BorgWarner
Emissions/Thermal Systems

Dipl.-Ing. (FH) Thomas Buchholz
Dipl.-Ing. (FH) Wolfgang Sorg

Embedding a KULI Model in Matlab/Simulink

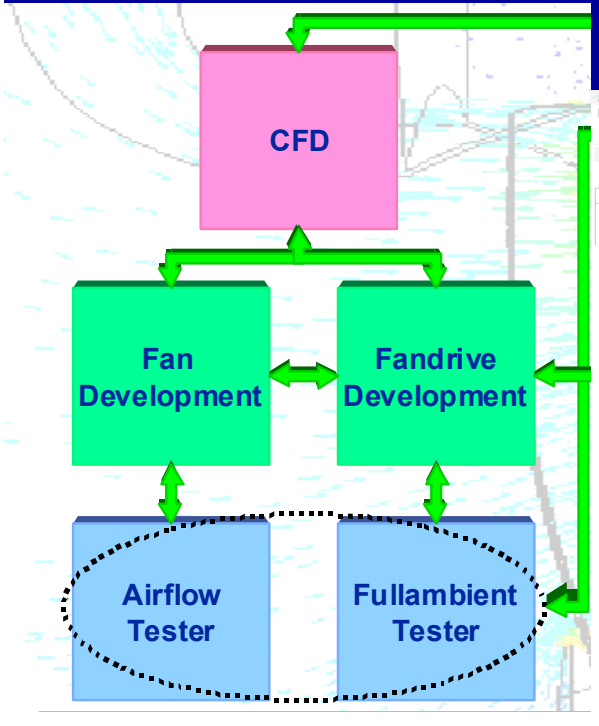
KULI as a supporting tool for software development

Overview

- Review of Kuli User Meeting 2001 and Wiener Motoren Symposium 2002
- Conclusions 2002
- The need to build a Tool Chain
- Embedding a KULI model in Matlab/Simulink
- Simulation Results
- Comparison to the Chassis Dynamometer
- Conclusions and Outlook

Review KULI User Meeting 2001

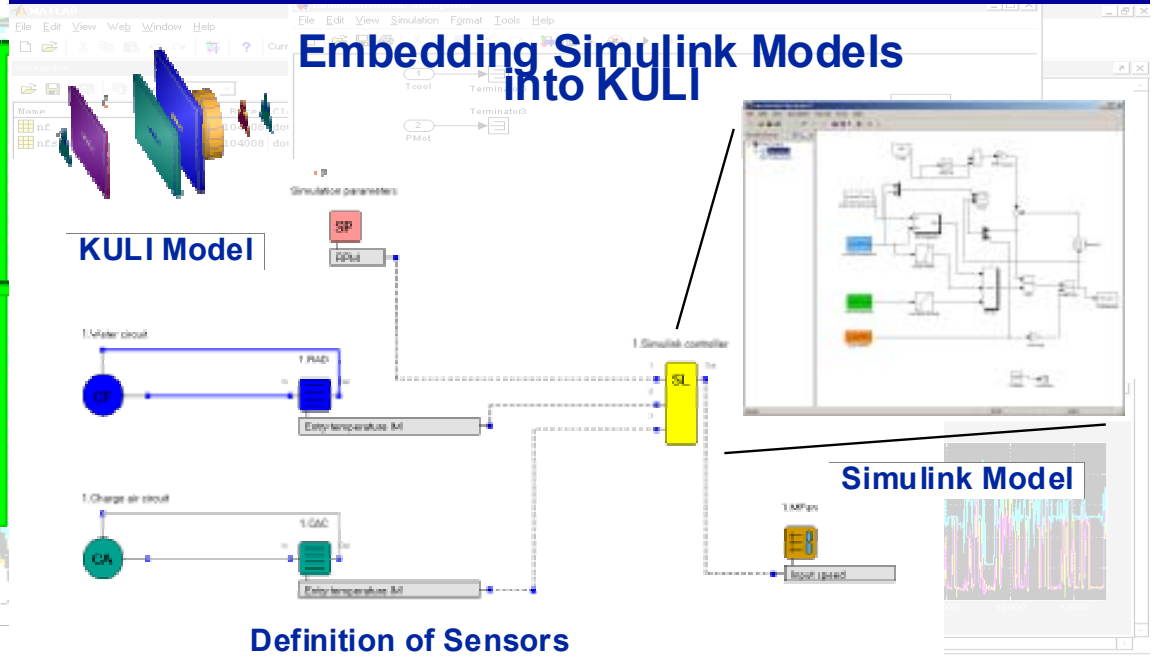
Verification of road tests on the chassis dynamometer and by simulation using KULI



BorgWarner Cooling Systems

Verification of road tests on the chassis dynamometer and by simulation using KULI

Embedding Simulink Models into KULI

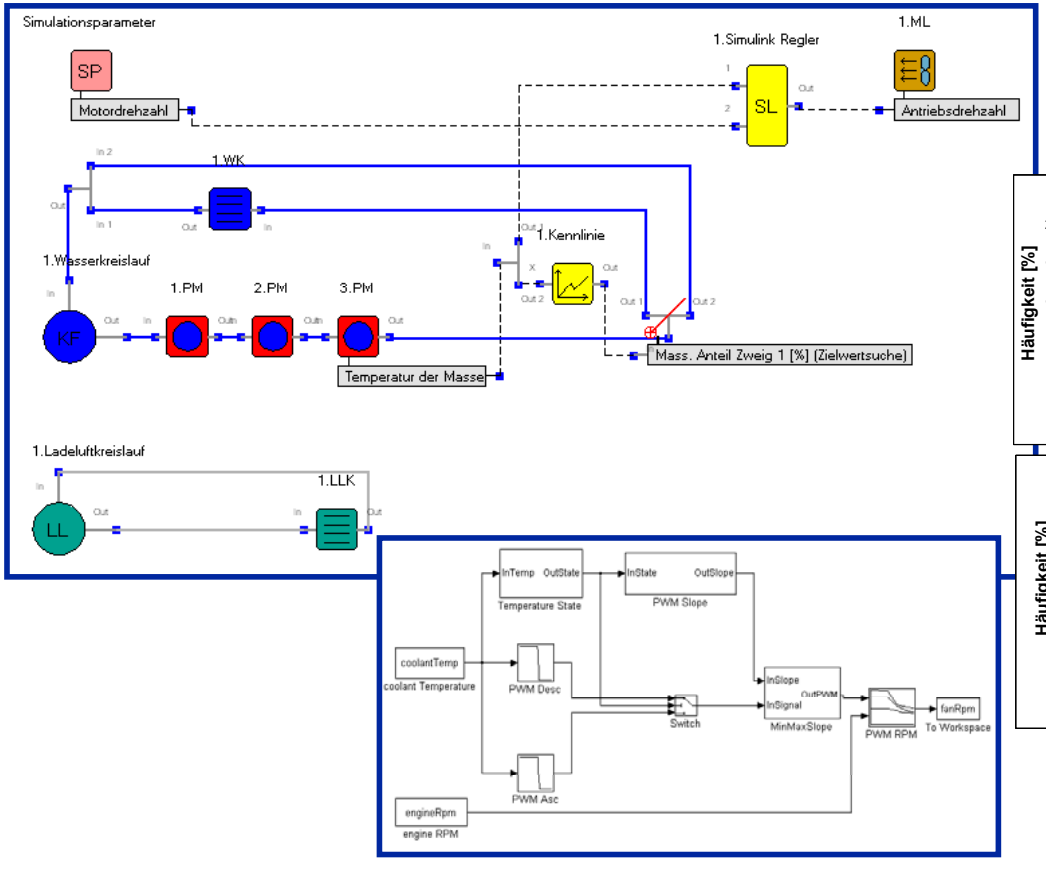


BorgWarner Cooling Systems

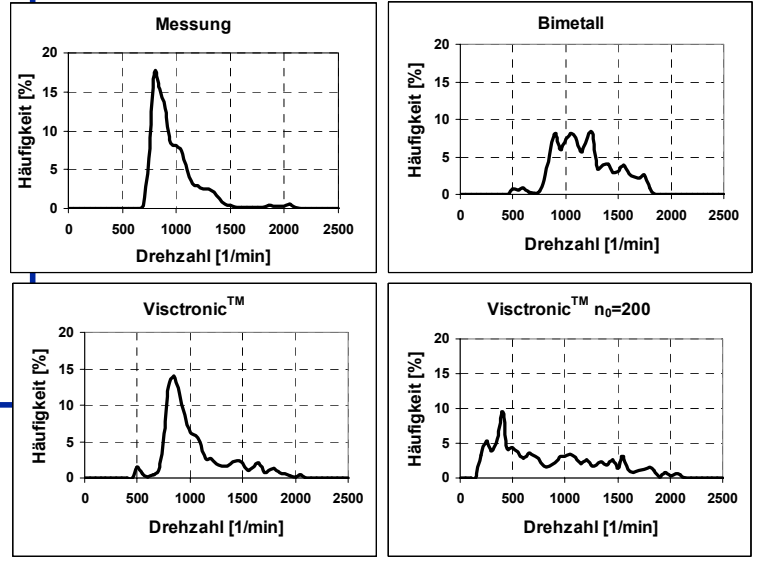
System Engineering
Markdorf, Germany
29.04.2003

