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#635



In-car HMI UX Evaluations

In-Car HMI UX Evaluation & Benchmarking

Mercedes-Benz S-Class

As vehicles continue to adopt more technologies, it is important the user feels they are interacting with a complete, well-designed system. The in-car experience is the new battleground for brand differentiation and will be the key to ensuring long-term consumer loyalty. In this report series, SBD Automotive's CASE technology specialists undertake UX Evaluations of 8 vehicles.

In testing the S-Class, **SBD Automotive's UX Team** has found MBUX cannot be considered a market leading system, but can be considered competitive. Notable approaches within the system with relatively new HMI and service offerings are clear, however the final implementation for such features are lacking at times.

In the new S-Class, MBUX is housed in a 12.8-inch center display lifted from the dashboard and angled upwards for easier access. Its 12.3-inch digital instrumental cluster adds an optional 3D display to enhance core vehicle functionality – for example, adding depth to navigation. This augmented reality navigation can be considered an impressive 'wow feature', but can have misleading results, which can be ambiguous and even incorrect.

COVERAGE



GLOBAL



NA



CHINA



EUROPE

FREQUENCY



ANNUALLY



QUARTERLY



CARS PER YEAR

8

PUBLICATION FORMAT



PDF



POWERPOINT



EXCEL



ONLINE

PAGES



170+

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Scoring

- > **Features and functionality:** evaluating whether the solutions provide features that customers expect, need and solve problems (or provide a wow factor).
- > **Reliability/stability:** evaluating the repeated usability and whether the users can have a similar (positive) experience each time.
- > **Usability:** evaluating whether the features available are easy to learn and use. This considers areas such as ergonomics, legibility, usability characteristics and how the system implements the various features.
- > **Perceived quality:** evaluating the potential perception in quality of the HMI components and how this contributes to the overall customer experience.

This research is useful for



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USER EXPERIENCE



MARKETING



C-SUITE



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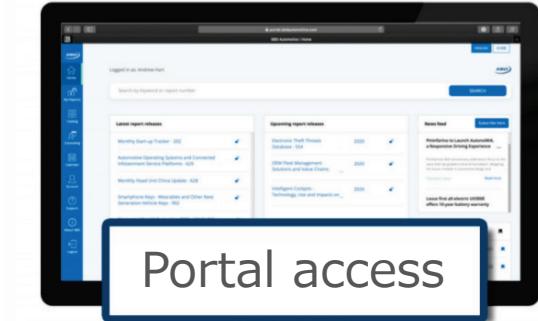
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May 2021

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MERCEDES-BENZ S-CLASS

In-Car HMI UX Evaluation & Benchmarking

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Introduction

Aim of this report

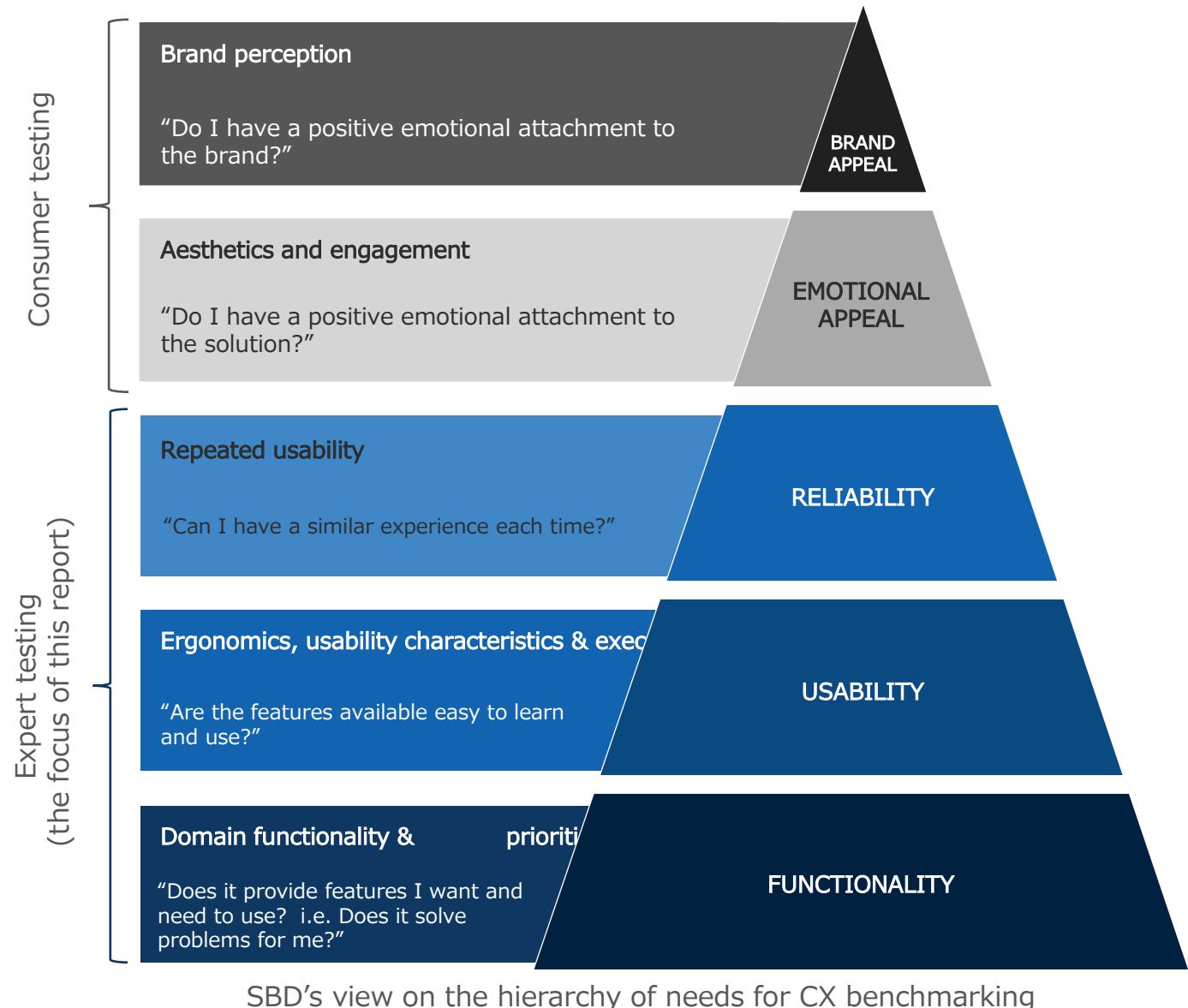
Welcome to the 2021 HMI benchmarking report series. This report has been created to provide a fair, unbiased and objective view of the latest in-vehicle HMI solutions in the European and US markets. Evaluations are carried out by SBD usability experts with a deep understanding of CASE domains such as the Connected Car and ADAS & autonomy domains.

