



SBD September 2021 In-Car HMI UX Evaluation & Benchmarking Tesla Model S 635-21(216)

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#635



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# In-Car HMI UX Evaluation & Benchmarking

## Tesla Model S Plaid

In SBD Automotive's **HMI UX Evaluation & Benchmarking series**, the latest in-car HMI is evaluated and benchmarked by our UX experts. SBD Automotive's UX Team has completed testing the refreshed Tesla Model S. It is the first major update to the electric sedan since its introduction in 2012, and provides a wealth of new technologies aimed at enhancing and expanding the in-vehicle UX. The most striking feature in the new Model S is its redesigned steering wheel - now a yoke - which removes the top and bottom of the wheel.

The learning curve to effectively and safely use the new HMI of the Model S has been raised by the UX Team. Changes made to the HMI often rely on, and disregard, traditional control methodologies at the same time. For example, the touch-activated turn signal control on the wheel, rather than a stalk. It keeps the "down for left, up for right" concept, but when removed from the stalk, loses its intuitive nature, is often accidentally activated, and becomes a point of potential confusion or distraction..

### COVERAGE



### FREQUENCY



### PUBLICATION FORMAT



### PAGES

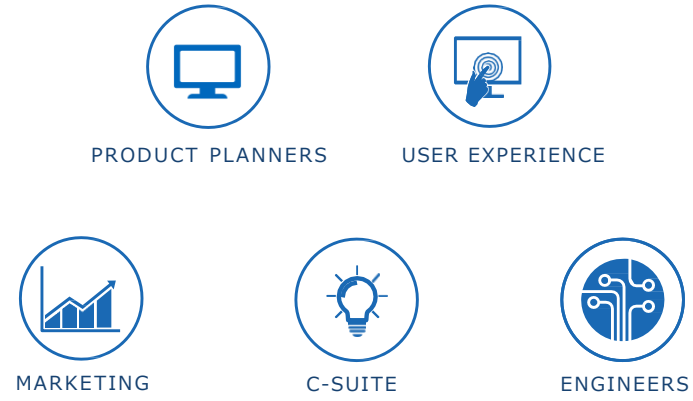


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# Scoring

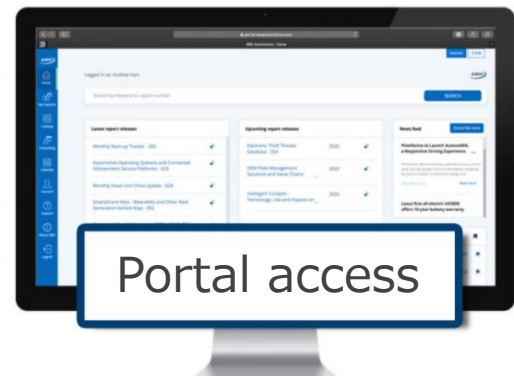
- > **Features and functionality:** evaluating whether the solutions provide features that customers expect, need and solve problems (or provide a wow factor).
- > **Reliability/stability:** evaluating the repeated usability and whether the users can have a similar (positive) experience each time.
- > **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.

