



SEMS'23

Phone Localization System for Vehicle Access

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Angelika Wronkowicz
Grzegorz Wyszyński

Kraków, 18-20.10.2023



Agenda

1. About Aptiv
2. Problem description
3. Model-Based Design
4. Localization Algorithm
5. Testing & Verification

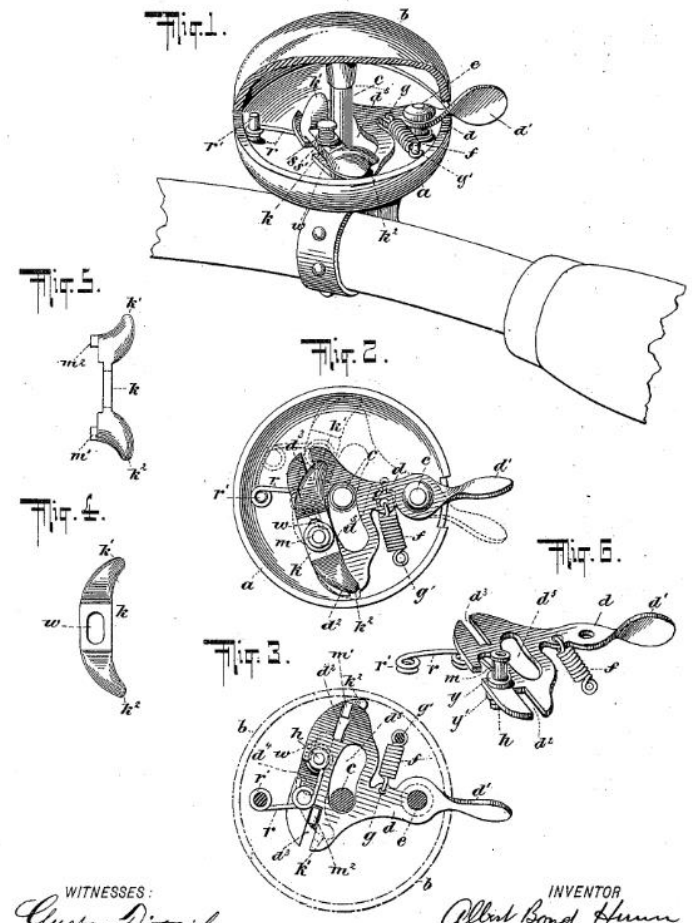
No. 658,501.

A. B. HUNN.
BELL.

Patented Sept. 25, 1900.

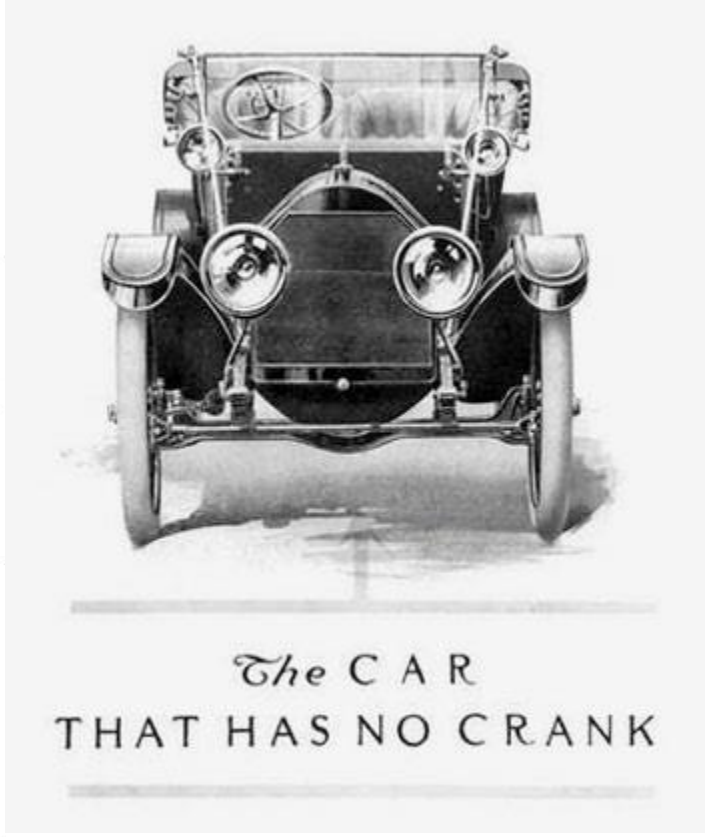
(Application filed Jan. 11, 1900.)

(No Model.)



WITNESSES:
Gustav Dietrich
John Schlenker

INVENTOR
Albert Boyd Hunn
 BY
Harold Jennings
 ATTORNEYS



“ Before I got my new Oldsmobile with Safety Power Steering, I was tired out after driving home through traffic. Now I feel like a new man when I get home—really relaxed in mind and body! ”

“ Maybe you think I don't need Safety Power Steering on my new Chevrolet—but I'd never give it up! It makes parking so much easier—and my feeling of security is worth 10 times the low price! ”

“ This is my second Buick with Safety Power Steering—and I'd never buy another car without it. Not only does it make driving fun—it added \$125 to the trade-in allowance on my previous car! ”

“ Safety Power Steering came as standard equipment on my new Cadillac this year—but I'd have gladly paid extra to get it. It's by far the greatest improvement in cars since automatic transmission! ”

“ After I took a "Show-Me Spin" in this new Pontiac with Safety Power Steering, I could hardly wait for delivery. My old car steered like a truck compared to this! ”

Ask any man or Woman who's got it!

Yes, anyone who's got it can give you plenty of good reasons why he (or she) is so sold on Safety Power Steering. A million motorists now enjoy it. And with thousands more new cars being equipped with it daily, remember you need it to protect your trade-in value. Before long, a car without Power Steering may well be almost obsolete.

Safety Power Steering is now standard equipment on all 1954 Cadillacs and Buick Roadmasters—and featured at a new low price on all other Buicks, Oldsmobiles, Pontiacs and Chevrolets. Ask your friends and neighbors who already have it. Then take a demonstration "Show-Me Spin." We'll rest our case on what they say—and what you feel at the wheel. Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan.

NOW AVAILABLE AT A NEW LOW PRICE!

Safety POWER STEERING BY Saginaw

YOU WANT IT FOR EASE — YOU NEED IT FOR SAFETY!

About Aptiv

ADDRESSING MOBILITY'S TOUGHEST CHALLENGES

 **48**
COUNTRIES

 **200,000+**
PEOPLE

 **11**
TECHNICAL
CENTERS

 **131**
MANUFACTURING
FACILITIES



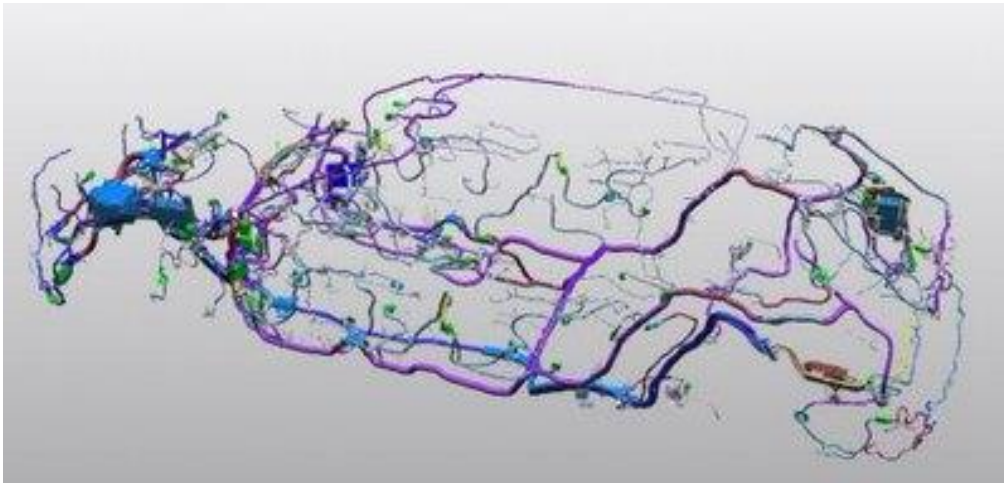


Aptiv in Poland



- Technical Centers (1)
- Manufacturing Sites (2)

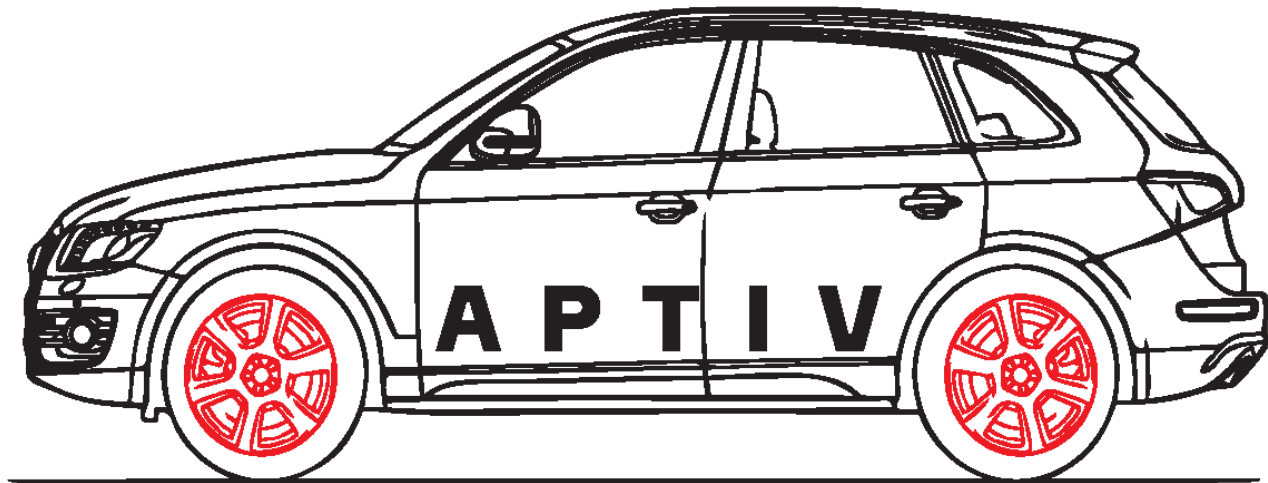
Aptiv Technology Portfolio



- Controls and Security Systems
- Active Safety Technologies
- Autonomous Driving
- Gesture Recognition Systems
- Driver Monitoring
- Advanced Infotainment Systems
- Power and Signal Distribution Systems

And much more!

Phone as a Key – „PaaK”



