

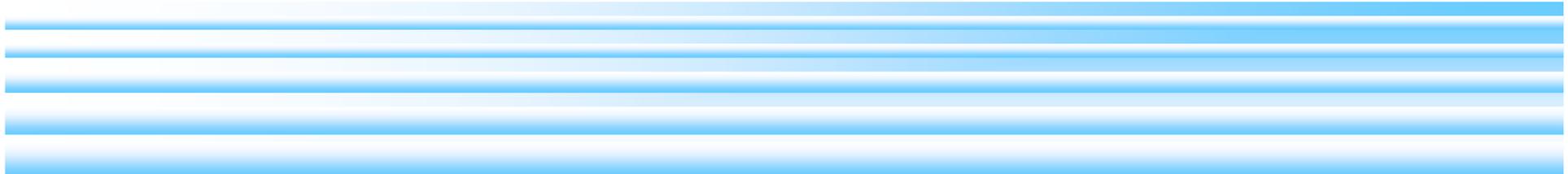
STAR European Conference 2010

London, March 22nd, 2010

Vehicle Thermal Reliability with STAR-GCM+

Dr. Fabiano Bet

Dr. Gerald Seider



Vehicle Thermal Reliability

Vehicle Thermal Management

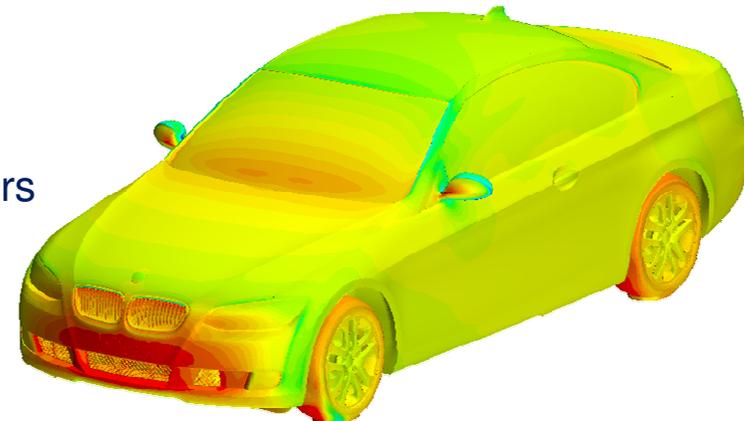
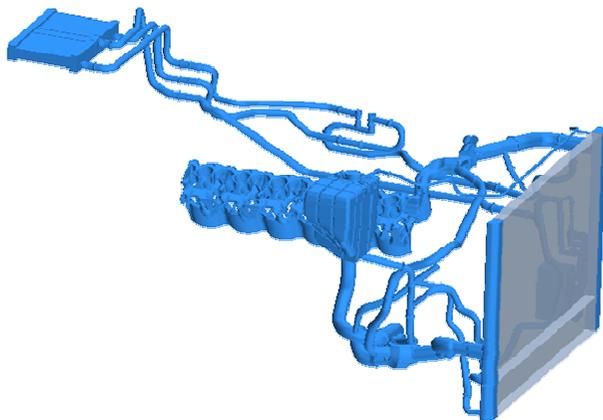
Thermal Sources:

Engine
Exhaust System
Alternator, etc.



Heat Release:

Heat Exchangers
Convection
Radiation



Vehicle Thermal Reliability

Design and Verification of Thermal Reliability



Concept

Prototypes/Testing

Thermal Verification

Start of Production

development process

- ⇒ Verification of thermal reliability is carried out late in the development process.
- ⇒ Engine's safety applications for combustion must be released, which guarantee secure operation of the engine in the earlier development stages.
- ⇒ Thermal load imposed by the exhaust system to the underhood environment will become more critical as the engine matures.
- ⇒ Underhood thermal reliability is very dependent on the proper location of air ducting components, seals and heat shields which are settled late in the developing process.

Therefore a simulation methodology is needed which can assess thermal reliability at a much earlier stage of the development process.

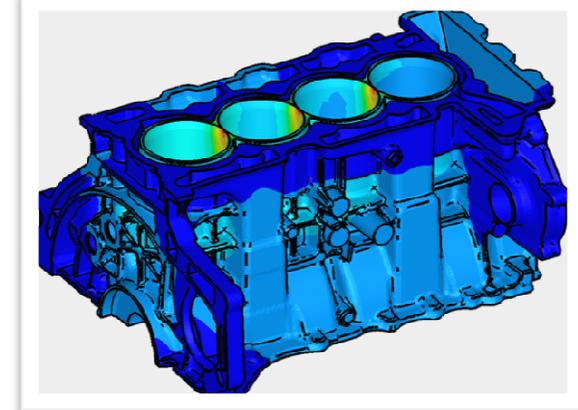
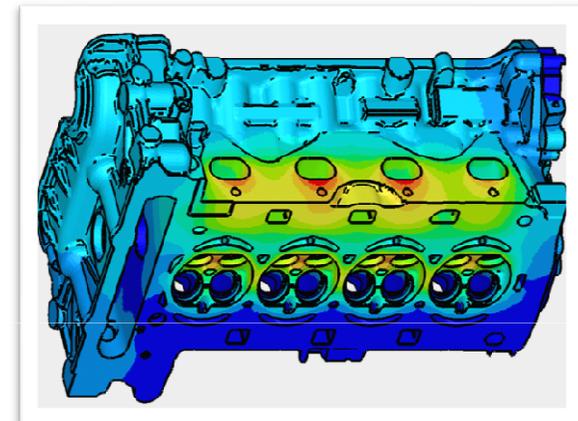
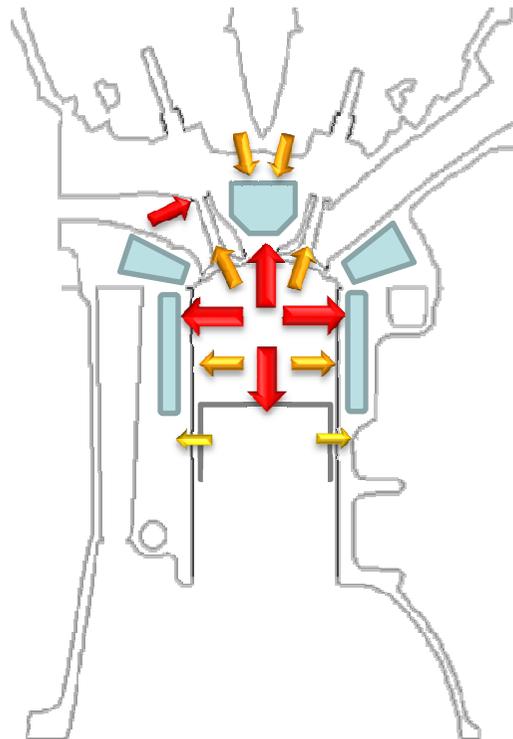
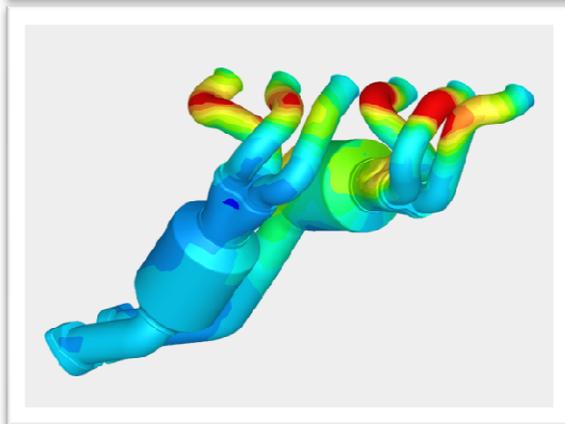
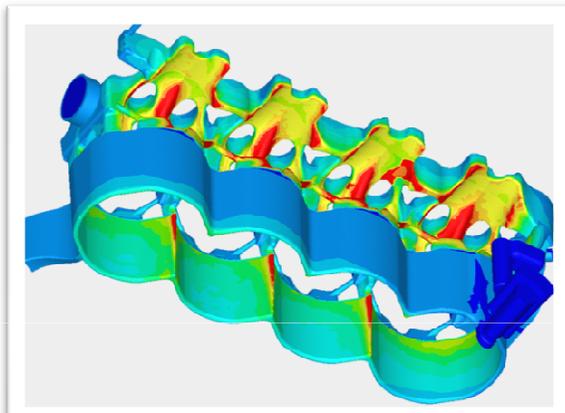
Vehicle Thermal Reliability

