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"From Advanced Active Safety Systems to Automated Systems: interactIVe and AdaptIVe"

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ICCS

VRA NETWORKING IN AUTOMATION

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What are the possible benefits of automated driving?

Assist the driver in monotonous and demanding tasks → Increase in traffic safety (VRU's too)

Solve traffic jams by increased outflow → Reduction in congestion (optimal distribution over the network) → **Improved travel experience**

Increase traffic stability → Reduction in congestion (optimal distribution over the network) → Improved energy efficiency

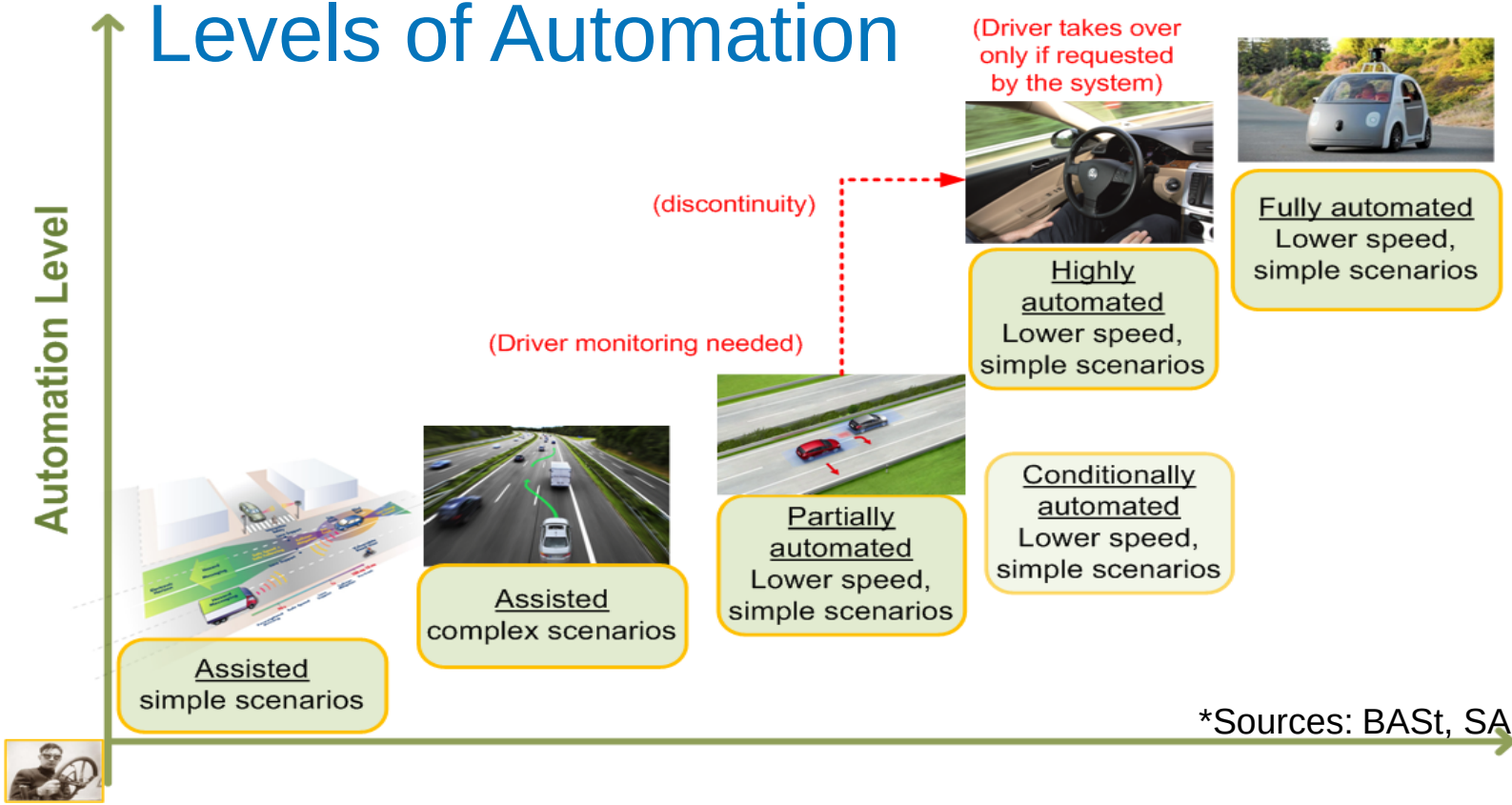
VRA NETWORKING IN AUTOMATION

How automated driving is defined

(Sourse: SAE standard (J3016, Jan 2014))

