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WE MAKE FUTURE MOBILITY SAFE AND RELIABLE.

Connected and automated driving in the conflict between regulation and standardization, technical opportunities and market requirements

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Kompetenznetzwerk für automatisierte und vernetzte Mobilität NRW

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Motivation

- With DARPA Grand Challenge 2005, automated driving no longer seems to be a pure vision, but a real option for future mobility
- Traditional car industry, tech-companies and service providers have entered technology
- Expectations were extremely high
- Almost 20 years later, this is the situation on market
  - ➢assisted driving well establish
  - ➢highly automated driving hardly widespread
  - ➢regular autonomous driving is practically non-existent
- **Have we turn wrong with automated driving? And if so, why?**

DARPA Grand Challenge winner „Stanley“
https://images.app.goo.gl/t7rvjCzQgQh94vUb9

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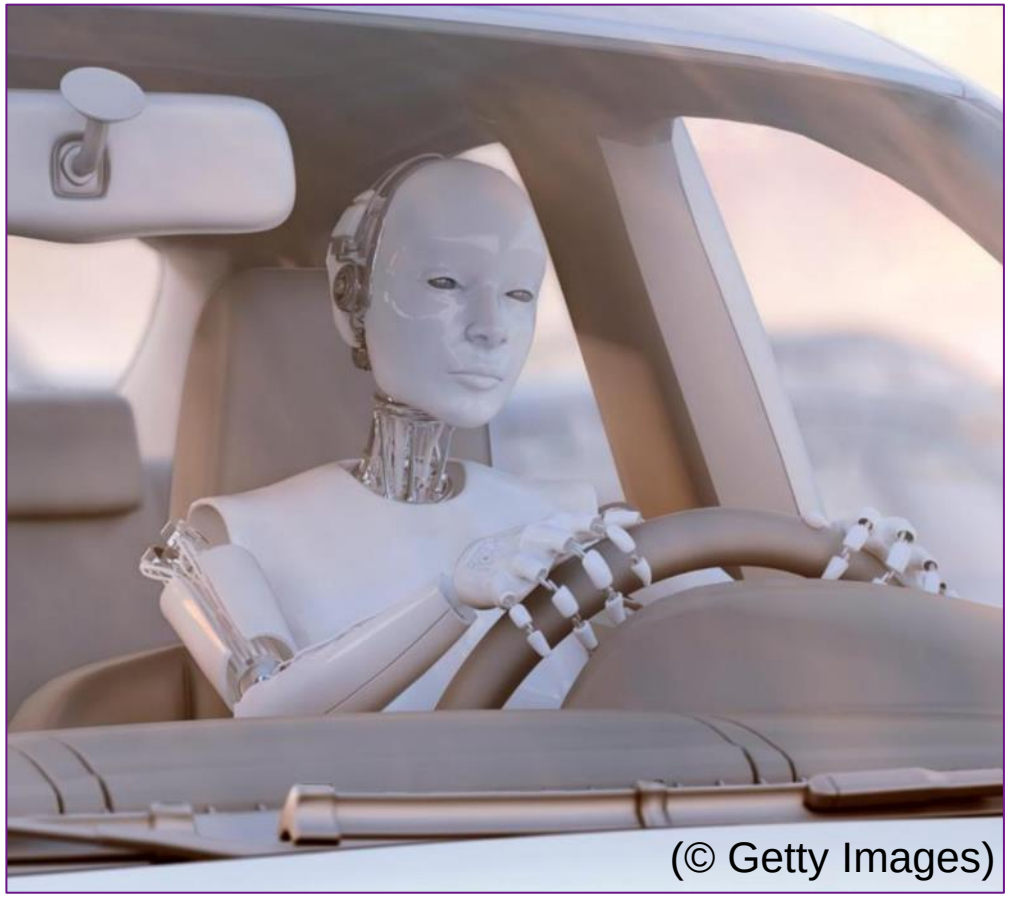
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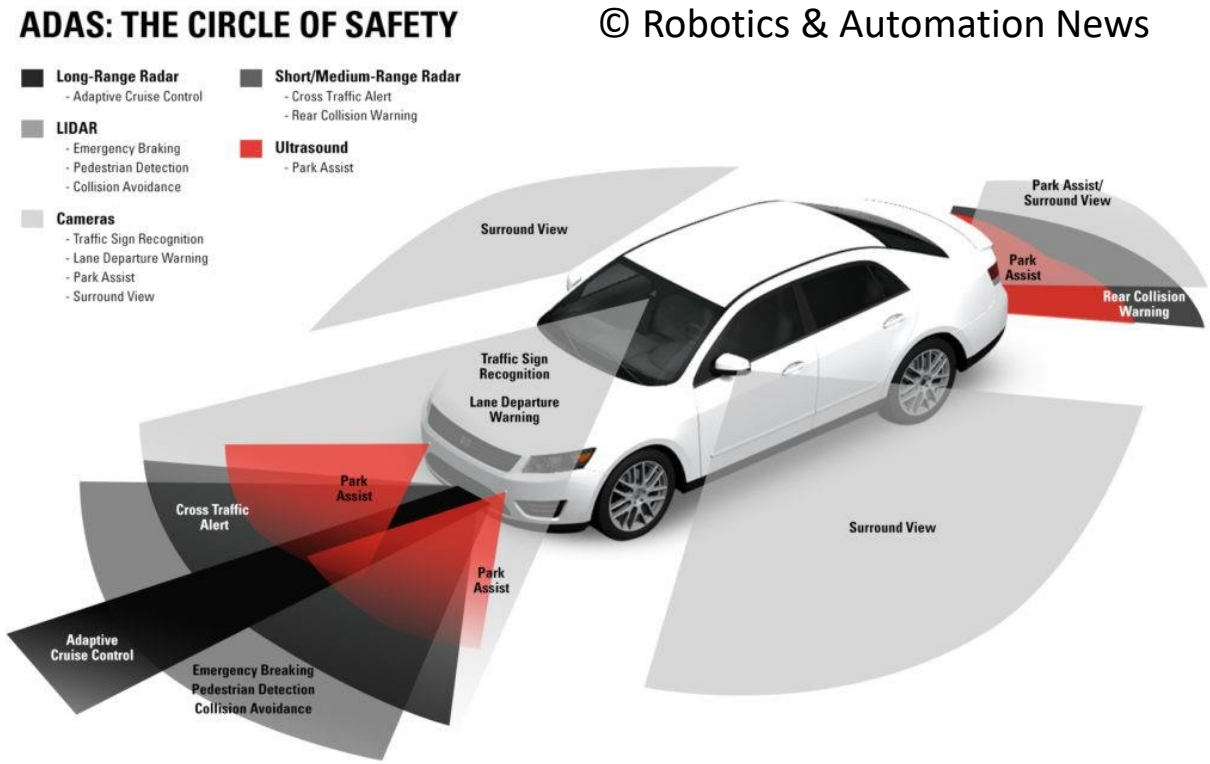
- Level 2 ADAS on their way to becoming standard equipment
- Level 3 in passenger cars is no blockbuster
- Level 4 people and goods mover on the verge of regular operation
- Summary and outlook

