



# Lap Time Simulation – Crucial for Racecar Concept Evaluation

Fabrice Oehler AMZ Racing, Christoph Hahn MathWorks



# Guinness World Record in Formula Student

- AMZ Racing set a new world record for the fastest 0-100 km/h acceleration of an electric car in 2014

**1.785 s**

# Guinness World Record in Formula Student

- AMZ Racing set a new world record for the fastest 0-100 km/h acceleration of an electric car in 2014

~~1.785 s~~

- Greenteam Stuttgart set a new record in summer 2015

1.779 s





# Formula Student





# About Formula Student

- Largest engineering competition worldwide
- Over 500 Teams with 10'000 members
- Combustion and electric class
- Different static and dynamic events



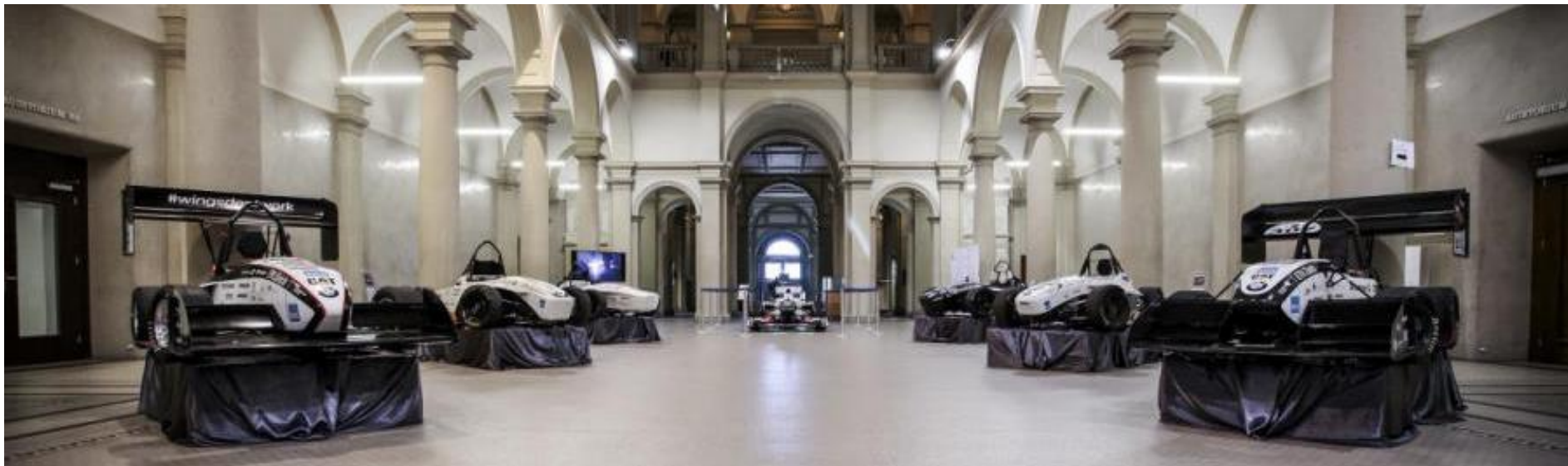


# AMZ Racing



# AMZ Racing

- Builds race cars for Formula Student since 2007
- Since 2010 six electric cars were built
- Since 2013 first place in Formula Student Electric world ranking





## Season 2015 - *flüela*

- 4 wheel hub motors
  - 25.7 Nm, 37 kW, 3.25 kg
- Lithium Polymer accumulator
  - 6.46 kWh
- Full Aerodynamics-Package
  - Drag Reduction System (DRS)
- Adaptive Damping System
- Simulink programmed Vehicle Control Unit
- 2<sup>nd</sup> place in Formula Student Germany, 1<sup>st</sup> places in Austria and Spain



