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AUT

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Localization & Map-based ADAS

In aiming to enhance the accessibility and overall user experience of their ADAS features and solutions, OEMs in different regions are overlaying map and localization information onto other on-board sensors. Among the benefits of this process, for the end user and OEM alike, are the ability to optimize existing systems as well as the opportunity to deliver a more refined system functionality.

However, as localization solutions begin to gain popularity, it is essential for any automaker investigating them to have a thorough, secure, understanding of their potential. This is especially important when considering the speed at which such solutions can develop, often starting with a small area before scaling rapidly to city- or even state-wide operations.

The Localization & Map-based ADAS report outlines the key technologies already being used by OEMs, alongside the various use cases they enable. In addition to analyzing the ecosystem for these technologies today, the report also looks ahead, offering a five and ten-year outlook for the adoption of map and localization systems for ADAS. Reflecting the broad scope of these solutions are illustrations of how they are implemented in a variety of use cases to address OEM challenges and innovation goals.

COVERAGE

GLOBAL NA CHINA EUROPE

FREQUENCY

ANNUALLY QUARTERLY 1 ONE-OFF

PUBLICATION FORMAT

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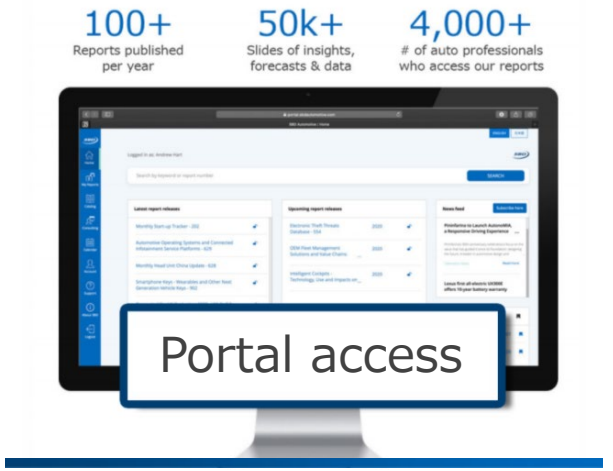
Key questions answered

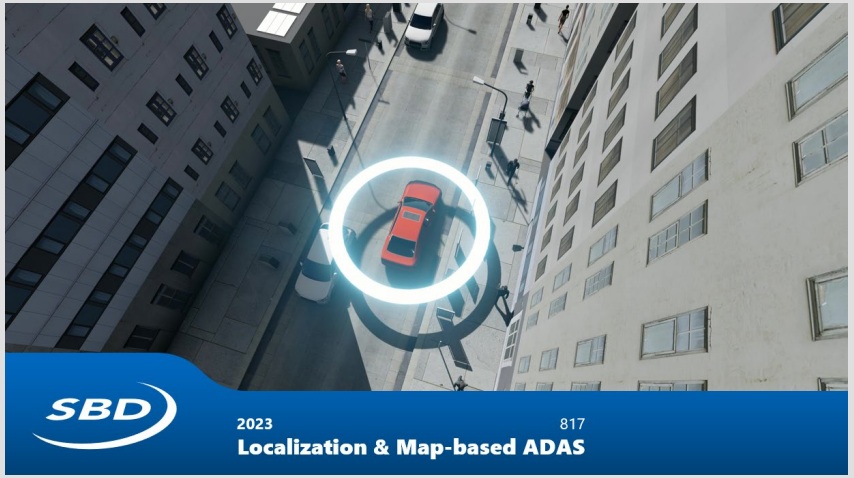
- Who is implementing localization & map-based ADAS, and with which partners?
- What are the main use cases for localization systems and digital maps for automotive?
- What are the technological enablers for localization systems?

This research supports

- Product Planners
- Engineering
- Marketing
- IT

Do I have access?





