ICSC 2019

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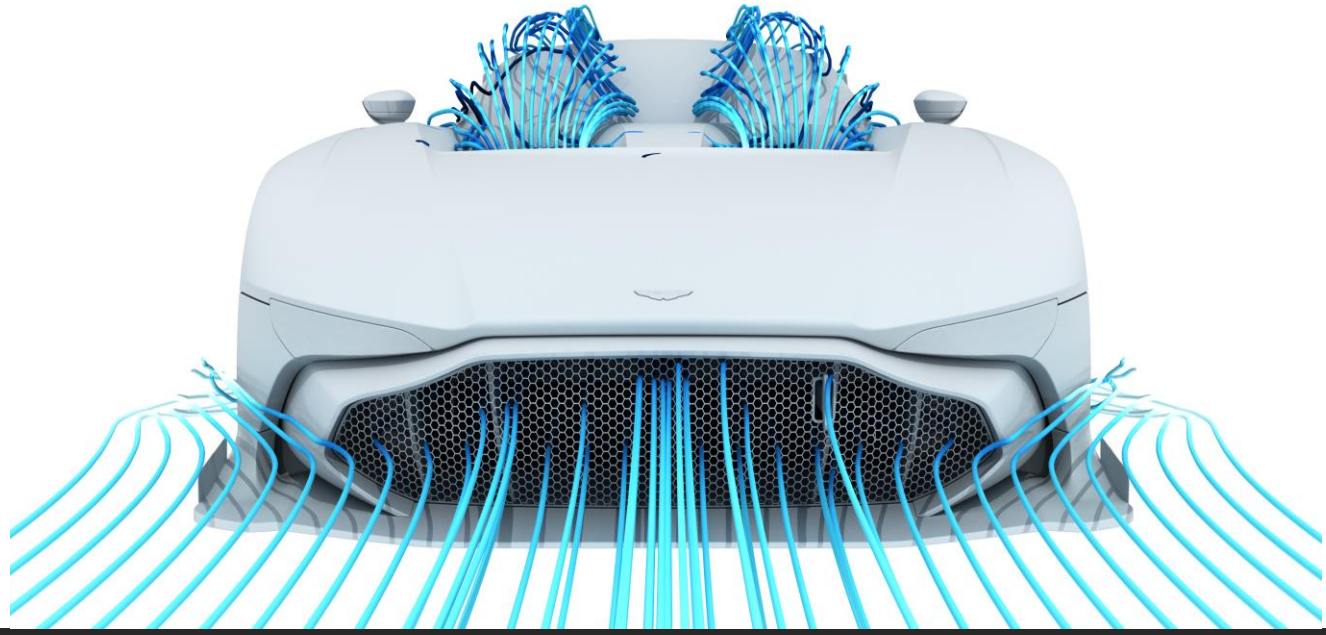
From CAD to CFD with iconCFD



Prepared / Presented by:

Benjamin Leroy – Senior Consulting CFD Engineer / Dr Punit Nayyar – iconCFD Product Manager / Senior Software Developer November 2019

Technology Process Consulting

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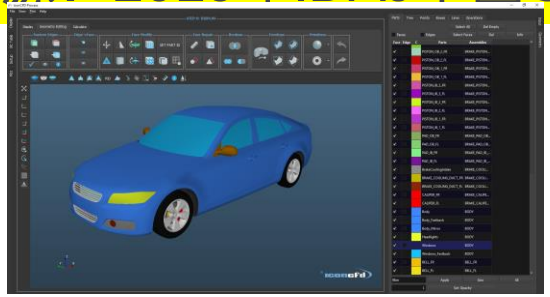
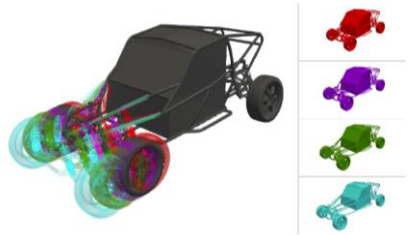
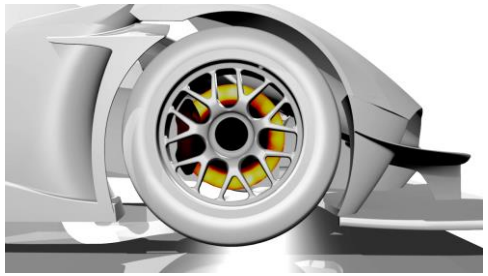
AGENDA

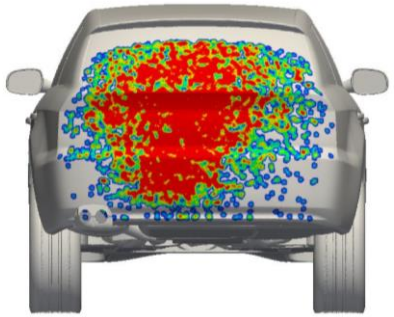
报告来源：2019年IDAJ中国CAE/MBD技术大会

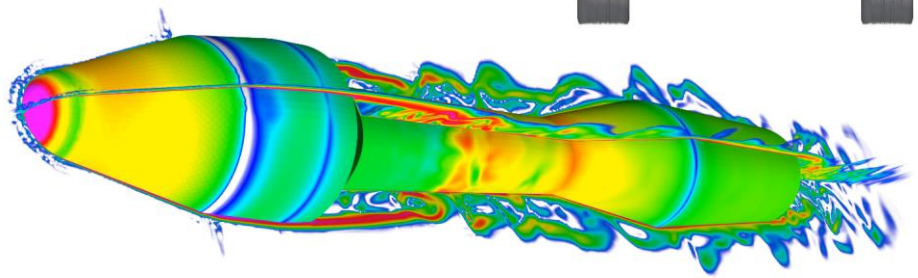
- Introduction
- DOE and Morphing
- Brakes and AMI
- Particles and Soiling
- Acoustic Noise Modelling
- Transonic / Hypersonic Flows











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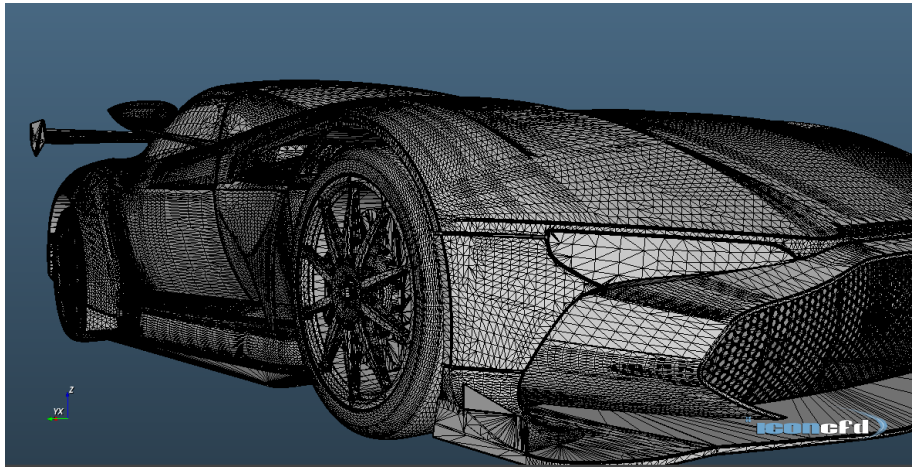
- iconCFD Transonic
- iconCFD EMP
- iconCFD FSI

- **Geometry Reader / Converter**
- Basic CAD Creation Tool
- Edge / Face Selection Methods
- CAD Modification / Repair
- Create Rotate Volumes
- Vehicle Positioning Tool / Ride Height Tool

STL
NASTRAN
OBJ
IGES
STEP
JT
VTK
(Compressed)



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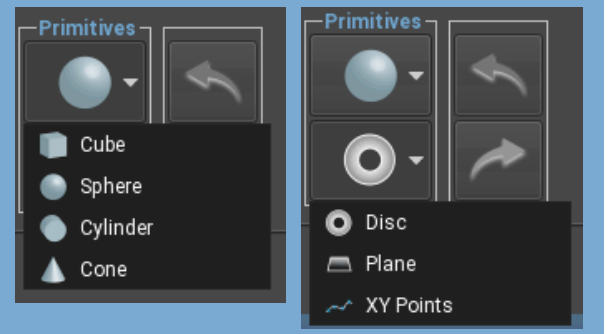
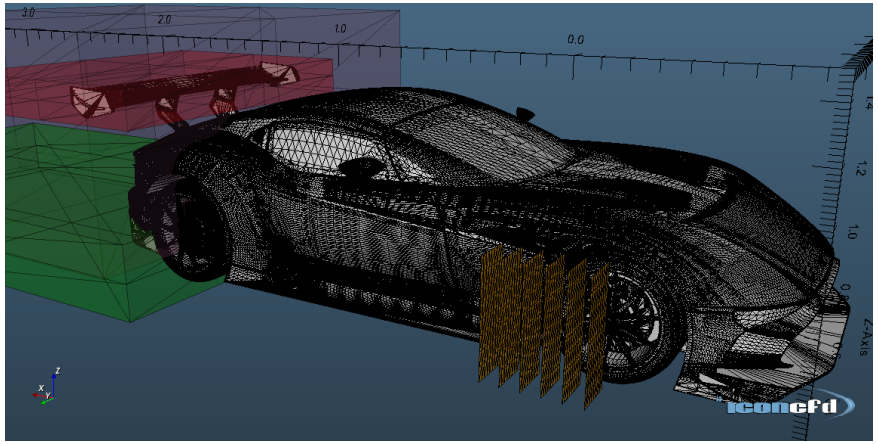
Sphere
Box
Cone
Cylinder
Plane
Disk





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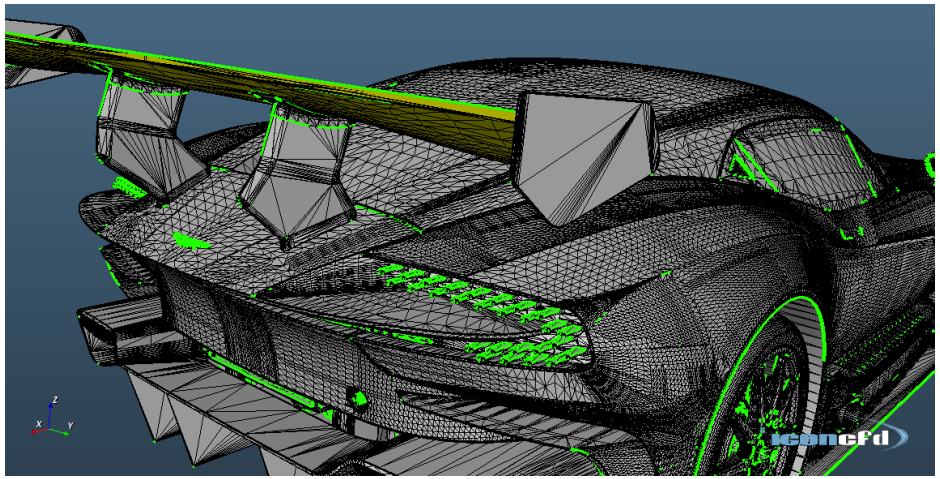
Edges:
Single, Linked, Band

Faces:
Single, Linked, Polygon, Band



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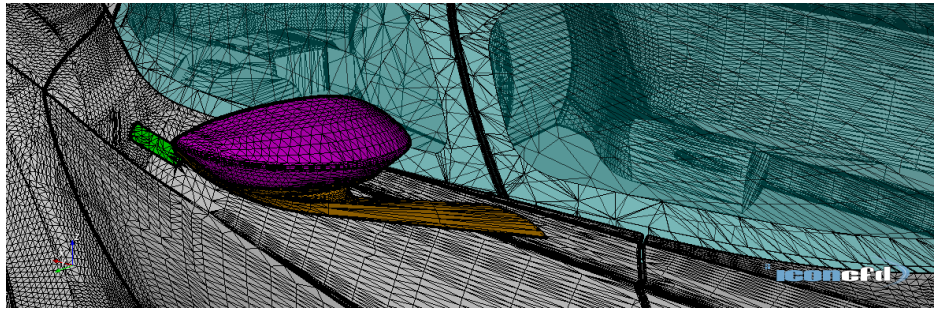
Flip normals
Fill gaps/holes
Delete duplicates (points and faces)
Split regions
Boolean operations: unite, intersect, difference
Transform: translate, scale, rotate and/or copy selected parts or whole geometry
Clean geometry



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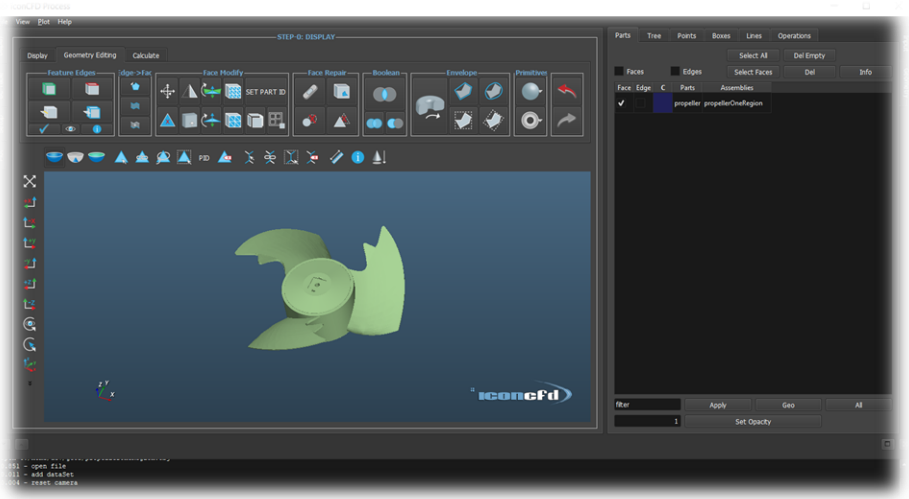

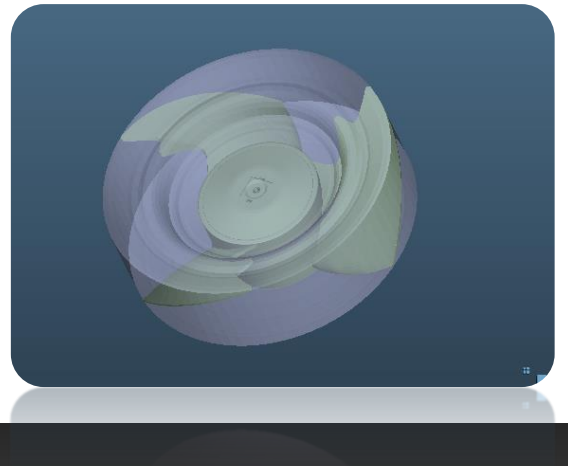

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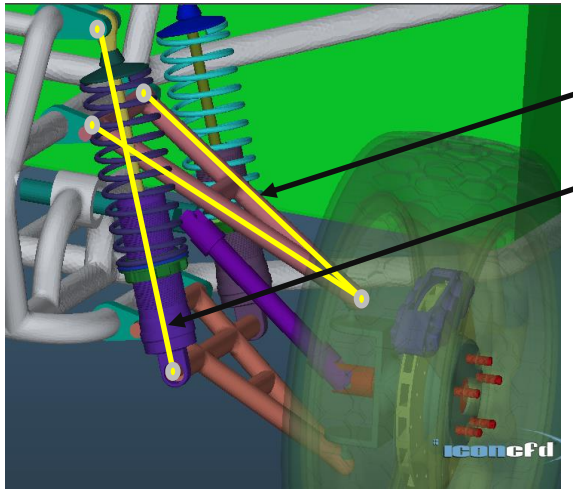

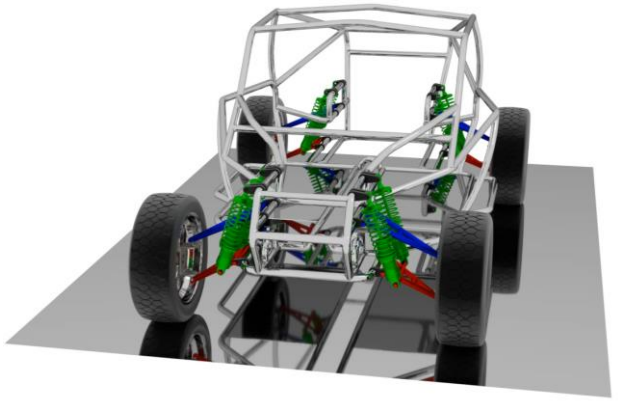

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- **BC Table**
- Setup Table
- Feature Switches
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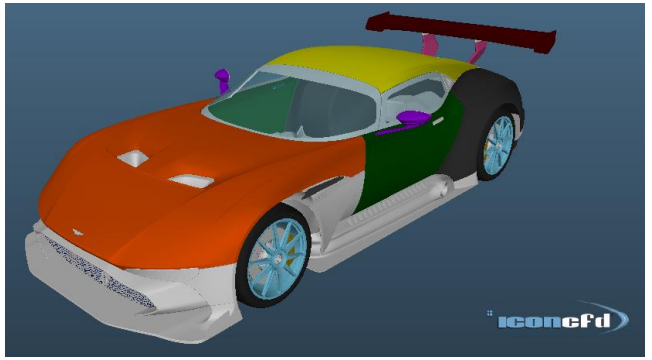
- Python API for Batch Setup
- Support for all iconCFD Modules

