

**NEW CAR ASSESSMENT PROGRAM (NCAP)
DYNAMIC ROLLOVER RESISTANCE TEST**

VOLVO CAR CORPORATION
2020 Volvo XC60 T5 FWD Inscription

TEST NUMBER: NCAP-DRI-RR-20-25

Final Report
14 April 2020



Prepared by:

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Prepared for:

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New Car Assessment Program
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		15. Supplemental Notes	
16. Abstract An NCAP Dynamic Rollover Maneuver (Fishhook) Test was conducted on a 2020 Volvo XC60 T5 FWD Inscription at Dynamic Research, Inc. on January 24, 2020. The vehicle did not experience two-wheel lift. The vehicle's steering angle at 0.3 g lateral acceleration at 50 mph was 26.4 degrees.			
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TABLE OF CONTENTS

	Page
I. INTRODUCTION.....	1
II. VEHICLE PREPARATION	2
A. Test Vehicle	2
B. Tires	2
C. Vehicle Loading.....	2
D. Steering Controller	6
E. Real-Time Controller and Data Acquisition	6
F. Equipment Weight.....	7
G. Sensors	7
H. Other Vehicle Preparation	7
III. TEST PROCEDURES.....	10
A. Test Procedure Overview.....	10
B. Test Conditions	11
IV. RESULTS.....	14
APPENDIX A Photographs	A-1
APPENDIX B Test Run Log.....	B-1
APPENDIX C Slowly Increasing Steer Test Worksheet.....	C-1
APPENDIX D Time History Plots	D-1

LIST OF FIGURES

	Page
1. Nominal Position of Video Cameras for Fishhook Tests	9
2. DRI-Minter Vehicle Dynamics Area	13

LIST OF TABLES

	Page
1. Test Vehicle Data	3
2. Tire Information	5
3. Vehicle Loading	5
4. Weight of In-Cab Test equipment.....	7
5. Sensor Specifications	8
6. Surface Friction	11
7. Handwheel Angles	11
8. Weather Conditions.....	12

Section I
INTRODUCTION

Beginning with the 2006 fiscal year, the National Highway Traffic Safety Administration (NHTSA) has engaged Dynamic Research, Inc. (DRI) of Torrance, CA to conduct dynamic rollover testing and gather data from that testing as part of NHTSA's New Car Assessment Program (NCAP).

The purpose of the testing reported herein was to determine if a typical 2020 Volvo XC60 T5 FWD Inscription would experience tip-up, defined as simultaneous two-wheel lift of two inches or more at an entry speed of 50 mph or less in the Fishhook Procedure developed by NHTSA. This procedure may be found at www.regulations.gov, docket item NHTSA-2006-26555-0136.

The testing reported herein was accomplished under contract DTNH22-14-D-00332. The task order is entitled, "NCAP Dynamic Rollover Testing."

Section II
VEHICLE PREPARATION

A. Test Vehicle

The test vehicle was new or in as-new condition, meaning the vehicle had been driven no more than 500 miles prior to the start of dynamic rollover testing. It was acquired through a commercial rental/leasing company. Details of the test vehicle are given in Table 1.

B. Tires

All tires used were new, and of the same make, model, size, and DOT specification of those installed on the vehicle when purchased new. Tire inflation pressures were in accordance with the recommendations indicated on each vehicle's identification placard. To further reduce the possibility of tire debanding, the tires were mounted to the rims without the use of tire mounting lubricant. Tire specifications are listed in Table 2.

C. Vehicle Loading

The multi-passenger load, described in the Fishhook Procedure, was used for all tests. The load and positioning of the load in the vehicle are listed in Table 3.

In addition to water dummies, the loading included instrumentation, a steering machine, and outriggers. Test vehicle bumper assemblies were removed for outrigger installation. The reduction in vehicle weight due to the removal of the bumpers was offset by the additional weight of the outriggers and their mounting system. The outrigger system typically outweighs the bumper assemblies.

Table 1. Test Vehicle Data

General Data					
Model year, make, model	2020 Volvo XC60 T5 FWD Inscription				
VIN	YV4102DL6L145xxxx				
Vehicle type/Body style	MPV/SUV				
Number of doors	4				
Trim level	T5 FWD INSCRIPTION				
Seating positions	Front:	2 nd row	3 rd row	4 th row	5 th row
	2	3	0	0	0
Electronic stability control	Yes				
4-Wheel ABS (Yes/No)	Yes				
Power steering (Yes/No)	Yes				
Major optional equipment	Inscription Exterior Elements, Tailored Dashboard, Driftwood Deco Inlays, Power Cushion Extensions, Front Seats, Power Passenger Seat Memory, 4-Zone Automatic Climate Control, Interior High Level Illumination, LED Front Fog Lights, Storage Net on Center Tunnel Heated Wiperblades with Integrated Washers, Power Retractable Rearview Mirrors, Autodimming Interior & Exterior Mirrors, HomeLink Garage Door Opener, Power Folding Rear Headrests, Compass in Rearview Mirror, Blind Spot Information System (BLIS) with Steer Assist & Cross Traffic Alert w/ Autobrake, Front Park Assist, Keyless Entry w/ Handsfree Tailgate Opening, Sensus Navigation Pro, 600W Harman Kardon Premium Audio w/14 Speakers, Heated Front Seats & Heated Steering Wheel, Metallic Paint, Exterior Styling Kit, Protection Package Premier, Linear Lime Deco Inlays, 20" Inscription Wheels w/All-Season Tires				
Odometer at start of testing	15 miles				

Table 1. Test Vehicle Data (continued)

Drivetrain	
Engine cylinder arrangement	Inline 4
Engine displacement	2 L
Transmission type	Automatic
Drive arrangement	2WD (FWD)
Chassis	
Track width	F: 64.5 in (1638.3 mm), R: 64.75 in (1644.6 mm)
Wheelbase	113 in (2870.2 mm)
Curb weight	4034 lb (1829.8 kg)
Certification Data from Vehicle's Label	
Vehicle manufactured by	VOLVO CAR CORPORATION
Date of manufacture	08/19
GVWR	5225 lb (2370 kg)
GAWR Front	2620 lb (1188 kg)
GAWR Rear	2690 lb (1220 kg)

Table 2. Tire Information

Tire Manufacturer	CONTINENTAL
Tire Model	CROSS CONTACT LX SPORT
Tire Size	Front: 255/45R20 Rear: 255/45R20
Load rating	Front: 105 Rear: 105
Speed rating	Front: H Rear: H
Treadwear grade	Front: 460 Rear: 460
Traction grade	Front: A Rear: A
Temperature grade	Front: A Rear: A
Location of "Recommended Tire Pressure" label	Driver's door jamb
Recommended cold tire pressure	Front: 35 psi, (240 kPa) Rear: 35 psi, (240 kPa)
First 8 digits of DOT code	Front: HW12 D48A Rear: HW12 D48A

Table 3. Vehicle Loading

Water dummy and other loading	3 water dummies in second row
Water dummy weight	175 lb (79.4 kg)
Fuel level	Full
Weight as Tested	
Left front	1339 lb (607.4 kg)
Right front	1287 lb (583.8 kg)
Left rear	1205 lb (546.6 kg)
Right rear	1210 lb (548.8 kg)

D. Steering Controller

Precise controlled steering is accomplished using a steering machine designed and constructed by DRI. DRI has used its Automated Vehicle Controller (AVC) steering machine for many vehicle tests including FMVSS 126 tests. It can provide up to 65 ft-lb torque and rates over 1300 deg/sec. The integrated angle encoder has an unlimited range with a resolution of 0.045 degrees and an accuracy of ± 0.045 degrees. The steering motor is controlled by a MicroAutoBox II from dSPACE, which also acts as the data acquisition system.

E. Real-Time Controller and Data Acquisition

Data acquisition is achieved using a MicroAutoBox II from dSPACE, which also serves as the real-time system for the steering controller. 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 Micro AutoBox. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (Table 5). The MicroAutoBox II specifications are:

Model: dSPACE Micro-Autobox II 1401/1513
Base Board SN 549068
I/O Board SN 588523

Two video cameras were used to record the Fishhook runs. They were positioned nominally as shown in Figure 1. The recorded videotapes were reviewed after the Fishhook runs to check for any two-wheel lift. If any two-wheel lift was observed, eight infrared distance- measuring sensors for measurement of wheel lift (two sensors at each wheel) were then mounted for use in subsequent confirmation Fishhook tests.

F. Equipment Weight

Table 4 lists the equipment and associated weights outlined in the NHTSA Laboratory Test Procedure for Dynamic Rollover and the equipment at DRI used for this specific test program. The equipment used at DRI for this test program differs slightly from the equipment that was previously used by NHTSA for rollover testing. Because DRI's equipment is lighter than NHTSA's equipment, DRI uses ballast to maintain a consistent weight and weight distribution in the vehicle.

Table 4. Weight of In-Cab Test Equipment

Equipment	Location	Equipment Weight (lb)	
		NHTSA*	DRI
Data Acquisition System	Front passenger seat	58	
Steering Machine	Handwheel	31	31
Steering Machine Electronics Box	Passenger row foot well behind the front passenger seat. If vehicle does not have a rear passenger row foot well, the Electronics Box should be placed in the front passenger seat foot well.	39	
MABX, and laptop	Front passenger seat		21
Motor control and power supply	Front passenger footwell		26
Ballast	Front passenger footwell		50
Total		128	128

* Table A.1 from US DOT NHTSA - Laboratory Test Procedure for Dynamic Rollover - The Fishhook Maneuver Test Procedure - New Car Assessment Program (NCAP) - March 2013

G. Sensors

A list of the sensors is given in Table 5.

H. Other Vehicle Preparation

In addition to installation and preparation discussed above, the test vehicle was prepared as follows:

- Front and rear bumpers were removed
- Outrigger mounts were installed in the bumper locations and titanium outriggers were fastened to these mounts
- Airbags were removed or otherwise disabled
- Photographs of the vehicle tested are given in Appendix A.

Table 5. Sensors

Measured Variable	Sensor	Range	Resolution	Accuracy	Specifics	Serial Number	Calibration
Vehicle Tire Pressure	Tire Pressure Gauge	0-100 psi 0-690 kPa	0.01 psi 6.89 kPa	< 1% error between 20 and 100 psi	Omega DPG8001	17042707002	By: DRI Date: 7/3/2019 Due: 7/3/2020
Vehicle Total, Wheel, and Axle Load	Platform Scales (Minter)	1200 lb/platform 5338 N/platform	1 lb 4.4 N	0.5% of applied load	Intercomp SWI	1110M206352	By: DRI Date: 1/6/2020 Due: 1/6/2021
	Platform Scales (Torrance)	1200 lb/platform 5338 N/platform	1 lb 4.4 N	0.5% of applied load	Intercomp SW500	0828MA19001	By: DRI Date: 9/12/2019 Due: 9/12/2020
Handwheel Angle	Steering Angle Encoder (Automated Steering Controller)	±800 deg	0.045 deg	±0.045 deg	DRI Automatic Vehicle Controller using dSPACE Micro-Autobox II	NA	Verified by DRI at installation ¹
Longitudinal, Lateral, and Vertical Acceleration Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle	Multi-Axis Inertial Sensing System	Accels ± 5 g, Angular Rate ±300 deg/s, Angle >45 deg, Velocity >200 km/h	Accels .001 g, Angular Rate 0.01 deg/s, Angle 0.05 deg, Velocity 0.1 km/h	Accels .001g, Angular Rate 0.01 deg/s, Angle 0.05 deg, Velocity 0.1 km/h	Oxford xNav 550	015386	By: Oxford Technical Solutions Date: 8/8/2019 Due: 8/8/2021

1 . The steering encoder is checked prior to beginning tests to verify that there are no faults. The steering controller is installed in the vehicle and the steering wheel is turned through two complete revolutions while recording data. The data are then reviewed for any dropouts or other nonlinearities that would indicate dust intrusion or faulty sectors.

