INTEGRATED DESIGN ANALYSIS GmbH InDesA

STAR European Conference 2011

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The InDesA Virtual Test Facility Environment

Dr. Gerald Seider
Dr. Fabiano Bet

Company Profile

INTEGRATED DESIGN ANALYSIS GmbH **InDesA**

Consulting- &
Engineering Services

Simulation and Analysis
of complex fluid flow and heat transfer systems
for engineering and industrial applications

- **Vehicle Thermal Management**
- **Engine Thermal Management**
- **Electronics & Battery Thermal Management**
- **Heat Exchanger Thermal Analysis**
- **Turbomachinery Flow and Thermal Analysis**
  and more …

3D CFD/CHT Analysis

STAR-CCM+

1D System Analysis

GT-SUITE

InDesA
Virtual Test Center

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INTEGRATED DESIGN ANALYSIS

InDesA Virtual Test Facility Center
Overview

The IndesA Virtual Test Facility Center

1. **Background and Motivation**
2. **Concept and Architecture**
3. **Example: Test Rig for an EGR Cooler Module**
4. **Example: An Innovative Generator/Water Pump Unit**
5. **Combined Applications**
6. **Conclusion**

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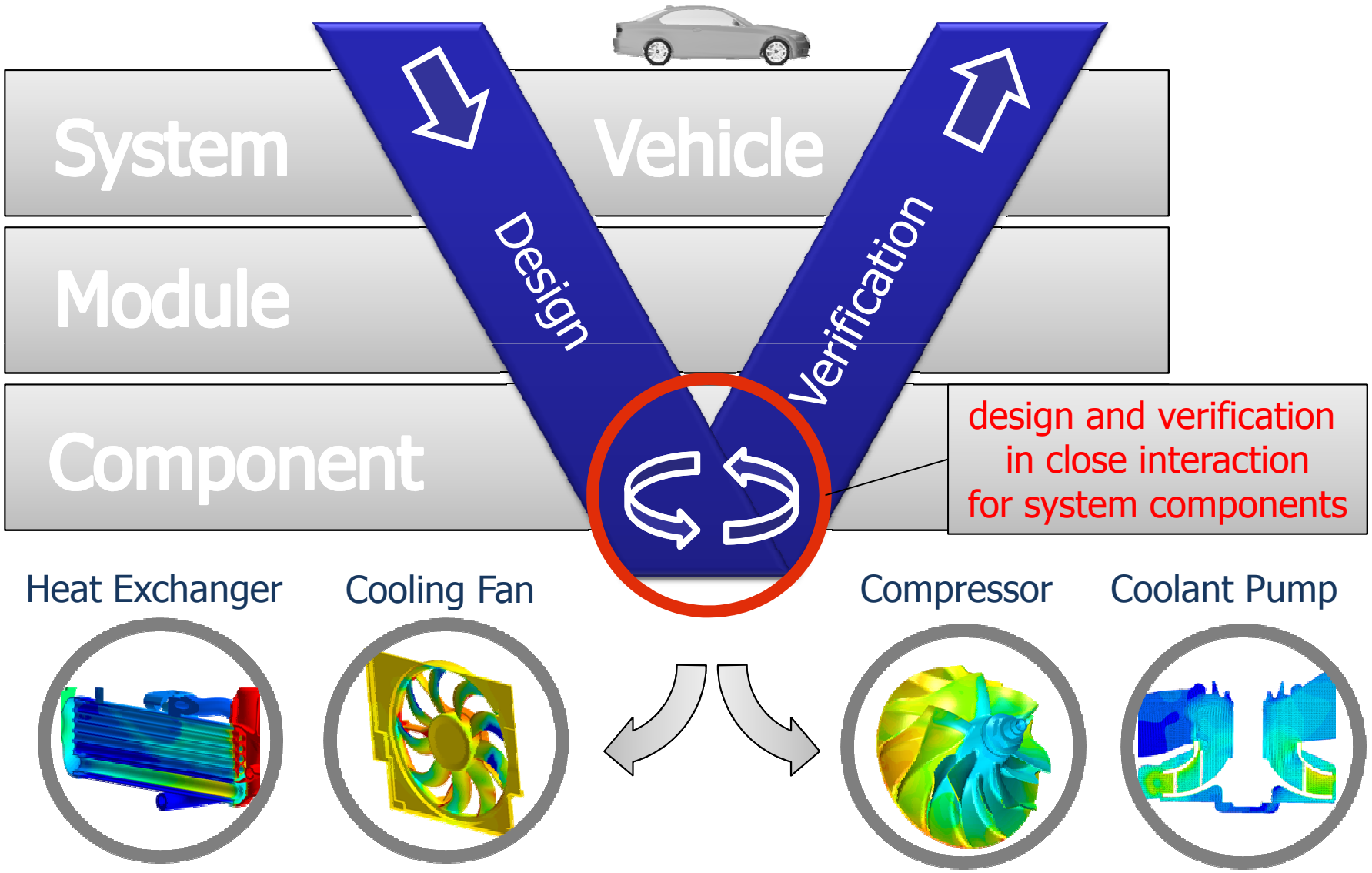
The OEM's V-Type Development Process



