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Advanced CFD Setup with DoE using iconCFD Process

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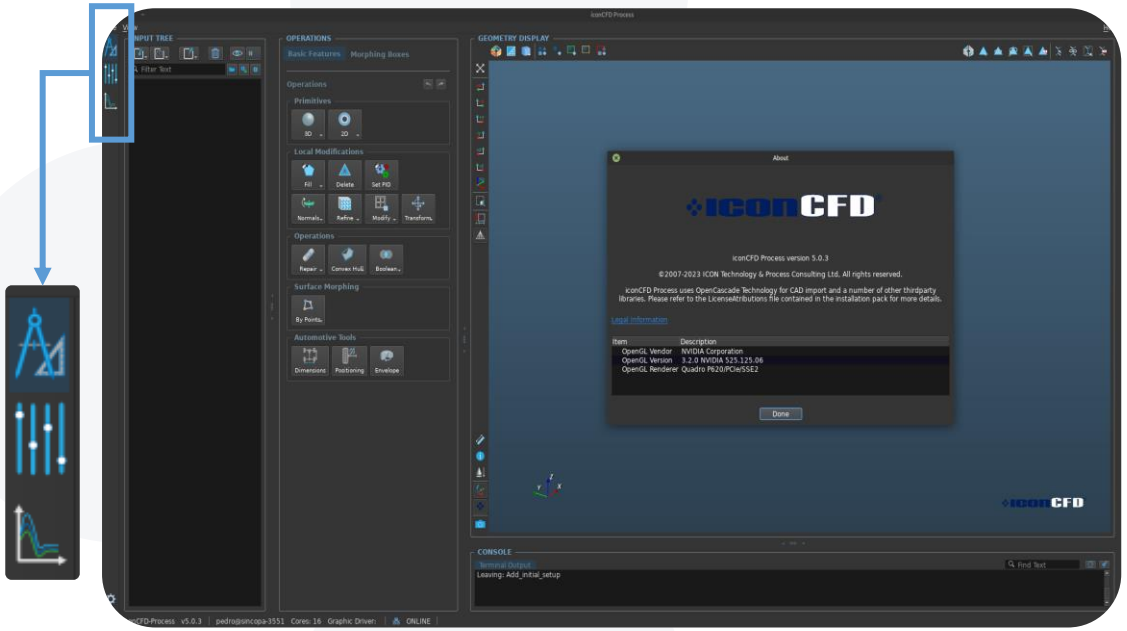
Agenda

- Introduction
- Aerodynamic Setup
- Morphing Boxes Setup
- DoE Setup
- Conclusions

Introduction

iconCFD Process

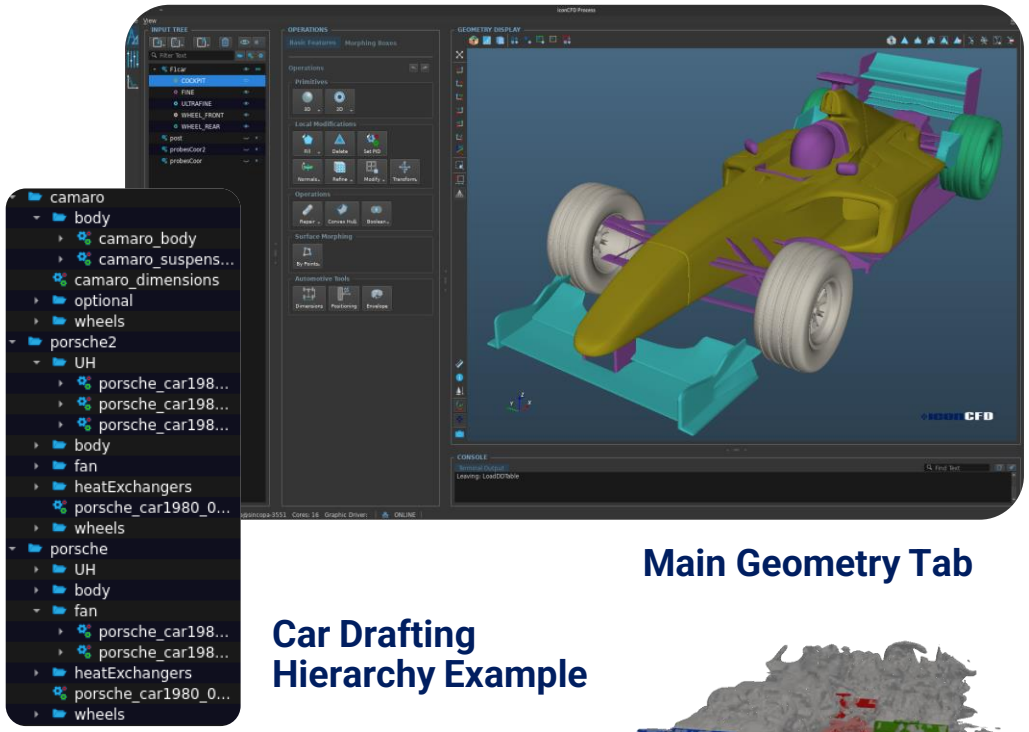
- Main Objective
  - Overview a design of experiment (DoE) setup with geometric morphing using iconCFD V5
  - Input geometry: car (*drivAer*, sedan variant)
- iconCFD V5 includes iconCFD Process
  - An intuitive pre/post-processing tool
  - From geometry editing, setup and post-processing
  - Full feature support of all iconCFD modules
- iconCFD Process is supported on different OS and offers different interfaces
  - OS: Windows/Linux
  - Interface: GUI and API/CLI



