April 23, 2021

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How Critical Are Localization and Perception Technologies for Enhanced Autonomous Driving?

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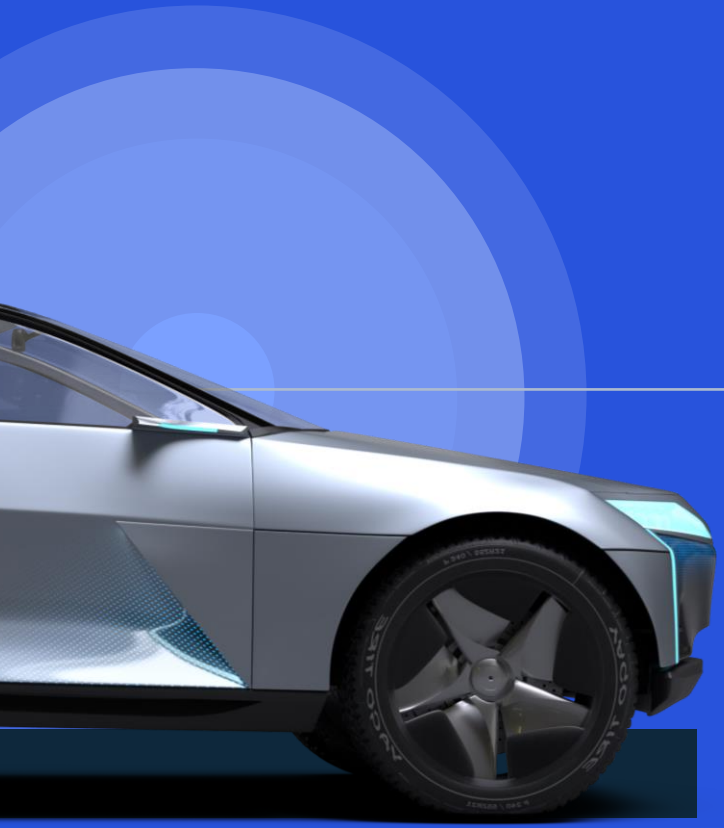
Autonomous driving is evolving

Features across each level of autonomous driving scale differently in performance and complexity



Level 1/2 → Level 2+ → Level 4+

Active safety

Forward collision warning, automatic emergency braking

Lane keep assist, departure warning

Blind-spot collision warning

Adaptive cruise control

Convenience

Adaptive cruise control with lane-keeping

Hands-off highway autopilot

Automated lane change

Autonomous parking

Self-driving

Robo taxis, robo delivery

Long-haul trucking

Parking lot to parking lot

Key solution requirements

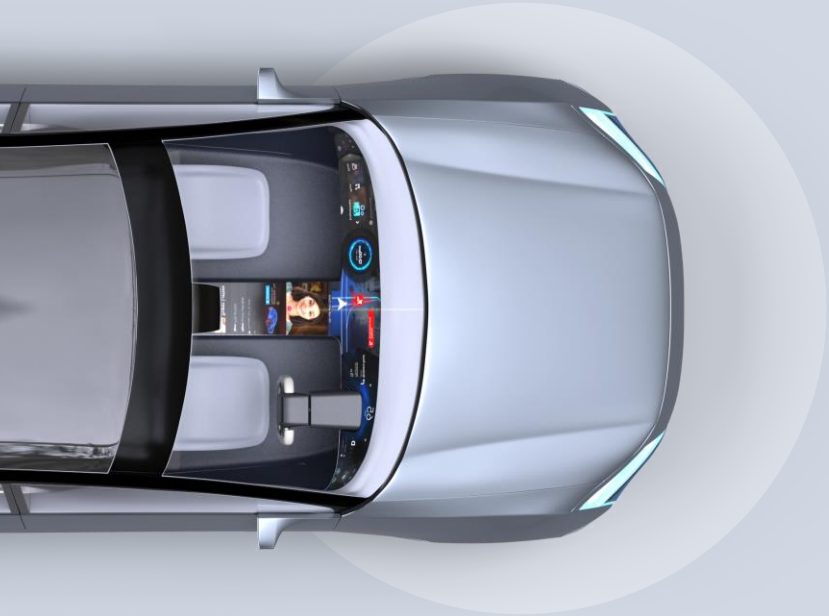
Safe, robust, and efficient

Power and thermal efficiency

Scalable across multiple car classes

For unique safety and convenience experiences

Focusing on the nervous system of the automated vehicle



Process information from diverse sensors

Active vehicle sensors

Radar
Bad weather conditions, long range, low light situations

Lidar
Depth perception, 3D long range

Camera
Interprets objects/signs, practical cost and FOV[1]