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## Introduction

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# Aim of this report

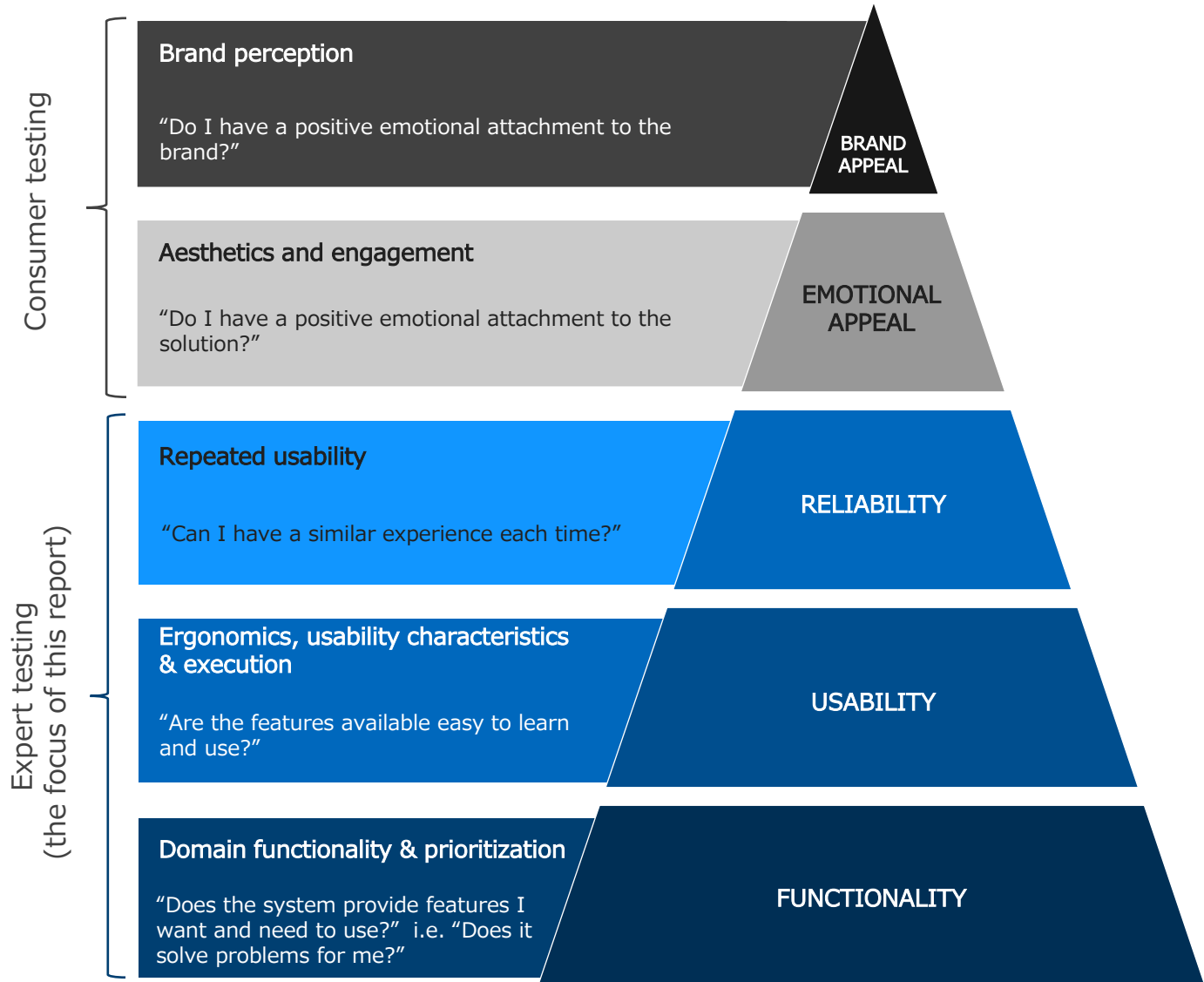
Welcome to the 2021 HMI benchmarking report series. This report has been created to provide a fair, unbiased and objective view of the latest in-vehicle HMI solutions in the European and US markets. Evaluations are carried out by SBD usability experts with a deep understanding of CASE domains such as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

One of the core goals of these studies is 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.



SBD's view on the hierarchy of needs for CX benchmarking



# 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 only a high level in this study as carrying out a full driver distraction evaluation requires 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 of car” experiences.

Within the vehicle, any HMI element the user interacts with is evaluated including steering wheel controls, touch screen displays, voice control, HUDs and digital keys. 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





# Vehicle list

SBD has chosen eight cars to evaluate in 2021, based on two selection categories. New/interesting UX focuses on systems with to never-seen-before features or functionality, or the implementation of a solution that has previously been a challenge or pain-point for end-users. New mass-market UX includes vehicles in segments that are sold in high numbers and are entering a new generation of UI for that vehicle. While we make best efforts to adhere to the chosen cars and schedule, the last year has seen release dates slipping significantly, so it may be necessary to make substitutions.

## Confirmed cars for 2021



Mercedes-Benz S-Class

- Advanced HUD with augmented reality
- Biometrics
- Multiple wow-features



CUPRA Formentor

- Volume brand offering
- CarPlay and Android Auto analysis
- Departure from VW group UI
- First CUPRA HMI test



Tesla Model S Plaid

- Updated Tesla UI
- New steering wheel approach
- High performance graphics
- US market test



Hyundai IONIQ 5

- AR head up display
- Highway Driving Assist 2 ADAS



Lexus LS

- Advanced ADAS feature set
- Japan market test



Rivian R1

- Possible new disruptor
- Appears to have an innovative approach to HMI
- US market test

## Potential cars for 2021 depending on vehicle availability



BMW iX/i4



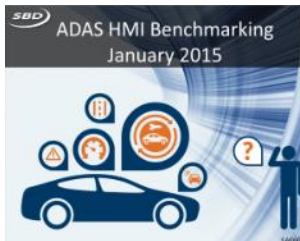
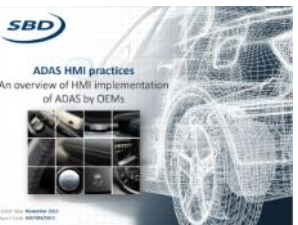
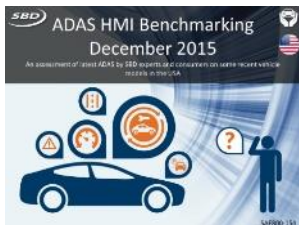
Lucid Air





# SBD experience through years of testing in-car solutions

Over the last eight 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.





# 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 test score is based on the expert testers' viewpoints 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.

