NEW CAR ASSESSMENT PROGRAM
LANE DEPARTURE WARNING CONFIRMATION TEST
NCAP-DRI-LDW-20-11

2020 Kia Optima LX

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30 March 2020

Final Report

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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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16. Abstract These tests were conducted on the subject 2020 Kia Optima 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 Kia Optima LX. 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 Kia Optima LX

VIN: *5XXGT4L36LG4xxxx*

Test Date: *3/10/2020*

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 Kia Optima LX

TEST VEHICLE INFORMATION

VIN: *5XXGT4L36LG4xxxx*

Body Style: *Sedan* Color: *Gravity Grey*

Date Received: *3/2/2020* Odometer Reading: *13 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *KIA MOTORS MANUFACTURING GEORGIA, INC.*

Date of manufacture: *JAN/16/20*

Vehicle Type: *Passenger Car*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *205/65R16*

Rear: *205/65R16*

Recommended cold tire pressure: Front: *235 kPa (34 psi)*

Rear: *235 kPa (34 psi)*

TIRES

Tire manufacturer and model: *NEXEN Npriz AH8 SMART FUEL*

Front tire size: *205/65R16 95H*

Rear tire size: *205/65R16 95H*

Front tire DOT prefix: *UAHE BMHL*

Rear tire DOT prefix: *UAHE BMHL*

LANE DEPARTURE WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2020 Kia Optima LX

GENERAL INFORMATION

Test date: *3/10/2020*

AMBIENT CONDITIONS

Air temperature: *16.1 C (61 F)*

Wind speed: *2.6 m/s (5.8 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: *235 kPa (34 psi)*

Rear: *235 kPa (34 psi)*

LANE DEPARTURE WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2020 Kia Optima LX

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*501.2 kg (1105 lb)*	Right Front:	*466.3 kg (1028 lb)*
Left Rear:	*327.9 kg (723 lb)*	Right Rear:	*317.1 kg (699 lb)*
		Total:	*1612.5 kg (3555 lb)*

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

(Page 1 of 2)

2020 Kia Optima LX

Name of the LDW option, option package, etc.: *Lane Departure Warning (LDW)*

Type and location of sensor(s) used:

Mono (1) 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? (Check all that apply)

- **X** Warning light
- **X** 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. 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. See Appendix A, Figure A11.

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

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2020 Kia Optima LX

Is the vehicle equipped with a switch whose purpose is to render LDW inoperable?

__X__ Yes

_____ No

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

The LKA (LDW) button located on the instrument panel on the lower left-hand side of the driver. When enabled, an indicator in the cluster display will initially illuminate white.

The color of indicator will change depend on the condition of LKA:

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

Is the vehicle equipped with a control whose purpose is to adjust the range setting or otherwise influence the operation of LDW?

_____ Yes

__X__ No

If yes, please provide a full description.

Are there other driving modes or conditions that render LDW inoperable or reduce its effectiveness?

__X__ Yes

_____ No

If yes, please provide a full description.

The limitations of the system are described in the Owner's manual on page 5-71 which is reproduced in Appendix B, page B-14.

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.

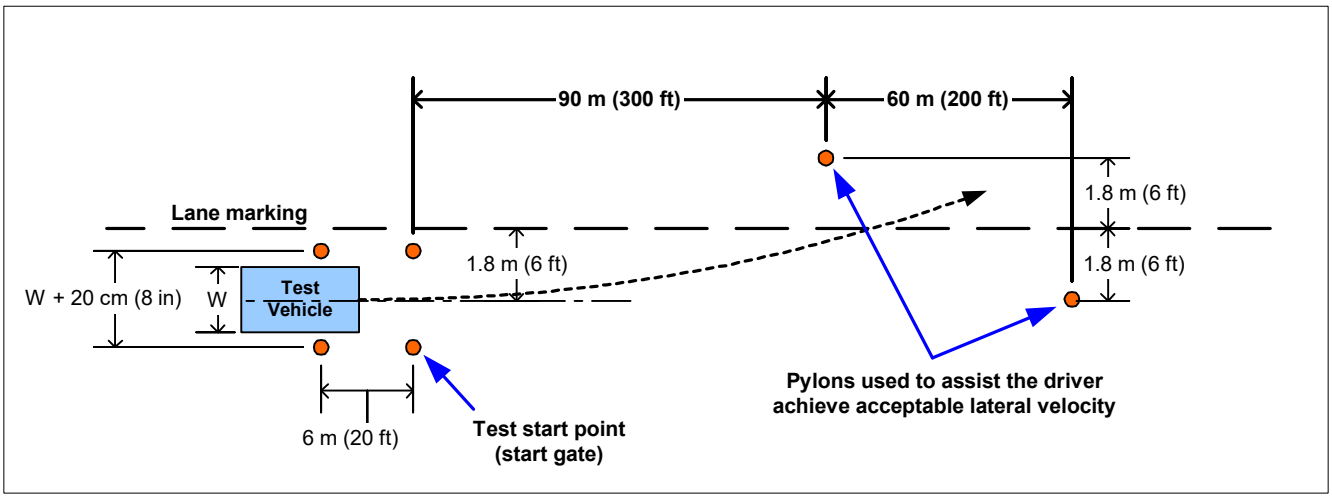

Figure 1. Position of Cones Used to Assist Driver

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.

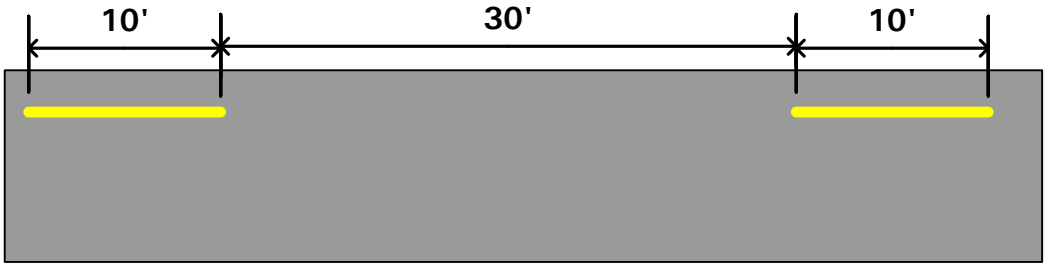

Figure 2. MUTCD Discontinuous Dashed Line Specifications

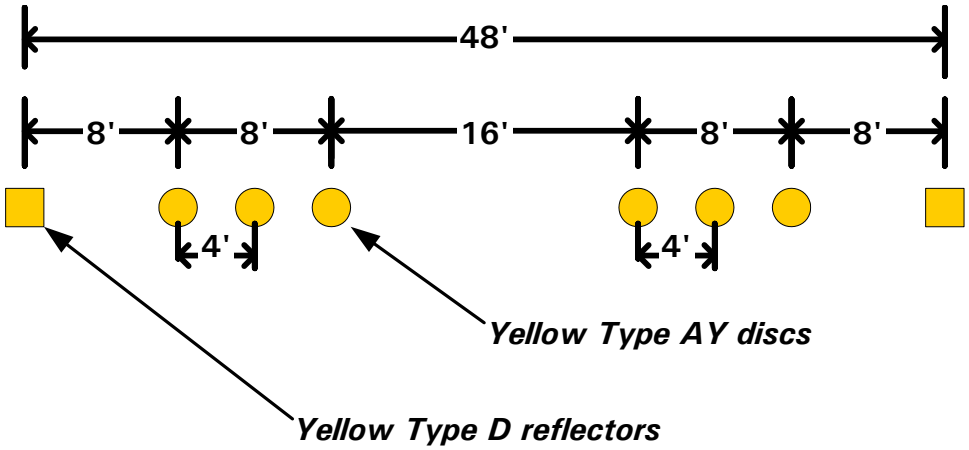

Figure 3. California Standard Plan A20A, Detail 4

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	0828MA19001	By: DRI Date: 9/12/2019 Due: 9/12/2020
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 Solutions1 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 ± 5%
Tactile	5^{th}	3 dB	60 dB	Identified Center Frequency ± 20%

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

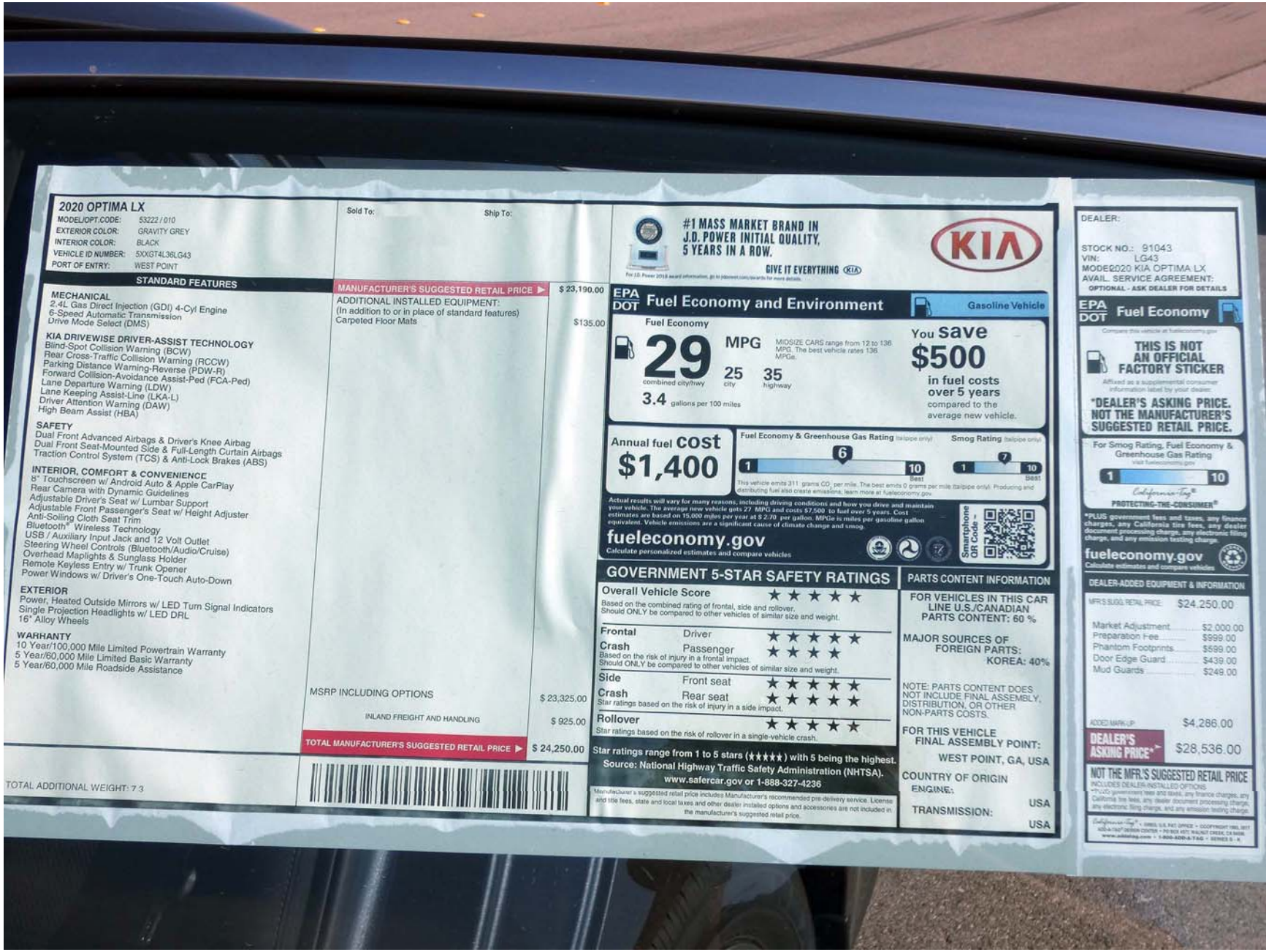

Figure A3. Window Sticker (Monroney Label)