Global Tabs **iconCFD Process V5**

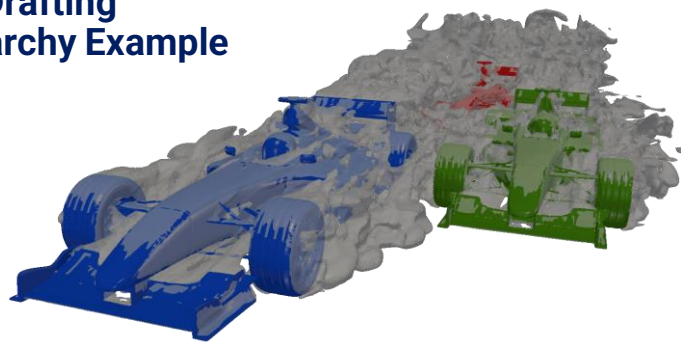
Introduction

Process Layout: Geometry Tab



Main Geometry Tab

Car Drafting Hierarchy Example

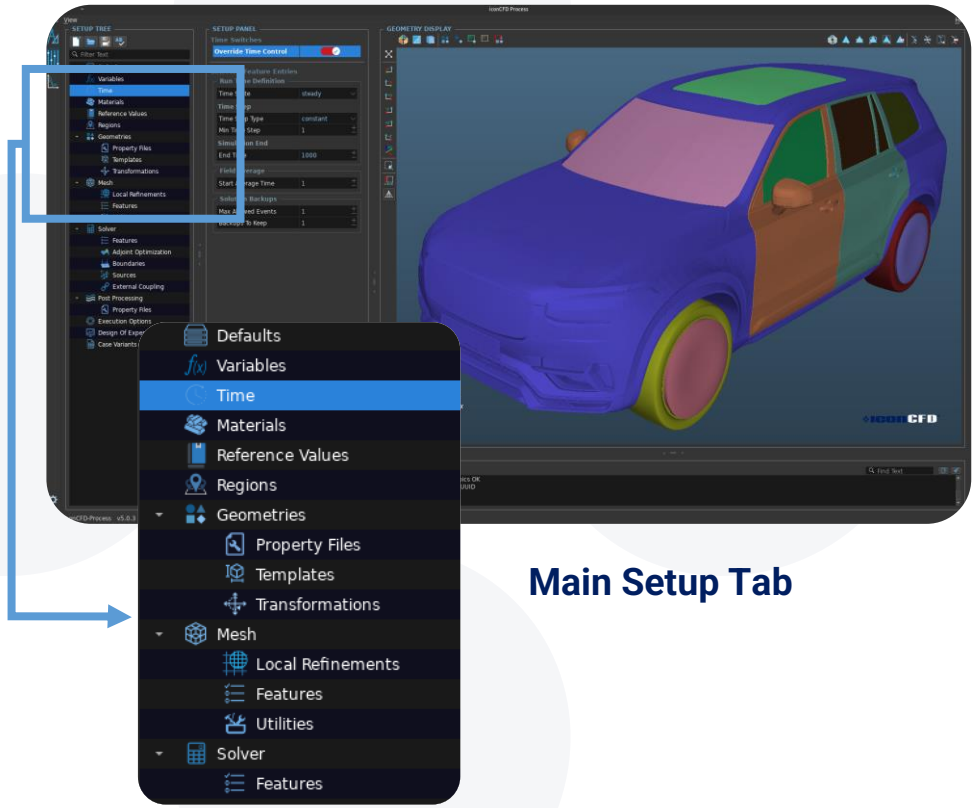


- Input Tree: files/folders can be imported and organized (into hierarchies)
  - Especially useful when working with large geometry assemblies or variant studies: e.g. car drafting
  - When case is exported, the full structure (as displayed in the *Input Tree*) is saved into a folder
- Operations: contains geometry/morphing operations in two tabs
  - *Basic Features*: Primitives, geometry editing etc.
  - *Morphing Boxes*: Parametric morphing boxes features
- Geometry Display: 3D render window for visualization and interaction

Introduction

Process Layout: Setup Tab

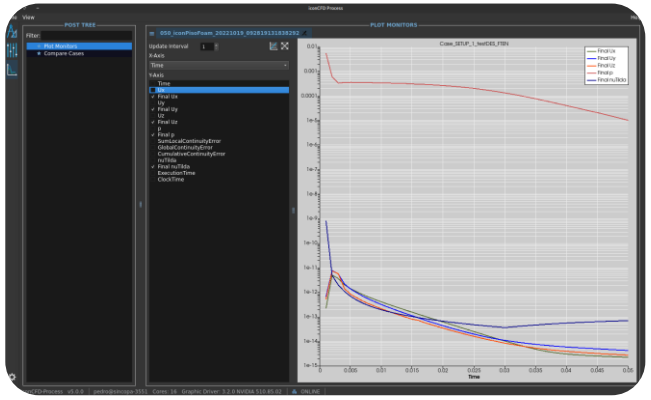
- Setup Tree: step-by-step wizard (from top to bottom)
  - Each node contains a setup category
  - When one node is selected, relevant properties will be shown in the Setup Panel
- Setup Panel: current node properties
  - Contains a group of feature switches available
  - When one switch is selected, relative inputs will be shown in the lower panel area
  - Allows user to modify/override feature defaults
- Geometry Display: 3D render window
  - Shared with the Geometry tab



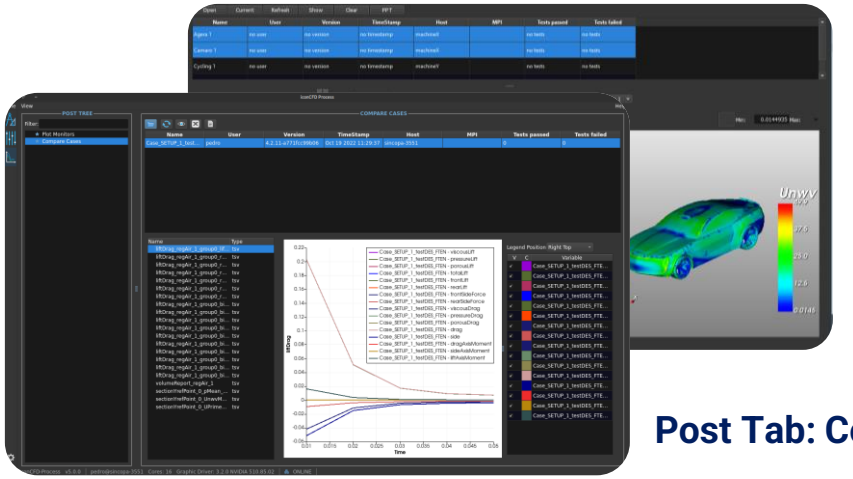
Main Setup Tab

Introduction

Process Layout: Post Tab



Post Tab: Plot



Post Tab: Compare cases

- Post Tree: contains post-processing categories
  - Run time monitoring: Plotting
  - Case output overview and comparison
- Post Properties: displays options
  - Specific to the active category selected in the Post Tree
- Post Display: different display types
  - 2D line charts when the run monitoring is selected
  - From text to images to surface fields when the comparison category is selected
    - Selected items can be saved to a ppt file

