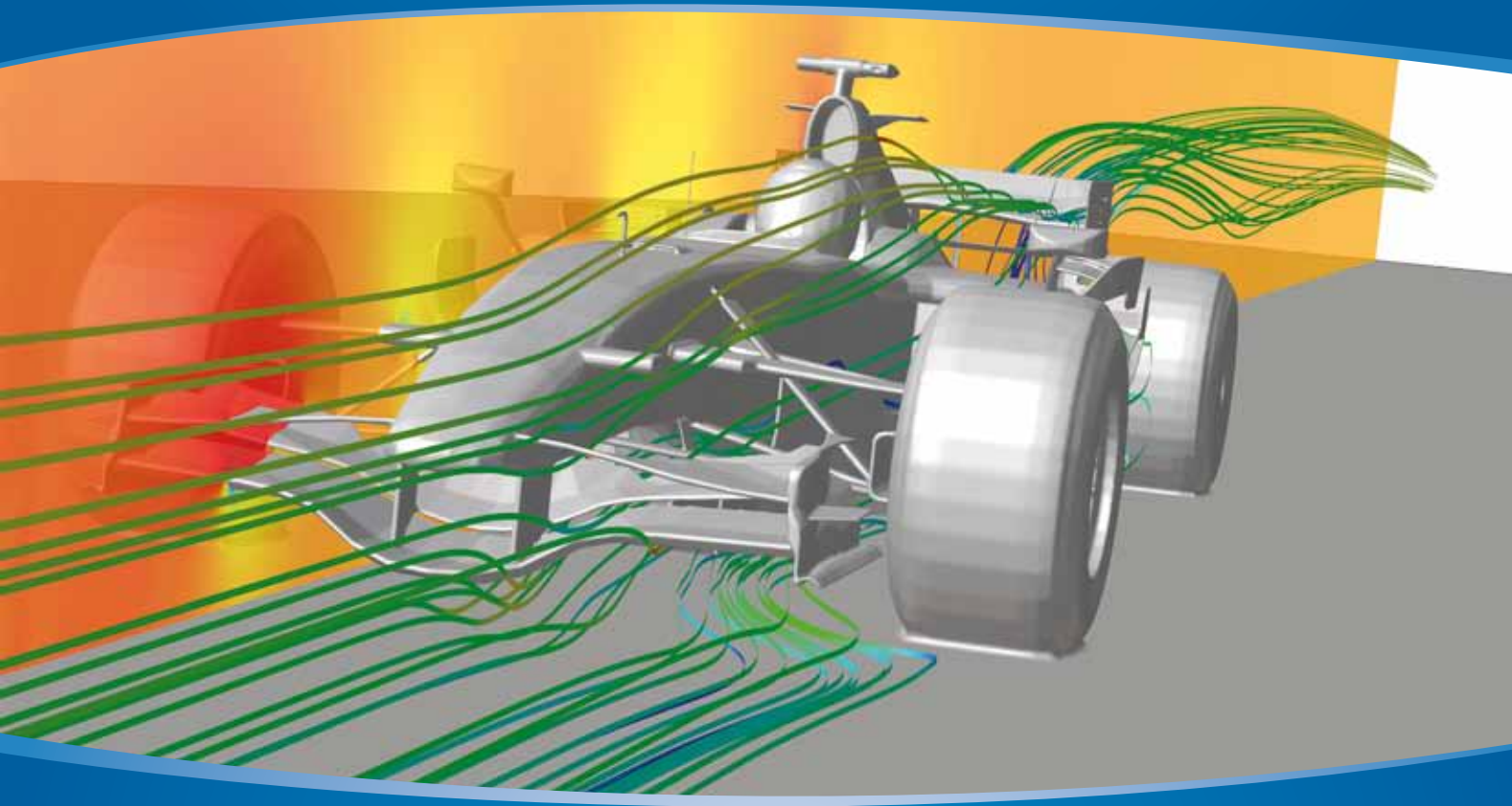
NUMECA INTERNATIONAL

NUMECA CFD Solution for the **Automotive Industry**

FINE™ / Hexa



A new wave in fluid dynamics

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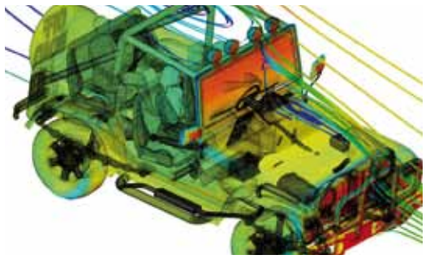
NUMECA CFD Solution for the **Automotive Industry**