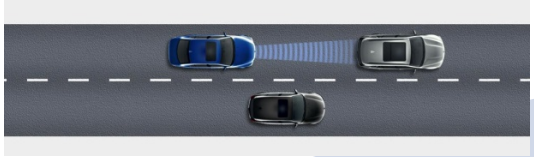
- **Level 0 – No Automation**: the full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems
- **Level 1 – Driver Assistance**: the driving mode-specific **execution by a** driver **assistance system** of **either steering or acceleration/deceleration** using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task
- **Level 2 – Partial Automation**: the driving mode-specific **execution by** one or more driver **assistance systems of both steering and acceleration/deceleration** using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task
- **Level 3 – Conditional Automation**: the driving mode-specific performance by an **automated driving system** of all aspects of the dynamic driving task **with the expectation that the human driver will respond appropriately to a request to intervene**
- **Level 4 – High Automation**: the driving mode-specific performance by an **automated driving system** of all aspects of the dynamic driving task, **even if a human driver does not respond appropriately to a request to intervene**
- **Level 5 – Full Automation**: the full-time performance by an **automated driving system** of all aspects of the dynamic driving task **under all roadway and environmental conditions** that can be managed by a human driver

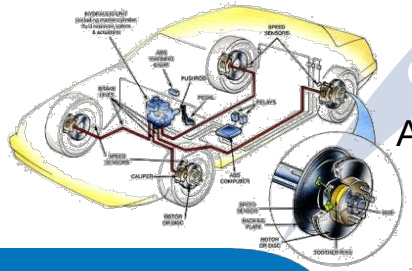
Levels of Automation



*Sources: BASt, SAE

Evolution of active safety systems

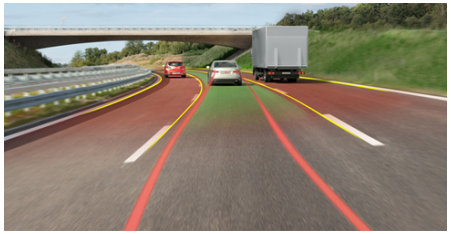




ABS

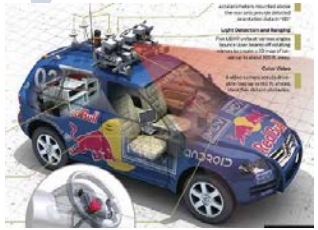
Warning systems
- collision
- lane departure

ACC, Blind spot detection, ESP



Active intervention
- lane keeping,
- longitudinal & lateral collision avoidance

Automated functions
- parking



Pole 1

- In your opinion, can automated driving systems decrease tragedies on the road?

❑ yes

❑ no

- Should the scope of fully automated driving lye within limited driving areas (e.g. airports, garages)?

❑ yes

❑ no

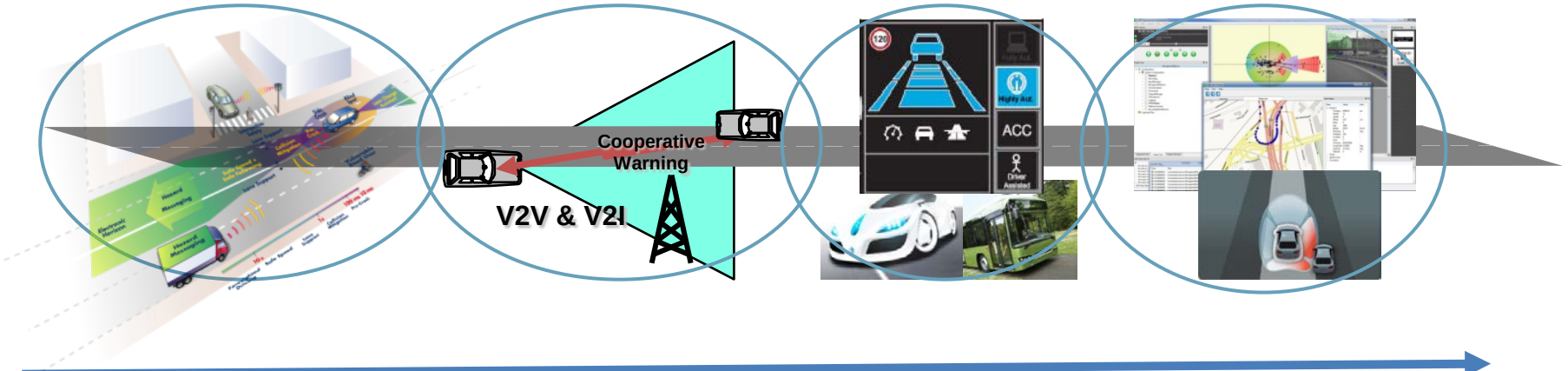
Active Safety Research Activity (EU)