FrontWheels.stl
RearWheels.stl
→ **Search Pattern** *Wheels* →
Rotating wall BC with level 9 and 4 layers

File/PID names are colour-coded with BCs



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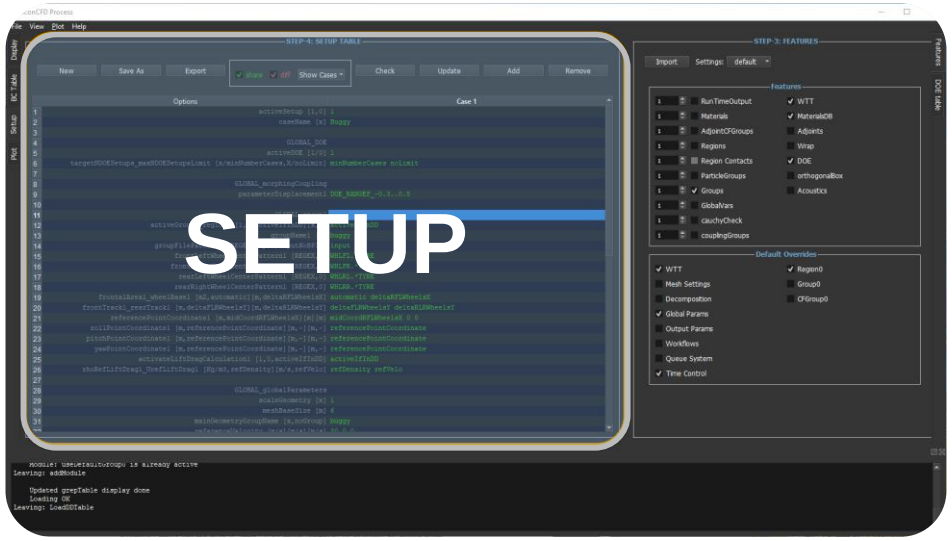

- Spreadsheet Table
- Table inputs are also colour-coded depending on row differences (green/red)

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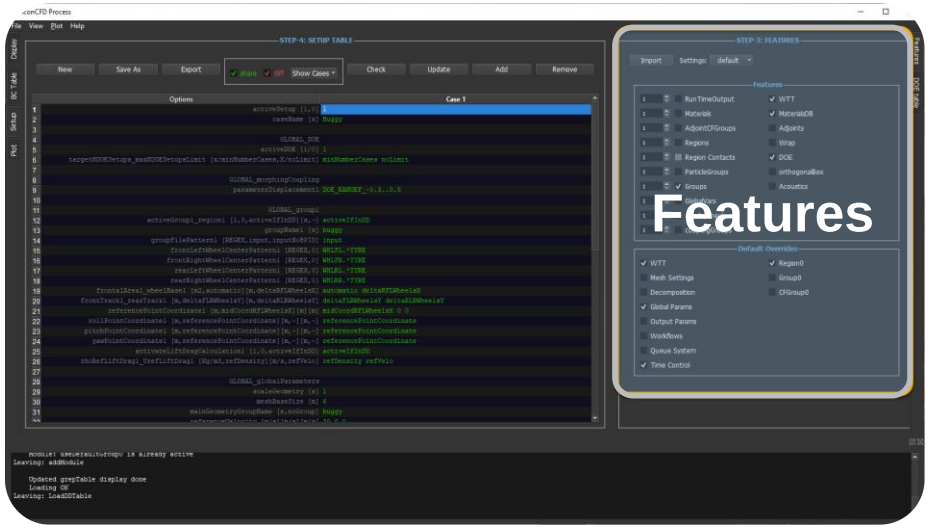

- Feature Activation
- Default Overrides

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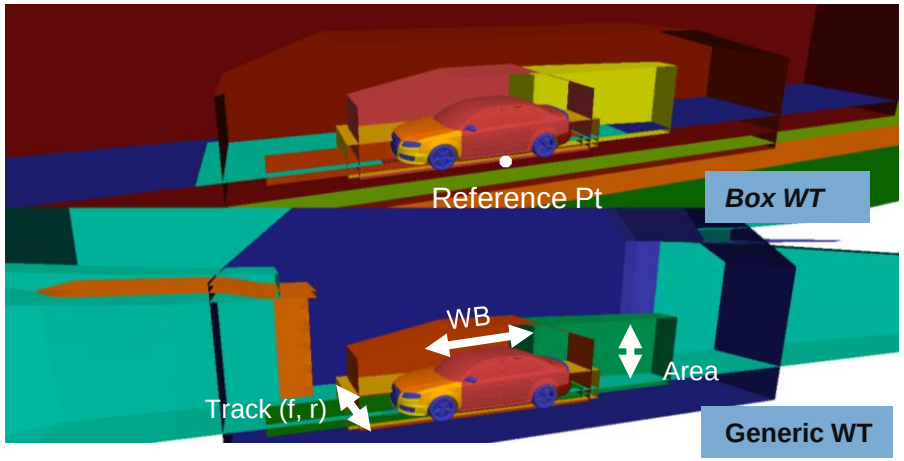

Geometry courtesy of Audi AG, I/EK-44

- Pre-define any template as combination of geometries
- Parametric Volumes of Refinement
- Easy application inside setups

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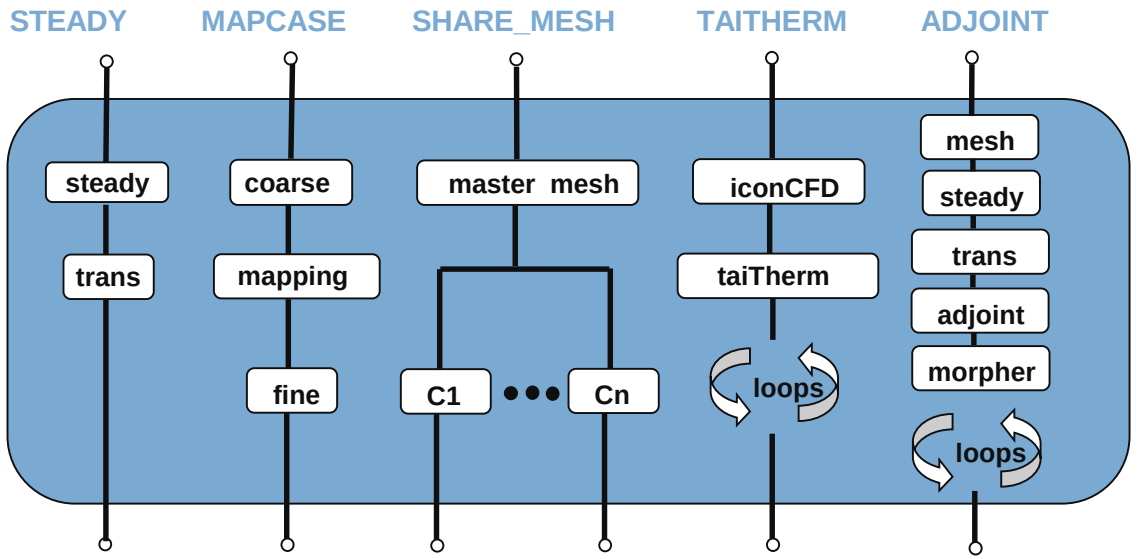

RESULTS (SMP and DMP environment support)

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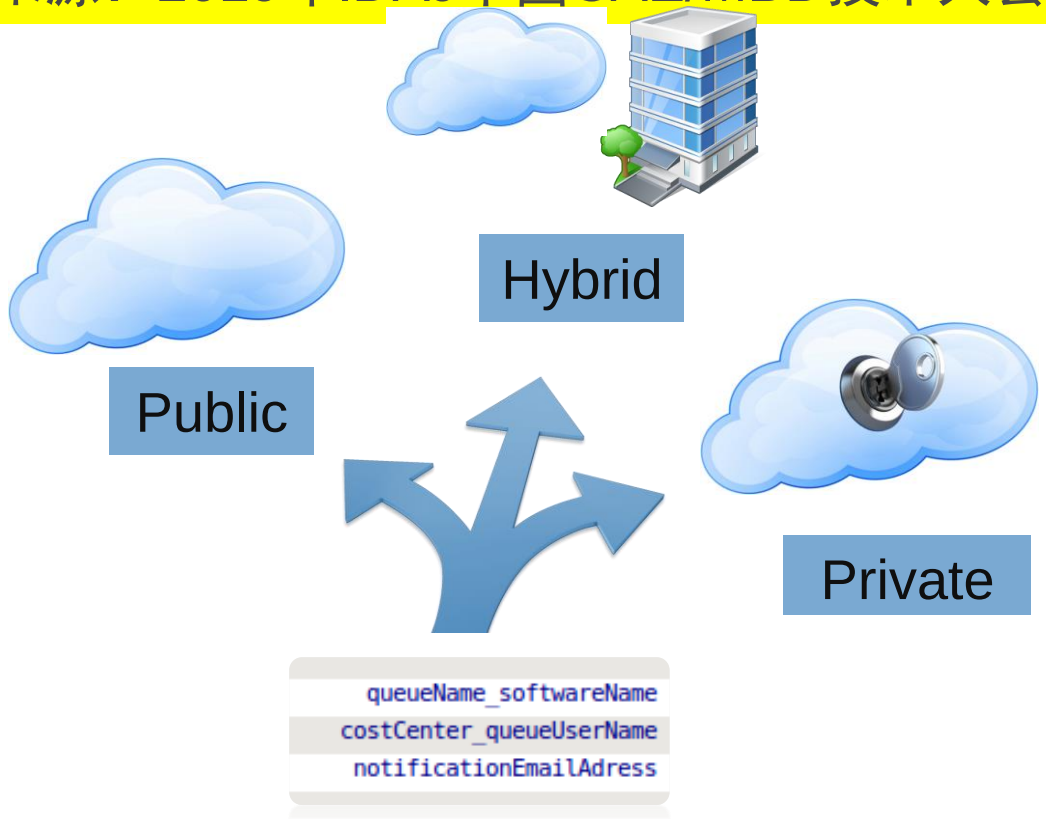

- Queue submission for: Torque, SGE, LSF, etc
- Customizable Queue Database
- Automatic Creation of runCase script for local / Remote Clusters
- Shared / Distributed File Systems Supported

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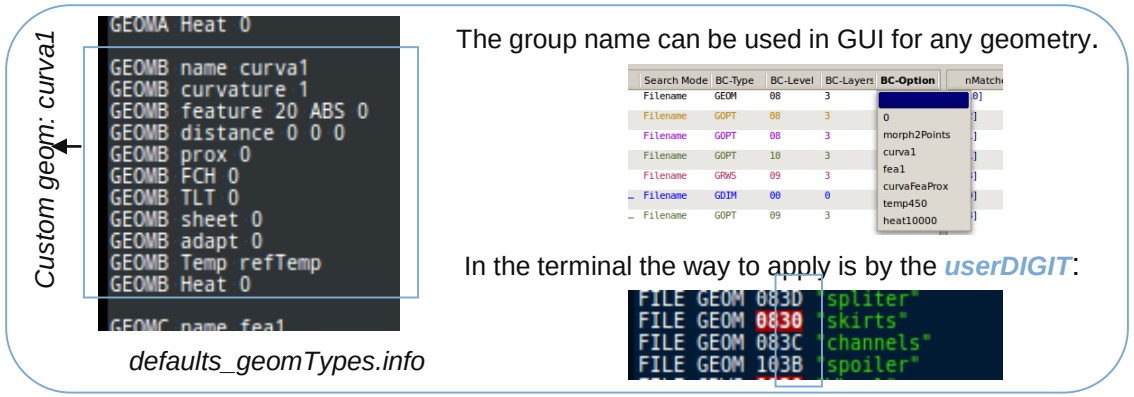

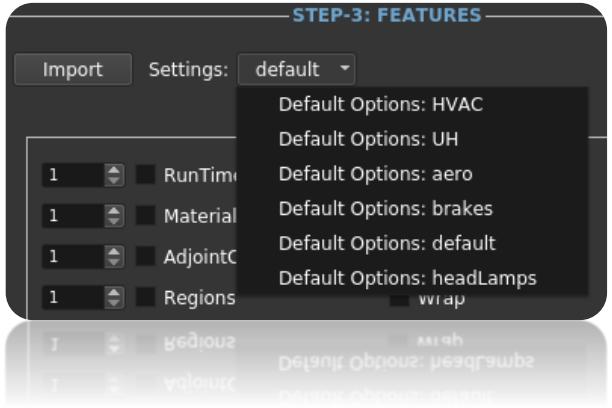

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```
#creating and setting api object
api=libAPI.BASEapi();

#settings folders
workingFolder="/tmp"
api.setAPI_folders(mcBaseFolder, workingFolder)
os.chdir(workingFolder)
print 'Working folder: ' + workingFolder + '\n'

#update default
api.setTMP_defaultPrefix ("GOPT0940")