Increase your productivity by one order of magnitude!

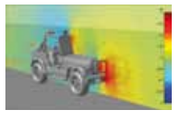
Breakthrough in full automatic meshing with HEXPRESS™/Hybrid

- NO CAD cleaning required
- Parallel meshing
- Full edge capturing



Breakthrough in CFD solution with FINE™/Hexa

- Full Second Order Accurate solution
- Agglomeration multigrid
- CPU Booster



From CAD to mesh to a full second order solution in hours instead of weeks!

NUMECA Software Environments

FINE™/Hexa is a NUMECA Flow Integrated Environment dedicated to the automotive industry, covering a large range of applications from car aerodynamics, undercarriage, underhood, HVAC, etc
FINE™/Hexa integrates full hex or hex dominant grid generators, powerful and fast second order Navier-Stokes solver and an embedded interactive and macro-based visualization system for full qualitative and quantitative CFD analysis.

- For simulations of parts of a car or simple car configurations, we propose HEXPRESS™ as a preprocessor, which generates high quality full hexahedral non-conformal meshes.
- For complete car configurations or very complex geometries, we propose HEXPRESS™/Hybrid, which produces hybrid conformal meshes fully parallel without any CAD repairing.

Automatic Full Hexahedral Meshing with **HEXPRESS™**

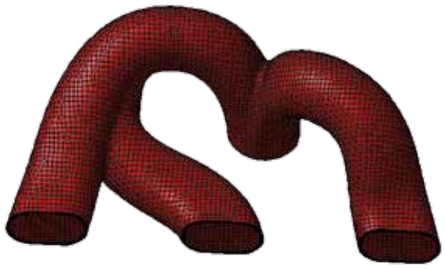
HEXPRESS™ is an automatic grid generator for complex geometries. It uses non-conformal full hexahedral unstructured technology for generating high quality meshes and captures all the edges of an arbitrary geometry.

Key features include:

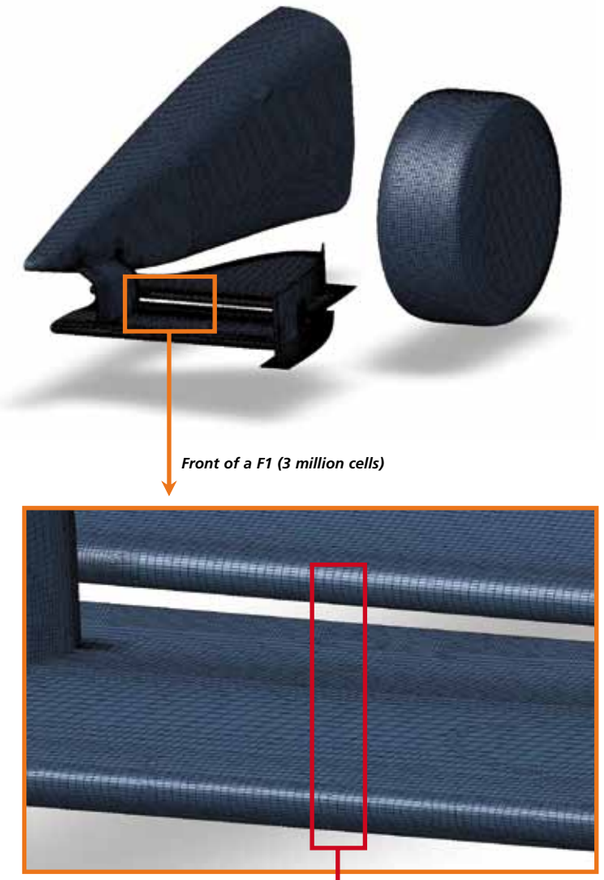
- Full Hexahedral Grids (no prism, no tetrahedra, no pyramid)
- Direct CAD import capabilities
- CAD manipulation and decomposition tools
- Mesh wizard for rapid solution set-up and easy back and forth operation
- Buffer cell and boundary layer insertion for high quality cells in boundary layer regions
- Automatic refinement procedures based on user defined sensors either next to solid walls or at specified area in the domain
- Multi domain capabilities allowing the treatment of CHT and multi-part geometry models
- Full non-matching multi-block connection, allowing multi-row turbomachinery meshing

