

**NEW CAR ASSESSMENT PROGRAM
LANE DEPARTURE WARNING CONFIRMATION TEST
NCAP-DRI-LDW-20-08**

2020 Hyundai Elantra Value Edition

DYNAMIC RESEARCH, INC.

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14 July 2020

Final Report

Prepared Under Contract No. DTNH22-14-D-00333

**U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
New Car Assessment Program
1200 New Jersey Avenue, SE
West Building, 4th Floor (NRM-110)
Washington, DC 20590**

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Date: 14 July 2020

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16. Abstract These tests were conducted on the subject 2020 Hyundai Elantra Value Edition in accordance with the specifications of the New Car Assessment Program's (NCAP) most current Test Procedure in docket NHTSA-2006-26555-0135 to confirm the performance of a Lane Departure Warning system. The vehicle passed the requirements of the test for all three lane marking types and for both directions.			
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Section I

INTRODUCTION

The purpose of the testing reported herein was to confirm the performance of a Lane Departure Warning (LDW) system installed on a 2020 Hyundai Elantra Value Edition. The LDW system for this vehicle provides both visual and audio alerts. The vehicle passed the requirements of the test for all three lane marking types and for both directions.

The test procedure is described in detail in the National Highway Traffic Safety Administration (NHTSA) document "LANE DEPARTURE WARNING SYSTEM CONFIRMATION TEST" dated February of 2013 (Docket No. NHTSA-2006-26555-0135). Its purpose is to confirm the performance of LDW systems installed on light vehicles with gross vehicle weight ratings (GVWR) of up to 10,000 lbs. Current LDW technology relies on sensors to recognize a lane delimiting edge line. As such, the test procedures described in the document rely on painted lines, taped lines, or Botts Dots being present on the test course to emulate those found on public roadways. Although it is impossible to predict what technologies could be used by future LDW systems (e.g., magnetic markers, RADAR reflective striping, ultra violet paint, infrared, etc.), it is believed that minor modifications to these procedures, when deemed appropriate, could be used to accommodate the evaluation of alternative or more advanced LDW systems.

Section II
DATA SHEETS

LANE DEPARTURE WARNING
DATA SHEET 1: TEST RESULTS SUMMARY

(Page 1 of 1)

2020 Hyundai Elantra Value Edition

VIN: 5NPD84LF0LH5xxxx

Test Date: 3/12/2020

Lane Departure Warning setting: Lane Departure On

Test 1 – Continuous White Line Left: Pass Right: Pass

Test 2 – Dashed Yellow Line Left: Pass Right: Pass

Test 3 – Botts Dots Left: Pass Right: Pass

Overall: Pass

Notes:

LANE DEPARTURE WARNING
DATA SHEET 2: VEHICLE DATA

(Page 1 of 1)

2020 Hyundai Elantra Value Edition

TEST VEHICLE INFORMATION

VIN: 5NPD84LF0LH5xxxx

Body Style: Sedan

Color: Lakeside Blue

Date Received: 3/9/2020

Odometer Reading: 25 mi

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: Hyundai Motor Manufacturing Alabama, LLC

Date of manufacture: Sep/24/19

Vehicle Type: Passenger Car

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: 205/55R16

Rear: 205/55R16

Recommended cold tire pressure: Front: 230 kPa (33 psi)

Rear: 230 kPa (33 psi)

TIRES

Tire manufacturer and model: Nexen Npriz AH8

Front tire size: 205/55R16 91H

Rear tire size: 205/55R16 91H

Front tire DOT prefix: UA8X BMHL

Rear tire DOT prefix: UA8X BMHL

LANE DEPARTURE WARNING
DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2020 Hyundai Elantra Value Edition

GENERAL INFORMATION

Test date: 3/12/2020

AMBIENT CONDITIONS

Air temperature: 18.9 C (66 F)

Wind speed: 5.1 m/s (11.5 mph)

- X Wind speed ≤ 10 m/s (22 mph)
- X Tests were not performed during periods of inclement weather. This includes, but is not limited to, rain, snow, hail, fog, smoke, or ash.
- X Tests were conducted during daylight hours with good atmospheric visibility (defined as an absence of fog and the ability to see clearly for more than 5000 meters). The tests were not conducted with the vehicle oriented into the sun during very low sun angle conditions, where the sun is oriented 15 degrees or less from horizontal, and camera "washout" or system inoperability results.

VEHICLE PREPARATION

Verify the following:

All non-consumable fluids at 100% capacity: X

Fuel tank is full: X

Tire pressures are set to manufacturer's recommended cold tire pressure: X

Front: 230 kPa (33 psi)

Rear: 230 kPa (33 psi)

LANE DEPARTURE WARNING
DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2020 Hyundai Elantra Value Edition

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front: 448.1 kg (988 lb)

Right Front: 421.4 kg (929 lb)

Left Rear: 299.4 kg (660 lb)

Right Rear: 273.5 kg (603 lb)

Total: 1442.4 kg (3180 lb)

LANE DEPARTURE WARNING
DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

(Page 1 of 3)

2020 Hyundai Elantra Value Edition

Name of the LDW option, option package, etc.:

Lane Departure Warning (LDW)

Type and location of sensor(s) used:

Mono camera located behind the windshield near the rearview mirror.

Lane Departure Warning Setting used in test: Lane Departure On

How is the Lane Departure Warning presented to the driver? Warning light
(Check all that apply) Buzzer or audible alarm
 Vibration
 Other

Describe the method by which the driver is alerted. For example, if the warning is a light, where is it located, its color, size, words or symbol, does it flash on and off, etc. If it is a sound, describe if it is a constant beep or a repeated beep. If it is a vibration, describe where it is felt (e.g., pedals, steering wheel), the dominant frequency, (and possibly magnitude), the type of warning (light, audible, vibration, or combination), etc.

The driver is alerted with both visual and audio alerts. The visual alert is on the instrument panel and consists of the vehicle and lane lines beside it (Appendix A, Figure A13). The visual lane lines are not illuminated solid until the system recognizes the respective lane. When vehicle departs the lane, the visual lane line blinks off-on-off-on momentarily. The audio alert consists of a quick 3-beep chime from the center console, and activates 2-3 times depending on the lane departure speed.

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

(Page 2 of 3)

2020 Hyundai Elantra Value Edition

Is the vehicle equipped with a switch whose purpose is to render LDW inoperable? Yes
 No

If yes, please provide a full description including the switch location and method of operation, any associated instrument panel indicator, etc.

There is a button on the bottom left of the instrument panel on the driver's side that activates or re-activates the lane departure warning system.

Similarly, the driver can turn the LDW system on and off by using buttons on the right side of the steering wheel to scroll through driver assistance settings. The menu hierarchy for disabling LDW is (Appendix A, Figure A10):

User Settings

Driver Assistance

Lane Safety

Lane Departure Warning

Select "Off"

Is the vehicle equipped with a control whose purpose is to adjust the range setting or otherwise influence the operation of LDW? Yes
 No

If yes, please provide a full description.

LANE DEPARTURE WARNING
DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

(Page 3 of 3)

2020 Hyundai Elantra Value Edition

Are there other driving modes or conditions that Yes
render LDW inoperable or reduce its effectiveness? No

If yes, please provide a full description.

Limitations of the system are described in the Owner's Manual, pages 5-106 through 5-107. These pages are reproduced in Appendix B, pages, B-16 through B-17.

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Each LDW test involved one of three lane marking types: solid white lines, dashed yellow lines, or Botts Dots. Lane departures were done both to the left and to the right, and each test condition was repeated five times, as shown in Table 1.

Table 1. LDW Test Matrix

Lane Geometry	Line Type	Departure Direction	Number of Trials
Straight	Solid	L	5
		R	5
	Dashed	L	5
		R	5
	Botts Dots	L	5
		R	5

Prior to the start of a test series involving a given lane marking type and departure direction combination, the accuracy of the distance to lane marking measurement was verified. This was accomplished by driving the vehicle to the approximate location at which the lane departure would occur and placing the tire at the lane marking edge of interest (i.e., distance to lane marking = 0). The real-time display of distance to the lane marking was then observed to verify that the measured distance was within the tolerance (5 cm). If the measured distance was found to be greater than the tolerance, the instrumentation setup was checked and corrected, if necessary. If the measured distance was found to be within the tolerance, the instrumentation setup was considered appropriate and the test series was begun.

To begin the maneuver, the vehicle was accelerated from rest to a test speed of 72.4 km/h (45 mph), while being driven in a straight line parallel to the lane marking of interest, with the centerline of the vehicle approximately 1.83 m (6.0 ft) from the lane edge (i.e., such that the vehicle would pass through the center of the start gate). The test speed was achieved at least 60 m (200 ft) before the start gate was reached. Striking any start gate cones was not permitted, and any run in which a cone was struck was considered to be invalid. Also, during the initialization and test phases, the test driver avoided using turn signals and avoided applying any sudden acceleration, sudden steering, or sudden braking, and any use of the turn signals, sudden acceleration, sudden steering, or sudden braking invalidated the test trial.

Data collection began with the vehicle at least 60 m (200 ft) from the start gate, which was configured using a pair of non-reflective, low-contrast color traffic cones. A second set of cones, placed 6 m (20 ft) longitudinally before the start gate, was used to guide the driver into the start gate. The lateral width between the cone pairs was 20 cm (8 in) greater than the width of the vehicle, and the centerline of each pair was laterally offset from the lane marking by 1.8 m (6 ft).

Once the driver passed the gate, the driver manually input sufficient steering to achieve a lane departure with a target lateral velocity of 0.5 m/s with respect to the lane line. As shown in Figure 1, two additional non-reflective cones were used to guide the driver in making this steering maneuver. Throughout the maneuver, the driver modulated the throttle or used cruise control, as appropriate, such that vehicle speed remained at constant speed. The test was considered complete when the vehicle crossed at least 1 m (3.3 ft) over the lane edge boundary.

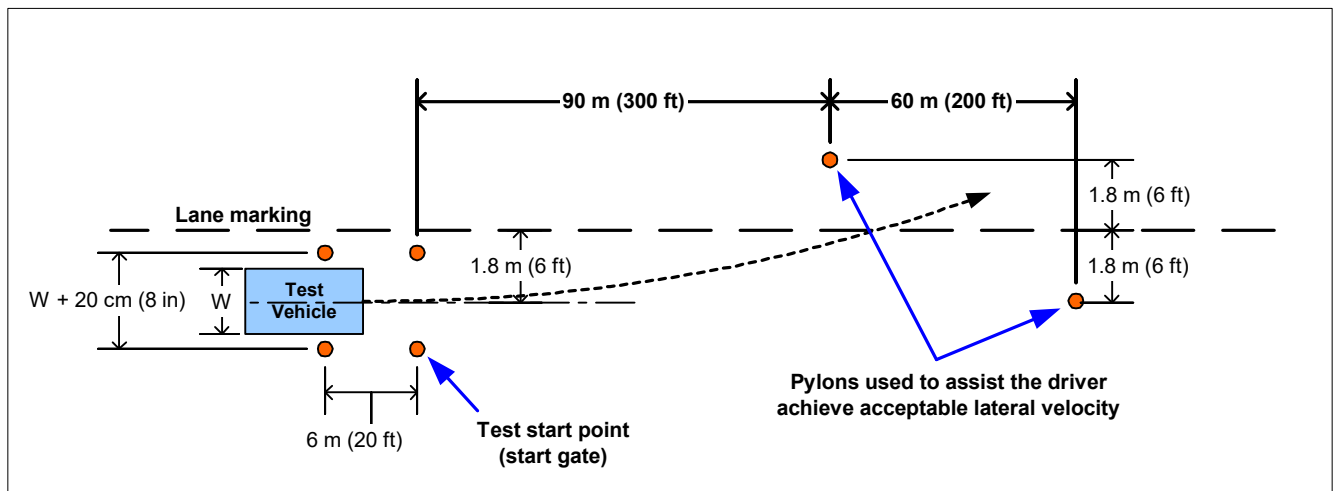


Figure 1. Position of Cones Used to Assist Driver

Data collected included vehicle speed, position, and yaw rate. In addition to cone strikes, vehicle speed and yaw rate data were used to identify invalid runs as described in Section C below. Data from trials where speed or yaw rate were outside of the performance specification were not considered valid.

B. Lane Delineation Markings

The New Car Assessment Program’s Test Procedure for the confirmation of a Lane Departure Warning system contains a requirement that all lane markings meet United States Department of Transportation (USDOT) specifications as described in the Manual on Uniform Traffic Control Devices (MUTCD) and be considered in “very good condition”.

1. Lane Marker Width

The width of the edge line marker was 10 to 15 cm (4 to 6 in). This is considered to be a normal width for longitudinal pavement markings under Section 3A.05 of the MUTCD.

2. Line Marking Color and Reflectivity

Lane marker color and reflectivity met all applicable standards. These standards include those from the International Commission of Illumination (CIE) for color and the American Society for Testing and Materials (ASTM) on lane marker reflectance.

3. Line Styles

The tests described in this document required the use of three lane line configurations: continuous solid white, discontinuous dashed yellow, and discontinuous with raised pavement markers.

- Continuous White Line

A continuous white line is defined as a white line that runs for the entire length of the test course.

- Dashed Yellow Line

As stated in the MUTCD, and as shown in Figure 2, a discontinuous dashed yellow line is defined as by a series of 3 m (10 ft) broken (dashed) yellow line segments, spaced 9.1 m (30 ft) apart.

- Raised Pavement Marker Line (Botts Dots)

California Standard Plans indicates raised pavement markers are commonly used in lieu of painted strips for marking roads in California. Other states, mainly in the southern part of the United States, rely on them as well. These markers may be white or yellow, depending on the specific application, following the same basic colors of their analogous white and yellow painted lines. Following the California 2006 Standard Plans, three types of raised pavement markings are used to form roadway lines. It is believed that these types of roadway markings are the hardest for an LDW sensor system to process. Type A and Type AY are non-reflective circular domes that are approximately 10 cm (4 in) in diameter and approximately 1.8 cm (0.7 in) high. Type C and D are square markings that are retro reflective in two directions measuring approximately 10 x 10 x 5 cm (4 x 4 x 0.5 in), and Type G and H that are the same as C and D only retro reflective in a single direction.

For the tests described in this document, raised pavement markers were set up following California Standard Plan A20A, Detail 4, as shown in Figure 3. Note that in this figure, the squares are Type D yellow reflectors and the circles are yellow Type AY discs.

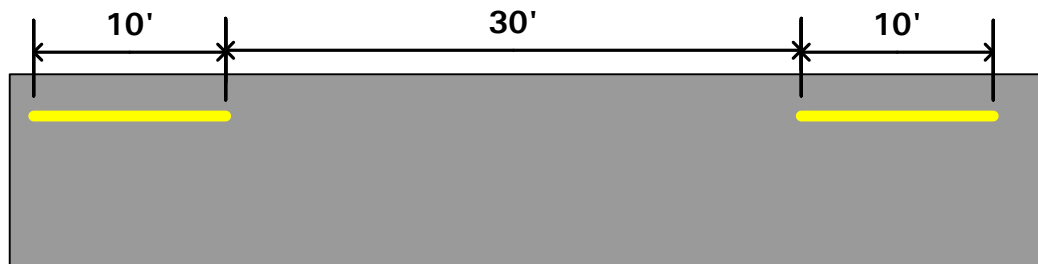


Figure 2. MUTCD Discontinuous Dashed Line Specifications

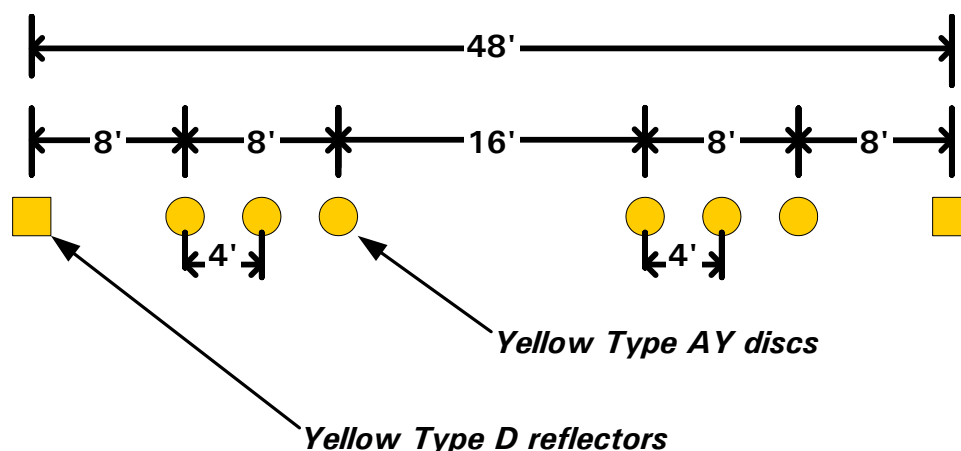


Figure 3. California Standard Plan A20A, Detail 4

C. Test Validity

1. Speed

All LDW tests were conducted at 72.4 km/h (45 mph). Test speed was monitored and a test was considered valid if the test speed remained within ± 2 km/h (± 1.2 mph) of the 72.4 km/h (45 mph) target speed. It was required that the speed must remain within this window from the start of the test until any part of the vehicle crossed a lane line by 1 m (3.3 ft) or more.

2. Lateral Velocity

All tests were conducted with a lateral velocity of 0.1 to 0.6 m/s (0.3 to 2.0 ft/s), measured with respect to the lane line at the time of the alert. To assist the test driver in being able to efficiently establish the target lateral velocity, cones were positioned in the manner shown in Figure 1.

3. Yaw Rate

It was required that the magnitude of the vehicle's yaw rate could not exceed 1.0 deg/sec at any time during lane departure maneuver, from the time the vehicle passes through the start gate to the instant the vehicle has crossed a lane line by 1 m (3.3 ft).

D. Pass/Fail Criteria

The measured test data were used to determine the pass/fail outcome for each trial. The outcome was based on whether the LDW produced an appropriate alert during the maneuver. In the context of this test procedure, a lane departure is said to occur when any part of the two-dimensional polygon used to represent the test vehicle breaches the inboard lane line edge (i.e., the edge of the line close to the vehicle before the departure occurs). In the case of tests performed in this procedure, the front corner of the polygon, defined as the intersection of the center of the front wheels (longitudinally) with the outboard edge of the front tire (laterally), crossed the line edge first. So, for example, if the vehicle departed its lane to the left, the left front corner of the polygon would first breach the lane line edge.

For an individual trial to be considered a "pass":

- Test speed, lateral velocity, and yaw rate validity conditions must be satisfied.
- The LDW alert must not occur when the lateral position of the vehicle is greater than 0.75 m (2.5 ft) from the lane line edge (i.e., prior to the lane departure).
- The LDW alert must occur before the lane departure exceeds 0.3 m (1.0 ft).

For an overall, "Pass" the LDW system must satisfy the pass criteria for 3 of 5 individual trials for each combination of departure direction and lane line type (60%), and pass 20 of the 30 trials overall (66%).

E. Instrumentation

Table 2 lists the sensors, signal conditioning, and data acquisition equipment used for these tests.

Table 2. Test Instrumentation and Equipment

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	0.5 psi 3.45 kPa	Ashcroft, D1005PS	17042707002	By: DRI Date: 7/3/2019 Due: 7/3/2020
Platform Scales	Vehicle Total, Wheel, and Axle Load	8000 lb 35.6 kN	±1.0% of applied load	Intercomp, SWII	1110M206352	By: DRI Date: 1/6/2020 Due: 1/6/2021
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	NA
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots Accel: ±100 m/s ² Angular Rate: ±100 deg/s Angular Disp: ±180 deg	Position: ±2 cm Velocity: 0.05 km/h Accel: ≤ 0.01% of full range Angular Rate: ≤ 0.01% of full range Roll/Pitch Angle: ±0.03 deg Heading Angle: ±0.1 deg	Oxford Technical Solutions (OXTS), Inertial+	2258	By: Oxford Technical Solutions ¹ Date: 5/3/2019 Due: 5/3/2021
Real-Time Calculation of Position and Velocity Relative to Lane Markings	Distance and velocity to lane markings	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	NA

¹ Oxford Technical Solutions recommends calibration every two years.

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	NA	NA
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	NA	NA
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2020 Due: 1/6/2021
Type	Description			Mfr, Model	Serial Number	
Data Acquisition System	Data acquisition is achieved using a dSPACE MicroAutoBox II 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 MicroAutoBox. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (listed above).			D-Space Micro-Autobox II 1401/1513		
				Base Board	549068	
				I/O Board	588523	

For systems that implement audible or haptic alerts, part of the pre-test instrumentation verification process is to determine the tonal frequency of the audible warning or the vibration frequency of the tactile warning through use of the PSD (Power Spectral Density) function in Matlab. This is accomplished in order to identify the center frequency around which a band-pass filter is applied to subsequent audible or tactile warning data so that the beginning of such warnings can be programmatically determined. The band-pass filter used for these warning signal types is a phaseless, forward-reverse pass, elliptical (Cauer) digital filter, with filter parameters as listed in Table 3.

Table 3. Audible and Tactile Warning Filter Parameters

Warning Type	Filter Order	Peak-to-Peak Ripple	Minimum Stop Band Attenuation	Passband Frequency Range
Audible	5 th	3 dB	60 dB	Identified Center Frequency \pm 5%
Tactile	5 th	3 dB	60 dB	Identified Center Frequency \pm 20%

APPENDIX A

Photographs

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Figure A1. Front View of Subject Vehicle
A-3



Figure A2. Rear View of Subject Vehicle



2020 ELANTRA VALUE EDITION

SOLD TO: SHIPPED TO:

VIN: 5NPD84LF0LH54
 MODEL: 484BCF4P
 ENGINE: G4NHKK025096
 PORT OF ENTRY: MA
 EXTERIOR COLOR: LAKESIDE BLUE
 INTERIOR/SEAT COLOR: GRAY/GRAY
 TRANSPORT: TRUCK
 ACCESSORY WEIGHT: 12 lbs. / 6 kgs.
 EMISSIONS: This vehicle meets California Emissions regulations and is Certified as a Super Ultra Low Emission Vehicle (SULEV)

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.	
▲ Safety Concern: Visit www.safercar.gov or call 1-888-327-4236 for more details.	
Frontal	Driver ★ ★ ★ ★ ★
Crash	Passenger ★ ★ ★ ★ ★
Based on the risk of injury in a frontal impact. Should ONLY be compared to other vehicles of similar size and weight.	
Side	Front seat ★ ★ ★ ★ ★
Crash	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

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

ADVANCED SAFETY TECHNOLOGY
 Forward Collision-Avoidance Assist
 Lane Keep Assist & Driver Attention Warning
 Blind-Spot Collision Warning
 Rear Cross-Traffic Collision Warning
 Front, Front Side Impact, Side Curtain & Driver Knee Airbags
 Electronic Stability Control (ESC) w/ Traction Control
 ABS w/ Electronic Brake Force Distribution & Brake Assist

POWERTRAIN TECHNOLOGY
 2.0L 147 HP, 132 lbs-ft Torque, DOHC 4-Cylinder
 Dual Continuous Variable Valve Timing
 Smartstream Intelligent Variable Transmission
 4-Wheel Disc Brakes

EXTERIOR
 16-Inch Alloy Wheels with 205/55 R16 Tires
 Power Sunroof
 Heated Outside Mirrors & Door Handle Approach Lights

COMFORT & CONVENIENCE
 7" Display Audio System w/ AM/FM/HD Radio® & 8 Speakers
 SiriusXM® Radio w/90 Day Trial. Not Available in AK & HI
 Android Auto (TM) & Apple CarPlay (TM)
 Blue Link® Connected Services 3-years Standard (enrollment req)
 Blue Link Remote Start (3-year Complimentary Service)
 Dual Automatic Temperature Control w/ Auto Defogger
 Bluetooth® Hands-free Phone System
 Steering Wheel Mounted Audio & Cruise Controls
 Leather-wrapped Steering Wheel & Shift Knob
 Auto Headlamp Control & 3.5" TFT Mono Cluster Display
 Heated Front Seats
 Auto-up Driver Window & Illuminated Vanity Mirrors
 Rearview Camera w/ Dynamic Guidelines
 Hands-free Smart Trunk Release
 Proximity Key w/ Push Button Start & Immobilizer
 Temporary Compact Spare Tire
 Full Tank of Gas

Manufacturer's Suggested Retail Price:	\$20,600.00
ADDED FEATURES:	
*Carpeted Floor Mats	\$135.00
*Cargo Net	\$50.00
*Cargo Tray	\$115.00
*Rear Bumper Applique	\$70.00

Inland Freight & Handling : \$930.00
Total Price : \$21,900.00

A bold sedan that's big on features and safety
 New Intelligent Variable Transmission



EPA DOT Fuel Economy and Environment

Fuel Economy

34 MPG
 combined city/hwy

30 40
 city highway

2.9 gallons per 100 miles

Midsize Cars range from 12 to 136 MPG. The best vehicle rates 136 MPGe.

You save
\$1,500
 in fuel costs
 over 5 years
 compared to the
 average new vehicle.

Annual fuel cost
\$1,200



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 \$7,500 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at \$ 2.70 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



Manufacturer's suggested retail price includes manufacturer'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: 35 %
 MEXICO: 20 %

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: MEXICO



Figure A3. Window Sticker (Monroney Label)



MANUFACTURED BY
HYUNDAI MOTOR MANUFACTURING ALABAMA, LLC

Sep/24/19

GVWR 3924 lbs

PAINT VU

GAWR
FRONT 2183 lbs

GAWR
REAR 2094 lbs

TRIM PK

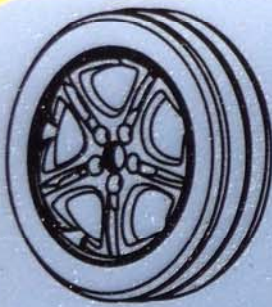
THIS VEHICLE CONFORMS TO ALL APPLICABLE U.S.A. FEDERAL
MOTOR VEHICLE SAFETY, BUMPER, AND THEFT PREVENTION STANDARDS
IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE

V.I.N 5NPD84LF0LH54

PASSENGER CAR



Figure A4. Vehicle Certification Label



TIRE AND LOADING INFORMATION RENSEIGNEMENTS SUR LES PNEUS ET LE CHARGEMENT

SEATING CAPACITY
NOMBRE DE PLACES

TOTAL 5

FRONT
AVANT 2

REAR
ARRIÈRE 3

The combined weight of occupants and cargo should never exceed 385 kg or 849 lbs.
Le poids total des occupants et du chargement ne doit jamais dépasser 385 kg ou 849 lb.

TIRE PNEU	SIZE DIMENSIONS	COLD TIRE PRESSURE PRESSION DES PNEUS À FROID
FRONT AVANT	205/55R16	230kPa, 33psi
REAR ARRIÈRE	205/55R16	230kPa, 33psi
SPARE DE SECOURS	T125/80D15	420kPa, 60psi

**SEE OWNER'S
MANUAL FOR
ADDITIONAL
INFORMATION**
**VOIR LE MANUEL
DE L'USAGER
POUR PLUS DE
RENSEIGNEMENTS**

E620

Figure A5. Tire Placard



Figure A6. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle



Figure A7. Sensor for Detecting Visual Alerts



Figure A8. Sensor for Detecting Auditory Alerts



Figure A9. Computer Installed in Test Vehicle



Figure A10. LDW Menus



Figure A11. Controls for Interacting with Settings Menus



Figure A12. LDW On/Off Switch

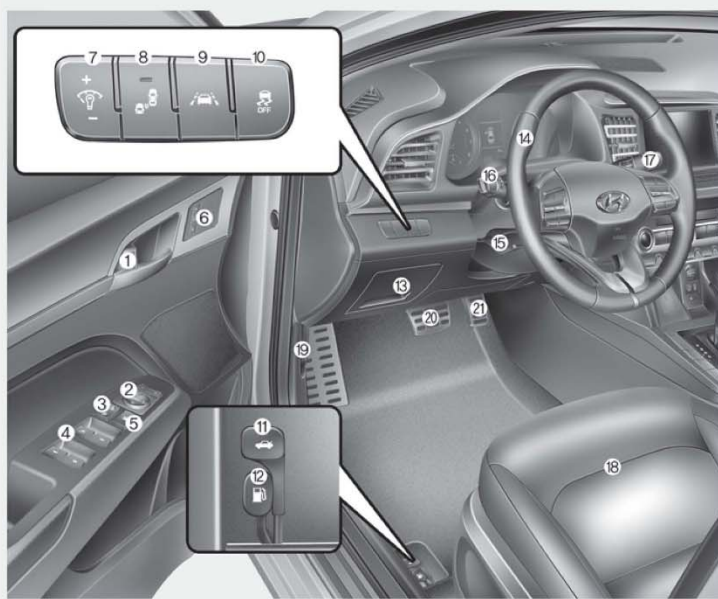


Figure A13. LDW Visual Alert

APPENDIX B

Excerpts from Owner's Manual

INTERIOR OVERVIEW



The actual shape may differ from the illustration.

- 1. Door lock/unlock button3-13
- 2. Side view mirror control switch3-32
- 3. Central door lock switch3-14
- 4. Power window switches3-35
- 5. Power window lock switch.....3-38
- 6. Driver position memory system3-18
- 7. Instrument panel illumination control switch3-53
- 8. Blind-spot Collision Warning (BCW) system.....5-54
- 9. Lane Keeping Assist (LKA) system5-100
- 10. ESC (Electronic Stability Control) OFF button5-44
- 11. Trunk lid release lever3-45
- 12. Fuel filler door release lever3-49
- 13. Fuse panel7-54
- 14. Steering wheel3-21
- 15. Steering wheel tilt/telescopic lever3-22
- 16. Light control/Turn signals3-99
- 17. Wiper/Washer3-110
- 18. Seat.....2-4
- 19. Hood release lever3-43
- 20. Brake pedal.....5-39
- 21. Accelerator pedal

* : if equipped

OAD018003N

Forward Collision Avoidance Assist Warning Light (if equipped)



This warning light illuminates :

- When you set the ignition switch or Engine Start/Stop button to the ON position.
 - It illuminates for approximately 3 seconds and then goes off.
- When there is a malfunction with FCA. In this case, have your vehicle inspected by an authorized dealer of HYUNDAI.

For more details, refer to "Forward Collision-Avoidance Assist (FCA) system" in chapter 5.

Lane Keeping Assist (LKA) System Indicator Light (if equipped)



This indicator light illuminates:

- [Green] When the system operating conditions are satisfied.
- [White] The system operating conditions are not satisfied.
- [Yellow] When there is a malfunction with the lane keeping assist system.
 - If this occurs, have your vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Lane Keeping Assist (LKA) system" in chapter 5.

Headlight Warning Light (if equipped)



This warning light illuminates:

This warning light illuminates if one of the exterior bulbs (headlamp, DRL, turn signal lamp, stop lamp, etc.) is not operating properly. One of the bulbs may need to be replaced. If the vehicle is equipped with LED headlamps, have the vehicle inspected by an authorized HYUNDAI dealer.

i Information

When replacing the bulb, use the same wattage bulb.

For more details, refer to "BULB WATTAGE" in chapter 8.

LED Headlight Warning Light (if equipped)



This warning light illuminates:

- When you set the ignition switch or the Engine Start/Stop button to the ON position.
- When there is a malfunction with the LED headlight.
If this occurs, have the vehicle inspected by an authorized HYUNDAI dealer.

This warning light blinks:

When there is a malfunction with a LED headlight related part.
If this occurs, have the vehicle inspected by an authorized HYUNDAI dealer.

NOTICE

Continuous driving with the LED Headlight Warning Light on or blinking can reduce LED headlight life.

Master Warning Light



This indicator light illuminates

- When there is a malfunction in operation in any of the following systems:
 - Exterior lamp malfunction
 - Blind-Spot Collision Warning (BCW) malfunction (if equipped)
 - Lane Keeping Assist (LKA) System malfunction (if equipped)
 - Tire Pressure Monitoring System (TPMS)
 - Service reminder

To identify the details of the warning, look at the LCD display.

Door Ajar Warning Light (for conventional cluster)



This warning light illuminates:

- When a door is not closed securely.

Trunk Open Warning Light (for conventional cluster)



This warning light illuminates:

- When the trunk is not closed securely.

Hood Open Warning Light (for conventional cluster)



This warning light illuminates:

- When the hood is not closed securely.

Check High Beam Assist (HBA) system (if equipped)

This warning message is displayed if there is a problem with the High Beam Assist (HBA) system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "High Beam Assist (HBA) system" in chapter 3.

Check Forward Collision Avoidance Assist system (if equipped)

This warning message is displayed if there is a problem with the Forward Collision-Avoidance Assist (FCA) system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Forward Collision-Avoidance Assist (FCA) system" in chapter 5.

Check Blind-Spot Collision Warning (BCW) system (if equipped)

This warning message is displayed if there is a problem with the Blind-Spot Collision Warning system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Blind-Spot Collision Warning or Rear Cross-Traffic Collision Warning (RCCW) System" in chapter 5.

Check Smart Cruise Control System (if equipped)

This warning message is displayed if there is a problem with the Smart Cruise Control system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Smart Cruise Control" in chapter 5.

Check Driver Attention Warning (DAW) system (if equipped)

This warning message is displayed if there is a problem with the Driver Attention Warning (DAW). Have the vehicle inspected by an authorized HYUNDAI dealer.

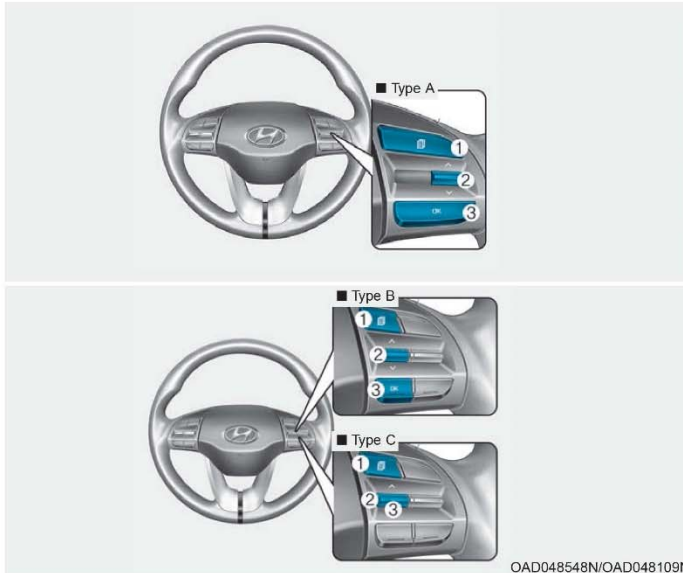
For more details, refer to "Driver Attention Warning (DAW)" in chapter 5.

Check Lane Keeping Assist (LKA) system (if equipped)


This warning message is displayed if there is a problem with the Check Lane Keeping Assist (LKA) system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Check Lane Keeping Assist (LKA) system" in chapter 5.

LCD DISPLAY (FOR SUPERVISION CLUSTER) LCD Display Control








The LCD display modes can be changed by using the control buttons on the steering wheel.

- (1)  : MODE button for changing modes
- (2) ▲, ▼ : MOVE switch for changing items
- (3) OK : SELECT/RESET button for setting or resetting the selected item

3

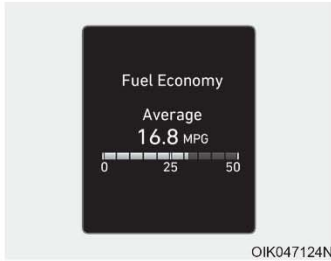
Convenient features of your vehicle

LCD Display Modes

Modes	Symbol	Description
Trip Computer		This mode displays information related to driving such as tripmeter, fuel economy, etc. For more details, refer to "Trip Computer" in this chapter.
Turn By Turn (TBT) (if equipped)		This mode displays the state of the navigation.
Assist (If equipped)		The Driver Assist mode displays the status of the following features: <ul style="list-style-type: none"> - Smart Cruise Control (SCC) system - Lane Keeping Assist (LKA) system - Driver Attention Warning (DAW) system - Tire pressure For more details, refer to "Smart Cruise Control", "Lane Keeping Assist (LKA) system", "Driver Attention Warning (DAW) system" in chapter 5 and "Tire Pressure Monitoring System (TPMS)" in chapter 6.
User Settings		In this mode, you can change settings of the doors, lamps, etc.
Master Warning		The Master Warning mode displays warning messages related to the vehicle when one or more systems is not operating normally.

The information provided may differ depending on which functions are applicable to your vehicle.

Trip computer mode



OIK047124N

The trip computer mode displays information related to vehicle driving parameters including range, fuel economy, trip meter information and vehicle speed.

For more details, refer to "Trip Computer" in this chapter.

Turn By Turn (TBT) mode



OIK047147N

This mode displays the state of the navigation.

Assist mode



OAD048535N

SCC/LKA/DAW

This mode displays the state of the Smart Cruise Control (SCC), Lane Keeping Assist (LKA) and Driver Attention Warning (DAW).

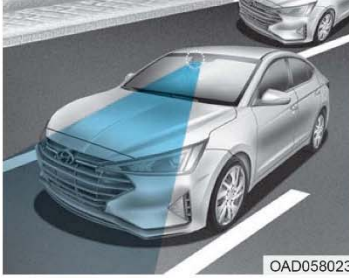
For more details, refer to each system information in chapter 5.

Driver Assistance

Items	Explanation
Lane safety	To adjust the Lane Keeping Assist (LKA) function. - Active LKA - Lane Keeping Assist - Lane Departure Warning For more details, refer to the "Lane Keeping Assist (LKA) system" in chapter 5.
Blind-Spot Safety	<ul style="list-style-type: none"> • Safe Exit Assist (SEA) To activate or deactivate the Safe Exit Assist (SEA) function. For more details, refer to "Safe Exit Assist" in this chapter.
	<ul style="list-style-type: none"> • Rear Cross-Traffic Safety To activate or deactivate the Rear Cross-Traffic Safety function. For more details, refer to "Blind-Spot Collision Warning" in chapter 5.
	<ul style="list-style-type: none"> • Warning Only: If selected, the system provides a warning when a collision is detected. • Off: Deactivates the system. For more details, refer to the "Blind-Spot Collision Warning" in chapter 5.

* The information provided may differ depending on which functions are applicable to your vehicle.

LANE KEEPING ASSIST (LKA) SYSTEM (IF EQUIPPED)



OAD058023

The Lane Keeping Assist (LKA) system helps detect lane markers on the road with a front view camera at the front windshield, and assists the driver's steering to help keep the vehicle between lanes.

When the system detects the vehicle straying from its lane, it alerts the driver with a visual and audible warning, while applying a counter-steering torque, to try to prevent the vehicle from moving out of its lane.

⚠ WARNING

The Lane Keeping Assist (LKA) system is not a substitute for safe driving practices, but a convenience function only. It is the responsibility of the driver to always be aware of the surroundings and steer the vehicle.

⚠ WARNING

Take the following precautions when using the Lane Keeping Assist (LKA) system:

- Do not turn the steering wheel suddenly when the steering wheel is being assisted by the system.
- LKA system helps to prevent the driver from moving out of the lane unintentionally by assisting the driver's steering. However, the driver should not solely rely on the system but always pay attention on the steering wheel to stay in the lane.

- The operation of the LKA system can be canceled or not work properly according to road condition and surroundings. Always be cautious when driving.
- Do not disassemble the LKA system camera temporarily to tint the window or attach any types of coatings and accessories. If you disassemble the camera and assemble it again, take your vehicle to an authorized HYUNDAI dealer and have the system checked for calibration.
- When you replace the windshield glass, LKA system camera or related parts of the steering wheel, take your vehicle to an authorized HYUNDAI dealer and have the system checked for calibration.

- The system helps detect lane markers and controls the steering wheel by a camera, therefore, if the lane markers are hard to detect, the system may not work properly. Please refer to "Limitations of the system".
- Do not remove or damage the related parts of LKA system.
- You may not hear a warning sound of LKA system if the audio volume is high.
- If any other warning sound such as seat belt warning chime is already generated, the Lane Keeping Assist (LKA) system warning may not sound.
- Do not place objects on the dashboard that reflects light such as mirrors, white paper, etc. This may prevent the LKA system from functioning properly.

- Always have your hands on the steering wheel while the LKA system is activated. Also, when Active LKA is selected from the User Settings mode and if you continue to drive with your hands off the steering wheel after the "Keep hands on steering wheel" warning message appears, the system will stop controlling the steering wheel. However, if the driver has their hands on the steering wheel again, the system will start controlling the steering wheel.
- The steering wheel is not continuously controlled so if the vehicle speed is at a higher speed when leaving a lane the vehicle may not be able to be controlled by the system. The driver must always follow the speed limit when using the system.
- If you attach objects to the steering wheel, the system may not assist steering or the hands off alarm may not work properly. When you tow a trailer, make sure that you turn off the LKA system.

LKA System Operation



To activate/deactivate the LKA system:

With the ignition switch in the ON position, press the LKA system switch located on the instrument panel on the left hand side of the steering wheel. The indicator in the cluster display will initially illuminate white. This indicates the LKA system is in the READY but NOT ENABLED state.

If you press the LKA button again, the indicator on the switch and cluster display will go off.



Note that the vehicle speed must be at least approximately 40 mph (64 km/h) to ENABLE the LKA system. The indicator in the cluster will illuminate green.

The color of indicator will change depending on the condition of LKA system.

- White : Sensor does not detect lane markers or vehicle speed is under 40 mph (64 km/h).
- Green : Sensor detects lane markers and the system is able to control vehicle steering.

i Information

If the indicator (white) is activated from the previous ignition cycle, the system will turn ON without any additional control. If you press the LKA switch again, the indicator on the cluster goes off.

LKA system operation



OAD058127N

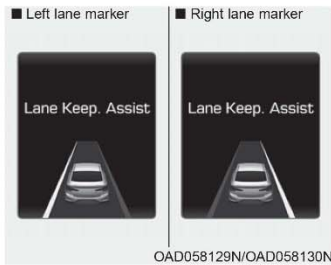
- To see the LKA system screen on the LCD display in the cluster, select Assist mode (A). For more details, refer to "LCD Display Modes" in chapter 3.



OAD058127N/OAD058128N

- If vehicle speed is over 40 mph (64 km/h) and the system detects lane markers, the color changes from gray to white.
- Both lane markers must be detected for the system to fully activate.

- If your vehicle departs from the projected lane in front of you, the LKA system operates as follows:



1. A visual warning appears on the cluster LCD display. Either the left lane marker or the right lane marker in the cluster LCD display will blink depending on which direction the vehicle is veering. Also, a warning sound will be heard.

2. The LKA system will control the vehicle's steering to prevent the vehicle from crossing the lane marker in below conditions.

- Vehicle speed is over 40 mph (64 km/h)
- The system detects both lane markers
- When driving, the vehicle is located between both lanes normally.
- The steering wheel is not turned suddenly.

When lanes are detected and all the conditions to activate the LKA system are satisfied, a LKA system indicator light will change from white to green. This indicates that the LKA system is in the ENABLED state and the steering wheel will be controlled.

Warning Light and Message

Keep hands on steering wheel



If the driver takes their hands off the steering wheel for several seconds while the LKA system is activated, the system will warn the driver.

i Information

If the steering wheel is held very lightly, the message may still appear because the LKA system may not recognize that the driver has their hands on the wheel.

5

Driving your vehicle

⚠ WARNING

The warning message may appear late according to road conditions. Therefore, always have your hands on the steering wheel while driving.

Driver's grasp not detected. LKA system will be disabled temporarily



If the driver still does not have their hands on the steering wheel after the message "Keep hands on steering wheel", the system will not control the steering wheel and warn the driver only when the driver crosses the lane markers.

However, if the driver has their hands on the steering wheel again, the system will start controlling the steering wheel.

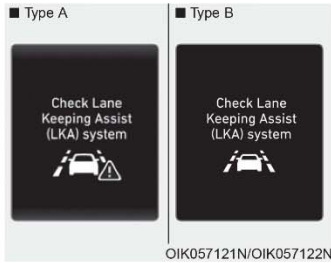
This warning message is available when Active LKA is selected from the User Settings mode.

⚠ WARNING

- The LKA system is a supplemental system only. It is the responsibility of the driver to safely steer the vehicle and to maintain it in its lane.
- Turn off the LKA system and drive without using the system in the following situations:
 - In bad weather
 - In bad road conditions
 - When the steering wheel needs to be controlled by the driver frequently.
 - When towing a vehicle or trailer

i Information

- Even though the steering is assisted by the system, the driver can still steer to control the steering wheel.
- The steering wheel may feel heavier when the steering wheel is assisted by the system than when it is not.



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Check Lane Keeping Assist (LKA) system

If there is a problem with the system a message will appear for a few seconds. If the problem continues the LKA system failure indicator will illuminate.

LKA system indicator



The LKA system indicator (yellow) will illuminate if the LKA system is not working properly. Have your vehicle checked by an authorized HYUNDAI dealer.

When there is a problem with the system do one of the following:

- Turn the system on after turning the engine off and on again.
- Check if the ignition switch is in the ON position.
- Check if the system is affected by the weather. (ex: fog, heavy rain, etc.)
- Check if there is foreign matter on the camera lens.

If the problem is not solved, have your vehicle checked by an authorized HYUNDAI dealer.

The LKA system will not be in the ENABLED state and/or the steering wheel will not be assisted when:

- The turn signal is turned on before changing a lane. If you change lanes without the turn signal on, the steering wheel might be controlled.
- The vehicle is not driven in the middle of the lane when the system is turned on or right after changing a lane.
- ESC (Electronic Stability Control) or VSM (Vehicle Stability Management) is activated.
- The vehicle is driven on a sharp curve.
- Vehicle speed is below 40 mph (64 km/h) and over 110 mph (177 km/h).
- The vehicle makes sharp lane changes.
- The vehicle brakes suddenly.
- The lane is very wide or narrow.
- There are more than two lane markers on the road. (e.g. construction area)

- Only one side of the lane marker is detected.
- Radius of a curve is too small.
- The vehicle is driven on a steep incline.
- The steering wheel is turned suddenly.
- Driving on a steep slope or hill.

Limitations of the System

The LKA system may operate prematurely even if the vehicle does not depart from the intended lane, OR, the LKA system may not warn you if the vehicle leaves the intended lane under the following circumstances:

When the lane and road conditions are poor

- It is difficult to distinguish the lane marker from the road because the lane marker is covered with dust or sand.
- It is difficult to distinguish the color of the lane marker from the road.
- There are markings on the road surface that look like a lane marker that is inadvertently being detected by the camera.
- The lane marker is indistinct or damaged.
- The lane marker is merged or divided (e.g. tollgate).
- The lane number increases or decreases or the lane marker are crossing complicatedly.

- There are more than two lane markers on the road in front of you.
- The lane marker is very thick or thin.
- The lane is very wide or narrow.
- The lane marker ahead is not visible due to rain, snow, water on the road, damaged or stained road surface, or other factors.
- The shadow is on the lane marker by a median strip, trees, guardrail, noise barriers, etc.
- The lane markers are complicated or a structure substitutes for the lines such as a construction area.
- There are crosswalk signs or other symbols on the road.
- The lane marker in a tunnel is stained with oil, etc.
- The lane suddenly disappears such as at the intersection.

When external condition is intervened

- The brightness outside changes suddenly such as when entering or exiting a tunnel, or when passing under a bridge.
- The brightness outside is too low such as when the headlamps are not on at night or the vehicle is going through a tunnel.
- There is a boundary structure in the roadway such as a concrete barrier, guardrail and reflector post that is inadvertently being detected by the camera.
- When light coming from a street light or an oncoming vehicle is reflected on a wet road surface such as a puddle in the road.
- The field of view in front is obstructed by sun glare.
- There is not enough distance between you and the vehicle in front to be able to detect the lane marker or the vehicle ahead is driving on the lane marker.

- Driving on a steep grade, over a hill, or when driving on a curved road.
- The adverse road conditions cause excessive vehicle vibrations while driving.
- The surrounding of the inside rear view mirror temperature is high due to direct sunlight, etc.

When front visibility is poor

- The windshield or the camera lens is blocked with dirt or debris.
- The windshield glass is fogged up; a clear view of the road is obstructed.
- Placing objects on the dashboard, etc.
- The sensor cannot detect the lane because of fog, heavy rain or snow.

⚠ WARNING

The Lane Keeping Assist (LKA) system is a system to help prevent the driver from leaving the lane. However, the driver should not solely rely on the system but always take the necessary actions for safe driving practices.

LKA System Function Change

The driver can change LKA to Lane Departure Warning from the LCD display. Go to the 'User Settings → Driver Assistance → Lane Safety → Active LKA/Lane Keeping Assist /Lane Departure Warning/Off.

Active LKA

The Active LKA mode provides more frequent steering wheel control in comparison with the Standard LKA mode. Active LKA can reduce the driver's fatigue to assist the steering for maintaining the vehicle in the middle of the lane.

Standard LKA

This mode guides the driver to help keep the vehicle within the lanes. It rarely controls the steering wheel, when the vehicle drives well inside the lanes. However, it starts to control the steering wheel, when the vehicle is about to deviate out of the lane.

Lane Departure Warning

LDW system alerts the driver with a visual warning and a warning alarm when the system detects the vehicle departing the lane. The steering wheel will not be controlled.