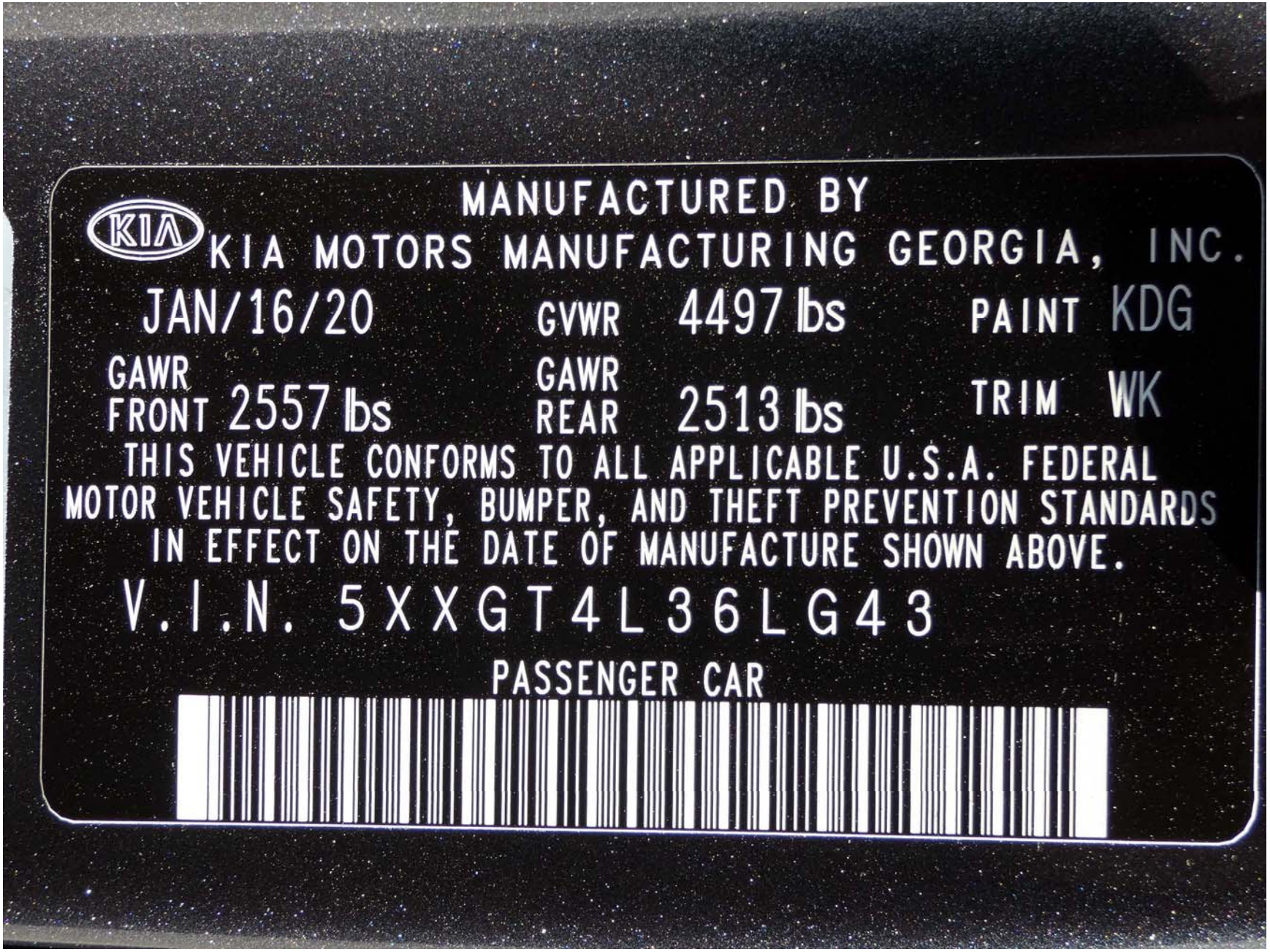

Figure A4. Vehicle Certification Label

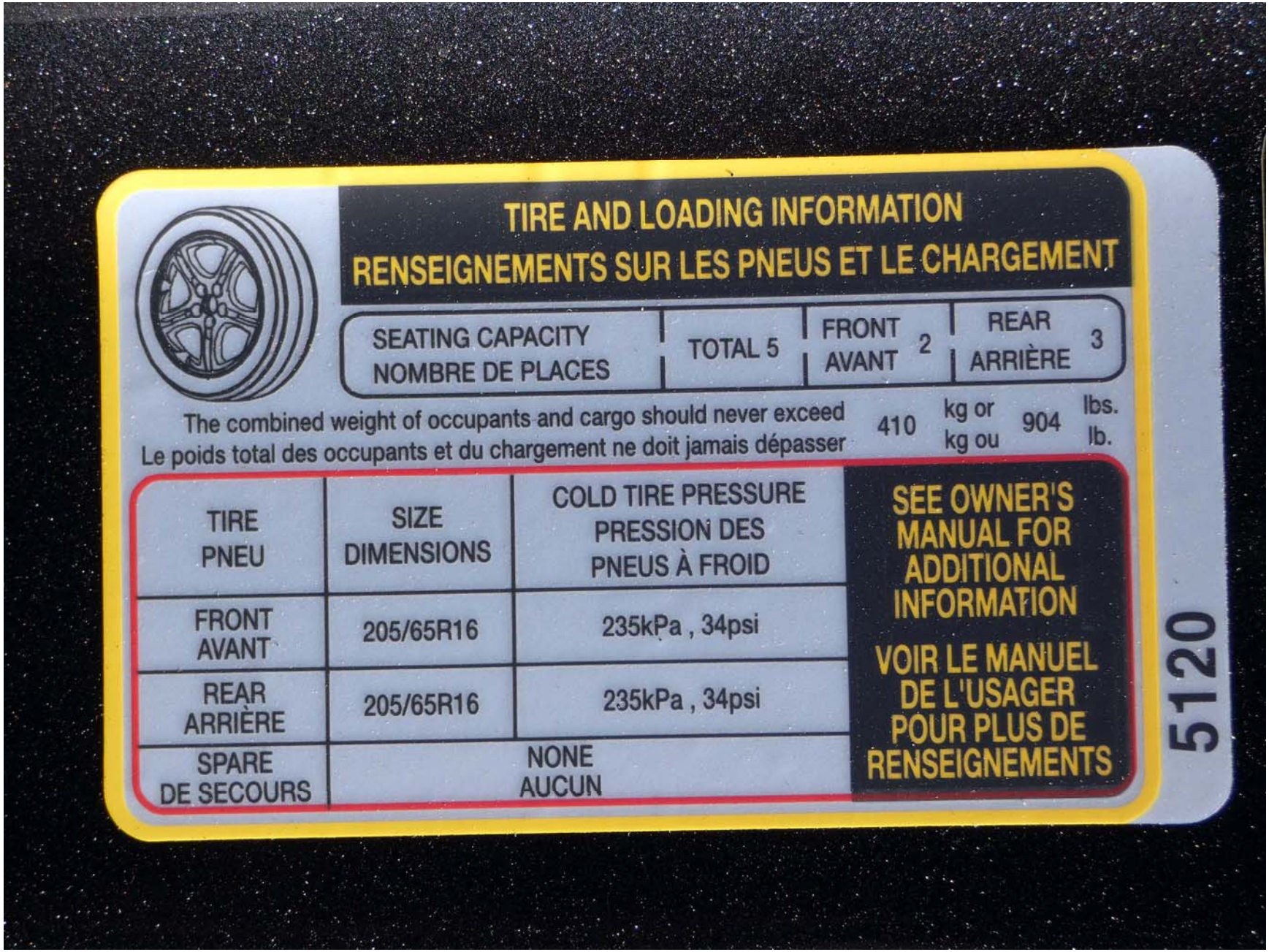

Figure A5. Tire Placard

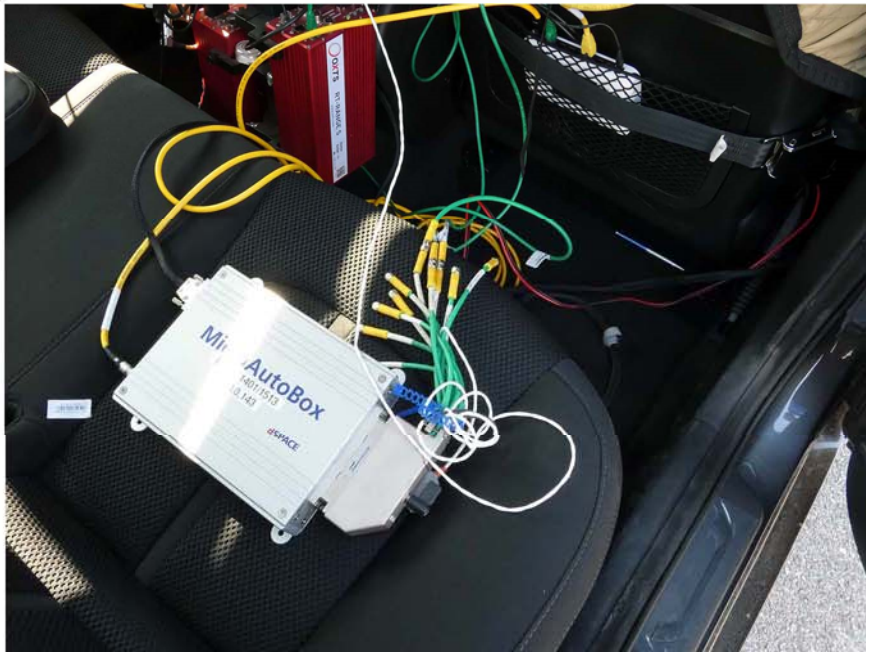

Figure A6. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

Figure A7. Sensor for Detecting Visual Alerts

Figure A8. Sensor for Detecting Auditory Alerts

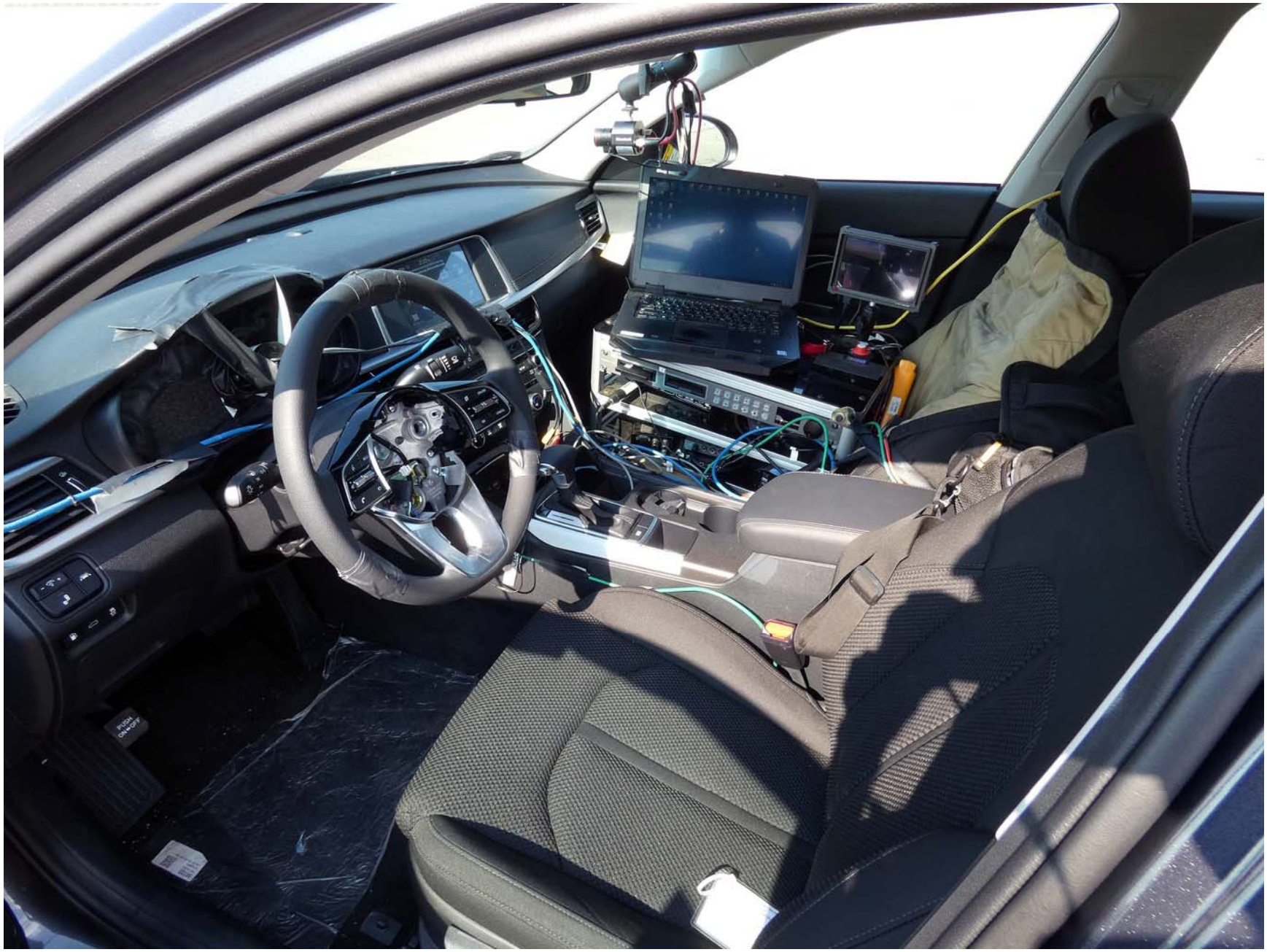

Figure A9. Computer Installed in Test Vehicle

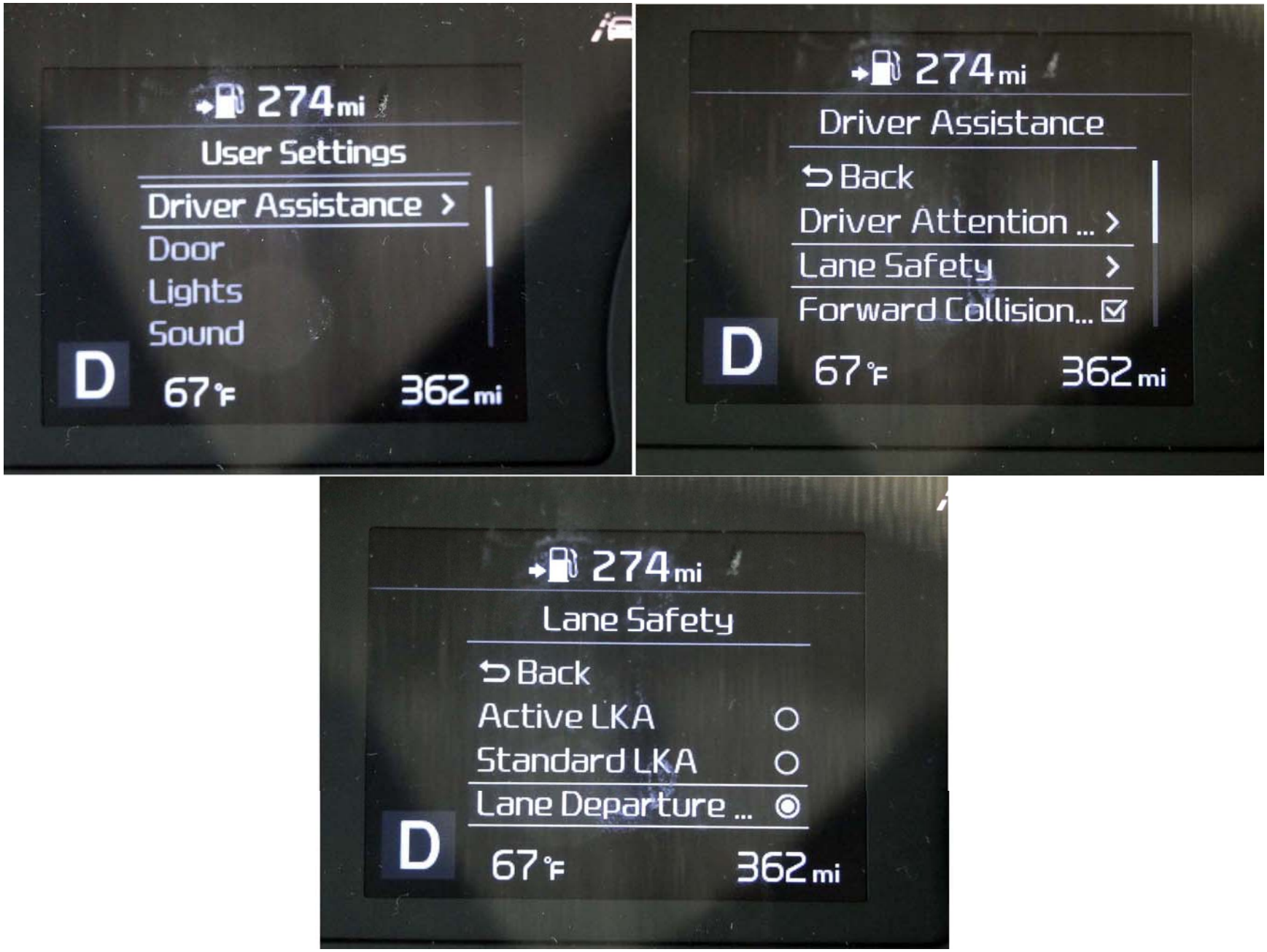

Figure A10. LDW Menus

Figure A11. LDW Visual Alert

Figure A12. LDW On/Off Switch

APPENDIX B

Excerpts from Owner’s Manual

INTERIOR OVERVIEW

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18. Parking brake pedal 5-23
19. Hood release lever 4-37
20. Seat 3-4

❈ The actual shape may differ from the illustration.

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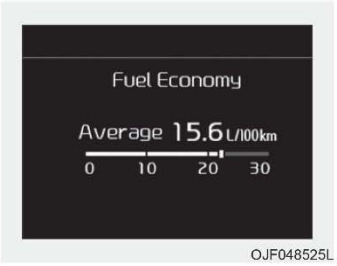
LCD DISPLAY

LCD Modes

Modes	Symbol	Explanation
Trip Computer		This mode displays driving information such as the tripmeter, fuel economy, and so on. ❉ For more details, refer to “Trip Computer” in this chapter.
Turn by Turn mode (if equipped)		This mode displays the state of the navigation.
Assist mode (if equipped)		This mode displays the state of below systems. - Lane Keeping Assist (Refer to “Lane keeping Assist (LKA) system” in chapter 5) - Driving Attention Warning (Refer to “Driving Attention Warning (DAW) system” in chapter 5) - Tire Pressure(Refer to “Tire Pressure Monitoring System (TPMS)” in chapter 6) ❉ For more details, refer to chapter 5 and 6.
User Settings		On this mode, you can change settings of the doors, lamps and so on.
Master warning mode		This mode informs of warning messages related to Low tire pressure or malfunction of Blind-spot Collision Warning and so on.

❉ For controlling the LCD modes, refer to "LCD Display Control" in this chapter.

Trip computer mode



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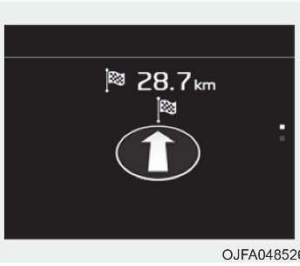
This mode displays driving information like the tripmeter, fuel economy, and so on.

❊ For more details, refer to “Trip Computer” in this chapter.

Turn By Turn mode (if equipped)



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This mode displays the state of the navigation.

Assist mode (if equipped)

■ LKA

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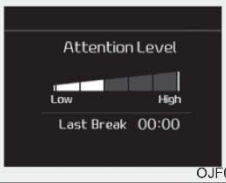
■ DAW



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■ TPMS

OJF068263L

Master warning mode (if equipped)

- This warning light informs the driver of the following situations
- Forward Collision-Avoidance Assist malfunction
- Blind-Spot Collision Warning radar blind
- Lamp malfunction
- High Beam Assist malfunction
- Tire Pressure Monitoring System (TPMS) malfunction
- Electronic Control Suspension (ECS) malfunction

The Master Warning Light illuminates if one or more of the above warning situations occur.

If the warning situation is solved, the master warning light will be turned off.

User Settings Mode

Description

OJF048553L

On this mode, you can change setting of the doors, lamps, and so on.

⚠ WARNING

Do not adjust the User Setting while driving.

You may lose your steering control which could cause an accident and bodily injury.

Shift to P to edit settings

OJF048554L

This warning message appears if you try to adjust the User Settings while driving.

For your safety, change the User Settings after parking the vehicle, applying the parking brake and moving the shift lever to P (Park).

Driver Assistance (if equipped)

- Driver Attention Warning :
  - Choose the alert stage (High sensitivity/Normal sensitivity/Off) of the Driver Attention Warning.

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

- Lane Safety :
  - Active LKA : To activate the active LKA mode.
  - Standard LKA : To activate the standard LKA mode.
  - Lane Departure Warning : To activate the lane departure warning function.

❊For more details, refer to “Lane Keeping Assist (LKA) System” in chapter 5.

- Forward Collision-avoidance Assist (FCA) :
  - To activate or deactivate the FCA system.

❊For more details, refer to “Forward Collision-avoidance Assist (FCA)” in chapter 5.

- Forward Collision Warning :
  - Choose the inital warning alert time of the forward collision warning. (Late/Normal/Early)

❊For more details, refer to “Forward Collision-avoidance Assist (FCA)” in chapter 5.

- Blind-Spot Collision Warning Timing :
  - Choose the initial warning alert time of the blind-spot collision warning timing. (Normal/Late)

❊For more details, refer to “Blind-Spot Collision Warning” in chapter 5.

- Rear Cross-Traffic Collision Warning :
  - If this item is checked, the rear cross-traffic collision Warning function will be activated.

❊For more details, refer to “Blind-spot Collision Warning” in chapter 5.

Cruise Indicator Light (if equipped) **CRUISE**

This indicator light illuminates:

- When the cruise control system is enabled.

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

Cruise SET Indicator Light (if equipped) **SET**

This indicator light illuminates:

- When the cruise control speed is set.

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

LKA (Lane Keeping Assist) System Indicator

This indicator light illuminates :

- When you turn the lane keeping assistant system on by pressing the LKA button.

  If there is a problem with the system, the yellow LKA indicator will illuminate.

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

⚠ WARNING - Distracted driving

Driving while distracted can result in a loss of vehicle control that may lead to an accident, severe personal injury, and death. The driver's primary responsibility is in the safe and legal operation of a vehicle, and use of any handheld devices, other equipment, or vehicle systems which take the driver's eyes, attention and focus away from the safe operation of a vehicle or which are not permissible by law should never be used during operation of the vehicle.

LANE KEEPING ASSIST (LKA) SYSTEM


OJF058305

The Lane Keeping Assist system is designed to detect the 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 in the lanes.

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

⚠ WARNING

The Lane Keeping Assist System is a supplemental system and is not a substitute for safe driving practices. It is the responsibility of the driver to always pay attention and drive safely.

⚠ WARNING

- **Driver is responsible for being aware of surroundings and steering the vehicle for safe driving practices.**
- **Do not steer the steering wheel suddenly when the steering wheel is being assisted by the system.**

✻ NOTICE

- **LKA helps prevent the driver from moving out of the lane unintentionally by assisting the driver's steering. However, the system is just a convenience function and the steering wheel is not always controlled. While driving, the driver should pay attention to the steering wheel.**
- **The operation of the LKA can be cancelled or not work properly according to road condition and surroundings. Always be cautious when driving.**
- **Do not disassemble a front view camera temporarily for tinted window or attaching any types of coatings and accessories.**
  If you disassemble the camera and assemble it again, take your vehicle to an authorized Kia dealer and have the system checked to need a calibration.

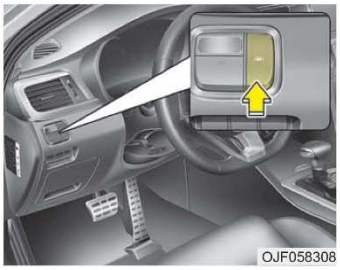
(Continued)

(Continued)
- When you replace the windshield glass, front view camera or related parts of the steering, take your vehicle to an authorized Kia dealer and have the system checked to need a calibration.
- The system detects lane markers and controls the steering wheel by a front view camera, therefore, if the lane markers are hard to detect, the system may not work properly. Always be cautious when using the system.
- When the lane markers are hard to detect, please refer to "Driver's Attention".
- Do not remove or damage the related parts of LKA.
- Do not place objects on the crash pad that reflects light such as mirrors, white paper, etc. it may cause malfunction of LKA if the sunlight is reflected.

(Continued)

(Continued)
- You may not hear warning sound of LKA because of the excessive audio sound.
- If you continue to drive with your hands off the steering wheel, the LKA will stop controlling the steering wheel after the hands off alarm. After then, if you drive with your hands on the steering wheel, the control will be activated again.
- If the vehicle speed is high, steering torque for assistance will not be enough to keep your vehicle within the lane. If so, the vehicle may move out of its lane. Obey speed limit when using LKA.
- If you attach objects to the steering wheel, the system may not assist steering.
- If you attach objects to the steering wheel, hands off alarm may not work properly.

LKA operation



To activate/deactivate the LKA:

With the ignition switch in the ON position, press the LKA button located on the instrument panel on the lower left hand side of the driver.

The indicator in the cluster display will initially illuminate white.

When the indicator(white) activated in the previous ignition cycle, the system turns on without any control.

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

The color of indicator will change depend on the condition of LKA.

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

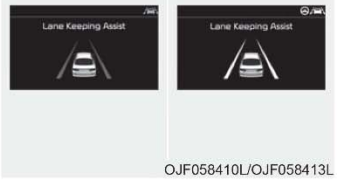
LKA activation

- To see the LKA screen on the LCD display in the cluster, Tab to the ASSIST mode ( ).
- For further details, refer to [menu settings] in chapter 4.
- After LKA is activated, if both lane markers are detected, vehicle speed is over 64 km/h (40 mph) and all the activation conditions are satisfied, a green steering wheel indicator will illuminate and the steering wheel will be controlled.

⚠ WARNING

The Lane Keeping Assist 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 check the road conditions when driving.

■ Lane undetected ■ Lane detected



OJF058410L/OJF058413L

If the speed of the vehicle is over 64 km/h (40 mph) and the system detects lane markers, the color changes from gray to white

When the conditions below are met, LKA will be enable to assist steering.

- Vehicle speed is above 64 km/h (40 mph).
- Both lane markers are detected by LKA.
- The vehicle is between the lane markers.

If LKA can assist steering, a green steering wheel indicator will illuminate.

Warning

■ Left lane ■ Right lane

OJF058414L/OJF058415L

If the vehicle leaves a lane, the lane marker you cross will blink on the LCD display.

If the vehicle moves out its lane because steering torque for assistance is not enough, the line indicator will blink.

- If all the conditions to activate LKA is not satisfied, the system will convert to LDW and warn the driver only when the driver crosses the lane markers. In this scenario, the LDW system does not provide any steering inputs into the vehicle for you. Accordingly, you must take the necessary steps to maintain control of the vehicle and keep it within the lanes.

OJF058416L

OJF058417L

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

⚠ WARNING

- **If you hold the steering wheel lightly, the system may generate a hands off warning because the Lane Keeping Assist may not detect the presence of the driver's hands on the steering wheel.**
- **If you hold the steering wheel lightly, the system would generate hands off warning because LKA can treat the situation as you do not grab the wheel.**

If the driver still does not have their hands on the steering wheel after several seconds, 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.

⚠ WARNING

- **The driver is responsible for accurate steering.**
- **Even though the steering is assisted by the system, the driver may control the steering wheel.**
- **Turn off the system and drive the vehicle in below situations.**
  - **In bad weather**
  - **In bad road condition**
  - **When the steering wheel needs to be controlled by the driver frequently.**
- **The steering wheel may feel heavier when the steering wheel is assisted by the system than when it is not.**

✻ NOTICE

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

The system will be cancelled when:

- You change lanes with the turn signal.
  - Using the turn signal to change lanes.
  - If you change lanes without the turn signal on, the steering wheel might be controlled.
- LKA can transit to steering assist mode when the car is near to middle of the lane after system on or the lane was changed. LKA can not assist steering if the vehicle follows lane marker too close continuously before transition to steering assist mode.
- The control of ESC (Electronic Stability Control) or VSM (Vehicle Stability Management) is activated.
- The steering will not be assisted when you drive fast on a sharp curve.
- The steering will not be assisted when vehicle speed is below 64 km/h (40 mph). and over 177 km/h (110 mph). Always obey all traffic laws and drive safely.
- The steering will not be assisted when you change lanes quickly.
- The steering will not be assisted when you brake suddenly.
- The steering will not be assisted when the lane is very wide or narrow.
- The steering will not be assisted when only one side lane marker is detected.
- There are more than two lane markers such as a construction area.
- Radius of a curve is too small.
- When you turn steering wheel suddenly, the LKA will be disabled temporarily.
- Driving on a steep slope or hill.

DRIVER'S ATTENTION

The driver must be cautious in the below situations may not work properly when recognition of the lane marker is poor or limited :

▶ When lane and road condition is poor

- **It is difficult to distinguish the lane marker from road when the lane marker is covered with dust or sand.**
- **It is difficult to distinguish the color of the lane marker from road.**
- **There is something looks like a lane marker.**
- **The lane marker is indistinct or damaged.**
- **The number of lanes increases/ decreases or the lane lines are crossing (Driving through a toll plaza/toll gate, merged/divided lane).**
- **There are more than two lane markers.**
- **The lane marker is very thick or thin.**

(Continued)

(Continued)

- **The lane marker is not visible due to snow, rain, stain, a puddle or other factors.**
- **A shadow is on the lane marker because of a median strip, guardrail, noise barriers and others.**
- **When 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 suddenly disappears such as at the intersection.**
- **The lane marker in a tunnel is covered with dirt or oil and etc.**

▶ When external condition is intervened

- **The brightness of outside changes suddenly when entering/existing a tunnel or passing under a bridge.**
- **The headlamps are not on at night or in a tunnel, or light level is low.**
- **There is a boundary structure in the roadway.**

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- **The light of street, sun, oncoming vehicle and so on reflects from the water on the road.**
- **When light shines brightly in the reverse direction you drive.**
- **The distance from the vehicle ahead is very short or the vehicle ahead drives hiding the lane line.**
- **You drive on a steep grade or a sharp curve.**
- **The vehicle vibrates heavily.**
- **The temperature near inside mirror is very high due to direct sun light and etc.**

▶ When front visibility is poor

- **The lens or windshield is covered by strange materials.**
- **The sensor cannot detect the lane because of fog, heavy rain or snow.**
- **The windshield is fogged by humid air in the vehicle.**
- **Putting something on the crash pad and etc.**

⚠ WARNING

The Lane Keeping Assist 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 malfunction

OJF058419L

- If there is a problem with the system a message will appear. If the problem continues the LKA fail indicator will illuminate.

LKA fail indicator

The LKA fail indicator (yellow) will illuminate with an audible warning if the LKA is not working properly. In this case, have the system checked by a professional workshop. Kia recommends to visit an authorized Kia dealer/service partner.

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, take your vehicle to an authorized Kia dealer and have the system checked.

LKA function change

The driver can change LKA to Lane Departure Warning (LDW) system or change the LKA mode between Standard LKA and Active LKA from the User Settings Mode on the LCD display.

The driver can choose them by placing the ignition switch to the ON position and by selecting 'User Settings', 'Driver Assistance', and 'Lane Safety'.

The system is automatically set to Standard LKA when your vehicle is first delivered from the factory.

Lane Departure

LDW alerts the driver with a visual and acoustic warning when the system detects the vehicle leaving the lane. In this mode, the steering wheel will not be controlled. When the vehicle's front wheel contacts the inside edge of lane line, LKA issues the lane departure warning.

Standard LKA

The Standard LKA mode guides the driver to 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 from the lanes.

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.

APPENDIX C

Run Log

Subject Vehicle: **2020 Kia Optima LX** Test Date: **3/10/2020**

Driver: **J. Robel** **Note: For Distance at Warning positive values indicate inside the lane**

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Audible Alert (ft)	Distance at Visual Alert (ft)	Pass/Fail	Notes
1	**Solid**	**Left**	Y	0.24	0.11	Pass	
2			N				Yaw Rate
3			Y	0.18	0.00	Pass	
4			Y	0.21	0.08	Pass	
5			Y	0.26	0.12	Pass	
6			Y	0.19	0.04	Pass	
7			Y	0.16	-0.03	Pass	
8			Y	0.24	0.10	Pass	
9	**Solid**	**Right**	Y	-0.20	-0.39	Pass	
10			Y	-0.16	-0.36	Pass	
11			Y	-0.17	-0.32	Pass	
12			Y	-0.10	-0.23	Pass	
13			Y	-0.19	-0.34	Pass	
14			Y	-0.16	-0.30	Pass	
15			Y	-0.18	-0.41	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Audible Alert (ft)	Distance at Visual Alert (ft)	Pass/Fail	Notes
16	**Dashed**	**Right**	Y	-0.20	-0.36	Pass	
17			N				Yaw Rate
18			Y	-0.28	-0.47	Pass	
19			Y	-0.28	-0.43	Pass	
20			Y	-0.26	-0.54	Pass	
21			Y	-0.25	-0.41	Pass	
22			Y	-0.22	-0.38	Pass	
23			Y	-0.30	-0.45	Pass	
24	**Dashed**	**Left**	N				SV Speed
25			Y	-0.01	-0.13	Pass	
26			Y	0.00	-0.10	Pass	
27			Y	0.01	-0.12	Pass	
28			Y	0.00	-0.11	Pass	
29			Y	-0.05	-0.21	Pass	
30			Y	0.01	-0.11	Pass	
31			Y	0.01	-0.09	Pass	
32	**Botts**	**Left**	N				SV Speed
33			Y	-0.10	-0.25	Pass	
34			Y	-0.04	-0.18	Pass	
35			Y	-0.13	-0.26	Pass	
36			Y	0.00	-0.11	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Audible Alert (ft)	Distance at Visual Alert (ft)	Pass/Fail	Notes
37			Y	-0.10	-0.22	Pass	
38			Y	-0.11	-0.25	Pass	
39			Y	-0.10	-0.29	Pass	
40	**Botts**	**Right**	Y	-0.11	-0.26	Pass	
41			Y	-0.15	-0.35	Pass	
42			Y	-0.09	-0.23	Pass	
43			Y	-0.08	-0.23	Pass	
44			Y	-0.09	-0.29	Pass	
45			Y	-0.06	-0.19	Pass	
46			Y	-0.18	-0.35	Pass	

APPENDIX D

Time History Plots

LIST OF FIGURES

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
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.

