

**NCAP-KAR-DR-21-10
NEW CAR ASSESSMENT PROGRAM (NCAP)
DYNAMIC ROLLOVER RESISTANCE TEST**

FORD MOTOR CO.

2021 FORD F-150 AWD 4-DOOR TRUCK

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



APRIL 21, 2021

FINAL REPORT

**PREPARED FOR:
U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
NEW CAR ASSESSMENT PROGRAM
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WASHINGTON, D.C. 20590**

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16. Abstract An NCAP Dynamic Rollover Maneuver (Fishhook) Test was conducted on a 2021 Ford F-150 AWD 4-Door Truck by Applus+ IDIADA KARCO Engineering, LLC. on April 14, 2021. The vehicle did not experience two-wheel lift. The vehicle's steering angle at 0.3 g lateral acceleration at 50 mph was 39.3 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 F-150 AWD 4-Door Truck 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 F-150				
VIN	1FTFX1E51MFA3xxxx				
Body style	Truck				
Number of doors	4				
Trim level	XL Supercab				
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	44 miles				
Drivetrain					
Engine cylinder arrangement	V8				
Engine displacement	5.0 L				
Transmission type	Automatic				
Drive arrangement	AWD				
Chassis					
Track width	F: 72.8 in (1850 mm), R: 73.2 in (1860 mm)				
Wheelbase	146.1 in (3710 mm)				
Curb weight	4848 lb (2199 kg)				
Certification Data from Vehicle's Label					
Vehicle manufactured by	Ford Motor Co.				
Date of manufacture	11/20				
GVWR	7050 lb (3198 kg)				
GAWR Front	3450 lb (1565 kg)				
GAWR Rear	3800 lb (1724 kg)				

Table 2. Tire Information

Tire Manufacturer	Pirelli
Tire Model	Scorpion ATR
Tire Size	Front: 265/70R17 Rear: 265/70R17
Load rating	Front: 115 Rear: 115
Speed rating	Front: T Rear: T
Treadwear grade	Front: 540 Rear: 540
Traction grade	Front: A Rear: A
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	Front: XLE6 865F Rear: XLE6 865F

Table 3. Vehicle Loading

Water dummy and other loading	Multi-Passenger Configuration 3 water dummies in second row
Water dummy weight	368.2 lb (167.0 kg)
Fuel level	N/A
Weight as Tested	
Left front	1742 lb (790.0 kg)
Right front	1749 lb (793.5 kg)
Left rear	1175 lb (533.0 kg)
Right rear	1174 lb (532.5 kg)
Total weight	5840 lb (2649.0 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>	Longitudinal speed	GPS inertial unit	-	0.01 %/s 0.01 m/s ²	±0.1	OXTS (RT)	1611	By: IDIADA Date: 6/16/2020 Due: 6/16/2022	km/h
<i>Distance Measuring System</i>	Lateral speed		-		±0.1				km/h
	Longitudinal acc.		±100		±0.1				m/s ²
<i>Radar Speed Sensor</i>	Lateral acc.		±100		±0.05				°
	Roll angle		±100		±0.05				°
<i>Data Flag (Roll Rate Flag)</i>	Pitch angle		±100		±0.1				%/s
	Yaw angle		±100		±0.1				%/s
	Roll rate		±100		±0.1				%/s
	Pitch rate		±100		±0.1				%/s
<i>Angle Encoder¹</i>	Steering angle		Steering wheel robot		>1000				0.25 deg
<i>Data Flag (Handwheel Command Flag)</i>	Steering torque	60		Nm					
<i>Infrared Distance Measuring System</i>	Tire wheel lift	Height sensors	300-700	0.01 mm	±0.8	OPTImess	OMS 4140-3098 OMS 4140-4506 OMS 4140-4508 OMS 4140-4509	By: IDIADA Date: 7/7/2020 Due: 7/7/2021	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	-

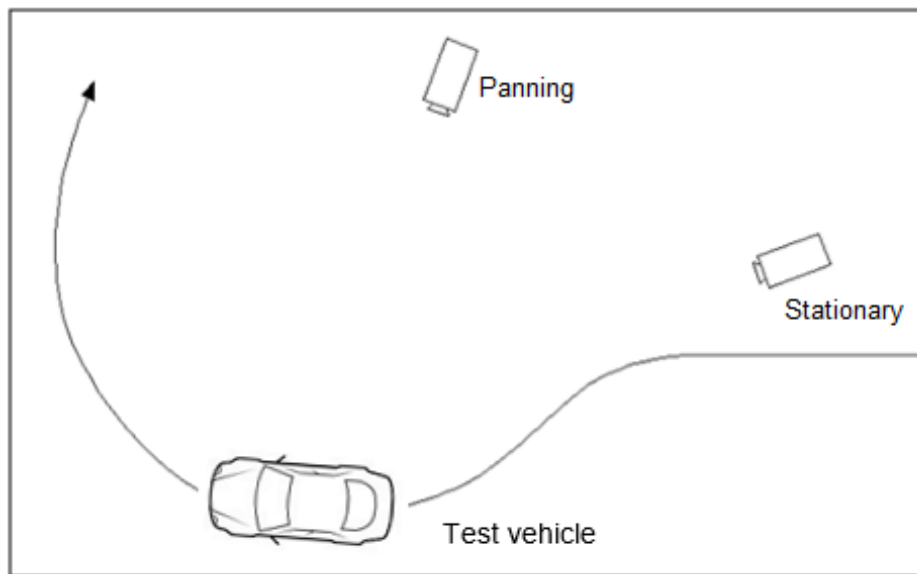


Figure 1. Nominal Position of Video Cameras for Fishhook Tests

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.

B. 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 4/14/2021. 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	4/14/2021
Average lateral friction coefficient	0.90
Date of peak braking friction 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

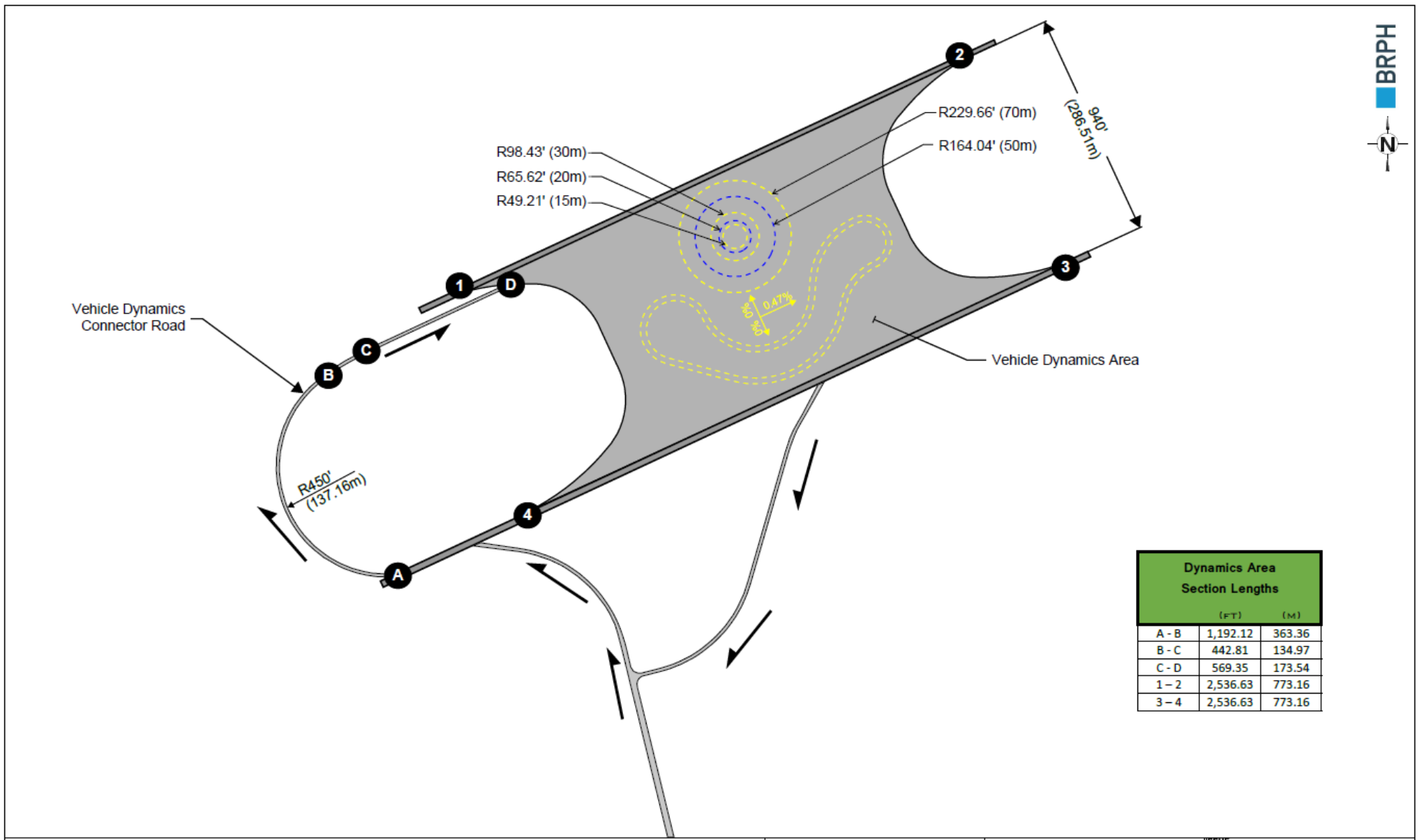
0.3 g handwheel angle (from SIS tests at 50 mph)	39.3°
5.5 scalar handwheel angle for Fishhook Test	216.2°
6.5 scalar handwheel angle for Fishhook Test	255.5°

3. Weather Conditions

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

Table 8. Weather Conditions

Ambient temperature	67.5 °F (19.7 °C)
Wind Speed	16.5 mph (7.4 m/s)
Wind Direction	SW



Dynamics Area Section Lengths		
	(FT)	(M)
A - B	1,192.12	363.36
B - C	442.81	134.97
C - D	569.35	173.54
1 - 2	2,536.63	773.16
3 - 4	2,536.63	773.16

VEHICLE DYNAMICS



HONDA PROVING CENTER
CANTIL, CALIFORNIA

ISSUE	JUNE 1, 2018
REVISION	JULY 12, 2019
	HPC-05

Figure 2. Vehicle Dynamics Area at Honda Proving Center

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 F-150 AWD 4-Door Truck, there was no two-wheel lift at any test condition.

