Implementation and Testing of Dynamic and Flexible Platoons in Urban Areas

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European H2020 project

- Period: 01-09-2016 ~ 31-08-2019
- Budget: € 3.149.661,-

Assumption:

- Road infrastructure applications will still play a key role in future cooperative automated driving era

Main objective

- Increasing traffic efficiency and safety in urban areas by exploiting automated driving

Approach

- C-ITS infrastructure-based traffic management solutions for cooperative automated vehicles (CAVs) at signalized intersections (traffic lights) and intersection corridors
- V2X-based automated driving extensions for perception and planning
- Use of simulation verification as well as road experiments with CAV and infra prototypes (ETSI ITS G5-based)

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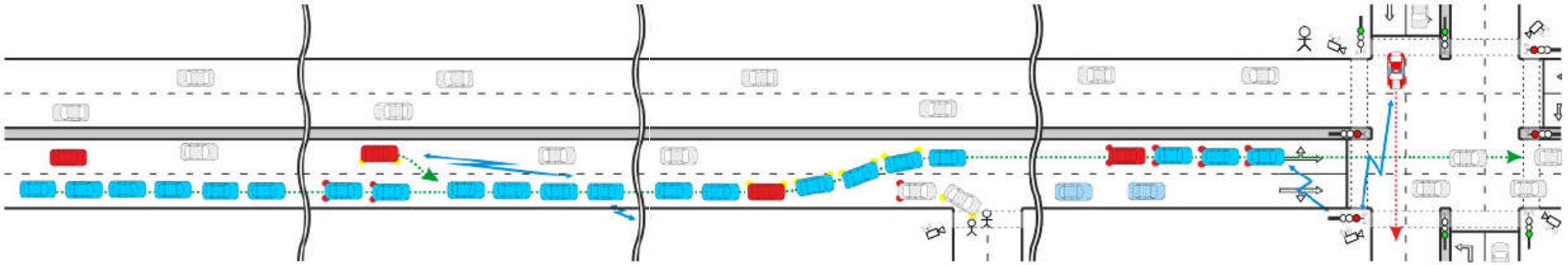
Use cases overview



- **I2V interactions**
  - ✓ V2I “explicit” probing + I2V speed/lane advisory + V2I feedbacks on compliance to advisories
- **Traffic controllers optimization**
  - ✓ Signal optimization, priority management, queue estimation, green wave
- **Platoon management**
  - ✓ Forming, joining, travelling in, leaving, breaking a platoon
- **Inclusion of conventional traffic and VRUs**
  - ✓ Detection/reaction in presence of non-coop cars & VRUs

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Highway Platooning vs. Urban Platooning

Main focus:

- **Reduced fuel consumption**

But:

- **Simple situations**
- **Rel. high speeds**

Main focus:

- **High throughput on intersections**

But:

- **Complex situations**
- **High flexibility needed**

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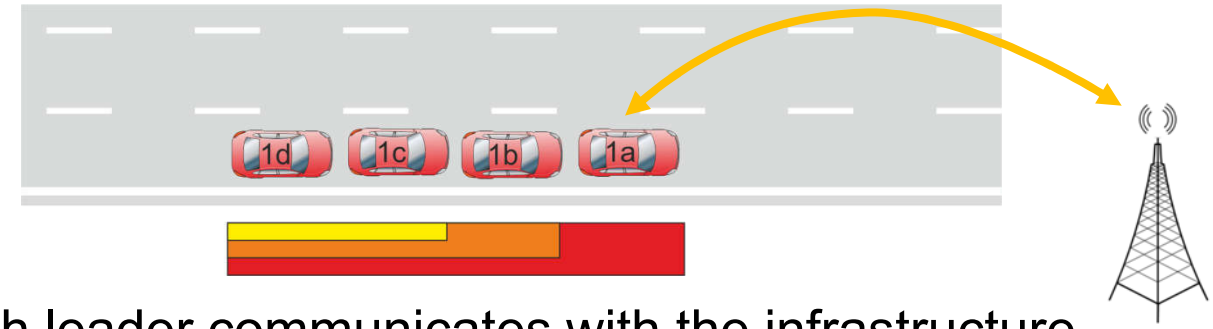
Urban Platooning: Approach

- **Flexibility in focus:**
  - Vehicles can join/leave at any time
  - Distances are set individually by the following vehicle
    - As done in Cooperative ACC
  - Each vehicle is the leader of its followers