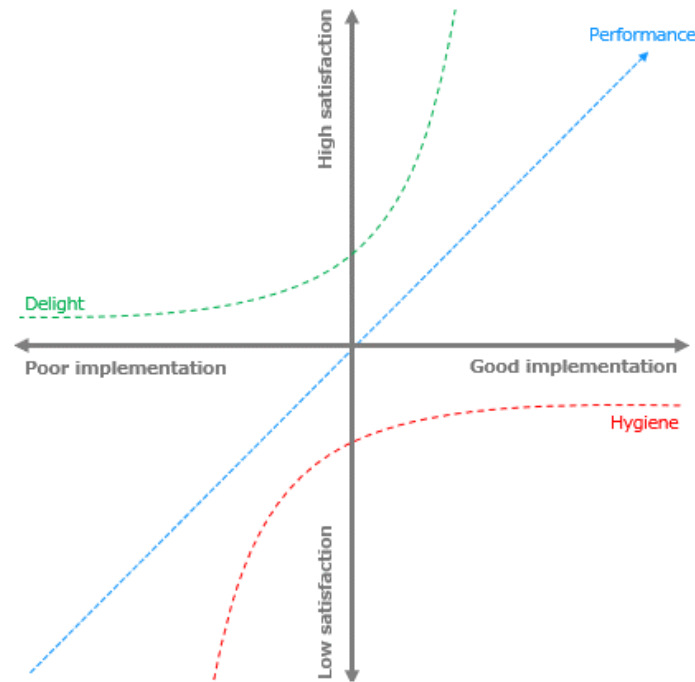
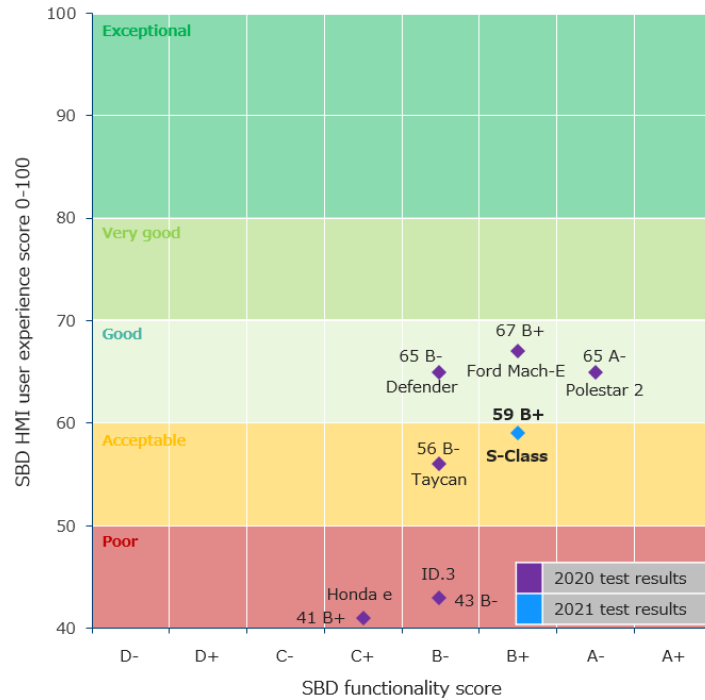
For a detailed discussion and presentation of SBD's methodology please [contact us](#).

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 heuristic	Score
Cockpit clutter	Good
GUI clutter	OK
Display quality/size	Good
Map aesthetics	Very good
Map layout	OK
Navigation routing	OK
Instrument cluster	Good
General system HMI	OK



## 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 eight 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 156 page report



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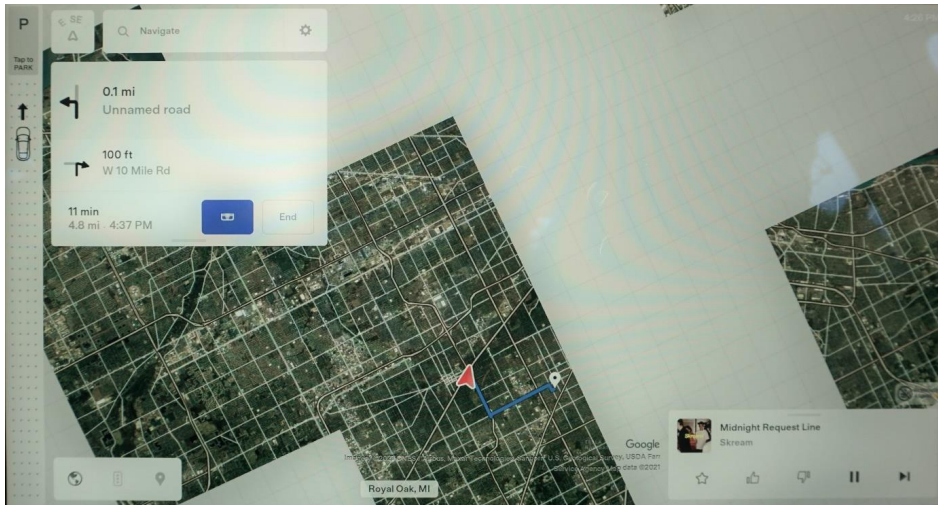
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The complex block represents a product listing for a report. It features a photograph of a Tesla Model S interior with a large central touchscreen. Below the photo is a blue banner containing the SBD logo, the date 'September 2021', the report ID '635-21(210)', and the title 'In-Car HMI UX Evaluation & Benchmarking Tesla Model S'. At the bottom of the listing is a blue button with the text 'Request price' and a white right-pointing chevron.



# Hygiene and navigation features leave minor room for improvement

- For the most part, hygiene features are well implemented in the Model S.
- Navigation searches are particularly effective with good autocorrection.
- The media interface is well implemented, using a common Tesla appearance while maintaining familiar interface traits of commonly recognized apps.
- Lack of data connection in poor reception areas can lead to a loss of functionality.