Engine Thermal Analysis - „State of the Art“

Cooling \Rightarrow Distortion \Rightarrow Stress \Rightarrow Endurance

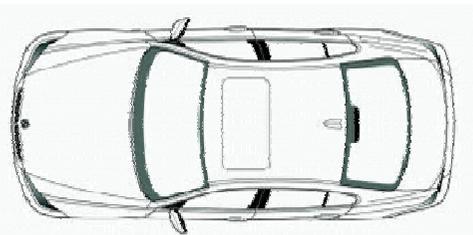
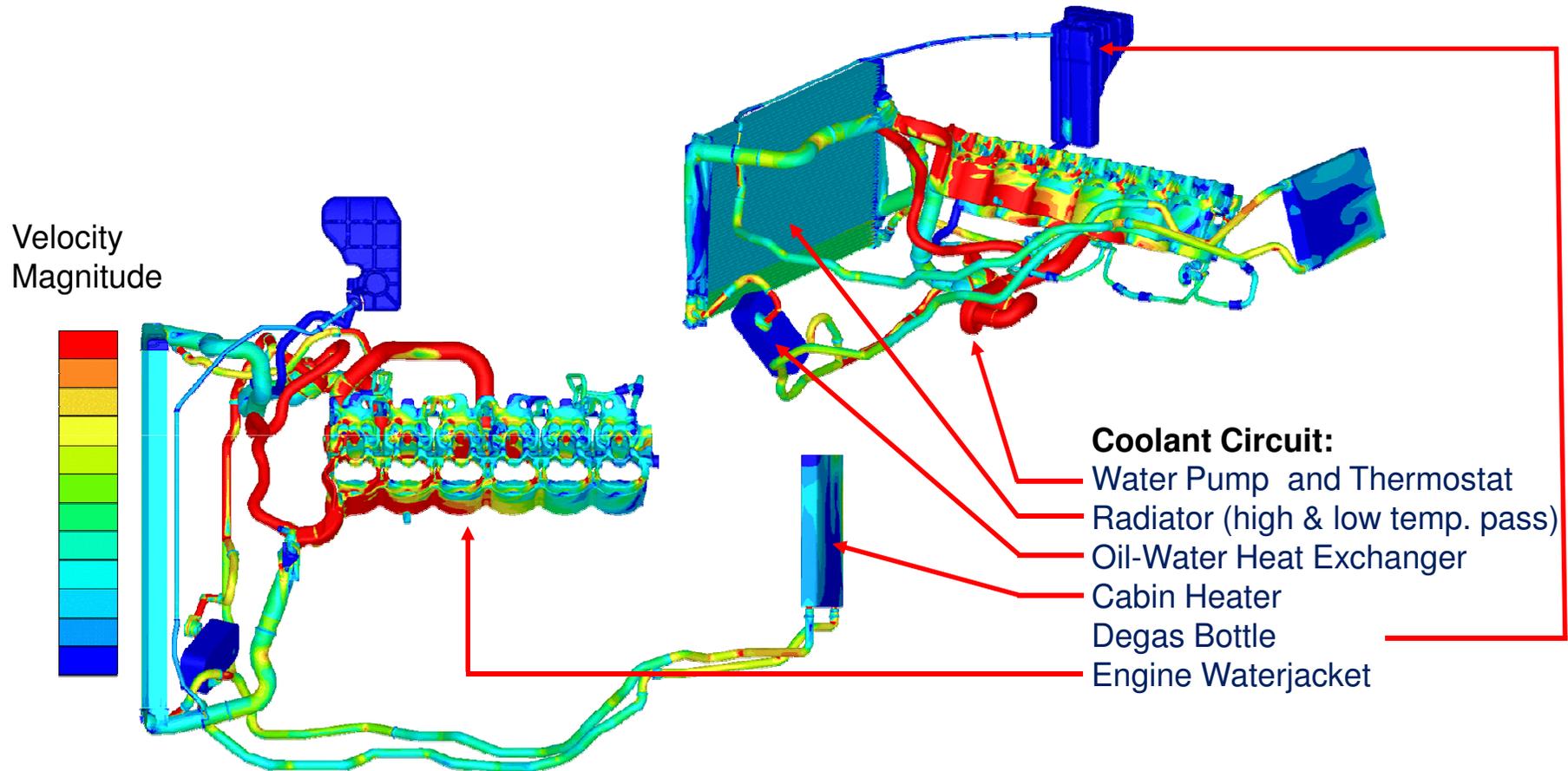


Thermal Management



Vehicle Thermal Reliability

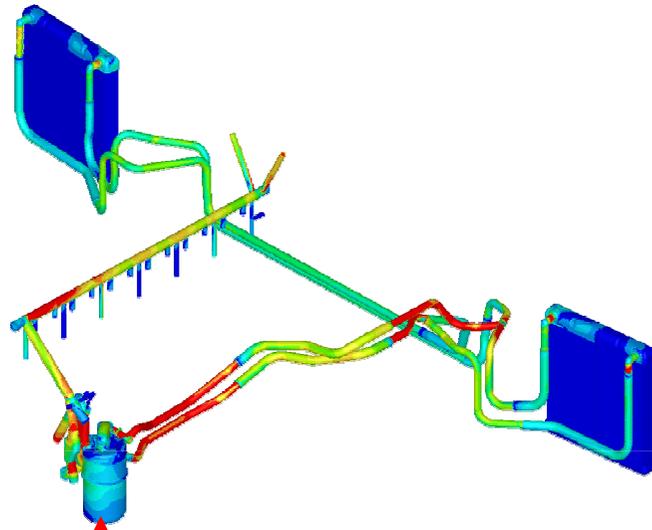
Analysis of Coolant Circuits - „State of the Art“



- Simulation decoupled from thermal analysis.
- constant temperature of coolant.
- analysis of volume flow rates
- analysis of pressure losses in components
- verification/Input data for 1D system analysis

Vehicle Thermal Reliability

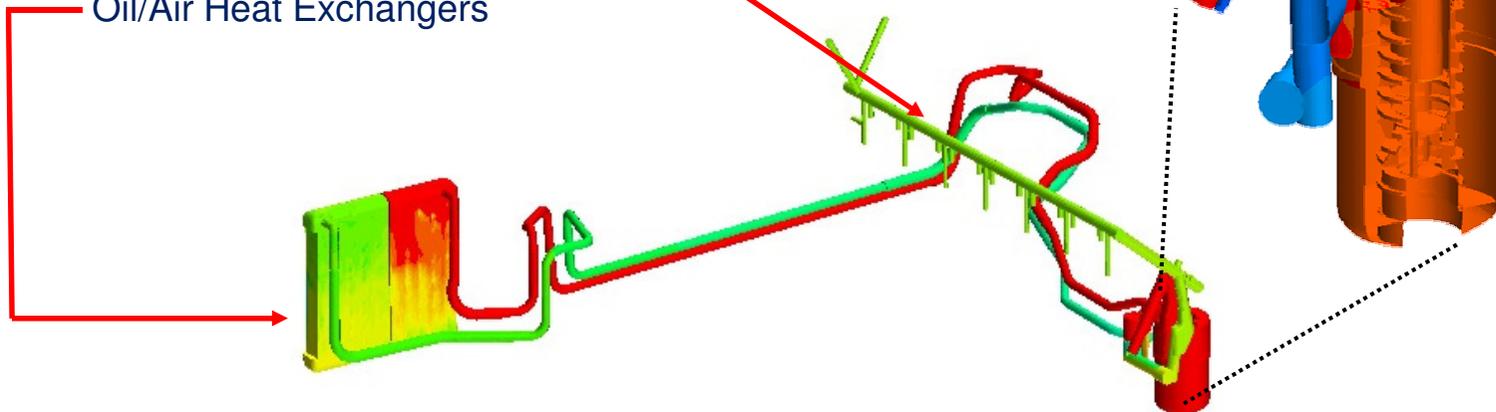
Analysis of Engine Oil Supply - „State of the Art“



- simulation decoupled from thermal analysis.
- fluid properties temperature dependent.
- analysis of volume flow rates (e.g. bypass)
- analysis of pressure losses in components
- verification/Input data for 1D system analysis

