Audi
Vorsprung durch Technik

Car2Pedestrian: Protection of vulnerable road users using smartphones

Sebastian Engel, AUDI AG

Agenda

1. Introduction / Motivation
2. Introduction of cooperative systems
3. System implementation
4. Measurement series
5. Outlook

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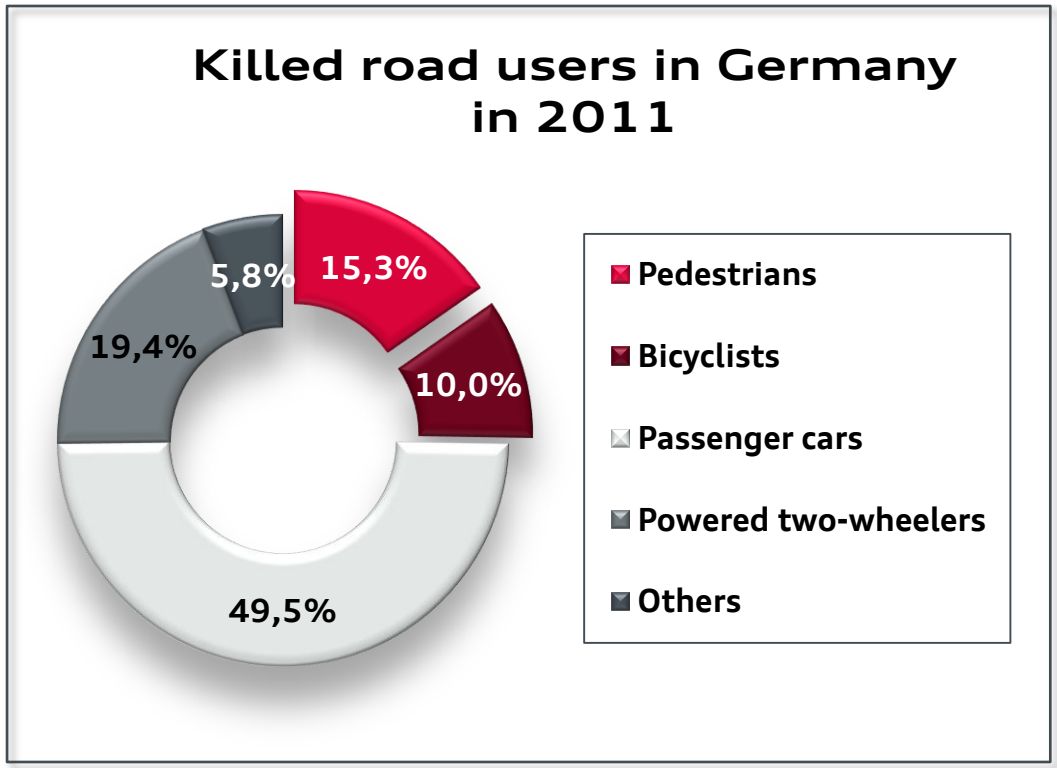
Introduction
Pedestrian protection as an important development aspect



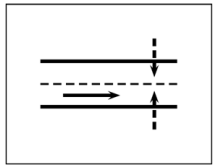
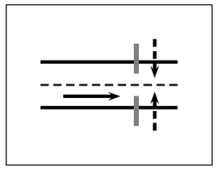
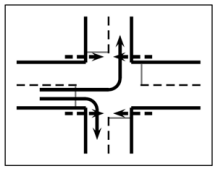
Source: Deutsches Statistisches Bundesamt: „Verkehrsunfälle 2011“

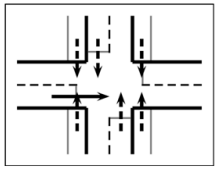
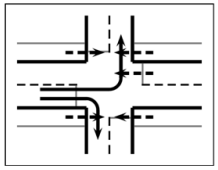
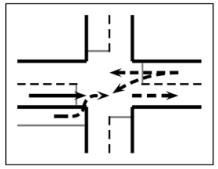
- A quarter of all killed road users in Germany in 2011 were vulnerable road users (VRUs)
- Increasing requirements on VRU protection which are driven by consumer ratings (e.g. EuroNCAP)

Further development of active safety systems for VRUs necessary

Motivation
Why another sensor for pedestrian protection?

