Opportunities and Challenges on the way towards piloted driving

Jacksonville| December 2015

Thomas Müller

Head of Development Braking, Steering and Driver Assistance Systems

Audi has a long heritage in piloted driving …

2009
Audi TT
Salt lake
Bonneville

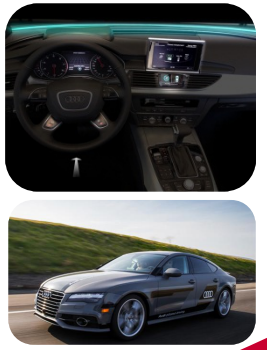
2010
Audi TT
Pikes Peak

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



Jan. 2015
Drive from
San Francisco to
Las Vegas with Jack
(Highway Pilot)

Jun. 2015
Traffic Jam Pilot in
Shanghai

Piloted Driving – Vehicles learn …

to combine driving expertise with perception of surroundings

… to see

… to communicate

… to decide

… and to drive

Safety, Comfort and Efficiency are the main goals for piloted driving and parking

1 Increased safety

+90 % of today's accident happen due to drivers mistake:
» inattention
» miscalculation

2 Environmentally friendly driving

3-5% fuel savings:
» consideration of topology
» preview

Piloted Driving

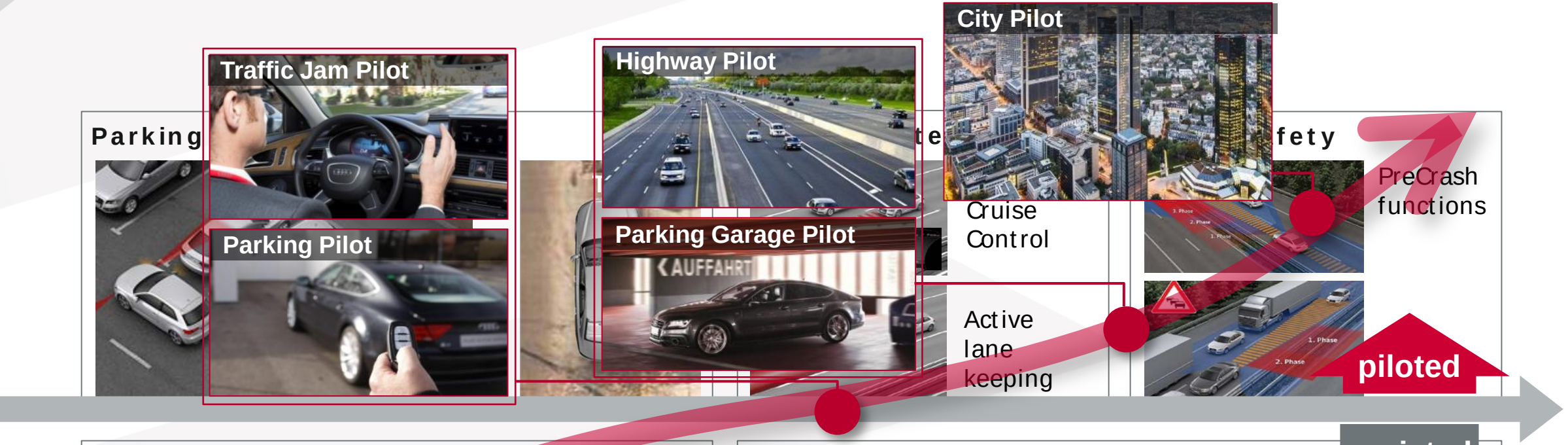
3 Enhanced customer convenience

Increase in comfort due to:
» time efficiency
» freedom of choice for available time
» no constrains with narrow parking spots

4 Efficient use of transport infrastructure

Gain in area especially in cities:
» parking garages (up to 30%)
» traffic density (5 to 10%)

The market introduction of ADAS and piloted driving will follow an evolutionary approach

