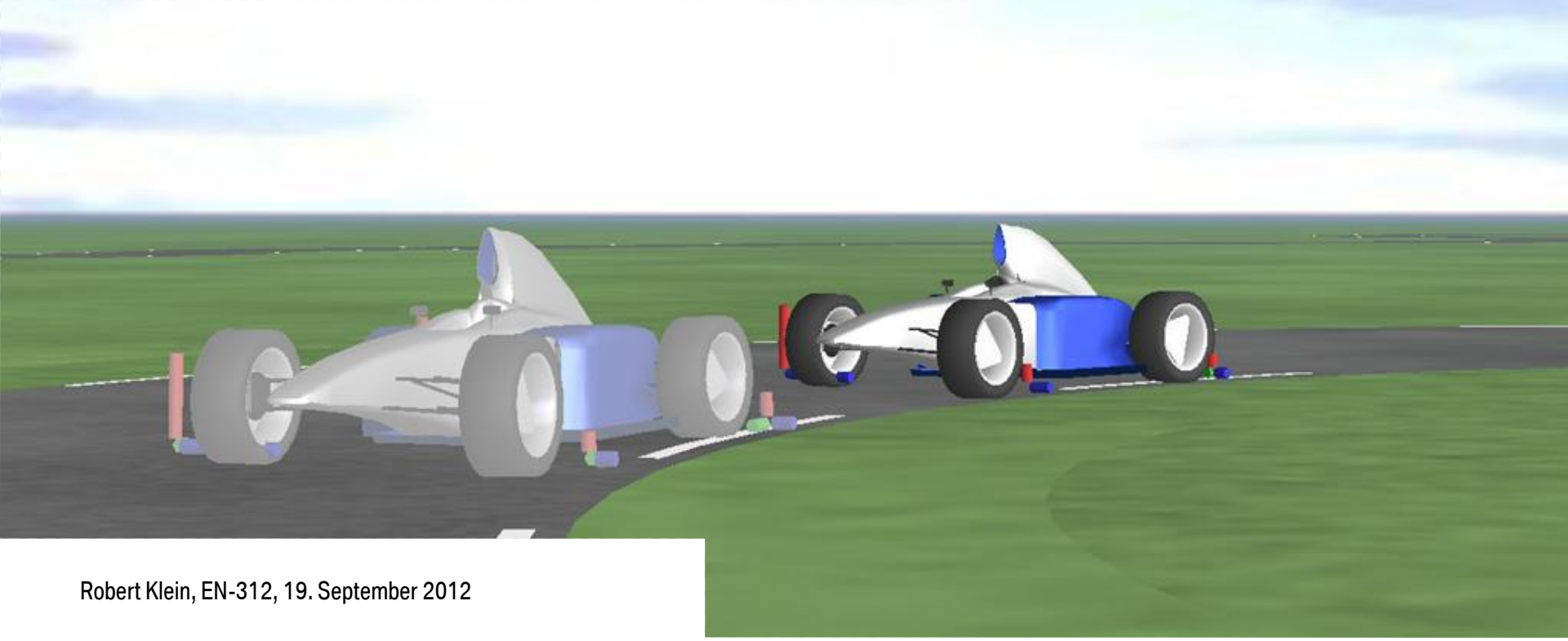


Robert Klein, EN-312, 19. September 2012

VIRTUAL SYSTEM PROTOTYPING.

**RESULTS OF THE MASTER THESIS ROBERT KLEIN
DR. STEFAN-ALEXANDER SCHNEIDER, BMW GROUP AND
PROF. DR. HERBERT PALM, HOCHSCHULE MÜNCHEN.**

BMW GROUP

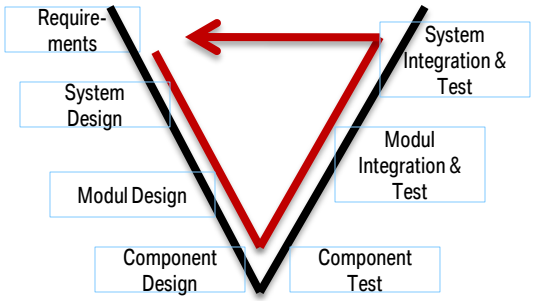
AGENDA.

- Problem Definition
- Virtual System Prototyping
  - Virtual System Design
  - Virtual System Integration
- Test of Numerical Stability
- Design Evaluation

PROBLEM DEFINITON.

As Is

Late system level response



→ The later failures are found, the more expensive they are!