Initial situation and benefit of Level 2 ADAS

- ADAS available in all markets and for many vehicle classes (most popular ACC, LKA)
- Systems offer high safety benefits because they support drivers exactly where support is needed (during monotonous driving tasks, at inattention or distraction)
- Complex driving tasks and situations that require high flexibility or anticipation remain in drivers' hands
- Effort for state-of-the-art systems considerable



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- But there are 2 effective ways of market introduction and dissemination

Mandatory introduction according to EU GSR 2019/2144

		M1	M2	M3	N1	N2	N3
AEB VRU	UN R152-02	NT 7/2024 NR 7/2026			NT 7/2024 NR 7/2026		
AEB Car-to-Car	UN R152-00	NT 7/2022 NR 7/2024			NT 7/2022 NR 7/2024		
VRU Collision Warning	UN R159		NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024		NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024
Blind Spot System	UN R151		NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024		NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024
ELK	EU 2021/646	NT 7/2022 NR 7/2024			NT 7/2022 NR 7/2024		
ISA	EU 2021/1958	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024
Drowsiness Detection & Warning	EU 2021/1341	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024
Advanced driver distraction warning		NT 7/2024 NR 7/2026	NT 7/2024 NR 7/2026	NT 7/2024 NR 7/2026	NT 7/2024 NR 7/2026	NT 7/2024 NR 7/2026	NT 7/2024 NR 7/2026
Event data recorders EDR	EU 2022/545	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024	NT 7/2022 NR 7/2024

NT = New Types
(Date for refusal to grant EU type-approval of vehicles that do not meet the requirements)

