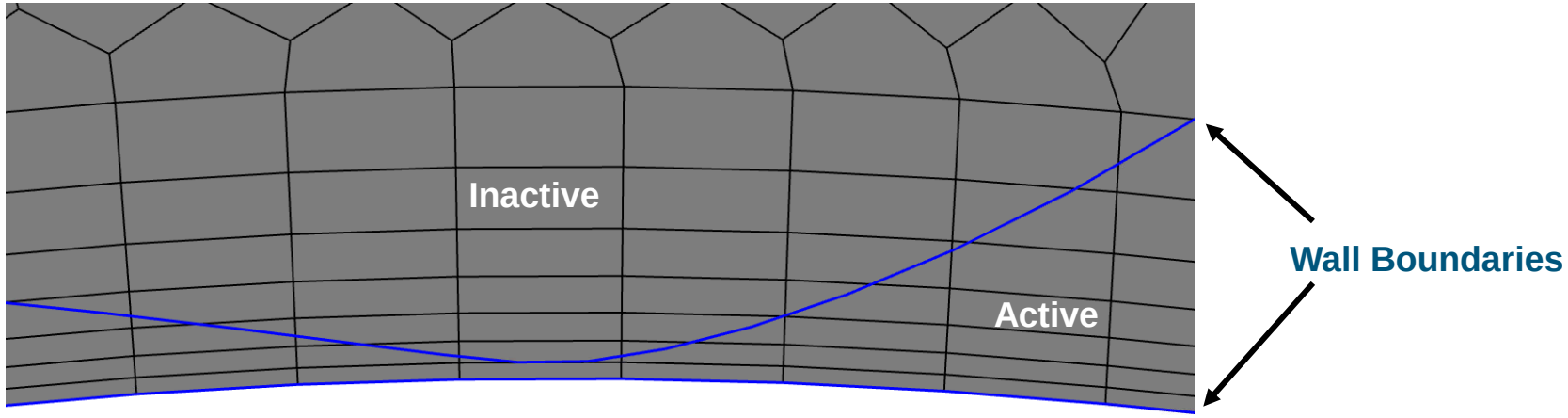
Overset Prism Layer Shrinking



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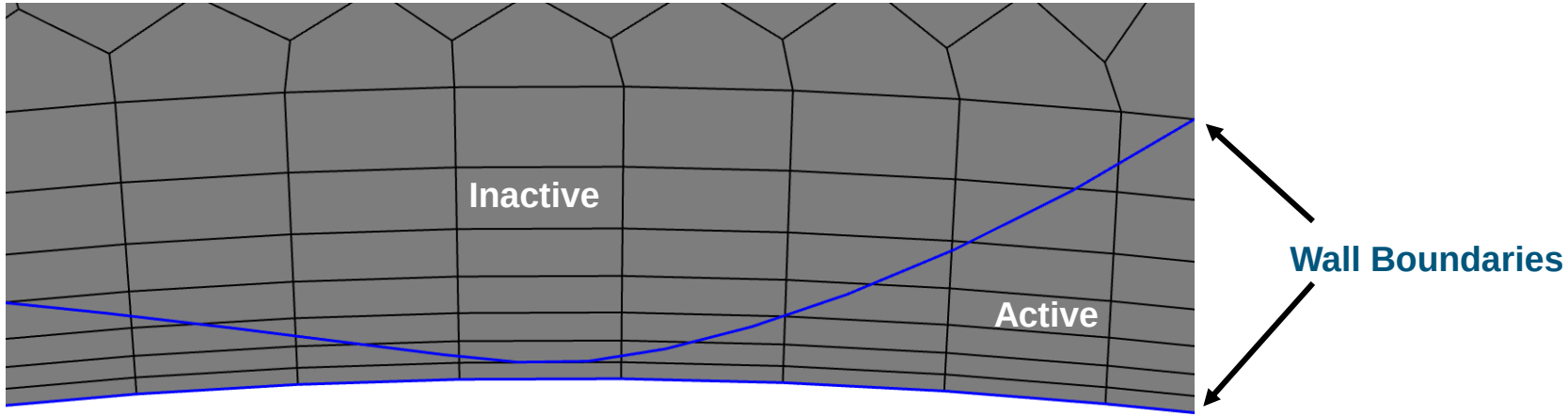
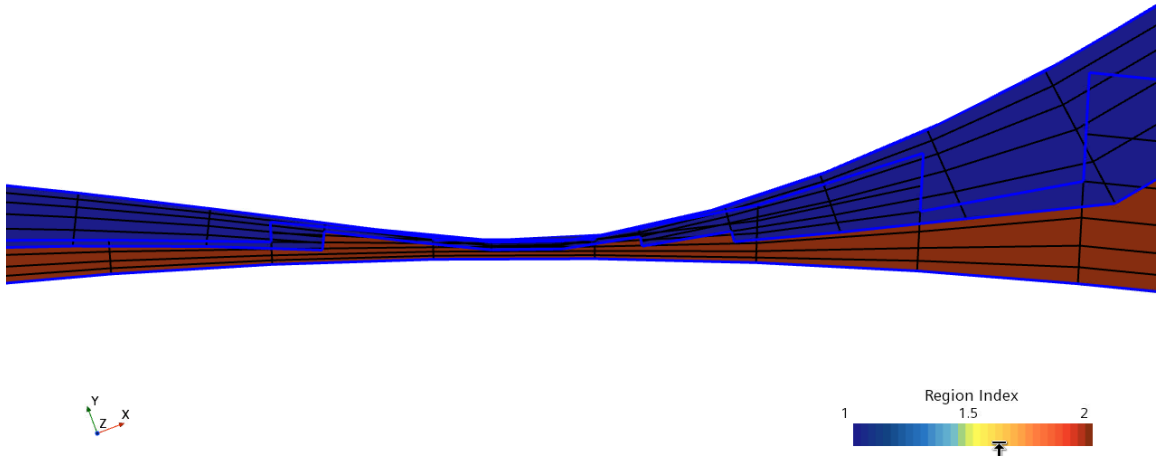
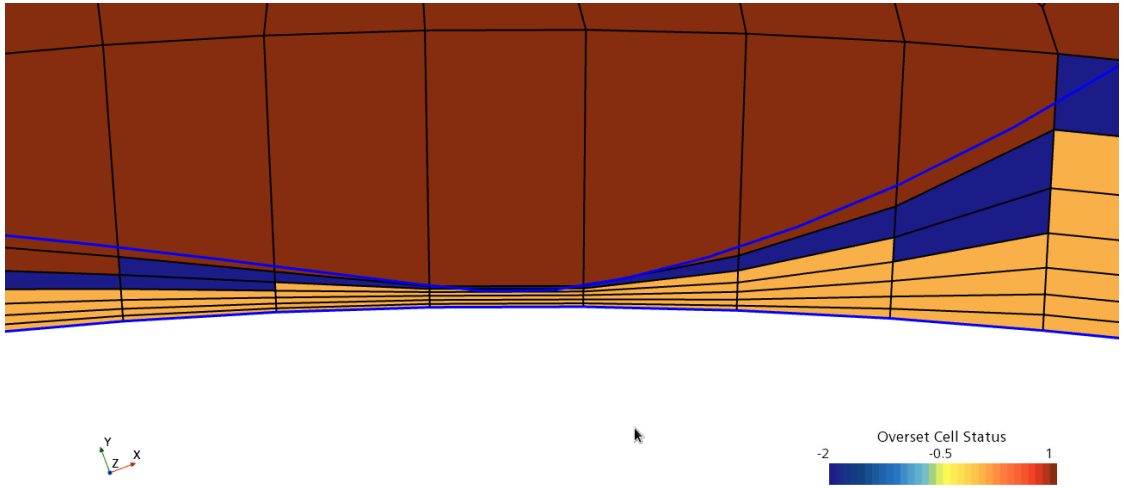
Overset Prism Layer Shrinking







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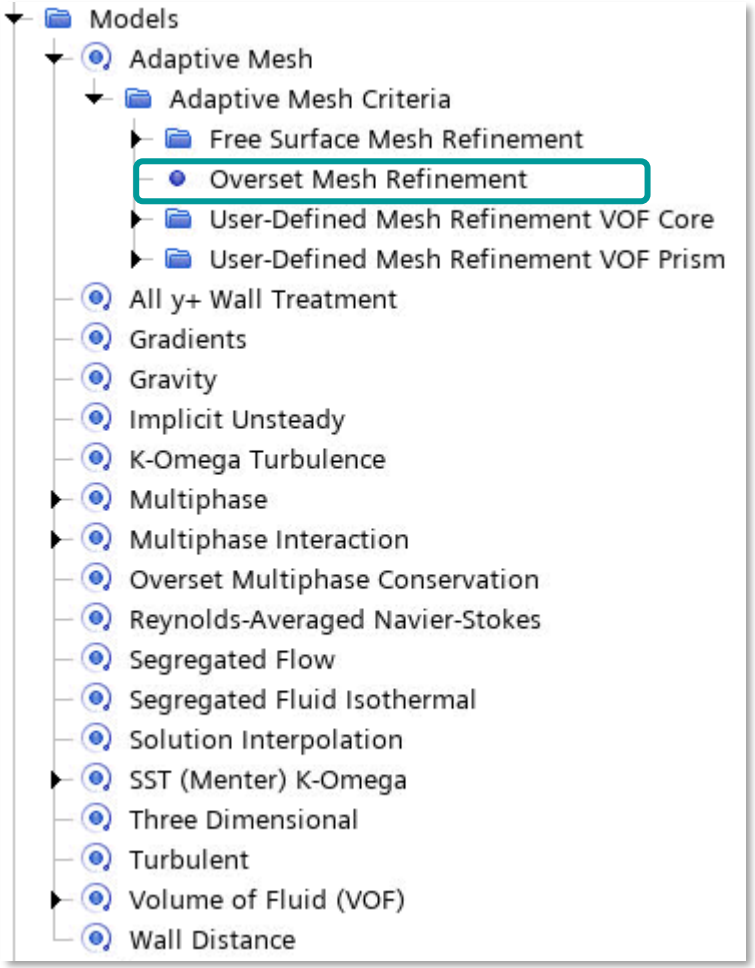
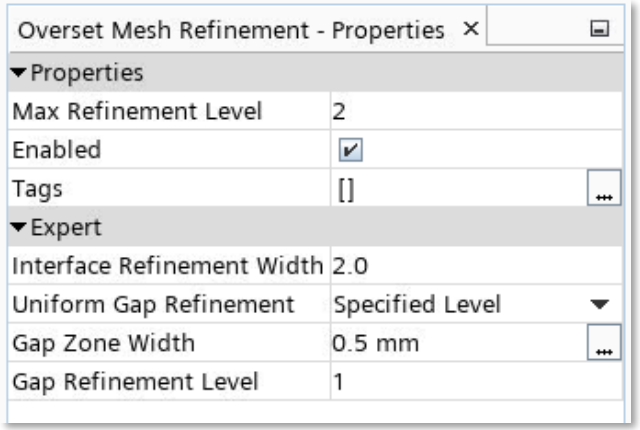
Overset-specific Physics Continua





