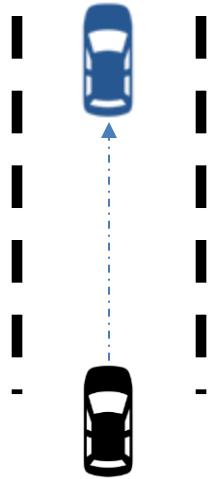# Map-based Localization of Autonomous Vehicle Using existing ADAS Camera

Dr. Jon Su
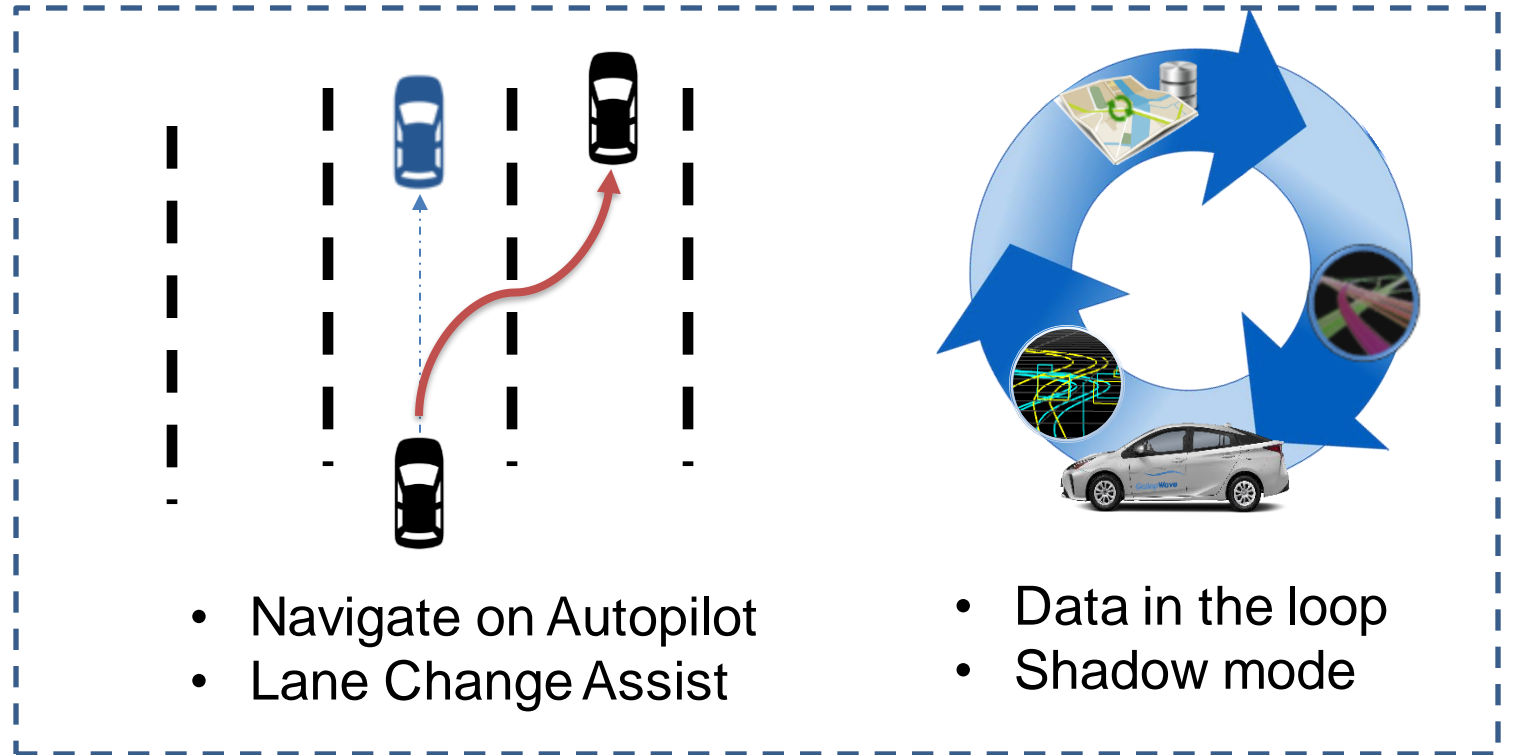**GallopWave INC. SLAM Dept, Director**