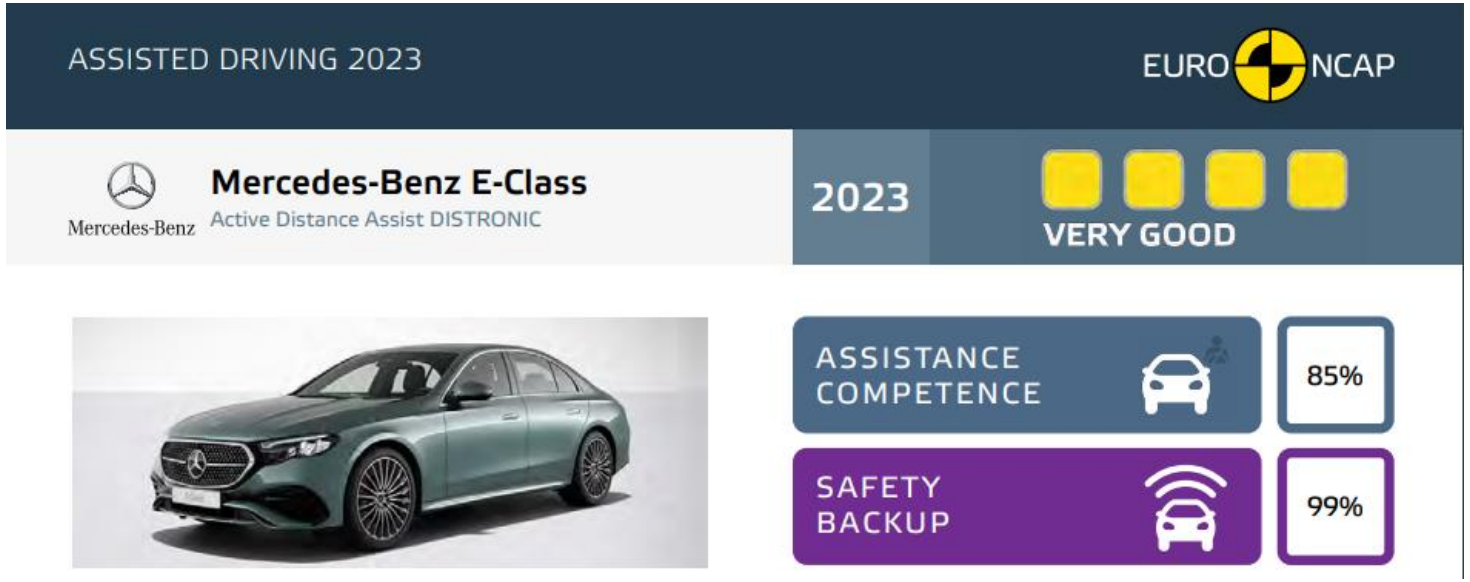
NR = New Registrations
(Date for the prohibition of the registration of vehicles that do not meet the requirements)

https://www.carhs.de/de/adas-companion.html

Voluntary introduction due to ratings

- Consumer protection organizations as ADAC or Euro NCAP promote dissemination of safety systems with their ratings

- Customers prefer vehicles with best ratings, at least in industrialized countries



https://www.euroncap.com/en/ratings-rewards/assisted-driving-gradings/

- Dissemination mechanism is well known from, e.g., ESC or airbags

- **Even ADAS that are not required by law will becoming standard equipment this way**

Hands-off ADAS

- Requirements on / approval of hands-on Level 1 & 2 systems is rather simple because driver is fully responsible for dynamic driving task
- It was sufficient to demonstrate that systems do not inadmissibly influence the longitudinal and lateral control of the vehicle by the driver, either during intended operation or in the event of a false negative or false positive action
- Situation is changing for hands-off systems, already available in several markets (Germany: BMW & Ford)

Hands-off ADAS

- Customer benefit increase but responsibility is still with drivers
- 2023 Jan.: Report of VDA commissioned Level 2 hands-off (L2H-off) project
- 2023 July: OICA/CLEPA proposal for hands-free provisions in Driver-Control Assistance Systems (DCAS) regulation (1st limited to roads with separation of oncoming traffic & no VRU)
- 2023 Sept.: ISO PAS 11585: Road vehicles Partial driving automation - Technical characteristics of conditional hands-free driving systems

Results of VDA L2H-off project

https://www.vda.de/de/aktuelles/publikationen/publication/level-2-hands-o---recommendations-and-guidance

- Visual attention to road does not decrease when Driver Monitoring System (DMS) is implemented (hands off + eyes on)
- Intervention times at functional limits do not increase
- Potential for misuse does not increase with a view-based DMS (closely related to DMS design)
- Mode confusion does not increase when providing prior information on driver role and system functioning
- No difference of interaction quality in terms of criticality metrics and perceived safety
- **Results must be confirmed by product monitoring and market surveillance measures!**

