

Under-hood Thermal Protection Coupling with HELYX/ELEMENTS

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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

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

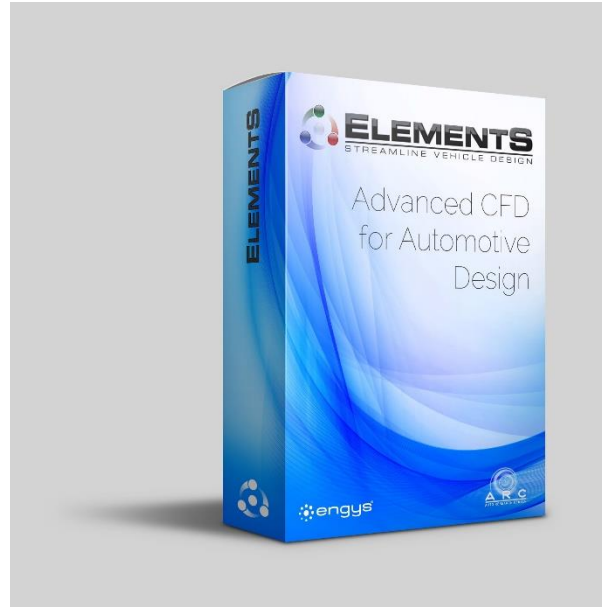


About ENGYS | Products



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

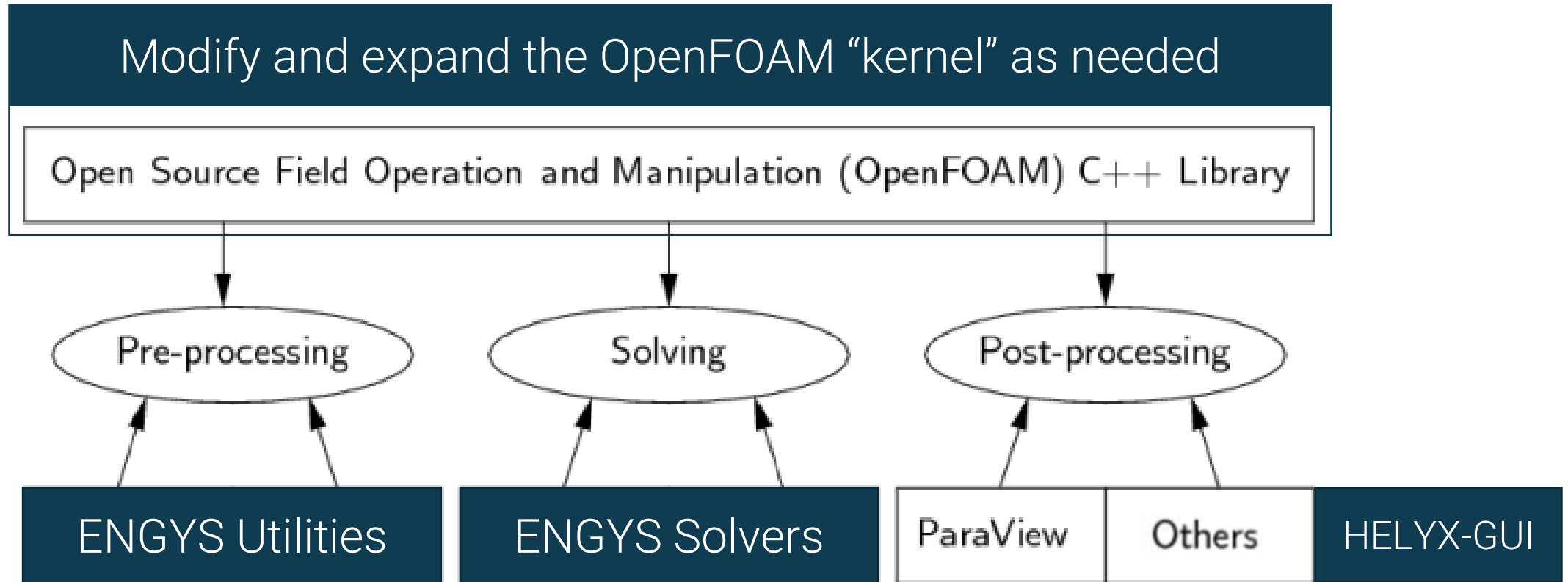


HELYX-OS

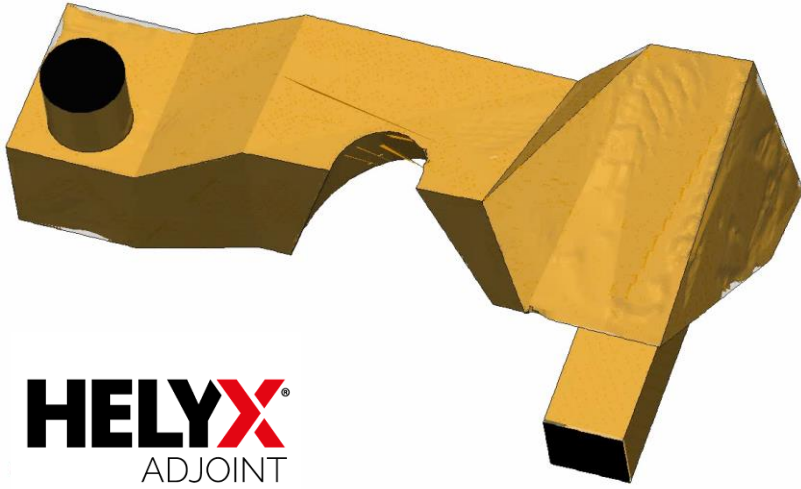
Open-source GUI for standard OpenFOAM

HELIX-Core

- Over 3000 new and modified files with respect to OPENFOAM

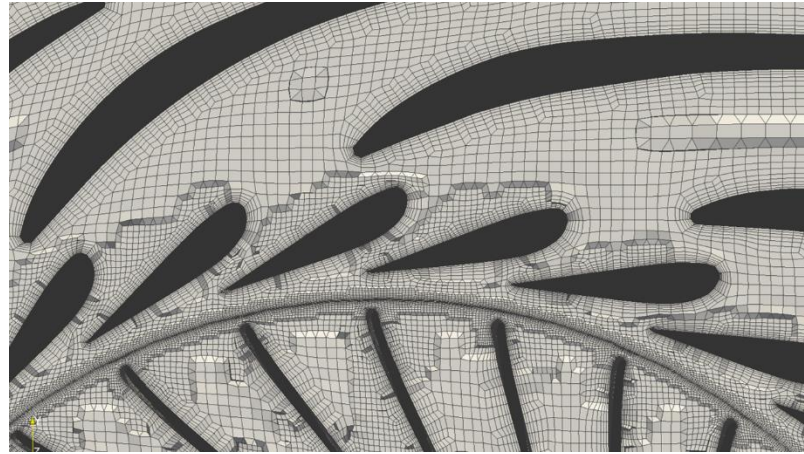


About ENGYS | Innovations



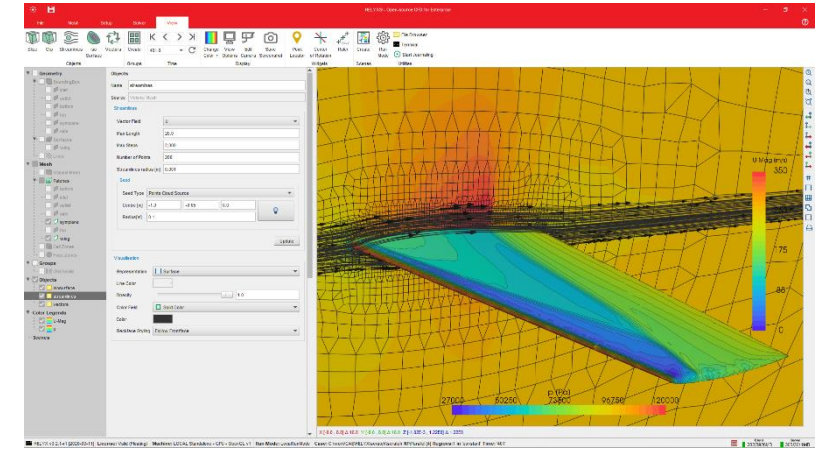
Adjoint Optimization

- Improve flow control
- Reduce energy consumption
