HIGHTS

High precision positioning for Cooperative-ITS

HIGHTS: towards sub-meter positioning accuracy in vehicular networks

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ETSI ITS Workshop

March 6-8, 2018

The HIGHTS Consortium

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High precision positioning for Cooperative-ITS

INNOTEC 21

BOSCH

Invented for life

JACOBS UNIVERSITY

CHALMERS

UNIVERSITY OF TECHNOLOGY

HIGHTS Associated Member Group

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15 AMG partners from 7 countries

11 Companies, 2 Universities, 1 Public Institute

ALPINE
Driving Mobile Media Innovation

Perfecting the Art of Electronics
ALPS

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car connect

commsignia

GGG

BMW

automotive engineering iav

Georepublic

BITGEAR
Gear up!

FernUniversität

MechLab Engineering

Acknowledgements

- Whole HIGHTS team for their support and feedback in preparing this work
  - In particular Nil Garcia (Chalmers), Benoît Denis (CEA-LETI), Ronald Raulefs (DLR), Paul Spaaderman (PSConsultancy) with supporting slides

Some Applications in ITS Requiring High Precision Positioning

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- **Road Hazard Warning**
- **Safety of vulnerable road users**
- **Autonomous driving**
- **Platooning**
- Cooperative adaptive cruise control
- Lane merge assistance
- Automated parking
- Emergency vehicle approaching
- Signal violation / Intersection Safety
- Traffic signal priority request by designated vehicles
- Green Light Optimal Speed Advisory (GLOSA)
- Probe vehicle data
- Information on fueling & charging stations for alternative fuel vehicles
- On street parking management & information
- Park & Ride information
- Traffic information & Smart routing

Today's Positioning Accuracy

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Where am I?

- **Absolute** positioning
- GNSS geo-location providing a positioning precision of the order of 2-7 meters in favorable conditions.
  - Favorable – access to at least 4 satellites

Where am I compared to others?

- **Relative** positioning
- UWB, Radar, LIDARs ranging providing sub-meter accuracy in the order of 10 cm (at short distance).

Technical Objectives of HIGHTS

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Technical Objectives of HIGHTS

- HIGHTS aims at providing up to a 0.25m precision in all vehicular traffic conditions.

Highly accurate dynamic map leveraging from GNSS

- Technological enablers to provide highly accurate dynamic maps (GNSS, sensors, radars, LIDARs, ITS-G5, etc)
- Enhanced precision through crowd sensing (between cars)
- Integrate into the LDM, new POTI message

Innovative solution for safety application and warning

- HIGHTS will address two prominent use cases: Highly Autonomous Driving (HAD) and Safety of Vulnerable Traffic Users

Support for European Wide Service Platforms (EWSP).

- Technological enabler for a service layer (called facilities in ETSI TC ITS)
- Participate to the EU-wide standardization (ETSI, CEN, ISO, IEEE)