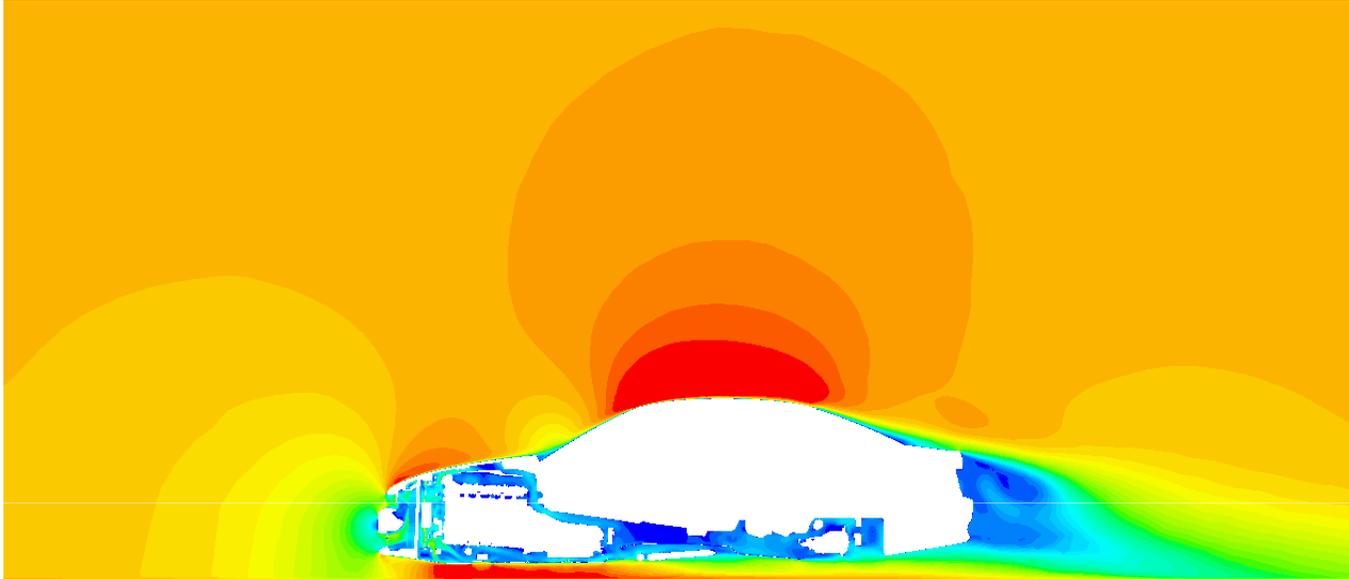
Oil supply with heat exchangers (pressure side):

Thermostat and Filter
Oil Main Gallery Crankcase
Oil/Air Heat Exchangers

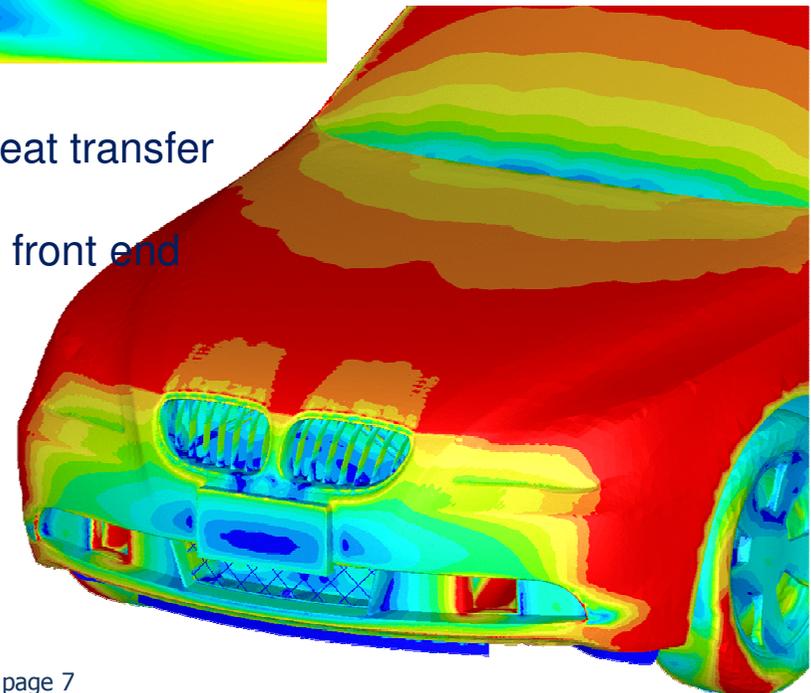


Vehicle Thermal Reliability

Underhood Analysis - „State of the Art“

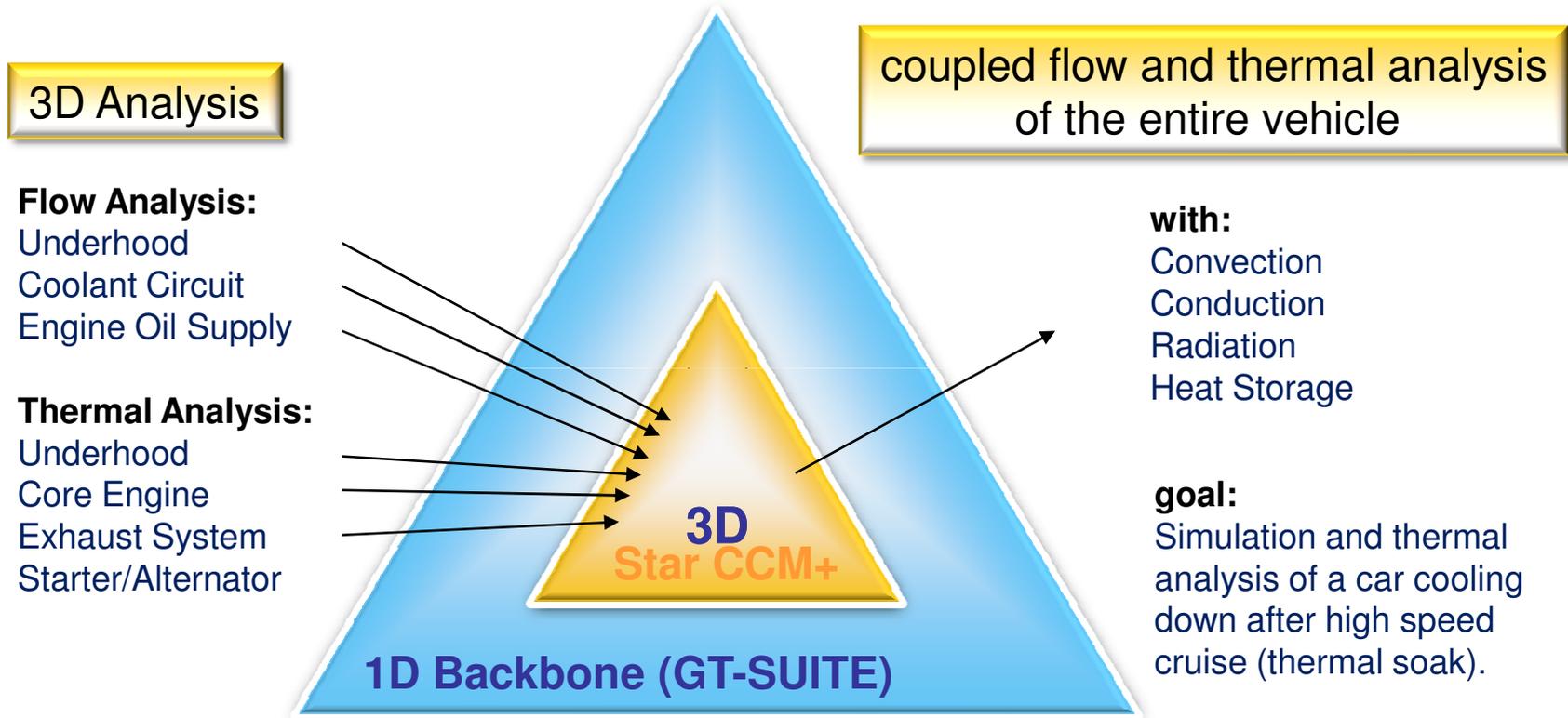


- simulation includes heat exchanger package with heat transfer
- fluid properties temperature dependent.
- analysis of flow rates through heat exchangers and front end
- analysis of heat transfer in heat exchangers
- verification/Input data for 1D system analysis