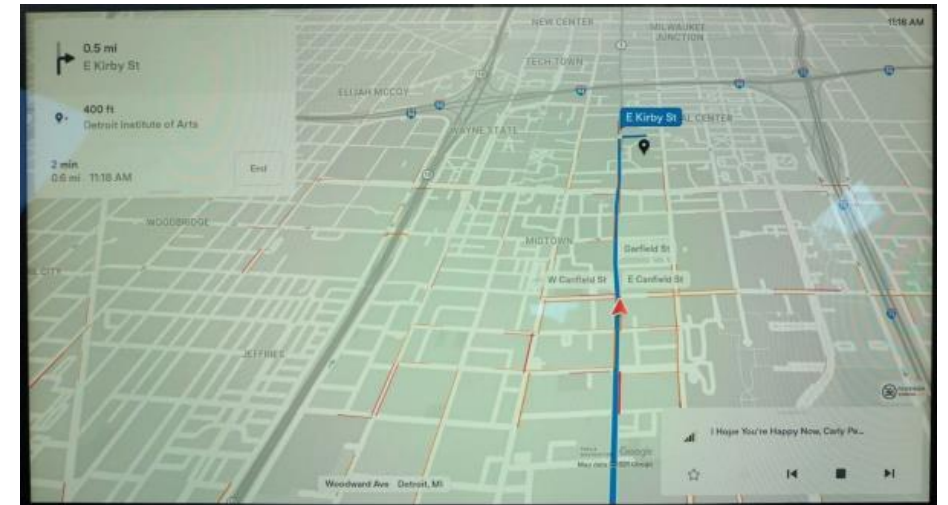
## Lack of data can restrict functionality

The fact that there is a strong reliance on the data connection can lead to a loss of core hygiene functionality, temporarily restricting access to essential features.

Mitigation for a loss of connection in poor signal areas would improve the user experience.

One example is intelligently predicting and downloading map areas to ensure sufficient levels of detail for the majority of use cases.

- Similarly to hygiene features, navigation features are mostly well implemented. Most users are expected to be satisfied with the overall navigation experience.
- Destination accuracy and map manipulation are mostly satisfactory. A small amount of lag is evident from time to time when loading new map tiles.
- Map clarity leaves room for improvement in terms of color differentiation and satellite view.
- Lane guidance demonstrates good accuracy, but visual presentation could be made clearer and more prominent.



## Visual appeal of map leaves room for improvement

Map clarity is mostly good with clear graphics and an appropriate level of information for each zoom level.

The map view could be considered too monotone, being almost entirely gray. This results in a somewhat unappealing visual presentation and also removes colors that could offer additional information on nearby landmarks without adding distraction.

The satellite view was found to be difficult to use and also presents contrast issues between the iconology and satellite image.



# Central display crashed

## 3. General system

At one point the central display crashed, not allowing any input other than drive and reverse. This prevented access to Park using the screen. Shortly after, the system rebooted, preventing access to gears for approximately 10 seconds. N.B. it was not known at the time that the alternative (hidden) gear panel is available in the central console.

Frequency	Low	Medium	High
Severity	Minor	Major	Critical





# Temperature slider vanished during operation

## 11. HVAC

When changing the climate temperature up and down, the window containing the temperature slider vanished although it was still possible to control the temperature by sliding on the area of screen where the slider should have been.