One of the core goals of these studies are to provide a true indication of what the final customer experience of each solution could be. To do this evaluations are focused on providing scoring and analysis in the following areas:

- **Features and functionality:** evaluating whether the solutions provide features that customers expect, need and solve problems (or provide a wow factor)
- **Usability:** evaluating whether the features available are easy to learn and use. This considers areas such as ergonomics, legibility, usability characteristics and how the system implements the various features
- **Reliability/stability:** evaluating the repeated usability and whether the users can have a similar (positive) experience each time
- **Perceived quality:** evaluating the potential perception in quality of the HMI components and how this contributes to the overall customer experience

SBD supports clients throughout the development of new HMI and products from a relatively simple companion app to a more complex multi-domain infotainment solution. The methodologies used in these reports take into account many years of experience with consumer testing and custom client projects to provide a fair and, as much as possible, objective methodology.

All viewpoints and analysis within the report are aimed defining areas of concern through a data driven approach. This report aims to benchmark and score solutions whilst also being able to provide actionable recommendations to design and development teams.



Scope of report: focus on in-car HMI evaluations

The scope of evaluations in this report are constrained to the in-car HMI experience, in both static and dynamic conditions. One notable element is driver distraction which SBD covers at a high level in this study as a full driver distraction evaluation must be carried out with biometrics test equipment to ensure the collected data is unbiased and objective.



A full evaluation of the end-to-end customer experience is not within scope of this report, but it is something which SBD has many years experience in from both a consumer and expert perspective. Other areas such as the companion app, online portal and in-home smart devices are not in scope as they are defined as "out the car" experiences.

Within the vehicle any HMI element the user interacts with is evaluated from steering wheel switches, touch screen displays, HUDs etc. The features and services on offer have been broadly grouped into the following domains (or test areas):

- ADAS domain
- Infotainment domain
- Navigation domain
- Voice recognition domain
- Connected services domain
- Convenience domain

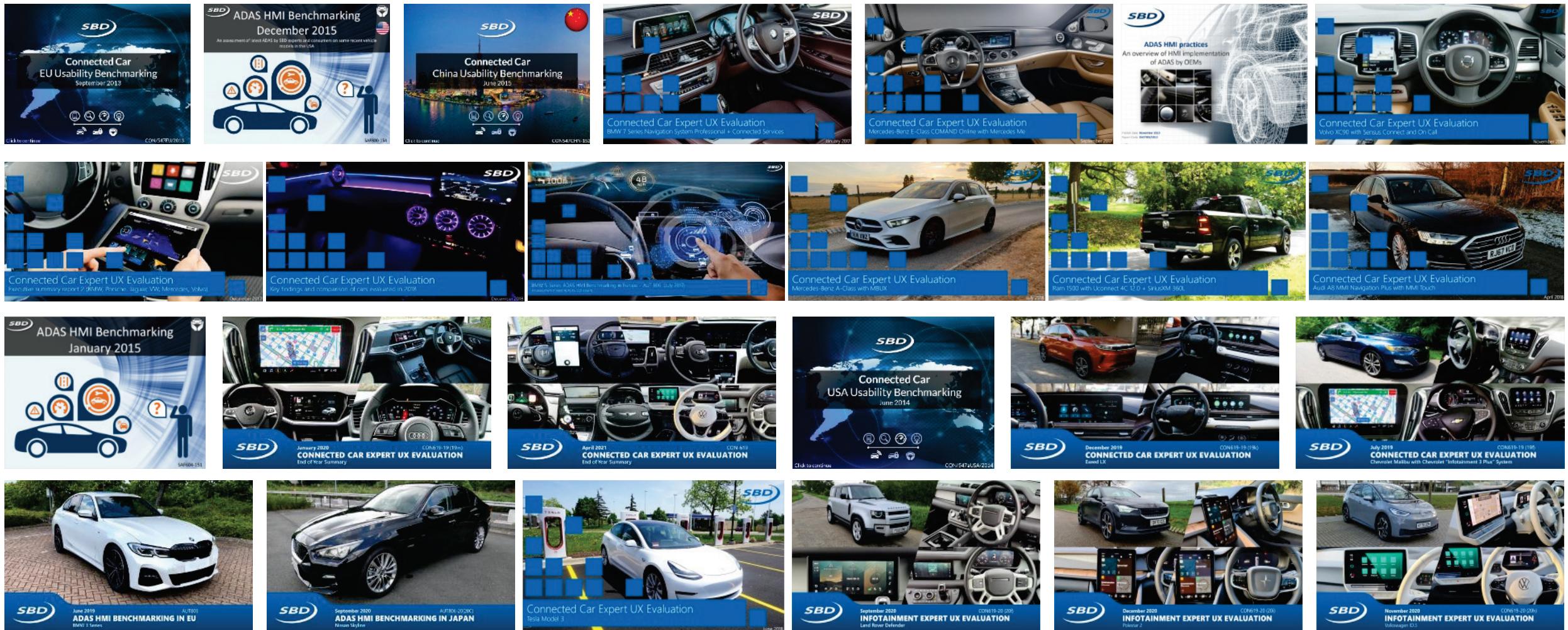


Biometrics evaluations used for detailed drive distraction
not in scope for this report

