

Enabling Analysis of Perception Phenomena for Highly Automated Driving by Using Redundant Sensor Setups in Automotive Scenarios

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- ▶ For automated driving, the urban environment in particular poses high challenges due to its complexity
- ▶ Proof of safety in new technology is key to acceptance in society
- ▶ Idea: Develop safety proof through verification & validation methods for automated vehicles
- ▶ Methods and standards should exploit opportunities for digitization; greater inclusion of resource-saving simulation tools as target image

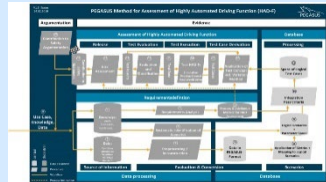
VVMETHODS PEGASUS Family – Publicly-Funded Projects in Germany

- The **PEGASUS Family** focuses on development / testing methods and tools for AD systems on highways and in urban environments

PEGASUS

<https://www.pegasusprojekt.de/en/home>

- Scope: **Basic methodological framework**
- Use-Case: L3/4 on highways
- Partners: 17



VV-Methods



- Scope: **Methods, toolchains, specifications for technical assurance**
- Use-Case: L4/5 in urban environments
- Partners: 23 partners
- Timeline: 07/2019 – 06/2023

SET Level



- Scope: **Simulation platform, toolchains, definitions for simulation-based testing**
- Use-Case urban environments
- Partners: 20 partners
- Timeline: 03/2019 – 08/2022

+ future projects of the PEGASUS Family

2016

2019

Time →

Systematic control of test space

- ▶ Methods to map the infinitely-complex open context onto a finite & manageable set of artifacts

$\infty \rightarrow n$



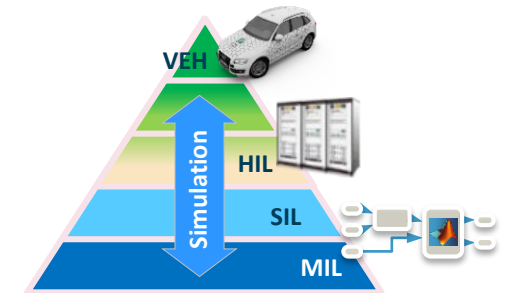
Consistent interfaces for assurance argumentation, systems and components across the supply chain

- ▶ Definition of incremental tests of subsystems and overall systems



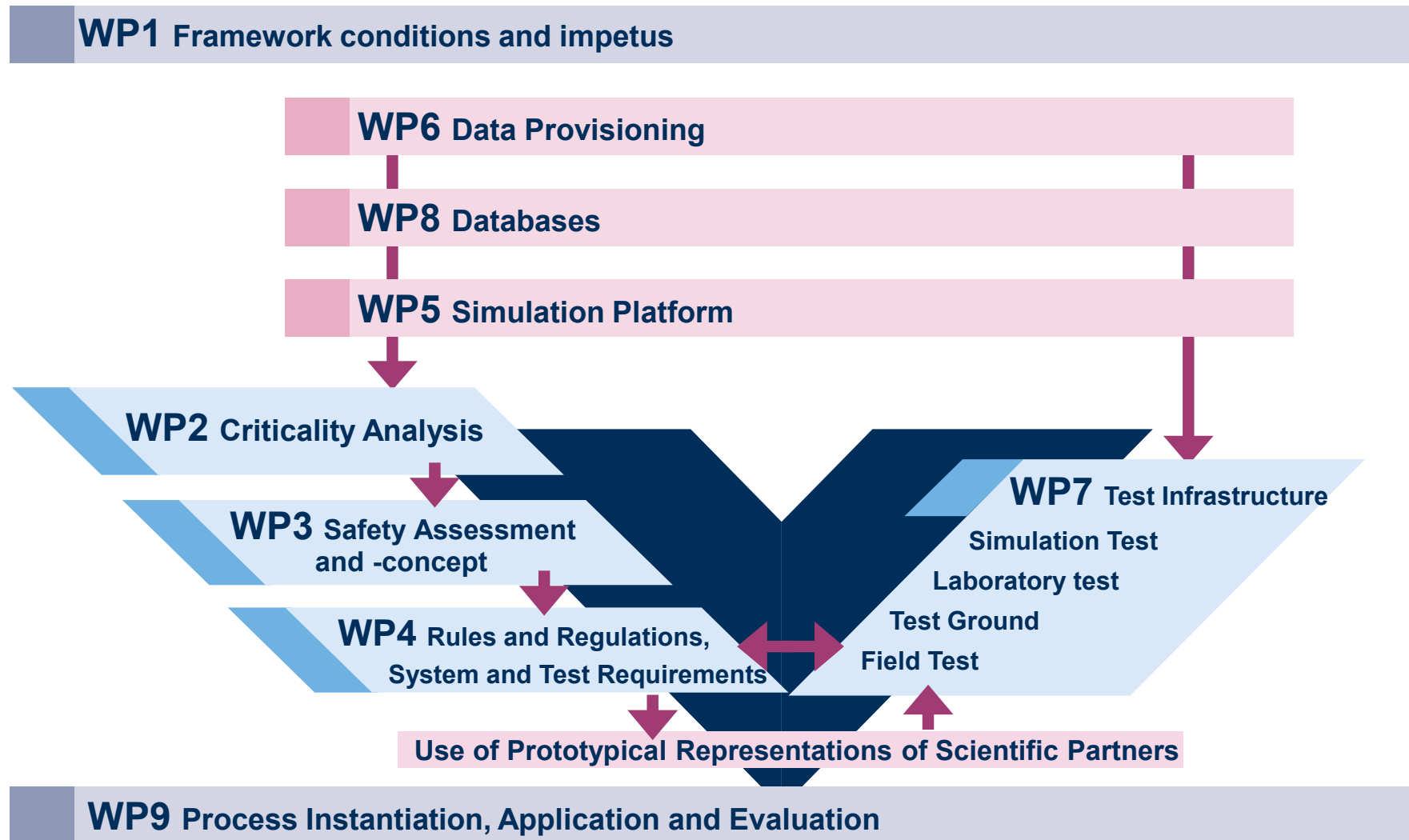
Significant shift from real-world testing to simulation