Ultrasonic
Low cost, short range

Extending horizon sensors

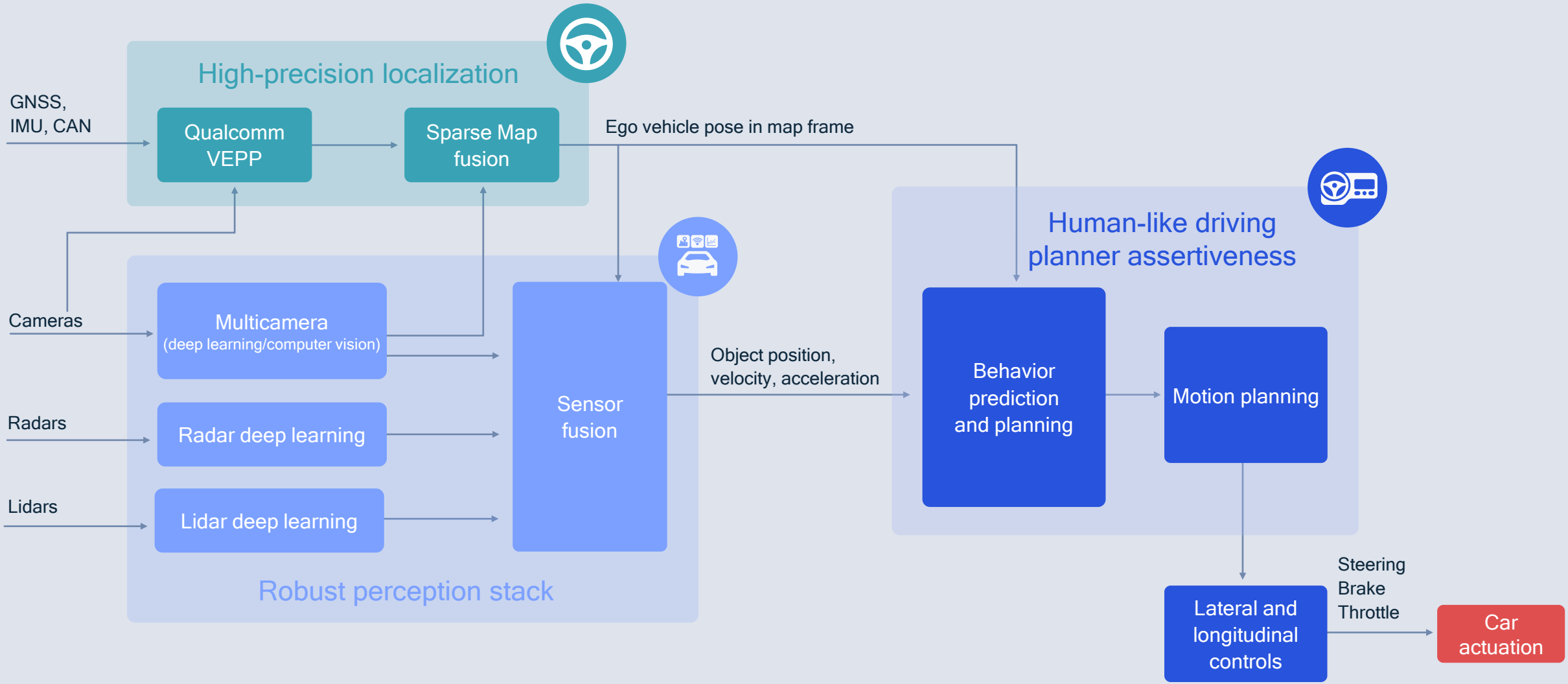
5G V2X wireless sensor
All weather, all lighting, 360◦ non-line of sight sensing, extended range sensing

3D HD maps
HD live map update, sub-meter level accuracy of landmarks

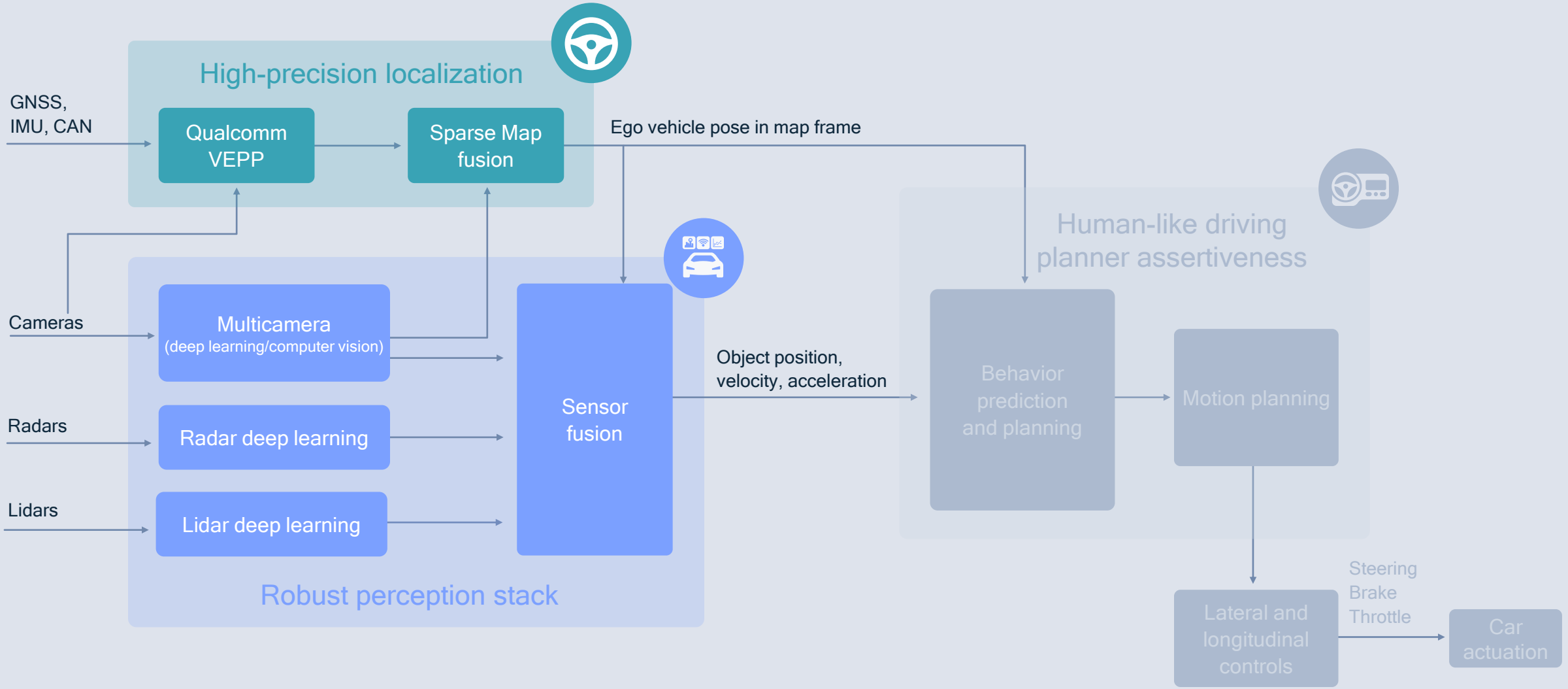
Precise positioning
GNSS[2] positioning, dead reckoning, Qualcomm VEPP[3]