  - Each leader communicates with the infrastructure

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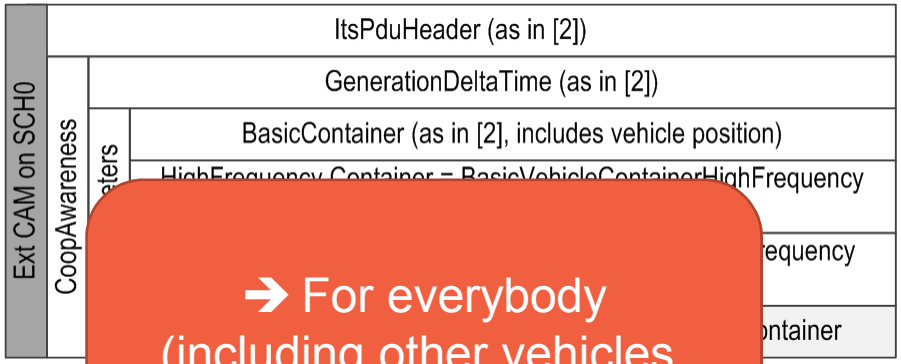
Communication

V2X Communication

- **Standard CAM with extension on standard channel**

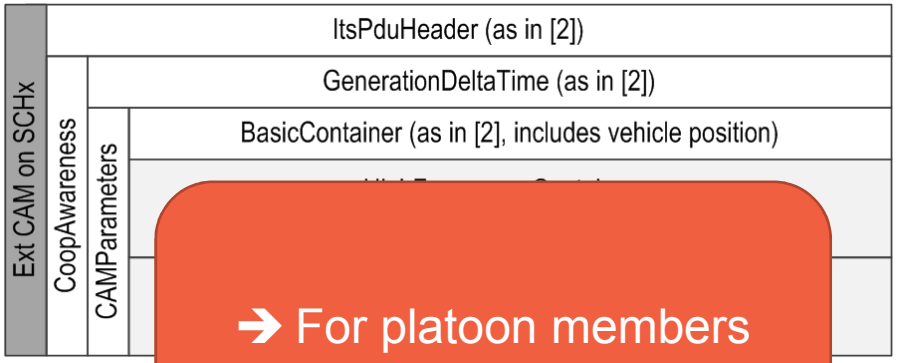


➔ For everybody (including other vehicles, infrastructure)

- Route on upcoming intersection
- …
- List of platoon members

V2V Communication

- **Standard CAM with extension on extra channel**



➔ For platoon members (esp. Followers)

- States of platoon logic
- …

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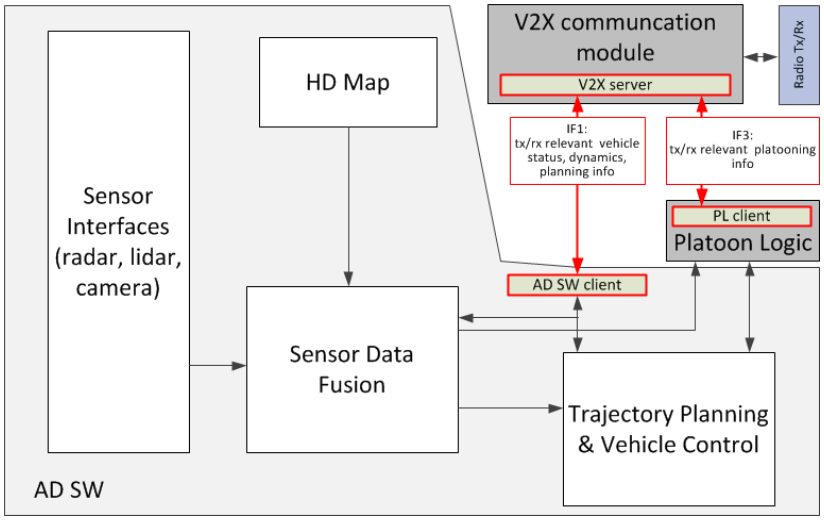
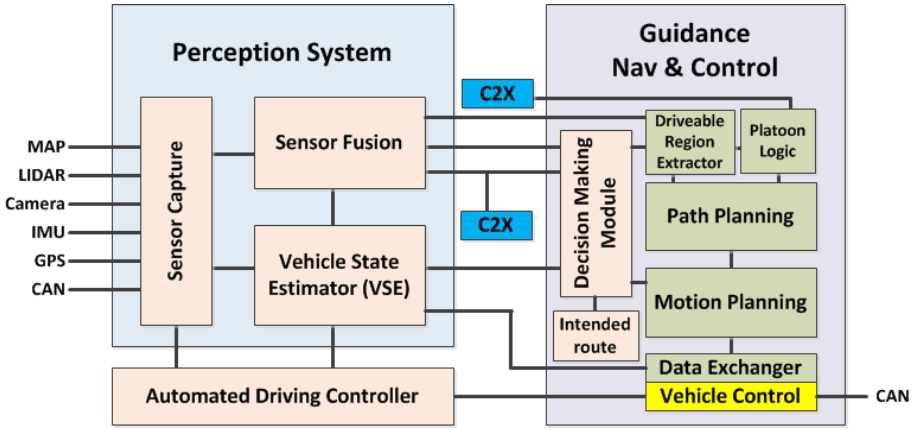
Vehicle automation architecture (DLR & Hyundai)





