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
- 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

Car parameters

Simulate

Calculate and analyze
Event

Visualize

Velocity difference
Structure of the Simulation Model

- Powertrain / Tires
- Control systems
- Two-track model
- Driver
Structure of the Simulation Model

- **Powertrain / Tires**
- **Two-track model**
- **Control systems**
- **Driver**
Software Demonstration
Results

Velocity difference of a 4WD car vs. a 2WD car

\[ \Delta v \text{ [km/h]} \]
Results – Energy Simulations 4WD with DRS

Battery Capacity [kWh]

Points FSG

5/10/2016

Akademischer Motorsportverein Zürich | Fabrice Oehler
Validation

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

<table>
<thead>
<tr>
<th>Laptime deviation</th>
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<td></td>
</tr>
<tr>
<td>Lapsim</td>
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<tr>
<td>+ 1 kg</td>
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<tr>
<td>+ 10 kg</td>
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Validation

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

### Laptime deviation Aero vs. no Aero

<table>
<thead>
<tr>
<th></th>
<th>Lapsim</th>
<th>On-track test</th>
<th>Delta</th>
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<tbody>
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<td></td>
<td>3.82 %</td>
<td>3.97 %</td>
<td>4 %</td>
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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.
Complimentary Software
MATLAB and Simulink Racing Lounge
Online Training for Physical Modeling
Thanks for Your Attention