1 Field of view 2 Global Navigation Satellite System 3 Qualcomm® Vision Enhanced Precise Positioning

Solving complex autonomous driving problems



Solving complex autonomous driving problems



Unified localization and mapping approach: Global and Local accuracy

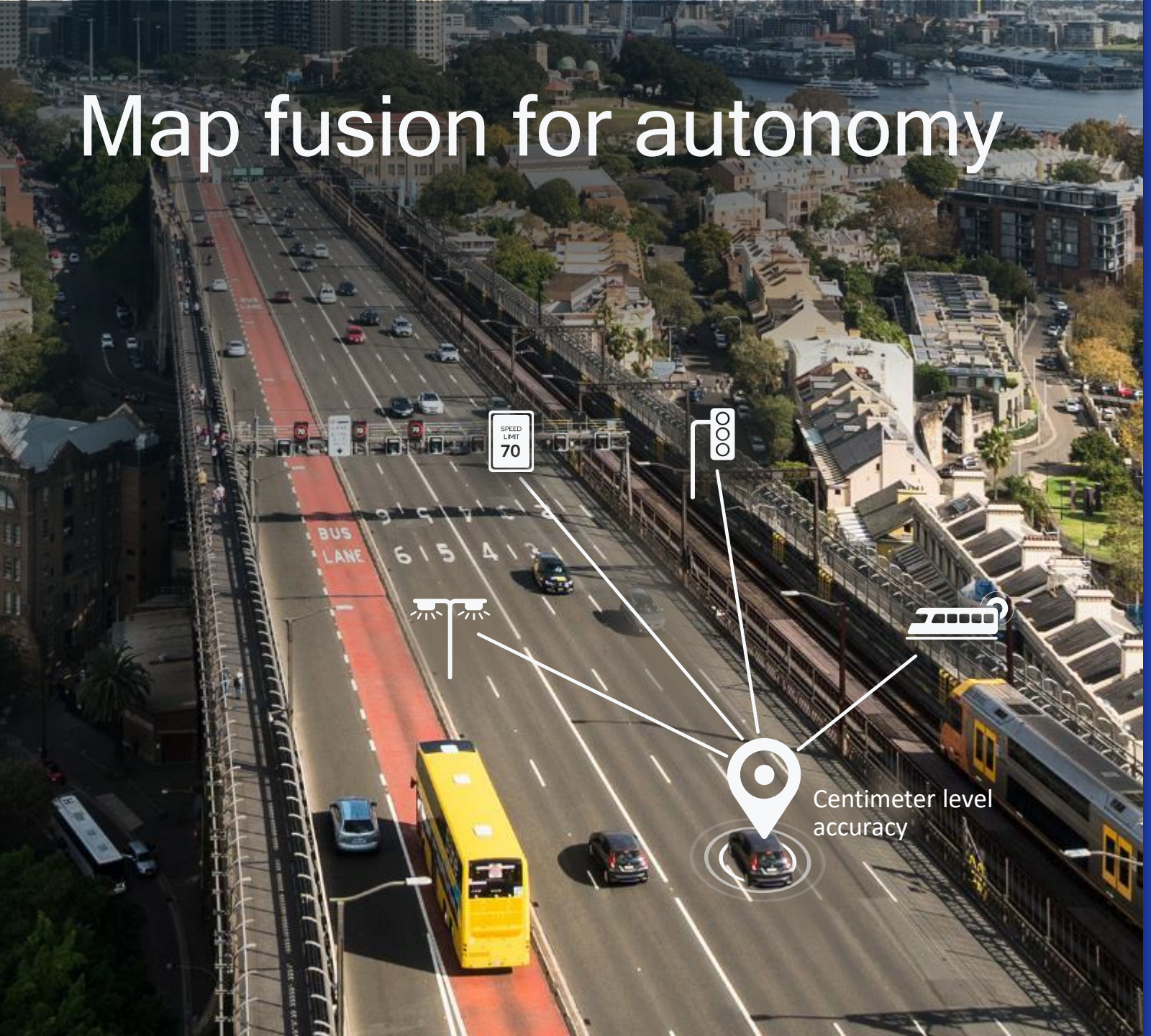
Qualcomm VEPP

Lane-level positioning virtually anywhere, anytime

Optimized for Qualcomm® Snapdragon™ processors

Qualcomm VEPP fuses camera and GNSS measurements to data from diverse on-board sensors providing lane-level accurate positioning and precise heading in the global frame in virtually all environments

