Scalable software solutions for driving and parking

Presentation

ADAS software solutions

Overview

Advanced driver assistance systems

	Entry segment	Mid segment	High segment
Requirement	 ▪ Regulations ▪ Consumer tests (NCAP, ...) ▪ Driving comfort L1 (ACC, ...) ▪ Driving comfort L2 with driver-initiated lane changes ▪ Simple parking use-cases	 ▪ Regulations ▪ NCAP ▪ Driving comfort L1 ▪ Driving comfort L2 with hands-free and system-proposed lane changes ▪ Simple urban driving ▪ Parking L2 advanced features ▪ Parking visualization features	 ▪ Regulations ▪ NCAP ▪ Driving comfort L1 ▪ Driving comfort L2 with hands-free and system-proposed lane changes ▪ Complex urban parking and driving ▪ Valet park assist ▪ Parking L2 advanced features ▪ Parking visualization features
Perception	▪ Perception (radar and video) ▪ Fusion	▪ Perception (radar and video) ▪ Fusion	▪ Perception (radar and video) ▪ Fusion
Sensors	▪ 1 front video camera ▪ Up to 4 corner and 1 front radar sensors ▪ Driver monitoring camera or occupant monitoring camera ▪ Up to 12 ultrasonic sensors ▪ Up to 4 surround view cameras	▪ 1 front video camera ▪ 1optional rear video camera ▪ 4 radar sensors and 1 optional front radar ▪ Driver monitoring camera or occupant monitoring camera ▪ 8 to 12 ultrasonic sensors ▪ 4 surround view cameras	▪ 7 video cameras ▪ 1optional rear video camera ▪ 4 radar sensors and 1 optional front radar ▪ Driver monitoring camera or occupant monitoring camera ▪ 8 to 12 ultrasonic sensors ▪ 4 surround view cameras ▪ Optional vehicle localization
Services	▪ Vehicle localization: road hazard warning and road signature behavior map on road level	▪ Vehicle localization: road hazard warning, road signature localization and behavior map on lane level	▪ Vehicle localization: road hazard warning, road signature localization and behavior map on lane level
Compute	▪ Decentral and central ECU solutions	▪ Central ECU solutions	▪ Central ECU solutions

Software stack

Portfolio overview

Software stack

Overview

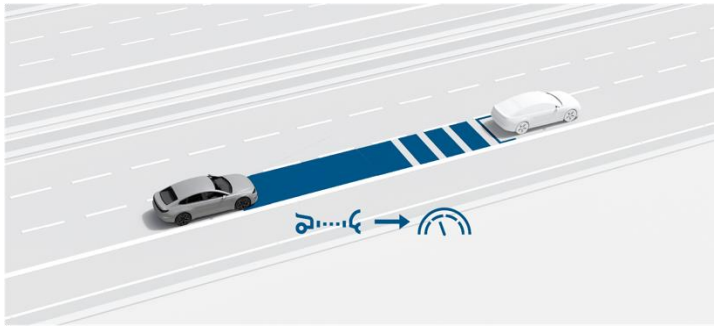
Vehicle localization				
Driving functions	Parking functions	Safety functions		
USS perception, radar perception, video perception				
Middleware	Bosch AOS preferred or (OEM defined)			
POSIX OS				
SoC				
Hardware	 Ultrasonic sensors	 Radar sensors	 Cameras	 Micro meachnics unit performance

Driving functions
Functions and features

Longitudinal	Lateral	Lane change	Emergency stop
Adaptive cruise control ▪ Base ▪ Stop&go ▪ Plus	**Lane centering assist** ▪ Base ▪ Enhanced ▪ Plus	**Active lane change** ▪ Enhanced ▪ Plus ▪ Premium	**Emergency stop** ▪ Base ▪ Enhanced ▪ Plus
Value-add features ▪ Braking on standing objects ▪ Advanced cut in/out prediction ▪ Red traffic light control	**Value-add features** ▪ Variable lateral offset ▪ Roundabout steering assist ▪ Hands-free	**Value-add features** ▪ Active gap approach ▪ Hands-free with gaze confirmation	**Value-add features** ▪ Stop at outer side of lane ▪ Park on shoulder

Driving functions

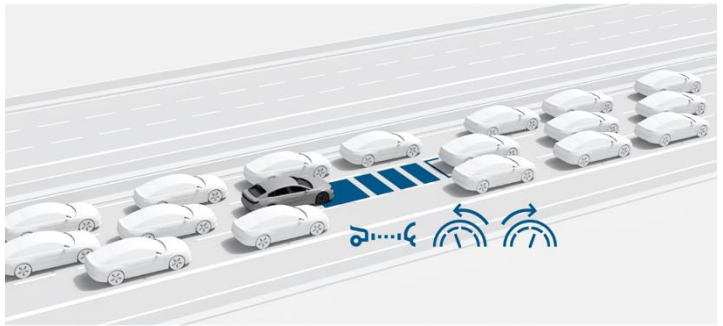
Adaptive cruise control (ACC)



ACC base

Feature description:
- Extends standard cruise control with an automatic adjustment of the speed and distance to preceding vehicles
- Distance to preceding vehicle can be adjusted by driver
- Includes curve speed control

Key benefits:
- Enhanced comfort: relief from adjusting speed & distance to preceding vehicle
- Increased safety: reduces speed before any automatic emergency braking (AEB) feature is triggered



ACC stop & go

Feature description:
- Extends standard ACC base with an automatic adjustment of the speed and distance to the preceding vehicle in stop & go traffic situations

Key benefits:
- Increased comfort: relieve from adjusting speed and distance in dense traffic and stop & go situations such as traffic jams
- Advanced availability: adaptive cruise control can be used within the complete speed range

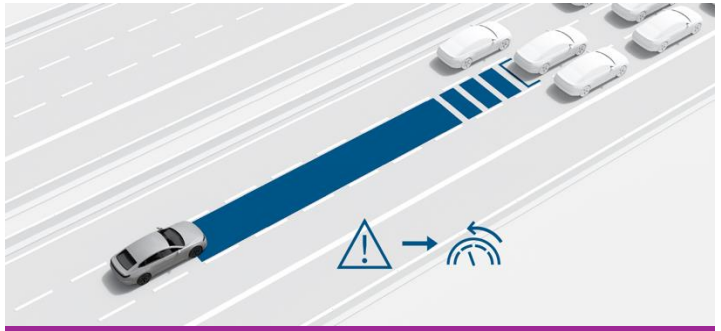
ACC plus

Feature description:
- Extends ACC stop & go with a predictive, automatic speed adjustment according to actual speed limits and road characteristics

Key benefits:
- Increased comfort: less driver interaction required, more natural driving style
- Increase safety: speed limits are always followed and speeding in curves is avoided
- Supports Euro NCAP: points for (1) automatic ACC set speed adaptation or (2) allowing the driver to change the set speed manually

Driving functions

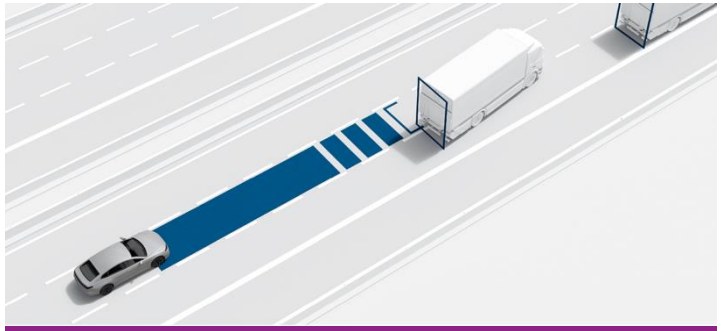
Adaptive cruise control (ACC): Value-add features



Braking on standing objects

Feature description:
- Decelerates comfortably to standing vehicles in the ego lane
- The feature is continuously extended to higher ego vehicle speeds and supports up to 130 kph

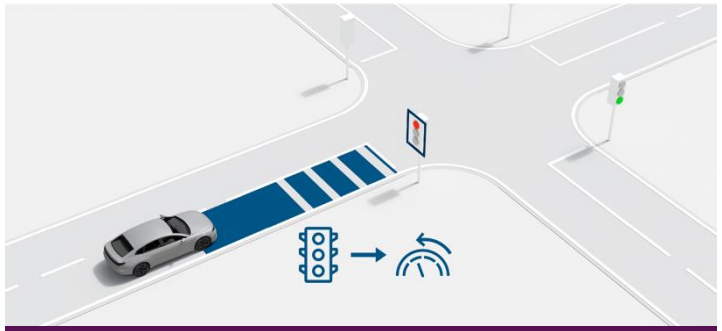
Key benefits:
- Increased safety: reduces ego vehicle speed before AEB features are triggered
- Extended availability: no driver interaction is needed when approaching a standing vehicle



Advanced cut in /out prediction

Feature description:
- Anticipates maneuvers by preceding and neighboring vehicles on multi-lane roads
- Trained neural network identifies lane changes of neighboring vehicles into ego lane proactively and enables a more natural ACC reaction
- Different regional traffic behavior can be trained and reflected in neural network

Key benefits:
- Enhanced comfort: faster reaction of ACC to lane change maneuvers of neighboring or preceding vehicles
- Increased safety: safety distance is achieved sooner when neighboring vehicles change into ego lane



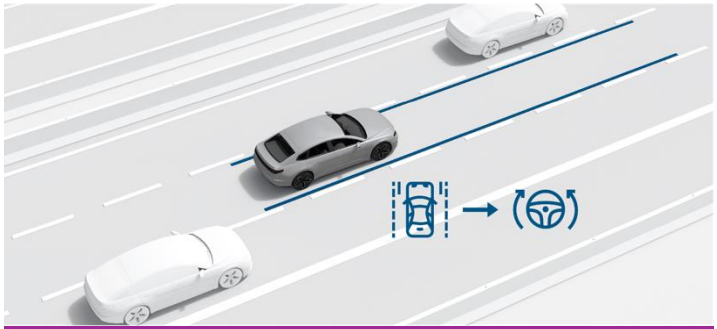
Red traffic light control

Feature description:
- Red traffic light control decelerates the vehicle and stops when a traffic light turns or is red
- The right traffic light is identified based on turn signal triggered by driver
- The identification of the right traffic light can be enhanced when navigation route information is provided

Key benefits:
- Enhanced comfort: automatically stops at traffic lights without driver intervention
- Increased safety: supports in awareness and reaction to traffic lights

Driving functions

Lane centering assist (LCA)