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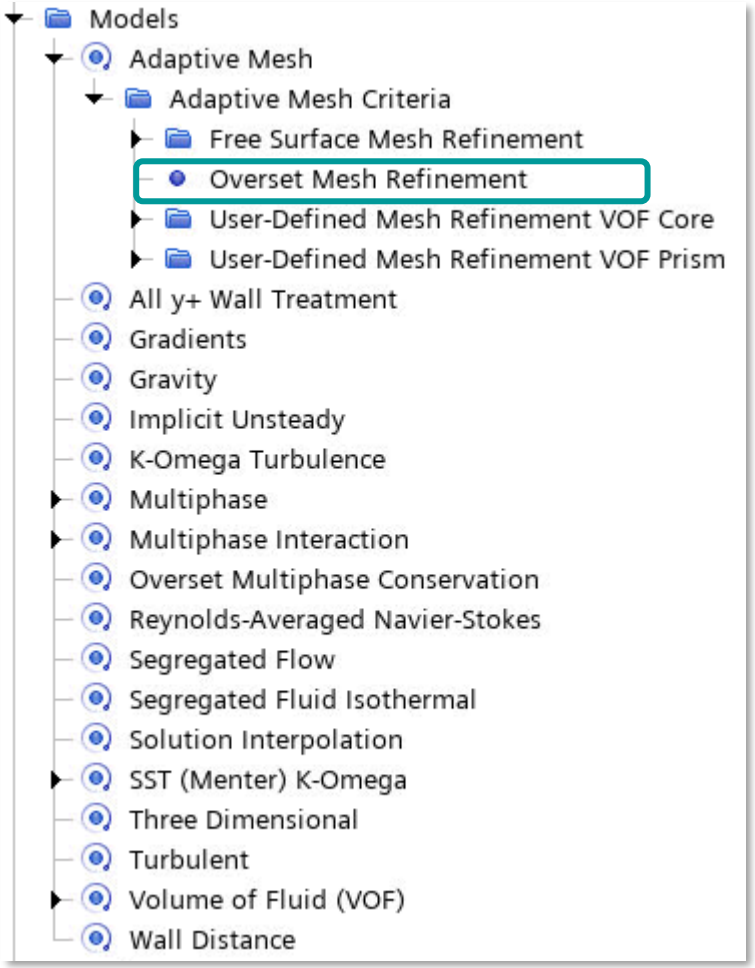
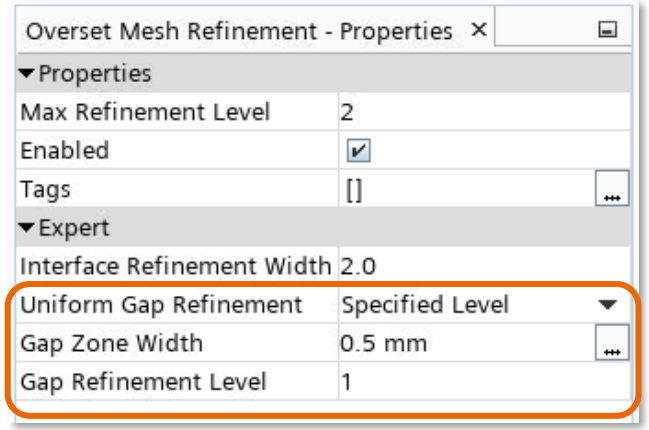
Physics Continua





Enabled Uniform Gap Refinement

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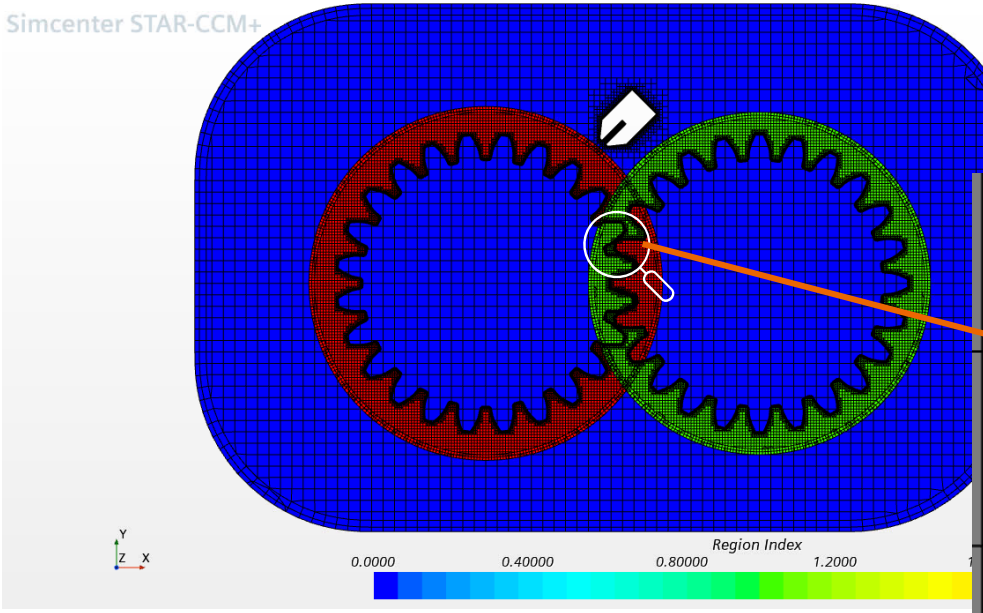
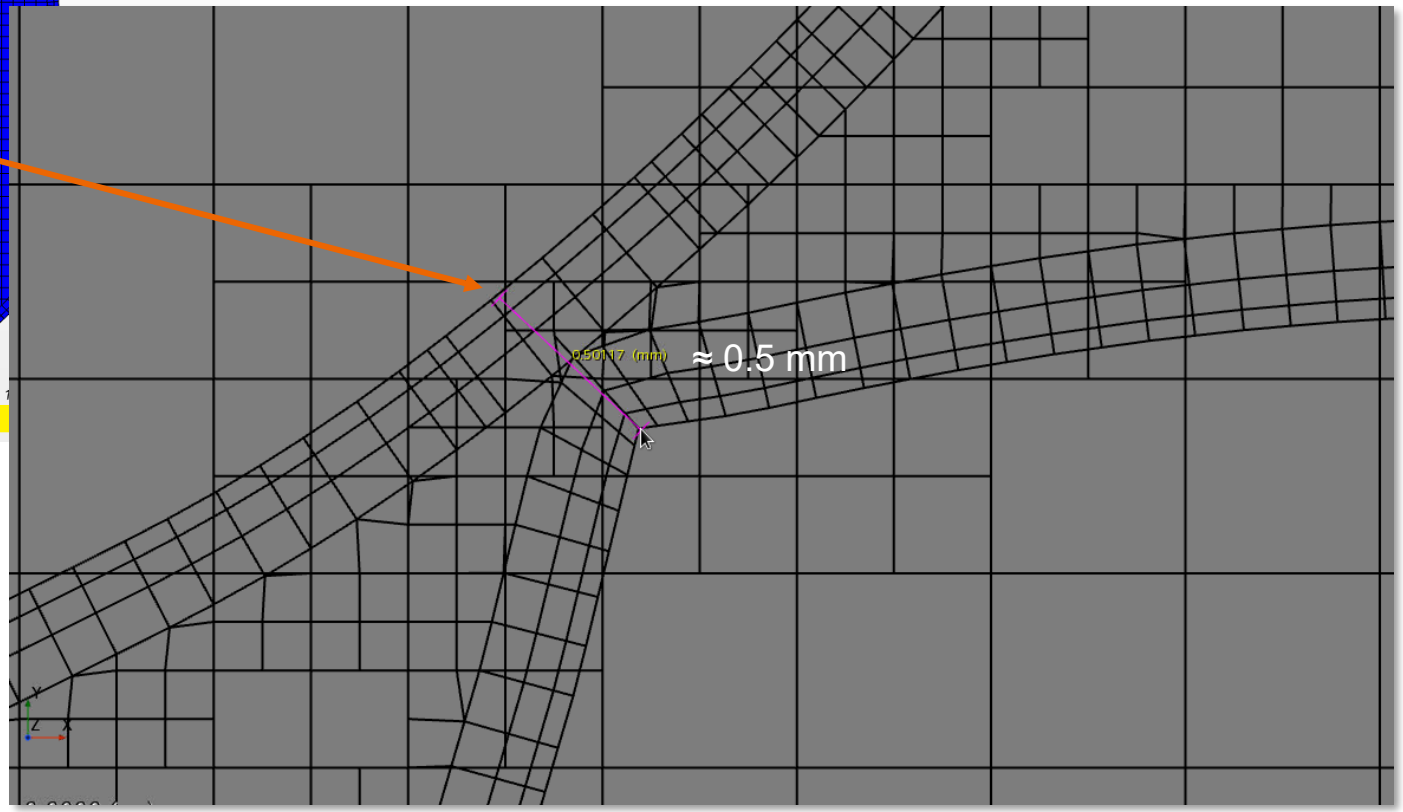
Overset Mesh Refinement





Overset Mesh Refinement - Properties

Properties	
Max Refinement Level	2
Enabled	☑
Tags	[]
Expert	
Interface Refinement Width	2.0
Uniform Gap Refinement	Specified Level
Gap Zone Width	0.5 mm
Gap Refinement Level	1

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Physics Continua: Overview

- Models
  - Adaptive Mesh
    - Adaptive Mesh Criteria
      - Free Surface Mesh Refinement
      - Overset Mesh Refinement
      - User-Defined Mesh Refinement VOF Core
      - User-Defined Mesh Refinement VOF Prism
  - All y+ Wall Treatment
  - Gradients
  - Gravity
  - Implicit Unsteady
  - K-Omega Turbulence
  - Multiphase
  - Multiphase Interaction
  - Overset Multiphase Conservation
  - Reynolds-Averaged Navier-Stokes
  - Segregated Flow
  - Segregated Fluid Isothermal
  - Solution Interpolation
  - SST (Menter) K-Omega
  - Three Dimensional
  - Turbulent
  - Volume of Fluid (VOF)
  - Wall Distance

- Multiphase
  - Eulerian Phases
    - Liquid
      - Models
        - Constant Density
        - Energy
        - Liquid
        - Turbulent
    - Gas
      - Models
        - Constant Density
        - Energy
        - Gas
        - Turbulent
  - Mixture
    - Material Properties
- Multiphase Interaction
  - Phase Interactions
    - Phase Interaction 1
      - Models
        - Multiphase Material
        - Surface Tension Force
        - VOF-VOF Phase Interaction

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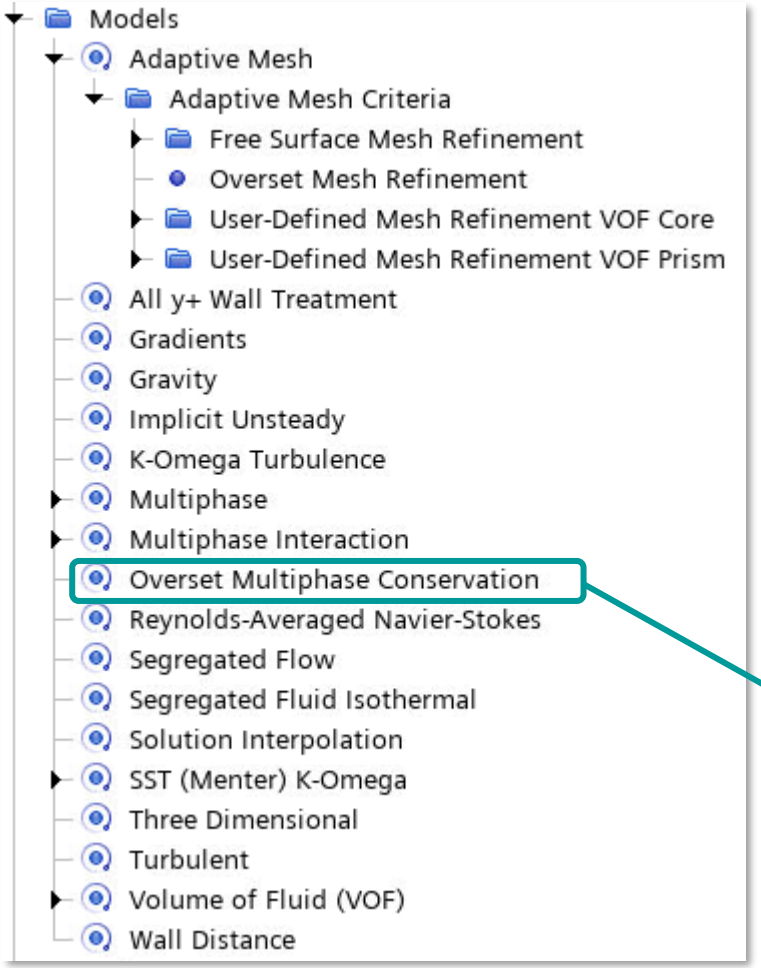
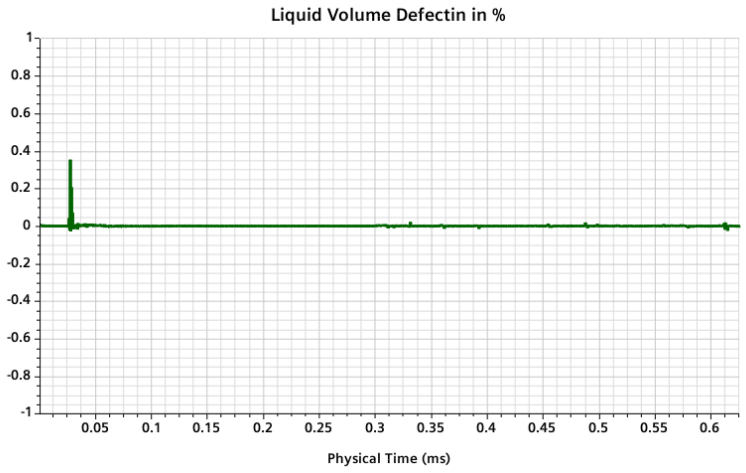
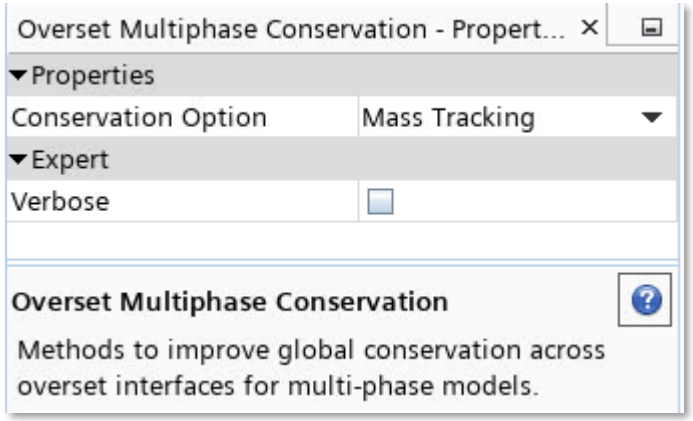
Overset-specific Physics Continua: Mass Conservation

