



Introducing DRIVE PILOT: An Automated Driving System for the Highway

Mercedes-Benz
The best or nothing.



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An Automated Driving System for the Highway

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Introduction

Ever since Carl Benz invented the automobile in 1886, Mercedes-Benz vehicles proudly bearing the three-pointed star have been setting standards in vehicle safety. Daimler AG, the manufacturer of all Mercedes-Benz vehicles, continues to refine and advance the field of safety in road traffic through the groundbreaking Mercedes-Benz “Intelligent Drive” assistance systems, which are increasingly connected as they set new milestones on the road to fully automated driving.





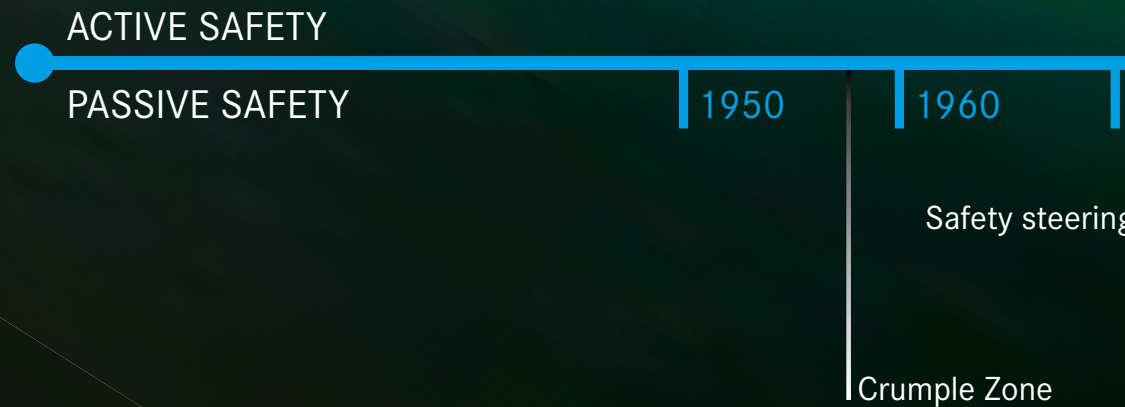
Our Vision for Automated Driving

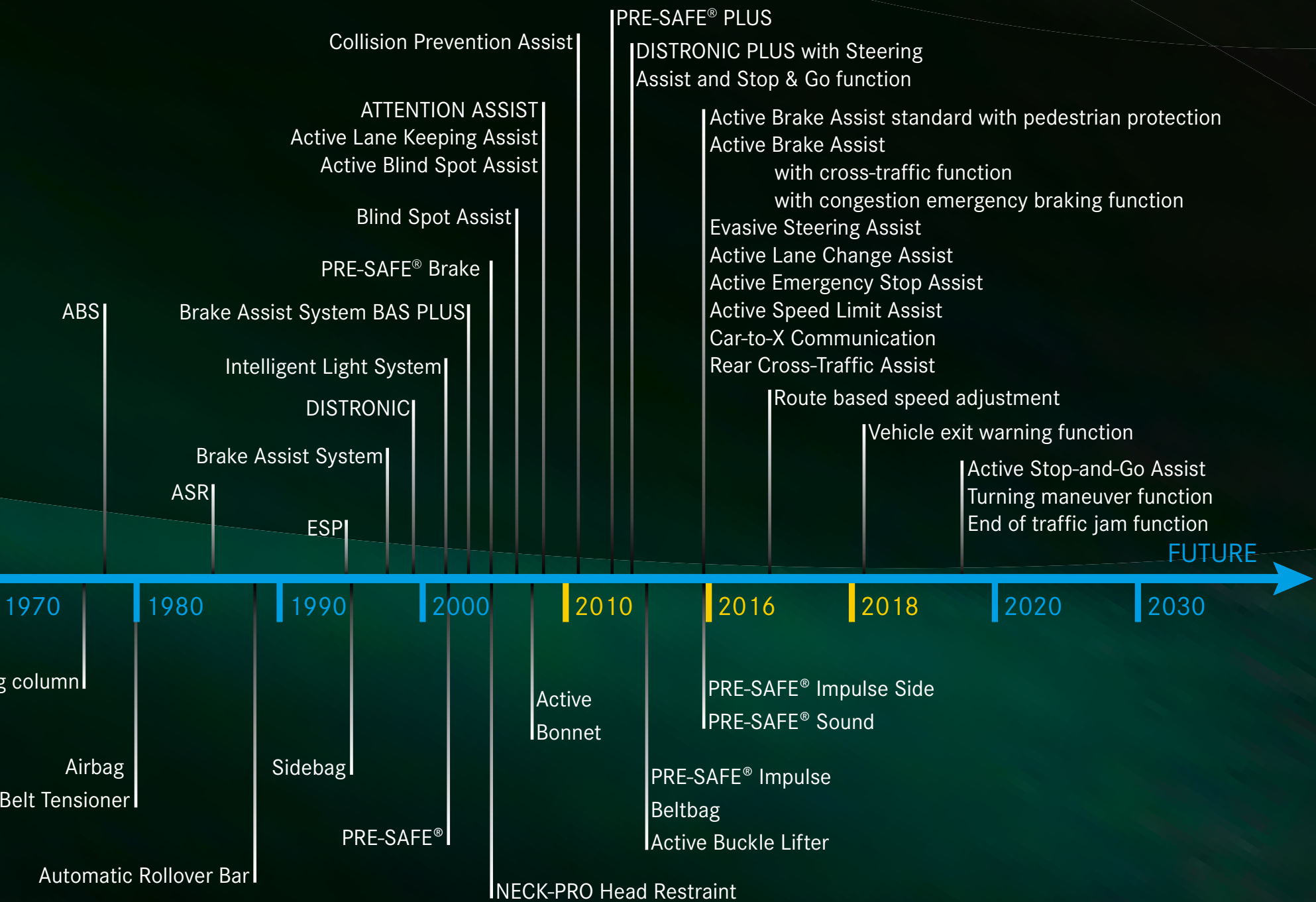
Mercedes-Benz envisions a future with fewer traffic accidents, less stress, and greater enjoyment and productivity for road travelers. We are working to achieve this vision through automation, electrification and connectivity. Automation is one of the biggest drivers of change in the transportation sector today – with the potential to make mobility safer for all, while reducing traffic congestion. Thanks to automated driving, a vehicle can also be a private retreat that enables us to use at least some of our time on the move as we wish.

The Safety Heritage of Mercedes-Benz

Mercedes-Benz can proudly point to decades of innovation in automotive safety systems, many of which are now standard equipment on vehicles across the industry. The figure below shows the timeline of safety systems introduced on Mercedes-Benz vehicles.

It ranges from the introduction of the Crumple Zone in 1959 to current systems that can reduce the risk of inner ear injuries: The PRE-SAFE® Sound feature emits a short interference signal via the sound system in the vehicle when there is a risk of collision. This can condition the passengers' hearing by triggering a reflex in the ears, and thus lessen the risk of hearing discomfort or damage.





Levels of Driving Automation

In order to better understand the capabilities of the next generation of Mercedes-Benz automated driving technologies, it's helpful to begin with an explanation of the differences in the Levels of Driving Automation.

SAE International (SAE) is a technical standards development organization that leverages the professional expertise of its engineering members in the automotive industry to develop consensus-based Standards, Recommended Practices, and Information Reports. Among the many technical documents published by SAE is one describing six levels of driving automation (Levels 0–5)¹, along with supporting terms and definitions. This taxonomy classifies driving automation system features (or vehicles, in some cases) in terms of the degree to which they replace human operation of vehicles in traffic.

The chart on the following page from SAE describes those six Levels in simplified terms to assist non-automotive engineers in understanding how driving automation features (or vehicles designed to be operated exclusively by an Automated Driving System rather than a human driver) are classified within the Levels.

In addition to offering a wide range of Level 0 warning and active safety features (many of them are standard equipment on Mercedes-Benz vehicles), as of the publication of this document in February, 2019, Mercedes-Benz vehicles offer Level 1 and Level 2 driving automation features. These assistance features support the driver's operation of the vehicle but do not replace him or her. We offer, for example, a Level 1 adaptive cruise control feature called Active Distance Assist DISTRONIC.

It automatically maintains desired following distance to a vehicle ahead in the same lane. While engaged, Active Distance Assist DISTRONIC will automatically brake and accelerate the vehicle under normal operating conditions. However, it is not able to handle all traffic situations, and thus requires an alert and attentive human driver to supervise the feature's performance and to brake or accelerate if needed, as well as to steer the vehicle.

We also offer a Level 1 steering assistance feature called Active Steering Assist that, when engaged, will help the driver maintain the vehicle's position within its lane of travel. However, similar to the Active Distance Assist DISTRONIC feature, Active Steering Assist is not able to handle all traffic situations and thus requires an alert and engaged human driver to supervise the feature's performance and to steer as needed to maintain safe operation of the vehicle. Active Steering Assist can only be activated in conjunction with Active Distance Assist DISTRONIC. When both of these Level 1 driving automation features are active they constitute a Level 2 driver support feature. This Level 2 feature automates braking, accelerating, and steering under normal conditions, while still requiring an alert and attentive human driver to supervise the vehicle's performance in real time – to manually steer, brake, and/or accelerate as needed to maintain safe operation. Mercedes-Benz also offers a Level 2 Active Parking Assist feature that will automatically park the vehicle while the driver supervises the parking maneuver.

¹J3016 – Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles (June 2018)

SAE J3016™ LEVELS OF DRIVING AUTOMATION

	SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?	You are driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You are not driving when these automated driving features are engaged – even if you are seated in “the driver's seat”		
	You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
	These are driver support features			These are automated driving features		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the driver	These features provide steering AND brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met		This feature can drive the vehicle under all conditions
Example Features	<ul style="list-style-type: none"> • automatic emergency braking • blind spot warning • lane departure warning 	<ul style="list-style-type: none"> • lane centering OR • adaptive cruise control 	<ul style="list-style-type: none"> • lane centering AND • adaptive cruise control at the same time 	<ul style="list-style-type: none"> • traffic jam chauffeur 	<ul style="list-style-type: none"> • local driverless taxi • pedals/steering wheel may or may not be installed 	<ul style="list-style-type: none"> • same as Level 4, but feature can drive everywhere in all conditions

For a more complete description, please download a free copy of SAE J3016: www.sae.org/standards/content/j3016_201806/

Levels of Driving Automation (continued)

In addition to the aforementioned driver support features, Mercedes-Benz is also actively developing a Level 3 conditional automated driving feature called DRIVE PILOT, which is described at length in this document. Unlike the Level 1 and Level 2 features described above, DRIVE PILOT does not require a driver to constantly supervise its performance while engaged. It thus frees the “driver” (who becomes a “fallback-ready user” while DRIVE PILOT is engaged) to do other things besides driving or supervising the driving automation feature. For example, subject to applicable laws, the fallback-ready user may use the in-vehicle multimedia system for communications, productivity and/or entertainment purposes. When the DRIVE PILOT feature senses that driving conditions have changed and anticipates that it can no longer reliably operate the vehicle, it will:

- Request the fallback-ready user to resume driving (with adequate take-over time).
- Operate the vehicle until s/he does so, up to and including bringing the vehicle to a controlled stop if the person fails to respond to the request to resume driving.

