

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

GENERAL MOTORS, LLC  
2018 Chevrolet Traverse FWD

TEST NUMBER: 18-22

Final Report  
14 May 2018



Prepared by:

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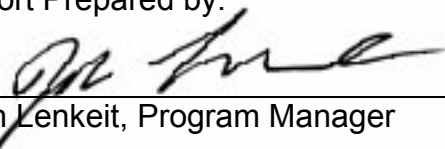
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16. Abstract  An NCAP Dynamic Rollover Maneuver (Fishhook) Test was conducted on a 2018 Chevrolet Traverse FWD at Dynamic Research, Inc. on October 23, 2017. The vehicle did not experience two-wheel lift. The vehicle's steering angle at 0.3 g lateral acceleration at 50 mph was 29.3 degrees.			
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## 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 2018 Chevrolet Traverse FWD 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](http://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, "New Car Assessment Program (NCAP) Non-Destructive Vehicle Testing and Data Gathering."

## 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 reduce the possibility of tire debanding during Fishhook testing, an appropriately sized inner tube was installed in each tire. 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

<b>General Data</b>					
Model year, make, model	2018 Chevrolet Traverse FWD				
VIN	1GNERKKW0JJ12xxxx				
Body style	SUV				
Number of doors	4				
Trim level	PREMIER				
Seating positions	Front:	2 <sup>nd</sup> row	3 <sup>rd</sup> row	4 <sup>th</sup> row	5 <sup>th</sup> row
	2	2	3		
Electronic stability control	Yes				
4-Wheel ABS (Yes/No)	Yes				
Power steering (Yes/No)	Yes				
Major optional equipment	REDLINE EDITION, DRIVER CONFIDENCE II PACKAGE				
Odometer at start of testing	7 miles				
<b>Drivetrain</b>					
Engine cylinder arrangement	V-6				
Engine displacement	3.6 L				
Transmission type	Automatic				
Drive arrangement	FWD				
<b>Chassis</b>					
Track width	F: 67.3 in (1709.4 mm) , R: 67 in (1701.8 mm)				
Wheelbase	120.9 in (3070.9 mm)				
Curb weight	4483 lb (2033.5 kg)				
<b>Certification Data from Vehicle's Label</b>					
Vehicle manufactured by	GENERAL MOTORS, LLC				
Date of manufacture	09/17				
GVWR	6173 lb (2800 kg)				
GAWR Front	3196 lb (1450 kg)				
GAWR Rear	3527 lb (1600 kg)				

Table 2. Tire Information

Tire Manufacturer	CONTINENTAL
Tire Model	CROSSCONTACT LX20
Tire Size	Front: 255/55 R20 Rear: 255/55 R20
Load rating	Front: 107 Rear: 107
Speed rating	Front: H Rear: H
Treadwear grade	Front: 680 Rear: 680
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: A3HH WC4F Rear: A3HH WC4F

Table 3. Vehicle Loading

Water dummy and other loading	3 water dummies - 2 in second row, 1 in center of third row
Water dummy weight	175 lb (79.4 kg)
Fuel level	Full
<b>Weight as Tested</b>	
Left front	1497 lb (679 kg)
Right front	1434 lb (650.5 kg)
Left rear	1320 lb (598.7 kg)
Right rear	1239 lb (562 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  $\pm 0.045$  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 4). The MicroAutoBox II specifications are:

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

A list of the sensors is given in Table 4.

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. 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

- A five point safety harness was installed.
- Airbags were removed or otherwise disabled

Photographs of the vehicle tested are given in Appendix A.

Table 4. Sensors

Measured Variable	Sensor	Range	Resolution	Accuracy	Specifics	Serial Number	Calibration
Vehicle Tire Pressure	Tire Pressure Gauge	0-100 psi 0-690 kPa	1 psi 6.89 kPa	0.5 psi 3.45 kPa	Omega DPG8001	17042707002	By: DRI Date: 6/8/2017 Due: 6/8/2018
Vehicle Total, Wheel, and Axle Load	Platform Scales (Minter)	8000 lb 35.6 kN	0.5 lb 2.2 N	±1.0% of applied load	Intercomp SW I	VS800W16-00455	By: DRI Date: 6/1/2017 Due: 6/1/2018
	Platform Scales (Torrance)				Proform 67644	24032361	By: DRI Date: 12/16/2016 Due: 12/16/2017
Handwheel Angle	Steering Angle Encoder (Automated Steering Controller)	±800 deg	0.25 deg	±0.25 deg	DRI Automatic Vehicle Controller using D-Space Micro-Autobox II	NA	Verified by DRI at installation <sup>1</sup>
Longitudinal, Lateral, and Vertical Acceleration Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle	Multi-Axis Inertial Sensing System	Accelerometers: ±10 g Angular Rate Sensors: ±100 deg/s Angle Sensors: >0.45deg Velocity > 200 km/h	Accelerometers: 0.001g Angular Rate Sensors: ≤0.01 deg/s Angle Sensors: .001 deg Velocity .01 km/h	Accelerometers: 0.1% Angular Rate Sensors: 0.1% Angle Sensors: .05 deg Velocity: 0.1 km/h	Oxford Technical Solutions Inertial+ Inertial and Motion Measurement Unit Calibration Interval 24 months	015386	By: Oxford Technical Solutions Date: 6/21/2017 Due: 6/21/2019

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.

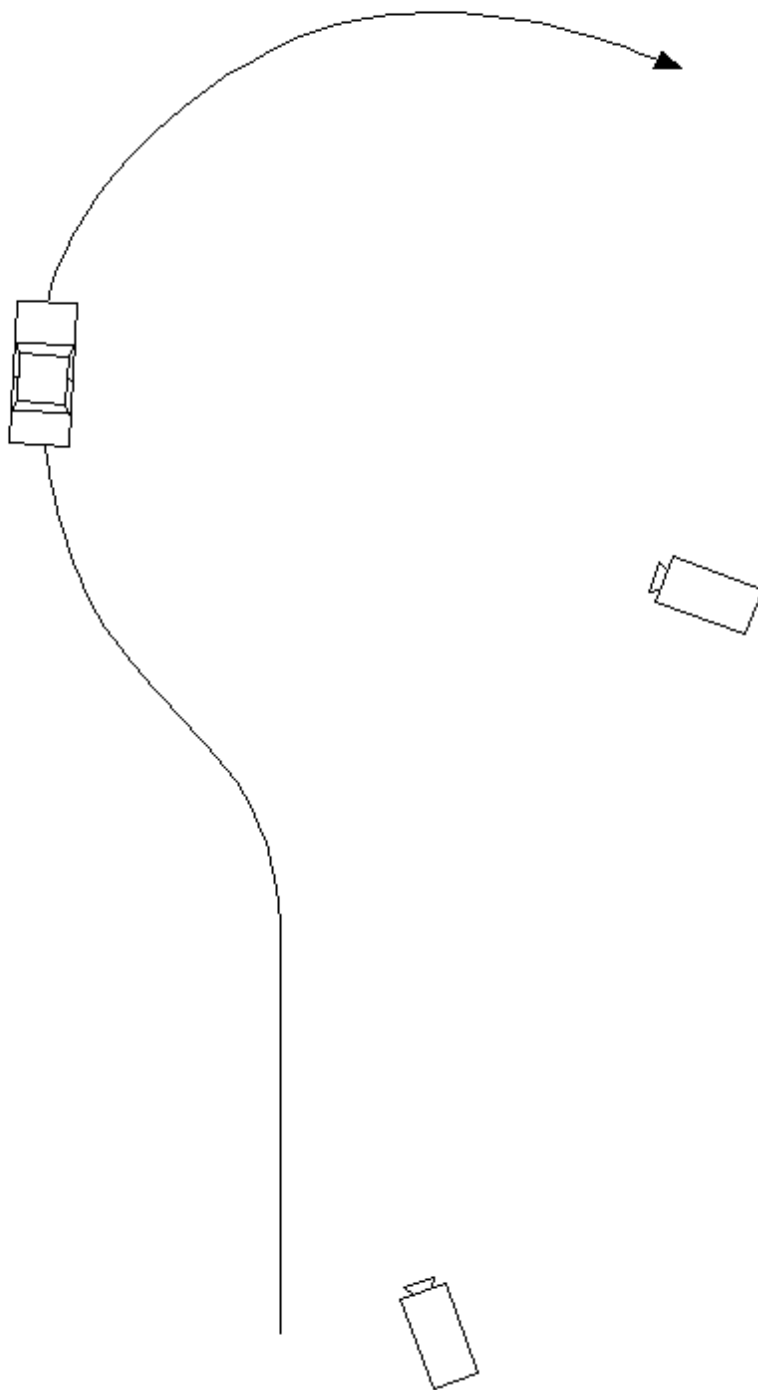


Figure 1. Nominal Position of Video Cameras for Fishhook Tests

## 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 10/23/2017. 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 ( $\pm 0.5$ ) psi at a test speed of 40 ( $\pm 0.5$ ) 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 5.

Table 5. Surface Friction

Date of surface friction measurements	10/23/2017
Average normalized lateral force	0.845

### 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 6.

Table 6. Handwheel Angles

0.3 g handwheel angle (from SIS tests at 50 mph)	29.3 °
5.5 scalar handwheel angle for Fishhook Test	161°
6.5 scalar handwheel angle for Fishhook Test	190 °



### 3. Weather Conditions

The weather conditions, recorded at the end of testing, are shown in Table 7.

