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UX EVALUATION

In-car HMI UX Evaluations

#635

In-Car HMI UX Evaluation & Benchmarking

Lexus LS

In this edition of SBD Automotive's HMI UX Evaluation report series, the UX Team tests the new Lexus LS. The newest model from Toyota's luxury division incorporates several features and technologies that prioritize convenience and comfort. The vehicle's core infotainment is hosted on a 12.3-inch central touchscreen, which can additionally be operated through voice commands or a touchpad on the center console.

The sedan's split-screen feature similarly draws inspiration from consumer technology, allowing for two apps to be displayed simultaneously. The system also supports smartphone mirroring integrations with Apple CarPlay and Android Auto. Independent of the main infotainment system is an 11.6-inch LCD screen behind the driver seat, which allows for playback from Blu-Ray Disc, or an SD Card, and includes an HDMI port for more entertainment options.

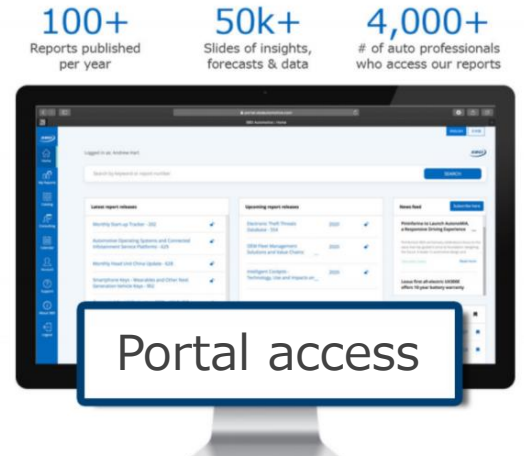| COVERAGE				FREQUENCY			PUBLICATION FORMAT				PAGES
GLOBAL	NA	CHINA	EUROPE	ANNUALLY	QUARTERLY	8 CARS PER YEAR	PDF	POWERPOINT	EXCEL	ONLINE	130+

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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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LEXUS LS

