NCAP-DRI-LDW-20-09
NEW CAR ASSESSMENT PROGRAM
LANE DEPARTURE WARNING CONFIRMATION TEST

2020 Hyundai Palisade SEL FWD

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5 February 2020

Final Report

Prepared Under Contract No.:DTNH22-14-D-00333

U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
New Car Assessment Program
1200 New Jersey Avenue, SE
West Building, 4th Floor (NRM-110)
Washington, DC 20590

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16. Abstract These tests were conducted on the subject 2020 Hyundai Palisade SEL FWD in accordance with the specifications of the New Car Assessment Program's (NCAP) most current Test Procedure in docket NHTSA-2006-26555-0135 to confirm the performance of a Lane Departure Warning system. The vehicle passed the requirements of the test for all three lane marking types and both directions.			
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Section I

INTRODUCTION

The purpose of the testing reported herein was to confirm the performance of a Lane Departure Warning (LDW) system installed on a 2020 Hyundai Palisade SEL FWD. The LDW system for this vehicle provides both visual and aural alerts. The vehicle passed the requirements of the test for all three lane marking types and both directions

The test procedure is described in detail in the National Highway Traffic Safety Administration (NHTSA) document "LANE DEPARTURE WARNING SYSTEM CONFIRMATION TEST" dated February of 2013 (Docket No. NHTSA-2006-26555-0135). Its purpose is to confirm the performance of LDW systems installed on light vehicles with gross vehicle weight ratings (GVWR) of up to 10,000 lbs. Current LDW technology relies on sensors to recognize a lane delimiting edge line. As such, the test procedures described in the document rely on painted lines, taped lines, or Botts Dots being present on the test course to emulate those found on public roadways. Although it is impossible to predict what technologies could be used by future LDW systems (e.g., magnetic markers, RADAR reflective striping, ultra violet paint, infrared, etc.), it is believed that minor modifications to these procedures, when deemed appropriate, could be used to accommodate the evaluation of alternative or more advanced LDW systems.

Section II

DATA SHEETS

LANE DEPARTURE WARNING

DATA SHEET 1: TEST RESULTS SUMMARY

(Page 1 of 1)

2020 Hyundai Palisade SEL FWD

VIN: *KM8R44HE0LU0xxxx*

Test Date: *12/19/2019*

Lane Departure Warning setting: *Normal*

Test 1 – Continuous White Line	Left: *Pass*	Right: *Pass*
Test 2 – Dashed Yellow Line	Left: *Pass*	Right: *Pass*
Test 3 – Botts Dots	Left: *Pass*	Right: *Pass*

Overall: *Pass*

LANE DEPARTURE WARNING

DATA SHEET 2: GENERAL TEST AND VEHICLE PARAMETER DATA

(Page 1 of 1)

2020 Hyundai Palisade SEL FWD

TEST VEHICLE INFORMATION

VIN: *KM8R44HE0LU0xxxx*

Body Style: *SUV* Color: *Becketts Black*

Date Received: *12/9/2019* Odometer Reading: *22 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Hyundai Motor Company*

Date of manufacture: *May/27/19*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *245/50R20*

Rear: *245/50R20*

Recommended cold tire pressure: Front: *240 kPa (35 psi)*

Rear: *240 kPa (35 psi)*

TIRES

Tire manufacturer and model: *Bridgestone Dueler H/P Sport AS*

Front tire size: *245/50R20*

Rear tire size: *245/50R20*

Front tire DOT prefix: *EJ KH*

Rear tire DOT prefix: *EJ KH*

LANE DEPARTURE WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2020 Hyundai Palisade SEL FWD

GENERAL INFORMATION

Test date: *12/19/2019*

AMBIENT CONDITIONS

Air temperature: *8.3 C (47 F)*

Wind speed: *0.0 m/s (0.0 mph)*

X Wind speed ≤10 m/s (22 mph)

X Tests were not performed during periods of inclement weather. This includes, but is not limited to, rain, snow, hail, fog, smoke, or ash.

X Tests were conducted during daylight hours with good atmospheric visibility (defined as an absence of fog and the ability to see clearly for more than 5000 meters). The tests were not conducted with the vehicle oriented into the sun during very low sun angle conditions, where the sun is oriented 15 degrees or less from horizontal, and camera “washout” or system inoperability results.

VEHICLE PREPARATION

Verify the following:

All non-consumable fluids at 100 % capacity: X

Fuel tank is full: X

Tire pressures are set to manufacturer's recommended cold tire pressure: X

Front: *240 kPa (35 psi)*

Rear: *240 kPa (35 psi)*

LANE DEPARTURE WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2020 Hyundai Palisade SEL FWD

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*597.4 kg (1317 lb)*	Right Front	*563.8 kg (1243 lb)*
Left Rear	*473.1 kg (1043 lb)*	Right Rear	*460.4 kg (1015 lb)*
		Total:	*2094.7 kg (4618 lb)*

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

(Page 1 of 3)

2020 Hyundai Palisade SEL FWD

Name of the LDW option: *Lane Keep Assist (LKA) - Lane Departure Warning (LDW)*

Type of sensor(s) used: *Mono camera LDW*

How is the Lane Departure Warning presented to the driver? (Check all that apply)

- **X** Warning light
- **X** Buzzer or audible alarm
- ____ Vibration
- **X** Other Steering torque

Describe the method by which the driver is alerted. For example, if the warning is a light, where is it located, its color, size, words or symbol, does it flash on and off, etc. If it is a sound, describe if it is a constant beep or a repeated beep. If it is a vibration, describe where it is felt (e.g., pedals, steering wheel), the dominant frequency, (and possibly magnitude), the type of warning (light, audible, vibration, or combination), etc.

When the system detects the vehicle straying from its lane, it alerts the driver with a visual and audible warning, while applying a counter-steering torque, trying to help prevent the vehicle from moving out of its lane.
The audible alert is a repeated beep. The visual alert is located in the lower left of the instrument cluster between the speedometer and tachometer. It depicts an overhead view of a vehicle centered between two lanes (see Figure A10).
The color of indicator will change depending on the condition of LKA system.

- *White: Sensor does not detect lane markers or vehicle speed is under 40 mph (64 km/h).*
- *Green: Sensor detects lane markers and the system is able to control vehicle steering.*
- *Flashing green on and off: The vehicle is close to the lane edge.*

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

(Page 2 of 3)

2020 Hyundai Palisade SEL FWD

Is the vehicle equipped with a switch whose purpose is to render LDW inoperable?

__**X**__ Yes

_____ No

If yes, please provide a full description including the switch location and method of operation, any associated instrument panel indicator, etc.

To activate/deactivate the LKA system:

With the ignition switch in the ON position, press the LKA system switch located on the instrument panel on the left hand side of the steering wheel. The indicator in the cluster display will initially illuminate white. This indicates the LKA system is in the READY but NOT ENABLED state.

If you press the LKA button again, the indicator on the cluster display will go off.

The driver can change LKA to Lane Departure Warning from the LCD display. Go to:

→*User Settings*

→*Driver Assistance*

→ *Lane Safety*

→*Lane Keeping Assist (LKA)/Lane Departure Warning (LDW)/Off'.*

Is the vehicle equipped with a control whose purpose is to adjust the range setting or otherwise influence the operation of LDW?

