Machine Design/Flumes
Research philosophy

Requirements

Physical Prototype

Mathematical Model
Machine Design/Flumes
Vertical Integration

- Component
- Subsystem
- System
Increased Intelligence in Products

- New products tend to have more intelligence than before. This apply to a wide range of products. This is particularly true for the CRL application areas:
  - Cars
  - Aircraft
  - Construction Machinery
  - Industrial Manufacturing Systems
Technologies

- These kind of systems are characterized by a close coupling between:
  - Mechanical system
  - Power transmission/Actuation system
  - Sensors
  - Control System

- This requires multi domain co-design.
Strong Trend Towards Multi Domain Analysis and Optimization

Integrated system analysis of an aircraft with both an aerodynamic model and a simulation model.

Spread sheet with design analysis and optimization tools.

Integrated system model

Simulation model

Other analysis model
CAD-Design Automation, Knowledge Based Engineering.

Develop methodologies for next generation CAD-software
Full Mission Simulation for Aircraft Design
Towards Full Mission Simulation for Aircraft Design

Figure 5. Simulated flight path (Farthest distance about 45 km from start point). Altitude scale is amplified 20 times for the plotting.

(6000 sec simulated in 105 seconds (normal PC), time step 0.01 sec)
Simulation in Heavy Vehicles
Project Examples

- Energy Efficient Hydraulic System (Volvo CE, Parker)
- Hybrid Systems (Volvo CE)
- Sensorsystems for Trucks (Scania)
- Advanced Trajectory control (Scania)
- Aircraft Systems (Airbus Saab)
- Design Optimisation for Industrial Robots (ABB)
- High Speed Simulation (Volvo CE, Atlas Copco, CybAero, Prevas, National Instrument)
High Speed Simulation for Product Design and Operation - HiPO

-Using the same models throughout the lifecycle

System level design:
- System simulation for design optimization and analysis
  *High Speed Simulation HSS*
- Human in the loop simulation, *Real time simulation RTS*

Subsystem design:
- System simulation for design *HSS*
- Hardware in the loop simulation *HWIL, RTS*

Prototype testing and evaluation:
- Dynamic testing using *HWIL, RTS*

Operation:
- Training simulators, *RTS*
- Embedded simulation models for condition monitoring and control
  *RTS and faster than real time simulation, FRTS*
- Mission planning
  *Faster than real time simulation, FRTS*
Industrial Partners and Applications

- Construction Machines
  - Volvo CE

- Helicopters
  - Cybaero AB

- Rock drills
  - Atlas Copco

Hardware in the loop systems
- Prevas,
- National Instrument
Distributed modelling using transmission lines

Maintain the physical structure of the system in the model

Use the finite signal propagation speed to numerical advantage

Distributed solver and allows for distributed processing
From sketch to physical prototype in 5 months
### 2008 *GlobaLiTH*

Light electric utility vehicle for development countries

<table>
<thead>
<tr>
<th>System characteristics</th>
<th>Motor power</th>
<th>Chassi cost</th>
<th>Safety weight</th>
<th>Battery weight</th>
<th>System parameters priorities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>Target value</td>
<td>Actual value</td>
<td>Target value</td>
<td>Actual value</td>
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<tr>
<td>Range km</td>
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<td>27816.31</td>
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<tr>
<td>Acceleration (0-70) s</td>
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<td>High speed km/h</td>
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<td>46.89</td>
<td>0.06</td>
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<td>Recharge time (hrs)</td>
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<td>0.10</td>
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<td>Handling</td>
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<td>Safety level</td>
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<td>Running cost/km EUR</td>
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*System parameters priorities: 0.58, 1.00, 1.28, 2.03*
Winners of Formula ATA Electric and Hybrid Vehicles, Class 2, Rome 2009.