Automated Driving – Challenges and Capabilities

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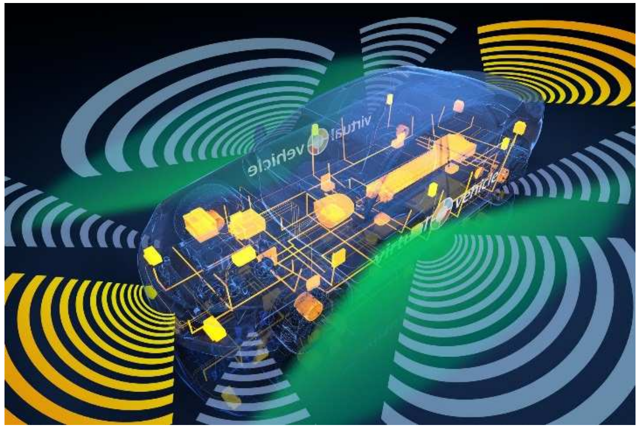
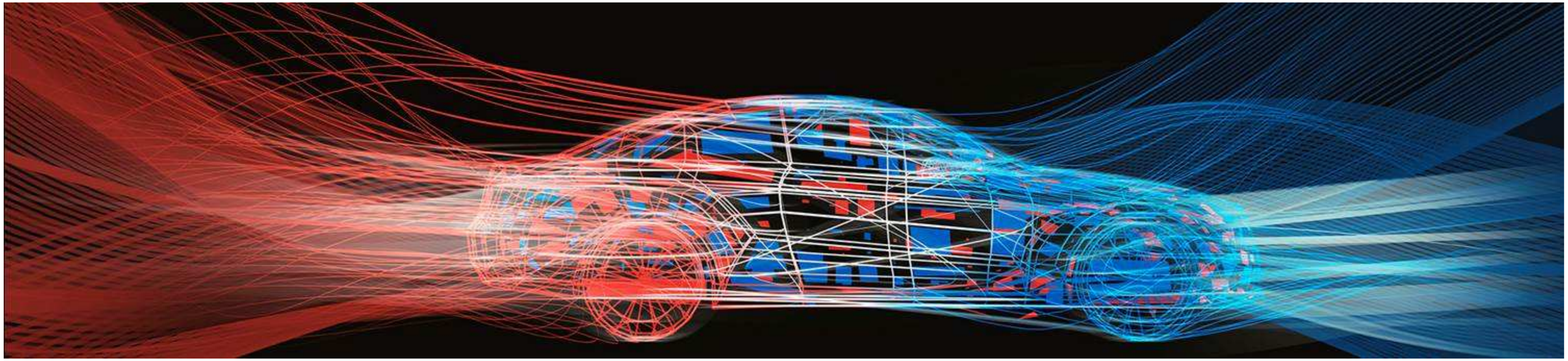


Smarte Produkte & Smarte Systeme
FH Kufstein, Tirol
November 25, 2016

Outline

- **Motivation**
- Automated driving – challenges and roadmap
- Building blocks of automated driving
- Safety and reliability
- Required fields of action



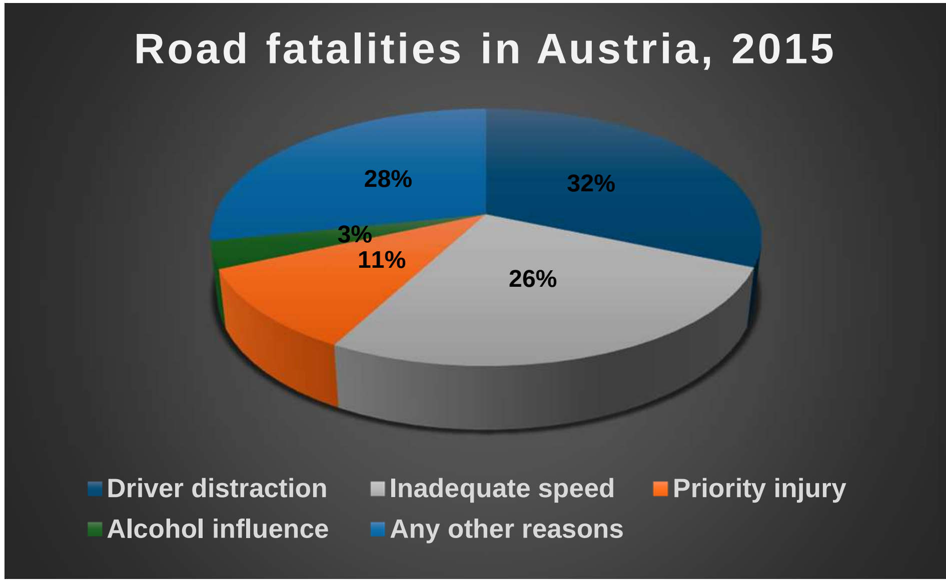
Motivation for automated driving

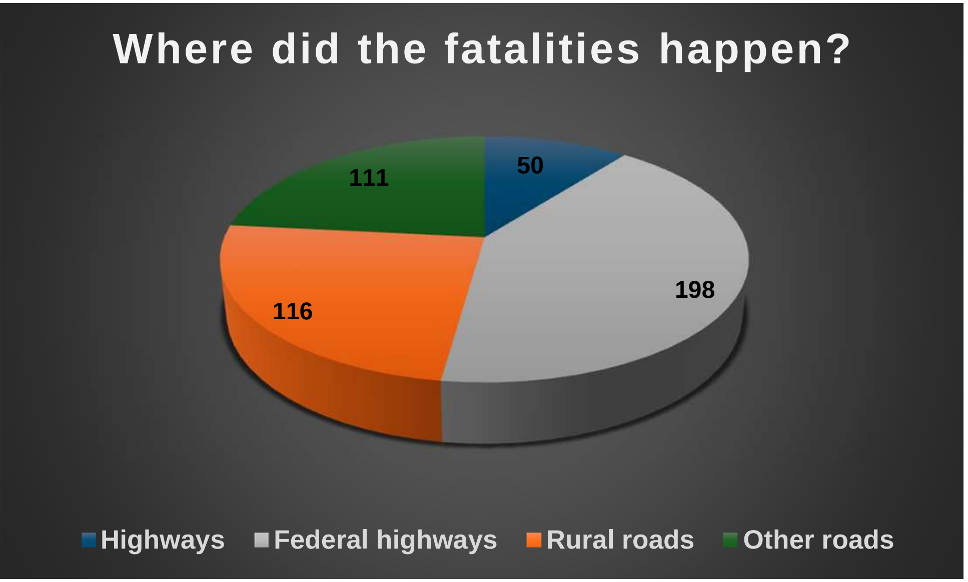
1	Road Safety: Vision Zero	Road safety improvements by reducing human driving errors → **90% of all accidents are caused by human errors**	
2	Traffic Management	- Optimization of traffic flow management - Convenient, time efficient driving via automation → **80% improvement in traffic troughput**	
3	Reducing Emissions	Reduction of fuel consumption & CO^2 emission (through optimization of traffic flow management) → **23 to 39% improvement in highway fuel economy**	
4	Demographic Change	- Support unconfident drivers - Enhance mobility for elderly people → **Allow a variety of age ranges to be mobile**	
5	Innovation High technology	- New economic paradigm – supporting innovation policies of regions, nations - Competitiveness / high skill employment → **56 minutes per day freed up for other uses (US)**	