Review Wiener Motoren Symposium 2002

KULI Model of vehicle



Predicted results for several clutch types



Conclusions 2002

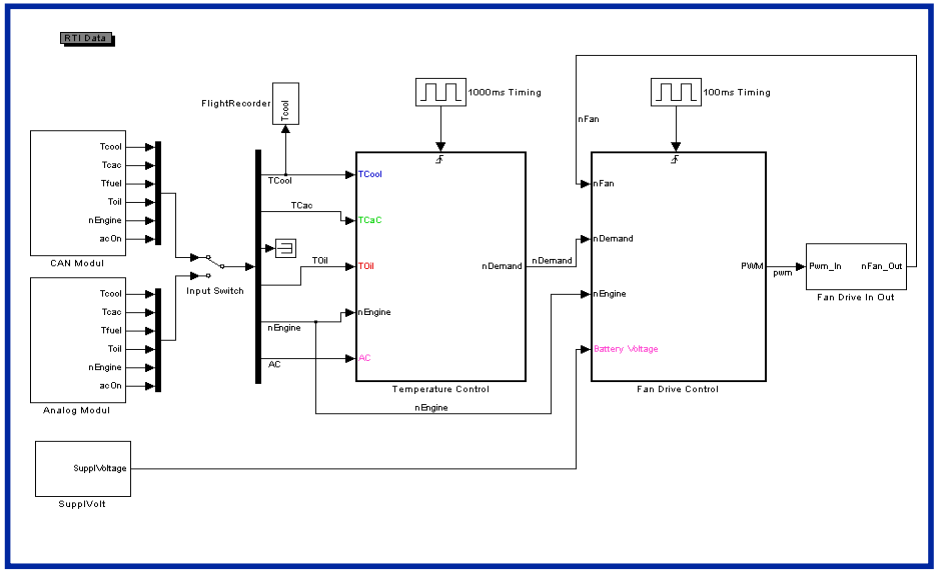
- Memory/Speed Problem in KULI (Postprocessor)
- One complex Matlab/Simulink controller needs to be divided into several ones
- High Sample Rates required for real world simulation of hydraulic devices
- Matlab/Simulink is the central tool for all activities
- To use KULI as the master simulation tool does not appear to be useful in our case
- Tools need to be reorganized for effective use ⇒ Tool Chain

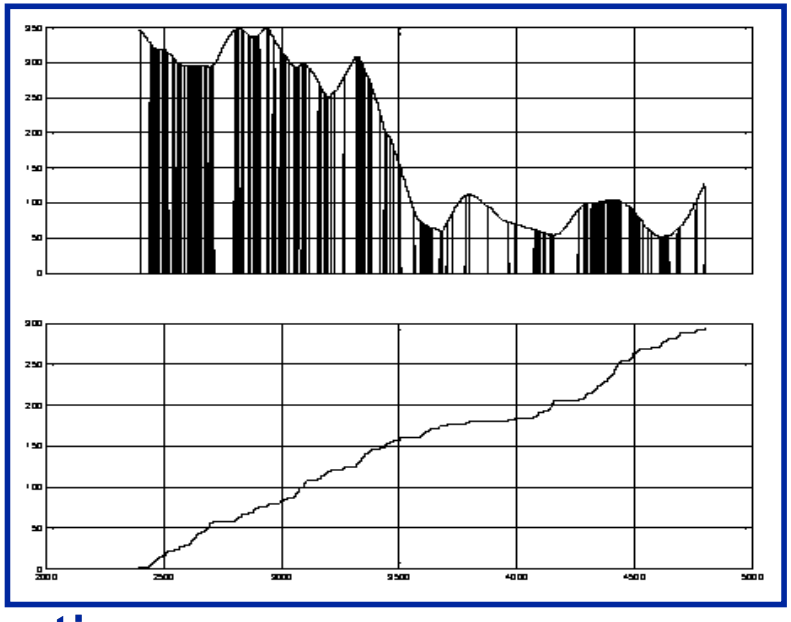
The need of building a Tool Chain

Current BorgWarner Tools:

- Matlab/Simulink for Programming, Simulation and Testing
- dSpace for Software Rapid Prototyping
- KULI for Cooling System Simulation
- Inhouse Tools for Invehicle Data Acquisition (Testing)
- RENK Chassis Dynamometer for transient Truck Testing

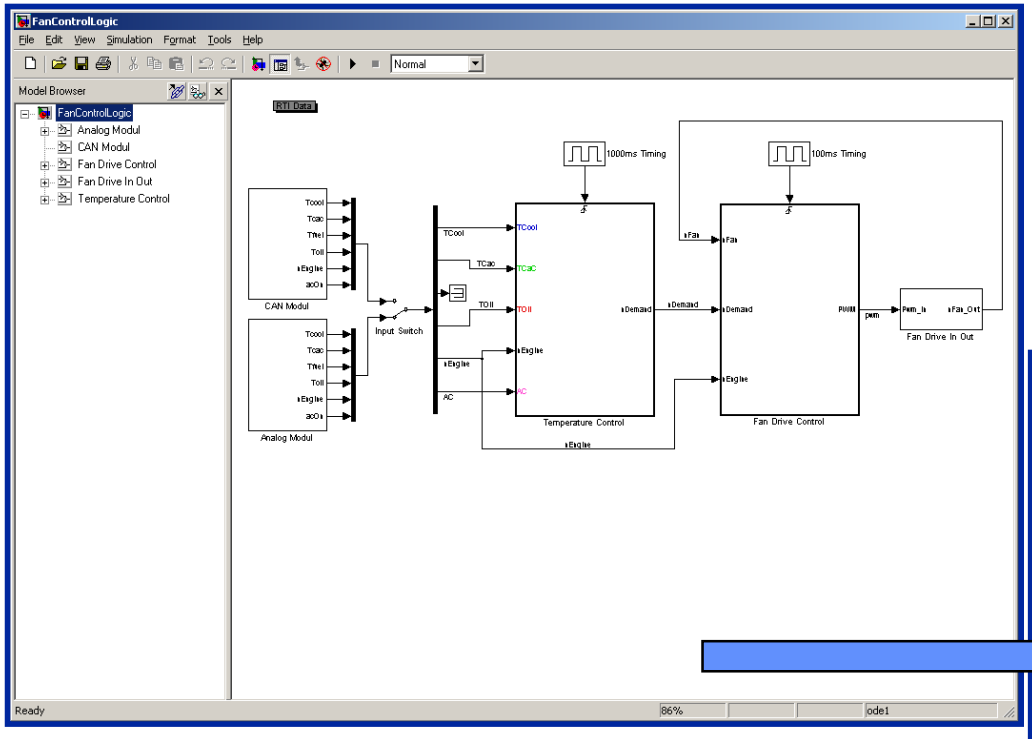
Matlab/Simulink





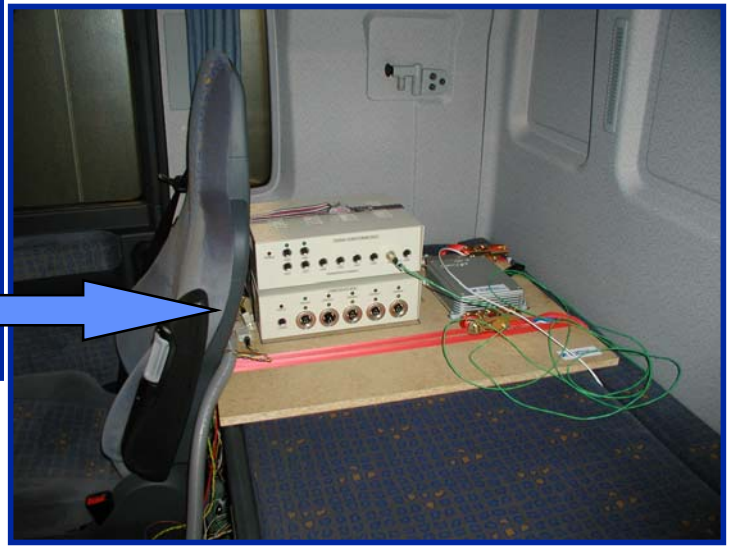
- Road Data Processing for Testing
- Road Data Processing for Simulation
- Simulation of BWETS Products
- **ECU Software Development**