In addition to making longer trips on highways more pleasant and productive for the driver/fallback-ready user, DRIVE PILOT also provides potentially safer transportation by mitigating or eliminating the effects of fatigue, distraction, boredom and annoyance that can otherwise lead to hazardous driving on longer trips.

Mercedes-Benz and Bosch are cooperating in the development of Level 4/5 highly/fully automated fleet vehicles capable of driverless operation for purposes of providing delivery and ride-hailing services beginning with urban and suburban areas. These automated fleet vehicles are the subject of another publication, “Reinventing Safety: A Joint Approach to Automated Driving Systems”, that describes the safety concept, design, and validation methods unique to this type of automated vehicle ([see here](#)).

Please note that the Mercedes-Benz DRIVE PILOT feature is still undergoing testing and refinement. Therefore, Mercedes-Benz reserves the right to revise and/or modify the descriptions provided herein prior to the feature’s market introduction.



INTELLIGENT
WORLD DRIVE

DIGITAL LIGHT

On the Road to Automated Driving: Intelligent World Drive on Five Continents

The vision of “driverless cars” is fascinating to increasing numbers of people. However, it will still be quite a few years before all vehicles are equipped with the level of automated driving technology that will allow them to be operated in driverless mode everywhere.

The sophisticated assistance systems already on the road today demonstrate the advanced stage the technology has reached. Nevertheless, missing links remain between today’s vehicles and the higher automated driving features of driverless-capable vehicles.

Mercedes-Benz is continually testing and improving its automated driving technology. With the Intelligent World Drive tour, Mercedes-Benz sent a test vehicle equipped with automated driving technology on an educational journey across five continents that lasted from September 2017 to January 2018. Over these five months we gained valuable experience during automated test drives on real roads under an extraordinarily wide variety of traffic conditions.

When traffic conditions in various countries and cultures are closely observed, clear differences and characteristic features become apparent. These specific characteristics must be “experienced” in real-world traffic in order for the automated driving technology to adapt to them. “The acquisition, processing, and interpretation of highly complex traffic situations is the key to safe automated and driverless vehicles,” explains Ola Källenius, Daimler Board of Management member responsible for Group Research & Mercedes-Benz Cars Development.

The Intelligent World Drive test project also highlights how important the international harmonization of both the legal framework for automated driving and the associated infrastructure will be to the successful market introduction of automated vehicles. Therefore, Mercedes-Benz continues to work with governmental and industry entities to promote international harmonization in laws, regulations, and standards related to automated driving and connected vehicle technologies.



USA

The last phase of the Intelligent World Drive was conducted in California and Nevada. In test drives in Greater Los Angeles and from there to the Consumer Electronics Show (CES) in Las Vegas, the test vehicle had to prove itself in dense urban traffic and on highways. In the process, it became familiar with the special characteristics of US road traffic.

For example, in the United States school buses are a special category of road user. When they stop and turn on their warning lights, all vehicles in their vicinity have to stop. US speed limit signs are also absolutely unique. They have completely different shapes and sizes than the speed limit signs in Europe, Australia, Asia, and Canada. The United States also has high-occupancy vehicle (HOV) lanes, as well as road markings made of raised plastic dots (Botts' Dots). And in certain situations, US drivers are also allowed to pass on the right. All of these factors place high demands on the test vehicle's sensor systems and algorithms.

Europe

The first phase began in Germany. Here the focus was on driver behavior specifically on highways and in traffic jams.



China

A city of millions. Countless people, bicycles, motorcycles, and ever more cars – as well as the distinctive features of Chinese traffic. Here the test drives focused on driving behavior in extremely dense traffic with a wide variety of road users.

In addition to traffic signs in Chinese script, there are lane markings that have different meanings depending on their context. For example, the broad white lines that are used to indicate crosswalks all over the world can also be found on Chinese highways, but there they indicate the minimum distance between vehicles. The sensor systems of automated and autonomous vehicles must recognize and correctly interpret such features. This also applies to speed limits, which may differ for different lanes – and seven-lane intersections that are crossed simultaneously by dozens of bicycles and pedestrians during rush hour.



South Africa

Traffic in South Africa poses some very unusual challenges, such as traffic signs that are unique to this country, wild animals on the road, and pedestrians crossing the road unexpectedly. During automated test drives on the West Cape and in Cape Town, the test vehicle rose to these South African challenges. It focused mainly on the pedestrian detection system. There are many pedestrians in South Africa's cities and countryside. Some of them walk in the roadway or cross the street in unusual traffic situations. On national roads outside towns and villages, and even on major highways, drivers have to constantly look out for pedestrians crossing the roadway. This places correspondingly high demands on the sensor systems of automated and autonomous vehicles. Cameras and radar systems must recognize pedestrians and interpret their movements correctly so that the vehicle can react in milliseconds if necessary.



Australia

Drivers making a right turn from the left lane, flashing speed limit signs, kangaroos hopping across the road – during the third stage of the Intelligent World Drive, the test vehicle had to master automated test drives on country roads, highways, and city traffic with a whole new set of specific requirements. The route began in Sydney, continued through Canberra and Albury, ending up in the urban traffic of Melbourne. One focus of the test drive was the validation of the digital map data from the company HERE. The system also had to recognize the country-specific traffic signs.



In addition, the engineers tested a new lighting technology. The test vehicle was equipped with the innovative DIGITAL LIGHT system. Inside the headlight prototypes, chips containing more than one million pixels per headlight provide anti-dazzle, continuous high beams in HD quality. Among other things, DIGITAL LIGHT can project light tracks onto the road in order to communicate with its surroundings.

Functional Description of DRIVE PILOT

Level 3 conditional automated driving features present the unique challenge of managing the interaction between the automated driving feature and the driver/fallback-ready user, which is foundational to the design of Mercedes-Benz's Level 3 DRIVE PILOT feature.

Three principles that are key to managing this interaction are:

- After engaging DRIVE PILOT, the fallback-ready user can resume manual driving at any time by steering, braking, accelerating, or manually switching the feature off.
- While the DRIVE PILOT feature is engaged, it continuously monitors the fallback-ready user's ability to resume driving when requested (e.g., s/he is not permitted to sleep, leave the driver's seat, etc.).
- After issuing a request for the fallback-ready user to resume driving, DRIVE PILOT continues safely operating the vehicle until the person resumes driving, or, if s/he fails to do so, brings the vehicle automatically to a controlled stop while turning on the hazard warning lamps. What DRIVE PILOT will not do is rely on the fallback-ready user to manage an urgent and hazardous situation. Instead, DRIVE PILOT will continue to operate the vehicle until the fallback-ready user is able to resume driving or the vehicle is brought to a controlled stop.

DRIVE PILOT's safety concept is supported by robust design and testing practices, including many simulator and closed course studies to validate the interaction between the driver/fallback-ready user and the feature (see "[Validation Methods](#)").



Driver Seat Role

DRIVE PILOT Tasks



Manual or Assisted Driving

Observing and responding to the environment

AVAILABLE

DRIVE PILOT evaluates system health, route clearance, and environmental conditions to determine feature availability. Once all conditions are met, DRIVE PILOT is offered to the driver.

FADE IN

After feature confirmation by the driver, the system adapts operating parameters, such as following distance, to be suitable for DRIVE PILOT.



How does DRIVE PILOT work?

Availability and Fade In

The Mercedes-Benz DRIVE PILOT feature can only be enabled when the vehicle is being driven within its Operational Design Domain (ODD). The ODD encompasses all of the operating conditions (road type, location, road features, traffic conditions, weather, etc.) under which the DRIVE PILOT feature is designed to operate (and outside of which it will not engage, even if the driver tries to turn it on). At the time of this publishing, the ODD for DRIVE PILOT includes driving in medium to dense traffic on fully access-controlled highways in fair weather (see “[Operational Design Domain](#)”). Once the driver of a DRIVE PILOT-equipped vehicle enters a highway within its ODD, DRIVE PILOT signals its availability, at which time the driver can choose to enable it. When the driver does so, the DRIVE PILOT feature adapts the operating parameters of the vehicle until it is able to enter conditional automated driving mode by, for example, adjusting the following distance and centering the vehicle within the lane. This period of adapting to current operating conditions is called “Fade In.”

Level 3 Conditional Automated Driving

Once in conditional automated driving mode, the person formerly driving the vehicle now has the role of fallback-ready user and may be permitted to engage in tasks, such as using the in-vehicle multimedia system for communications, productivity and/or entertainment purposes. DRIVE PILOT continuously monitors (in compliance with applicable data protection laws; see “[Data Recording](#)”) the fallback-ready user’s ability to respond to potential requests by the feature to resume driving. Behaviors that would inhibit the fallback-ready user’s ability to take over driving in a timely manner, such as sleeping, are prohibited and, when detected, will cause the system to issue a series of escalating warnings. If those warnings are ignored DRIVE PILOT will automatically bring the vehicle to a controlled stop while turning on the hazard lamps. If the driver remains unresponsive, DRIVE PILOT will secure the vehicle from rolling away, seek aid by placing an emergency call to our response center, and prepares the vehicle for emergency assistance by unlocking the doors.

Unavailability and Failure Mitigation

When DRIVE PILOT senses that it will be unable to continue operating the vehicle (whether due to exiting its ODD or a malfunction), it will prompt the fallback-ready user to resume driving and provide time for him or her to do so in an orderly manner. In the event the fallback-ready user is unable or unwilling to resume driving, DRIVE PILOT will bring the vehicle to a controlled stop while activating the hazard lamps. During this failure mitigation sequence, and even in the event of a malfunction, DRIVE PILOT will continue to safely operate the vehicle, including making emergency maneuvers as needed, until the vehicle is brought to a controlled stop.

 Watch video envisioning DRIVE PILOT in use.



General Design Rules of DRIVE PILOT

Operational Design Domain

The “Operational Design Domain” (ODD) comprises the geographical area and conditions under which an Automated Driving System feature, such as DRIVE PILOT, is designed to operate. These conditions include, but are not limited to, weather, traffic, lighting, and road types.

At the time of this publishing, DRIVE PILOT’s ODD is limited to fully access-controlled highways (commonly called “freeways”) up to a specific maximum speed. (A fully access-controlled highway is defined as a divided highway with at least two lanes of traffic in each direction that has no intersections – only on-ramps and off-ramps.) DRIVE PILOT’s ODD is further restricted according to the presence or absence of certain road features and/or conditions, such as:

- Machine-detectable lane markings
- The absence of tunnels, toll booths and traffic control devices (stop signs, traffic lights, etc.)
- Applicable legal requirements

The resulting ODD boundaries (including available routes) are defined within a precise, high-definition map. These boundaries comprise the “geo-fence” for the area of operation of DRIVE PILOT; it will not allow the driver to engage the feature, nor will the feature operate the vehicle, outside of these boundaries. To fulfill Mercedes-Benz’s strong safety goals, a sophisticated solution comprising two independent positioning methods is implemented to safeguard the geo-fence. As a first method, the vehicle has a high precision and high integrity satellite positioning system using live correction data to eliminate certain satellite and transmission errors which impact the accuracy and integrity of conventional navigation systems. As a second method, a variety of objects such as signs, poles and guardrails are stored in the high-definition map. The expected locations of these landmarks are continuously compared to their real counterparts as detected by the vehicle’s sensors to yield a highly reliable position.