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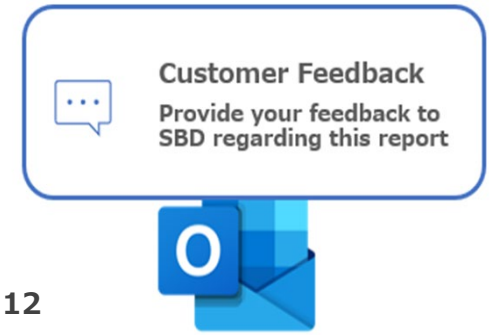

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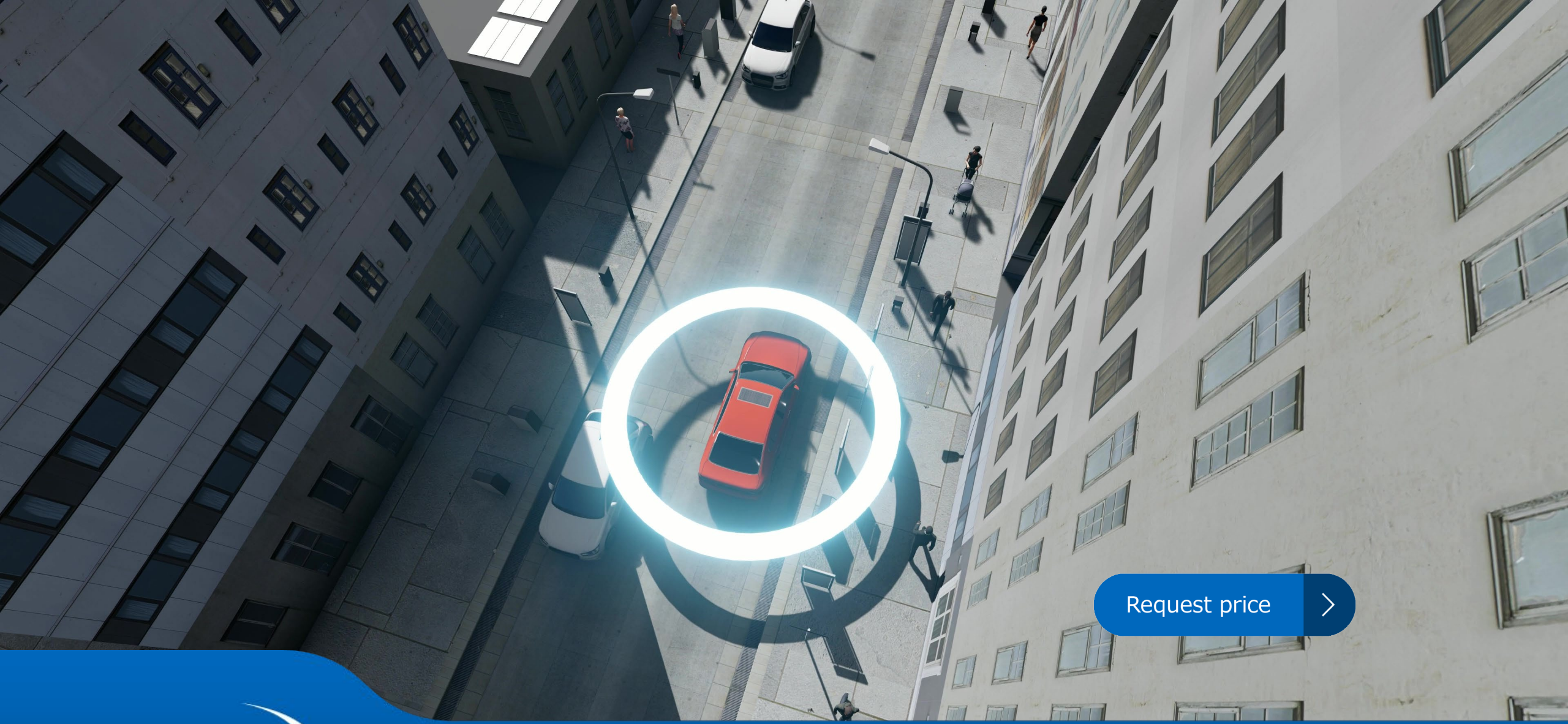

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Localization & Map-based ADAS

Introduction

Introduction

Though a clear path to automation has been set out with SAE levels of autonomy, the actual path for OEMs, and teams within OEMs is not clear. Increasing automation requires more hardware, which increases cost. Increasing automation also requires hardware redundancy. At low levels of automation, the OEM can consider the driver to be a form of redundancy, but when automation increases to 'hands off, eyes off', this will not be available.