[Source: Tech.AD, Conference on Automated Driving, Berlin, 2015]

Road fatalities in Austria (2015)

Road fatalities	2014	2015
Austria	430	**475**
Germany	3.377	**3.475**
EC	25.700	**26.000**





[Source: Austrian Federal Ministry for Transport, Innovation, and Technology, 2016]

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- **Automated driving – roadmap and challenges**
- Building blocks of automated driving
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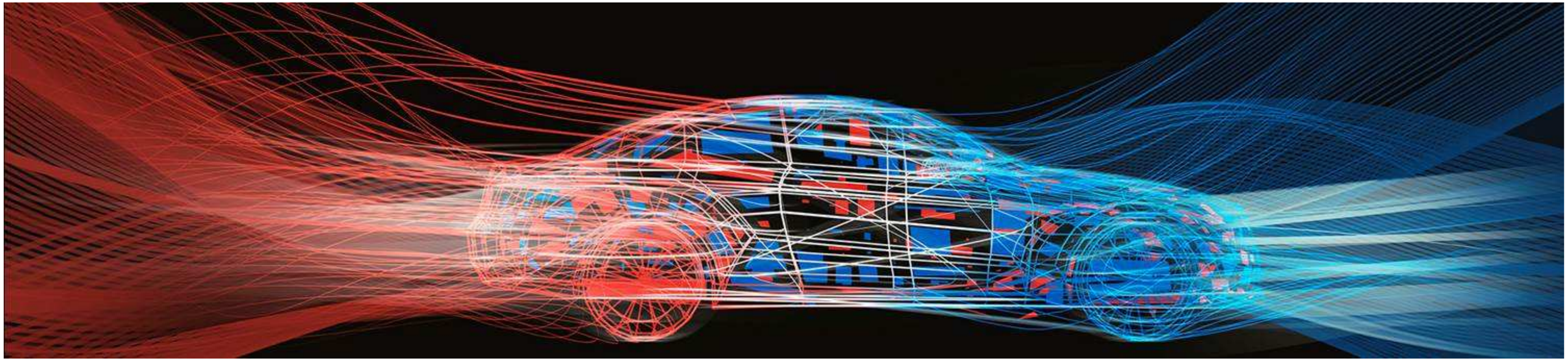
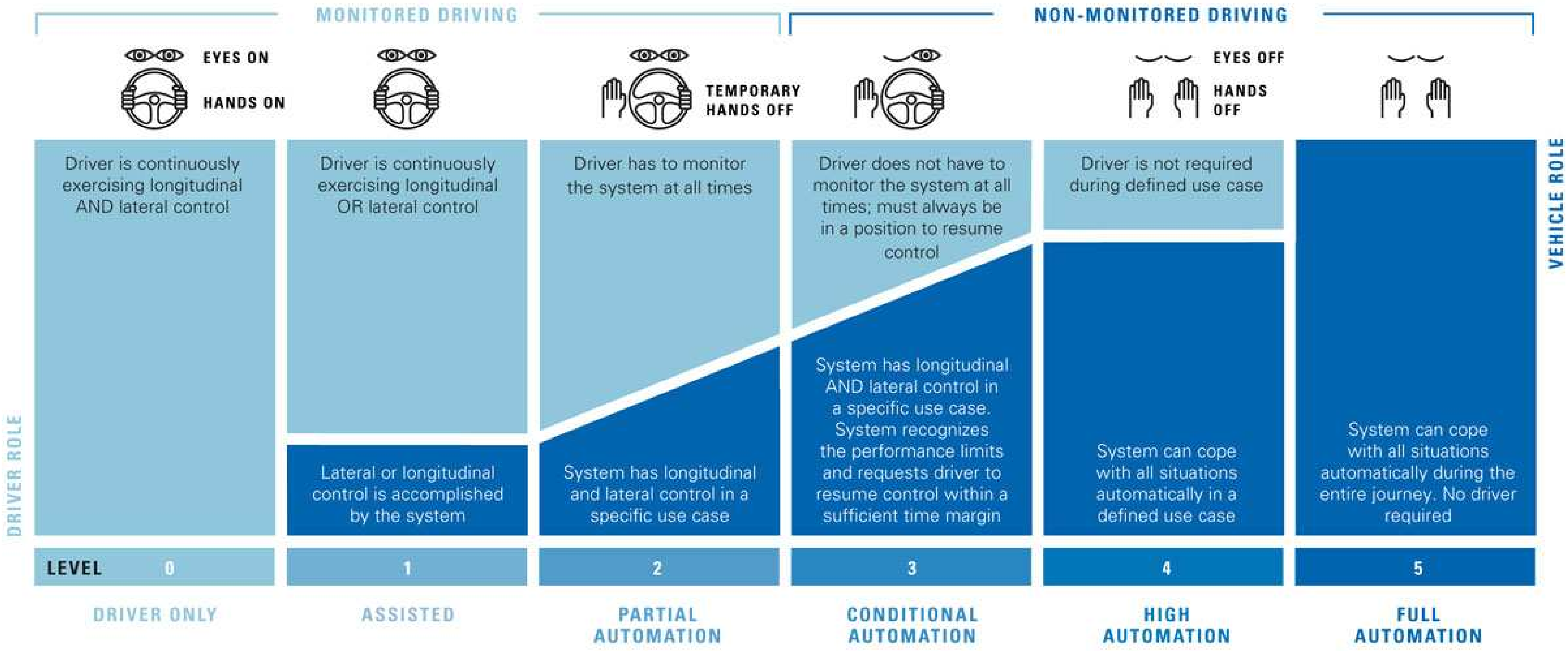


Levels of automated driving (SAE J3016)

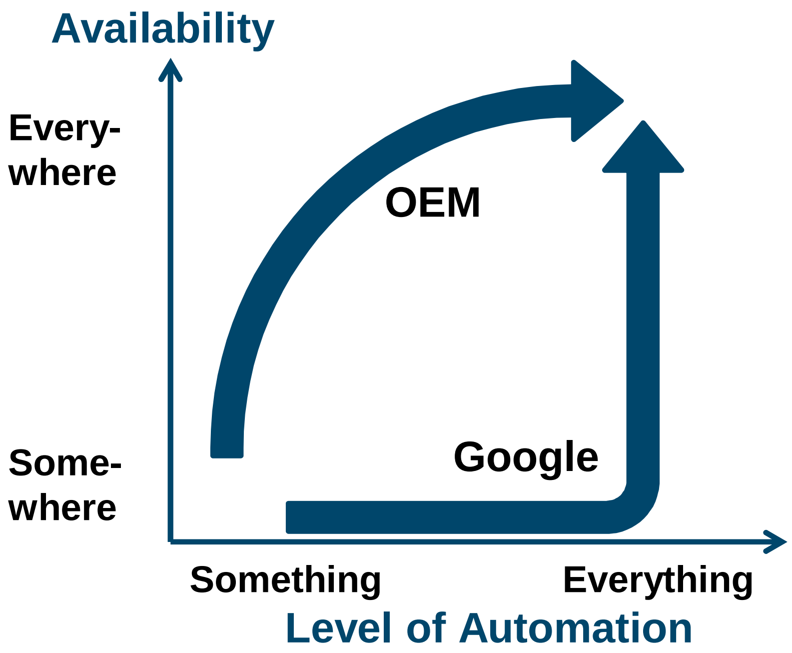


[according to SAE J3016]

Availability vs. degree of automation

Where and under what conditions is the automation available?