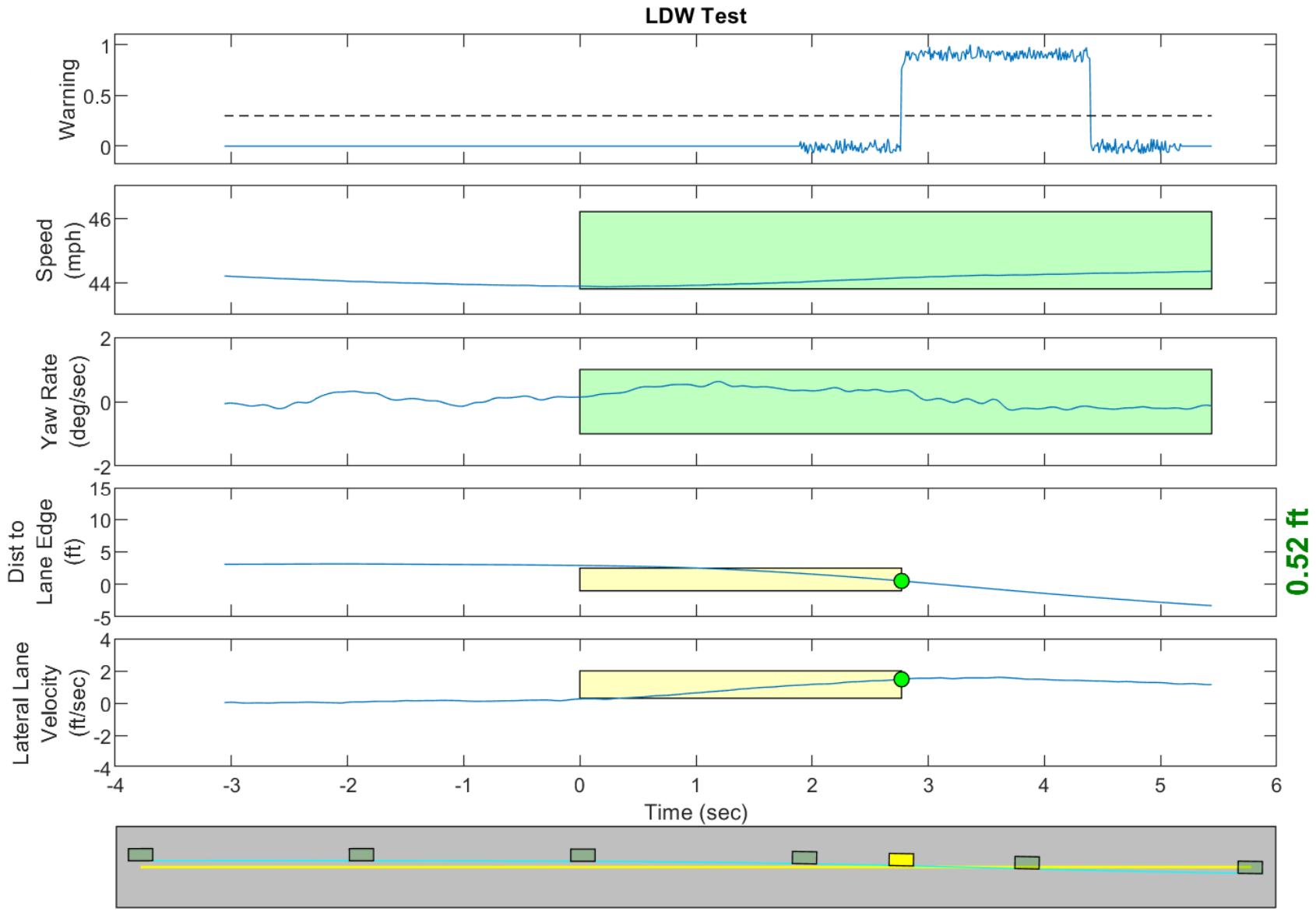

Figure D1. Example Time History for Lane Departure Warning Test, Passing

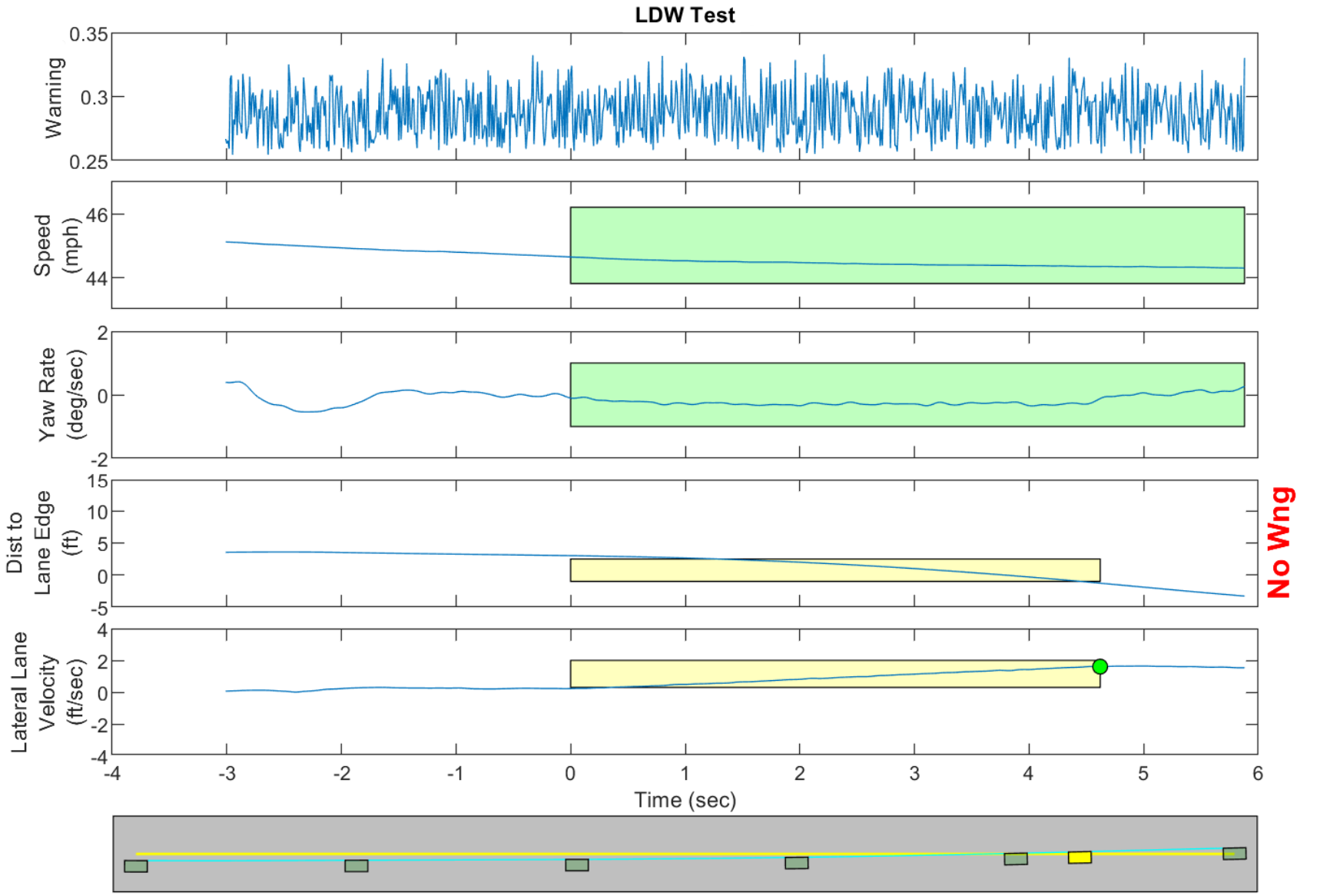

Figure D2. Example Time History for Lane Departure Warning Test, Failing, No Warning Issued

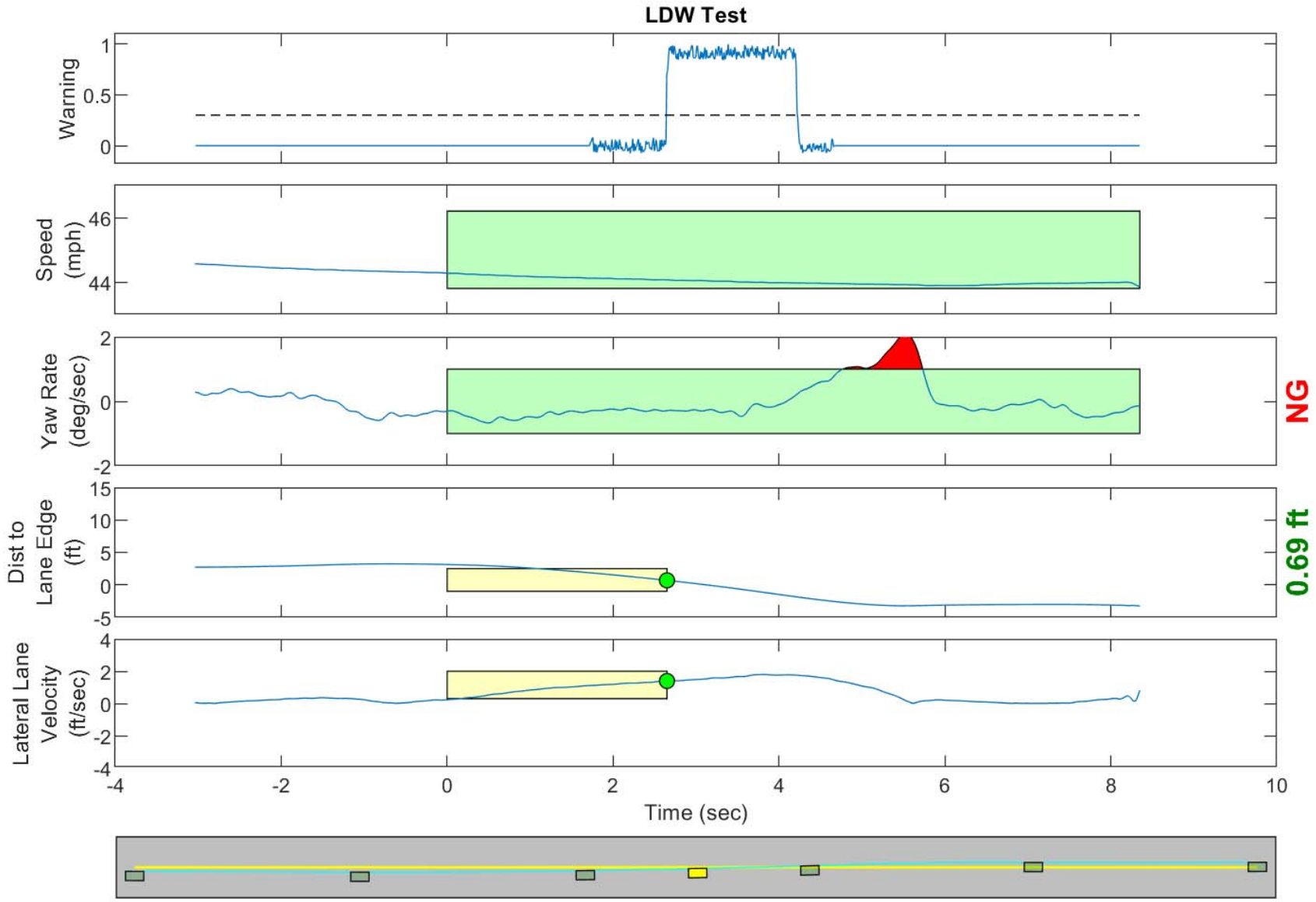

Figure D3. Example Time History for Lane Departure Warning Test, Invalid Run Due to Subject Vehicle Yaw Rate