- Improve performance



Hex-Dominant Meshing

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



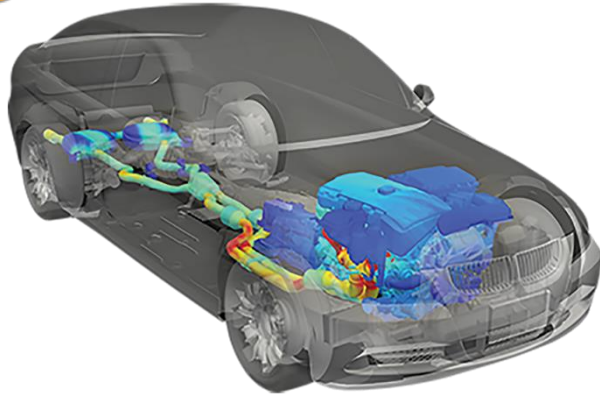
HELIX/ELEMENTS GUI

- Reduce complexity
- Increase productivity
- Streamline analysis

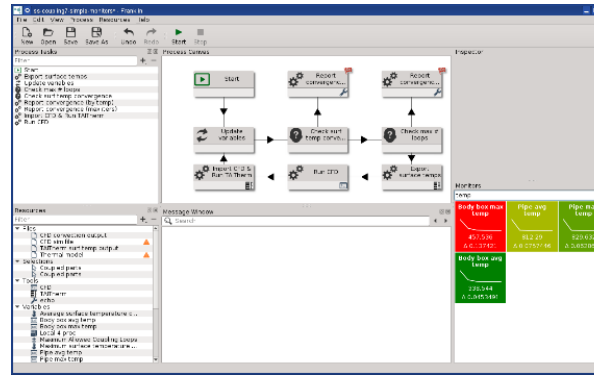
About ThermoAnalytics



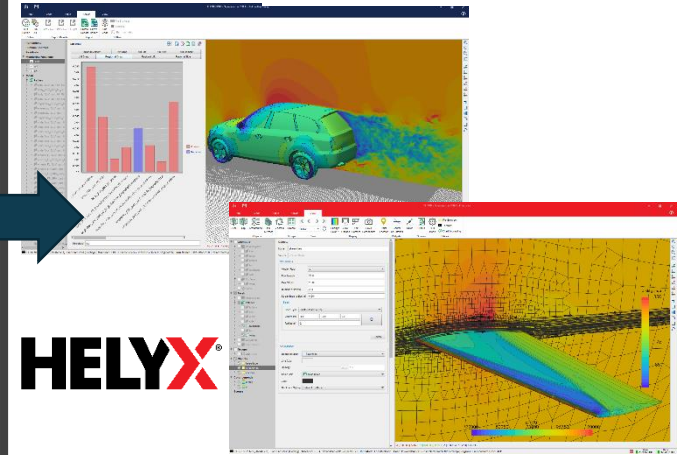
TAI Therm



CoTherm

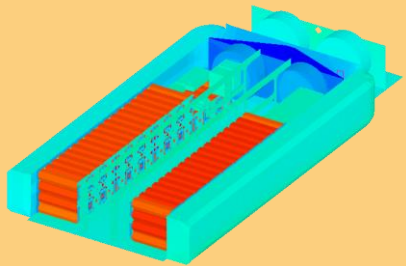


ELEMENTS
STREAMLINE VEHICLE DESIGN

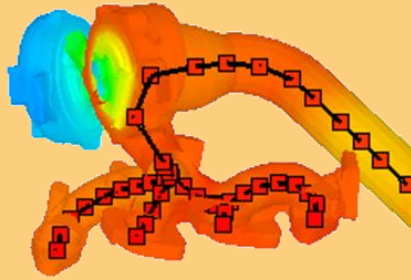


HELYX

Battery
Extension



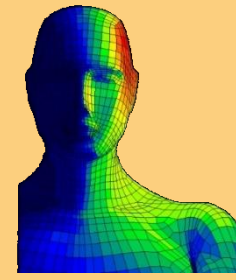
Exhaust
Extension



Drive Cycle
Extension

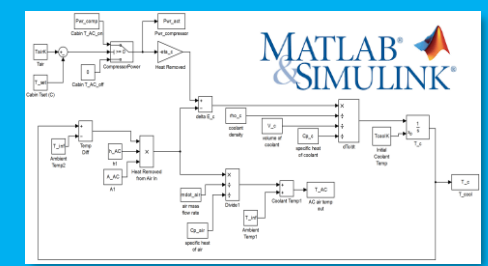


Human Comfort
Extension

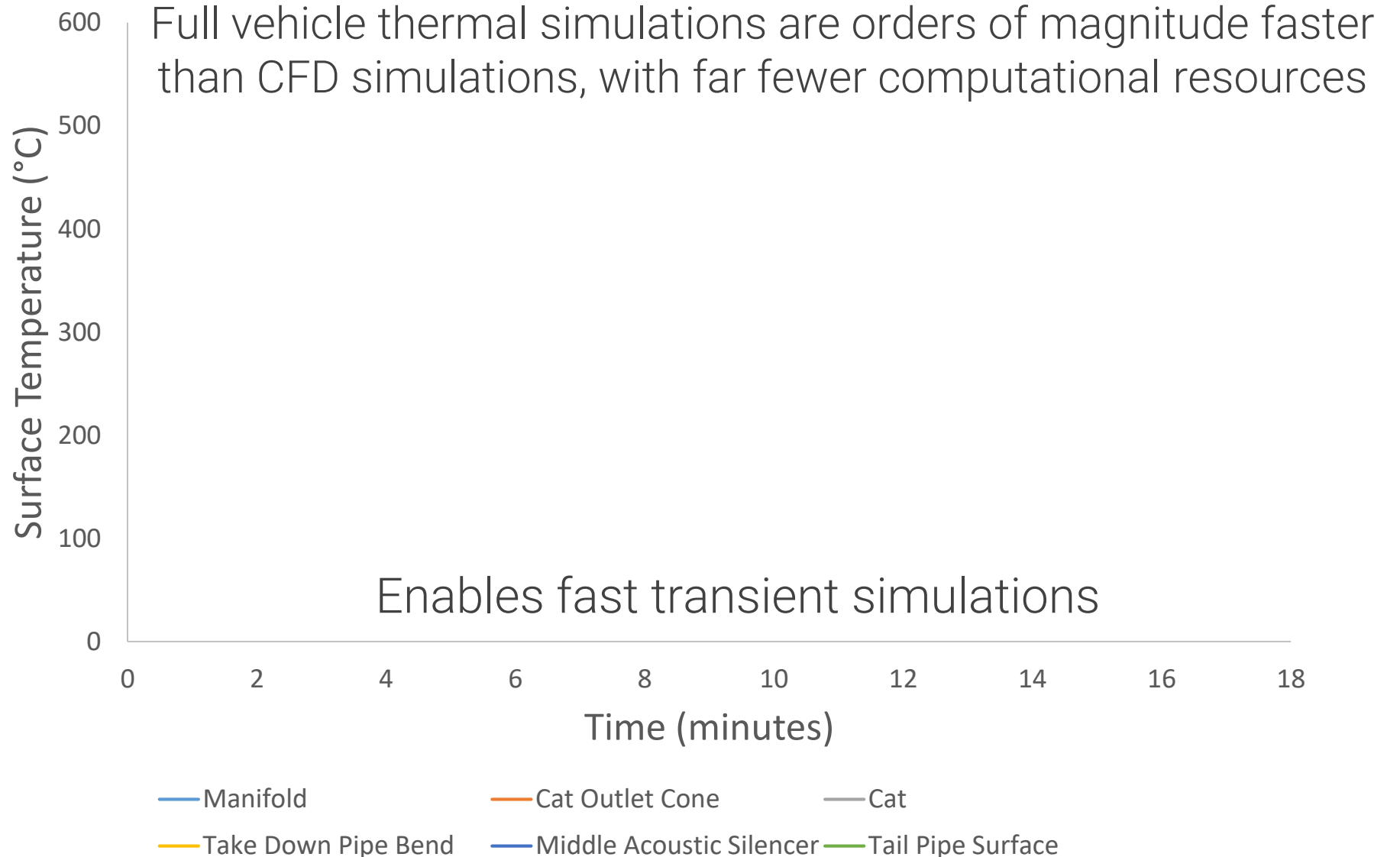


1D System Tool

