NEW CAR ASSESSMENT PROGRAM (NCAP)

DYNAMIC ROLLOVER RESISTANCE TEST

HYUNDAI MOTOR MANUFACTURING ALABAMA, LLC

2018 Hyundai Santa Fe FWD

TEST NUMBER: 18-23

Final Report
14 May 2018

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Prepared for:

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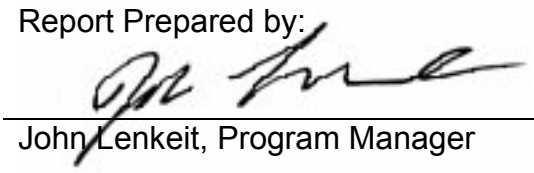
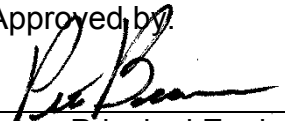
Report Prepared by:



Date: 14 May 2018

John Lenkeit, Program Manager

Report Approved by:



Date: 14 May 2018

Peter Broen, Principal Engineer

Technical Report Documentation Page

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16. Abstract

An NCAP Dynamic Rollover Maneuver (Fishhook) Test was conducted on a 2018 Hyundai Santa Fe FWD at Dynamic Research, Inc. on October 24, 2017. The vehicle did not experience two-wheel lift. The vehicle's steering angle at 0.3 g lateral acceleration at 50 mph was 30.2 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 Hyundai Santa Fe 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 debeading during Fishhook testing, an appropriately sized inner tube was installed in each tire. To further reduce the possibility of tire debeading, 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 Hyundai Santa Fe FWD				
VIN	5NMZU3LBXJH05xxxx				
Body style	SUV				
Number of doors	4				
Trim level	Sport				
Seating positions	Front:	2nd row	3rd row	4th row	5th row
	2	3			
Electronic stability control	Yes				
4-Wheel ABS (Yes/No)	Yes				
Power steering (Yes/No)	Yes				
Major optional equipment	VALUE PACKAGE, PREMIUM PACKAGE, TECH PACKAGE, CARGO PACKAGE				
Odometer at start of testing	16 miles				
Drivetrain					
Engine cylinder arrangement	Inline 4				
Engine displacement	2.4 L				
Transmission type	Automatic				
Drive arrangement	FWD				
Chassis					
Track width	F: 64.3 in (1633.2 mm) , R: 64.7 in (1643.4 mm)				
Wheelbase	106.3 in (2700 mm)				
Curb weight	3766 lb (1708.2 kg)				
Certification Data from Vehicle's Label					
Vehicle manufactured by	HYUNDAI MOTOR MANUFACTURING ALABAMA, LLC				
Date of manufacture	05/17				
GVWR	4872 lb (2210 kg)				
GAWR Front	2976 lb (1350 kg)				
GAWR Rear	3075 lb (1395 kg)				

Table 2. Tire Information

Tire Manufacturer	KUMHO
Tire Model	CRUGEN PREMIUM
Tire Size	Front: 235/65 R17 Rear: 235/65 R17
Load rating	Front: 104 Rear: 104
Speed rating	Front: H Rear: H
Treadwear grade	Front: 440 Rear: 440
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: 34 psi, (235 kPa) Rear: 34 psi, (235 kPa)
First 8 digits of DOT code	Front: 000 5AYANH Rear: 000 5AYANH

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	1260 lb (571.5 kg)
Right front	1222 lb (554.3 kg)
Left rear	1191 lb (540.2 kg)
Right rear	1107 lb (502.1 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.

Ashcroft D1005PS	1039350
Intercomp SW I	24032361
Proform 67644	VS800W16-00455

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[1]
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.

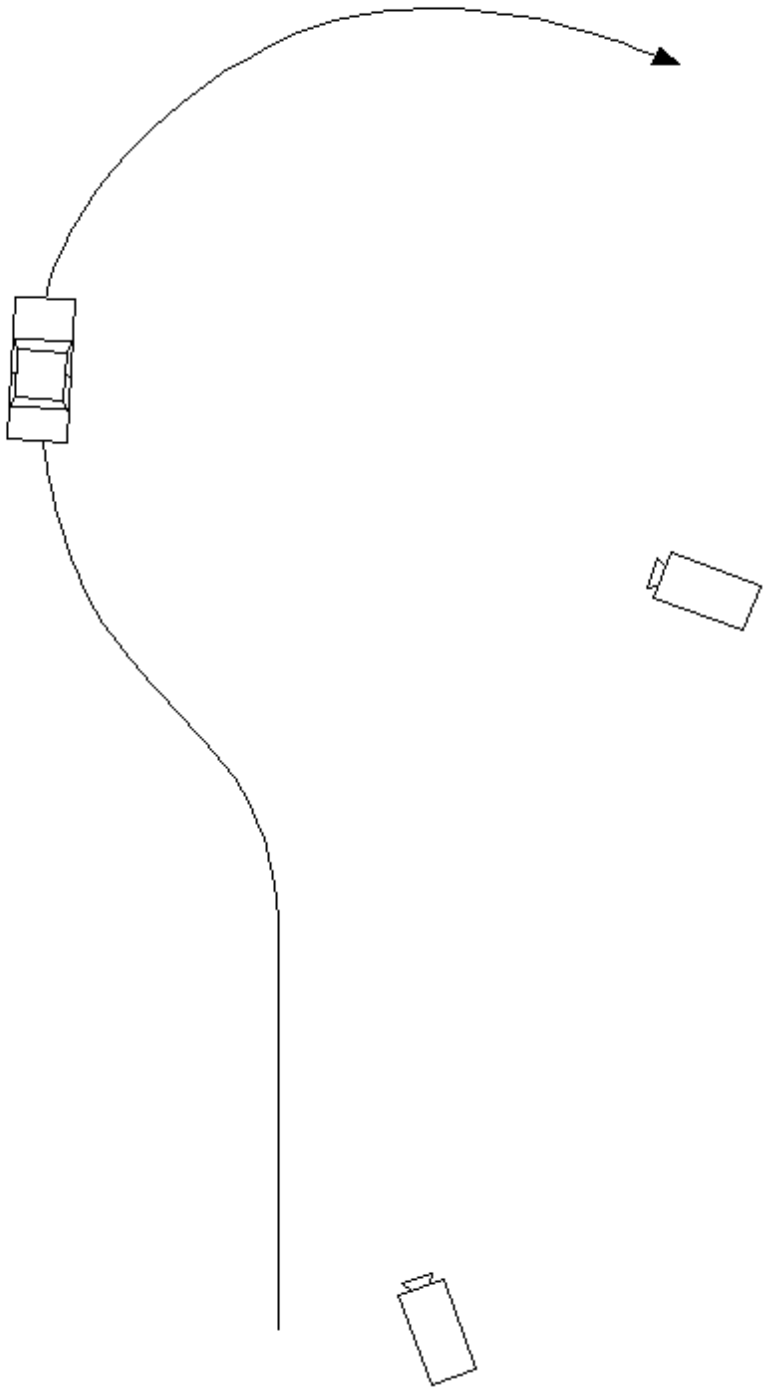


Figure 1. Nominal Position of Video Cameras for Fishhook Tests

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 10/24/2017. 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	10/24/2017
Average normalized lateral force	0.851

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)	30.2 º
5.5 scalar handwheel angle for Fishhook Test	166º
6.5 scalar handwheel angle for Fishhook Test	196 º