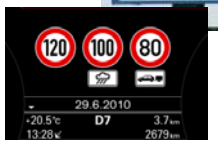


Information and warning

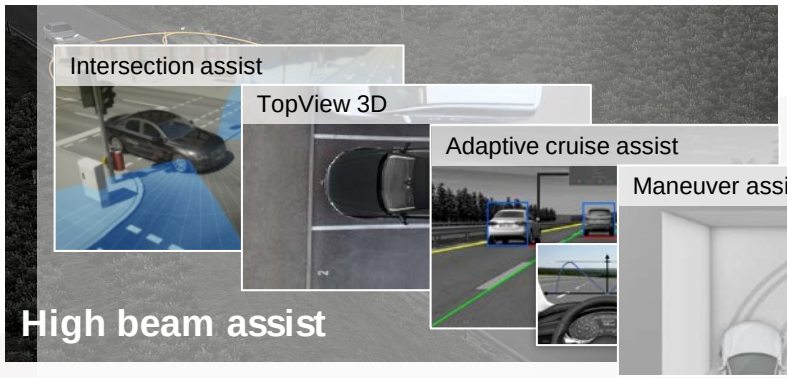
Nightview

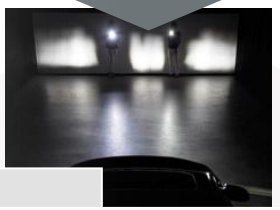
Lane change assist

Traffic sign recognition

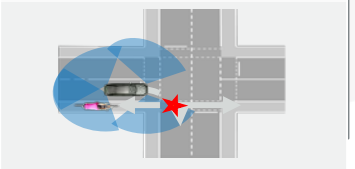


Future assistance functions



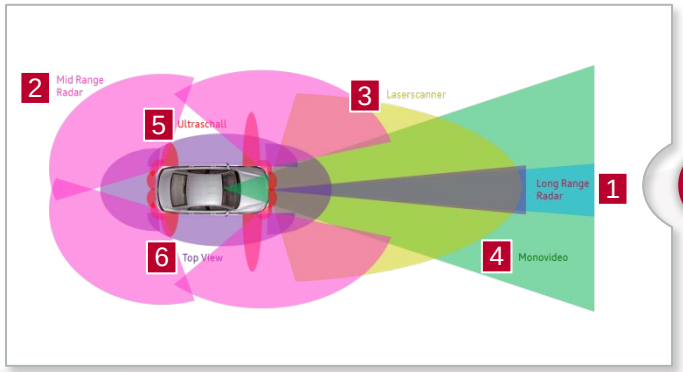


Turn assist

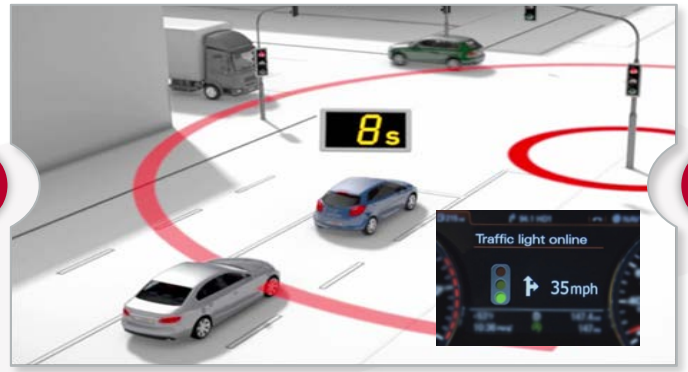


Action required for implementing automated driving and parking

1. Technology



2. Infrastructure



3. Regulation

Action required for implementing automated driving and parking

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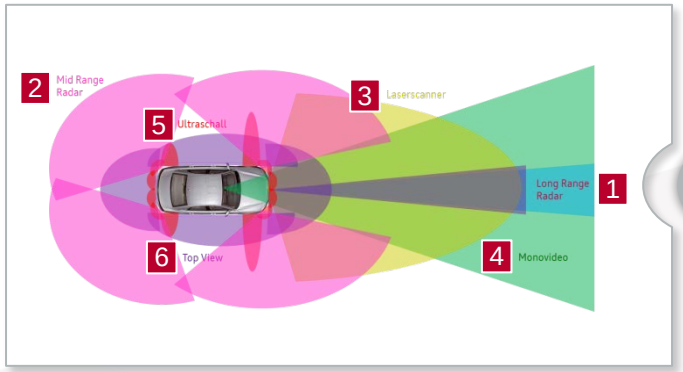

