iconCFD® v4.0
New Features

ICSC 2017
CAE for virtual product
CAE for innovation
CAE for process transformation

A summary of the new features which will be available in iconCFD 4.0

David Winkler
d.winkler@iconcfd.com
November 2017

iconcfd
Modularized ● Industrialized ● Customized

icon
Technology ● Process ● Consulting

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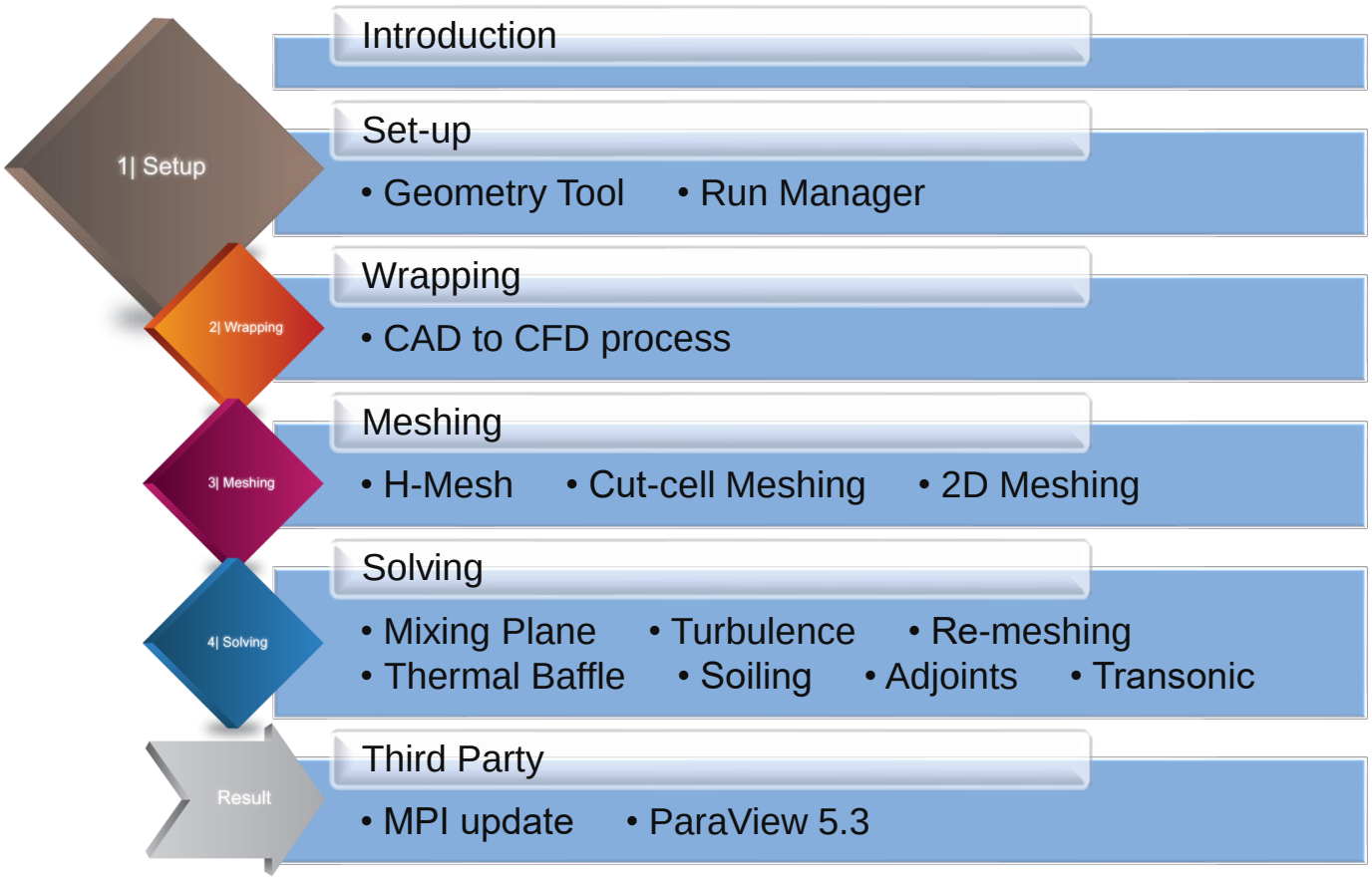
iconCFD v4.0

AGENDA



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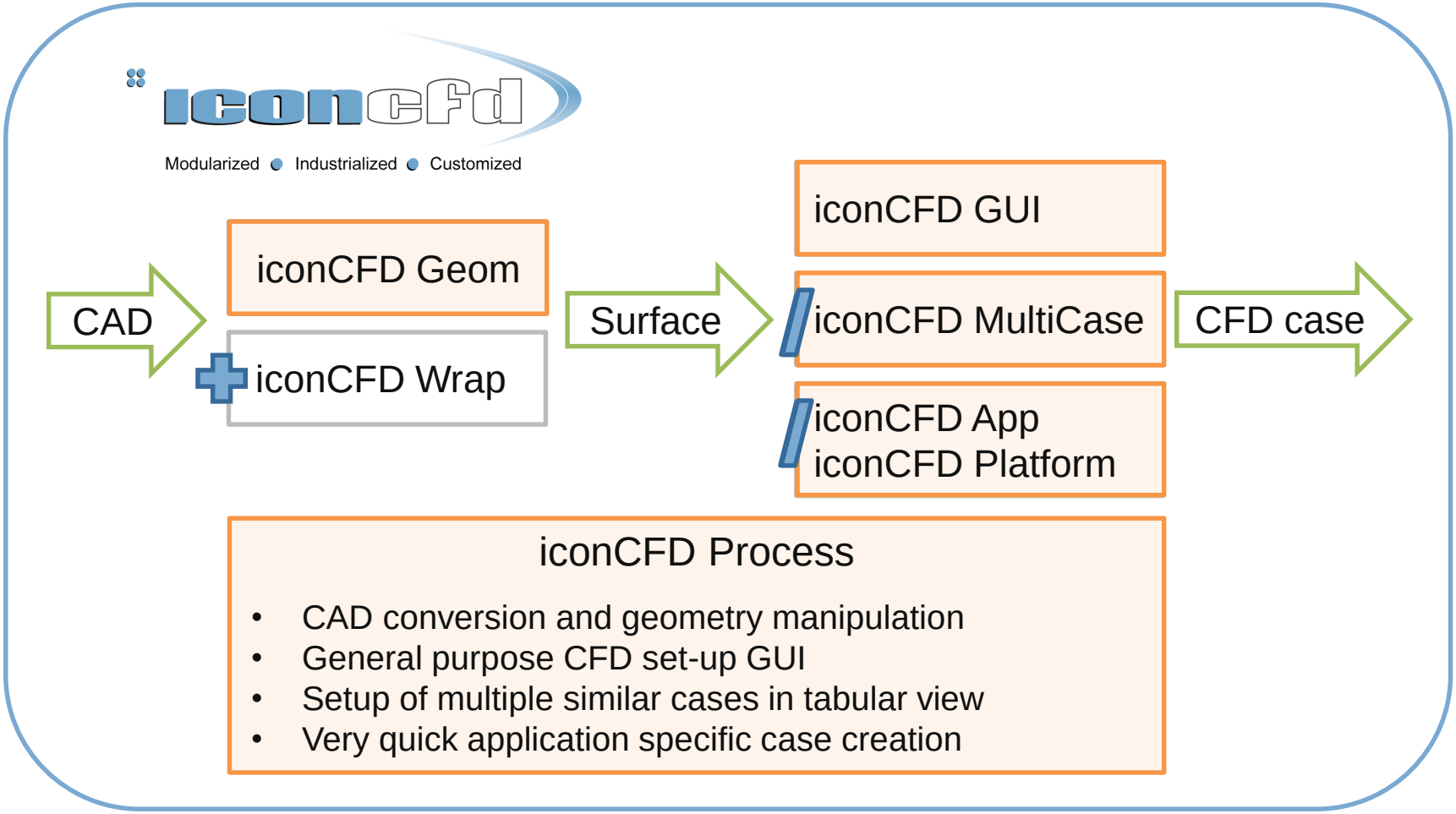
iconCFD PROCESS
CASE SETUP WORKFLOW



iconCFD Process

- CAD conversion and geometry manipulation
- General purpose CFD set-up GUI
- Setup of multiple similar cases in tabular view
- Very quick application specific case creation

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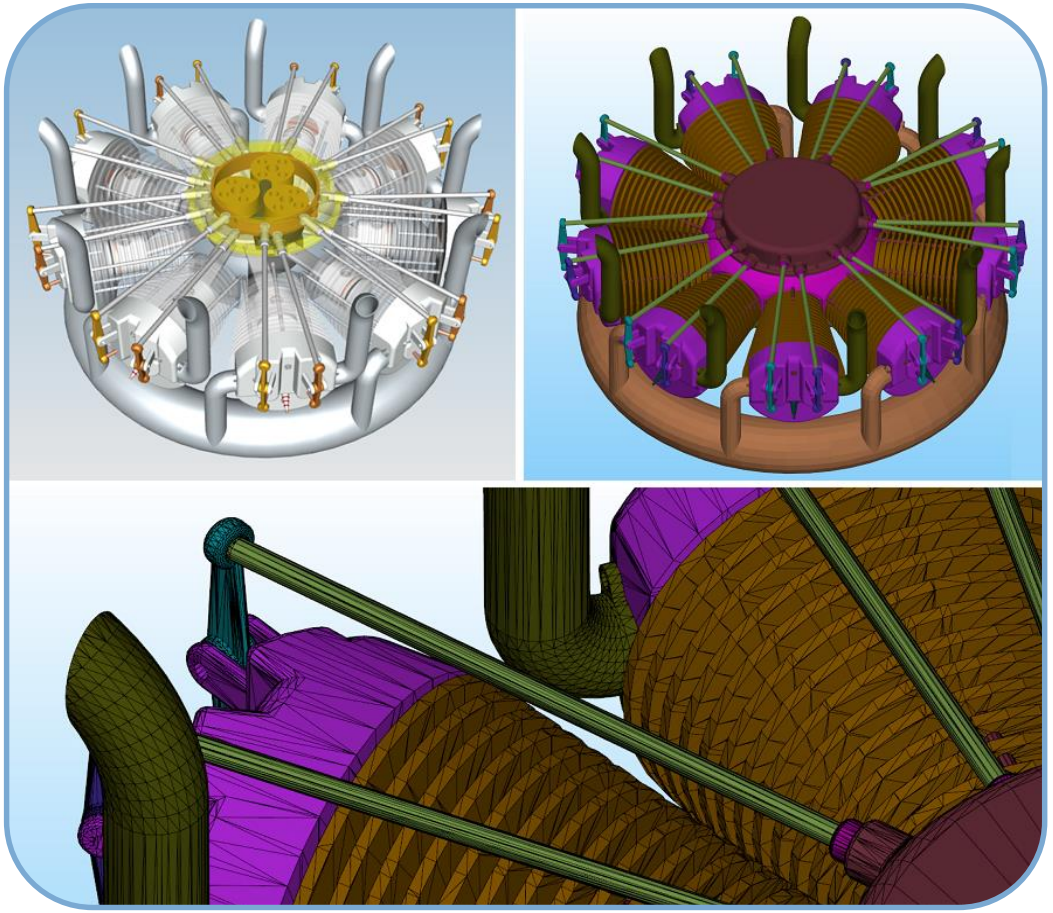
iconCFD PROCESS
GEOM TOOL

- Geometry pre-processing
  - Import and triangulate CAD data
    - IGES, STEP, JT
  - Modify triangulated surface data
    - STL, VTK, NASTRAN, OBJ
    - Assign patch IDs
    - Transform and copy parts
    - Detect and stitch leaks
    - Fill holes, connect edges
    - Manipulate surfaces
    - Adjust surface normals



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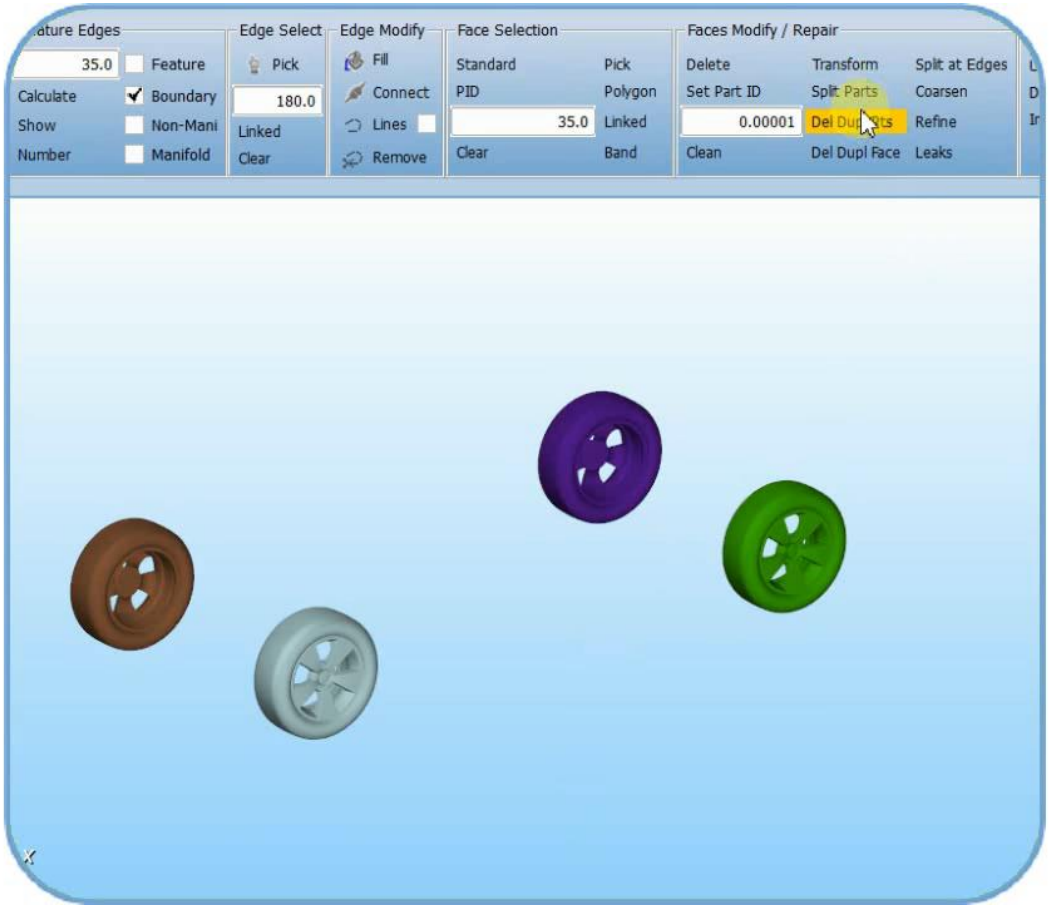

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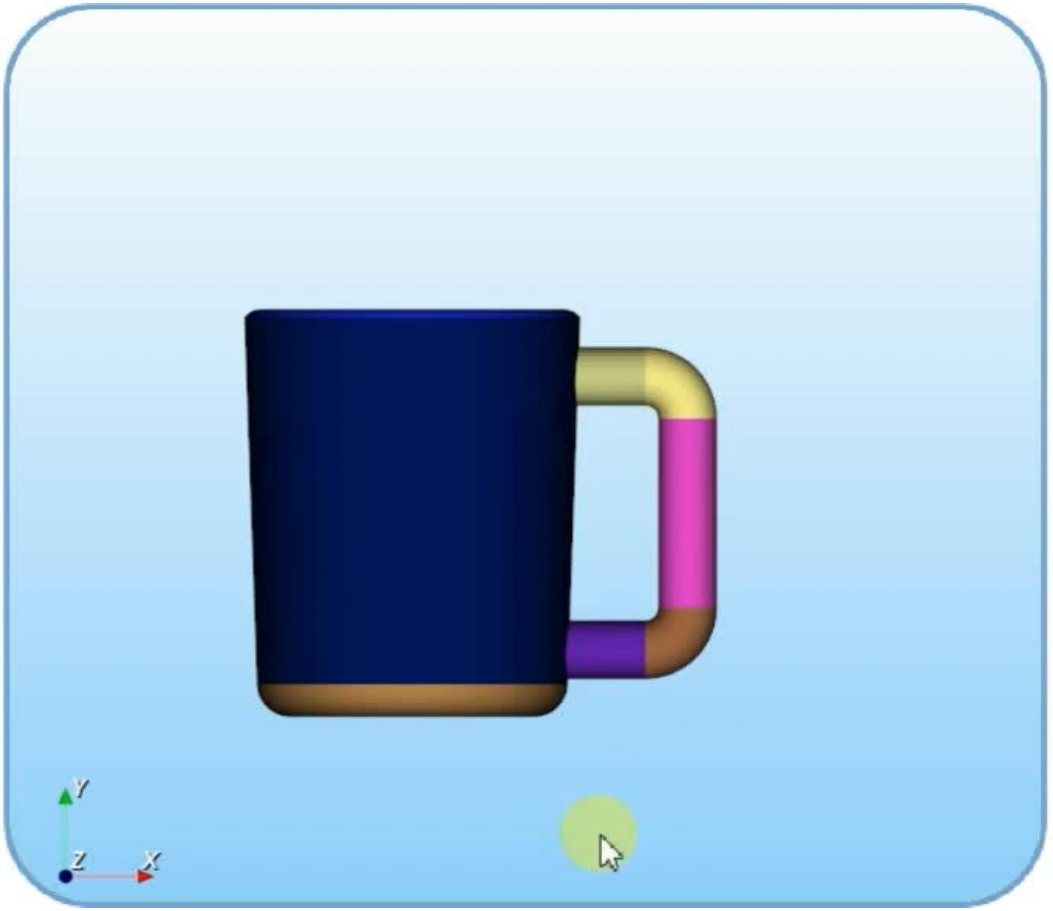

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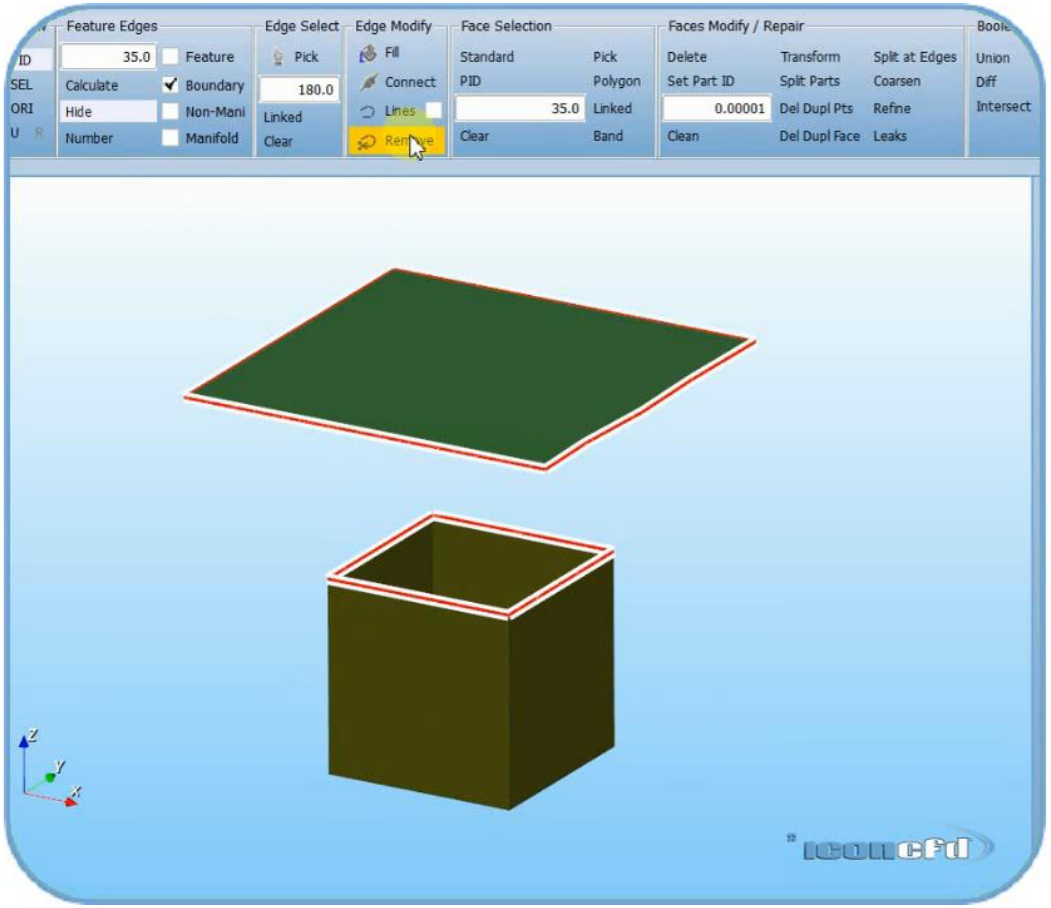