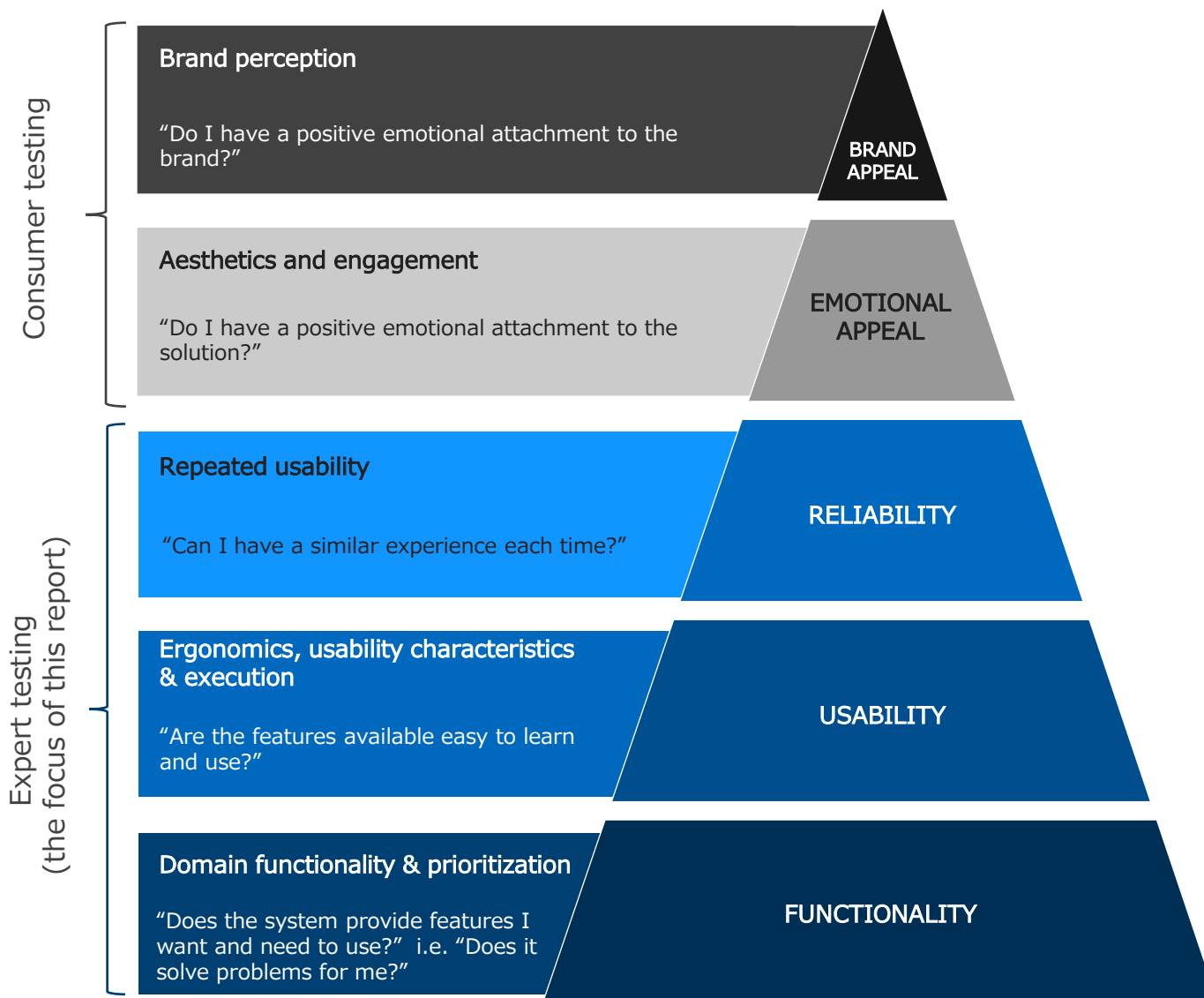Introduction

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 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.

Consumer testing

Brand perception

"Do I have a positive emotional attachment to the brand?"

BRAND APPEAL

Aesthetics and engagement

"Do I have a positive emotional attachment to the solution?"

EMOTIONAL APPEAL

Expert testing (the focus of this report)

Repeated usability

"Can I have a similar experience each time?"

RELIABILITY

Ergonomics, usability characteristics & execution

"Are the features available easy to learn and use?"

USABILITY

Domain functionality & prioritization

"Does the system provide features I want and need to use?" i.e. "Does it solve problems for me?"

FUNCTIONALITY

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.

Pre-purchase • Purchase • Activation • In-car HMI • Driver distraction • IoT

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 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 best efforts have been made to adhere to the chosen cars and schedule, slippages in release dates have continued and been exacerbated by the chip shortage, so it has been necessary to make some substitutions.

Cars tested so far in 2021

Mercedes-Benz S-Class	CUPRA Formentor	Tesla Model S	Hyundai Ioniq 5	Lexus LS

Remaining cars due for testing in 2021

Cadillac Escalade	BMW iX	NIO ES8

Cadillac Escalade
- 38-inch OLED screen area
- SuperCruise

BMW iX
- New generation of iDrive
- Expanded BMW VPA
- Most advanced BMW ADAS
- Digital Key Release 3.0

NIO ES8
- Latest OS3 software
- Fully updated GUI
- European market car

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.
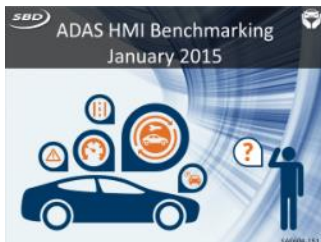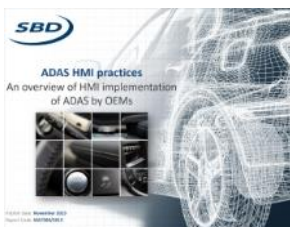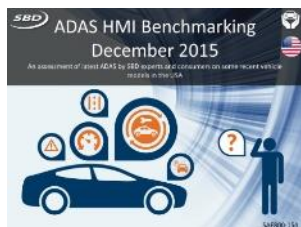
One page methodology overview

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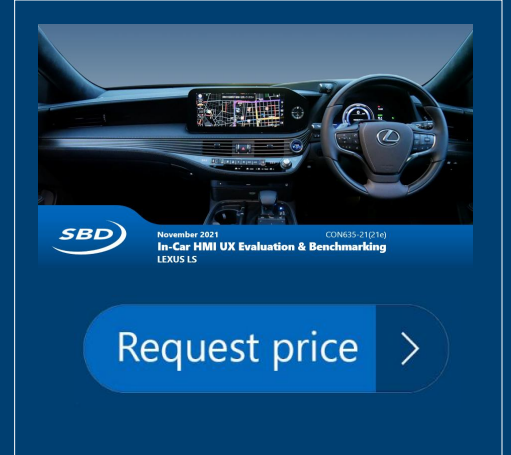
This document does not provide a detailed description of the methodology and this page serves to provide an overview of the approach.