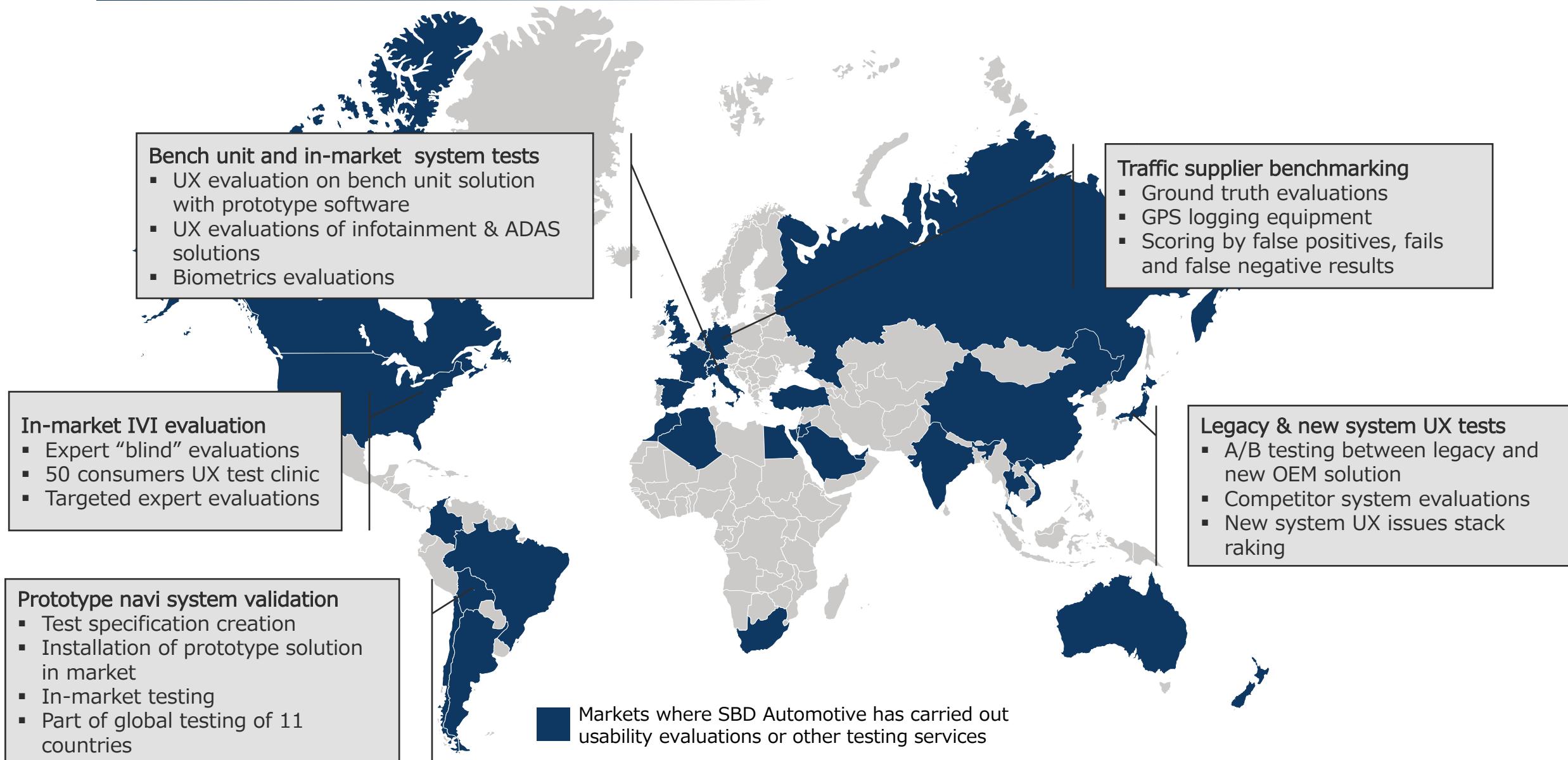
evaluations are

SBD experience through years of testing in-car solutions

Over the last 8 years SBD has evaluated 86 solutions from a Connected Car or ADAS perspective for our public report series (many more for private client evaluations). This current report series is an evolution of both test methodologies to provide a holistic view of in-car HMI. Furthermore, custom evaluations methodologies used across the globe for SBD clients have been included where applicable to enhance to overall approach.



Example custom projects & global experience used for methodology development



One page methodology overview

One of SBD's core goals of this report is to be as objective, fair and as transparent as possible. To achieve this various methodologies are used throughout the testing to evaluate different areas of the solution in various conditions.

These methodologies are a mix of different types of tests:

- **Objective tests:** where the value provided is not influenced by a tester's viewpoint e.g. response time
- **Subjective tests:** the score of viewpoint is based on the expert teste's viewpoint e.g. task ease of use
- **Task based:** evaluations carried out based on a predefined task list e.g. navigate to a pizza restaurant near location X
- **Freeform:** random free testing by the tester with no clear pre-defined task list. This allows the testers flexibility to dig deeper into various parts of a solution when needed
- **Scoring range:** ranges and definitions of how to score a test element e.g. poor depth and accuracy score = the results provided are not in line with what is reasonably expected by the user
- **Static:** tests are carried out when the vehicle is not moving
- **Dynamic:** tests are carried out when the vehicle is moving in various road conditions and locations e.g. motorways/highways, cities, villages, country roads etc.
- **Misuse/failures:** carried out to evaluate the stability of the solution in unusual conditions e.g. repeatedly pressing the voice command button