Table 7. Weather Conditions

Ambient temperature	68 °F ( 20 °C)
Wind Speed	3 mph (1.3 m/s)
Wind Direction	W-NW

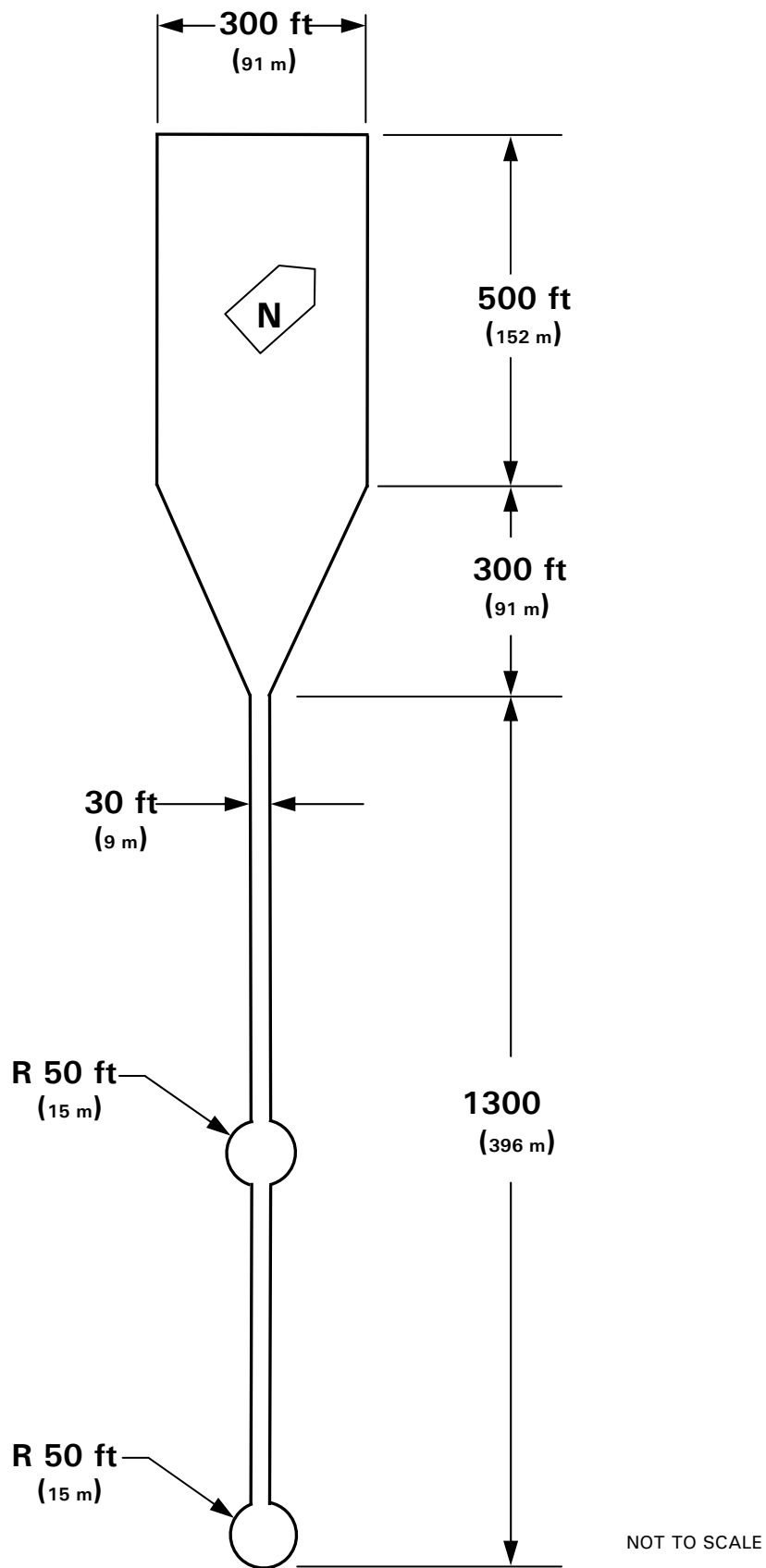


Figure 2. DRI-Minter Vehicle Dynamics Area

## 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. For the 2018 Chevrolet Traverse FWD, there was no two-wheel lift at any test condition.

APPENDIX A

Photographs

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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





Figure A6. Instrumentation in Test Vehicle



Figure A7. Steering Controller and Computer





Figure A8. Ballast Condition

APPENDIX B

Test Run Log

Vehicle: **2018 Chevrolet Traverse  
FWD**

Driver: **John Partridge**

Date: **10/23/2017**

Run Number	Test Type	Speed (mph)	Handwheel Angle (deg)	Dir. of First Steer	2 Wheel Lift	Notes
1	Tire Warm-Up	35	60	Right	Yes	Resulted in ay = 0.42g
2			80			Resulted in ay = 0.52g
3						
4						
5						2x SWA last cycle
6						ng
7	Static	0	0			
8	Steady State	50	0			
9	Slowly Increasing Steer	50	60	Left		Resulted in ay = ?g
10			50	Left		
11				Left		NG
12				Left		
13				Right		
14				Right		
15				Right		
16	Fishhook 6.5 Scalar	35	190	Left	No	
17		40			No	
18		45			No	
19		47.5			No	
20		50			No	
21	Fishhook 5.5 Scalar	45	161	Left	No	
22		47.5			No	
23		50				

Vehicle: **2018 Chevrolet Traverse  
FWD**Driver: **John Partridge**Date: **10/23/2017**

Run Number	Test Type	Speed (mph)	Handwheel Angle (deg)	Dir. of First Steer	2 Wheel Lift	Notes
24	Fishhook 5.5 Scalar	35	161	Right	No	
25		40			No	
26		45			No	
27		47.5			No	
28		50			No	
29	Fishhook 6.5 Scalar	35	190	Right	No	
30		40			No	
31		45			No	
32		47.5			No	
33		50			No	



APPENDIX C

Slowly Increasing Steer Test Worksheet

## NCAP, 2018 Chevrolet Traverse FWD , Multi-Passenger Load, Test Date: 10/23/2017

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
9	Left	50.1	7.3	85.5	1218	-28.3	-0.295	-184.0	-0.2556	-155.7	-0.2163	0.9884	600	800
10	Left	50.0	0.2	99.5	1242	-29.4	-0.308	-190.9	-0.2651	-161.5	-0.2244	0.9900	600	800
12	Left	49.8	3.2	93.5	1241	-29.3	-0.299	-190.6	-0.2647	-161.3	-0.2240	0.9912	600	800
13	Right	50.0	4.8	90.4	1246	29.7	0.292	193.3	0.2684	163.5	0.2271	0.9949	600	800
14	Right	50.0	5.3	89.4	1240	29.3	0.301	190.7	0.2648	161.3	0.2241	0.9942	600	800
15	Right	Right	4.1	91.9	1243	29.5	0.296	191.7	0.2663	162.2	0.2253	0.9951	600	800

Mean: 29.3 0.298 190 0.264 161 0.224

## Steering Controller Input Values

## Scalar 6.5 values:

Initial HW angle: 190 deg  
Initial time: 0.264 s  
Reversal HW angle: -190 deg  
Reversal time: 0.528 s

## Scalar 5.5 values:

Initial HW angle: 161 deg  
Initial time: 0.224 s  
Reversal HW angle: -161 deg  
Reversal time: 0.447 s

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### Time History Plots

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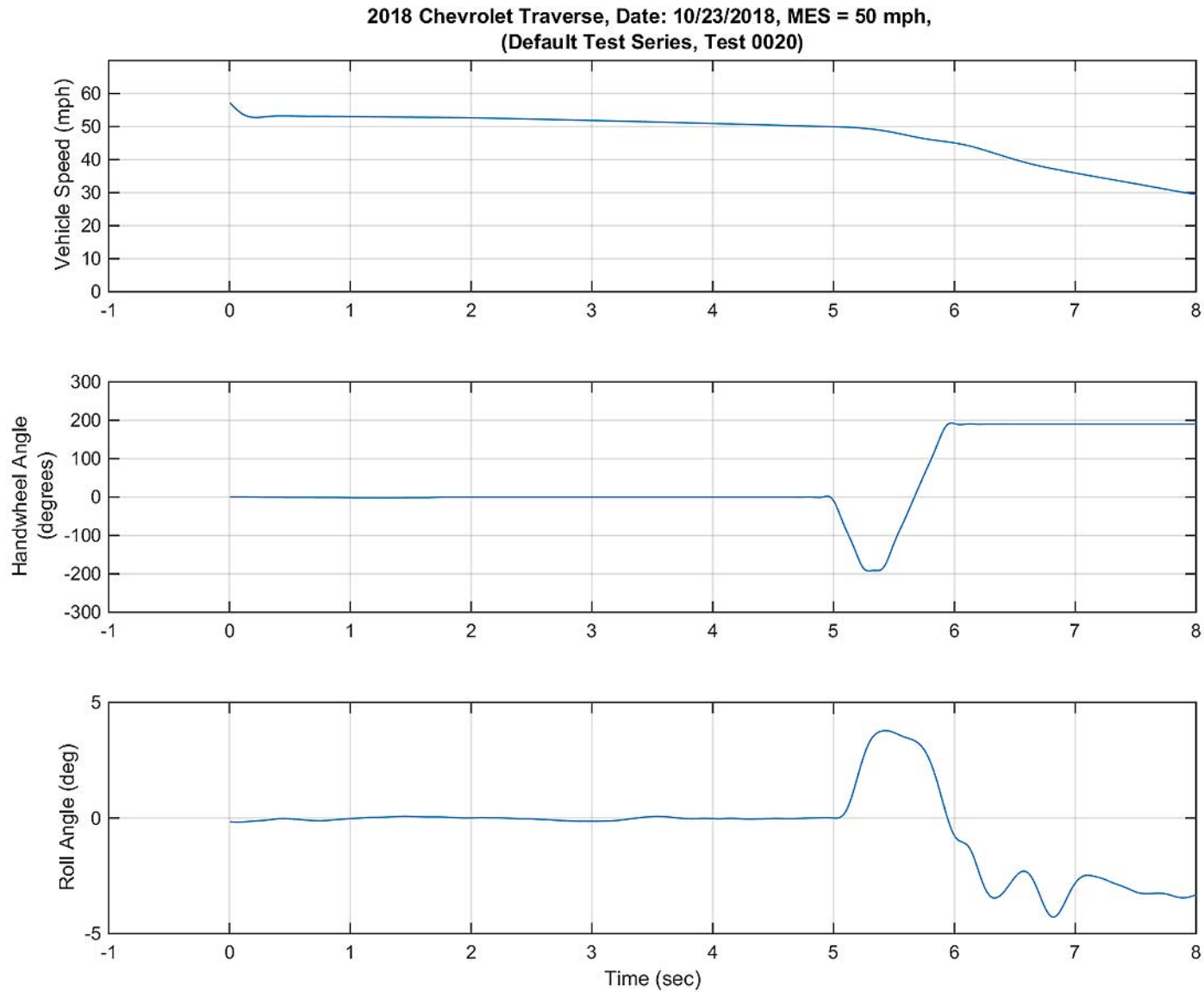