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)	✓	✓	✓	✓	✓	✓	✓	

Example slides from the full 134 page report

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LEXUS LS

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System suffers from poor implementations in hygiene features

- Some of the hygiene features on the Lexus are likely to disappoint consumers due to their poor implementation.
- The major frustration point during testing was touchscreen operation, which gave the impression of an incomplete implementation. Touchscreen input is better in many use cases such as keyboard entry and selecting items from a list in terms of intuitiveness and brevity, however it is not possible to access the home menu which can only be reached via the touchpad. Additionally, some basic map and HVAC functionality cannot be controlled as expected using the touchscreen. This means the user is forced to use the touchpad in some use cases even when they prefer to use touchscreen input.

- Disappointing hygiene features can also be seen in the navigation domain. While "Web search", which directs to an internet POI search, offers a high level of flexibility in POI searches, the on-board POI search suffers from a legacy automotive information architecture which has a siloed and narrow information structure.
- Compared to modern navigation systems offered by global competitors such as Mercedes-Benz or Tesla, the information architecture used in the LS is awkward to use as the deep and siloed information architecture prevents the user from intuitively searching for POIs.
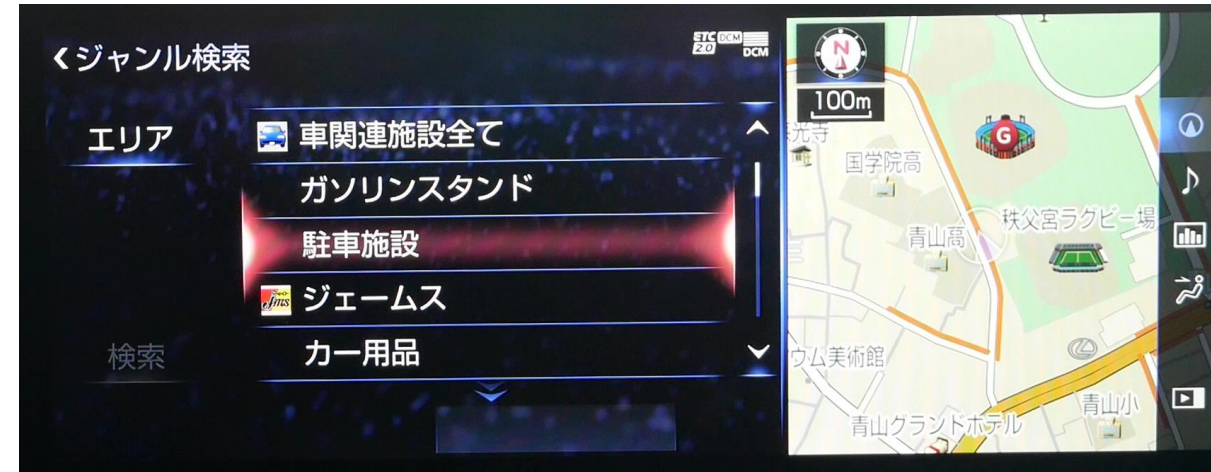

Touchscreen operation doesn't offer full control of on-screen assets

The Lexus LS is the first generation in recent times with touchscreen input. Traditionally Lexus has advocated a touchpad approach with most interaction being carried out via a control on the centre console. This input has been retained and works well in some cases, offering easy access to the control as the driver does not have to reach their arm to the display.

The multi-modal input expands flexibility in input, however those modalities must be designed from a holistic viewpoint to offer a good experience. The poor implementation in the LS can be seen as a typical pitfall in implementing a new interface and will likely disappoint many users.

