



Sensor & Fusion Layer

Final Event Ulm
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The RobustSENSE approach



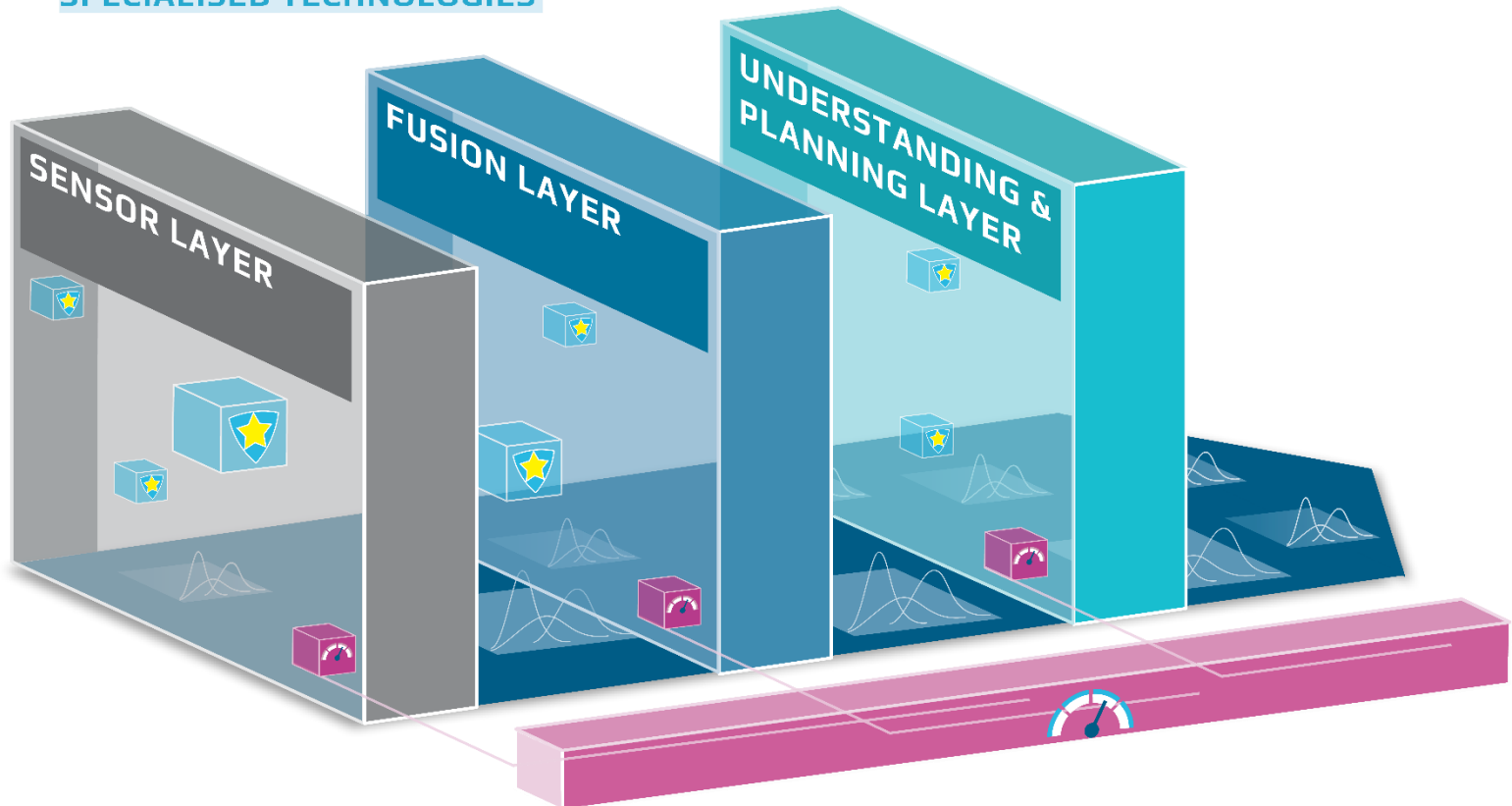
PROBABILISTIC PROCESSING



PERFORMANCE ASSESSMENT



SPECIALISED TECHNOLOGIES



Objectives

Environment Perception:

Sensor Performance Monitoring

Defining a modular architecture to handle uncertainties on every level of processing for environment perception

Sensor Adaption

Adaption of lidar sensors towards a better robustness

Data Acquisition

Data Acquisition

Definition and implementation of robustness and accuracy measures on sensor level

