126-TRC-21-004

SAFETY COMPLIANCE TESTING FOR FMVSS 126
Electronic Stability Control Systems

Toyota Motor Manufacturing, Indiana, Inc.
2022 Toyota Highlander
NHTSA No. C20215104

TRANSPORTATION RESEARCH CENTER INC.
10820 State Route 347
East Liberty, Ohio 43319

December 17, 2021

FINAL REPORT

Prepared Under Contract No.: DTNH22-16-D-00027

U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Enforcement
Office of Vehicle Safety Compliance
1200 New Jersey Avenue, SE
West Building, 4th Floor (NEF-210)
Washington, DC 20590

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16. Abstract A test was conducted on a 2022 Toyota Highlander, NHTSA No. C20215104, in accordance with the specifications of the Office of Vehicle Safety Compliance Test Procedure No. TP-126-03 for the determination of FMVSS 126 compliance. Test failures identified were as follows: None			
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1.0 PURPOSE OF COMPLIANCE TEST

The purpose of this test is to determine if the test vehicle, a MY 2022 Toyota Highlander, appears to meet the minimum equipment and performance requirements stated in Federal Motor Vehicle Safety Standard (FMVSS) 126, "Electronic Stability Control Systems."

This standard establishes performance and equipment requirements for Electronic Stability Control (ESC) Systems installed in passenger cars, multipurpose passenger vehicles, trucks, and buses with a gross vehicle weight rating of 4,536 kilograms or less.

2.0 TEST PROCEDURE AND DISCUSSION OF RESULTS

Testing of the MY 2022 Toyota Highlander was conducted at Transportation Research Center (TRC) in accordance with NHTSA TP-126-03, dated September 9, 2011.

The vehicle was inspected to ensure it was equipped with an ESC System that:

- Augments vehicle directional stability by applying and adjusting brake torques individually at each wheel to induce a correcting yaw moment to a vehicle;
- Is computer controlled with the computer using a closed-loop algorithm to limit vehicle oversteer and to limit vehicle understeer;
- Has a means to determine the vehicle's yaw rate and to estimate its side slip or side slip derivative with respect to time;
- Has a means to monitor driver steering inputs;
- Has an algorithm to determine the need, and a means to modify engine torque, as necessary, to assist the driver in maintaining control of the vehicle, and
- Is operational over the full speed range of the vehicle (except at vehicle speeds less than 20km/h (12.4mph), when being driven in reverse, or during system initialization).

The vehicle was subjected to a 0.7Hz Sine with Dwell (SWD) Steering Maneuver to ensure that it would meet the stability and responsiveness requirements of the standard as follows:

- At 1.00 second after completion of steer (COS) of a required sine with dwell steering input, the yaw rate of the vehicle must not exceed 35 percent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks during the same test run).
- At 1.75 seconds after completion of steer (COS) of a required sine with dwell steering input, the yaw rate of the vehicle must not exceed 20 percent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks during the same test run).

- The lateral displacement of the vehicle center of gravity with respect to its initial straight path must be at least 1.83 m (6 feet) for vehicles with a GVWR of 3,500kg (7,716 lb) or less, and 1.52 m (5 feet) for vehicles with GVWR greater than 3,500kg (7,716 lb) when computed 1.07 seconds after the Beginning of Steer (BOS) at the specified steering wheel angles.

System malfunction simulations were executed to verify vehicle could identify and indicate a malfunction.

System related malfunction and Off telltales, and related controls were inspected for required identification and labeling.

Any deviation(s) from the conditions (i.e. environmental, loading, etc.) stated in NHTSA test procedure (TP-126-03) are noted in the remarks section of the applicable data sheets. Testing with any deviation(s) from the specified conditions was performed at the request of the customer, having decided that the deviation(s) were not likely to have a significant positive or negative impact on vehicle performance.

The vehicle's ESC System appears to meet the performance and equipment requirements as required by FMVSS 126. The test results are summarized on the following summary sheet.

2.0 TEST PROCEDURE AND DISCUSSION OF RESULTS …continued

DATA SUMMARY (Sheet 1 of 2)

VEHICLE MAKE/MODEL/BODY STYLE: Toyota / Highlander / SUV

VEHICLE NHTSA NO.: C20215104 VIN: 5TDHZRBH1NS164524

VEHICLE TYPE: MPV DATE OF MANUFACTURE: 10-21

LABORATORY: Transportation Research Center Inc.

REQUIREMENTS	**PASS/FAIL**
ESC Equipment and Operational Characteristics (Data Sheet 2)	
The vehicle is to be equipped with an ESC System that meets the equipment and operational characteristics requirements. (S126, S5.1, S5.6)	PASS
ESC Malfunction Telltale – Location, Labeling and Bulb Check (Data Sheet 3)	
Telltale meets the requirements for mounting, symbol or text, color and check of lamp function (S126, S5.3.1, S5.3.2, S5.3.4, S5.3.5, S5.3.6 and S5.3.8)	PASS
"ESC Off" and other System Controls and Telltale (Data Sheet 3 & 4)	
If provided, telltale meets the requirements for mounting, symbol, or text, color and check of lamp function (S126, S5.5.1, S5.5.2, S5.5.3, S5.5.6, S5.5.7, S5.5.8)	PASS
If provided, off control meets the label requirements (S126, S5.4.3)	PASS
If provided, off control and other system controls as well as the ESC off telltale meets the operational requirements (S126, S5.4, S5.4.1, S5.4.4, S5.5.4, and S5.5.9)	PASS

2.0 TEST PROCEDURE AND DISCUSSION OF RESULTS …continued

DATA SUMMARY (Sheet 2 of 2)

REQUIREMENTS	PASS/FAIL
Vehicle Lateral Stability (Data Sheet 8)	
Yaw Rate Ratio at 1.00 second after COS is less than 35% of peak value. (S126, S5.2.1)	PASS
Yaw Rate Ratio at 1.75 seconds after COS is less than 20% of peak value. (S126, S5.2.2)	PASS
Vehicle Responsiveness (Data Sheet 8)	
Lateral displacement at 1.07 seconds after BOS is at least 1.83 m (6 feet) for vehicles with a GVWR of 3,500 kg (7,716 lbs.) or less, and 1.52 m (5 feet) for vehicles with a GVWR greater than 3,500 kg (7,716 lbs.). (S126 S5.2.3)	PASS
ESC Malfunction Warning (Data Sheet 9)	
Warning is provided to driver after malfunction occurrence. (S126. S5.3)	PASS
Malfunction telltale stayed illuminated as long as malfunction existed and must extinguish after malfunction was corrected. (S126, S5.3.3 and S5.3.7)	PASS

REMARKS:

3.0 TEST DATA

DATA SHEET 1 (Sheet 1 of 2)
TEST VEHICLE INSPECTION AND TEST PREPARATION

VEHICLE MAKE/MODEL/BODY STYLE: Toyota / Highlander / SUV

NHTSA No.: C20215104 TEST DATE: 11-24-21

VIN: 5TDHZRBH1NS164524 MANUFACTURE DATE: 10-21

GVWR: 2,690 KG FRONT GAWR: 1,635 KG REAR GAWR 1,635 KG

SEATING POSITIONS: FRONT 2 MID _____ REAR 5

ODOMETER READING AT START OF TEST: 5 (8) Miles (Kilometers)

DESIGNATED TIRE SIZE(S) FROM VEHICLE LABELING:

Front Axle 235/65R18 Rear Axle 235/65R18

INSTALLED TIRE SIZE(S) ON VEHICLE:

From Tire Sidewall	Front Axle	Rear Axle
Manufacturer and Model	Michelin Premier LTX	
Tire Size Designation	235/65R18	235/65R18

TIN Left Front DOT B9MB 020X 4121 Right Front DOT B9MB 020X 4121

Left Rear DOT B9MB 020X 4121 Right Rear DOT B9MB 020X 4121

Are installed tire sizes same as labeled tire sizes? X Yes _____ No
If no, contact COTR for further guidance.

DRIVE CONFIGURATIONS (MARK ALL THAT APPLY):

_____ Two Wheel Drive (2WD): ( ) Front Wheel Drive ( ) Rear Wheel Drive
X All Wheel Drive (AWD)
_____ Four Wheel Drive Automatic – differential not locked full time (4WD Automatic)
_____ Four Wheel Drive High Gear Locked Center Differential (4WD HGLD)
_____ Four Wheel Drive Low Gear (4WD Low)
_____ Other (define _____)

3.0 TEST DATA….continued

DATA SHEET 1 (Sheet 2 of 2)
TEST VEHICLE INSPECTION AND TEST PREPARATION

DRIVE CONFIGURATIONS AND MODES: (ex. default, performance, off-road)
(For each of the vehicle's drive configurations identify available operating modes)

Drive Configuration AWD
Mode(s) default

Drive Configuration _____
Mode(s) _____

Drive Configuration _____
Mode(s) _____

VEHICLE STABILITY SYSTEMS (Check applicable technologies):

X ESC X Traction Control ____ Roll Stability Control

____ Active Suspension X Electronic Throttle Control ____ Active Steering

X ABS

List other systems; _____

_____

REMARKS:

RECORDED BY: David Karls DATE: 12-08-21
APPROVED BY: Jordan Piening DATE: 12-08-21

3.0 TEST DATA….continued

DATA SHEET 2 (Sheet 1 of 2)
ESC SYSTEM HARDWARE AND OPERATIONAL CHARACTERISTICS

VEHICLE MAKE/MODEL/BODY STYLE: Toyota / Highlander / SUV

NHTSA No.: C20215104 TEST DATE: 11-24-21

ESC SYSTEM IDENTIFICATION:

Manufacturer / Model ADVICS 44540-0E420

ESC SYSTEM HARDWARE (Check applicable hardware):

X Electronic Control Unit	X Hydraulic Control Unit
X Wheel Speed Sensors	X Steering Angle Sensor
X Yaw Rate Sensor	X Lateral Acceleration Sensor

List other components; _____

ESC SYSTEM OPERATIONAL CHARACTERISTICS:

System is capable of generating brake torques at each wheel
X Yes (PASS)
_____ No (FAIL)

Brief explanation with reference to components used:
VSC, by way of solenoid valves, controls the fluid pressure generated by the pump and applies it to each wheel cylinder in the following 3 modes: pressure reduction, pressure holding and pressure increase modes. As a result, the tendency to understeer or oversteer is controlled.

System is capable of determining yaw rate
X Yes (PASS)
_____ No (FAIL)

Brief explanation with reference to components used:
The yaw rate and lateral and longitudinal acceleration are determined by the yaw and acceleration sensor.

System is capable of monitoring driver steering input
X Yes (PASS)
_____ No (FAIL)

Brief explanation with reference to components used:
The driver steering input is determined by a steering wheel angle sensor.

3.0 TEST DATA….continued

DATA SHEET 2 (Sheet 2 of 2)
ESC SYSTEM HARDWARE AND OPERATIONAL CHARACTERISTICS

ESC SYSTEM OPERATIONAL CHARACTERISTICS (continued):

System is capable of estimating side slip or side slip derivative ___X___ Yes (PASS)
_____ No (FAIL)

Brief explanation with reference to data collected and method used:
In this module, the actual side slip angle of the vehicle and the road surface coefficient (mu) are estimated. Also, the side slip angular velocity and the difference between the nominal and actual value of the yaw rate are determined.
The actual yaw rate value is obtained from the yaw rate sensor. The nominal yaw rate value is derived from the vehicle speed and steering angle. The actual vehicle slip angle is estimated by the observer program in this module.

System is capable of modifying engine torque during ESC activation.
___X___ Yes (PASS)
_____ No (FAIL)

Brief explanation of method used to modify engine torque:
During the TRAC or VSC activation, the brake computer outputs control signal to the powertrain control computer. Upon receiving this signal, the power train system reduces driving torque.

System is capable of activation at speeds of 20 km/h (12.4 mph) and higher. ___X___ Yes (PASS)
_____ No (FAIL)

Speed system becomes active. ESC becomes fully active at 15 km/h (9.3 mph).

System is capable of activation during the following driving phases (acceleration, deceleration, coasting, and during activation of ABS or traction control). ___X___ Yes (PASS)
_____ No (FAIL)

Vehicle manufacturer submitted documentation explaining how the ESC system mitigates understeer? ___X___ Yes (PASS)
_____ No (FAIL)

DATA INDICATES COMPLIANCE PASS/FAIL _____PASS_____

RECORDED BY: David Karls DATE: 12-08-21
APPROVED BY: Jordan Piening DATE: 12-08-21

3.0 TEST DATA….continued

DATA SHEET 3 (Sheet 1 of 4)
ESC MALFUNCTION AND OFF TELLTALES
Location, Labeling and Bulb Check

VEHICLE MAKE/MODEL/BODY STYLE: Toyota / Highlander / SUV

VEHICLE NHTSA NO. C20215104 TEST DATE: 11-24-21

ESC Malfunction Telltale

Vehicle is equipped with malfunction telltale? X Yes (Pass) ____ No (Fail)

Telltale Location Left side of instrument cluster, inside the tachometer

Telltale is mounted inside the occupant compartment in front of and in clear view of the driver?

X Yes (Pass) ____ No (Fail) If no, explain ____

Malfunction Telltale symbol or abbreviation required by FMVSS No. 101.

Or **ESC**

X Vehicle uses this symbol
____ Vehicle uses this abbreviation
____ Other (Fail)

Note any words or additional symbols used.

Is ESC malfunction telltale part of a common space? ____ Yes X No

Is ESC malfunction telltale also used to indicate activation of the ESC system?

X Yes ____ No

If yes, explain telltale operation during ESC activation:

During ESC activation, the ESC telltale flashes.

DATA SHEET 3 (Sheet 2 of 4)
ESC MALFUNCTION AND OFF TELLTALES
Location, Labeling and Bulb Check

"ESC OFF" Telltale (if provided)

Vehicle is equipped with "ESC Off" telltale? __X__ Yes _____ No

Is "ESC OFF" telltale combined with "ESC Malfunction" telltale utilizing a two part telltale?

_____ Yes __X__ No

Telltale Location Left side of instrument cluster, inside the tachometer

Telltale is mounted inside the occupant compartment in front of and in clear view of the driver?

__X__ Yes (Pass) _____ No (Fail) If no, explain _____

"ESC OFF" Telltale symbol or abbreviation required by FMVSS No. 101.

Or **ESC OFF**

__X__ Vehicle uses this symbol
_____ Vehicle uses this abbreviation
_____ Other (Fail)

Note any words or additional symbols used.

