3rd Conference
Active Safety through Driver Assistance

Safe, superior and comfortable driving
- Market needs and solutions

Dr. Werner Struth - President, Chassis Systems Control
Safe, superior & comfortable driving

Global trends

Legislation
- Safety legislation being tightened
- Enhanced passenger and pedestrian protection
  -> Safe driving

Economy
- Steep growth in emerging markets
  -> Increased mobility
- Growing globalization
  -> Networks and standards growing

Politics & Environment
- “Global warming”
- Rising oil prices
  -> Energy efficiency

Society
- Ageing society
- Urbanization
  -> Comfortable driving

Technology
- Higher share of electronics/software
- Driver assistance
  -> Superior driving

Consumer behavior
- Individualization
  -> Fun to drive
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Accident research is used for evaluation and identification of vehicle motion systems on the way towards Vision Zero.

**Bottom-up Approach**
*from existing systems to accident data*

**Top-down Approach**
*from accident data to new systems*

**Driver**
- Existing Functions
- Vision, Strategy, Market

**Analysis**
1. field of effect: chronological classification during event of accident
2. efficiency: potential of accident avoidance or mitigation
3. multiple system assessment: interaction in behavior between other systems

**Result**
- function efficiency
- new function idea
## Road safety in 2005 – a public health issue

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>91.4</td>
<td>0.93</td>
<td>7,931</td>
</tr>
<tr>
<td>European Union</td>
<td>268.2*</td>
<td>1.26</td>
<td>41,600</td>
</tr>
<tr>
<td>USA</td>
<td>242.7</td>
<td>1.85</td>
<td>43,443</td>
</tr>
<tr>
<td>South Korea</td>
<td>19.0</td>
<td>0.22</td>
<td>6,376</td>
</tr>
<tr>
<td>China</td>
<td>130.4</td>
<td>0.45</td>
<td>98,738</td>
</tr>
<tr>
<td>Brazil</td>
<td>23.3</td>
<td>0.38</td>
<td>26,409</td>
</tr>
<tr>
<td>India</td>
<td>72.7*</td>
<td>0.44</td>
<td>94,968</td>
</tr>
</tbody>
</table>


* 2004
Evolution EU Road Fatalities 1990 - 2010

- Introduction ESP
- Start
- Target 2010

Fatalities EU-25

2010 objective: 25,000 lives to save

Source: CARE
Fatalities in Road Traffic in the Federal Republic of Germany considering location of accident and type of vehicle

- **other**
- **car passengers**
- **motorcyclists**
- **cyclists**
- **pedestrians**

**Historical Data:**
- 1970 - 20k people
- 1972 - 100kph on secondary
- 1973 - 0.8 per mil blood alcohol limit
- 1973 - oil crisis
- 1974 - recom. 130kph on highways
- 1977 - mandatory to use seatbelts
- 1978 - mandatory to install seatbelts
- 1980 - driver air bag introduced
- 1984 - mandatory to use seatbelts
- 1988 - front passenger air bag introduced
- 1995 - ESC (Electronic Stability Control) introduced
- 1995 - side air bag introduced
- 1998 - 0.5 per mil blood alcohol limit

**Policy Highlights:**
- 1980 - mandatory to install seatbelts
- 1973 - 0.8 per mil blood alcohol limit
- 1975 - oil crisis
- 1977 - mandatory to use seatbelts
- 1980 - driver air bag introduced
- 1984 - mandatory to use seatbelts
- 1988 - front passenger air bag introduced
- 1995 - ESC (Electronic Stability Control) introduced
- 1995 - side air bag introduced
- 1998 - 0.5 per mil blood alcohol limit

**Source:** Federal statistical office

**Notes:**
- 1977: mandatory to use front seatbelts
- 1978: - recom. 130kph on highways
- 1980: driver air bag introduced
- 1984: mandatory to use seatbelts (warning charge)
- 1988: front passenger air bag introduced
- 1995: ESC (Electronic Stability Control) introduced
- 1995: side air bag introduced
- 1998: 0.5 per mil blood alcohol limit

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Safe

Superior

Comfortable
## Safety functions - Examples

<table>
<thead>
<tr>
<th>Safety Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Side View Assist: US-based Blind Spot Detection</strong></td>
<td>- Monitoring of the adjacent and rear lanes</td>
</tr>
<tr>
<td></td>
<td><em>Reduction of accident risk while changing lanes</em></td>
</tr>
<tr>
<td><strong>Lane Departure Warning</strong></td>
<td>- Tracking the vehicle position within lane markings</td>
</tr>
<tr>
<td></td>
<td><em>Early correction of driving mistakes</em></td>
</tr>
<tr>
<td><strong>Night Vision and Night Vision Plus</strong></td>
<td>- Light detection with infrared sensitive camera</td>
</tr>
<tr>
<td></td>
<td><em>Early recognition of possible dangers</em></td>
</tr>
<tr>
<td><strong>Evasive Steering Support (ESS-T)</strong></td>
<td>- Improve steerability and brake performance</td>
</tr>
<tr>
<td></td>
<td><em>Optimal steering support to avoid collisions</em></td>
</tr>
</tbody>
</table>
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ESS-T Function Description

critical driving situation  potential driver intention: avoidance by evasion  evasion support triggered by driver

time to collision

reaction time  decreasing number of options for driver in order to avoid collision

risk of rear-end collision  collision unavoidable

ESS – window for initiation of support

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Demonstration maneuver description

**What the driver does:**
- Approaches the obstacle with a constant speed of 50 km/h
- Does not brake
- Performs an evasive maneuver to avoid the obstacle

