

MANAGED AUTOMATED DRIVING

Julian Schindler – German Aerospace Center (DLR)

Traffic system perspective



Connected & Automated Vehicles
(various levels of automation)



Passengers &
Other Road Users



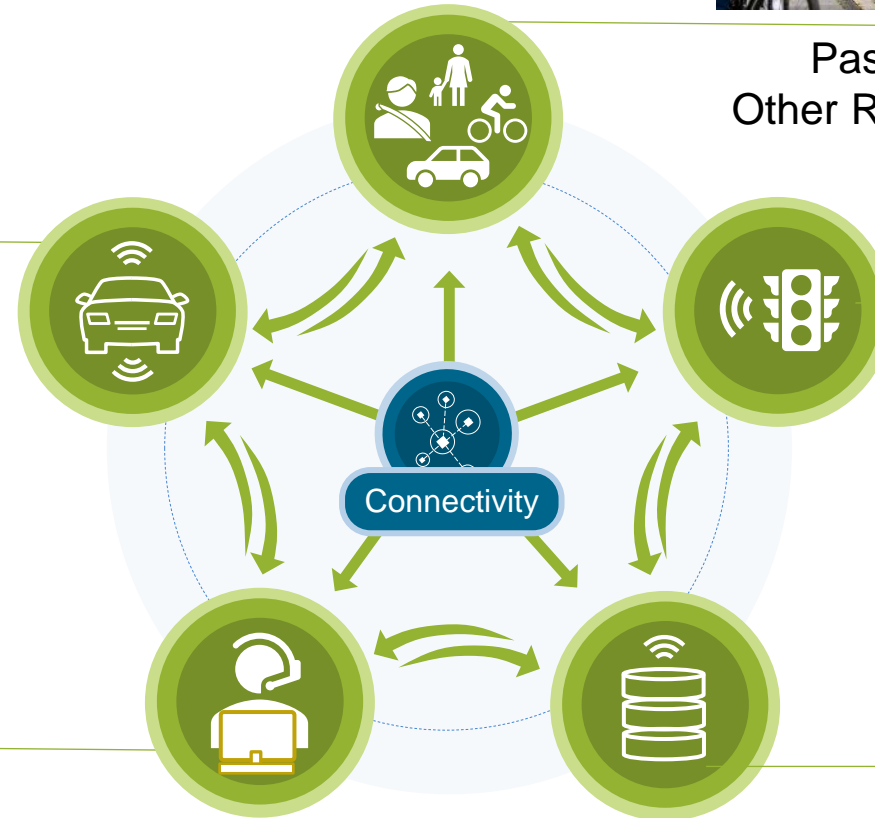
Road & Local
Infrastructure



Remote (Fleet)
Operators



Remote
Infrastructure



Automated and autonomous vehicles

Act

Vehicles on different
automation levels



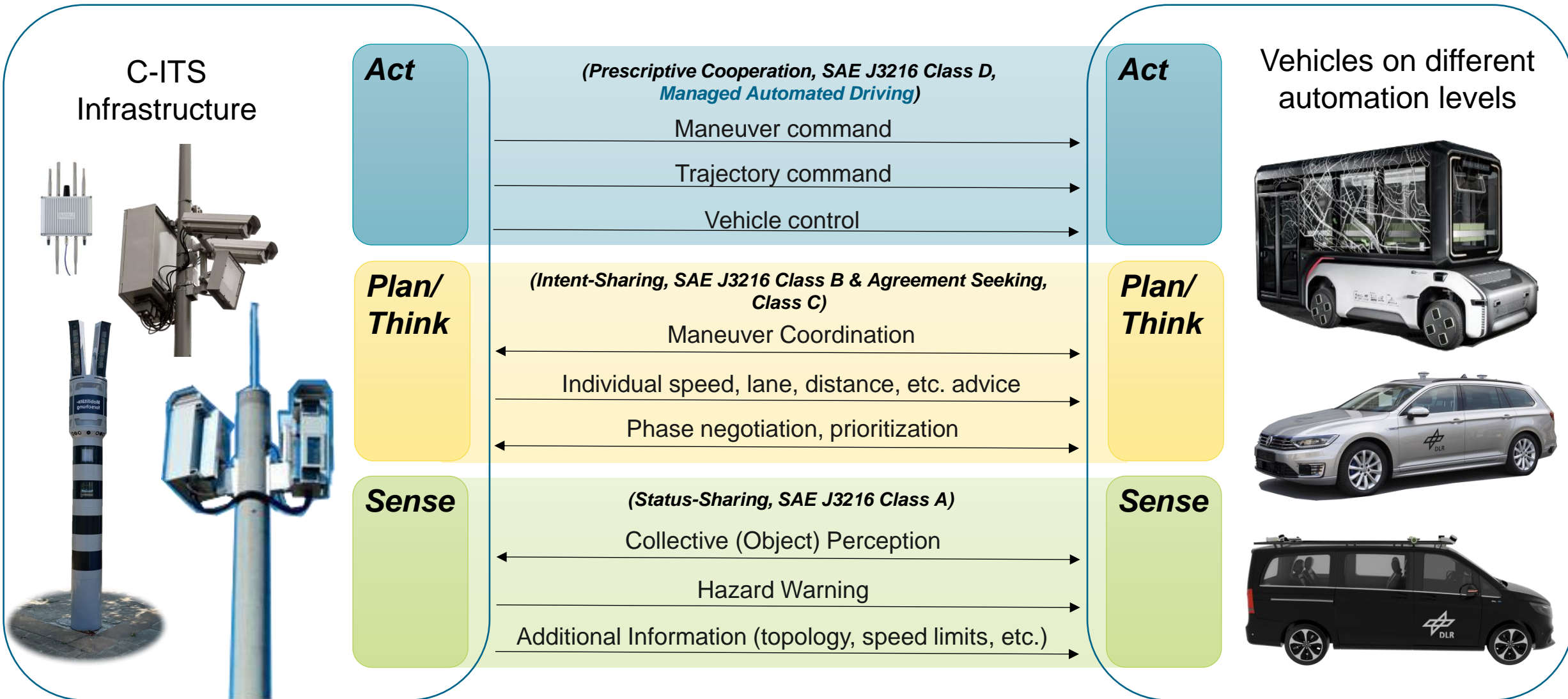
**Plan/
Think**