Off

If you select "Off", the LKA system is deactivated.

APPENDIX C

Run Log

Subject Vehicle: **2020 Hyundai Elantra Value Edition**

Test Date: **3/12/2020**

Driver: **J. Robel**

Note: For Distance at Warning positive values indicate inside the lane

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Auditory Alert (ft)	Distance at Visual Alert (ft)	Pass/Fail	Notes
1	Botts	Right	N				Lateral Velocity
2			N				Lateral Velocity
3			Y	-0.32	-0.45	Pass	
4			Y	-0.36	-0.59	Pass	
5			Y	-0.24	-0.41	Pass	
6			N				Lateral Velocity
7			Y	-0.32	-0.47	Pass	
8			Y	-0.22	-0.40	Pass	
9			Y	-0.20	-0.30	Pass	
10			Y	-0.30	-0.47	Pass	
11	Botts	Left	N				Microphone location
12			Y	0.13	0.00	Pass	
13			Y	0.07	-0.08	Pass	
14			Y	-0.01	-0.08	Pass	
15			Y	0.01	-0.13	Pass	
16			Y	0.05	-0.06	Pass	
17			Y	0.06	-0.07	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Auditory Alert (ft)	Distance at Visual Alert (ft)	Pass/Fail	Notes
18			Y	0.05	-0.10	Pass	
19	Solid	Left	Y	0.00	-0.10	Pass	
20			Y	-0.01	-0.08	Pass	
21			Y	-0.01	-0.13	Pass	
22			Y	-0.24		Pass	Visual Alert - Lateral Velocity
23			Y	-0.20	-0.43	Pass	
24			Y	-0.12	-0.23	Pass	
25			N				SV speed
26			Y	-0.09	-0.24	Pass	
27	Solid	Right	Y	-0.08	-0.25	Pass	
28			Y	-0.10	-0.27	Pass	
29			N				SV yaw
30			Y	-0.04	-0.20	Pass	
31			Y	0.00	-0.14	Pass	
32			Y	-0.02	-0.19	Pass	
33			Y	0.07	-0.05	Pass	
34			Y	0.03	-0.09	Pass	
35	Dashed	Right	N				Lane velocity
36			N				Yaw rate
37			Y	-0.02	-0.12	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Auditory Alert (ft)	Distance at Visual Alert (ft)	Pass/Fail	Notes
38			N				Yaw rate
39			Y	-0.11	-0.27	Pass	
40			Y	-0.15	-0.33	Pass	
41			Y	-0.19	-0.37	Pass	
42			Y	-0.10	-0.22	Pass	
43			Y	-0.12	-0.27	Pass	
44			N				Lane velocity
45			Y	-0.14	-0.27	Pass	
46	Dashed	Left	Y	-0.05	-0.21	Pass	
47			Y	-0.03	-0.14	Pass	
48			Y	0.01	-0.09	Pass	
49			Y	-0.06	-0.19	Pass	
50			Y	0.00	-0.10	Pass	
51			Y	-0.06	-0.19	Pass	
52			Y	-0.01	-0.11	Pass	

APPENDIX D

Time History Plots

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Description of Time History Plots

A set of time history plots is provided for each valid run in the test series. Each set of plots comprises time varying data from the Subject Vehicle, as well as pass/fail envelopes and thresholds. The following is a description of data types shown in the time history plots, as well as a description of the color code for data envelopes.

Time History Plot Description

Time history figures include the following sub-plots:

- Warning – Indicates timing of warning issued by LDW system. Depending on the type of LDW alert or instrumentation used to measure the alert, this can be any of the following:
 - Filtered and rectified sound signal
 - Filtered and rectified acceleration (e.g., steering wheel vibration)
 - Light sensor signal
 - Discrete on/off value
- Speed (mph) – Speed of the Subject Vehicle
- Yaw Rate (deg/sec) – Yaw rate of the Subject Vehicle
- Distance to Lane Edge (ft) – Lateral distance (in lane coordinates) from the outer front tire bulge to the inside edge of the lane marking of interest for a given test (a positive value indicates the vehicle is completely within the lane while a negative value indicates that the outer front tire bulge has crossed over the inner lane marking edge). The distance to the lane edge at the moment the LDW alert is issued, is displayed to the right of subplot.
- Lateral Lane Velocity (ft/sec) – Lateral velocity (in lane coordinates) of the outer front tire bulge
- Bird's Eye View – Indicates the position of the Subject Vehicle with respect to the lane marking of interest for a given test. Green rectangles represent the Subject Vehicle's position at approximately 2 second intervals, while the yellow rectangle indicates the position of the Subject Vehicle at the time of LDW warning issuance.

Envelopes and Thresholds

Each of the time history plot figures can contain either green or yellow envelopes and/or black threshold lines. These envelopes and thresholds are used to programmatically and visually determine the validity of a given test run. Envelope and threshold exceedances are indicated with either red shading or red asterisks, and red text is placed to the right side of the plot indicating the type of exceedance.

Green envelopes indicate that the time-varying data should not exceed the envelope boundaries at any time within the envelope. Exceedances of a green envelope are indicated by red shading in the area between the measured time-varying data and the envelope boundaries.

Yellow envelopes indicate that the time-varying data should not exceed the envelope only at the right end. Exceedances at the right extent of a yellow envelope are indicated by red asterisks. Data within the boundaries at the right extent of a yellow envelope are indicated by green circles.

For the warning plot, a dashed black threshold line indicates the threshold used to determine the onset of the LDW alert. The alert is considered on the first time the alert signal crosses this threshold line.

Color Codes

Color codes have been adopted to easily identify the types of data, envelopes, and thresholds used in the plots.

Color codes can be broken into three categories:

1. Validation envelopes and thresholds
 1. Validation envelopes and thresholds
 2. Instantaneous samplings
 3. Text
1. Validation envelope and threshold color codes:
 - Green envelope = time varying data must be within the envelope at all times in order to be valid
 - Yellow envelope = time varying data must be within limits at right end
 - Black threshold (Solid) = time varying data must not exceed this threshold in order to be valid
 - Black threshold (Dashed) = for reference only – this can include warning level thresholds which are used to determine the timing of the alert
2. Instantaneous sampling color codes:
 - Green circle = passing or valid value at a given moment in time
 - Red asterisk = failing or invalid value at a given moment in time

3. Text color codes:

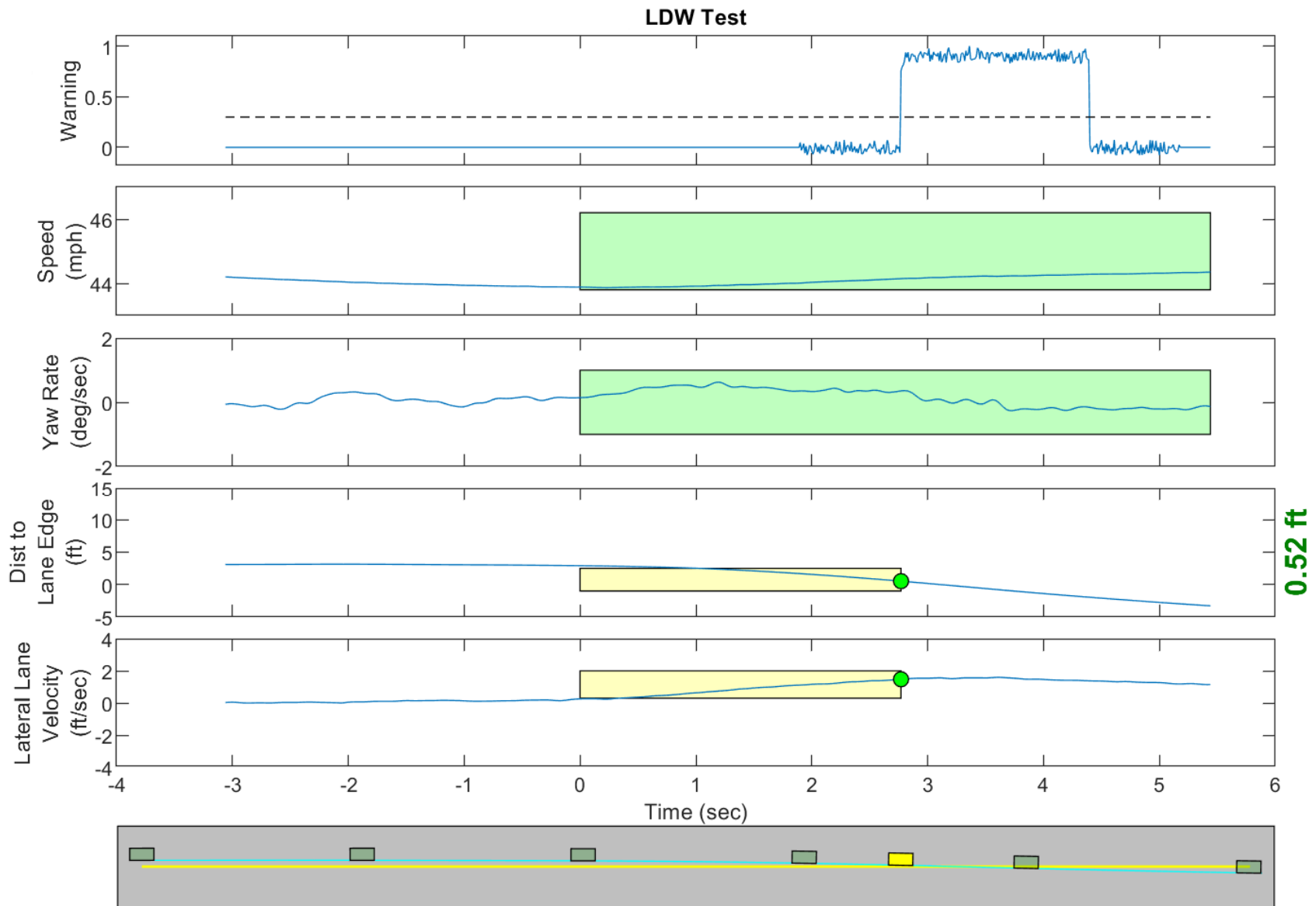
- Green = passing or valid value
- Red = failing or invalid value

Other Notations

- NG – Indicates that the value for that variable was outside of bounds and therefore “No Good”.
- No Wng – No warning was detected.

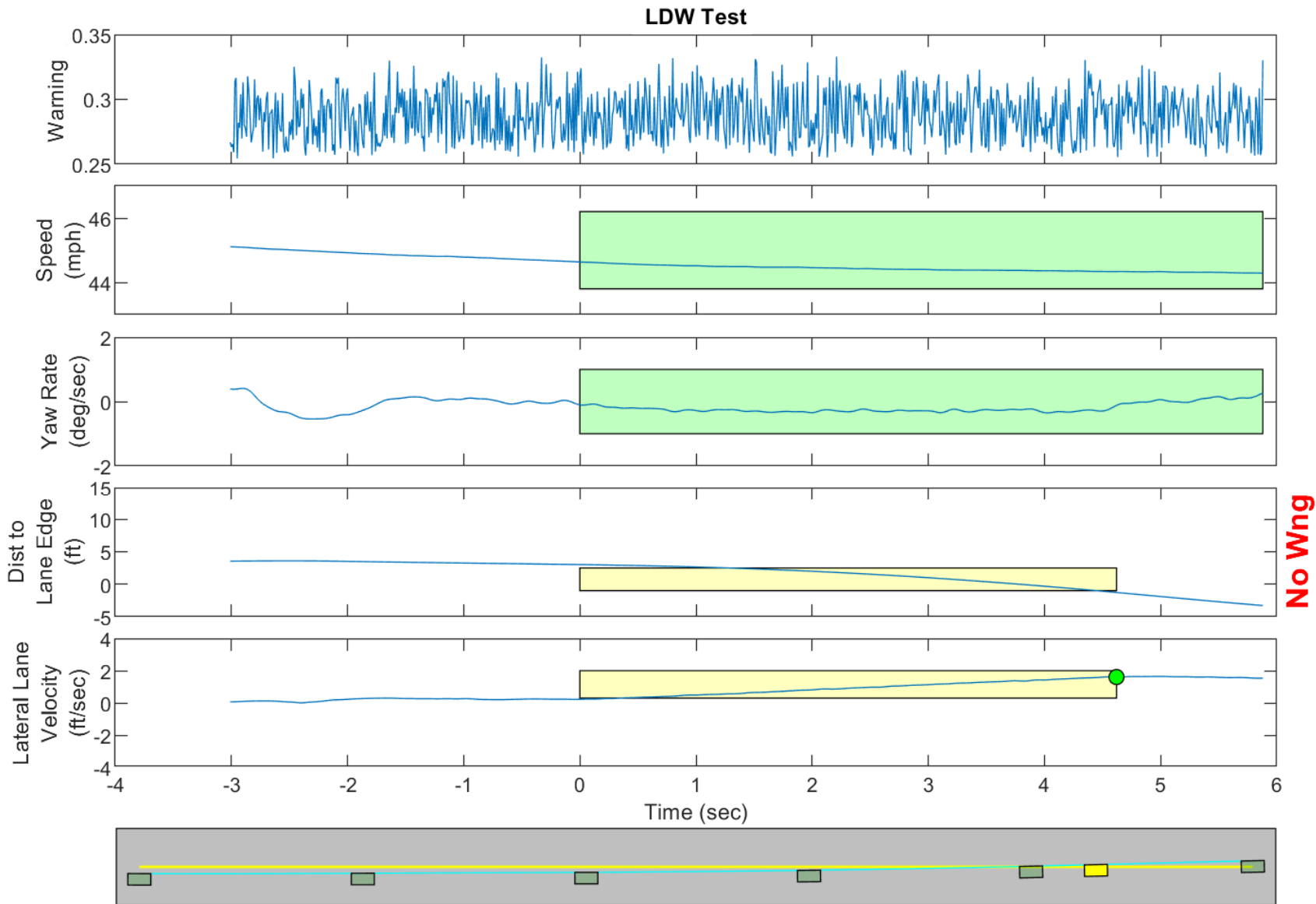
The minimum (worst) GPS fix type is displayed in the lower right corner of each page. The only valid fix type is RTK fixed (displayed in green). If the fix type during any portion of the test was anything other than RTK fixed, then “RTK Fixed OR LESS!!” is displayed in red.

Examples of time history plots (including passing, failing and invalid runs) are shown in Figure D1 through Figure D3. Actual time history data plots for the vehicle under consideration are provided subsequently.



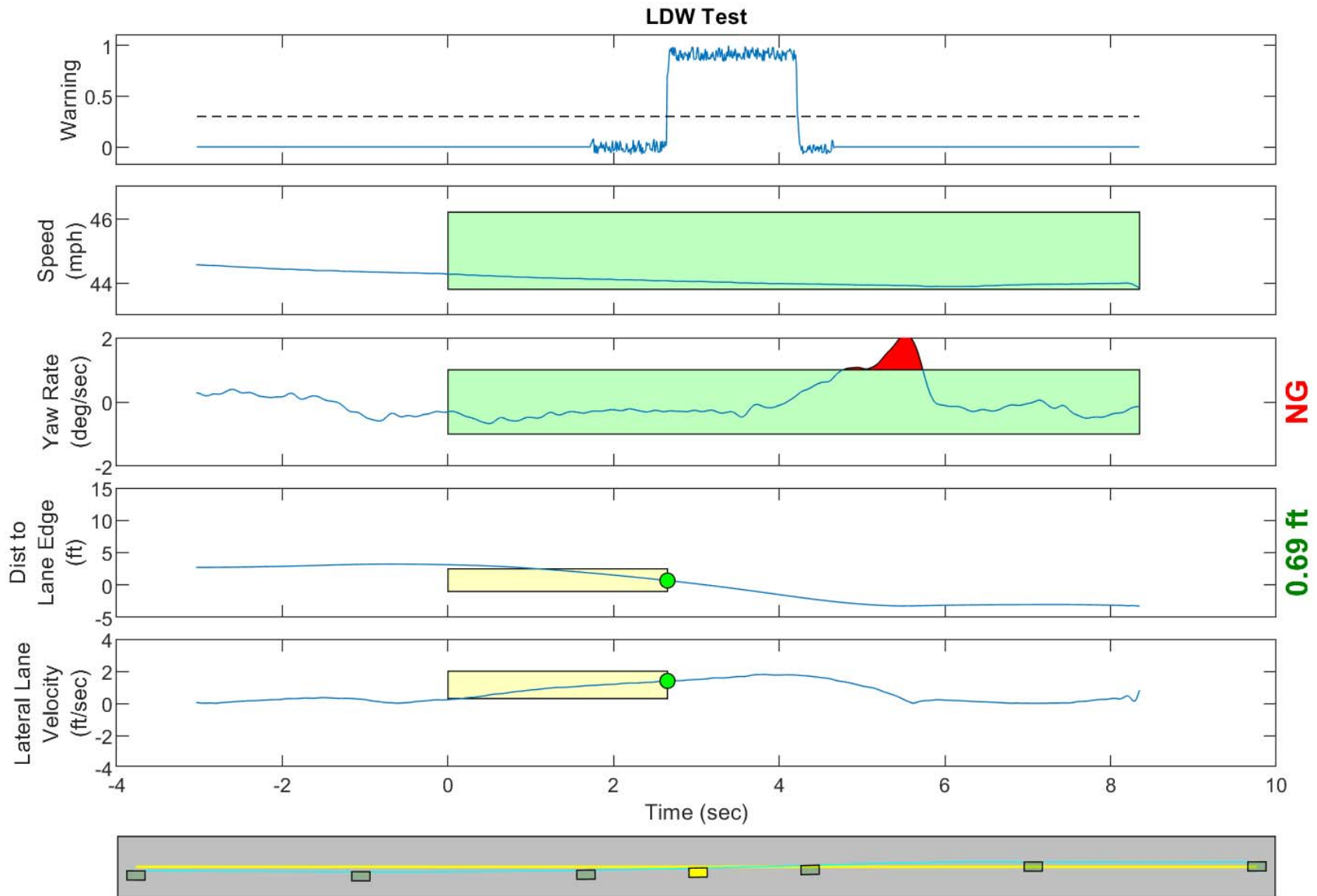
GPS Fix Type: RTK Fixed

Figure D1. Example Time History for Lane Departure Warning Test, Passing



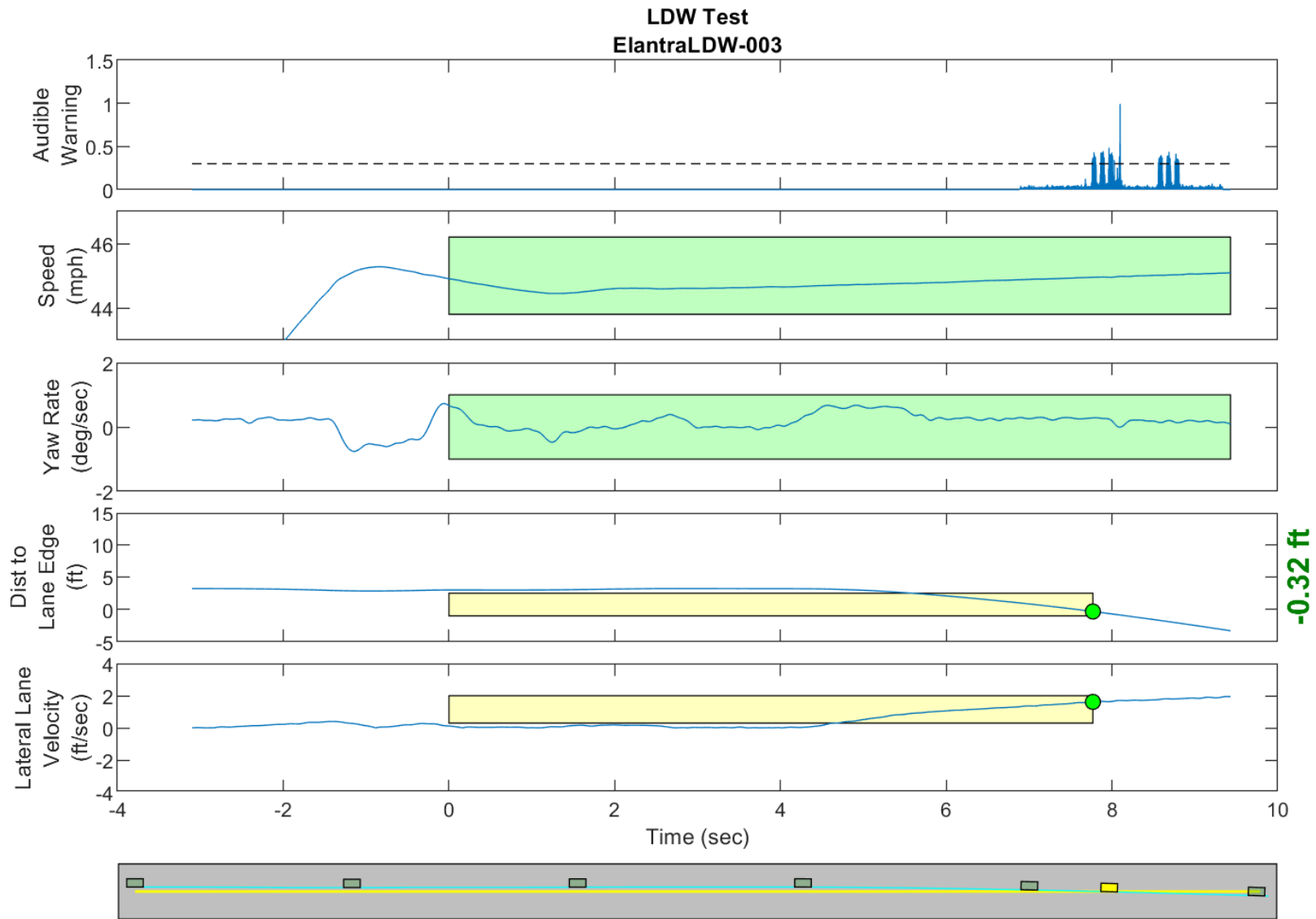
GPS Fix Type: RTK Fixed

Figure D2. Example Time History for Lane Departure Warning Test, Failing, No Warning Issued



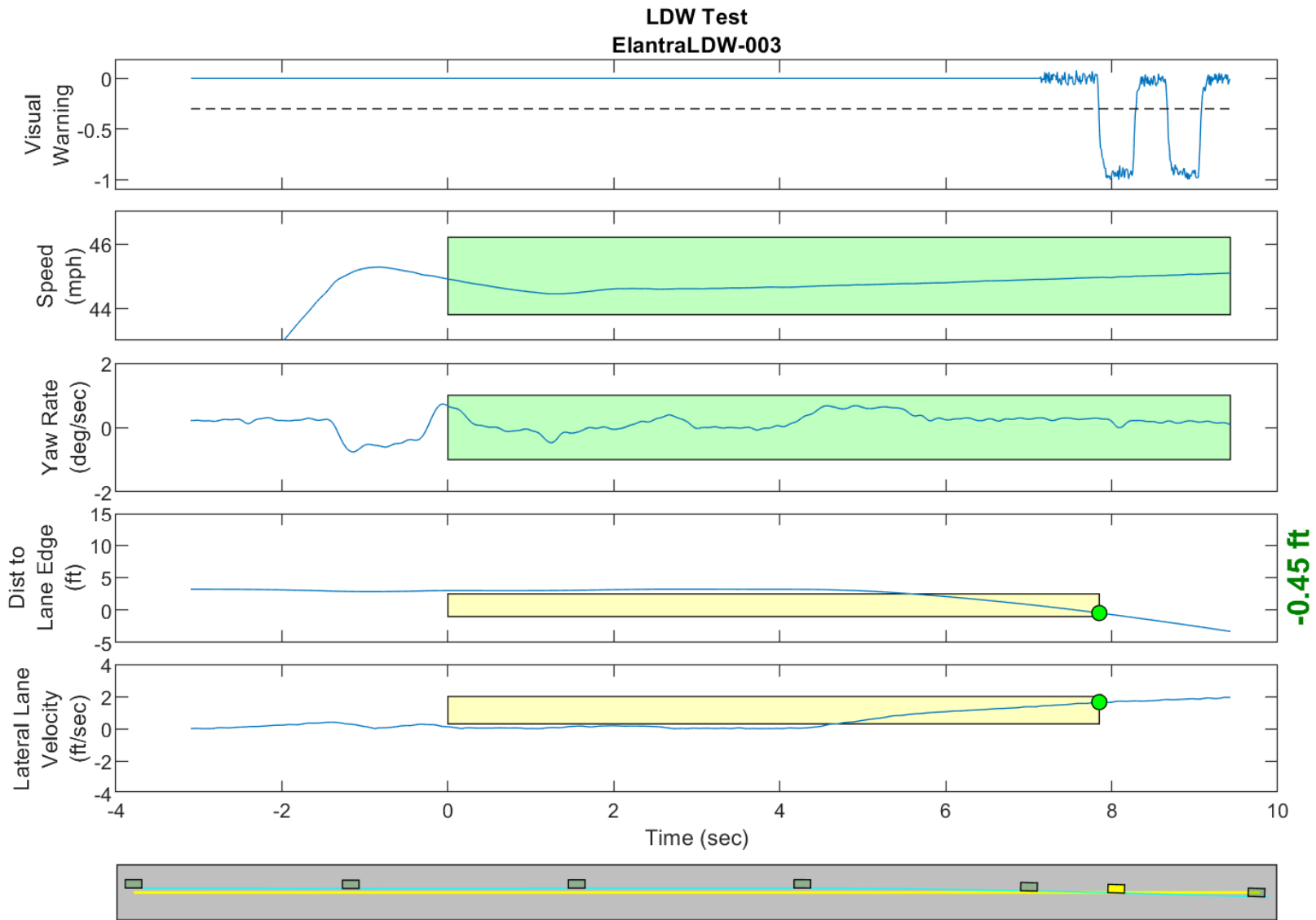
GPS Fix Type: RTK Fixed

Figure D3. Example Time History for Lane Departure Warning Test, Invalid Run Due to Subject Vehicle Yaw Rate



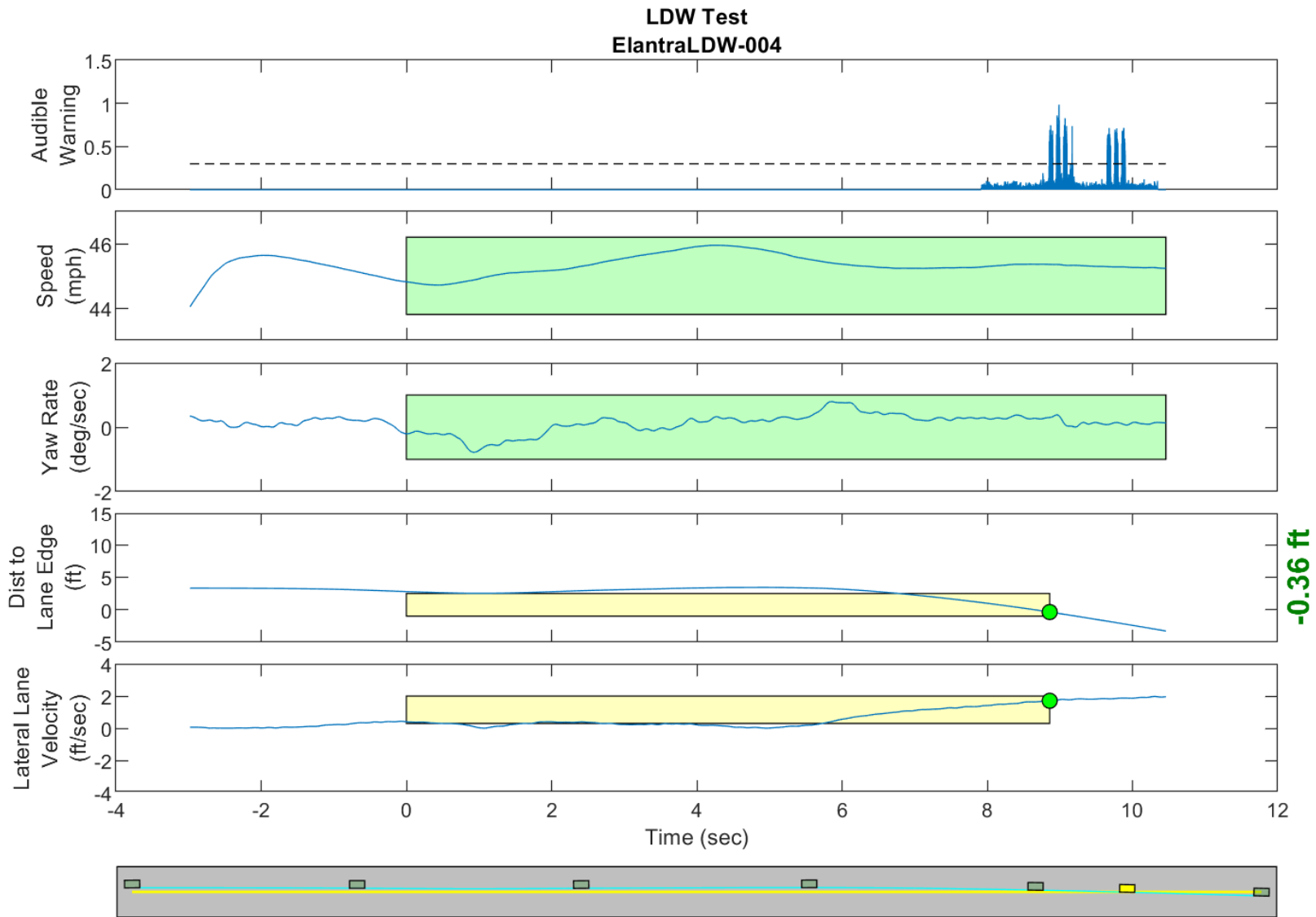
GPS Fix Type: RTK Fixed

Figure D4. Time History for Run 03, Botts Dots, Right Departure, Audible Warning



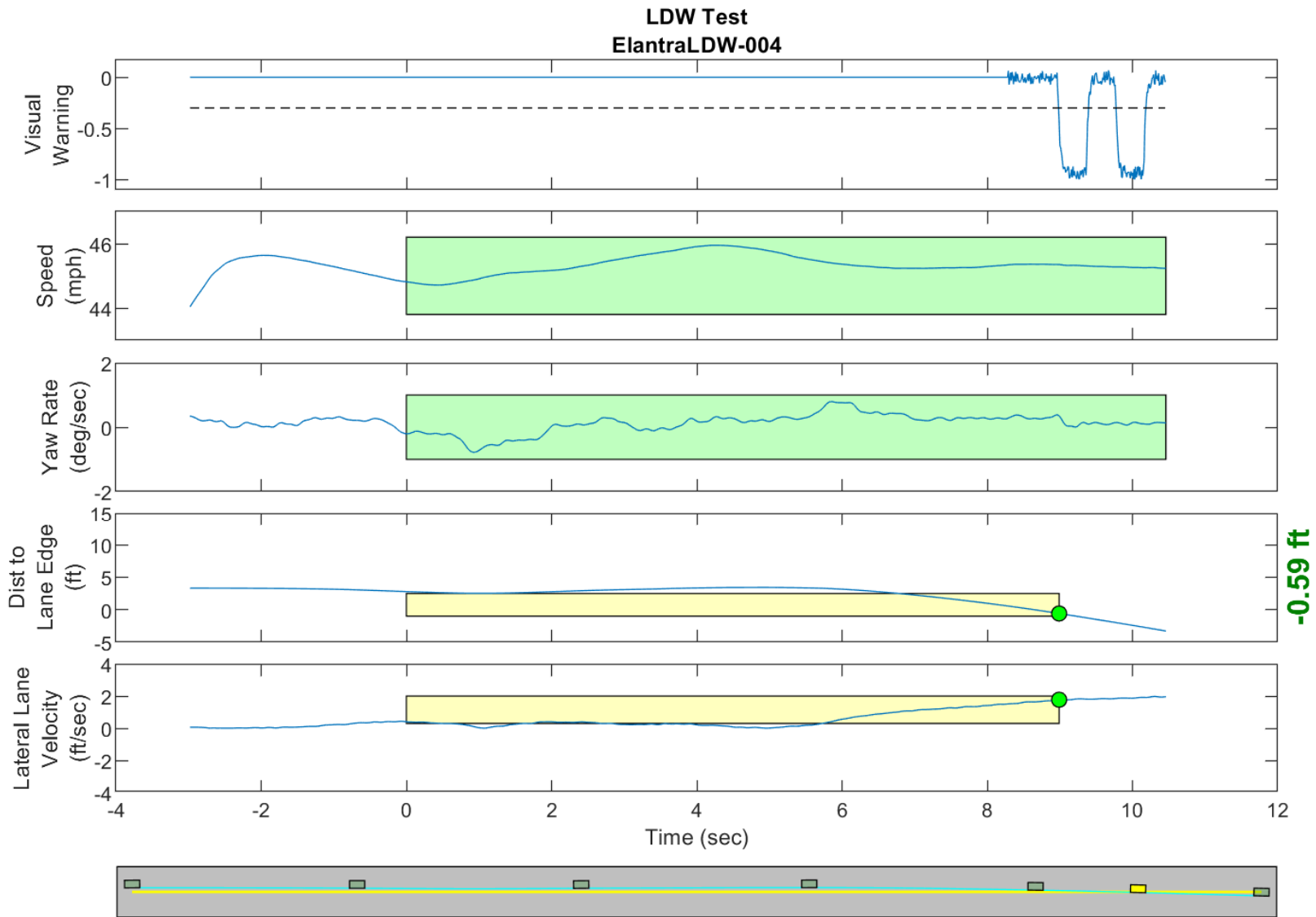
GPS Fix Type: RTK Fixed

Figure D5. Time History for Run 03, Botts Dots, Right Departure, Visual Warning



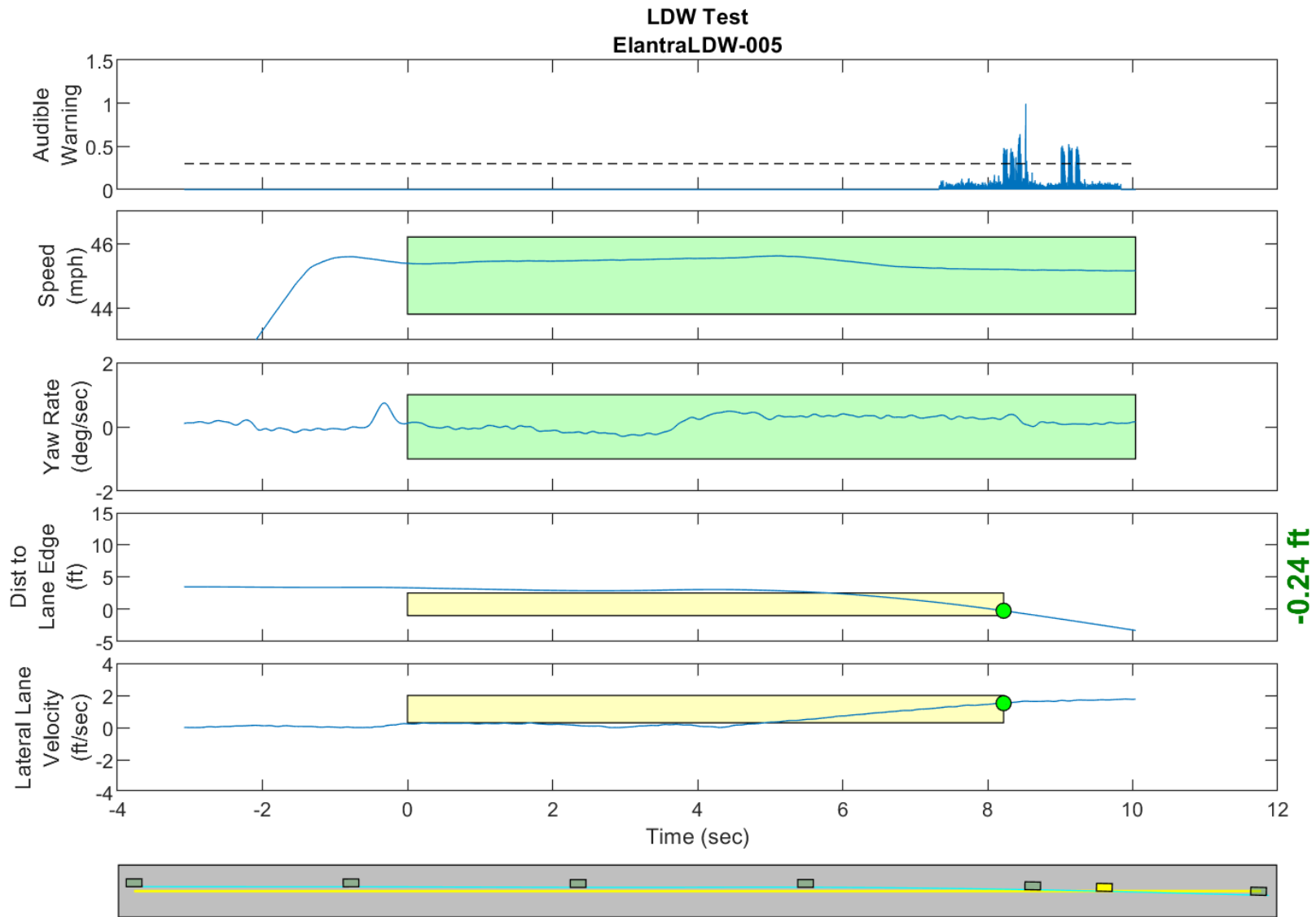
GPS Fix Type: RTK Fixed

Figure D6. Time History for Run 04, Botts Dots, Right Departure, Audible Warning



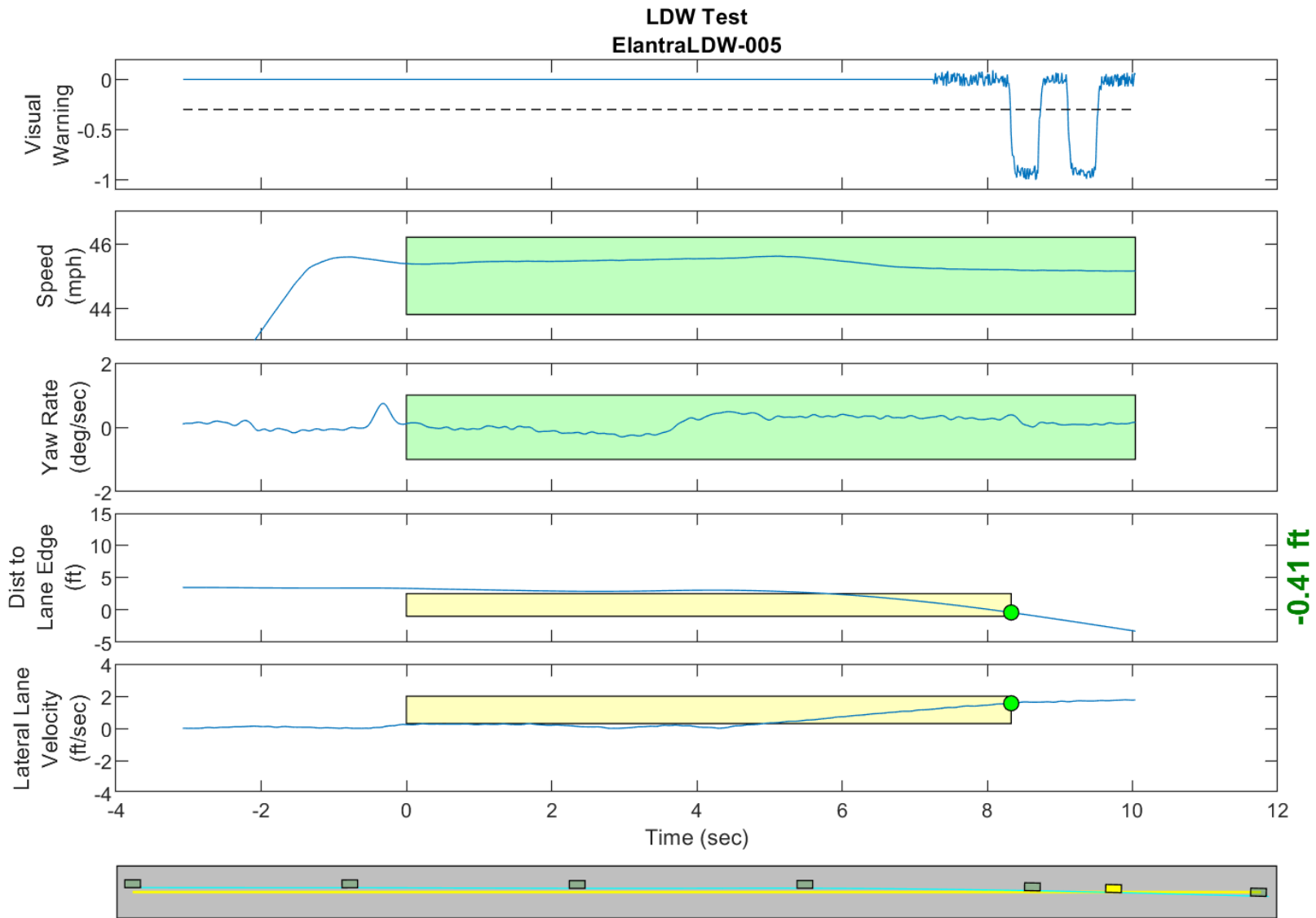
GPS Fix Type: RTK Fixed

Figure D7. Time History for Run 04, Botts Dots, Right Departure, Visual Warning



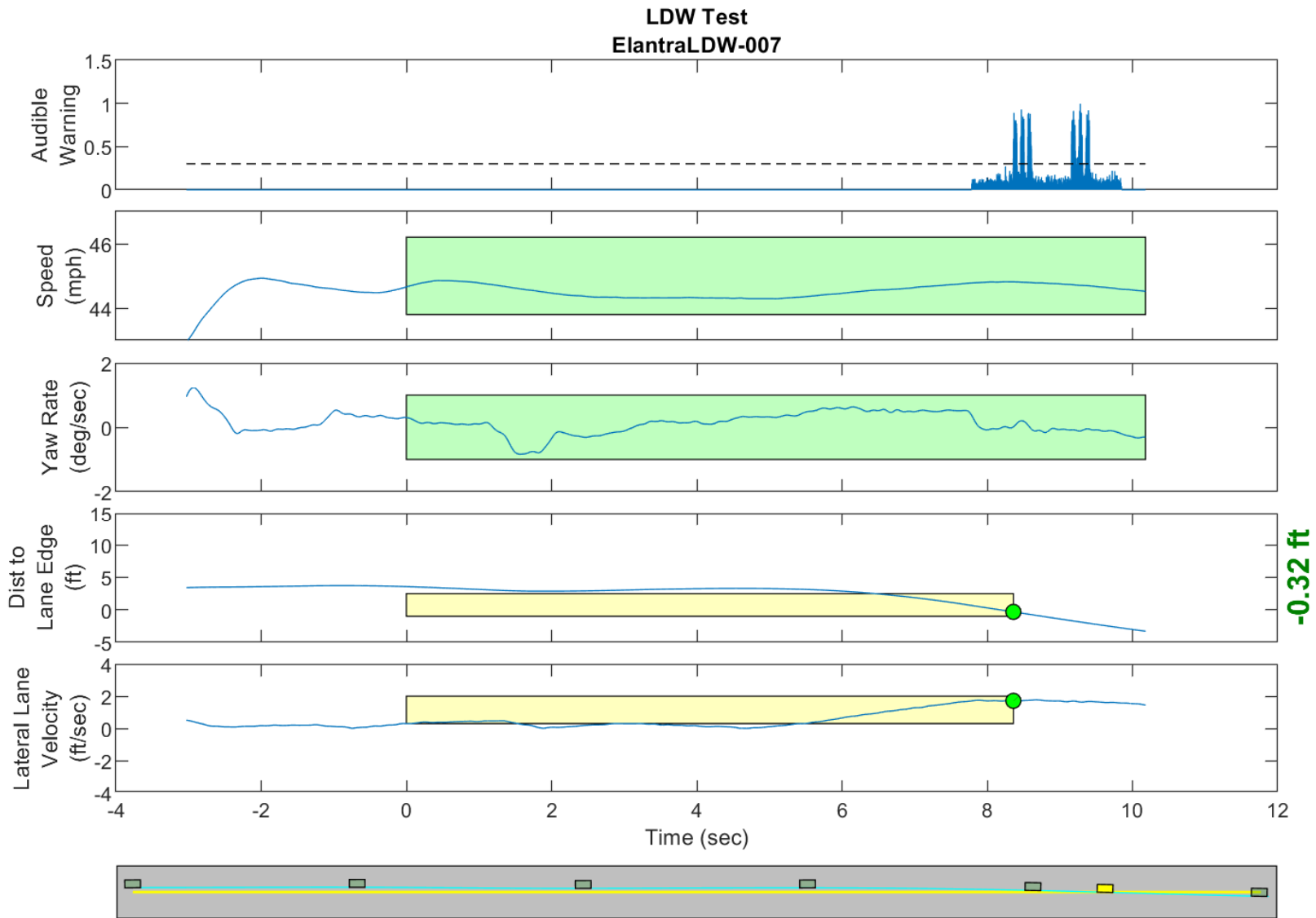
GPS Fix Type: RTK Fixed

Figure D8. Time History for Run 05, Botts Dots, Right Departure, Audible Warning



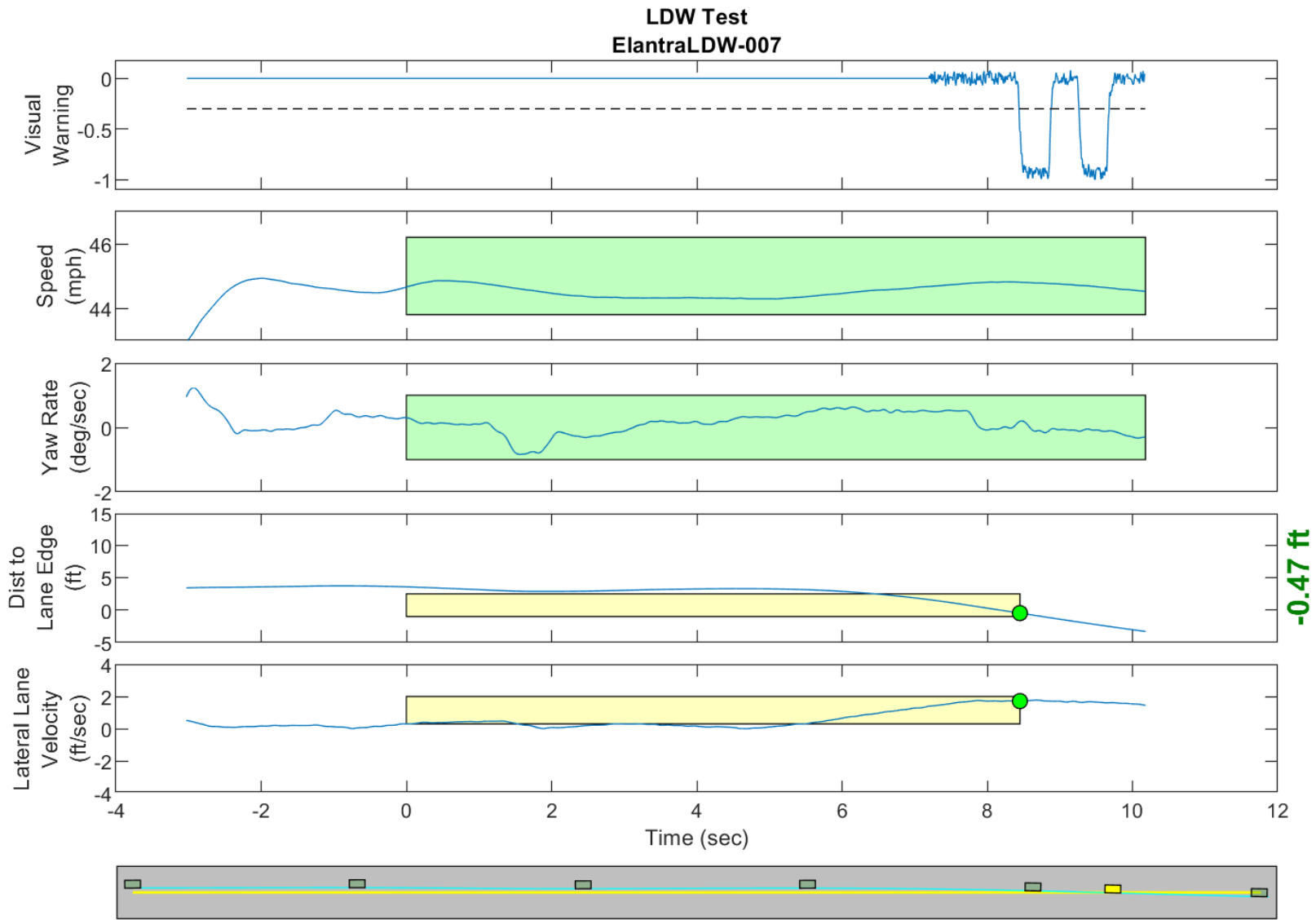
GPS Fix Type: RTK Fixed

Figure D9. Time History for Run 05, Botts Dots, Right Departure, Visual Warning



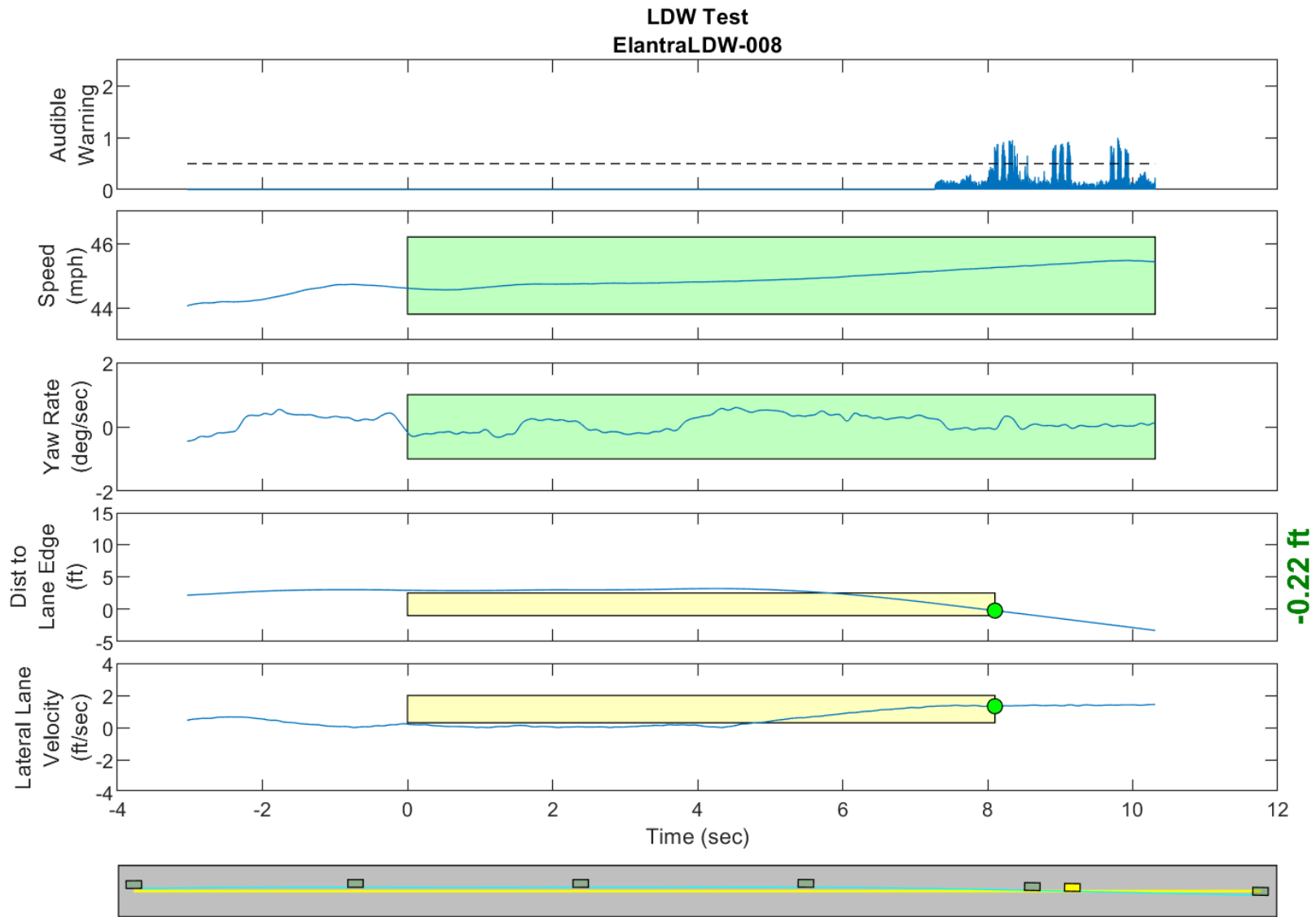
GPS Fix Type: RTK Fixed

Figure D10. Time History for Run 07, Botts Dots, Right Departure, Audible Warning