# Lap Time Simulation





# Motivation to Use Lap Time Simulation

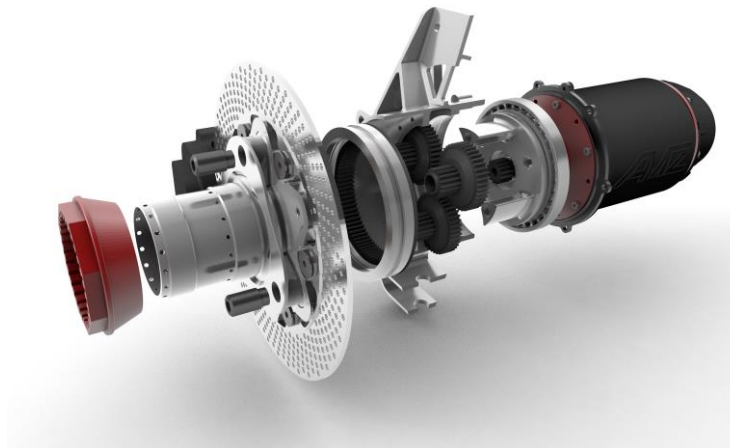
- Only eight months for design and manufacturing a race car
- We need a tool for decision making
- Different concept decisions can be analyzed

Accumulator Capacity



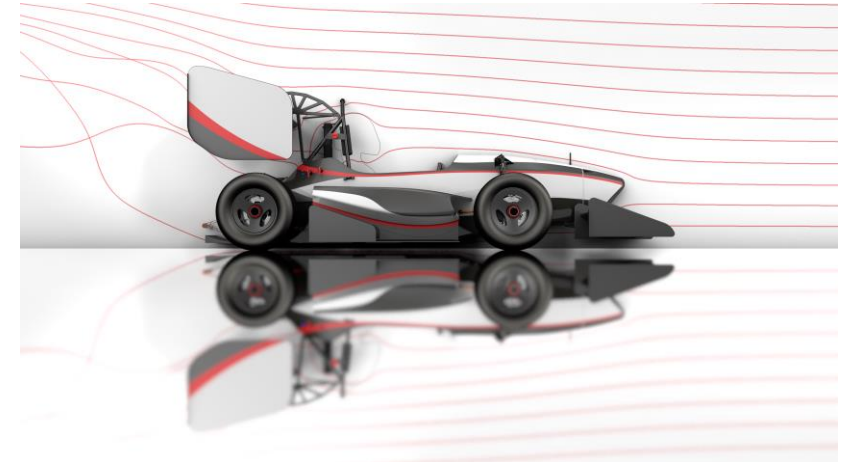
5/10/2016

Gearbox Transmission Ratio



Akademischer Motorsportverein Zürich | Fabrice Oehler