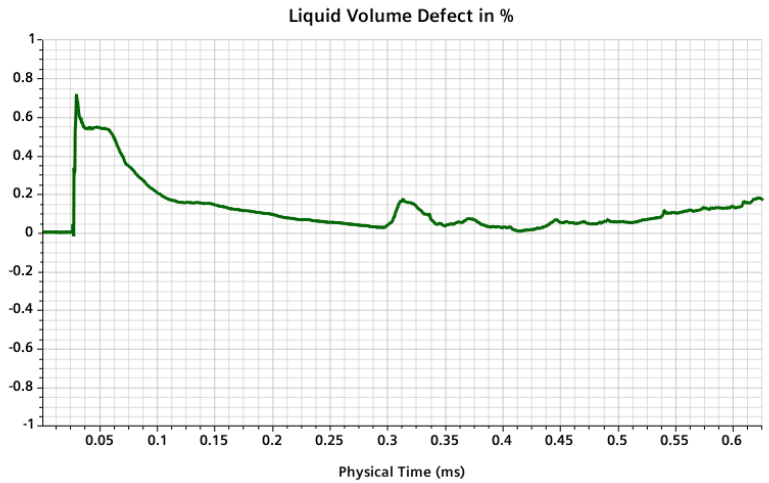


With Overset Multiphase Conservation Model





Without Overset Multiphase Conservation Model



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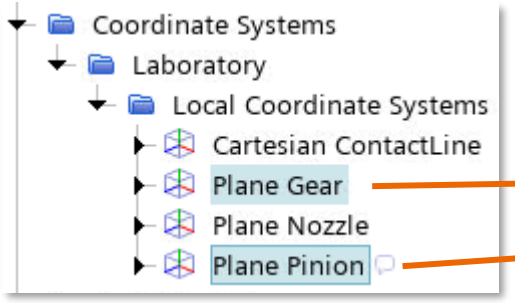
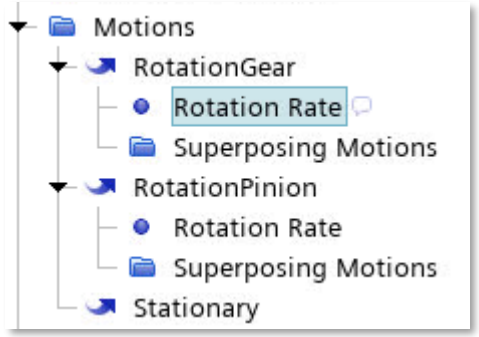
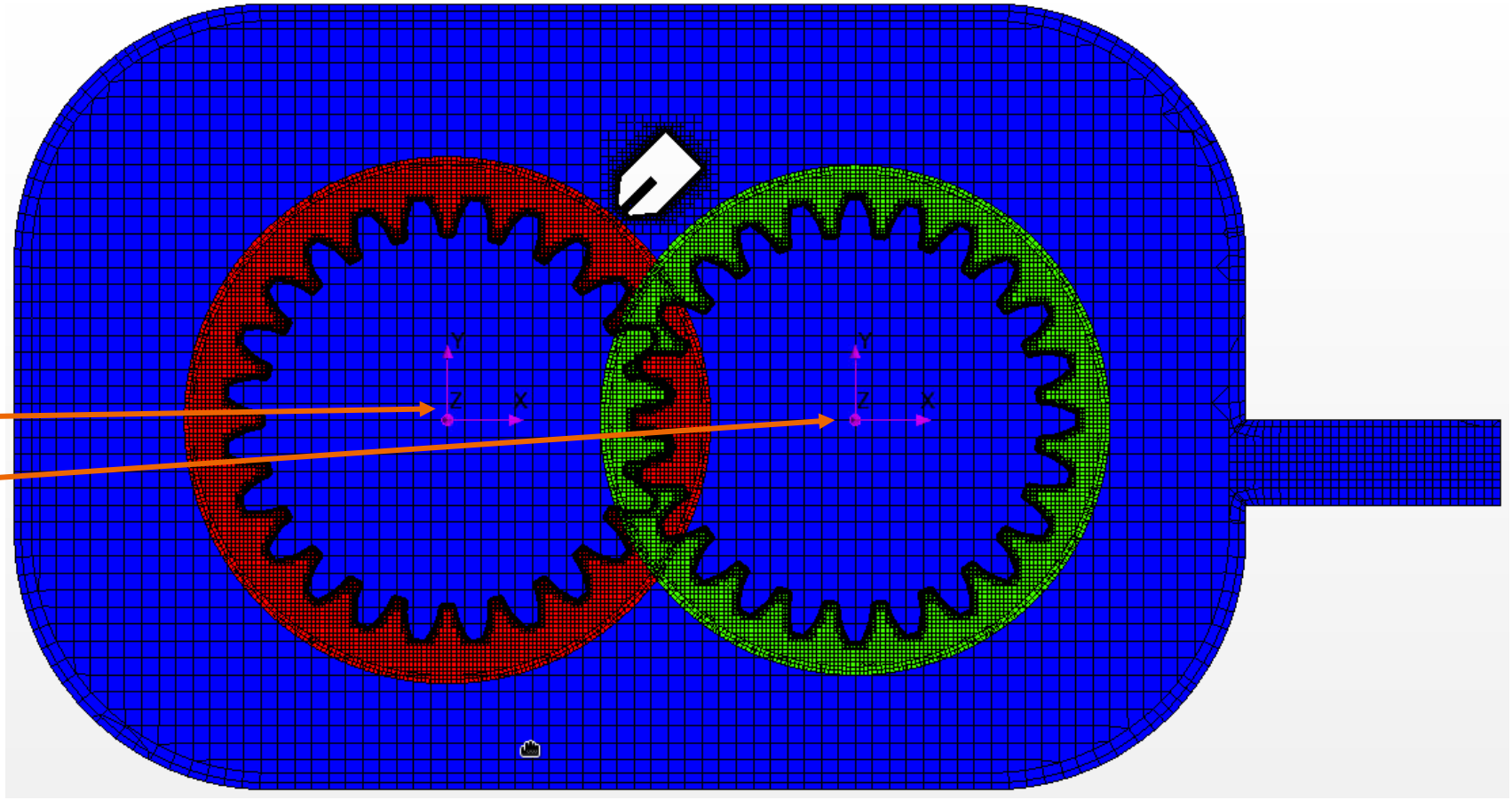
Motion Setup







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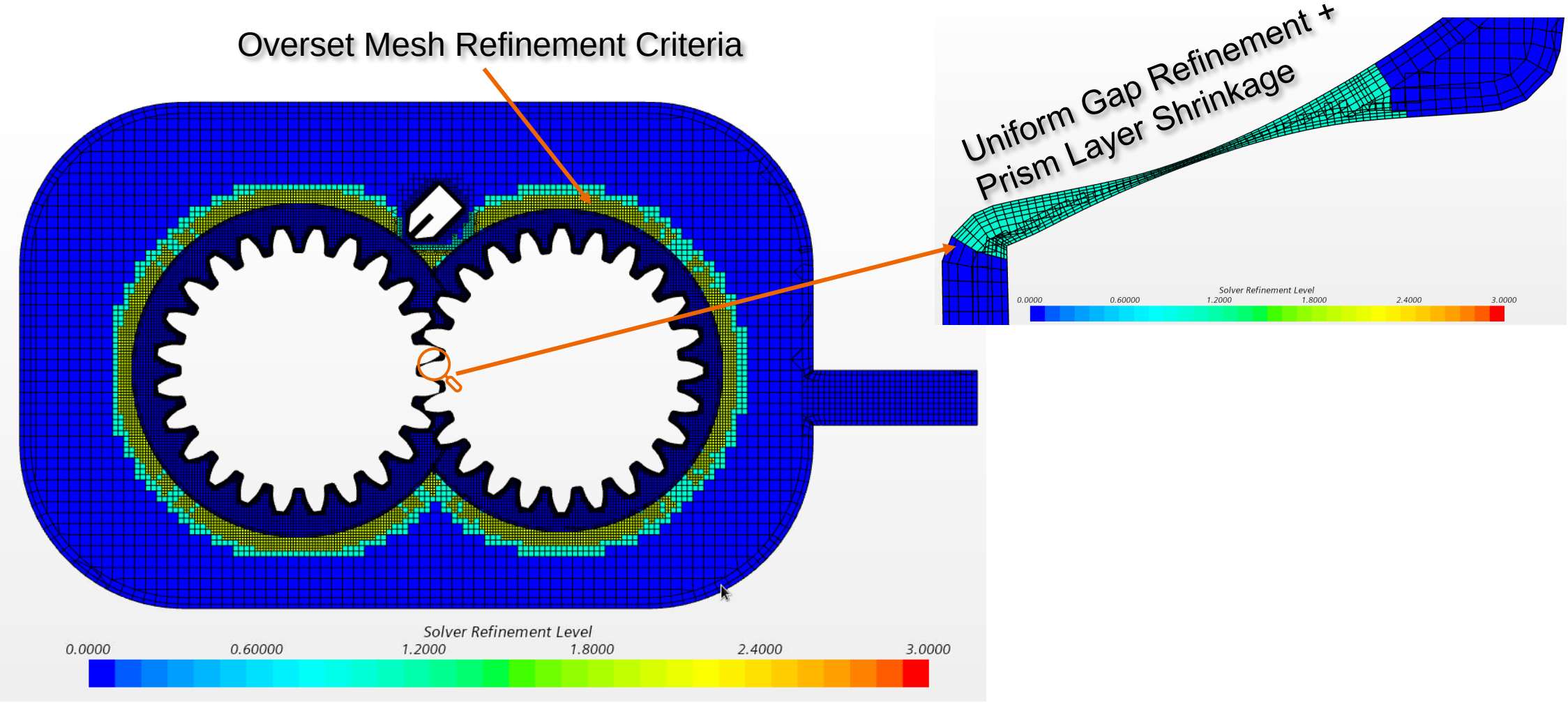
Solution Initialization