PReVENT
Advanced ADAS

SAFESPOT
Cooperative systems

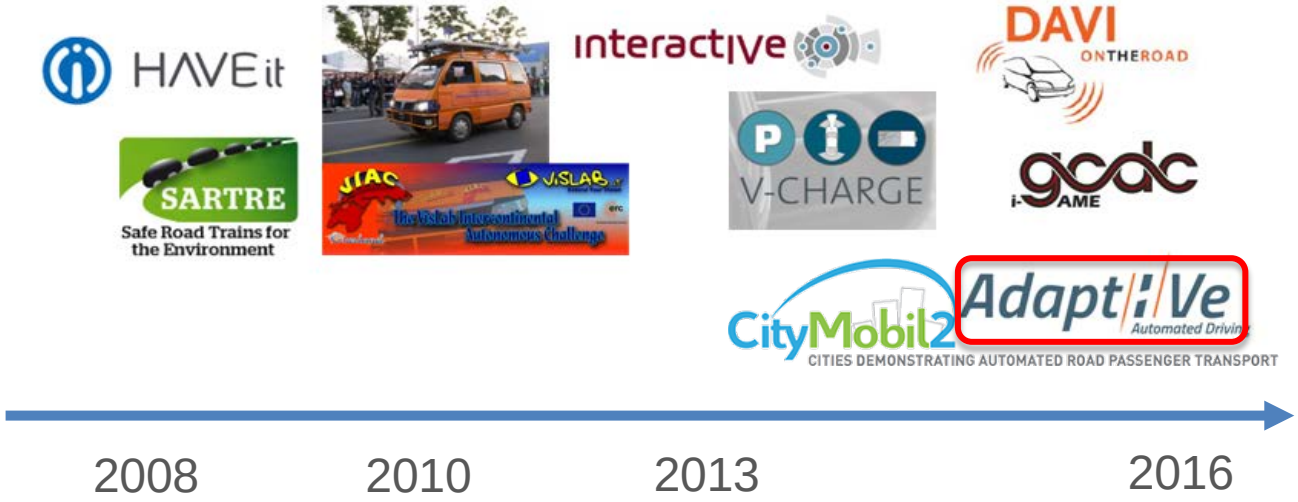
HAVEit
Highly automated driving

interactIVe
Active intervention



2008 2010 2012 2013

Automation Research Activity (EU)



SENSOR SET EMPLOYED:

- Radar (short/long range), Camera (mono-, stereo-), Laser Scanner, Ultrasonic, INU
- Digital maps
- Wireless communication (V2I, V2V)

Automated & Connected Driving

- active interventions
  - continuous support
  - transitions among automation levels

…level of automation is set dynamically

Adapt!Ve Automated Driving

- cooperative support of neighbouring vehicles
- cooperative support of the infrastructure

…resilient to different types of system and human failure

VRA NETWORKING IN AUTOMATION

Challenges

Real-time environment perception

- **Reliability** of sensing has to be **quantified;**
- Reliability has to be **improved** for real life conditions (e.g. adverse weather conditions + complex traffic scenarios);

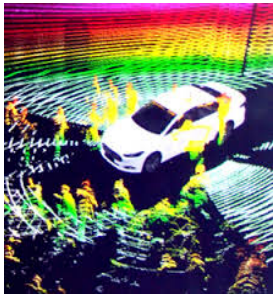
Automation control strategies

- Up to now focus on longitudinal control; **Lateral control** systems are predominantly advisory
- Complex use cases like **overtaking**, **lane merging** and **crossroad** entering/exiting need more investigation

Human factors

- Driver becomes a **supervisor** of a system instead of a **manual controller** of the vehicle
- In partial and high automation, a capable driver is still required to **resume** manual **control**
- Profound insight is needed into the **determinants** of the quality of the **interaction of the driver with the automated vehicle**
- Most knowledge in relation to driver behavior is based on **driving simulator studies and not real traffic conditions**

Deployment barriers I



- enhanced perception techniques, reliable VRU detection, collaboration with the infrastructure

- high cost of the sensors required for the full environmental perception
- immature testing and evaluation in unconstrained real conditions

Technical

- information warning and intervention strategies, mode transition, driver-vehicle-infrastructure collaboration

- integration issues, open platforms, data handling, …

Deployment barriers II

- legal and regulatory framework that implies that the driver must always be in full control of the vehicle

Legal & societal

- **Vienna convention terms “driver” and “control” allow for open interpretations (CARS Stanford study)**
- **A recent amendment has been made this year by the U.N. Working Party on Road Traffic Safety which would allow a vehicle to indeed drive itself, as long as the system "can be overridden or switched off by the driver“.**

- identify and gather relevant stakeholders (incl. governments) and present the benefits automation brings in transport, financial planning

- user acceptance, education/training, benefits/incentives, campaigns, workshops

Pole 2

- Which of the below deployment barriers do you consider as the most important?