Levels of Autonomous Driving: From L2 to L2++

L2

- Adaptive Cruise Control
- Lane Keeping Assist

L2+/L2++

- Navigate on Autopilot
- Lane Change Assist

- Data in the loop
- Shadow mode

➢Localization is part of HD-map

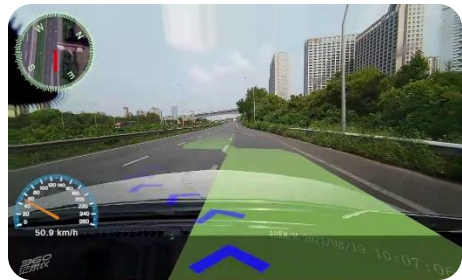HD-Map **+** HD-Localization

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Evolution of Navigation

>> Immersive

Road Level Navigation	Lane Level Navigation	AR Navigation	AR HUD
GPS grade positioning	Lane level positioning	Perception from AR cam	AR-ADAS on 3D AR HUD

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Localization is part of Map/Digital Cockpit

P-Box
- L2/L2+/L3 localization in a single box
- Provide lane level/decimeter positioning with SD-lane and HD-map for ADAS and ADS

Customer: tier-1

Navigation/Map Licensing
- Localization is part of HD/SD map
- Lane level positioning and lane navigation
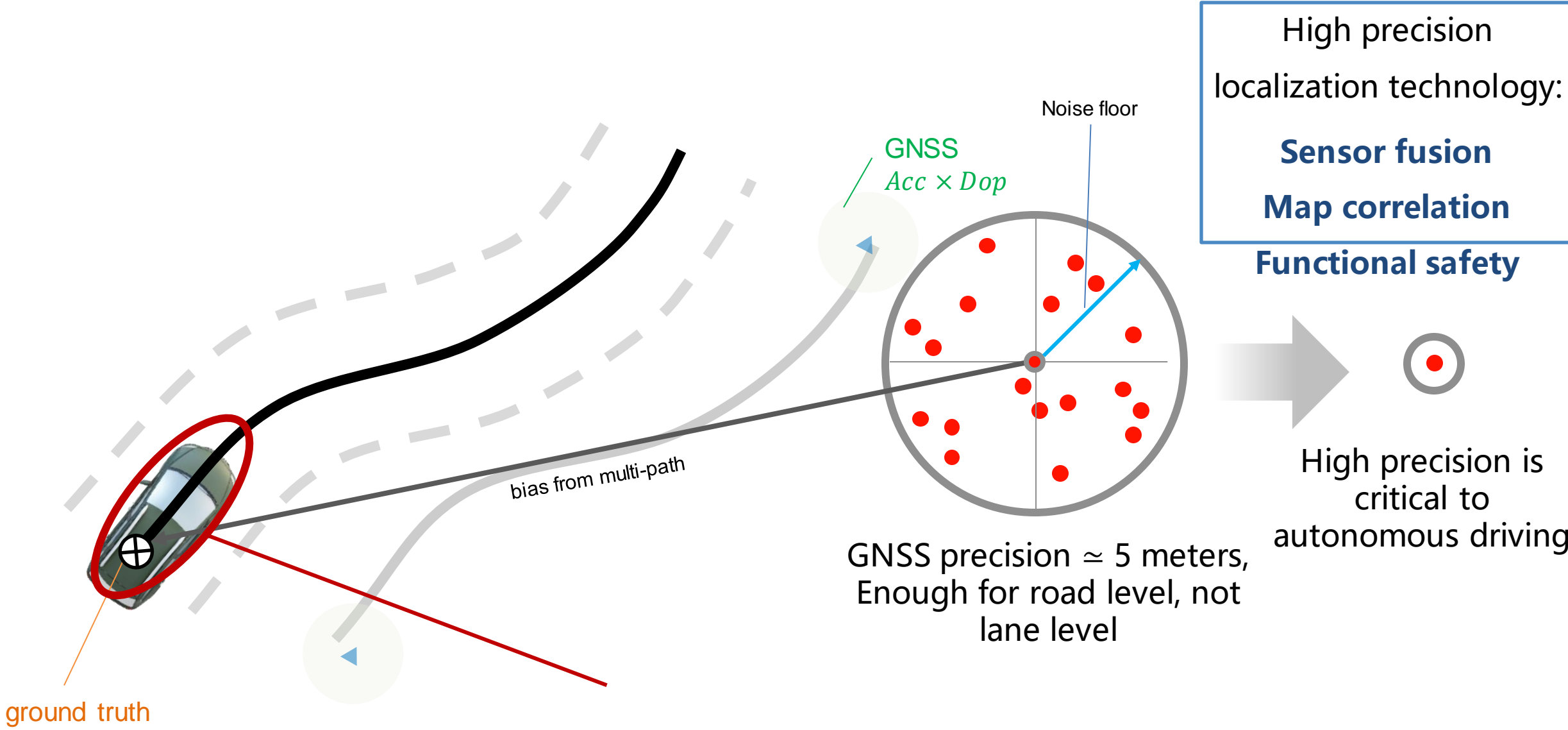- SDK on IVI SoC