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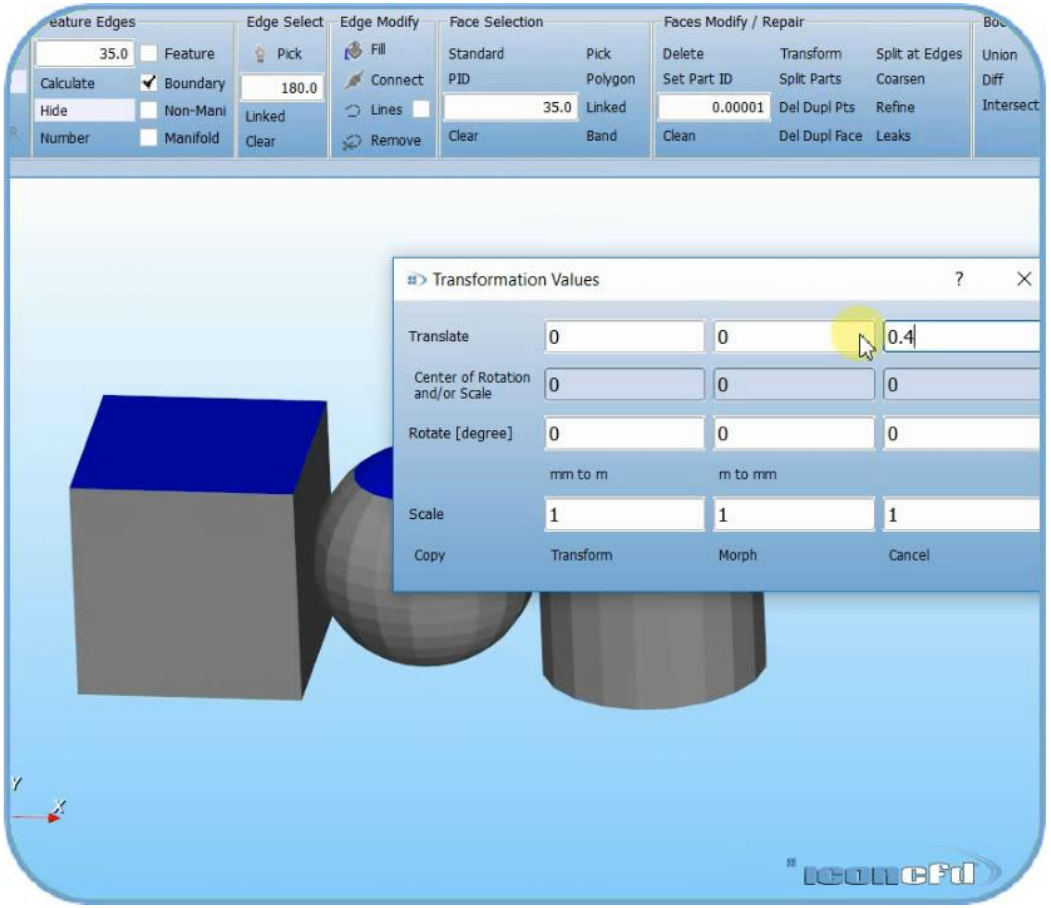

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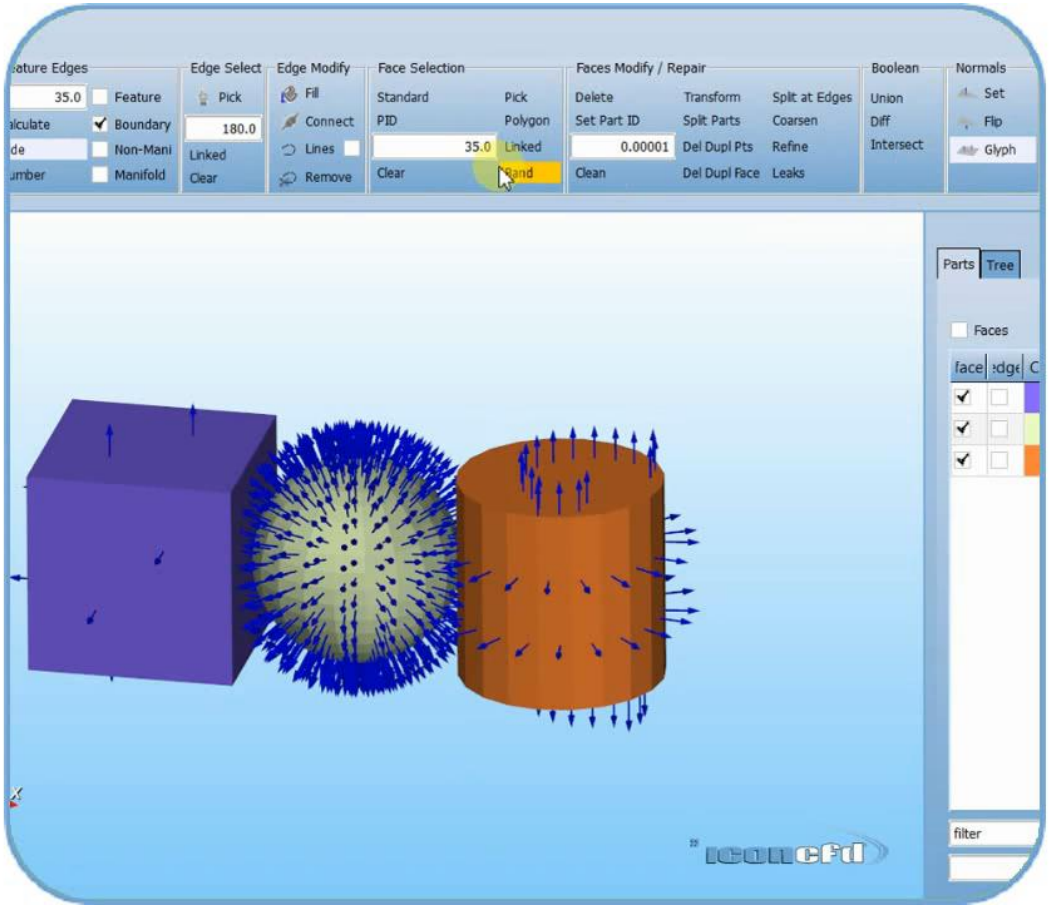

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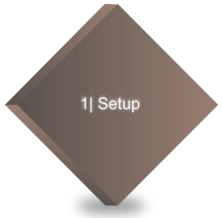
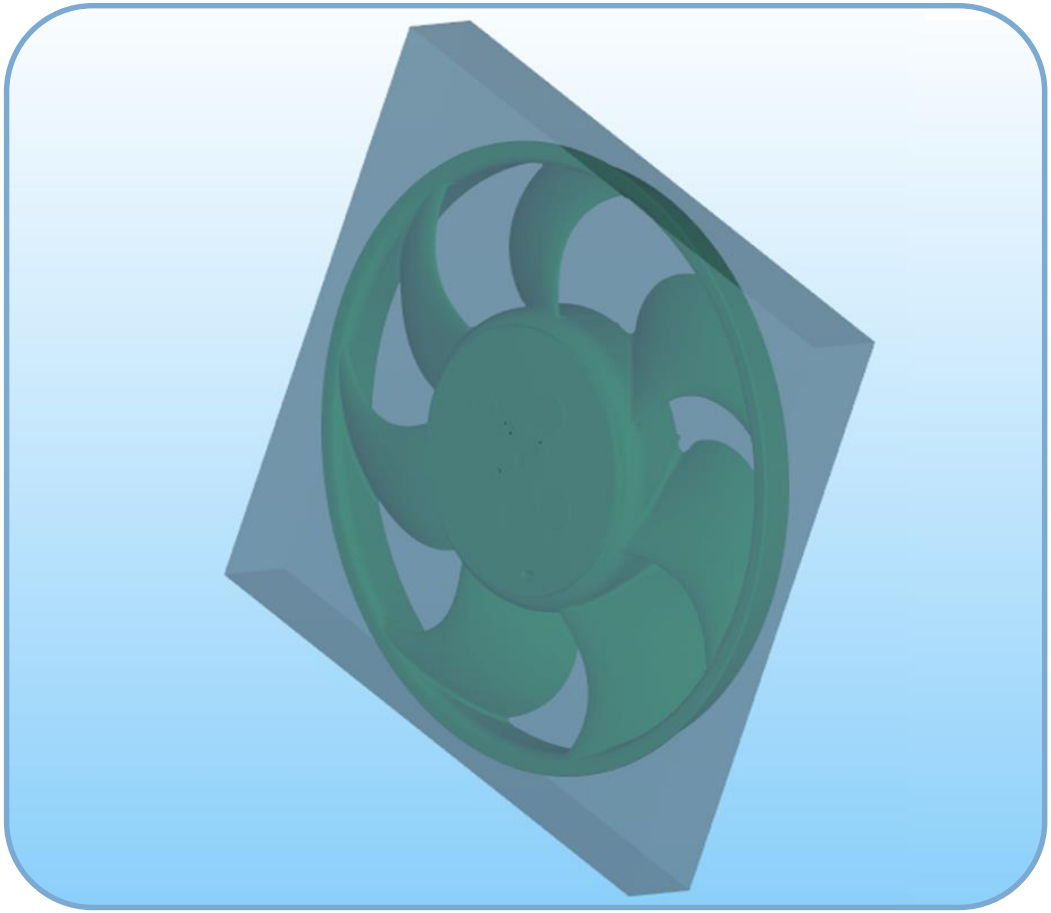


iconCFD PROCESS

GEOM TOOL

- Geometry pre-processing
  - Create surfaces for computational domain, cell or face zones
    - (Rotated) Bounding box
    - Convex object around part
    - Surface offset
    - Rotational volumes
- Support Aero-CFD case setup with calculations of
  - Distance
  - Projected frontal area
  - Surface area and normal
- Surface morphing
  - Based on adjoint sensitivities



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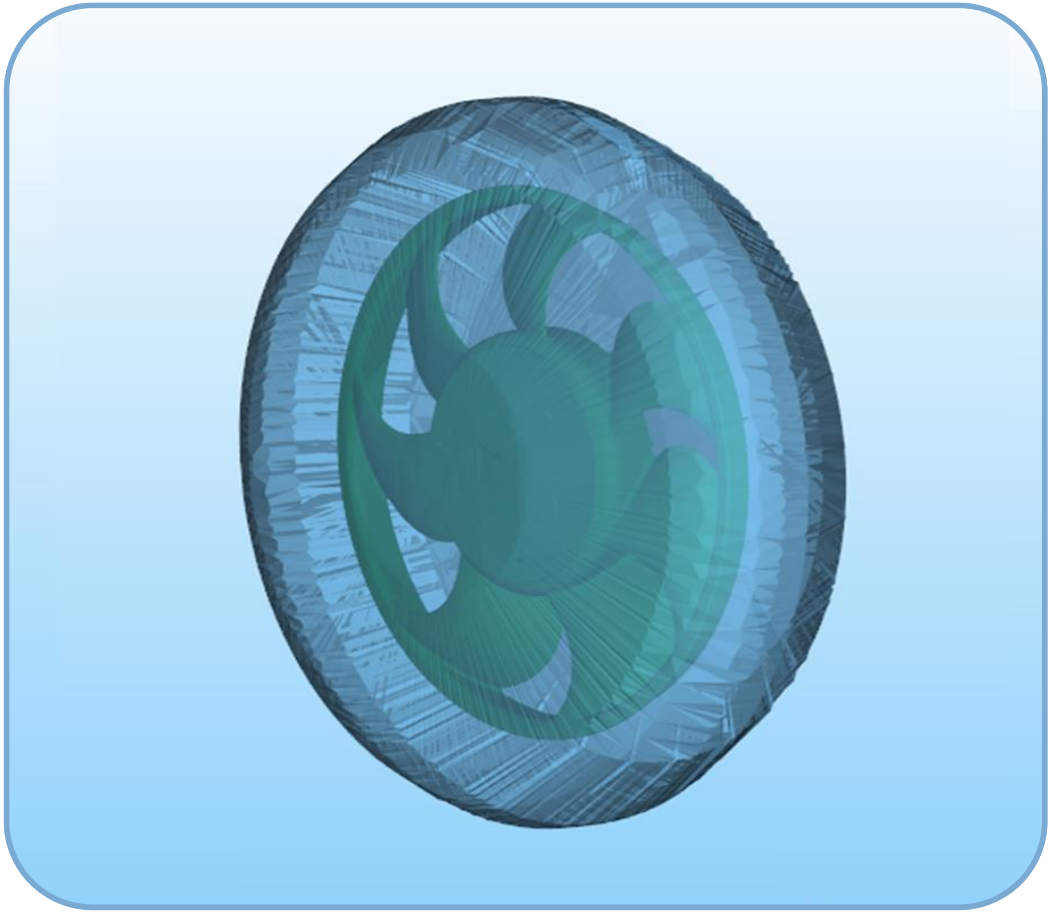

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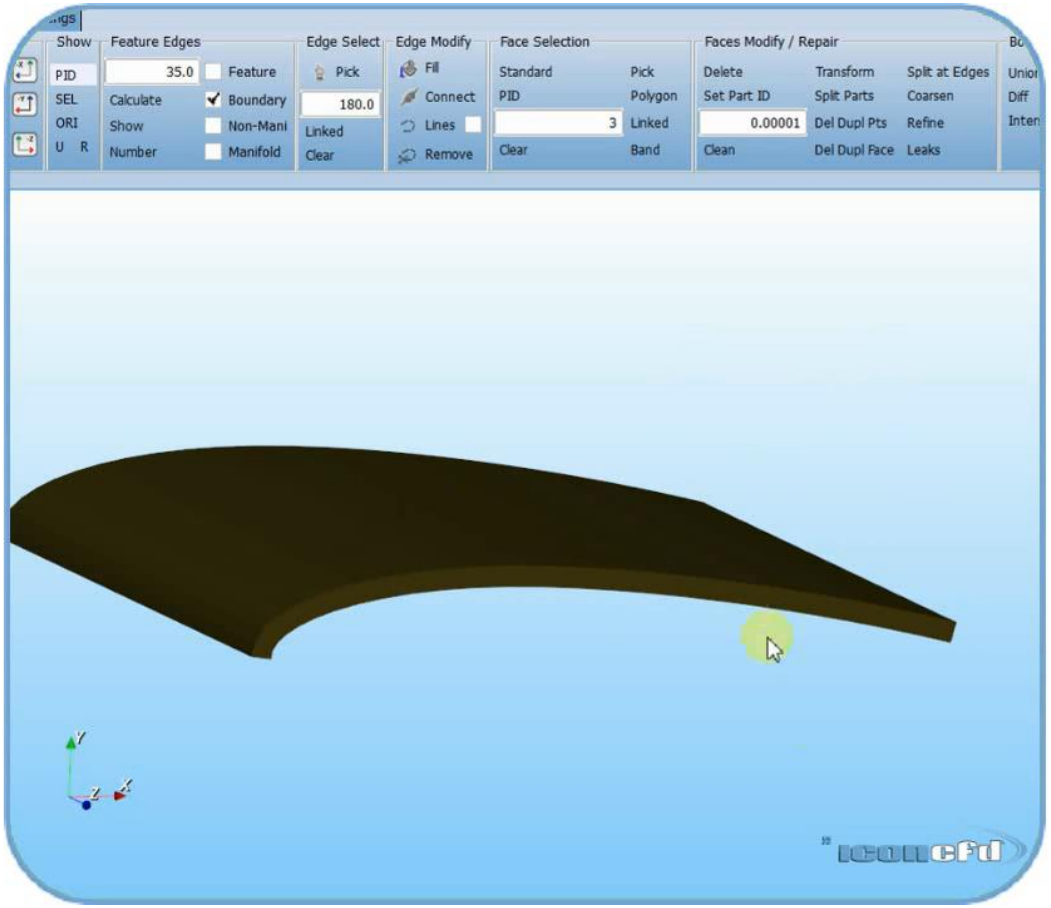

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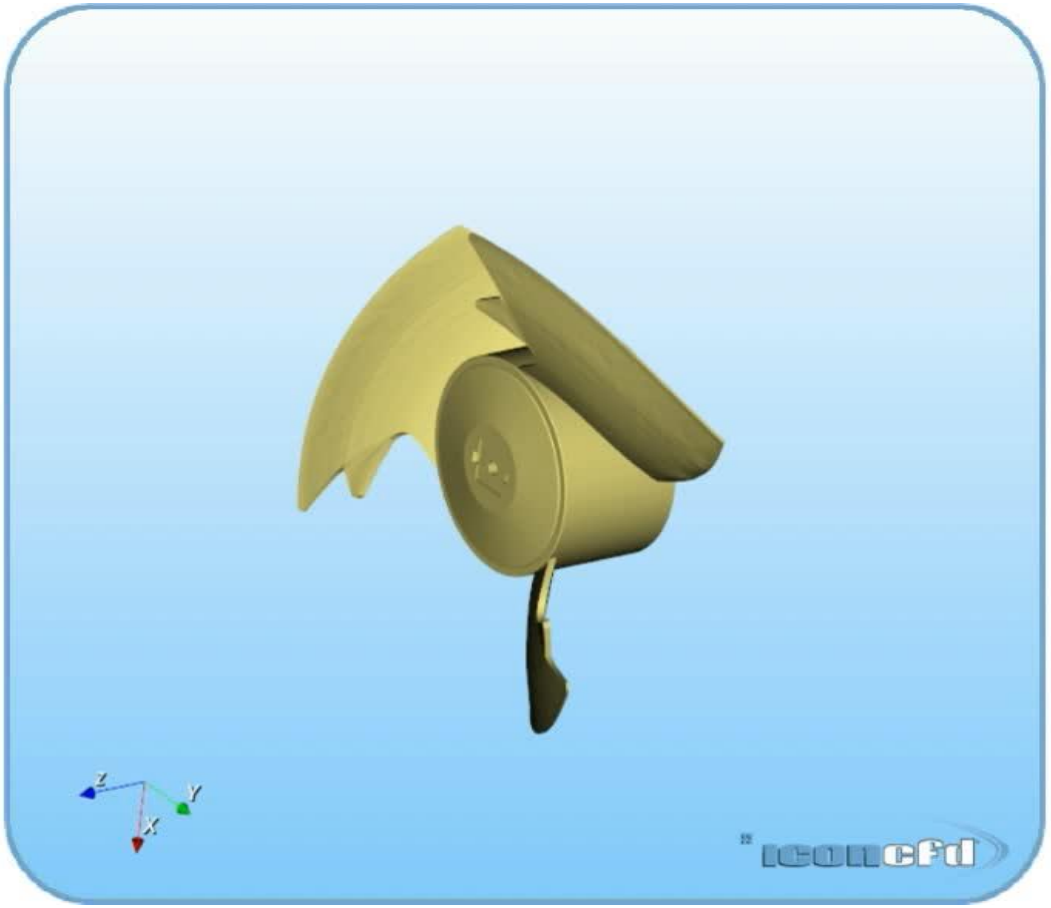