Key Features - unlocking new opportunities

PASSIVE ENTRY PASSIVE START WITH SMART DEVICE
Eg. Smartphone / watch

REMOTE START, WELCOME MODE / APPROACH DETECTION

CAR SHARING, CAR RENTAL

ON DEMAND REMOTE SERVICES
in-car shopping delivery, service

PASSENGER OCCUPANT DETECTION

AUTOMATIC PARKING

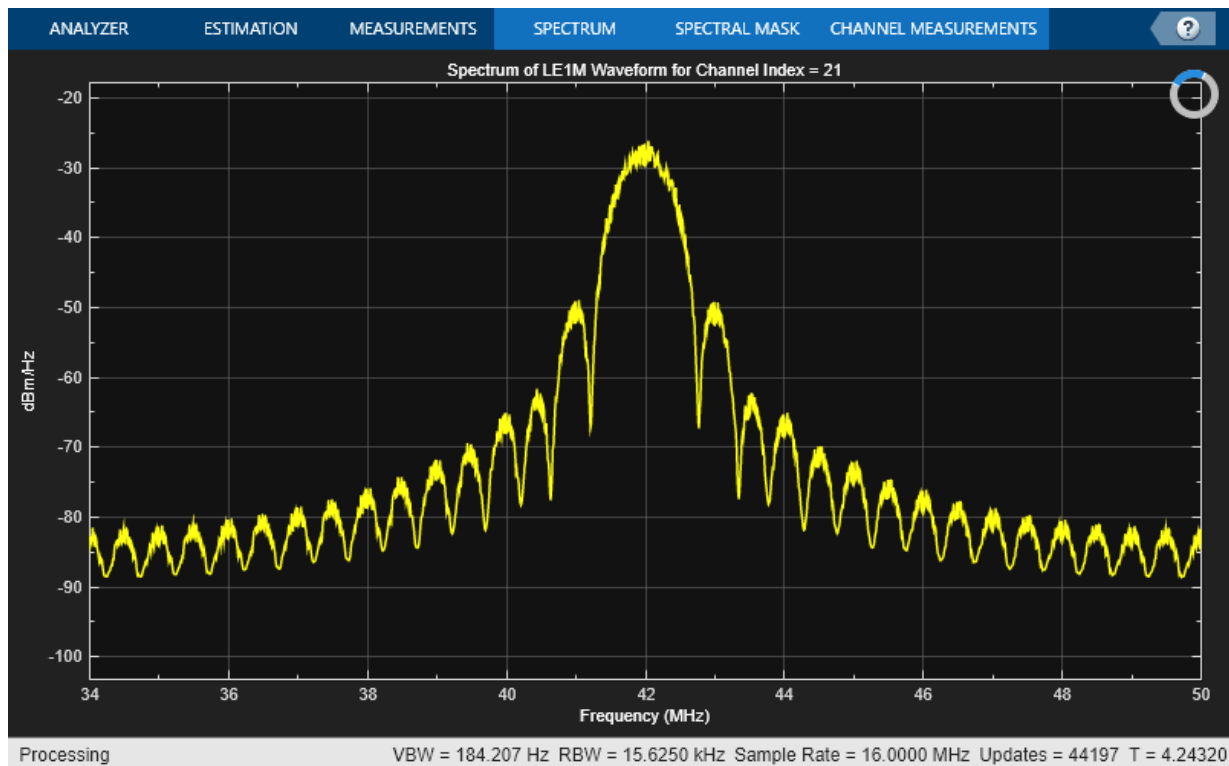
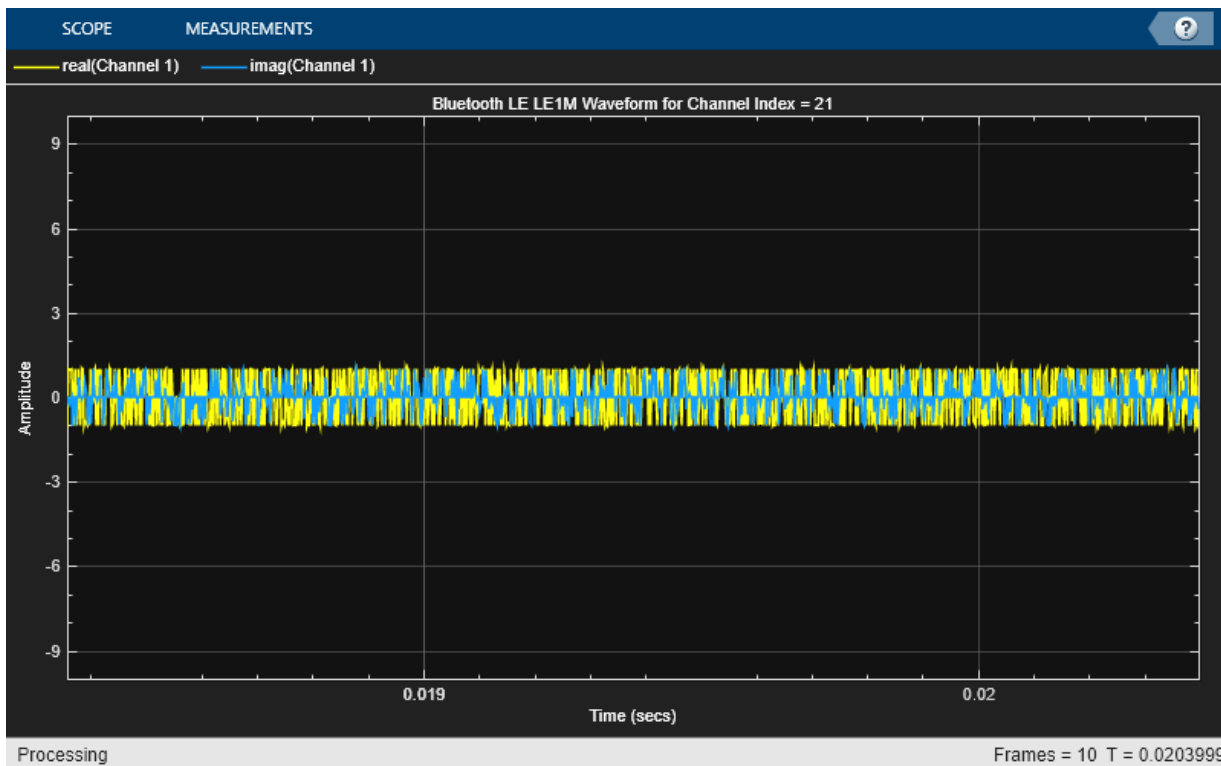
VULNERABLE ROAD USER (VRU) ALERTS

..and much more

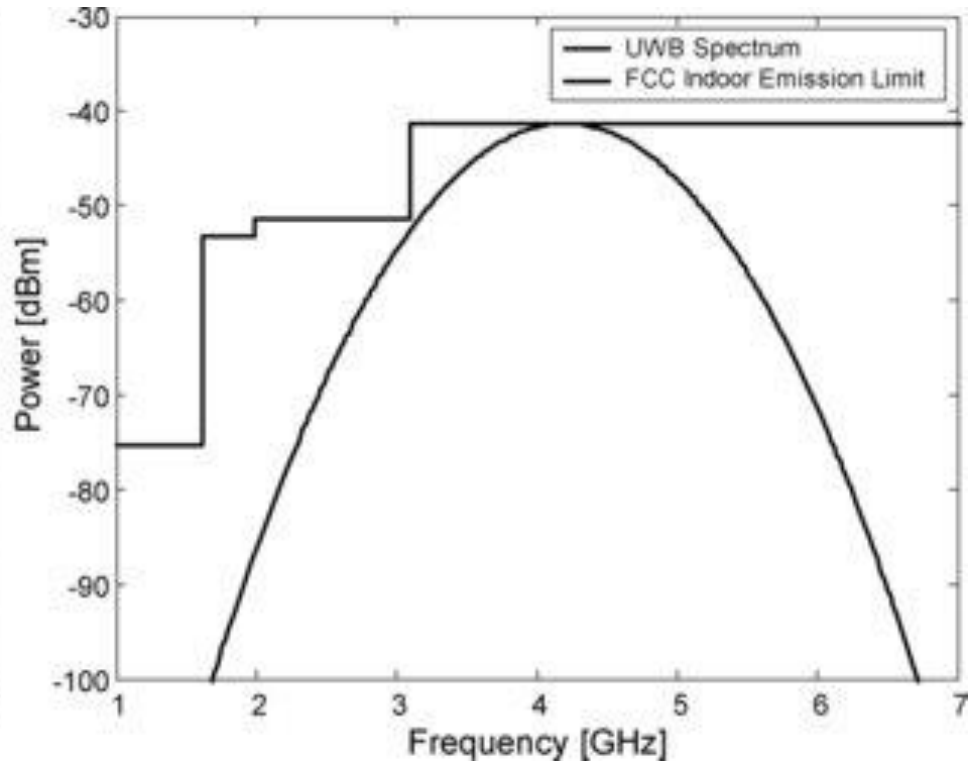
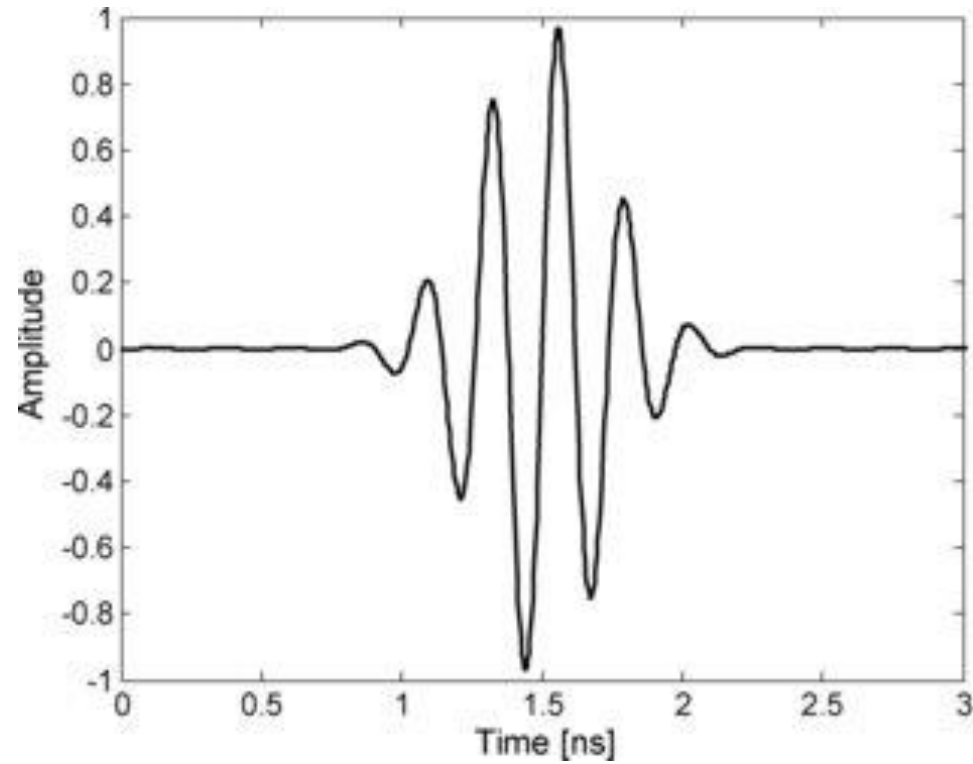
Problems with classical keyless



