Trends in Market and Release of Automated Driving

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Charles Degutis, Director Product Management
Dr. Bernhard Pauli, Director Release Strategy

Robert Bosch GmbH, Chassis Systems Control, Business Unit Automated Driving, Abstatt (Germany)
# Automated Driving

## Benefits of self-driving cars

<table>
<thead>
<tr>
<th>Improved safety</th>
<th>Democratization of mobility</th>
<th>Higher fuel efficiency</th>
<th>Reduced congestion</th>
<th>Gain in productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction in motor vehicle accident rates</td>
<td>Allow all age ranges to be mobile</td>
<td>Up to 39% improvement in highway fuel economy</td>
<td>80% improvement in traffic throughput</td>
<td>56 minutes per day freed up for other uses</td>
</tr>
</tbody>
</table>

- **Higher fuel efficiency**: Up to 39% improvement in highway fuel economy
- **Reduced congestion**: 80% improvement in traffic throughput
- **Gain in productivity**: 56 minutes per day freed up for other uses
- **Democratization of mobility**: Allow all age ranges to be mobile
- **Improved safety**: Reduction in motor vehicle accident rates
More than €5 BN Investment in AD 10.2018 – 03.2019…

…primarily through Softbank in commercially oriented ventures

(ZF Acquires Stake in Engineering Services Provider ASAP)

- ZF buys 35 percent stake in ASAP Holding GmbH which has over 1,100 employees at 12 locations on en-mobility, autonomous driving and connected cars
- ZF expands its ecosystem to include a further partnership in future mobility fields

SOFTBANK INVESTS $1B IN ROBO-DELIVERY STARTUP NURO

For information only - For information only - For information only
Driver Assistance with increasing importance...  
...pushed by new safety regulation and enhanced L2 functionality

#RoadSafety – Parliament approves EU rules requiring life-saving technologies in vehicles

Safeguard features such as advanced speed assistance and advanced emergency braking systems will have to be installed in new vehicles as of May 2022.

ZF ProAI central computer features powerful AI capabilities, NVIDIA DRIVE Xavier processor and Level 2+ software stack

Nissan Leaf Assistenzsysteme
Entspannt fahren mit ProPilot
Mit einer Reihe von Fahrerassistenzsystemen entlässt der Nissan Leaf den Fahrer bei Routinenaufgaben. Das bringt mehr Komfort und Sicherheit.

Tesla: New feature enables car to drive itself through a parking lot to pick you up

Super Cruise
Cadillac Tops Tesla in Consumer Reports’ First Ranking of Automated Driving Systems

Intel sets the stage for new ‘Level 2+’ automated driving

ZF coPILOT Enables Enhanced Safety and Driving Comfort

10 automakers equipped most of their 2018 vehicles with automatic emergency braking
Cooperation / joint development take on greater importance... …and NCAP influence leads to core business price pressure

**COOPERATION**
- OEM cooperation targets other OEMs
- Tier 2 suppliers drive new cooperation models providing ADDA kits

**NCAP**
- GSR / NCAP pushes installation rates and increases price pressure
- Legal parameter development lags technology development

**JOINT DEVELOPMENT**
- Open source takes hold in a wide range of topic areas

**FUNCTIONS**
- OEMs target advanced L2 functions as bridge to L3
Automated Driving
Evolutionary and disruptive development paths

Evolutionary and disruptive development paths for Automated Driving include:

- **Automated Private cars**
- **Urban Automated Taxis**
- **Carsharing Movement**

The diagram illustrates the evolution from Individual to Shared vehicle ownership, with and without autonomous vehicle control and assists. The green arrow indicates a revolution towards urban automated taxis (UAT) in the context of carsharing movement.
Global Mega Trends on Connected and Automated Driving
AD Market Potential

Automated driving, passenger cars

<table>
<thead>
<tr>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 15</td>
<td>20 - 25</td>
</tr>
</tbody>
</table>

Automated driving, commercial use (UAT)

<table>
<thead>
<tr>
<th>2025</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 3</td>
<td>4 - 16</td>
</tr>
</tbody>
</table>

Sources:
IHS Markit Auto Executive Briefing, April 2017
McKinsey, Automotive revolution, January 2016
just-auto.com
Roland Berger
BCG

TJP – Traffic Jam Pilot
HWP – Highway Pilot
UAT – Urban Automated Taxi
SYSTEM REQUIREMENTS
## Automated Driving

### Partial vs. High Automation - Fail Safe vs. Fail Operational

<table>
<thead>
<tr>
<th>Decision Making</th>
<th>Partial Automation</th>
<th>Conditional Automation</th>
<th>High Automation</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Responsibility</td>
<td>Driver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insufficient Actuation</td>
<td>Driver take over</td>
<td>Not permissible</td>
<td></td>
</tr>
<tr>
<td>Situations addressed</td>
<td>Selected use cases</td>
<td>Selected use cases</td>
<td></td>
</tr>
<tr>
<td>System failure</td>
<td>Fail safe / fail silent</td>
<td>Fail operational (driver backup with delay)</td>
<td></td>
</tr>
</tbody>
</table>

### Conditional and High Automation require

- Redundancy for sensors, ECUs, communication and actuation
- New methods for data fusion and decision making

*levels of driving automation definition per SAE*
Global Mega Trends on Connected and Automated Driving

Fundamentals

Safety is non-negotiable!