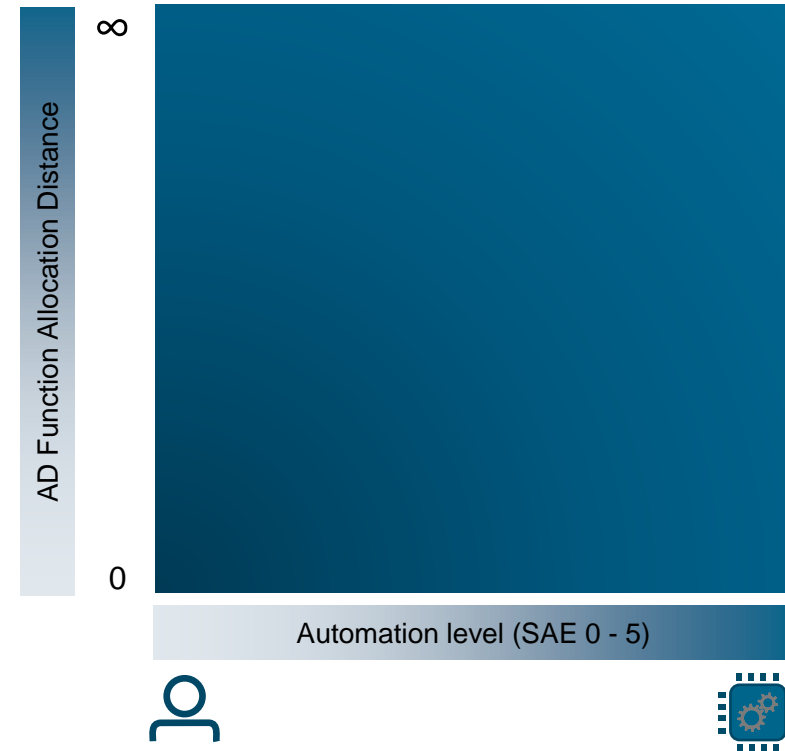
Sense



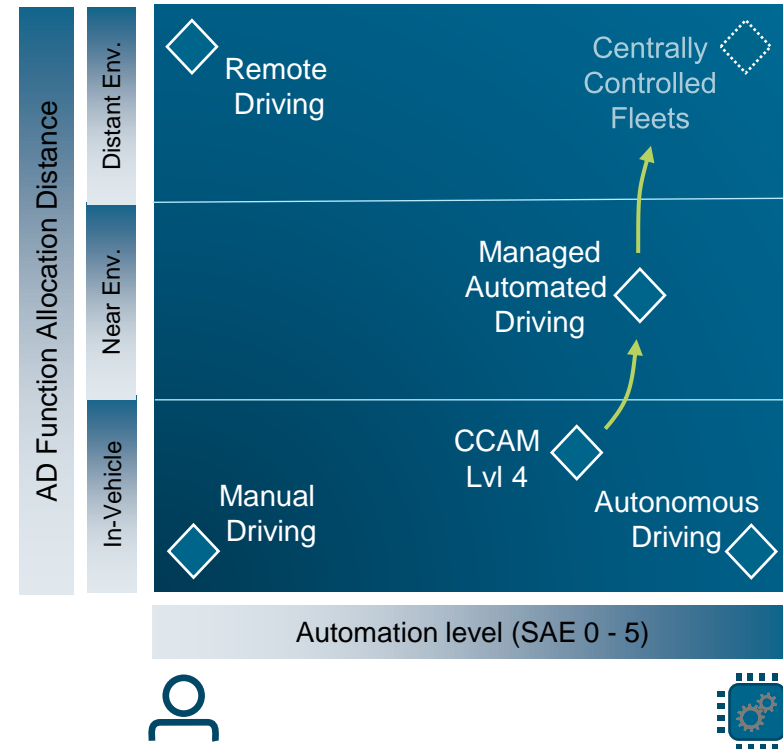
Role of C-ITS Infrastructure



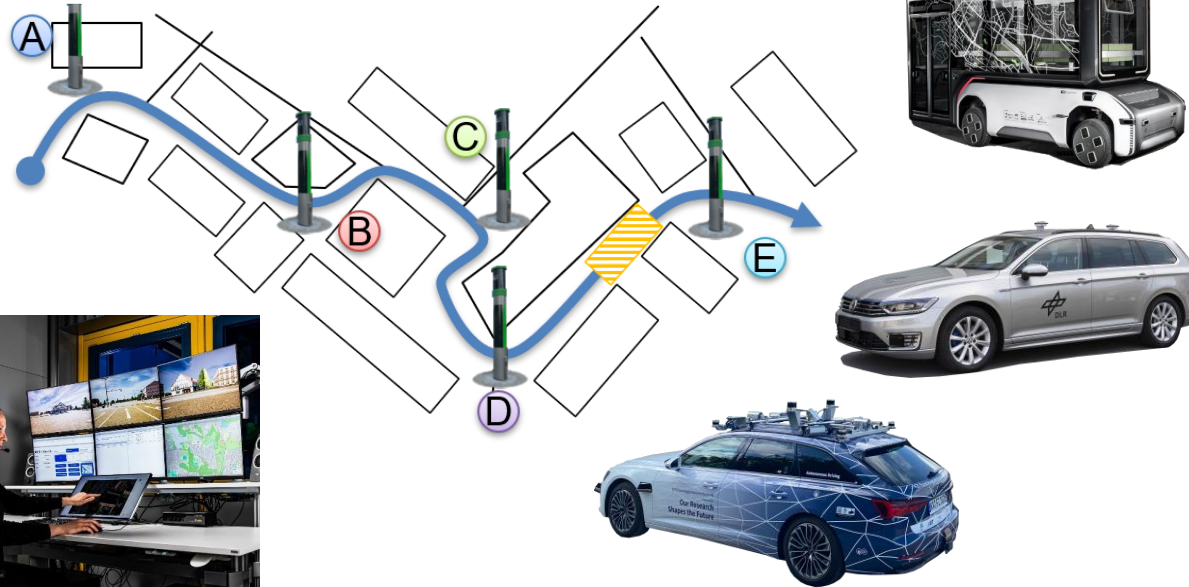
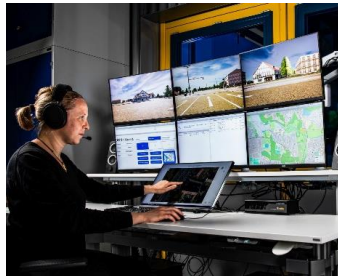
From “who is in control”... ...to “who is where in control”



From “who is in control”to “who is where in control”



Managed Automated Driving (MAD)



Vision:

Level 4 autonomous driving
with enhanced safety
and low unit costs per vehicle,
started on dedicated routes.
