



# Continuous Updating of Backend HD Map Data Based on Vehicle Fleet Data

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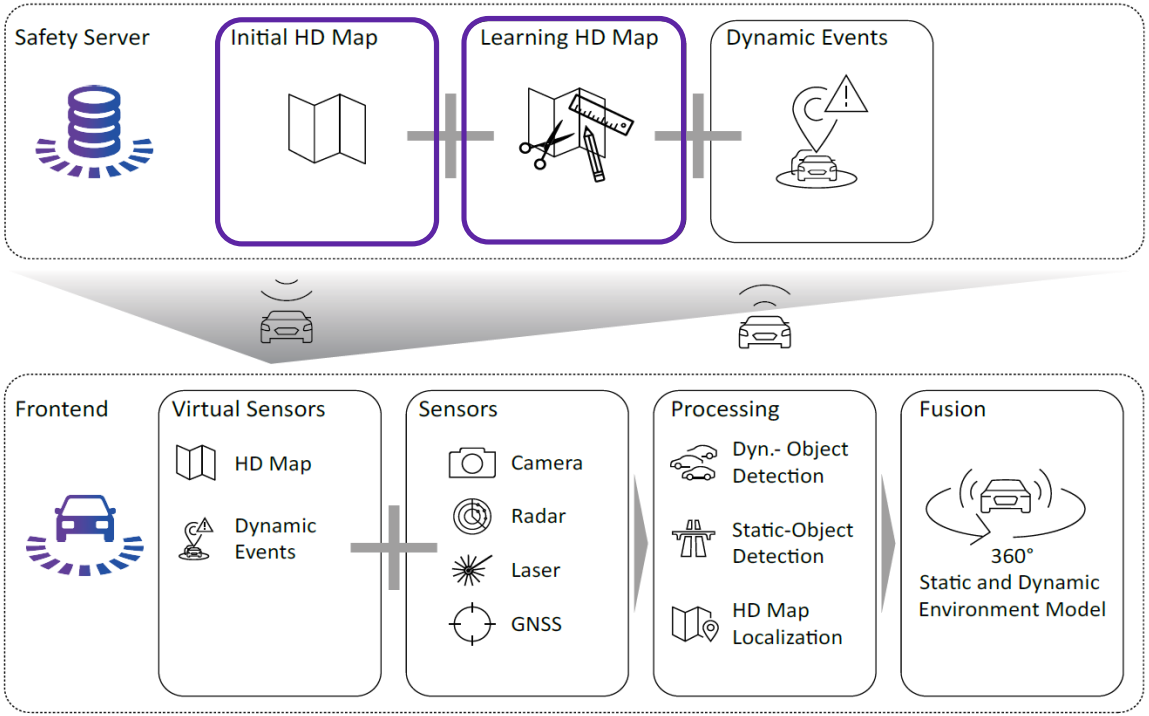
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