_____ Yes

__**X**__ No

If yes, please provide a full description.

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

(Page 3 of 3)

2020 Hyundai Palisade SEL FWD

Are there other driving modes or conditions that render LDW inoperable or reduce its effectiveness? **X** Yes ____ No

If yes, please provide a full description.

LDW can be inoperable in the following conditions:

- *The radar or the camera is contaminated with foreign substances*
- *It heavily rains or snows*
- *There is interruption by electric waves*
- *There is severe irregular reflection from the radar*
- *The driver's view is unclear due to the backlight, the reflected light, or darkness*
- *The camera cannot contain the full image of the vehicle in front*
- *The vehicle in front is a special vehicle, such as a heavily-loaded truck or a trailer.*

LDW can be inoperable in the following driving modes:

- *The gear status is 'P'(Parking) or 'R'(Reverse)*
- *The velocity of the subject vehicle is under the minimum velocity and over the maximum velocity.*

See Owner's Manual pages 5-114 through 5-115 in Appendix B pages 15, 16 for a more complete description of the LKA limitations.

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Each LDW test involved one of three lane marking types: solid white lines, dashed yellow lines, or Botts Dots. Lane departures were done both to the left and to the right, and each test condition was repeated five times, as shown in Table 1.

Table 1. LDW Test Matrix

Lane Geometry	Line Type	Departure Direction	Number of Trials
Straight	Solid	L	5
		R	5
	Dashed	L	5
		R	5
	Botts Dots	L	5
		R	5

Prior to the start of a test series involving a given lane marking type and departure direction combination, the accuracy of the distance to lane marking measurement was verified. This was accomplished by driving the vehicle to the approximate location at which the lane departure would occur and placing the tire at the lane marking edge of interest (i.e., distance to lane marking = 0). The real-time display of distance to the lane marking was then observed to verify that the measured distance was within the tolerance (5 cm). If the measured distance was found to be greater than the tolerance, the instrumentation setup was checked and corrected, if necessary. If the measured distance was found to be within the tolerance, the instrumentation setup was considered appropriate and the test series was begun.

To begin the maneuver, the vehicle was accelerated from rest to a test speed of 72.4 km/h (45 mph), while being driven in a straight line parallel to the lane marking of interest, with the centerline of the vehicle approximately 1.83 m (6.0 ft) from the lane edge (i.e., such that the vehicle would pass through the center of the start gate). The test speed was achieved at least 60 m (200 ft) before the start gate was reached. Striking any start gate cones was not permitted, and any run in which a cone was struck was considered to be invalid. Also, during the initialization and test phases, the test driver avoided using turn signals and avoided applying any sudden acceleration, sudden steering or sudden braking, and any use of the turn signals, sudden acceleration, sudden steering, or sudden braking invalidated the test trial.

Data collection began with the vehicle at least 60 m (200 ft) from the start gate, which was configured using a pair of non-reflective, low-contrast color traffic cones. A second set of cones, placed 6 m (20 ft) longitudinally before the start gate, was used to guide the driver into the start gate. The lateral width between the cone pairs was 20 cm (8 in) greater than the width of the vehicle, and the centerline of each pair was laterally offset from the lane marking by 1.8 m (6 ft).

Once the driver passed the gate, the driver manually input sufficient steering to achieve a lane departure with a target lateral velocity of 0.5 m/s with respect to the lane line. As shown in Figure 1, two additional non-reflective cones were used to guide the driver in making this steering maneuver. Throughout the maneuver, the driver modulated the throttle or used cruise control, as appropriate, such that vehicle speed remained at constant speed. The test was considered complete when the vehicle crossed at least 1 m (3.3 ft) over the lane edge boundary.

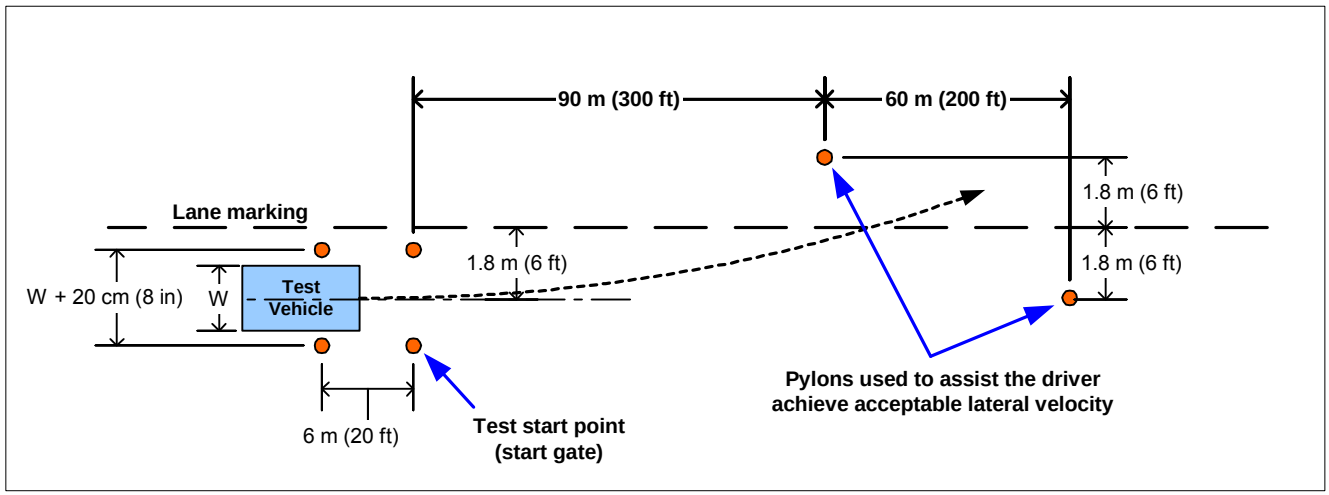

Figure 1. Position of Cones Used to Assist Driver

Data collected included vehicle speed, position, and yaw rate. In addition to cone strikes, vehicle speed and yaw rate data were used to identify invalid runs as described in Section C below. Data from trials where speed or yaw rate were outside of the performance specification were not considered valid.

B. Lane Delineation Markings

The New Car Assessment Program's Test Procedure for the confirmation of a Lane Departure Warning system contains a requirement that all lane markings meet United States Department of Transportation (USDOT) specifications as described in the Manual on Uniform Traffic Control Devices (MUTCD) and be considered in "very good condition".

1. Lane Marker Width

The width of the edge line marker was 10 to 15 cm (4 to 6 in). This is considered to be a normal width for longitudinal pavement markings under Section 3A.05 of the MUTCD.

2. Line Marking Color and Reflectivity

Lane marker color and reflectivity met all applicable standards. These standards include those from the International Commission of Illumination (CIE) for color and the American Society for Testing and Materials (ASTM) on lane marker reflectance.

3. Line Styles

The tests described in this document required the use of three lane line configurations: continuous solid white, discontinuous dashed yellow, and discontinuous with raised pavement markers.