Siloed and deep information structure is awkward to use

The information architecture for POI search has a siloed and deep structure, causing the user to traverse several levels instead of being able to gain intuitive and quick access from the higher levels of the system. This is an obsolete implementation compared to global competitors, who are offering intuitive and flexible POI searches. For example, Tesla has a shortcut to its charging point search on the map display, allowing the user to quickly search charging points whenever needed.
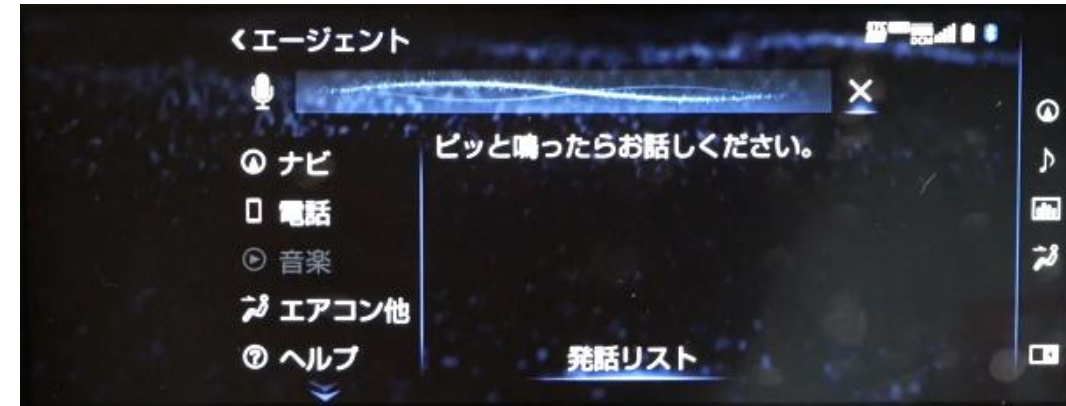
System returned to listening mode during interaction

2. Voice recognition

The system was started and a command was spoken. At this point, the system requested the command again as if it had restarted. This only happened on one occasion and may be due to a loss of connectivity during the interaction.

Frequency	Low	Medium	High
Severity	Minor	Major	Critical

Key lowlight

Area under the display is too thin to support hands

Very small space under the display to support hands

The central display has little physical support with a very thin area under the display

The central display has a very thin area underneath which is insufficient to use as a stabilising support while operating the touchscreen.

Many users are likely to feel that there is very little physical support in touchscreen operation compared to the remote control on centre console.

Perceived Quality: Tactile

| Level 1	Tactile
SBD viewpoint	**Stiffness & looseness:** Hardware tolerances in the Lexus are excellent, and likely to meet user expectation for this category of vehicle. The stiffness of buttons and other hardware provides a sense of solidity and high quality. **Force feedback:** Generally speaking, the hardware was all found to provide a good quality of force feedback in use, particularly the haptic output from the track pad which has a highly perceivable and tactile "thump". What could be improved however is the balance between these feedback sensations between HMI across all zones of the car. Switches in the door for example feel somewhat softer and less tactile to operate than those on the centre console or steering wheel. **Material quality:** Quality of materials used for the HMI can be considered good, and likely to meet expectation for this type of vehicle. The material used also matches its appearance, unlike some other vehicles which use a silver finish to make buttons appear like metal but feel very clearly like plastic. **Material harmony:** Similar to the clashing appearances in the visual attributes, there were some tactile clashes to be found too. The volume knob and start engine button were found to be possibly the most noticeable clashes to the majority of the other HMI in the vehicle, and to a lesser degree the steering wheel controls in comparison to centre console buttons. **Geometric & Positioning:** The main positioning issue is in the layout of buttons on the right-hand side of the steering wheel which is somewhat random and doesn't allow their function to be identified by their position or shape.