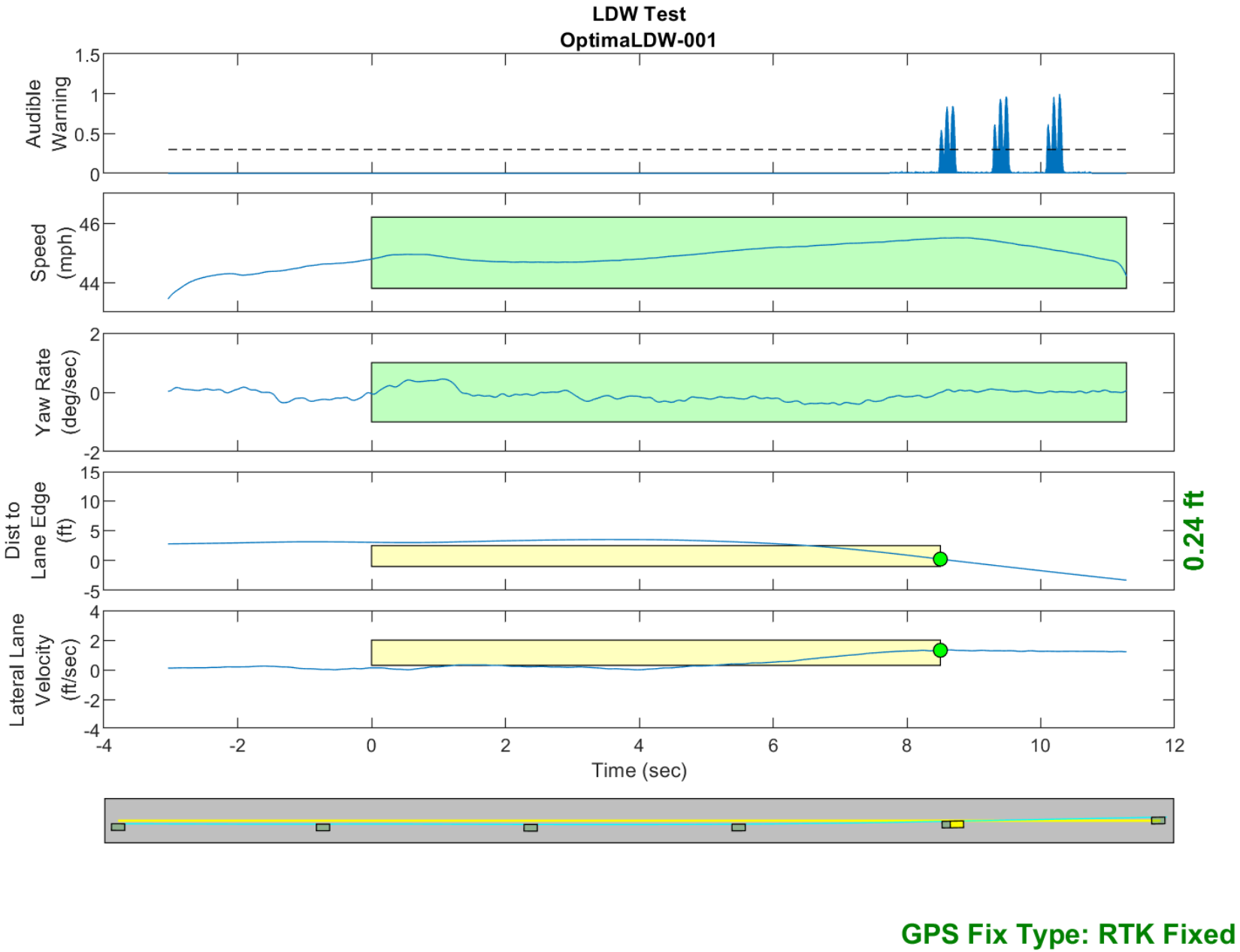

Figure D4. Time History for Run 01, Solid Line, Left Departure, Audible Warning

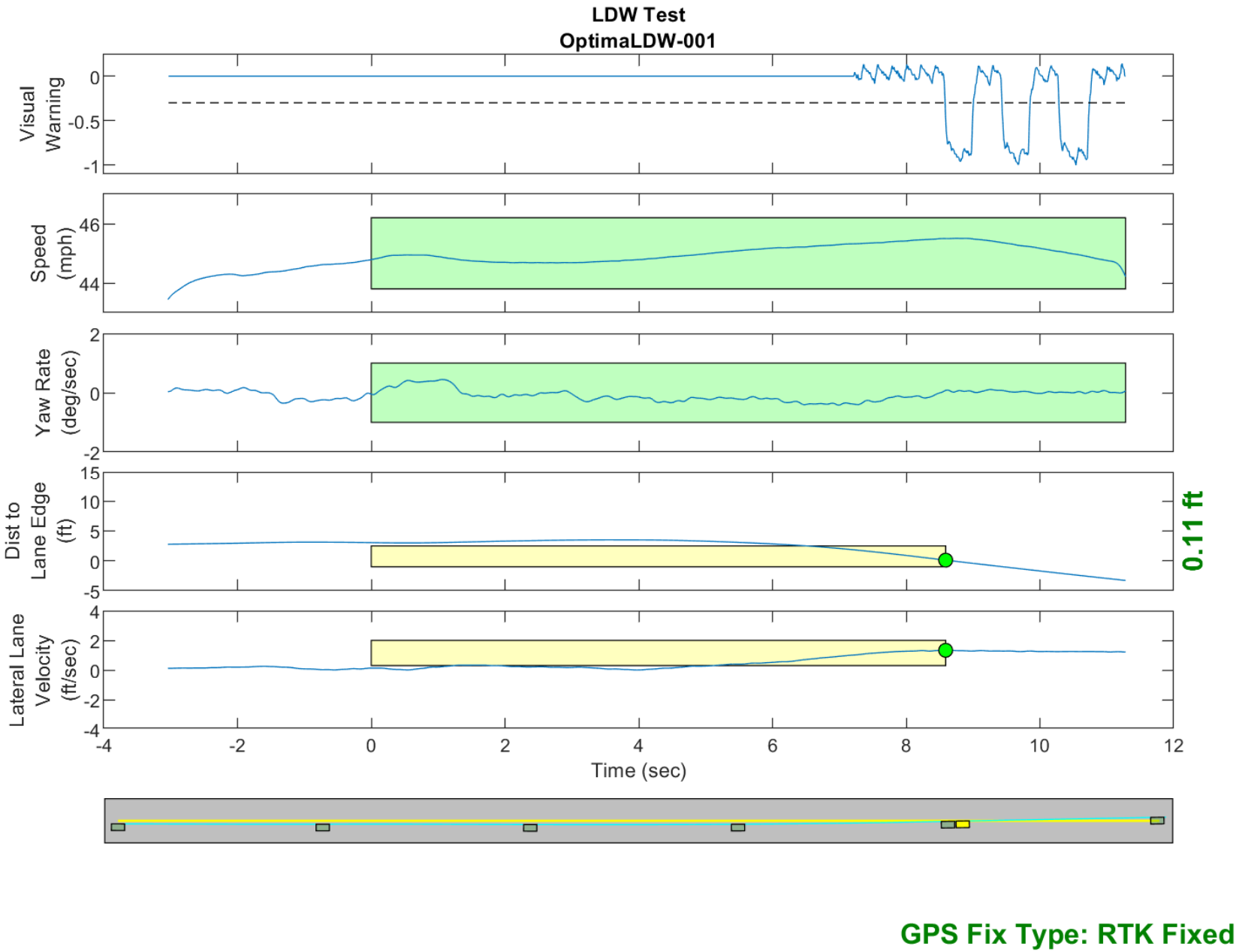

Figure D5. Time History for Run 01, Solid Line, Left Departure, Visual Warning

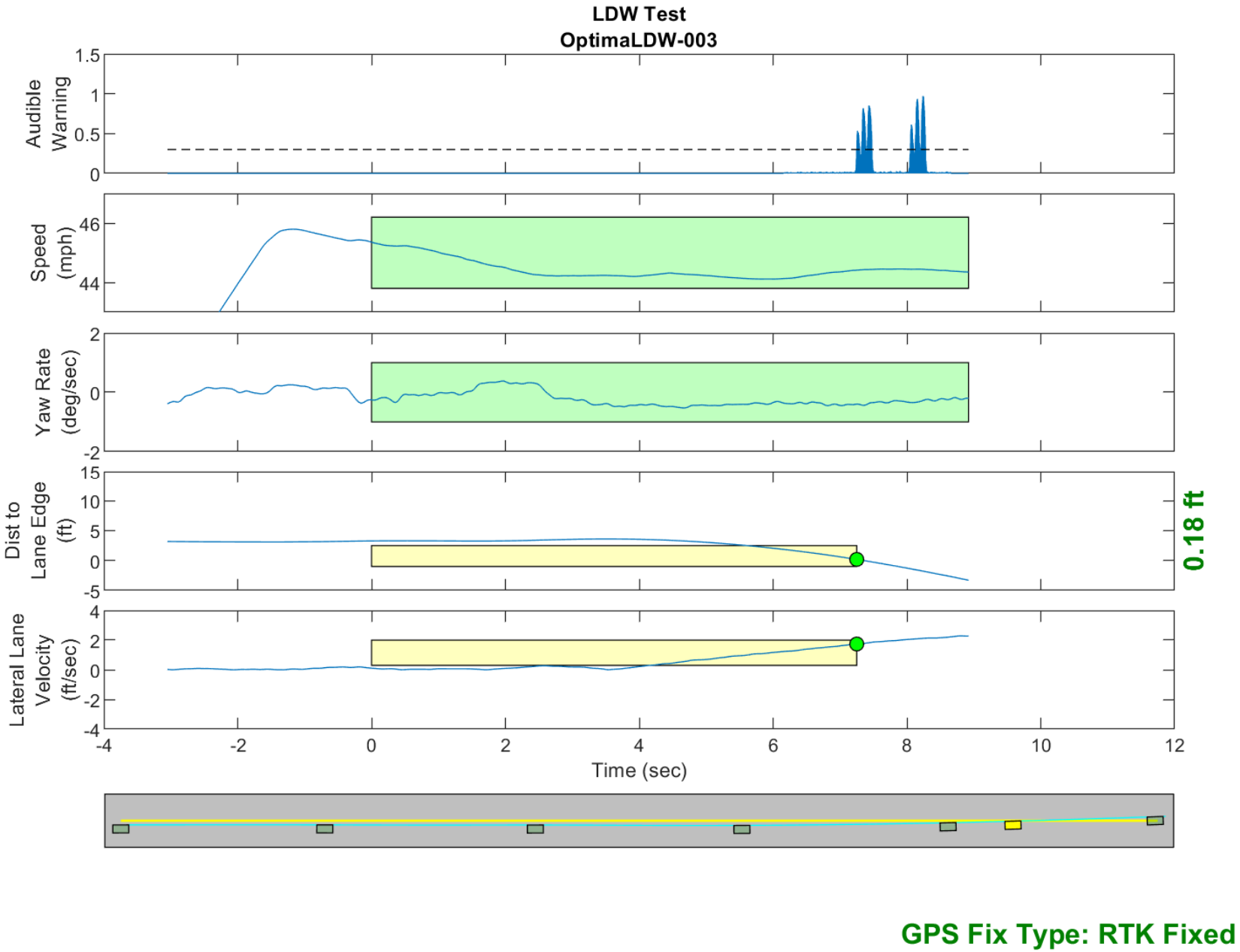

Figure D6. Time History for Run 03, Solid Line, Left Departure, Audible Warning

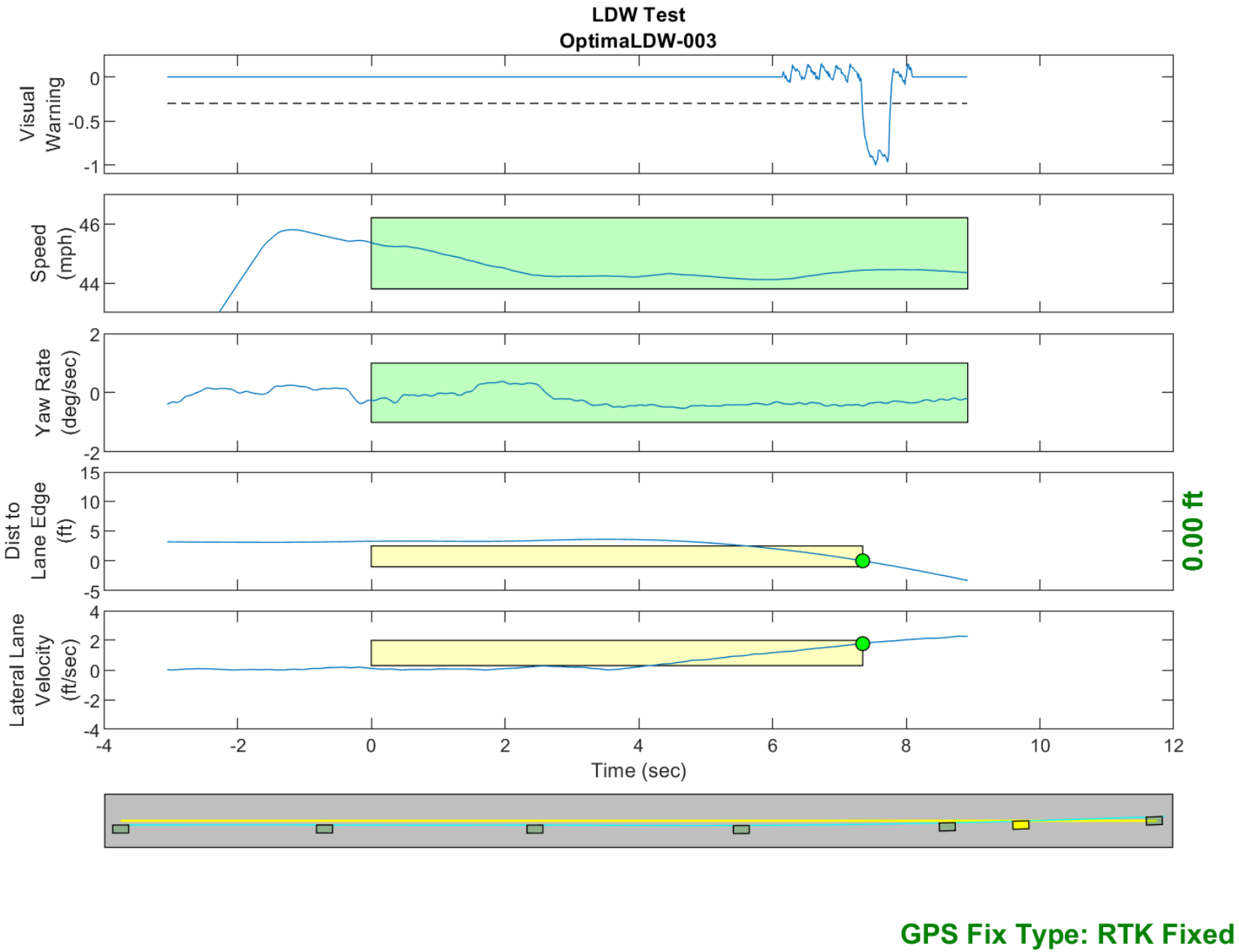

Figure D7. Time History for Run 03, Solid Line, Left Departure, Visual Warning

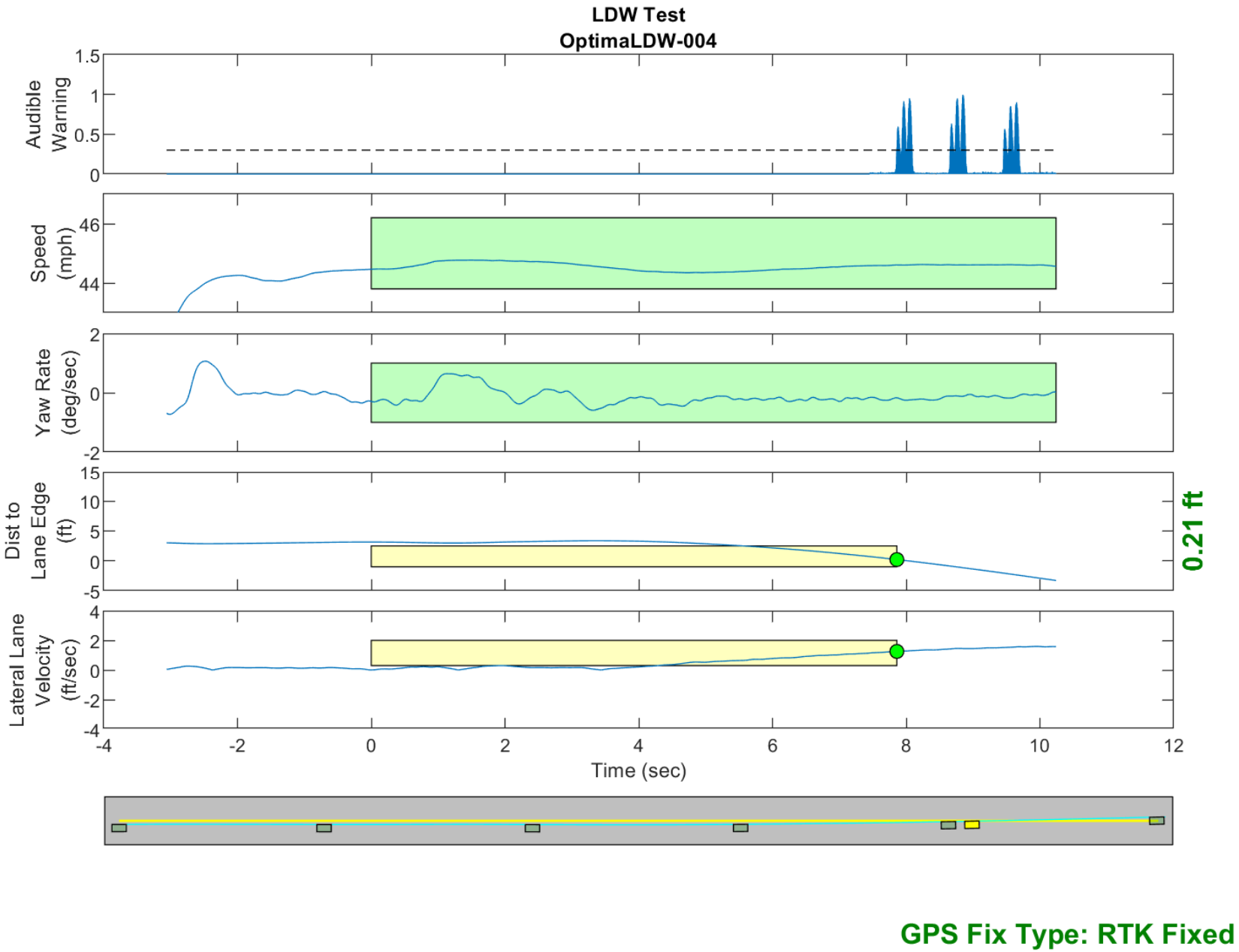

Figure D8. Time History for Run 04, Solid Line, Left Departure, Audible Warning

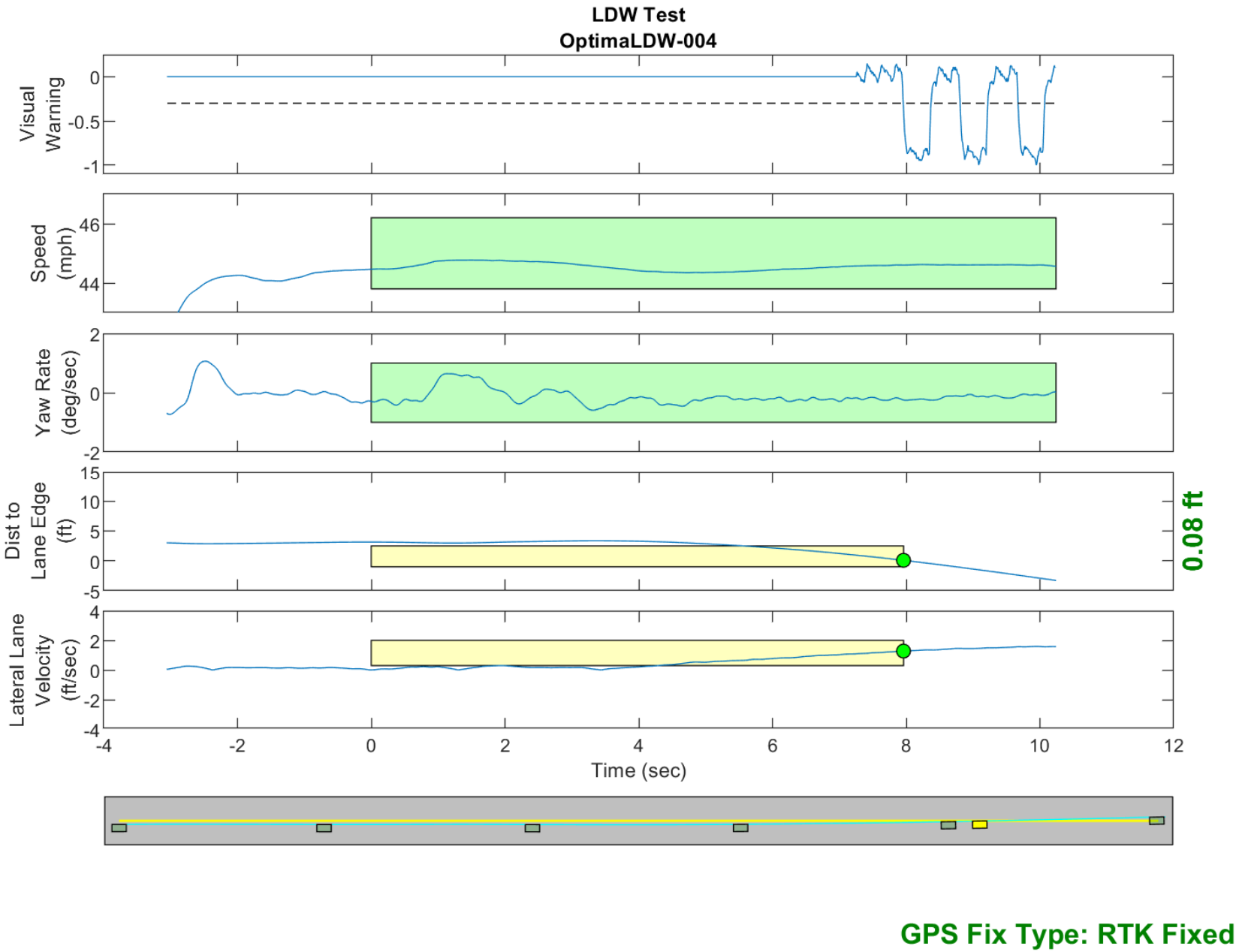

Figure D9. Time History for Run 04, Solid Line, Left Departure, Visual Warning

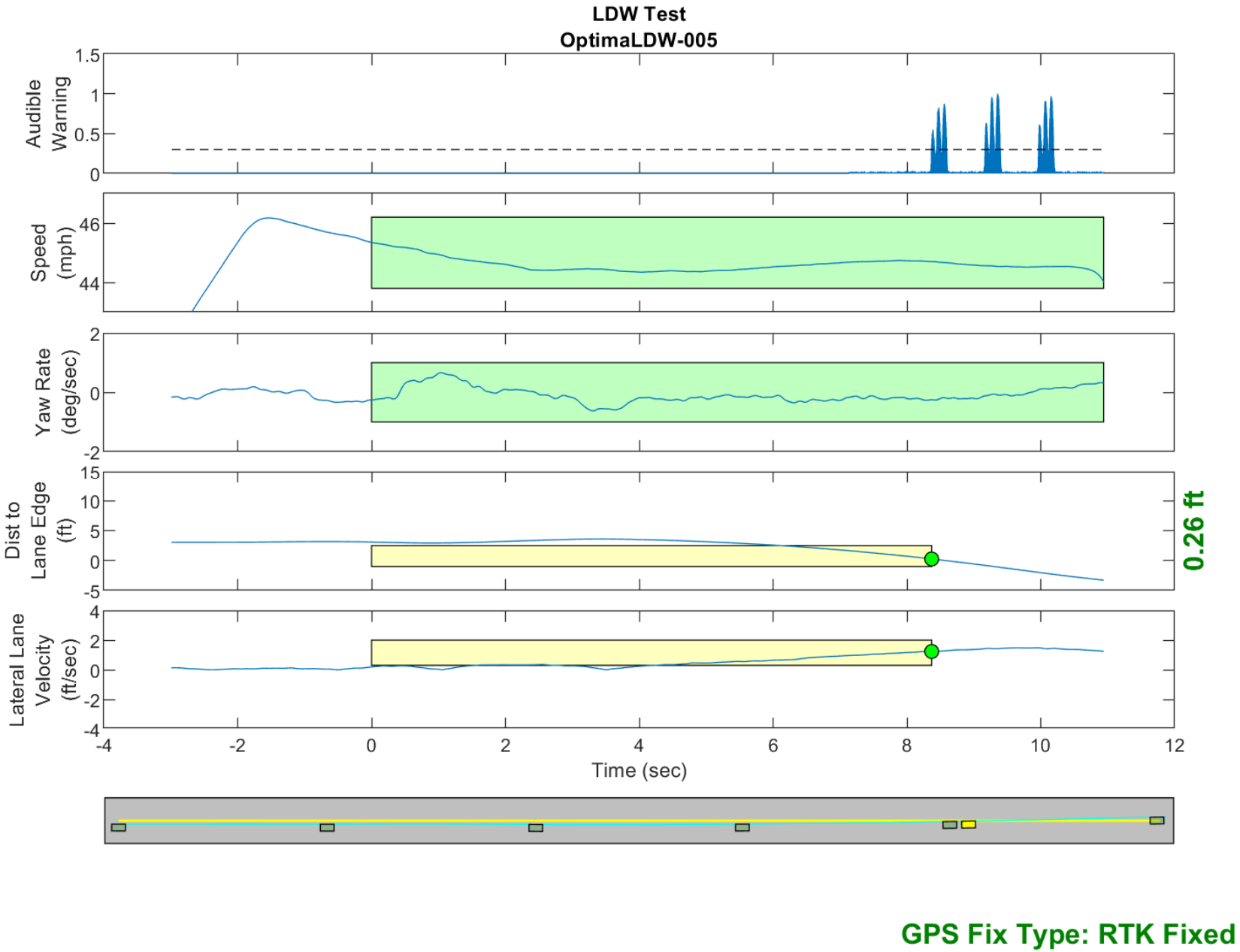

Figure D10. Time History for Run 05, Solid Line, Left Departure, Audible Warning

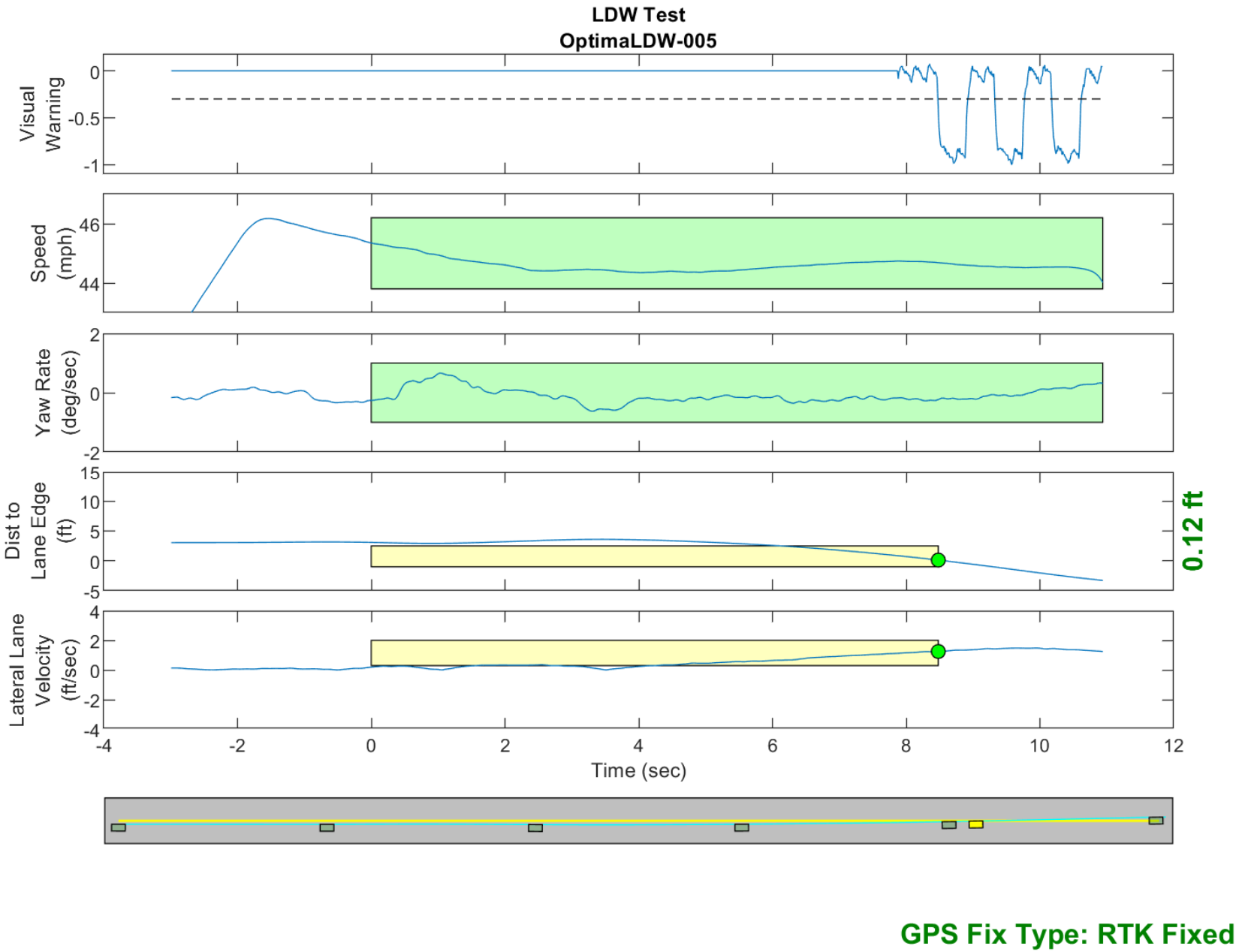