- Continuous White Line

  A continuous white line is defined as a white line that runs for the entire length of the test course.

- Dashed Yellow Line

  As stated in the MUTCD, and as shown in Figure 2, a discontinuous dashed yellow line is defined as by a series of 3 m (10 ft) broken (dashed) yellow line segments, spaced 9.1 m (30 ft) apart.

- Raised Pavement Marker Line (Botts Dots)

  California Standard Plans indicates raised pavement markers are commonly used in lieu of painted strips for marking roads in California. Other states, mainly in the southern part of the United States, rely on them as well. These markers may be white or yellow, depending on the specific application, following the same basic colors of their analogous white and yellow painted lines. Following the California 2006 Standard Plans, three types of raised pavement markings are used to form roadway lines. It is believed that these types of roadway markings are the hardest for an LDW sensor system to process. Type A and Type AY are non-reflective circular domes that are approximately 10 cm (4 in) in diameter and approximately 1.8 cm (0.7 in) high. Type C and D are square markings that are retro reflective in two directions measuring approximately 10 x 10 x 5 cm (4 x 4 x 0.5 in), and Type G and H that are the same as C and D only retro reflective in a single direction.

For the tests described in this document, raised pavement markers were set up following California Standard Plan A20A, Detail 4, as shown in Figure 3. Note that in this figure, the squares are Type D yellow reflectors and the circles are yellow Type AY discs.

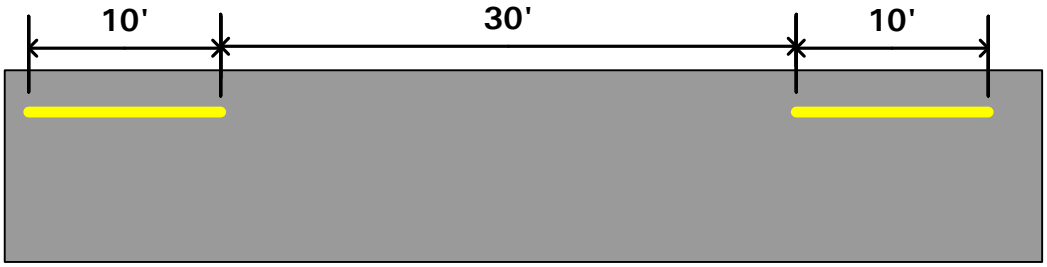

Figure 2. MUTCD Discontinuous Dashed Line Specifications

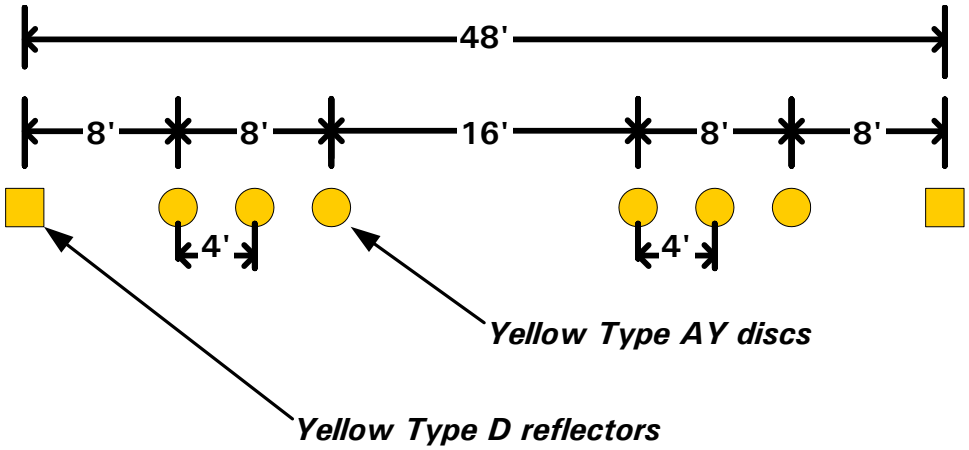

Figure 3. California Standard Plan A20A, Detail 4

A. Test Validity

1. Speed

All LDW tests were conducted at 72.4 km/h (45 mph). Test speed was monitored and a test was considered valid if the test speed remained within ± 2 km/h (± 1.2 mph) of the 72.4 km/h (45 mph) target speed. It was required that the speed must remain within this window from the start of the test until any part of the vehicle crossed a lane line by 1 m (3.3 ft) or more.

2. Lateral Velocity

All tests were conducted with a lateral velocity of 0.1 to 0.6 m/s (0.3 to 2.0 ft/s), measured with respect to the lane line at the time of the alert. To assist the test driver in being able to efficiently establish the target lateral velocity, cones were positioned in the manner shown in Figure 1.

3. Yaw Rate

It was required that the magnitude of the vehicle's yaw rate could not exceed 1.0 deg/sec at any time during lane departure maneuver, from the time the vehicle passes through the start gate to the instant the vehicle has crossed a lane line by 1 m (3.3 ft).

C. Pass/Fail Criteria

The measured test data were used to determine the pass/fail outcome for each trial. The outcome was based on whether the LDW produced an appropriate alert during the maneuver. In the context of this test procedure, a lane departure is said to occur when any part of the two-dimensional polygon used to represent the test vehicle breaches the inboard lane line edge (i.e., the edge of the line close to the vehicle before the departure occurs). In the case of tests performed in this procedure, the front corner of the polygon, defined as the intersection of the center of the front wheels (longitudinally) with the outboard edge of the front tire (laterally), crossed the line edge first. So, for example, if the vehicle departed its lane to the left, the left front corner of the polygon would first breach the lane line edge.

For an individual trial to be considered a "pass":

- Test speed, lateral velocity, and yaw rate validity conditions must be satisfied.
- The LDW alert must not occur when the lateral position of the vehicle is greater than 0.75 m (2.5 ft) from the lane line edge (i.e., prior to the lane departure).
- The LDW alert must occur before the lane departure exceeds 0.3 m (1.0 ft).

For an overall, "Pass" the LDW system must satisfy the pass criteria for 3 of 5 individual trials for each combination of departure direction and lane line type (60 percent), and pass 20 of the 30 trials overall (66 percent).

D. Instrumentation

Table 2 lists the sensors, signal conditioning, and data acquisition equipment used for these tests.

Table 2. Test Instrumentation and Equipment

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	0.5 psi 3.45 kPa	Ashcroft, D1005PS	17042707002	By: DRI Date: 7/3/2019 Due: 7/3/2020
Platform Scales	Vehicle Total, Wheel, and Axle Load	8000 lb 35.6 kN	±1.0% of applied load	Intercomp, SWII	1110M206352	By: DRI Date: 1/3/2019 Due: 1/3/2020
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	NA
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots Accel: ±100 m/s^2 Angular Rate: ±100 deg/s Angular Disp: ±180 deg	Position: ±2 cm Velocity: 0.05 km/h Accel: ≤ 0.01% of full range Angular Rate: ≤ 0.01% of full range Roll/Pitch Angle: ±0.03 deg Heading Angle: ±0.1 deg	Oxford Technical Solutions (OXTS), Inertial+	2258	By: Oxford Technical Solutions1 Date: 5/3/2019 Due: 5/3/2021
Real-Time Calculation of Position and Velocity Relative to Lane Markings	Distance and velocity to lane markings	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	NA

[1] Oxford Technical Solutions recommends calibration every two years.