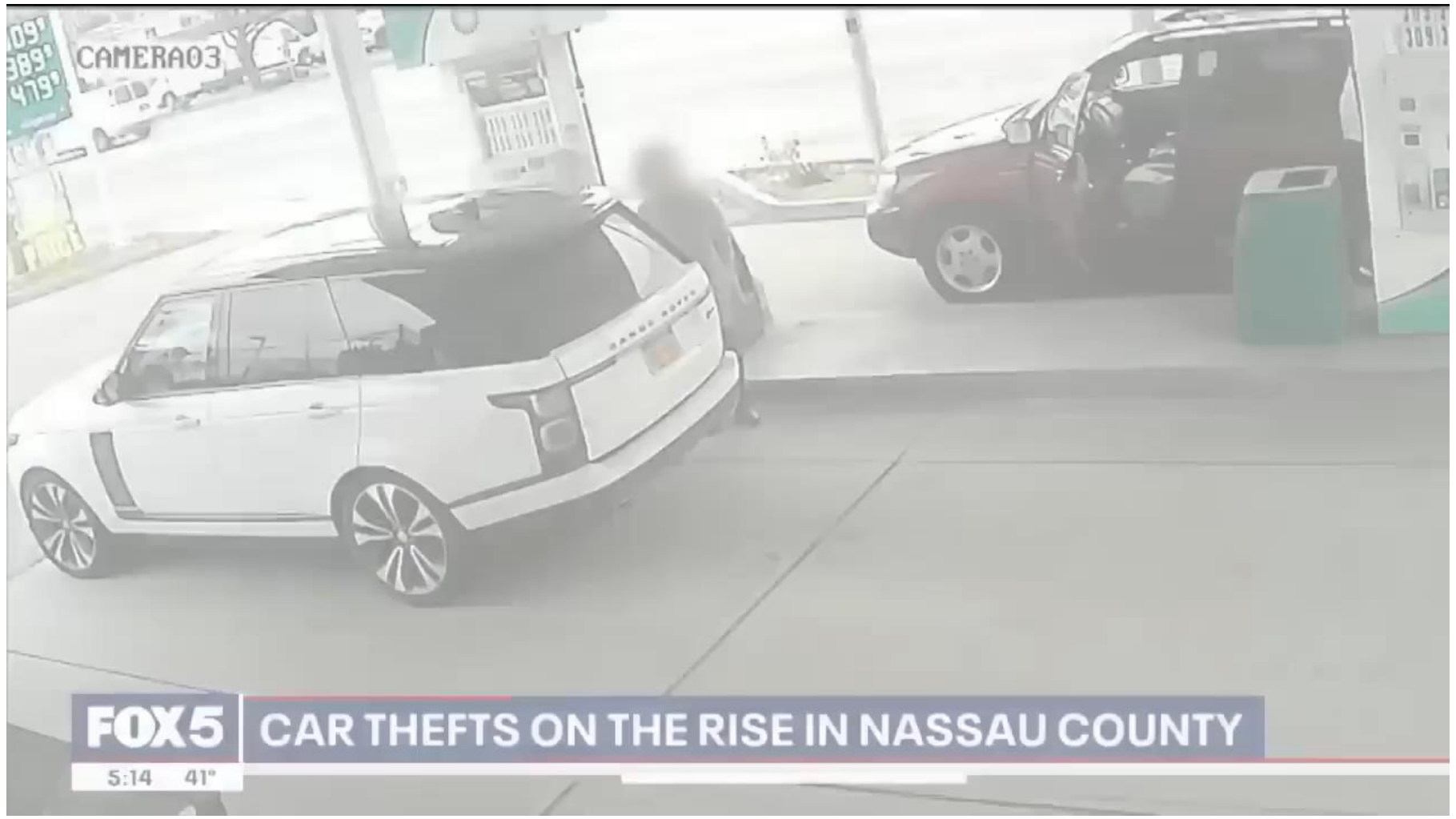
„PaaK” under the hood – BLE



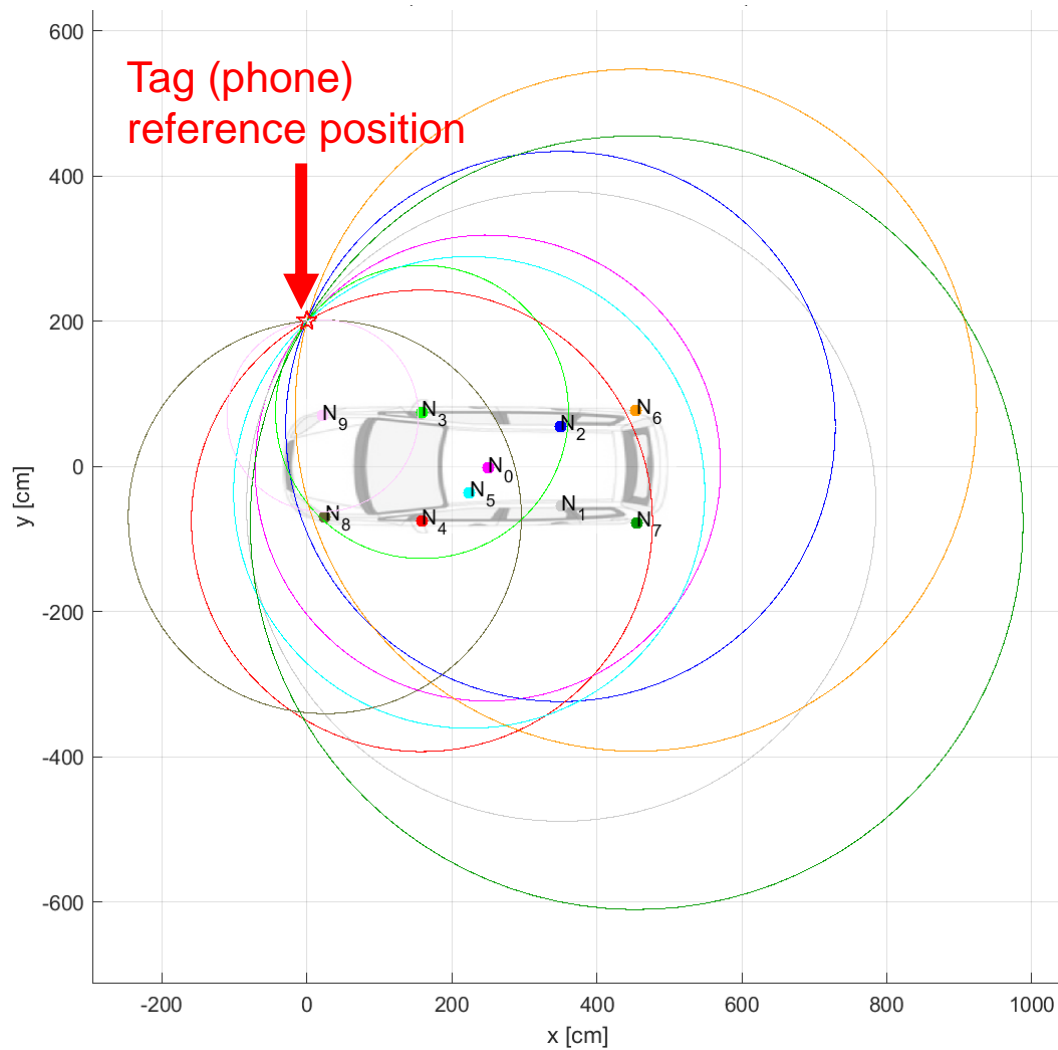
„PaaK” under the hood – UWB



When distance is not good enough



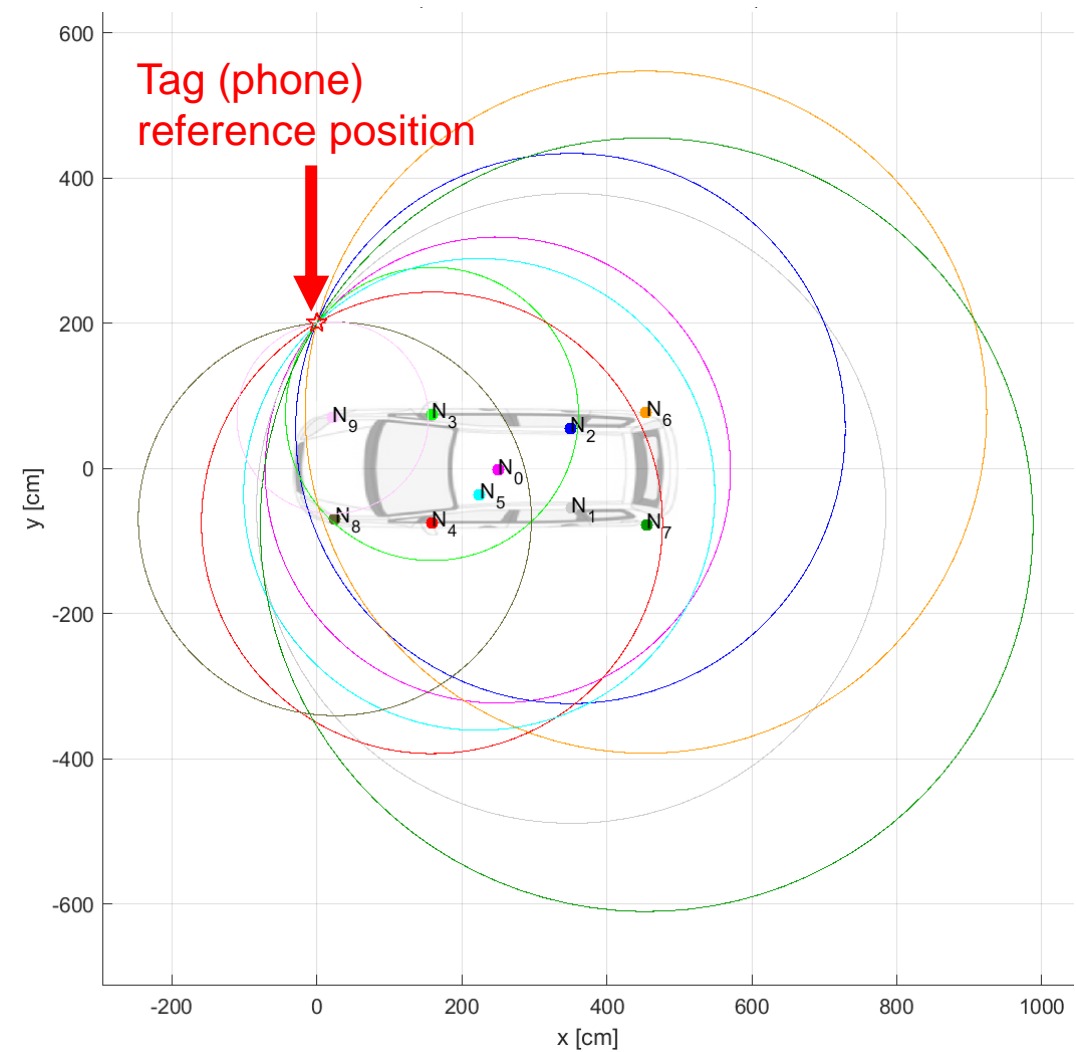
Localization



PERFECT SITUATION (exact distances, all nodes active)

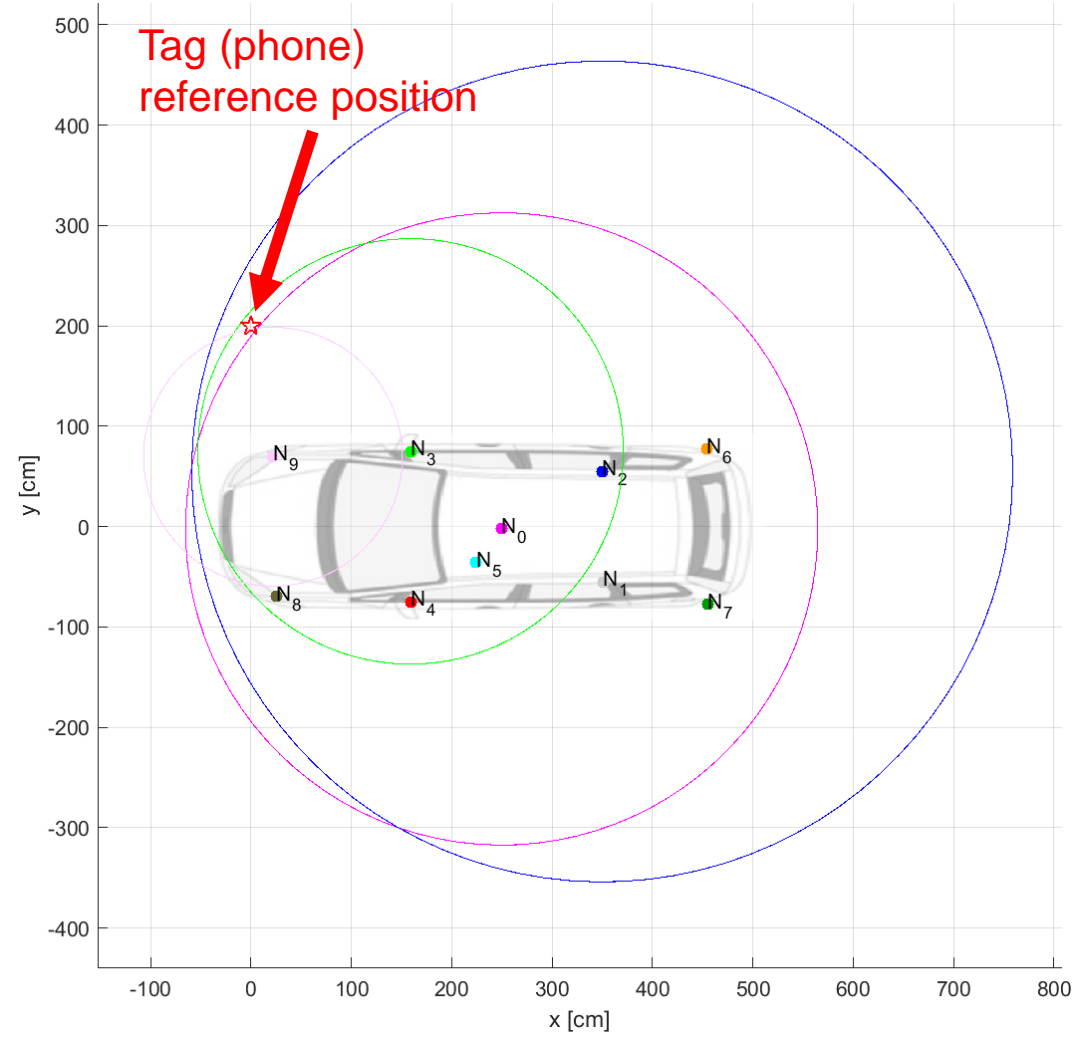
- UWB nodes measure time, corresponding to distance – d
- System needs (x,y) position information

Localization



PERFECT SITUATION

VS.



REAL SITUATION

Localization

Challenges:

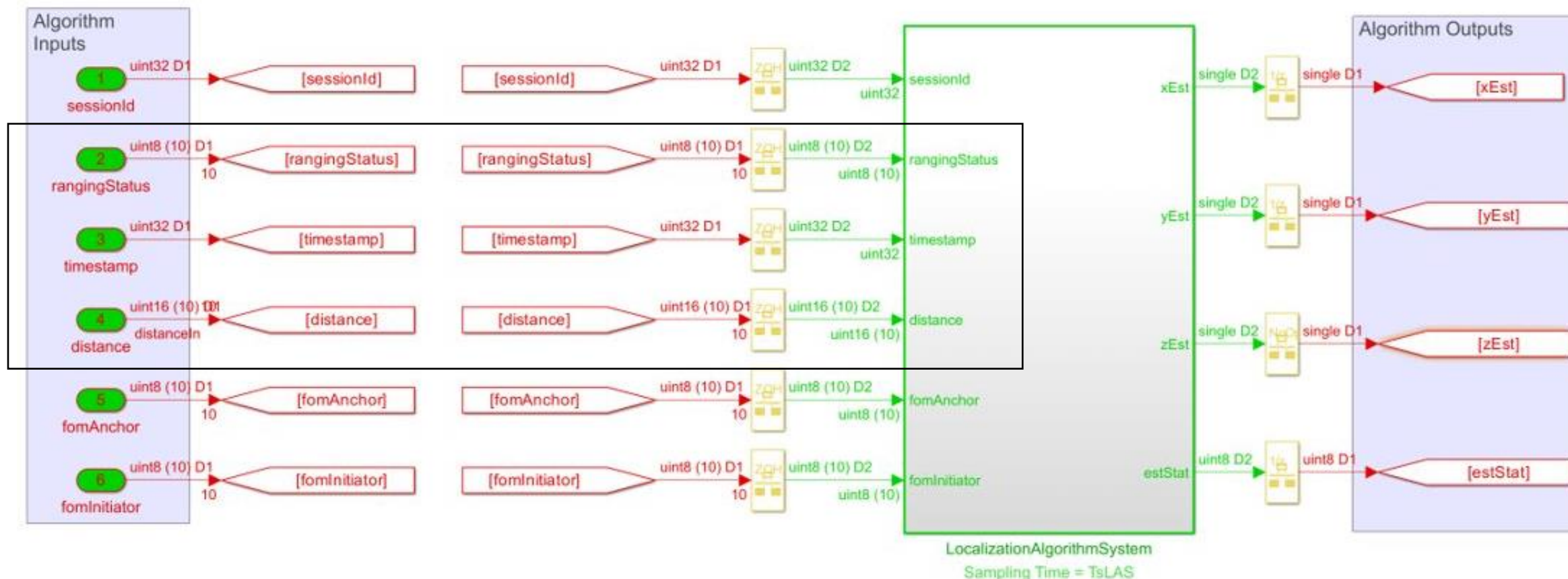
- **Absorption** (missing measurements)
- **Reflections** (larger measurements)
- Working **fast** on embedded



