# SIMULATION-BASED SAFEGUARDING AND OPERATIONAL DOMAIN APPROVAL OF AUTOMATED VEHICLES – TWO EXAMPLES FROM LOGISTICS AND COMBINED GOODS/PASSENGER TRANSPORT

11th Symposium Driving Simulation, Wolfsburg

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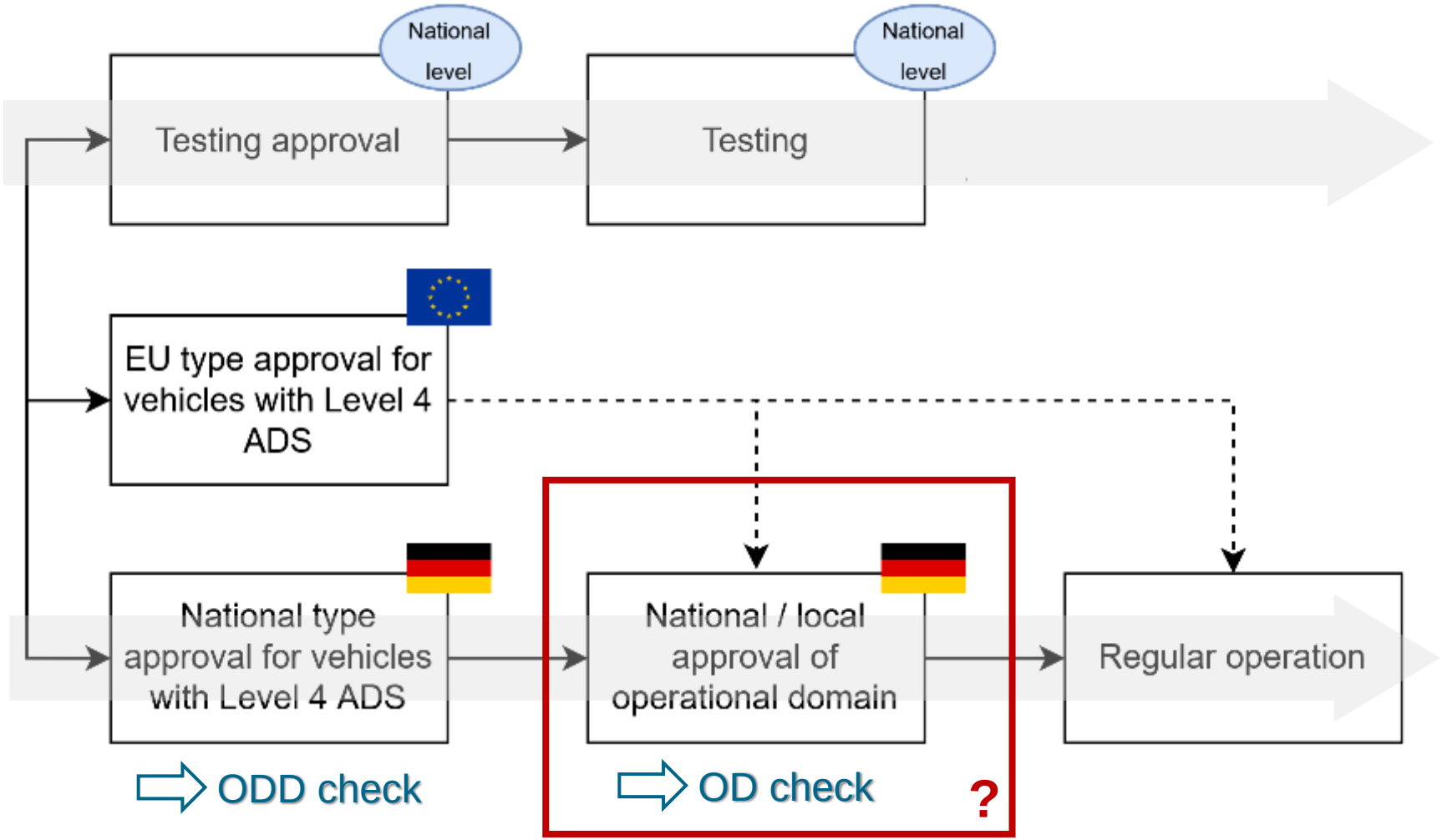
# Motivation

**Core challenge**: Prove of **reliability & robustness of Automated Driving Systems** (ADS)

- **Commercial L4 deployment** progressing in the **USA & China** (e.g., Waymo, Baidu), where **Europe is still largely in testing phase**
- **EU and national regulations** define the specific approval of automated vehicles
  - Not fully applied yet
- **Real-road testing** is costly & time-intensive

→ **Shift to simulation-based testing** is inevitable!