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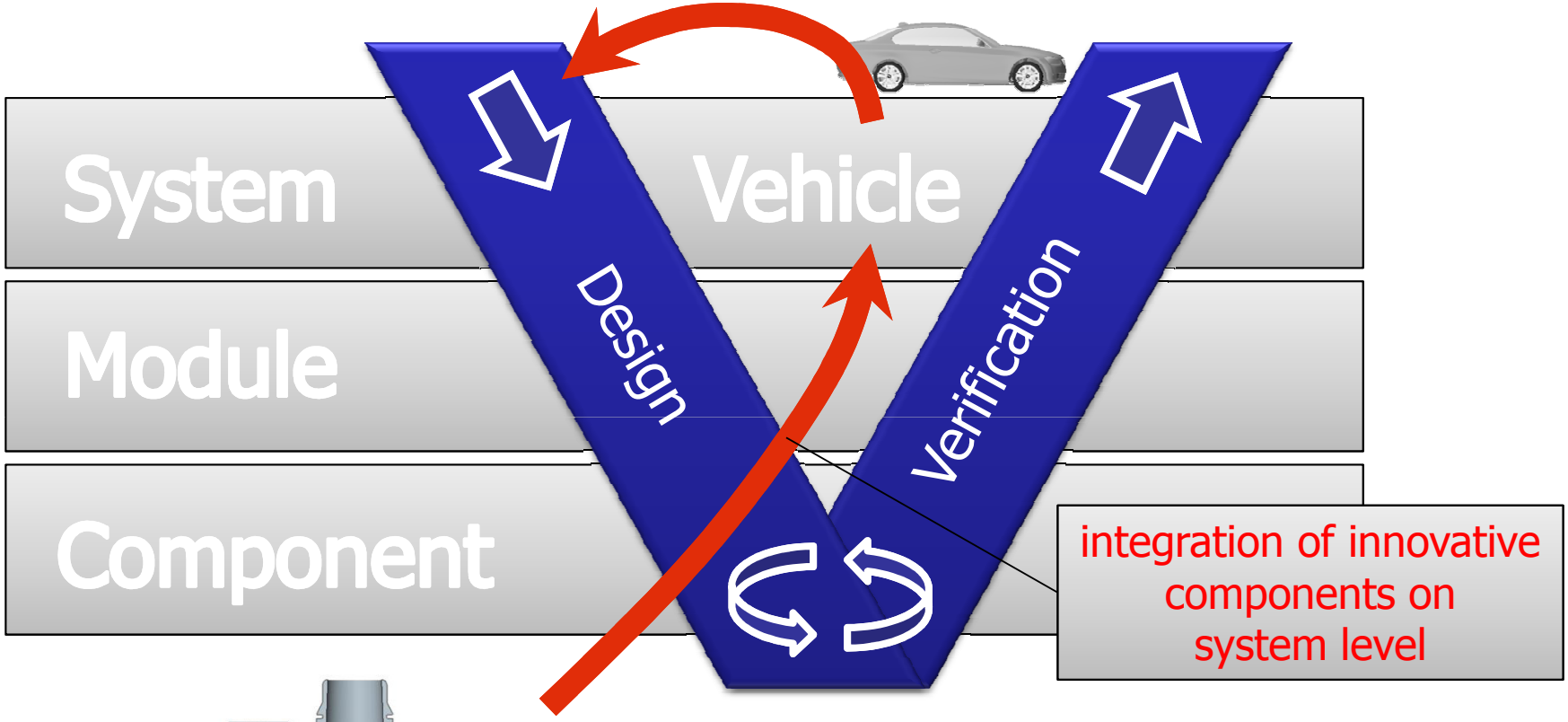

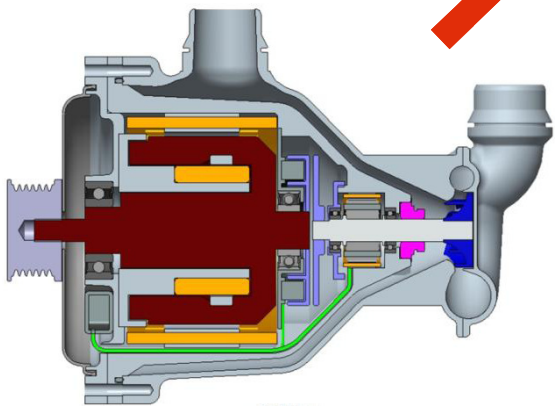

Innovative Accessory Units
like the
alternator with integrated coolant pump
must be integrated on the system level

