Under-hood Thermal Protection Coupling with HELYX/ELEMENTS

Sacha Jelić (ThermoAnalytics),

Salvatore Renda (Engys)

July 16th 2020

Overview

- Introduction
  - About ENGYS
  - About ThermoAnalytics
  - Coupling Methodology and Applications
- Coupling Workflow in CoTherm
- Case-study DrivAer vehicle
  - Methodology and Setup
  - Results
- Conclusions

About ENGYS | The Company

- Global providers of CFD products and services
- Founded in the UK (2009), celebrating 10 years
- Focus on enabling open-source software in industry
  - FOAM/OpenFOAM developers since 1999
- 7 offices worldwide
  - UK, Germany, Italy, USA, Australia, RSA, Brazil
- Established distributor network
  - Japan, South Korea, USA, France, Spain


About ENGYS | Products

HELYX
General-purpose, open-source CFD for enterprise

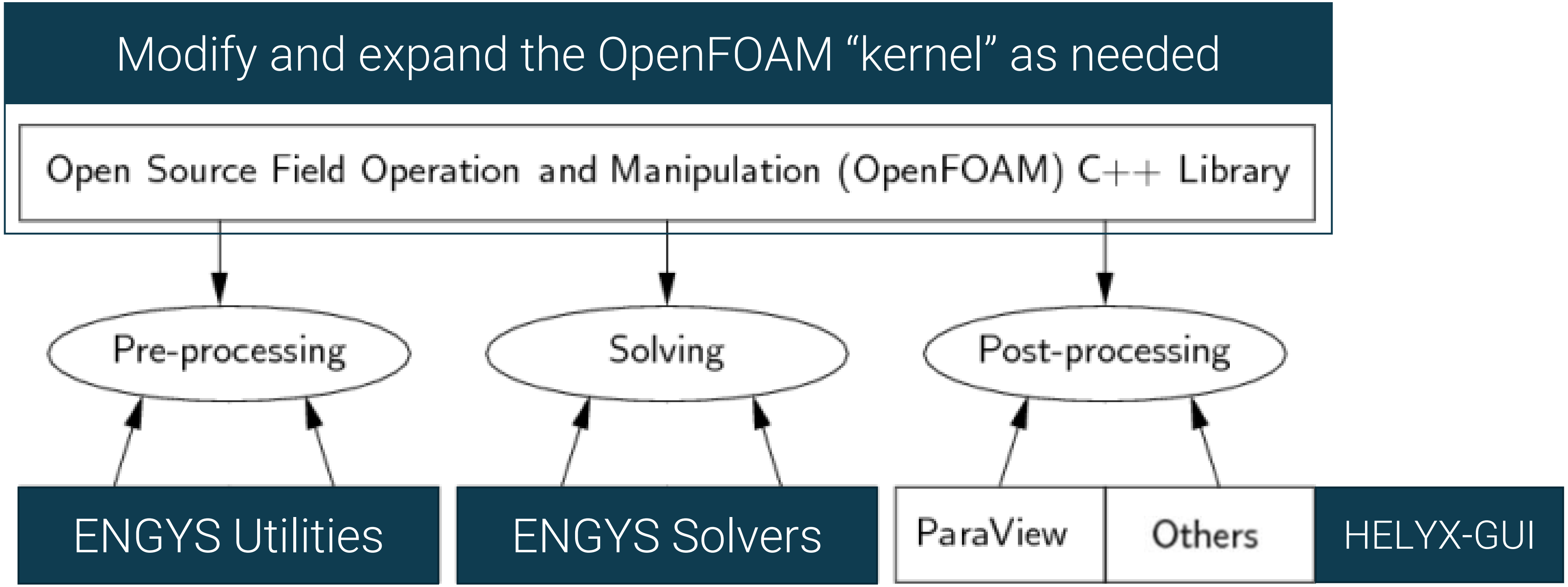
ELEMENTS
Advanced open-source CFD for automotive design

HELYX ADD-ONS
Adjoint optimisation
Block-coupled solvers
Marine hydrodynamics
Advanced multi-phase flow

HELYX-OS
Open-source GUI for standard OpenFOAM

HELYX-Core

- Over 3000 new and modified files with respect to OPENFOAM



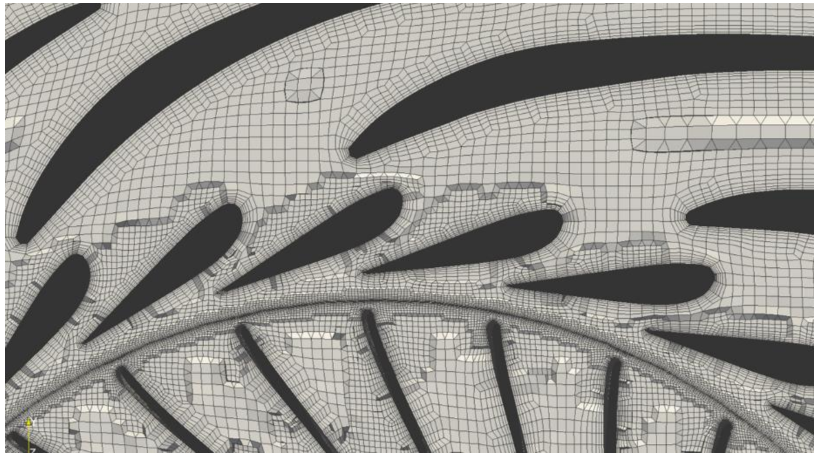
OPENFOAM® and OpenCFD® are registered trade marks of OpenCFD Ltd.