- ▶ Methods for seamless testing across all test instances



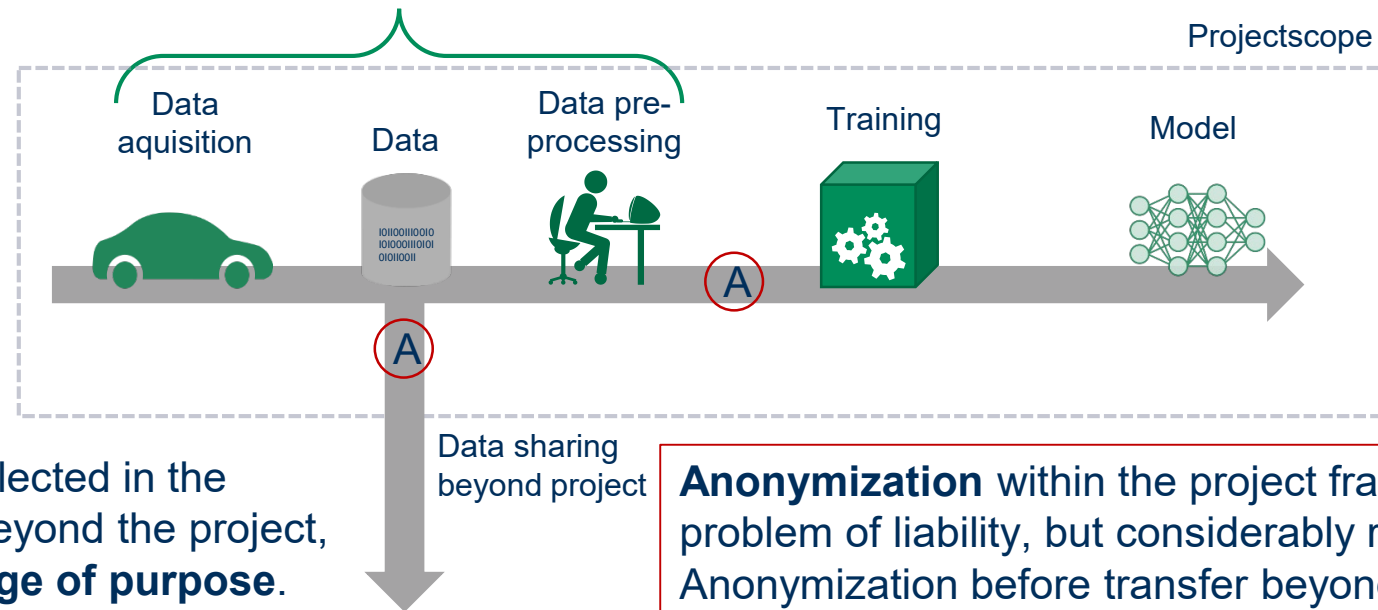
...and a coherent assurance argument linking the developed methods.

Project Structure



Challenge for Data Provisioning

Data collection and pre-processing is generally done in **joint subcontracts**. Current legal assessment in projects: Through joint subcontracts, the means and purposes of data processing are jointly determined by the consortium, if applicable. This joint controllership creates **joint liability** (Art. 6 (4) GDPR).



If the personal data collected in the project is **passed** on beyond the project, this constitutes a **change of purpose**. This is only permissible under special conditions (Art. 6 (4) GDPR).

Anonymization within the project framework may solve the problem of liability, but considerably restricts project research. Anonymization before transfer beyond the project framework solves the problem of change of purpose, but considerably reduces the **usability** of this data for further research.