# Big Loop Interplay of Frontend & Safety Server

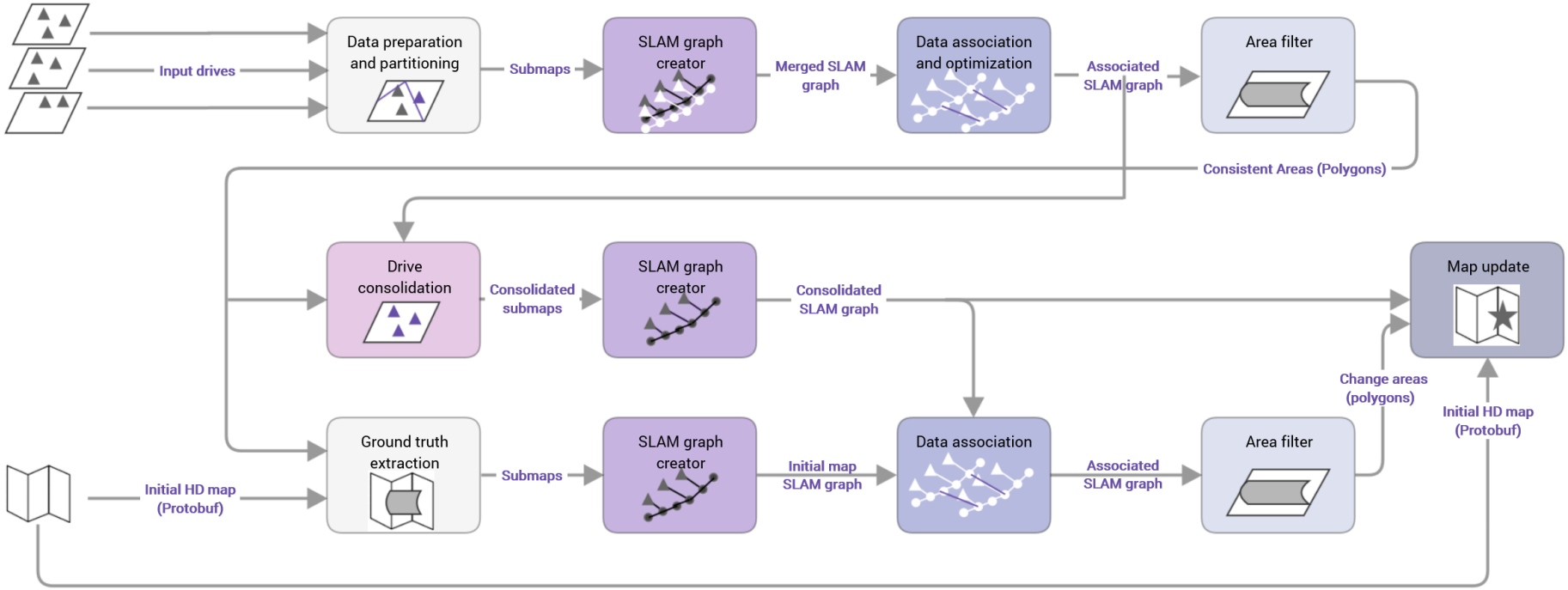



Continuous Data Exchange between Frontend and Safety Server

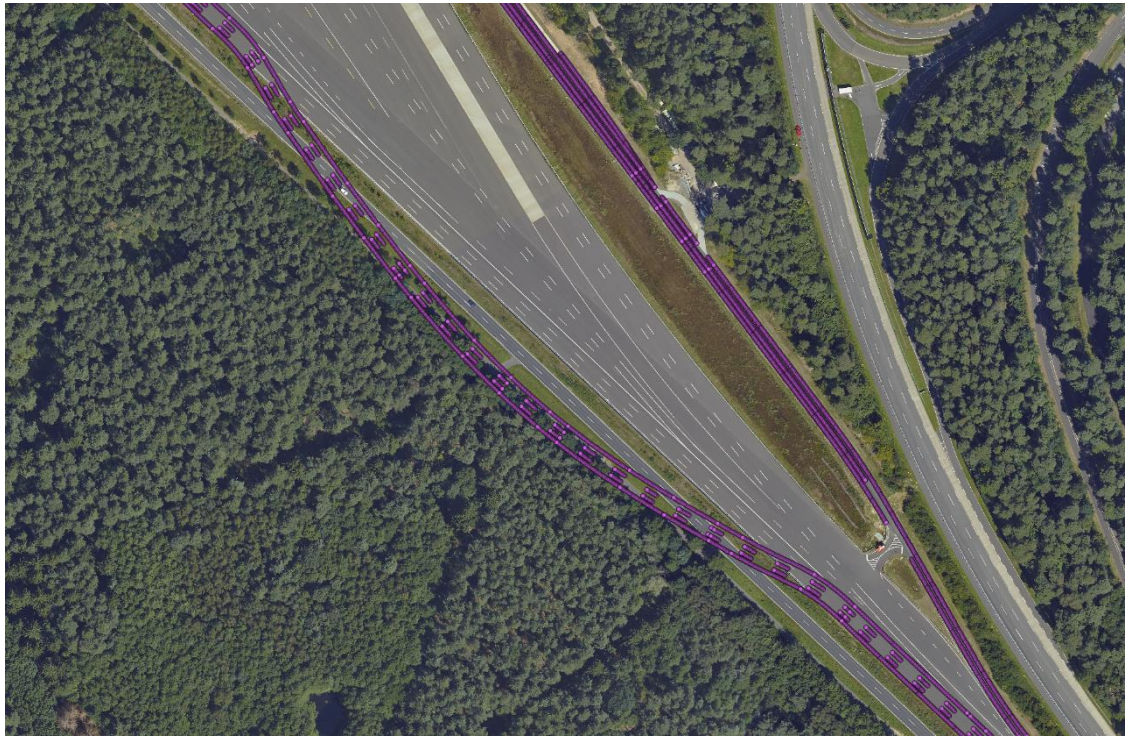

Learning HD Map

# Aggregation of HD Map Data

# HD Map Updates from Fleet Data



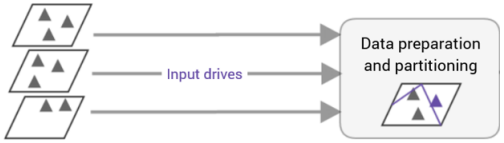
# Change Detection Case: Dudenhofen Detour



This and the following map visualizations were generated with QGIS: *http://qgis.org/*

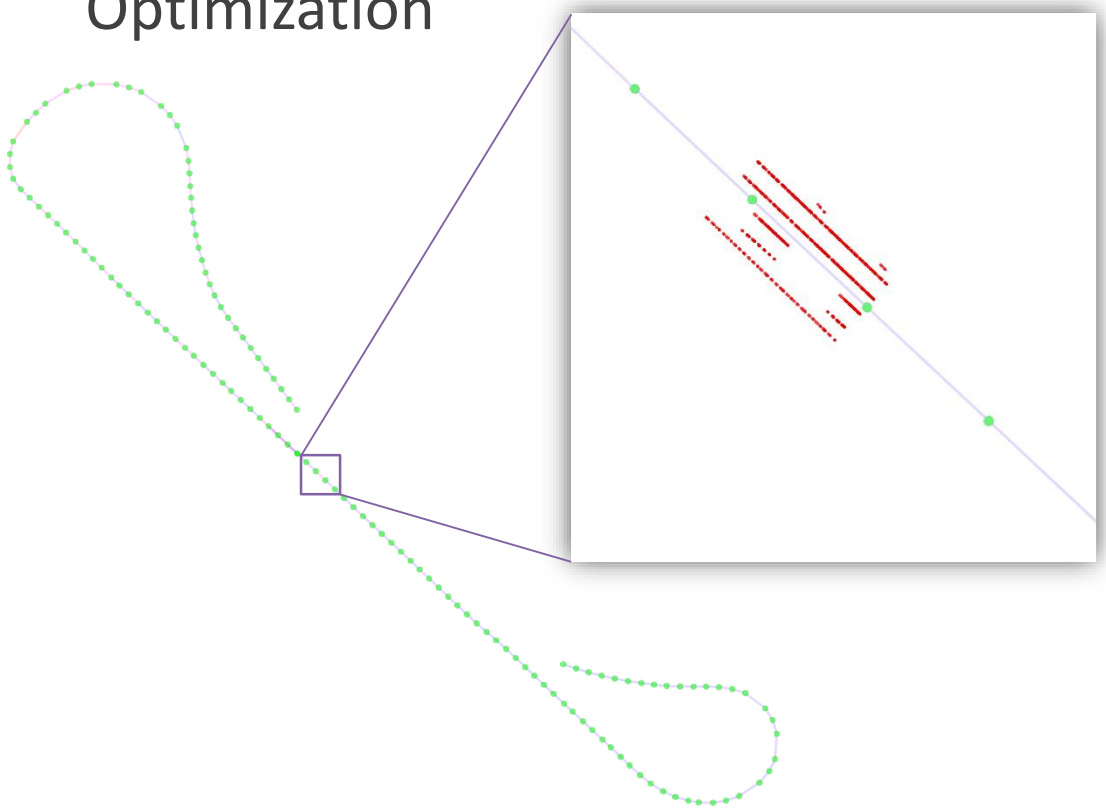
- Case study „Initial Safety Server HD map with detour“:
  - Detour part on the straight (geometry)
  - Same number of lanes (topology)
  - Lane markings shifted
  - Vehicles send data that should be detected as changes

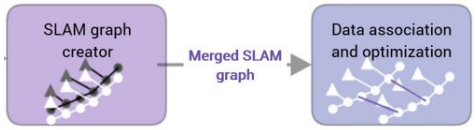
# Fleet Data Preparation




- Data from vehicles contains observed features (here: Lane markings)
- But also artefacts
- In vehicles, data can be classified according to a confidence value
- Data preparation filters the features based on this classification and other constraints
- Aim: Less, but better data

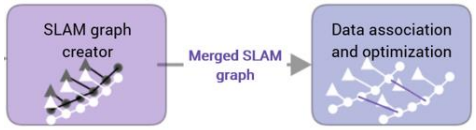
# SLAM Graph Creator, Association and Optimization