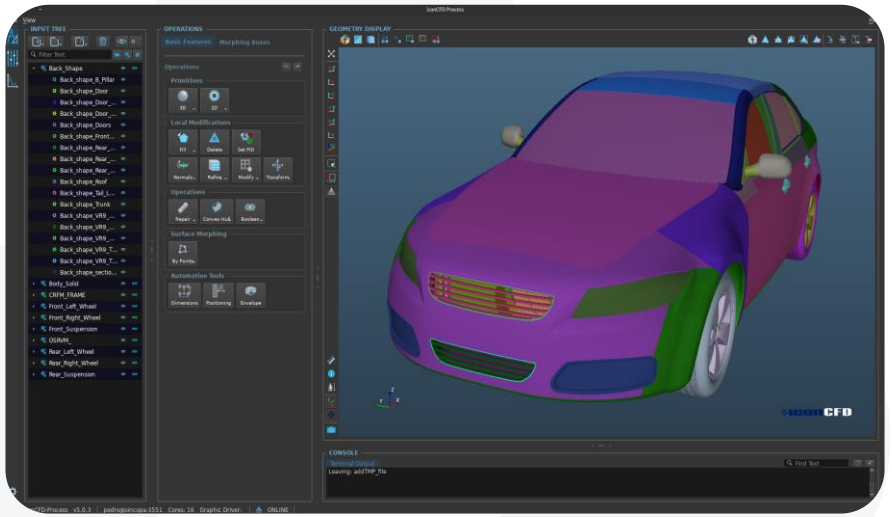
Aerodynamic Setup

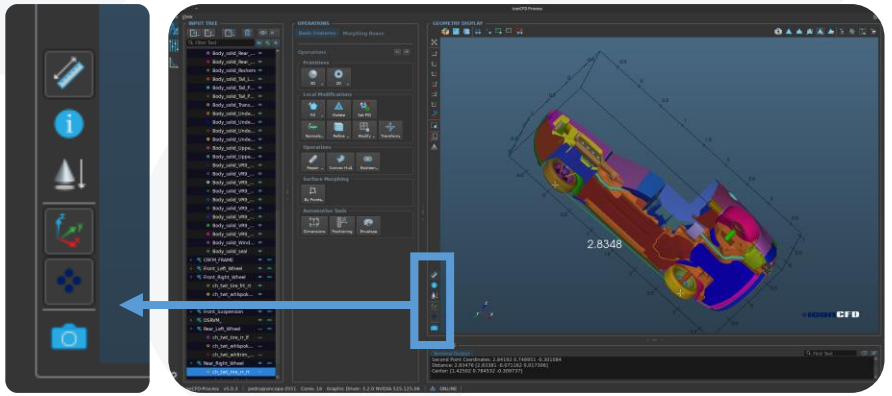
Geometry Tab: Files Input

- External Aero setup walkthrough
- Import files: load all *drivAer* assemblies
  - Geometry is ready: no operations or PID management
- Verifications: Geometry Display
  - Dimensions: *ruler* and *bounding grid* toolbar buttons
  - Area: *area* toolbar button
  - Geometry browsing: hide/show
    - Input tree: file/PID through *eye* icon
    - Geometry Display: selections with *OR/AND/NOT* logic

Visualization and Selection Toolbars

drivAer assembly





Information Toolbar

Hide faces and measurements

Aerodynamic Setup

Setup Tab: Defaults, Time & Materials

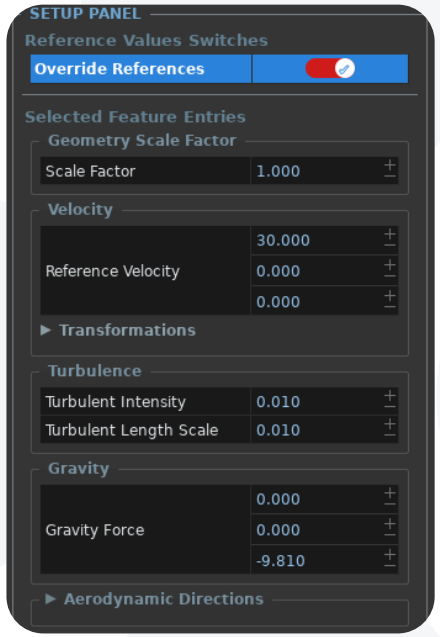
Defaults, Time and Material Nodes

- Default Node
  - Setup name: *drivAer* (representative string)
  - *default* as main settings group is selected
- Time Node
  - Initial simulation times are sufficient for this case
  - Number of backups can be updated if required
- Materials
  - Database activation: *air* properties definition
  - Custom materials can also be created

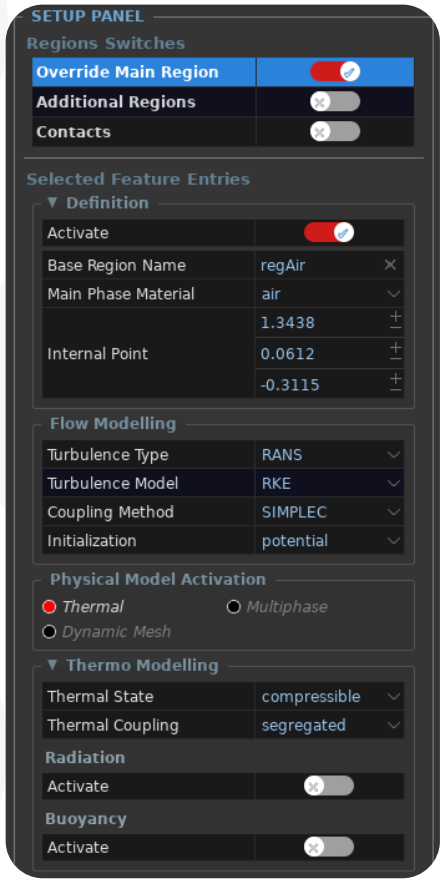
Aerodynamic Setup

Setup Tab: Reference Values & Regions

- Reference Values
  - Scale factor updated to 1 (geometry in meters)
  - Other values remain in their default state
- Regions
  - Default *air* material is selected from the database
  - Internal point to isolate the region domain
    - Right mouse button: *Coordinate picker*
  - Flow modeling: keep initial definition
  - Physical model activation: Thermal activation with default options



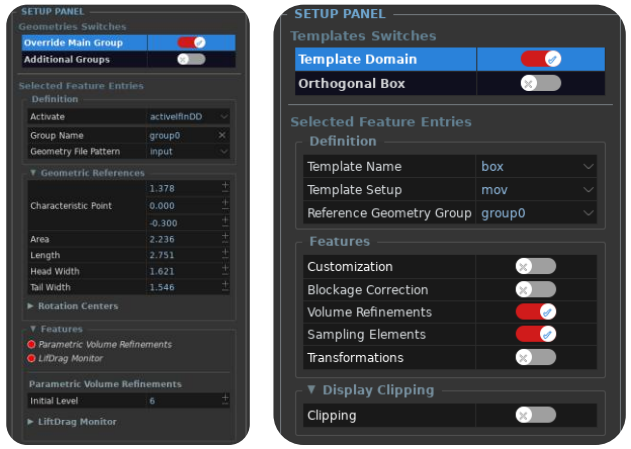
Reference Values Node



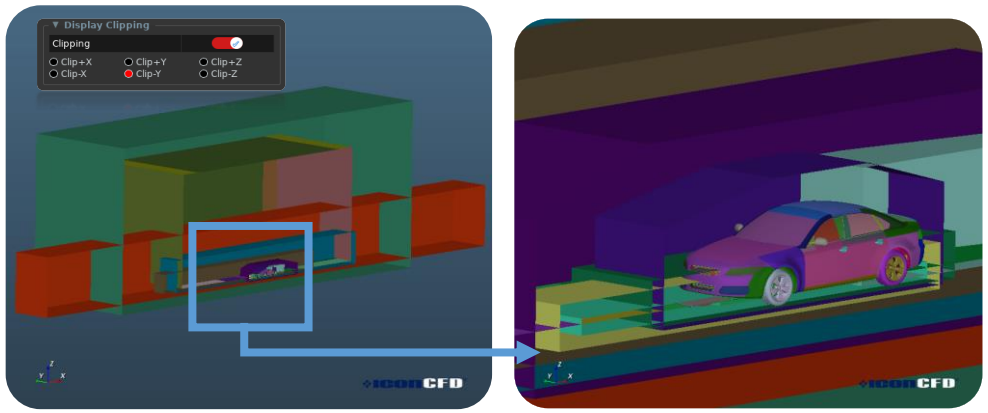
Regions Node

Aerodynamic Setup

Setup Tab: Geometry Groups & Templates



Group and Template Definition



Template Clipping

- Geometry Groups
  - To simplify geometry selection step on other features
  - Main group (*group0*) activation
    - Selection: all *input* geometry
    - Area: measured in display (*area* button) and copied
    - Tracks and wheelBase: measured with the *ruler* and copied
    - Reference Point: *Coordinate picker* will be used
- Templates Database
  - Selected by domain/setup names: *box* and *mov*
    - Include mesh and BC definition
    - Parameterized through variables: e.g. inlet velocity
  - Placement defined from *group0* reference point
  - Clipping: template can be clipped and displayed