In addition to the aforementioned, pre-determined ODD conditions, there are transient conditions that can further restrict the ODD. Prominent examples of such transient conditions are inclement weather, such as heavy rain, snowstorms or heavy fog, or adverse traffic conditions, such as a temporary construction site.

These conditions are detected by several dedicated sensors and by continuously monitoring the performance of the vehicle’s sensors in order to detect whether environmental conditions are interfering with DRIVE PILOT’s ability to perceive the operating environment. DRIVE PILOT’s weather sensing is further augmented by online road and weather condition data, which helps it to manage transient ODD restrictions in a timely and orderly fashion.

Should environmental conditions deteriorate to the point that the DRIVE PILOT feature is unable to accurately and reliably perceive its environment or to operate safely due to inclement road (e.g., icing) conditions, activation of the DRIVE PILOT feature is denied. If already activated, a request to resume driving is issued to the fallback-ready user.

Mercedes-Benz aims to continually expand the ODD of DRIVE PILOT as technology permits. The ODD may also require modification in response to changing laws or regulatory requirements. The ultimate goal for DRIVE PILOT is to be able to operate in as many geographical areas as possible, under most environmental conditions and at any time of day or night.



Route Clearance on HD Map

Physical Separation of Traffic Directions

Machine Detectable Lane Markings

No Inclement Weather

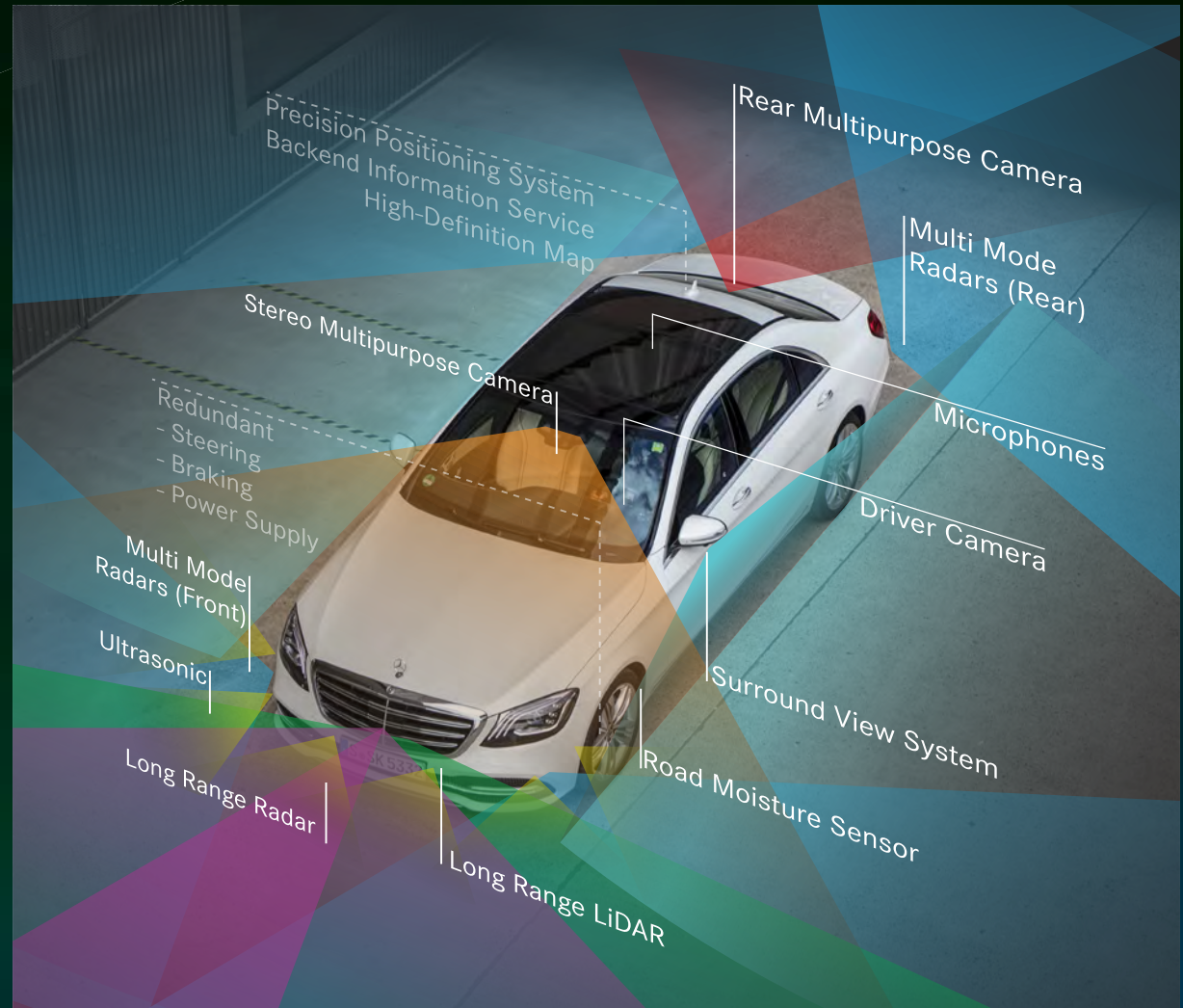
Moderate to Heavy Traffic Conditions

Object and Event Detection and Response

The Mercedes-Benz DRIVE PILOT feature uses a sensor suite that consists of radar, LiDAR, camera, road moisture, ultrasonic sensors, and microphones, to perceive relevant traffic and roadway conditions in a 360-degree field of view around the vehicle. Different sensors overlap in their fields of view where necessary to provide robust and redundant perception capability.

In the unlikely event that a sensor fails, the redundancy of the environmental perception sensors allows DRIVE PILOT to continue to function appropriately while it hands over control to the fallback-ready user. Moreover, should the fallback-ready user fail to takeover driving when requested, DRIVE PILOT will automatically bring the vehicle to a controlled stop while turning on the hazard lamps.

Each sensor technology adds specific strengths to the overall perception system for the many detection tasks required of DRIVE PILOT. The input from all sensors is combined into an accurate and comprehensive representation of the vehicle's immediate operating environment. In this way, the individual strengths of the various sensors unite to provide robust environmental perception performance.



Dynamic objects such, as other vehicles in the vicinity, are tracked in real time to enable the prediction of their behavior in the near future. Additionally, the vehicle is located on a high-definition digital map via the robust positioning system described earlier. By combining the fused sensor information with map data like traffic events or changes in infrastructure, the car's knowledge about its surroundings can be extended far beyond the sensor perception range. In this way the system provides a robust, real-time representation of the dynamic operating environment and the vehicle's position within it. This approach to object and event detection enables DRIVE PILOT to provide appropriate responses to dynamically changing road and traffic conditions.

Under normal operating conditions, the object and event detection and response capabilities of DRIVE PILOT maintain the vehicle's lateral position within the present lane of travel and within a speed-dependent, safe distance to the preceding vehicle. Under these conditions DRIVE PILOT performs all tasks necessary to safely operate the vehicle, such as responding to changes in speed by the preceding vehicle, merging traffic, lane endings, etc., all with enough lead time to permit a comfortable and appropriate vehicle response. DRIVE PILOT can also tolerate difficult-to-detect lane markings by temporarily relying on HD-map information of the lane geometry. However, prolonged loss of lane marking data will trigger a request to the fallback-ready user to

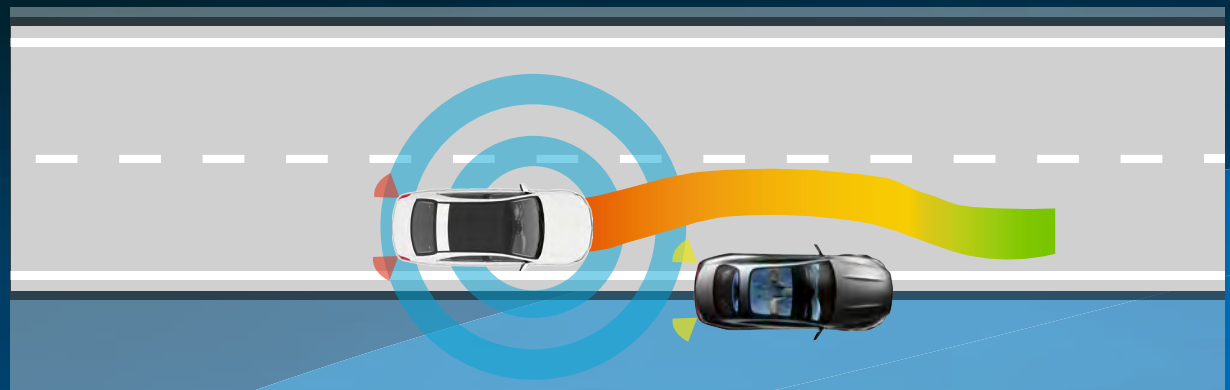
resume driving, as machine detectable lane markings are a required aspect of DRIVE PILOT's ODD. DRIVE PILOT is also equipped with microphones, which, in addition to cameras, enable it to detect the presence of an emergency vehicle approaching the vicinity of the DRIVE PILOT vehicle. When an approaching emergency vehicle is detected, DRIVE PILOT issues a request to the fallback-ready user to resume driving until the emergency vehicle has passed.

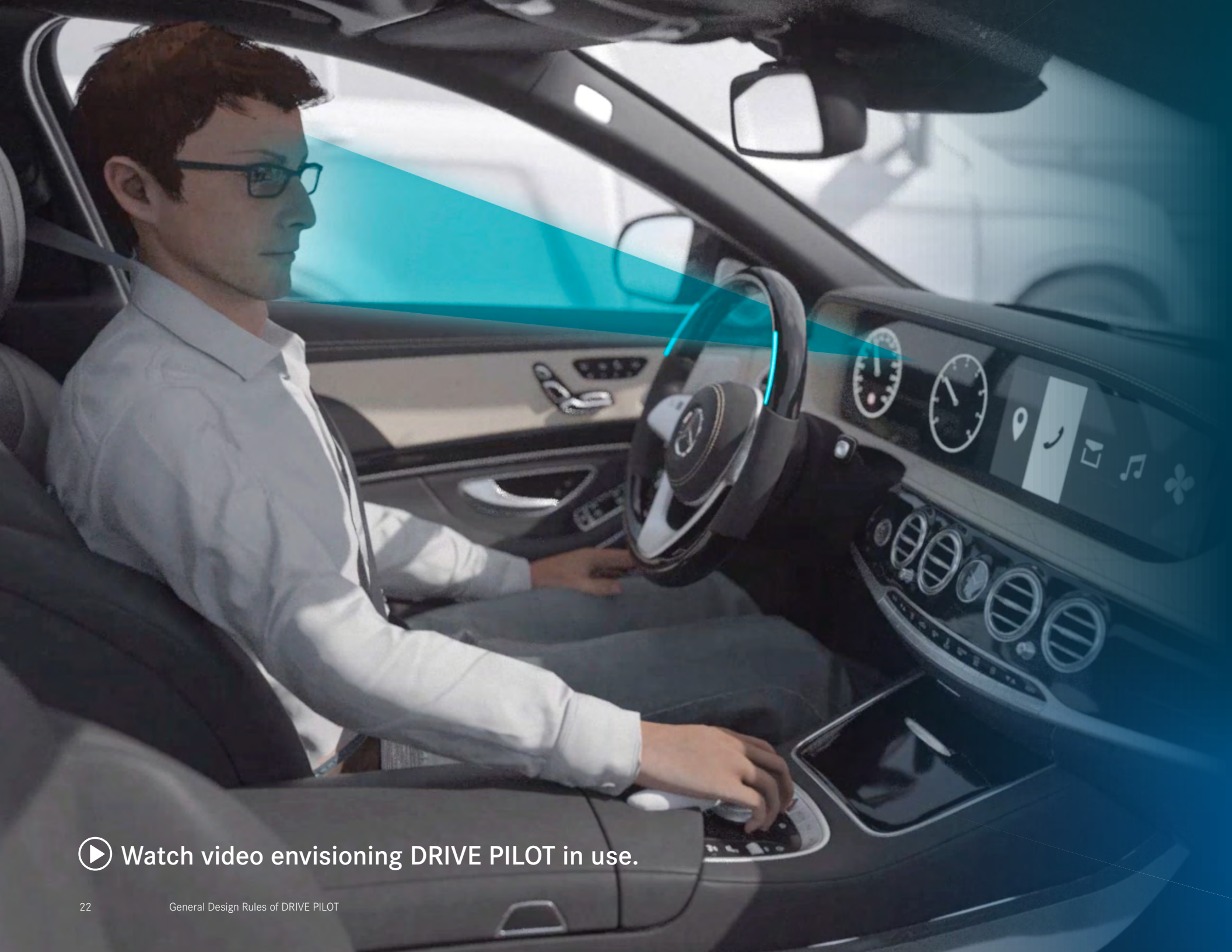
DRIVE PILOT is also capable of managing crash-imminent scenarios through emergency crash avoidance braking and/or steering, such as:

- Sudden hard-braking by the lead vehicle
- Sudden merging by a slower-moving vehicle from an adjacent lane into the DRIVE PILOT vehicle's pathway

- Sudden appearance of a substantial road obstacle, such as a large box

It should be noted, however, that there are physical limits to what the technology can do to avoid certain, sudden events, just as there are physical limits to what the best of drivers can do to avoid crashes during sudden events. For example, if a deer darts into the roadway immediately in front of a vehicle being operated by DRIVE PILOT, impact might be unavoidable. Similarly, if there is an extremely late and aggressive cut-in maneuver by another vehicle, a crash may be unavoidable. DRIVE PILOT will, however, do as much as it can to mitigate the severity of the crash through emergency steering and/or braking.





[!\[\]\(529949c2c3dadbaa4e538e8c643454bc_img.jpg\) Watch video envisioning DRIVE PILOT in use.](#)

Human Machine Interface

In order for drivers to understand when DRIVE PILOT is available, what mode it is operating in, and when it is requesting the fallback-ready user to resume driving, Mercedes-Benz is designing the human-machine interface (HMI) for DRIVE PILOT to be as intuitive and pleasing as possible. While the vehicle is operating within DRIVE PILOT's ODD and no faults are detected, the feature will offer its availability to the driver, who may choose to manually engage the feature. Once engaged, DRIVE PILOT is capable of operating in the various modes previously described.

Given the various operating modes of DRIVE PILOT and lower-level driving automation features, our human factors scientists have developed means to address the potential for mode confusion by introducing turquoise as a new color for cuing users of our Level 3 DRIVE PILOT feature. By contrast, our Level 2 feature (Active Distance Assist DISTRONIC in conjunction with Active Steering Assist) uses bright green to cue users. This unique color cuing scheme for Mercedes-Benz driving automation features is further reinforced by other aspects of the HMI design, such as the additional placement of lighting elements on the steering wheel rim. The unique color and placement of these cuing elements help users to easily understand the operating mode of the vehicle, thus reducing the potential for mode confusion.

In addition, users are provided with feedback as to when DRIVE PILOT is available or why it may be unavailable. Similarly, when DRIVE PILOT requests the fallback-ready user to resume driving, it provides feedback as to why it has sent such a request via visual messages or, upon verbal request by the user, via voice feedback. DRIVE PILOT's operating status, as well as its takeover requests, are thus apparent and easy to understand.

When the driver activates DRIVE PILOT using dedicated control elements, the fade in phase is triggered. Fade in is indicated by a status display that pulsates until the fade in period ends, at which time the pulsating stops. The fade in phase is accompanied by a status message notifying the driver that DRIVE PILOT is initiating. If the fade in does not successfully complete and DRIVE PILOT is unable to be activated, a red status message and icon informs the driver that DRIVE PILOT is unavailable. After a successful fade in phase, DRIVE PILOT displays a message indicating to the user that it is active, and that s/he must remain available to take over driving upon request. The DRIVE PILOT status display is visible and non-reflective under all ambient lighting conditions.

If DRIVE PILOT or the vehicle experience a failure that prevents continued vehicle operation by DRIVE PILOT, or the vehicle is approaching an ODD limit that will prevent continued operation, a request to resume driving is issued to the fallback-ready user. To emphasize the importance of the alert, a multimodal warning strategy is used: The status display pulsates red while the multimedia display also provides a visual warning indicating the need for the fallback-ready user to resume driving, interrupting any secondary task in which s/he may have been engaged. In addition, audible and/or haptic cues reinforce the need for the fallback-ready user to resume driving. If the fallback-ready user fails to take over within a reasonable period of time, DRIVE PILOT will automatically bring the vehicle to a controlled stop while turning on the hazard warning lamps.

A warning message informs the driver of the automated stop and continues to request that s/he resume driving. Prolonged failure to respond to the takeover request will cause DRIVE PILOT to automatically place an emergency call to our response center and to prepare the vehicle for emergency assistance by unlocking the doors.

Human Machine Interface (continued)

DRIVE PILOT's HMI is being further developed and refined based on on-going testing and evaluation, including driving simulator tests (shown below) involving more than a thousand test subjects, some of which participated in multiple studies. The HMI is also being evaluated in field operational tests that include both professional and non-professional drivers of varied experience levels. In addition to helping in the design of an intuitive and pleasing HMI, these tests and evaluations help ensure the HMI enables a driver/fallback-ready user to readily disengage DRIVE PILOT at any time via a button on the steering wheel, or by

actively steering, braking or accelerating, including in response to a DRIVE PILOT-issued takeover request. Inadvertent “bumps” or “brushes” of the steering wheel or pedals, however, are filtered out to avoid unwanted disengagement of DRIVE PILOT.

Finally, in order to monitor and enforce the fallback-ready user's ability to respond to a DRIVE PILOT-issued takeover request, DRIVE PILOT includes a camera-based monitoring system for the fallback-ready user. While DRIVE PILOT is engaged, this monitoring system detects if the fallback-ready user engages in

certain behaviors that would inhibit their ability to resume driving when requested to do so.

It will issue a warning, followed by a takeover request if the warning is ignored, when such behaviors are detected.

If the fallback-ready user fails to resume driving as requested, DRIVE PILOT will bring the vehicle to a controlled stop while turning on the hazard warning lamps, and, if necessary, will summon emergency assistance and prepare the vehicle for emergency assistance by unlocking the doors .

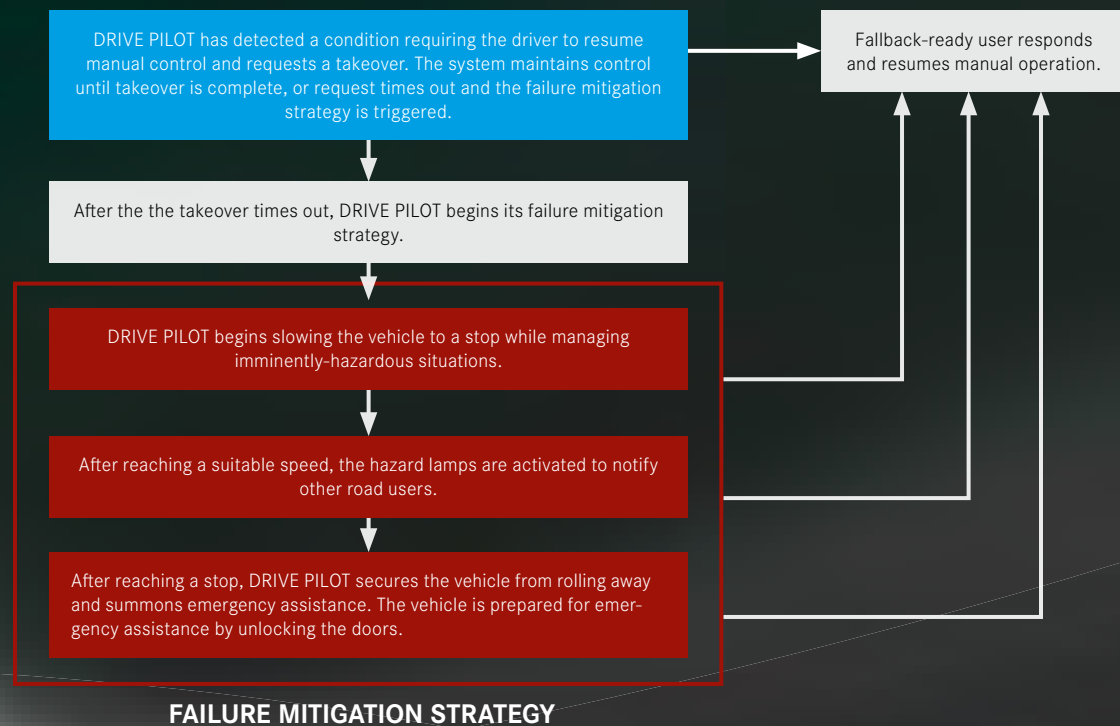


Fallback and Minimal Risk Condition

As an SAE Level 3 feature, DRIVE PILOT expects the fallback-ready user seated in the driver's seat to resume driving when requested to do so. It is also the fallback-ready user who decides whether to continue to drive the vehicle manually, or to achieve a minimal risk condition by, for example, steering the vehicle to a road shoulder and activating the hazard warning lamps.

However, even during an active takeover request situation, DRIVE PILOT is designed to manage imminently hazardous situations. It does not rely on the fallback-ready user to do so. Although the fallback-ready user is expected and obliged to resume driving without undue delay if requested to do so by DRIVE PILOT, should s/he fail to do so DRIVE PILOT will automatically bring the vehicle to a controlled stop while maintaining its crash avoidance capabilities. Hazard warning lamps are automatically turned on during a controlled stop maneuver and, if necessary, emergency assistance is summoned and the vehicle is prepared for emergency assistance by unlocking the doors.

DRIVE PILOT has a comprehensive and robust diagnostics system that continuously looks for imminent ODD limits, as well as technical failures in the feature or vehicle that prevent continued vehicle operation by DRIVE PILOT. Redundancies in critical system components, such as sensors, actuators (steering and braking), controllers, communication networks, and power supply, support continued operation of the vehicle by DRIVE PILOT in case of technical failures.



Safety Design Rules

Current Mercedes-Benz vehicles offer benchmark active and passive safety technologies that help to avoid crashes and serve to protect occupants and other road users when crashes are unavoidable. Corresponding safety technologies are also built into Mercedes-Benz vehicles equipped with DRIVE PILOT and are explained in the Crashworthiness section.

