INTEGRATED DESIGN ANALYSIS GmbH InDesA

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# The InDesA Virtual Test Facility Environment

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# 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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# 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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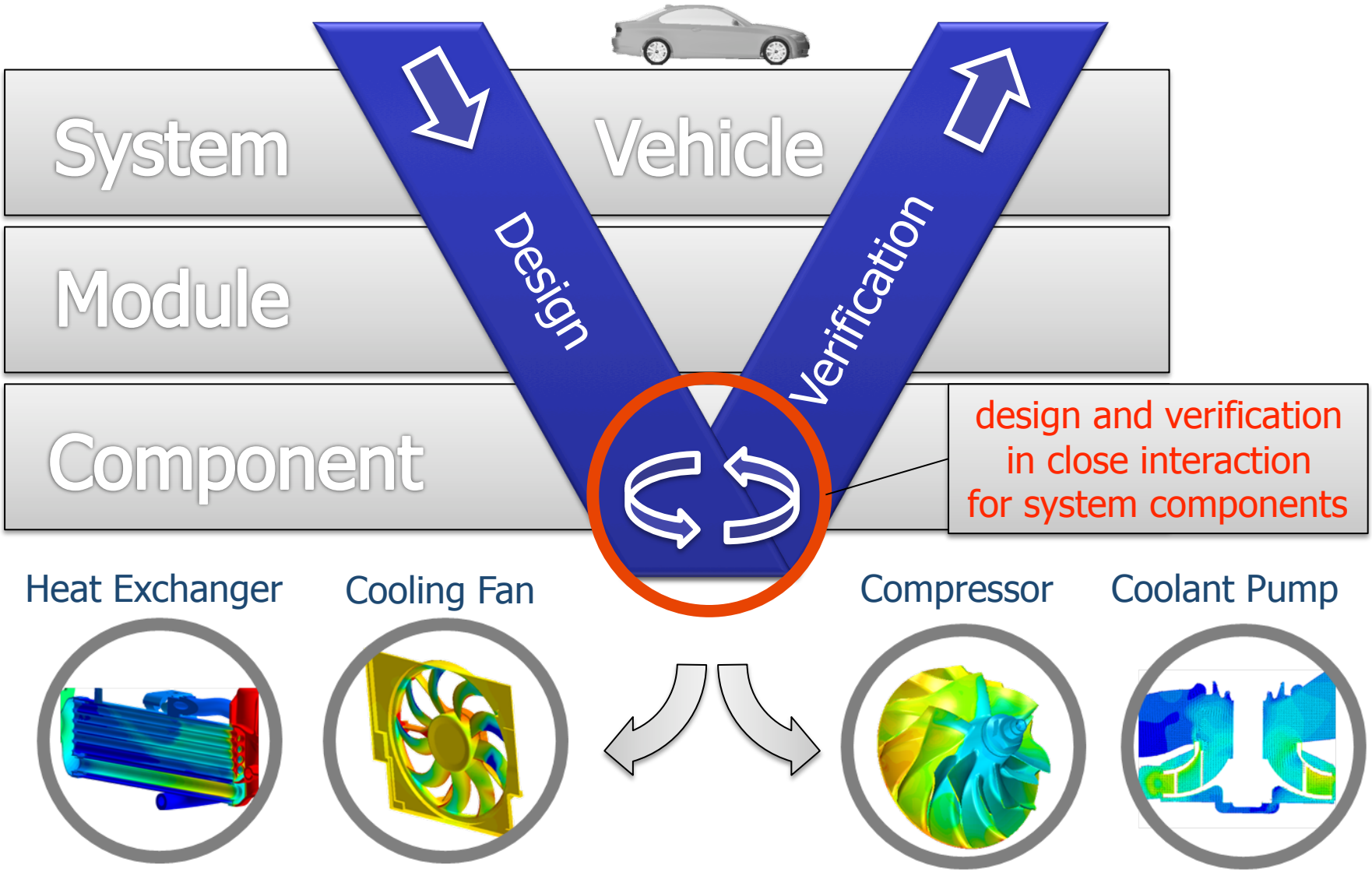
# InDesA Virtual Test Facility Center