#load your files from your dataBase
api.addTMP_file(rootPath+"/examples/000_geo/porscheUH/porsche_car1980_0000_911_body.nas")
api.addTMP_file(rootPath+"/examples/000_geo/porscheUH/porsche_car1980_0000_911_engine.nas")
```

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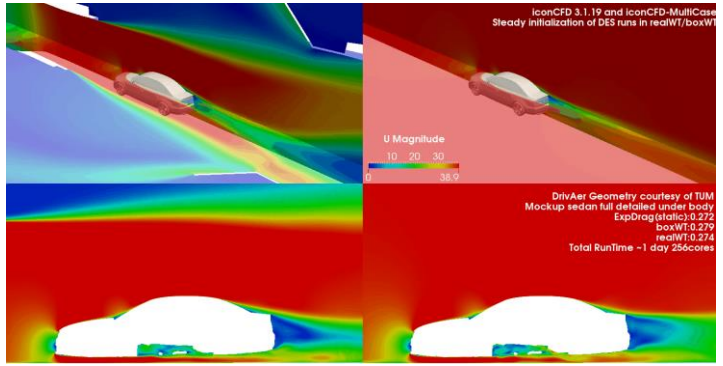
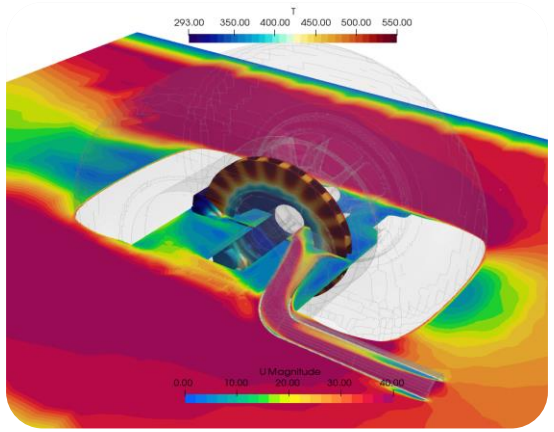
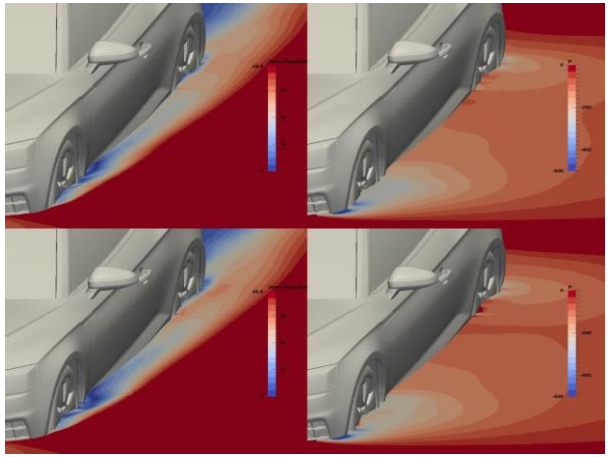


Geometry courtesy of Audi AG, I/EK-44





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Tutorial Demo

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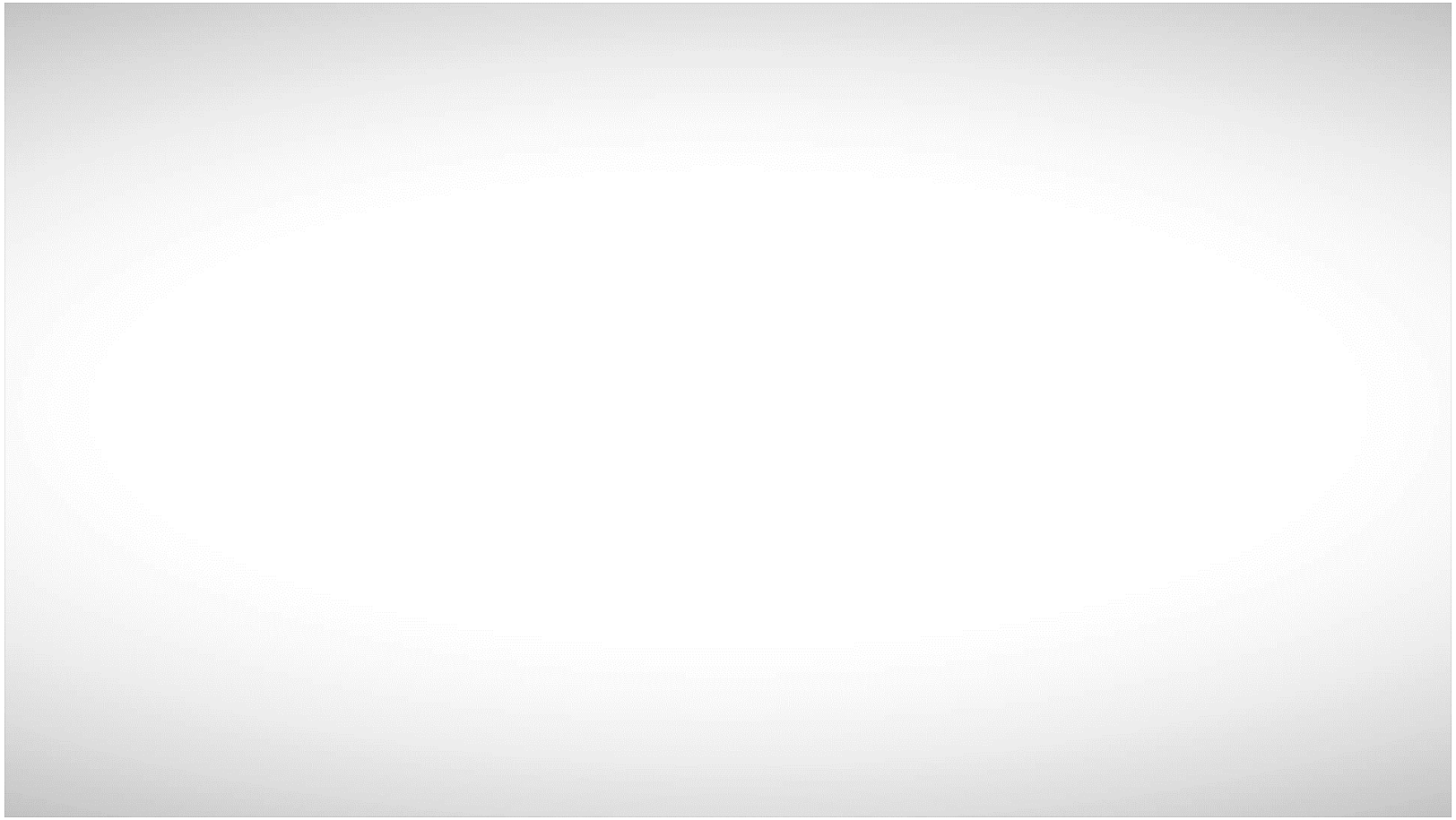

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WRAPPING

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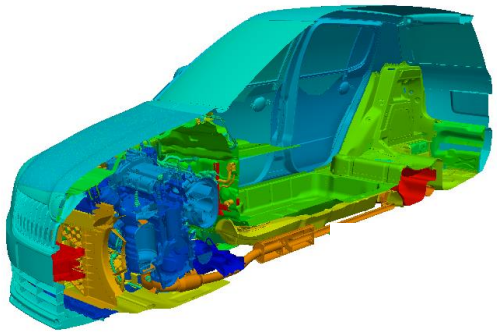
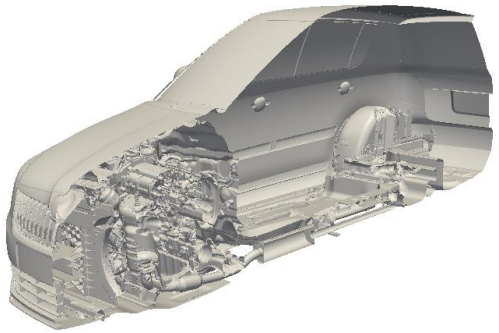
- Combined Wrapping & Meshing Capability [v4.0]
- Handle Gaps Much Larger Than Local Element Size
- Fully Parallelised
- Handles Complex Industrial Models

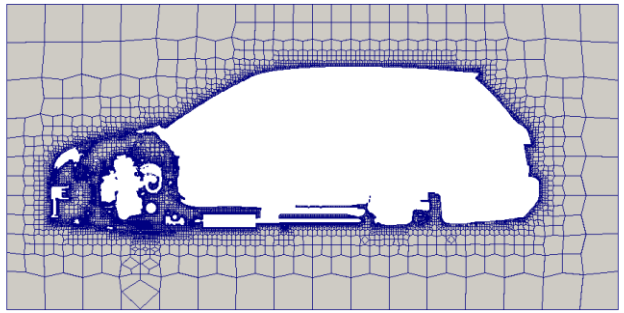


Wrapped surface: 12.5M triangles



Geometry courtesy of SKODA

Initial Cartesian mesh element size 0.625m
Surface mesh refined to level 8 ~ 2.44mm
2 levels of curvature refinement applied
Wrap level of 4 → 40mm hole size
Completed in 2h 42m on 32 cores with Intel Xeon E5-2670 (2.60GHz) processors



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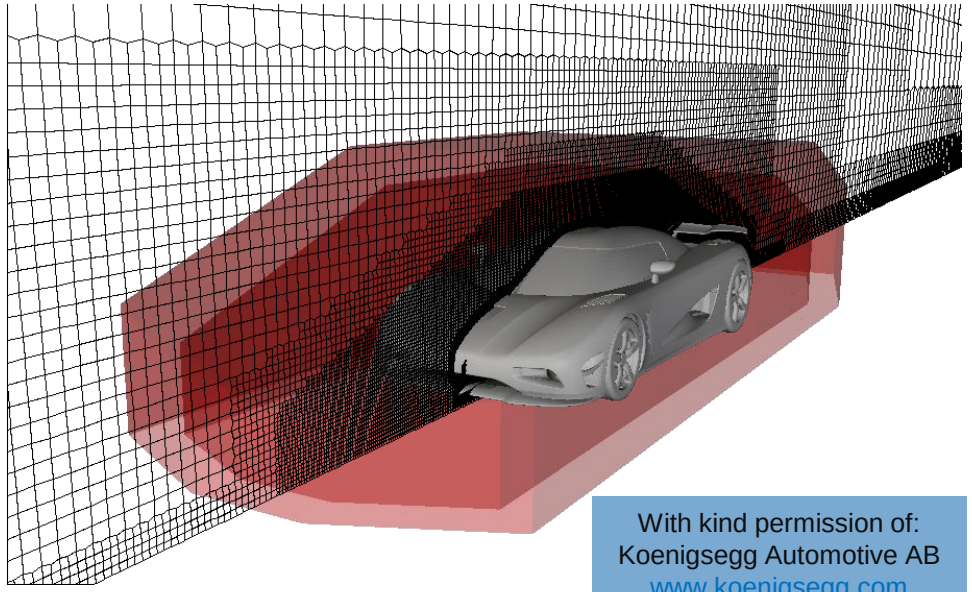

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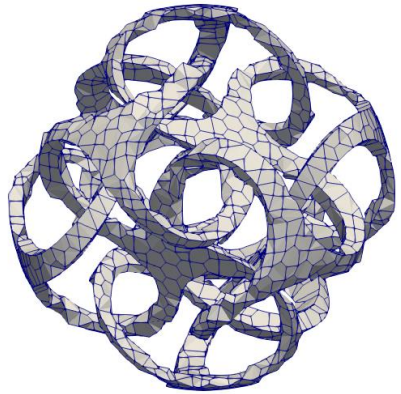

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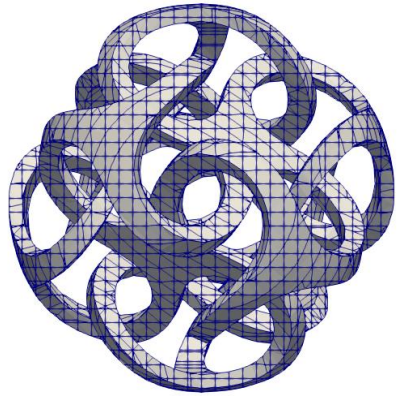

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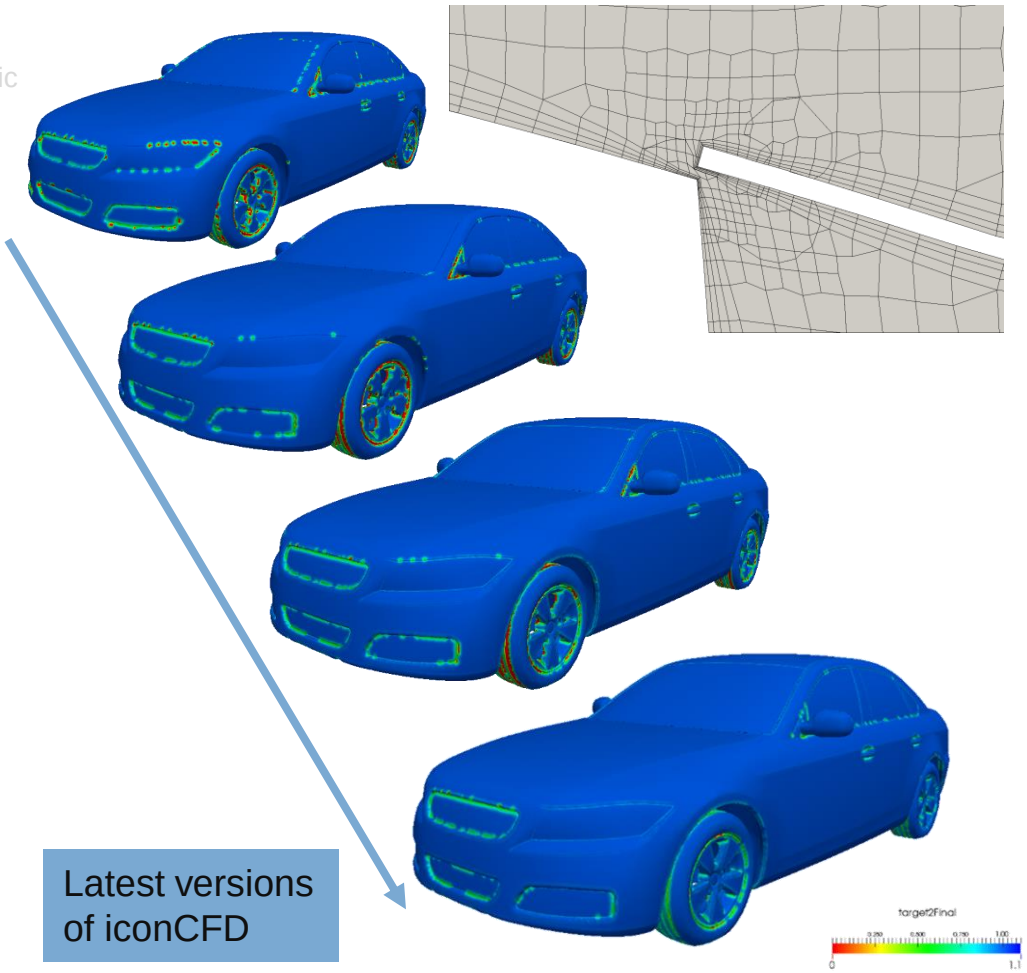

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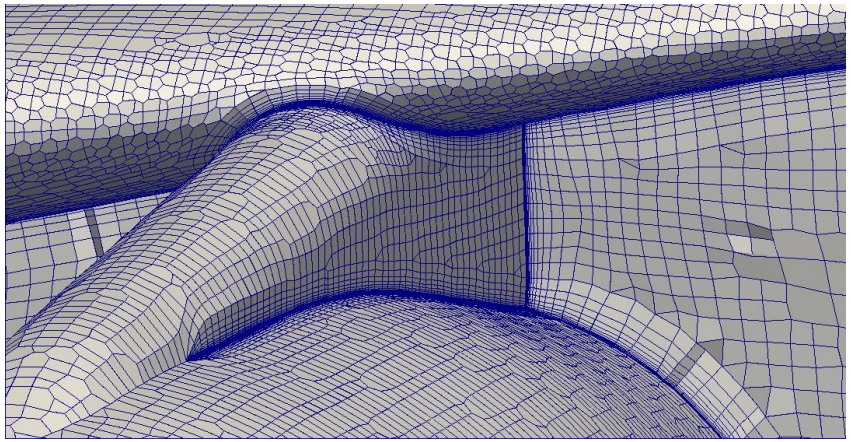

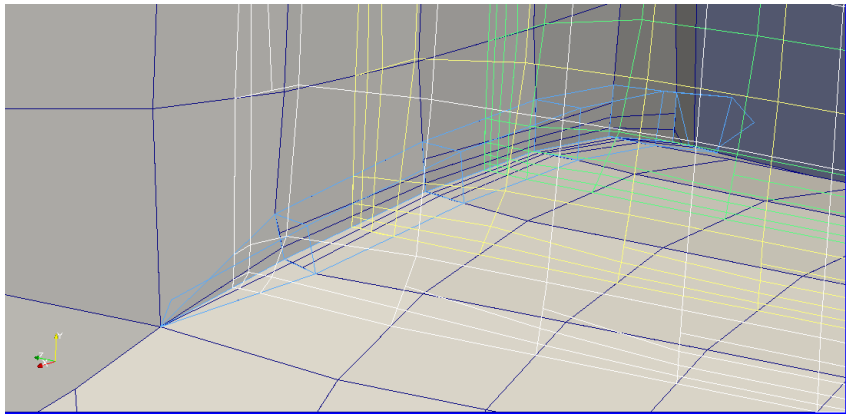

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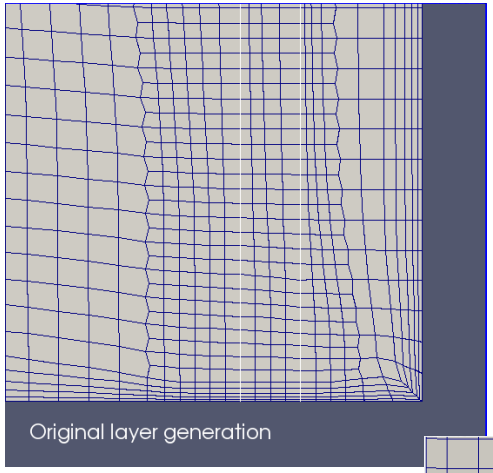

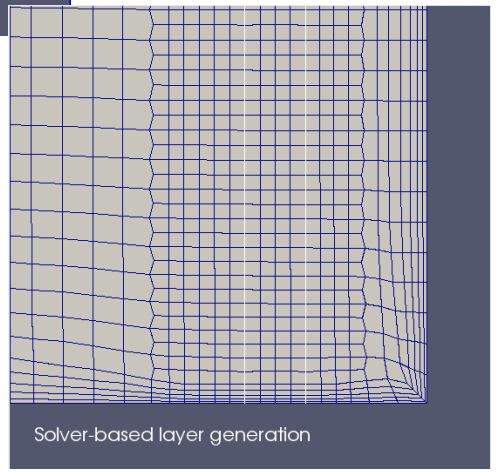

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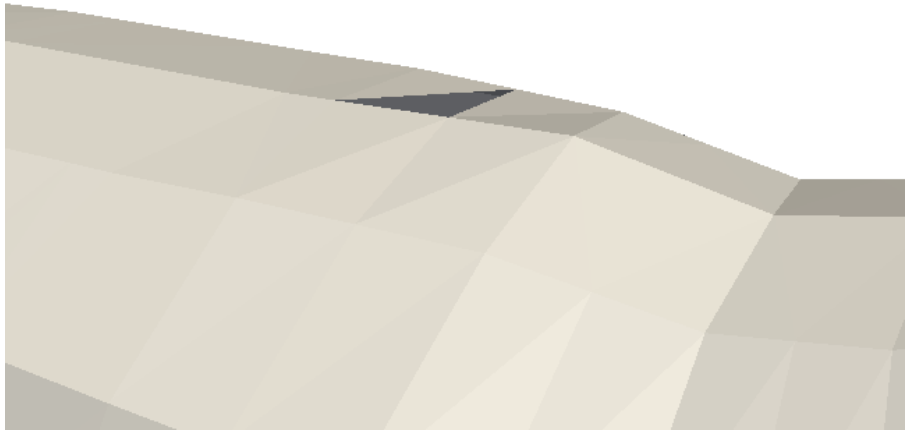

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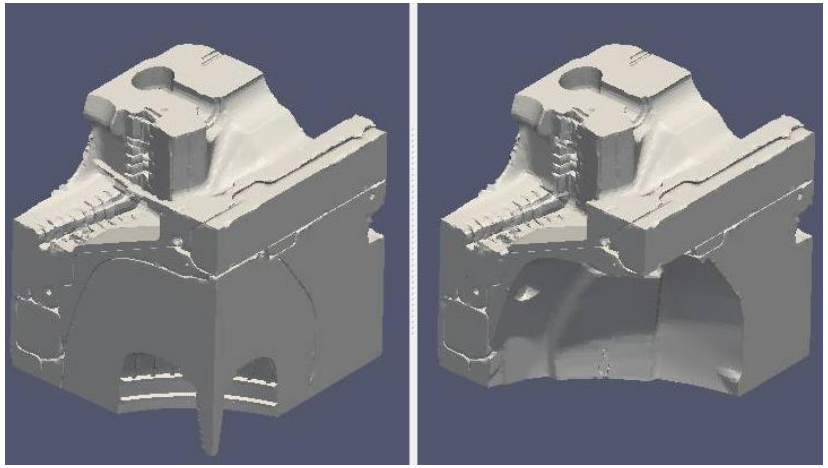

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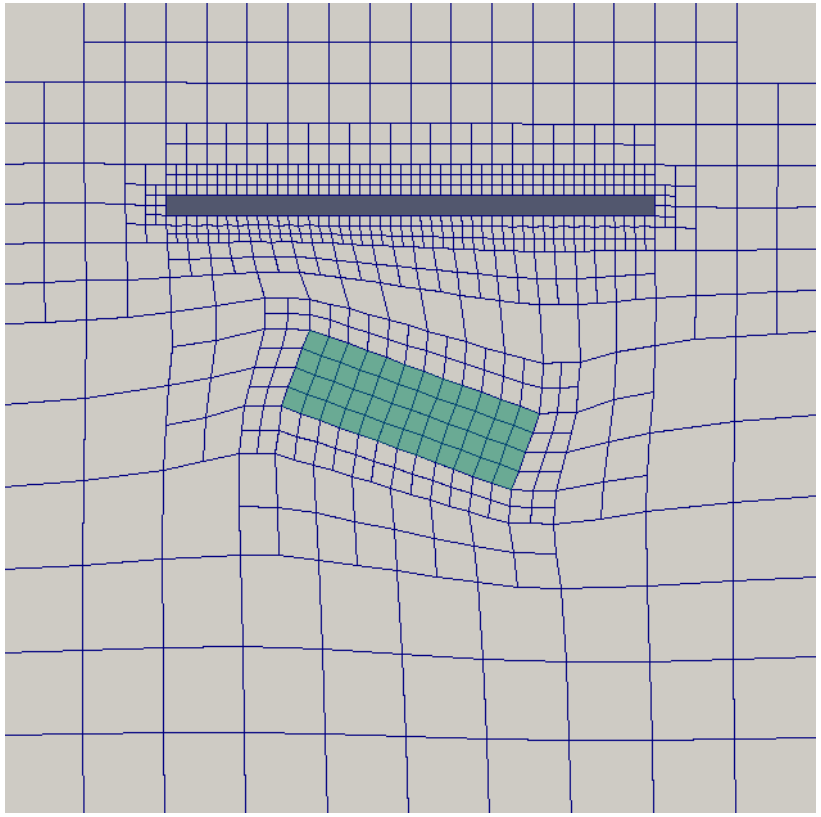

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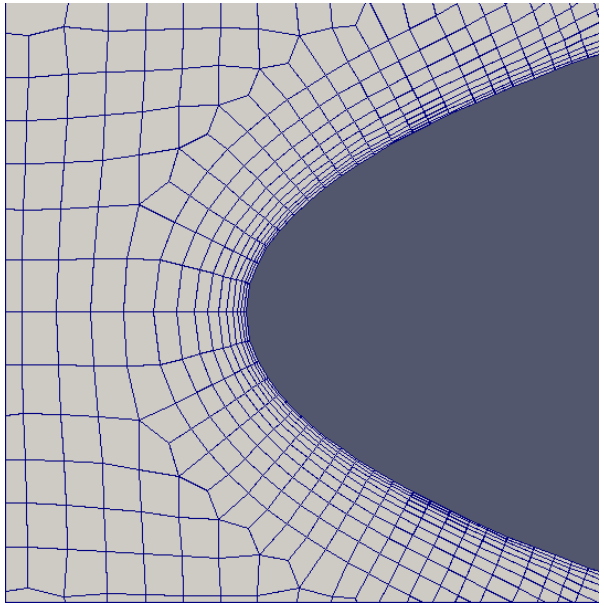

Mesh generation time for RAE2822 reduced from 1h 11m (on 16 CPUs) to 3.63s in serial

All meshing features (e.g. wake planes, feature line snapping, AMI) working correctly in direct 2D implementation

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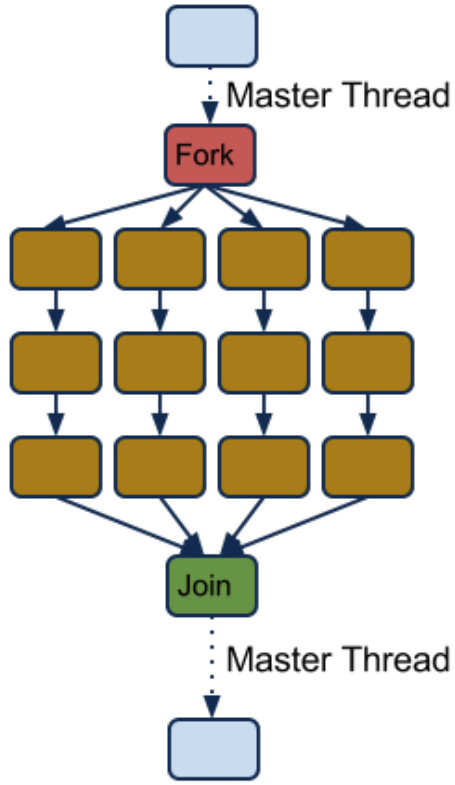

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Decoupled cell zone and face zone construction

- Cell zones can be specified using set of keep points, or searchable surfaces
- Cell zones can now optionally be written out as cell sets, sub-meshes or mesh regions instead of cell zones

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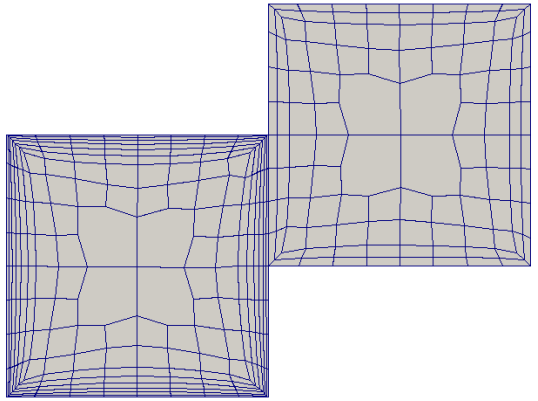
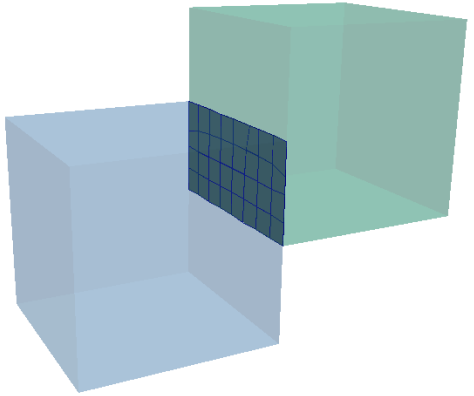
Generation of mesh consisting of multiple fluid and/or solid regions
Automatic creation of conformal mapped patches at region interfaces





Ability to specify different layer parameters on either side of region interfaces

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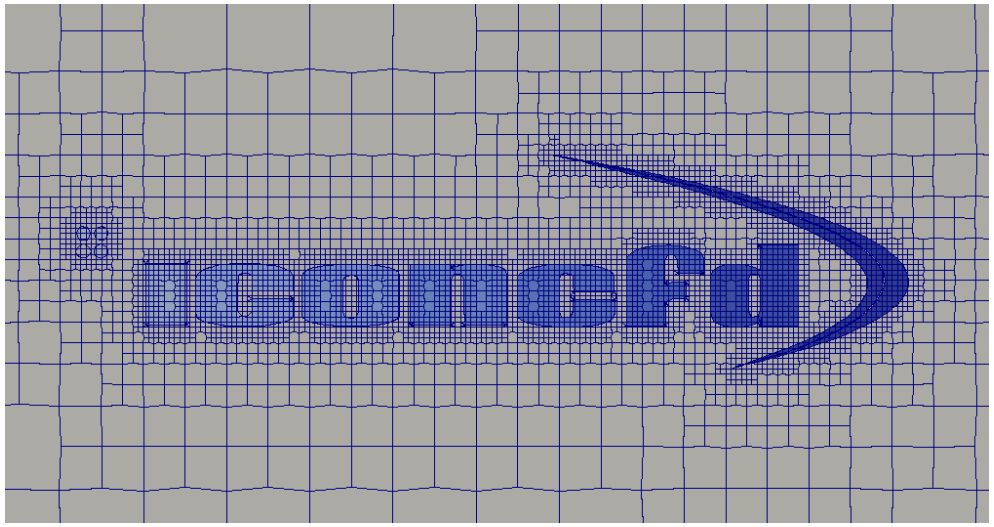