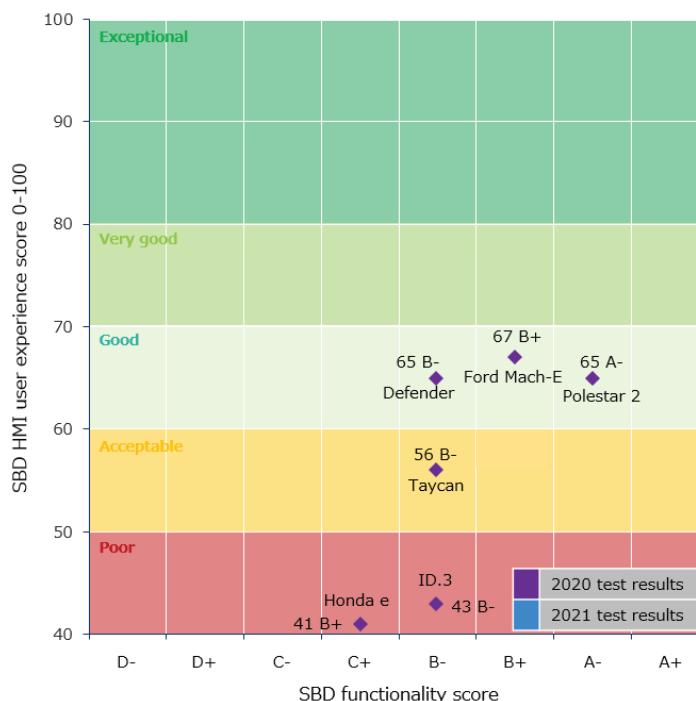
This document does not provide a detailed description of the methodology and this page serves to provide an overview of the approach.

For a detailed discussion and presentation of SBD's methodology please [contact us](#).

Test area	Type of tests							
	Objective	Subjective	Task based	Freeform	Scoring range	Static	Dynamic	Misuse/ failures
First impressions		✓		✓		✓	✓	
Static tasks	✓	✓	✓		✓	✓		
Dynamic tasks	✓	✓	✓		✓		✓	
Random free	✓	✓		✓		✓	✓	✓
Navigation specific tests	✓	✓	✓		✓		✓	✓
Voice recognition	✓	✓	✓	✓	✓	✓	✓	✓
Performance & response	✓		✓			✓	✓	✓
System Usability Scale (SUS)		✓			✓			
Final SBD UX score	✓	✓			✓			
ADAS	✓	✓	✓		✓	✓	✓	✓
UX heuristics	✓		✓			✓	✓	
Execution		✓			✓			
Ergonomics	✓	✓	✓			✓	✓	
Legibility & readability	✓		✓			✓	✓	
Perceived Quality (PQ)	✓	✓	✓	✓	✓	✓	✓	

Report structure and how to interpret certain data sets

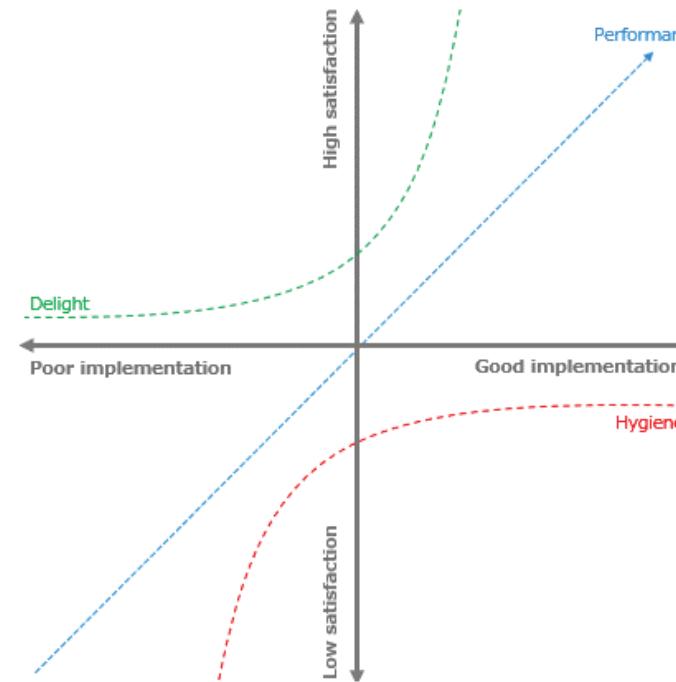
Throughout the testing and evaluation process SBD uses multiple methodologies to align to the situation and test area. Outputs from these evaluations can be broadly grouped into the following three types of report outputs - SBD's goal with these options is to ensure understanding of the results are as clear and fair as possible.



UX & functionality score

Final usability scored based on a 100 point scale with solutions scoring less than 40 defined as "not fit for purpose" with major user complaints expected and score above 80 defined as "exceptional".

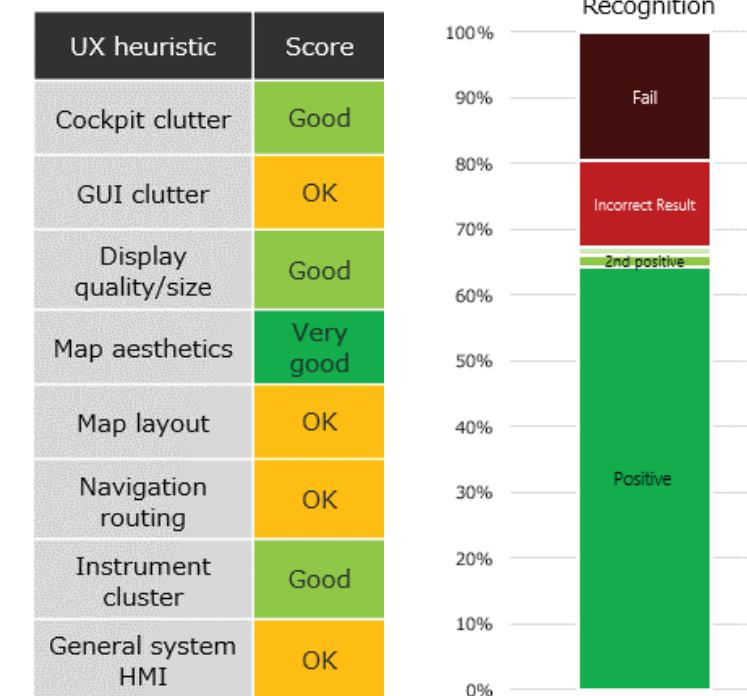
Functionality score based on 8 core feature set areas: delight features, performance features, hygiene features, navigation feature, ADAS, IoT integration, music, entertainment and info features.