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	NA	NA
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	NA	NA
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/2/2019 Due: 1/2/2020

Type	Description	Mfr, Model	Serial Number
Data Acquisition System	Data acquisition is achieved using a dSPACE MicroAutoBox II Data from the Oxford IMU, including Longitudinal, Lateral, and Vertical Acceleration, Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle are sent over Ethernet to the MicroAutoBox. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (listed above).	D-Space Micro-Autobox II 1401/1513	
		Base Board	549068
		I/O Board	588523

For systems that implement audible or haptic alerts, part of the pre-test instrumentation verification process is to determine the tonal frequency of the audible warning or the vibration frequency of the tactile warning through use of the PSD (Power Spectral Density) function in Matlab. This is accomplished in order to identify the center frequency around which a band-pass filter is applied to subsequent audible or tactile warning data so that the beginning of such warnings can be programmatically determined. The bandpass filter used for these warning signal types is a phaseless, forward-reverse pass, elliptical (Cauer) digital filter, with filter parameters as listed in Table 3.

Table 3. Audible and Tactile Warning Filter Parameters

Warning Type	Filter Order	Peak-to-Peak Ripple	Minimum Stop Band Attenuation	Pass-Band Frequency Range
Audible	5^{th}	3 dB	60 dB	Identified Center Frequency ± 5%
Tactile	5^{th}	3 dB	60 dB	Identified Center Frequency ± 20%

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

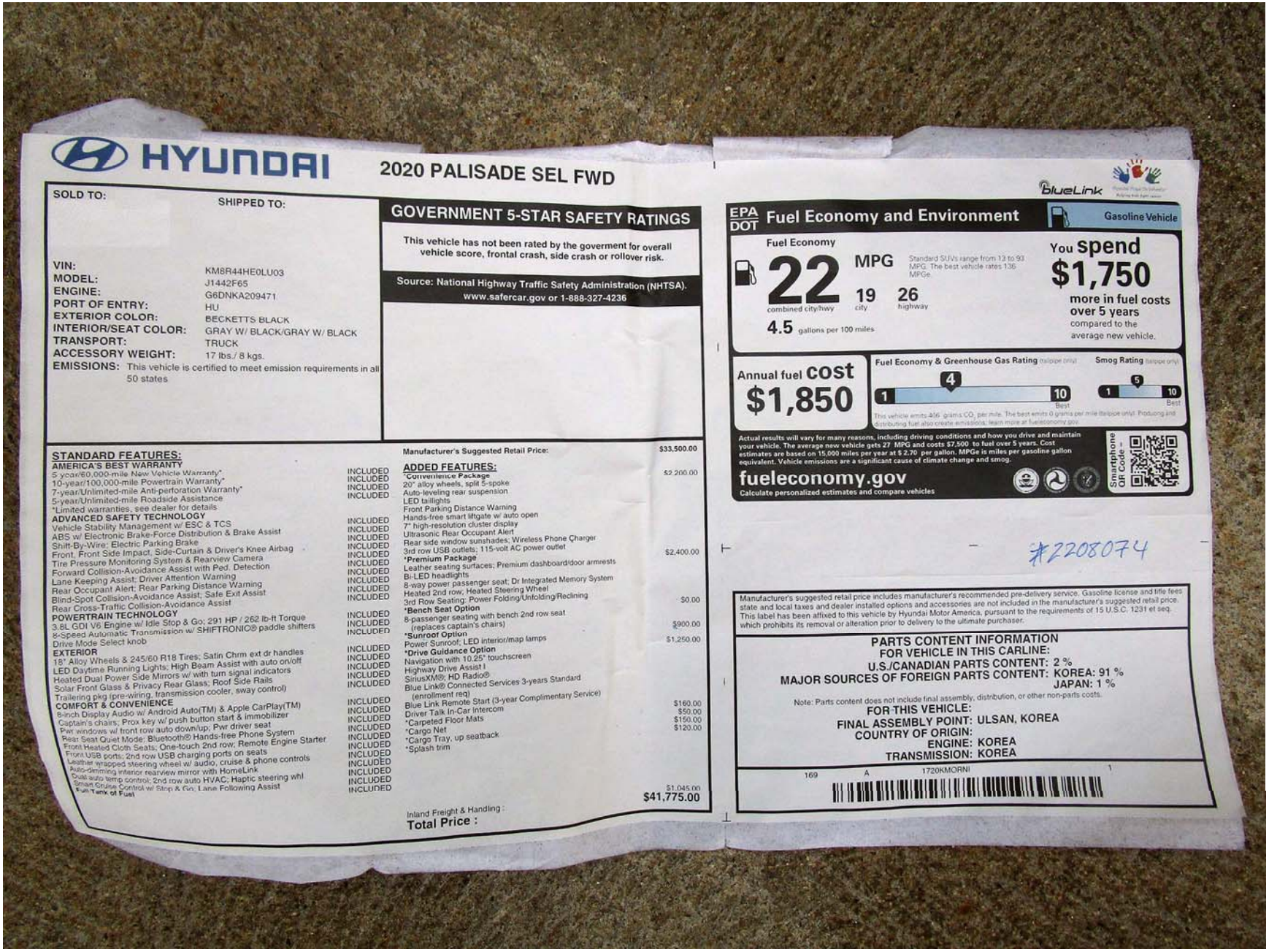

Figure A3. Window Sticker (Monroney Label)