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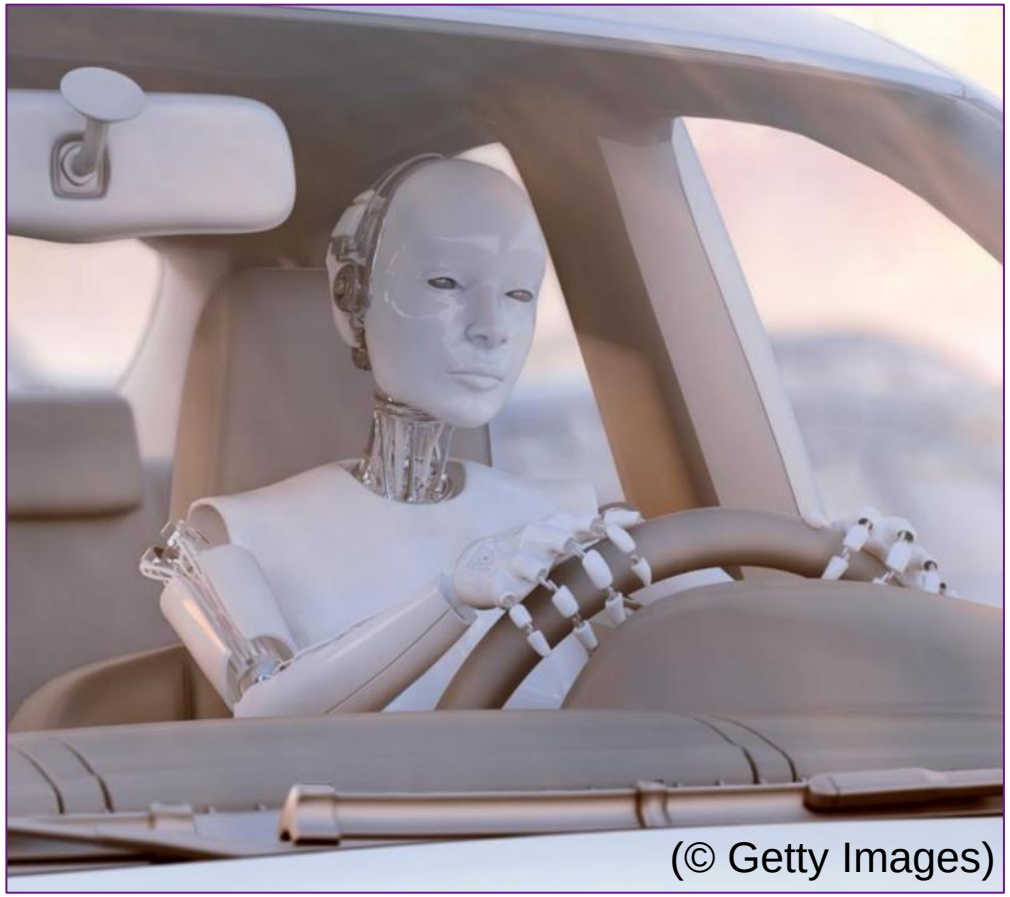
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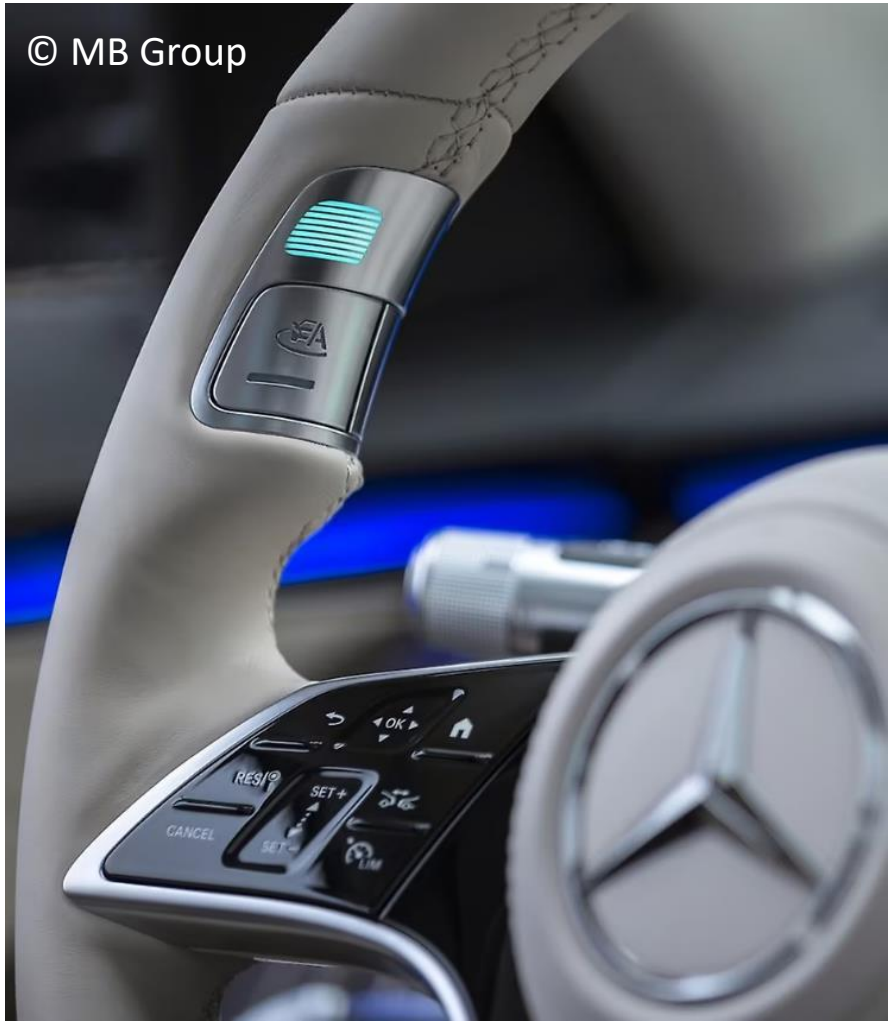
Initial situation for level 3 systems in passenger cars

- Legal and normative framework and technology are in place
- List of currently available Level 3 systems fairly short:
  - Honda Legend 2021 (only Japan)
  - Mercedes S Class / EQS 2022 (only Germany, stepwise introduction in US and China)
  - BMW 7 series “available to order” since 2024 (1st only Germany)
- ODD is limited to motorways, good road and weather conditions and up to 60 km/h
- Gradual increase to UN R157 (2022) speed limit 130 km/h is planned