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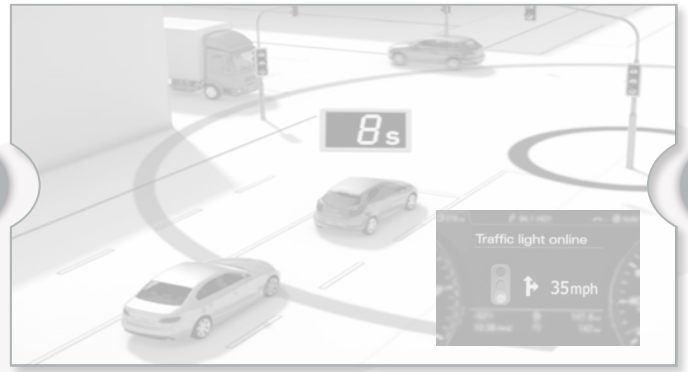
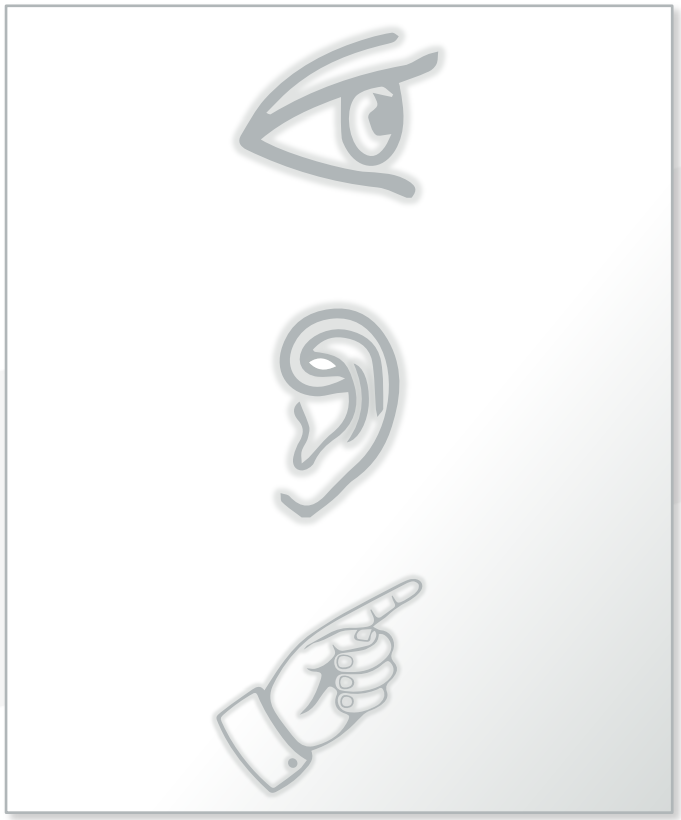