Problem

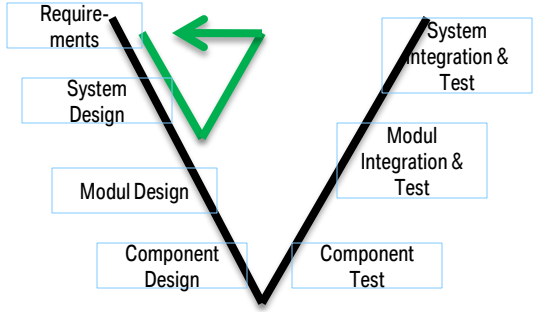
How to achieve an earlier system level response?

Solution

Virtual System Prototyping

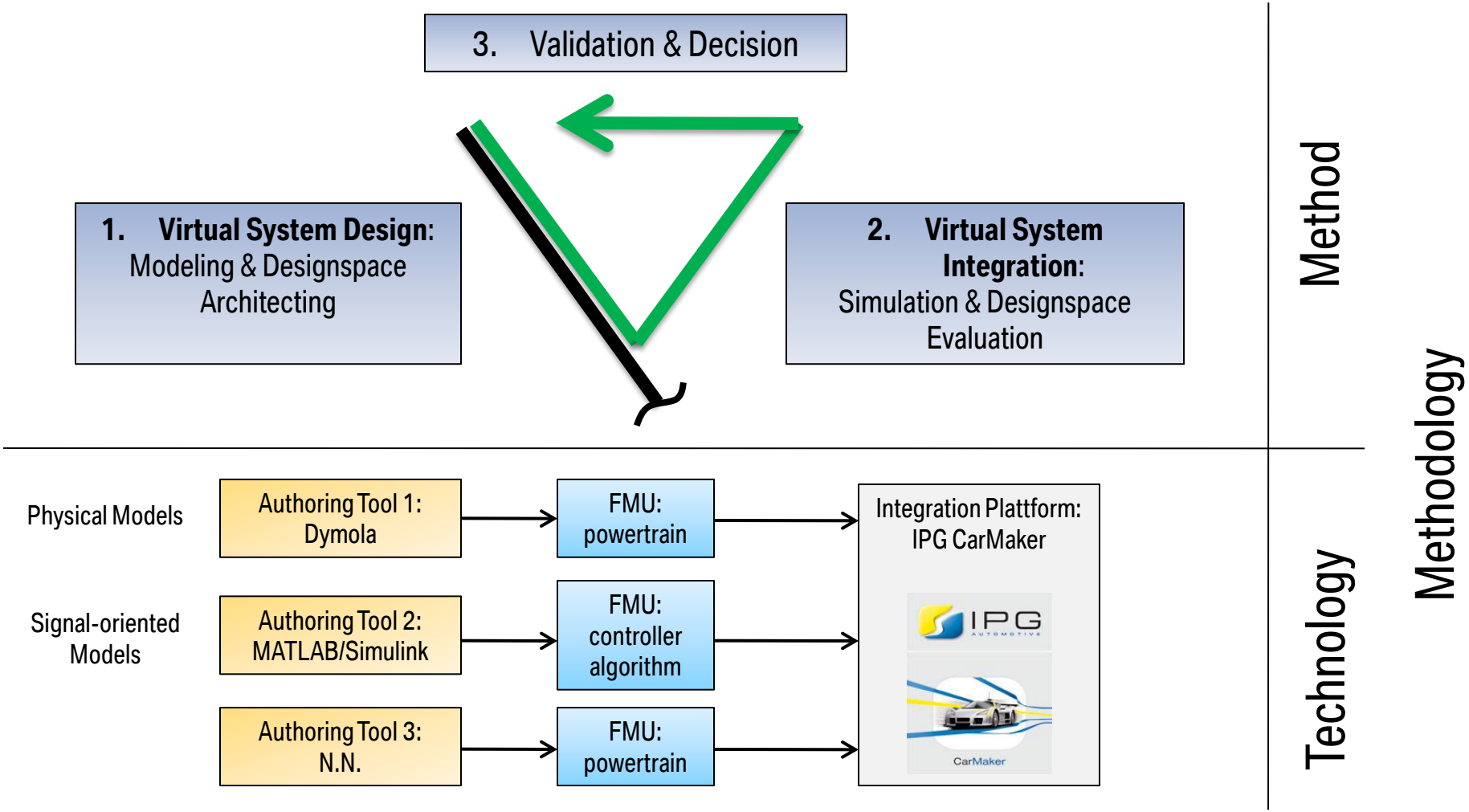
To Be