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VEHICLE DESCRIPTION

F-150

2021 F-150 4X4 SUPER CAB
145" WHEELBASE
5.0L V8 ENGINE
ELEC TEN-SPEED AUTO W/TOW M

MF A3

EXTERIOR OXFORD WHITE
INTERIOR DARK SLATE CLOTH 40/20/40

STANDARD EQUIPMENT INCLUDED AT NO EXTRA CHARGE

<p>EXTERIOR</p> <ul style="list-style-type: none"> • DAYTIME RUNNING LAMPS • EASY FUEL® CAPLESS FILLER • FULLY BOXED STEEL FRAME • HALOGEN HEADLAMPS • HEADLAMPS - AUTO HIGH BEAM • HEADLAMPS - AUTOLAMP (ON/OFF) • LOCKING REMOVABLE TAILGATE • PICKUP BOX TIE DOWN HOOKS • REAR, 170-DEGREE DOOR • TRAILER SWAY CONTROL • WIPERS - INTERMITTENT 	<p>INTERIOR</p> <ul style="list-style-type: none"> • 4" PRODUCTIVITY SCREEN • 60/40 FOLD-UP REAR BENCH SEAT • DUAL SUNVISORS • MESSAGE CTR; OUTSIDE TEMP, COMPASS, TRIP COMPUTER • POWERPOINTS - 12V • TILT/TELESCOPE STR COLUMN 	<p>FUNCTIONAL</p> <ul style="list-style-type: none"> • AUTO HOLD • AUTO START STOP TECH • CURVE CONTROL • DYNAMIC HITCH ASSIST • ELECT 4X4 SHIFT-ON-FLY • FAIL-SAFE COOLING SYSTEM • FORDPASS CONNECT™ 4G • HOTSPTOT TELEMATICS MODEM • GAS-CHARGED SHOCKS • OUTBOARD MNTD REAR SHOCKS • PRE-COLLISION ASSIST W/AEB • PWR RACK AND PINION STEER • REAR VIEW CAMERA • SELECTSHIFT® 	<p>SAFETY/SECURITY</p> <ul style="list-style-type: none"> • ADVANCETRAIC® WITH RSC® • AIRBAGS - FRONT SEAT MOUNTED SIDE IMPACT • AIRBAGS - SAFETY CANOPY® • CTR HIGH MOUNT STOP LAMP • SECURILOCK® ANTI-THEFT SYS™ • SOS POST-CRASH ALERT SYS™ • TIRE PRESSURE MONIT SYS
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INCLUDED ON THIS VEHICLE

EQUIPMENT GROUP 101A	(MSRP)	
-XL SERIES	2,280.00	
-XL POWER EQUIPMENT GROUP		
-CRUISE CONTROL		
-REVERSE SENSING SYSTEM		
OPTIONAL EQUIPMENT/OTHER		
.17" SILVER STEEL WHEELS		
5.0L V8 ENGINE	1,995.00	
.265/70R 17 OWL ALL-TERRAIN		
3.31 ELECTRONIC LOCK RR AXLE	420.00	
705# GVWR PACKAGE		
FRONT LICENSE PLATE BRACKET		
50 STATE EMISSIONS		
CLASS IV TRAILER HITCH		
FLEX FUEL VEHICLE	NO CHARGE	
	NO CHARGE	
	205.00	

PRICE INFORMATION

BASE PRICE	\$36,455.00
TOTAL OPTIONS/OTHER	4,900.00
<hr/>	
TOTAL VEHICLE & OPTIONS/OTHER	41,355.00
DESTINATION & DELIVERY	1,695.00
<hr/>	
TOTAL BEFORE DISCOUNTS	43,050.00
XL HIGH DISCOUNT	- 750.00
<hr/>	
TOTAL SAVINGS	- 750.00



RAMP ONE	
RH27	

RAMP TWO	
RAIL	
ITEM #:	71-3005 O/T 2

TOTAL MSRP \$42,300.00



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Annual fuel cost \$2,150

Fuel Economy & Greenhouse Gas Rating (tailpipe only) 1 to 10, Best is 10. This vehicle rates 3.

Smog Rating (tailpipe only) 1 to 10, Best is 10. This vehicle rates 5.

Actual results will vary for many reasons, including driving conditions and how you drive and maintain your vehicle.

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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. Source: National Highway Traffic Safety Administration (NHTSA). www.safercar.gov or 1-888-327-4236

1FTFX1E51MFA



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.

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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.
FRONT GAWR: 1565 KG (3450 LB)
WITH 265/70R17 115T
17x7.5J

AT 240 kPa/ 35 PSI COLD

THIS VEHICLE CONFORMS TO ALL APPLICABLE FEDERAL MOTOR VEHICLE
SAFETY STANDARDS IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE.

VIN: 1FTFX1E51MFA3

DATE: 11/20 GVWR: 3198 KG (7050 LB)

REAR GAWR: 1724 KG (3800 LB)
TIRES WITH 265/70R17 115T
RIMS 17x7.5J

AT 240 kPa/ 35 PSI COLD

TIRES
RIMS

TYPE: Truck



EXT PNT: YZ

RC: 71 DSO:

WB	INT TR	TP/PS	R	AXLE	TR	SPR	F0059
145	CS		A	L3	G	SSBB	T0856
MADE IN U.S.A.		2202011104706				ULC	▽ 5U5A-3520472-AA

Figure A6. Vehicle's Certification Label



TIRE AND LOADING INFORMATION

SEATING CAPACITY TOTAL : 6 FRONT: 3 REAR: 3

The combined weight of occupants and cargo should never exceed : **979 kg or 2160 lbs.**

▽ 5U5A-1532-AA (TLU)

TIRE	SIZE	COLD TIRE PRESSURE
FRONT	265/70R17 115T	240 KPA, 35 PSI
REAR	265/70R17 115T	240 KPA, 35 PSI
SPARE	245/75R17 112T	240 KPA, 35 PSI

**SEE OWNERS
MANUAL FOR
ADDITIONAL
INFORMATION**

1FTFX1E51MFA3



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 = 0.19 g
2	"	"	82.9	"	"	Resulted in ay = 0.41 g
3	"	"	"	"	"	
4	"	"	"	"	"	
5	2x SWA last cycle	"	165.8	"	"	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	"	"	52.5	Left	"	HW angle at 0.3 g = -39.6
10	"	"	"	Left	"	HW angle at 0.3 g = -42.7
11	"	"	"	Left	"	HW angle at 0.3 g = -40.6
12	"	"	"	Right	"	HW angle at 0.3 g = 38.8
13	"	"	"	Right	"	HW angle at 0.3 g = 36.2
14	"	"	"	Right	"	HW angle at 0.3 g = 38.0
						Average = 39.3
15	Fishhook 6.5 Scalar	35	255.5	Left	No	
16	"	40	"	"	"	
17	"	45	"	"	"	
18	"	47.5	"	"	"	
19	"	50	"	"	"	
20	Fishhook 6.5 Scalar	35	255.5	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	216.2	Left	No	
26	"	47.5	"	"	"	
27	"	50	"	"	"	
28	Fishhook 5.5 Scalar	45	216.2	Right	No	
29	"	47.5	"	"	"	
30	"	50	"	"	"	

APPENDIX C
SLOWLY INCREASING STEER TEST WORKSHEET

2021 Ford F-150 AWD 4-Door Truck, Multi-Passenger Configuration,
 Test Date: 4/14/2021



Slowly Increasing Steer



Vehicle: 2021 Ford F-150
 Test Date: 4/14/2021
 Analysis Date: 4/14/2021
 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	49.9	0.5	99.1	813	-39.6	-0.300	-257.3	-0.3573	-217.7	-0.3024	0.9915	26	226
sis_002	L	49.9	0.1	99.9	835	-42.7	-0.300	-277.4	-0.3853	-234.7	-0.3260	0.9862	45	245
sis_003	L	50.1	0.3	99.4	801	-40.6	-0.300	-263.7	-0.3662	-223.1	-0.3099	0.9897	56	256
sis_004	R	50.1	-0.3	100.5	775	38.8	0.300	251.9	0.3499	213.2	0.2961	0.9978	19	219
sis_005	R	49.9	0.1	99.7	739	36.2	0.300	235.2	0.3266	199.0	0.2764	0.9953	0	175
sis_006	R	50.5	0.3	99.4	784	38.0	0.300	247.0	0.3431	209.0	0.2903	0.9944	0	189

Mean: 39.3

Steering Controller Input values

Scalar 6.5 values:

Initial HW angle: 255.5 deg

Reversal HW angle: -255.5 deg

Scalar 5.5 values:

Initial HW angle: 216.2 deg

Reversal HW angle: -216.2 deg

APPENDIX D
TIME HISTORY PLOTS

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FILENAME: FH_019

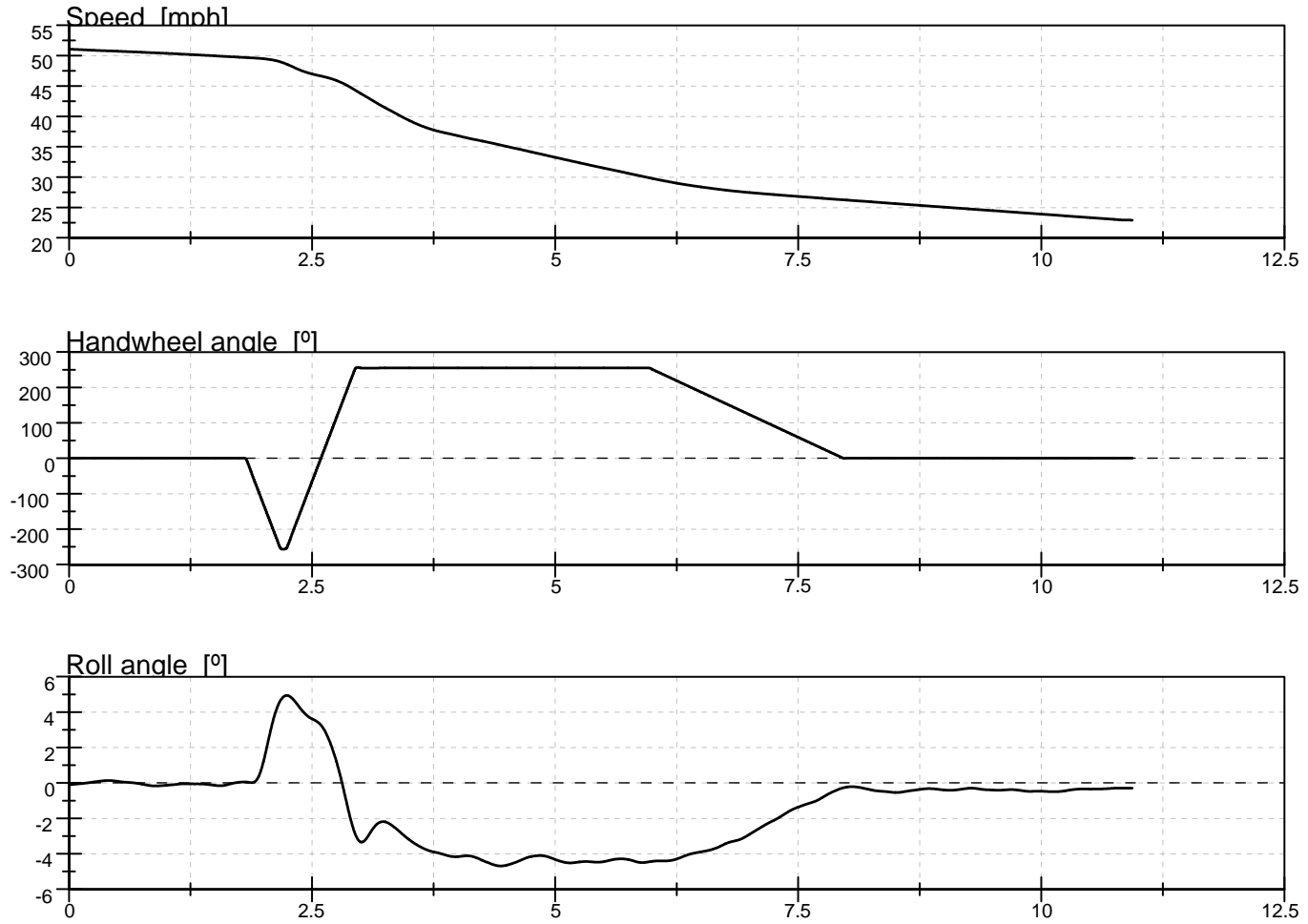


Figure D1. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, L-R, 50 mph

FILENAME: FH_019

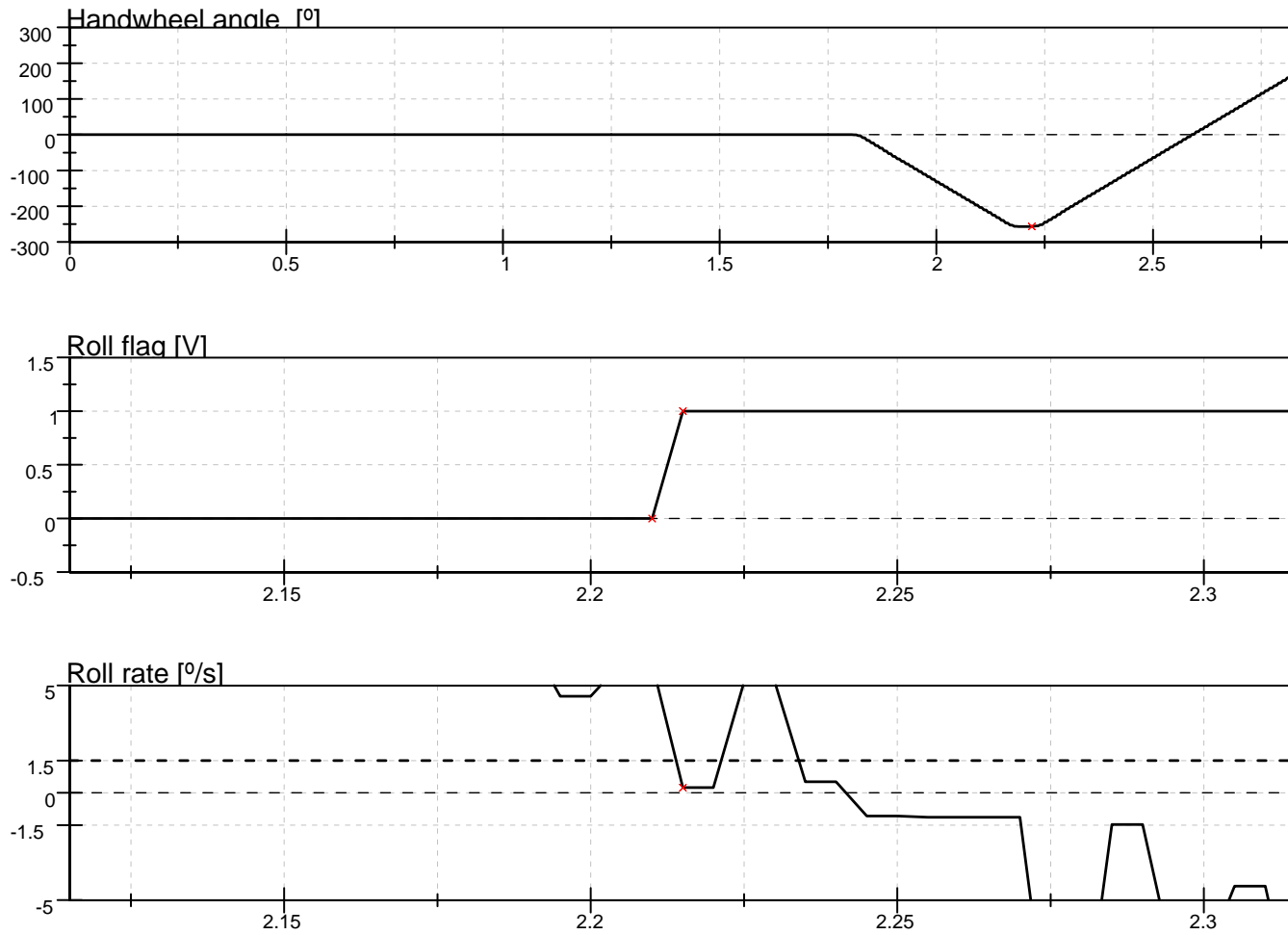


Figure D2. Steering Machine Operation Time History Plots for Default Test Series, L-R, 50 mph

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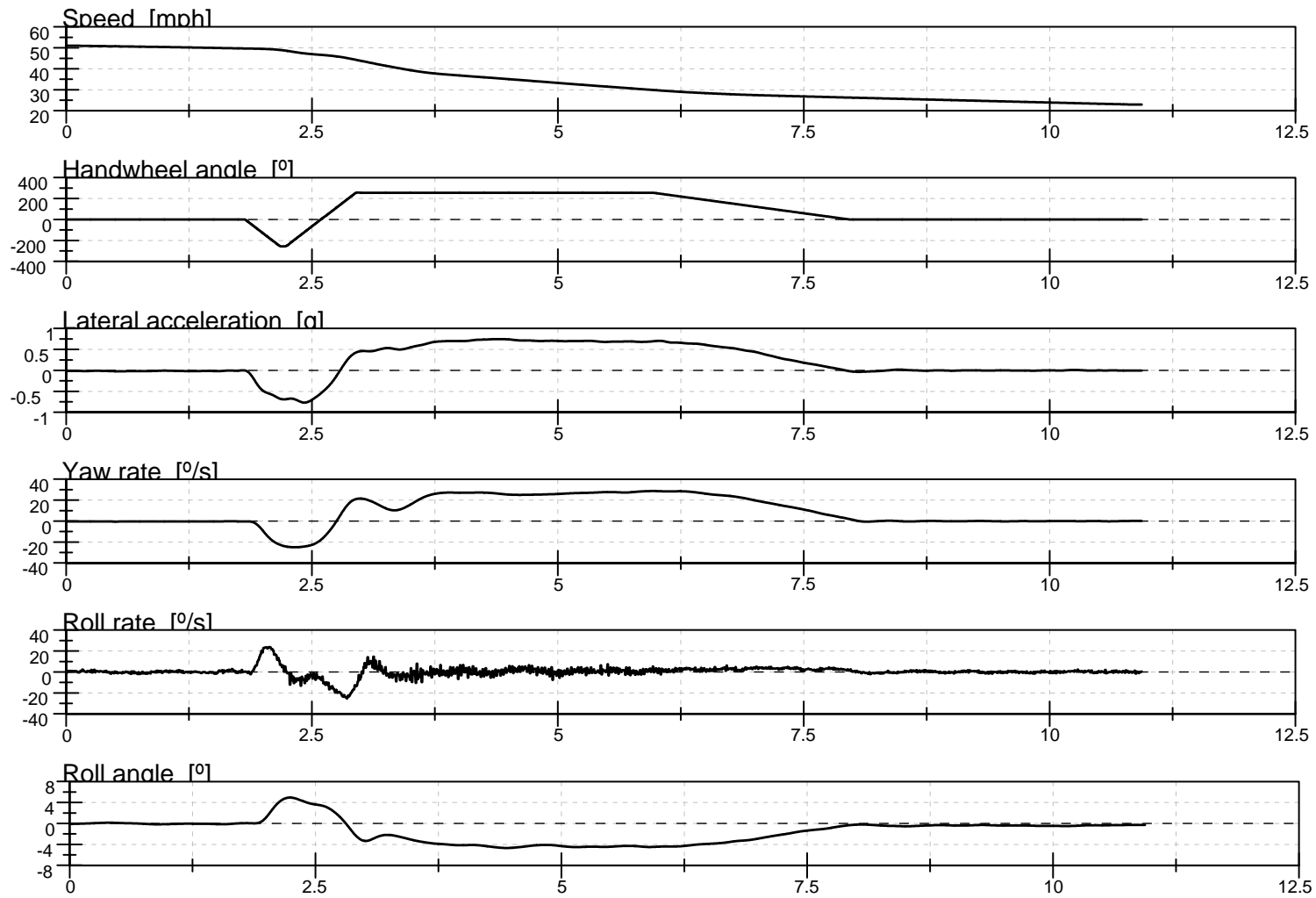