- **Partner-specific implementation of "core" AD SW modules**
  - DLR: Dominion-based, Hyundai: ROS-based
- **Common implementation of C2X functionalities**
  - Same message set and interfacing with AD modules
- **Common implementation of Platoon logic**
  - Provided DLR as a library integrated in decision making modules

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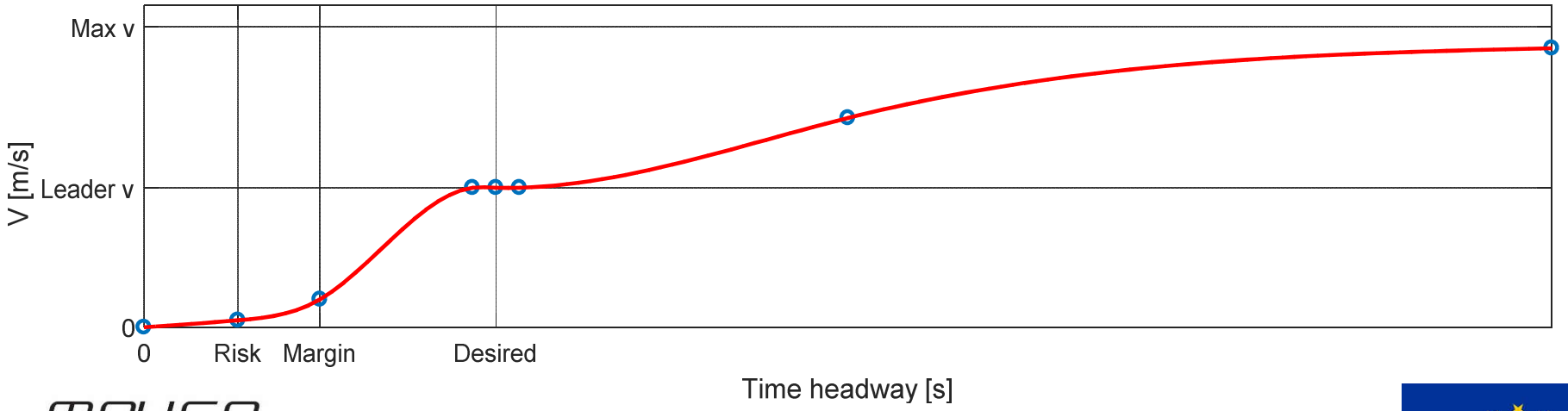
Platoon forming, driving, break up

- **Based on state machine rules:**
  - If two or more vehicles detect having same features (speed/acceleration ranges) & objectives (route at next intersection)
  - If no obstacle in between (e.g. Non-cooperative vehicle)

- **Respects a predefined time headway:**
  - When a cooperative and automated vehicle is detected, a time headway-velocity profile is generated and kept as below figure.
  - For forming desired time headway is 2s and for break up is 4.



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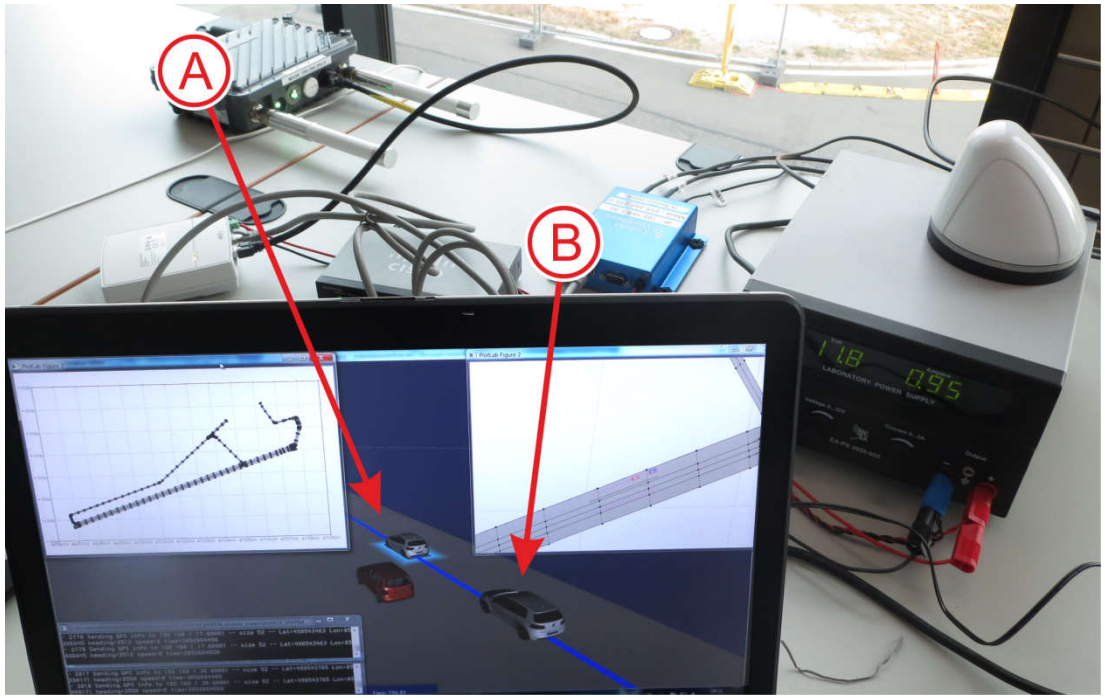
HiL testing of communication