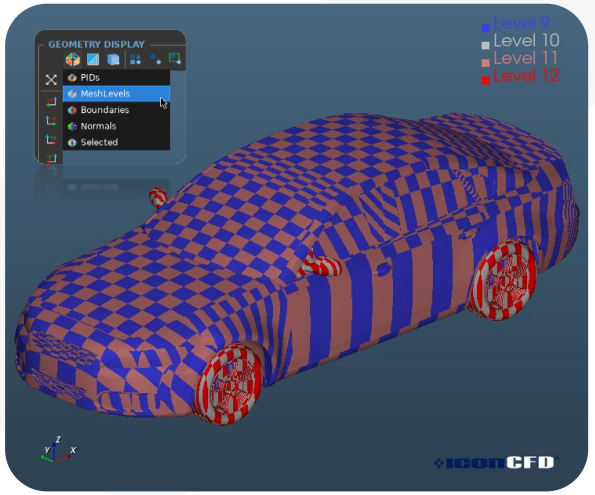
Aerodynamic Setup

Setup Tab: Mesh

- Mesh definition updated with a Base Size of 3m
  - Background grid: to see geometry vs. mesh levels
- Local Refinements at side mirrors and wheels
  - Level 10, 6 layers and 2 curvature offset
- Other parts will have:
  - Default surface: Level 9 and 4 layers
  - Global curvature refinement: 2 offset
  - Global distance refinement: Level 8 within 0.01m
- Mesh levels overview inside Display
  - Geometries can be colored by mesh levels
  - Textures will be used when mesh levels are defined as a range (chessboard pattern)

Mesh Definition

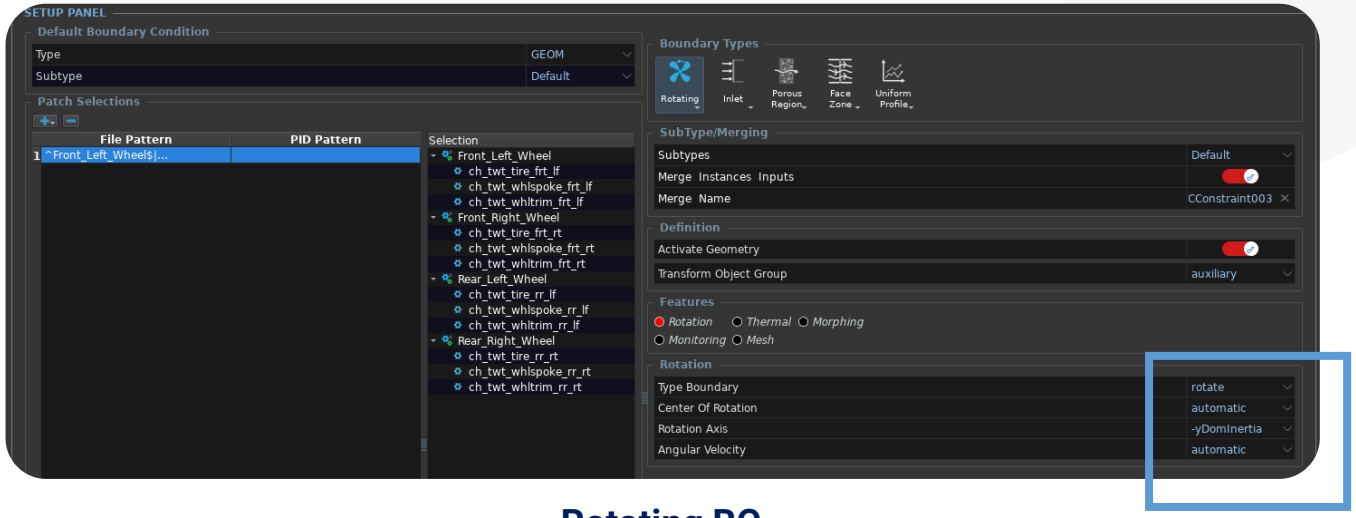
Mesh Level visualization



Aerodynamic Setup

Setup Tab: Boundary Conditions (BC)

- Rotating BC set on wheels with automatic methods (center, axis and rotation velocity)
- On other parts, default BC will be kept: adiabatic static wall
- BC definition overview inside display: equivalent to the mesh levels