Figure D1. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, L-R, 50 mph

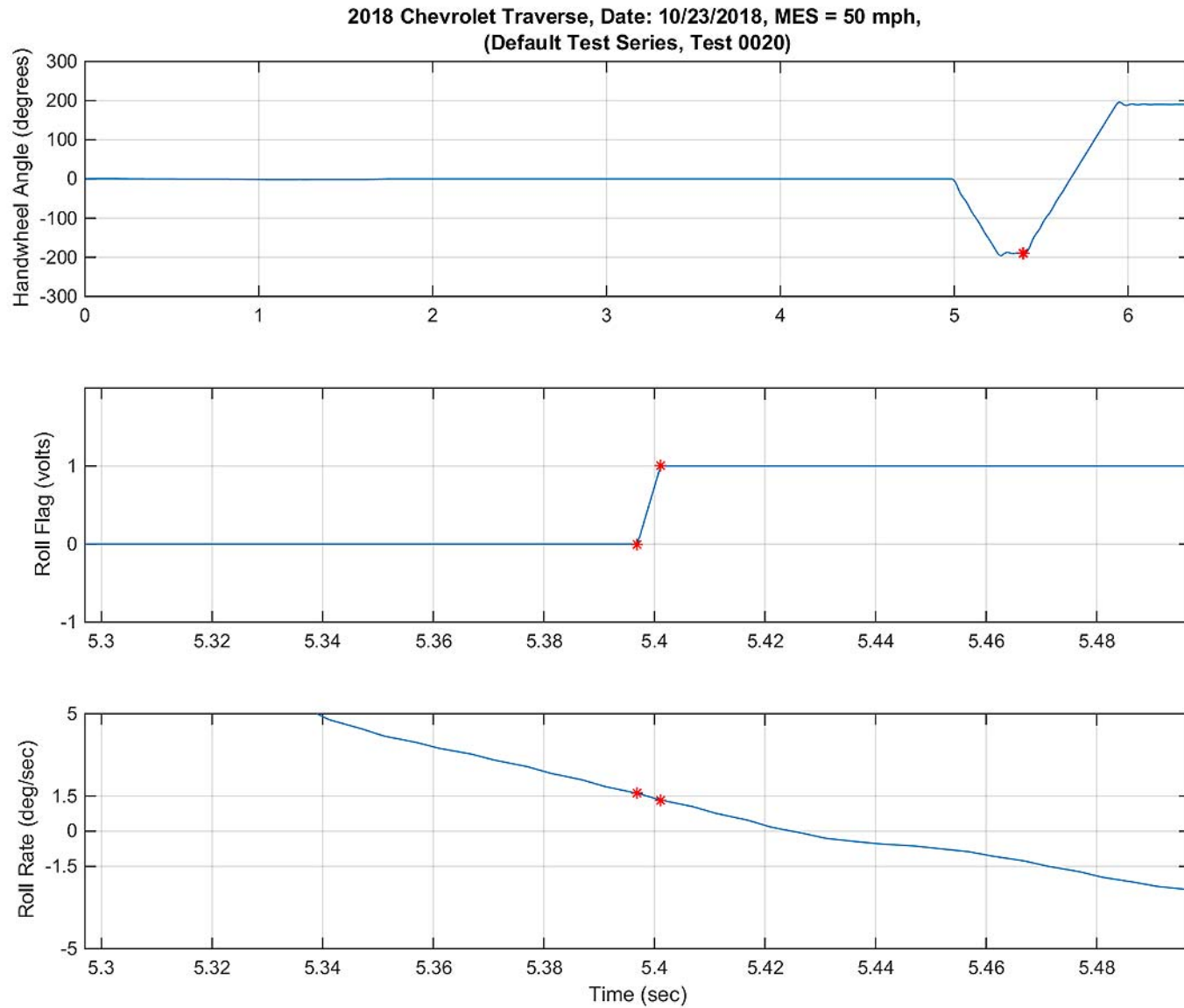


Figure D2. Steering Machine Operation Time History Plots for Default Test Series, L-R, 50 mph

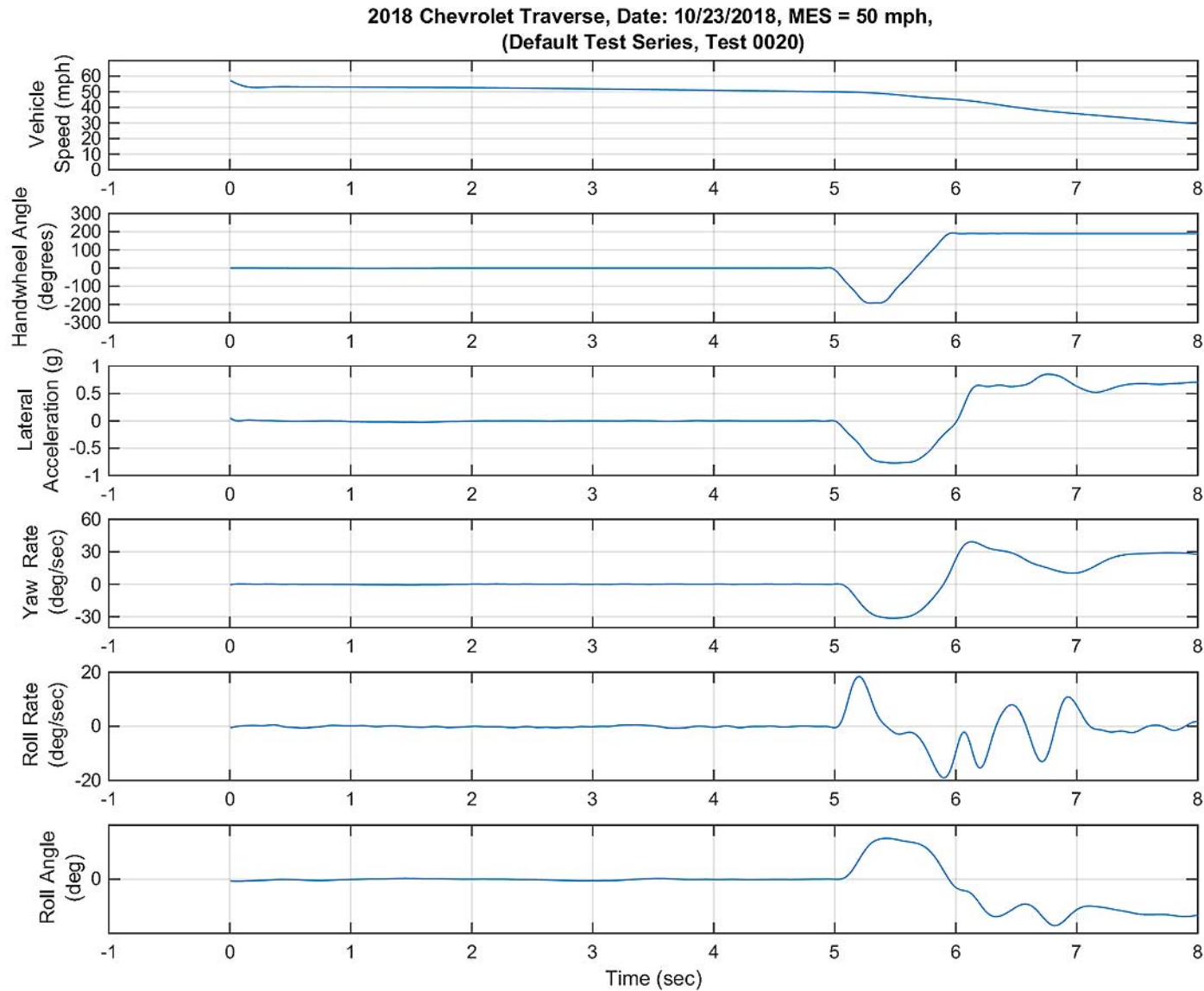


Figure D3. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots For Default Test Series, L-R, 50 mph