Vehicle Thermal Reliability

Coupled Flow & Thermal Analysis

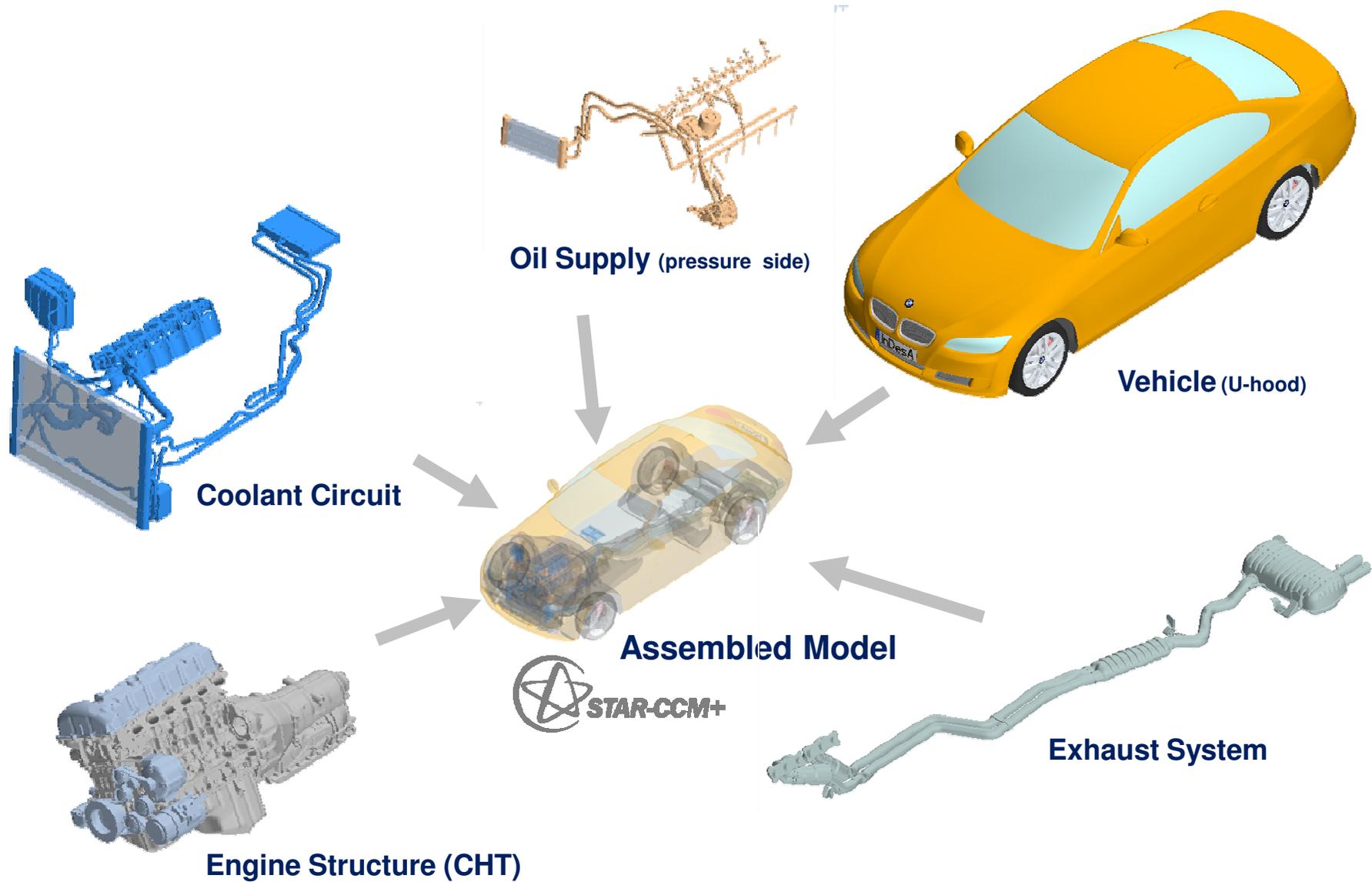


Challenge:

1. Handling of CFD/CHT Mega Simulation Models
2. Providing of Synchronized Sub-Models and Boundary Conditions

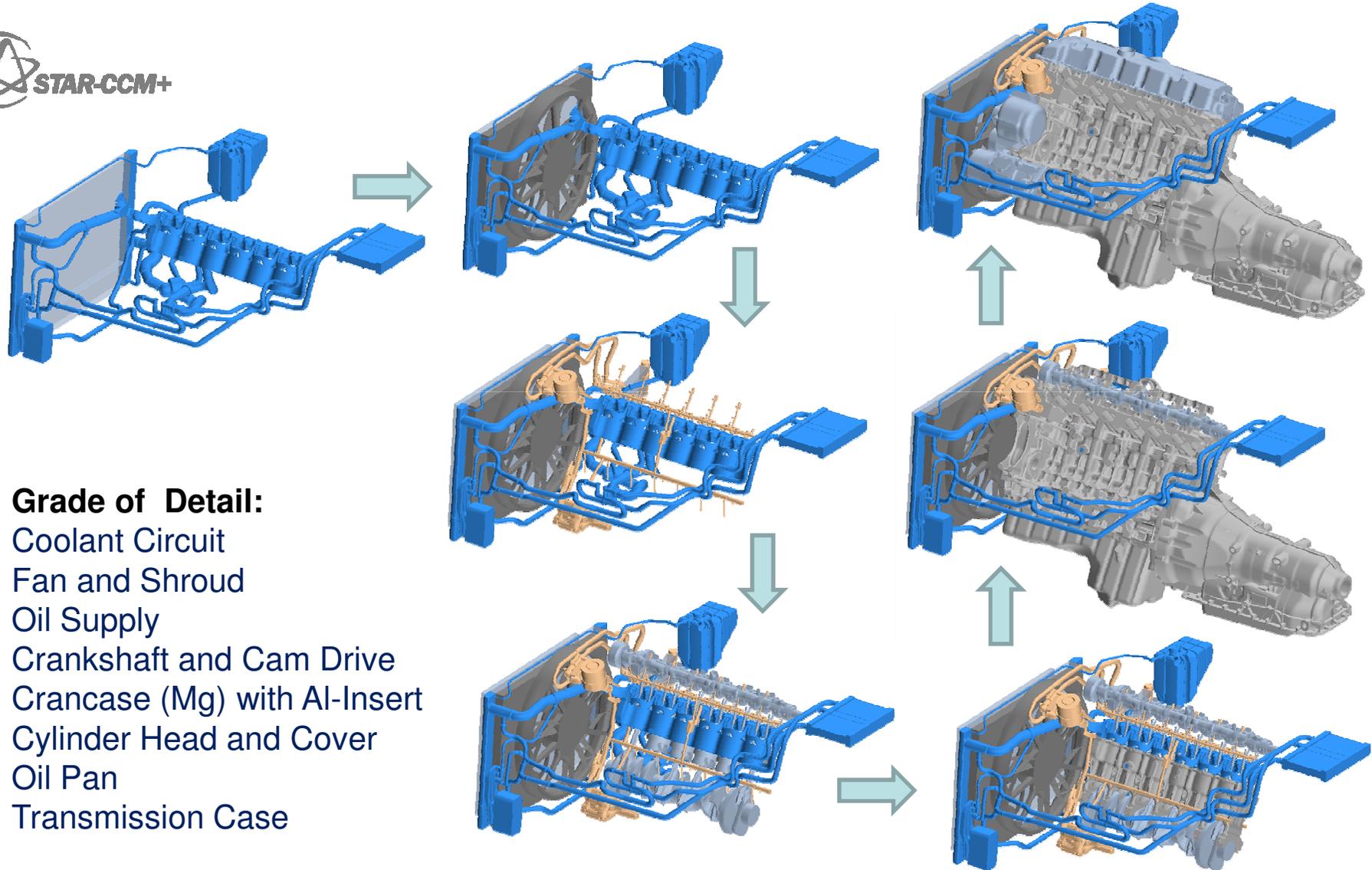
Vehicle Thermal Reliability

Thermal Coupling of Simulation Models



Vehicle Thermal Reliability

Assembling of Simulation Models

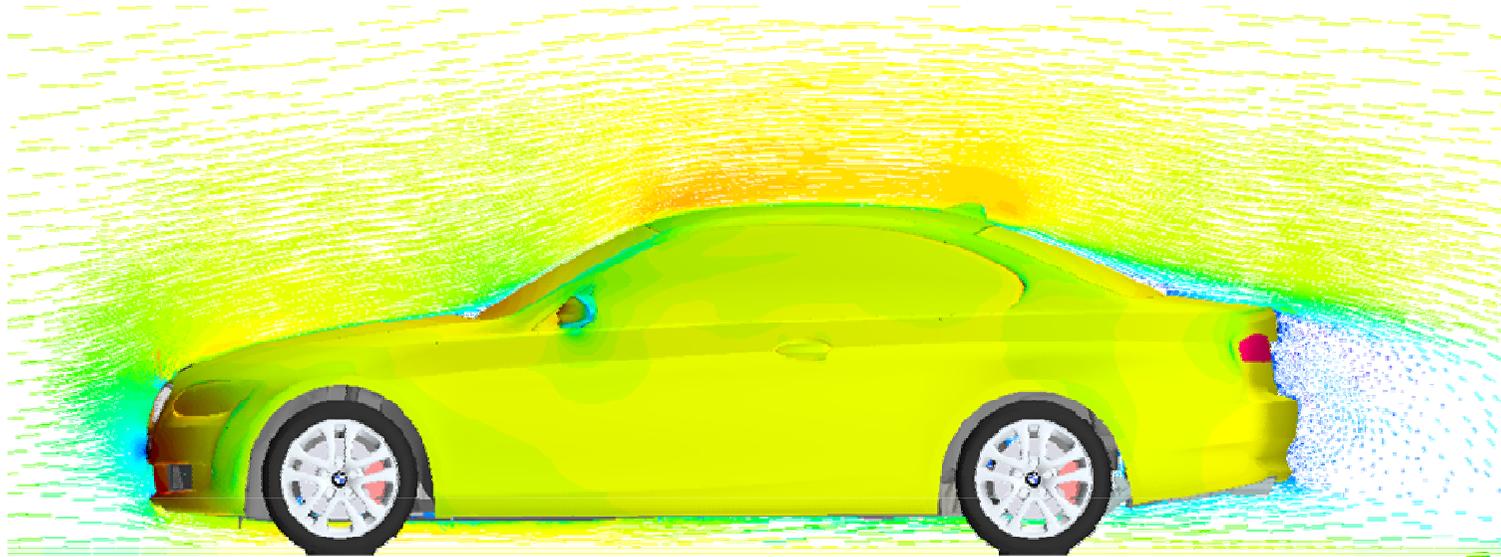


Grade of Detail:

- Coolant Circuit
- Fan and Shroud
- Oil Supply
- Crankshaft and Cam Drive
- Crankcase (Mg) with Al-Insert
- Cylinder Head and Cover
- Oil Pan
- Transmission Case

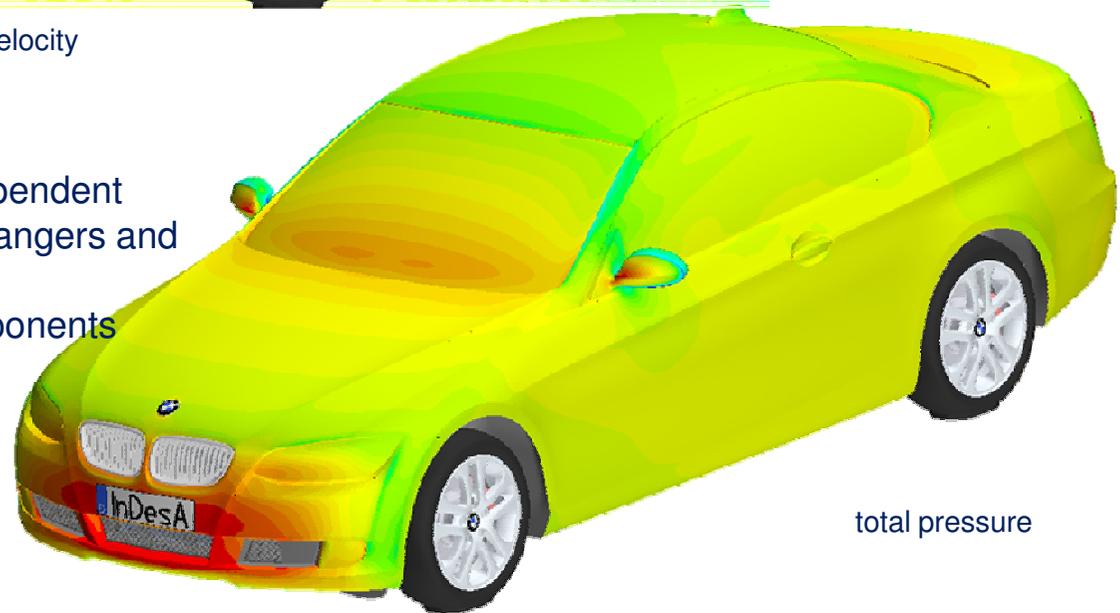
Vehicle Thermal Reliability

Coupled Flow & Thermal Analysis



total pressure and velocity

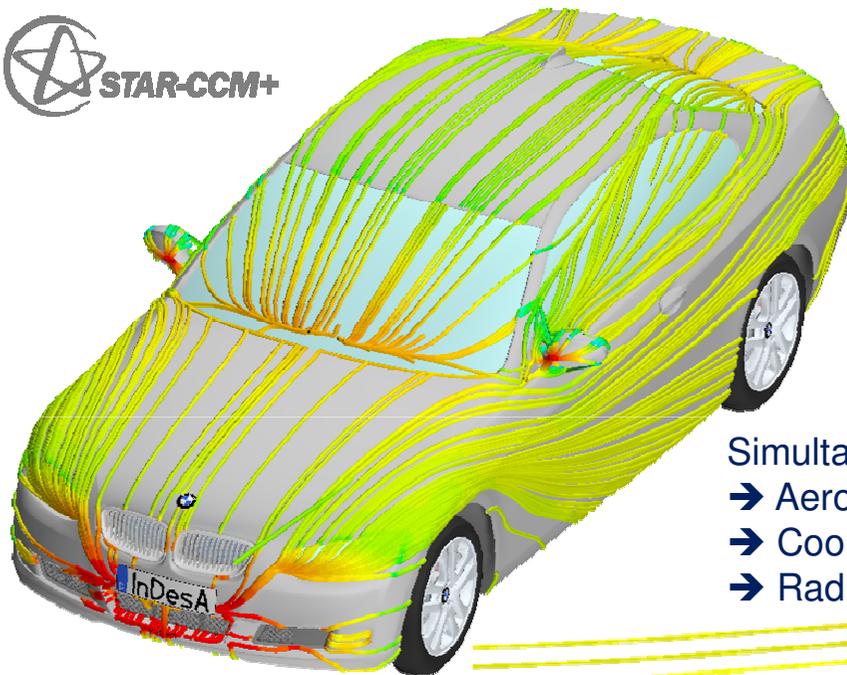
- fully coupled thermal analysis
- fluid/material properties temperature dependent
- analysis of flow rates through heat exchangers and front end inlets
- thermal interaction of all fluids and components