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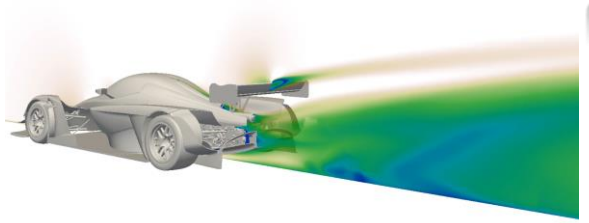
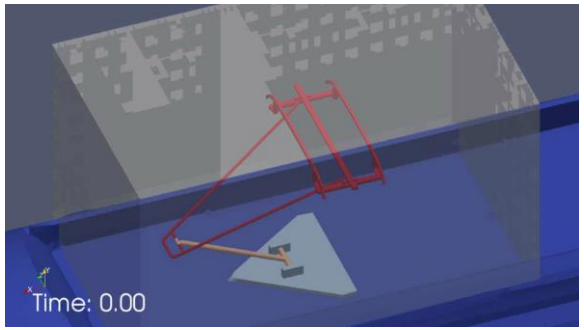
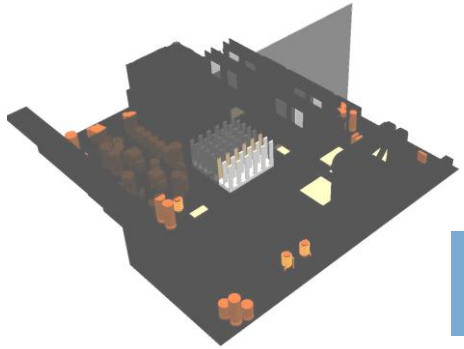
- Cold Flow Simulations (Cold)
- Compressible Flow Simulations With Support for Radiation and Buoyancy Modelling (Thermal)
- CHT (Thermal)
- Brake Flow Simulations (Thermal) [v4.0]
- Multiphase Flow Simulations / Wading (VOF)
- Adjoint Shape / Topology Optimization With Multi-Objective Design & Morphing Capability (Optimize)
- Dynamic Mesh Rotation & Take Over Simulations (Move)
- Advanced Soiling Simulations & Wiper Modelling (L2P) [v4.0]
- Active Species & Chemistry Modelling (React)
- Cabin Noise & Buffeting Simulations (Acoustic) [v4.0]
- Density-Based Solver for Aerospace Applications (Transonic) [v4.0]
- Fluid Structure Interaction (FSI) [v4.0]
- Pump Simulations With Cavitation (Move, VOF, EMP) [v4.1+]



External Aerodynamics Simulation of the Praga Race Car



Dynamic Mesh Simulation of a Train Pantograph



Thermal Simulation of a Computer Motherboard

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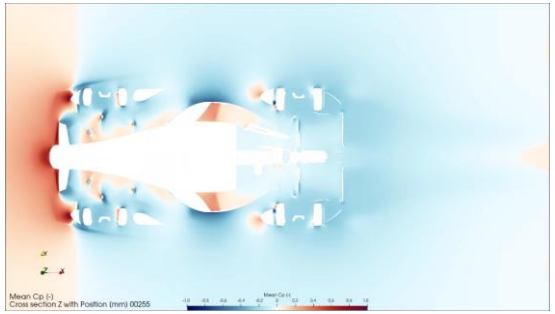
- iconCFD VOF
- iconCFD Optimize
- iconCFD Move
- iconCFD L2P
- iconCFD React
- iconCFD Acoustic
- iconCFD Transonic
- iconCFD EMP
- iconCFD FSI

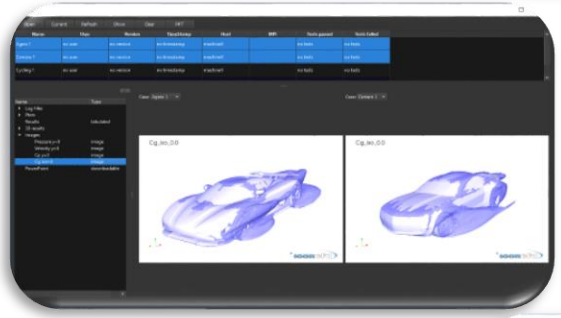
- Comparison / Analysis of Post-Processed Data in Generic Interface
- Generic Automated Post-Processing
- ParaView Customization

Geometry courtesy of PRAGA

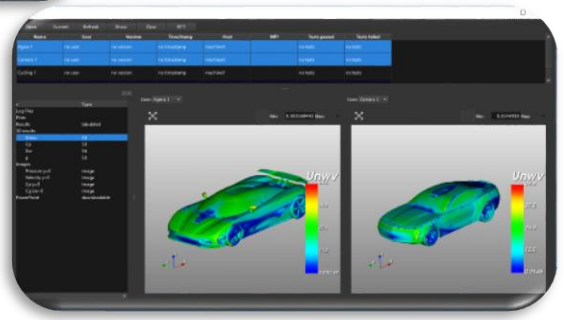


1000s of images automatically generated in few seconds of setup

Plotting



Images



3D surface data

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Application Example

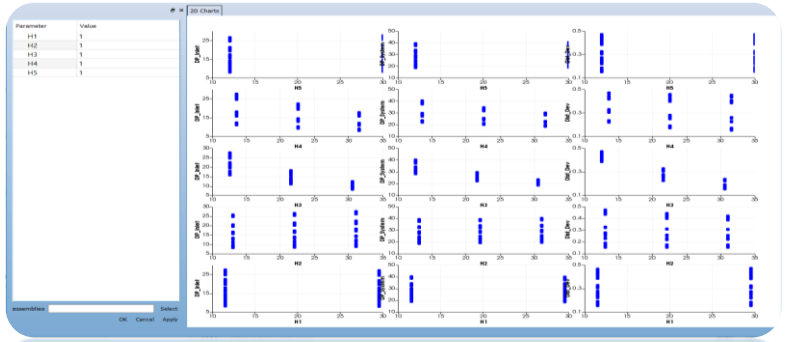
DOE Setup of Different Vehicle Positions Combined With Morphing with iconCFD

[iconCFD Process, iconCFD Mesh, iconCFD Cold]

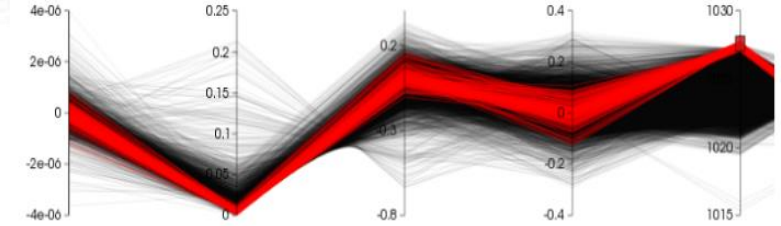
APPLICATION EXAMPLE

DOE

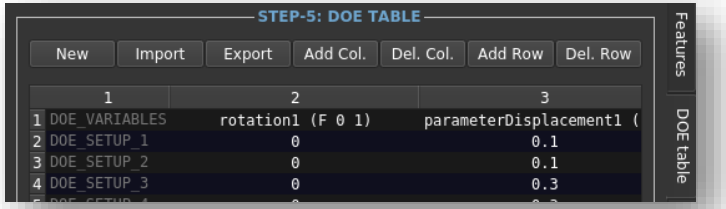
- Each entry from the setup table can be defined as DOE variable
- Multiple types of DOE variables:
  - Integer: DOE_RANGEI_-1..2
  - Float: DOE_RANGEF_-0.5..0.5
  - String: DOE_LIST_SA_RKE_KO
  - Binary: DOE_ON
  - BinaryExclusive: DOE_excON_mirrorParts
    - Only one component per group & setup can be active
- User defines number of cases to be created. Cases will be populated automatically keeping homogeneous distributions
- Parameter distribution can be customized based on external applications like LHS, Taguchi etc



Visualize effect of each DOE parameter in Slider Tool in iconCFD Process



Parallel Charts in Slider Tool in iconCFD Process



Import DOE parameters from CSV into DOE table in iconCFD Process

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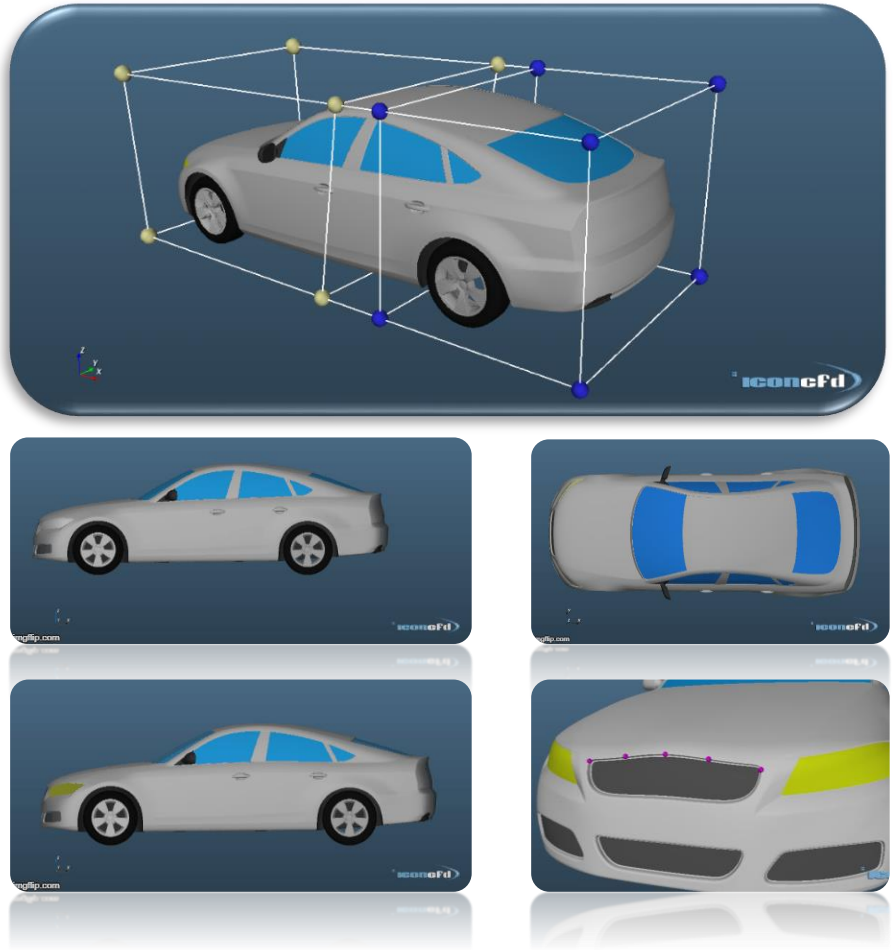
APPLICATION EXAMPLE
MORPHING

- iconCFD Process allows external morphing coupling with any morphing program through session files
- Built-in morphing functionalities are also available:
  - Morphing Lines based on splines
  - Morphing Boxes based on B-splines
  - Radial Basis Functions
  - Displacement : along specified axis and with given value
  - Rotation : around specified axis and with given value
  - Attached Solid : unique transformation for parts following other operations
- Morph Parameters can be defined inside the setup table as a normal input or as a DOE variable if needed

