

**NCAP-KAR-DR-21-14
NEW CAR ASSESSMENT PROGRAM (NCAP)
DYNAMIC ROLLOVER RESISTANCE TEST**

FORD MOTOR CO.

2021 FORD BRONCO BIG BEND 4WD 4-DOOR SUV

**PREPARED BY:
APPLUS IDIADA KARCO ENGINEERING, LLC.
9270 HOLLY ROAD
ADELANTO, CA 92301**



SEPTEMBER 16, 2021

FINAL REPORT

**PREPARED FOR:
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NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
NEW CAR ASSESSMENT PROGRAM
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Prepared By: Mr. Eduard Lucas, Project Engineer
Applus IDIADA KARCO Engineering, LLC.

Approved By: Mr. Bernat Ferrer, Program Manager
Applus IDIADA KARCO Engineering, LLC.

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16. Abstract An NCAP Dynamic Rollover Maneuver (Fishhook) Test was conducted on a 2021 Ford Bronco Big Bend 4WD 4-Door SUV by Applus+ IDIADA KARCO Engineering, LLC. on September 9, 2021. The vehicle did not experience two-wheel lift. The vehicle's steering angle at 0.3 g lateral acceleration at 50 mph was 36.4 degrees.			
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SECTION I

INTRODUCTION

The National Highway Traffic Safety Administration (NHTSA) has engaged Applus+ IDIADA KARCO Engineering, LLC 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 2021 Ford Bronco Big Bend 4WD 4-Door SUV 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 Dynamic Rollover Test 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 693JJ920D000011.

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	2021 Ford Bronco				
VIN	1FMDE5BHXMLA6xxxx				
Body style	SUV				
Number of doors	4				
Trim level	Big Bend				
Seating positions	Front:	2 nd row	3 rd row	4 th row	5 th row
	2	3			
Electronic stability control	Yes				
4-Wheel ABS (Yes/No)	Yes				
Power steering (Yes/No)	Yes				
Major optional equipment	-				
Odometer at start of testing	977 miles				
Drivetrain					
Engine cylinder arrangement	Inline 4				
Engine displacement	2.3 L				
Transmission type	Manual				
Drive arrangement	4WD				
Chassis					
Track width	F: 60.9 in (1547 mm), R: 60.9 in (1547 mm)				
Wheelbase	115.8 in (2942 mm)				
Curb weight	4618 lb (2094.5 kg)				
Certification Data from Vehicle's Label					
Vehicle manufactured by	Ford Motor Co.				
Date of manufacture	06/21				
GVWR	5920 lb (2685 kg)				
GAWR Front	3090 lb (1402 kg)				
GAWR Rear	3070 lb (1393 kg)				

Table 2. Tire Information

Tire Manufacturer	Bridgestone
Tire Model	Dueler AT
Tire Size	Front: 255/75R17 Rear: 255/75R17
Load rating	Front: 115 Rear: 115
Speed rating	Front: T Rear: T
Treadwear grade	Front: 400 Rear: 400
Traction grade	Front: B Rear: B
Temperature grade	Front: B Rear: B
Location of "Recommended Tire Pressure" label	Driver's door jamb
Recommended cold tire pressure	Front: 35 psi, (240 kPa) Rear: 35 psi, (240 kPa)
DOT code (8 last digits)	Front: RHD2 0521 Rear: RHD2 0521

Table 3. Vehicle Loading

Water dummy and other loading	Multi-Passenger Configuration 3 water dummies in second row
Water dummy weight	525.1 lb (238.2 kg)
Fuel level	Full
Weight as Tested	
Left front	1468 lb (666 kg)
Right front	1448 lb (657 kg)
Left rear	1347 lb (611 kg)
Right rear	1294 lb (587 kg)
Total weight	5557 lb (2521 kg)

D. STEERING CONTROLLER

Precise steering control is accomplished using a steering machine designed and constructed by ABD. It can provide up to 45 ft-lb torque and at rates over 1000 deg/sec. The integrated angle encoder has an unlimited range with a resolution of 0.25 degrees and an accuracy of ± 0.25 degrees. The steering motor is controlled by RC8 software from ABD, which also acts as the data acquisition system.

E. REAL-TIME CONTROLLER AND DATA ACQUISITION

Data acquisition is achieved using a MOSES Meas X, which also serves as the real-time system for the steering controller. Data from the OXTS, 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 MOSES MeasX. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (Table 5).

Two video cameras were used to record the Fishhook runs. They were positioned nominally as shown in Figure 1. The recorded video was reviewed after the Fishhook runs to check for any two-wheel lift. If any two-wheel lift was observed, four 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 Applus+ IDIADA KARCO Engineering, LLC used for this specific test program.

Table 4. Weight of In-Cab Test Equipment

Equipment	Location	Equipment Weight (lb)	
		NHTSA*	IDIADA
Data Acquisition System	Front passenger seat	58	35
GPS Inertial unit	At the chassis in a flat and rigid surface		7
Steering Machine	Handwheel	31	51
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 footwell.	39	39
	Total	128	132

* 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. Sensor Specifications

Type	Measured Variable	Sensor	Range	Resolution	Accuracy	Specifics	Serial Number	Calibration	Unit
<i>Multi-Axis Inertial Sensing System</i> <i>Distance Measuring System</i> <i>Radar Speed Sensor</i> <i>Data Flag (Roll Rate Flag)</i>	Longitudinal speed Lateral speed Longitudinal acc. Lateral acc. Roll angle Pitch angle Yaw angle Roll rate Pitch rate Yaw rate	GPS inertial unit	- - ±100 ±100 ±100 ±100 ±100 ±100 ±100 ±100	0.01 %/s 0.01 m/s ²	±0.1 ±0.1 ±0.1 ±0.1 ±0.05 ±0.05 ±0.1 ±0.1 ±0.1	OXTS (RT)	1611	By: IDIADA Date: 6/16/2020 Due: 6/16/2022	km/h km/h m/s ² ° ° ° %/s %/s %/s
<i>Angle Encoder¹</i> <i>Data Flag (Handwheel Command Flag)</i>	Steering angle Steering torque	Steering wheel robot	>1000 60	0.25 deg	±0.20 ±0.25	ABD	1491/20	By: IDIADA Date: 11/16/2020 Due: 11/16/2021	° Nm
<i>Infrared Distance Measuring System</i>	Tire wheel lift	Height sensors	300-700	0.01 mm	±0.8	OPTImess	OMS 4140-9155 OMS 4140-9156 OMS 4140-9157 OMS 4140-9158	By: IDIADA Date: 10/16/2020 Due: 10/16/2021	mm
<i>Load Cell</i>	Brake Pedal Force	Load Cell	±600	-	±0.5	Novatech	29730	By: IDIADA Date: 01/18/2021 Due: 01/18/2022	N
<i>Acquisition system</i>	-	Acquisition system	200	-	-	IDIADA Moses MEAS X	180749	By: IDIADA Date: 05/21/2020 Due: 05/21/2022	-

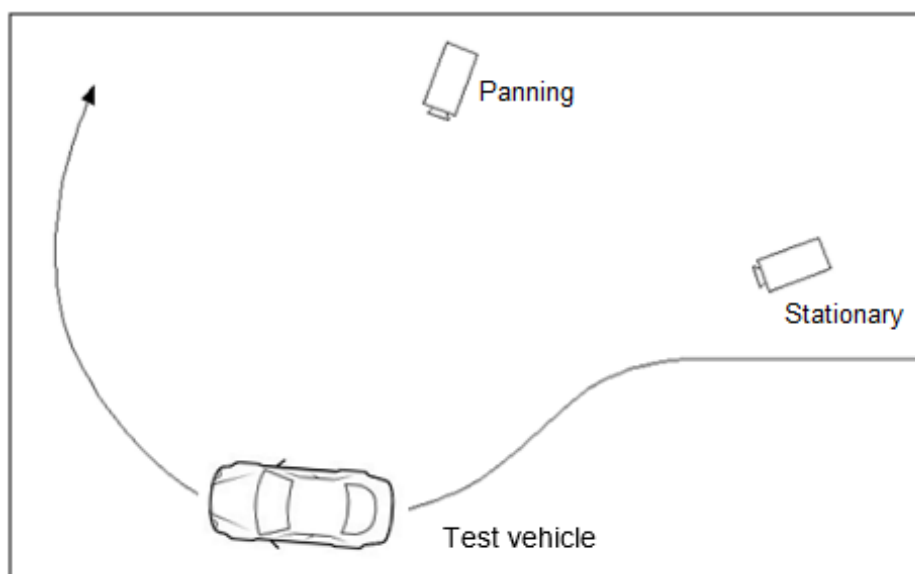


Figure 1. Nominal Position of Video Cameras for Fishhook Tests

SECTION III

TEST PROCEDURES

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 3 seconds, and then returned to zero angle in 2 seconds.

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.

A. TEST CONDITIONS

1. Test Surface

The tests were conducted on the Vehicle Dynamics Area (VDA) at HONDA Proving Center facility, located in Cantil, California, on 9/9/2021. The VDA has a smooth, flat (slope less than 0.5% throughout) asphaltic concrete surface. Its dimensions are as shown in Figure 2. 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 surface friction measurement results are shown in Table 6.

Table 6. Lateral Surface Friction

Date of surface friction measurements	9/9/2021
Average lateral friction coefficient	0.94
Date of peak breaking coefficient measurements	11/9/2020
Peak braking coefficient	0.92

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)	36.4°
5.5 scalar handwheel angle for Fishhook Test	200.2°
6.5 scalar handwheel angle for Fishhook Test	236.6°

3. Weather Conditions

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

Table 8. Weather Conditions

Ambient temperature	97.6 °F (36.4 °C)
Wind Speed	2.2 mph (1.0 m/s)
Wind Direction	SE

SECTION IV



RESULTS

There is Appendix A with the photographic documentation. The test run log is given in Appendix B. A summary of the Slowly Increasing Steer Test 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 2021 Ford Bronco Big Bend 4WD 4-Door SUV there was no two-wheel lift at any test condition.