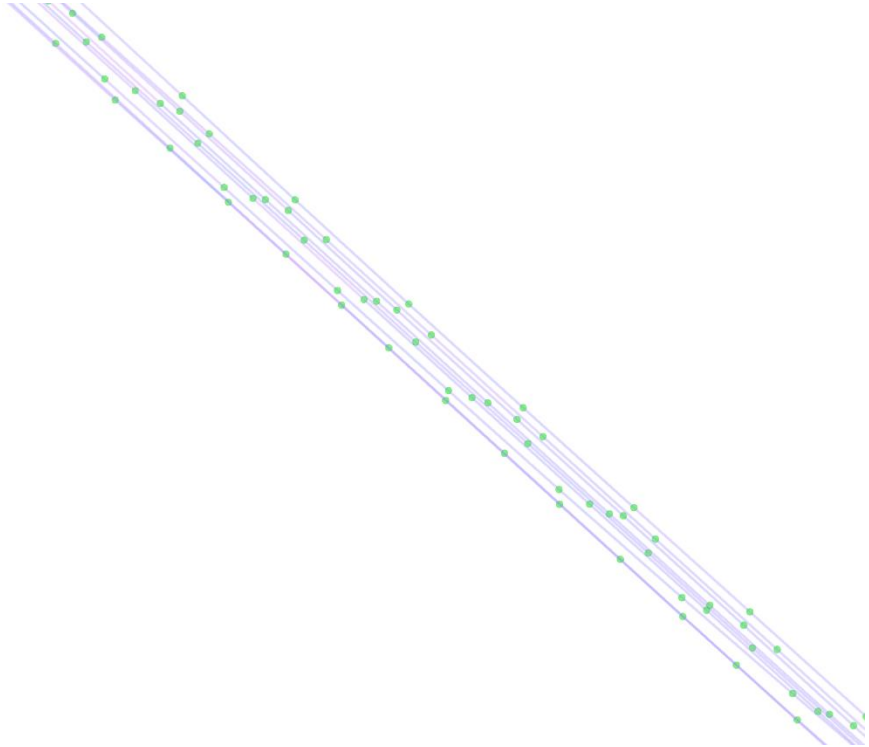

- SLAM graphs are a state-of-the-art approach to model trajectories and observations of robots
- Based on these graphs, an optimization can be executed with the aim of adjusting the data under the observed and modelled contraints
- Fleet data is transformed into SLAM graphs in the pipeline to allow an aggregation and thus comparison of data from several drives

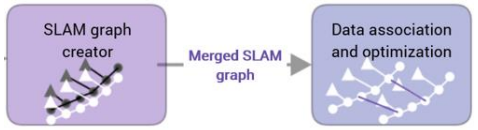
# SLAM Graph Creator, Association and Optimization




- Fleet data from different drives is usually inconsistent:
  - Varying localization quality
  - Occlusion leading to missing features
  - Sensor artefacts and classification
  - Differing trajectories
- SLAM graphs allow to compute the consistent parts (association)
- This is done based on observed features, trajectories and models

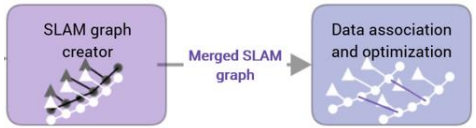
# SLAM Graph Creator, Association and Optimization





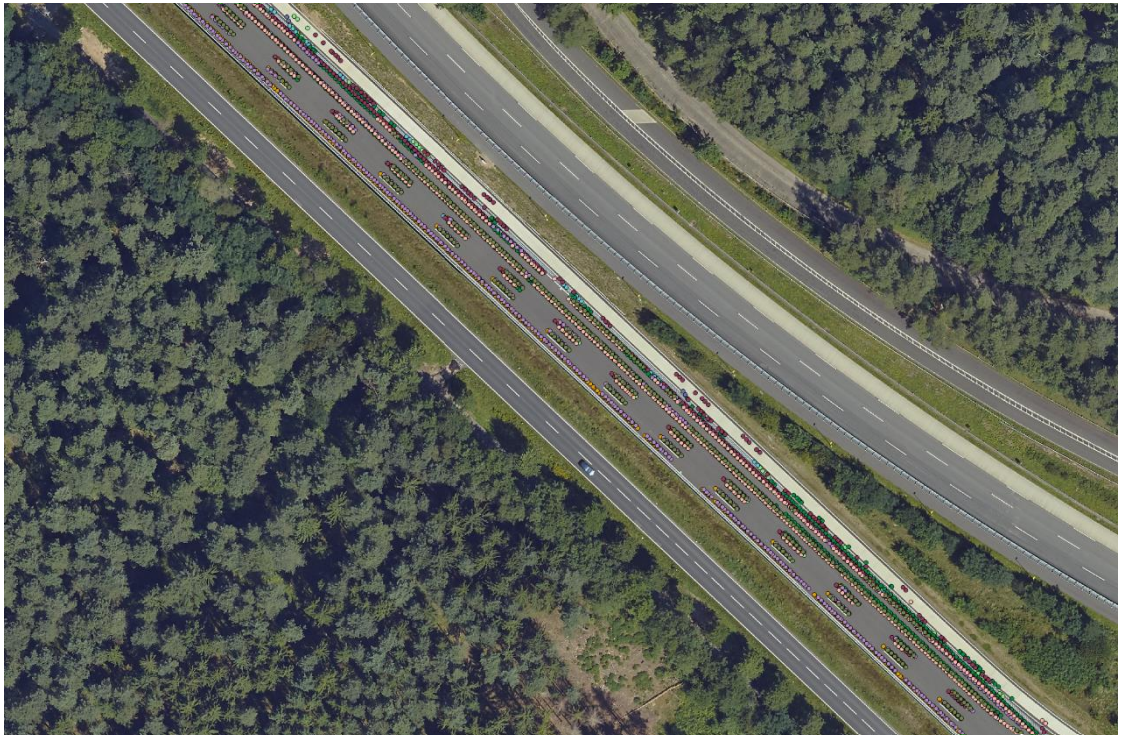

- Association of multiple drives

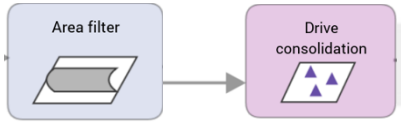
# SLAM Graph Creator, Association and Optimization