_____

_____

_____

Is ESC Off telltale part of a common space? _____ Yes __X__ No

DATA SHEET 3 (Sheet 3 of 4)
ESC MALFUNCTION AND OFF TELLTALES
Location, Labeling and Bulb Check

Malfunction Telltale Lamp Function, OR Two-Part Malfunction/Off Telltale Lamp Function:
Identify position of starting system when telltale illuminates.

☐ OFF/LOCK ☐ Between OFF/LOCK and ON/RUN
☒ ON/RUN ☐ Between ON/RUN and Start

Is telltale yellow in color? __X__ Yes _____ No (fail)

Time telltale remains illuminated __3__ seconds

Note: If telltale is part of common space, it is not required to illuminate during this check of lamp function.

Starter Interlock:
Does vehicle have any starter, transmission or other interlocks that affect operation of the telltale lamp check functions? _____ Yes __X__ No

If yes, describe the interlock feature:

_____

_____

"ESC OFF" Telltale Lamp Function (If separate from Malfunction Telltale):
Identify position of starting system when "ESC OFF" telltale illuminates.

☐ OFF/LOCK ☐ Between OFF/LOCK and ON/RUN
☒ ON/RUN ☐ Between ON/RUN and Start

Is telltale yellow in color? __X__ Yes _____ No (fail)

Time telltale remains illuminated __3__ seconds

Note: If telltale is part of common space, it is not required to illuminate during the check of lamp function.

DATA SHEET 3 (Sheet 4 of 4)
ESC MALFUNCTION AND OFF TELLTALES
Location, Labeling and Bulb Check

Starter Interlock:
Does vehicle have any starter, transmission or other interlocks that affect operation of the "ESC OFF" telltale lamp check functions? _____ Yes __X__ No

If yes, describe the interlock feature:

_____

_____

DATA INDICATES COMPLIANCE PASS/FAIL ____PASS___

REMARKS:

RECORDED BY: __David Karls_____ DATE: 12-08-21
APPROVED BY: __Jordan Piening_____ DATE: 12-08-21

3.0 TEST DATA….continued

DATA SHEET 4 (Sheet 1 of 4)
ESC AND ANCILLARY SYSTEM CONTROLS

"ESC OFF" Controls Identification and Operational Check:

Is the vehicle equipped with a control or controls whose purpose is to deactivate the ESC system or place the ESC system in a mode or modes that may no longer satisfy the performance requirements of the standard?

__X__ Yes _____ No

Type of control or controls provided? (mark all that apply)

_____ Dedicated "ESC Off" control
__X__ Multi-functional control with an "ESC Off" mode
_____ Other (describe)

REMARKS:

Identify each control location, labeling and selectable modes.

First Control: (If applicable)

Location Center console, near the cupholder
Labeling Skidding car symbol
Modes Traction Control Off (momentary press), ESC Off (press and hold)

"ESC OFF" Control identification symbol or abbreviation required by FMVSS No. 101.

Or **ESC OFF**

__X__ Vehicle uses this symbol
_____ Vehicle uses this abbreviation

Note any words or additional symbols used.

3.0 TEST DATA….continued

DATA SHEET 4 (Sheet 2 of 4)
ESC AND ANCILLARY SYSTEM CONTROLS

Second Control: (If applicable)
Location N/A
Labeling _____
Modes _____

"ESC OFF" Control identification symbol or abbreviation required by FMVSS No. 101.

Or **ESC OFF**

_____ Vehicle uses this symbol
_____ Vehicle uses this abbreviation

Note any words or additional symbols used.

_____

_____

Identify standard or default drive configuration Default - AWD

Verify standard or default drive configuration selected. X Yes _____ No

Does the "ESC Off" telltale illuminate upon activation of the ESC off control or selection of the "ESC Off" mode on the multi-function control?

_____ NA X Yes _____ No (fail)

Does the "ESC Off" telltale extinguish when the starting system is cycled from "On" ("Run") to "Lock" or "Off" and then back again to the "On" ("Run") position?

_____ NA X Yes _____ No (fail)

If no, describe how the off control functions:

_____

_____

3.0 TEST DATA….continued

DATA SHEET 4 (Sheet 3 of 4)
ESC AND ANCILLARY SYSTEM CONTROLS

If a multi-function control is provided, cycle through each mode setting on the control and record which modes illuminate the "ESC Off" telltale. Also, for those modes that illuminate the "ESC Off" telltale, identify if the telltale extinguishes upon cycling the ignition system.

Control Modes	"ESC Off" telltale illuminates upon activation of control? (Yes/No)	"ESC Off" telltale extinguishes upon cycling ignition? (Yes/No)
ESC Off	Yes	Yes

For each mode that illuminates the "ESC Off" telltale, did the telltale extinguish when the ignition was cycled from "On" ("Run") to "Lock" or "Off" and then back again to the "On" ("Run") position?

_____ NA ___X__ Yes _____ No (fail)

Other System Controls that have an ancillary effect on ESC Operation:

Is the vehicle equipped with any ancillary controls that upon activation may deactivate the ESC System or place the ESC System in a mode or modes that may no longer satisfy the performance requirements of the standard?

___X__ Yes _____ No

List and describe each control (i.e. alternate drive configuration selection controls):

Ancillary Control: System Drive Mode Selector
Control Description Button on the center console
Labeling Mud & Sand

Ancillary Control: System _____
Control Description _____
Labeling _____

3.0 TEST DATA….continued

DATA SHEET 4 (Sheet 4 of 4)
ESC AND ANCILLARY SYSTEM CONTROLS

Activate each control listed above and record whether the control illuminates the "ESC Off" telltale. Also, record warnings or messages provided regarding the ESC System.

Ancillary Control	Control Activates "ESC Off" Telltale? (Yes/No)	Warnings or Messages Provided
Mud & Sand	Yes	

For those controls that illuminate the "ESC Off" telltale above identify if the "ESC Off" telltale extinguishes upon cycling the ignition system.

Ancillary Control	"ESC Off" telltale extinguishes upon cycling ignition? (Yes/No)
Mud & Sand	Yes

For each control that illuminates the "ESC Off" telltale, did the telltale extinguish when the ignition is cycled from "On" ("Run") to "Lock" or "Off" and then back again to the "On" ("Run") position? If the control activated places the vehicle into a low-range four-wheel drive configuration designed for low-speed, off–road driving, the ESC System may remain turned off after the ignition has been cycled off and then back on and therefore the "ESC Off" telltale may not extinguish.

_____ NA ___X__ Yes _____ No (fail)

DATA INDICATES COMPLIANCE: PASS/FAIL ___PASS____

REMARKS:

RECORDED BY: __David Karls_____ DATE: 12-08-21___
APPROVED BY: __Jordan Piening_____ DATE: 12-08-21___

3.0 TEST DATA….continued

DATA SHEET 5 (Sheet 1 of 3)
VEHICLE AND TEST TRACK DATA

VEHICLE MAKE/MODEL/BODY STYLE: Toyota / Highlander / SUV

NHTSA No.: C20215104 TEST DATE: 11-24-21

Test Track Requirements: Test Surface Slope (0-1 %) 1 %

Peak Friction Coefficient (at least 0.9) 0.93

Test Track Data Meets Requirements: Yes/No Yes
If no, explain: _____

Full Fluid Levels: Fuel N/A Coolant X Other Fluids Washer (specify)

Tire Pressures: Required: Front Axle 250 kPa Rear Axle 250 kPa

Actual: LF 250 kPa RF 250 kPa
LR 250 kPa RR 250 kPa

Vehicle Dimensions: Track Width 166.4 cm Wheelbase 285.8 cm

Vehicle weight ratings: GAWR Front 1,635 KG GAWR Rear 1,635 KG

Unloaded Vehicle Weight (UVW)

Front Axle 1104.2 KG Left Front 552.6 KG Right Front 551.6 KG

Rear Axle 871.4 KG Left Rear 449.0 KG Right Rear 422.4 KG

Total UVW 1975.6 KG

Baseline Weight and Outrigger Selection (only for MPVs, Trucks, Buses)

Calculated Baseline Weight (UVW+ 73 kg) 2048.6 KG

Outrigger size required ("Light," "Standard" or "Heavy") Standard
Light – Baseline weight under 1,588 kg (3,500 lbs.)
Standard - Baseline weight equal to or greater than 1,588 kg (3,500 lbs.) and under 2,722 kg (6,000 lbs.)
Heavy - Baseline weight equal to or greater than 2,722 kg (6,000 lbs.)

DATA SHEET 5 (Sheet 2 of 3)
VEHICLE AND TEST TRACK DATA

UVW with Outriggers (only for MPVs, Trucks, Buses)

Front Axle 1126.2 KG Left Front 563.0 KG Right Front 563.2 KG

Rear Axle 936.6 KG Left Rear 471.0 KG Right Rear 465.6 KG

Total UVW w/ Outriggers 2062.8 KG

Loaded Vehicle Weight w/ Driver and Instrumentation (No Ballast)

Front Axle 1218.0 KG Left Front 622.4 KG Right Front 595.6 KG

Rear Axle 995.0 KG Left Rear 529.4 KG Right Rear 465.6 KG

Vehicle Weight 2213.0 KG

Ballast Required = [**Total UVW** + 168 KG] - **Loaded Weight w/ Driver and Instrumentation**

= [2062.8 KG + 168 KG] - 2213.0 KG

= 17.8 KG

Total Loaded Vehicle Weight w/Driver, Instrumentation and Ballast

Front Axle 1221.2 KG Left Front 628.6 KG Right Front 592.6 KG

Rear Axle 1009.4 KG Left Rear 539.8 KG Right Rear 469.6 KG

Total Loaded Vehicle Weight 2230.6 KG

3.0 TEST DATA….continued

DATA SHEET 5 (Sheet 3 of 3)
VEHICLE AND TEST TRACK DATA

Center of Gravity and Inertial Sensing System Location at Loaded Vehicle Condition

x-distance (longitudinal) Point of reference is the front axle centerline. (Positive from front axle toward rear of vehicle.)

y-distance (lateral) Point of reference is the vehicle centerline. (Positive from the center toward the right.)

z-distance (vertical) Point of reference is the ground plane. (Positive from the ground up.)

Locations:

	Center of Gravity	Inertial Sensing System
x-distance	129.3 cm	167.9 cm
y-distance	-4.0 cm	-3.3 cm
z-distance	65.5 cm	94.9 cm

Roof Height: 172.3 cm

Distance Between Body Roll Sensors: 205.1 cm

The NHTSA test procedure (TP-126-03) states that the vehicle's vertical CG coordinate is estimated to be 38% of the vehicle's roof height. The lateral and longitudinal CG coordinates are determined using the individual corner weights of the vehicle in its test condition.

REMARKS:

RECORDED BY: David Karls DATE: 12-08-21
APPROVED BY: Jordan Piening DATE: 12-08-21

3.0 TEST DATA….continued

DATA SHEET 6 (Sheet 1 of 3)
BRAKE AND TIRE CONDITIONING

VEHICLE MAKE/MODEL/BODY STYLE: Toyota / Highlander / SUV

VEHICLE NHTSA No.: C20215104

Measured Cold Tire Pressures: LF 250 kPa RF 250 kPa

LR 250 kPa RR 250 kPa

Wind Speed 6.4 m/sec
(10m/sec (22mph) max for passenger cars; 5m/s (11mph) max. for MPVs and Trucks)

Ambient Temperature (7°C (45°F) - 40°C (104°F)) 3.4 °C

Brake Conditioning Time; 11:10 AM Date; 11-24-21

56 km/h (35 mph) Brake Stops

Number of stops executed (10 required) 10 stops

Observed deceleration rate range (.5g target) 0.48 – 0.53 g

72 km/h (45 mph) Brake Stops

Number of stops executed (3 required) 3 stops

Number of stops ABS activated (3 required) 3 stops

Observed deceleration rate range 0.95 – 1.05 g

72 km/h (45 mph) Brake Cool Down Period

Duration of cool down period (5 minutes min.) 5.5 minutes

3.0 TEST DATA….continued

DATA SHEET 6 (Sheet 2 of 3)
BRAKE AND TIRE CONDITIONING

Tire Conditioning Series No. 1 Time: 11:30 AM Date: 11-24-21

Measured Tire Pressures: LF 248 kPa RF 248 kPa

LR 248 kPa RR 248 kPa

Wind Speed 4.8 m/sec
(10m/sec (22mph) max for passenger cars; 5m/s (11mph) max. for MPVs and Trucks)

Ambient Temperature (7°C (45°F) - 40°C (104°F)) 4.3 °C

30 meter (100 ft) Diameter Circle Maneuver				
Test Runs	Steering Direction	Target Lateral Acceleration (g)	Observed Lateral Acceleration (g)	Observed Vehicle Speed (km/h)
1-3	Clockwise	0.5-0.6	0.57	46.2
4-6	Counterclockwise	0.5-0.6	0.57	46.2

1 Hz 5 Cycle Sinusoidal Steering Maneuver to Determine Steering Wheel Angle For 0.5-0.6g Lateral Acceleration				
Test Runs	Vehicle Speed Km/h(mph)	Steering Wheel Angle (degrees)	Target Peak Lateral Acceleration (g)	Observed Peak Lateral Acceleration (g)
1	56±2 (35±1)	30	0.5-0.6	0.28
2	56±2 (35±1)	60	0.5-0.6	0.59
3	56±2 (35±1)		0.5-0.6	
4	56±2 (35±1)		0.5-0.6	

Steering wheel angle that corresponds to a peak 0.5–0.6g lateral acceleration; 60 degrees

1 Hz 10 Cycle Sinusoidal Steering Maneuver				
Test Runs	Vehicle Speed km/h (mph)	Steering Wheel Angle (degrees)	Target Peak Lateral Acceleration (g)	Observed Peak Lateral Acceleration (g)
1 - 3	56±2 (35±1)	60 (cycles 1-10)	0.5-0.6	0.59
4	56±2 (35±1)	60 (cycles 1-9)	0.5-0.6	0.59
		120 (cycle 10)*	N/A	0.80

* The steering wheel angle used for cycle 10 should be twice the angle used for cycles 1-9.

