

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

Volkswagen Group of America, Chattanooga

2018 Volkswagen Atlas FWD

TEST NUMBER: 18-01

Final Report
10 July 2017



Prepared by:

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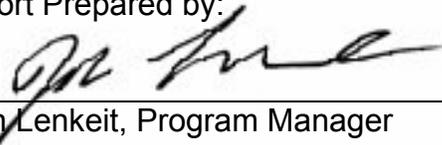
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Office of Crash Avoidance Standards
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Washington, DC 20590

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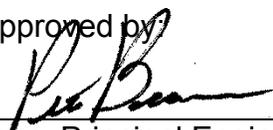
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Date: 10 July 2017

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16. Abstract An NCAP Dynamic Rollover Maneuver (Fishhook) Test was conducted on a 2018 Volkswagen Atlas FWD at Dynamic Research, Inc. on June 22, 2017. The vehicle did not experience two-wheel lift. The vehicle's steering angle at 0.3 g lateral acceleration at 50 mph was 28 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 Volkswagen Atlas 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, 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

General Data					
Model year, make, model	2018 Volkswagen Atlas FWD				
VIN	1V2BR2CA33JC5xxxx				
Body style	SUV				
Number of doors	4				
Trim level	Launch Edition				
Seating positions	Front:	2 nd row	3 rd row	4 th row	5 th row
	2	3	2		
Electronic stability control	Yes				
4-Wheel ABS (Yes/No)	Yes				
Power steering (Yes/No)	Yes				
Major optional equipment	6sp transmission w tiptronic, Monster Mats with heavy duty trunk liner, cargo blocks, Titan black cloth interior, Roadside assistance kit, wheel locks and dust caps				
Odometer at start of testing	28 miles				
Drivetrain					
Engine cylinder arrangement	V-6				
Engine displacement	3.6 L				
Transmission type	Automatic				
Drive arrangement	FWD				
Chassis					
Track width	F: 67.2 in (1706.9 mm) , R: 67.8 in (1722.1 mm)				
Wheelbase	117.3 in (2979.4 mm)				
Curb weight	4314 lb (1956.8 kg)				
Certification Data from Vehicle's Label					
Vehicle manufactured by	Volkswagen Group of America, Chattanooga				
Date of manufacture	04/2017				
GVWR	5732 lb (2600 kg)				
GAWR Front	2888 lb (1310 kg)				
GAWR Rear	2954 lb (1340 kg)				

Table 2. Tire Information

Tire Manufacturer	Continental
Tire Model	CrossContact LX Sport
Tire Size	Front: 245/60R18 Rear: 245/60R18
Load rating	Front: 105 Rear: 105
Speed rating	Front: T Rear: T
Treadwear grade	Front: 480 Rear: 480
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: A383 W39V Rear: A383 W39V

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	1425 lb (646.4 kg)
Right front	1458 lb (661.3 kg)
Left rear	1293 lb (586.5 kg)
Right rear	1231 lb (558.4 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 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

Type	Output	Range	Resolution	Accuracy	Specifics	Serial Number	Calibration
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	1 psi 6.89 kPa	0.5 psi 3.45 kPa	Ashcroft D1005PS	1039350	By: DRI Date: 12/13/2016 Due: 12/13/2017
Platform Scales	Vehicle Total, Wheel, and Axle Load	8000 lb 35.6 kN	0.5 lb 2.2 N	±1.0% of applied load	Intercomp Model SWII	1110M206352	By: DRI Date: 12/13/2016 Due: 12/13/2017
Steering Angle Encoder (Automated Steering Controller)	Handwheel Angle	±800 deg	0.25 deg	±0.25 deg	DRI Automatic Vehicle Controller using D-Space Micro-Autobox II	NA	Verified by DRI at installation ¹
Multi-Axis Inertial Sensing System	Longitudinal, Lateral, and Vertical Acceleration Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle	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	2176	By: Oxford Technical Solutions Date: 3/9/2016 Due: 3/9/2018
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm Fusion	UO8-05-08-06636	By: DRI Date: 1/17/2017 Due: 1/17/2018

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.

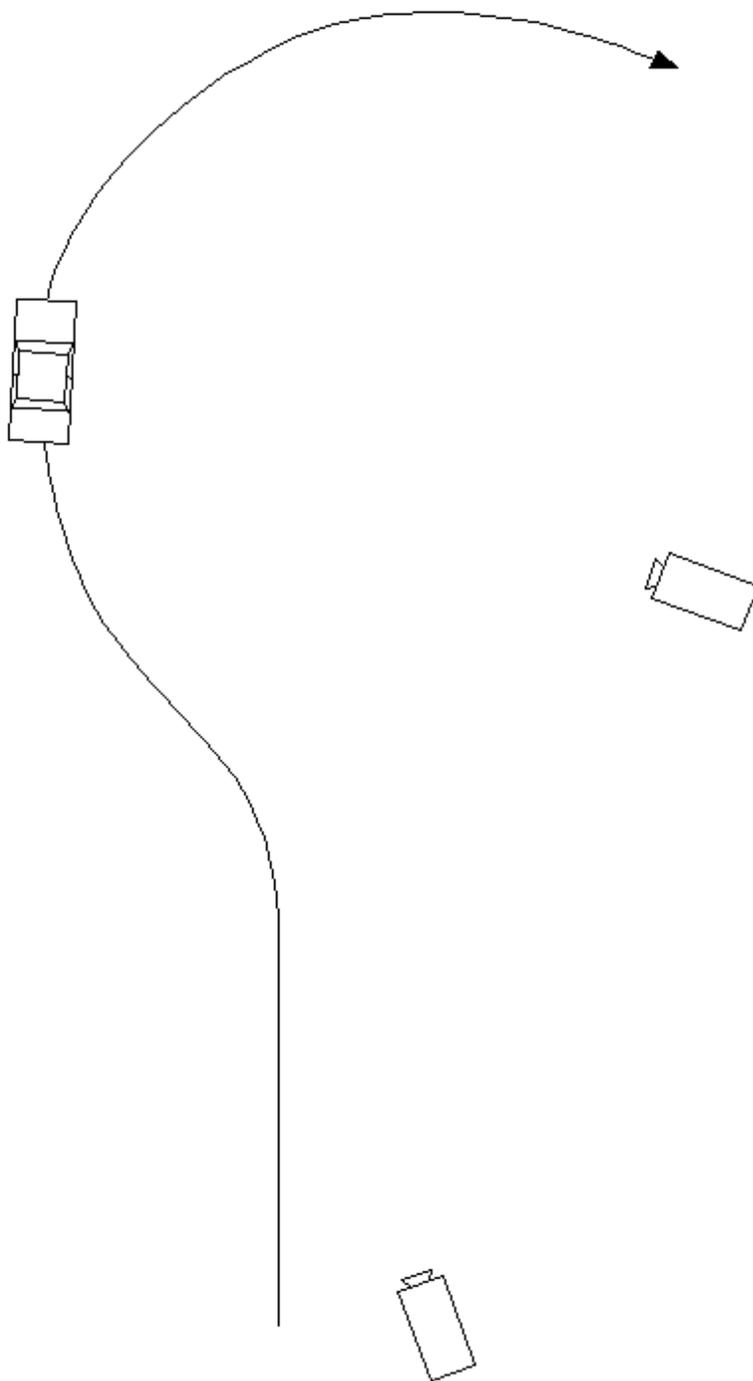


Figure 1. Nominal Position of Video Cameras for Fishhook Tests

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 6/22/2017. 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 (± 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 5.

Table 5. Surface Friction

Date of surface friction measurements	6/22/2017
Average normalized lateral force	0.822

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)	28 °
5.5 scalar handwheel angle for Fishhook Test	154°
6.5 scalar handwheel angle for Fishhook Test	182 °

3. Weather Conditions

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

Table 7. Weather Conditions

Ambient temperature	97 °F (36.1 °C)
Wind Speed	3 mph (1.3 m/s)
Wind Direction	W-SW