Rapid Prototyping

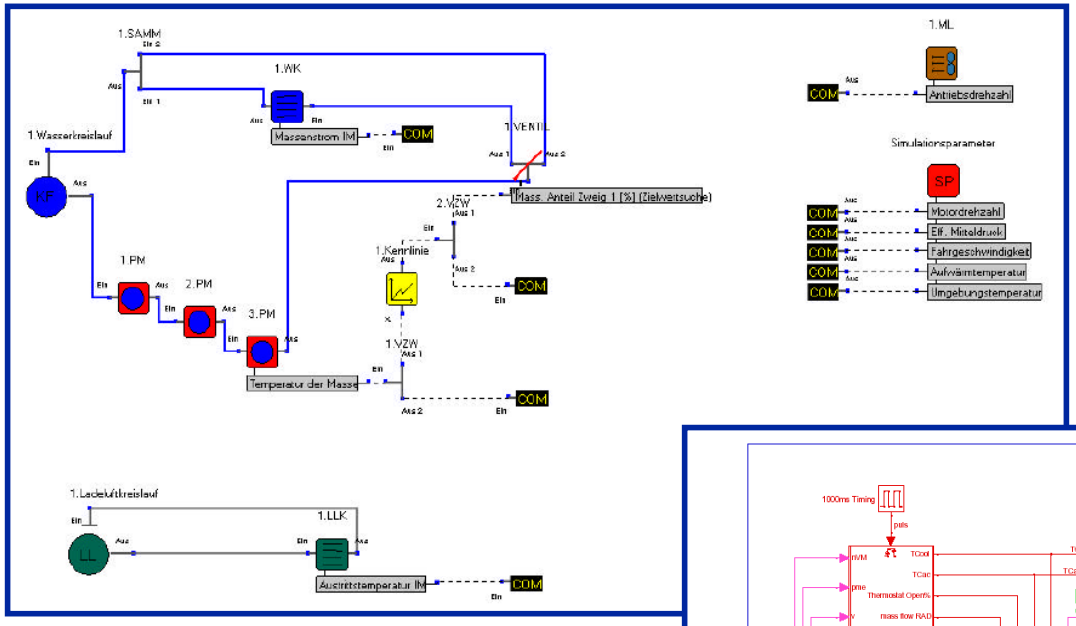


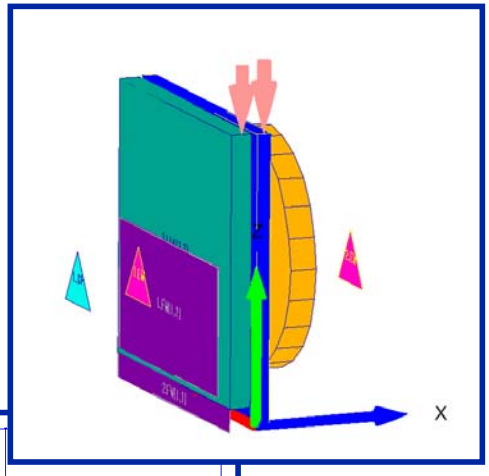
Matlab/Simulink Controls

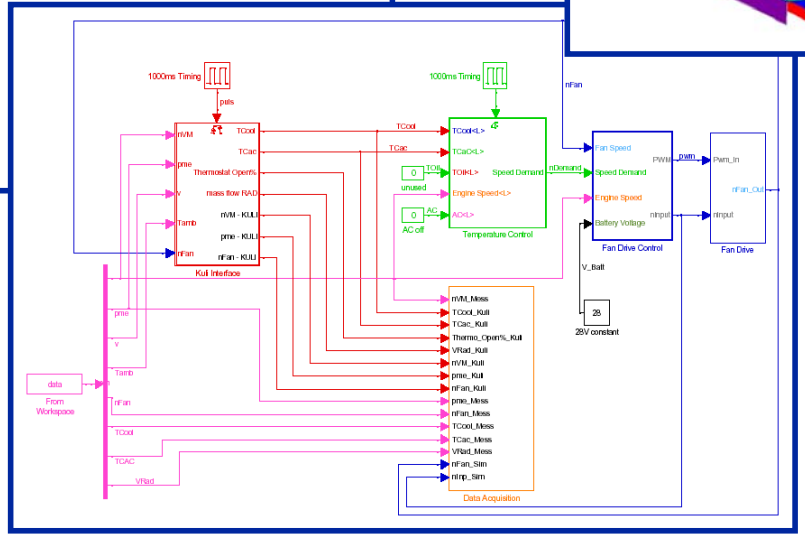
Rapid Prototyping ECU



Cooling System Simulation

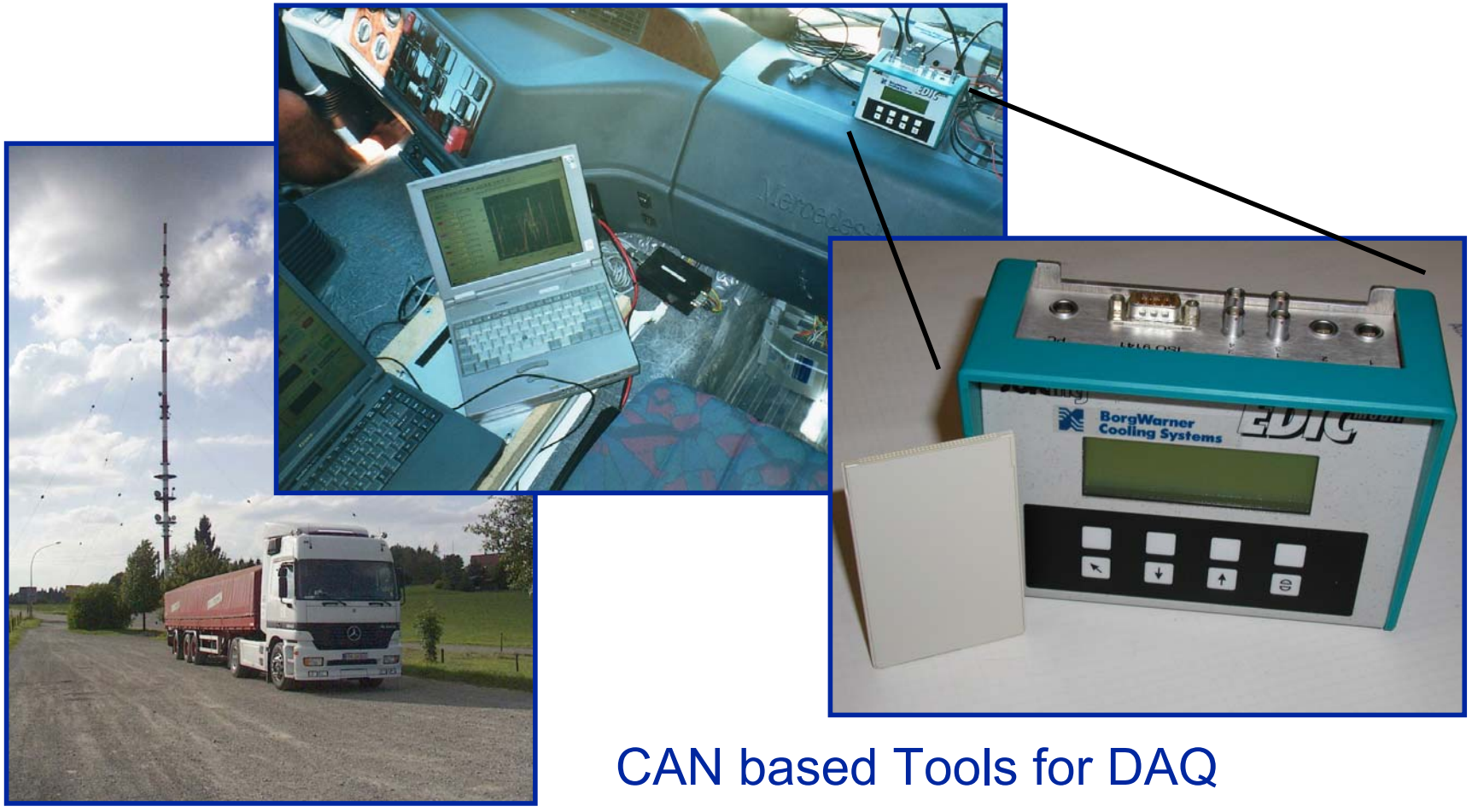






KULI Model using COM Controller

Invehicle Data Acquisition



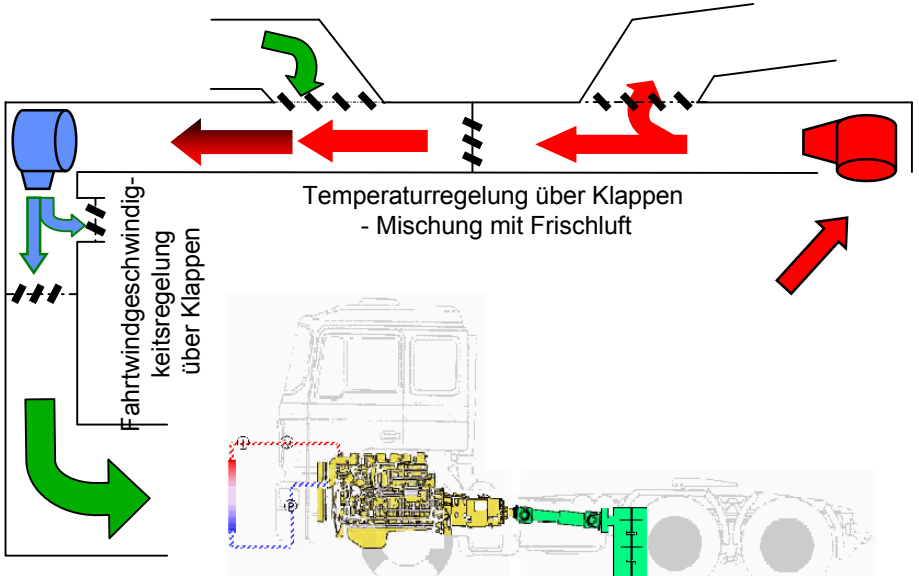
CAN based Tools for DAQ

Transient Truck Testing

Meßtechnik:
32x Temperaturkanäle
11x Druckkanäle
4x Drehzahlkanäle
Drehmoment
AVL Kraftstoffwaage
Öl- und Wasserdurchfluß