Diagram taken from: https://cfd.direct/openfoam/

About ENGYS | Innovations

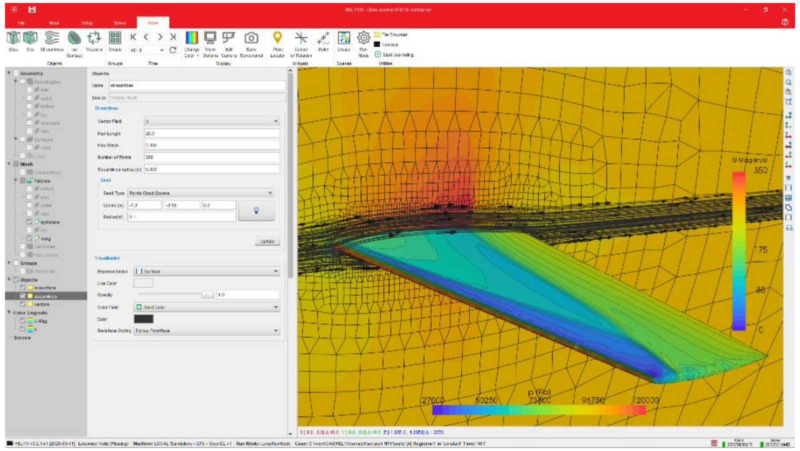
Adjoint Optimization

- Improve flow control
- Reduce energy consumption
- Improve performance



Hex-Dominant Meshing

- Robust and Scalable
- Suitable for complex geometries
- Included in software

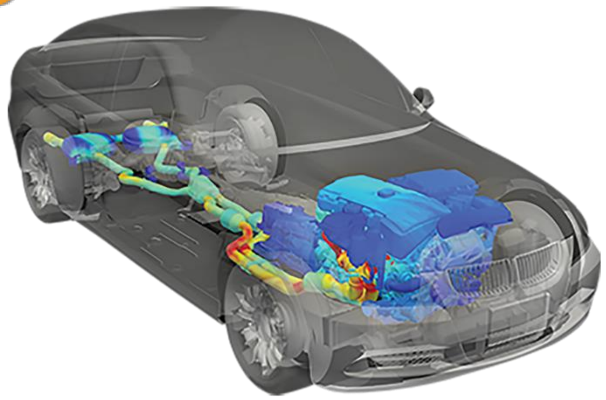


HELYX/ELEMENTS GUI

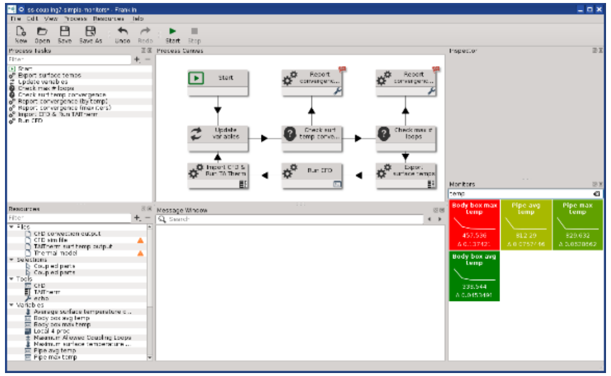
- Reduce complexity
- Increase productivity
- Streamline analysis

