

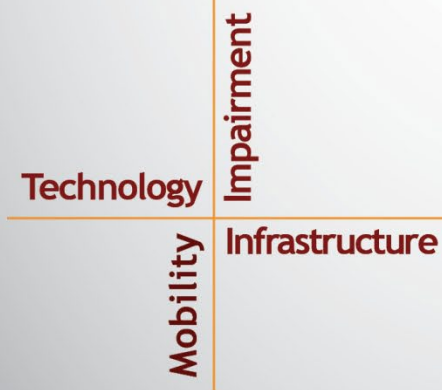
NSTSCCE

National Surface Transportation Safety Center for Excellence

Level 2 Automated Driving Systems: Market Inventory and Development of a Reference Guide

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Submitted: June 14, 2024



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ACKNOWLEDGMENTS

The authors of this report would like to acknowledge the support of the stakeholders of the National Surface Transportation Safety Center for Excellence (NSTSCE): Zac Doerzaph from the Virginia Tech Transportation Institute; John Capp from General Motors Corporation; Terri Hallquist from the Federal Motor Carrier Safety Administration; Mike Fontaine from the Virginia Department of Transportation and the Virginia Transportation Research Council; and Melissa Miles from State Farm Insurance.

The NSTSCE stakeholders have jointly funded this research for the purpose of developing and disseminating advanced transportation safety techniques and innovations.

EXECUTIVE SUMMARY

This study was a comprehensive research initiative focused on original equipment manufacturers (OEMs) with significant market shares of Level 2 (L2) automation features in model year 2022 and beyond vehicles. The primary goal of this research was to analyze and categorize operating constraints and human-machine interface (HMI) implementations associated with L2 advanced driver assistance systems (ADAS), emphasizing complex functions and interactivity. The research also prioritized understanding the nuances in implementation across different OEMs, particularly within features like adaptive cruise control and lane-keeping technologies.

This assessment focused on identifying and prioritizing OEMs with significant market shares and on-road presence of L2 automation features, streamlining the scope to vehicles with immediate impact. L2 ADAS features were emphasized, particularly adaptive cruise control and lane-keeping technologies, to understand their operational complexity and nuanced HMI components. HMI interactions were categorized across sensory modalities—visual, auditory, and haptic—encompassing all forms of feedback. Describing L2 ADAS features and their communication through HMIs was a key component, alongside creating an OEM matrix outlining feature implementations and conducting cross-OEM comparisons. The matrix is a living documented resource, with the intention that it will be continuously updated with new information, serving as a comprehensive reference for L2 automation features and HMIs. Lessons learned underscore the need for deeper exploration given the variance in OEM approaches and potential pandemic-related supply chain impacts at the time of the initial data collection phase. This research initiative aims to illuminate the landscape of L2 automation features and their intricate HMI interactions, ultimately contributing to a better understanding of these technologies for both internal and external stakeholders.

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LIST OF ABBREVIATIONS AND SYMBOLS

ADAS	advanced driver assistance systems
DMS	driver monitoring system
HMI	human-machine interface
L2	Level 2
OEM	original equipment manufacturer

CHAPTER 1. INTRODUCTION

This study focused on original equipment manufacturers (OEMs) with significant market shares of Level 2 (L2) automation features in model year 2022 and later vehicles. The primary goal of the research was to analyze and categorize operating constraints and human-machine interface (HMI) implementations associated with L2 advanced driver assistance systems (ADAS), emphasizing complex functions and interactivity. The research also prioritized understanding the nuances in implementation across different OEMs, particularly within features like adaptive cruise control and lane-keeping technologies.

The study's primary deliverable is an Inventory Matrix, an Excel document containing information gathered during the data collection phase, presented in table form, intended to provide high-level overviews of OEM feature availability. This research primarily utilized OEM websites for gathering information on vehicles from model years 2022 and 2023 with Level 2 (L2) automation features and associated options and packages. The "build" option on these websites allowed for a detailed exploration of vehicle configurations. Additional sources like "My Car Does What?" (<https://mycardoeswhat.org/>) and <https://www.cars.com/> were sparingly used for verification. The main objective was to consolidate information on makes, models, and L2 ADAS features. Each manufacturer was reviewed. Makes were assigned to rows and ADAS features to columns. Research involved examining trim levels and option packages to determine feature availability. Tables were created to compare manufacturer approaches, aiming for a concise reference and comparison of available features across brands.