Zuluftventilator
konstante Drehzahl
135.000 m³/h

Abluftventilator
geregelt auf
Hallendruck -10Pa

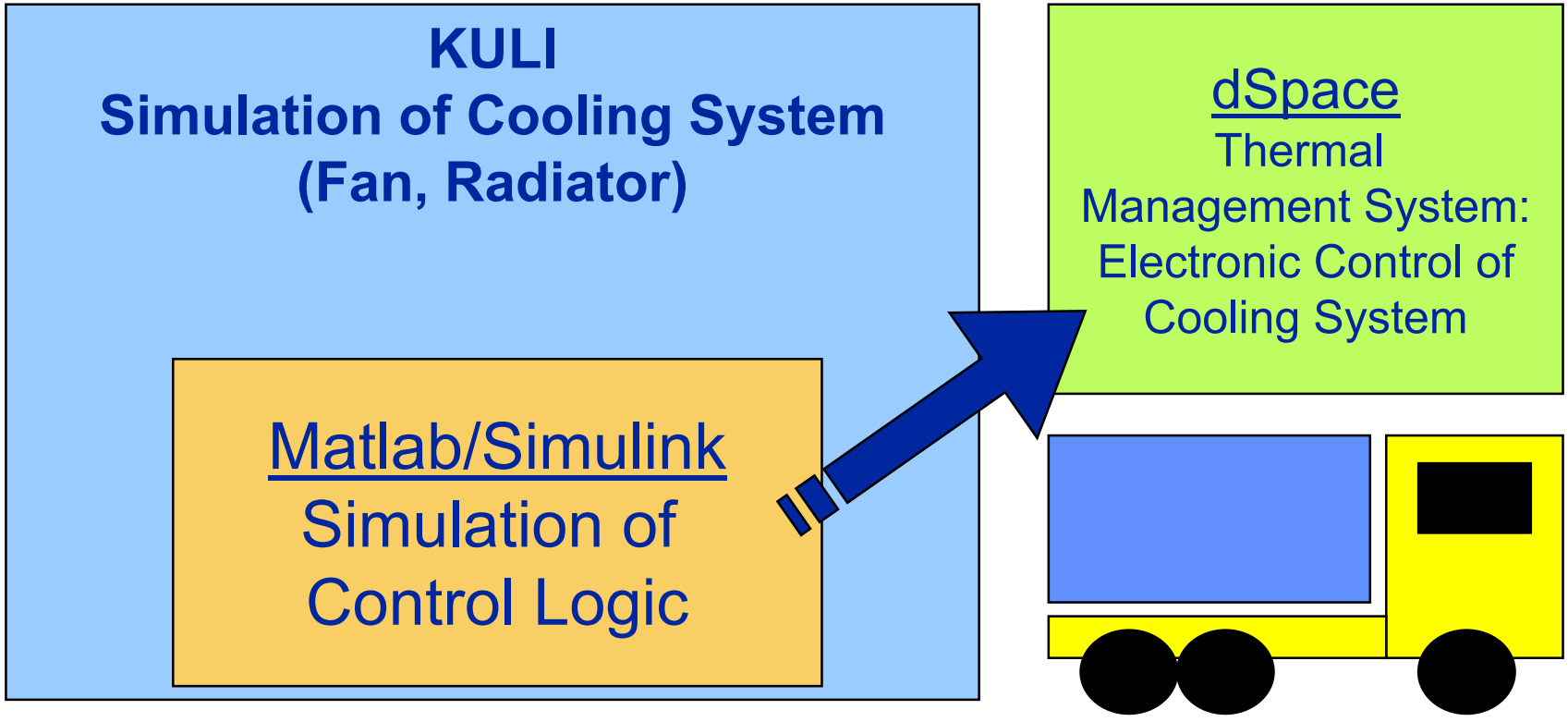


Temperatur 20 bis 40°C
Fahrtwindgeschw. bis 90 km/h

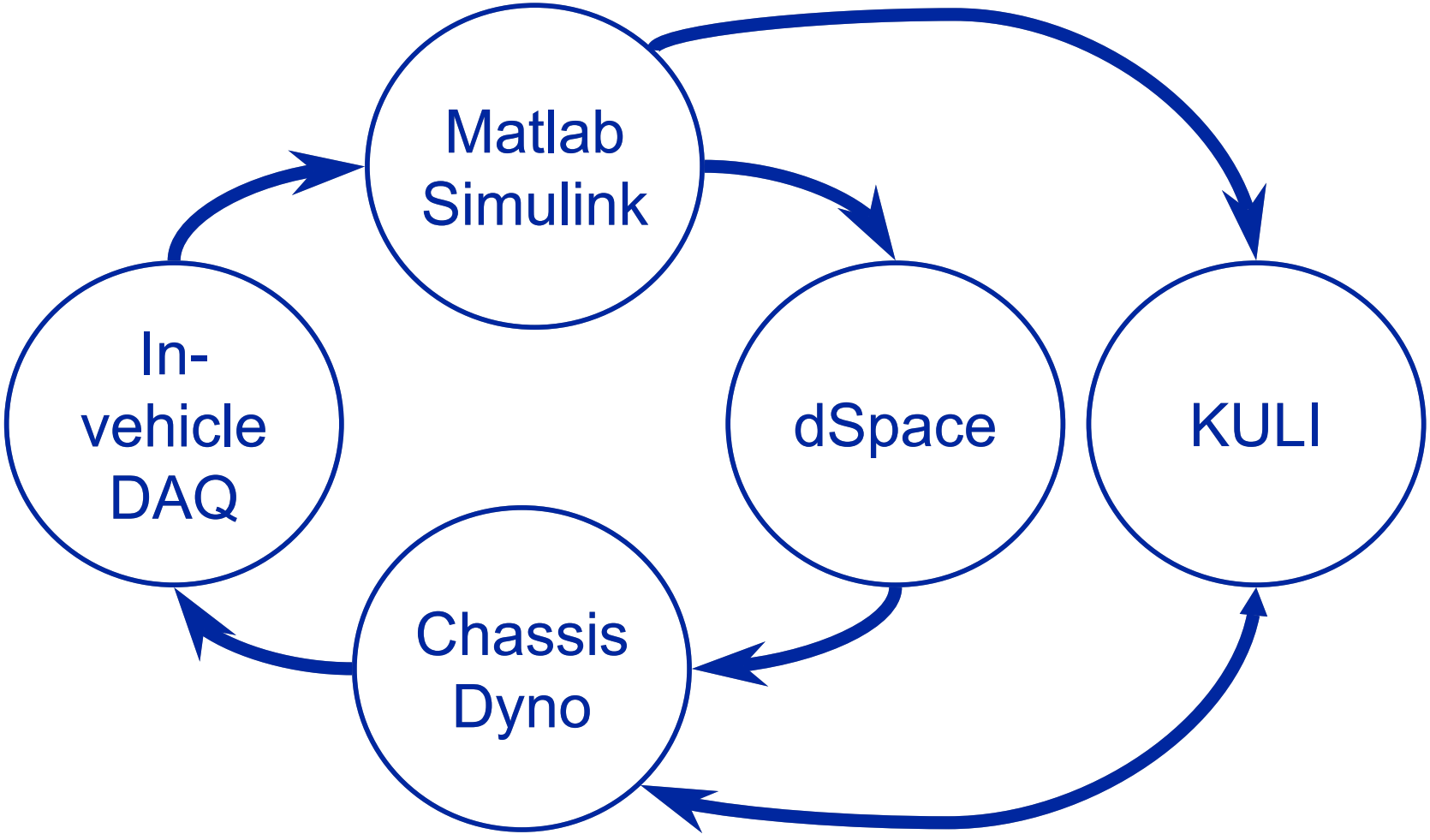
Motor Tests 600kW
Retarder Tests 700kW

The need of building a Tool Chain

Last Year‘s Idea:



The need of building a Tool Chain

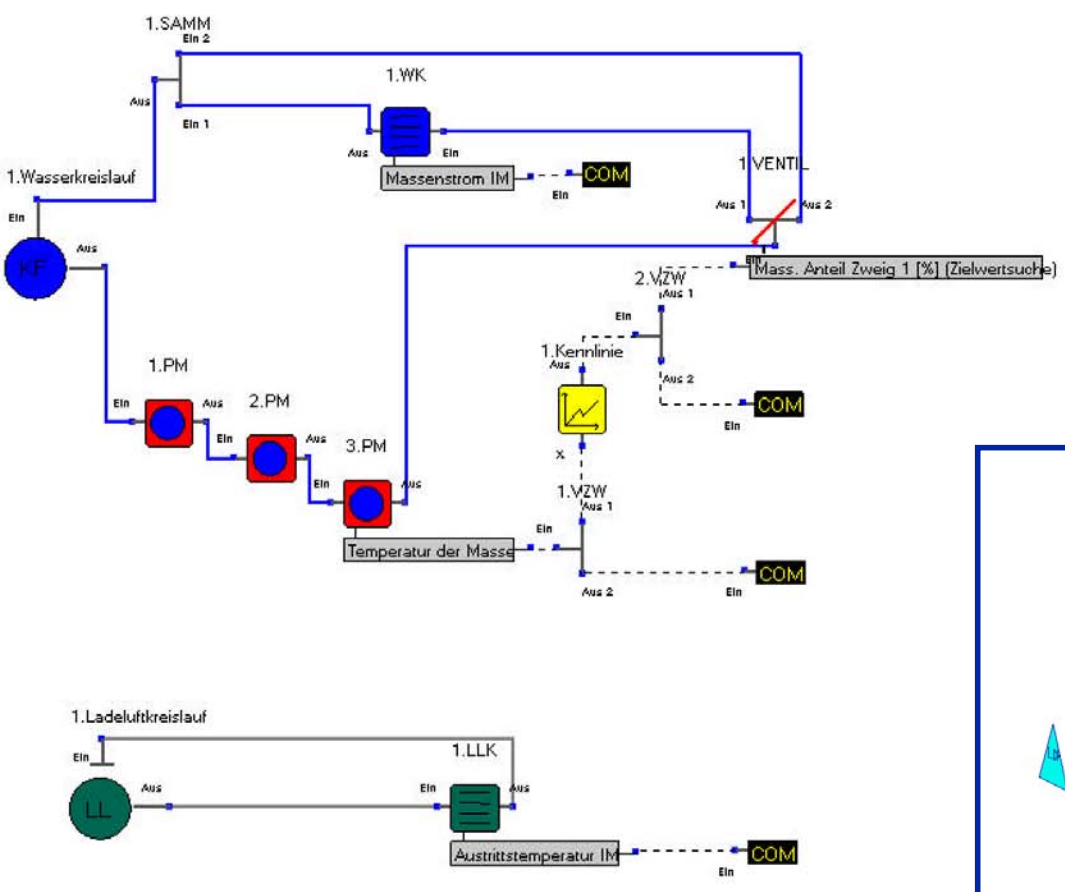


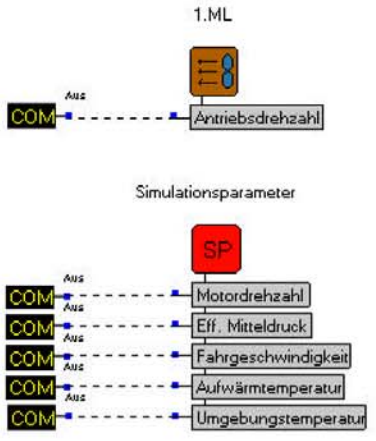
Embedding a KULI model in Matlab/Simulink

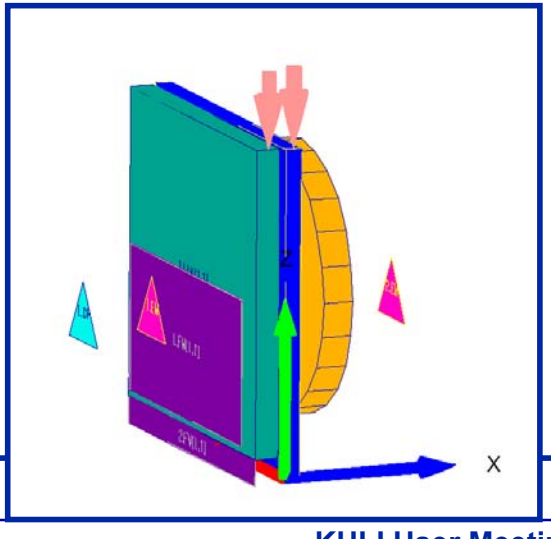
How to embed KULI into Matlab/Simulink

- Building a transient model in KULI
- Adjusting the KULI model with transient data
- Building a vehicle and control model in Matlab/Simulink
- Control of KULI by the vehicle and control logic
  - Adjustment using road data
  - Simulation using vehicle and control logic

Building a transient model in KULI

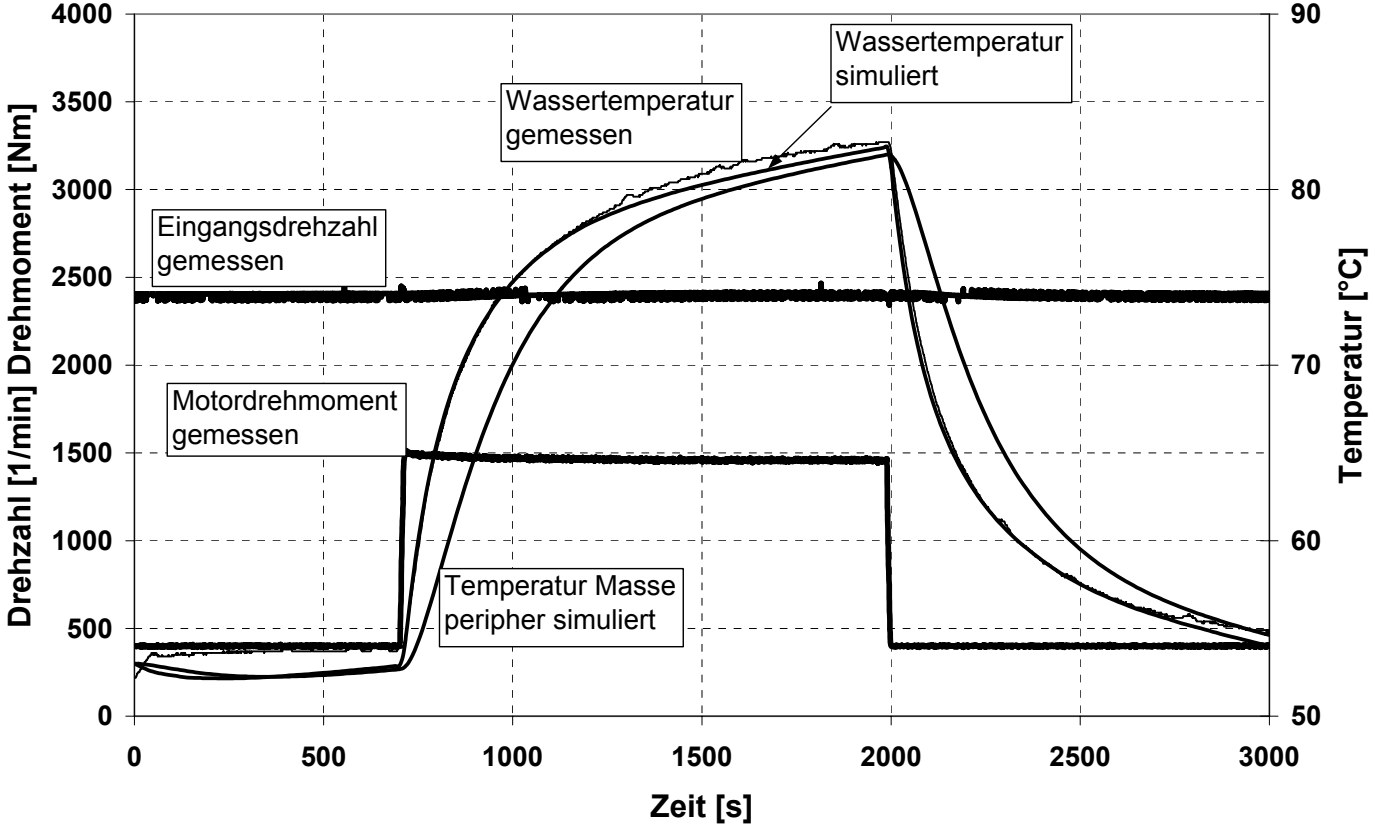






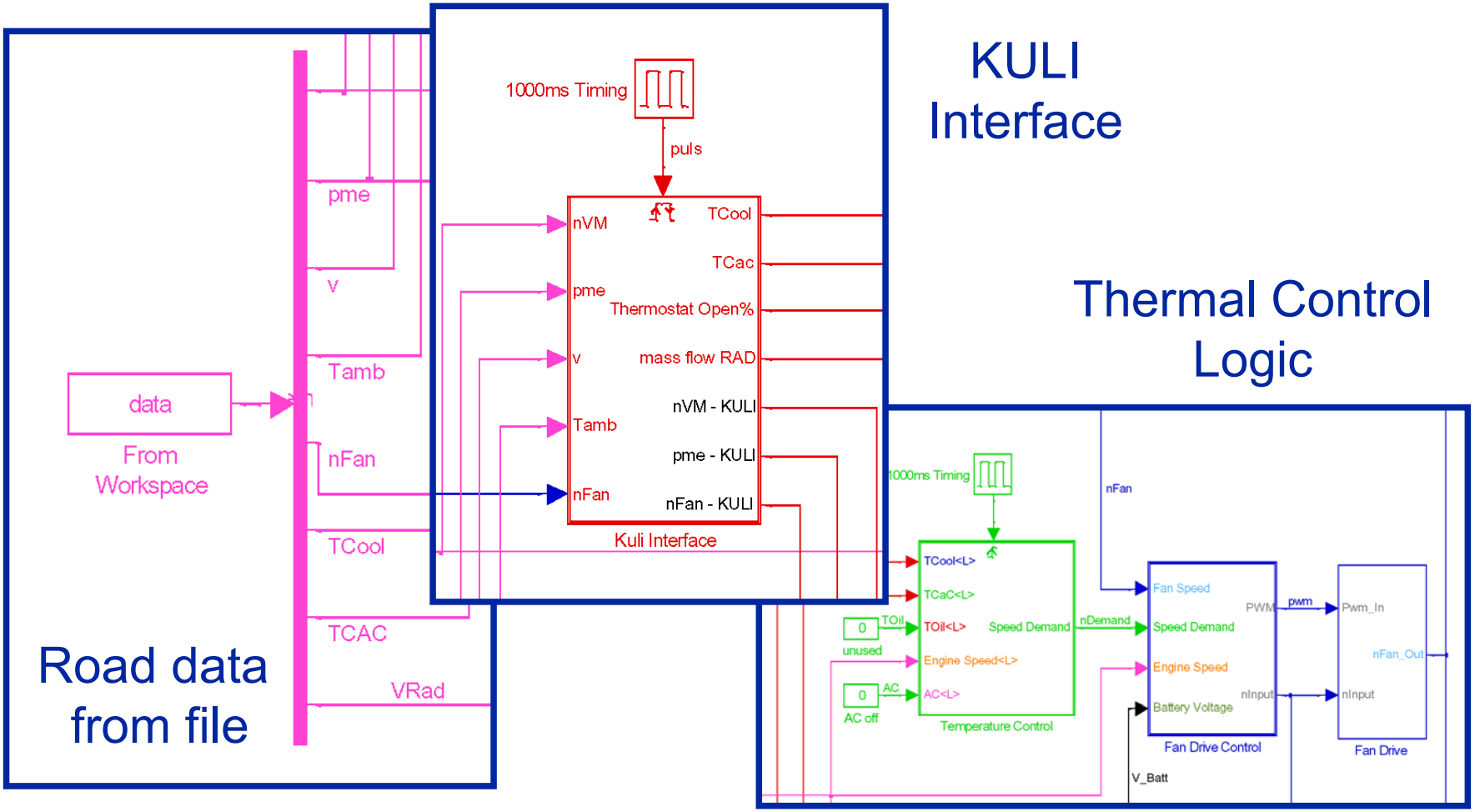
Adjusting the KULI model with transient data

