Light Signalling and Lighting Requirements for ADS Vehicles

This is a corrected version of the file presented to the ITS/AD Group on 21 June 2018.

The corrigendum concerns the second paragraph on page 17 that has been corrected, to avoid any suggestion that the work should be carried out initially under the 1958 agreement and subsequently transferred into a GTR, as follows:

- develop one set of global technical requirements suitable for implementation ~~initially~~ under the 1958 and 1998 Agreements ~~and subsequently under the 1998 Agreement~~

Geoffrey R Draper
GTB President
03 July 2018

Light Signalling and Lighting Requirements for ADS Vehicles

- Safety signals – A two-stage approach
- Road Scene illumination

Please refer also to GRE-79-36e

Author: **Helmut Tiesler-Wittig**
GTB Focus Group on ADS Lighting

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The International Automotive Lighting and Light Signalling Expert Group
Groupe de Travail "Bruxelles 1952"

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Light-Signalling for ADS Vehicles

i.   Motivation for the activities in GTB

ii.   Justification

iii. Safety signals

iv.   Explanation of the 2-Step-approach

v.   ADS Signalisation :

Future possibilities, Implementation, Conclusion and GTB Proposal

Road Scene illumination for ADS Vehicles

i.   Could better lighting have prevented UBER's accident?

ii.   Possible solutions to assist the optical sensors

National authorities recognise the need for traffic safety of automated driving systems

Federal Ministry
of Transport and
Digital Infrastructure

- DE, Ethics commission Automated and connected driving (Report June 2017, Federal Ministry of Transport and Digital Infrastructure)
  - Paragraph No. 5 to read
    - *„…the technology must be designed in such*
    - *a way that* **critical situations do not arise in the first place…** *the entire spectrum of technological options – …* **signals for persons at risk, …** *– should be used and continuously evolved…"*
  - Paragraph No. 16 to read
    - *„…it must be possible* **to clearly distinguish whether a driverless system is being used or whether a driver retains accountability** *with the option of overruling the system…"*

National authorities recognise the need for traffic safety of automated driving systems

- CN, 450-page roadmap published by SAEC (Society of Automotive Engineers of China).
  - *Officials said earlier this year the draft would be released* **to set out technical standards, including a common language for cars to communicate with each other and regulatory guidelines.**

National authorities recognise the need for traffic safety of automated driving systems

- US National Highway Traffic Safety Administration, chapter 5 of Federal Automated Vehicles Policy, September 2016
    - *„...manufacturers and other entities should consider how HAVs will **signal intentions to the environment around the vehicle, including pedestrians, bicyclists, and other vehicles…**"*

Traffic safety is dependent on the interaction with other road users

- Traffic safety always relies on "seeing" and "being seen"
- The simpler the method of communication, the higher the chance of clear understanding

Established methods

Vehicle lights (Indicators, High-low beam)
Vehicle sound (Horn and Engine sound)

Driver Interaction (Gestures, Voice)
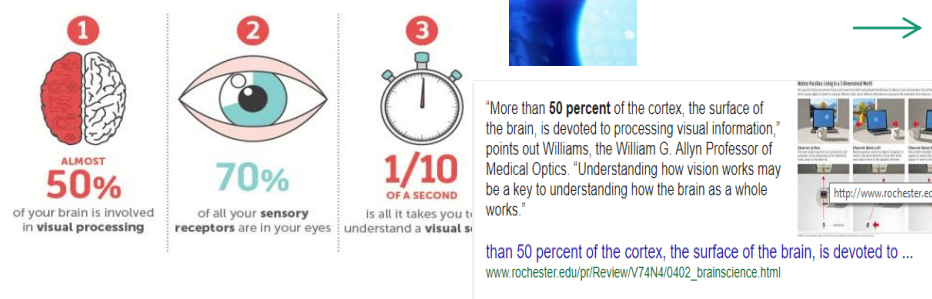Pedestrian/Cyclist intuition (Speed detection / Legacy Behaviour)

Future → **Can lighting be an easy and good solution?**

What does research and experiment conclude?