## The OEM's V-Type Development Process



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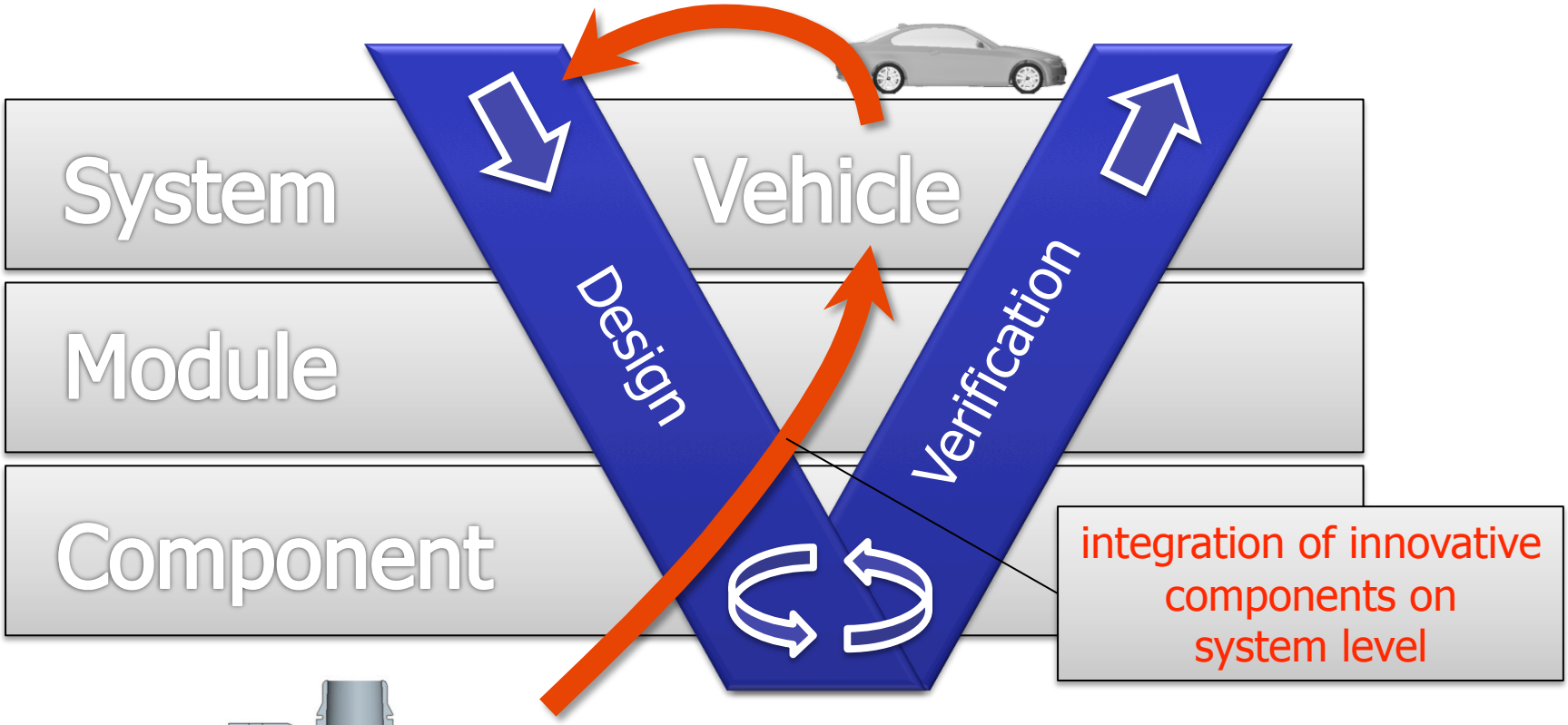
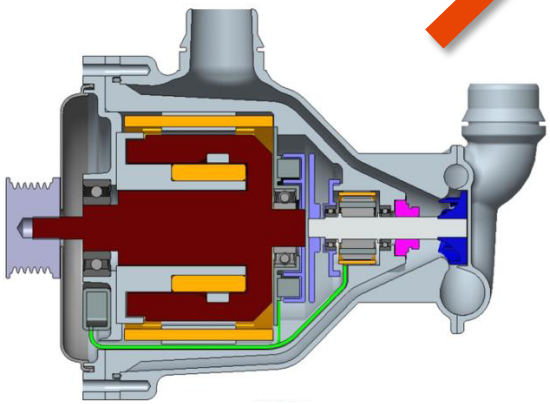
## The OEM's V-Type Development Process