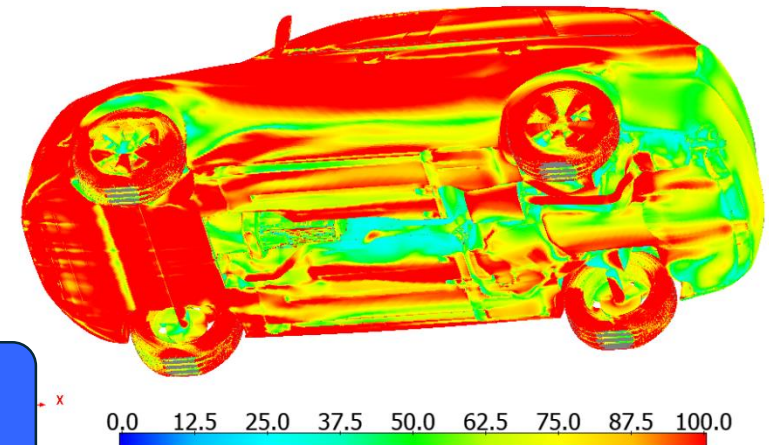
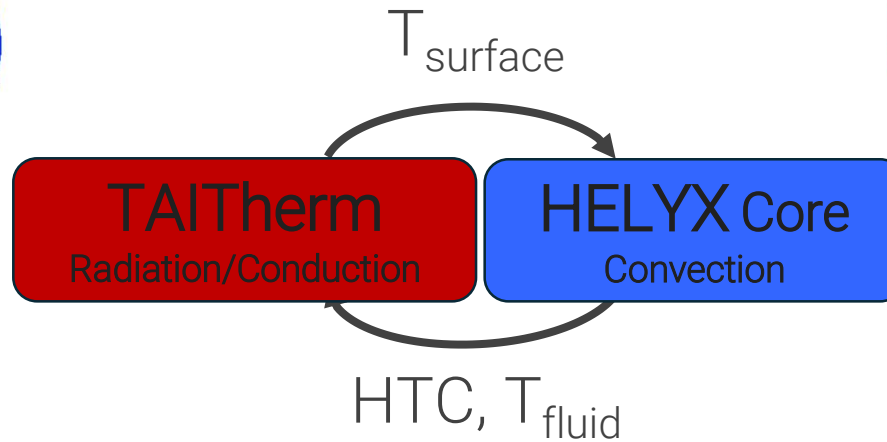
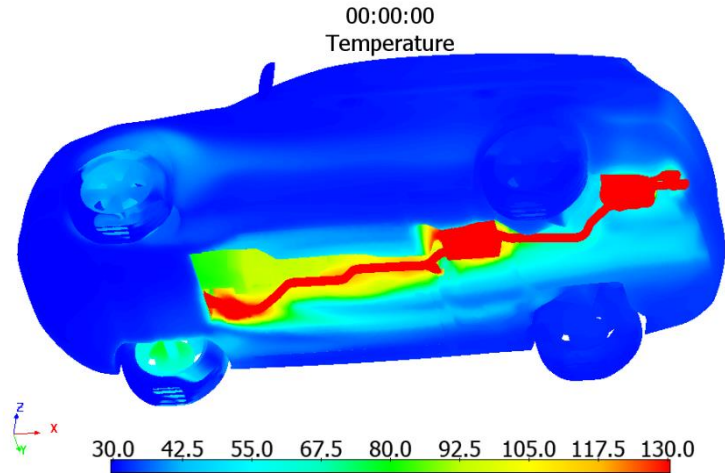
GT **LMS**
ENGINEERING INNOVATION



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



Key Properties

Filter

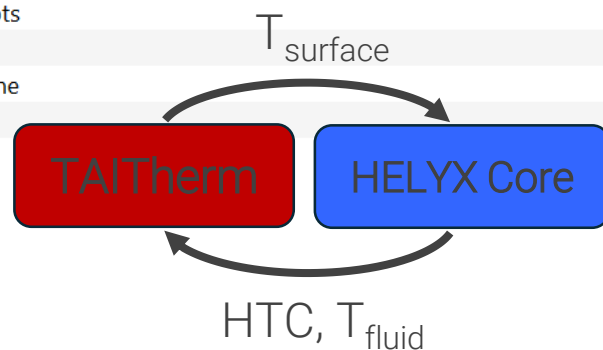
Property	Value
Executable	/apps/software/ThermoAnalytics/tai therm...
Additional Arguments	-nostop -quiet
Use Server Mode	<input checked="" type="checkbox"/>
▼ HELYX solver	
Executable	buoyantBoussinesqSimpleFoam
MPI Launcher	/apps/software/openmpi/4.0.1/bin/mpirun
Additional Arguments	
▼ Parallel processing options (TAItherm)	
Number of Processes	4
Hosts	Local Machine
Additional Arguments	-localonly
▼ Parallel processing options (HELYX)	