Enabling High Precision Ubiquitous Positioning

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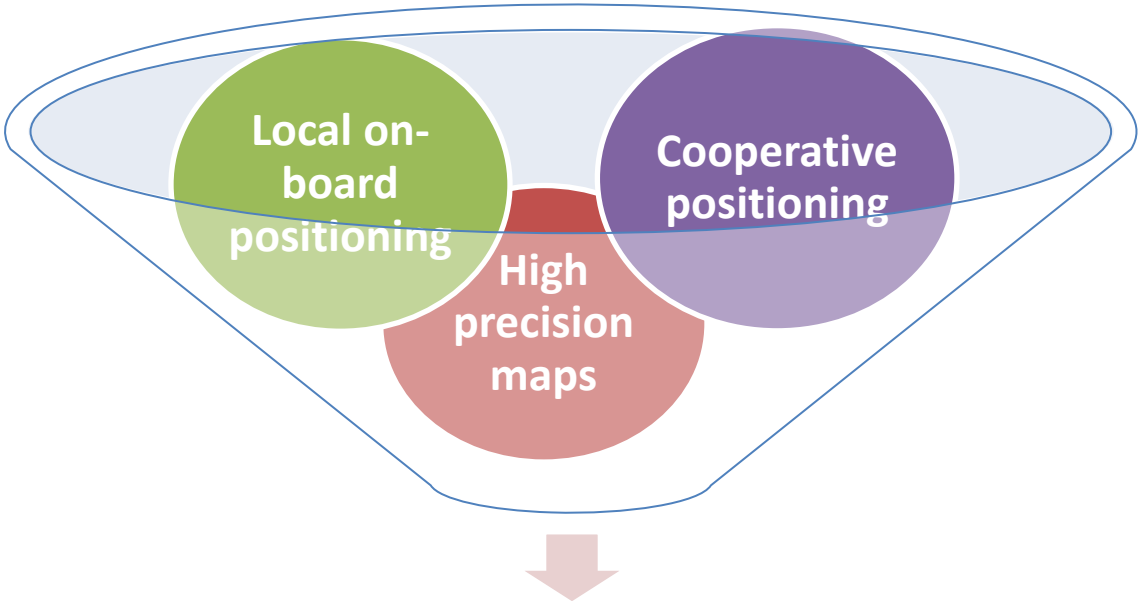
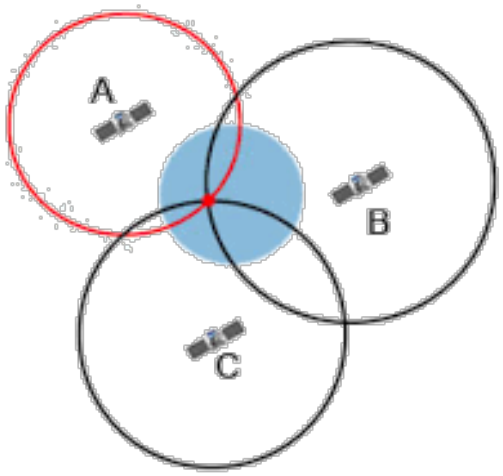
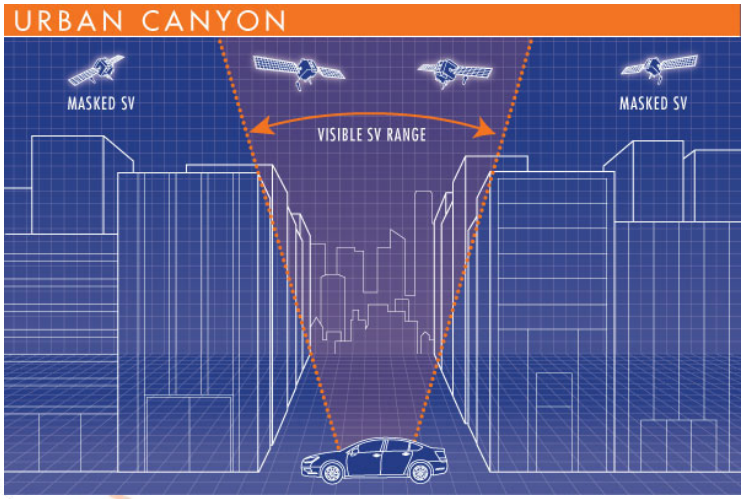
- What's the "magic" behind the 25 cm?



Local on-Board Positioning





- On-board positioning
  - Typically GNSS (e.g., GPS)
  - Trilateration using pseudoranges from satellites
  - From 7 to 2 m
- Challenges
  - Signal easily blocked on urban canyons
  - Dynamic environment causes changing multipath propagation (reflections)
  - Multipath propagation induces significant positioning errors and ambiguities

Cooperative Positioning

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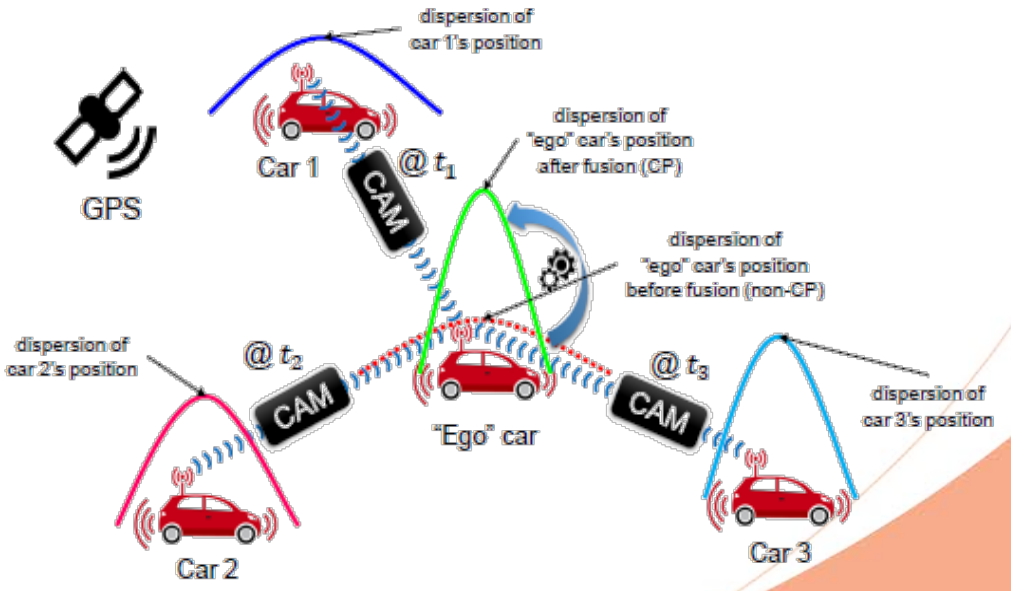
- Current research based on ITS-G5 or “vehicular Wi-Fi”
- Trilateration using ranges betwen vehicles
- More vehicles better precision
- Challenges:
  - Complex fusion
  - Careful neighbor selection
  - Highly dynamic V2V channel (e.g., Urban)
  - Multipath propagation
  - Correlated shadowing



Local Dynamic Maps (LDM)