```
GLOBAL_morphingCoupling :
 parameterDisplacement1 : DOE_RANGEF_-0.3..0.5     :
```

Geometry courtesy of TUM



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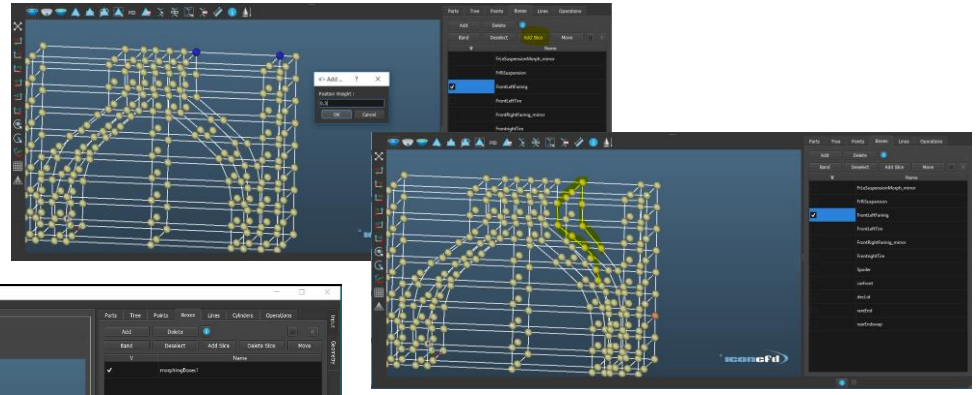
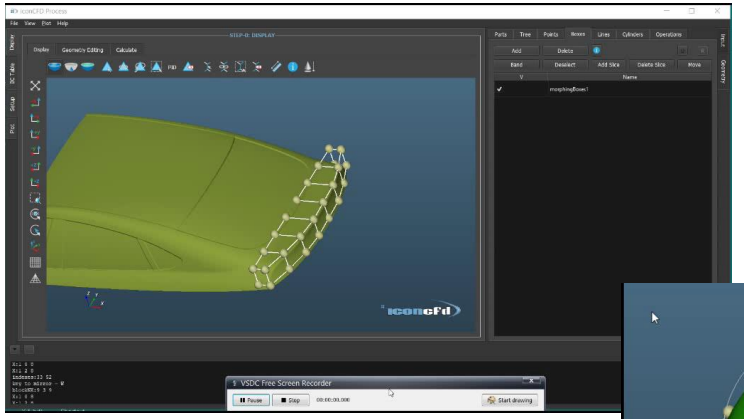
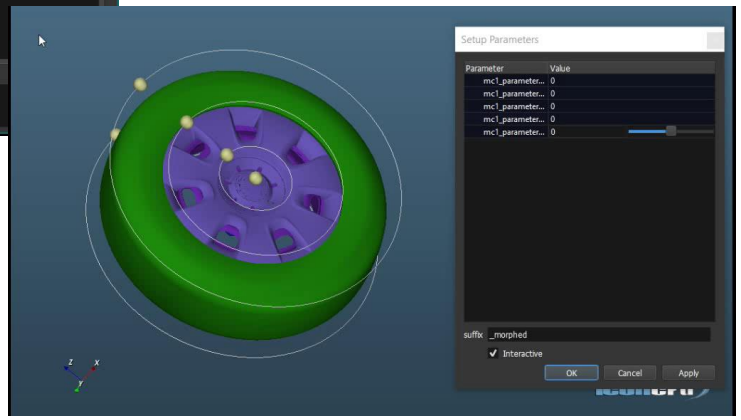
APPLICATION EXAMPLE
MORPHING

- Enhanced usability features for generating morphing geometries
  - Insert / delete slices in morphing boxes
  - Mirror morphing boxes
  - Interactive symmetric handle motion
  - Morphing cylinders
- RBF Morphing
- Batch capability with iconCFD-GeomBatch tool







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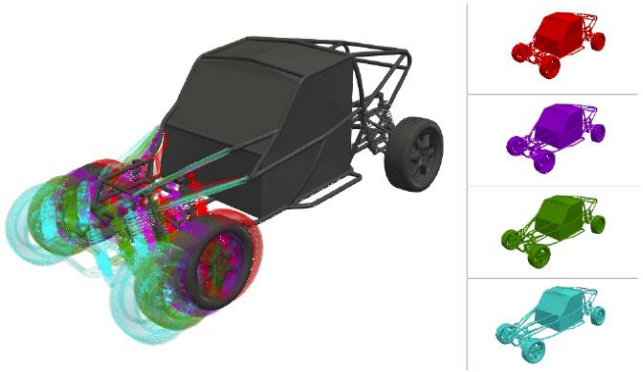
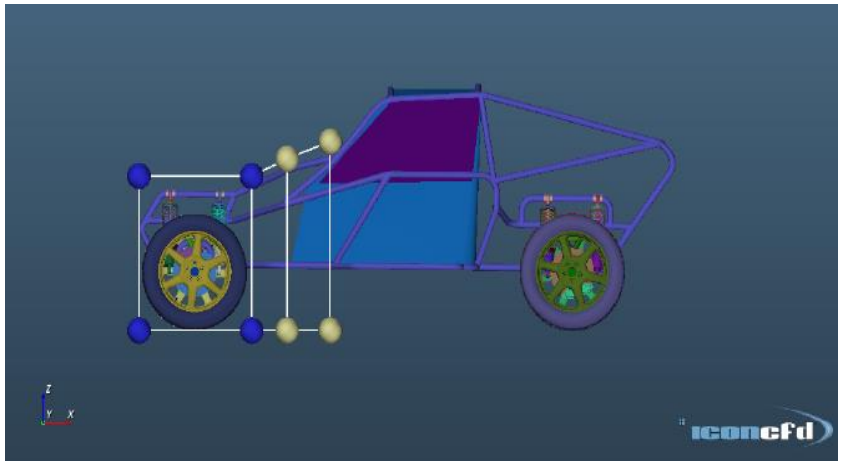
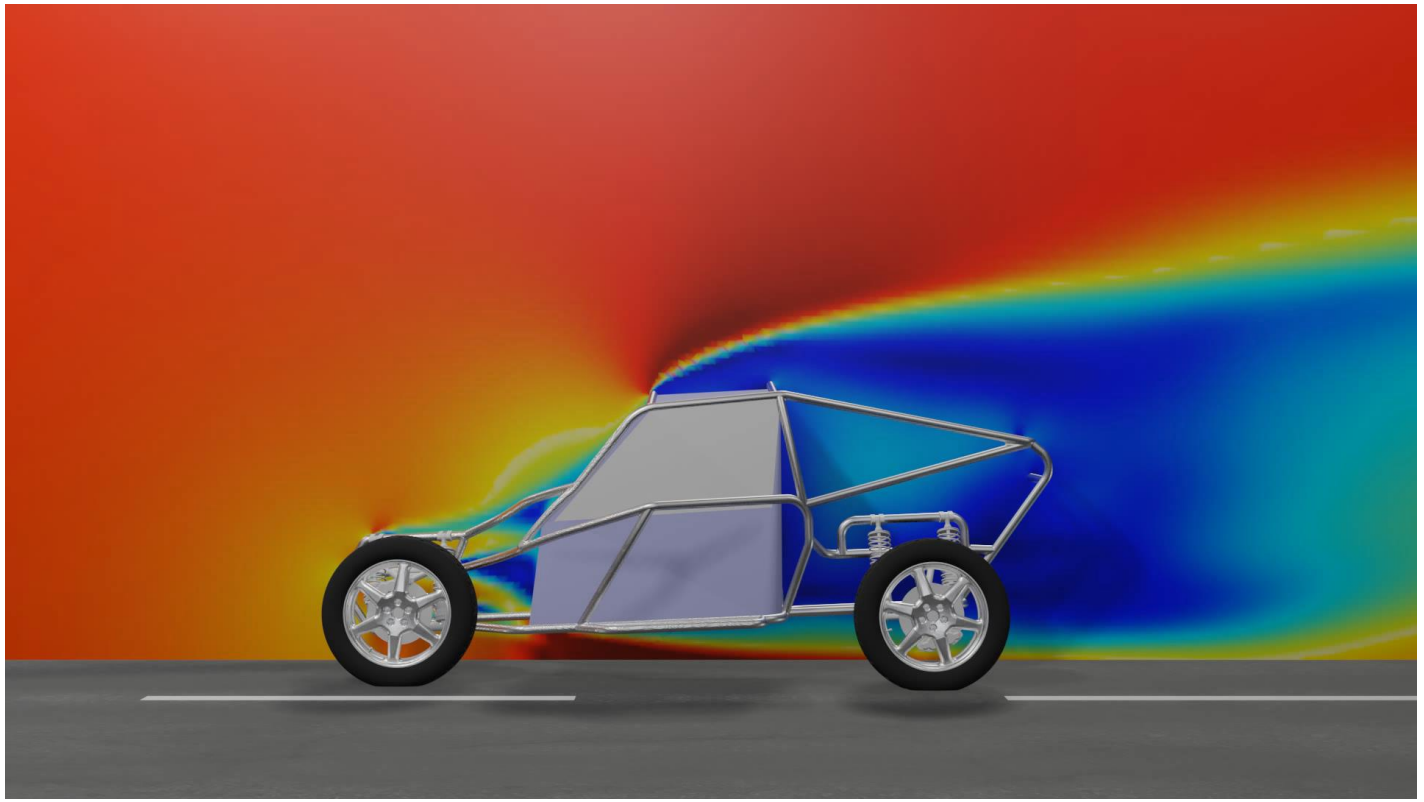
APPLICATION EXAMPLE

DOE SETUP COMBINED WITH MORPHING







Application Example

Rapid Brake Disc Cooling Simulation with CHT On A Simplified, Isolated Wheel Assembly And Faster AMI Performance on Industrial Brake Disc Models with iconCFD

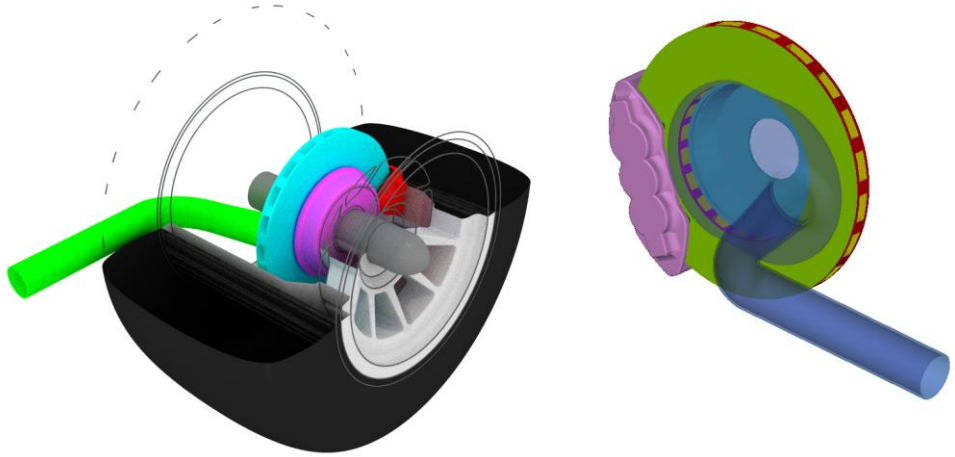
[iconCFD Process, iconCFD Mesh, iconCFD Thermal]

APPLICATION EXAMPLE

RAPID BRAKE DISC COOLING SIMULATION WITH CHT

- Far-field domain geometry created automatically in iconCFD Process using Wind Tunnel Template
- Setup created in few minutes using iconCFD Process pre-processing tool to export all required input files
  - All brake disc modelling properties and files created automatically from few input parameters
- Mesh ~2.5 million cells generated using iconHexMesh
- Steady-state (RANS with realizable KE turbulence model) and transient (using IDDES-SA) flow solved using different solvers and 6 mesh regions (5 solid, 1 fluid)

Simplified wheel assembly for brake cooling simulation



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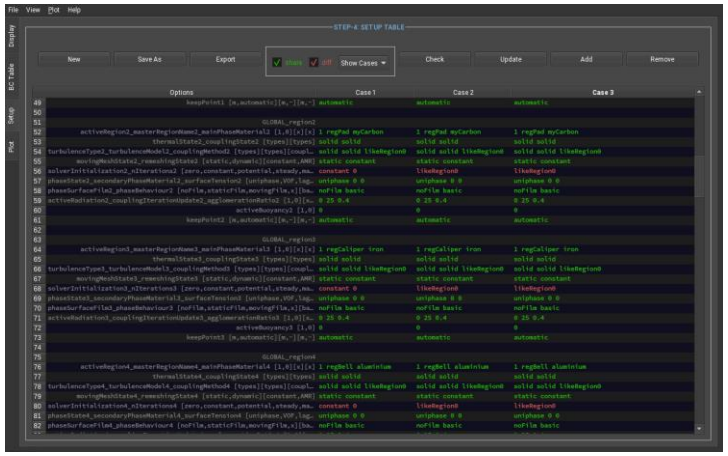
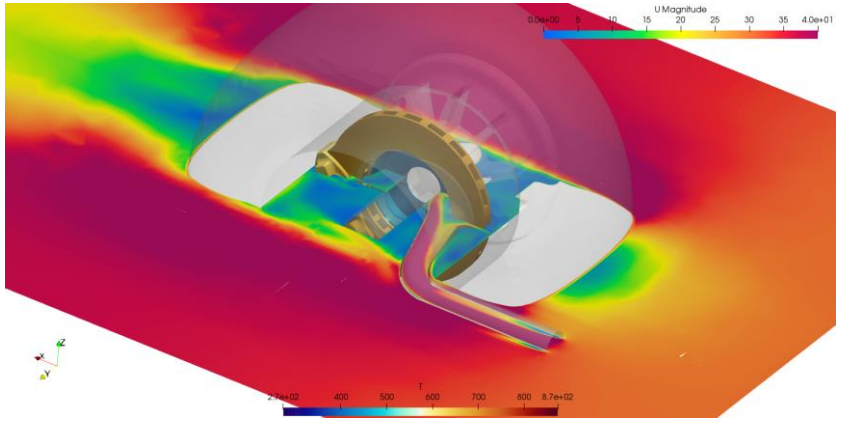
APPLICATION EXAMPLE

RAPID BRAKE DISC COOLING SIMULATION WITH CHT

- Different material properties applied to brake discs/pads (carbon), calliper (iron) and brake bell (aluminium)
  - Easily administered during setup using integrated material database in iconCFD Process
- Tire and brake bell rotation modelling using rotating wall boundary condition
- Brake disc system rotation modelled using rotating wall velocity boundary condition in conjunction with special BAF (band-averaged flux) method
  - More accurately solve the circumferential temperature distribution of the brake disc without the need of applying a dynamic mesh method
- iconSimplecFoam with for steady-state solution followed by thermal CHT solver iconTempChtFoam with frozen primal flow solution

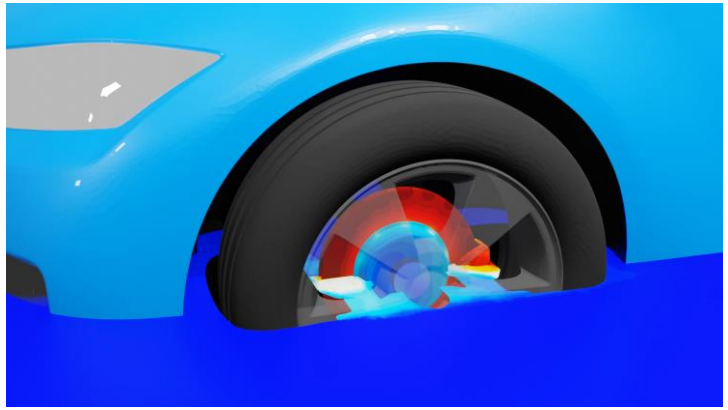




APPLICATION EXAMPLE

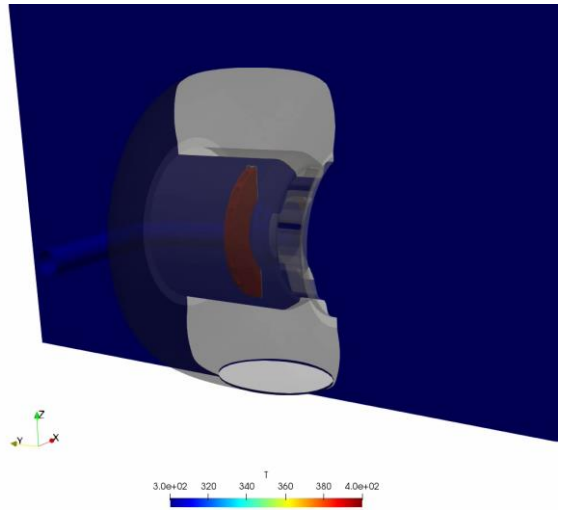
RAPID BRAKE DISC COOLING SIMULATION WITH CHT

- Transient brake cool-down simulation with constant heat release of 4000W applied for initialisation phase at region contact interfaces



Brake Cool-Down

- Compressible heat soak with buoyancy



Heat Soak

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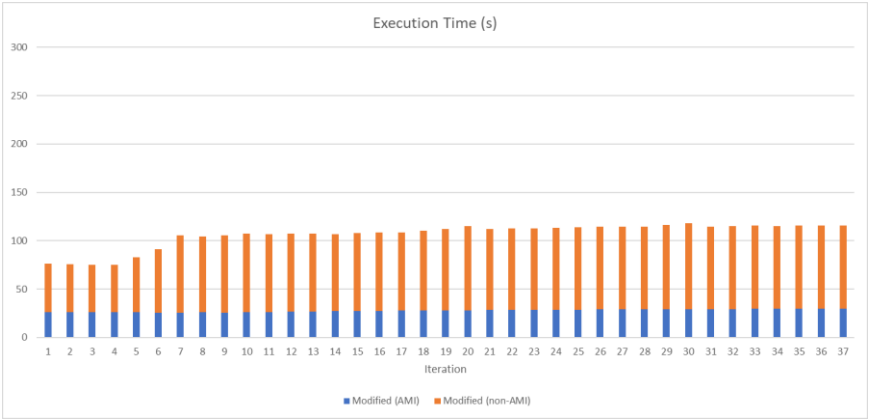
APPLICATION EXAMPLE

FASTER AMI PERFORMANCE FOR BRAKE DISC COOLING SIMULATIONS

- On industrial brake disc cooling models, rotating brake disc with AMI is run-time “heavy”
- New enhancements in iconCFD (v4.1) can deliver up to 50% speed-up in some cases