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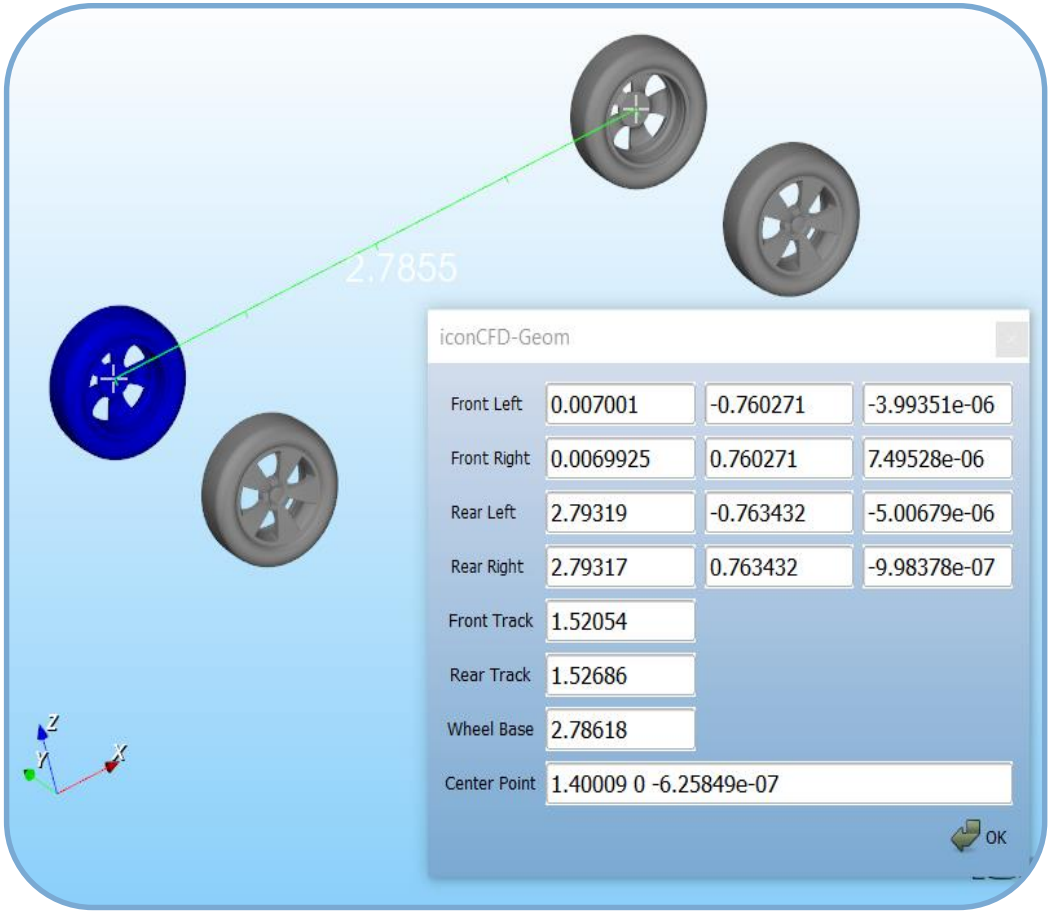

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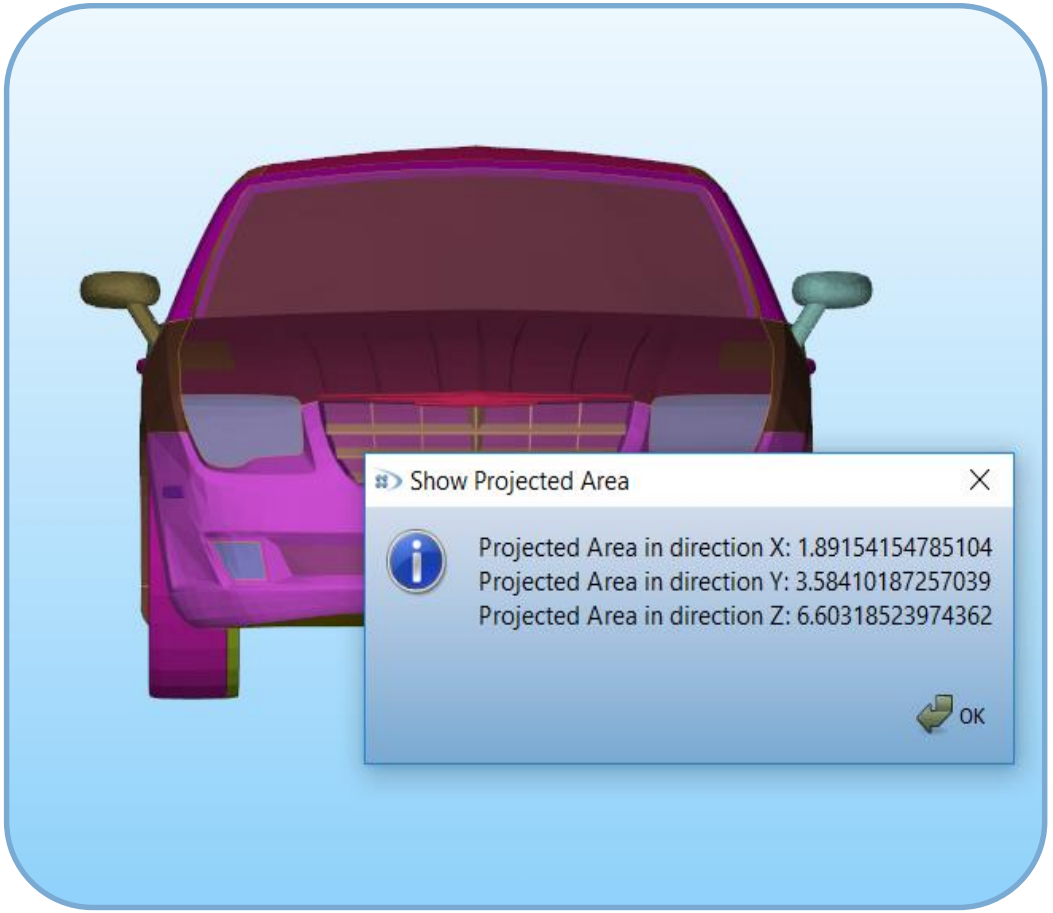

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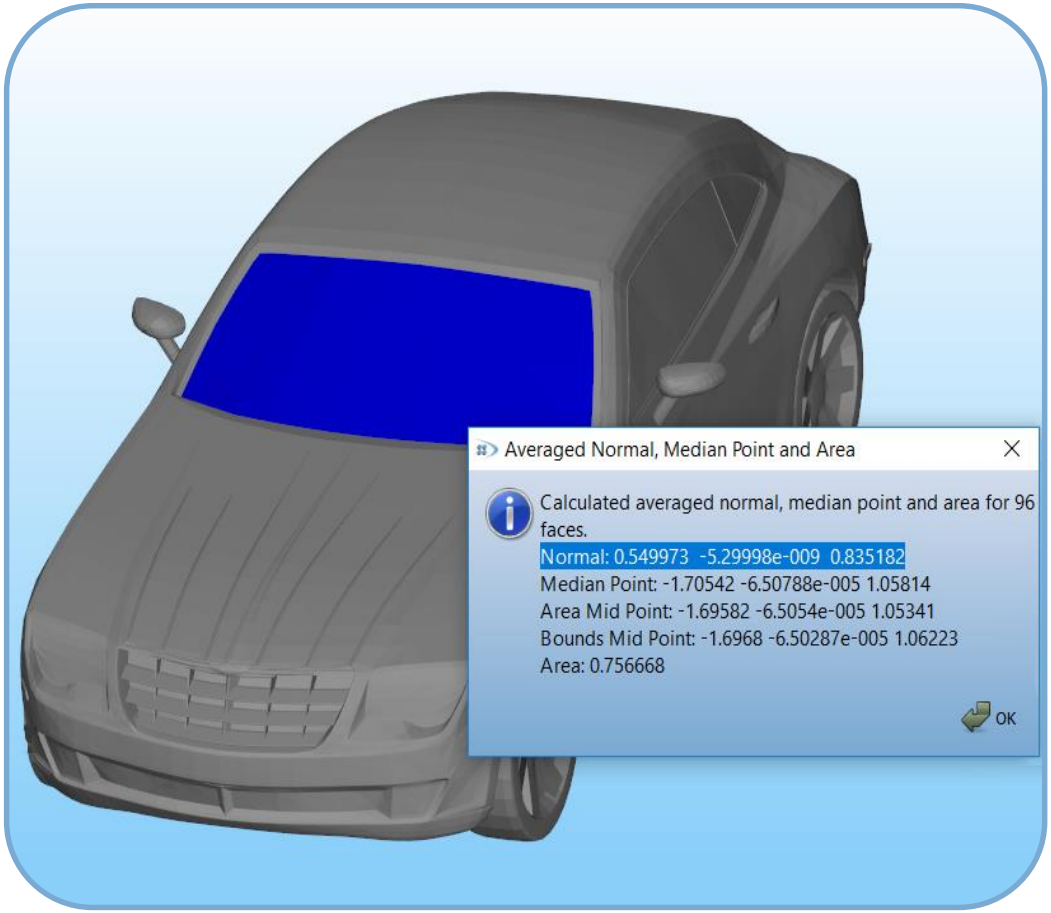

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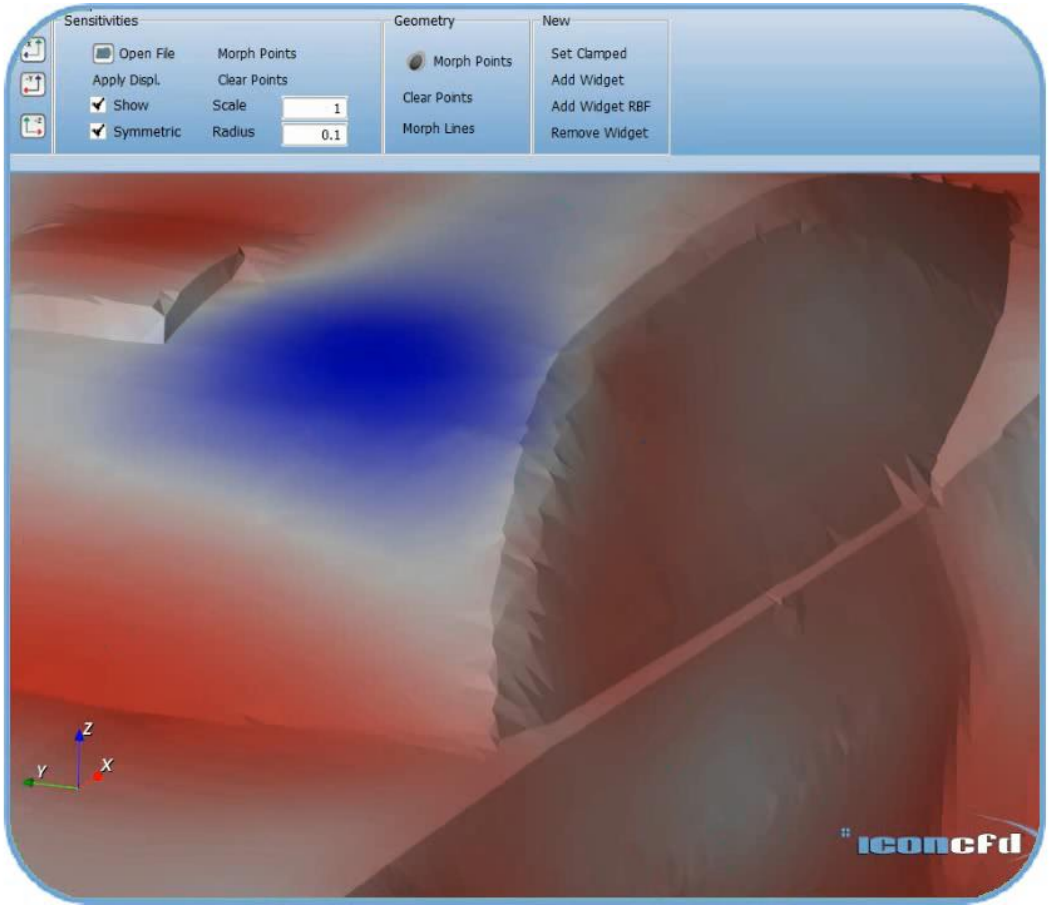

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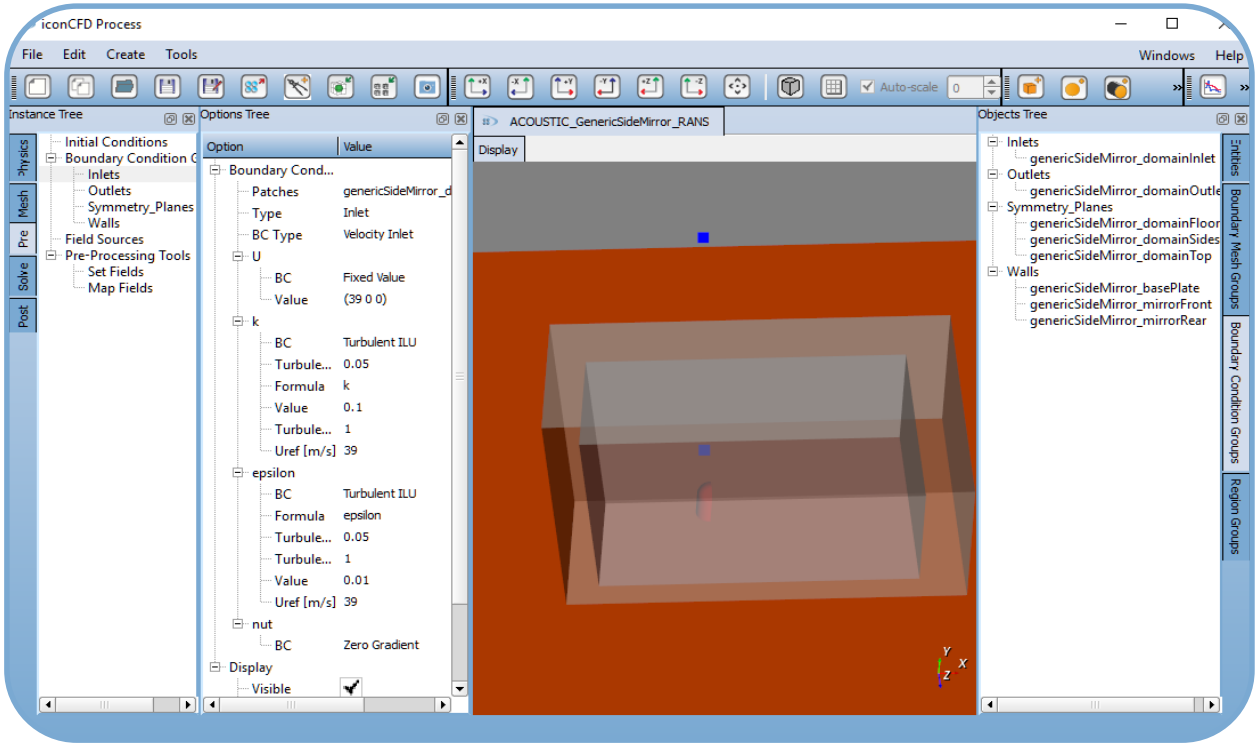
iconCFD PROCESS

ICONCFD GUI

- **Purpose:**
  - Set up (mesh and solver) and run iconCFD cases



- New Key Feature:
  Run Manager
  - Resource Library
  - Job and Workflow Libraries
  - Python API

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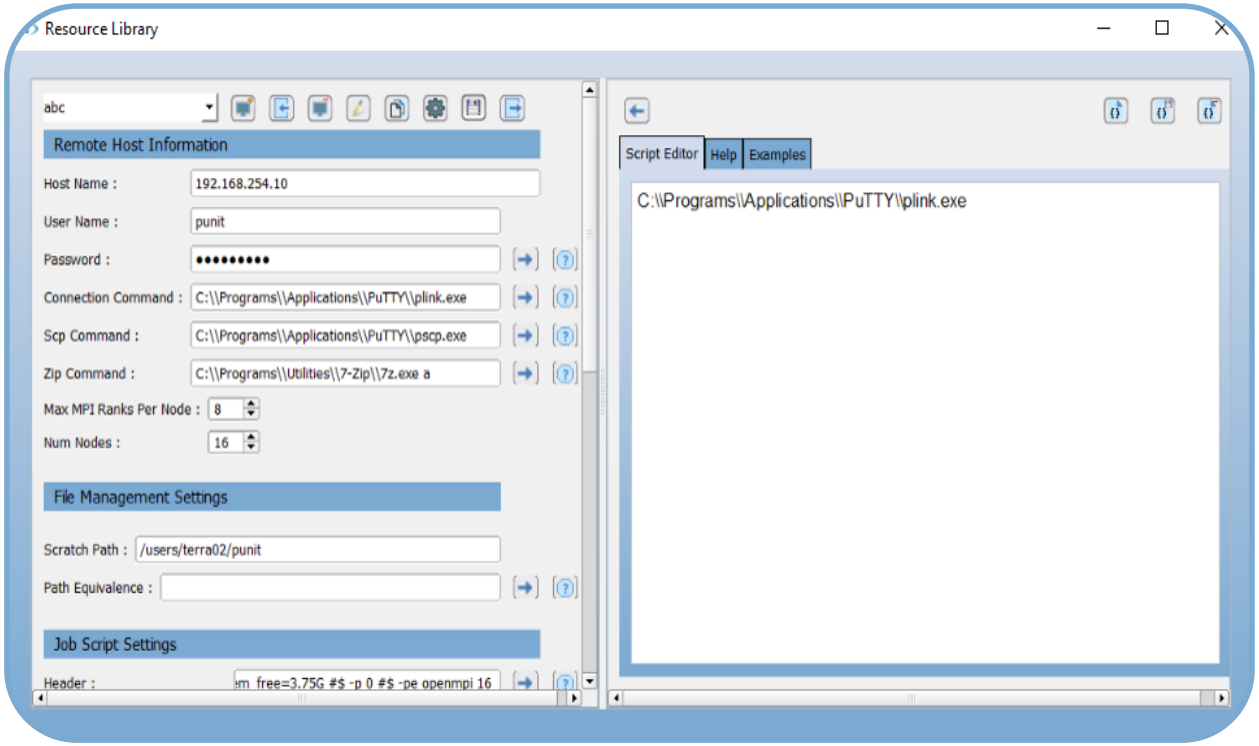
iconCFD PROCESS
GUI – RUN MANAGER

- **Resource Library:**
  - Definition of resources, i.e. specifications of machines to submit to, how to run, etc.



- Host settings
- Job settings
- Submit script

- Set-up by IT or expert user

- Script editor
- Detailed help menu
- Examples

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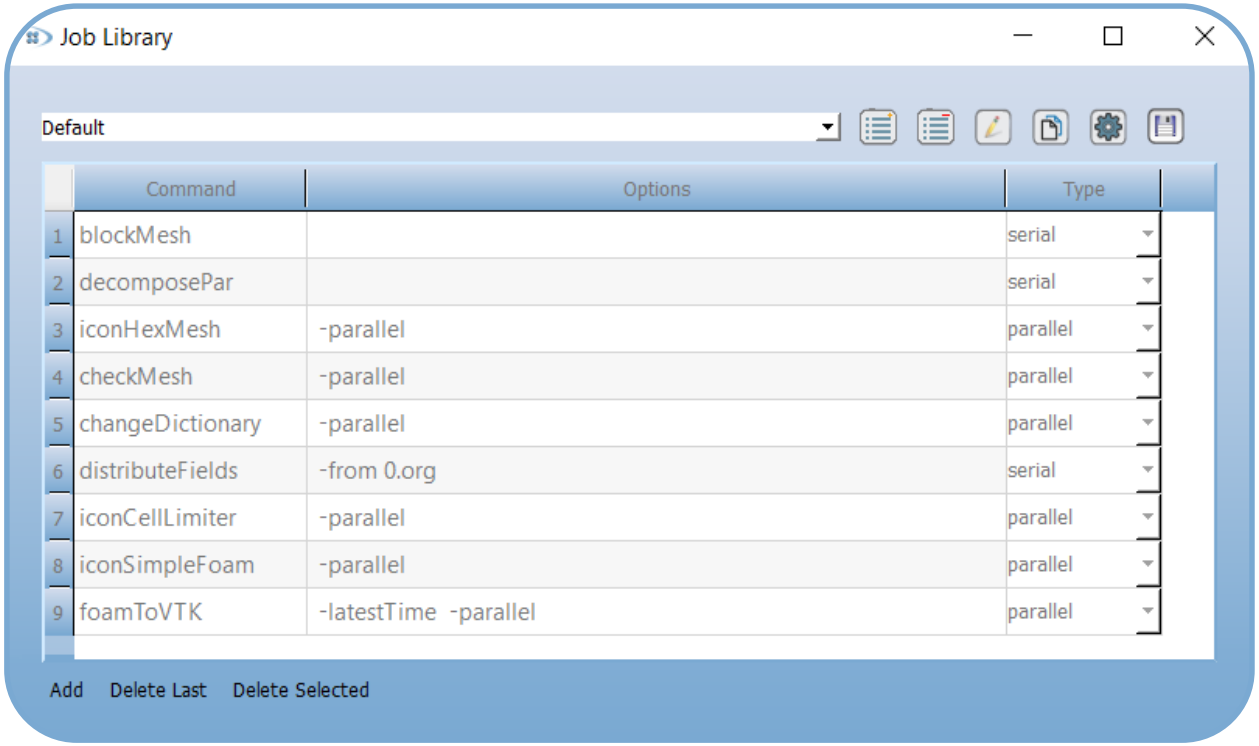
GUI – RUN MANAGER