Sensor Data Processing

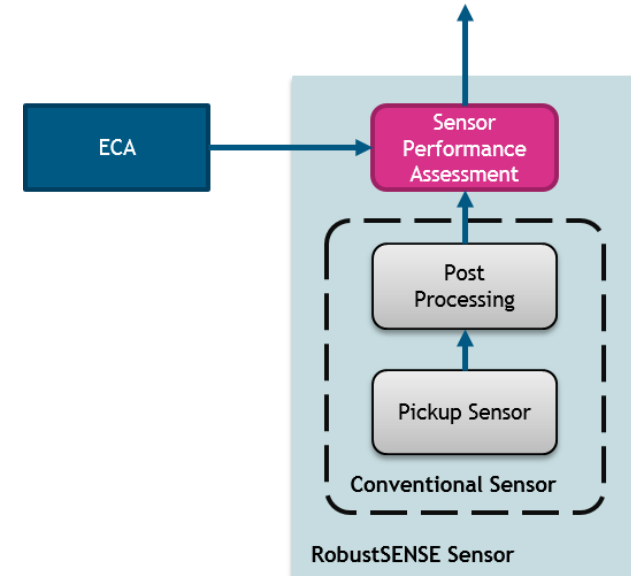
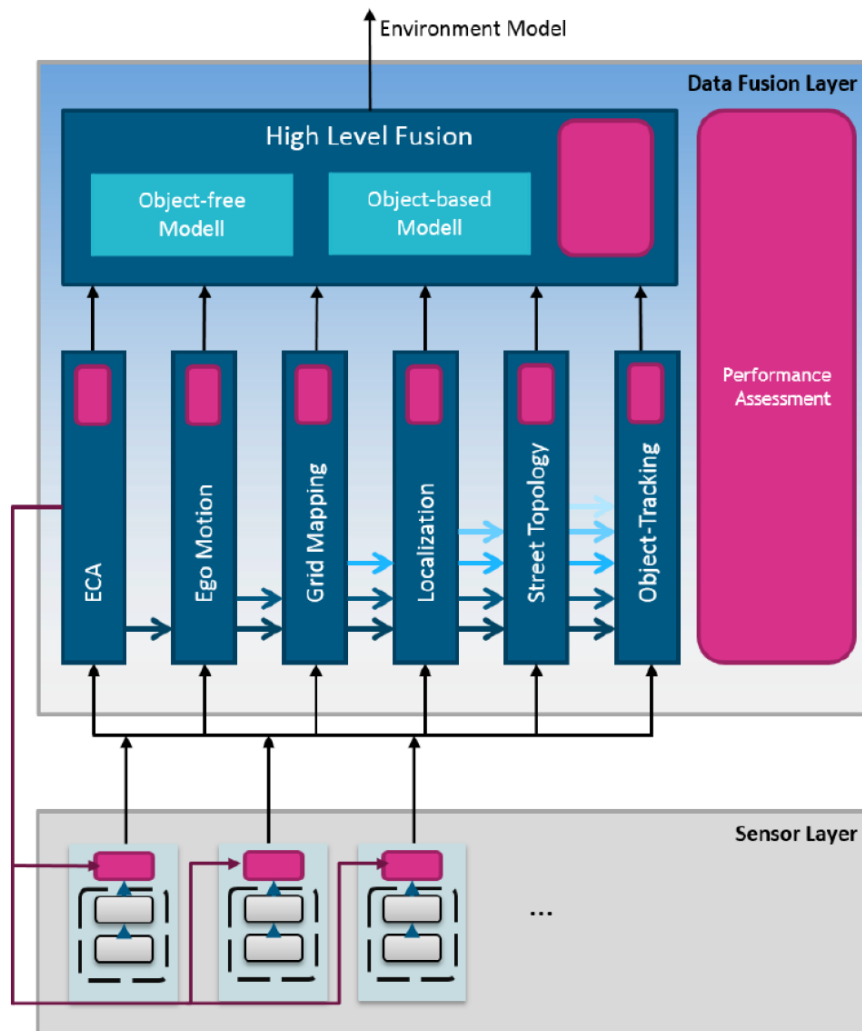
Definition of the algorithm strategy for lidar, radar and camera data processing

Define a quality metric for each data item

Information Fusion

Fusion of all available data with respect to overall system performance

Work on Sensor Layer



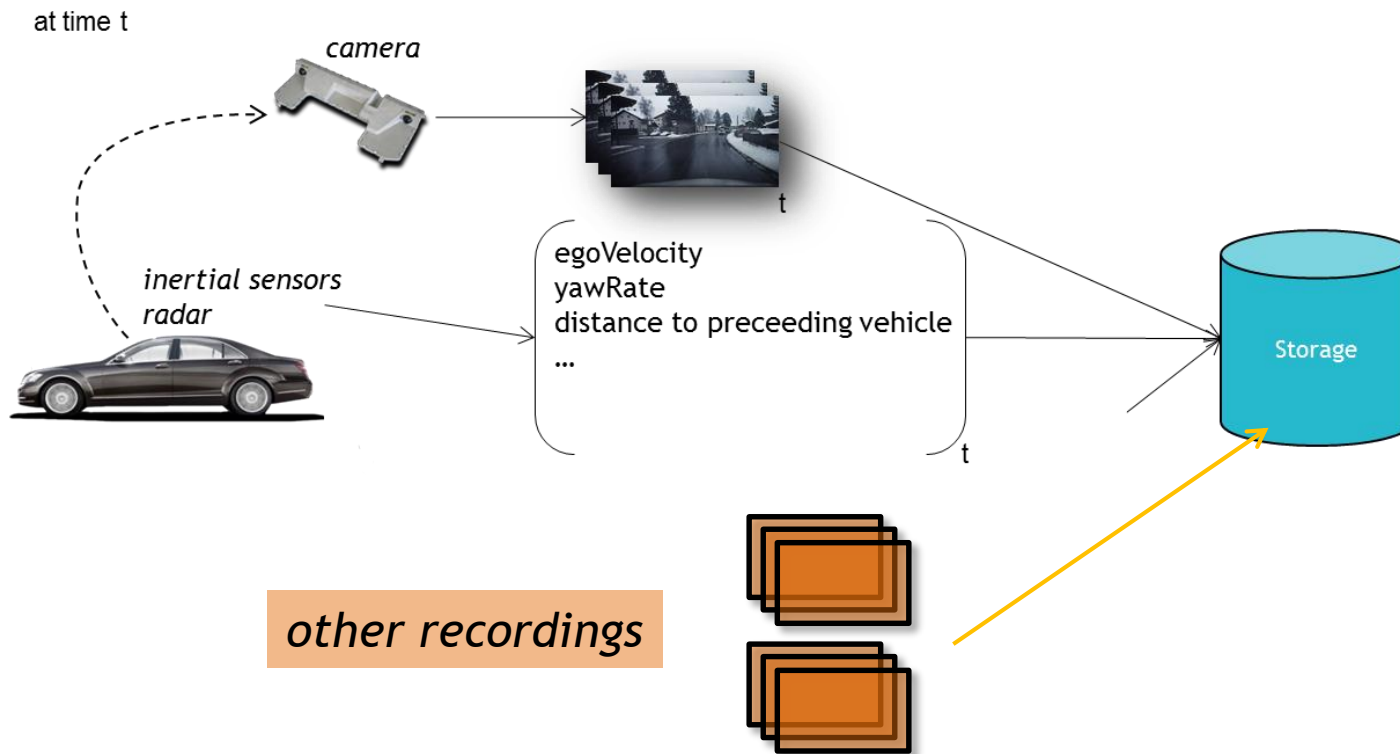
Concept of RobustSENSE
Sensors Components