- **Verification of cooperative functionality at partner-specific implementation**
  - Separate tests @ DLR and Hyundai with simulated cars & real communication HW



HiL test of Platoon Logic using two Cohda MK5 units:

(A) RSU for the platoon leader
(B) OBU for the follower.

(The functionality of RSU and OBU is equal in this test.)

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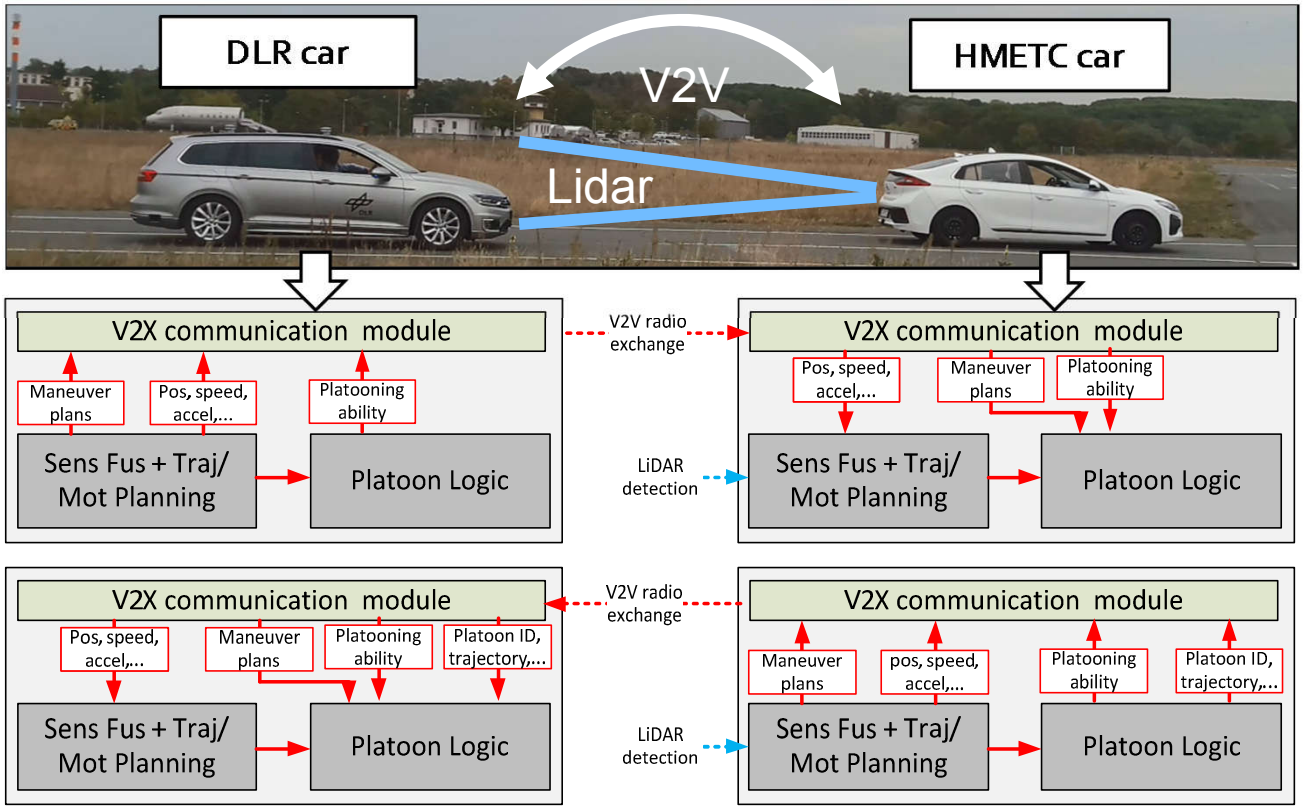
Test track testing of platoon forming/driving

