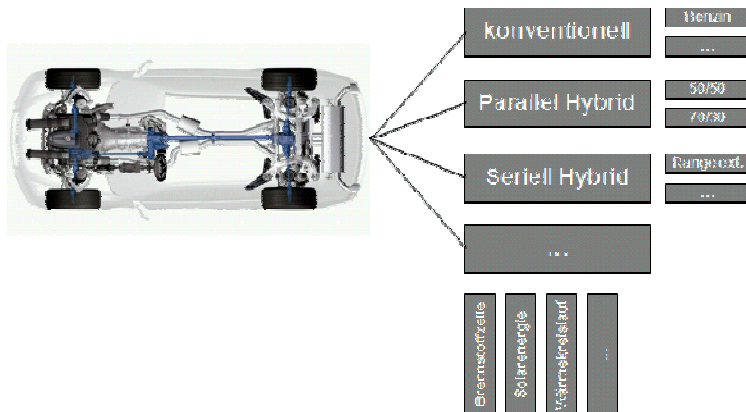


# Selecting an Optimal Hybrid Car Configuration by means of a Simulation Automation System



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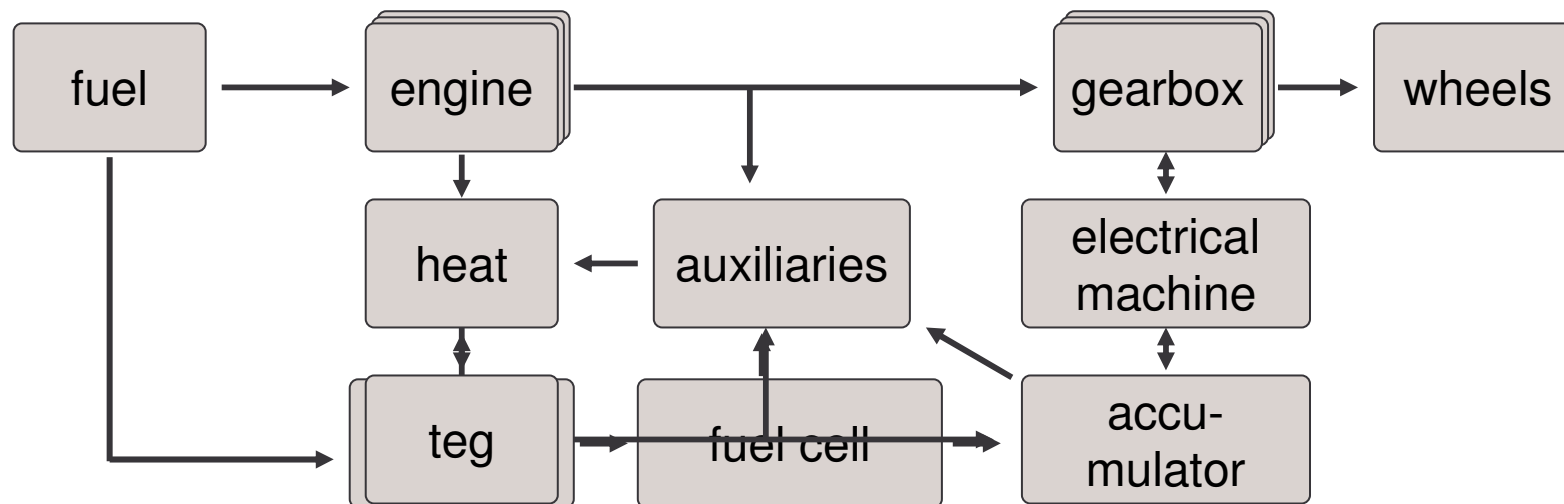
Technical University of Munich