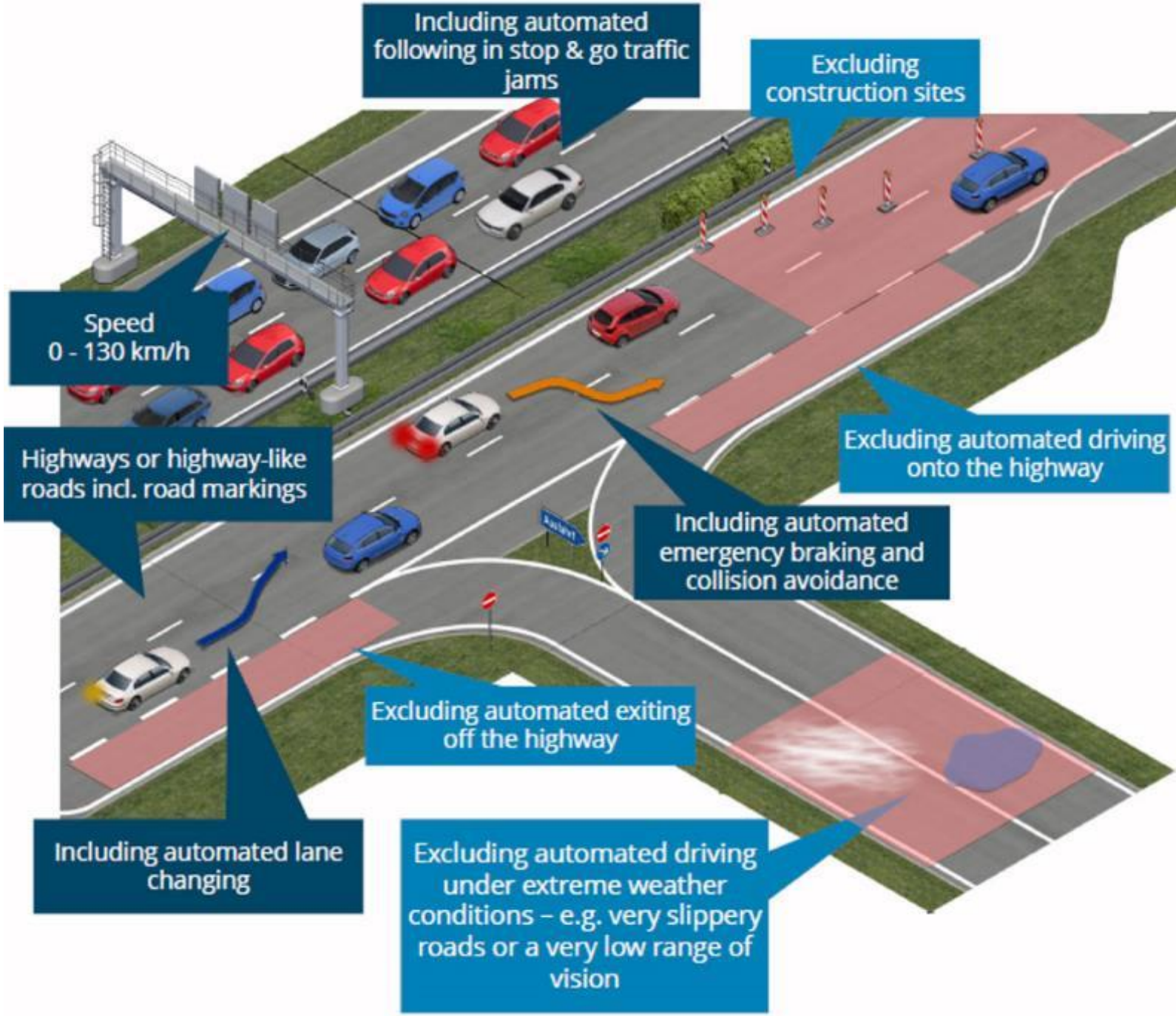
# Approval process and state-of-the art



# ODD

- **Definition.** *The Operational Design Domain (ODD) is defined as the set of all "operating conditions for which a given system under test (driving automation system) is designed, including all restrictions regarding environmental, geography and time of day and/or the required presence or absence of certain traffic or road features". The ODD is the design area of a system under test with regard to its operation*

*Example: Highway Chauffeur*





[1] Pegasus homepage, www.pegasusprojekt.de

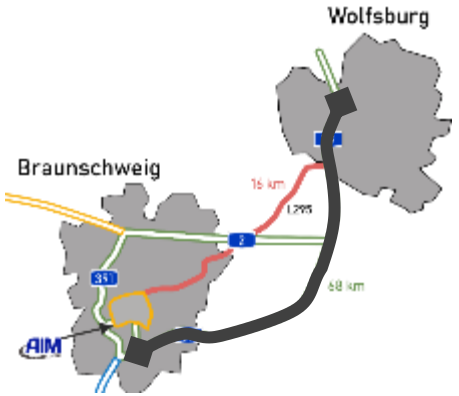
[2] Glossar Pegasus, SET Level, VVMethoden, VIVALDI, GAIA-X 4 PLC-AAD, https://zenodo.org/records/11503217

# ODD-OD comparison
## Artificial example

abstract and/or general

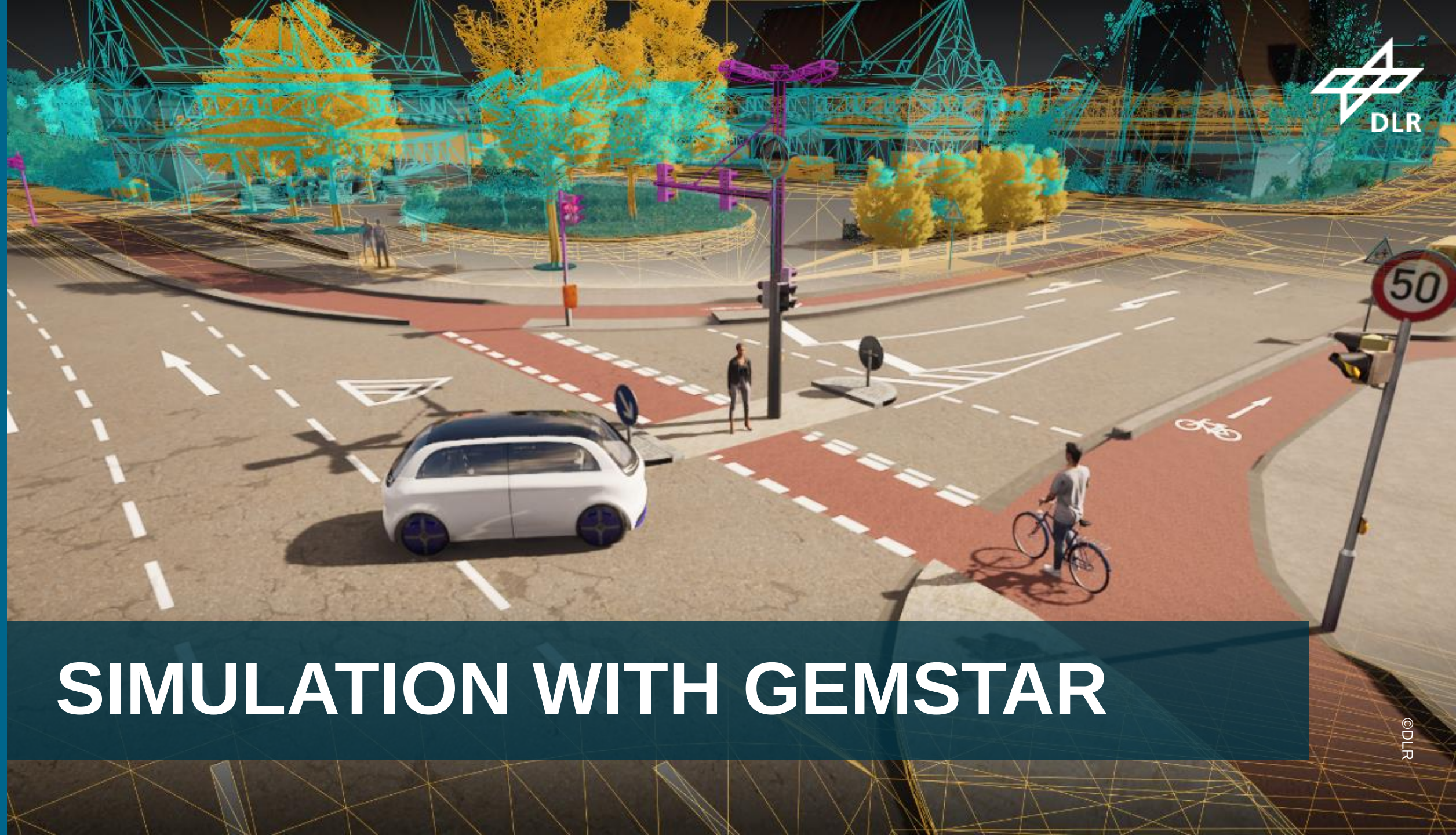
| ODD | | OD |
|---|---|---|
| n. a. | Layer 6 | Full 4G coverage |
| Sunny weather & rain up to 0,5 mm | Layer 5 | X days with <0,5 mm rain<br>Mean 1,5 mm/day |
| Interaction with trucks and cars | Layer 4 | Specific interactions in OD |
| no building sites | Layer 3 | 1-2 times per year |
| up to 95 km/h | Layer 2 | Max 100 km/h |
| Highways, no tunnels, no exits | Layer 1 | A39: between WOB West and BS South |