"More than **50 percent** of the cortex, the surface of the brain, is devoted to processing visual information," points out Williams, the William G. Allyn Professor of Medical Optics. "Understanding how vision works may be a key to understanding how the brain as a whole works."

than 50 percent of the cortex, the surface of the brain, is devoted to ...
www.rochester.edu/pr/Review/V74N4/0402_brainscience.html

➢ Vulnerable Road Users (VRUs) expect some external communication interacting with autonomous vehicles

➢ The majority of human sensing is guided by visual interaction

➢ Road users are experienced with light signals!

Research Study including 664 participants from

🇫🇷 🇨🇭 🇬🇷

(Vulnerable Road Users) VRUs expect the same behavior from the autonomous vehicle as from a traditional vehicle, feel less safe and want external communication ..**For the traffic safety - clear communication and interaction strategy** is required to facilitate safe and successful operation of the automated vehicles

Basic questions of the interaction between the automated vehicles and other road users
- When it is turning
- When it is stopping
- How fast is it going
- Whether it has detected me
- Whether it is going to start moving

The Vulnerable Road Users expect external communication to interact with autonomous vehicles

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Lighting is a strong option to solve these requirements!

Is there a need for a signal?

- ## ADS Vehicles might behave differently than a driver driven car

  - More Information through more sensors available
  - Higher speed of calculation / reaction
  - "Car-brains" are programmed, hence they are different from human (false) behavior or intuitive self-protecting reactions
  - Self learning software (AI) based upon autonomous driving results and incidents
  - Vehicles may be connected to other vehicles but may not connect to humans outside the ADS vehicle
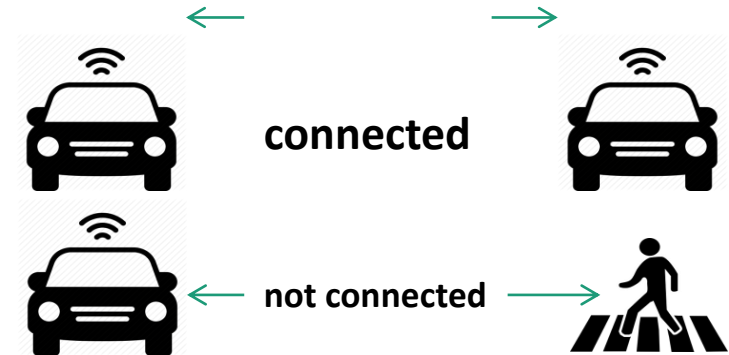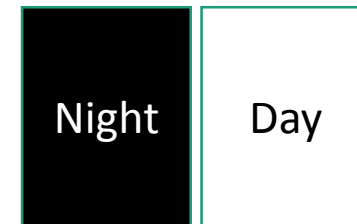
- ## Protection for other road users:

  - Pedestrians, Cyclists, Drivers (Motorcycle, Cars, Trucks), Animals
  - Adaptation to Night and Day
  - On all roads: Highway, Urban, Rural, Parking place, Public and Private areas
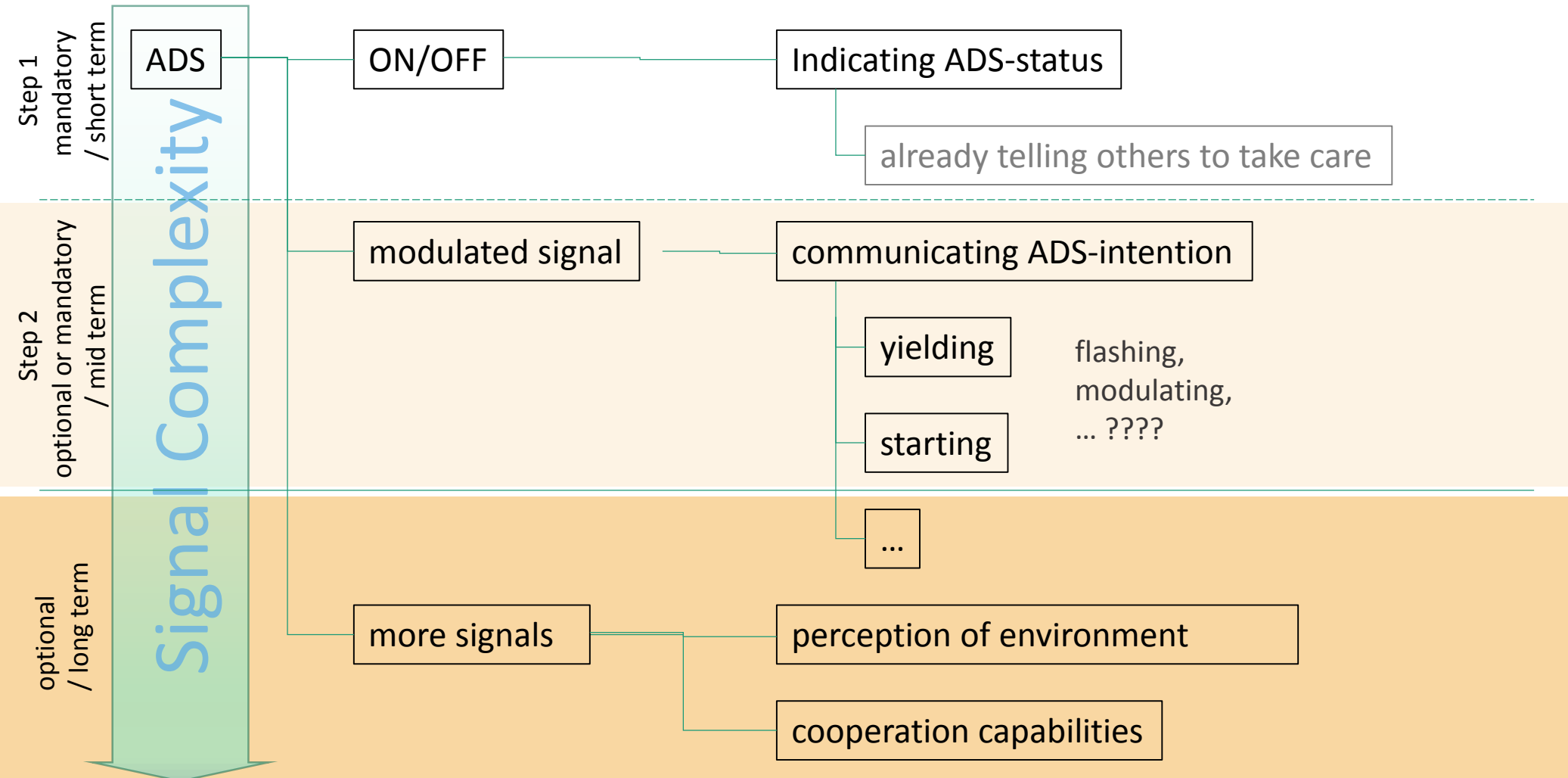 - Remote parking

- ## Law enforcement (police)

  - Needs to know whether a driver is allowed to do other tasks than driving such as using a mobile phone, depending on the level of autonomous driving

connected

not connected

Night | Day

- Single vs. multi-step communication
- What kind of communication is needed for ADS?

Step 1 — mandatory / short term

Step 2 — optional or mandatory / mid term

optional / long term

Signal Complexity

ADS → ON/OFF → Indicating ADS-status

already telling others to take care

modulated signal → communicating ADS-intention

yielding

starting

flashing, modulating, … ????

…

more signals → perception of environment

cooperation capabilities

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Explanation of the 2-Step-approach

- Step 1 → Step 2 → Future preparation

Regulation

Step 1 (now):
Define basic On/Off Signal
- Position
- Color
- Brightness
- Visibility & Size

Open framework, enabling Step 2 and Future

Step 2 (midterm):
- Modulated Signals (flashing, blinking, …)