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VEHICLE DESCRIPTION		ML A62234	
 <p>Go Further ford.com</p>		<p>2021 4-DOOR 4X4 BIG BEND - 5 PASSENGER 2.3L ECOBOOST I-4 ENGINE 7-SPEED MANUAL TRANSMISSION</p>	
<p>STANDARD EQUIPMENT INCLUDED AT NO EXTRA CHARGE</p>		<p>EXTERIOR SHADOW BLACK INTERIOR CLOTH GRAY/BLACK SEATS</p>	
<p>EXTERIOR</p> <ul style="list-style-type: none"> EASY FUEL® CAPLESS FILLER FENDER TIE-DOWN HOOKS GRILLE-GRAY/BRONCO WHIT HEADLAMPS - AUTO HIGH BEAM HEADLAMPS - AUTO LED MIRRORS-HTD/POWER GLASS, MANUAL FOLD/SPOTTER MIRROR TOW HOOKS-FRT (2)/REAR (1) 	<p>INTERIOR</p> <ul style="list-style-type: none"> 1 TOUCH UP/DOWN DRVPASS WIN 6-WAY MANUAL DRVPASS SEAT 60/40 SPLIT FOLD REAR SEAT CARPET FLOORING, BOTH ROWS CLOTH BUCKET FRONT SEATS CRUISE CONTROL IP CLUSTER 8" DIGITAL SCRN LOCKING GLOVE BOX LTHR GEAR KNOB/STR WHEEL MANUAL A/C, SINGLE ZONE POWERPOINTS - 12V TILT/TELESCOPE STR COLUMN USB A(1)/C(1)-1ST/2ND ROWS 	<p>FUNCTIONAL</p> <ul style="list-style-type: none"> AM/FM STEREO W/8 SPEAKERS AUTO START STOP TECH BRAKES, 4-WHEEL DISC/ABS FORDPASS™ CONNECT 4G/LTE HOTSPOT TELEMATICS MODEM FRONT STABILIZER BAR HILL START ASSIST PRE-COLLISION ASSIST W/ABS PUSH-BUTTON START REAR VIEW CAMERA REMOTE KEYLESS ENTRY SIRIUSXM® W/360L-NA AK&HI SYNC®4 W/8" SCREEN TERR MGMT W/O.A.T. MODES TOOL KIT- DOOR/TOP REMOVAL 	<p>SAFETY/SECURITY</p> <ul style="list-style-type: none"> ADVANCETRAC™ WITH RSC® AIRBAGS-FRONT (DUAL STAGE) & SIDE IMPACT/SAFETY CANOPY® SYSTEM (ALL ROWS) BELT-MINDER CHIME CHILD SAFETY REAR DR LOCKS ELCTR STABILITY/TRACTN CTL INDIV TIRE PRESS MONIT SYS LATCH CHILD SAFETY SYSTEM PERIMETER ALARM PERSONAL SAFETY SYSTEM™
<p>INCLUDED ON THIS VEHICLE</p> <p>EQUIPMENT GROUP 221A</p> <ul style="list-style-type: none"> BIG BEND SERIES <p>OPTIONAL EQUIPMENT/OTHER</p> <ul style="list-style-type: none"> 17" GRAY-PNTD ALUM WHEELS J255/75R17 A/T TIRES (32") 4-6 REAR AXLE-OPEN DIFF SOFT TOP, CLOTH STORAGE BAGS - DOOR CARGO AREA PROTECTOR FRONT AXLE-OPEN DIFFRNTL FLOOR LINERS, FRONT/REAR AUXILIARY SWITCHES FRONT LICENSE PLATE BRACKET 		<p>PRICE INFORMATION</p> <p>BASE PRICE \$35,880.00</p> <p>TOTAL OPTIONS/OTHER \$25.00</p> <p>TOTAL VEHICLE & OPTIONS/OTHER \$36,705.00</p> <p>DESTINATION & DELIVERY 1,495.00</p>	
 <p>Bronco Off-Road is an outdoor adventure playground offered in four epic U.S. locations where Bronco 2/4 door owners can test the new Bronco lineup in challenging terrain, experience unique outdoor adventures and immerse themselves in all things Bronco. Original retail Bronco 2/4 door owners are eligible to attend. Fleet vehicles not included. For all program details visit: broncooffroadeo.com</p>		<p>GOVERNMENT 5-STAR SAFETY RATINGS</p> <p>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.</p> <p>Frontal Crash Driver Passenger Not Rated Not Rated Based on the risk of injury in a frontal impact. Should ONLY be compared to other vehicles of similar size and weight.</p> <p>Side Crash Front seat Rear seat Not Rated Not Rated Based on the risk of injury in a side impact.</p> <p>Rollover Not Rated Based on the risk of rollover in a single-vehicle crash.</p> <p>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</p>	
<p>RA84</p> <p>RAIL</p> <p>72-1929 QIT 2</p>		<p>TOTAL MSRP \$38,200.00</p> <p>Whether you decide to lease or finance your vehicle, you'll find the choices that are right for you. See your dealer for details or visit www.ford.com/finance.</p> <p>MF101 N RB 2X 125 001108 06 10 21</p>	
<p>This label is affixed pursuant to the Federal Automobile Information Disclosure Act. Gasoline, License, and Title Fees, State and Local taxes are not included. Dealer installed options or accessories are not included unless listed above.</p>		<p>1FMDESBHXMLA6</p> <p>WARNING: Operating, servicing and maintaining a passenger vehicle, pickup truck, van, or off-road vehicle can expose you to chemicals including engine exhaust, carbon monoxide, phthalates, and lead, which are known to the State of California to cause cancer and birth defects or other reproductive harm. To minimize exposure, avoid breathing exhaust, do not idle the engine except as necessary, service your vehicle in a well-ventilated area and wear gloves or wash your hands frequently when servicing your vehicle. For more information go to www.P65Warnings.ca.gov/passenger-vehicle.</p>	

08/18/2021

3202106173868

Figure A1. Monroney Label



Figure A2. Right Front View, Test Vehicle As-Delivered



Figure A3. Left Rear View, Test Vehicle As-Delivered



Figure A4. Left Front View, Test Vehicle in Test Condition



Figure A5. Right Rear View, Test Vehicle in Test Condition

MFD. BY FORD MOTOR CO. DATE: 06/21 GVWR: 2685 KG (5920 LB)
 FRONT GAWR: 1402 KG (3090 LB) REAR GAWR: 1393 KG (3070 LB)
 WITH 255/75R17 115T TIRES WITH 255/75R17 115T TIRES
 17x7.5J RIMS 17x7.5J RIMS
 AT 240 kPa/ 35 PSI COLD AT 240 kPa/ 35 PSI COLD
 THIS VEHICLE CONFORMS TO ALL APPLICABLE FEDERAL MOTOR VEHICLE SAFETY AND THEFT
 PREVENTION STANDARDS IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE.
 VIN: 1FMDE5BHXMLA6 TYPE: MPV



EXT PNT: G1		RC: 72 DSO:						
WB	INT TR	TP/PS	R	AXLE	TR	SPR		
116	LV		B	46	Q	TTDD	F0379	
MADE IN U.S.A.		3202106173868				ULC	T0696	
							▽ 5U5A-3520472-AA	

Figure A6. Vehicle's Certification Label



TIRE AND LOADING INFORMATION

SEATING CAPACITY TOTAL : 5 FRONT: 2 REAR: 3

The combined weight of occupants and cargo should never exceed : **655 kg or 1446 lbs.**

▽ 5U5A-1532-AA (TLU) FoMoCo

TIRE	SIZE	COLD TIRE PRESSURE
FRONT	255/75R17 115T	240 KPA, 35 PSI
REAR	255/75R17 115T	240 KPA, 35 PSI
SPARE	255/75R17 115T	240 KPA, 35 PSI

SEE OWNERS
MANUAL FOR
ADDITIONAL
INFORMATION

1FMDE5BHXMLA6



Figure A7. Vehicle's Tire Information Placard

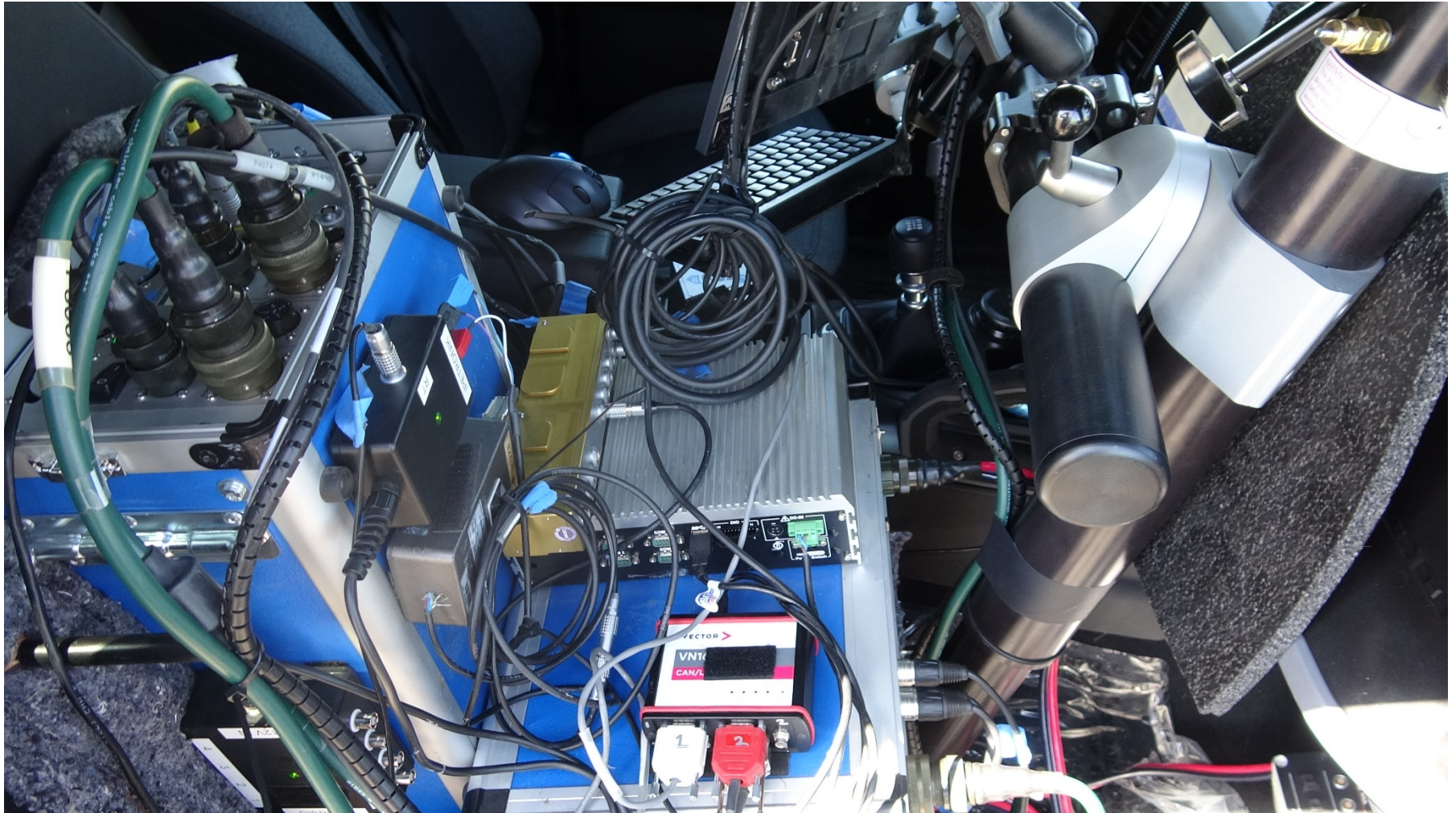


Figure A8. Instrumentation in Test Vehicle



Figure A9. Steering Controller and Computer



Figure A10. Ballast Condition

APPENDIX B
TEST RUN LOG

Run Number	Test Type	Speed (mph)	Handwheel Angle (deg)	Dir. of First Steer	2 Wheel Lift	Notes
1	Tire Warm-Up	35	30.0	Left	N/A	Resulted in ay = 0.18 g
2	"	"	61.7	"	"	Resulted in ay = 0.35 g
3	"	"	"	"	"	
4	"	"	"	"	"	
5	2x SWA last cycle	"	123.4	"	"	2x SWA last cycle
6	Static	0	0	N/A	N/A	
7	Steady State	50	0	N/A	N/A	
8	Slowly Increasing Steer	50	30.0	Left	N/A	
9	"	"	54.1	Left	"	HW angle at 0.3 g = -38.6
10	"	"	"	Left	"	HW angle at 0.3 g = -36.9
11	"	"	"	Left	"	HW angle at 0.3 g = -38.0
12	"	"	"	Right	"	HW angle at 0.3 g = 35.6
13	"	"	"	Right	"	HW angle at 0.3 g = 34.6
14	"	"	"	Right	"	HW angle at 0.3 g = 34.6
						Average = 36.4
15	Fishhook 6.5 Scalar	35	236.6	Left	No	
16	"	40	"	"	"	
17	"	45	"	"	"	
18	"	47.5	"	"	"	
19	"	50	"	"	"	
20	Fishhook 6.5 Scalar	35	236.6	Right	No	
21	"	40	"	"	"	
22	"	45	"	"	"	