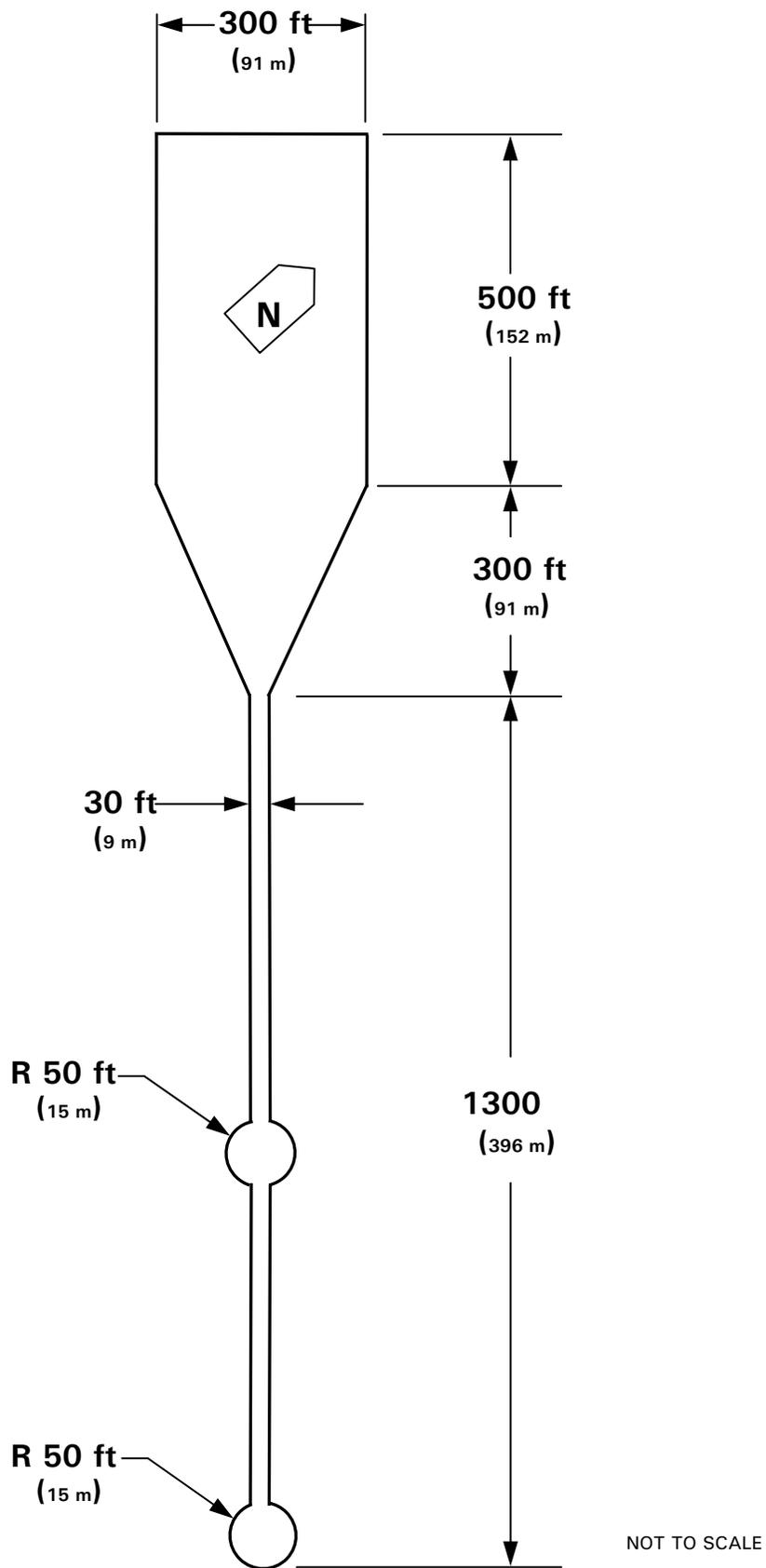


Figure 2. DRI-Minter Vehicle Dynamics Area

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 Volkswagen Atlas FWD, there was no two-wheel lift at any test condition.

APPENDIX A

Photographs

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2018 Atlas V6 Launch Edition

Platinum Gray Metallic Exterior Titan Black Cloth Interior



STANDARD FEATURES (unless replaced by options)

PERFORMANCE

- 3.6L 24-valve DOHC narrow-angle V6 engine w/ FSI® direct fuel injection
- Front-wheel-drive
- Four-wheel independent suspension

SAFETY FEATURES

- Driver & front passenger front & side airbag supplemental restraint systems
- Side Curtain Protection® head impact airbags
- 3-point safety belts, all seating positions
- Anti-lock Braking System (ABS) w/ disc brakes
- Anti-Slip Regulation (ASR) & Engine Brake Assist (EBA)
- Electronic Brake-pressure Distribution (EBD) & Hydraulic Brake Assist (HBA)
- Electronic Stability Control (ESC) & Electronic Differential Lock (EDL)
- Intelligent Crash Response System (ICRS)
- Lower Anchors & Tethers for Children (LATCH)
- Tire Pressure Monitoring System (TPMS)

EXTERIOR

- 18" alloy wheels w/ all-season tires
- LED headlights w/ LED Daytime Running Lights (DRL)
- Foldable, power adjustable side mirrors w/ integrated turn signals
- Variable intermittent front wipers
- Silver roof rails & chrome window trim
- Power tilting & sliding panoramic sunroof

INTERIOR

- Dual-zone manual climate control w/ air vents for all three rows
- 3-spoke, multi-function steering wheel
- Tiltting & telescoping adjustable steering column
- Driver's seat: 6-way manual w/ height adjustment
- Front passenger seat: 4-way manual
- 2nd-row seat: 60/40 split-folding, adjustable w/ 3rd-row Easy Access
- 3rd-row seat: 50/50 split-folding & folds flat
- Cloth seating surfaces
- Front center console w/ cup holders, armrest & storage
- Reading lights, all three rows (2 per row)

TECHNOLOGY

- Rear View Camera System
- Composition Media: 8" touchscreen AM/FM/HD radio & CD player w/ USB input, aux-in & voice control
- 6-speaker sound system
- Bluetooth® connectivity (for compatible devices)
- SiriusXM® Satellite Radio (w/ limited time trial subscription)
- Cruise control
- Color multi-function display (MFD) w/ trip computer
- HomeLink® integrated garage door opener
- Electric parking brake

Manufacturer's Suggested Retail Price: \$33,500.00

Manufacturer's Suggested Retail Price: \$33,500.00

VW CAR-NET® EQUIPPED. Features include:

- > App-Connect® (Smartphone Integration & Interface)

DRIVER CARE PACKAGE

WARRANTY INFORMATION

- Volkswagen New Vehicle Limited Warranty
- 6 years/72,000 miles (whichever occurs first)
- * Includes coverage for powertrain components
- Limited Warranty against Corrosion Perforation
- * 7 years/100,000 miles (whichever occurs first)
- Please ask your dealer for a copy of the Volkswagen warranty booklet for details.
- 24-HOUR ROADSIDE ASSISTANCE
- * 3 years/36,000 miles (whichever occurs first)
- (Towing, Jump Starts, Tire Changes, Out of Fuel, and Lock-Out)
- Provided by a third party supplier

PACKAGES/OPTIONS

- Platinum Gray Metallic Exterior No Charge
- Titan Black Cloth Interior No Charge
- Monster Mats® w/ Heavy Duty Trunk Liner & VW CarGo Blocks \$285.00
- Roadside Assistance Kit \$85.00
- Wheel locks & dust caps (4 each) w/ coded key \$90.00
- 8-Speed Automatic w/ TipTronic® No Charge

Destination Charge \$925.00

Total Price: \$34,875.00

Fuel, license, title fees, taxes and dealer-installed accessories are not included.

PARTS CONTENT INFORMATION	
FOR VEHICLES IN THIS CARLINE:	FOR THIS VEHICLE:
U.S./CANADIAN	FINAL ASSEMBLY POINT:
PARTS CONTENT: 46%	CHATTANOOGA TN,U.S.A.
MAJOR SOURCES OF FOREIGN	COUNTRY OF ORIGIN:
PARTS CONTENT:	ENGINE: GERMANY
GERMANY: 27%	TRANSMISSION: JAPAN

NOTE: PARTS CONTENT DOES NOT INCLUDE FINAL ASSEMBLY, DISTRIBUTION OR OTHER NON-PARTS COSTS.

EPA DOT Fuel Economy and Environment Gasoline Vehicle

Fuel Economy **20** MPG **18** **25** **5** gallons per 100 miles

combined city/hwy city highway

Small Sport Utility Vehicles range from 18 to 34 MPG. The best vehicle rates 136 MPGe.

You spend \$2,250 more in fuel costs over 5 years compared to the average new vehicle.

Annual fuel cost \$1,800

Fuel Economy & Greenhouse Gas Rating (tailpipe only) **Smog Rating** (tailpipe only)

1 4 10 Best 1 5 10 Best

This vehicle emits 438 grams of CO₂ per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel also create emissions; learn more at fueleconomy.gov.

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 \$6,750 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at \$2.40 per gallon. MPGe is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

fueleconomy.gov
Calculate personalized estimates and compare vehicles

Smartphone QR Code

GOVERNMENT 5-STAR SAFETY RATINGS

Overall Vehicle Score Not Rated
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	Not Rated
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	Not Rated
Based on the risk of injury in a side impact.		
Rollover		Not Rated
Based on the risk of rollover in a single-vehicle crash.		

Star ratings range from 1 to 5 stars (★★★★★) with 5 being the highest.
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Who better to get you into a Volkswagen than us? Volkswagen Credit

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



Figure A6. Instrumentation in Test Vehicle



Figure A7. Steering Controller and Computer



Figure A8. Ballast Condition

APPENDIX B

Test Run Log

Vehicle: **2018 Volkswagen Atlas**
FWD

Driver: **Peter Broen**

Date: **6/22/2017**

Run Number	Test Type	Speed (mph)	Handwheel Angle (deg)	Dir. of First Steer	2 Wheel Lift	Notes
1	Tire Warm-Up	35	80	Right	5P	
2			80			Resulted in ay = 0.55g
3			80			
4			80			2x SWA last cycle
5	Static	0	0			
6	Steady State	50	0			
7	Slowly Increasing Steer	50	50	Left		Resulted in ay = 0.55g
8				Left		
9				Left		
10				Right		
11				Right		
12				Right		
13	6.5 Scalar Fishhook	35	182	Left	5P	
14		40				
15		45				
16		47.5				
17		50				
18	5.5 Scalar Fishhook	45	154	Left		
19		47.5				
20		50				
21	6.5 Scalar Fishhook	35	182	Right		
22		40				

Vehicle: **2018 Volkswagen Atlas**
FWD

Driver: **Peter Broen**

Date: **6/22/2017**

Run Number	Test Type	Speed (mph)	Handwheel Angle (deg)	Dir. of First Steer	2 Wheel Lift	Notes
23		45				
24		47.5				
25		50				
26	5.5 Scalar Fishhook	45	154	Right		
27		47.5				
28		50				

APPENDIX C

Slowly Increasing Steer Test Worksheet

NCAP, 2018 Volkswagen Atlas FWD , Multi-Passenger Load, Test Date: 6/22/2017

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
7	1	49.7	0	100.0	792	-28.1	-0.286	-182.8	-0.2538	-154.6	-0.2148	0.9849	10	90
8	1	50.0	6	87.9	1019	-27.8	-0.297	-180.8	-0.2511	-153.0	-0.2125	0.9940	300	500
9	1	49.8	7	86.0	1020	-27.9	-0.308	-181.2	-0.2516	-153.3	-0.2129	0.9943	300	500
10	0	49.8	0.5	99.1	851	27.4	0.297	178.4	0.2477	150.9	0.2096	0.9939	10	90
11	0	50.0	8.7	82.7	1020	28.0	0.308	182.1	0.253	154.1	0.2140	0.9917	301	500
12	0	50.0	5.9	88.3	1031	28.7	0.311	186.9	0.2595	158.1	0.2196	0.9932	300	500

Mean: 28 0.301 182 0.253 154 0.214

Steering Controller Input Values

Scalar 6.5 values:

Initial HW angle: 182 deg
 Initial time: 0.253 s
 Reversal HW angle: -182 deg
 Reversal time: 0.506 s

Scalar 5.5 values:

Initial HW angle: 154 deg
 Initial time: 0.214 s
 Reversal HW angle: -154 deg
 Reversal time: 0.428 s