(A) Possible anonymized data

Approach Inside VVMETHODEN

- ▶ Only data collecting partner has raw data (**safety-cage**), all other partners get access to anonymized data, that means
 - ▶ Recognizable faces
 - ▶ License plates



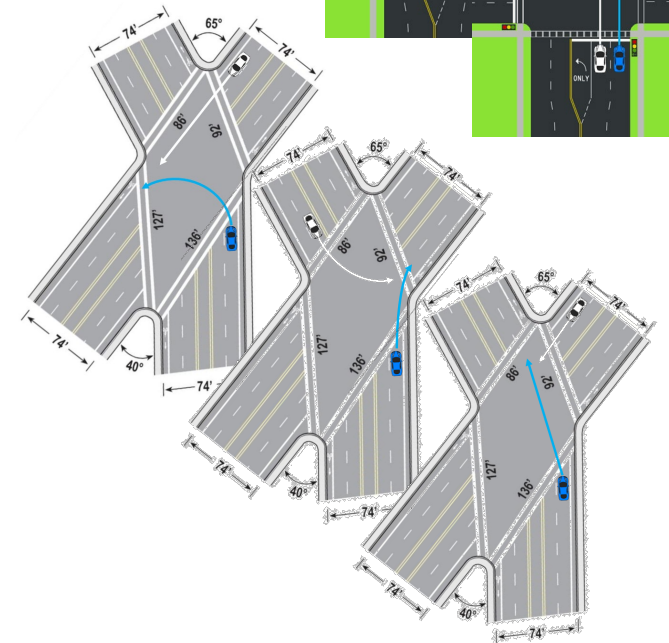
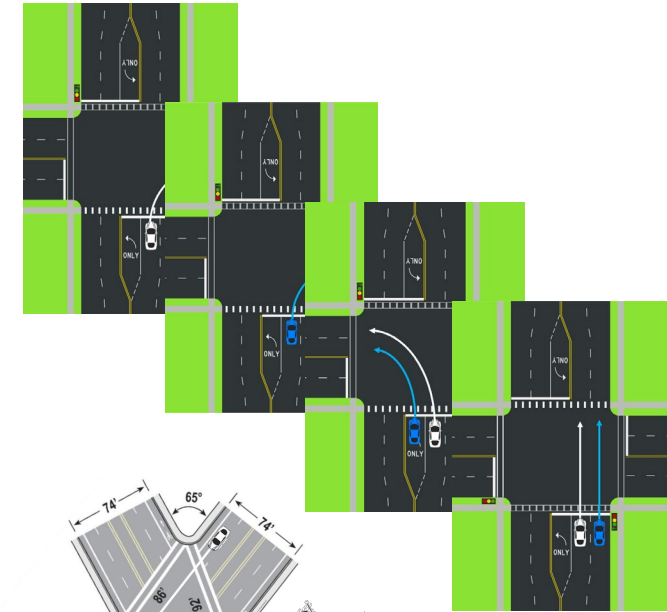
Requirements for Measurement System

Offline Perception

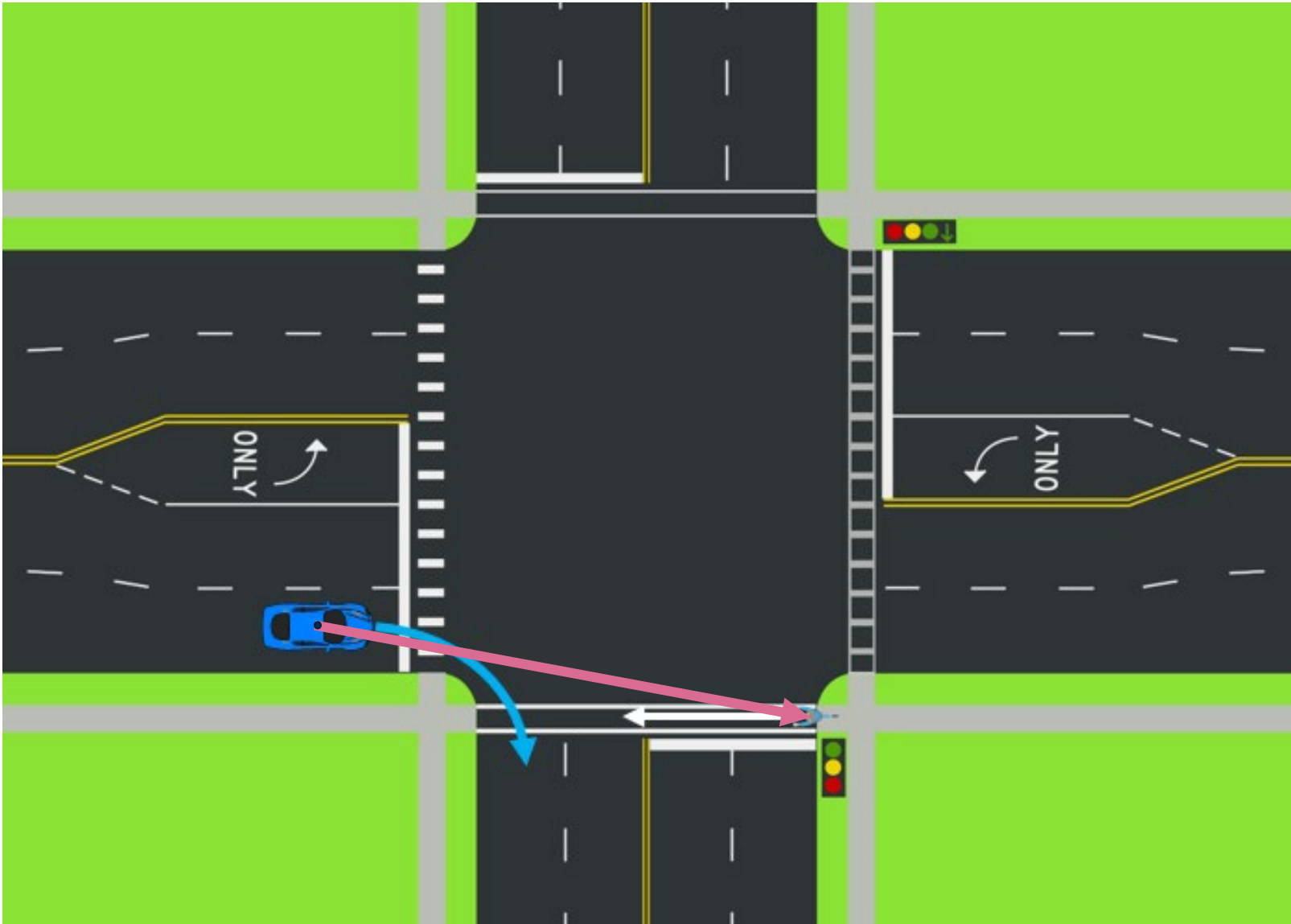
- To identify an object the following requirements, need to be fulfilled:
 - HxV pixels in camera image
 - N points in LiDAR point cloud