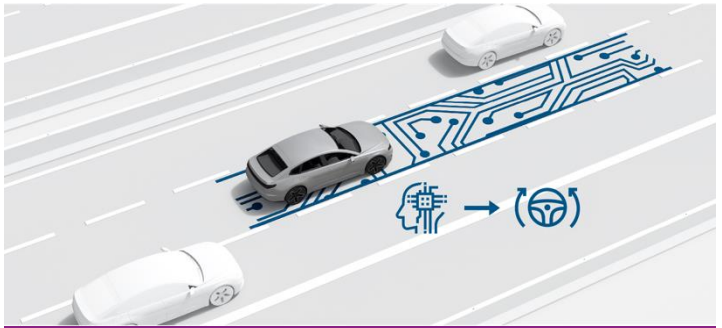


LCA base

Feature description:
- Continuously supports the driver by keeping the vehicle centered in its lane
- Can be activated when clear lane markings are present
- The driver can intervene at any time seamlessly via the steering wheel

Key benefits:
- Increased comfort: actively keeps vehicle in its lane
- Enhanced safety: prevents drifting outside of lane
- Supports achievement of up to 5 stars in Euro NCAP
- Availability: above 90 % on highways and 80 % on all roads*

*Based on Bosch reference route

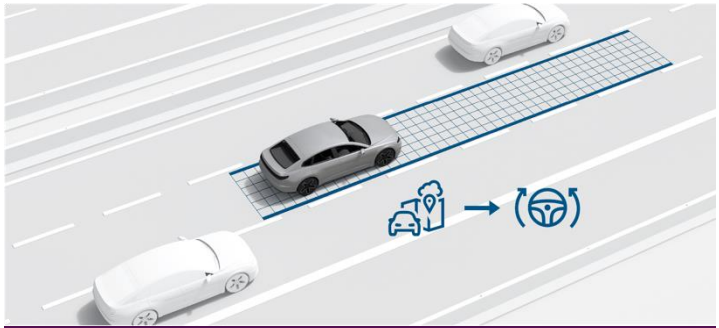


LCA enhanced

Feature description:
- Keeps the vehicle centered in its lane when line markings are not perfectly visible or only partly present
- Higher availability and natural driving position through a model trained with field data

Key benefits:
- Increased comfort: extended foresight and more natural steering behavior through real-life training
- Enhanced safety: offers support when limited guidance is available for driver
- Availability: above 98 % on highways and 93 % on all roads*

*Based on Bosch reference route



LCA plus

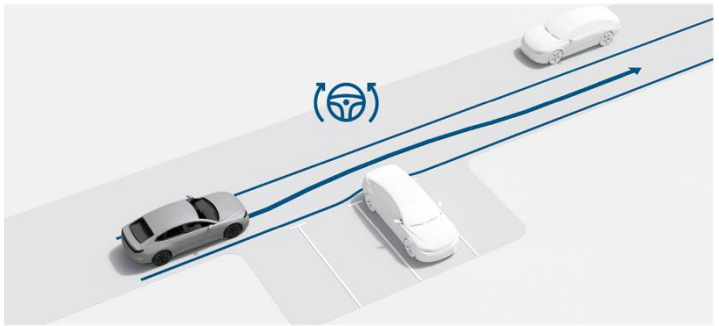
Feature description:
- Keeps the vehicle centered in lane for nearly any driving situation, lane marking visibility and presence
- The vehicle position is determined via video or radar sensor data and a constantly updated localization map layer
- The lateral position is determined with a map-based planning layer which is created with field data from other vehicles

Key benefits:
- Increased comfort: natural and precise positioning of vehicle in driving lane
- Enhanced safety: offers support when limited guidance or visibility is available for driver
- Availability: 97 % overall, 99 % highway*

*Based on Bosch reference route

Driving functions

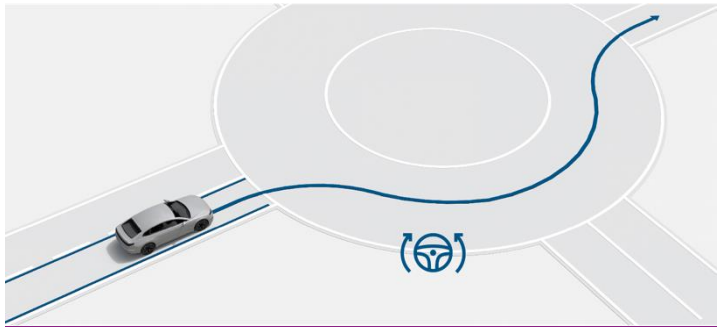
Lane centering assist (LCA): Value-add features



LCA variable lateral offset

Feature description:
- Multi-lane roads: continuously monitors lateral position of neighboring vehicles and adjusts the ego vehicle position within its lane to ensure a safe distance
- Urban driving: handles static objects reaching into driving lane and increases safety distance towards dynamic objects in front of vehicle close to ego vehicle lane

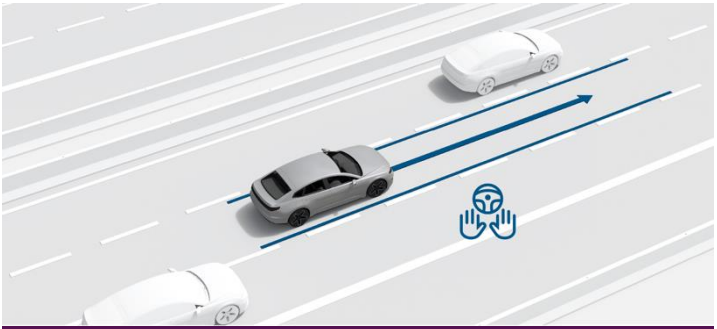
Key benefits:
- Increased safety: reduces risk of side collisions on multi-lane roads and in urban areas
- Extended comfort: more natural and foresighted lane centering by incorporating other traffic participants



LCA roundabout steering assist

Feature description:
- Provides support in roundabouts by using data-driven models trained with real-life data
- The vehicle is automatically steered into the roundabout and follows it until the driver actively steers towards the exit

Key benefits:
- Extended availability: lane centering assistance in roundabouts
- Increased comfort: support in unaccustomed driving situations



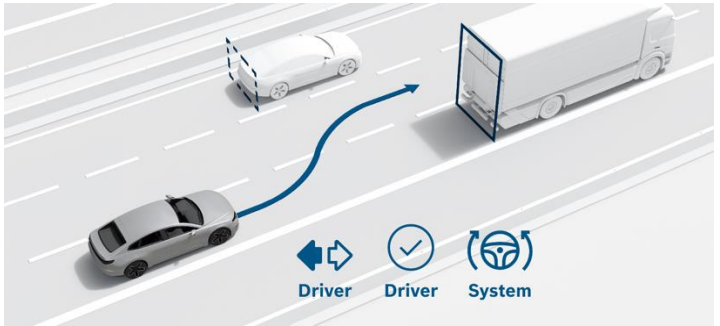
LCA hands-free

Feature description:
- Allows the driver to keep hands off the steering wheel if pre-defined conditions are met
- Independent monitoring module assesses all relevant conditions simultaneously to ensure a safe operation of L2 hands-free driving
- Available on motorways with physical separation of driving directions and access limited to passenger cars, trucks and motorcycles
- Supported driving speed up to 138 kph (85 mph)

Key benefits:
- Increased comfort: allows drivers to take their hands off the steering wheel and focus on monitoring the drive
- Increased safety: ases additional monitoring systems for activation of hands-free driving

Driving functions

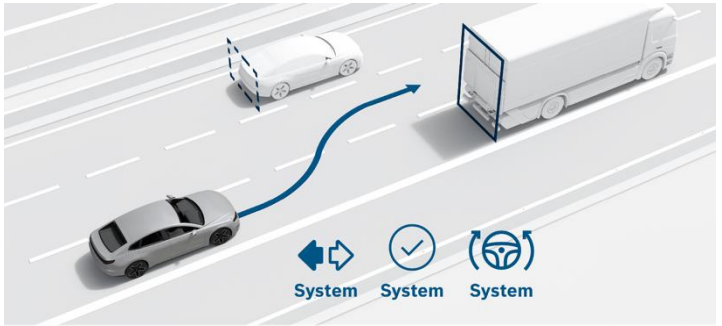
Active lane change (ALC)



ALC enhanced

Feature description:
- Assists the driver in conducting an actively triggered lane change on multi-lane roads
- Verifies sufficient vacancy in neighboring target lane to conduct lane change
- Accelerates or decelerates during lane change to reach ideal speed for target lane sooner

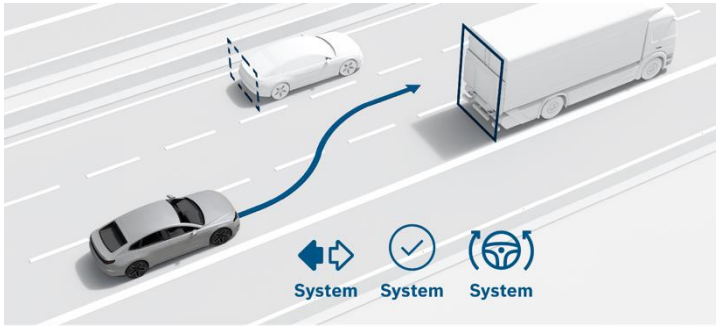
Key benefits:
- Increased comfort: supports driver in conducting lane changes and ensuring target lane vacancy
- Enhanced safety: additional monitoring of neighboring lanes to ensure safe lane change



ALC plus

Feature description:
- Proposes lane change to the driver according to traffic situation and navigation route information
- Driver can confirm via turn signal or gaze into the side mirror
- System fully performs lane change after driver conformation

Key benefits:
- Increased comfort: constantly monitors overall traffic situation and automatically proposes a lane change
- Added safety: system waits for driver confirmation before performing a lane change
- Enhanced support: proactively proposes lane change when required by navigation route



ALC premium

Feature description:
- System automatically initiates and conducts lane change according to traffic situation
- No driver confirmation necessary
- Optional notification in advance to allow driver cancelation

Key benefits:
- Enhanced comfort: comprehensive lane change functionality relieves the driver on multi-lane roads

Driving functions

Active lane change (ALC): Value-add features

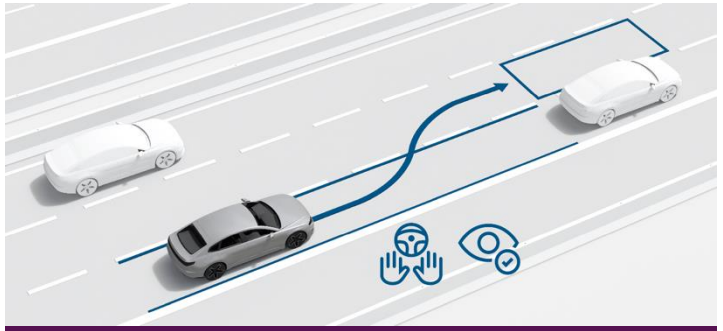
Active gap approach

Feature description:

- Prepares system-initiated lane change with an optimal positioning of the ego vehicle according to the target lane traffic
- Positions vehicle next to an insufficient gap and monitors widening of gap and supports zipper rule at merging sections