- Not only the level of automation and the use case offer evolutionary paths
- Also an evolution in availability is reasonable
- Different approaches exist (most OEM vs. Google)



What are the current challenges?

- Environment modeling, perception, detection, decision making
- Driver involvement, HMI, response times (SAE level 3)
- Infrastructure and connectivity
- Demonstration of reliability, safety, and security
- Test requirements, test scenarios, standards
- Legal framework
- Customer acceptance

Current regulatory situation for UN regulation and road traffic code / law

VIENNA Convention & GENEVA Convention

- The VIENNA Convention includes harmonized minimum requirements for the signatories
- A driver shall **at all times be able to control his vehicle** (Vienna Convention Art. 8 &13)
- **Requires a driver** (Vienna Convention Art. 1 & 8)
- **March 2014: Traffic Safety allows a car to drive itself, as long as the system "can be overridden or switched off by the driver". A driver must be present and able to take the wheel at any time.**

Future Level 4 and 5 systems are mostly impossible with the current Vienna Convention and with the amendment from 2014, because a driver may not be required. Therefore, further evolution is necessary.

UN R 79 steering equipment

- Automatically commanded steering function allowed only up to 10 km/h (parking maneuvers)
- Beyond 10 kph, only „**corrective steering function**" is allowed (LKA)
- **March 2016: "Vehicle systems … shall be deemed to be in conformity …when such systems can be overridden or switched off by the driver"**

Some Level 2, 3, 4, 5 systems are impossible with current requirements of UN R79.

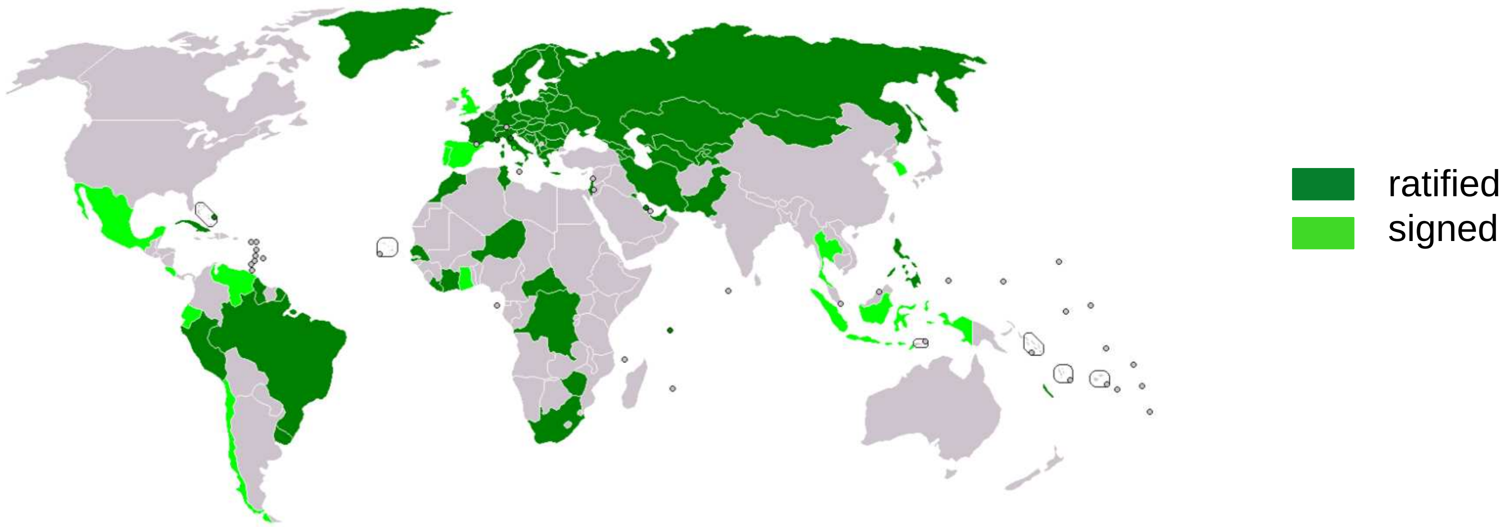
National Traffic Laws

- Often based on the VIENNA Convention, but details can be different for each country

Level 3, 4 and 5 require evaluation for each country. amendments may become necessary.

[Source: International Organization of Motor Vehicle Manufacturers, ITS/AD-04-14, Berlin, June 2015]

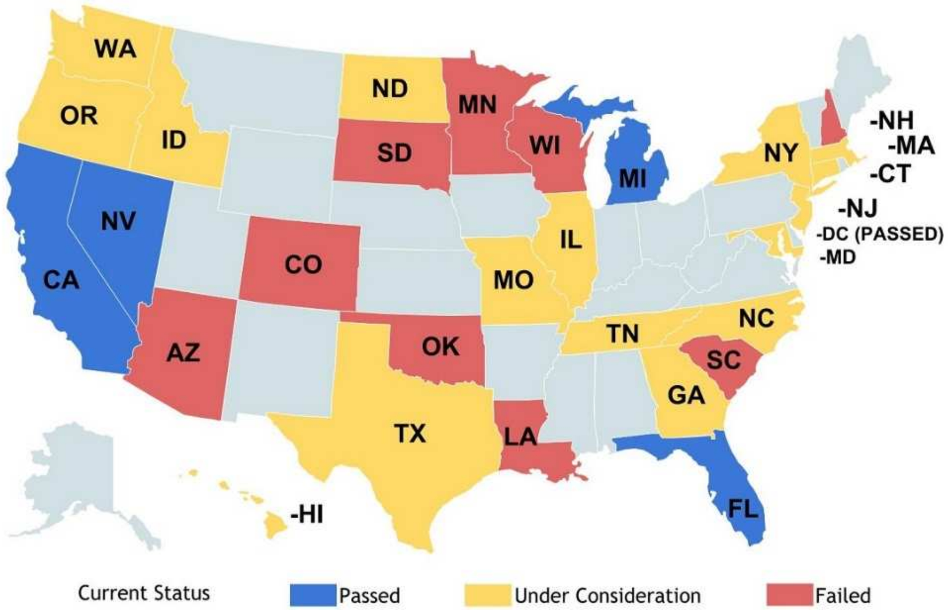
Convention on road traffic – Vienna (1968)



- **AT: signed 1968, ratified 1981**
- **Partial automation (driver monitors continuously) → No conflict with the convention.**
- **For higher automation levels → Adaption/clarification of convention is required.**

What about the US?