Run Number	Test Type	Speed (mph)	Handwheel Angle (deg)	Dir. of First Steer	2 Wheel Lift	Notes
23	"	47.5	"	"	"	
24	"	50	"	"	"	
25	Fishhook 5.5 Scalar	45	200.2	Left	No	
26	"	47.5	"	"	"	
27	"	50	"	"	"	
28	Fishhook 5.5 Scalar	45	200.2	Right	No	
29	"	47.5	"	"	"	
30	"	50	"	"	"	

APPENDIX C
SLOWLY INCREASING STEER TEST WORKSHEET

2021 Ford Bronco Big Bend 4WD 4-Door SUV, Multi-Passenger Configuration,
Test Date: 9/9/2021



Slowly Increasing Steer



Vehicle: 2021 Ford Bronco Big Bend
Test Date: 9/9/2021
Analysis Date: 09/09/2021
Analysed by: EL
Executed by: OG
Configuration: ESC on

Weight Condition: Test condition
Test Track: Dynamic Platform
Test Speed: 50 mph

Run	Dir of Steer	Start speed [mph]	End speed [mph]	Speed red [%]	Index of ay	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
sis_001	L	49.8	-0.5	100.9	778	-38.6	-0.300	-250.6	-0.3481	-212.1	-0.2946	0.9960	24	224
sis_002	L	49.8	0.4	99.2	769	-36.9	-0.300	-239.6	-0.3327	-202.7	-0.2815	0.9840	14	214
sis_003	L	49.3	0.1	99.7	772	-38.0	-0.300	-246.9	-0.3429	-208.9	-0.2902	0.9921	16	216
sis_005	R	49.8	-0.2	100.5	728	35.6	0.300	231.3	0.3213	195.7	0.2719	0.9917	0	200
sis_006	R	50.1	0.1	99.7	716	34.6	0.300	225.0	0.3124	190.3	0.2644	0.9955	2	202
sis_007	R	49.7	0.1	99.7	703	34.6	0.300	224.9	0.3124	190.3	0.2643	0.9923	0	161

Mean: 36.4

Steering Controller Input values

Scalar 6.5 values:

Initial HW angle: 236.6 deg

Reversal HW angle: -236.6 deg

Scalar 5.5 values:

Initial HW angle: 200.2 deg

Reversal HW angle: -200.2 deg

APPENDIX D
TIME HISTORY PLOTS

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FILENAME: FH_019

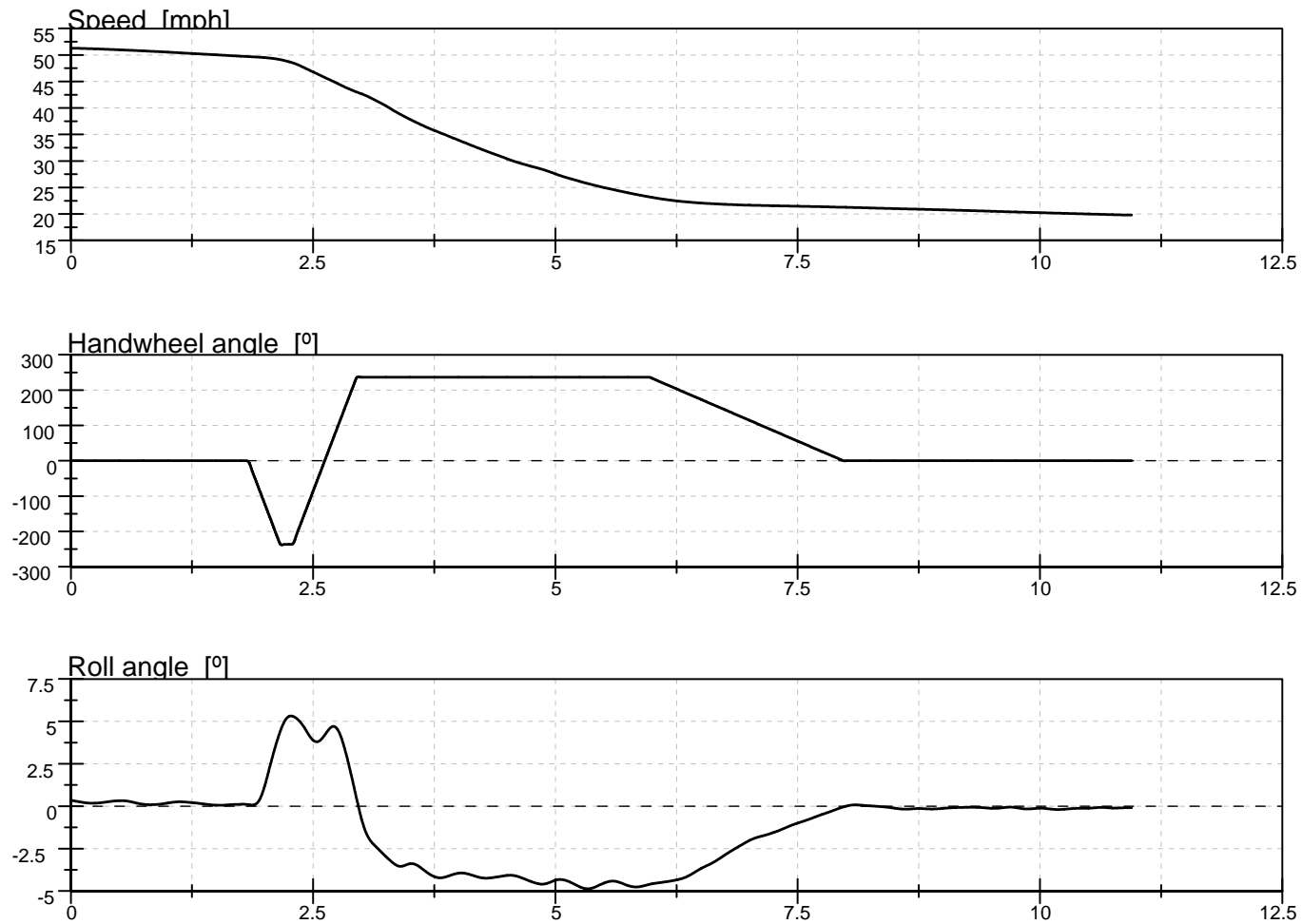


Figure D1. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, L-R, 50 mph

FILENAME: FH_019

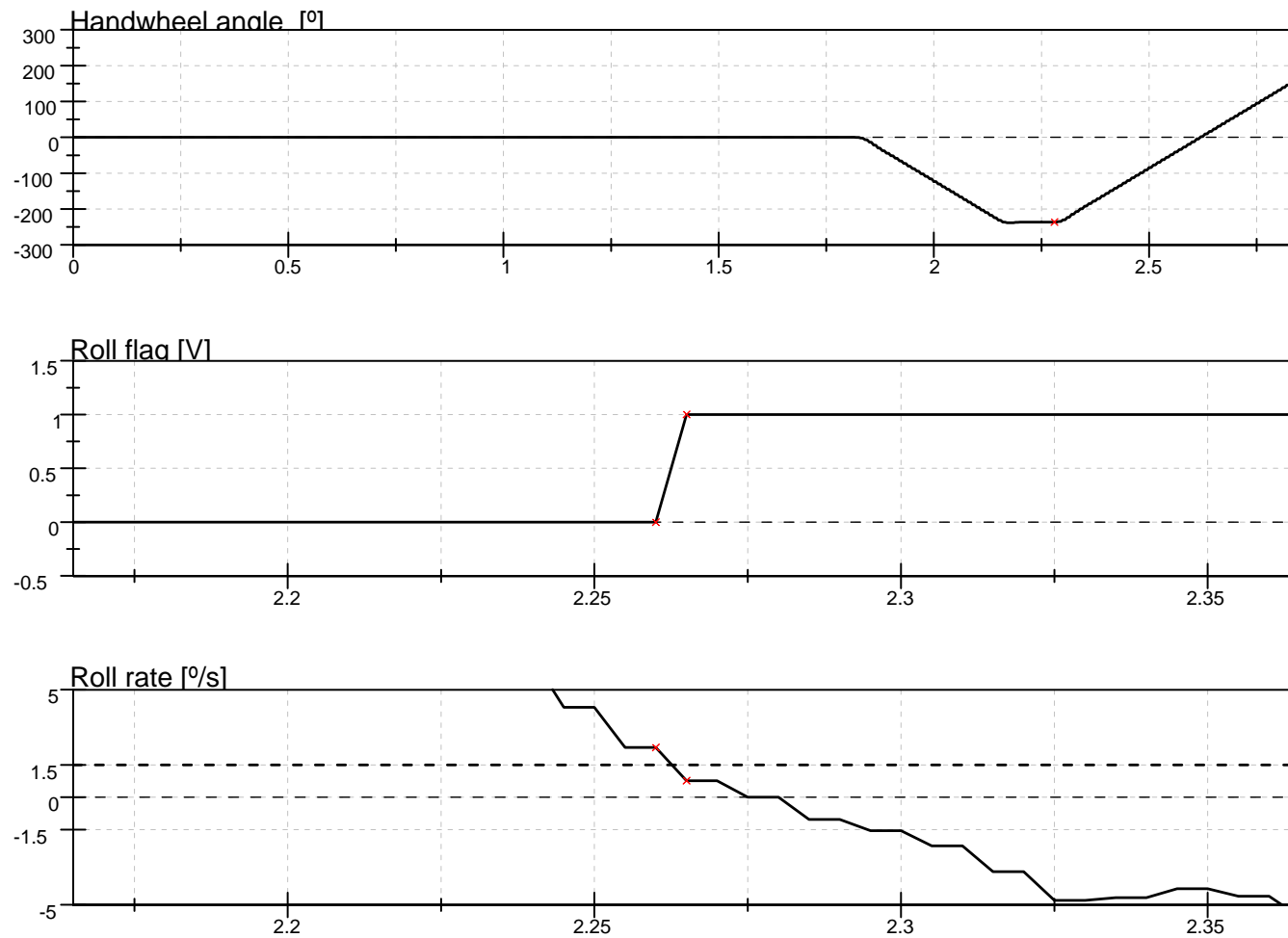


Figure D2. Steering Machine Operation Time History Plots for Default Test Series, L-R, 50 mph