Customization to User Specific Features

- **All commands python based and accessible through scripts**
- **Users can develop their own scripts for batch mode operation into CAE design cycle or optimization loop**

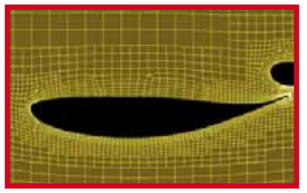


Exhaust manifold (130 000 cells)



Front of a F1 (3 million cells)

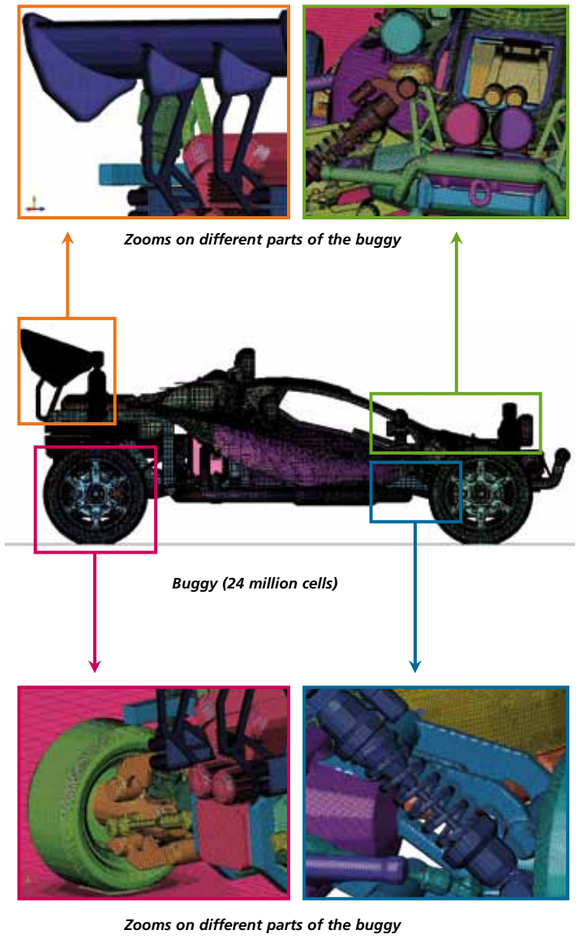
Zoom on the leading edge



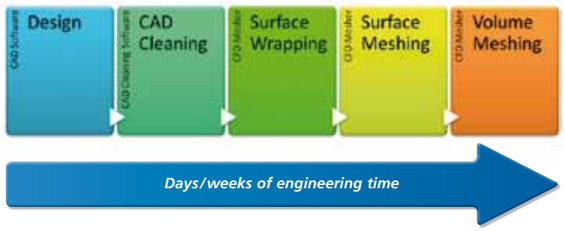
Viscous layers

Full Automatic Parallel Meshing with **HEXPRESS™ / Hybrid**

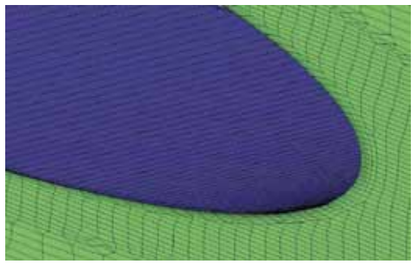
HEXPRESS™/Hybrid is a parallel grid generator with fully automatic & integrated CAD cleaning, wrapping, and meshing. HEXPRESS™/Hybrid produces conformal hex-dominant meshes in or around very complex geometries in a matter of hours.