Use Case Analysis

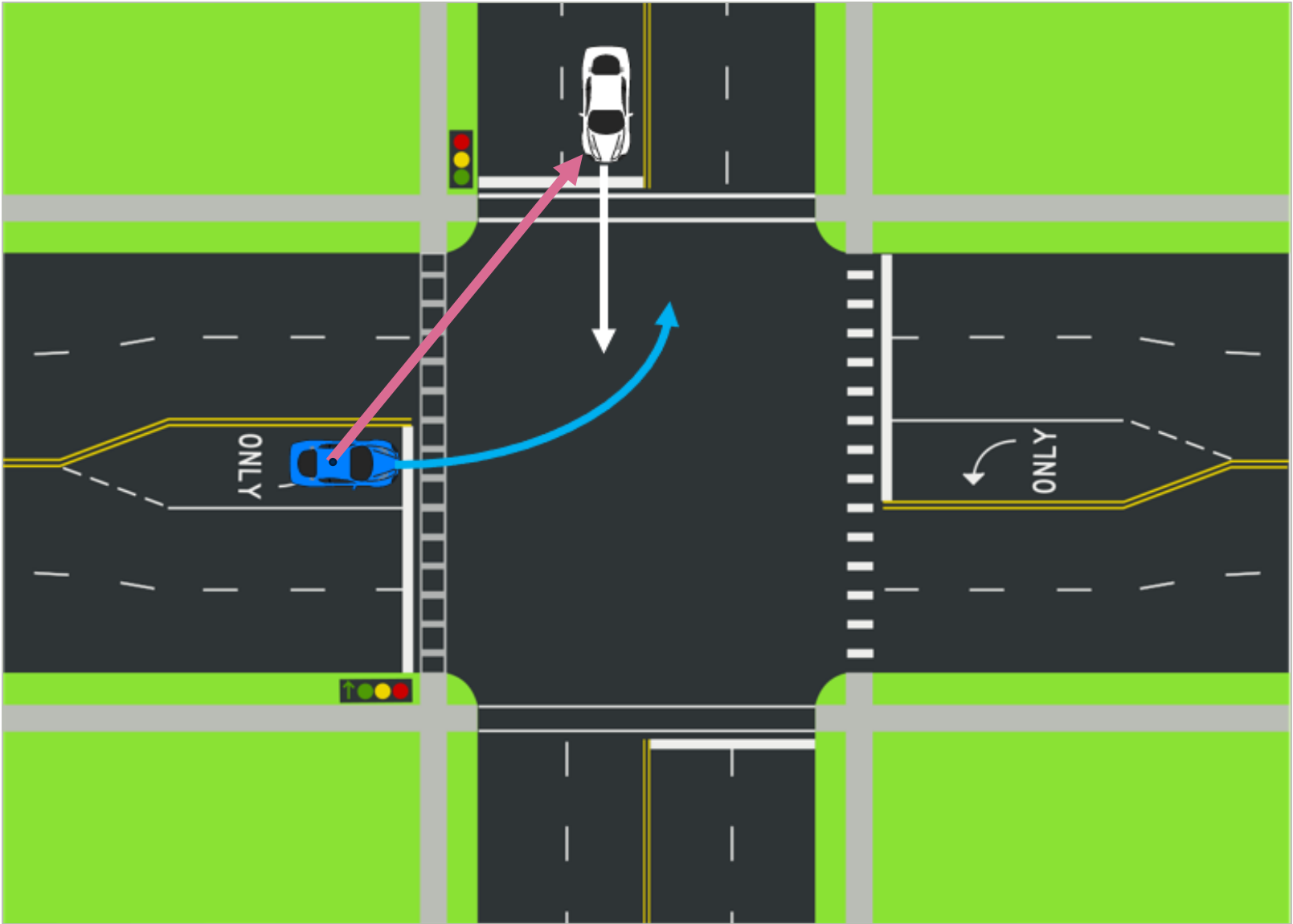
- Differentiation between scenario **Stop & Go** and **Passing**
- Relevant targets **motorcyclist**, **bicyclist** (recumbent) and **pedestrians** (child 1m tall)
- Calculation of required perception range, certain assumptions were made for **deacceleration**, **acceleration**, **friction coefficient**, **minimum number of pixels** (horizontal and vertical), **width** and **height of relevant target**, etc.
- Different **intersection scenarios** were evaluated