**What ESS-T does:**
- Provides no support at all as long as the driver does not decide to perform an evasive maneuver
- Supports the driver during evasion by either:
  - **Additional torque** on the steering wheel (in case the driver has under-reacted)
  - **Corrective torque** on the steering wheel (in case the driver has over-reacted)
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Demonstrations: over and under-reaction

1. Driver under-reacts (with ESS-T)

2. Driver over-reacts (with ESS-T)

ESS-T corrects the driver’s insufficient input in case no.1 and the excessive reaction in case no.2. In both cases the right amount of steering torque is finally input. The obstacle is safely avoided.
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Demonstrations: over and under-reaction

1. Driver under-reacts (with ESS-T)

ESS-T provides additional torque

2. Driver over-reacts (with ESS-T)

ESS-T provides counter-torque

→ ESS-T corrects the driver’s insufficient input in case n°1 and the excessive reaction in case n°2. In both cases the right amount of steering torque is finally input. The obstacle is safely avoided.

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Evasive Steering Support by Torque (ESS-T)

**Situation**
- Potential rear-end collision
- Emergency braking is insufficient to avoid accident
  - Evasive maneuver must be undertaken
  - Driver inexperienced and stressed
- **Driver likely over-reacts or under-reacts**

**Hazards**
- Getting off road
- Incomplete manoeuvre (rear-end collision)
- **High risk of even more severe crashes**

**ESS-T**
- Optimal steering support to avoid front crashes
- Reduced risk of crashes and injuries

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Semi-Autonomous Parking

**Specifications**

- Functional extension of Park Pilot and Parking Space Measurement
- Driver guided via HMI to follow a calculated trajectory
  - Coupled with steering angle sensor
  - Dynamic recalculation in case of false steering
- System consists of ECU and up to 10 ultrasound sensors (incl. 2 sensors with a detection range of approx. 4 m)

**Customer benefits**

- Easier and more convenient parallel parking
- Avoidance of long or unsuccessful parking attempts
- Available parking space is used more efficiently
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Semi-Autonomous Parking

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Safe

Superior

Comfortable
### Highlights of Vehicle Dynamics Management functions (VDM)

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dynamic Steering Torque Control (DST)</strong></td>
<td>- motivate the driver to more adequate steering</td>
</tr>
<tr>
<td></td>
<td>* Improve the driver’s steering reactions</td>
</tr>
<tr>
<td><strong>Dynamic Steering Angle Control (DSA)</strong></td>
<td>- improve yaw stability and straight running</td>
</tr>
<tr>
<td></td>
<td>* Steering like a perfect driver</td>
</tr>
<tr>
<td><strong>Dynamic Wheel Torque Control (DWT)</strong></td>
<td>- enhance agility, traction and stability</td>
</tr>
<tr>
<td></td>
<td>* Emphasize the sporty characteristics of a vehicle</td>
</tr>
<tr>
<td><strong>Dynamic Damper Force Control (DDF)</strong></td>
<td>- improve steerability and brake performance</td>
</tr>
<tr>
<td></td>
<td>* Comfortable support for ESP®</td>
</tr>
</tbody>
</table>

- **EPS** – Electric Power Steering
  - Picture: ZF Lenksysteme GmbH
- **AFS** – Active Front Steering
  - Picture: ZFLS GmbH
- **ETV** – Electr. Torque Vectoring
  - Picture: GKN
- **Semi-active damper control**
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Principle of Dynamic Wheel Torque Control (DWT)

Physical effects for DWT - general

DWT-B with ESP® premium

DWT-D: Combination of differential and ESP® interventions

Comfortable interventions for improved agility without deceleration.

DWT-B: Dynamic Wheel Torque Control by Brake
DWT-D: Dynamic Wheel Torque Control by Differential

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Dynamic Wheel Torque Control
Reduced steering effort

Maneuver: 18 m slalom on high-μ at vehicle speed 55 kph
Vehicle: Rear wheel drive vehicle of E segment, sporty ESP calibration

![Graph showing integral of steering wheel angle for ESP\textsuperscript{premium}, DWT-B, and DWT-D]

- ESP\textsuperscript{premium}: -6 ... -20%
- DWT-B: -12 ... -30%
- DWT-D: Dynamic Wheel Torque Control by Differential

Significant agility improvements for quick steering wheel inputs

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VDM Functional Integration of three Actuators

ESP® premium

Synergies between functions

- Acceleration on split-\(\mu\)
  - optimized traction by DWT-D
  - automatic counter-steering by new DSA function
- Oversteering control w/ optimized distribution to actuators
  - increased intervention comfort
  - reduced brake interventions
  - reduced speed loss

Drive presentation at 2008 winter testing in Sweden
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Multi Actuator Vehicle (MAV) Benefit: 
Optimal Distribution of Interventions

Test conditions:
- 80 km/h
- 100 deg steering amplitude,
- \( \mu = 1 \)
- stability always maintained

AFS: Active Front Steering
TV: Torque Vectoring
MAV: Multi-Actuator VDM

Significant speed and comfort benefit by networking ESP® + AFS + TV

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Vehicle Motion Management - VMM

Visions future networking of vehicle domains

Networking of safety & comfort

- Predictive Safety Systems
- Adaptive Cruise Control
- Stop & Go
- Coupling steering with ESP®

Networking of stability & agility

- CAPS - Combined Active & Passive Safety → accident avoidance & mitigation
- VMM - Vehicle Motion Management
- Park assist

Vehicle guidance & Accident-free driving

2000 2010 2020 future
Thank you very much for your attention