(Public transport and logistics)

German National Project




Goals:

- Definition of the MAD architecture and communication protocols
- Setting up example implementations at Testbed Lower Saxony and Testbed Autonomous Driving Baden-Württemberg
- Demonstration on public roads

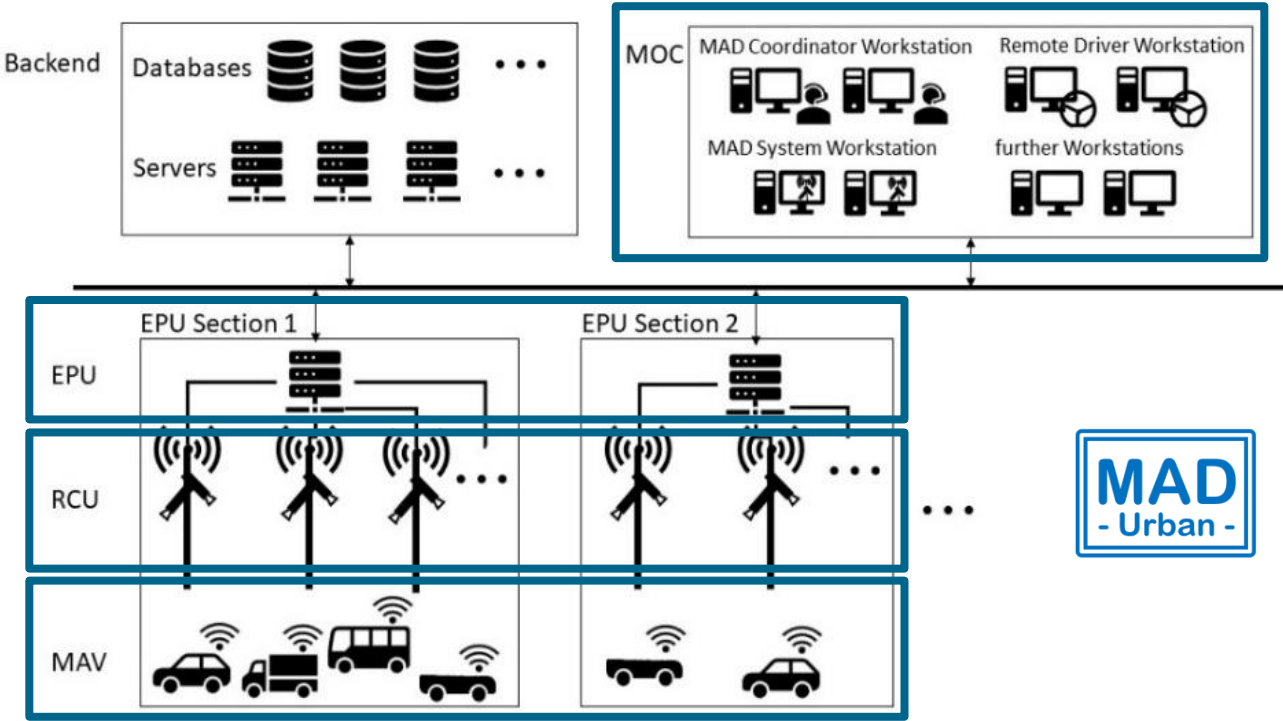
Duration: 07/2022-09/2025

Partners:



Funded by:  Bundesministerium für Wirtschaft und Klimaschutz

Architecture Overview



MAD Operation Center (MOC)