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Time History Plots

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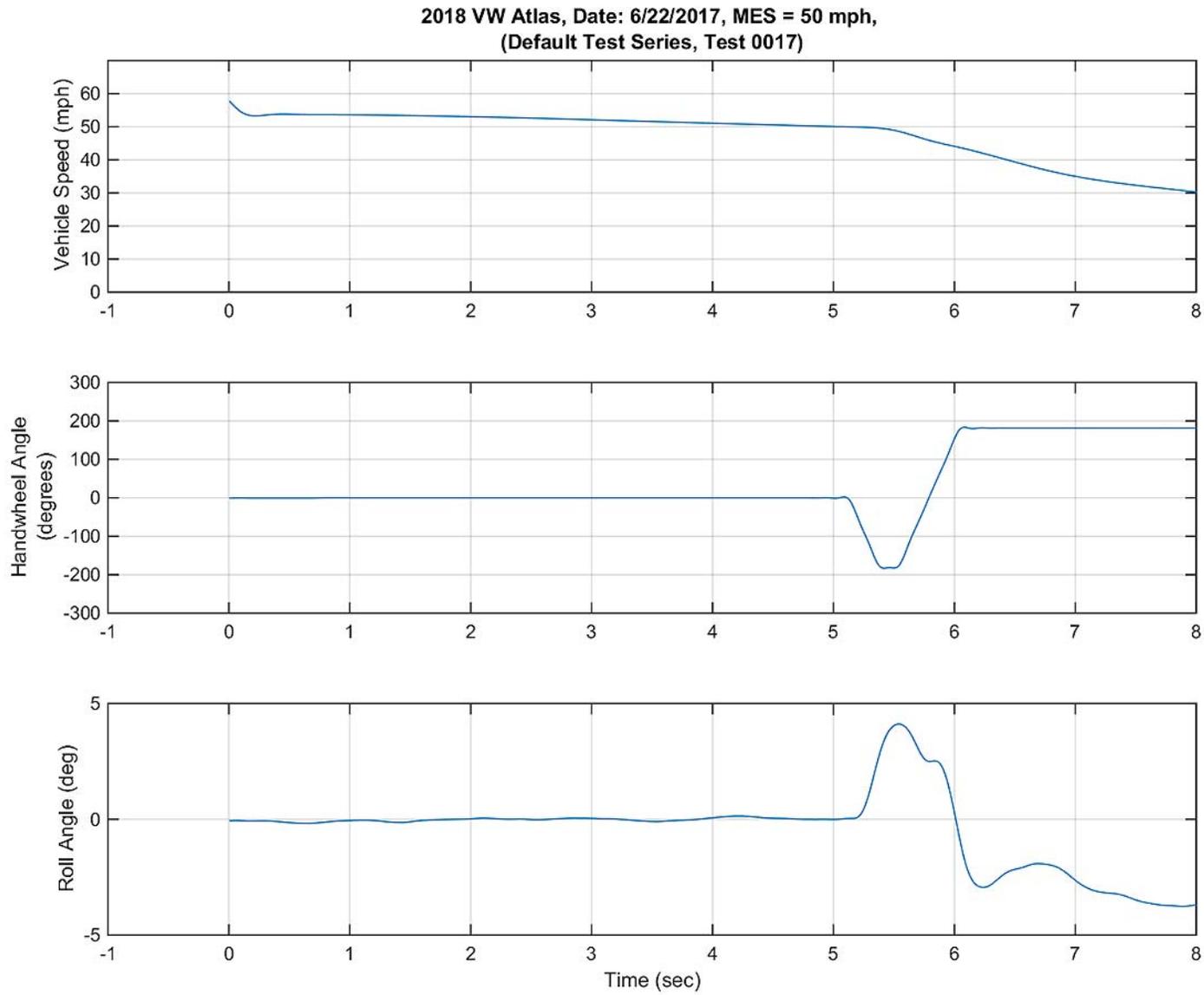


Figure D1. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, L-R, 50 mph

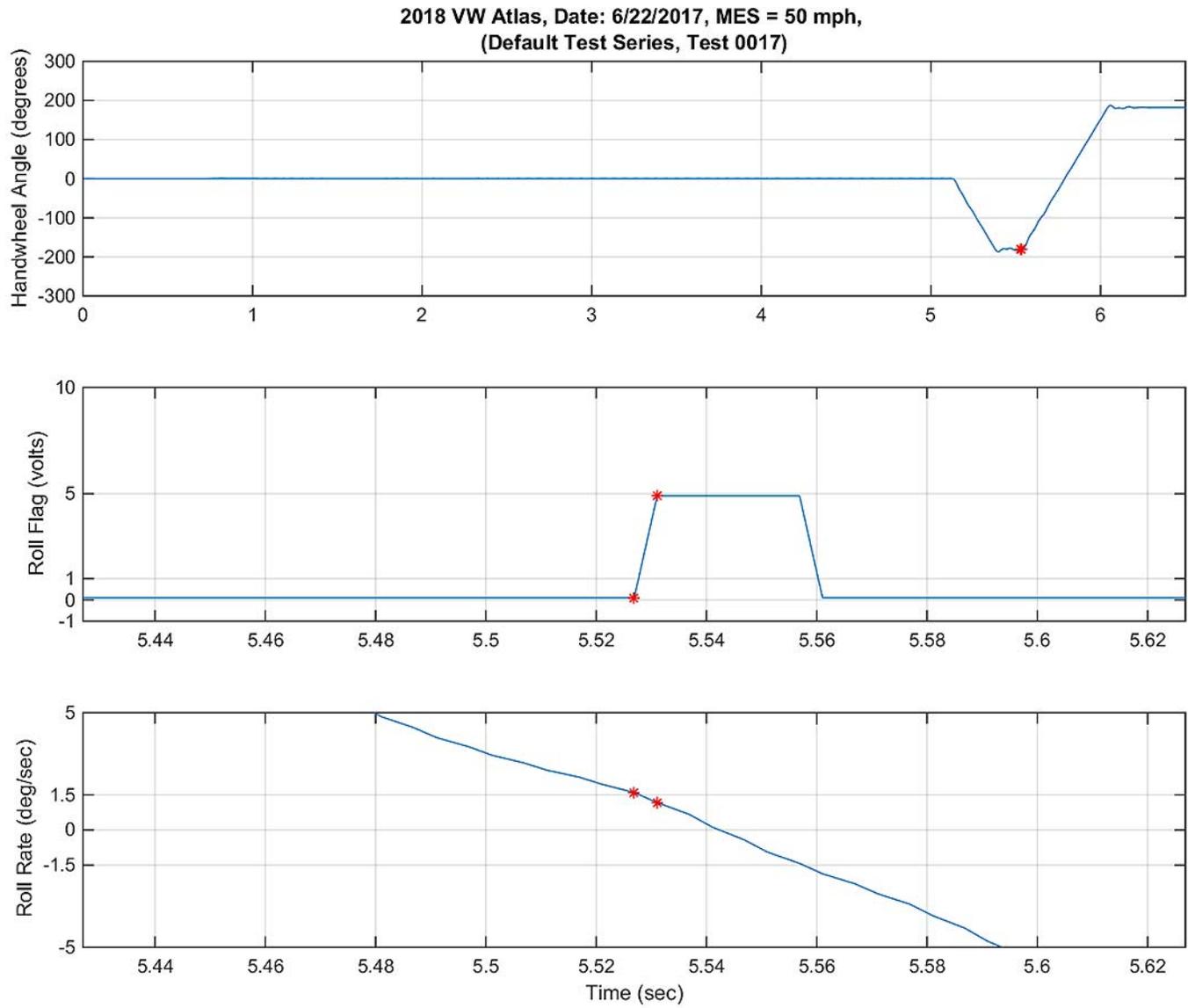


Figure D2. Steering Machine Operation Time History Plots for Default Test Series, L-R, 50 mph

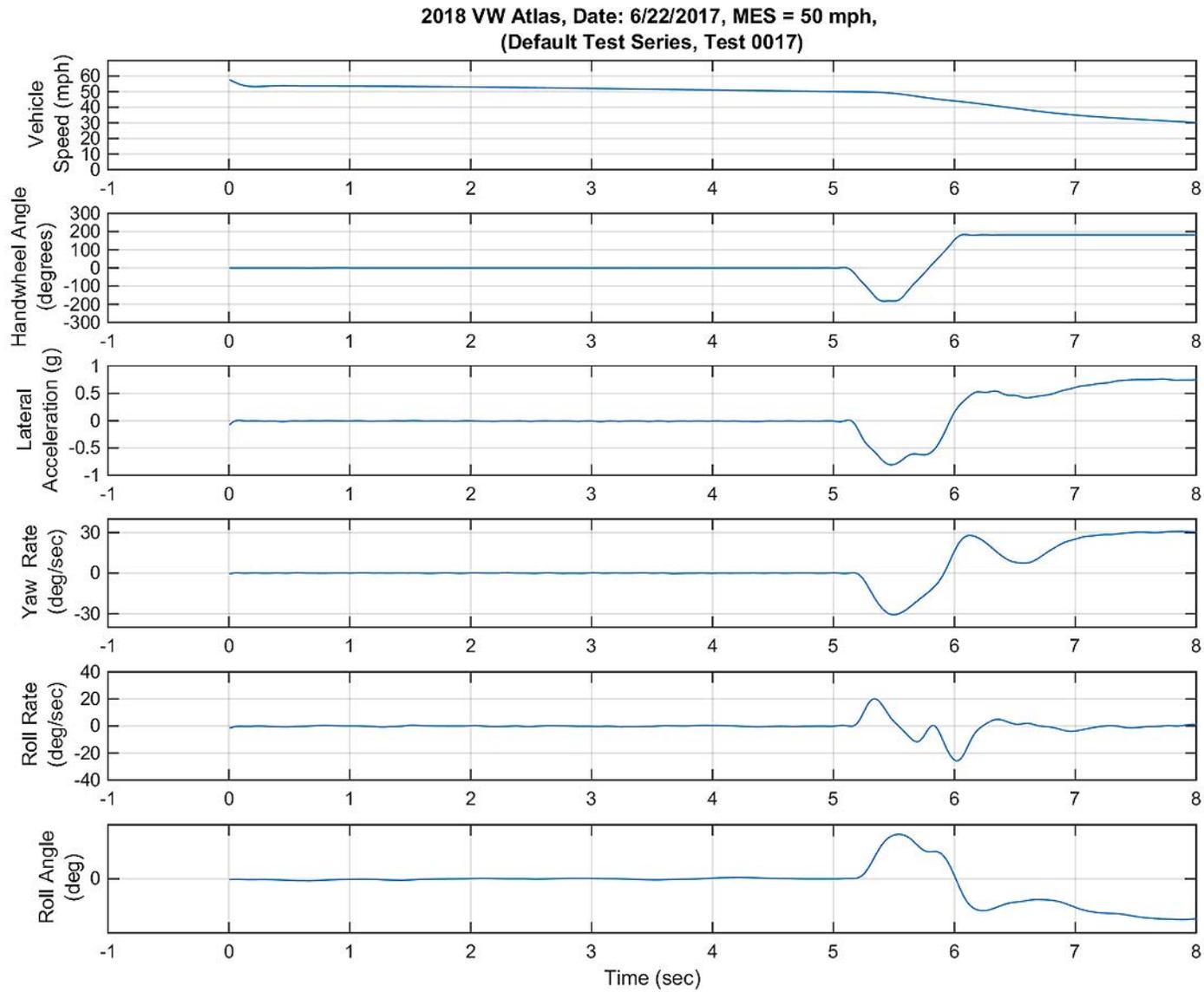


Figure D3. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots For Default Test Series, L-R, 50 mph

