



**- Road Vehicle Automation Workshop -**

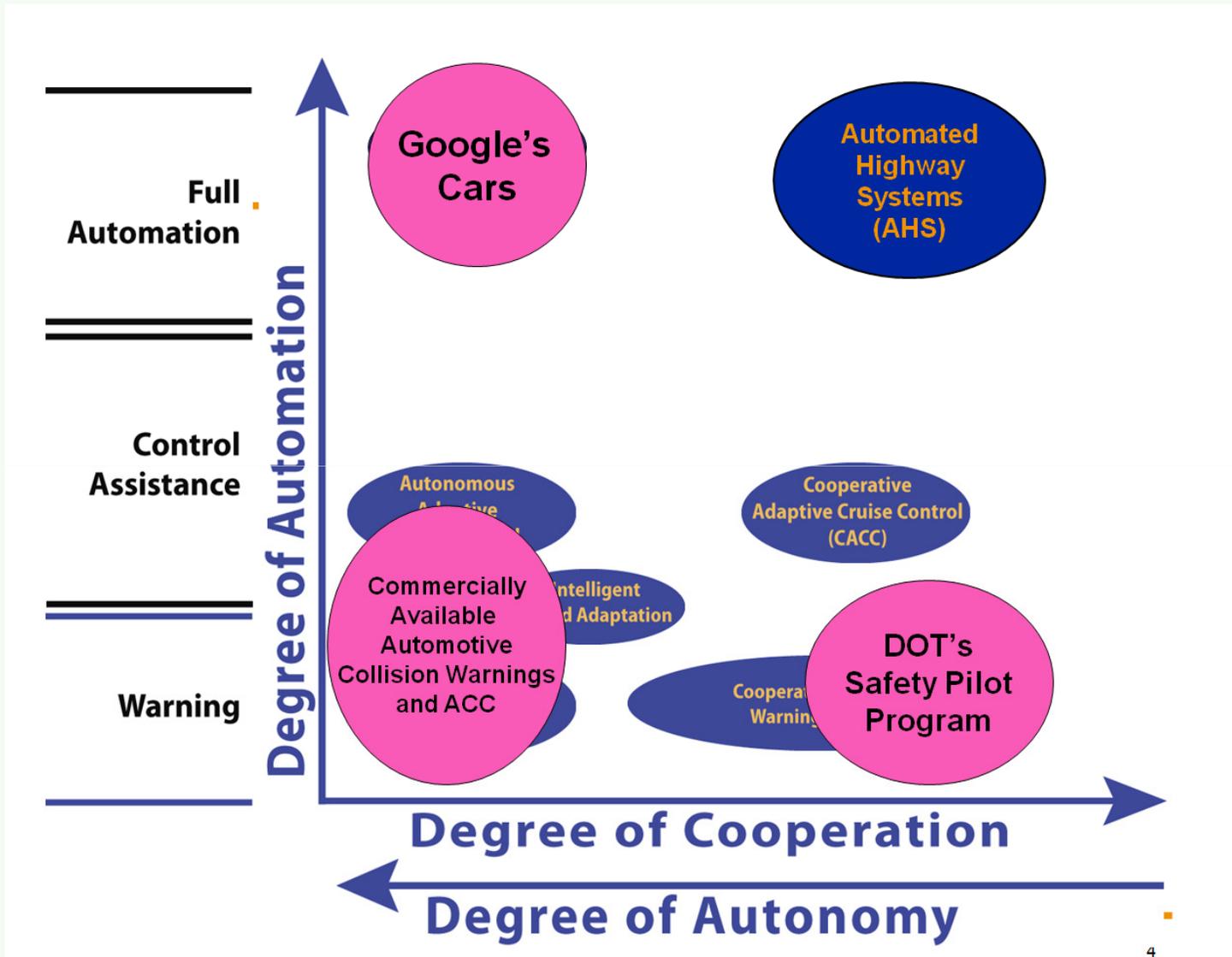
# **BASt-study: Definitions of Automation and Legal Issues in Germany**

25<sup>th</sup> July 2012

Tom M. Gasser / Daniel Westhoff

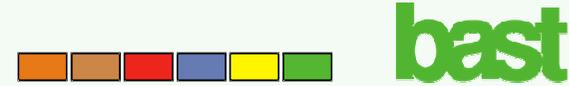
German Federal Highway Research Institute

# Orientation:

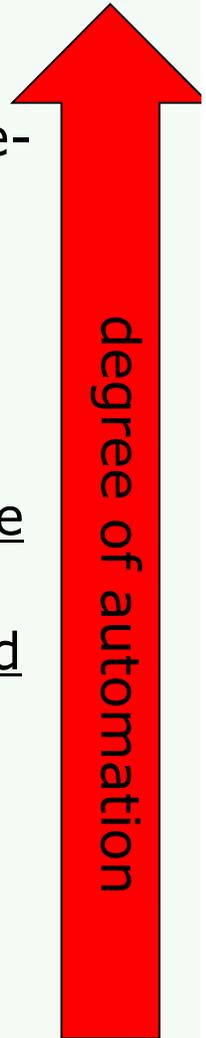


Source: Steven E. Shladover  
University of California PATH  
Program

# BASSt-Expert-Group definitions of vehicle automation-degrees:



- **Full automation:** The system takes over longitudinal and lateral control completely and permanently. In case of a take-over request that is not followed, the system will return to the minimal risk condition by itself.
- **High automation:** The system takes over longitudinal and lateral control; the driver is no longer required\* to permanently monitor the system. In case of a take-over request, the driver must take-over control with a certain time buffer.
- **Partial automation:** The system takes over longitudinal and lateral control, the driver shall permanently monitor the system and shall be prepared to take over control at any time.
- **Driver Assistance:** The driver permanently controls either longitudinal or lateral control. The other task can be automated to a certain extent by the assistance system.
- **Driver Only:** Human driver executes manual driving task



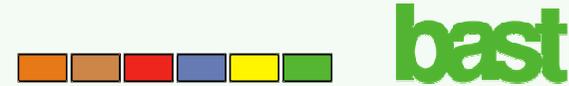
# Further dimensions:



Nomenclature	Task of the driver according to automation level	
Fully automated	The system takes over lateral and longitudinal control completely within the individual specification of the application. <ul style="list-style-type: none"> <li>▪ The driver <u>need not</u> monitor the system</li> <li>▪ Before the specified limits of the application are reached, the system requests the driver to take over with sufficient time buffer.</li> <li>▪ In absence of a takeover, the system will return to the minimal risk condition by itself</li> <li>▪ All system limits are detected by the system, the system is capable to return to the minimum risk condition in all situations.</li> </ul>	
Highly automated	The system takes over lateral and longitudinal control for a certain amount of time in specific situations. <ul style="list-style-type: none"> <li>▪ The Driver <u>need not</u> permanently monitor the system as long as it is active</li> <li>▪ If necessary, the driver is requested to take over control by the system with a certain time buffer.</li> <li>▪ All system limits are detected by the system. The system is not capable of re-establishing the minimal risk condition from every initial state.</li> </ul>	
Partially automated	The system takes over lateral <u>and</u> longitudinal control (for a certain amount of time and/ or in specific situations). <ul style="list-style-type: none"> <li>▪ The driver must permanently monitor the system</li> <li>▪ The Driver must at any time be prepared to take over complete control of the vehicle</li> </ul>	
Assisted	The driver continuously accomplishes <u>either</u> lateral <u>or</u> longitudinal control. The other/ remaining task is accomplished by the automating system to a certain level. <ul style="list-style-type: none"> <li>▪ The Driver must permanently monitor the system</li> <li>▪ The Driver must at any time be prepared to take over complete control of the vehicle</li> </ul>	
Driver only	The driver continuously (throughout the complete trip) accomplishes longitudinal (accelerating /braking) and lateral (steering) control.	