3. Weather Conditions

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

Table 7. Weather Conditions

Ambient temperature	59 ºF (15 ºC)
Wind Speed	0 mph (0 m/s)
Wind Direction	N

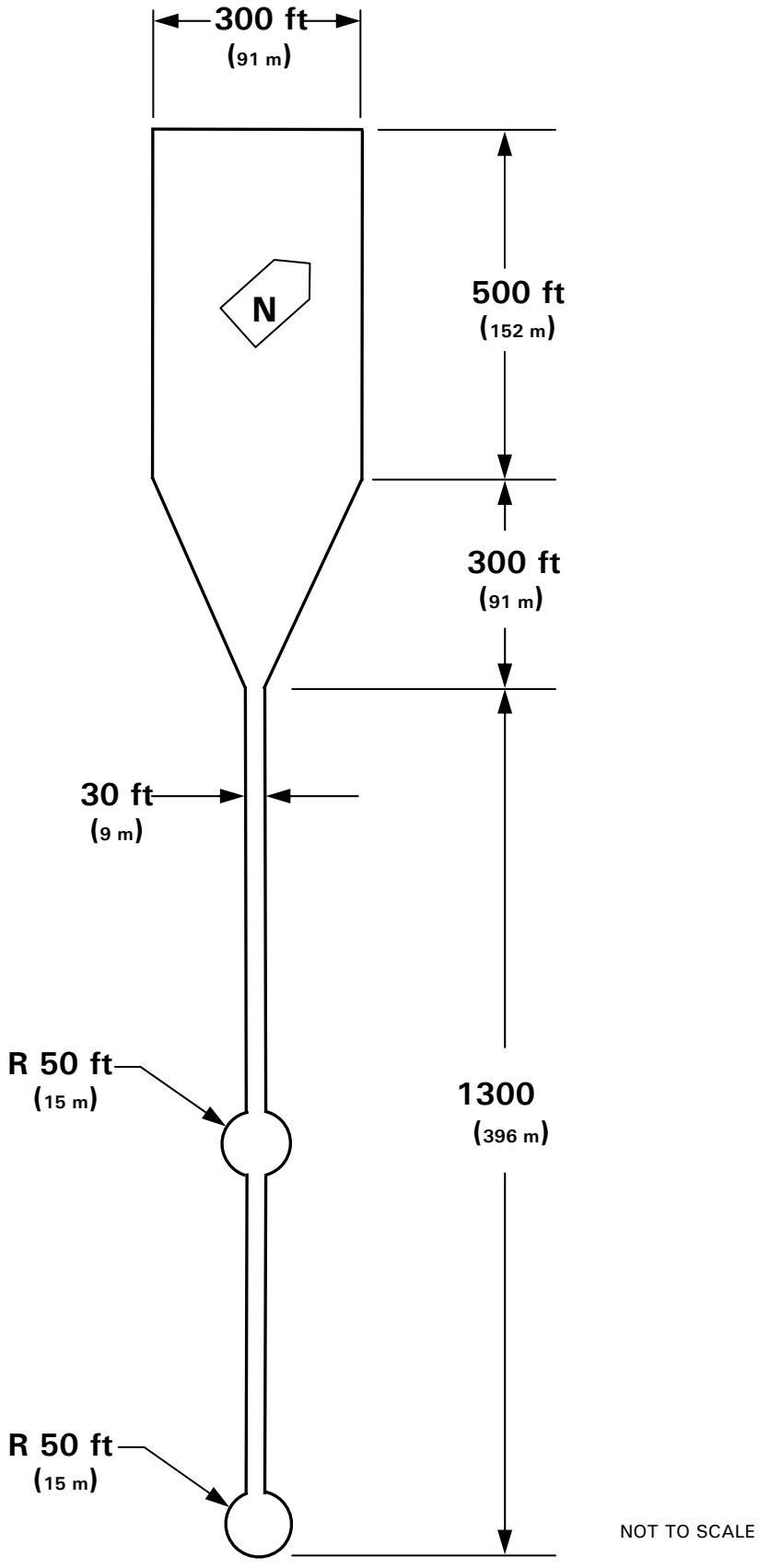


Figure 2. DRI-Minter Vehicle Dynamics Area

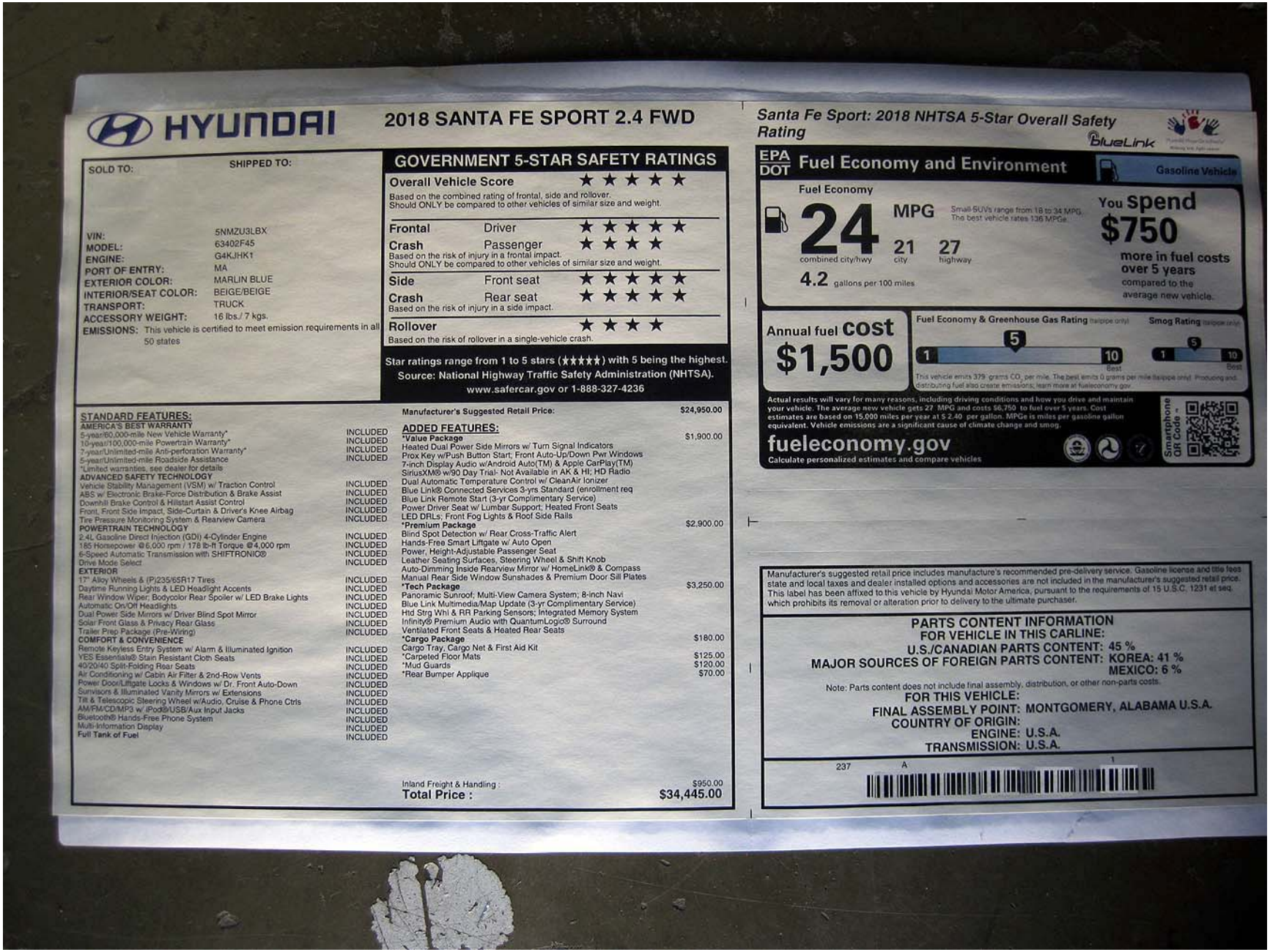
Section IV
RESULTS

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 Hyundai Santa Fe FWD, there was no two-wheel lift at any test condition.

APPENDIX A

Photographs

LIST OF FIGURES



HYUNDAI

2018 SANTA FE SPORT 2.4 FWD

SOLD TO: SHIPPED TO:

VIN:	5NMZU3LBX
MODEL:	63402F45
ENGINE:	G4KJHK1
PORT OF ENTRY:	MA
EXTERIOR COLOR:	MARLIN BLUE
INTERIOR/SEAT COLOR:	BEIGE/BEIGE
TRANSPORT:	TRUCK
ACCESSORY WEIGHT:	16 lbs./ 7 kgs.
EMISSIONS:	This vehicle is certified to meet emission requirements in all 50 states

GOVERNMENT 5-STAR SAFETY RATINGS

Overall Vehicle Score ★★★★★
Based on the combined rating of frontal, side and rollover.
Should ONLY be compared to other vehicles of similar size and weight.

Frontal Crash — Driver ★★★★★ / Passenger ★★★★
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 ★★★★★
Based on the risk of injury in a side impact.

Rollover ★★★★
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

Santa Fe Sport: 2018 NHTSA 5-Star Overall Safety Rating

BlueLink

EPA DOT Fuel Economy and Environment — Gasoline Vehicle

Fuel Economy
24 MPG combined city/hwy (21 city, 27 highway)
Small SUVs range from 18 to 34 MPG. The best vehicle rates 136 MPGe.
4.2 gallons per 100 miles

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

Annual fuel cost $1,500

Fuel Economy & Greenhouse Gas Rating (tailpipe only): 5 (1 – 10, Best)
Smog Rating (tailpipe only): 5 (1 – 10, Best)
This vehicle emits 379 grams 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

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AMERICA'S BEST WARRANTY
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10-year/100,000-mile Powertrain Warranty* — INCLUDED
7-year/Unlimited-mile Anti-perforation Warranty* — INCLUDED
5-year/Unlimited-mile Roadside Assistance — INCLUDED
*Limited warranties, see dealer for details

ADVANCED SAFETY TECHNOLOGY
Vehicle Stability Management (VSM) w/ Traction Control — INCLUDED
ABS w/ Electronic Brake-Force Distribution & Brake Assist — INCLUDED
Downhill Brake Control & Hillstart Assist Control — INCLUDED
Front, Front Side Impact, Side-Curtain & Driver's Knee Airbag — INCLUDED
Tire Pressure Monitoring System & Rearview Camera — INCLUDED

POWERTRAIN TECHNOLOGY
2.4L Gasoline Direct Injection (GDI) 4-Cylinder Engine — INCLUDED
185 Horsepower @ 6,000 rpm / 178 lb-ft Torque @ 4,000 rpm — INCLUDED
6-Speed Automatic Transmission with SHIFTRONIC® — INCLUDED
Drive Mode Select — INCLUDED

EXTERIOR
17" Alloy Wheels & (P)235/65R17 Tires — INCLUDED
Daytime Running Lights & LED Headlight Accents — INCLUDED
Rear Window Wiper, Bodycolor Rear Spoiler w/ LED Brake Lights — INCLUDED
Automatic On/Off Headlights — INCLUDED
Dual Power Side Mirrors w/ Driver Blind Spot Mirror — INCLUDED
Solar Front Glass & Privacy Rear Glass — INCLUDED
Trailer Prep Package (Pre-Wiring) — INCLUDED

COMFORT & CONVENIENCE
Remote Keyless Entry System w/ Alarm & Illuminated Ignition — INCLUDED
YES Essentials® Stain Resistant Cloth Seats — INCLUDED
40/20/40 Split-Folding Rear Seats — INCLUDED
Air Conditioning w/ Cabin Air Filter & 2nd-Row Vents — INCLUDED
Power Door/Liftgate Locks & Windows w/ Dr. Front Auto-Down — INCLUDED
Sunvisors & Illuminated Vanity Mirrors w/ Extensions — INCLUDED
Tilt & Telescopic Steering Wheel w/ Audio, Cruise & Phone Ctrls — INCLUDED
AM/FM/CD/MP3 w/ iPod®/USB/Aux Input Jacks — INCLUDED
Bluetooth® Hands-Free Phone System — INCLUDED
Multi-Information Display — INCLUDED
Full Tank of Fuel — INCLUDED

Manufacturer's Suggested Retail Price: $24,950.00

ADDED FEATURES:

*Value Package — $1,900.00
Heated Dual Power Side Mirrors w/ Turn Signal Indicators
Prox Key w/Push Button Start; Front Auto-Up/Down Pwr Windows
7-inch Display Audio w/Android Auto(TM) & Apple CarPlay(TM)
SiriusXM® w/90 Day Trial- Not Available in AK & HI; HD Radio
Dual Automatic Temperature Control w/ CleanAir Ionizer
Blue Link® Connected Services 3-yrs Standard (enrollment req
Blue Link Remote Start (3-yr Complimentary Service)
Power Driver Seat w/ Lumbar Support; Heated Front Seats
LED DRLs; Front Fog Lights & Roof Side Rails

*Premium Package — $2,900.00
Blind Spot Detection w/ Rear Cross-Traffic Alert
Hands-Free Smart Liftgate w/ Auto Open
Power, Height-Adjustable Passenger Seat
Leather Seating Surfaces, Steering Wheel & Shift Knob
Auto-Dimming Inside Rearview Mirror w/ HomeLink® & Compass
Manual Rear Side Window Sunshades & Premium Door Sill Plates

*Tech Package — $3,250.00
Panoramic Sunroof; Multi-View Camera System; 8-inch Navi
Blue Link Multimedia/Map Update (3-yr Complimentary Service)
Htd Strg Whl & RR Parking Sensors; Integrated Memory System
Infinity® Premium Audio with QuantumLogic® Surround
Ventilated Front Seats & Heated Rear Seats

*Cargo Package — $180.00
Cargo Tray, Cargo Net & First Aid Kit

*Carpeted Floor Mats — $125.00
*Mud Guards — $120.00
*Rear Bumper Applique — $70.00

Inland Freight & Handling : $950.00
Total Price : $34,445.00

Manufacturer's suggested retail price includes manufacture's recommended pre-delivery service. Gasoline license and title fees state and local taxes and dealer installed options and accessories are not included in the manufacturer's suggested retail price. This label has been affixed to this vehicle by Hyundai Motor America, pursuant to the requirements of 15 U.S.C. 1231 et seq. which prohibits its removal or alteration prior to delivery to the ultimate purchaser.