Edge Processing Units (EPUs)

Sensor data fusion, digital twins and behaviour planning



Road Capturing Units (RCUs)

composed of various sensors and local communication devices



Agents



Legacy Vehicles & VRUs
(behaviour prediction by infrastructure)



Cooperative Automated Vehicles
(participating in e.g. Collective Perception)



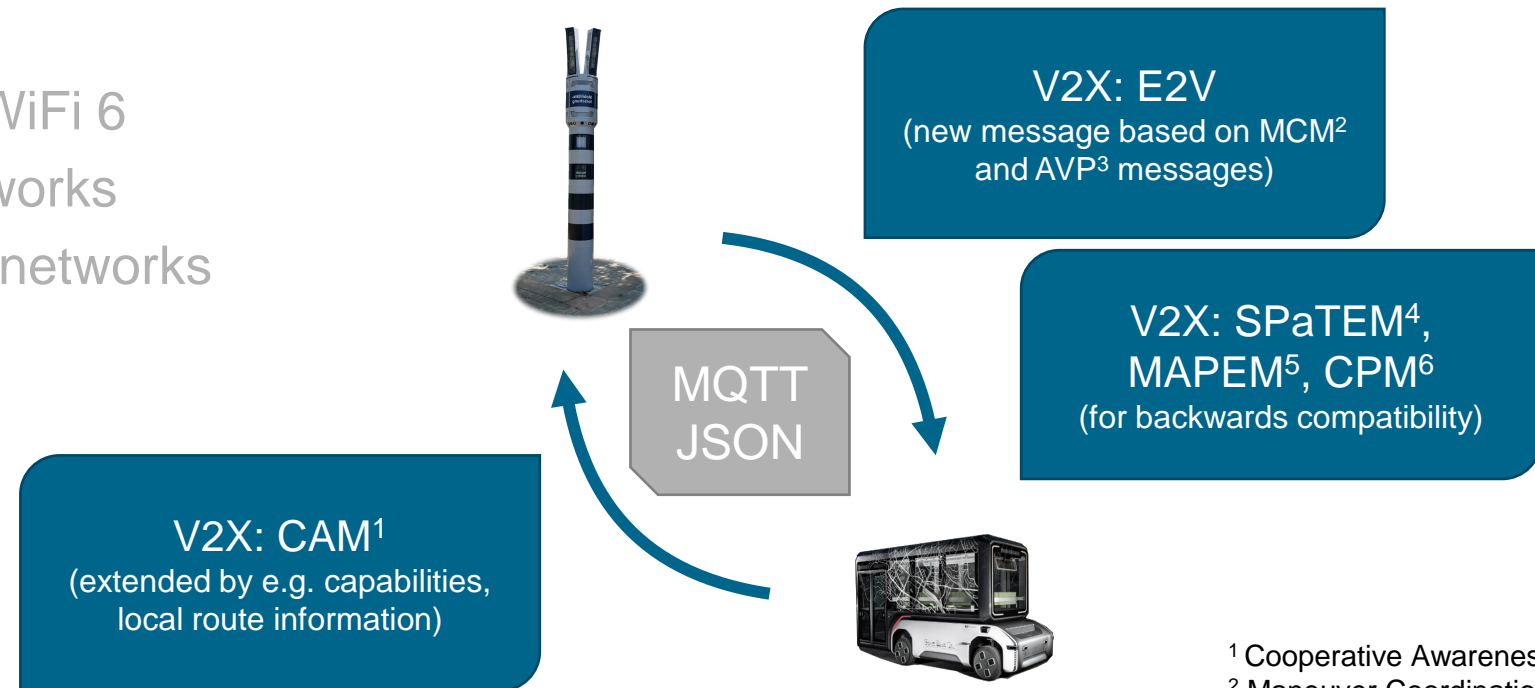
Guest MAVs
(fully controlled in specific areas)



Managed Automated Vehicles (MAV, fully controlled by infrastructure)

Technical Detail: Communication

- Redundant communication using standardized messages
- Different network types:
 - ITS-G5 V2X
 - Standard Mesh-WiFi 6
 - 5G Campus Networks
 - Standard 4G/5G networks
- Used protocols:



¹ Cooperative Awareness Message

² Maneuver Coordination Message

³ Automated Valet Parking

⁴ Signal Phase and Timing Extended Message

⁵ Map Extended Message

⁶ Collective Perception Message

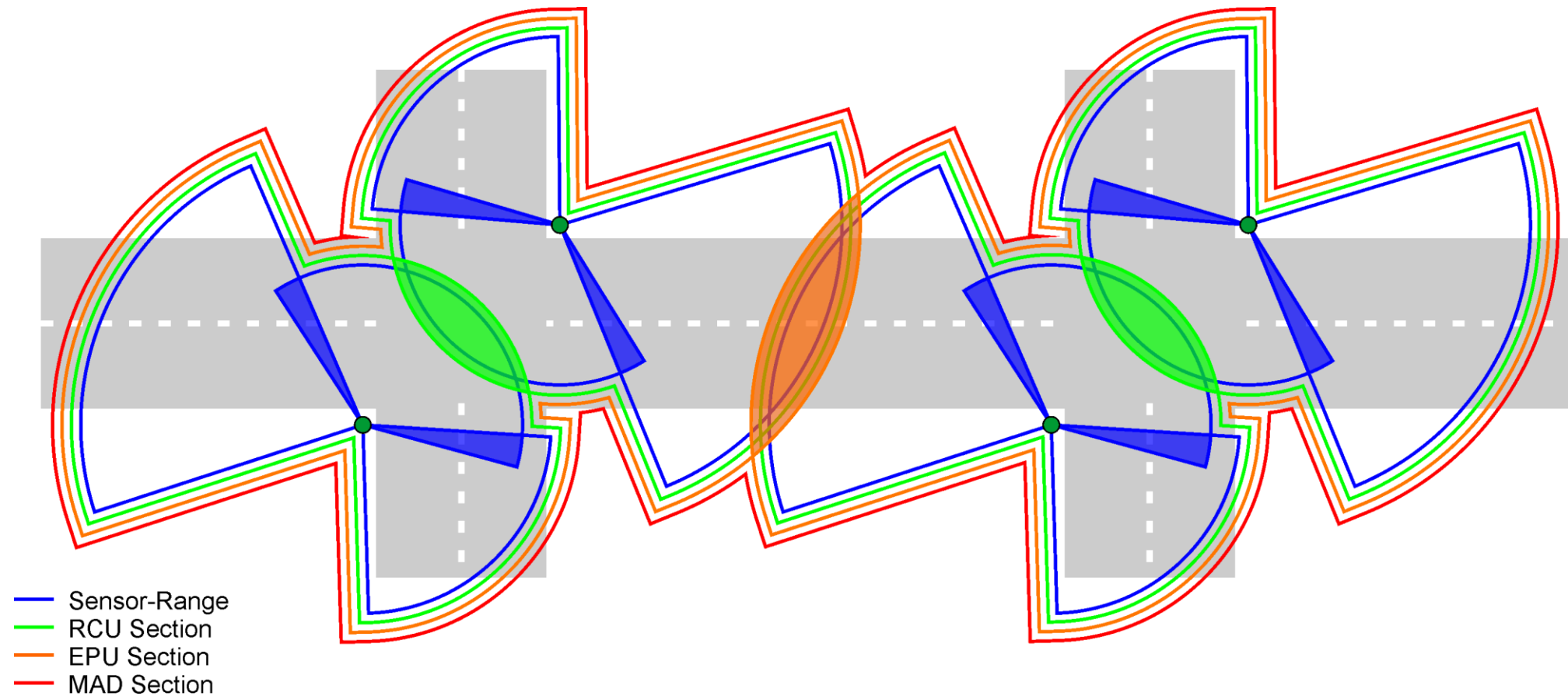
Specific implementations by

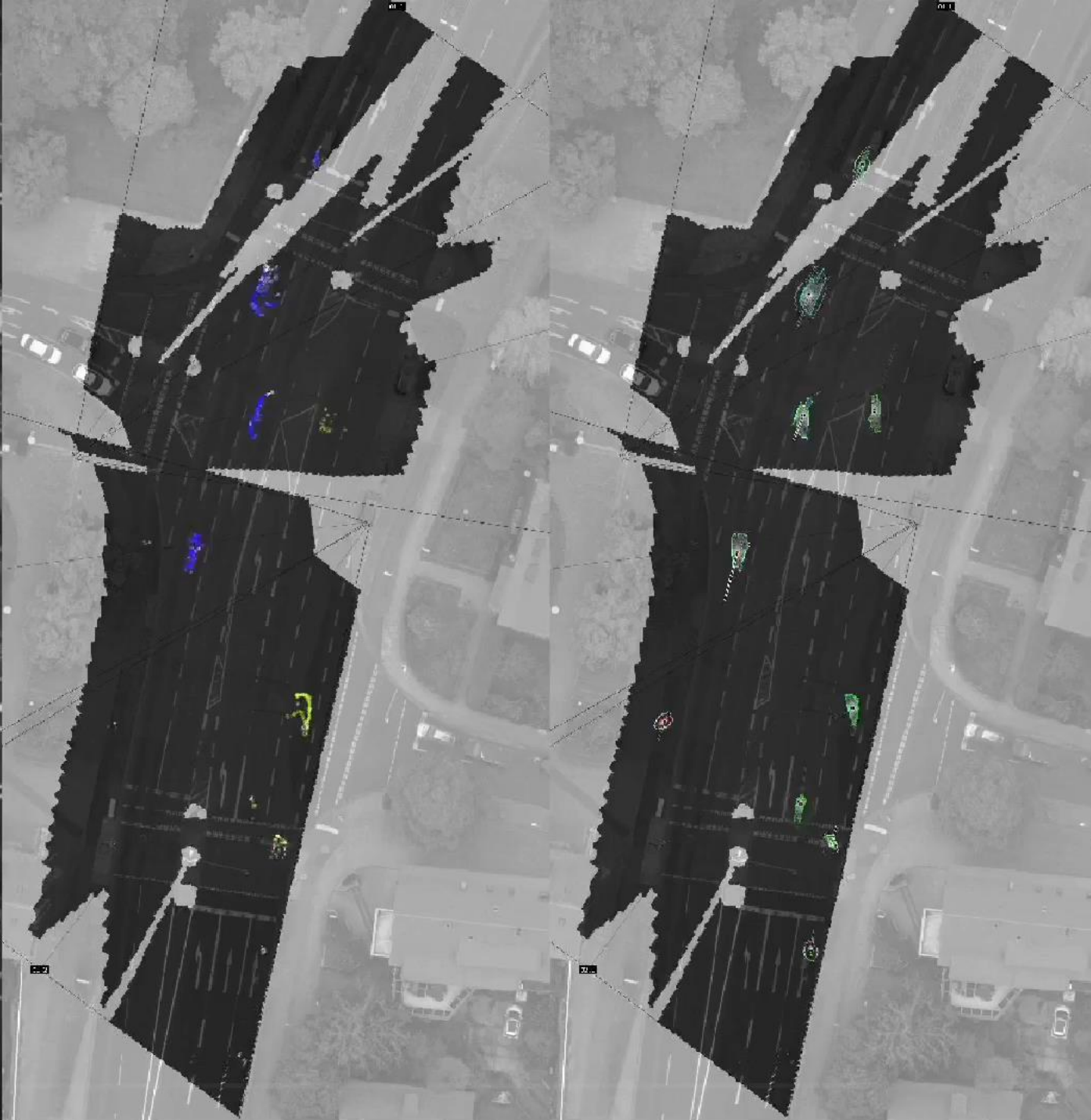


- Research roadside equipment on Tostmannplatz, Braunschweig, Germany
- 2x VITRONIC sensor poles equipped with (total)
 - 4x Stereo camera pairs (Balluff MV)
 - 2x 4D Radars (Smartmicro)
 - 1x 4D Lidar (Aeva)
- Additionally 2x hemispheric cameras (Axis)
- Computing on three performance levels
 - High-Definition: 4x Apple Mac Pro
 - Medium-Definition: 2x Jetson Orin AGX and 2x Nuvo CarPC
 - Low-Definition: 1x Jetson Orin NX
- Communication: 1x V2X-RSU (Cohda), 2x WiFi6 (Rukkus)