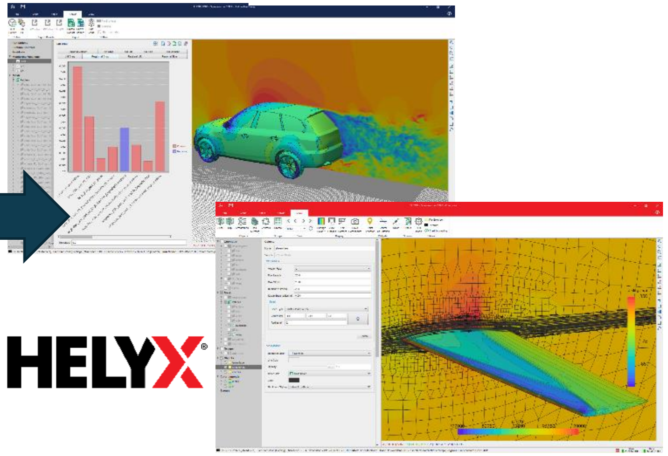
About ThermoAnalytics

TAITherm

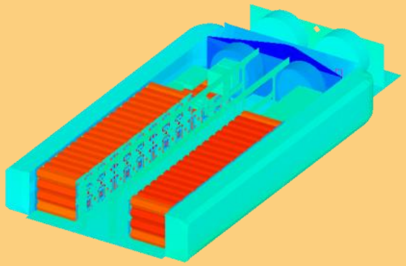


CoTherm

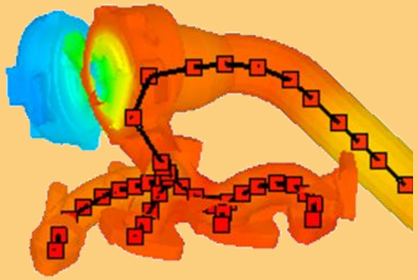




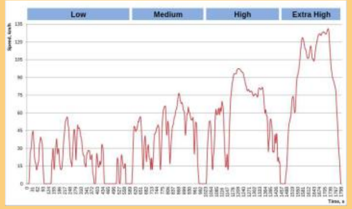
Battery Extension



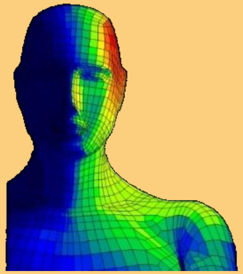
Exhaust Extension



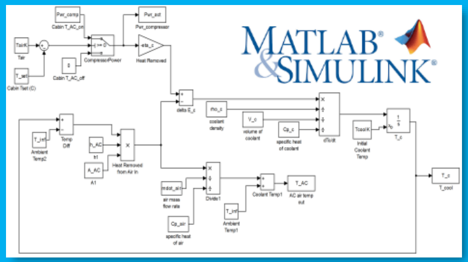
Drive Cycle Extension



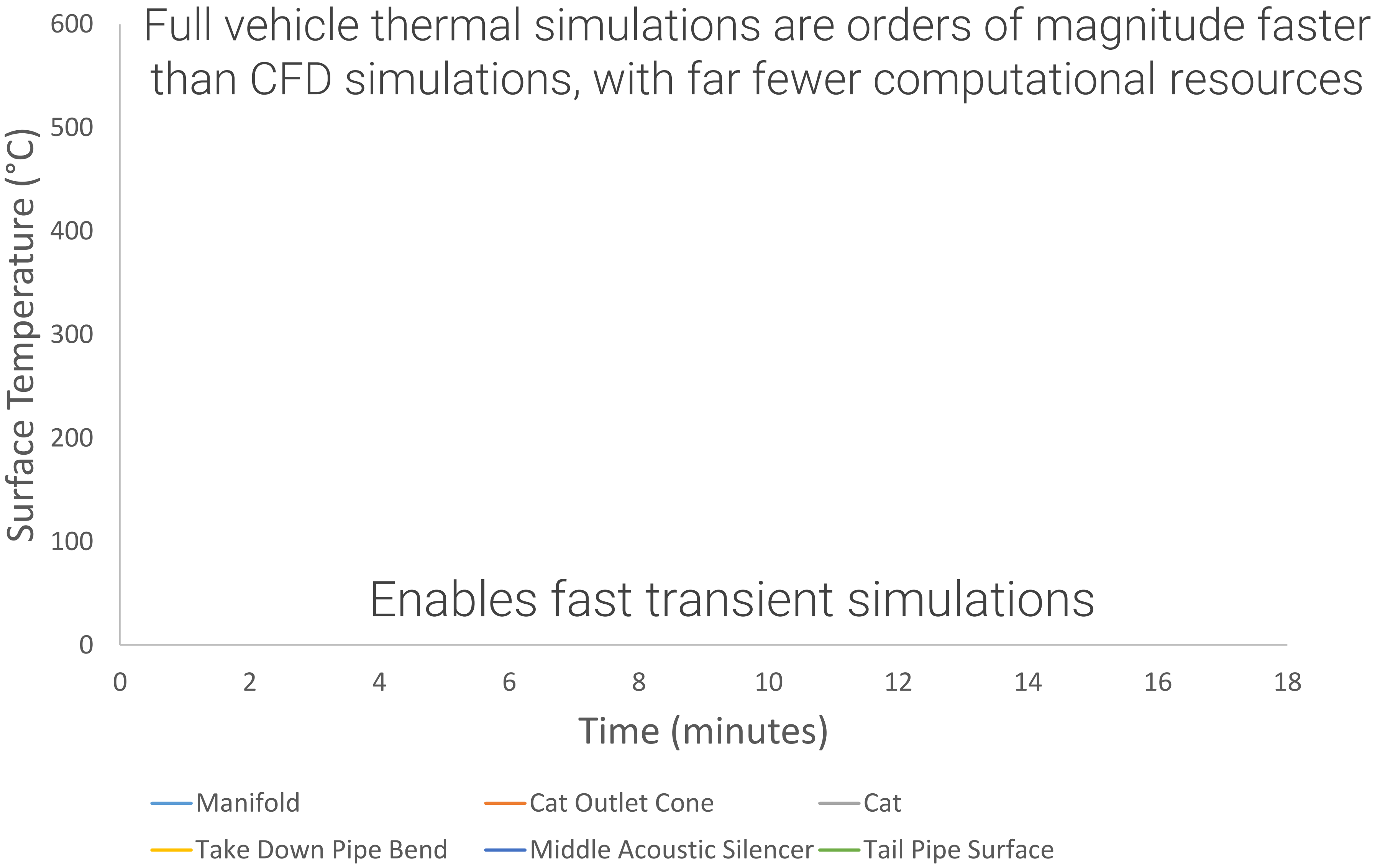
Human Comfort Extension



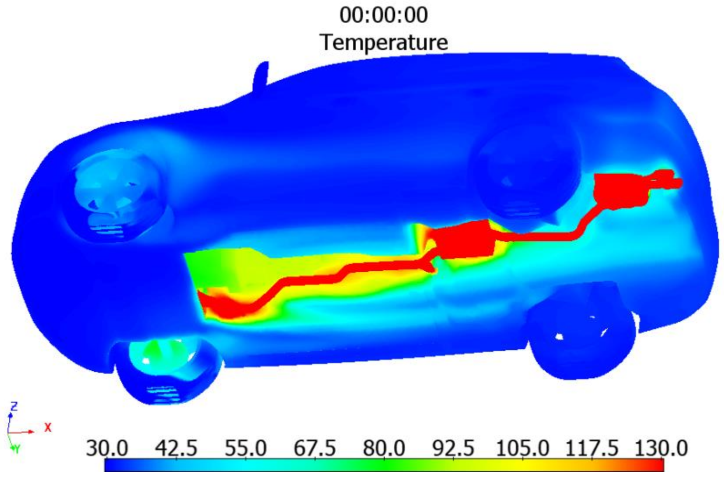
1D System Tool

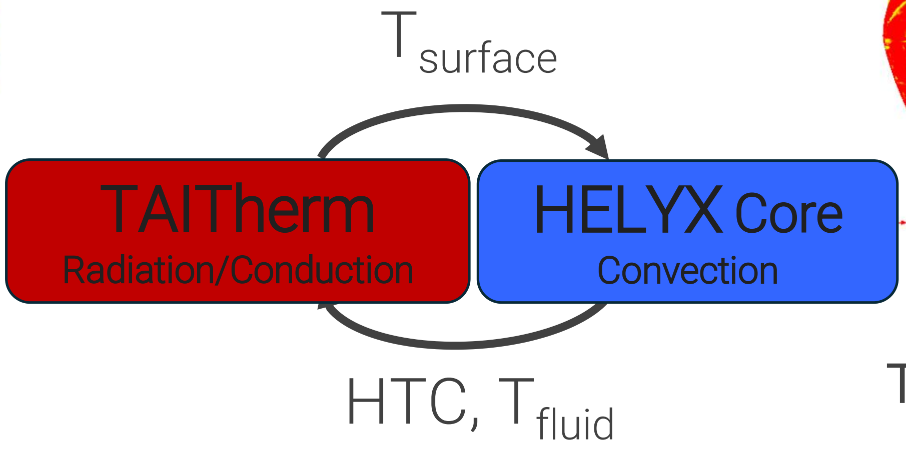


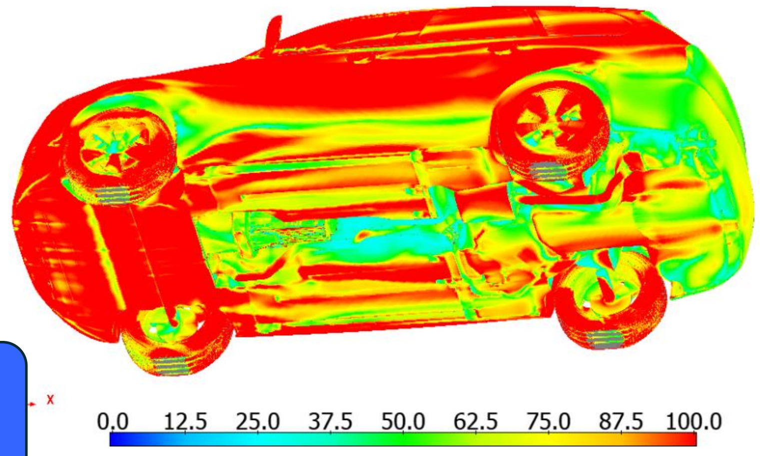
About ThermoAnalytics



Coupling Methodology and Applications





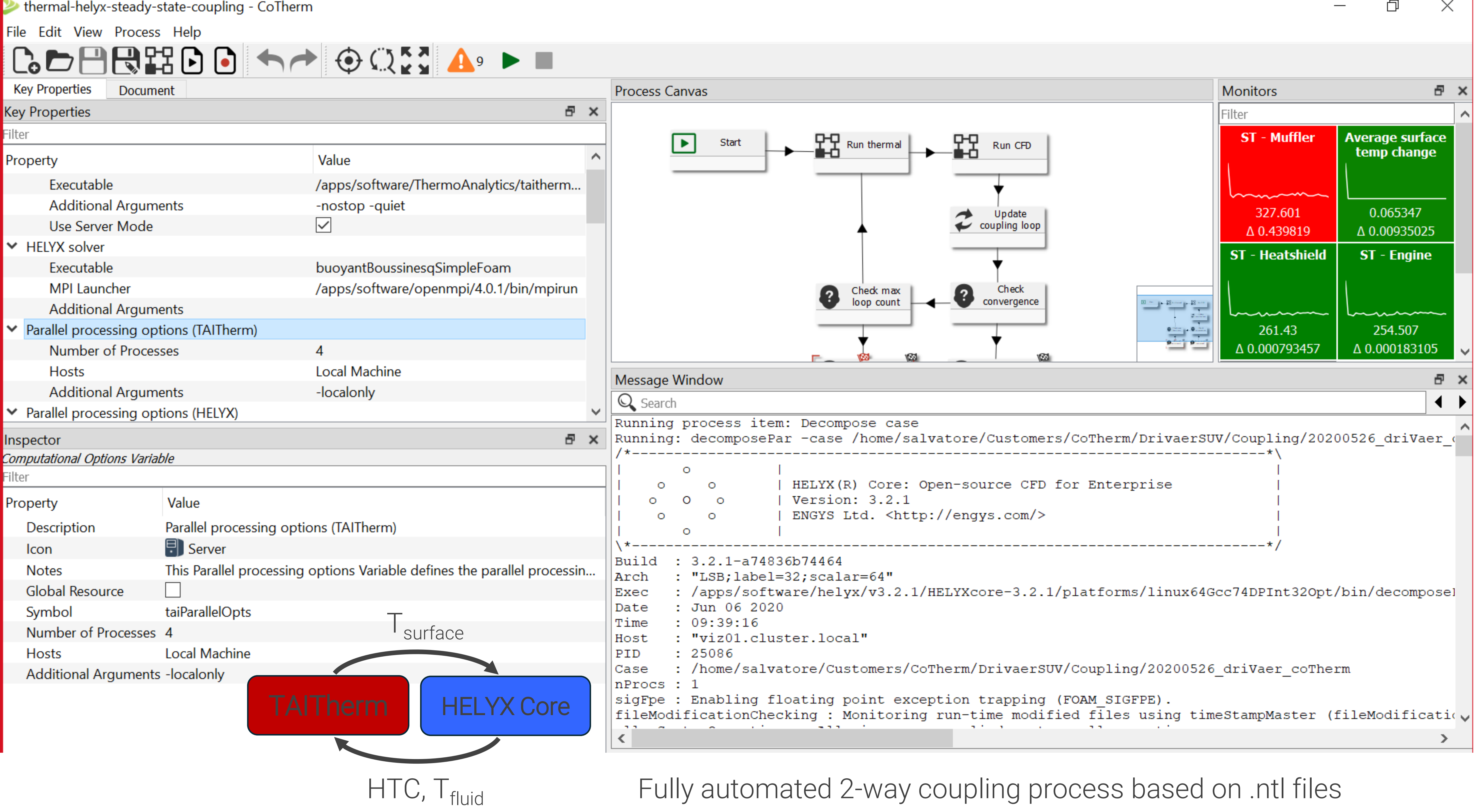


Applications

- Thermal Protection
- Engine Idle/Soak
- Brake Cooling
- Human Comfort
- Battery Modelling