DATA SHEET 6 (Sheet 3 of 3)
BRAKE AND TIRE CONDITIONING

Tire Conditioning Series No. 2 Time: 1:30 PM Date: 11-24-21

Measured Tire Pressures: LF 250 kPa RF 250 kPa

LR 255 kPa RR 255 kPa

Wind Speed 5.4 m/sec
(10m/sec (22mph) max for passenger cars; 5m/s (11mph) max. for MPVs and Trucks)

Ambient Temperature (7°C (45°F) - 40°C (104°F)) 8.3 °C

30 meter (100 ft) Diameter Circle Maneuver				
Test Runs	Steering Direction	Target Lateral Acceleration (g)	Observed Lateral Acceleration (g)	Observed Vehicle Speed (km/h)
1-3	clockwise	0.5-0.6	0.57	46.2
4-6	counterclockwise	0.5-0.6	0.57	46.2

1 Hz 5 Cycle Sinusoidal Steering Maneuver to Determine Steering Wheel Angle For 0.5-0.6g Lateral Acceleration				
Test Runs	Vehicle Speed Km/h (mph)	Steering Wheel Angle (degrees)	Target Peak Lateral Acceleration (g)	Observed Peak Lateral Acceleration (g)
1	56±2 (35±1)	N/A	0.5-0.6	N/A
2	56±2 (35±1)		0.5-0.6	
3	56±2 (35±1)		0.5-0.6	
4	56±2 (35±1)		0.5-0.6	

Steering wheel angle that corresponds to a peak 0.5–0.6g lateral acceleration; 60 degrees

1 Hz 10 Cycle Sinusoidal Steering Maneuver				
Test Runs	Vehicle Speed km/h (mph)	Steering Wheel Angle (degrees)	Target Peak Lateral Acceleration (g)	Observed Peak Lateral Acceleration (g)
1 - 3	56±2 (35±1)	60 (cycles 1-10)	0.5-0.6	0.59
4	56±2 (35±1)	60 (cycles 1-9)	0.5-0.6	0.59
		120 (cycle 10)*	N/A	0.80

* The steering wheel angle used for cycle 10 should be twice the angle used for cycles 1-9.

REMARKS: Deviations from the environmental condition requirements stated on Data Sheets 6-8 in NHTSA test procedure (TP-126-03) were made during this testing.

RECORDED BY: David Karls DATE: 12-08-21
APPROVED BY: Jordan Piening DATE: 12-08-21

3.0 TEST DATA….continued

DATA SHEET 7 (1 of 2)
SLOWLY INCREASING STEER (SIS) MANEUVER

VEHICLE MAKE/MODEL/BODY STYLE: Toyota / Highlander / SUV

VEHICLE NHTSA No.: C20215104 TEST DATE: 11-24-21

Measured Tire Pressures: LF 248 kPa RF 248 kPa
LR 248 kPa RR 248 kPa

Wind Speed 3.3 m/sec
(10m/sec (22mph) max for passenger cars; 5m/s (11mph) max. for MPVs and Trucks)

Ambient Temperature (7°C (45°F) - 40°C (104°F)) 7.3 °C

Selected Drive Configuration: AWD (default)

Selected Mode: ESC On (default)

Preliminary Left Steer Maneuver:
Lateral Acceleration measured at 30 degrees steering wheel angle ($a_{y,30\ degrees}$)

$a_{y,30\ degrees}$ = 0.26 g

Assuming a linear relationship the following ratio should be used to calculate the steering wheel angle at .55g.

$$\frac{30\,\text{degrees}}{a_{\text{y,30degrees}}} = \frac{\delta_{SIS}}{0.55\,\text{g}}$$

δ_{SIS} = 63.5 degrees @ 0.55g

δ_{SIS} = 60 degrees (rounded)

Steering Wheel Angle at Corrected 0.3 g Lateral Acceleration:

Maneuver #	Initial Steer Direction	Time Clock (5 min max between runs)	Steering Wheel Angle to nearest 0.1 degree (degrees)	All Conditions Met?
0008	Left	12:03 pm	-27.3	Yes
0009	Left	12:06 pm	-27.3	Yes
0010	Left	12:08 pm	-26.9	Yes
0011	Right	12:10 pm	29.8	Yes
0012	Right	12:12 pm	28.6	Yes
0013	Right	12:14 pm	28.6	Yes

3.0 TEST DATA….continued

DATA SHEET 7 (2 of 2)
SLOWLY INCREASING STEER (SIS) MANEUVER

Average Overall Steering Wheel Angle:

$$\delta_{0.3\ g,\ overall} = (|\delta_{0.3\ g,\ left\ (1)}| + |\delta_{0.3\ g,\ left\ (2)}| + |\delta_{0.3\ g,\ left\ (3)}| + \delta_{0.3\ g,\ right\ (1)} + \delta_{0.3\ g,\ right\ (2)} + \delta_{0.3\ g,\ right\ (3)}) / 6$$

$\delta_{0.3\ g,\ overall}$ = 28.1 degrees
[to nearest 0.1 degree]

REMARKS:

RECORDED BY: David Karls DATE: 12-08-21
APPROVED BY: Jordan Piening DATE: 12-08-21

3.0 TEST DATA….continued

DATA SHEET 8 (1 of 3)
VEHICLE LATERAL STABILITY AND RESPONSIVENESS

VEHICLE MAKE/MODEL/BODY STYLE: Toyota / Highlander / SUV

VEHICLE NHTSA No.: C20215104 TEST DATE: 11-24-21

Tire conditioning completed	X Yes	___ No
ESC system is enabled	X Yes	___ No
On track calibration checks have been completed	X Yes	___ No
On track static data file for each sensor obtained	X Yes	___ No

Selected Drive Configuration: AWD
Selected Mode: ESC On (default)

Overall steering wheel angle ($\delta_{0.3\ g,\ overall}$) 28.1 degrees

Lateral Stability Test Series No. 1 – Counterclockwise Initial Steer Direction

Maneuver #	Clock Time (1.5 – 5 min between each test run)	Commanded Steering Wheel Angle[1] (degrees)		Yaw Rates (degrees/sec)			YRR at 1.0 sec after COS [≤ 35%]		YRR at 1.75 sec after COS [≤ 20%]	
		Scalar	Angle	Ψ_{Peak}	$\Psi_{1.0sec}$	$\Psi_{1.75sec}$	%	Pass/ Fail	%	Pass/ Fail
0015	1:45 pm	1.5* δ0.3 g	42	11.452	-0.127	-0.184	-1.112	Pass	-1.606	Pass
0016	1:47 pm	2.0* δ0.3 g	56	14.634	-0.077	0.137	-0.528	Pass	0.937	Pass
0017	1:49 pm	2.5* δ0.3 g	70	18.496	0.129	0.173	0.696	Pass	0.934	Pass
0018	1:51 pm	3.0* δ0.3 g	84	22.460	0.004	0.307	0.017	Pass	1.365	Pass
0019	1:53 pm	3.5* δ0.3 g	98	27.881	-0.485	0.119	-1.741	Pass	0.426	Pass
0020	1:55 pm	4.0* δ0.3 g	112	31.510	-0.802	-0.118	-2.545	Pass	-0.376	Pass
0021	1:57 pm	4.5* δ0.3 g	126	35.905	-1.164	-0.254	-3.242	Pass	-0.707	Pass
0022	1:59 pm	5.0* δ0.3 g	141	40.144	-0.446	0.083	-1.111	Pass	0.206	Pass
0023	2:01 pm	5.5* δ0.3 g	155	43.648	-0.702	0.033	-1.608	Pass	0.076	Pass
0024	2:03 pm	6.0* δ0.3 g	169	47.334	-0.452	0.282	-0.954	Pass	0.596	Pass
0025	2:05 pm	6.5* δ0.3 g	183	49.065	-0.375	0.338	-0.765	Pass	0.689	Pass
0026	2:07 pm	7.0* δ0.3 g	197	50.769	-0.212	0.328	-0.417	Pass	0.645	Pass
0027	2:09 pm	7.5* δ0.3 g	211	50.527	-0.609	0.075	-1.205	Pass	0.148	Pass
0028	2:11 pm	8.0* δ0.3 g	225	54.523	-0.585	0.137	-1.074	Pass	0.251	Pass
0029	2:13 pm	8.5* δ0.3 g	239	53.846	-0.656	-0.039	-1.218	Pass	-0.073	Pass
0030	2:15 pm	9.0* δ0.3 g	253	54.348	-0.606	-0.206	-1.114	Pass	-0.379	Pass
0031	2:17 pm	9.5* δ0.3 g	267	54.186	-0.117	0.373	-0.217	Pass	0.688	Pass
0032	2:19 pm	9.6* δ0.3 g	270	54.435	-0.023	0.244	-0.042	Pass	0.448	Pass

1. Maneuver execution should continue until a steering wheel angle magnitude factor of $6.5*\delta_{0.3\ g,\ overall}$ or 270 degrees is utilized, whichever is greater provided the calculated magnitude of $6.5*\delta_{0.3\ g,\ overall}$ is less than or equal to 300 degrees. If $6.5*\delta_{0.3\ g,\ overall}$ is less than 270 degrees maneuver execution should continue by increasing the steering wheel angle magnitude by multiples of $0.5*\delta_{0.3\ g,\ overall}$ without exceeding the 270 degree steering wheel angle.

3.0 TEST DATA….continued

DATA SHEET 8 (2 of 3)
VEHICLE LATERAL STABILITY AND RESPONSIVENESS

Lateral Stability Test Series No. 2 – Clockwise Initial Steer Direction

Maneuver #	Clock Time (1.5 – 5 min between each test run)	Commanded Steering Wheel Angle[1] (degrees)		Yaw Rates (degrees/sec)			YRR at 1.0 sec after COS [≤ 35%]		YRR at 1.75 sec after COS [≤ 20%]	
		Scalar	Angle	Ψ_{Peak}	$\Psi_{1.0sec}$	$\Psi_{1.75sec}$	%	Pass/ Fail	%	Pass/ Fail
0033	2:21 pm	1.5* δ0.3 g	42	-11.475	0.275	0.262	-2.395	Pass	-2.286	Pass
0034	2:23 pm	2.0* δ0.3 g	56	-15.485	0.245	0.315	-1.581	Pass	-2.037	Pass
0035	2:25 pm	2.5* δ0.3 g	70	-19.356	0.179	0.262	-0.924	Pass	-1.353	Pass
0036	2:27 pm	3.0* δ0.3 g	84	-24.204	0.087	0.126	-0.361	Pass	-0.521	Pass
0037	2:29 pm	3.5* δ0.3 g	98	-27.846	-0.005	-0.136	0.019	Pass	0.487	Pass
0038	2:31 pm	4.0* δ0.3 g	112	-31.432	0.364	0.147	-1.157	Pass	-0.469	Pass
0039	2:33 pm	4.5* δ0.3 g	126	-36.738	0.227	0.151	-0.618	Pass	-0.412	Pass
0040	2:35 pm	5.0* δ0.3 g	141	-41.626	0.042	-0.026	-0.100	Pass	0.063	Pass
0041	2:37 pm	5.5* δ0.3 g	155	-44.737	0.135	-0.069	-0.301	Pass	0.154	Pass
0042	2:39 pm	6.0* δ0.3 g	169	-48.208	0.029	-0.215	-0.060	Pass	0.447	Pass
0043	2:41 pm	6.5* δ0.3 g	183	-48.921	-0.353	-0.971	0.722	Pass	1.984	Pass
0044	2:43 pm	7.0* δ0.3 g	197	-52.603	-0.140	-0.269	0.266	Pass	0.512	Pass
0045	2:45 pm	7.5* δ0.3 g	211	-54.539	-0.071	-1.382	0.131	Pass	2.533	Pass
0046	2:47 pm	8.0* δ0.3 g	225	-56.713	0.043	-0.518	-0.076	Pass	0.914	Pass
0047	2:49 pm	8.5* δ0.3 g	239	-54.873	0.185	0.021	-0.338	Pass	-0.037	Pass
0048	2:51 pm	9.0* δ0.3 g	253	-58.637	0.189	-1.051	-0.323	Pass	1.793	Pass
0049	2:53 pm	9.5* δ0.3 g	267	-58.094	-1.376	-2.117	2.368	Pass	3.644	Pass
0050	2:55 pm	9.6* δ0.3 g	270	-54.809	0.300	-0.047	-0.547	Pass	0.086	Pass

1. Maneuver execution should continue until a steering wheel angle magnitude factor of $6.5*\delta_{0.3\ g,\ overall}$ or 270 degrees is utilized, whichever is greater provided the calculated $6.5*\delta_{0.3\ g,\ overall}$ is less than or equal to 300 degrees. If $6.5*\delta_{0.3\ g,\ overall}$ is less than 270 degrees maneuver execution should continue by increasing the steering wheel angle magnitude by multiples of $0.5*\delta_{0.3\ g,\ overall}$ without exceeding the 270 degree steering wheel angle.

During execution of the sine with dwell maneuvers were any of the following events observed?

Rim-to-pavement contact	_____ Yes	__X__ No
Tire debeading	_____ Yes	__X__ No
Loss of pavement contact of vehicle tires	_____ Yes	__X__ No
Did the test driver experience any vehicle loss of control or spinout?	_____ Yes	__X__ No

If "Yes" explain the event and consult with the COTR. _____

_____

3.0 TEST DATA….continued

DATA SHEET 8 (3 of 3)
VEHICLE LATERAL STABILITY AND RESPONSIVENESS

Responsiveness – Lateral Displacement

Maneuver #	Initial Steer Direction	Commanded Steering Wheel Angle ($5.0*\delta_{0.3\ g,\ overall}$ or greater)		Calculated Lateral Displacement[1]	
		Scalar	Angle (degrees)	Distance (m)	Pass/Fail
0022	Counter Clockwise	5.0* δ0.3 g	141	-3.21	Pass
0023	Counter Clockwise	5.5* δ0.3 g	155	-3.34	Pass
0024	Counter Clockwise	6.0* δ0.3 g	169	-3.40	Pass
0025	Counter Clockwise	6.5* δ0.3 g	183	-3.35	Pass
0026	Counter Clockwise	7.0* δ0.3 g	197	-3.39	Pass
0027	Counter Clockwise	7.5* δ0.3 g	211	-3.35	Pass
0028	Counter Clockwise	8.0* δ0.3 g	225	-3.40	Pass
0029	Counter Clockwise	8.5* δ0.3 g	239	-3.34	Pass
0030	Counter Clockwise	9.0* δ0.3 g	253	-3.42	Pass
0031	Counter Clockwise	9.5* δ0.3 g	267	-3.28	Pass
0032	Counter Clockwise	9.6* δ0.3 g	270	-3.26	Pass
0040	Clockwise	5.0* δ0.3 g	141	3.12	Pass
0041	Clockwise	5.5* δ0.3 g	155	3.24	Pass
0042	Clockwise	6.0* δ0.3 g	169	3.22	Pass
0043	Clockwise	6.5* δ0.3 g	183	3.29	Pass
0044	Clockwise	7.0* δ0.3 g	197	3.34	Pass
0045	Clockwise	7.5* δ0.3 g	211	3.27	Pass
0046	Clockwise	8.0* δ0.3 g	225	3.32	Pass
0047	Clockwise	8.5* δ0.3 g	239	3.33	Pass
0048	Clockwise	9.0* δ0.3 g	253	3.29	Pass
0049	Clockwise	9.5* δ0.3 g	267	3.16	Pass
0050	Clockwise	9.6* δ0.3 g	270	3.33	Pass

1. Lateral displacement should be ≥ 1.83 m (6 ft) for vehicles with a GVWR of 3,500 kg (7,716 lb) or less; and ≥ 1.52 m (5ft) for vehicles with a GVWR greater than 3,500 kg (7,716 lb).