Inspector

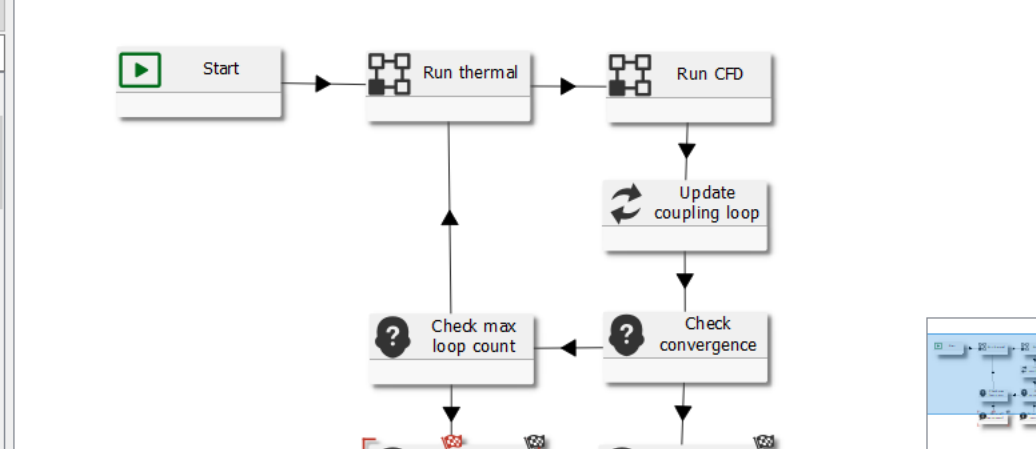
Computational Options Variable

Filter

Property	Value
Description	Parallel processing options (TAItherm)
Icon	Server
Notes	This Parallel processing options Variable defines the parallel processin...
Global Resource	<input type="checkbox"/>
Symbol	taiParallelOpts
Number of Processes	4
Hosts	Local Machine
Additional Arguments	-localonly



Process Canvas



Monitors

Filter	
ST - Muffler	Average surface temp change
327.601 Δ 0.439819	0.065347 Δ 0.00935025
ST - Heatshield	ST - Engine
261.43 Δ 0.000793457	254.507 Δ 0.000183105

Message Window

Search

Running process item: Decompose case

Running: decomposePar -case /home/salvatore/Customers/CoTherm/DrivaerSUV/Coupling/20200526_driVaer_c

```

/*-----*
|   o   o   | HELYX(R) Core: Open-source CFD for Enterprise
|   o   o   | Version: 3.2.1
|   o   o   | ENGYS Ltd. <http://engys.com/>
|   o   o   |
/*-----*

```

```

Build : 3.2.1-a74836b74464
Arch  : "LSB;label=32;scalar=64"
Exec  : /apps/software/helyx/v3.2.1/HELYXcore-3.2.1/platforms/linux64Gcc74DPInt32Opt/bin/decompose
Date  : Jun 06 2020
Time  : 09:39:16
Host  : "viz01.cluster.local"
PID   : 25086
Case  : /home/salvatore/Customers/CoTherm/DrivaerSUV/Coupling/20200526_driVaer_coTherm
nProcs : 1
sigFpe : Enabling floating point exception trapping (FOAM_SIGFPE).
fileModificationChecking : Monitoring run-time modified files using timeStampMaster (fileModification

```

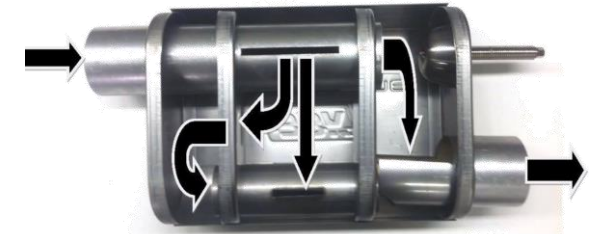
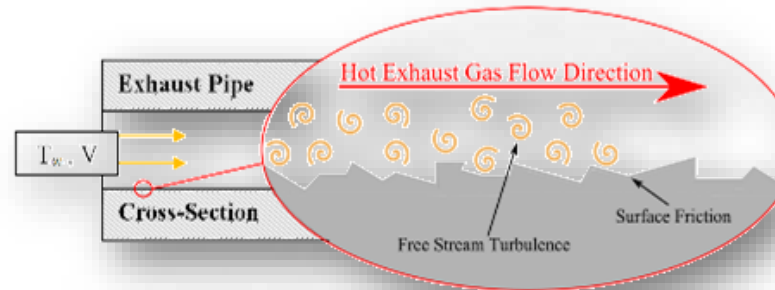
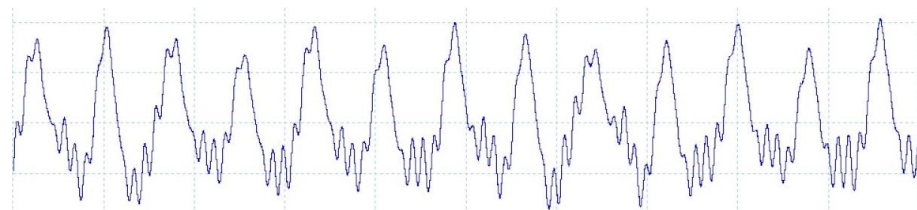
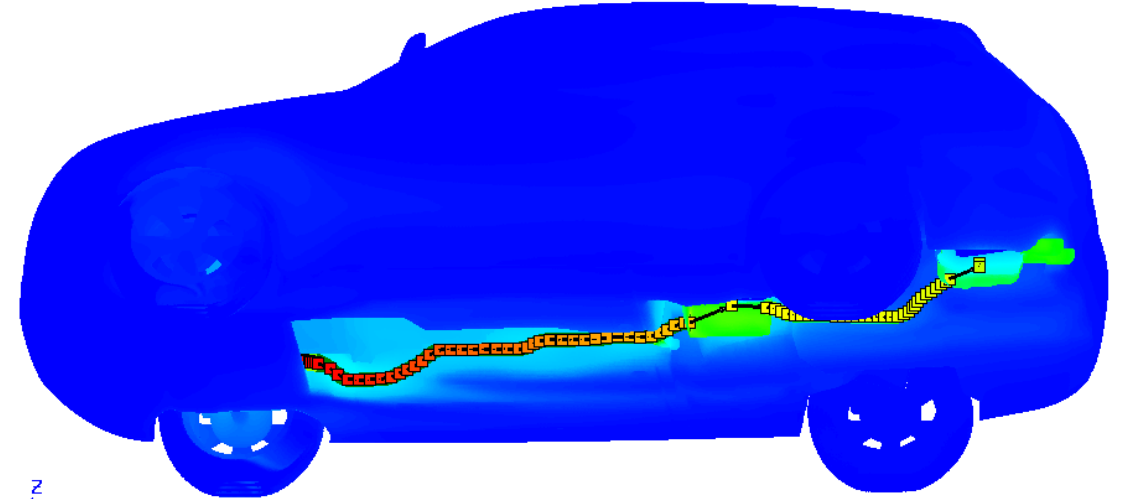
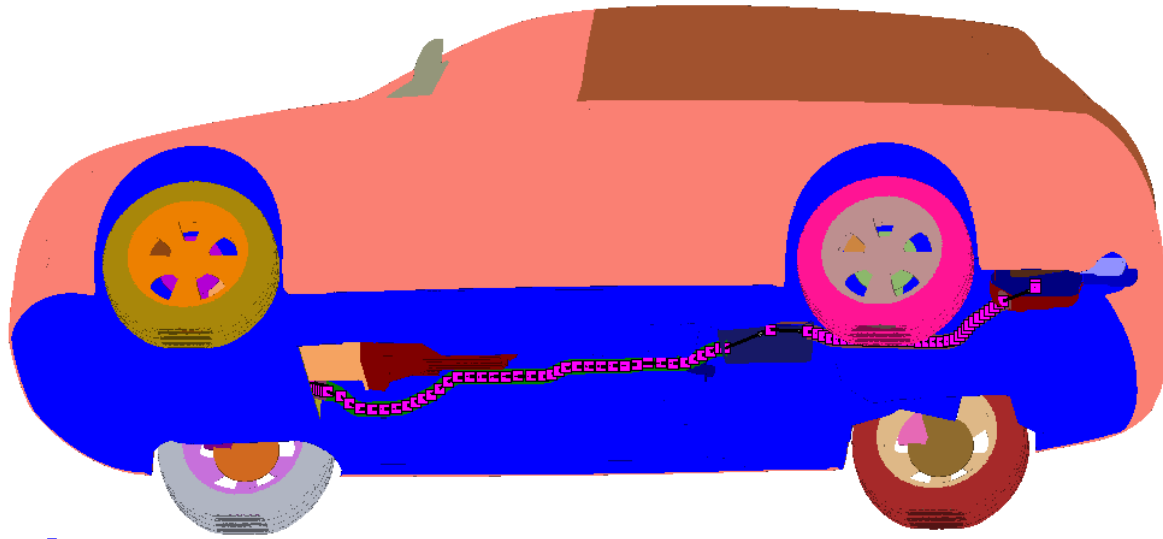
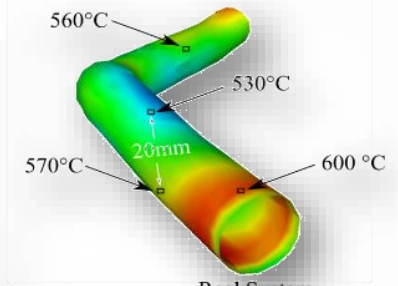
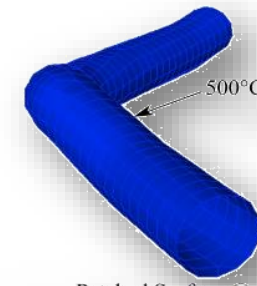
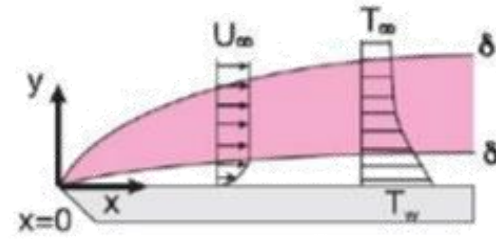
Fully automated 2-way coupling process based on .ntl files