Figure D11. Time History for Run 05, Solid Line, Left Departure, Visual Warning

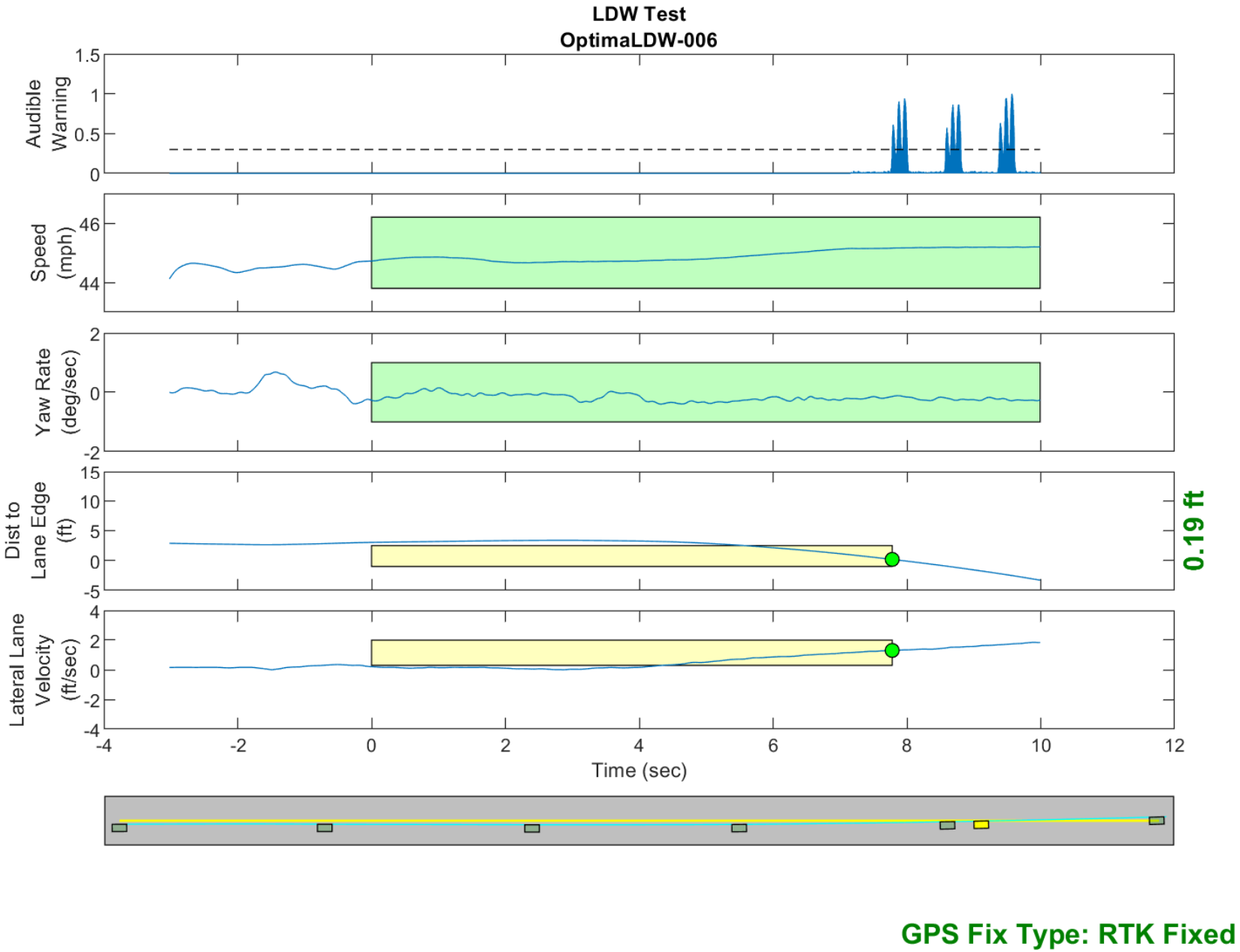

Figure D12. Time History for Run 06, Solid Line, Left Departure, Audible Warning

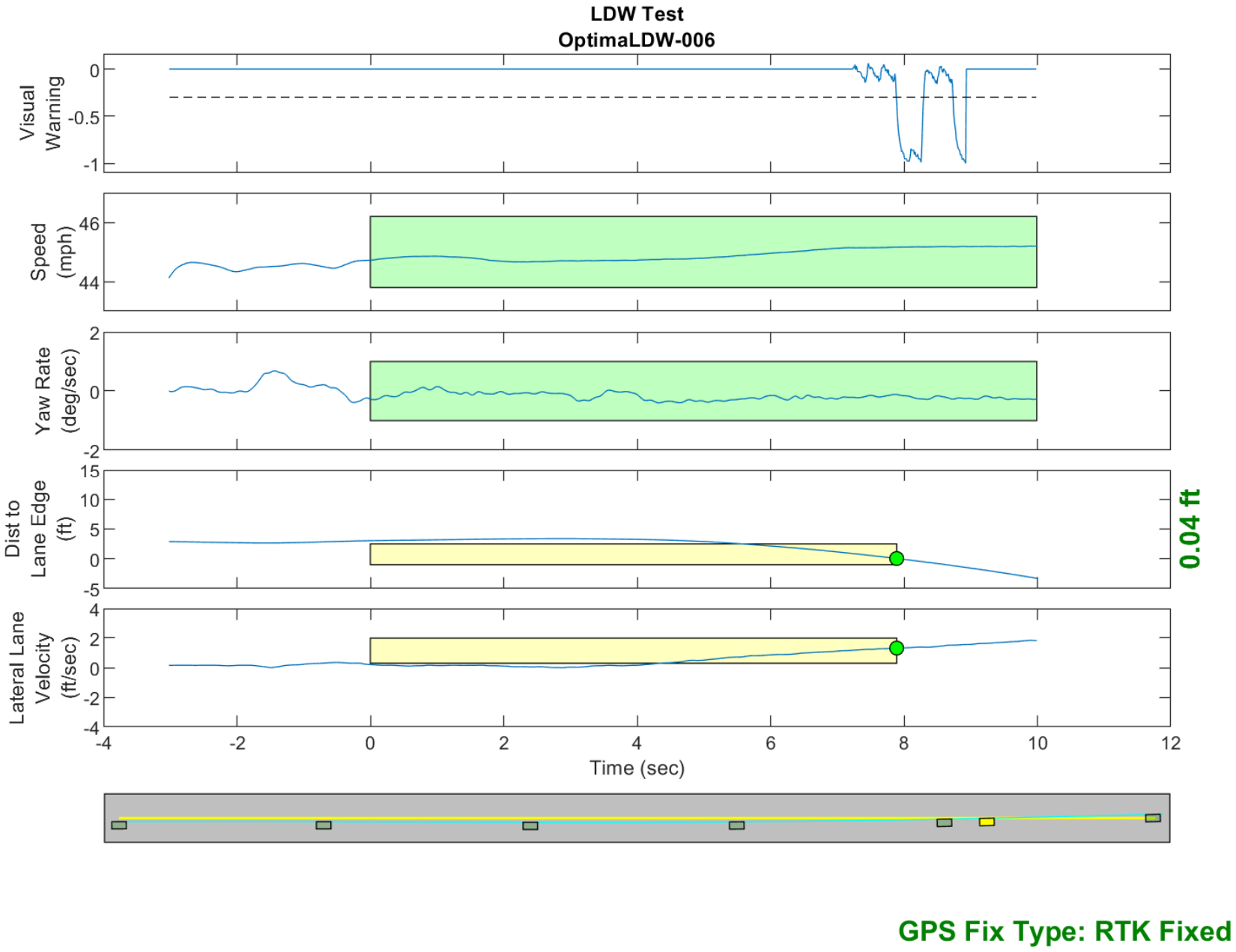

Figure D13. Time History for Run 06, Solid Line, Left Departure, Visual Warning

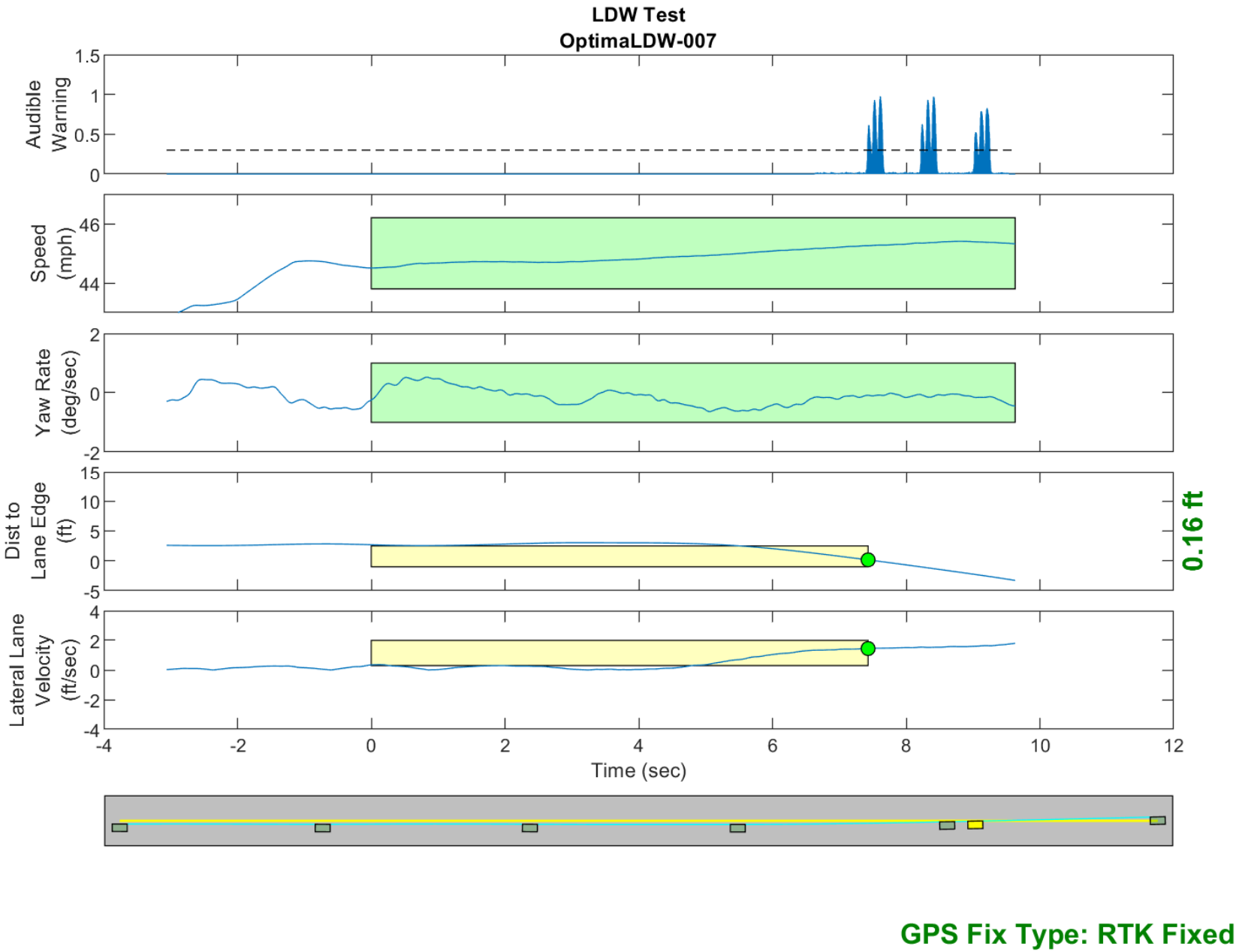

Figure D14. Time History for Run 07, Solid Line, Left Departure, Audible Warning

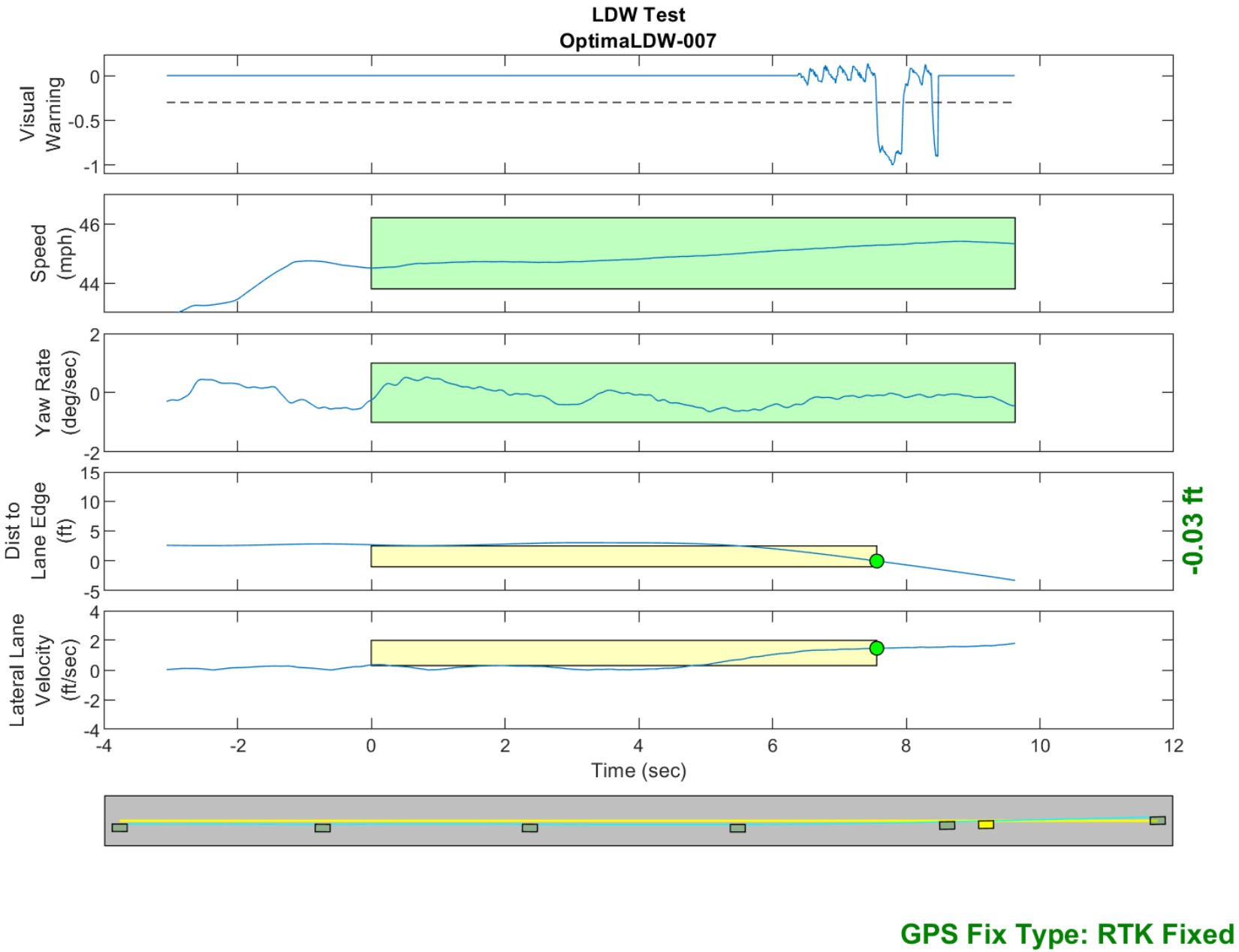

Figure D15. Time History for Run 07, Solid Line, Left Departure, Visual Warning

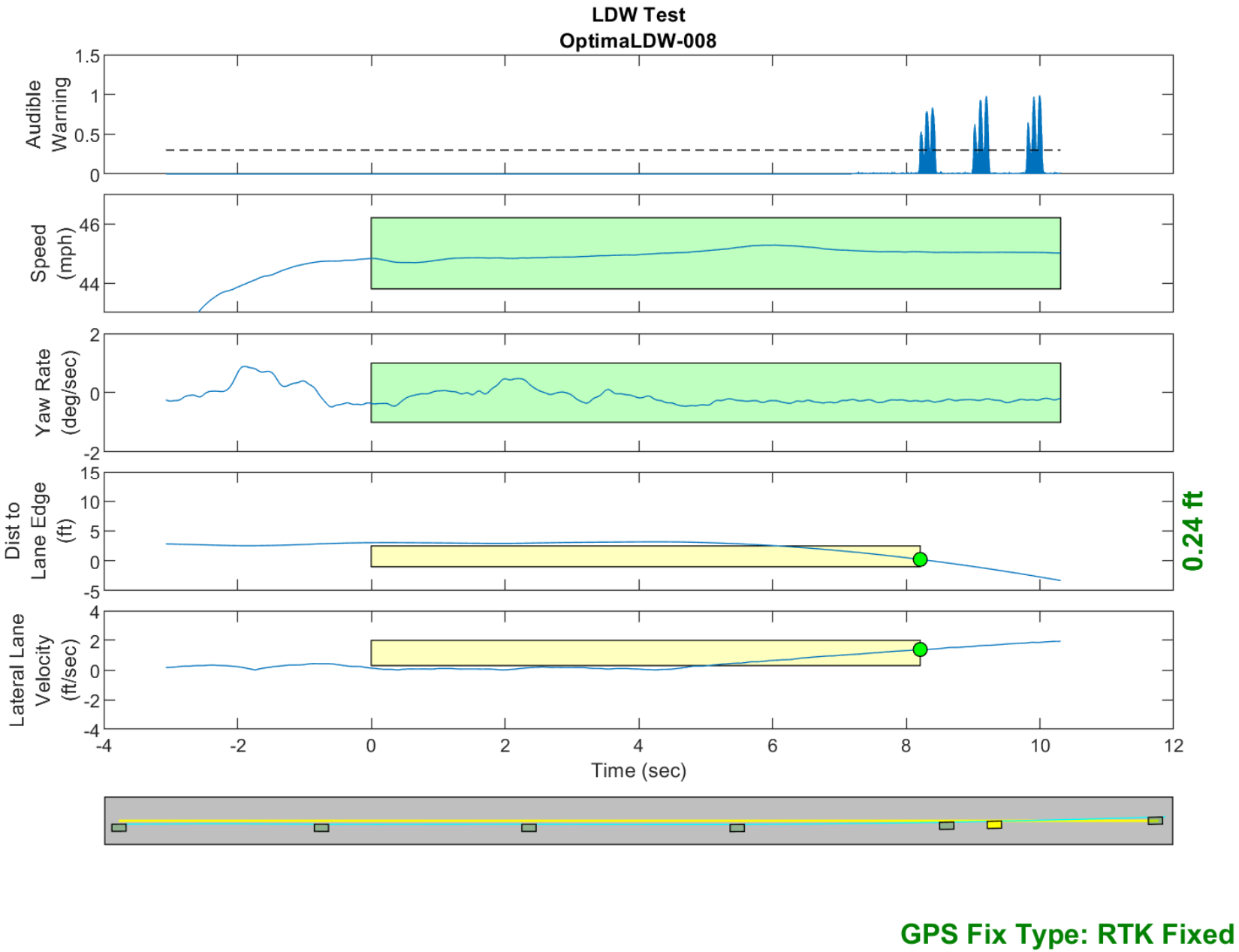

Figure D16. Time History for Run 08, Solid Line, Left Departure, Audible Warning

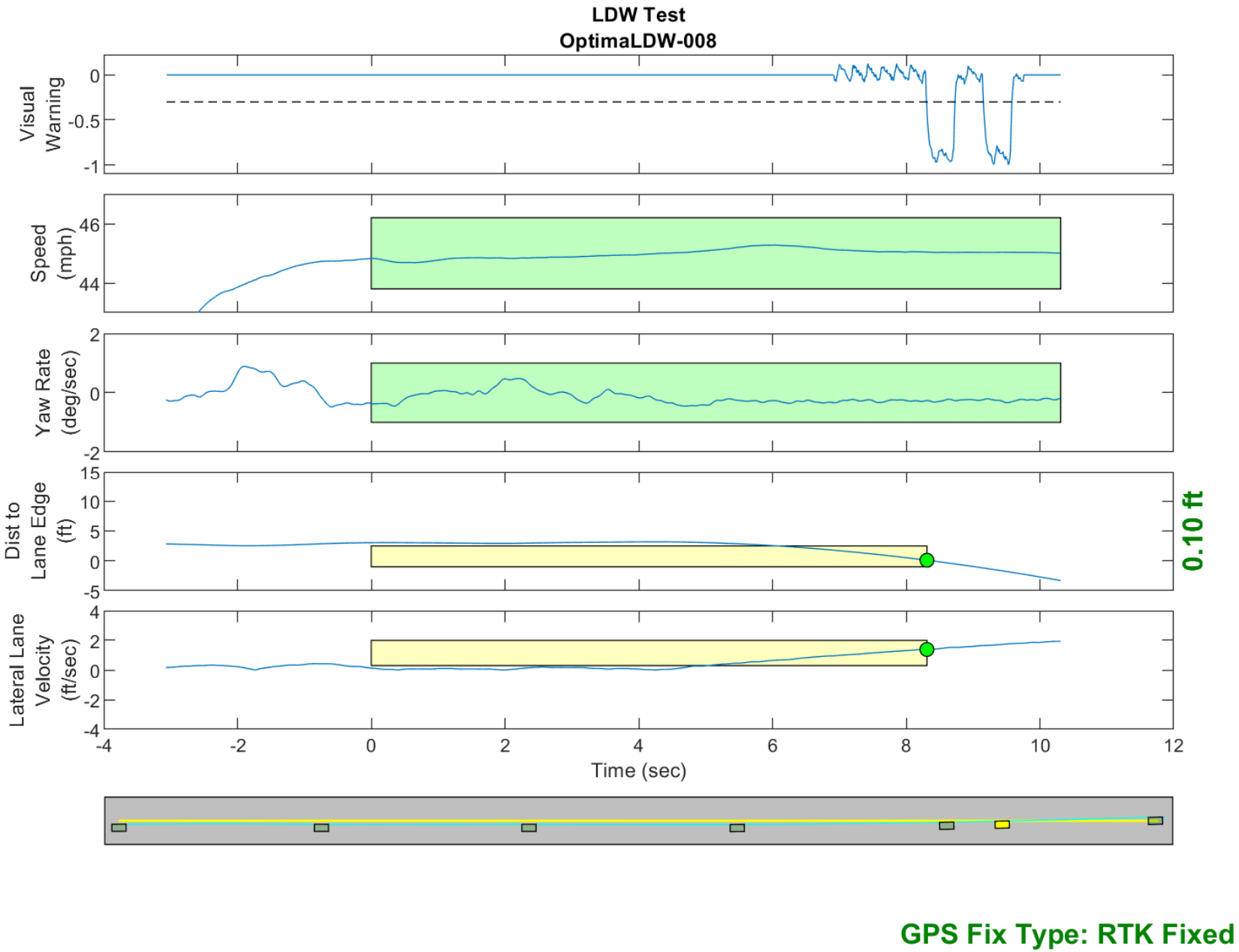

Figure D17. Time History for Run 08, Solid Line, Left Departure, Visual Warning

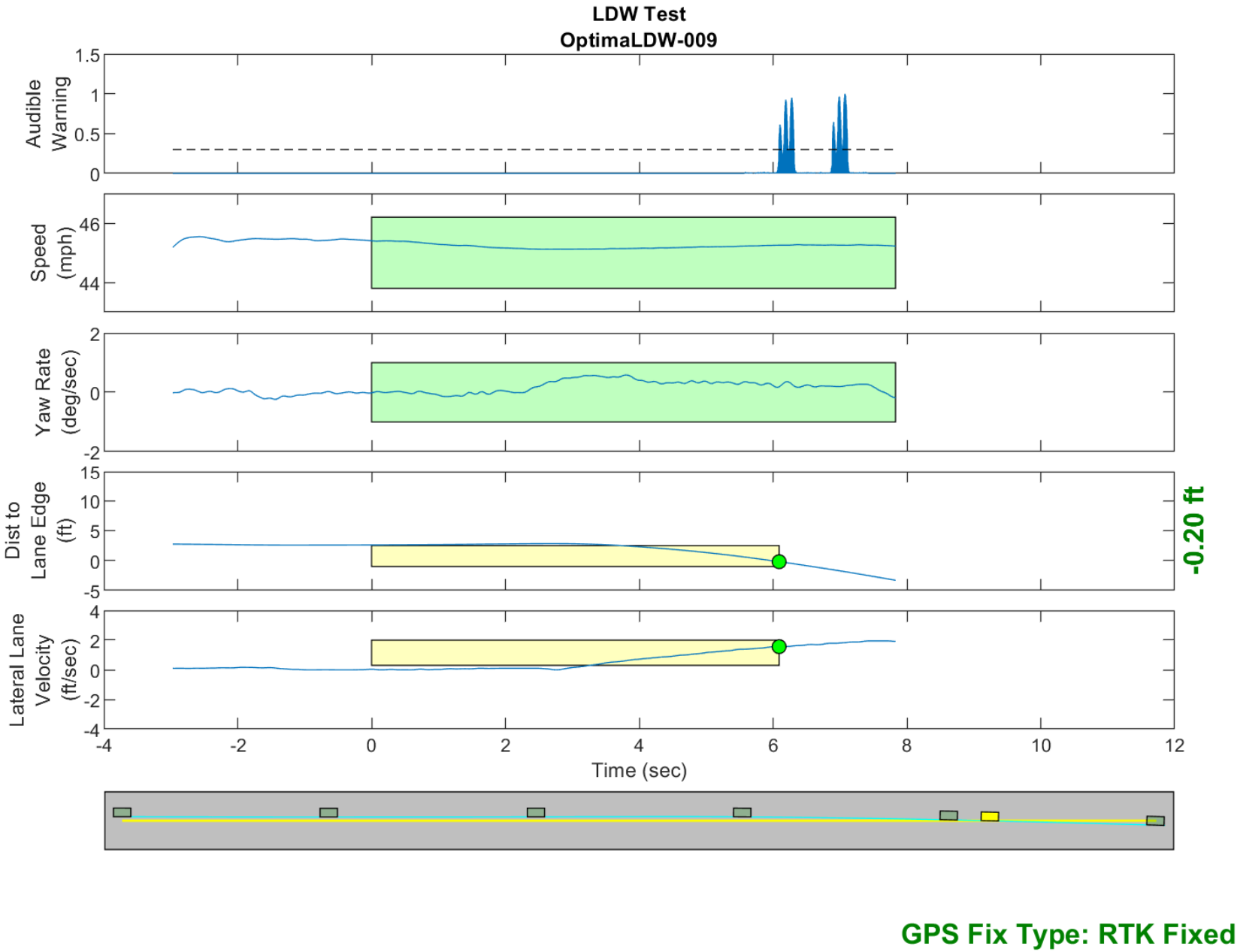

Figure D18. Time History for Run 09, Solid Line, Right Departure, Audible Warning