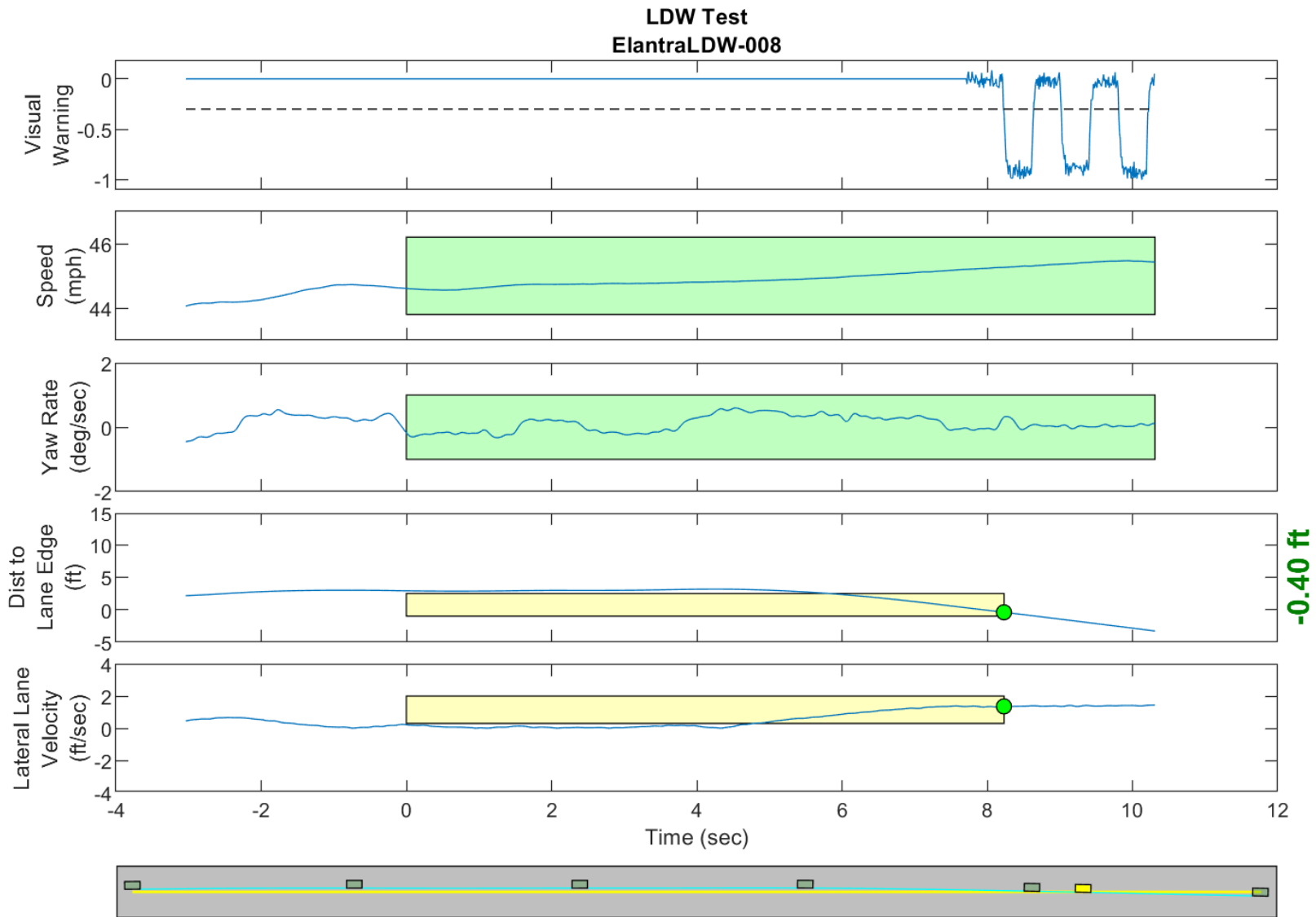
GPS Fix Type: RTK Fixed

Figure D11. Time History for Run 07, Botts Dots, Right Departure, Visual Warning



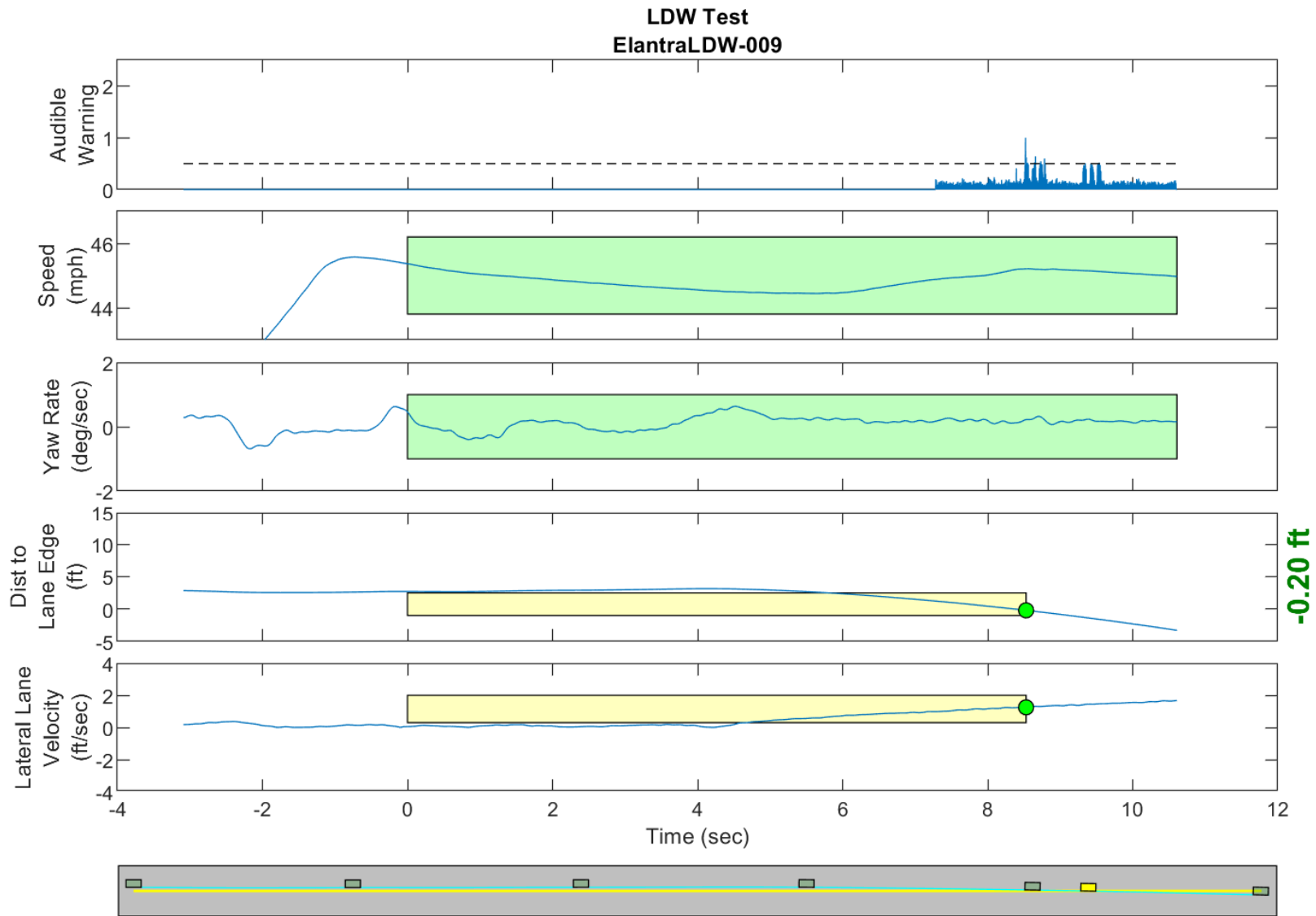
GPS Fix Type: RTK Fixed

Figure D12. Time History for Run 08, Botts Dots, Right Departure, Audible Warning



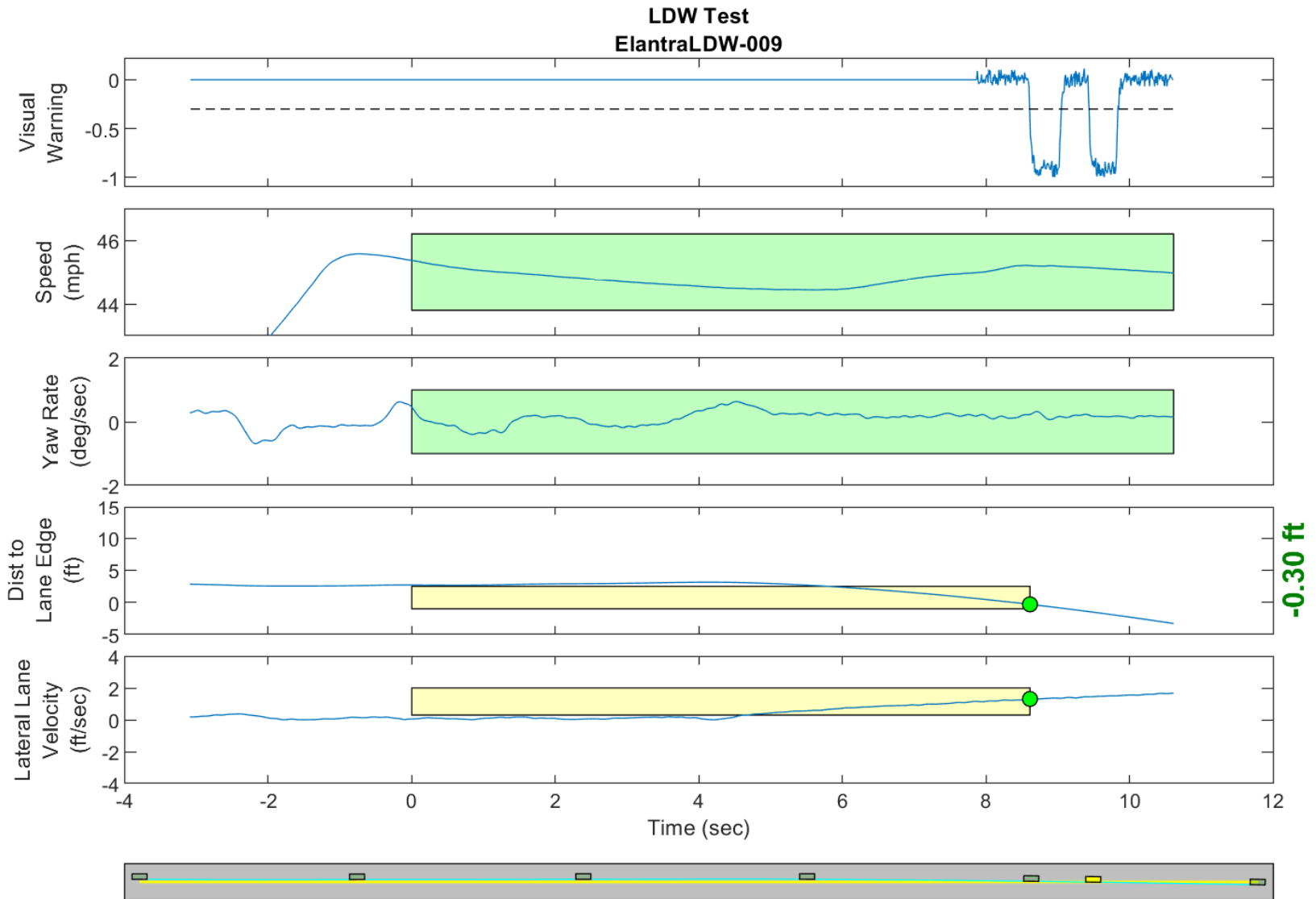
GPS Fix Type: RTK Fixed

Figure D13. Time History for Run 08, Botts Dots, Right Departure, Visual Warning



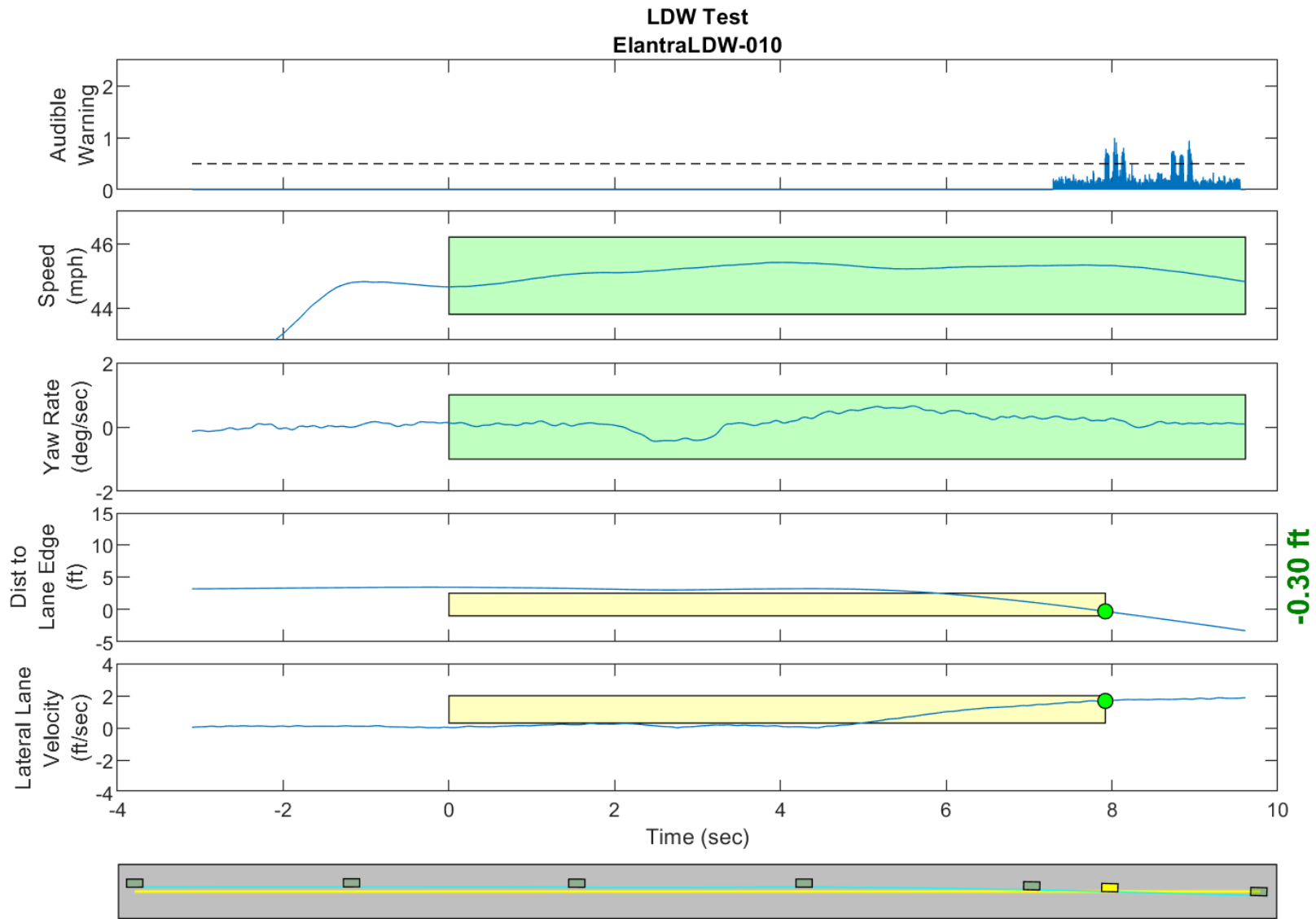
GPS Fix Type: RTK Fixed

Figure D14. Time History for Run 09, Botts Dots, Right Departure, Audible Warning



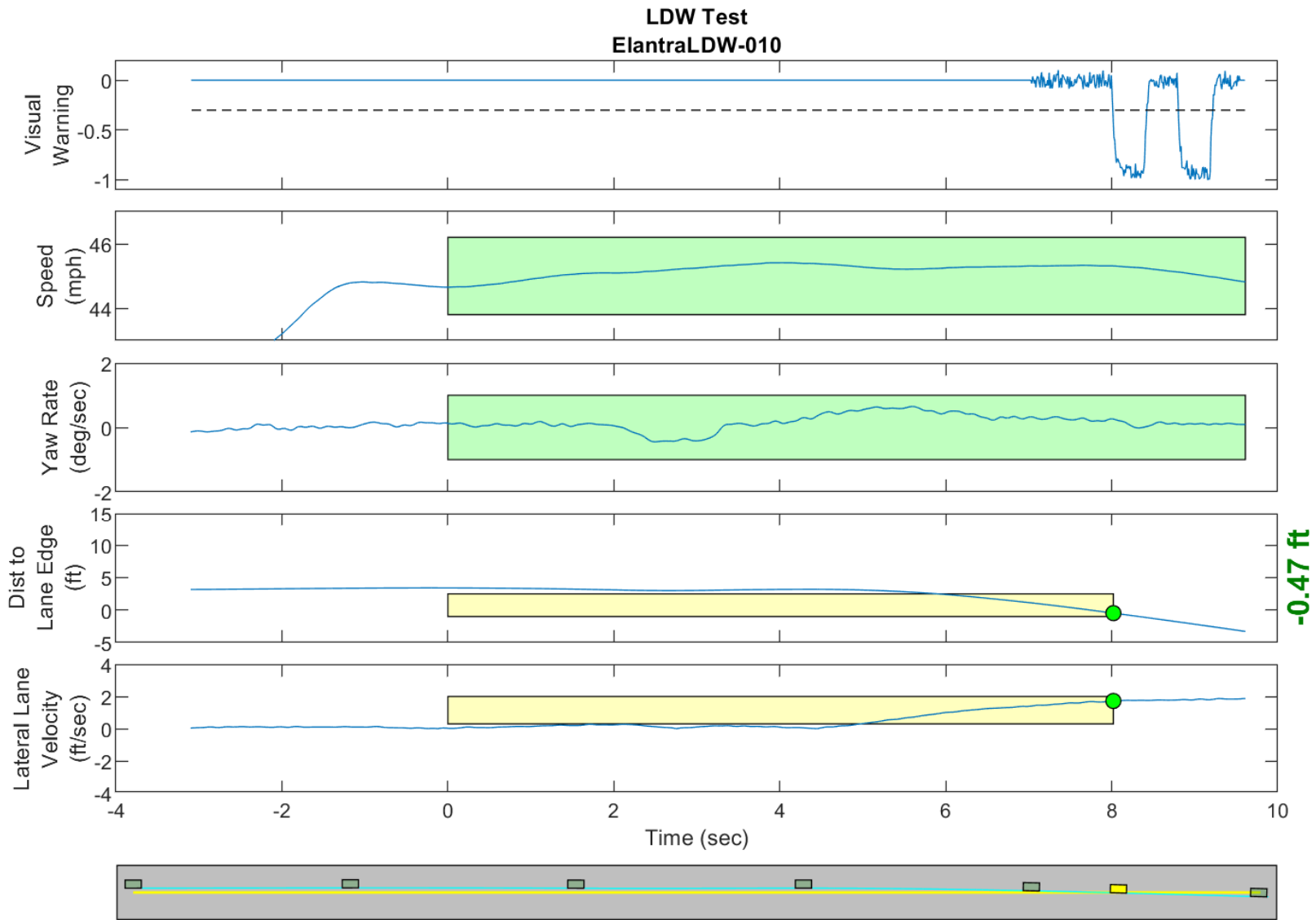
GPS Fix Type: RTK Fixed

Figure D15. Time History for Run 09, Botts Dots, Right Departure, Visual Warning



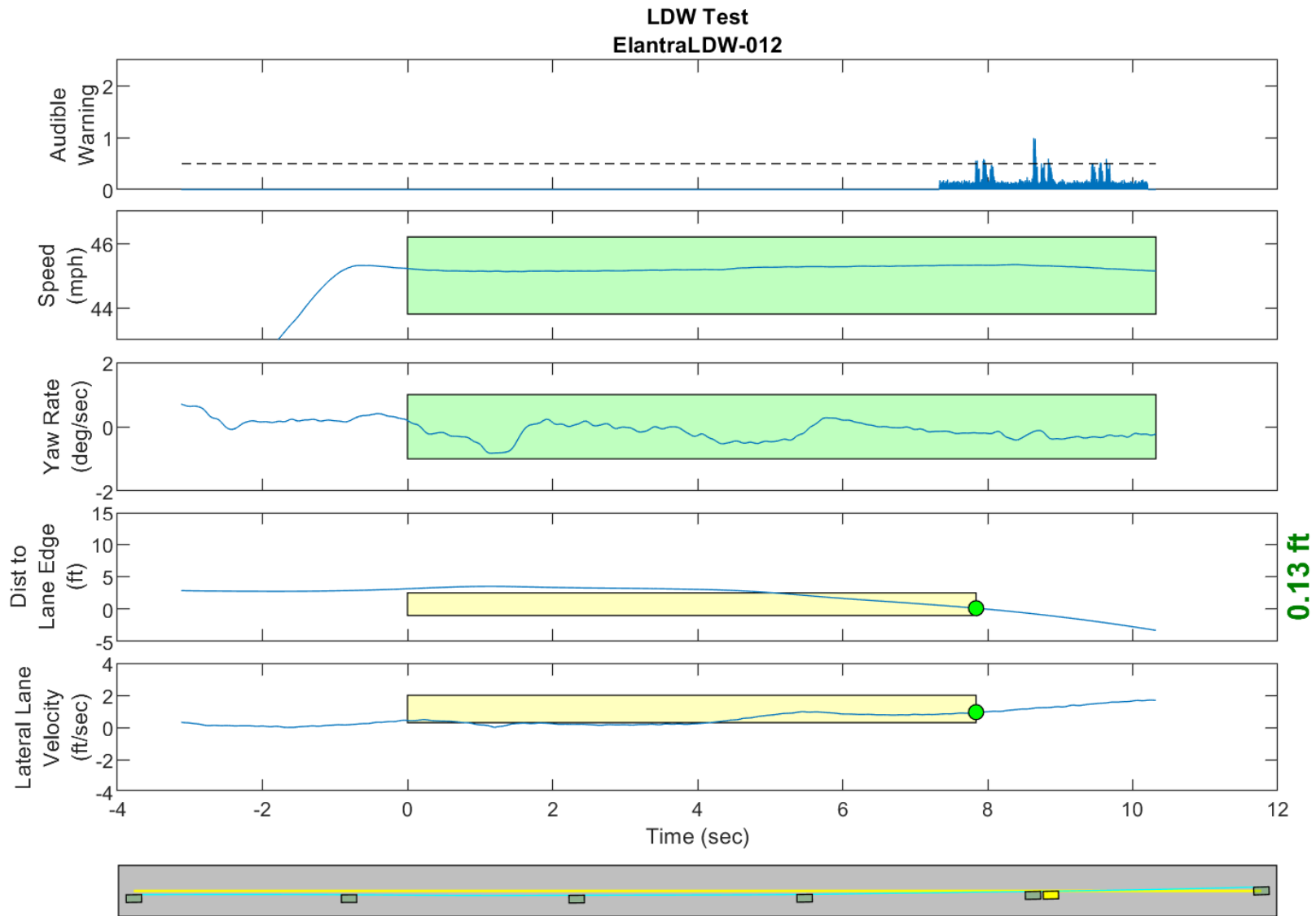
GPS Fix Type: RTK Fixed

Figure D16. Time History for Run 10, Botts Dots, Right Departure, Audible Warning