- Optimization of associated graphs

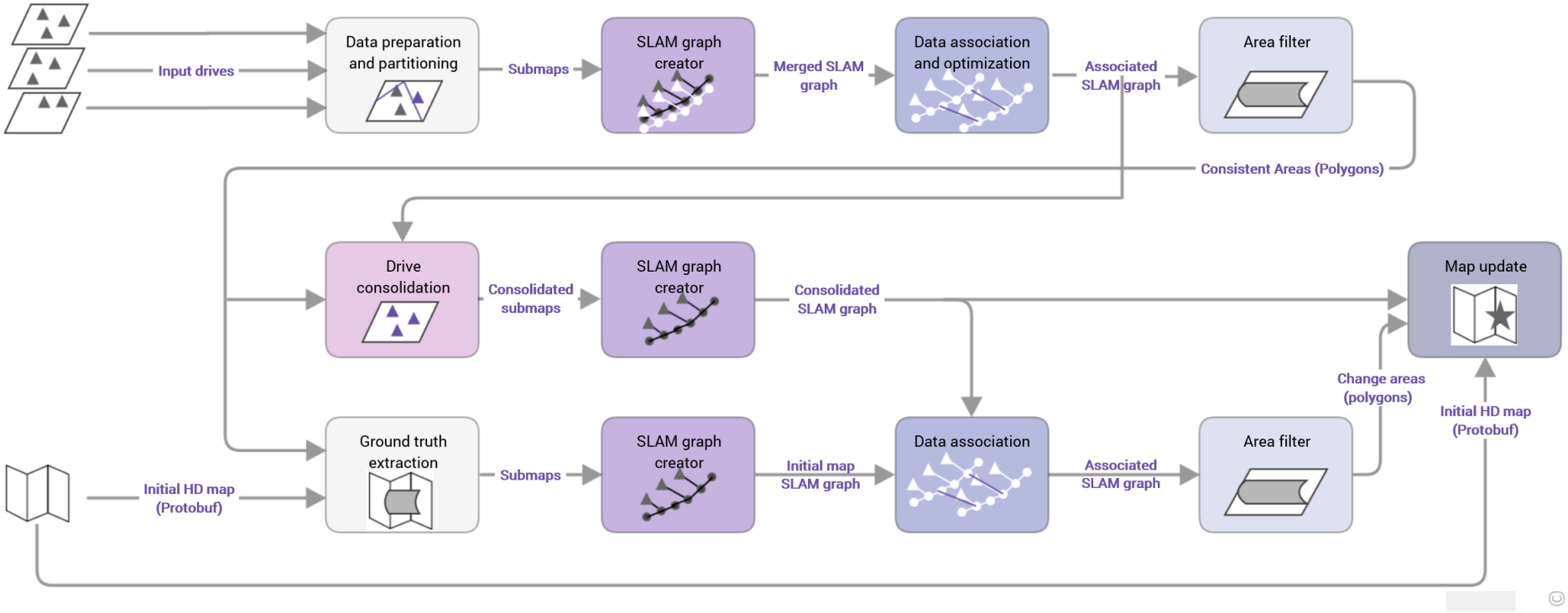
# Area Filter and Consolidation



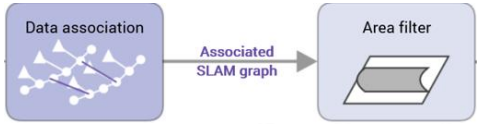


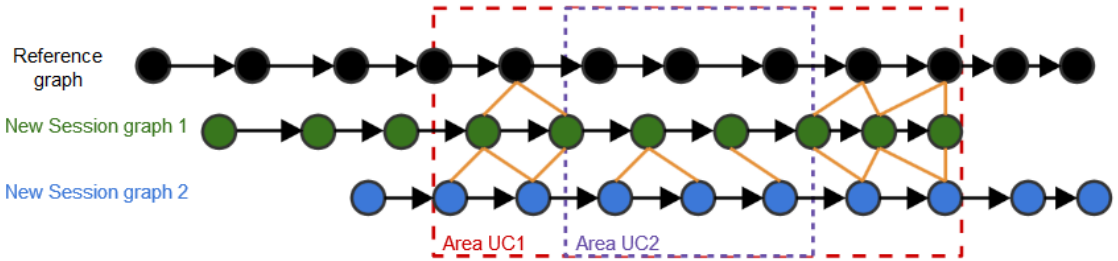

- On this associated graph, an area filter is applied to determine consistent areas of the drives (polygons)
- These polygons and the respective graph are then consolidated
- Consolidation is based on statistics and geometric approaches and produces an aggregated view on the features
- This filters out false positives and allows to consider partly occluded areas

# HD Map Updates from Fleet Data



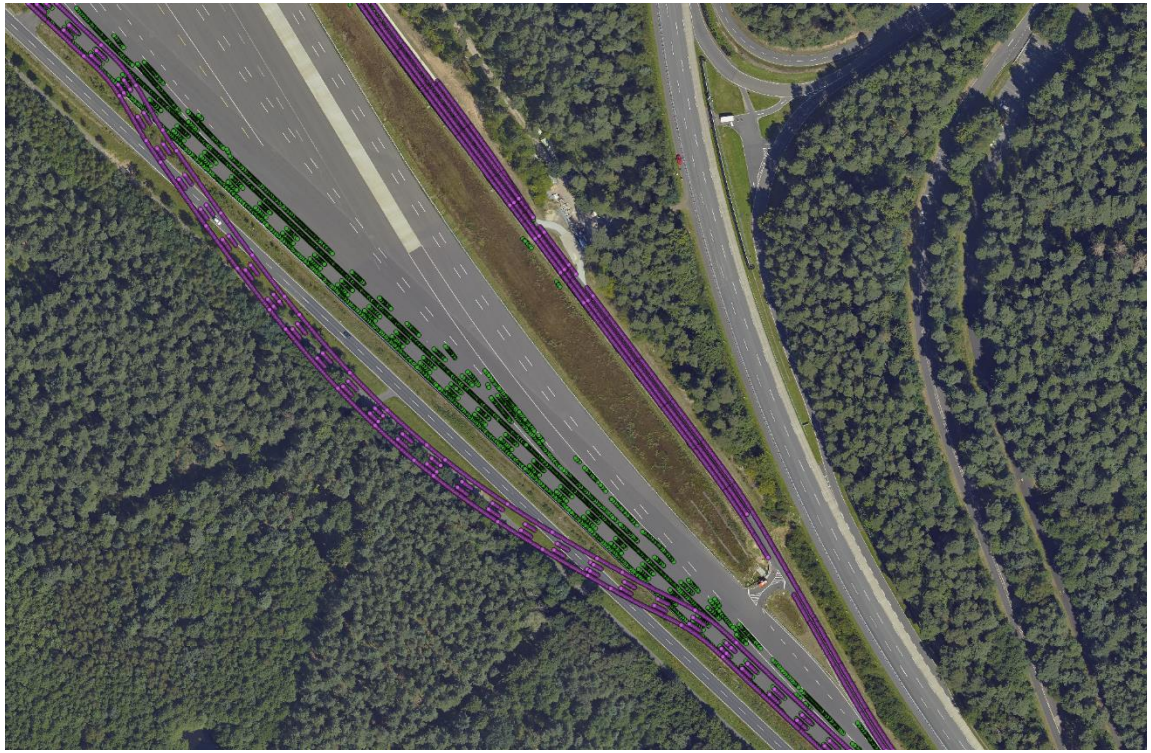
# Association of Consolidated Drives with Initial HD Map and Area Filter