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

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# InDesA Virtual Test Facility Center

## 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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# InDesA Virtual Test Facility Center
## 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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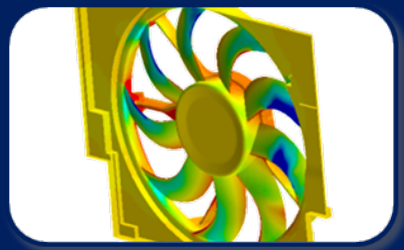
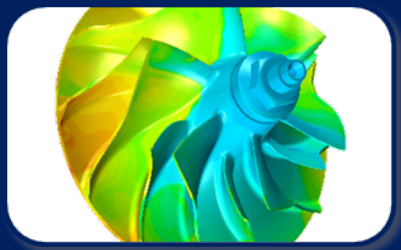
# InDesA Virtual Test Facility Center

## Concept

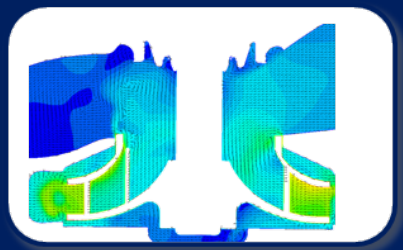
Cooling Fan



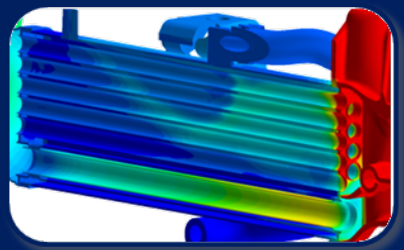
Compressor



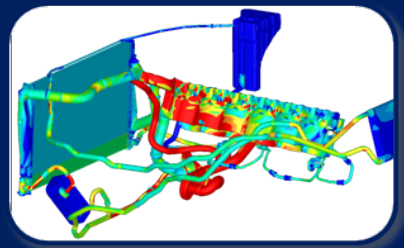
Coolant Pump



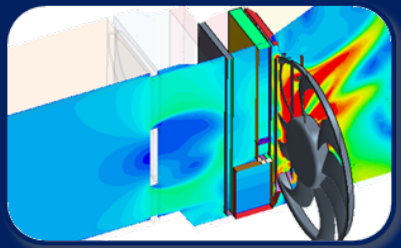
Heat Exchanger



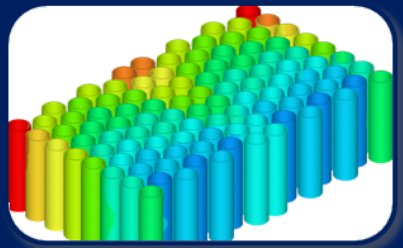
Coolant Systems



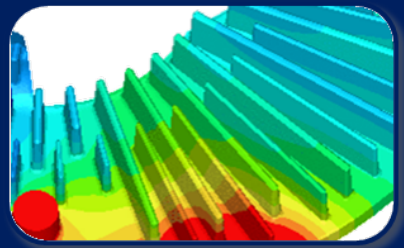