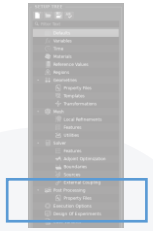


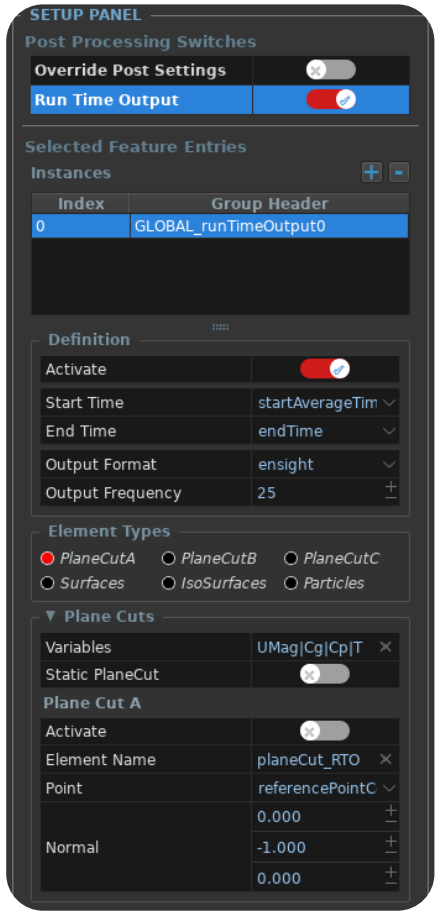
Rotating BC

BC visualization

Aerodynamic Setup

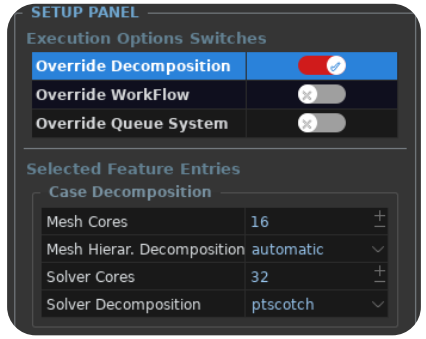
Setup Tab: RTO, Execution and Export



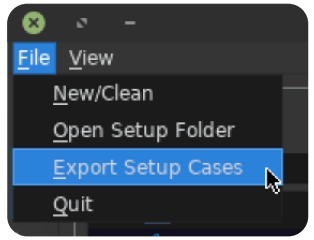


Post-Processing Node

Decomposition Node



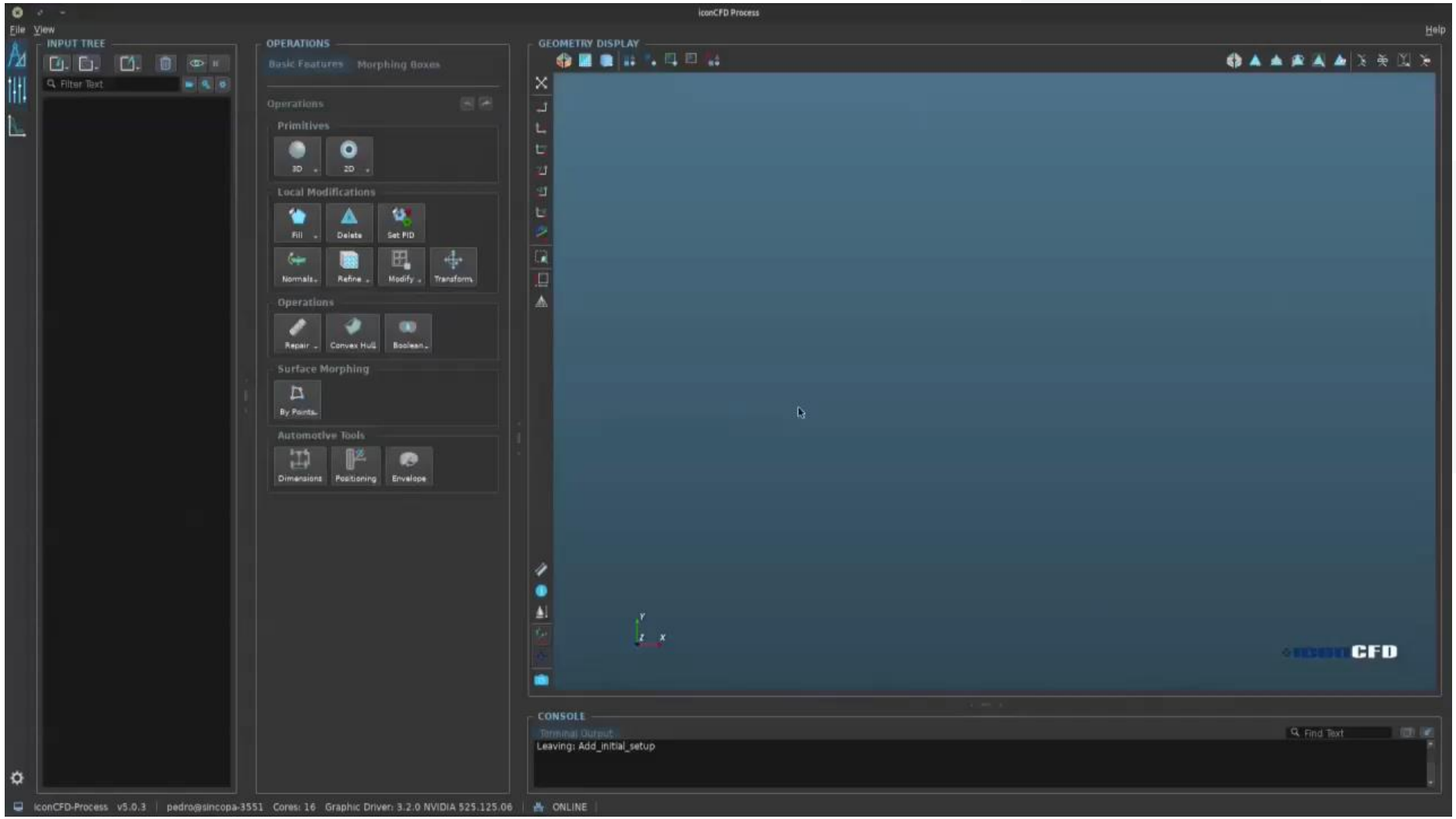
Export Cases



- Post-processing: 1 Run Time Output
  - *PlaneCut* at main group *refPoint* in -Y direction
- Execution Options: Decomposition
  - Mesher: 16 cores *hierarchical*
  - Solver: 32 *ptScotch*
- Export case through *File* menu
  - Export Setup Cases dialog to select the output folder
  - Console log expanded to show output evolution
  - Final setup files will be created in some seconds

Aerodynamic Setup

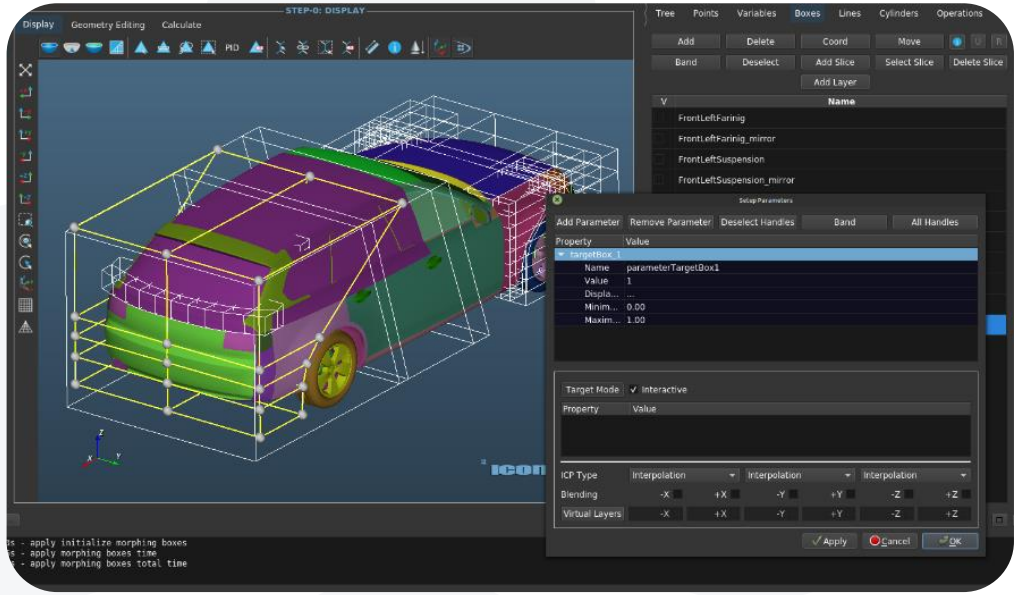
Demo Video



Morphing Boxes Setup

Geometry Tab: Definition and Session Files

- Morphing boxes require an hexahedral grid around the assemblies to control how the geometry inside will change when the handles (vertex from the grid) are moved
- Variables/parameters can be defined as a prescribed movement over a set of handles
  - It is recommended to define an input range per variable
- Once the morphing setup is defined/verified, it can be saved
  - JSON files