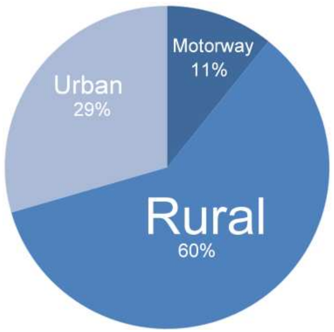
- Driver
- Data logging
- Easy to switch between modes
- Sum of liability



[Source: Wikipedia, October 2015]

Roadmap to automated driving

	Low Velocity	High Velocity
Structured Traffic Environment	**Traffic Jam** Level 2 (limited*) already introduced **Level 3 in development**	**Highways** Level 2 (limited*) already introduced **Level 3 in development**
Unstructured (complex) Traffic Environment	**Parking and Maneuvering** Level 2 already introduced **Level 4 in research/development**	**Urban and Rural Roads** Level 2 (limited*) already introduced **Level 3 in research**



Let‘s recall: Fatalities on German roads.

* Current **UN R 79** allows above 10 kph **only corrective steering** (lateral assistance). Therefore steering capability of today‘s Level 2 functions is still limited.

Automated driving – exemplary functions

virtual vehicle

Longterm Gens.						Urban & rural roads	Robot Taxi
					Urban & rural roads	Highway System	
Automation Gen. 2					Highway System	Valet Parking System	
Automation Gen. 1					Highway Traf. Jam-system		
ADAS new				Traffic Jam Ass. Park Ass.			
ADAS established	AEBS ABS ESC	FCW LKAS	ACC AEBS				
	Intervening only in emergency	Driver Only	Assisted	Partial Automation	Conditional Automation	High Automation	Full Automation
		0	1	2	3	4	5

Existing | Low velocity in structured environment | High velocity in structured environment | Unstructered environment

ADAS	Advanced Driver Assistance Systems	LKAS	Lane Keeping Assistance
AEBS	Advanced Emergency Braking	FCW	Forward Collision Warning
ESC	Electronic Stability Control	ACC	Adaptive Cruise Control
ABS	Antilock Braking System		

„autonomous“

Can we learn from Aeronautics?

Vehicle safety topics

- At peak times there are less than **30k planes in the air worldwide** (about 6-7k peak in the US)
- At peak times in the US there are **about 20 million vehicles on the road**, and the majority of those within 50 miles of a major city.
- The number of planes that crash into one another is infinitesimally low compared to the number of vehicles that crash (considering only multi-vehicle crashes).
- Take over / hand over time
- The management problem with road vehicles in and around cities is several order of magnitude more difficult than with planes.

Functional safety and security

- Redundancy concepts (HW and SW)
- Security conceps

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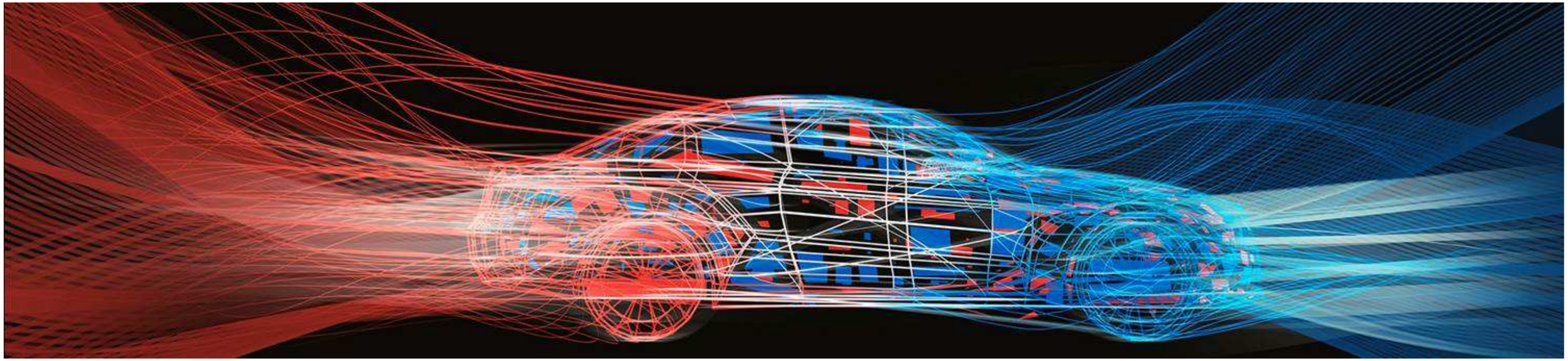
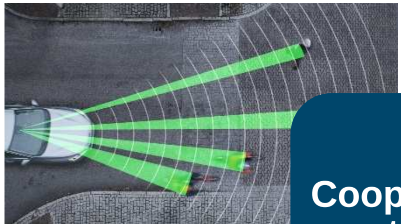
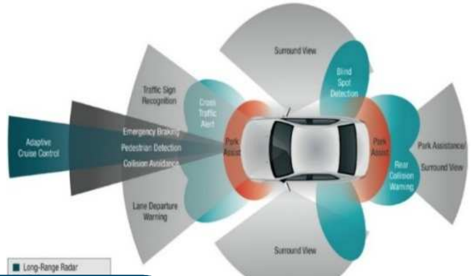


Autonomous Driving
(SAE level 5)





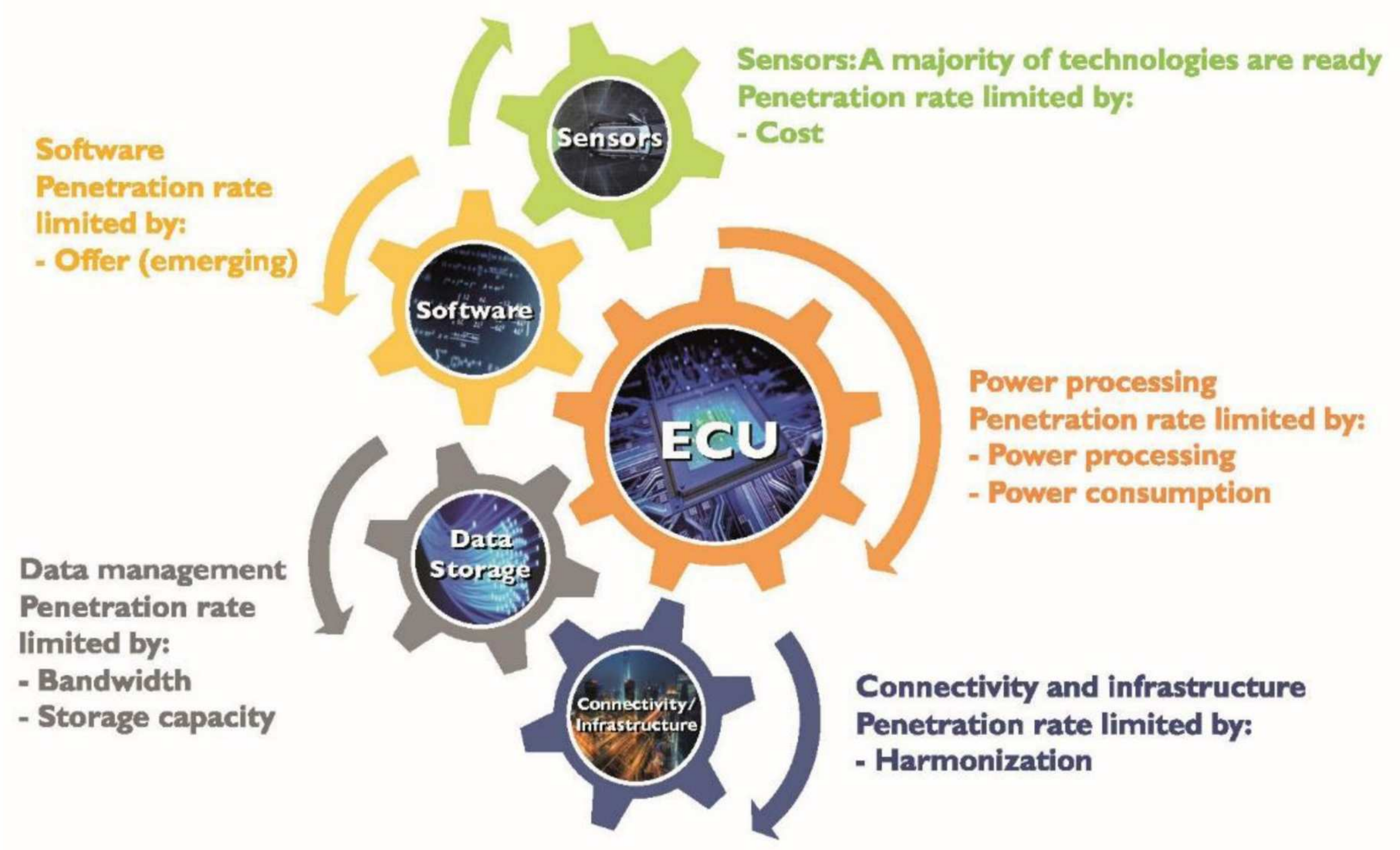
Cooperative and active safety → **Automated Driving**