Cooling Pack



Battery Pack



Electronics

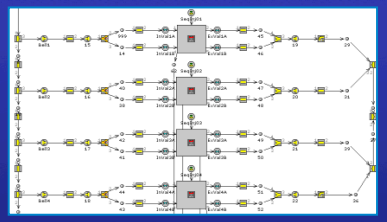


Computing Cluster

STAR-CCM+

Facility Supply

GT-SUITE



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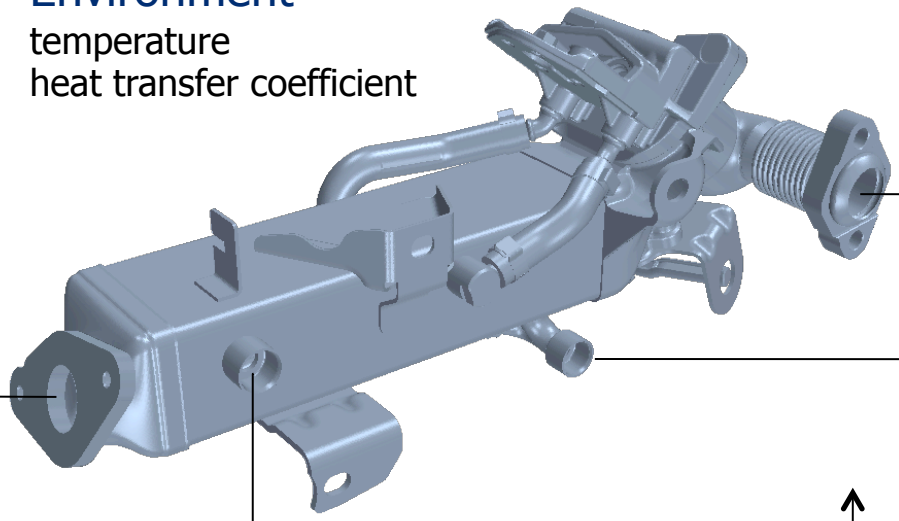
## Test Rig Set-Up for an EGR Cooler Module

### Environment

temperature
heat transfer coefficient



Exhaust

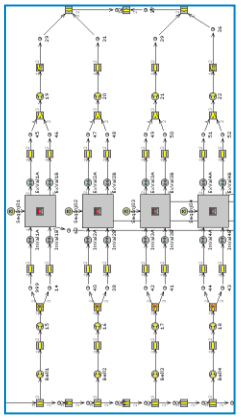
Coolant

### Flow Rates

optional from
*GT-SUITE*
engine model

Exhaust

Coolant



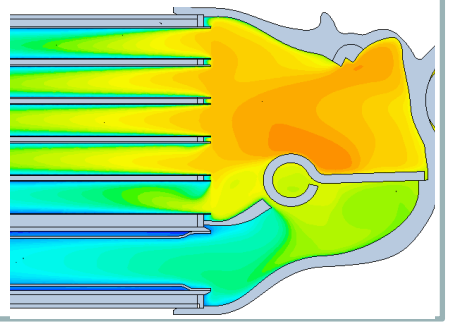
### Model Set-up with STAR-CCM+

- 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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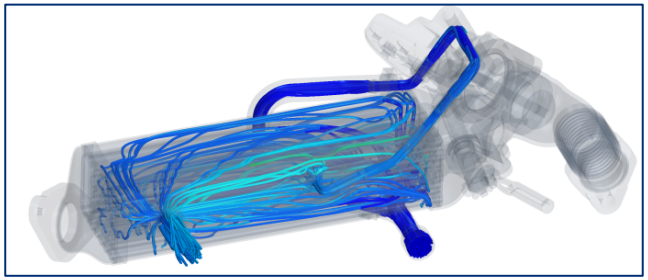
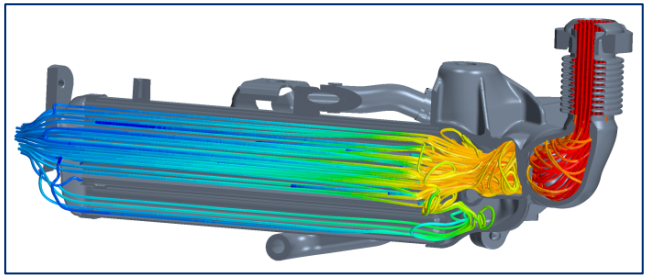
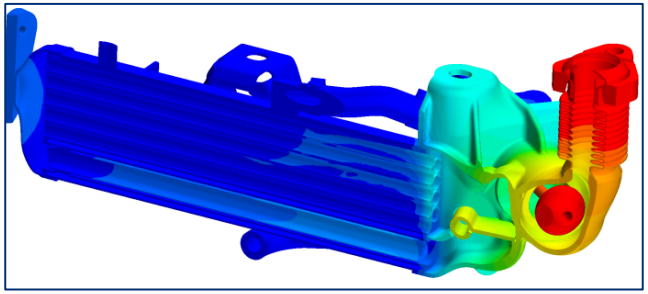
## Test Rig Results for an EGR Cooler