RobustSENSE Architecture Sensor and Fusion Layer

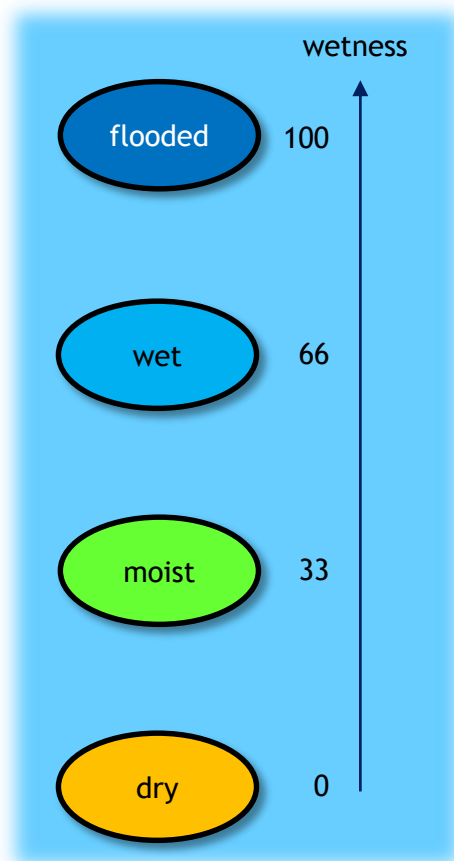
1) Key Achievement (ECA)

Classification of Road Conditions using Machine Learning

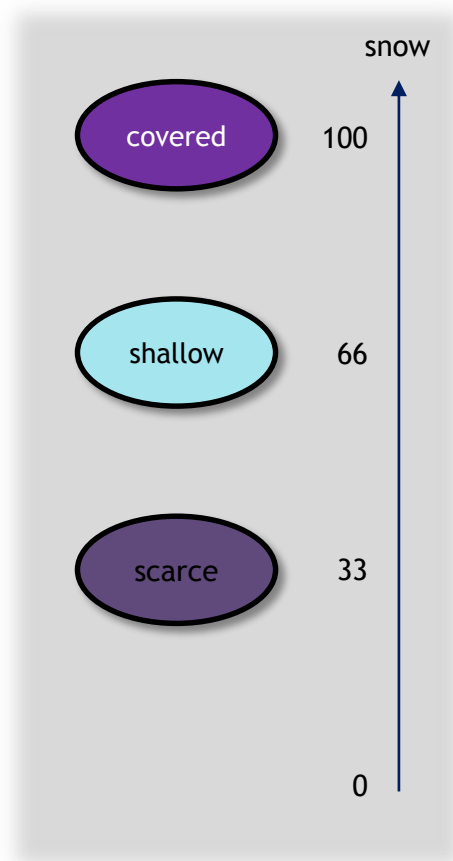
- ▼ Data recording to get training data for the neuronal network
- ▼ Train a Deep Neural Network able to recognize different road condition