Map fusion for autonomy



Map fusion: Centimeter level accuracy for autonomous driving

MAP fusion with “sparse” HD maps provides high accuracy

Using front and side cameras to identify localization features on road

Less than 10 cm lateral and longitudinal accuracy

Supports APIs from leading HD map providers

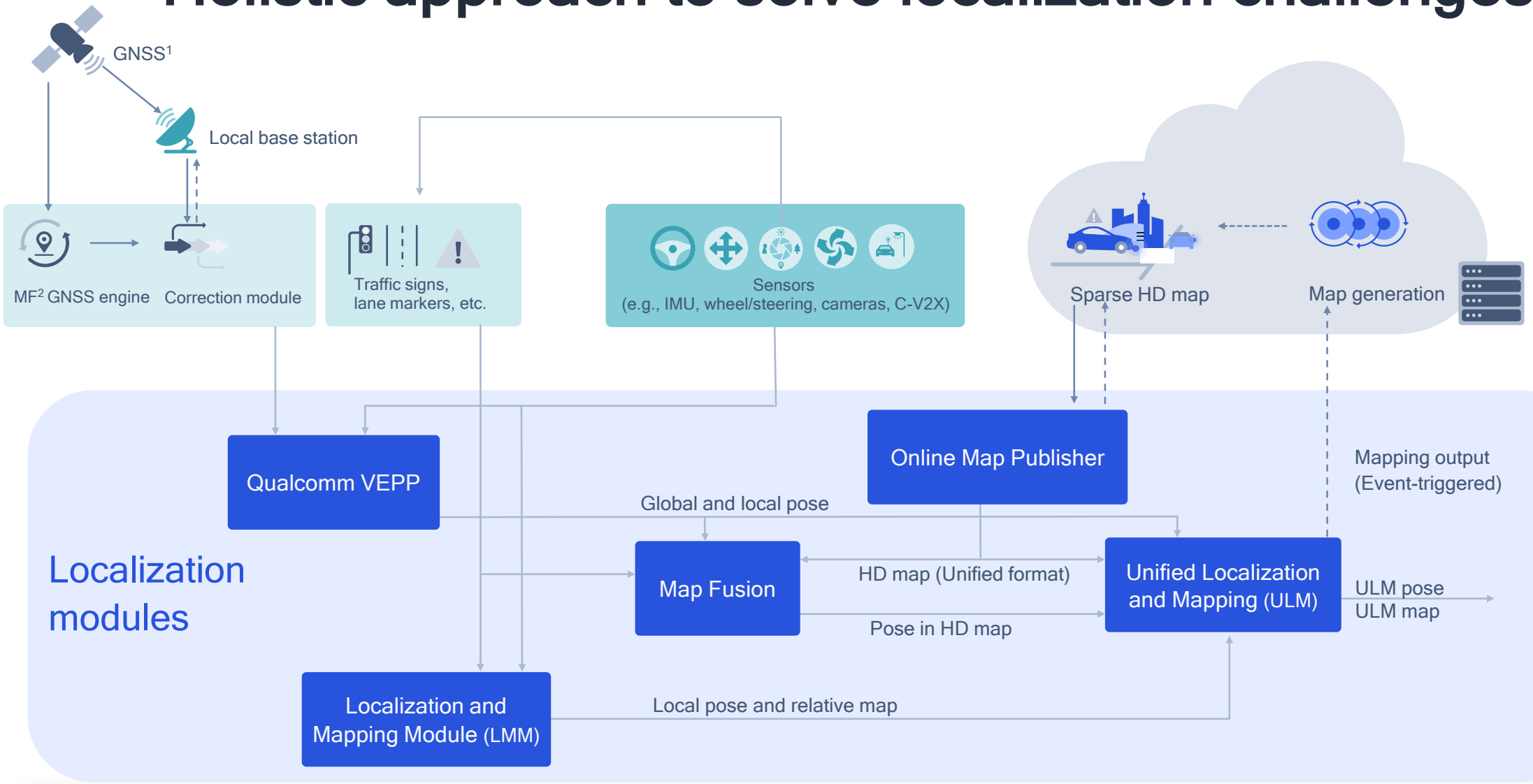
Unified localization approach

With or without HD maps

Solve challenges associated with new and/or repainted lanes