Adjustment of the point masses with step test data

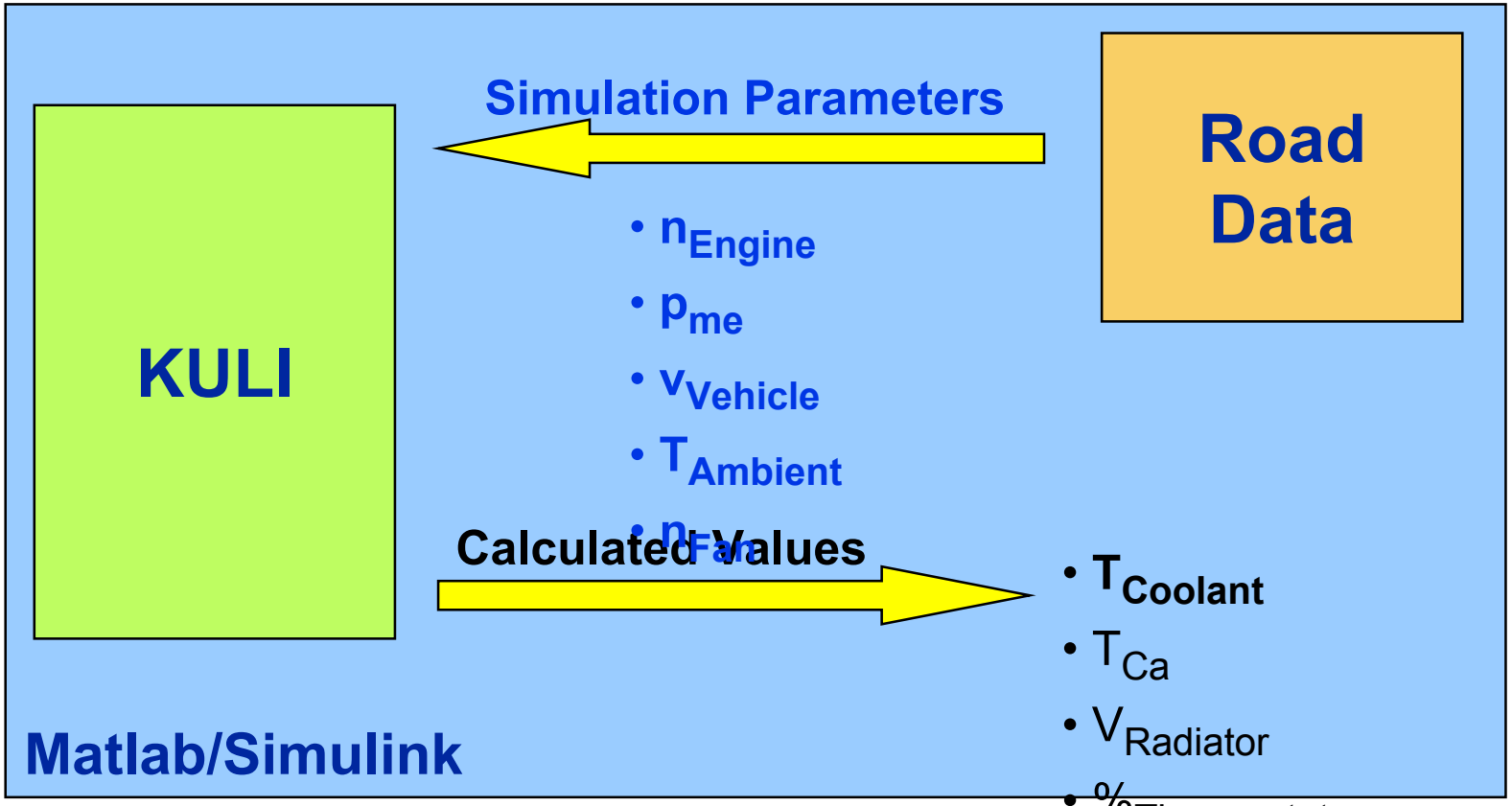


Plot taken from the Magna Steyr, BorgWarner paper for the Motoren Symposium 2002 in Vienna