- **Job Library:**
  - Generic interface to allow specification of job types



  - List of commands to run a single job

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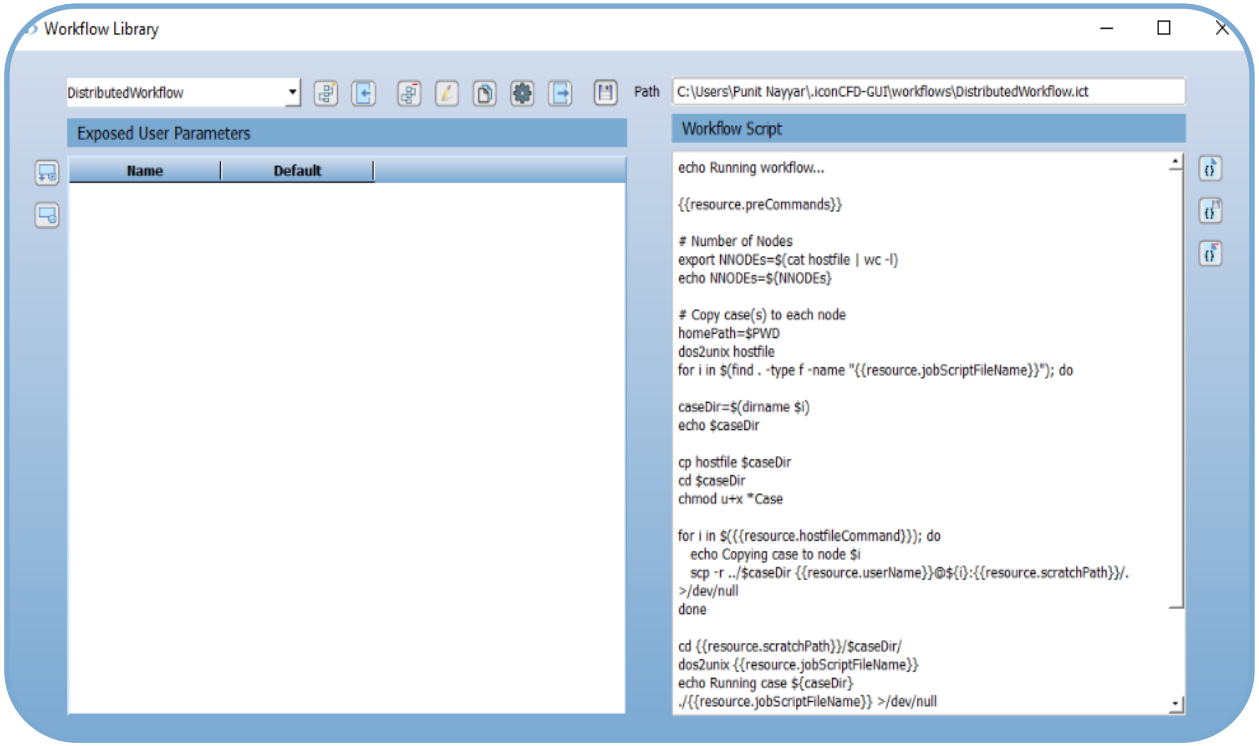
GUI – RUN MANAGER

- **Workflow Library:**
  - Generic interface to allow specification of workflow types



- Multiple simulation jobs in one run
  - Sequential jobs
  - Steady – transient
  - Primal – adjoint
- Set-up by expert user
- Important parameters exposed to user

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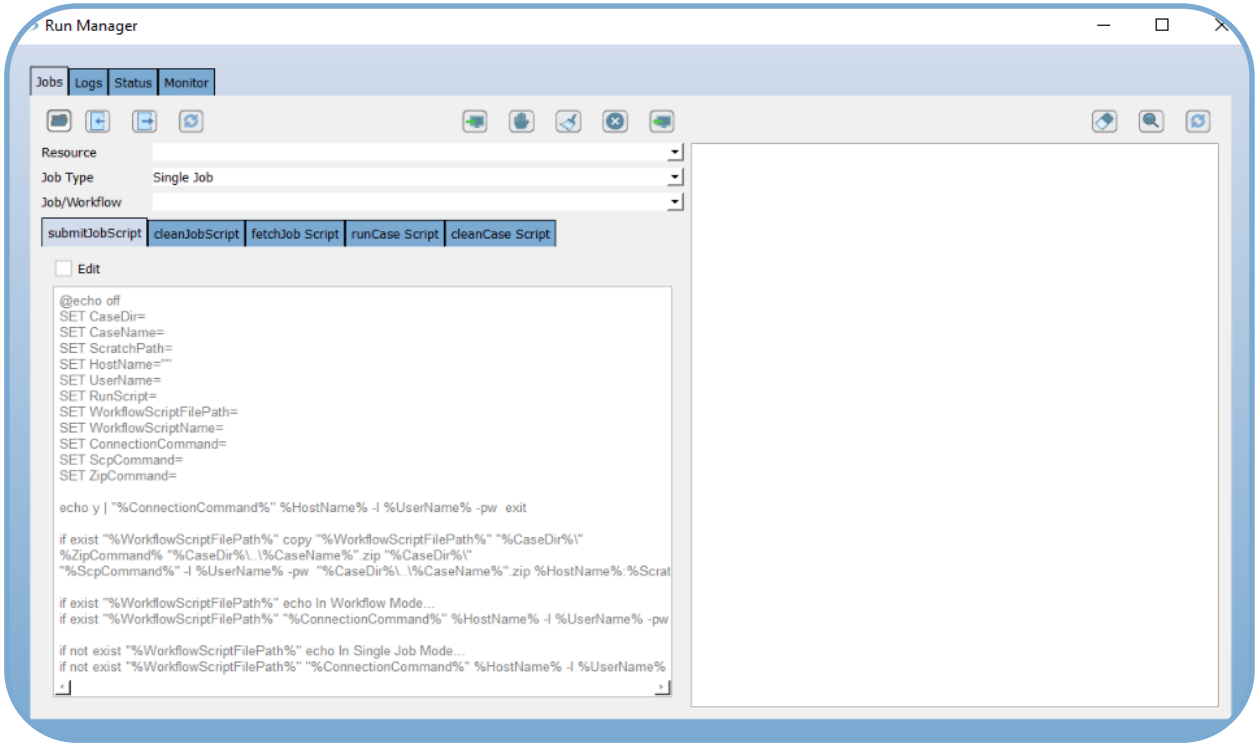
GUI – RUN MANAGER

- **Run Manager:**
  - Main interface



- Select case path
- Pick resource
- Pick job/workflow type
- Submit job

- Scripts can be edited

- Python API: main components of Run Manager can be invoked by user in Python script

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iconCFD PROCESS

GUI – RUN MANAGER

- **Run Manager:**
  - Main interface

```
#!/usr/bin/env python

##- Demo script demonstrating how to use the Run Manager Python API

import libIconRunManager as rm
import os

##- Create run object
run = rm.Run()

##- Select machine to submit job to
run.listResources()
run.setResource('zephyr_ic3121')
run.getResourceName() #for confirmation

##- Select single-job type
run.listJobTypes()
run.setJobType('Default',rm.runType.JOB)
run.getJobName() #for confirmation

##- Run job
os.environ['ICONCFD_GUI_ROOT'] = '/c/Users/Punit Nayyar/WORK/PROJECTS/ICON/iconCFD
Process/Code/iconCFD-develop/install'
run.run('/c/Users/Punit Nayyar/WORK/PROJECTS/ICON/iconCFD Process/Code/Test')
```

Import the module

Instantiate an object of the Run Manager

Select the resource

Select the job type (single job or workflow)

Set ICONCFD_GUI_ROOT env

Submit job

- Select case path
- Pick resource
- Pick job/workflow type
- Submit job

- Scripts can be edited

- Python API: main components of Run Manager can be invoked by user in Python script

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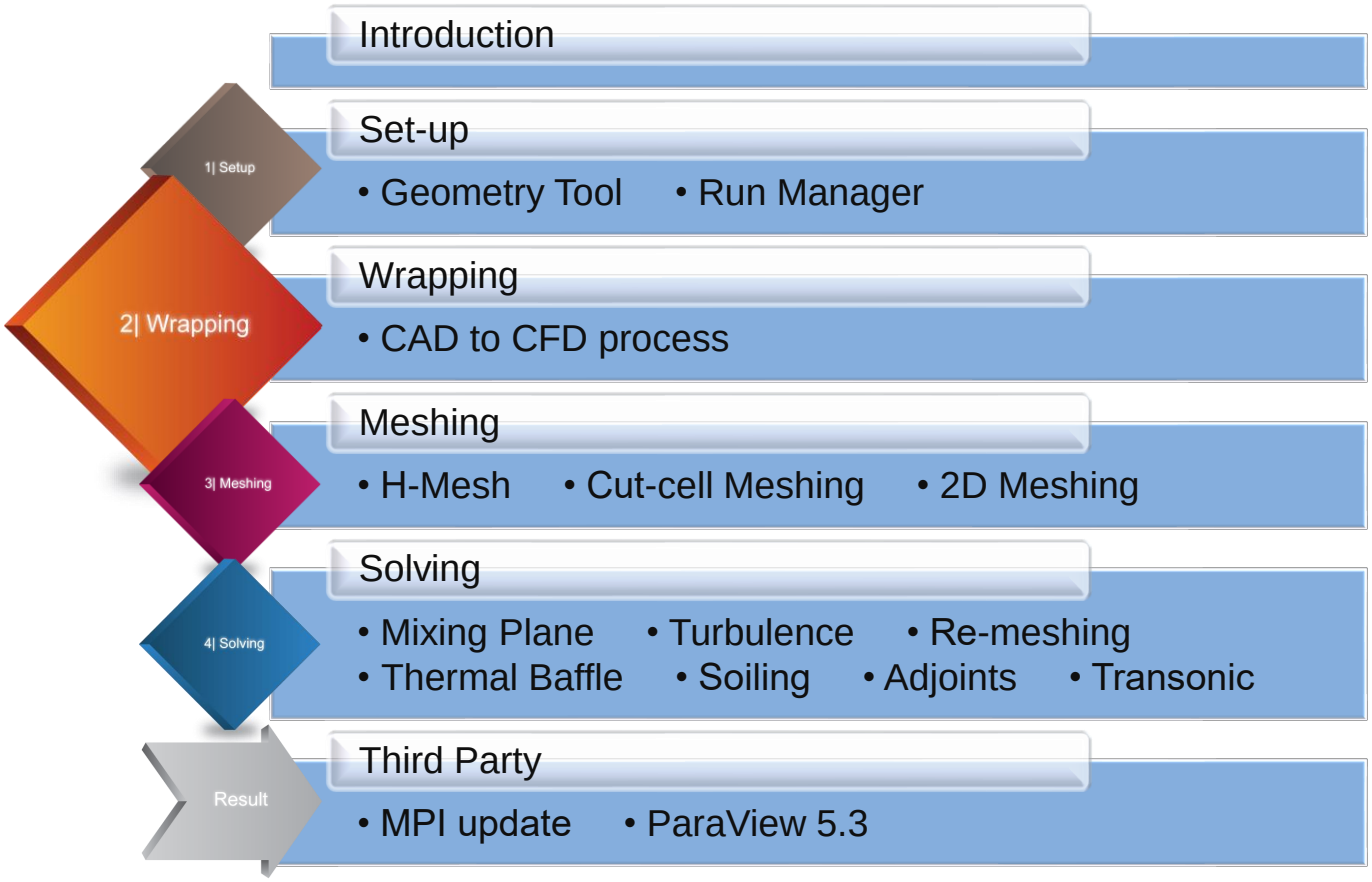

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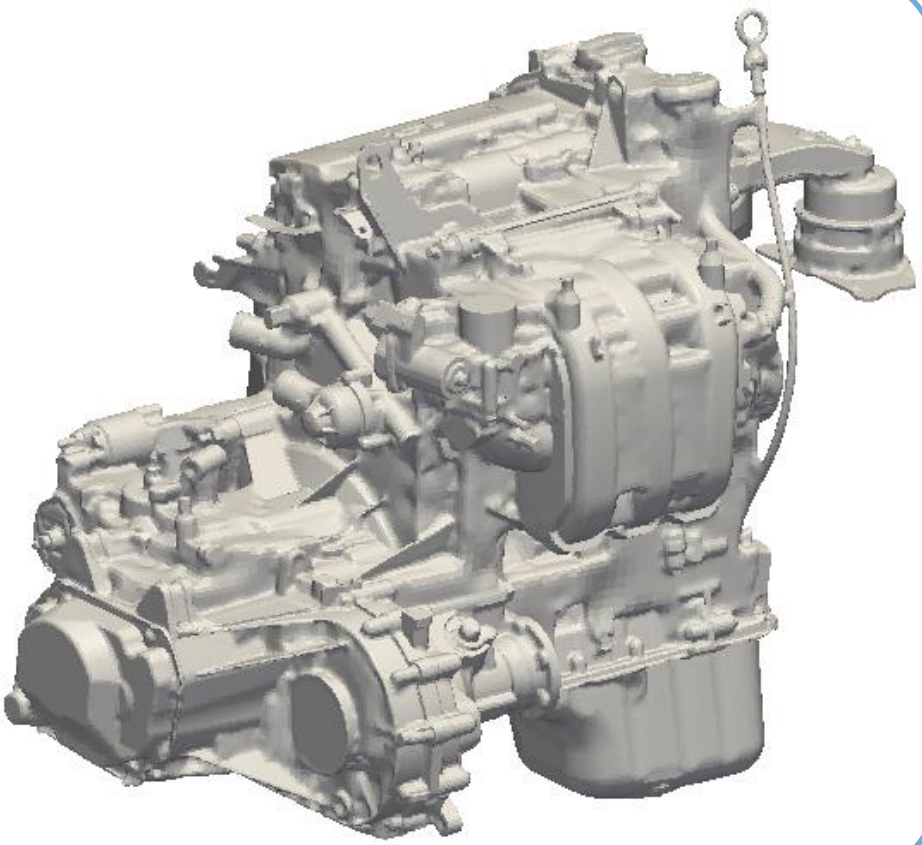
iconCFD WRAP
CAD TO CFD PROCESS

- CAD to CFD
  - CAD triangulation and minimal surface mesh preparation with iconCFD Geom
  - Automatic surface wrapping with iconHexMesh-based approach in iconCFD Wrap
  - Case creation with iconCFD Gui or iconCFD MultiCase
  - Hexa-dominant meshing with iconCFD Mesh



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iconCFD WRAP
CAD TO CFD PROCESS

SUMMARY from CAD to CFD:

CAD Preparation = 15min
Wrapping = 2h16min
Case creation = 5min
Meshing= 1h37min

TOTAL = 4h14min

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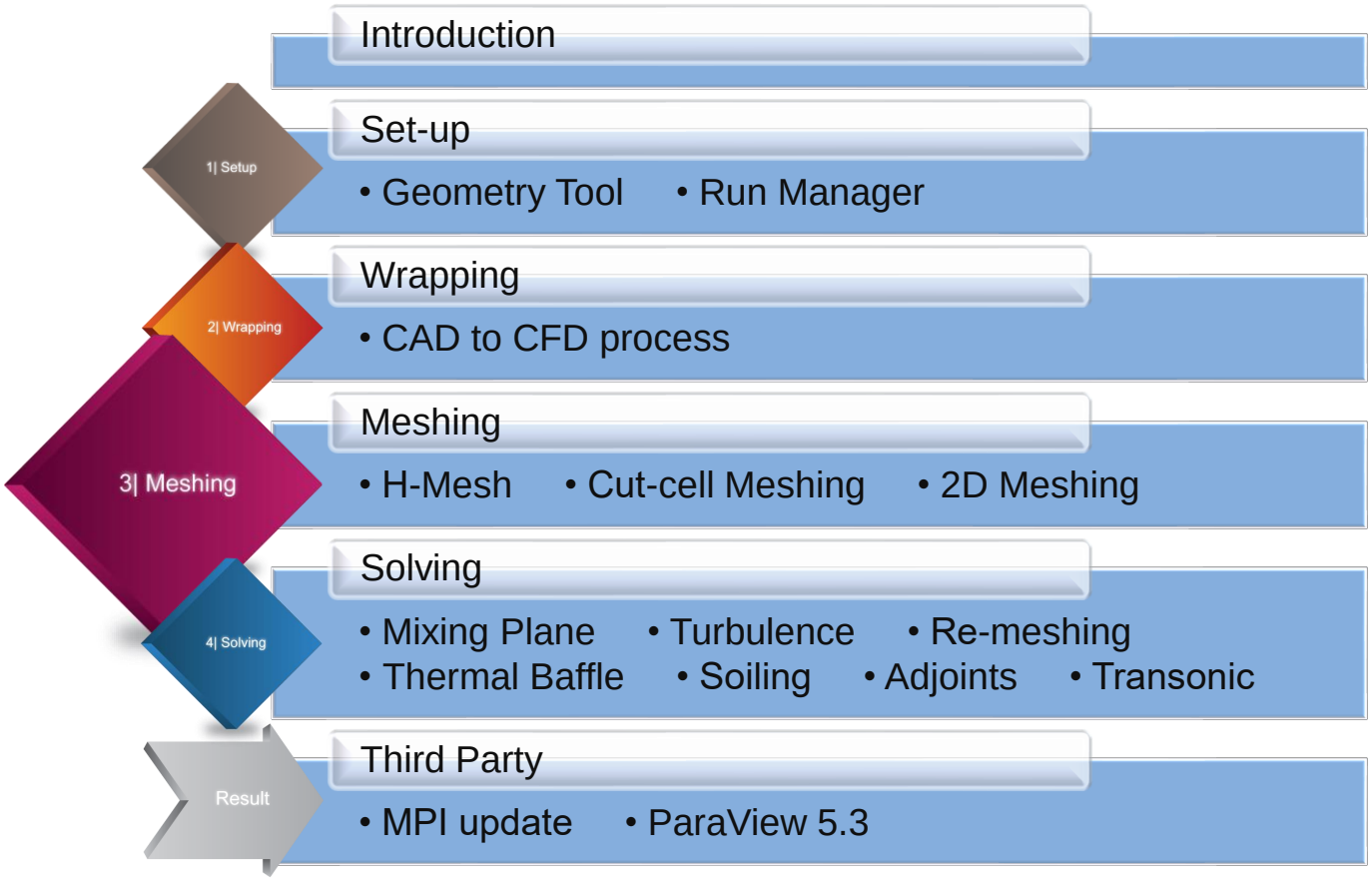

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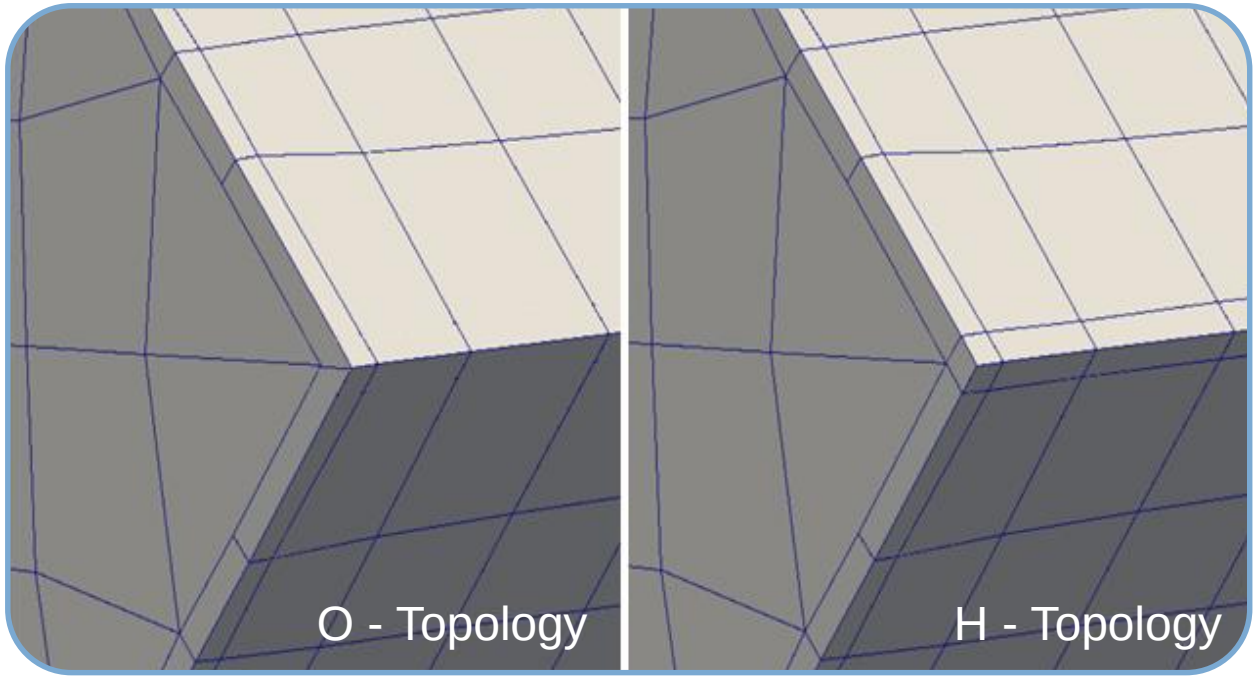
iconCFD MESH