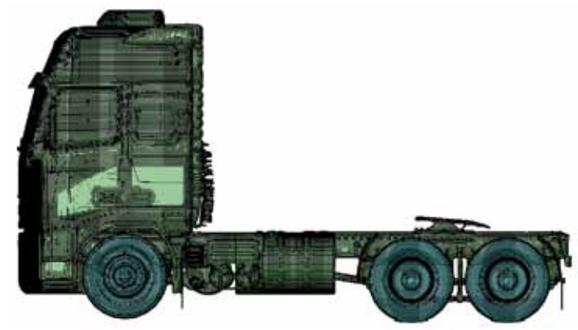
Standard Approach:



NUMECA's solution:



HEXPRESS™/Hybrid allows flexible viscous layers insertion with smooth transitions

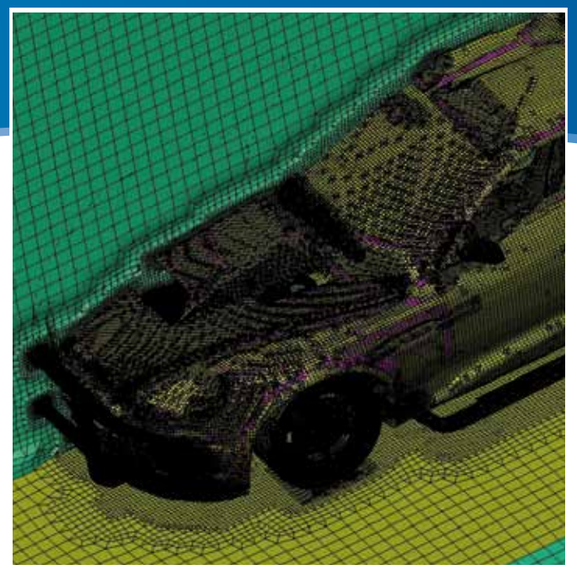


Truck (27 million cells)

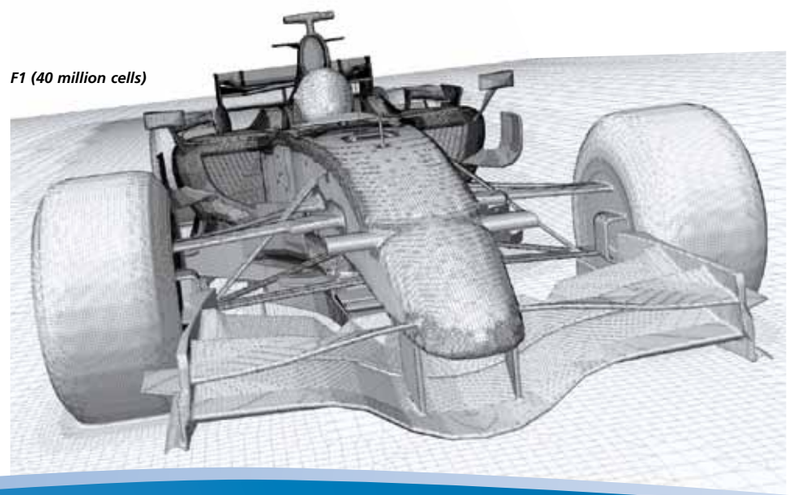
Key features include:

- Robust and integrated CAD wrapping, cleaning and hole closing
- Level of details selection, based on user selected details
- Full Parallel Meshing on shared memory computers
- Flexible insertion of viscous layers
- Default Hex-dominant meshing with option for full Tetrahedra or Hexahedra meshing
- Built-in mesh deformation engine

HEXPRESS™/Hybrid produces 40 millions cells grid a full car including underhood in 30 minutes on 8 cores, starting from unrepeared STL files.