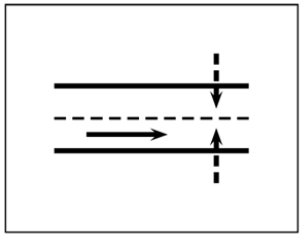
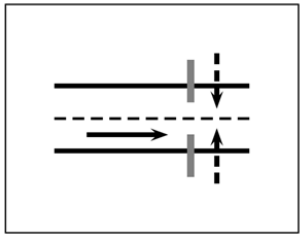
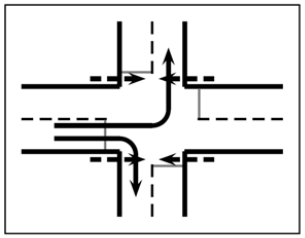
- Analysis of the most frequent pedestrian and bicyclist accident scenarios with passenger cars
  - Source: GIDAS (German In-Depth Accident Study)

Scenario	Description
	Scenario 1 Accident with a pedestrian that is crossing the street without visual obstruction 49.9 %
	Scenario 2 Accident with a pedestrian that is crossing the street with visual obstruction 29.7 %
	Scenario 3 Accident with a pedestrian that is crossing the street while a vehicle is turning into this street 7.6 %

Scenario	Description
	Scenario 1 Accident with a bicyclist at an intersection 65.1 %
	Scenario 2 Accident with a bicyclist that is crossing the street while a vehicle is turning into this street 29.7 %
	Scenario 3 Accident with a bicyclist in longitudinal traffic 7.6 %

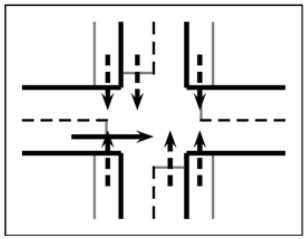
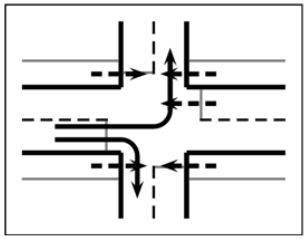
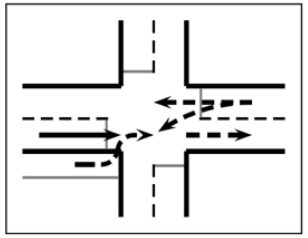
Motivation
Why another sensor for pedestrian protection?

- Analysis of the most frequent pedestrian and bicyclist accident scenarios with passenger cars
  - Pedestrian accidents: 1180 analyzed scenarios

Scenario	Description
	Scenario 1 Accident with a pedestrian that is crossing the street without visual obstruction 49.9 %
	Scenario 2 Accident with a pedestrian that is crossing the street with visual obstruction 29.7 %
	Scenario 3 Accident with a pedestrian that is crossing the street while a vehicle is turning into this street 7.6 %

Motivation
Why another sensor for pedestrian protection?

- Analysis of the most frequent pedestrian and bicyclist accident scenarios with passenger cars
  - Bicyclist accidents: 1155 analyzed scenarios

Scenario	Description
	Scenario 1 Accident with a bicyclist at an intersection 65.1 %
	Scenario 2 Accident with a bicyclist that is crossing the street while a vehicle is turning into this street 29.7 %
	Scenario 3 Accident with a bicyclist in longitudinal traffic 7.6 %

Motivation
Why another sensor for pedestrian protection?

- Necessity of a sensor system, that…
  - is able to detect pedestrians or bicyclists if they are hidden by other road users or buildings
  - delivers a wide opening angle to detect pedestrians or bicyclists at crossing streets

Car2Pedestrian-Communication

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Introduction of cooperative systems
Market penetration

- Car2Car-Communication Introduction Dilemma
  - High market penetration is needed for cooperative systems
  - Memorandum of Understanding: signed by European OEMs to introduce Car2Car technology as of 2015

Source: www.car-to-car.org

- Car2Pedestrian-Communication
  - Promising research projects
    - → Amulett
    - → Ko-TAG
  - Use of proprietary active sensor devices
    - → Power supply necessary
    - → VRU has to carry the device
    - → Special antennae for the vehicle necessary