Aerodynamic Sensitivities



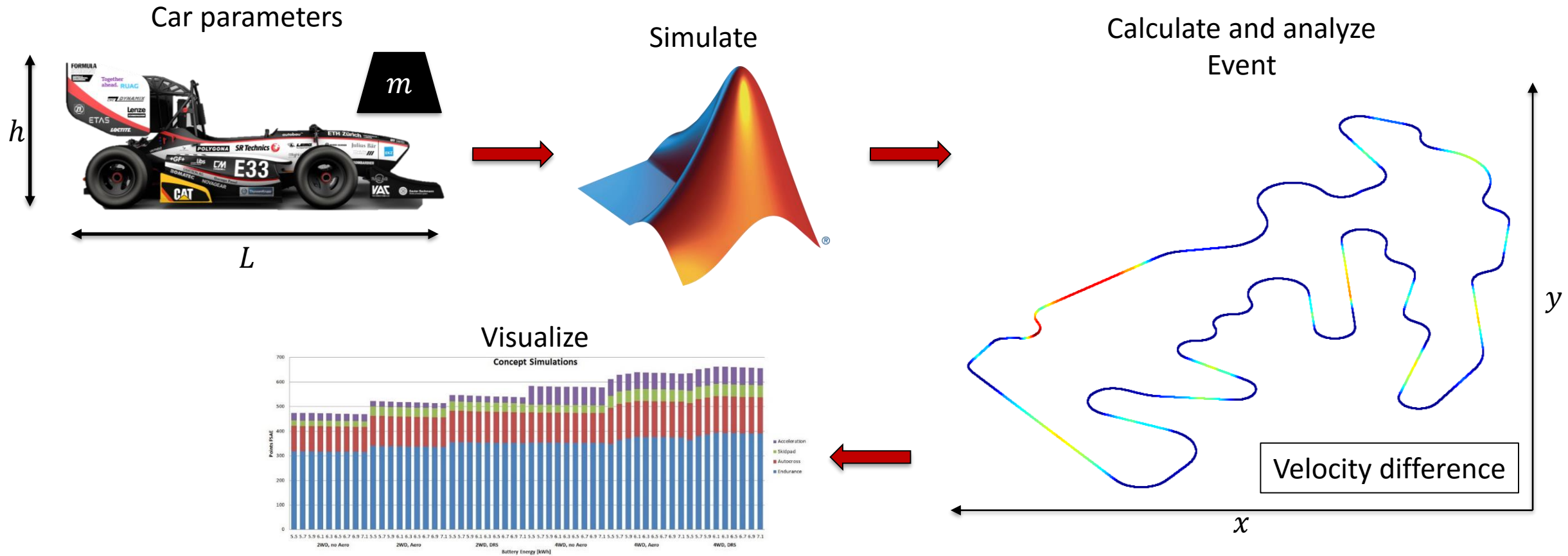
11

# Workflow

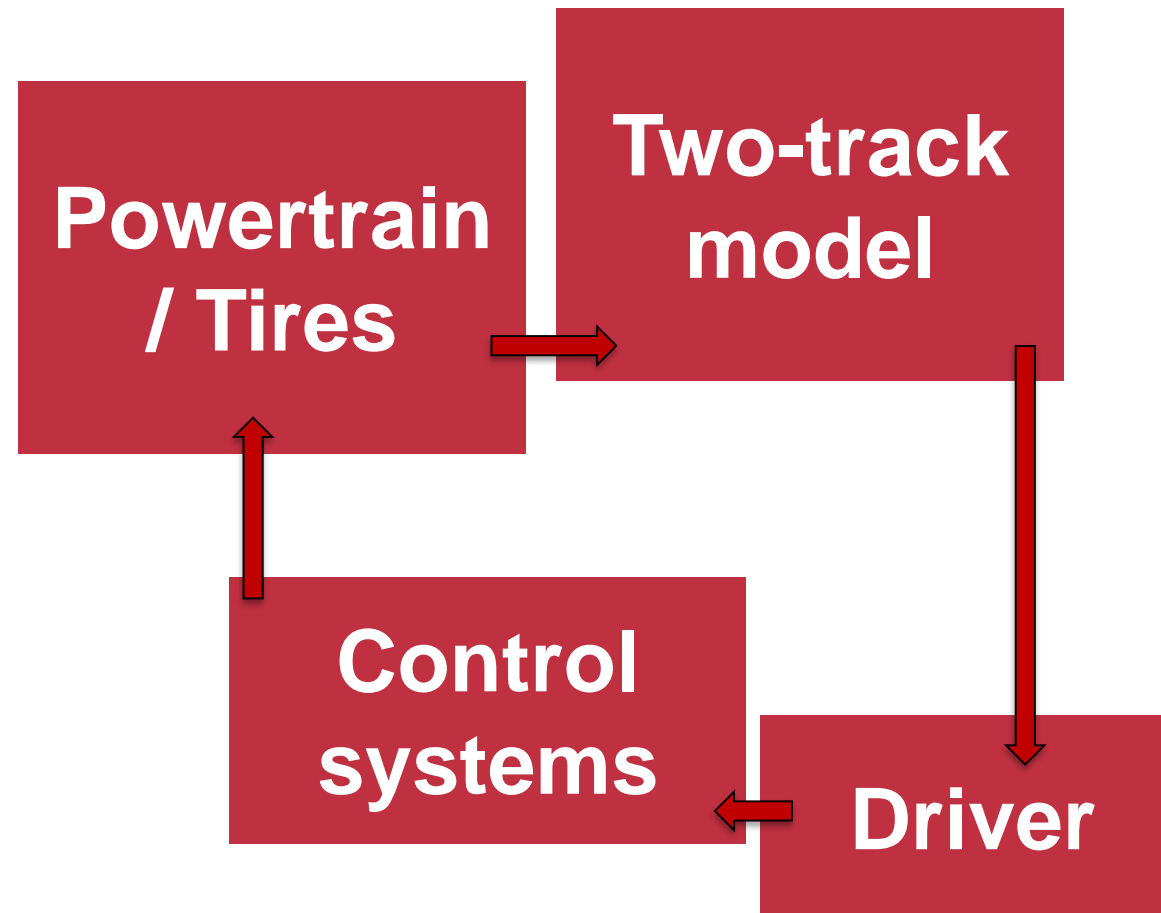




# Workflow

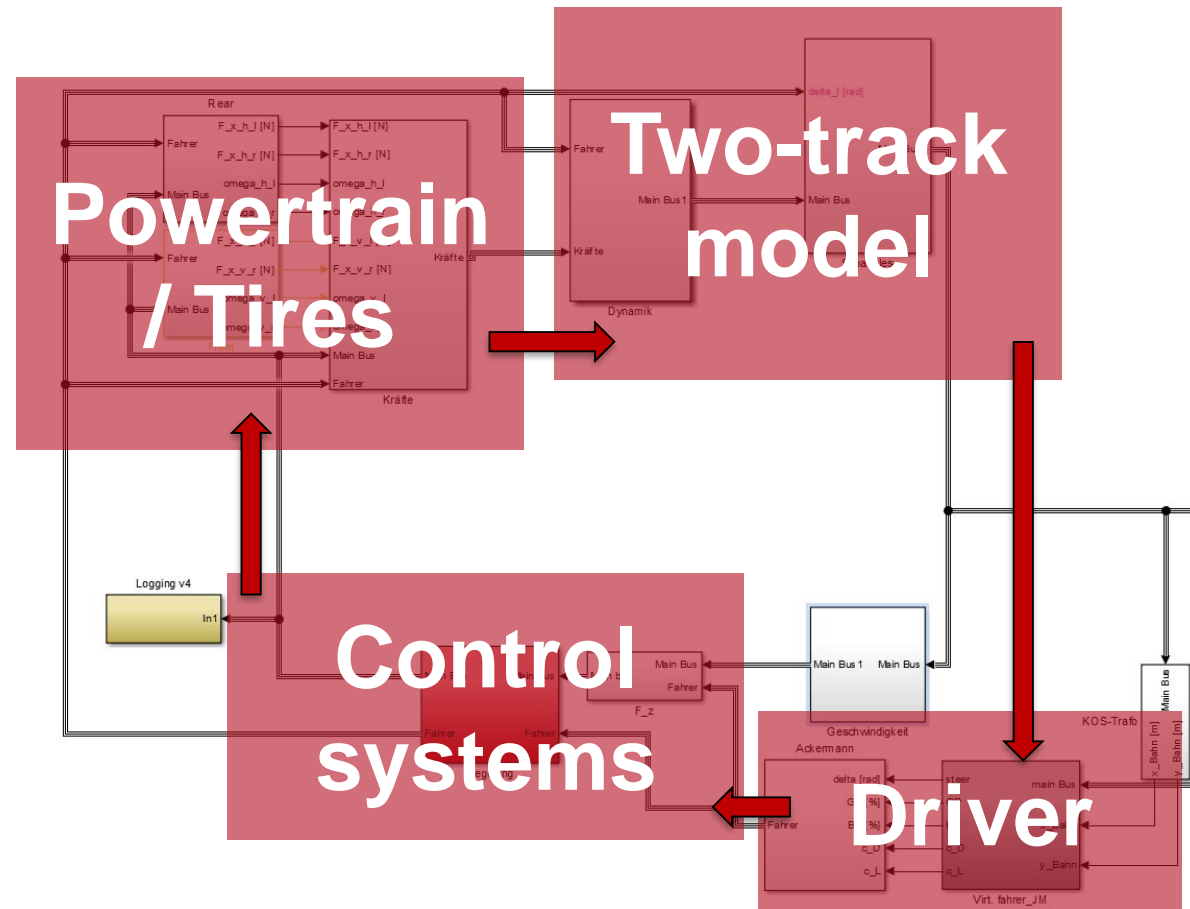


# Structure of the Simulation Model





# Structure of the Simulation Model



# Software Demonstration

HOME PLOTS APPS

New Script New Open Find Files Compare Import Data Save Workspace Clear Workspace Analyze Code Run and Time Clear Commands Simulink Library Layout Set Path Parallel Help Community Request Support Add-Ons

FILE VARIABLE CODE SIMULINK ENVIRONMENT RESOURCES

C:\Users\Fabrice\polybox\ETH\AMZ\LapSim\lapsim15\_v16

Current Folder

- modell
- new\_results
- skripts
- slprj
- driver4.mat
- fluela.mat
- fluela\_approx.mat
- Hockenheim2012.mat
- params2.mat
- simfunv7.m

simfunv7.m (Function)

find starting point

simfunv7(trackmap, car, driver)