Early system level response

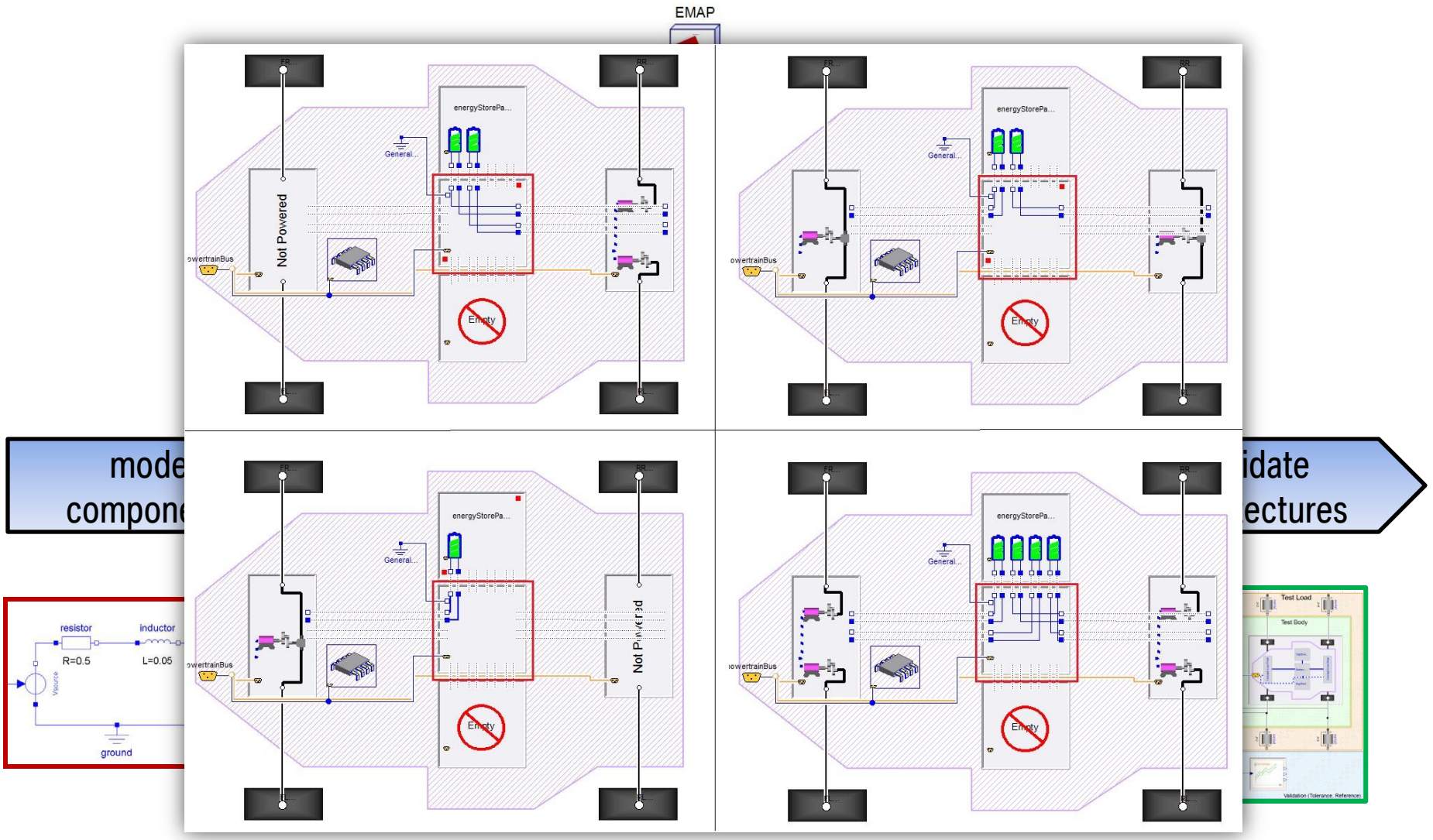


→ Early evaluation of system reduces the risk of missing the „best solution“!

VIRTUAL SYSTEM PROTOTYPING.



VIRTUAL SYSTEM DESIGN.