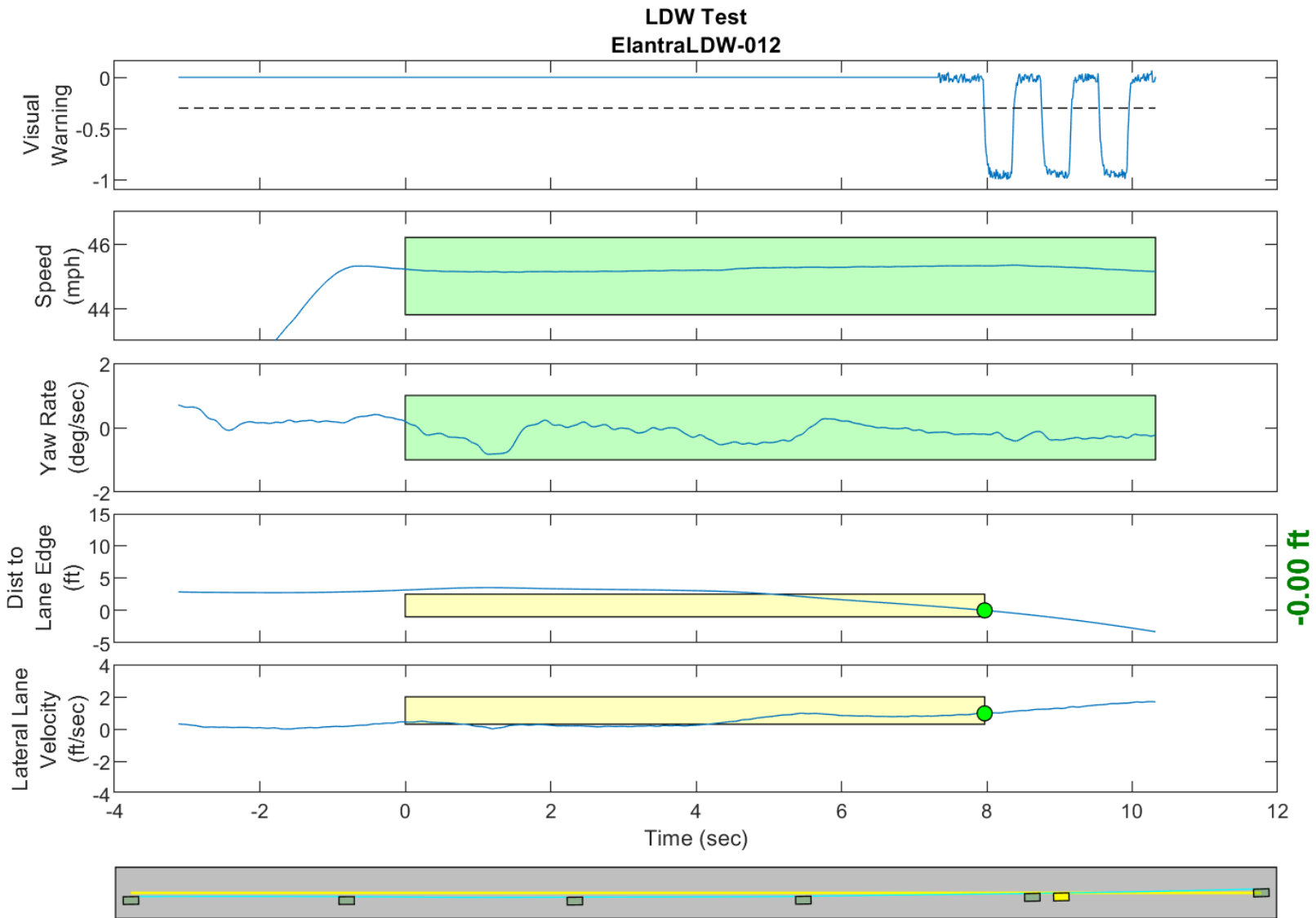
GPS Fix Type: RTK Fixed

Figure D17. Time History for Run 10, Botts Dots, Right Departure, Visual Warning



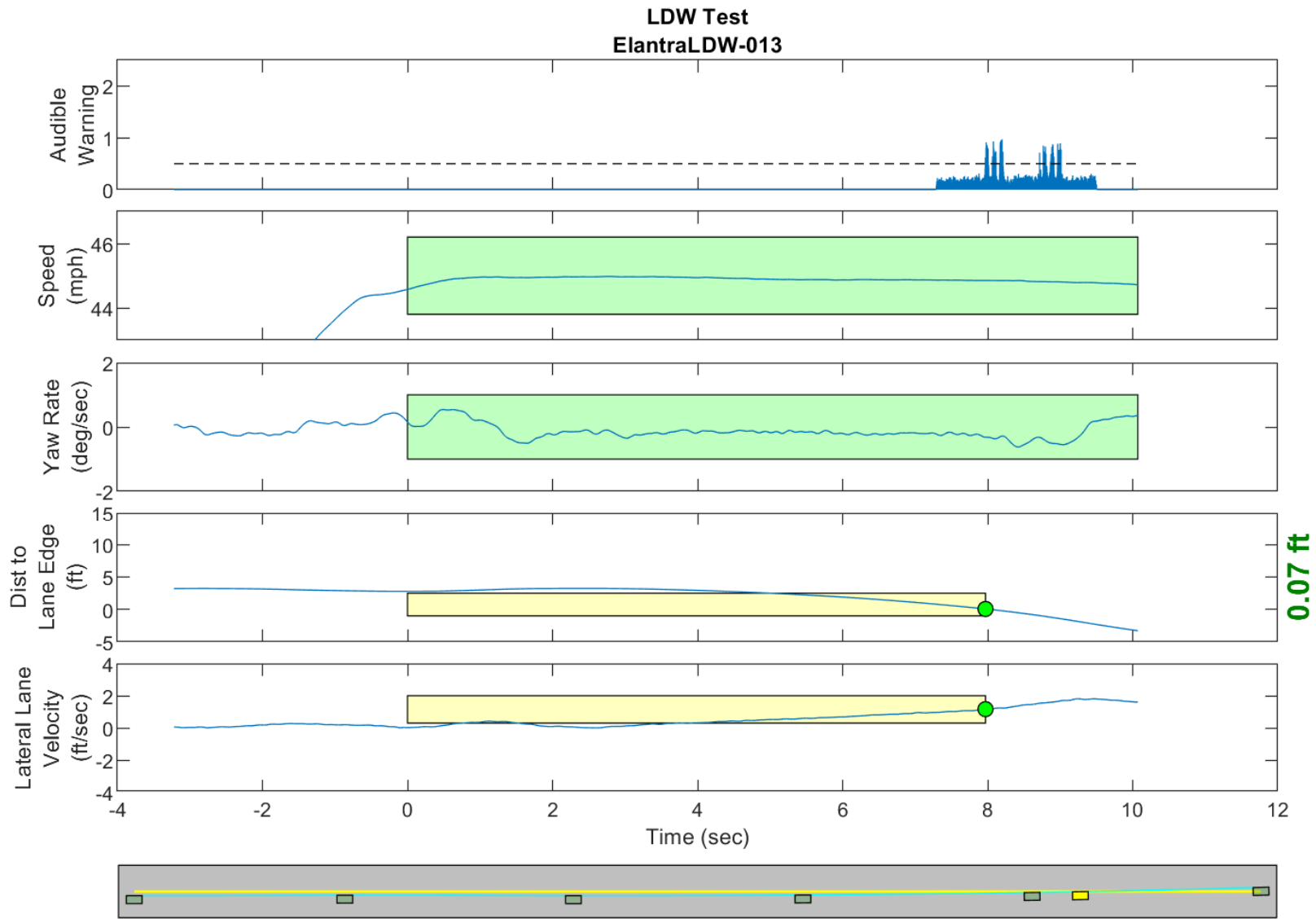
GPS Fix Type: RTK Fixed

Figure D18. Time History for Run 12, Botts Dots, Left Departure, Audible Warning



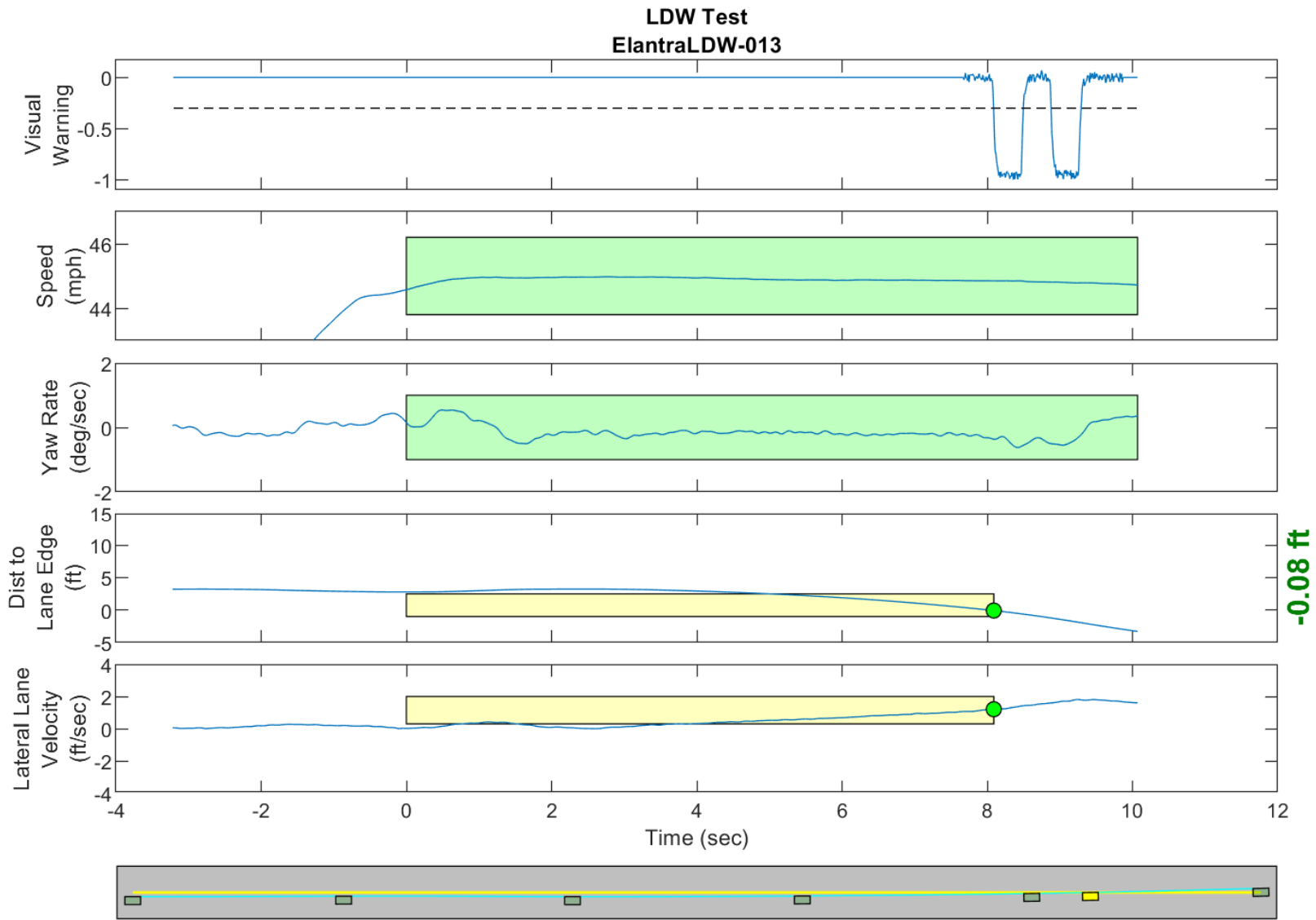
GPS Fix Type: RTK Fixed

Figure D19. Time History for Run 12, Botts Dots, Left Departure, Visual Warning



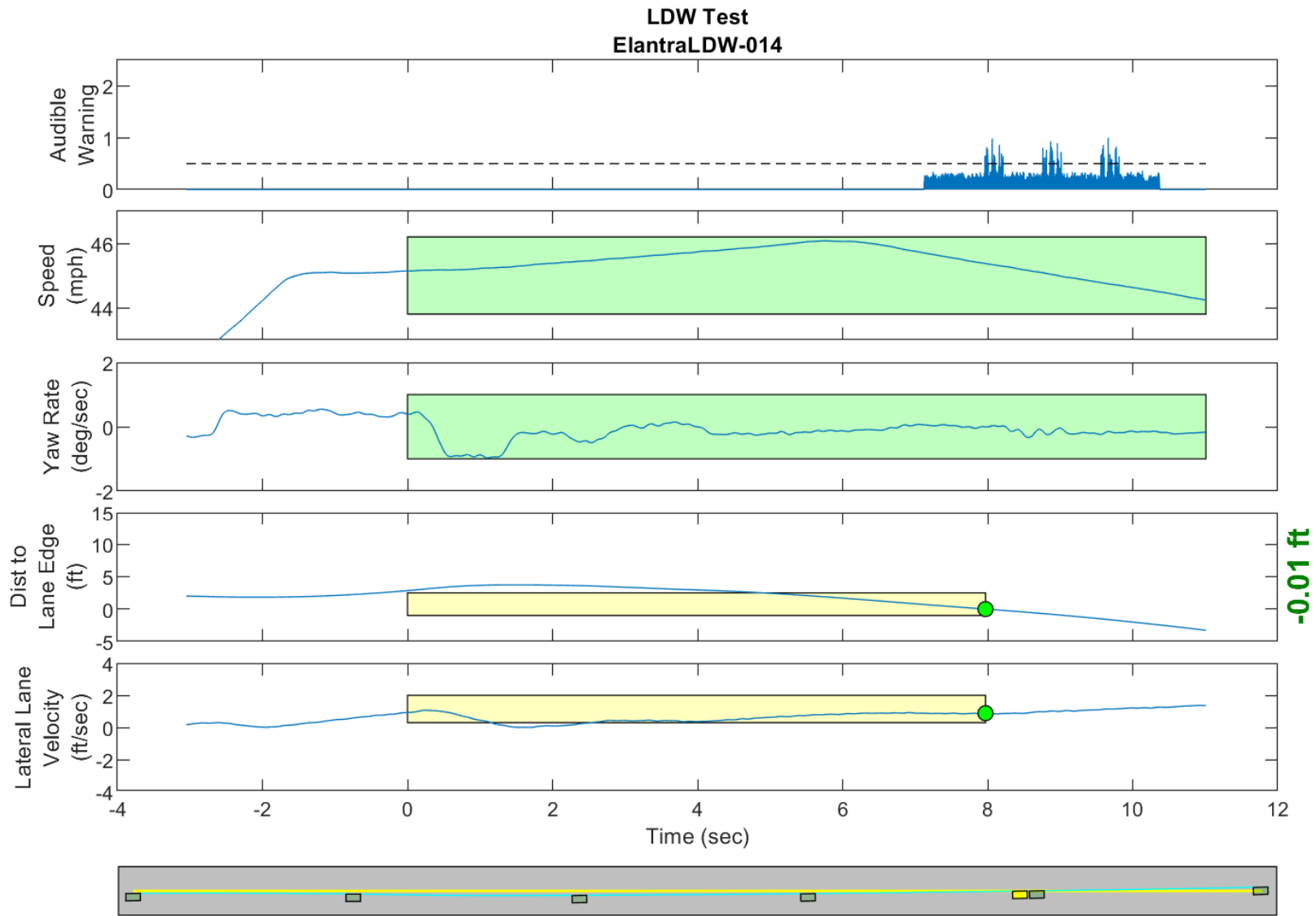
GPS Fix Type: RTK Fixed

Figure D20. Time History for Run 13, Botts Dots, Left Departure, Audible Warning



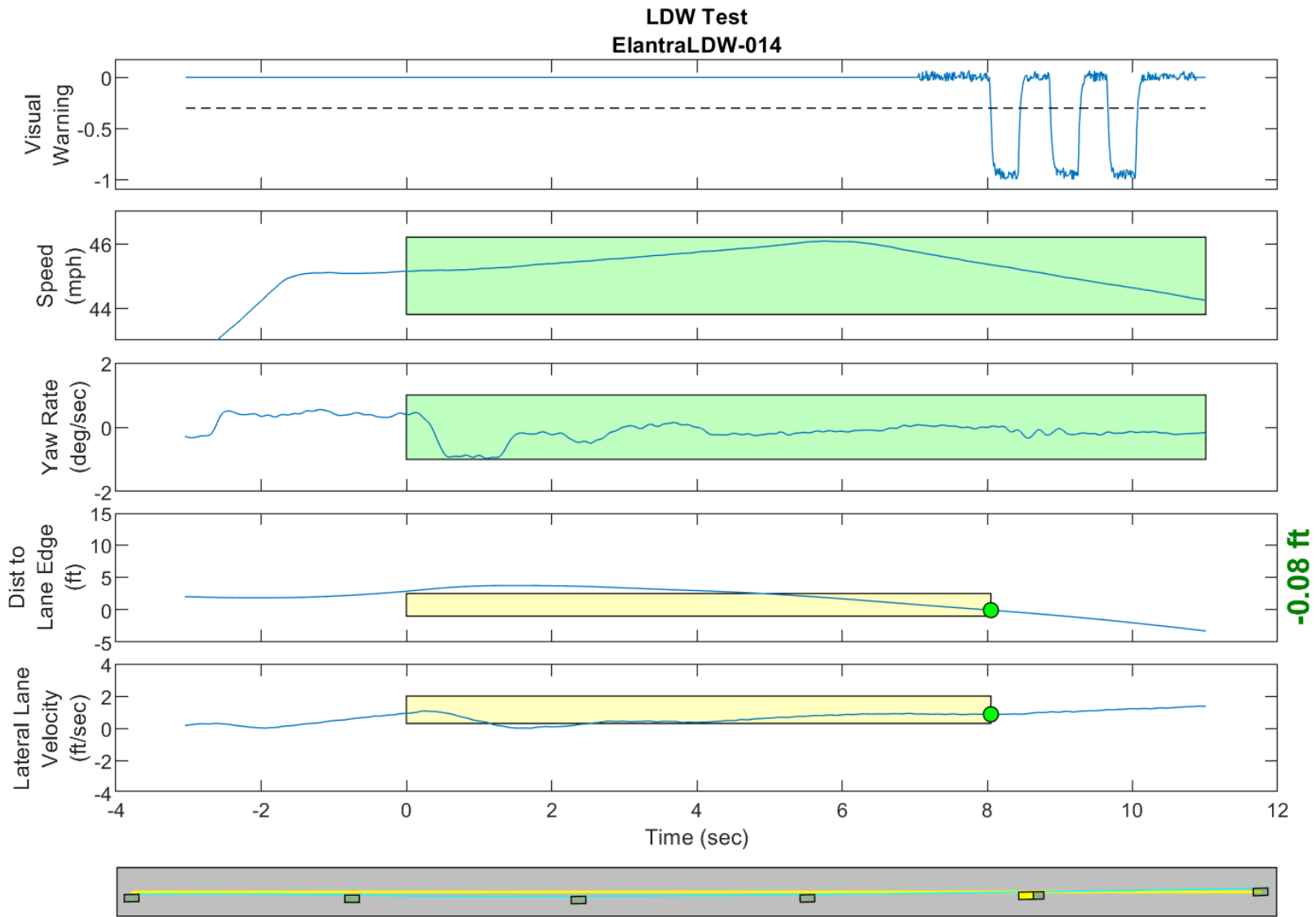
GPS Fix Type: RTK Fixed

Figure D21. Time History for Run 13, Botts Dots, Left Departure, Visual Warning



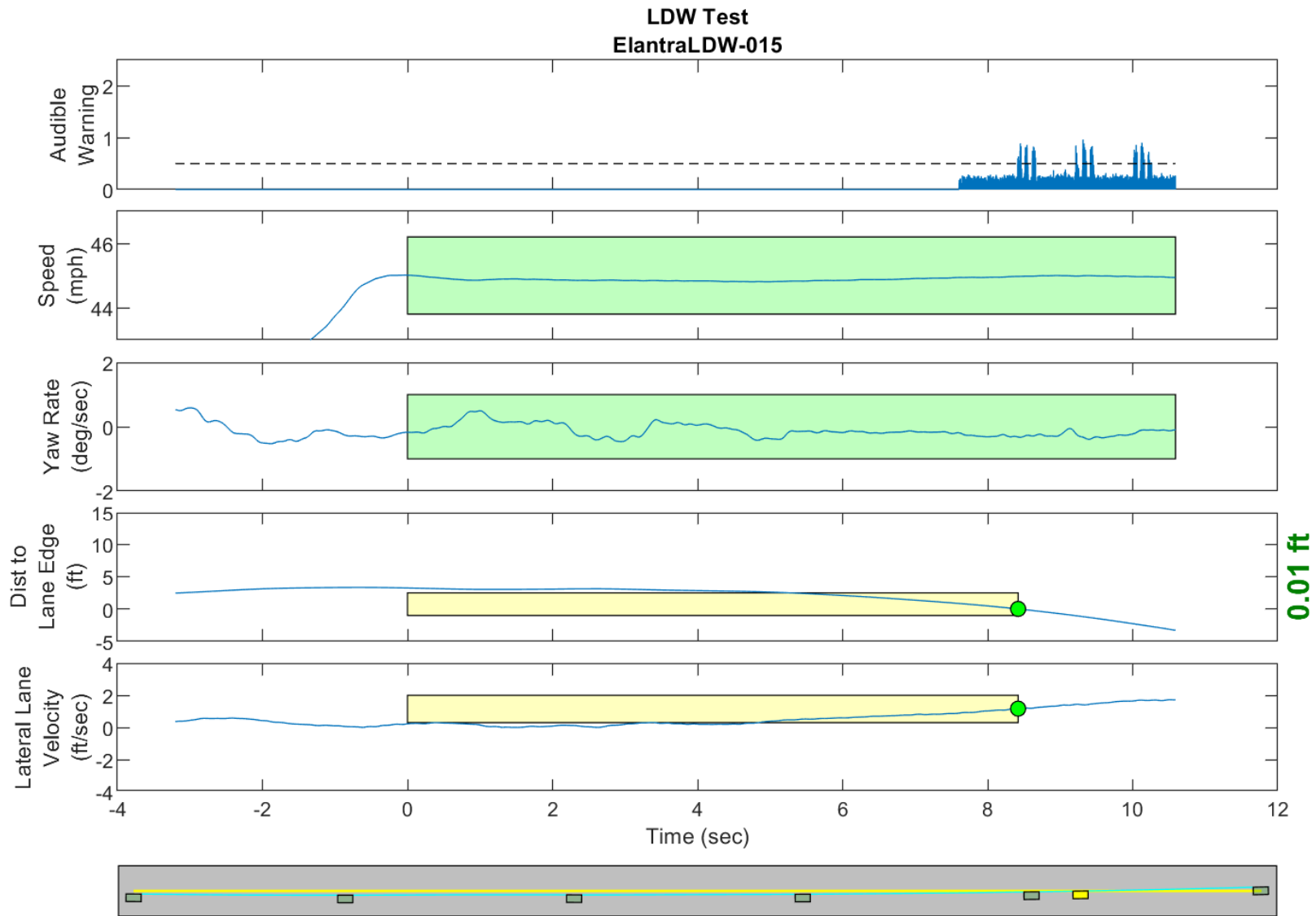
GPS Fix Type: RTK Fixed

Figure D22. Time History for Run 14, Botts Dots, Left Departure, Audible Warning



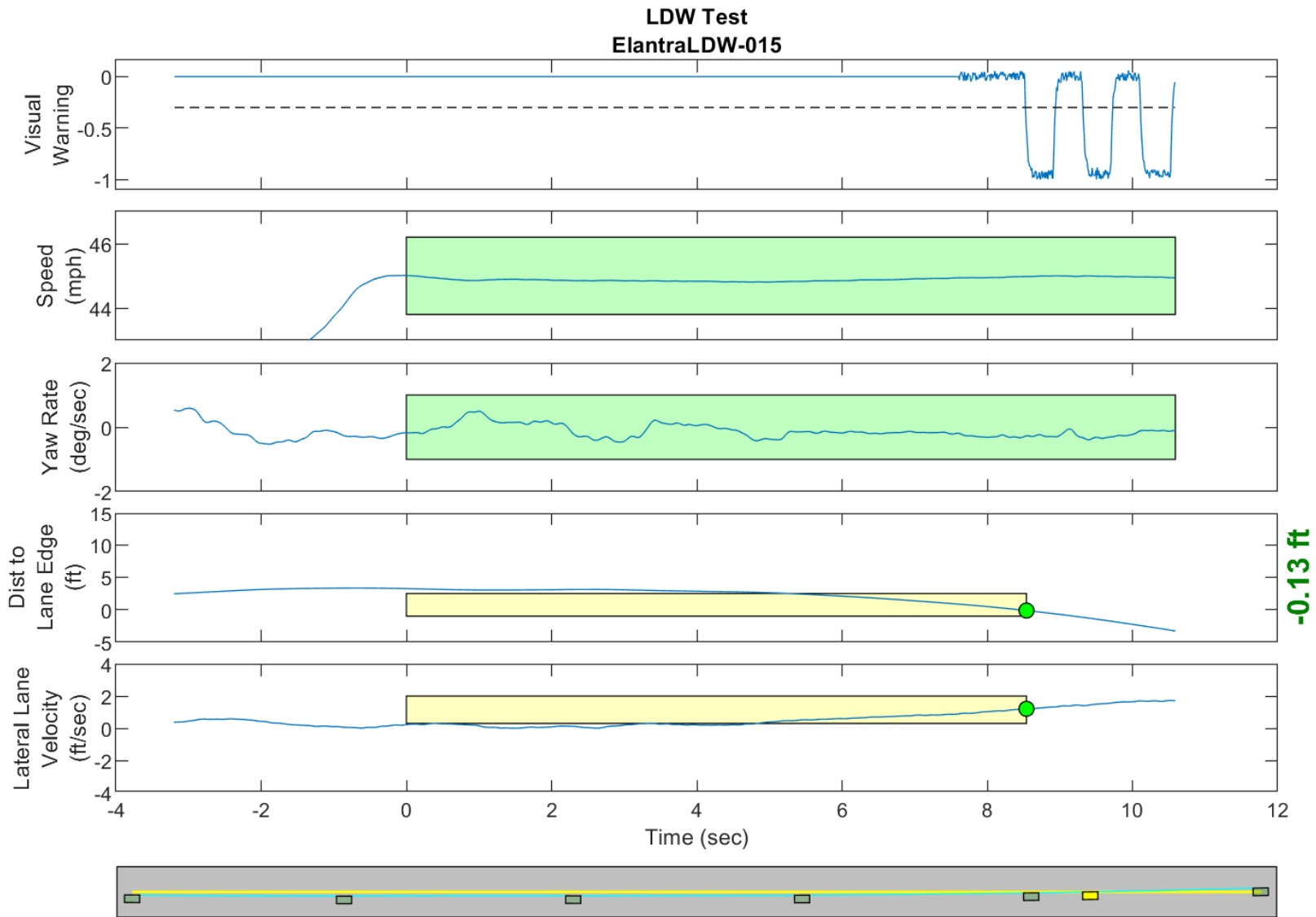
GPS Fix Type: RTK Fixed

Figure D23. Time History for Run 14, Botts Dots, Left Departure, Visual Warning



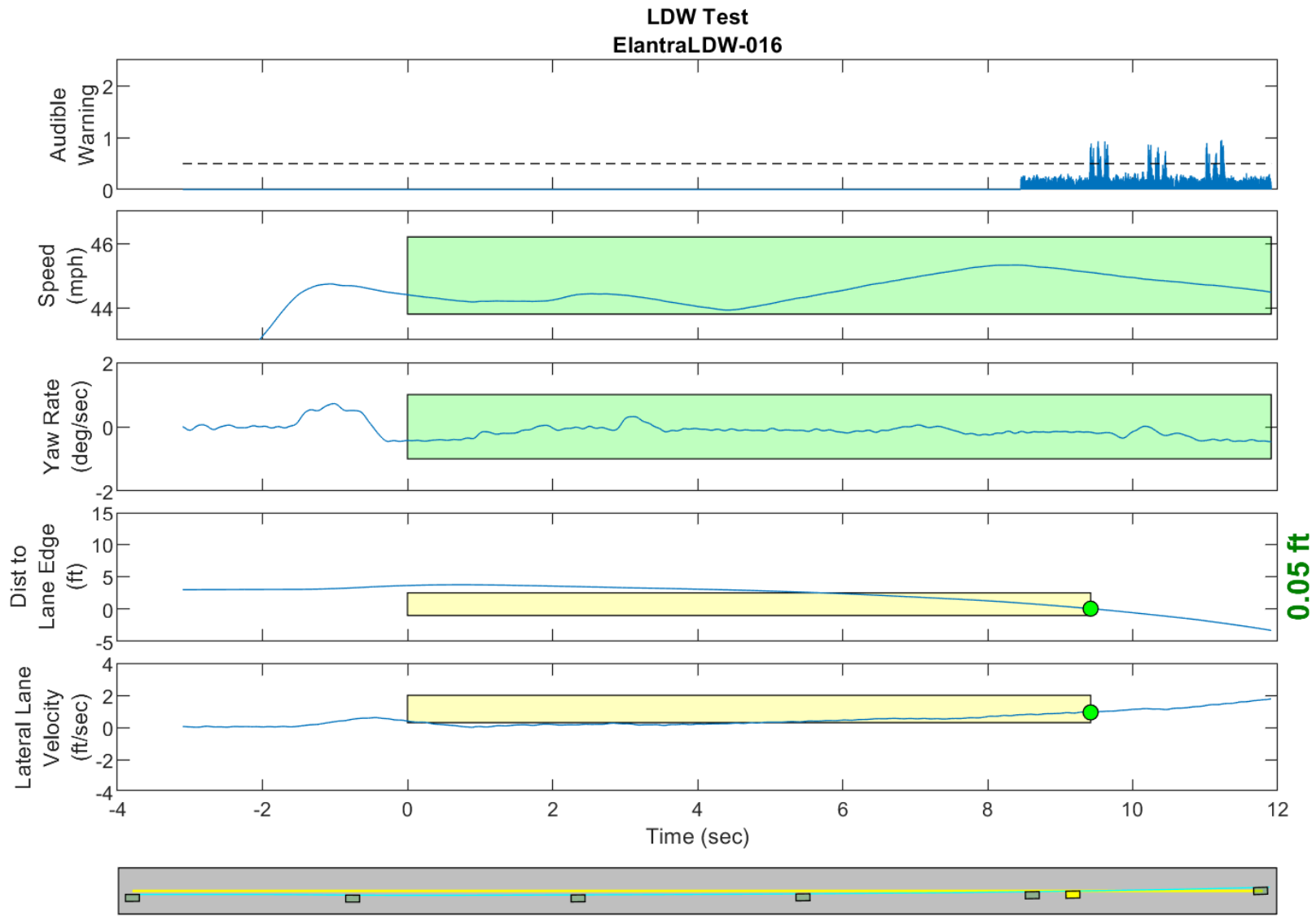
GPS Fix Type: RTK Fixed

Figure D24. Time History for Run 15, Botts Dots, Left Departure, Audible Warning



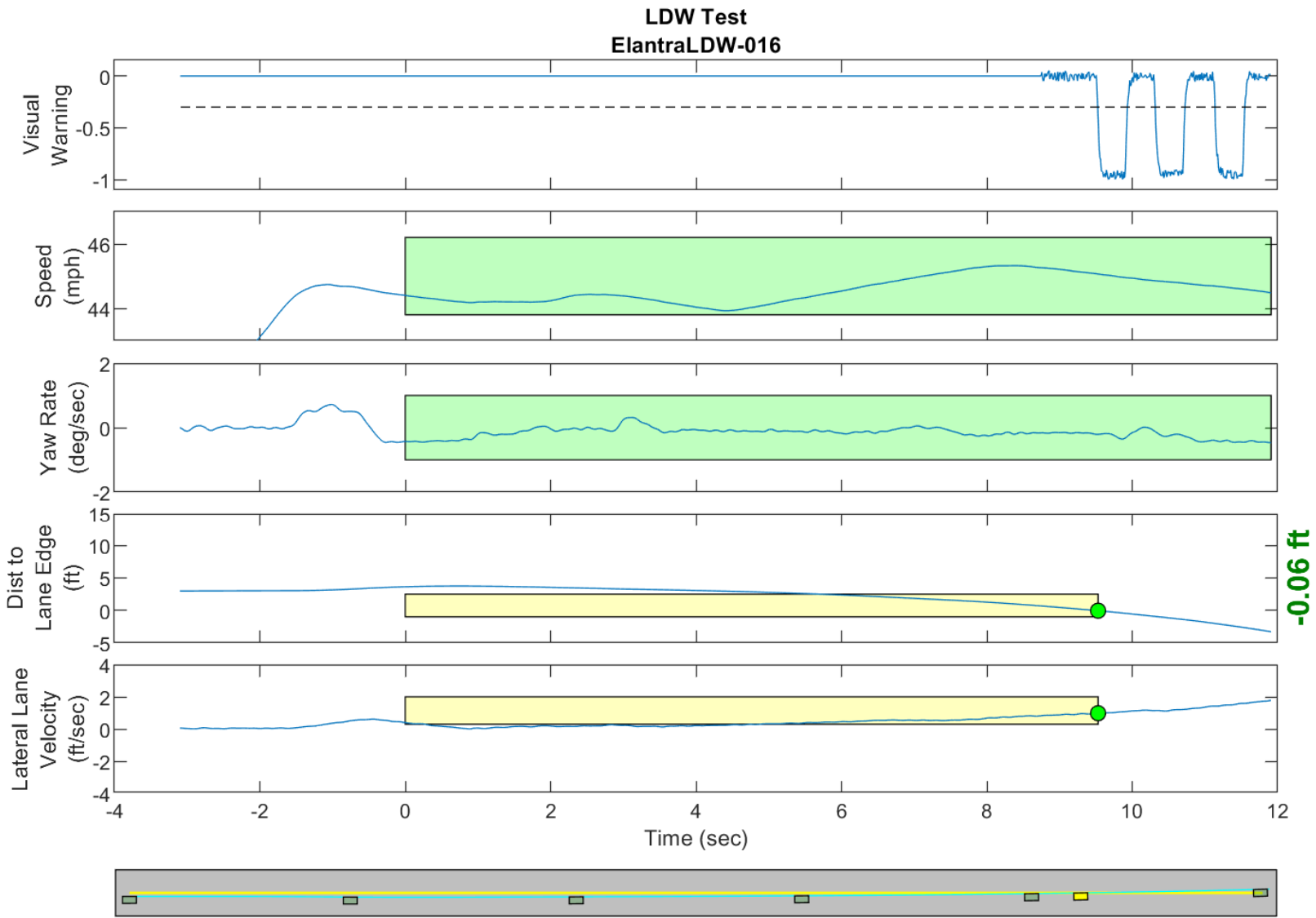
GPS Fix Type: RTK Fixed

Figure D25. Time History for Run 15, Botts Dots, Left Departure, Visual Warning



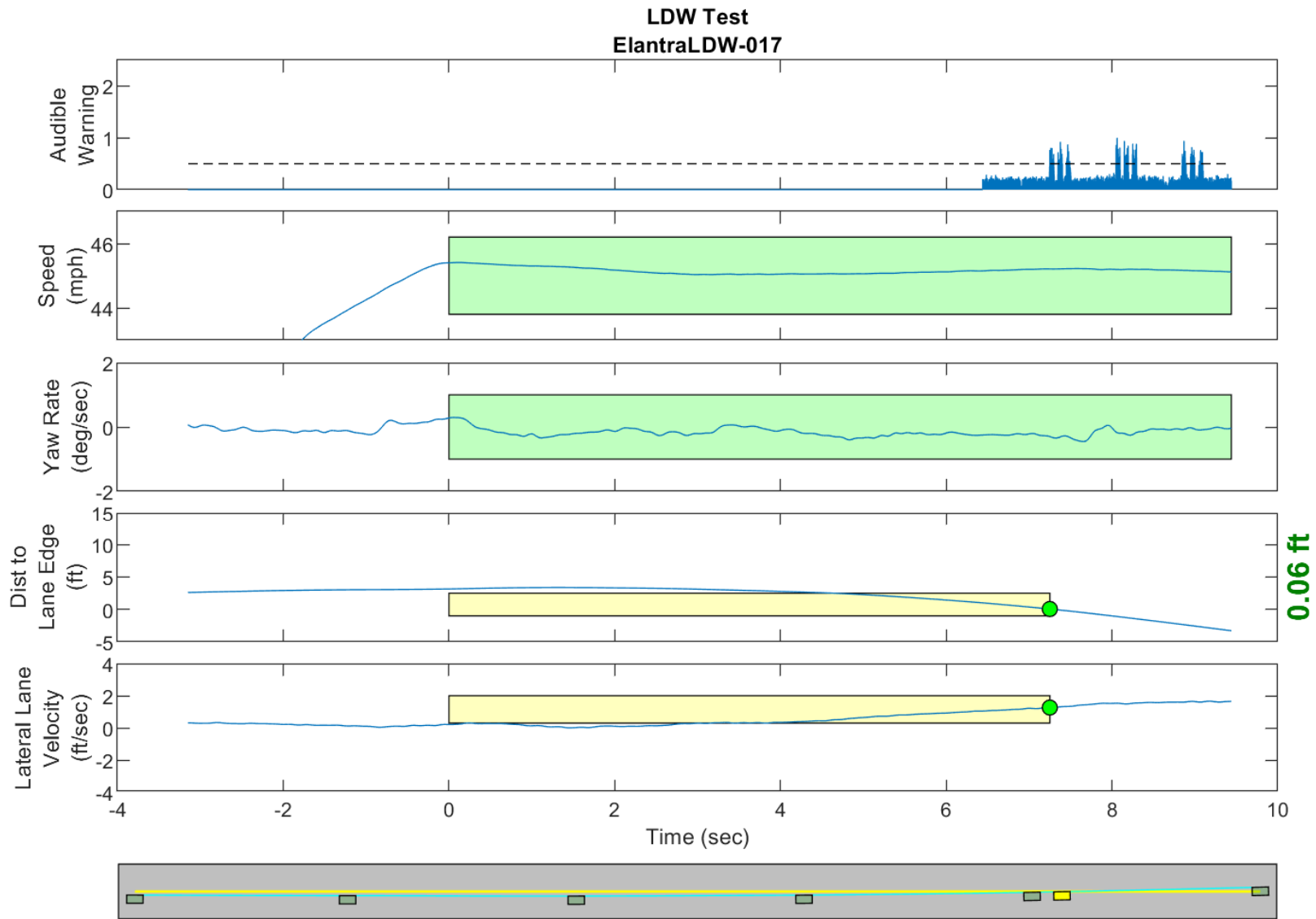
GPS Fix Type: RTK Fixed

Figure D26. Time History for Run 16, Botts Dots, Left Departure, Audible Warning



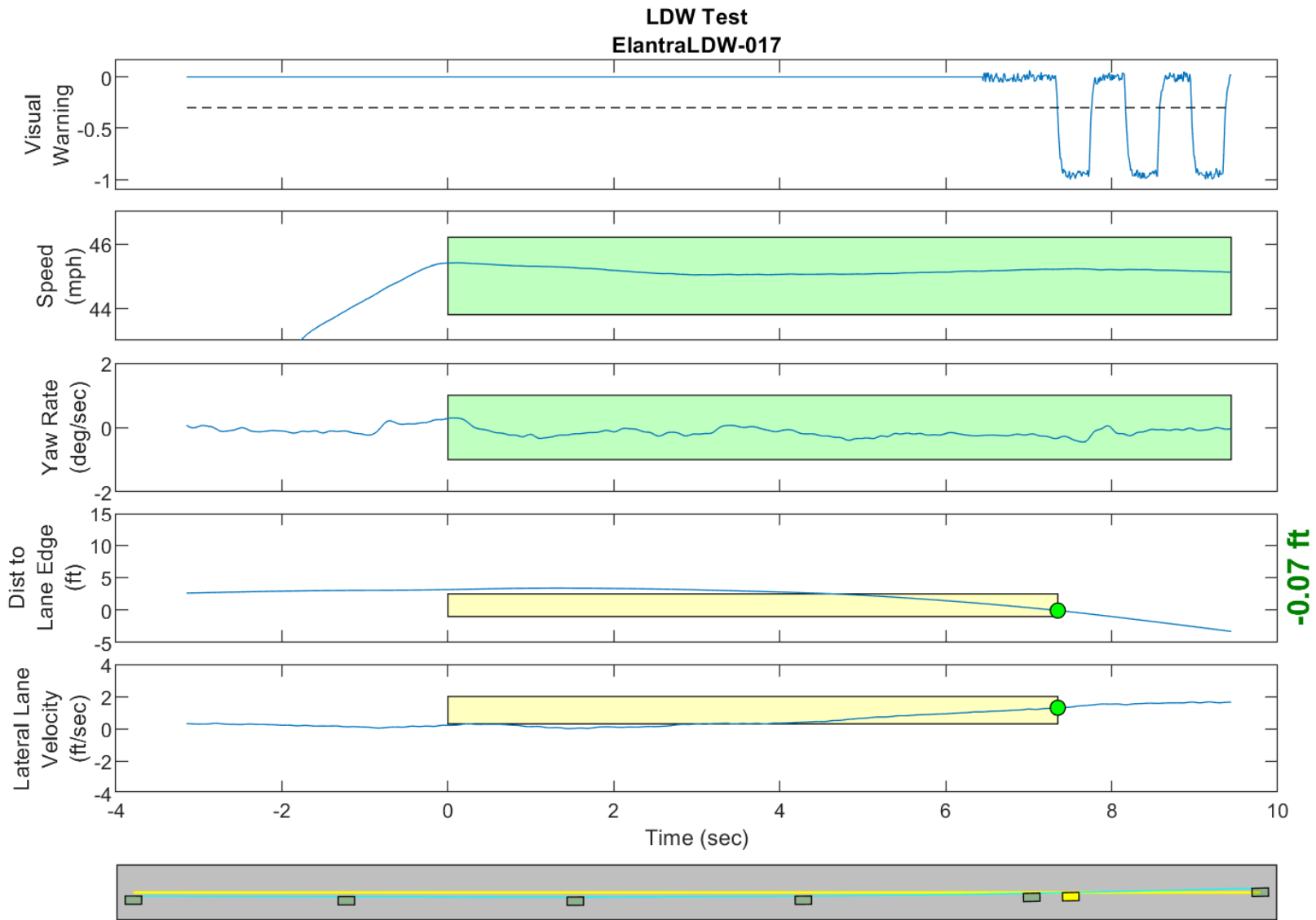
GPS Fix Type: RTK Fixed

Figure D27. Time History for Run 16, Botts Dots, Left Departure, Visual Warning



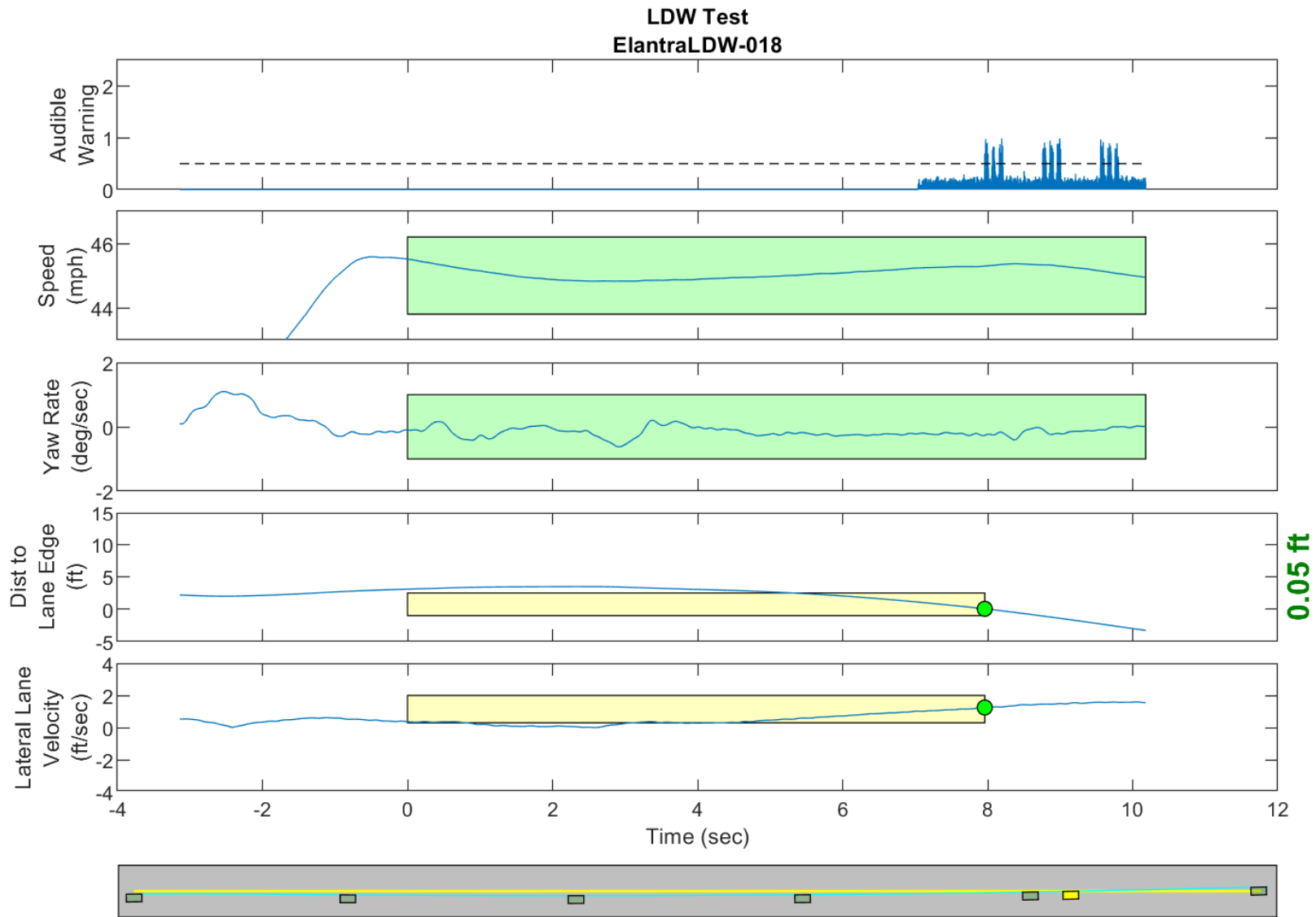
GPS Fix Type: RTK Fixed

Figure D28. Time History for Run 17, Botts Dots, Left Departure, Audible Warning



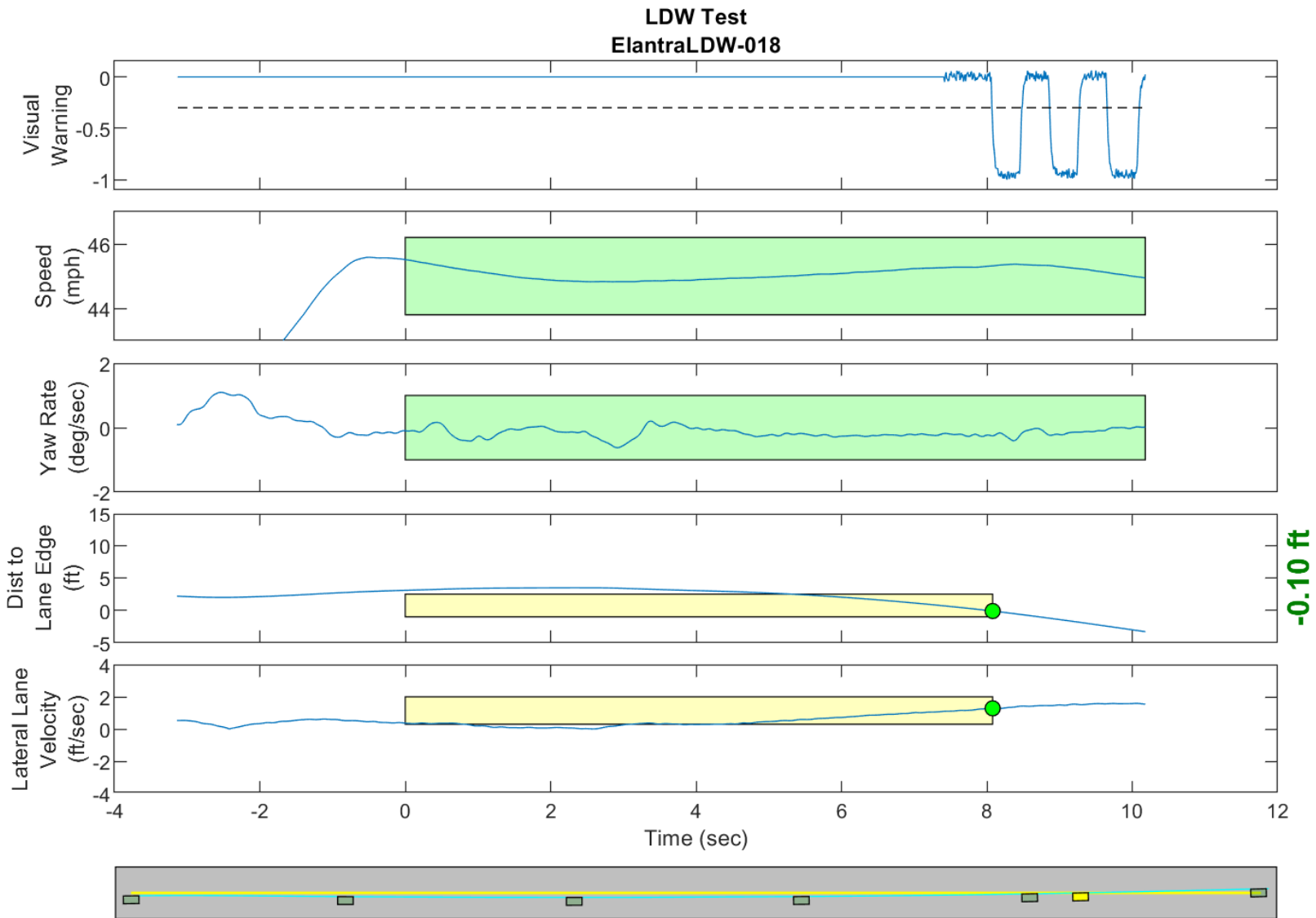
GPS Fix Type: RTK Fixed

Figure D29. Time History for Run 17, Botts Dots, Left Departure, Visual Warning



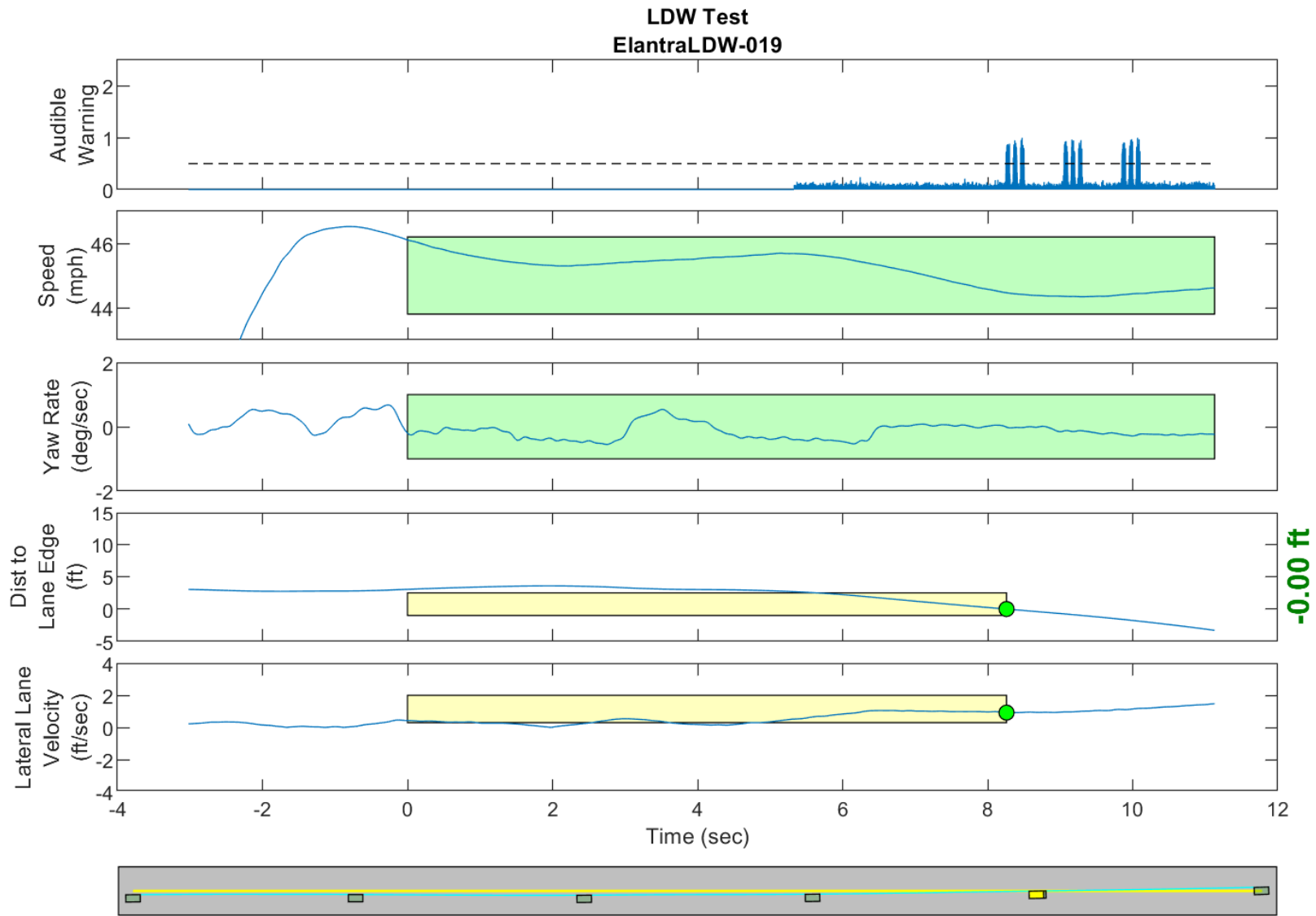
GPS Fix Type: RTK Fixed

Figure D30. Time History for Run 18, Botts Dots, Left Departure, Audible Warning



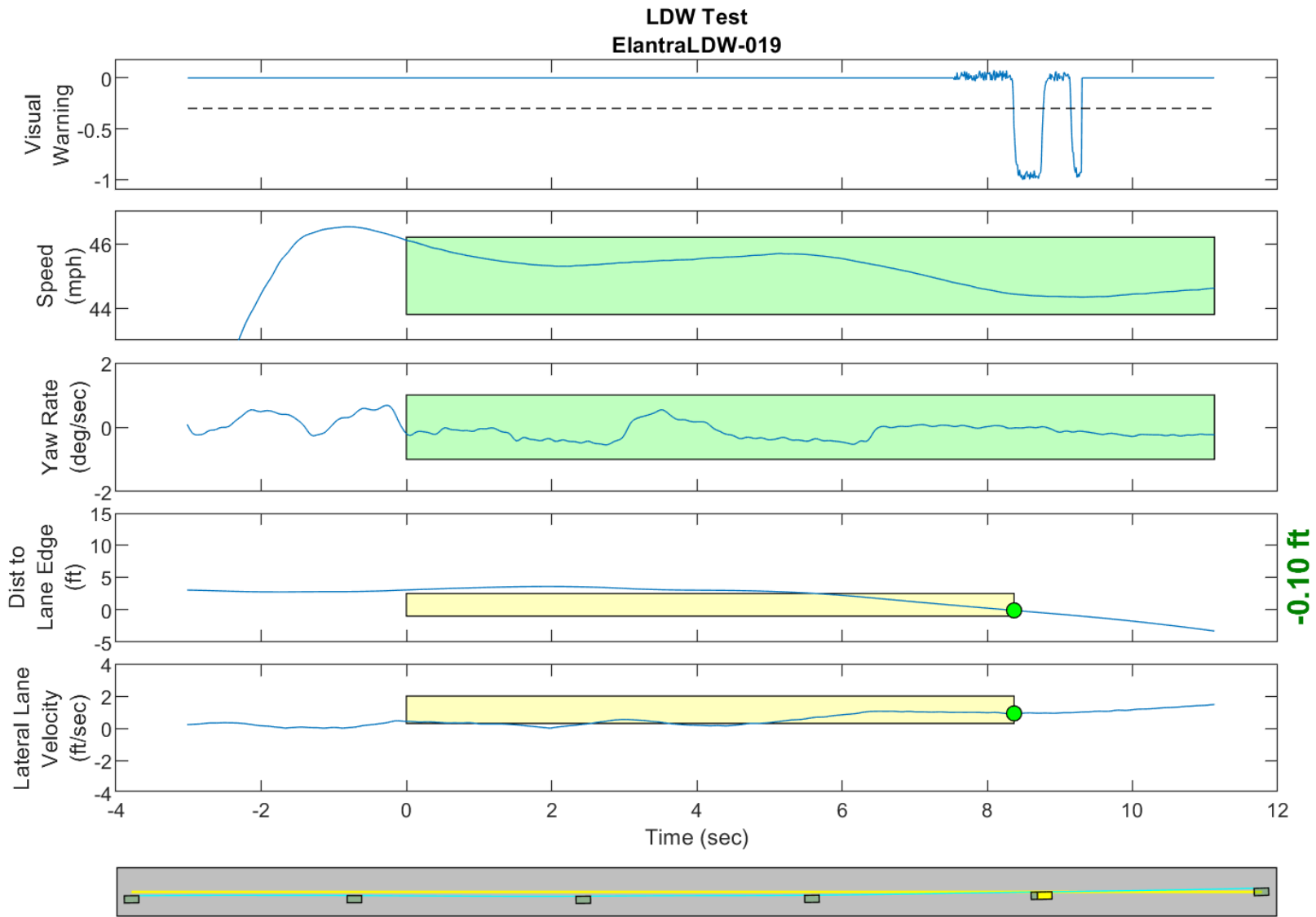
GPS Fix Type: RTK Fixed

Figure D31. Time History for Run 18, Botts Dots, Left Departure, Visual Warning



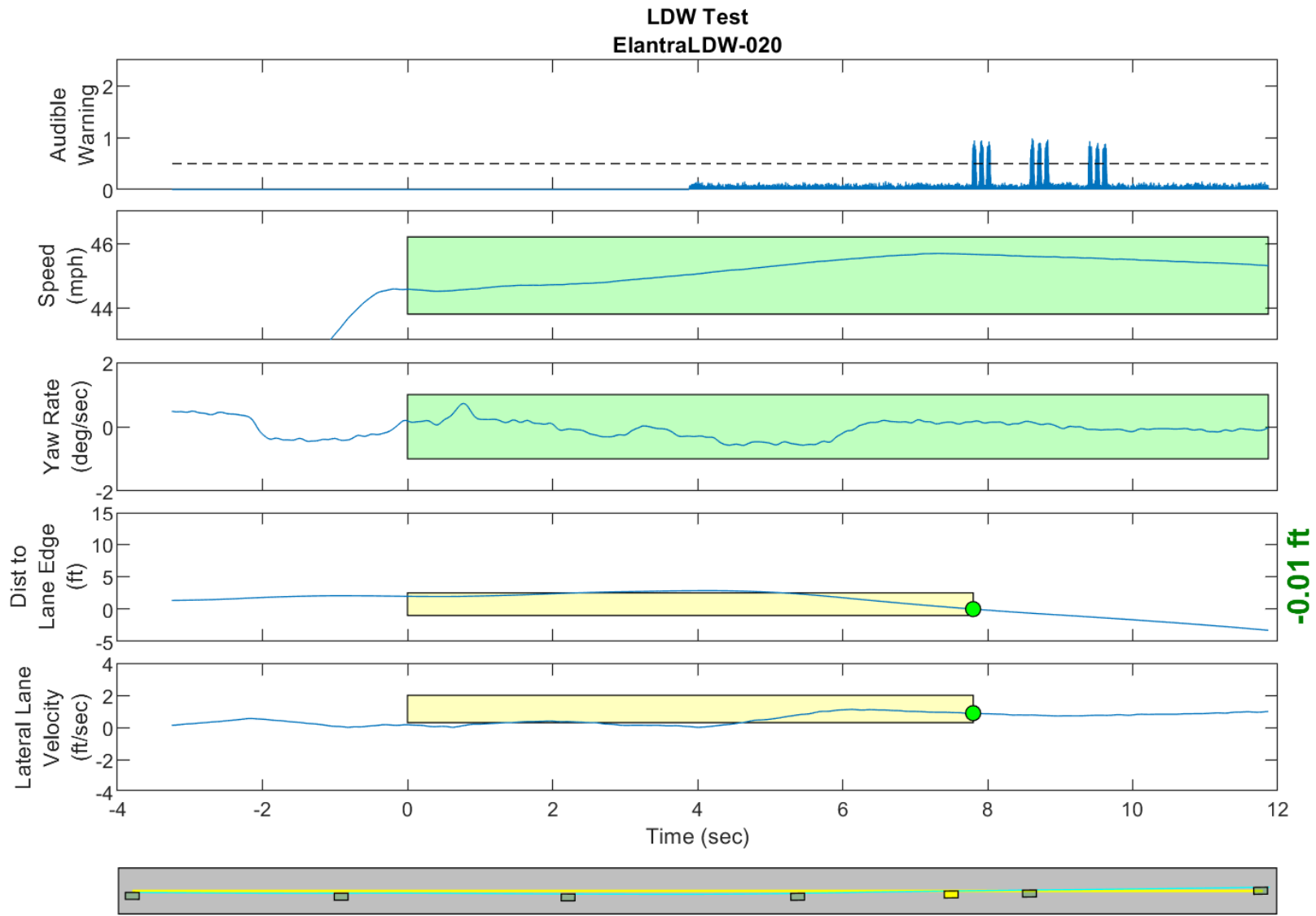
GPS Fix Type: RTK Fixed

Figure D32. Time History for Run 19, Solid Line, Left Departure, Audible Warning