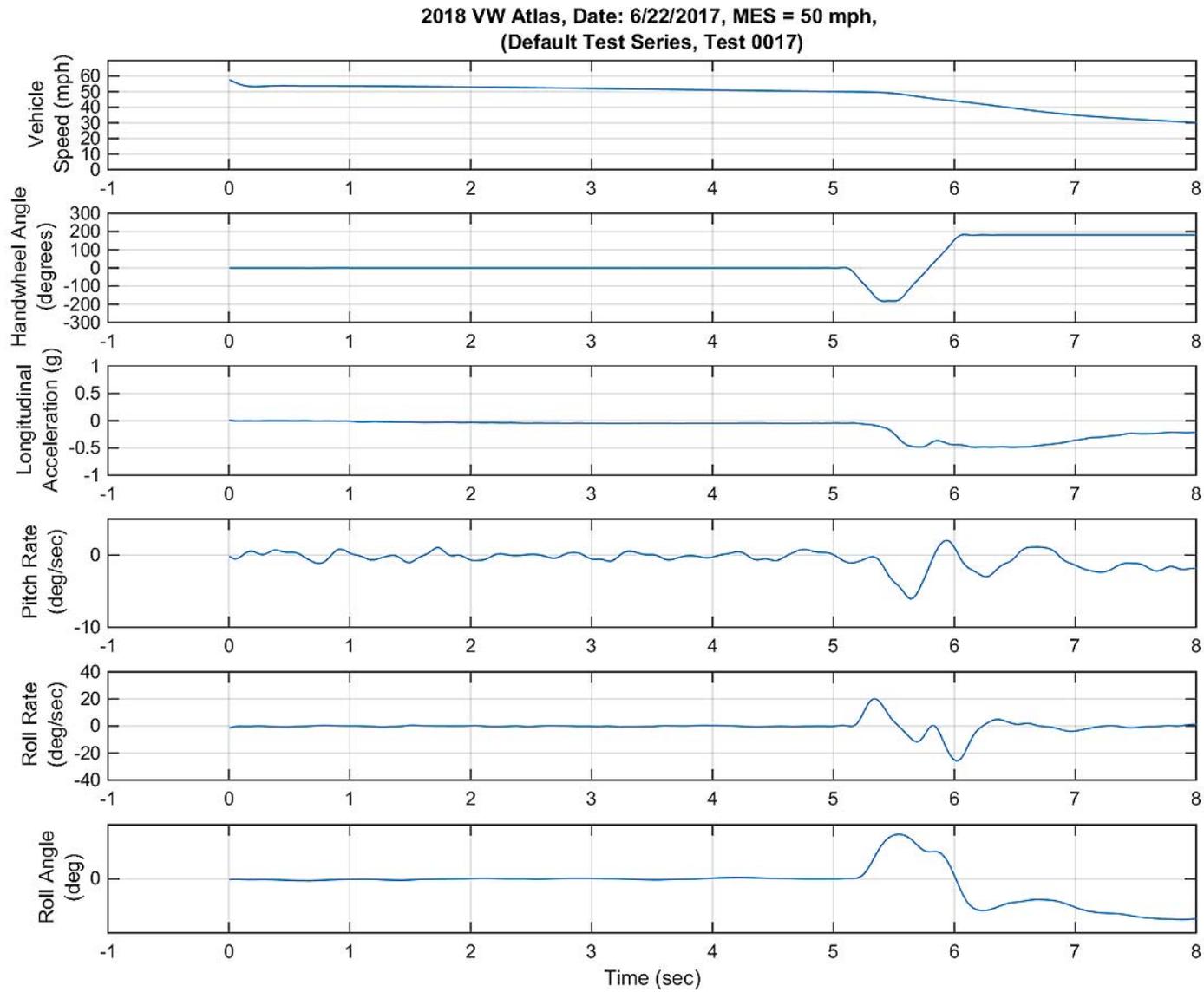


Figure D4. Pitch Rate and Longitudinal Acceleration Time History Plots for Default Test Series, L-R, 50 mph