  - Improved AMI load balance
  - AMI weights caching

Before

After



Application Example

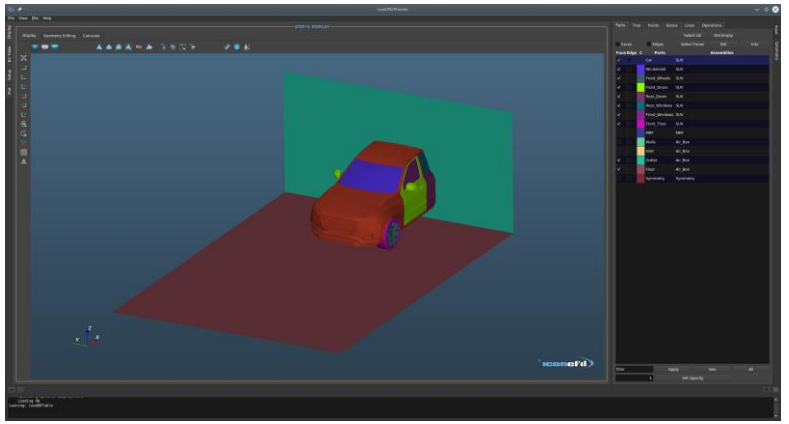
Soiling Simulations with Wiper Motion on a SUV with iconCFD

[iconCFD Process, iconCFD Mesh, iconCFD L2P]

APPLICATION EXAMPLE

SOILING AND WIPER MOTION ON A SUV

- CAD created using morphing boxes in iconCFD Process to adapt shape of generic car model
- Far-field domain geometry created automatically in iconCFD Process using Wind Tunnel Template
- Setup created in few minutes using iconCFD Process pre-processing tool to export all required input files
  - All soiling properties and files created automatically from few input parameters
- Mesh ~12 millions cells generated using iconHexMesh
- Steady-state (RANS with Spalart-Allmaras turbulence model) and transient (using IDDES-SA) flow solved using iconCloudPisoFoam solver (without surface film) and iconCloudFilmPisoFoam (with surface film)



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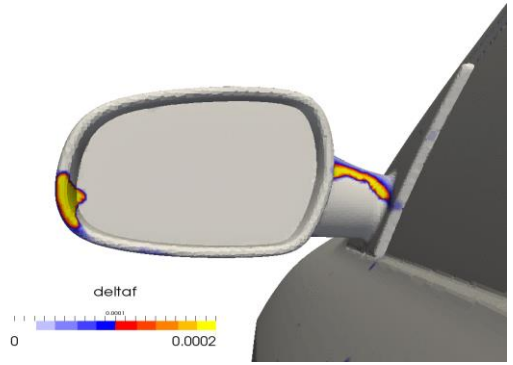
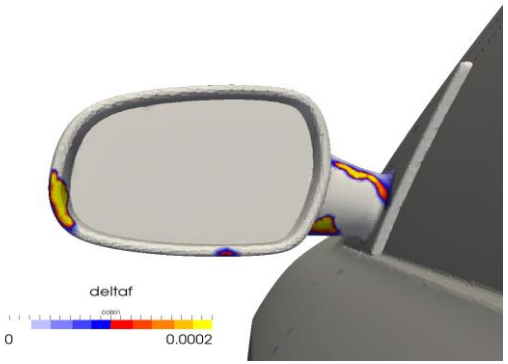
APPLICATION EXAMPLE
SOILING AND WIPER MOTION ON A SUV

- One-way coupling with surface film on wing mirror
  - Lagrangian particle modelled with frozen flow-field
  - Moving surface film



Film Development on Wing Mirror using One-Way Coupling with DES

- Two-way coupling (with DES) with surface film on wing mirror
  - Momentum is transferred from Lagrangian phase to Eulerian phase
  - Moving surface film



Film Development on Wing Mirror using Two-Way Coupling with DES

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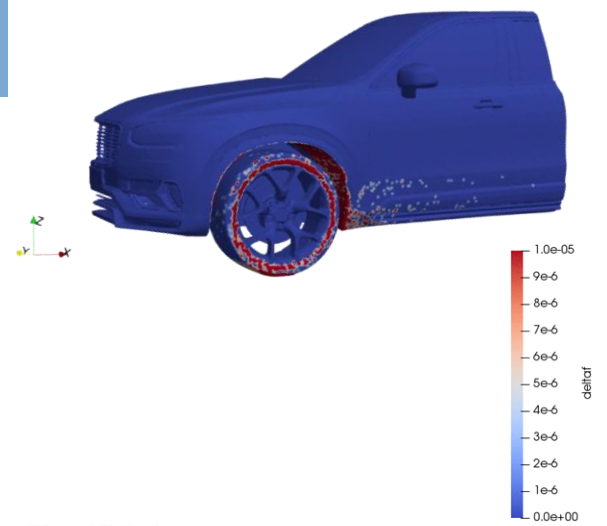
APPLICATION EXAMPLE

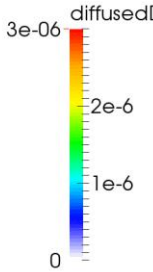
SOILING AND WIPER MOTION ON A SUV

- Self-soiling modelled using particle injection models (e.g. cone injection) applied at specific locations (e.g. front/rear wheels)
  - Particle cloud solver (e.g. iconCloudPisoFoam) used to monitor deposition of particles on nearby patches
- Wheel & tire treatment using MRF

Self-Soiling simulation with particle injection applied at front wheel



Time = 0.05 Sec.



Self-Soiling simulation with particle injection applied at rear wheel

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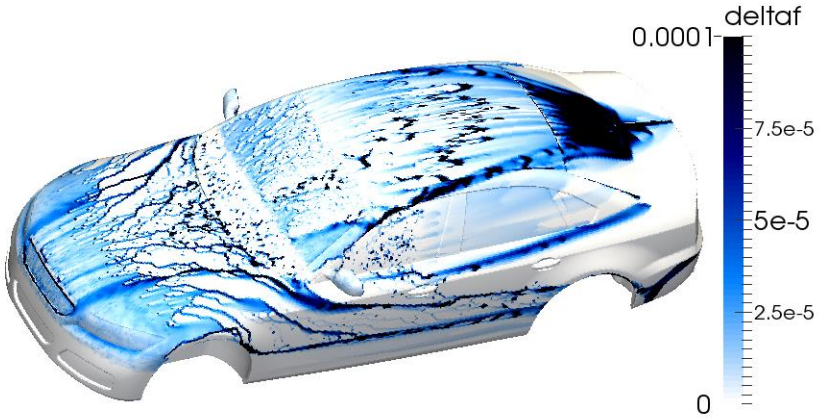
APPLICATION EXAMPLE
SOILING AND WIPER MOTION ON A SUV

- Wiper Modelling

Wiper motion

- Also possible to do with iconCFD L2P:
  - Full vehicle soiling simulation with improvements to creating film region mesh
  - Particle soiling simulation on sub-domain



Full vehicle film region

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Application Example

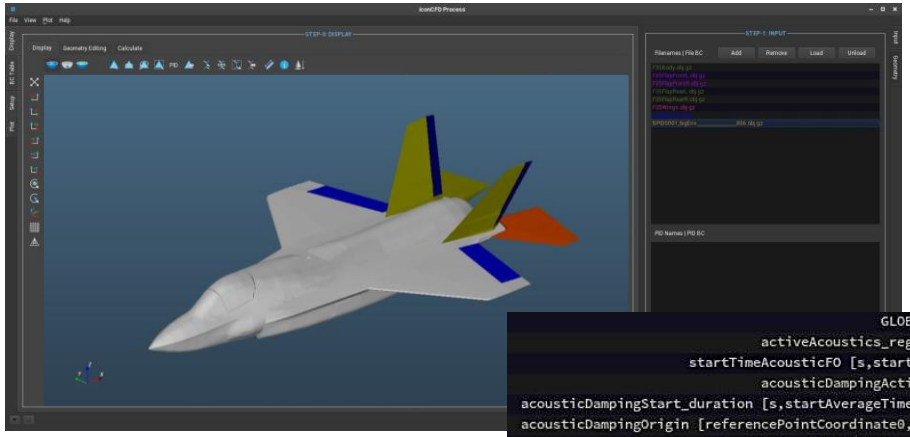
Acoustic Noise Modelling on a F-35 Aircraft with iconCFD

[iconCFD Process, iconCFD Mesh, iconCFD Thermal, iconCFD Acoustic]

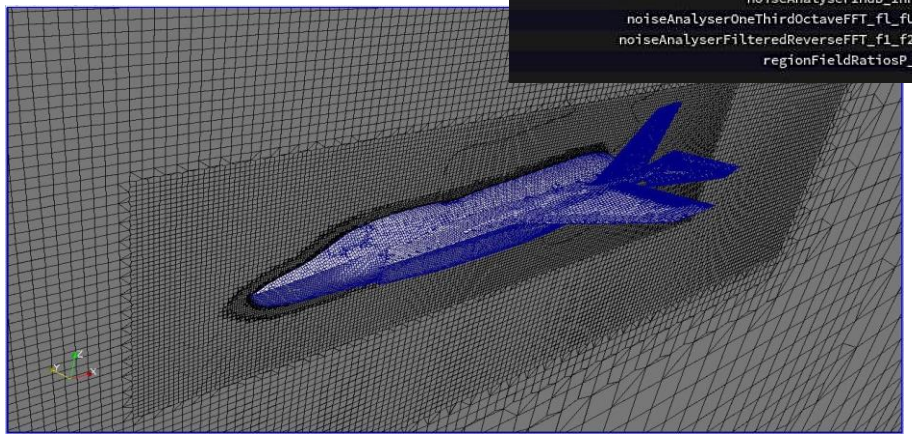
APPLICATION EXAMPLE

ACOUSTIC NOISE MODELLING ON A F35 AIRCRAFT

- Far-field domain geometry created automatically in iconCFD Process using Wind Tunnel Template
- Setup created in few minutes using iconCFD Process pre-processing tool to export all required input files
  - All acoustic properties and files created automatically from few input parameters
- Mesh ~1.8 million cells generated using iconHexMesh
- RANS, transient, compressible flow solved using iconHotRhoPisoFoam solver with Spalart-Allmaras turbulence model