High-Definition maps and map-based ADAS (advanced driver assistance systems) have attraction as a critical technology by some to enhance autonomous driving. HD maps contain information about environments in the 3D space. This could be information about lanes, traffic furniture and relative elevation of the road. OEMs are already using maps in multiple ways to improve and supplement ADAS.

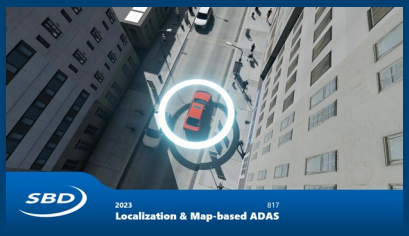
One of the ways a map can improve ADAS is to supplement the on-board sensing systems. A sensing system can be a camera and radar providing information to a central computer, which then determines the location of the vehicle on the road.

Sensing systems can be noisy. They may have clutter, blur, weather variations and time of day variations. Furthermore, developing a robust system that can detector specific objects (traffic signs, road markings) is still challenging. Object detection in urban areas is more complicated.

In this report, we present use cases and recommendations on how to deploy localization and map-based ADAS.

Section	Content
Executive summary	From the point of view of a vehicle manufacturer, this chapter evaluates the motivations and concerns that need to be balanced when developing localization systems and map based ADAS.
Localization and maps overview	This chapter introduces the basics of localization and map based ADAS.
Challenges associated with localization and maps	A more in depth look at the challenges that OEMs and map providers are facing.
Goals	A list of the goals that OEMs and Tier 1s may have when developing localization systems.
Localization and map techniques	Potential techniques for the goals outlined in the previous chapter.
OEM and Tier 1 case studies	A closer look at different examples of how localization is being used by OEMs and Tier 1s.
Analysis	SBD insight into the nuisances of localization and map based ADAS, focusing on sensor fitment and the sourcing of maps. The use of artificial intelligence and 5G is discussed.
Outlook	A forward look and outline of the potential relationships between map providers and OEMs and examples of companies not using maps for ADAS.
Appendix	Glossary of terms, list of OEMs and their predominant map data suppliers. Profile pages for major map data suppliers.

Example slides from the report



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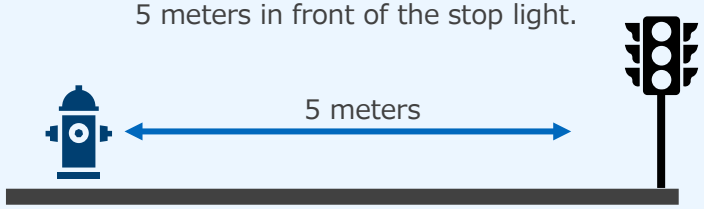
A quick background to maps and localization

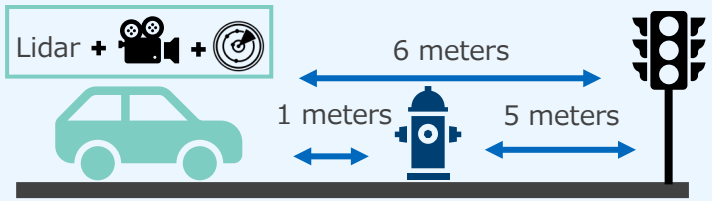
What are maps?

Map data shows the fire hydrant is 5 meters in front of the stop light.



1. GPS provides the location of the vehicle

3. With this information, the vehicle can localize itself on the map. This helps to prepare for the traffic light.



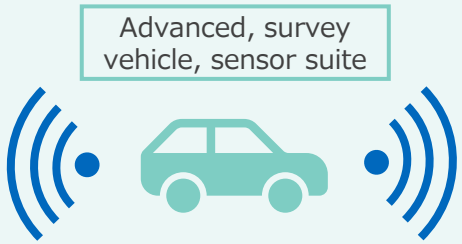
2. Sensor suite detects fire hydrant

How are maps made?

Survey vehicle

Survey vehicles are equipped with advanced sensors to detect and record changes in the environment with high accuracy

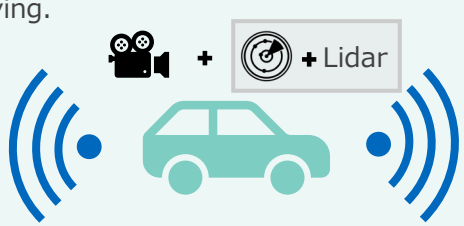
- Highly accurate detection up to centimeter level.
- High costs and slower map refresh time.