TERMINOLOGY

The Inventory Matrix uses terms common within the sphere of ADAS:

- ADAS
- Driver Monitoring System (DMS)
- Face-based DMS
- Algorithmic DMS
- Radar
- Camera
- Lidar
- Ultrasonic Sensor
- HMI

While the naming and branding conventions of L2 ADAS features vary by OEM, within the Inventory Matrix L2 features have been siloed into the following categories based on functionality and limitations of the features:

- Lane Centering
- Lane Keep Assist
- Evasive Steering
- Adaptive Cruise Control
- Automatic Emergency Braking
- Pedestrian Braking
- Post-collision Braking
- Reverse Braking
- Lane Change Assist
- Hands-off Cruise Control
- Pre-collision Throttle Control

CHAPTER 2. NAVIGATING THE DATABASE

INVENTORY MATRIX ORGANIZATION

The spreadsheets within the Inventory Matrix document are organized by overviews, all vehicles, and then broken down into brands thereafter following an alphabetical organization. These tabs allow quick navigation to whichever OEM is of interest, as well as quick access to comparisons across manufacturers (Figure 1).



Figure 1. Screen capture. Inventory matrix organization.

The sorting and organization of the data within those tables is explained below in greater detail.

High-level Comparisons

These two tabs present a minimal showcase of L2 feature availability across the OEMs researched and provide a quick reference as to which manufacturers have specific features available in their line of consumer vehicles in the model year(s) surveyed for this study. The “High-level Comparison v1” tab is shown in Figure 2 with a link to the OEM’s website and the “build and price” tool that was used to derive the information. The features are divided into Lateral Control, Longitudinal Control, and Employed Technology/Sensors categories.

Make	Lateral Control			
	Lane Centering	Lane Keeping	Lane Change Assistance	Evasive Steering
Acura	•	•	-	-
Audi	-	•	-	-
BMW	•	•	•	-
Buick	-	•	-	-
Cadillac	•	•	•	-
Chevrolet	-	•	-	-
Chrysler	-	•	-	-
Dodge	-	•	-	-
Ford	•	•	•	•
Genesis	•	•	•	•
GMC	-	•	-	-

Figure 2. Screen capture. High-level comparison v1.

High-level Comparison v2 (Figure 3) displays the same information but with the axes reversed from v1 to provide another quick reference table with the OEMs across the columns. As with the first comparison table, the links provided in the manufacturer name link to the tool used on the corresponding website used to build the vehicle and ascertain the available features.

	Acura	Audi	BMW	Buick	Cadillac
Lane Centering	●	-	●	-	●
Lane Keeping	●	●	●	●	●
Lane Change Assistance	-	-	●	-	●
Evasive Steering	-	-	-	-	-
Adaptive Cruise Control	●	●	●	●	●
Hands-Off Cruise Control	-	-	-	-	●
Automatic Emergency Braking	●	●	●	●	●
Enhanced AEB	-	-	-	-	●
Post-Collision Braking	-	●	-	-	-

Figure 3. Screen capture. High-level comparison v2.

The third comparative table (Figure 4) is a comprehensive explanation of the differences between manufacturers that pulls detail from the corresponding OEM websites to explain branding terminology, nomenclature, and feature availability. It is laid out in the same manner as the High-level Comparison v1 table.

Make	Suite/Branding	Lateral Control		
		Lane Centering	Lane Keeping	Lane Change Assistance
Dodge	Adaptive Cruise Control with Stop	N/A	Available LaneSense® Lane Departure Warning with Lane Keep Assist measures the vehicle's position within lane boundaries and alerts you if you drift from the lane. LaneSense then helps course correct the Durango back into its lane if you do not respond.	N/A
Ford	Co-Pilot 360 / Intelligent Adaptive Cruise Control with Stop-and-Go and Lane Centering / BlueCruise	Available Adaptive Cruise Control (ACC) with Stop-and-Go and Lane Centering can detect lane markings that help you keep your vehicle centered in the lane.	Available Lane-Keeping System can let you know if you are drifting out of your lane by using a forward-facing camera that scans lane markings on both sides of your vehicle. The system has three modes: Lane-Keeping Aid applies steering torque to direct you back to the center of the lane. Lane-Keeping Alert warns you through steering wheel vibrations that simulate driving over a rumble strip. You can set the system to activate either the Alert or Aid mode, or both. Driver Alert sends out warnings in the message center when it detects repeated lane drifts – a reminder to pull over and take a break.	N/A
Genesis	Smart Cruise Control with Stop and Go and Highway Driving Assist or Highway Driving Assist 2.	When driving on the highway, it maintains the distance from the vehicle in front and helps the driver to keep the center of the lane even on curved roads at the speed set by the driver. If you get close to the vehicle next to you while driving, it deflects the vehicle into the lane to avoid danger. When driving over a certain speed, hold the steering wheel and move the turn signal switch in the direction of the desired lane to change lanes automatically.	Lane Keep Assist helps detect lane departure and applies slight corrective steering measures to help keep vehicle from drifting out of lane.	When driving on the highway, it maintains the distance from the vehicle in front and helps the driver to keep the center of the lane even on curved roads at the speed set by the driver. If you get close to the vehicle next to you while driving, it deflects the vehicle into the lane to avoid danger. When driving over a certain speed, hold the steering wheel and move the turn signal switch in the direction of the desired lane to change lanes automatically.
GMC	Adaptive Cruise Control / Super Cruise	N/A	Lane Keep Assist with Lane Departure Warning can alert you if you might be unintentionally drifting out of detected lane lines so you can quickly take action. It will not alert you if you're using your turn signal or it detects you may be intentionally leaving your lane.	N/A