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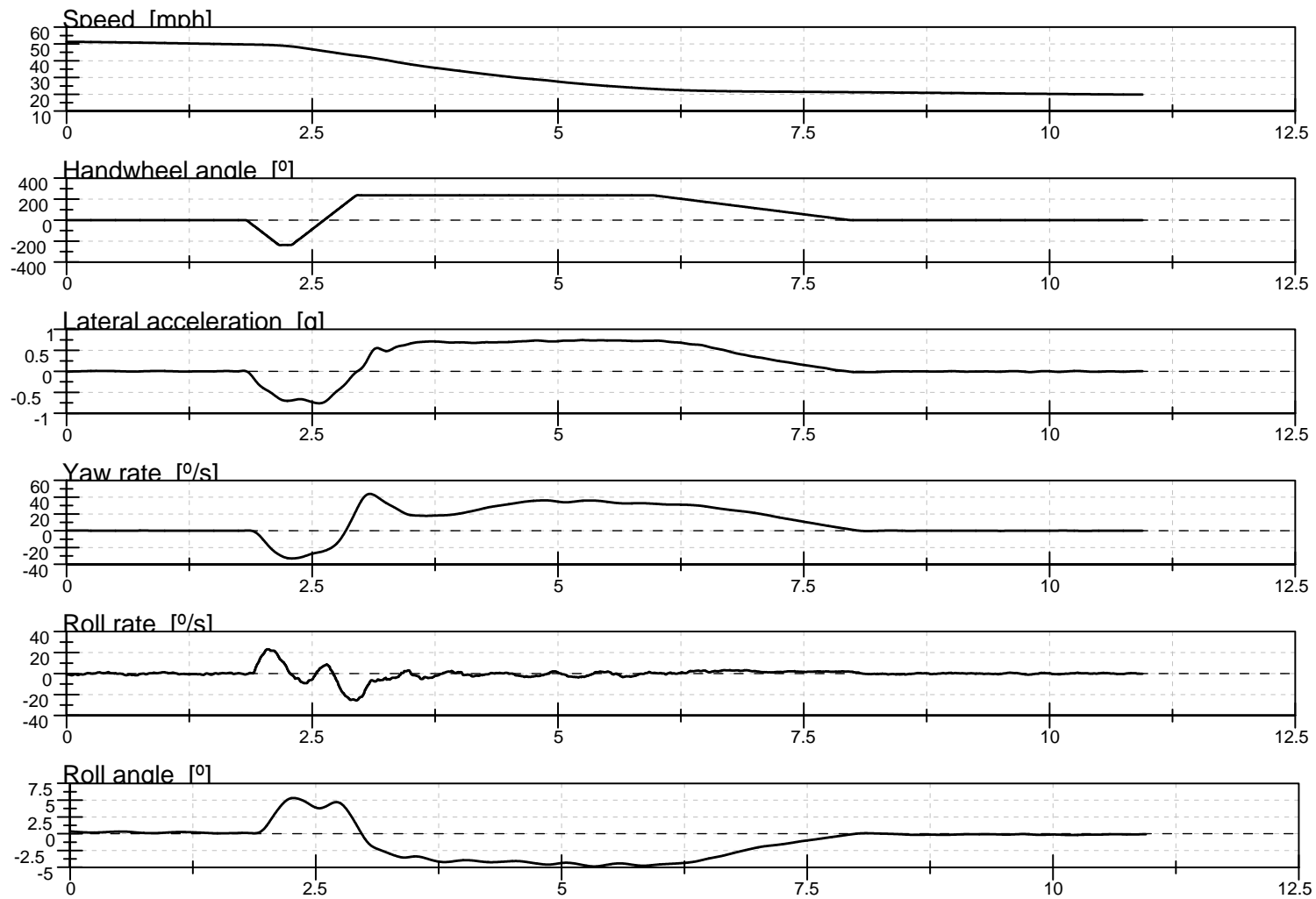


Figure D3. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots For Default Test Series, L-R, 50 mph

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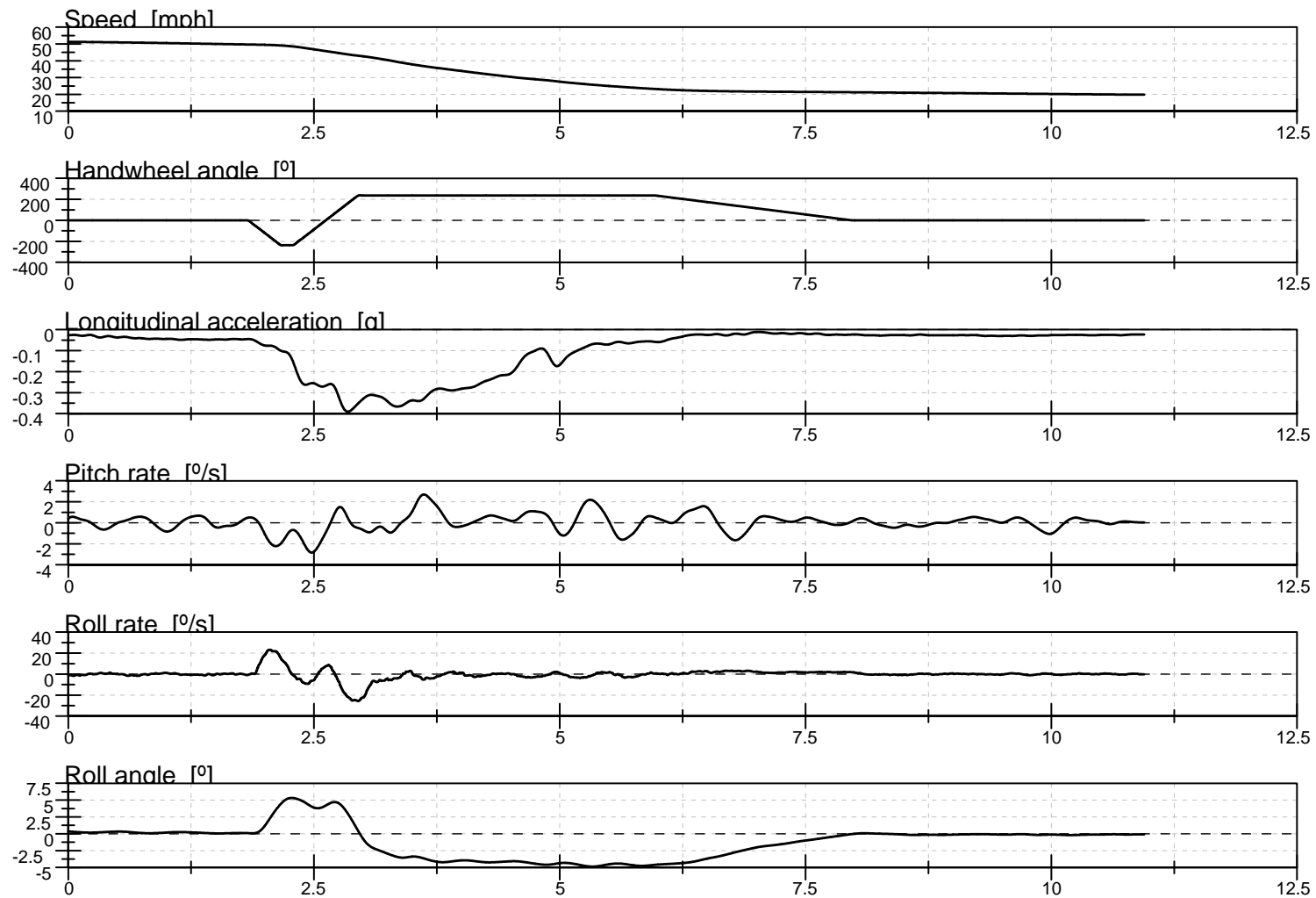


Figure D4. Pitch Rate and Longitudinal Acceleration Time History Plots for Default Test Series, L-R, 50 mph