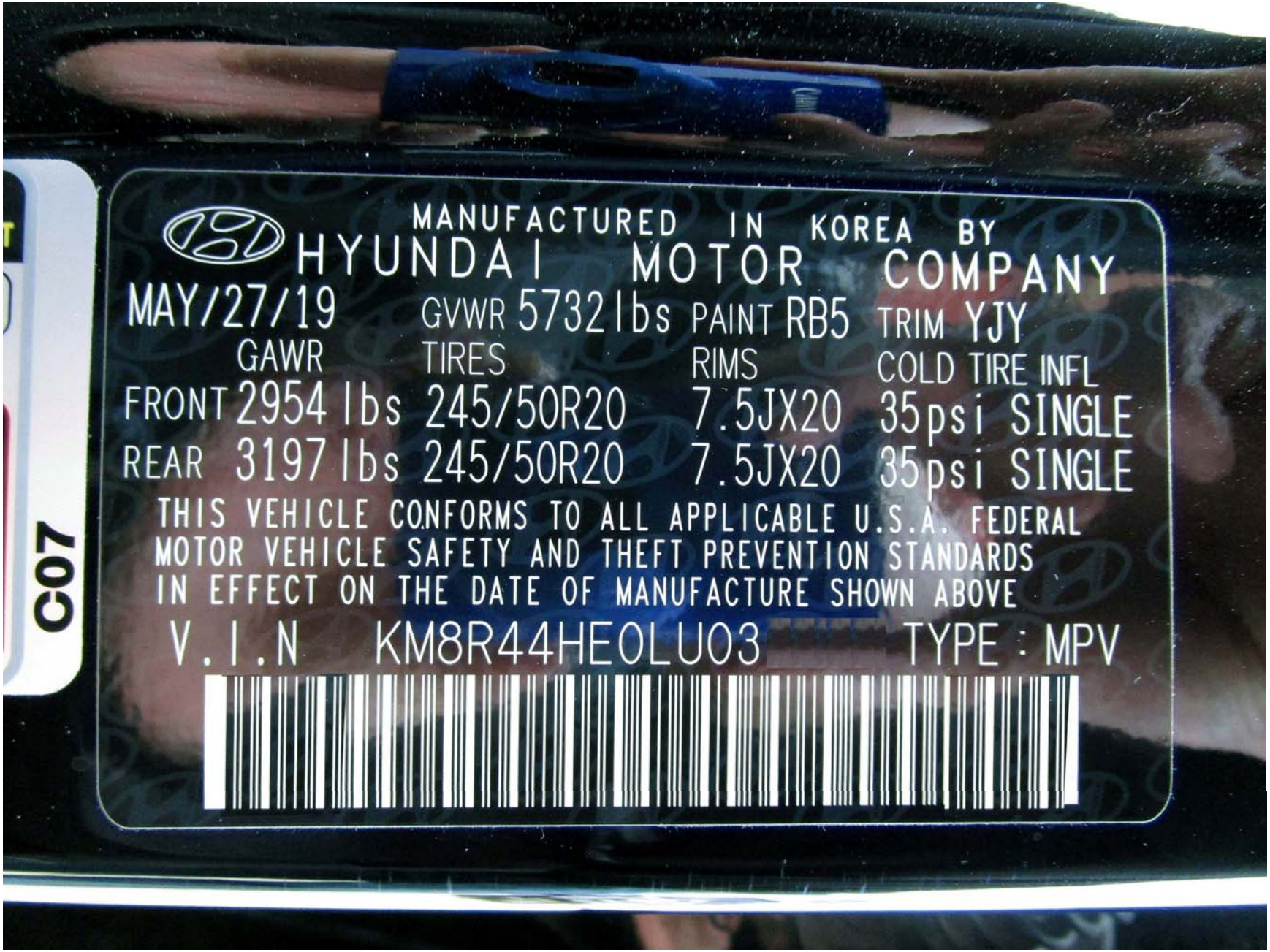

Figure A4. Vehicle Certification Label

Figure A5. Tire Placard

Figure A6. DGPS, Inertial Measurement Unit and MicroAutoBox Installed in Subject Vehicle

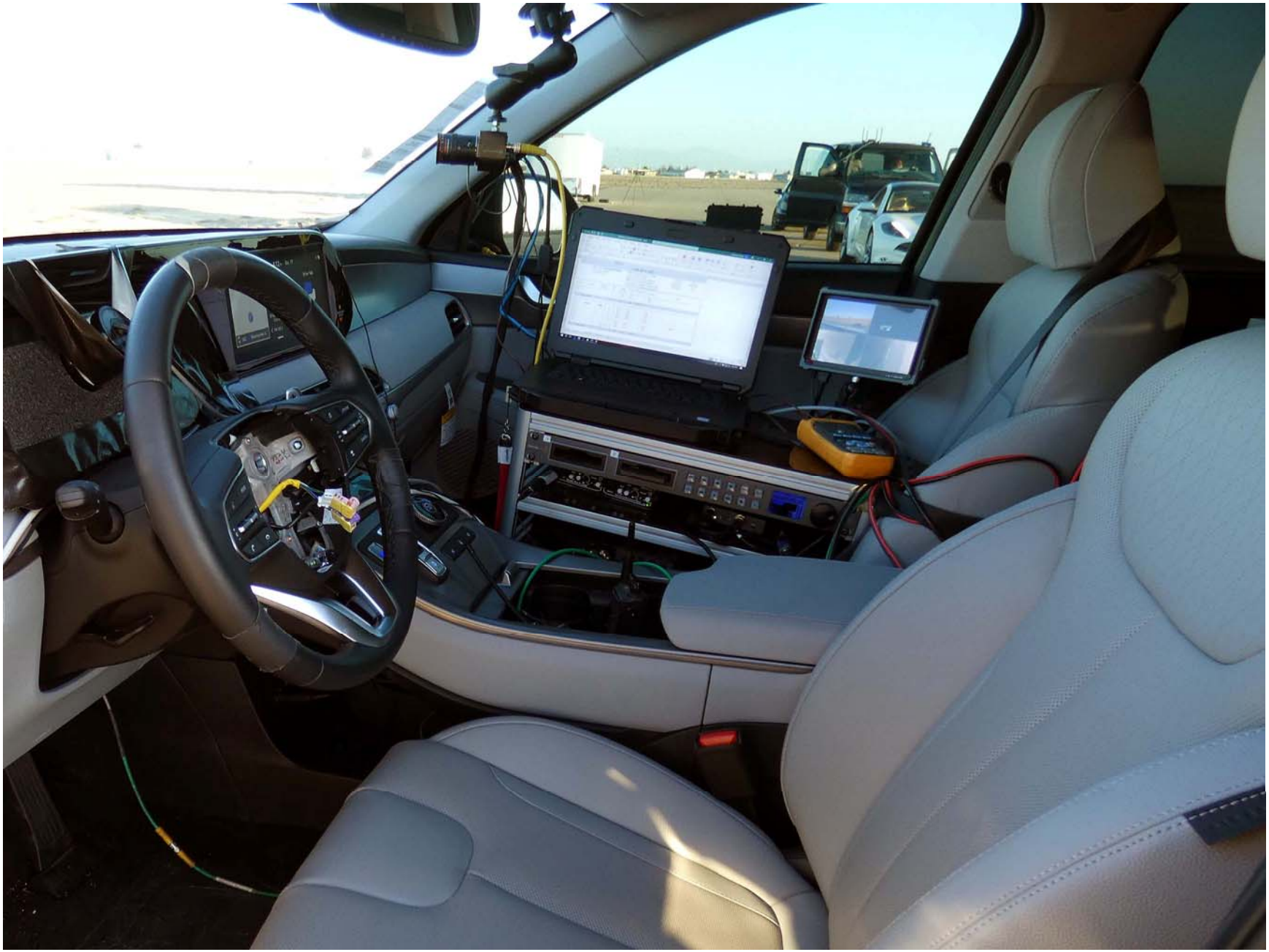

Figure A7. Computer Installed in Test Vehicle

Figure A8. Sensor for Detecting Auditory Alerts

Figure A9. Sensor for Detecting Visual Alerts

Figure A10. LKA (LDW) Visual Alert

Figure A11. LKA (LDW) On/Off Switch

Figure A12. Steering Wheel Mounted Controls for Interacting with LKA (LDW) Settings

Figure A13. Menus for LKA (LDW) Settings

APPENDIX B

Excerpts from Owner's Manual

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15. Seat.....2-4
16. Fuse box 7-51

The actual shape may differ from the illustration.