Building a Vehicle and Control Model in Simulink

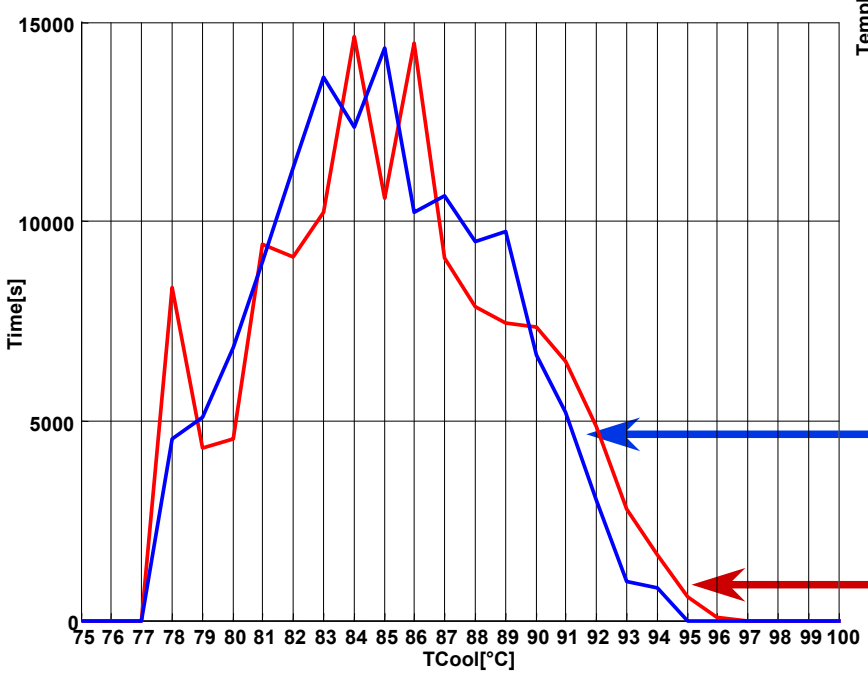


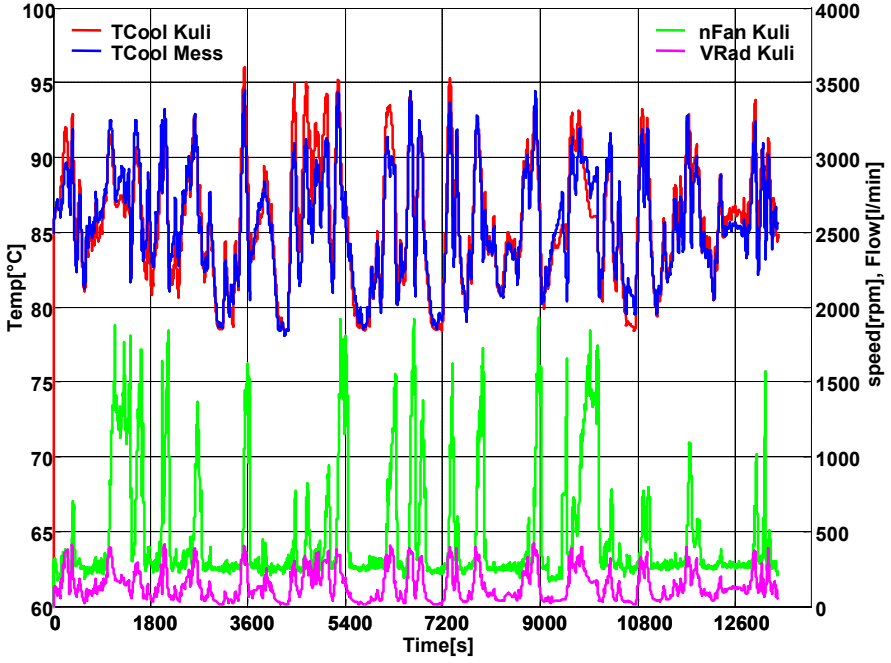
Adjustment using Road Data



Adjustment using Road Data

Investigation of Coolant Temperature

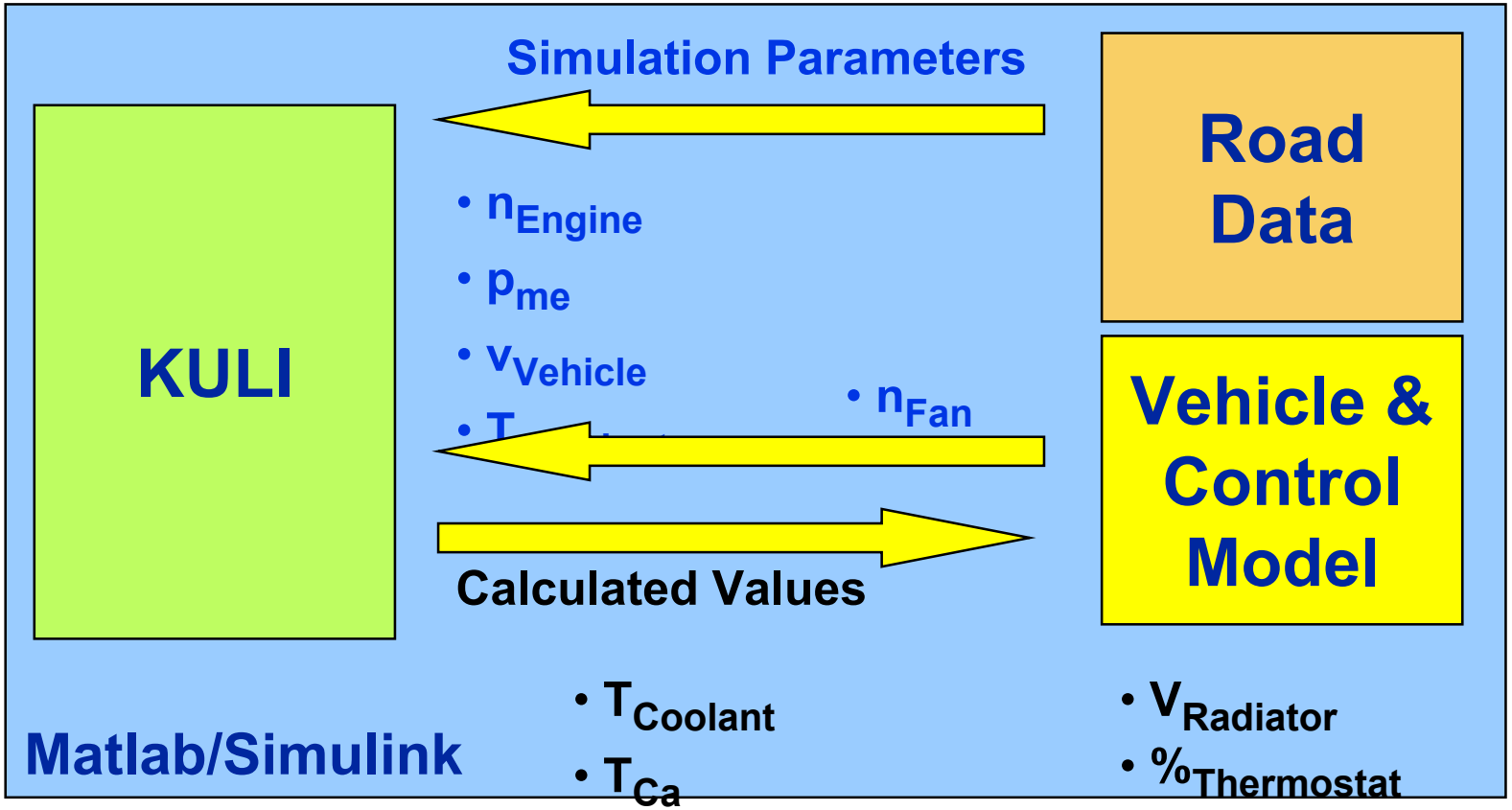




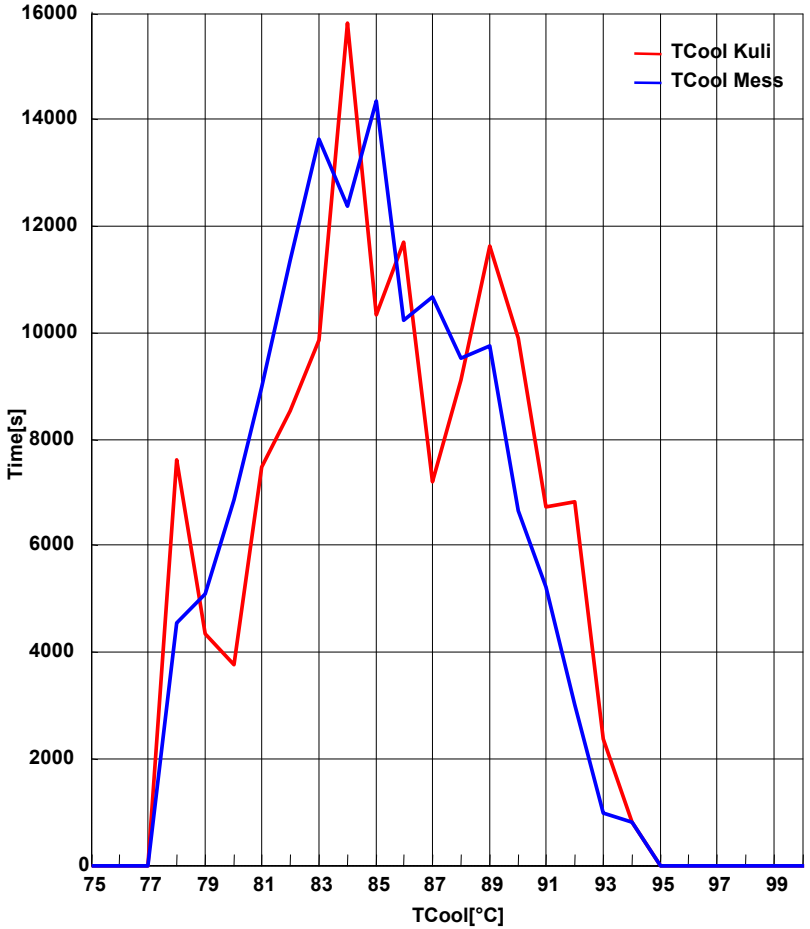
Real World Distribution of Coolant Temperature

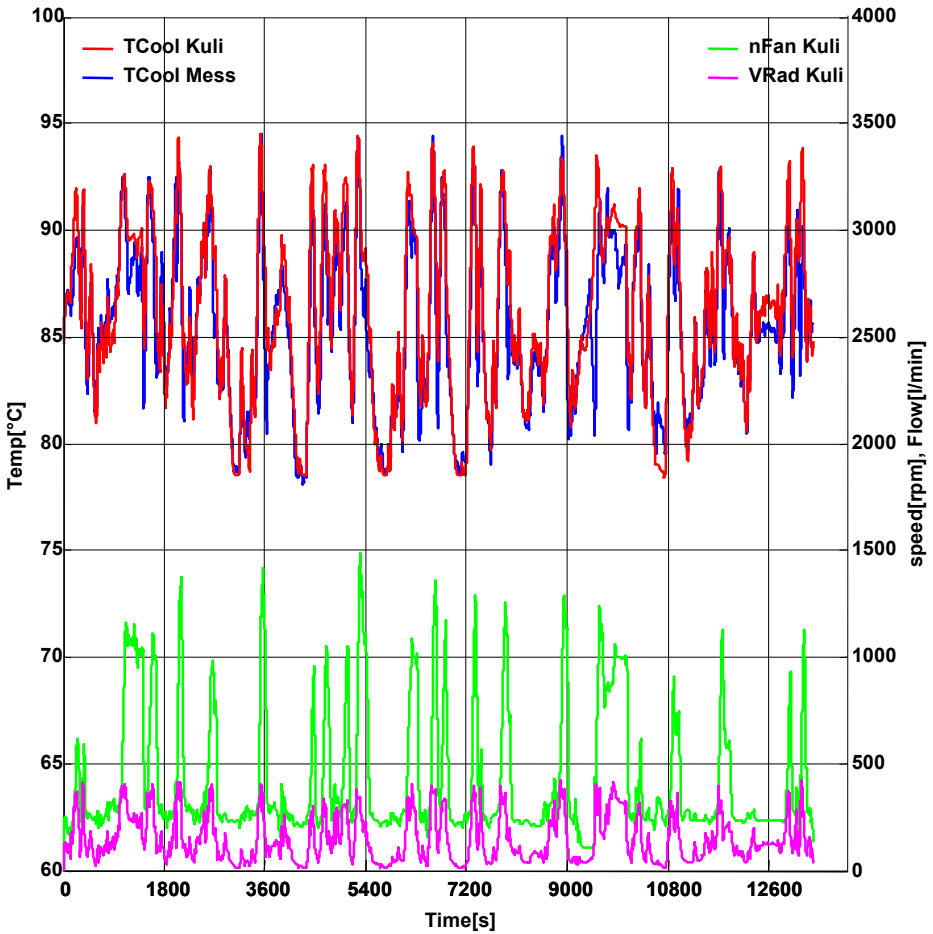
Simulation Distribution of Coolant Temperature