At the highest level, operational safety refers to the processes used by a manufacturer to ensure that a product is safe in three key respects:

- as conceived and designed
- as executed and manufactured
- as used by customers under real-world conditions

Operational safety for the Mercedes-Benz DRIVE PILOT feature means that its driving “behaviors” consistently and reliably deliver safe performance in all reasonably foreseeable traffic situations, including after the occurrence of a system failure. For the DRIVE PILOT feature, this safety principle is upheld by rigorous systems engineering to reliably deliver robust sensing to feed the computer algorithms. Those, in turn, comprehend the operating environment of the vehicle and derive optimal and legally-compliant vehicle maneuvering decisions to be carried out by various vehicle motion control actuators.

Before executing the design of our DRIVE PILOT feature, Mercedes-Benz engineers undertook a stringent analysis of the safety concept that supports robust

safety performance. This safety concept analysis method, called “safety of the intended functionality” (SOTIF), is designed to avoid a case where a product delivers well-executed and reliable performance that is nonetheless conceptually flawed from a safety standpoint (e.g., a hazard warning feature that unduly startles drivers).

Once the safety concept is confirmed by this analysis, a functional safety analysis is undertaken to ensure that, even when electronic failures occur, DRIVE PILOT will deliver fail-operational performance. This functional safety analysis is undertaken in accordance with ISO 26262 – Functional Safety, another industry standard Mercedes-Benz helped to develop. Functional safety includes the provision of redundant components and systems necessary to mitigate foreseeable hazards, as well as mechanisms for reliable failure detection and appropriate response to ensure safe operation. Although “perfect” safety is unattainable, the functional safety process defined by ISO 26262 is designed to ensure that a given product development process for a complex electrical/electronic system, such as DRIVE PILOT, reduces the residual risk to the state-of-the-art minimum.

“Operating safety” refers to the third aspect of Operational Safety indicated above, namely, safety as used by our customers under real-world conditions. Operating safety means ensuring to the extent practicable that the driver/user can safely interact with the operating elements of DRIVE PILOT, and that s/he understands its operating state at all times (e.g., available vs. unavailable; engaged vs. disengaged; functioning normally vs. malfunctioning, etc.). DRIVE PILOT’s driver monitoring system will also warn the fallback-ready user when it detects that s/he is falling asleep or is engaging in certain activities that would make it difficult or impossible to resume driving when requested, such as leaving the driver’s seat. As such, both intended use and reasonably foreseeable misuse are considered in the design of DRIVE PILOT.



Safety Process

The development and production of a safe product requires a specific safety process over the entire product life cycle. The Mercedes-Benz Development System is a proprietary process standard used for development of all our passenger vehicles sold worldwide. This process specifies mandatory quality gates and criteria for the advancement of a product through the development process. The safety process considers all relevant, established safety and quality standards (e.g., ISO 26262, PAS 21448, Technical Standard 16949, etc.).

The starting point for building functional safety into a feature such as DRIVE PILOT is conducting a hazard analysis and risk assessment (HARA) from which safety goals and automotive safety integrity levels (ASIL) are derived. ASIL designations take into account the predicted exposure for a given hazard (i.e., its expected frequency of occurrence in use), the potential severity of the hazard and the extent to which the driver could be expected to compensate for the hazard (controllability). Resultant ASIL designations, which vary according to the relative risk presented by each identified hazard, correlate with guidance regarding the types of countermeasures required to prevent the hazardous condition from occurring – or to substantially mitigate the associated risks should one occur.

The key features regarding countermeasures for avoiding and/or mitigating the risk associated with identified hazards are:

- Redundancies in sensing, computation, steering, braking, power supply, and intra-vehicle communications (i.e., communications occurring over the vehicle's databuses that enable DRIVE PILOT to function) to support continued safety, even if a component fails or a malfunction occurs.
- Overlapping, complementary, and/or redundant sensing systems that enable DRIVE PILOT to verify sensor signals and maintain vehicle guidance if a sensor fails or delivers implausible data. For example, comparing radar data with redundant stereo camera and LiDAR data to prevent unwanted reactions to irrelevant objects, such as overpasses or manhole covers.
- Continuous monitoring of the road (e.g., road type, pavement markings, curbs, guard rails, etc.), environmental conditions (e.g., traffic, weather, lighting, etc.), and DRIVE PILOT's state (i.e., normal operation vs. malfunctioning) in order to determine whether conditions are suitable for DRIVE PILOT engagement or continued operation.
- Providing the driver/fallback-ready user with a well-designed HMI for activation and deactivation of DRIVE PILOT, as well as for providing unambiguous indication of the system state (unavailable, available but disengaged, available and engaged, fading-in, fading-out, requesting the fallback-ready user to resume driving, or automatically resorting to a controlled stop).
- Continuous monitoring of the fallback-ready user by DRIVE PILOT in order to detect and discourage prohibited behaviors, such as sleeping or leaving the driver's seat. This helps to ensure that the fallback-ready user is able to resume driving in a reasonably prompt and orderly manner when requested by the system to do so.

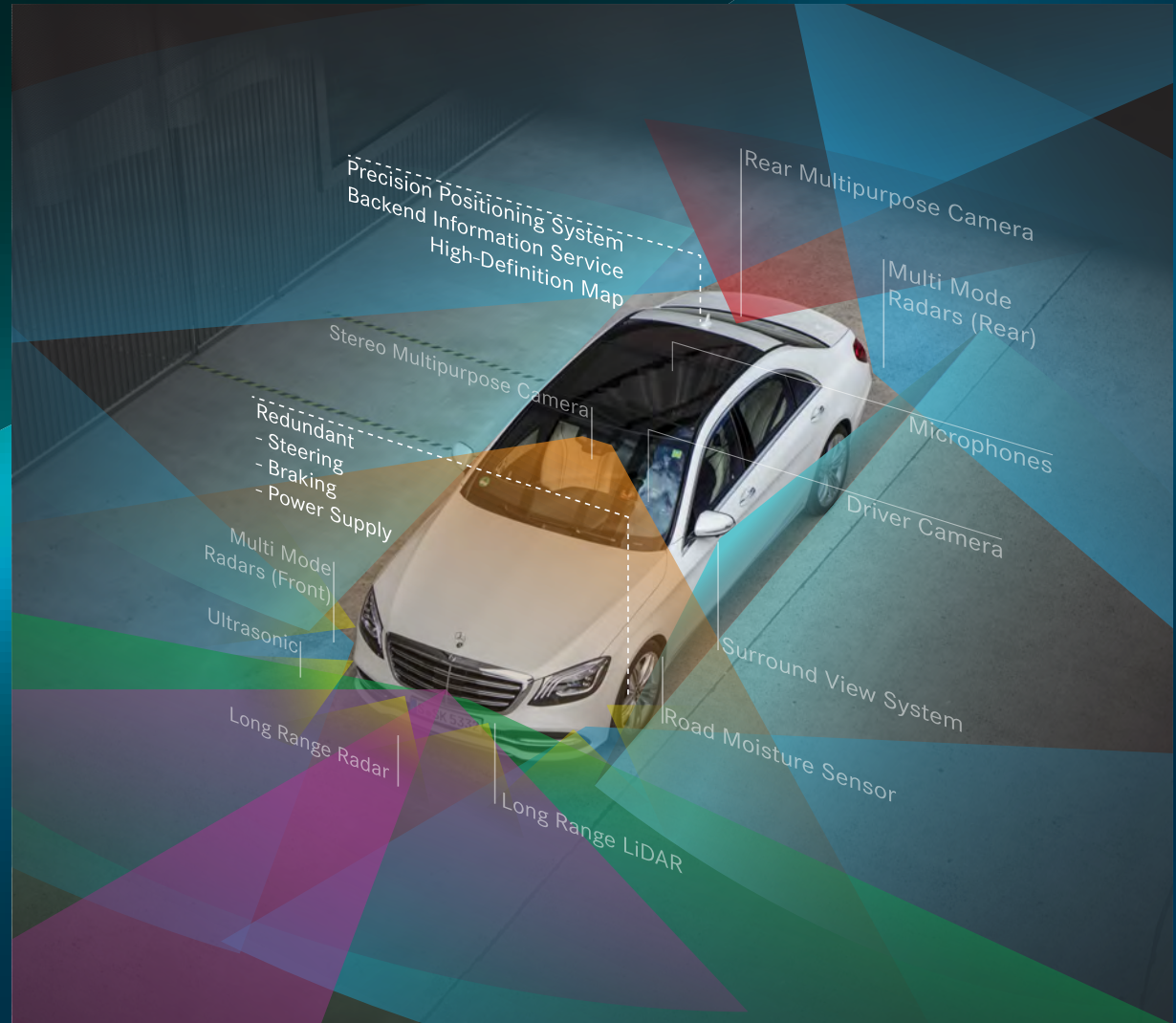
Safety is further reinforced through verification and validation. The design of DRIVE PILOT is subject to review according to various engineering processes, such as Fault Tree Analysis (FTA), Failure Modes and Effects Analysis (FMEA), Failure Mode Effect and Diagnostic Analysis (FMEDA), and safety analysis on the software level. The objective of these analyses is to prove the efficacy of DRIVE PILOT's safety concept or reveal potential safety gaps in it.

Testing and simulation are also employed to verify the correct implementation of DRIVE PILOT at various levels of integration (i.e., software, hardware, component, system, and vehicle). All test activities are integrated in a common test concept (see “[Validation Methods](#)”).

Safety and quality assurance are further supervised by five groups/entities within the Mercedes-Benz Passenger Car Division of Daimler AG:

- Supplier Product Development Department
- Product Development Department
- Active Safety Test and Assurance Department
- Vehicle Platform Department
- Quality Assurance Department

Periodic audits review the documents, specifications, and reports created during the development for consistency and correctness. Additionally, audits and assessments are carried out to examine the implemented processes that make up the Mercedes-Benz Development System.



Crashworthiness

A Mercedes-Benz vehicle equipped with the DRIVE PILOT feature provides all of the same innovative crashworthiness protections that are built into Mercedes-Benz vehicles not equipped with DRIVE PILOT.

Mercedes-Benz has a long tradition in vehicle safety innovation. In fact, Mercedes-Benz was the first vehicle manufacturer to recognize the importance of structurally designing the vehicle to absorb energy during a crash in order to reduce injury to vehicle occupants. This safety design concept originated at Mercedes-Benz in 1959 and remains valid today: Front and rear “crumple zones” are designed to absorb crash energy that would otherwise be transferred to vehicle occupants during a crash. These crumple zones, combined with a high-strength passenger compartment and optimized restraint systems, provide robust injury protection for the vehicle occupants in the event of a crash.

Today, the Mercedes-Benz “Integral Safety Strategy” views vehicle safety in four phases:

1. Safe operation
2. Critical driving situations
3. During a crash
4. After a crash

Safe Operation The Mercedes-Benz DRIVE PILOT feature consistently and reliably delivers safe vehicle operation in all reasonably foreseeable traffic situations, including after the occurrence of a system failure. DRIVE PILOT reacts to critical events and conditions with emergency braking or steering measures to avoid collisions.

If a collision is unavoidable, the vehicle also takes measures to mitigate the risk of injury during the collision with our integrated PRE-SAFE® system. Depending on the situation, PRE-SAFE® automatically closes the vehicle’s windows and prepares occupants by activating reversible seatbelt pretensioners that remove slack in the seatbelt, as well as help to position the occupant to maximize the benefits of the vehicle’s restraint and crash protection systems.