customer: map provider

Digital cockpit
- Localization is key enabler for digital cockpit
- ADAS-SD cross reference
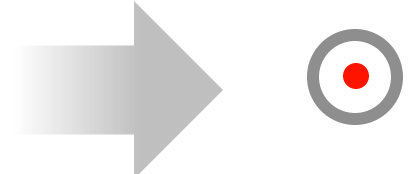- Lane level perceptional visualization
- AR navigation

Customer: OEM, tier-1

>> Market Size

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High Precision Localization

GNSS
$Acc \times Dop$

Noise floor
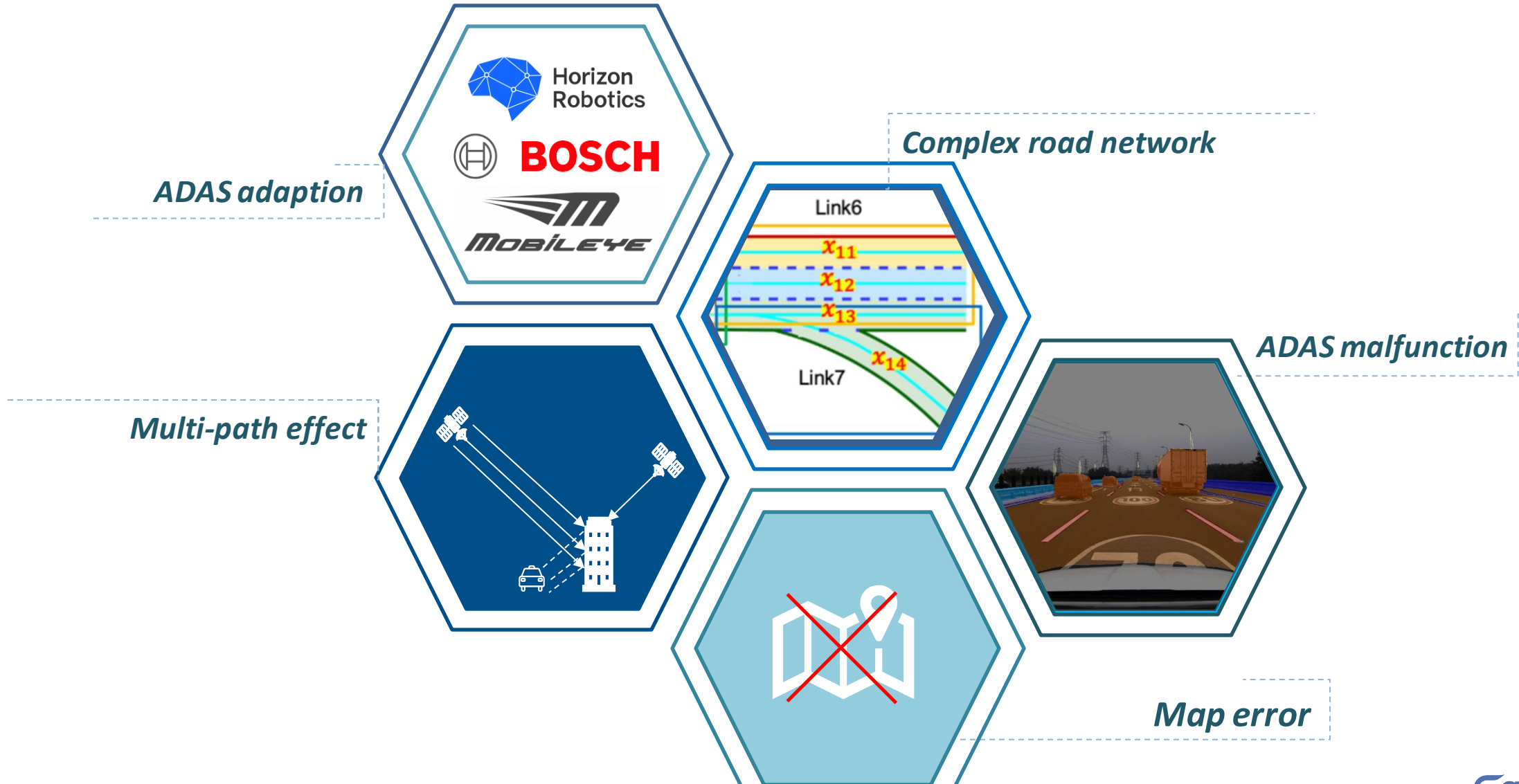
bias from multi-path

ground truth

High precision localization technology:

Sensor fusion

Map correlation

Functional safety

High precision is critical to autonomous driving

GNSS precision $\simeq$ 5 meters, Enough for road level, not lane level