DATA INDICATES COMPLIANCE: PASS/FAIL PASS

REMARKS:

RECORDED BY: David Karls DATE: 12-08-21
APPROVED BY: Jordan Piening DATE: 12-08-21

3.0 TEST DATA….continued

DATA SHEET 9 (Sheet 1 of 6)
MALFUNCTION WARNING TEST
(Test Number __1__)

VEHICLE MAKE/MODEL/BODY STYLE: ____Toyota / Highlander / SUV_____

VEHICLE NHTSA No.:___C20215104___ TEST DATE:_____11-24-21_____

METHOD OF MALFUNCTION SIMULATION:
Describe method of malfunction simulation:_____

_____Disconnect the left front wheel speed sensor._____

MALFUNCTION TELLTALE ILLUMINATION:
Telltale illuminates and remains illuminated after ignition locking system is activated and if necessary the vehicle is driven at least 2 minutes as specified in section 13.12. B.

___X___ Yes _____No (Fail)

Telltale illuminated when engine was started, no driving required.

___X___ Yes (Pass) _____No

Driving was required to illuminate telltale. _____ Yes ___X___No

When driving was required, telltale illuminated before vehicle speed of 48± 8 km/h (30± 5mph) was reached.

___X___NA _____ Yes (Pass) _____No

If driving required, approximate driving time below vehicle speed of 48± 8 km/h (30± 5mph) to activate telltale.

_____ Seconds

When driving was required, telltale illuminated after a vehicle speed above 48± 8 km/h (30± 5mph) was reached.

___X___NA _____ Yes _____No

If driving required, time for telltale to illuminate after starting system is activated and vehicle speed of 48± 8 km/h (30± 5mph) is reached.

_____ Seconds (must be within 2 minutes) _____ Pass _____ Fail

3.0 TEST DATA….continued

DATA SHEET 9 (Sheet 2 of 6)
MALFUNCTION WARNING TEST
(Test Number __1__)

Identify all other telltales and/or warning messages activated upon simulating subject ESC system malfunction. ESC and ABS telltales illuminated. "Collision Mitigation", "Park Brake", "Blind Spot Monitor", "Drive Start Control" and "Rear Cross Traffic Alert" messages also displayed.

Did the malfunction telltale re-illuminate after the starting system was shut off for five minutes and then turned back on with the engine running?

__X__ Yes (Pass) _____ No (Fail)

ESC SYSTEM RESTORATION:
Describe method used to restore system to normal operation:

Reconnect left front wheel speed sensor.

After system restoration is completed, telltale extinguishes after vehicle starting system is activated and if necessary the vehicle is driven at least 2 minutes as specified in section 13.12. D.

__X__ Yes _____ No (Fail)

Telltale extinguished when engine was started, no driving required.

__X__ Yes (Pass) _____ No

Driving was required to extinguish telltale. _____ Yes __X__ No

When driving was required, telltale extinguished before vehicle speed of 48± 8 km/h (30± 5mph) was reached.

__X__ NA _____ Yes (Pass) _____ No

If driving required, approximate driving time below vehicle speed of 48± 8 km/h (30± 5mph) to extinguish telltale.

_____ Seconds

3.0 TEST DATA….continued

DATA SHEET 9 (Sheet 3 of 6)
MALFUNCTION WARNING TEST
(Test Number __1__)

When driving was required, telltale extinguished after a vehicle speed above 48± 8 km/h (30± 5mph) was reached.

___X___NA _____ Yes _____No

If driving required, time for telltale to extinguish after starting system is activated and vehicle speed of 48± 8 km/h (30± 5mph) is reached.

_____ Seconds (must be within 2 minutes) _____ Pass _____ Fail

DATA INDICATES COMPLIANCE: PASS/FAIL ___PASS____

REMARKS:

RECORDED BY: __David Karls_____ DATE:_____12-08-21___
APPROVED BY: __Jordan Piening_____ DATE:_____12-08-21___

3.0 TEST DATA….continued

DATA SHEET 9 (Sheet 4 of 6)
MALFUNCTION WARNING TEST
(Test Number __2__)

VEHICLE MAKE/MODEL/BODY STYLE: ____Toyota / Highlander / SUV_____

VEHICLE NHTSA No.:___C20215104___ TEST DATE:_____11-24-21_____

METHOD OF MALFUNCTION SIMULATION:
Describe method of malfunction simulation:_____

_____Disconnect the steering angle sensor._____

MALFUNCTION TELLTALE ILLUMINATION:
Telltale illuminates and remains illuminated after ignition locking system is activated and if necessary the vehicle is driven at least 2 minutes as specified in section 13.12. B.

___X___ Yes _____No (Fail)

Telltale illuminated when engine was started, no driving required.

___X___ Yes (Pass) _____No

Driving was required to illuminate telltale. _____ Yes ___X___No

When driving was required, telltale illuminated before vehicle speed of 48± 8 km/h (30± 5mph) was reached.

___X___NA _____ Yes (Pass) _____No

If driving required, approximate driving time below vehicle speed of 48± 8 km/h (30± 5mph) to activate telltale.

_____ Seconds

When driving was required, telltale illuminated after a vehicle speed above 48± 8 km/h (30± 5mph) was reached.

___X___NA _____ Yes _____No

If driving required, time for telltale to illuminate after starting system is activated and vehicle speed of 48± 8 km/h (30± 5mph) is reached.

_____ Seconds (must be within 2 minutes) _____ Pass _____ Fail

3.0 TEST DATA….continued

DATA SHEET 9 (Sheet 5 of 6)
MALFUNCTION WARNING TEST
(Test Number __2__)

Identify all other telltales and/or warning messages activated upon simulating subject ESC system malfunction. ESC and ABS telltales illuminated. "Collision Mitigation", "LTA Malfunction", "Blind Spot Monitor", "AWD System Malfunction" and "Rear Cross Traffic Alert" messages also displayed.

Did the malfunction telltale re-illuminate after the starting system was shut off for five minutes and then turned back on with the engine running?

__X__ Yes (Pass) _____No (Fail)

ESC SYSTEM RESTORATION:
Describe method used to restore system to normal operation:

Reconnect the steering angle sensor.

After system restoration is completed, telltale extinguishes after vehicle starting system is activated and if necessary the vehicle is driven at least 2 minutes as specified in section 13.12. D.

__X__ Yes _____No (Fail)

Telltale extinguished when engine was started, no driving required.

__X__ Yes (Pass) _____No

Driving was required to extinguish telltale. _____ Yes __X__No

When driving was required, telltale extinguished before vehicle speed of 48± 8 km/h (30± 5mph) was reached.

__X__NA _____ Yes (Pass) _____No

If driving required, approximate driving time below vehicle speed of 48± 8 km/h (30± 5mph) to extinguish telltale.

_____ Seconds

3.0 TEST DATA….continued

DATA SHEET 9 (Sheet 6 of 6)
MALFUNCTION WARNING TEST
(Test Number __2__)

When driving was required, telltale extinguished after a vehicle speed above 48± 8 km/h (30± 5mph) was reached.

___X___NA _____ Yes _____No

If driving required, time for telltale to extinguish after starting system is activated and vehicle speed of 48± 8 km/h (30± 5mph) is reached.

_____ Seconds (must be within 2 minutes) _____ Pass _____ Fail

DATA INDICATES COMPLIANCE: PASS/FAIL ___PASS____

REMARKS:

RECORDED BY: __David Karls_____ DATE:_____12-08-21___
APPROVED BY: __Jordan Piening_____ DATE:_____12-08-21___

4.0 TEST EQUIPMENT LIST AND CALIBRATION INFORMATION

Type	Output	Range	Resolution	Accuracy	Specifics	Serial Number	Calibration
Tire Pressure Gauge	Vehicle Tire Pressure	0-150 psi	0.01 psi	±0.5% of applied pressure	Intercomp 360045-150-BC	AG-0422SS08645	By: TRC Inc. Date: 7-28-21 Due: 1-28-22
Platform Scales	Vehicle Total, Wheel, and Axle Load	0-2500 lb per each of four pads	0.5 lb	±1.0% of applied load	Mettler Toledo Model: JXGA1000	5225831-5JC	By: Kanawha Scales Date: 6-18-21 Due: 12-18-21
Automated Steering Machine with Steering Angle Encoder	Handwheel Angle	±800 deg	0.25 deg	±0.25 deg	Heitz Automotive Testing Model: Sprint 3	60303	By: ATI-Heitz Date: 2-10-21 Due: 2-10-22
Multi-Axis Inertial Sensing System	Longitudinal, Lateral, and Vertical Acceleration Roll, Yaw, and Pitch Rate	Accelerometers: ±2 g Angular Rate Sensors: ±100 deg/s	Accelerometers: ≤10 ug Angular Rate Sensors: ≤0.004 deg/s	Accelerometers: ≤0.05% of full range Angular Rate Sensors: 0.05% of full range	BEI Technologies Model: MotionPAK MP-1	0767	By: BEI Tech. Date: 1-19-21 Due: 1-19-22
Radar Speed Sensor and Dashboard Display	Vehicle Speed	0-125 mph	0.009 mph	±0.25% of full scale	A-DAT Corp. Radar Model: DRS-6 Display Model: RD-2	1400603	By: TRC Inc. Date: 4-15-21 Due: 4-15-22
Laser Height / Body Roll Measuring System	Left and Right Side Vehicle Height	145 to 895 mm	0.075 mm	±0.15%	Acuity Model: AR500-750	HS-27380 & HS-27378	By: TRC Inc. Date: 1-20-21 Due: 1-20-22
Data Acquisition System [Amplify, Anti-Alias, and Digitize]	Record Time; Velocity; Distance; Lateral, Longitudinal, and Vertical Accelerations; Roll, Yaw, and Pitch Rates; Steering Wheel Angle.	Sufficient to meet or exceed individual sensors	200 Hz	Sufficient to meet or exceed individual sensors	Link Vmax 4000	41284-004	By: TRC Inc. Date: 1-18-21 Due: 1-18-22
Load Cell	Vehicle Brake Pedal Force	0-300 lb	1 lb	±0.05% of full scale	DATRON Model: DTM-LPA	4970-1103	By: TRC Inc. Date: per test Due: per test
Coordinate Measurement Machine	Inertial Sensing System Location	0-10 feet	0.001 inch	±0.003% of full scale	FARO International Model: Faro Advantage	E12-05-13-10989	By: FARO Date: 1-13-21 Due: 1-13-22
Outriggers	No output. Safety Item.	N/A	N/A	N/A	NHTSA Titanium Outriggers Model: Docket 2007-27662-11	Asset ID: 70725	N/A
Weather Station	Temperature and Wind Speed	-40-150°F 0-200mph	0.1°F 1mph	±1°F ±2mph	Davis Instruments Vantage Pro2	200102N01	By: Davis Inst. Date: 1-11-21 Due: 1-11-22

5.0 PHOTOGRAPHS

5.1 ¾ FRONT VIEW FROM LEFT SIDE OF VEHICLE
5.2 ¾ REAR VIEW FROM RIGHT SIDE OF VEHICLE
5.3 VEHICLE CERTIFICATION LABEL
5.4 TIRE AND LOADING INFORMATION LABEL
5.5 WINDOW STICKER (MONRONEY LABEL)
5.6 ESC OFF AND ESC MALFUNCTION TELLTALES
5.7 ESC OFF CONTROL LOCATION
5.8 ESC OFF CONTROL
5.9 ¾ FRONT VIEW - TEST VEHICLE INSTRUMENTED
5.10 ¾ REAR VIEW - TEST VEHICLE INSTRUMENTED
5.11 STEERING WHEEL CONTROLLER AND DATA ACQUISITION SYSTEM
5.12 STEERING CONTROLLER BATTERY BOX
5.13 INERTIA MEASUREMENT UNIT
5.14 VEHICLE SPEED SENSOR
5.15 BODY ROLL SENSOR (DRIVER SIDE)
5.16 BODY ROLL SENSOR (PASSENGER SIDE)
5.17 BRAKE PEDAL FORCE TRANSDUCER