Two-ways coupling

- Steady to steady
- Steady to transient
- Transient to transient



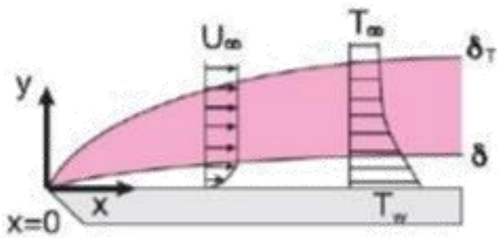
Fully automated 2-way coupling process based on .ntl files

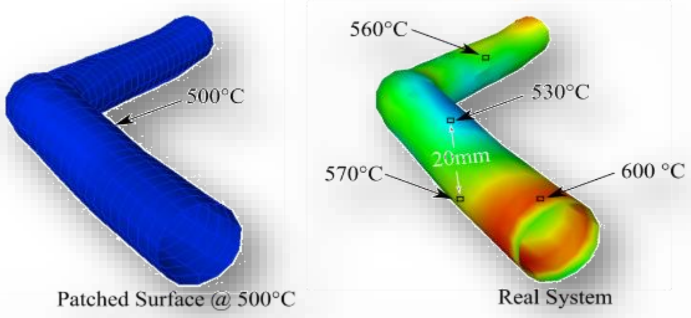
Case Study DrivAer Vehicle

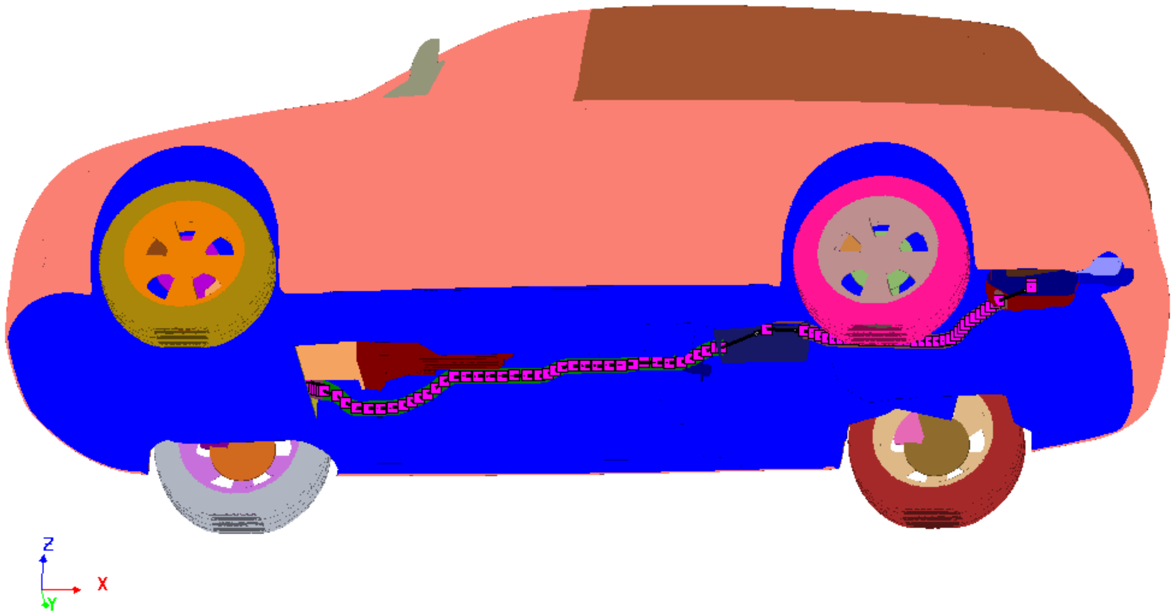
- Vehicle constant driving, followed by 20 min key-off/soak
  - Ambient temperature: 30°C
  - Vehicle velocity: 140km/h
  - Exhaust Module for accurate exhaust gas modelling

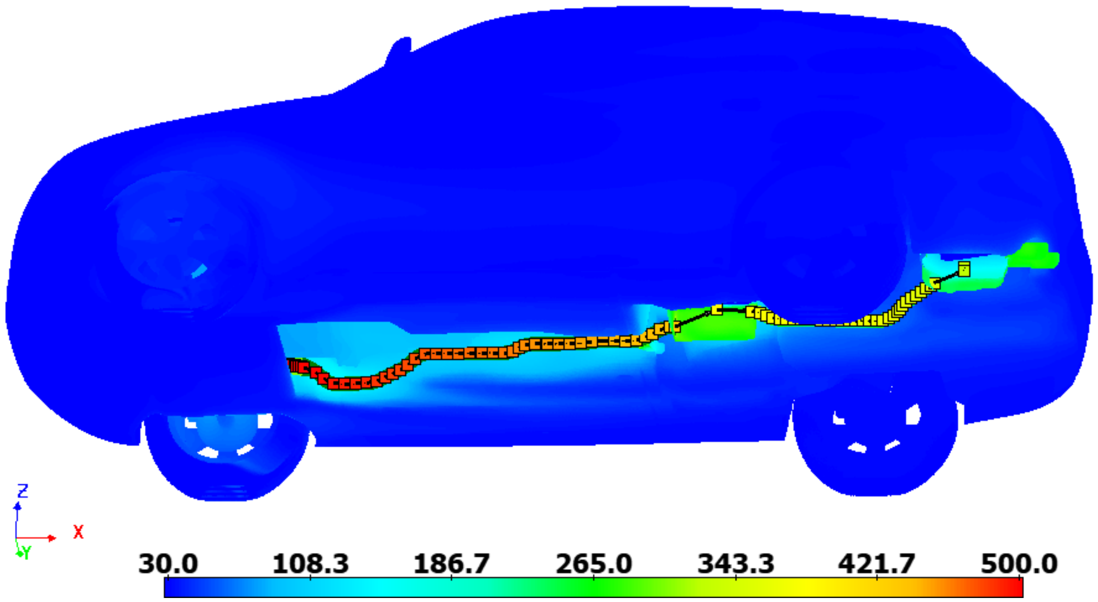
Time	Exhaust flow rate (kg/s)	Exhaust inlet temp (deg C)	External air speed (km/h)
Constant speed	0.1	650	140
Soak	Off	Off	0.1

