Formula Student - Lap Time Simulation

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

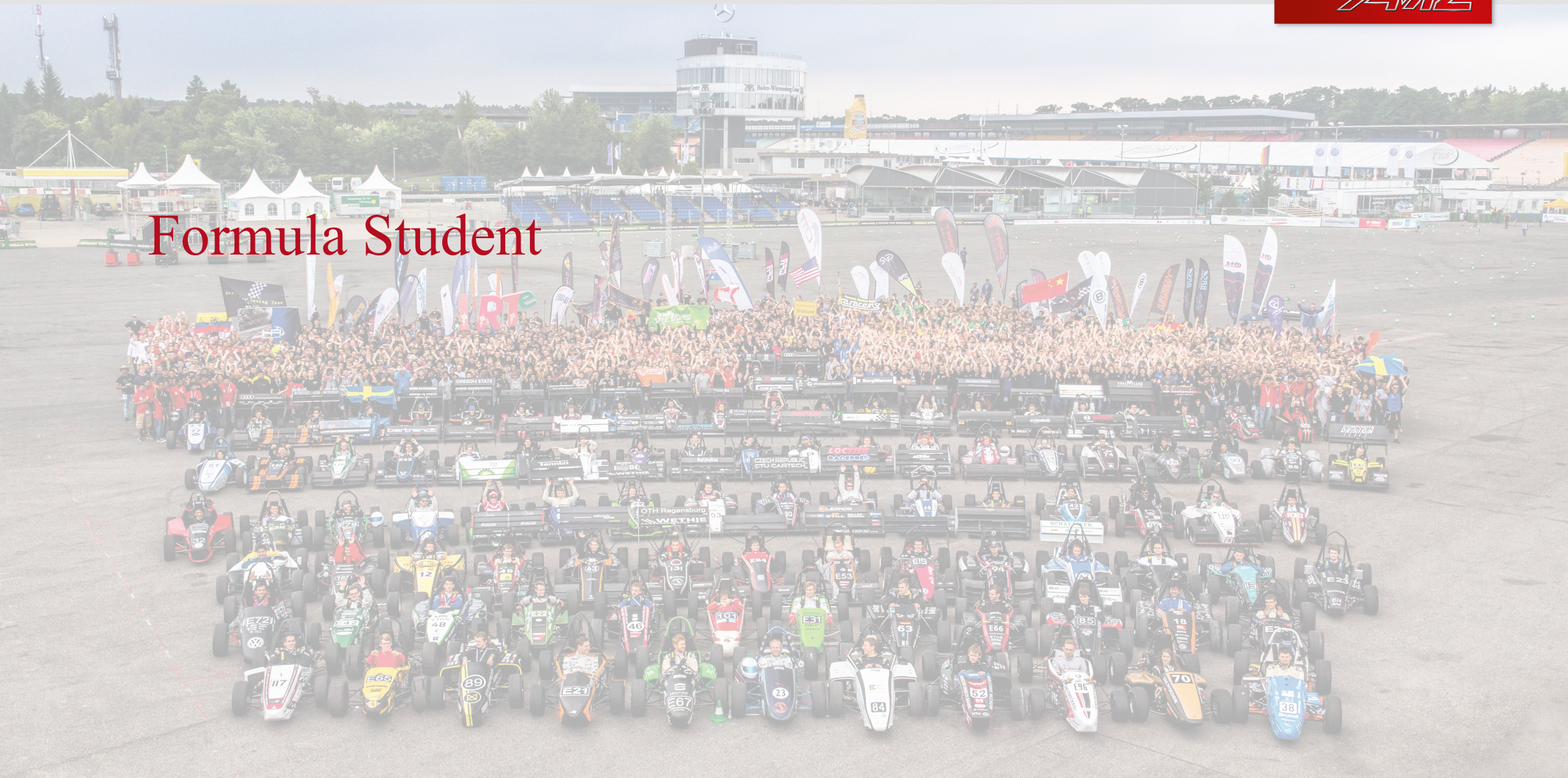
- AMZ Racing set a new world record for the fastest 0-100 km/h acceleration of an electric car in 2014