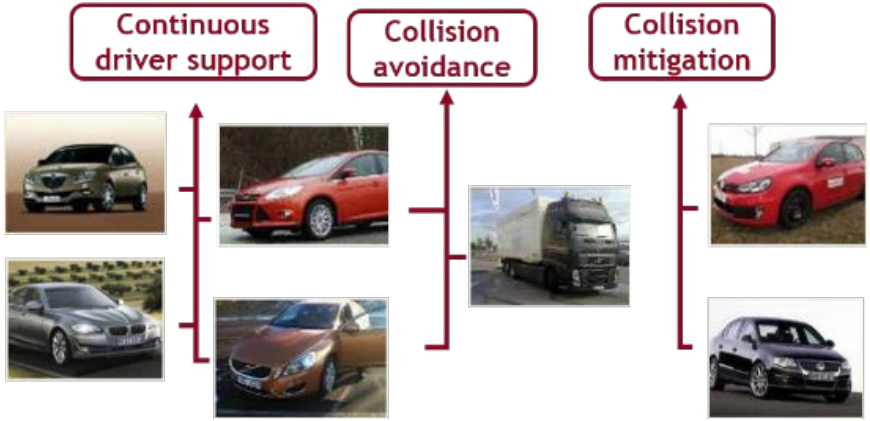
- ❑ Sensor set cost
- ❑ Technical immaturity of active safety systems
- ❑ Legal and liability issues

A closer look in…

(2010-2013)

VRA NETWORKING IN AUTOMATION

Overview



Current systems:

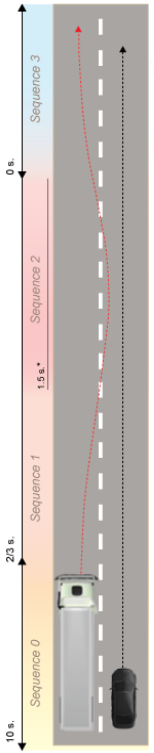
- independent functions for a dedicated task
- multiple expensive sensors

interactIVe:

- Active intervention poses “hard” real-time requirements for application data processing & sensor fusion modules
- Design of a **unified perception framework** for multiple safety applications
  - Different sensor types and products attached based on the **plug-in concept**
- Advance research on **path control algorithms** for active **collision avoidance** and **mitigation**
- Advance research on IWI strategies and **assistance** ⇔ **intervention** transition modes

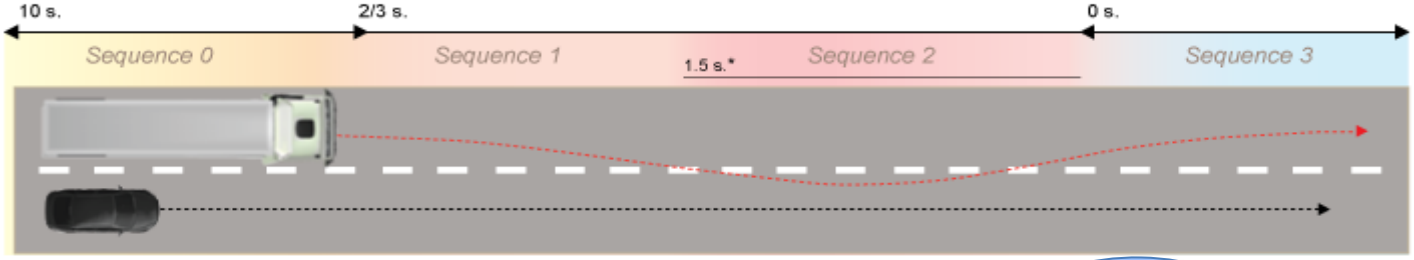
Functions

- **Continuous driver support**
  - Continuous Support
  - Curve Speed Control
  - Enhanced Dynamic Pass Predictor
  - Safe Cruise
- **Collision avoidance**
  - Lane Change Collision Avoidance & Side Impact Avoidance
  - Oncoming Vehicle Collision Avoidance/Mitigation
  - Rear End Collision Avoidance
  - Run-off Road Prevention
- **Collision mitigation**
  - Collision Mitigation System
  - Emergency Steer Assist



Functions' features

Partial + conditional automation (SAE)



- Oncoming vehicle collision avoidance / mitigation
- Side impact avoidance (depicted above):
  - Lane Change Collision avoidance
  - Rear end collision avoidance
  - Run off road prevention (curve)
- Automated emergency braking
- Emergency Steer Assist

soft feedback on the steering wheel is provided supported by corrective steering

Auto-braking+ Evasive maeuver

Assisted mode: adapts its speed automatically to the curve radius ahead.