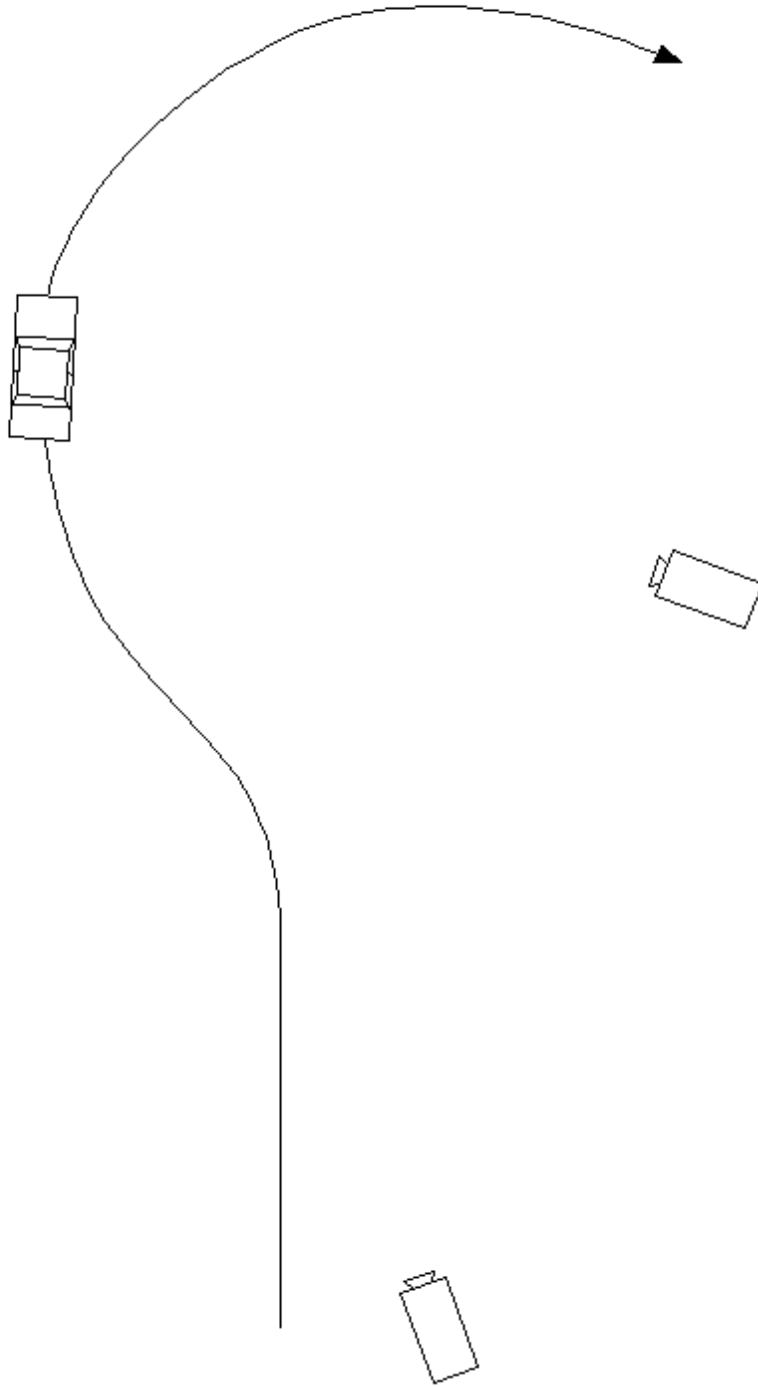


Figure 1. Nominal Position of Video Cameras for Fishhook Tests

Section III

TEST PROCEDURES

This section includes a general overview of the test procedures and details of the particular test.

A. Test Procedure Overview

This test was conducted in accordance with NHTSA's NCAP Rollover Resistance Test Procedure (Fishhook) as described in the Federal Register (68 FR 59250). Detailed descriptions of the test procedure, pass/fail criteria, and data acquisition specifications may be found at docket NHTSA-2001-9663.

There are two major components of the test procedure, the Slowly Increasing Steer (SIS) pre-test and the Fishhook test.

The Slowly Increasing Steer (SIS) maneuver was used to characterize the steady state lateral dynamics of each vehicle, and is based on the "Constant Speed, Variable Steer" test defined in SAE J266. The maneuver is used to determine the handwheel angle that produces a lateral acceleration of 0.3 g at 50 mph. This handwheel angle is then used to determine the magnitude of steering to be used for the NHTSA Fishhook maneuver.

SIS tests were performed at a constant speed of 50 mph. Handwheel angle was input at a rate of 13.5 deg/sec, from 0 to an angle that provided at least 0.55 g. Three tests were conducted in each direction, and the data for the six runs were averaged to obtain the handwheel angle that produced 0.3 g at 50 mph.

The Fishhook test is a programmed steering maneuver that is implemented via the steering controller. The vehicle was initially steered in one direction and then the steering was reversed. The timing, magnitude, and rate of the steering were prescribed by the Fishhook Procedure.

To begin the maneuver, the vehicle was driven in a straight line at a speed slightly greater than the desired entrance speed. The driver then released the throttle. When the vehicle was at the target speed, the steering controller automatically initiated the steering maneuver. Following completion of the steering reversal, the handwheel position was maintained for three seconds and then returned to zero angle in 1 second.

The tests were conducted in both left-right and right-left directions. The "Default" test series used a handwheel angle equal to 6.5 times the handwheel angle that produced 0.3 g at 50 mph in the SIS tests, and initial vehicle speeds beginning at 35 mph and concluding up to 50 mph (if no two-wheel lift occurs). Supplemental tests were also done, as specified in the Fishhook Procedure.

B. Test Conditions

1. TEST SURFACE

The tests were conducted on the Vehicle Dynamics Area at DRI's Minter Field facility, located near Bakersfield, California, on 1/24/2020. The VDA has a smooth, flat (slope less than 0.5% throughout) asphaltic concrete surface. Its dimensions are as shown in Figure 2. It was built in the spring of 2005.

VDA surface friction measurements were accomplished using the DRI Mobile Tire Tester. Three runs were done, one at each of three previously determined locations. Each run provided for a minimum of 3 seconds of tire friction at constant normal load, slip angle, and speed in a free rolling condition. The test was accomplished using an ASTM E1136 tire with an inflation pressure of 35 (± 0.5) psi at a test speed of 40 (± 0.5) mph. The net slip angle of the test tire for each test run was 7.5 deg. The test tire was no older than 6 months from the date of manufacture. The surface friction measurement results are shown in Table 6.

Table 6. Surface Friction

Date of surface friction measurements	1/24/2020
Average normalized lateral force	0.773

2. FISHHOOK HANDWHEEL ANGLES

The 0.3 g handwheel angle obtained from the SIS tests and the handwheel angles used in the Fishhook tests are shown in Table 7.

Table 7. Handwheel Angles

0.3 g handwheel angle (from SIS tests at 50 mph)	26.4°
5.5 scalar handwheel angle for Fishhook Test	145°
6.5 scalar handwheel angle for Fishhook Test	172°

3. WEATHER CONDITIONS

The weather conditions, recorded at the end of testing, are shown in Table 8.

Table 8. Weather Conditions

Ambient temperature	55.9° F (13.3° C)
Wind Speed	2 mph (0.8 m/s)
Wind Direction	180

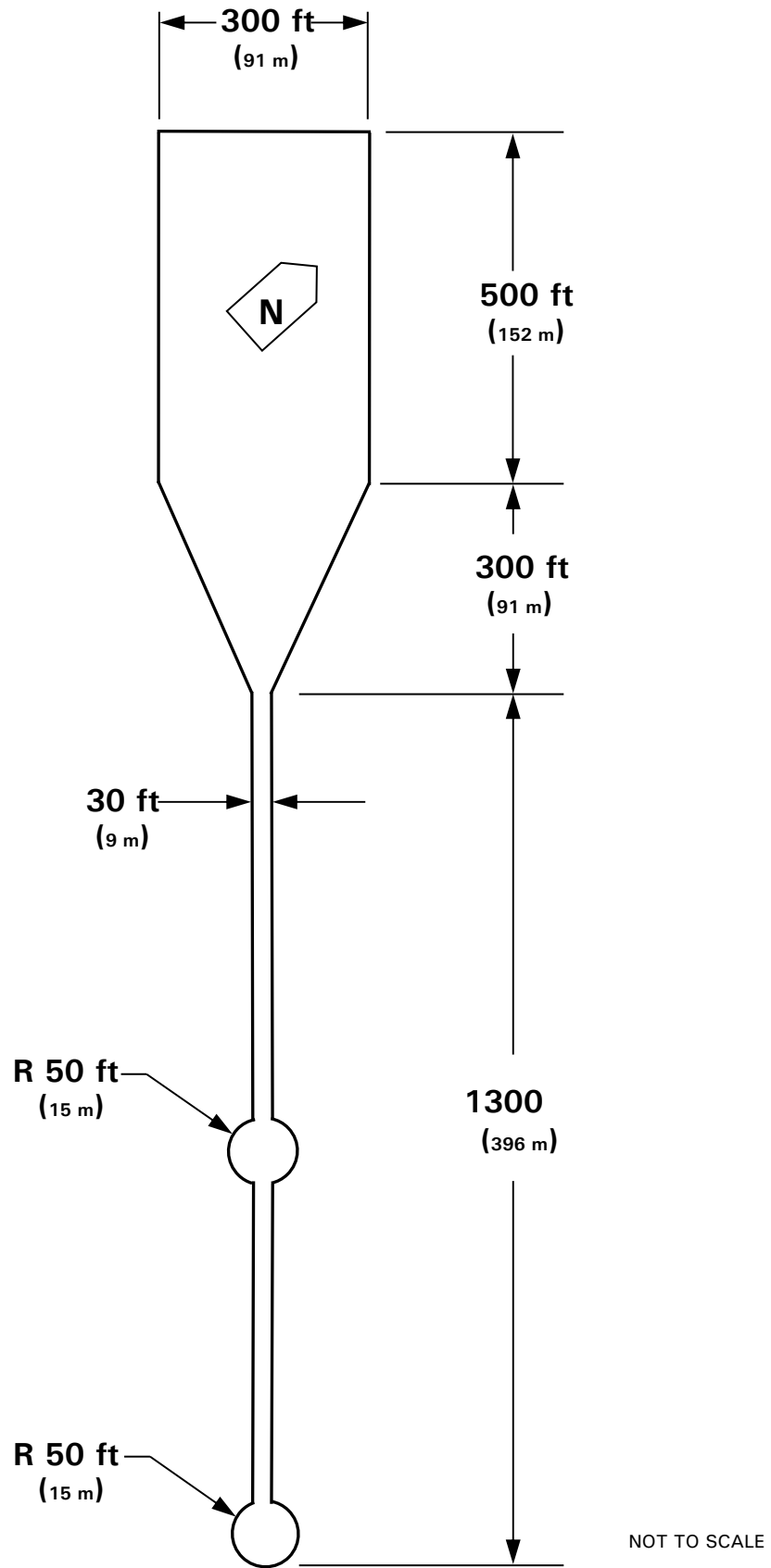


Figure 2. DRI-Minter Vehicle Dynamics Area

Section IV

RESULTS

The test run log is given in Appendix B. The Slowly Increasing Steer Test Worksheet is given in Appendix C. Appendix D contains time history plots for the 50 mph runs and any runs which resulted in two-wheel lift. There was no two-wheel lift at any test condition for the 2020 Volvo XC60 T5 FWD Inscription.

APPENDIX A

Photographs

LIST OF FIGURES

	Page
A1. Window Sticker.....	A-3
A2. Front View, Test Vehicle as Delivered	A-4
A3. Rear View, Test Vehicle as Delivered	A-5
A4. Front View, Test Vehicle in Test Condition	A-6
A5. Rear View, Test Vehicle in Test Condition	A-7
A6. Certification Label.....	A-8
A7. Tire Placard	A-9
A8. Instrumentation in Test Vehicle	A-10
A9. Steering Controller and Computer	A-11
A10. Ballast Condition.....	A-12

2020VOLVO

XC60 T5 FWD INSCRIPTION



Volvo Car USA LLC
www.volvocars.com/us

PERFORMANCE

2.0L Turbo-Charged, Direct Inject Engine
250 HP @ 5500 RPM and 298 lb-ft Torque @ 1500 RPM
8-Speed Geartronic Automatic Trans w/ Start-Stop
Double Wishbone Front & Integral Link Rear Susp
Adjustable Drive-Mode Settings
Anti-Lock Braking Sys (ABS) w/ Hill Start Assist
Advanced Electronic Stability Control (ESC)
Dynamic Chassis
Electric Power Assisted Steering
19" Inscription Alloy Wheels with All-Season Tires

AUTHORIZED RETAILER

WARRANTY

48 Month/50,000 Mile Limited Warranty Coverage
144 Month Corrosion Protection "Unlimited Mileage"
Refer to Warranty Info Book for Specific Limitations.