- **Verification of cooperative functionality with combined implementationa**
  - Joint real tests with real DLR and Hyundai cars & real communication HW



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Test track testing of Platooning + GLOSA (DLR)

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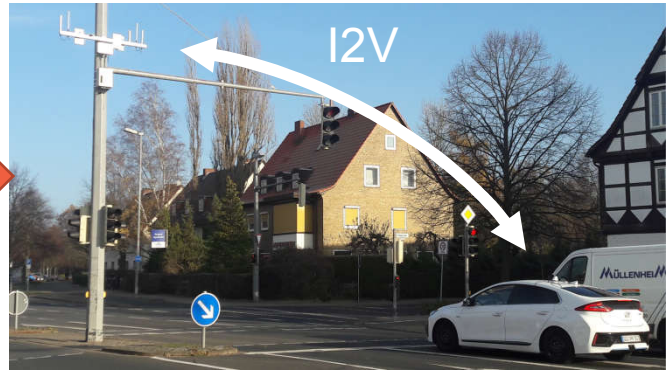
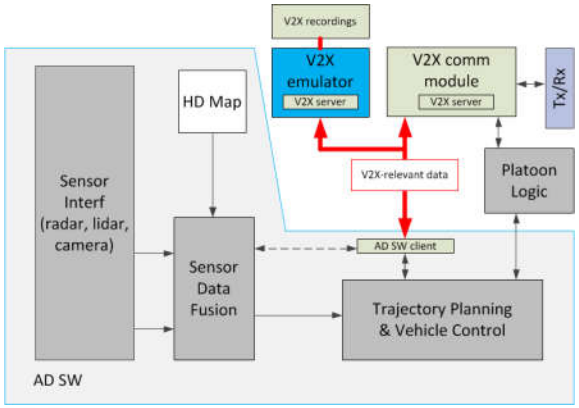
Augmented Reality Testing:
Using real-road GLOSA on test track

- **Recording of SPAT/MAP + GLOSA traces at Tostmann platz**



- **Replaying of SPAT/MAP + GLOSA traces on Griesheim test track**
  - Verifying AD speed adaptation to GLOSA speed



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Test track testing of real-road GLOSA (HMETC)

GLOSA ADVISORY
GLOSA STATUS : Not Available
PREVIOUS ZONE NUMBER : Not Available AND ADVISED SPEED : Not Available
CURRENT ZONE NUMBER : Not Available AND ADVISED SPEED : Not Available
NEXT ZONE NUMBER : Not Available AND ADVISED SPEED : Not Available
CURRENT SIGNAL STATUS : Not Available
GLOSA ADVISED SPEED : Not Available
CURRENT SPEED : 1.37095e-25
DISTANCE TO INTERSECTION : Not Available

REMAINING TIME : Not Available

LANE CHANGE ADVISORY
CURRENT LANE INDEX : 0
REQUESTED LANE INDEX : Not Available
DISTANCE TRAVELLED : 0.109736
ORIGINATING LEADER : ACTUAL GAP: Not Available AND DESIRED GAP : Not Available
LEFTLANE LEADER : ACTUAL GAP: Not Available AND DESIRED GAP : Not Available
LEFTLANE FOLLOWER : ACTUAL GAP: Not Available AND DESIRED GAP : Not Available
RIGHTLANE LEADER : ACTUAL GAP: Not Available AND DESIRED GAP : Not Available
RIGHTLANE FOLLOWER : ACTUAL GAP: Not Available AND DESIRED GAP : Not Available
DISTANCE TO INITIATE LANE CHANGE : Not Available
LANE CHANGE STATUS : Not Available

C2X OBJECT INFORMATION
OBJECT INFO FROM C2X : Not Available
C2X OBJECT DISTANCE : Not Available

