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
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

- 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
Workflow

Concept idea → Simulation → Evaluation
Workflow

1. Car parameters
2. Simulate
3. Calculate and analyze Event
4. Visualize

- Car parameters: $m$, $h$, $L$
- Simulate: $x$, $y$
- Calculate and analyze Event: Velocity difference
Structure of the Simulation Model

Powertrain / Tires

Two-track model

Control systems

Driver
Structure of the Simulation Model

Powertrain / Tires

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Driver
Software Demonstration
MATLAB R2014b

Current Folder

simfunv7.m

find starting point

simfunv7(trackmap, car, driver)

Command Window

Command History

load('driver4.mat')
load('fluela_approx.mat')
load('Hockenheim2012.mat')
car.DRS = 0;
resnoDRS = si...
Results

Velocity difference of a 4WD car vs. a 2WD car
Results – Concept Simulation

<table>
<thead>
<tr>
<th>2WD, no Aero</th>
<th>2WD, Aero</th>
<th>2WD, DRS</th>
<th>4WD, no Aero</th>
<th>4WD, Aero</th>
<th>4WD, DRS</th>
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<tbody>
<tr>
<td>Points FSG</td>
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<td>Skidpad Points</td>
<td>Autocross Points</td>
<td>Endurance Points Total</td>
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</tr>
</tbody>
</table>

10/2/15

Akademischer Motorsportverein Zürich | Fabrice Oehler
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
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Sensation

SKF Schweiz AG

suhr-Kunststoff AG

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Bino Glasowski AG

Ulbrich Mechanic

ZF Friedrichshain AG
MathWorks Support for Formula Student

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