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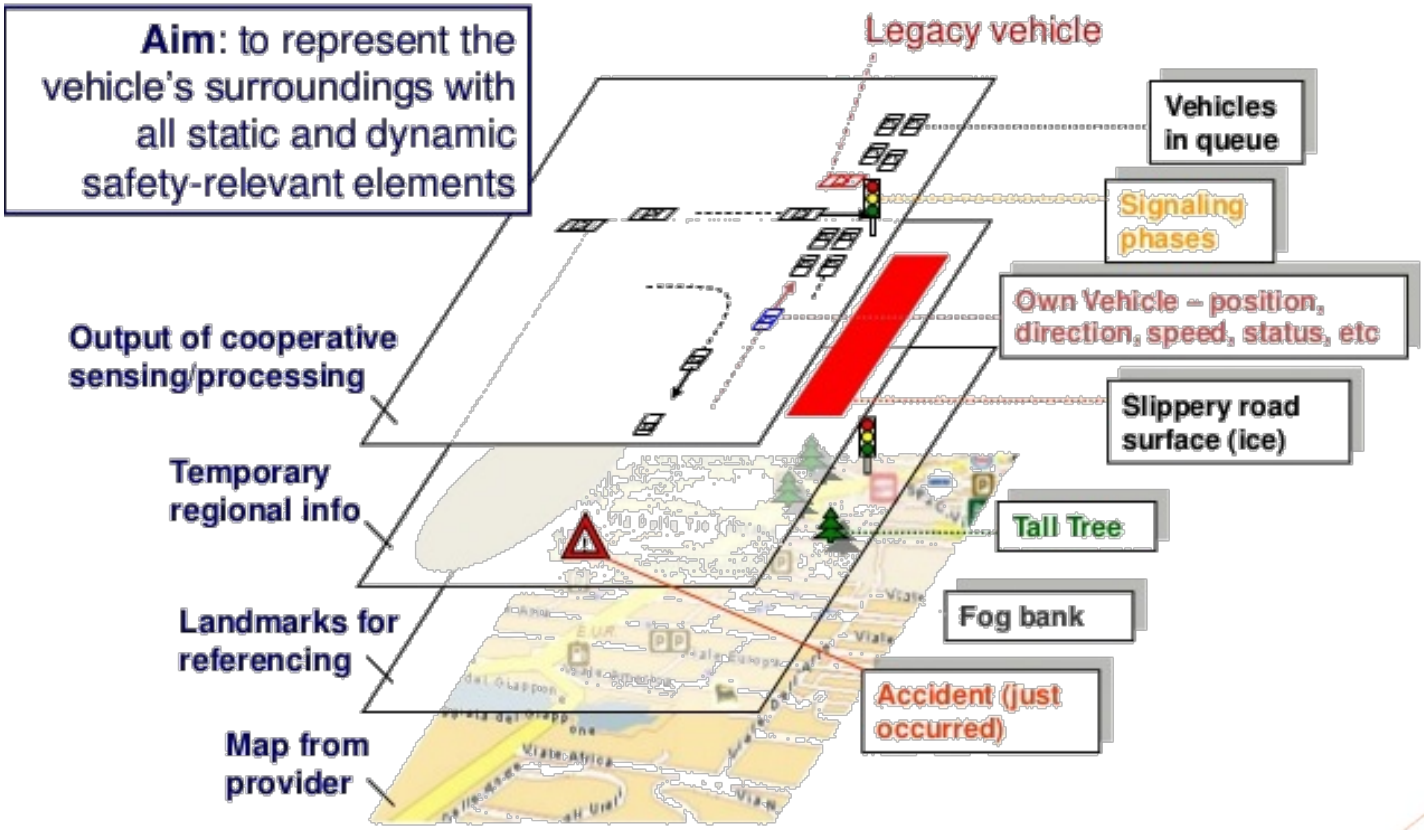