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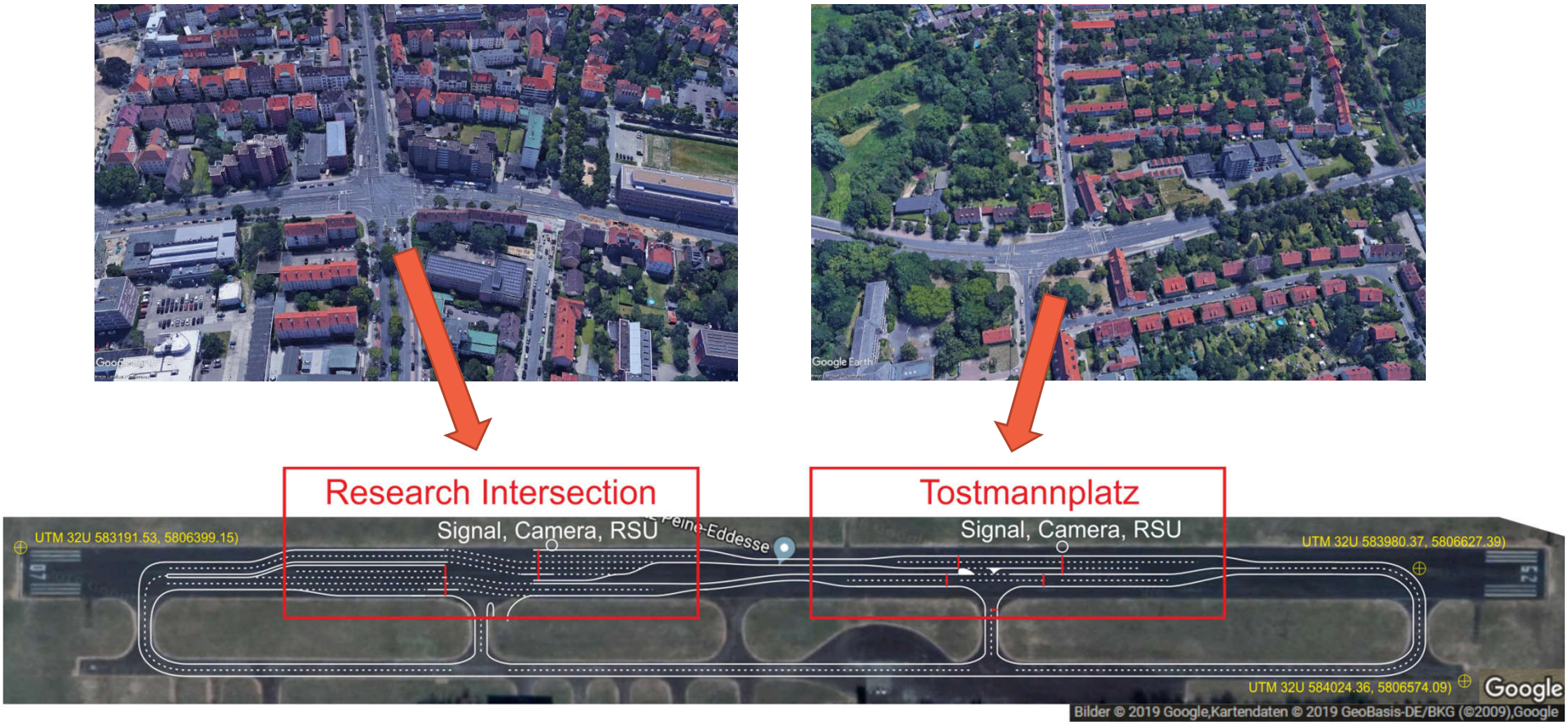
Augmented Reality Testing:
Using quasi-real road layouts on test track