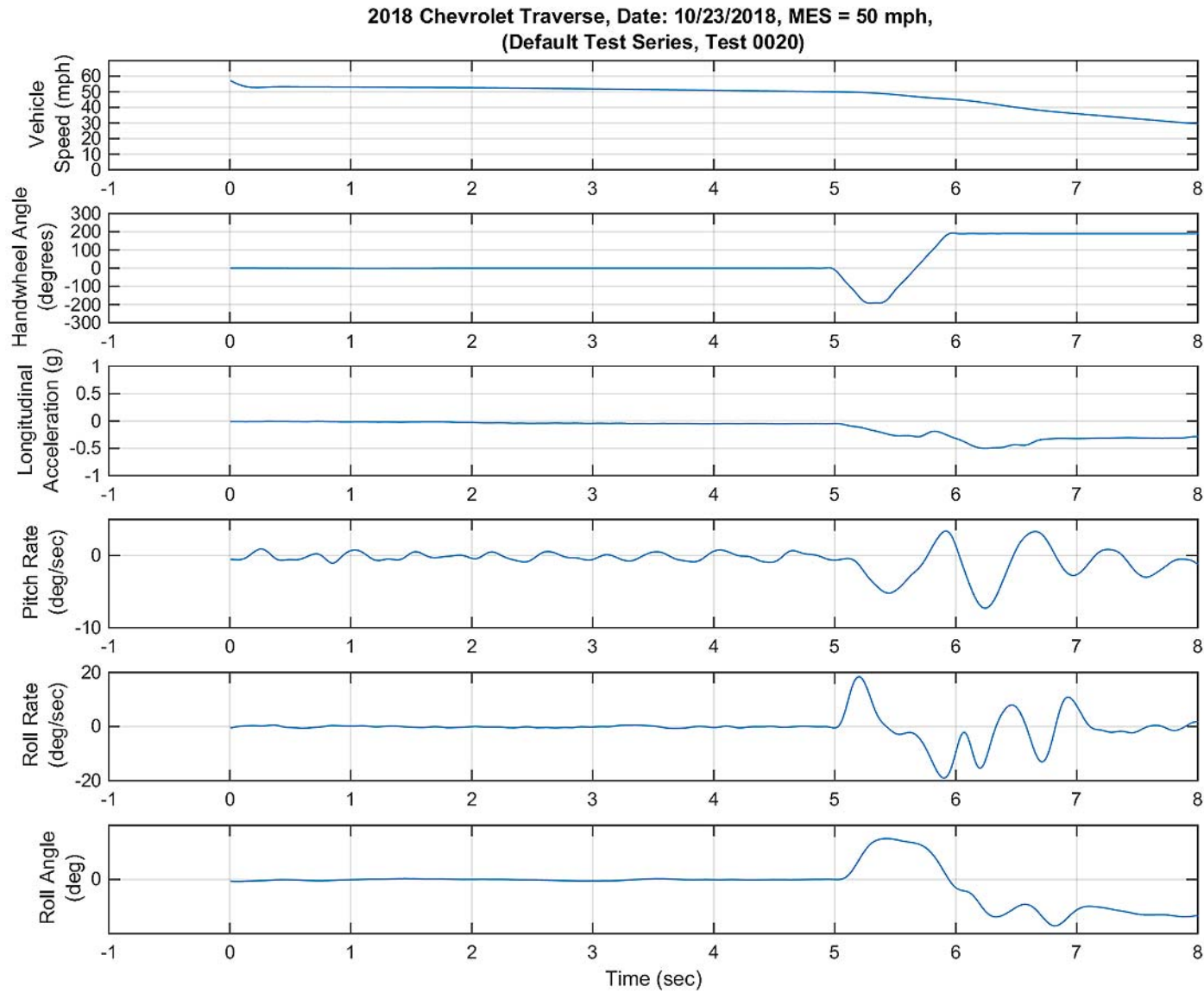


Figure D4. Pitch Rate and Longitudinal Acceleration Time History Plots for Default Test Series, L-R, 50 mph



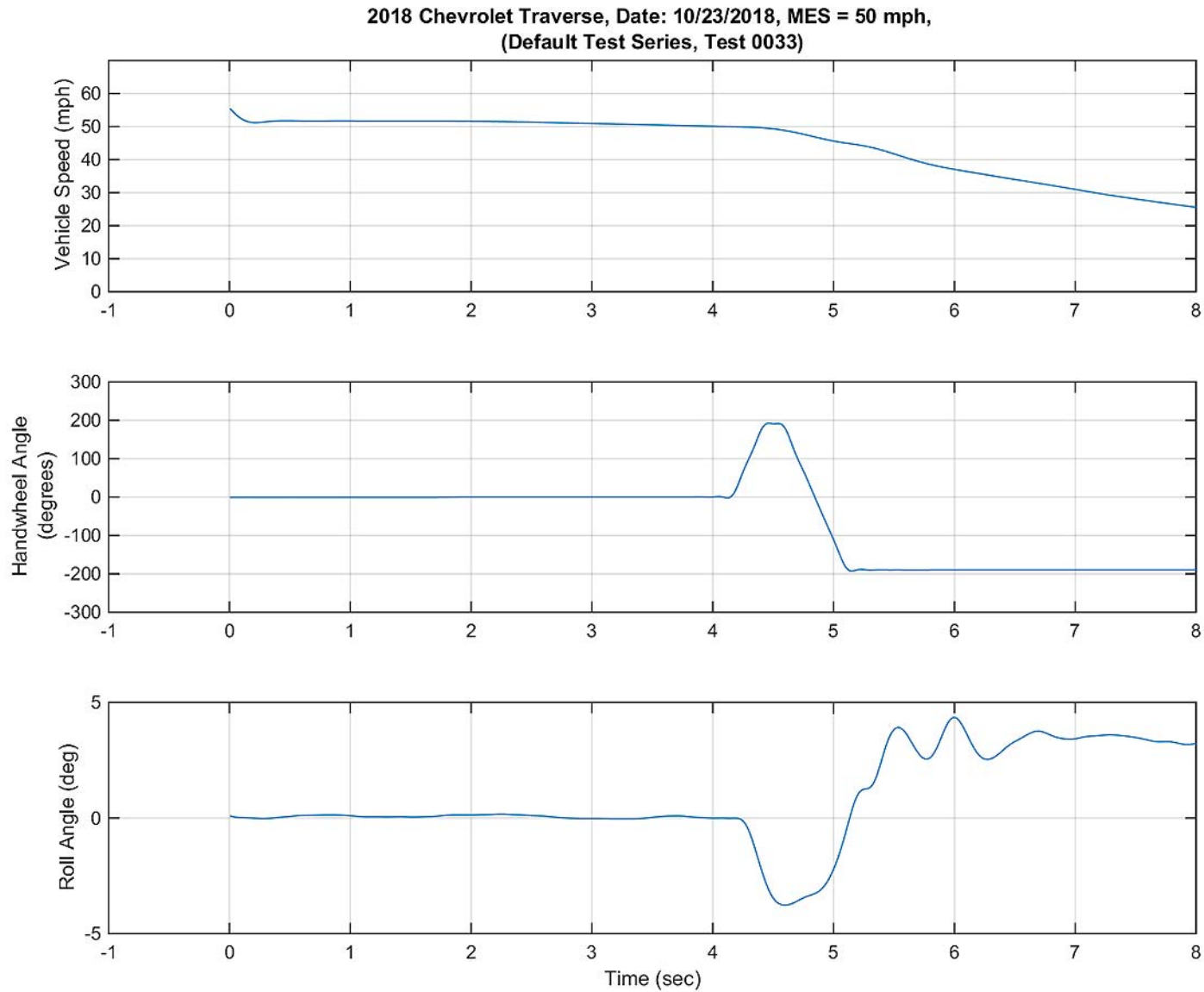


Figure D5. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, R-L, 50 mph

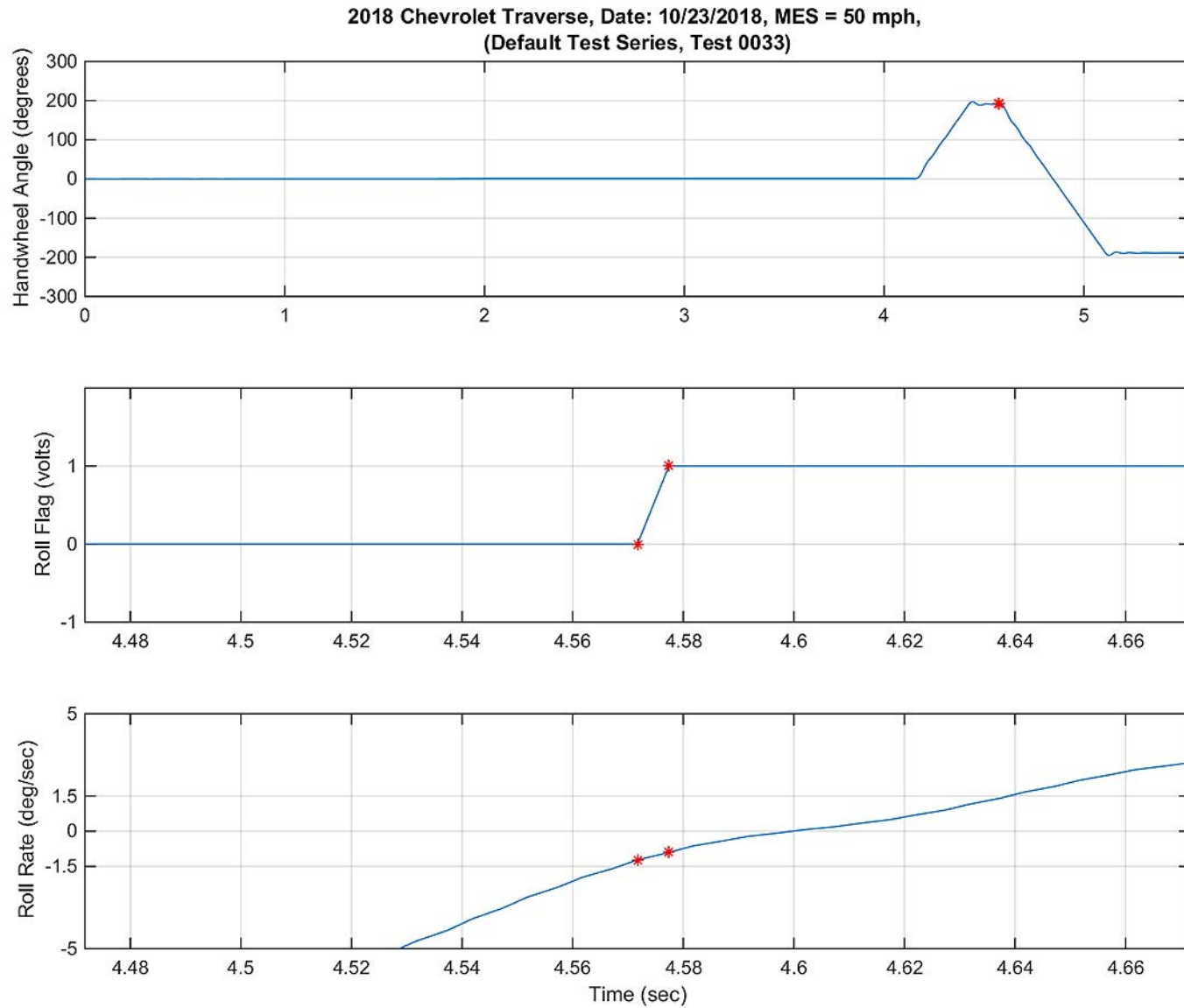


Figure D6. Steering Machine Operation Time History Plots for Default Test Series, R-L, 50 mph