H-MESH

- H-topology layer mesh in concave corners
  - Improve quality and accuracy of boundary layer flow simulation
  - Structured-style layer mesh automatically generated in concave corners



- Topology automatically transitions from O to H-topology
- Based on angle between adjacent face normals
- Fully parallelised algorithm with minimal user input

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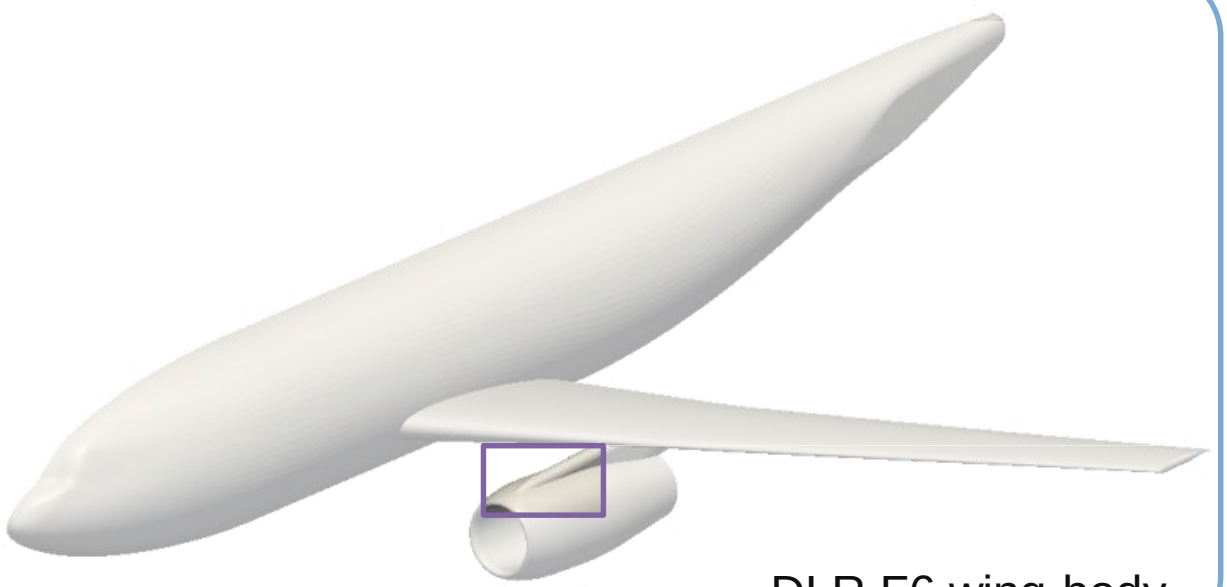

DLR F6 wing-body

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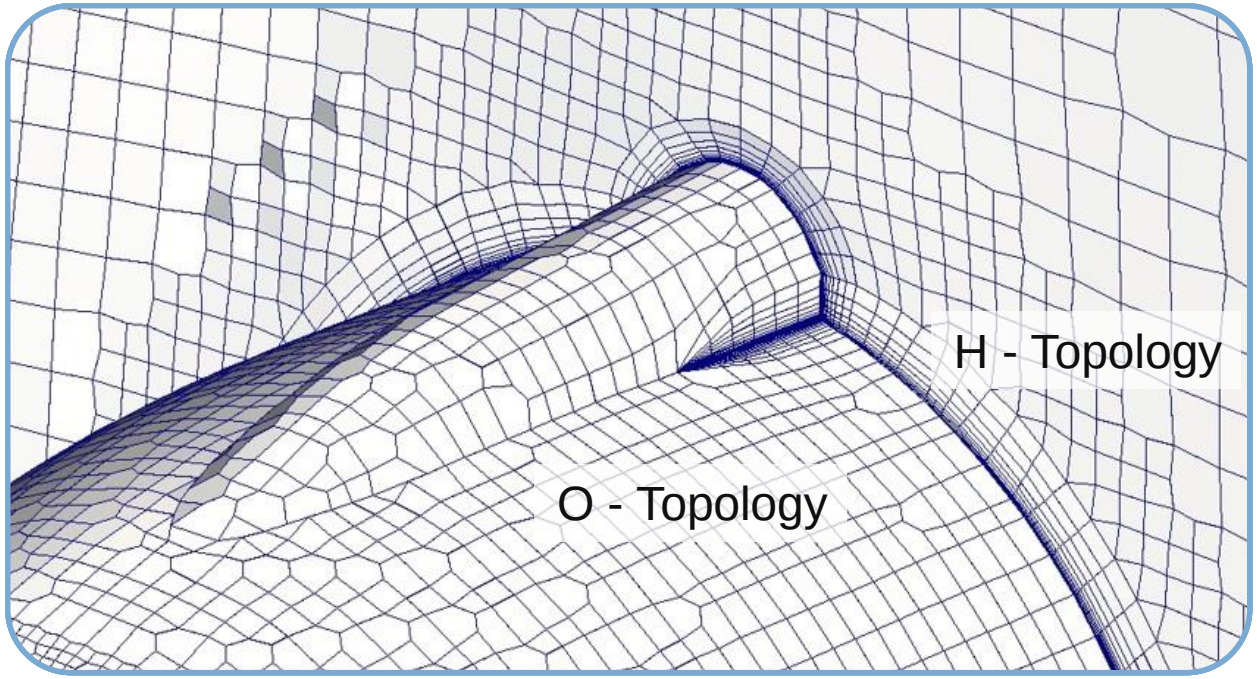

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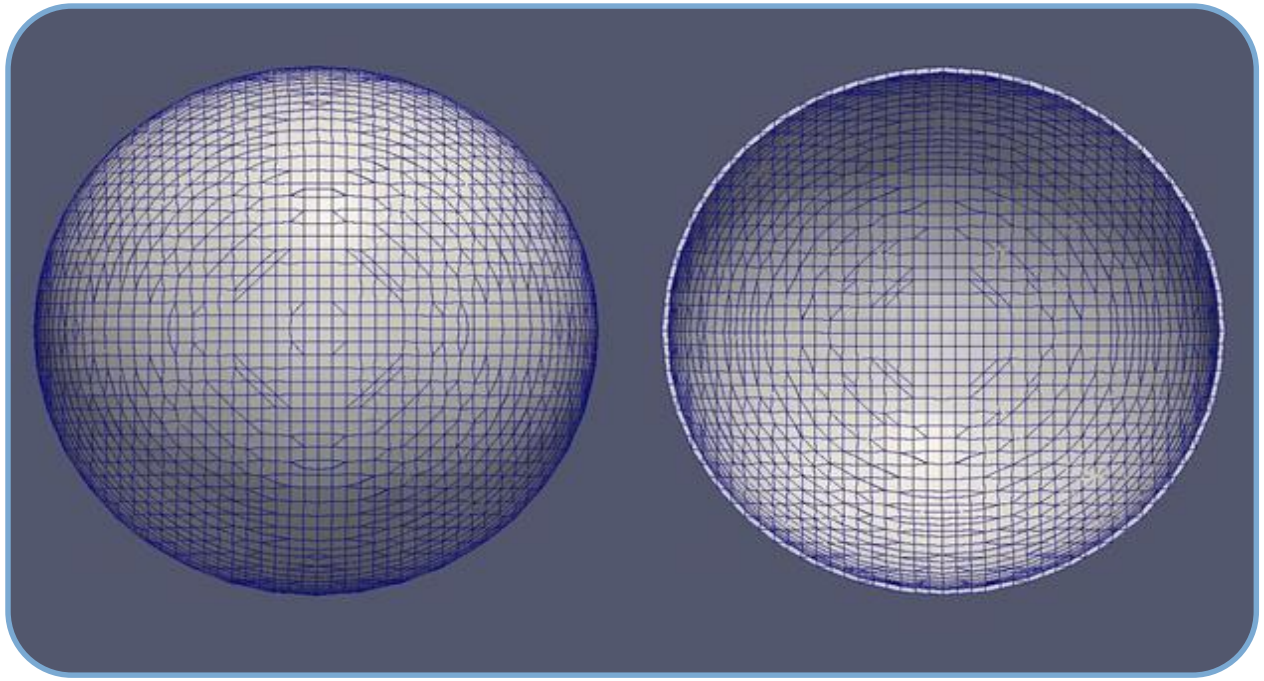
iconCFD MESH
CUT-CELL MESHING

- Cut cells at surfaces instead of snapping
  - Improved mesh quality due to less distortion
  - Advantageous for face zones, narrow gaps, high fidelity meshes with good quality

  - Cells are cut
  - Cells outside domain are removed
  - Surface layers are added



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iconCFD MESH
CUT-CELL MESHING

- Cut cells at surfaces instead of snapping
  - Improved mesh quality due to less distortion
  - Advantageous for face zones, narrow gaps, high fidelity meshes with good quality

  - Cells are cut
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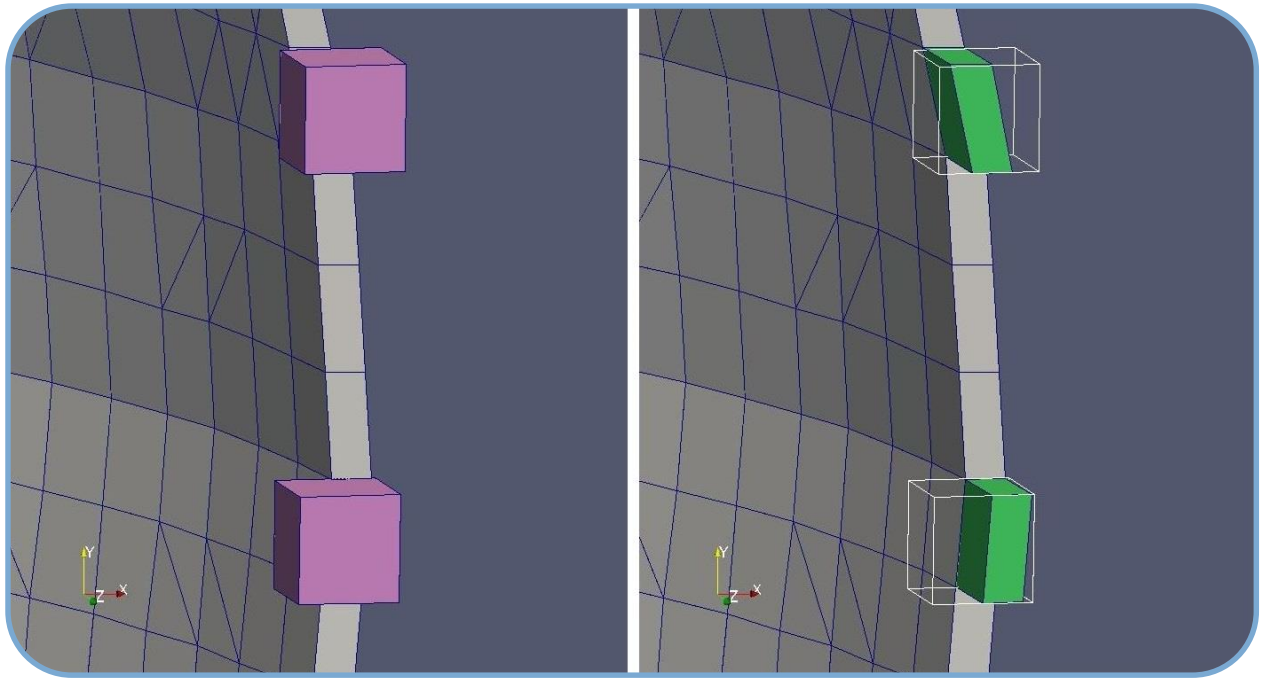

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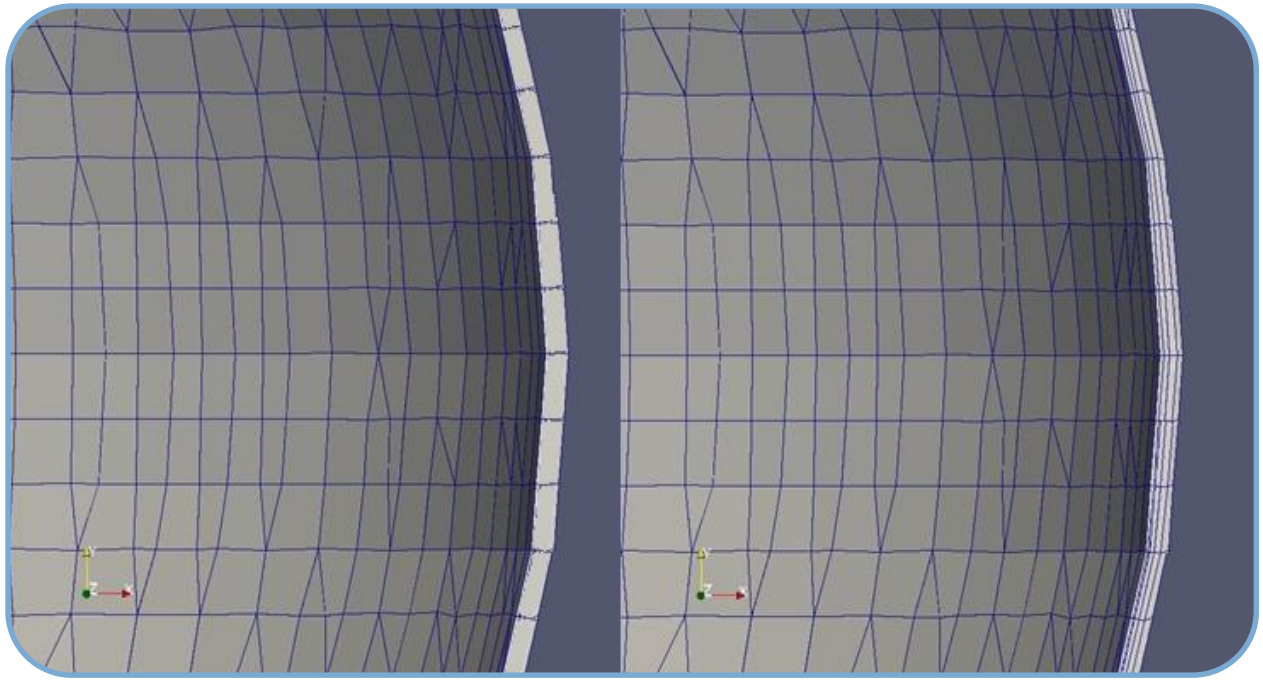

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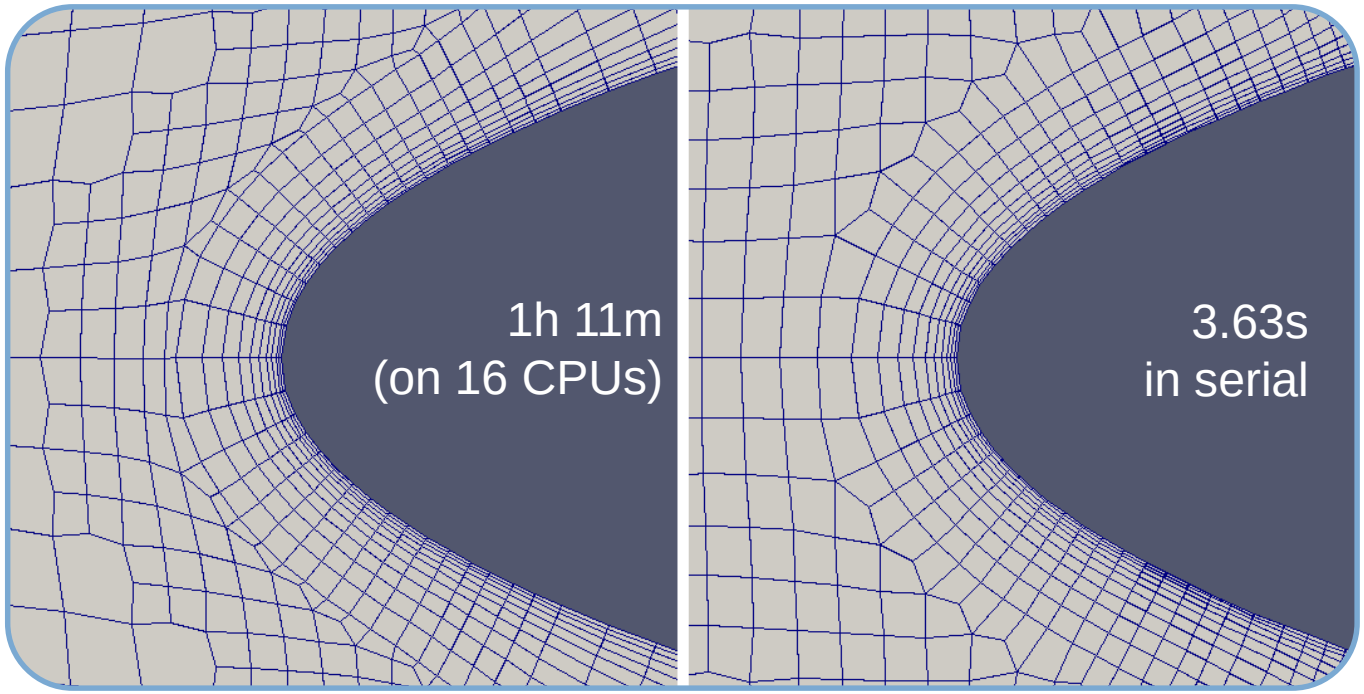
iconCFD MESH
DIRECT 2D MESHING

- Mesh directly in 2D, instead of generating 3D mesh and then extruding 2D mesh from a patch
  - Refinement, snapping and layering now performed in 2D

Original 2D Mesh



Direct 2D Mesh

~8000 cells
Max RL: 12

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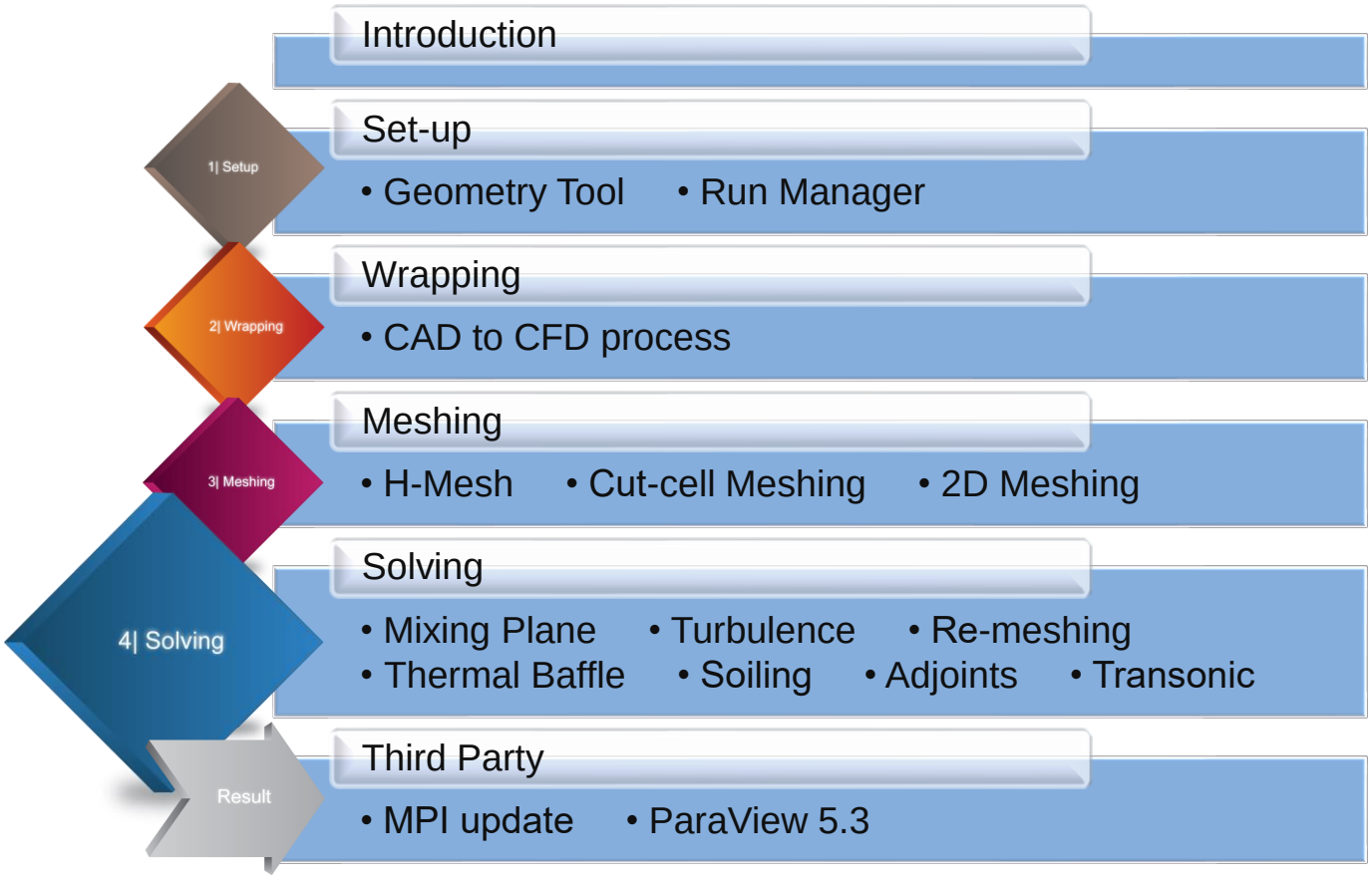

