Digital Automotive Development -
Electronic systems as significant contributors and challenge of dealing with complexity

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From boundary conditions to an engineering tool environment

- The development of a vehicle is influenced by competition, differentiation, legal requirements and trends in a global society as well as by customers.

- These complex and partly contradictory requirements have to be balanced for an exceptional product and have to be integrated in the vehicle. This results in a high complexity in the car developing process.

- The process of managing the complexity is organized by a systematic model. The application of this model focuses on the organizational and technical aspects.

- One of the main focus concerns the application of digital prototypes. Vehicle engineering needs further development and extension of current tools.
The automotive market demands attractive products and leads to a permanently rising variety of model versions.
Beyond the variety of model versions, each vehicle has to meet additional requirements.

- The automotive overall system has to meet all legal demands, requirements of consumer protection and inhouse demands.

- The automotive overall system has to meet trends of interest in a global society for at least the product life cycle.

- The automotive overall system gets its distinguishing by the styling of the overall system and the integrated innovations. The value of the overall system thereby is higher than the value of the addition of its subsystems.

- The automotive overall system accomplishes the economical competitiveness.
The amount of safety requirements to be fulfilled has tenfold since 1980.

<table>
<thead>
<tr>
<th>Year</th>
<th>Inhouse</th>
<th>Consumer</th>
<th>U.S. laws</th>
<th>RoW laws</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-1980</td>
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<td>1980-1990</td>
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<td>1990-2000</td>
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<td>Ausblick bis 2012</td>
<td></td>
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Electronic systems as significant contributors and challenge of dealing with complexity
The characteristics of a brand are also designed by inhouse demands.

Feel Porsche
- emotions, wellbeing, precious moments, fun by driving, relaxation, pleasure

Porsche Engineering
- new technologies and innovations

Performance
- oriented towards uncompromising, purposeful sport

Safety
- minimisation of risks by applying latest technology

Costumers
- sport-tuned, performance-oriented as well as efficient and comfortable, quality, reliability

Performance oriented costumers
- sport-tuned, performance-oriented, fun by driving, individualisation, motorsport up to professional racing

Harmony with environment
- consumer electronics, information technology

Social responsibility and acceptance
- responsible consumption

Women as customers
- sport-tuned, performance-oriented, fun by driving, ergonomics, aesthetics, operations

Electronic systems as significant contributors and challenge of dealing with complexity
Essential global trends drive the change and generate additional requirements for the vehicle.

<table>
<thead>
<tr>
<th>Environment</th>
<th>Information</th>
<th>Society</th>
<th>Traffic &amp; Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>• need for resources</td>
<td>• assistance systems &amp;</td>
<td>• customers in best</td>
<td>• overcrowded areas</td>
</tr>
<tr>
<td>• CO2 emissions</td>
<td>integrated safety</td>
<td>age</td>
<td></td>
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<tr>
<td>• petroleum dependency/</td>
<td>• tracking systems</td>
<td>• cultural differences</td>
<td></td>
</tr>
<tr>
<td>market-price</td>
<td>• tele service</td>
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</tr>
</tbody>
</table>

Electronic systems as significant contributors and challenges of dealing with complexity.
The start-stop-system is an innovation to reduce fuel consumption with high requirements for implementation.

Partitioning of the „Start-Stop“-function

- Gateway
- Gear box
- Engine
- Battery sensor
- Airbag
- Occupant classification
- Sensor cluster
- PSM
- Level
- Chassis
- All-wheel-drive
- Axle-differential-lock
- Wheel angle sensor
- Power Lift Gate
- Seat
- Steering-column-switch
- Back side door (2x)
- Front side door (2x)
- Trailer
- Bodycontroller (front)
- Bodycontroller (back)
- Rear view camera
- RDK
- Assistance systems 1
- Assistance systems 2
- Dash board
- Air-condition control unit
- Parking assistance
- Independant car heating
- Infotainment
- Cooled generator
- Reinforced starter
- DC/DC transmitter
- AGM battery
- RPM transmitter

Electronic systems as significant contributers and challenge of dealing with complexity
The partially contradictory requirements result in a high complexity for the automotive development.