REAL SITUATION

3. Model-Based Design

Localization Algorithm System Interface



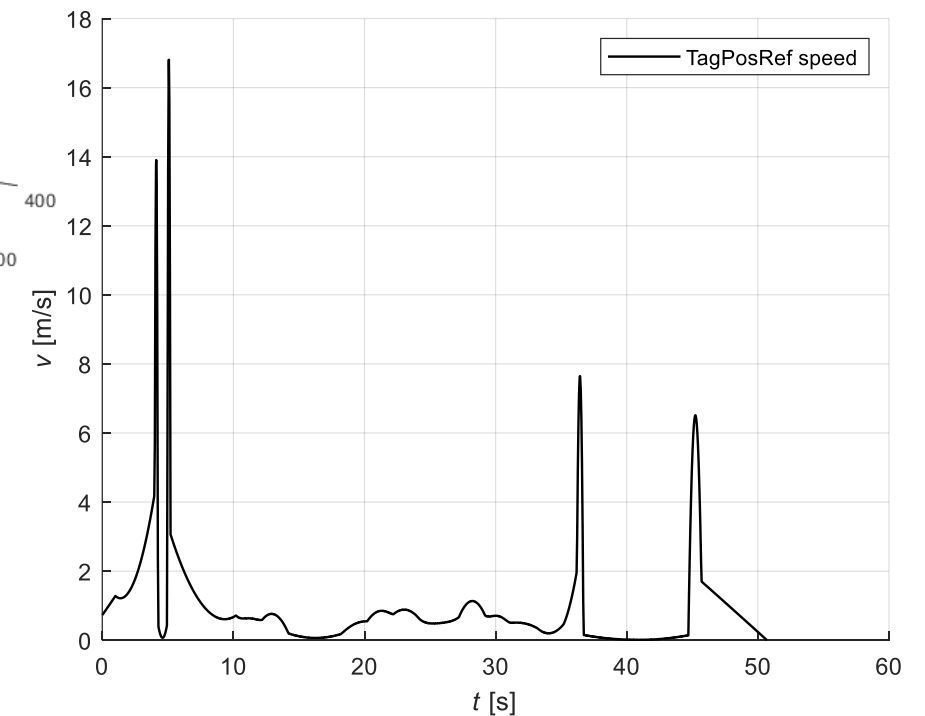
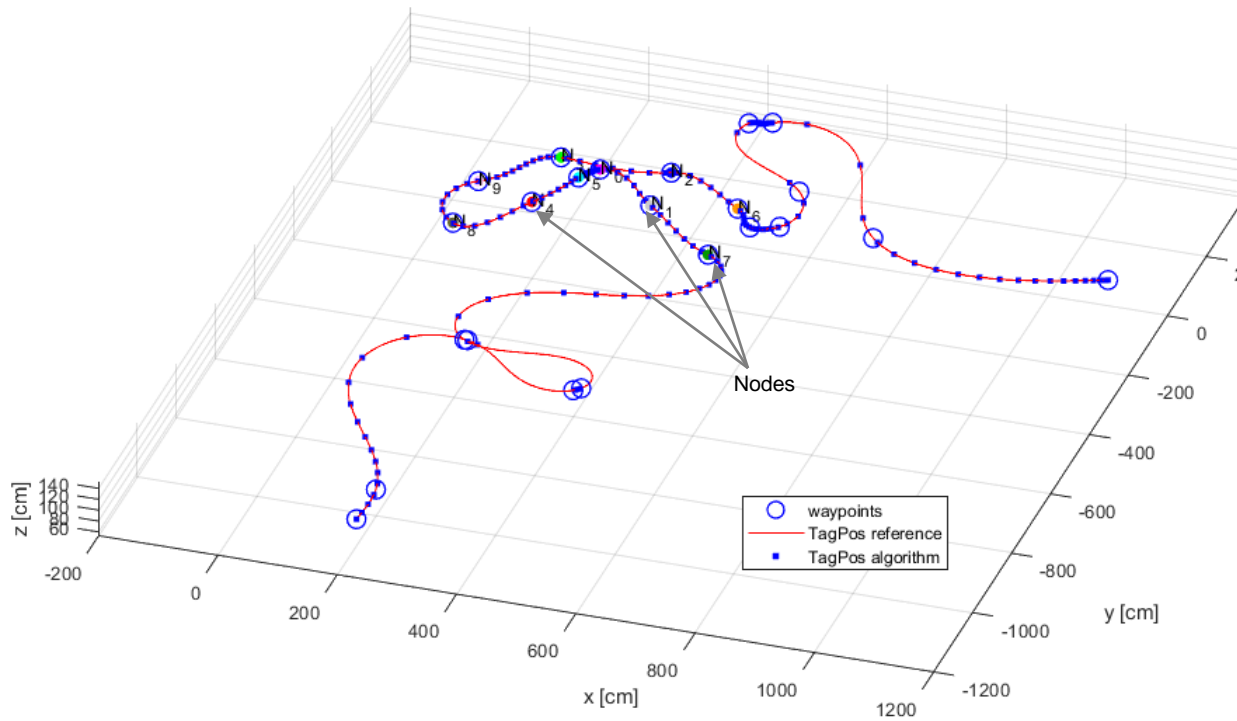
(1) Algorithm

(2) Communication Nodes <-> Algorithm

(3) Source of input data

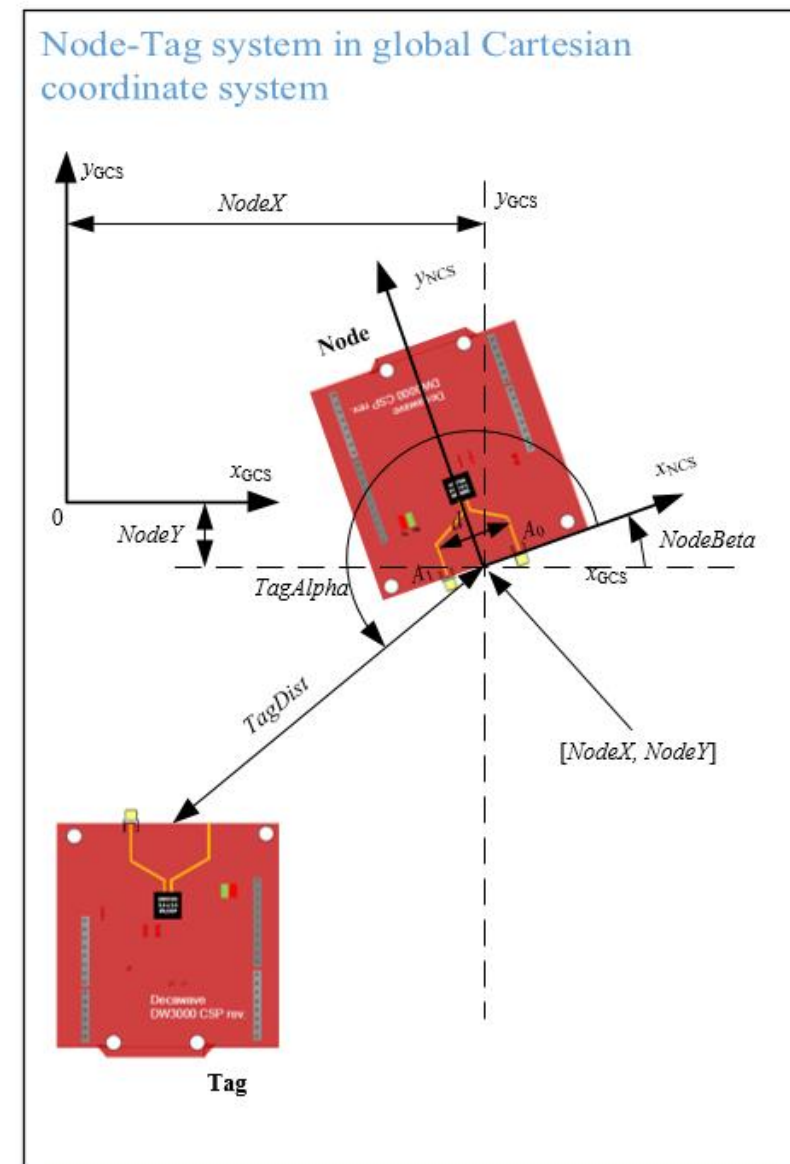
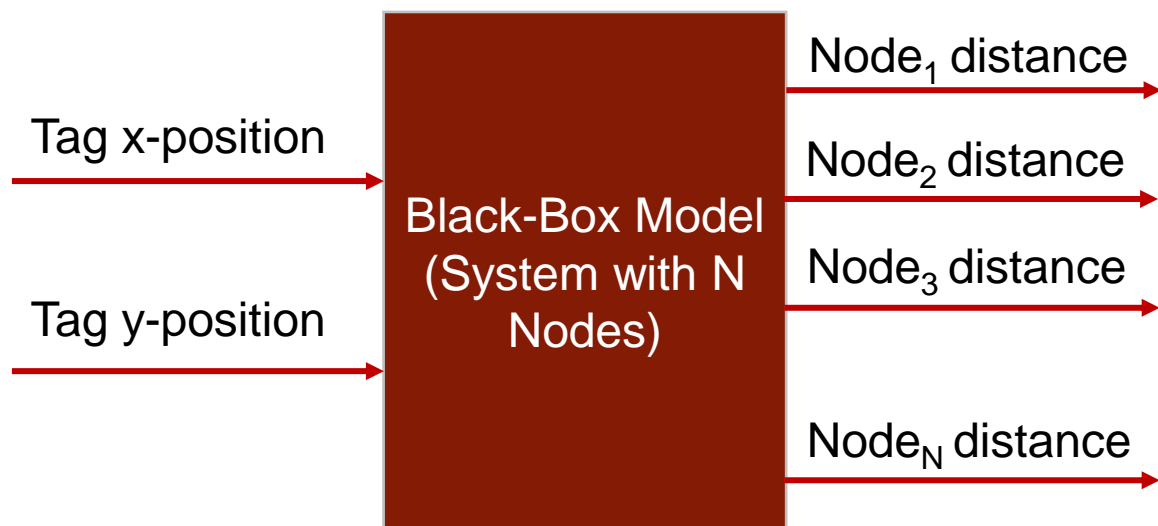
Source of input data

1. Simulation
2. Black-Box model (based on real data)
3. Real data
4. Hybrid 1 + 3



Source of input data

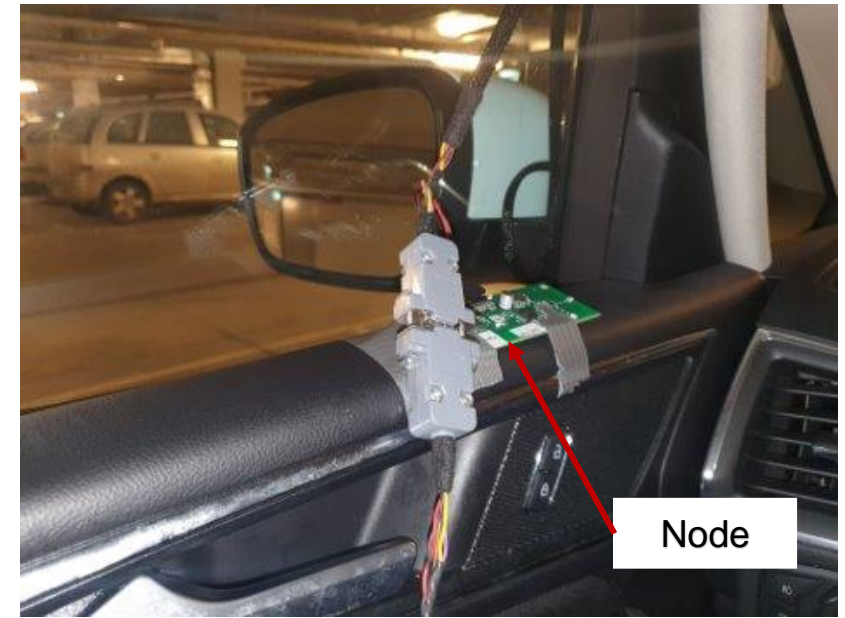
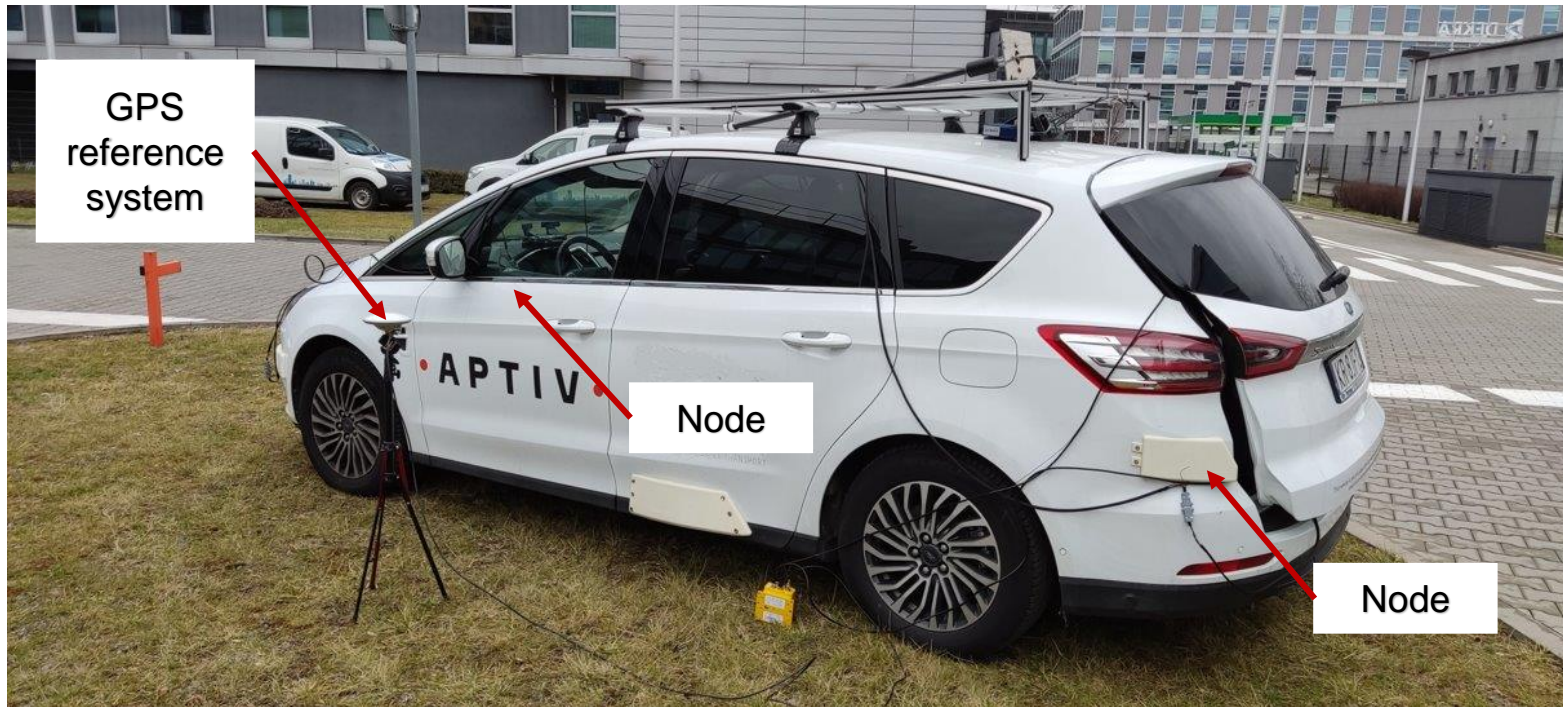
1. Simulation
2. Black-Box model (based on real data)
3. Real data
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Source of input data