Force feedback very good, could be better harmonised

Some clashing of HMI finishes

Button layout somewhat random, makes identification by touch unnatural

Level 2 scoring				
Stiffness & looseness	Force feedback	Material quality	Material harmony	Geometric & positioning
Excellent	Good	Good	Fair	Fair
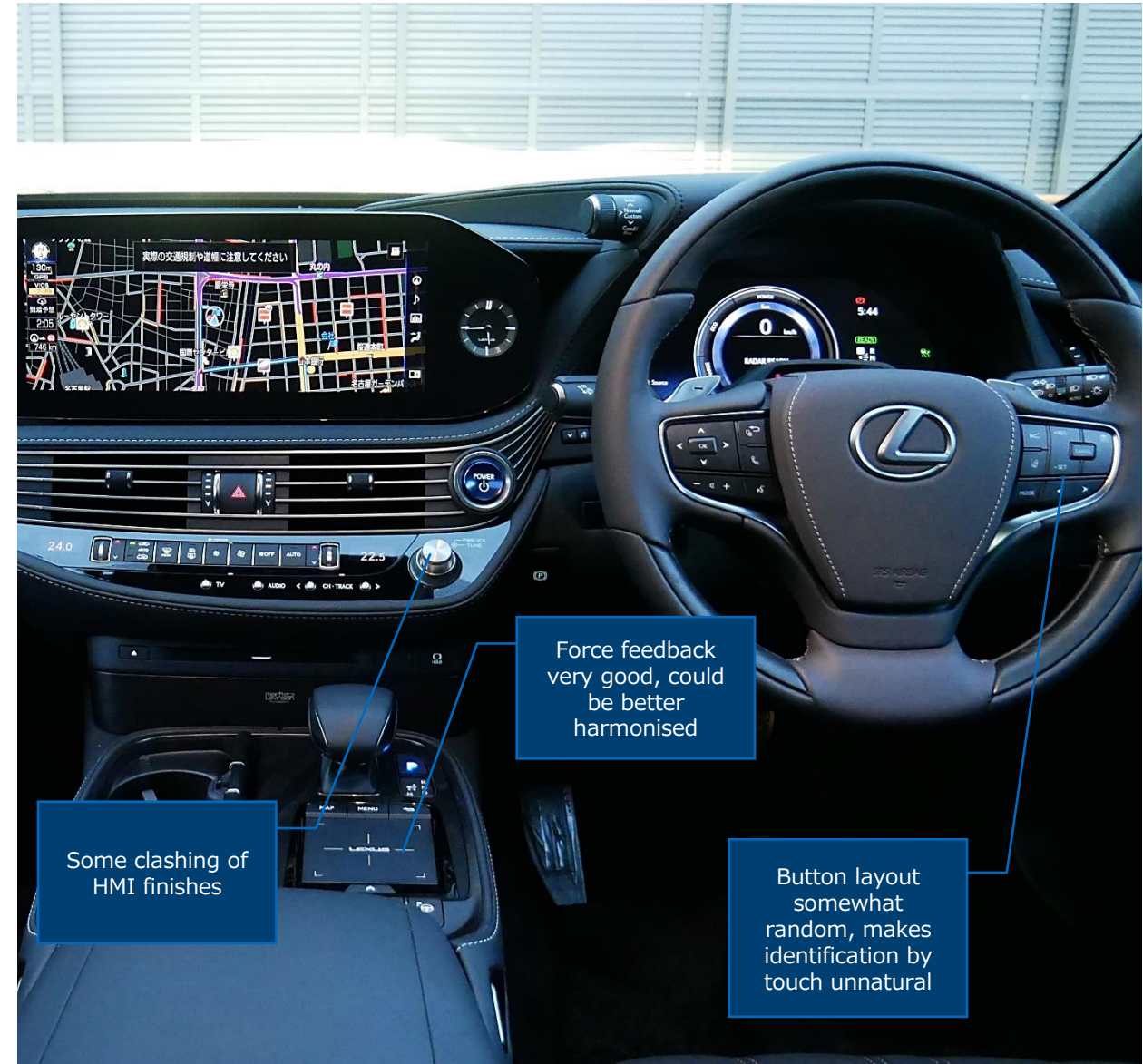
SAE Level 0 ADAS: System usage
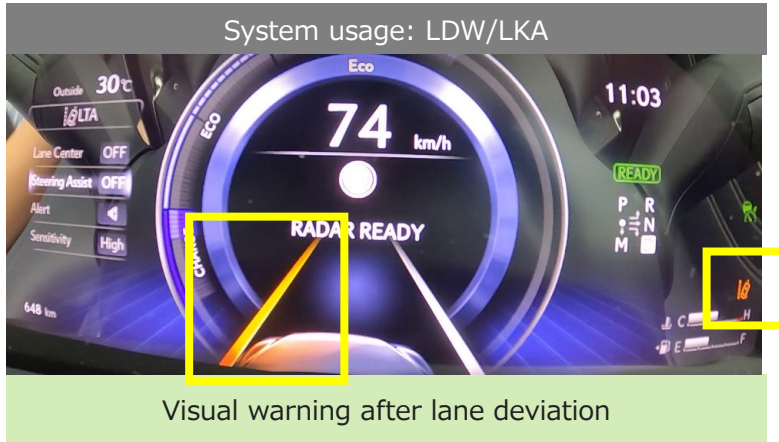
System usage: LDW/LKA
Visual warning after lane deviation