Introduction of cooperative systems

Solution: Use smartphones as sensor devices and for communication

- Smartphones deliver a multitude of sensors …
  - Acceleration Sensor
  - Gyroscope
  - Magnetic compass
  - GPS-Receiver
- … and communication interfaces
  - WLAN communication
  - Mobile radio communication
  - Bluetooth

- Rising smartphone penetration in Germany
  - Q1/2011: **18 %**, Q1/2012: **29 %**

    [Source: Google: „Our Mobile Planet: Germany“]
  - **9** of **10** sold phones are smartphones

    [Source: www.thinkwithgoogle.com]

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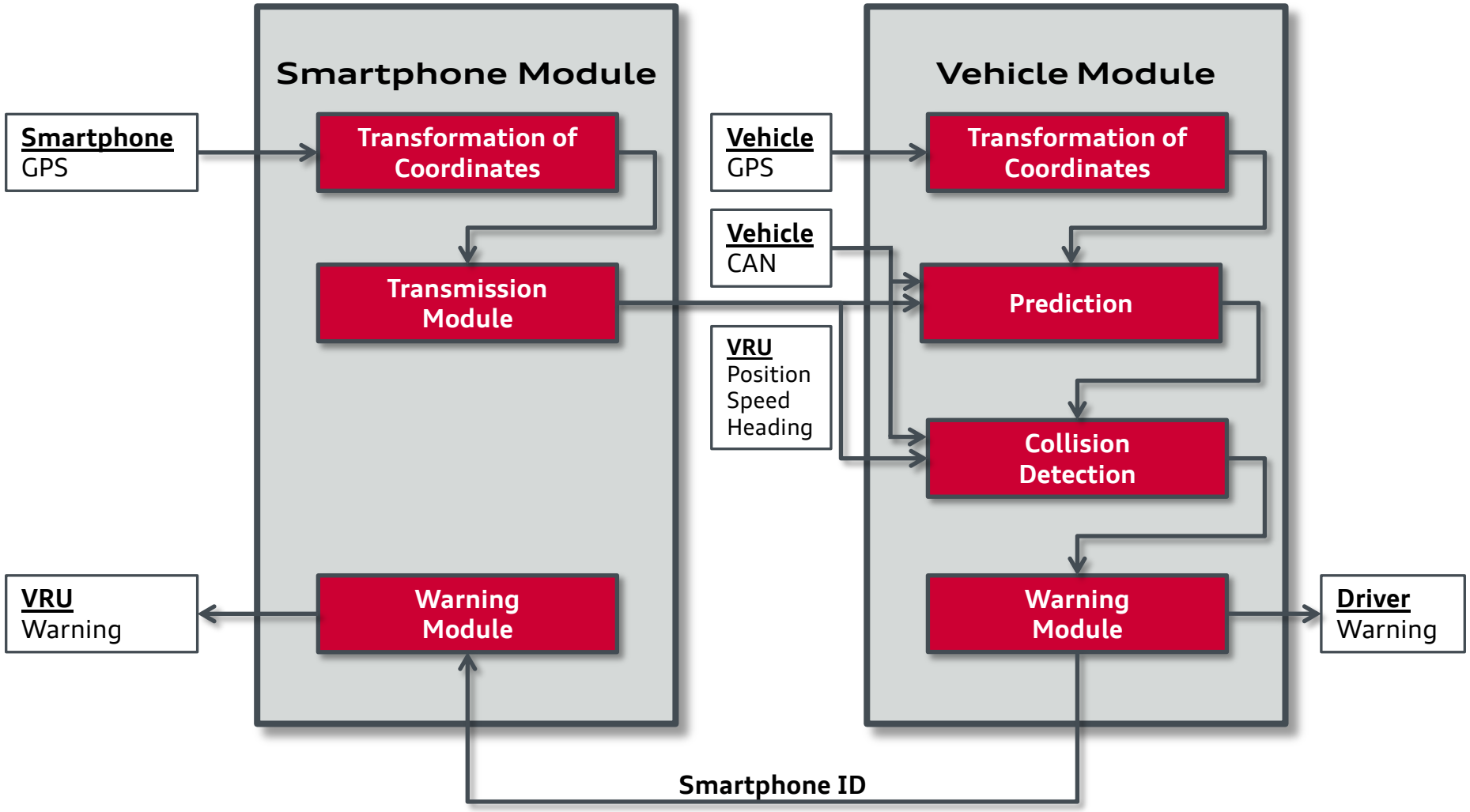
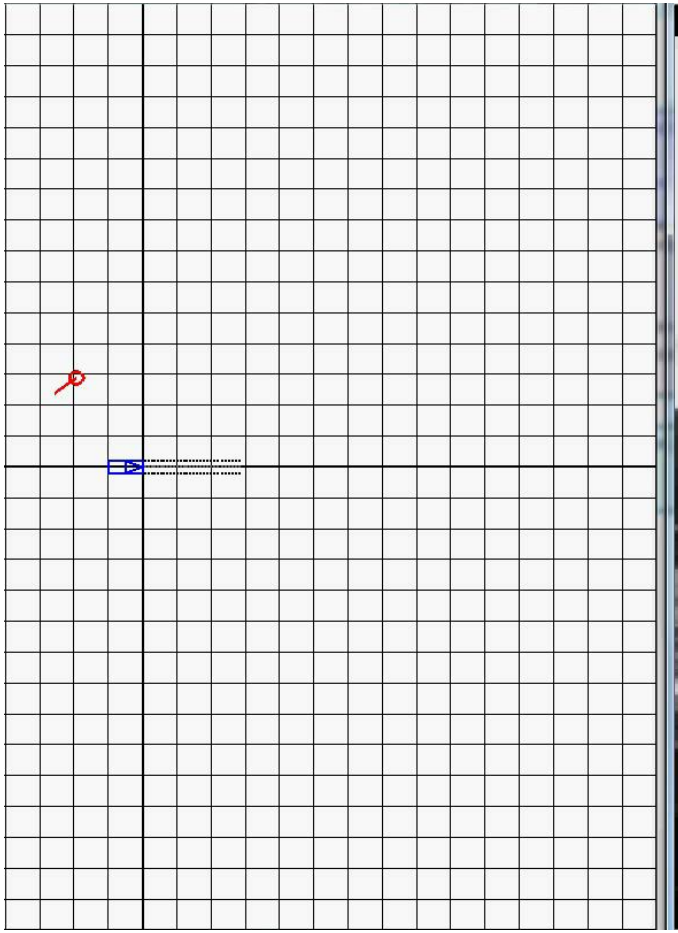
System concept
First development version