Modified Kano feature analysis

Features plotted against three lines based on their implementation and satisfaction levels:

- **Delight** features: "wow" features likely to provide high satisfaction even with poor implementation
- **Performance** features: as the level of implementation increases so does the customer satisfaction
- **Hygiene** features: poor implementation provides low satisfaction, but good implementation may not provide positive satisfaction as it can be considered as expected functionality



Subjective & objective scores

Scoring across multiple areas through subjective scoring with pre-defined ranges, definitions, and comparison to past results.

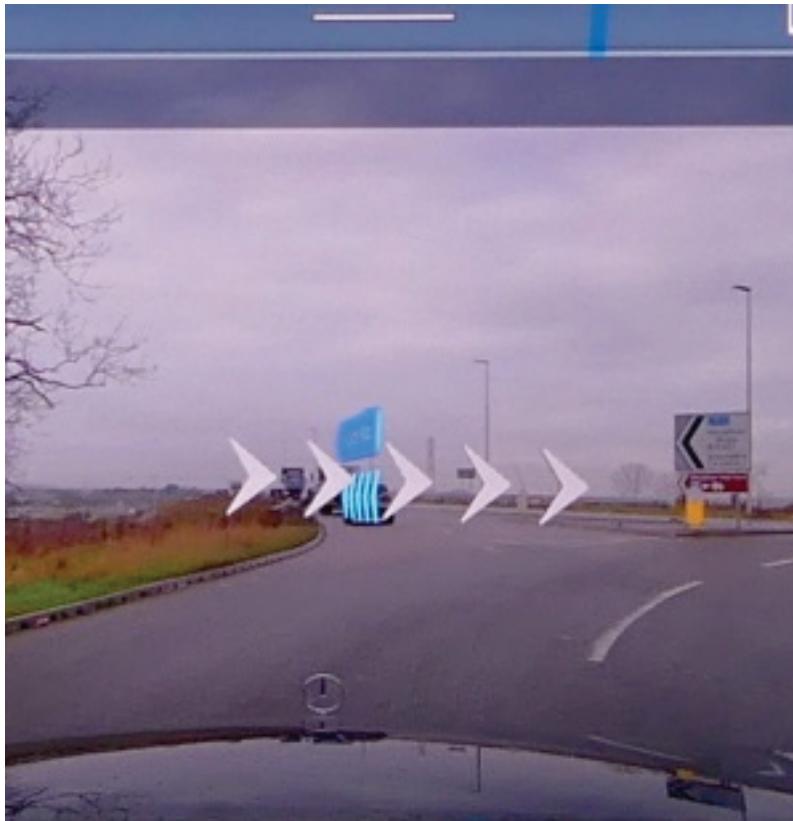
Objective scoring generally based on a pass/fail criteria or time-based considerations. SBD attempts to minimize subjectivity as much as possible with results aimed at being fair and reasonable with a minimal level of bias.

Example slides from the report



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'Wow features' exist, but implementations feel incomplete



AR navi is both a 'wow' feature & misleading

Augmented reality navigation features are likely to be viewed by the end consumers as a wow feature. However, the final implementation is lacking with directions being frequently ambiguous, lacking necessary information or incorrect, often conflicting with the correct instruction shown elsewhere. The stability of the arrow in relation to the outside environment is sub optimal as it has sufficient movement to spoil the illusion that it is fixed.



Ambient lighting also an effective feedback HMI

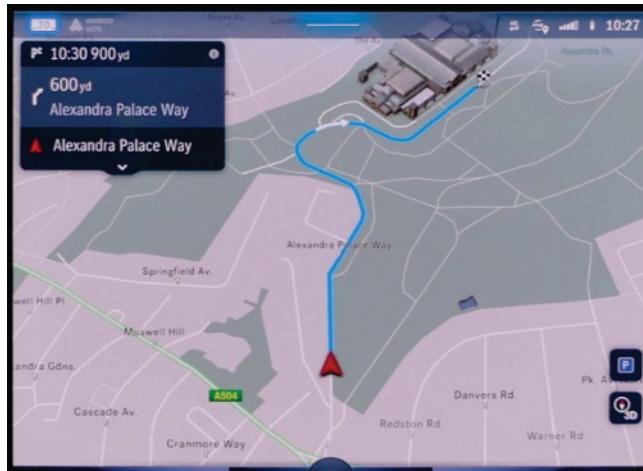
The S-Class features lighting strips that extend across the width of the instrument panel and across all four doors. These are more than just ambient illumination and provide feedback for certain use cases such as interactions with the voice recognition system and ADAS alerts such as lane keep assist and blind spot monitoring.



Cluttered HUD appearance

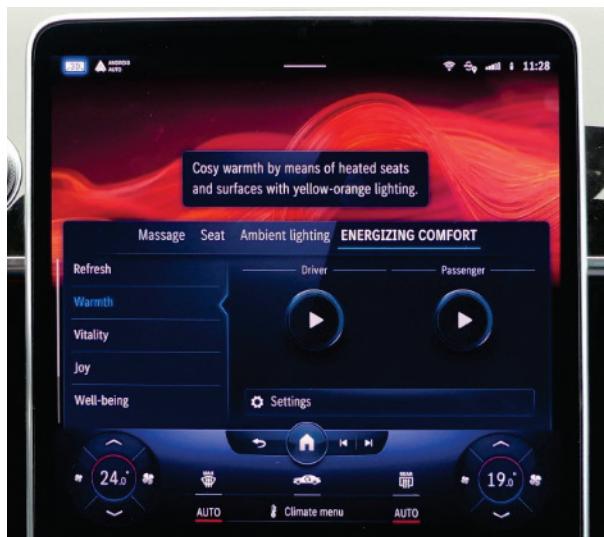
Due to the AR HUD element taking up a large portion of the display, the conventional content is tightly packed in the lower part of the display, giving a cluttered appearance. Additionally, AR elements sometimes overlap conventional elements.

Appearance examples (positive)



Map aesthetics

Map aesthetics are considered very good, with a look and feel consistent with popular consumer device solutions such as Google Maps. Both dark and light modes are well implemented and colouring is clear. A large amount of traffic information is shown.