Results from Requirements

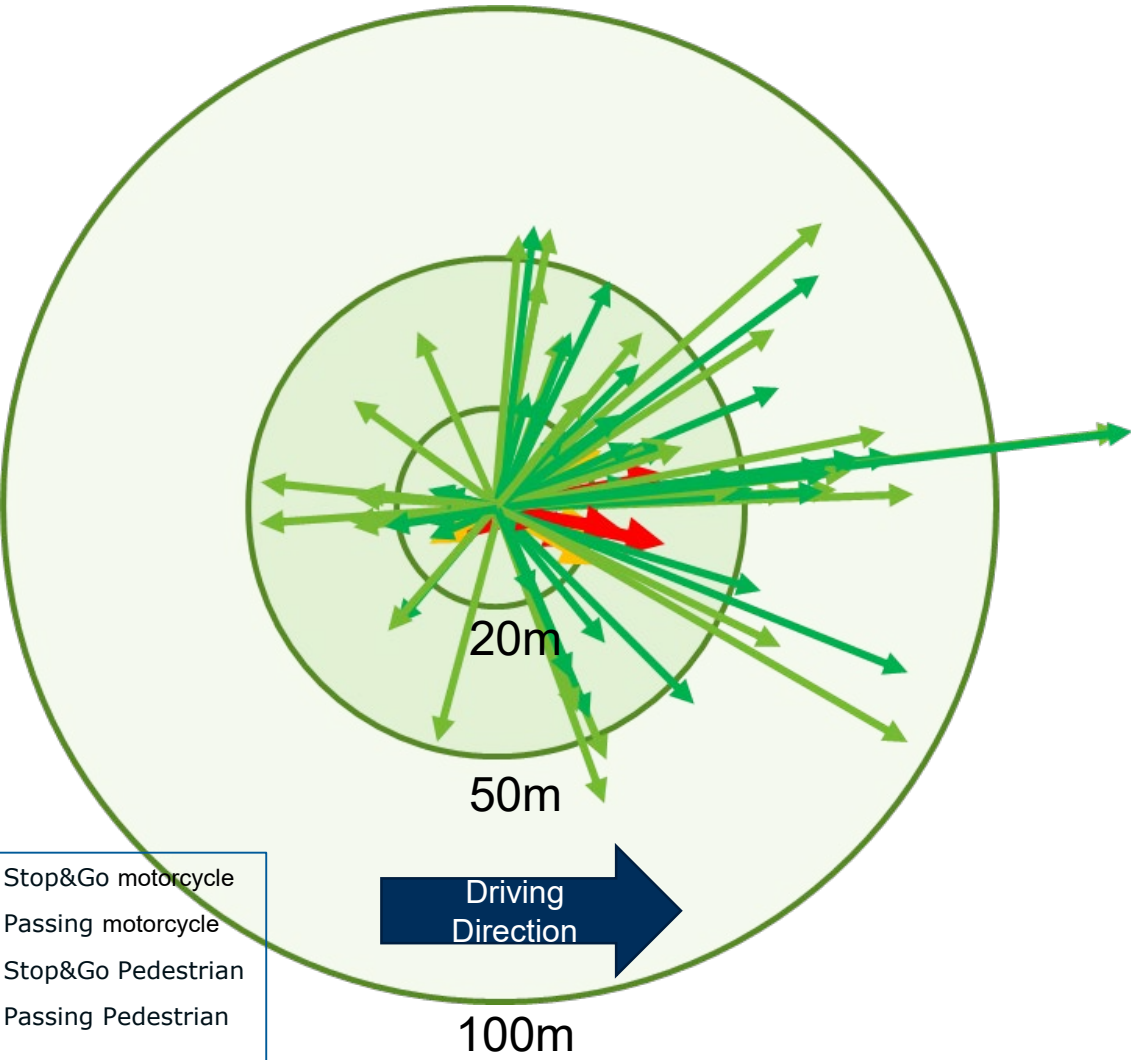


Results from Requirements

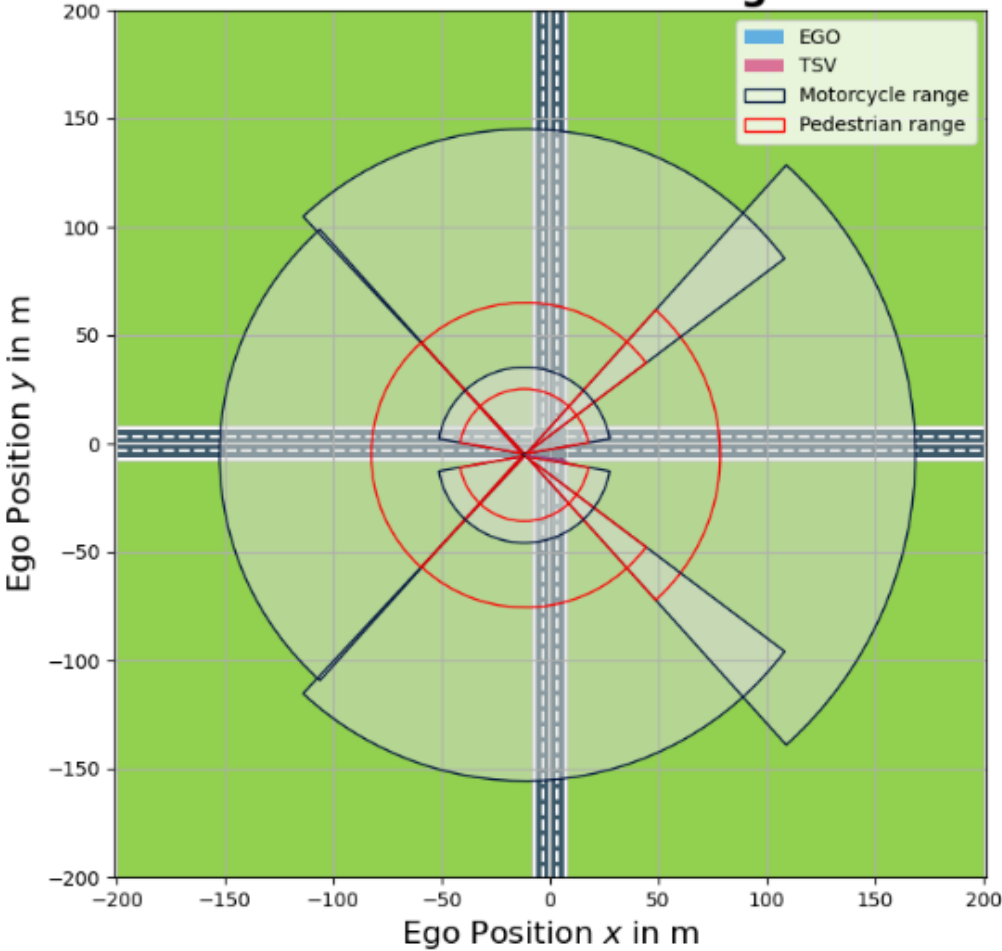