PARTS CONTENT INFORMATION
FOR VEHICLE IN THIS CARLINE:
U.S./CANADIAN PARTS CONTENT: 45 %
MAJOR SOURCES OF FOREIGN PARTS CONTENT: KOREA: 41 %
MEXICO: 6 %
Note: Parts content does not include final assembly, distribution, or other non-parts costs.
FOR THIS VEHICLE:
FINAL ASSEMBLY POINT: MONTGOMERY, ALABAMA U.S.A.
COUNTRY OF ORIGIN:
ENGINE: U.S.A.
TRANSMISSION: U.S.A.

237 A 1

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 Hyundai Santa Fe FWD** Driver: **John Partridge** Date: **10/24/2017**

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	
2			80			Resulted in ay = 0.6g
3						
4						
5						2x SWA last cycle
6	Static	0	0			
7	Steady State	50	0			
8	Slowly Increasing Steer	50	60	Left		Resulted in ay = 0.61g
9				Left		
10				Left		
11				Right		
12				Right		
13				Right		
14	Fishhook 6.5 Scalar	35	196	Left	No	
15		40			No	
16		45			No	
17		47.5			No	
18		50			No	
19	Fishhook 5.5 Scalar	45	166	Left	No	
20		47.5			No	
21		50			No	
22	Fishhook 6.5 Scalar	35	196	Right	No	

Vehicle: **2018 Hyundai Santa Fe FWD** Driver: **John Partridge** Date: **10/24/2017**

Run Number	Test Type	Speed (mph)	Handwheel Angle (deg)	Dir. of First Steer	2 Wheel Lift	Notes
23		40			No	
24		45			No	
25		47.5			No	
26		50			No	
27	Fishhook 5.5 Scalar	45	166	Right	No	
28		47.5			No	
29		50			No	

APPENDIX C

Slowly Increasing Steer Test Worksheet

NCAP, 2018 Hyundai Santa Fe FWD , Multi-Passenger Load, Test Date: 10/24/2017

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
8	Left	50.3	4.1	91.8	1261	-30.5	-0.296	-198.4	-0.2756	-167.9	-0.2332	0.9974	600	800
9	Left	50.3	3.5	93.0	1263	-30.7	-0.302	-199.6	-0.2773	-168.9	-0.2346	0.9943	600	800
10	Left	50.4	0.4	99.1	1265	-30.8	-0.312	-200.2	-0.2780	-169.4	-0.2353	0.9939	600	800
11	Right	50.4	4.6	90.8	1249	29.9	0.292	194.7	0.2704	164.7	0.2288	0.9957	600	800
12	Right	50.3	8.6	82.9	1241	29.5	0.303	191.9	0.2665	162.4	0.2255	0.9915	600	800
13	Right	50.3	4.7	90.7	1248	29.9	0.307	194.4	0.2700	164.5	0.2284	0.9965	600	800
					Mean:	30.2	0.302	197	0.273	166	0.231			

Steering Controller Input Values

Scalar 6.5 values:

Initial HW angle:	197	deg
Initial time:	0.273	s
Reversal HW angle:	-197	deg
Reversal time:	0.546	s

Scalar 5.5 values:

Initial HW angle:	166	deg
Initial time:	0.231	s
Reversal HW angle:	-166	deg
Reversal time:	0.462	s

APPENDIX D

Time History Plots

LIST OF FIGURES

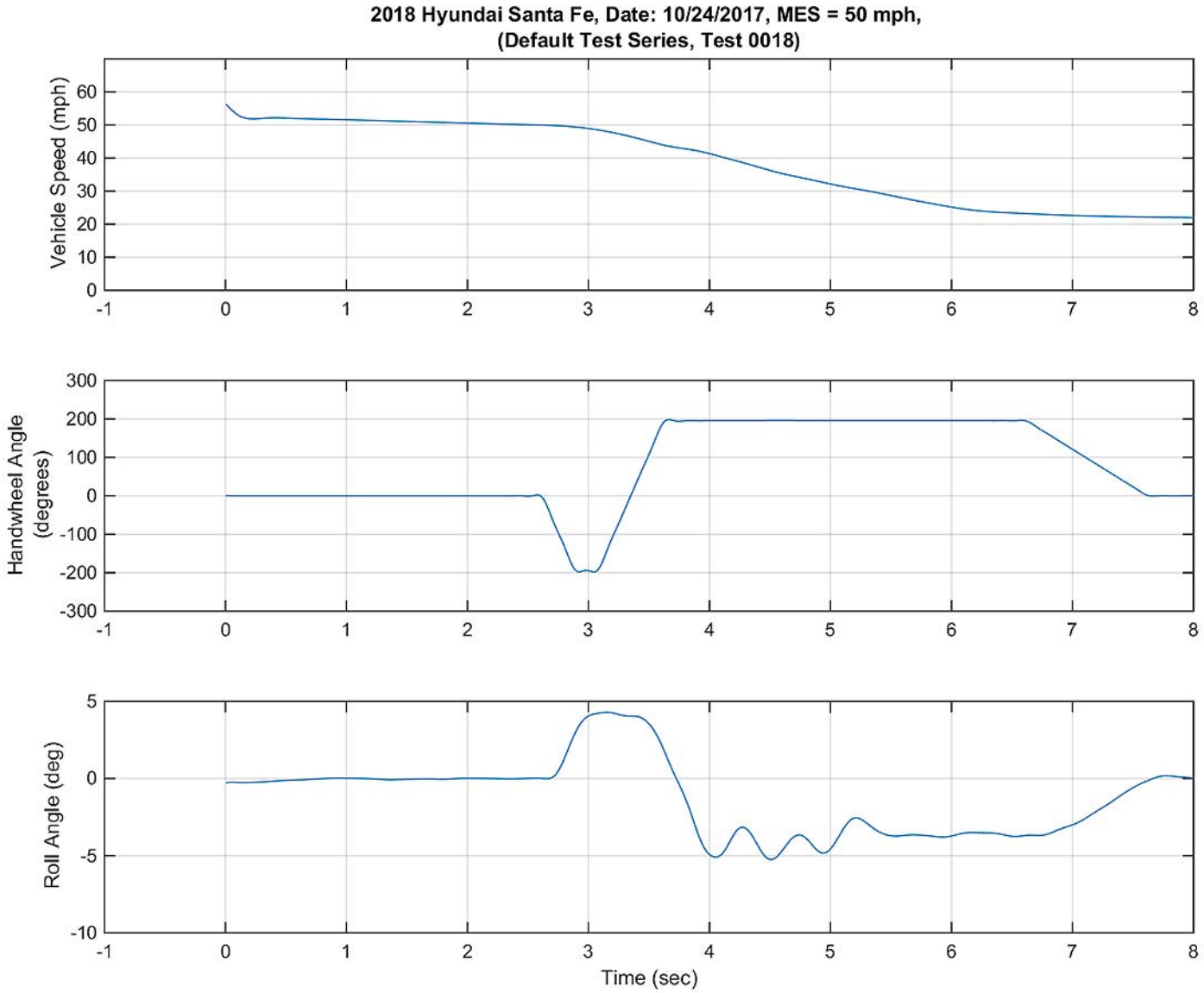
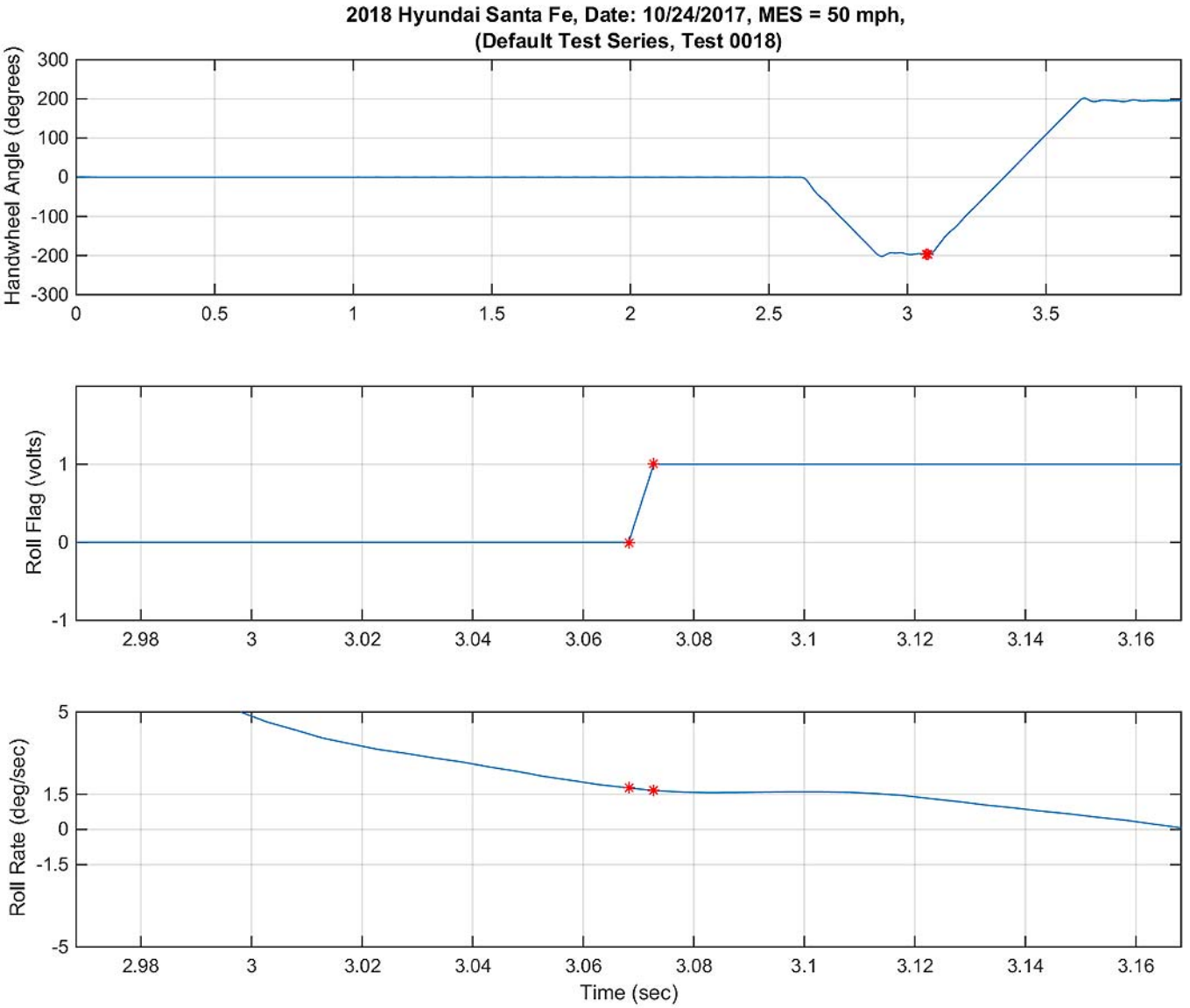