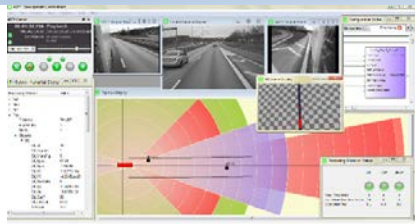
- **Optimized point of impact**
- Any braking and/or steering intervention of the function can be overridden by the driver

Other automation areas covered

- **IWI strategies provide**
  - sequence of interaction
  - automation scale
    - …which allow the integration of a high number of ADAS
- **Tests on System – User shared** control concept in highway, rural and urban environments with emphasis on haptic feedback
- **Legal aspects study**
  - vehicle type-approval for interactive functions according to relevant UN ECE
  - legal framework on EU-level

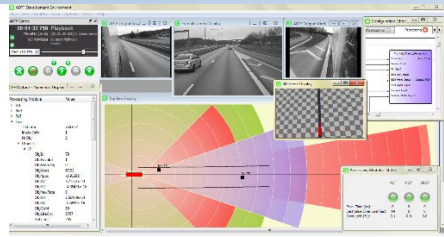
The **Driver Override Detection module** monitors the driver actions and decides if the driver is considered to be performing an action out of a predefined set that includes braking, steering, manoeuvring and accelerating

Lessons learned I



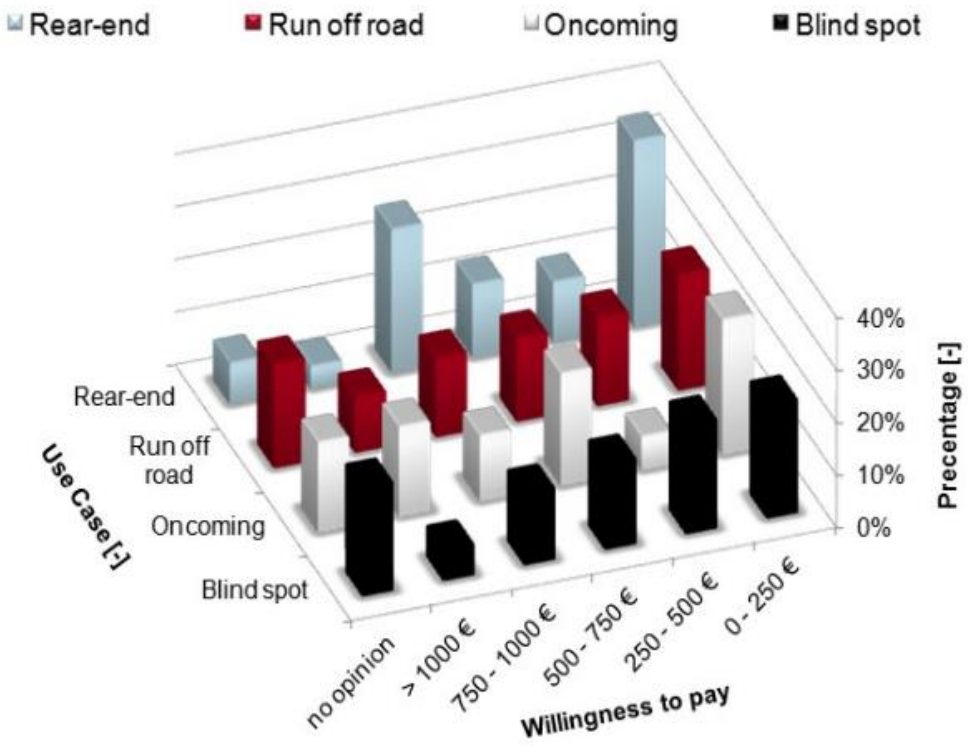
- Often drivers start a reflexive reaction by counteracting the intervention to some extent:
  - Active interventions, especially when steering and braking are combined, requires further investigations with a larger set of subjects and situations.
  - The drivers should be allowed to overrule the functions. Which strategy is best depends on the function.
  - IWI strategies should ensure a smooth transition with regard to the different levels of human and system control. It appears convenient to group automation functions into modes of increasing degree of automation, as well as to the type of support and direction.

Lessons learned II



- Obtain near real time perfrmance
  - **Real time OS** + **object-level fusion** (need for new sensors)
- Extensive evaluation of RunOfRoadPrevention
  - **Need for** common groundtruth data such as **road edge annotations**
- Longitudinal and lateral **optimal control models** for understanding driver's intentions can proliferate from **cognitive science based driver models**
- A very high reliability is needed for the **lane change manoeuvre** to ensure that the adjacent lane is free. Also, more efforts are needed to improve the **estimate of the vehicle position**, e.g. by implementing all the available signals and fully exploiting the GNSS techniques

Lessons learned III



Pole 3

- Which of the following systems would you care to purchase for your vehicle?