The Integral Safety Strategy of Mercedes-Benz

Integral Safety Approach



Safe driving
Provide safe driving environment with Intelligent Drive



In detected critical driving situations
Assist with Intelligent Drive and prepare for a possible crash with PRE-SAFE®



During a crash
Protect with sophisticated vehicle structures and adaptive restraint systems



After a crash
Warn other road users and call for professional assistance if needed

Active Safety
Intelligent Drive Next Level

Passive Safety
Intelligent Protect

Real Life Safety



During a Crash

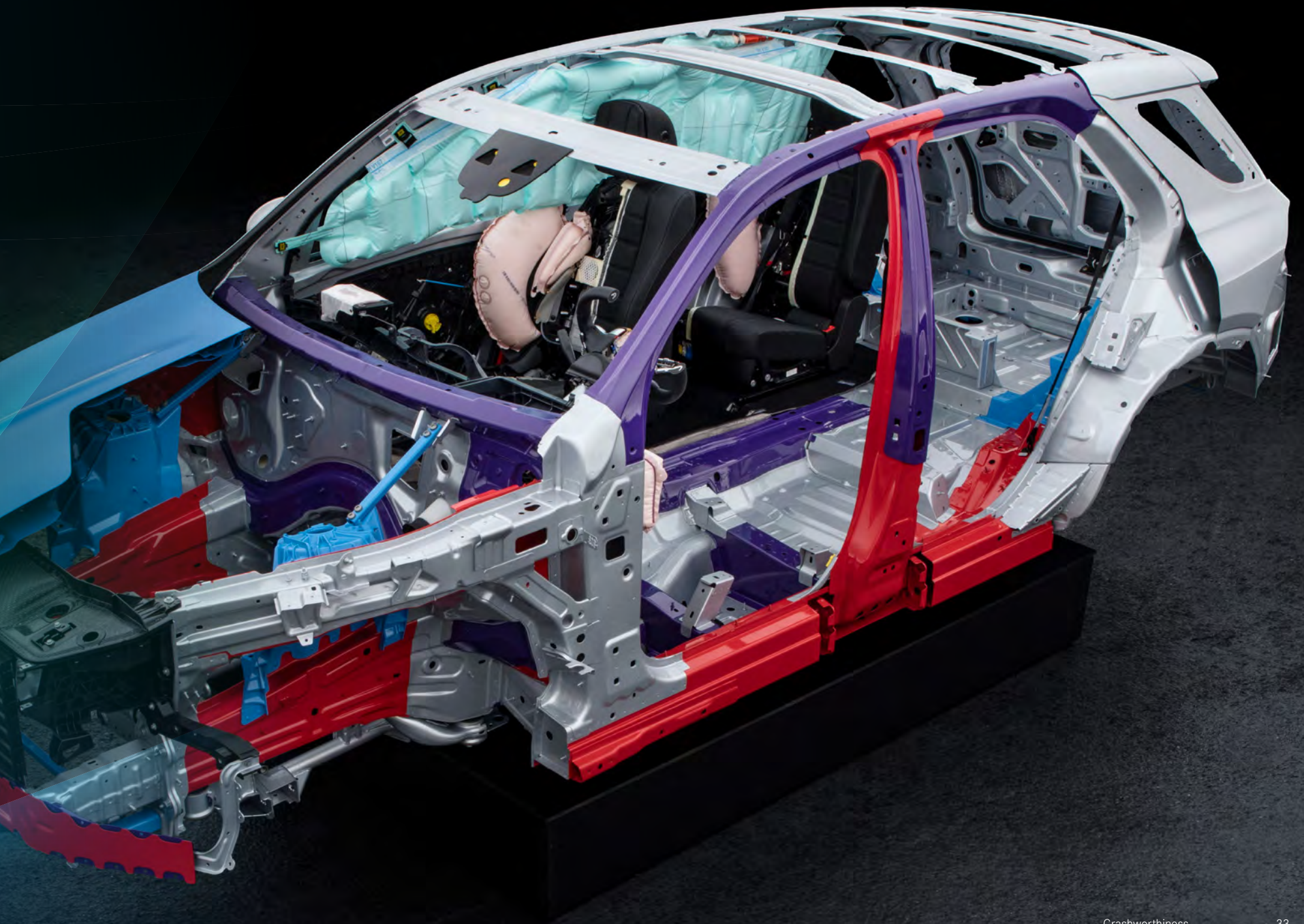
The vehicle's structure provides the foundation for the safety of its occupants. Ultra-high-strength steel and hot-formed steel alloys are used in critical load paths to preserve the passenger compartment and to absorb energy during a crash. Aluminum elements are also integrated into the vehicle structure to further enhance the structural rigidity and crash energy absorption properties. Advanced simulation and test methods are used to develop the hybrid structure and to validate that it meets Mercedes-Benz's high standards for occupant protection.

Building on the vehicle's optimized structure, occupant protection is further enhanced by state-of-the-art restraint systems (seatbelts and airbags), which function in concert with the integrated PRE-SAFE® system described above. For rear seat occupants, the outboard seatbelts also incorporate pre-tensioners and belt force limiters. The rear seat includes LATCH anchors for the installation of specially designed child restraint systems (i.e., special child seats designed to reduce injury in a crash, which are optimally secured in the vehicle using the LATCH anchors).

Advanced airbags provide additional occupant protection in the event of a frontal crash. In such cases, the frontal airbags are designed to provide two levels of inflation energy, depending upon crash severity. They automatically adapt the airbag inflation energy based upon the occupant's weight and position relative to the airbag. The front occupant positions also include airbags integrated into the seat backrest to provide thorax and pelvis protection, as well as curtain airbags to provide head protection in the event of a side crash.

When the vehicle detects that it is involved in a collision while the DRIVE PILOT feature is active, a takeover request will be issued to the fallback-ready user. If the fallback-ready user is unable to take over, the DRIVE PILOT feature will try to maintain steering control and bring the vehicle to a controlled stop. If steering control is not possible due to crash severity or other circumstances, a full braking maneuver is performed in order to reduce the possibility of secondary impacts with other road users or objects in the vicinity of the crash.





The Mercedes-Benz logo is rendered in a stylized, glowing 3D effect. It features three curved lines in silver and gold, with a jagged, lightning-bolt-like edge on the right side. The logo is positioned above the text 'Mercedes-Benz' and 'Safety'.

Mercedes-Benz

Safety



After a Crash

Even after a crash the vehicle provides protection for its occupants by:

- Securing the area around the vehicle by automatically activating hazard warning lamps and automatically summoning emergency assistance.
- Providing orientation to passengers by turning on the cabin lights and ventilating the interior after an airbag activation.
- Giving emergency response personnel information relevant to the vehicle with the Mercedes-Benz Rescue Assist App. A QR-code on the inside of the re-fueling door provides easy access to the Mercedes-Benz Rescue Assist App, which displays schematics of the vehicle that facilitate the rescue phase and ensure the safety of emergency response personnel.

If a crash is detected, certain event data will be recorded automatically in order to facilitate reconstruction of the crash event. When provided, crash data helps our safety development engineers, who strive to continuously develop new safety innovations and improvements for the protection of our customers and other road users.



Validation Methods

Maximum safety and quality are major brand values of Mercedes-Benz and are key goals of every vehicle development program. To achieve these goals we rely on our well-proven Mercedes-Benz Development System. This system integrates state-of-the-art safety standards with quality-verified release gates to help ensure the product's design intent has been correctly and accountably executed. This process specifies an effective and extensive verification and validation program to prove that our vehicles are capable, robust, and safe. It includes the following six verification and validation elements:

Integrated Verification Testing

Hardware and software components are tested and validated on different levels. The source code itself must meet stringent quality requirements, many of which are already standardized in the automotive domain. Each single line of code, each software component and each hardware component undergoes a well-defined test plan and is repeatedly examined against thousands of functional and safety requirements prior to its release and integration into DRIVE PILOT.

Before a new feature is tested on-road, we utilize software test suites, hardware test rigs and hardware-in-the-loop test benches to jointly evaluate and stress all aspects of the feature's hardware and software. This battery of tests is followed by in-vehicle tests conducted on our company-owned proving grounds where we evaluate the system's performance during

standard operation and in more challenging and potentially hazardous traffic situations. We use state-of-the-art test equipment, such as a programmable, remotely-controlled soft "target" vehicle, as well as pedestrian and bicycle targets, to enable us to repeat the same exact scenario over and over again to assist our developers in achieving specific performance goals. Only when all safety requirements are met during this thorough testing do we continue our intensive test program on public roads.

Integrated Verification Testing ensures a basic safety and quality level. It is rigorously conducted according to our Mercedes-Benz Development Process. In each cycle of our well-established system development process we require a full evaluation of all implemented system features. Our extensive experience and well-proven development process has yielded comprehensive specification books that help us ensure the design intent for each product is precisely executed in a well-ordered, disciplined and accountable manner.

Our testing process meets both external functional and system safety standards, such as ISO 26262, as well as our strict internal quality and safety guidelines.



Field Operation Testing

The second element in our verification and validation program is extensive on-road testing to build on our Integrated Verification Testing. Professionally trained drivers conduct extensive test programs to identify and address potential deficiencies and, eventually, to verify the safety of our system design for release to our customers. System performance goals and safety criteria are evaluated under real-world conditions in widely diverse traffic situations prior to release.

This phase of real-world testing builds on decades of internal testing involving our Level 1 and Level 2 driving automation system features, which have so far logged millions of test miles. The procedural experience gained during this previous testing informs the approach we have taken in validating DRIVE PILOT, including data management, test driver experience, route planning, equipment needs, etc.

Field Operational Testing mainly addresses three aspects of safe operation:

- **Operational Safety** focuses on realizing safe operation by DRIVE PILOT – not only in predefined scenarios but also in diverse real-world traffic situations. For example, we conduct a comprehensive evaluation of the system performance under different road, light and weather conditions around the world. In Field Operational Testing we verify that DRIVE PILOT's detection and maneuvering decisions, as previously developed on test tracks, are consistently correct when DRIVE PILOT encounters similar situations under diverse, real-world conditions.
- **Operating Safety** focuses on safety as used by our customers and is first examined using our highly-advanced driving simulators and then on our company-owned proving grounds. After feature confirmation by simulator testing, our professional test drivers conduct on-road testing to evaluate and further refine the safe and intuitive design of our HMI concept for DRIVE PILOT.

- **Legal and behavioral traffic rule** compliance is verified by ensuring robust performance under diverse, real-world operating conditions. This includes DRIVE PILOT's ability to operate in compliance with speed limits, respond to police and emergency vehicles, maintain a safe driving distance to other road users, and generally deliver predictable and safe driving behaviors.

Given DRIVE PILOT's extensive operational design domain, Mercedes-Benz will comprehensively evaluate system performance on all highway sections in the U.S. on which it is designed to operate before we will release DRIVE PILOT to our customers. This evaluation process will include DRIVE PILOT's driving behavior and the performance of the various sensors, high definition maps and high-precision positioning system, accounting for a wide variety of geographical and infrastructural characteristics.