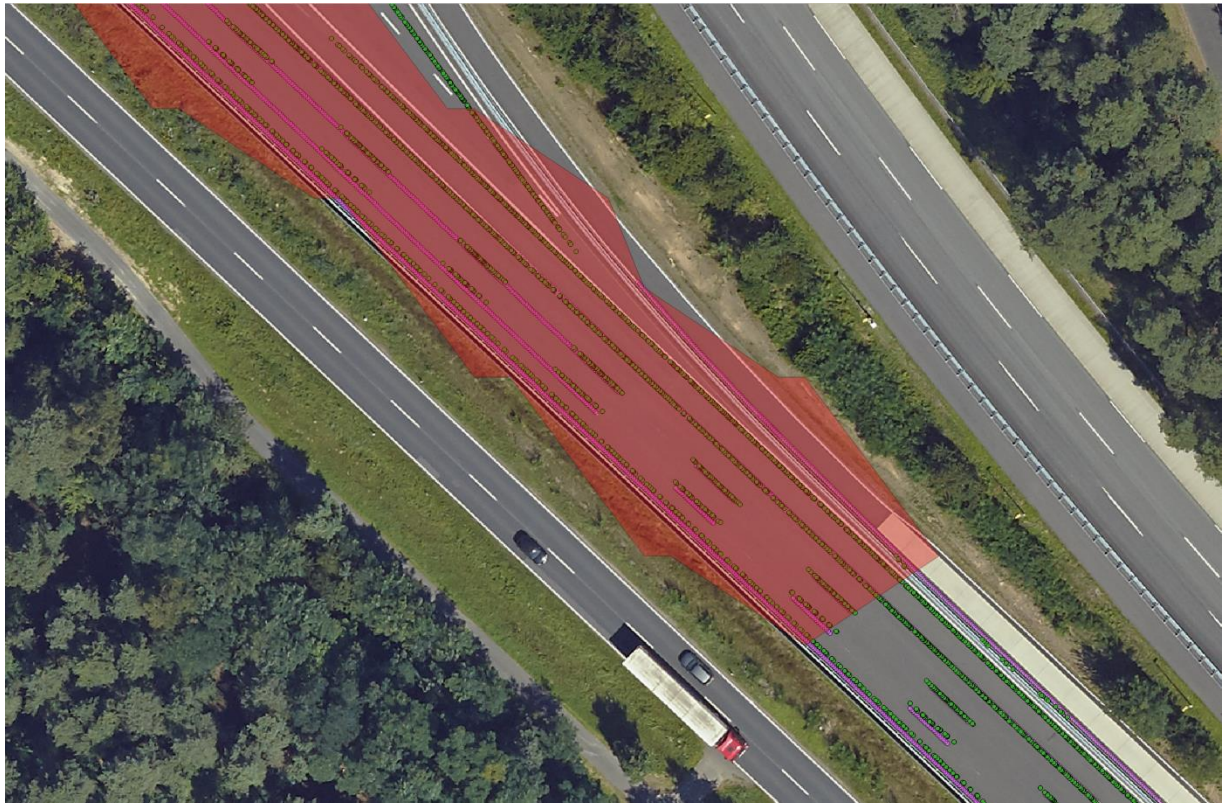

- Necessary steps: Preparation of the initial HD map (extraction and SLAM graph creation)
- Change detection mainly consists of the association of extracted initial HD map graph with the graph of the consolidated drives in consistent areas
- Assumption here: In changed areas, drives are consistent to each other and inconsistent to initial HD map
- The area filter outputs these changed areas

# Association of Consolidated Drives with Initial HD Map and Area Filter




- Final step: For each changed area, the consolidated drives are merged into the initial HD map
- Current limitations:
  - Geometric and topological representation without potential semantics as contained in the initial HD map
  - Handling of outdated parts is treated conceptually only

# Additional Change Classes



Additionally detected changes include areas with changed lane marking types (depicted) and traffic sign occurances


Learning HD Map

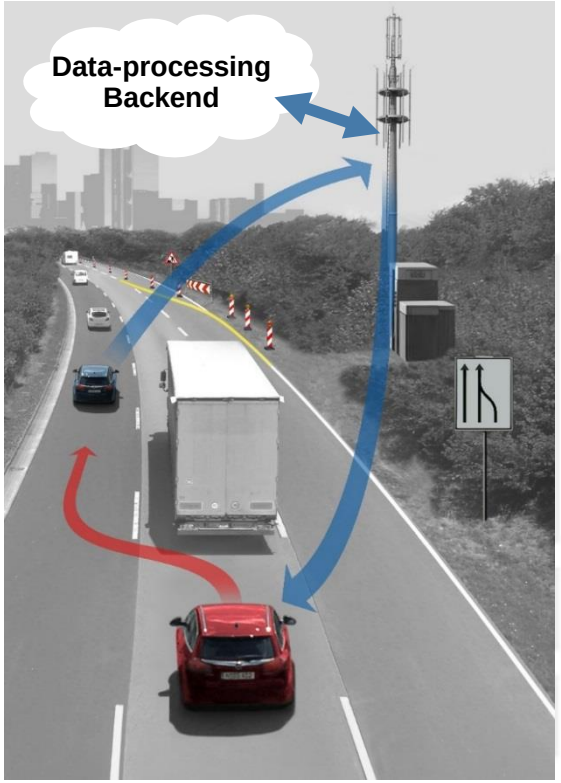
# Aggregation of data from cellular networks

Measuring key network parameters to enable robust communication for Highly Automated Driving

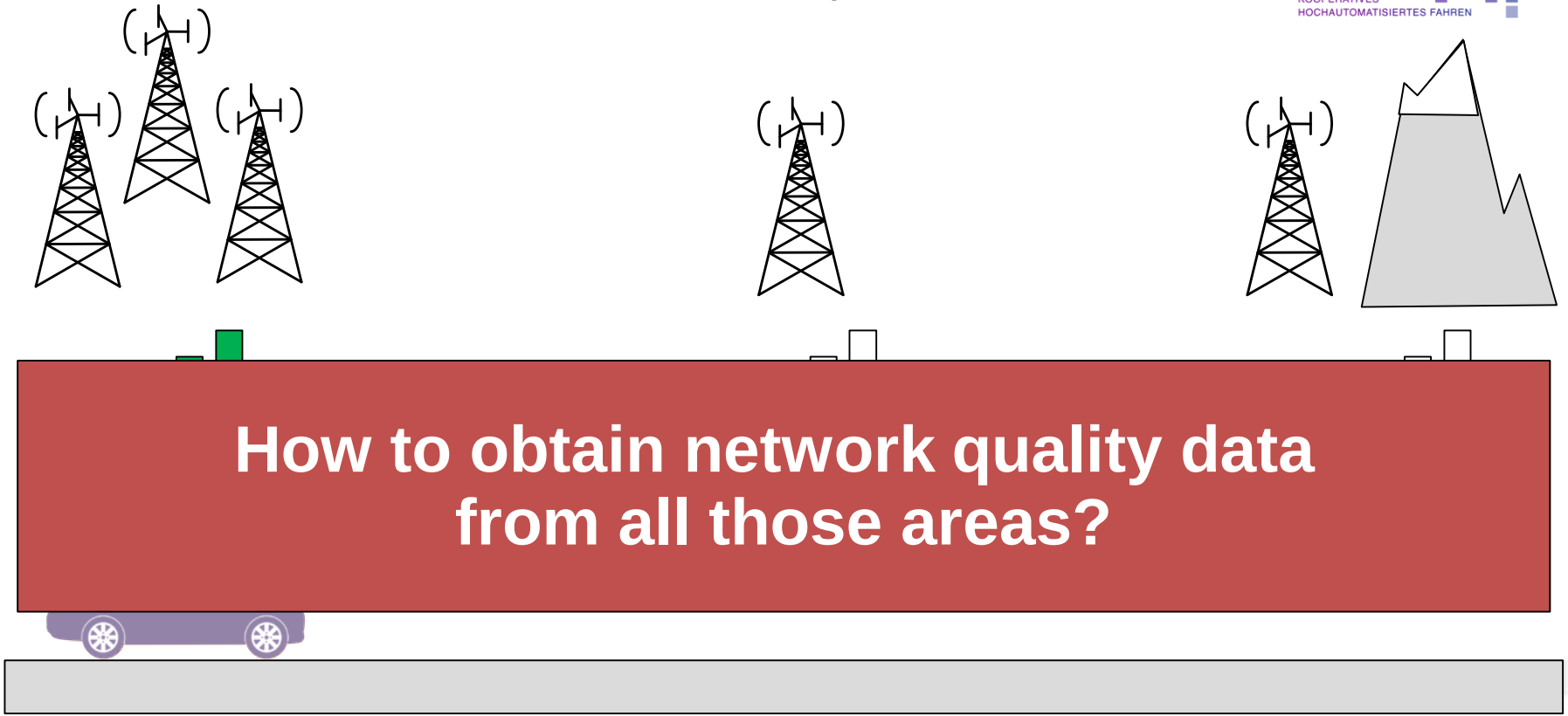
# Highly automated cars are consumers and producers of data