Figure D3. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots For Default Test Series, L-R, 50 mph

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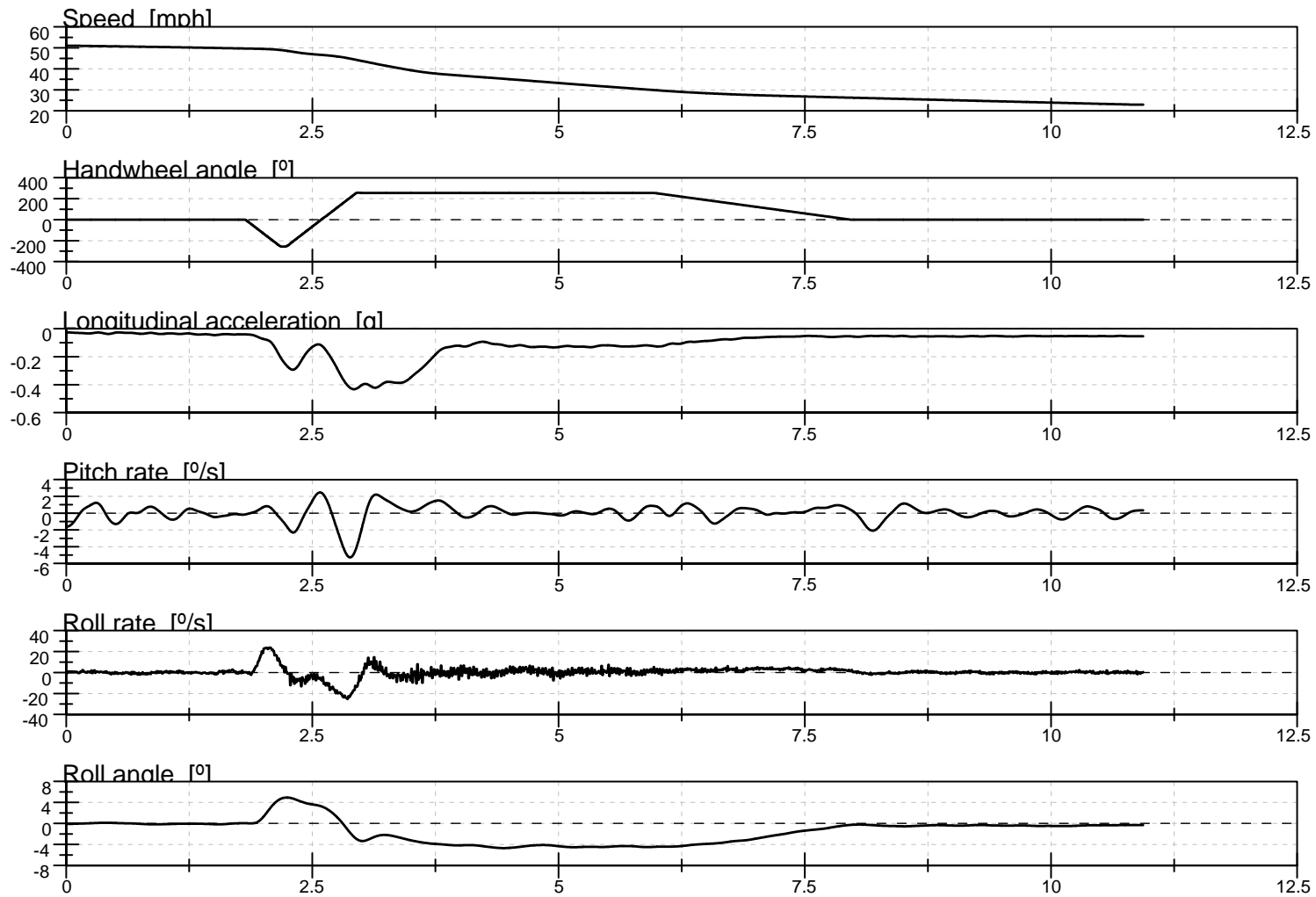


Figure D4. Pitch Rate and Longitudinal Acceleration Time History Plots for Default Test Series, L-R, 50 mph