Vehicle continues safely in autonomous mode

Holistic approach to solve localization challenges



Levels of autonomous driving

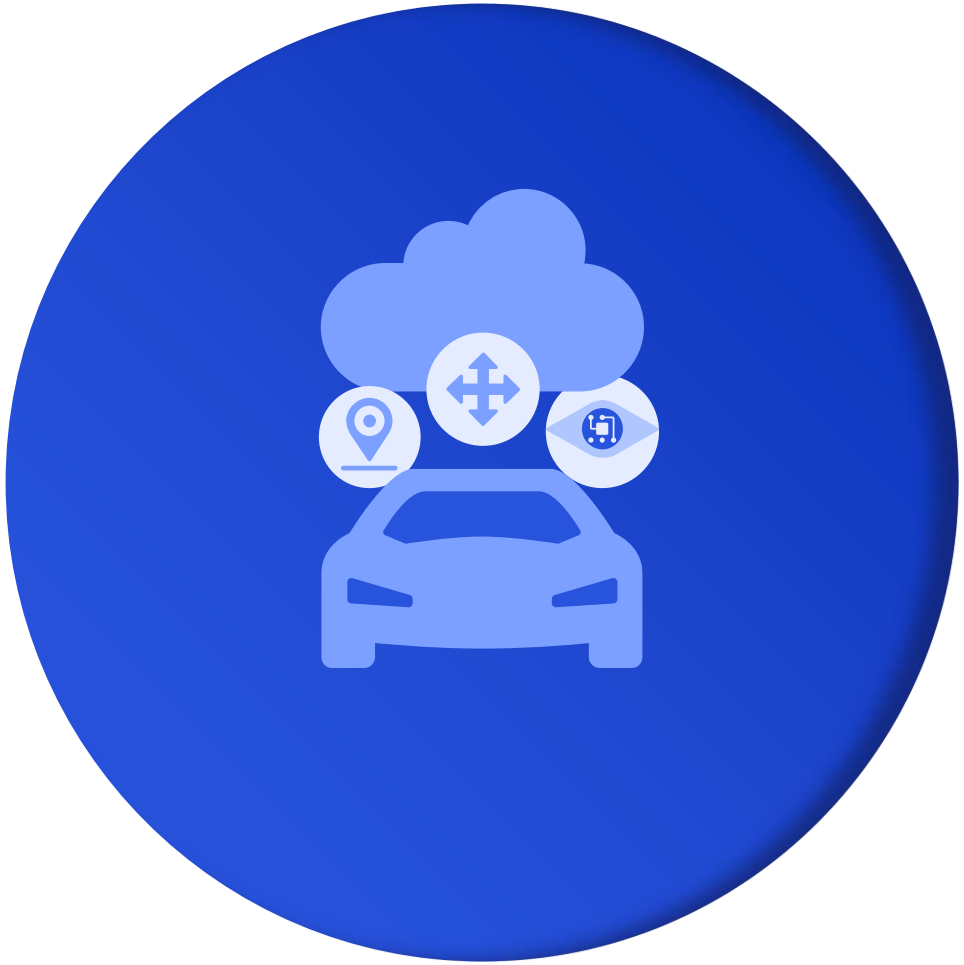
1 Global Navigation Satellite System 2 Multi-frequency

Qualcomm® Snapdragon Ride™

On Device real time map estimation for autonomous driving

- Seamless operation in the presence of gaps and errors in HD-Map
- Crowdsourcing of road changes to refresh HD-Map