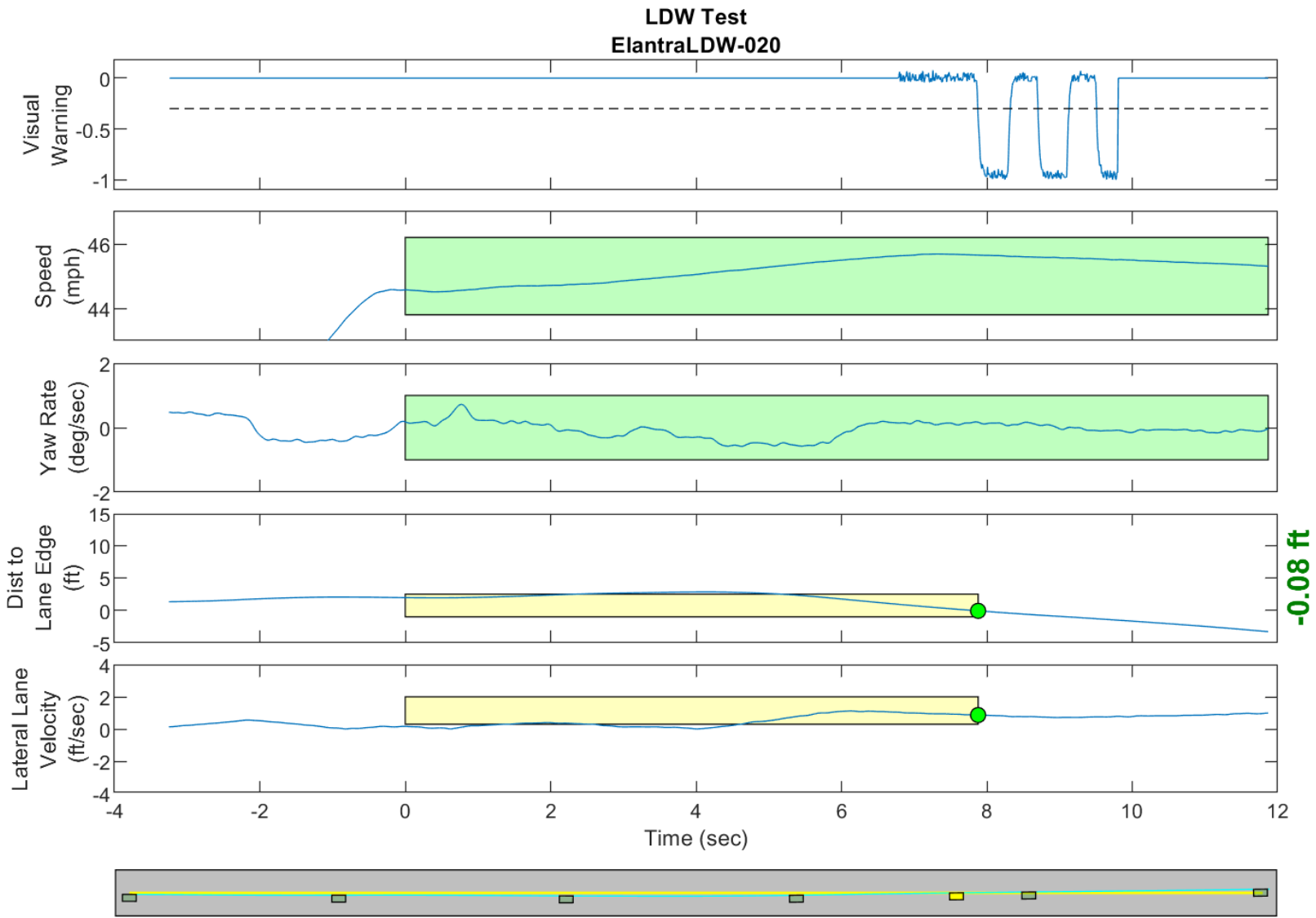
GPS Fix Type: RTK Fixed

Figure D33. Time History for Run 19, Solid Line, Left Departure, Visual Warning



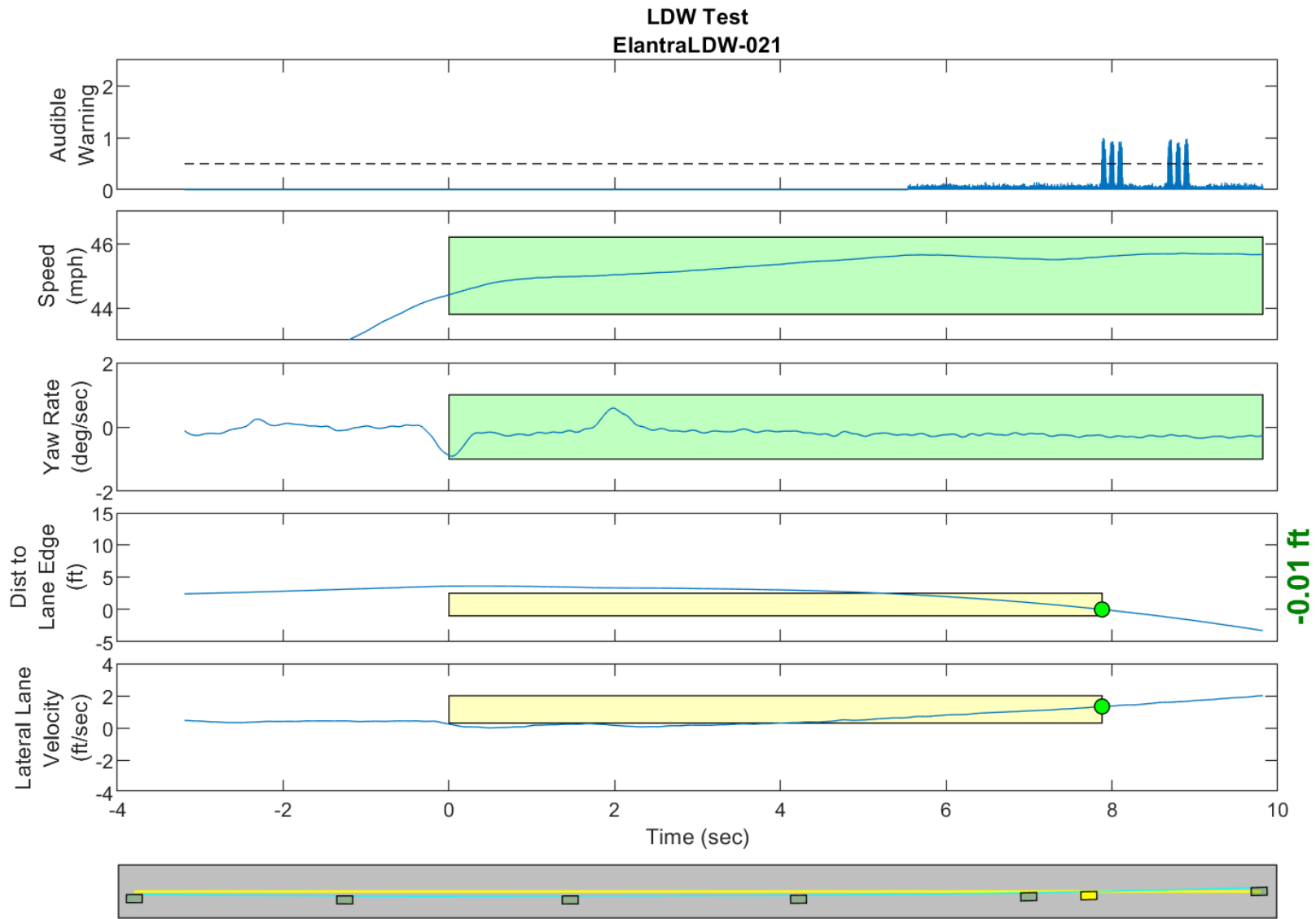
GPS Fix Type: RTK Fixed

Figure D34. Time History for Run 20, Solid Line, Left Departure, Audible Warning



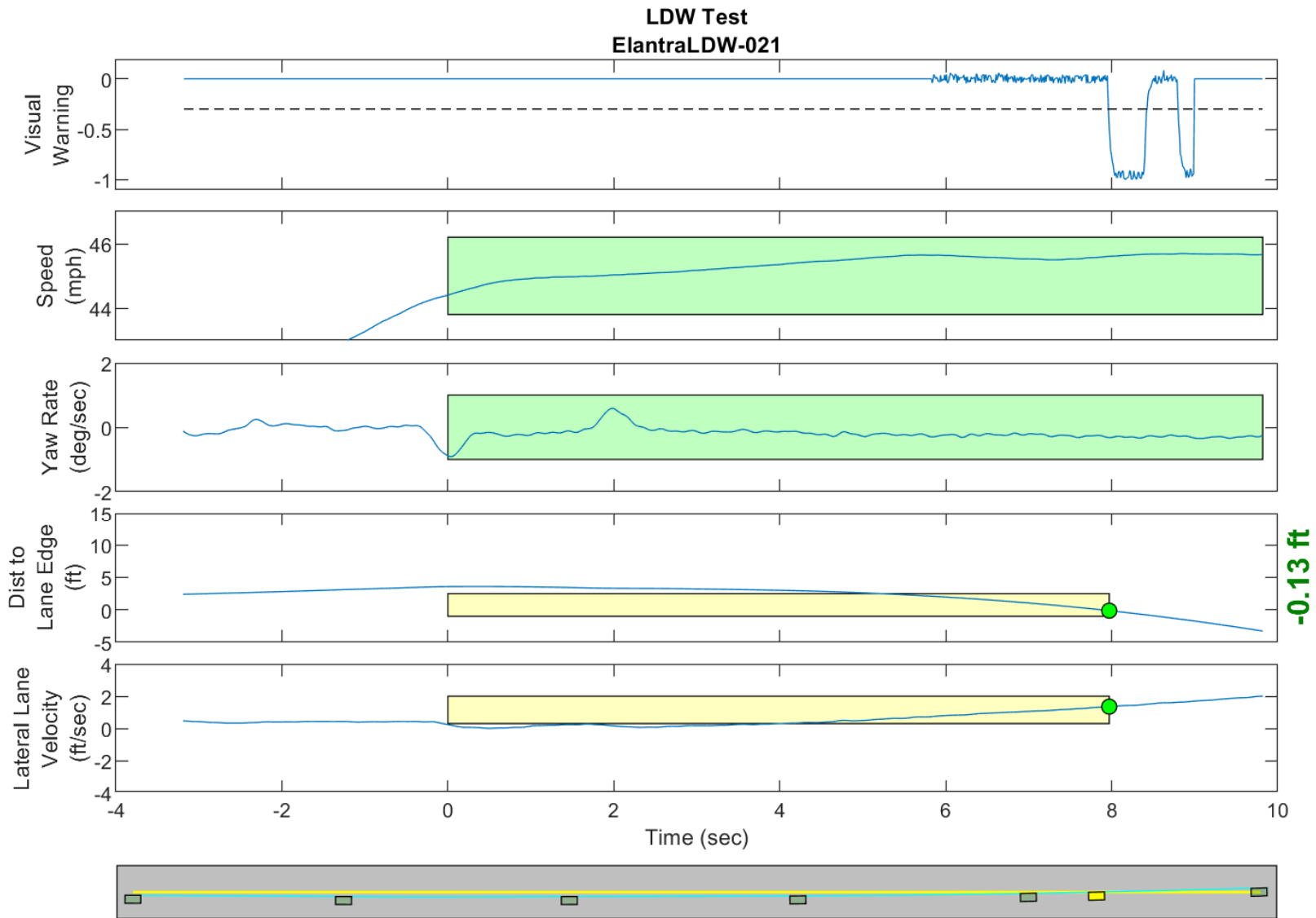
GPS Fix Type: RTK Fixed

Figure D35. Time History for Run 20, Solid Line, Left Departure, Visual Warning



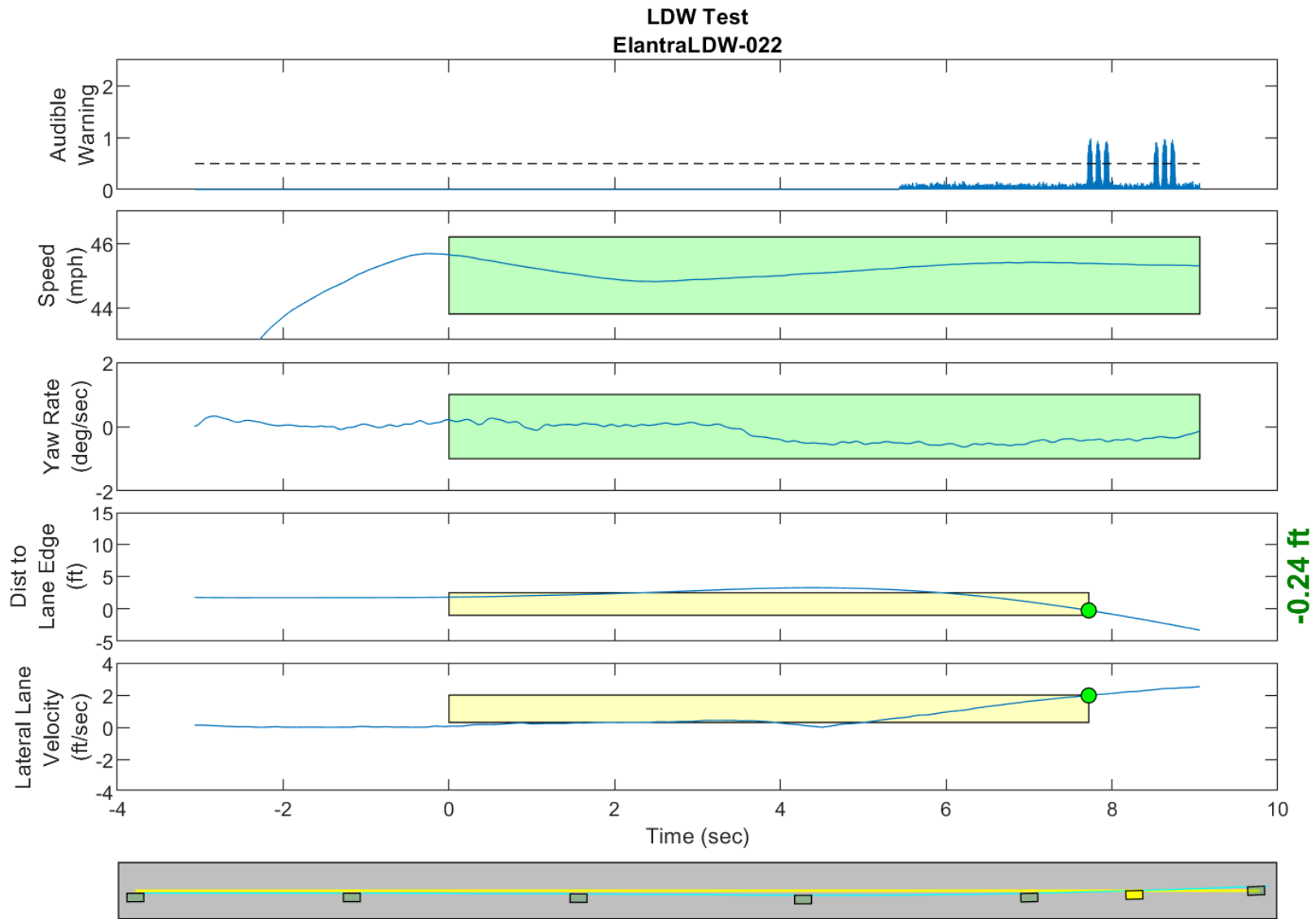
GPS Fix Type: RTK Fixed

Figure D36. Time History for Run 21, Solid Line, Left Departure, Audible Warning



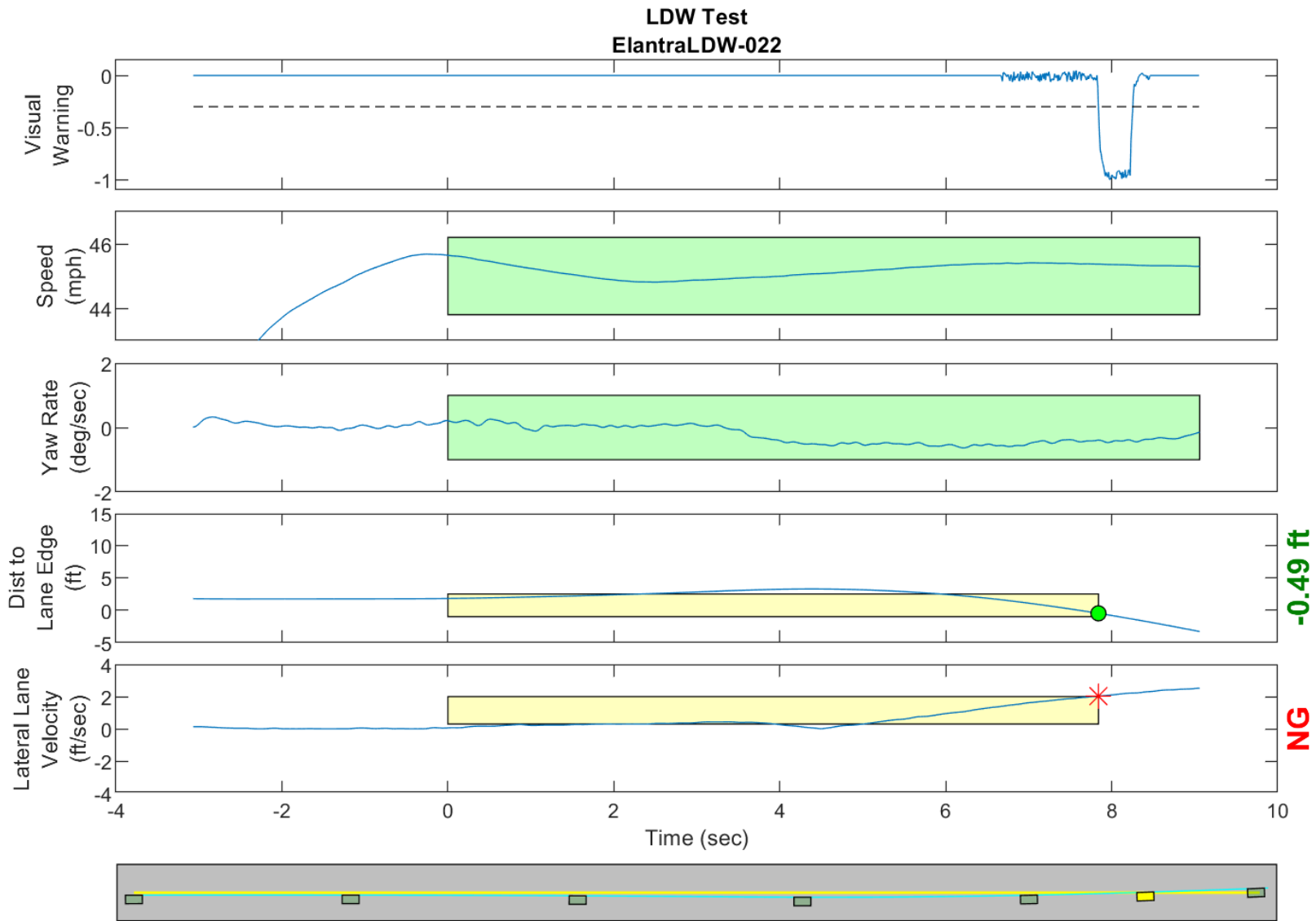
GPS Fix Type: RTK Fixed

Figure D37. Time History for Run 21, Solid Line, Left Departure, Visual Warning



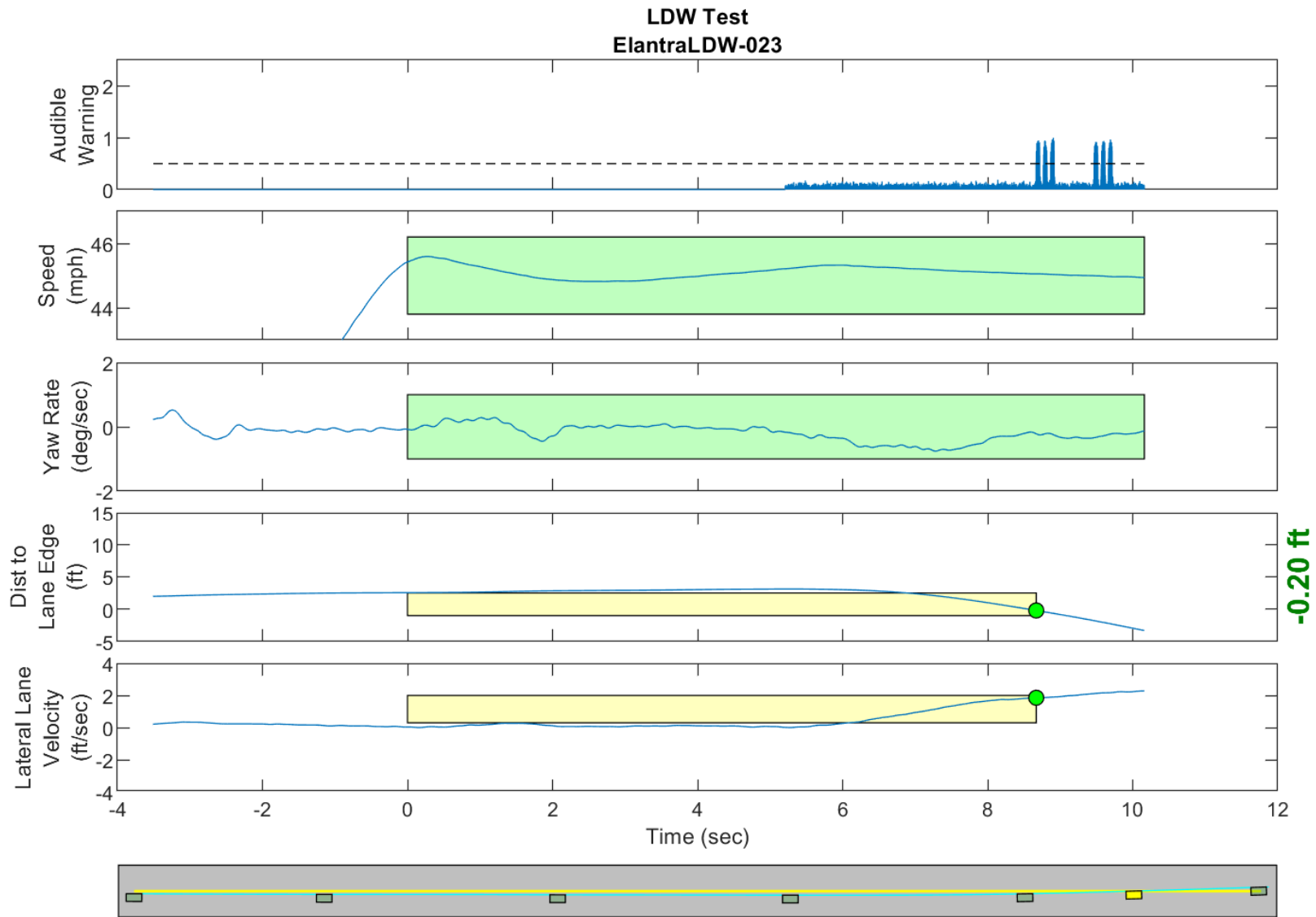
GPS Fix Type: RTK Fixed

Figure D38. Time History for Run 22, Solid Line, Left Departure, Audible Warning



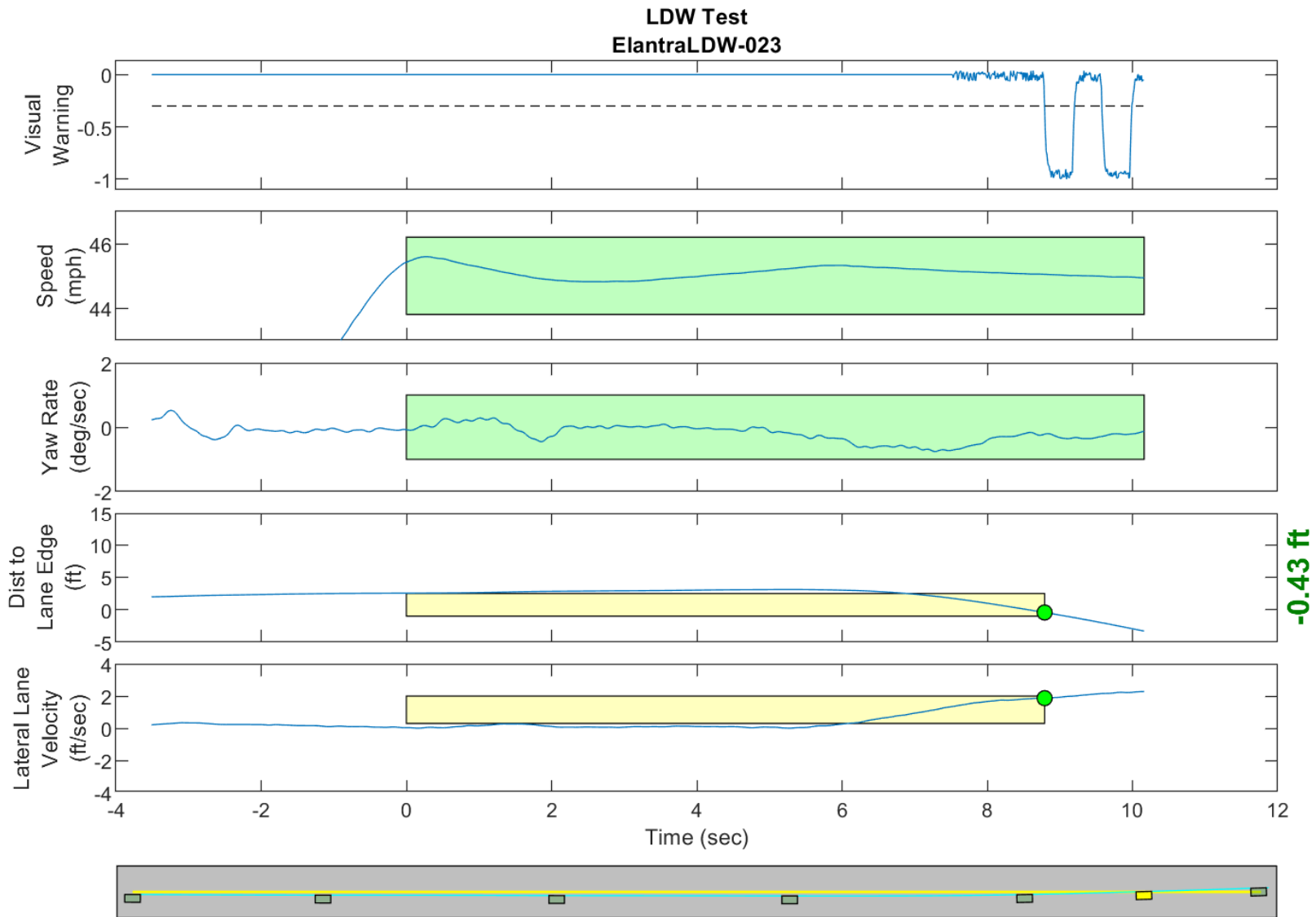
GPS Fix Type: RTK Fixed

Figure D39. Time History for Run 22, Solid Line, Left Departure, Visual Warning



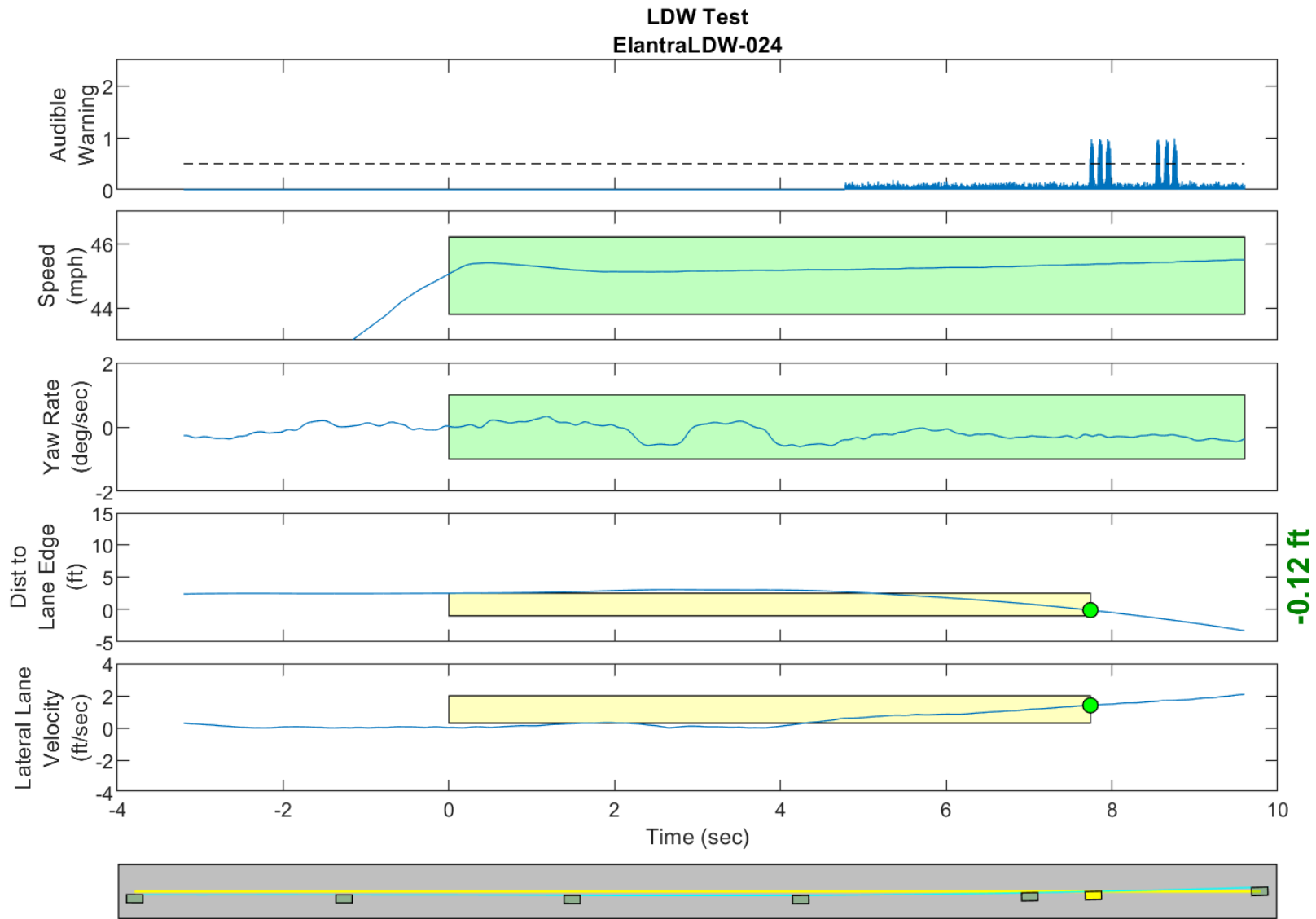
GPS Fix Type: RTK Fixed

Figure D40. Time History for Run 23, Solid Line, Left Departure, Audible Warning



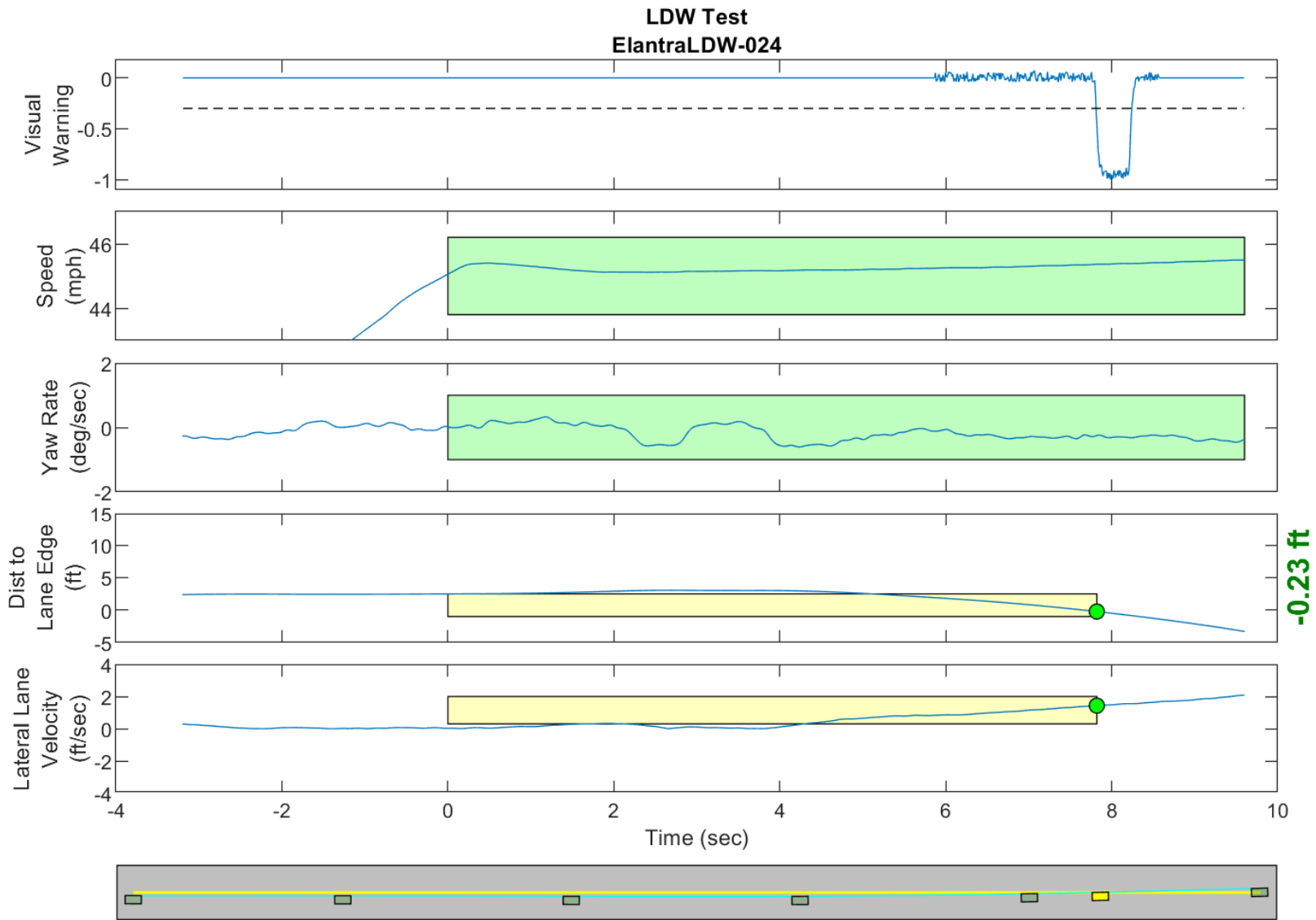
GPS Fix Type: RTK Fixed

Figure D41. Time History for Run 23, Solid Line, Left Departure, Visual Warning



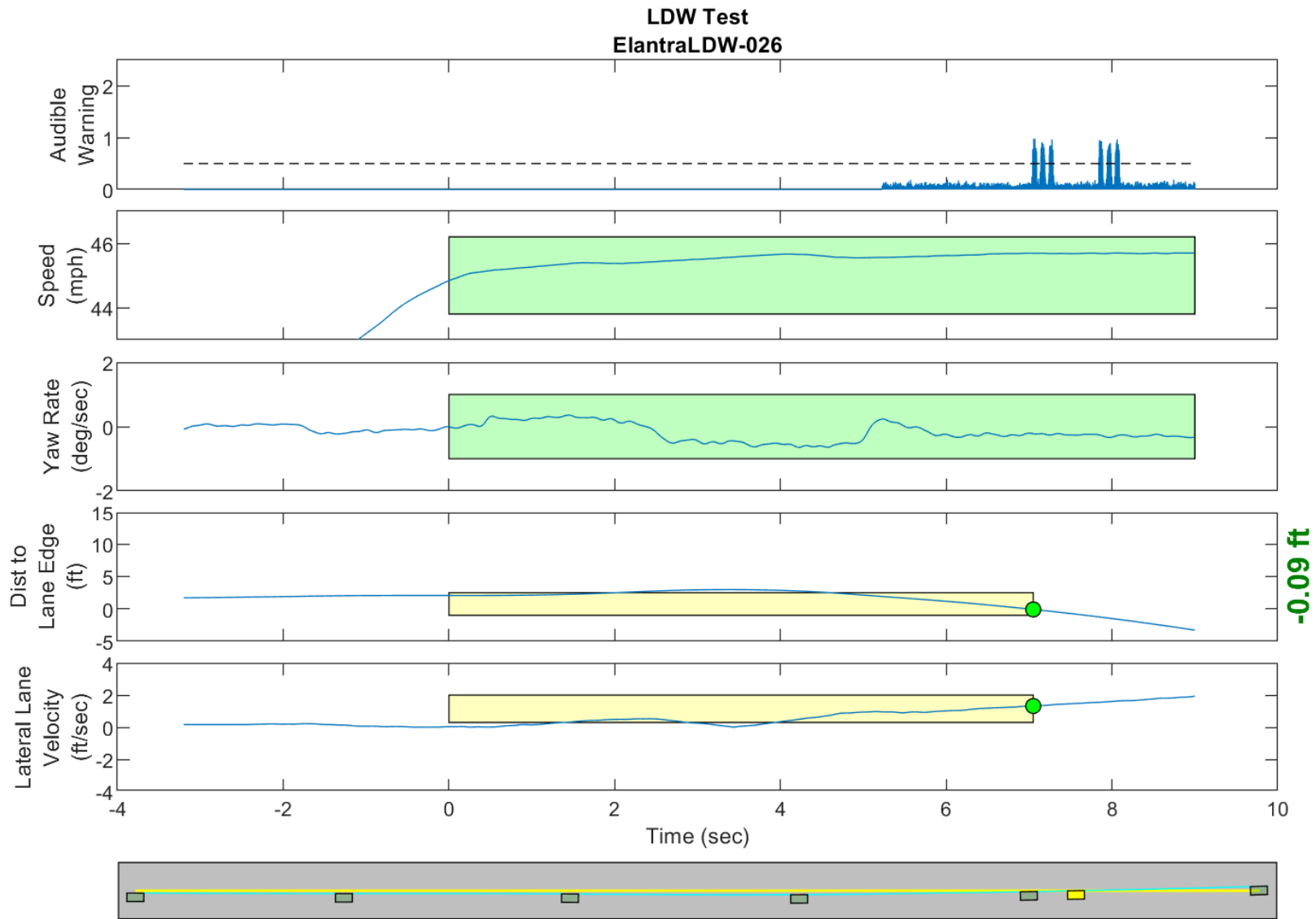
GPS Fix Type: RTK Fixed

Figure D42. Time History for Run 24, Solid Line, Left Departure, Audible Warning



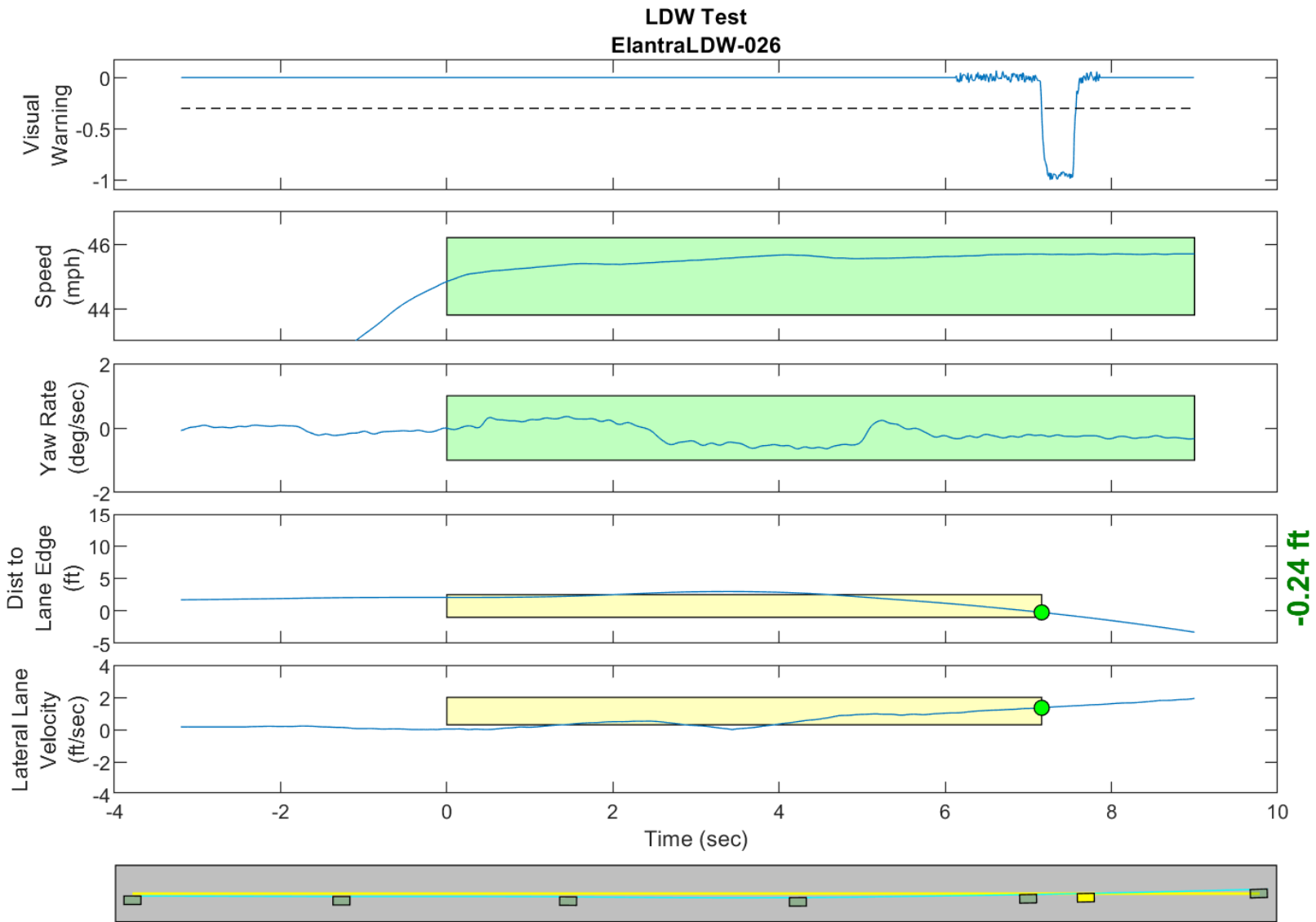
GPS Fix Type: RTK Fixed

Figure D43. Time History for Run 24, Solid Line, Left Departure, Visual Warning



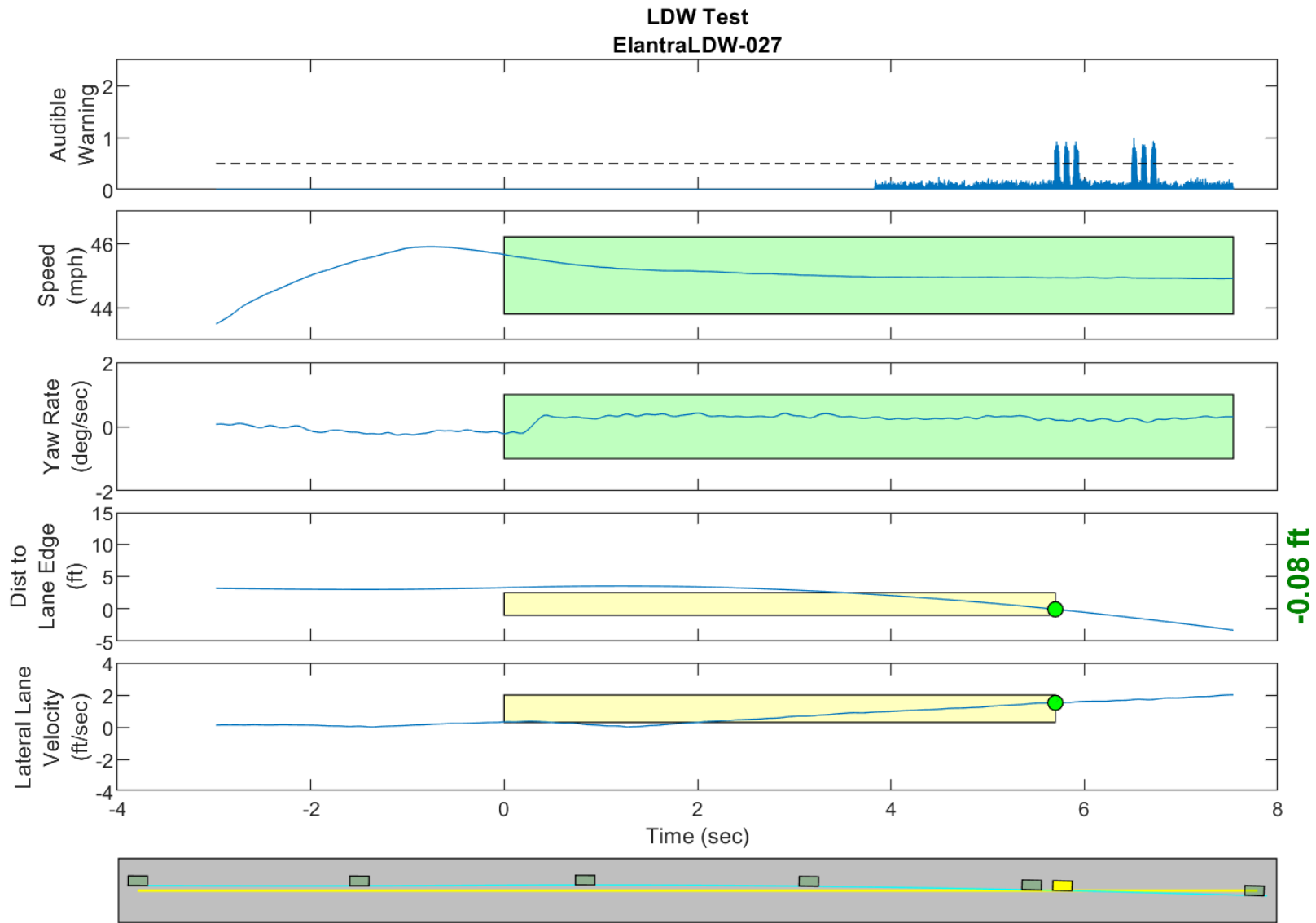
GPS Fix Type: RTK Fixed

Figure D44. Time History for Run 26, Solid Line, Left Departure, Audible Warning



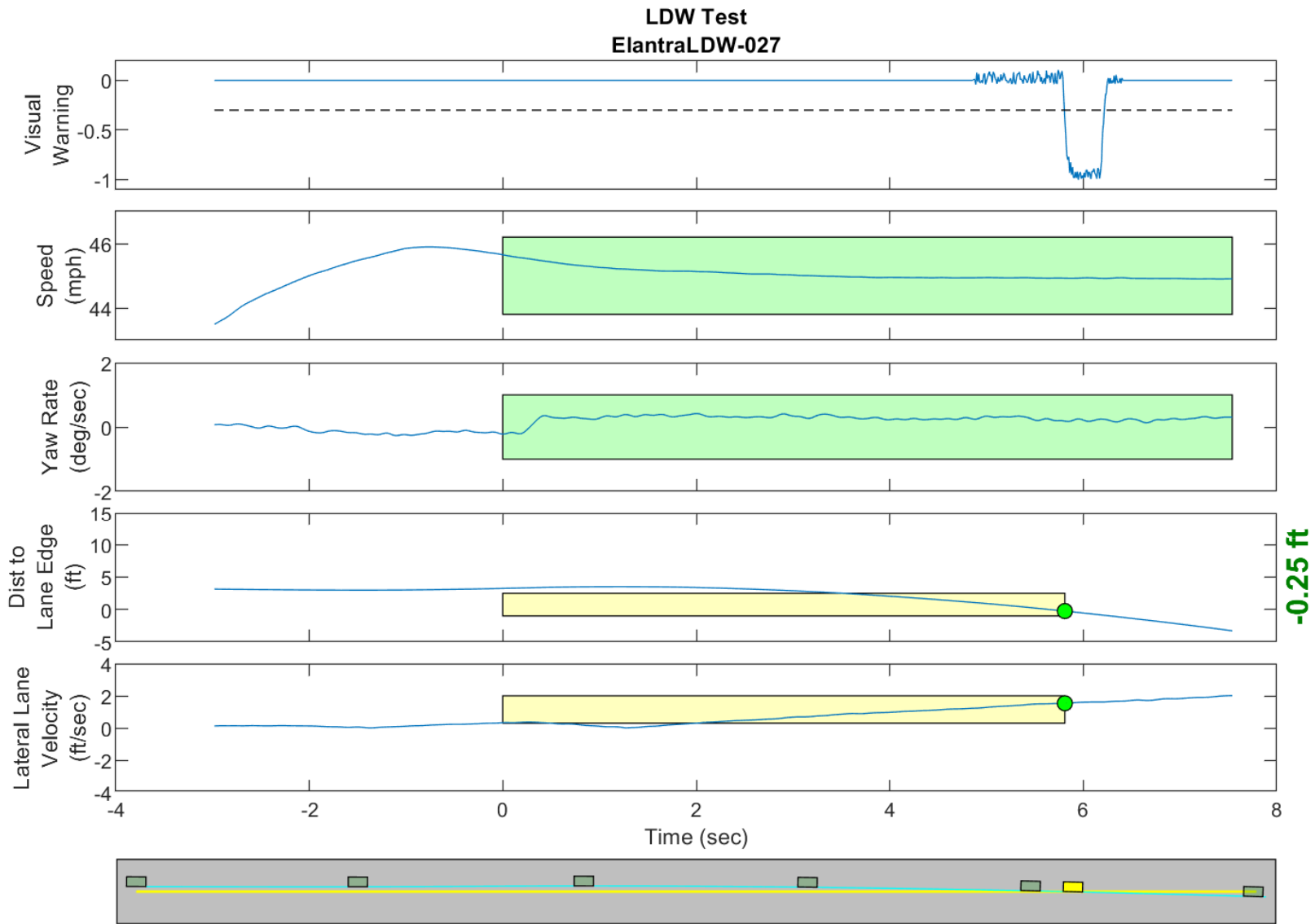
GPS Fix Type: RTK Fixed

Figure D45. Time History for Run 26, Solid Line, Left Departure, Visual Warning



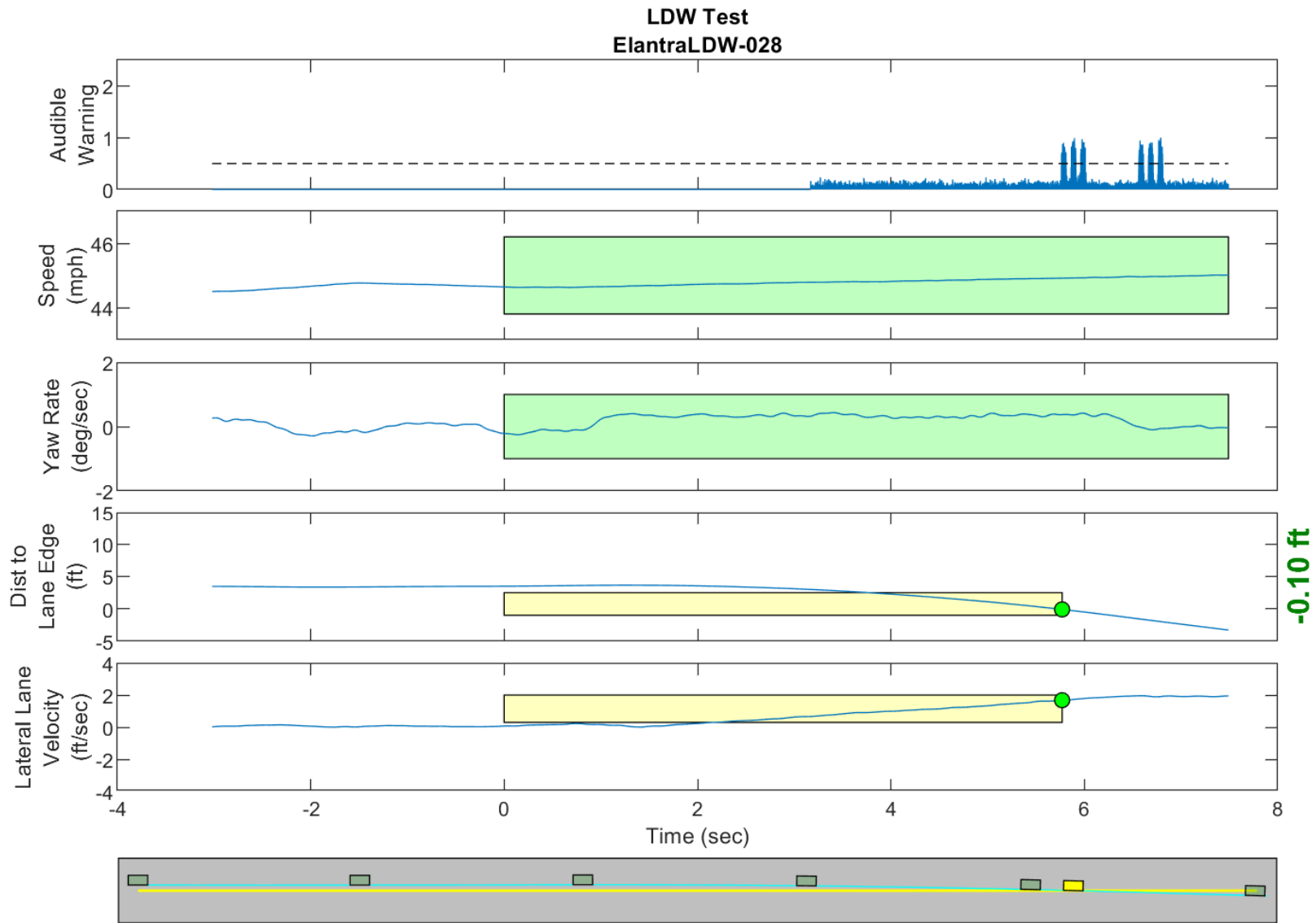
GPS Fix Type: RTK Fixed

Figure D46. Time History for Run 27, Solid Line, Right Departure, Audible Warning



GPS Fix Type: RTK Fixed

Figure D47. Time History for Run 27, Solid Line, Right Departure, Visual Warning



GPS Fix Type: RTK Fixed

Figure D48. Time History for Run 28, Solid Line, Right Departure, Audible Warning