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

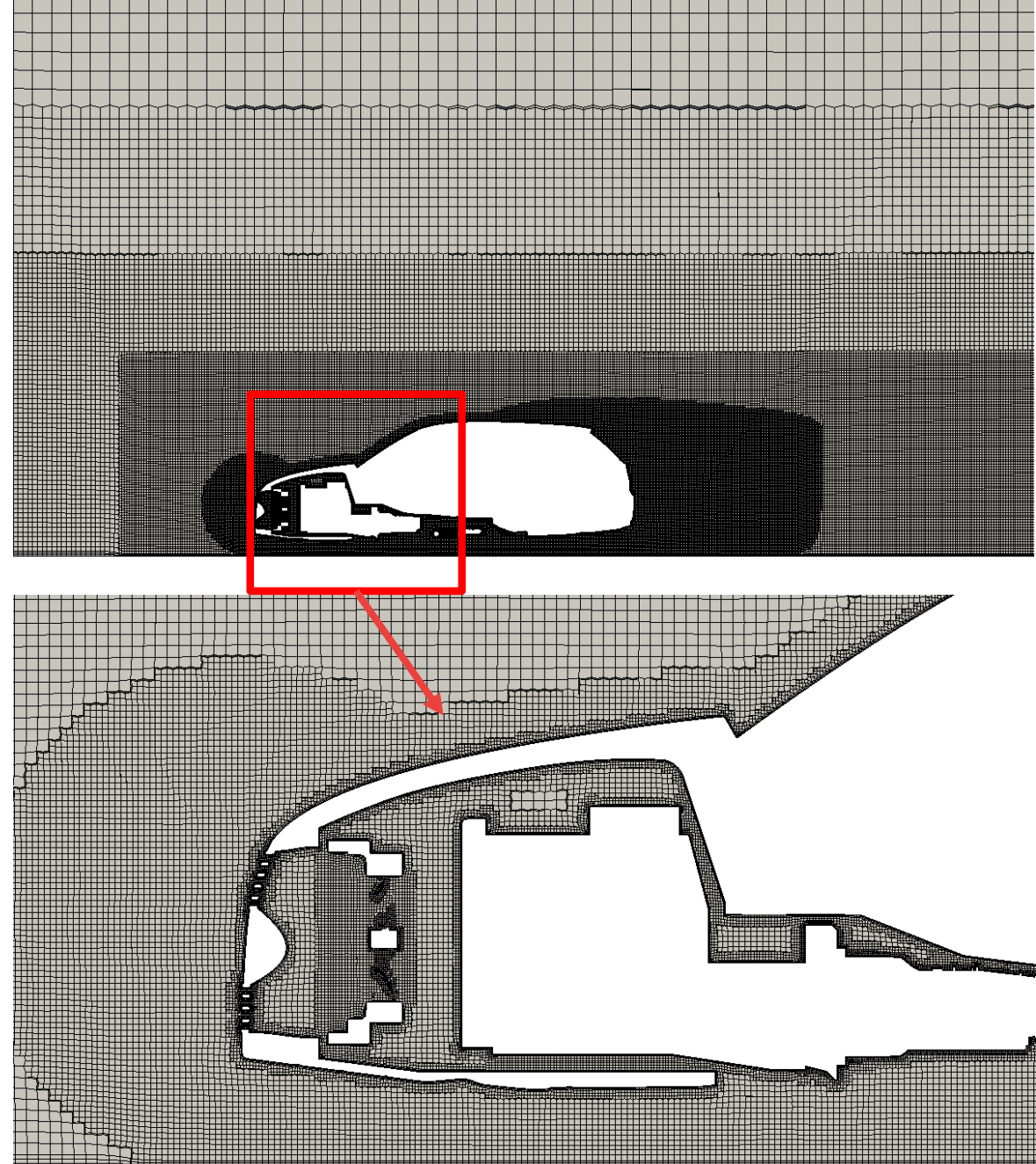
Time	Exhaust flow rate (kg/s)	Exhaust inlet temp (deg C)	External air speed (km/h)
Constant speed	0.1	650	140
Soak	Off	Off	0.1

