Technologie- und Innovationstrends aus der Zuliefer-Perspektive

Neue Fahrzeugkonzepte erfordern einen ganzheitlichen Ansatz in der Integrationsstrategie – Am Beispiel der Elektronik und Sensorik im Fahrzeug

Bernd Gombert
Megatrends are influencing all business areas
Automotive industry needs to master fundamental technological challenges

Global megatrends – urbanization and demographic change

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Automotive-specific trends

Growing concern for the environment

- Rising oil prices drive demand for improved fuel efficiency
- Compliance with ever-higher emission standards
- Increased attractiveness of alternative propulsion concepts (e.g. hybrids)

Increasing demand for safety

- Further penetration of existing safety systems (e.g. airbags, ESP)
- Advanced driver assistance systems (e.g. adaptive cruise control)

Car of the future

Increasing need for in-car information management

- Increasing penetration of existing applications (e.g. navigation devices)
- More connectivity and integration of consumer electronic devices

Necessity to control increased complexity

- Improvement of vehicle reliability by managing the growing complexity of electronic architectures
Siemens VDO is perfectly aligned to capture the future opportunities of the automotive industry.

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Automotive-specific trends

- **Growing concern for the environment**
  - Zero emission
    - Powertrain
  - Always on
    - Interior Electronics and Infotainment
  - Zero accidents
    - Safety and Chassis
  - Necessity to control increased complexity
    - Managed complexity
  - Vehicle Integration

Increasing demand for safety

Increasing need for in-car information management

Growing need for environmental care

Shortening of natural resources

Shift of economic gravity among regions

Increasing demand for safety and security, information, and communication

Increasing need for environmental care

Shift of economic gravity among regions

Increasing concern for the environment

Zero emission

Always on

Zero accidents

Necessity to control increased complexity

Managed complexity

Vehicle Integration

Commercial Vehicles

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The carriageless horse

When the pioneers of the automobile removed the horse to create the horseless carriage, they removed the intelligence as well. Now, through electronics and software, we can put the intelligence back in.
The Skateboard Principle: Chassis and Body
The Skateboard Principle: Chassis and Body

Command Level

1. Driver’s Interface
   - Capture of Driver commands
   - Display of information to driver
   - Infotainment

2. Power and Signal Distribution
   - wiring harness
   - multiplexing
   - passive safety
   - entrance system

Coordination Level

3. Drivetrain
   - Motion execution
   - Energy-creation and -management
   - Stability = reactive active safety

Execution Level

4. Passenger management (all non-driving related tasks)
   - radio / entertainment
   - heating / climate
   - passive safety ...

5. Virtual Copilot ADAS
   - Predictive surrounding evaluation
   - Creation of the motion strategy based on primary / redundant surrounding evaluation

* Human Machine Interface

Drivetrain
Translation of desired motion vector into actuator commands

Assistance
Information about the environment

Actuator commands

1 2 3 4 5

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Modularization as an answer to handle complexity and increase functionality

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Assistant systems
Driver’s Interface
Passenger Management
E/E Infrastructure
Drivetrain / Chassis

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Recombination of Components to the eCorner Car

- Car
  - Powertrain
    - Propulsion System
      - Engine
      - Valve Train
      - Electrical System
      - Ignition System
      - Exhaust System
      - Engine Block
    - Electric Motor
      - Transmission / Gear box
      - Drive Shaft
      - Differential
  - Control System
    - Drive-Train
  - Body
    - Steering
  - Chassis
    - Suspension
      - Shocks
      - Springs
      - Bushings
    - Brakes
      - Brake Lines
      - Master Cylinder
      - Calipers / Rotors
      - Wheel
        - Rim
        - Tire
      - Brake Pads

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Recombination of Components to the eCorner Car

- **Powertrain**
  - Propulsion System
    - Engine
    - Electric Motor
  - Drive-Train
    - Transmission / Gear box
    - Drive Shaft
    - Differential

- **Control System**

- **Body**

- **Chassis**
  - Suspension
    - Shocks
    - Springs
    - Bushings
  - Brakes
    - Brake Lines
    - Master Cylinder
    - Calipers / Rotors
    - Wheel
    - Rim
    - Tire
    - Brake Pads

**Energy Source**

**Energy Generator**

**eCorner**
The eCorner Car Architecture

Example for a holistic integration strategy:
The Electronic Wedge Brake
The Electronic Wedge Brake Principle

- The brake pad is moved by an electric motor via a series of rollers along a wedge-shaped slanting surface.
- The rotation of the wheel automatically reinforces the effect of the wedge.

→ A very high braking force can be produced with very little electric motor torque.
Shorter Stopping Distance with the EWB

ABS: Comparison of Control Strategies

- Hydraulic
- EWB

High µ
Low µ

High temperature
Room temperature

Δp₁ > > Δp₂
Δt₁ > > Δt₂

EWB

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Simulation and Real Testing

Traction Control on µ-split with 18% uphill gradient

Simulation  Braking Tests  Real Testing

© Siemens VDO Automotive AG | Bernd Gombert
The eCorner Car Architecture

Example for a holistic integration strategy:
The In-Wheel Motor
Ext. EPS & Chassis and Drivetrain Controller: Interaction of the segments

- **tomorrow**
  - eCorner
  - eChassis
  - HEV
  - CE

- **today**
  - EWB
  - Brake Controller
  - BU C
  - HEV
  - CE
  - BU P

**Brake Blending for recuperation**
First Approaches...
A Lunar Rover was used during Apollo missions 16 and 17. Altogether, three Rovers were used on the Lunar surface and driven a total of 88.3 kilometers (54.8 miles).
The first approaches of the Wheel Hub Motor

Porsche-Lohner 1898

- World exhibition, Paris 1900: Ferdinand Porsche introduces his new electro vehicle.
- September 1900: Lohner-Porsche with four wheel-hubs, the first fully-operative wheel-hub motor, with a battery-weight of 1800kg.