~~1.785 s~~

- Greenteam Stuttgart set a new record in summer 2015

1.779 s

Formula Student



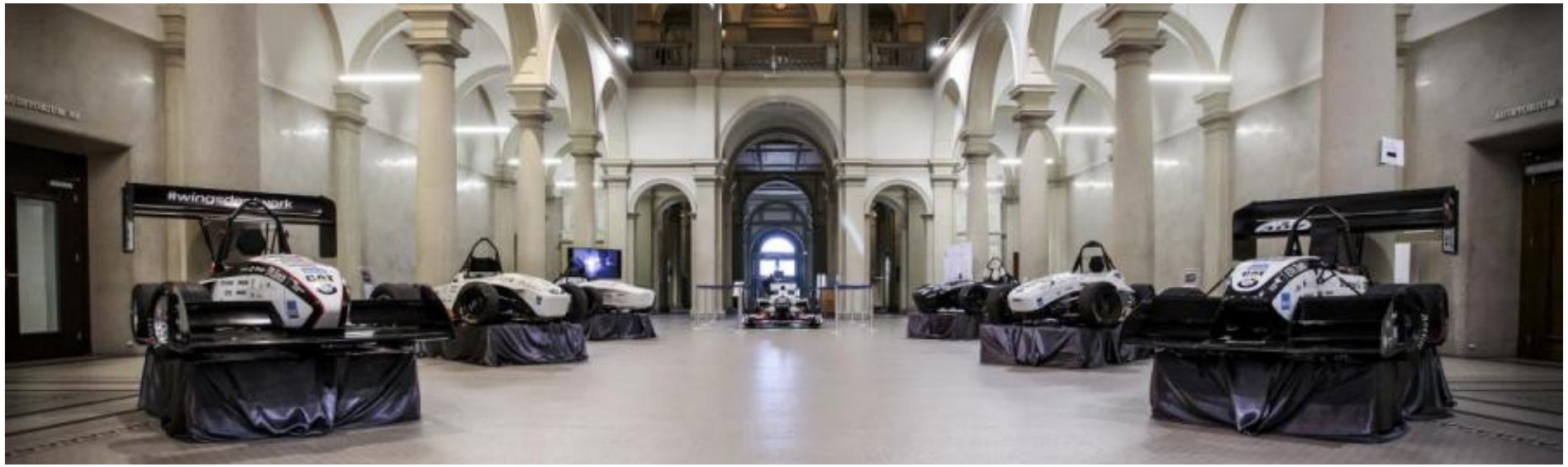
About Formula Student

- 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
- 2nd place in Formula Student Germany, 1st places in Austria and Spain

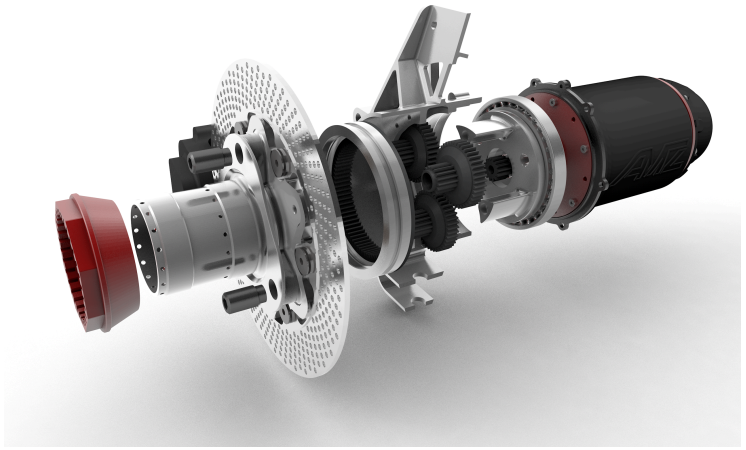
Lap Time Simulation

Motivation to Use Lap Time Simulation

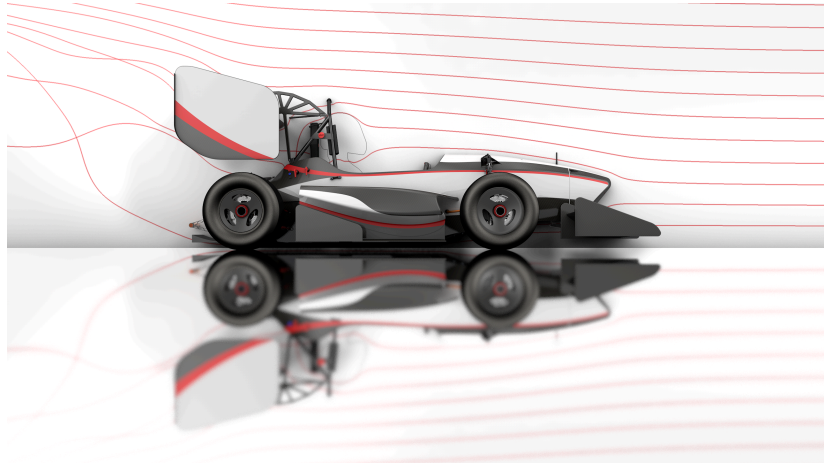
- Only eight months for design and manufacturing a race car
- We need a tool for decision making
- Different concept decisions can be analyzed