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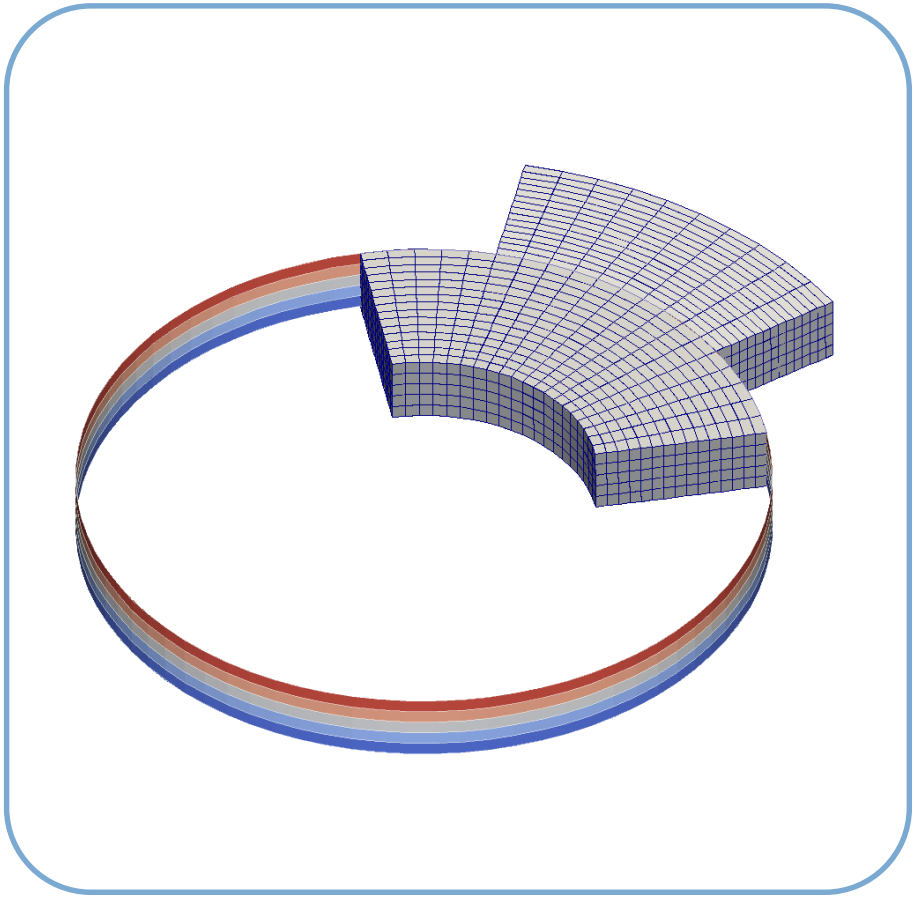
MIXING PLANE

- Mixing Plane Interface
  - Turbo-machinery simulations in steady-state
  - Couples rotor and stator mesh regions at rotationally symmetric interface
  - Circumferential averaging of fields (area or flux weighted)
  - Matrix-coupled mesh interface
  - Used in combination with
    - Multiple Reference Frame (MRF) in rotating domain
    - Periodic cyclicAMI boundaries



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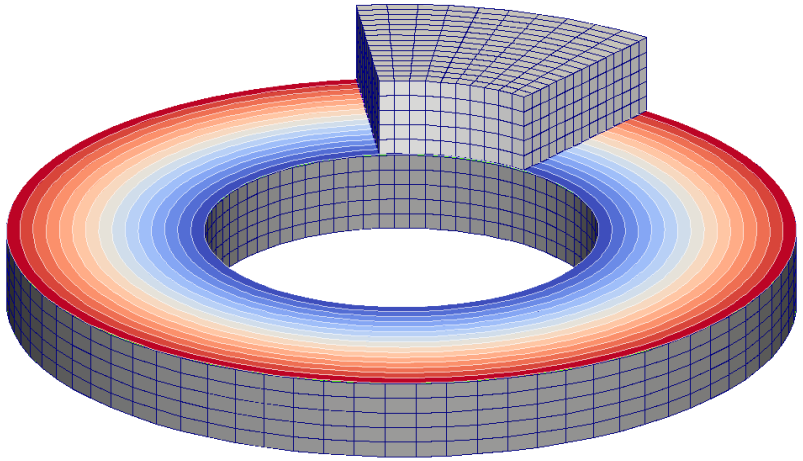

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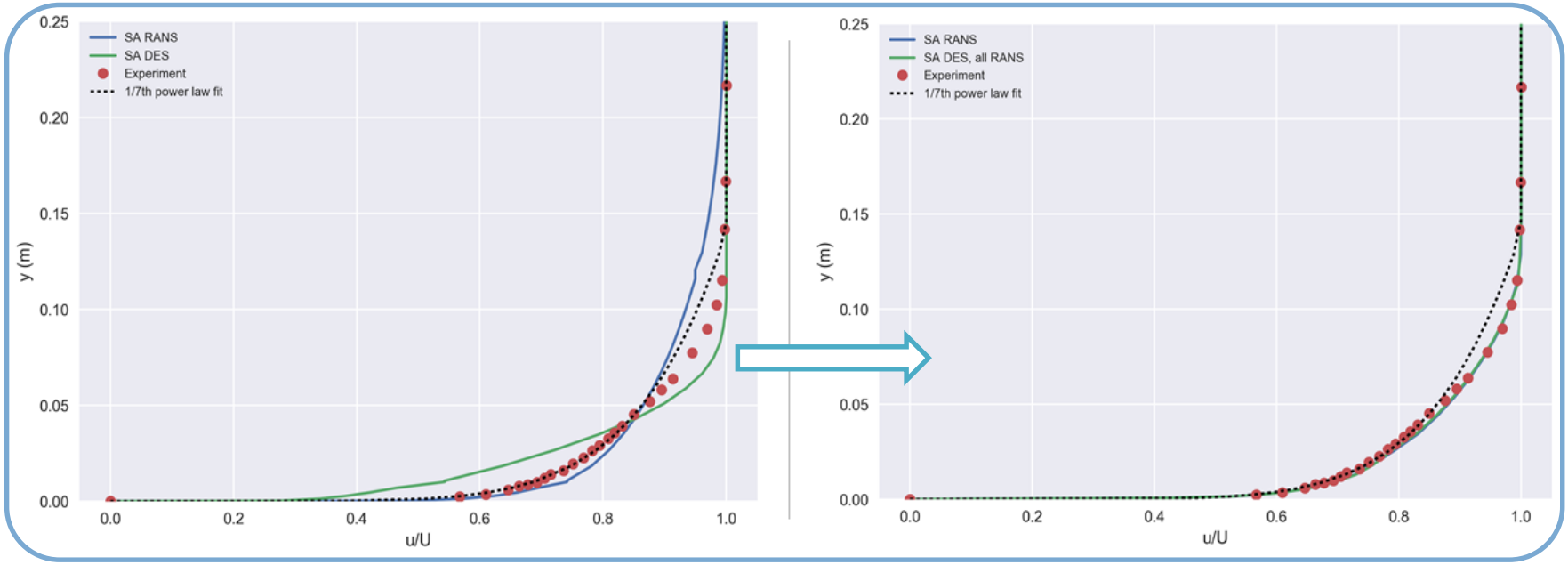
TURBULENCE ENHANCEMENTS

- Spalart Allmaras DES:
  - Enhancements:
    - Explicit specification of RANS zones
    - Corrections to S-term
  - Results:
    - Corrected boundary layer profiles
    - Avoided grid-induced separation



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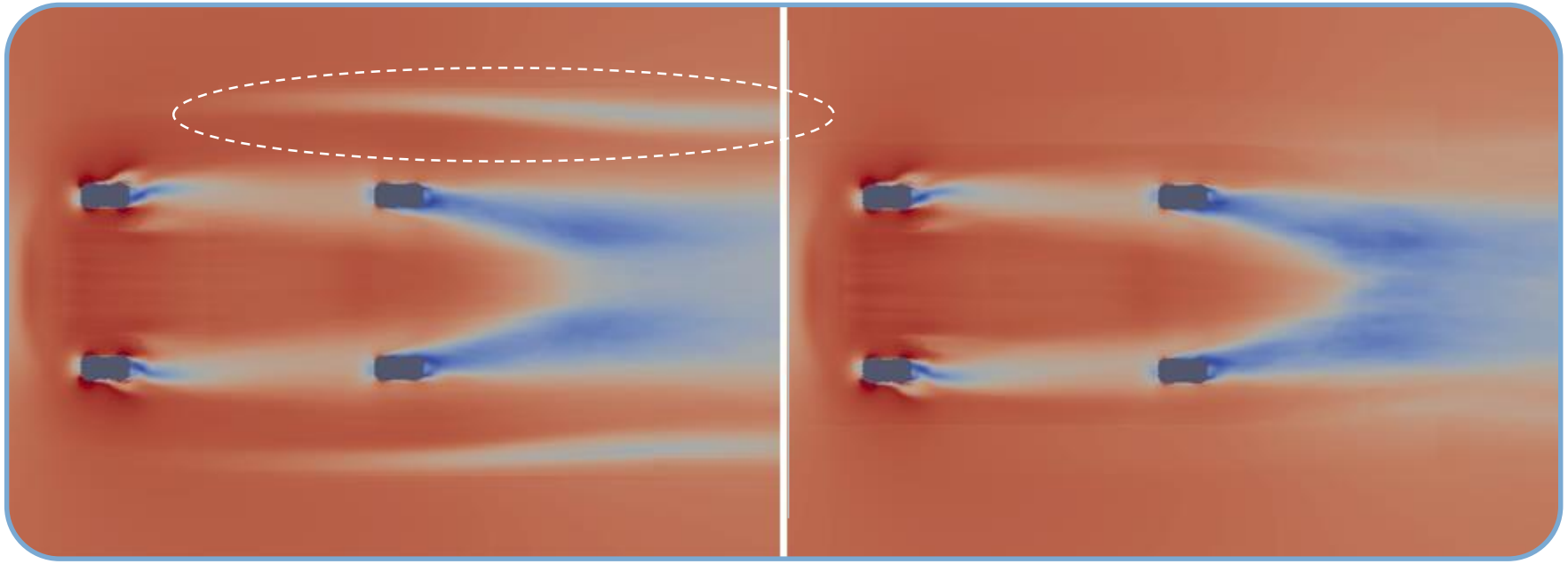

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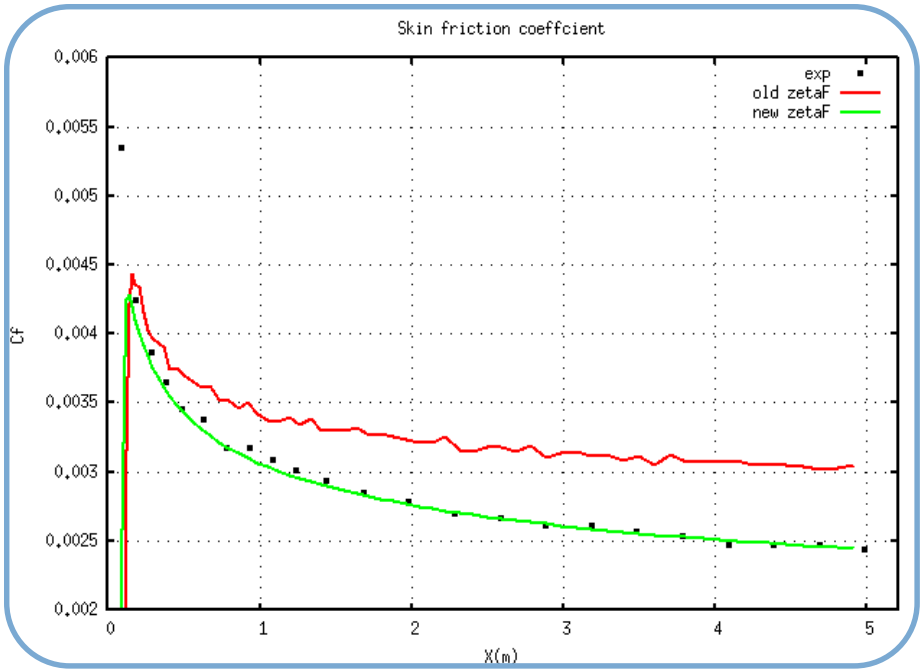
TURBULENCE ENHANCEMENTS

- URANS Zeta-F improvements:
  - Proving beneficial to external vehicle aerodynamics simulations
- New kOmegaSST models:
  - kOmegaSST DES, DDES, IDDES
- DES hybrid convection scheme
  - For hybrid RANS/LES calculations
  - Blends between two convection schemes based on wall distance, velocity gradient and eddy viscosity



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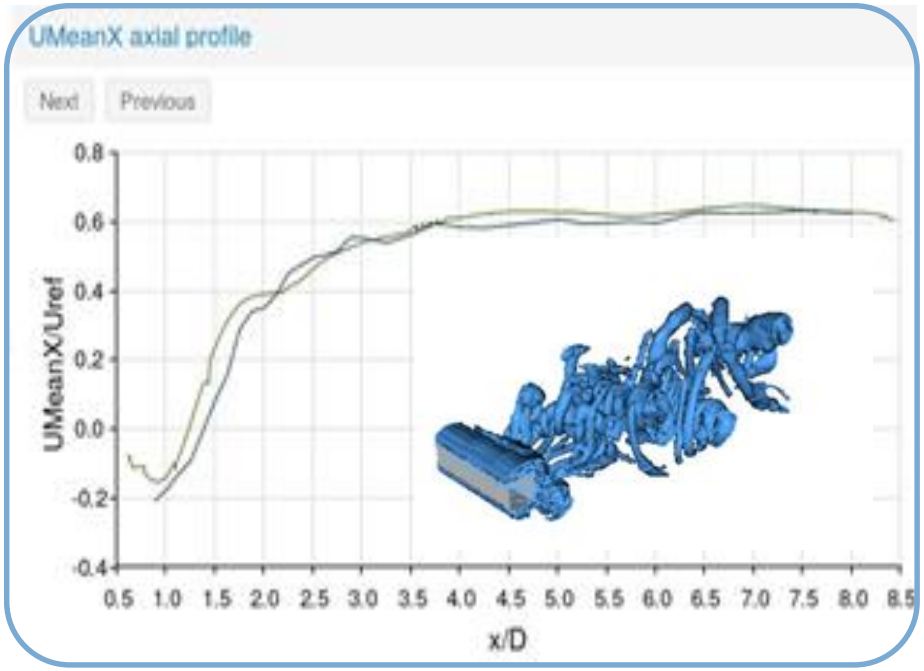

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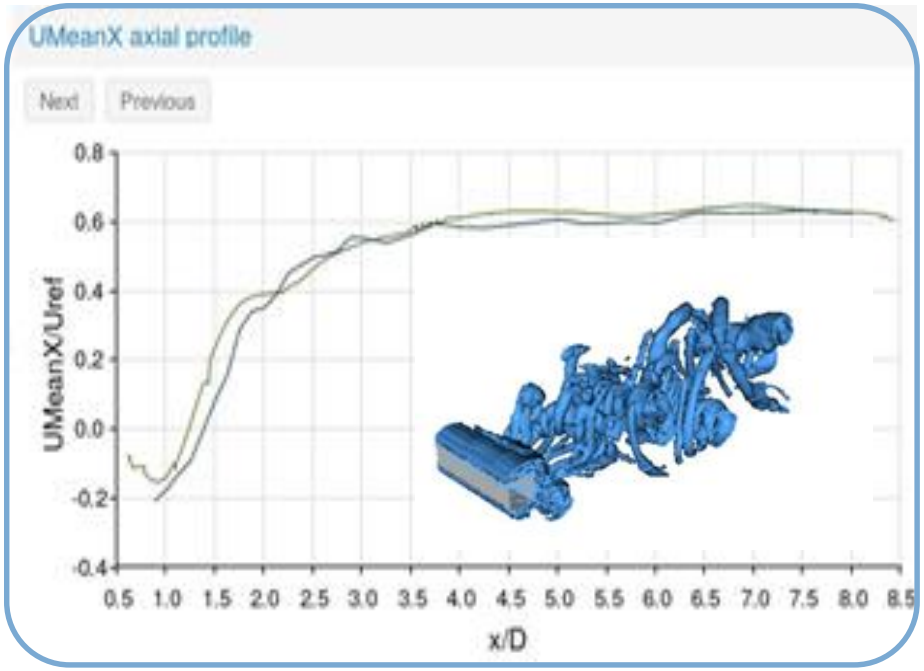

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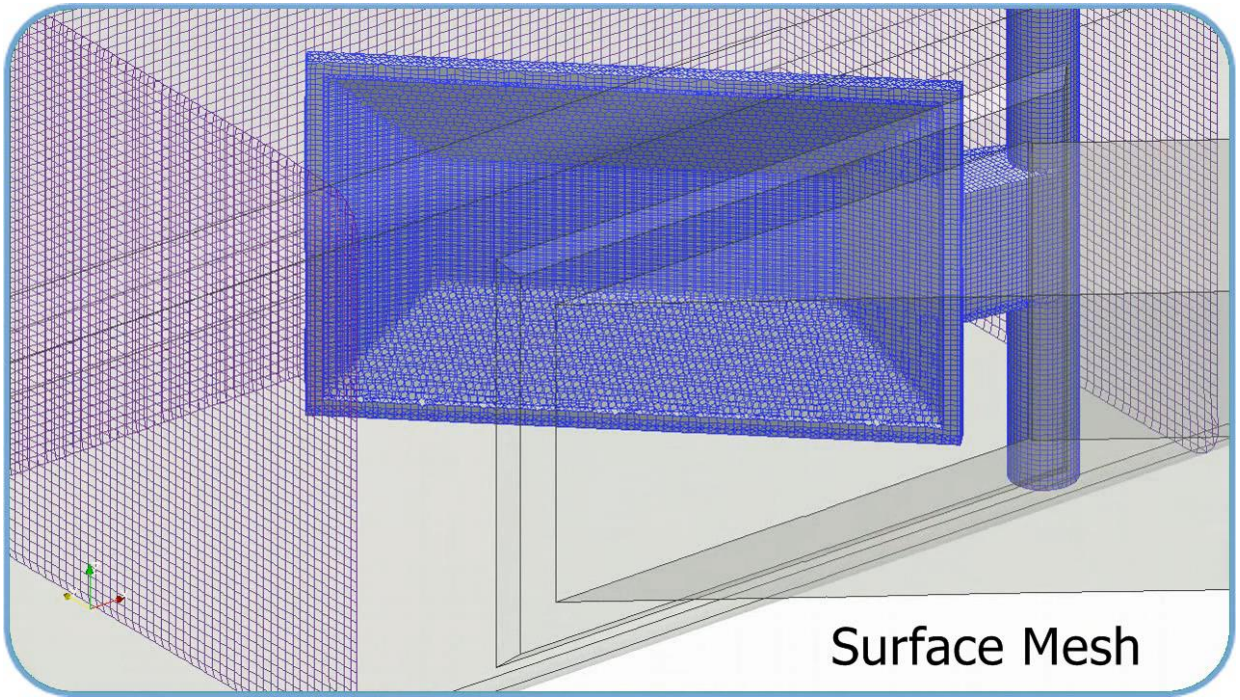
iconCFD MOVE

DYNAMIC LOCAL RE-MESHING

- Dynamic local re-meshing algorithm
  - Seamless re-meshing in solver run
  - Global or local re-meshing
  - Conservative field mapping
  - Fully automated and parallelized
  - Surface geometry updated based on
    - Patch faces
    - Surfaces moved with patches
  - Cell zones for
    - Frozen points
    - Prescribed movements

