

Introduction

Area B – Thermodynamics investigates thermal and fluid-dynamic issues in and around the vehicle system with a special focus on aerodynamics, thermal management, automobile air conditioning, and automotive propulsion concepts. The core research work of this area consists of simulation techniques and developing models that correlate with experimental results.

Main Topics

- Thermal Management Systems
- Internal Combustion Concepts
- Thermal Comfort
- HVAC – Systems
- Aerodynamics / Aeroacoustics

Targets

- Reduction of CO<sub>2</sub> emissions
- Environmental friendly vehicles
- Efficient vehicle development



Innovative technologies

VIRTUAL VEHICLE is a leading research and development center with over 170 employees that is dedicated to vehicle innovations. Our worldwide network of partners in research and industry provides us with a strong foundation.

Comprehensive services

Our comprehensive know-how and network of partners in numerous fields of automotive engineering research make us an attractive cooperation and research platform in the automotive sector.

Simulation technology opens up new avenues

Enhanced simulation techniques can lead to early product design, the evaluation of alternatives, and new optimization opportunities. A much more efficient vehicle development can be achieved.

Individual aspects and Overall System

Our main focus is on virtual vehicle development. This includes innovative simulation models, effective integration with test procedures, and dealing with complex overall systems.

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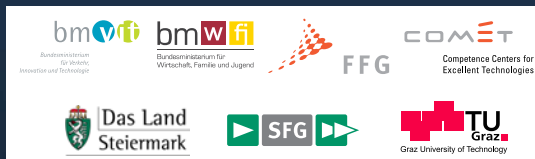


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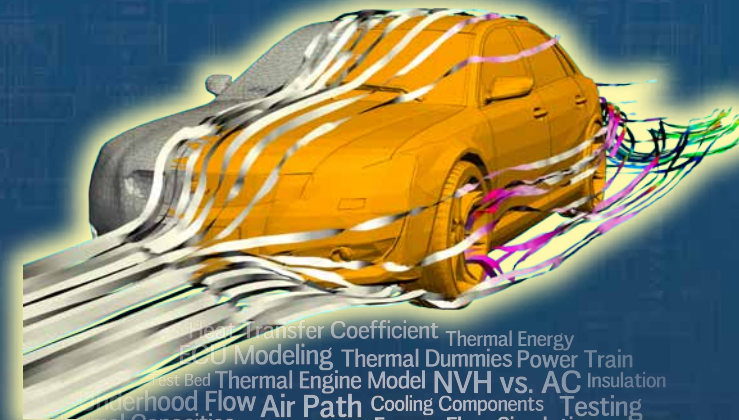
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Funding:



VIRTUAL VEHICLE Research Center is funded within the COMET – Competence Centers for Excellent Technologies – programme by the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT), the Federal Ministry of Economy, Family and Youth (BMWFJ), the Austrian Research Promotion Agency (FFG), the province of Styria and the Styrian Business Promotion Agency (SFG). The COMET programme is administered by FFG.



Heat Transfer Coefficient Thermal Energy  
CFD Modeling Thermal Dummies Power Train  
Test Bed Thermal Engine Model NVH vs. AC Insulation  
Underhood Flow Air Path Cooling Components Testing  
Thermal Capacities Fuel Consumption Energy Flow Simulation  
Multi-Phase Flows Cooling Strategies Fluorescence  
PIV Exhaust Gas Aftertreatment CFD Warm-Up Strategies  
Interferometry Internal Combustion Concepts Cooling System  
Energy Management LDA Coupled Simulation ViFAQ  
Limited Emissions Range Extender Pressure  
Thermal Management Gear Box Aerodynamics  
Temperature Enthalpy Full-Vehicle Simulation Optimization  
Simulation Radiation Modeling 3D - Simulation Alternative Vehicle C  
Density Co-Simulation Aeroacoustics Energy Consumption  
Heat Flux Hybrid/Electric Vehicle Energy Conversion Electrical Components  
Mechanical Energy Experimental Analysis 1D - Simulation Battery Thermal Models  
Gas Dynamic Thermal Behavior Friction Losses Cooling Package  
Drive Train Integration Coolant Media Thermal Comfort