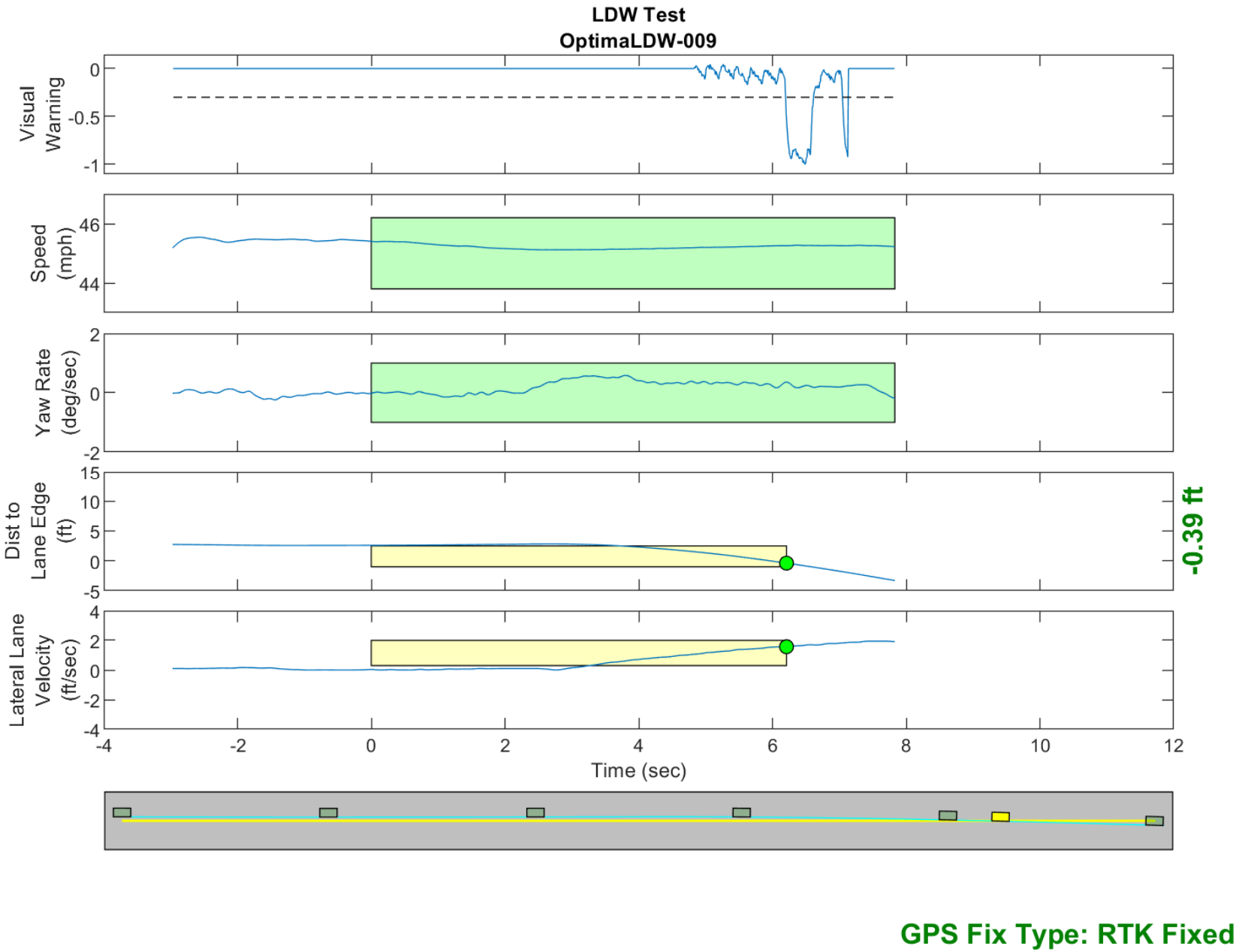

Figure D19. Time History for Run 09, Solid Line, Right Departure, Visual Warning

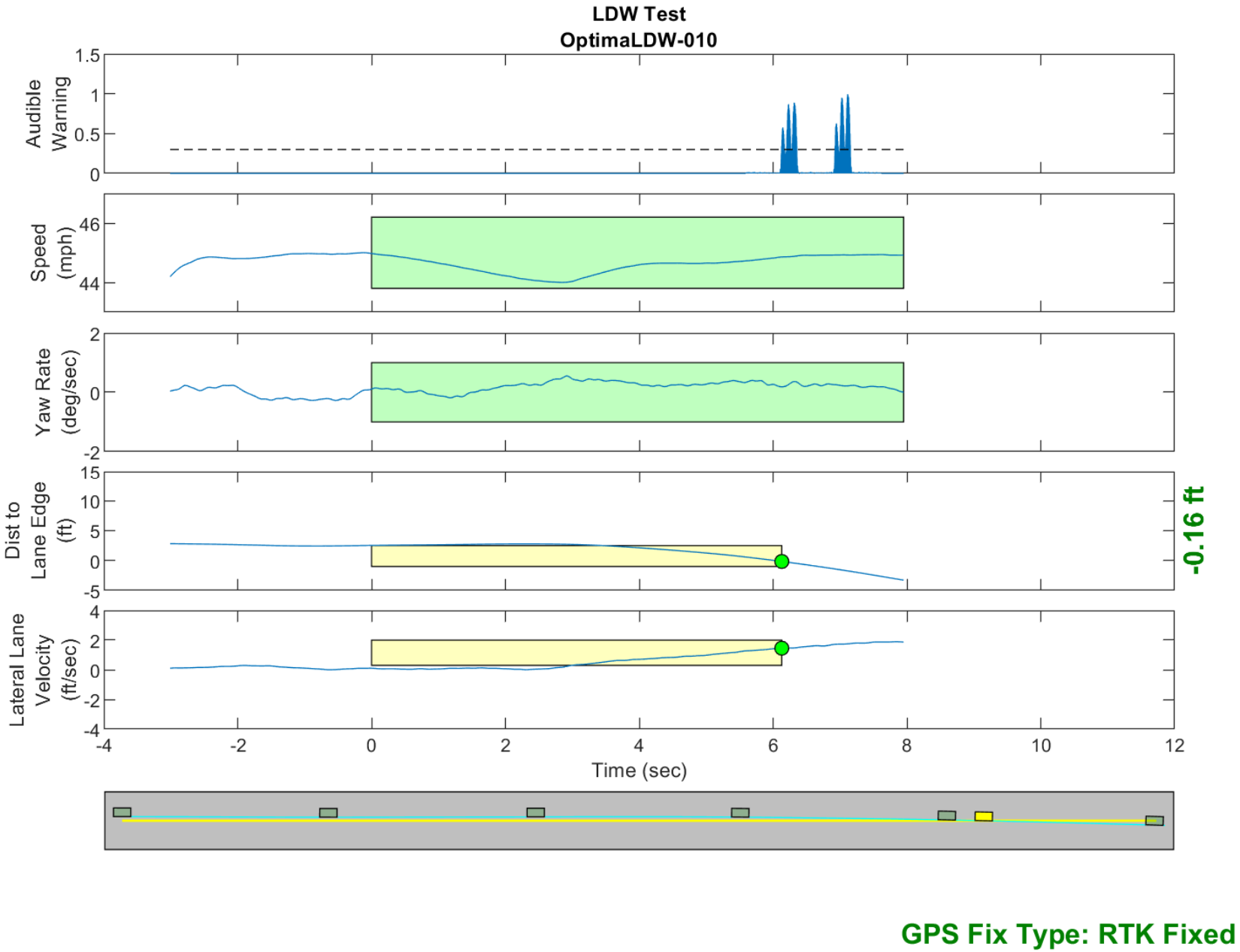

Figure D20. Time History for Run 10, Solid Line, Right Departure, Audible Warning

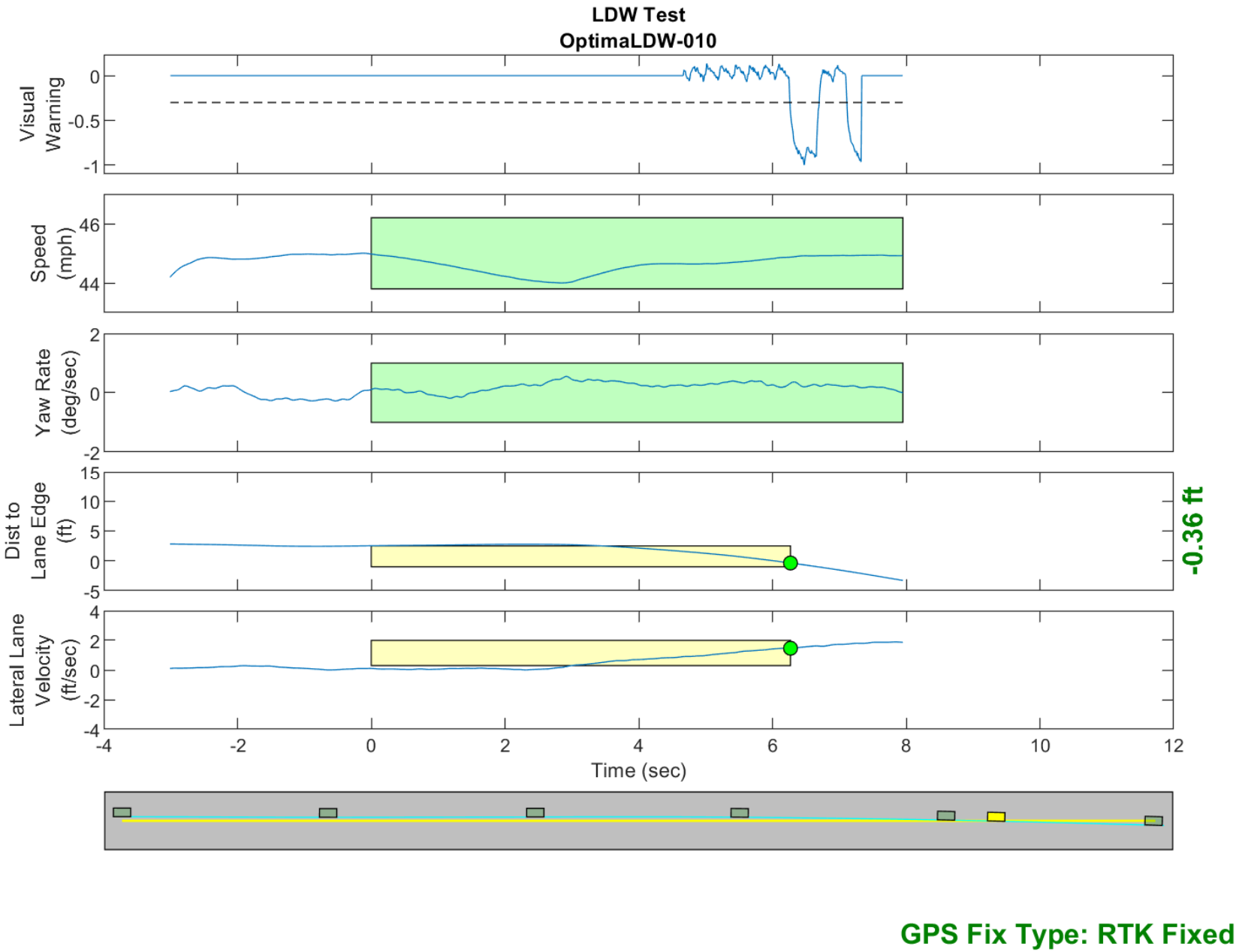

Figure D21. Time History for Run 10, Solid Line, Right Departure, Visual Warning

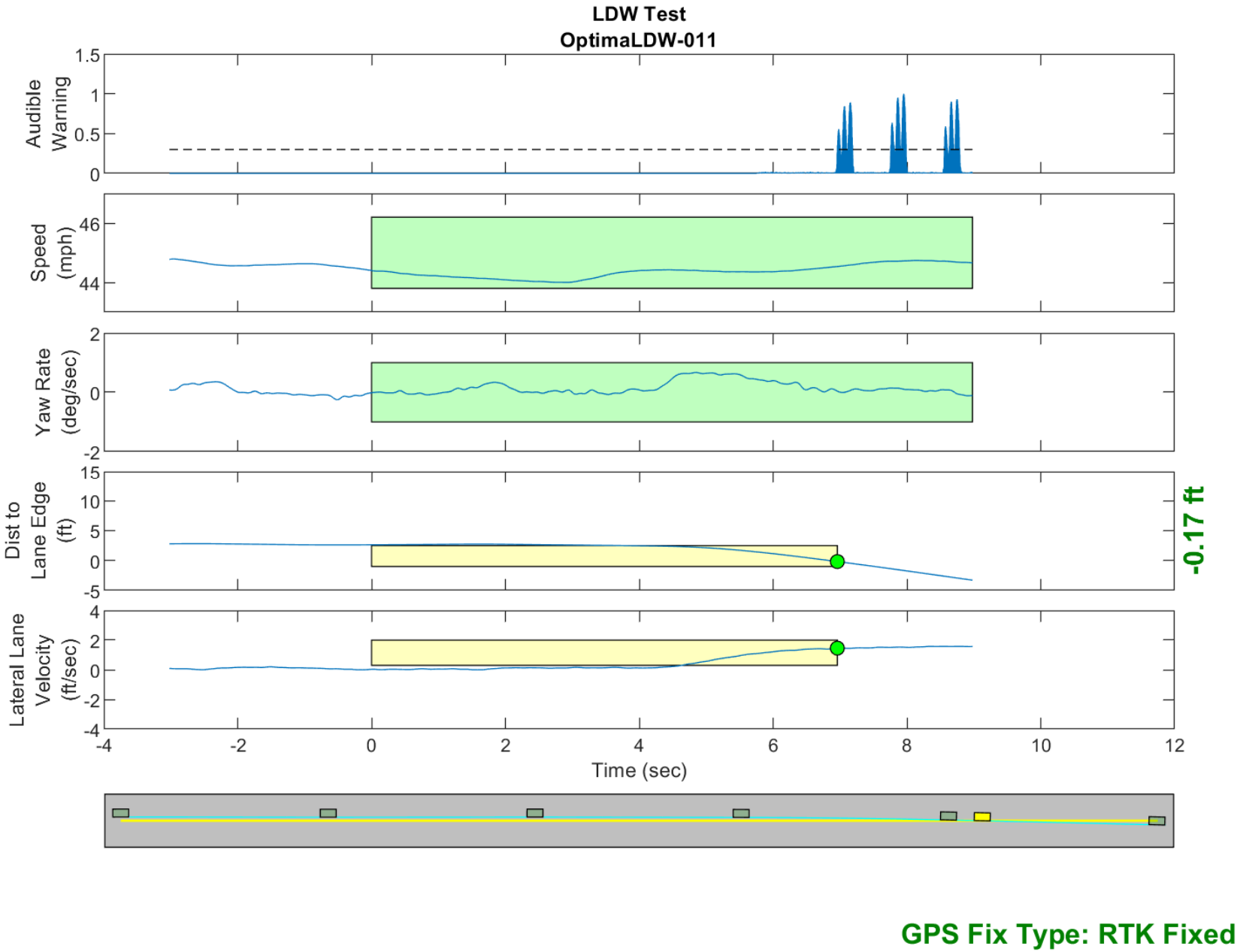

Figure D22. Time History for Run 11, Solid Line, Right Departure, Audible Warning

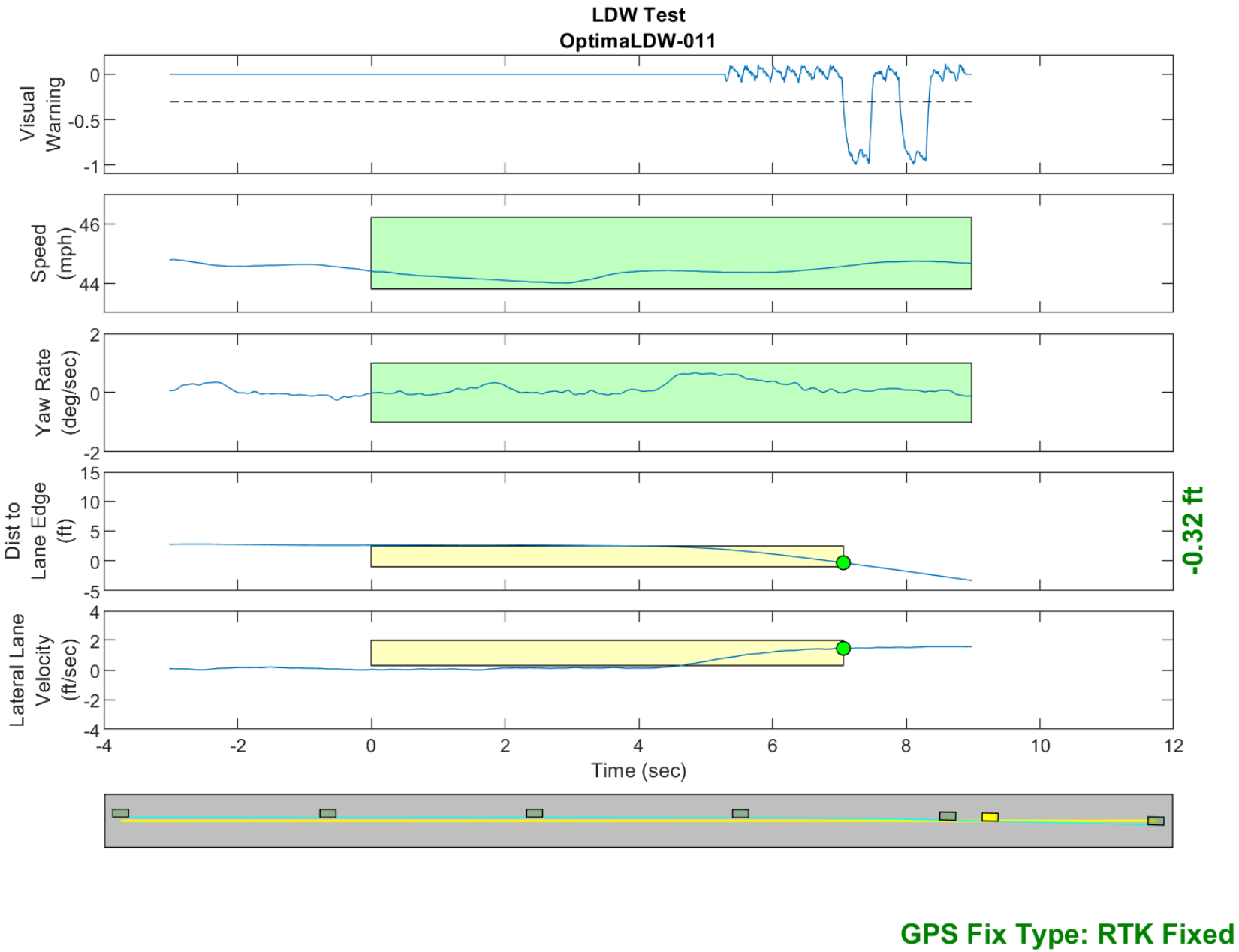

Figure D23. Time History for Run 11, Solid Line, Right Departure, Visual Warning

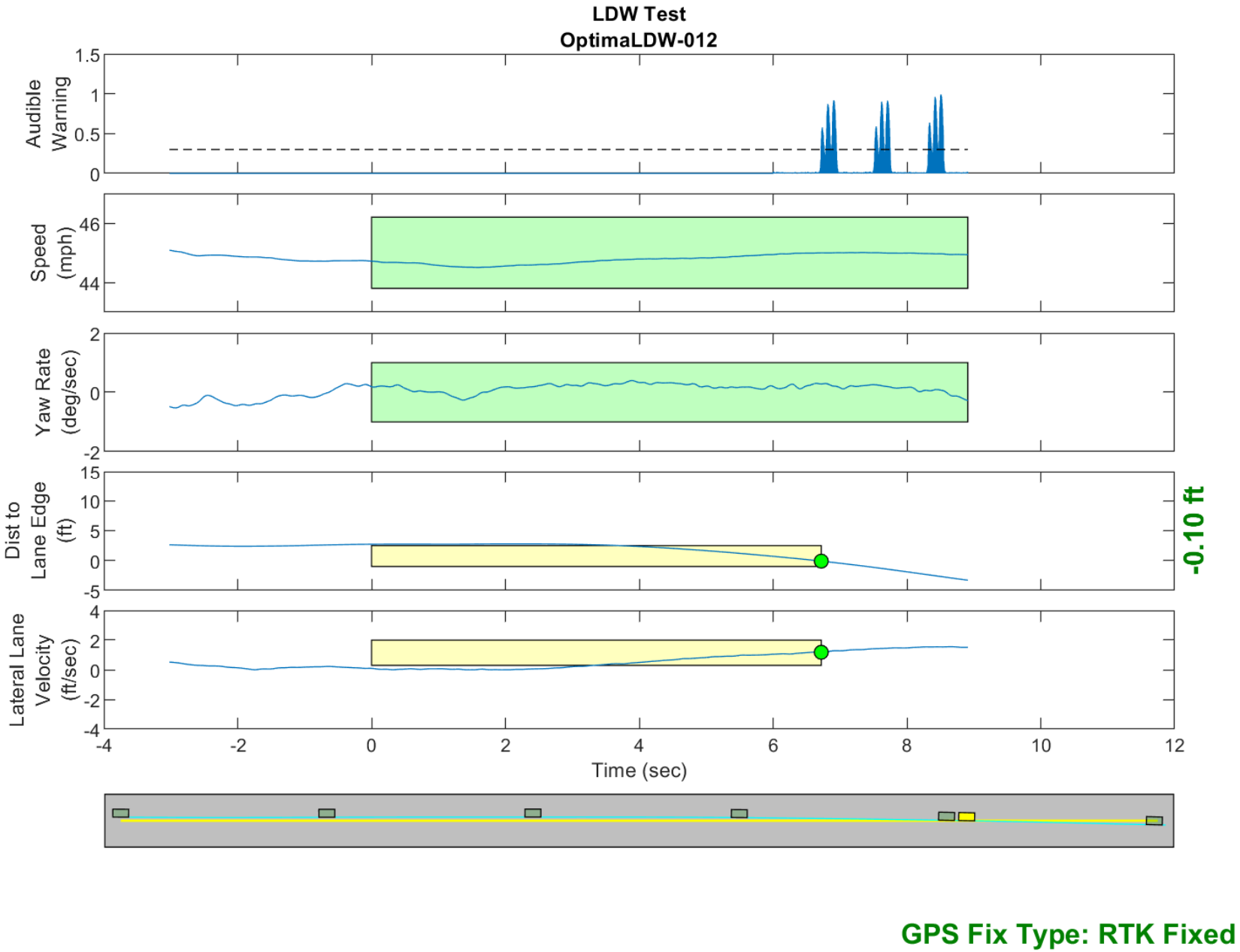

Figure D24. Time History for Run 12, Solid Line, Right Departure, Audible Warning