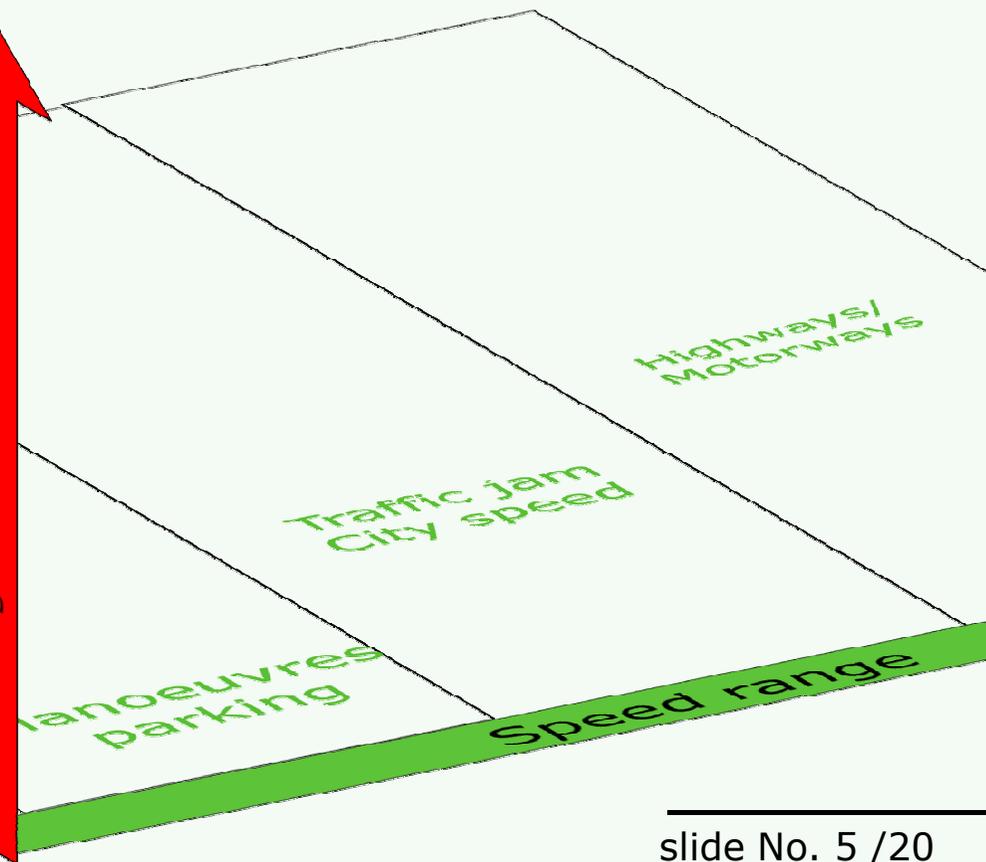
Source: BASt

# Further dimensions:

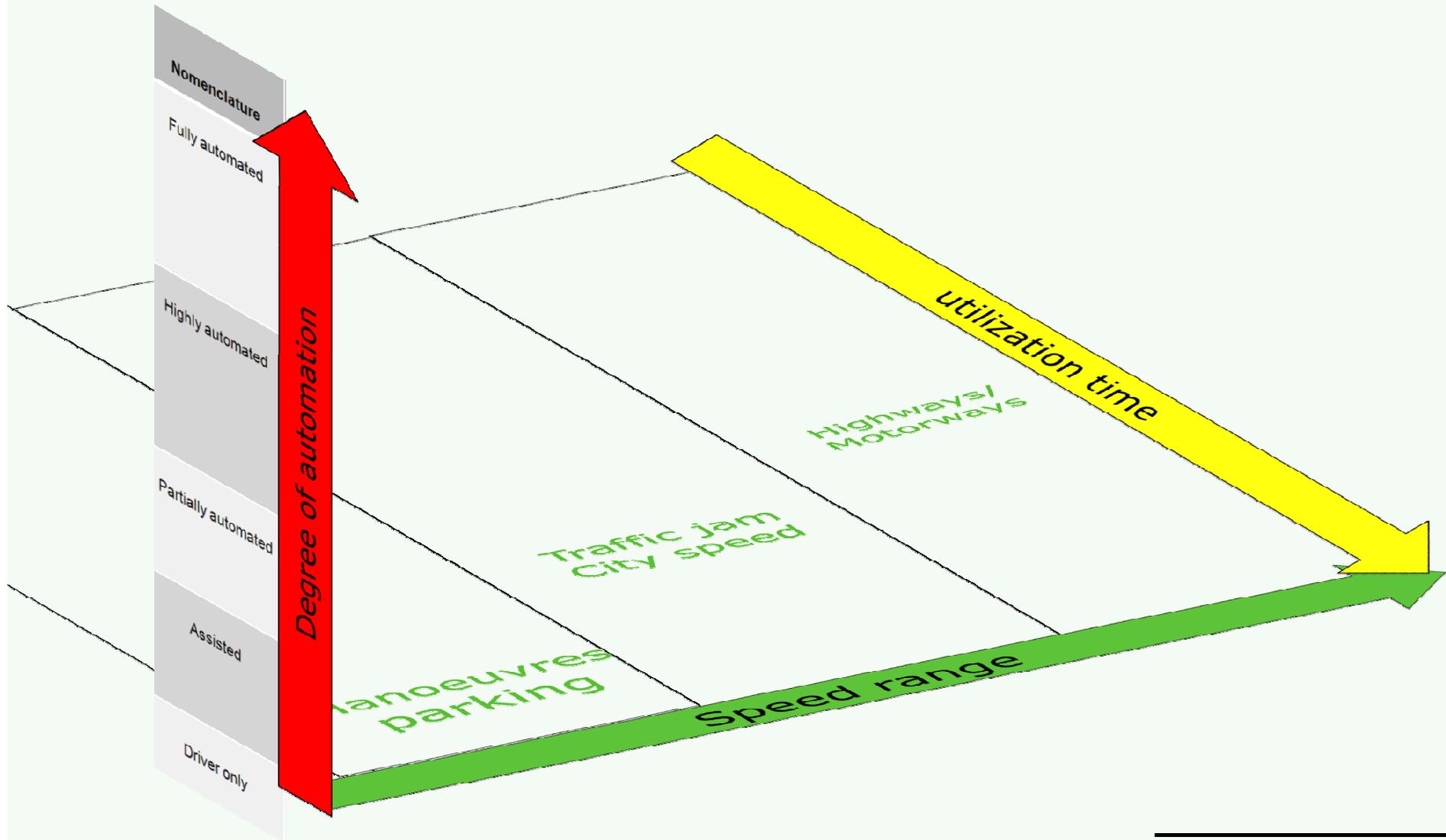


Automation level	Task of the driver according to automation level
unattended	The system takes over lateral and longitudinal control completely within the individual specification of the application. <ul style="list-style-type: none"> <li>The driver <u>need not</u> monitor the system</li> <li>Before the specified limits of the application are reached, the system requests the driver to take over with sufficient time buffer.</li> <li>In absence of a takeover, the system will return to the minimal risk condition by itself</li> <li>All system limits are detected by the system, the system is capable to return to the minimum risk condition in all situations.</li> </ul>
automated	The system takes over lateral and longitudinal control for a certain amount of time in specific situations. <ul style="list-style-type: none"> <li>The Driver <u>need not</u> permanently monitor the system as long as it is active</li> <li>If necessary, the driver is requested to take over control by the system with a certain time buffer.</li> <li>All system limits are detected by the system. The system is not capable of re-establishing the minimal risk condition from every initial state.</li> </ul>
automated	The system takes over lateral <u>and</u> longitudinal control (for a certain amount of time and/ or in specific situations). <ul style="list-style-type: none"> <li>The driver must permanently monitor the system</li> <li>The Driver must at any time be prepared to take over complete control of the vehicle</li> </ul>
assisted	The driver continuously accomplishes <u>either</u> lateral <u>or</u> longitudinal control. The other/ remaining task is accomplished by the automating system to a certain level. <ul style="list-style-type: none"> <li>The Driver must permanently monitor the system</li> <li>The Driver must at any time be prepared to take over complete control of the vehicle</li> </ul>
driver only	The driver continuously (throughout the complete trip) accomplishes longitudinal (accelerating /braking) and lateral (steering) control.