3. Regulation

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

The Human Control Loop

Perception



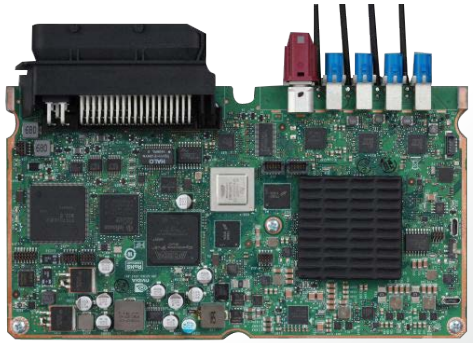
Processing the information

Action

Piloted Driving Control Loop

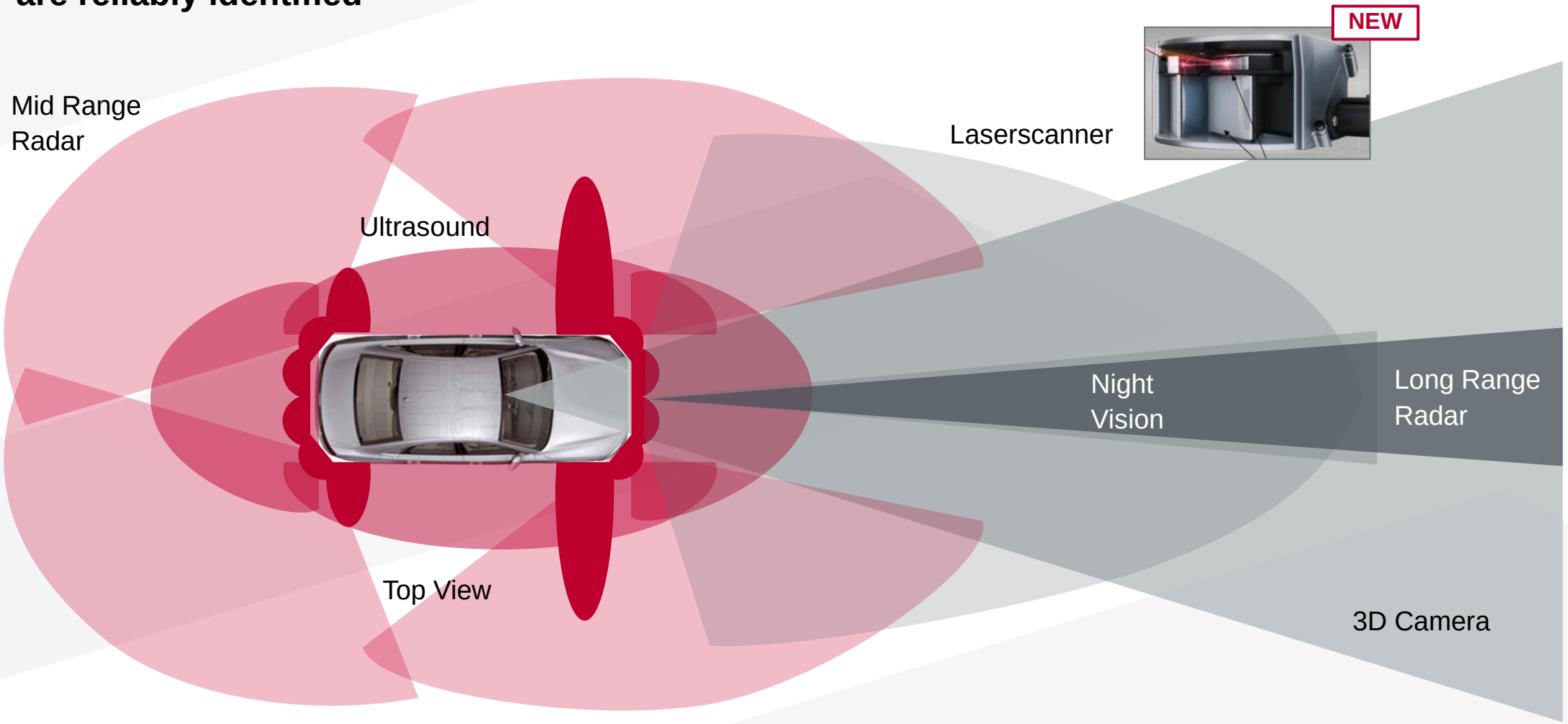
Environment detection

Data processing



Actuators

A large number of sensors and redundant sensor technologies ensure the surroundings are reliably identified

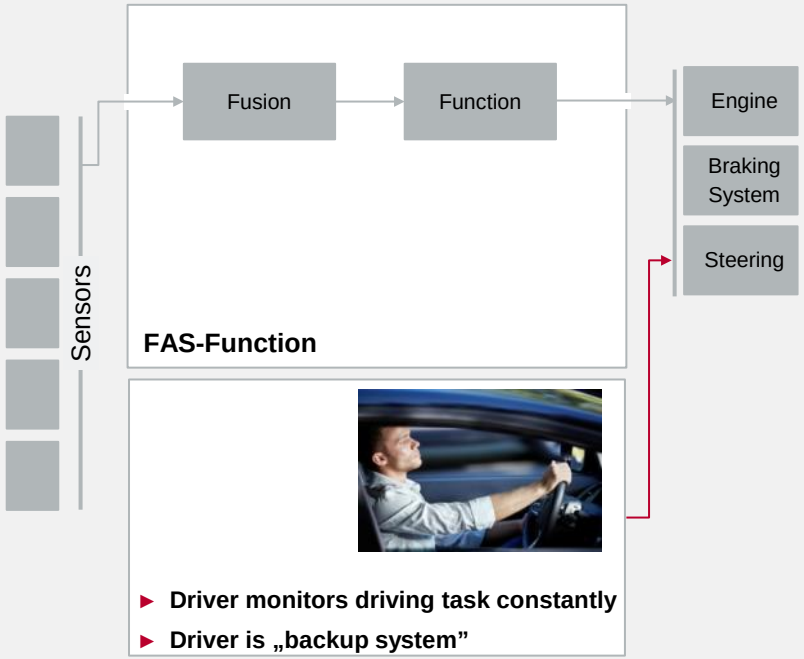


A redundant technology layer is built in piloted systems to make sure the system is operating properly