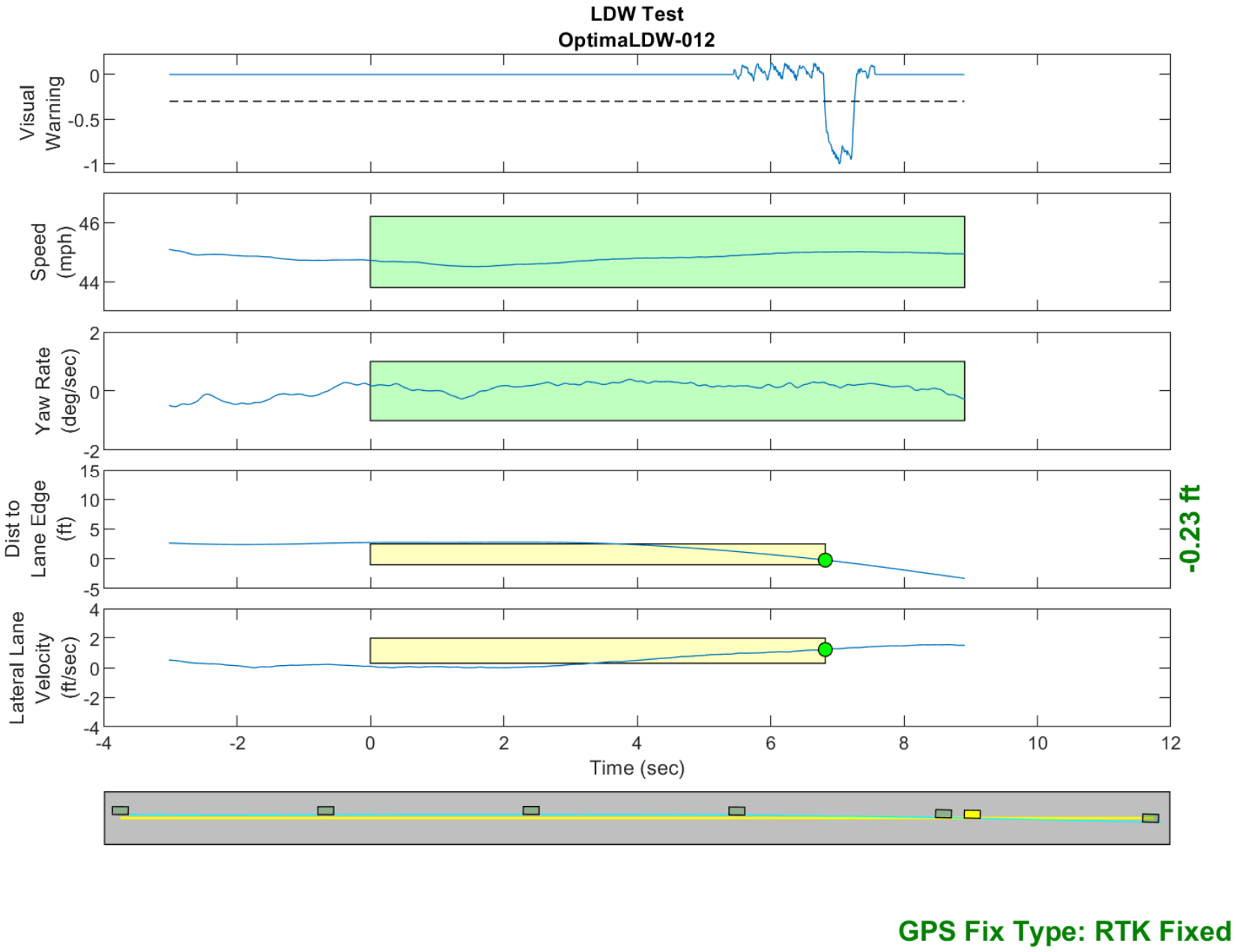

Figure D25. Time History for Run 12, Solid Line, Right Departure, Visual Warning

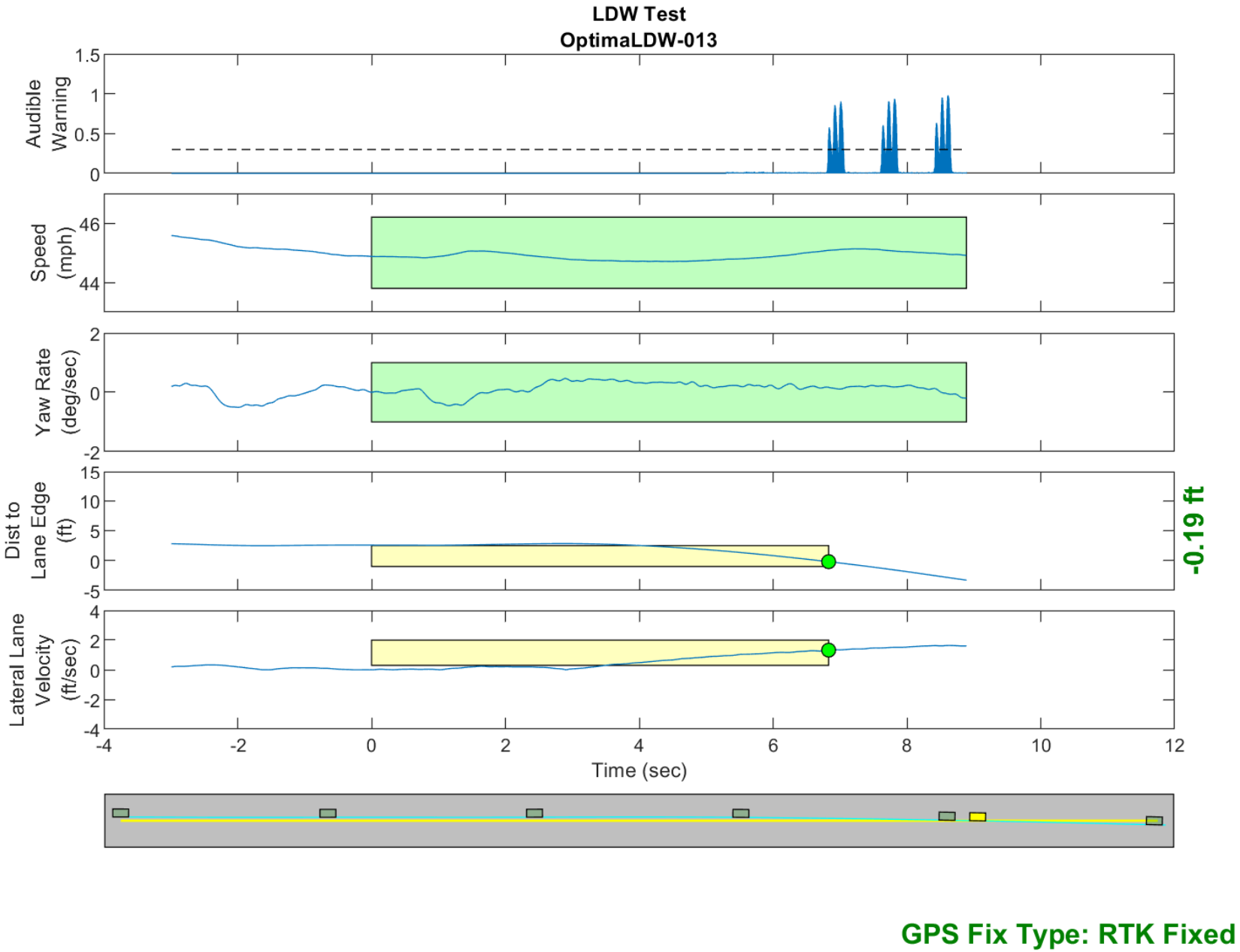

Figure D26. Time History for Run 13, Solid Line, Right Departure, Audible Warning

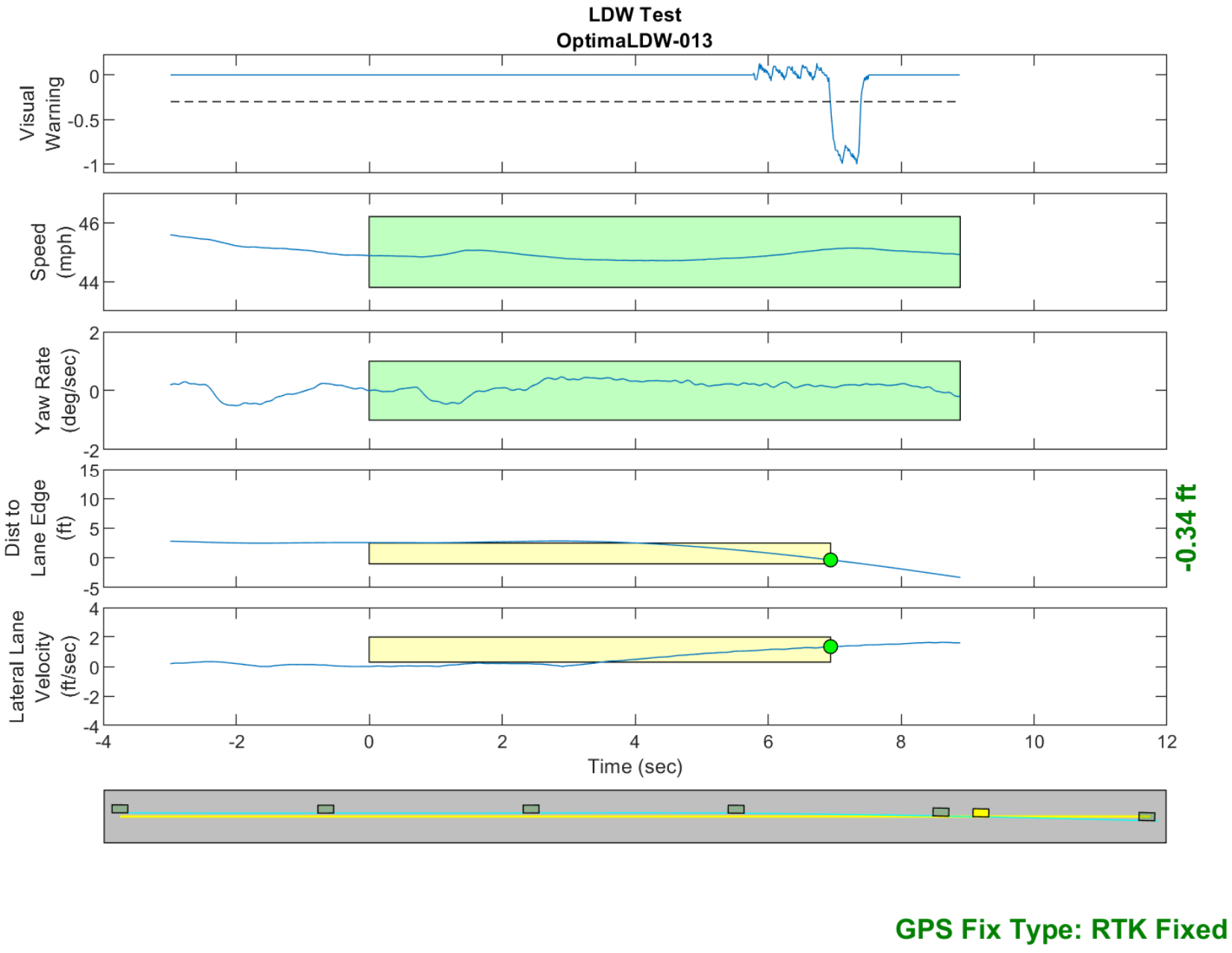

Figure D27. Time History for Run 13, Solid Line, Right Departure, Visual Warning

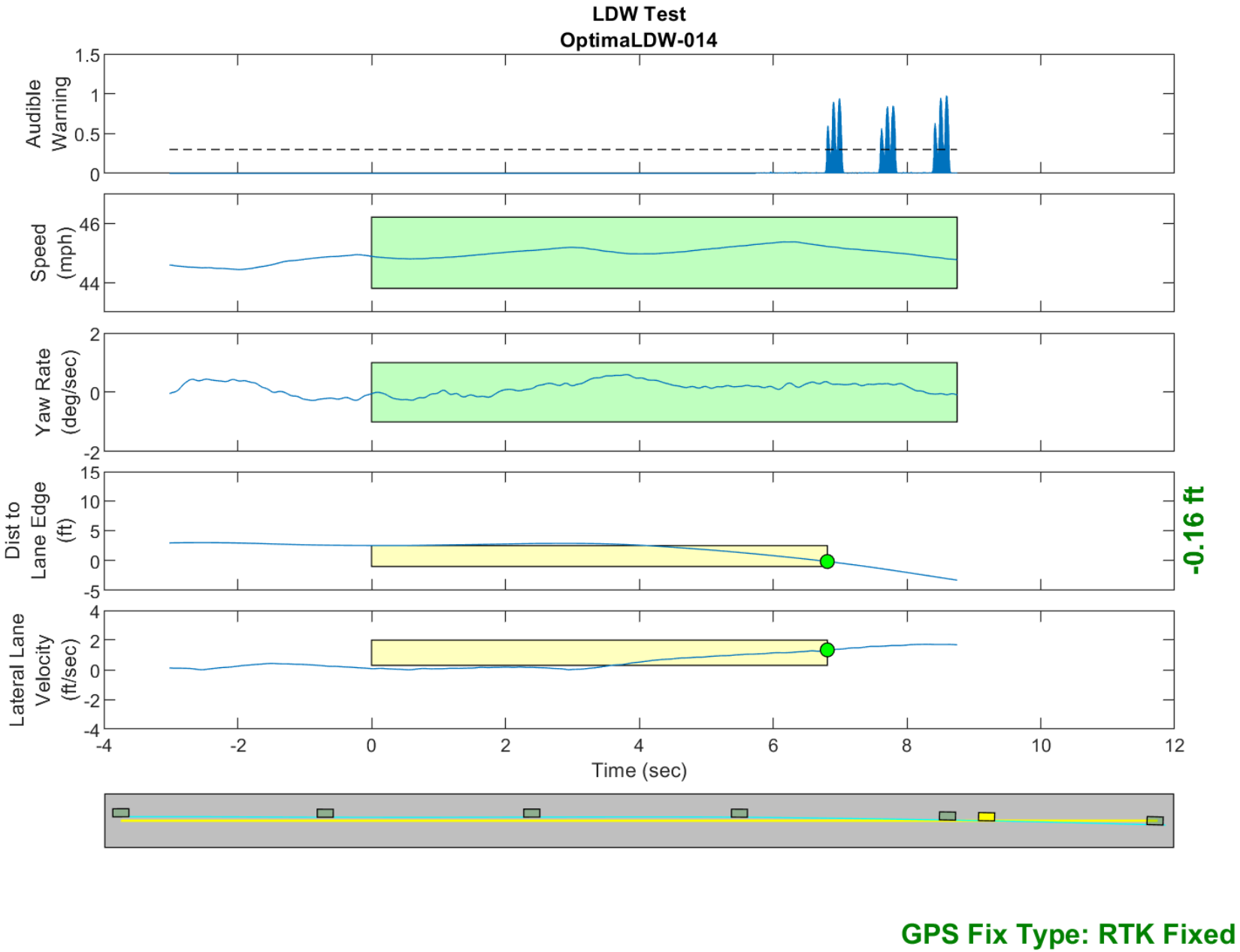

Figure D28. Time History for Run 14, Solid Line, Right Departure, Audible Warning

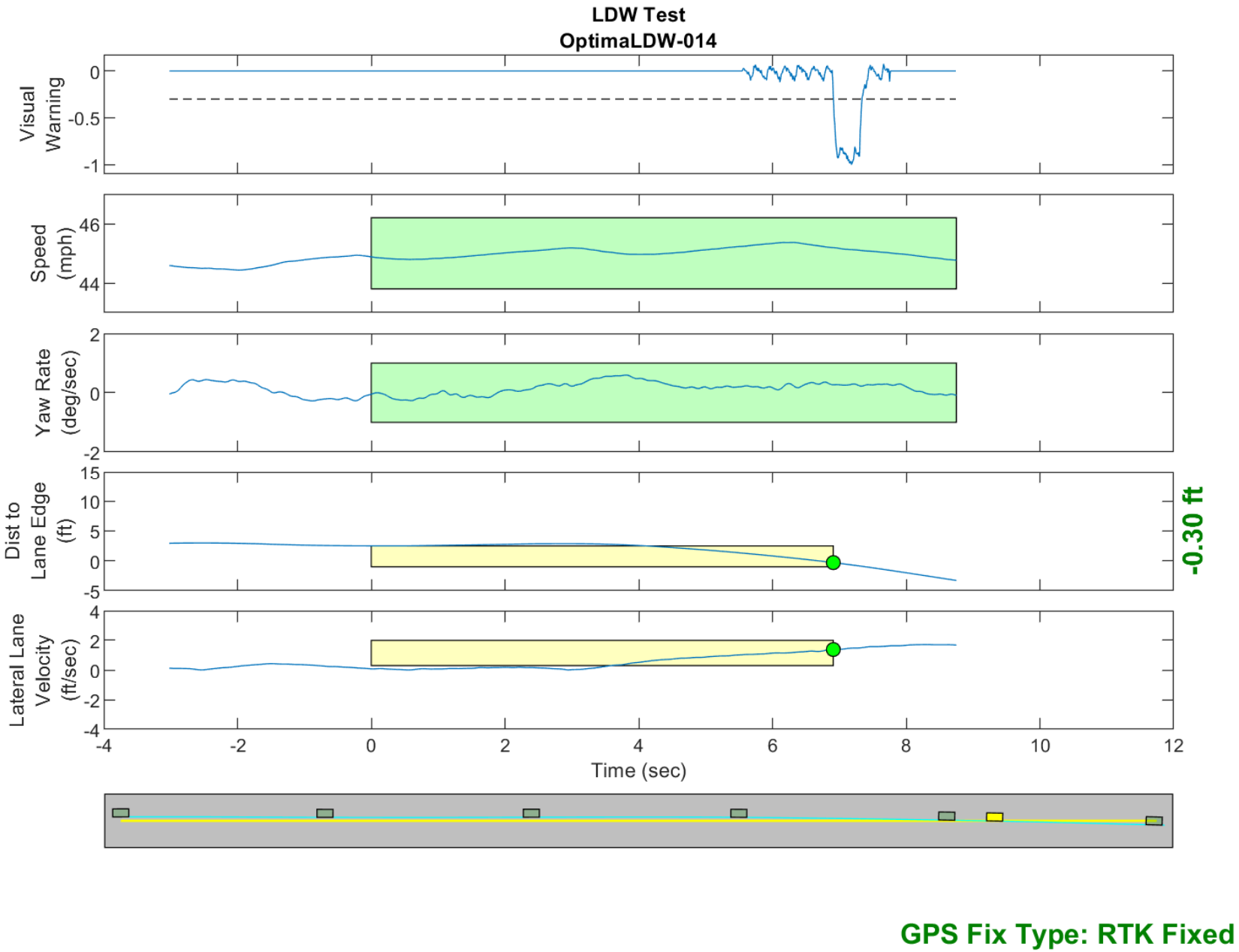

Figure D29. Time History for Run 14, Solid Line, Right Departure, Visual Warning

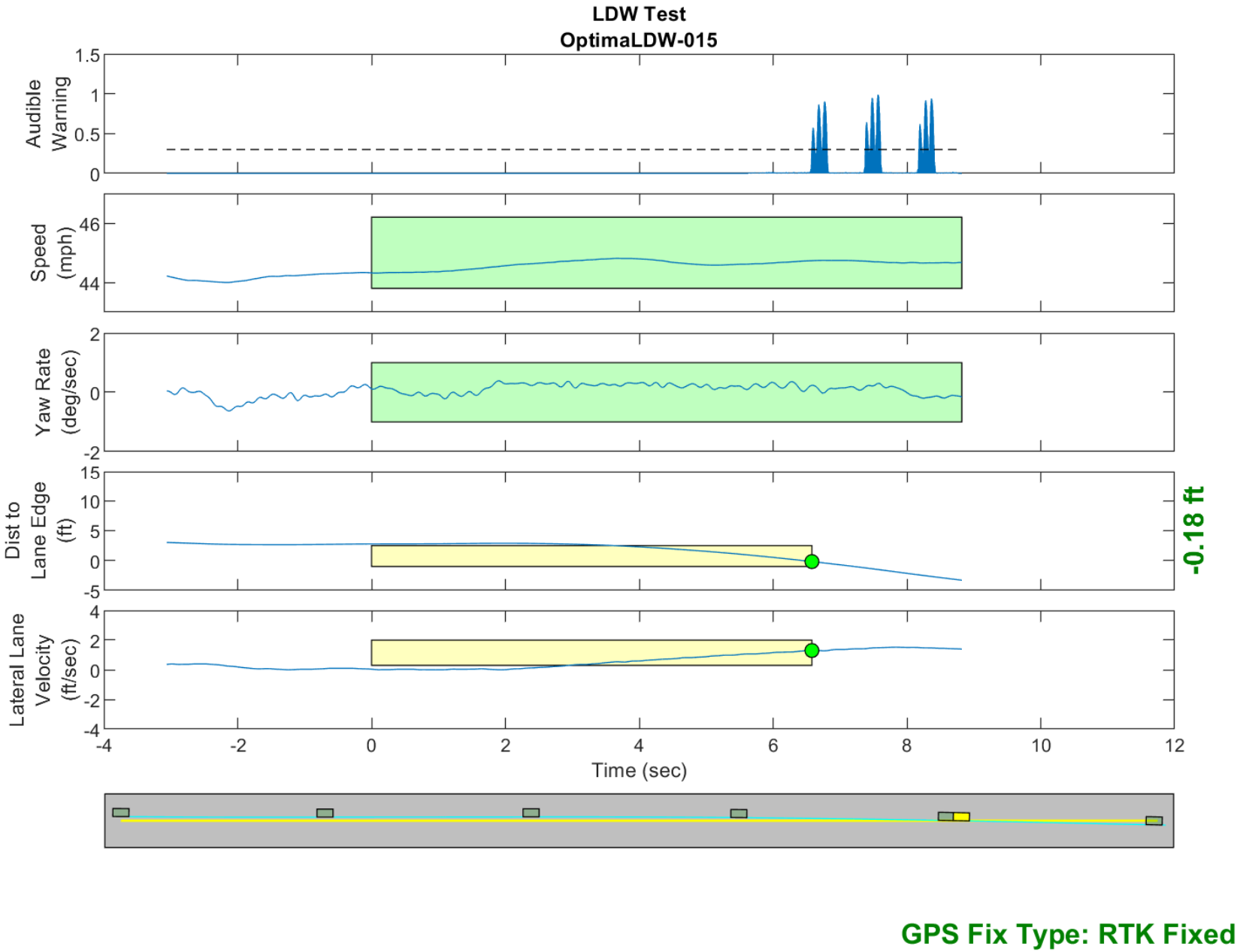

Figure D30. Time History for Run 15, Solid Line, Right Departure, Audible Warning