FILENAME: FH_024

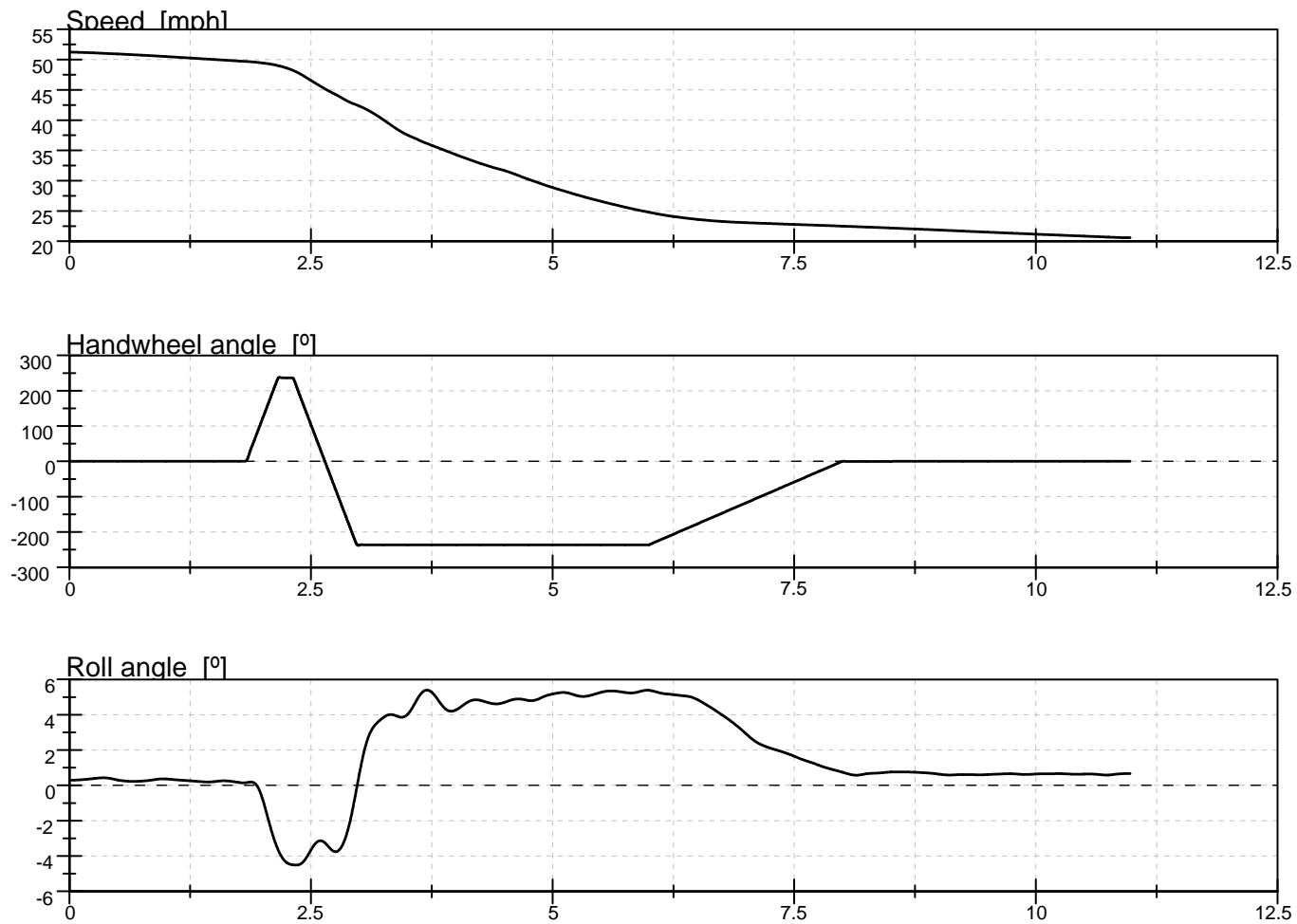


Figure D5. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, R-L, 50 mph

FILENAME: FH_024

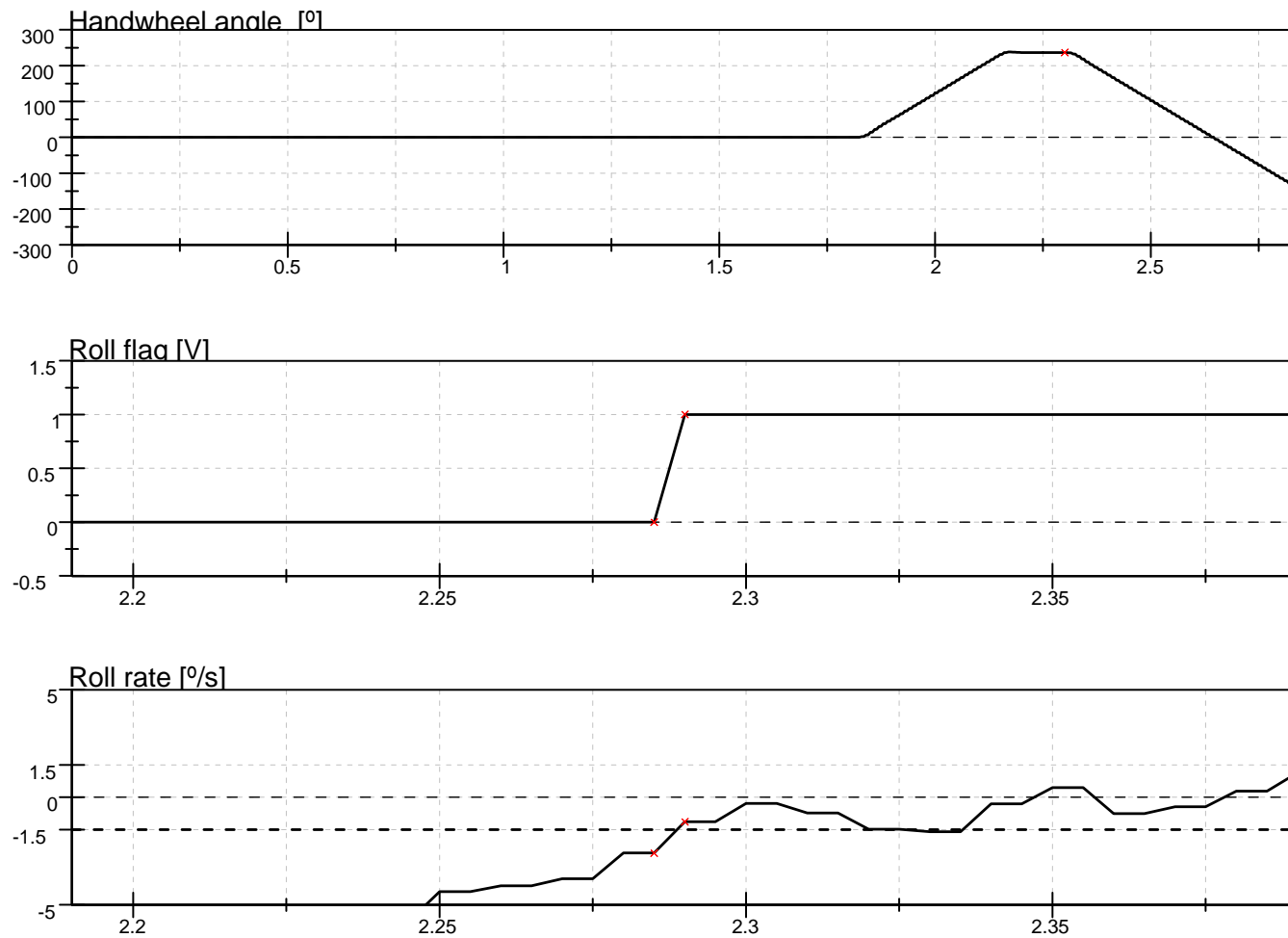


Figure D6. Steering Machine Operation Time History Plots for Default Test Series, R-L, 50 mph

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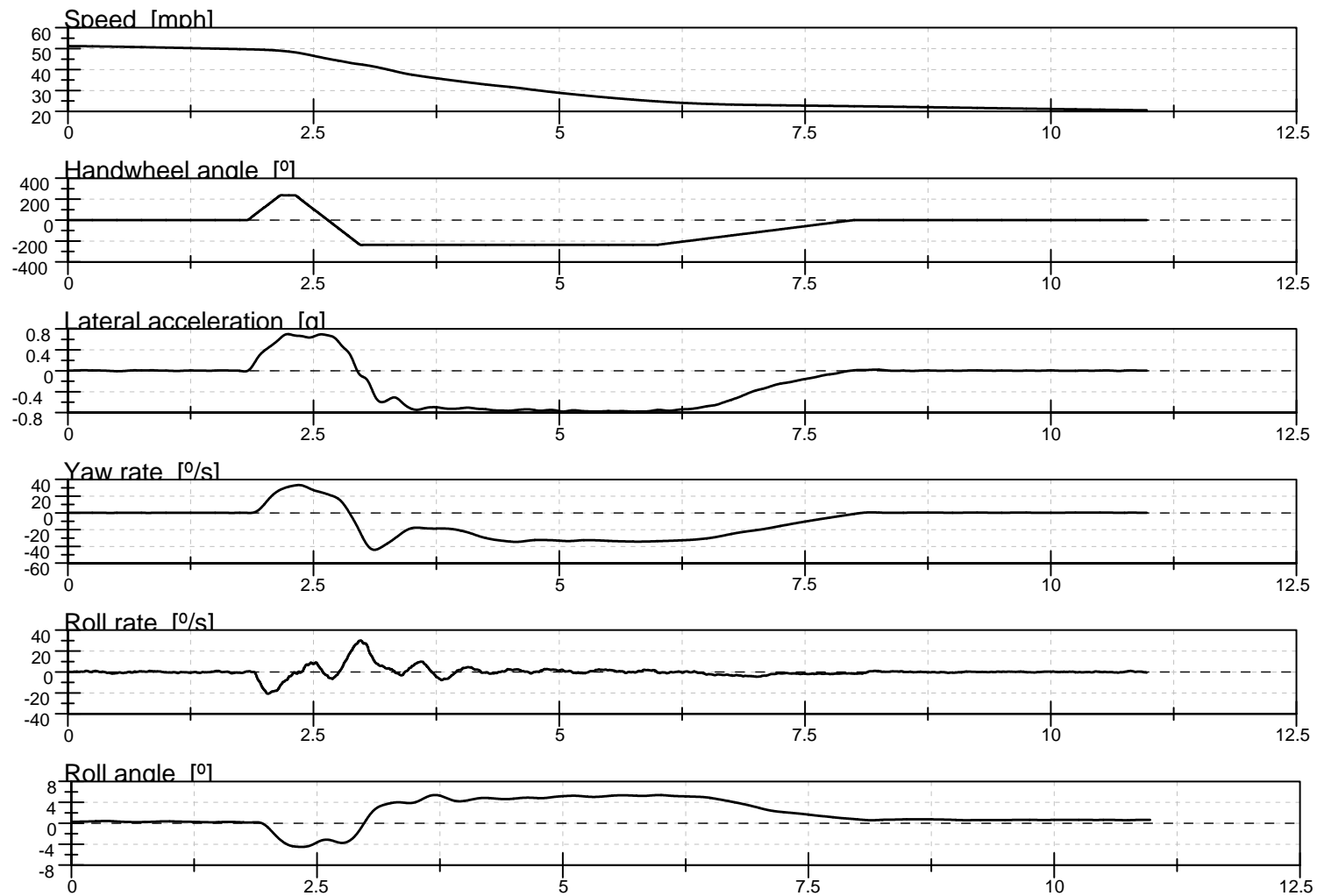


Figure D7. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Default Test Series, R-L, 50 mph

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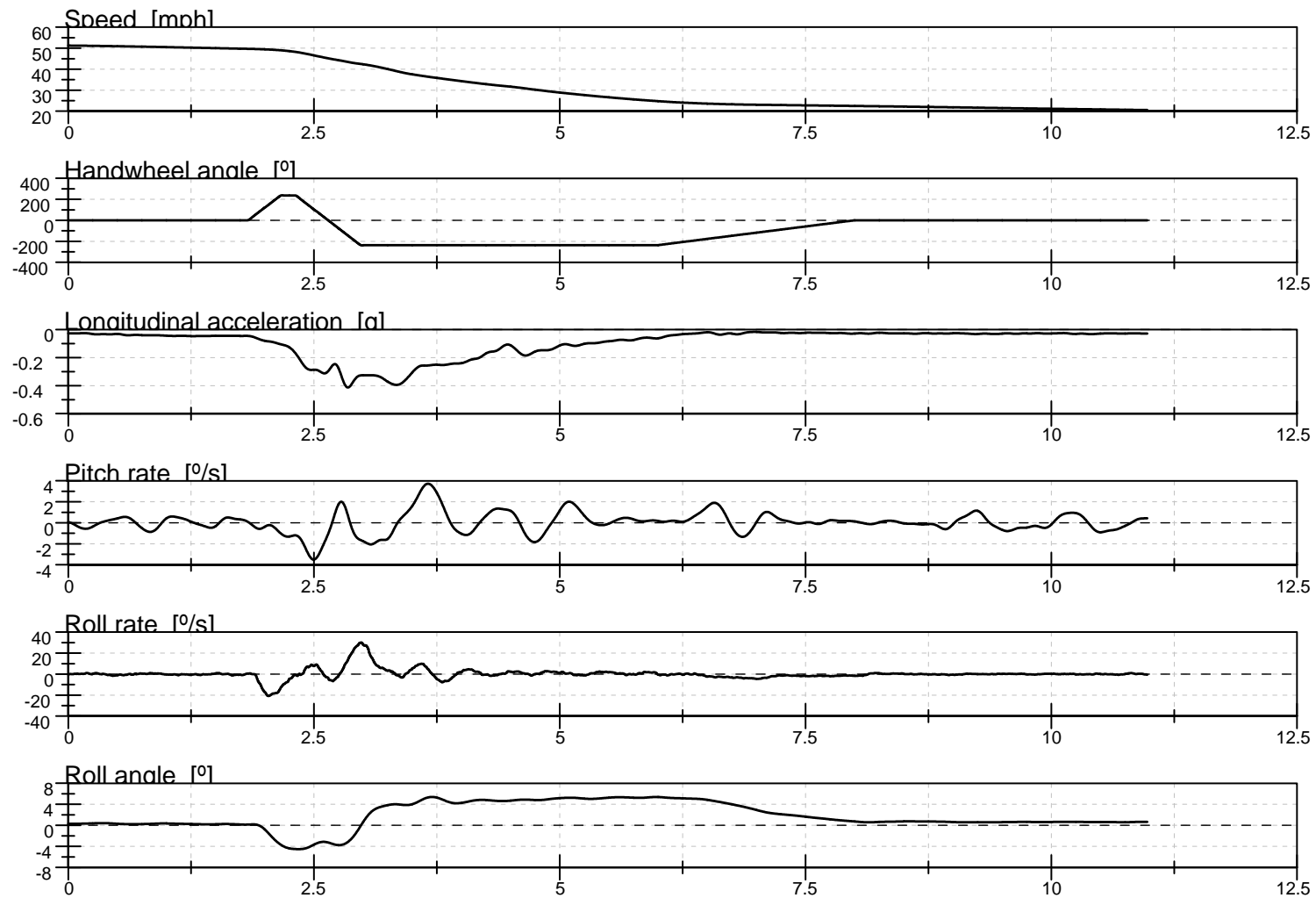