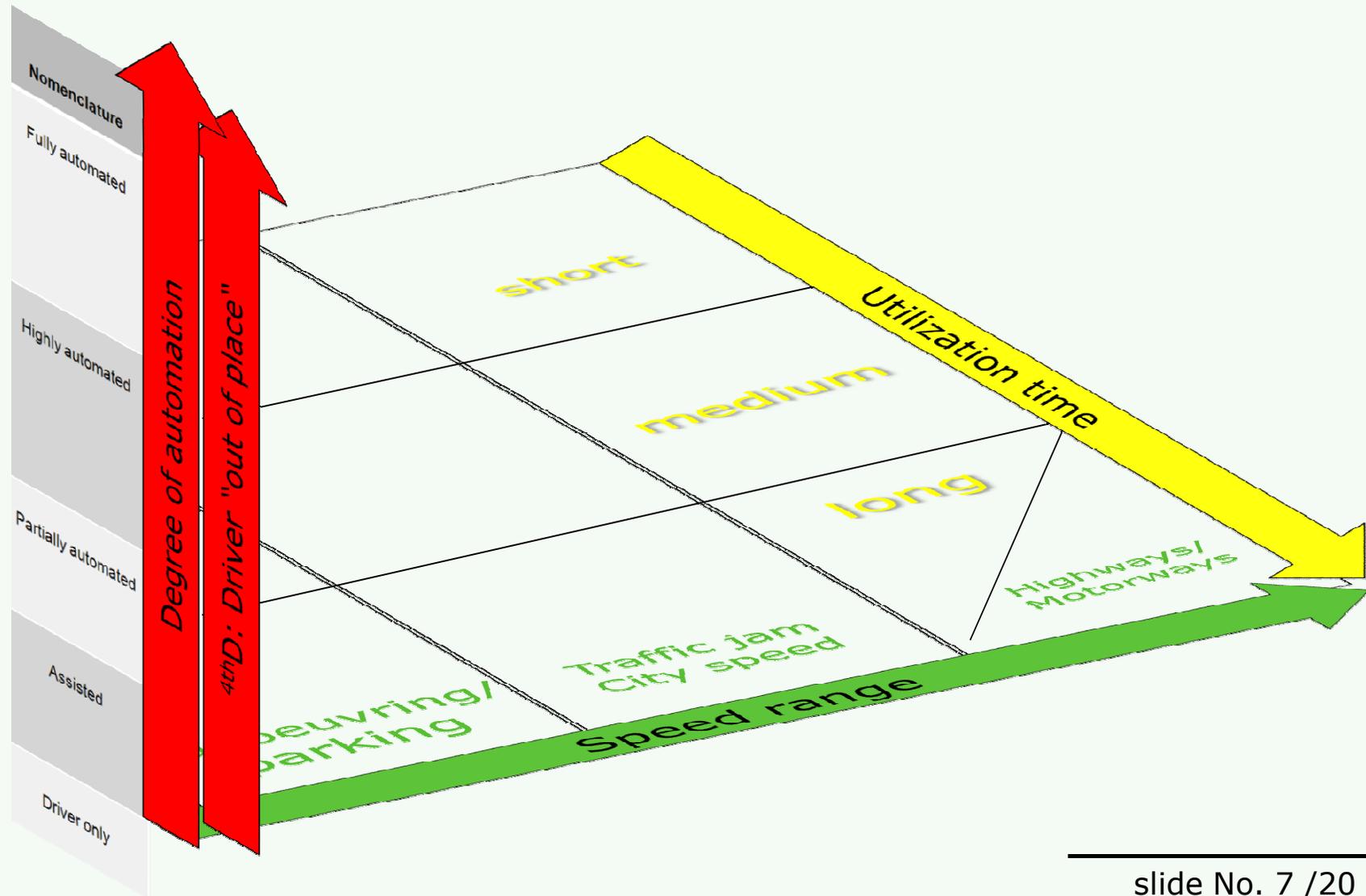
Degree of automation



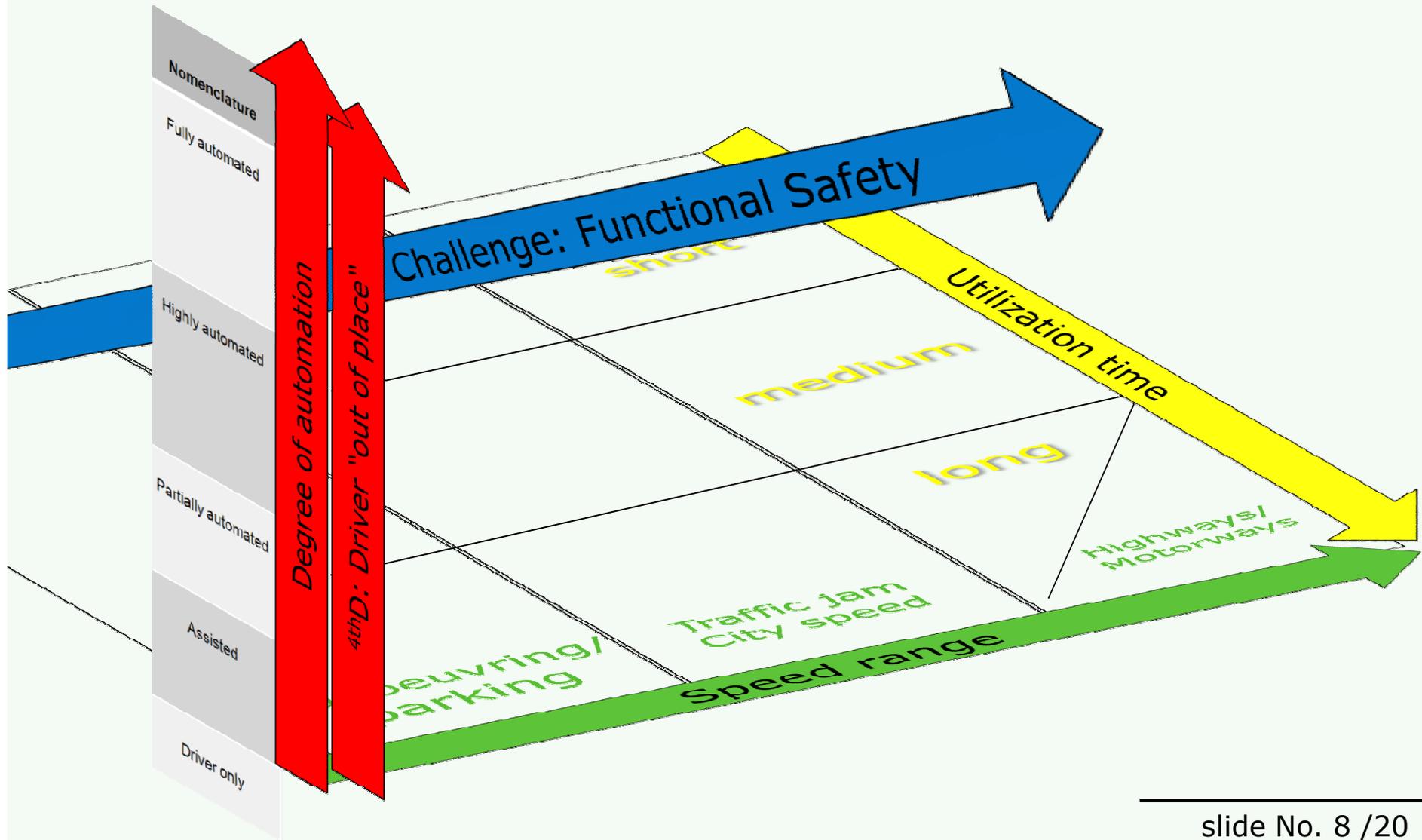
# Further dimensions:



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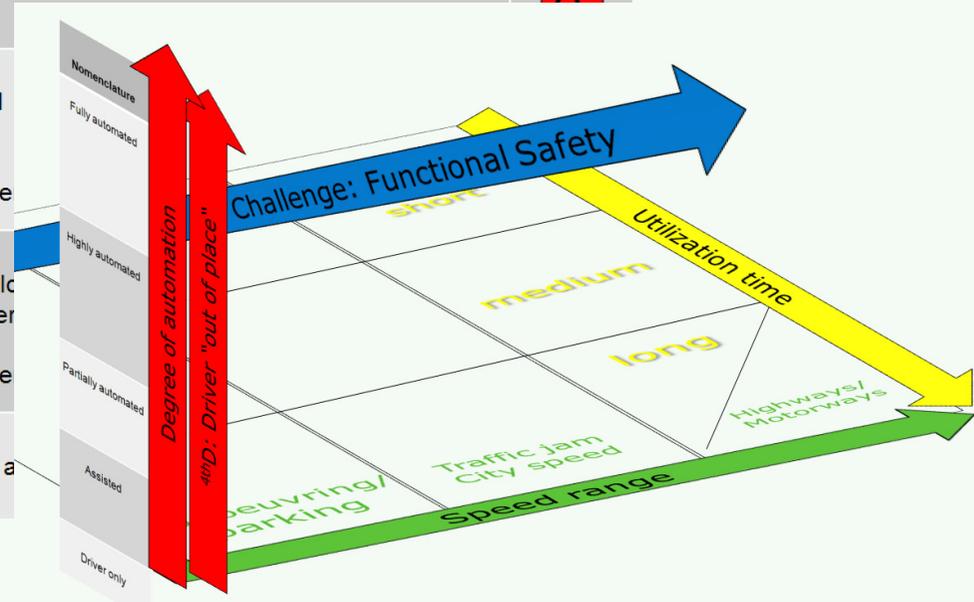


# Further dimensions:



# Criticism:

Nomenclature	Task of the driver according to automation level
Fully automated	<p>The system takes over lateral and longitudinal control completely within the individual specification of the application.</p> <ul style="list-style-type: none"> <li>The driver <u>need not</u> monitor the system</li> <li>Before the specified limits of the application are reached, the system requests the driver to take over with sufficient time buffer.</li> <li>In absence of a takeover, the system will return to the minimal risk condition by itself</li> <li>All system limits are detected by the system, the system is capable to return to the minimum risk condition in all situations.</li> </ul>
Highly automated	<p>The system takes over lateral and longitudinal control for a certain amount of time in specific situations.</p> <ul style="list-style-type: none"> <li>The Driver <u>need not</u> permanently monitor the system as long as it is active</li> <li>If necessary, the driver is requested to take over control by the system with a certain time buffer.</li> <li>All system limits are detected by the system. The system is not capable of re-establishing the minimal risk condition from every initial state.</li> </ul>
Partially automated	<p>The system takes over lateral <u>and</u> longitudinal control (in specific situations).</p> <ul style="list-style-type: none"> <li>The driver must permanently monitor the system</li> <li>The Driver must at any time be prepared to take over</li> </ul>
Assisted	<p>The driver continuously accomplishes <u>either</u> lateral <u>or</u> longitudinal control. The task is accomplished by the automating system to a certain degree.</p> <ul style="list-style-type: none"> <li>The Driver must permanently monitor the system</li> <li>The Driver must at any time be prepared to take over</li> </ul>
Driver only	<p>The driver continuously (throughout the complete trip) accomplishes all driving tasks (acceleration/braking) and lateral (steering) control.</p>



# Legal evaluation:

## Consistency with Regulatory Law

Regulatory Law = National Road Traffic Codes  
("danger defence"-law in traffic)

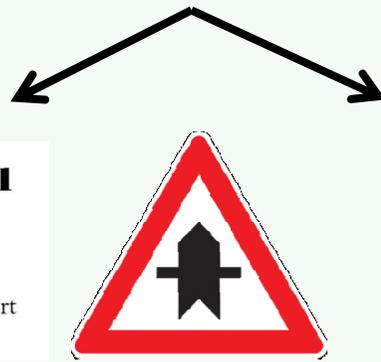


Source: SARTRE-Project, press Release

→ Addressee is the (human) driver,  
→ drivers' Duties:

National Road Traffic Codes

I. Allgemeine Verkehrsregeln §§ 1, 2 StVO I  
**I. Allgemeine Verkehrsregeln**  
**§ 1 Grundregeln.** (1) Die Teilnahme am Straßenverkehr erfordert ständige Vorsicht und gegenseitige Rücksicht.



Source: DVR

Vienna Convention

Übereinkommen über den Straßenverkehr  
Convention on Road Traffic  
Convention sur la circulation routière  
(Übersetzung)  
THE CONTRACTING PARTIES, DESIRING to facilitate international road traffic and to increase road safety through the adoption of uniform traffic rules,  
LES PARTIES CONTRACTANTES, DESIREUSES de faciliter la circulation routière internationale et d'accroître la sécurité sur les routes grâce à l'adoption de règles uniformes de circulation,  
DIE VERTRAGSPARTHEIN, IN DEM WUNSCH, den internationalen Straßenverkehr zu erleichtern und die Sicherheit auf den Straßen durch die Annahme einheitlicher Verkehrsregeln zu erhöhen,  
HAVE AGREED upon the following provisions:  
SONT CONVENUES des dispositions suivantes:  
HABEN die folgenden Bestimmungen VEREINBART,  
Chapter I Chapitre premier Kapitel I

**Drivers' obligation** is to permanently:

– monitor surrounding traffic and status of the vehicle

**Conflict with higher degrees of automation! (cp. Definitions!)**  
– may override/ oversteer in case system control seems inadequate

# Legal evaluation:

## Consistency with Regulatory Law

### Relevant step: taking the driver ,out of the loop`

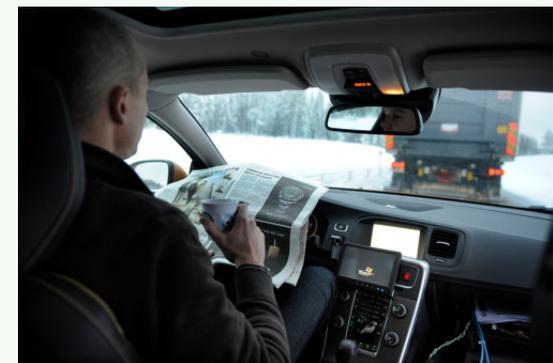
Going beyond partial automation (that is still permanently monitored by the driver)...