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Motivation

The V-Development Process …

➔ leaves hardly time for prototype testing of system components

➔ requires fast adaption of components to changing module and system requirements

or simply …

the V-Development Process requires more
Virtual Testing on component level

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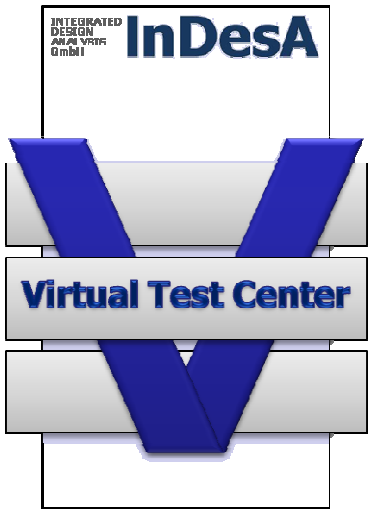
Motivation

We identified a need for …

a highly optimized virtual test environment, that is fast, flexible and cost efficient

for performance prediction (maps) of standard automotive accessory units
(fans, pumps, compressors, heat exchanger)

for functional testing & confirmation of engine and vehicle thermal systems
(coolant circuit, heat exchanger packs, electronics cooling, battery packs)



⇨ **Design of the InDesA virtual test facility environment**

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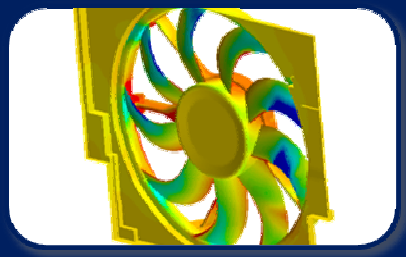
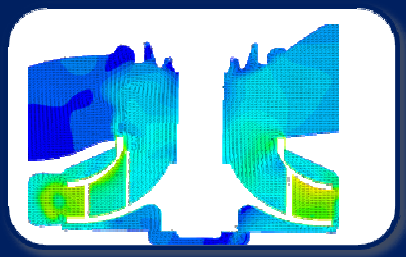
InDesA Virtual Test Facility Center
Concept