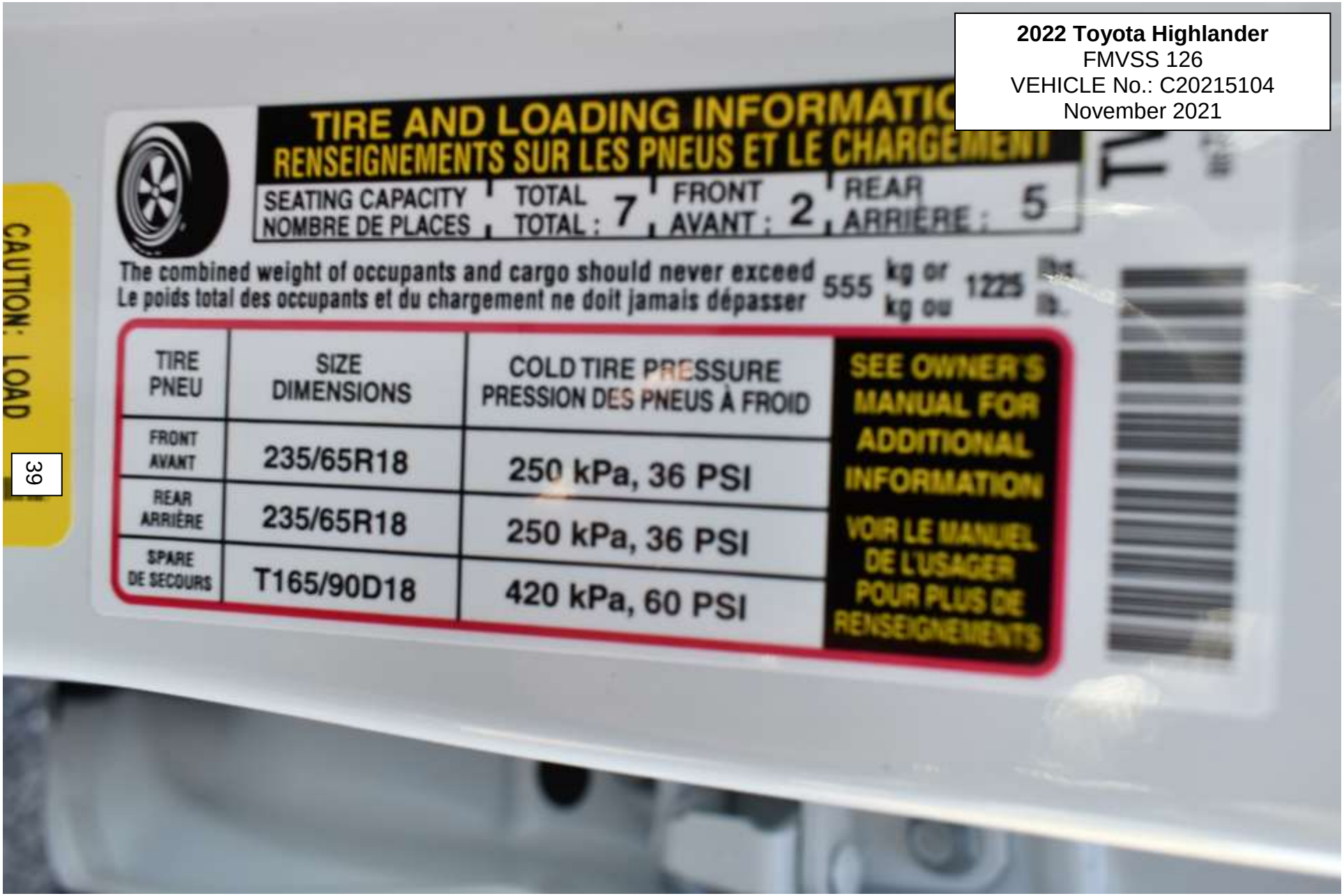
5.1 ¾ FRONT VIEW FROM LEFT SIDE OF VEHICLE

5.2 ¾ REAR VIEW FROM RIGHT SIDE OF VEHICLE

2022 Toyota Highlander
FMVSS 126
VEHICLE No.: C20215104
November 2021

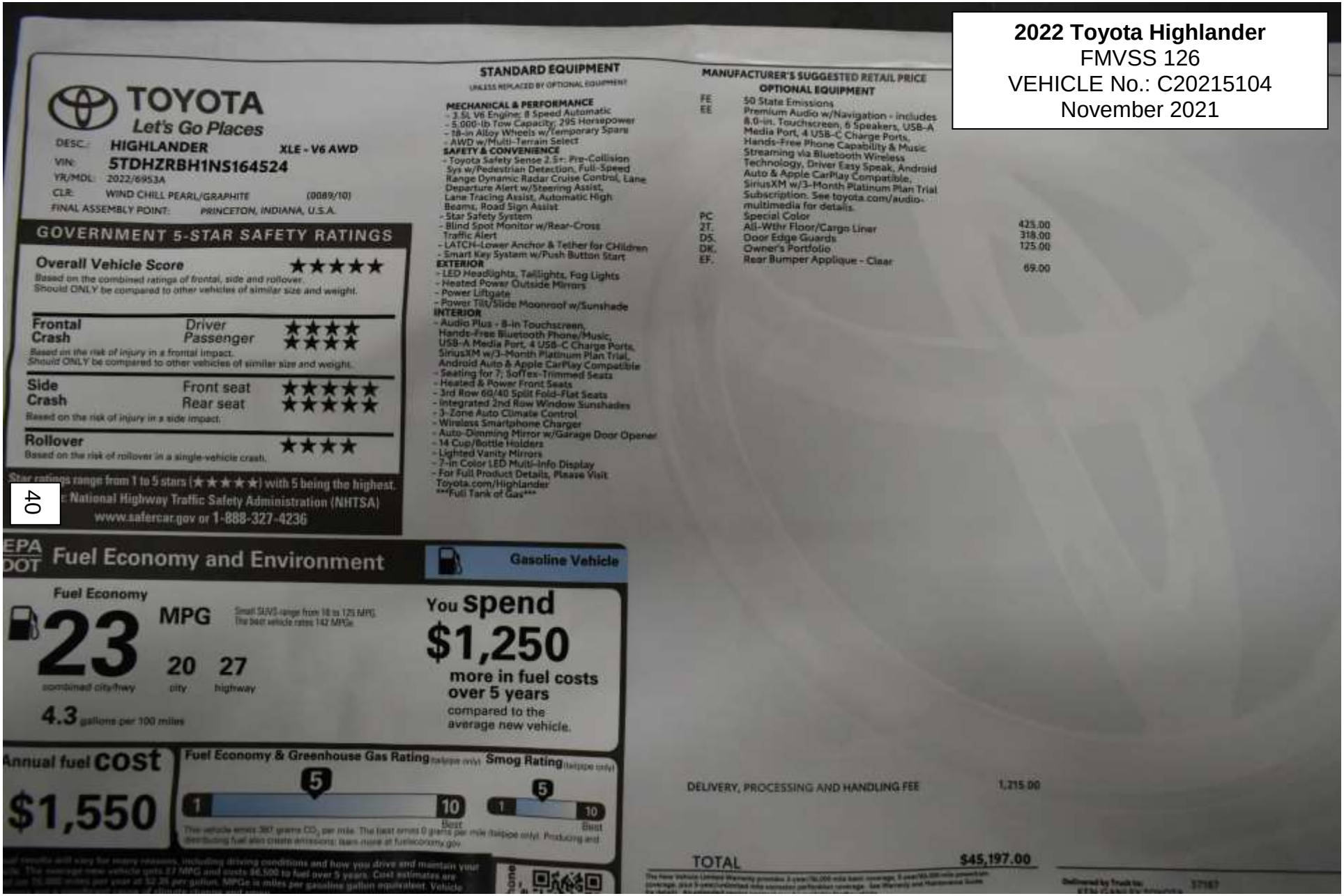
5.3 VEHICLE CERTIFICATION LABEL

2022 Toyota Highlander
FMVSS 126
VEHICLE No.: C20215104
November 2021



5.4 TIRE AND LOADING INFORMATION LABEL

2022 Toyota Highlander
FMVSS 126
VEHICLE No.: C20215104
November 2021



TOYOTA
Let's Go Places

DESC.: HIGHLANDER XLE - V6 AWD
VIN: 5TDHZRBH1NS164524
YR/MDL: 2022/6953A
CLR: WIND CHILL PEARL/GRAPHITE (0089/10)
FINAL ASSEMBLY POINT: PRINCETON, INDIANA, U.S.A.

GOVERNMENT 5-STAR SAFETY RATINGS

Overall Vehicle Score ★★★★★
Based on the combined ratings of frontal, side and rollover.
Should ONLY be compared to other vehicles of similar size and weight.

Frontal Crash — Driver ★★★★ / Passenger ★★★★
Based on the risk of injury in a frontal impact.
Should ONLY be compared to other vehicles of similar size and weight.

Side Crash — Front seat ★★★★★ / Rear seat ★★★★★
Based on the risk of injury in a side impact.

Rollover ★★★★
Based on the risk of rollover in a single-vehicle crash.

Star ratings range from 1 to 5 stars (★★★★★) with 5 being the highest.
Source: National Highway Traffic Safety Administration (NHTSA)
www.safercar.gov or 1-888-327-4236

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STANDARD EQUIPMENT
UNLESS REPLACED BY OPTIONAL EQUIPMENT

MECHANICAL & PERFORMANCE
- 3.5L V6 Engine; 8 Speed Automatic
- 5,000-lb Tow Capacity; 295 Horsepower
- 18-in Alloy Wheels w/Temporary Spare
- AWD w/Multi-Terrain Select

SAFETY & CONVENIENCE
- Toyota Safety Sense 2.5+: Pre-Collision Sys w/Pedestrian Detection, Full-Speed Range Dynamic Radar Cruise Control, Lane Departure Alert w/Steering Assist, Lane Tracing Assist, Automatic High Beams, Road Sign Assist
- Star Safety System
- Blind Spot Monitor w/Rear-Cross Traffic Alert
- LATCH-Lower Anchor & Tether for CHildren
- Smart Key System w/Push Button Start

EXTERIOR
- LED Headlights, Taillights, Fog Lights
- Heated Power Outside Mirrors
- Power Liftgate
- Power Tilt/Slide Moonroof w/Sunshade

INTERIOR
- Audio Plus - 8-in Touchscreen, Hands-Free Bluetooth Phone/Music, USB-A Media Port, 4 USB-C Charge Ports, SiriusXM w/3-Month Platinum Plan Trial, Android Auto & Apple CarPlay Compatible
- Seating for 7; SofTex-Trimmed Seats
- Heated & Power Front Seats
- 3rd Row 60/40 Split Fold-Flat Seats
- Integrated 2nd Row Window Sunshades
- 3-Zone Auto Climate Control
- Wireless Smartphone Charger
- Auto-Dimming Mirror w/Garage Door Opener
- 14 Cup/Bottle Holders
- Lighted Vanity Mirrors
- 7-in Color LED Multi-Info Display
- For Full Product Details, Please Visit Toyota.com/Highlander
Full Tank of Gas

MANUFACTURER'S SUGGESTED RETAIL PRICE

OPTIONAL EQUIPMENT

FE	50 State Emissions	
EE	Premium Audio w/Navigation - includes 8.0-in. Touchscreen, 6 Speakers, USB-A Media Port, 4 USB-C Charge Ports, Hands-Free Phone Capability & Music Streaming via Bluetooth Wireless Technology, Driver Easy Speak, Android Auto & Apple CarPlay Compatible, SiriusXM w/3-Month Platinum Plan Trial Subscription. See toyota.com/audio-multimedia for details.	
PC	Special Color	
2T.	All-Wthr Floor/Cargo Liner	425.00
DS.	Door Edge Guards	318.00
DK.	Owner's Portfolio	125.00
EF.	Rear Bumper Applique - Clear	69.00

DELIVERY, PROCESSING AND HANDLING FEE 1,215.00

TOTAL $45,197.00

EPA DOT Fuel Economy and Environment — Gasoline Vehicle

Fuel Economy
23 MPG combined city/hwy
20 city 27 highway
4.3 gallons per 100 miles

Small SUV3 range from 18 to 125 MPG
The best vehicle rates 142 MPGe

You spend $1,250 more in fuel costs over 5 years compared to the average new vehicle.

Annual fuel cost $1,550

Fuel Economy & Greenhouse Gas Rating (tailpipe only) 5 (1 Worst – 10 Best)
This vehicle emits 387 grams CO_2 per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel also create emissions; learn more at fueleconomy.gov

Smog Rating (tailpipe only) 5 (1 Worst – 10 Best)

Your results will vary for many reasons, including driving conditions and how you drive and maintain your vehicle. The average new vehicle gets 27 MPG and costs $6,500 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at $2.26 per gallon. MPGe is miles per gasoline gallon equivalent. Vehicles

Delivered by Truck to: 37167

5.5 WINDOW STICKER - MONRONEY LABEL

2022 Toyota Highlander
FMVSS 126
VEHICLE No.: C20215104
November 2021

5.6 ESC OFF AND ESC MALFUNCTION TELLTALES

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5.7 ESC OFF CONTROL LOCATION