OLX2019003N

Forward Collision-Avoidance Assist (FCA) System Warning Light

This warning light illuminates:

- When you set the ignition switch or the Engine Start/Stop button to the ON position.
  - It illuminates for approximately 3 seconds and then goes off.
- When there is a malfunction with the FCA.

If this occurs, have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Forward Collision-Avoidance Assist (FCA) system" in chapter 5.

Lane Keeping Assist (LKA) System Indicator Light

This indicator light illuminates:

- [Green] When the system operating conditions are satisfied.
- [White] The system operating conditions are not satisfied.
- [Yellow] When there is a malfunction with the lane keeping assist system.

  If this occurs, have your vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Lane Keeping Assist (LKA) system" in chapter 5.

LED Headlight Warning Light (if equipped)

This warning light illuminates:

- When you set the ignition switch or the Engine Start/Stop button to the ON position.
- When there is a malfunction with the LED headlight.

  If this occurs, have the vehicle inspected by an authorized HYUNDAI dealer.

This warning light blinks:

When there is a malfunction with a LED headlight related part.

If this occurs, have the vehicle inspected by an authorized HYUNDAI dealer.

NOTICE

Continuous driving with the LED Headlight Warning Light on or blinking can reduce LED headlight life.

Check Smart Cruise Control System (if equipped)

This warning message is displayed if there is a problem with the Smart Cruise Control system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Smart Cruise Control with Stop & Go" in chapter 5.

Check Driver Attention Warning (DAW) system (if equipped)

This warning message is displayed if there is a problem with the Driver Attention Warning (DAW). Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Driver Attention Warning (DAW)" in chapter 5.

Check Lane Keeping Assist (LKA) system (if equipped)

This warning message is displayed if there is a problem with the Check Lane Keeping Assist (LKA) system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Check Lane Keeping Assist (LKA) system" in chapter 5.

LCD Display Modes

Modes	Symbol	Explanation
Trip Computer		The Trip Computer mode displays driving information such as the tripmeter, fuel economy, etc. **For details, refer to "Trip Computer" in this chapter.**
Turn By Turn (TBT) (if equipped)		This mode displays the state of the navigation.
Assist		The Driver Assist mode displays the status of the following features: - Smart Cruise Control (SCC) system - Lane Keeping Assist (LKA) system - Driver Attention Warning (DAW) system - Tire pressure - Traction force distribution status of front-wheels and rear-wheels **For more information, refer to "Smart Cruise Control with Stop & Go)", "Lane Keeping Assist (LKA) system", "Driver Attention Warning (DAW) system", "Traction force distribution status of front-wheels and rear-wheels" in chapter 5 and "Tire Pressure Monitoring System (TPMS)" in chapter 6.**
User Settings		The User Settings mode provides user options for a variety of settings including door lock/unlock features, convenience features, driver assistance settings, etc.
Master Warning		The Master Warning mode displays warning messages related to the vehicle when one or more systems is not operating normally.

The information provided may differ depending on which functions are applicable to your vehicle.

Trip computer mode

OIK047124N

The trip computer mode displays information related to vehicle driving parameters including fuel economy, tripmeter information and vehicle speed.

For more details, refer to "Trip Computer" in this chapter.

Turn By Turn (TBT) mode

OIK047147N

This mode displays the state of the navigation.

Assist mode

OLX2049119N

SCC/LKA/DAW

This mode displays the state of the Smart Cruise Control (SCC), Lane Keeping Assist (LKA) and Driver Attention Warning (DAW).

For more details, refer to each system information in chapter 5.

Driving Assist View Mode

OLX2059118N

SCC/LKA/HAD/FCA

This mode displays the state of the Smart Cruise Control (SCC) and Lane Keeping Assist (LKA).

For more details, refer to system information in chapter 5.

TBT (Turn By Turn) Mode

OLX2059119N

It shows the information by interworking with the navigation.

Parking Assist View Mode

9145N

It displays the information related to the parking assist system movement.

2. Driver Assistance

Items	Explanation
Forward Safety	• Active Assist: If selected, the system controls the vehicle and provides a warning when a collision is detected. • Warning Only: If selected, the system provides a warning when a collision is detected. • Off: Deactivates the system. **For more details, refer to the "Forward Collision-Avoidance Assist system" in chapter 5.**
Lane Safety	To adjust the Lane Keeping Assist (LKA) function. - Lane Keeping Assist - Lane Departure Warning - Off **For more details, refer to the "Lane Keeping Assist (LKA) system" in chapter 5.**
Blind-Spot Safety	• Blind-Spot View To activate or deactivate the Blind-Spot View. **For more details, refer to the "Blind-Spot View" in this chapter.**
	• SEA(Safe Exit Assistance) To activate or deactivate the Safe Exit Assistance. **For more details, refer to the "Safe Exit Assistance" in chapter 5.**
	• Active assist • Warning only • Off **For more details, refer to "Blind-spot Collision-Avoidance Assist (BCA)" in chapter 5.**

❉ The information provided may differ depending on which functions are applicable to your vehicle.

Head-up display ON/OFF

OIK047152N

To activate the head up display, select 'Head-UP Display' on the User Settings mode on the instrument cluster LCD display.

If you do not select 'Head-Up Display', the head up display will be deactivated.

Head-up display information

OLX2049419N

1. Turn By Turn (TBT) navigation information (if equipped)
2. Speed limit signs (if equipped)
3. Speedometer
4. Cruise setting speed (if equipped)
5. Smart Cruise Control (SCC) information (if equipped)
6. Lane Keeping Assist (LKA) system information (if equipped)
7. Blind-spot Collision Warning (BCW) system information (if equipped)
8. Warning lights (Low fuel, etc.)
9. Audio/Video information

Information

If you select the Turn By Turn (TBT) navigation information as HUD contents, the Turn By Turn (TBT) navigation information will not be displayed in the instrument cluster LCD display.

Head-up display setting

On the LCD display, you can change the head up display settings as follows.

- Enable Head-up display
- Display Height
- Rotation
- Brightness
- Content Selection
- Speed Size
- Speed Color

For more details, refer to "LCD Display" in this chapter.

LANE KEEPING ASSIST (LKA) SYSTEM (IF EQUIPPED)


OLX2059028N

The Lane Keeping Assist (LKA) system helps detect lane markers on the road with a front view camera at the front windshield, and assists the driver's steering to help keep the vehicle between lanes.

When the system detects the vehicle straying from its lane, it alerts the driver with a visual and audible warning, while applying a counter-steering torque, trying to help prevent the vehicle from moving out of its lane.

⚠ WARNING

The Lane Keeping Assist (LKA) system is not a substitute for safe driving practices, but a convenience function only. It is the responsibility of the driver to always be aware of the surroundings and steer the vehicle.