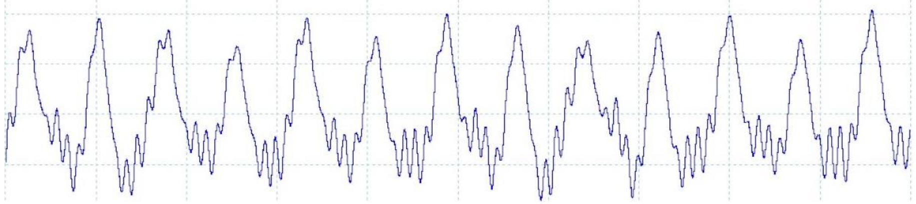
Set-up TAITherm Exhaust Module

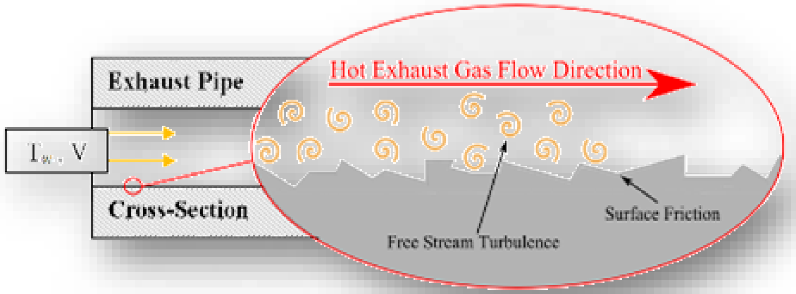


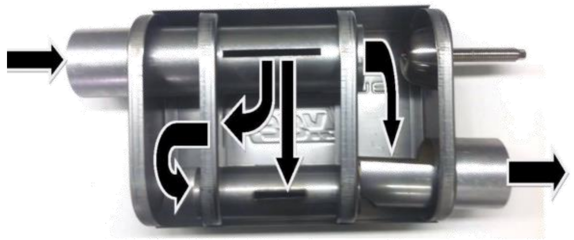






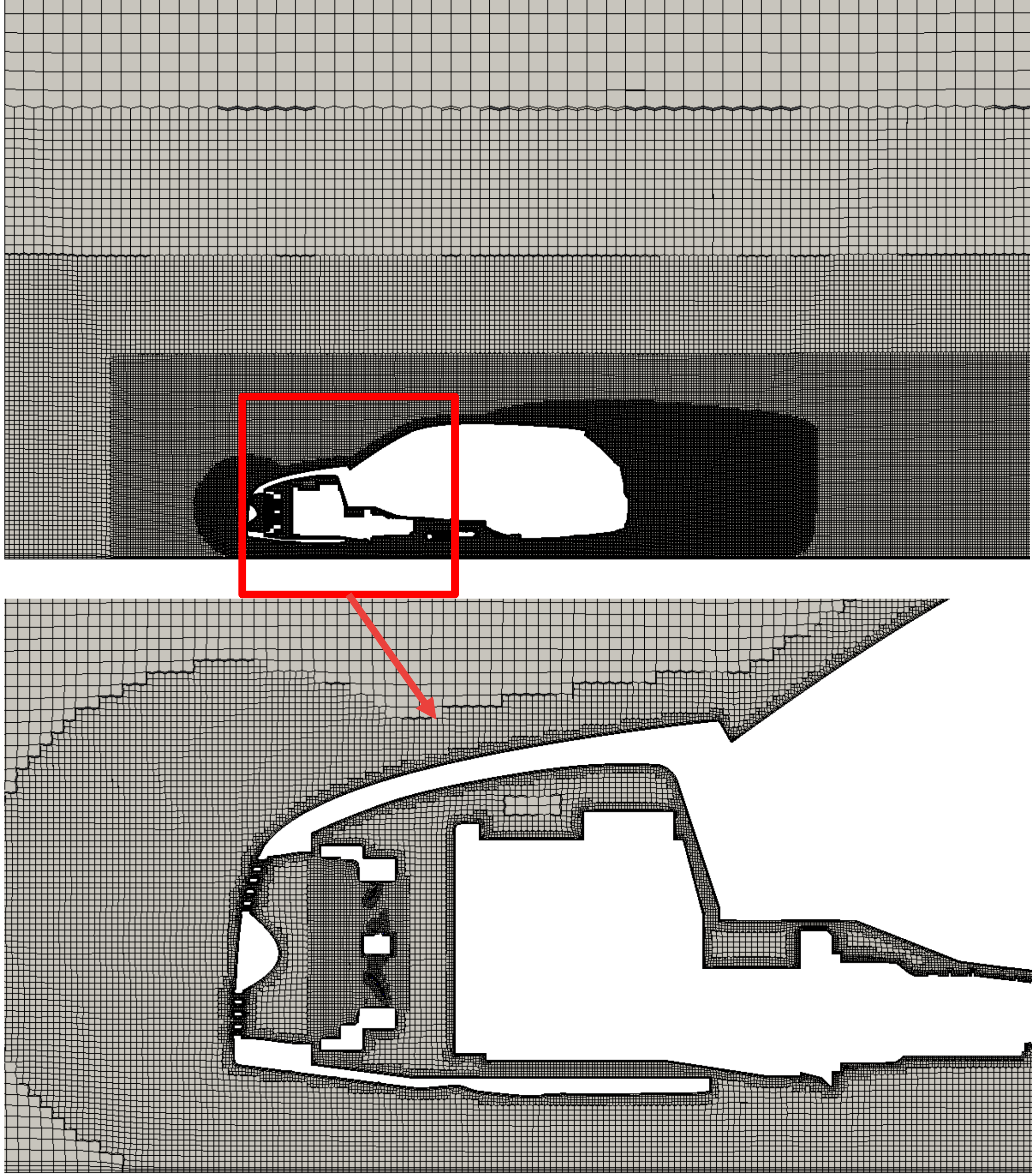






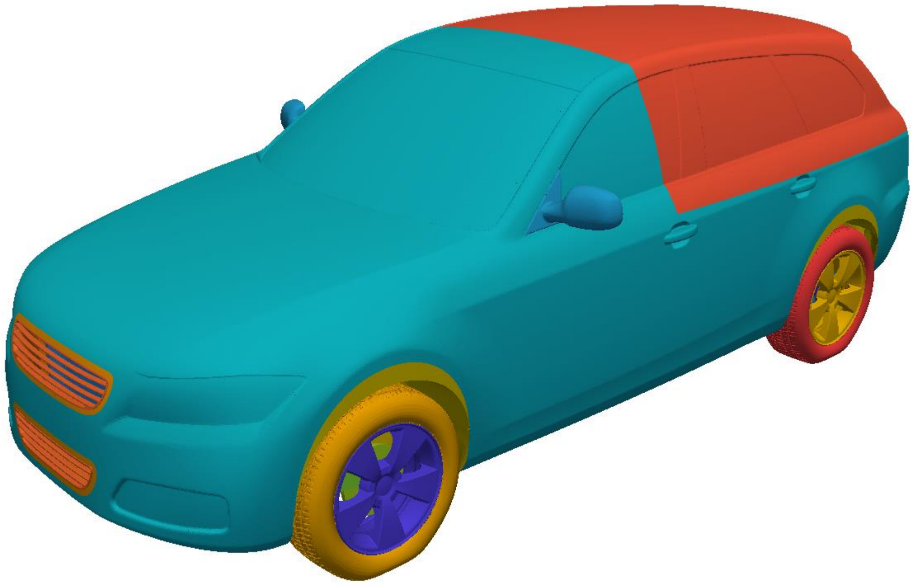
Set-up HELYX Mesh

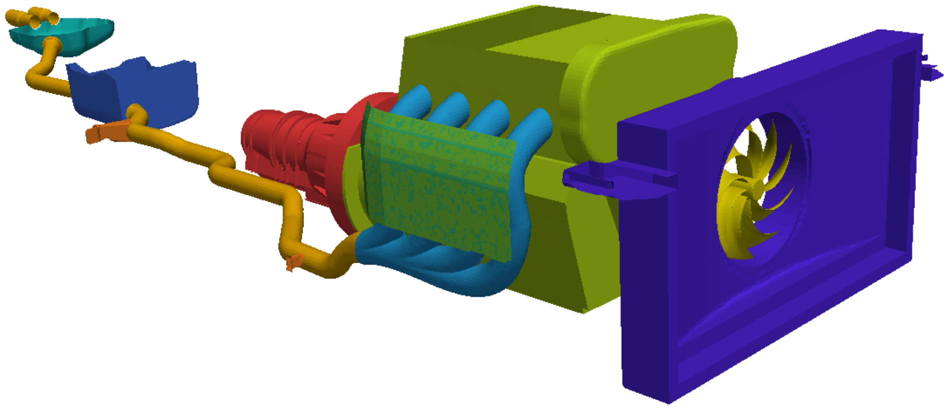
- Max. Cell Size → 0.957 m
- Min. Cell Size → 1.87 mm
- Near-wall layers → 3 layers, 99.2 % coverage
- Total Mesh Size → 21M cells
- Multiple surface and local volume mesh refinements applied to capture relevant flow features
- 2 cell zones to identify rotating and porous regions
- Coarse mesh for demo sake