Video Recording of Driver

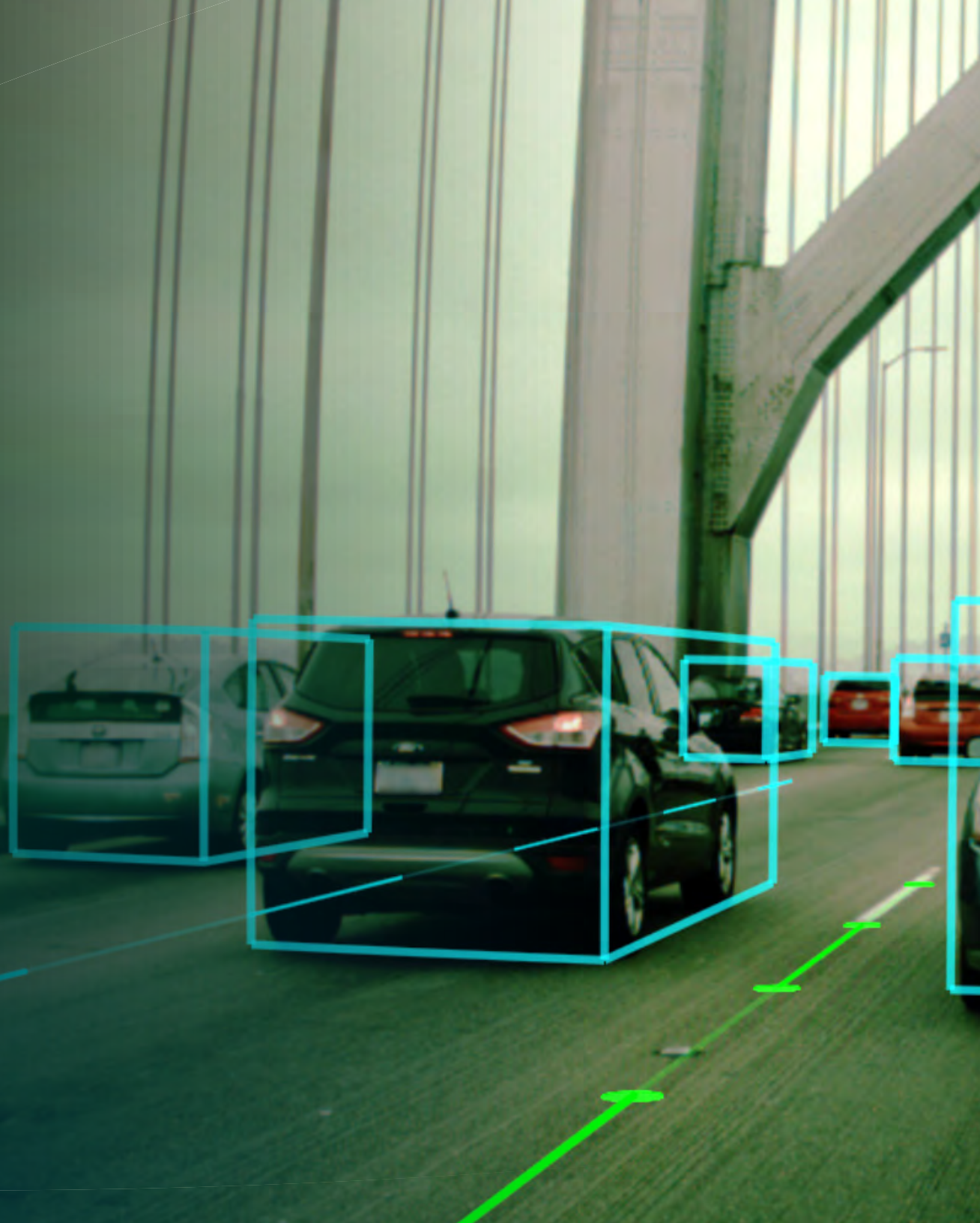
Video-Aufzeichnung vom Fahrer

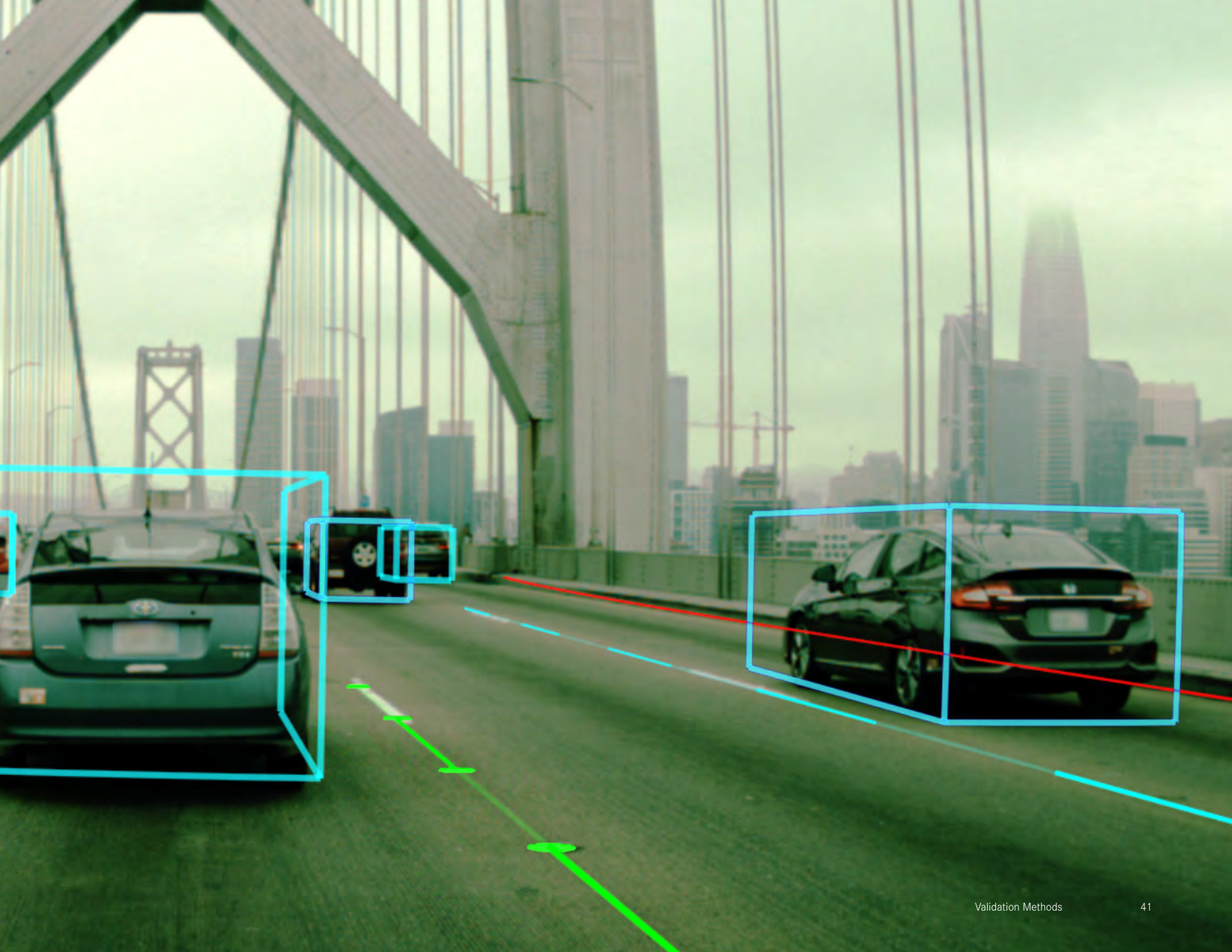


Validation of Environmental Perception and Positioning

Field Operational Testing yields valuable data that is used to further investigate the overall performance of DRIVE PILOT. Here we sharply focus on Environmental Perception and Positioning, which is vital for safe and reliable object and event detection and response. The valuable data we collect helps our development engineers to further refine DRIVE PILOT's safety and reliability, as well as its comfort and utility.

We rely on our large-scale worldwide data infrastructure that enables us to efficiently upload large quantities of data directly from test vehicles to our dedicated servers. The incoming data is then automatically processed and prepared for subsequent analysis and investigation. We utilize "big data" analysis processes and tools to search the data for system abnormalities and challenging situations. As mentioned above, we focus especially on evaluating the performance of our optical, radar, LiDAR, and positioning sensors, their combined view of the real world and its correlation with the continuously-updated, high-definition digital map. All relevant findings, such as challenging environmental situations, data mismatches, or other significant events are then marked for further analysis and follow-up to support our continuous-improvement development process for DRIVE PILOT.





Virtual On-Road Testing

The fourth component in our established verification testing process is virtual test driving based on defined edge cases, as well as real-world events recorded during on-road testing.

Digital simulation is a key element for validating the safe and predictable operation of DRIVE PILOT. Whereas scenarios encountered during Field Operational Testing are invaluable for evaluating the performance under real-world conditions, they are limited to the specific environment and traffic situations encountered, and thus can be insufficiently comprehensive. Simulation in the form of virtual test driving enables us to intelligently and efficiently extend the number and variety of scenarios against which DRIVE PILOT is tested, including very rare and unusual events.

According to the latest state-of-the-art methodology and research results as compiled and published by the German [PEGASUS](#) project, we use a complete digital description of relevant traffic scenarios. This includes the original software code of our DRIVE PILOT system, detailed models of the vehicle, its sensors and actuators and a complete parameterized description of the static and dynamic environment.

We apply intelligent search algorithms and evaluate millions of scenario variants in order to identify potentially critical situations and system deficiencies.

These situations are then used to iterate exhaustive and reproducible tests of the system's performance. This includes very challenging and hazardous scenarios, such as extremely late and aggressive cut-in maneuvers, which can be tested much more rapidly, safely and comprehensively than performing on-road testing alone.

Every potentially critical result is then thoroughly evaluated by our development engineers. If necessary, we are able to reconstruct individual scenario variants under real-life conditions on our proving grounds using our advanced, programmable test equipment. This helps to assess the system performance and identify potential deficiencies, while also providing a method for continuously checking and calibrating the fidelity of our virtual test drive simulation technology.



Non-critical cut in because of low value of deceleration, high distance between system vehicle and object.



Variations of the cut in scenario yielding potentially critical situations with hard braking of cut in vehicle (red arrow).

Validation of Driver Interaction

The close interaction between DRIVE PILOT and the fallback-ready user requires Validation of Driver Interaction as an important aspect of Operating Safety, the primary focus of which is the human-machine interface (HMI). DRIVE PILOT's HMI comprehends operating modes, transition phases and all user interactions under all operating circumstances.

Mercedes-Benz has extensive experience investigating driver interaction using our advanced driving simulators. We have conducted a multitude of studies and trials with both expert and normal test subjects in simulators, as well as in real vehicles operated on our proving grounds. Our objective is to enable the driver/fallback-ready user to safely interact with the operating elements in the vehicle and to be able to understand DRIVE PILOT's operating state at all times. Example studies of driver interaction include comprehensibility, mode confusion, foreseeable misuse, transition phases and more. We place special emphasis on using a wide range of subjects representing the vast diversity of our global customer base.

After having thoroughly examined the driver interaction by means of driving simulator and proving ground, as well as in Field Operational Testing with professional drivers, our final verification and validation program requires an on-road test program with normal test subjects who are unfamiliar with the feature.

Final Customer-Oriented On-Road Validation

Once the previously mentioned validation measures are successfully completed and our feature is deemed to be sufficiently robust, we perform on-road tests with normal test subjects who are unfamiliar with the feature. We start by having professional evaluators accompany our test subjects on test drives during which they practice engaging and disengaging the feature and experience its various operating modes. This phase is followed by subsequent testing phases in which we gradually allow the test subjects (i.e., fallback-ready users) to engage in tasks otherwise unsuitable for a driver, such as using the vehicle's multimedia system for productivity and entertainment purposes.