Key benefits:

- Assist the driver in heavy and stressful traffic situations when a lane change is planned by the system



Hands-free with gaze confirmation

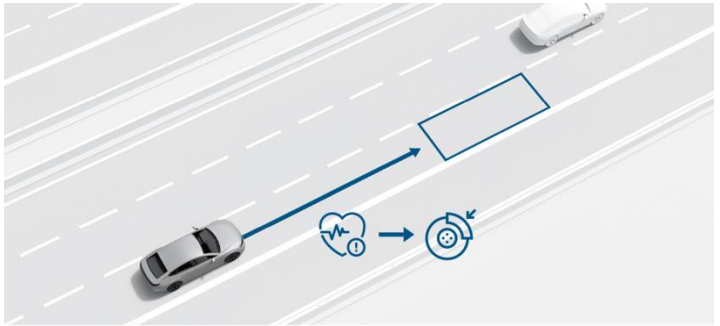
Feature description:

- Completes hands-free driving with lane changes
- Extended safety concept covers driver controllability
- Recommended in combination with lane change proposal and gaze confirmation for full hands-free driver experience

Key benefits:

- Increased comfort: fulfills driver's expectations of a fully hands-free experience on multi-lane roads

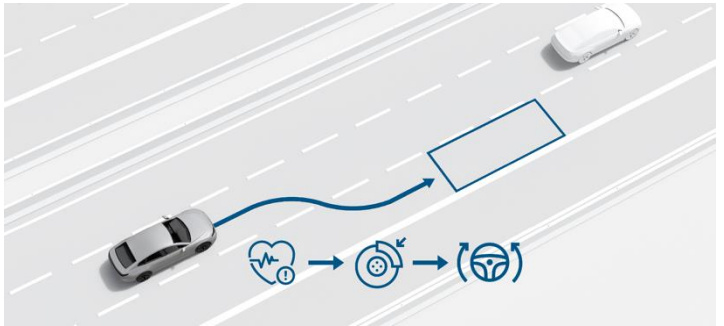
Driving functions
Emergency stop (EST)



EST base

Feature description:
- Brings the vehicle to a full stop in its current lane if the driver is unable to control his car (e.g. due to a health issue)
- Driver monitoring or driver state system detects unconscious driver and activates feature
- Driver reactivation phase with warning cascade (audio, haptic, brake jerks) is followed by deceleration up to standstill

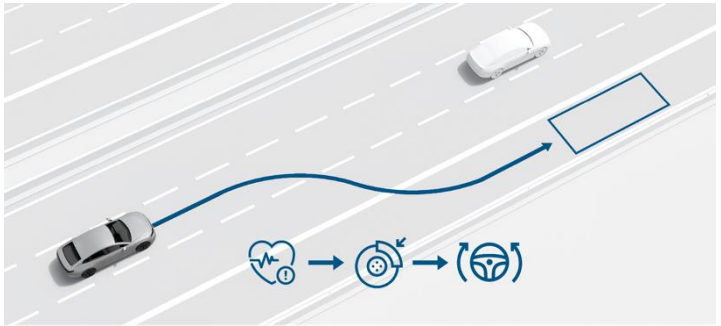
Key benefits:
- Increased safety: reduces accident risk by reacting to an unconscious driver with a stop within its own lane



EST enhanced

Feature description:
- Brings the vehicle to a full stop on the slowest lane if the driver is unable to control his car
- During the maneuver, the vehicle can conduct lane changes to the far-right lane (Active lane change feature required)
- Risk optimized parking position can be achieved via additional value-add features

Key benefits:
- Increased safety: reduces accident risk by reacting to un-conscious driver behavior with a full stop including lane changes to the slowest lane (right or left depending on target region)



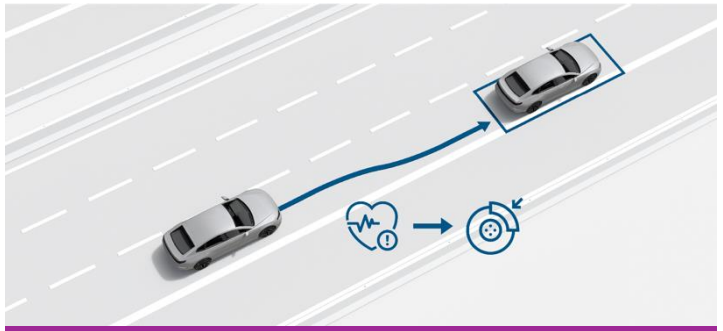
EST plus

Feature description:
- Brings the vehicle to a full stop on the emergency shoulder if the driver is unable to control his car
- During the maneuver the vehicle can conduct lane changes up to the emergency hard shoulder (Active lane change feature required)

Key benefits:
- Increased safety: reduce accident risk by reacting to unconscious driver behavior with a full autonomous lane change and stop on shoulder

Driving functions

Emergency stop (EST): Value-add features



Stop at outer side of lane

Feature description:
- Brings ego vehicle to a full stop at the outer side of the lane
- Ego vehicle is steered towards one side of the ego lane before stopping
- If the vehicle is on one of the middle lanes, no offset is applied

Key benefits:
- Increased safety: reduces accident risk by increasing the safety distance to other road users

Park on shoulder

Feature description:
- Maneuvers the vehicle onto the emergency shoulder after slowing down to parking speed on the slowest lane
- Park on shoulder maneuver is performed by the parking system, its sensors and capabilities (i.e. speed)
- Can be combined with Emergency stop base and enhanced

Key benefits:
- Increased safety: reduce risk of collisions with following traffic by maneuvering the vehicle onto the emergency shoulder
- Reduced cost: implement feature by using the parking system

Parking functions

Overview

Features and functions

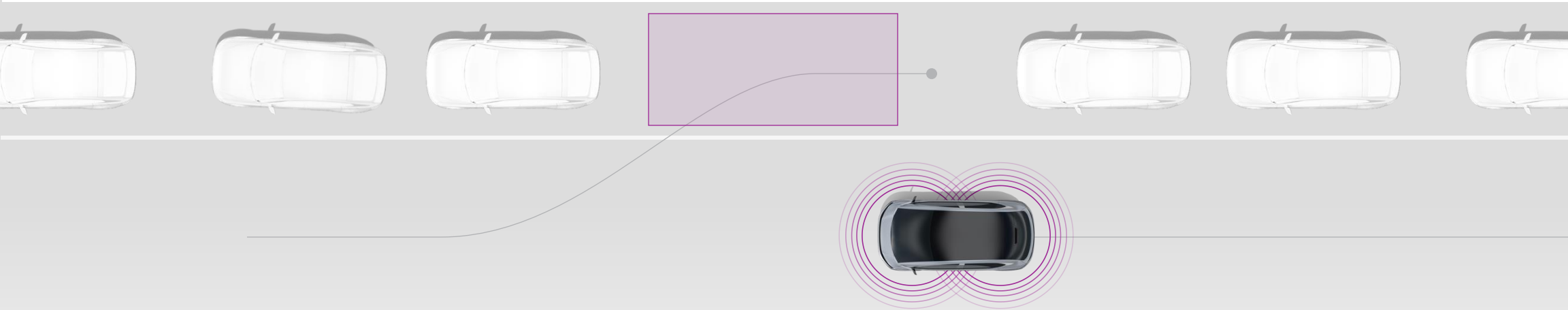
Pallet garage assist with maneuvering (JP and CN) Automated parking	**Narrow parking** with garage use case Automated parking	**Automated park assist** with short duration Automated parking	**Video perception** with early detection Advanced video perception
Map localization including visualization Trained and valet parking	**Homezone park assist** Gen 2 Trained and valet parking	**MVP valet park assist** Early parking lot detection (CNN based) with seamless transition from offering to park-in Trained and valet parking	**Virtual surround view** Enhanced visualization
Maneuver steering support Manuever support	**Transparent trailer view** Trailer	**Anywhere parking trailer** Trailer	**Remote parking** Park anywhere with android based advanced SVS on your mobile phone Automated parking

Adressed UX targets

- The system shall be **available** in cases where the driver feels uncomfortable!
- The system shall be quicker than the driver and do parking in outstanding **duration**!
- The driver shall be **aware** of the personal benefit of automated parking!
- The driver shall be excited to use the system and feel safe!

Parking functions

Understanding user experience for parking



Awareness

"I didn't even know I have this kind of parking feature!"

"I don't know how to activate this feature!"

Availability

"The feature is not showing the parking spot I like to park!"

Execution

"It takes too long to get parked."

"I'm not able to get things out of the car comfortable."

Holistic experience

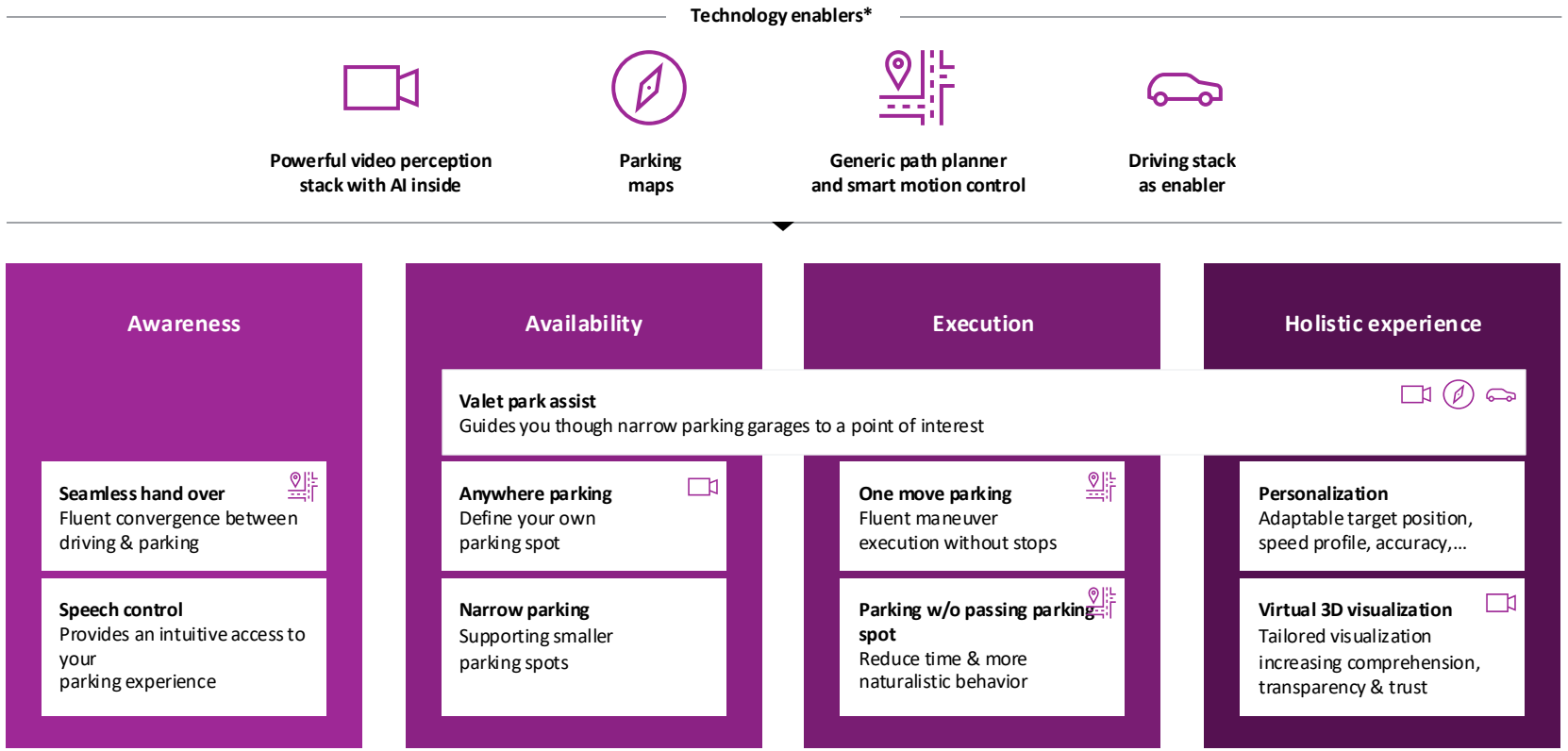
"I feel unsafe, because I don't know what is happening"

"I don't use IPA due to bad experiences in the past."