- Sensor data provider for backend services (update traffic/map data)
- Consumer of traffic/map data (from backend – federal / OEM)
- To realize safe and convenient driving

- Comfort services like infotainment (streaming, …)



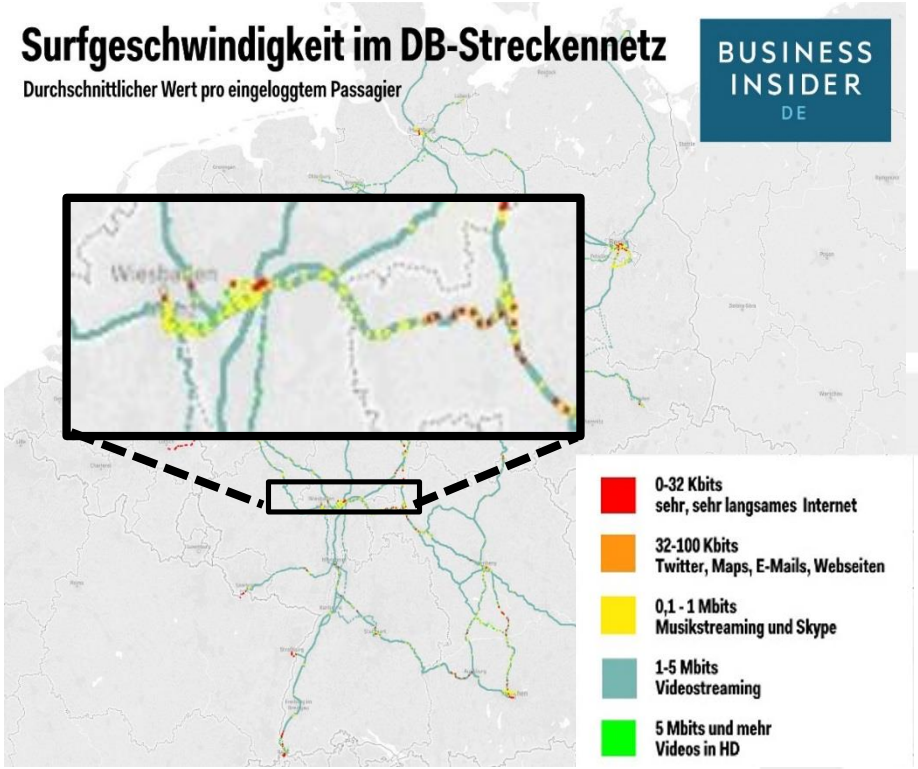
# Problem for Services: Mobility



**How to obtain network quality data from all those areas?**

# Connectivity as Layer in the HD-Map

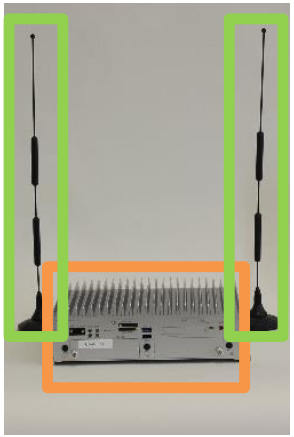
- Map can provide a-priori knowledge of cellular network quality
- Deutsche Bahn collected such data for their network
- Similar map can be created by vehicles
- Vehicles can share information




https://www.businessinsider.de/eine-karte-zeigt-wie-schnell-das-wlan-in-den-ices-der-deutschen-bahn-ist-2018-5

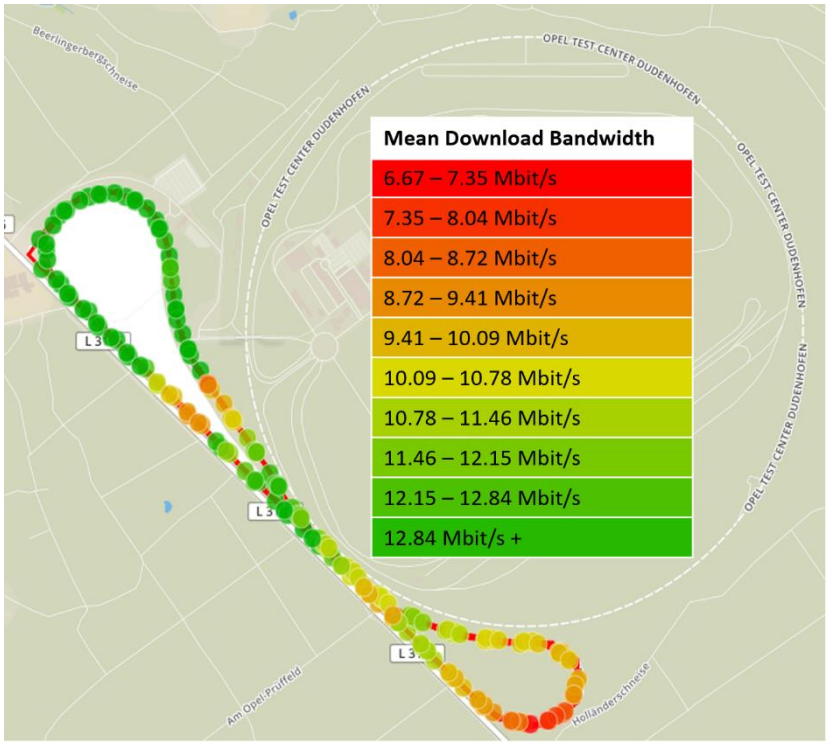
# Ko-HAF Setup

- Vehicles can measure the available network quality
- Onboard communication module provides all necessary quality parameters
- Information aggregated on Safety Server