HEXPRESS™/Hybrid allows meshing of complete car configurations…



F1 (40 million cells)

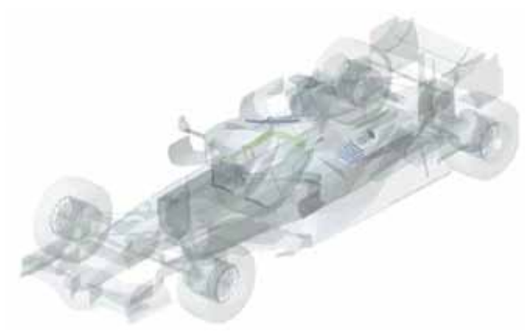
… including complex underbodies and motor blocs

Equivalent Performance: 6 minutes for 1 million cells per core!

HoleSearcher
HEXPRESS™ / Hybrid

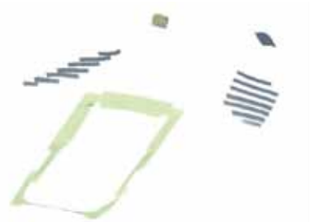
CAD repairing and cleaning can take around 50% of the engineering time in the process of doing a CFD calculation. HEXPRESS™/Hybrid automatically deals with any holes and increases your productivity by at least half an order of magnitude!

Example:
Complete car with inside, trunk, motor and underbody.



Missing features are approximated.

The initial unclean and incomplete CAD



The HoleSearcher defines the outside as cold and the inside as warm. Then, it generates a list of isothermal surfaces indicating the holes. The user can control the isothermal surfaces in the Viewer, and select the best one to close the holes.

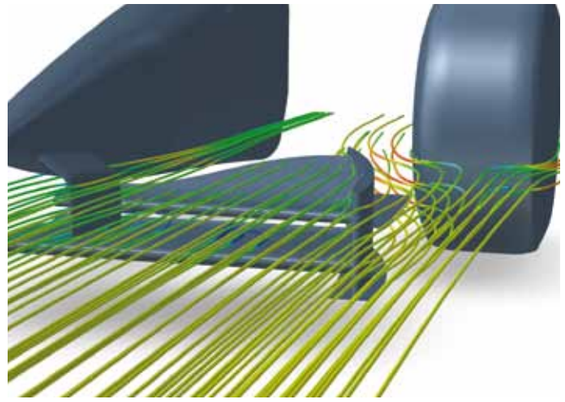
The HoleSearcher finds automatically any gaps or holes (green/blue)

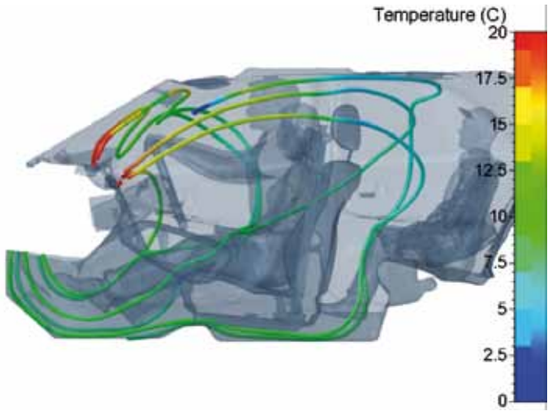
Unstructured Navier-Stokes Solver
FINE™ / Hexa

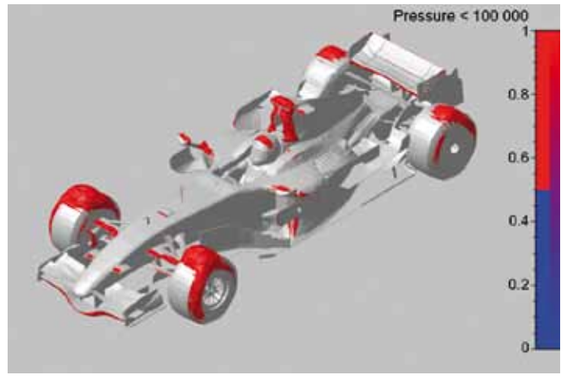
The FINE™/Hexa solver is a full second order accurate unstructured Navier-Stokes density based code with local and robust preconditioning, with extended turbulence and physical models. FINE™/Hexa can solve any flow, from incompressible to low and high speed flows. Its advanced numerical schemes, agglomeration multigrid algorithms and CPU Booster produces very fast 2nd order accurate results.