Regular executed studies worldwide (EU, NA, CN, JP,...) with ~ 500 participants

Parking functions

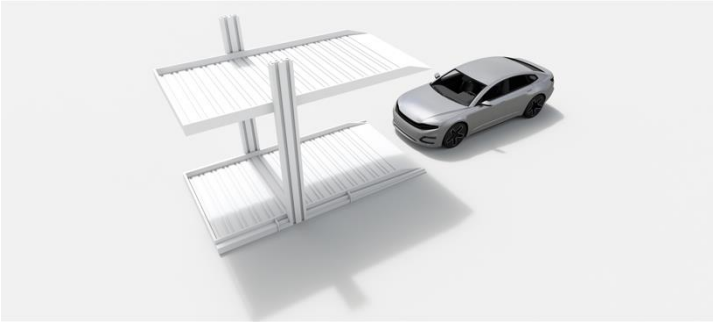
Shaping best in class user experience for parking



*assuming higher computing power and SoC architectures

Parking functions

Pallet garage assist



Detection and visualization

Feature description

- Detect pallet garage with classic CV algo and then activate specific visualizations to support the driver
- Near range camera system 2 based vehicle

Customer benefits

- Bosch is working on solutions for complex and regional parking use cases
- Detection and visualization is the first level of driver support

With automated maneuvering

Feature description

- Detect pallet with ML based algo (instead of classic CV in demo before) and add automated maneuvering
- Near range camera system 2 based vehicle + external hardware for ML based approach

Customer benefits

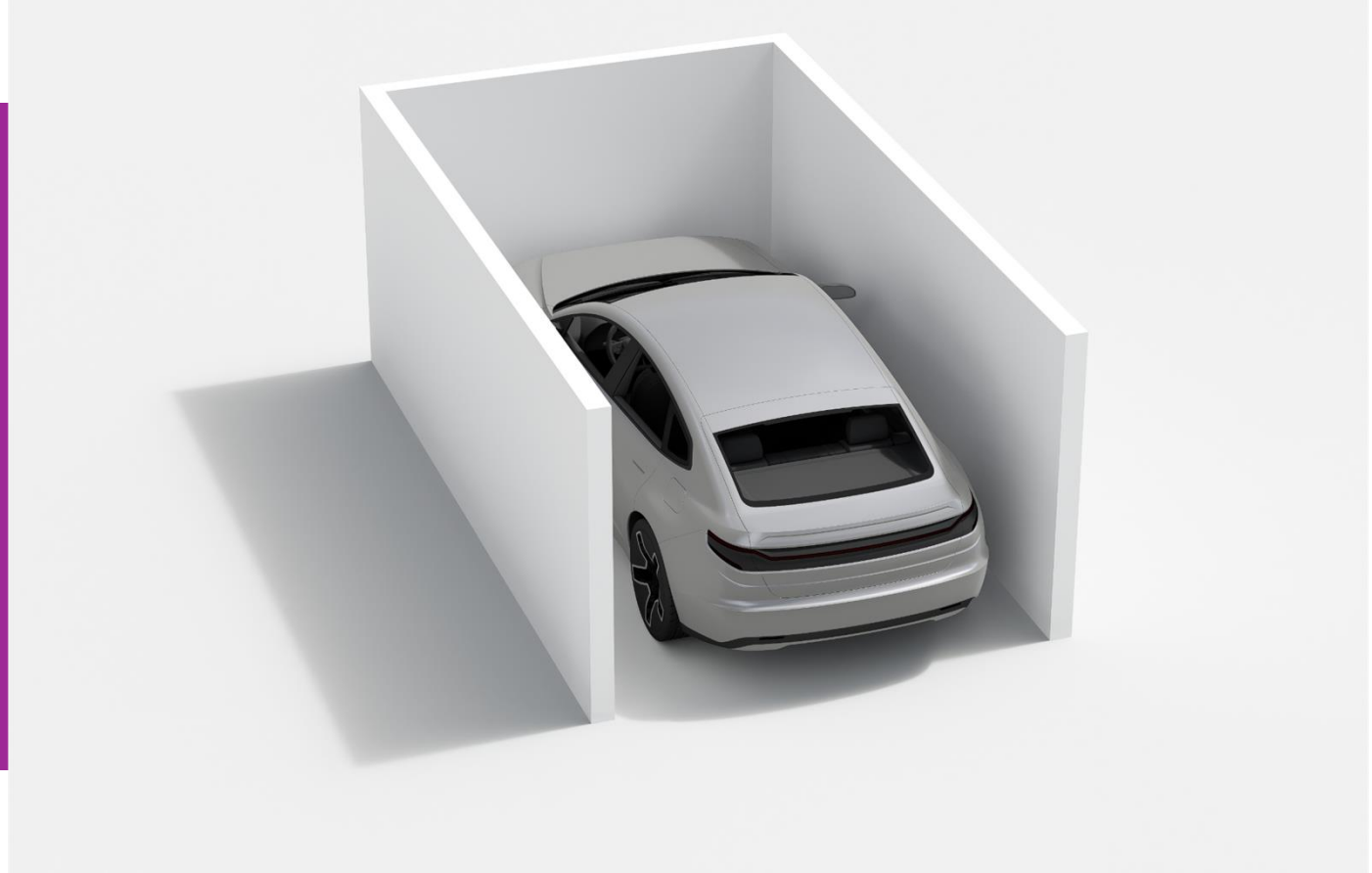
- Compare CV based and ML based detection solutions
- Show automated maneuvering as prototype and use it for further focused analysis

Parking functions
Narrow parking

Development of new concept in OneParking architecture how to handle narrow spaces

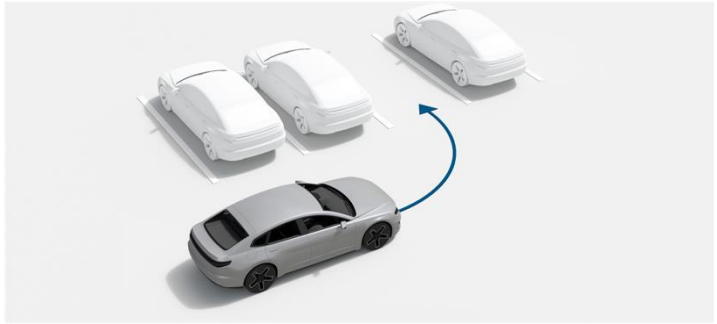
Feature description
- Show special handling of narrow areas and how this differs from environment handling of usual areas
- Prove of the new concepts for narrow areas especially garages

Customer benefits
- By detection and special handling of narrow situations they can be managed without negative effects on other usual situations



Parking functions

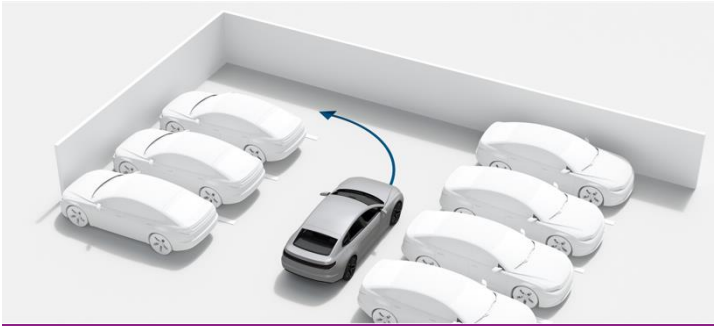
Automated park assist (APA)



APA USS only on POSIX with generic path planner

Feature description
- APA based on new OneParking architecture and algorithms running in vehicle
- Basic use cases to prove new concepts like the generic path planner

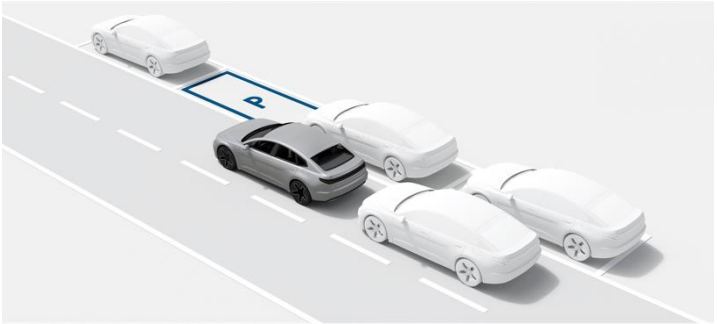
Customer benefits
- Show APA running on POSIX system
- Show a parking function using algorithms that have not been available on previous generations



APA fusion based on POSIX and new use cases

Feature description
- Run APA in fused system (Ultrasonic sensors + video perception input) and use new video perception algorithms in APA e.g. video-based park space detection, CNN based, early detection
- Show new APA use cases e.g. parking into last slot before wall

Customer benefits
- Show performance of new video perception algos
- Show capability of generic path planner
- Show portability of parking functions to different SoCs



APA with short duration

Feature description
- Main complaint related to APA in old generations was “maneuvers taking too long”
- Show new implementations that cope with this complaint by improving absolute parking duration (time from activation till finish) and also felt duration (driver feeling)