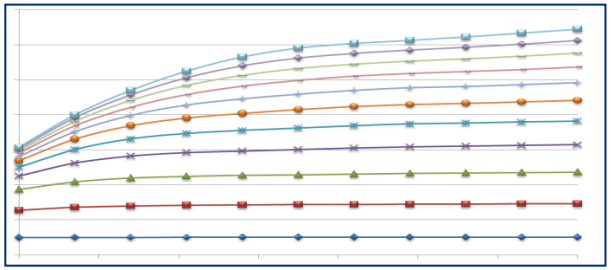


### Coolant
- temperatures
- pressure loss
- onset of boiling
- volume flow rates
- flow uniformity

### 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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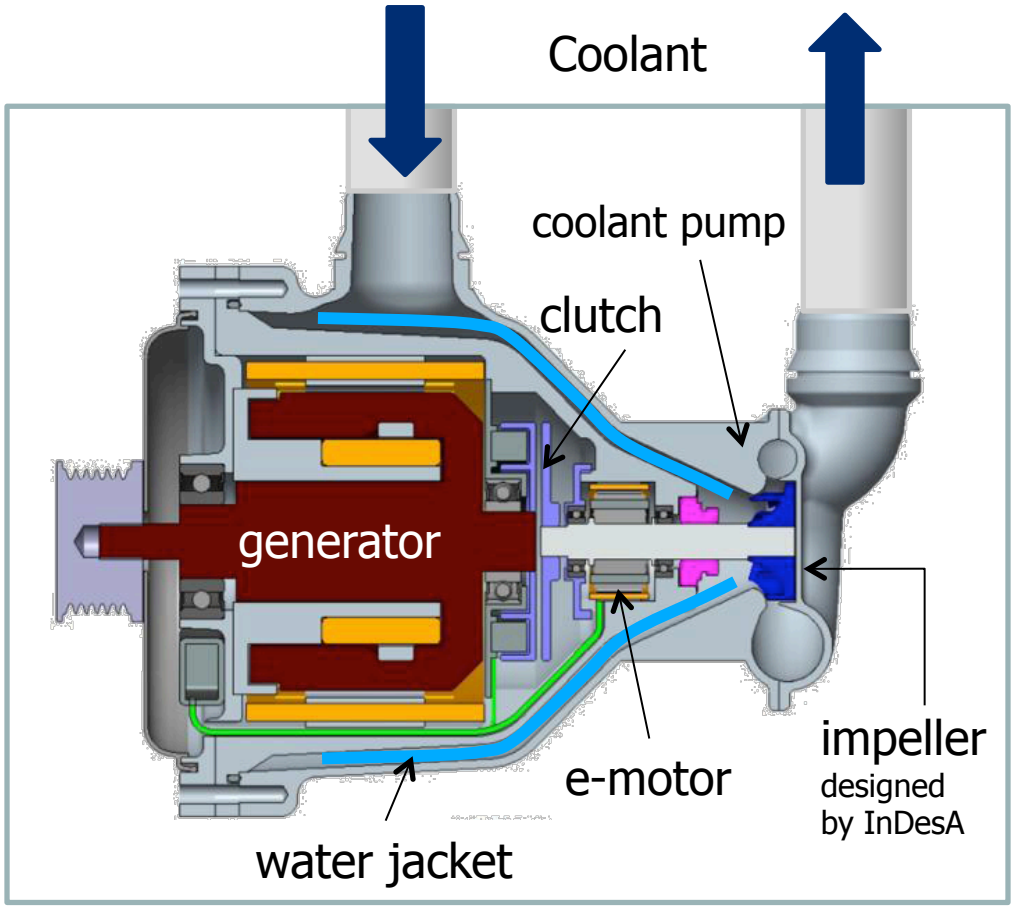
## Innovative Coolant Pump/Generator Unit