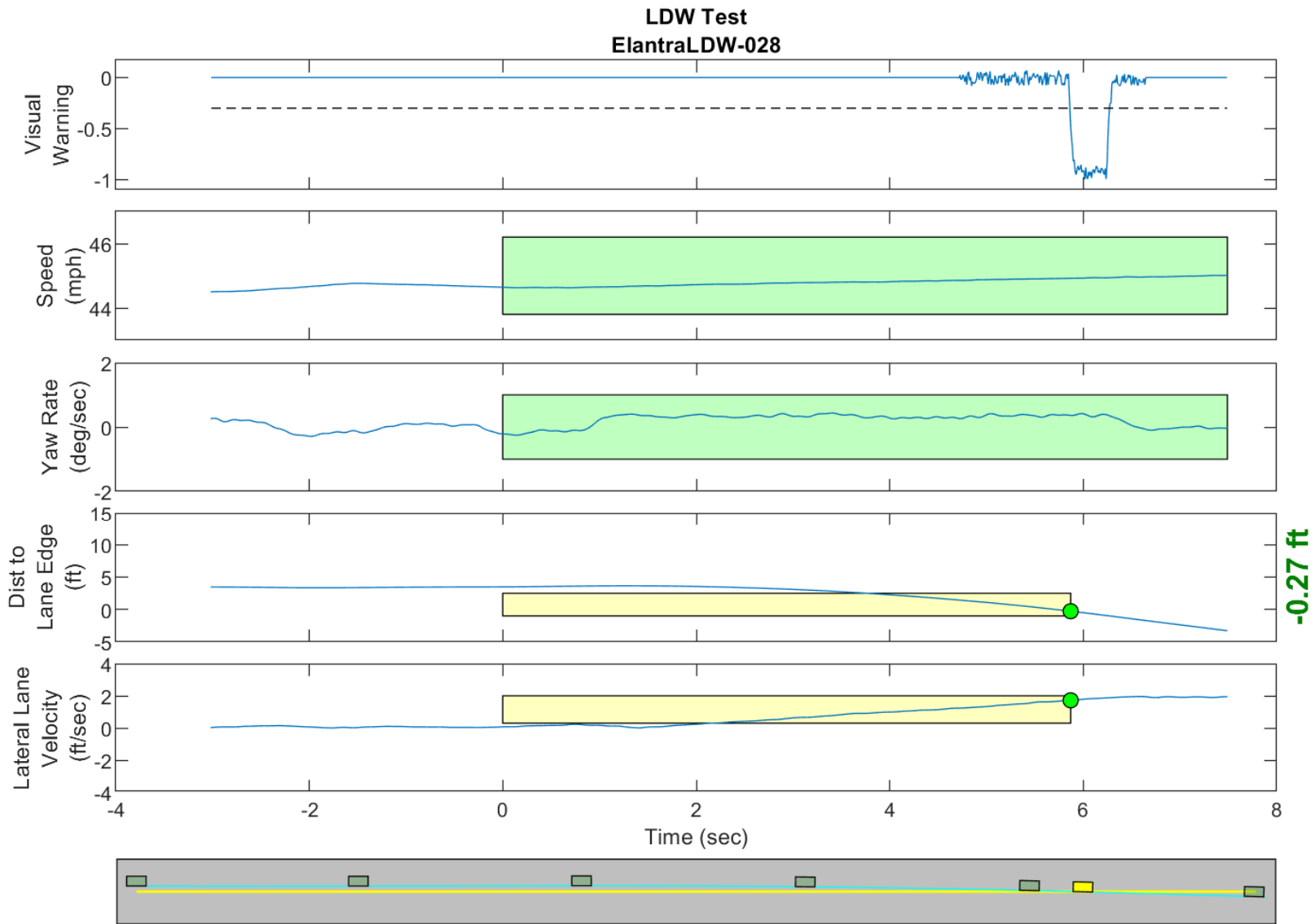
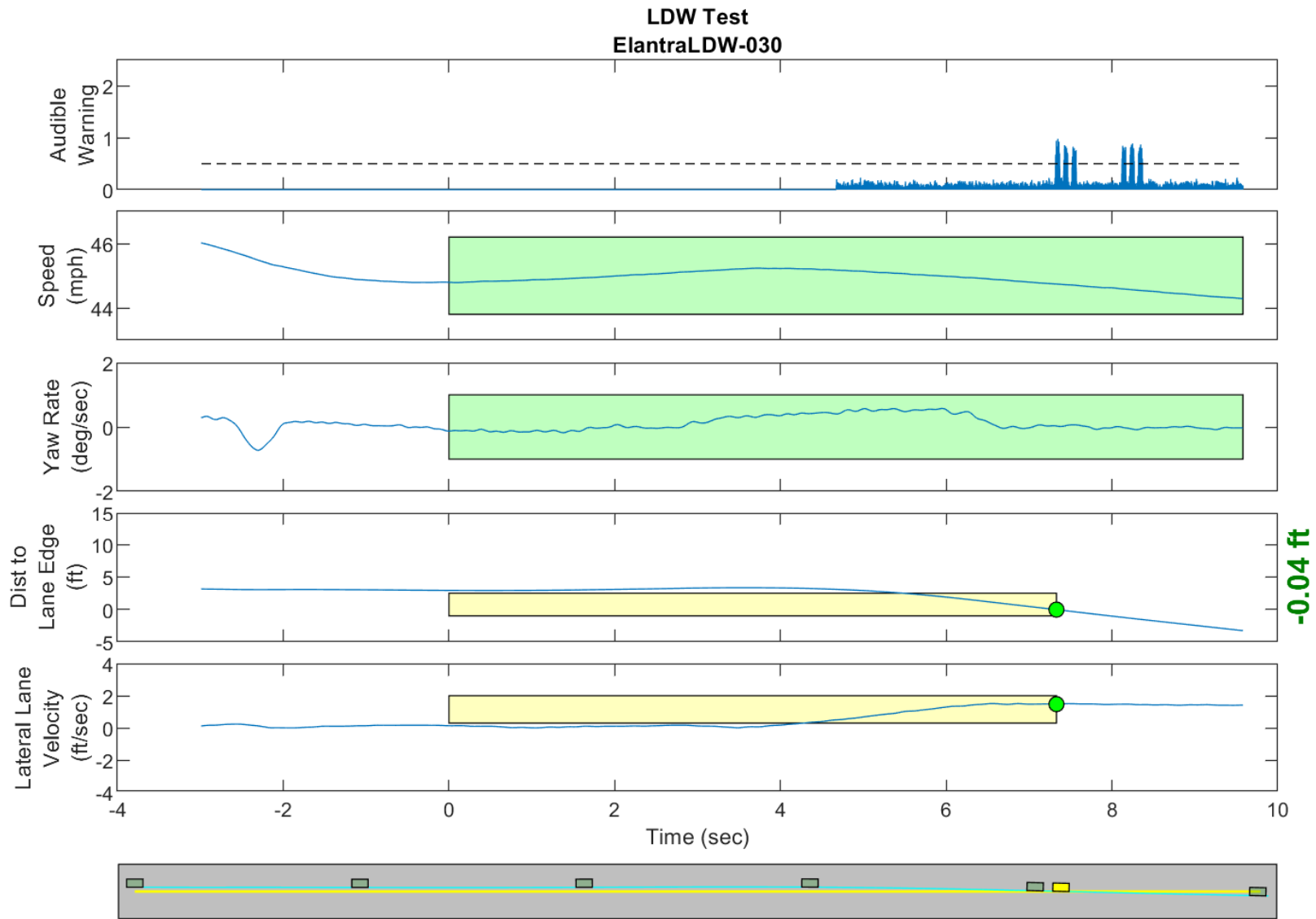
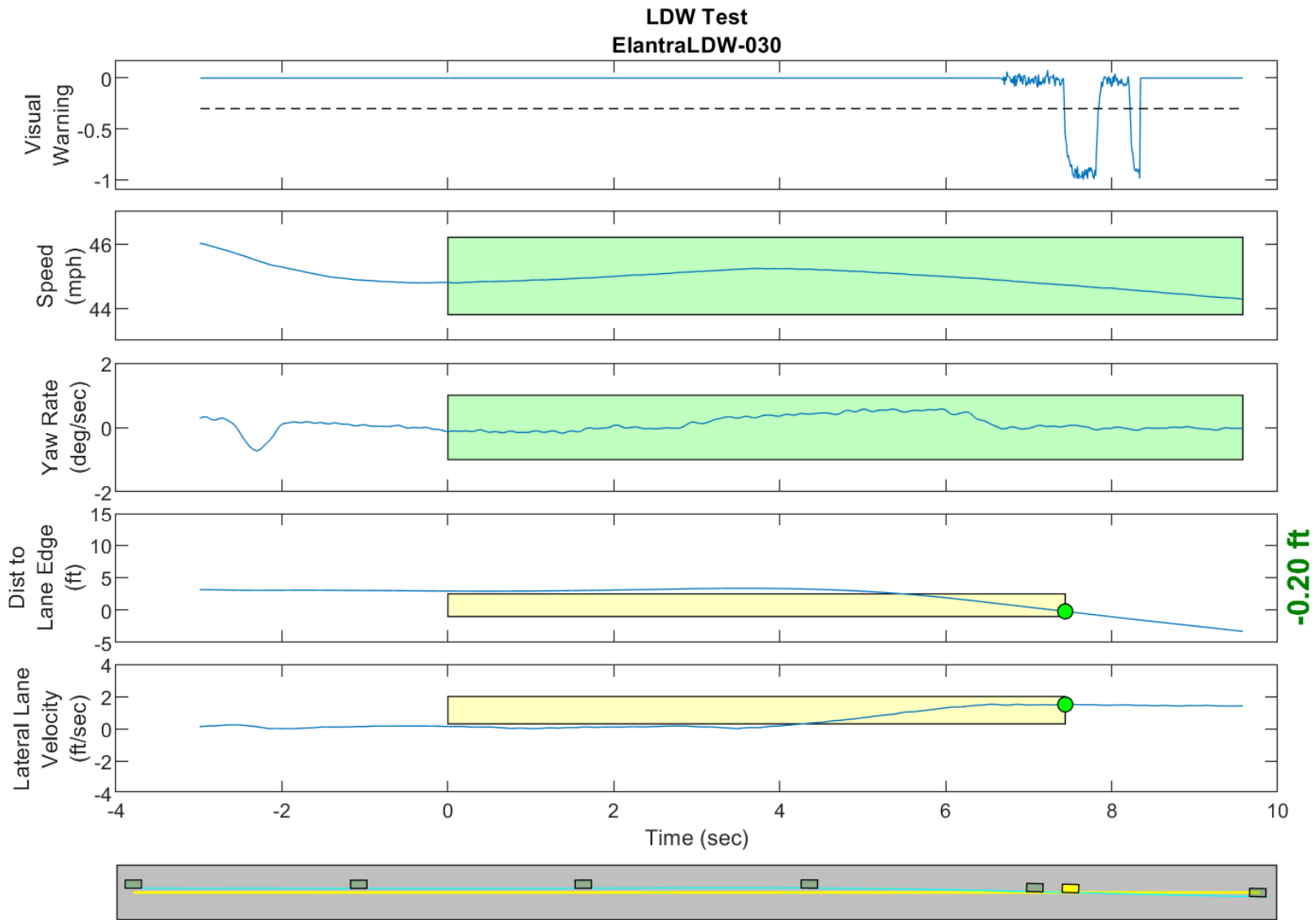


Figure D49. Time History for Run 28, Solid Line, Right Departure, Visual Warning



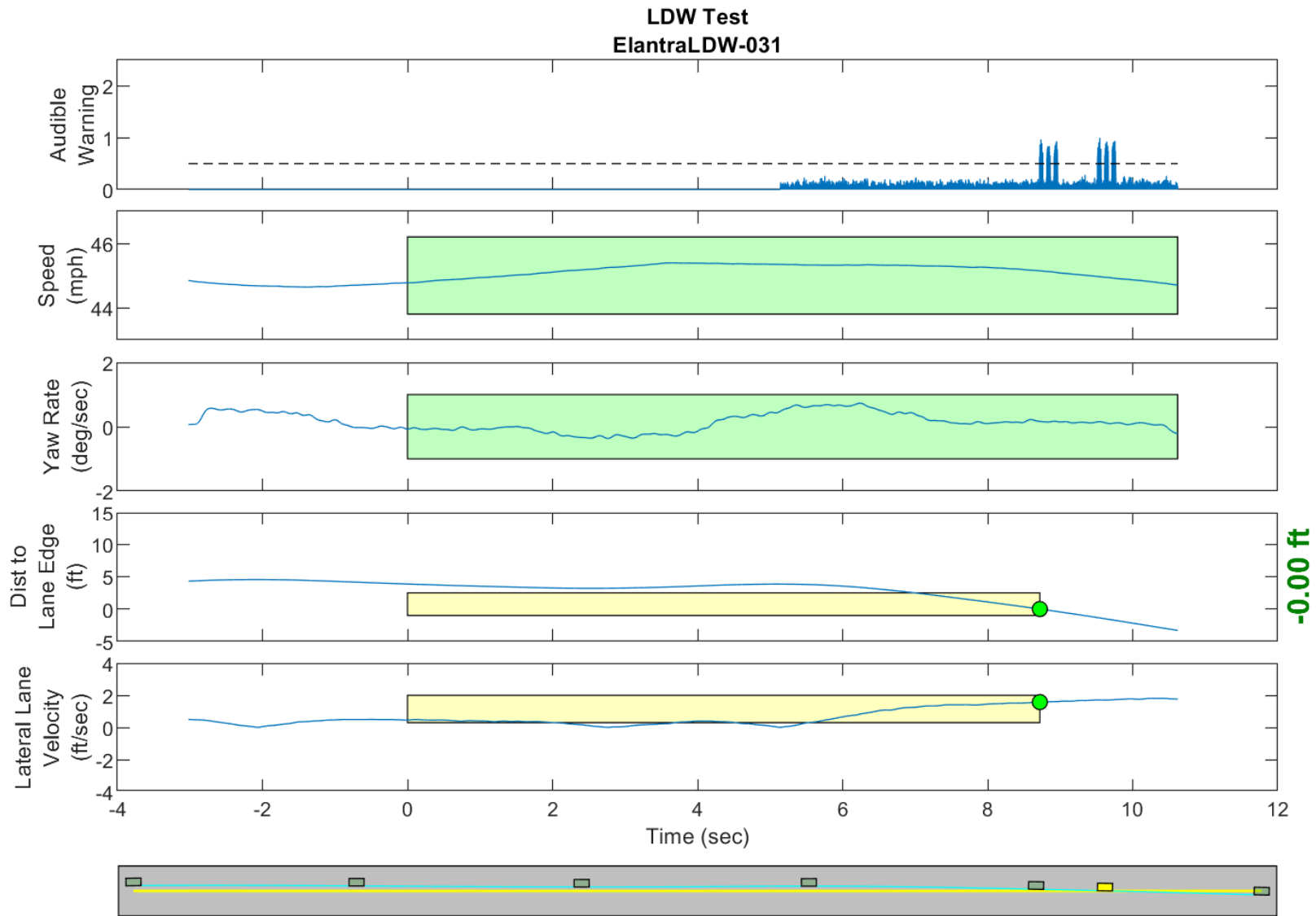
GPS Fix Type: RTK Fixed

Figure D50. Time History for Run 30, Solid Line, Right Departure, Audible Warning



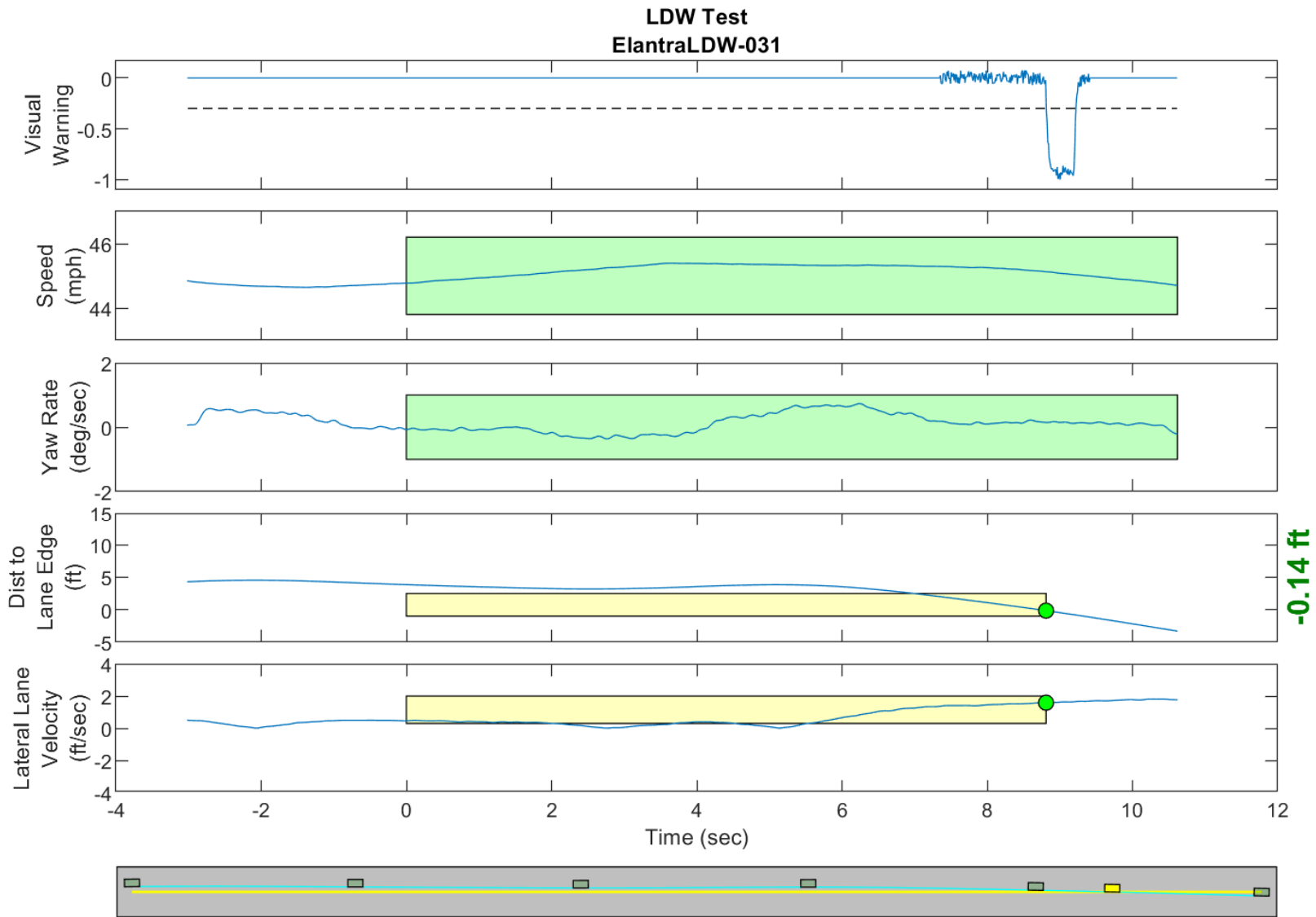
GPS Fix Type: RTK Fixed

Figure D51. Time History for Run 30, Solid Line, Right Departure, Visual Warning



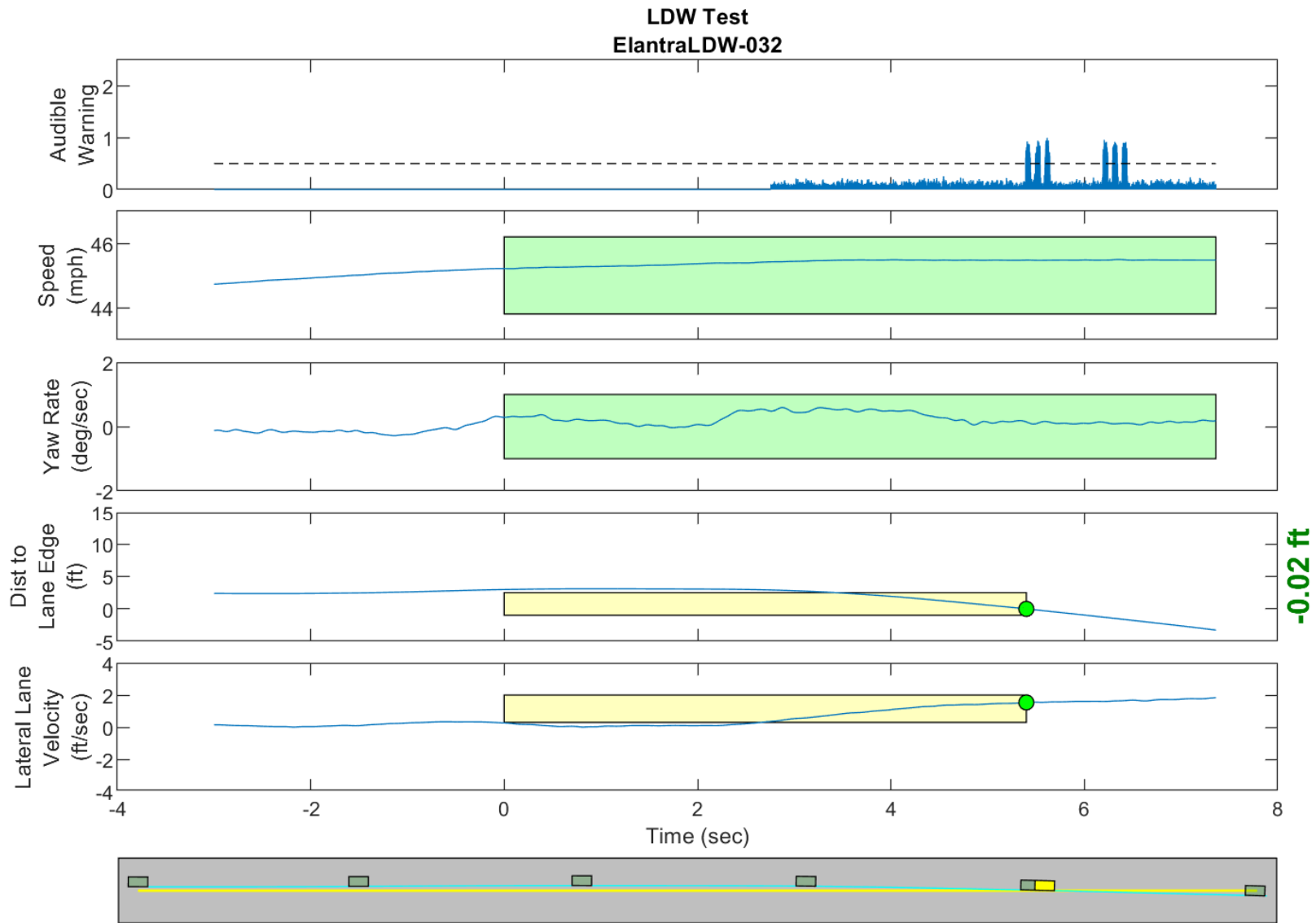
GPS Fix Type: RTK Fixed

Figure D52. Time History for Run 31, Solid Line, Right Departure, Audible Warning



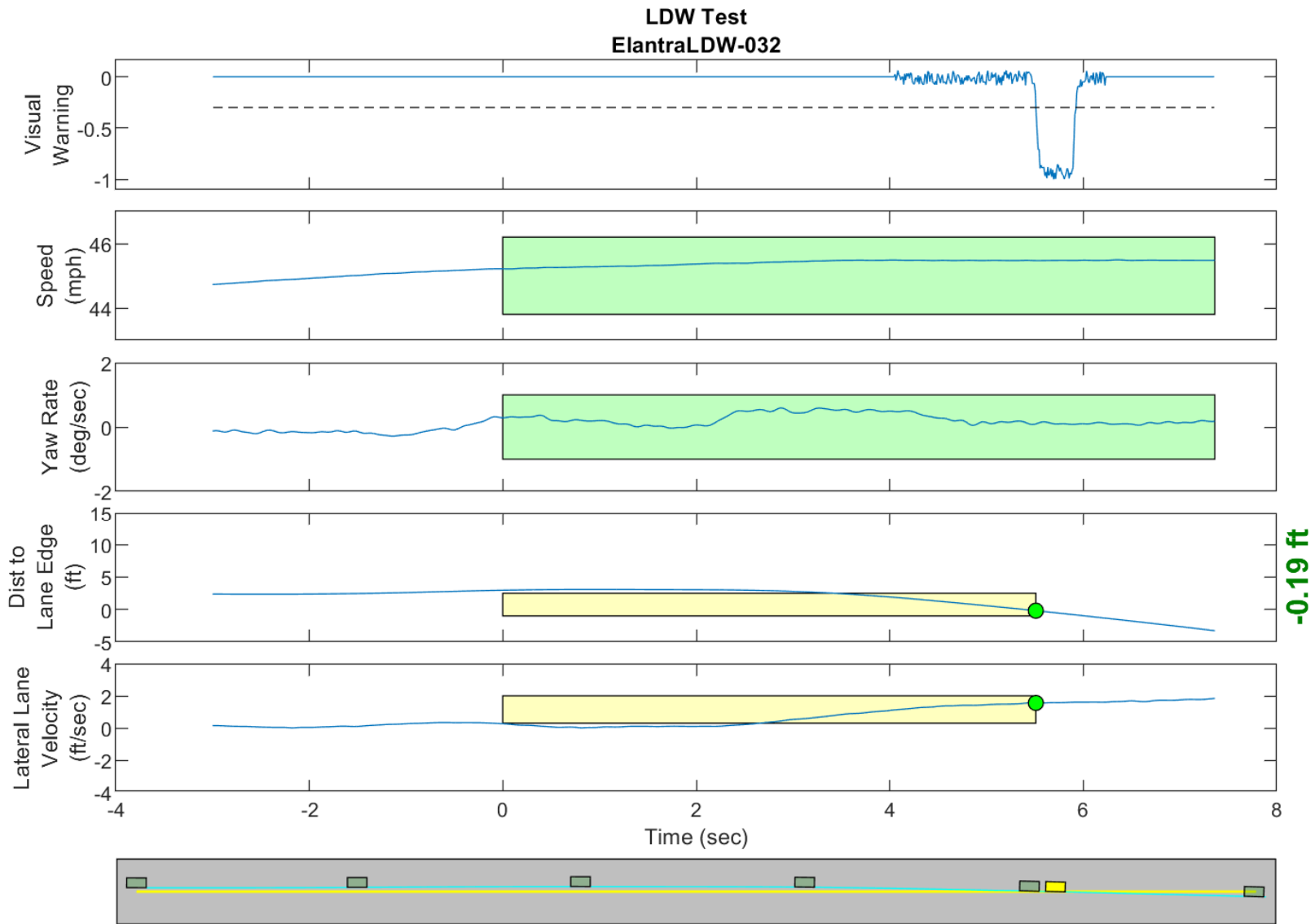
GPS Fix Type: RTK Fixed

Figure D53. Time History for Run 31, Solid Line, Right Departure, Visual Warning



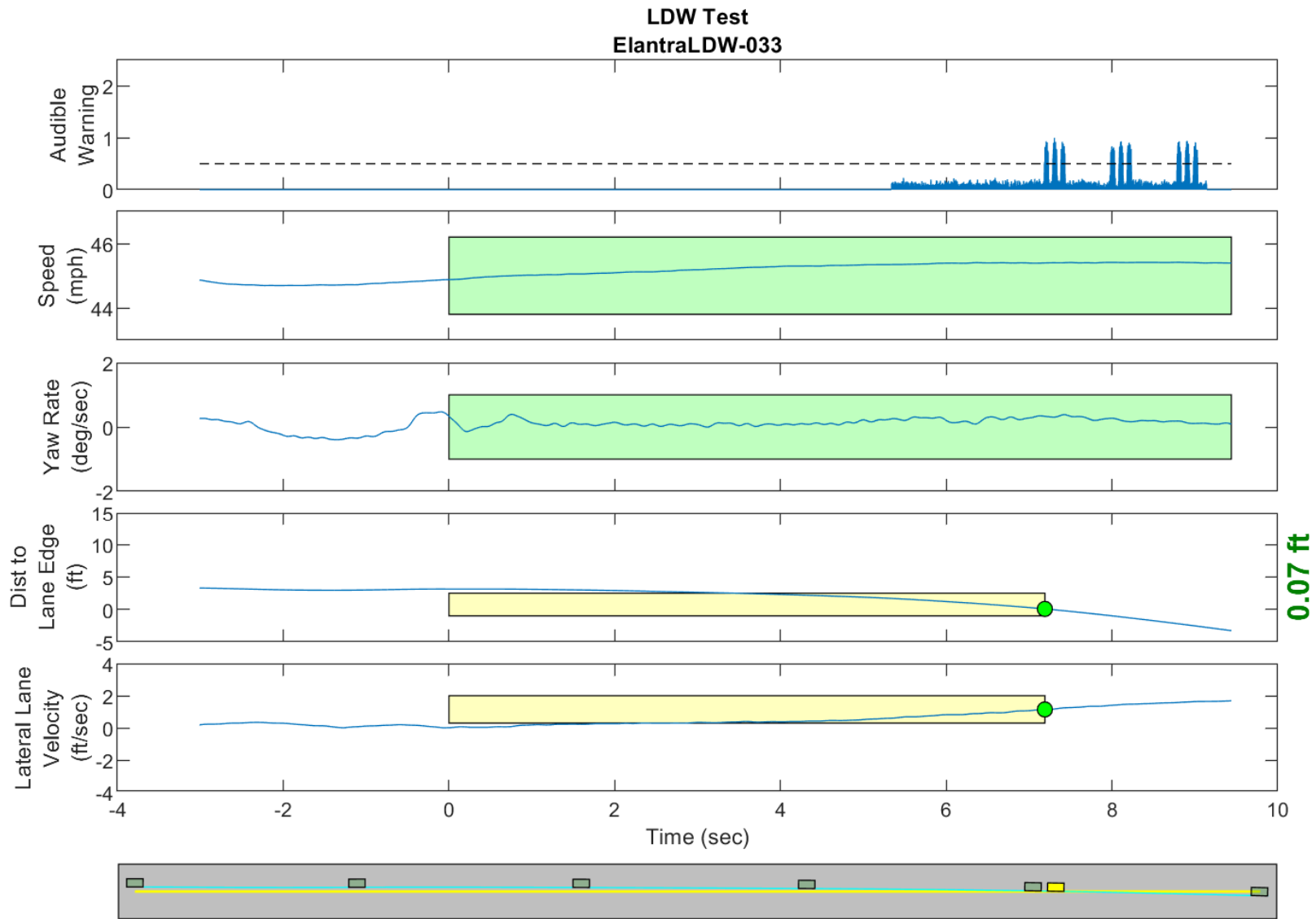
GPS Fix Type: RTK Fixed

Figure D54. Time History for Run 32, Solid Line, Right Departure, Audible Warning



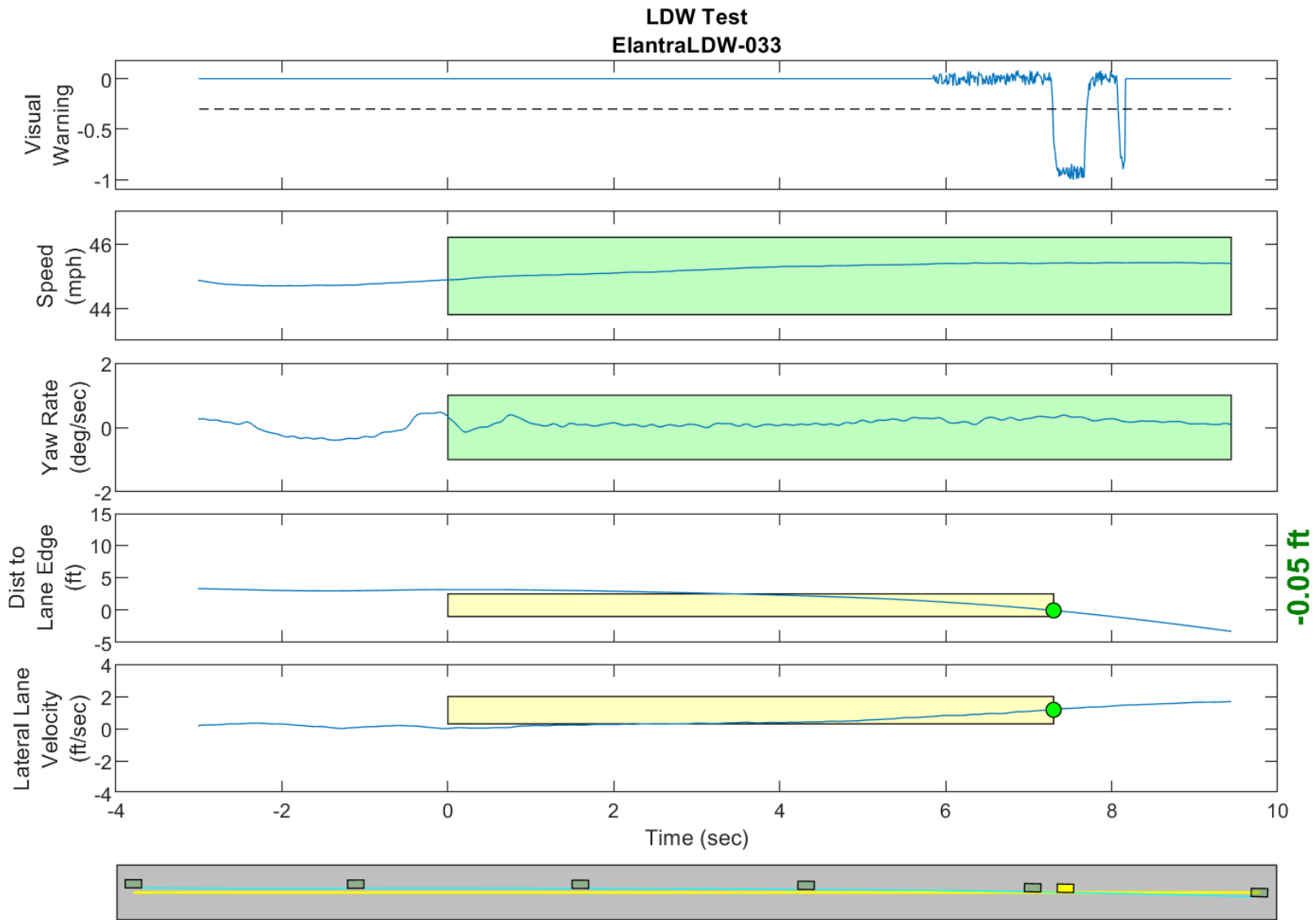
GPS Fix Type: RTK Fixed

Figure D55. Time History for Run 32, Solid Line, Right Departure, Visual Warning



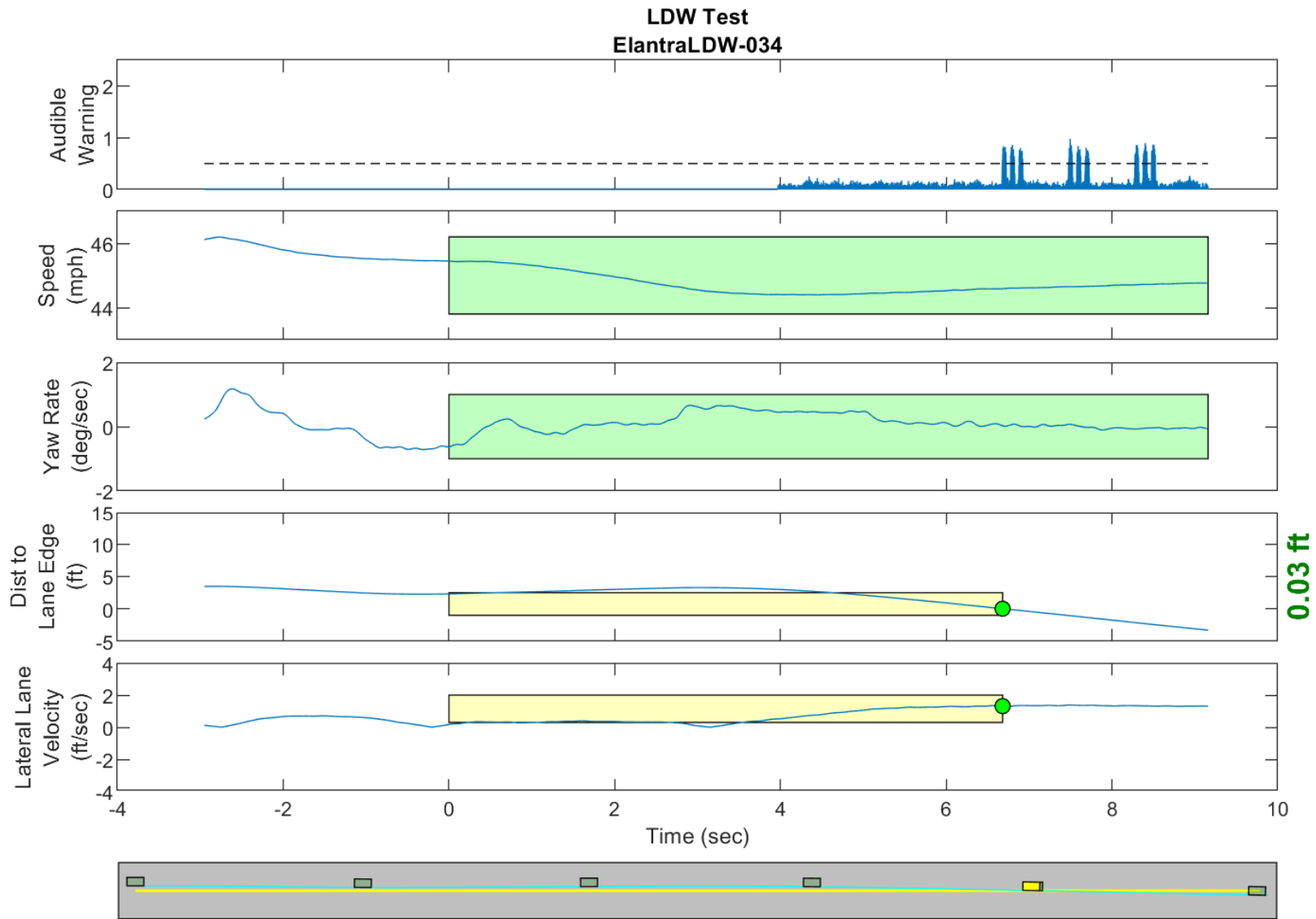
GPS Fix Type: RTK Fixed

Figure D56. Time History for Run 33, Solid Line, Right Departure, Audible Warning



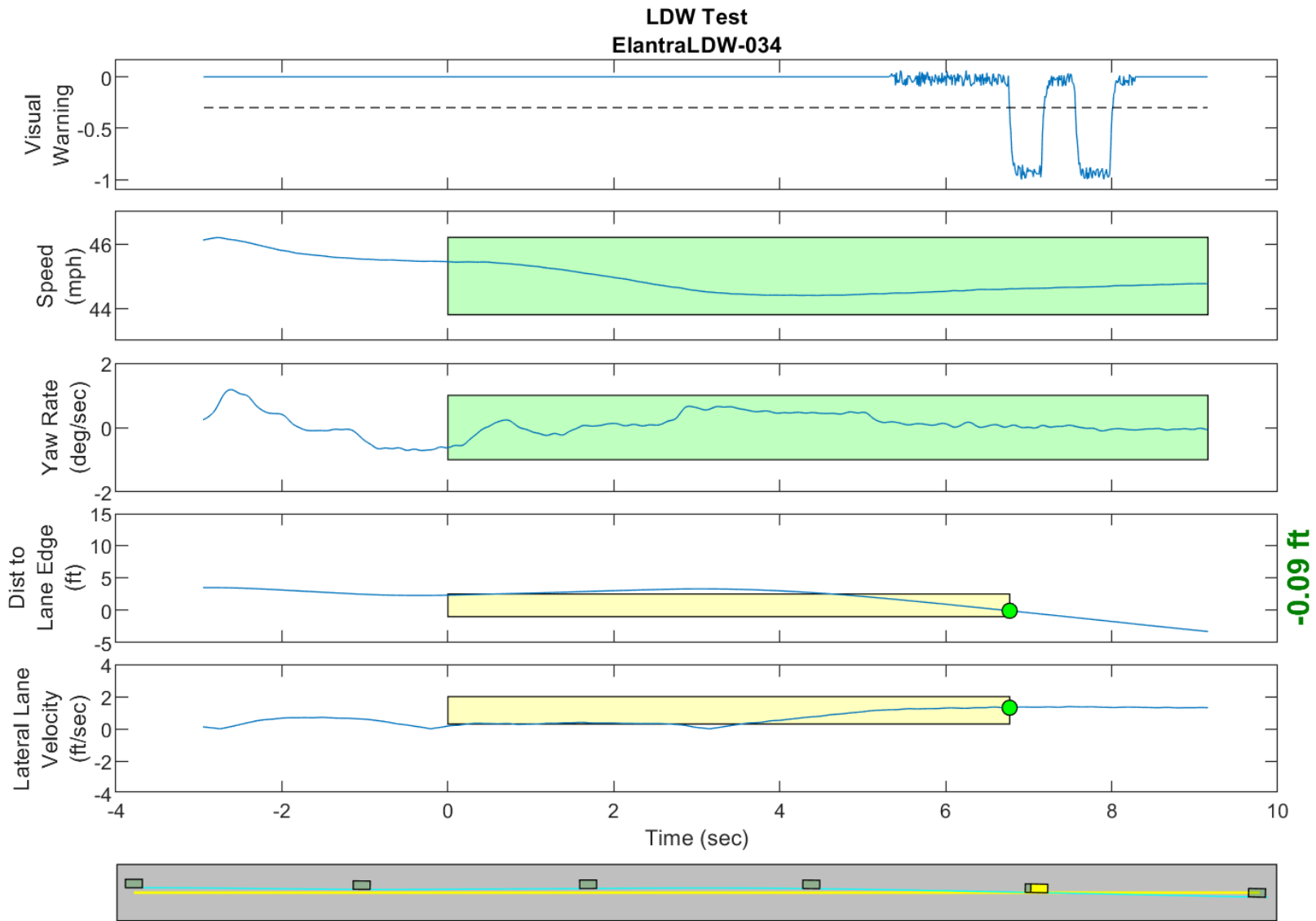
GPS Fix Type: RTK Fixed

Figure D57. Time History for Run 33, Solid Line, Right Departure, Visual Warning



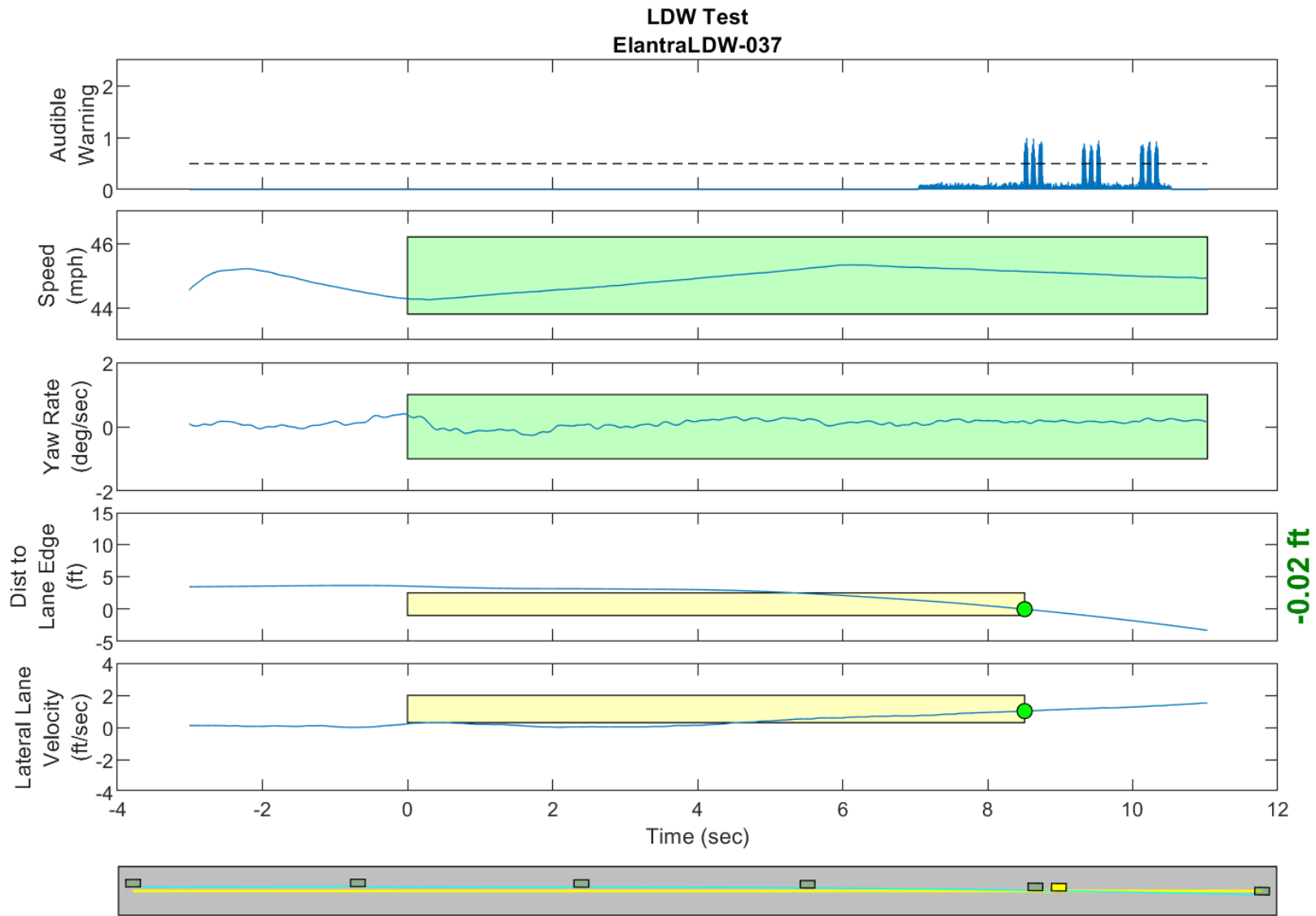
GPS Fix Type: RTK Fixed

Figure D58. Time History for Run 34, Solid Line, Right Departure, Audible Warning



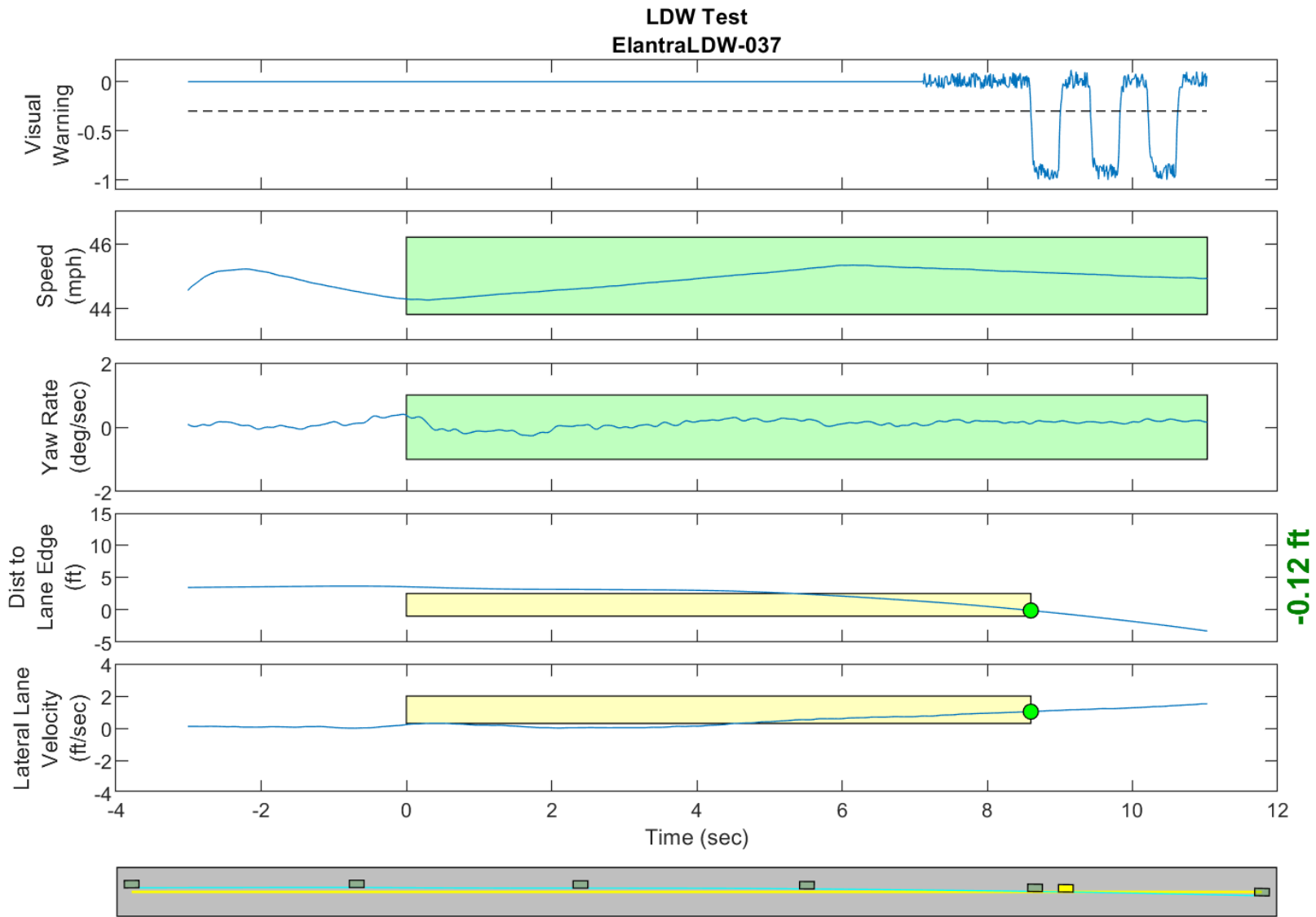
GPS Fix Type: RTK Fixed

Figure D59. Time History for Run 34, Solid Line, Right Departure, Visual Warning



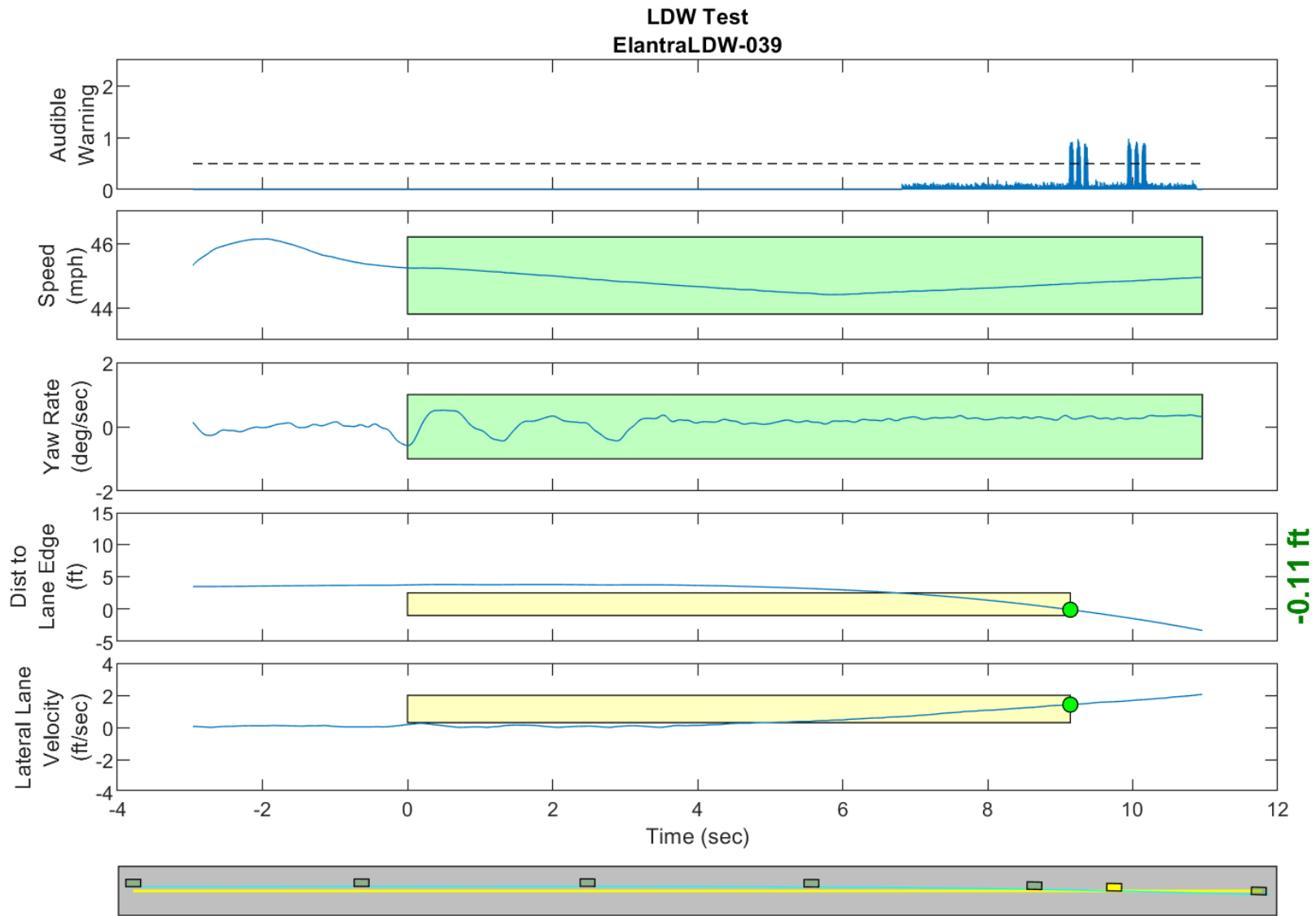
GPS Fix Type: RTK Fixed

Figure D60. Time History for Run 37, Dashed Line, Right Departure, Audible Warning