Customer benefits
- Function execution focused on improved UX

Parking functions

Video perception with early detection

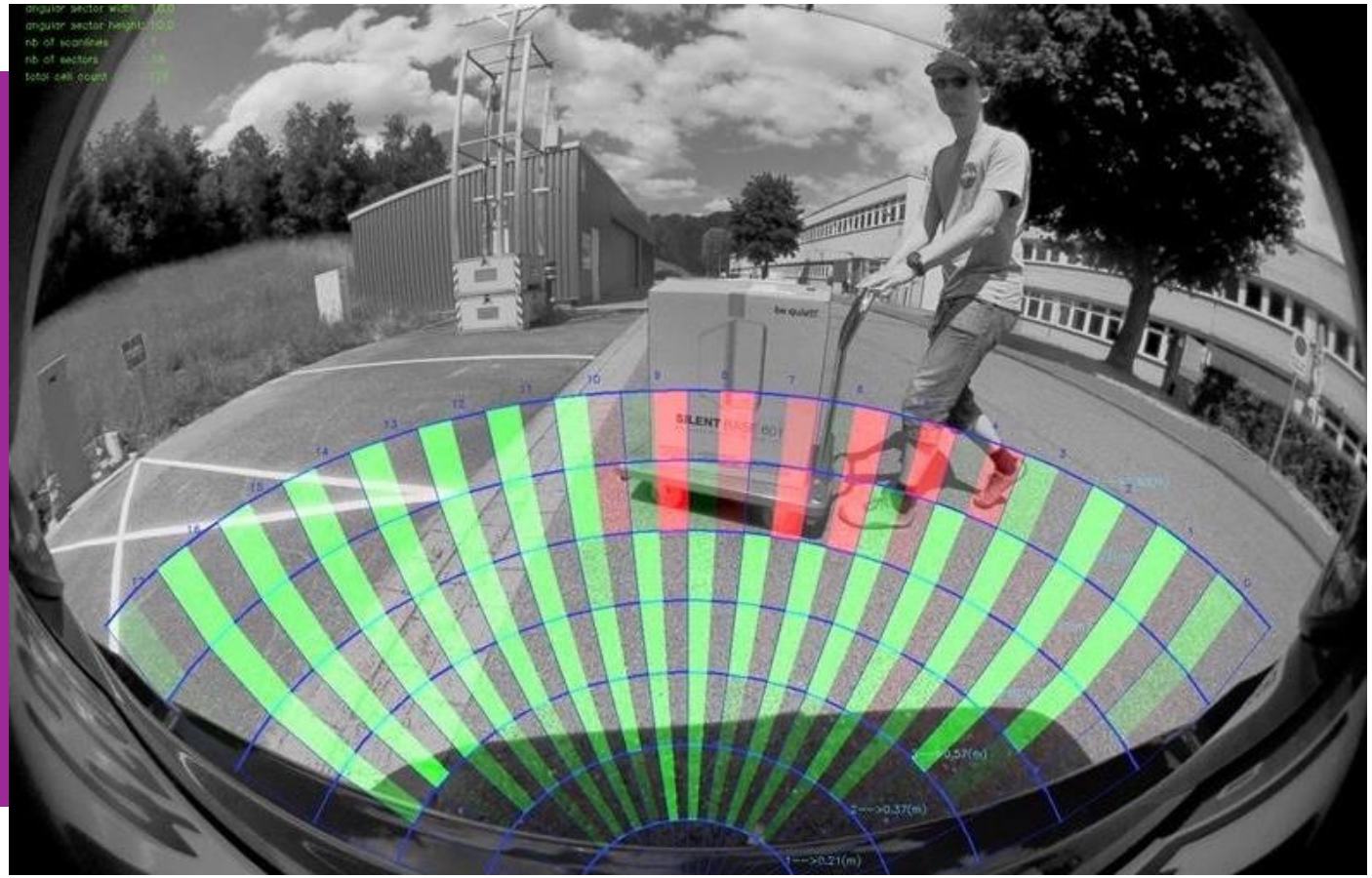
Computer vision algorithms as an enabler for advanced parking functions and visualization

Feature description

- PF-Demo of video perception S1/S2 in vehicle with visualization
- Video perception features: Semantic segmentation, StixelNet, freespace, parking spot detection, vehicle detection, pedestrian detection, blockage

Key benefits

- Reliable and early detection of objects and parking slots
- Enables natural way of parking (front-in approach)

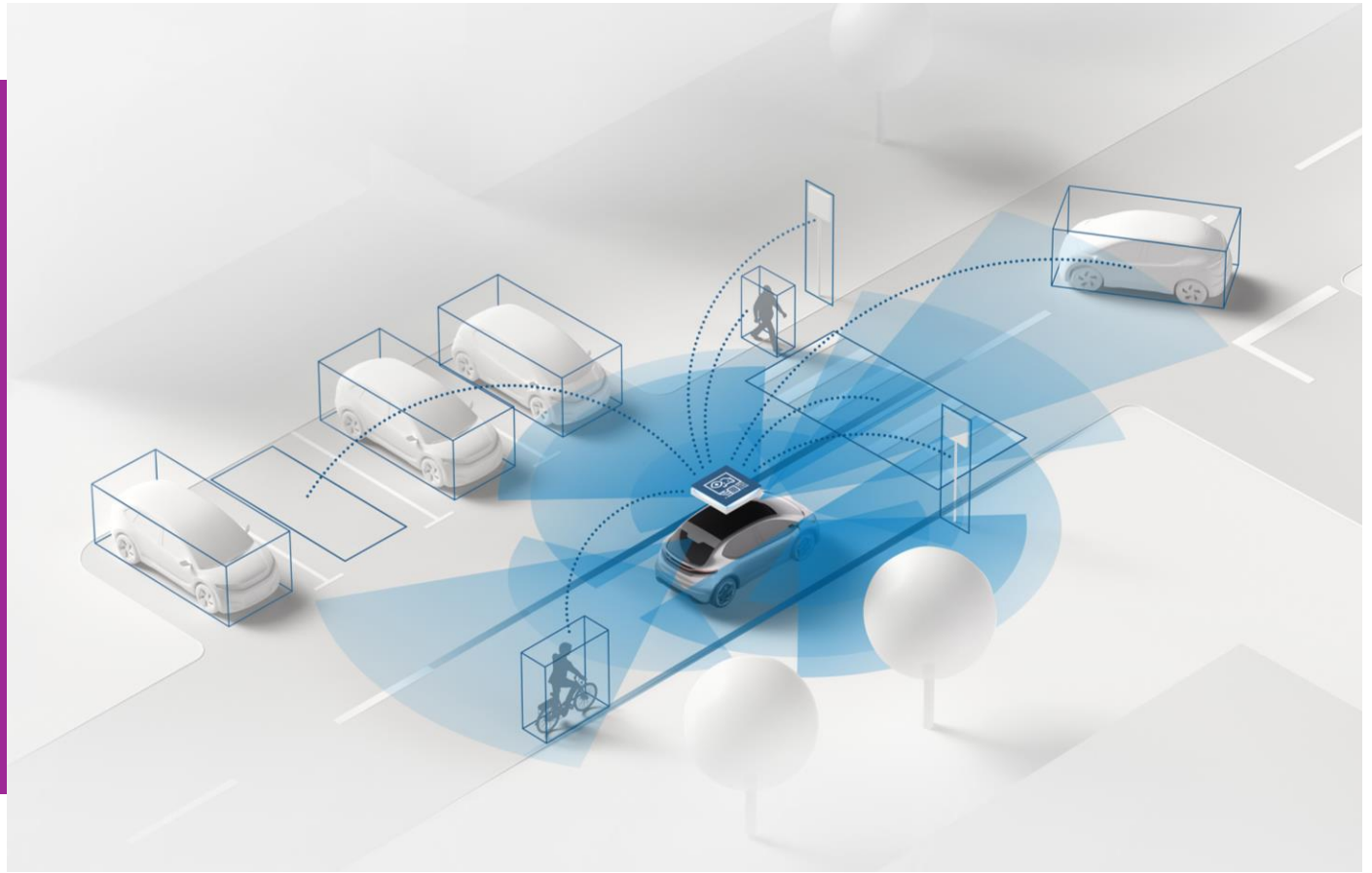


Parking functions
Map localization

Advanced mapping and localization as an enabler for advanced parking functions

Feature description
- Single-source mapping of public underground garage + generic localizer for home zone

Key benefits
- Crowd-sourced mapping (based on fleet data) to continously enable availability and accuracy of advanced functions
- Enables long distance cruise, generic path planning for e.g. object evasion during maneuver
- Enables seemless transition between cruise and parking maneuver



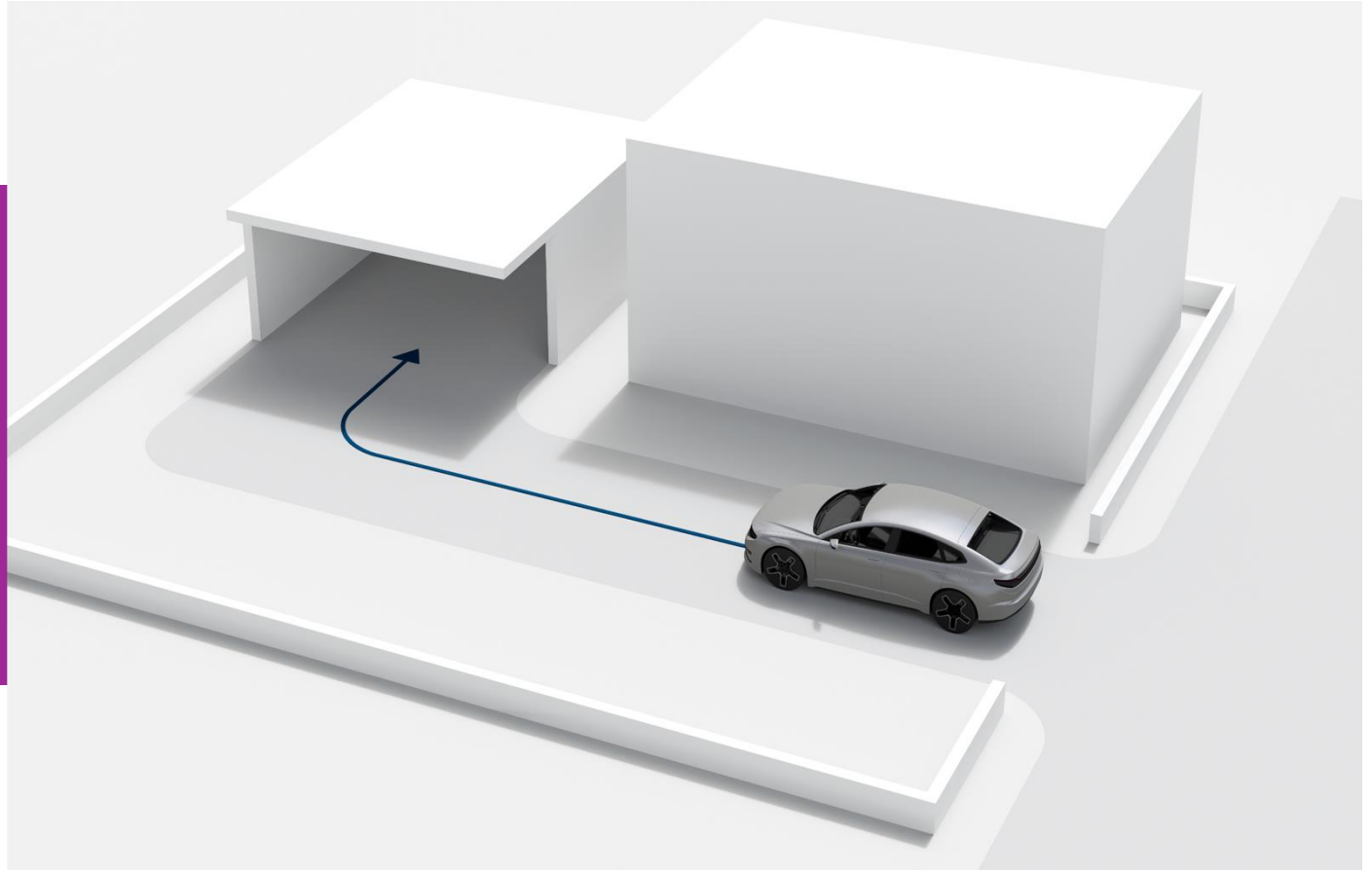
Parking functions

Homezone park assist generation 2

A trained trajectory is stored and replayed

Feature description
- Parking space search while driving on trajectory using advance mapping and localization