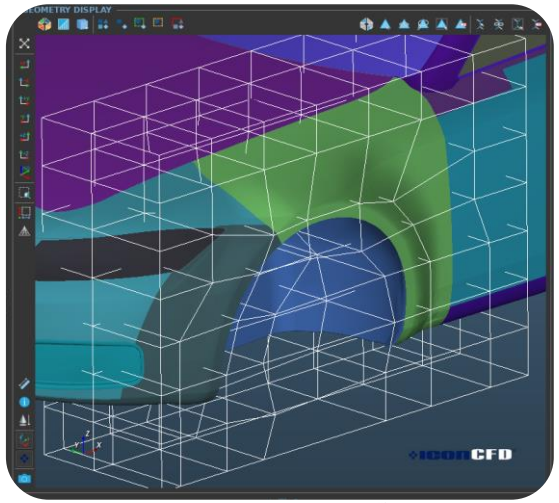


Complex Morphing Box Setup

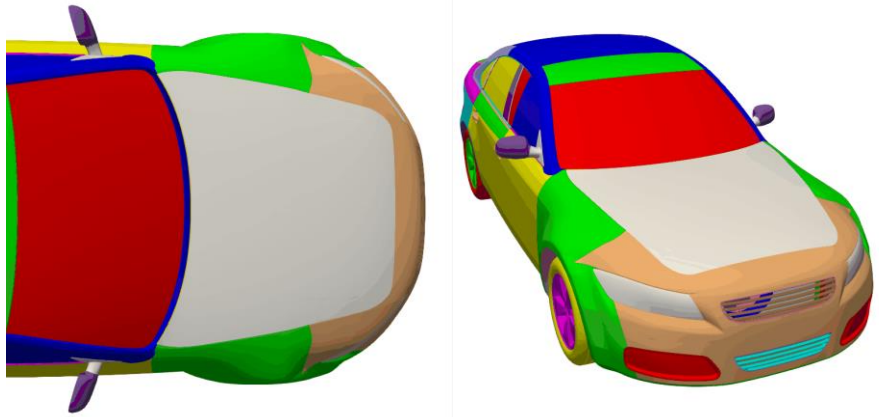
***drivAer* morphing examples**

Morphing Boxes Setup

Geometry Tab: Morphing Boxes Walkthrough



Left Morphing Box

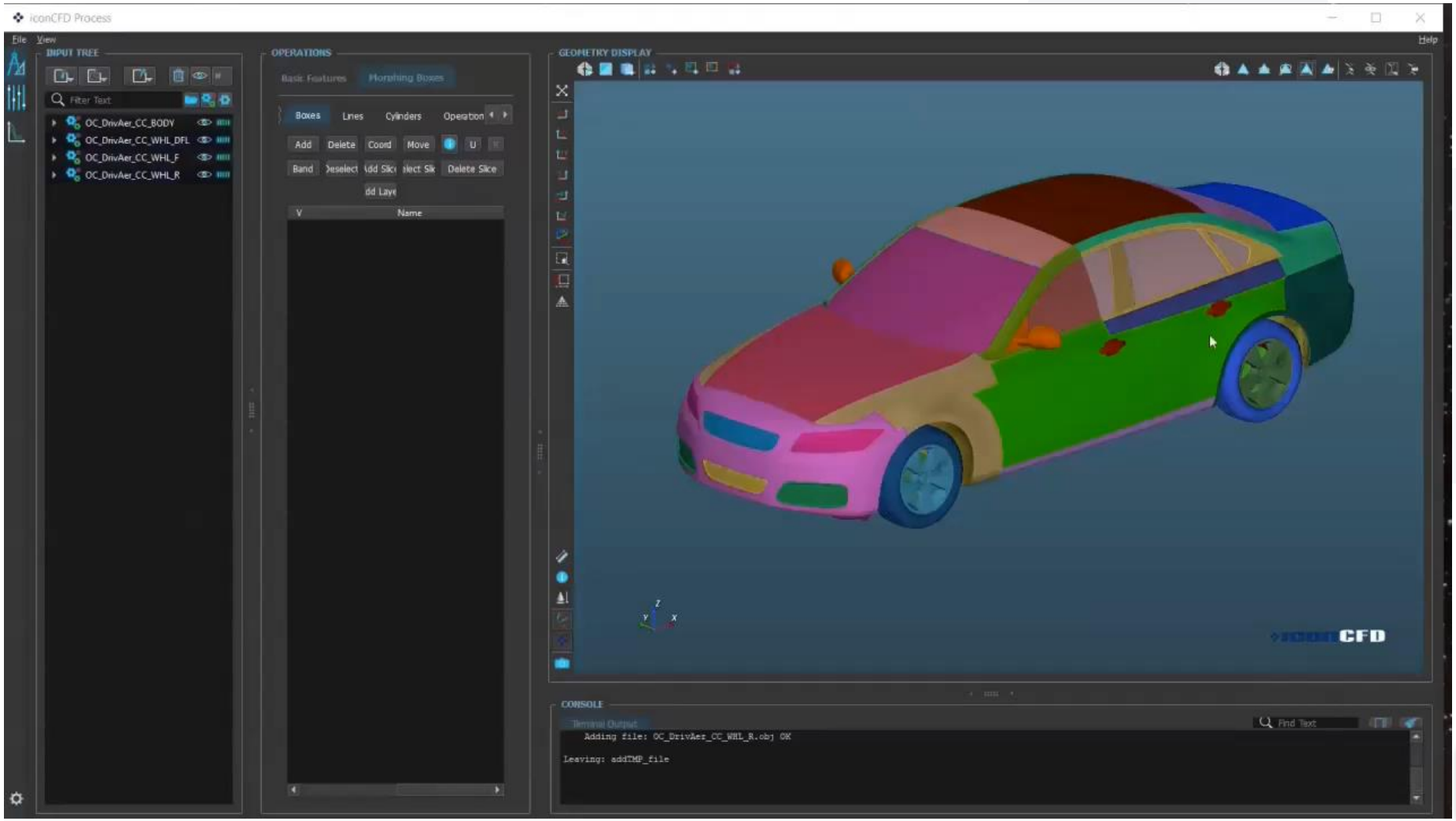


Front Fairing Morphing

- Left Fairing morphing
  - Box created around a geometry selection. Grid split and adapted to the main shape
  - Added a variable (displacement) with the wheel arch handles. Default movement: 0.1m in –Y
  - Morphing box operation: box with the geometry to morph
- Right Fairing morphing
  - Box mirrored from left (variable auto-updated +Y direction)
  - Another equivalent morph operation is added for this side
- Apply morph operations (**verification purpose**)
  - Both variables are populated with the target magnitudes
  - A morph folder will be created inside Input tree
- Save morphing session files