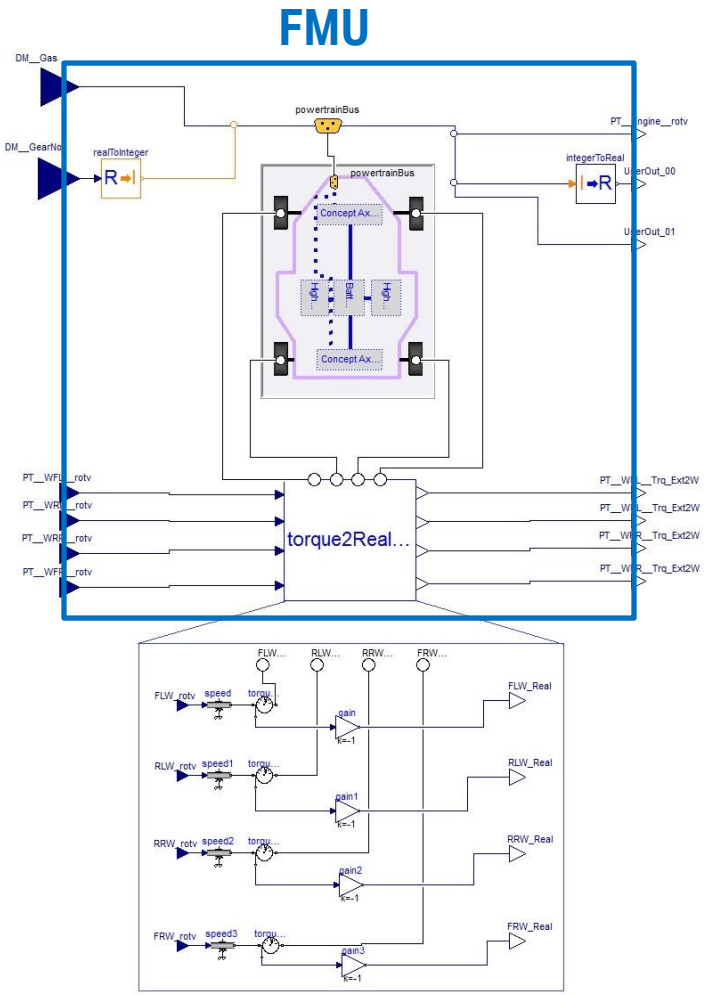


VIRTUAL SYSTEM INTEGRATION.

1. Definition of FMU with signal-oriented, CarMaker-specific interfaces

2. Converting physical interfaces into signal-oriented interfaces with modelica sensor component

3. Synchronizing axes with modelica speed component

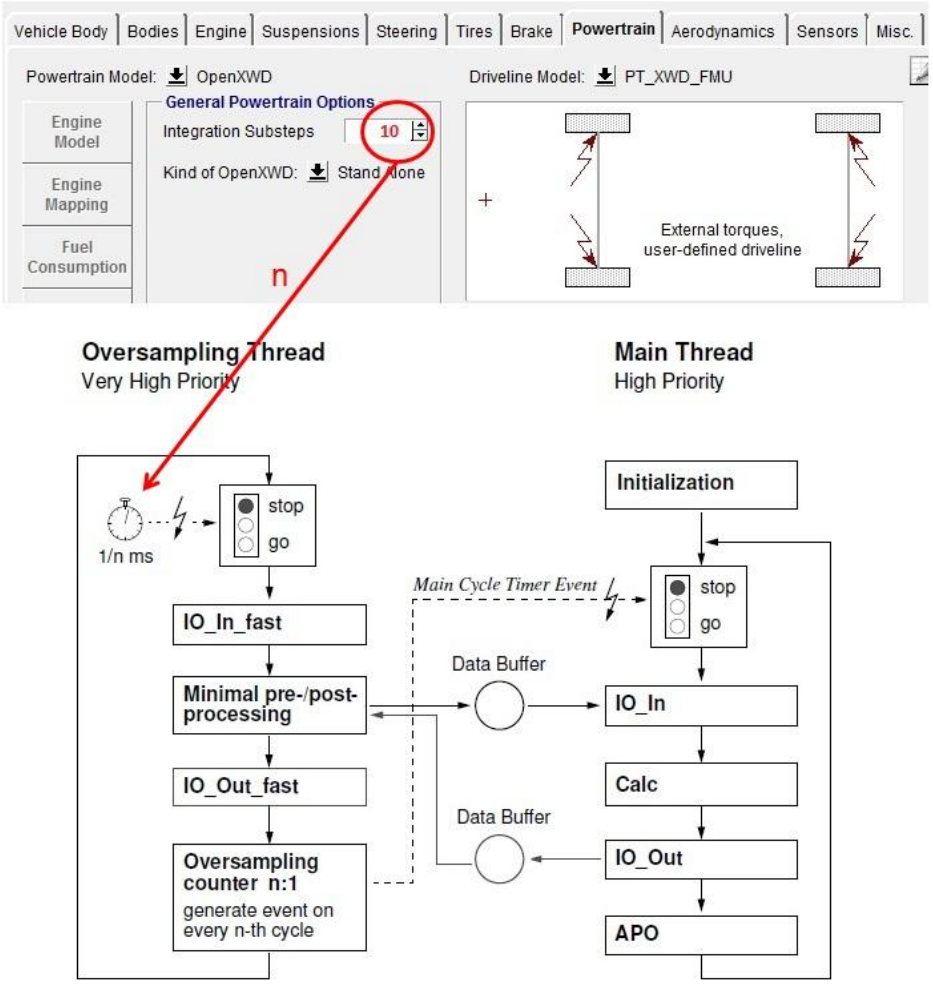


VIRTUAL SYSTEM INTEGRATION.