Customer benefits
- Training of trajectory without driver interaction
- Up to 10 kph guidance speed

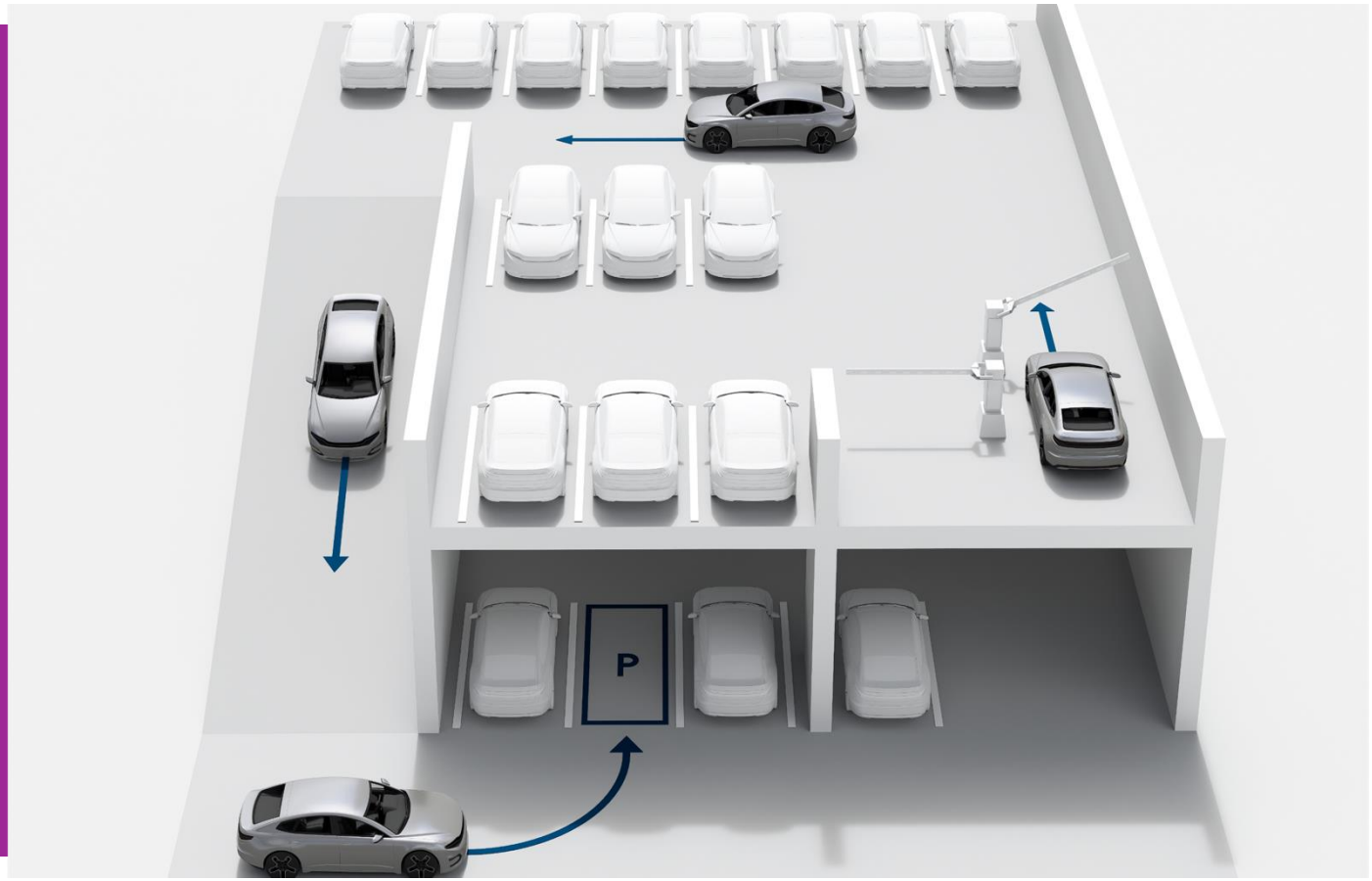


Parking functions
MVP valet park assist

Parking assistance on large facilities

Feature description
- Experience a parking system that is specifically designed for human-like parking on large parking lots (malls, airport parkings, …) as one building block of a valet park assist
- Combine high availability and flexibility automated park assist, intelligent slot preselection and seamless handover to a fully new experience for parking on large parking facilities

Customer benefits
- Hand over seamlessly from manual driving to automated guidance while driving at any time the driver prefers
- Park with a minimum of user interaction
- No need to stop, no need to pass by the parking lot
- Intelligent parking space preselection
- Visual guidance before steering is released



Parking functions

Virtual surround view

Showing a virtual surrounding with maneuver relevant objects

Feature description
- Rendering of virtual environment containing recognized objects

Customer benefits
- Gives orientation and trust while maneuvering by depicting the perception of the system
- End customer fascination
- Makes parking easier by giving an overview of the surroundings

Parking functions

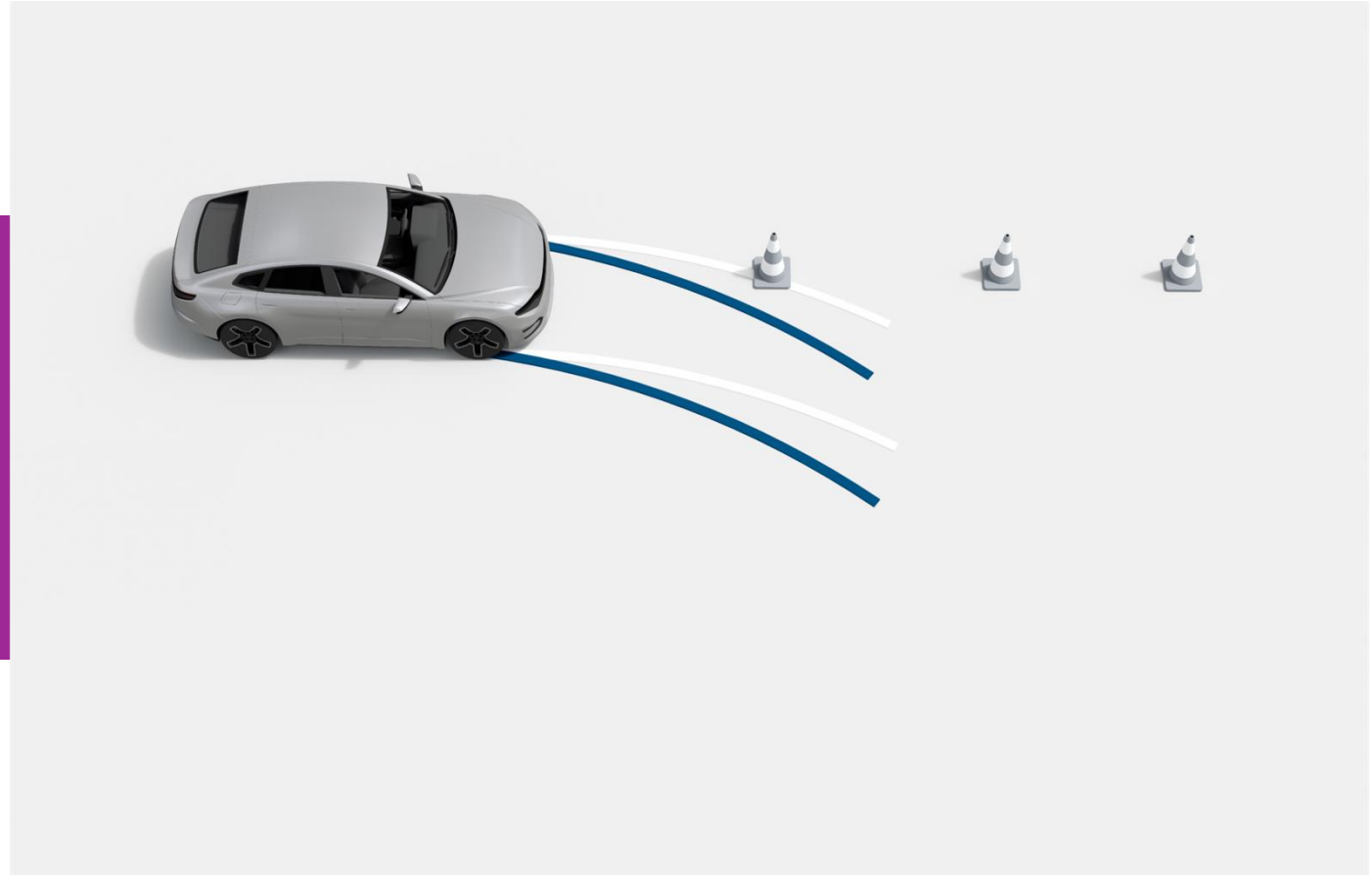
Maneuver steering support

Feature description

- Haptic steering interventions to avoid front, rear and side collisions and assist with steering in narrow forward and backward maneuver situation

Customer benefits

- Helps to avoid vehicle damages while maneuvering
- Stress relief by assisting the driver in low-speed maneuvers in tight parking spaces or narrow lanes/alleys