FILENAME: FH_024

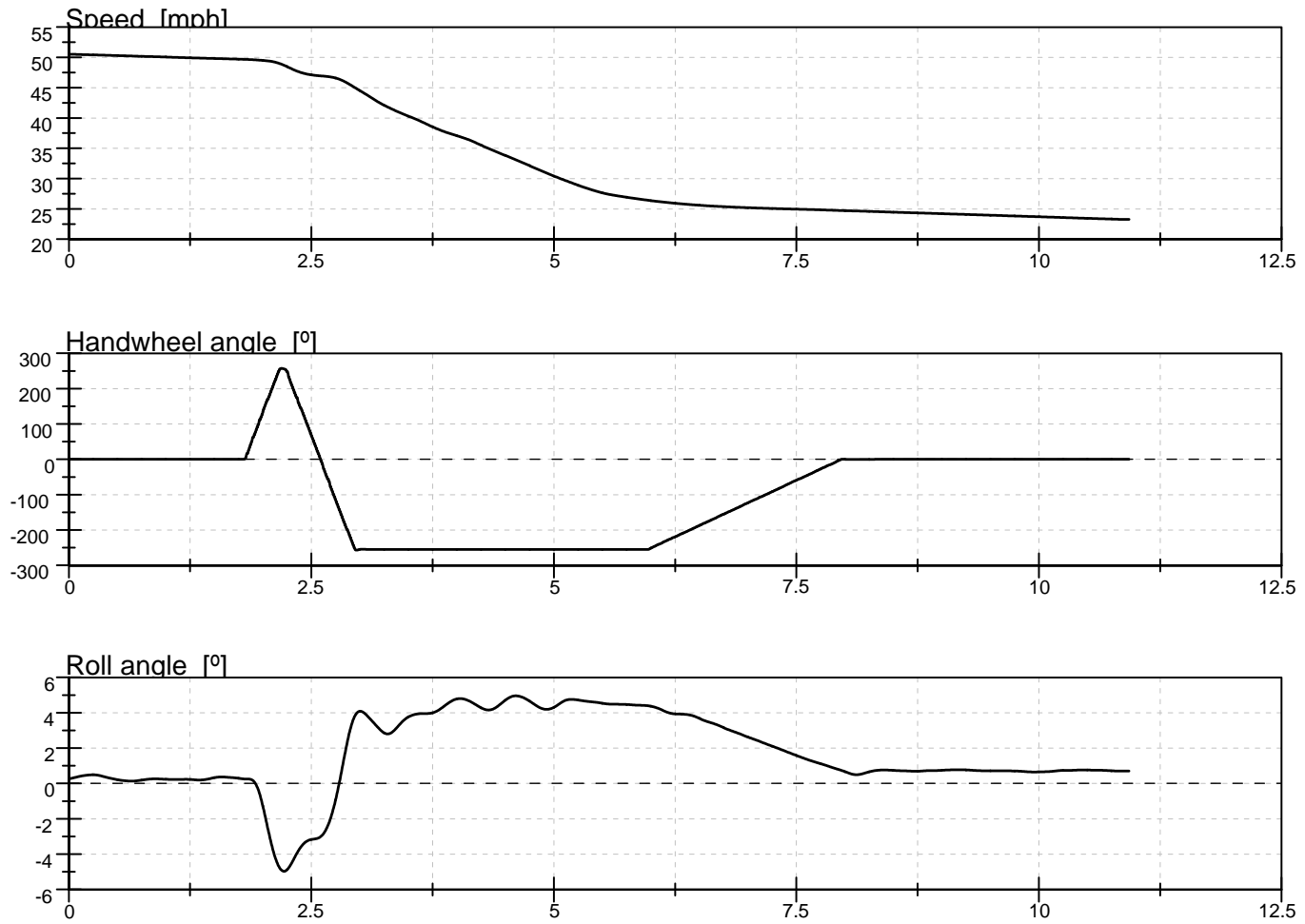


Figure D5. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, R-L, 50 mph

FILENAME: FH_024

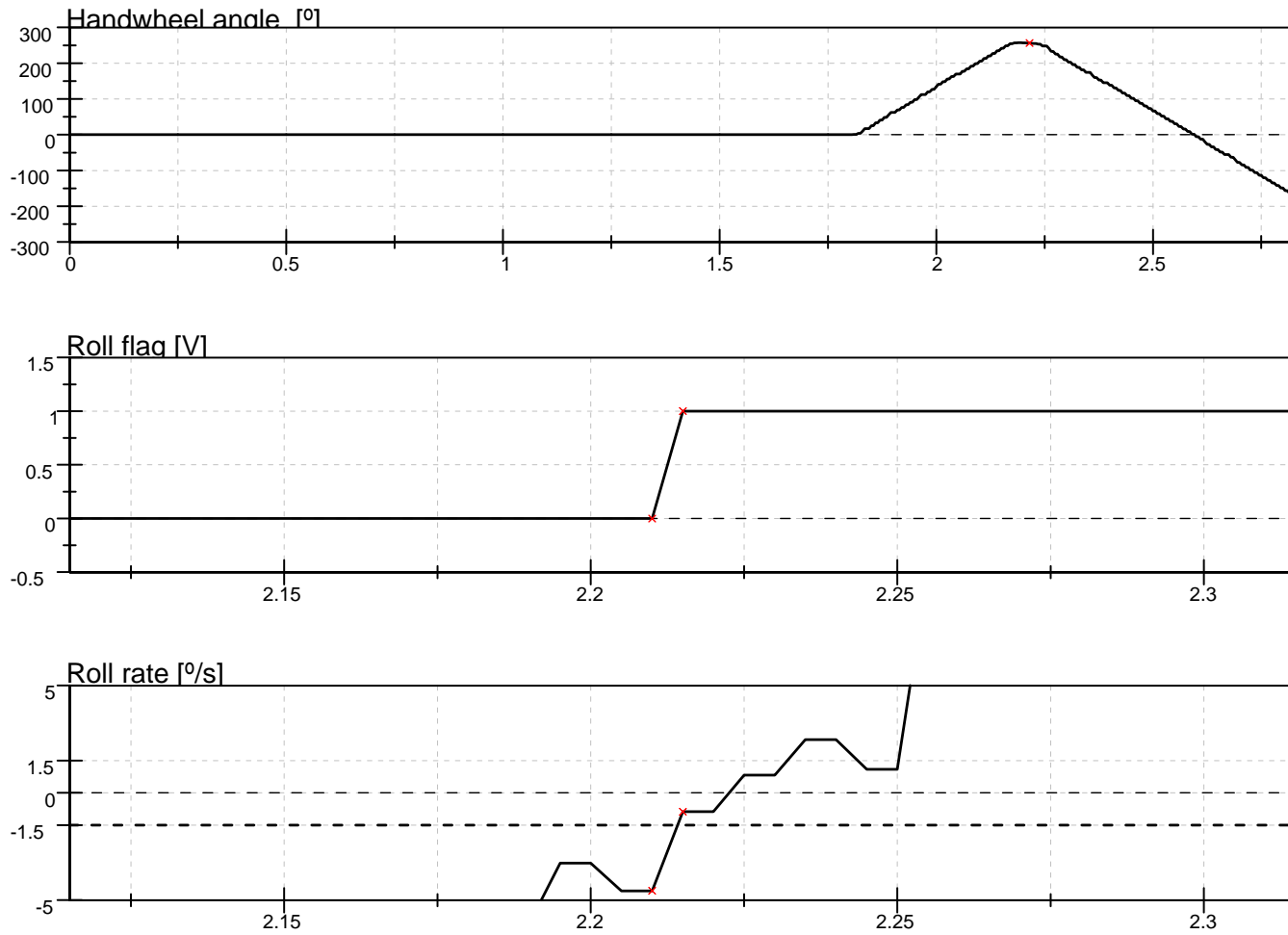


Figure D6. Steering Machine Operation Time History Plots for Default Test Series, R-L, 50 mph

FILENAME: FH_024

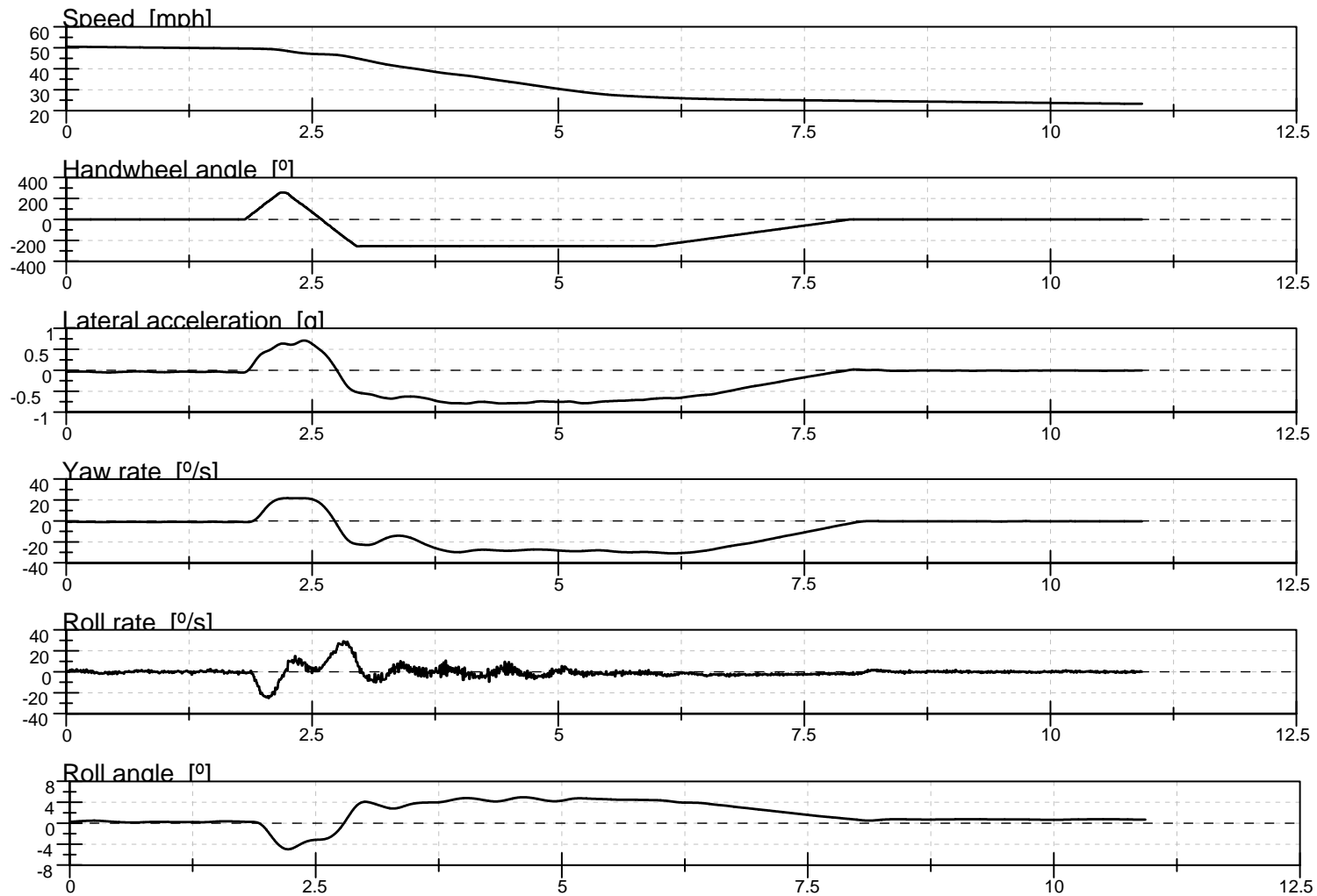


Figure D7. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Default Test Series, R-L, 50 mph

FILENAME: FH_024

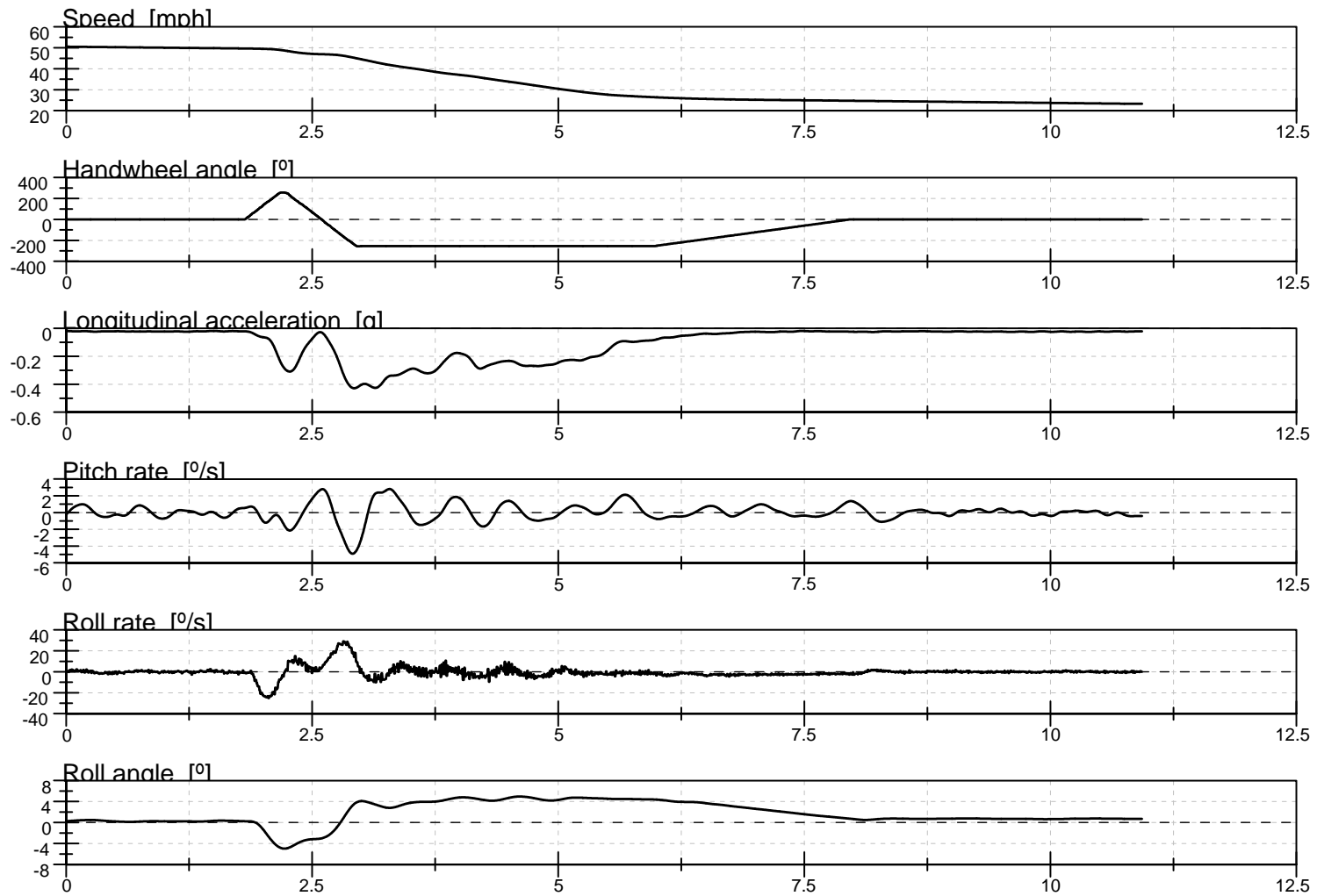


Figure D8. Pitch Rate and Longitudinal Acceleration Time History Plots or Default Test Series, R-L, 50 mph