```
GLOBAL_acoustics
activeAcoustics_region [1,0][x] 1
startTimeAcousticFO [s,startAverageTime] startAverageTime
acousticDampingActivation [1,0] 1
acousticDampingStart_duration [s,startAverageTime][s,endTime] startAverageTime endTime
acousticDampingOrigin [referencePointCoordinate0,m][m,-][m,-] referencePointCoordinate0
acousticDampingRadius1_radius2 [m][m] 20 50
noiseAnalyserIndB_InPa [1,0][1,0] 1 1
noiseAnalyserOneThirdOctaveFFT_f1_fU [1,0][x][x] 1 20 1e3
noiseAnalyserFilteredReverseFFT_f1_f2 [1,0][x][x] 1 20 1e3
regionFieldRatiosP_T [1,x][1,x] 1 1
```



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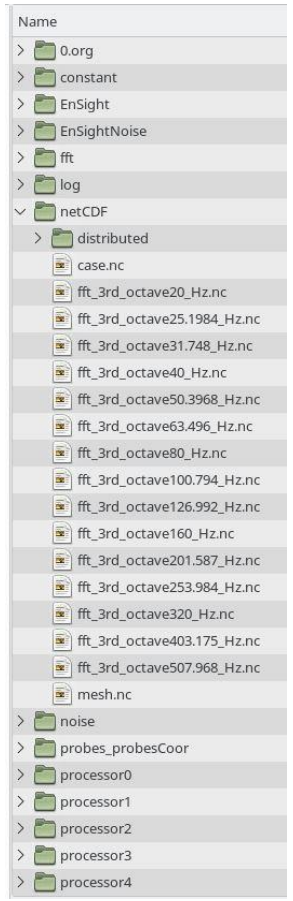
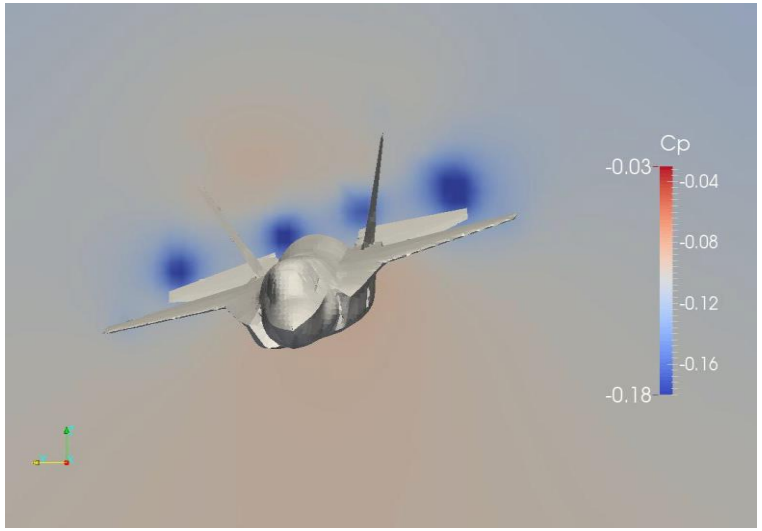
APPLICATION EXAMPLE

ACOUSTIC NOISE MODELLING ON A F35 AIRCRAFT

- Non-reflecting wave boundary conditions applied to mitigate spurious acoustic pressure fluctuations
- Acoustic damping applied using acousticDampingSource function object
- Compact output of multiple time dumps into monolithic netCDF file format for each processor directory using netCDFDumpTime function object





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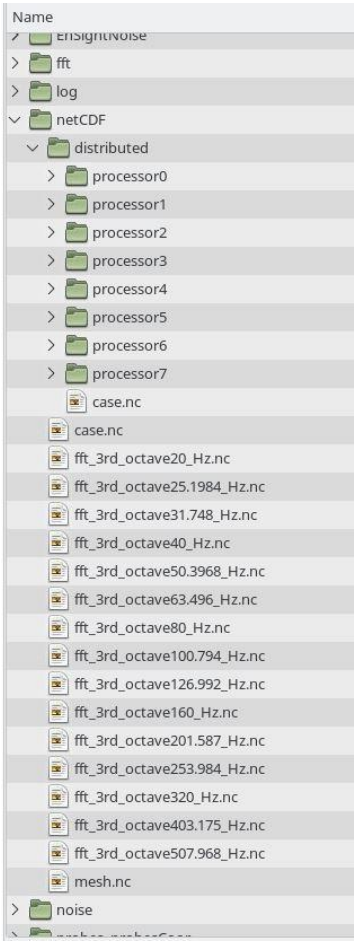
APPLICATION EXAMPLE

ACOUSTIC NOISE MODELLING ON A F35 AIRCRAFT

- FFT analysis performed using iconNoiseAnalyser utility in iconCFD Acoustic
  - SPL
  - 1/3rd octave bands
- SPL dB maps can be visualised using specially developed netCDF plugin for EnSight
- Support for distributed file systems for reconstructing netCDF data into single folder to facilitate retrieving from remote cluster



Surface FFT with 1/3 octave bands

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Application Example

Validation of Hammerhead Launch Vehicles and Basic Finner Projectile at Transonic Speeds with iconCFD

[iconCFD Mesh, iconCFD Transonic]

Application Example

报告来源：2019年IDAJ中国CAE/MBD技术大会

VALIDATION OF HAMMERHEAD LAUNCH VEHICLES AT TRANSONIC SPEEDS

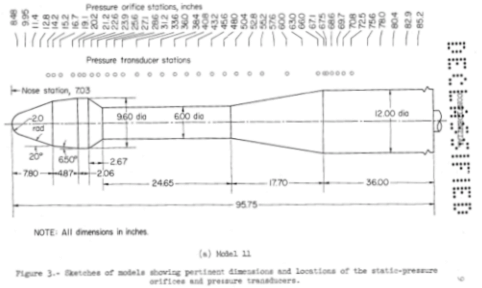
- Model 11 of the NASA Tech Memo X778

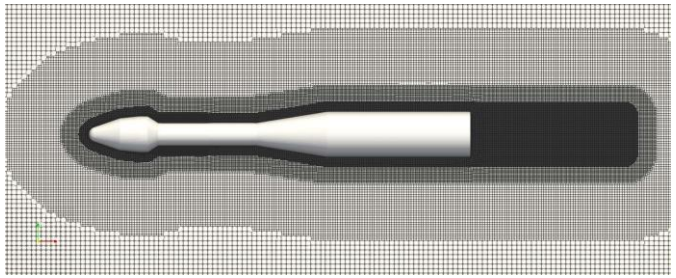
  Ref.

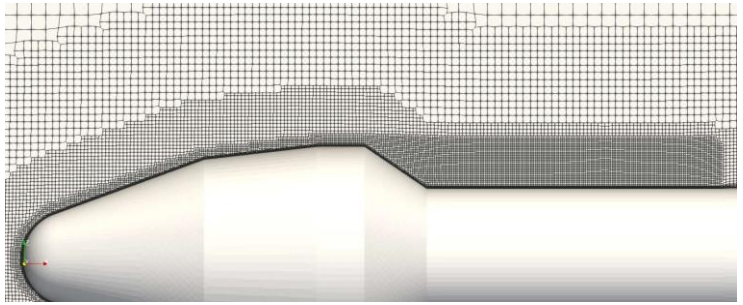
  “Steady and fluctuating pressures at transonic speeds on hammerhead launch vehicles” NASA -1962

- Half-domain model containing ~5 million cells meshed with iconHexMesh

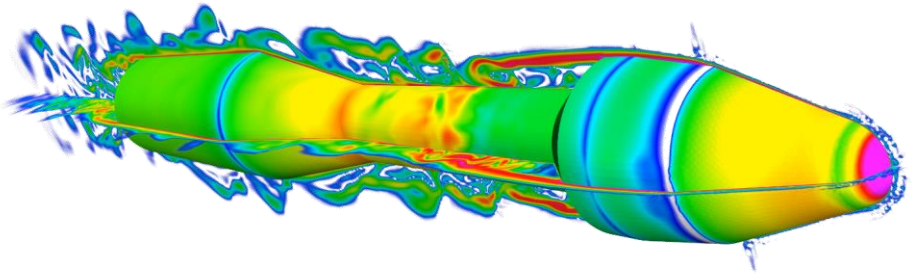