1. Simulation
2. Black-Box model (based on real data)
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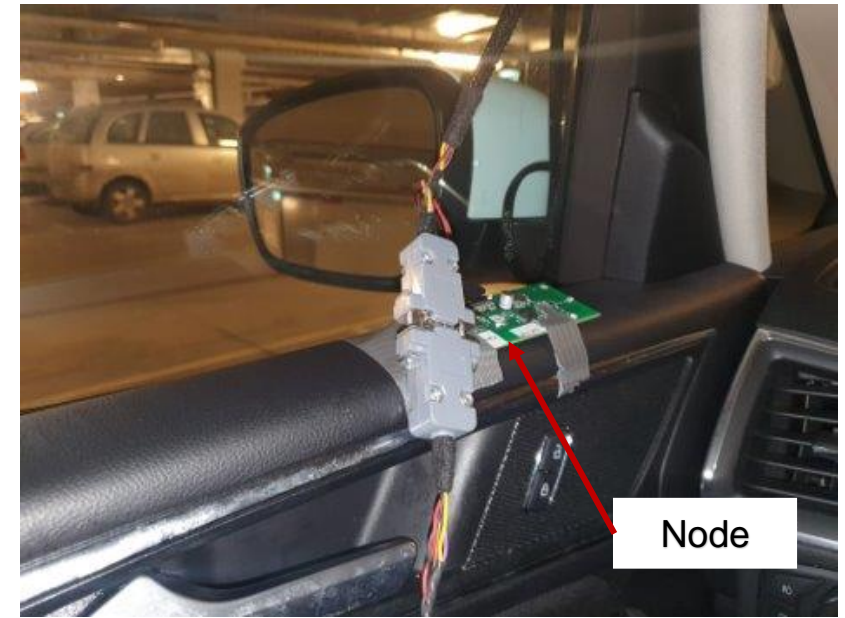
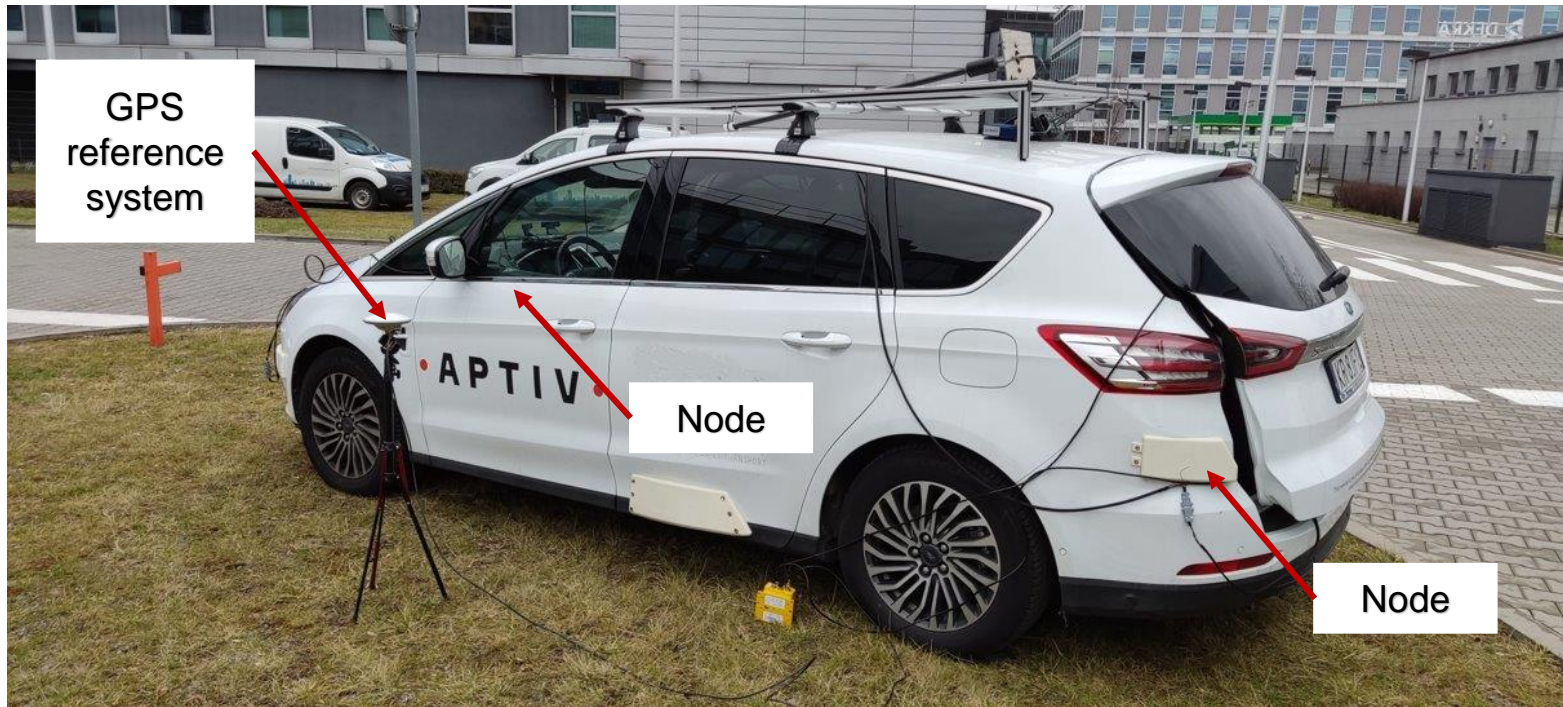
dynamic & static



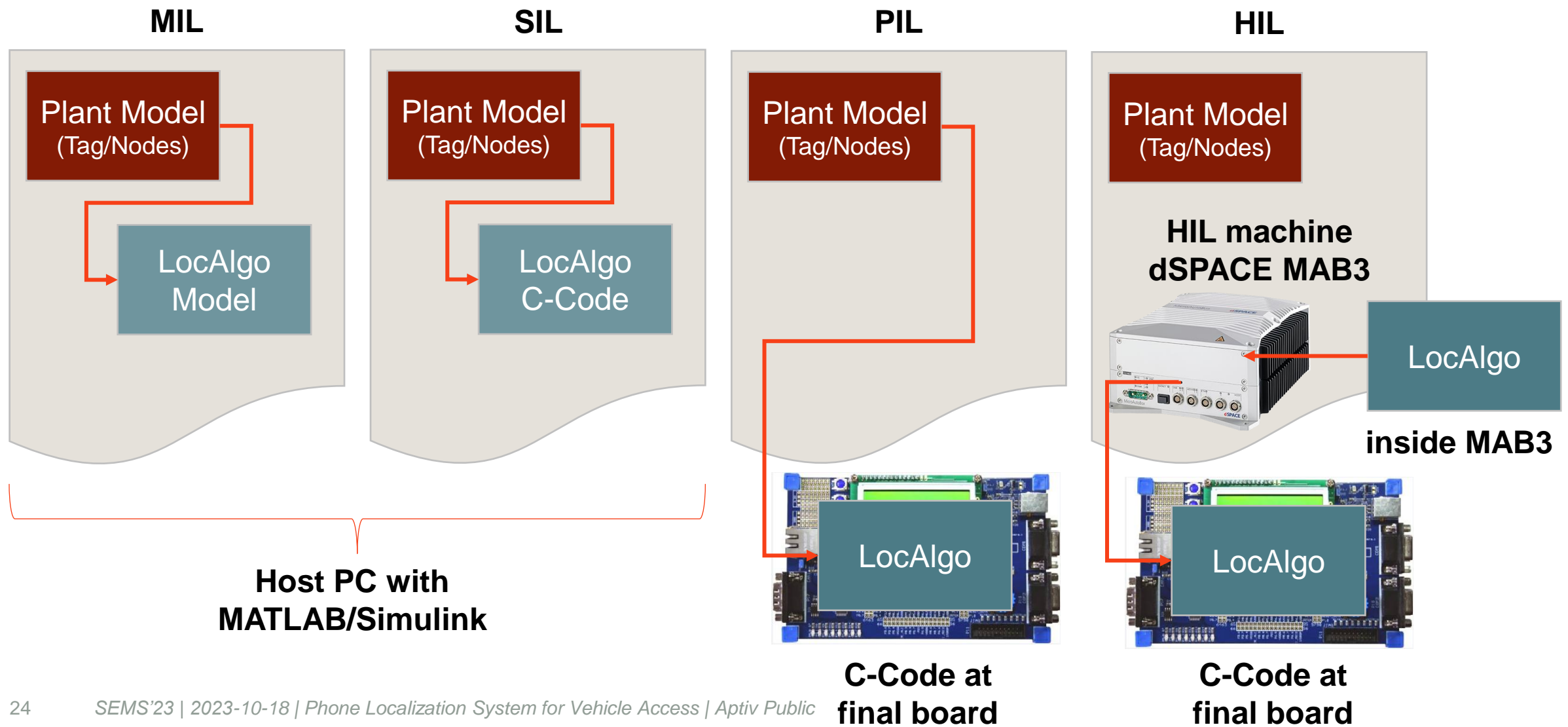
Source of input data

1. Simulation
2. Black-Box model (based on real data)
3. Real data
4. Hybrid 1 + 3

dynamic & static



MBD Tests/Validation Methodology



Simulink: Embedded Coder

The screenshot displays the Simulink Embedded Coder environment. The top menu bar includes SIMULATION, DEBUG, MODELING, FORMAT, APPS, and C CODE. The C CODE tab is active, showing a toolbar with icons for Embedded Code, Quick Start, C/C++ Code Advisor, Automatic Settings, Code Interface, Generate Code, View Code, Open Report, Remove Highlighting, Verify Code, and Share. The 'Generate Code' button is circled in red, with a red arrow pointing to the C code editor.