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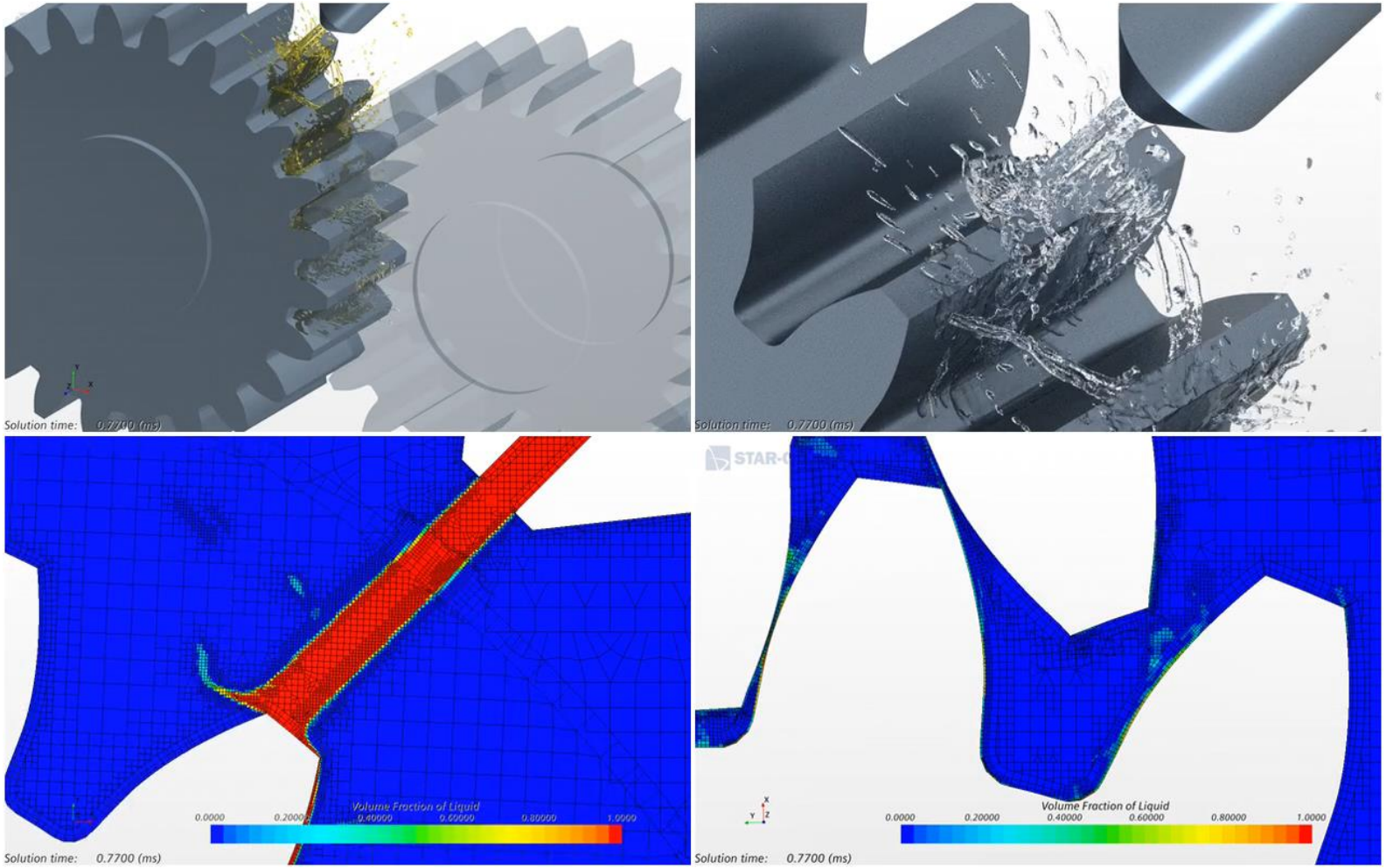
Simulating Oil Jet Lubrication of High Speed Gears
Animated results



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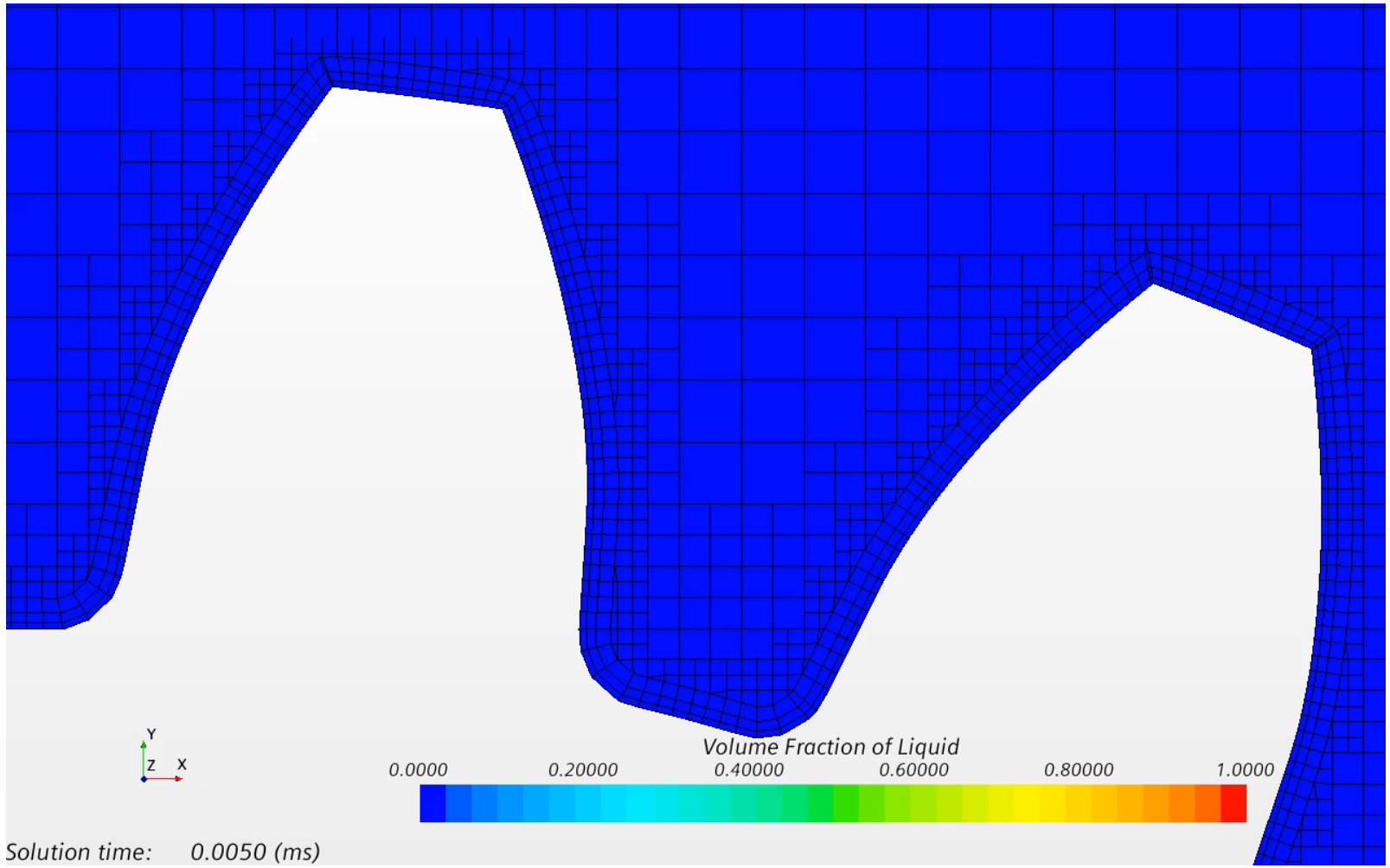
Simulating Oil Jet Lubrication of High Speed Gears

Animated results



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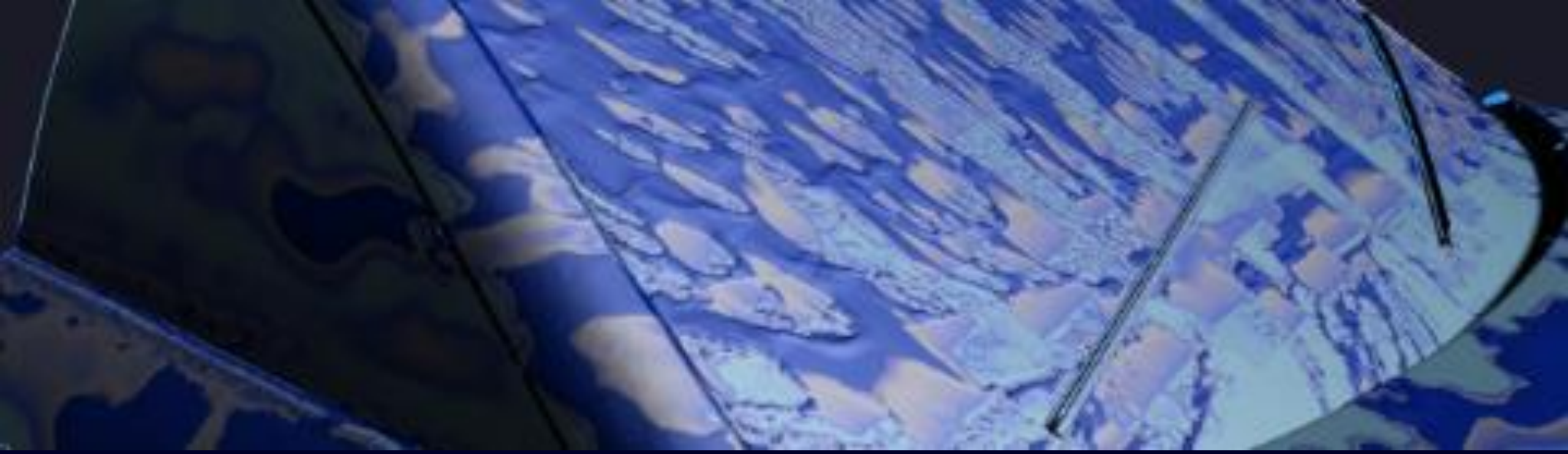

Windshield Wiper Simulation

- Different Multiphase Models
- Overset for Fluid-Film
- Overset with Morphing

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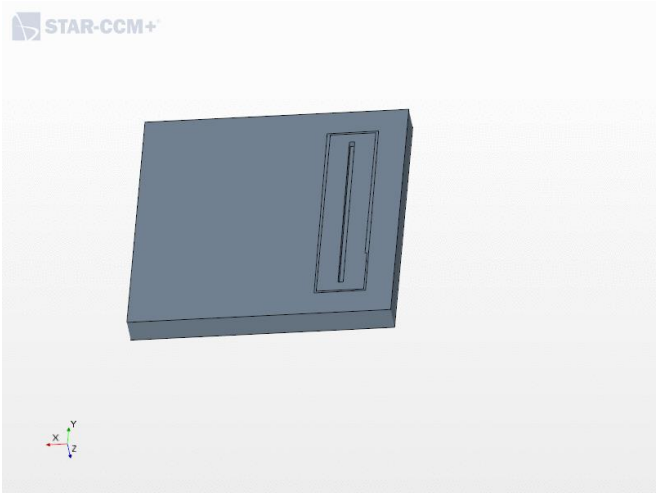
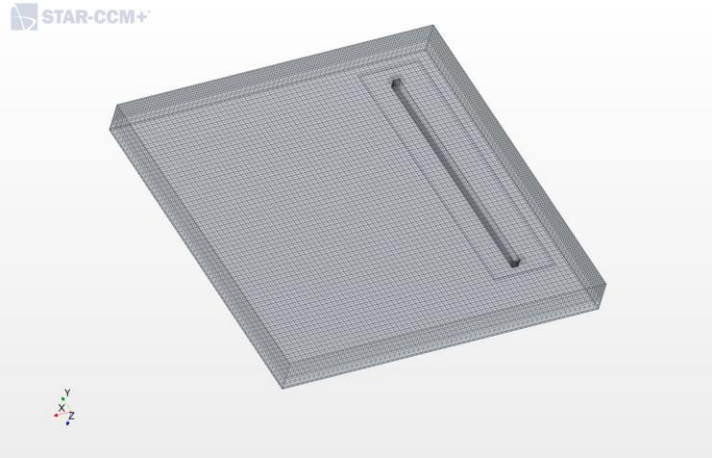
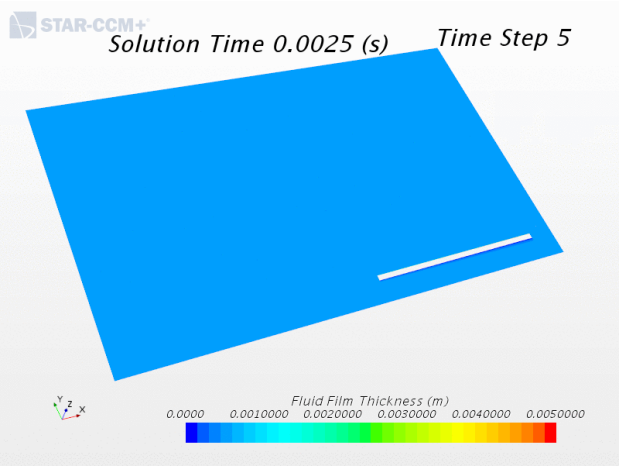
Start with a Simplified Model & Geometry: Volume of Fluid & Fluid Film