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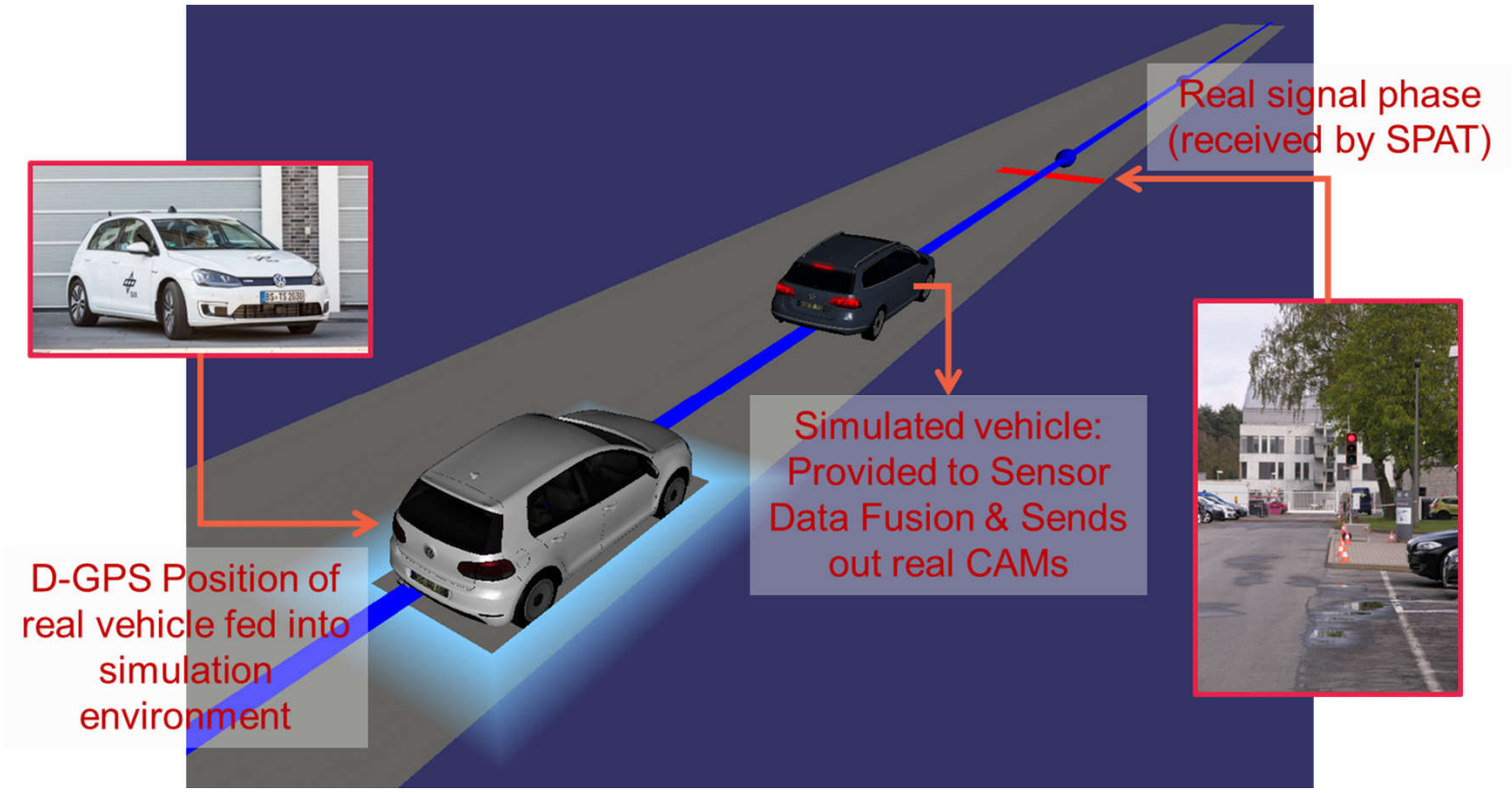
Augmented Reality Testing: Interacting with virtual vehicles



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Augmented Environment Architecture

Dominion Simulation Environment

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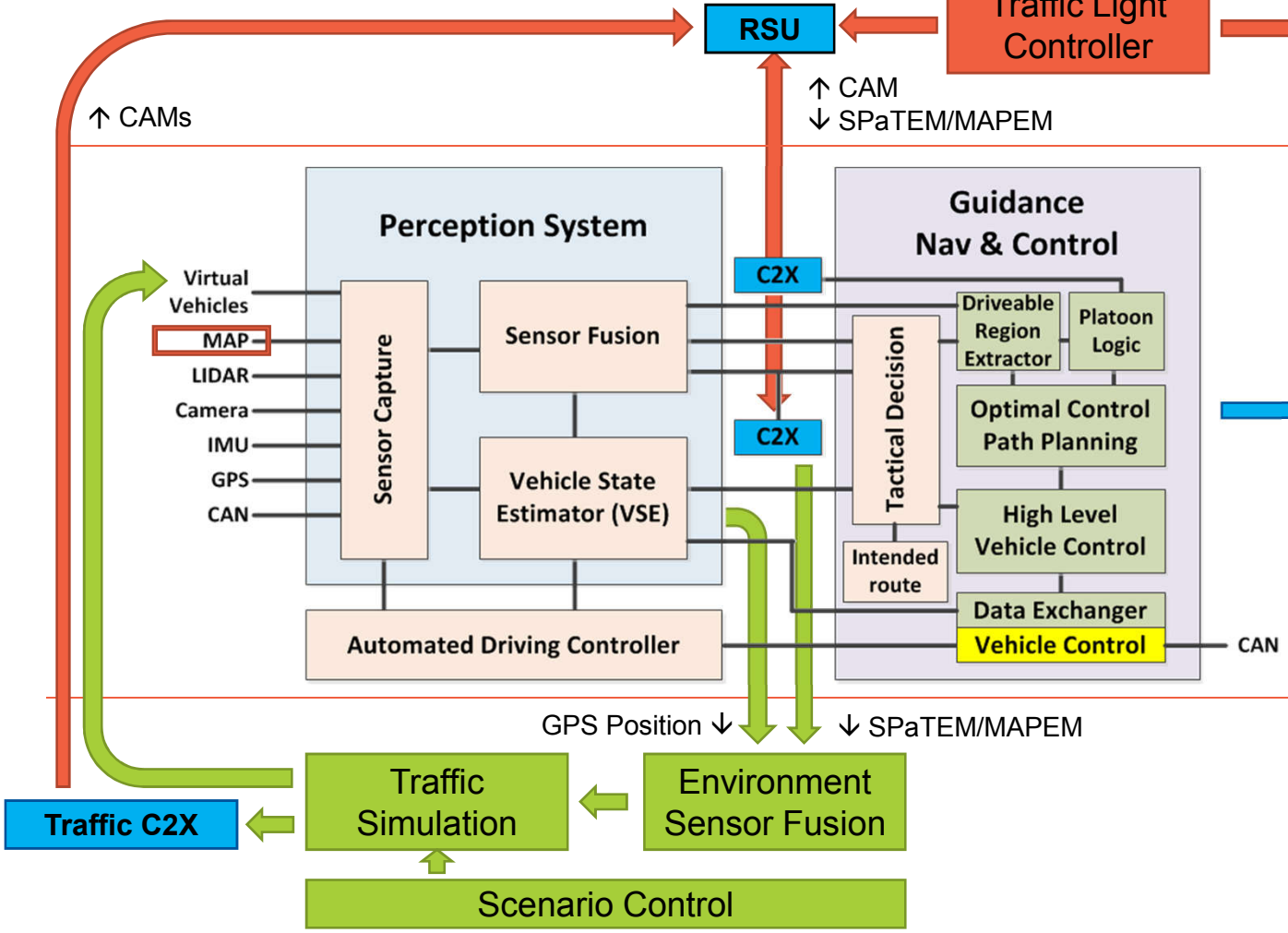
Extension 1: AGLOSA