Wheel-hub motor,
front wheel steering & drive,
2.5 PS/Motor,
44 cells battery, 300 Ah, up to 80 Volt,
\( v_{\text{max}} = 50 \text{ km/h} \) (35), \( s = 50 \text{ km} \),
\( m = 1000 \text{ kg} \),
1st car with 4-wheel brake,
\( m_{\text{Rad}} = 100 \text{ kg} \);
1900: Allwheel drive \( m_{\text{Bat}} = 1800 \text{ kg} \)
1902: Hybrid with petrol motor
The first approaches of the Wheel Hub Motor

1900 "Semper Vivus" (benzin-elektrischer Antrieb) / Mixte

1901 Porsche-Lohner-Mixte (15 PS-Daimler-Vierzylinder-Benzin-Reihenmotor, 80 Volt-Dynamo, 2,5 PS Radnaben-Elektromotoren in den Vorderrädern)

1902 "Semper Vivus" Training zum Exelberg-Rennen (28 PS-Benzin-Reihenmotor und 80 Volt/10 kW-Generator)

1903 Elektro-Benzin-Chassis ohne großen Akkumulator

Source: Porsche AG Archive

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The eCorner (Movie)
New Generation - In Wheel Hub Motor

Specification:
- 150 NM torque
- 60A / 400 V DC-link voltage
- 400 Nm overboost for 20 s
- 2000 rpm
- weight: 8kg
- Dimension: fits into 17” wheel
- non fluidic cooling
### eCorner Market Introduction Strategies of OEMs

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**Legend:**
- High: ☀
- Low: ○

Unsprung mass is a major drawback
Auto Motor Sport 2/2007

E-Antrieb über vier Radnabenmotoren
Mini-Prototyp mit über 650 PS

Der britische Spezialist für elektrische Antriebe PLM Flightlink hat einen Mini mit vier jeweils 120 kW (163 PS) starken Radnabenmotoren ausgerüstet. Neben einer Li-Ionen-Batterie dienen Hochleistungs-Kondensatoren (Ultra-Caps) zur Speicherung der elektrischen Energie. Zum Nachladen während der Fahrt dient ein Generator, der von einem 250-cm³-Zweizylinder-Benziner mit 20 PS angetrieben wird. Die Reichweite soll so bis zu 1500 Kilometer betragen.

Fahrdynamikregelung und Bremsen allein über die Radnabenmotoren
New Honda FCX
Fuel Cell and Wheel Hub Motor Concept Car

SOP 2009/10
PML Flightlink supply wheels motors for ZAP

U.K. COMPANY TO SUPPLY WHEEL MOTORS FOR ZAP ELECTRIC VEHICLE CONCEPT

Santa Rosa, Calif.-based Zap has inked a deal with PML FlightLink Ltd. to use the U.K. company’s wheel motor technology in the high-performance ZAP-X electric car it is developing with Lotus Engineering. The agreement is part of a feasibility study the companies announced earlier this year. In exchange for exclusive rights for the technology, Zap has committed to an initial order of wheel motors worth $10 million.

Zap says the motors will allow it to achieve the power-to-weight ratio to meet the performance goals of the sporty ZAP-X wagon. Targets include a peak output of 844 hp, top speed of 155 mph and zero to 60 mph acceleration in 4.6 seconds.

Wheel motors enable greater overall design efficiencies by distributing the weight and displacement of the drivetrain to the corners of the vehicle, Zap notes. TEAMing the motor and drive electronics in an integrated unit helps to produce up to 20 times more power density than conventional systems, according to PML. It also claims that such a configuration is 20 times more reliable than competitive systems. The flat motor package provides high torque and has minimal impact on suspension dynamics. In addition, the use of heavy-duty tapered roller bearings helps the system withstand heavy radial loads, which is important for the all-wheel-drive capability of the ZAP-X.

Privately held PML Flightlink, based in Hampshire, England, has demonstrated its wheel motor technology in a converted Mini car. The company has more than 30 years of experience in advanced wheel motor and control system development. Company officials met with Zap last week in California to discuss potential suppliers and distributors.
Electro-Mini and Lightning GT with wheel motors
Toyota Fine-X
Fuel Cell and Wheel Hub Motor Concept Car

- Electric motors in each of the four wheels
- Compact fuel-cell hybrid powertrain
- Each wheel can steer independently (90 degrees) for extraordinary maneuverability.
- It can rotate on its own axis a full 360 degrees
Impressions of Toyota Fine-X
Thank's for your attention
The eCorner – drivers and benefits

Benefits in comparison to conventional systems

- Safety benefits (no steering column with steer-by-wire)
- More safety through driver assistance systems
- Decrease in fuel costs
- Cost reduction over the whole product life cycle
- Benefits for the environment:
  - automobile without hydraulic liquids
- Possibility of self-managed driving
- More freedom during the production:
  - no difference between right-hand and left-hand steering due to flexible positioning of steering gear and steering column