Driver Assistance (ADAS) → **Automated Driving**

Visualization enhancement → **Automated Driving**

Automated Driving → **Autonomous Driving (SAE level 5)**

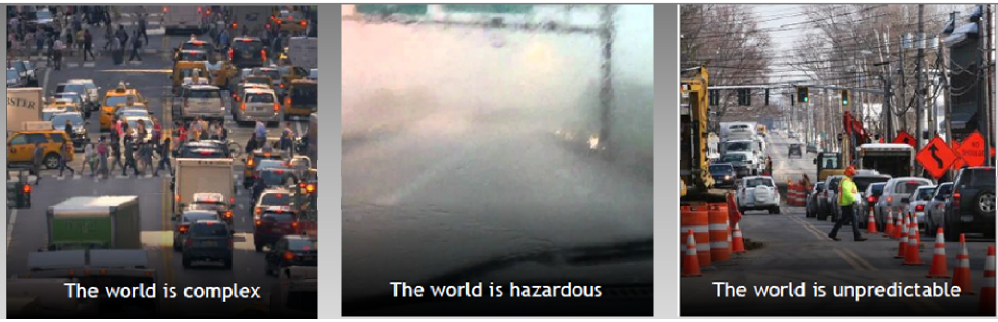
Basic building blocks of automated driving

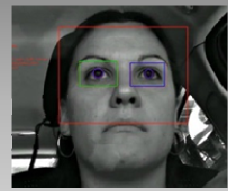


[Yole Développement, Sensor technology roadmap and autonomous functions associated, 2015.]

Automated driving – system architecture

unpredictable conditions





fuse all input to one model

Radar | LIDAR | Cameras | Infrared | Ultrasonic | V2X | Other Sensors

Reliable sensor data processing and fusion
- Raw data analysis of all sensors
- Deliver consistent environmental model

plan safe actions under current conditions

Scene understanding, driver monitoring, decision making, and planning
- Situation and behaviour prediction
- Planning of provably safe trajectories
- Handover/takeover planning

System Performance and Driver Monitoring
- Out-of-position
- Warning
- Intervention
- Measure reliability and uncertainty
- Detection and decision on function availability
- System degradation
- Sensor self-diagnosis
- Ensuring fail-operational behaviour
- …

steer functions and vehicle

Fail-operational X-by-wire actuation (low level control)

[Source: based on EC ECSEL project RobustSENSE, 2015-2017]

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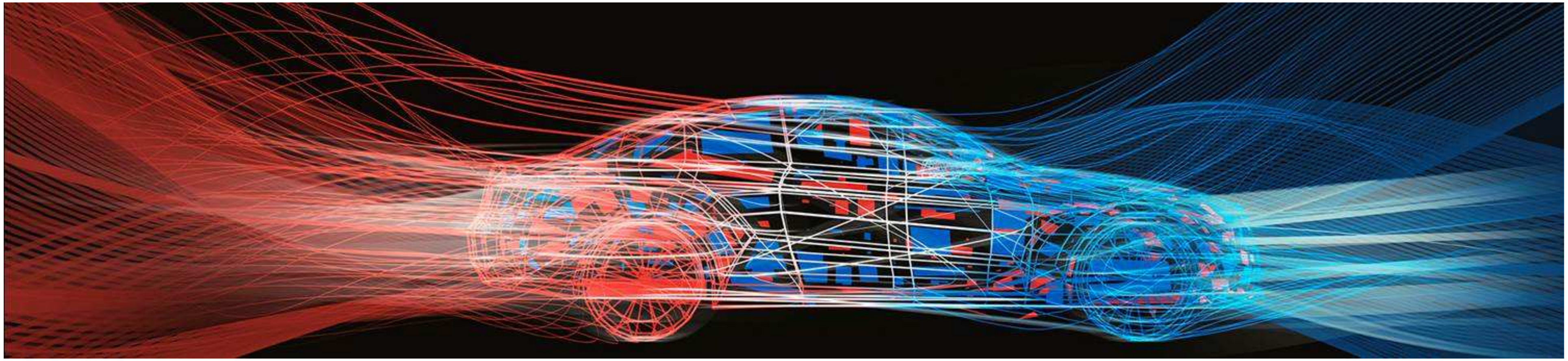


Self-driving is a tough task

[Source: NVIDIA, GSVF, May 2016]