Set-up TAITherm Exhaust Module



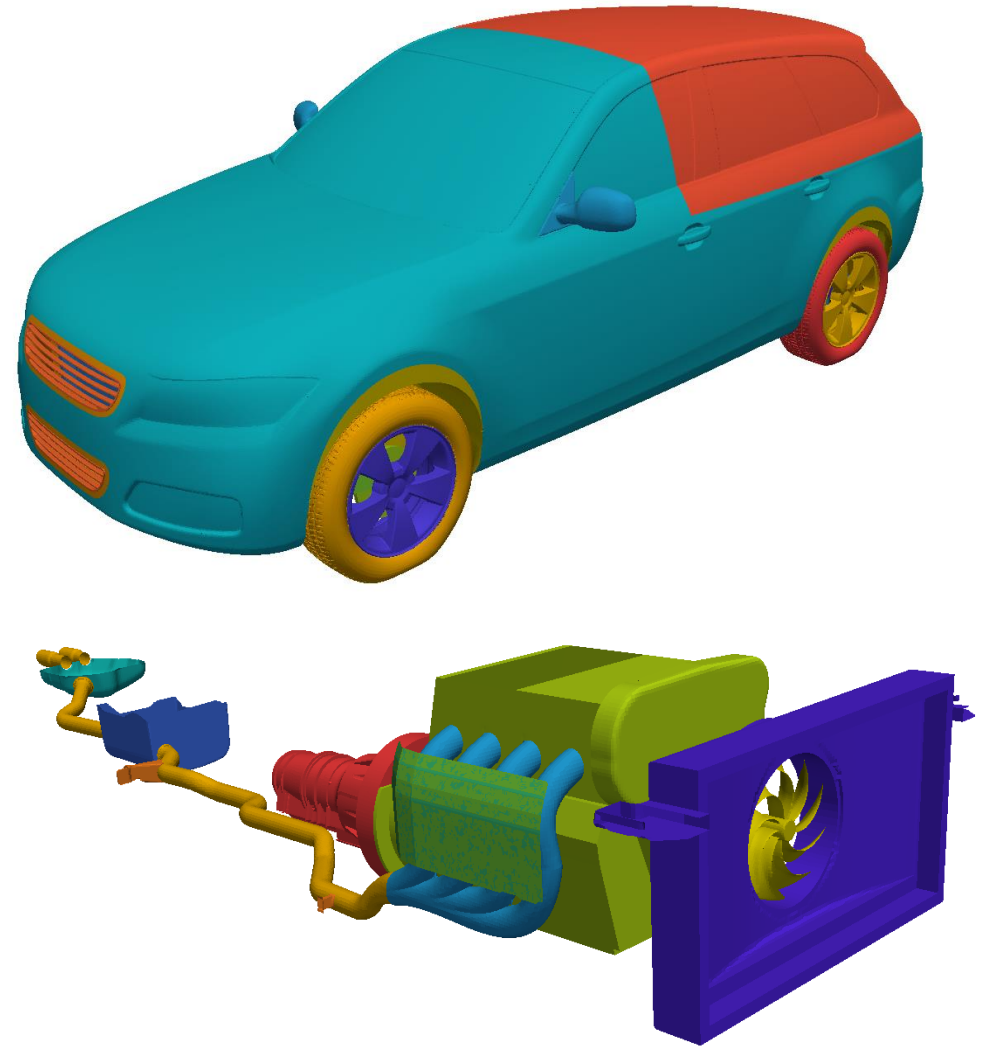
Set-up HELYX Mesh

- 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



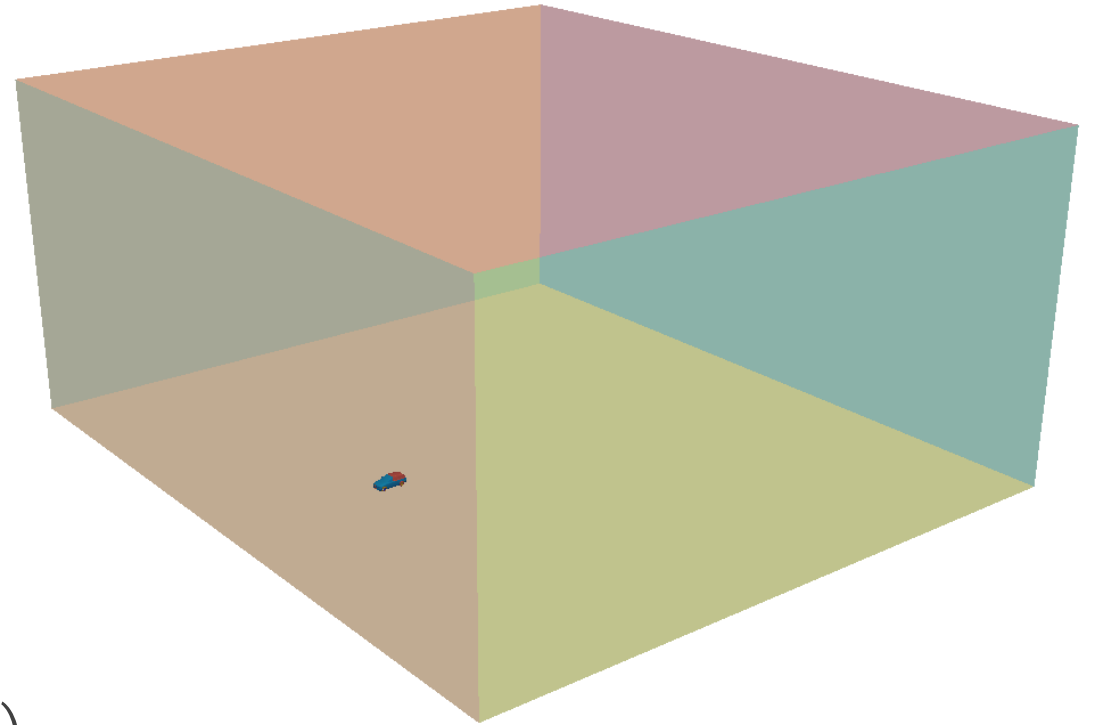
Set-up HELYX CFD SOLVER

- Steady-state RANS solution
 - Turbulence → $k-\omega$ 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