VOLVO On Call Roadside Assistance

Volvo Increased Protection: Ask Your Volvo Retailer About an Extended Service Contract

AUDIO & TECHNOLOGY

9" Integrated Sensus Connect Touchscreen Inlet,
Sensus Navigation Pro
WiFi Hotspot and Complimentary Trial Subscription
Smartphone Integ. (Apple CarPlay/Android Auto)
12.3" Digital Driver Display
Volvo On Call with 4-Yr Complimentary Subscription
Incl. Mobile App w/ Remote Start & Nav Send to Car
600W Harman Kardon Premium Sound w/ 14 Speakers
HD Radio / 2 USB Ports
Bluetooth Handsfree w/ Audio Streaming
SensusXM Radio w/ 3-month Trial Subscription

SAFETY & SECURITY

Collision Avoidance by City Safety
Detects Vehicle/Pedestrian/Cyclist/Large Animal
Run-off Road Protection & Run-off Road Mitigation
Lane Keeping Aid & Oncoming Lane Mitigation
Road Sign Information
Supplemental Restraint System (Airbags):
Driver Adaptive & Front Pass Dual Stage, Driver
Knee, Driver/Front Pass Dual Chamber Side-Impact,
Inflatable Curtain Head Side-Impact (Incl. Rear)
Side Impact Protection System (SIPS)
Whiplash Protection System (WHIPS) in Front Seats
Unibody High Strength Steel Safety Cage
Five, 3-Point Safety Belts w/ Pretensioners
Lower Anchors and Tethers for Child Seats
Child Safety Locks in Rear Doors
Hill Descent Control
LED Headlights w/Thor's Hammer DRL & Auto Highbeam
Rear Park Assist & Rear Park Assist Camera

LUXURY & CONVENIENCE

Blind Spot Information System (BLIS) with
Steer Assist & Cross Traffic Alert with Autobrake
Laminated Panoramic Moonroof w/Power Sunshade
Power Cushion Extensions, Front Seats
10-way, Power Front Seats w/ Memory
Keyless Entry w/ Handsfree Tailgate Opening
Rear Park Assist Camera
Power Tailgate with Programmable Height
4-Zone Automatic Climate Control + CleanZone
Driftwood Deco Inlays
Tailored Dashboard
Split Folding Backrest with Load Through Hatch
Aluminum Grill Plates / Illuminated Door Handles
Interior High Level Illumination
Heated Wiperblades with Integrated Washers
Heated Front Seats
12V Power Outlet in Rear

MAINTENANCE

Complimentary Factory Scheduled Maintenance for the
First 3 Years or 36,000 Miles

ACCESSORIES

Enhance the driving pleasure with Volvo accessories.
Enrich the styling, integrate technology, boost
performance, or simply carry more cargo - from
function to fun, there's something for everyone.

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Scan this Smartphone QR code
or visit <https://accessories.volvocars.com/us>

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YouTube: Volvo Car USA

The price shown does not include Gasoline, License and Title Fees, State and
Local Taxes and Dealer Installed Options and Accessories. The factory reserves
the right to modify price, design and equipment without previous notice.

PRICING

IMPORTER'S SUGGESTED LIST PRICE P.O.E.: \$ 40,150.00

Inscription Features
Inscription Exterior Elements
Tailored Dashboard
Driftwood Deco Inlays
Power Cushion Extensions, Front Seats
Power Passenger Seat Memory
4-Zone Automatic Climate Control
Interior High Level Illumination
LED Front Fog Lights
19" Inscription Wheels with All-Season Tires
Storage Net on Center Tunnel
Heated Wiperblades with Integrated Washers
Power Retractable Rearview Mirrors
Autodimming Interior & Exterior Mirrors
HomeLink Garage Door Opener
Power Folding Rear Headrests
Compass in Rearview Mirror
Blind Spot Information System (BLIS) with
Steer Assist & Cross Traffic Alert w/ Autobrake
Front Park Assist
Keyless Entry w/ Handsfree Tailgate Opening
Sensus Navigation Pro
600W Harman Kardon Premium Audio w/ 14 Speakers

Heated Front Seats & Heated Steering Wheel	750.00
Metallic Paint	645.00
Exterior Styling Kit*	1,540.00
Protection Package Premier*	605.00
Linear Lime Deco Inlays	
20" Inscription Wheels w/ All-Season Tires	800.00
Destination Charge	995.00
Total Suggested Retail Price:	\$ 52,185.00

EPA DOT Fuel Economy and Environment

Gasoline Vehicle

Fuel Economy

24 MPG Small SUV-ZWD range from 18 to 120 MPG. The best vehicle rates 135 MPG.

22 29
Combined city/hwy city highway

4.2 gallons per 100 miles

You spend
\$ 2,750
more in fuel costs
over 5 years
compared to the
average new vehicle.

Annual Fuel Cost

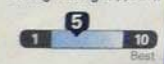
\$ 2,050

Fuel Economy & Greenhouse Gas Rating (tailpipe only)



This vehicle emits 262 grams CO2 per mile. The best emits 9 grams per mile (tailpipe only). Producing and distributing fuel also create emissions; learn more at fuel-economy.gov

Smog Rating (tailpipe only)



Actual 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 \$ 7,500 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at \$3.25 per gallon. MPGe is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

fuel-economy.gov

Calculate personalized estimates and compare vehicles



PARTS CONTENT INFORMATION

FOR VEHICLES IN THIS
CARLINE: VOLVO SERIES

U.S./CANADIAN PARTS
CONTENT: 1%

MAJOR SOURCES OF
FOREIGN PARTS CONTENT:
SWEDEN: 25%

FOR THIS VEHICLE:
FINAL ASSEMBLY POINT:
GOTHENBURG, SWEDEN

COUNTRY OF ORIGIN:
ENGINE PARTS:
SWEDEN

TRANSMISSION PARTS:
JAPAN

Note: Parts contents does not include
final assembly, distribution, or other
non-parts costs.

GOVERNMENT 5-STAR SAFETY RATINGS

This vehicle has not been rated by the government for overall
vehicle score, frontal crash or rollover risk.

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

VEHICLE IDENTIFICATION
Type & Chassis: 246 453703
Model Year: 2020
Color: Onyx Black Metallic
VIN: YV4102DL6L145

Port of Importation: Hueneme, CA
Delivered by: Truck
DELIVERY ADDRESS



YV4102DL6L145

Figure A1. Window Sticker



Figure A2. Front View, Test Vehicle as Delivered



Figure A3. Rear View, Test Vehicle as Delivered



Figure A4. Front View, Test Vehicle in Test Condition

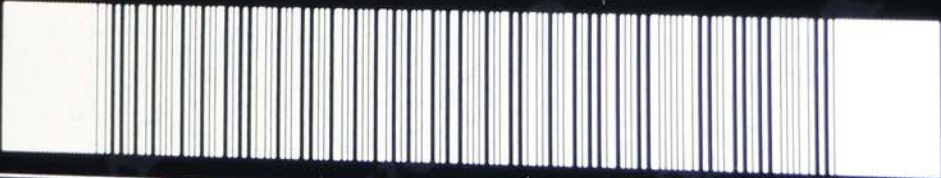


Figure A5. Rear View, Test Vehicle in Test Condition

MFD BY VOLVO CAR CORPORATION DATE: 08/19

VIN: YV4102DL6L145 MARKET CODE: 31 GVWR: 5225 LB
PRESSURE FRONT: 35 PSI, 240 KPA COLD GAWR FRONT: 2620 LB
PRESSURE REAR: 35 PSI, 240 KPA COLD GAWR REAR: 2690 LB
TIRES: 255/45R20 RIM: 8Jx20x52.5 COLOUR: 717

THIS VEHICLE CONFORMS TO ALL APPLICABLE FEDERAL MOTOR
VEHICLE SAFETY AND THEFT PREVENTION STANDARDS IN EFFECT
ON THE DATE OF MANUFACTURE SHOWN ABOVE. TYPE: MPV



VOLVO 31689473

Figure A6. Certification Label



TIRE AND LOADING INFORMATION

SEATING CAPACITY | TOTAL 5 | FRONT 2 | REAR 3

The combined weight of occupants and cargo should never exceed : 430kg or 950lbs.

TIRE	SIZE	COLD TIRE PRESSURE	SEE OWNERS MANUAL FOR ADDITIONAL INFORMATION
FRONT	255/45R20	240kPa, 35psi	
REAR	255/45R20	240kPa, 35psi	
SPARE	T125/80R18	420kPa, 60psi	

VOLVO 31416488

Figure A7. Tire Placard

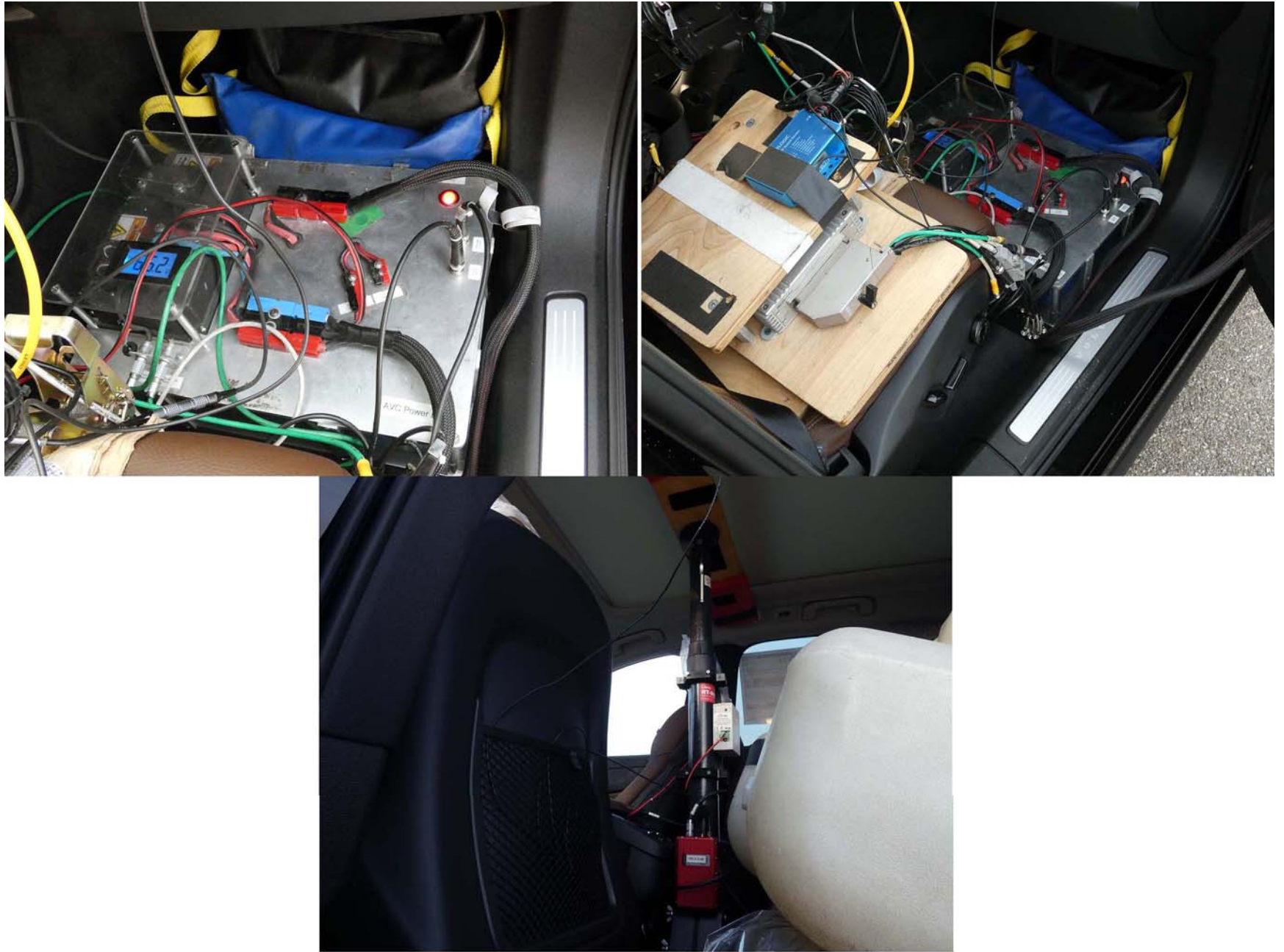


Figure A8. Instrumentation in Test Vehicle



Figure A9. Steering Controller and Computer



Figure A10. Ballast Condition

APPENDIX B

Test Run Log

Vehicle: **2020 Volvo XC60 T5 FWD Inscription**

Driver: **Jonathan Robel**

Test Date: **1/24/2020**

Run Number	Test Type	Speed (mph)	Handwheel Angle (deg)	Dir. of First Steer	2 Wheel Lift	Notes
1	Tire Warm-Up	35	60	Right	NA	
2					"	
3					"	
4					"	
5	2x SWA last cycle				"	
6	Static	0	0			
7	Steady State	50	0			
8	Slowly Increasing Steer	50	50	Left	NA	
9	"	"	"	Left	"	
10	"	"	"	Left	"	
11	"	"	"	Right	"	
12	"	"	"	Right	"	
13	"	"	"	Right	"	
14	6.5 Scalar Fishhook	35	172	Left	No	
15	"	40	"	"	"	
16	"	45	"	"	"	
17	"	47.5	"	"	"	

Run Number	Test Type	Speed (mph)	Handwheel Angle (deg)	Dir. of First Steer	2 Wheel Lift	Notes
18	"	50	"	"	"	
19	5.5 Scalar Fishhook	45	145	Left	No	
20	"	47.5	"	"	"	
21	"	50	"	"	"	
22	6.5 Scalar Fishhook	35	172	Right	No	
23	"	40	"	"	"	
24	"	45	"	"	"	
25	"	47.5	"	"	"	
26	"	50	"	"	"	
27	5.5 Scalar Fishhook	45	145	Right	No	
28	"	47.5	"	"	"	
29	"	50	"	"	"	