4. Exporting FMU using the Modelon FMI Toolbox

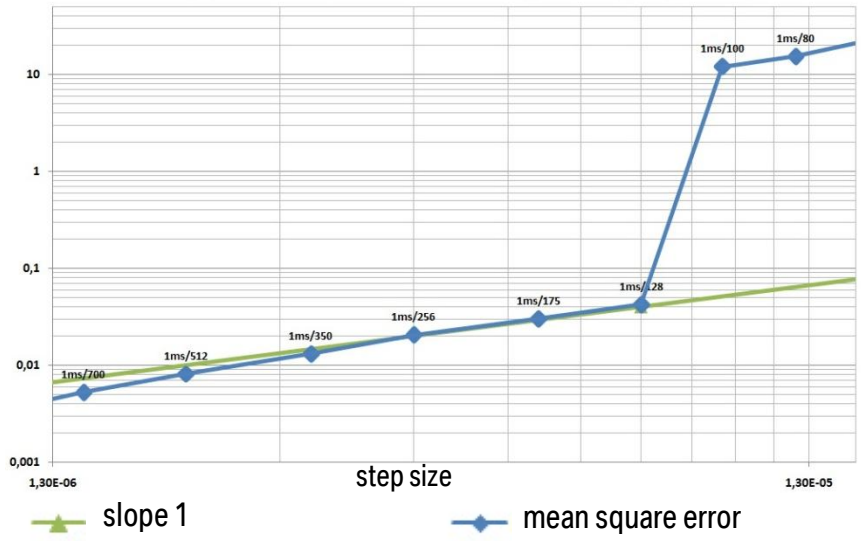
5. Integrating the powertrain model using the OpenXWD framework

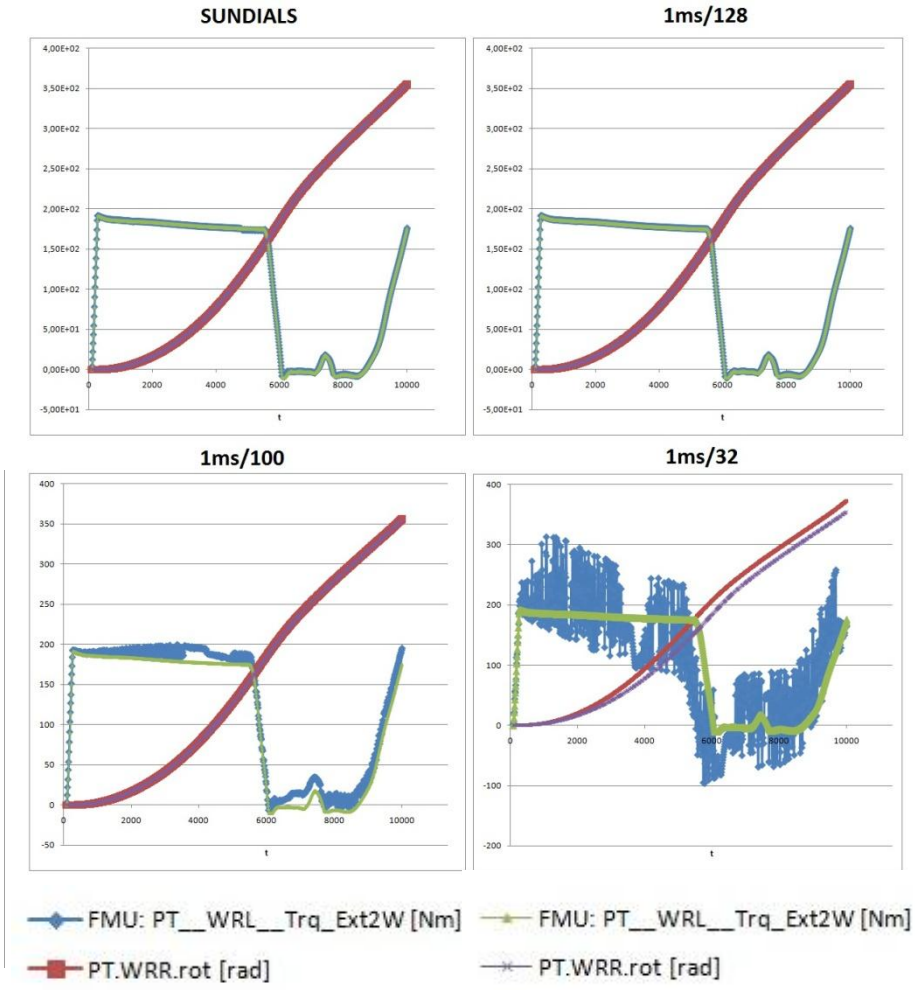
→ Use of „Integration Substeps“ with Euler solver possible