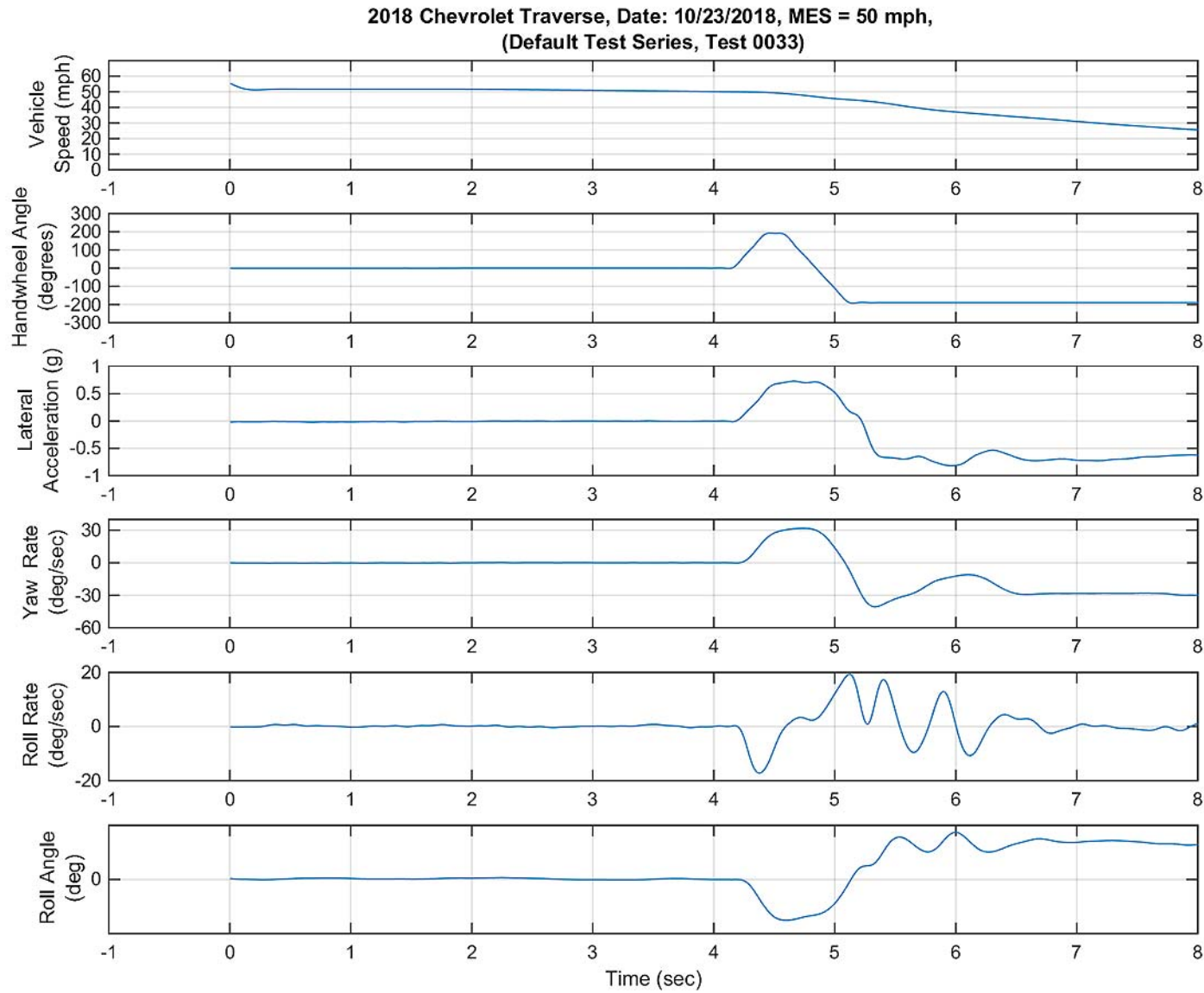


Figure D7. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Default Test Series, R-L, 50 mph

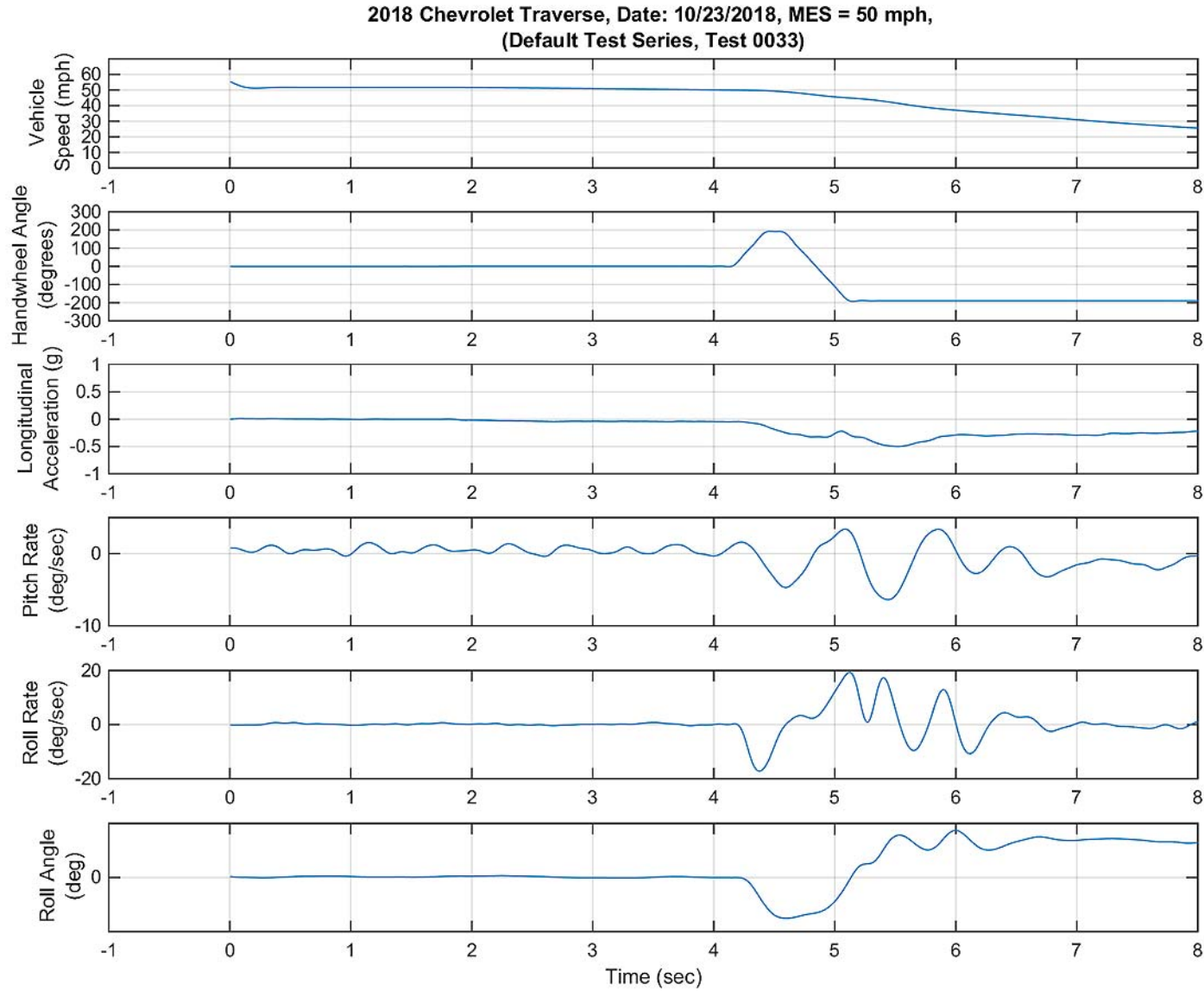


Figure D8. Pitch Rate and Longitudinal Acceleration Time History Plots or Default Test Series, R-L, 50 mph