APPENDIX C

Slowly Increasing Steer Test Worksheet

NCAP, 2020 Volvo XC60 T5 FWD Inscription, Multi-Passenger Load,

Test Date: 1/24/2020

SIS_out_v2

Run	Dir of Steer	Start Speed (mph)	End Speed (mph)	Speed Red. (%)	Index of ay @ 0.3g	HW Angle (deg) at 0.3g	ay (g) @ 0.3g index	6.5x HW Angle (deg)	Ramp Time (sec) at 6.5x	5.5x HW Angle (deg)	Ramp Time (sec) at 5.5x	R2	Zero Begin Index	Zero End Index
8	L	50.1	0.0	99.9	1201	-26.6	-0.304	-172.9	-0.2402	-146.3	-0.2032	0.9947	600	800
9	L	49.9	0.0	100.0	1200	-26.6	-0.303	-172.7	-0.2399	-146.2	-0.2030	0.9962	600	800
10	L	49.8	0.4	99.2	1204	-26.8	-0.300	-174.4	-0.2422	-147.5	-0.2049	0.9957	601	800
11	R	50.3	0.5	98.9	1190	26.0	0.298	168.8	0.2344	142.8	0.1984	0.9980	600	800
12	R	50.2	1.4	97.2	1194	26.2	0.303	170.6	0.2369	144.3	0.2005	0.9970	600	800
13	R	49.8	0.4	99.2	1194	26.2	0.296	170.6	0.2370	144.4	0.2005	0.9983	600	800

Mean: 26.4 0.301 172 0.238 145 0.202

Steering Controller Input Values

Scalar 6.5 values:

Initial HW angle: 172 deg
 Initial time: 0.238 s
 Reversal HW angle: -172 deg
 Reversal time: 0.477 s

Scalar 5.5 values:

Initial HW angle: 145 deg
 Initial time: 0.202 s
 Reversal HW angle: -145 deg
 Reversal time: 0.404 s

APPENDIX D

Time History Plots

LIST OF FIGURES

	Page
D1. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, L-R, 50 mph	D-3
D2. Steering Machine Operation Time History Plots for Default Test Series, L-R, 50 mph.....	D-4
D3. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Default Test Series, L-R, 50 mph	D-5
D4. Pitch Rate and Longitudinal Acceleration Time History Plots for Default Test Series, L-R, 50 mph	D-6
D5. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, R-L, 50 mph	D-7
D6. Steering Machine Operation Time History Plots for Default Test Series, R-L, 50 mph	D-8
D7. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Default Test Series, R-L, 50 mph	D-9
D8. Pitch Rate and Longitudinal Acceleration Time History Plots for Default Test Series, R-L, 50 mph	D-10
D9. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Supplemental 2 Test Series, L-R, 50 mph.....	D-11
D10. Steering Machine Operation Time History Plots for Supplemental 2 Test Series, L-R, 50 mph.....	D-12
D11. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Supplemental 2 Test Series, L-R, 50 mph.....	D-13
D12. Pitch Rate and Longitudinal Acceleration Time History Plots for Supplemental 2 Test Series, L-R, 50 mph.....	D-14
D13. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Supplemental 2 Test Series, R-L, 50 mph.....	D-15
D14. Steering Machine Operation Time History Plots for Supplemental 2 Test Series, R-L, 50 mph.....	D-16
D15. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Supplemental 2 Test Series, R-L, 50 mph.....	D-17
D16. Pitch Rate and Longitudinal Acceleration Time History Plots for Supplemental 2 Test Series, R-L, 50 mph.....	D-18

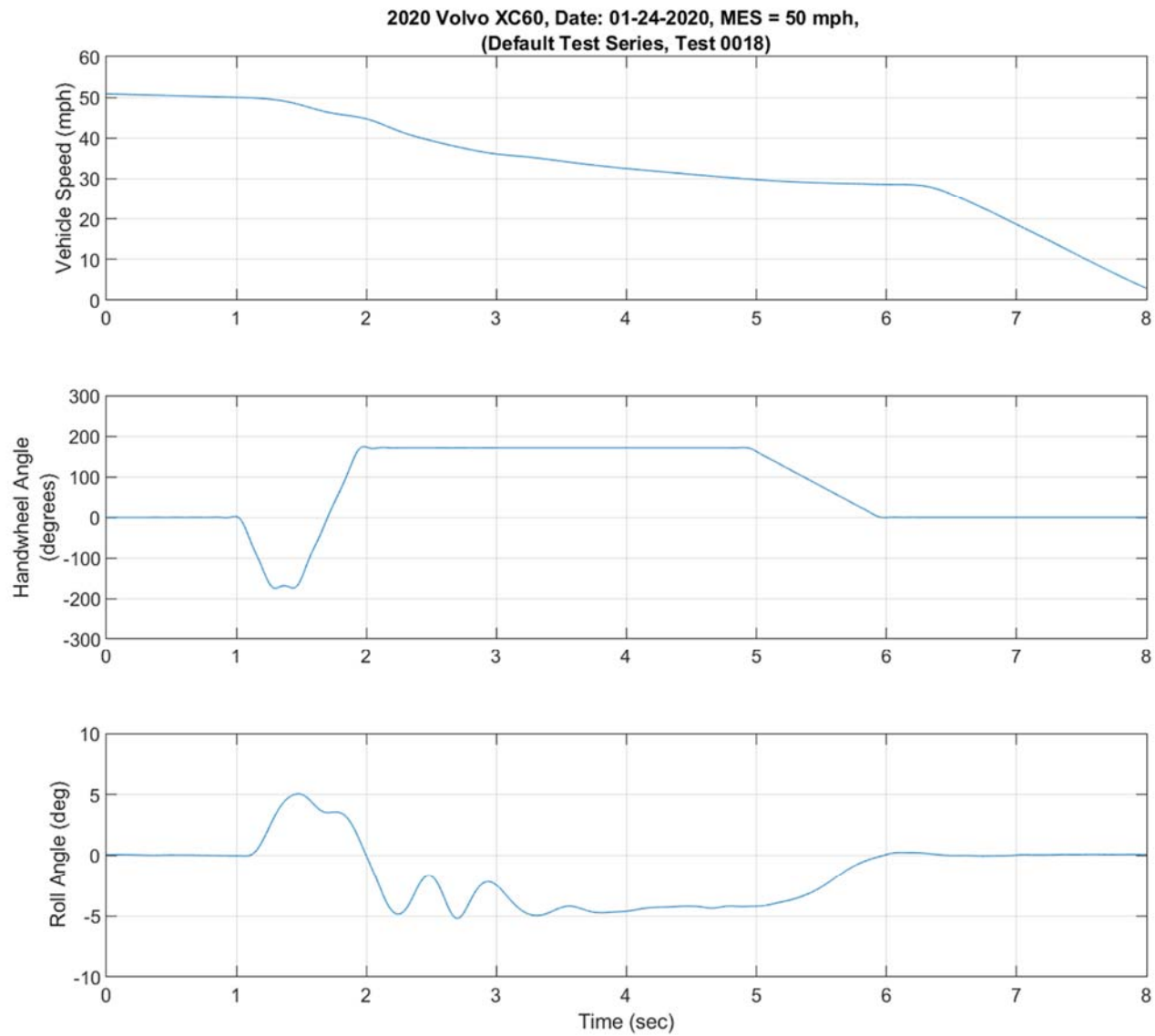


Figure D1. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, L-R, 50 mph

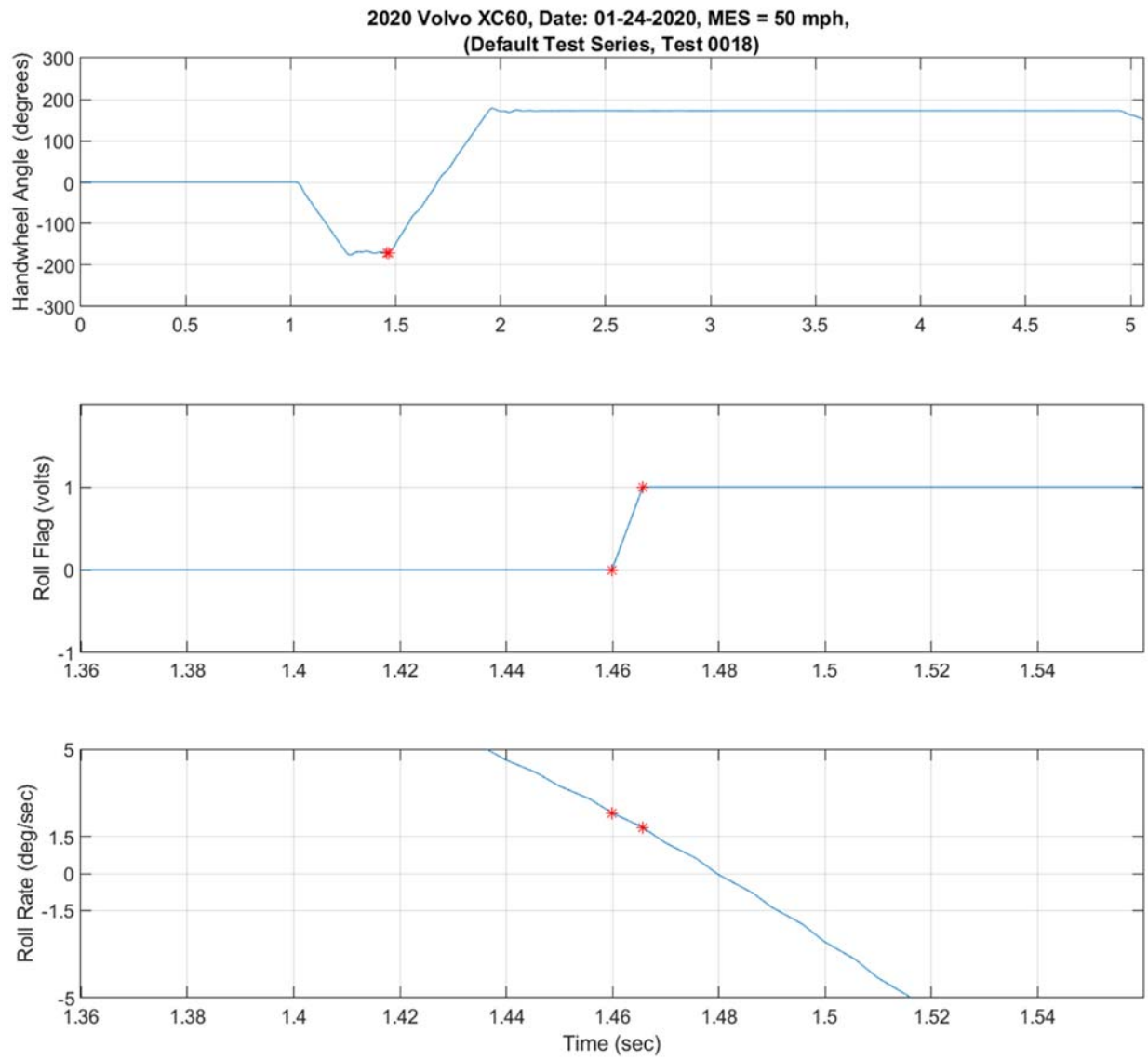


Figure D2. Steering Machine Operation Time History Plots for Default Test Series, L-R, 50 mph

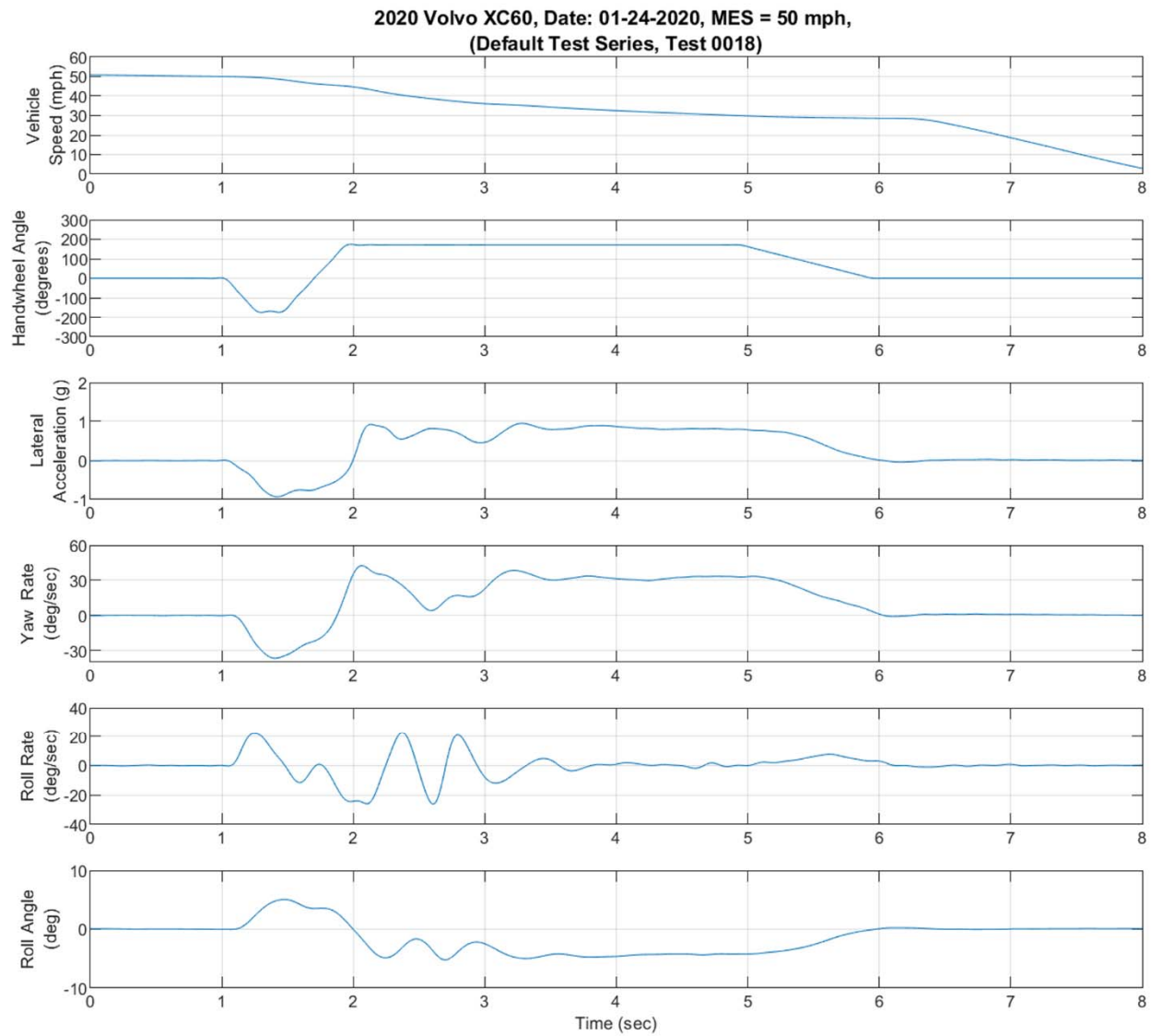


Figure D3. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots For Default Test Series, L-R, 50 mph