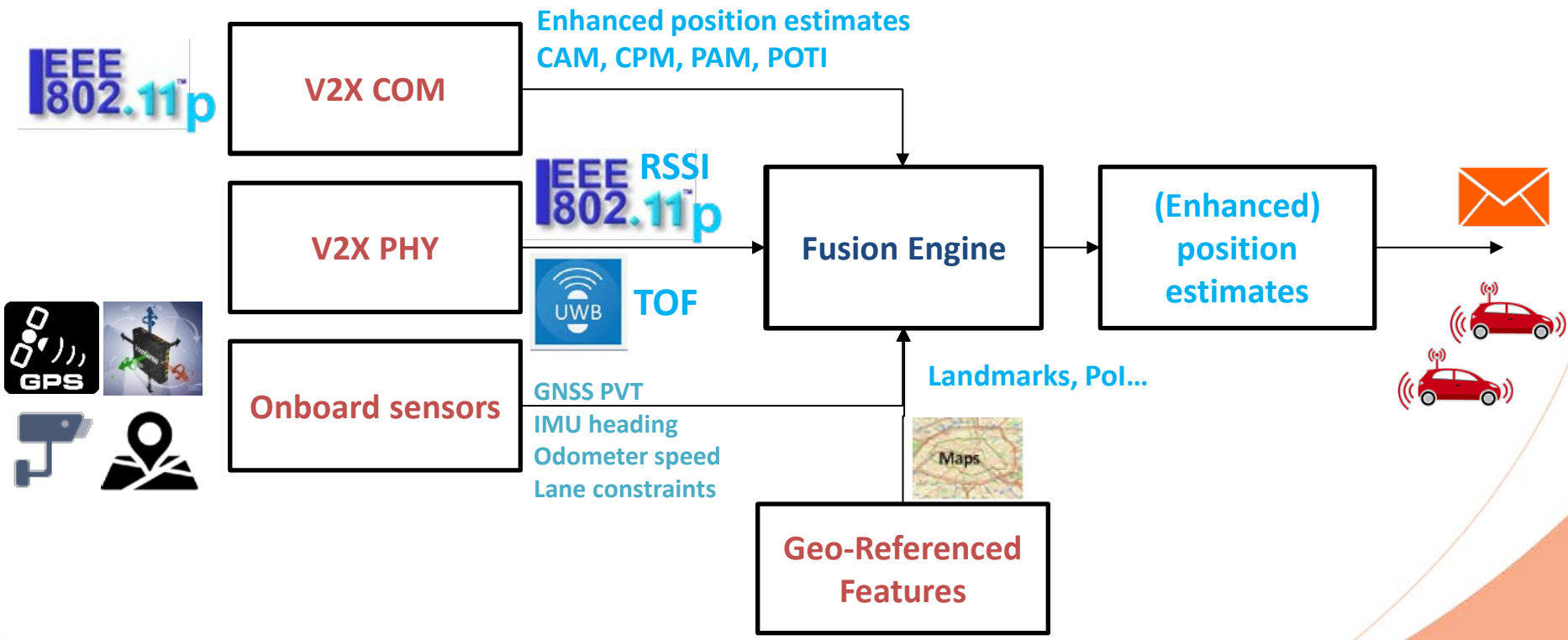
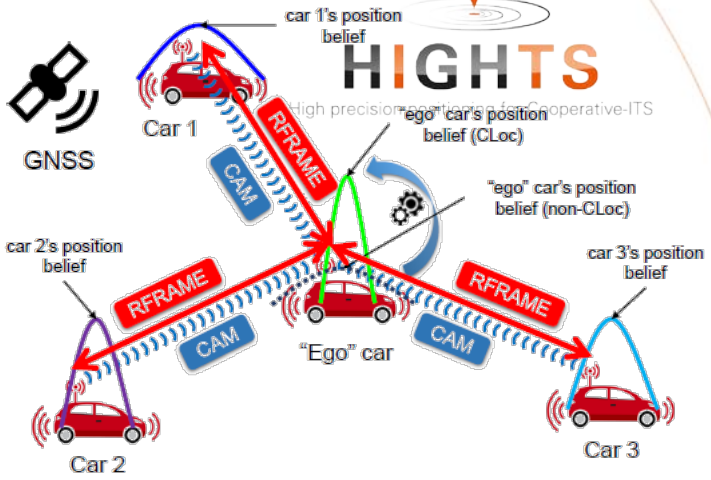