Accumulator Capacity

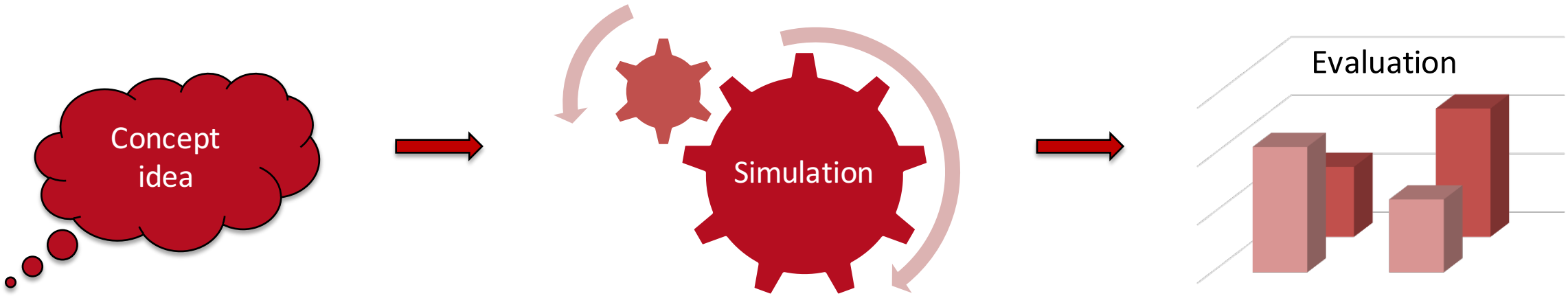
Gearbox Transmission Ratio



Aerodynamic Sensitivities

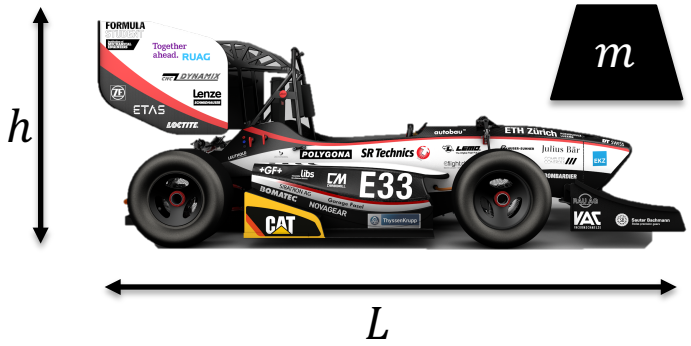


Workflow

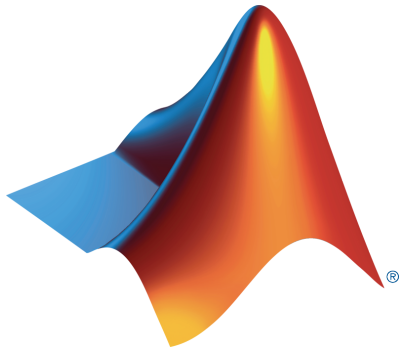


Workflow

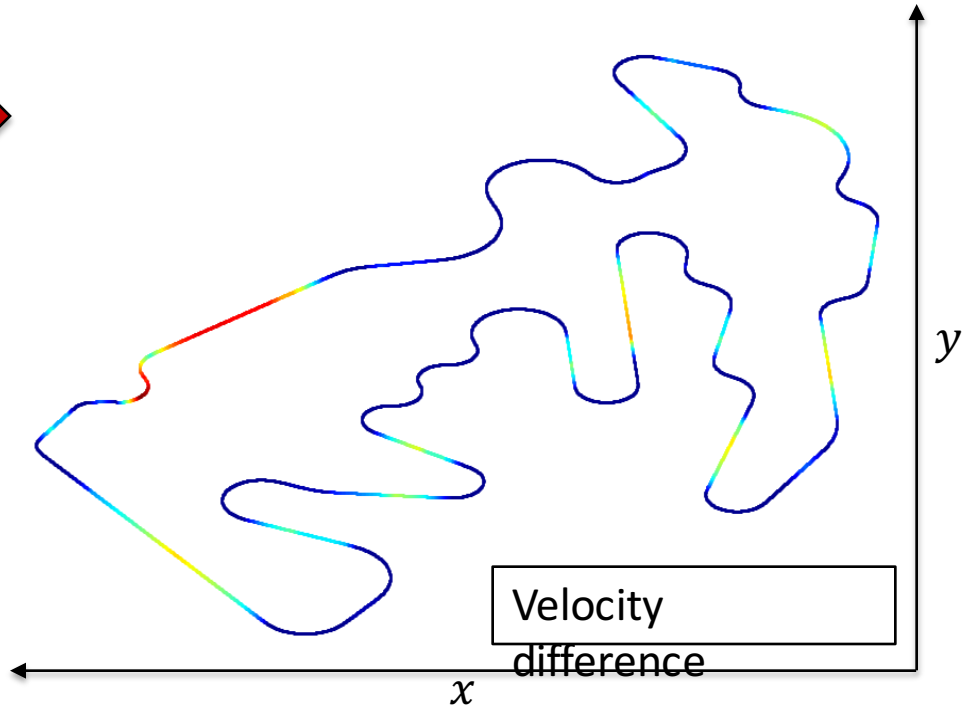
Car parameters