Figure D1. Vehicle Speed, Handwheel Angle, and Roll Angle Time History Plots for Default Test Series, L-R, 50 mph



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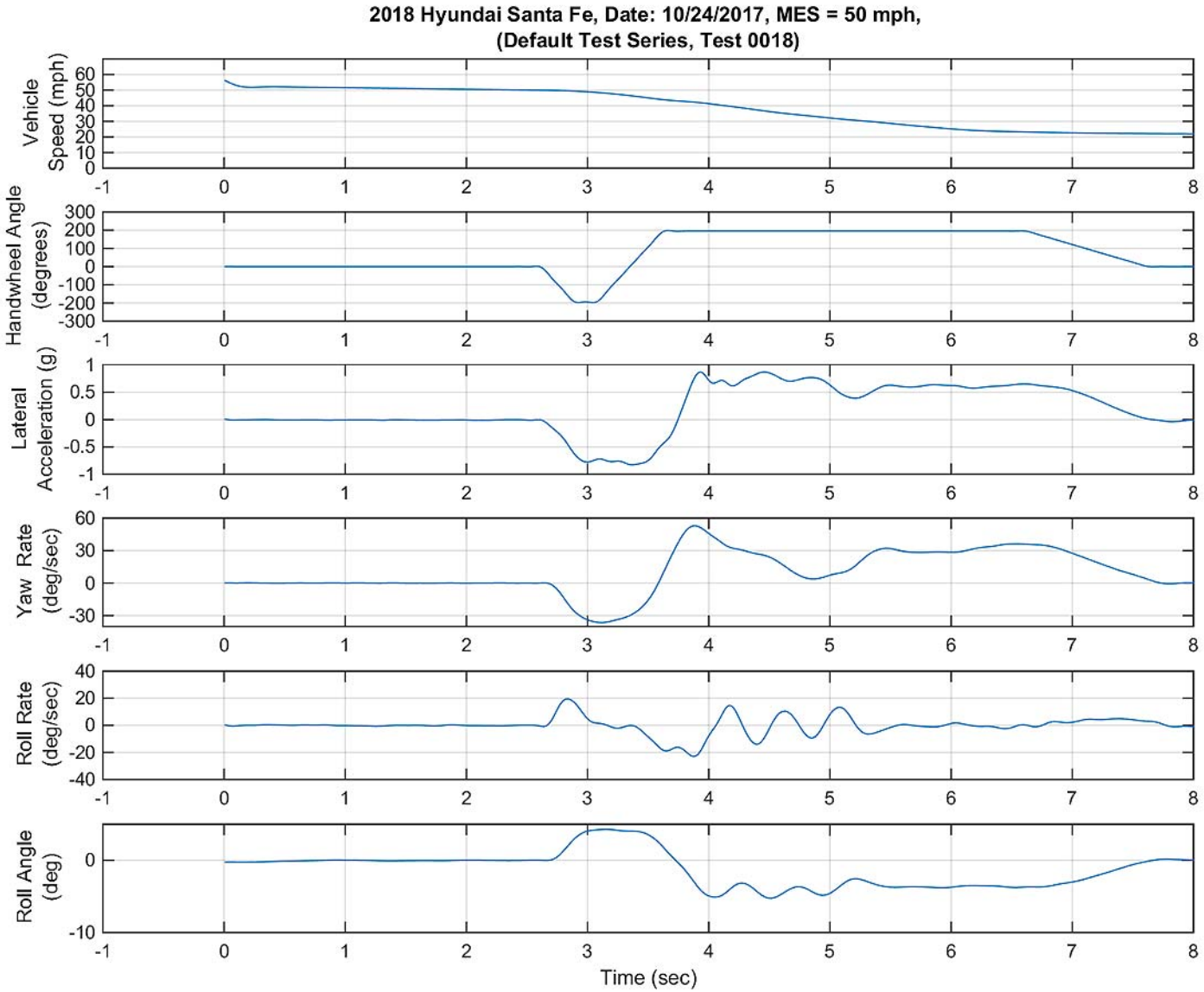

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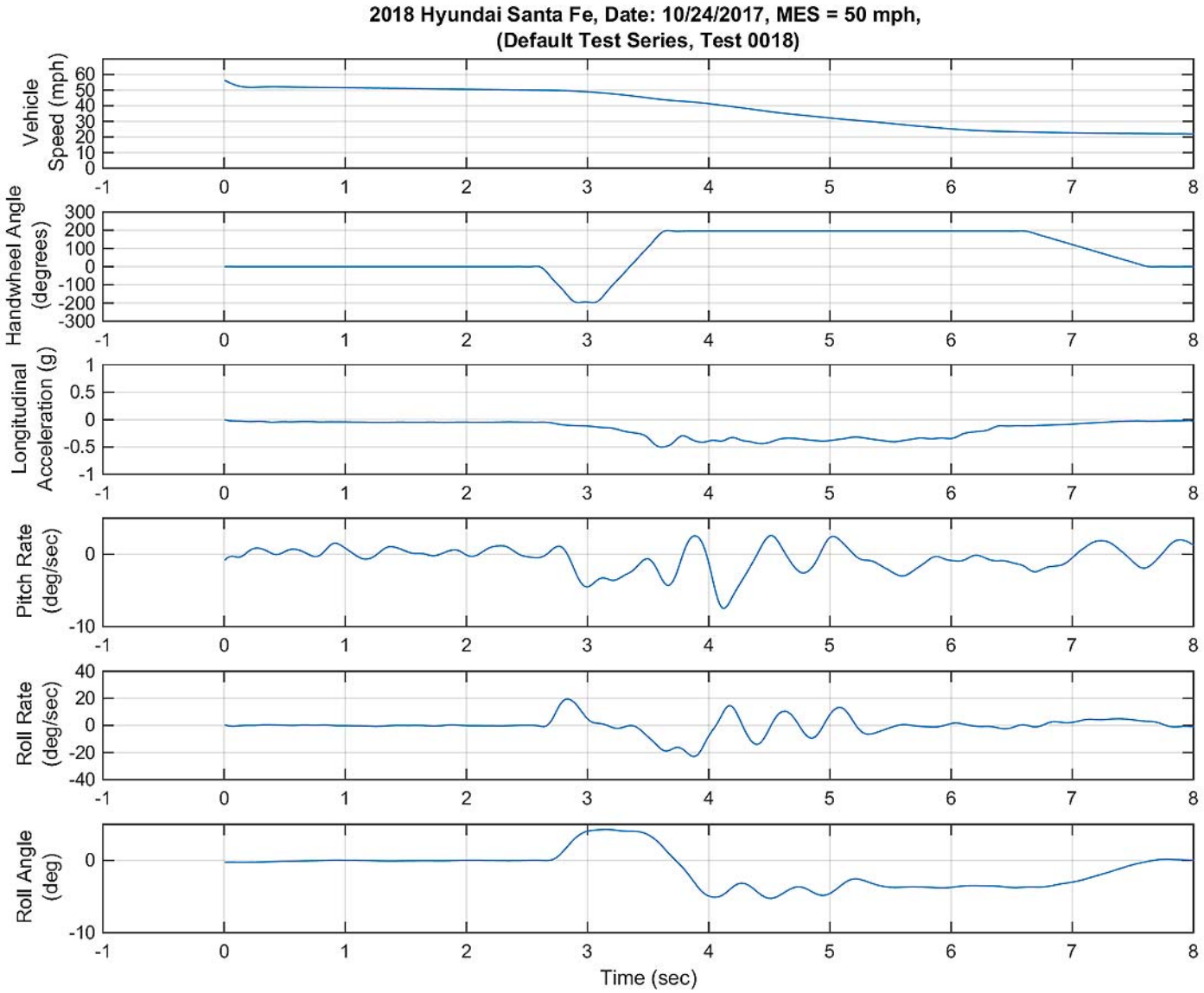

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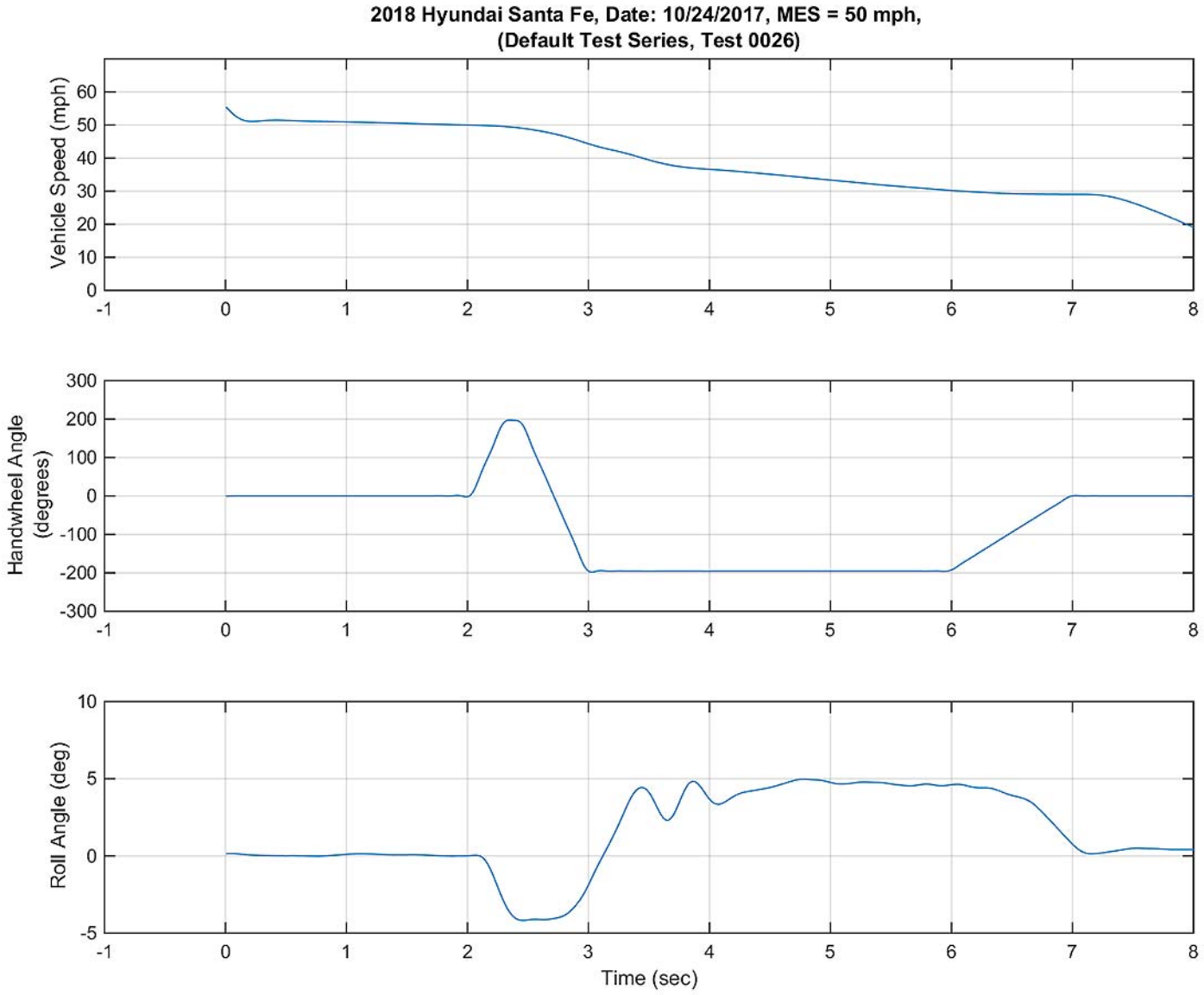