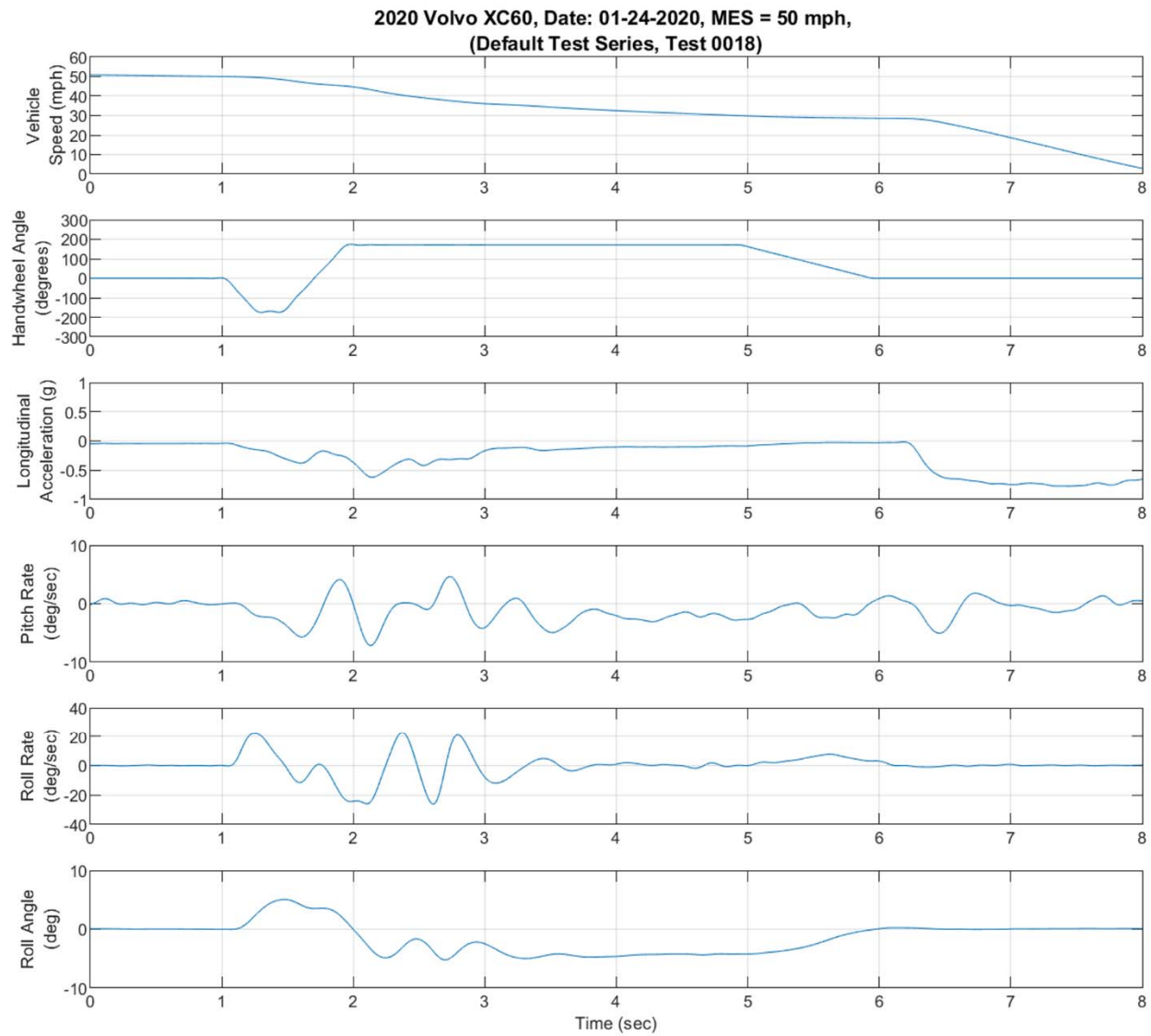


Figure D4. Pitch Rate and Longitudinal Acceleration Time History Plots for Default Test Series, L-R, 50 mph

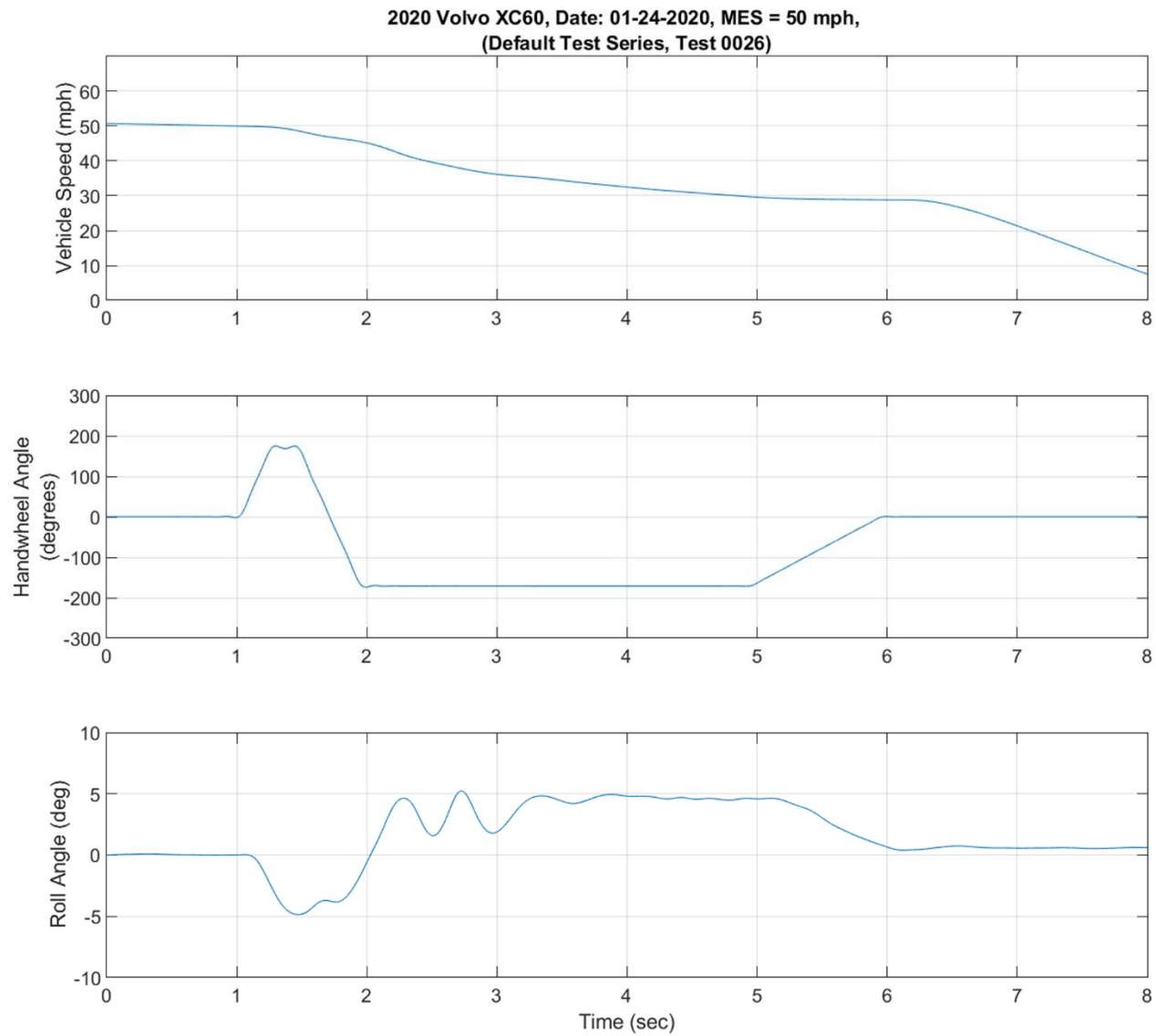


Figure D5. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, R-L, 50 mph

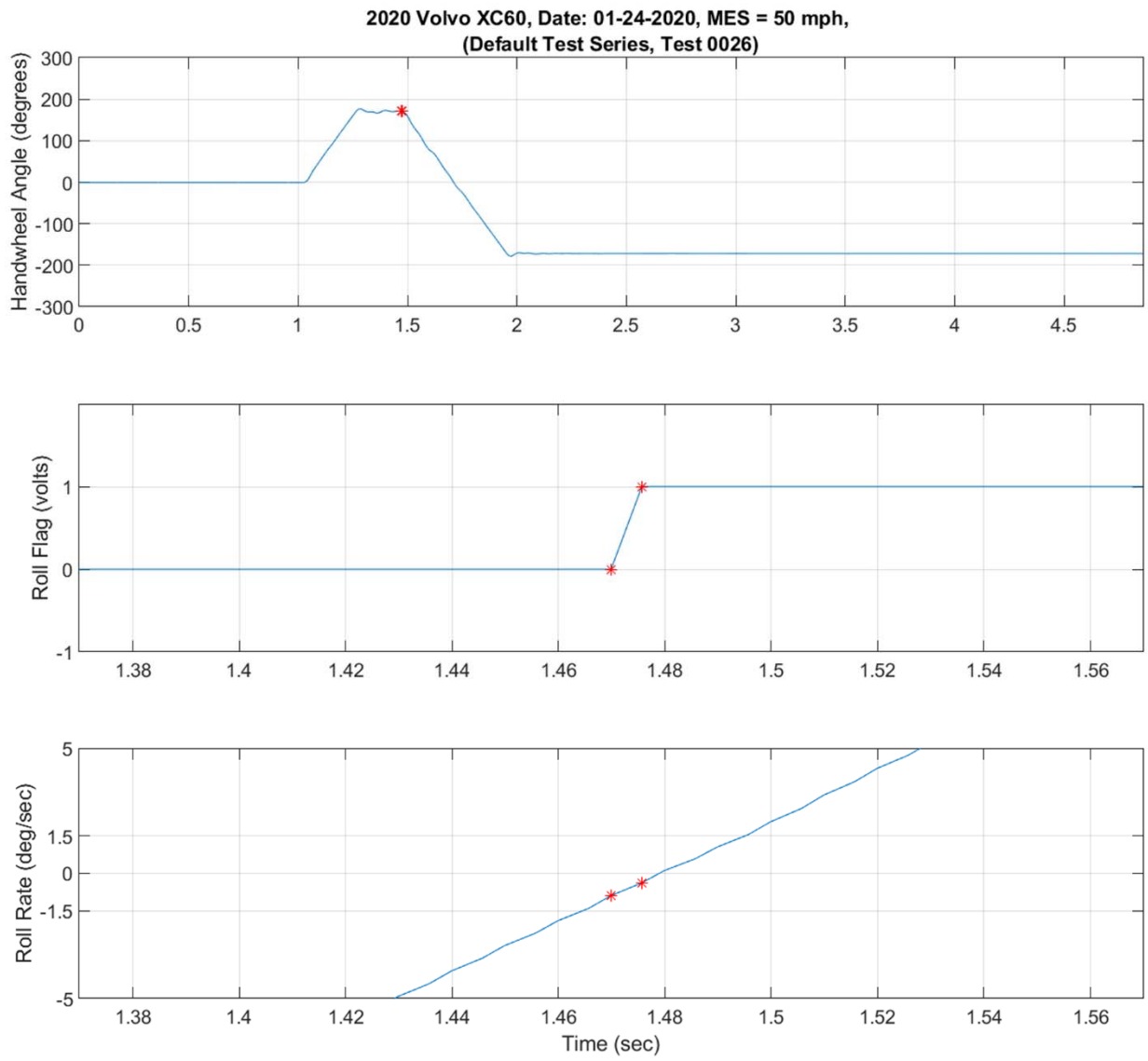


Figure D6. Steering Machine Operation Time History Plots for Default Test Series, R-L, 50 mph