specific



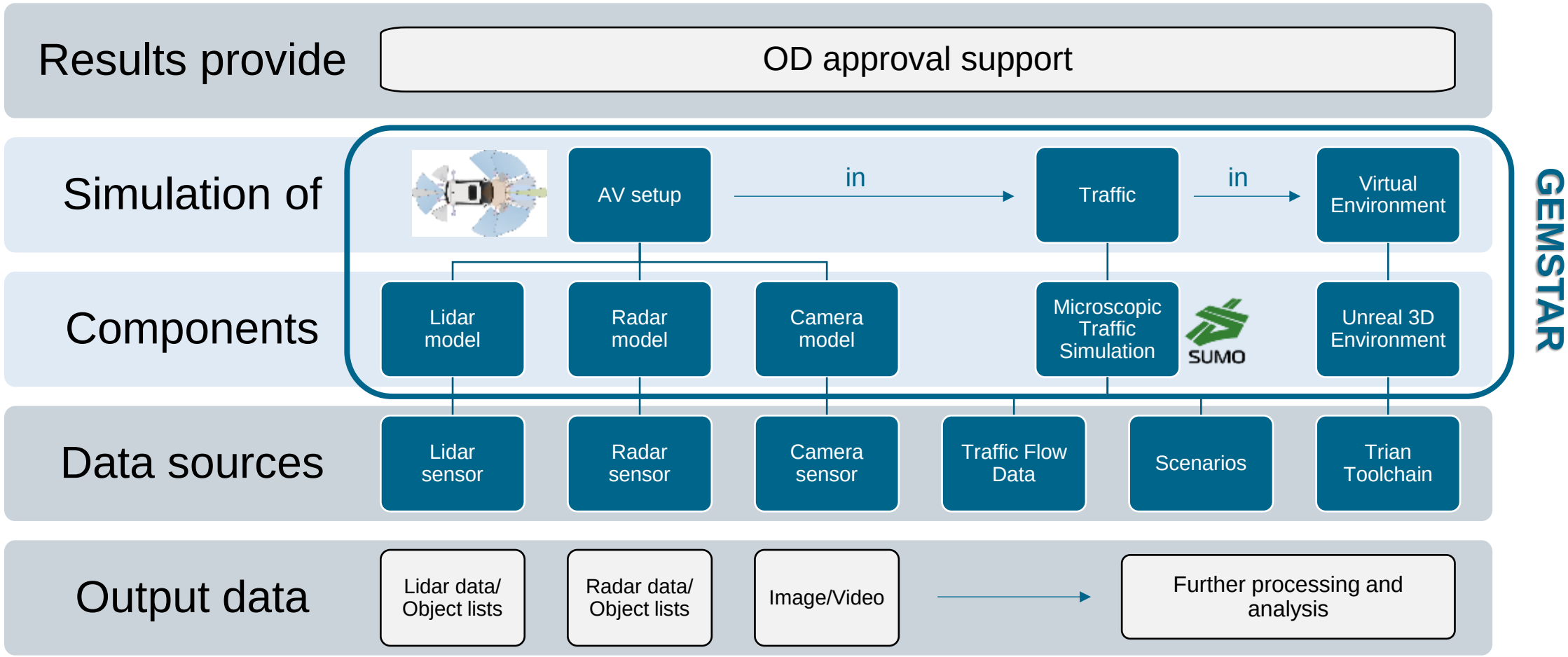
# Simulation in Approval Processes

- **Current state of practice**
  - Simulation is already used for homologation, but not for novel OD approval
- **Research Question**
  - What and how can simulation contribute to OD evaluation?
- **Research gap**
  - **No defined quality requirements** for simulation as part of OD approval
  - **No established method for ODD-OD compatibility checks** via simulation to support authorities




# SIMULATION WITH GEMSTAR

# Simulation for OD approval




→ Can a Vehicle Drive Safely in an OD with a Specific Sensor Setup?

# GEMSTAR - GEoMetry based sensor Simulation Toolchain for Automotive and Rail Research

## Demand / Challenge

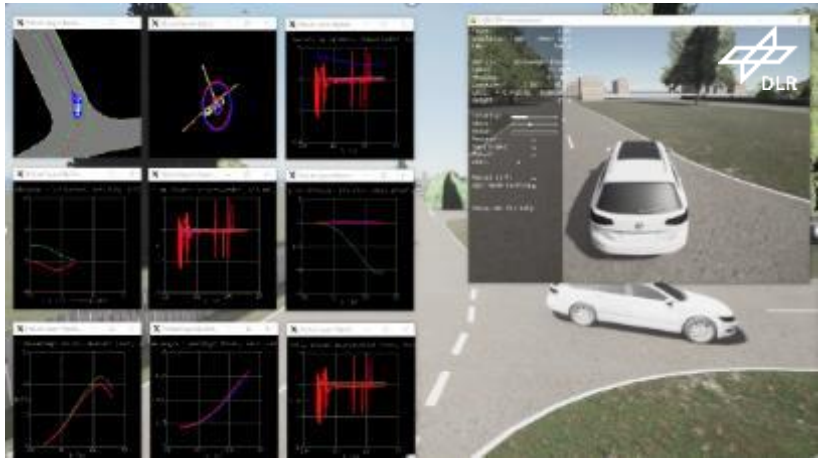
- Neutral decision basis for approval of operational domain (OD) and Operational Design Domain (ODD) for automated vehicles needed

## Solution

- **GE**o**M**etry based sensor **S**imulation **T**oolchain for **A**utomotive and **R**ail Research **(GEMSTAR)*:** System tests of driving functions and OD analysis
- **GEMSTAR** available as **open source** product for easy access, adaptability and expandability
- **GEMSTAR** allows easy way to **assess automated vehicle and road compatibility** and generate test reports as basis for e.g. authorization

(Fischer, 2023, doi: 10.13140/RG.2.2.24770.76481)