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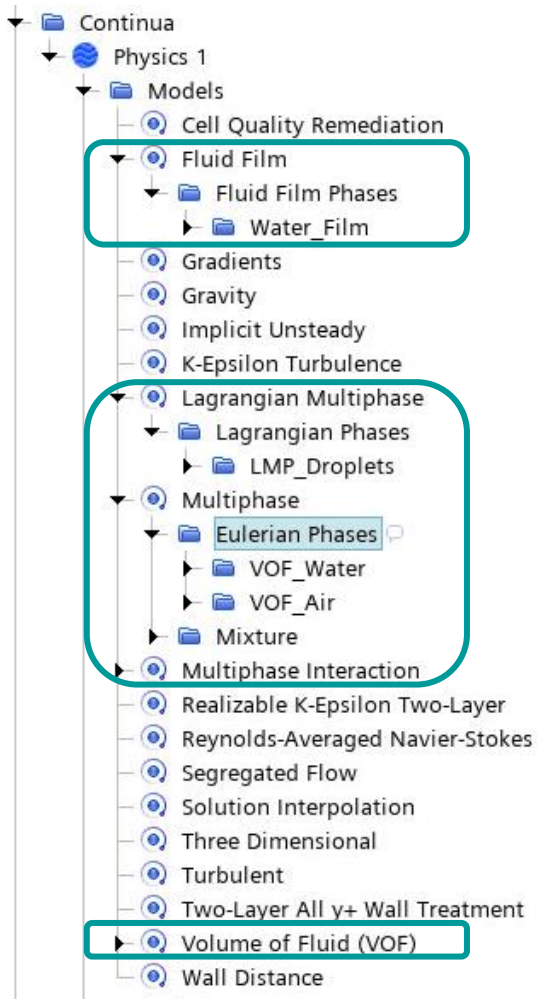
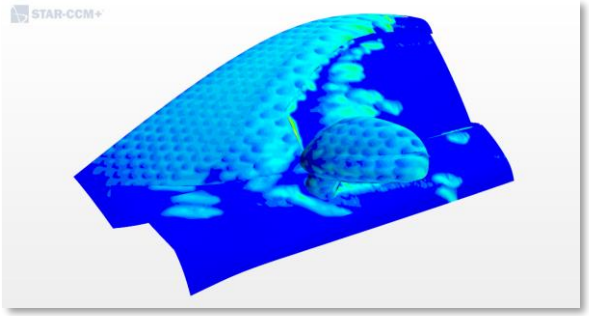
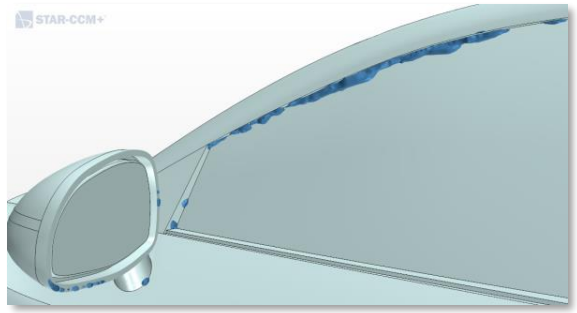
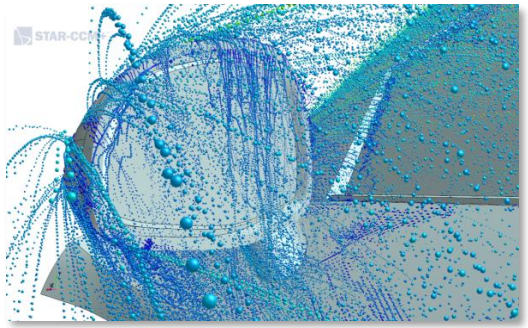
Physics Continua









- There are multiphase models for every regime in STAR-CCM+: Eulerian Multiphase (EMP), Mixture Multiphase (MMP), *Volume Of Fluid (VOF),* Dispersed Multiphase (DMP), *Fluid Film (Film), Lagrangian Multiphase (LMP),* Discrete Element Method (DEM)
- Each multiphase model is suited to a different regime
- Models can interact exchanging mass, momentum and energy by various mechanisms
- **Overset is compatible with various multiphase models!**

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Modelling Wiper Simulation in Simcenter STAR-CCM+ Multiphysics

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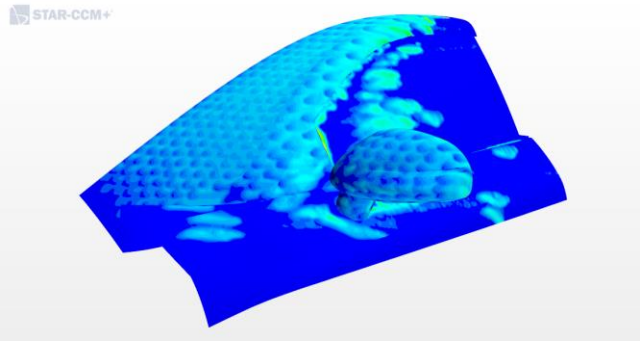
Discretization

LMP-VOF-Film is the most common combination of Multiphase models

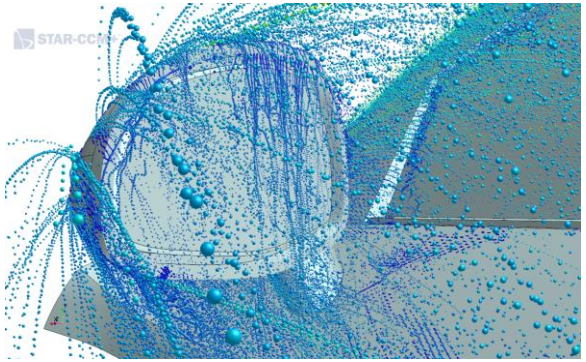


LMP - Fluid Film Interaction

- Models the interaction between the fluid film and a Lagrangian phase
- Droplets impingement into fluid film
- Droplets stripping – wave and edge stripping

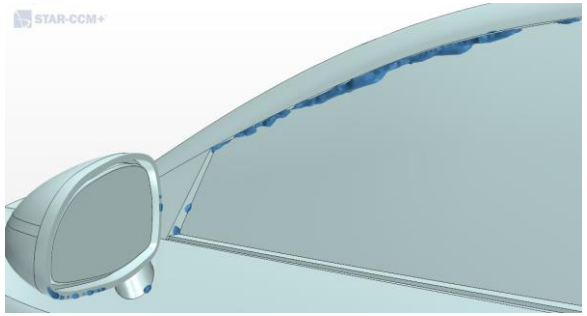
Film – VOF phase interaction

- Resolved Fluid Film model:
- Controls the transition between the specified fluid film phase and VOF phase
  - Fluid film transitions into VOF when it becomes thick compared to the mesh
  - VOF transitions into Fluid Film when it becomes thin compared to the mesh
- Modeling Fluid Film Surface Tension

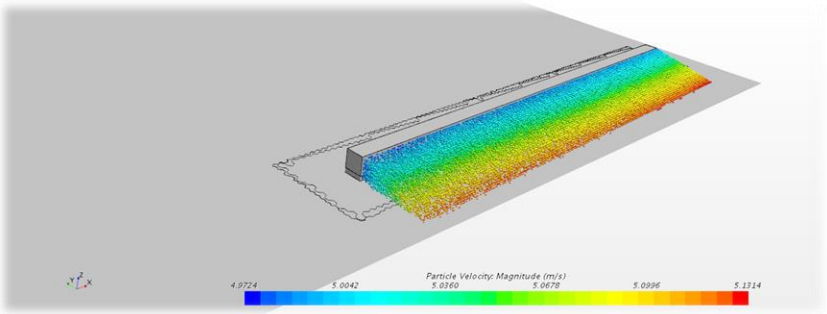


LMP – VOF phase interaction

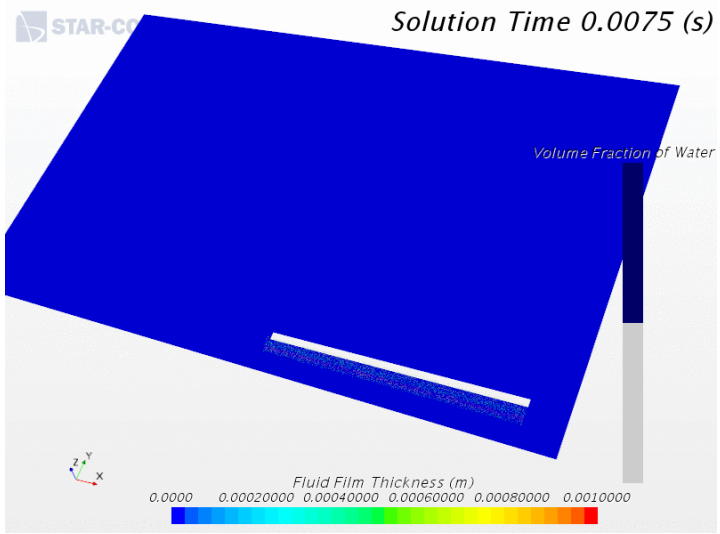
- Impingement of Lagrangian droplets into VOF



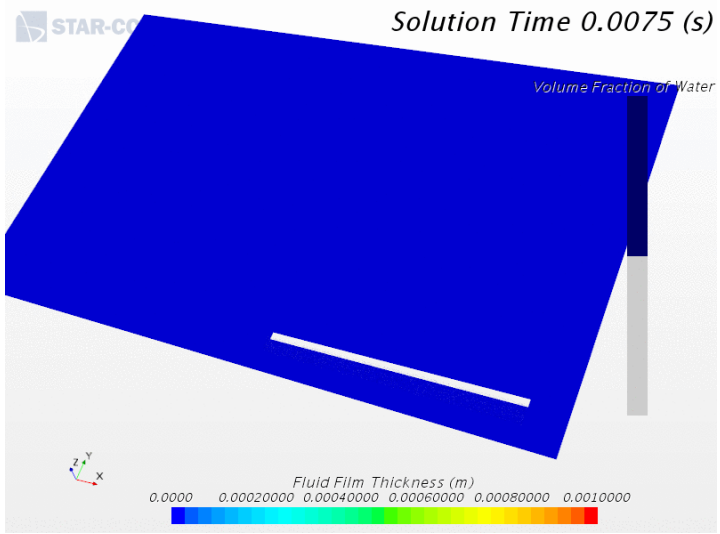
Increase Model Complexity:
Adding Lagrangian Multiphase (LMP)



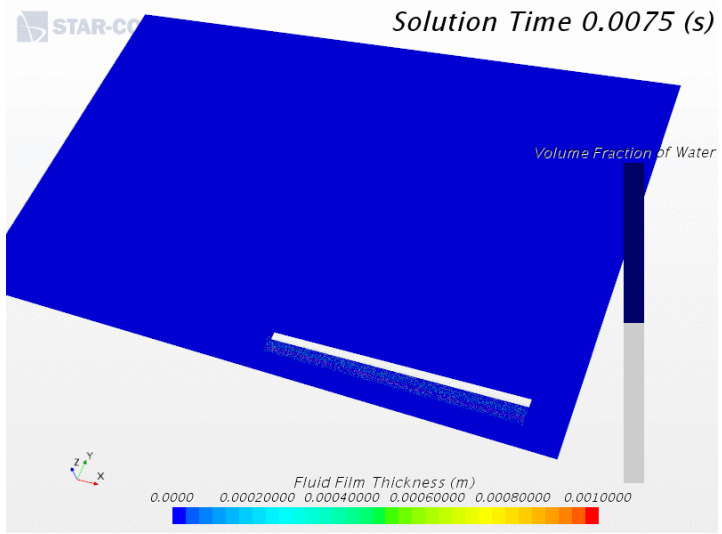
No Surface Tension for fluid film, incoming airflow through the bottom boundary with velocity of 10m/s:



With Surface Tension for fluid film, incoming airflow through the bottom boundary with velocity of 10m/s:



With Surface Tension for fluid film, without incoming airflow:



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Sensitivity Study: Finalization of grid, timestep and inner iterations