Key features include:

- Advanced density-based code with robust local pre-conditioning
- Convergence acceleration with CPU Booster and agglomeration multigrid
- Parallel computing performance based on MPI
- Wide variety of turbulence and physical models, including S-A, k-ε, k-omega and SST models with extended wall functions
- Multiphysics: porous material, combustion, radiation
- Fluid-structure interaction options
- Thermal engine for large scale conjugate heat transfer
- Rotating Reference Frames with rotor-stator interaction
- Liquid, perfect, real gases and thermodynamic table
- Possibility to model free surface flow problems based on VOF numerical approach
- Fully scriptable
- Batch or interactive GUI
- Mesh adaptation







Performance CPUBooster with **FINE™ / Hexa**

To save computation time, NUMECA introduces two advanced numeric algorithms for fast convergence:

- *Agglomeration multigrid*
- *CPU Booster which allows to run at a CFL of 1000 without extra memory cost!*

Agglomeration Multigrid

In the agglomeration multigrid, the coarse levels are generated by fusing cells with neighbors to form a coarse polyhedral control volume. This is an extremely robust method to generate coarse grid levels with an optimum ratio of 1/8, whatever the geometric complexity, at the expense of element complexity.

FINE™/Hexa allows fast convergence due to the combination of the CPUBooster with the agglomeration multigrid
***Example:** exhaust manifold (level 0 = 109 790 cells, level 1 = 19 128 cells, level 2 = 3 361 cells and level 3 = 639 cells)*

CPU Booster

The CPU Booster is a novel convergence acceleration technique allowing to run FINETM/Hexa at CFL 1000.

F1 (18 million cells)

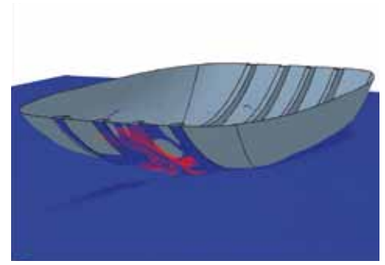
Jeep (19 million cells)

NUMECA CPU Booster combined with the agglomeration multigrid allows to run with CFL 1000 in around 50 cycles for complete car geometries! This translates in a gain of a least one order of magnitude in convergence time compared to other CFD codes!

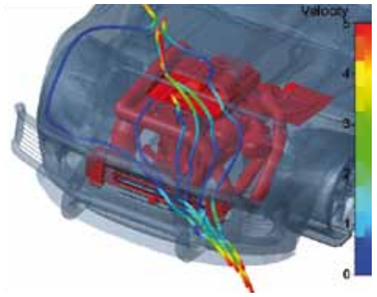
Applications **FINE™ / Hexa**

Automotive Applications:

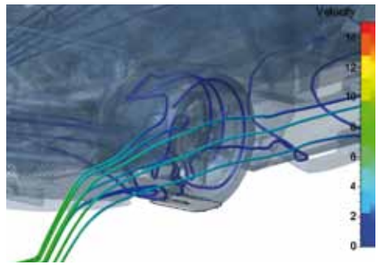
- Aerodynamics
- Brake Cooling
- Climate Control
- Engine Cooling Systems
- Engine Flow and Combustion
- Engine Thermal Management
- Exhaust Systems
- HVAC
- Internal Flow
- Manifolds
- Pumps
- Thermal Comfort
- Tires
- Underbody
- Underhood
- Etc