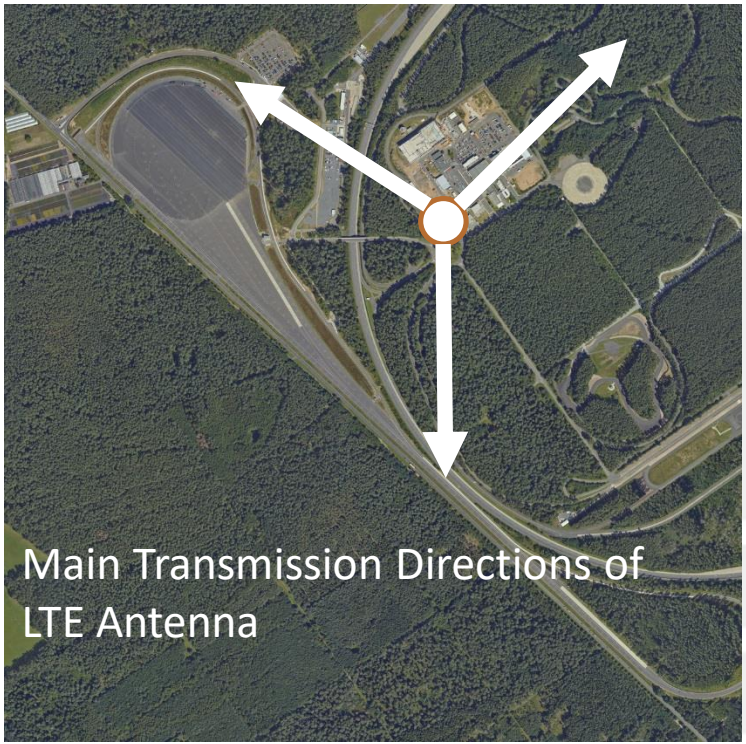



- Key Performance Indicators
  - Data throughput (upload/download)
  - Latency

# Throughput – Opel Testtrack Dudenhofen

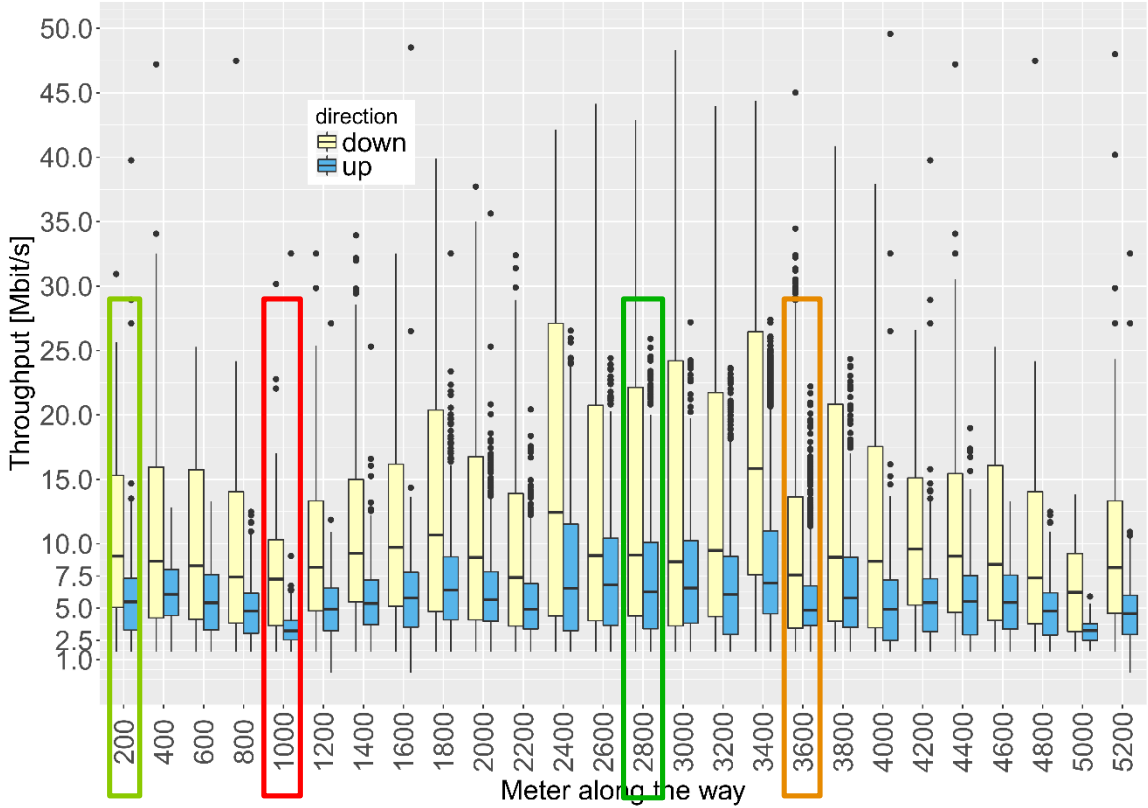


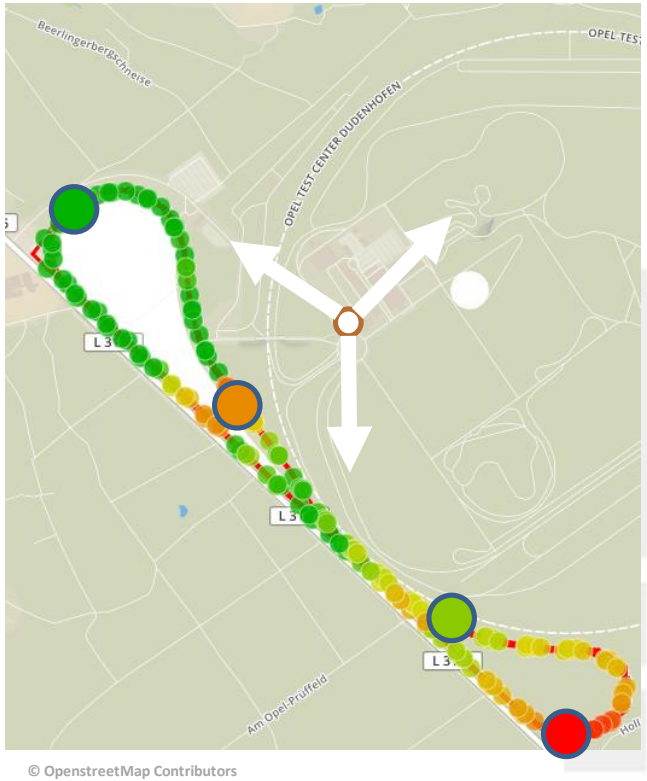


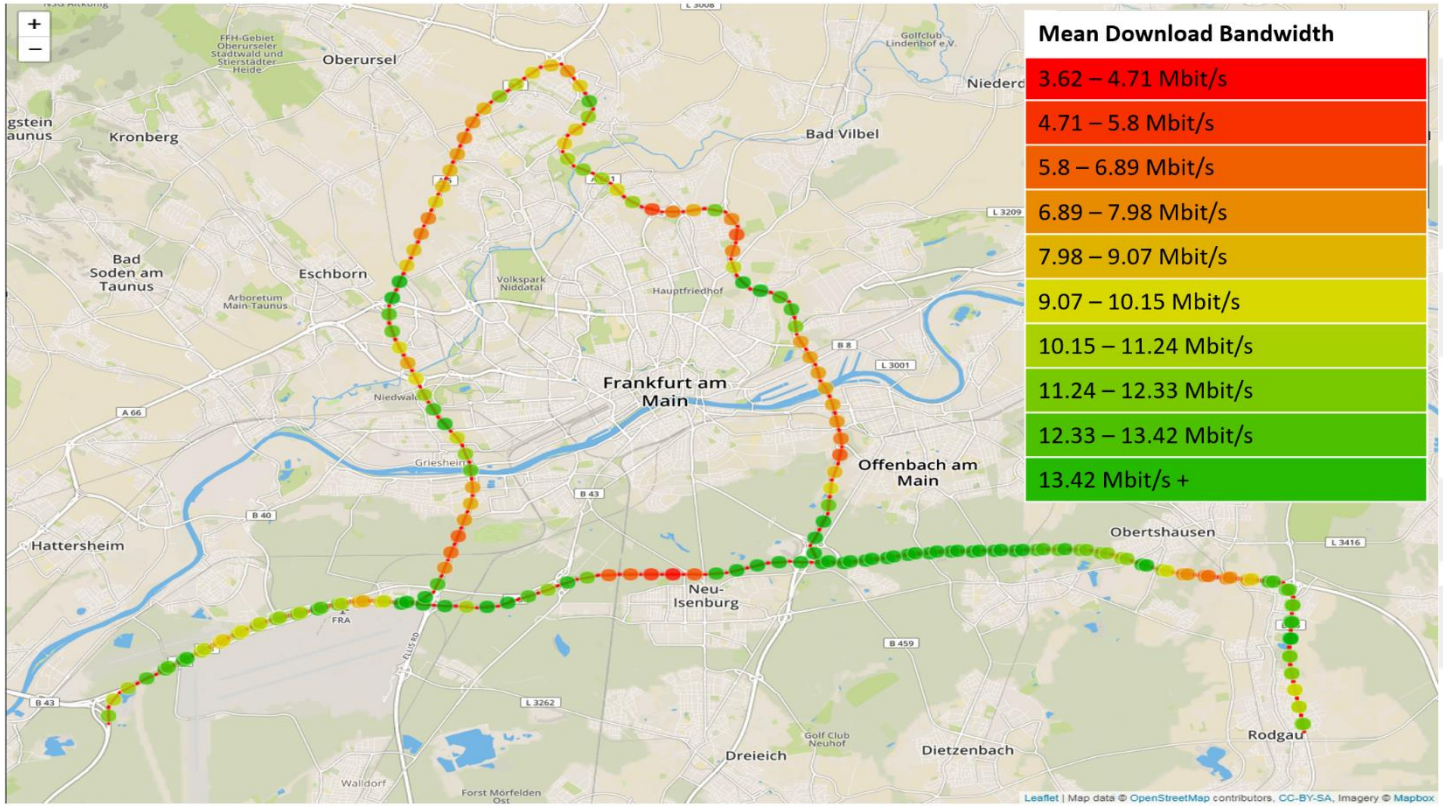

Quelle: Aero West

# Detailed investigation of measured throughput



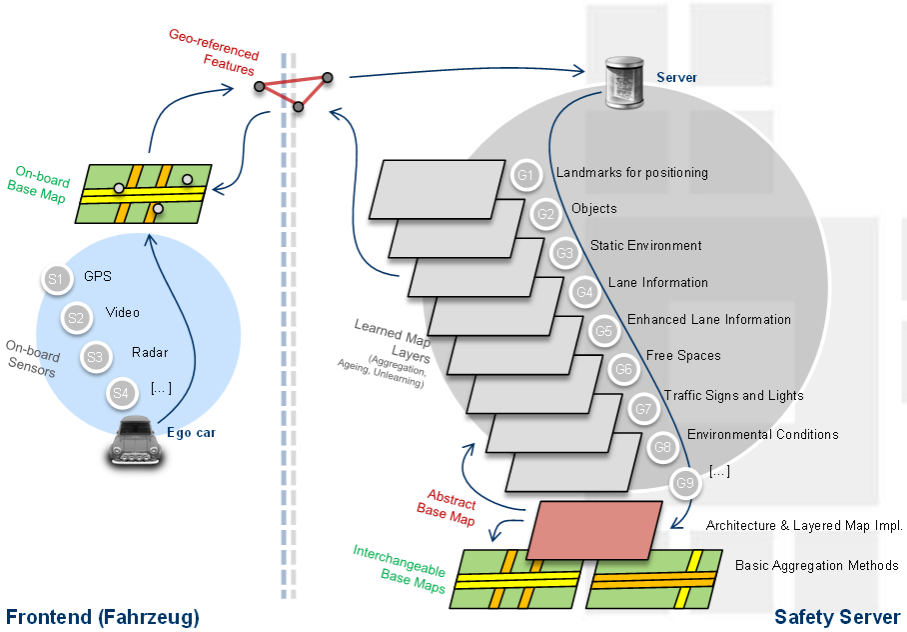



# Download Throughput Ko-HAF Test Area



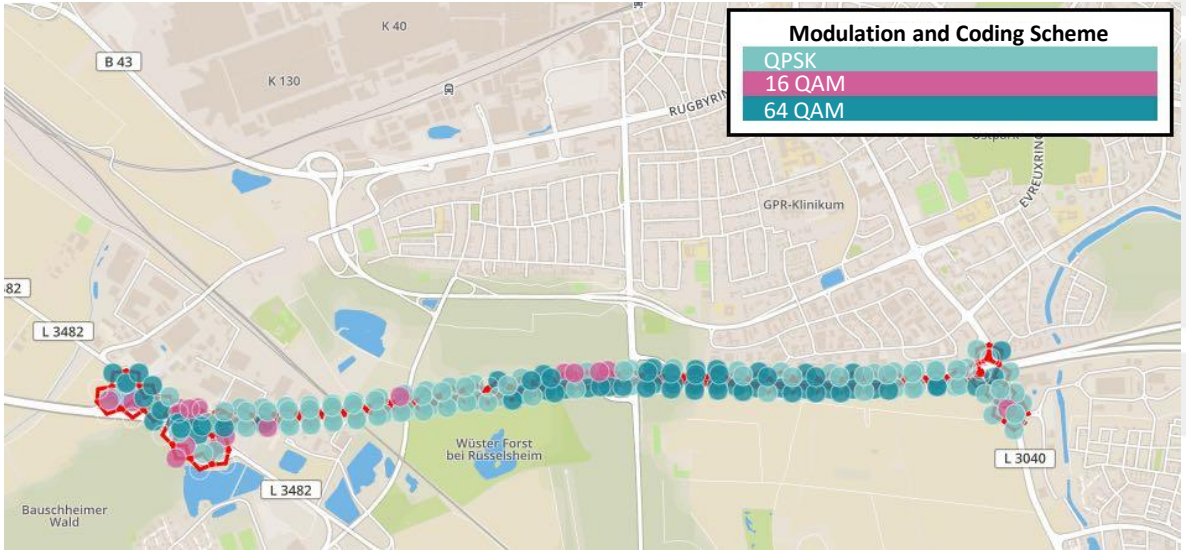
# Connectivity Layer in HD-Map

- We consider connectivity information as a further layer in the map
- Vehicles can share such information with each other through Safety Server
- Provides information for e.g. further data scheduling algorithms
- Enables robust communication



# Live Visualization in the “Glashaus”

- Further details and discussions
- Technical aspects of the cellular network







# Thank you

## for your attention!



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