HIGHTS Positining - Input Systems



Selected High Positioning Algorithms

- V2X-enhanced GNSS (ITS-G5 + IR-UWB + GNSS +…)
  - Cooperative particle-based fusion integrating:
    - Virtual anchors' positions (data in ITS-G5 CAMs)
    - V2V RT-ToF (IR-UWB) or V2V RSS (out of received CAMs)
    - On-board GNSS (various classes) and sensors (inertial unit, camera-based lane detector…)

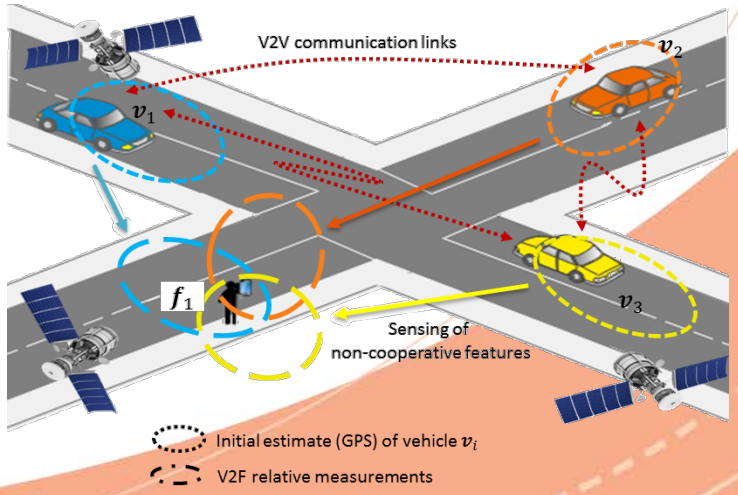


  - Mitigation of harmful effects inherent to cooperative particle-based hybrid data fusion (overconfidence in high-dimensional cooperative fusion filters and error propagation)