Benefit and dissemination

- Systems seems to be unattractive for customers (may be for manufacturers, too) in terms of cost-benefit ratio because of
  - Limited ODD
  - Although non-driving activities are permitted, requirement of sufficient driver attention limits their scope
  - Price of about 6.000 Euro + costs for connectivity services

- Manufacturers fear increase of liability issues

- Although some manufacturers announce Level 3 systems for near future, no rapid breakthrough is in sight in passenger cars, especially not in lower vehicle segments

Future development of level 3 systems and components

- Sensor equipment for level 3 applications is very similar to ADAS
- Benefit from development of ADAS into standard equipment and associated economies of scale
- Costs for LIDAR systems for passenger cars, e.g., was estimated at
  - 50.000 Euro in 2015 (Boston Consulting Group)
  - 1.000 Euro in 2023 (automotiveIT)

- New developments of sensor technology, e.g., 4D imaging or full range RADAR with
  - lower costs than LIDAR
  - comparable features (measurement of distance, speed, horizontal and vertical extension of objects)
  - currently 1° resolution far away from 0,05° for LIDAR

Future development of vehicle architecture and connectivity

- Level 3 (and beyond) systems reach limits in complex environments and/or at higher speeds caused, e.g., by
  - ➢current decentral E/E architecture and
  - ➢restricted view of on-board sensors (range, occlusion)
- Reduction of limitations & increase of customer benefit
  - ➢transition to software defined vehicles with central E/E architectures and
  - ➢use of external data (from other vehicles, smart infrastructure, digital mobility ecosystems)
- Safeguarding and approval of safety relevant, distributed & connected systems is still unsolved and, therefore, subject of current research work (see, e.g, ConnRAD https://www.forschung-it-sicherheit-kommunikationssysteme.de/projekte/connrad)


https://www.openaccessgovernment.org/wp-content/uploads/2021/06/dreamstime_xl_192386794-scaled.jpg

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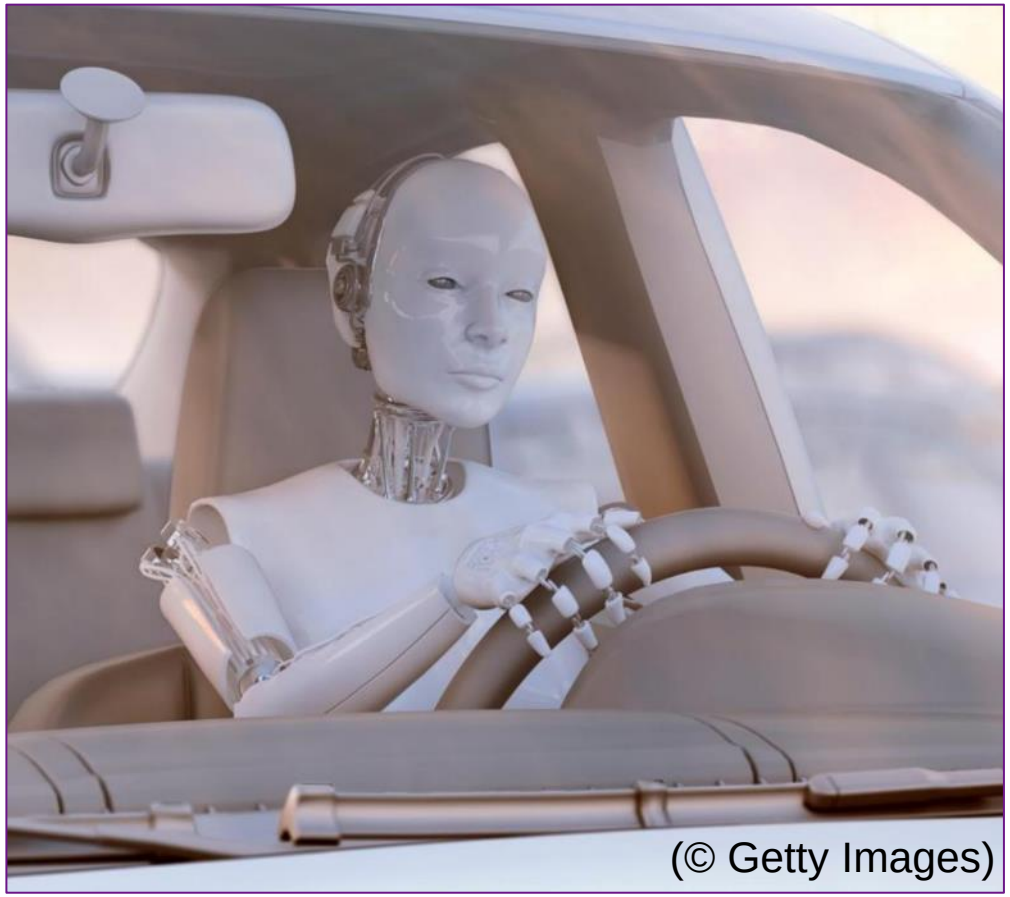
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Initial situation for level 4 People and Goods Movers