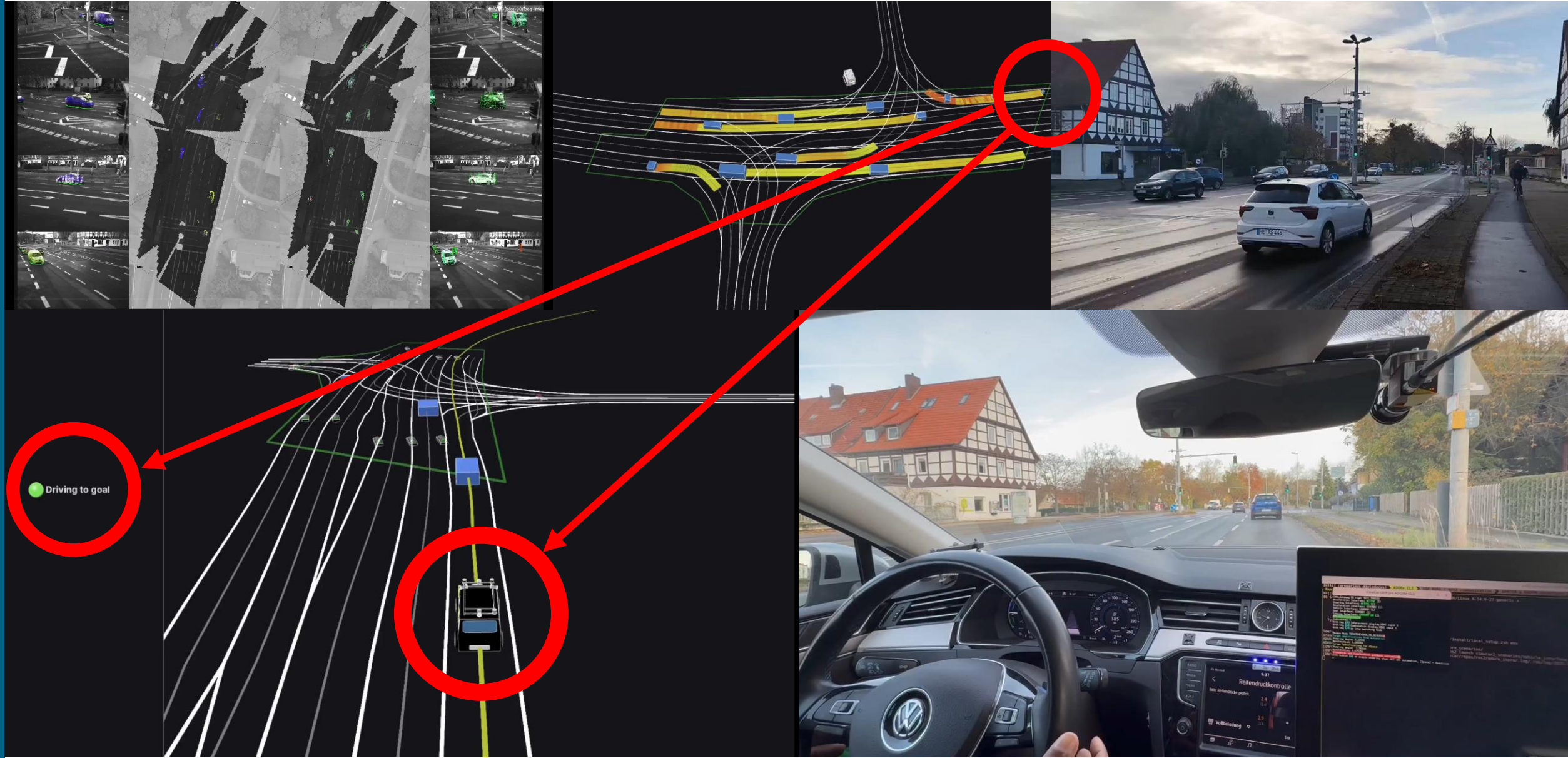


Topological mapping of infrastructure components





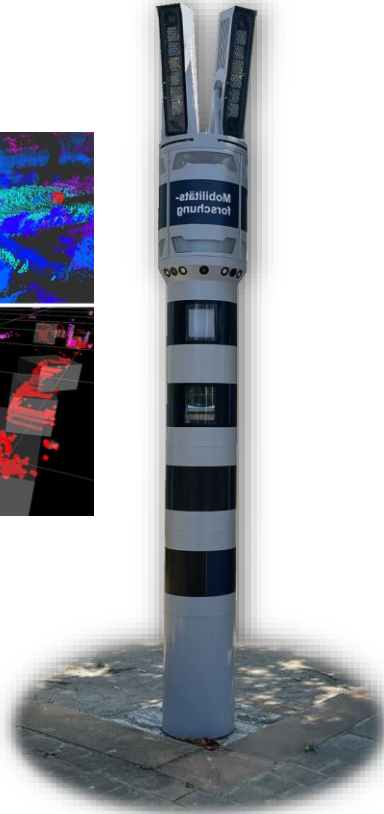
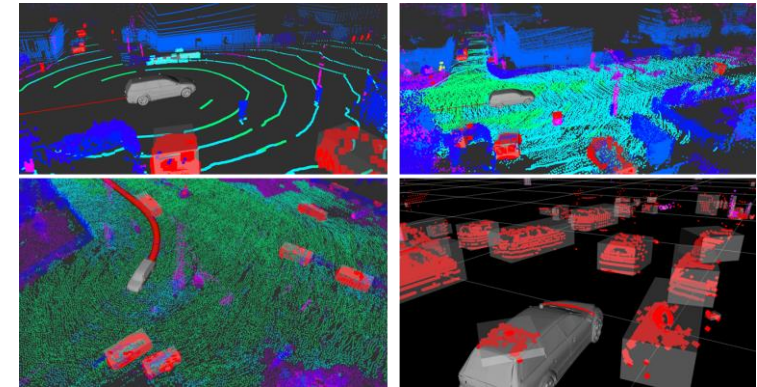
Managed Automated Driving from various perspectives



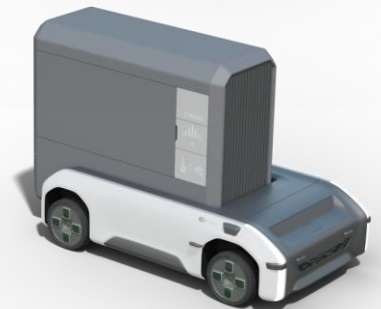
Results & Outlook



- Performed several test campaigns between 11/2024 – 09/2025:
 - Performed sensor data fusion of different data sources, also including collective perception and vehicle positions received via V2X
 - Demonstration of distributed vehicle automation functions on public roads
 - Performed smooth transitions of control between vehicle- and infrastructure-based automation
- Detected Issues:
 - Infrastructure-based perception has a better situational overview, but needs to deal with dynamic blind spots
 - Technical feasibility shown, but trusted data exchange still not available