The Classes to be detected on the Lane



Water-Layer



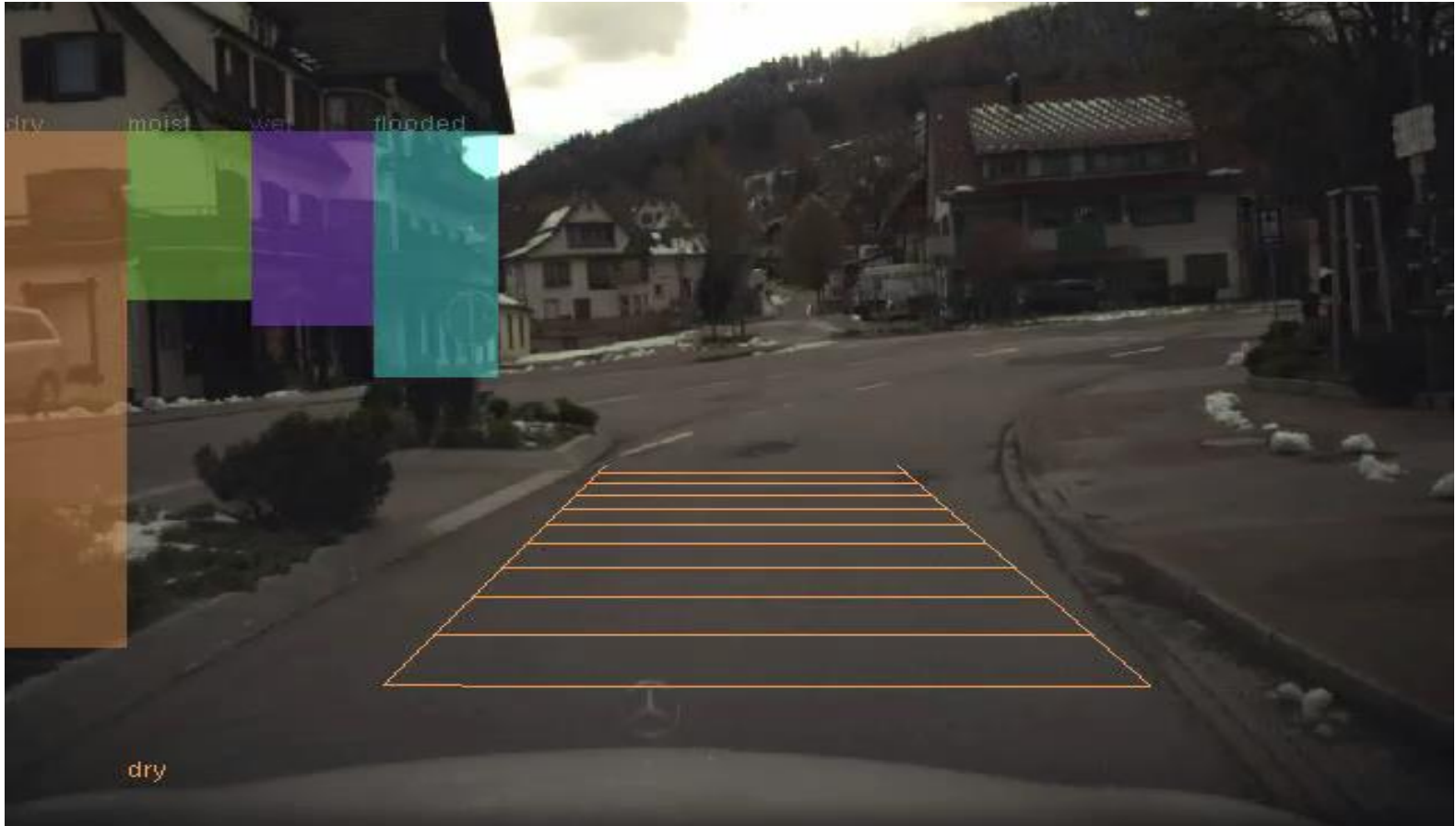
Snow



Road Surface

Example Video: Classification of Road Conditions

Focus on **Dry**/**Moist**/**Wet**/**Flooded**.



Notice: Curves are not considered.