- Typical use case: on-demand / first and last mile services
- Mobility as a Service (MaaS) for people where public transportation is currently not available, e.g.,
  - ➢Off-peak times
  - ➢Outlying areas
  - ➢Rural areas
- Transportation as a Service (TaaS) for goods without local emission, lower consumption of traffic area and - if it is done well - with lower packaging effort etc.
- Often less complex traffic situations and therefore less demanding technology
- Integration with smart infrastructure relatively easy

© Deutsche Bahn, REWE

Benefits and dissemination

- Easier to implement and with higher benefit from environmental and transport policy perspective, compared with, e.g., robotaxi
- Use cases are extensively tried and tested - VDV listed more than 60 project only in Germany (https://www.vdv.de/liste-autonome-shuttle-bus-projekte.aspx)
- Service providers want to start with regular operation
- Legal and normative requirements are available in principle
  - Autonome-Fahrzeuge-Genehmigungs-und-Betriebsverordnung (AFGBV) or Implementation Directive (EU) 2022/1426 for Automated Driving Systems (ADS)
  - Application standards for safety and cybersecurity (ISO 26262, ISO 21448, ISO/SEA 21434)
  - Application standards for ADS (ISO TR 4804 and ISO/CD TS 5083)

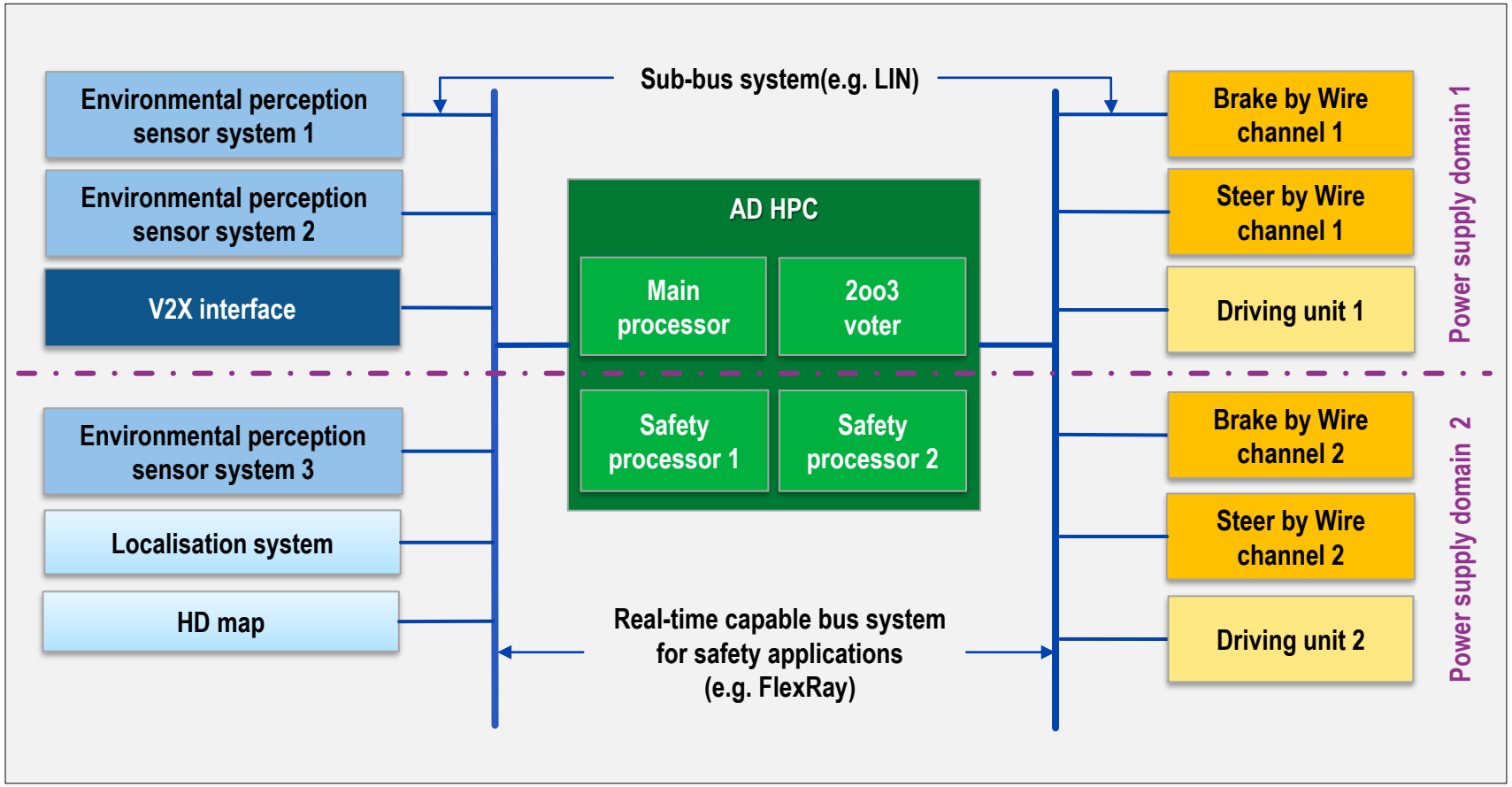
Main problems for implementation

- 1st generation of People and Goods Movers do often not fulfill legal and normative requirements for regular driverless operation
- Interpretation of laws and proof of compliance with standards is not easy for manufacturer and system developers