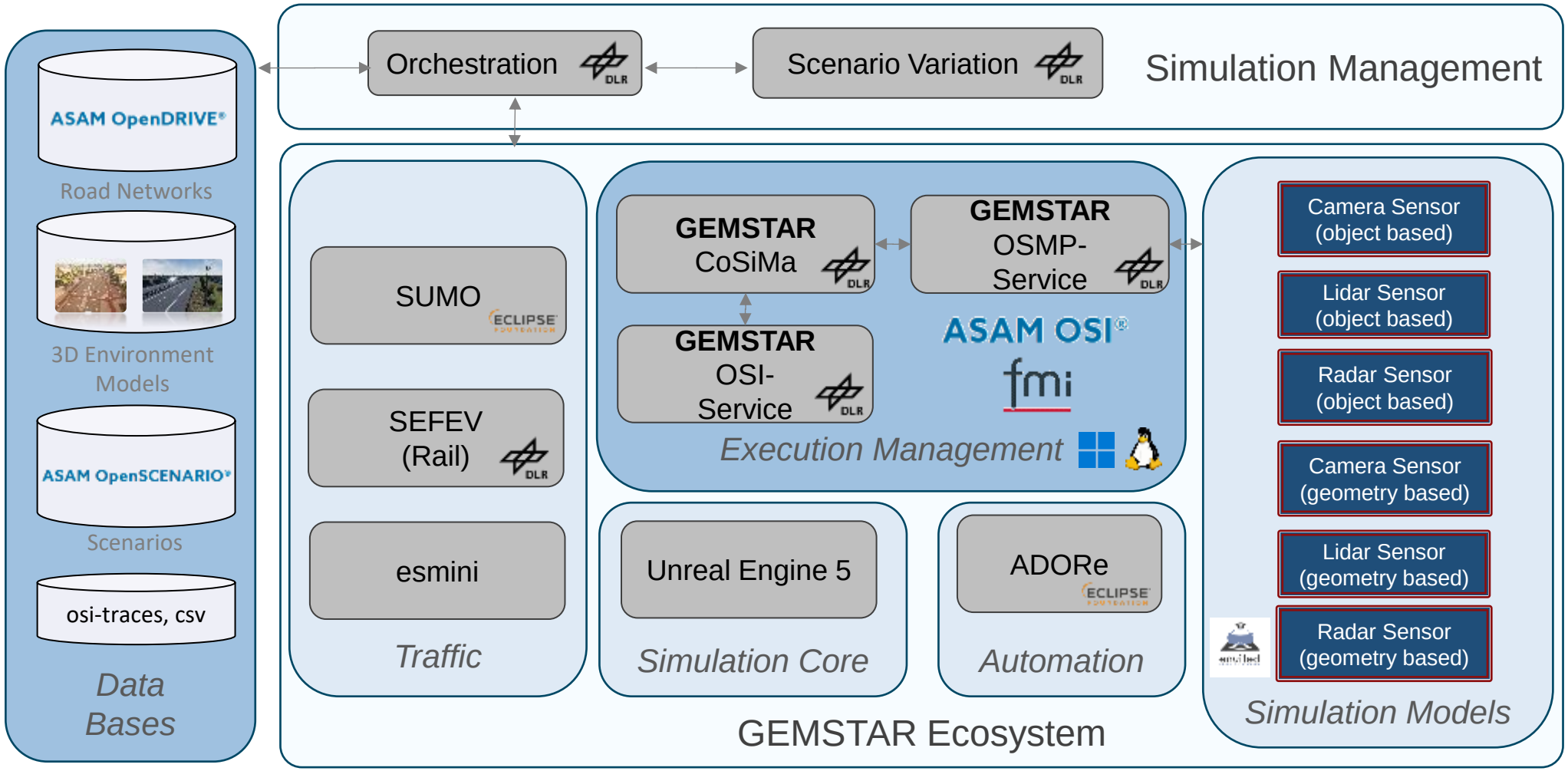

GEMSTAR: Simulation




GEMSTAR: System tests and ODD-OD matching analysis

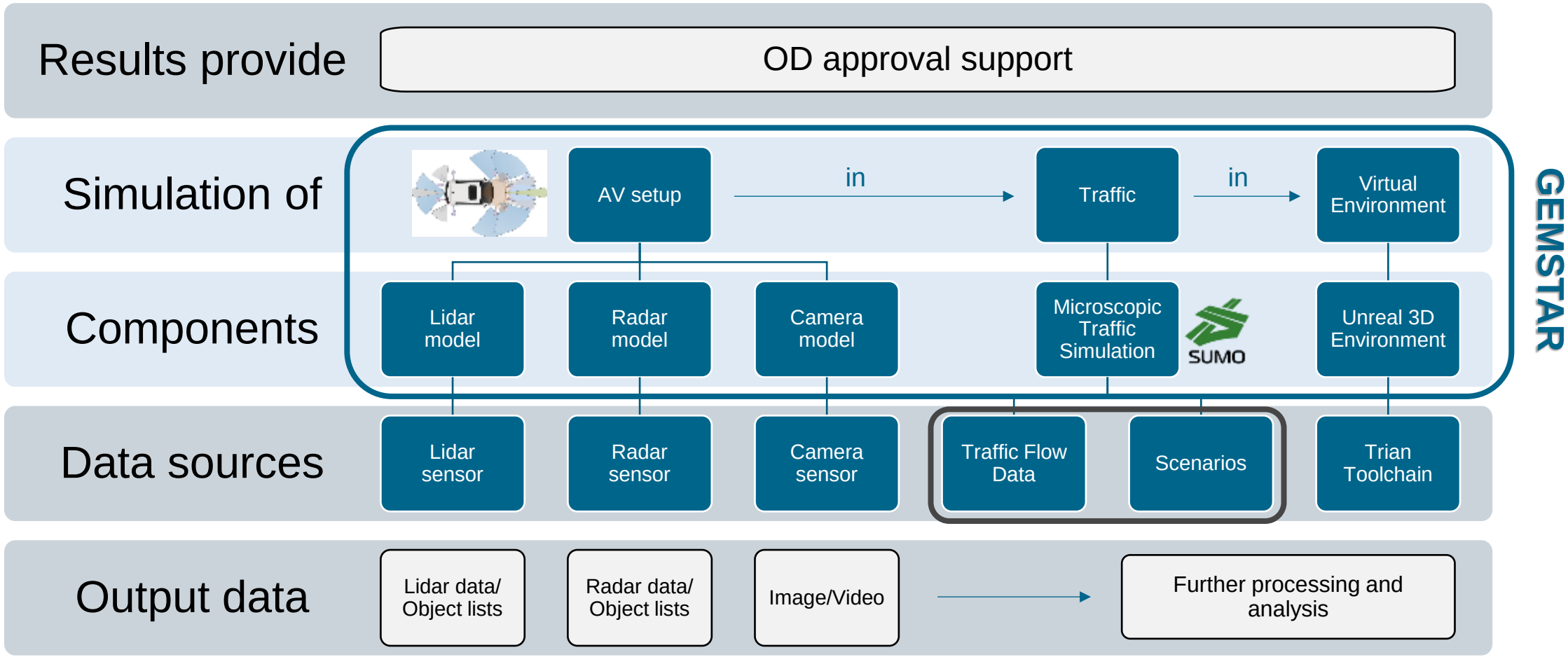
*aka OSTAR

# GEMSTAR Architecture




https://github.com/DLR-TS/gemstar

# Simulation for OD approval




→ Can a Vehicle Drive Safely in an OD with a Specific Sensor Setup?

# PROJECTS

M. Fischer, Institute of Transportation Systems, 6.11.2025