Relevant Perception Range and Direction

Intersection Requirements

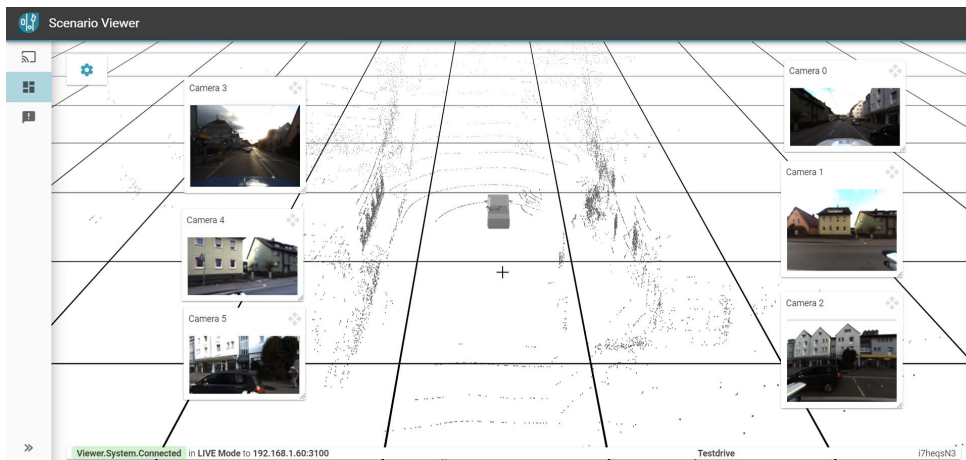
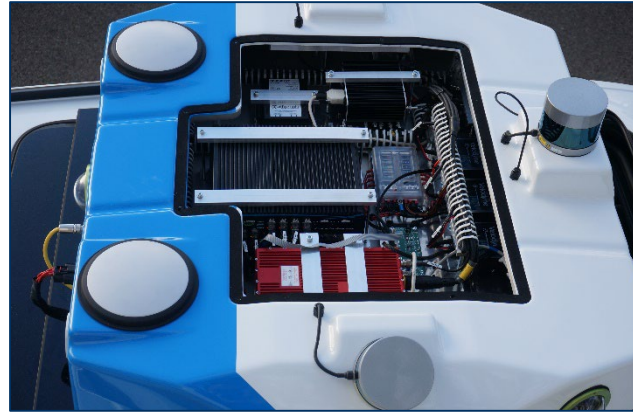