Aerodynamics & 3D Simulation

Thermal Management & 1D Simulation

Internal Combustion Concepts

Mobile Air Conditioning

Testing & Validation



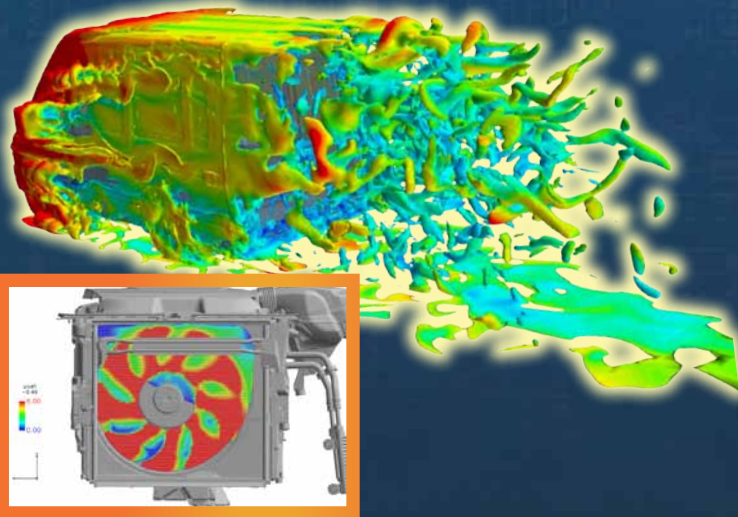
## Aerodynamics & 3D Simulation

The main focus of the working group „Aerodynamics & 3D Simulations“ is the application of advanced CFD methods, which range from the simulation of the air flow through the engine compartment, the computation of fluid induced noise, over sophisticated multiphase simulation including combustion and soot formation.

Modern model reduction techniques are employed establishing an equilibrium between computation speed and accuracy of the results.

### Main Topics

- Multi-Phase Flows
- Aeroacoustics & Aerodynamics
- Model Reduction



## Mobile Air Conditioning

The work group „Mobile Air Conditioning (MAC)“ of Area „Thermodynamics“ deals with methods and processes for model based development of energy efficient heating, ventilating, and air conditioning (HVAC) systems for vehicles. The ultimate goal is the verification and the implementation of the comprehensive models, which allow the analysis of the heating, ventilating, and air conditioning system and it's interaction with the control system of the vehicle's thermal management.

### Main Topics

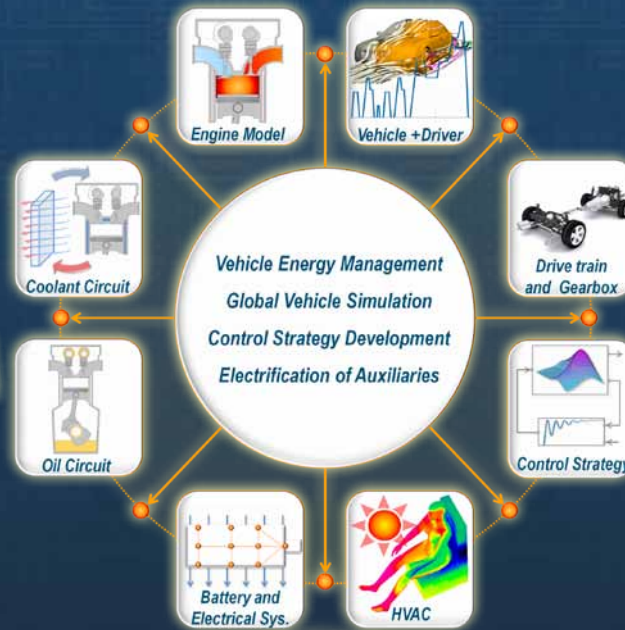
- Energy Efficient AC-Systems
- Heat Pump Technologies
- NVH vs. AC-Systems

## Thermal Management & 1D Simulation

The 'Thermal Management & 1D Simulation' work group investigates energy fluxes within the vehicle. The optimal distribution of mechanical, electrical, and thermal energy is the key to further reductions in energy consumption in modern vehicles. The group uses a variety of 1D tools that simulate essential vehicle subsystems, including the engine, thermal system, drive train, and electrical components. New models are also being developed that will improve existing software tools and enable the simulation of alternative vehicle concepts, such as hybrid or electric vehicles.

### Main Topics

- Thermal Behaviour of Drive Train
- Full-Vehicle Simulation (Energy Flows)
- Auxiliaries and Control



## Internal Combustion Concepts

Research on innovative internal combustion for the optimization of combustion relevant parameters with internal (e.g. EGR) and external measures with exhaust gas aftertreatment systems (EAS) is the main focus of the work group „Internal Combustion Concepts“.

The approach of reduction of engine out emission is followed by fundamental research and consequent development of conventional and homogenous diesel combustion concepts and operation strategies for air systems including charging and cooling concepts.

The experimental investigations of EAS, especially selective catalytic reduction (SCR), are massively supported by intensive simulation methodology of emission formation. Research on operation strategies of hybrid powertrains is done by simulation and with experimental investigations on engine testbed.

### Main Topics

- Innovative Combustion and Exhaust Gas Aftertreatment Systems
- Thermodynamic Simulation and Experimental Investigation
- Passenger Cars, Commercial and Hybrid Vehicles up to Large Engines

## Testing & Validation

The Testing & Validation work group conducts sophisticated measurements both within the framework of the K2 programme and for external clients. A wide range of research topics and applied methods such as:

- Optical Measurements Methods (LDA, PIV, Interferometry, Fluorescence)
- Thermodynamical Analysis
- Thermal Application Methods
- Aerostatical Measurements
- ViFDAQ (wireless small sized data acquisition system)

### Main Topics

- Engine Test Beds
- Dynamometer Test Beds
- Test Bed for Cooling Components
- Refrigerant Cycle Test Beds
- Climatic Chambers
- AC – Compressor Test Bed
- Oil Circulation Ratio Calibration Test Bed