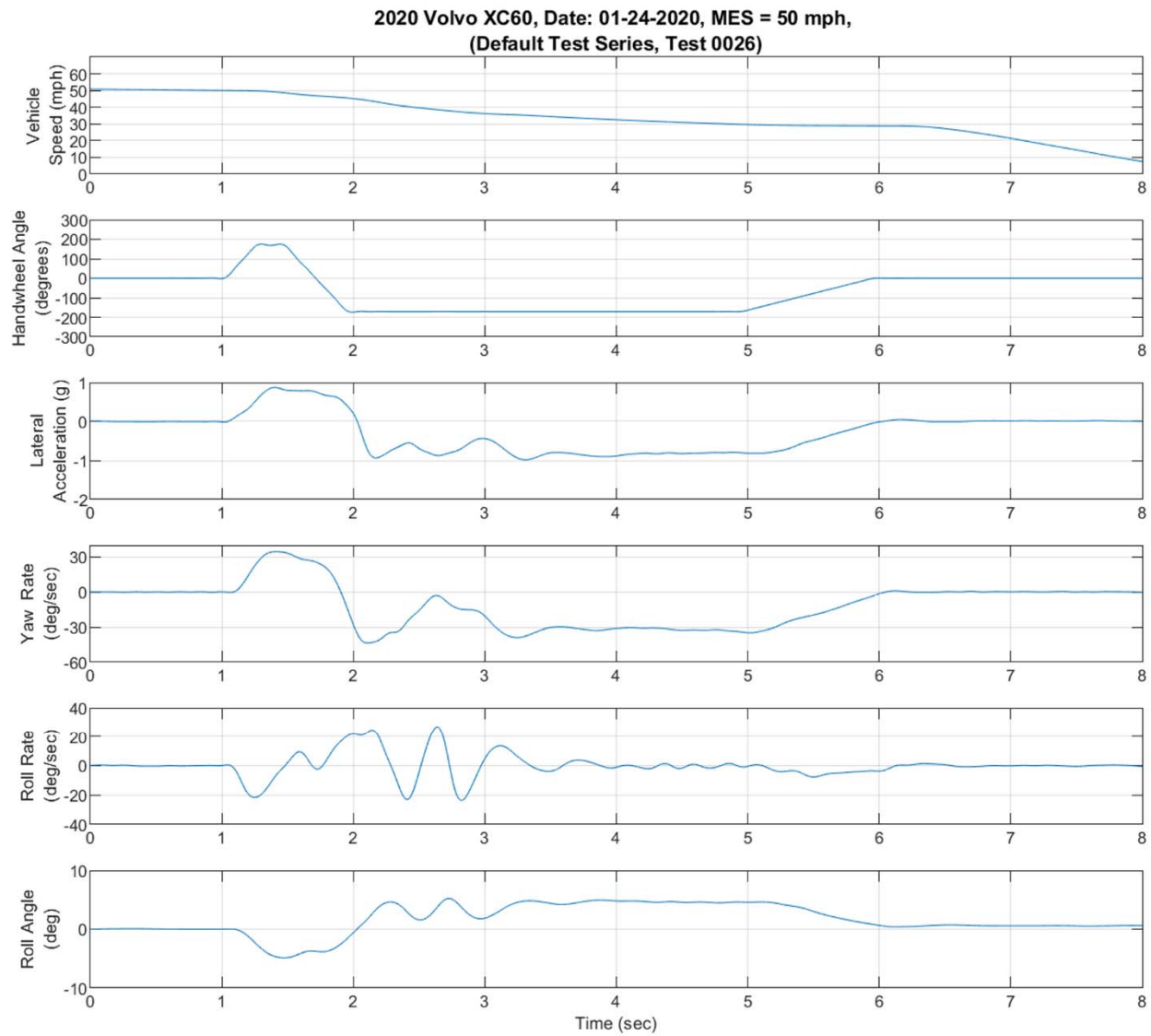


Figure D7. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Default Test Series, R-L, 50 mph

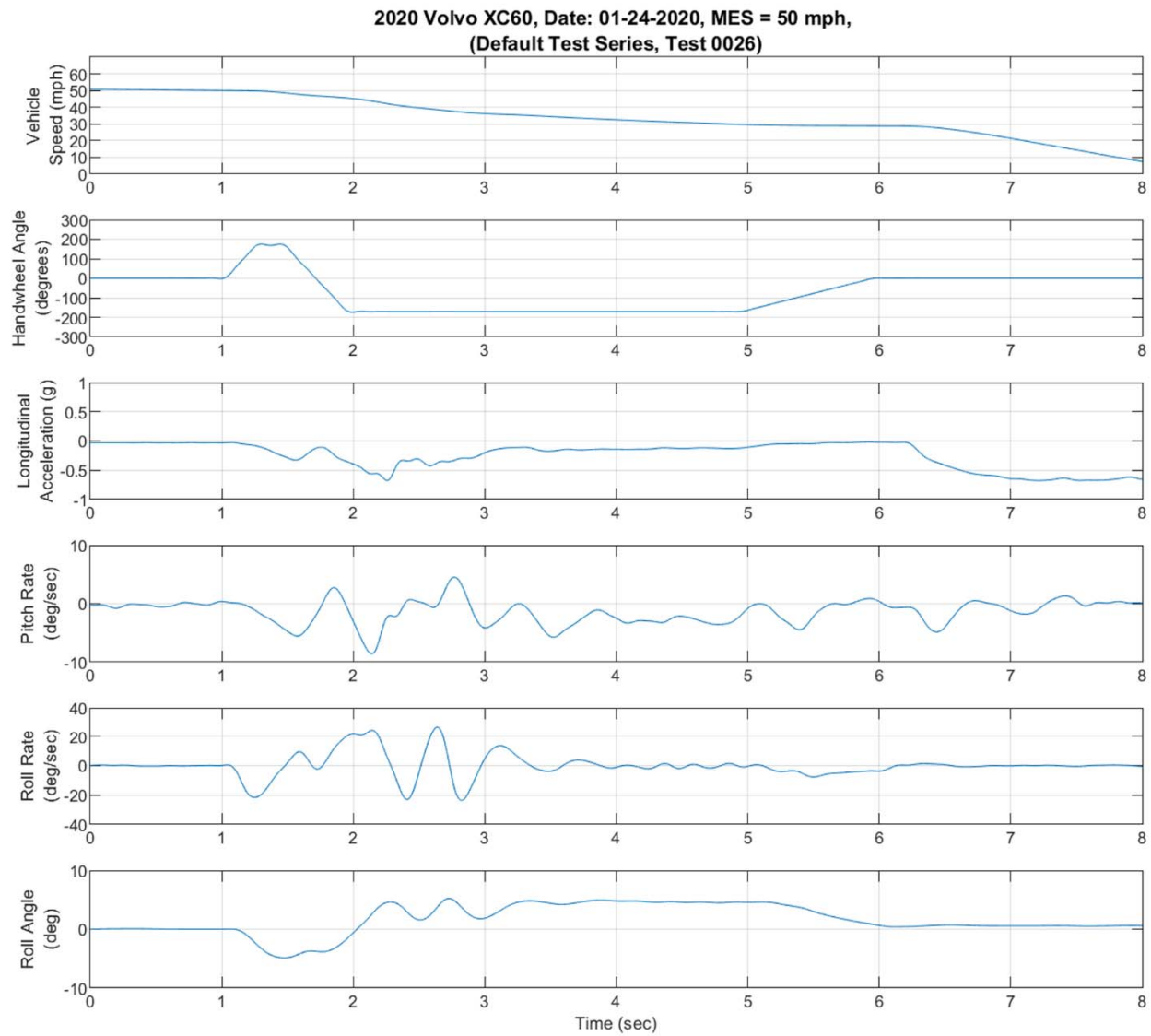


Figure D8. Pitch Rate and Longitudinal Acceleration Time History Plots or Default Test Series, R-L, 50 mph