Command Window

```
fx >>
```

Workspace

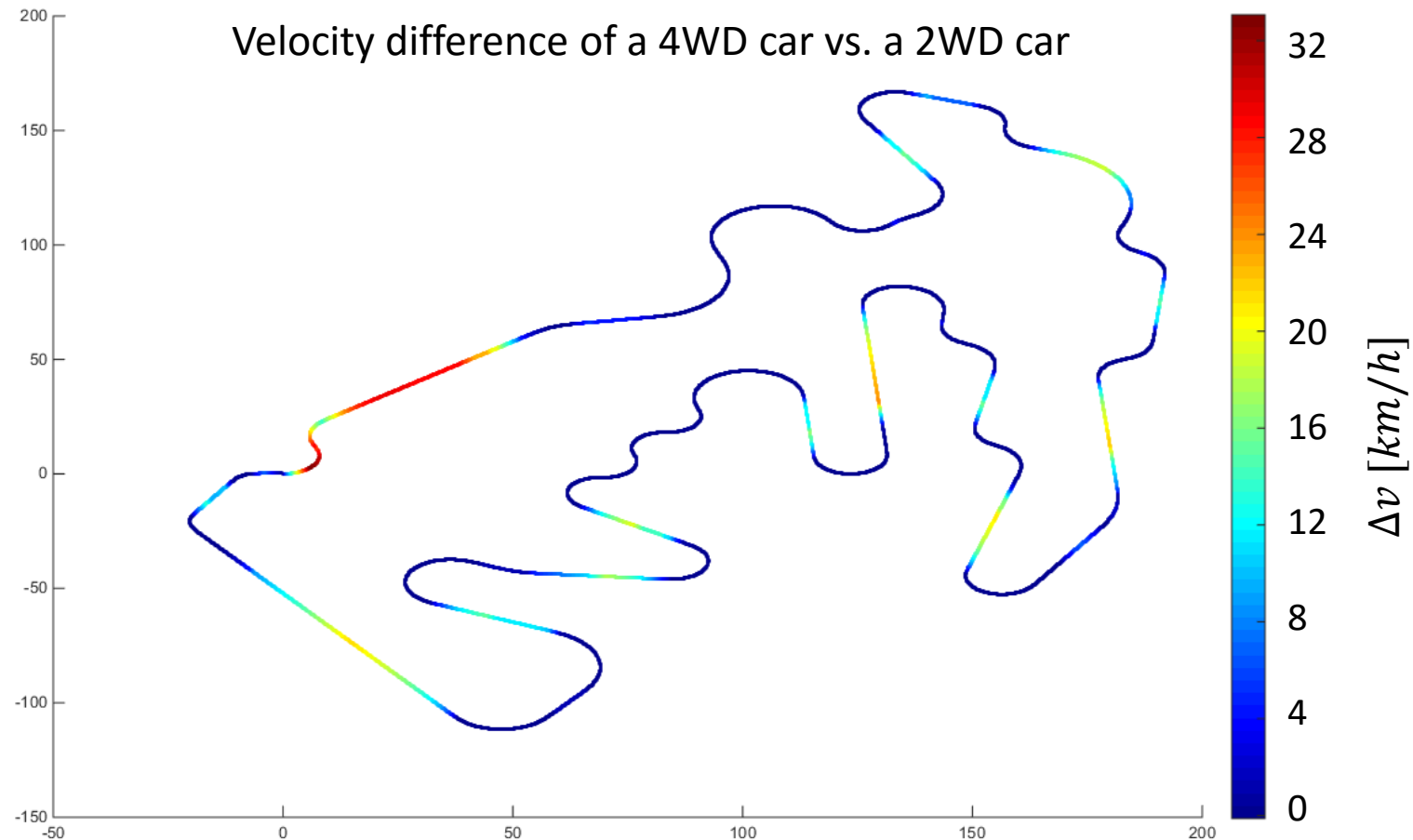
Name	Value
resnoDRS	1x1 struct

Command History

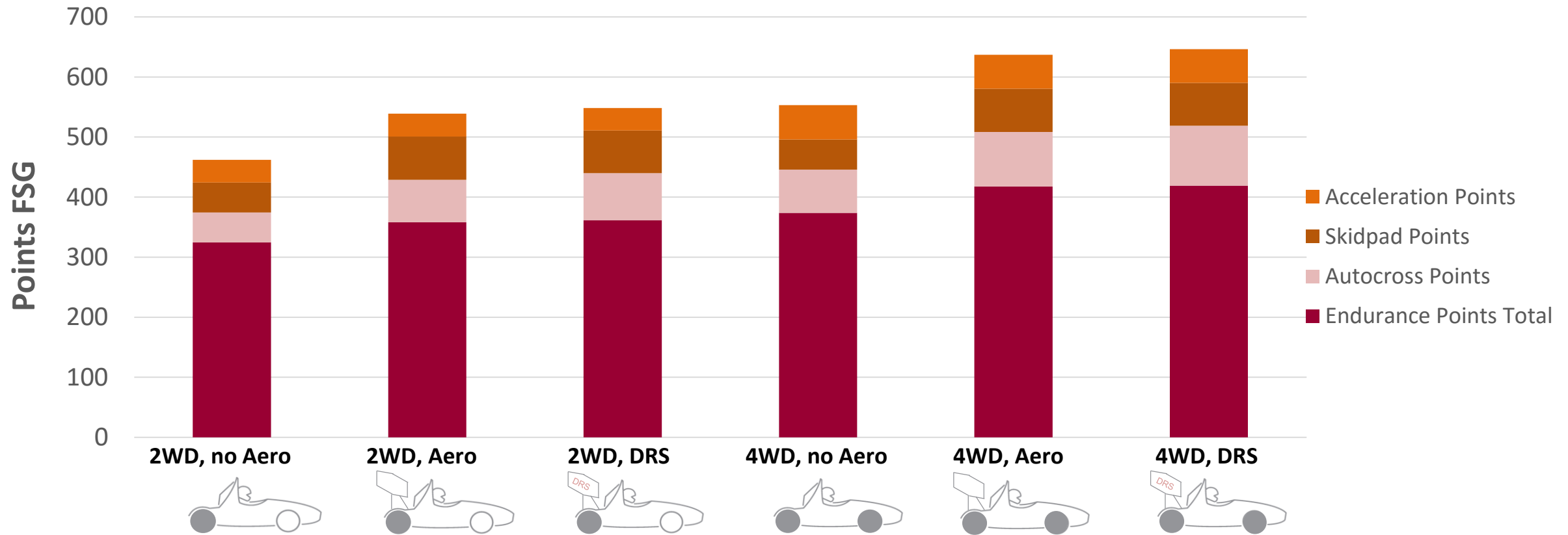
```
%-- 18.09.201...  
load('driver4...  
load('fluela...  
load('Hockenh...  
car.DRS = 0;  
resnoDRS = si... 38.69 sec  
clc
```