Parking functions

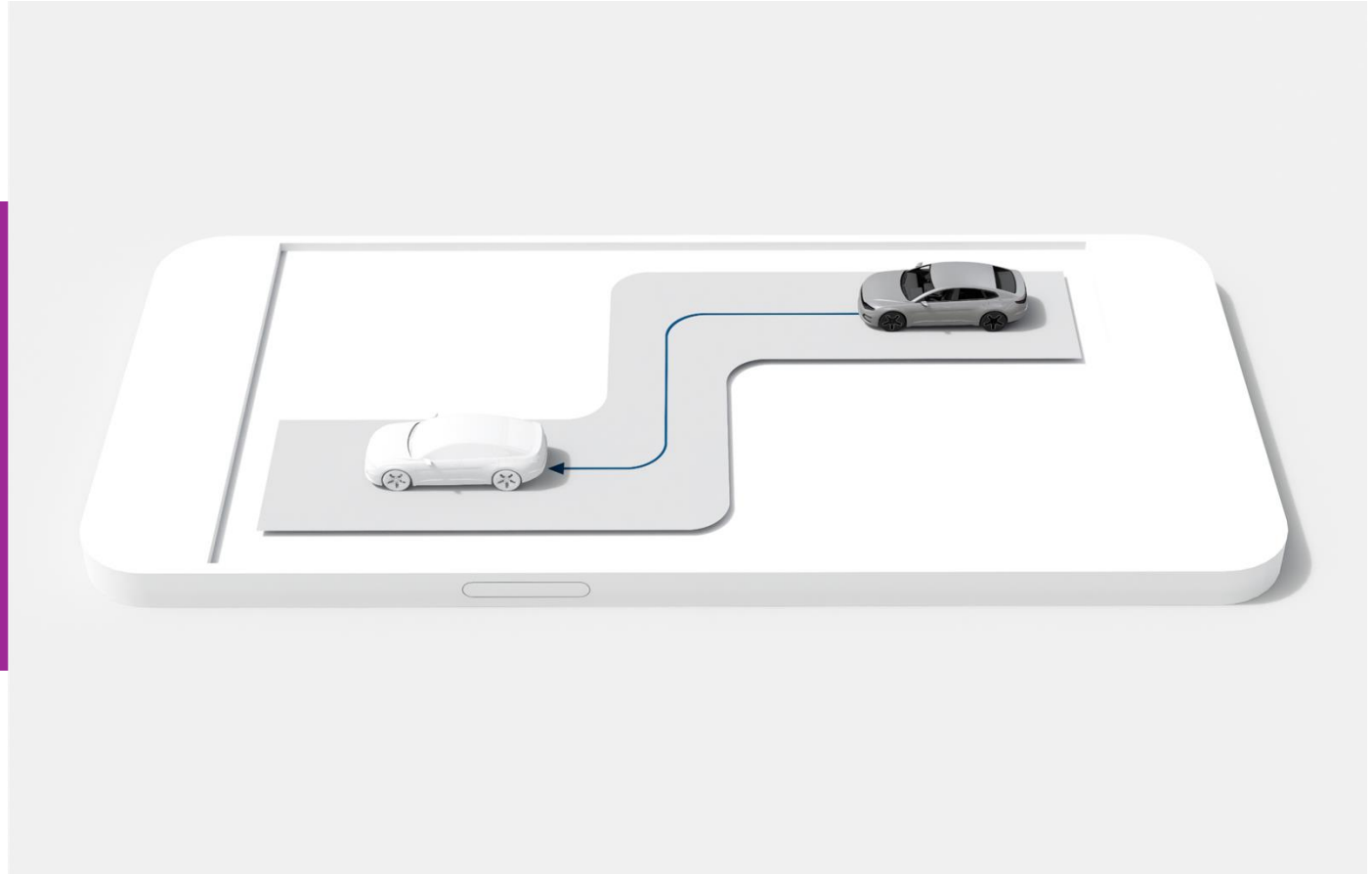
Remote park assist

Feature description

- Remote control parking via mobile device within a 6 m range
- Seamless park-in and park-out functionality
- Convenient maneuvering in narrow spaces

Customer benefits

- Effortless parking and unparking in tight spots
- Reduced stress and time spent searching for parking
- Enhanced comfort for entering and leaving the car



Parking functions

Anywhere parking trailer

Feature description
- Makes trailer's walls "disappear" in a console display

Customer benefits
- See "through" the obstructed view of a towed trailer
- Aids in maneuvering and reversing with augmented rear visualization

Parking functions

Transparent trailer view

Feature description

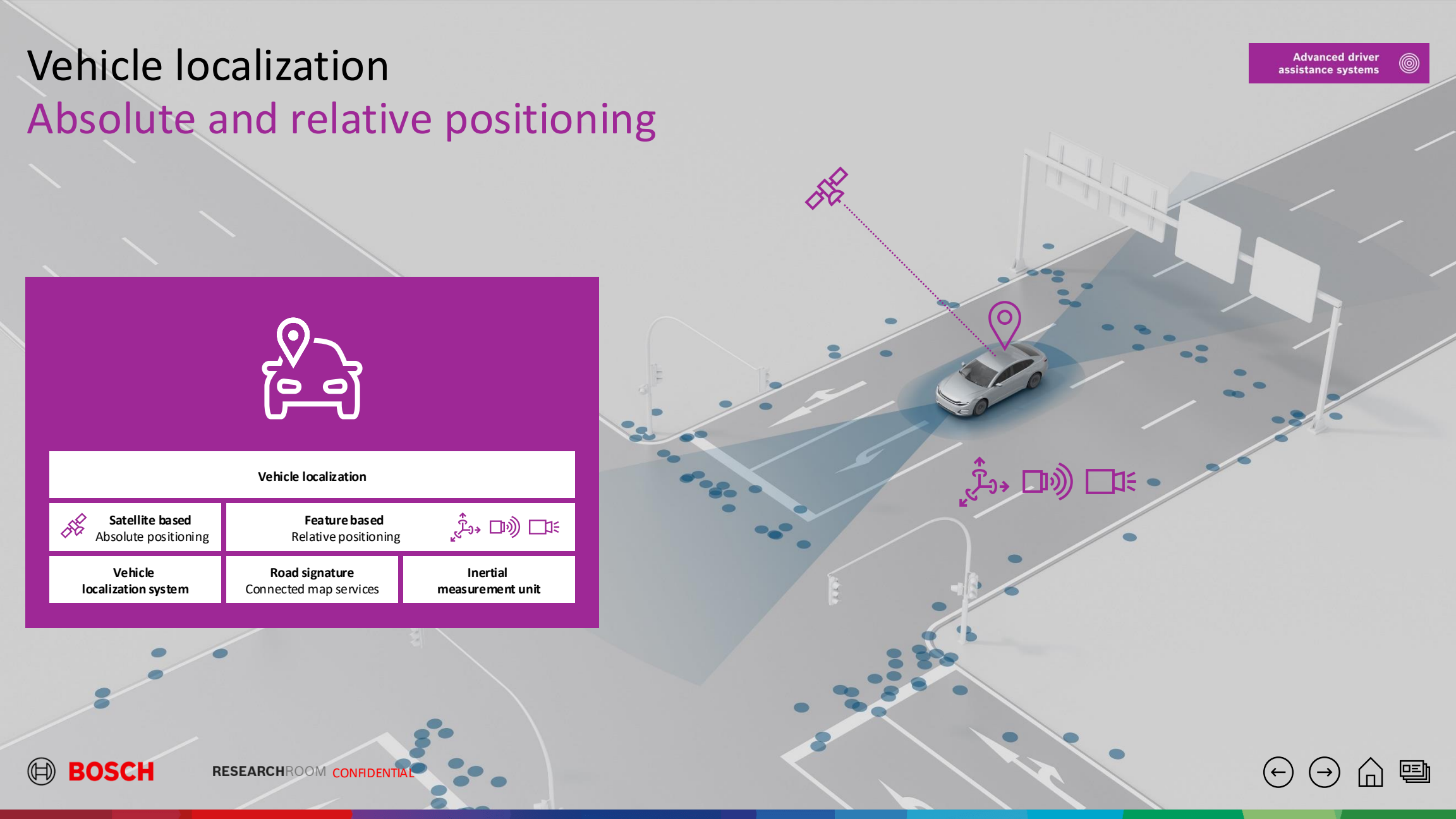
- Allows a driver to freely select a target parking spot based on the top view to automatically park a trailer

Customer benefits

- Makes parking a trailer less stressful
- Does not require driving past a spot
- Intuitive display for position and adjustment

Vehicle localization

Absolute and relative positioning



Vehicle localization		
Satellite based Absolute positioning	**Feature based** Relative positioning	
Vehicle localization system	**Road signature** Connected map services	**Inertial measurement unit**

Vehicle localization

Why choose Bosch vehicle localization system

Advanced driver assistance systems

Modularity

Runs on OEM- specified interfaces and supports centralized and decentralized vehicle architectures

Key enabler

Technology for assisted and automated driving applications under all driving conditions, increasing availability and robustness of ADAS functions

High precision

Localization enables accurate and reliable positioning of the vehicle (typ. ≤ 10 cm), lane-level positioning