Morphing Boxes Setup

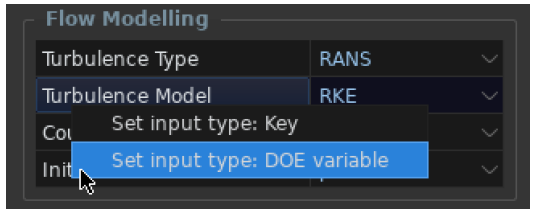
Demo Video



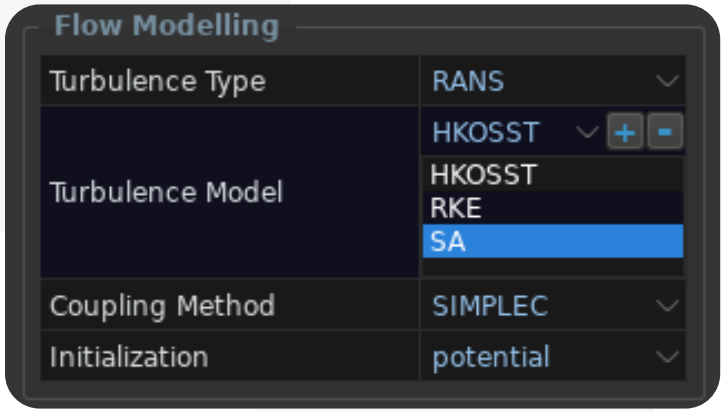
DoE Setup

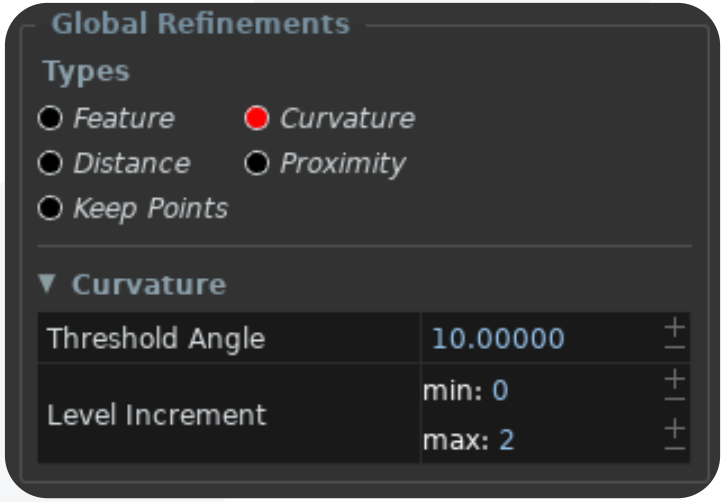
Setup Tab: Variable Definition

- Starting point
  - Aerodynamic setup: loaded now
  - Saved morphing session files: to be included on next steps
- At the Variables node, DoE switch will be activated
- Right-clicking on the description field of any entry will pop up a context menu allowing the user to modify the input type as DoE variable
  - Regions (Turbulence): List with HKOSST, RKE and SA types
  - Mesh (global curvature offset): Integer from 0 to 2



Context menu with DoE

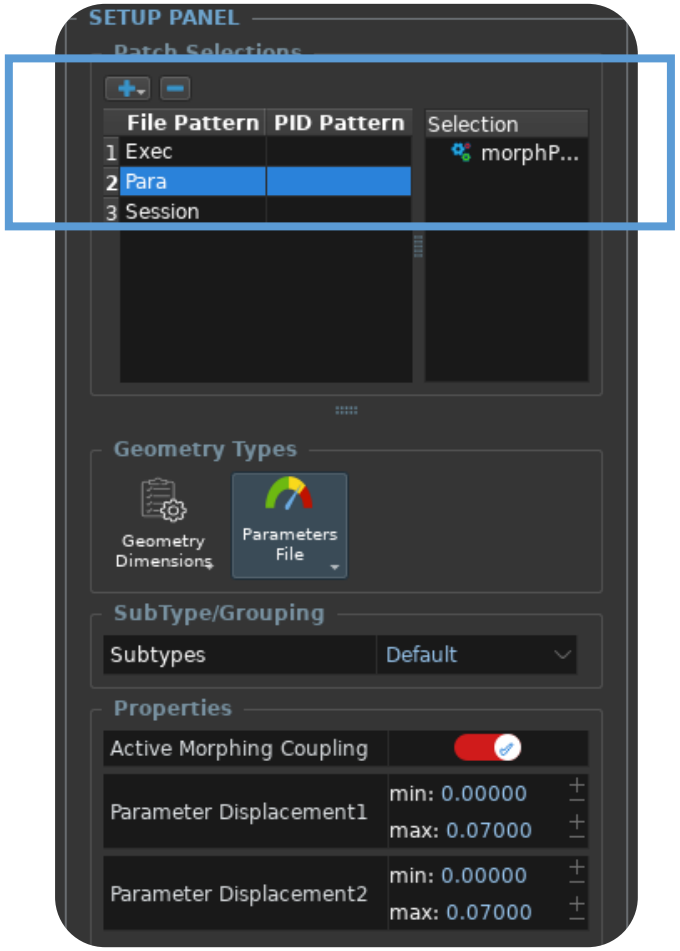




Setup DOE Variables

DoE Setup

Setup Tab: Morphing Variables

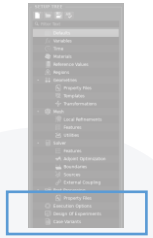


Morphing session coupling

- Morph session files must be added inside Input tree
- Set morph conditions at the Geometry node (Property Files)
  - Morph execution: JSON with the morpher executable properties
  - Morph session: templated JSON morph session (*.json.ict)
  - Morph variables: JSON file with variable names and ranges
- Similar to the DoE setup entries, right-clicking on the morph variables will pop up the context menu with DoE type
  - ParameterDisplacement1: Float from 0 to 0.07
  - ParameterDisplacement2: Float from 0 to 0.07
- To avoid dependencies between setup inputs and morphing modifications, automatic variables are recommended
  - For example, area in aerodynamic monitors

DoE Setup

Setup Tab: Design Space Table



- At the Design of Experiments node, *Proposed Case Number* will be updated to 50
- Automatic homogeneous variable distribution will be shown on the table
  - No customization is required for this case
- Cases are ready to be created: Export Setup Cases