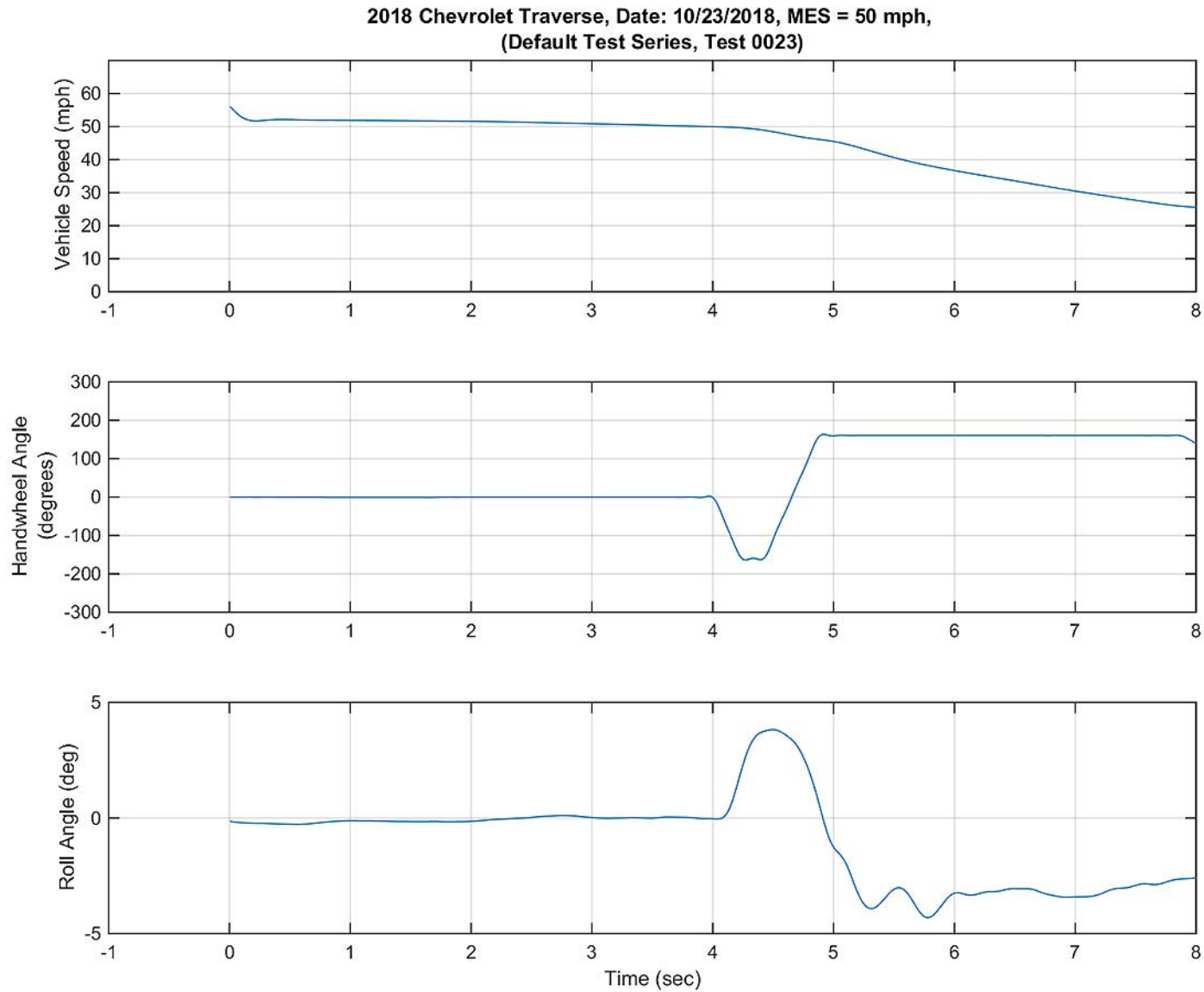


Figure D9. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

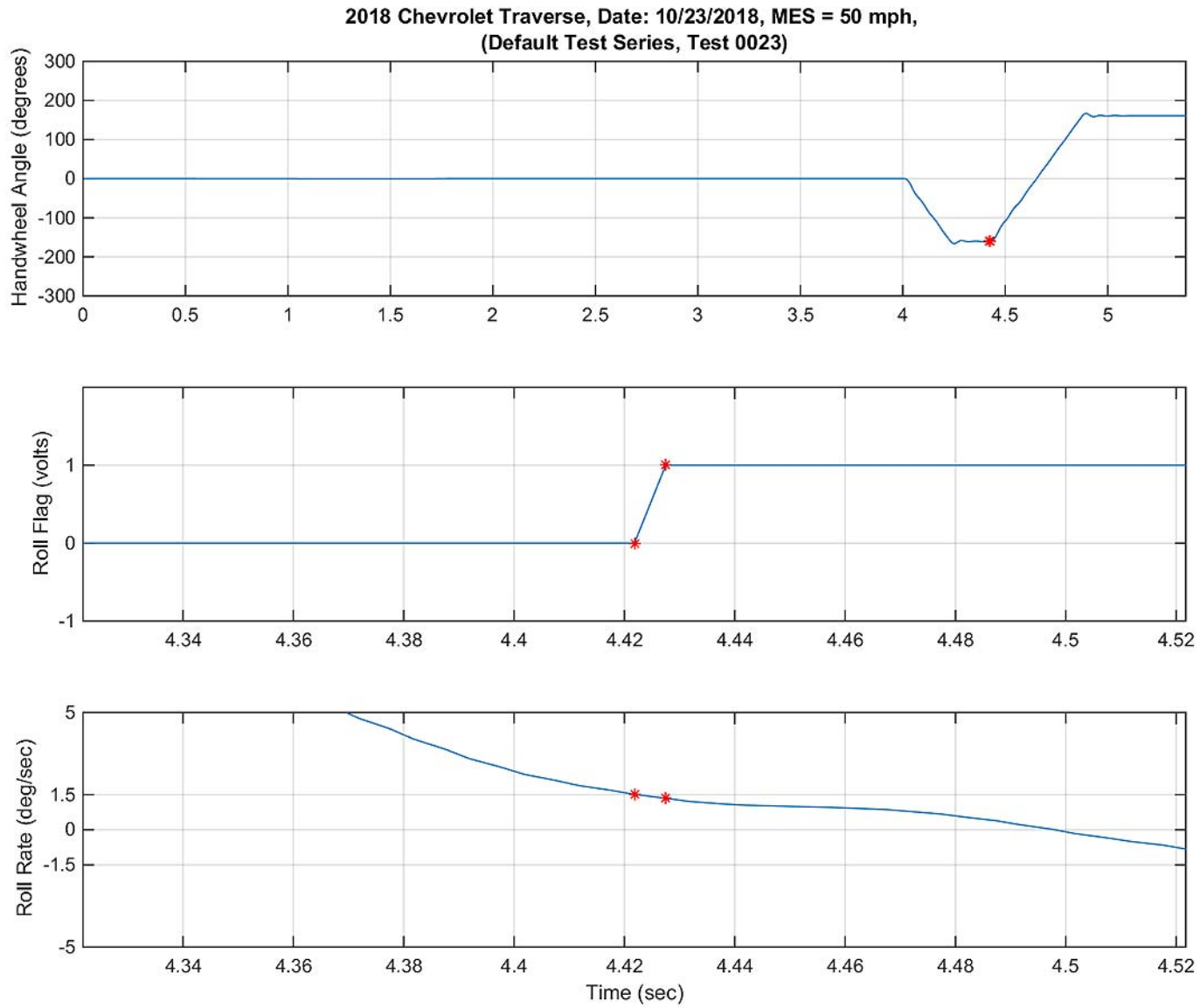


Figure D10. Steering Machine Operation Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