System architecture piloted driving

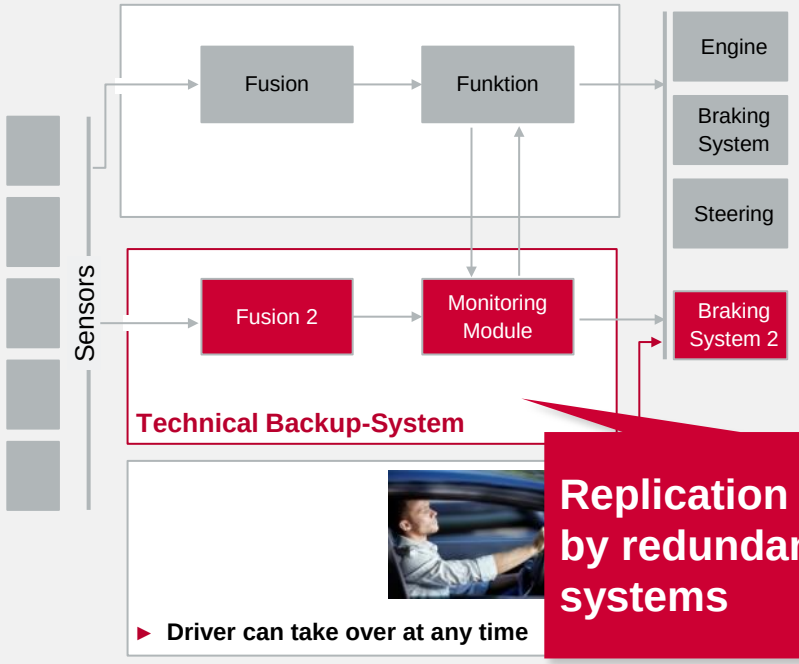
simplified

Assisted Driving (Level 0-2)



In critical situations immediate reaction of driver needed

Piloted Driving (Level 3-5)



Replication of driving by redundant systems

No immediate reaction of driver needed

WHAT IS THE DRIVER BEHAVIOR WHILE PILOTED DRIVING

?

Audi is investigating ways to keep drivers attentive for a fast take over in Level 3 systems

Humans have difficulty staying alert if they are bored.
Research shows motorists make more mistakes when the driving task is too monotonous or too alarming

In Level 3 systems SAE, BASt, OICA (and implicitly Audi) say:
„The driver does not need to monitor the dynamic driving task nor the driving environment at all times; **however he must be attentive to and follow system's requests / warnings to resume the dynamic driving task."**

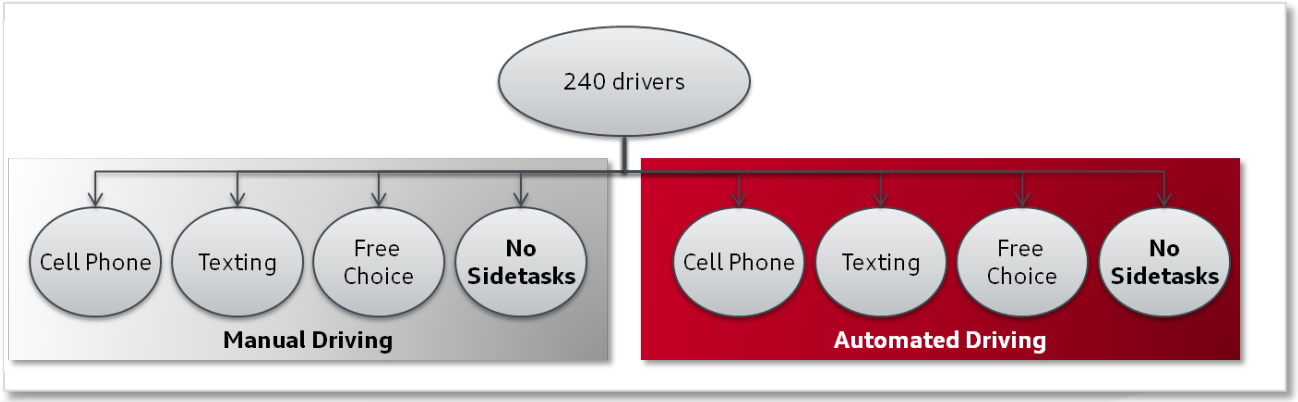
In „manual driving“ or „assisted driving“ modes, the driver is involved in the driving task