- Startups, tech-companies and other "young savages" and service providers without industry knowledge meet Technical Services, KBA and regional / local authorities (the latter often do not know themselves whether or what they are responsible for)
- Nobody has experience with implementation (best practice is not available)
- To overcome this hurdles, we have to discuss
  - ➢ technical requirements and
  - ➢ procedural aspects

Technical requirements for Level 4 People and Goods Movers

Generic SOTIF-HARA* delivers a Level 4 ADS with

- Redundant / diverse sensor systems
- Redundant Drive-by-wire systems and power supply
- Fail-degraded processing, e.g., central AD High Performance Computer with 2oo3 logic
- ASIL** D capability



* *Safety Of The Intended Functionality - Hazard Analysis and Risk Assessment according to ISO 21448*

** *Automotive Safety Integrity Level according to ISO 26262*

Procedural aspects for Level 4 People and Goods Movers

- All parties – vehicle manufacturers, service providers, independent experts and authorities – should develop implementation procedures together
- Start with *model procedures* for class M, N and L vehicles and vehicles with maximum design speed up to 6 km/h
- Defined operating areas have to be permitted by regional authorities – harmonized procedures for Germany or, if possible, for Europe should be agreed, therefore
- Finally, codes of practice, fact sheets or guidelines can be derived by stakeholders according to their special needs (see, e.g., Hi-Drive CoP for harmonized admission procedure for test operation of automated driving systems on public roads in Europe https://www.hi-drive.eu)

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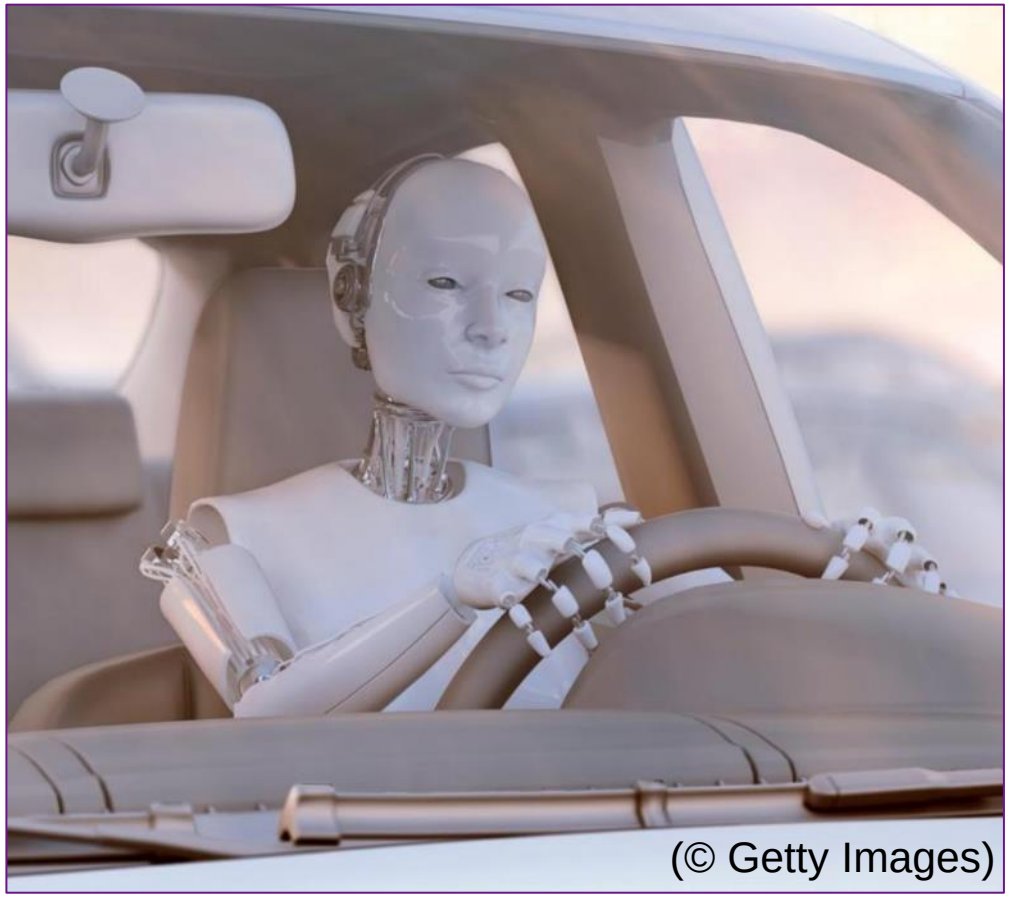
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Summary and outlook