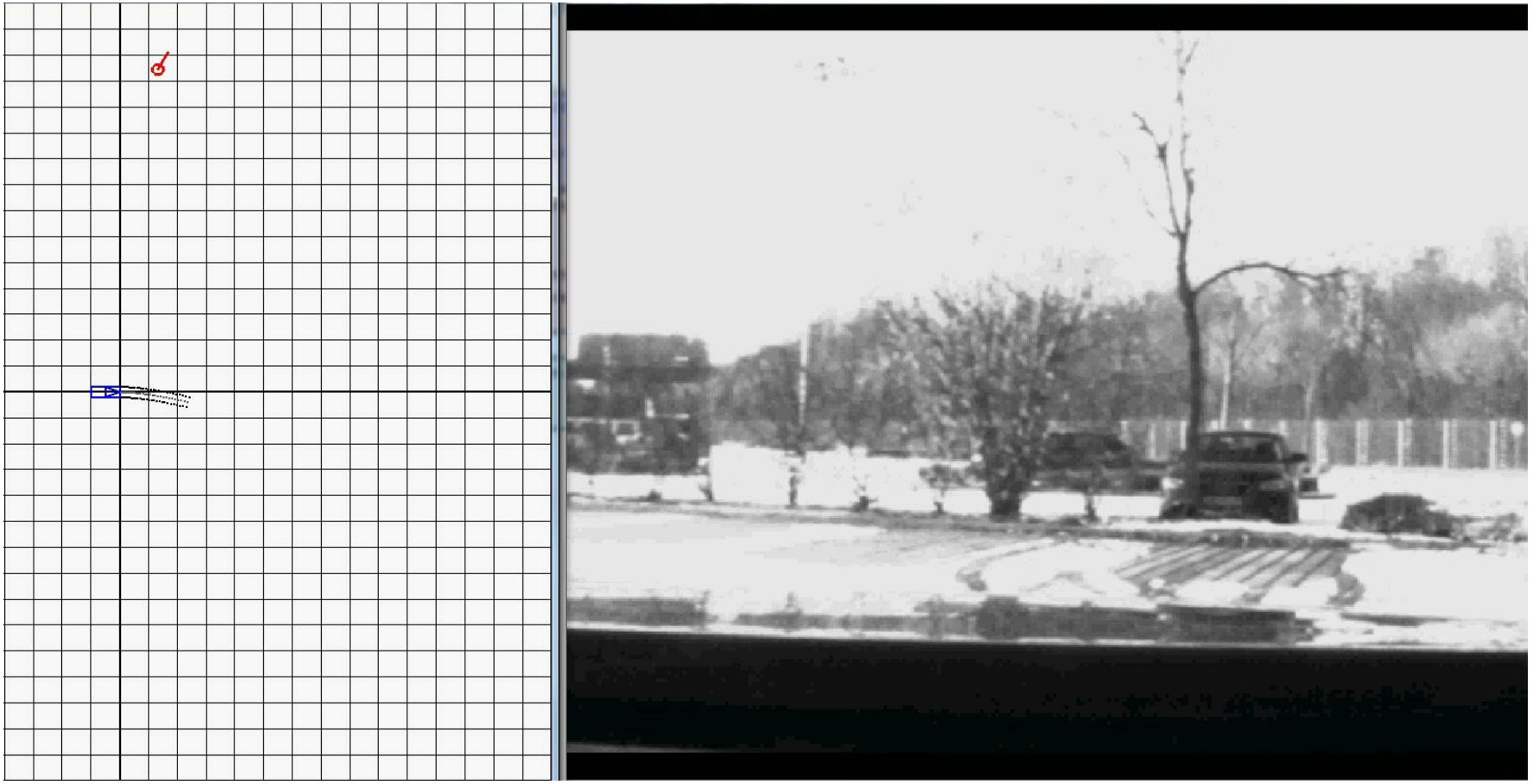
System implementation

Accident scenario with a hidden pedestrian is addressed



System implementation

Accident scenario under bad lightening condition is addressed