Figure D8. Pitch Rate and Longitudinal Acceleration Time History Plots of Default Test Series, R-L, 50 mph

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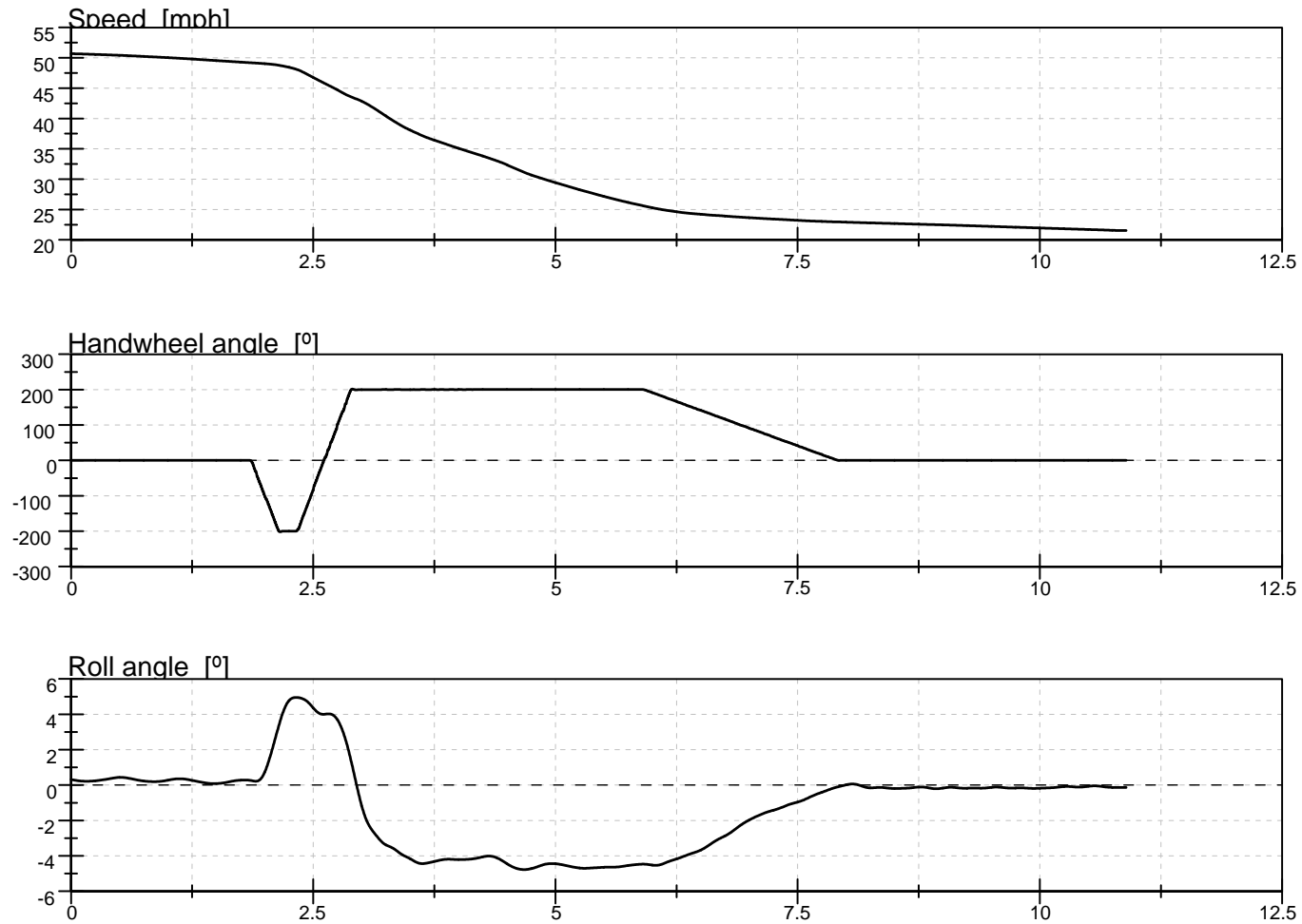


Figure D9. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

FILENAME: FH_027

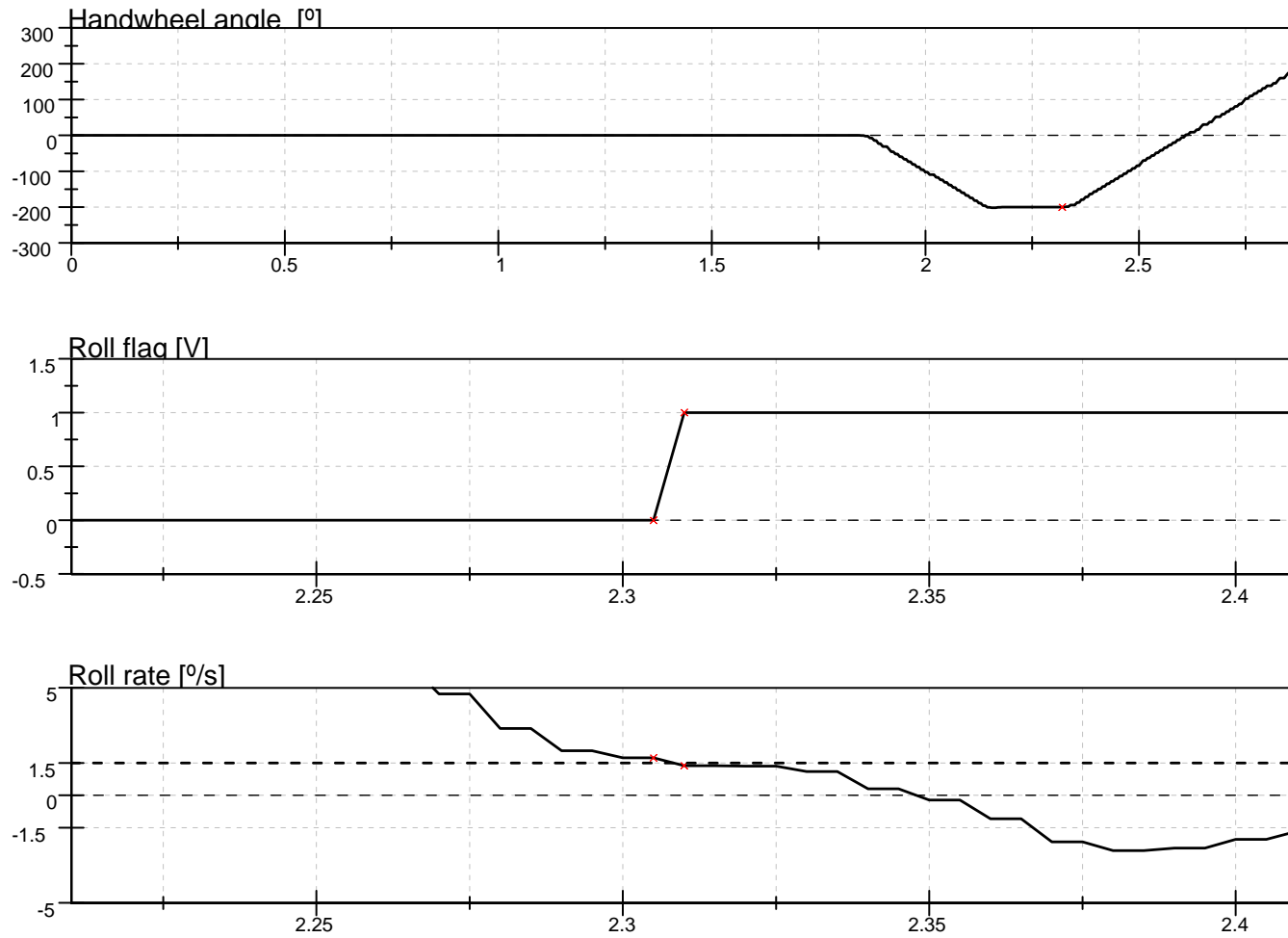


Figure D10. Steering Machine Operation Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