2) Key Achievement

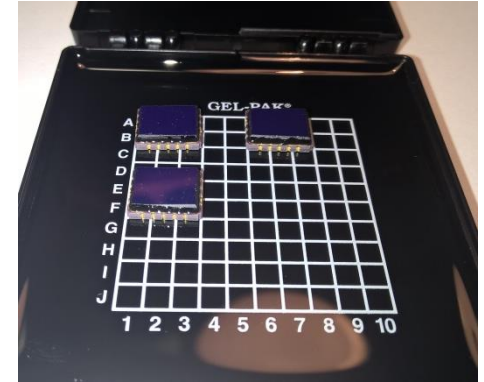
1550-nm-Lidar prototype with 4 layers



Receive optics for
1550 nm



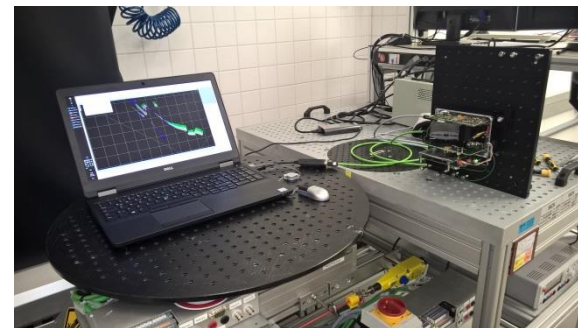
4-layer Lidar @ 1550 nm



1550 nm APD arrays with
filters from Oplatek



Transmit optics
with beam forming



Receiving adjustment setup

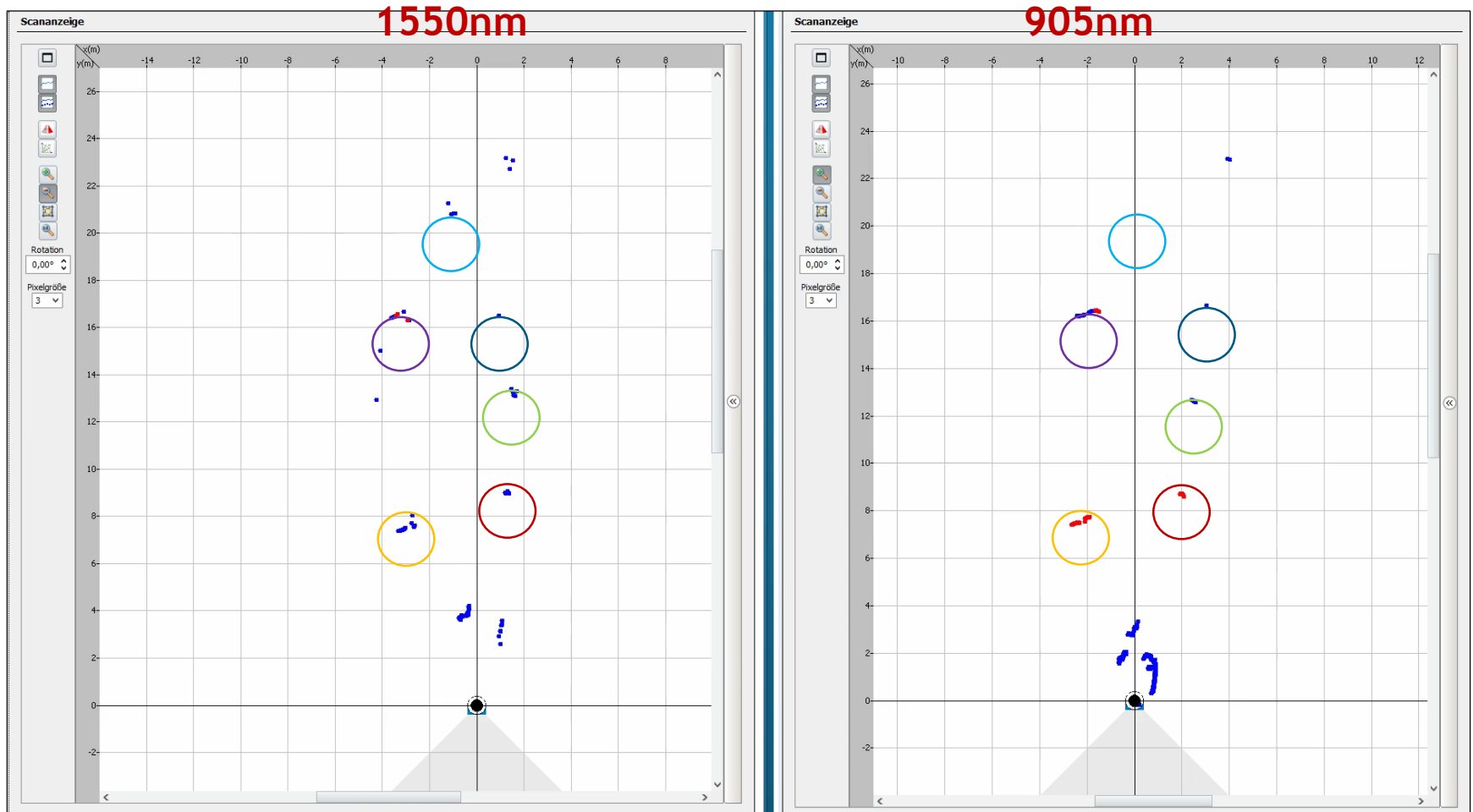
Exhaustive fog chamber testing



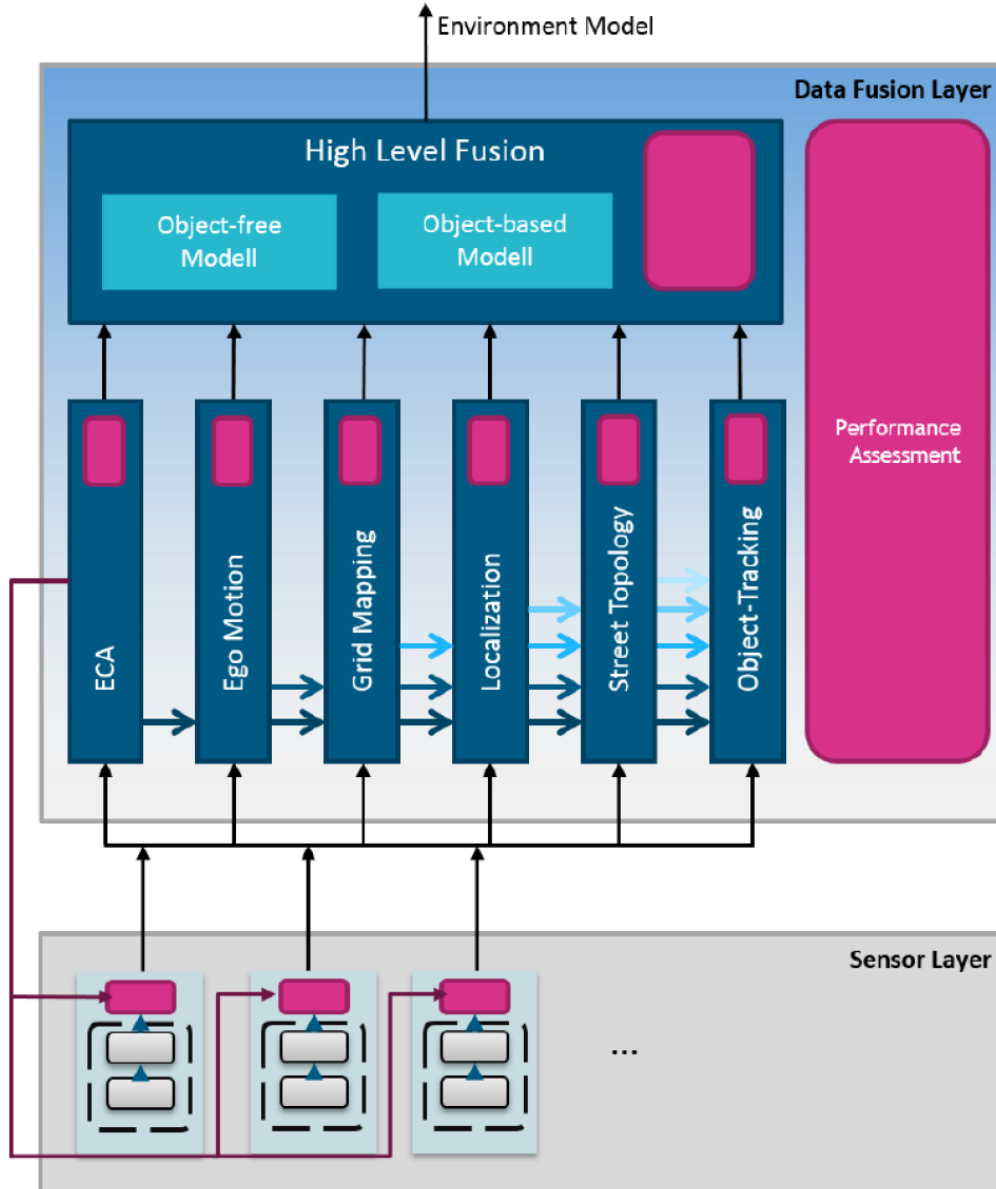
Test Environment in Fog Chamber

Fog penetration @Visibility Range 55m

Reflectors and Persons walking around



Work on Data Fusion Layer



4) Key Achievement

Multi-Object-Tracking using Fusion Lidar/Camera at a crossing in Ulm

- ▼ Uncertainty measures available for position, orientation, velocity, yaw-rate and existence of object-class.
- ▼ Green boxes represent objects detected with existence probability above 90%