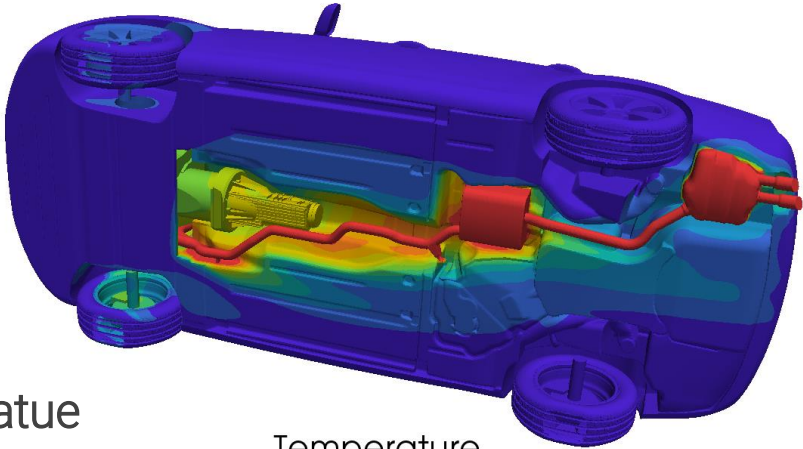


Set-up HELYX CFD BC's

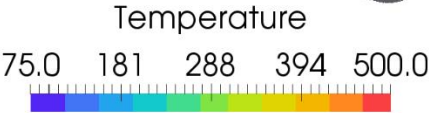
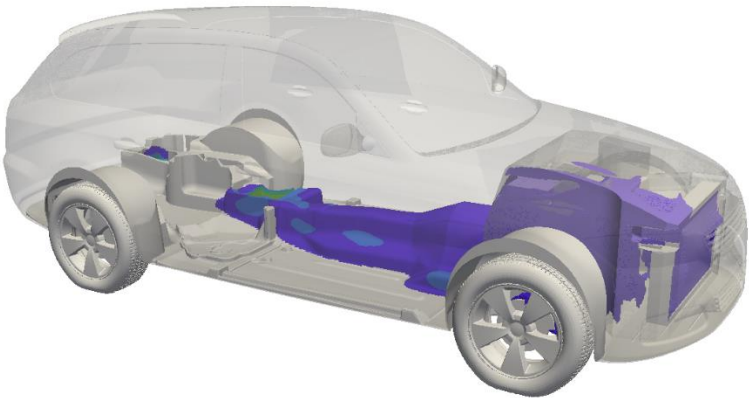
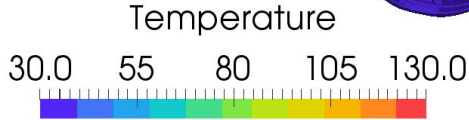
- Constant speed phase
 - Wheels → Rotating wall velocity
 - Ground → Translating wall velocity
 - Sides → Inlet/Outlet/Slip Wall
- Soak phase
 - Wheels → Fixed wall
 - Ground → Fixed wall
 - Sides → Openings
- Wall Thermal → “*mapFromFile*” BC (.ntl)



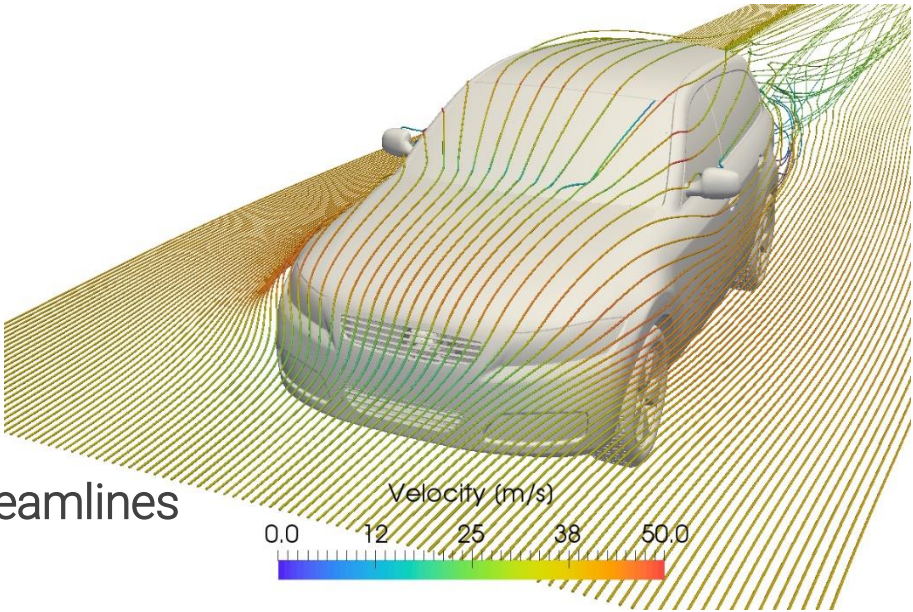
Constant Speed Phase Results



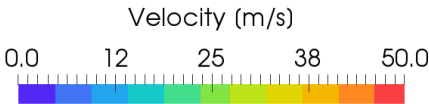
Surface Temperature



Iso-surface > 70°C

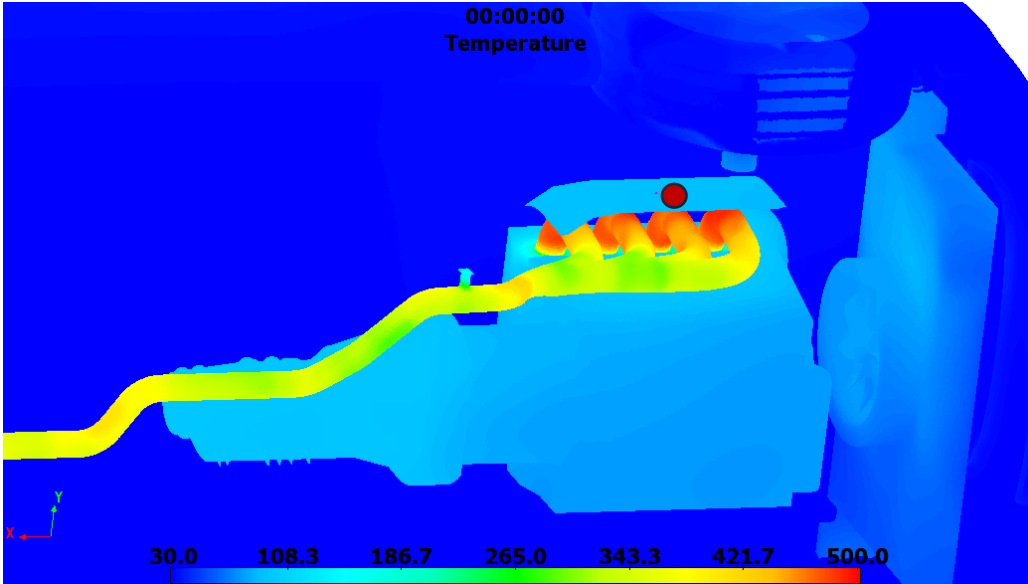


Velocity Streamlines



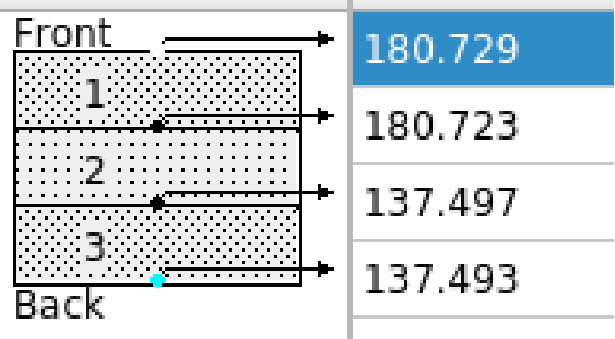
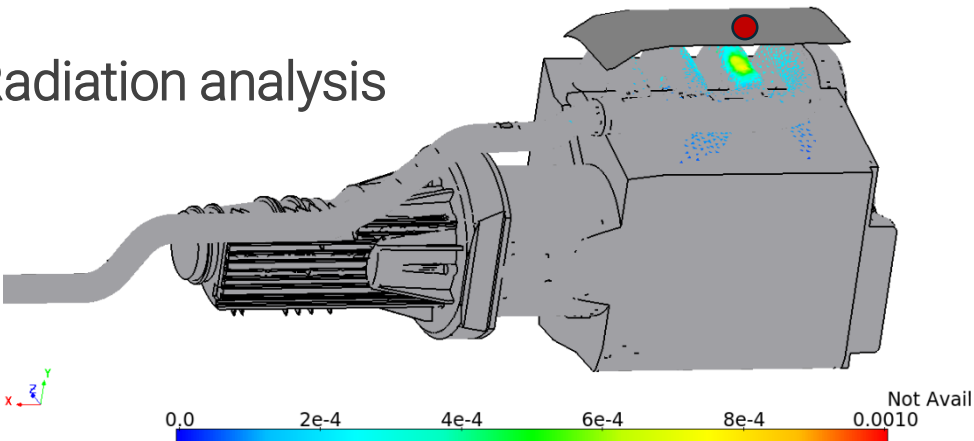
Flow Field