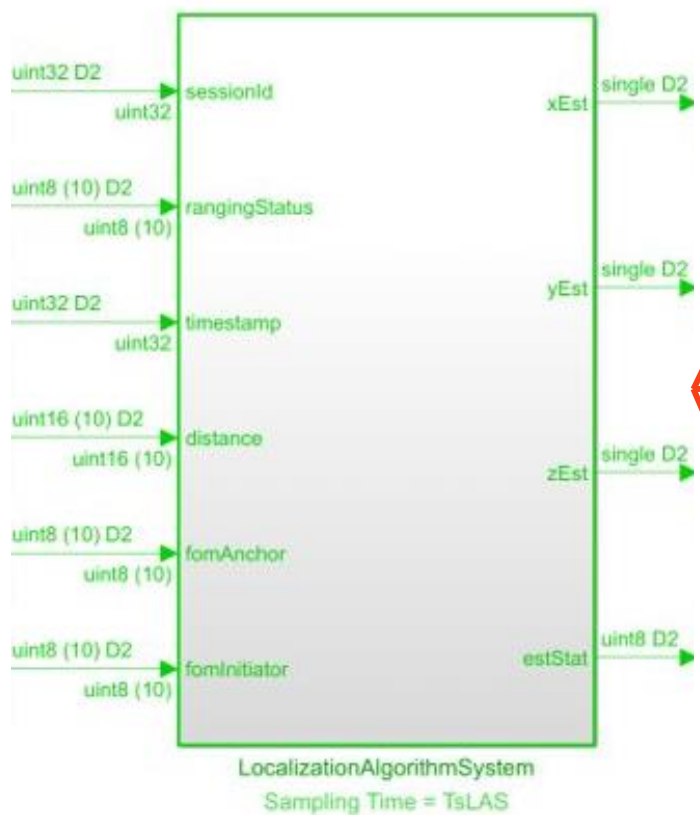
The main workspace shows a Simulink model with several blocks: Stage1_PreProcessing, Stage2_LocalizationAlgorithm, and Stage3_PostProcessing. A sub-system block 'StageA_CheckTimeAndConnection_SetEstStat' is highlighted in green. The 'Code' window on the right shows the generated C code for 'ngDivSim.c'. The code includes comments and logic for handling a switch state and triggering a localization algorithm.

```

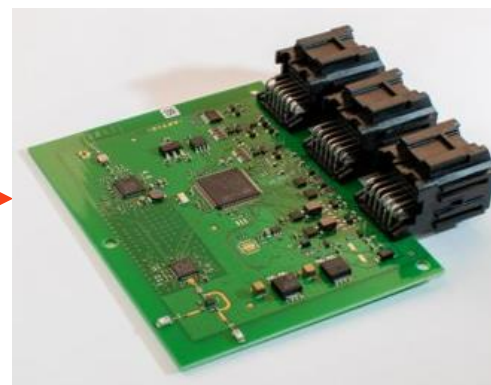
113 /* End of Switch: '<S7>/Switch' */
114
115 /* Outputs for Triggered SubSystem: '<S1>/Stage2_LocalizationAlgorithm' incorporates:
116  * TriggerPort: '<S4>/Trigger'
117  */
118 if (((ngDivSim_PrevZCX->Stage2_LocalizationAlgorithm_Tr == POS_ZCSIG) !=
119      (int32_T)ngDivSim_B->Switch_1) &&
120      (ngDivSim_PrevZCX->Stage2_LocalizationAlgorithm_Tr != UNINITIALIZED_ZCSIG))
121 {
122     /* ModelReference: '<S21>/LAK' */
123     ref_LAK(&ngDivSim_B->Switch4[0], &ngDivSim_U->timestamp,
124            &ngDivSim_B->DataTypeConversion[0], &ngDivSim_B->LAK_o1,
125            &ngDivSim_B->LAK_o2, &ngDivSim_B->LAK_o3,
126            &ngDivSim_B->estimationStatus, &ngDivSim_B->LAK_o5,
127            &(ngDivSim_DW->LAK_InstanceData.rtb),
128            &(ngDivSim_DW->LAK_InstanceData.rtdw));
129 }
130
131 ngDivSim_PrevZCX->Stage2_LocalizationAlgorithm_Tr = ngDivSim_B->Switch_1;
132
  
```

At the bottom of the window, the status bar shows 'Code Mappings - Component Interface', 'Ready', '50%', and 'FixedStepDiscrete'.

C-Code generation and deployment



dSPACE MAB3



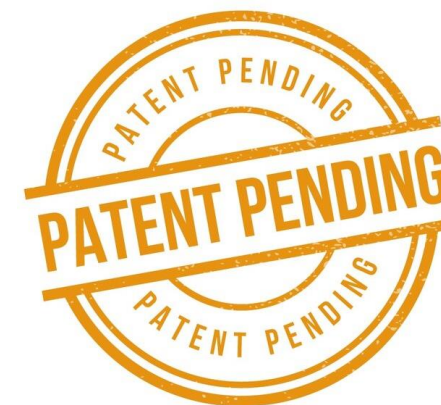
APTIV Paak HUB (AURIX AUTOSAR)



APTIV CVC (Linux)

4. Localization Algorithm

Localization Algorithm System



Stage 1: Pre-processing

- preparation of signals:
 - check validity of sensors' measurements;
 - calibration of the measured distances.

Stage 2: Localization Algorithm

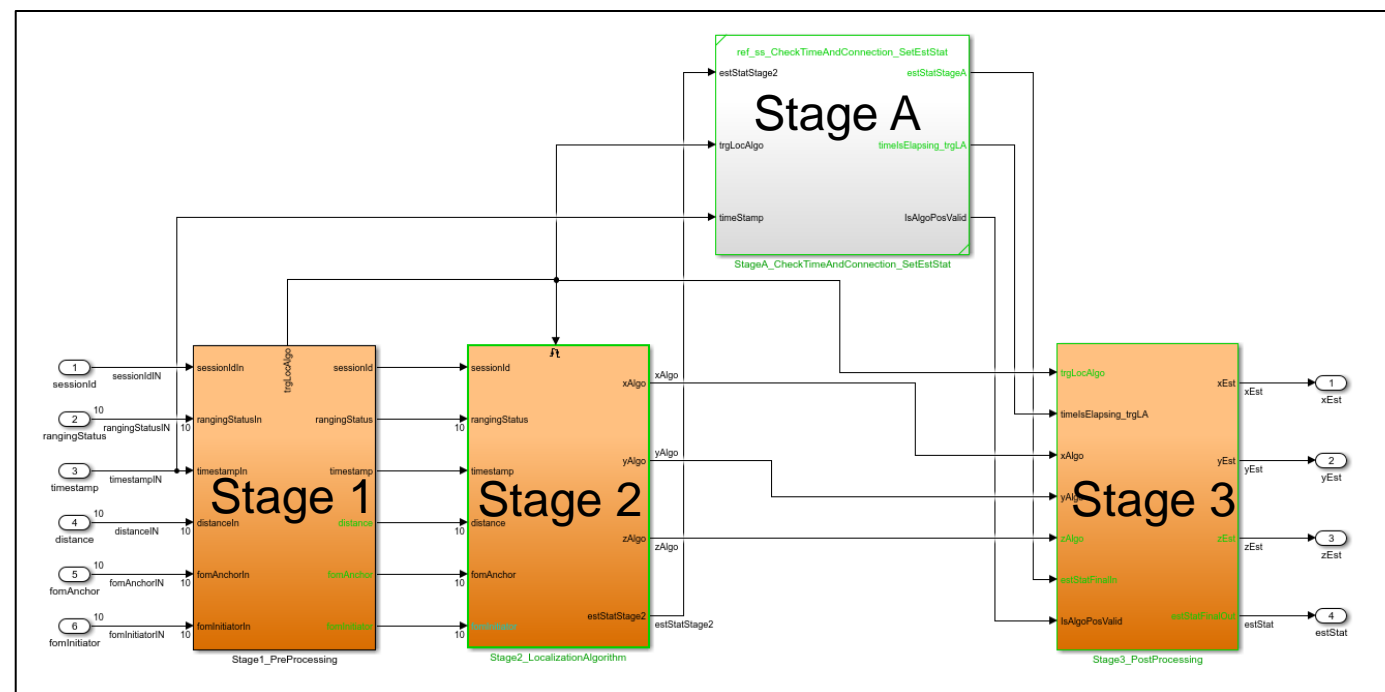
- estimation of object's position;
- returning estimation status;

Stage A: Time-based analysis

- detection of lost connection;
- analysis of signals in time domain.

Stage 3: Post-Processing

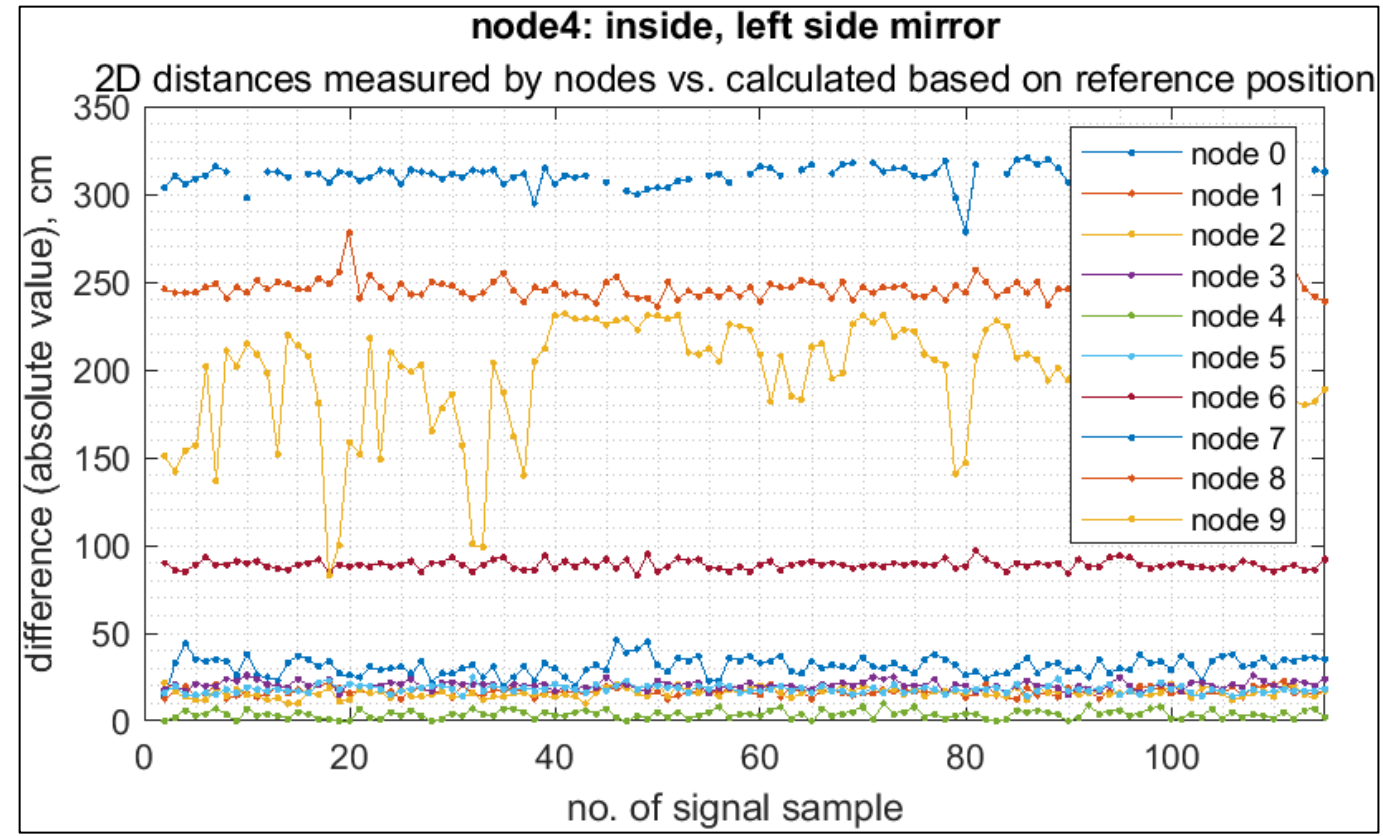
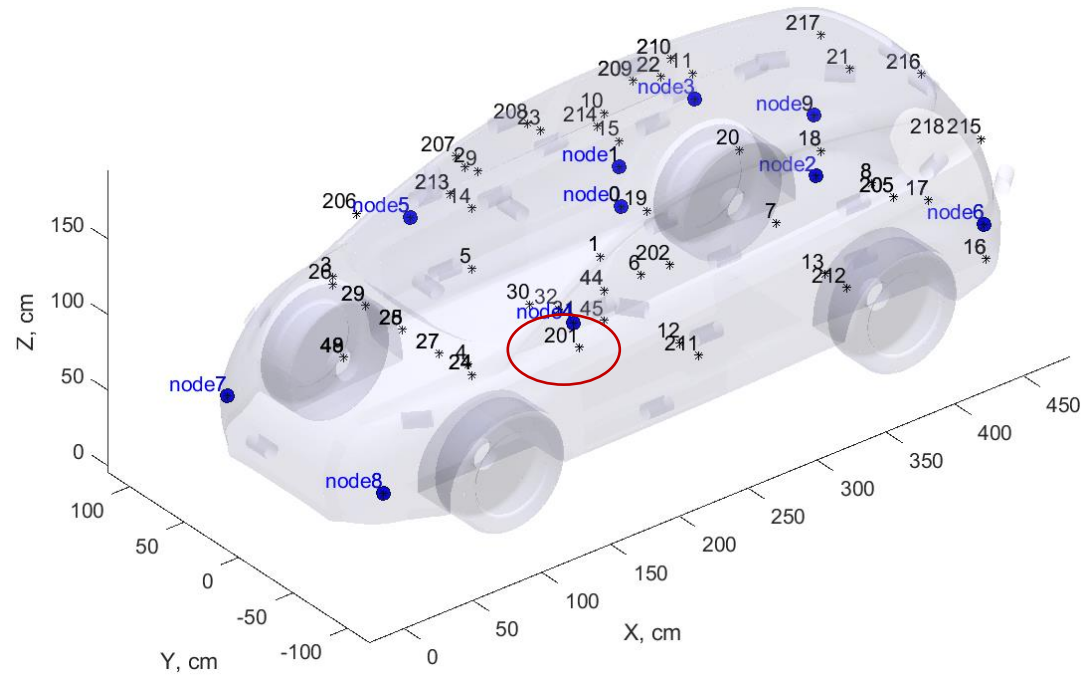
- analysis of measurement reliability;
- Tag (human) movement model.