# Selecting an Optimal Hybrid Car Configuration by means of a Simulation Automation System

- motivation
- concept
- procedure
- realisation
- conclusion

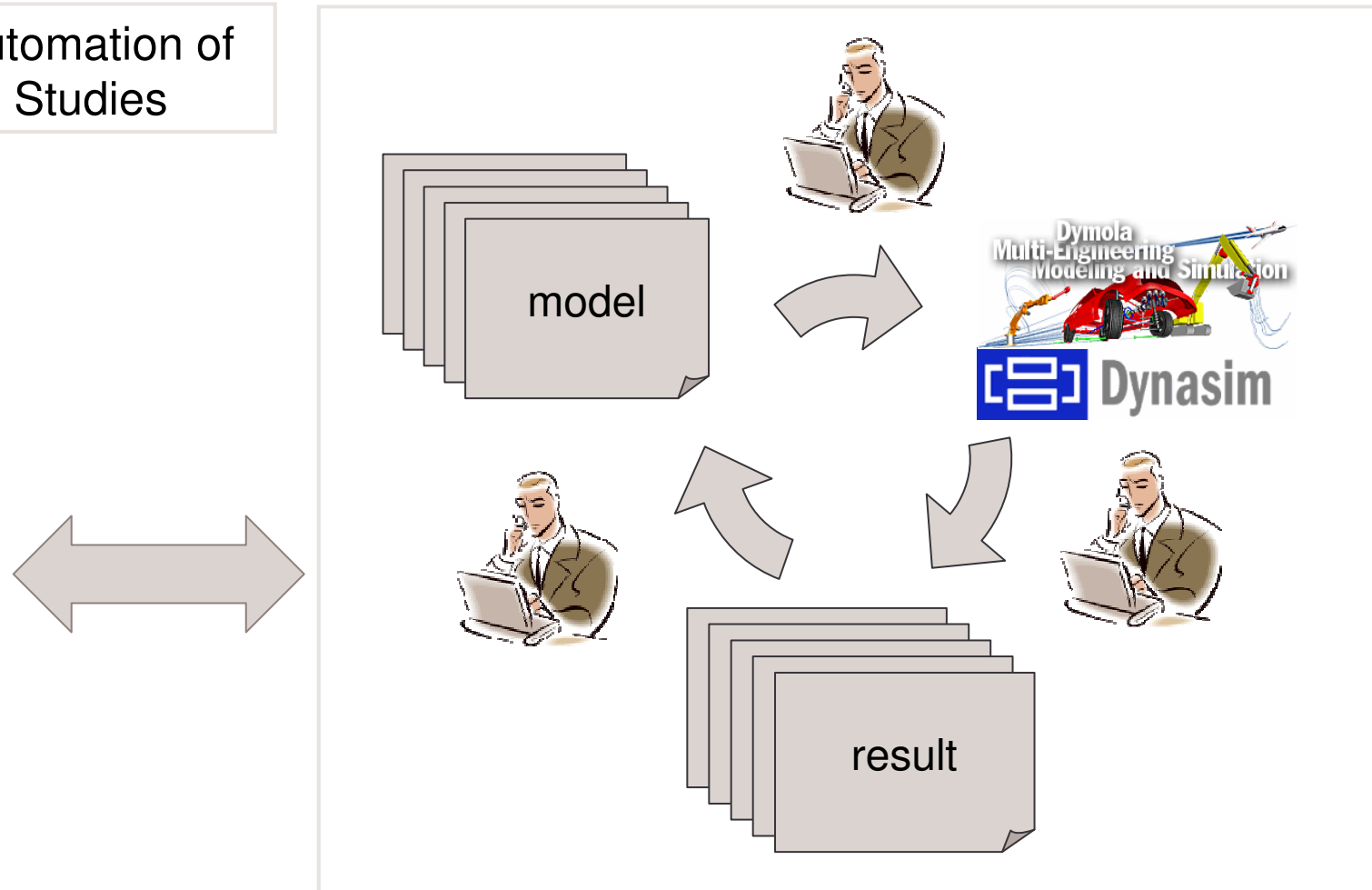
## motivation (1/2)

Various possible hybrid car configurations



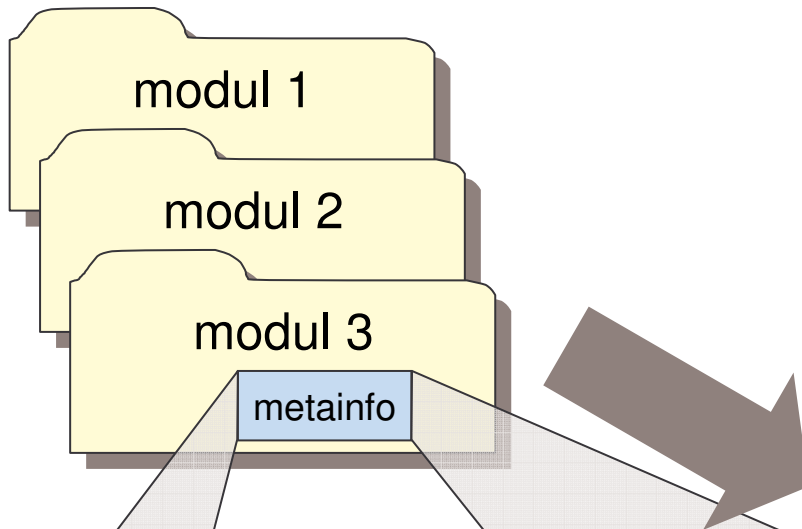
## motivation (2/2)