2022 Toyota Highlander
FMVSS 126
VEHICLE No.: C20215104
November 2021

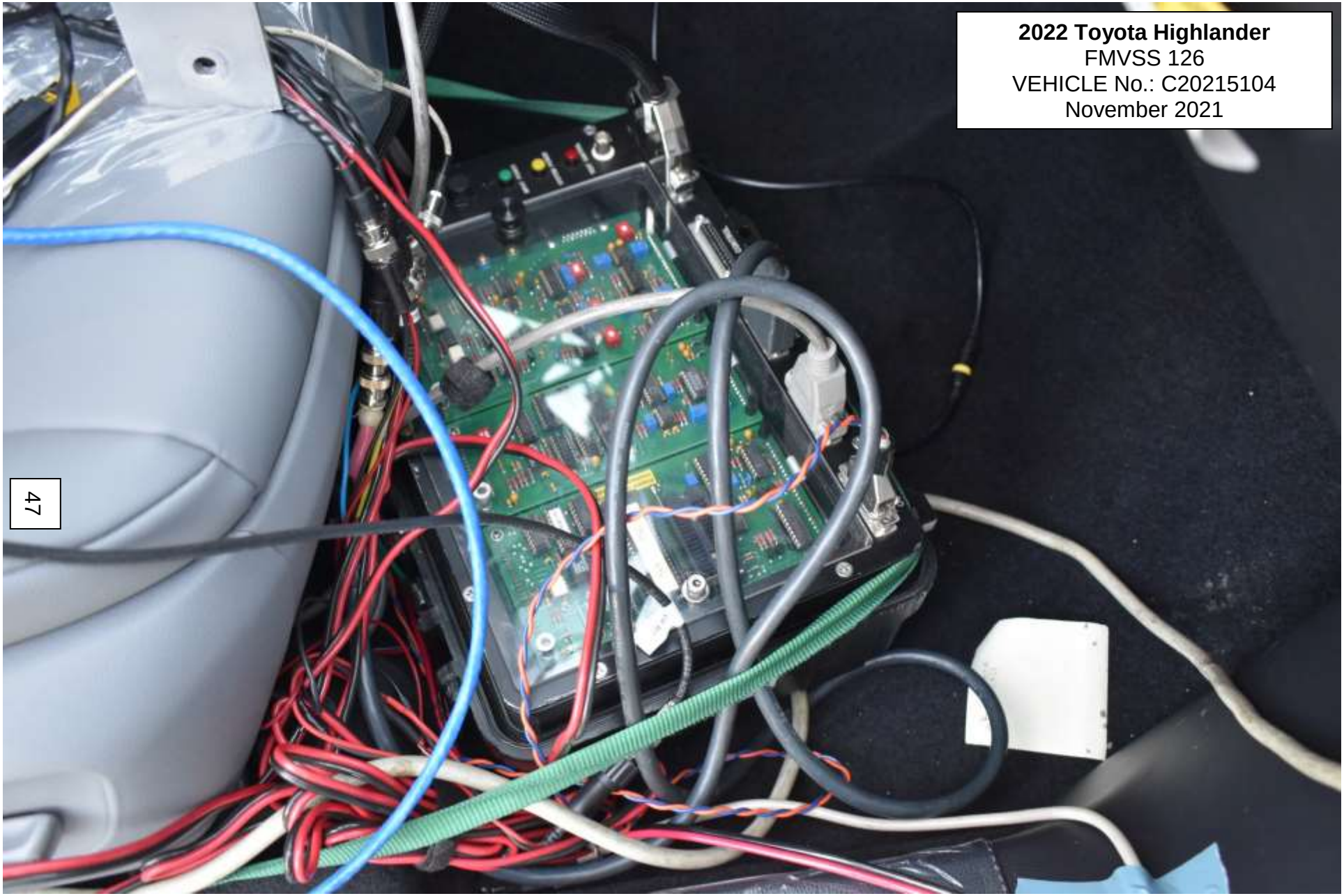
5.8 ESC OFF CONTROL

5.9 ¾ FRONT VIEW - TEST VEHICLE INSTRUMENTED

5.10 ¾ REAR VIEW - TEST VEHICLE INSTRUMENTED

2022 Toyota Highlander
FMVSS 126
VEHICLE No.: C20215104
November 2021

5.11 STEERING WHEEL CONTROLLER AND DATA ACQUISITION SYSTEM



5.12 STEERING CONTROLLER BATTERY BOX

5.13 INERTIA MEASUREMENT UNIT

2022 Toyota Highlander
FMVSS 126
VEHICLE No.: C20215104
November 2021

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5.14 VEHICLE SPEED SENSOR

5.15 BODY ROLL SENSOR (DRIVER SIDE)

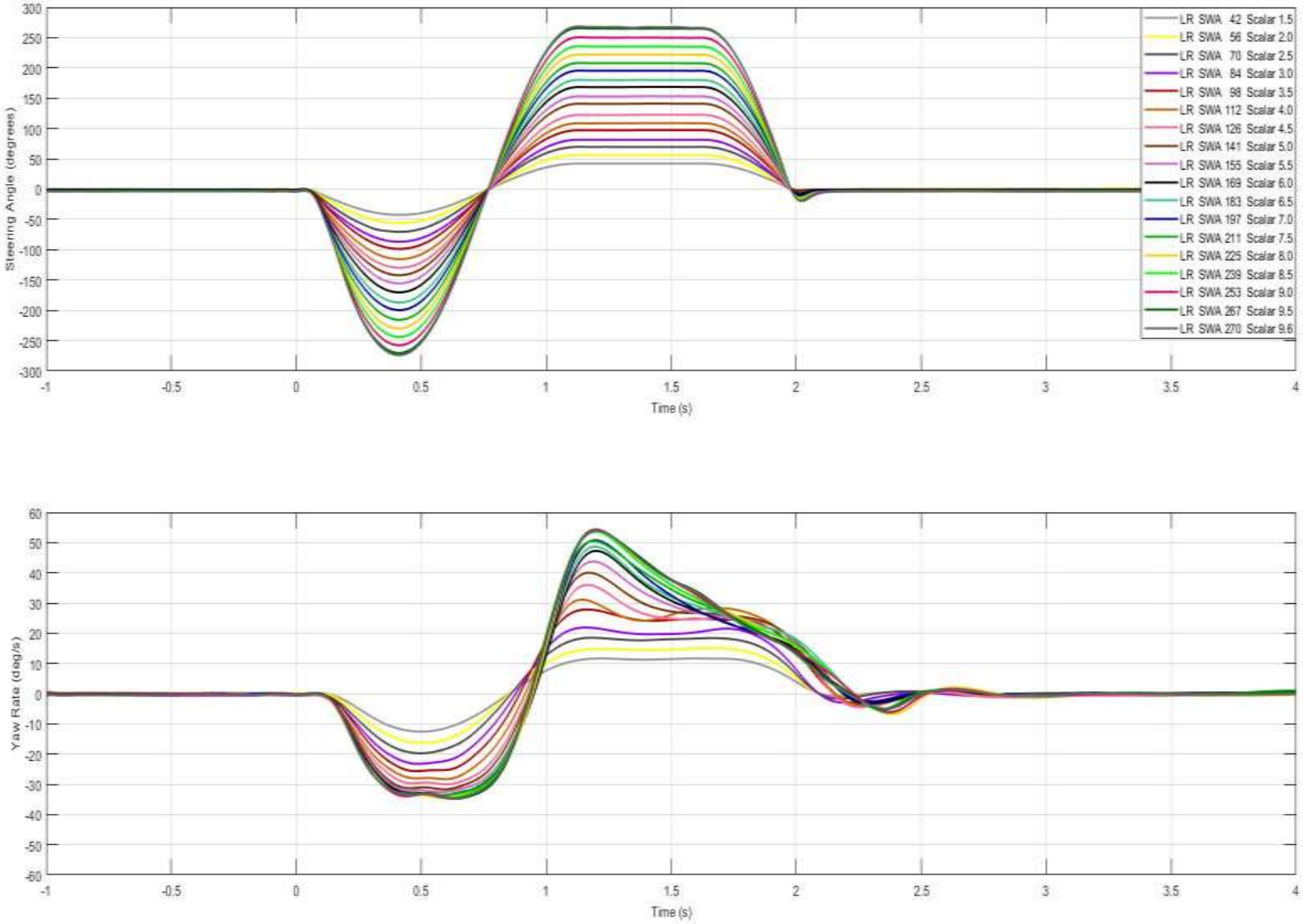
5.16 BODY ROLL SENSOR (PASSENGER SIDE)

5.17 BRAKE PEDAL FORCE TRANSDUCER

6.0 DATA PLOTS

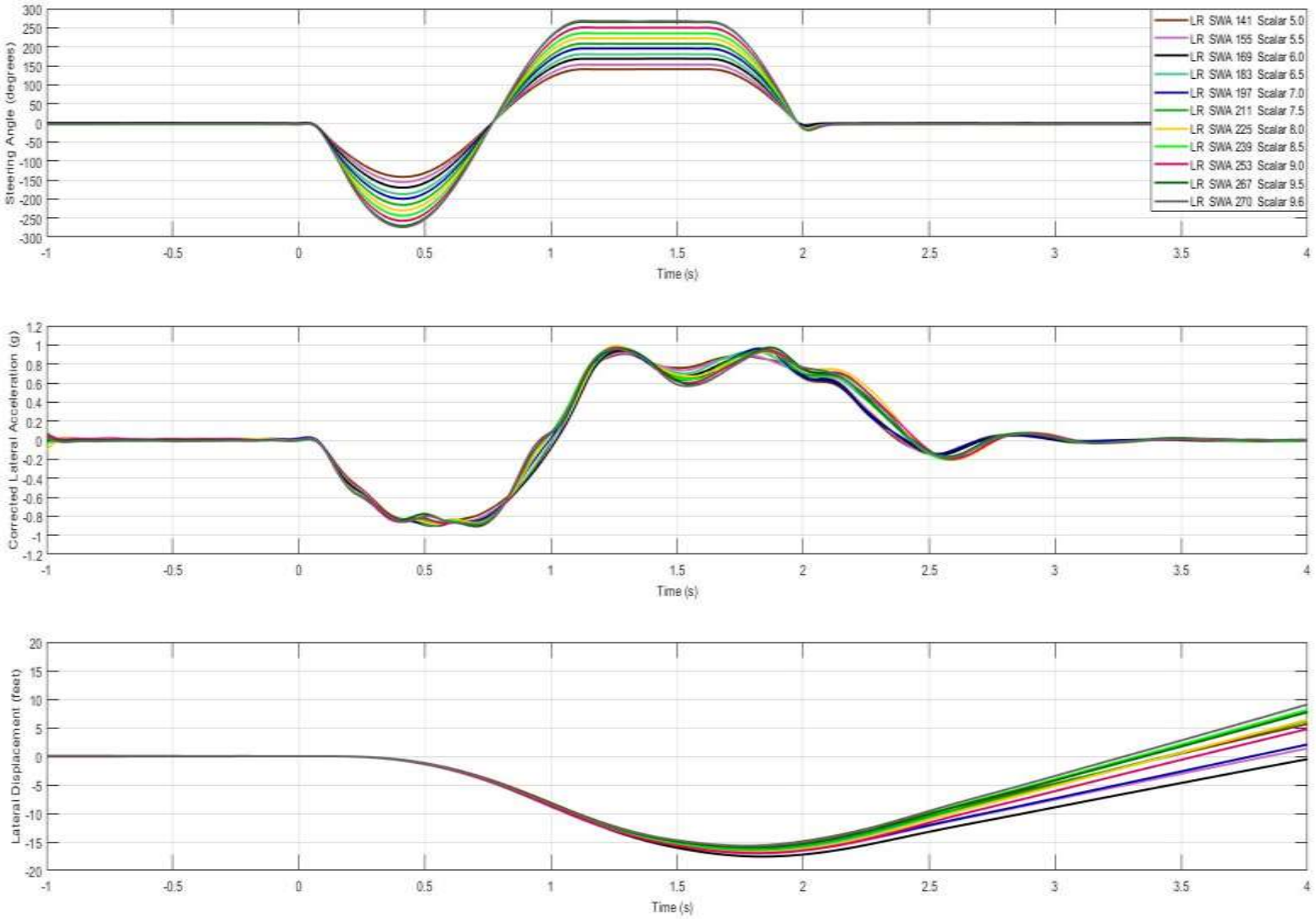
6.0 2022 Toyota Highlander DATA PLOTS

Figure 1. Steering Angle and Yaw Rate Time History, Counter-Clockwise Initial Steer Tests



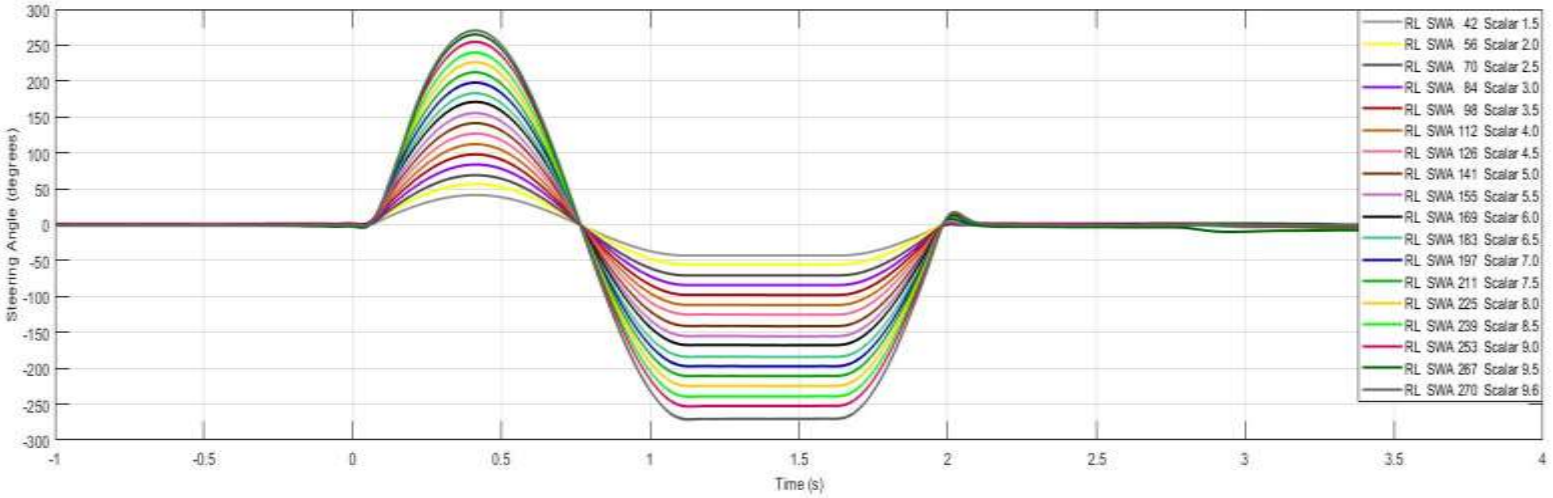
6.0 2022 Toyota Highlander DATA PLOTS …continued

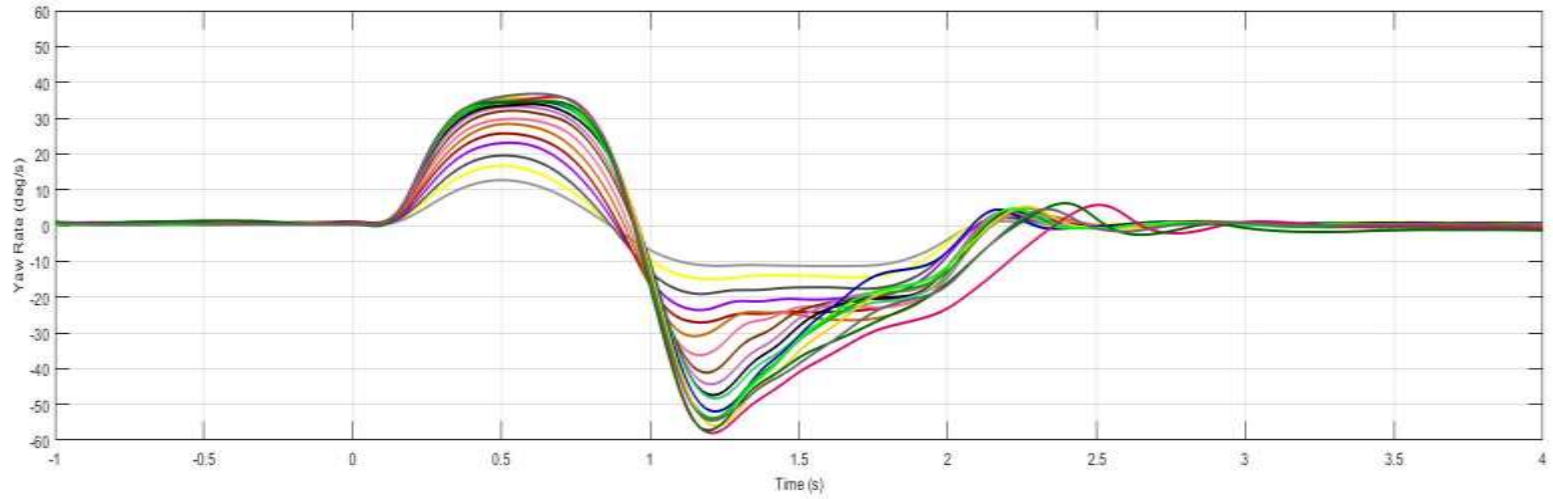
Figure 2. Steering Angle and Yaw Rate Time History, Counter-Clockwise Initial Steer Tests