Crowd source

Consumer vehicle sensor suite detects and records changes in the environment

- Can be less accurate than survey vehicle equipment.
- Typically costs less and faster map updates than surveying.



Maps and Localization

- Localization and maps are key for autonomous goals. Localization is needed to support the vehicle placing itself within an environment. Maps can add safety benefits because they can provide the vehicle with information outside of the range of the sensors.

- OEMs can have localization without the use of maps, but not maps without the use of localization. AI can support localization in a dynamically generated model via object detection, allowing for autonomous functions without a pre-recorded map. Some OEMs have opted for this approach. It allows for the vehicles to be operated on any unmapped road but at the cost of losing some safety benefits of maps.

- Maps require localization as part of their platform. Localization techniques are used to find where the vehicle is in the environment and place it in the corresponding area in the map. Upkeep of these maps can be difficult depending on the map resolution. HD (High-definition) maps are being used by some OEMs for autonomous systems. These maps will require frequent updates, higher data transfer sizes, and higher costs to maintain. SD (Standard-definition) and MD (Medium-definition) maps will be better for use cases that require SAE level 2 capabilities.

What is localization?

Absolute position

Latitude and Longitude and GPS Coordinates

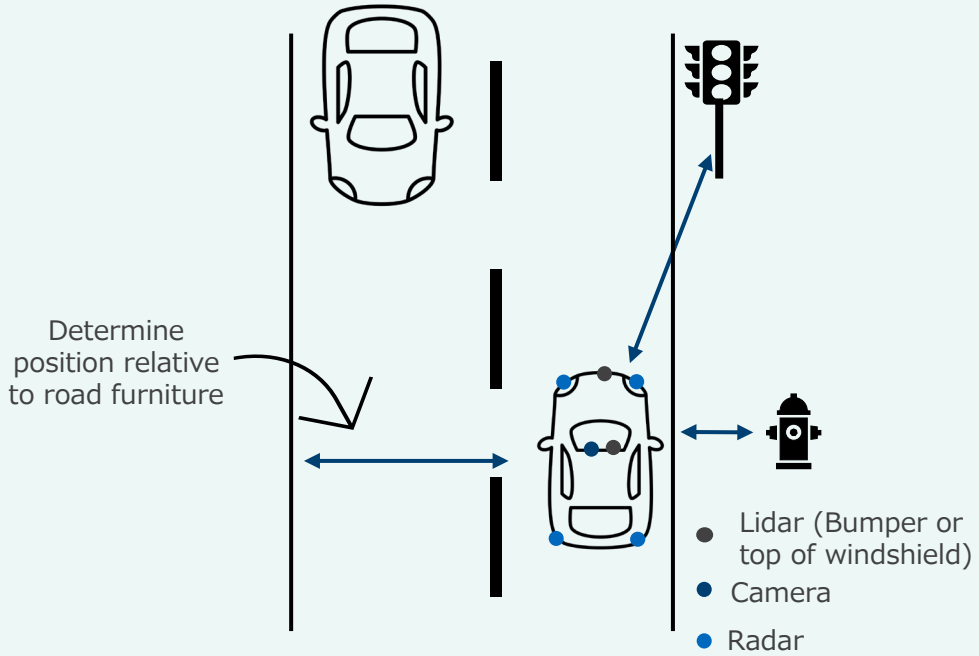
Decimal: (52.015707, -0.793956)

Degrees, Minutes, Seconds:

52° 0' 56.5452'' N0° 47' 38.2416'' W

- Localization can be the obtaining of the position of the vehicle on the earth.
- Matching the absolute position on the globe is challenge because of the size of the area being covered.
- Small errors in sensing or map add up over large scales.
- Long strings of latitude and longitude could result in floating point errors, large storage needs, or efficiency tricks. Map formats and compilation address these issues.
- Navigation uses absolute positioning to match to mapped real-world locations.