Level 2

- ADAS offer high safety benefits and will become standard equipment
  (1) by legal requirements and
  (2) due to ratings of consumer protection organizations
- Hands-off ADAS will increase customer benefit
- Because of responsibility is still with drivers, Driver Monitoring Systems will be unavoidable for safe operation of L2H-off systems

Level 3

- Legal and normative framework and technology in place, but poor cost-benefit ratio likely to prevent wide market dissemination in passenger cars
- Transition to software defined vehicles with central PC architectures and integration into digital mobility eco-systems can increase customer benefit
- Safeguarding and approval of safety relevant, distributed, connected systems is subject of current research work

Summary and outlook

Level 4 People and Goods Movers

- MaaS and TaaS offer high benefit from environmental and transport policy perspective
- Implementation will start in less complex traffic environments, e.g., on first and last mile
- For safe and reliable operation (“safety and ease of traffic”), fail-degraded system design is necessary
- Stakeholders should develop implementation procedures together

Outlook for Level 4 in long-distance traffic of trucks and busses

- Hub-to-hub operation for trucks useful, e.g., in combination with teleoperation between hubs and highway entrances and exits (in hearing: Straßenverkehr-Fernlenkverordnung - StVFernLV)
- Transport companies and freight forwarders often express expectation that automation can replace tens of thousands of missing professional bus and truck drivers - from today's perspective, this is rather unrealistic

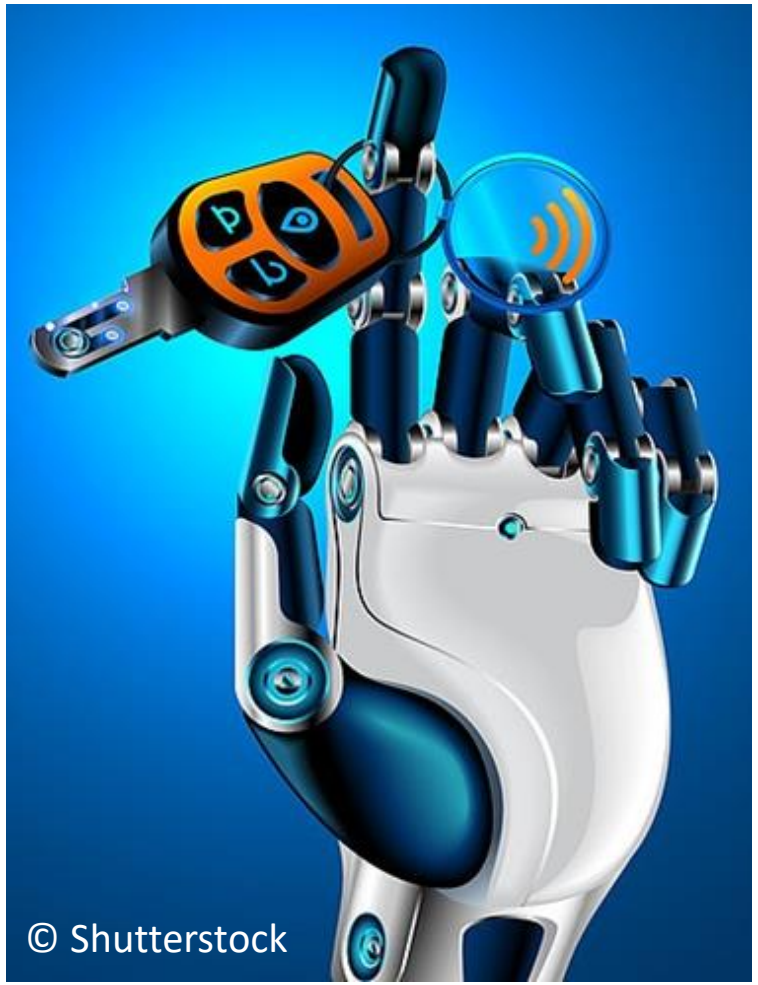
Summary and outlook

Personal, today's perspective regarding Level 4 & 5 in passenger cars

- Considering the situation with market introduction and dissemination of Level 3 systems in passenger cars, Level 4 systems, e.g. Automated Valet Parking, will probably not achieve significant market shares

- Level 5 makes no sense from environmental and transport policy perspective and a *business case* is currently not in sight

Resume



- Questions we have addressed
  - What requirements arise from regulation and standards?
  - What can be implemented technically?
  - What stands in the way of market introduction and dissemination and what can we do about it?
- No dissemination without business case
  - End consumers are willing to pay for individual safety and comfort …
  - Society is willing to pay for overall traffic safety, less traffic, less pollution …
- Potential of automated driving to fulfill expectations of individuals and society and to resolve conflicts of interest between stakeholders is far from exhausted!

Thank you for your time.
Are there any questions?

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