Intersection Coverage

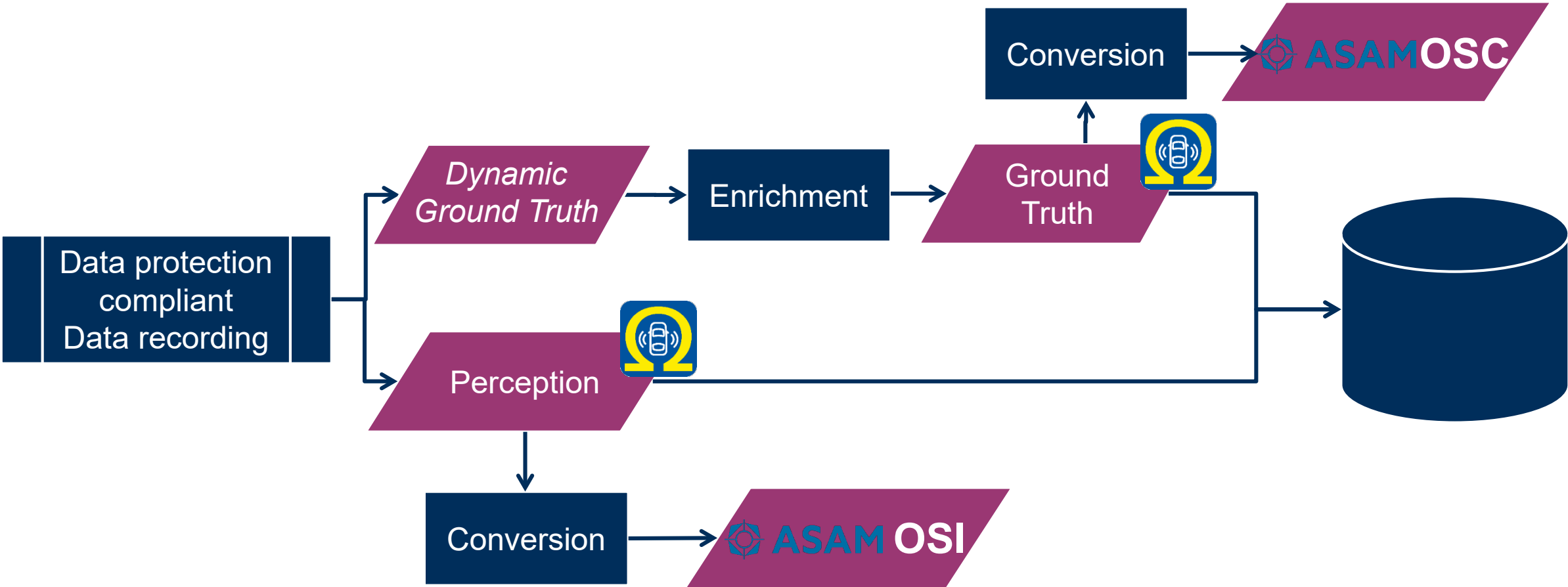


Data collection

- Commissioning completed
- Data collection after coordination in the consortium



Overview Data Flow VVMETHODS





- ▶ Novel scenario description format
- ▶ Supports multiple types of scenario data
 - ▶ Reference (Ground Truth) Data
 - ▶ Perception Data
- ▶ Classtypes referenced with examples, to clarify meaning

Example:

RoadUser.Type. pushable_pullable = 7

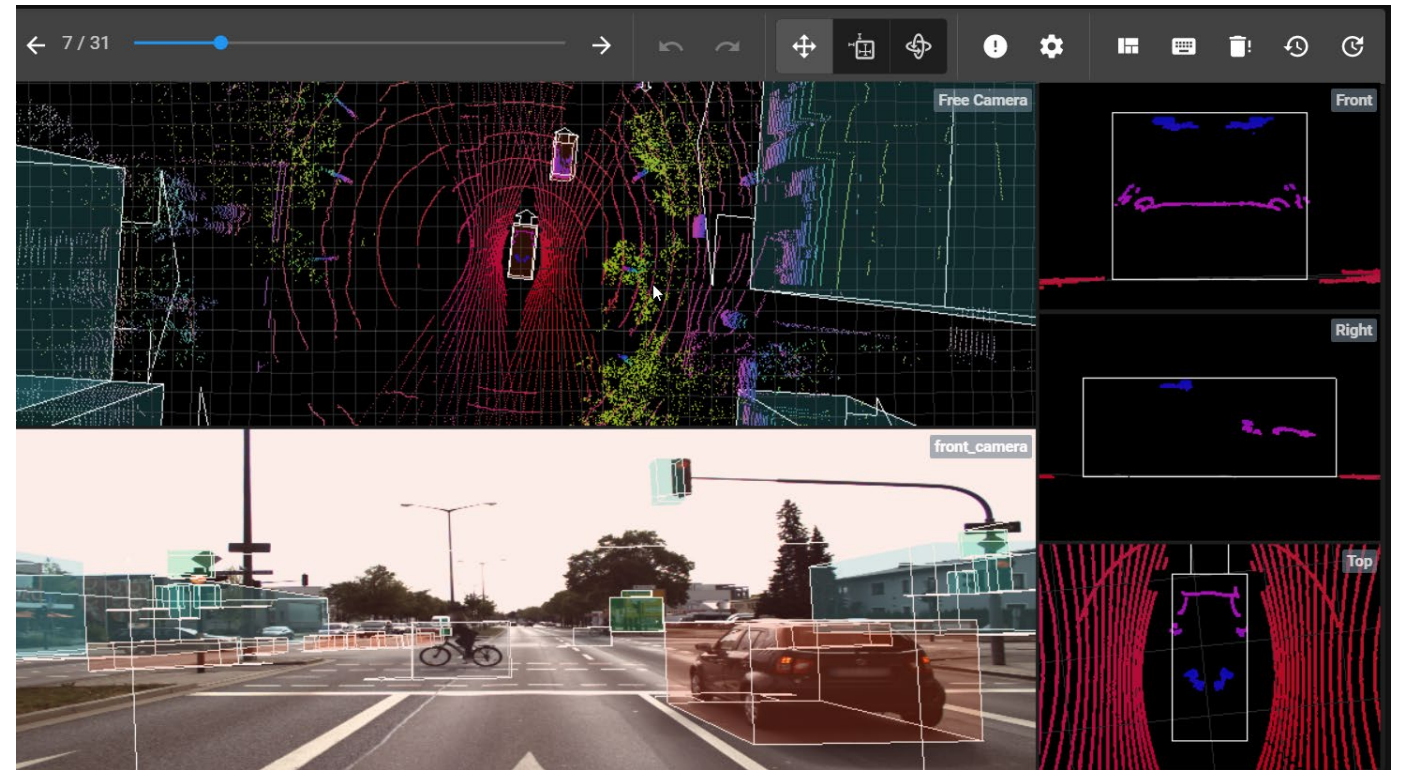
“includes all pusable or pullable object such as trolleys, shopping carts, strollers etc.). Does not include wheel chairs (see category wheel chair)”



https://github.com/ika-rwth-aachen/omega_format

Labelling

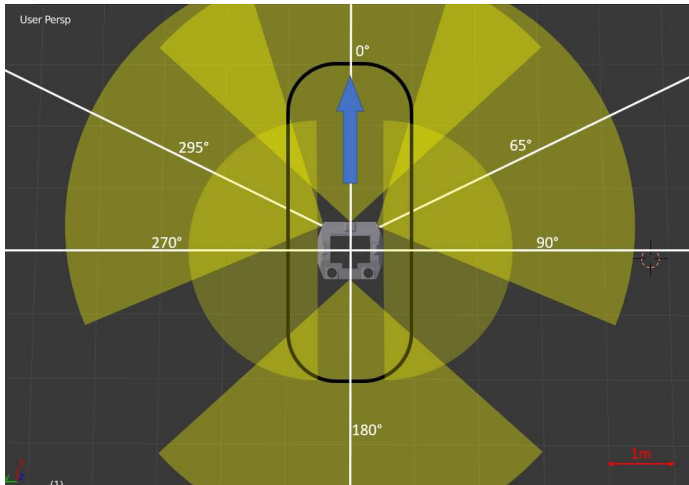
- Semi automatic labelling
- Enrichment of reference data to serve as ground truth consisting of **road network**, **traffic signs**, and **surrounding traffic participants**
- Classification of **objects** via bounding boxes
- Generation of **object lists** as .JSON files



Source: Understand.ai

Summary - What We Have Achieved

- Reference measurement technology concept developed and commissioned
- Modular approach for integration and recording of Sensor-under-Test
- Process for measurement drive planning defined
- Data provisioning challenges solved inside a consortium with 20+ (from OEM, TIER1 and R&D) members
- Data format between anonymized raw data and labelling supplier aligned



Thank you for your attention

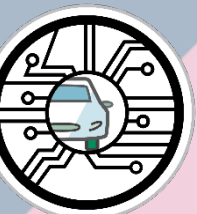
Save the Date

VVMETHONDE Half Time Event

14.03.2022

Further Information to the Project

<https://www.vvm-projekt.de/en/>



Gefördert durch:



Bundesministerium
für Wirtschaft
und Energie

aufgrund eines Beschlusses
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