Tool for automation of  
Simulation Studies

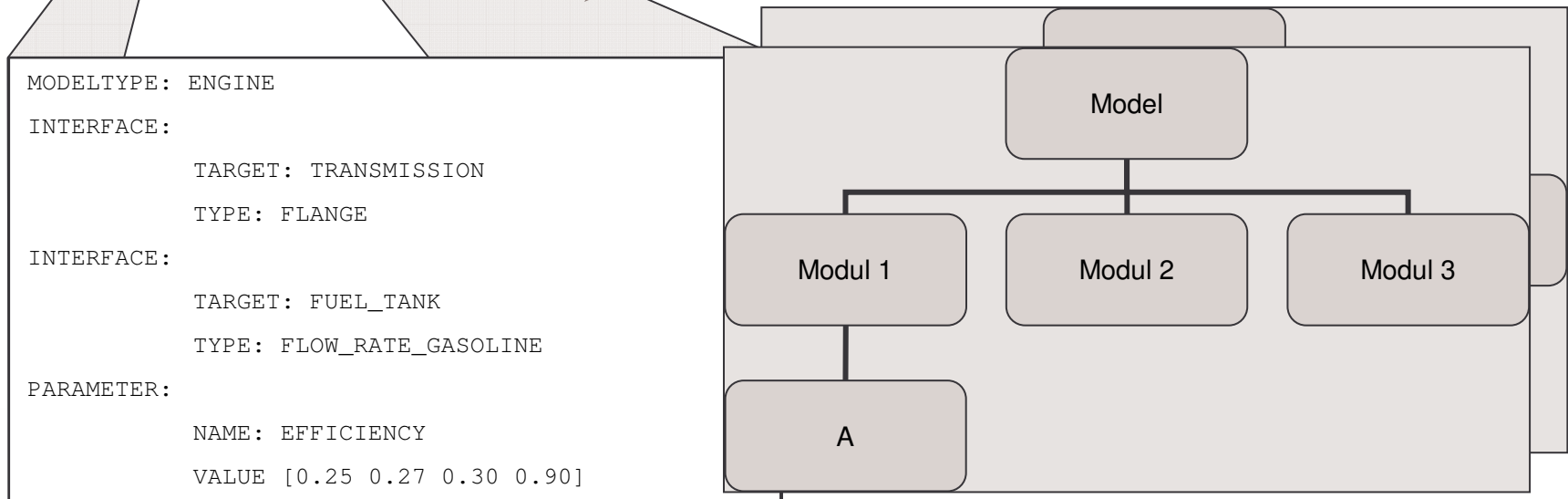


# Concept of a Simulation Automation System (1/2)

generic generation of car configurations out of modules





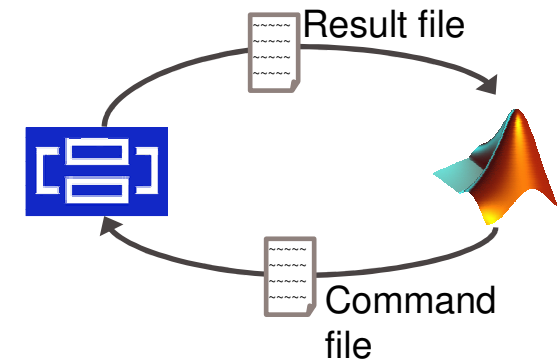
- + • generic applicable for many simulation systems
- small implementation effort per simulation system