Framework stays open, enabling Future

Future:
- More Signals (e.g. Signs/Icons via Display)
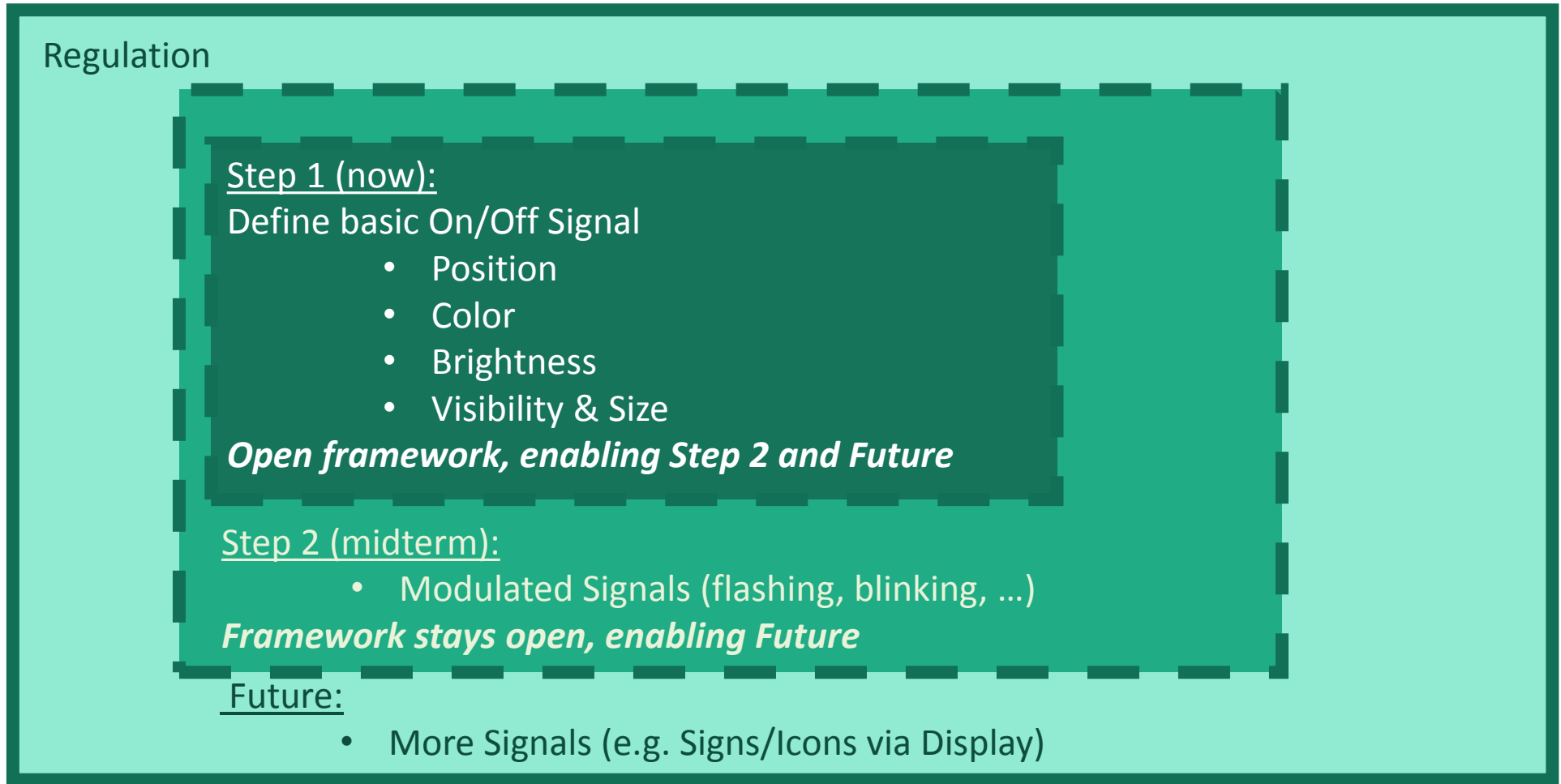
Explanation of the 2-Step-approach