Set-up HELYX CFD SOLVER

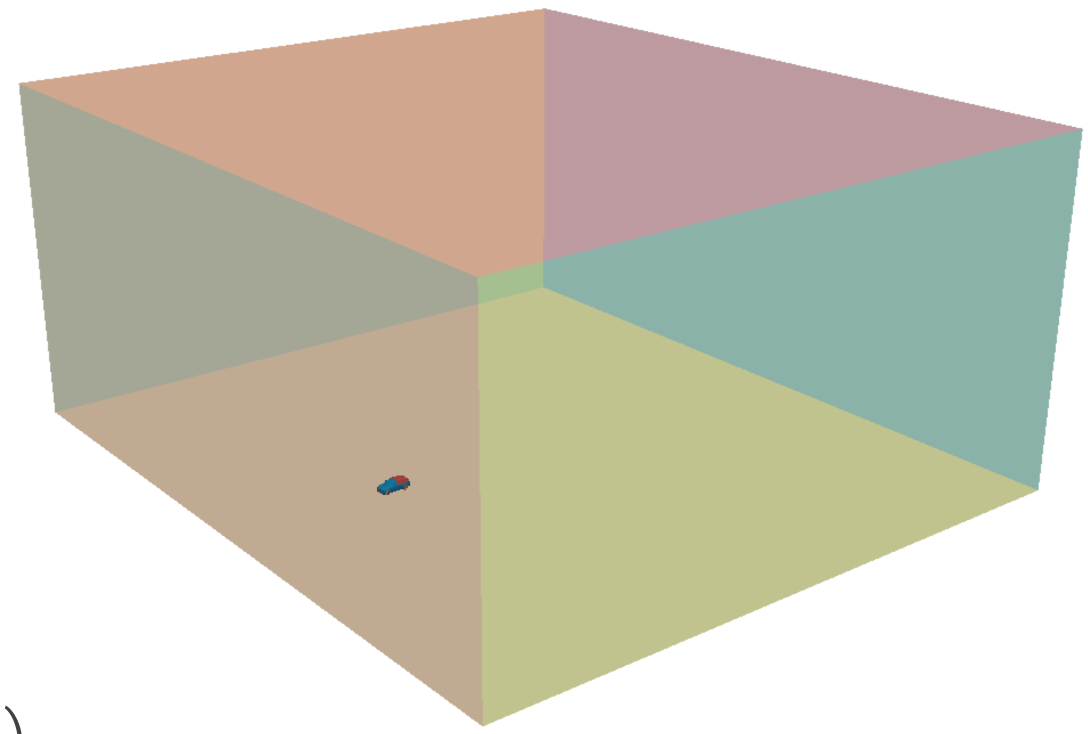
- Steady-state RANS solution
  - Turbulence → k-ω SST model
  - Buoyancy → Boussinesq's approximation
- Constant Speed phase
  - Fan → Multiple Reference Frame
  - Radiator
    - flow resistance → Darcy porosity model
    - thermal → Fixed temperature source (80°C)
- Soak phase
  - Radiator
    - flow resistance → Darcy porosity model



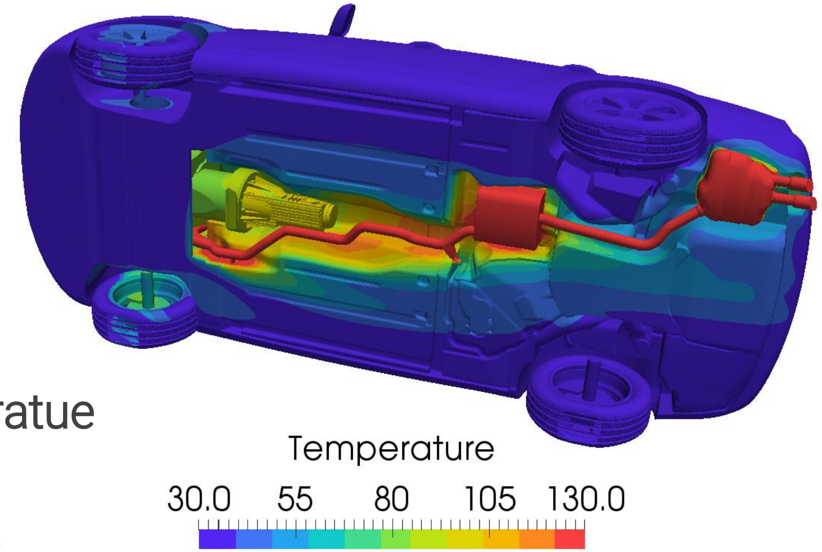


Set-up HELYX CFD BC's

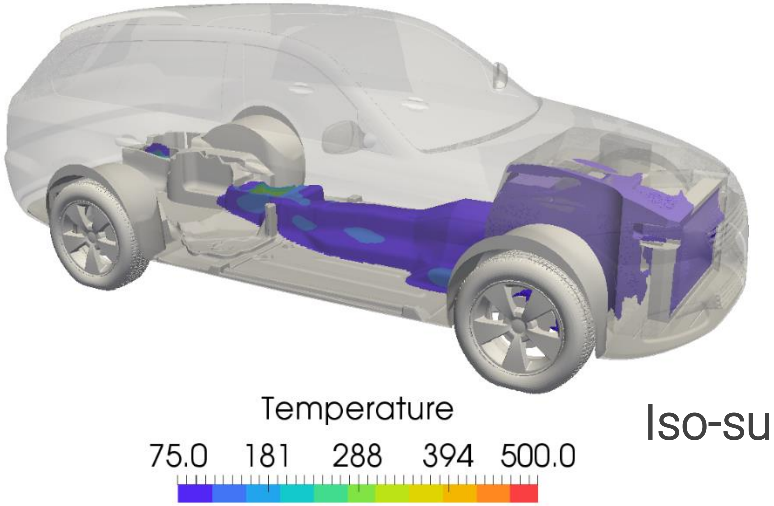
- Constant speed phase
  - Wheels → Rotating wall velocity
  - Ground → Translating wall velocity
  - Sides → Inlet/Outlet/Slip Wall
- Soak phase
  - Wheels → Fixed wall
  - Ground → Fixed wall
  - Sides → Openings
- Wall Thermal → "*mapFromFile*" BC (.ntl)