Dominion Simulation Environment

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Extension 2: Platooning with 2 real cars

Traffic Light Controller

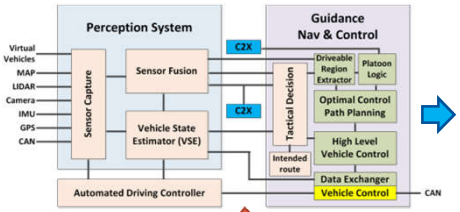
RSU

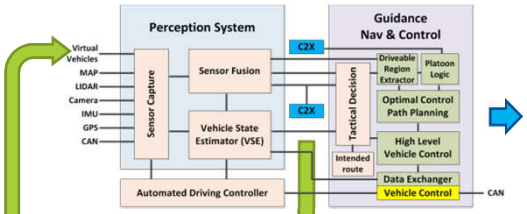
↑ CAM
↓ SPaTEM/MAPEM

↑ CAMs

↑ CAM
↓ SPaTEM/MAPEM

←CAMs →





↑ CAMs

GPS Position ↓

↓ SPaTEM/MAPEM

Traffic C2X

Traffic Simulation

Environment Sensor Fusion

Scenario Control

Dominion Simulation Environment

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Tostmannplatz public road testing

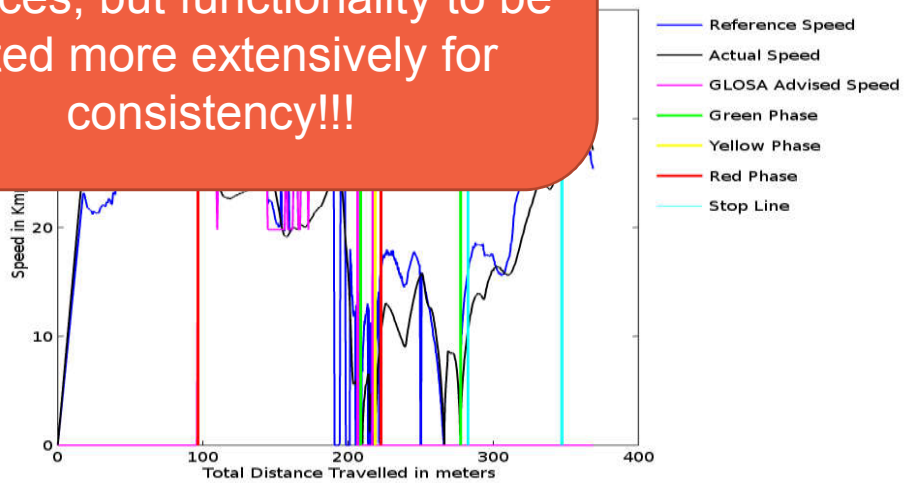
Hyundai and DLR cars

AVEN HMI on DLR car car

WORK IN PROGRESS!!!

Some platoon initialization instances, but functionality to be tested more extensively for consistency!!!

GLOSA adaptation on car



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Additional information can be found atat:

www.maven-its.eu

Do not hesitate to contact us!

Thank you!

Questions?

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