Result Analysis in TAITherm



00:00:00
Incident Radiation

Radiation analysis

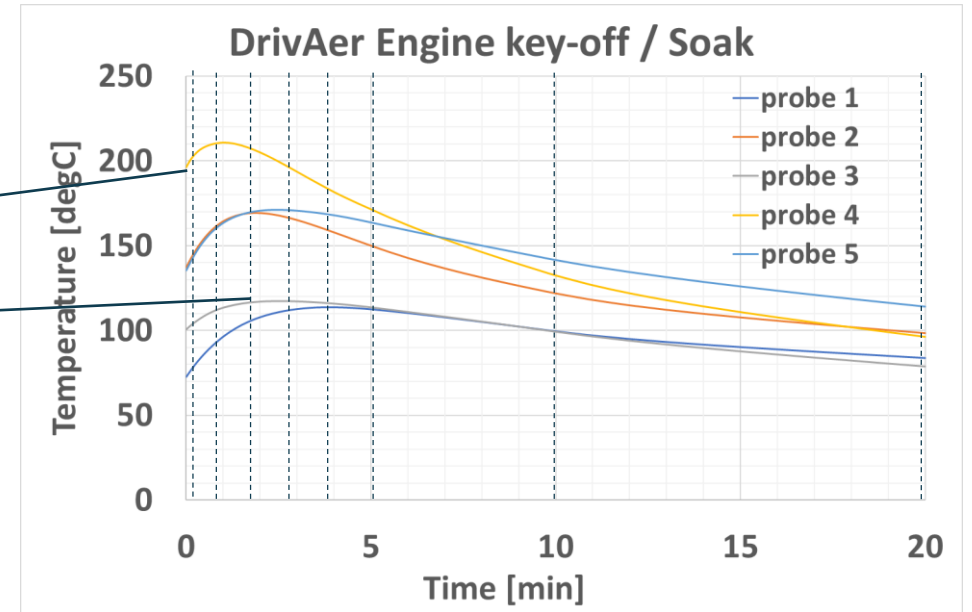
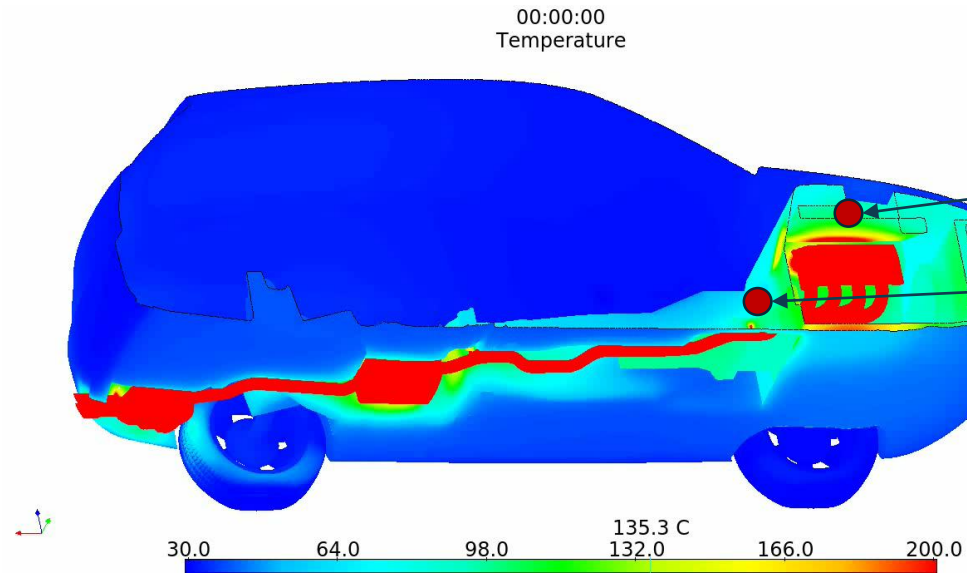


The multi-layer heatshield is reducing the heat conduction through the thickness

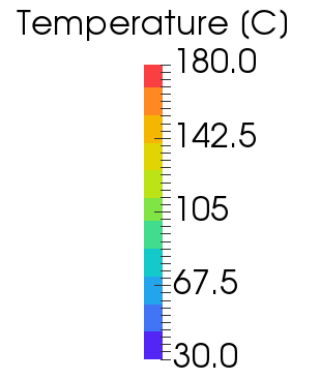
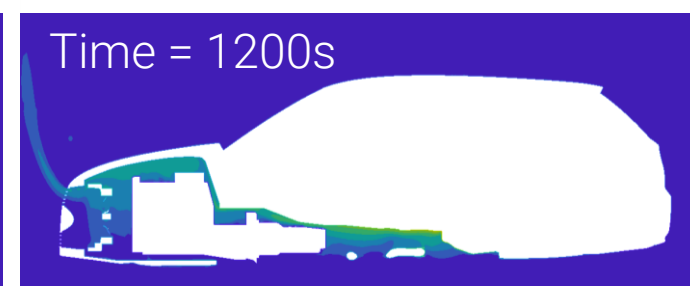
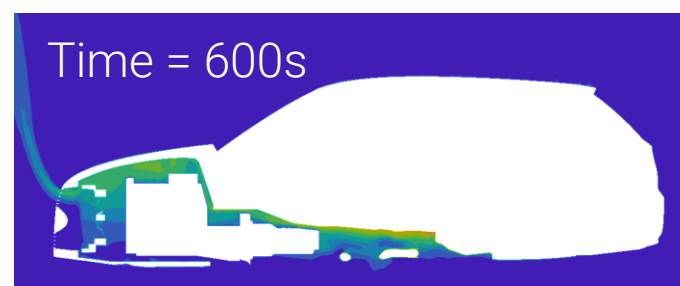
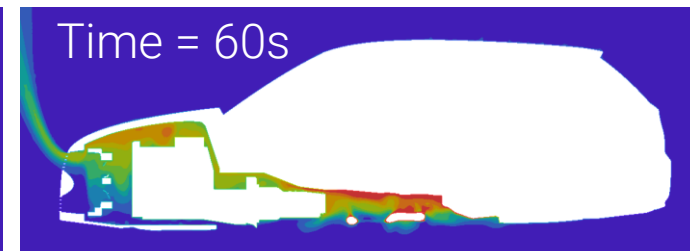
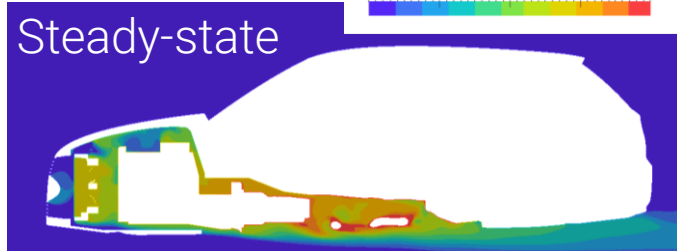
The heatshield is mainly receiving radiation and is cooled by convection

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



Temperature (C)
30.0 47.5 65 82.5 100.0



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



THERMO
ANALYTICS



For more information, see:

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