Agenda

» eFuture outline

» Functional architecture
  › Intedis

» Vehicle and key components
  › TMETC, Tata Motors European Technical Centre

» Control unit architecture
  › Hella

» Data fusion and Green ADAS
  › IFSTTAR, French Institute of science and technology for transport, development and networks

» Driver integration
  › WIVW, Würzburg Institute for Traffic Science

» Conclusion
Agenda

eFuture outline
Outline of eFuture
„Safe and Efficient Electrical Vehicle“

» Funded by the European Commission (grant no. 258133)
» Duration 3 years (until October 2013)
» Budget ca. 7 Mio. Euro
» Funding ca. 4 Mio. Euro
» 6 partners from 4 countries
  4 from industry
  2 research institutes
» Coordinator:
  Intedis, Würzburg
Addressing the main goals
Overall results for Safety and Efficiency

Safety
- Robust functional architecture
- Component selection
- Safety functions
- Functional Safety Concept

Efficiency
- Intelligent functional architecture
- Energy management
- Green ADAS
- Driver Integration
Safety achievements
Overall results for Safety and Efficiency

Robust functional architecture
- Function hierarchy
- Signal logic
- Decision unit concept

Component selection
- Inverters and Motors
- VHU
- Battery
- BMS unit

Safety functions
- Vehicle Observer
- Torque Vectoring
- Decision Unit 2

Functional Safety Concept
- Safety Goals
- Implementation strategy
- Hardware concept

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Efficiency achievements
Overall results for Safety and Efficiency

Intelligent functional architecture
• Parameters for efficiency
• Scalability and plug’n’play approach

Energy management
• Centralised management function
• Efficiency concepts

Green ADAS
• Route prediction (eHor)
• Green concepts

Driver Integration
• Driving style evaluation
• Driver Coaching
• Driver Feedback
• Energy Modes

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Architecture
(Intedis)
Functional architecture
Lean, scalable, domain oriented

- Sensors
- Navi/eHor
- Perception Layer
- Sensor Fusion
- Driver
- Guiding ADAS
- HMI
- Command Layer
- Decision Unit 1
- VehObs
- TorVec / Stabilising ADAS
- Decision Unit 2
- Battery Mgmt
- Energy Mgmt
- Energy Layer
- Braking
- Steering
- Drivetrain
- Execution Layer
eFuture’s compact functional architecture
...supports energy efficiency and safety

» Corresponding domains between SW and HW
» Introduction of decision units as central intelligence functions
» Allowing for various new functions
Vehicle and key components (TMETC)
Base vehicle for demonstrator
First generation EV

Donor vehicle
» 110 km/h maximum speed
» 9 seconds 0 - 60 km/h
» 165 km homolgated range
» 8 hours charging time
» ABS, Airbags
» Vista EV vehicles running on limited customer release as part of CABLED fleet

eFuture modifications
» HMI
» New VHU
» ADAS
» Independent wheel motors
» Updated energy system
Vehicle changes - eFuture

Updated HMI

Front and rear cameras

Super Polymer Li-Ion Traction battery modules and battery tray

Radar

New Hella VHU

Twin independent Motors – delete gearbox

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The electric motor

<table>
<thead>
<tr>
<th>Electric Motor: YASA-750</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td><strong>Peak/continuous torque</strong></td>
</tr>
<tr>
<td><strong>Peak/continuous power</strong></td>
</tr>
<tr>
<td><strong>Peak system efficiency</strong></td>
</tr>
<tr>
<td><strong>Motor weight</strong></td>
</tr>
<tr>
<td><strong>Speed range</strong></td>
</tr>
<tr>
<td><strong>Max. voltage</strong></td>
</tr>
</tbody>
</table>
Torque Vectoring
Reduced steering effort

Steering effort (Nm) vs. lateral acceleration (g)

- Steering_Effort_Vectoring_OFF
- Steering_Effort_Vectoring_ON
- Poly. (Steering_Effort_Vectoring_OFF)
- Poly. (Steering_Effort_Vectoring_ON)

W/O TORVEC

WITH TORVEC
Hella tests
NEDC @ Lippstadt roller test stand

energy consumption during NEDC: 15.6kWh/100km
resulting range (based on 26kWh HV battery charge available): 172km
Prototype validation

» Safety tests

» Motor failure – other motor did not go into limp home.

» Wheel speed sensor failure. No impact during acceleration, causes system derate during regen

» SAS failure

» Implausible value.

» System ignores values of +770 deg. Pass

» Does not ignore -760 deg.

» Lost signal (wire cut)

» System does not react. Stays in TV mode at last value.

» Software updated
BMS assembly and contact springs

Battery by Miljobil

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Cell chemistry</td>
<td>Li(NiCoMn)O₂</td>
</tr>
<tr>
<td>Cell configuration</td>
<td>2p6s10s3p</td>
</tr>
<tr>
<td>Weight</td>
<td>255 kg</td>
</tr>
<tr>
<td>Energy content</td>
<td>26,1 kWh</td>
</tr>
<tr>
<td>Energy density</td>
<td>103 Wh/kg</td>
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<tr>
<td>Nominal voltage</td>
<td>220 V</td>
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<tr>
<td>Discharge power</td>
<td>44 kW</td>
</tr>
<tr>
<td>Discharge current (cont./peak)</td>
<td>200 / 400 A</td>
</tr>
</tbody>
</table>
Retention design

Modules retention allowing individual replacement of modules

Modules with BMS integrated, arranged in two equally shaped strings

HVJB and Main BMS between the two strings

Flat bottom tray with reinforcement structure

Battery assembled, ready for lid and sealing
Control unit architecture
(Hella)
Data fusion and Green ADAS (IFSTTAR)
Driver integration
(WIVW)
Conclusion
Development of two electrical vehicles showing reliable and safe operation

Accomplishment of superior safety level for FEV by applying the ISO26262 methodology, a system FMEA and fault injection testing

Development of a Matlab/Simulink vehicle model and an Adams/CarMaker handling model for function development and failure detection

Integration of a new HV battery with high energy density (+18% compared to serial batteries), reliable assembly, re-usability, and thermal management

Integration of energy management strategies for current smoothing, consumption/range estimation and energy budgeting

Implementation of a cost efficient and manufacturable control unit architecture

Proposal for a lean domain oriented and safe architecture for the FEV

Implementation of safe drivetrain functions (Torque Vectoring, Vehicle Observer) with high dynamic stability

A new radar and camera based platform for perception and data fusion has been implemented

Integration of a novel approach for Green ADAS

Introduction of a new HMI concept for driver coaching and ECO modes

Improvement of driving efficiency by accepted limitations up to 12% and by driver coaching up to 27%
Conclusion

» Achievements
  › Proposal for a lean and scalable architecture
  › Proof of a safe two front motor drivetrain
  › Efficiency gain by Green ADAS
  › Driving style improvement by driver integration

» eFuture proposed many pieces of the puzzle for an affordable and accepted full electrical vehicle
Thank you for your attention.