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ConnRAD – Connectivity and Resilience for Automated Driving

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ConnRAD
Connectivity & Resilience for automated Driving Functions in Germany

Ability Awareness Graph

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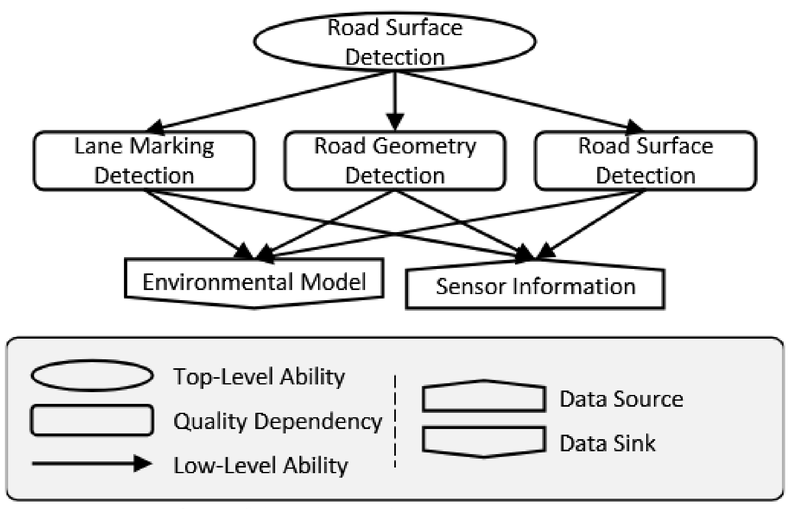
Ability Awareness:

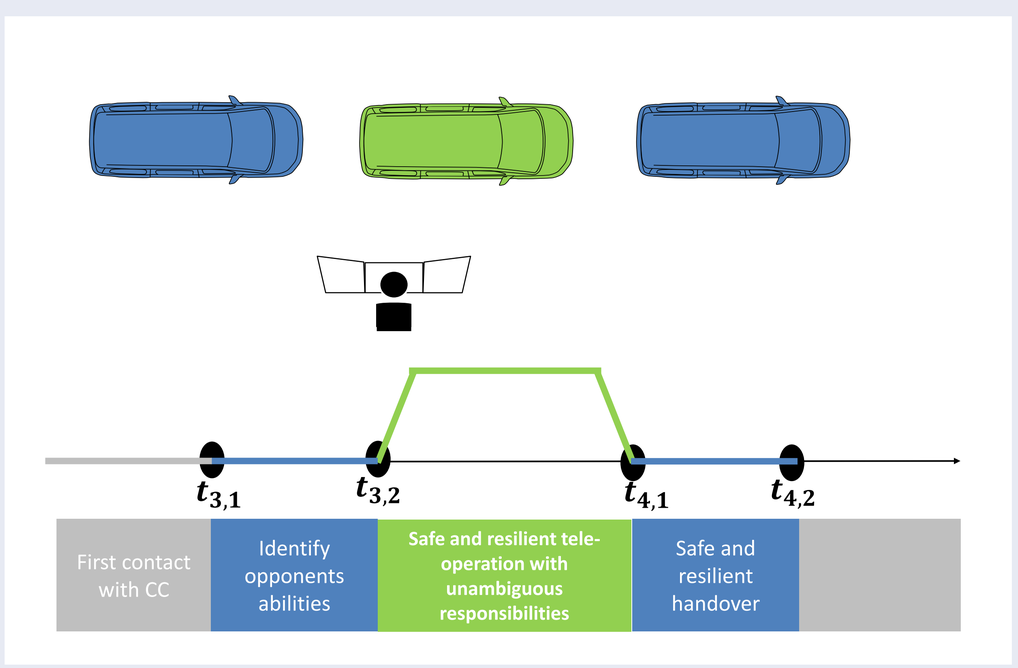
In case of two unknown remote operation concepts, both systems shall have a unified method to determine whether a safe operation is possible. This can be done by splitting a holistic set of abilities between the two systems. To display the relation between abilities, a graph is used. This representation allows to determine the impact of missing abilities on the overall system performance. An exemplary Ability Graph is displayed below:



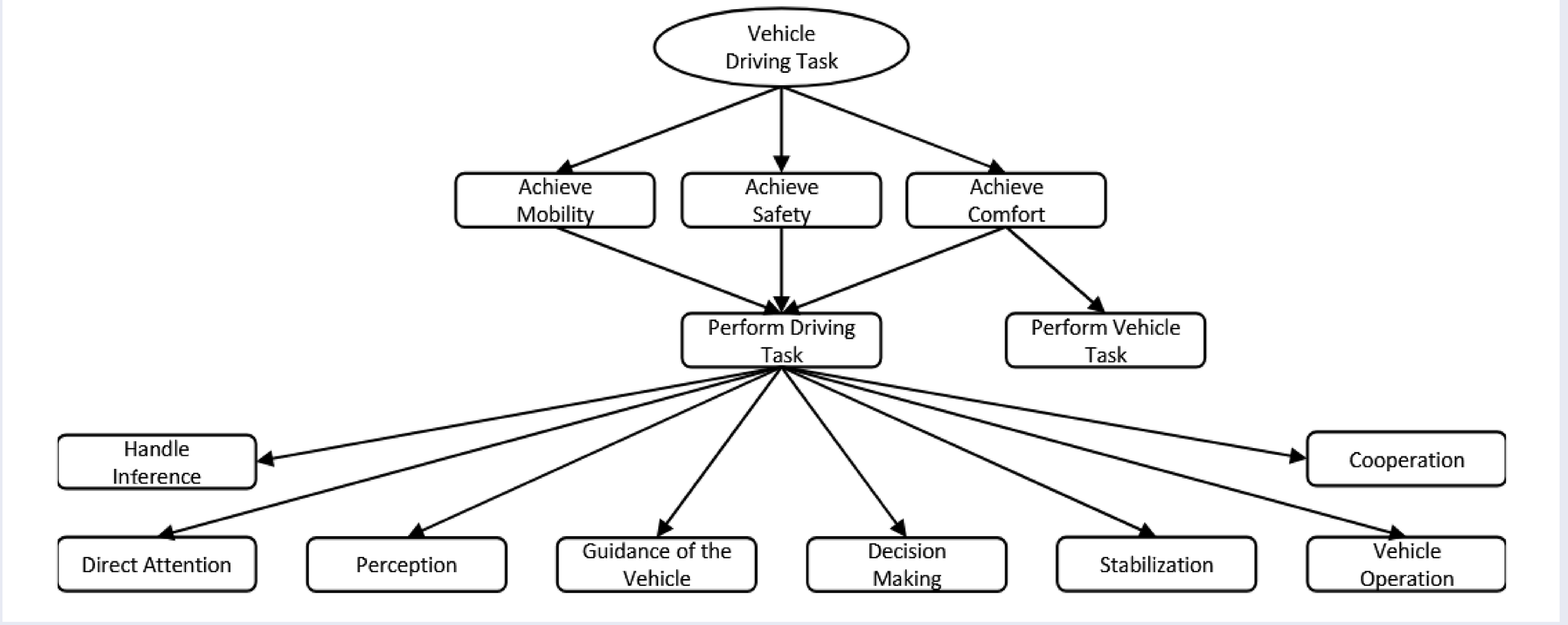
see **How to Drive -** Pfab, Gehrke, Diermeyer 2024

Application Area for Remote Driving

The Protocol is applied during the handover phases. It ensures that both systems together provide the full driving ability, or after the remote driving if the automated system can now again take over all abilities.



Holistic Ability Graph:



Each Abilities has an individual ODD for the vehicle/CC

Each subsystem vehicle or control center must assign each ability from the ability graph an ODD value in case it can achieve this ability in a certain ODD. An ODD is also considered to be present if the ODD has single values like 0km/h. This tells the other subsystem that it can hand over the specific ability at stillstand and is this very important for the handover to the vehicle-only automation after a remote operating phase. Here the ODD definition from NHTSA is used:

Category	Sub-Category
Physical Infrastructure	Road Type, Road Surface, …
Operational Constraints	Speed Limit, Traffic Condition
Objects	Signage, Road Users, …
Connectivity	Vehicles, Infrastructure, …
Environmental Conditions	Weather, Illumination, …
Zone	Geofencing, Construction Zone, …

Merging Strategies for Remote Driving

During the Protocol, two individual ability graphs with corresponding ODDs need to be merged into one graph. This ensures that all abilities are performed by either vehicle or operator. The merging can be considered as an optimization of the ODD of the merged graph. Setting the optimization problem is thus important to ensure that both subsystems consecutively reach the same result for a merged graph. Some optimization strategies are:

Strategy 1: Optimizing System Maximum Velocity

$$v_{max}^{(system)} = \min_{nodes} \max\{v_{node}^{(VEH)}, v_{node}^{(CC)}\}$$

Strategy 2: Optimizing System ODDs Application Area

$$ODD_{max}^{(system)} = \max A(\min_{nodes} ODD_{node}^{(system)})$$

With A being the Area where the current ODD is applicable. This involves selecting suitable ODDs on node level based on vehicle and control center ODD for a node.