Innovating novel ways for efficient and accurate environment perception



Harnessing complementary sensors for robustness and redundancy

Camera

Analyze road types, text on road signs, color of lanes/traffic lights

Radar

Affordable, long range, low visibility, velocity measurement

Lidar

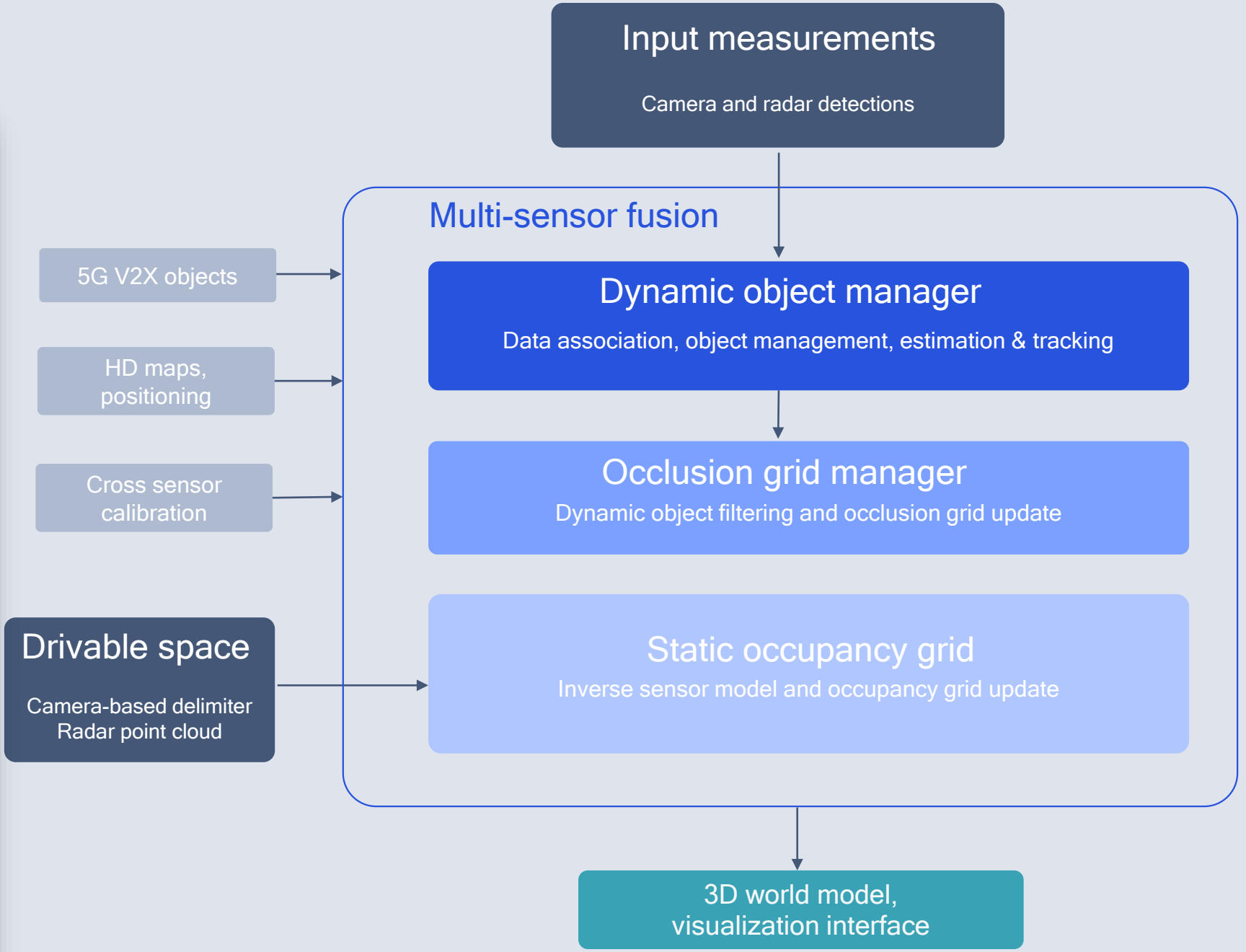
3D, long-range, high-precision

360° surround perception

Accurate 6DoF estimation

Range, velocity, and orientation

Driving advanced sensor fusion technology for scalability and robustness



Apply

Multiview geometry

Applying 3D multiview geometry

- Analyzing images from multiple cameras

Multicamera association

Use

Appearance features

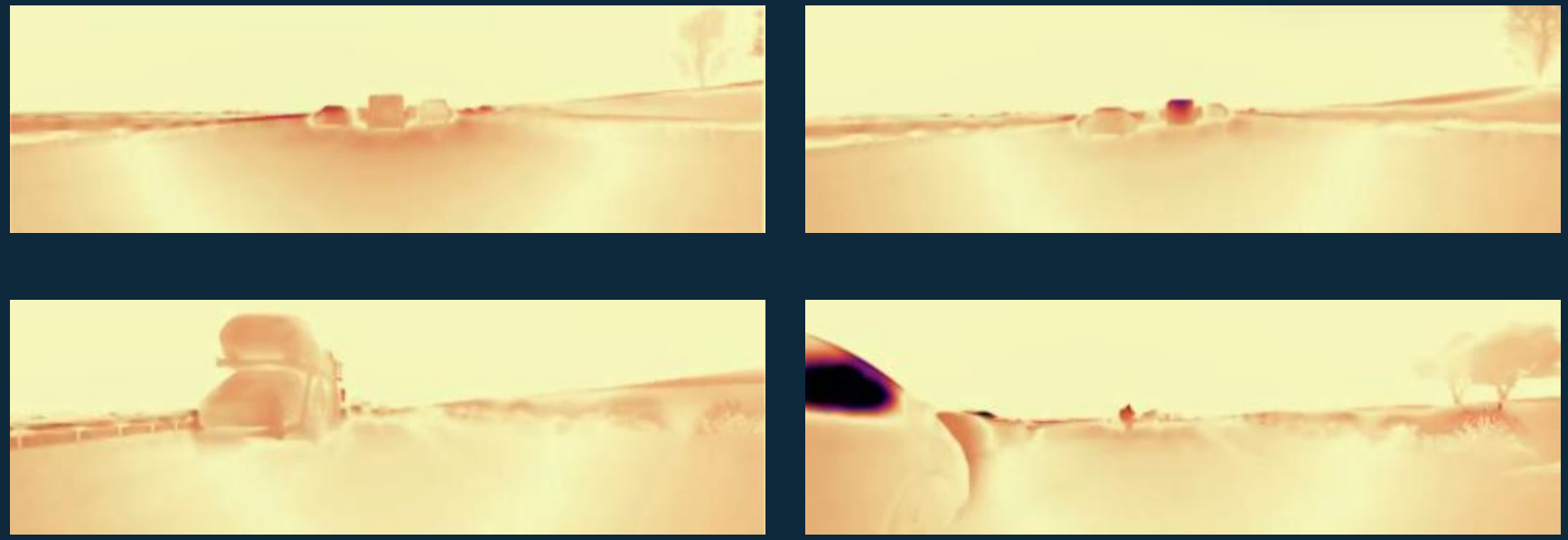
Reusing what is computed before

- CNN[1]-based feature descriptor for temporal consistency

Unique approaches to solve data association using multiple cameras to achieve robust estimation and tracking

1 Convolutional neural networks

Novel self-supervised learning technique



Screen captures from test video during on-road testing

Monocular depth estimation

Extracting depth of objects using a single camera

Achieving accuracy in vehicle keypoint detection for improved 3D object detection and ranging