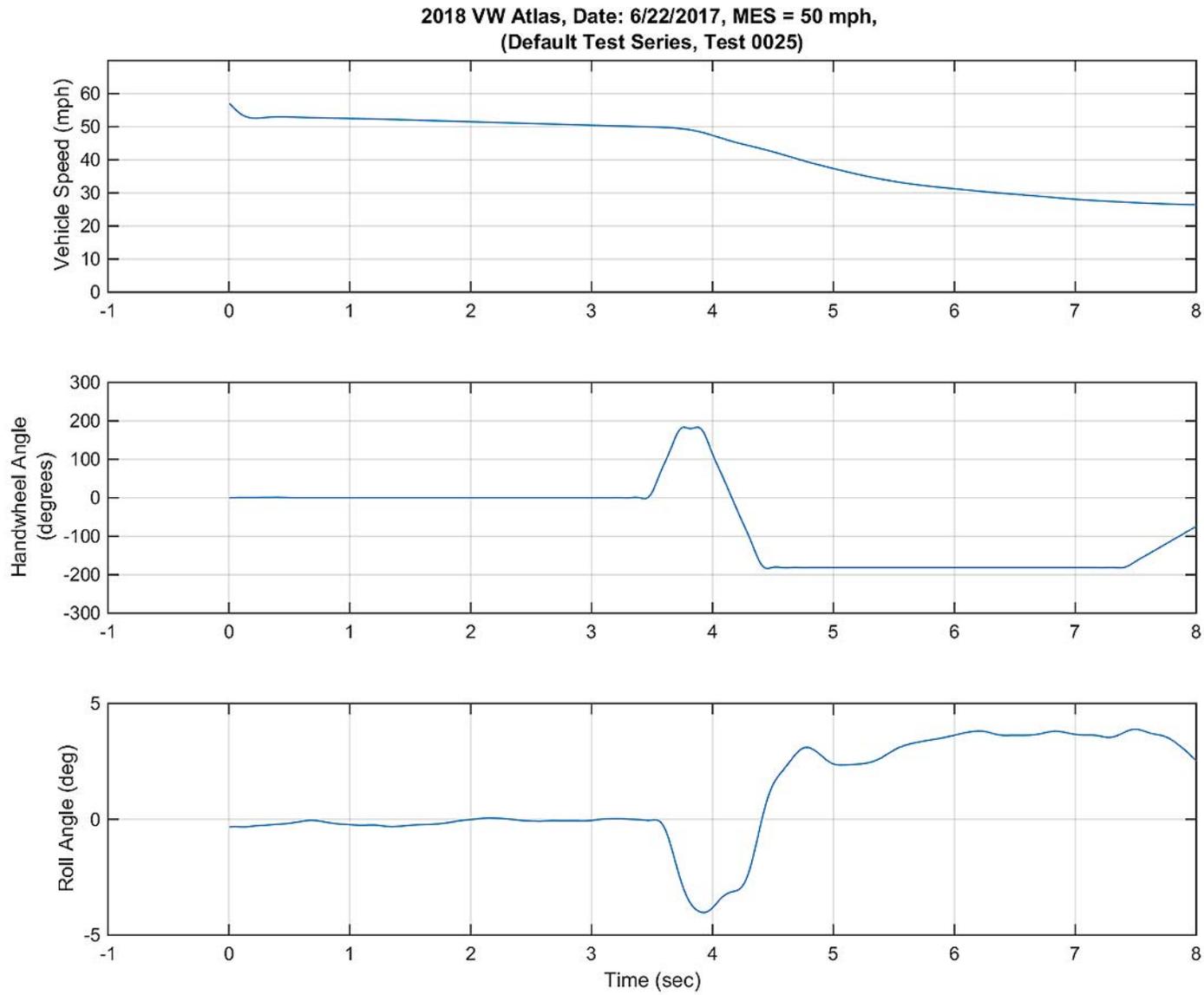


Figure D5. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, R-L, 50 mph

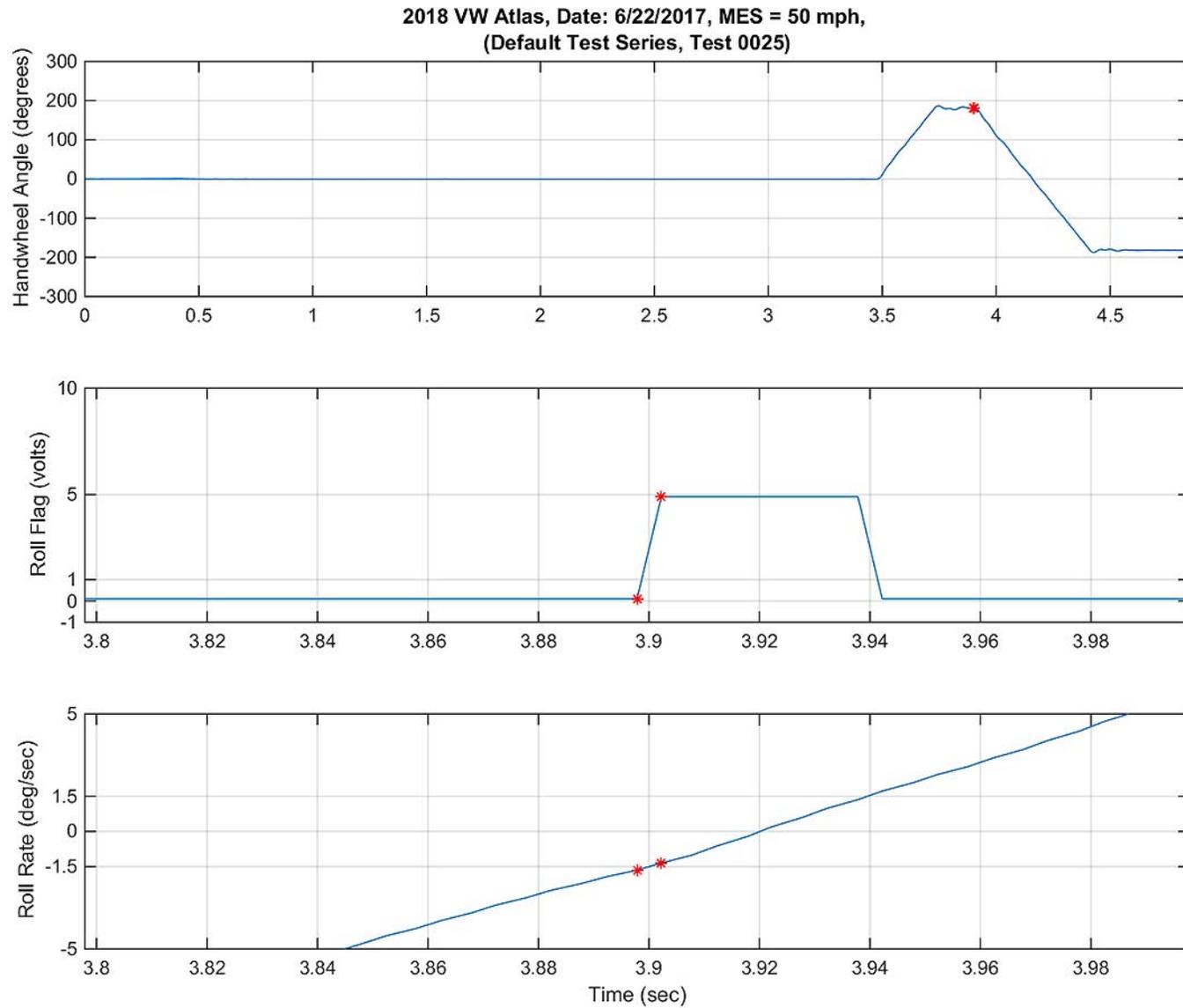


Figure D6. Steering Machine Operation Time History Plots for Default Test Series, R-L, 50 mph

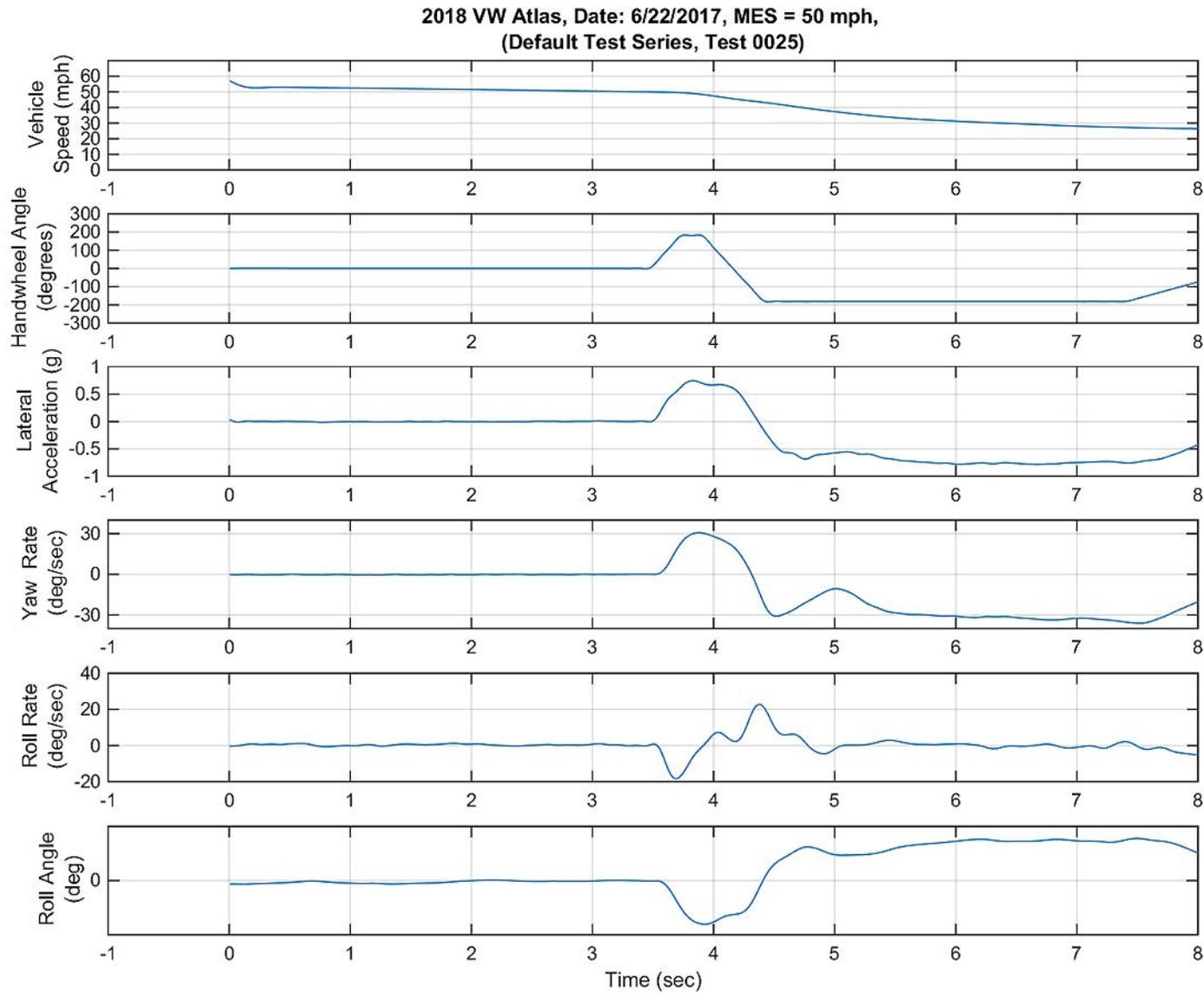


Figure D7. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Default Test Series, R-L, 50 mph

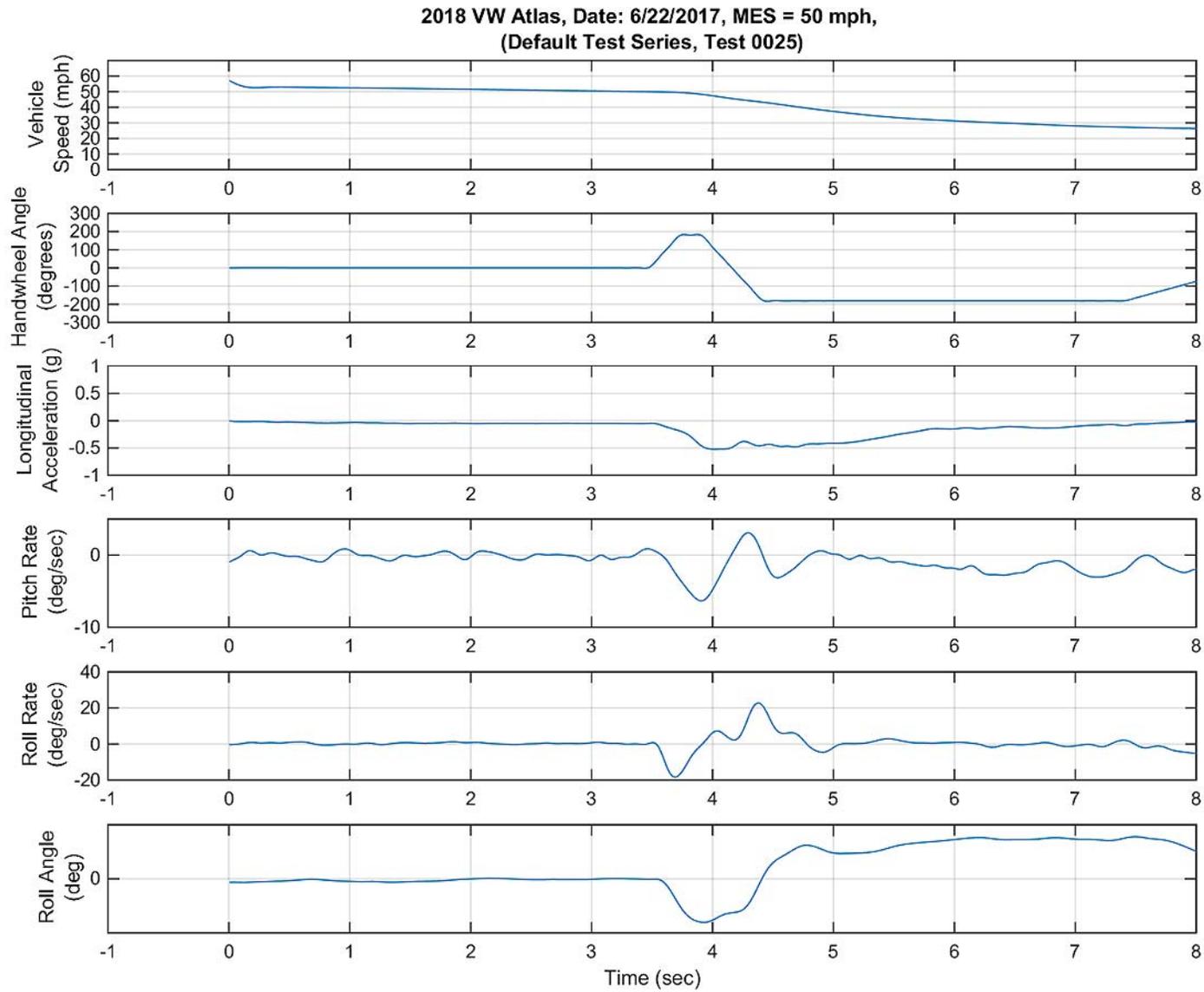


Figure D8. Pitch Rate and Longitudinal Acceleration Time History Plots or Default Test Series, R-L, 50 mph