SAE / BASt levels 0-2

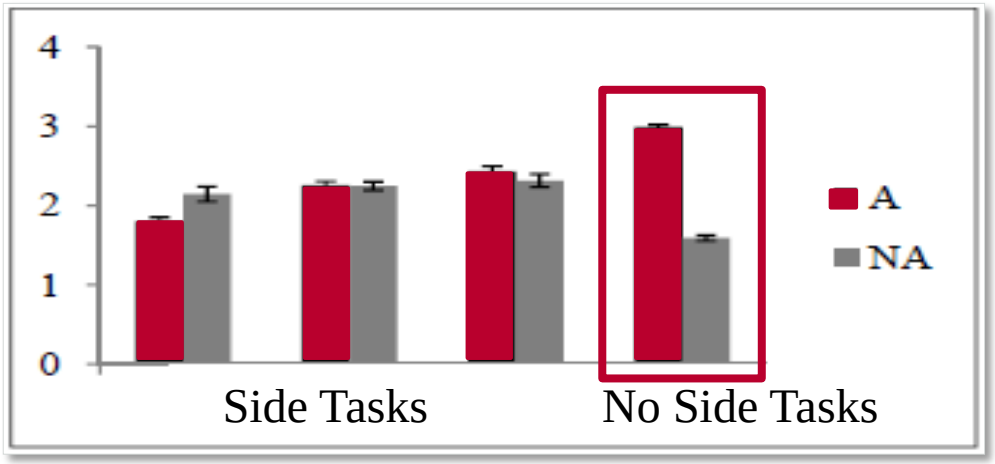
Attention

All laws for distracted driving are made for this case.

But: how does the reaction time change if the driver is not performing the driving task?



C. Neubauer
University of Cincinnati
2012



Mean Take-Over Time (Braking)

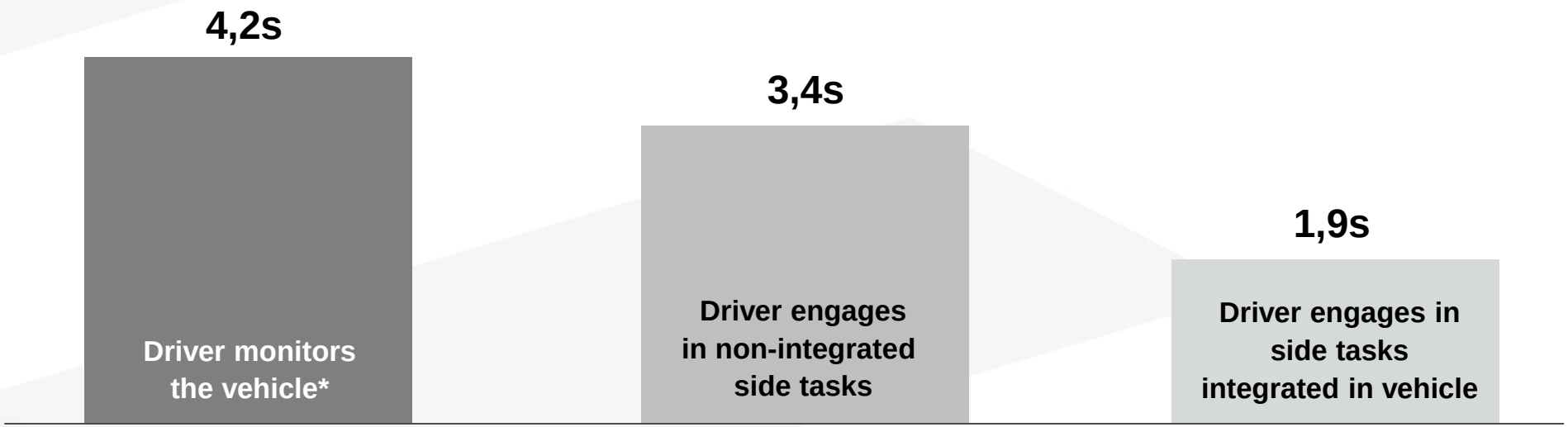
"[Sidetasks]* may enhance driver alertness subsequent to exposure to full vehicle automation."