Screen captures from test video during on-road testing

Multimodal robust 3D estimation

Appearance and geometry based

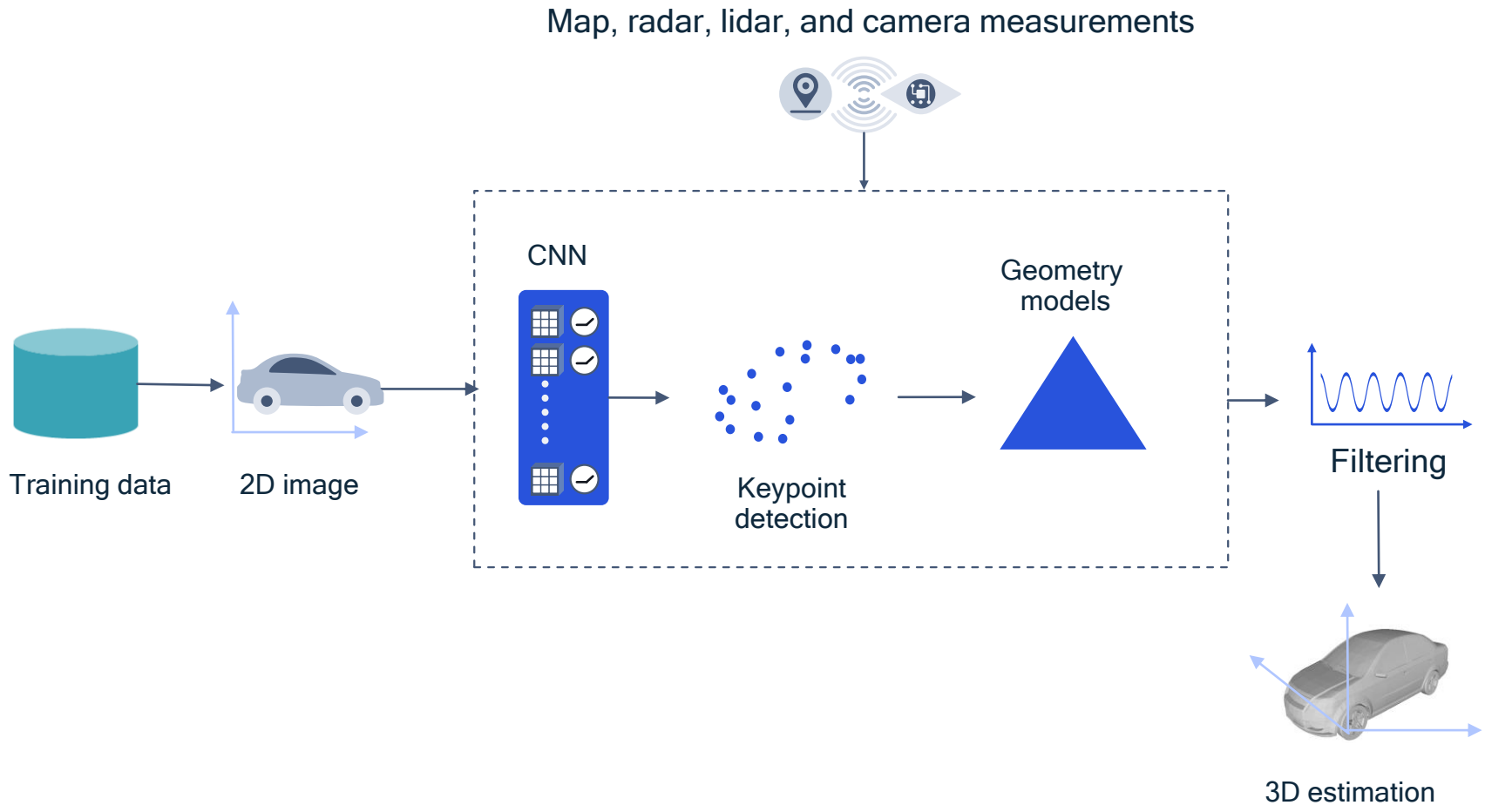
Combining visual and semantic features with deep learning and geometry models

Tracking using advanced uncertainty-aware filter

Position and speed estimation in dynamic real-world conditions with uncertainty in sensor detections and localization

Using camera, radar, and map

Uses measurement from multiple cameras, radars, and map information



Transforming 2D camera data to 3D estimations of dynamic objects

Enhancing autonomous driving with more accurate estimations

Benefits of multimodal 3D estimation

More accurate pose estimation

Provides accurate 6DoF pose of other vehicles on roads for safer driving

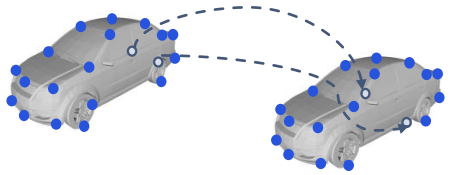
More precise size tracking

Localize large sized objects (e.g., trucks) with improved accuracy

Enable advanced autonomous features

E.g., In-lane maneuvers, lane merges, different trucks, lane-splitting motorcycles, and other complex scenarios

Multiview tracking for accurate 3D estimation



Corner points and semantic points along with feature tracking on a time-axis

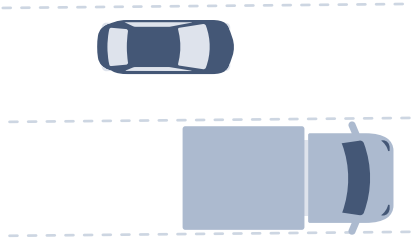
Self-supervised monocular depth estimation

Power/compute efficient and cost-effective technique for depth estimation using single image

Camera and radar-based size tracking

Hybrid geometry and learning-based estimations, Kalman filter, improved localization