# Case Study AUTOGVZ

## Funding volume
approx. €3.6 million from BMV

## Project duration
01/2025 – 06/2027

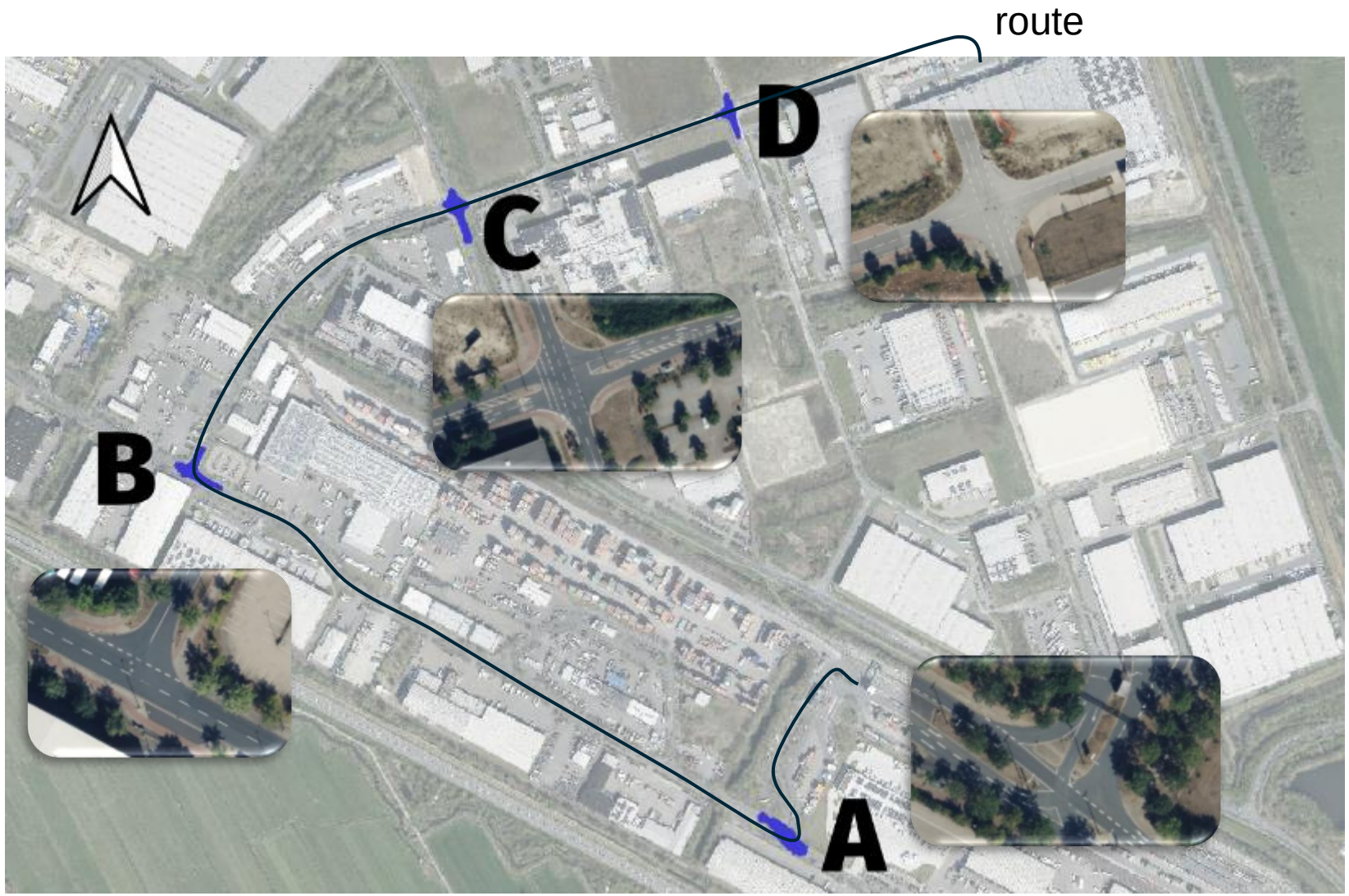
## Project participants
- to-be-now-logistics-research-gmbh
- LUB Consulting GmbH (LUB)
- Roland Umschlagsgesellschaft für kombinierten Güterverkehr mbH & Co. KG
- Götting KG
- German Aerospace Center (DLR) Institute for Transportation Systems