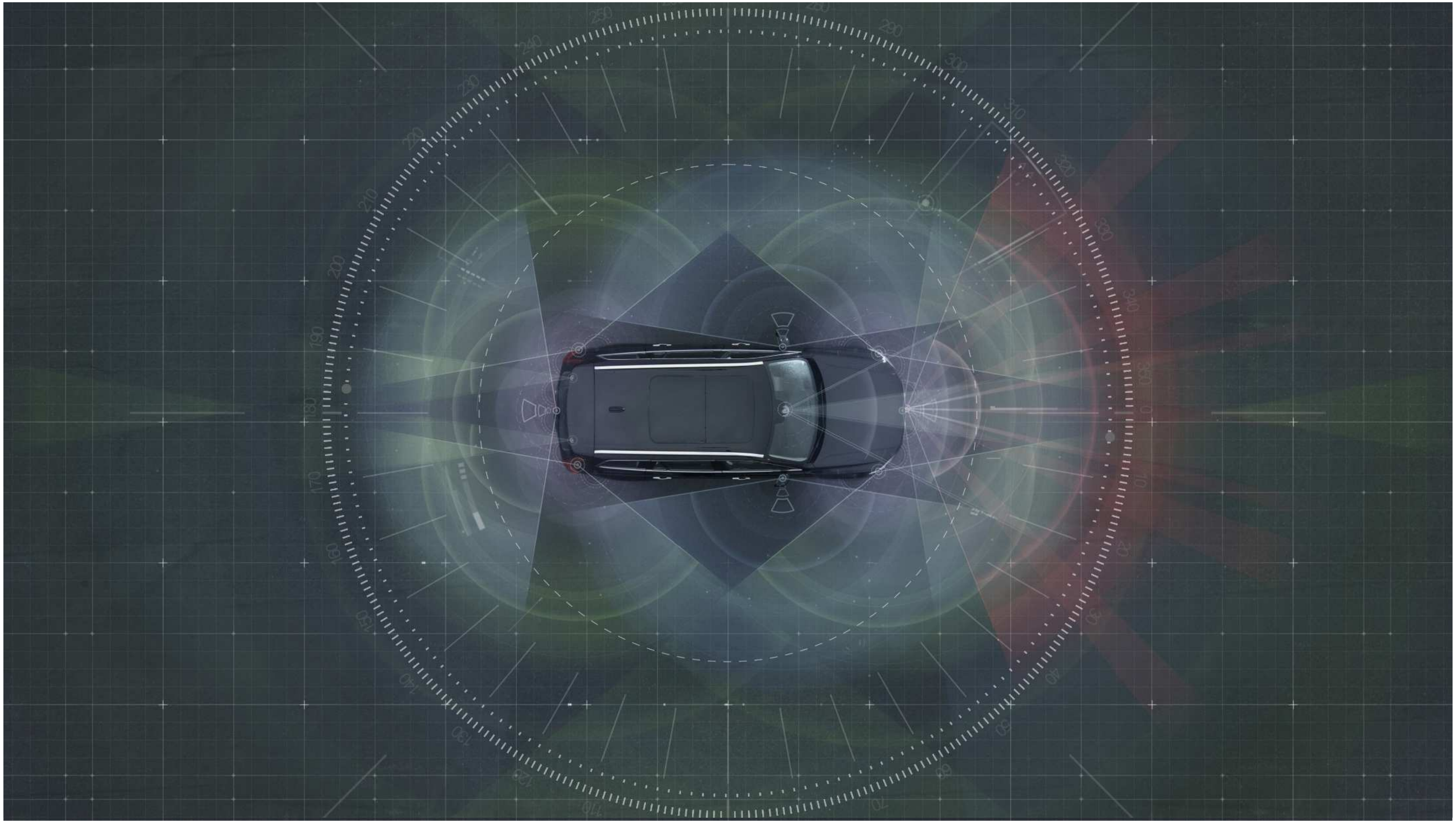
Limits of sensors

As effective sensors are, they have some drawbacks

- Limited range
- Performance is susceptible to common environmental conditions (rain, fog, varying lighting conditions)
- “False positives”
- Range determination not as accurate as required
- The use of several sensor types can ensure a higher level of confidence in target detection and characterization

→ Robust sensors and sensor self-diagnosis
→ Redundancy in HW and SW (“fail-operational”)

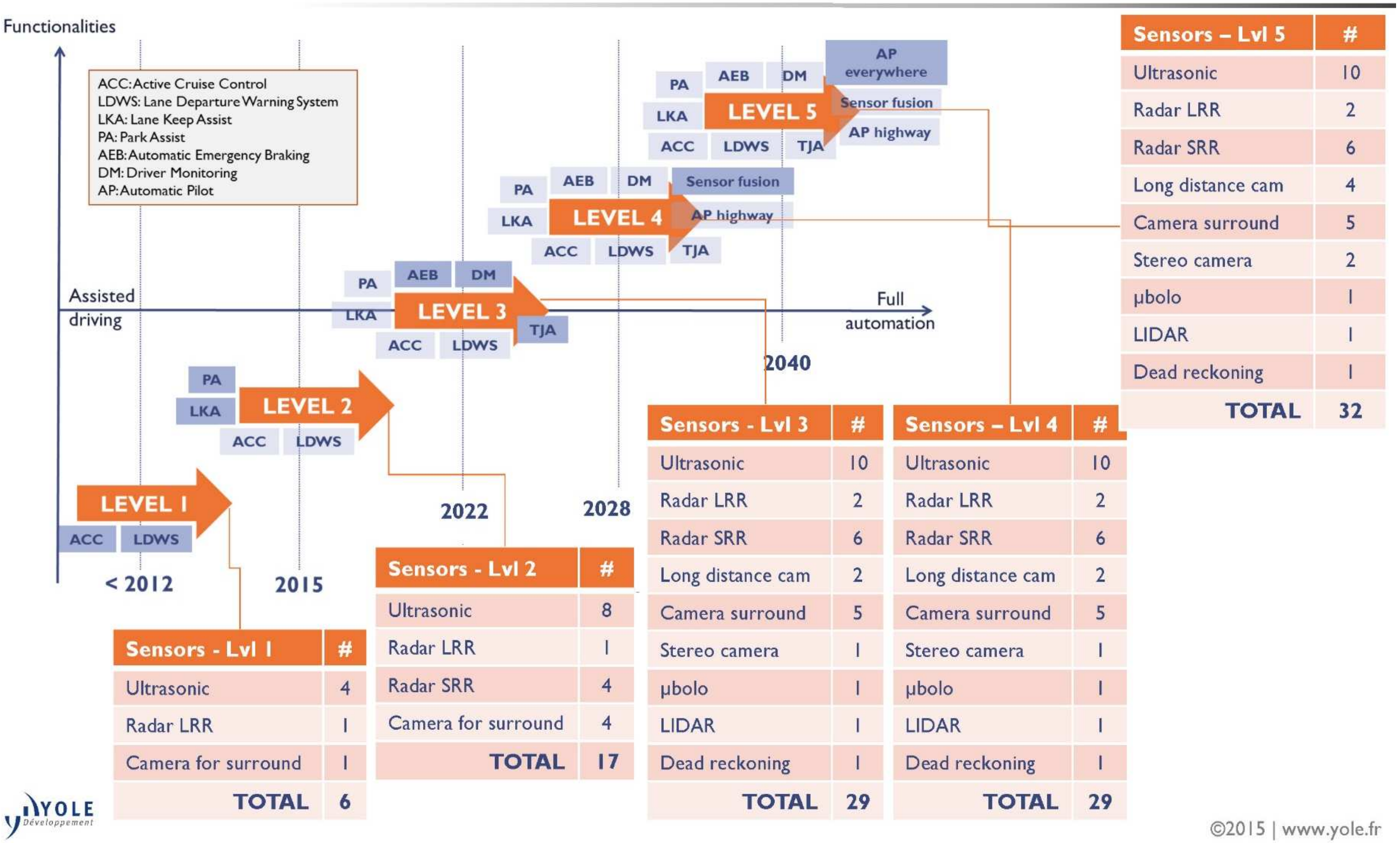
360° environmental awareness



[Ultrasonic – Camera – Radar – Laser, Volvo Cars 2016]