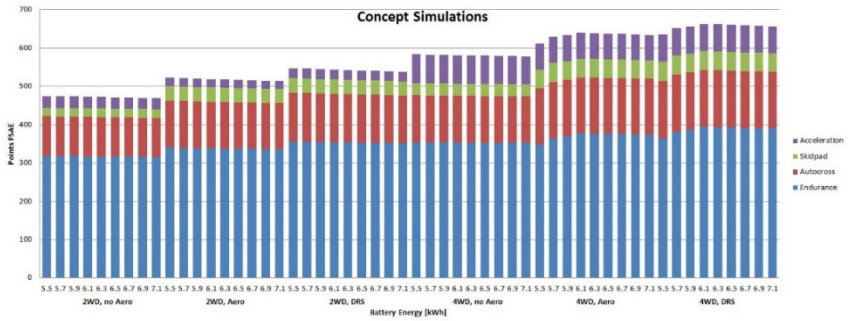
Simulate



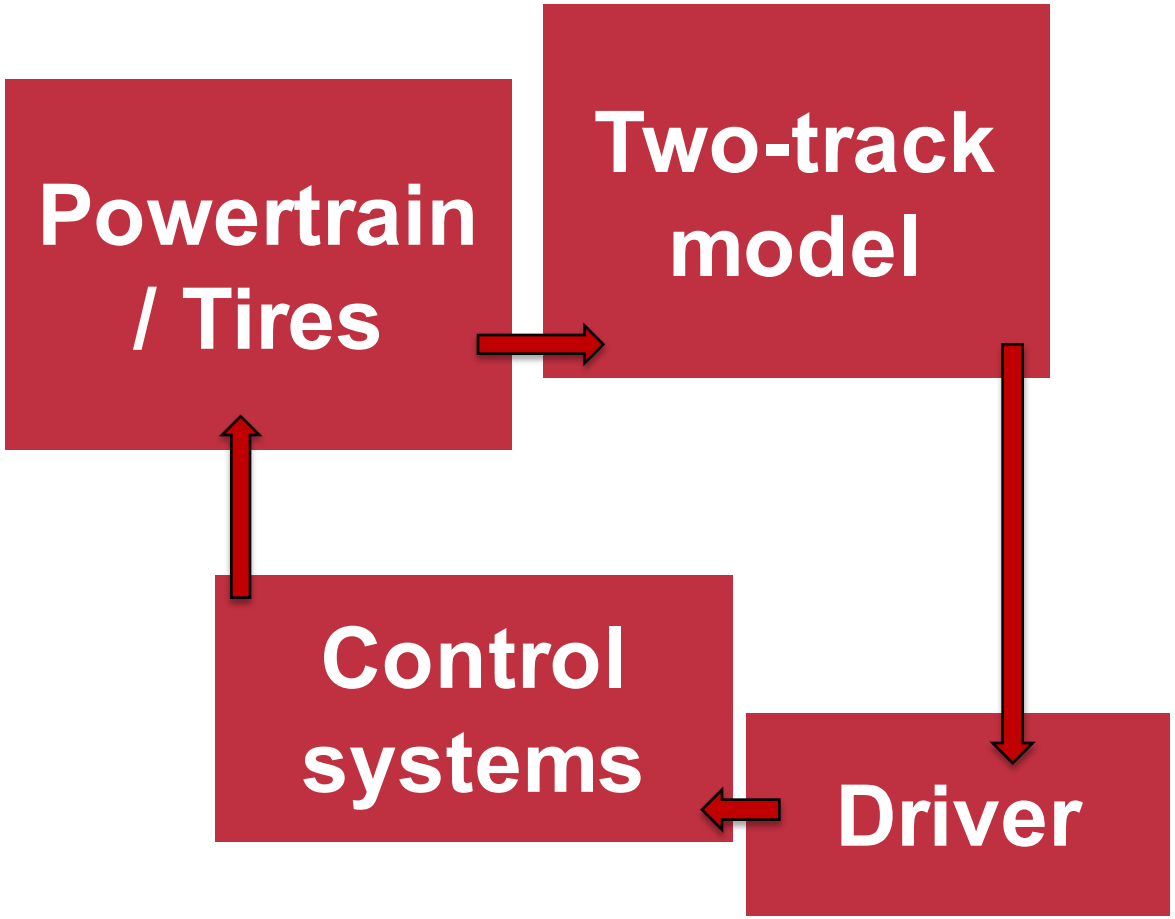
Calculate and analyze Event



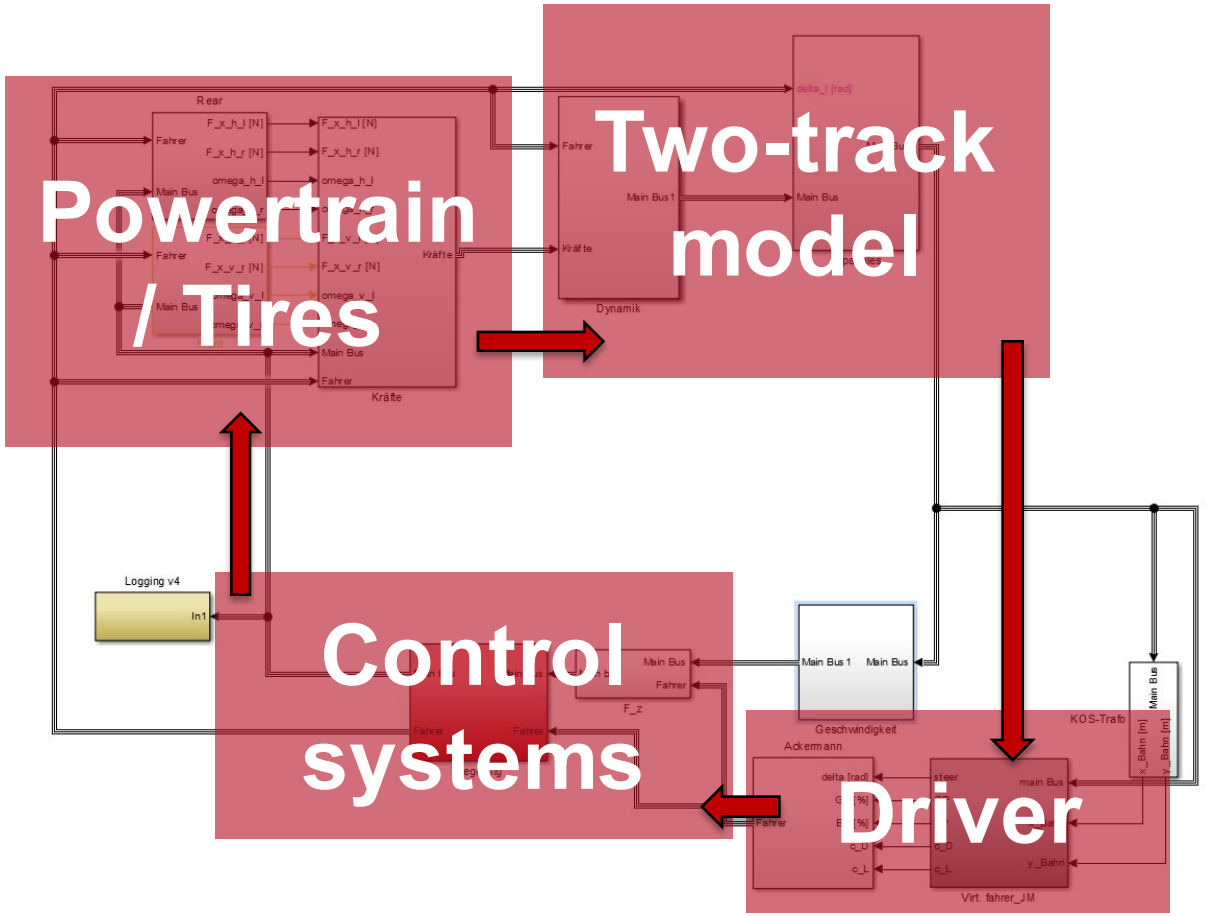
Visualize



Structure of the Simulation Model



Structure of the Simulation Model



Software Demonstration

MATLAB R2014b

HOME | PLOTS | APPS

Search Documentation

New Script | New | Open | Find Files | Compare | Import Data | Save Workspace | New Variable | Open Variable | Clear Workspace | Analyze Code | Run and Time | Clear Commands | Simulink Library | Layout | Preferences | 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