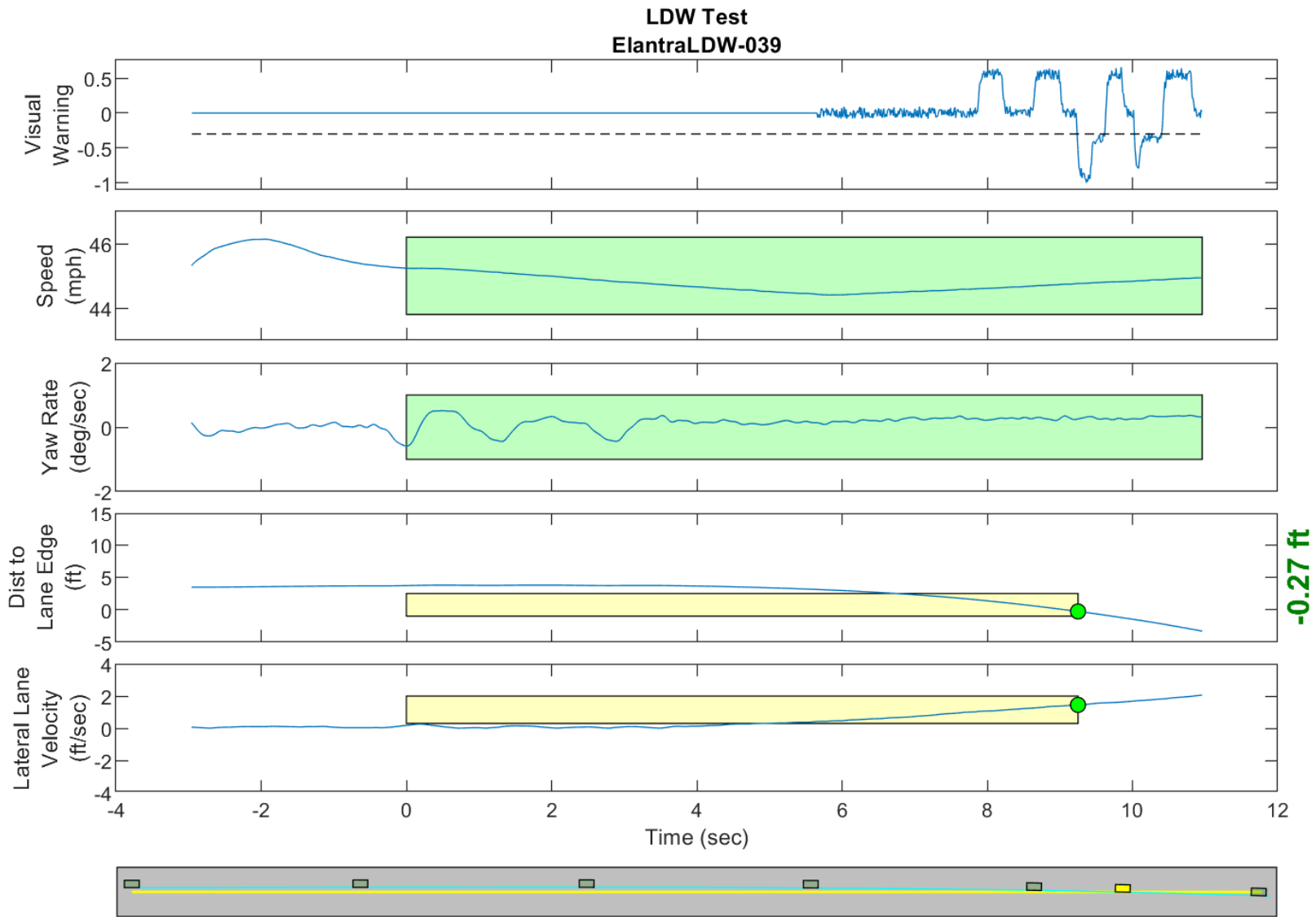
GPS Fix Type: RTK Fixed

Figure D61. Time History for Run 37, Dashed Line, Right Departure, Visual Warning



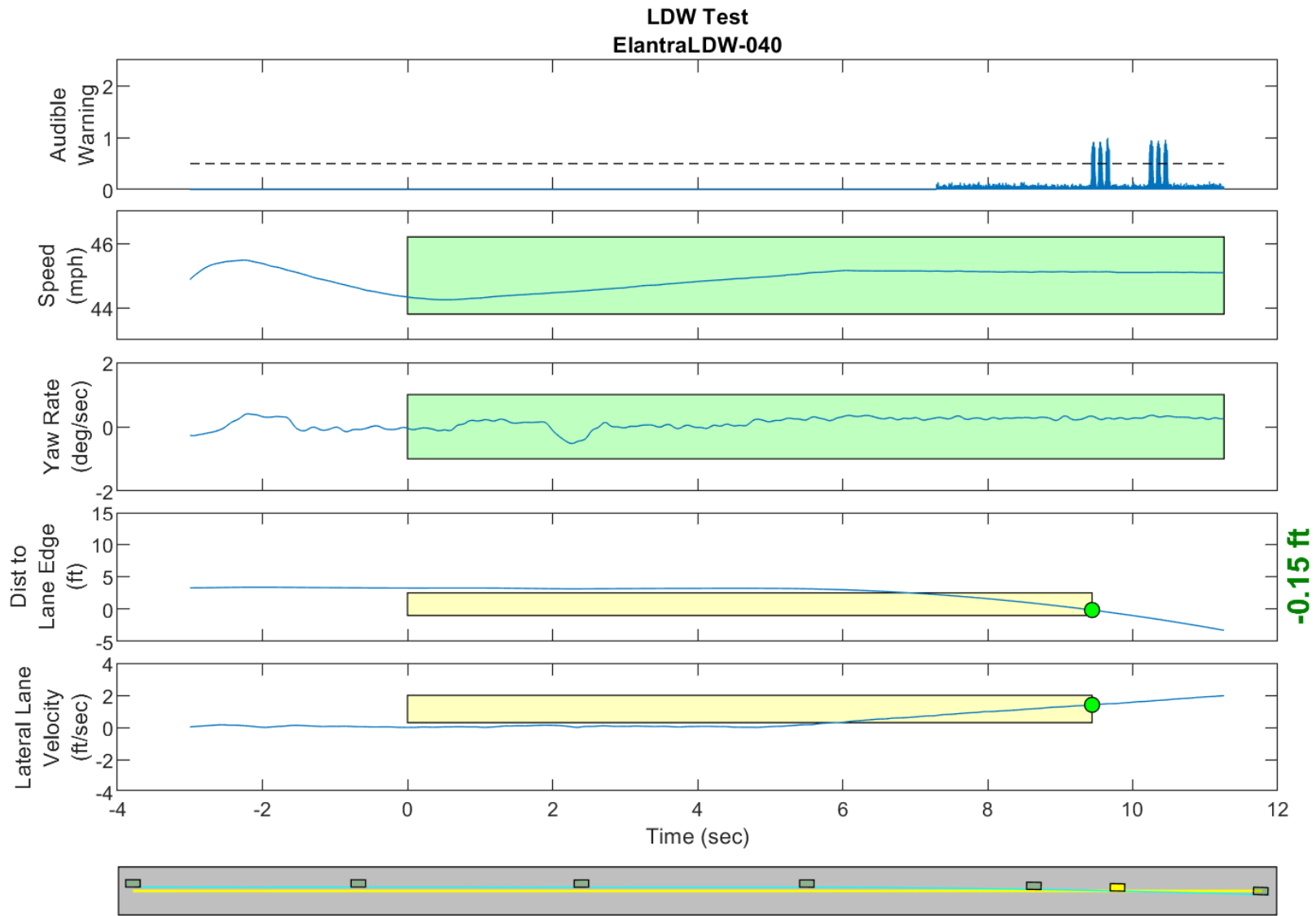
GPS Fix Type: RTK Fixed

Figure D62. Time History for Run 39, Dashed Line, Right Departure, Audible Warning



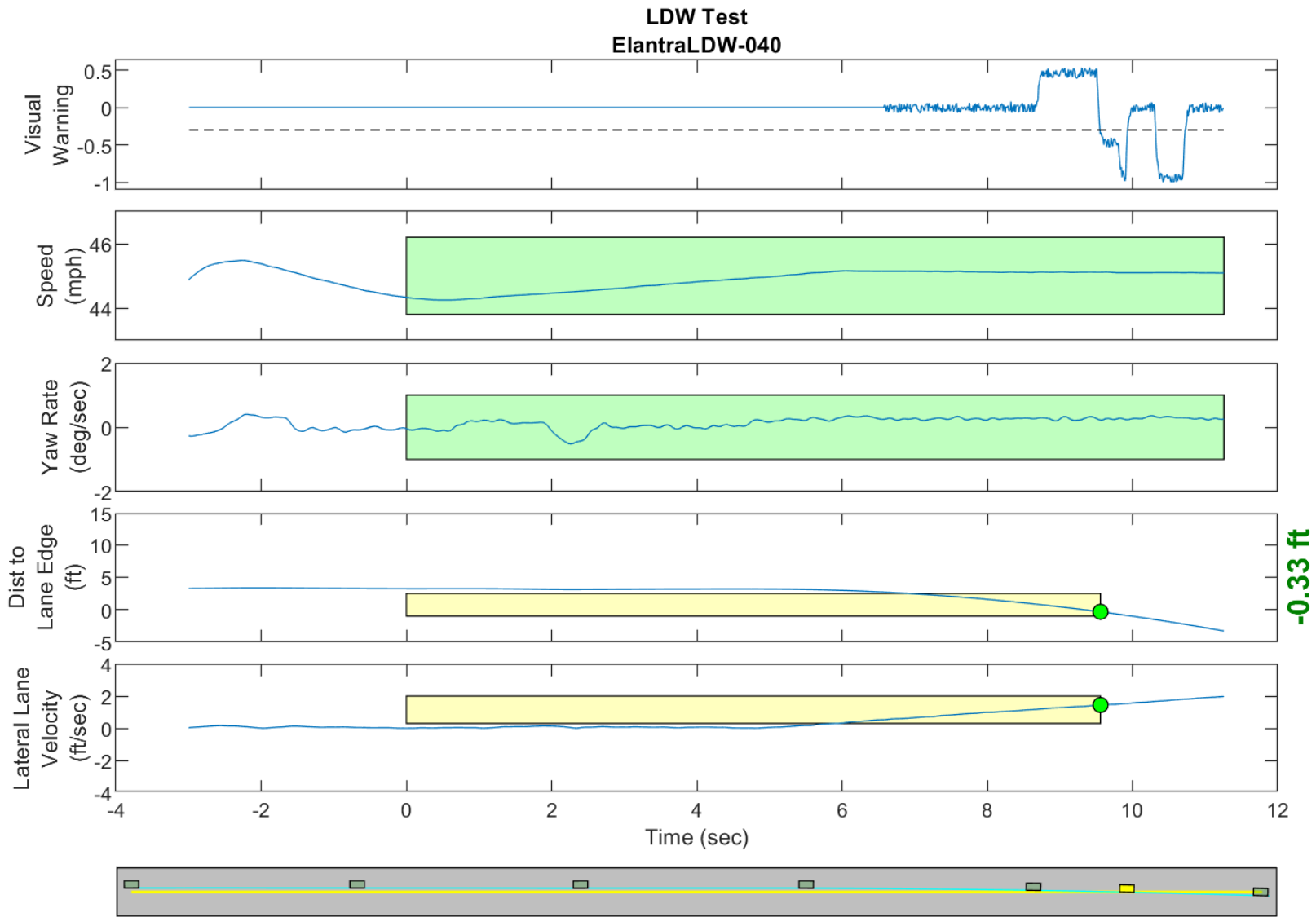
GPS Fix Type: RTK Fixed

Figure D63. Time History for Run 39, Dashed Line, Right Departure, Visual Warning



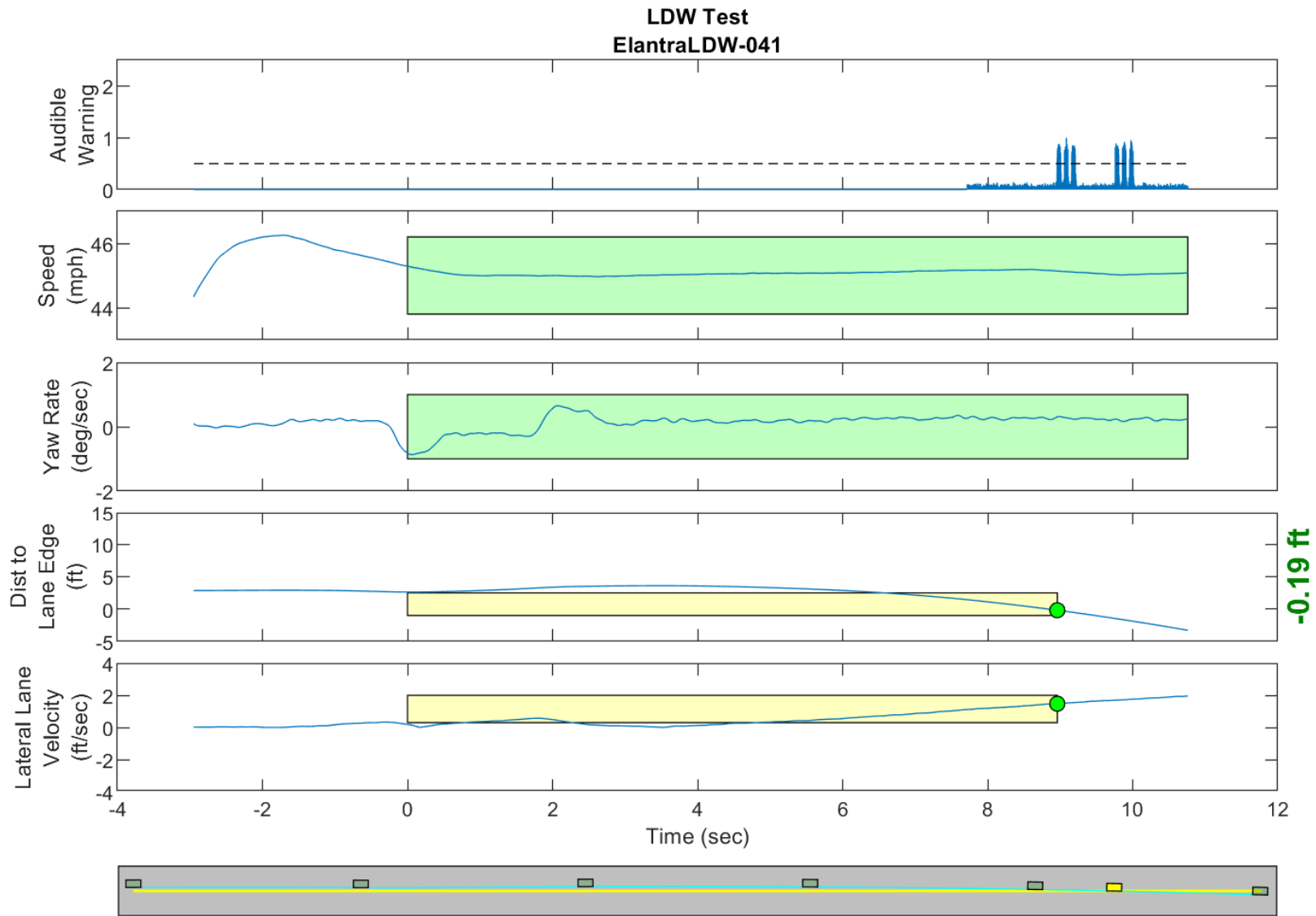
GPS Fix Type: RTK Fixed

Figure D64. Time History for Run 40, Dashed Line, Right Departure, Audible Warning



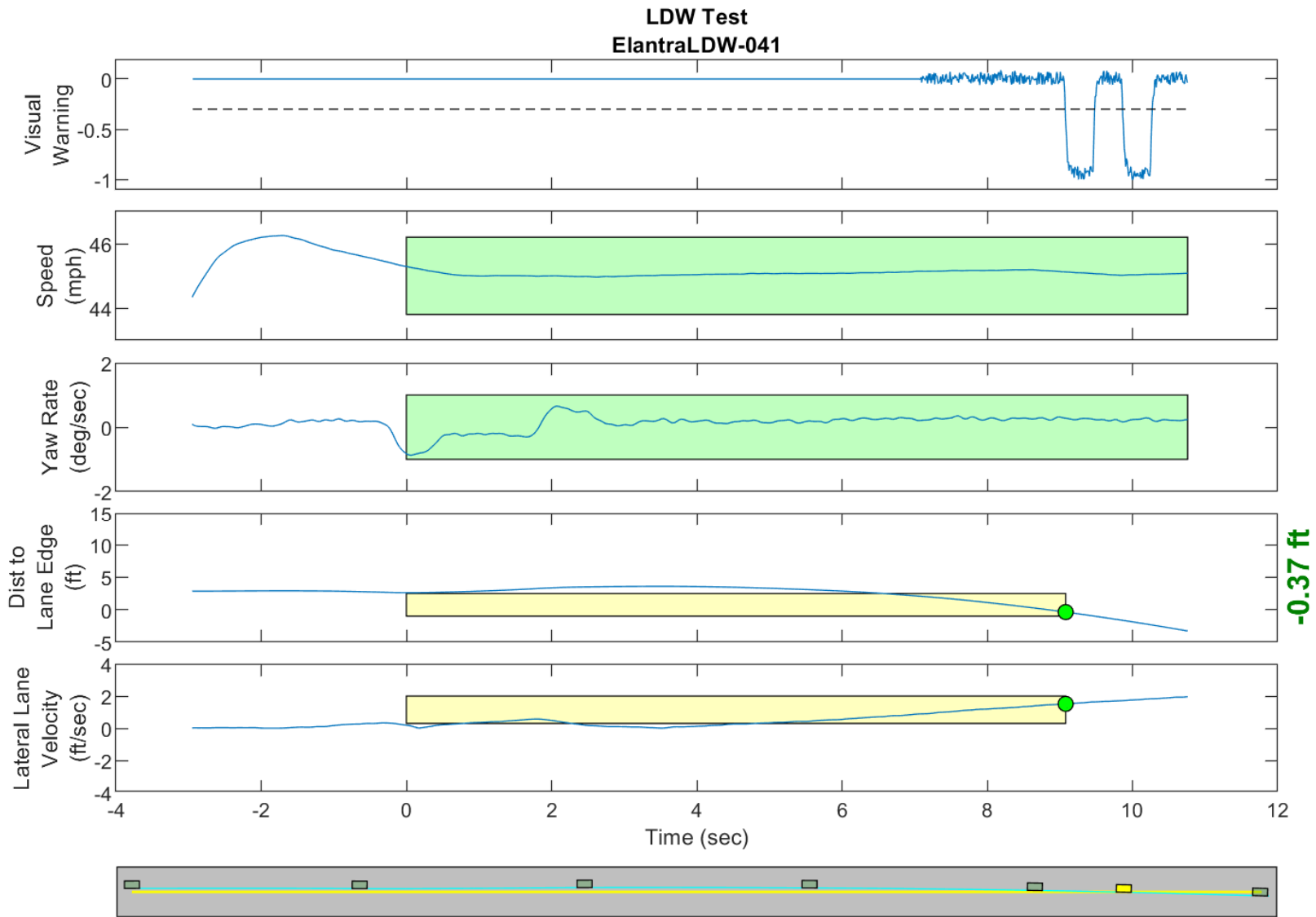
GPS Fix Type: RTK Fixed

Figure D65. Time History for Run 40, Dashed Line, Right Departure, Visual Warning



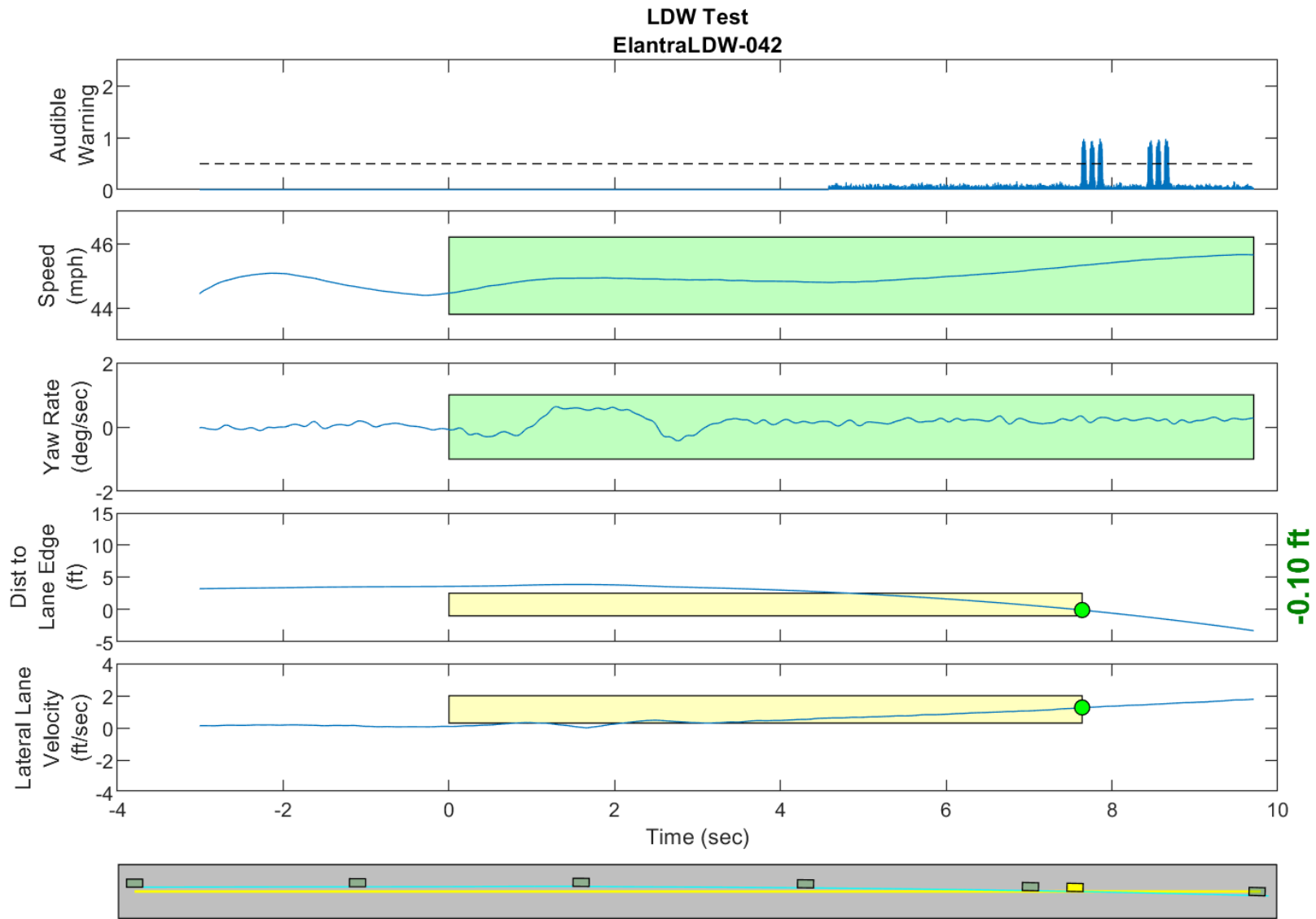
GPS Fix Type: RTK Fixed

Figure D66. Time History for Run 41, Dashed Line, Right Departure, Audible Warning



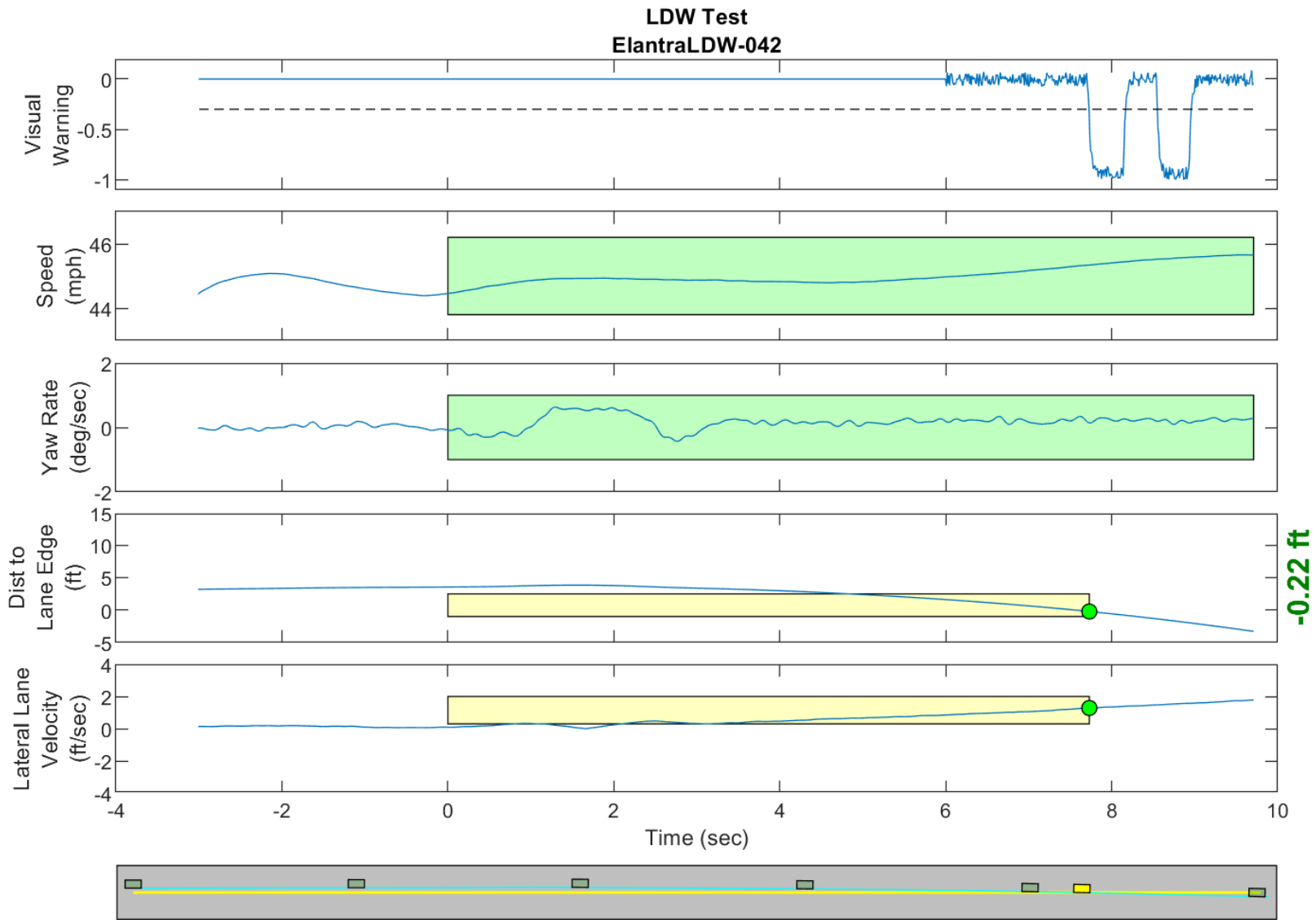
GPS Fix Type: RTK Fixed

Figure D67. Time History for Run 41, Dashed Line, Right Departure, Visual Warning



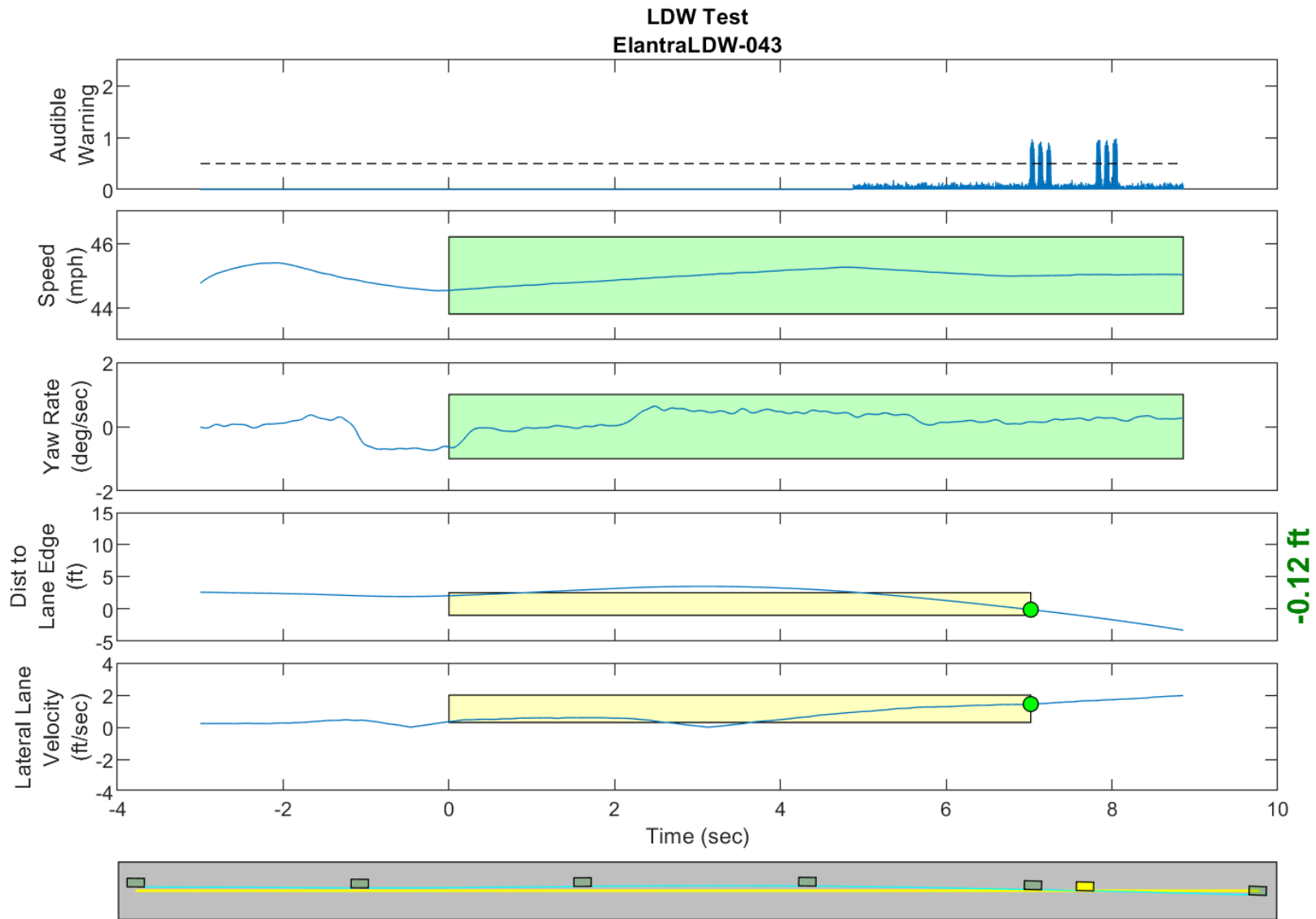
GPS Fix Type: RTK Fixed

Figure D68. Time History for Run 42, Dashed Line, Right Departure, Audible Warning



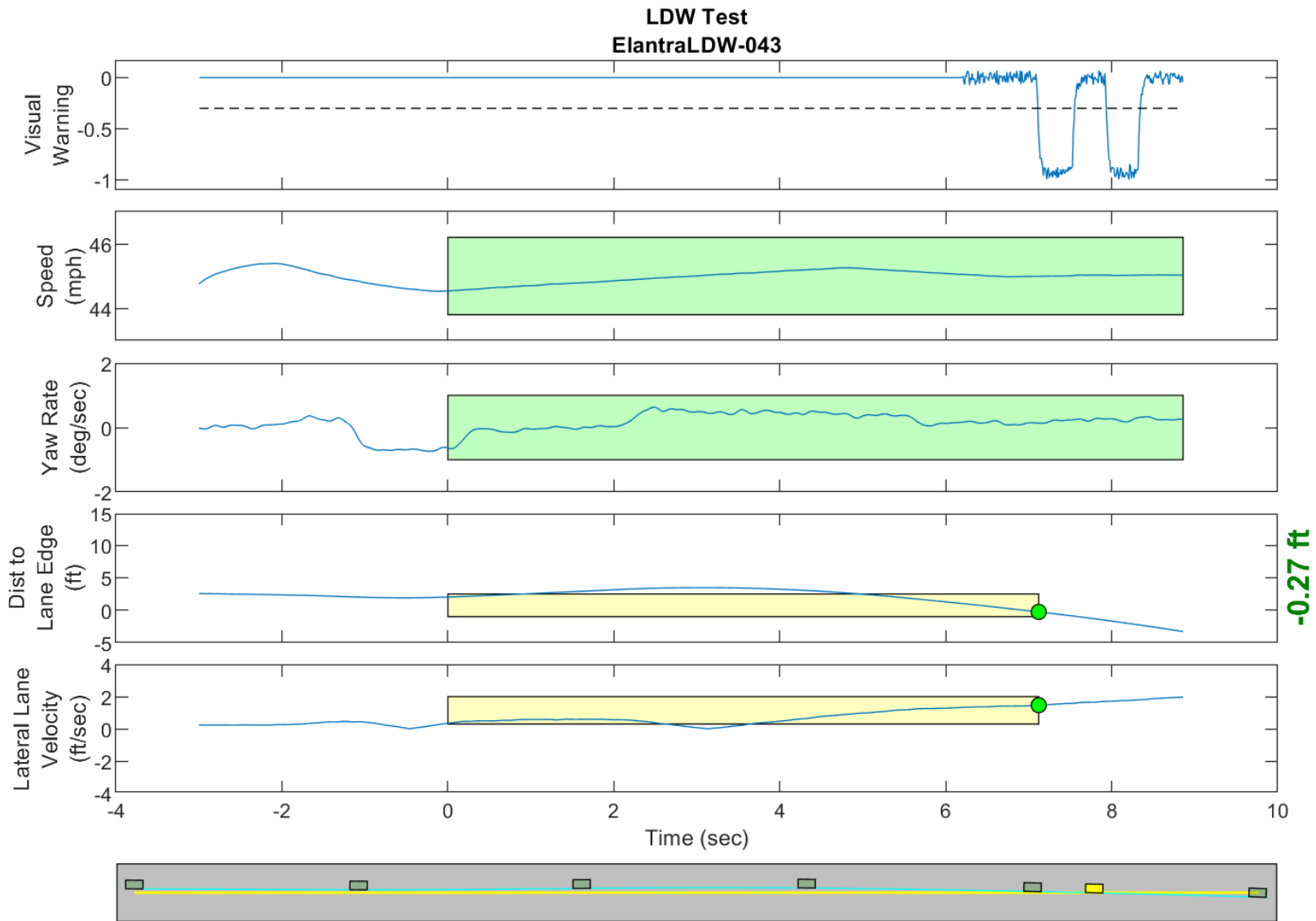
GPS Fix Type: RTK Fixed

Figure D69. Time History for Run 42, Dashed Line, Right Departure, Visual Warning



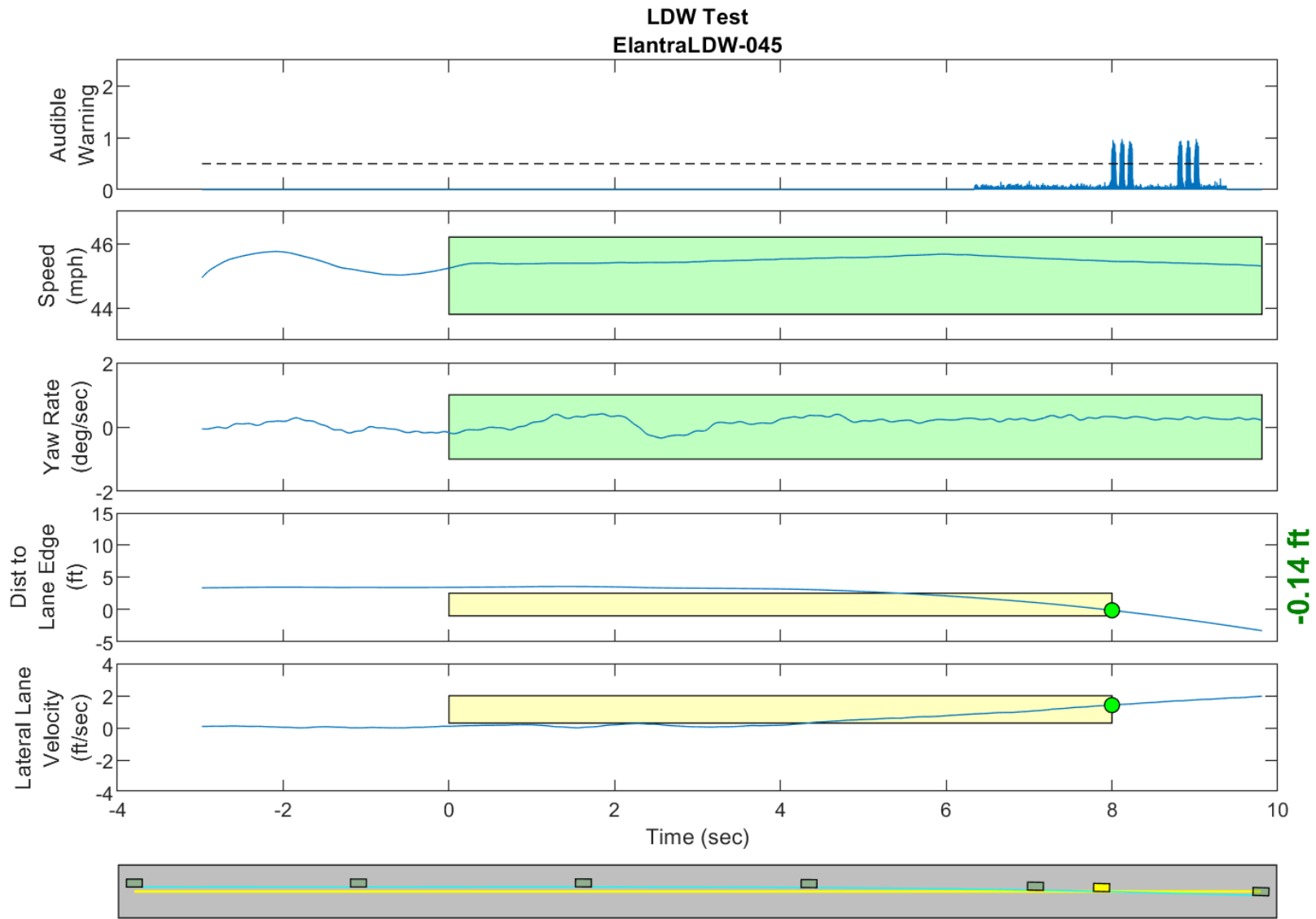
GPS Fix Type: RTK Fixed

Figure D70. Time History for Run 43, Dashed Line, Right Departure, Audible Warning



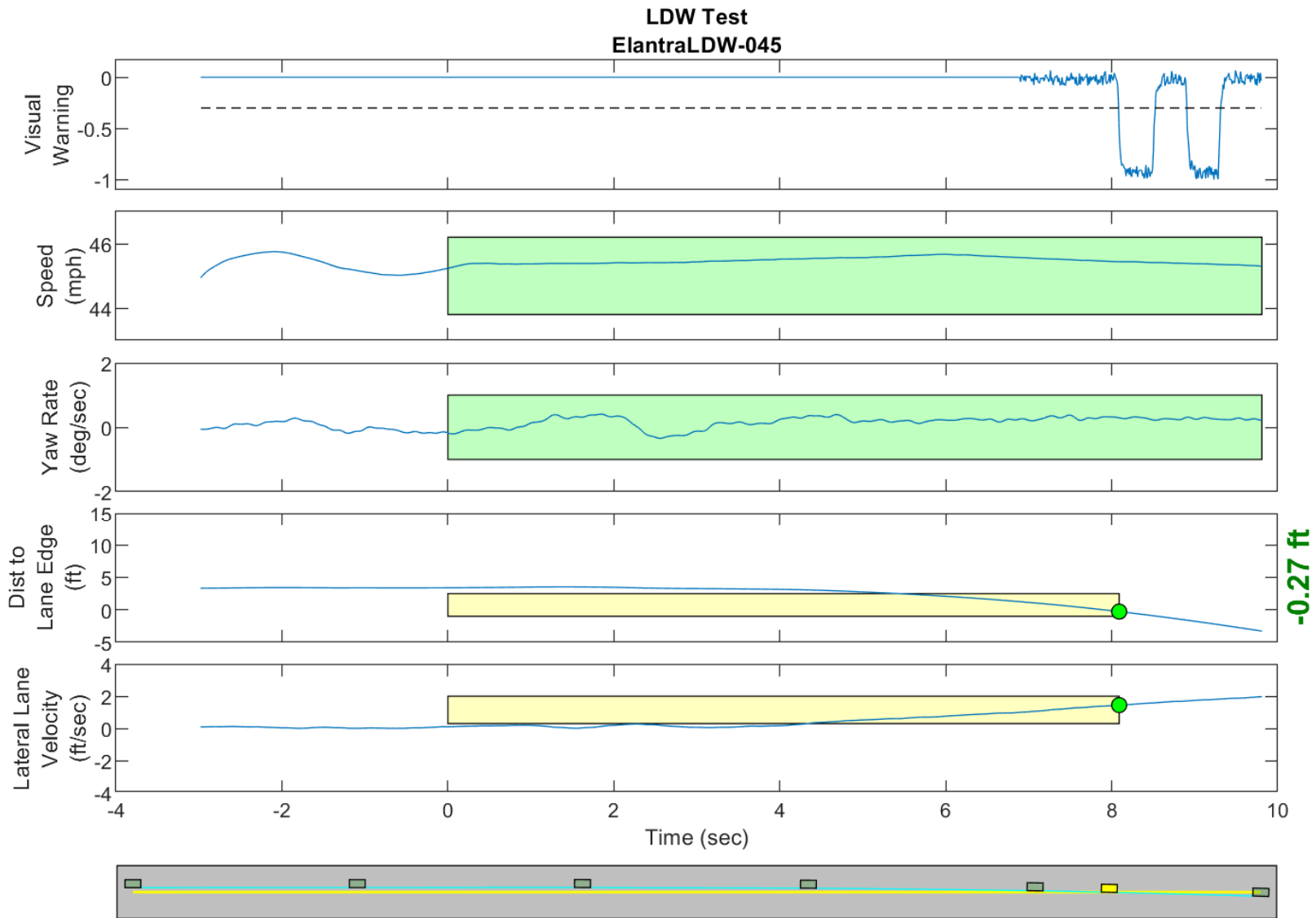
GPS Fix Type: RTK Fixed

Figure D71. Time History for Run 43, Dashed Line, Right Departure, Visual Warning



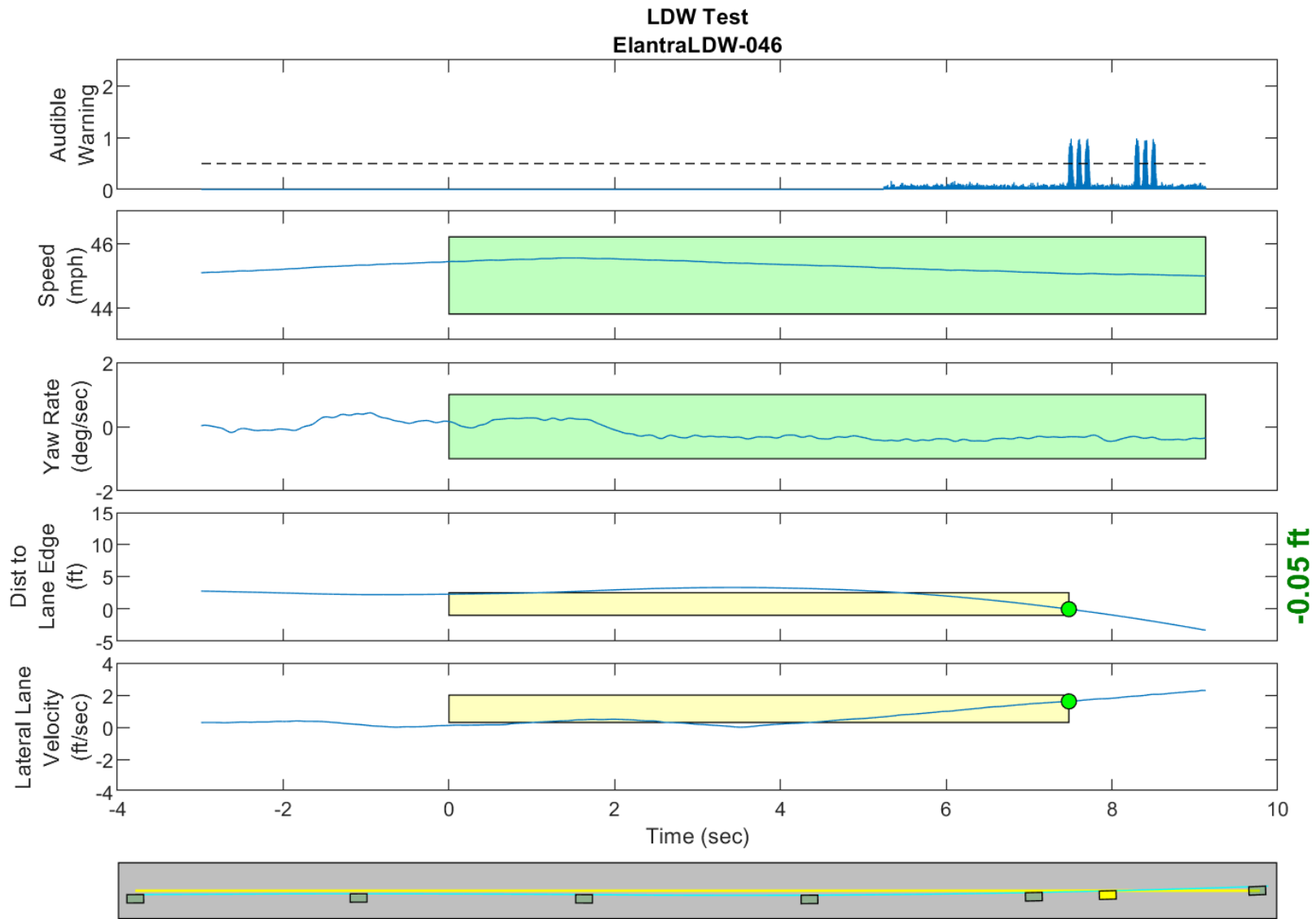
GPS Fix Type: RTK Fixed

Figure D72. Time History for Run 45, Dashed Line, Right Departure, Audible Warning



GPS Fix Type: RTK Fixed

Figure D73. Time History for Run 45, Dashed Line, Right Departure, Visual Warning



GPS Fix Type: RTK Fixed

Figure D74. Time History for Run 46, Dashed Line, Left Departure, Audible Warning