6.0 2022 Toyota Highlander DATA PLOTS …continued

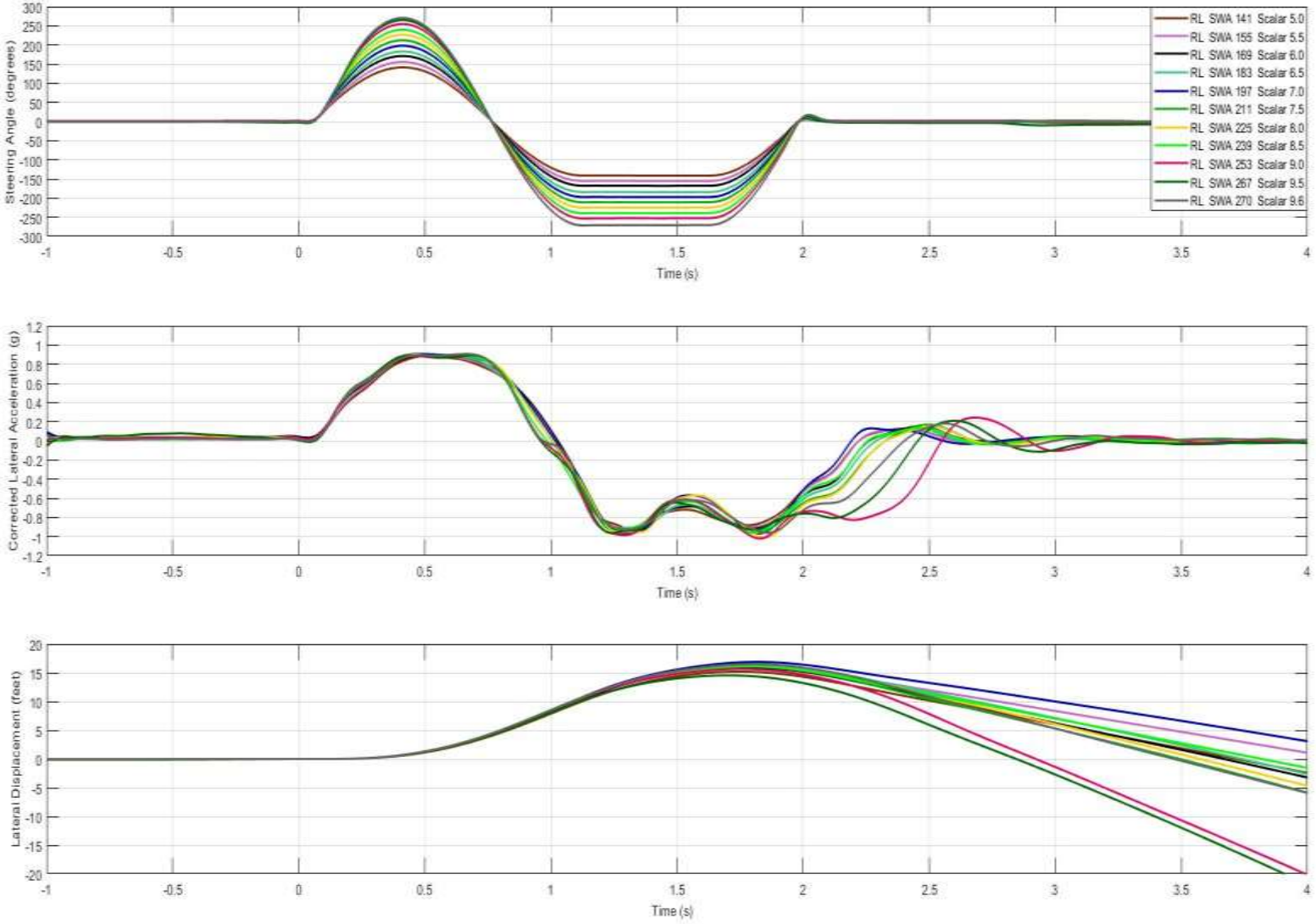
Figure 3. Steering Angle and Yaw Rate Time History, Clockwise Initial Steer Tests





6.0 2022 Toyota Highlander DATA PLOTS …continued

Figure 4. Steering Angle, Lateral Acceleration, and Lateral Displacement Time History, Clockwise Initial Steer Tests



7.0 OTHER DOCUMENTATION

7.1 OWNER'S MANUAL PAGES
7.2 VEHICLE ARRIVAL CONDITION REPORT
7.3 VEHICLE COMPLETION CONDITION REPORT
7.4 SINE WITH DWELL TEST RESULTS
7.5 SLOWLY INCREASING STEER TEST RESULTS
7.6 INERTIA SENSOR MEASUREMENTS

7.1 OWNER'S MANUAL PAGES

Driving assist systems

To keep driving safety and performance, the following systems operate automatically in response to various driving situations. Be aware, however, that these systems are supplementary and should not be relied upon too heavily when operating the vehicle.

Summary of the driving assist systems

■ ABS (Anti-lock Brake System)

Helps to prevent wheel lock when the brakes are applied suddenly, or if the brakes are applied while driving on a slippery road surface

■ Brake assist

Generates an increased level of braking force after the brake pedal is depressed when the system detects a panic stop situation

■ VSC (Vehicle Stability Control)

Helps the driver to control skidding when swerving suddenly or turning on slippery road surfaces

■ Enhanced VSC (Enhanced Vehicle Stability Control)

Provides cooperative control of the ABS, TRAC, VSC and EPS. Helps to maintain directional stability when swerving on slippery road surfaces by controlling steering performance.

■ Trailer Sway Control

Helps the driver to control trailer sway by selectively applying brake pressure for individual wheels and reducing driving torque when trailer sway is detected.

■ TRAC (Traction Control)

Helps to maintain drive power and prevent the drive wheels from spinning when starting the vehicle or accelerating on slippery roads

■ Active Cornering Assist (ACA)

Helps to prevent the vehicle from drifting to the outer side by performing inner wheel brake control when attempting to accelerate while turning

■ Hill-start assist control

Helps to reduce the backward movement of the vehicle when starting on an uphill

■ EPS (Electric Power Steering)

Employs an electric motor to reduce the amount of effort needed to turn the steering

wheel

■ Dynamic Torque Control AWD system (AWD models)

Automatically switches from front-wheel drive to all-wheel drive (AWD) according to the driving conditions, helping to ensure reliable handling and stability. Examples of conditions where the system will switch to AWD are when cornering, going uphill, starting off or accelerating, and when the road surface is slippery due to snow, rain, etc.

■ Dynamic Torque Vectoring AWD system (AWD models)

Automatically switches from front-wheel drive to all-wheel drive (AWD) according to the driving conditions, helping to ensure reliable handling and stability. Examples of conditions where the system will switch to AWD are when cornering, going uphill, starting off or accelerating, and when the road surface is slippery due to snow, rain, etc.

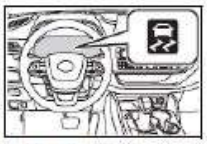
Also, when the vehicle is cornering, the drive torque distribution between the front and rear wheels and between the rear left and right wheels is precisely controlled to improve drivability and stability.

■ The Secondary Collision Brake

When the SRS airbag sensor detects a collision and the system operates, the brakes and brake lights are automatically controlled to reduce the vehicle speed and help reduce the possibility of further damage due to a secondary collision.

■When the TRAC/VSC/Trailer Sway Control systems are operating

The slip indicator light will flash while the TRAC/VSC/Trailer Sway Control systems are operating.



■Disabling the TRAC system

If the vehicle gets stuck in mud, dirt or snow, the TRAC system may reduce power from the engine to the wheels. Pressing the switch to turn the system off may make it easier for you to rock the vehicle in order to free it.

To turn the TRAC system off, quickly press and release the switch.

The "Traction Control Turned OFF" will be shown on the multi-information display.

Press the switch again to turn the system back on.

■ **Turning off both TRAC, VSC and Trailer Sway Control systems**

To turn the TRAC, VSC and Trailer Sway Control systems off, press and hold the switch for more than 3 seconds while the vehicle is stopped.

The VSC OFF indicator light will come on and the "Traction Control Turned OFF" will be shown on the multi-information display.*

Press the switch again to turn the system back on.

*: On vehicles with PCS (Pre-Collision System), PCS will also be disabled (only Pre-Collision warning is available). The PCS warning light will come on and a message will be displayed on the multi-information display. (→P.235)

■ **When the message is displayed on the multi-information display showing that TRAC has been disabled even if the switch has not been pressed**

TRAC is temporary deactivated. If the information continues to show, contact your Toyota dealer.

■ **Operating conditions of hill-start assist control**

When the following four conditions are met, the hill-start assist control will operate:

- The shift lever is in a position other than P or N (when starting off forward/backward on an upward incline)
- The vehicle is stopped
- The accelerator pedal is not depressed
- The parking brake is not engaged

■ **Automatic system cancelation of hill-start assist control**

The hill-start assist control will turn off in any of the following situations:

- The shift lever is shifted to P or N
- The accelerator pedal is depressed
- The parking brake is engaged
- 2 seconds at maximum elapsed after the brake pedal is released

■ **Sounds and vibrations caused by the ABS, brake assist, VSC, Trailer Sway Control, TRAC and hill-start assist control systems**

- A sound may be heard from the engine compartment when the brake pedal is depressed repeatedly, when the engine is started or just after the vehicle begins to move. This sound does not indicate that a malfunction has occurred in any of these systems.
- Any of the following conditions may occur when the above systems are operating. None of these indicates that a malfunction has occurred.
  - Vibrations may be felt through the vehicle body and steering.
  - A motor sound may be heard also after the vehicle comes to a stop.
  - The brake pedal may pulsate slightly after the ABS is activated.
  - The brake pedal may move down slightly after the ABS is activated.

■ **Active Cornering Assist operation sounds and vibrations**

When the Active Cornering Assist is operated, operation sounds and vibrations may be generated from the brake system, but this is not a malfunction.

■ **AWD system operation sounds and vibrations when switching between AWD and front wheel drive**

When the vehicle switches from AWD to front wheel drive and vice versa, operation sounds and vibra-

tions may be generated, but this is not a malfunction.

■EPS operation sound

When the steering wheel is operated, a motor sound (whirring sound) may be heard. This does not indicate a malfunction.

■Reduced effectiveness of the EPS system

The effectiveness of the EPS system is reduced to prevent the system from overheating when there is frequent steering input over an extended period of time. The steering wheel may feel heavy as a result. Should this occur, refrain from excessive steering input or stop the vehicle and turn the engine off. The EPS system should return to normal within 10 minutes.

■Automatic reactivation of TRAC, Trailer Sway Control and VSC systems

After turning the TRAC, Trailer Sway Control and VSC systems off, the systems will be automatically re-enabled in the following situations:

- When the engine switch is turned OFF
- If only the TRAC system is turned off, the TRAC will turn on when vehicle speed increases. If both the TRAC and VSC systems are turned off, automatic re-enabling will not occur when vehicle speed increases.

■Operating conditions of Active Cornering Assist

The system operates when the following occurs.

- TRAC/VSC can operate
- The driver is attempting to accelerate while turning
- The system detects that the vehicle is drifting to the outer side
- The brake pedal is released

■Secondary Collision Brake operating conditions

The system operates when the SRS airbag sensor detects a collision while the vehicle is in motion. However, the system does not operate in any of the following situations.

- The vehicle speed is below 6 mph (10 km/h)
- Components are damaged

■Secondary Collision Brake automatic cancellation

The system is automatically canceled in any of the following situations.

- The vehicle speed drops below approximately 6 mph (10 km/h)
- A certain amount of time elapses during operation
- The accelerator pedal is depressed a large amount

⚠ WARNING

■The ABS does not operate effectively when

- The limits of tire gripping performance have been exceeded (such as excessively worn tires on a snow covered road).
- The vehicle hydroplanes while driving at high speed on wet or slick roads.

■Stopping distance when the ABS is operating may exceed that of normal conditions

The ABS is not designed to shorten the vehicle's stopping distance. Always maintain a safe distance from the vehicle in front of you, especially in the following situations:

- When driving on dirt, gravel or snow-covered roads
- When driving with tire chains

WARNING

- When driving over bumps in the road
- When driving over roads with potholes or uneven surfaces

■ TRAC/VSC may not operate effectively when

Directional control and power may not be achievable while driving on slippery road surfaces, even if the TRAC/VSC system is operating. Drive the vehicle carefully in conditions where stability and power may be lost.

■ Active Cornering Assist does not operate effectively when

- Do not overly rely on Active Cornering Assist. Active Cornering Assist may not operate effectively when accelerating down slopes or driving on slippery road surfaces.
- When Active Cornering Assist frequently operates, Active Cornering Assist may temporarily stop operating to ensure proper operation of the brakes, TRAC and VSC.

■ Hill-start assist control does not operate effectively when

- Do not overly rely on hill-start assist control. Hill-start assist control may not operate effectively on steep inclines and roads covered with ice.
- Unlike the parking brake, hill-start assist control is not intended to hold the vehicle stationary for an extended period of time. Do not attempt to use hill-start assist control to hold the vehicle on an incline, as doing so may lead to an accident.

■ When the TRAC/VSC/Trailer Sway Control is activated

The slip indicator light flashes. Always drive carefully. Reckless driving may cause an accident. Exercise particular care when the indicator light flashes.

■ When the TRAC/VSC/Trailer Sway Control systems are turned off

- Be especially careful and drive at a speed appropriate to the road conditions. As these are the systems to help ensure vehicle stability and driving force, do not turn the TRAC/VSC/Trailer Sway Control systems off unless necessary.
- Trailer Sway Control is part of the VSC system and will not operate if VSC is turned off or experiences a malfunction.

■ Dynamic Torque Vectoring AWD system

The cornering performance of the AWD system has been improved. However, do not overly rely on the system and drive with caution.

■ Replacing tires

Make sure that all tires are of the specified size, brand, tread pattern and total load capacity. In addition, make sure that the tires are inflated to the recommended tire inflation pressure level.

The ABS, TRAC, Trailer Sway Control and VSC systems will not function correctly if different tires are installed on the vehicle. Contact your Toyota dealer for further information when replacing tires or wheels.

7.2 VEHICLE ARRIVAL CONDITION REPORT

CONTRACT NO. DTNH22-16-D-00027 DATE: 11-12-21

FROM: Automotive Allies

TO: TRC Inc.