5. Testing & Verification

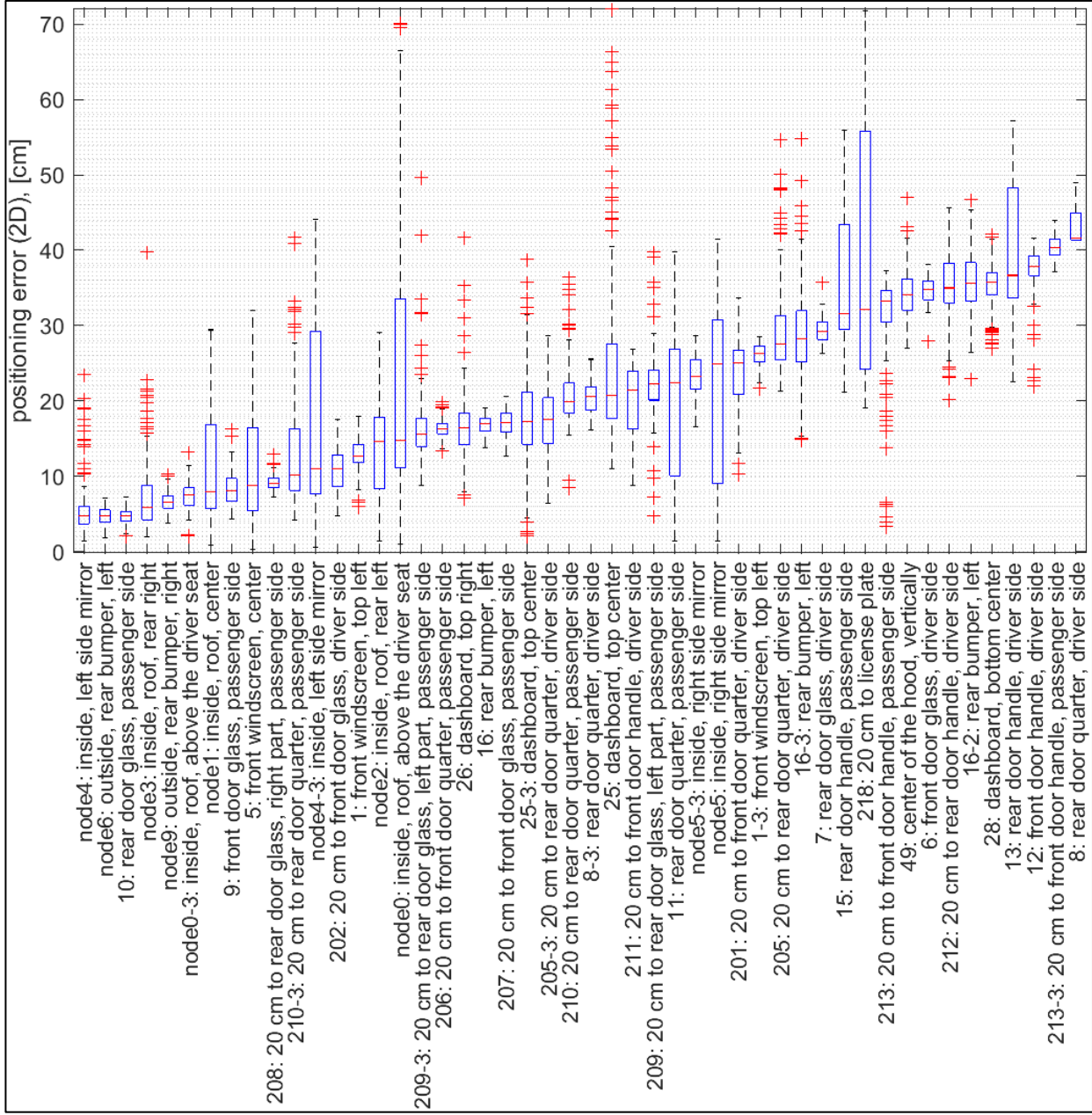
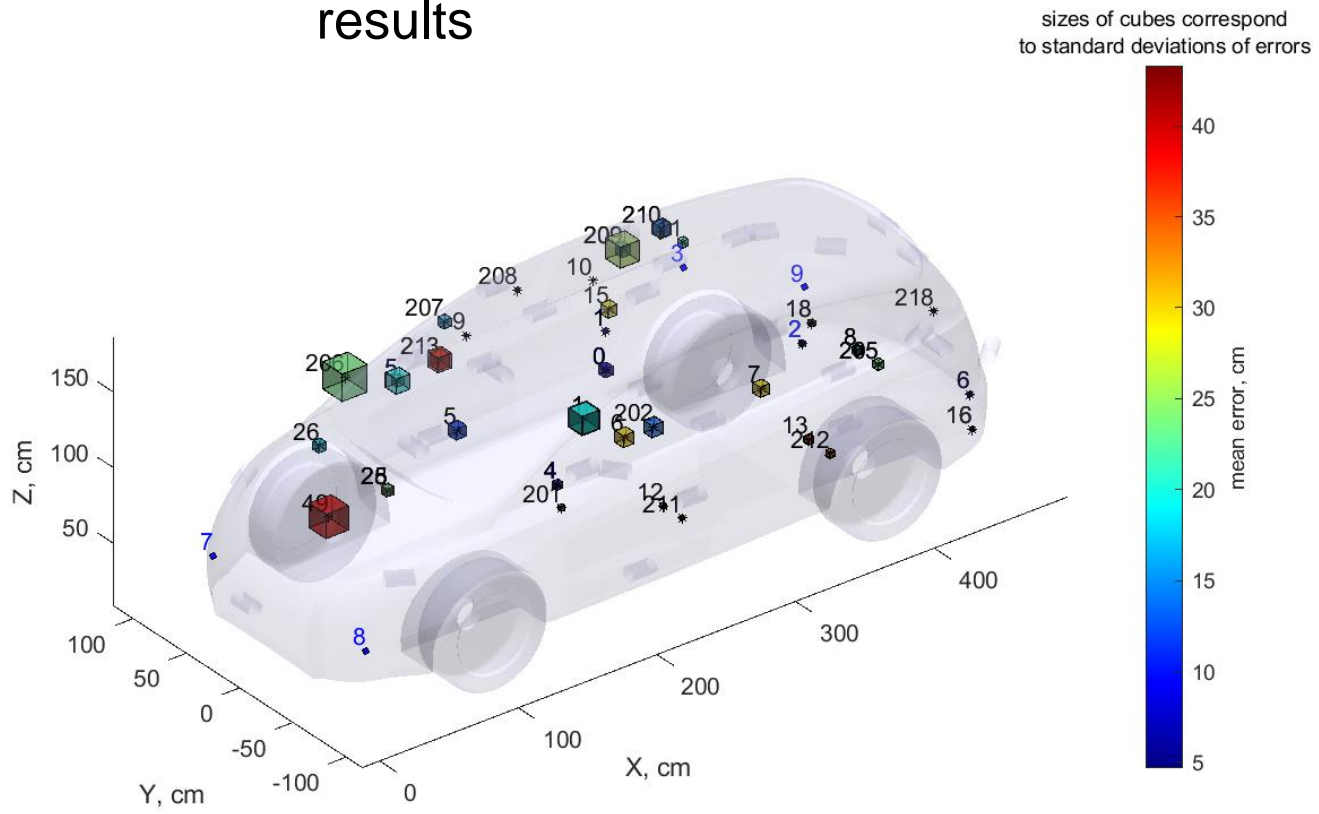
Testing and Verification

- **Static measurements**
 - reference-based analysis of distances measured by sensors (Thatcham Standards)



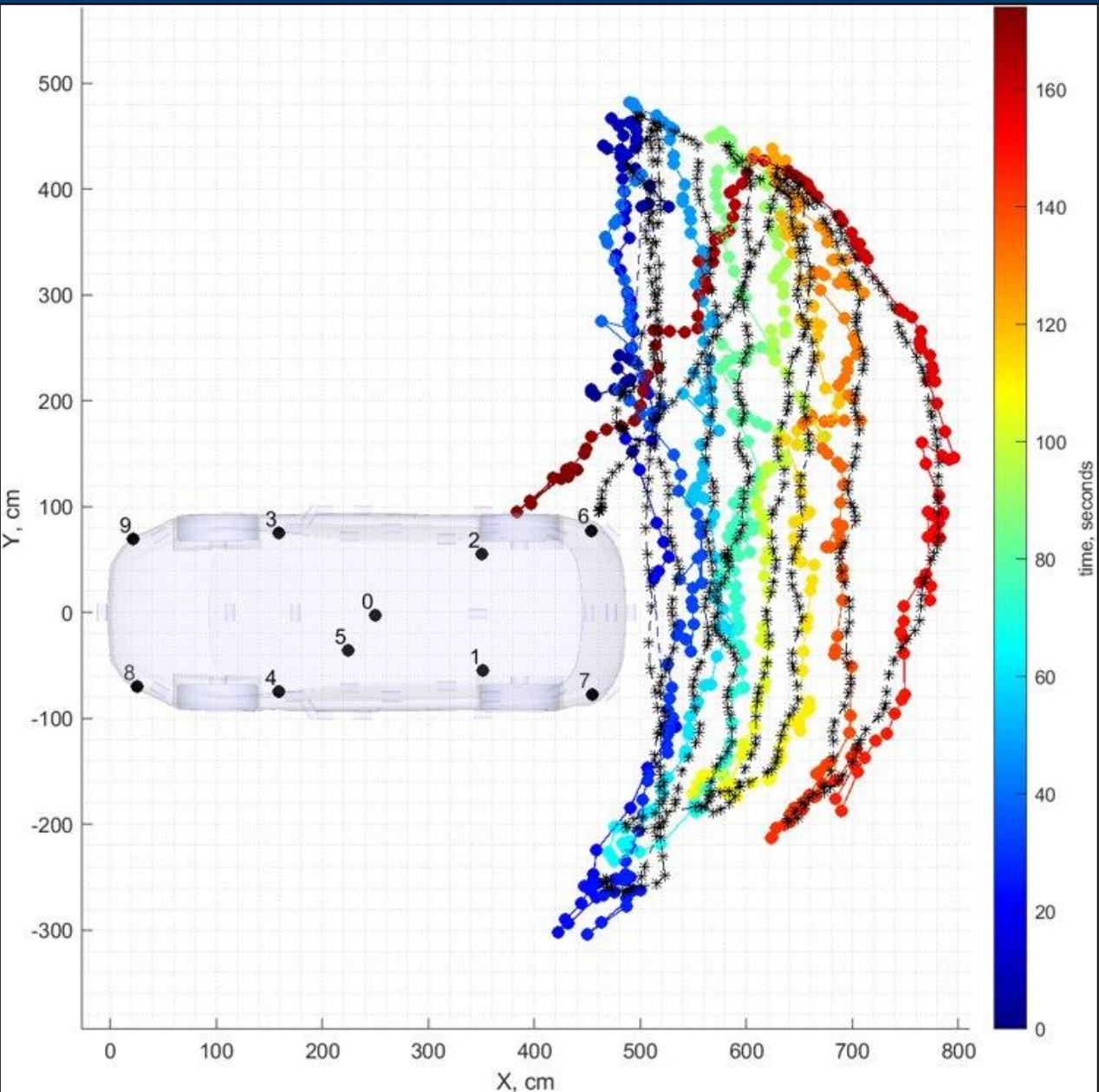
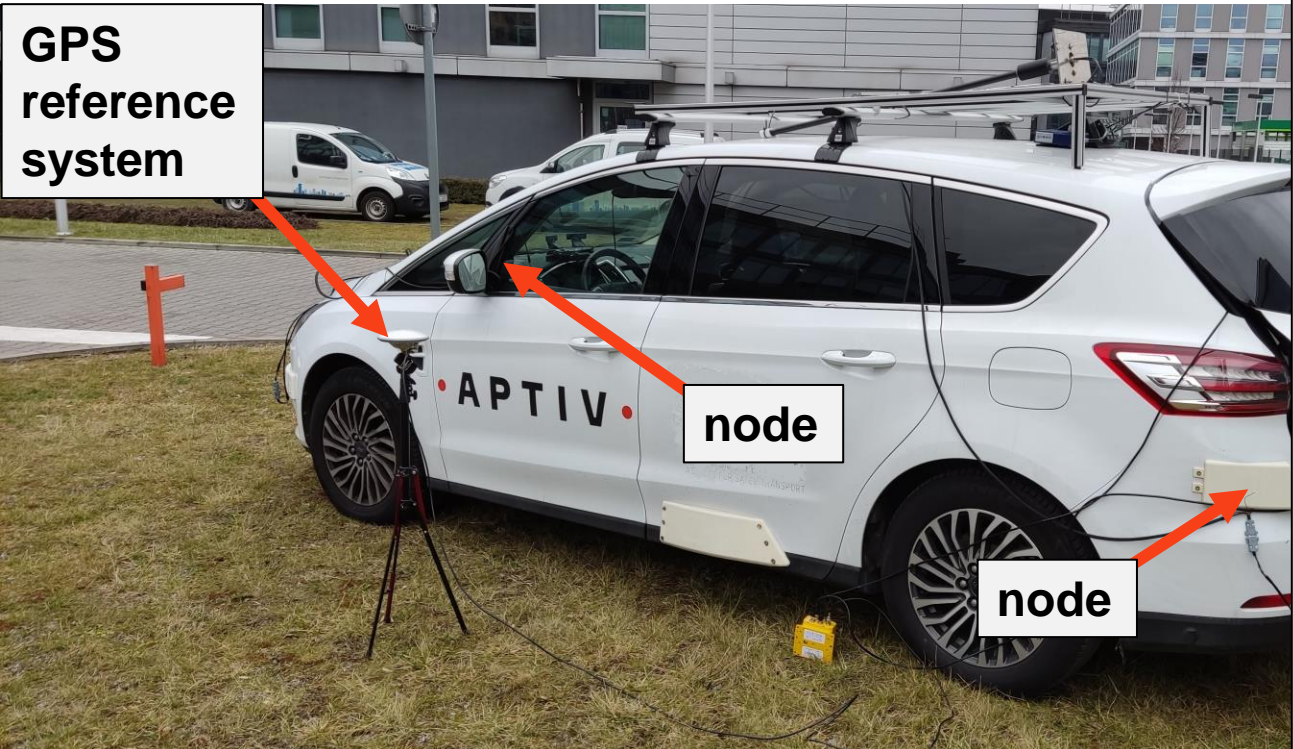
Testing and Verification