Lane-vehicle association for each vehicle



Supports HD-map or camera lane detections, lateral offset estimation for all vehicles, complex situations like merges and truck overtaking

Applying multimodal multiview optimizations for 3D estimation

Camera | Radar | Maps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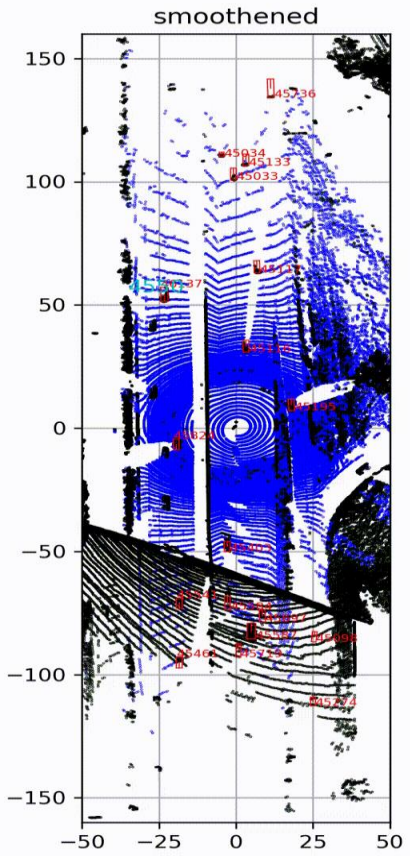
Lidar-based detection and tracking for enhanced reliability



Creating a redundancy path

Lidar-camera fusion for lane detection and classification

Object classification for road edges, static objects, traffic signs, and more

Building a validation pipeline

Facilitates automated annotation and training of camera/radar

Verification and validation of camera-radar fusion pipeline

System approach to scale autonomous driving solutions

From lab to roads

Over 100 million vehicles using our automotive solutions

Qualcomm Snapdragon Ride and Qualcomm 9150 C-V2X are products of Qualcomm Technologies, Inc. and/or its subsidiaries.

Accelerate with comprehensive frameworks and tools

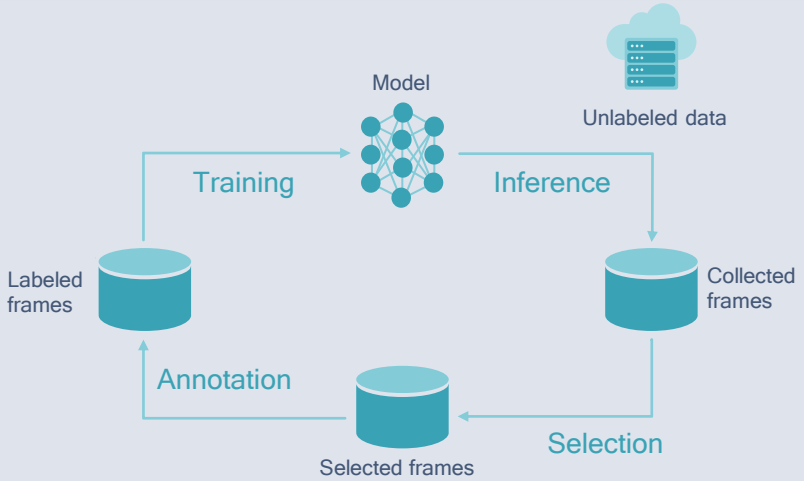
Solving key challenges in taking autonomous driving from lab to mass market

Cross sensor calibration

Data-driven technique for stringent and complex requirements

Auto calibration using optimized transformation parameters

Pre-calibrated parameters updated for aging and fluctuation



Active learning

Continuous learning framework

Improved failure identification and performance of deep learning networks

Automated system that expedites the cycle from data collection to retraining the network

Big data management

Vehicles equipped with data collection mechanism

Cloud-based data ingestion and management

Hardware-in-loop and software-in-loop testing for real-time testing

3G/4G
5G, C-V2X

CPU

GPU

DSP

Power
management

Computer
vision

AI
acceleration

Hardware-in-loop
Software-in-loop

Precise
position

Virtualization safe
RTOS integration

ADAS SoC and
accelerator

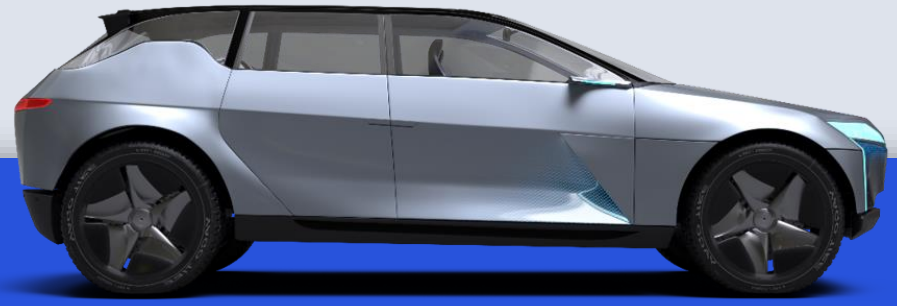
Autonomous
driving stack

Radar
perception

Image signal
processor

Safety
certification

Security



Build on our strengths in foundational technologies

Develop
new capabilities

Focus
on exceeding customer expectations

Expedite
time-to-market and new offerings

Driving automakers to continuously transform

Qualcomm

Thank you

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