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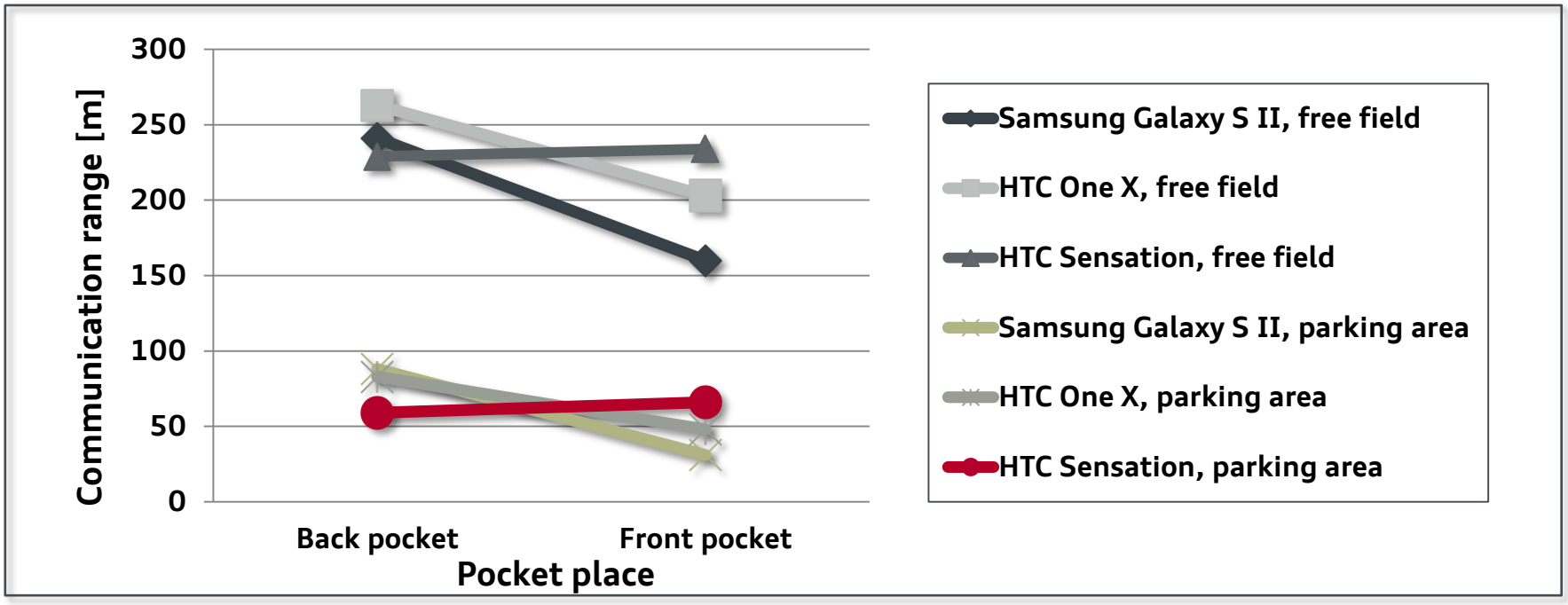
Measurement series
Feasibility of smartphones for pedestrian protection