Cooling Fan

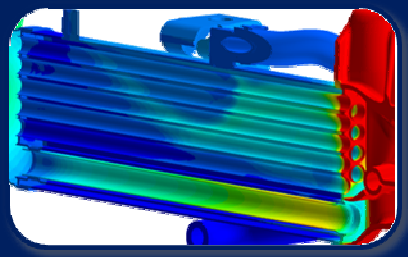


Compressor

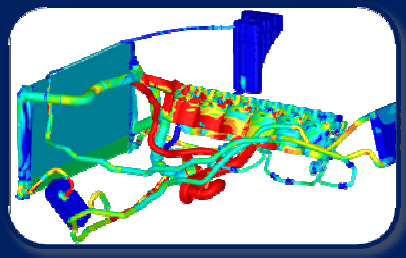
Coolant Pump



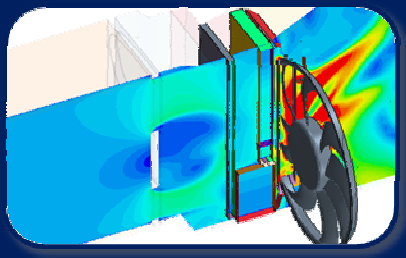
Heat Exchanger



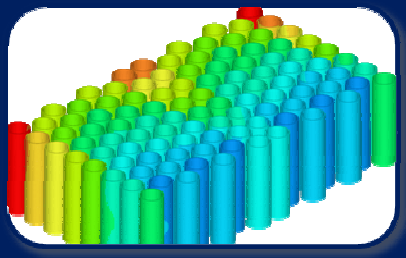
Coolant Systems



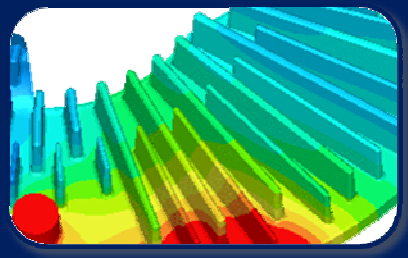
Cooling Pack



Battery Pack



Electronics

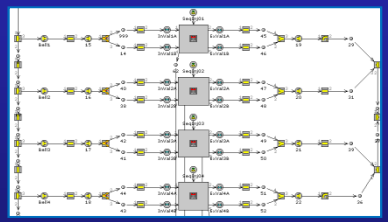


Computing Cluster

STAR-CCM+

Facility Supply

GT-SUITE



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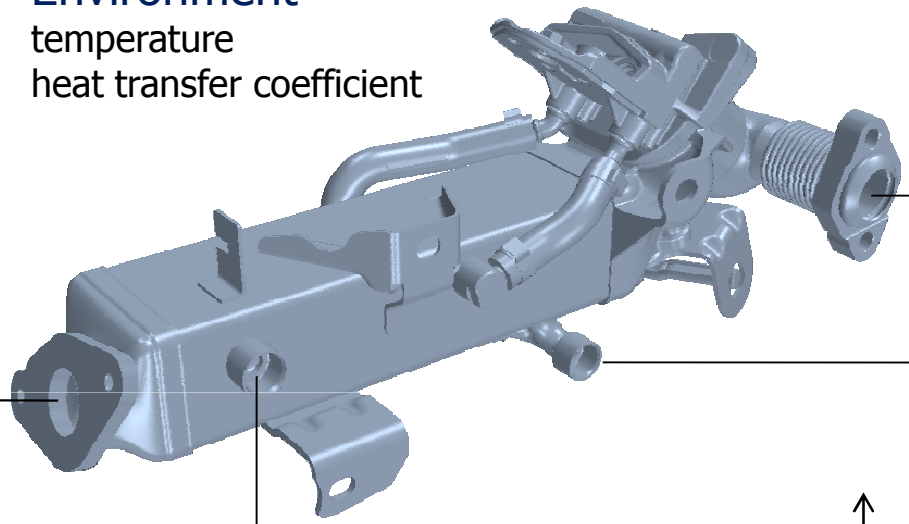
Test Rig Set-Up for an EGR Cooler Module

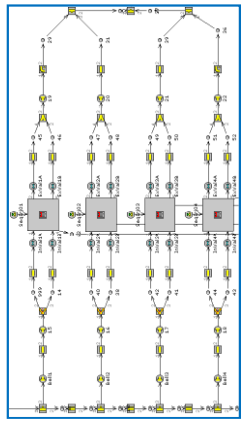
Environment
temperature
heat transfer coefficient



Exhaust

Coolant

Flow Rates
optional from
GT-SUITE
engine model



Exhaust

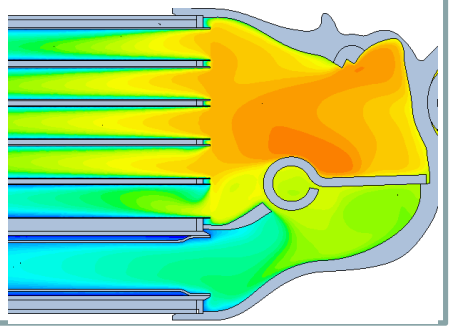
Coolant

Model Set-up with STAR-CCM+

- Thermal Fluid/Structure Coupling
- Full details of pipes or plates
- EGR valve cooling and
flow leakage at by-pass flap included

Additional Boundary Conditions

- Flap position for bypass-flow
- EGR valve position



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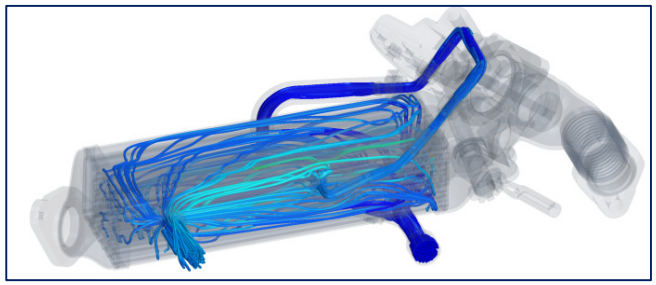
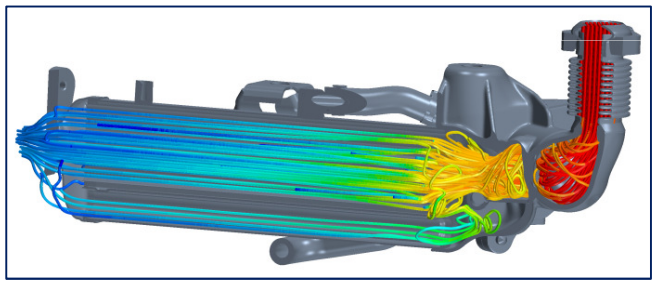
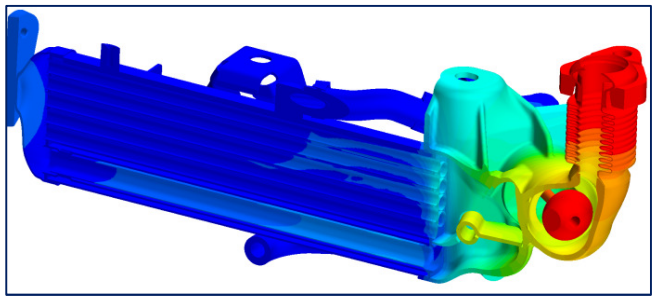
Test Rig Results for an EGR Cooler