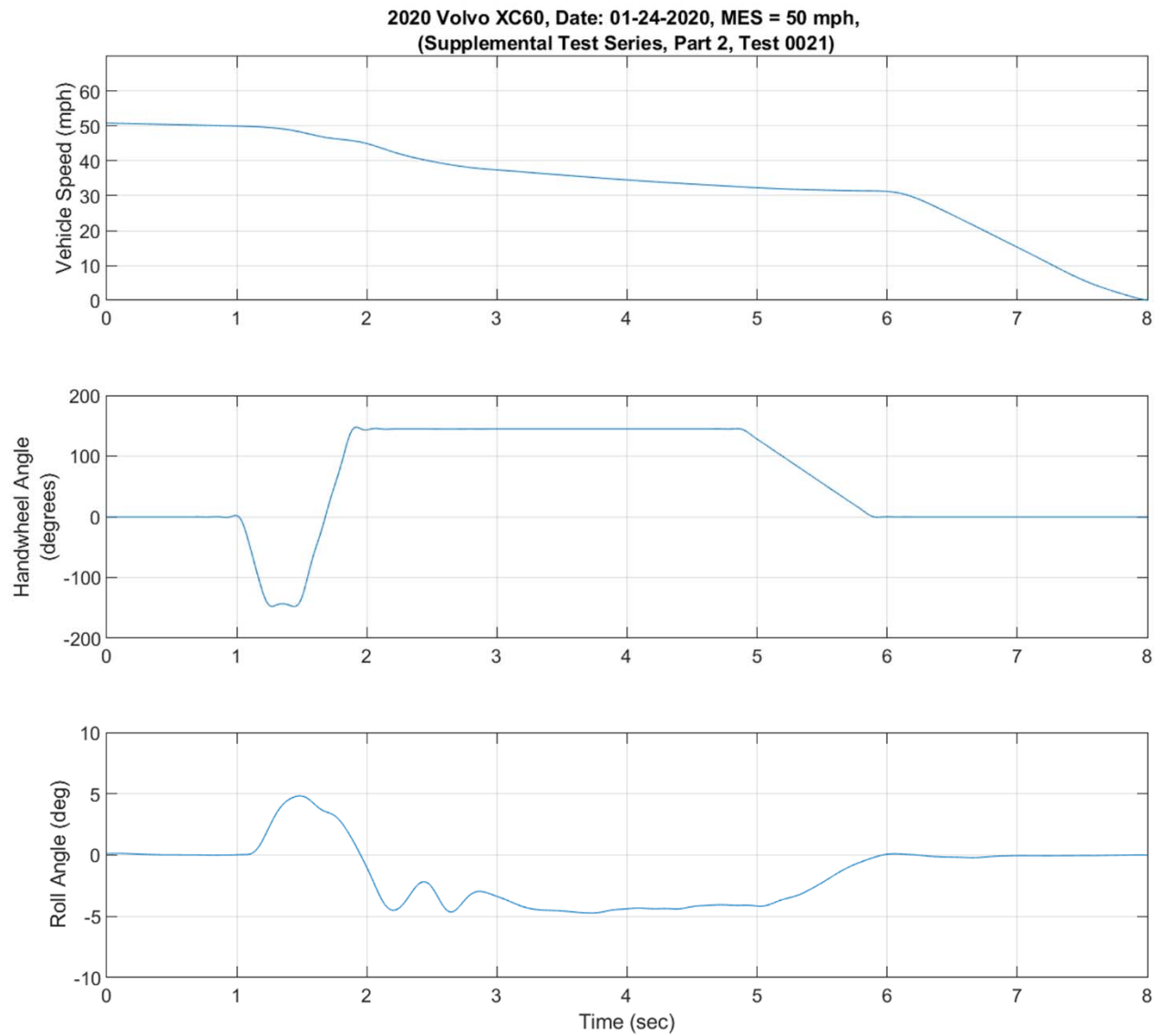


Figure D9. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

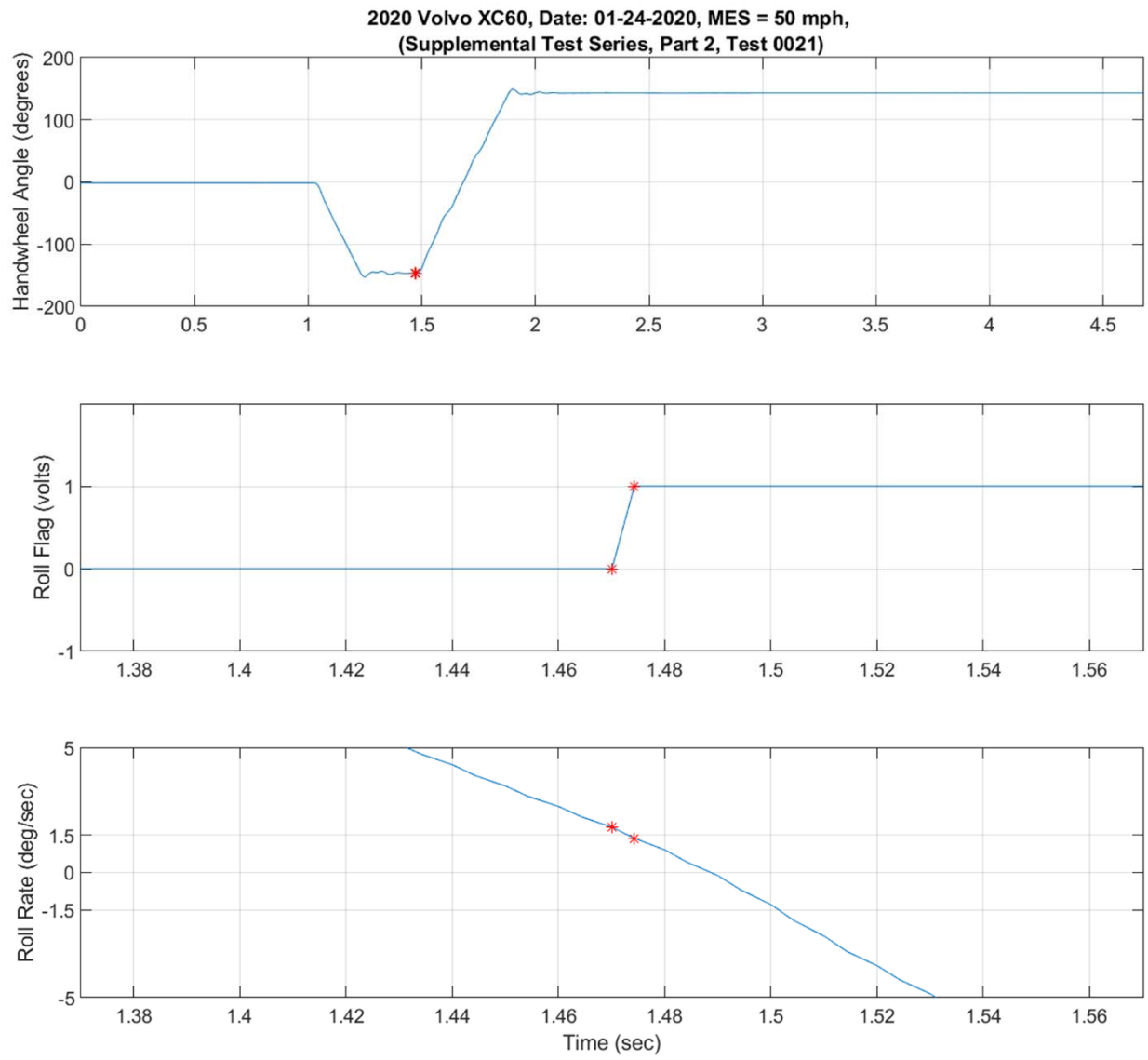


Figure D10. Steering Machine Operation Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

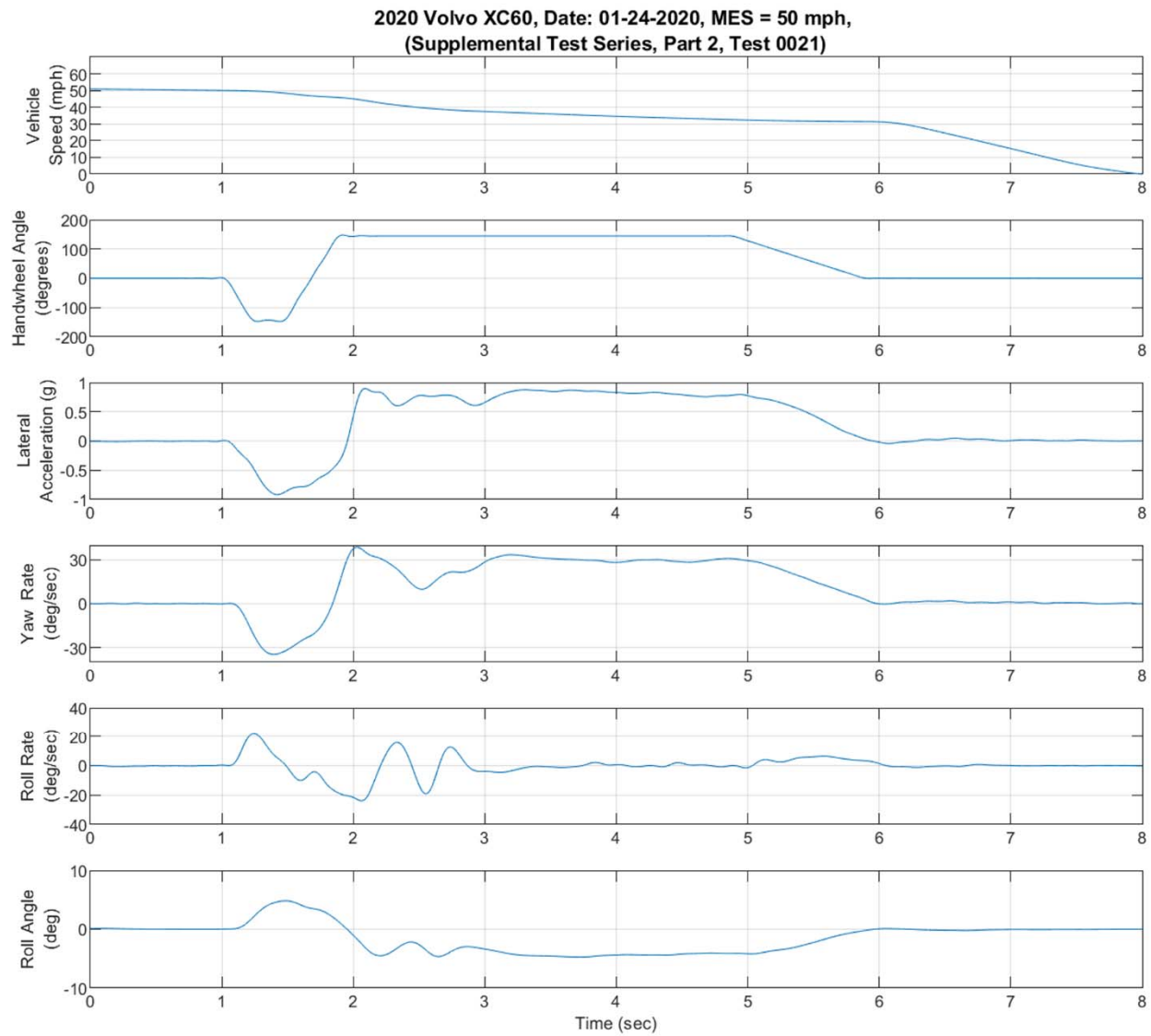


Figure D11. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

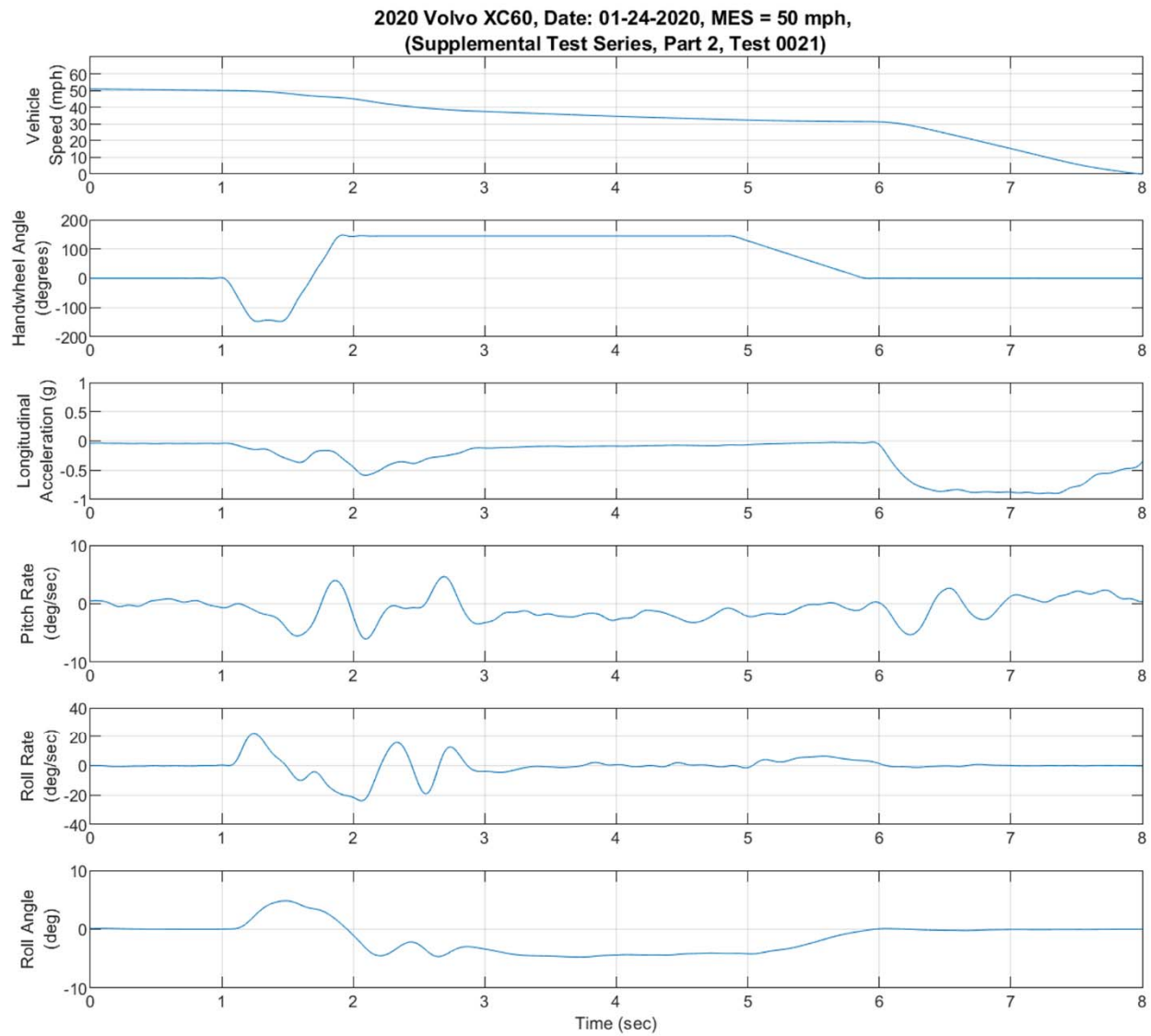


Figure D12. Pitch Rate and Longitudinal Acceleration Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