Name

- 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

```
>>
```

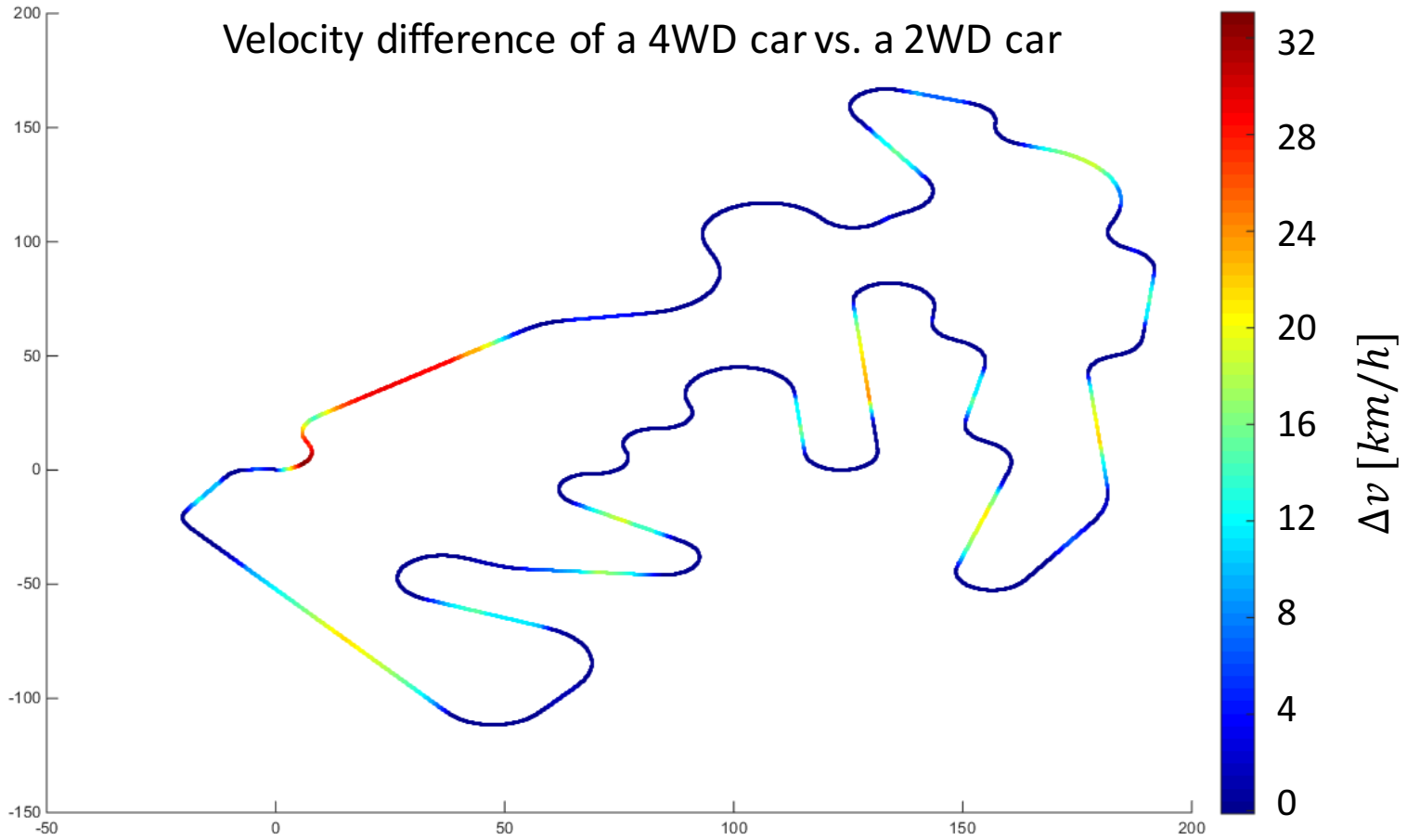
Workspace

Name	Value
resnoDRS	1x1 struct

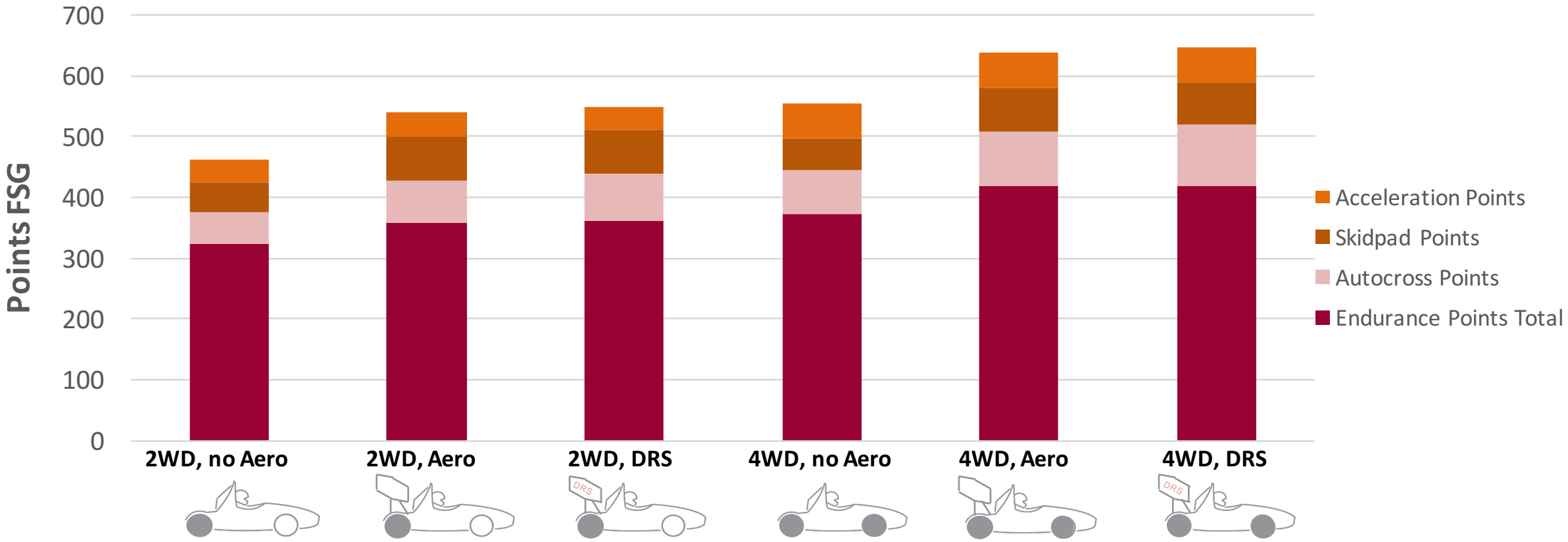
Command History

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

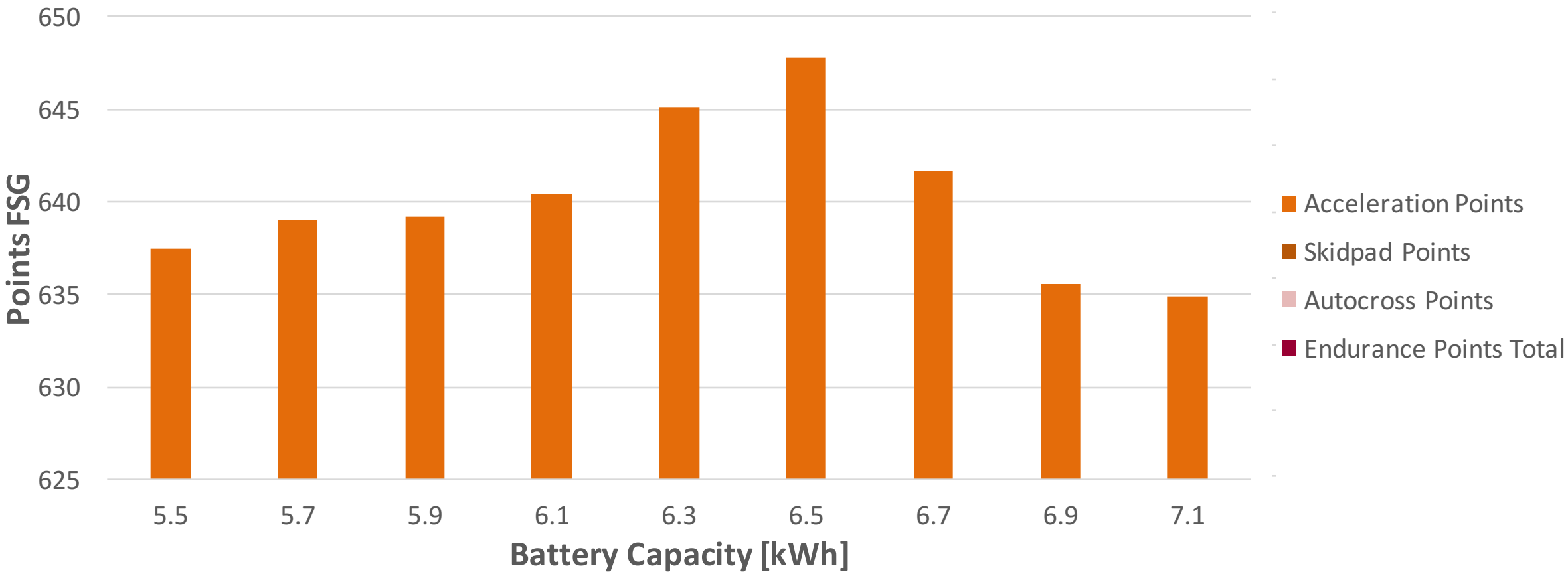
Results


Velocity difference of a 4WD car vs. a 2WD car
200
150
100
50
0
-50
-100
-150
-50
0
50
100
150
200
32
28
24
20
16
12
8
4
0
$\Delta v\ [km/h]$

Results – Concept Simulation



Results – Energy Simulations 4WD with DRS



Conclusions

- By using Lap Time Simulation we get a decision-making basis for different concepts
  - Aerodynamic setups
  - Amount of accumulator capacity
  - Transmission ratio
- Not everything can be determined since the model is simplified

Hauptsponsoren

BMW GROUP · Rolls-Royce Motor Cars Limited

CATERPILLAR®

Wir bringen Energie EKZ

Together ahead. RUAG

SR Technics

ThyssenKrupp
ThyssenKrupp Presta Steering

Premiumsponsoren

CNC DYNAMIX

connova

DT SWISS

LEMO® The Original Push-Pull Connector

Lenze SCHMIDHAUSER

POLYGONA

qualicut.ch wasserstrahlschneiden

VAC VACUUMSCHMELZE

Sponsoren

asic ROBOTICS

autobau™

BOMATEC

BOMBARDIER the evolution of mobility

CM CARBOMILL

DELTApreg™

eflight.ch Electric power - what else...