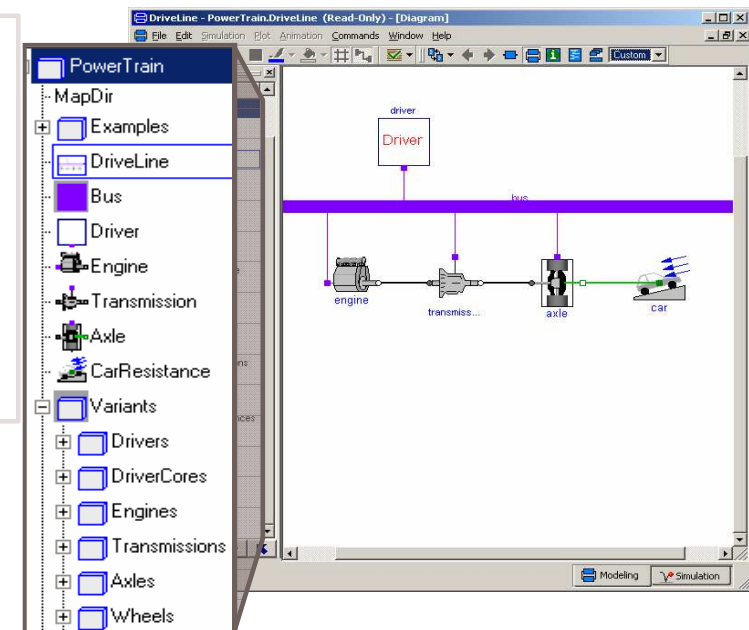
## Concept of a Simulation Automation System (2/2)

Approach:

- Simulation system: Dymola 
- Simulation automation system: Implemented in Matlab  **MATLAB**
- Coupling via command and result files



- Use of Dymola Powertrain library, which contains subcomponents, like comb. engines
  - DRIVER: 2
  - ENGINE: 1 (+1)
  - TRANSMISSION: 3
  - AXLE: 2
  - CARRESISTANCE: 2



# Procedure of the Simulation Automation System (1/2)

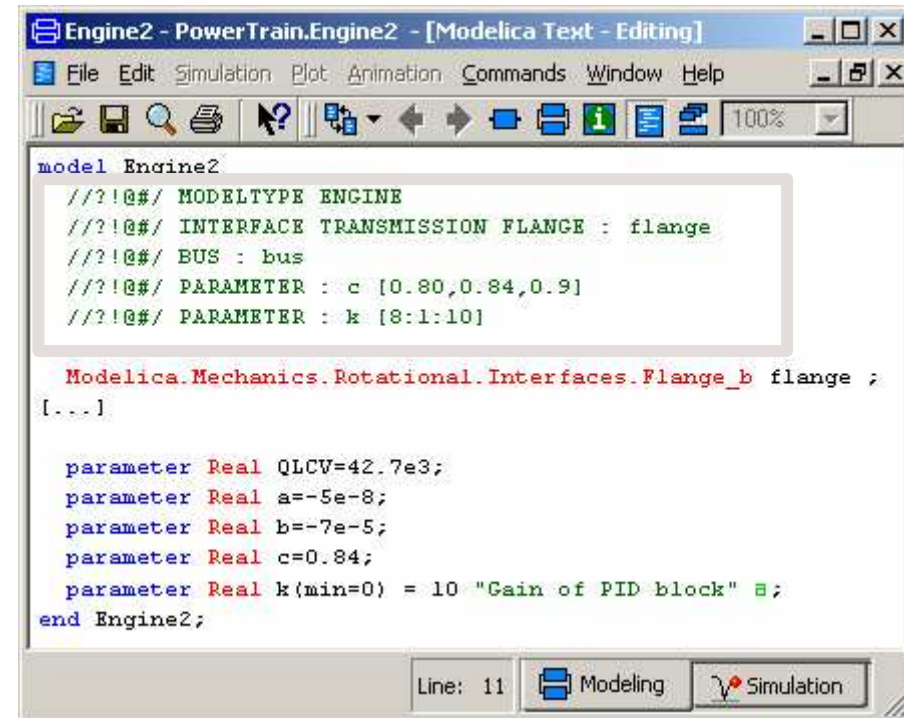
## Prearrangement:

- Modifying the Powertrain library: Additional information for model generation in each module

model engineA

```
// accessory model information
MODELTYPE: ENGINE
INTERFACE:
  TARGET: TRANSMISSION
  TYPE: FLANGE
PARAMETER:
  NAME: EFFICIENCY
  VALUE: [0.25 0.27 0.30 0.31]
```

```
// physical description
(tau*w) = (fluelflow*calorific_value) * efficiency
...
end engineA
```