# Results

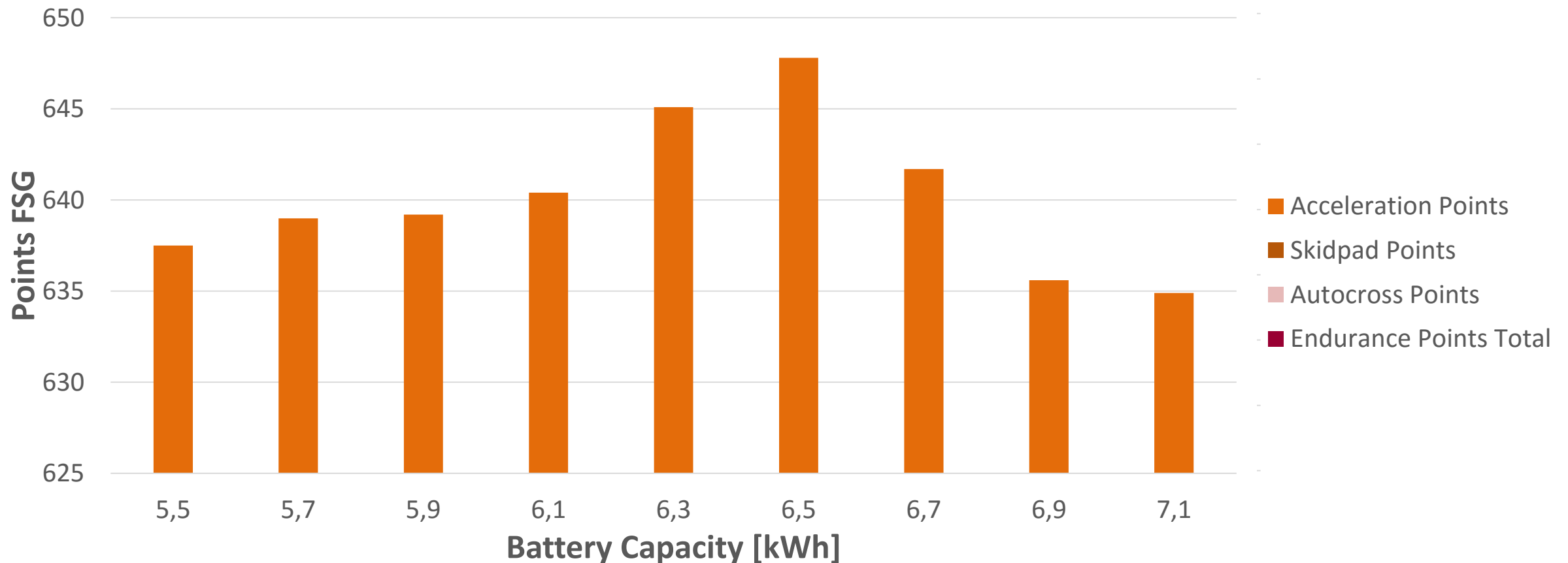


# Results – Concept Simulation





# Results – Energy Simulations 4WD with DRS



# Validation

- Different tests were made to validate our results:
- Weight sensitivity validation