Source: HAVE-it Project, press Release



...would definitely require a new approach to legal framework in road traffic: Otherwise drivers would be breaching their legal obligations

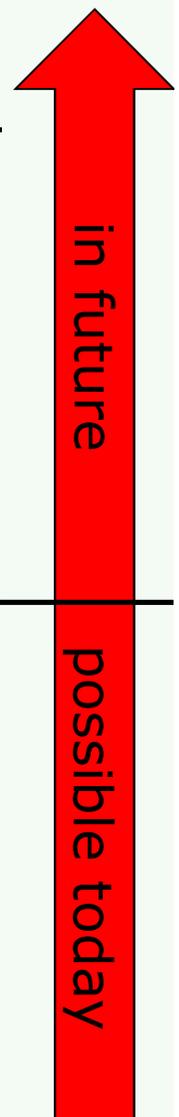


Source: SARTRE-Project, press Release

# BASSt-Expert-Group definitions of vehicle automation-degrees:



- **Full automation:** The system takes over longitudinal and lateral control completely and permanently. In case of a take-over request that is not carried out, the system will return to the minimal risk condition by itself.
- **High automation:** The system takes over longitudinal and lateral control; the driver is no longer required\* to permanently monitor the system. In case of a take-over request, the driver must take-over control with a certain time buffer.
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- **Driver Only:** Human driver executes manual driving task



## Automation: Product Liability

### partial automation:

- „Defectiveness“: Decisive are user instructions
- Risk of the manufacturer: Is it possible to sufficiently differentiate between: reasonably foreseeable misuse  $\leftrightarrow$  system abuse?



Source: DVR

### Additionally for high and full automation:

- Damages during highly and fully automated operation mode lead to manufacturers' liability (in case the accident is not solely caused by ill-driving on the side of a third party or an override by the driver).



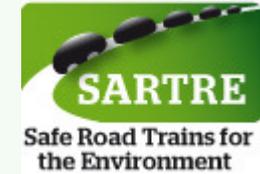
Source: SARTRE-Project, press Release

# Platooning – keeping in line with „individual“ mobility?

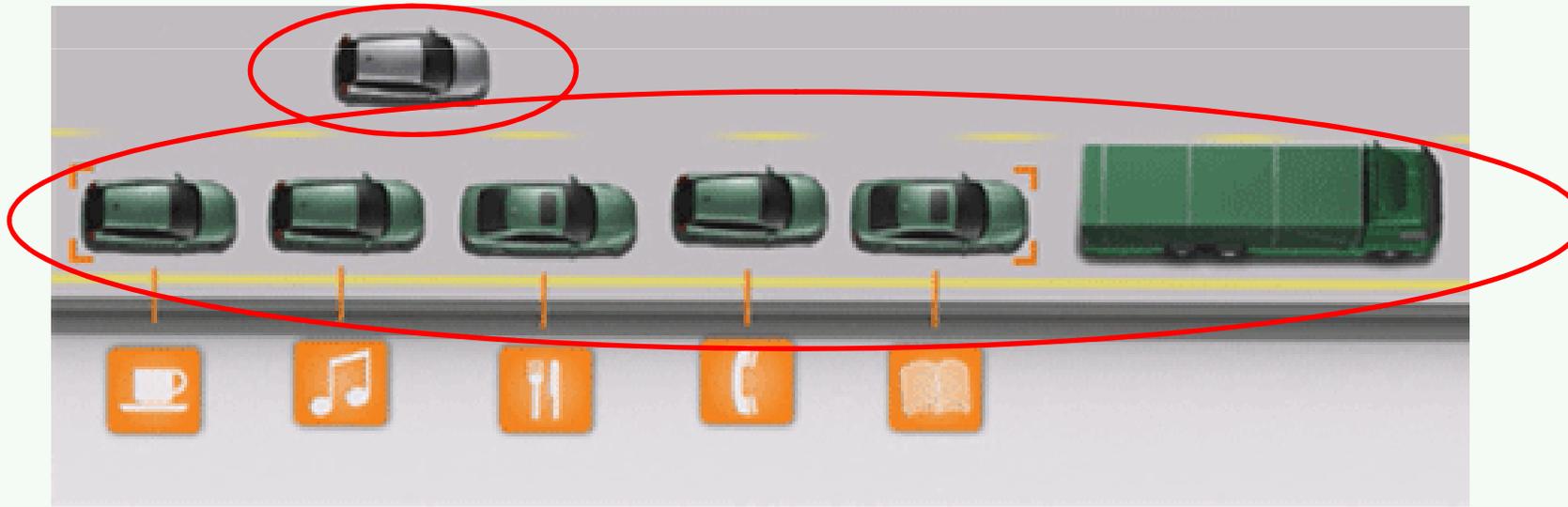


## Specific legal consequences of platooning:

○ = Individual vehicle ?