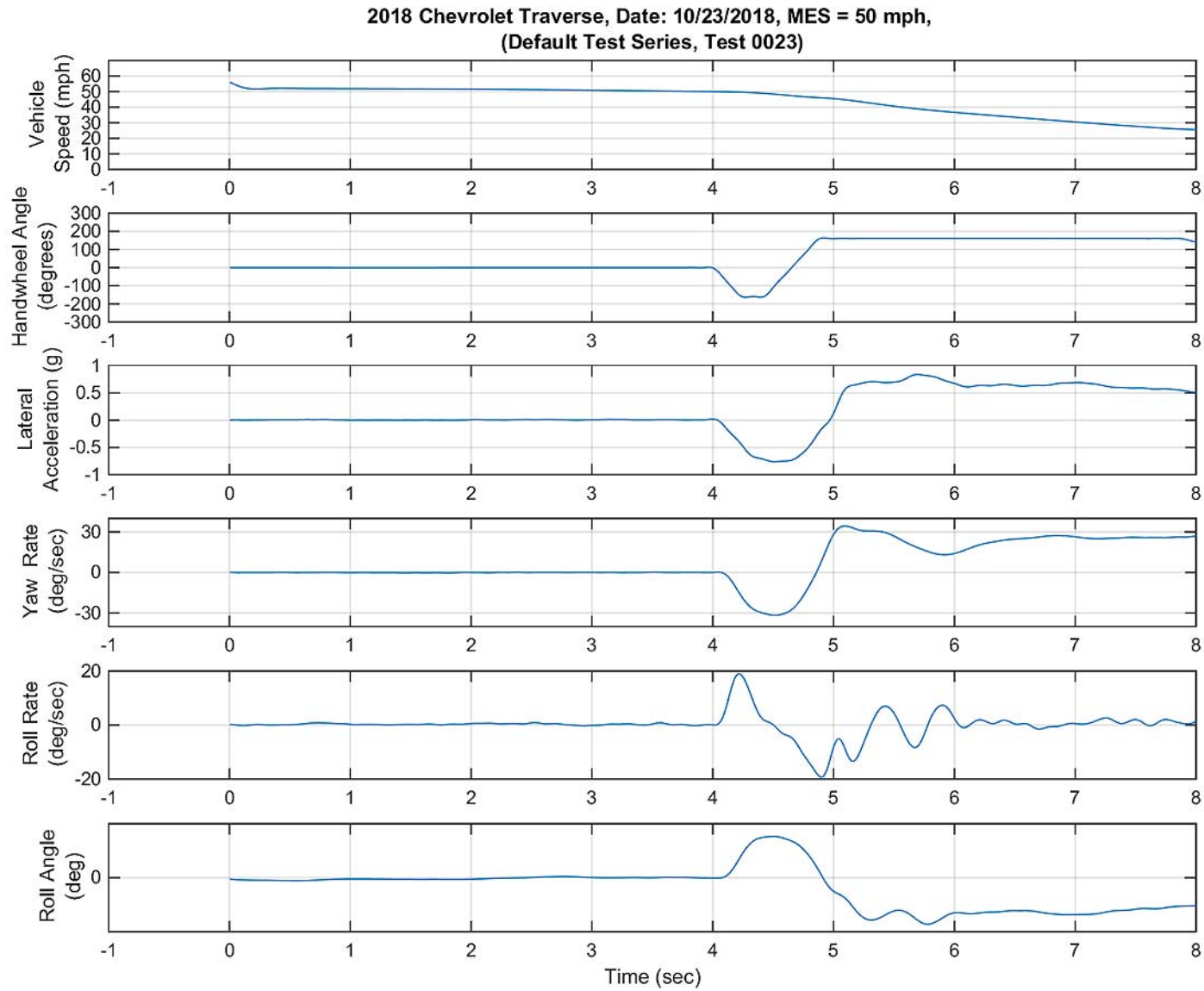


Figure D11. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

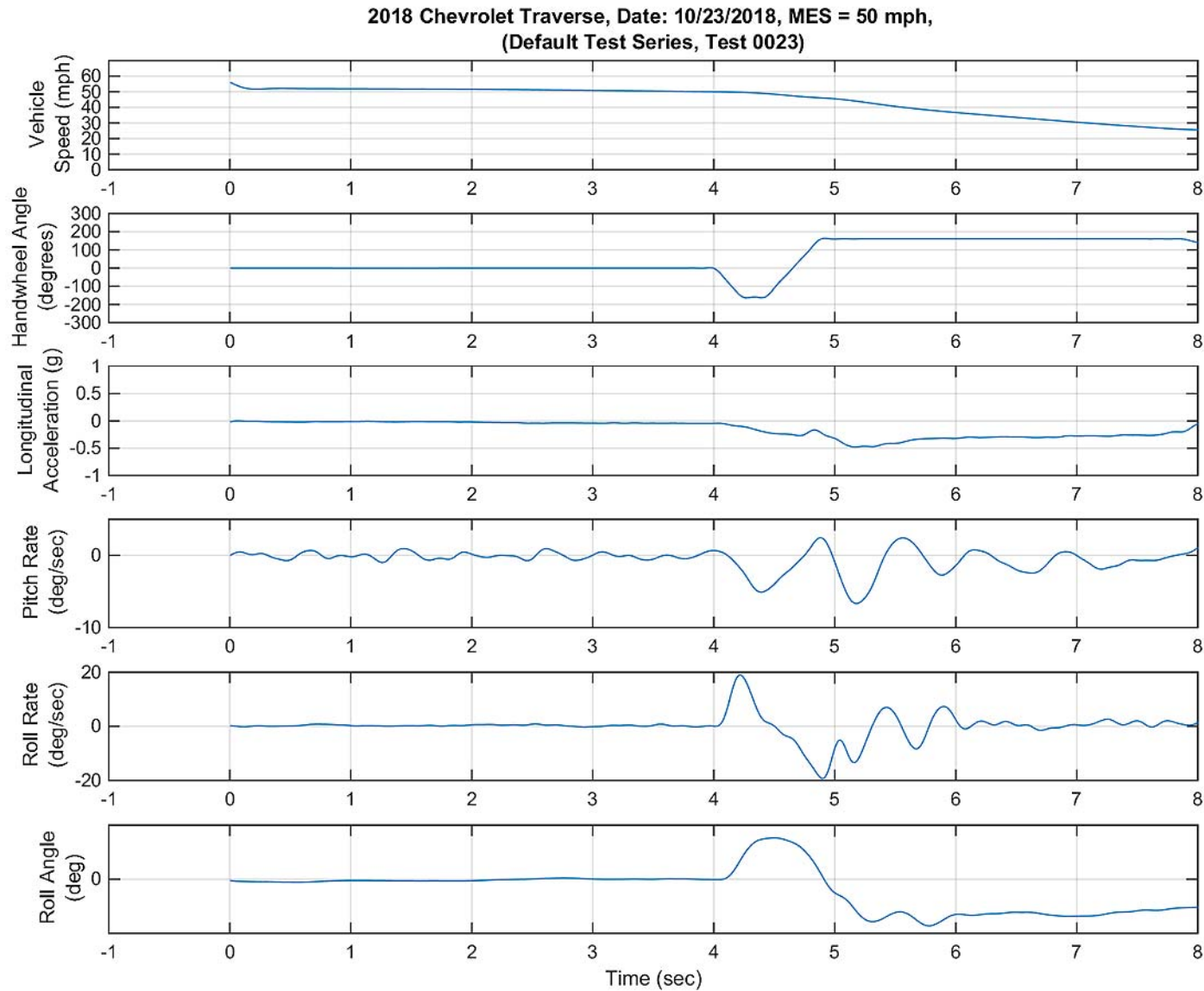


Figure D12. Pitch Rate and Longitudinal Acceleration Time History Plots for Supplemental 2 Test Series, L-R, 50 mph