ETAS

EVTEC

Garage Fasel Düdingen

+GF+

Industrielle Berufslehren Schweiz libs

LOCTITE®

RAU AG

Sauter Bachmann Swiss precision gears

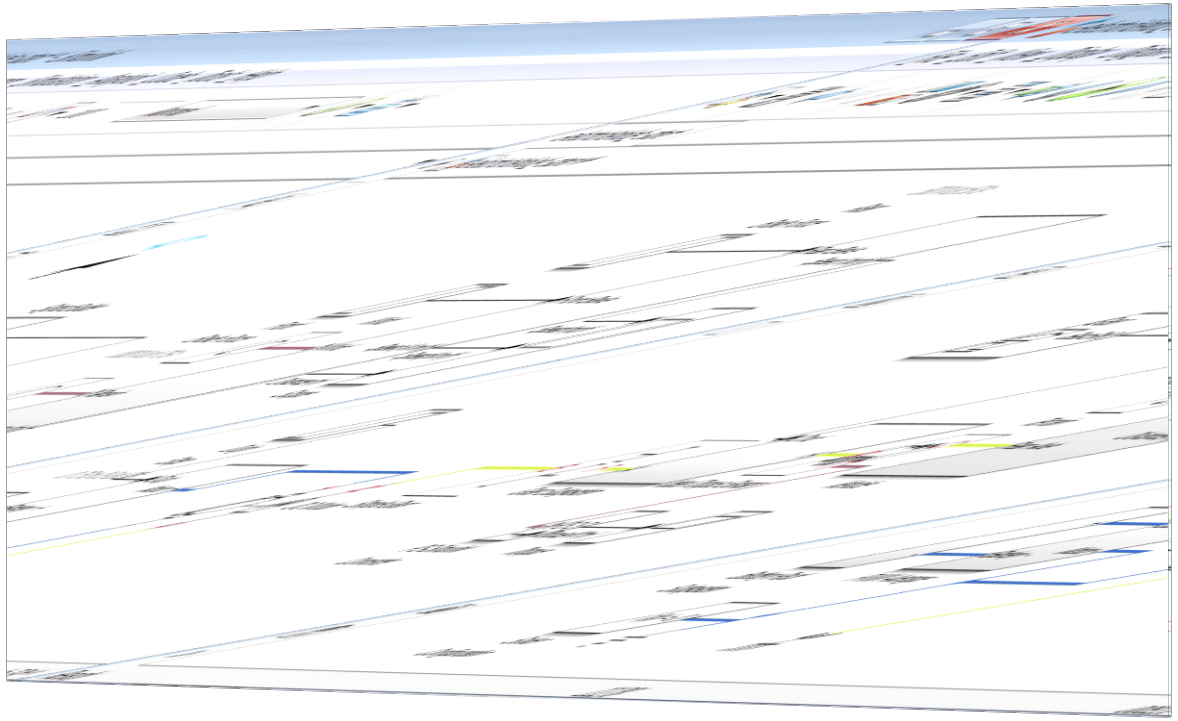
SIBATRON AG

Gönner

3M AG
Argotec AG
BAUMANN Federn AG
Bender GmbH & Co. KG
Berner Fachhochschule für Technik und Informatik
Bossard AG
BWB Oberflächentechnik
CADFEM AG
Centre of Structure Technologies
distec ag
Durovis AG
Dynamic Test Center AG
Evonik Industries AG
FE-DESIGN GmbH
GEDORE
General Dynamics – European Land Systems
Georg Utz AG
Global Tool Trading AG
H.A. Schlatter Fonds
HABA AG
Helly Hansen
HUBER+SUHNER AG
ILSEBO Handels AG
Jenny + Co. AG
Jörg Hartmeier AG
Kistler Automotive GmbH
Kronoswiss
KTR Kupplungstechnik AG
Leuthold AG
maxon motor
MechaniXclub.ch
Müri Prototech
Rigi-Kühler AG
Rofam GmbH
RoViTec GmbH
SAE Switzerland
SAM Group AG
SATW
Schreinerei Maag + Takacs AG
Sensirion
SKF Schweiz AG
suter-kunststoffe ag
Thoma Folierungen
tissa Glasweberei AG
Utzinger Mechanic
ZF Friedrichshafen AG

MathWorks Support for Formula Student

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



Thanks for Your Attention