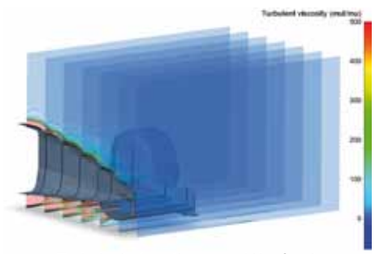
Hydroplaning simulation of a tire, employing free-surface and splash, plus particle tracking within the grooves



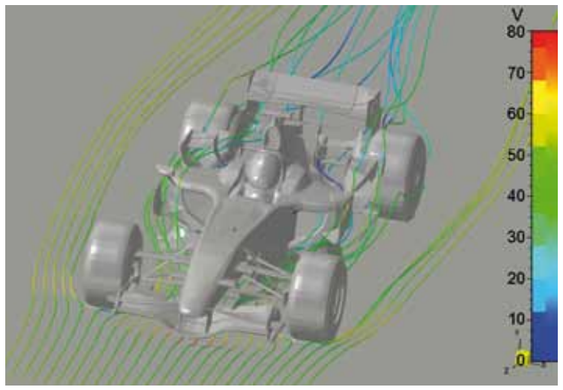
Flow over a motor bloc



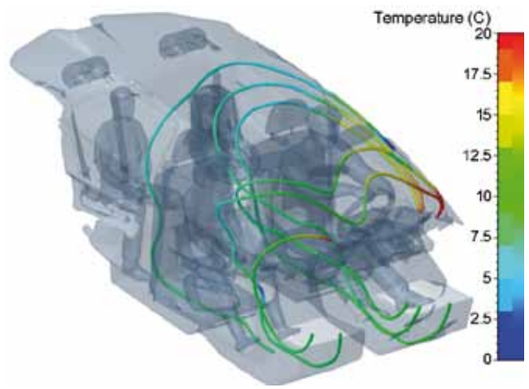
Flow around a tire



Turbulent viscosity around the front of a generic F1 car



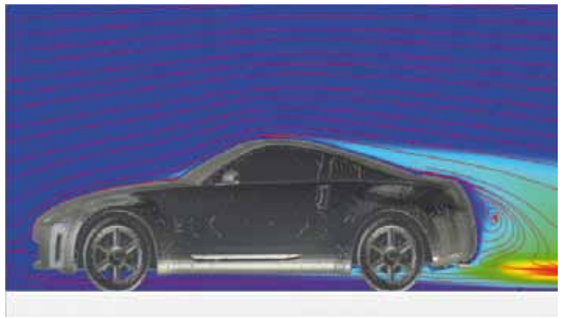
Velocity around a generic F1 car

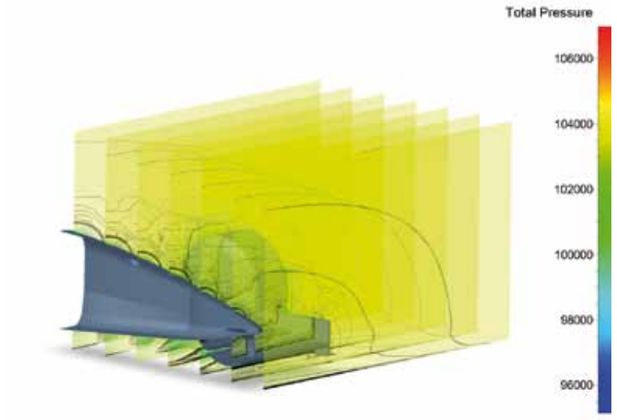


Thermal flow in a cabin

Visualization System
CFView™

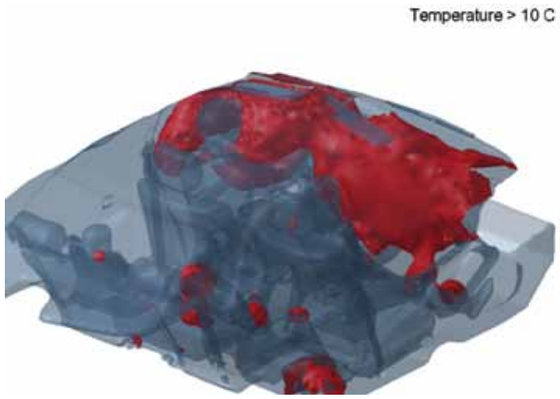
CFView™ is a visualization system offering all type of qualitative and quantitative outputs for 2D and 3D scalar or vector fields. Steady or unsteady data can be loaded, with 2D/3D steady-state or transient animations. CFView™ supports scripts for parametric visualization. Recorded templates can be used for automatic replay of saved screenshots on a new data set.