→ ***Drawing max. gains from accurate relative V2V ranging (e.g., IR-UWB within 0.2m) and make it global***

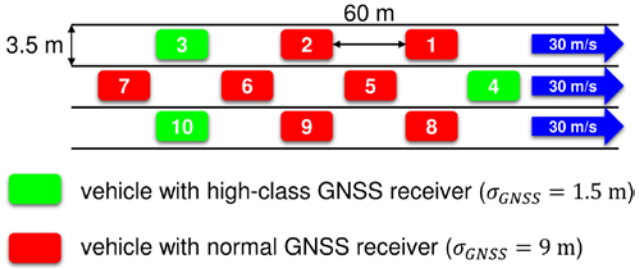
- Implicit Cooperative Positioning (ICP)
  - Joint estimation of sensed features' and sensing vehicles' positions without V2V measurements
  - Initial positions via GPS
  - Distributed Gaussian message passing + Consensus (for features' beliefs and outgoing messages)

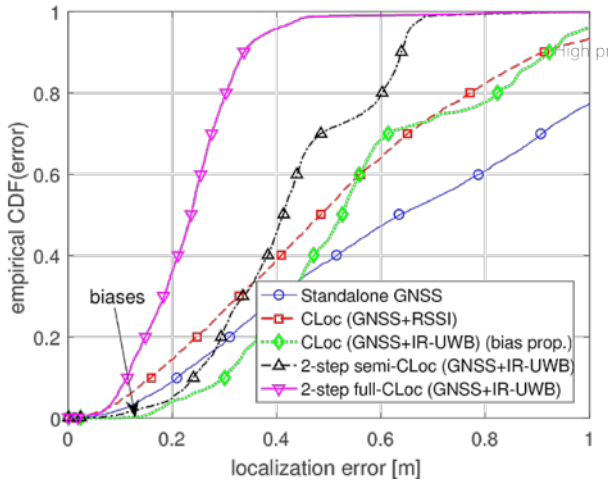
→ ***"Ego" loc RMSE improvement in urban canyons (depending on nb of features)***



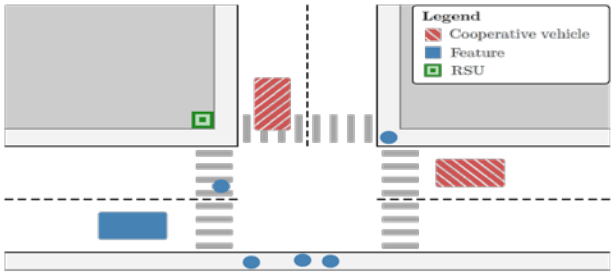
Selected Results

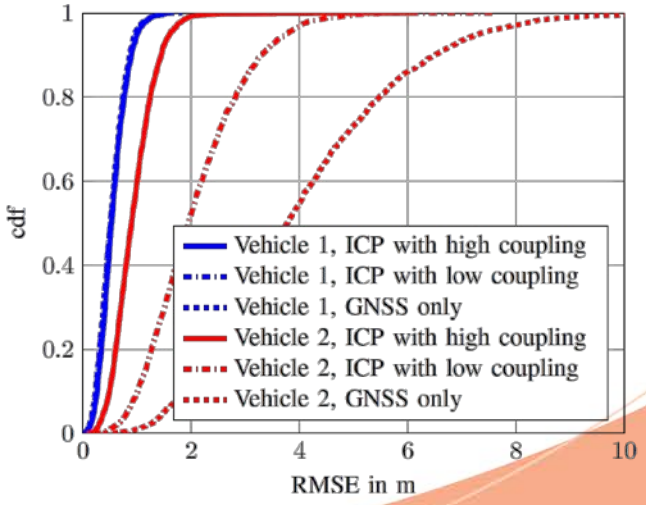
- V2X-enhanced GNSS (ITS-G5 + IR-UWB + GNSS +…)





- Implicit Cooperative Positioning (ICP)