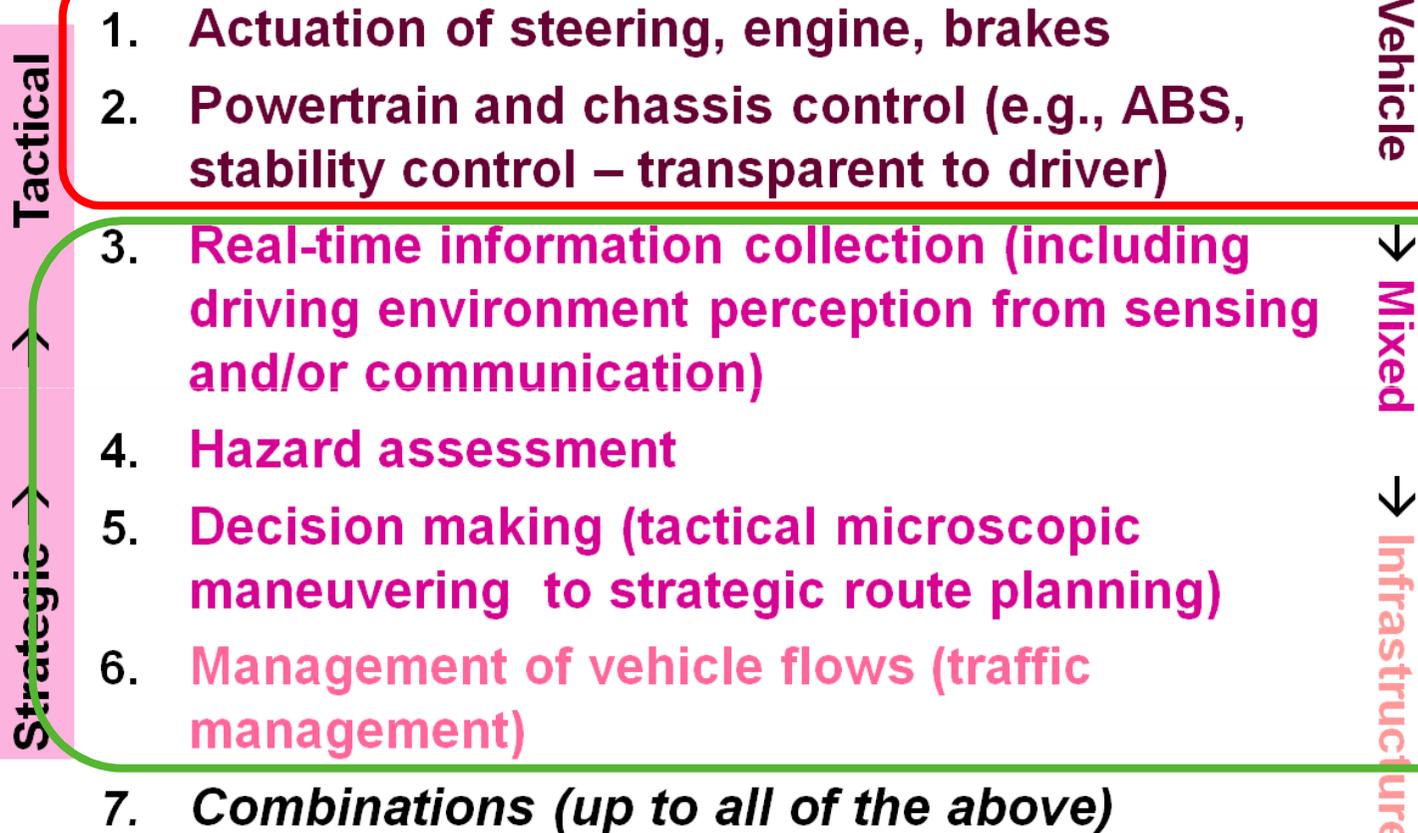


Source: SARTRE-Project, press Release



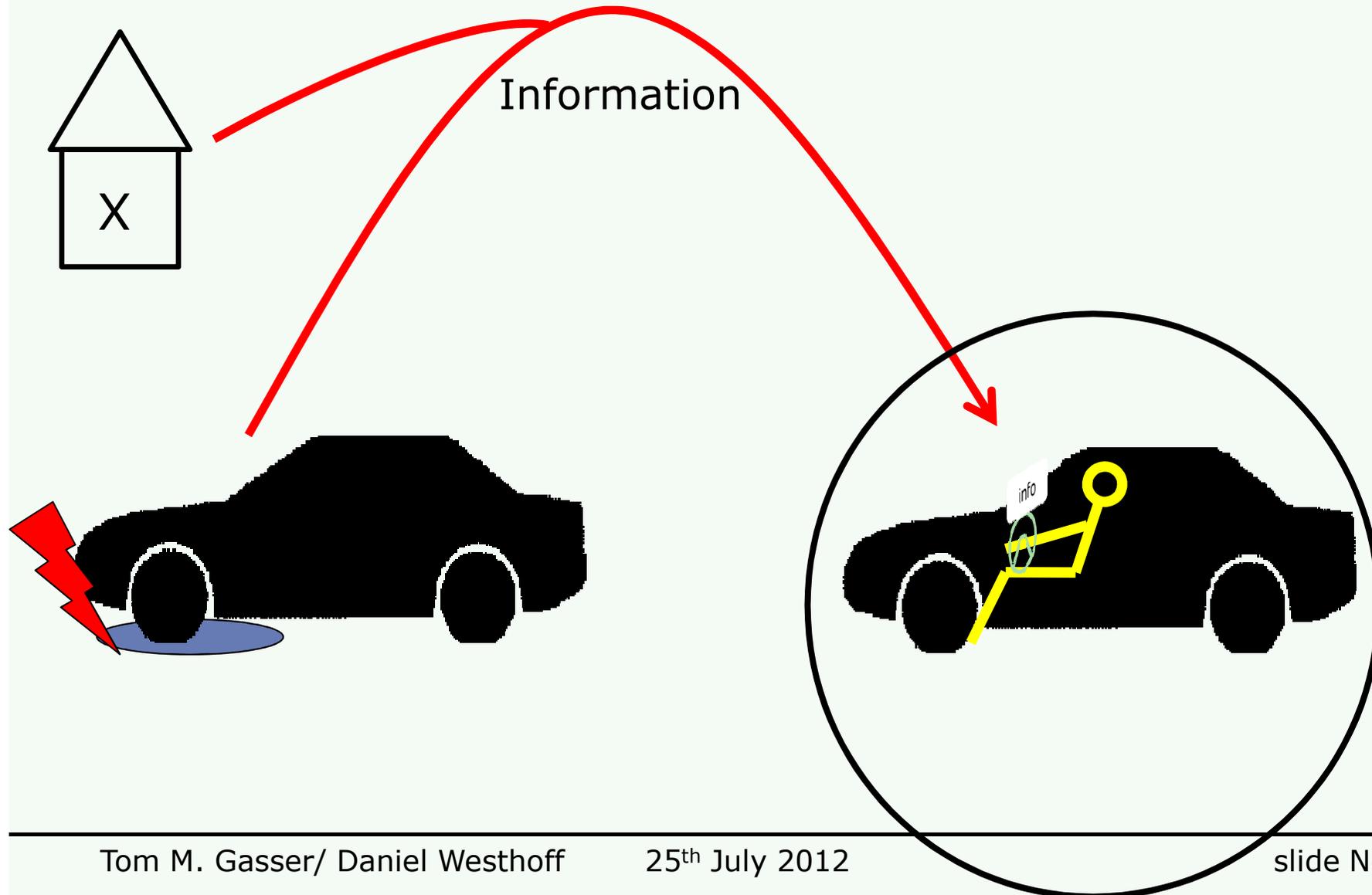
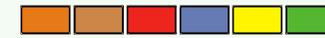
Source: SARTRE-Project, press Release (with modifications by author)

## Driving Functions that Could Potentially be Automated

- 
- A diagram showing seven driving functions. A red rounded rectangle encloses items 1 and 2, with 'Tactical' written vertically on the left and 'Vehicle' on the right. A green rounded rectangle encloses items 3, 4, 5, and 6, with 'Strategic' written vertically on the left. On the right, 'Mixed' is written vertically with an arrow pointing to item 3, and 'Infrastructure' is written vertically with an arrow pointing to item 5. Item 7 is not enclosed in any box.
1. Actuation of steering, engine, brakes
  2. Powertrain and chassis control (e.g., ABS, stability control – transparent to driver)
  3. Real-time information collection (including driving environment perception from sensing and/or communication)
  4. Hazard assessment
  5. Decision making (tactical microscopic maneuvering to strategic route planning)
  6. Management of vehicle flows (traffic management)
  7. Combinations (up to all of the above)