**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 inter-action 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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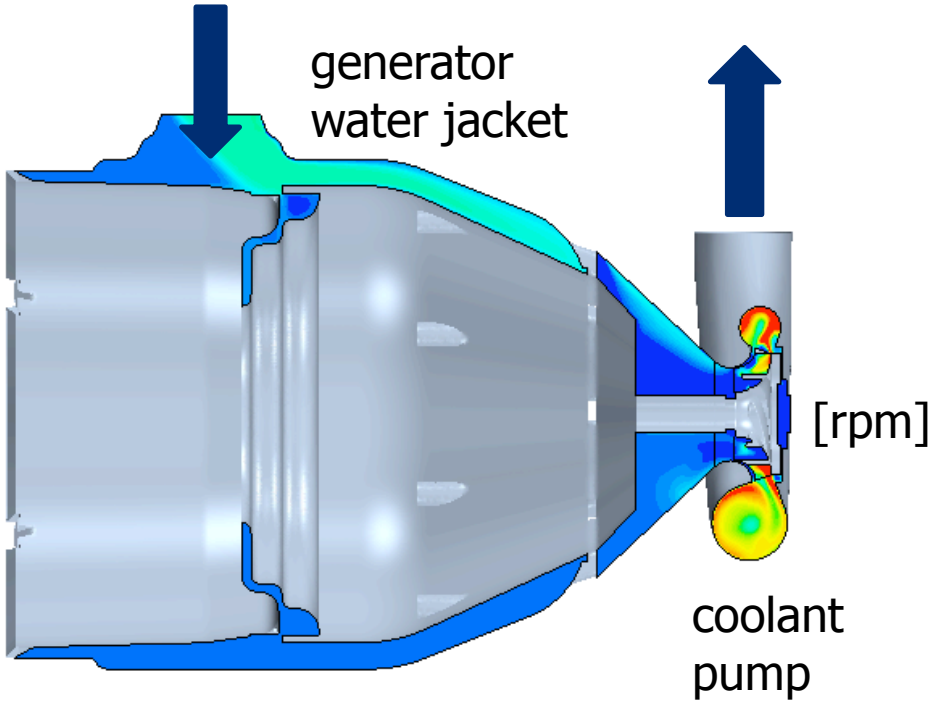
## Results for Coolant Pump/Generator Concept




### Coolant Pump

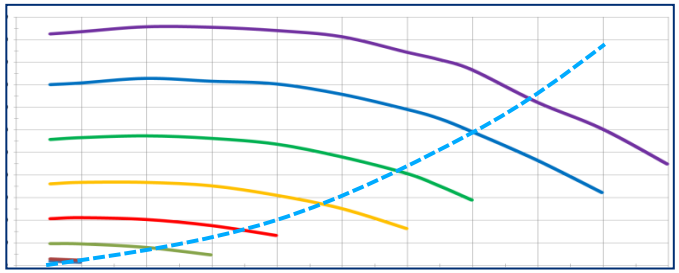
- volume flow rate for different impeller speeds
- pressure rise of pump
- hydraulic efficiency of pump
- onset of cavitation