C.Neubauer et al.: *The Effects of Cell Phone Use and Automation on Driver Performance and Subjective State in Simulated Driving*

* Original paper says "Cell phone use" here.

Audi studies underline these results

Average take-over times [in seconds]



Source: I. Petermann-Stock et al.: Wie lange braucht der Fahrer? (2013)

* Comparable study design

How should the driver be occupied while the piloted driving mode is active?

SAE / BASt levels 3

An **unoccupied driver** has the longest take-over time

Attention

Forbidden by law.
Very probable, though.

Forbidden by law.
Also, not a good idea.

None of the existing laws and rules for distracted driving were defined based on the existence of these studies for piloted driving mode

A possible improvement: offering built-in infotainment features during the piloted driving mode could reduce the average takeover time

Technical Concept

- Built-in infotainment features are **controlled** by the **piloted driving system**
  - **Enabled** when piloted mode is **on**
  - **Disengaged/Disabled** when piloted mode **requests the take over**
- Keep the driver alert and minimize **take-over time**
- **Minimize** "foreseeable **misuse**“ (e.g. mobile phones)
- Enhance **customer experience** while piloted driving

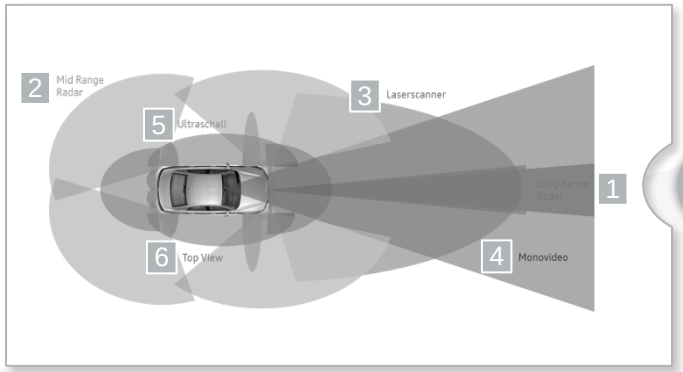
Source: Audi AG, Video Conferencing in Audi prototype

» **Enabling built-in infotainment features** are an important part of the **customer experience** of piloted driving, potentially **reducing takeover times** and thus **increasing safety**

Action required for implementing automated driving and parking

In general | worldwide

1. Technology



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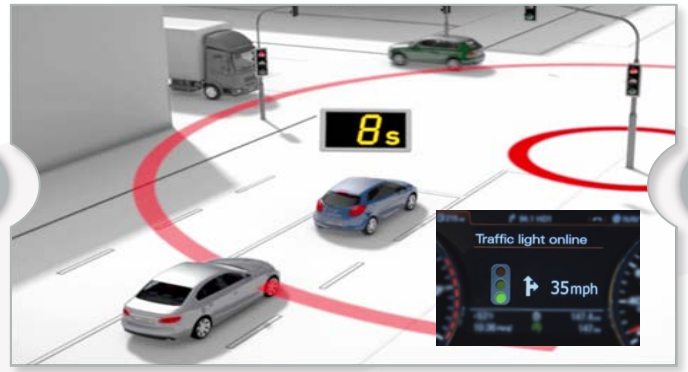


- Maintaining and expanding infrastructure
- Implementing standards
- Implement standards for additional a-priori knowledge
  - Temporary use of traffic areas, construction areas
  - Sudden danger information, constriction sites, accidents, traffic jam, etc.

3. Regulation

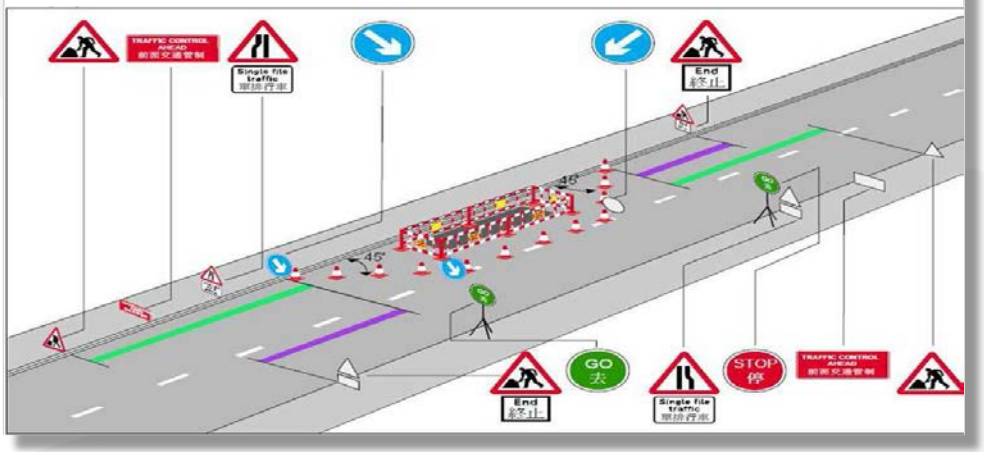
Good infrastructure conditions provide high quality of surrounding input