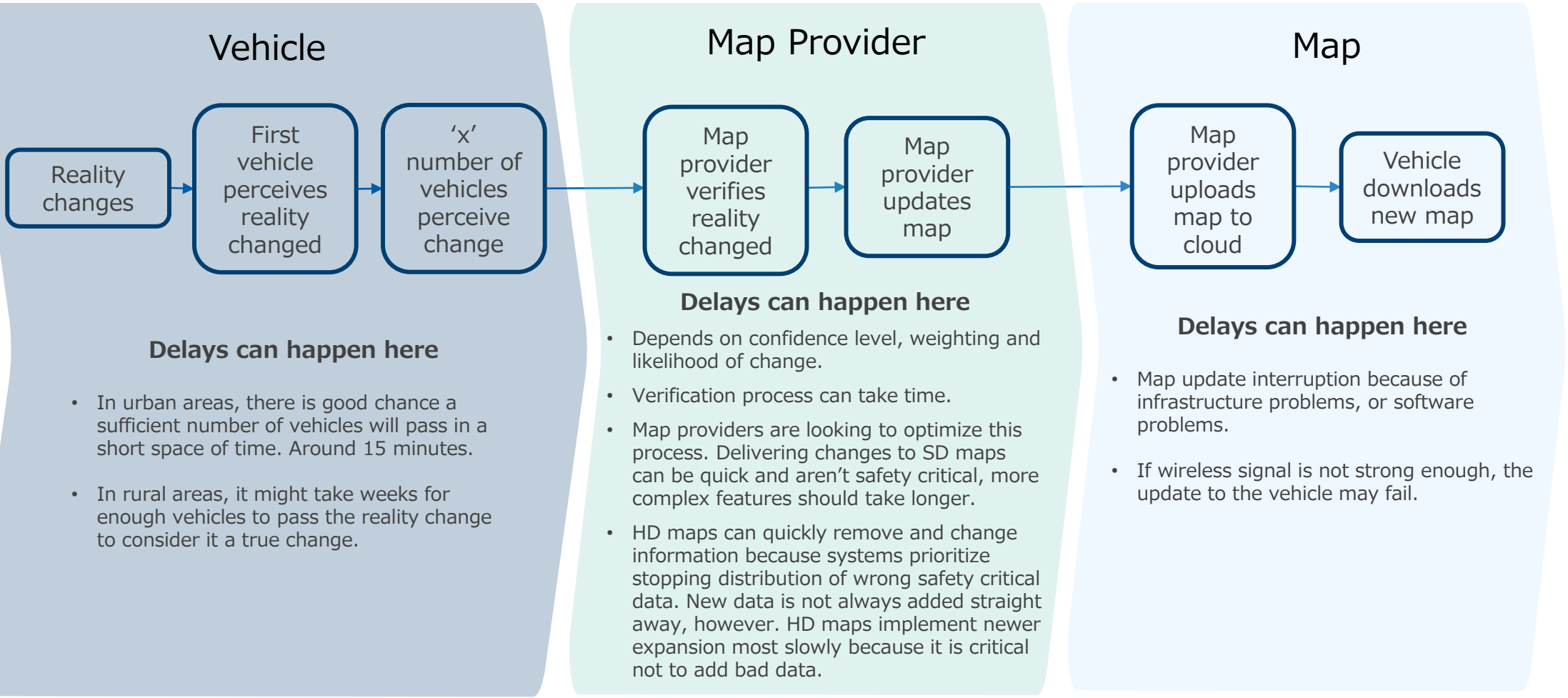
Relative position



- Using the relative position of a vehicle instead of the absolute position reduces impact of global map errors.
- Relative positioning can be performed using road furniture and lane features. These can be matched with a map to determine the vehicles position relative to all items on the map.
- Relative positioning is used many ADAS such as Mobileye based systems.

Challenge No. 1: Delays to updates can occur

Data collection for a map can be by survey vehicle or crowdsourcing or both. Survey vehicles must be driven frequently to provide accurate data which is costly (and unrealistic). Crowdsourcing is reliant on private vehicles to collect data to map out an area. Lower grade sensors on consumer vehicles can lead to less accurate data collection than survey vehicles. Survey vehicles have expensive dedicated hardware for map data collection. Consumer privacy can be a concern with crowdsourcing.



Compliance with intelligent speed assistance regulation

Overview

Some regions have made intelligent speed assistance (ISA) mandatory, which can increase driver awareness of the current speed limit (passively implemented, provide warnings only) or prevent speeding by automatically decelerating (actively implemented).