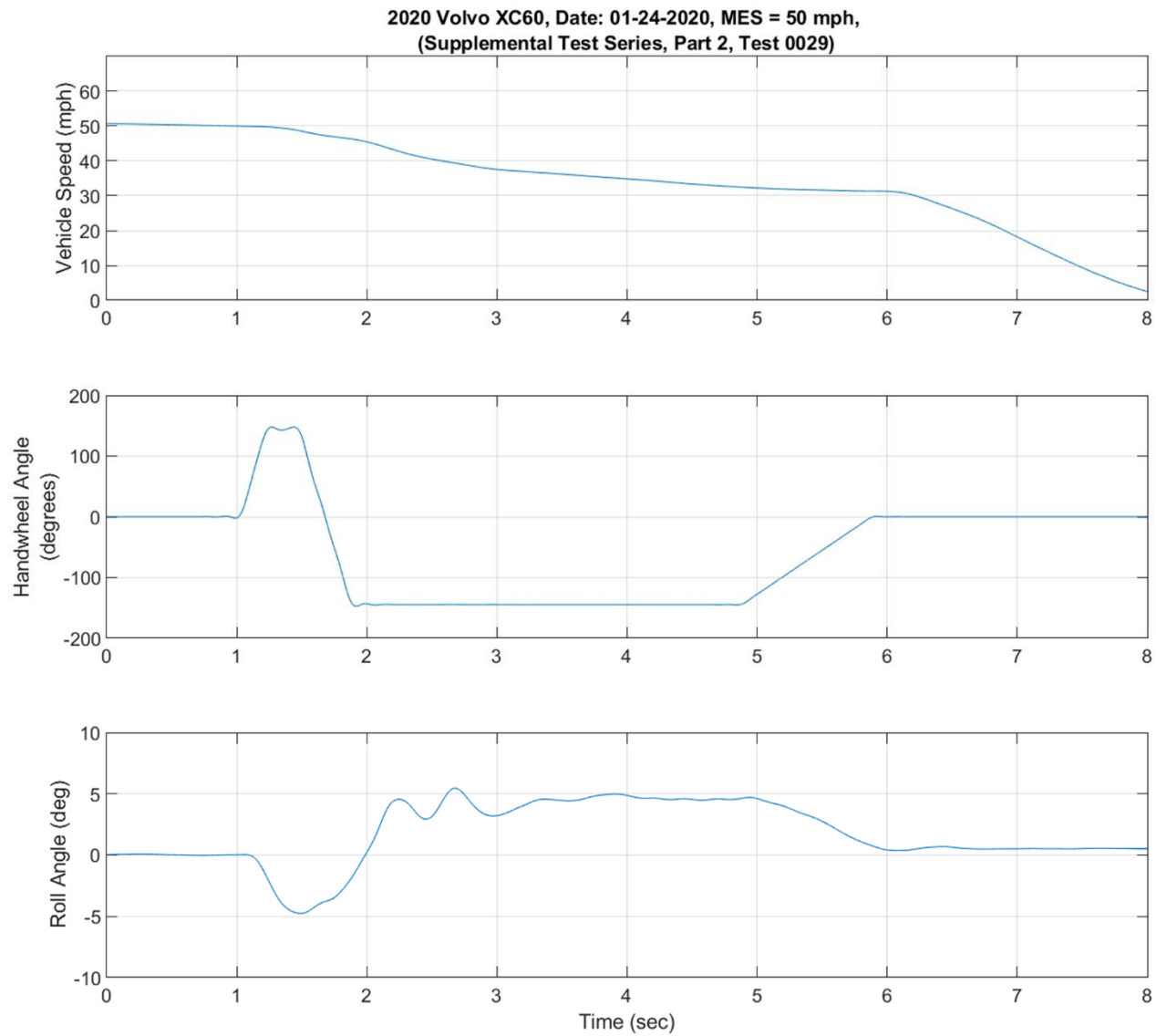


Figure D13. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

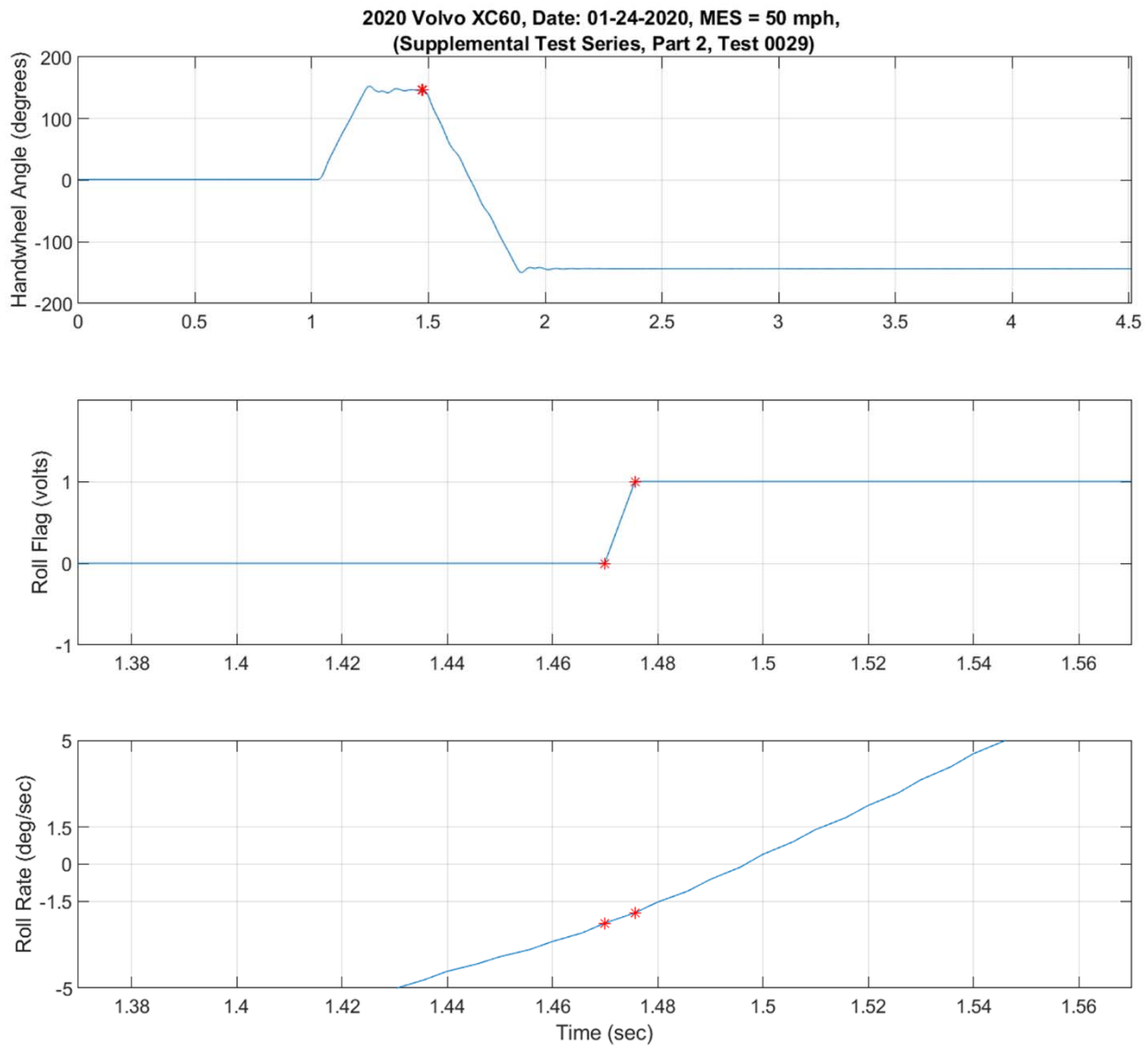


Figure D14. Steering Machine Operation Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

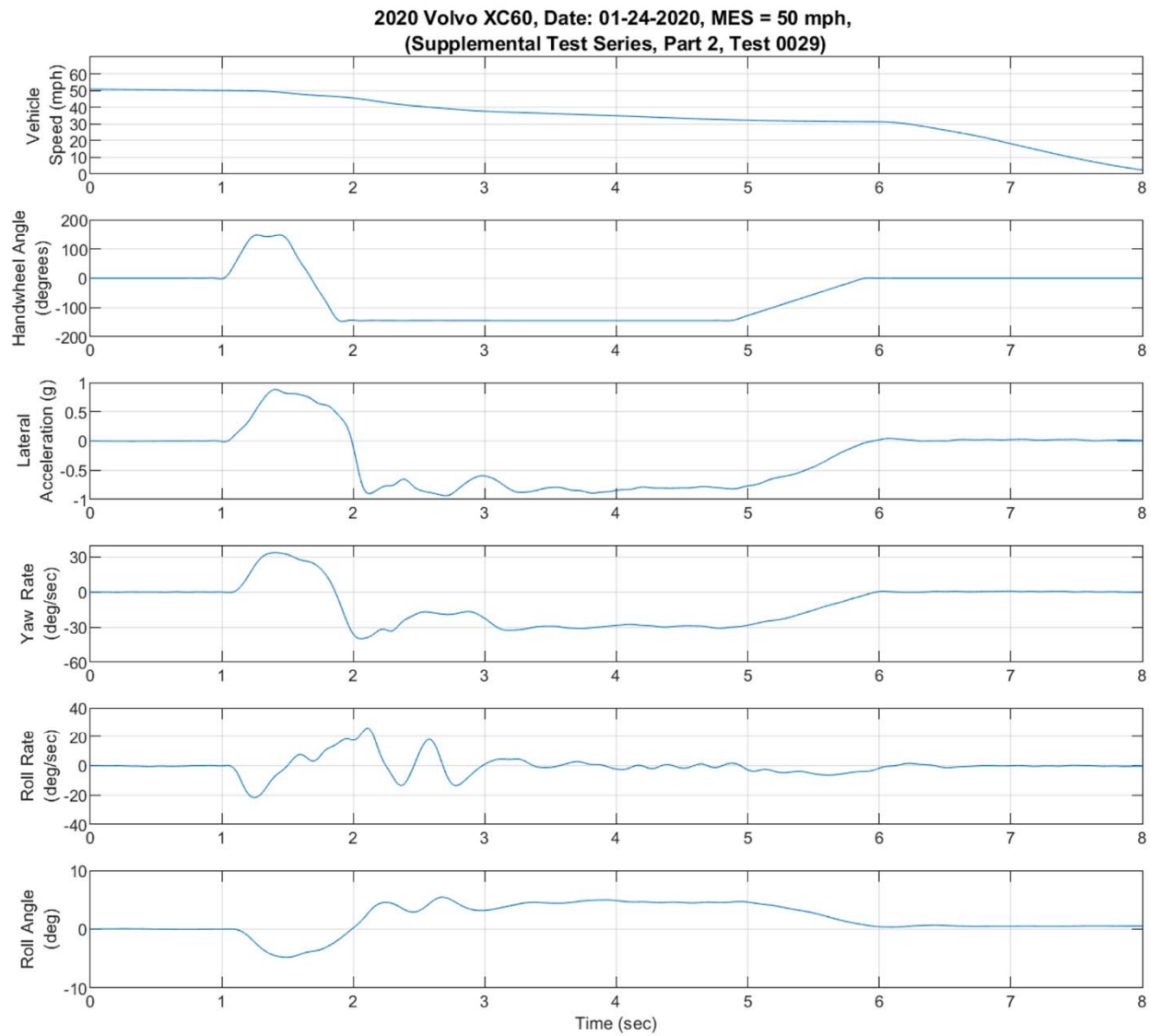


Figure D15. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

2020 Volvo XC60, Date: 01-24-2020, MES = 50 mph,
(Supplemental Test Series, Part 2, Test 0029)

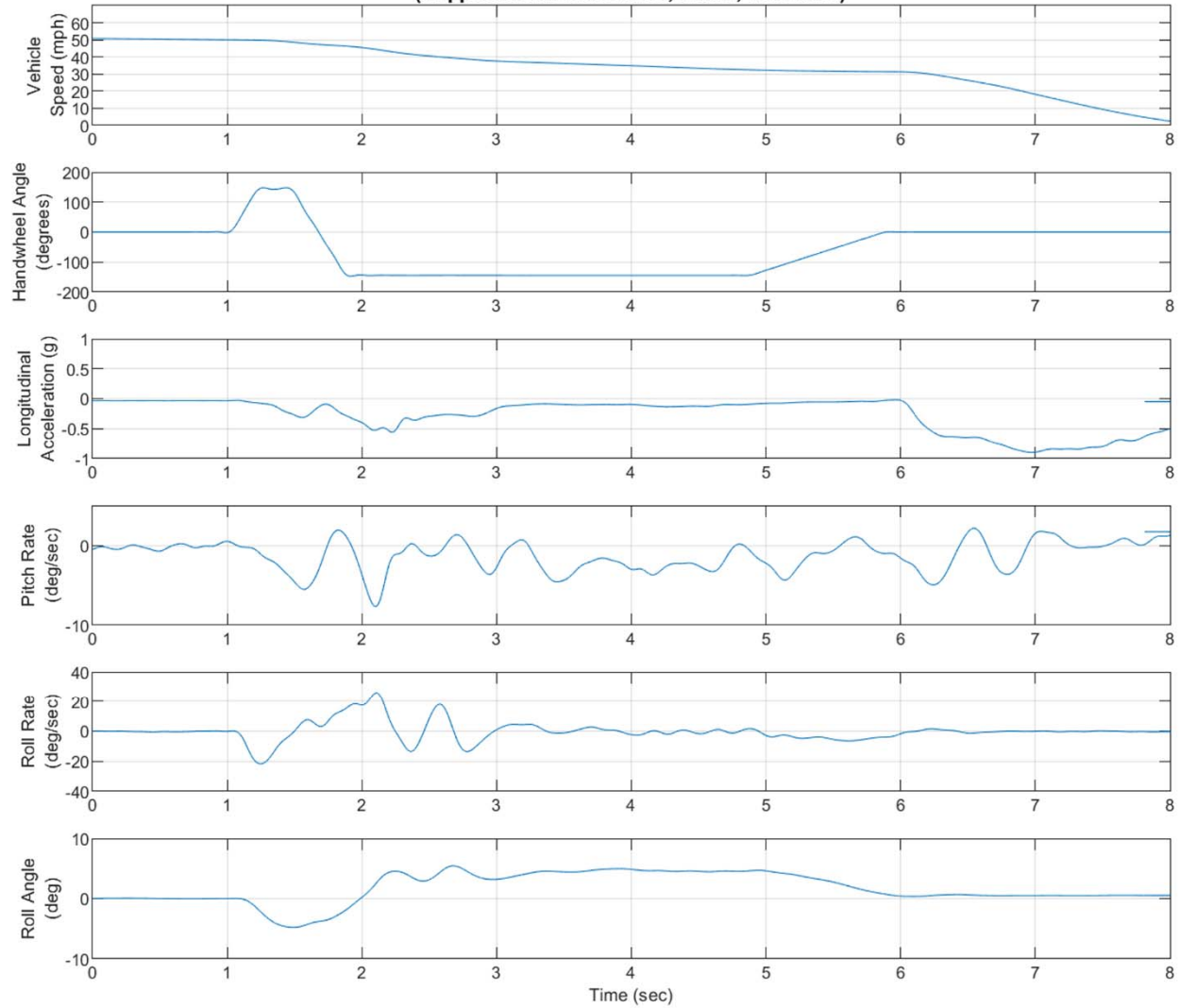


Figure D16. Pitch Rate and Longitudinal Acceleration Time History Plots for Supplemental 2 Test Series, R-L, 50 mph