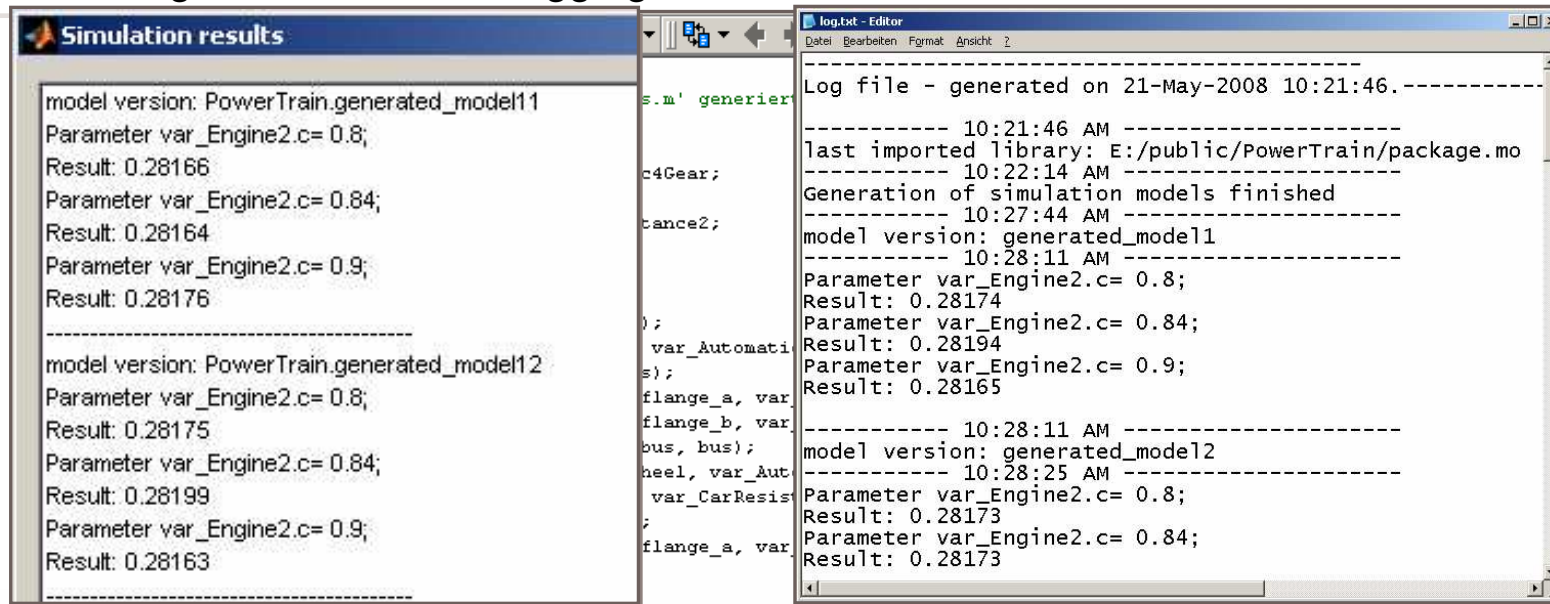
```
model Engine2
  //?!@#// MODELTYPE ENGINE
  //?!@#// INTERFACE TRANSMISSION FLANGE : flange
  //?!@#// BUS : bus
  //?!@#// PARAMETER : c [0.80,0.84,0.9]
  //?!@#// PARAMETER : k [8:1:10]

  Modelica.Mechanics.Rotational.Interfaces.Flange_b flange ;
  [...]

  parameter Real QLCV=42.7e3;
  parameter Real a=-5e-8;
  parameter Real b=-7e-5;
  parameter Real c=0.84;
  parameter Real k(min=0) = 10 "Gain of PID block" #;
end Engine2;
```

## Procedure of the Simulation Automation System (2/2)

- Importing of library:
  - SAS parses indicated library and extracts modules
- Generation of simulation models
  - SAS generates possible model alternatives
- Parameter variation and running simulations
  - Generation of Dymola scripts for each simulation model
  - Running simulations and logging results