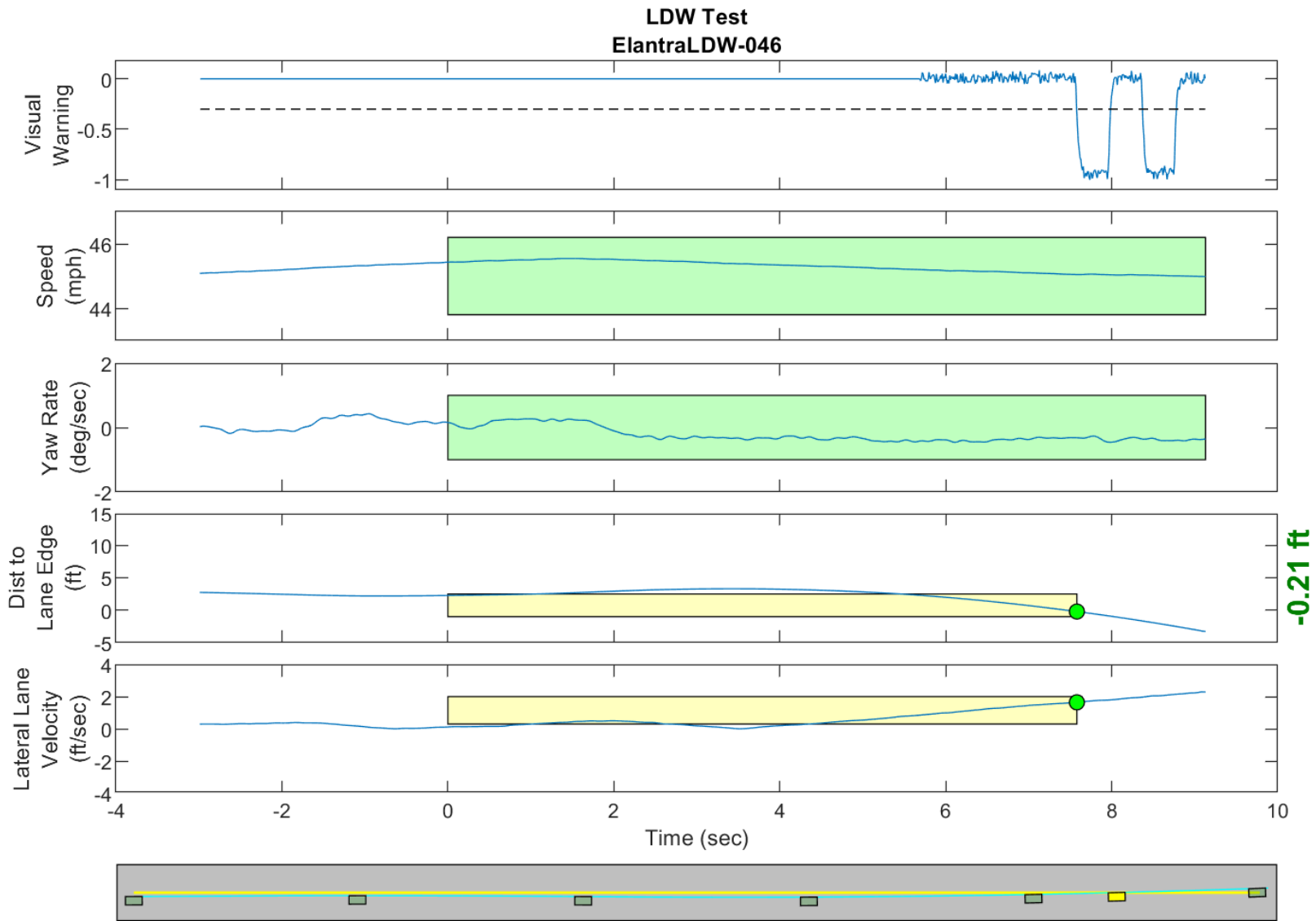
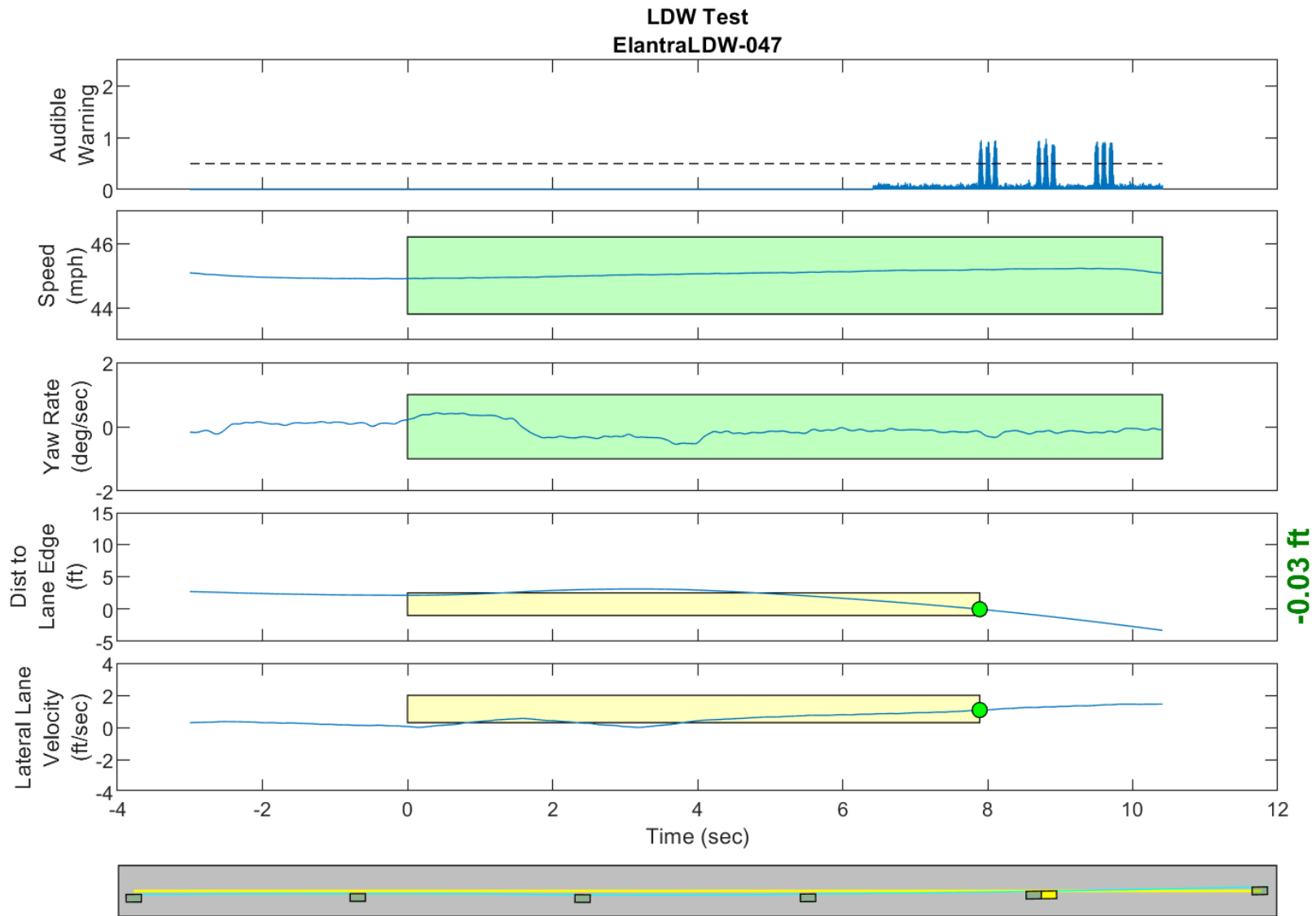
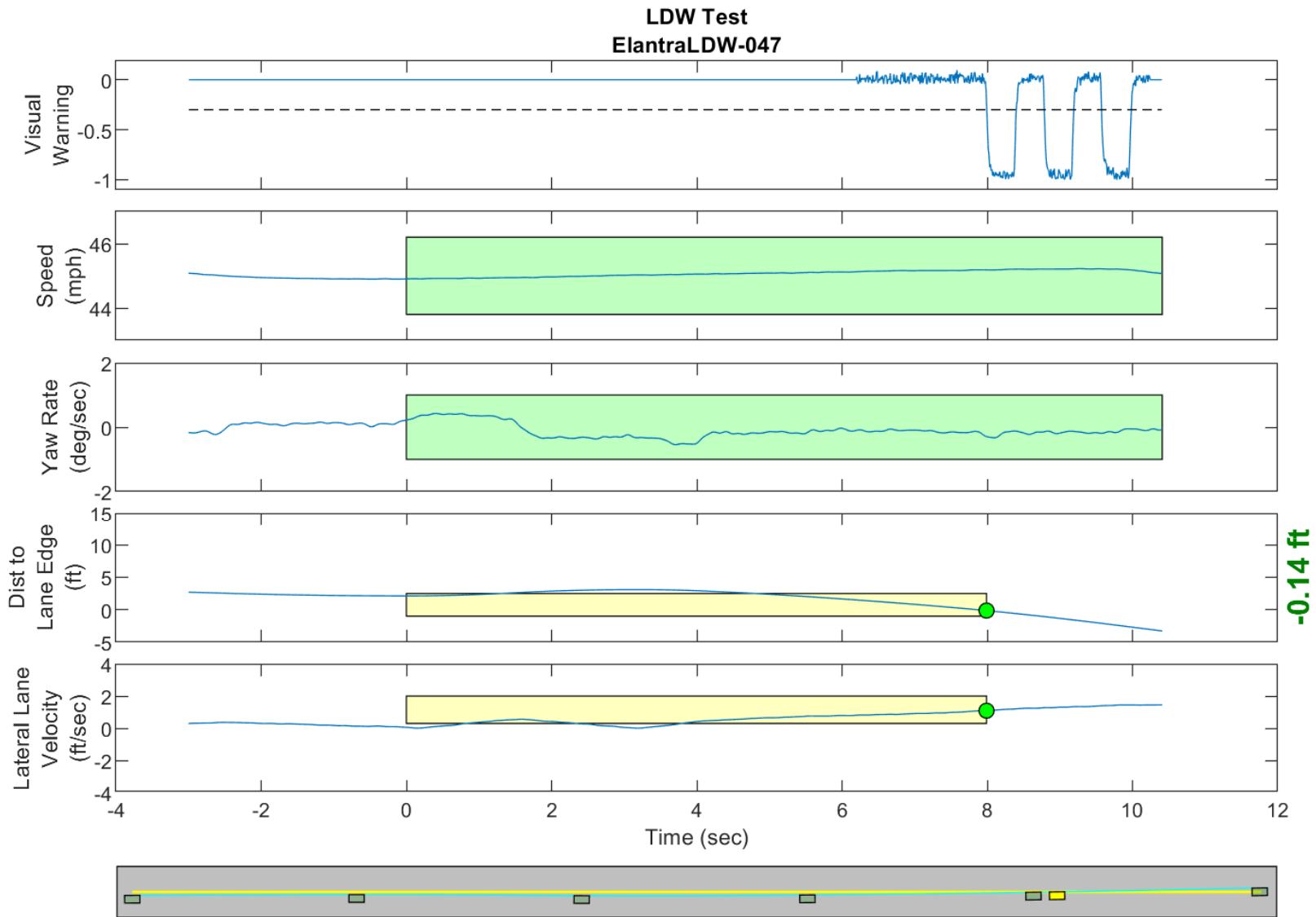


Figure D75. Time History for Run 46, Dashed Line, Left Departure, Visual Warning



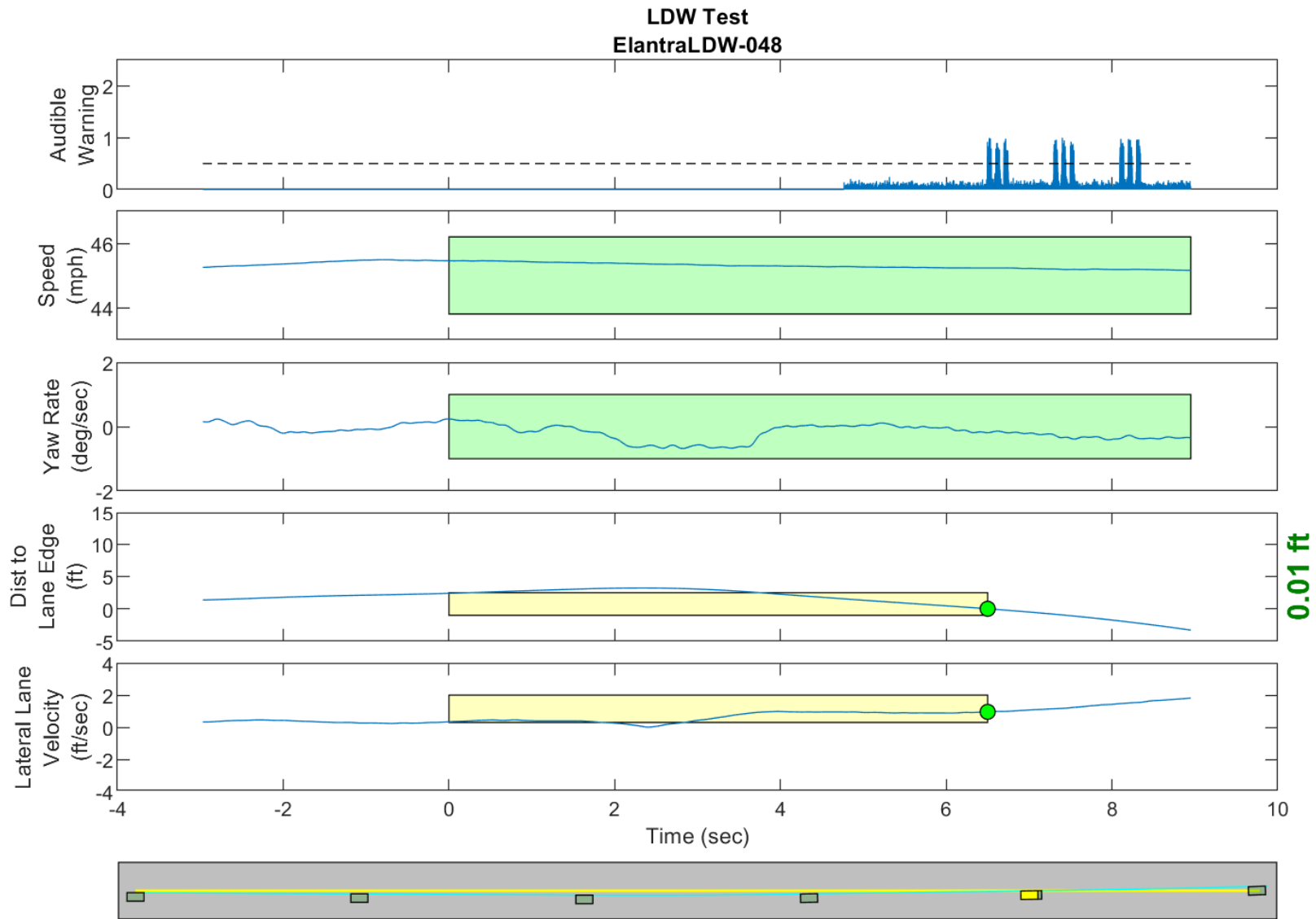
GPS Fix Type: RTK Fixed

Figure D76. Time History for Run 47, Dashed Line, Left Departure, Audible Warning



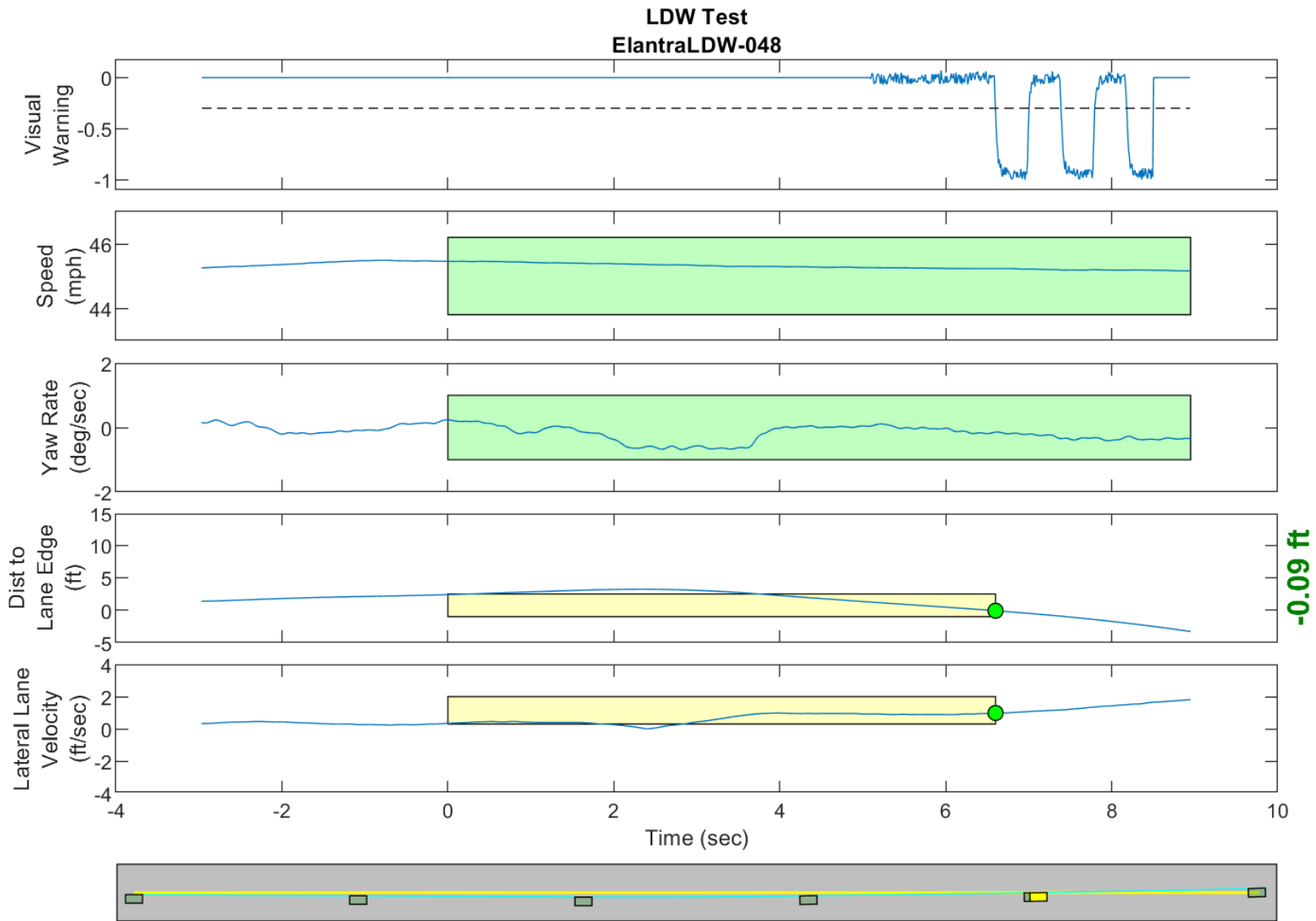
GPS Fix Type: RTK Fixed

Figure D77. Time History for Run 47, Dashed Line, Left Departure, Visual Warning



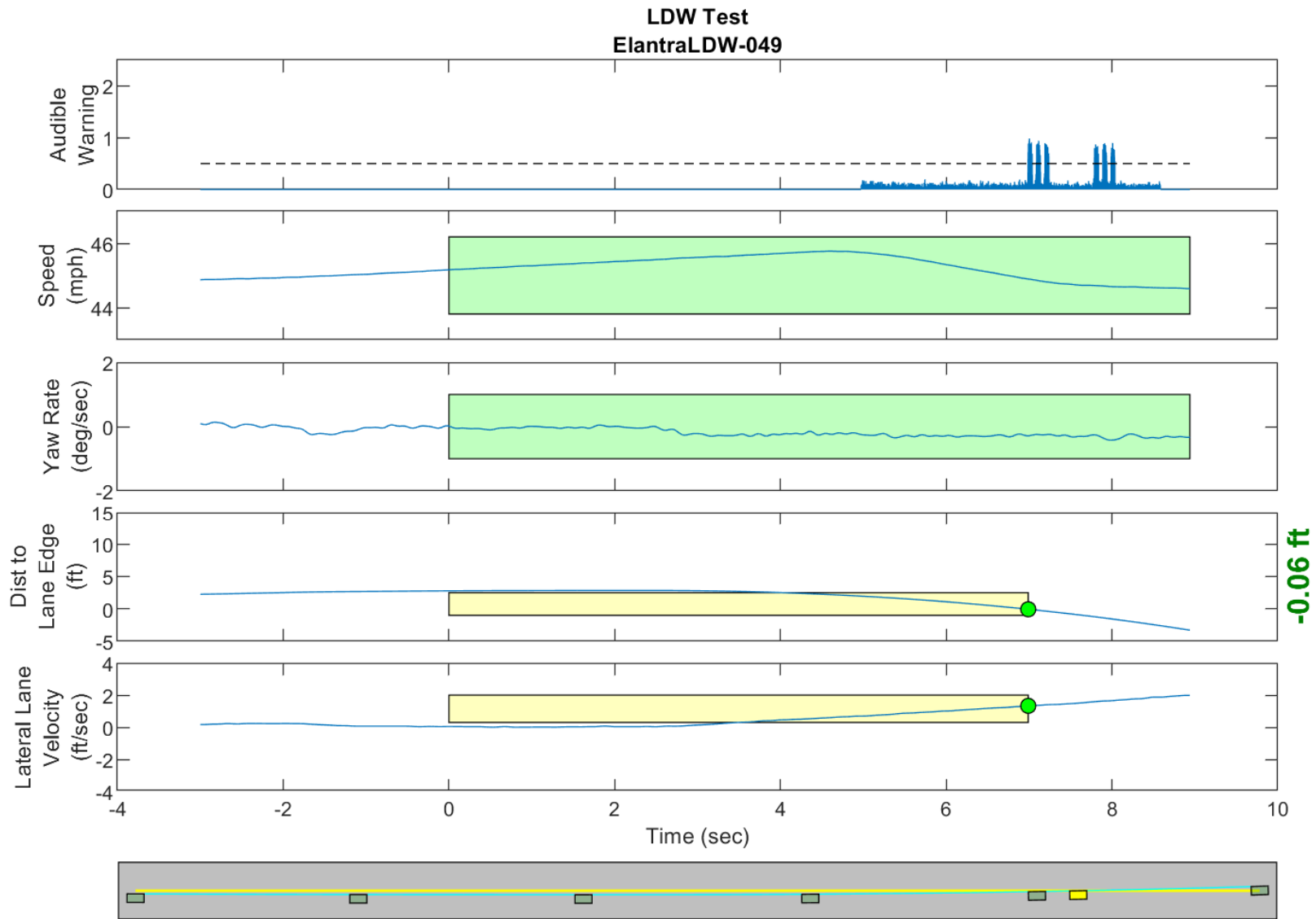
GPS Fix Type: RTK Fixed

Figure D78. Time History for Run 48, Dashed Line, Left Departure, Audible Warning



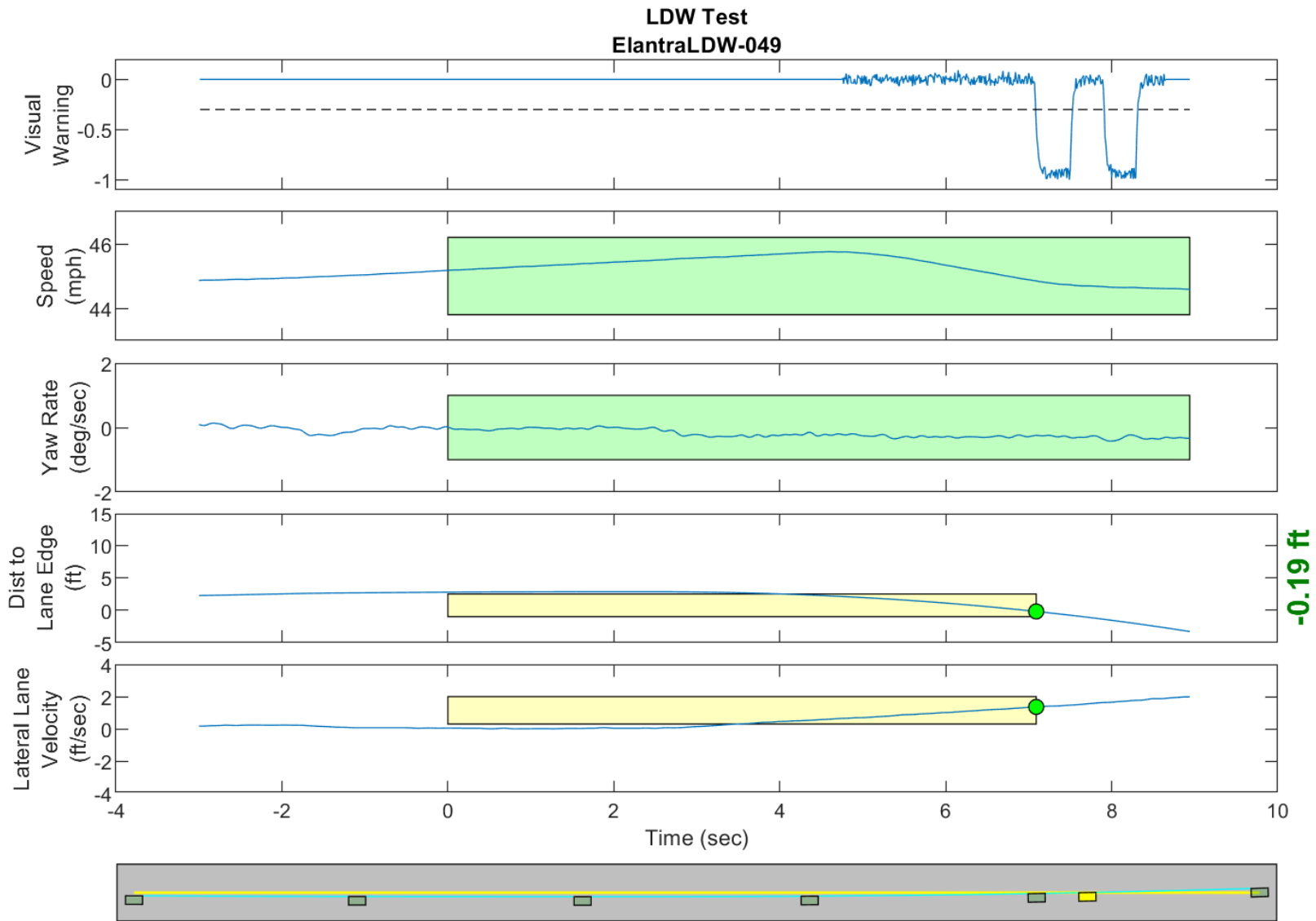
GPS Fix Type: RTK Fixed

Figure D79. Time History for Run 48, Dashed Line, Left Departure, Visual Warning



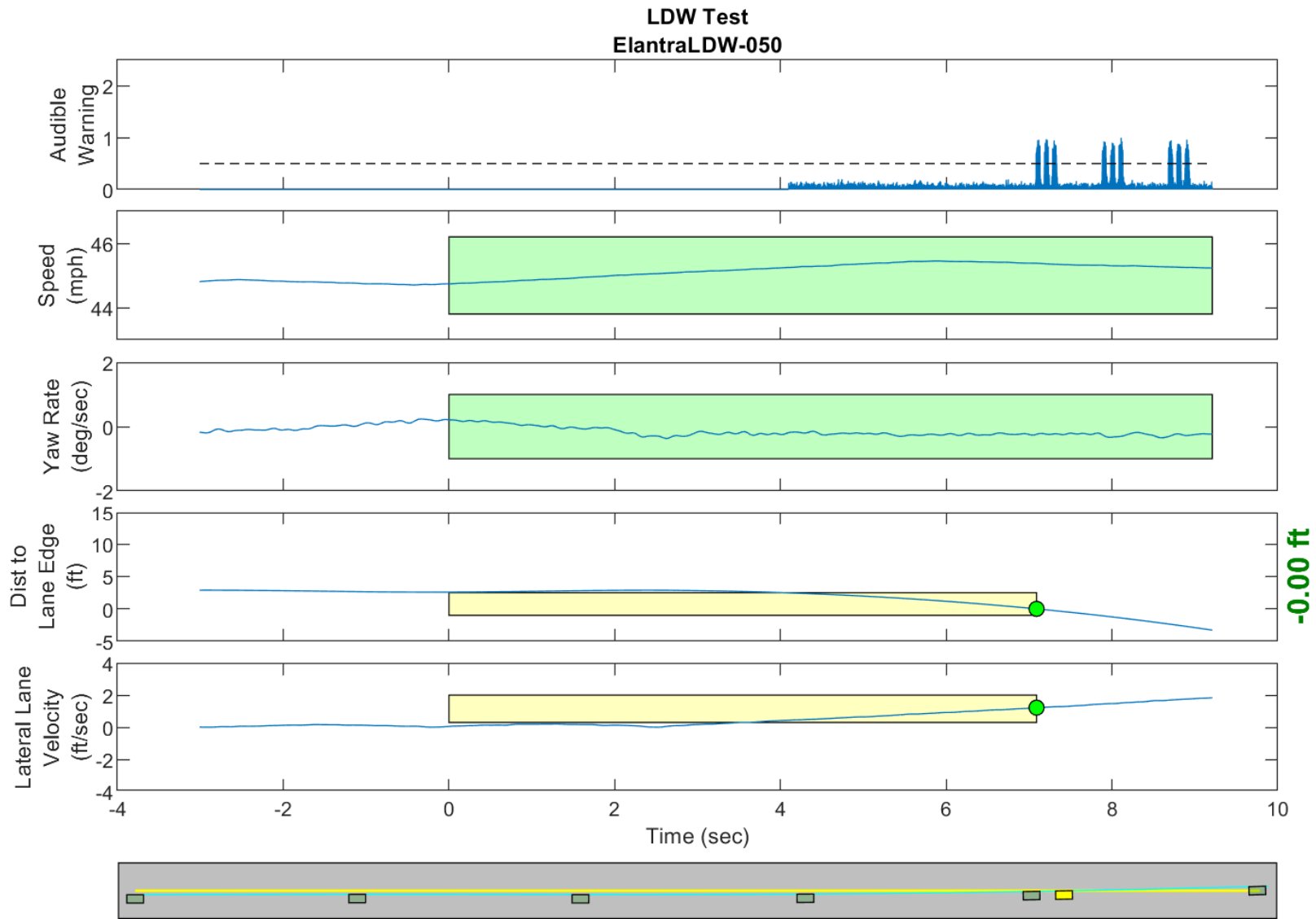
GPS Fix Type: RTK Fixed

Figure D80. Time History for Run 49, Dashed Line, Left Departure, Audible Warning



GPS Fix Type: RTK Fixed

Figure D81. Time History for Run 49, Dashed Line, Left Departure, Visual Warning



GPS Fix Type: RTK Fixed

Figure D82. Time History for Run 50, Dashed Line, Left Departure, Audible Warning

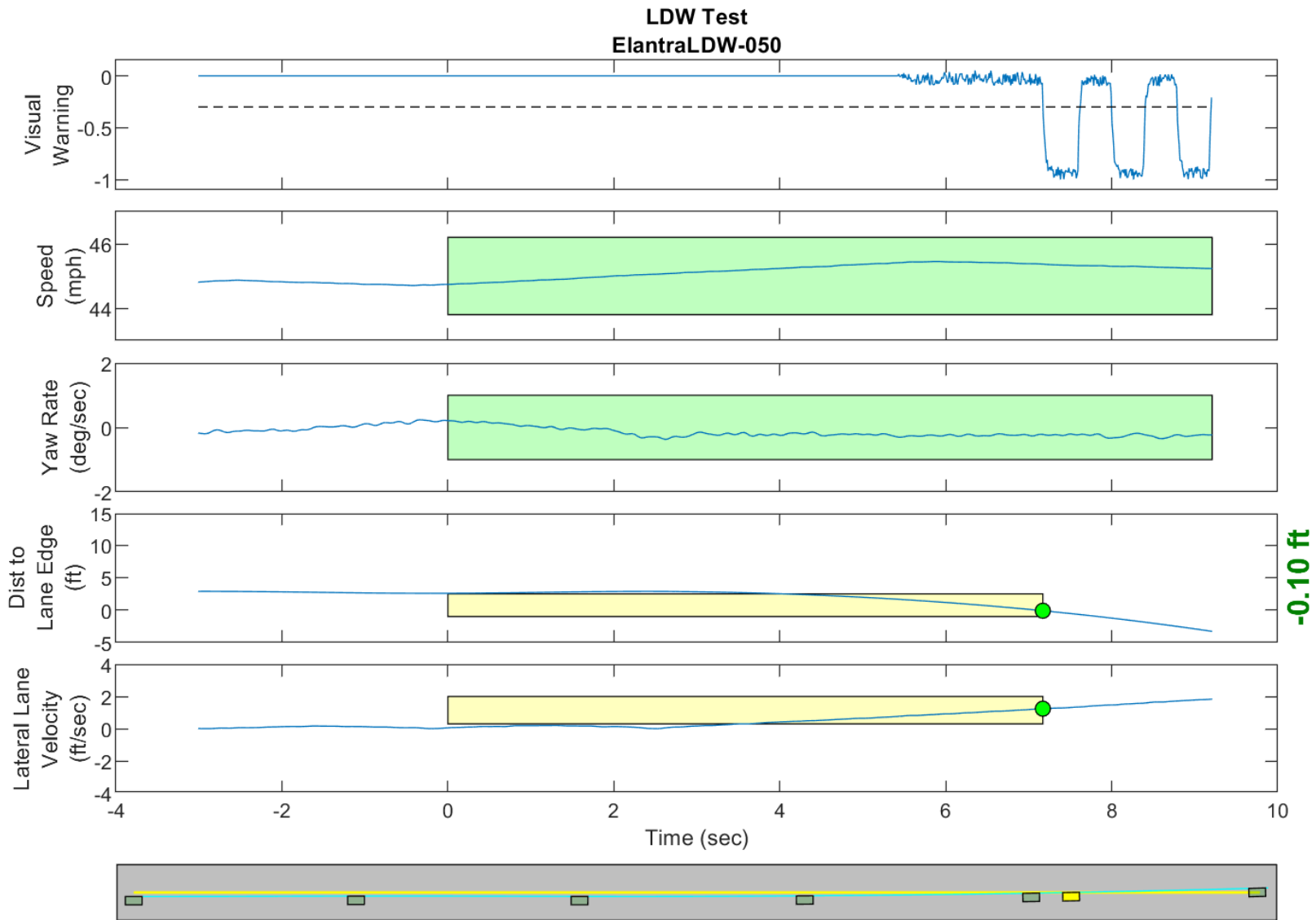
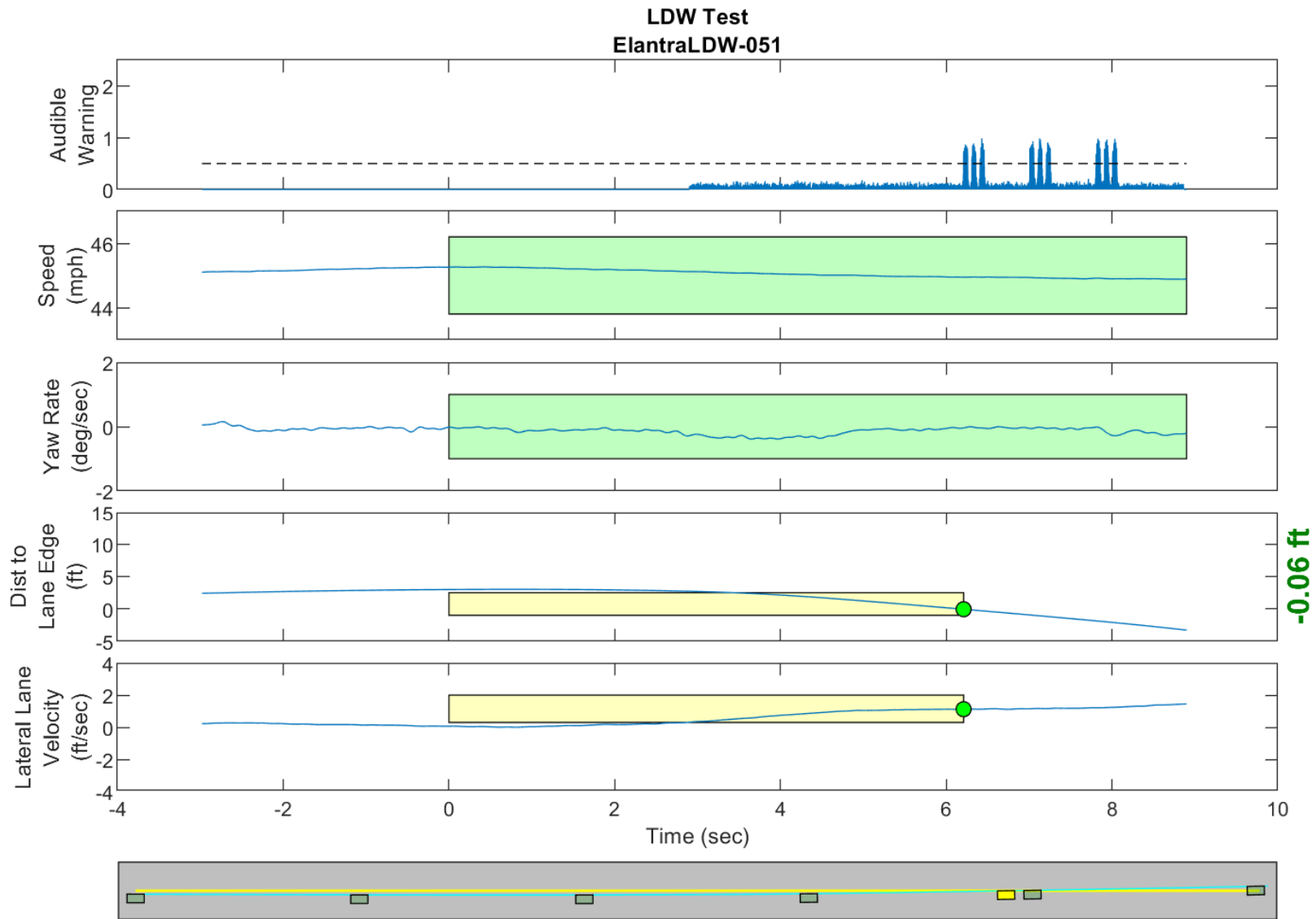
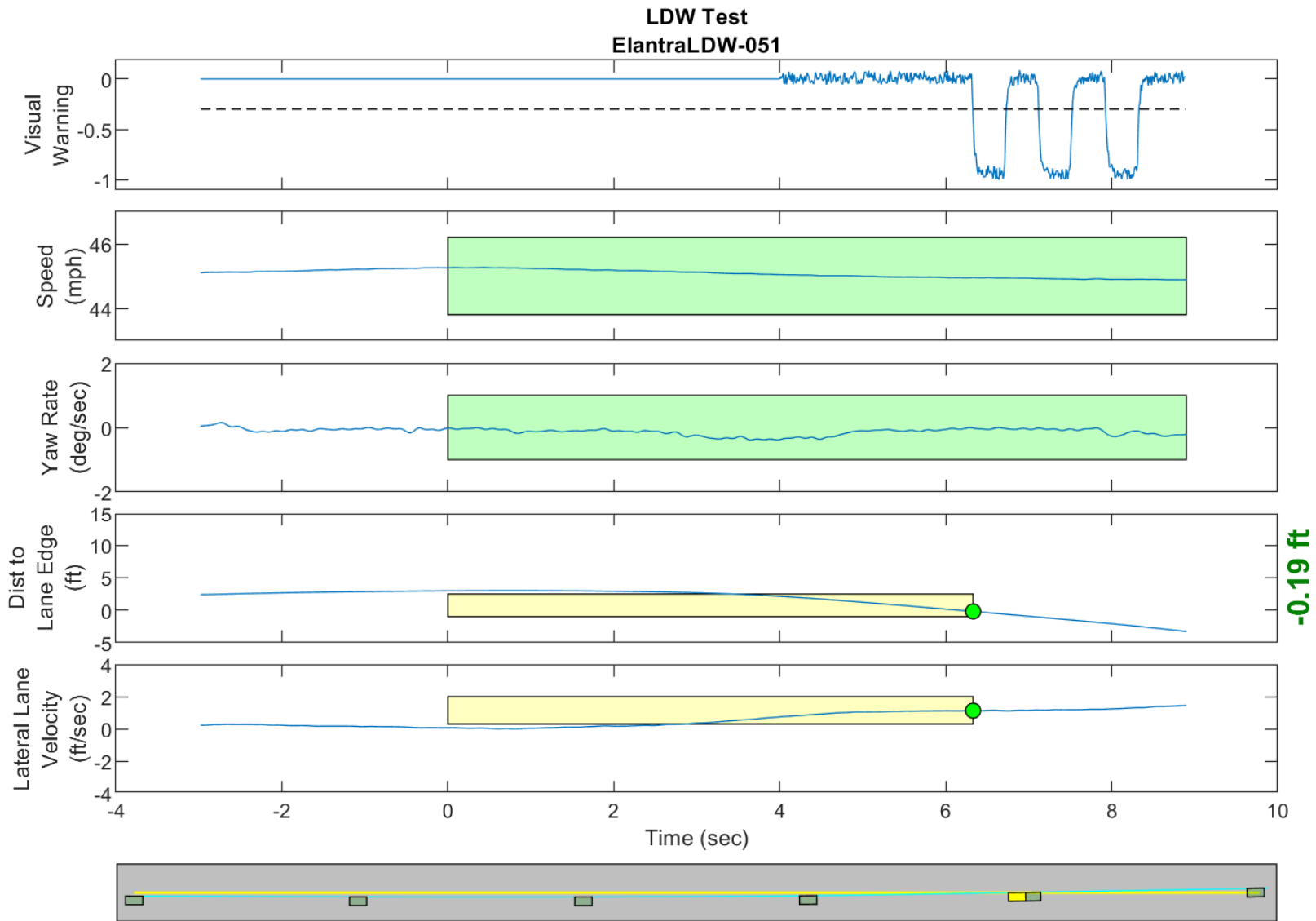


Figure D83. Time History for Run 50, Dashed Line, Left Departure, Visual Warning



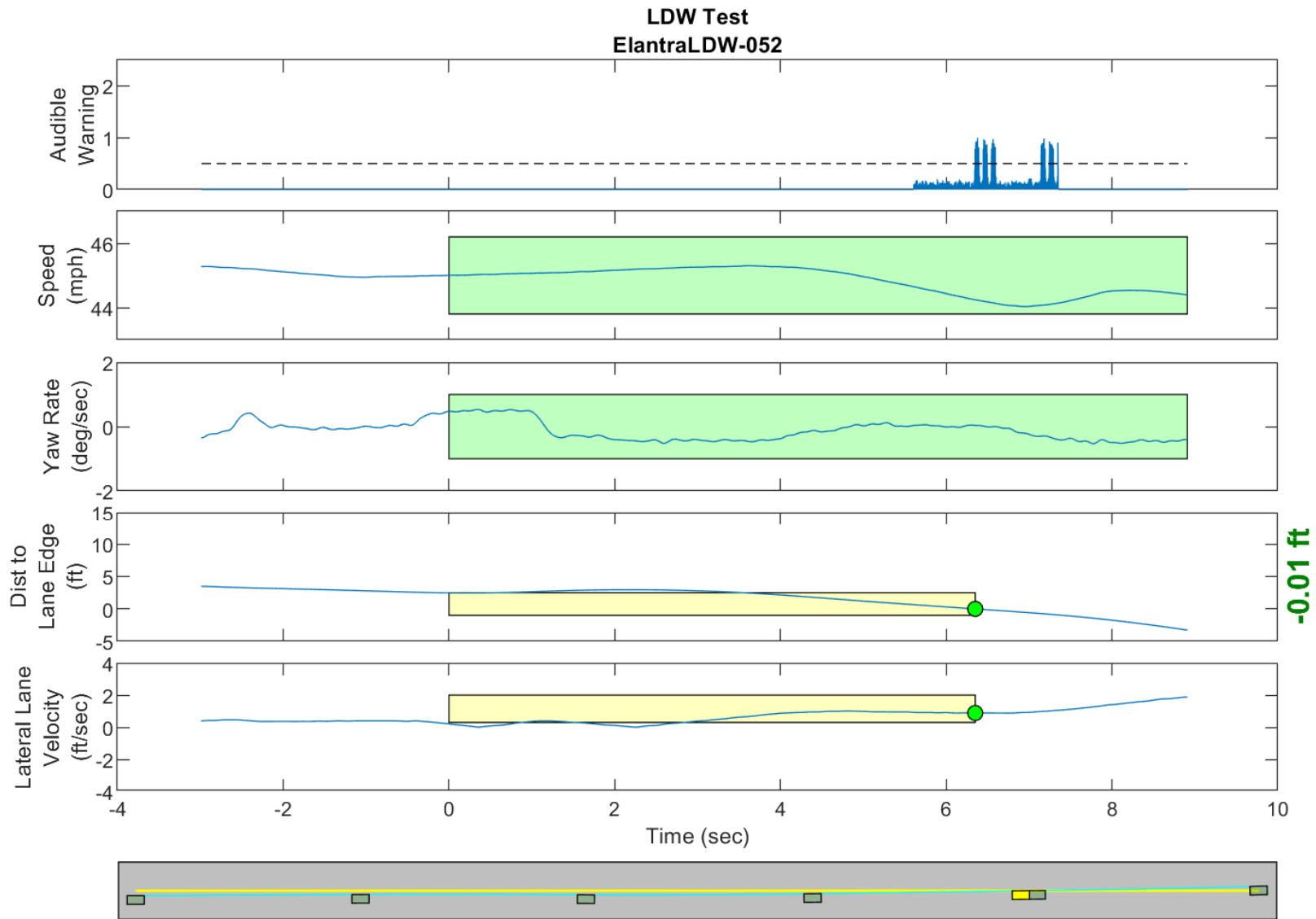
GPS Fix Type: RTK Fixed

Figure D84. Time History for Run 51, Dashed Line, Left Departure, Audible Warning



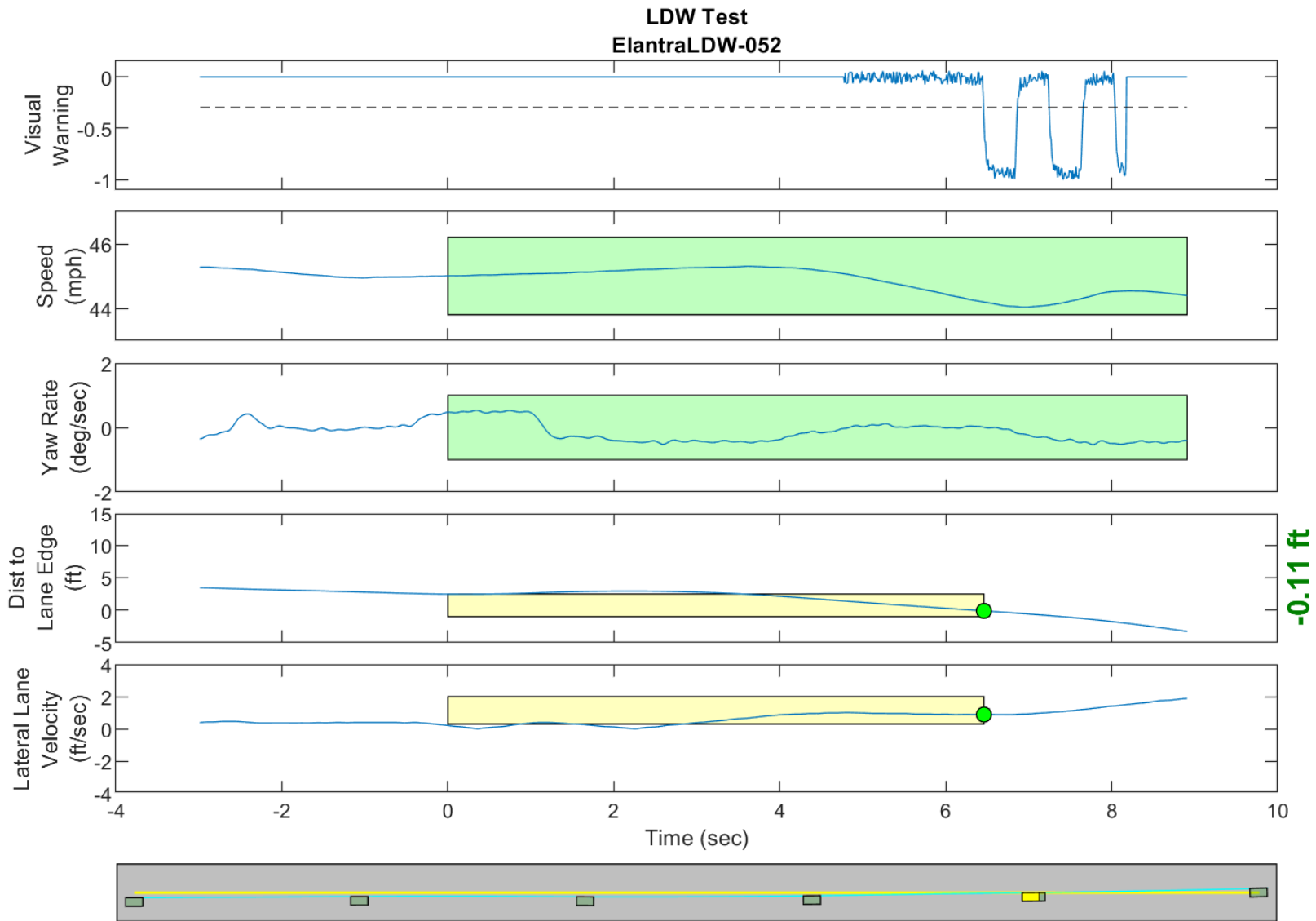
GPS Fix Type: RTK Fixed

Figure D85. Time History for Run 51, Dashed Line, Left Departure, Visual Warning



GPS Fix Type: RTK Fixed

Figure D86. Time History for Run 52, Dashed Line, Left Departure, Audible Warning



GPS Fix Type: RTK Fixed

Figure D87. Time History for Run 52, Dashed Line, Left Departure, Visual Warning