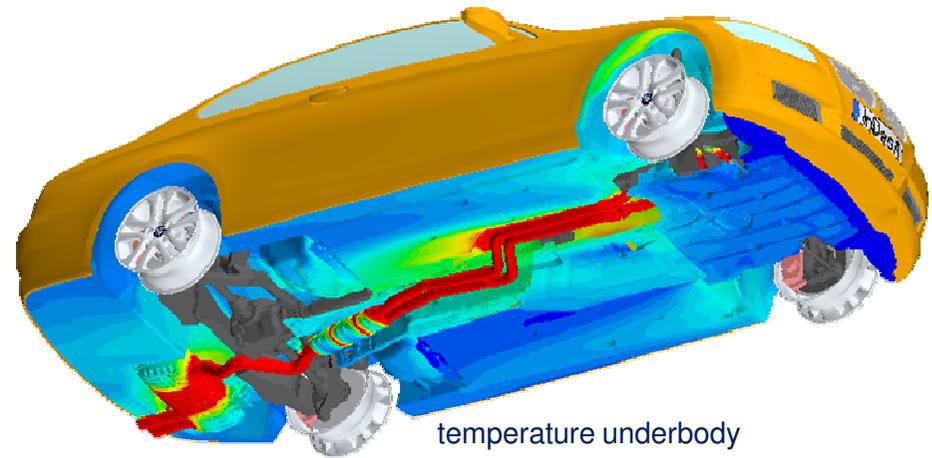
total pressure

Vehicle Thermal Reliability

Coupled Flow & Thermal Analysis



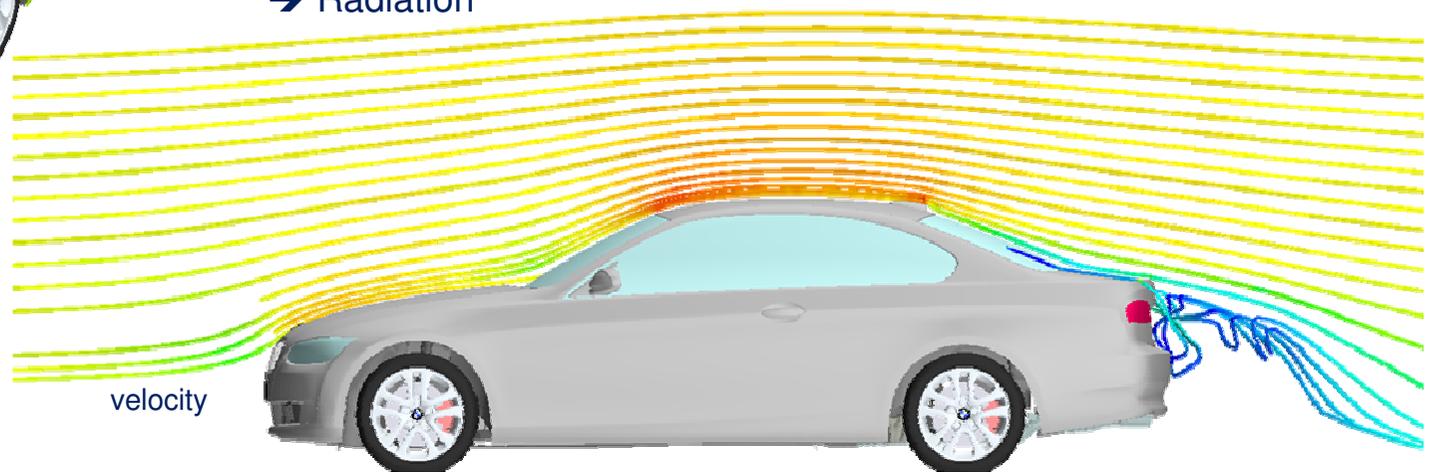
total pressure



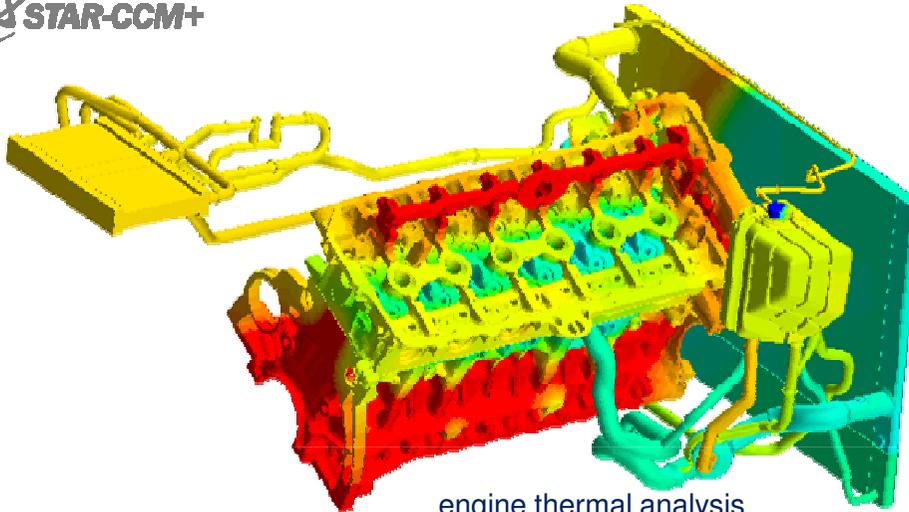
temperature underbody

Simultaneous Simulation of:

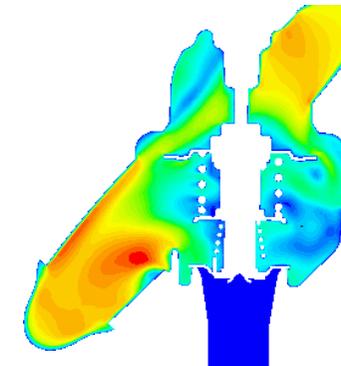
- Aerodynamics
- Cooling and Temperature Fields
- Radiation



velocity



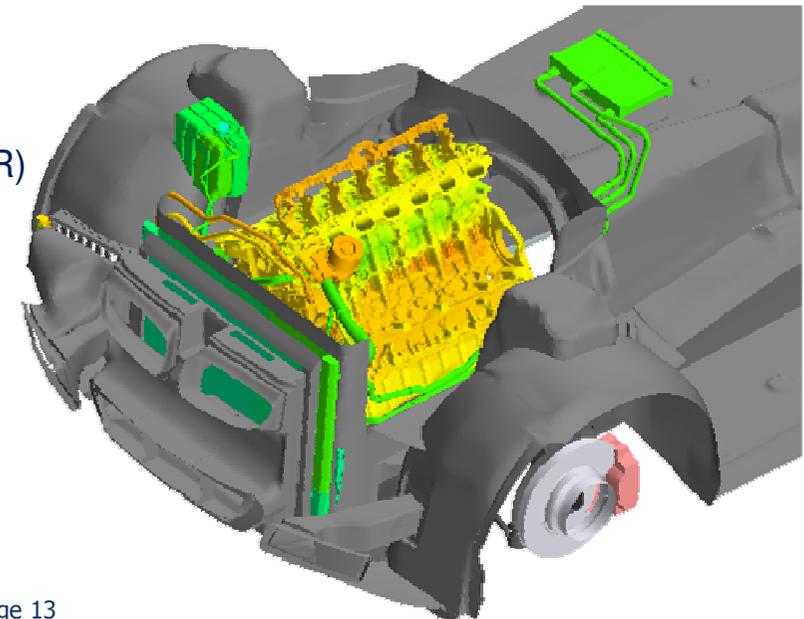
engine thermal analysis



cut through thermostat

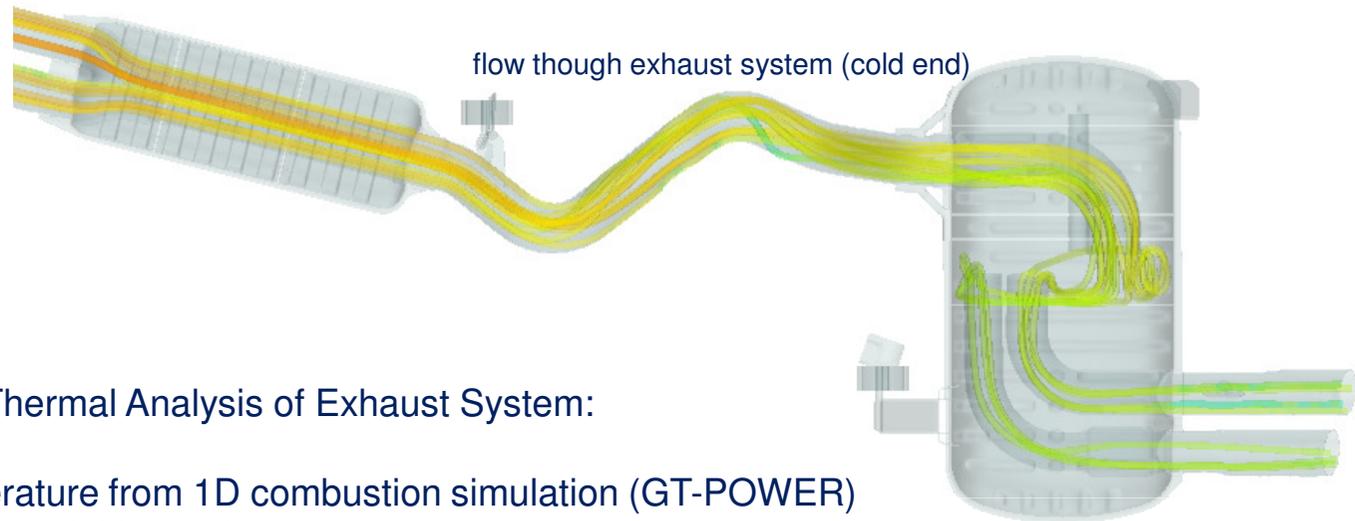
Coupled Thermal Analysis:

- thermal load e.g. from 1D combustion simulation (GT-POWER)
- conduction through engine structure
- convective transport through coolant
- heat release through heat exchangers (dual-stream)
- convective transport through engine oil



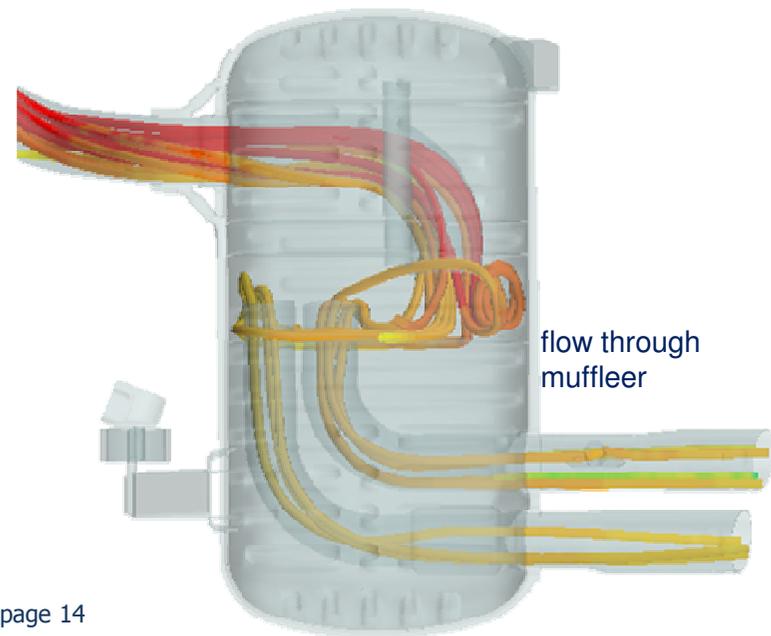
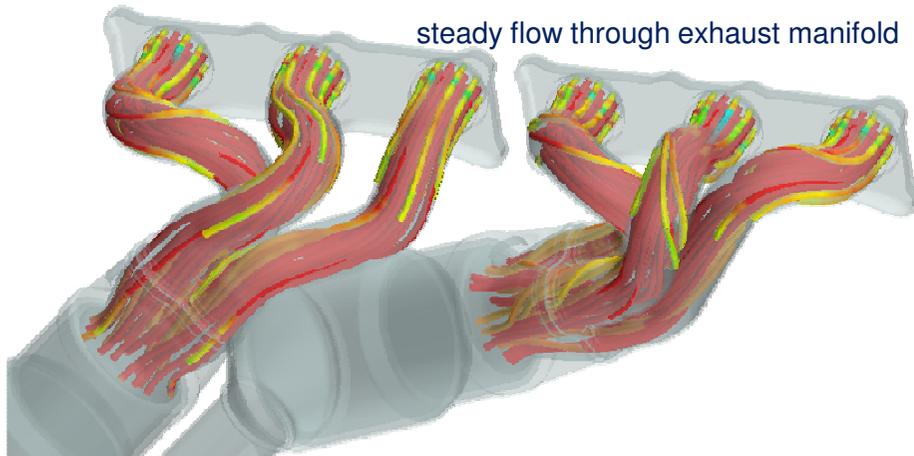
Vehicle Thermal Reliability