PURPOSE: (X) Initial Receipt ( ) Received via Transfer ( ) Present vehicle condition

MODEL YEAR/MAKE/MODEL/BODY STYLE: 2022 / Toyota / Highlander / SUV

MANUFACTURE DATE: 10-21 NHTSA NO.: C20215104

BODY COLOR: White VIN: 5TDHZRBH1NS164524

ODOMETER READING: 5 miles GVWR: 2,690 KG

PURCHASE PRICE: $ rented / leased DEALER'S NAME: Ken Ganley Toyota, 1110 Clairton Blvd., Pleasant Hills, PA 15236

X ALL OPTIONS LISTED ON "WINDOW STICKER" ARE PRESENT ON THE TEST VEHICLE

X TIRES AND WHEEL RIMS ARE NEW AND THE SAME AS LISTED

X THERE ARE NO DENTS OR OTHER INTERIOR OR EXTERIOR FLAWS

X THE VEHICLE HAS BEEN PROPERLY PREPARED AND IS IN RUNNING CONDITION

X THE GLOVE BOX CONTAINS AN OWNER'S MANUAL, WARRANTY DOCUMENT, CONSUMER INFORMATION, AND EXTRA SET OF KEYS

X PROPER FUEL FILLER CAP IS SUPPLIED ON THE TEST VEHICLE

X PLACE VEHICLE IN STORAGE AREA

X INSPECT THE VEHICLE'S INTERIOR AND EXTERIOR, INCLUDING ALL WINDOWS, SEATS, DOORS, ETC., TO CONFIRM THAT EACH SYSTEM IS COMPLETE AND FUNCTIONAL PER THE MANUFACTURER'S SPECIFICATIONS. ANY DAMAGE, MISADJUSTMENT, OR OTHER UNUSUAL CONDITION THAT COULD INFLUENCE THE TEST PROGRAM OR TEST RESULTS SHALL BE RECORDED. REPORT ANY ABNORMAL CONDITION TO THE NHTSA COTR BEFORE BEGINNING ANY TEST

RECORDED BY: David Karls DATE: 12-08-21

APPROVED BY: Jordan Piening DATE: 12-08-21

7.3 VEHICLE COMPLETION CONDITION REPORT

CONTRACT NO. DTNH22-16-D-00027 DATE: 11-26-21

MODEL YEAR/MAKE/MODEL/BODY STYLE: 2022 / Toyota / Highlander / SUV

MANUFACTURE DATE: 10-21 NHTSA NO.: C20215104

BODY COLOR: White VIN: 5TDHZRBH1NS164524

ODOMETER READING: 62 miles GVWR: 2,690 KG

LIST OF FMVSS TESTS PERFORMED BY THIS LAB: 126

X THERE ARE NO DENTS OR OTHER INTERIOR OR EXTERIOR FLAWS

X THE VEHICLE HAS BEEN PROPERLY MAINTAINED AND IS IN RUNNING CONDITION

X THE GLOVE BOX CONTAINS AN OWNER'S MANUAL, WARRANTY DOCUMENT, CONSUMER INFORMATION, AND EXTRA SET OF KEYS

X PROPER FUEL FILLER CAP IS SUPPLIED ON THE TEST VEHICLE

REMARKS:

Equipment that is no longer on the test vehicle as noted on Vehicle Arrival Condition Report:

None.

Explanation for equipment removal:

N/A

Test Vehicle Condition:

Like new.

RECORDED BY: David Karls DATE: 12-08-21
APPROVED BY: Jordan Piening DATE: 12-08-21

7.4 SINE WITH DWELL TEST RESULTS

2022 Toyota Highlander

NHTSA No.: C20215104

Date Created 24-Nov-21

LEFT-TO-RIGHT (INITIAL COUNTER-CLOCKWISE STEER)

File	SWA @ 5deg Ct	MES	Time@5deg	COS	Time@COS	MOS	Time@MOS	YRR1(%)	YR1 (deg/sec)	YRR1 Ct	YRR175(%)	YR175 (deg/sec)
0015	218	50.405	0.085	599	1.990	355	0.769	-1.112	-0.127	799	-1.606	-0.184
0016	217	49.765	0.078	599	1.989	355	0.768	-0.528	-0.077	799	0.937	0.137
0017	216	48.494	0.071	599	1.986	355	0.768	0.696	0.129	799	0.934	0.173
0018	215	49.320	0.070	599	1.985	355	0.767	0.017	0.004	799	1.365	0.307
0019	215	50.255	0.068	598	1.984	355	0.766	-1.741	-0.485	798	0.426	0.119
0020	214	50.358	0.063	597	1.979	355	0.768	-2.545	-0.802	797	-0.376	-0.118
0021	213	50.529	0.057	597	1.976	356	0.771	-3.242	-1.164	797	-0.707	-0.254
0022	214	49.138	0.065	598	1.983	355	0.765	-1.111	-0.446	798	0.206	0.083
0023	214	50.262	0.062	597	1.980	355	0.766	-1.608	-0.702	797	0.076	0.033
0024	214	50.849	0.064	598	1.982	355	0.765	-0.954	-0.452	798	0.596	0.282
0025	214	49.453	0.064	598	1.983	355	0.766	-0.765	-0.375	798	0.689	0.338
0026	214	49.105	0.065	598	1.983	355	0.766	-0.417	-0.212	798	0.645	0.328
0027	214	49.408	0.064	598	1.982	355	0.767	-1.205	-0.609	798	0.148	0.075
0028	215	49.643	0.065	598	1.983	355	0.766	-1.074	-0.585	798	0.251	0.137
0029	214	49.930	0.065	598	1.982	355	0.767	-1.218	-0.656	798	-0.073	-0.039
0030	214	50.121	0.064	598	1.982	355	0.767	-1.114	-0.606	798	-0.379	-0.206
0031	214	50.027	0.063	598	1.981	355	0.766	-0.217	-0.117	798	0.688	0.373
0032	214	49.998	0.064	598	1.982	355	0.766	-0.042	-0.023	798	0.448	0.244

RIGHT-TO-LEFT (INITIAL CLOCKWISE STEER)

File	SWA @ 5deg Ct	MES	Time@5deg	COS	Time@COS	MOS	Time@MOS	YRR1(%)	YR1 (deg/sec)	YRR1 Ct	YRR175(%)	YR175 (deg/sec)
0033	218	49.714	0.082	598	1.982	356	0.771	-2.395	0.275	798	-2.286	0.262
0034	217	50.329	0.077	599	1.985	355	0.768	-1.581	0.245	799	-2.037	0.315
0035	216	50.410	0.075	599	1.988	355	0.767	-0.924	0.179	799	-1.353	0.262
0036	216	50.068	0.071	599	1.986	355	0.768	-0.361	0.087	799	-0.521	0.126
0037	215	49.640	0.069	599	1.987	354	0.765	0.019	-0.005	799	0.487	-0.136
0038	215	49.704	0.067	598	1.984	355	0.766	-1.157	0.364	798	-0.469	0.147
0039	215	50.444	0.066	598	1.983	355	0.766	-0.618	0.227	798	-0.412	0.151
0040	215	49.866	0.065	598	1.983	355	0.766	-0.100	0.042	798	0.063	-0.026
0041	214	50.148	0.063	598	1.981	355	0.767	-0.301	0.135	798	0.154	-0.069
0042	214	50.241	0.064	598	1.982	355	0.767	-0.060	0.029	798	0.447	-0.215
0043	214	49.514	0.064	598	1.983	355	0.766	0.722	-0.353	798	1.984	-0.971
0044	214	50.149	0.064	598	1.982	355	0.767	0.266	-0.140	798	0.512	-0.269
0045	214	50.285	0.064	598	1.982	355	0.766	0.131	-0.071	798	2.533	-1.382
0046	214	50.098	0.065	598	1.982	355	0.766	-0.076	0.043	798	0.914	-0.518
0047	214	50.091	0.064	598	1.982	355	0.767	-0.338	0.185	798	-0.037	0.021
0048	214	49.279	0.065	598	1.983	355	0.766	-0.323	0.189	798	1.793	-1.051
0049	215	50.575	0.067	598	1.985	354	0.765	2.368	-1.376	798	3.644	-2.117
0050	214	49.344	0.065	598	1.983	355	0.767	-0.547	0.300	798	0.086	-0.047

7.4 SINE WITH DWELL TEST RESULTS
2022 Toyota Highlander
NHTSA No.: C20215104

Date Created 24-Nov-21

LEFT-TO-RIGHT (INITIAL COUNTER-CLOCKWISE STEER)

File	YRR175 Ct	2nd Yaw Peak(deg/sec)	2nd Yaw Peak Ct	Lat Disp (ft)	Lat. Acc. 1.07s (g)	1st SWA Peak(deg)	1st SWA Peak Ct	2nd SWA Mean(deg)
0015	949	11.452	445	-4.549	0.445	42.209	284	42.328
0016	949	14.634	446	-5.711	0.548	55.921	283	56.205
0017	949	18.496	437	-6.535	0.623	70.151	284	69.936
0018	949	22.460	433	-7.581	0.704	84.073	283	84.085
0019	948	27.881	434	-8.961	0.716	97.679	283	98.138
0020	947	31.510	430	-9.547	0.707	113.220	284	111.107
0021	947	35.905	434	-10.373	0.639	128.941	284	123.420
0022	948	40.144	435	-10.527	0.695	141.411	283	141.597
0023	947	43.648	439	-10.946	0.623	155.322	283	153.444
0024	948	47.334	441	-11.148	0.562	169.527	283	169.349
0025	948	49.065	440	-10.979	0.633	183.716	284	183.580
0026	948	50.769	440	-11.120	0.632	197.248	283	197.794
0027	948	50.527	439	-10.978	0.695	212.214	283	211.283
0028	948	54.523	441	-11.149	0.620	226.535	283	225.696
0029	948	53.846	441	-10.950	0.718	239.944	283	239.210
0030	948	54.348	441	-11.229	0.672	254.481	283	253.027
0031	948	54.186	441	-10.764	0.656	268.103	283	267.363
0032	948	54.435	441	-10.705	0.710	270.633	283	270.609

RIGHT-TO-LEFT (INITIAL CLOCKWISE STEER)

File	YRR175 Ct	2nd Yaw Peak(deg/sec)	2nd Yaw Peak Ct	Lat Disp (ft)	Lat. Acc. 1.07s (g)	1st SWA Peak(deg)	1st SWA Peak Ct	2nd SWA Mean(deg)
0033	948	-11.475	447	4.180	-0.426	42.838	284	41.323
0034	949	-15.485	442	5.428	-0.559	56.398	283	55.569
0035	949	-19.356	435	6.414	-0.638	69.860	284	69.726
0036	949	-24.204	434	7.521	-0.701	84.240	284	83.640
0037	949	-27.846	435	8.160	-0.739	97.480	283	98.263
0038	948	-31.432	431	9.077	-0.725	112.095	284	111.885
0039	948	-36.738	434	9.664	-0.718	126.426	284	125.787
0040	948	-41.626	439	10.221	-0.628	141.550	284	141.116
0041	948	-44.737	442	10.640	-0.570	156.194	283	154.565
0042	948	-48.208	443	10.576	-0.547	169.844	283	168.950
0043	948	-48.921	445	10.809	-0.501	183.538	283	183.572
0044	948	-52.603	445	10.944	-0.520	197.951	283	197.087
0045	948	-54.539	443	10.742	-0.576	211.702	283	211.291
0046	948	-56.713	446	10.890	-0.537	225.657	283	225.365
0047	948	-54.873	443	10.920	-0.657	239.926	283	238.930
0048	948	-58.637	443	10.778	-0.679	253.845	283	253.384
0049	948	-58.094	440	10.356	-0.665	265.901	283	269.433
0050	948	-54.809	443	10.912	-0.600	270.884	283	270.150

7.5 SLOWLY INCREASING STEER TEST RESULTS

2022 Toyota Highlander

NHTSA No.: C20215104

Date Created 24-Nov-21

File	Vehicle	EventPt	DOS	MES [mph]	Mean SPD [mph]	AYcount_3	THETAENCF_3 [degree]	AYCG_CD2_3 [g]	r_squared	ZeroBegin	ZeroEnd
0008	2022 Toyota Highlander	300	1	49.149	50.083	702	-27.254	-0.307	0.994	100	300
0009	2022 Toyota Highlander	300	1	49.220	50.111	703	-27.345	-0.304	0.997	100	300
0010	2022 Toyota Highlander	212	1	49.145	49.853	693	-26.909	-0.302	0.991	12	212
0011	2022 Toyota Highlander	278	0	49.590	49.819	737	29.791	0.301	0.996	78	278
0012	2022 Toyota Highlander	303	0	49.804	49.439	728	28.639	0.309	0.997	103	303
0013	2022 Toyota Highlander	304	0	49.632	50.087	728	28.631	0.304	0.993	104	304
	Averages						28.1	0.305			

Scalars	Steering Angles (deg)
1.5	42
2.0	56
2.5	70
3.0	84
3.5	98
4.0	112
4.5	126
5.0	141
5.5	155
6.0	169
6.5	183
7.0	197
7.5	211
8.0	225
8.5	239
9.0	253
9.5	267
9.6	270

7.6 INERTIA SENSOR MEASUREMENTS

2022 Toyota Highlander

NHTSA No.: C20215104

Serial Number : E12-05-13-10989					x-distance (longitudinal)	Point of reference is the front axle centerline.			
Calibration Date : 1/13/21						(Positive from front axle toward rear of vehicle.)			
Units : millimeters									
					y-distance (lateral)	Point of reference is the vehicle centerline.			
Date Created : 11/16/21						(Positive from the center toward the right.)			
					z-distance (vertical)	Point of reference is the ground plane.			
						(Positive from the ground up.)			
Label	ActualX	ActualY	ActualZ		**Track Width (mm)**			1663.700	
					Roof Height (relative to ground)			1723.206	
M_FRT_AXLE_CENTER	0.0000	0.0000	0.0000		**Motion Pak - x-distance (mm)**	1678.768			
C_COORDSYS001	0.0000	0.0000	0.0000		**Motion Pak - y-distance (mm)**		-32.512		
M_TIRE_TREAD_CENTER	-238.2947	70.65838	291.6419		**Motion Pak - z-distance (mm)**			948.555	
M_INERTIA_PACK	1678.768	869.9969	674.5443						
M_ROOF	2149.752	763.9865	1360.295						
M_GROUND	2114.3	-115.0613	-362.911		**Motion Pak - x-distance (inches)**	66.093			
M_REAR_AXLE_CENTER	2858.042	-2.777634	-2.46149		**Motion Pak - y-distance (inches)**		-1.280		
					Motion Pak - z-distance (inches)			37.345	