### Generator Waterjacket

- pressure loss of waterjacket
- heat transfer coefficients

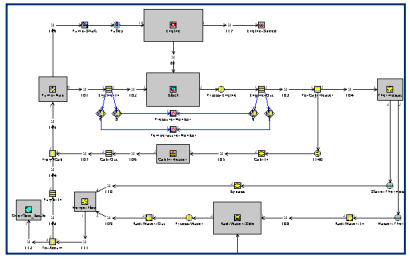
### Pump Performance Map

(affinity laws)



### System Pressure Loss

optional from
*GT-SUITE*
coolant system model



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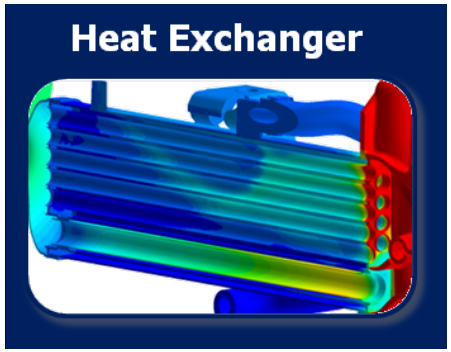
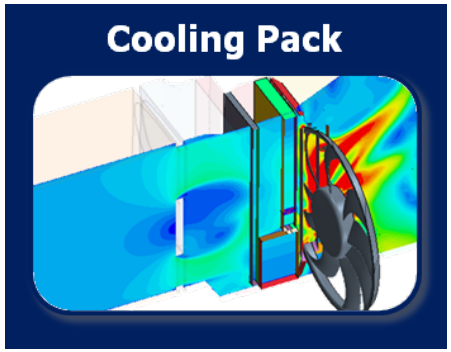
## Combination for Cooling Package

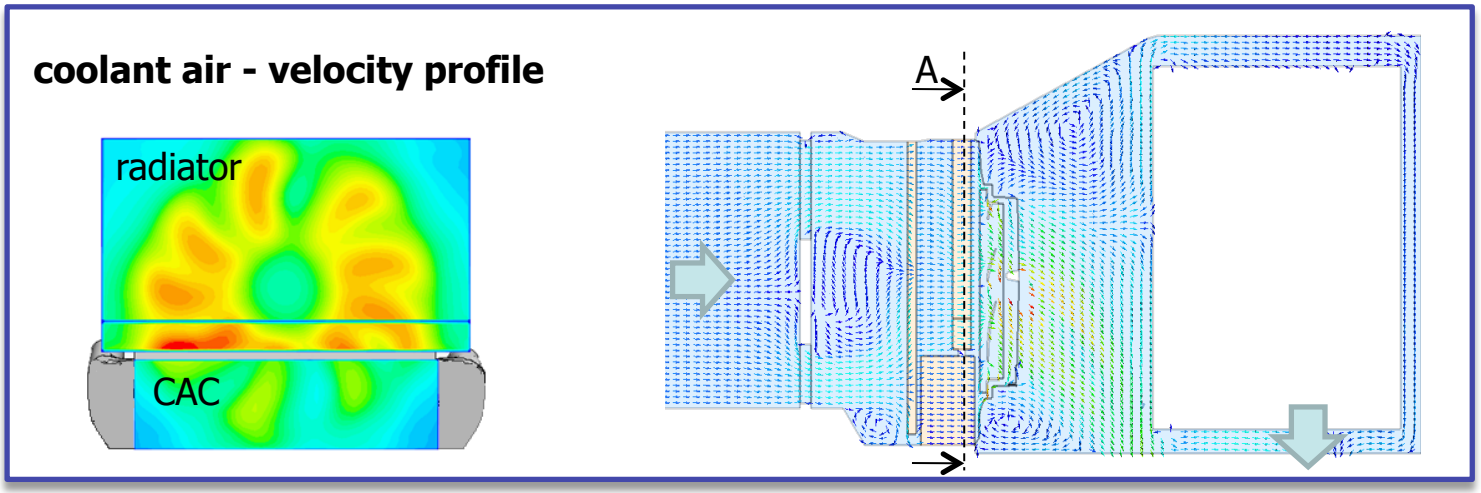




3D CFD model
or derived
performance map.