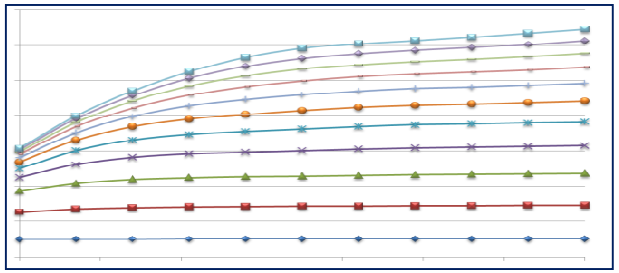


Coolant
- temperatures
- pressure loss
- onset of boiling
- volume flow rates
- flow uniformity

Exhaust
- outlet temperature
- pressure loss
- force on flap
- flow leakage

Structure
- temperatures esp. valve seat
- heat transfer

Heat Transfer Map



Nusselt Correlation
Nu = f (Re,Pr)

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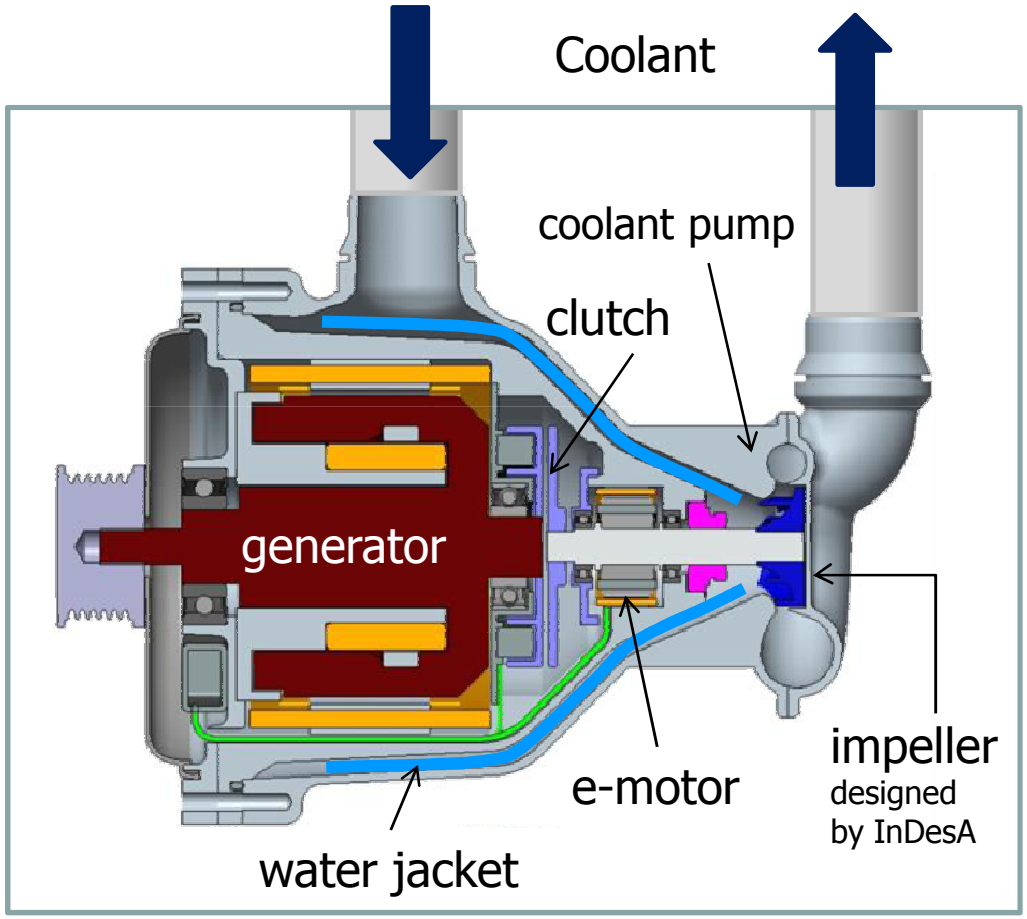
Innovative Coolant Pump/Generator Unit



Fluid mechanical design goals:

- verification of generator cooling
- target pump performance
- target pump efficiency

⇨ low pressure loss in waterjacket

⇨ design of efficient high speed impeller

Challenge:

Concept must be adapted and integrated for different vehicles on system level.

⇨ Need of a fast and efficient virtual process with direct interaction of design and verification.