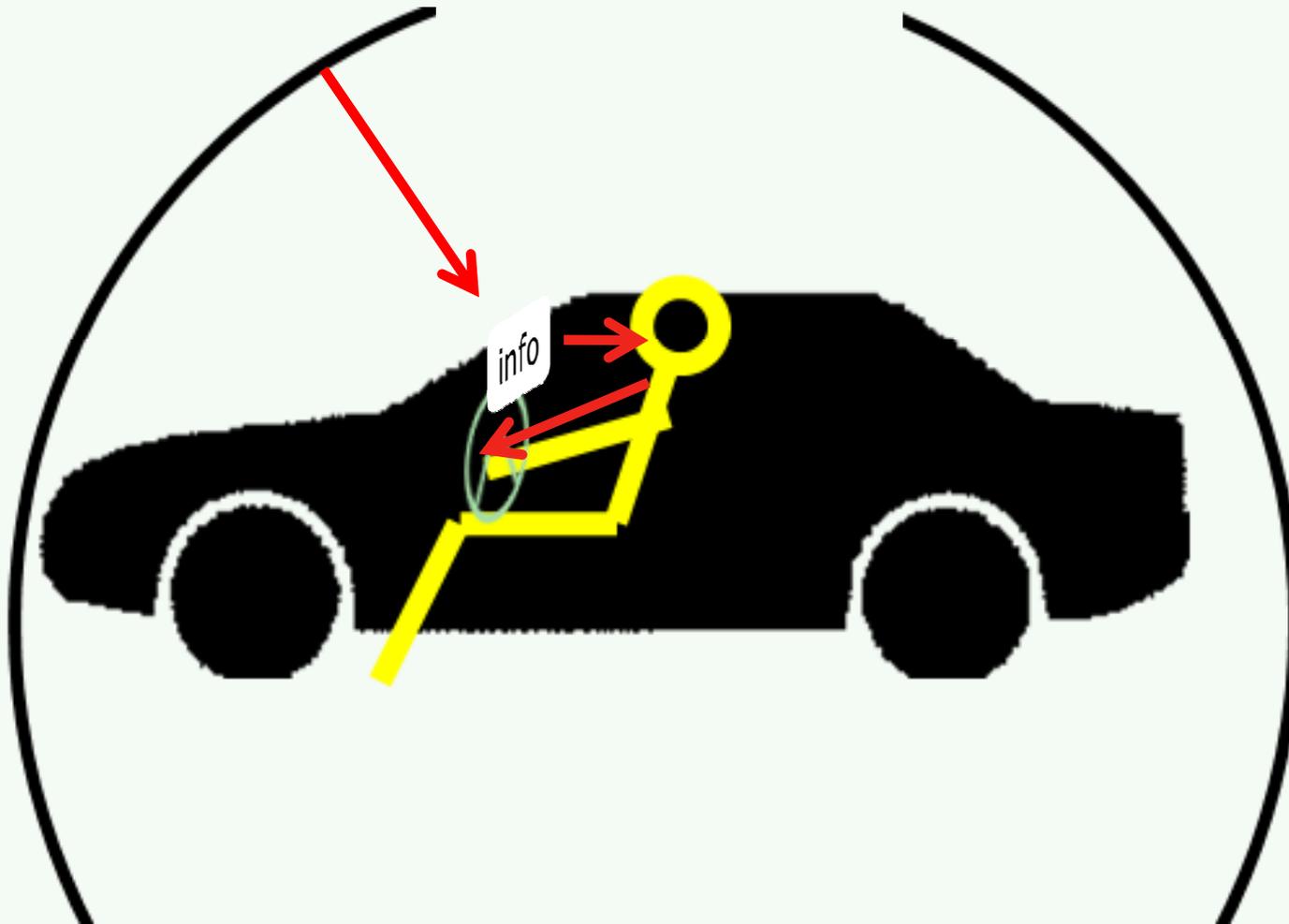
Source: Steven E. Shladover  
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Program

# Indirect function of V2X-technology: (V2V or V2I, same effect!)

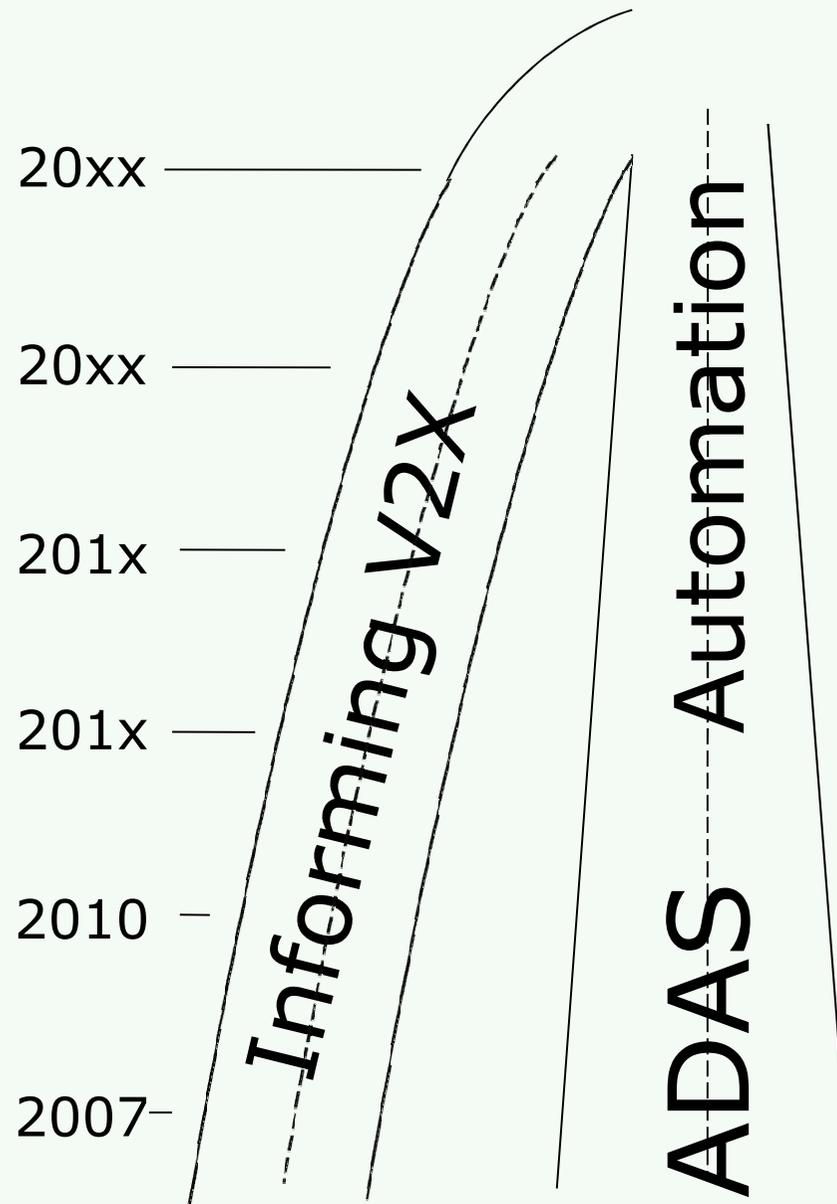
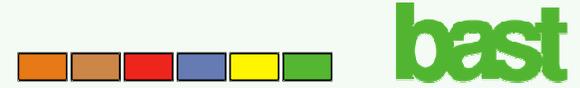