Sensor technology roadmap

virtual vehicle



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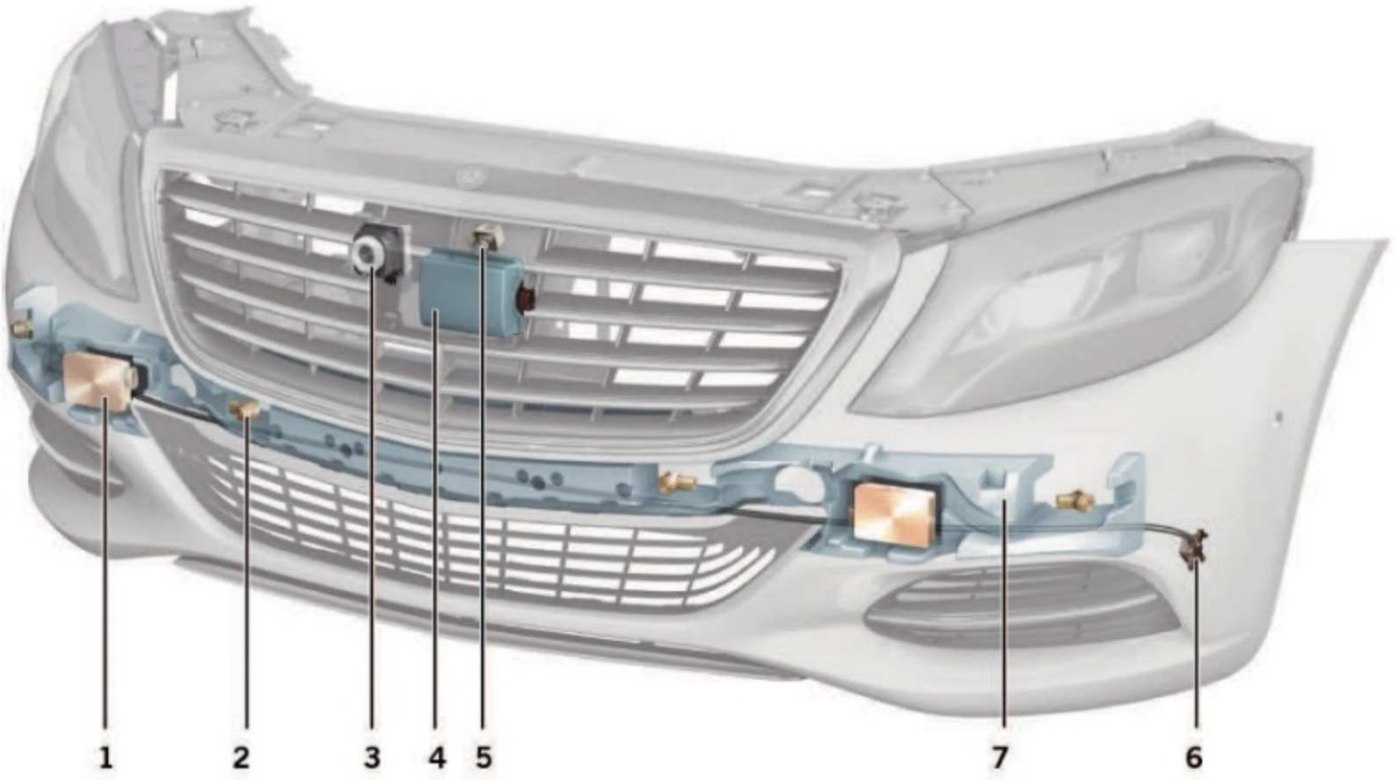
360° environmental awareness



1 Nahbereichsradarsensor
2 Abstandssensor Ultraschall
3 Ferninfrarotsensor
4 Fernbereichsradarsensor
5 Surroundviewkamera
6 Drucksensor Fußgängerschutz
7 Deformationselement

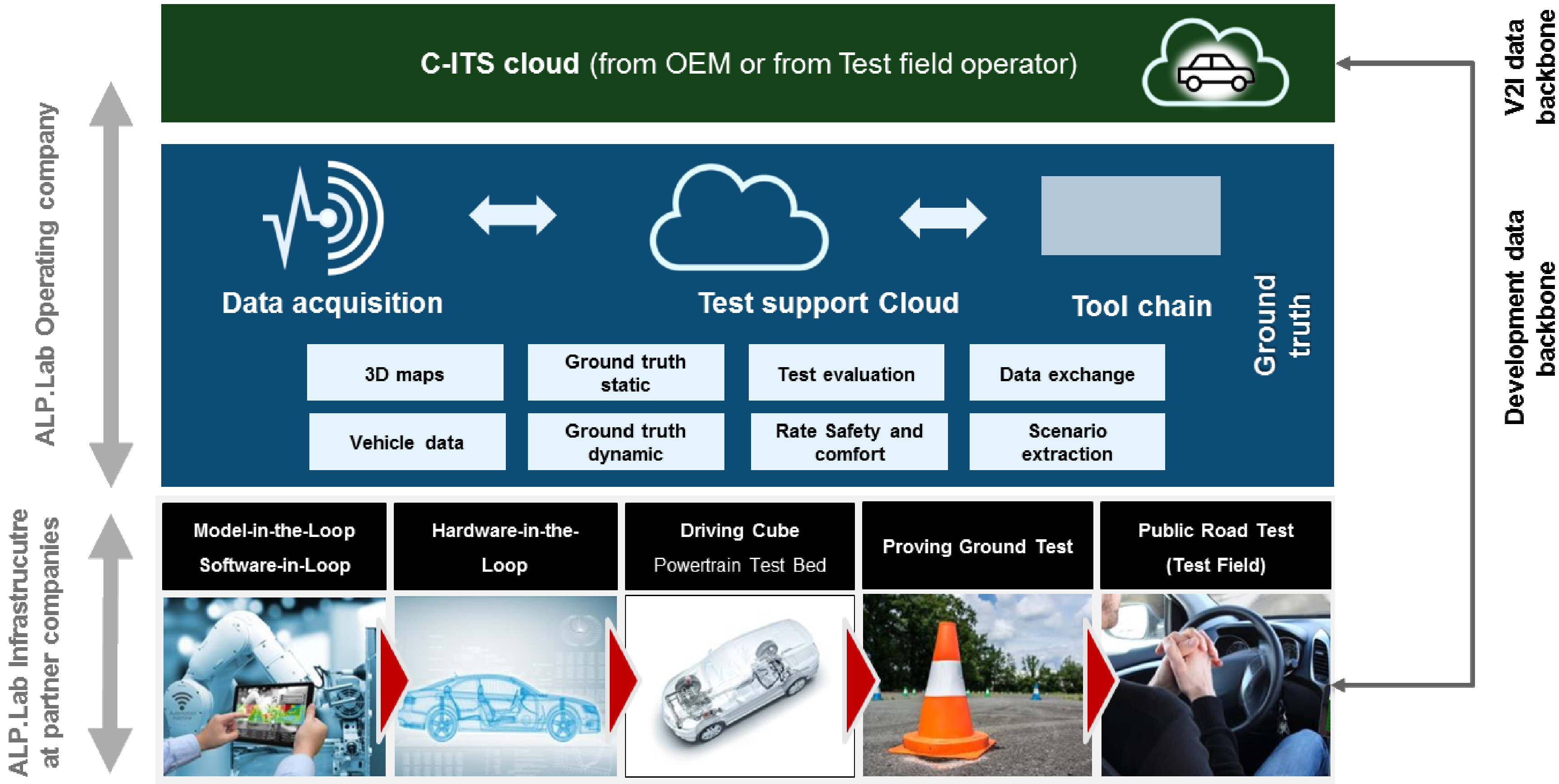
[Kiebach, Aktive Sciherheit, Essen, 2016]

How to test?