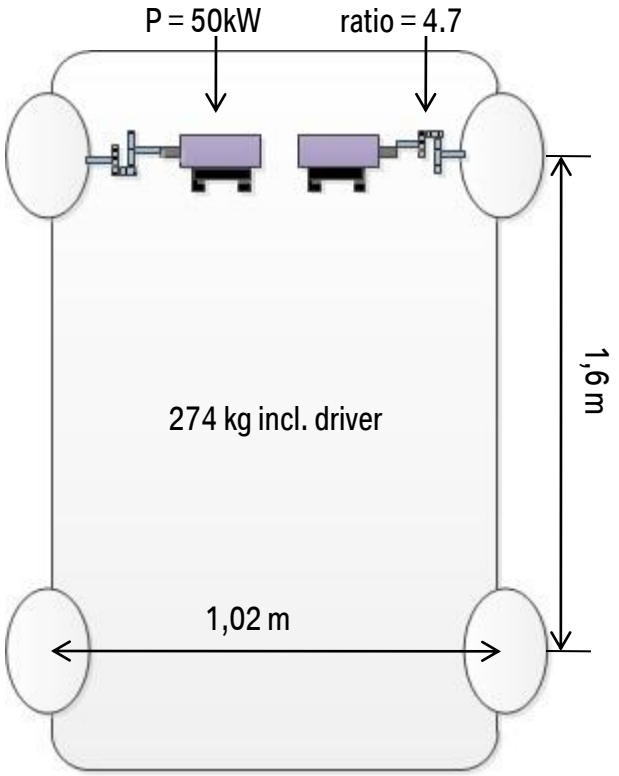
TEST OF NUMERICAL STABILITY.

- Analysing error with different step sizes
- Mean square error over step size shows euler convergence in stabilized area

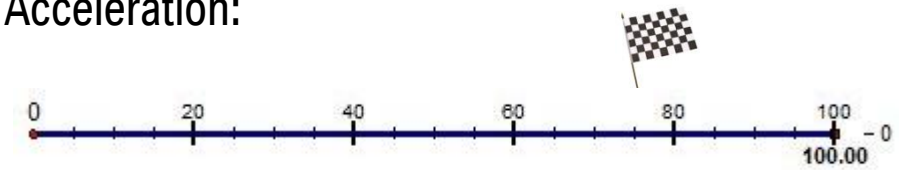




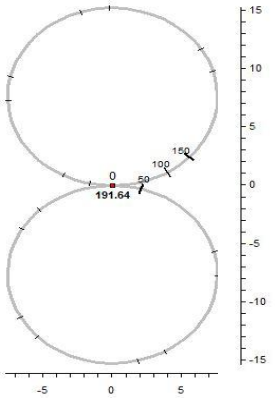
DESIGN EVALUATION.



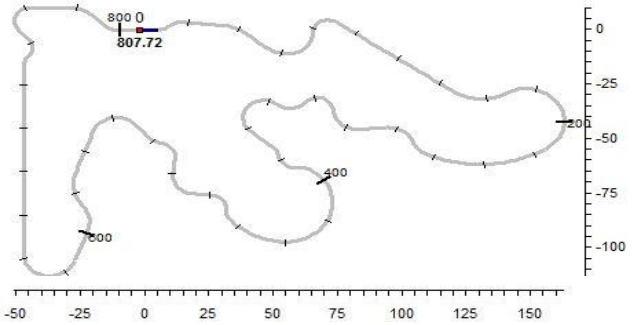
Acceleration:



Skidpad:

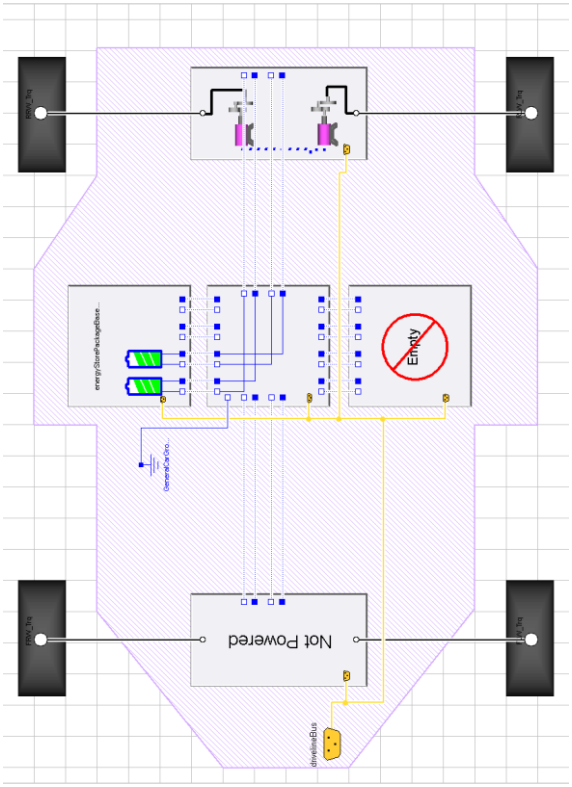


Endurance:

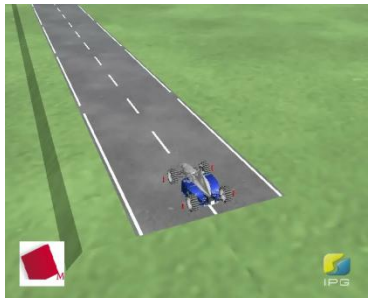


How does the variation of Engine-Power influences the 3 FSE competitions?

DESIGN EVALUATION.



Acceleration:



Skidpad:

Endurance:

DESIGN EVALUATION.

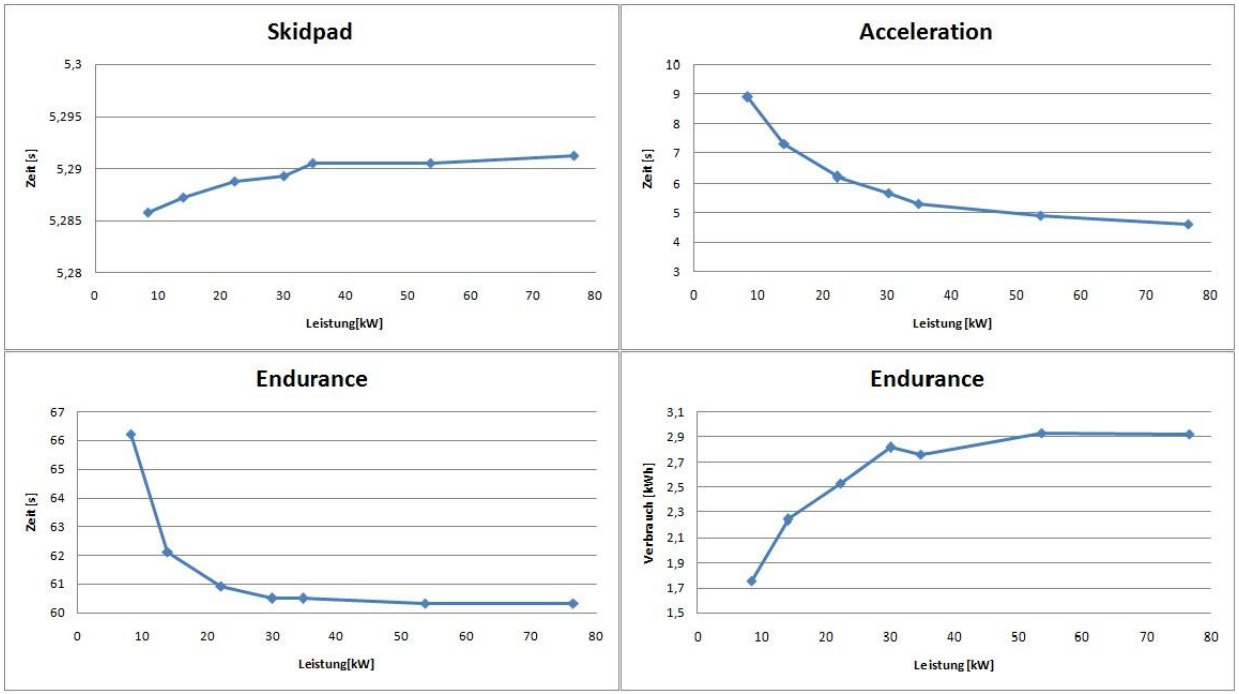
	M1	M2	M3	M4	M5	M6	M7
Motor-Speed[rpm]	7600	6000	4000	4320	3300	2900	2300
Motor-Torque[Nm]	90	80	80	64	60	43	32
Motor-Power[kW]	76,5	53,6	34,8	30,1	22,2	14	8,3
Acceleration-Time[s]	4,62	4,91	5,31	5,67	6,2	7,32	8,91
Skidpad-Time[s]	5,29	5,29	5,29	5,29	5,29	5,29	5,29
Endurance-Time[s]	60,3	60,3	60,5	60,5	60,9	62,12	66,2
Endurance-Consumption[kWh]^2	2,93	2,93	2,76	2,82	2,53	2,24	1,76