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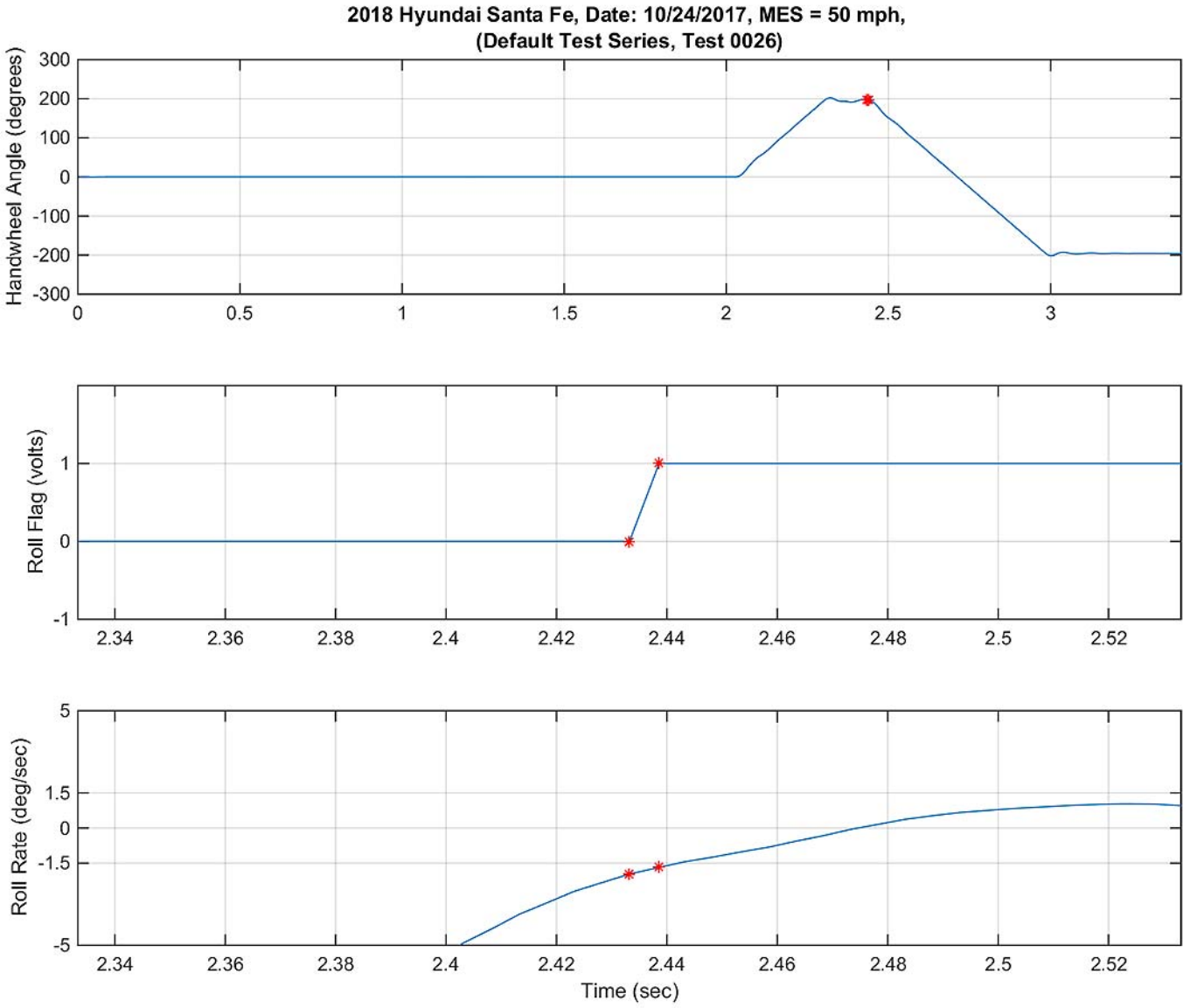

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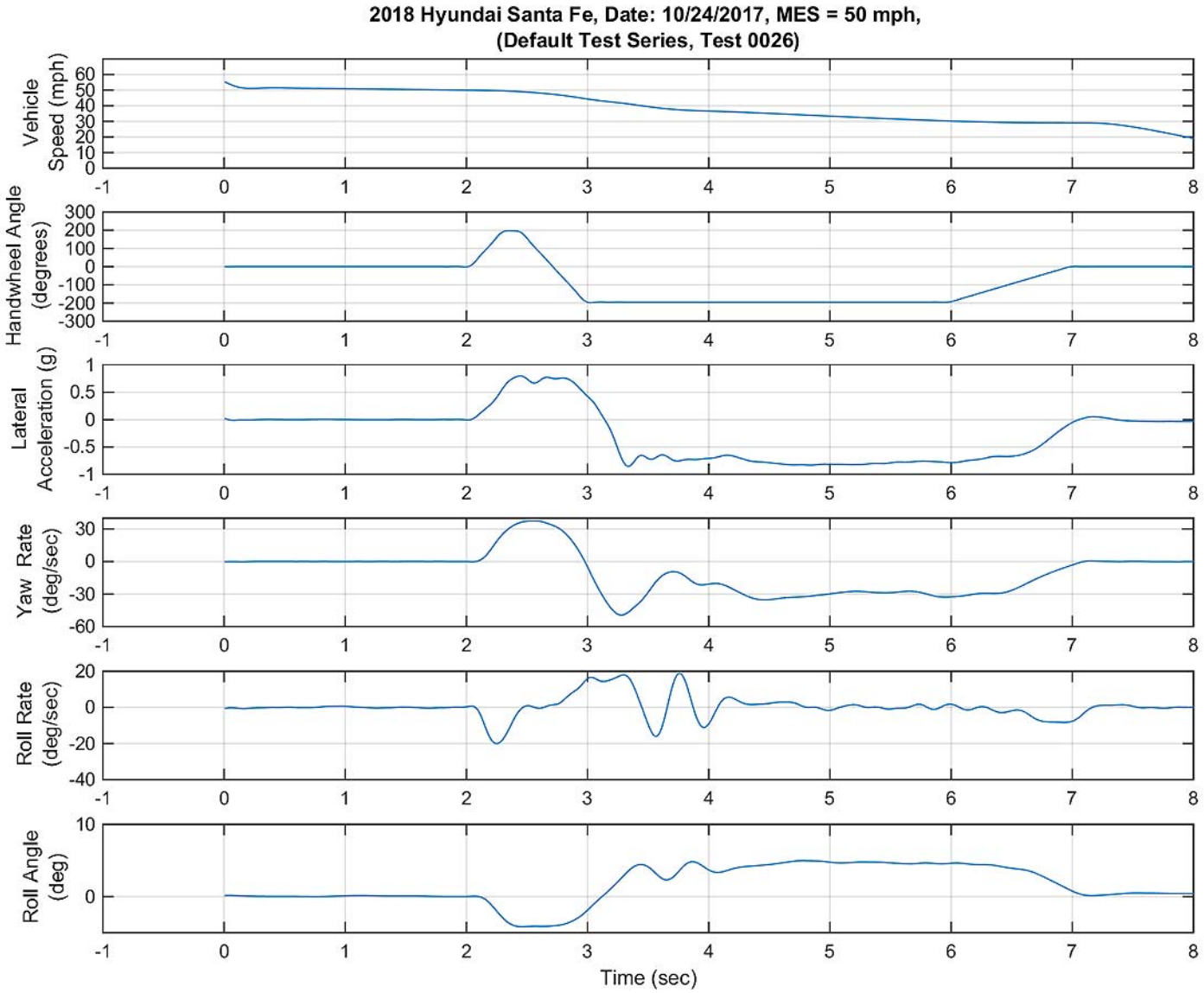

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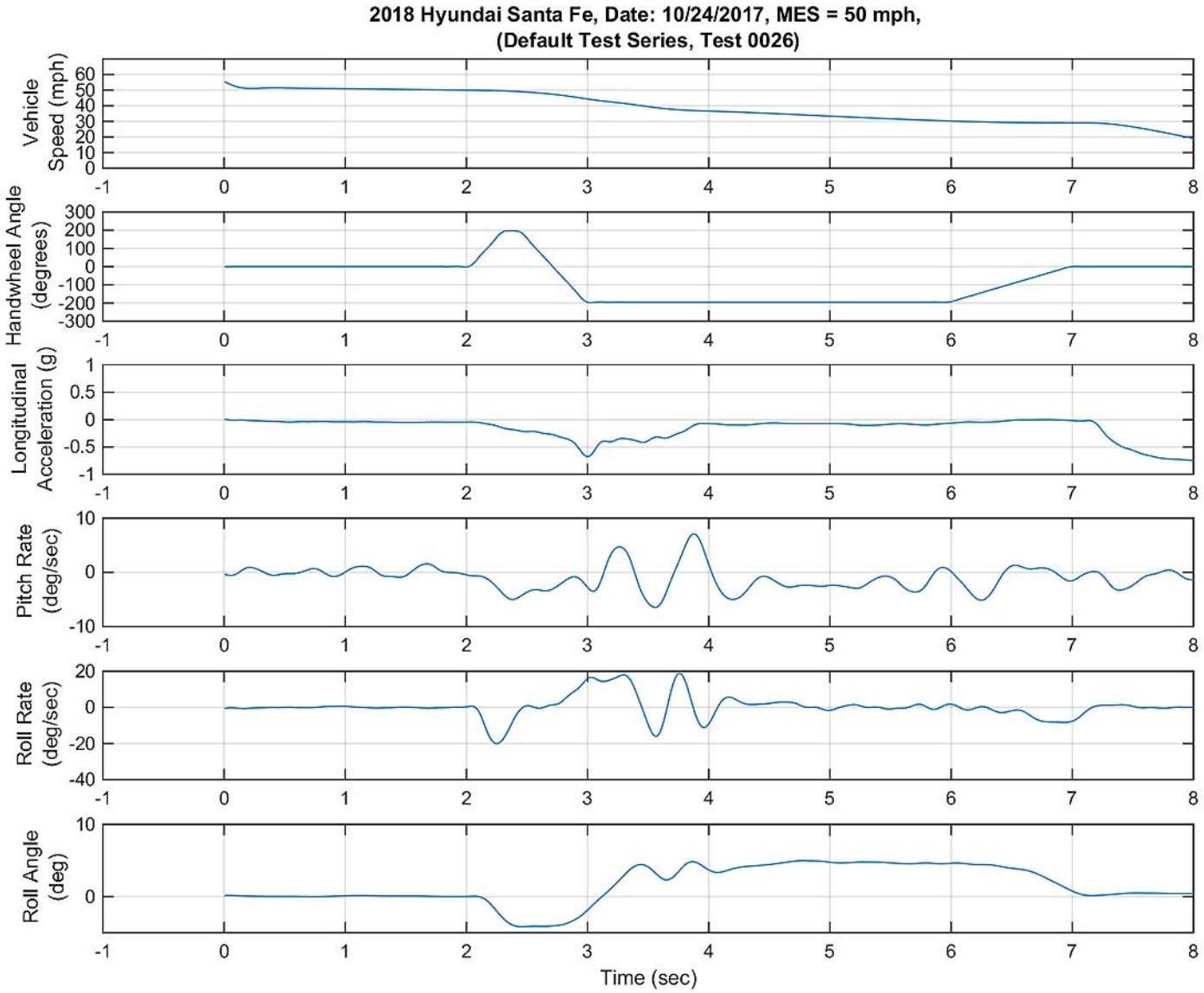