Generator/Pump design by IGEL AG;
Winning "Award of Innovation" granted by the "Würzburger Automobil Gipfel 2010"

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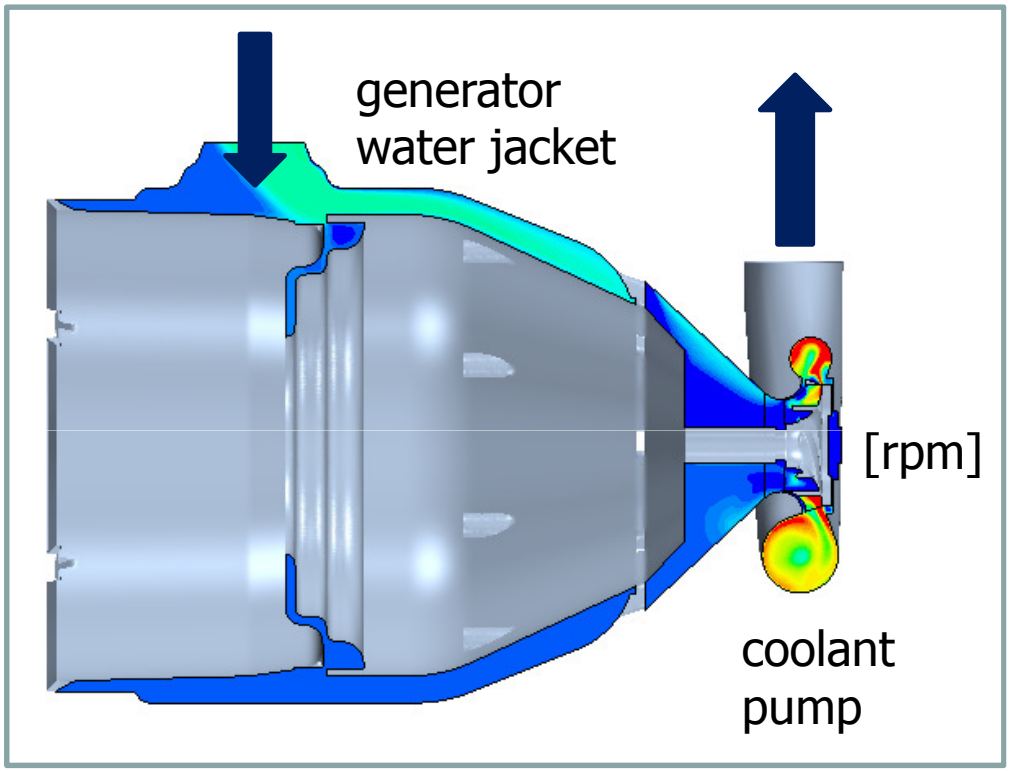
Results for Coolant Pump/Generator Concept



Coolant Pump

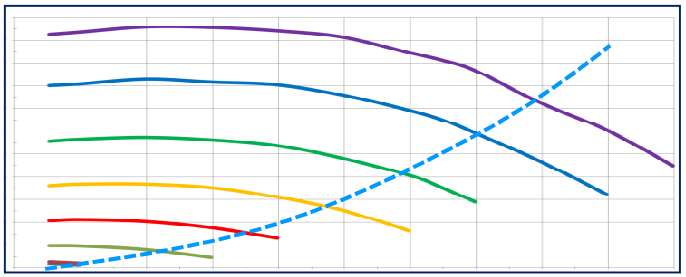
- volume flow rate for different impeller speeds
- pressure rise of pump
- hydraulic efficiency of pump
- onset of cavitation

Generator Waterjacket

- pressure loss of waterjacket
- heat transfer coefficients

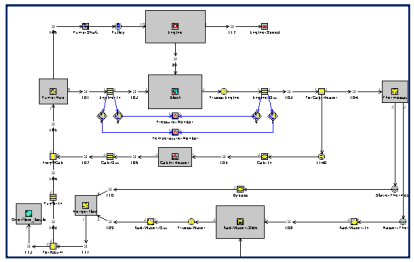
Pump Performance Map

(affinity laws)