Coupled Flow & Thermal Analysis



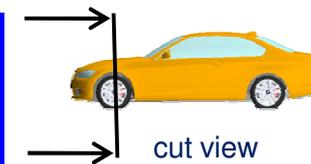
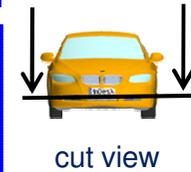
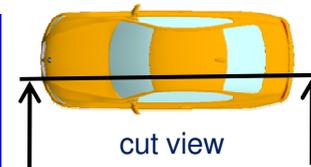
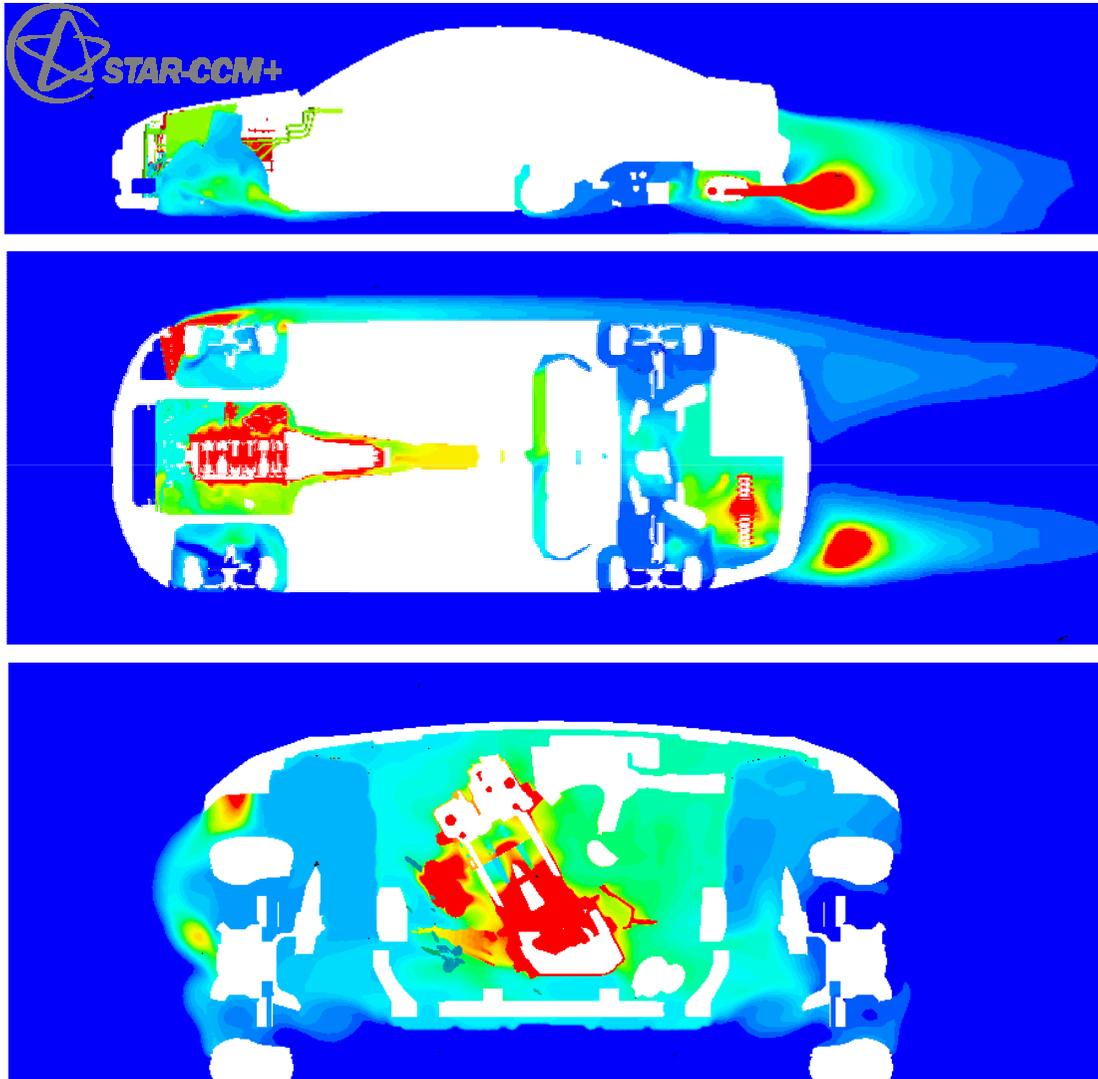
Coupled Thermal Flow and Thermal Analysis of Exhaust System:

- mass flow rate and temperature from 1D combustion simulation (GT-POWER)
- conduction through walls; partial insulation
- temperature fields and heat release through radiation
- addition of heat sources in catalyts