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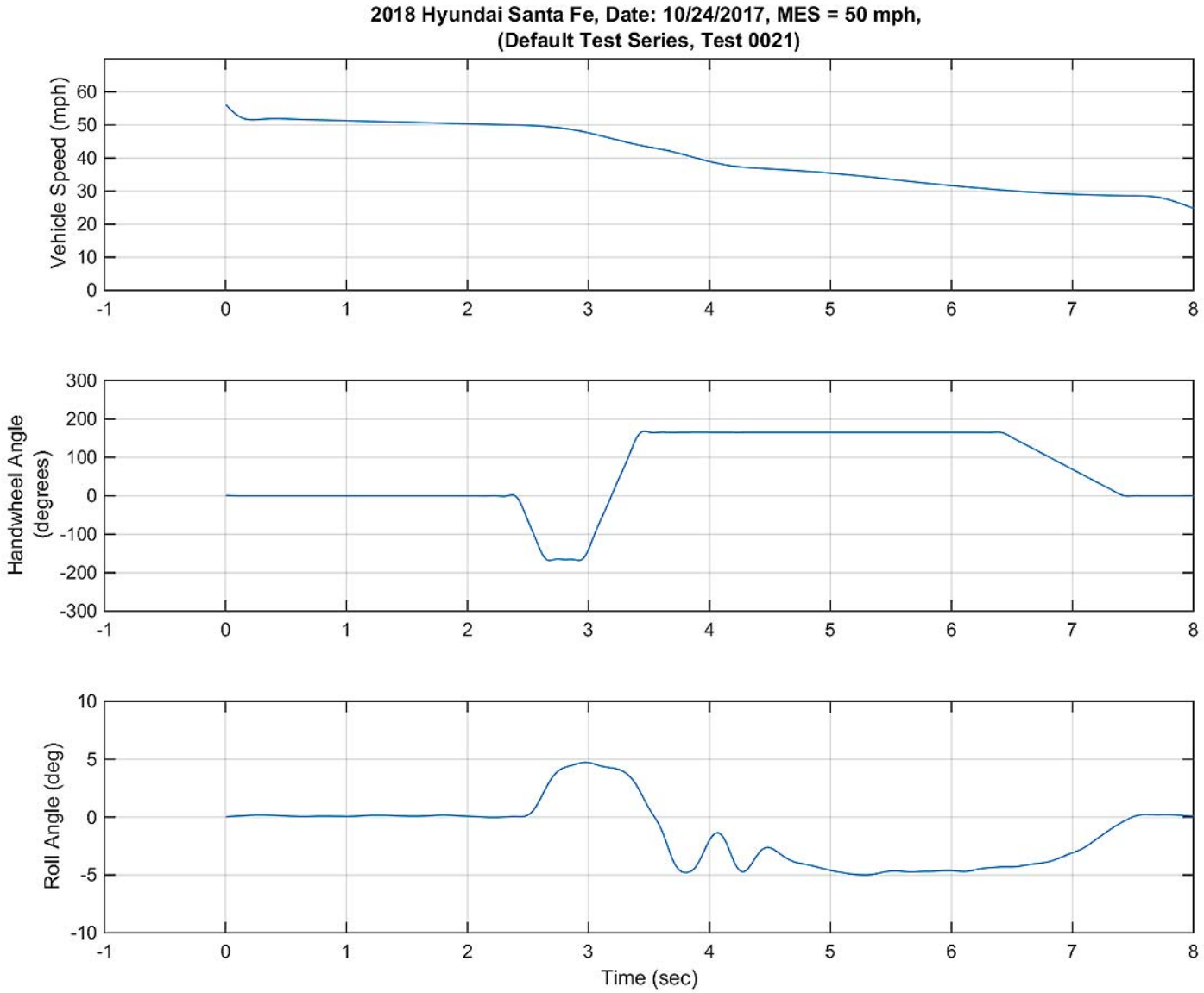

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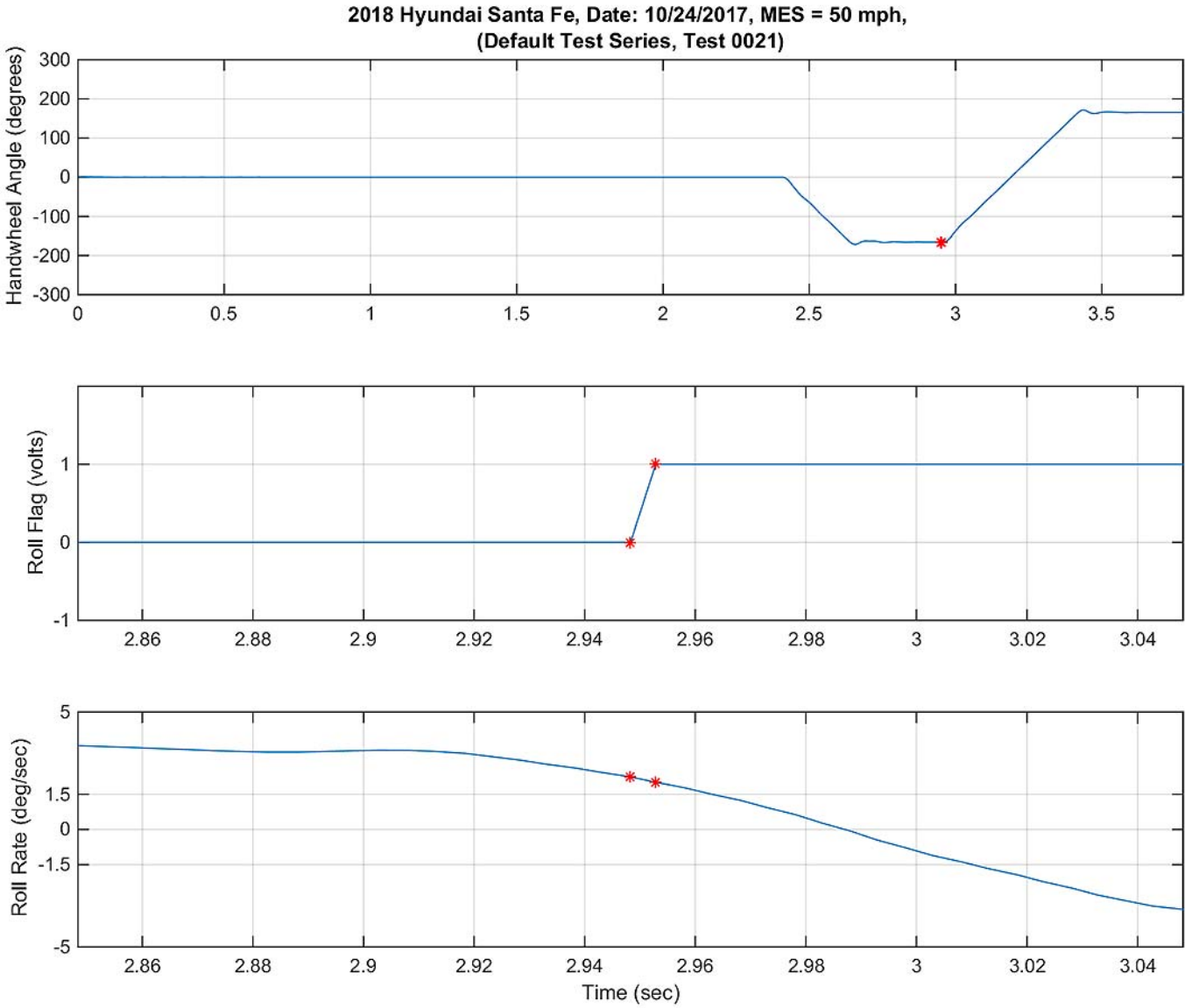