FILENAME: FH_027

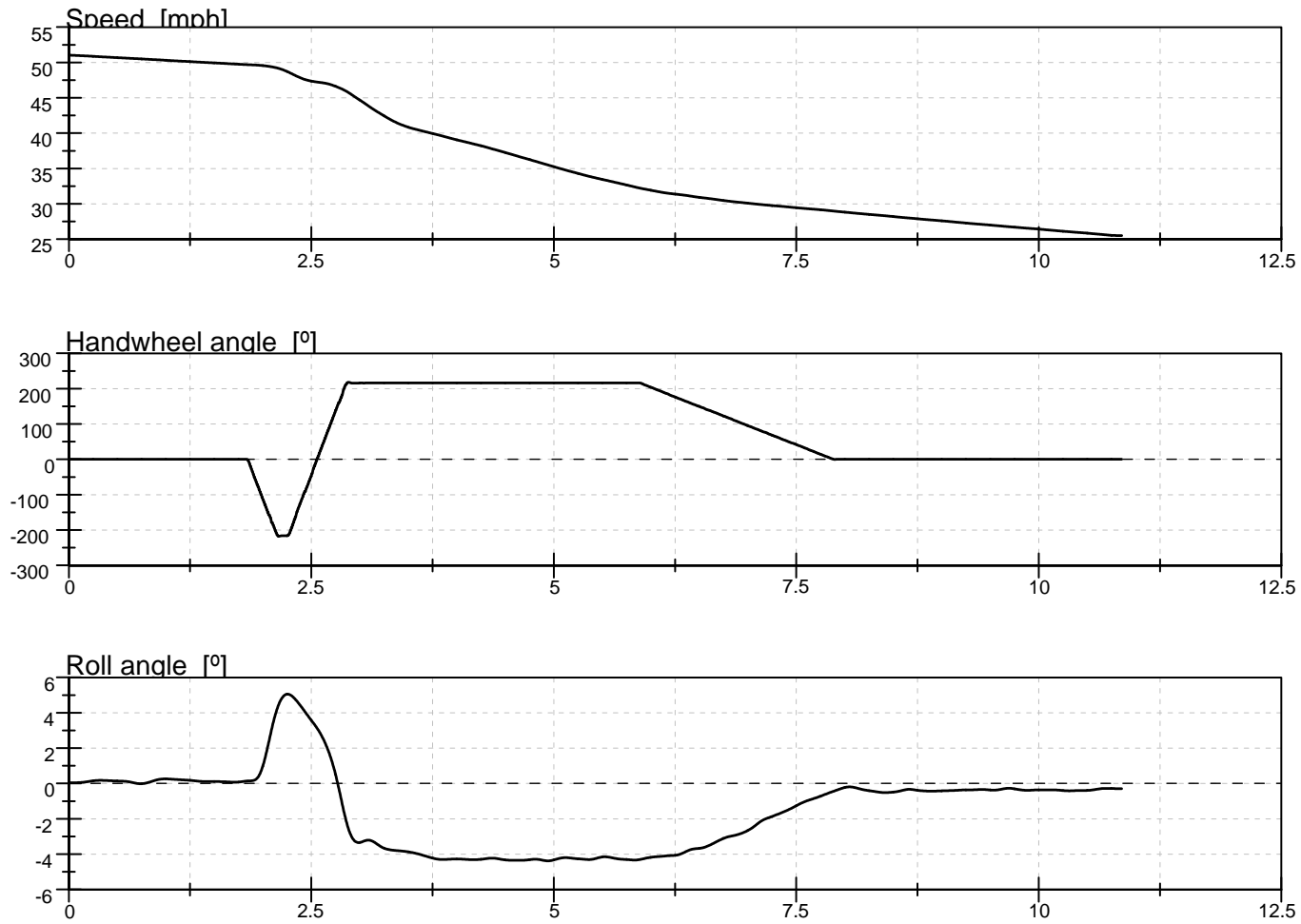


Figure D9. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

FILENAME: FH_027

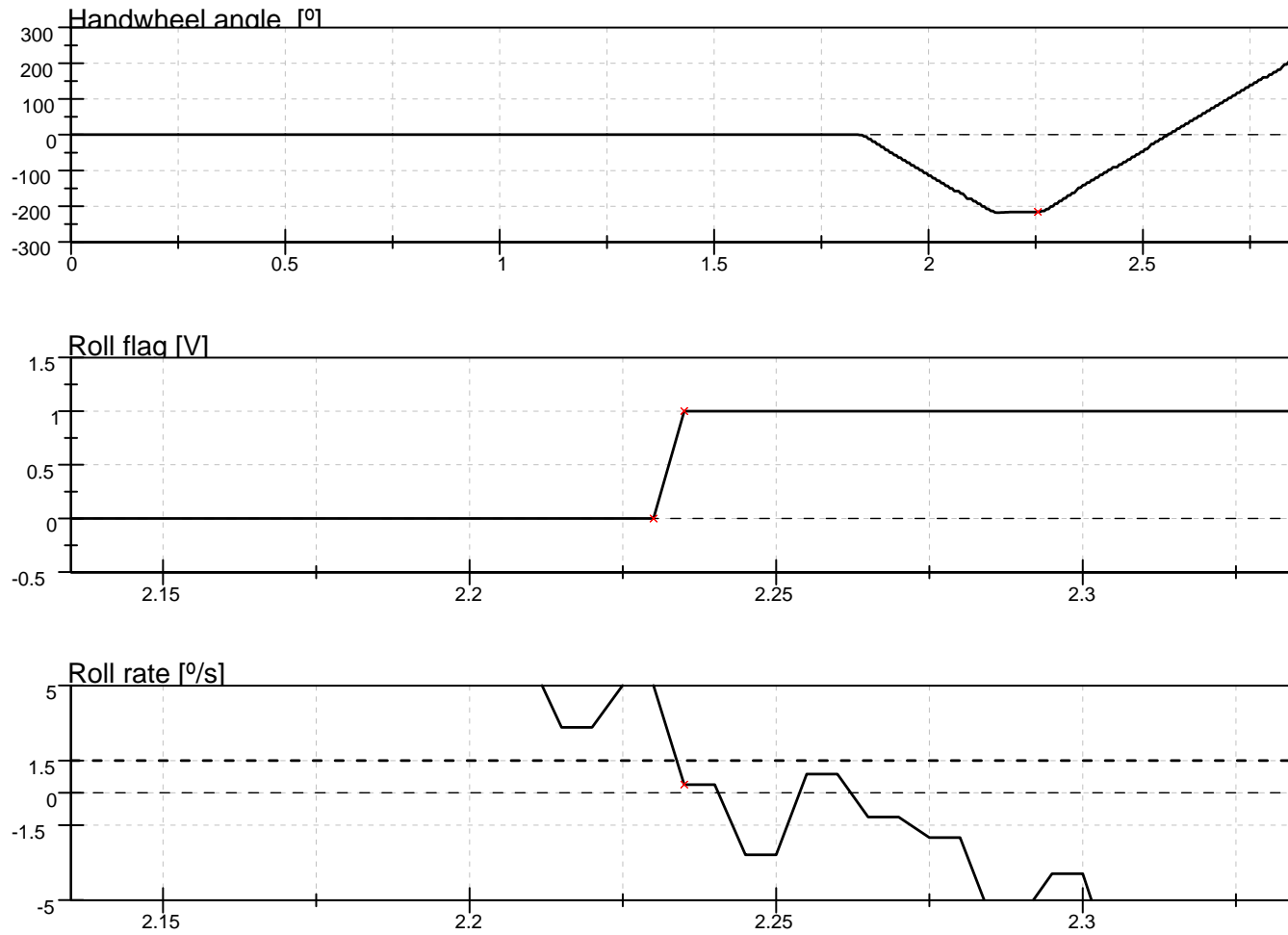


Figure D10. Steering Machine Operation Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