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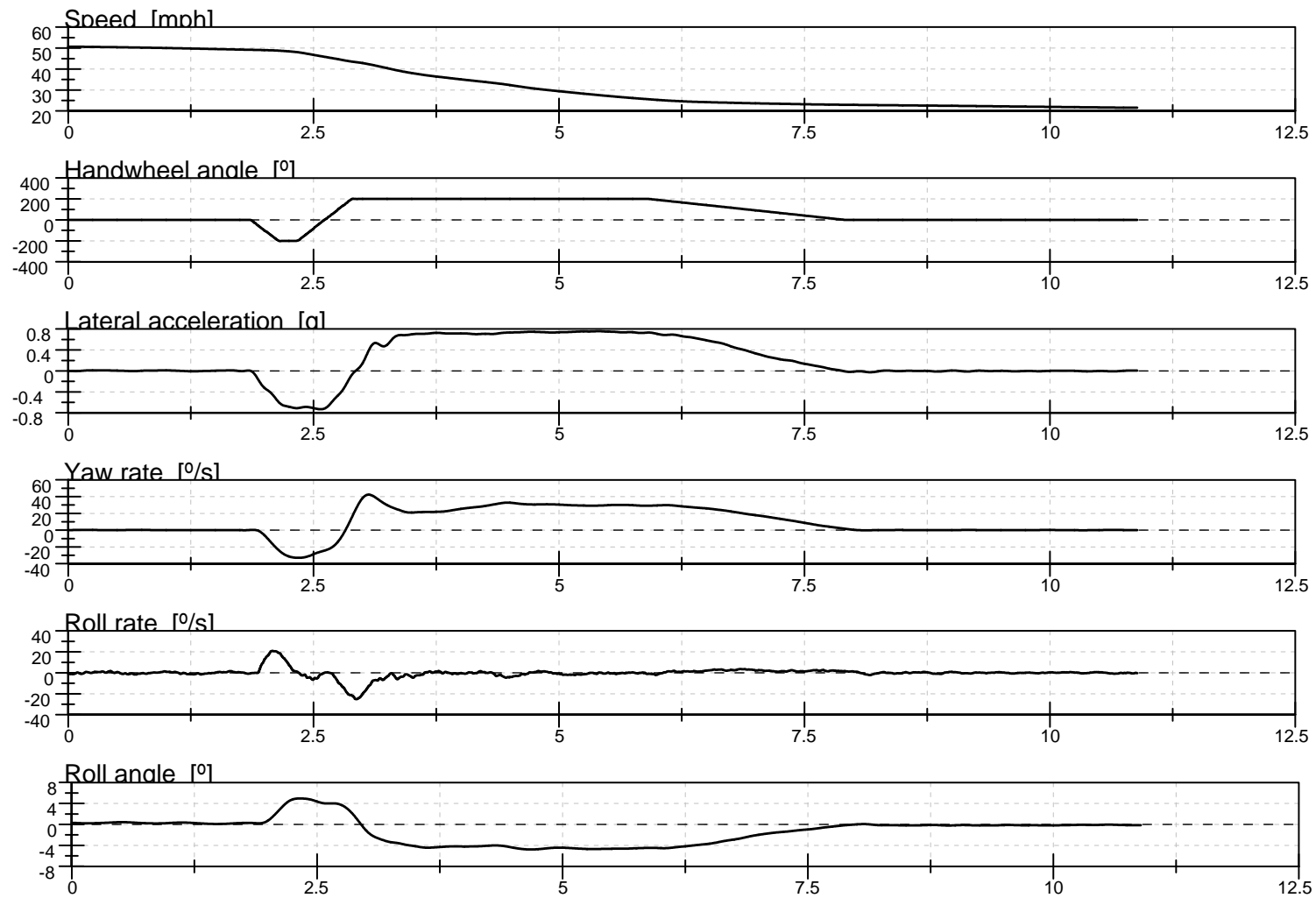


Figure D11. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

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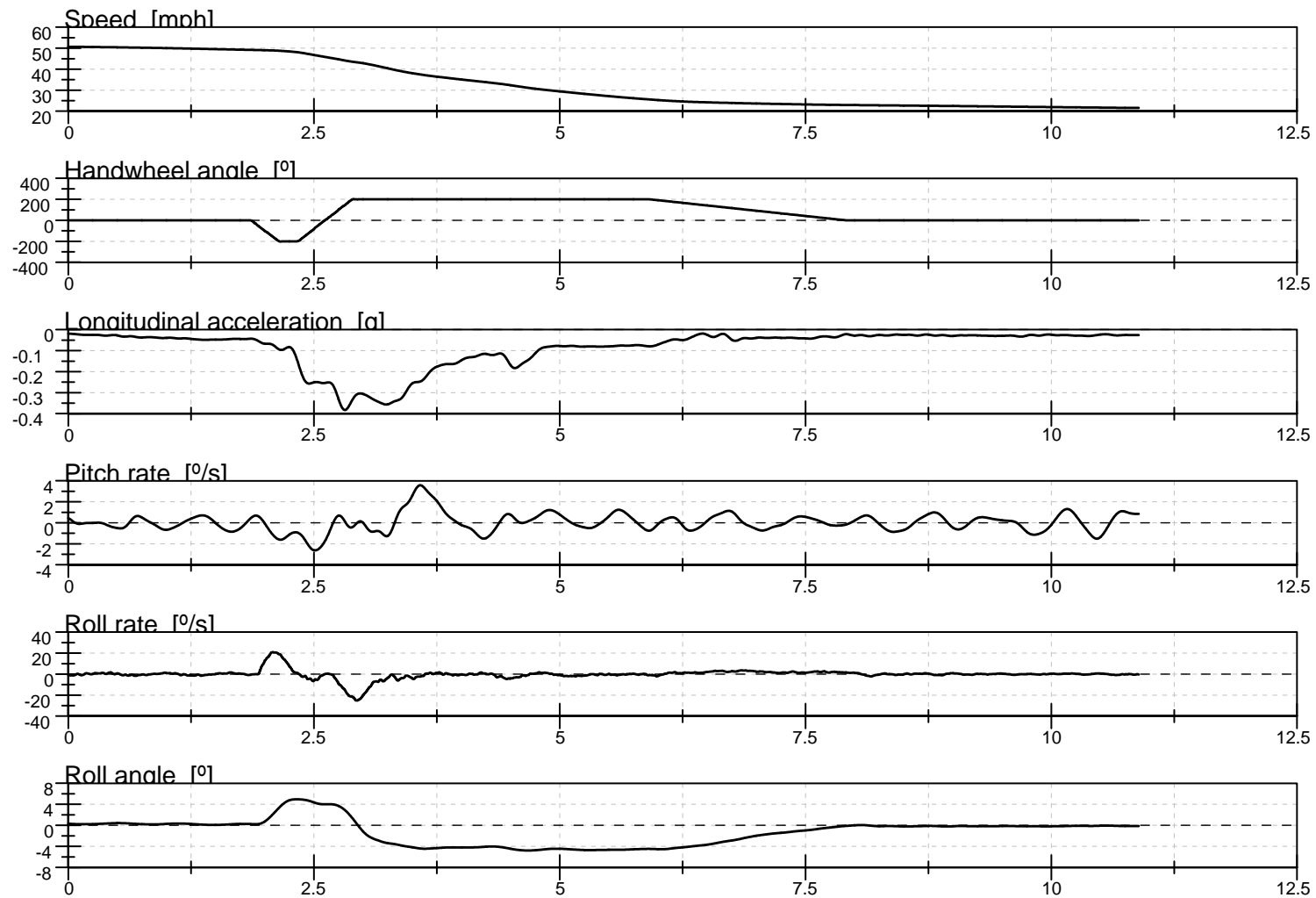


Figure D12. Pitch Rate and Longitudinal Acceleration Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

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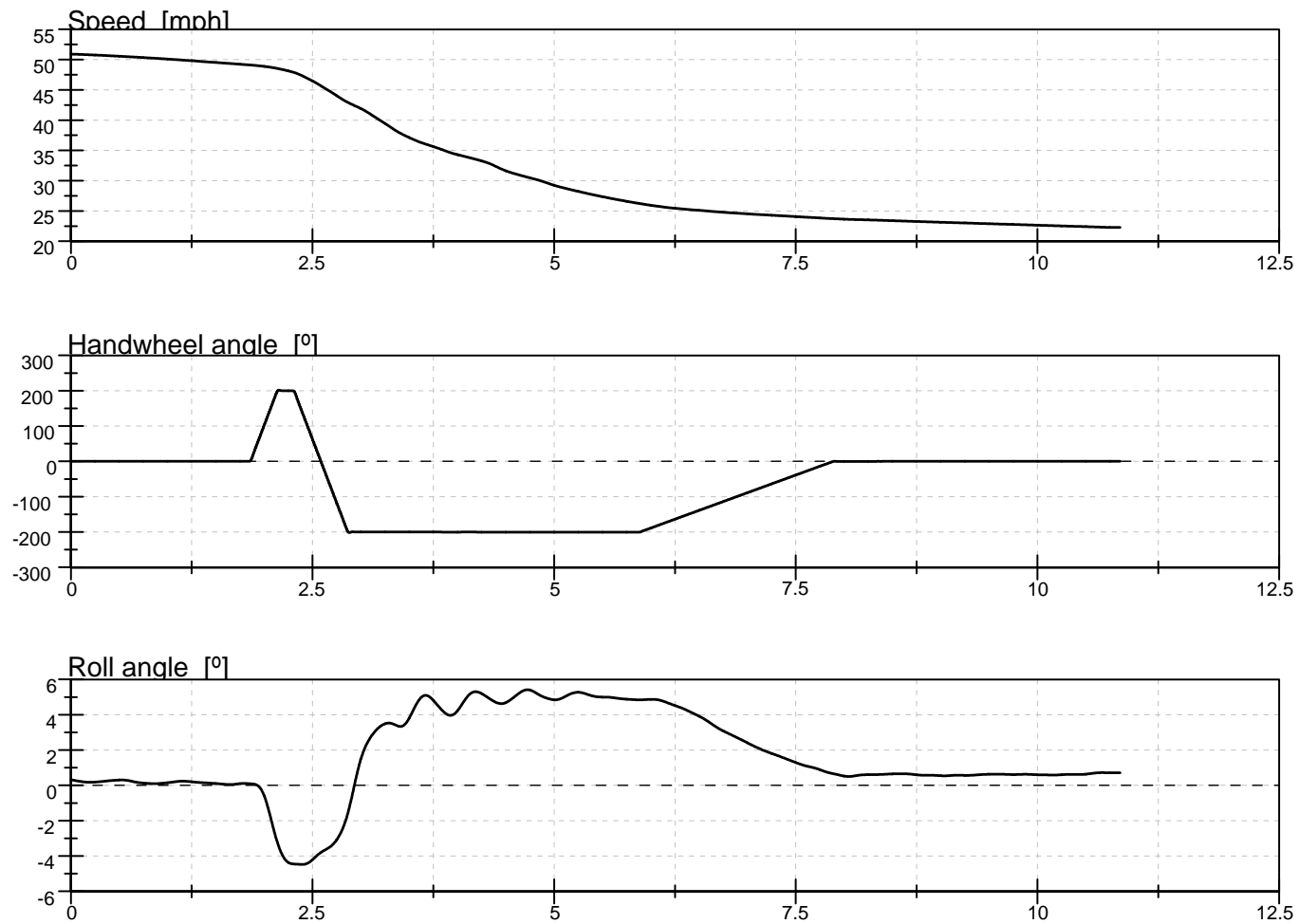