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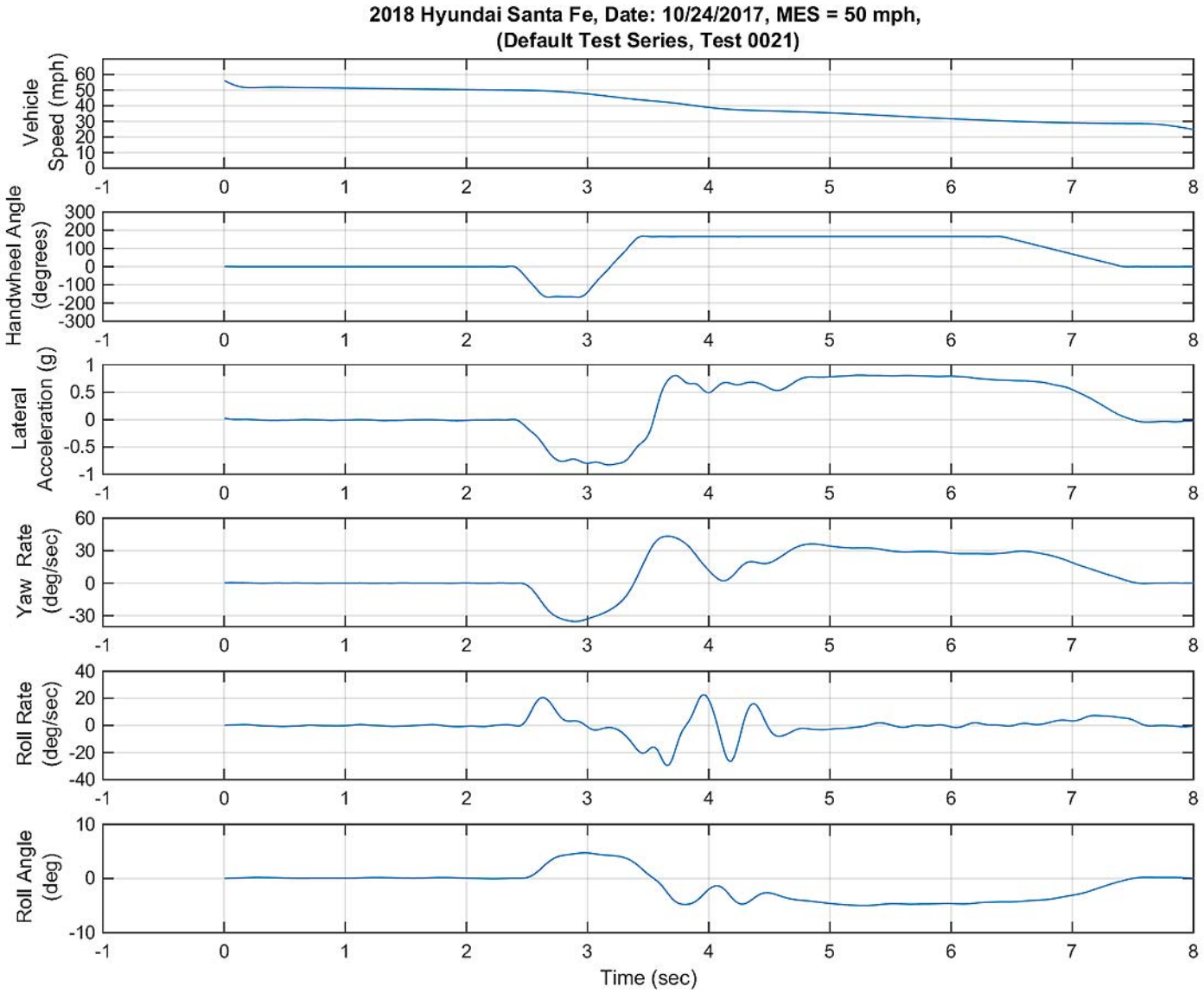

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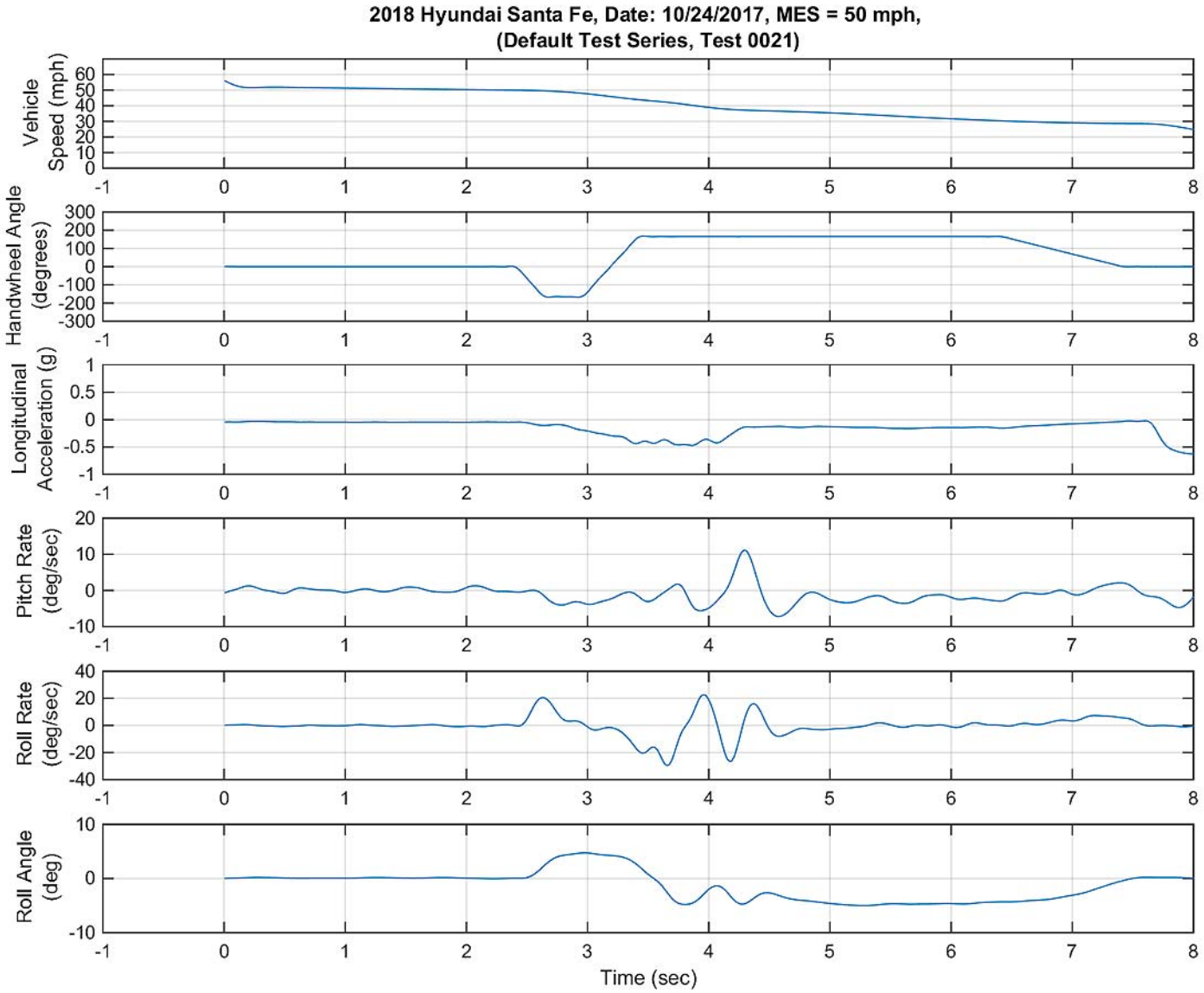

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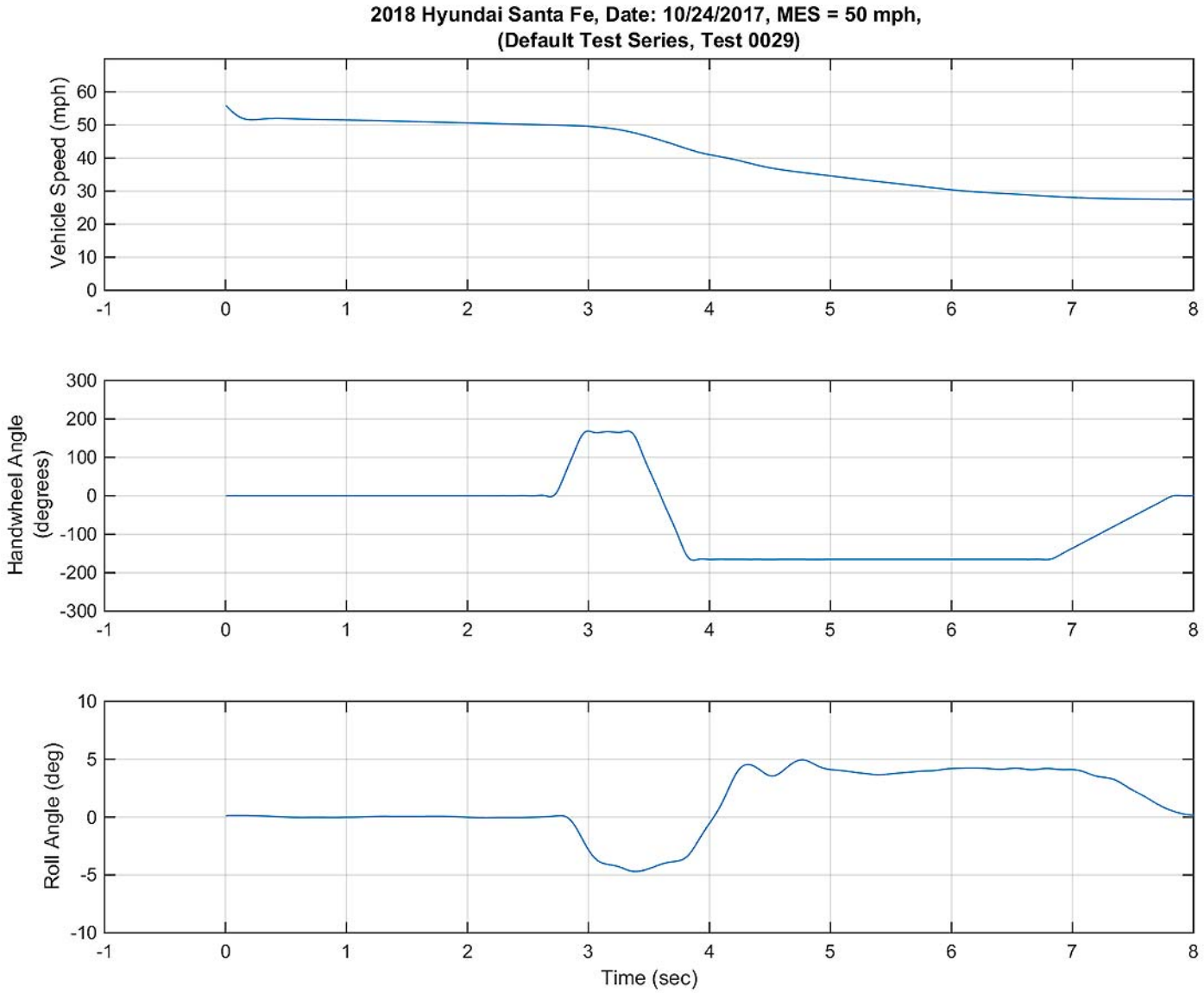