European-wide Positioning Service Platform

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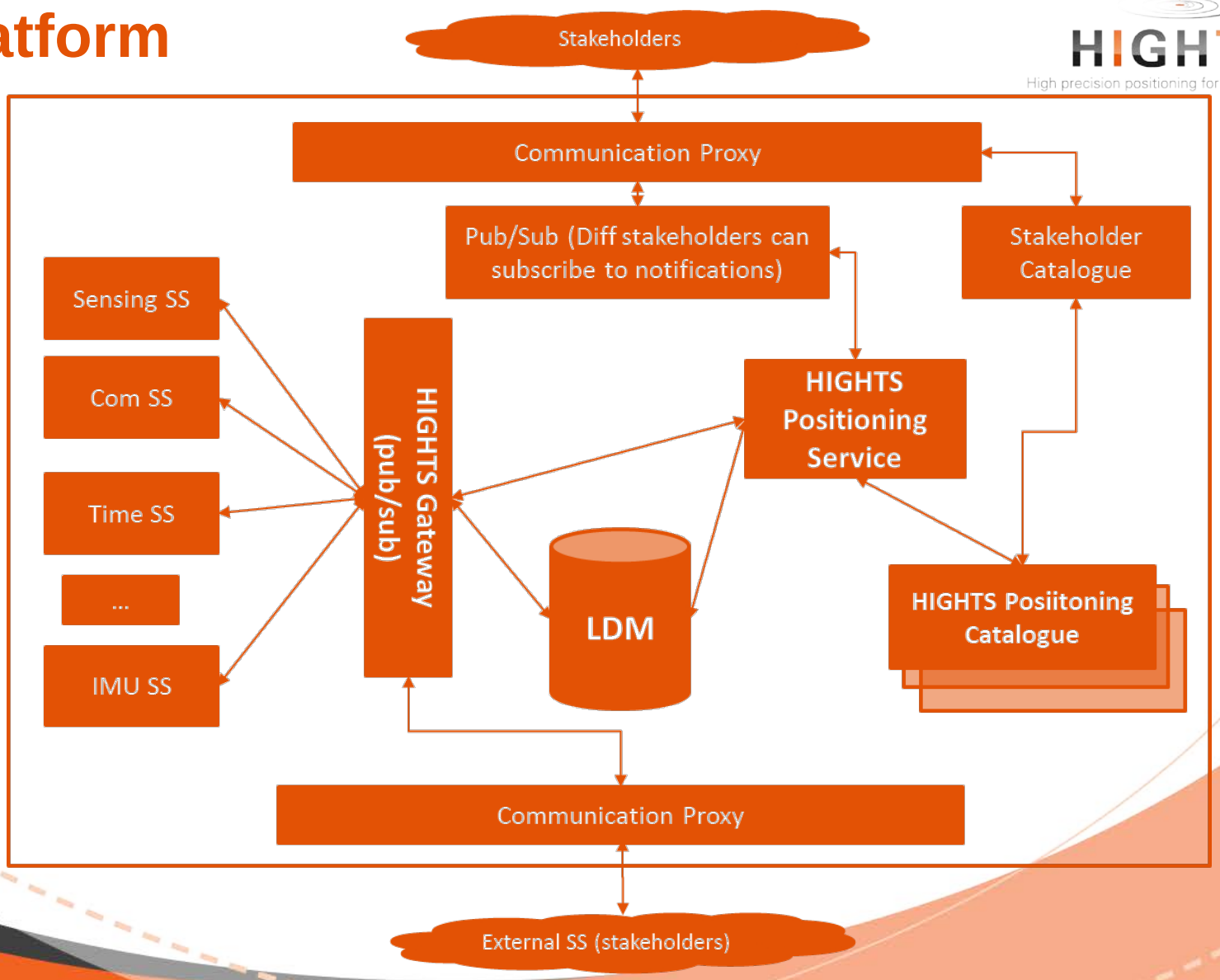

Selecting optimal Positioning Algorithm

European-wide Positioning Service Platform

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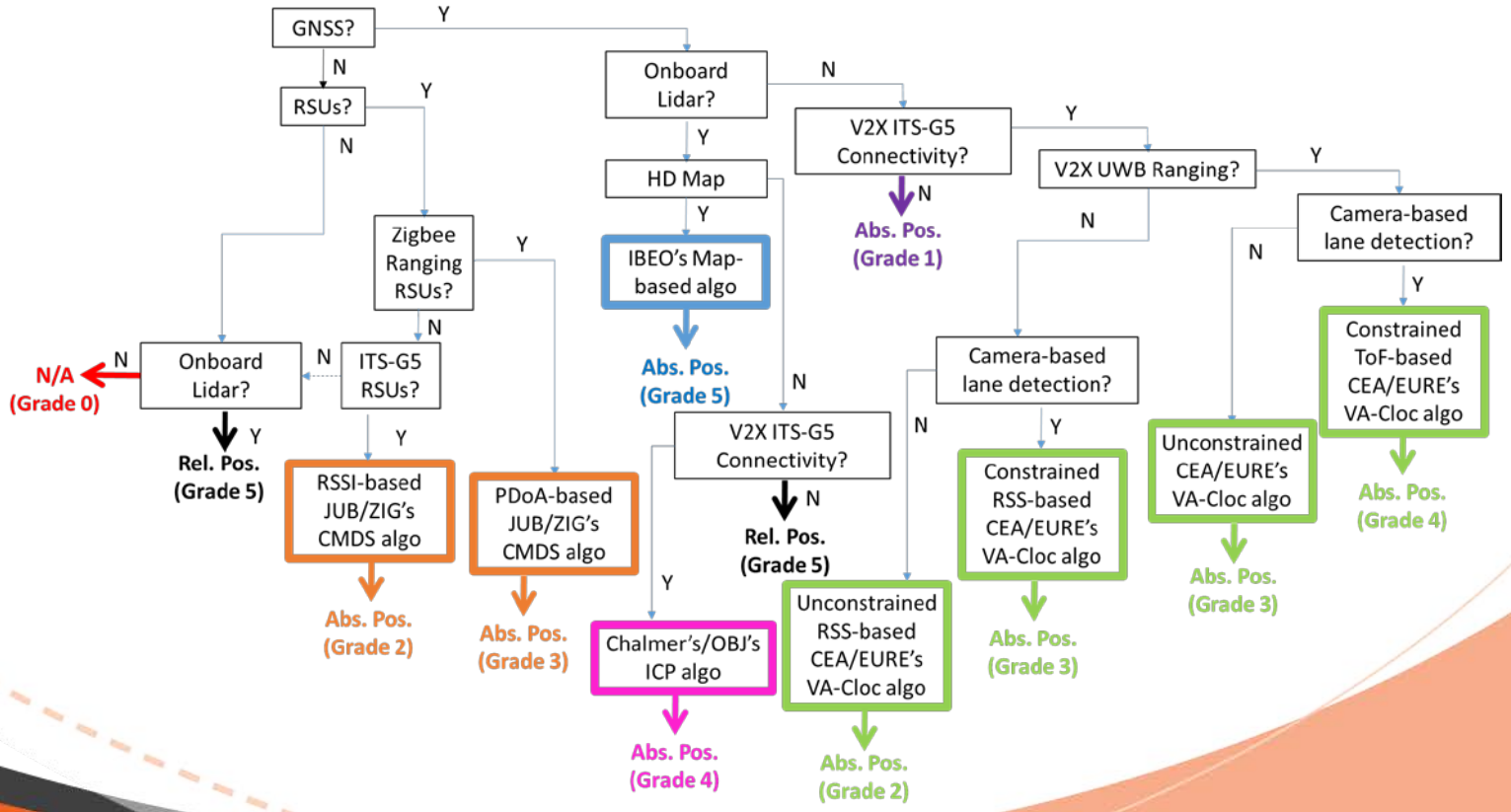
- Input – Available technologies & technologies operating level
- Output – Cooperative Algorithm required and Positioning Grade