Tried and tested

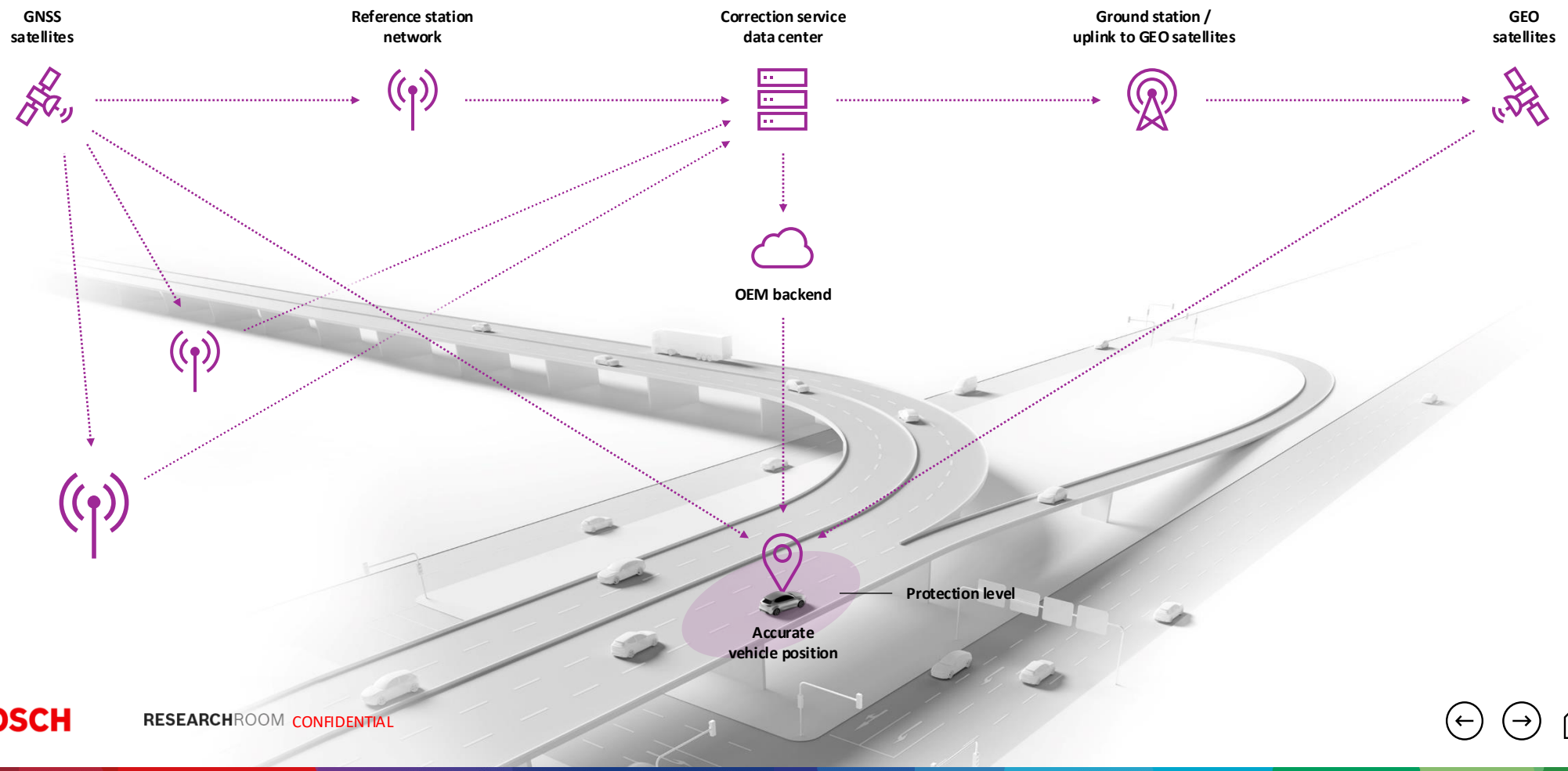
Long-term expertise in GNSS, IMUs, and localization systems to support OEM system specifications and lead integration and release

Worldwide

Worldwide coverage of compatible safe correction service

Vehicle localization

Vehicle localization system



Vehicle localization

Why choose Bosch inertial measurement unit

Advanced driver assistance systems

Market leader

in high-performance inertial sensors for ADAS and vehicle motion applications

End-to-end development

with in-house MEMS technology, design, production & testing

>30

Years

of IMU-development expertise

Turnkey solution

Bosch offering all-in-one solution by ensuring customer specified calibration, validation and release

High scalability

Our concept offers broad range of safety and performance levels for optimal customer fit

Vehicle localization

Why choose Bosch connected map services

>30

years of system
and sensor expertise

>2 billion

kilometers harvested
since January 2021

Robust and lane-accurate localization to the centimeter in all weather conditions

Event and priority triggered map updates from daily up to weekly

Open cross-OEM ecosystem without lock-ins

Combined radar and video mapping – a Bosch USP

Map service coverage beyond highways on the five highest road classes

Vehicle localization

Connected map services

Localization map

Landmarks for high precise vehicle localization

Behavior map

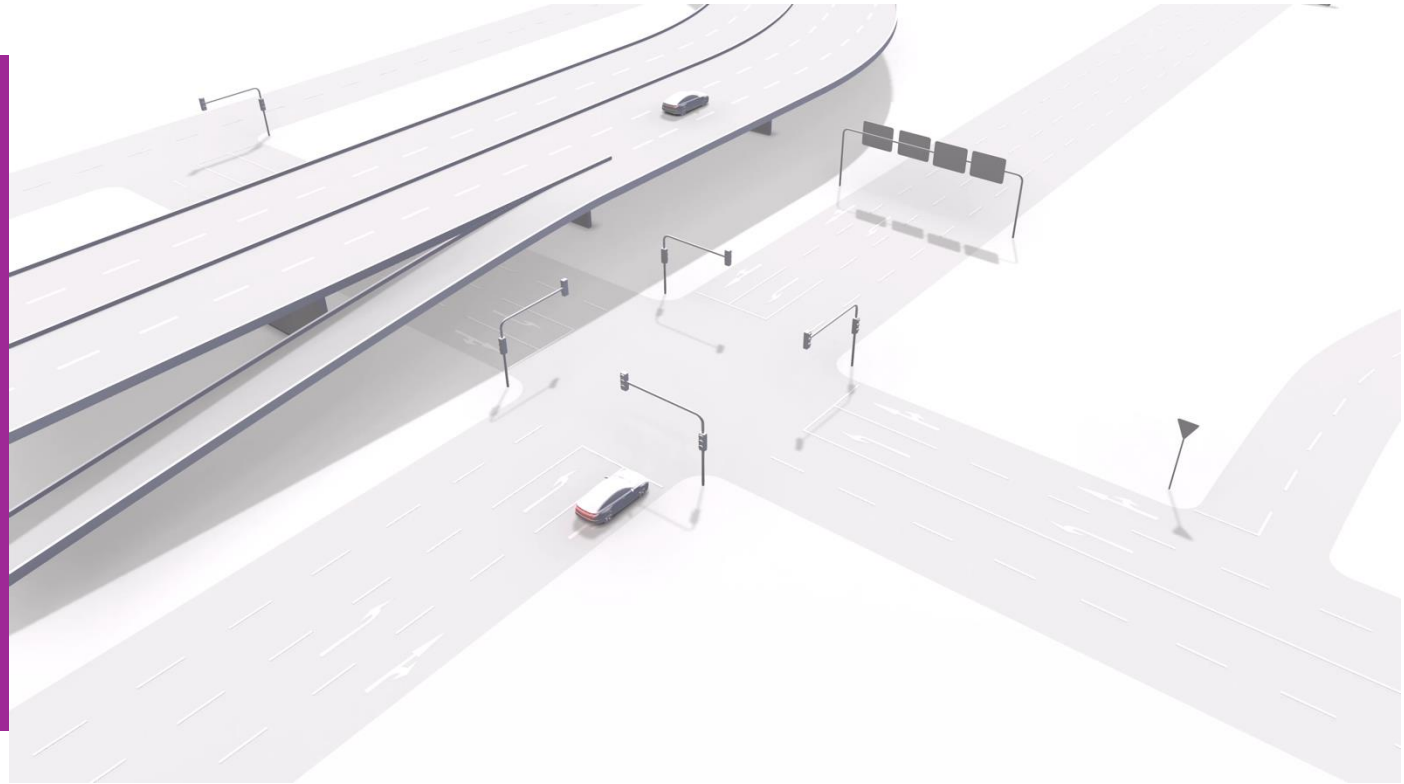
Swarm trajectories, optimal driving speed and more

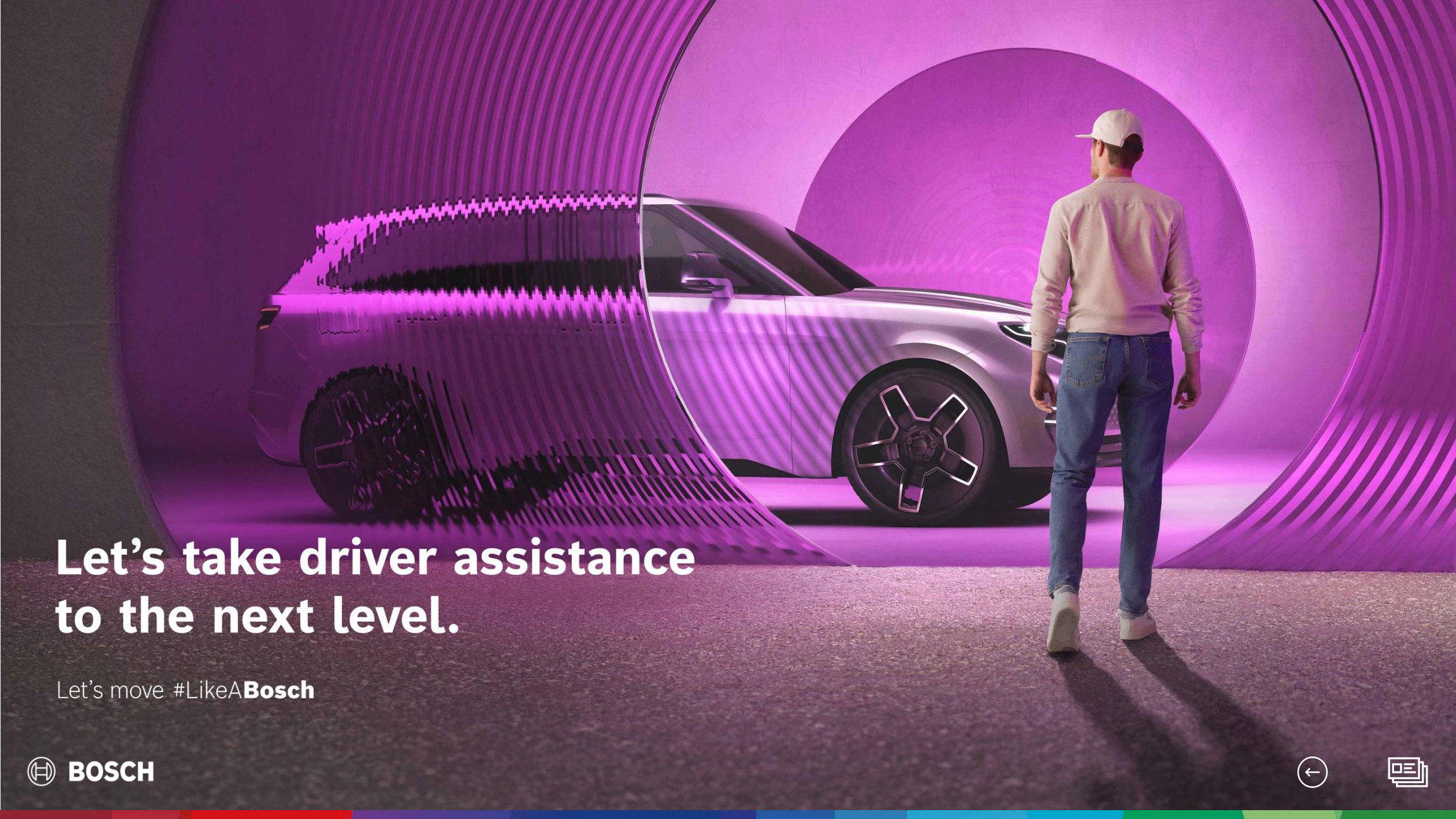
Planning map

Road lane geometry and semantic information like traffic signs

Road hazard

- Events like **wrong-way drivers**
- Dangerous **road conditions**




Let’s take driver assistance
to the next level.
Let’s move #LikeABosch
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