Opportunities and Challenges on our way to piloted driving

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Thomas Müller
Head of Development Braking, Steering and Driver Assistance Systems
DID YOU KNOW
Gathering all driving hours, we spend two years and six months in the driver seat.

Source: DIE WELT (German newspaper)
Searching for a parking space in Germany on average takes almost 10 minutes, which means driving around on average 4.5 kilometers.
Every driver on average spends **100 hours** per year searching for a parking space.

Source: Roland Berger
Usage rate

On average every car is driven one hour and is parked 23 hours per day
The automotive business is moving towards a new age of technology.

- **Age of mechanic**
- **Age of electronic**
- **Age of software**
- **Age of cloud / data / new business models**

Product / technology / performance vs. time (1900 to today).
Piloted driving is one of the top three areas of innovation in the automotive industry.
Piloted driving – vehicles learn …
Safety, convenience, traffic flow management, quality time

... to see
... to communicate
... to decide

... and to drive
Safety, comfort and efficiency are the main goals for piloted driving and parking

1. Improved safety
   90% of today’s accidents happen due to mistakes of the driver:
   » inattention
   » miscalculation

2. Environmentally friendly driving
   3-5% fuel savings:
   » consideration of topology
   » preview

3. Enhanced customer convenience
   Increase in comfort due to:
   » time efficiency
   » freedom of choice for available time
   » no constraints with narrow parking lots

4. Efficient use of transport infrastructure
   Gaining space especially in cities:
   » parking garages (up to 30%)
   » traffic density (5-10%)
Automated driving is the next logical step after the development of driver assistance systems.

### Assistance systems

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
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<tbody>
<tr>
<td>0</td>
<td>Driver only</td>
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<tr>
<td>1</td>
<td>Assisted</td>
</tr>
<tr>
<td>2</td>
<td>Partial automation</td>
</tr>
<tr>
<td>3</td>
<td>Conditional automation</td>
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<td>4</td>
<td>High automation</td>
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<tr>
<td>5</td>
<td>Full automation (driverless)</td>
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- **Level 0 (Driver only)**: Driver permanently in charge of longitudinal and lateral control.
- **Level 1 (Assisted)**: Driver permanently in charge of either longitudinal or lateral control. Driver is ready to take over immediately.
- **Level 2 (Partial automation)**: Driver permanently monitors. Driver is ready to take over immediately.
- **Level 3 (Conditional automation)**: Driver does not need to monitor the dynamic driving task nor the driving environment at all times but be attentive to take over.
- **Level 4 (High automation)**: Driver is not required during defined use case. Vehicle takes full charge of longitudinal and lateral control in defined use case. The system is capable of establishing a risk-minimized state in all situations, all ancillary activities possible.
- **Level 5 (Full automation (driverless))**: System performs the lateral and longitudinal dynamic driving task in all situations encountered during the entire journey. No driver required. Vehicle does not have steering wheel or pedals.

### Next generation
- **Today’s driver assistance systems**: Vehicle takes charge of the other function.
- **Next generation**: Vehicle takes charge of longitudinal and lateral control for a certain time and in certain situations.

Source: SAE
The market introduction of ADAS and piloted driving will follow an evolutionary approach.
Action required for implementing automated driving and parking

1. Technology
2. Infrastructure
3. Regulation
Action required for implementing automated driving and parking

1. Technology
   - Sensors
   - Safety architecture
   - Functions
   - Redundant actors such as brakes
   - High-performance computer
   - User interface
   - Validation concepts

2. Infrastructure

3. Regulation
The human control loop

Perception

Processing the information

Action
Piloted driving control loop

Environment detection

Data processing

Actuators
A large number of sensors and redundant sensor technologies ensure the surroundings are reliably identified.
A redundant technology layer is built in piloted systems to make sure the system is operating properly.

**System architecture piloted driving**

**Assisted driving (Level 0-2)**
- Driver monitors driving task constantly
- Driver is „backup system”

**Piloted driving (Level 3-5)**
- Driver can take over at any time

**In critical situations immediate reaction of driver needed**

**No immediate reaction of driver needed**
Action required for implementing automated driving and parking

In general | worldwide

1. Technology

2. Infrastructure

3. Regulation

- Maintaining and expanding infrastructure
- Implementing standards
- Implement standards for additional a-priori knowledge
  - Temporary use of traffic areas, construction areas
  - Sudden danger information, construction sites, accidents, traffic jam, etc.
The requirements of piloted driving towards infrastructure can be clustered in two steps

**Step 1: maintenance of current infrastructure (examples)**
- **Road markings** present and clearly visible (contrast)
- **Emergency lanes** present and usable
- **Wildlife fences** present and intact

**Step 2: potential for future infrastructure (examples)**
- **Traffic lights, roundabouts, complex crossroads**
- **Temporary use of traffic areas, construction areas**
- **Accidents, sudden hazards**
Action required for implementing automated driving and parking

In general | worldwide

1. Technology
   - Vehicle registration regulations
   - Regulatory law (Vienna Convention, highway traffic regulations)
   - Liability

2. Infrastructure

3. Regulation
Audi has a long heritage in piloted driving …

- **2009**
  - Audi TT
  - Salt lake
  - Bonneville

- **2010**
  - Audi TT
  - Pikes Peak

- **CES 2013**
  - Park pilot & traffic jam pilot
  - Permission to test piloted driving in Nevada

- **Aug. 2014**
  - Permission to test piloted driving in Florida

- **Sept. 2014**
  - Permission to test piloted driving in California

- **Oct. 2014**
  - The world best performing piloted driving prototype in the world at the Hockenheimring

- **Jun. 2015**
  - Drive from San Francisco to Las Vegas with Jack (Highway Pilot)

- **Jan. 2015**
  - Traffic Jam Pilot in Shanghai
Piloted driving: Revolution?
In the last 10 years the driver assistant systems penetrated top down up to the A segment (e.g. Adaptive Cruise Control, ACC)

Models with ACC – 2005

- A8
- A6
- Q7

6,600 number of cars equipped with ACC

Models with ACC – 2014

- A8
- A6
- A4
- A3
- A5
- A7
- Q7
- Q5

141,500

The installation rate of Adaptive Cruise Control ACC in the Audi A8 increased in the last 12 years from 2% to 65%

Source: AUDI AG
The development of different technologies for autonomous driving will boost the growth of the ADAS market.

Market size arising out of autonomous driving technology (in addition to current DAS)

By 2030, the new opportunities from autonomous driving will be around USD 40-60 bn

Source: Roland Berger Study „Autonomous Driving“, November 2014
In a nutshell….

Piloted driving will experience an evolutionary development, but has the long-term potential to revolutionize mobility.
The automotive business is moving towards a new age of technology

“In my opinion, all previous advances in the various lines of invention will appear totally insignificant, when compared with those, which the present century will witness.

I almost wish, that I might live my life over again to see the wonders, which are at the threshold.”

[Charles Holland Duell, 1902]

Charles Holland Duell (April 13, 1850 – January 29, 1920) was the commissioner of the United States Patent and Trademark Office in 1898 to 1901, and was later a United States federal judge.
Disclaimer

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