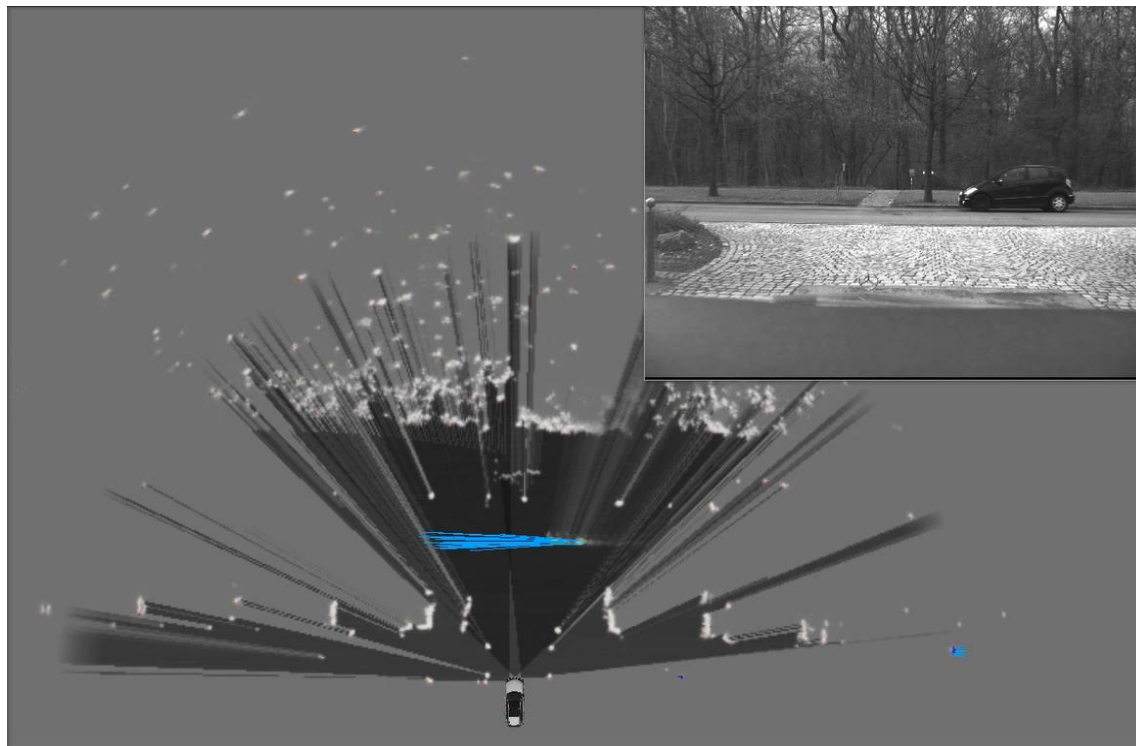


6) Key Achievement

Grid-Map using Fusion of Lidar / Radar

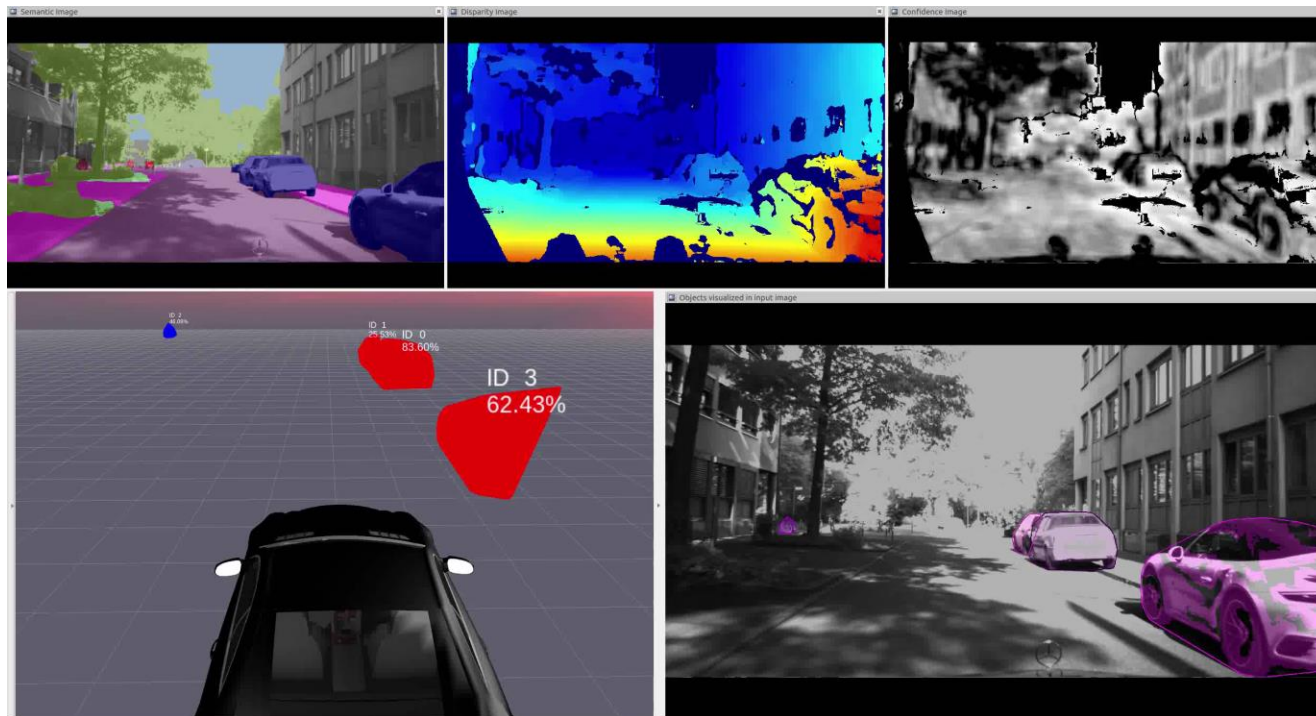
Video-Information for documentation only

- ▼ Grid occupancy probabilities: dark represents free, white occupied, grey unknown regions
- ▼ Colored lines represent dynamic cells, the length code the velocity