For example, European legislation has made ISA mandatory for all new vehicles starting in 2022 and all vehicle types sold will be equipped with ISA, where 90% accuracy is required. It means that digital map data needs to be in place to satisfy this requirement, which is also pushed by Euro NCAP. Other regions, including the USA, are expected to develop similar regulations.

Success Factors

Sensor fusion technologies, high map accuracy and freshness.

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Taking ISA as an example, to show why map can act as an additional sensor on the vehicle, camera-based ISA can be sufficient in most of the scenarios, but cameras handle conditional speed poorly which can impact compliance. A fusion approach can be considered to mitigate the disadvantages of each sensor.

When it comes to safety regulation compliance, the required map freshness may need to improve (e.g. Euro NCAP stipulate the speed limits must be updated at least quarterly), as incorrect map data can impact compliance.

European ISA regulations also require OEMs to have a long-term map update strategy, which OEMs already had in place voluntarily.

Summary Table

Drivers		
Lead Innovation	Smoother Drive	Consumer Demand
Added Customer Convenience	Higher Autonomy	**Increase Vehicle Safety**
Sensor Costs		
<$1000	$1000 - $5000	>$5000
Maturity		
In-development	Pilot	**Market ready**
Map Level Required		
SD Map	MD Map	HD Map

Vehicle alignment to refueling or recharging systems

Overview

Vehicle location is one of the primary data points that is needed to share with other systems to achieve certain features. For example, in wireless charging the alignment of the transmitter and receiver coils is significant for the high performance and efficiency of wireless power transfer. Some localization technologies considered here include the UWB-based localization and camera and RF-based solution.

Nio launched their battery swapping service in January 2022 and upgraded their battery swapping stations in 2023, which enable Nio vehicles automatically park in the battery swapping stations precisely and then conduct battery swapping. The battery stations is equipped with 200+ sensors (cameras and ultrasonics) to localize the vehicle and communicate to the vehicle to perform automatic maneuvering.

Success Factors

Well-defined business model, V2I communication techniques and hardware, related guidelines and standards.

SBD Insights

Vehicle alignment is the prerequisite condition for innovative solutions. The hardware and software system need to be calibrated and well-developed to cooperate together to achieve the features. This may require the solution providers work with car manufacturers to gain more vehicle data and vehicle access. Another potential bottleneck for these innovative solutions can be the scalability issue; finding a sustainable way to gradually launch and expand the service can be challenging for these solution providers.

Summary Table

Drivers		
Lead Innovation	Smoother Drive	Consumer Demand
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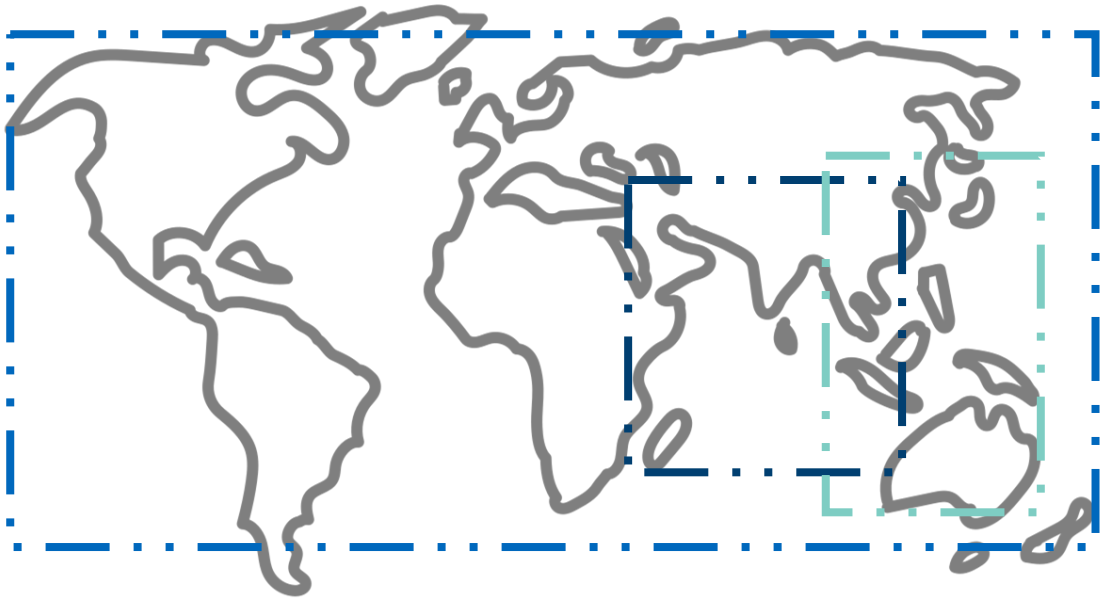
SD Map	MD Map	HD Map