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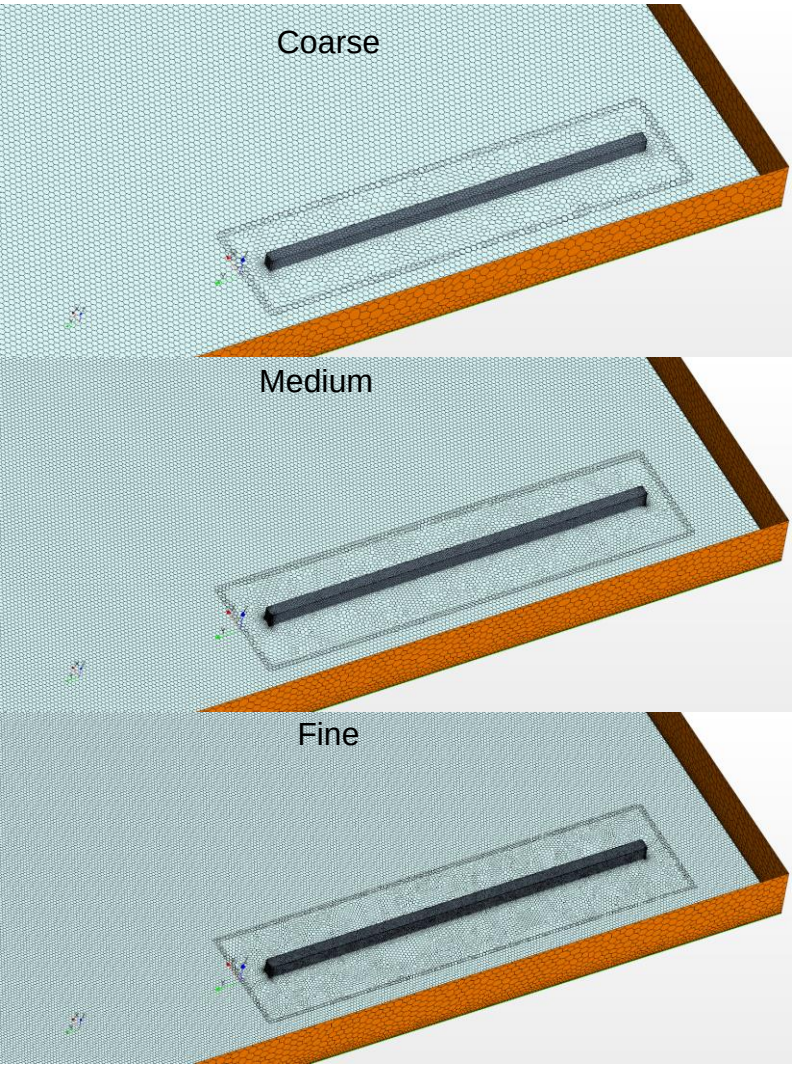
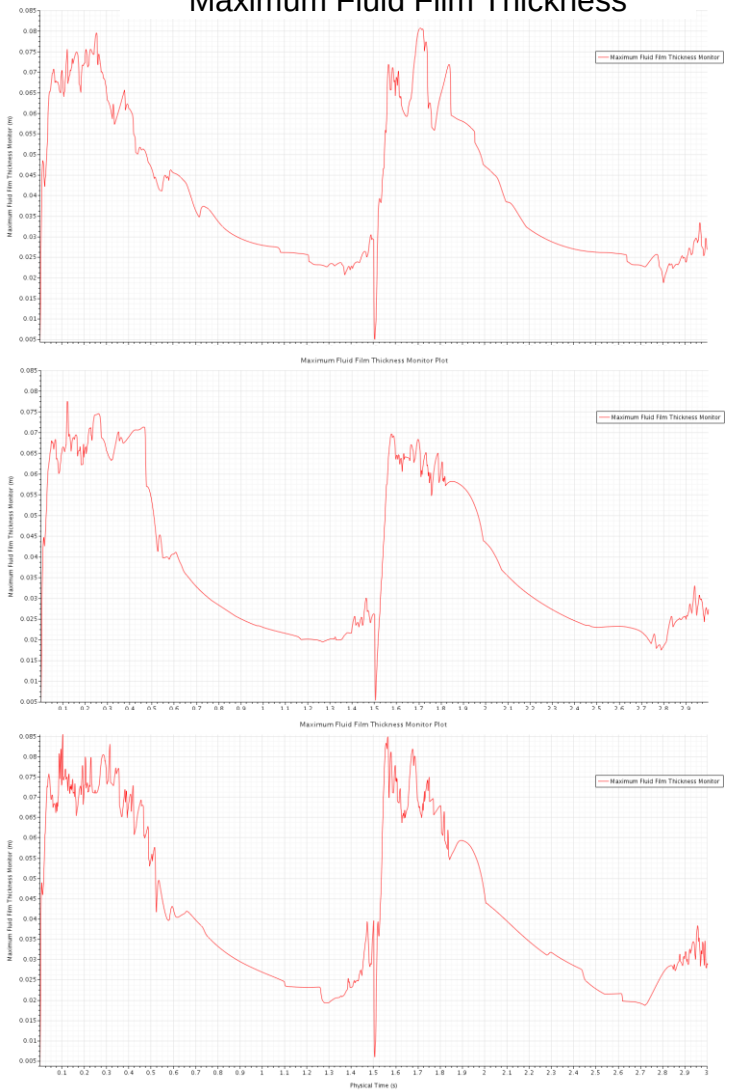


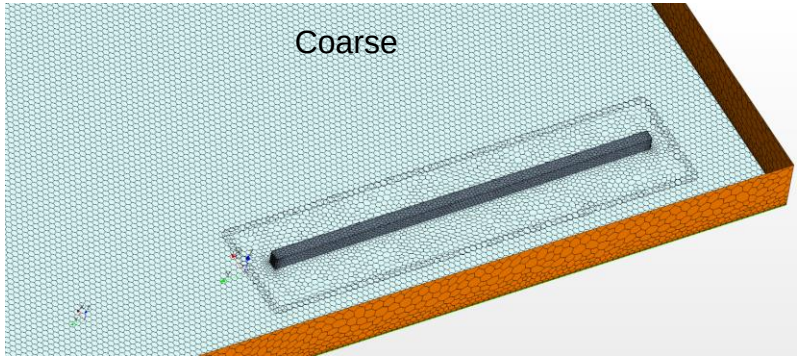
Maximum Fluid Film Thickness

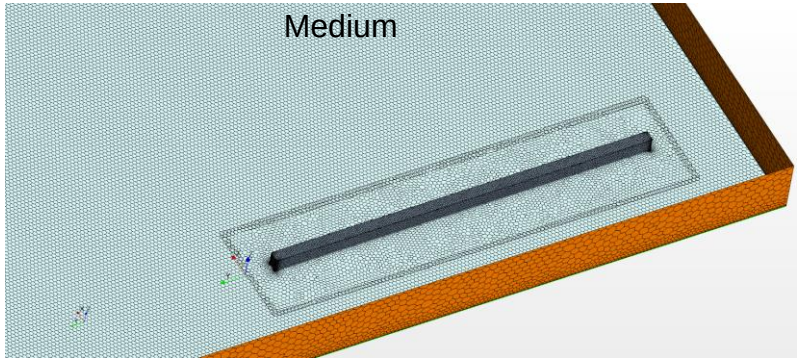


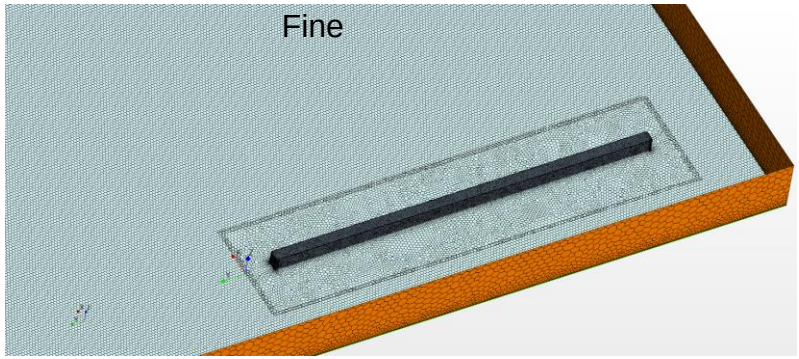
	Coarse mesh	Medium mesh	Fine mesh
Number of cells	228162	451875	784713

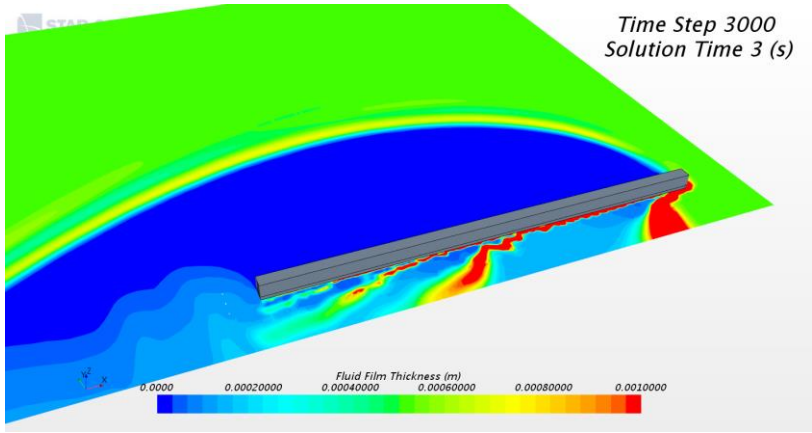
- Simulations are very much sensitive to mesh resolution, timestep and inner iterations
- Timestep of 1e-03 s and 10 inner iterations were adopted

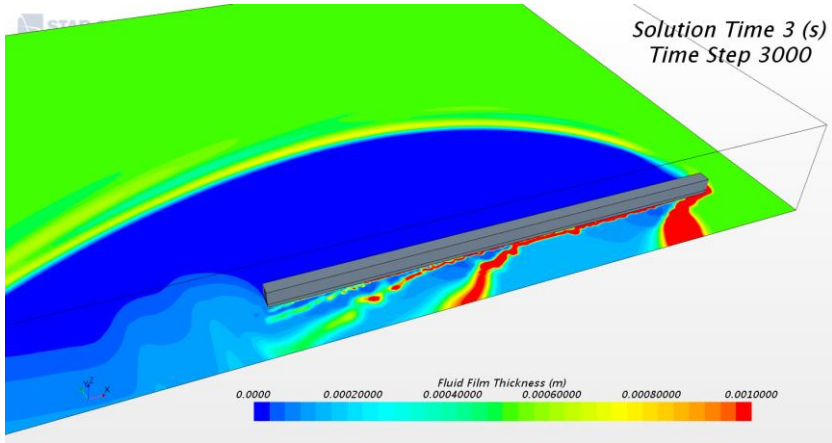
Sensitivity Study: Finalization of grid

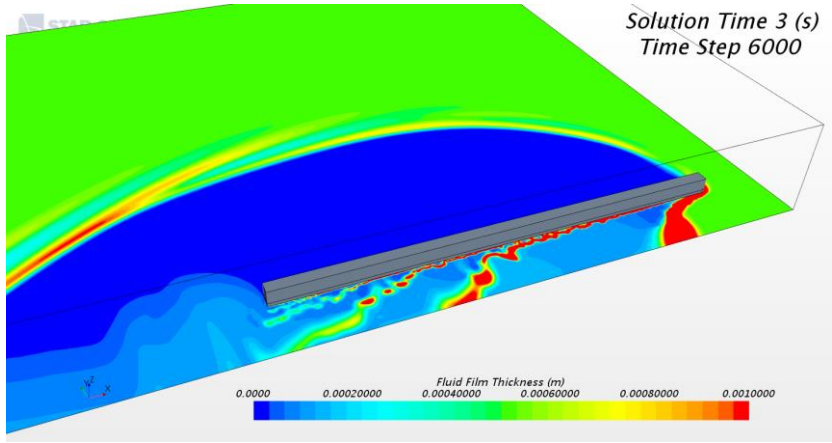












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Sensitivity Study: Finalization of grid, timestep and inner iterations Conclusion