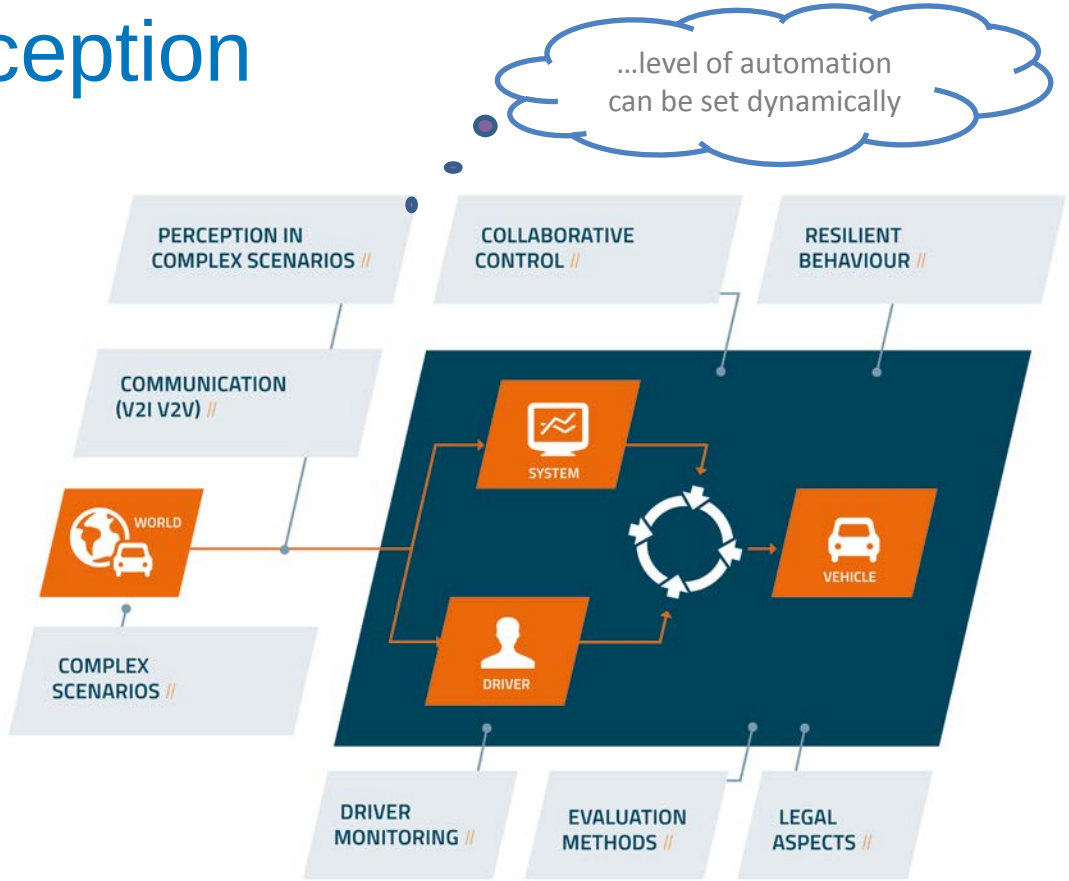
- ❑ Oncoming vehicle collision avoidance
- ❑ Rear-end collision avoidance
- ❑ Run-off road prevention
- ❑ Blind spot warning
- ❑ Collision mitigation system

A closer look in…

(2014 - 2017)