Step 1: Basic On/Off Signal

- Position

- Color

- Brightness

- Visibility & Size

Explanation of the 2-Step-approach

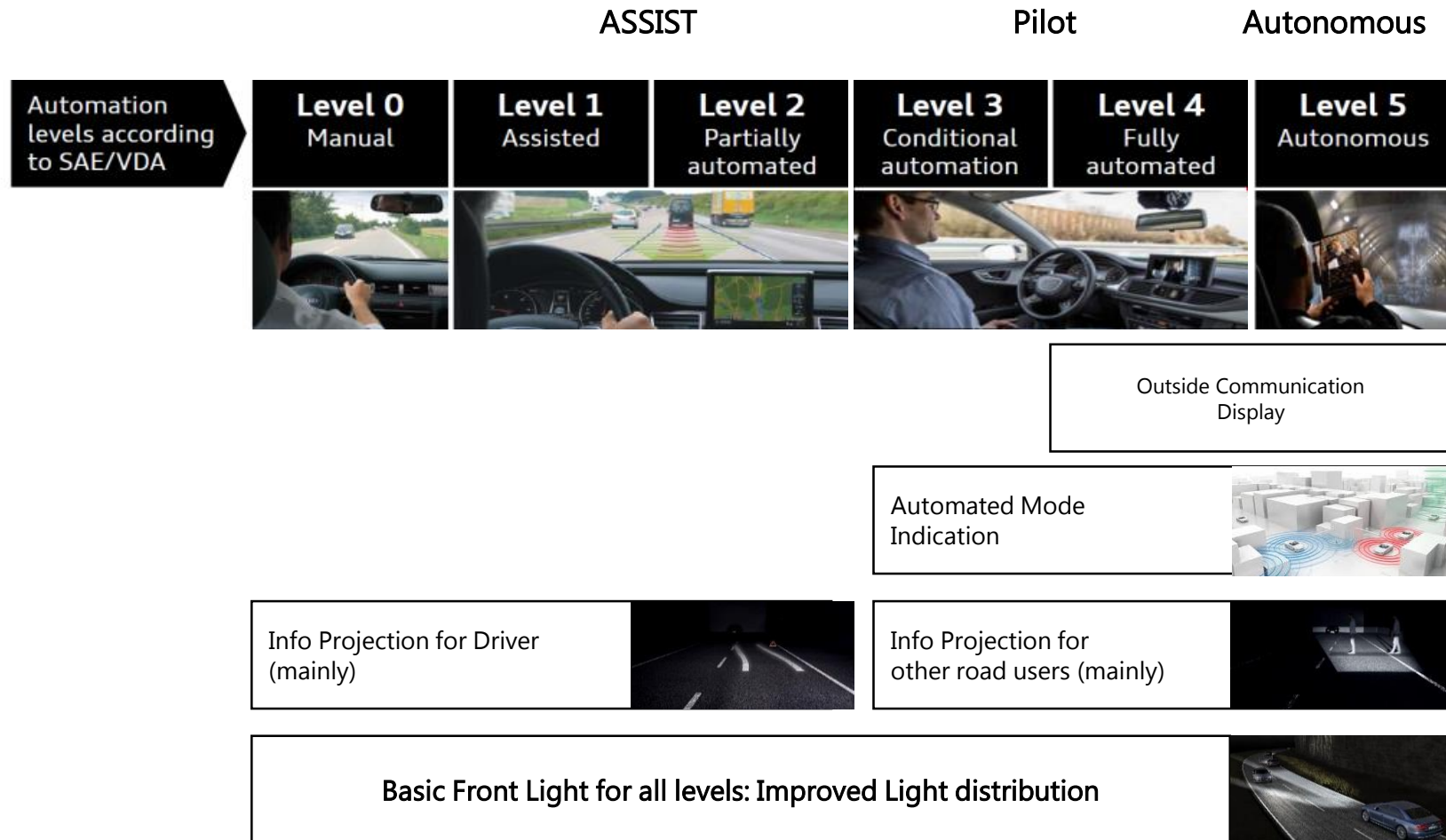## Step 2: Modulated Signals (flashing, blinking, …)

ADS Signalisation – Future Possibilities

Future: More Signals (e.g. Signs/Icons via Display)

ADS Signalisation - Implementation

Translation of ADS-signalisation to the level of automation

ASSIST   Pilot   Autonomous

Automation levels according to SAE/VDA	Level 0 Manual	Level 1 Assisted	Level 2 Partially automated	Level 3 Conditional automation	Level 4 Fully automated	Level 5 Autonomous