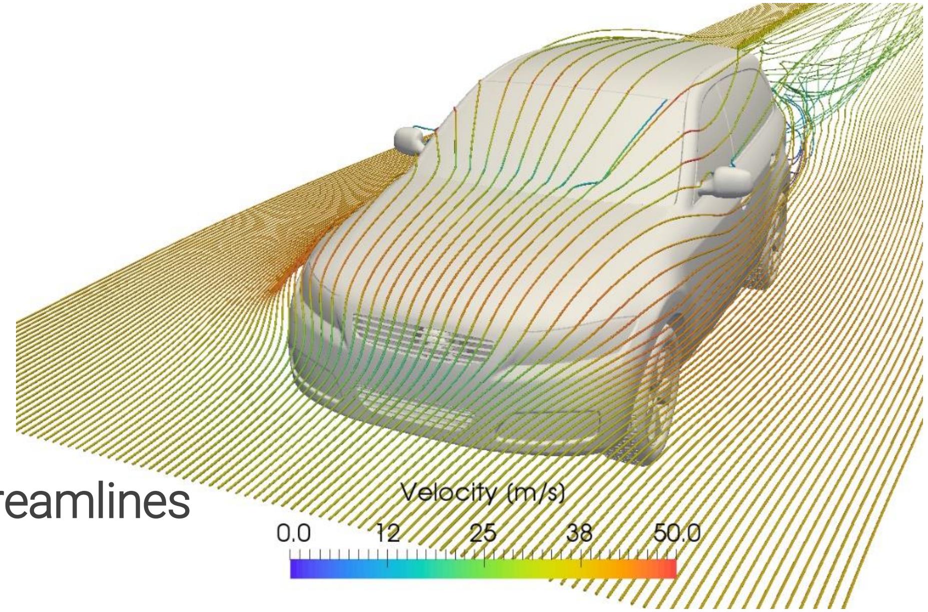
Constant Speed Phase Results



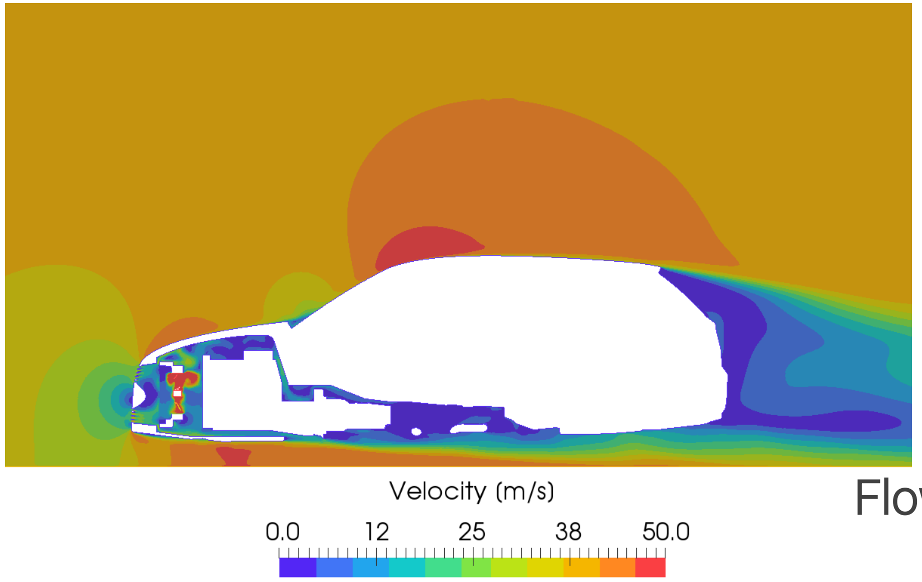
Surface Temperatue



Iso-surface > 70°C

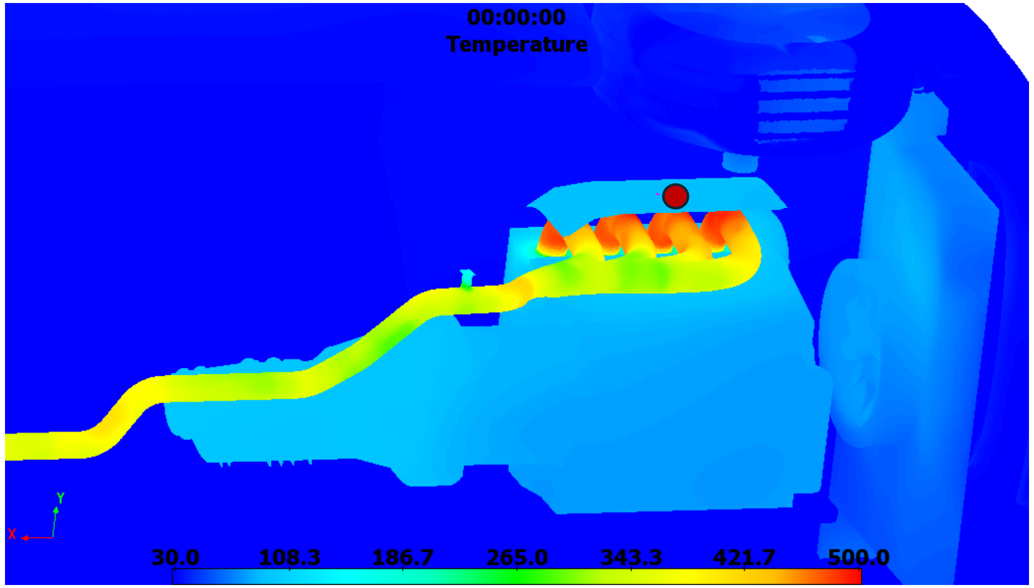


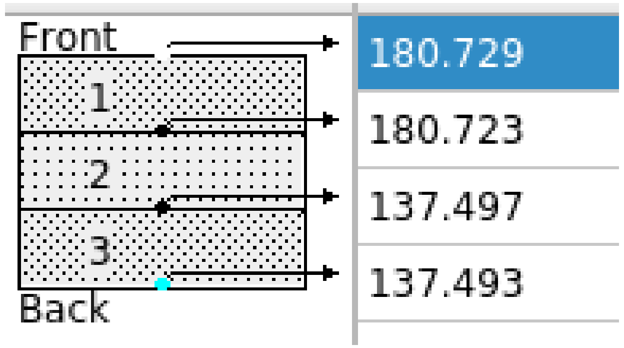
Velocity Streamlines



Flow Field

Result Analysis in TAITherm

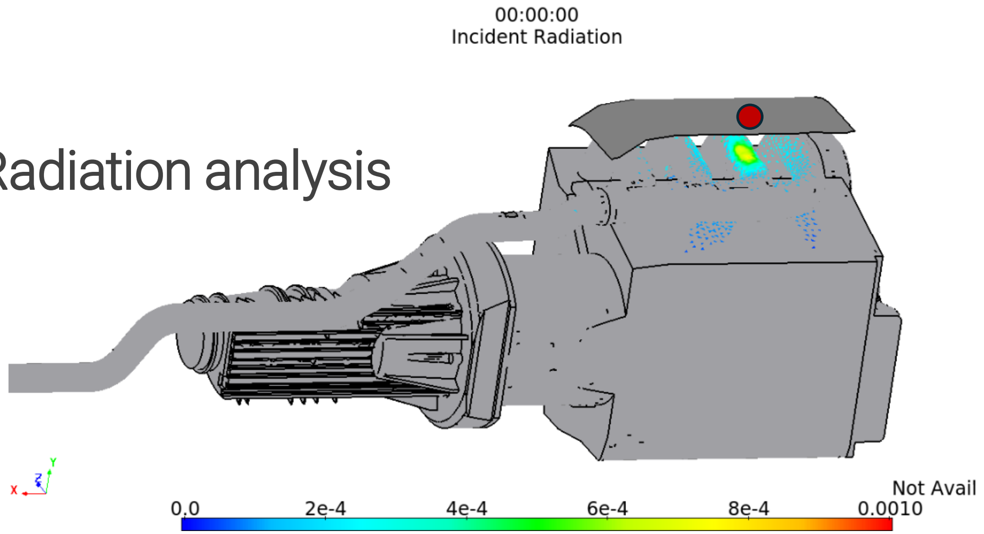




The multi-layer heatshield is reducing the heat conduction through the thickness

The heatshield is mainly receiving radiation and is cooled by convection

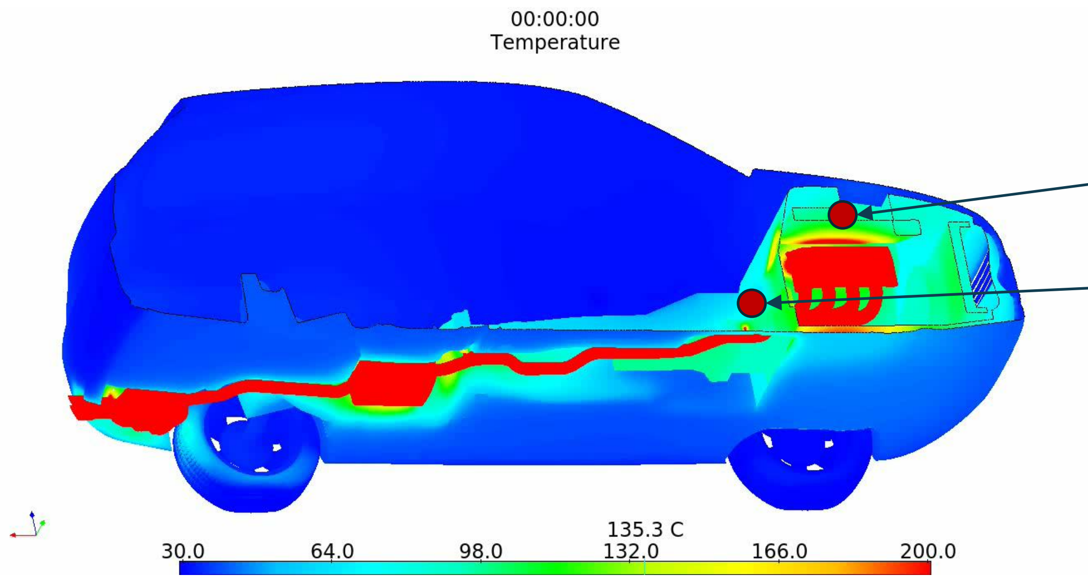
Radiation analysis

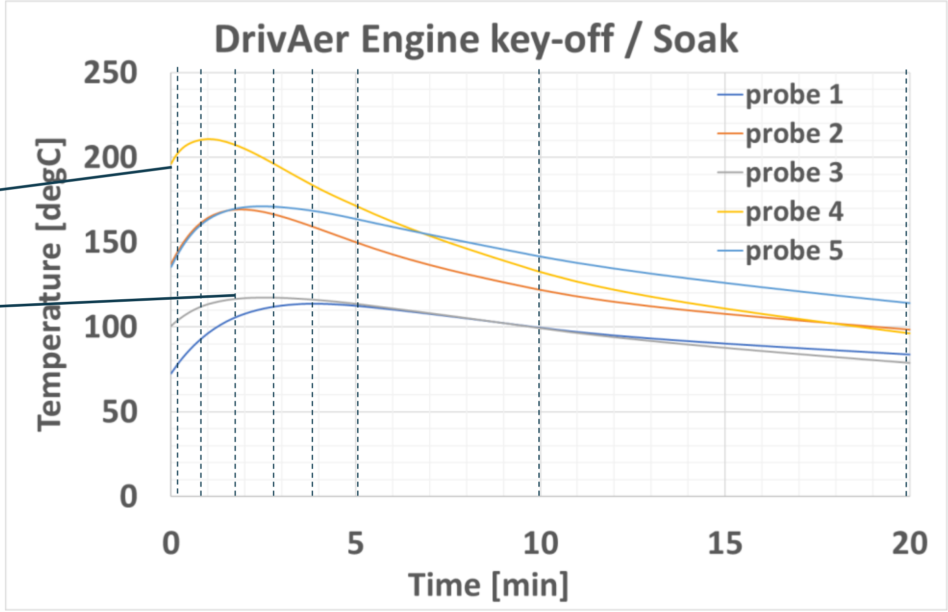


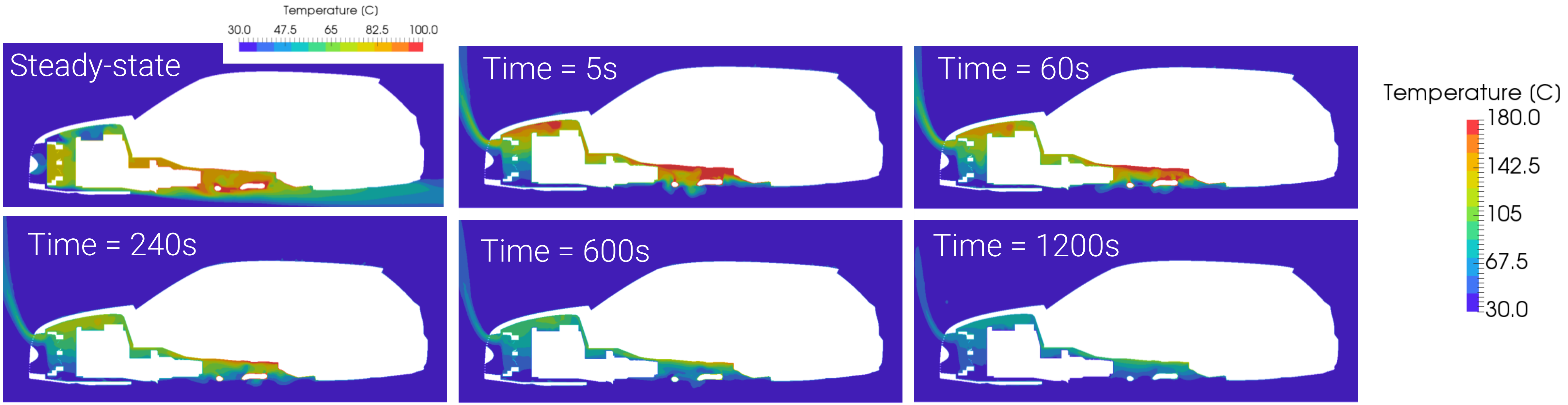
Heat Rate Flux (W/m²)

	Incident	Outgoing	Net
Q Conduction	1308.62	2652.88	-1344.27
Q Convection	0	5199.51	-5199.51
Q Radiation	11248.9	4705.51	6543.41
Q Solar			0
Q Imposed			0

Soak Phase Results







Conclusions

- TAITherm and HELYX-CORE provide Integrated coupling process
  - TAITherm takes care of the radiation and conduction
  - HELYX/ELEMENTS takes care of the CFD convection
- 2-way Automated Coupling Process
- Ready to use Templates for Steady State or Transient Scenarios
- TAITherm Special Modules for Dedicated Applications:
  - Engine Thermal Protection, Exhaust, Battery, Human Comfort, Electronics, etc.
- Coupling can be added into ELEMENTS best practices

For more information, see:

www.engys.com www.thermoanalytics.com

Or contact us at:

info@engys.com support@thermoanalytics.com