Display quality

The central display at 12.8-inches is large* and high quality with a high level of contrast, resolution and definition, providing a large area for content. The lower 5th of the screen is taken up by HVAC controls but this still leaves ample space on the remainder of the screen.

*The average screen size according to SBD's Head Unit Tracker is approximately 9 inches.



Access to controls

The S-Class's cockpit has a driver-centric focus, with the majority of mechanical switches and buttons clustered to the left of the driver. All controls are within easy reach, including the top right of the central display which in many cars requires the driver to lean forward to access.



Cockpit clutter

The cockpit of the Mercedes gives an impression of overall minimalism and low clutter. It has 27 fewer mechanical buttons than its predecessor, yet manages to retain its feeling of advanced technology.

Software bugs

4. General system

Ambient lighting stopped working for approximately 24 hours, an error message was displayed on the instrument cluster.

The fault occurred once, so was not reproducible. The trigger for the fault could not be identified, nor could the recovery method.

Frequency	Low	Medium	High
Severity	Minor	Major	Critical



SAE Level 1 & level 2 ADAS – System usage

System usage: ACC



Multiple headway graphics can overcrowd the cluster

System usage: PD



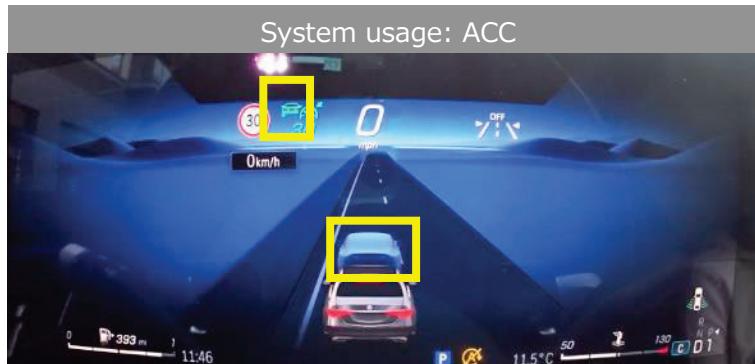
Good level of warning for 'hands off' event

System usage: FAPA



FAPA scanning for available space

System usage: ACC



Car ahead moving on is too subtle

System usage: PD



Warning escalates and vehicle comes to a stop if ignored

System usage: FAPA



Good graphics overlaying camera view



Misuse of ADAS

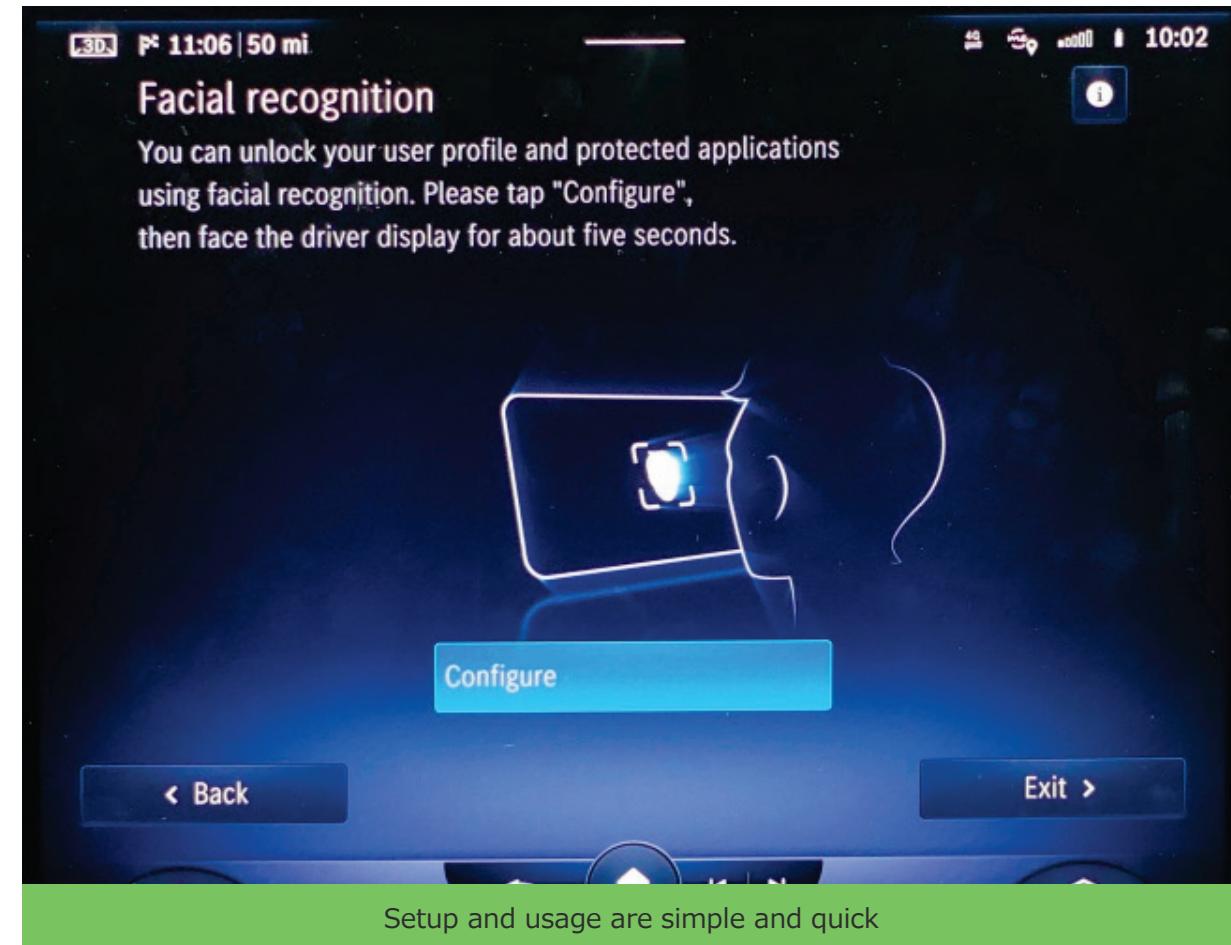
The misuse of ADAS within todays vehicles has been a challenge that OEMs have been trying to address for sometime. Common examples of misuse involve the driver attempting to trick a system into supporting the driving task beyond its intended operational limits. For example, placing a weight on a steering wheel to trick a Piloted Driving (PD) system into continuing to operate, while the driver sits back and engages in other tasks other than driving. Deceiving an assistance system to continue operating outside of intended limits is not only irresponsible but incredibly dangerous. Below are a few examples of potential opportunities for exploitation and misuse of ADAS on the 2021 Mercedes-Benz S-Class.