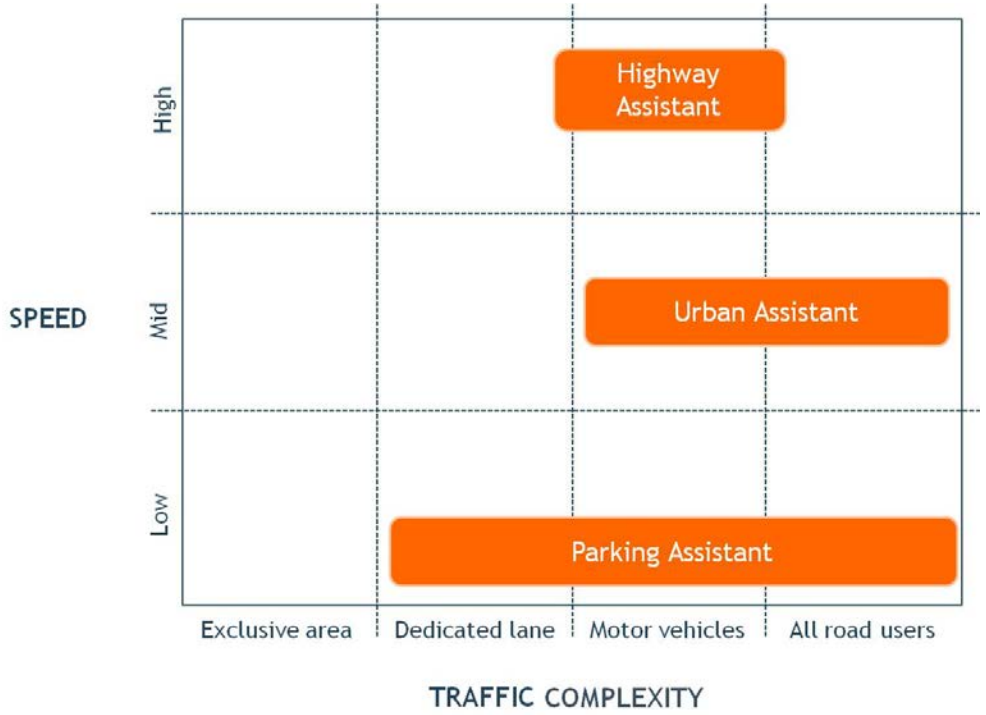
VRA NETWORKING IN AUTOMATION

Conception

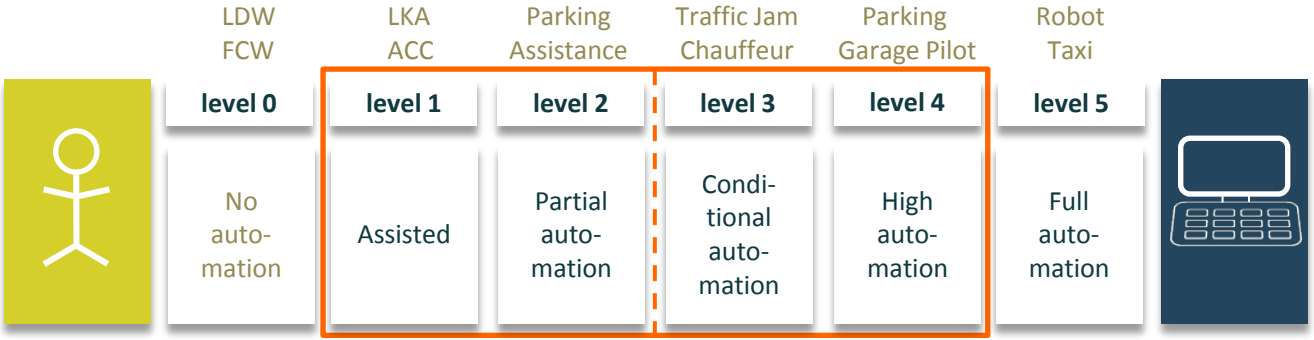

…level of automation
can be set dynamically
PERCEPTION IN COMPLEX SCENARIOS //
COLLABORATIVE CONTROL //
RESILIENT BEHAVIOUR //
COMMUNICATION (V2I V2V) //
SYSTEM
WORLD
VEHICLE
DRIVER
COMPLEX SCENARIOS //
DRIVER MONITORING //
EVALUATION METHODS //
LEGAL ASPECTS //

Application domain

- suited for **mixed traffic**
- **real world** complex **environments**
- provide **adaptive support** based on the driving task demand (bidirectional **V2V** also included)
- **design “take over requests”** based on system and driver state
- **deployable in a short to medium time**



Automation concept



Driver in the loop

- No significant change with respect to existing driver assistance systems

Driver out of the loop

- Not in accordance with regulatory law (Vienna Convention, national road law)
- Extra risk with respect to product liability

➔ need for action

Features (1/2)

- Supervised automated driving deployed into **assistance**, **partial**, **conditional** and **high** automation
  - advanced parking applications;
  - stop&go functionality in high traffic/slow speeds
- **Full** automation will be studied for **special** situations:
  - return to a minimal risk condition;
- **Controlled and graceful degradation** from high to partial automation and from partial automation to driver assistance will be exploited as a strategy to manage complex scenarios in a robust and safe way.

Pole 4

- What is the best strategy for increasing user confidence on a mixed-automation system

- ❑ Design that promotes resilience to different human failure or system failure errors (including automatic return to a minimal risk condition)
- ❑ System-User shared control concept with graceful transitions among different automation modes
- ❑ User should be always able to override the system

Features (2/2)

New features

- suited for **mixed traffic**
- **real world** complex environments
- provide **adaptive support** based on the driving task demand (bidirectional **V2V** also included)
- **design "take over requests"** based on system and driver state

→ …design and develop solutions for the automation of vehicles that will become **deployable in a short to medium time frame** in new vehicle models

Pole 5

- How close are we to sensor fusion systems that can adapt their detection resolution based on the dynamic context of the road scene?