⚠ WARNING

Take the following precautions when using the Lane Keeping Assist (LKA) system:

- **Do not turn the steering wheel suddenly when the steering wheel is being assisted by the system.**
- **LKA system helps to prevent the driver from moving out of the lane unintentionally by assisting the driver's steering. However, the driver should not solely rely on the system but always pay attention on the steering wheel to stay in the lane.**
- **The operation of the LKA system can be canceled or not work properly according to road condition and surroundings. Always be cautious when driving.**
- **Do not disassemble the LKA system camera temporarily to tint the window or attach any types of coatings and accessories. If you disassemble the camera and assemble it again, take your vehicle to an authorized HYUNDAI dealer and have the system checked for calibration.**
- **When you replace the windshield glass, LKA system camera or related parts of the steering wheel, take your vehicle to an authorized HYUNDAI dealer and have the system checked for calibration.**

- **The system helps detect lane lines and controls the steering wheel by a camera, therefore, if the lane lines are hard to detect, the system may not work properly.**

  Please refer to "Limitations of the System".
- **Do not remove or damage the related parts of LKA system.**
- **You may not hear a warning sound of LKA system if the audio volume is high.**
- **If any other warning sound such as seat belt warning chime is already generated, the Lane Keeping Assist (LKA) system warning may not sound.**
- **Do not place objects on the dashboard that reflects light such as mirrors, white paper, etc. This may prevent the LKA system from functioning properly.**

- **Always have your hands on the steering wheel while the LKA system is activated.**
- **The steering wheel is not continuously controlled so if the vehicle speed is at a higher speed when leaving a lane the vehicle may not be able to be controlled by the system. The driver must always follow the speed limit when using the system.**
- **If you attach objects to the steering wheel, the system may not assist steering or the hands off alarm may not work properly. When you tow a trailer, make sure that you turn off the LKA system.**
- **When you tow a trailer, make sure that you turn off the LKA system.**

LKA System Operation

To activate/deactivate the LKA system:

With the ignition switch in the ON position, press the LKA system switch located on the instrument panel on the left hand side of the steering wheel. The indicator in the cluster display will initially illuminate white. This indicates the LKA system is in the READY but NOT ENABLED state.

If you press the LKA button again, the indicator on the cluster display will go off.

Note that the vehicle speed must be at least approximately 40 mph (64 km/h) to ENABLE the LKA system. The indicator in the cluster will illuminate green.

The color of indicator will change depending on the condition of LKA system.

- White : Sensor does not detect lane markers or vehicle speed is under 40 mph (64 km/h).
- Green : Sensor detects lane markers and the system is able to control vehicle steering.

Information

If the indicator (white) is activated from the previous ignition cycle, the system will turn ON without any additional control. If you press the LKA switch again, the indicator on the cluster goes off.

LKA system operation

OLX2059058N

- To see the LKA system screen on the LCD display in the cluster, select Assist mode ( ). **For more details, refer to "LCD Display Modes" in chapter 3.**

■ Lane marker undetected ■ Lane marker detected

OLX2059058N/OLX2059059N

- If vehicle speed is over 40 mph (64 km/h) and the system detects lane markers, the color changes from gray to white.

• If your vehicle departs from the projected lane in front of you, the LKA system operates as follows:

OLX2059061N/OLX2059060N

1. A visual warning appears on the cluster LCD display. Either the left lane marker or the right lane marker in the cluster LCD display will blink depending on which direction the vehicle is veering. Also, the steering wheel will vibrate.
2. The LKA system will help control the vehicle's steering to prevent the vehicle from crossing the lane maker in below conditions.
   - Vehicle speed is over 40 mph (64 km/h)
   - When driving, the vehicle is located between both lanes normally.
   - The steering wheel is not turned suddenly.

When lanes are detected and all the conditions to activate the LKA system are satisfied, a LKA system indicator light ( ) will change from white to green. This indicates that the LKA system is in the ENABLED state and the steering wheel will be controlled.

Warning Light and Message

Keep hands on steering wheel

OLX2059062N

If the driver takes their hands off the steering wheel for several seconds while the LKA system is activated, the system will warn the driver.

Information

If the steering wheel is held very lightly, the message may still appear because the LKA system may not recognize that the driver has their hands on the wheel.

⚠ WARNING

The warning message may appear late according to road conditions. Therefore, always have your hands on the steering wheel while driving.

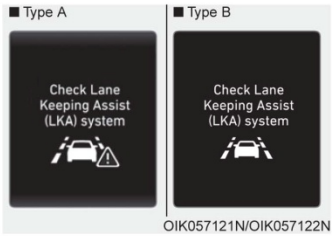
⚠ WARNING

- The LKA system is a supplemental system only. It is the responsibility of the driver to safely steer the vehicle and to maintain it in its lane.
- Turn off the LKA system and drive without using the system in the following situations:
  - In bad weather
  - In bad road conditions
  - When the steering wheel needs to be controlled by the driver frequently.

Information

- Even though the steering is assisted by the system, the driver can still steer to control the steering wheel.
- The steering wheel may feel heavier when the steering wheel is assisted by the system than when it is not.

Check Lane Keeping Assist (LKA) system



OIK057121N/OIK057122N

If there is a problem with the system a message will appear for a few seconds. If the problem continues the LKA system failure indicator will illuminate.

LKA system indicator

The LKA system indicator (yellow) will illuminate if the LKA system is not working properly. Have your vehicle checked by an authorized HYUNDAI dealer.

When there is a problem with the system do one of the following:

- Turn the system on after turning the engine off and on again.
- Check if the ignition switch is in the ON position.
- Check if the system is affected by the weather. (ex: fog, heavy rain, etc.)
- Check if there is foreign matter on the camera lens.

If the problem is not solved, have your vehicle checked by an authorized HYUNDAI dealer.

The LKA system will not be in the ENABLED state and/or the steering wheel will not be assisted when:

- The turn signal is turned on before changing a lane. If you change lanes without the turn signal on, the steering wheel might be controlled.
- The vehicle is not driven in the middle of the lane when the system is turned on or right after changing a lane.
- ESC (Electronic Stability Control) or VSM (Vehicle Stability Management) is activated.
- The vehicle is driven on a sharp curve.
- Vehicle speed is below 35 mph (56 km/h) and over 110 mph (177 km/h).
- The vehicle makes sharp lane changes.
- The vehicle brakes suddenly.
- The lane is very wide or narrow.
- There are more than two lane lines on the road. (e.g. construction area)
- Radius of a curve is too small.
- The vehicle is driven on a steep incline.
- The steering wheel is turned suddenly.
- The system may not operate for 15 seconds after the engine is started or the camera is initialized.

Limitations of the System

The LKA system may operate prematurely even if the vehicle does not depart from the intended lane, OR, the LKA system may not warn you if the vehicle leaves the intended lane under the following circumstances:

When the lane and road conditions are poor

- It is difficult to distinguish the lane marker from the road because the lane marker is covered with dust or sand.
- It is difficult to distinguish the color of the lane marker from the road.
- There are markings on the road surface that look like a lane marker that is inadvertently being detected by the camera.

- The lane marker is indistinct or damaged.
- The lane marker is merged or divided (e.g. tollgate).
- The lane number increases or decreases or the lane marker are crossing complicatedly.
- There are more than two lane markers on the road in front of you.
- The lane marker is very thick or thin.
- The lane is very wide or narrow.
- The lane marker ahead is not visible due to rain, snow, water on the road, damaged or stained road surface, or other factors.
- The shadow is on the lane marker by a median strip, trees, guardrail, noise barriers, etc.
- The lane markers are complicated or a structure substitutes for the lines such as a construction area.
- There are crosswalk signs or other symbols on the road.
- The lane marker in a tunnel is stained with oil, etc.
- The lane suddenly disappears such as at the intersection.