## Laptime deviation

	Lapsim	On-track test	Delta
+ 1 kg	+ 0.087 %	+ 0.082 %	<b>6 %</b>
+ 10 kg	+ 0.893 %	+ 0.821 %	<b>8 %</b>

# Validation

- Different tests were made to validate our results:
- Weight sensitivity validation
- Aerodynamics sensitivity validation



## Laptime deviation Aero vs. no Aero

Lapsim	On-track test	Delta
3.82 %	3.97 %	<b>4 %</b>

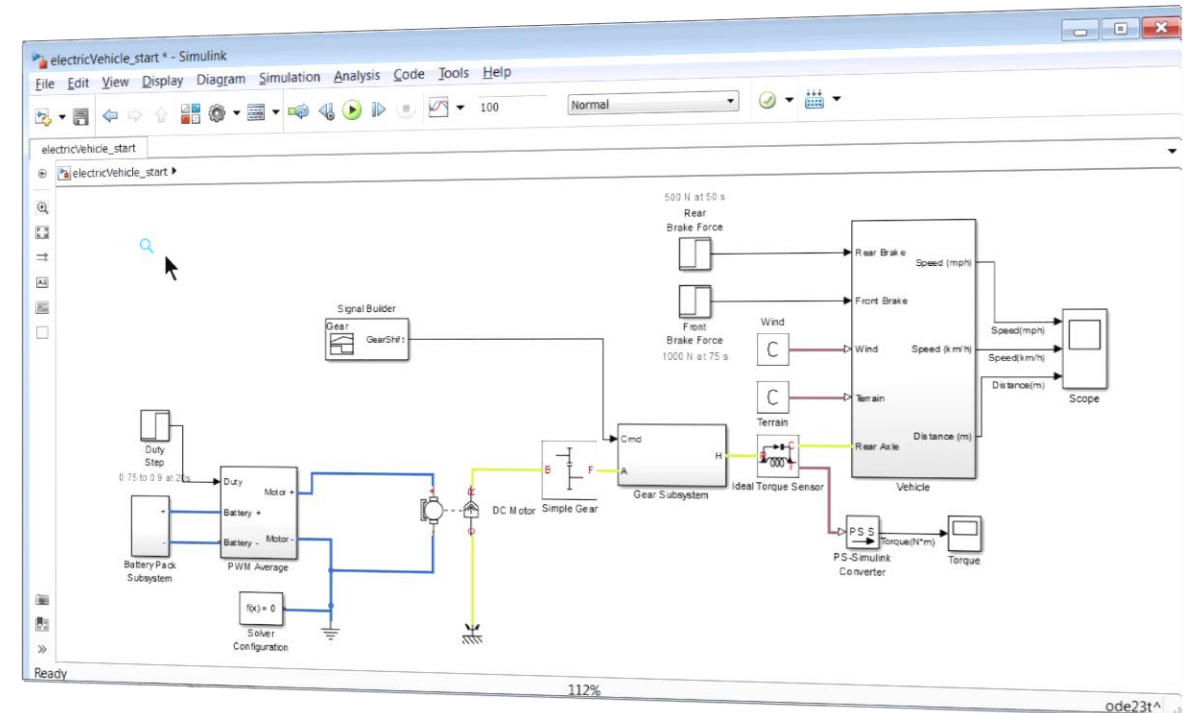


# Conclusions

- By using Lap Time Simulation we get a decision-making basis for different concepts
  - Aerodynamic setups
  - Amount of accumulator capacity
  - Transmission ratio
- Models are simplifications, but they are very helpful. Currently implementing suspension system.

# MathWorks Support for Formula Student

- Complimentary Software
- MATLAB and Simulink Racing Lounge
- Online Training for Physical Modeling



## Hauptsponsoren



Wir bringen Energie **EKZ**

Together  
ahead. **RUAG**



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suter-kunststoffe ag



AMZ



Thanks for Your Attention