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Localization – critical path toward lane level navigation

➢ Lane level positioning challenge

ADAS adaption

Complex road network

ADAS malfunction

Multi-path effect

Map error

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Localization System Architecture

Sensor fusion

GNSS (RTK) | **IMU** | **CAN**

Pseudo Range

UTC

Gyroscope Accelerometer

Odometry Heading

Hard Synchronization

RTK decoding → Multi-Sensor Fusion

Dely fusion

+
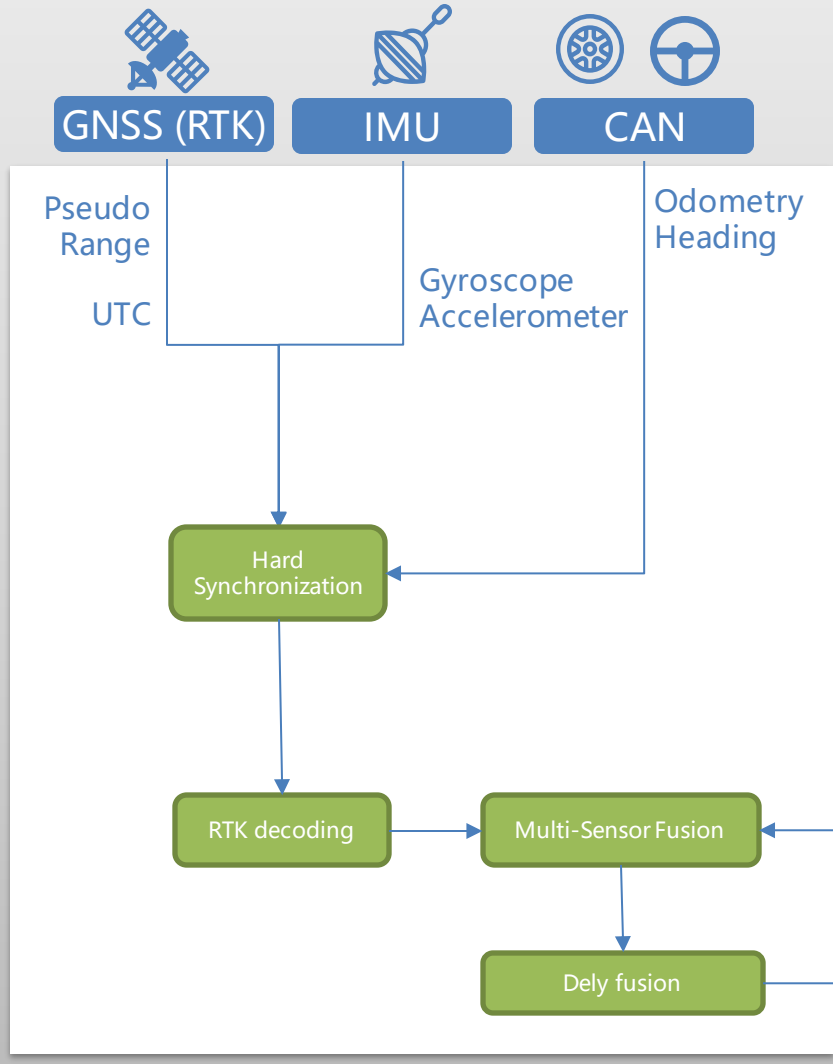
Map-Fusion module
(Capable of operating on P-Box or DCU)

ADAS Camera | **HD-Map**

Object Detection

Landmarks

Road info: (Slope/Hight)