# Indirect function of

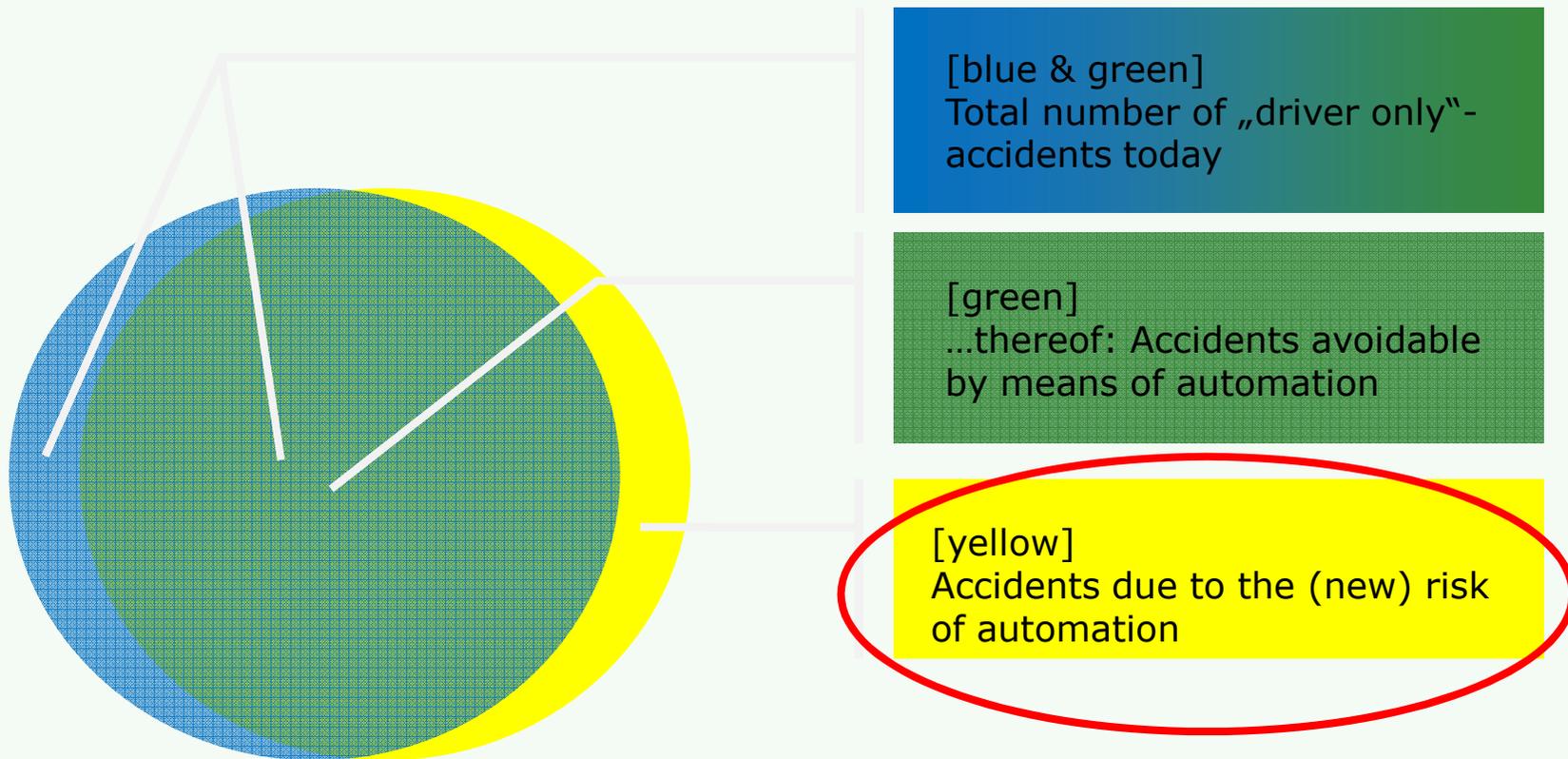
## V2X-technology: (V2V or V2I: same effect!)



# Realistic view on V2X:



# Theoretical potential of vehicle automation for traffic safety (not quantified):



Source: Report of the BAST Expert Group



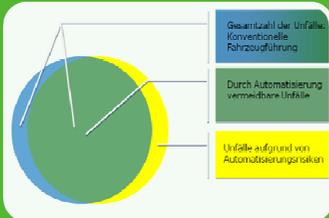
## Cluster: Human-Machine-Interaction

- Driver-Feedback/ Driver in the loop
- Stabilization at system limits/ Driver takeover



## Cluster: functional safety

- Requirements according to ISO 26262
- Application to vehicle automation



## Cluster: Societal acceptance

- Benefits for traffic safety
- Societal acceptance of the automation risk



## Cluster: legal

- Intended use (product liability)
- Adjustment of laws

Federal Highway Research Institute



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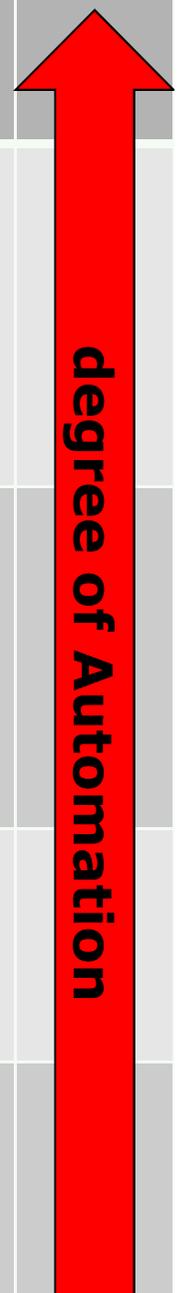
German Federal Highway Research Institute

# Description and categorization of automated driving functions

(not exhaustive)



Nomenclature	Description of automation level according to drivers' expectations	Exemplary systems
Driver Only	The driver continuously (throughout the complete trip) accomplishes longitudinal (accelerating /braking) and lateral (steering) control.	No (driver assistance) system active that intervenes into longitudinal and lateral control
Assisted	<p>The driver continuously accomplishes <u>either</u> lateral <u>or</u> longitudinal control. The other/ remaining task is accomplished by the automating system to a certain level only.</p> <ul style="list-style-type: none"> <li>▪ The Driver must permanently monitor the system</li> <li>▪ The Driver must at any time be prepared to take over complete control of the vehicle</li> </ul>	<p>Adaptive Cruise Control:</p> <ul style="list-style-type: none"> <li>- Longitudinal control with adaptive distance and speed control</li> <li>-Parking assistance: Lateral control is accomplished by the parking assistance (automatic steering into a parking space. The Driver accomplishes longitudinal control).-</li> </ul>
Partially automated	<p>The system takes over lateral <u>and</u> longitudinal control (for a certain amount of time and/ or in specific situations).</p> <ul style="list-style-type: none"> <li>▪ The driver must permanently monitor the system</li> <li>▪ The Driver must at any time be prepared to take over complete control of the vehicle</li> </ul>	<p>Motorway assistant:</p> <ul style="list-style-type: none"> <li>- Automatic longitudinal and lateral control</li> <li>- On motorways up to an upper speed limit</li> <li>- The driver must permanently monitor and take over immediately in case of takeover request by the system.</li> </ul>
Highly automated	<p>The system takes over lateral and longitudinal control for a certain amount of time in specific situations.</p> <ul style="list-style-type: none"> <li>▪ The Driver <u>need not</u> permanently monitor the system as long as it is active</li> <li>▪ If necessary, the driver is requested to take over control by the system with a certain time buffer.</li> <li>▪ All system limits are detected by the system. The system is not capable of re-establishing the minimal risk condition from every initial state.</li> </ul>	<p>Motorway-chauffeur:</p> <ul style="list-style-type: none"> <li>- Automatic longitudinal and lateral control</li> <li>- On motorways up to an upper speed limit</li> <li>-The driver need not permanently monitor. In case of a take over request, the driver must react with a certain time buffer.</li> </ul>
Fully automated	<p>The system takes over lateral and longitudinal control completely within the individual specification of the application.</p> <ul style="list-style-type: none"> <li>▪ The driver <u>need not</u> monitor the system</li> <li>▪ Before the specified limits of the application are reached, the system requests the driver to take over with sufficient time buffer.</li> <li>▪ In absence of a takeover, the system will return to the minimal risk condition by itself</li> <li>▪ All system limits are detected by the system, the system is capable to return to the minimum risk condition in all situations.</li> </ul>	<p>Motorway-pilot:</p> <ul style="list-style-type: none"> <li>- Automatic longitudinal and lateral control</li> <li>-On motorways up to an upper speed limit</li> <li>-The driver need not monitor.</li> <li>- In case the driver does not react to a take over request, the system will brake down to standstill</li> </ul> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-left: auto; margin-right: auto;"> <p>Source: Report of the BAST Expert Group</p> </div>



Nomenclature	Task of the driver according to automation level
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Driver only	<p>The driver continuously (throughout the complete trip) accomplishes longitudinal (accelerating /braking) and lateral (steering) control.</p>