Vehicle Thermal Reliability

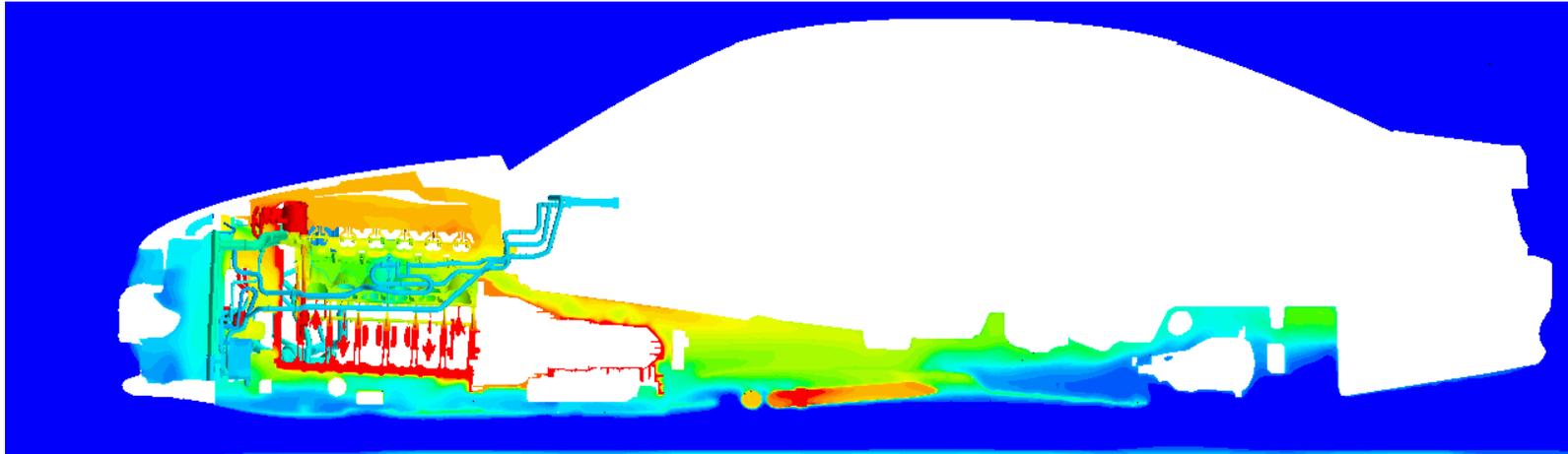
Coupled Flow & Thermal Analysis



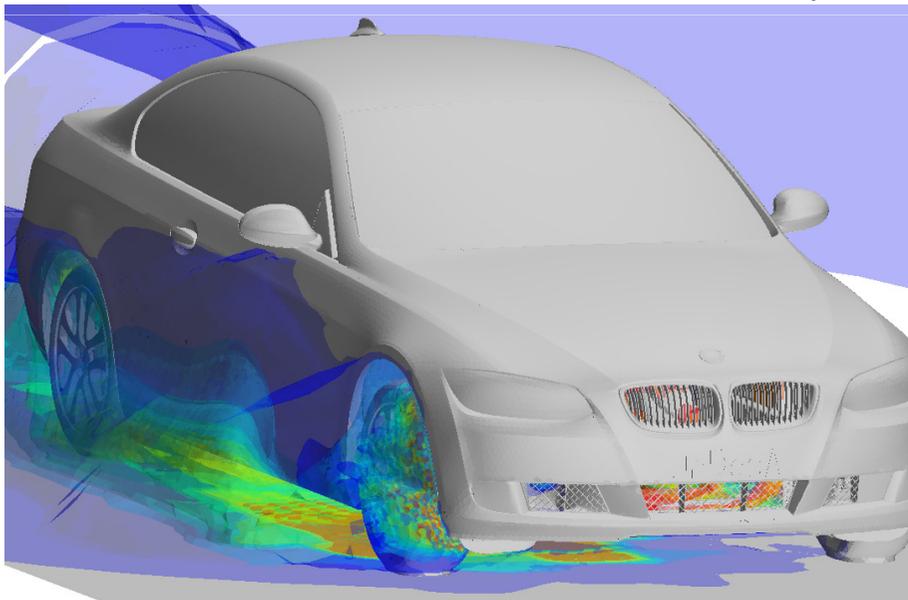
Temperature Distribution

Vehicle Thermal Reliability

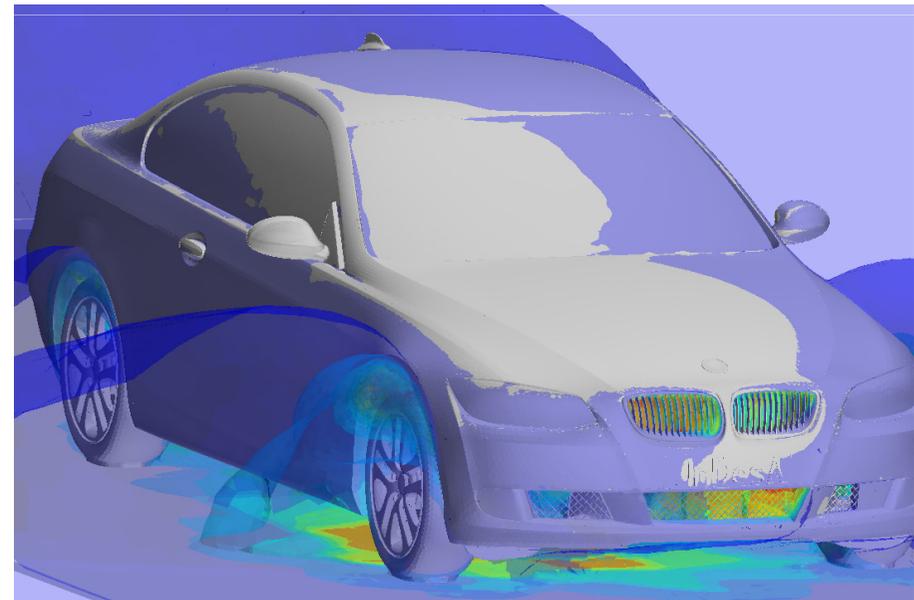
Thermal Soak Analysis



temperature ditribution



t = 0 s

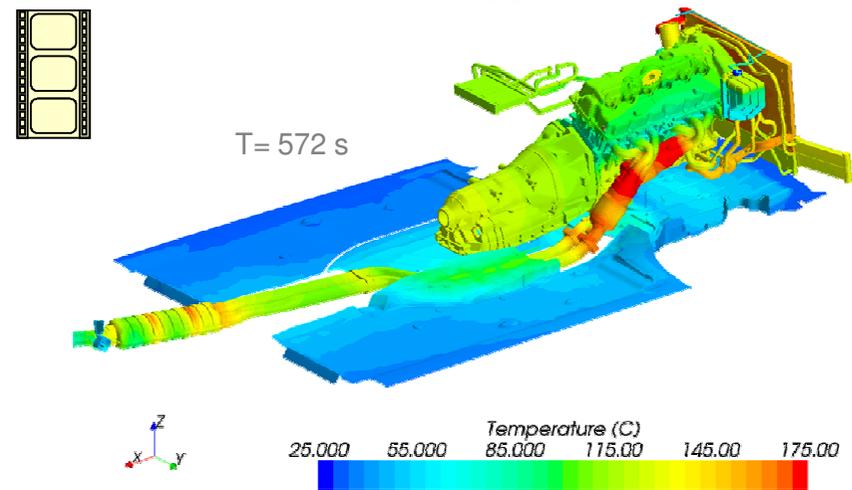
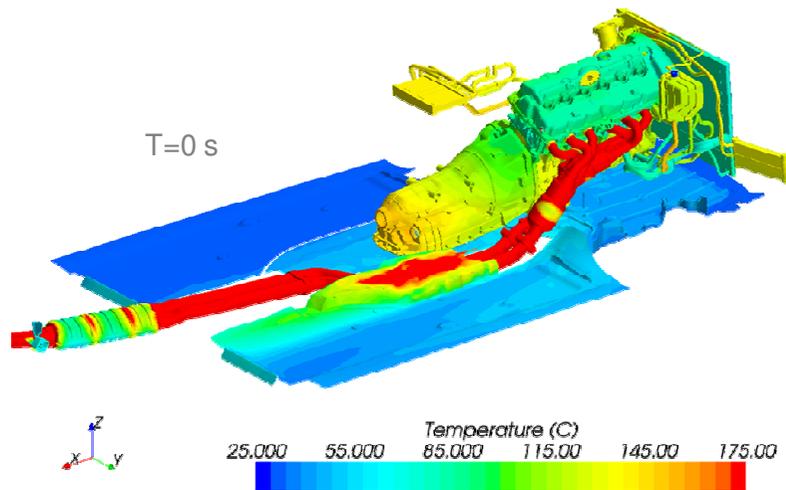
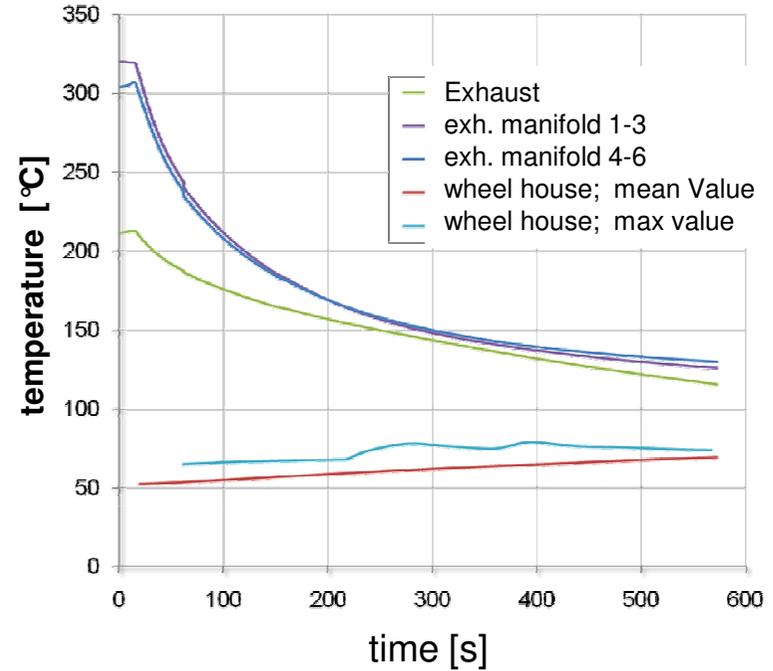
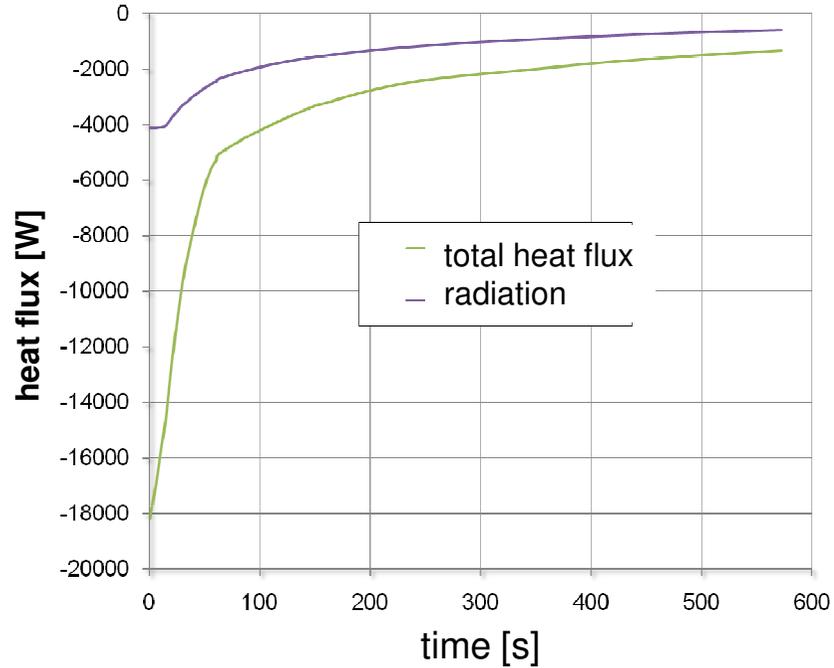


t = 572 s

temperature iso-surfaces

Vehicle Thermal Reliability

Thermal Soak Analysis



Vehicle Thermal Reliability

Thank you for your attention !