Map Fusion

Pose Synchronization

Map correction

Pose & Speed →

Finite-State →

Host Lane ID →

Control
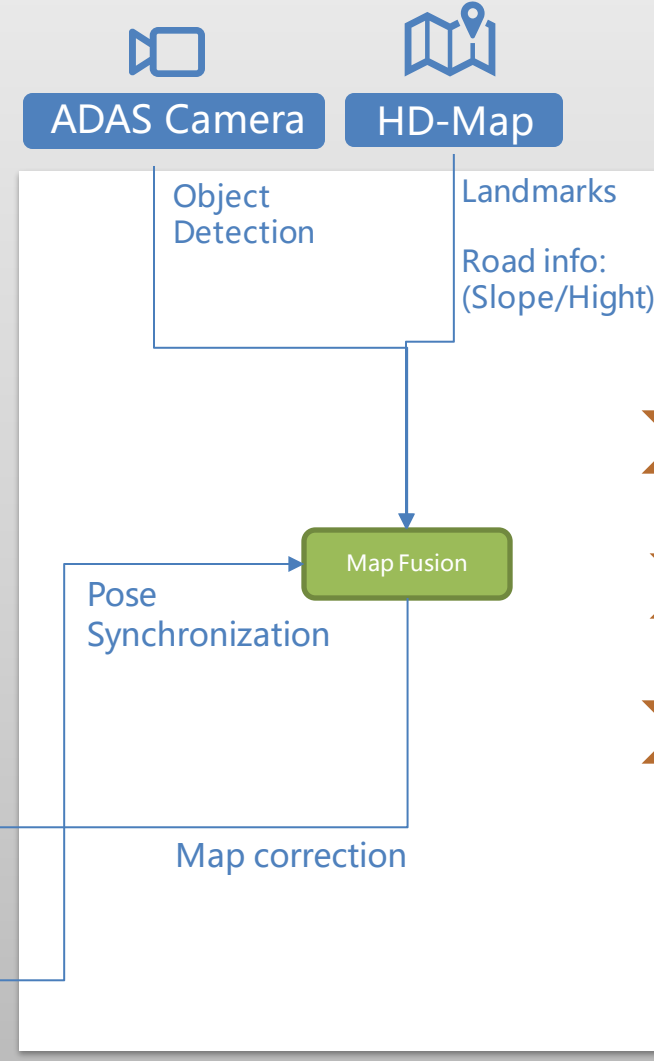
*Single hardware structure is suitable for P-Box lite/P-Box/P-Box+
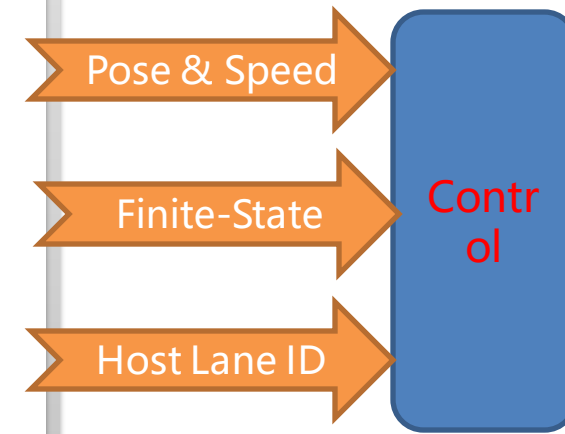
High precision
- Lateral < 0.2m@95% ,
- Longitudinal < 2m@95%
- Straight < 0.2°@95%
- Curve < 0.5°@95%
- DR < 1.5‰@68%

Low cost
- Low computing power:
- Single-core(A53) Comsumer-grade IMU Single-frequency GNSS Equipped ADAS Camera

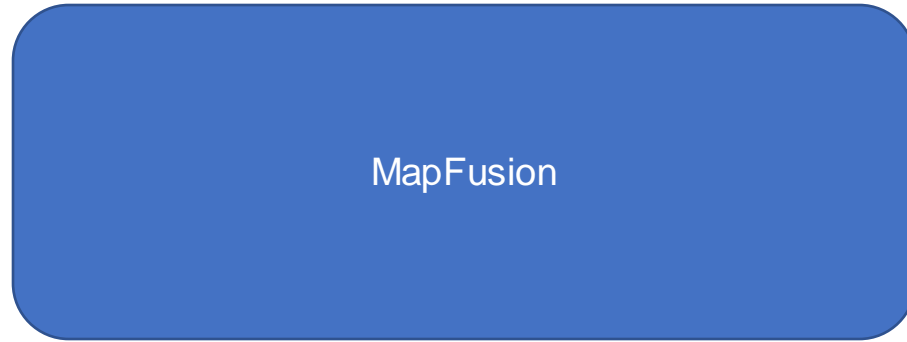### Full ODD
- Tunnel and City canyon
- Complex road network