AUTOGVZ

Gefördert durch:
Bundesministerium für Verkehr
aufgrund eines Beschlusses des Deutschen Bundestages

**Status quo**: Every day, approximately 100 containers are transported from the Roland Umschlag intermodal terminal to two logistics centers in the Bremen freight village via public roads.
**Goal**: Replace 1-2 trucks with automated and teleoperated trucks.

# Freight Village Bremen - Points of Measurements



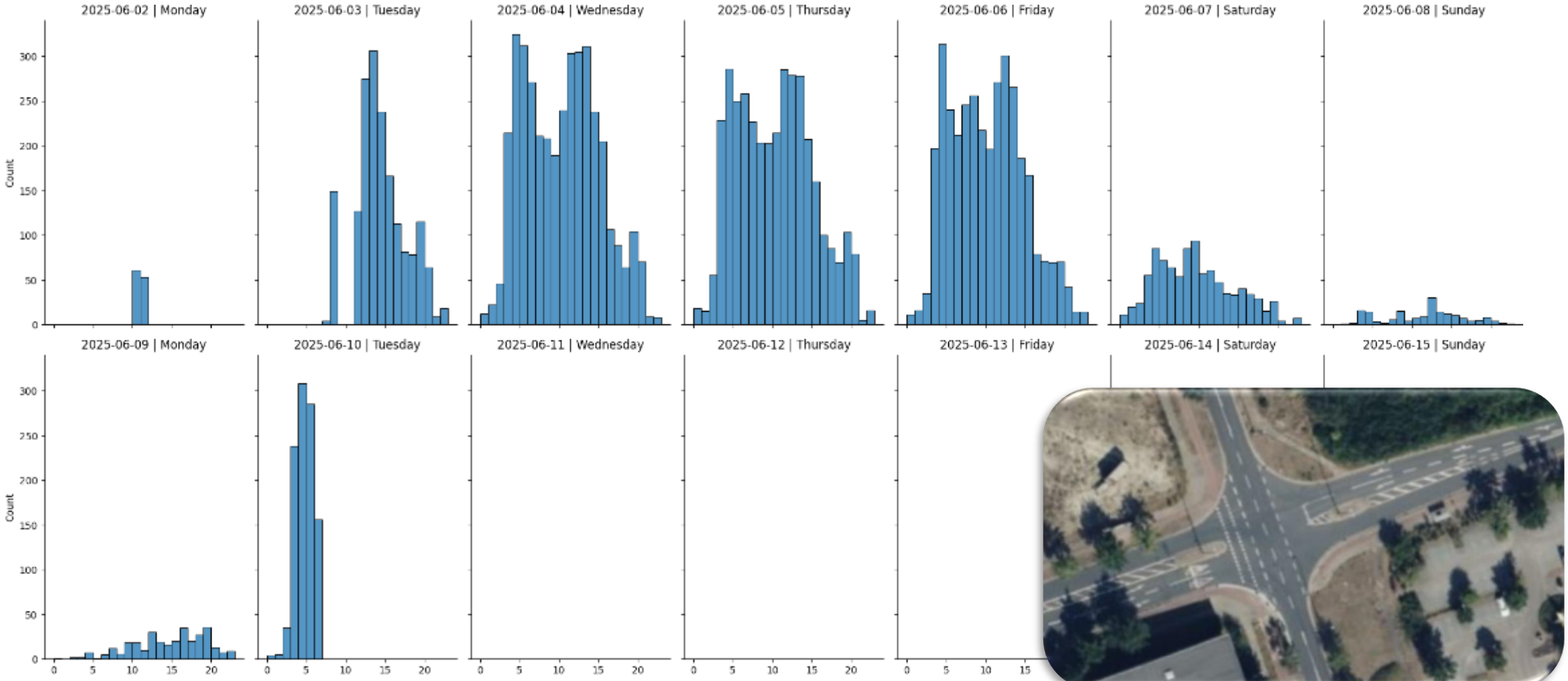

Areas of traffic measurements



Mobile traffic measurement unit

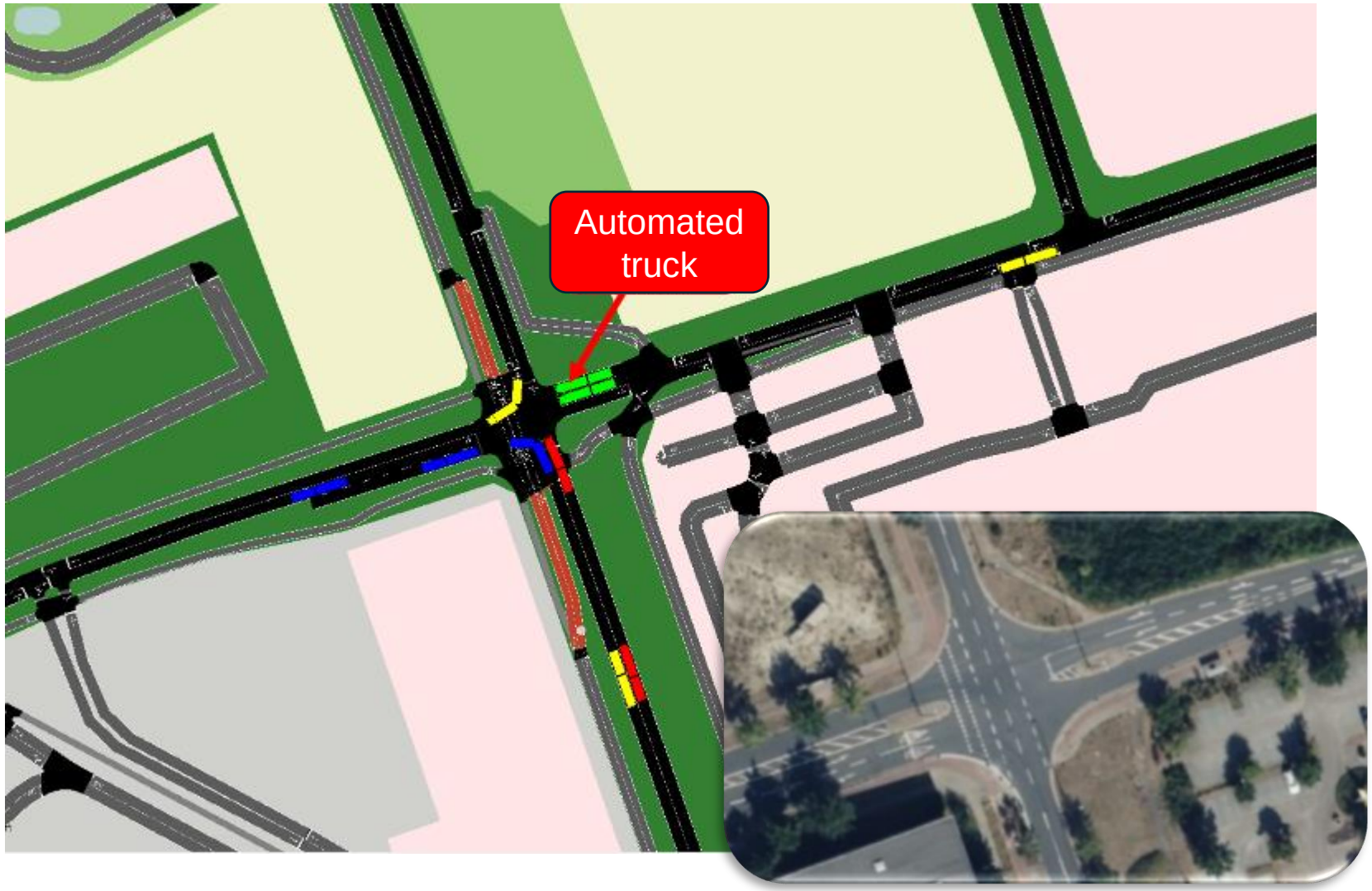
# Traffic Volume

## Example: Traffic Flow at Measurement Point C



# Simulation in SUMO

- SUMO traffic is calibrated according to measurements
- Automated truck is put into traffic flow
- E.g. waiting times are analysed



# Blocked Road (@ A)

## Observed Scenario

- A **truck** enters the junction slowly and with its hazard warning lights switched on
- It comes to a standstill behind a **traffic island** and blocks the entire lane

## Effect

- The **traffic** behind the **truck** has to cross a solid line and drive a short bit on the wrong side of the road (not conform to regulations)
- Other **trucks** briefly block the entire junction while turning and passing the blocking **truck**

# Turning Manoeuvres







Road users are using the intersection area to turn at measurement points A, B and C

# Vulnerable Road Users on the road (@ B)

## Bus (entry and exit)




## Pedestrian


## E-Scooter

# Next Steps

- Creation of virtual copy of the frigt village Bremen
- Simulation of normal traffic and specific scenarios
- Analysis of sensor set-up

Gefördert durch:

Bundesministerium für Verkehr

aufgrund eines Beschlusses des Deutschen Bundestages

# IMOGER [ˈɪMƏDʒɜːR]

## INNOVATIVE MODULAR MOBILITY MADE IN GERMANY

**Modular, automated Mobility with potential for more**

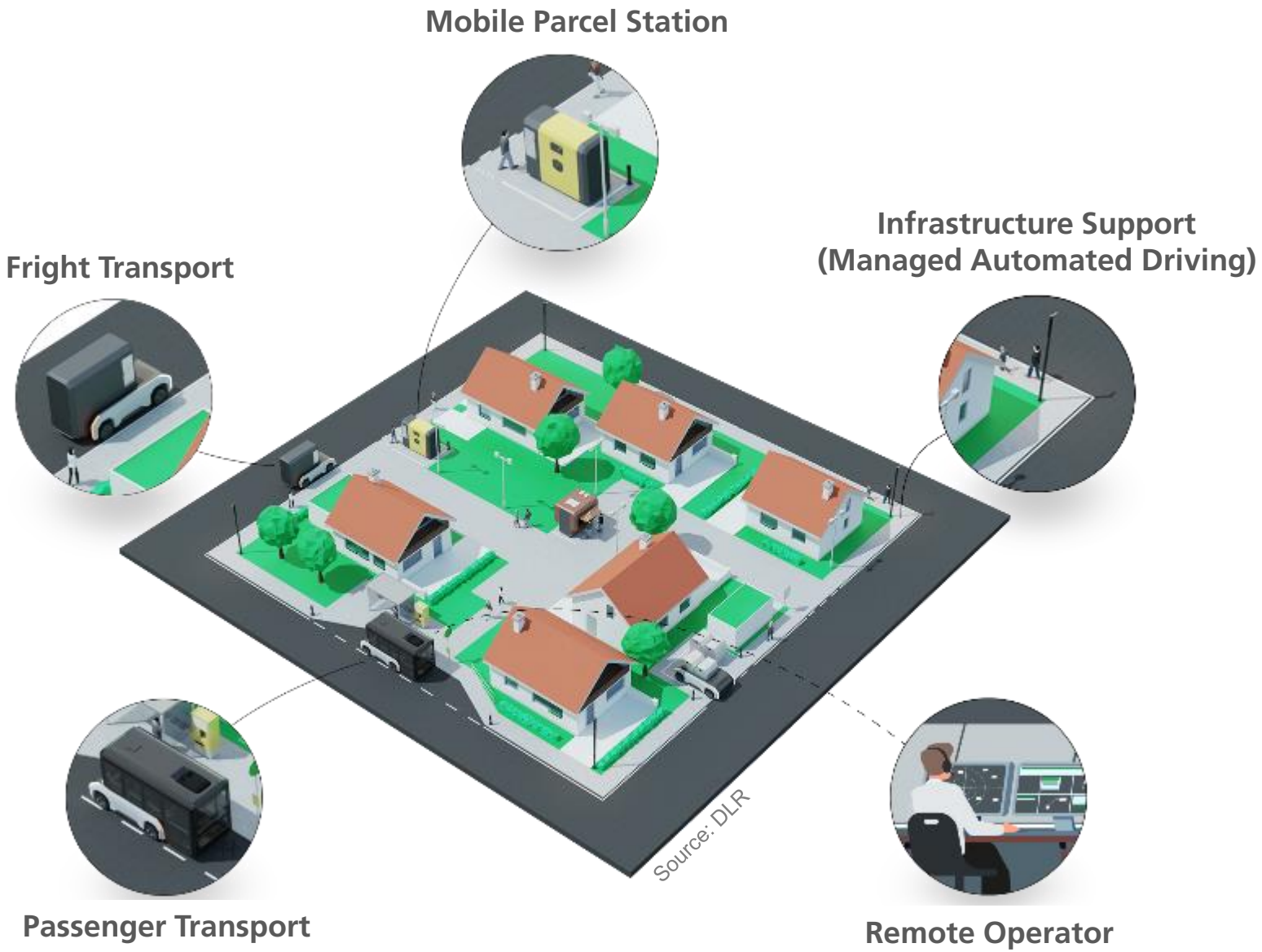
DLR BSVG DIMOS motor ups VITRONIC

# The U-Shift concept:
# A modular solution for logistics and public transport

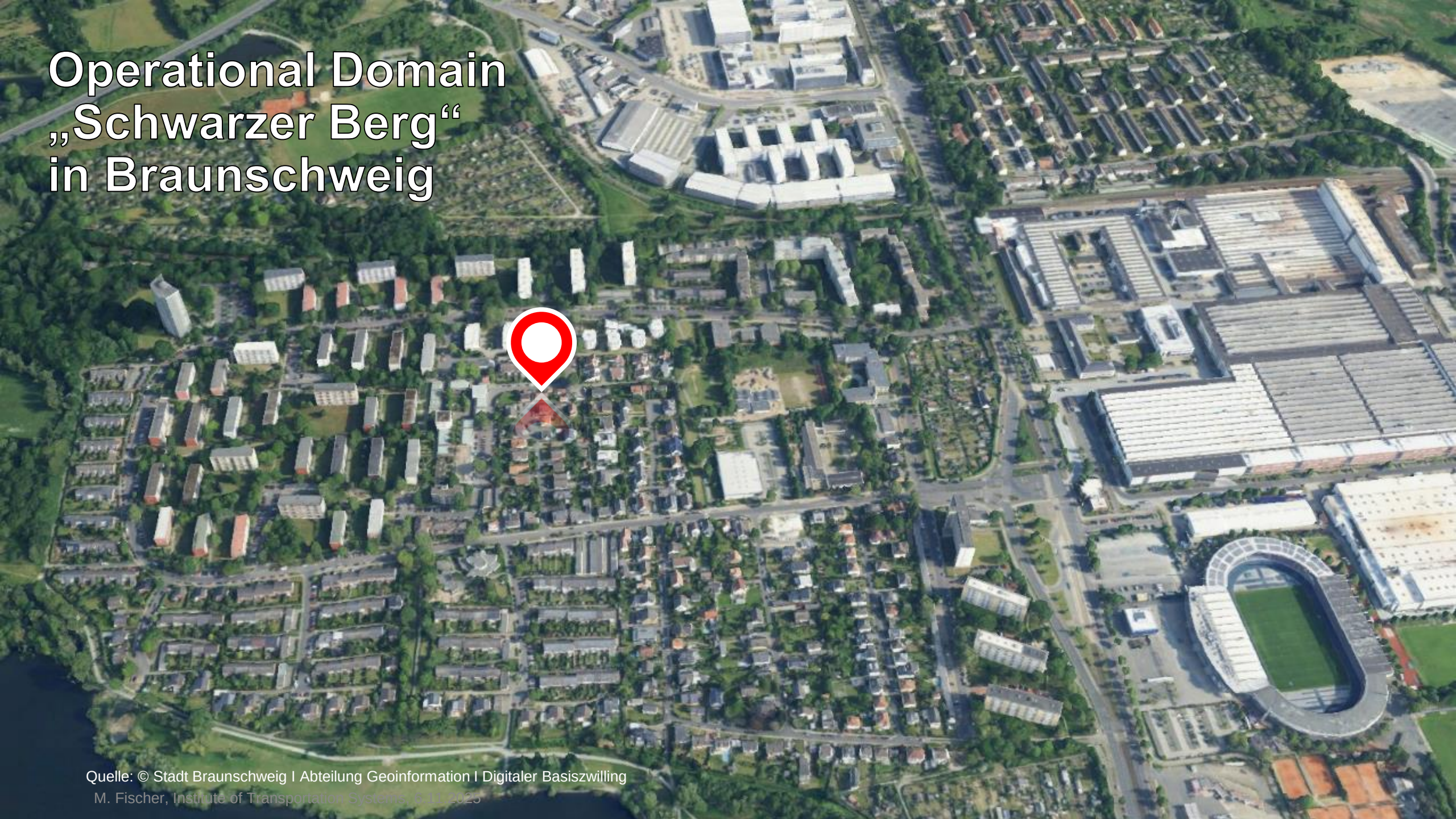

Source: DLR

**The U-Shift concept** is a modular, driverless system for logistics and public transport.
**Passenger and freight capsules** are automatically interchangeable during operation.