System usage: BSM
BSM icon shown in mirror during warning

System usage: RCTA
Good visual warning in infotainment during RCTA event

System usage: LDW/LKA
Lane tracking status clearly defined

Touchscreen control not fully integrated in entire system

Category	Infotainment
Description	Touchscreen input does not offer full control of the system

SBD viewpoint	Lexus moved away from touchscreen input following the implementation of *Remote Touch* in 2010 and it has taken them longer to return to touchscreen input than most other OEMs. • The LS features touchscreen input on the central display, however its integration is poor and very much gives the impression of being an "add-on" to the previous system which had only the *Remote Touch* pad on the centre console. • The major issue is that it is not possible to bring up home menu via touchscreen, which means the user first has to press the MENU button on the centre console to access many functions. • A secondary issue is that the touchscreen does not accept slide/swipe inputs. This requires some counterintuitive actions in some cases, such as reverting to the touch pad to move the map or tapping the screen to increase/decrease the temperature, despite the appearance of the interface suggesting a slider input. While a return to touchscreen input is likely to please the vast majority of customers, this 'halfway-house' implementation is likely to cause frustration very quickly due to is lack of adherence to well-established expectations of touchscreen interaction.

Since touch input will not bring up the home menu as shown above, the user is unable to access many functions without pressing the HOME button on the centre console

Temperature setting appears as if it can be set by swiping, but only tapping is accepted

UX impact	Major negative	Minor negative	No impact	Minor positive	Major positive

Very good location precision in complex conditions

Category	Navigation
Description	The system showed good position precision in complex conditions
SBD viewpoint	As a part of navigation testing, SBD included complex/challenging conditions to evaluate how the system coped. • The test route included long underwater tunnels, underground curved tunnels, "rat nest" type layouts with intricate layouts and junctions, and complex neighbourhoods to name a just a few of the different scenarios captured. • The Lexus LS solution showed great capability in all conditions with regards to positioning, with no major position jumping or deviations from the road observed. These locations are notorious for tricking navigation systems, and SBD assumes that the Lexus system's performance may perform accurately in part due to the benefits provided by high-precision positioning systems as a part of the advanced ADAS suite.