ADAS	Description of issue	Potential fix
Piloted Driving (PD)	While PD and ACC are active and supporting the driver, the test driver unbuckled the seatbelt and noted the reaction of the systems. A small seatbelt warning icon was illuminated, however the PD and ACC system failed to give any reaction and continued to support the driver. This lack of reaction could lead to a potentially dangerous scenario where the driver may remove themselves from the drivers seat completely.	Ideally, the system should cancel or at minimum display message to indicate handing back control to the driver once the seatbelt has been unbuckled to prevent any kind of misuse.
Fully Automated Parking Assistant (FAPA)	The Fully Automatic Parking Assistant (FAPA) in the Mercedes-Benz S-Class was found to have similar issues to PD in preventing the misuse of the system. When the driver unbuckled the seatbelt, the system continued to operate and support the driver. Again, this could lead to dangerous situation where the driver tries to leave the drivers seat or the vehicle completely during a parking procedure.	Ideally the system should be bringing the vehicle to a stop and cancelling when detecting a drivers seatbelt unbuckle, similar to when driver intervention is detected by the system.



Effective passive login with facial recognition

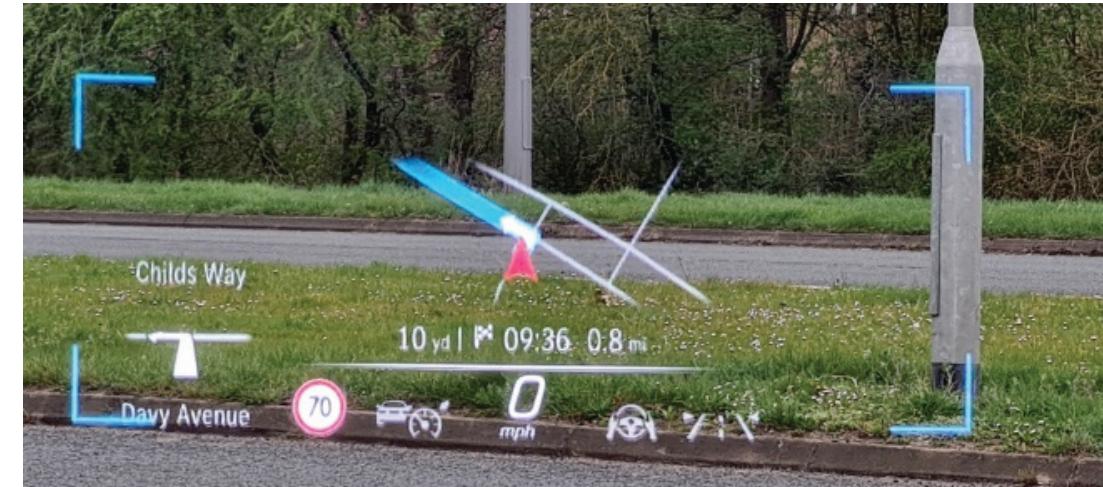
Category	Biometrics				
Description	Facial recognition provides seamless login to system				
SBD viewpoint	<p>User account access is strict in the S-Class: when the driver is logged in, by default opening the driver's door logs them out, meaning that a login is required each time the driver enters the car. Multiple login options are offered, including three biometric methods, with the one that works most elegantly being facial recognition.</p> <ul style="list-style-type: none">• Saving the user's facial details is very simple and takes a few seconds. From the biometrics section of the system, the user simply has to tap 'Facial recognition', tap 'Configure' and look at the instrument cluster for approximately five seconds.• To log into the system, the user simply has to look at the instrument cluster when entering the car, however it was often found that this wasn't needed, simply by entering the car and sitting in the driver's seat facing forward, the system detected the user's face passively and logged in straight away. <p>Frequent logins are a hurdle to good usability. Minimising or removing the pain-point (as has been achieved with biometric logins on many CE devices) persuades the user firstly to take advantage of a personal account and secondly to protect it with a login.</p>				
UX impact	Major negative	Minor negative	No impact	Minor positive	Major positive