Full opening and closing of gaps



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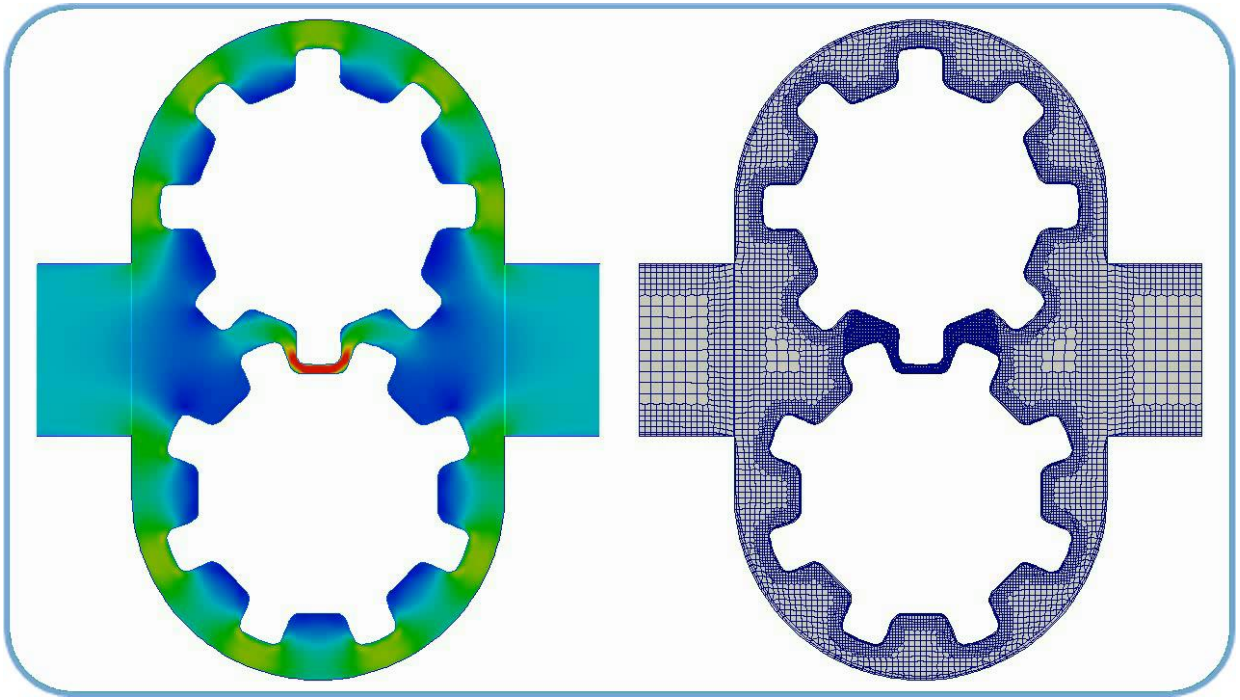
Intersecting paths



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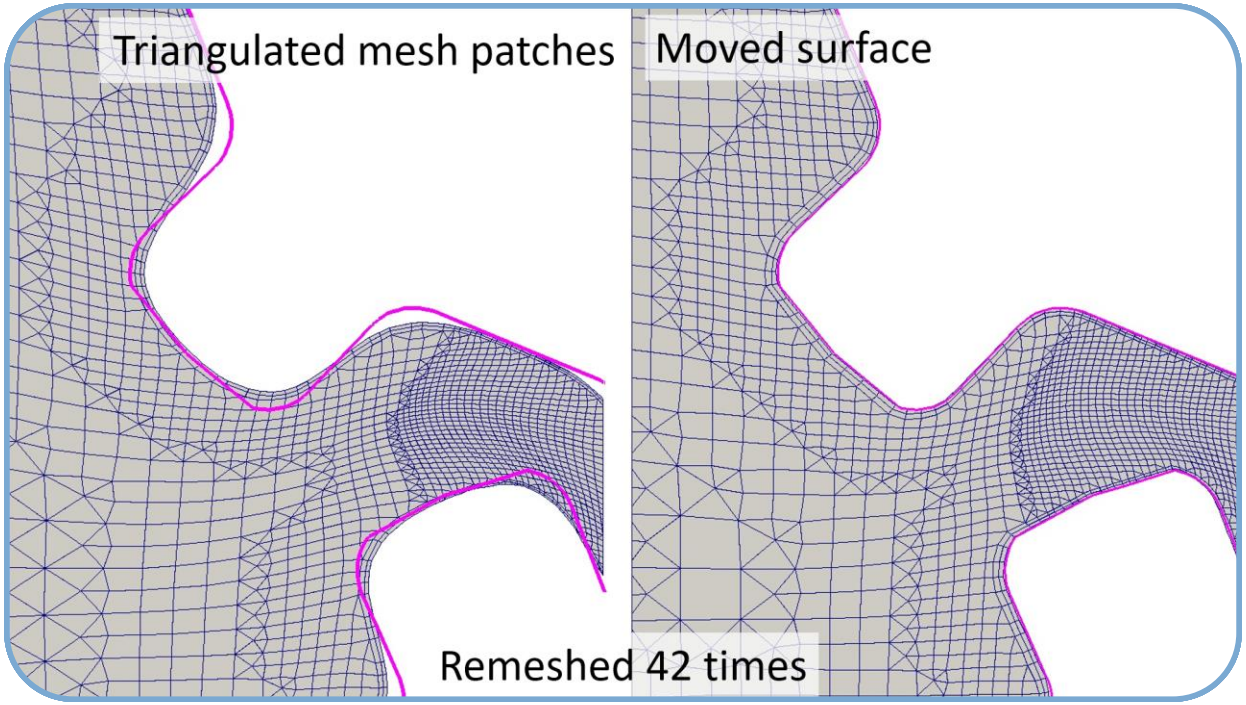

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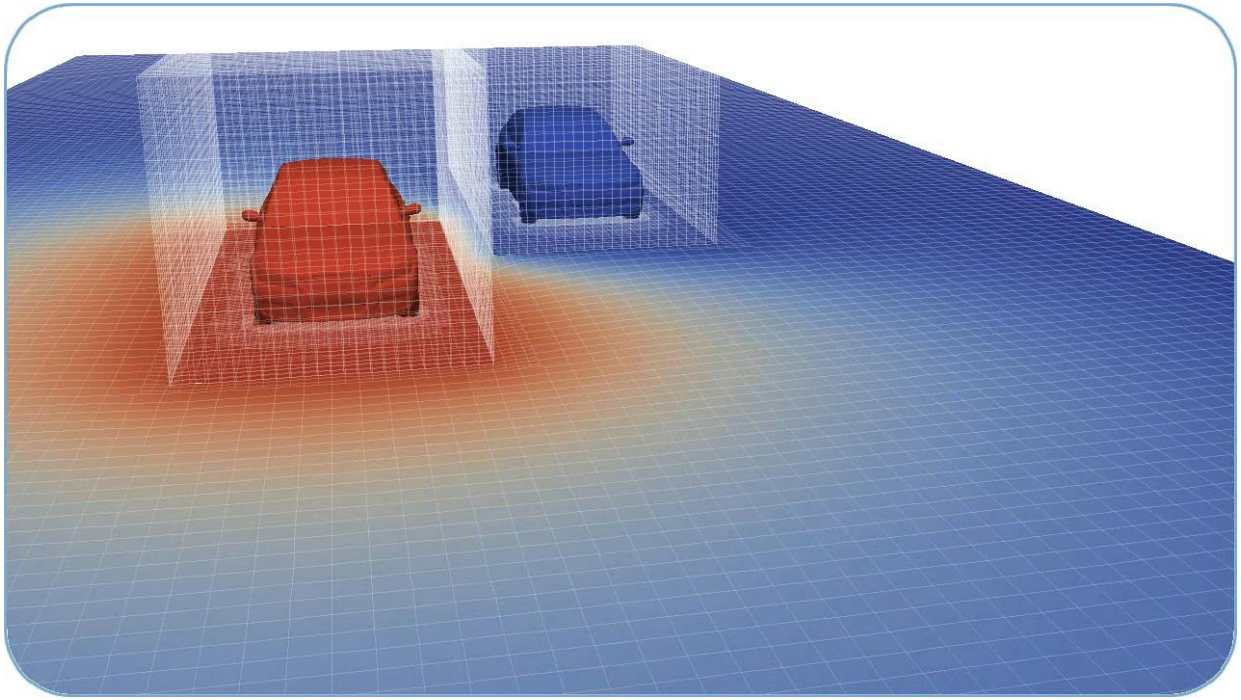
Take-over simulation



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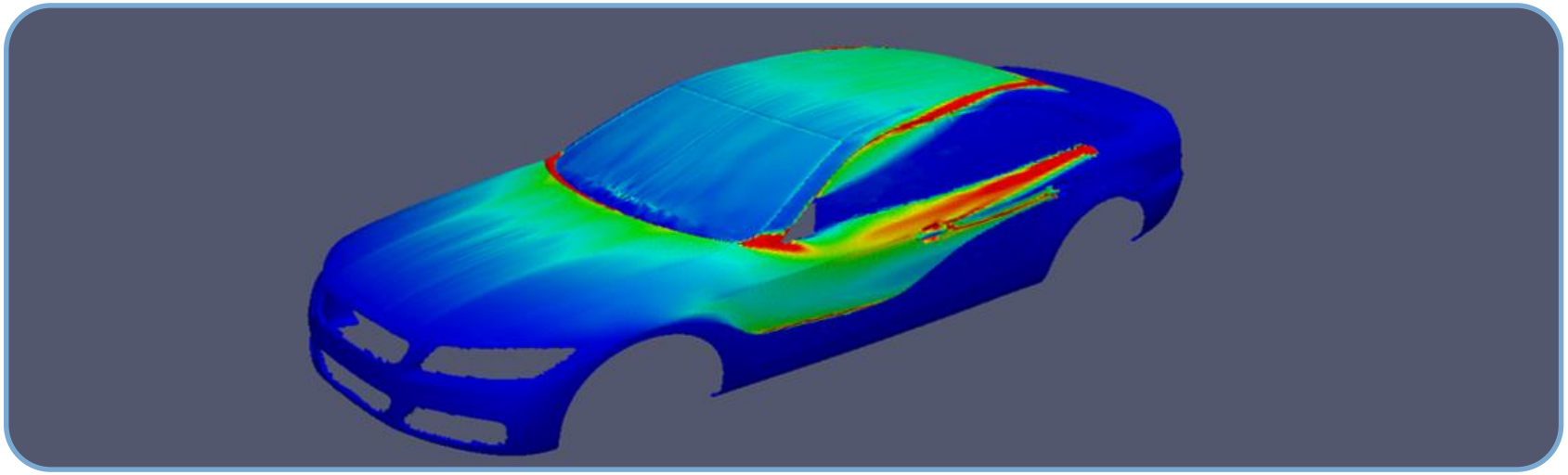
iconCFD L2P
SOILING

- Soiling simulations
  - Eulerian carrier flow: steady-state or transient, turbulent, incompressible
  - Lagrangian cloud transport: in frozen Eulerian solution or fully coupled
  - Surface film model
    - 1-cell extrusion of surface patches
    - Velocity coupling between Eulerian and surface film regions



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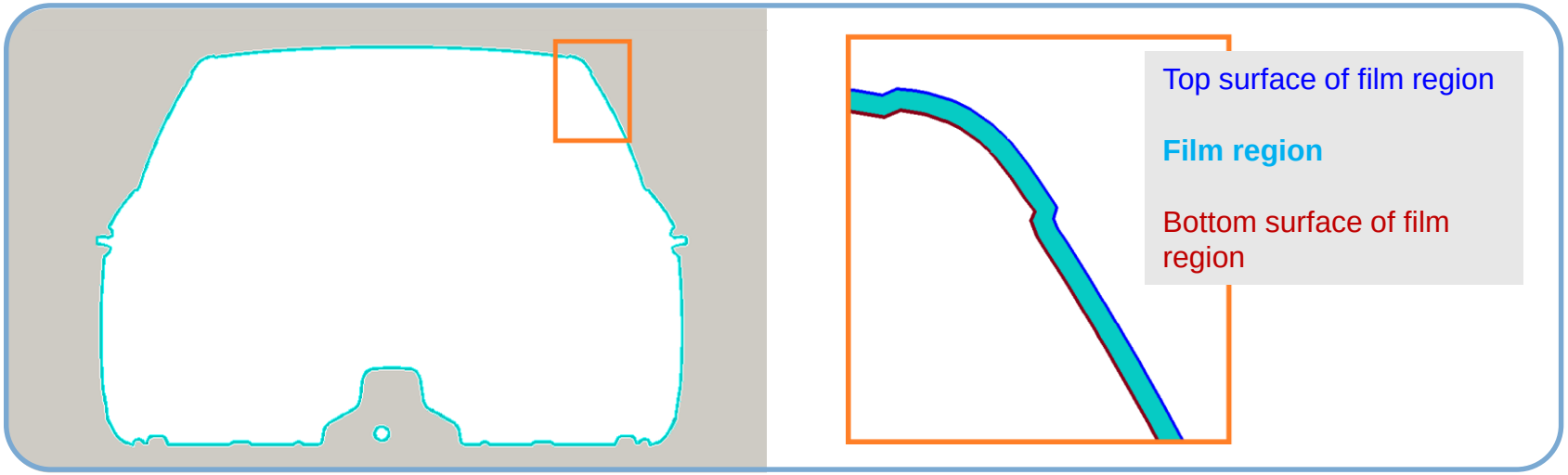

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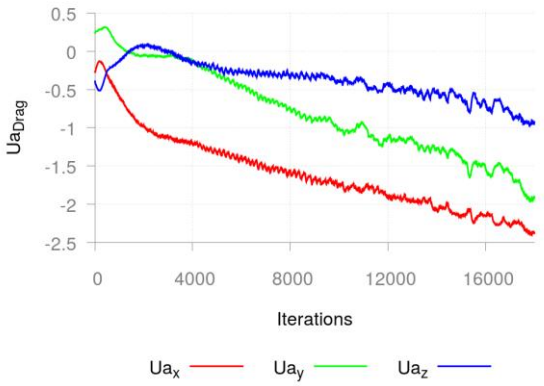
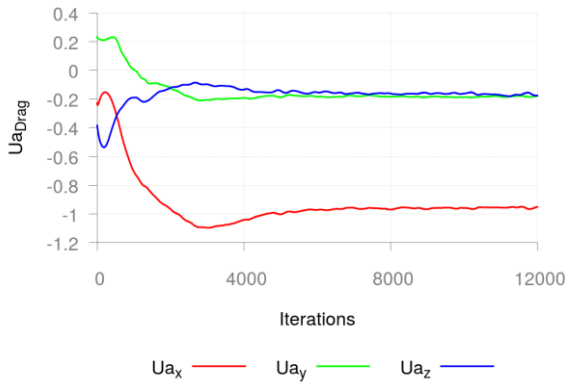
iconCFD OPTIMIZE
EXTERNAL AERO

- Local damping of ATC term
  - Much better convergence of adjoint equations
  - Symmetrical sensitivity field
  - Better optimization reached
- 2nd order adjoint discretization
  - Same schemes for primal and adjoint

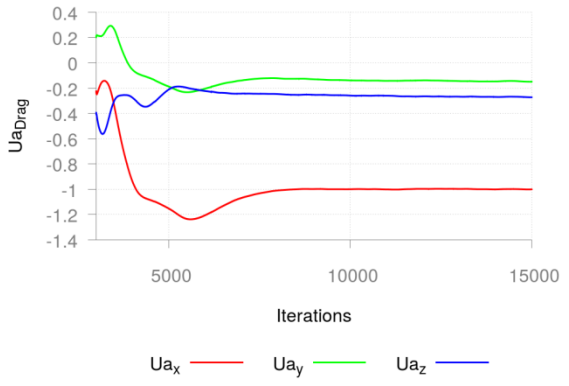
Ua probe in back of fully resolved car for aerodynamic drag optimization



Without ATC damping, 1st order



With ATC damping, 1st order



With ATC damping, 2nd order

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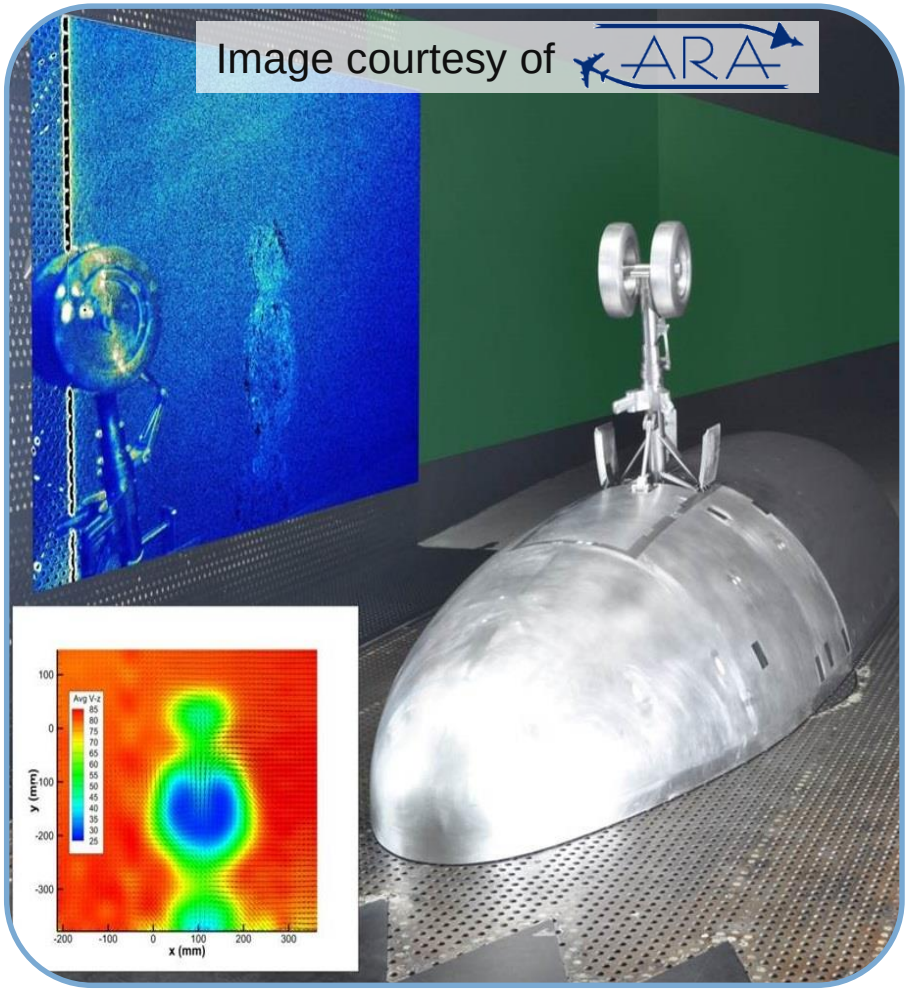
iconCFD TRANSONIC

NEW MODULE

- Collaboration between ICON and Aircraft Research Association (ARA).
- Transonic solver
  - Implicit, block-coupled, density based
  - Semi-implicit RANS turbulence modelling
- Validation case: Onera M6
  - Swept, semi-span wing
  - Mach: 0.8395
  - Reynolds Number: 11.72 E+6
  - Angle of Attack: 3.06 deg
  - Structured C-H grid: 884736 cells
  - Important phenomenon: λ-shock
    - Two shocks meet close to 85% of wing span
    - Well captured with iconCFD