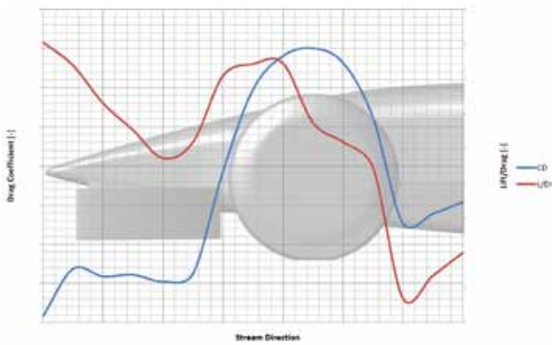




Key features include:

- Analyzing structured/unstructured and non-conformal/conformal hexahedral cases
- Steady or unsteady data
- Represent scalar and vector quantities
- Cartesian plots
- Contour plots
- (Animated) streamlines
- Animations
- Computing derived quantities
- Fully scriptable (python)





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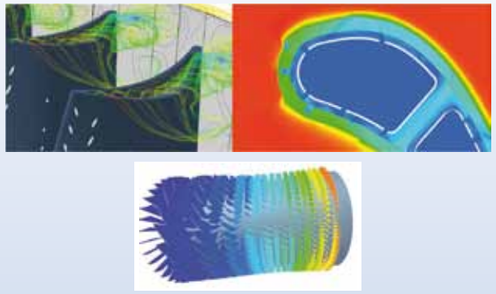
Also available at NUMECA :

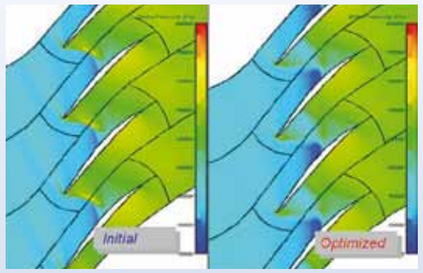
FINE™/Turbo:

FINE™/Turbo is a Flow Integrated Environment available for the simulation of internal, rotating and turbomachinery flows.



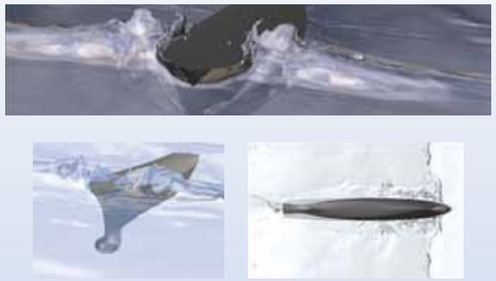
FINE™/Design3D:

FINE™/Design3D is a Flow Integrated Environment for the design and optimization of rotating and turbomachinery blades.



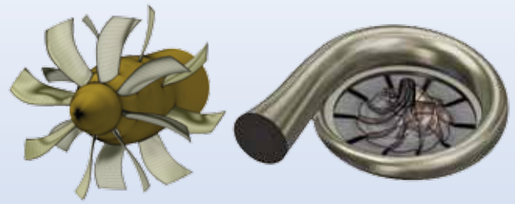
FINE™/Marine:

FINE™/Marine is a Flow Integrated Environment offering high accuracy flow stimulation for marine applications, such as ships, boats, yachts, containers...



AutoMes-4G™:

The new AutoMesh-4G NUMECA product covers the full market for grid generation, whatever the kind of applications (Turbomachinery, Automotive, Marine, etc), whatever the complexity or the characteristics of the mesh needed (Unstructured, Structured, Non-Conformal, Conformal, Full Hex, Hybrid, etc).



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