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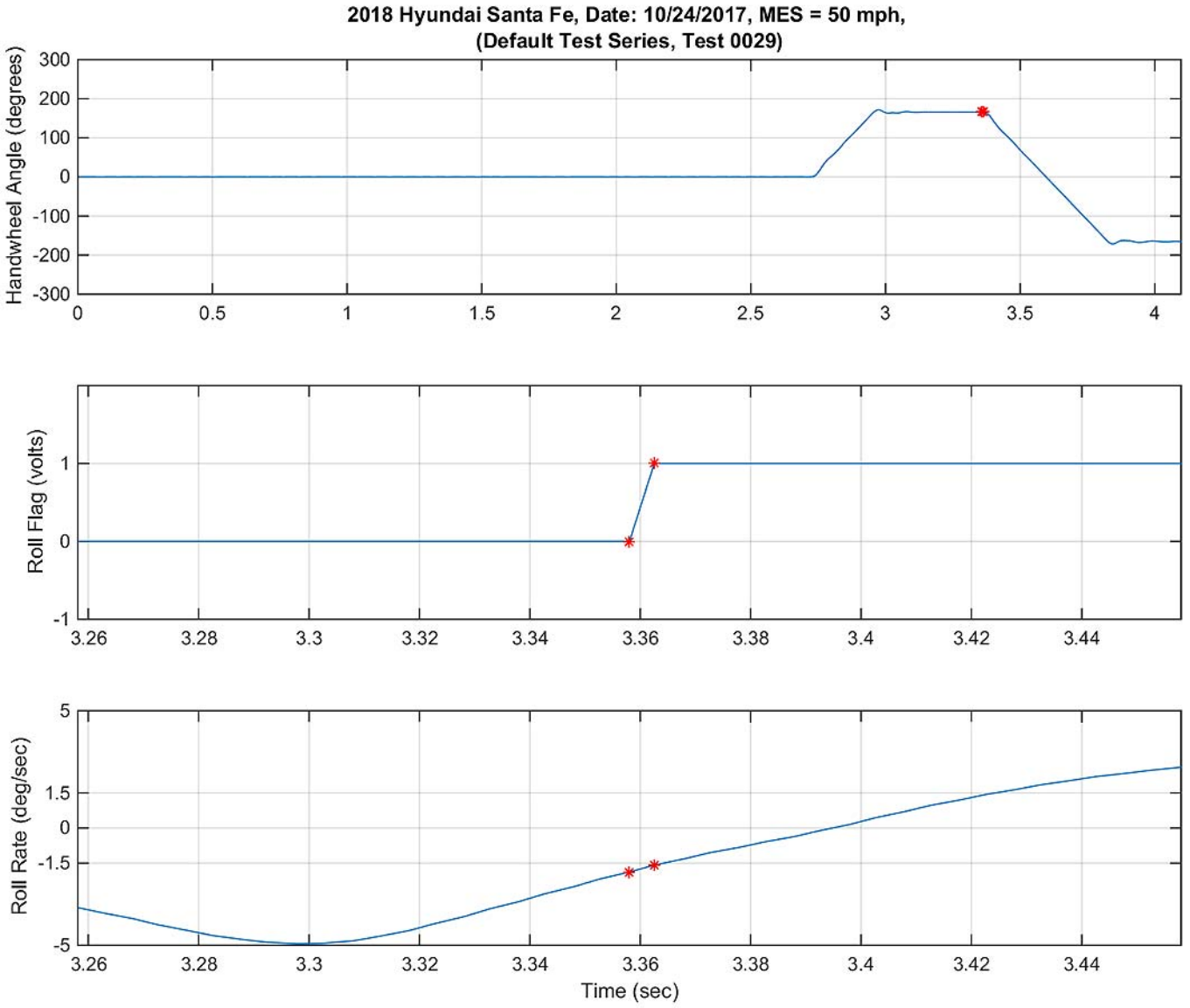

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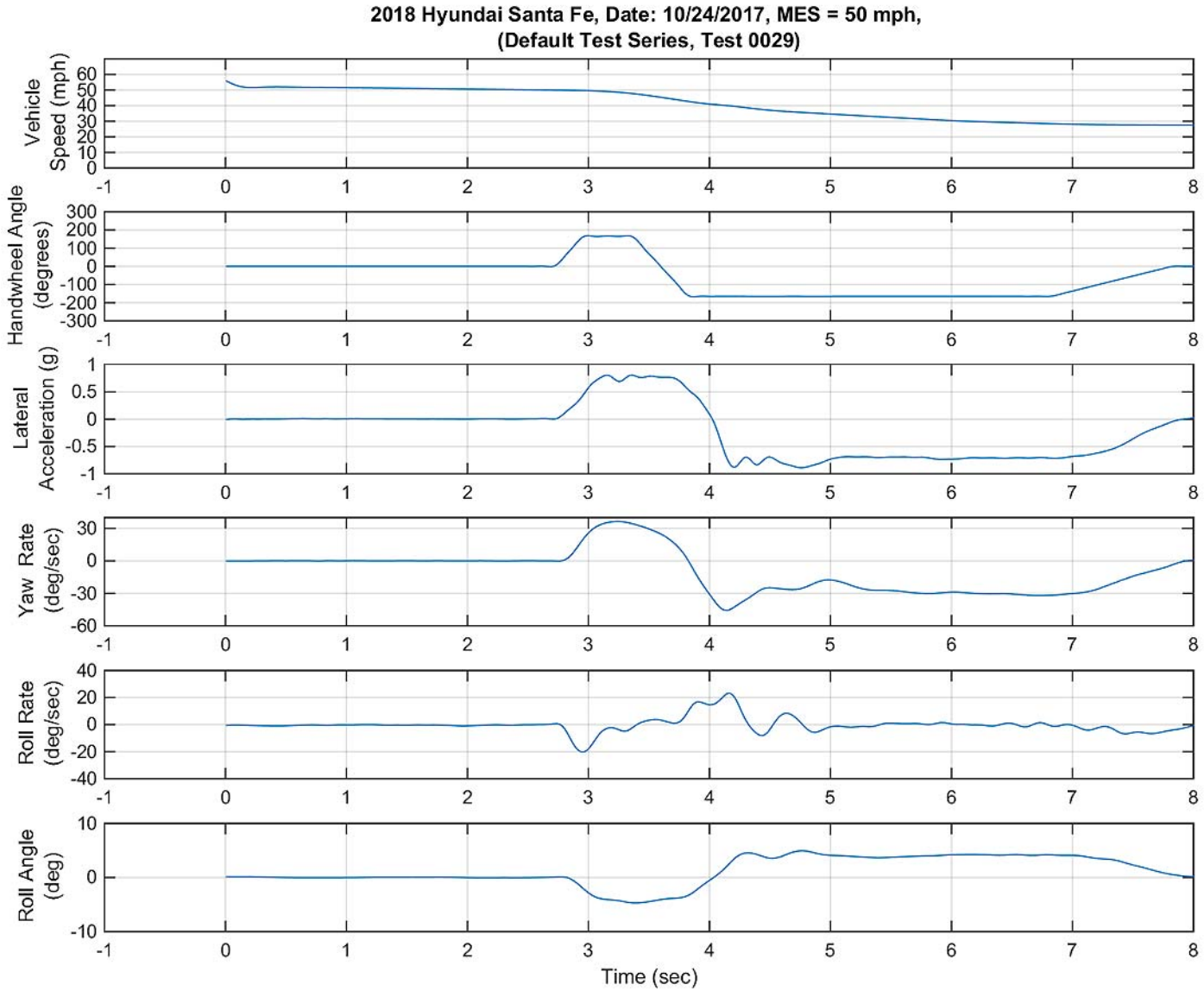

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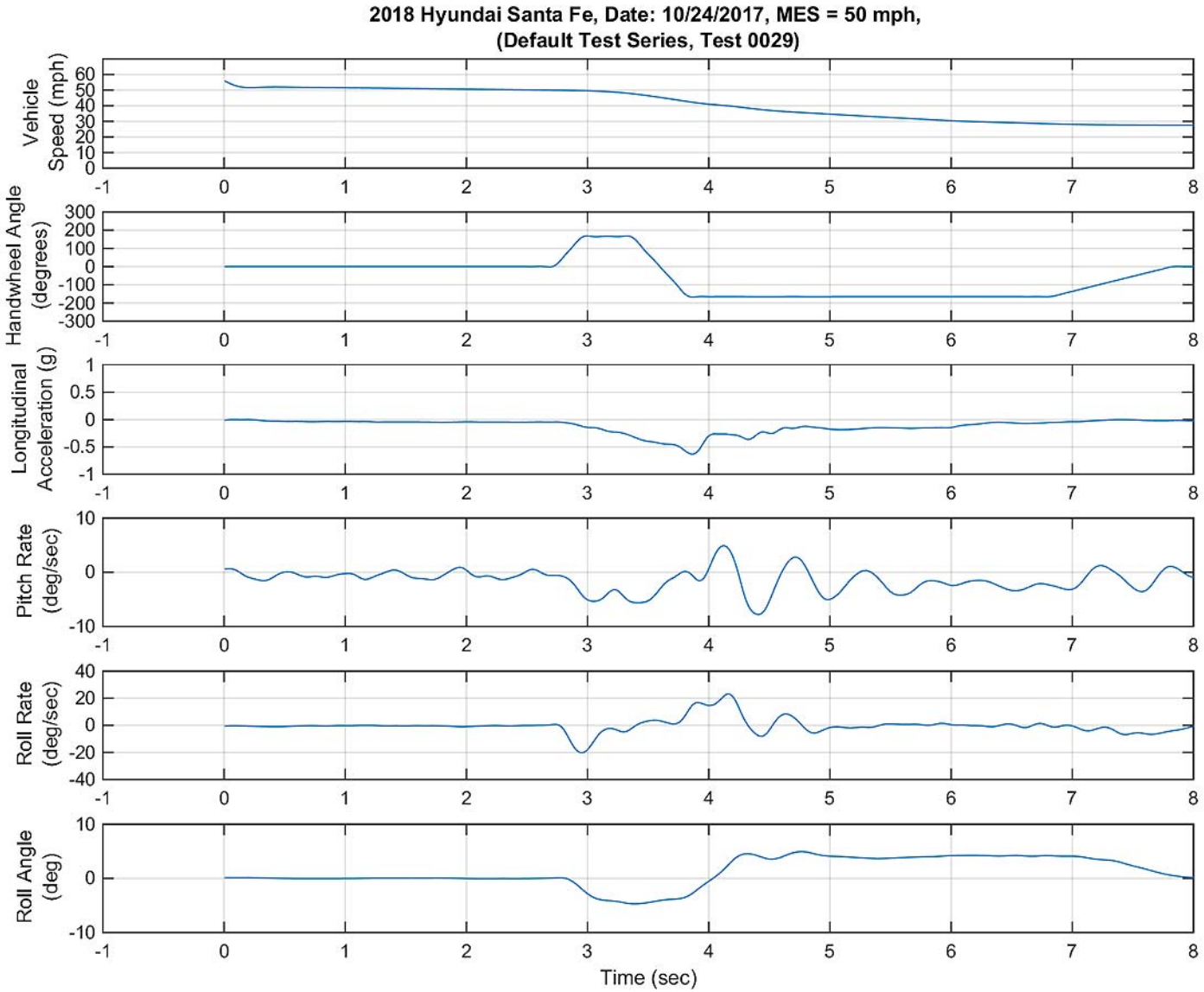

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