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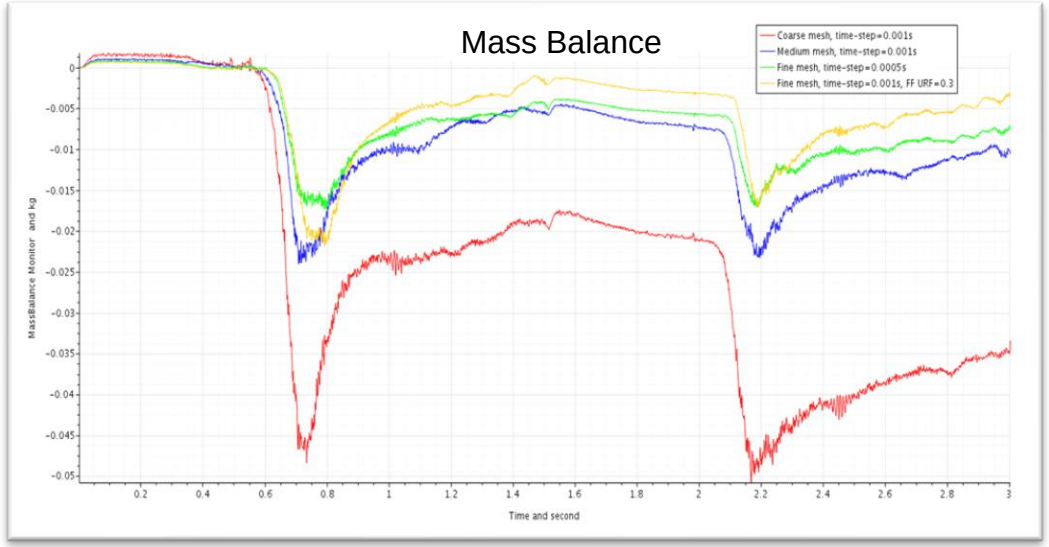
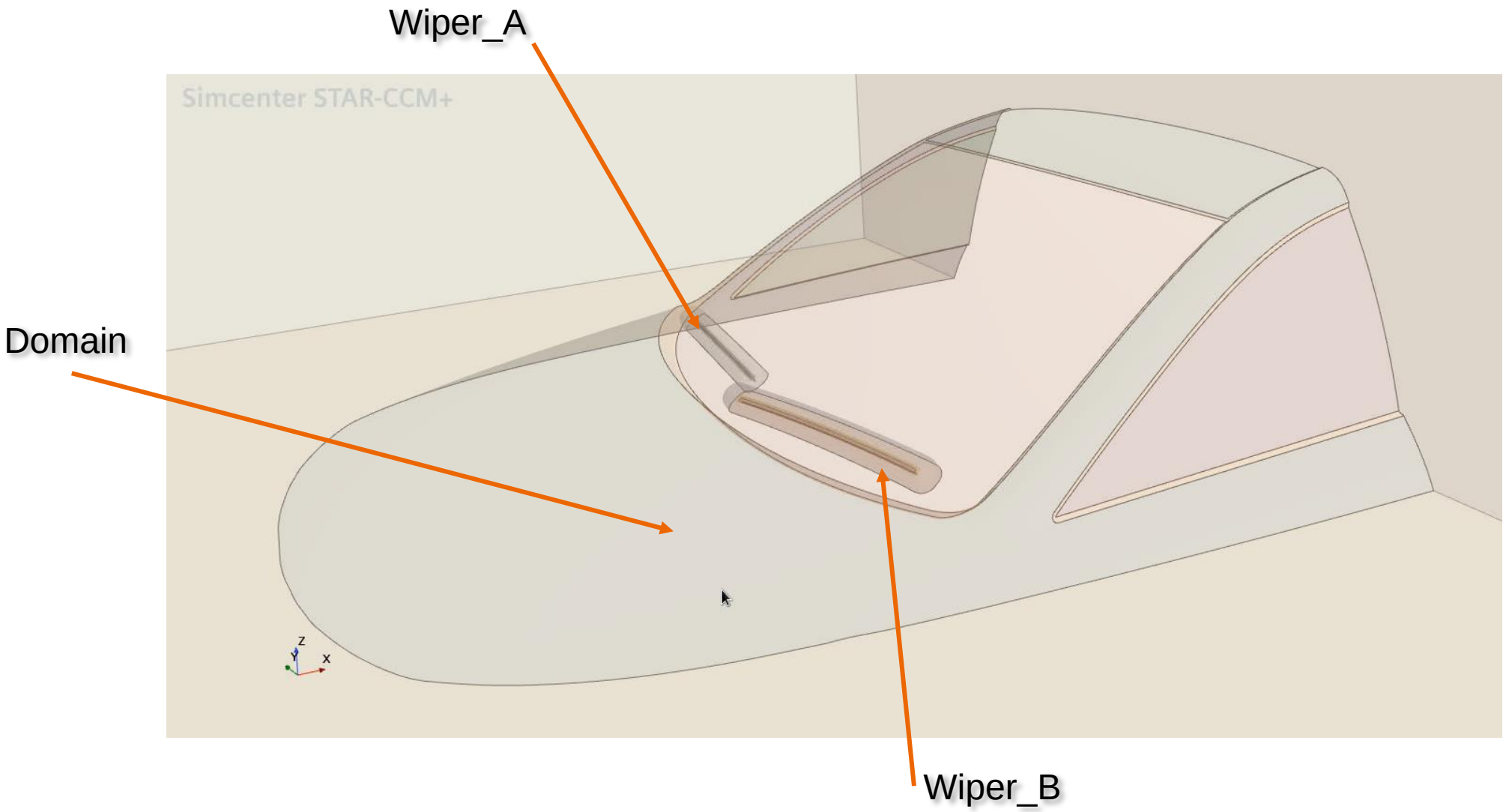
Tips and Tricks

- The size of volume cells adjacent to the fluid film must be consistent for the background and the overset region.
- Use an appropriate time-step size such that the movement of the overset region within one time step is not more than ½ cell size
- Mesh resolution and timestep has a significant influence on fluid film mass conservation
- Medium mesh with 0.0005 s timestep and 10 inner iterations produces similar mass imbalance when compared with fine mesh with 0.0005 s timestep and 10 inner iterations
- Medium Mesh with 0.0005 s Time Step and 10 Inner Iterations is probably a good tradeoff between accuracy and computational time



Increase Geometric Complexity: Geometry / Parts



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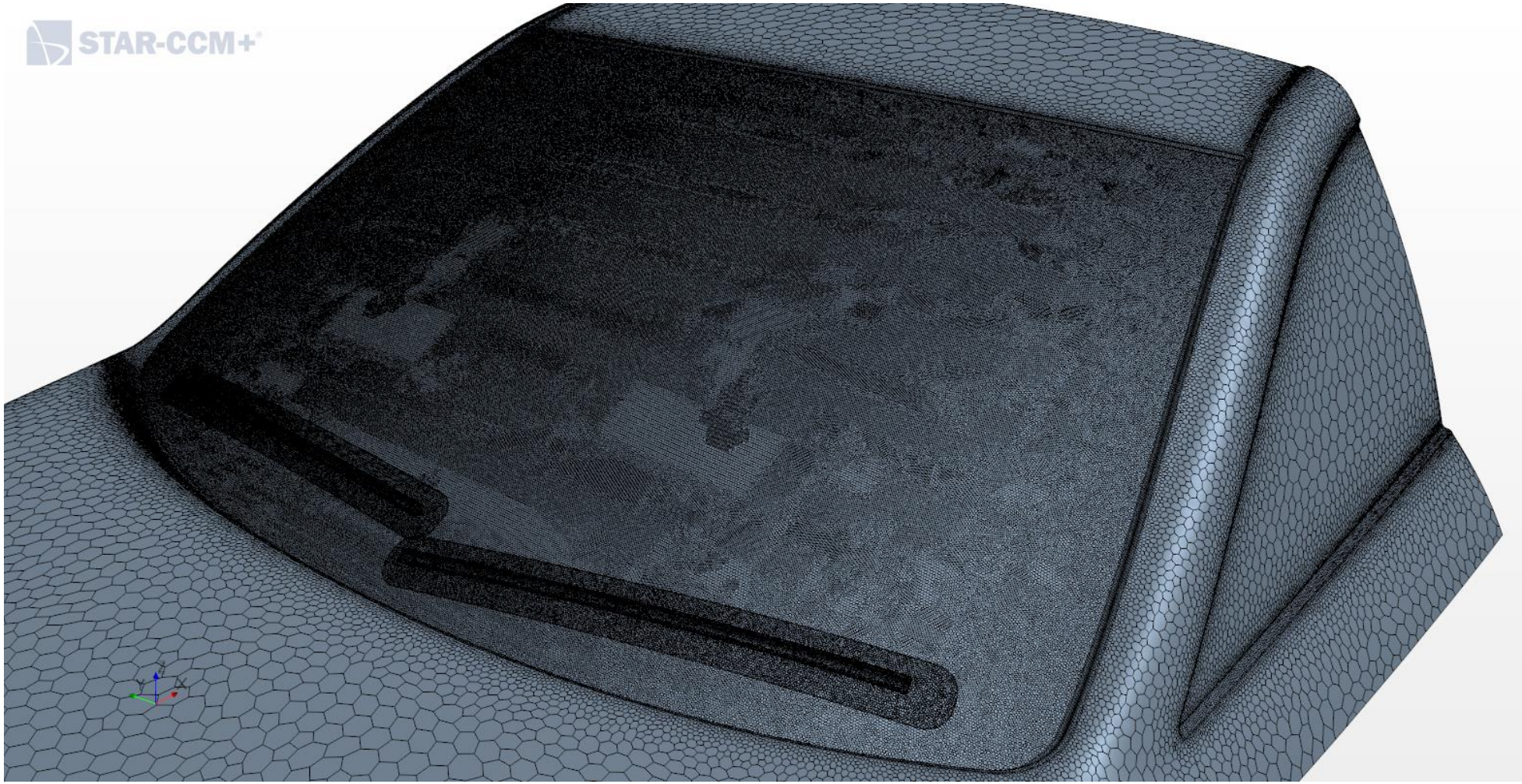
Meshed Geometry



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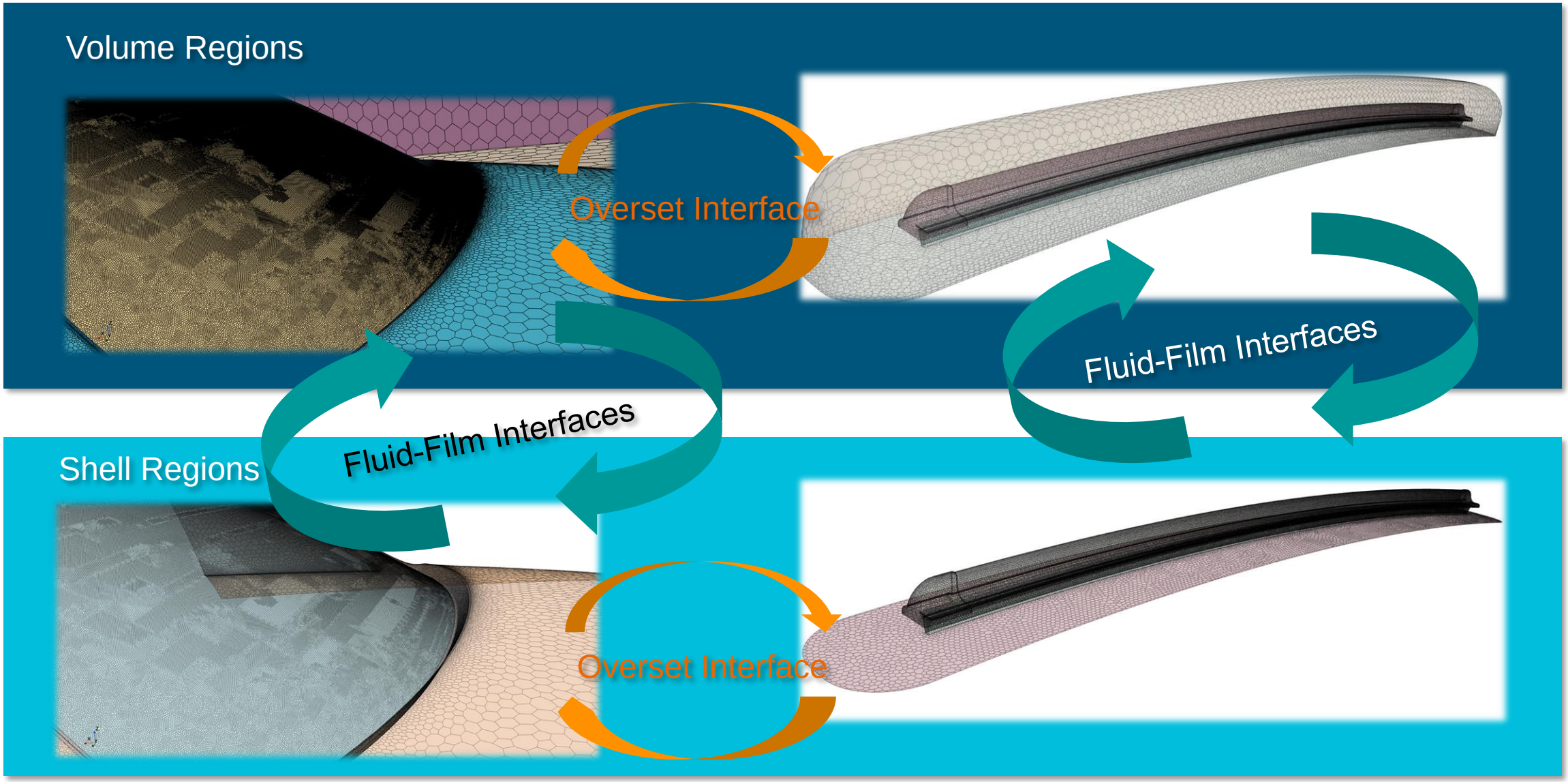
Regions & Interfaces (4 of 6 regions)