Frequency	Low	Medium	High
Severity	Minor	Major	Critical

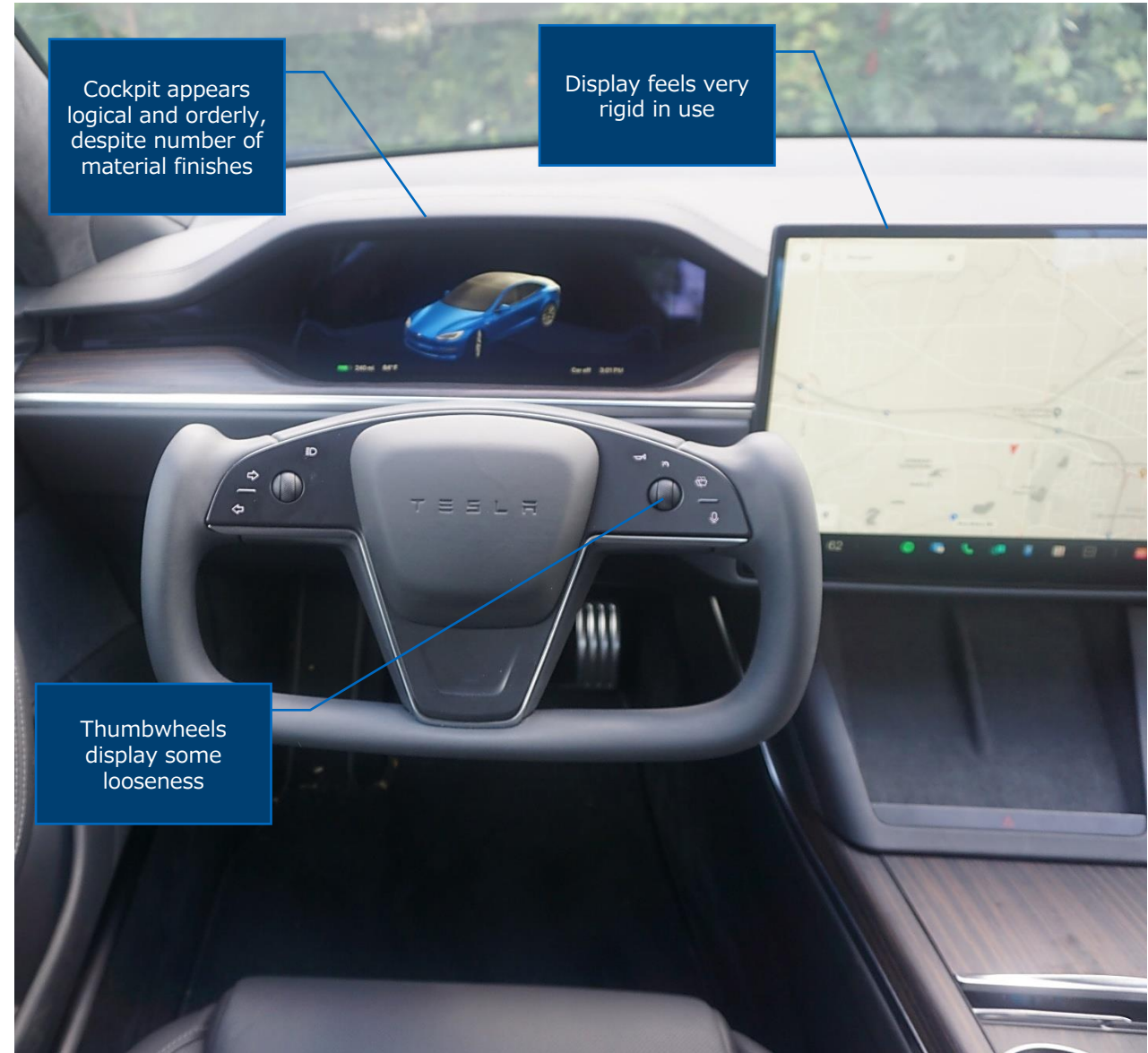




# Perceived Quality: Tactile

Level 1	Tactile
SBD viewpoint	<p><b>Stiffness &amp; looseness:</b> The only physical buttons are the two thumbwheel controls on the left and right spokes of the steering wheel. These click both centrally, and left and right. The stiffness/looseness of these controls is acceptable, but some slight wobble was found in the left and right direction.</p> <p><b>Force feedback:</b> The button-press action feel is OK for the steering wheel thumbwheels, but it is possible to accidentally press left/right when intending to press the center.</p> <p><b>Material quality:</b> The smooth leather touch surfaces such as the steering wheel and interior door pulls are of a satisfying quality. Plastic trims could be better, and detract from the overall impression. Wood trims on the center console area in this variant feel somewhat hollow and don't positively contribute to overall quality. As they don't house any HMI, it's less likely for the user to interact with these trims on a regular basis.</p> <p><b>Material harmony:</b> Overall the harmony of materials in the cockpit is good, but again leaves some slight room for improvement. The overall aesthetic is surprisingly good given the total number of different finishes applied across the cabin. As more finishes are offered, the more difficult it becomes to make them appear coherent and from the same vehicle. In this regard, Tesla manages to mostly coherently apply 6 different surface finishes across the cockpit.</p> <p><b>Geometric &amp; Positioning:</b> Positioning balance and geometry is excellent in the Model S and manages to provide an interior space that is above expectation for this segment of vehicle.</p>