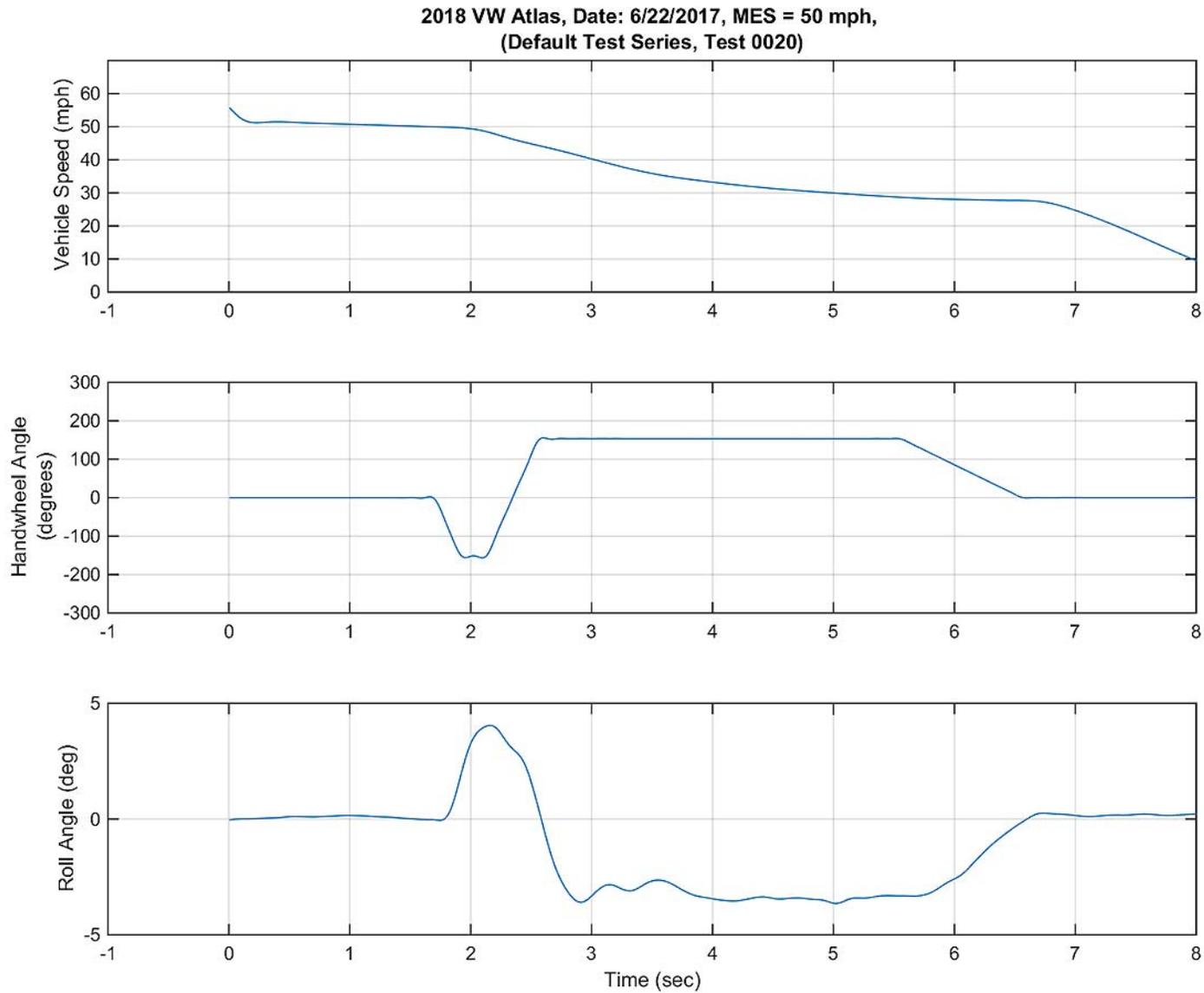


Figure D9. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

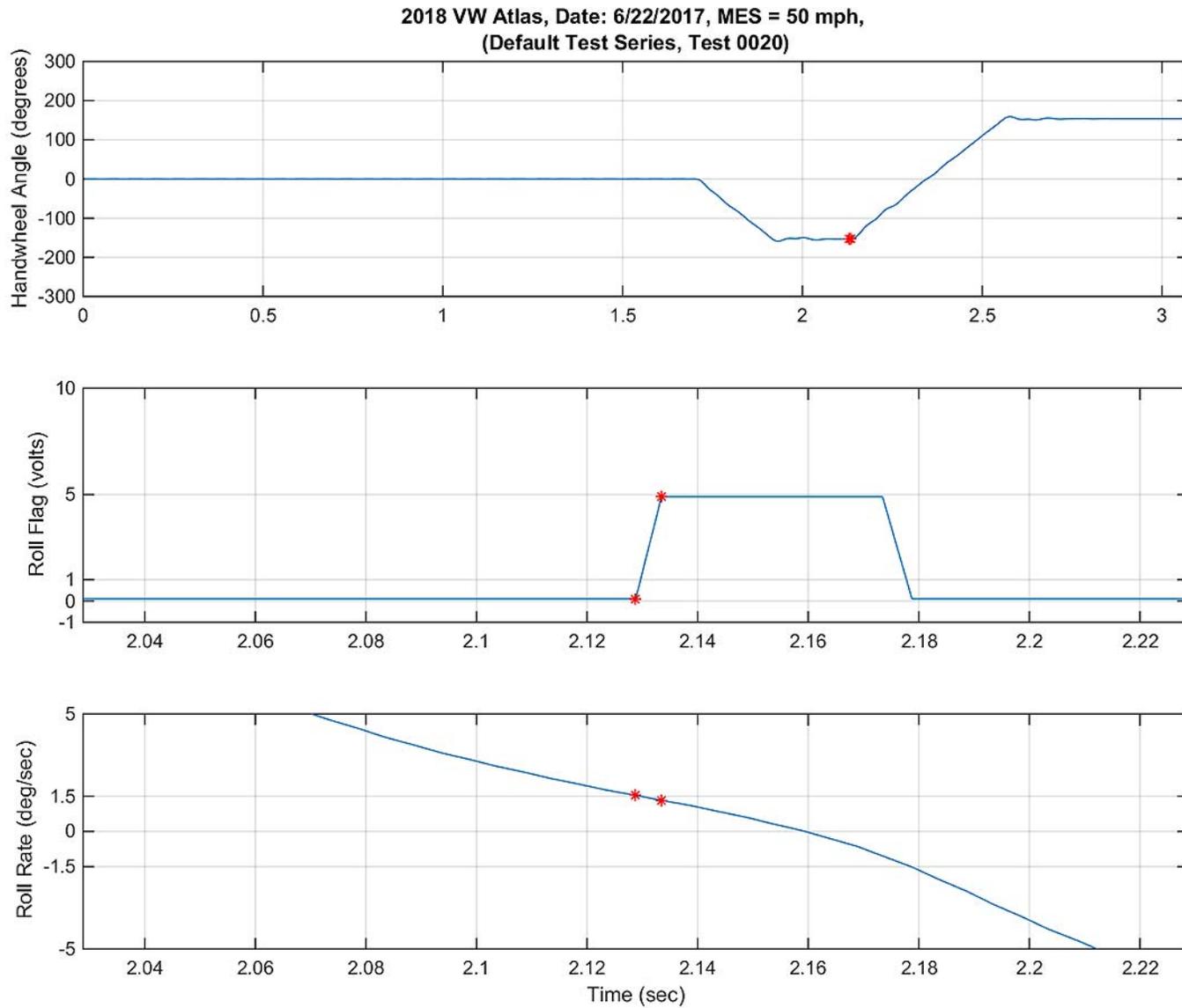


Figure D10. Steering Machine Operation Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