Outside Communication Display

Automated Mode Indication

Info Projection for Driver (mainly)

Info Projection for other road users (mainly)

Basic Front Light for all levels: Improved Light distribution

Huhn, WG-S, May 21st 2018

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Conclusion

GTB sees a safety benefit from the introduction of Light Signalling Requirements for ADS Vehicles

- The introduction of further automation in road transportation will lead to an increased demand for reliable and unambiguous communication between road users

- The automation of vehicles will not just influence improve the safety aspects of the vehicle itself but also affect the safety of OTHER road users

- Road safety improvement can be provided by the introduction of dedicated ADS signals to communicate with other road users

- ADS signals shall be visible during day-time and night-time

ADS-Signalisation

GTB Proposal

- ADS signals shall be standardised & regulated at a global level, but already <u>there are several groups working in parallel</u>

- It is time to focus efforts under the direction of the World Forum (WP.29/GRE) to:

  ➢ develop one set of global technical requirements suitable for implementation under the 1958 and 1998 Agreements

  ➢ prevent unnecessary regulatory hurdles and non harmonised solutions being created for the future.

- <u>This is a completely new subject and may be considered as a good candidate for development as a GTR</u>

- GTB is already prepared to sponsor independent research to support this activity

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Could better Lighting have prevented Uber's Accident?

(Sources: Amit Mehta, NAL and Dr. M. Hamm, Audi AG)
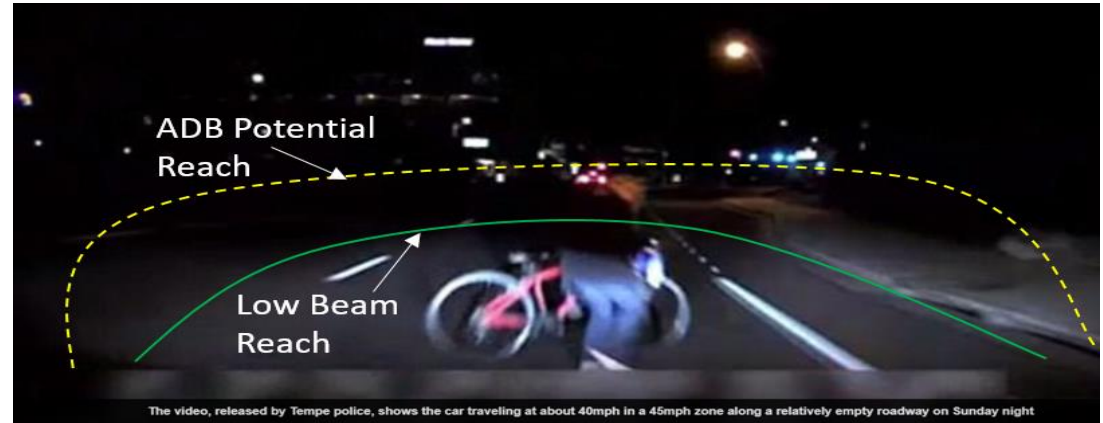
- **ADS Light Signals could have alerted the cyclist to take care!**
- **Improved lighting would have increased the visibility on the road**

➢ As a consequence, driver could have reacted MUCH earlier

➢ First calculations confirmed a 100% to 140% gain – compared to installed standard lights

➢ Improved lighting would have also augmented the sensor reaction by giving a better contrast and detection speed

➢ Both driver (if in operation) and automated system would have had a benefit of improved lighting!

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Road Scene illumination for ADS

Possible solutions to assist the optical sensors

GTB foresees a safety benefit from the introduction of specific illuminance requirements for ADS vehicles

- In addition to providing signals indicating status and communicating with other road users, the ADS vehicles should be required to provide sufficient illumination of the road to assure efficient operation of the optical sensors.

- It is likely that such requirements could be incorporated into the existing UN Regulation for Road Illumination Devices (RID).

Note: *This subject has been introduced to present a complete appraisal of the role of lighting and light-signalling for ADS vehicles. However it is a matter for initial consideration by GRE as part of its routine activity.*

Light Signalling and Lighting Requirements for ADS Vehicles

Thank you for your attention