More safer
- ASIL-B
- SOTIF

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Map Fusion - Map as a sensor

MapFusion

1. Mobile EyeQ3/Q4
2. Bosch MPC3
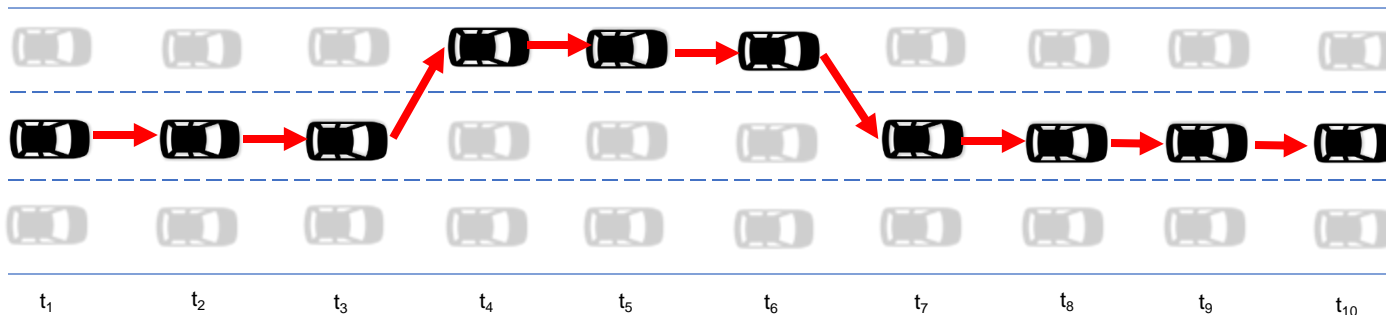3. Horizon Robotics J3
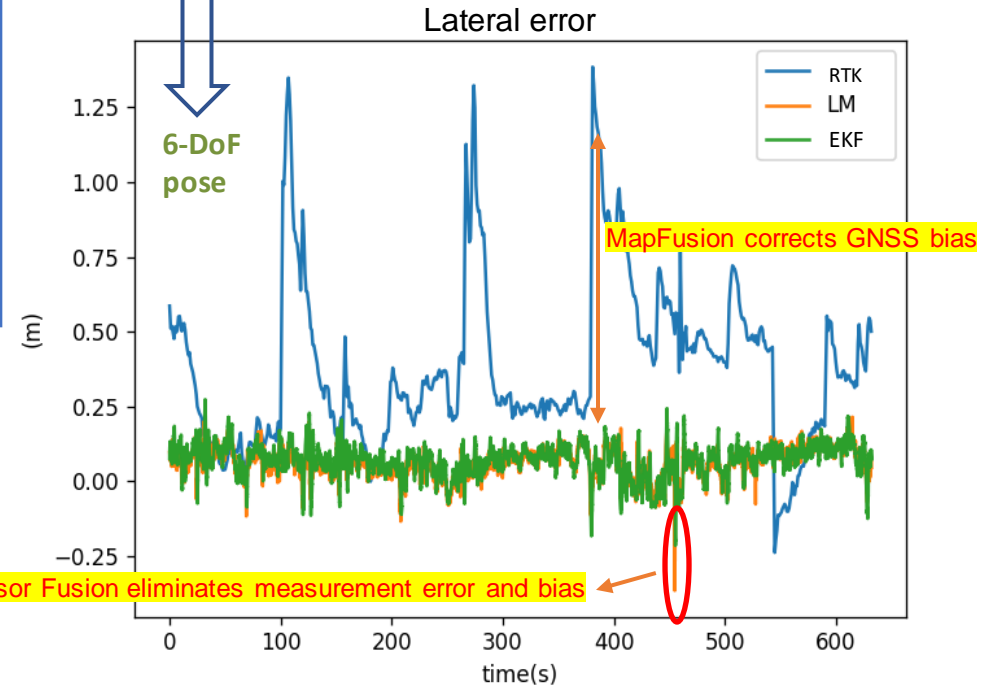
Pose