Figure D13. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

FILENAME: FH_030

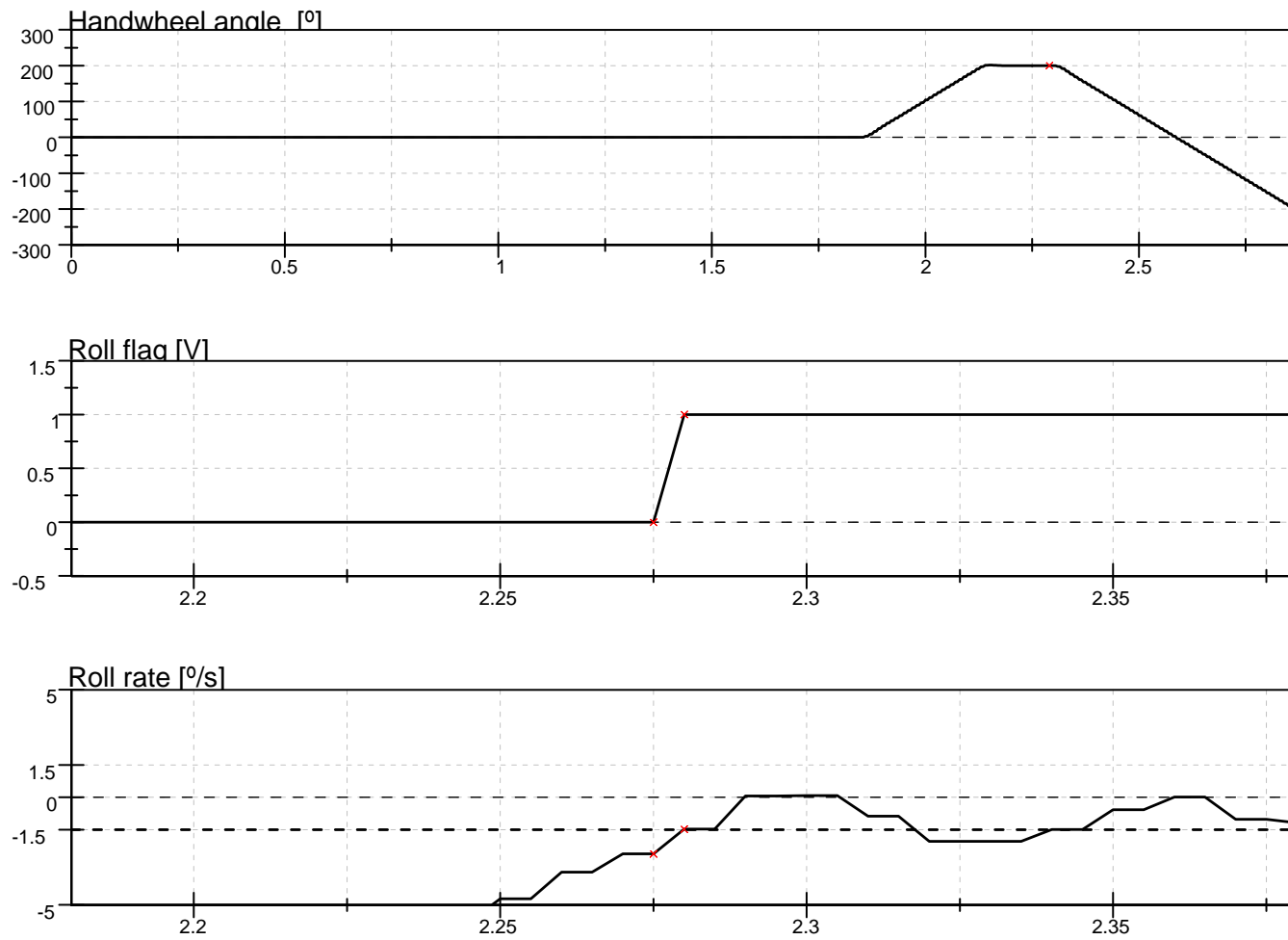


Figure D14. Steering Machine Operation Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

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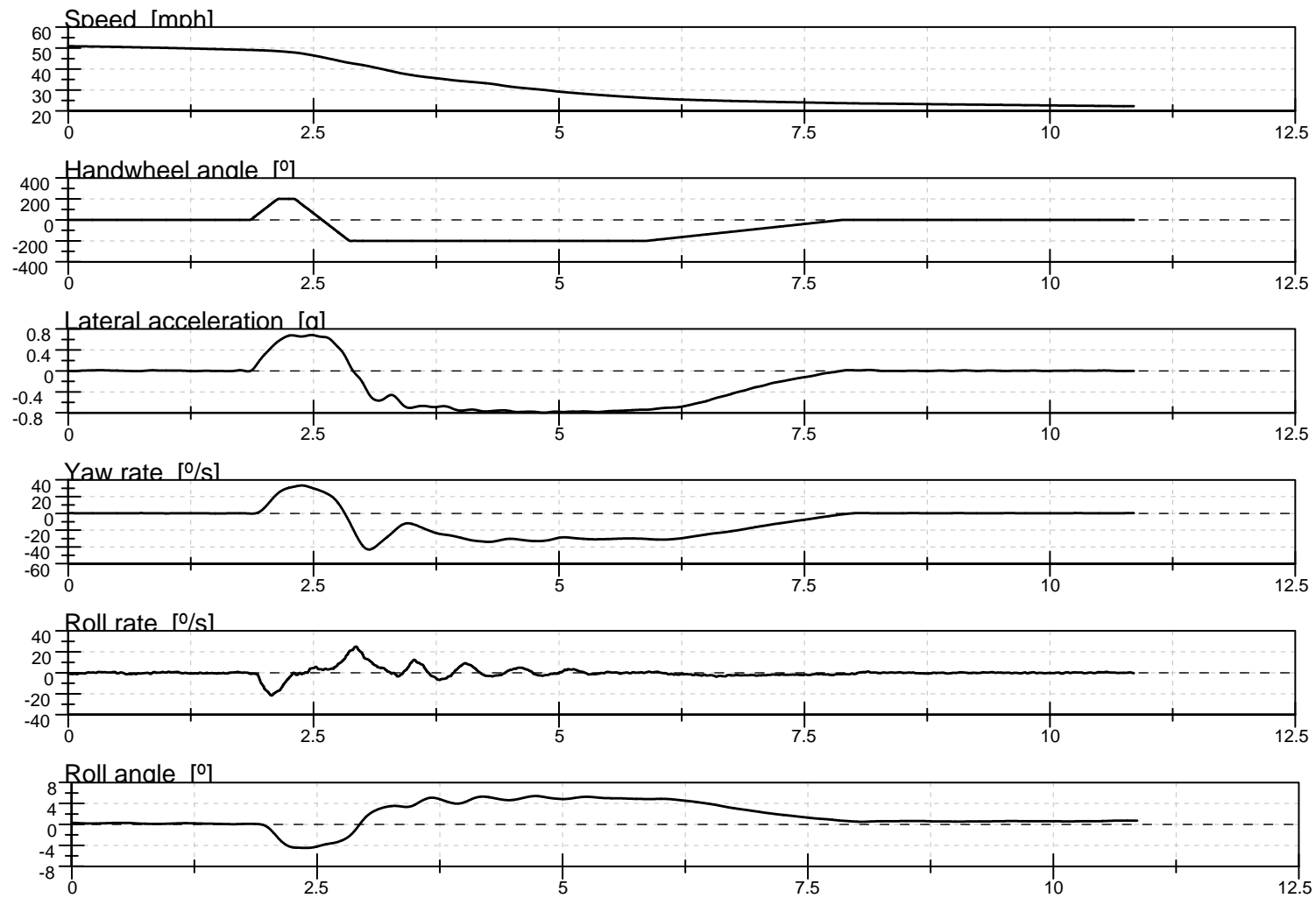


Figure D15. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

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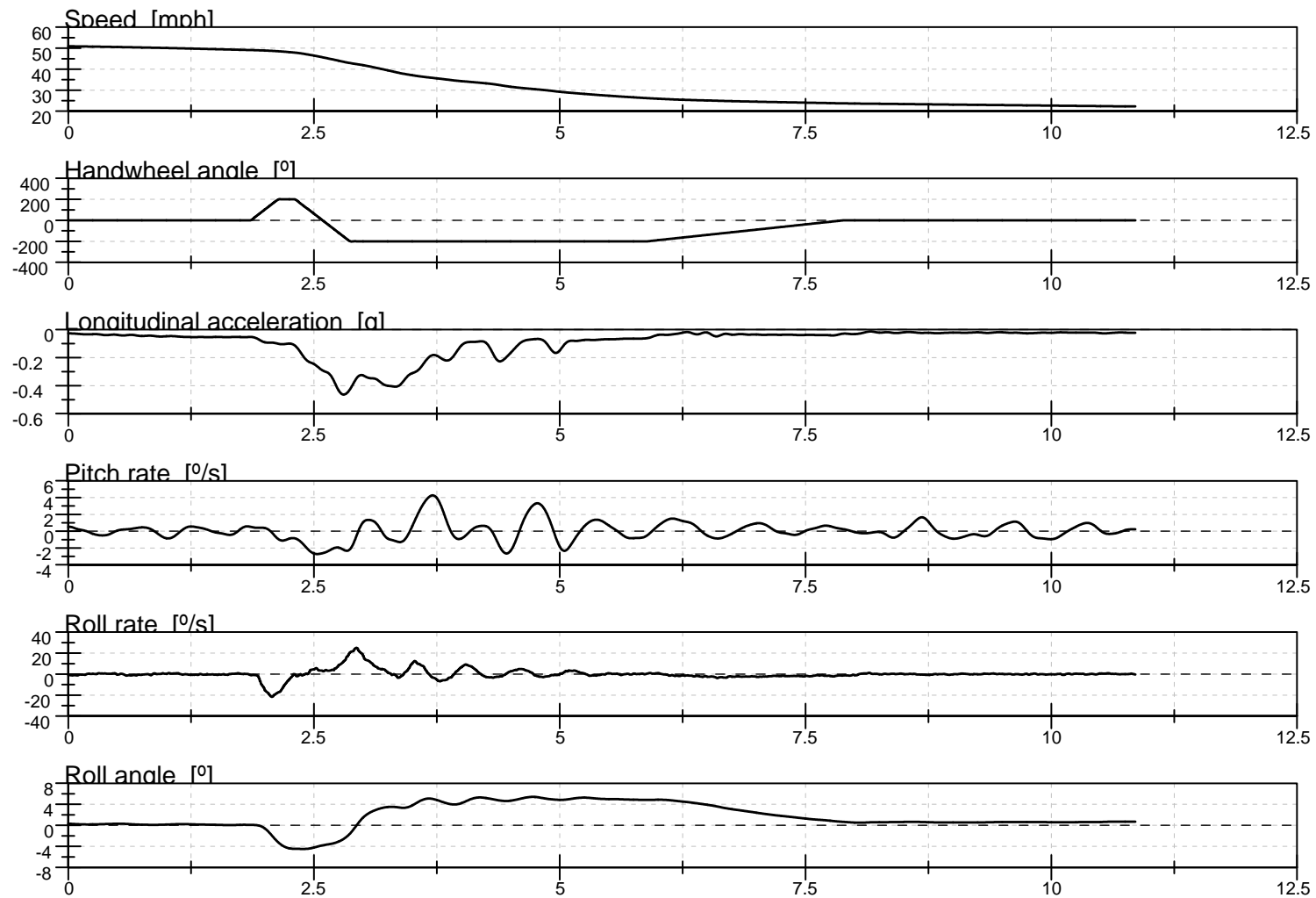


Figure D16. Pitch Rate and Longitudinal Acceleration Time History Plots for Supplemental 2 Test Series, R-L, 50 mph