In summary, only if all six verification and validation elements are successfully completed and DRIVE PILOT's robustness is proven will we release it to our customers.





Security, Data Policy and Legal Framework

Vehicle Cybersecurity

Vehicle cybersecurity is an essential component in helping to keep the vehicle, passengers and other traffic participants safe. To achieve end-to-end security, Mercedes-Benz follows a defense-in-depth approach that comprehends all layers of the product and vehicle.

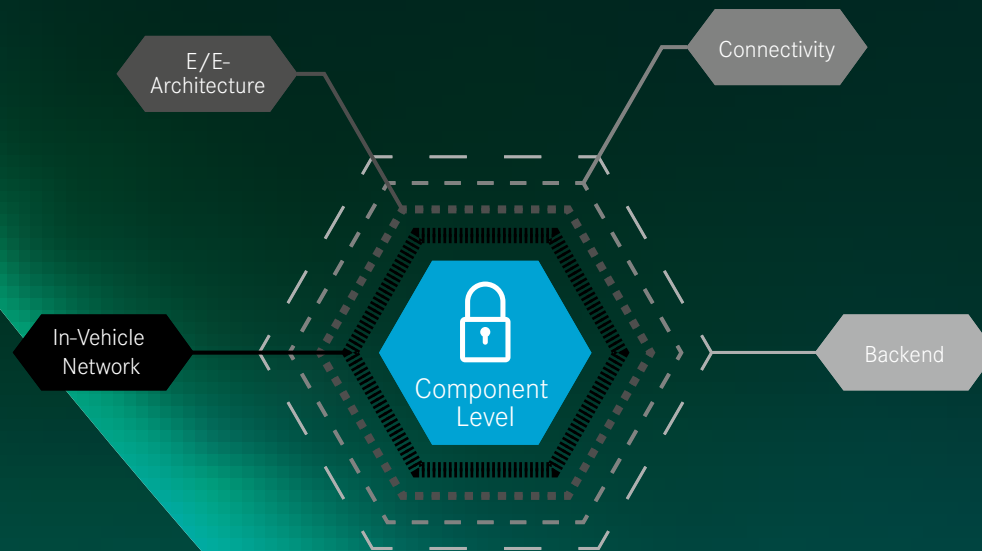
Our main objective is to provide safety while preventing and mitigating all malfunctions due to unauthorized manipulation, interference or any kind of cyber-attack.

Our security engineering process follows the principles of ISO norms 27005 and 31000 for risk-based engineering in an iterative manner:

- Threats and Risk Analysis: What could go wrong? How bad would it be? How likely is it to happen?
- Security Concept: What should we do about it?
- Residual Risk Analysis: Have we done enough?

This approach is implemented in conjunction with the recommendations being developed in the automotive security standard ISO/SAE 21434. In addition to applying a methodical approach to system development, it includes the definition and use of best practices as a baseline for technical implementations with a focus on the complete life cycle of an ADS-equipped vehicle.

In addition, because high-definition maps are provided to the vehicle through wireless means by backend services, the cyber-attack surfaces resulting from the very nature of connectivity must be addressed in the security design. We therefore provide protection against attacks targeted at the backend connection as well.



Heritage, Cooperation, Continuous Improvement

In addition to being a pioneer in automotive safety, Mercedes-Benz is also an innovator in automotive security for connected vehicles. Our contributions to cooperative research activities such as E-Safety Vehicle Intrusion Protected Applications (EVITA), Crash Avoidance Metrics Partnership (CAMP) and Automotive Open System Architecture (AUTOSAR) to name a few, have led to the specification of automotive hardware security modules for vehicles and secure communication standards for in-vehicle databuses. Mercedes-Benz is a strong contributor to the new automotive cybersecurity norm ISO/SAE 21434. We are also a founding member of the Automotive Information Sharing and Analysis Center (Auto-ISAC), which helps to ensure continuous improvement by sharing experiences and best practices with the rest of the automotive industry.

Auto-ISAC is designed to provide a forum for vehicle manufacturers and suppliers to share information on cybersecurity threats that could adversely affect the safety of road transportation in the U.S. Mercedes-Benz is an active member of Auto-ISAC, which is also aligned with ISO/SAE 21434 – “Road vehicles – Cybersecurity engineering” and covers the following areas:

1. Incident response
2. Collaboration and engagement with appropriate third parties
3. Governance
4. Risk management
5. Security by design
6. Threat detection and protection
7. Awareness and training

Data Recording

Every Mercedes-Benz vehicle offered for sale in the U.S. is equipped with a 49CFR Part 563-compliant event data recorder (EDR) designed to facilitate crash reconstruction. DRIVE PILOT-equipped vehicles have additional data recording capabilities for crashes that may occur while DRIVE PILOT is engaged in order to better understand what the DRIVE PILOT feature perceived and how it responded prior to the crash, and whether (and, if so, how) the fallback-ready user intervened prior to or during the crash. This information allows for the analysis of a particular event and development of appropriate countermeasures when warranted.

In the future, customer-owned/leased Mercedes-Benz vehicles equipped with DRIVE PILOT will store some safety and business relevant data both on-and off-board the vehicle in order to continuously improve the security and utility of the feature. Collected data will be recorded, stored and maintained in compliance with applicable privacy laws and regulations. As a member of the Alliance of Automobile Manufacturers, Mercedes-Benz also follows the “Automotive Consumer Privacy Principles” published in November 2014 and updated in early 2018. These principles incorporate Fair Information Practices and Federal Trade Commission guidance to establish a set of protections for personally identifying information collected and used by modern vehicles. They reflect an industry-wide commitment to be responsible stewards of personally identifiable information used in providing vehicle and transportation services.

In regard to data collection during testing, Mercedes-Benz conducts extensive testing of DRIVE PILOT on U.S. roads to ensure robust performance under unique deployment conditions applicable to the U.S. market. Scenarios of particular interest encountered during testing are electronically time-tagged by trained test engineers during testing. In addition, offline analyses of the complete driving traces are conducted using algorithms to identify threshold events. All of these scenarios/events are reviewed by the responsible engineering teams in the U.S. or other Daimler locations worldwide, who use the data to refine DRIVE PILOT for deployment in the U.S. and elsewhere. Similar test and engineering feedback data are provided by other markets and are also used to refine the design of DRIVE PILOT for the U.S. and other markets.

Federal, State and Local Laws and Regulations

Mercedes-Benz places the utmost importance on compliance with legal requirements and the maintenance of road safety.

Given that human driving is replaced by DRIVE PILOT while it is engaged, there will be requirements and standards that need to be adapted in order to apply to a vehicle when it is not being operated by a human driver. For example, while it is not safe for drivers to engage in distracting behaviors while operating a vehicle, the same is not true for fallback-ready users: The fallback-ready user may use the in-vehicle multimedia system for communications, productivity and/or entertainment purposes, because DRIVE PILOT is

operating the vehicle. For this reason, state and local laws against distracted driving may need to be modified to distinguish between a driver and fallback-ready user. Mercedes-Benz, along with other ADS and vehicle manufacturers, are working with state and local authorities to identify requirements that may need to be adapted for vehicles being operated by a Level 3 ADS feature, such as DRIVE PILOT.

With regard to traffic law compliance, Mercedes-Benz follows the “designed to comply” principle adopted by the California Department of Motor Vehicles in its deployment regulations for “automated vehicles” published in 2017. This principle recognizes that, like a human driver, an ADS will, under certain circumstances, justifiably prioritize rules in order to maintain driving safety and complete a trip. Such actions might include crossing a solid lane marking – when safe to do so – in order to avoid being side-swiped by another vehicle encroaching on its lane. Other states have since adopted similar regulatory language. Their foresight is appreciated and commended.

Consumer Education and Training

Before customers experience the DRIVE PILOT feature it is important to inform them of the best practices for operating their vehicle. Mercedes-Benz's rich heritage of safety innovation stretching over more than a century has motivated the development of robust processes for providing our customers with comprehensive information and training to facilitate the safe and effective use of our vehicles. We will continue to develop and enhance these processes for our first generation of ADS-equipped vehicles through education and enhanced training assistance, as well as providing opportunities for our customers to inform and train themselves.

To help ensure customers with varying technical backgrounds are well informed about DRIVE PILOT, information will be provided in multiple formats, such as hands-on training by sales personnel at dealerships, printed materials and a variety of digital media. [Our website](#) is a rich resource for additional information on different driving systems in written, graphical and video format. Mercedes-Benz applications, such as "Mercedes me[®] connect", enable customers to learn more about their vehicle's capabilities and diagnostics.

New how-to videos uploaded in multiple locations and populated in our consumer application, Mercedes me[®] connect, will give our customers tools to understand how to better operate their vehicles.

Our well-trained Sales and After-sales Specialists are also available to support customers with answers about novel vehicle functions. In conjunction with the aforementioned educational materials, such on-demand assistance provides robust educational and training resources for all Mercedes-Benz customers. In addition, every Mercedes-Benz vehicle contains a "Quick Start Guide," which is a printed brochure explaining important vehicle features and functions in a brief and easy-to-understand format.

Many of our authorized dealers enhance the ownership experience by offering personalized deliveries, going above and beyond what is required, focusing on educating customers and ensuring they have a strong level of comfort with the operation of high-tech features and functions of their new vehicles when they take delivery. Dealership personnel can also be contacted directly through the Mercedes me[®] application for continuing education, even after delivery.

Mercedes-Benz training teams continue to learn about what is required and most helpful for our customers and their overall vehicle ownership experience. As we continue to better understand our customers we strive to provide the most up-to-date product information via our many printed media and digital channels.



Conclusion

At Mercedes-Benz the same passion for safety and innovation that motivated us to pioneer now widely adopted safety advancements such as the crumple zone, airbag, and electronic stability control continues to thrive. In the last decade, this culture of innovation and safety has made our cars safer than ever before with advanced driver-assistance safety features like Active Brake Assist and many more.

The introduction of automated driving technology comes with the potential to transform the way people live and work. The car can become a space for work, relaxation or rejuvenation. Automated driving provides the opportunity to reduce accidents caused by human error.

The possibilities offered by automated driving have captured the public's imagination in a way that few new vehicle technologies have. At Mercedes-Benz we share this enthusiasm and embrace the changes it will bring to our industry and the world.

Our passion to make the world a safer, more accessible place drives us to develop a full range of automated driving options and experiences for every need, eventually up to and including Level 5 full automated driving, which will offer the same degree of mobility provided by human-driven vehicles today. Some automated driving features will be designed for personal vehicles, such as the DRIVE PILOT feature described in this document.

Other features will be designed to provide shared mobility, as demonstrated by the automated vehicle described in our brochure ["Reinventing Safety: A Joint Approach to Automated Driving Systems"](#). Further developments will enable automated package and freight delivery services. All of these future Mercedes-Benz automated driving features and vehicles will have this in common: The three-pointed star representing our uncompromising commitment to excellence.

The distinguished safety heritage of Mercedes-Benz will consistently guide the design and development of our automated driving capabilities and help ensure we continue to deliver products that meet or exceed our customers' expectations for safety, reliability and comfort. Our well-established safety culture remains the very center of our process design, system development, component selection, testing and validation.

We are excited by the potential for DRIVE PILOT to offer a safer, more comfortable and convenient travelling experience on highway trips. With Mercedes-Benz DRIVE PILOT people can begin to experience the advantages of automated driving in the comfort of their own vehicles.



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