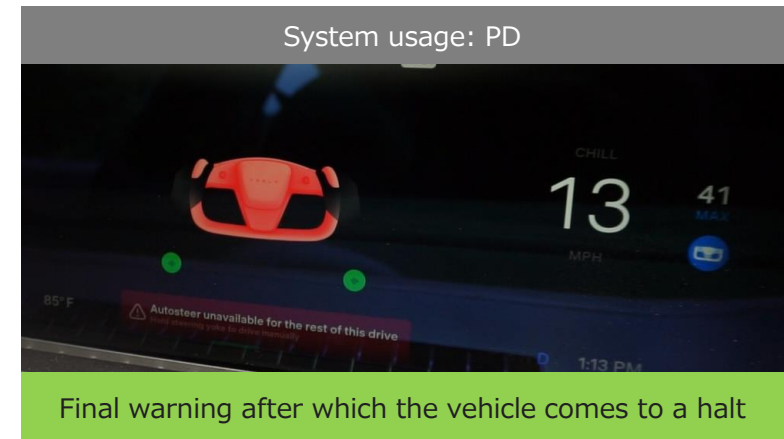
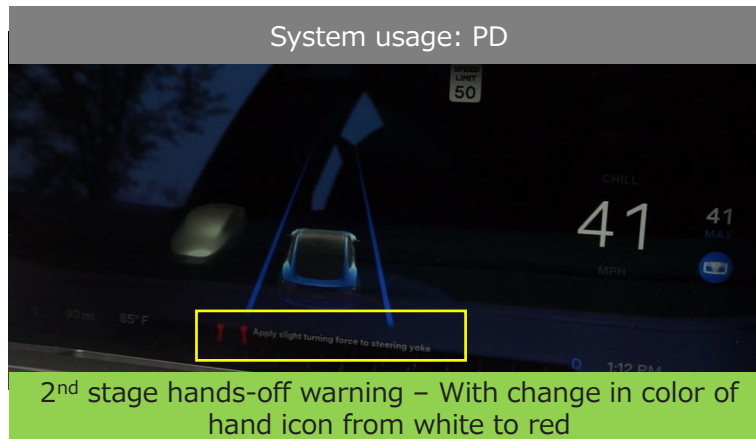
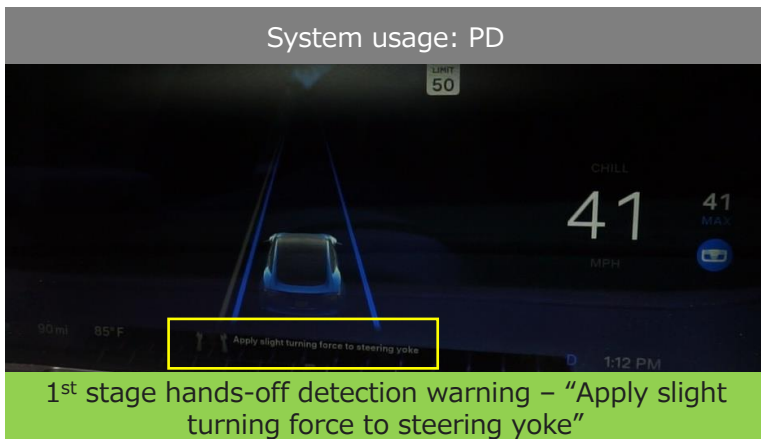
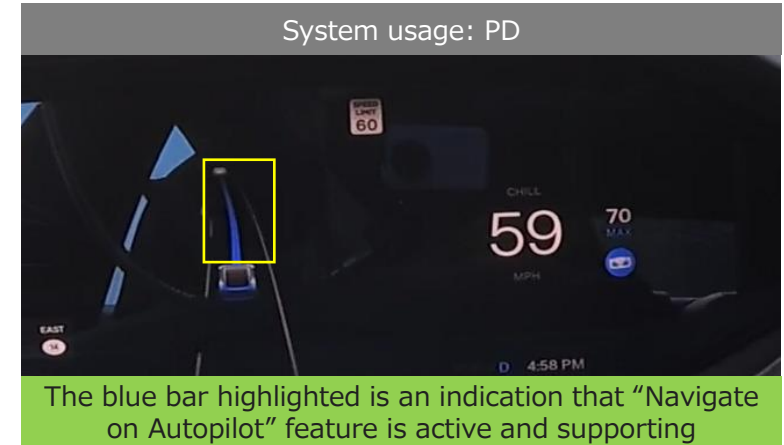
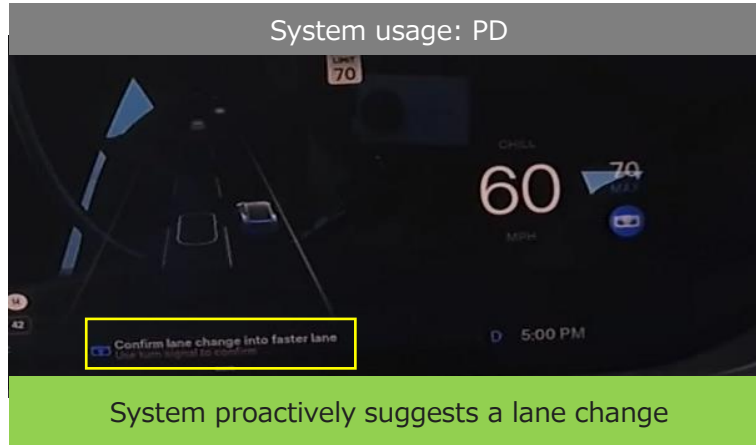
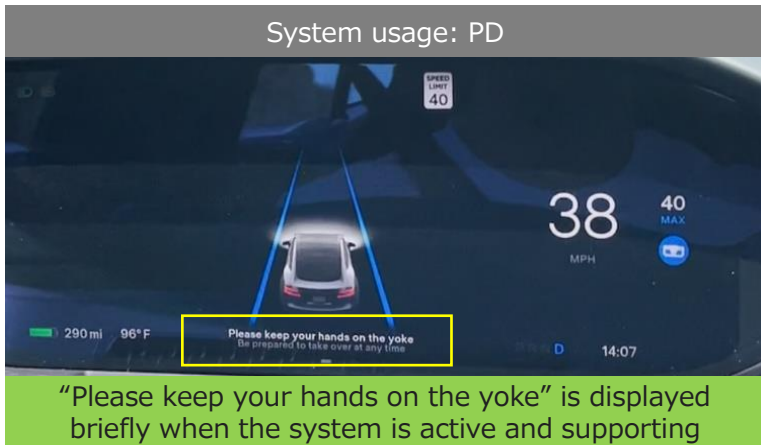
Level 2 scoring				
Stiffness & looseness	Force feedback	Material quality	Material harmony	Geometric & positioning
Good	Good	Good	Good	Excellent