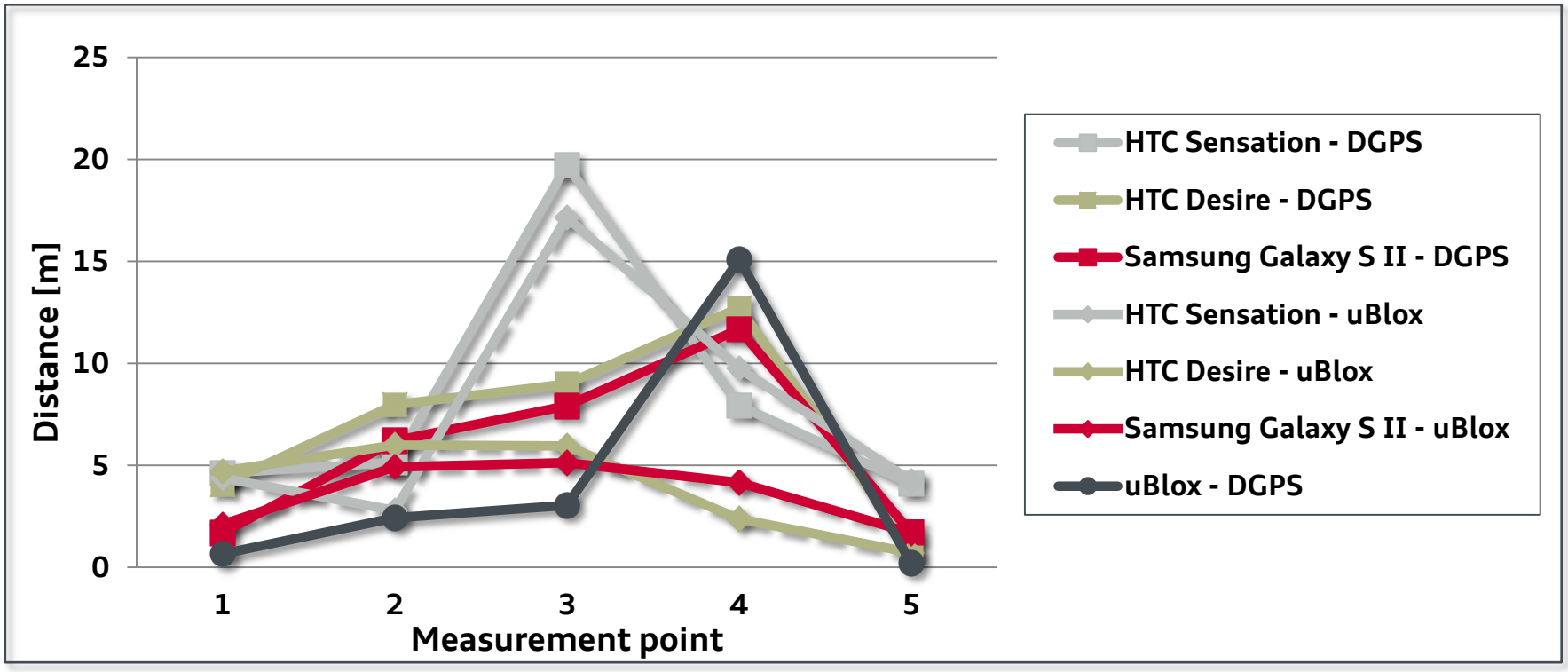
- WLAN communication range that could be achieved in different measurement series
  - Free field scenario **~ 200 m**
  - Parking area scenario **~ 60 m**
  - Damping caused by human body