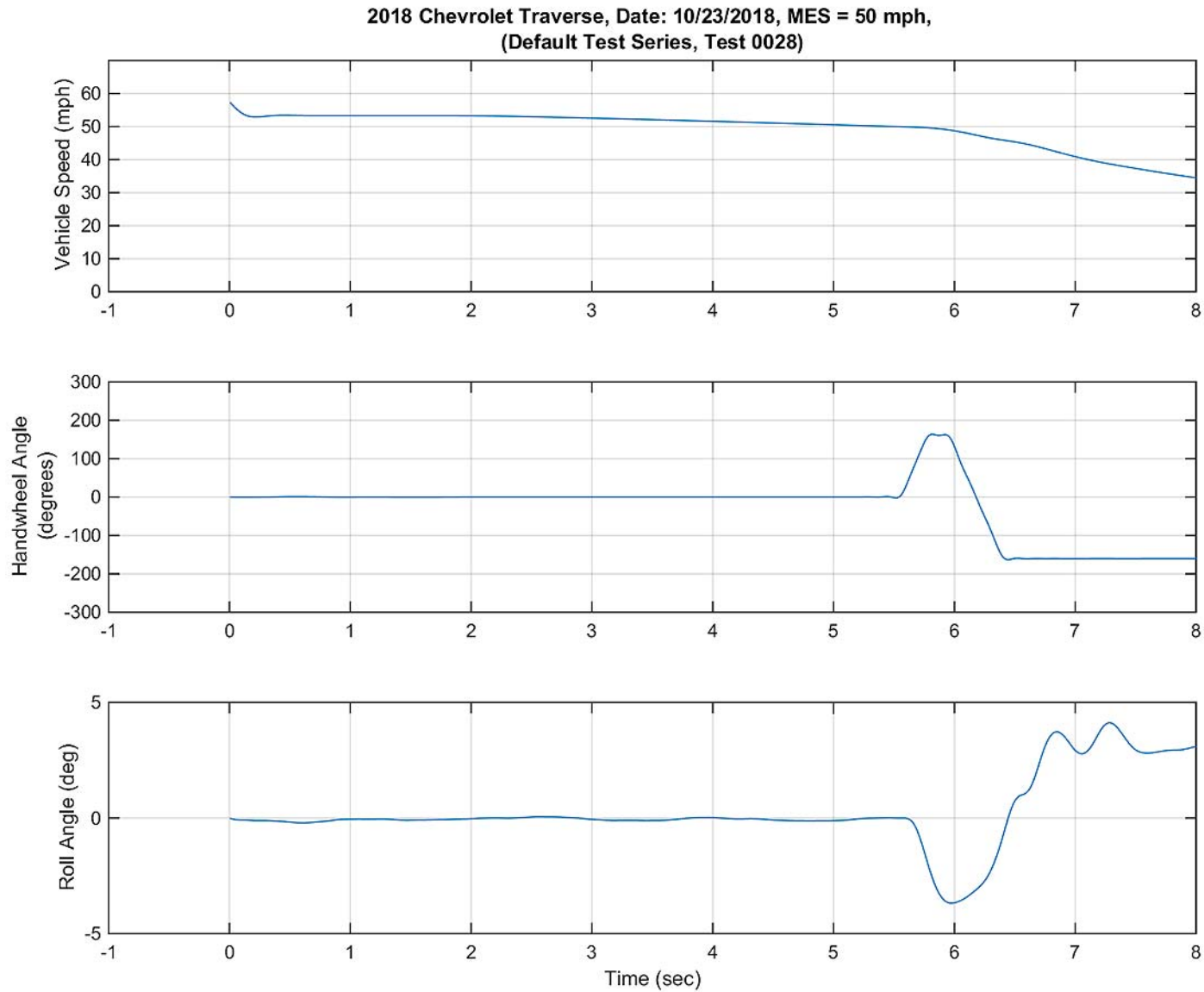


Figure D13. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

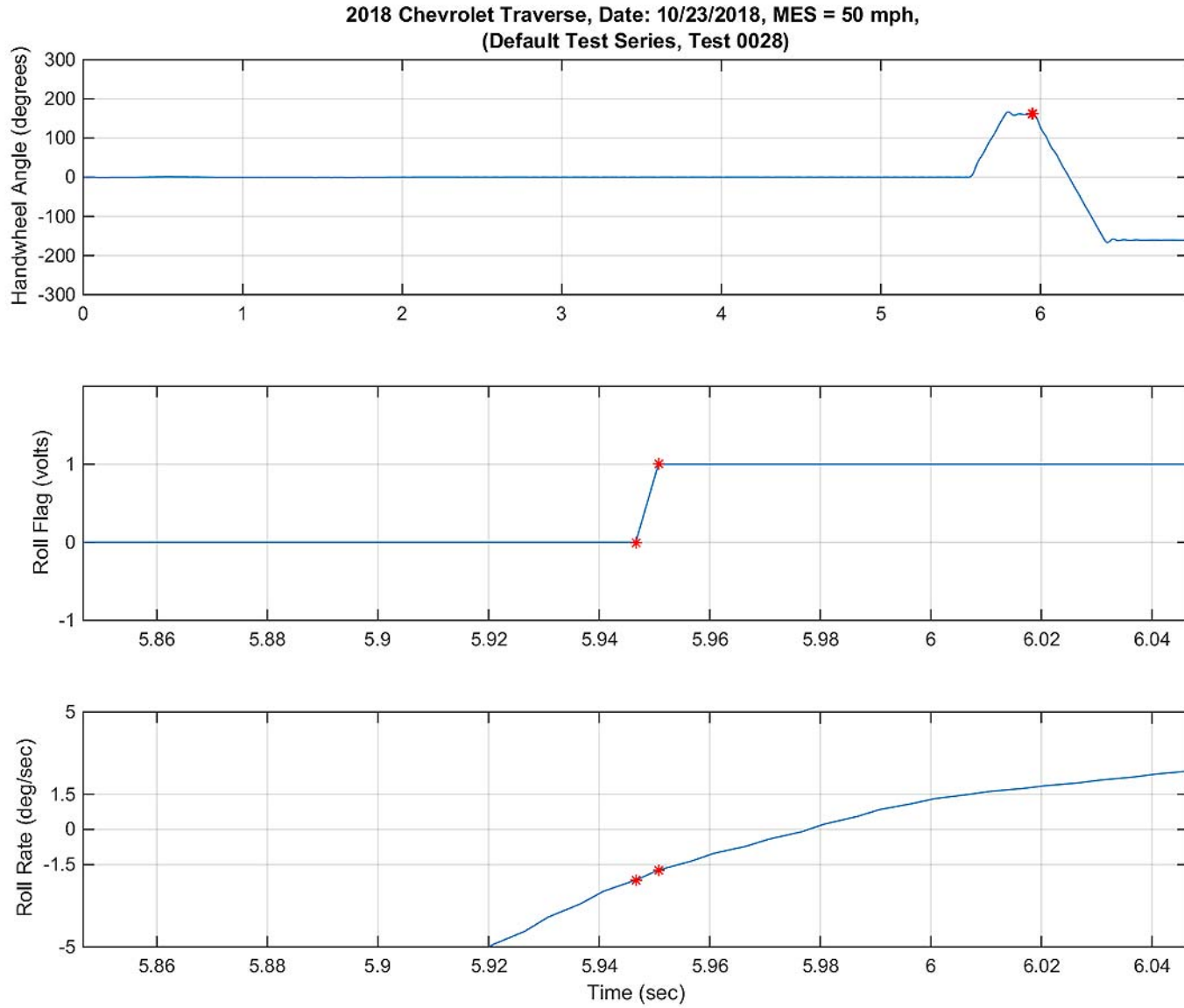


Figure D14. Steering Machine Operation Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

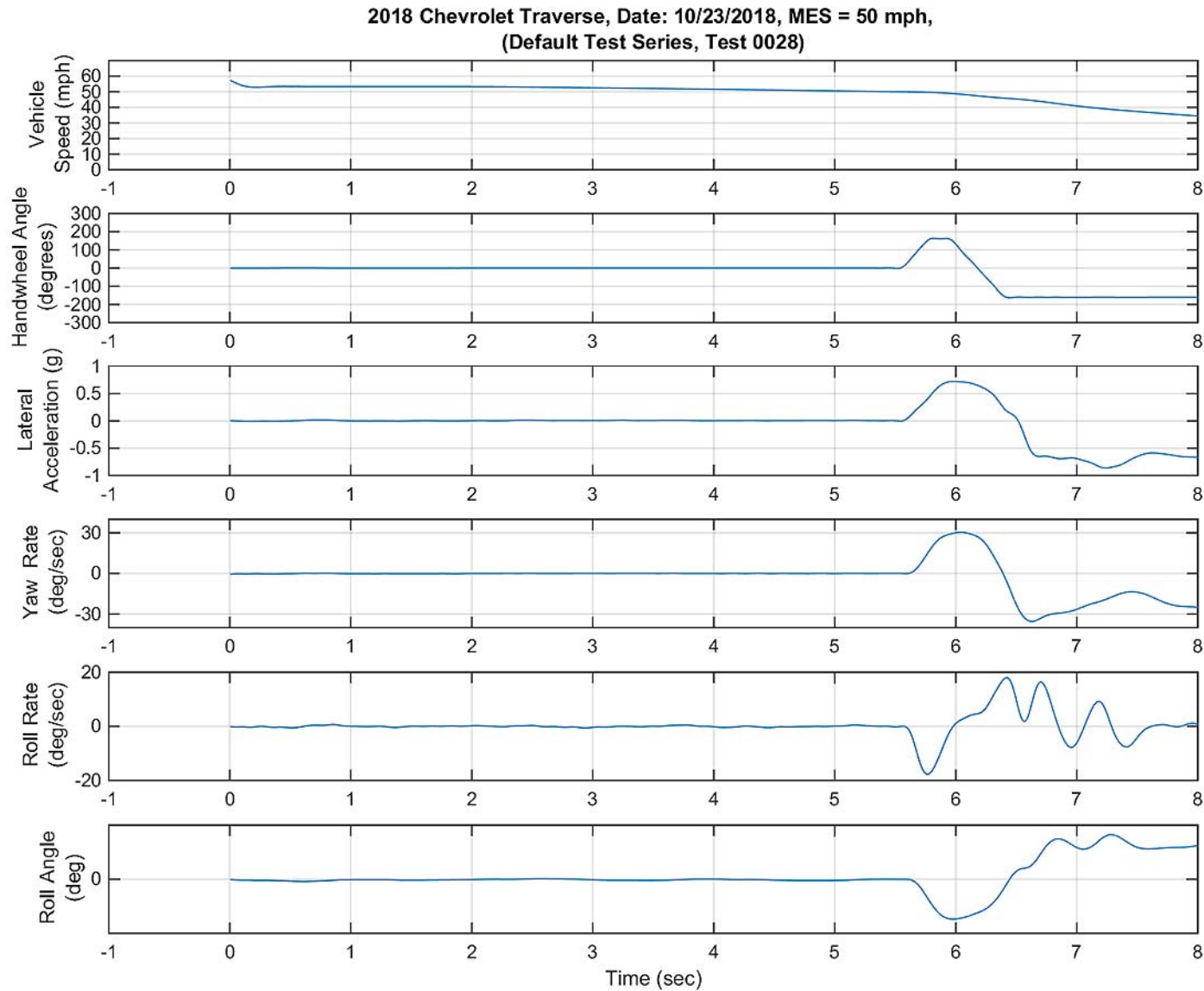


Figure D15. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

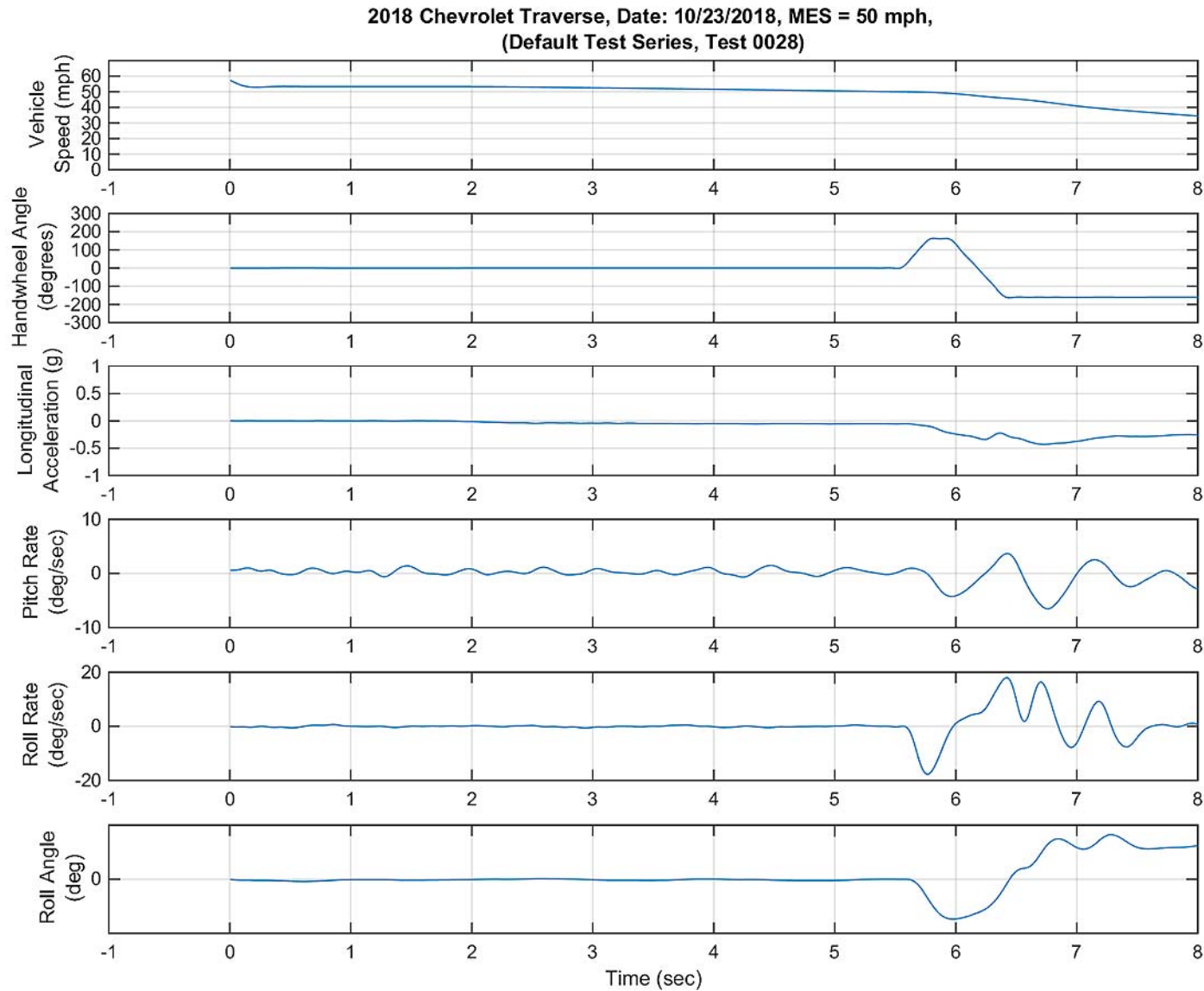


Figure D16. Pitch Rate and Longitudinal Acceleration Time History Plots for Supplemental 2 Test Series, R-L, 50 mph