Electronic systems as significant contributors and challenge of dealing with complexity
Integrating the requirements in the overall vehicle requires the content related synchronisation of the development's core processes.

Electronic systems as significant contributors and challenge of dealing with complexity
An early project evaluation minimizes project risks and increases the scope of action.

- **Definition**: Decision stage and basic concept
- **Concept**: Product optimisation, problem analysis and trouble shooting
- **Production-vehicle development**: Frontloading
- **Production**:

- **Production-vehicle development** characteristics:
  - low degree of specification
  - high degree of variety
  - forecast as good as possible
  - short response time

- **Production** characteristics:
  - high degree of specification
  - several small modifications
  - high forecast precision
  - short/medium response time

Electronic systems as significant contributors and challenge of dealing with complexity
The process of managing complexity follows the V-model used in electronics development.

The model is valid for both real vehicles and digital vehicles.

Electronic systems as significant contributors and challenge of dealing with complexity
Main processes are model build up, assembly and operation of digital prototypes and support processes.

**Model build up**
- Requirements
- Executable specification

**Digital prototype**
- Status of requirements met
- Evaluation and interpretation
- Parts, modules, systems testing

**Evolution and assembly**

**Support processes**
- Change management
- Configuration management
- Quality management

Electronic systems as significant contributors and challenge of dealing with complexity
The requirements are realized by executable specifications.

**Project specifications**
- Product and project descriptions

**Executable specifications**
- design models
  - geometry data design
- surface models
  - geometry data styling
- functional models
  - technology data

Electronic systems as significant contributors and challenge of dealing with complexity
Data of model set up and digital prototypes are organized in the data management.

Electronic systems as significant contributors and challenge of dealing with complexity.
Depending on the use of digital prototypes, the results are presented in different ways.
In order to develop a product by using analogy models, significant aspects have to be considered.

- Model build up towards executable specification with different data models from different domains like CAD and electronics

- Suitable representation of results - e.g. visualization

- Data management for models, digital prototypes, support processes and supplier integration for digital prototypes

- Build up and operation of digital prototypes
Steps for experimental validation are mostly transferable to the virtual world.

Electronic systems as significant contributors and challenge of dealing with complexity
MATLAB and Simulink can be used to run digital prototypes on complete vehicle level.

With an organized process and modularised structure the digital prototype is „easy“ to handle and use.
For electronic systems a full test environment exists including a digital prototype.

1.0
Initial situation

2.0
Products

3.0
Requirements

4.0
Complexity Management

5.0
Fields of action

6.0
Digital Prototype

7.0
Summary

Electronic systems as significant contributors and challenge of dealing with complexity
Non-electronic based systems are used in an individual test environment. They are based on mechanics and hydraulics.
The influence of electronic functions on full vehicle level has to be organized by co-simulation.

Electronic systems as significant contributors and challenge of dealing with complexity
Interactions of digital prototypes causes a lot of time to build up the digital prototype.

Electronic systems as significant contributors and challenge of dealing with complexity.
The integration environment should support the set up, configuration and operation of the digital prototypes.

Central goals for the digital prototype are short build up time and easy to use.

Electronic systems as significant contributors and challenge of dealing with complexity
In the next step the integration environment offers a complete integration platform for the build up of the digital prototypes.

The digital prototype has to be build up in an autonomized work flow. Additionally a digital concept prototype will be integrated.
Based on the integration environment the validation of the digital prototypes will be managed.

The validation will be automated by a workflow and dedicated user interfaces. The complexity in this stage increases especially by the execution and test data management. The test cases will be key for product quality in the future.
## Digital Automotive Development - requirements to an engineering tool

- Increasing complex requirements and legal regulations evolve extensive demands on the overall vehicle system.

- In addition to the complexity management tools, models and methods to develop an overall vehicle can be used in analogy to the electric/electronic process.

- Improvement potentials for faster processes can be seen in the data management, support process, in new problem solving methods of co-simulation of digital prototypes and in the improvement of calculation speed.

- Long term goal is an integration environment on complete vehicle level that allows to build up and work on a digital prototype with various technologies in early stage and seamless structure. Additionally the environment has to be automated and easy to use.
Thank you very much for your attention