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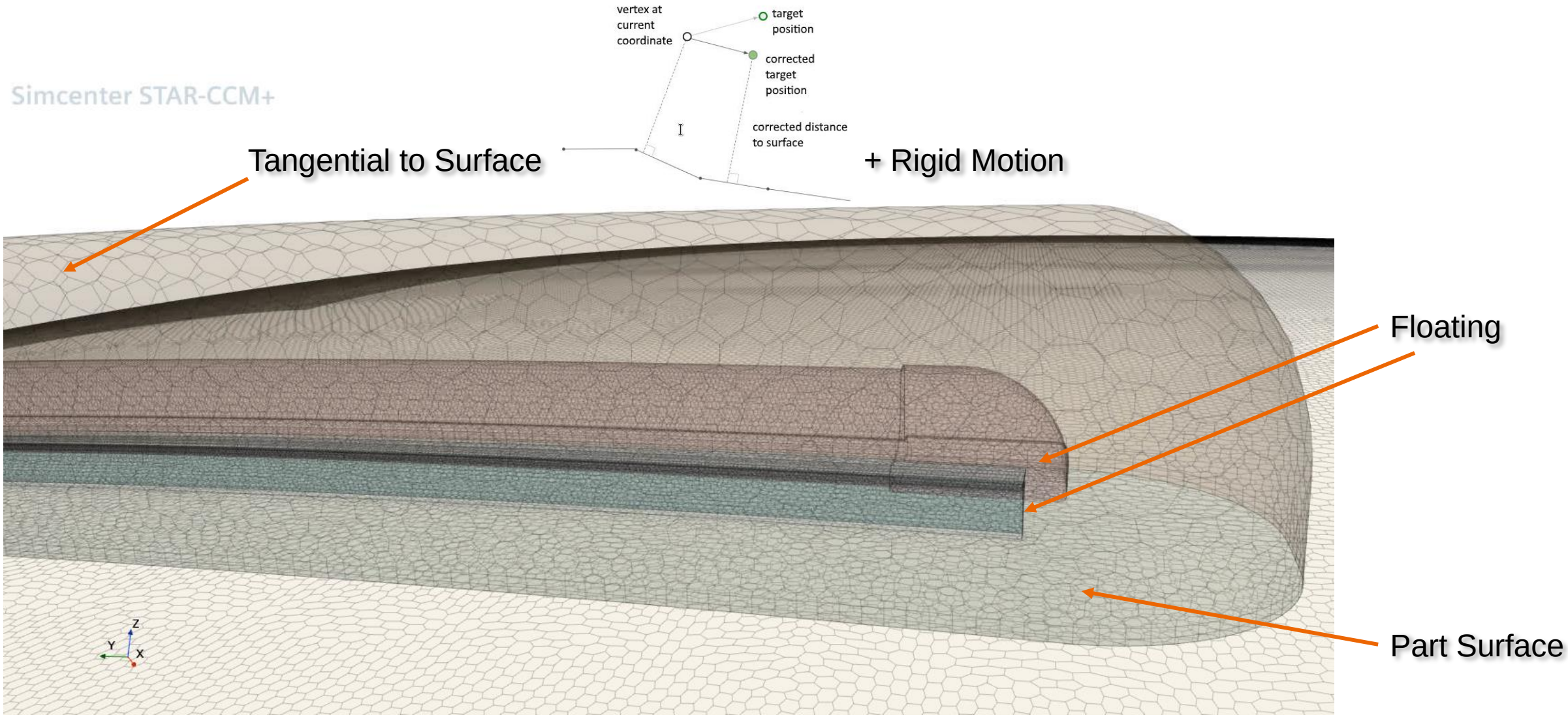
Morphing Boundary Conditions



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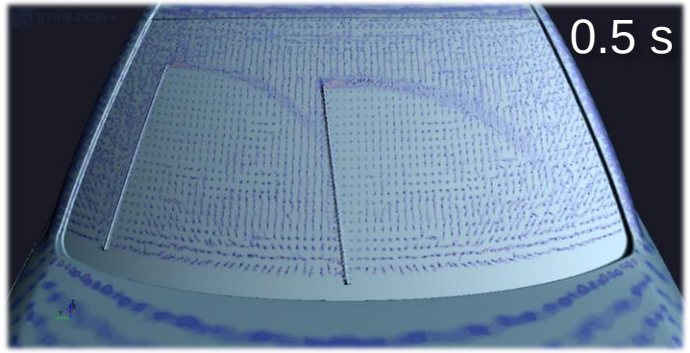
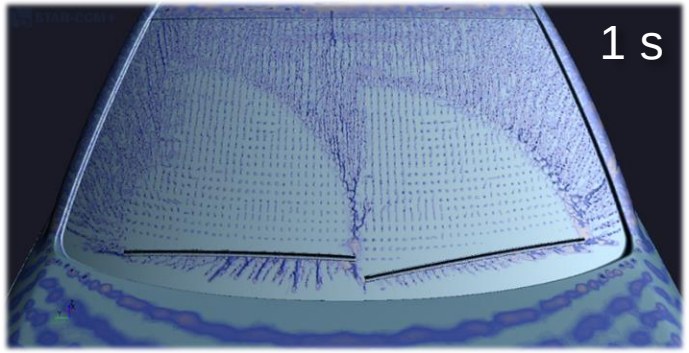
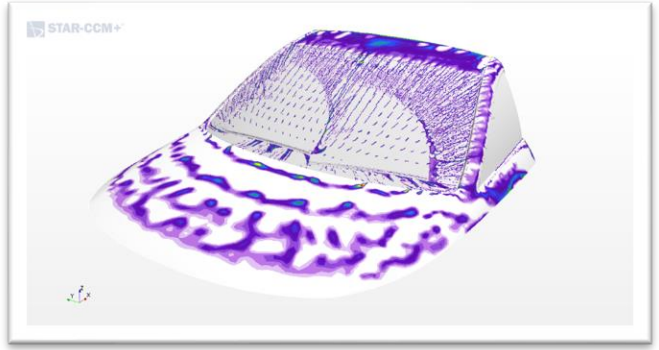
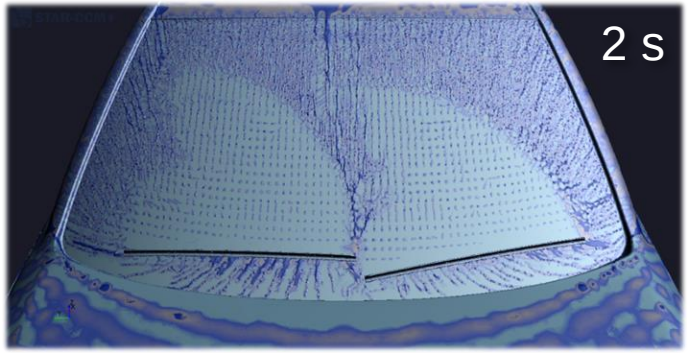
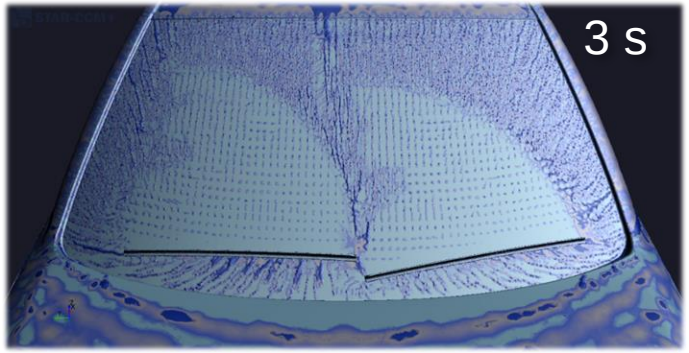
Fluid Film Distribution

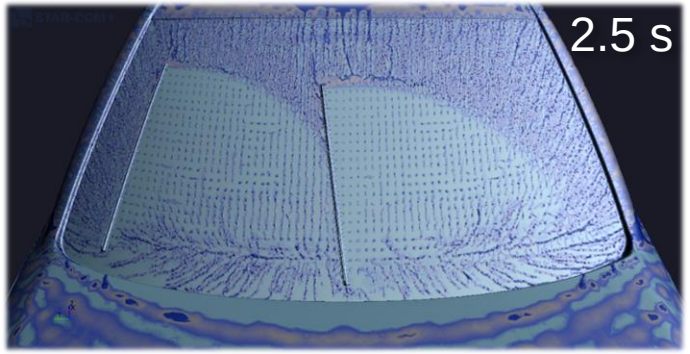


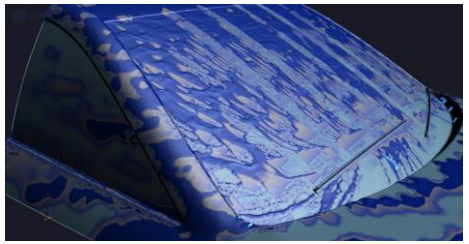












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Thank you!

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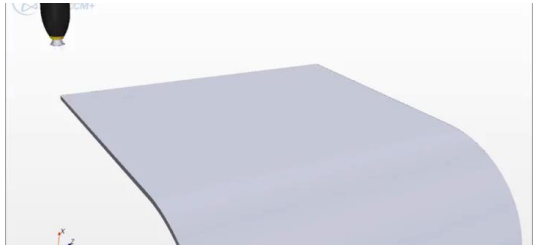
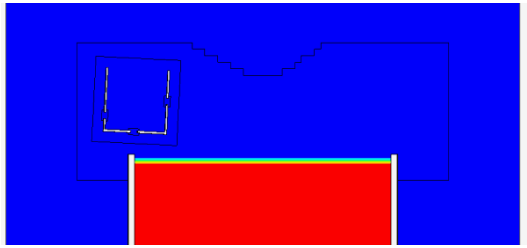
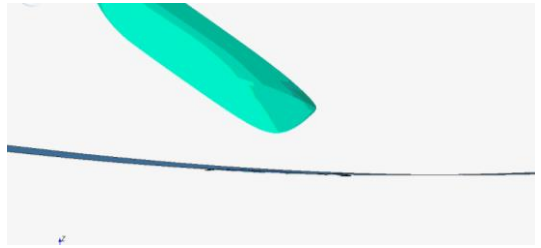
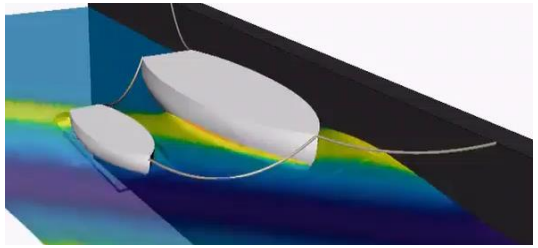
Ground Transportation

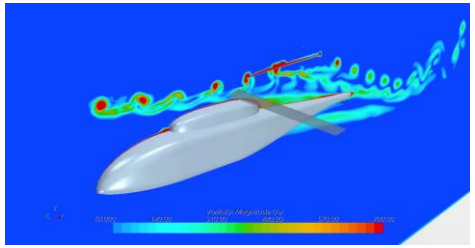

Spray Painting

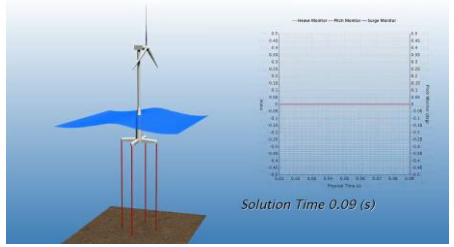

Paint Dipping

Gear Lubrication

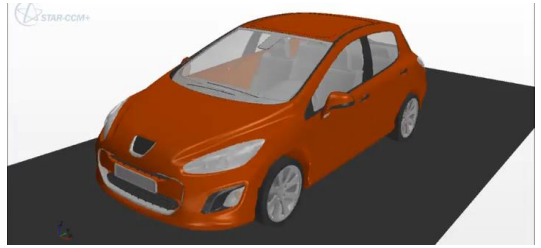

Lifeboat Launching

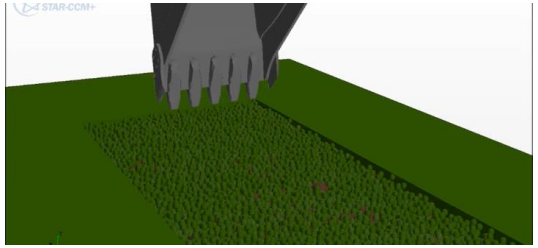

Seakeeping

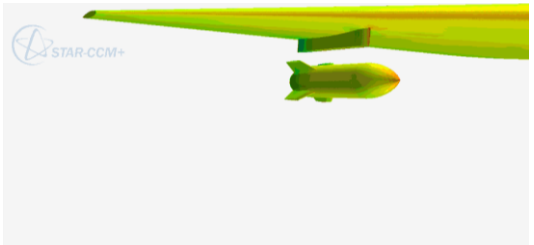

Rotorcraft

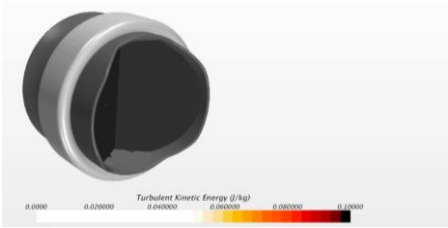


Floating Wind Turbine


Windscreen Wipers


Industrial Machinery


Store Separation


Heart Valve