FILENAME: FH_027

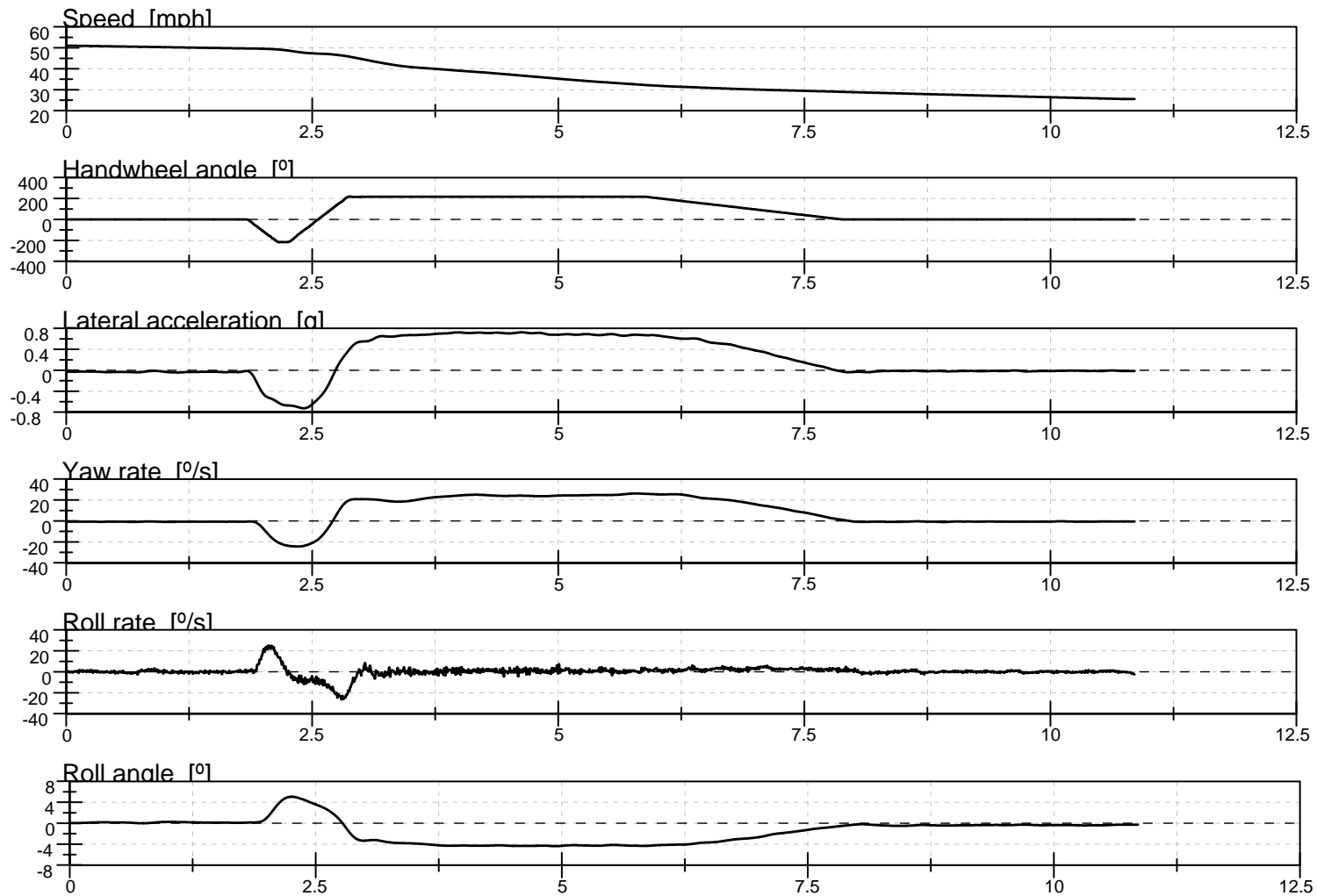


Figure D11. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

FILENAME: FH_027

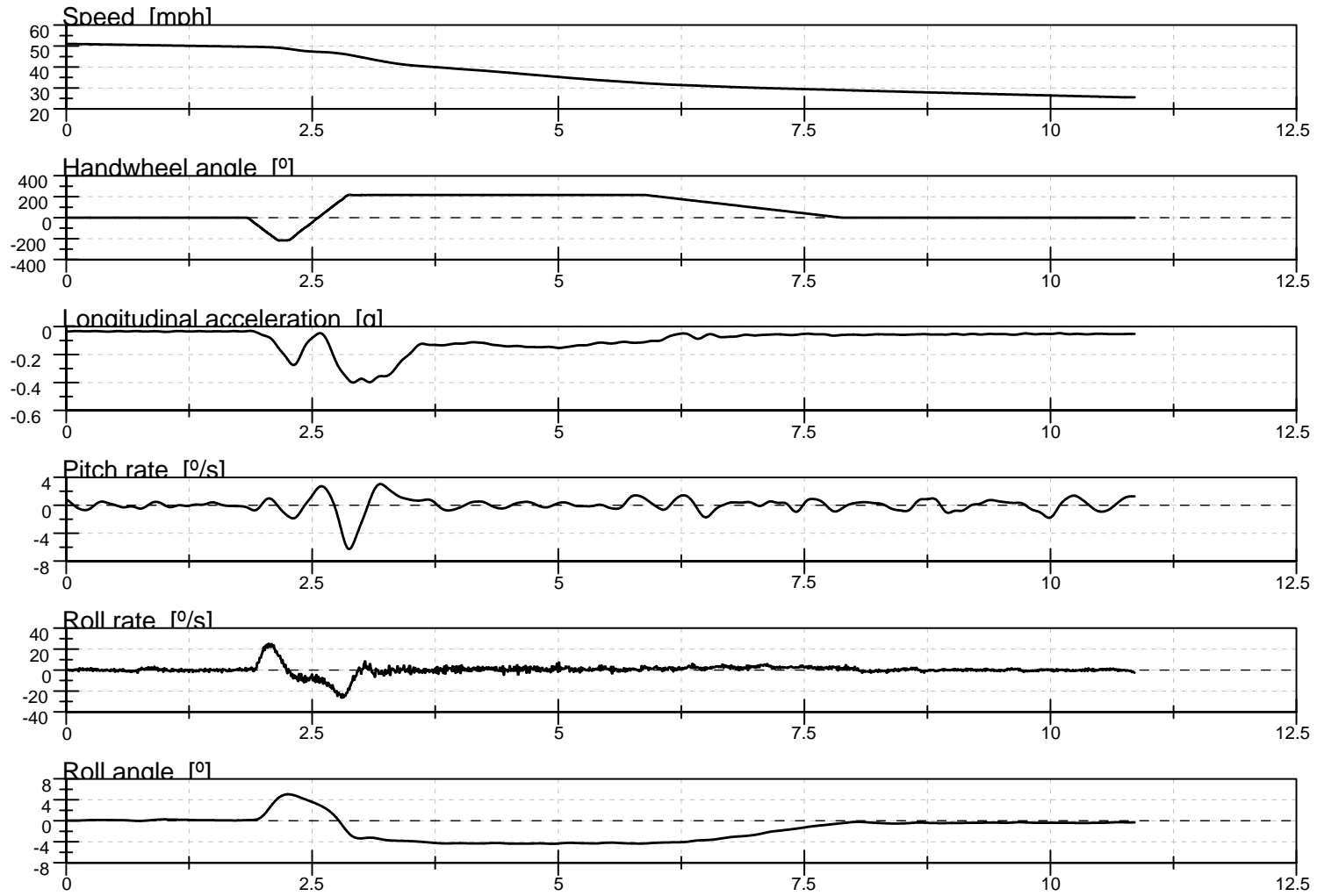


Figure D12. Pitch Rate and Longitudinal Acceleration Time History Plots for Supplemental 2 Test Series, L-R, 50 mph