A note on global navigation satellite systems

Coverage of satellite constellations



Box Color	Constellation
Teal	QZSS
Dark Blue	NavIC
Light Blue	GLONASS, GPS, BeiDou, Galileo

Approximation of coverage shown

GLONASS

- Global coverage since 2011
- 1602 MHz band only
- Positional accuracy of 5-10 meters

GPS

- Global coverage since 1995
- 1176.45 and 1575.42MHz band
- Positional accuracy of 3.5 – 7.8 meters

BeiDou

- Global coverage.
- 1176.45 and 1575.42 MHz bands
- Positional accuracy of 2-3 meters

Galileo

- Global coverage since 2019
- 1176.45 and 1575.42 MHz bands
- Positional accuracy of 2-3 meters

Geely

- Low earth orbit (not GNNS)
- Can support V2X and autonomous driving
- Centimeter level accuracy

NavIC

- Regional coverage
- 1176.45 and 1575.42 MHz bands
- 3m accuracy

QZSS

- Regional coverage since 2018
- Designed to enhance signal in urban canyons in Japan
- 2 m accuracy, sub-meter with included augmentation signal

BMW HD maps for hands-free driving

Overview

BMW is utilizing HERE for Predictive Routing and Real-time traffic information, which is a cloud-based routing functionality that learns individual driving patterns to propose more personalized journeys. BMW group uses HERE HD Live Map for hands-free driving in the United States and Canada. Hands-free driving is available on 7-Series, up to 85mph or 130 km/h on selected highways.

The HERE HD Live Map provides road geometry, route profile and traffic signs, enabling hands-free driving on interstates and highways. HERE is planning to support the expansion of level 2+ support to all types of roads.

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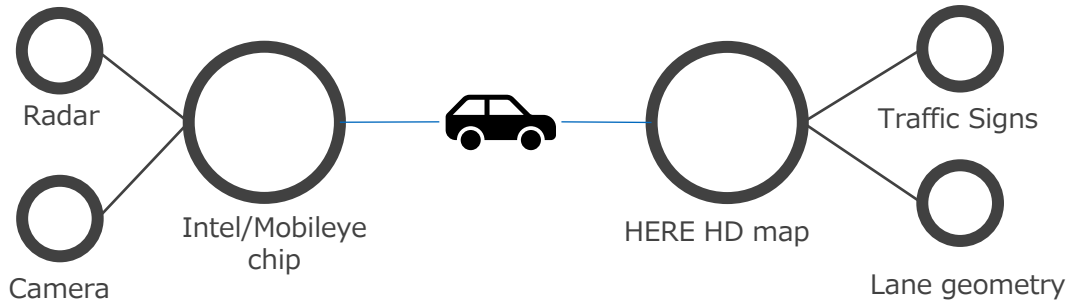
HERE's lane-level data serves as a redundant source of information to the vehicle on-board sensors, which can provide additional quality assurances for the system. However, in reality, the performance of the SAE level 2 hands-free driving is highly depended on how good the perception, decision and control systems are, as the live map data cannot determine the quality of the ADAS. Also, "hands free driving" can be a false term in the regions that currently not legally allow driver's hands off the steering wheels.

Technical Information

Sensor choice					
Lidar		Radar		Camera	
Localization Input					
V2I	GNSS	Map Matching	Sensor-Based	Dead Reckoning/IMU	
SAE Automation Level Demonstrated					
L1	L2	L2+	L3	L4	L5