Extended Kalman Filter

GNSS IMU Odom

➤ The matching algorithm does not depend on a single frame and the current lane, but looks for the most likely lane by combining temporal and spatial information across several frames:

➤ Using ICP algorithm to match features between perception and Map to estimate vehicle pose.
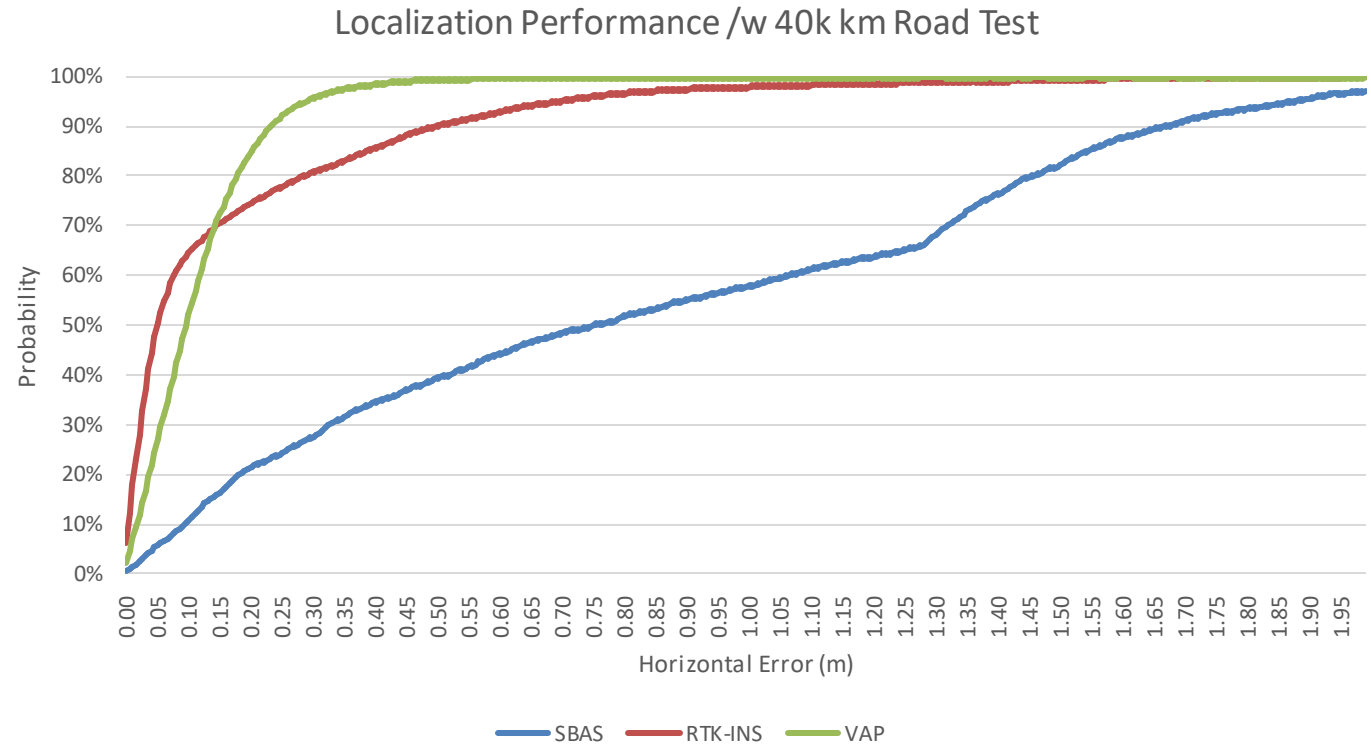
t₁ t₂ t₃ t₄ t₅ t₆ t₇ t₈ t₉ t₁₀

Path with the highest probability

6-DoF pose

Lateral error

RTK
LM
EKF

MapFusion corrects GNSS bias

Sensor Fusion eliminates measurement error and bias

(m)

time(s)

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Map Fusion - Map as a sensor

Where our localization outperform other solutions:

Localization Performance /w 40k km Road Test

Error (m)	68%	95%	99%
SBAS	1.30	1.87	2.05
RTK-INS	0.13	0.69	1.29
GW Solution	**0.14**	**0.27**	**0.76**