Figure 4. Screen capture. Detailed comparison table.

Make and Model Information

The bulk of the data for this project was roughly two thousand vehicle builds via the OEM website to ascertain L2 feature availability. This is represented within the manufacturer tabs, as well as the comprehensive “All Makes & Models” tab. The L2 feature availability is represented as “Standard,” “Available,” and “Not Available,” as seen in Table 1. “Available Option”

indicates that the vehicle has the capacity for the feature via an add-on package but the feature is not standard equipment. “Not Available” indicates that the vehicle does not have the capability or capacity for the feature.

Table 1. Key to feature availability.

• = Standard Feature	○ = Available Option	- = Not Available
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Each manufacturer tab is laid out in the same order, detailing the model year, make, model, vehicle type, and trim level (if applicable), followed by the iconographic indicators of L2 feature availability across Lateral Control and Longitudinal Control, and the technology used to implement the features. This layout is intended to allow users to quickly ascertain feature availability. If further information is needed, the link(s) to the OEM website provided within the Inventory Matrix can provide further clarification and up-to-date information. An example snapshot of this tab is included in Figure 5.

Make	Model	Year	Vehicle Type	Trim	Lateral L2 Features			
					Lane Centering	Lane Keeping	Evasive Steering	Adaptive Cruise Control
GMC	Canyon	2022	Truck	Standard	-	-	-	-
GMC	Canyon	2022	Truck	Elevation	-	-	-	-
GMC	Canyon	2022	Truck	Denali	-	-	-	-
GMC	Terrain	2022	SUV	SLE	-	•	-	○
GMC	Terrain	2022	SUV	SLT	-	•	-	○
GMC	Terrain	2022	SUV	AT4	-	•	-	○
GMC	Terrain	2022	SUV	Denali	-	•	-	•
GMC	Terrain	2023	SUV	SLE	-	•	-	○
GMC	Terrain	2023	SUV	SLT	-	•	-	○
GMC	Terrain	2023	SUV	AT4	-	•	-	○
GMC	Terrain	2023	SUV	Denali	-	•	-	•
GMC	Acadia	2022	SUV	SLE	-	•	-	-
GMC	Acadia	2022	SUV	SLT	-	•	-	-
GMC	Acadia	2022	SUV	AT4	-	•	-	○
GMC	Acadia	2022	SUV	Denali	-	•	-	○

Figure 5. Screen capture. Manufacturer information example.

CHAPTER 3. LIMITATIONS AND FUTURE UPDATES

The scope of the project and the resulting tools within the Inventory Matrix are intended to be a high-level reference document to inform users of the L2 feature availability within the surveyed manufacturers. Aside from the Detailed Comparison table, information regarding specifics of how the L2 features are implemented is limited within the Inventory Matrix; ergo, the links to the sites used to gather the information are included. Further work—outside of including additional model years—should focus on bringing more detailed information about these manufacturer-specific approaches to the tool for a more comprehensive dataset and source. The initial data collection phase for this project was during a supply chain slump, and therefore some features and information could have changed since that time. Given the ongoing evolution of this field, information within this spreadsheet will need to be monitored and updated to be a relevant and useful source. Corrections to the existing data can be addressed through the process outlined in Feedback and Support within the Inventory Matrix.