- CFD results obtained with iconTransonicFoam at Mach 0.8 & Mach 1.17 at different angles of incidence







Half-domain
~5 million cells

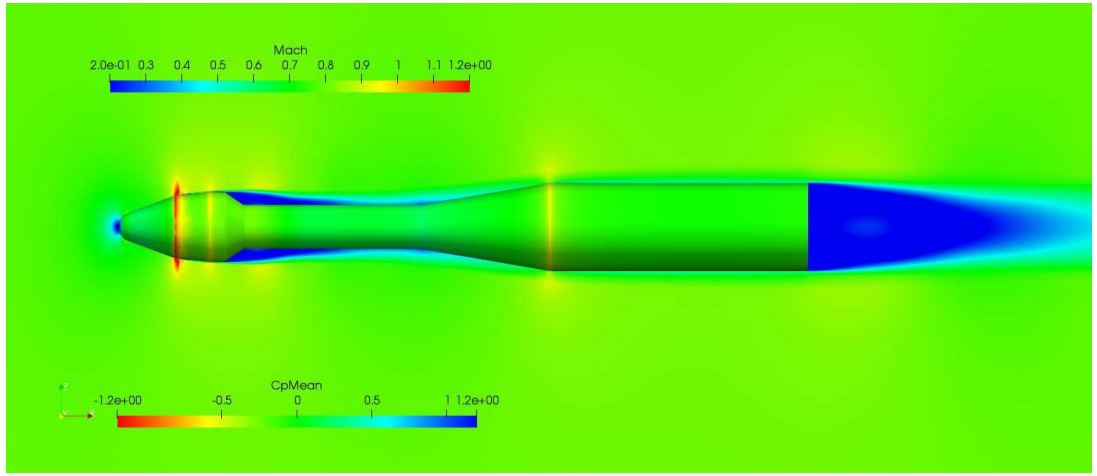


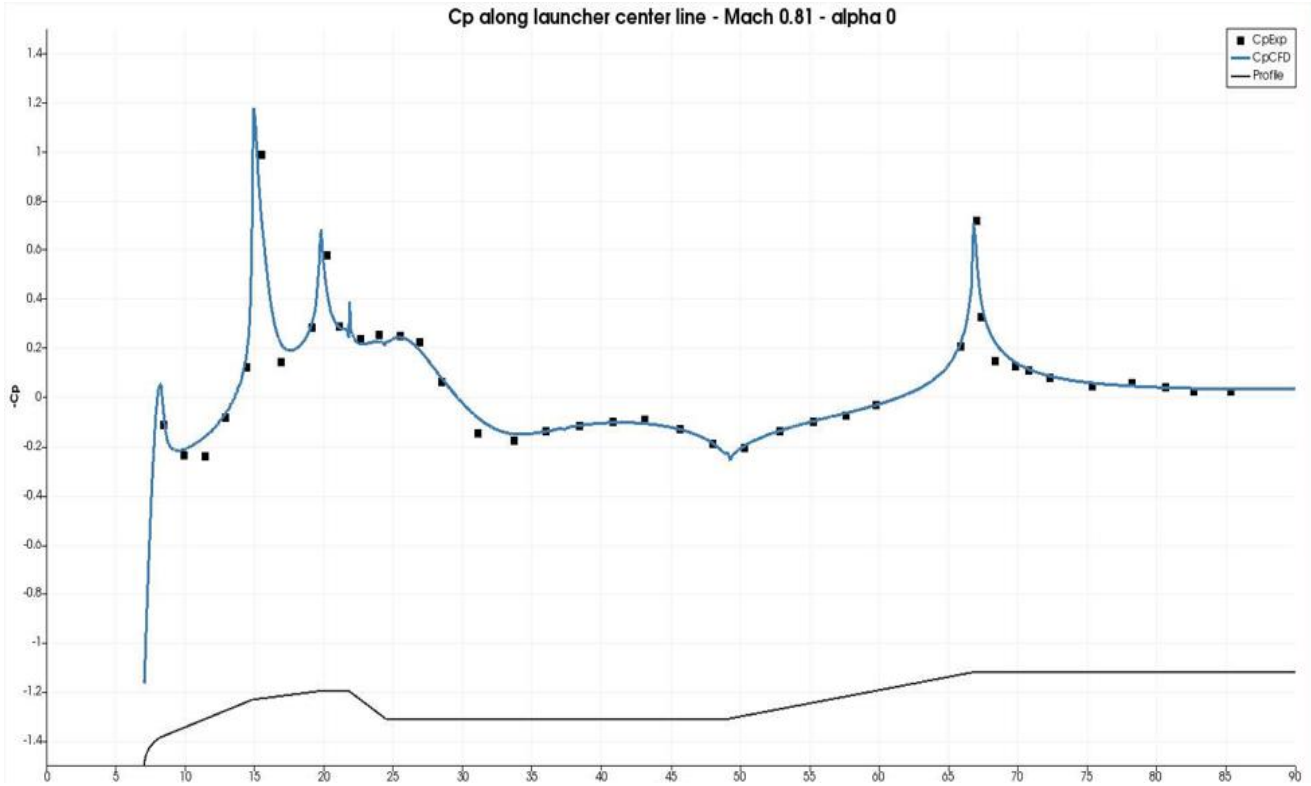
Application Example

报告来源：2019年IDAJ中国CAE/MBD技术大会

VALIDATION OF HAMMERHEAD LAUNCH VEHICLES AT TRANSONIC SPEEDS

M = 0.8, α = 0º. Mach in volume, Cp on surface.



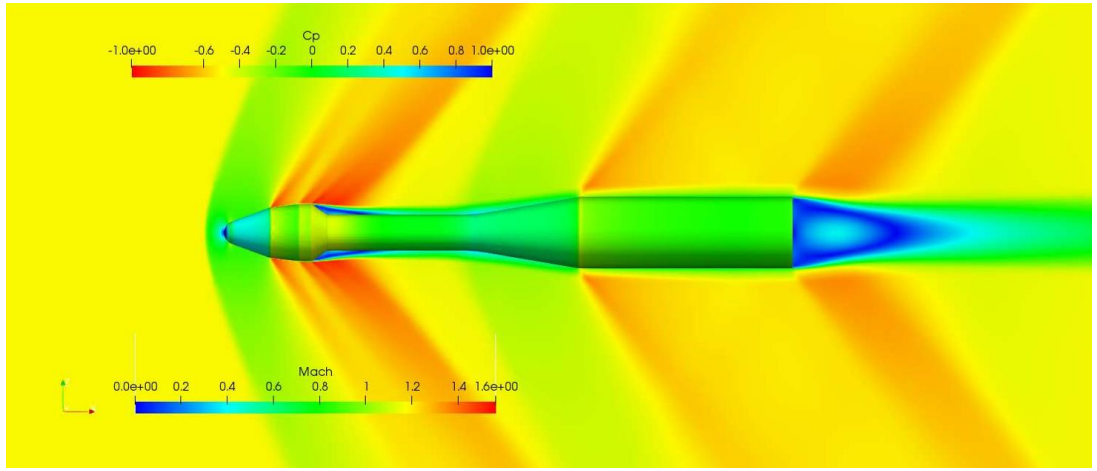


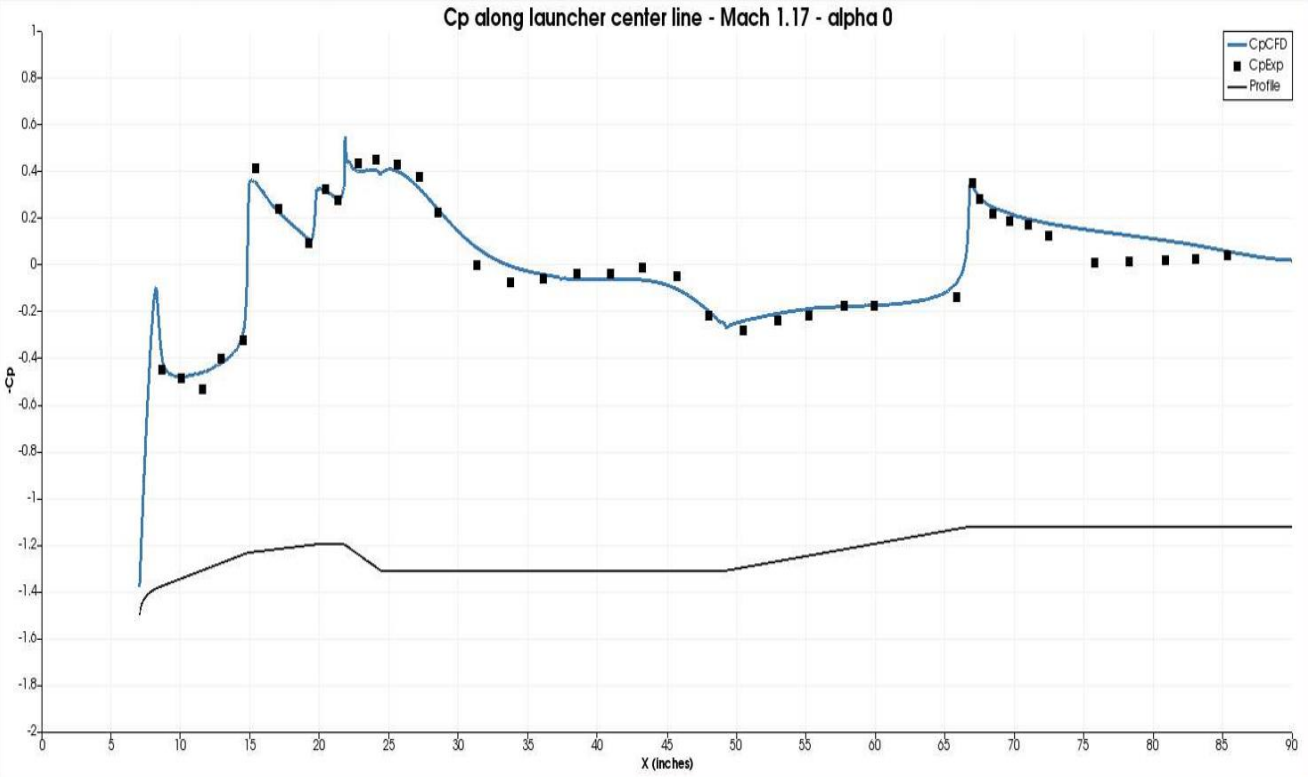
Application Example

报告来源：2019年IDAJ中国CAE/MBD技术大会

VALIDATION OF HAMMERHEAD LAUNCH VEHICLES AT TRANSONIC SPEEDS

M = 1.17, α = 0º. Mach in volume, Cp on surface.



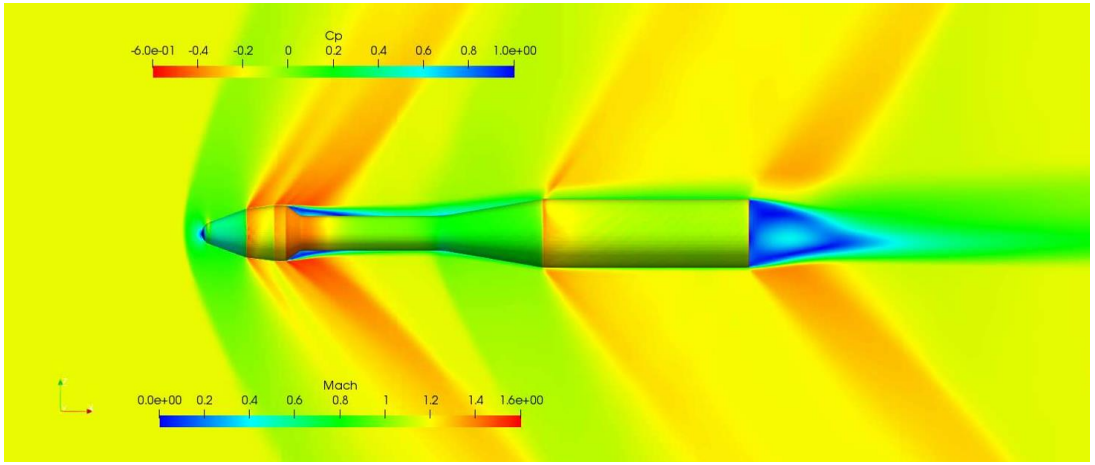


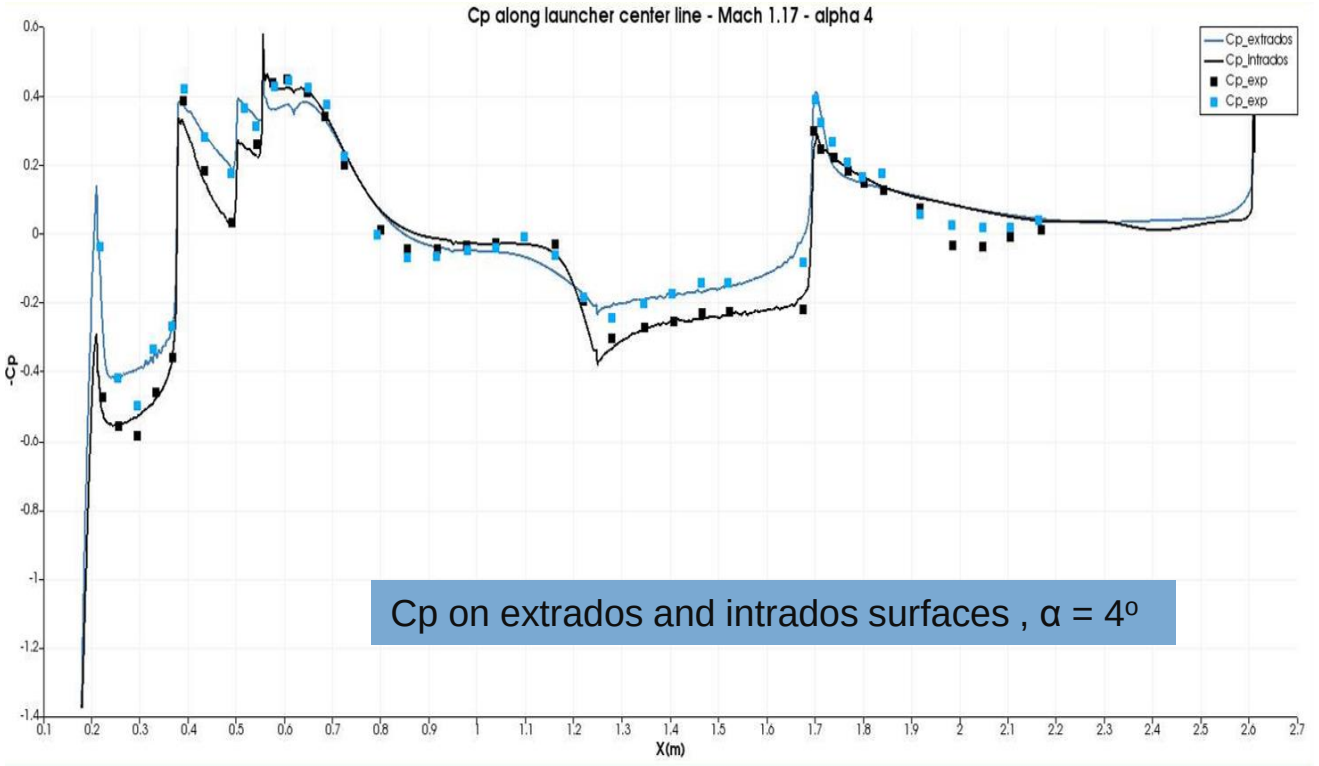
Application Example

报告来源：2019年IDAJ中国CAE/MBD技术大会

VALIDATION OF HAMMERHEAD LAUNCH VEHICLES AT TRANSONIC SPEEDS

M = 1.17, α = 4º. Mach in volume, Cp on surface.





Cp on extrados and intrados surfaces , α = 4º

Application Example

报告来源：2019年IDAJ中国CAE/MBD技术大会

VALIDATION OF BASIC FINNER PROJECTILE AT TRANSONIC SPEEDS

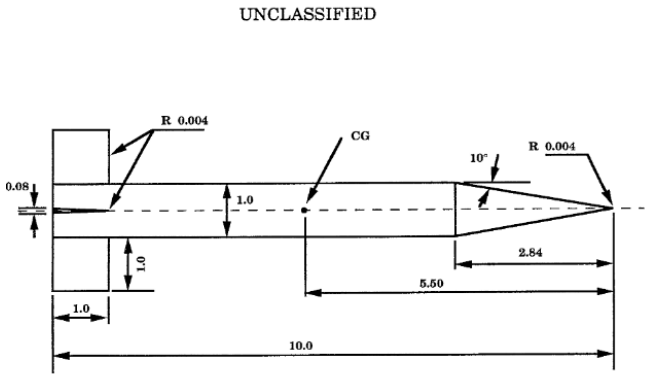
- Basic projectile with fins

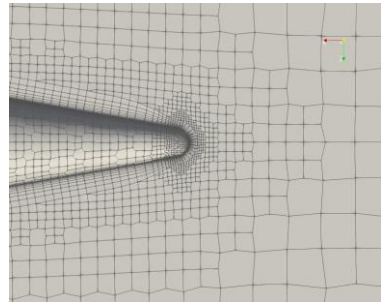
Ref.

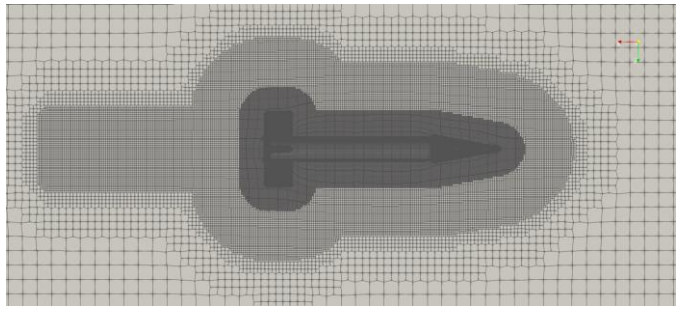
"Aerobalistic range tests of the basic finner reference projectile at supersonic velocities" A.D.Dupuis et Al. 1997

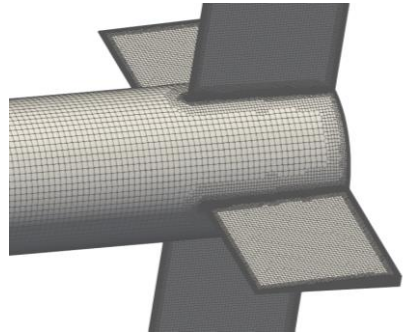
- Simulations intended to complement the validation of iconCFD Transonic in the supersonic range up to Mach 5

- Domain model containing ~5 million cells meshed with iconHexMesh









Domain ~5 million cells

Application Example

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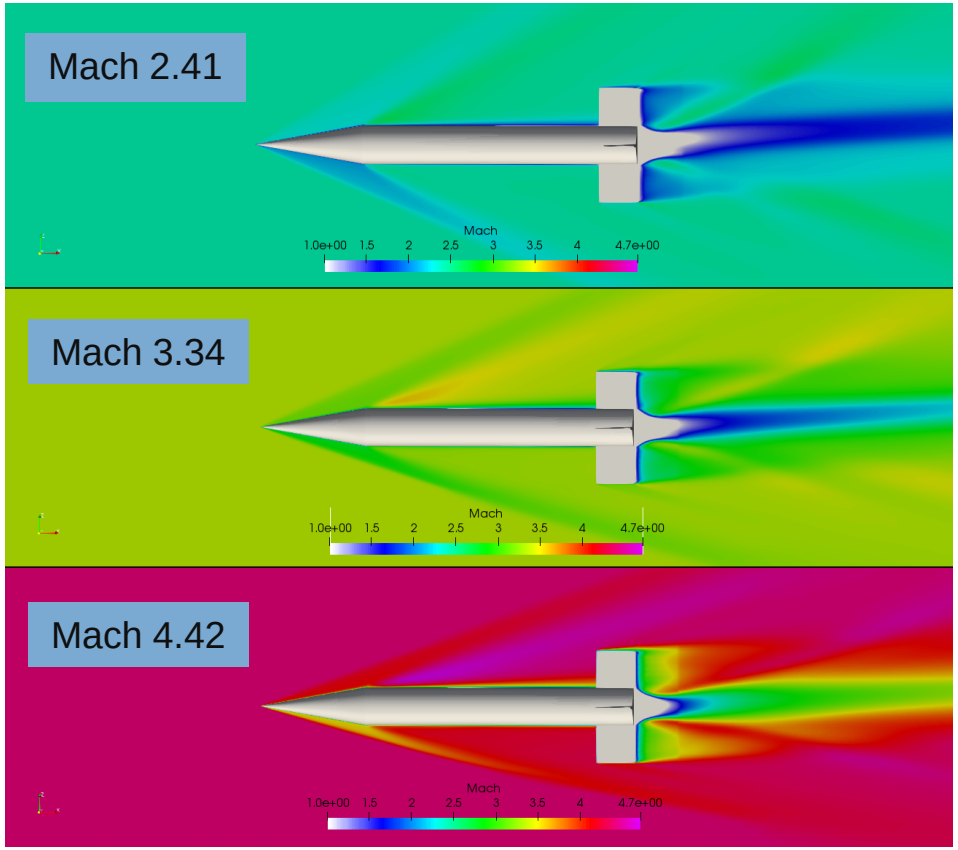
VALIDATION OF BASIC FINNER PROJECTILE AT TRANSONIC SPEEDS

- CFD results obtained with iconTransonicFoam covering 3 Mach numbers (2.4, 3.3, 4.4)



M = 2.41 to 4.42, α = 5º. Mach in volume

Application Example

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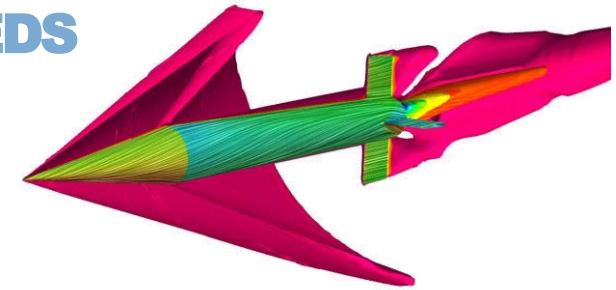
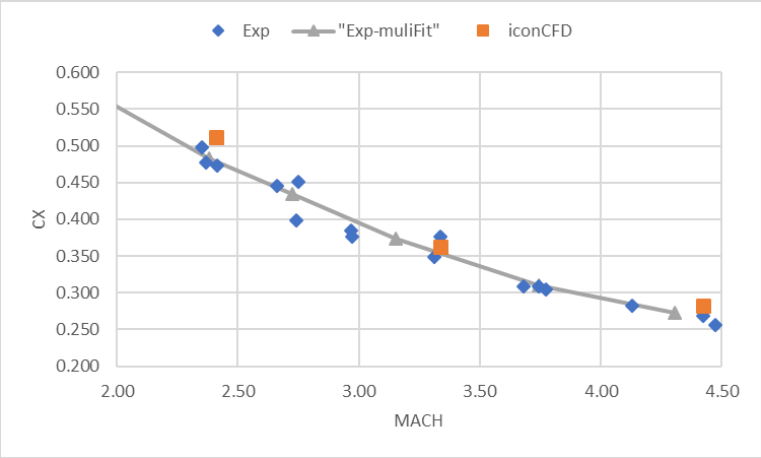
VALIDATION OF BASIC FINNER PROJECTILE AT TRANSONIC SPEEDS

- Good comparison with experimental data across the investigated range

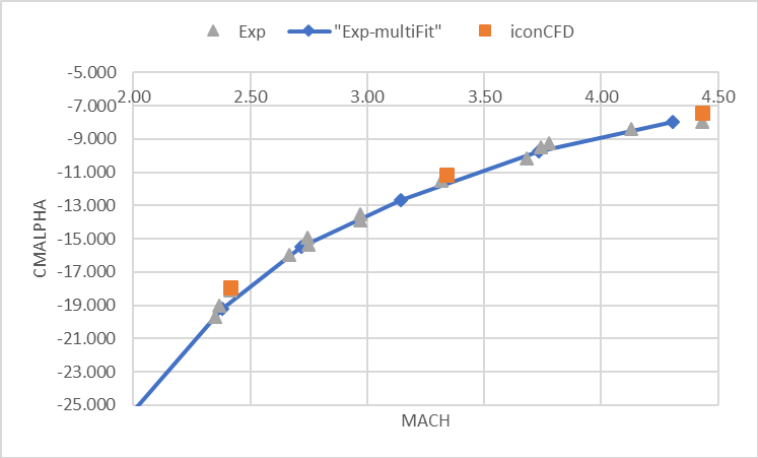


Drag coefficient Cx = f(Mach)



Lift coefficient dCz/dα = f(Mach)

Pitch moment coefficient dCm/dα = f(Mach)



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