System Pressure Loss

optional from
GT-SUITE
coolant system model



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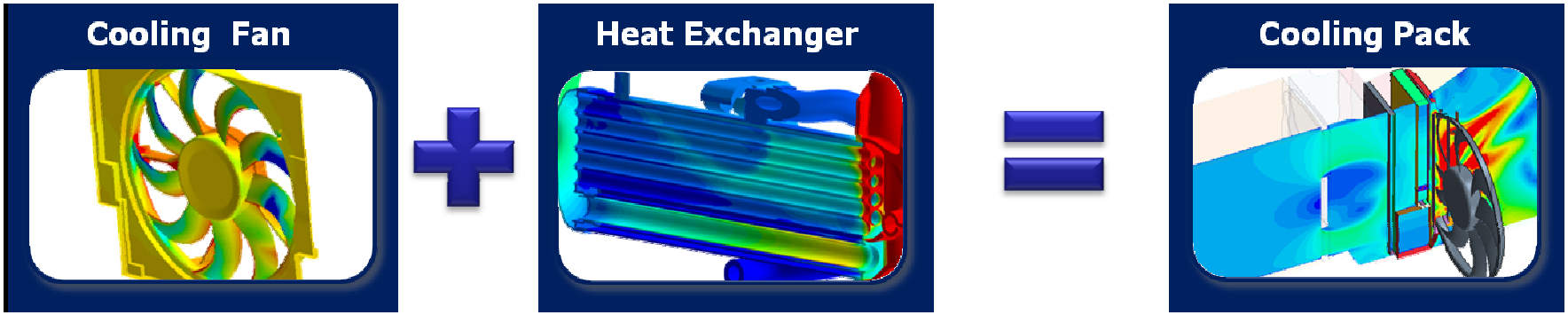
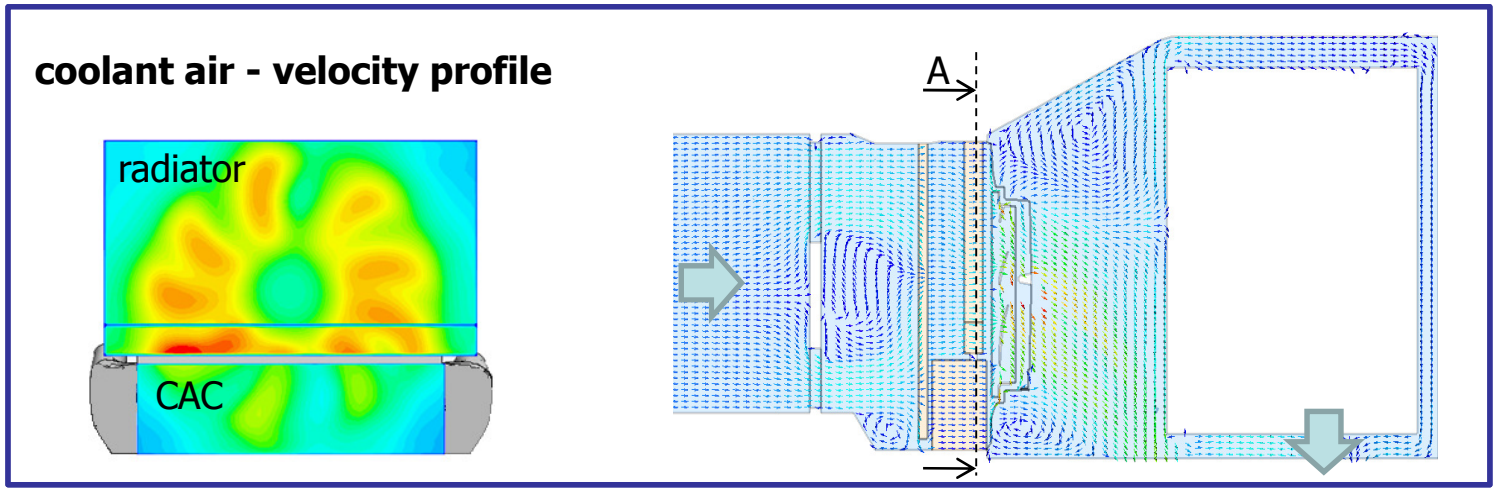
Combination for Cooling Package



3D CFD model
or derived
performance map.

porosity parameters
for cooling air side and
Nu-Correlation derived
from CFD results.

Simplified underhood
model for the
investigation of cooling
module performance.