❑ 1-2 years

❑ 4-5 years

❑ more than 5 years

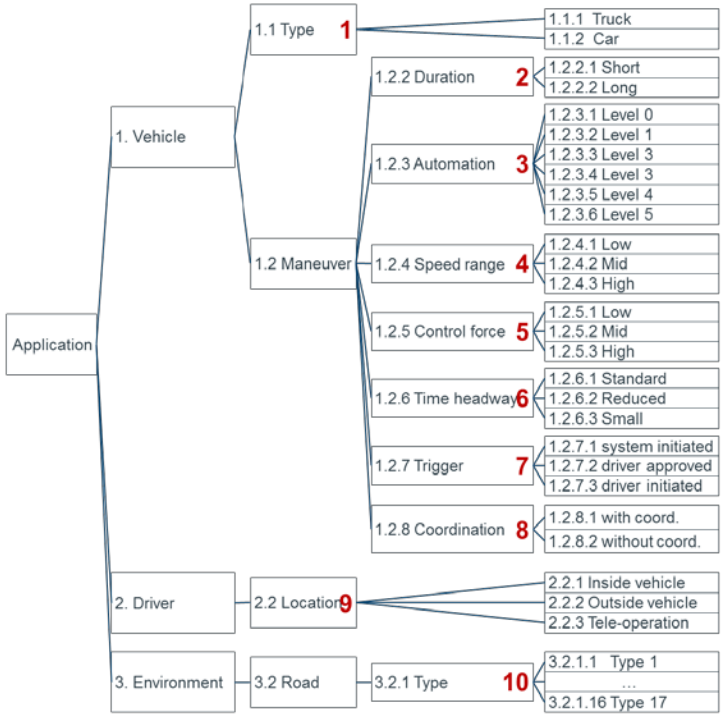
Scenarios overview

- Close distance scenarios
  - Automated parking in
    - Private areas (dwellings, large parking garages, etc.)
    - Outdoor environments (street side, parking lots, etc.)
  - Construction site assistant
  - Reverse manoeuvring in controlled environments
- Urban scenarios
  - Urban Speed and Headway Control (longitudinal)
  - Full Vehicle Control in urban traffic (longitudinal and lateral)
- Highway scenarios
  - Enter / Exit highway
  - Driving in traffic jam
  - Following lane
  - Lane Change & Overtaking
  - Danger spot intervention

- Common
  - Stop & go
  - Minimum risk manoeuvre

Functions classification (ongoing work)

- Classification by level of automation and speed is not sufficient for further work
- Additional parameters are needed (see example aside)
- Collect and structure parameters, limit to essentially needed ones



Pole 6

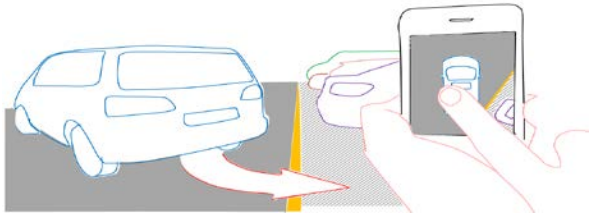
- In which scenarios do you think highly automated functions could help your everyday driving the most?

- ❑ highway scenarios
- ❑ inside city scenarios (e.g. crossroads)
- ❑ parking

Legal issues (ongoing work)

- Cover relevant legal areas for industry
- Assess national laws for main target markets (Europe and overseas)
- Need for harmonization
- Built on function classification

Which laws and regulations have to be changed?



Vienna Convention	National Regulatory Law	Homologation -> UNECE	Liability		Data privacy and data security
			Product liability/tort law	Criminal liability	Ownership, Use, Tampering

Conclusions

- New active safety / automation functions need to be verified:
  - from legal perspective
  - from functional safety perspective
  - from human factors perspective
- Testing protocols and ground truth data are crucial!

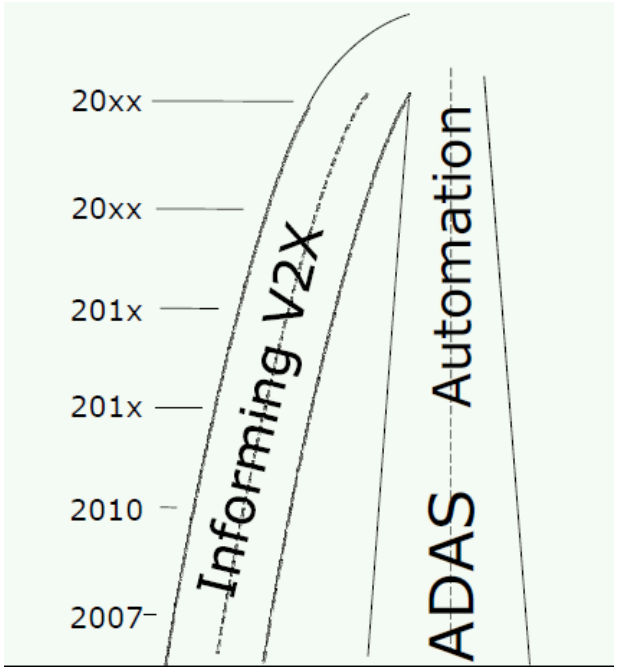


*Image source: T. Gasser 2012 (BASt)

Thank you for your attention!

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