Watzenig

[Source: ALP.Lab, 2016]

How to test?



Data aquired in-vehicle: 1 GByte/s (~4-10 TByte/h)

[Source: Nvidia, Youtube, 2016]

Test regions in Central Europe

already implemented | just before start | in development

[Source: ALP.Lab, 2016]

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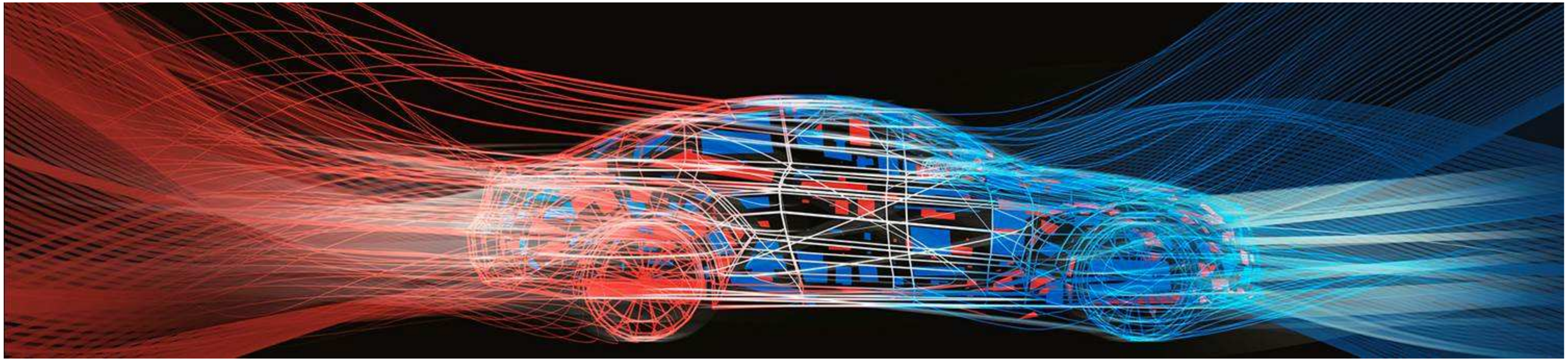


Required fields of action (vehicle-related)

- Environment recognition, interpretation, and data distribution within vehicles (automotive, avionics, space, rail, maritime, mobile machinery, others)
- Robust (embedded) control strategies
- In-vehicle architectures
- Communication and connectivity
- Cloud backbone ("fog computing")
- Demonstrating dependability
  - Safety, security, reliability, availability, integrity, maintainability
- Development methods and tools
- Covering human factors
  - within a vehicle, when taking the role of a driver/operator
  - as a road user, when interacting with automated vehicles
  - Knowledge and theories from social-psychological and behavioral sciences are useful

[ARTEMIS-IA, MASRIA 2016, Chapter on Smart Mobility, 2016]

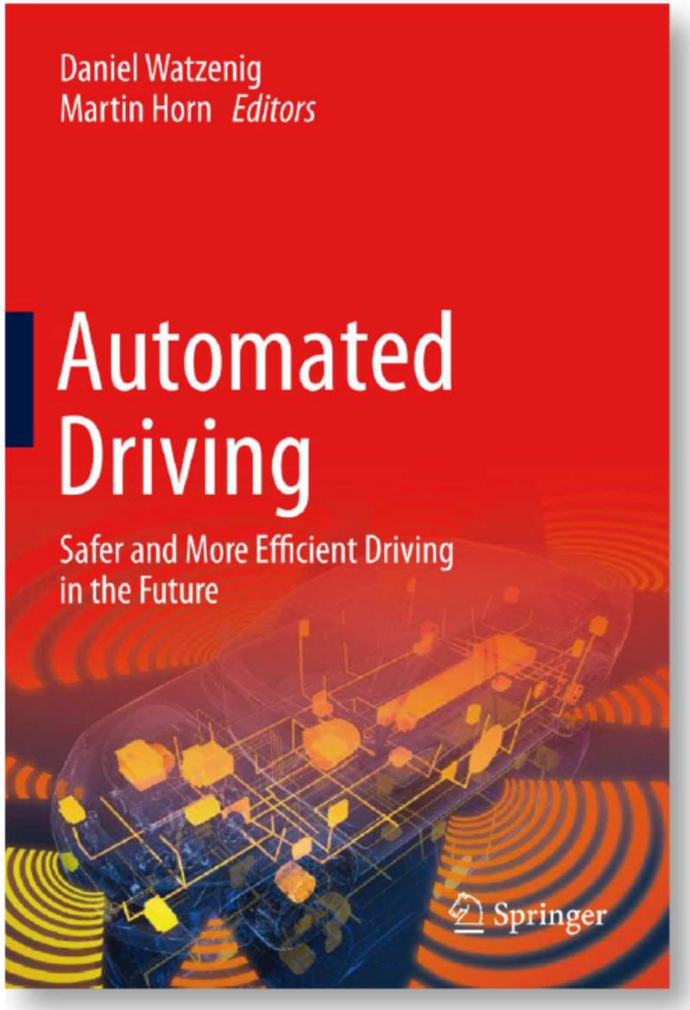
Required fields of action

- Legal constraints (international and national frameworks, approval of vehicles, technical maintenance and monitoring, driver training)
- From test tracks to test regions in Europe (stepwise growth)
- Digital infrastructure (e.g. 50 Mbit/s by 2018 in Germany, nationwide)
- Interaction of vehicles and their infrastructure
  - open-source data cloud for geographic and mobility data, digital radio board (Germany: DAB+ to retrieve detailed and locally precise data in real-time)
  - Swarm intelligence
  - High-precision digital maps
  - Intelligent communication to traffic lights, traffic signs, signalling
- Standards for intelligent roads (harmonized)
- Standardization of IT security
- Privacy (collection, processing, linking of data) according to data privacy laws

Book on Automated Driving

- Industrial contributions from Daimler, BMW, Volvo, Renault, Jaguar Landrover, Volkswagen, Skoda, AVL, Magna, Bosch, NXP…
- Academic contributions from TU Graz, Virtual Vehicle, TU Braunschweig, TU Darmstadt, KTH, Surrey University…
- Initiatives: ERTRAC, ARTEMIS-IA, A3PS, SafeTRANS…

- See http://www.springer.com
- See http://www.amazon.de



[Source: Springer, 2016]

Austrian RDI Roadmap for Automated Vehicles

Available at ECSEL Austria homepage:

http://www.ecsel-austria.net/newsfull/items/automated-driving-roadmap.html

Thank you!

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