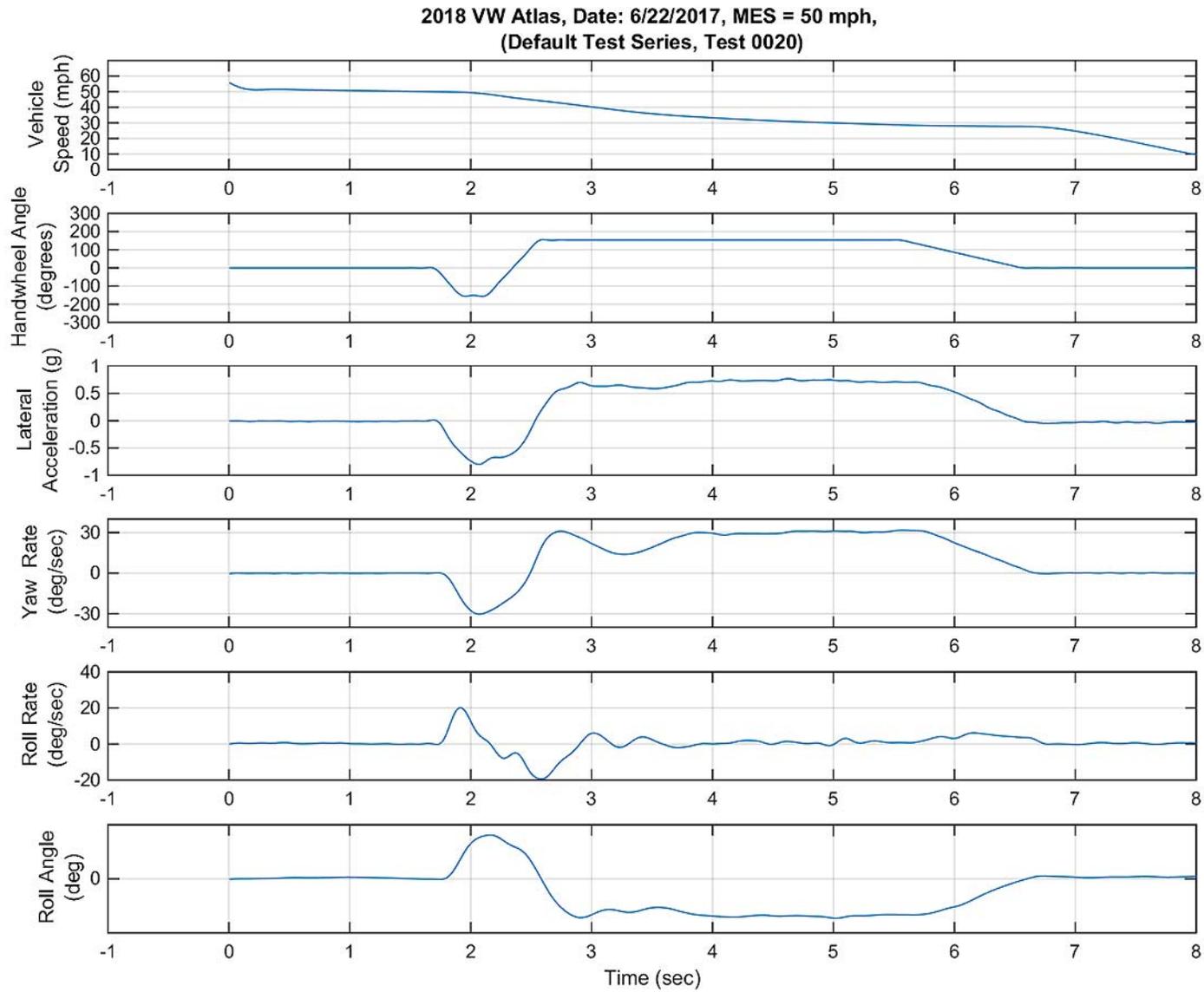


Figure D11. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

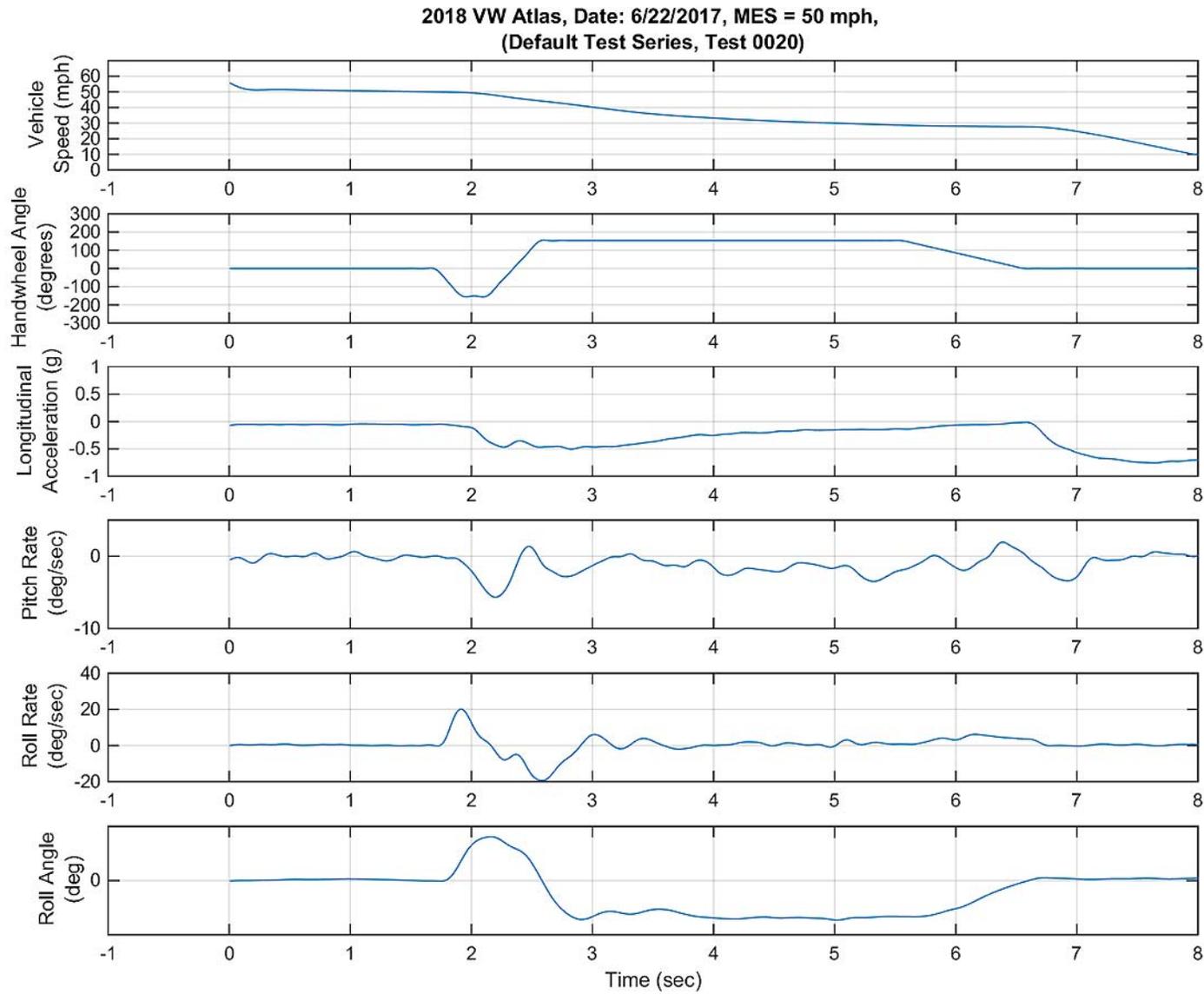


Figure D12. Pitch Rate and Longitudinal Acceleration Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