and the color the direction of movement relative to the own vehicle

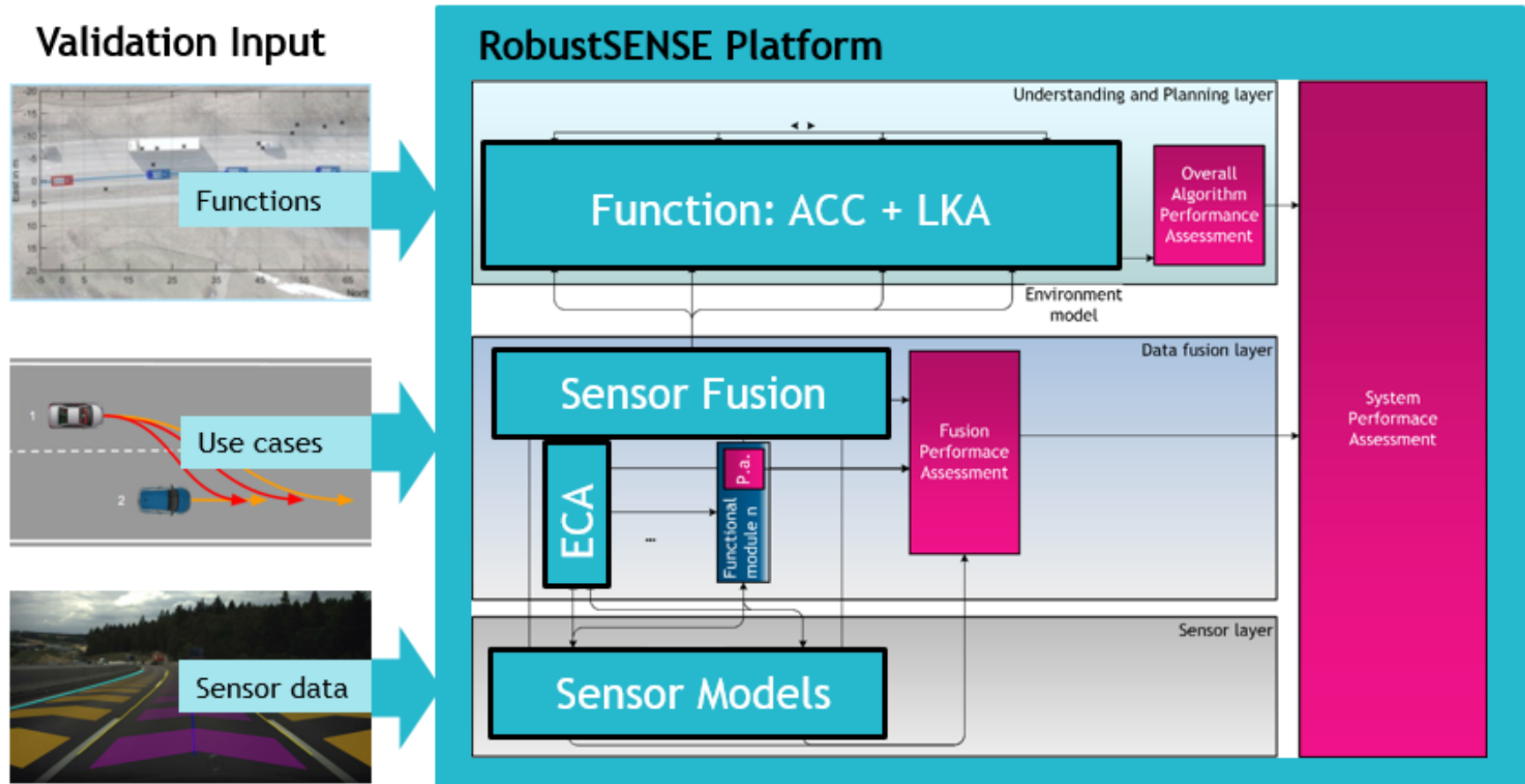


7) Key Achievement Probabilistic Object Recognition

- ▼ Clustering of disparity image with an adaptable threshold depending on semantic information and confidence values
- ▼ Uncertainty measures for position, orientation and existence