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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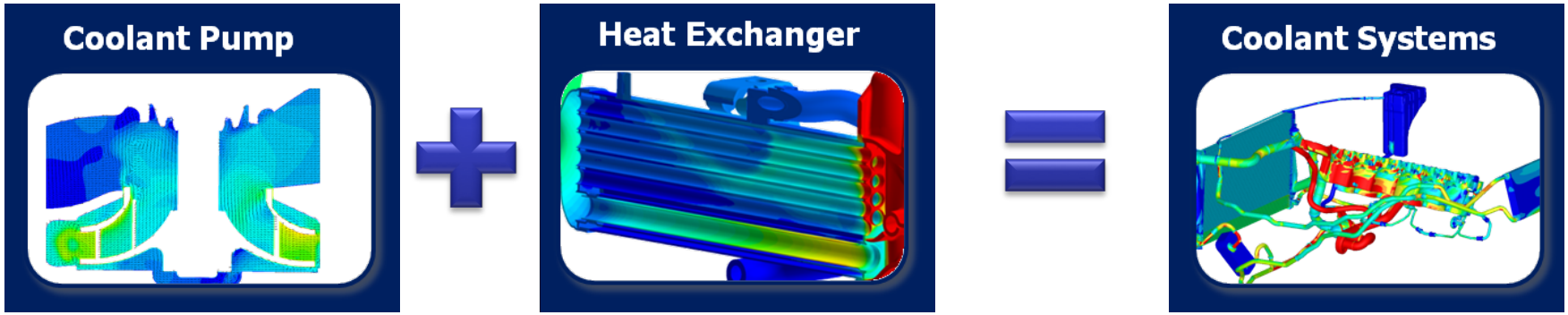
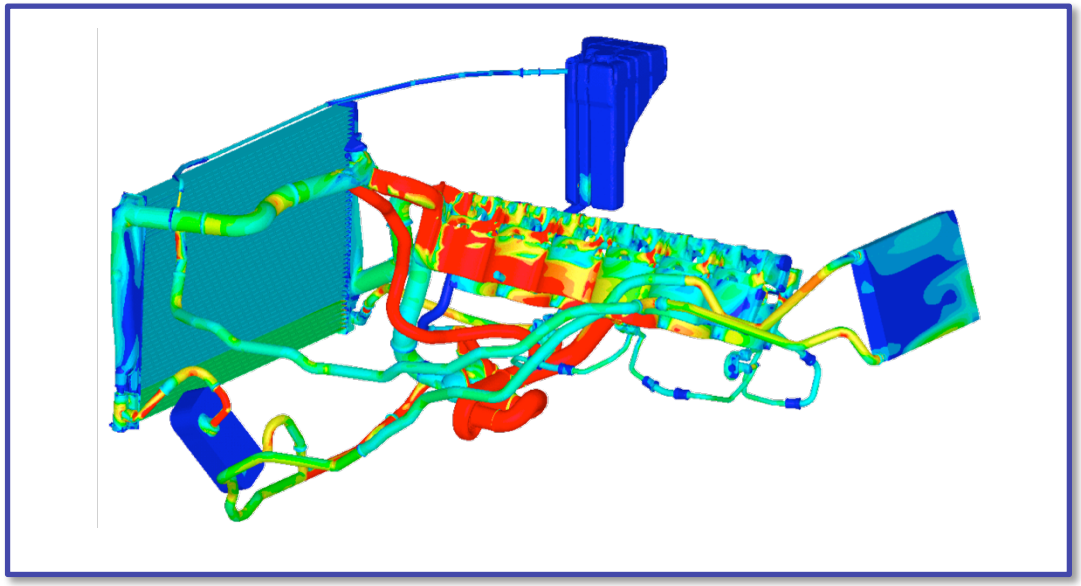
## Combination for Coolant System




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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# InDesA Virtual Test Facility Center

## 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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# InDesA Virtual Test Facility Center

## 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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# InDesA Virtual Test Facility Center
## 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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## Aspire for Engineering Success.

## Thank you for your attention.

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