# SAE Level 1 & level 2 ADAS – System usage





# System demonstrates high level of responsiveness

Category	Infotainment					
Description	Highly responsive system leads to increased satisfaction					
SBD viewpoint	<p>System performance is extremely good with no lag experienced at all during testing other than in two isolated areas.</p> <ul style="list-style-type: none"> <li>Although this is only one element of the system, this level of performance gives the impression of a new, competitive product, similar to the experience of buying a new high-level consumer electronics device.</li> <li>Gameplay is fast and responsive, and also likely to satisfy users.</li> <li>One unexpected exception was noticed:             <ul style="list-style-type: none"> <li>A critical level of system lag was evident in YouTube operation to the extent that in some cases it was unusable.</li> </ul> </li> </ul> <p>The impressive hardware in the Tesla Model S Plaid shows what is possible for an in-vehicle infotainment system and experience of this high-performance system is likely to set an expectation for all IVI systems in the near future.</p> <p>Solutions which perform slowly or laggy will likely appear outdated in comparison to the Tesla hardware, so capable hardware to achieve a similar performance output is highly recommended for other manufacturers.</p> <p>Unlike a high number of cars recently evaluated by SBD, particularly the S-Class and Formentor, the hardware specifications are more than adequate for current requirements. This results in the perception of a highly capable system and is likely to lead to increased satisfaction.</p>					
	UX impact	Major negative	Minor negative	No impact	Minor positive	Major positive