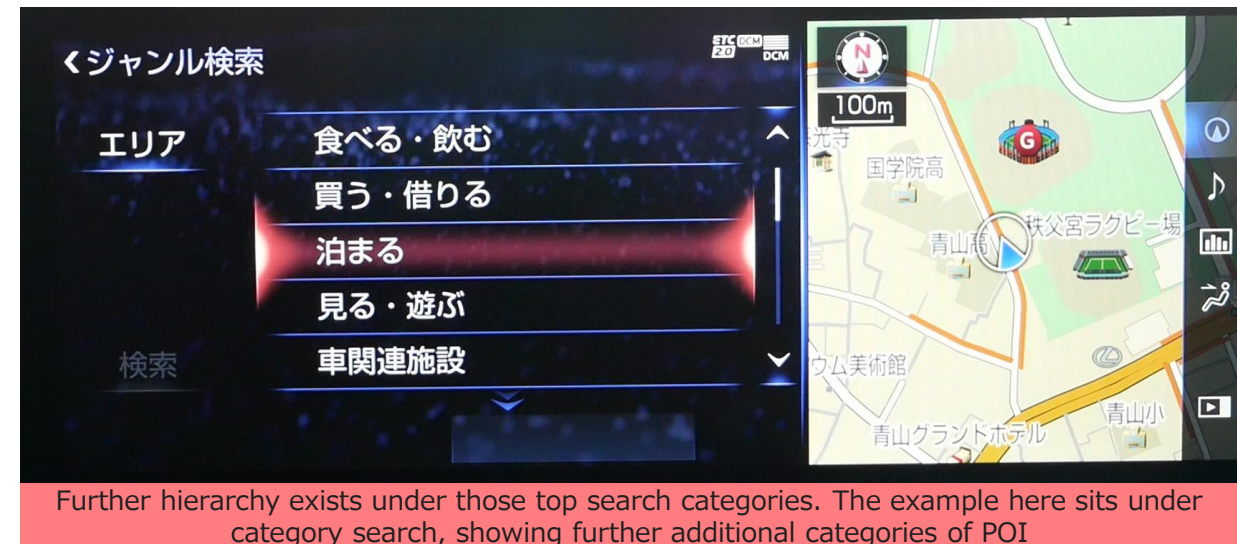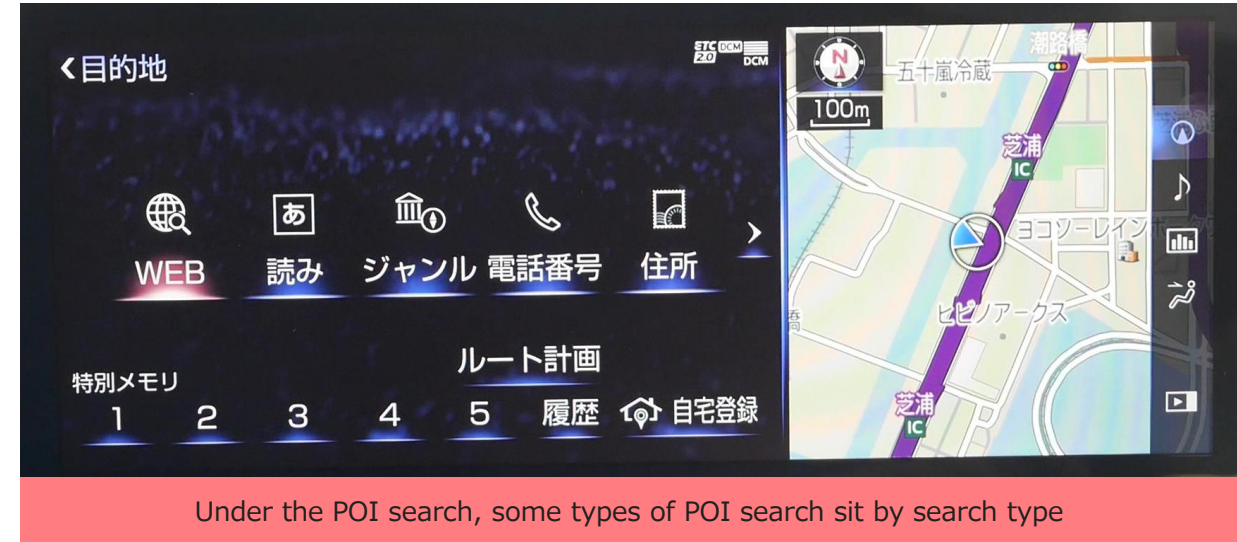| UX impact	Major negative	Minor negative	No impact	Minor positive	Major positive

Long under-sea tunnel
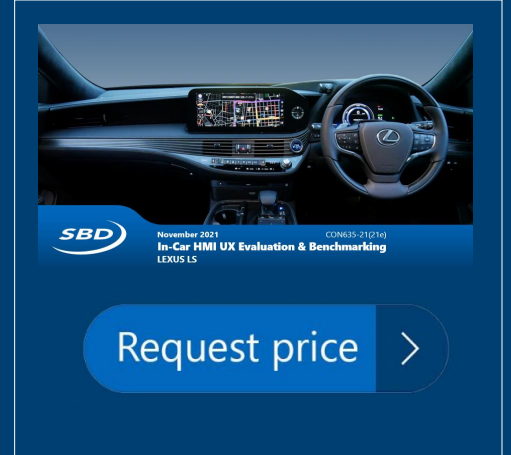

Underground curved tunnel

Conventional, deep, narrow silo information architecture

Category	Navigation
Description	Information architecture has an especially deep silo structure
SBD viewpoint	The information architecture within the navigation domain has a deep and siloed structure which requires too many steps to access the desired information and features. • Considering POI search as a leading example of this complexity: Although the "WEB" menu item accepts several types of search such as keywords, city, telephone number, or POI category, the conventional search methods are still provided in parallel creating a deep and complex menu system within POI search. Because those offline POI searches will be the only POI search methods when connectivity is not available, Toyota should consider implementing an offline-text box search to offer more convenience.

UX impact	Major negative	Minor negative	No impact	Minor positive	Major positive

Under the POI search, some types of POI search sit by search type

Further hierarchy exists under those top search categories. The example here sits under category search, showing further additional categories of POI

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Do you have any questions?

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