Localization Techniques & System Diagram

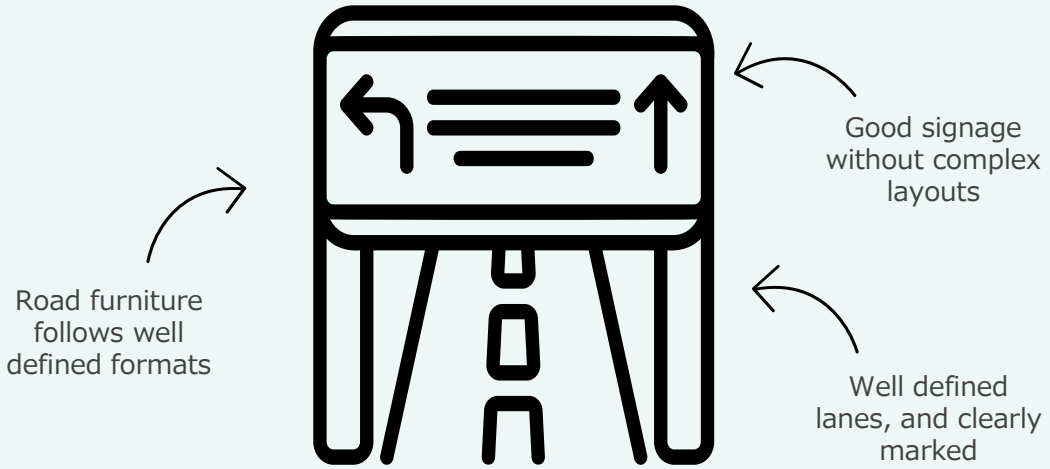


Future Possible Applications

Hands-free driving is considered as a SAE L2 ADAS, which needs constant driver's monitoring. This is the level that most OEMs and ADAS will stay for a long period of time. However, this level of autonomy will have multiple constraints so that many potential applications cannot be implemented since the driver is still highly interacting with different ADAS.

OEM and Map Provider – pick and choose the data you use

The map can have varying levels of influence

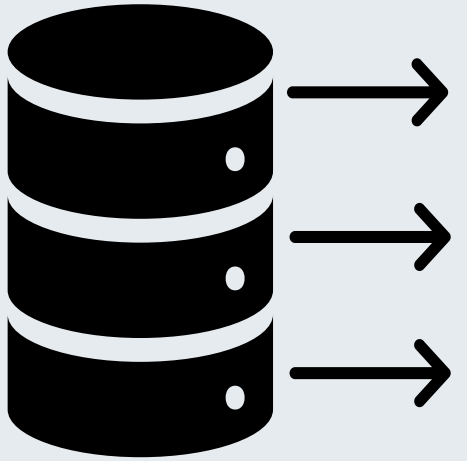


This is a potential operational design domain where dependence on a map can be reduced

- Currently, there is a clear use case for maps. The use of maps is a way of achieving the required certainty in localization for autonomous functions.
- Rather than using a map in all cases, OEMs can approach the map as a sensor with varying levels of influence. This helps distribute the safety burden more evenly across other sensors.
- Level of trust and reliance on maps should depend on the type of information, the confidence of the sensors, the parameters of the map (freshness, quality estimate and precision). The system should find a middle ground between always trusting the map and trusting a sensor more than a map.
- Maps can be expensive. Compilation and processing of maps is also costly. In certain location types the map could be marked with ‘no map required here’.

Identify the data that allows you to differentiate from competitors

Representation of data in the map ecosystem



Map providers may tailor a map to an OEM. This cost of recompiling a map each time is high. This is important for an OEM to consider.

Map data that is not essential to its operation and is generated by user. This could be data related to regular habits of the users or information about destinations and journey times.

Core map data, provided by map supplier.

- Consider keeping the data that is not essential to map function, and not sharing it with your map provider.
- As an OEM, you may have to accept that this will limit the map providers’ ability to tailor and improve their system. Instead, in-house expertise would be needed to benefit from this differentiating data.
- As shown above, there are different types of data that are present in the map ecosystem. An OEM may wish to develop a strategy for identifying the data that can be used to help the OEM differentiate their ADAS from competitors.
- Expect crowd sourcing partners to be interested in receiving high quality data and being involved in the specification of hardware (to ensure good quality data is provided).

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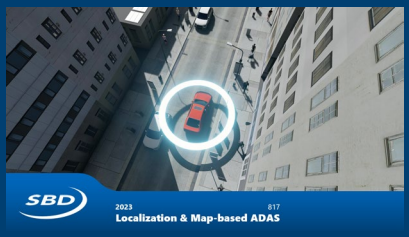

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