# IMoGer - Complete system with automated U-Shift fleet

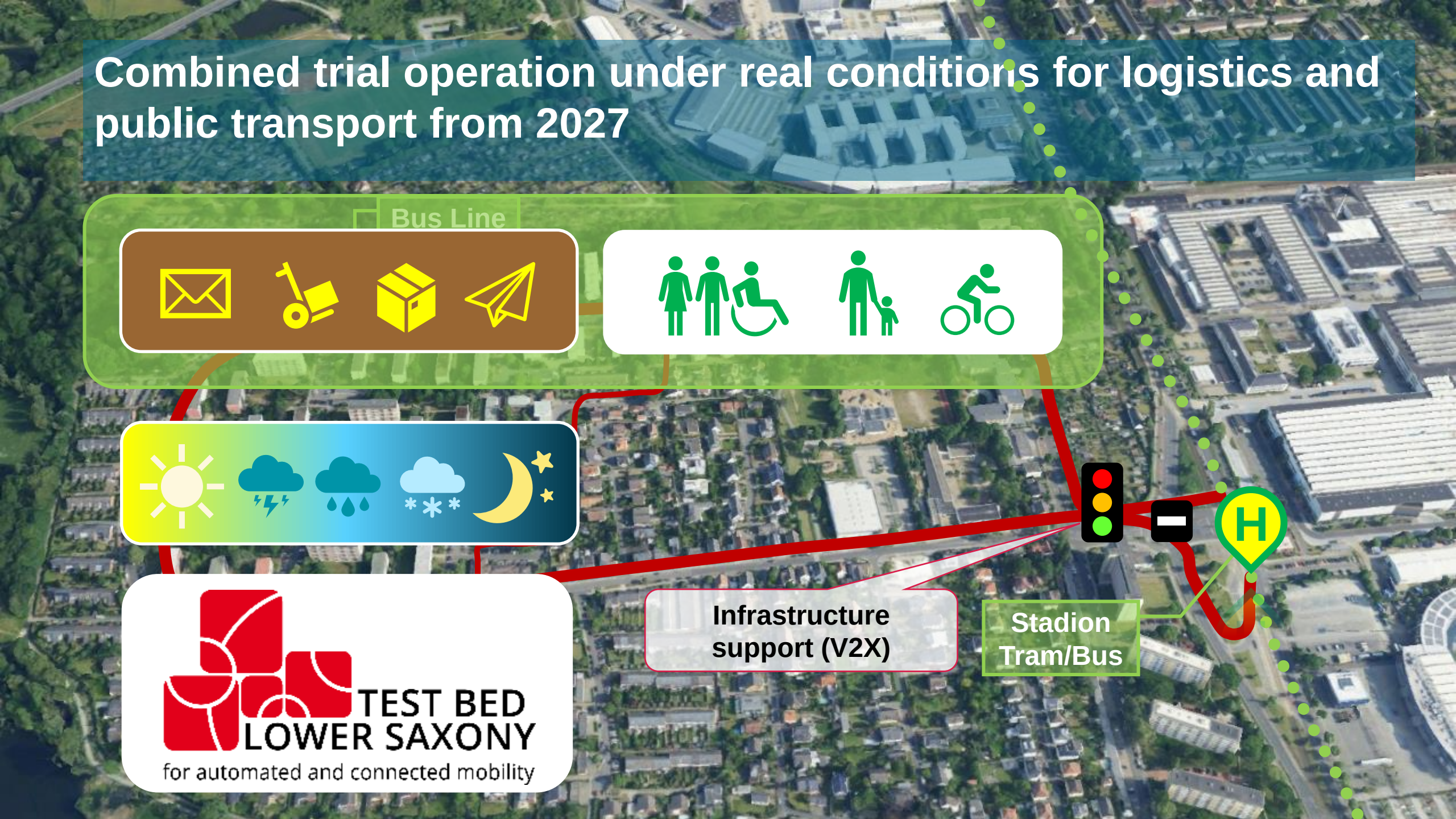


# Operational Domain „Schwarzer Berg“ in Braunschweig

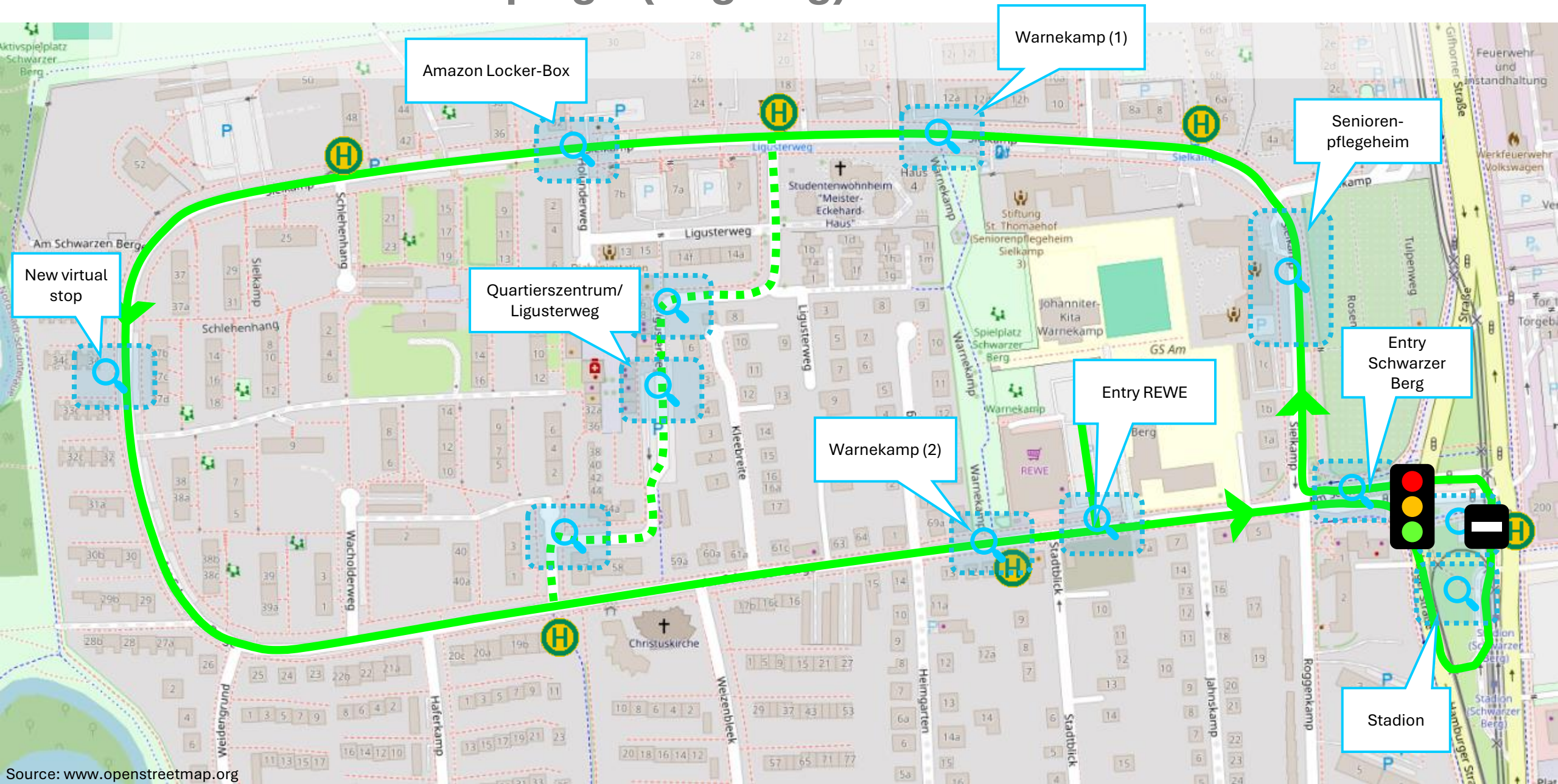


Quelle: © Stadt Braunschweig I Abteilung Geoinformation I Digitaler Basiszwilling

# Combined trial operation under real conditions for logistics and public transport from 2027

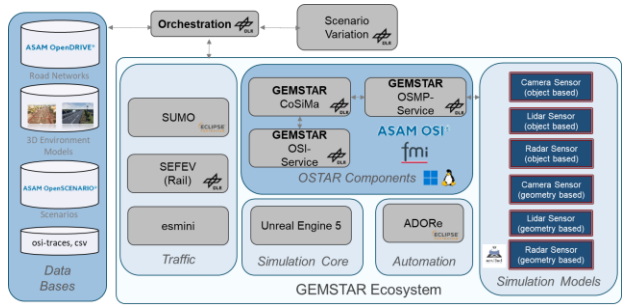


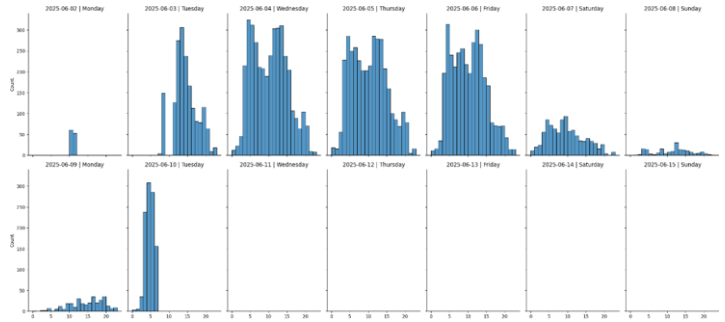
# Measurement Campaign (ongoing)

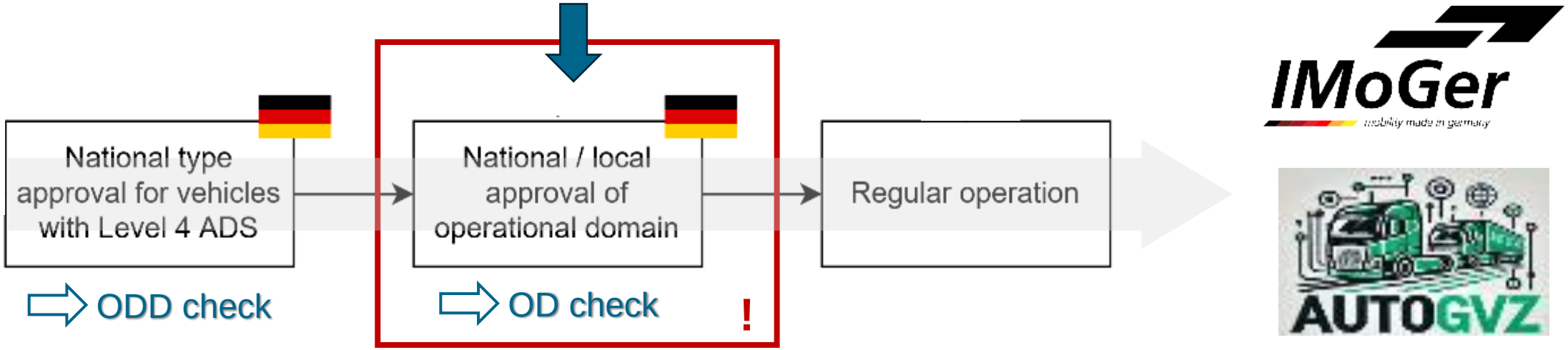



Source: www.openstreetmap.org

# Simulations supporting the OD approval!






IMoGer
mobility made in germany

AUTOGVZ

# Thank you for your attention!

**GERMAN AEROSPACE CENTER**

TRAFFIC RESEARCH

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