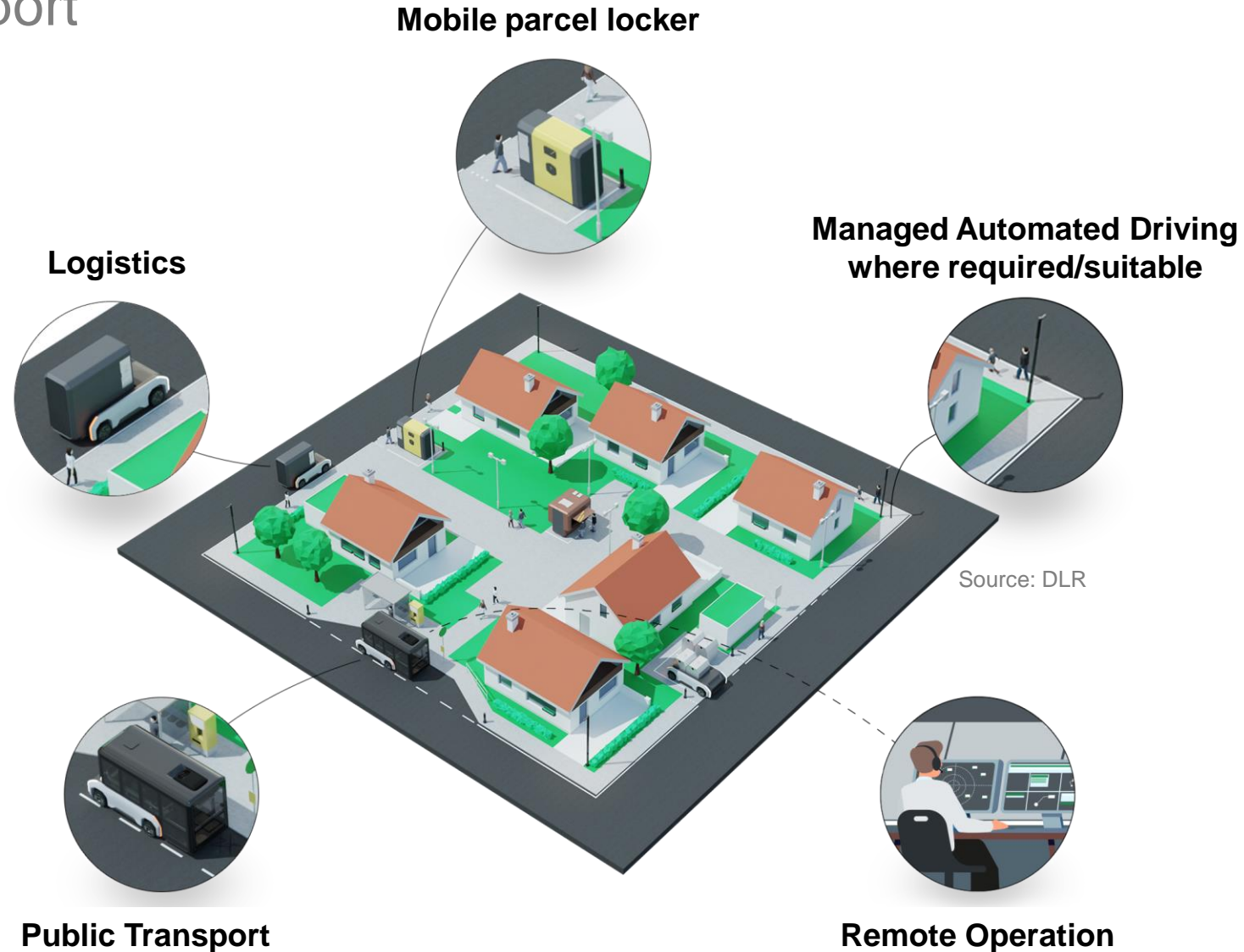
The U-Shift-Concept



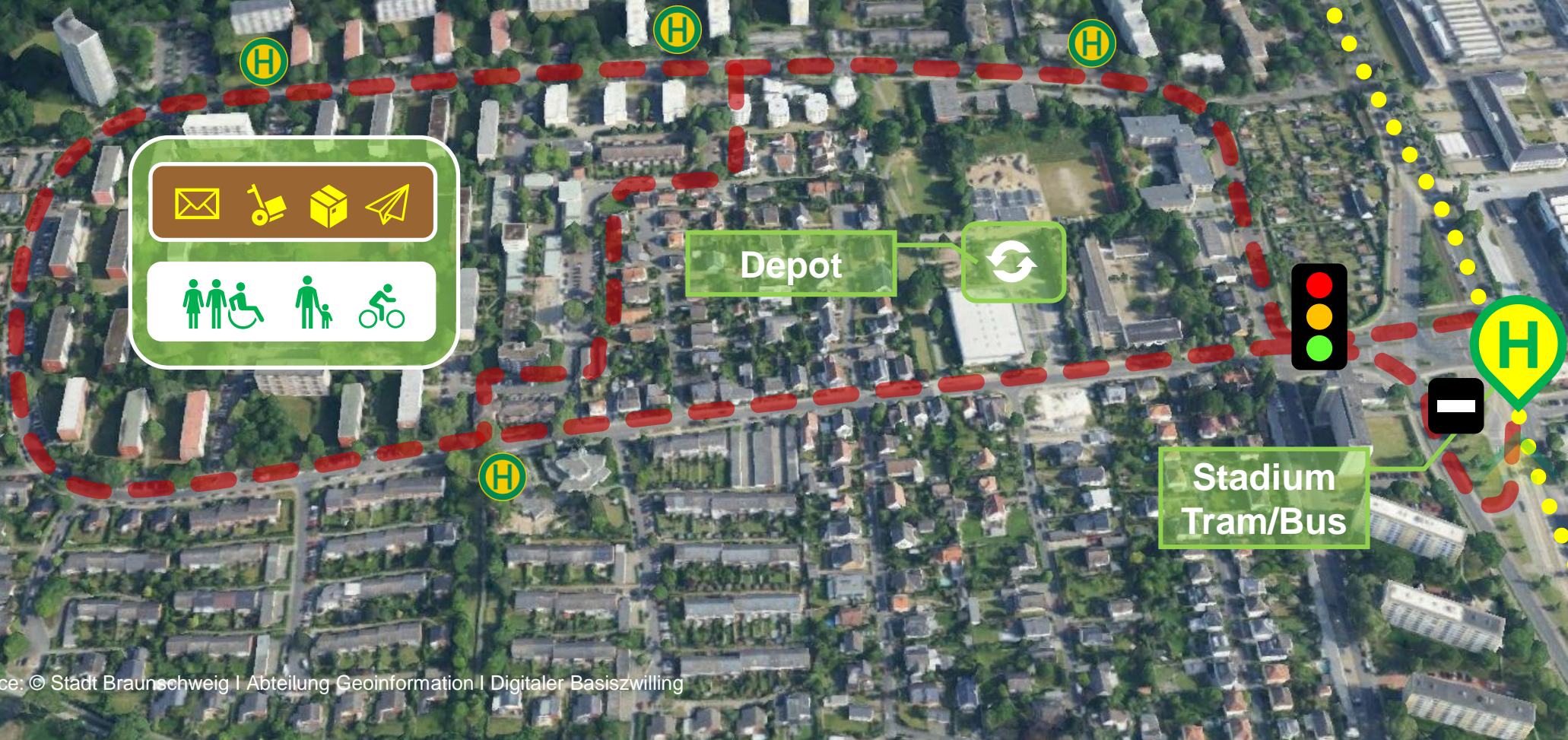
Source: DLR

IMoGer in a Nutshell

3 Driveboards & up to 9 Capsules for Logistics and Public Transport



Planned Operating Area in Braunschweig, Germany, Starting 2027



Thank You!

Contact



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Further Project Information



www.managedautomateddriving.com



www.dlr.de/en/ts/research-transfer/projects/imoger