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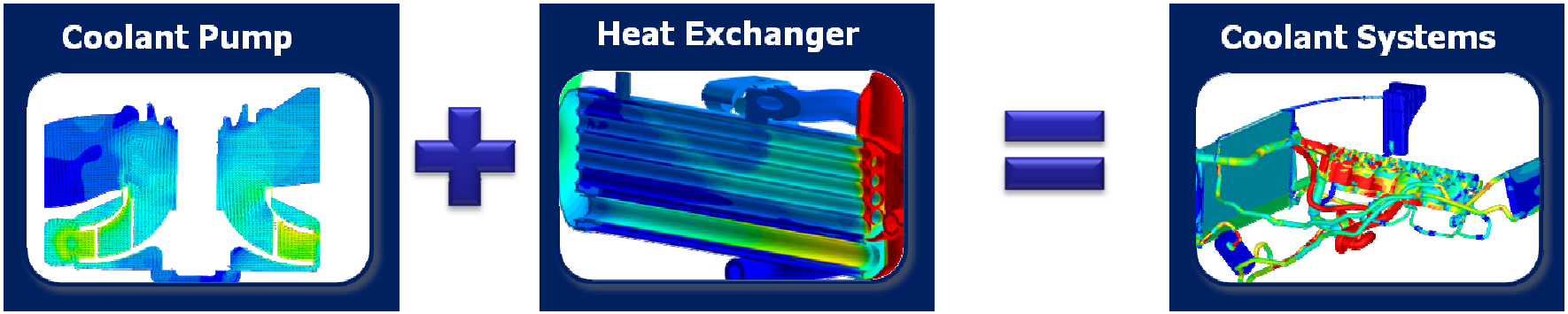
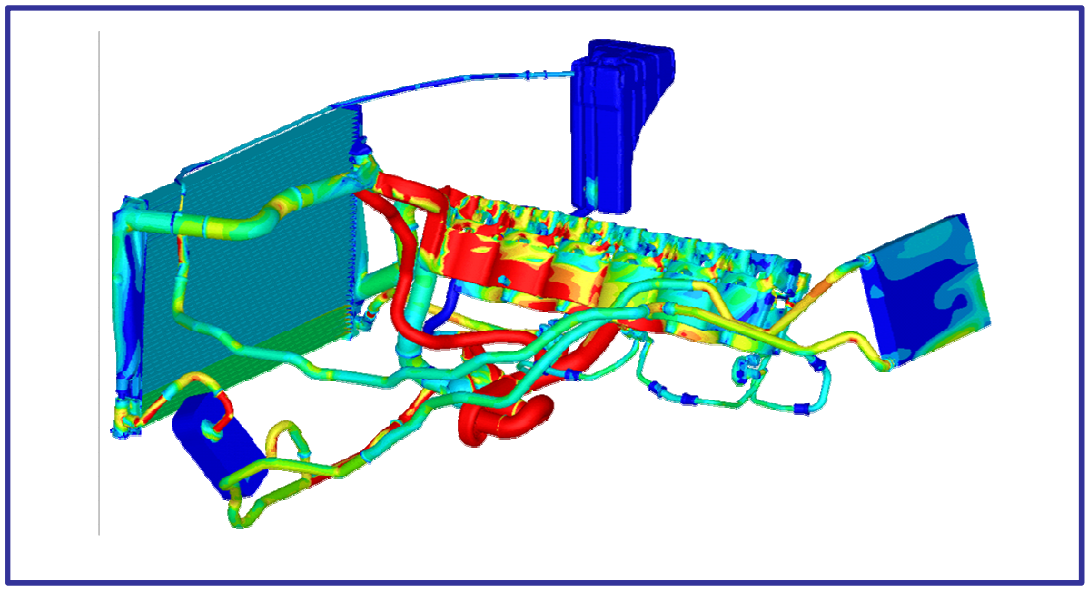
Combination for Coolant System



3D CFD model

3D CFD model of coolant side

3D CFD model for coolant system



➔Analysis of flow rates in entire coolant system for different pump speeds and thermostat /valve settings.

➔ Investigation of system filling procedure and de-gas behavior

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Conclusion I

The IndesA Virtual Test Facility Center

… an Efficient and Environment-Friendly Concept.

standardized and customized procedures for virtual test rig set-up and post-processing.

over 100 processors linked with a high performance communication and storage system tuned for optimal performance of StarCCM+

decent energy consumption -
only ventilation; no air conditioning of compute cluster;
no energy needed to feed heat exchangers for performance tests.

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Conclusion II

The IndesA Virtual Test Facility Center

… High Fidelity, Repeatability and Comparability

High resolution CFD models ensure detailed capturing of geometry
(allows for capturing of flow leakage in pumps, hinges, etc.)

Use of advanced StarCCM+ physical model library
(radiation, two-phase for boiling, kinematic module for pressure actuated flaps, etc.)

CFD model of test rig and test object are packed and stored with all results for reuse.
(allows to run additional operating points at request anytime; also used for documentation of test cases)

Comparability of results for different prototype stages
(same boundary conditions, same solution method, same mesh resolution)

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Conclusion III

The IndesA Virtual Test Facility Center

… 3D CFD/CHT and More!

CFD/CHT analysis can be extended to stress /strain analysis
(indication for possible fatigue problems)

Sophisticated boundary conditions can be added by 1D system analysis
(GT-POWER engine model, GT-SUITE coolant circuit, etc.)

Extended POST-Processing and results analysis
(Derivation of general Nu-Correlation for heat exchangers)

Combination of test rig models can be used to investigate larger systems
(underhood flow, coolant systems)

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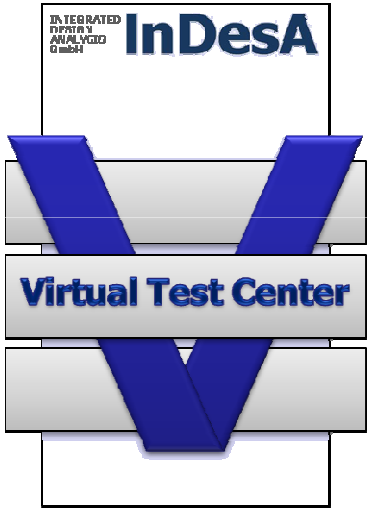

Thank you for your attention.