SETUP PANEL

▼ Properties

Proposed Case Number	50
Max Allowed Cases	noLimit
Case Indexes to Output	all

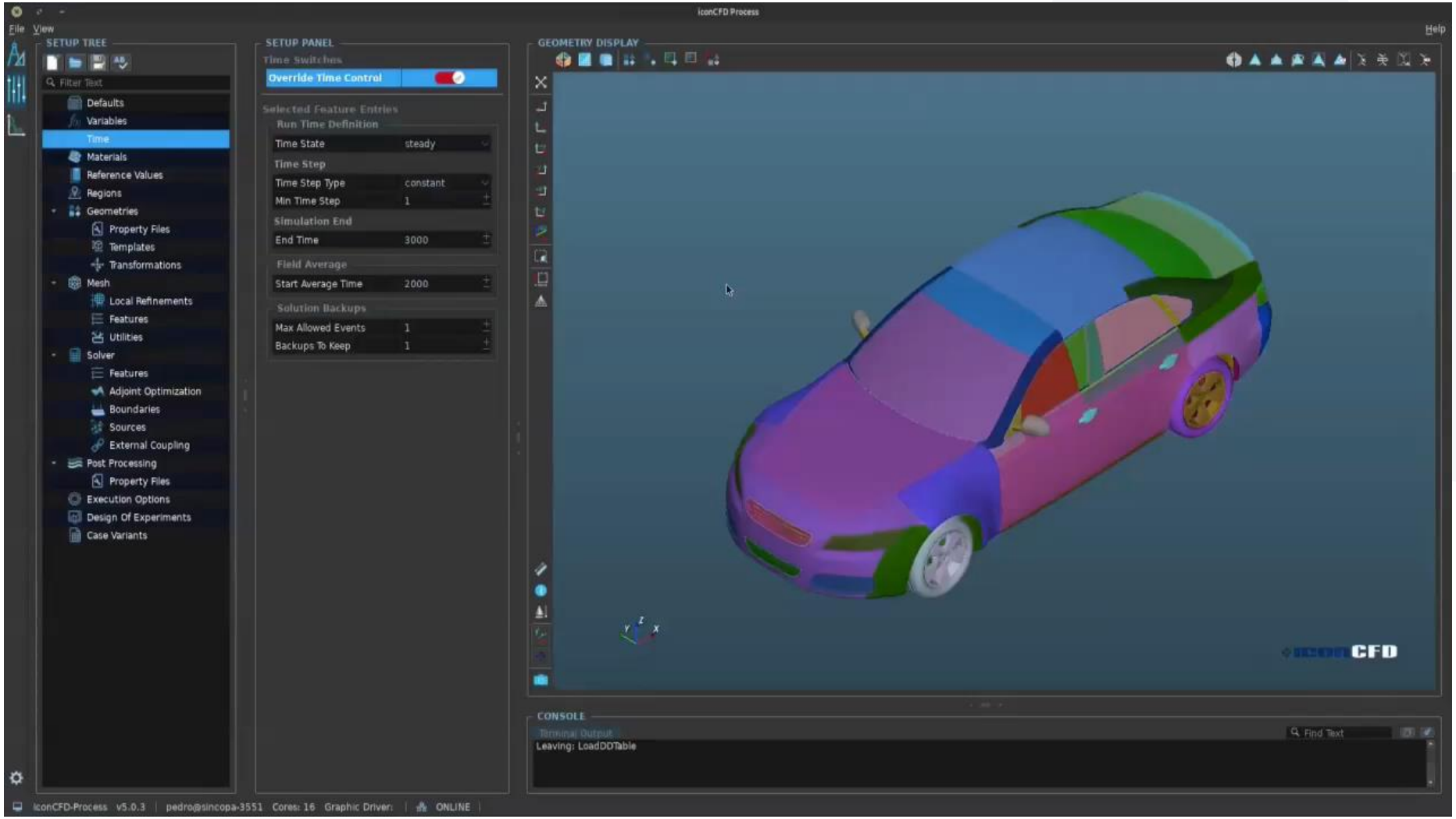
Distribution

	1	2	3	4	5
1	DOE_VARIAB...	parameterDisplacement1_GLOBAL_m...	parameterDisplacement2_GLOBAL_m...	turbulenceModel0_GLOBAL_region0 (...	CRIncrement_GLOBAL_meshSettings ...
2	DOE_SETUP_1	0	0	HKOSST	0
3	DOE_SETUP_2	0	0	HKOSST	2
4	DOE_SETUP_3	0	0	RKE	0
5	DOE_SETUP_4	0	0	RKE	2
6	DOE_SETUP_5	0	0	SA	0
7	DOE_SETUP_6	0	0	SA	2
8	DOE_SETUP_7	0	0.07	HKOSST	0
9	DOE_SETUP_8	0	0.07	HKOSST	2
10	DOE_SETUP_9	0	0.07	RKE	0
11	DOE_SETUP_10	0	0.07	RKE	2
12	DOE_SETUP_11	0	0.07	SA	0
13	DOE_SETUP_12	0	0.07	SA	2

Design Space Table

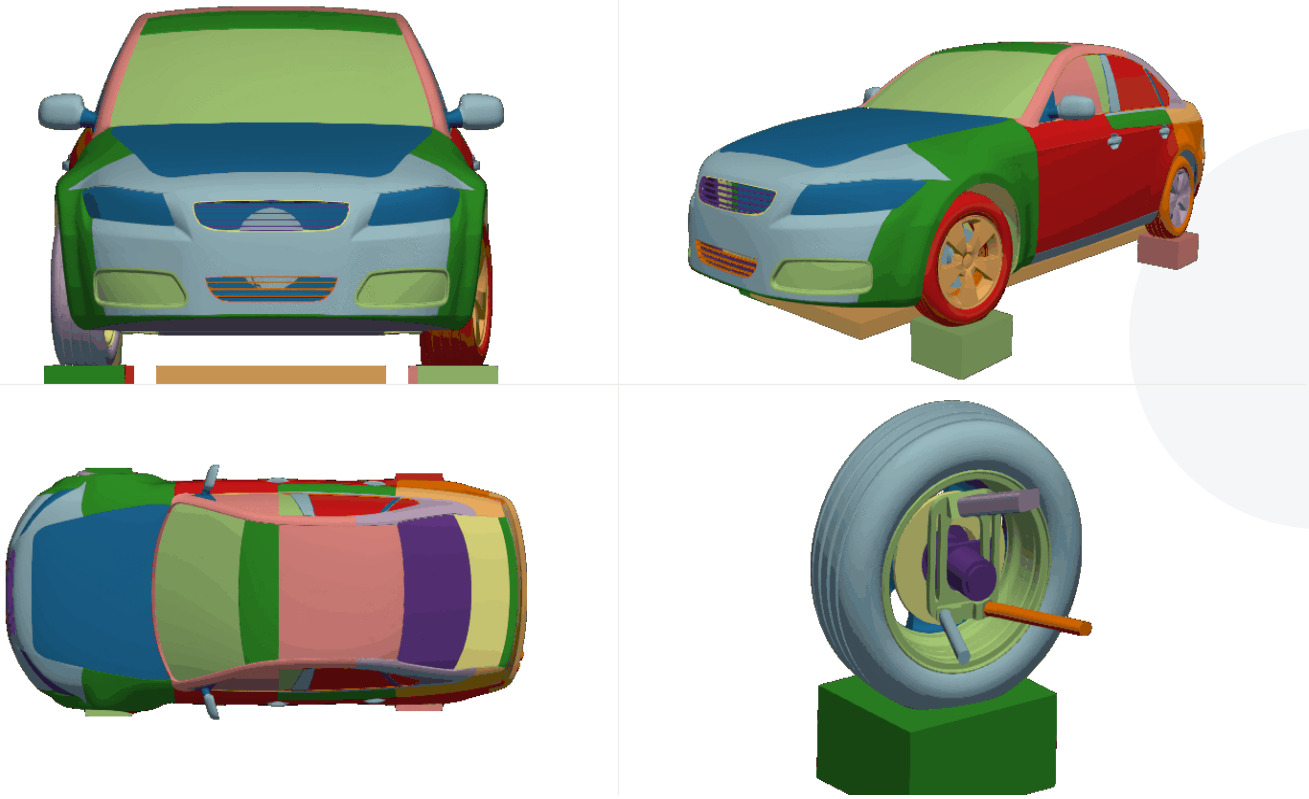
DoE Setup

Demo Video



DoE Setup

More Advanced Features with DoE



Sweep geometry studies: car positioning, wheel steering and surface morphing boxes through DoE

- Complex workflows
  - Adjoint optimization
  - External coupling: FEM-CFD
  - Raining/wading/soiling studies
  - Thermal car brake cycles
- Ride heights with kinematic morphing
- Parametric Wheel Steering
- Drafting studies (Race conditions)
  - Overtake Optimizations
- Conjugate heat transfer simulations
- Variant studies with DoE per setup

Concluding Remarks

- iconCFD Process V5 has been used to prepare a DoE simulation with:
  - CFD Setup variables: turbulence and global curvature refinement
  - Geometric morphing variables: parametric morphing boxes
- Base setup is straightforward to prepare with the help of:
  - Default/overrides definitions
  - Template Domains
  - Automatic features: like wheel rotation (center, axis, speed)
- Morphing session can be created/parametrized inside the GUI and be integrated inside the CFD setup without complexity
- 48 cases has been created as a simple DoE example using the *drivAer* sedan geometries
  - Extra complexity can be added easily: like ride height studies, component studies etc.

Questions? More Information?

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- iconDevelopment
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