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Accuracy Heatmap

Wrong Lane

0.5

0.28

0.25

0.13

0

Status ✕

1624767701252

2021-06-27T04:21:41Z
Timestamp: 8689283
Response: 2.95 ms
FilterStatus: FULLST
LLH: 121.491161144442,
31.207769146637, 23.345428466797
RPY: 1.16;1.26;-131.18
Local LLH Error: -0.08, 0.62, -0.81
RPY Error: 0.76,-1.13,0.04
Estimated Accuracy: 0.00,0.00,0.00, 0.16
PositioningLevel: LaneLevel
Lane Id: [(557040097;0;0;18;1)], road Id:
[(557040097;0;0;18;0)]

Map Fusion – real example

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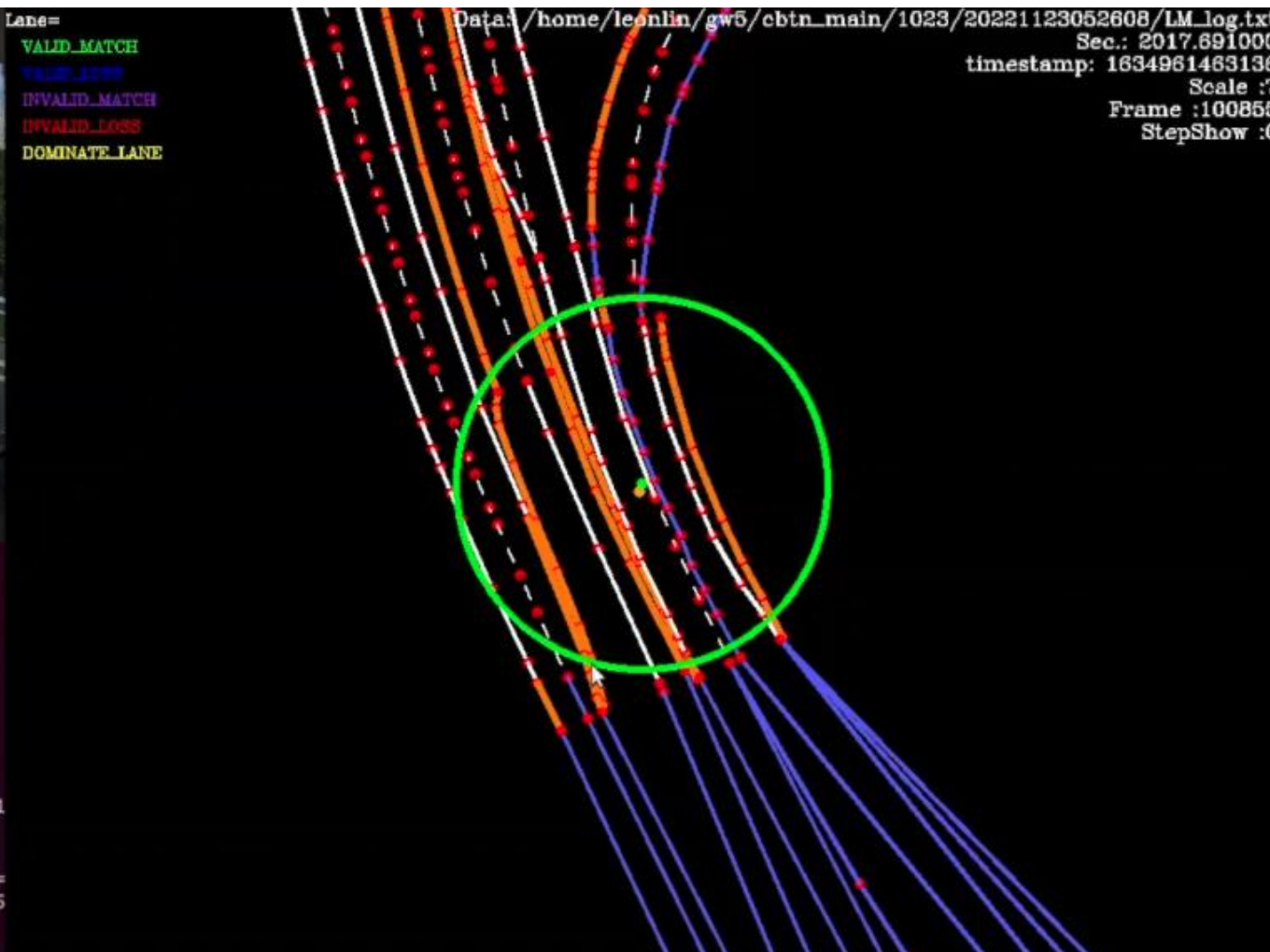
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