→ Achievable WLAN communication range is sufficient

Measurement series
Feasibility of smartphones for pedestrian protection

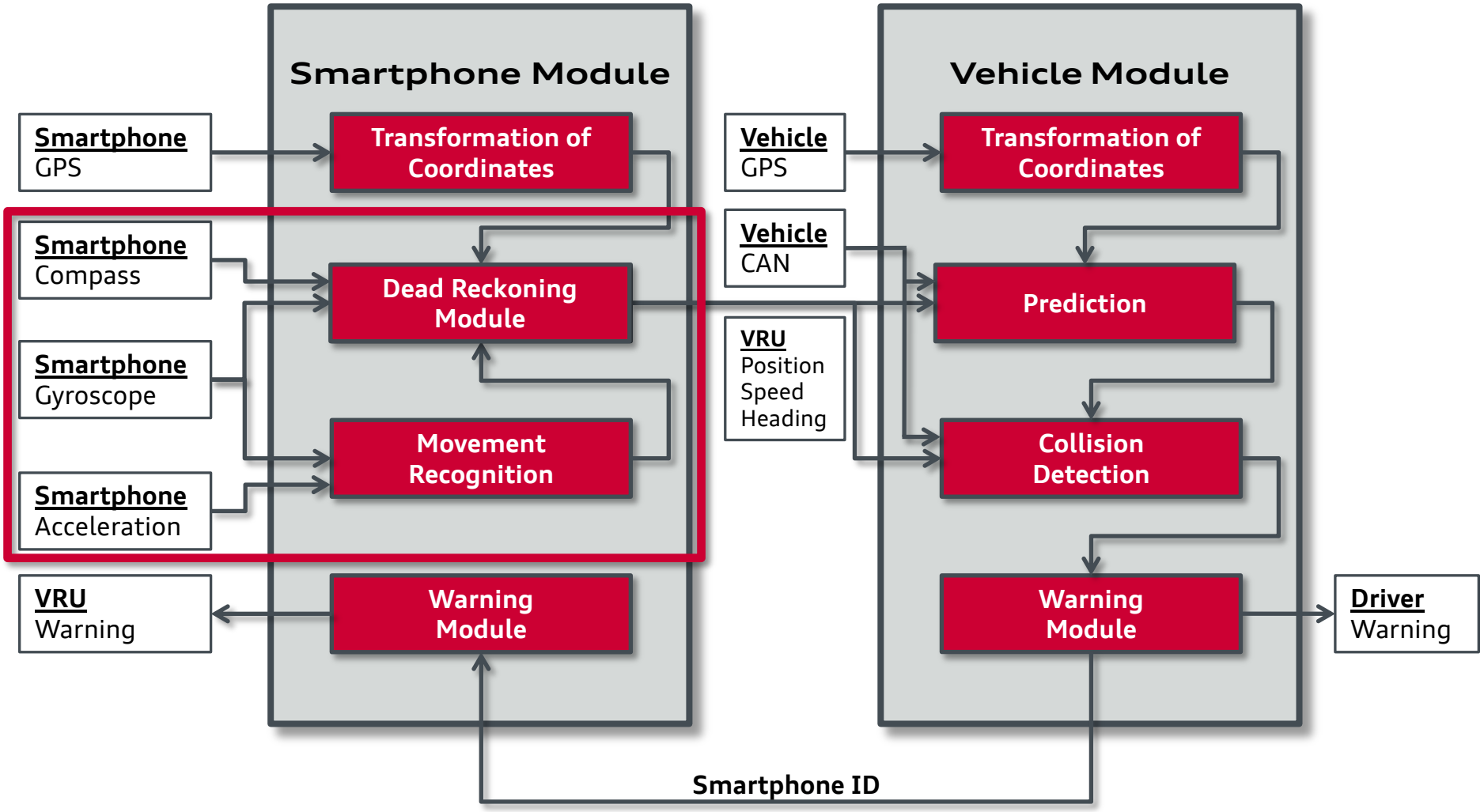
- GPS accuracy that could be achieved in static measurement series
  - Relative distance between **smartphone** and **DGPS reference point ~ 7m**
  - Relative distance between **smartphone** and **ublox GPS receiver ~ 5m**