- Security
- System architecture
- Surround sensing
- Localization
- Decision making
- Validation & release process

Legislation
Automated Driving
Safety is part of Bosch’s core business

Increased safety with assisting functions

- ESP®
- ABS
- Automatic emergency braking
- Traction control system
- Electrical steering systems
- Active pedestrian protection
- Airbag control unit
- Lane departure warning
- Evasive steering support

Fundamentals of safety

- Safe driving
  - Driving rules and behavior
- Integrated safety (ISO26262)
  - System malfunctions
- Safety of the intended functionality
  - Misinterpretations of environment and foreseen misuse

Safe automated driving (L3-L5)

We are a member or founder of many committees

Bosch has driven safety on system level for decades

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RELEASE

REQUIREMENTS
Currently missing Regulations and Standards for AD lead to a complex overall situation with various risks.
Release Strategy for AD avoids and controls risks based on a...

### Systematical Resolution Approach

#### Strategy

**Avoiding and controlling of risks**

(analogical to standards for safety ISO 26262 and security ISO/PAS 21448, e.g.)

- **Risk identification**
- **Root cause analysis**
- **Measures**
- **Risk evaluation**
- **Release decision**

#### Procedure

1. **Risks by**
   - Liability /Product Liability
   - Warranty
   - Market Acceptance

2. **Failure of organization and of employees**
3. **Release process and verifiable application**
4. **Engineering process and work products**
5. **Judgement of processes and work products**
   - Evaluation of
     - unknown risks based on processes and methods
     - known risks based on work products
6. **Decision based on**
   - all remaining risks (liability, warranty, acceptance)
   - achieved safety compared to public expectation
   - result of benefit risk analysis

#### Modality

**Structured procedure based on legal needs and principles**

- Hazard and threat analysis focused on technical and belonging legal aspects
- Organizational and technical causes
- Systematic proceeding
- Reasonable and needed measures
- Evaluation of all risks, i.e. unknown and known risks
- Safety expected by the public
- Positive benefit risk ratio

- **Liability /Product Liability**
- **Warranty**
- **Market Acceptance**
One main Element of the Release Strategy for AD is the ... Release Argumentation applying well proven Systematics

The release argumentation provides the methods and the needed work products to prove the fulfillment of the mandatory product properties: function, conformity, safety, security, reliability.

The overall release strategy is centrally developed and provides a systematical and legally sound framework for the company and the employees to develop and to release AD systems.

Only a structured proceeding in development and release makes AD systems reality!
Wide spectrum in open world varying:

- from simple to complex situations
- from usual to exceptional objects
- from safe to dangerous behaviors
- ...
What are the exciting topics?

Example: Typical, but safety relevant Situation (@5 sec)
What are the exciting topics?

Example: Detection of ghost object (@10 sec)

Video example:

- Scenario:
  Driving on an empty street at night
- Special conditions:
  wet bumpy street, many light sources, reflections and shades with different forms
- Initiator:
  Ghost object
- System reaction:
  possibly wrong intervention
What are the goals to be achieved? The industry is discussing ...

Various Approaches for Safety Goals

Absolute 100% safety is totally impossible – that’s real life! But what are the goals to be achieved?

- Probability of accidents per hour at maximum 10E-7/h
  - Not safe
  - Assuming a small fleet of e.g. 100,000 vehicles, an accident happens every 100 h
  - Waiting for the accident

- Driving Tests without accidents at 30 Billion Miles
  - Not feasible
  - Statistical approach with several uncertainties
  - Assuming 1000 test vehicles driving 24/7/52, test takes more than 100 years

- Better than the human driver x-times
  - Not consistent
  - Which factor x and why?
  - Which driver, the ideal in theory, the average or the worst?
  - Which accident statistics? The German, US or ...? Which year?
An alternative Approach for Safety Goals

What are the goals to be achieved? The industry is discussing...

**Alternative approach**

- The top goal is to improve road safety.
- The AD system provides a rule-consistent and predictable behavior and causes no accidents.
- If other road users, animals, objects or obstacles cause a hazard, the AD system reacts in the best way possible to prevent upcoming accidents or, if this is impossible, to mitigate the severity.

**This approach is ...**

- ... adopted from established safety systems like Airbag, ABS, ESP
- ... derived from requirements on the behavior of a human driver
- ... in accordance with regulations by the European Commission and the UN ECE Trans/WP.29
Automated Driving Summary

Technology plays a crucial role
Brain is everywhere … vehicle, cloud, infrastructure

Complexity
Collaboration, partnerships & shared system development are key success factors

Concept & Solutions
Clear separation of L1-L2, L3, L4-L5 → different user groups, different needs

Legal
Comprehensive legal framework required to establish clear AD parameters