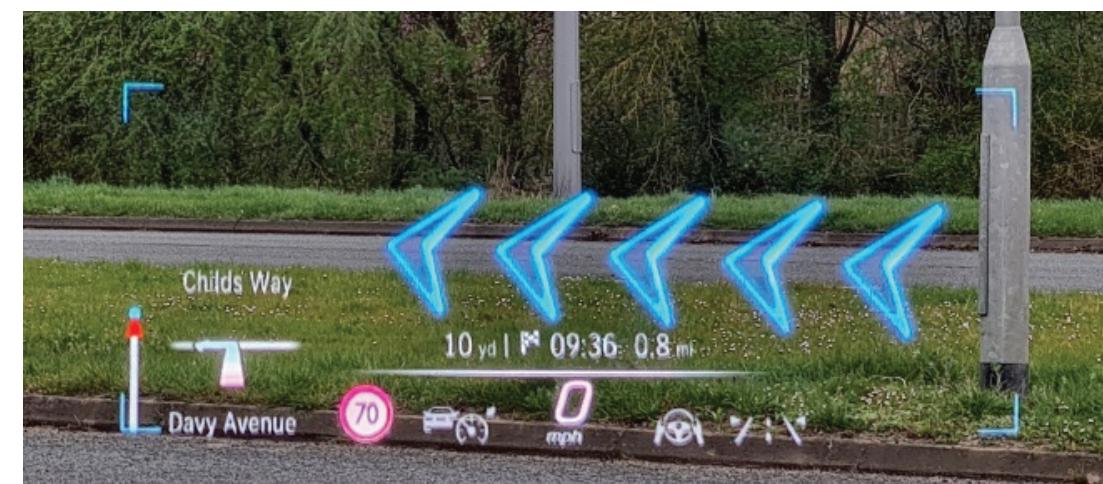


Good HUD is compromised by AR integration

Category	Navigation				
Description	AR integration compromises the normal HUD				
SBD viewpoint	<p>The augmented reality HUD on the S-Class is one of the showcase features in the car and amongst the first AR HUDs to reach market. In addition to the conventional HUD, projected on a single plane, the AR element projects over a variable perceived distance to overlay graphical elements on the outside landscape in a similar (but more advanced) manner to the AR navigation implementation on the central display. While the animations are slick and impressive, the overall solution has significant issues which in SBD's view make it unfit for purpose.</p> <ul style="list-style-type: none">• Due to the fact that the HUD in the Mercedes uses a single mirror, and the need for AR projections to be higher up the windscreen, the conventional HUD element is also higher. This means in some situations information is less clear as outside objects are more likely to cause interference. Also, being closer to the driver's natural line of sight, it is constantly within the driver's central focus. This can add to distraction and cognitive load during times when the driver does not need to see this information.• As both elements share the same windscreen space, when AR guidance is enabled, elements of the conventional HUD are necessarily removed/reduced. The most significant difference is the removal of the map view which is in most situations more useful, accurate and informative than the AR version. <p>The HUD in the S-Class is an extremely capable and advanced system, however the current AR implementation causes significant issues and is unlikely to be used by a large number of drivers in its current form.</p>				
UX impact	Major negative	Minor negative	No impact	Minor positive	Major positive



Conventional view shows road layout and clear guidance for turn ahead (centre)



AR view replaces map view with turn arrows which are often more distracting and complex to understand



Multiple connected services are offered

Category	Connected features				
Description	A large number of connected services are available				
SBD viewpoint	<p>The S-Class offers the largest number of connected services yet seen in a Mercedes.</p> <ul style="list-style-type: none"> • 12 'Safety and Service' services are offered including 'Theft Notification and parking damage detection', 'Remote vehicle diagnostics', 'Software updates' and 'Forward Anonymised Data'. • 10 'Infotainment' services are offered including 'Augmented Radio Information', 'Links to content providers', 'Internet in the car' and 'Music Streaming'. • 12 'Navigation' services are offered including 'Car-to-X-Communication', 'Satellite Images', 'Online-Routing' and 'Predictive Navigation'. • 15 'Comfort' features are offered including 'Energizing Comfort', 'Energizing Coach', 'Remote Parking Assist' and 'Interface to Third-Party Providers: Vehicle Data'. • Some services are unlimited term, some free for one or three years and one requires an additional subscription. <p>Although some services are hygiene, there are many new and interesting services offered that are very likely to filter through the segments and become more popular in the coming years.</p>				
UX impact	Major negative	Minor negative	No impact	Minor positive	Major positive

Car-To-X Communication.

Cutting-edge technology for safer driving.

The Mercedes me connect service Car-to-X Communication warns you in good time of dangerous situations, e.g. an accident, a broken-down vehicle or slippery road surfaces, enabling you to adapt your driving accordingly.

How does the Car-to-X technology work?

The vehicles that are networked via Car-to-X Communication identify dangerous situations automatically and exchange the corresponding information. When a vehicle receives notification of a danger, e.g. an accident, the location is marked on the navigation map. When the vehicle is approaching the danger, the marked location is highlighted on the map, and in some instances there is also a spoken warning. This enables you as a driver to react in good time and adapt your driving style and speed accordingly, so as to avoid a dangerous situation.

You can also make an active contribution to road safety by signalling dangers you observe. If you see an object on the road, for example, you can put out a general danger message via the map menu. This warning message will then be transmitted to all vehicles equipped with Car-to-X technology in the vicinity of the danger spot.

The benefits at a glance:

- Avoidance or mitigation of critical situations in road traffic
- Fast warning and precise location of dangers

This Mercedes me connect service forms part of COMAND Online. You can activate it under "Manage Mercedes me connect > Manage services".



Explanation for Car-to-X service

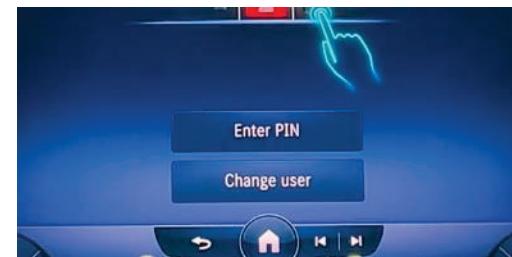
Fingerprint recognition setup process

Set up Mercedes Me account and register vehicle



Your profile will be shown on the head unit screen

Enter PIN to unlock screen



Four-digit PIN

Select profile photo and click Settings



Drop-down box appears when profile is clicked

Click on Fingerprint recognition under the Set up tab



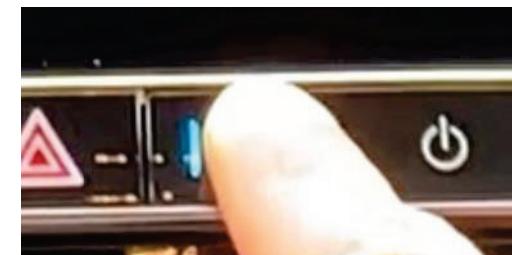
The option to delete fingerprint profiles is shown if already set up

Click on Configure



Configure button appears in middle of screen

Place finger onto the scanner



Fingerprint scanner at the bottom of the screen illuminates during set up process

Repeat 10 times



Screen prompts to repeat fingerprint reading but not guidance on which part of the finger to place on the scanner

Shows registration completion



After 10 readings have been recorded, the process is complete



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MERCEDES-BENZ S-CLASS
In-Car HMI UX Evaluation & Benchmarking

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Contact SBD Automotive

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