Simulation using the Vehicle and Control Model

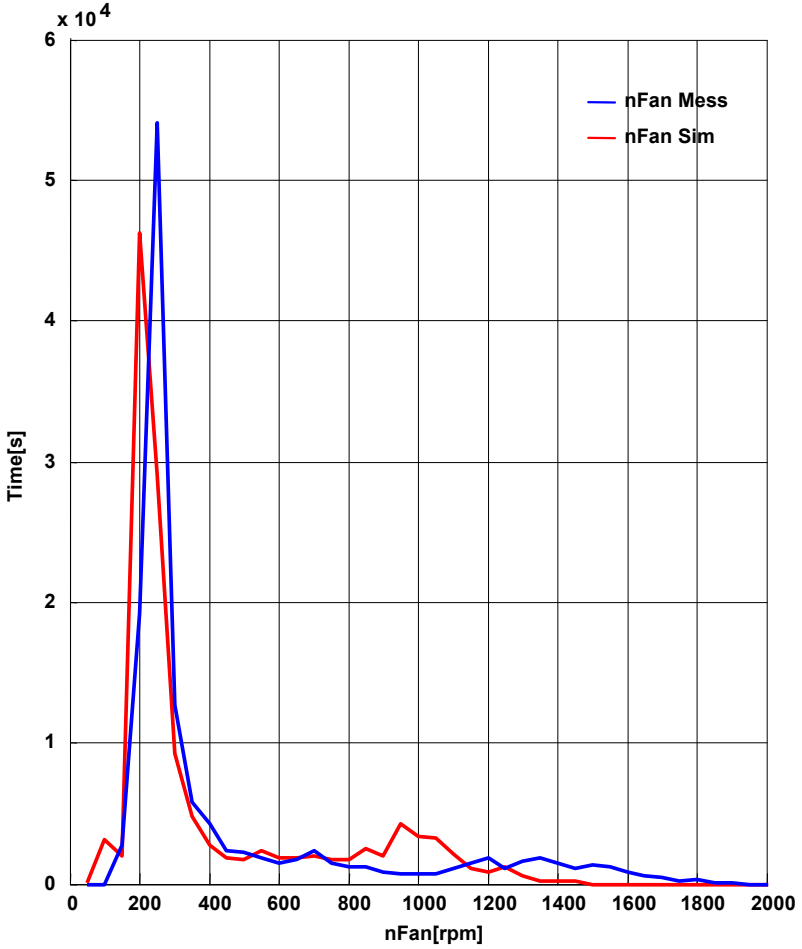


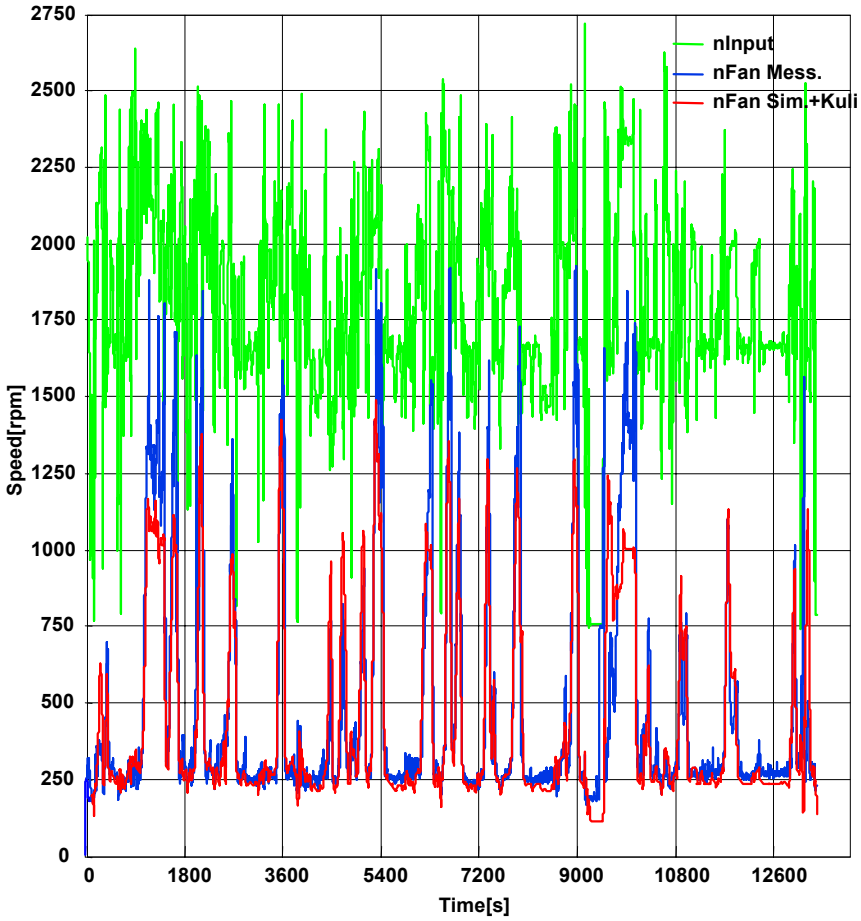
Simulation using the Vehicle and Control Model



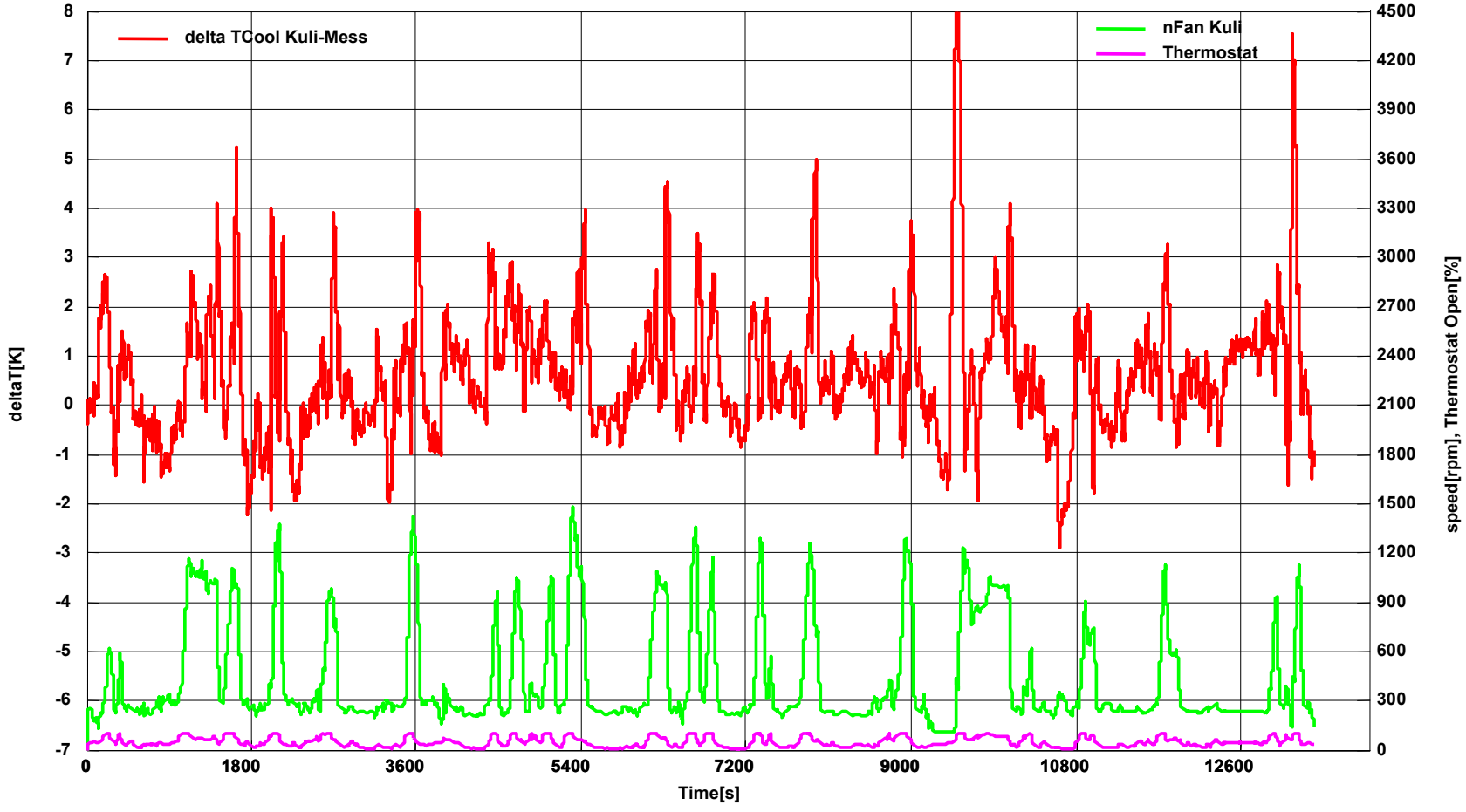


Simulation using the Vehicle and Control Model





Simulation using the Vehicle and Control Model



Conclusions

- The created simulation environment can be used for future software development
- High level of software complexity is now possible
- Impact of improved product performance to the system can be investigated more easily
- New products can be tested before prototypes are build
- **Finally: A new development platform for advanced engineering activities has been created**

Outlook

- Future simulations will consider a family of remote controlled products:
  - Remote controlled Fan Drives
  - Remote controlled Thermostats
  - Remote controlled Waterpumps
- Impact of retarder brakes to the cooling system will be investigated
- Possible potentials for improvement of performance or better fuel consumption will be tested with prototypes in the truck tester.

Embedding a KULI Model in Matlab/Simulink

BorgWarner
Emissions/Thermal Systems

Dipl.-Ing. (FH) Thomas Buchholz
Dipl.-Ing. (FH) Wolfgang Sorg

Thank you!