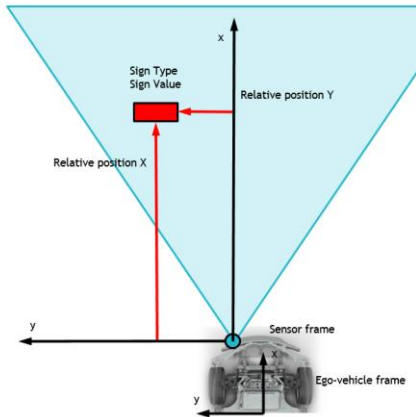


8) Key Achievement Simulation Framework

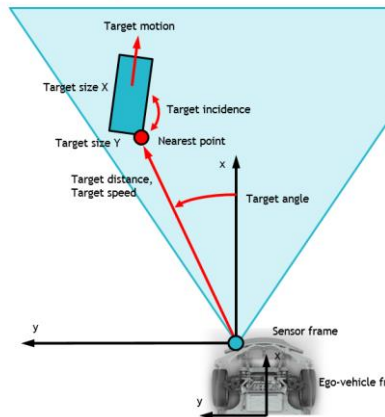


Example of realized augmented Sensor Models for Simulation Framework

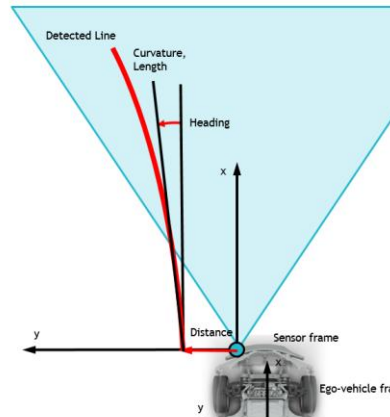
Road Sign Sensor



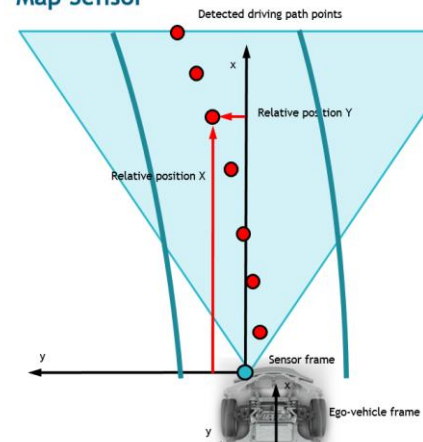
Traffic Object Sensor



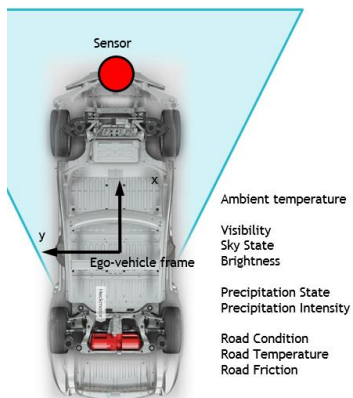
Road Line Sensor



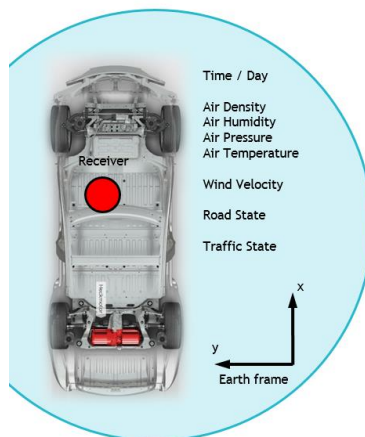
Map Sensor



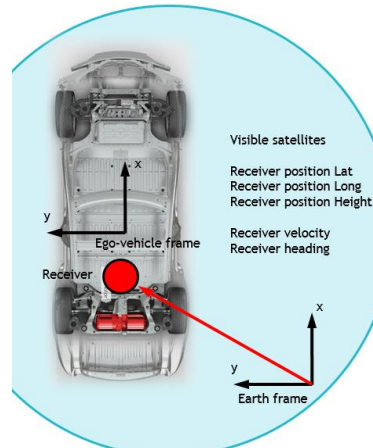
Ambient Sensor



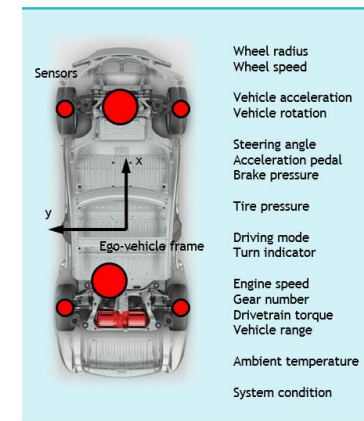
Infrastructure Sensor



Satellite Sensor



Vehicle Sensor





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Thank you.



FFG

Tekes



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