FILENAME: FH_030

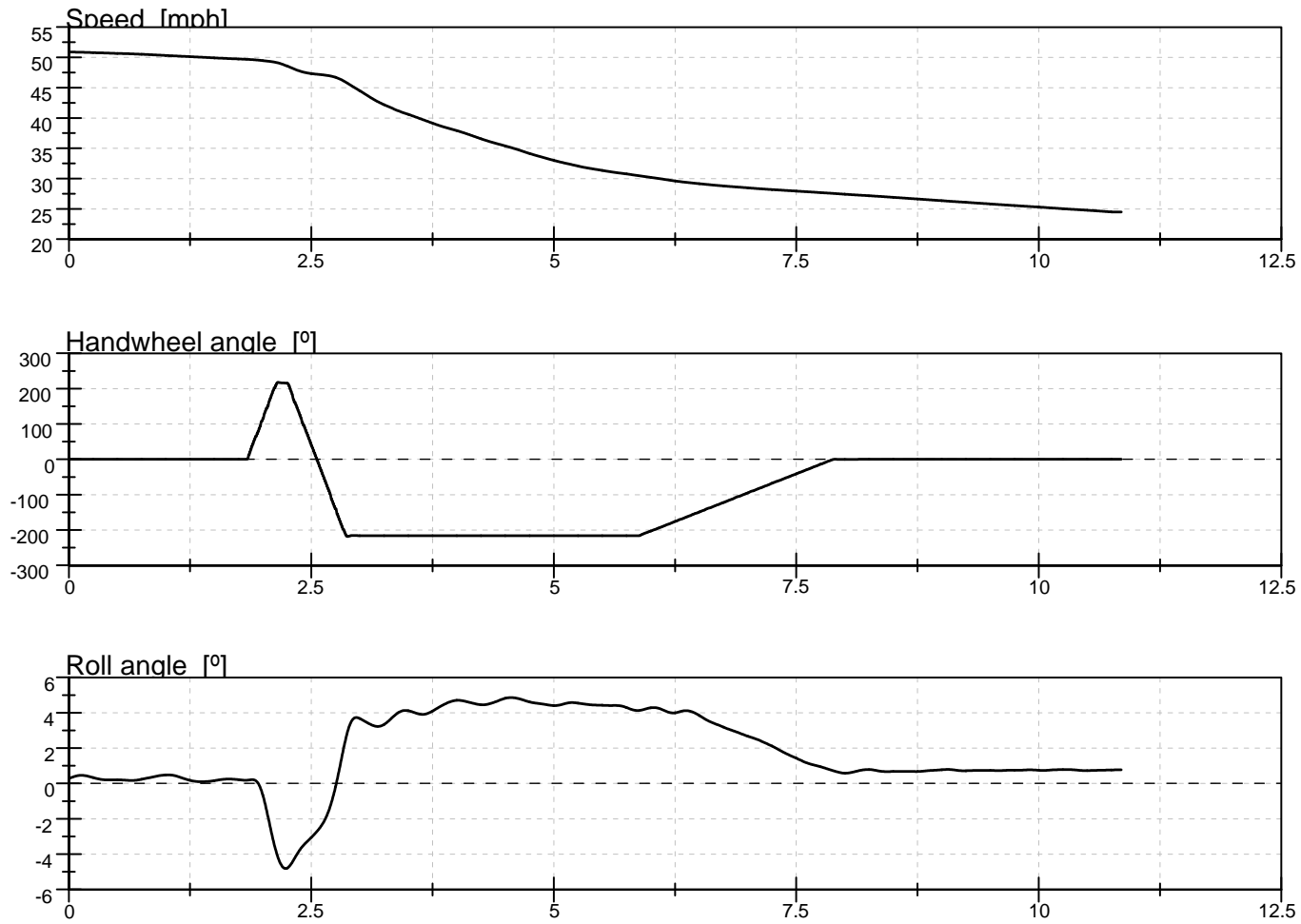


Figure D13. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

FILENAME: FH_030

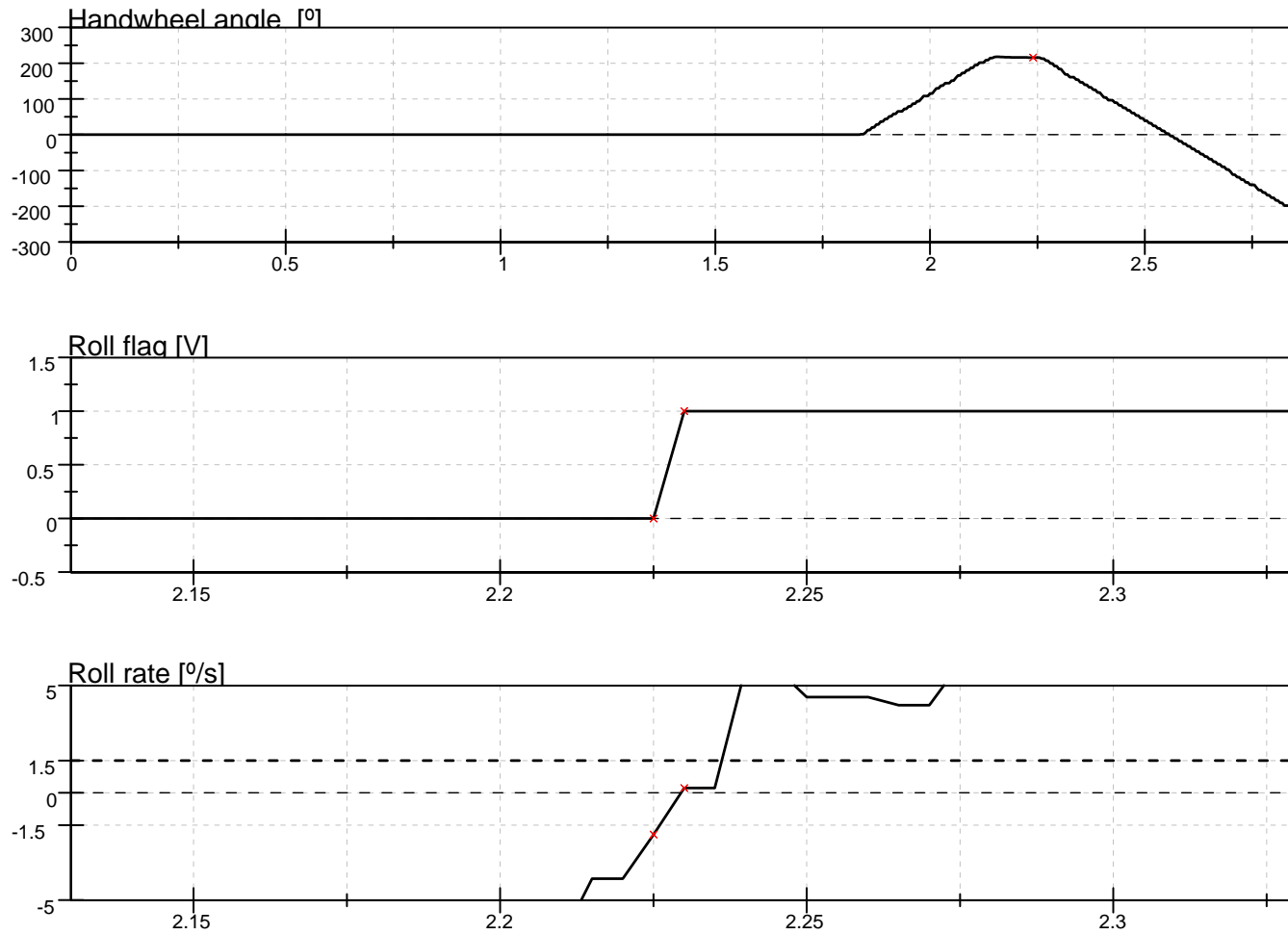


Figure D14. Steering Machine Operation Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

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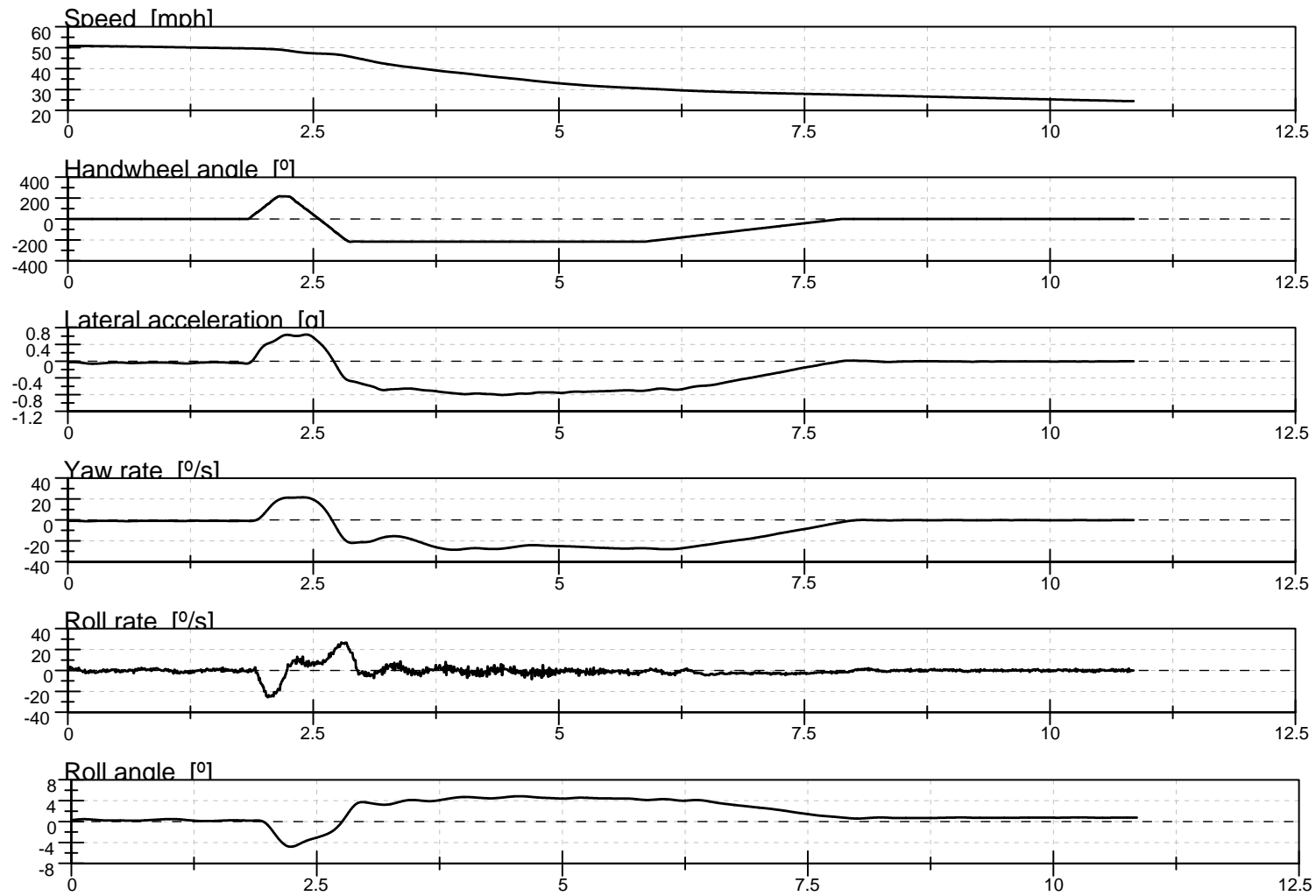


Figure D15. Yaw Rate, Roll Rate, and Lateral Acceleration Time History Plots for Supplemental 2 Test Series, R-L, 50 mph

FILENAME: FH_030

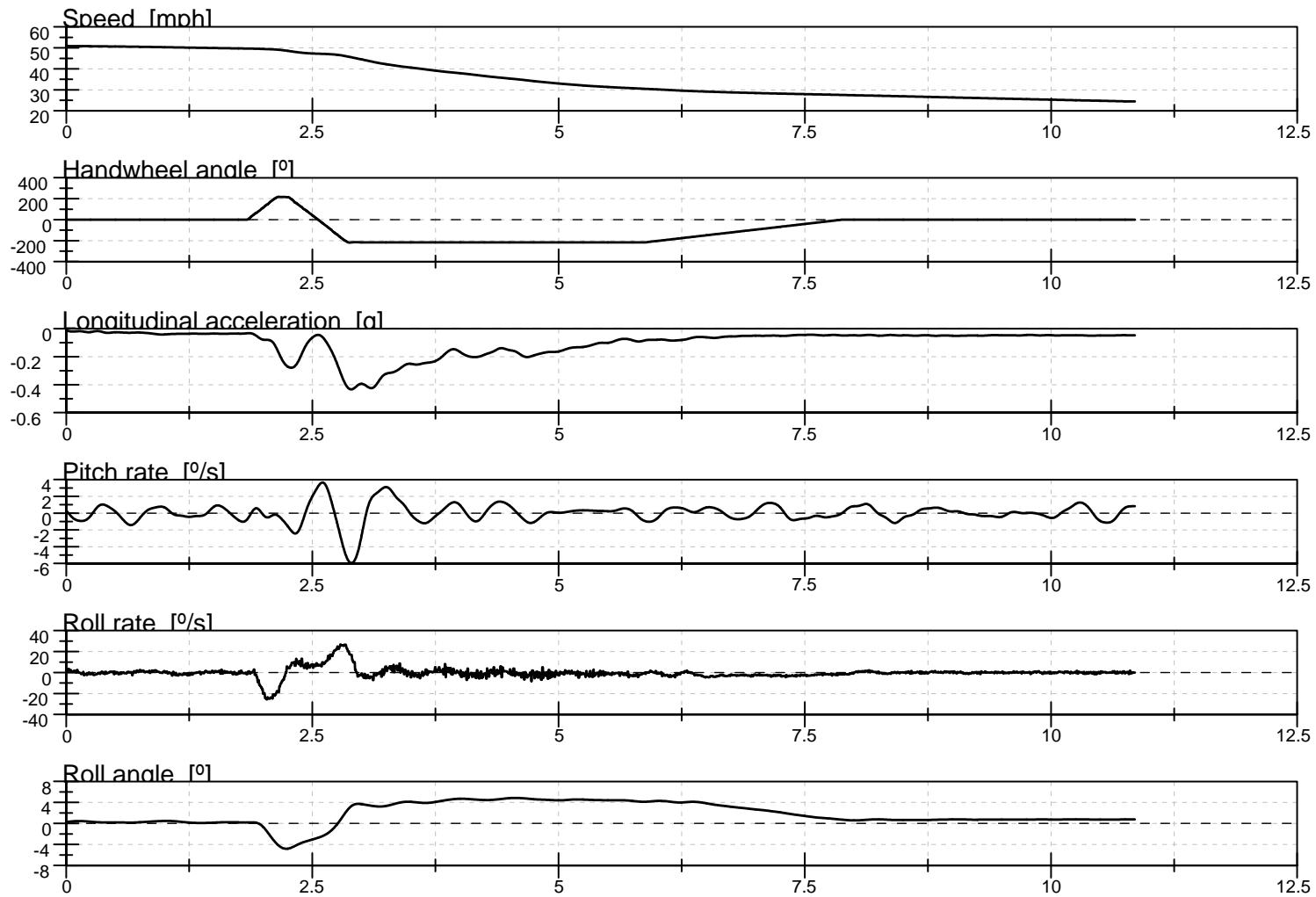


Figure D16. Pitch Rate and Longitudinal Acceleration Time History Plots for Supplemental 2 Test Series, R-L, 50 mph