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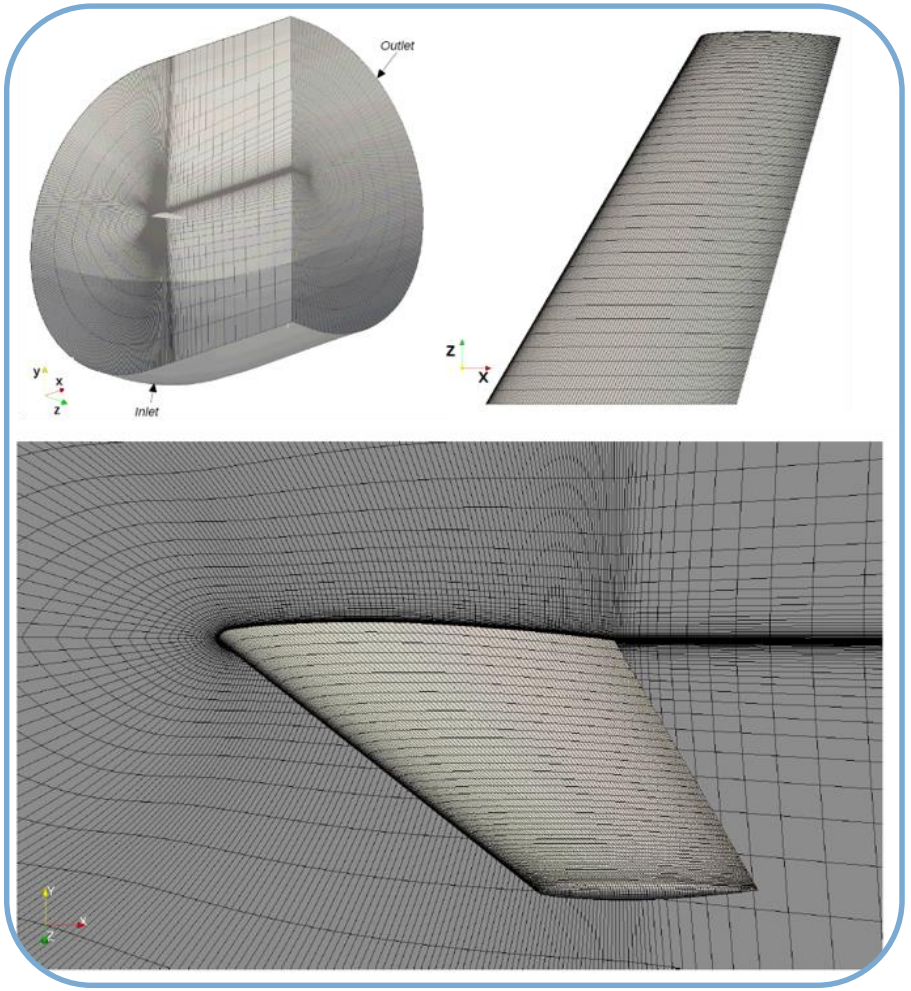

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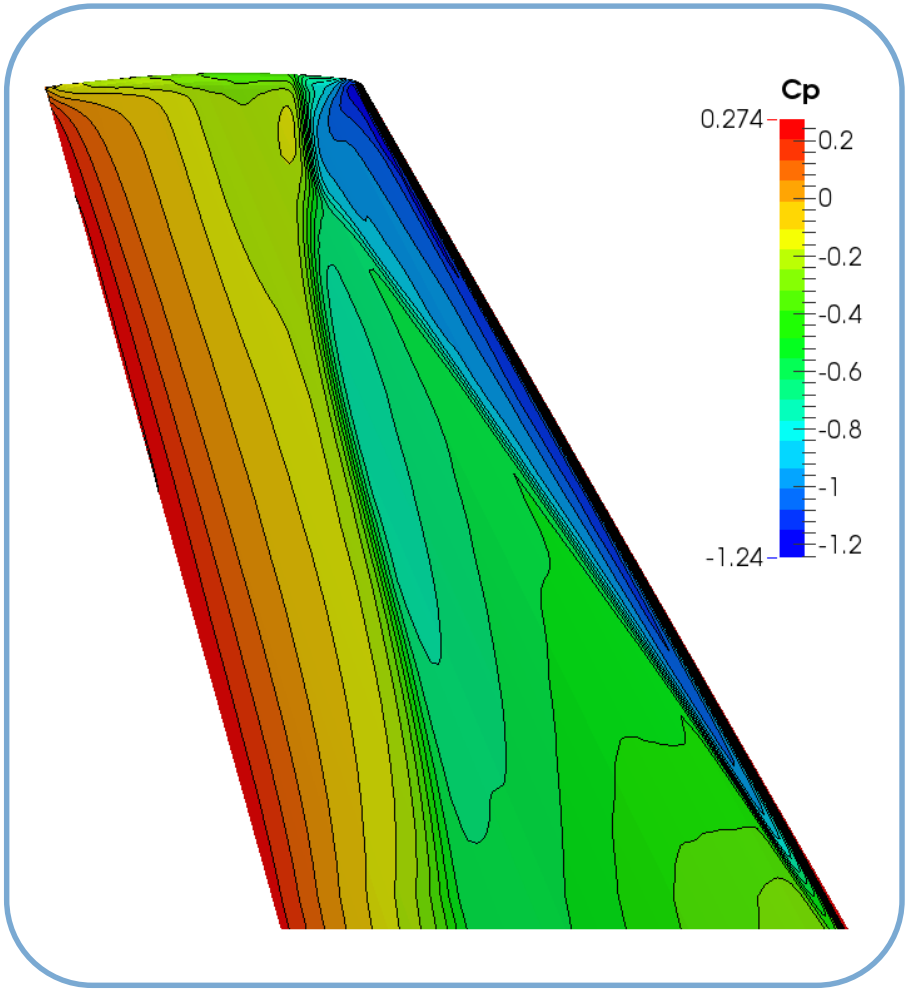

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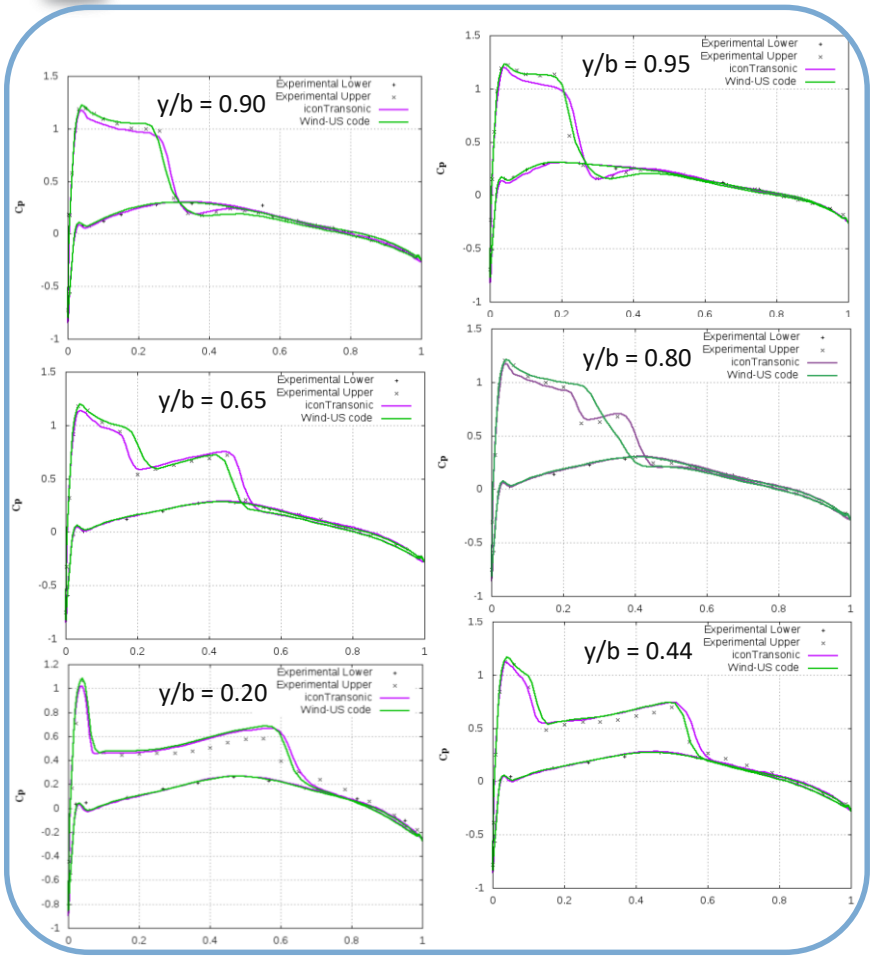

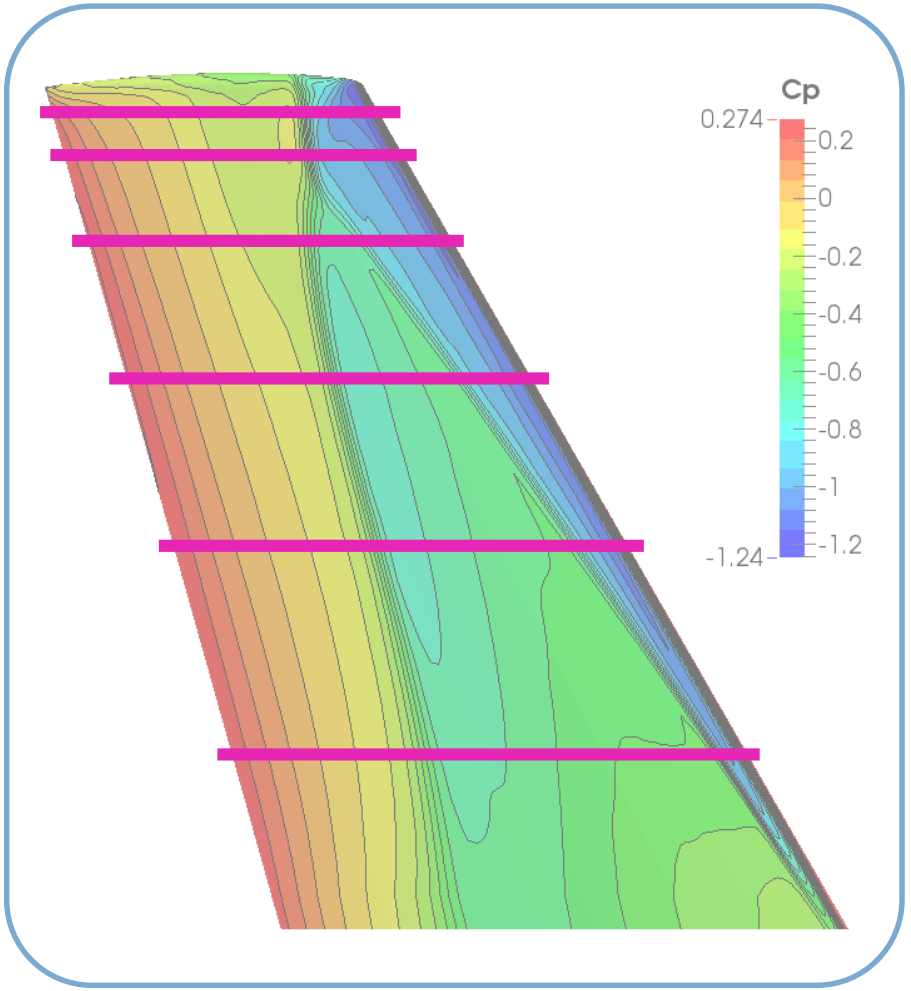

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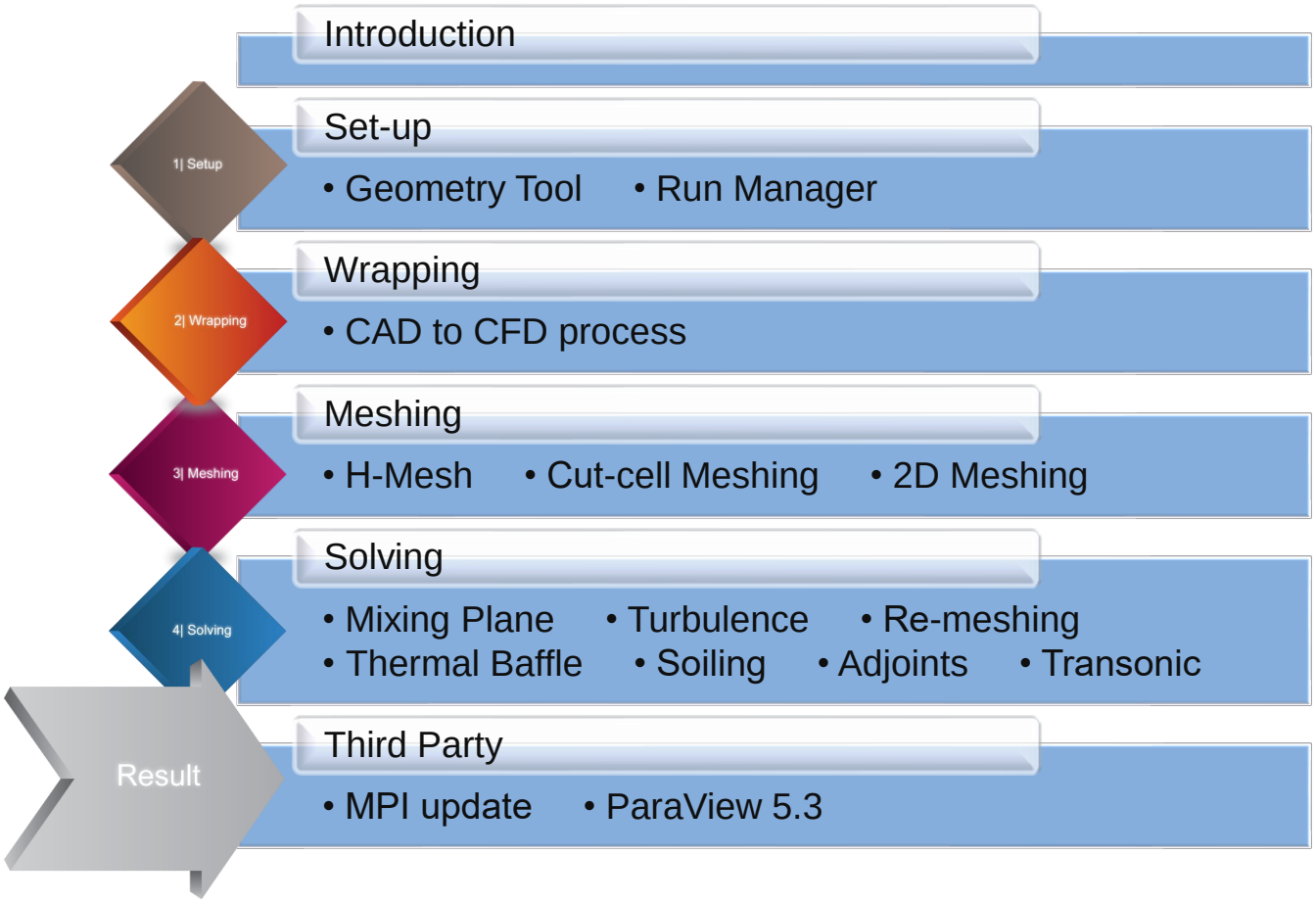

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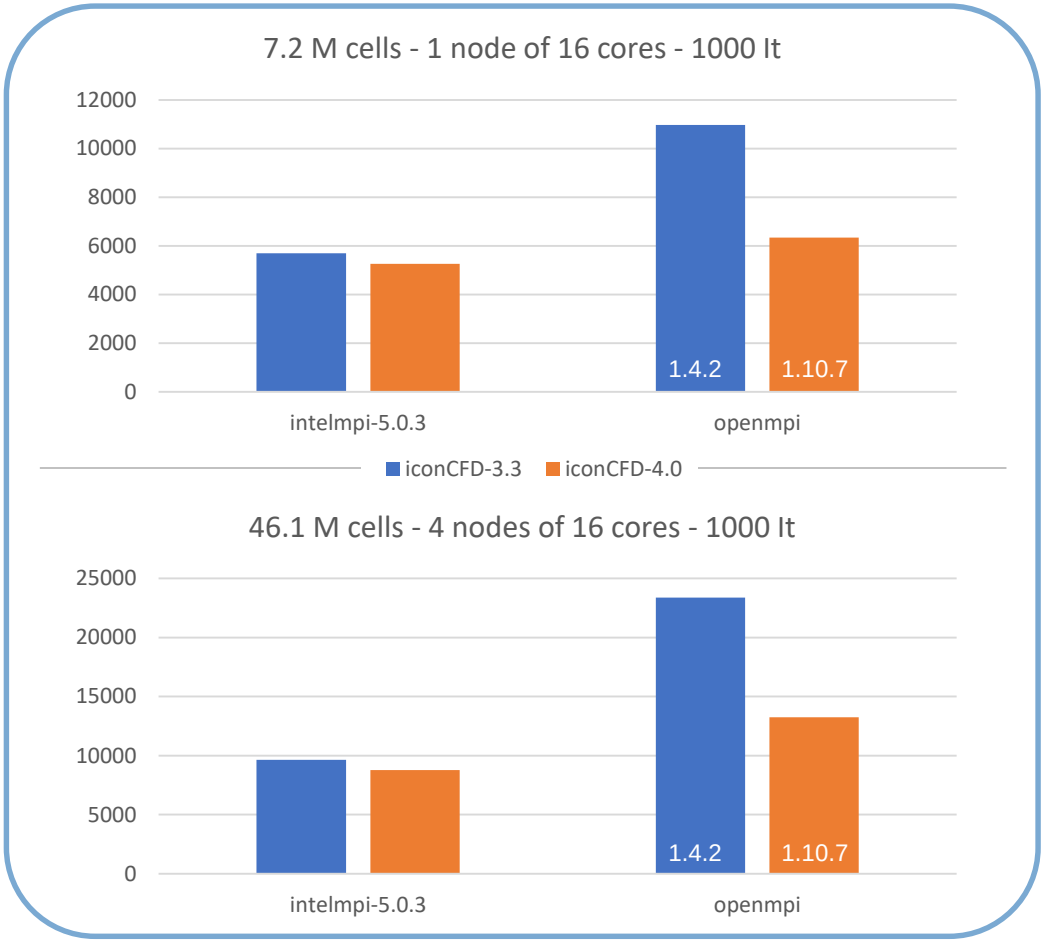
THIRD-PARTY UPGRADES

- Code performance upgrades
- Openmpi upgrade
  - From openmpi-1.4.2
  - To openmpi-1.10.7



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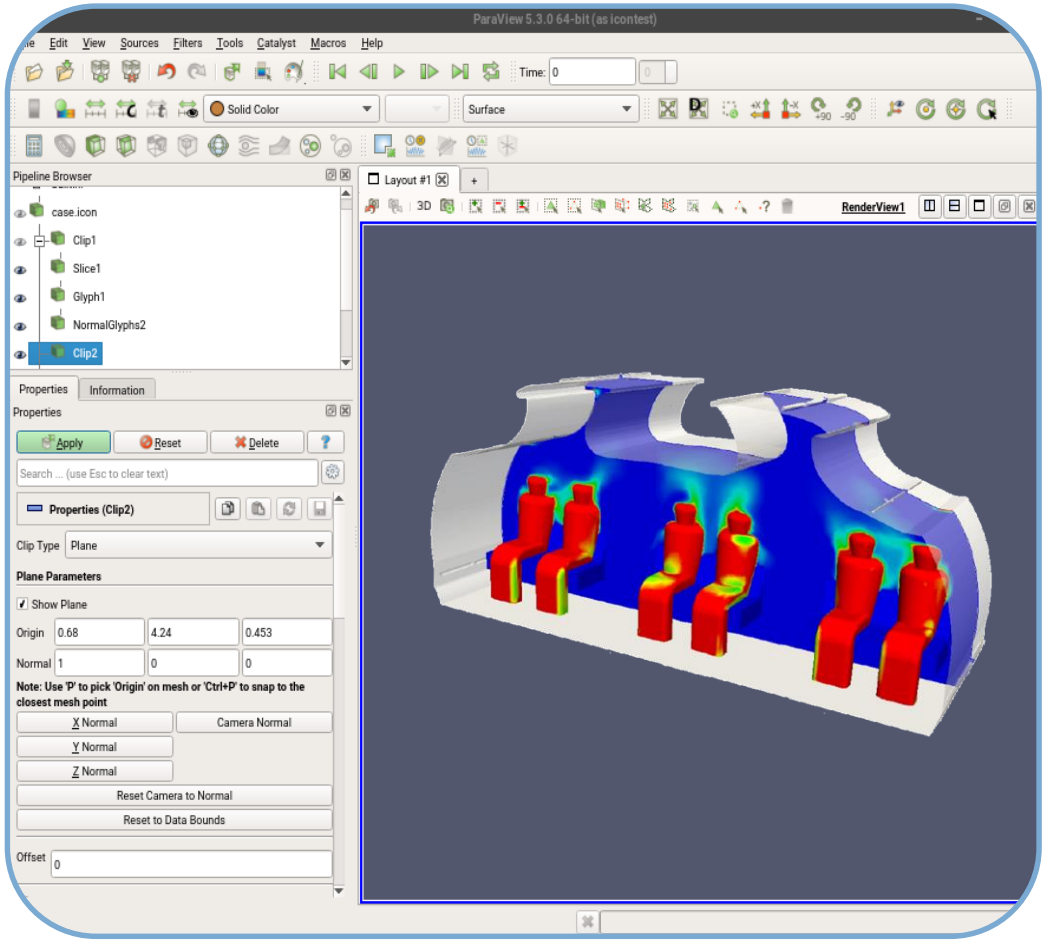
THIRD-PARTY UPGRADES

- Upgrade to ParaView 5.3
  - Previously 4.1, only server
  - One build with OpenGL 2 and Mesa:
    - Uses GPUs and CPU
    - Considerably faster
    - Server, Python API and client
  - Second build with OSMesa:
    - For off-screen rendering on clusters without GPUs
    - Server and Python API
    - Use python scripts or remote-connect with client



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