Driving virtual Prototyping of Automotive Electronics

B. Hellenthal, AUDI AG, Competence Center Electronics & Semiconductor, DVCon, Munich, October 17th, 2017
More space for passengers – enabled by decreasing size of modules.
What drives us
... new business

CONNECTED CAR

CONNECTED DATA

myAudi ID

CONNECTED SERVICES

CONNECTED DATA

CONNECTED MOBILITY
Semiconductors@Audi
a necessary new core competence

6,000-8,000 Semiconductors /vehicle

>100 connected electronic control units (ECU)

Innovations
>80% enabled by Semiconductors

Development
2 years vs. 7 years
Audi comprehensive semiconductor strategy
Audi Progressive SemiConductor Program (PSCP)

**AUDI PSCP**
Progressive SemiConductor Program

Demands on semiconductors and their application

- Prelaunch
- Launch
- Application
- Lifetime support

Key factors:
- On time
- Competence
- Communication
- Innovation
- Quality

Partnership with semiconductor manufacturer at eye level
The effective project environment
Solution Space – Tension Triangle

... only synergy enables new potentials

New project partner: semiconductor manufacturer
Electronic value chain

Source: European Industrial Strategic Roadmap for Micro- and Nano-Electronic Components and Systems – Report to VP Kroes by the Electronic Leaders Group’ (June 14, 2014)
Key elements
... innovations

- Full Digital Cockpit
- Always online
  Millions of Apps
- Autonomous Driving
- Everything connected
- Electrification
## Autonomous Driving Levels

### Level 0
**Assisted Functions**
- **No Automation**
  - Driver only / assisted: **full-time performance by the human driver.**

### Level 1-2
**Partial Automation**
- Driver controls the automated functions.

### Level 3
**Piloted Functions**
- **High Automation**
  - System controls its **functional borders** and hands over time delayed to driver, when those are reached.

### Level 4
**Full Automation**
- Within a **specific use-case** the system can master all tasks on its own. **No driver necessary.**

### Level 5
**Driverless**
- System can master all tasks in all situations on its own. **No driver necessary.**
Traffic Jam Pilot and Parking Pilot are the First Automated Driving Functions

### Automated Driving

#### Traffic Jam Pilot
- **Highly automated Driving in Traffic jam „hands-off“** up to 60 km/h on highways.
- **Driver basically stays in control** of the vehicle.
- **Offering** of legally allowed side activities.
- **Increase in comfort and safety,** due to no tiring manual driving in traffic jam.

### Automated Parking

#### Parking Pilot
- **Partly automated driving in and out** of public and private parking spaces or private underground parking garages.
- **Increase in comfort** due to easier access and exit
- **Start of process with Smartphone or key.** The vehicle then drives automated in and out of parking space. Driver supervises the procedure.
## Autonomous Driving Levels

<table>
<thead>
<tr>
<th>Level 0</th>
<th>Level 1-2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assisted Functions</td>
<td>Piloted Functions</td>
<td>Autonomous</td>
<td>Driverless</td>
<td></td>
</tr>
<tr>
<td><strong>No Automation</strong></td>
<td><strong>Partial Automation</strong></td>
<td><strong>High Automation</strong></td>
<td><strong>Full Automation</strong></td>
<td><strong>Driverless</strong></td>
</tr>
<tr>
<td>Driver only / assisted: <strong>full-time performance by the human driver.</strong></td>
<td>Driver controls the automated functions.</td>
<td>System controls its <strong>functional borders</strong> and hands over time delayed to driver, when those are reached.</td>
<td>Within a <strong>specific use-case</strong> the system can master all tasks on its own. <strong>No driver necessary.</strong></td>
<td>System can master <strong>all tasks in all situations</strong> on its own. <strong>No driver necessary.</strong></td>
</tr>
</tbody>
</table>
End-2-End Electronics (E³) Architecture
Building Blocks

- Technical Architecture
- Software platform
- Functional Architecture
Basic Concept of a 3-Level Architecture

Off-board
- Seamless integration of Car2x-as well as off-board level for swarm data applications and computing-intensive functions

Computing level
- Scalable computing level as an enabler for new functions with technical expendability as well as new business models

Sensor/Actuator
- Sensor/actuator level with a unified interface to mechanics, control of complexity through function shifting

› Clear functional separation in 3 architecture levels
› Function shifting from sensor / actuator level in computing and off-board level
High Availability and Redundancy is a Central Cornerstone for Highly Automated Driving Functions Level 4+ (ASIL-D)

- Highly available braking system
- Highly available steering
- Highly available energy supply
- Highly available bus communication
- Redundant computing unit
- Redundant sensors

E³
Development cycles

Observation

- Vehicle development cycle: 7 years
- Semiconductor development cycle: technology development, de-risking, product
- Technology cycle MOSFET
- Moore’s law
- MNAND cycle: start of mass production till end of production
- AEC-Q100 qualification
- Qualified semiconductor 2 years before SOP

1 year
Hardware / Software CoDesign for Automotive Electronics
Virtual Prototyping from Device to System/Vehicle Level

**Today:**
- All virtual development process
- Hardware/Software CoDesign
- Virtual Prototyping
- Simulation models
- Semiconductor industry standard

**Today:**
- Linear non virtual development process
- No virtual prototypes

**Tomorrow:**
- Virtual development process
- Hardware/Software CoDesign
- Virtual Prototyping
- ECU simulation models
Automotive Electronic Design Flow
today: sequential (simplified)
Automotive Electronic Design Flow

tomorrow: parallel (simplified)

- System Design
- Function Design & Function Allocation (ECU)
  - Specifications, Reliability
  - Specifications Debug

Automotive Value Chain

- Hardware Design
- Software Design

Specifications, Prototypes, Debug
Automotive Electronic Design Flow
for one electronic control unit (ECU)
Automotive Electronic Design Flow
for >100 electronic control units
Electric / electronic supply chain collaboration
yesterday / today

SC manufacturer ➔ Tier 1 ➔ Car manufacturer

Semiconductor specifications ➔ ECU & function specifications
Electric / electronic supply chain collaboration
today / tomorrow

SC manufacturer

Tier 1

Semiconductor specifications

Car manufacturer

Semiconductor specifications

ECU & function specifications
Virtual Prototyping today
mostly for production, mechanics and user interface development
Hardware / Software CoDesign for Automotive Electronics

Challenges & benefits

› A new technology/process for the automotive industry and value chain
  - needs new development processes
  - needs new competences along the value chain
  - needs to be adopted by OEM / Tier 1/ Tier n
  - software-/ tool-/IP-licensing model needs to be adjusted to device application

› Enables higher development speed and lower risk
  - verify concept & architecture before realization
  - high software quality earlier
  - enables faster development cycle
  - enables continuous software development

› Positive business case
  - distributed development without real prototype hardware (less real prototypes)
  - enables more projects with the same team due to specialization
  - decreases the number of expensive late changes & upgrades
Pushing new technologies
Example: infotainment

Strategic partnerships enable consumer like innovation cycles
## Next challenges

<table>
<thead>
<tr>
<th>5G</th>
<th>Cloud Computing and Data Analytics</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Speed</td>
<td>High Performance Computing</td>
</tr>
<tr>
<td>Communication</td>
<td>High End Graphic Performance</td>
</tr>
<tr>
<td>Virtualization</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>End-2-End Security</td>
<td>Sensor Fusion</td>
</tr>
<tr>
<td>Safety</td>
<td></td>
</tr>
</tbody>
</table>
Thank you