→ **Achievable GPS accuracy is not sufficient**

Solution for GPS positioning accuracy

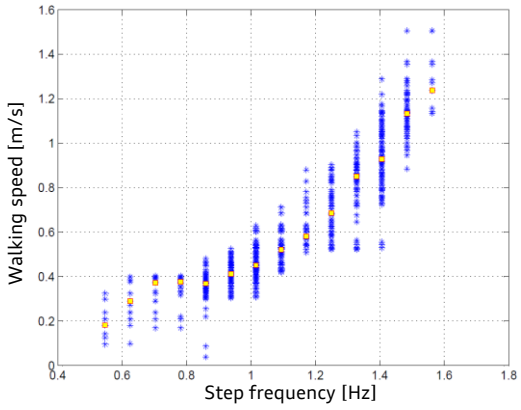
Implementation of dead reckoning positioning for VRUs

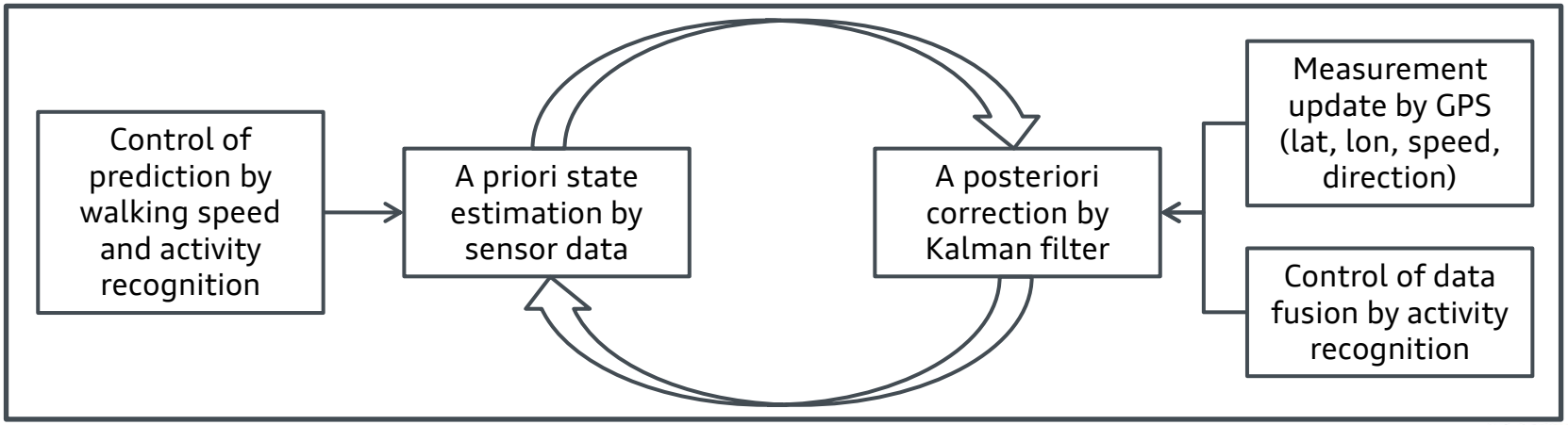


Solution for GPS positioning accuracy
Implementation of dead reckoning positioning for VRUs

- Use of Kalman filtering for dead reckoning of pedestrians

- Sensor input
  - GPS data: latitude, longitude, speed, direction
  - Magnetic compass and gyroscope data for an improved estimation of the walking direction
  - Estimation of movement type by activity recognition using a decision tree
  - Estimation of walking speed by step frequency





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Outlook
What has to be done to enable Car2Pedestrian-Communication

- No message sets exist for the communication between VRUs and other road users
  - Define and standardize messages for communication exchange
  - Analogue to CAM/DENM which were defined within the Car2Car Communication Consortium and are in the final standardization phase

CAR 2 CAR COMMUNICATION CONSORTIUM

Source: www.car-to-car.org

ETSI World Class Standards

Source: www.etsi.org

- Ad hoc communication not possible with today's smartphone WLAN chipsets (IEEE 802.11 b/g/n)
  - Integrate Car2X hardware (IEEE WLAN 802.11 p) and software modules (ETSI ITS G5) in smartphones

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Thank you!