The screenshot shows two windows. The left window, titled 'Simulation results', displays the output of two simulation runs. The right window, titled 'log.txt - Editor', shows the log file content.

```
Simulation results
-----
model version: PowerTrain.generated_model11
Parameter var_Engine2.c= 0.8;
Result: 0.28166
Parameter var_Engine2.c= 0.84;
Result: 0.28164
Parameter var_Engine2.c= 0.9;
Result: 0.28176
-----
model version: PowerTrain.generated_model12
Parameter var_Engine2.c= 0.8;
Result: 0.28175
Parameter var_Engine2.c= 0.84;
Result: 0.28199
Parameter var_Engine2.c= 0.9;
Result: 0.28163
-----

log.txt - Editor
-----
Log file - generated on 21-May-2008 10:21:46.-----
----- 10:21:46 AM -----
last imported library: E:/public/PowerTrain/package.mo
----- 10:22:14 AM -----
Generation of simulation models finished
----- 10:27:44 AM -----
model version: generated_model11
----- 10:28:11 AM -----
Parameter var_Engine2.c= 0.8;
Result: 0.28174
Parameter var_Engine2.c= 0.84;
Result: 0.28194
Parameter var_Engine2.c= 0.9;
Result: 0.28165
----- 10:28:11 AM -----
model version: generated_model12
----- 10:28:25 AM -----
Parameter var_Engine2.c= 0.8;
Result: 0.28173
Parameter var_Engine2.c= 0.84;
Result: 0.28173
```

# Screenshots of the Simulation Automation System

The screenshot displays the 'Simulation results' window with a list of simulation models and their results. A callout box highlights the 'load models' button and the 'Selected Dymola model library' text. Another callout box shows the endresult for the simulation study over 24 different simulation models, with the aim of minimizing the variable bus.fuelFlow. A third callout box shows the simulation status, including the time taken for the simulation to finish.

**Simulation results:**

```

model version: PowerTrain.generated_model11
Parameter var_Engine2.c= 0.8;
Result: 0.28166
Parameter var_Engine2.c= 0.84;
Result: 0.28164
Parameter var_Engine2.c= 0.9;
Result: 0.28176
-----
model version: PowerTrain.generated_model12
Parameter var_Engine2.c= 0.8;
Result: 0.28175
Parameter var_Engine2.c= 0.84;
Result: 0.28199
Parameter var_Engine2.c= 0.9;
Result: 0.28163
-----
model version: PowerTrain.generated_model13
Parameter var_Driver1.driverCore1.k= 95; Parameter var_Engine2.c= 0.8;
Result: 0.28174
Parameter var_Driver1.driverCore1.k= 95; Parameter var_Engine2.c= 0.84;
Result: 0.28174
Parameter var_Driver1.driverCore1.k= 95; Parameter var_Engine2.c= 0.9;
Result: 0.28174
Parameter var_Driver1.driverCore1.k= 100; Parameter var_Engine2.c= 0.8;
Result: 0.28172
Parameter var_Driver1.driverCore1.k= 100; Parameter var_Engine2.c= 0.84;
Result: 0.27978
Parameter var_Driver1.driverCore1.k= 100; Parameter var_Engine2.c= 0.9;
Result: 0.28174
-----
model version: PowerTrain.generated_model14
Parameter var_Driver1.driverCore1.k= 95; Parameter var_Engine2.c= 0.8;
Result: 0.28172
    
```

**Selected Dymola model library**

**The endresult for this simulation study over 24 different simulation models with the aim of minimise the variable bus.fuelFlow**

----- is: 0.27978 -----

...for the simulation model 1  
and Parameter var\_Engine2.c= 0.84;

...for the simulation model 13  
and Parameter var\_Driver1.driverCore1.k= 100; Parameter var\_Engine2.c= 0.84;

**Simulation settings**

**Simulation status**

14:13:11.5  
462.937 sec  
14:21:24.453  
finished

## conclusion

- A tool for automated execution of simulation studies was introduced
- The focus of that tool is the possibility to automatically generate car model variations
- The first prototype of the tool was implemented and demonstrated
- further works:
  - Import model interfaces out of modelica models
  - Include automated parameter variation and optimization on the generated car models
  - intelligent reduction of variants
  - parallel execution of different structure models with the help of grid technologies
  - improve framework and user interface

# Thank you for your attention