M5

3300
60
22,2

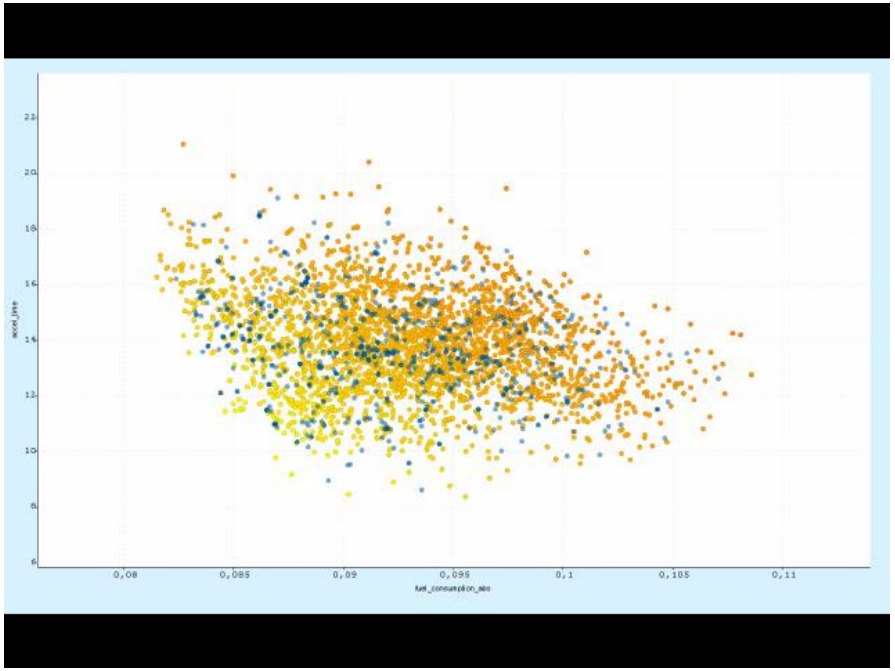
6,1
5,29
60,9
2,39

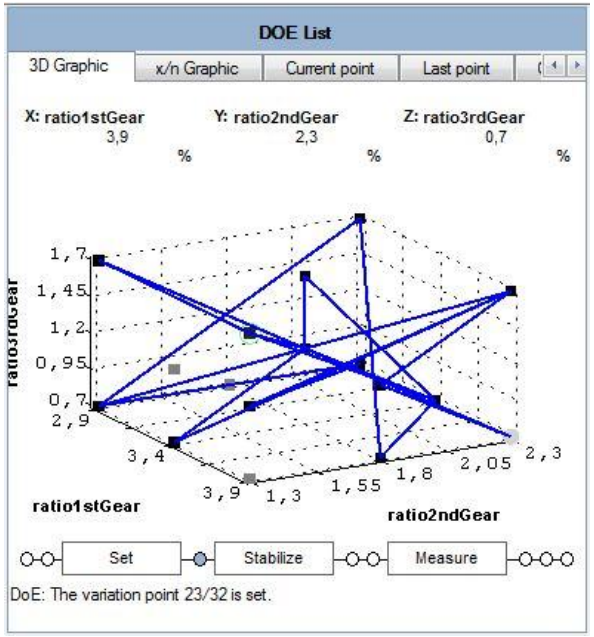
with reduced weight by 20 kg at 274 kg total weight



PROSPECT.

- Systematic Evaluation with Design of Experiments
- Localize optimized Trade-Offs





THANK YOU.

Fakultät für Elektrotechnik
und Informationstechnik

HOCHSCHULE
FÜR ANGEWANDTE
WISSENSCHAFTEN · FH
MÜNCHEN

BMW Group