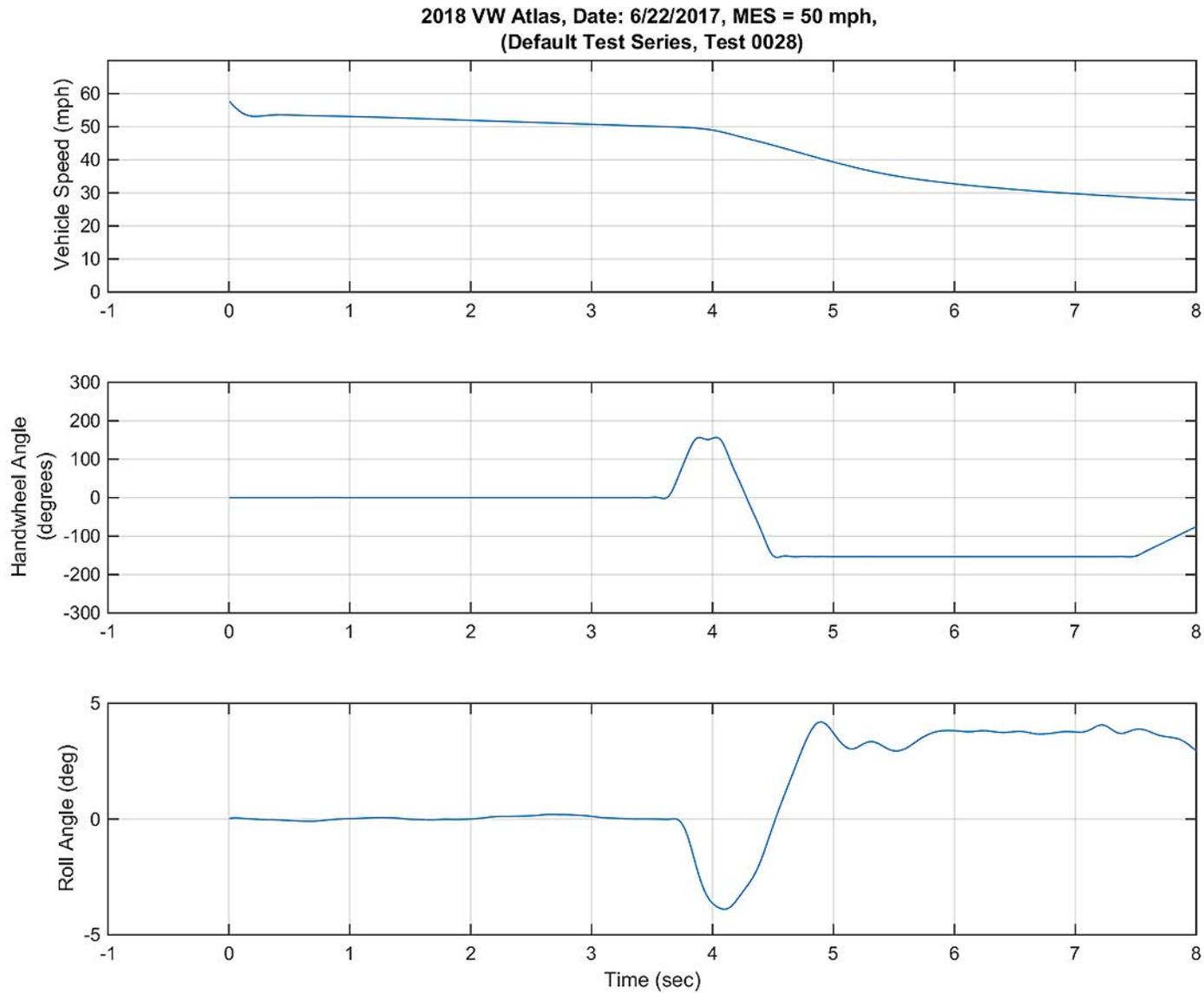


Figure D13. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

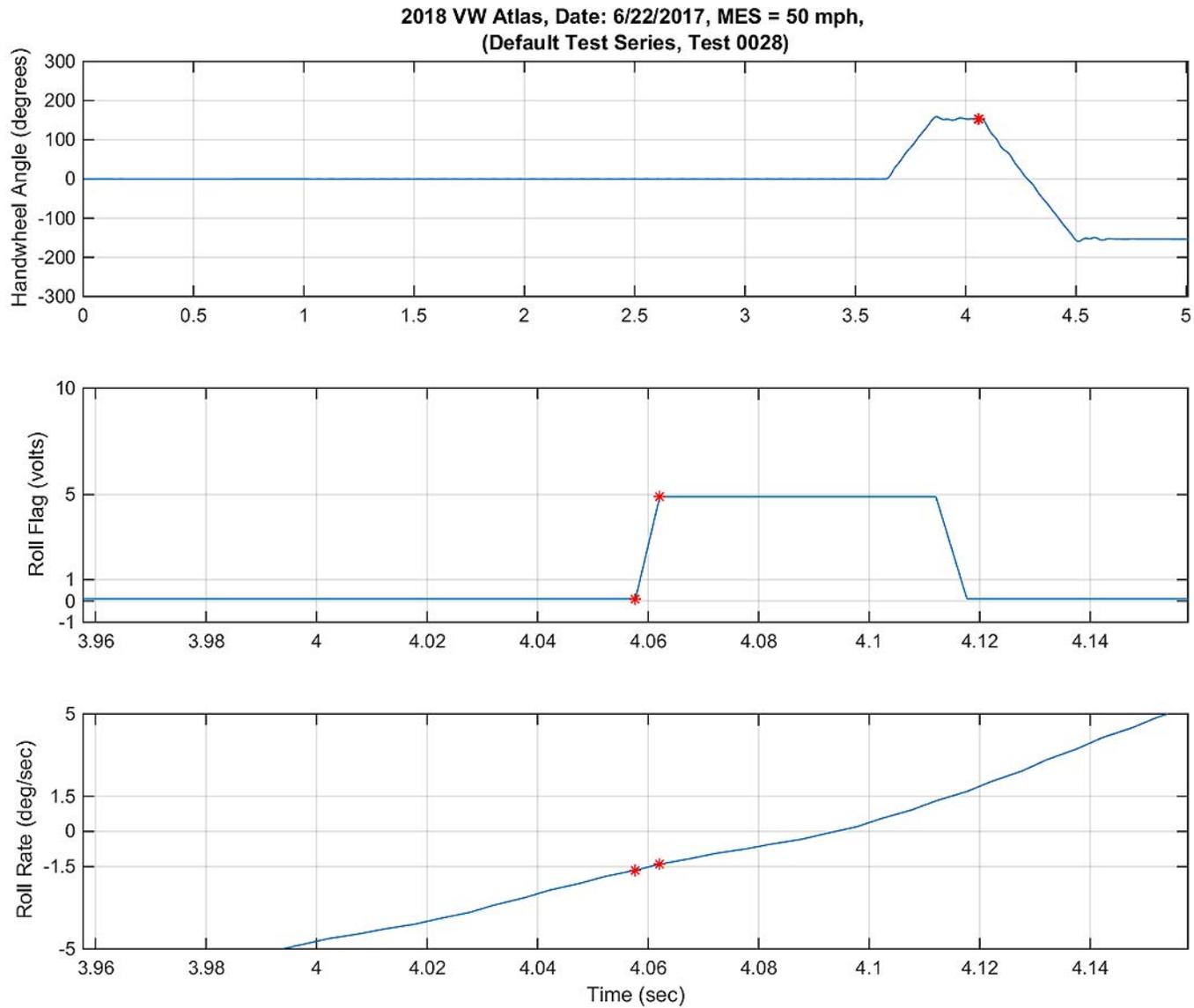


Figure D14. Steering Machine Operation Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

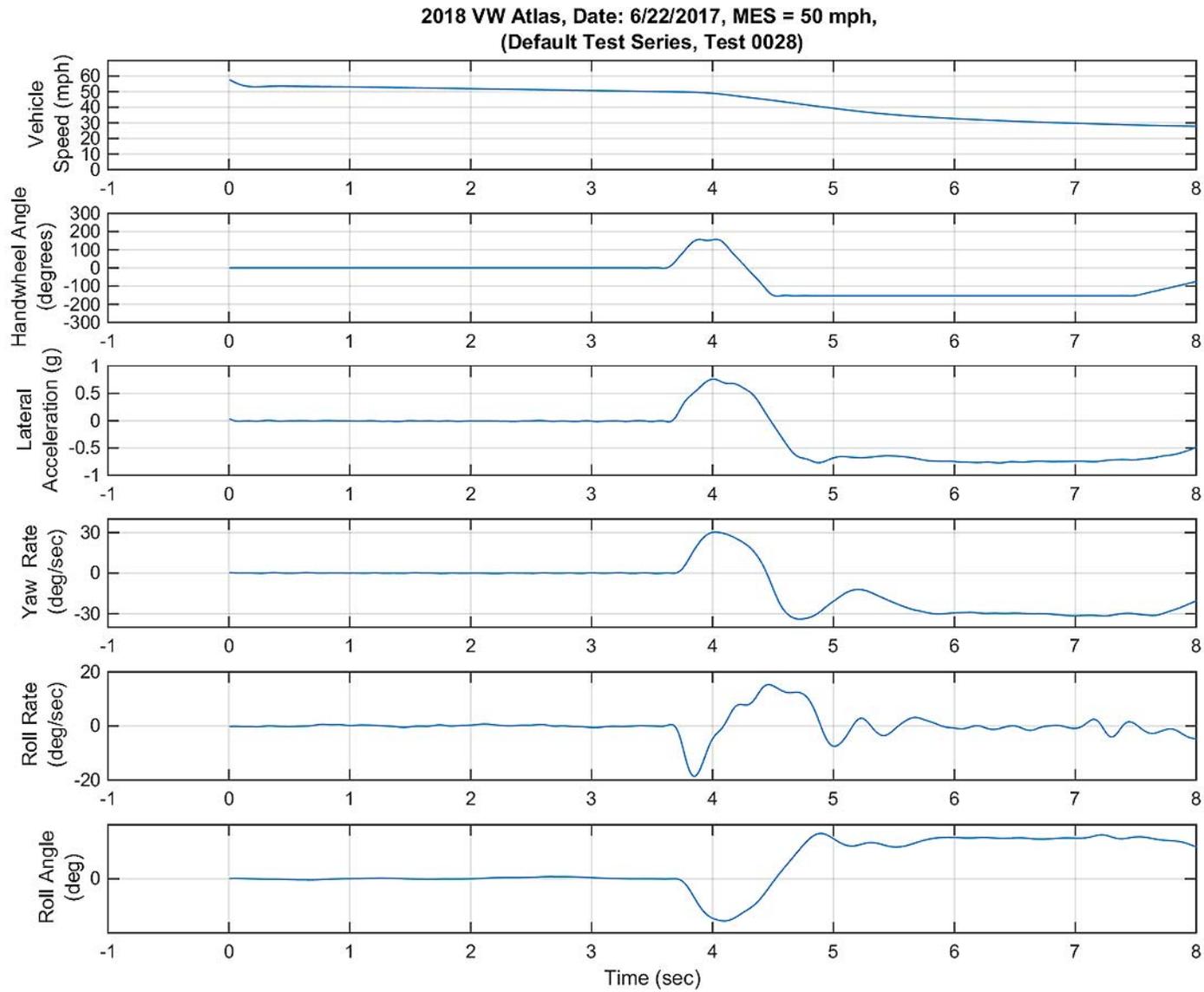


Figure D15. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

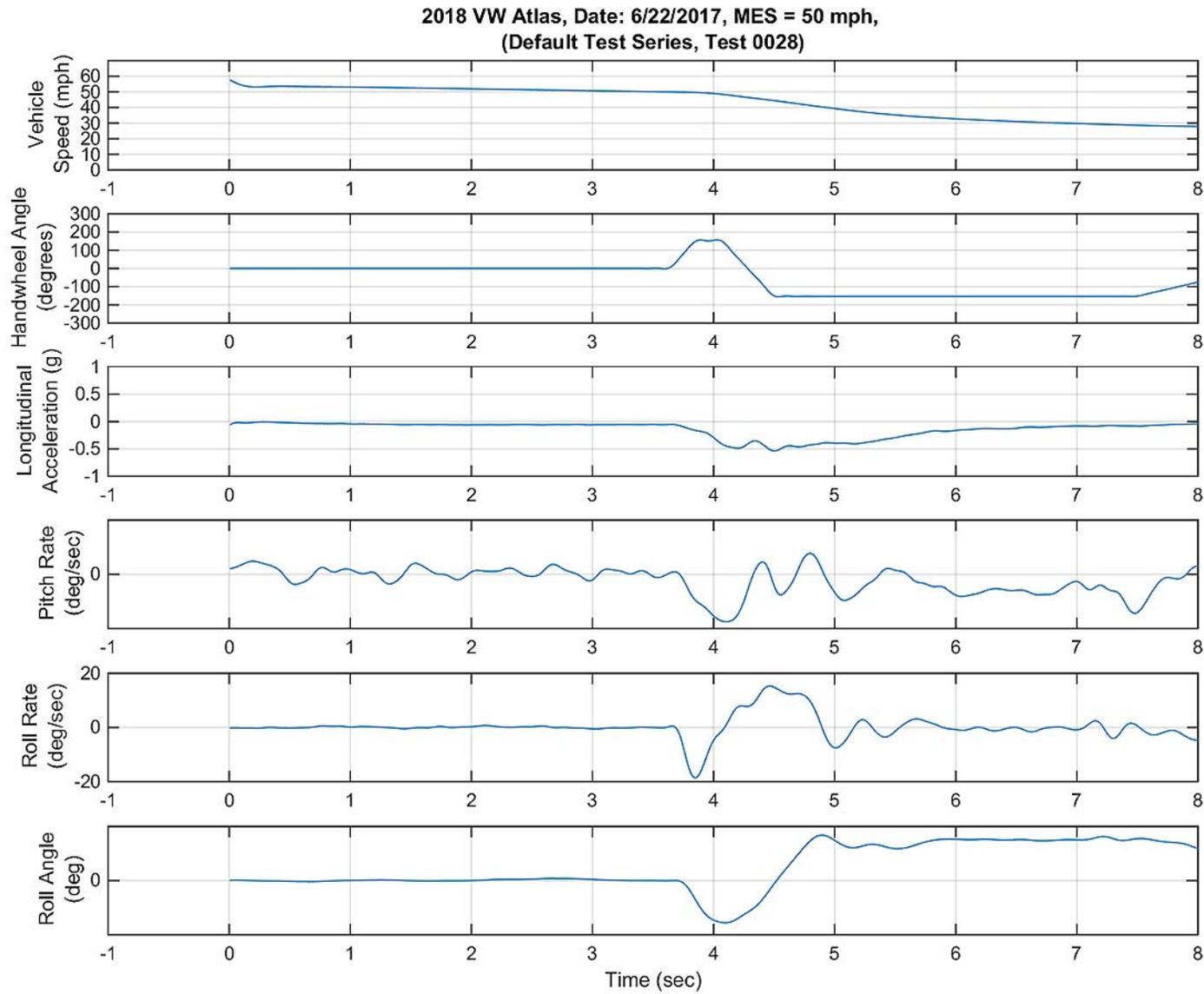


Figure D16. Pitch Rate and Longitudinal Acceleration Time History Plots for Supplemental 2 Test Series, R-L, 50 mph