Helmond Integration Meeting

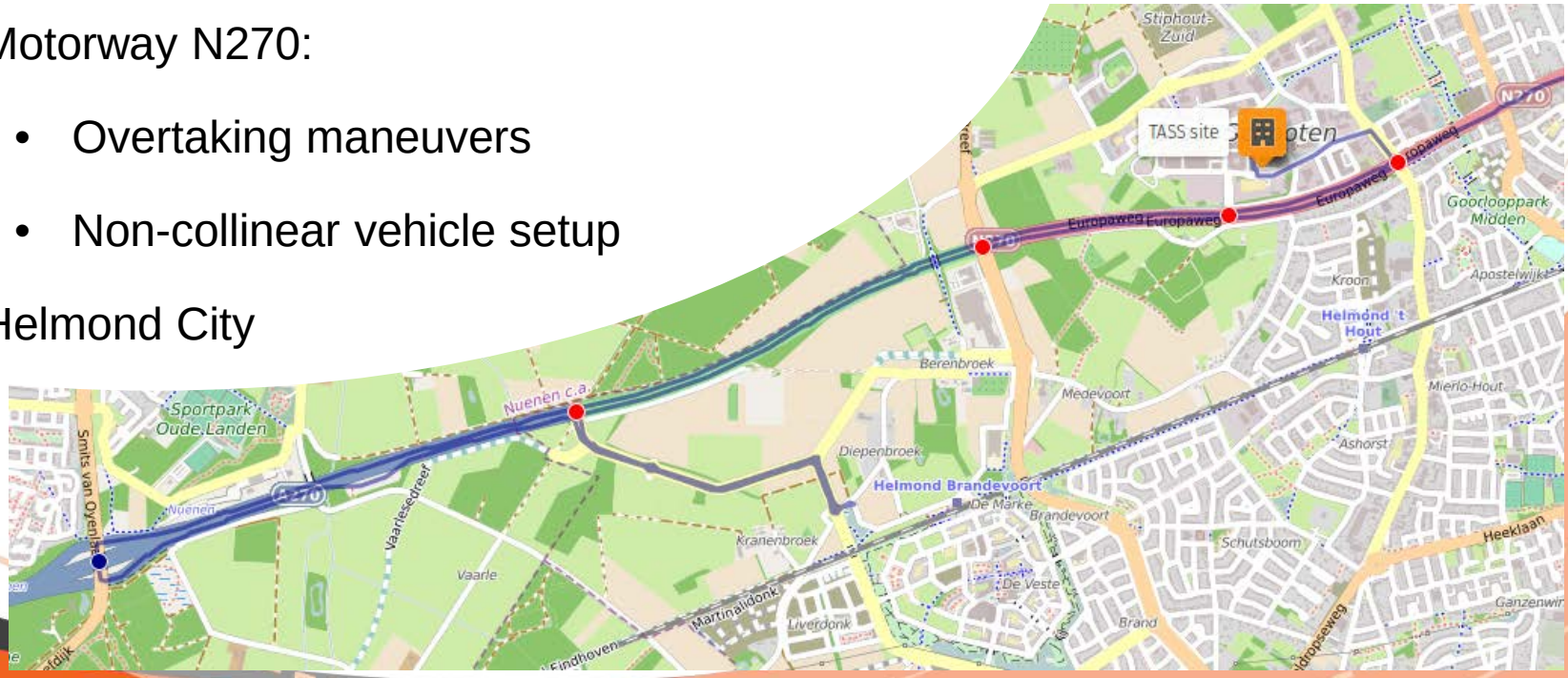
Vehicle Configuration

	EGO Objective	Observer TASS	Observer IBEO	Target TASS
Radio	• ITS-G5 (Cohda) • ZigPos radio unit • **BeSpoon OBU**	• ITS-G5 (Cohda) • **BeSpoon OBU**	• ITS-G5 (Cohda) • **BeSpoon OBU**	• **ITS-G5 (Cohda)**
Ego-Sensors	• Ibeo Lidar system • OxTS RTK-GPS • XSENS GPS/IMU • Bosch IMU • Camera system • Velodyne 360° Lidar	• Ibeo Lidar system • OxTS RTK-GPS • XSENS GPS/IMU	• Ibeo Lidar system • GeneSys RTK-GPS • XSENS GPS/IMU	• Cohda GPS
	• Data logging PC • **NTP Server (Cohda)**	• Data logging PC • **NTP Server (Cohda)**	• Data logging PC • **NTP Server (Cohda)**	

Helmond Test meeting 12/2017

Test Scenarios

- Brandevoort Roundabouts:
  - Roundabout with full platoon
  - Roundabout with incoming vehicles from all directions
  - Oncoming traffic (De Voort, between roundabouts)
- Motorway N270:
  - Overtaking maneuvers
  - Non-collinear vehicle setup
- Helmond City



HIGHTS Proof-of-Concept

Results

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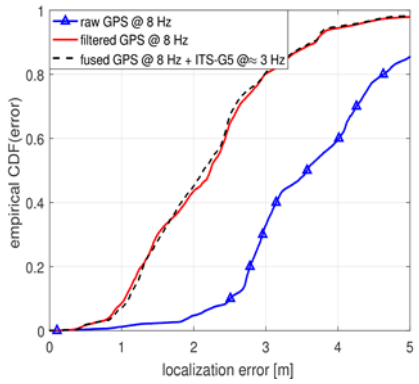
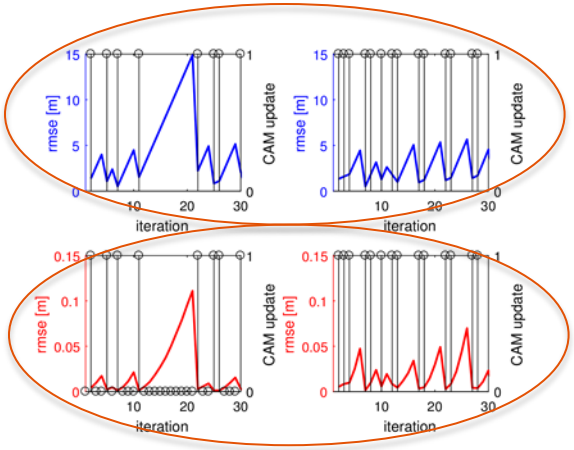
Critical ECDF values	10%	50%	90%
Raw GPS (local, harsh GPS) 1st trip	6.8m	6.9m	7.1m
ICP	3.5m	3.8m	4.2m
Raw GPS (local, harsh GPS) 2nd trip	2.5m	3.6m	>5m
VA-CLOC	0.6m	2.1m	4.0m



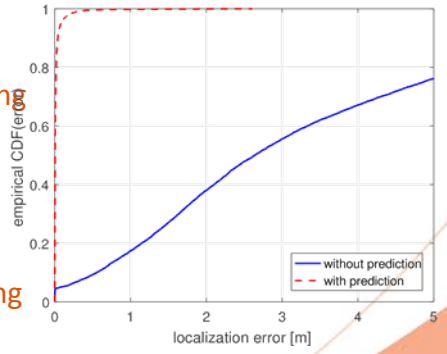
Ego localization error



Localization RMSE of the LDM

Without Dead-reckoning

With Dead-reckoning



Localization CDF of the LDM

Wrap Up – where we are and where we still need to go

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- Achievements –
  - Develop a set of complementary High precision protocols reaching sub-meter accuracy
  - Performed a proof-of-concept and prototyping in TASS test site
  - Specified the architecture and a prototype of the HIGHTS EWPSP
  - Contributed to standard with new messages (PAM, POTI) and LDM
- Challenges ahead –
  - Need efficient protocols for sensor exchange (CPM) and Fusion data
  - ITS-G5 beneficial but its Tx profile need to be tweaked...
    - Tx profile not adapted to DCC
  - Still required work on Maps and degree of uncertainties
- Looking into the telescope –
  - EWPSP – Positioning as a Service

Dissemination...

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- TRA 2018 – Come see our joint workshop (with TIMON, ROADART)

- IEEE WPNC 2018
  - Submission open soon !!

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Thank you. Any questions?

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http://hights.eu/