- **Static measurements**
 - reference-based analysis of algorithm results



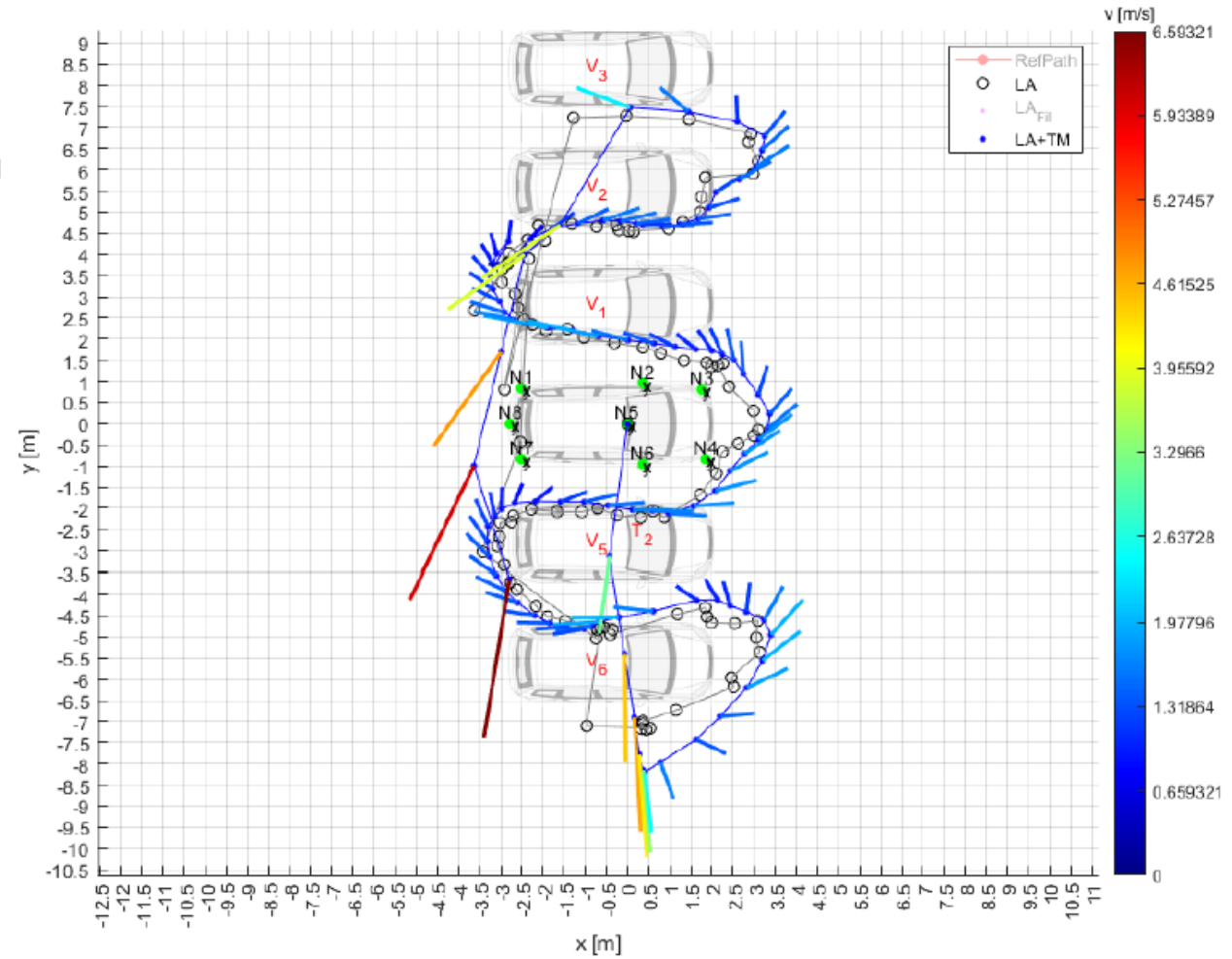
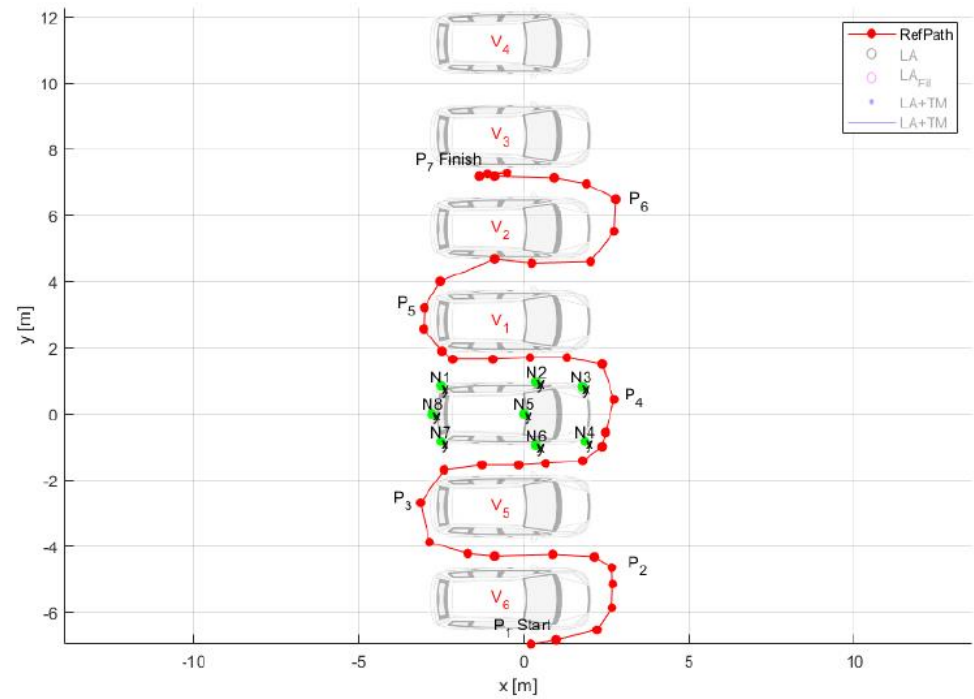
Testing and Verification

- **Dynamic measurements**
 - reference-based analysis of algorithm results



Testing and Verification

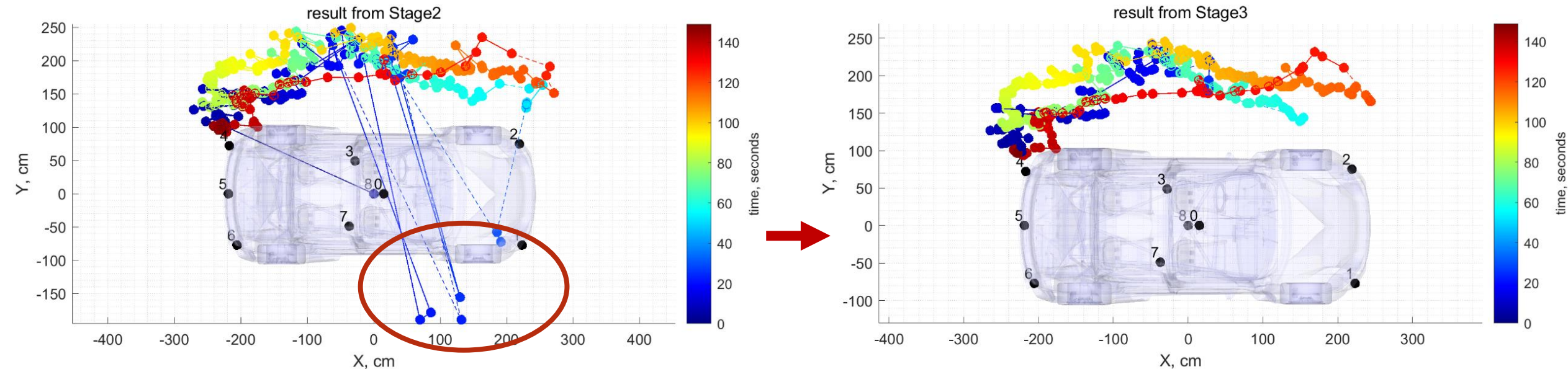
- **Dynamic measurements**
 - reference-based analysis of algorithm results



Testing and Verification

Stage 3: Post-Processing

- analysis of phone position in time domain;
- elimination of possible errors.



Phone Localization System for Vehicle Access



Source (Aptiv): <https://www.youtube.com/watch?v=gz2cCrOy7Q4>

Phone as a Key Team

Project Technical Manager

Tomasz Klatka

Project Coordinator

Klaudia Siereńska

Software Development

Grzegorz Jędrzejczak

Łukasz Ziętek

Tomasz Smoleń

Dawid Kasieczka

Jefftha D'Silva

Gniewomir Stefański

Krystian Turczyn

Paweł Wojtasiński

Marek Żuchowicz

Algorithm Development

Mateusz Romaszko

Angelika Wronkowicz

Aleksandra Wróblewska

Grzegorz Wyszyński

Krzysztof Hołoń

Jakub Korta

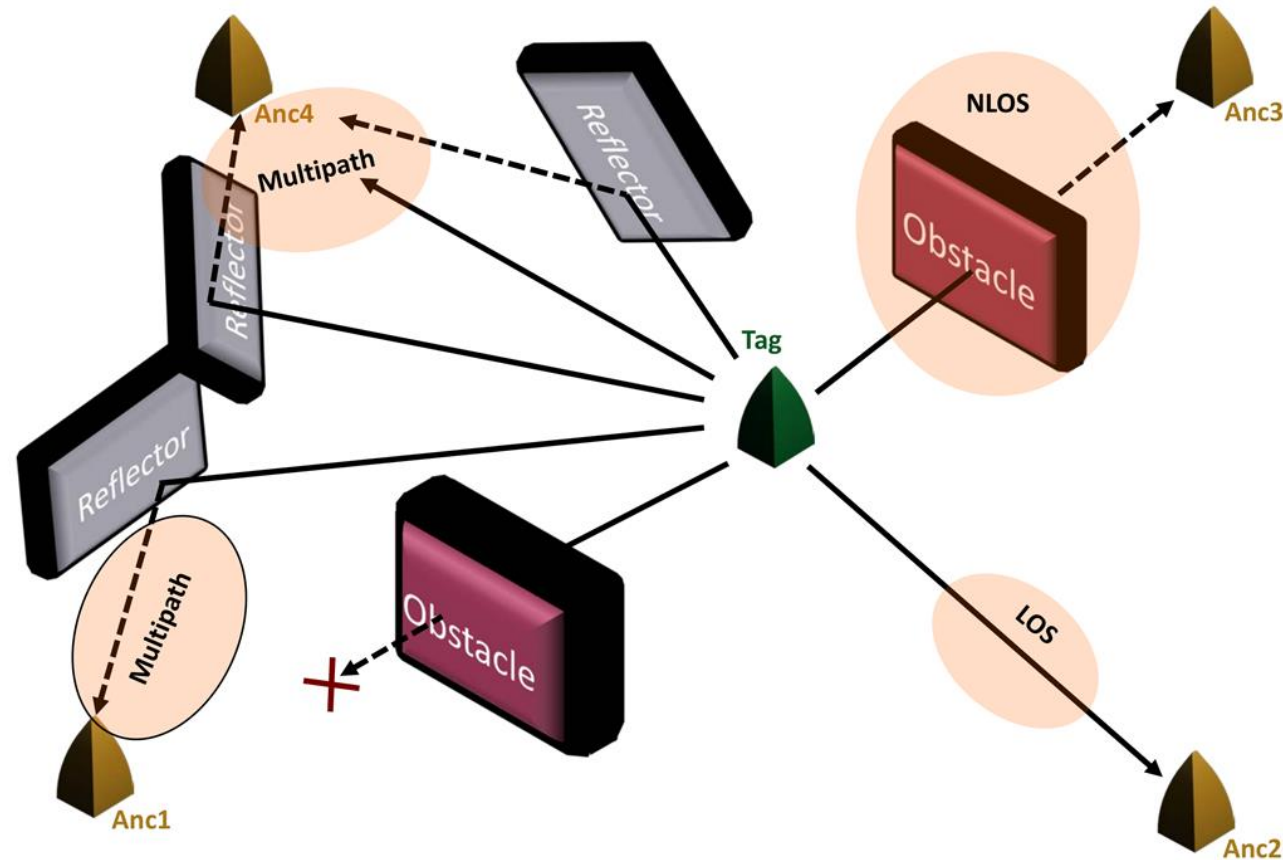
Hardware and System Development

Mateusz Pułapa

Krzysztof Zych

Thank you

LOS vs. NLOS



Sang CL, Steinhagen B, Homburg JD, Adams M, Hesse M, Rückert U. Identification of NLOS and Multi-Path Conditions in UWB Localization Using Machine Learning Methods. Applied Sciences. 2020; 10(11):3980. <https://doi.org/10.3390/app10113980>