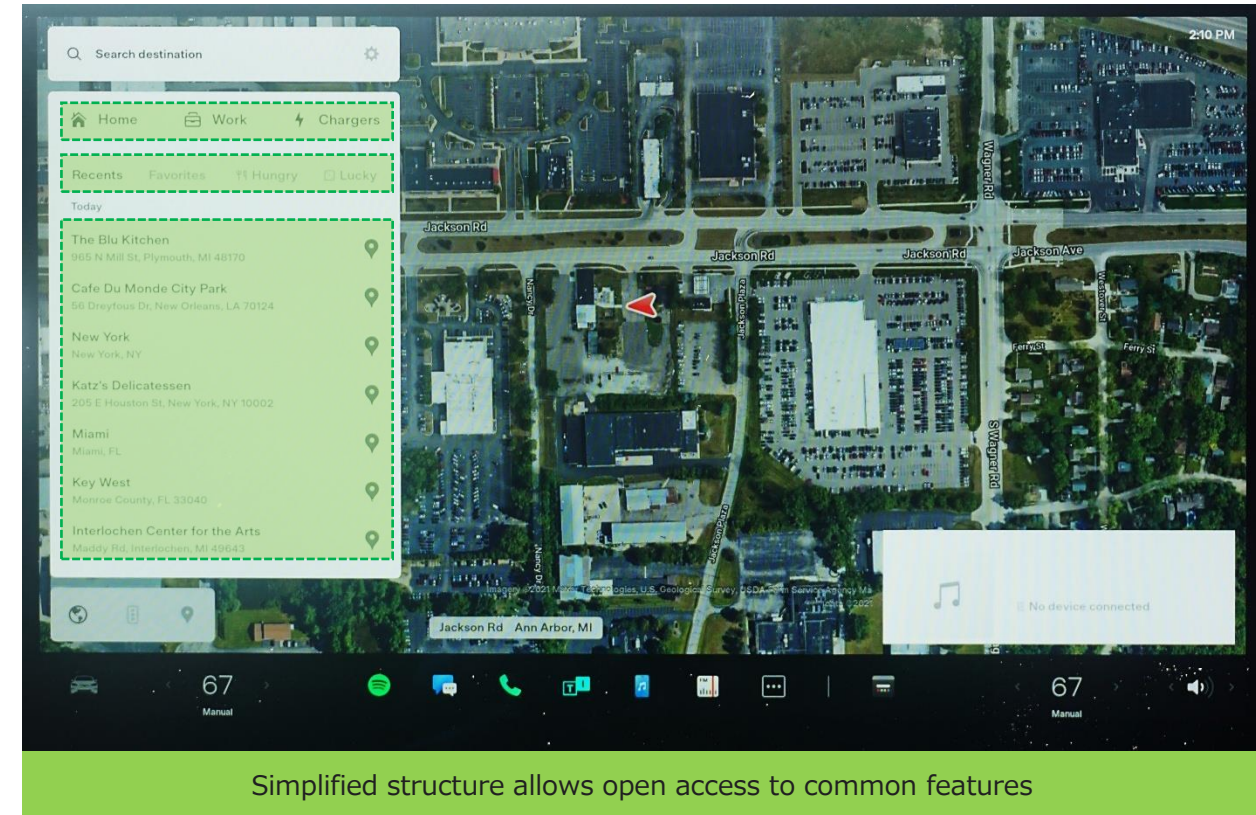


Capable hardware that supports console-quality gaming



# Fast, intuitive, simplified destination search

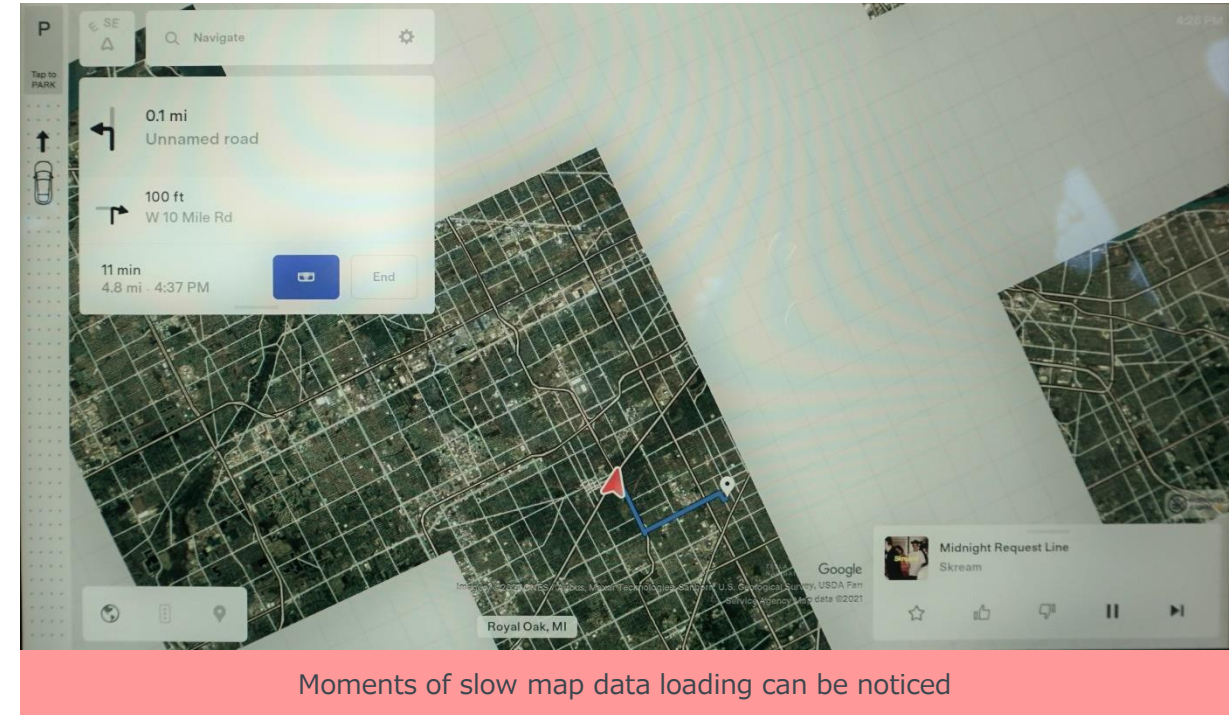
Category	Navigation				
Description	Destination input process is quick & convenient, likely to meet user expectations				
SBD viewpoint	<p>The Tesla navigation system remains a fast and efficient implementation with a clear effort made to simplify the user journey.</p> <ul style="list-style-type: none"> <li>• Direct access to the one-line destination search box avoids redundant steps e.g. opening a navigation menu to start the destination input process</li> <li>• The process can be likened to smartphone implementations such as Google Maps or Apple Maps in terms of simplicity e.g. number of steps required</li> <li>• When a result from the list is chosen, additional information is shown such as contact number, reviews and opening hours/days</li> <li>• Destination history is another instance of a readily accessible feature that avoids unnecessary steps</li> <li>• Home and work shortcut buttons are also provided when the search box is pressed</li> <li>• Destination history is sorted by day without additional display clutter, making it faster finding less recent destinations</li> </ul> <p>Combined with highly capable hardware, this makes the overall experience fast, fluid, responsive and highly satisfying.</p>				
UX impact	Major negative	Minor negative	No impact	Minor positive	Major positive






# Low cellular coverage impacts the user experience

Category	Connected services				
Description	High reliance on connectivity: poor signal leads to long waiting times for relatively basic functionality				
SBD viewpoint	<p>Many of the Tesla system's major features rely on a data connection to function correctly, even Navigation which uses offboard mapping.</p> <ul style="list-style-type: none"> <li>Navigation relies on connectivity for map data and route calculation, so maps may not load fully or route calculation can take an unusually long time to complete</li> <li>Voice recognition will experience long waiting times</li> <li>Entertainment features such as audio and video streaming will be interrupted or take a long time to buffer</li> </ul> <p>At times of low cellular coverage, many features fail to work correctly and this has a significant impact on the user experience – particularly core system features like navigation and voice recognition.</p> <p>To counter this, core functionality should ideally have an offline mode that uses onboard data to complete the use case.</p>				
UX impact	Major negative	Minor negative	No impact	Minor positive	Major positive





# Request the price



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## Do you have any questions?

If you have any questions or feedback about this research report or SBD Automotive's consulting services, you can email us at [info@sbdautomotive.com](mailto:info@sbdautomotive.com) or discuss with your local account manager below.



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