When external condition is intervened

- The brightness outside changes suddenly such as when entering or exiting a tunnel, or when passing under a bridge.
- The brightness outside is too low such as when the headlamps are not on at night or the vehicle is going through a tunnel.
- There is a boundary structure in the roadway such as a concrete barrier, guardrail and reflector post that is inadvertently being detected by the camera.
- When light coming from a street light or an oncoming vehicle is reflected on a wet road surface such as a puddle in the road.
- The field of view in front is obstructed by sun glare.
- There is not enough distance between you and the vehicle in front to be able to detect the lane marker or the vehicle ahead is driving on the lane marker.
- Driving on a steep grade, over a hill, or when driving on a curved road.
- The adverse road conditions cause excessive vehicle vibrations while driving.
- The surrounding of the inside rear view mirror temperature is high due to direct sunlight, etc.

When front visibility is poor

- The windshield or the camera lens is blocked with dirt or debris.
- The windshield glass is fogged up; a clear view of the road is obstructed.
- Placing objects on the dashboard, etc.
- The sensor cannot detect the lane because of fog, heavy rain or snow.

LKA System Function Change

The driver can change LKA to Lane Departure Warning from the LCD display. Go to the 'User Settings → Driver Assistance → Lane Safety → Lane Keeping Assist (LKA)/Lane Departure Warning (LDW)/Off'.

The system is automatically set to Lane Keeping Assist(LKA) if a function is not selected.

- Lane Keeping Assist

  Lane Keeping Assist guides the driver to help keep the vehicle within the lanes. It rarely controls the steering wheel, when the vehicle drives well inside the lanes. However, it starts to control the steering wheel, when the vehicle is about to deviate out of the lane.

- Lane Departure Warning

  Lane Departure Warning alerts the driver with a visual warning and a warning alarm when the system detects the vehicle departing the lane. The steering wheel will not be controlled.

- Off

  If you select 'off', the LKA system is deactivated.

NOTICE

The Driver Attention Warning system utilizes the camera sensor on the front windshield for its operation. To keep the camera sensor in the best condition, you should observe the followings:

- NEVER install any accessories or stickers on the front windshield, or tint the front windshield.
- NEVER place any reflective objects (i.e. white paper, mirror) over the crash pad. Any light reflection may prevent the system from functioning properly.
- Pay extreme caution to keep the camera sensor dry.
- Never disassemble the camera assembly, or apply any impact on the camera assembly.

  If the sensor is forcibly moved out of proper alignment, the system may not operate correctly. Take your vehicle to an authorized HYUNDAI dealer and have the system checked for calibration.

⚠ CAUTION

The Driver Attention Warning (DAW) system may not provide alerts in the following situations:

- The lane detection performance is limited. (For more details, refer to "Lane Keeping Assist (LKA) system" in this chapter.)
- The vehicle is erratically driven or is abruptly turned for obstacle avoidance (e.g. construction area, other vehicles, fallen objects, bumpy road).
- Forward drivability of the vehicle is severely undermined (possibly due to wide variation in tire pressures, uneven tire wear-out, toe-in/toe-out alignment).
- The vehicle drives on a curvy road.
- The vehicle drives on a bumpy road.
- The vehicle drives through a windy area.
- The vehicle is controlled by the following driving assist systems:
  - Forward Collision-avoidance Assist (FCA)
  - Smart Cruise Control (SCC)
  - Lane Following Assist (LFA)
  - Lane Keeping Assist (LKA)
  - Blind-Spot Collision-Avoidance Assist (BCA)
  - Highway Driving Assist (HDA)

⚠ CAUTION

Playing the vehicle audio system at high volume may prevent occupants from hearing the Driver Attention Warning (DAW) system warning sounds.

APPENDIX C

Run Log

Subject Vehicle: **2020 Hyundai Palisade SEL FWD**

Test Date: **12/19/2019**

Driver: **JDP**

Note: For Distance at Warning positive values indicate inside the lane

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Auditory Alert (ft)	Distance at Visible Alert (ft)	Pass/Fail	Notes
1	**Botts**	**Left**	N				light signal not good for post processing
2			N				light signal not good for post processing
3			N				light signal not good for post processing
4			N				lateral velocity
5			Y	-0.21	-0.36	Pass	
6			Y	-0.27	-0.40	Pass	
7			N				lateral velocity
8			Y	-0.23	-0.41	Pass	
9			N				yaw rate
10			Y	-0.35	-0.48	Pass	
11			Y	-0.35	-0.46	Pass	
12			Y	-0.23	-0.35	Pass	
13			N				yaw rate
14			Y	-0.28	-0.39	Pass	
15	**Botts**	**Right**	Y	-0.47	-0.61	Pass	
16			N				cone
17			N				lateral velocity
18			Y	-0.37	-0.49	Pass	
19			Y	-0.29	-0.41	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Auditory Alert (ft)	Distance at Visible Alert (ft)	Pass/Fail	Notes
20			Y	-0.38	-0.57	Pass	
21			Y	-0.37	-0.50	Pass	
22			Y	-0.36	-0.47	Pass	
23			Y	-0.40	-0.50	Pass	
24	**Solid**	**Right**	Y	-0.21	-0.38	Pass	
25			Y	-0.21	-0.35	Pass	
26			Y	-0.03	-0.10	Pass	
27			Y	-0.07	-0.17	Pass	
28			Y	-0.06	-0.21	Pass	
29			Y	-0.02	-0.17	Pass	
30			N				yaw rate
31			Y	0.06	-0.02	Pass	
32	**Solid**	**Left**	Y	-0.28	-0.48	Pass	
33			Y	-0.35	-0.50	Pass	
34			Y	-0.37	-0.47	Pass	
35			N				yaw rate
36			N				yaw rate
37			Y	-0.36	-0.49	Pass	
38			Y	-0.32	-0.47	Pass	
39			N				yaw rate
40			Y	-0.33	-0.45	Pass	
41			Y	-0.25	-0.48	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Auditory Alert (ft)	Distance at Visible Alert (ft)	Pass/Fail	Notes
42	**Dashed**	**Left**	Y	-0.44	-0.65	Pass	
43			N				yaw rate
44			Y	-0.43	-0.62	Pass	
45			N				yaw rate
46			Y	-0.51	-0.63	Pass	
47			Y	-0.54	-0.70	Pass	
48			Y	-0.44	-0.58	Pass	
49			Y	-0.44	-0.54	Pass	
50			Y	-0.51	-0.66	Pass	
51	**Dashed**	**Right**	Y	-0.10	-0.20	Pass	
52			Y	-0.18	-0.34	Pass	
53			Y	-0.15	-0.27	Pass	
54			Y	-0.18	-0.28	Pass	
55			Y	-0.23	-0.32	Pass	
56			N				speed
57			Y	-0.31	-0.41	Pass	
58			Y	-0.14	-0.27	Pass	
59			Y	-0.16	-0.28	Pass	