Regular requirements

- Consistent infrastructure
- Clear and visible lane marking
- Existing and useable emergency lane

Additional requirements

- Additional knowledge about dangerous spots and complex traffic situations.
- Early information about road works and rerouting.



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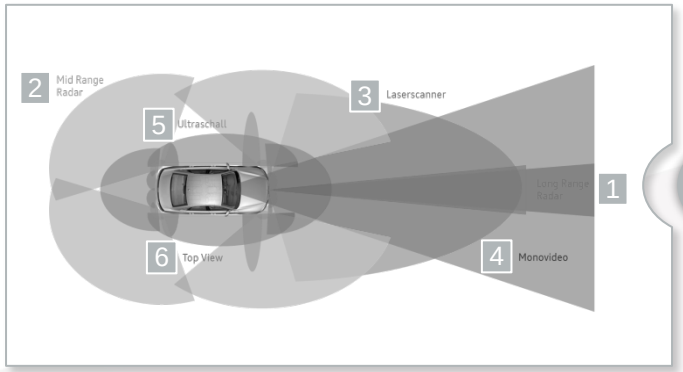

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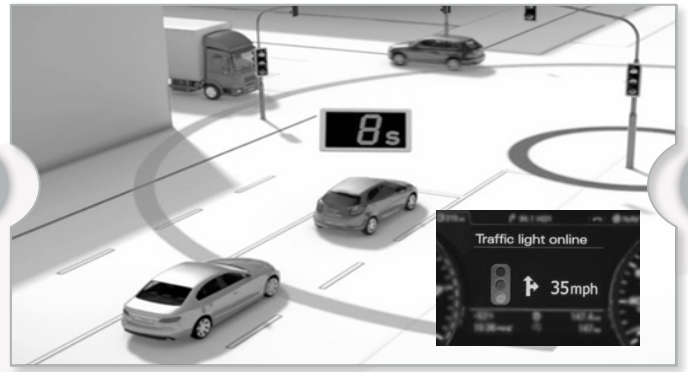

3. Regulation

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

Our view for the US » in a nutshell…

Traffic Jam Pilot will be the first piloted driving function (Level 3) in the market

- Audi is demonstrating the potential of automated driving in different showcases (traffic jam pilot, highway pilot, race pilot). The first system to be implemented into series production is the traffic jam pilot on highways/highway-similar roads (less complexity). The TJP system takes over the driving task when conditions are met from 0-35 mph on highways. This system generates customer benefits mainly in safety, comfort and efficiency.

The Traffic Jam Pilot fits into the current US legal framework*

- The Traffic Jam Pilot will be ready for market soon. We think the current US legal framework does not prohibit Level 3 systems per se and thus our Traffic Jam Pilot can be deployed.

Allowing built-in infotainment features can increase safety by decreasing takeover times

- Our human factors research indicates that an engaged driver can take over control of the vehicle faster than an operator without “stimuli”. A technical solution that allows the driver to use vehicle integrated infotainment systems allow the driver to remain engaged and refocus his attention when he/she needs to take over the dynamic driving task.

An adaptation/interpretation of road traffic legislation is needed to allow vehicle integrated side tasks

- In some States, behavioral regulations and driver distraction laws will prevent the use of vehicle integrated side tasks (reading emails, video call, texting, …). Paradoxically, this could lead to the operator’s attention being focused on nomadic devices that cannot be controlled by the system and ultimately delay his/her takeover time of the dynamic driving task.

A close cooperation between industry and politics is needed

- The industry focuses on consistency in regulations across the States and on harmonized federal requirements.

* NY has a „one hand on the steering wheel law“ and therefore does not comply with the requirements of piloted driving

Thank you for your attention

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