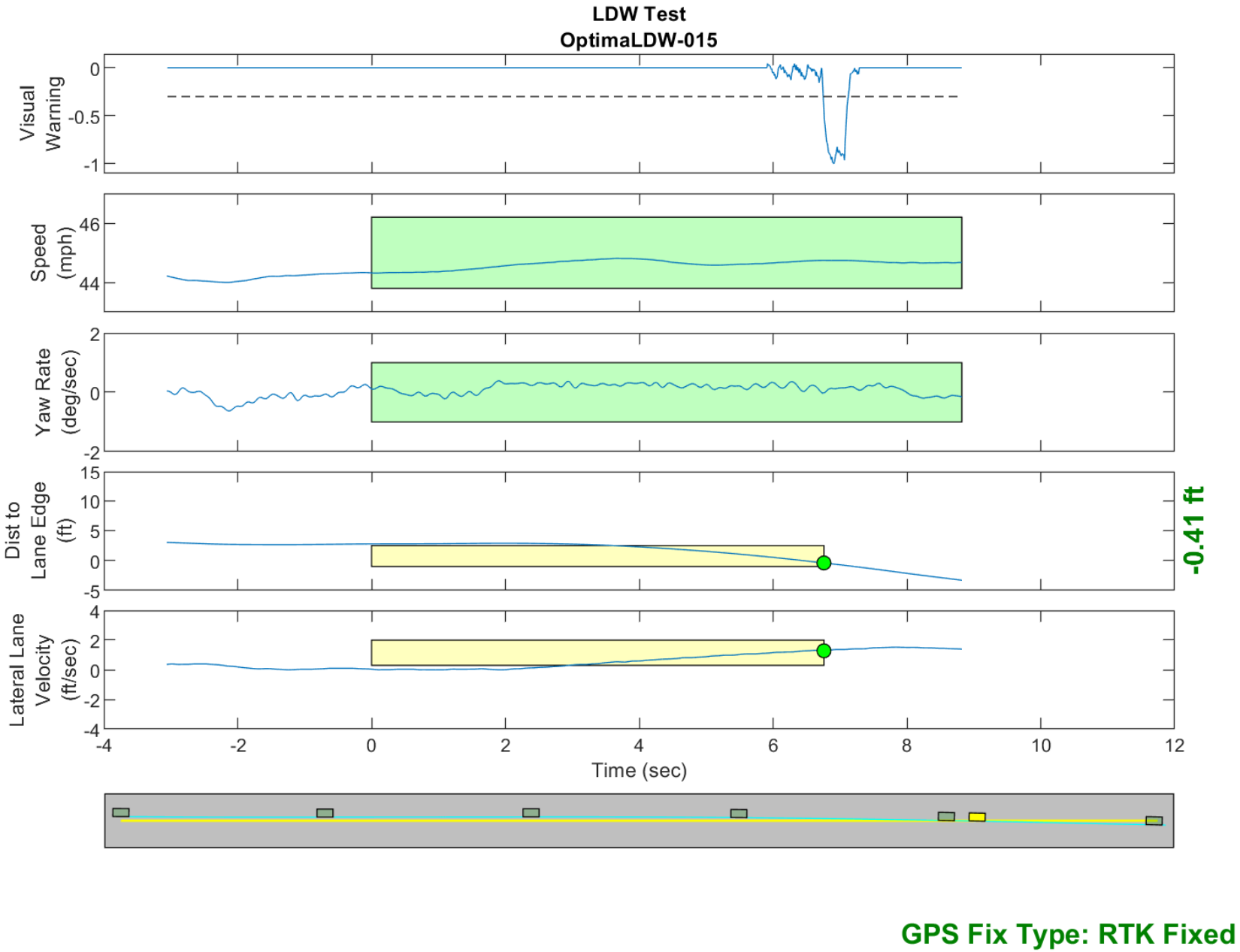

Figure D31. Time History for Run 15, Solid Line, Right Departure, Visual Warning

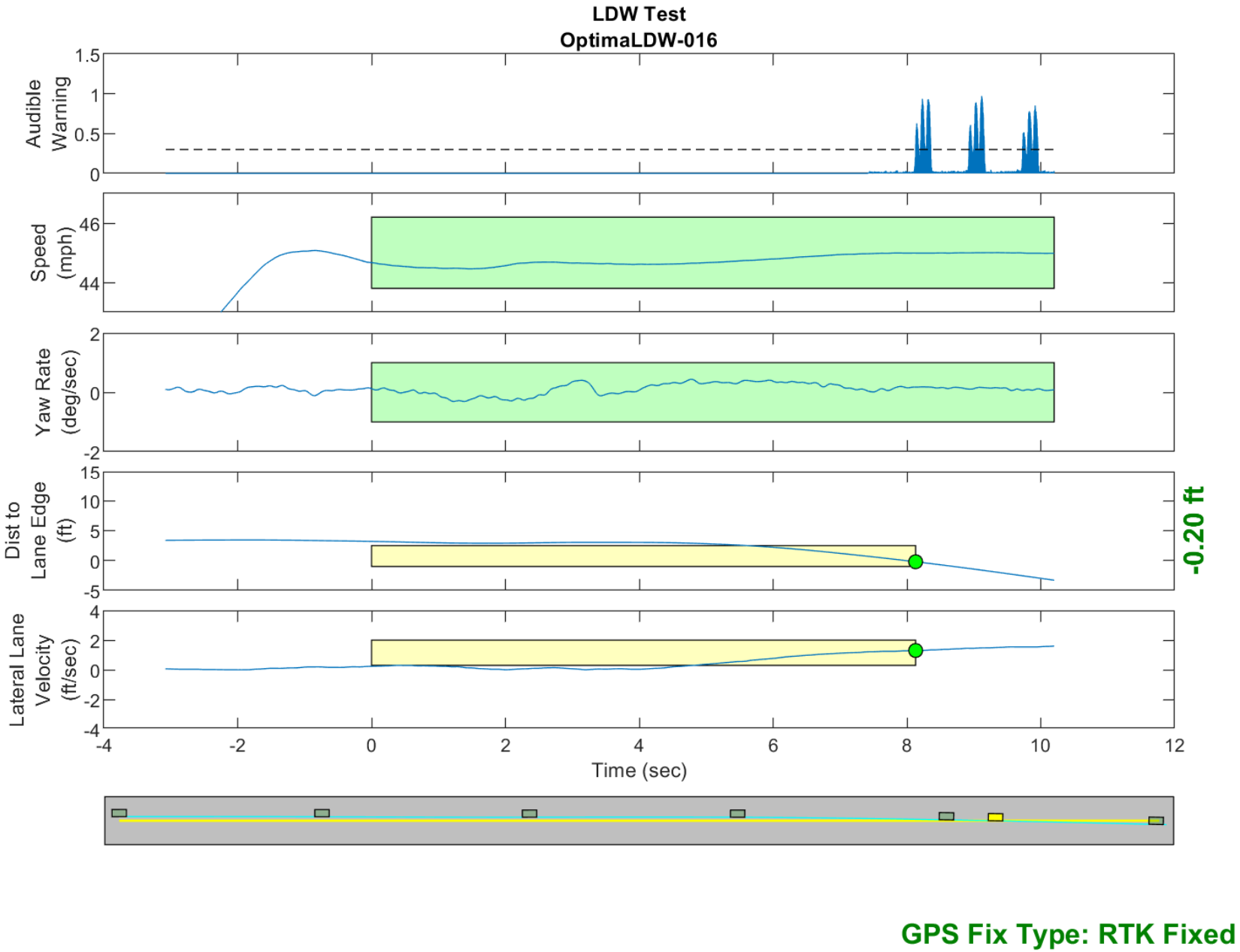

Figure D32. Time History for Run 16, Dashed Line, Right Departure, Audible Warning

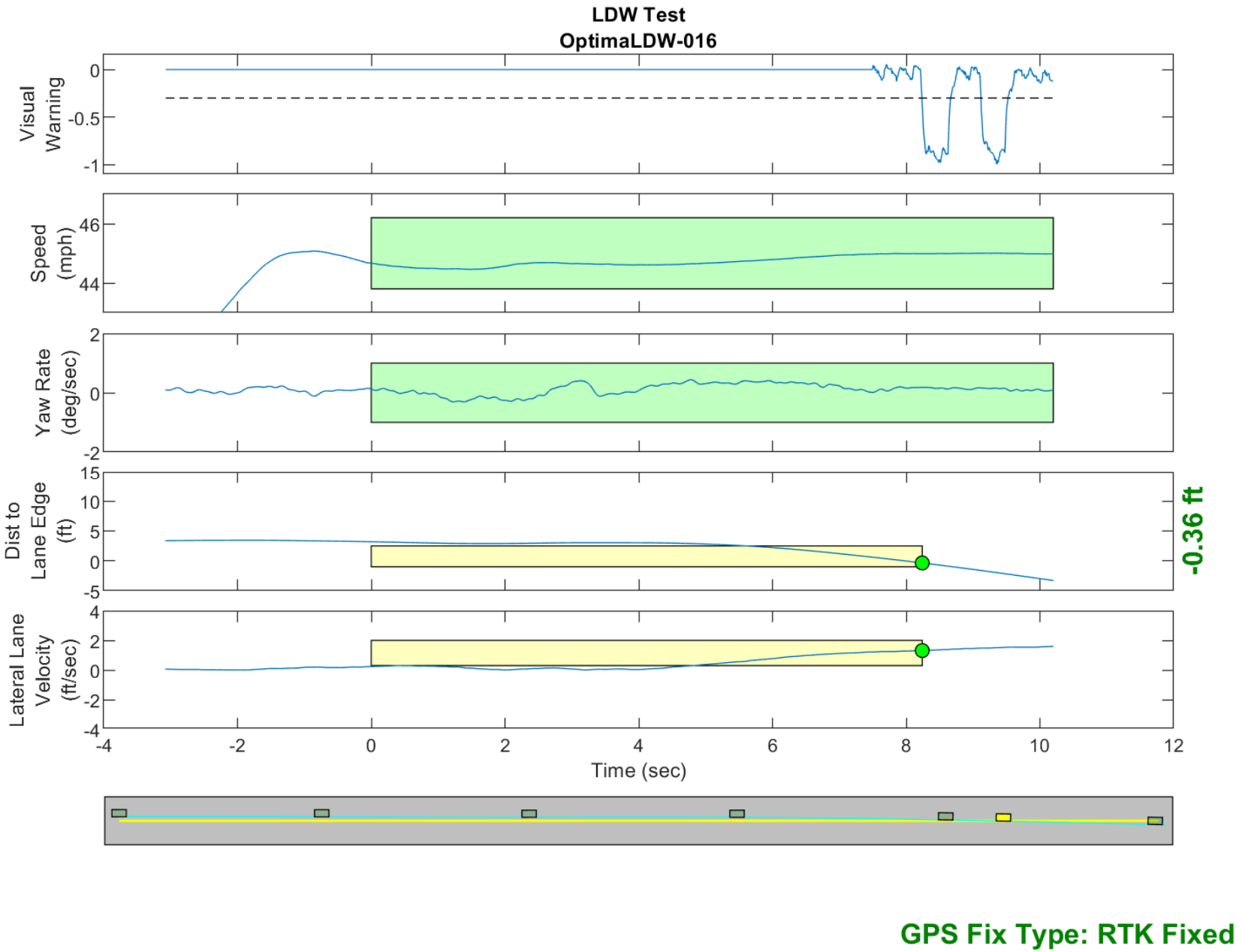

Figure D33. Time History for Run 16, Dashed Line, Right Departure, Visual Warning

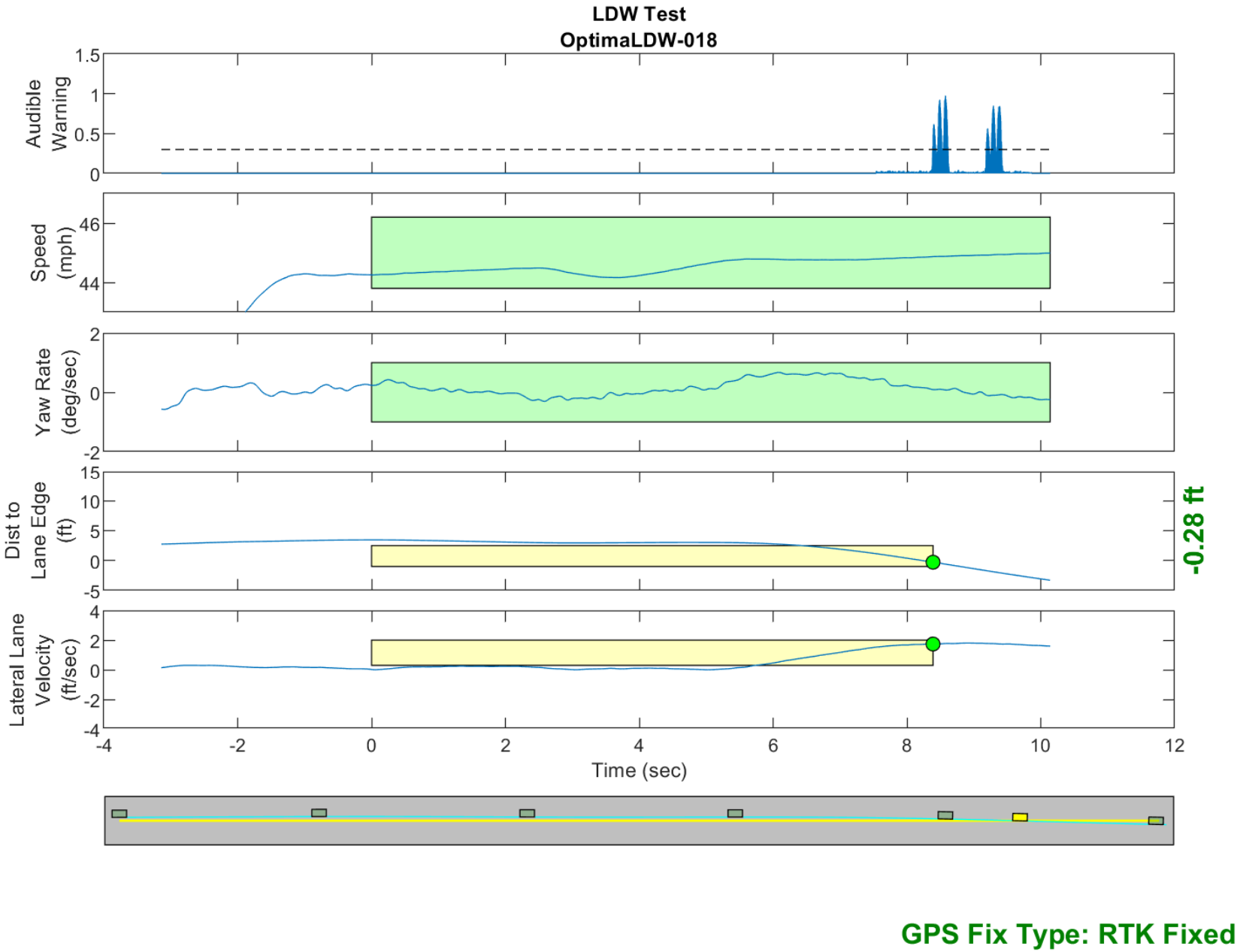

Figure D34. Time History for Run 18, Dashed Line, Right Departure, Audible Warning

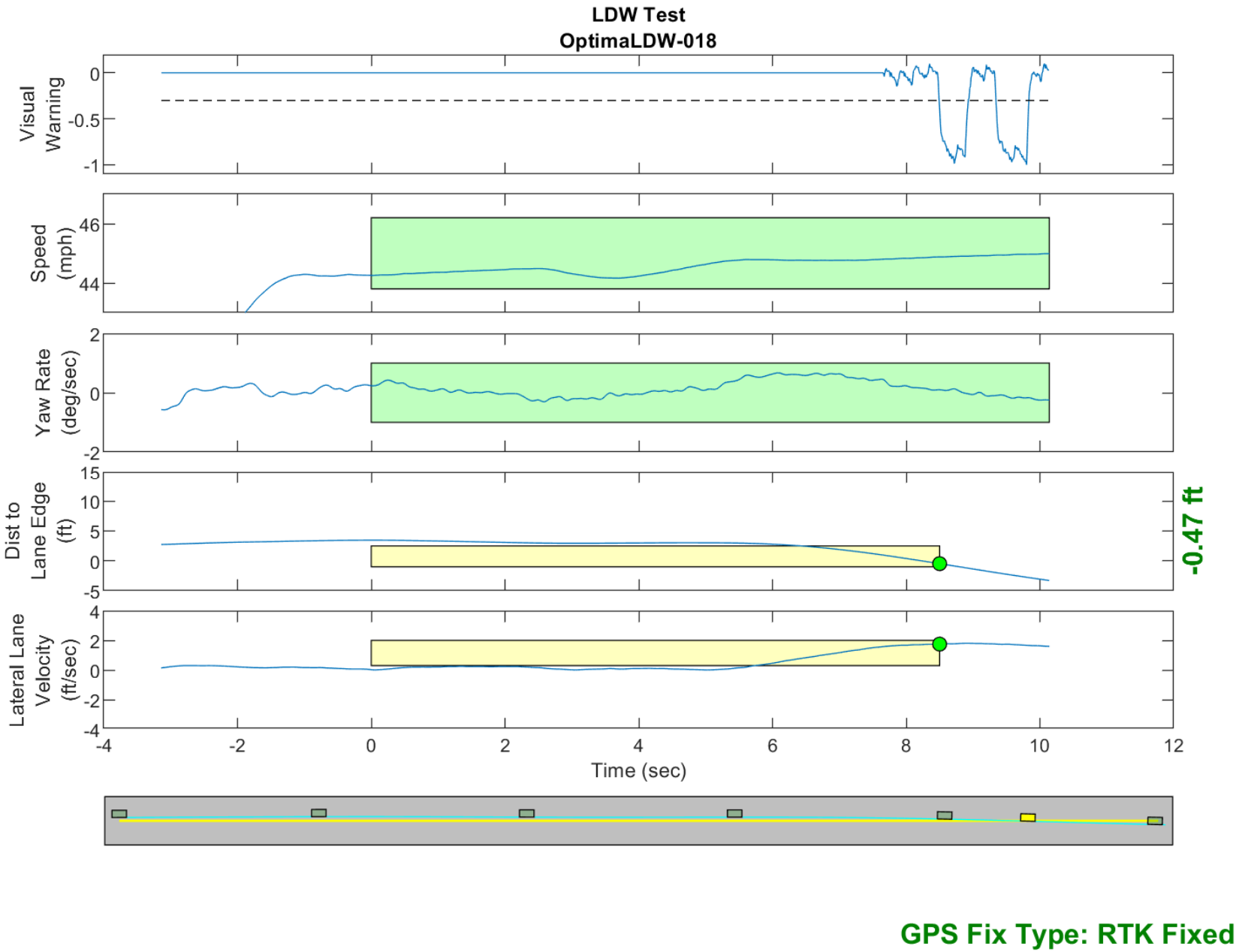

Figure D35. Time History for Run 18, Dashed Line, Right Departure, Visual Warning

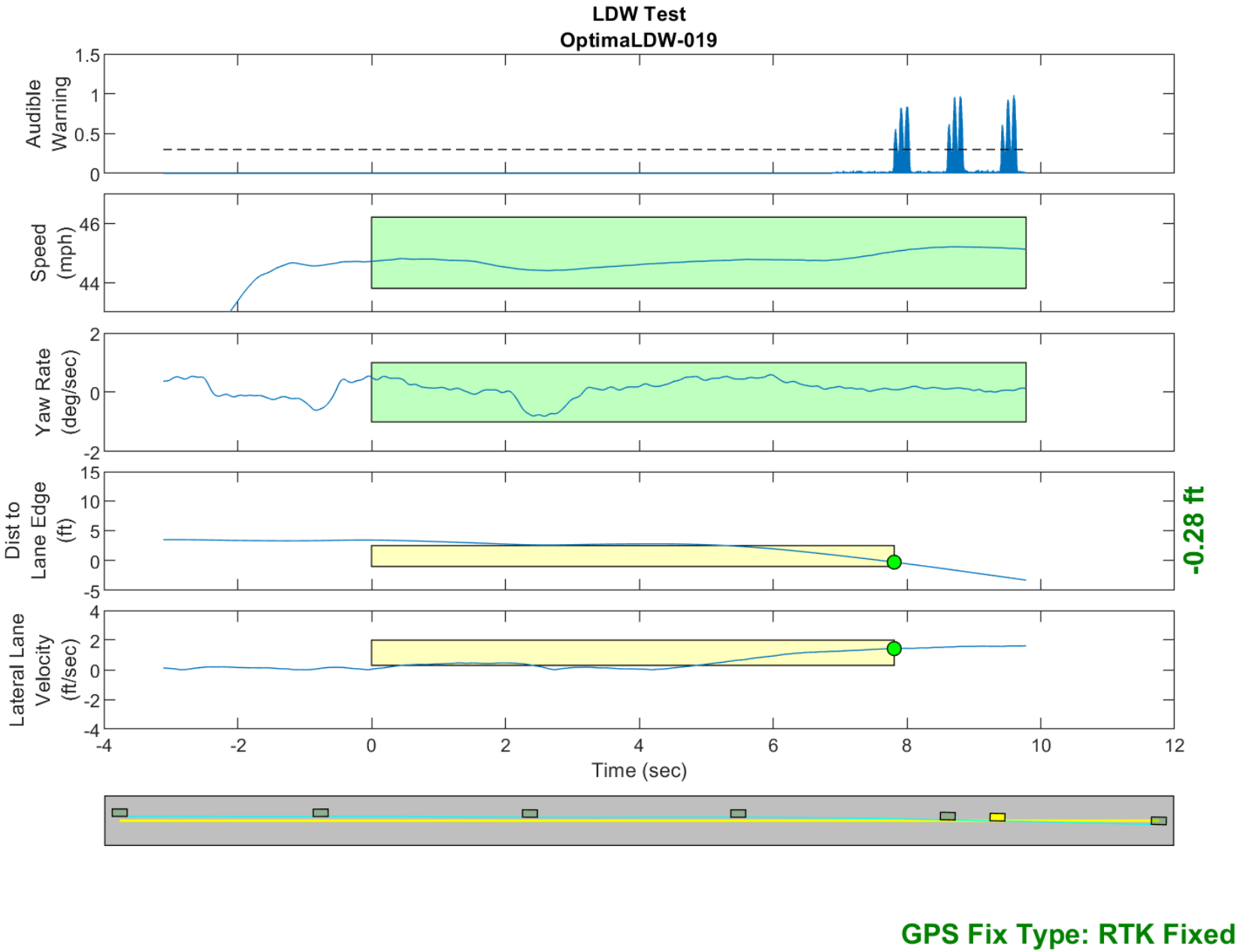

Figure D36. Time History for Run 19, Dashed Line, Right Departure, Audible Warning

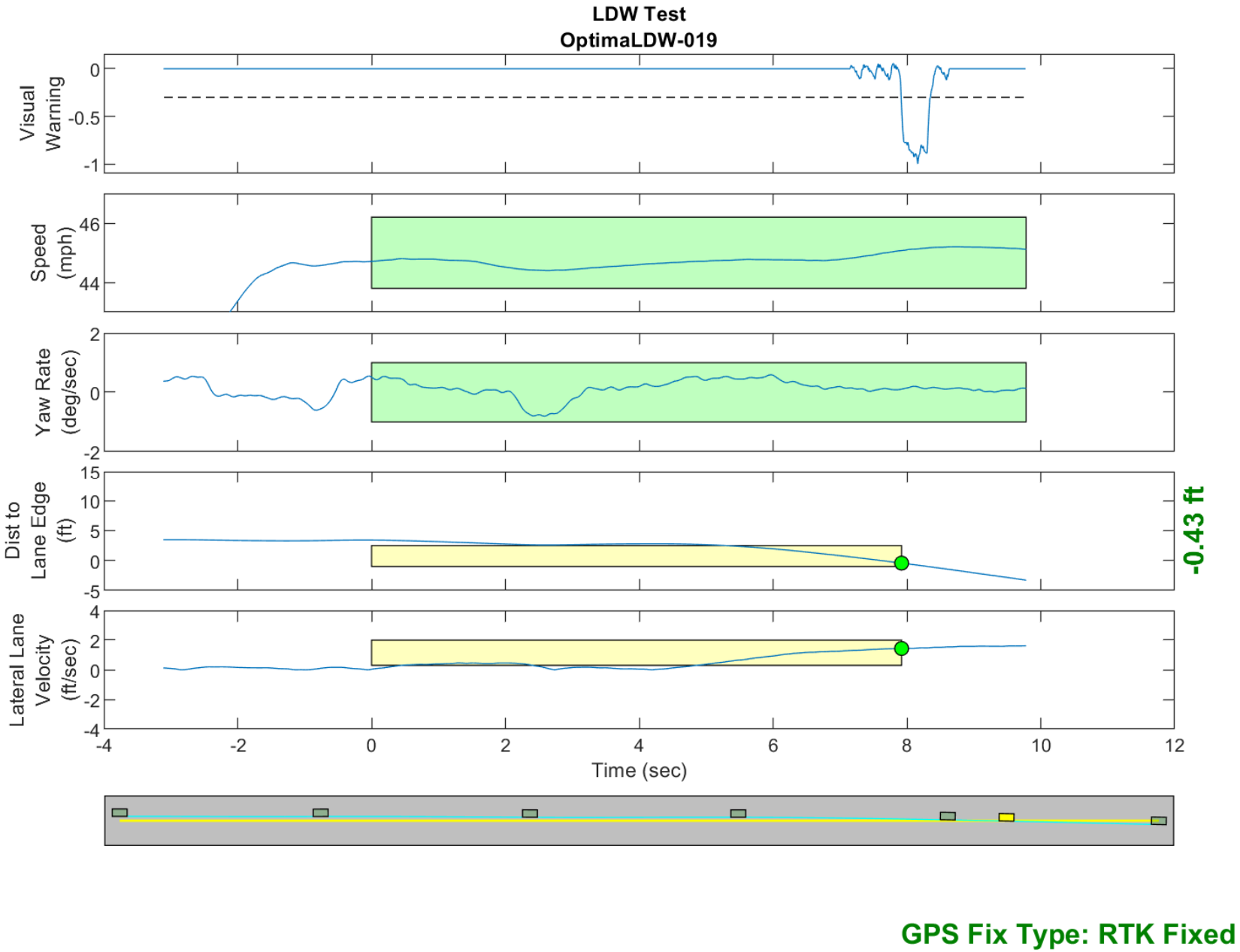

Figure D37. Time History for Run 19, Dashed Line, Right Departure, Visual Warning

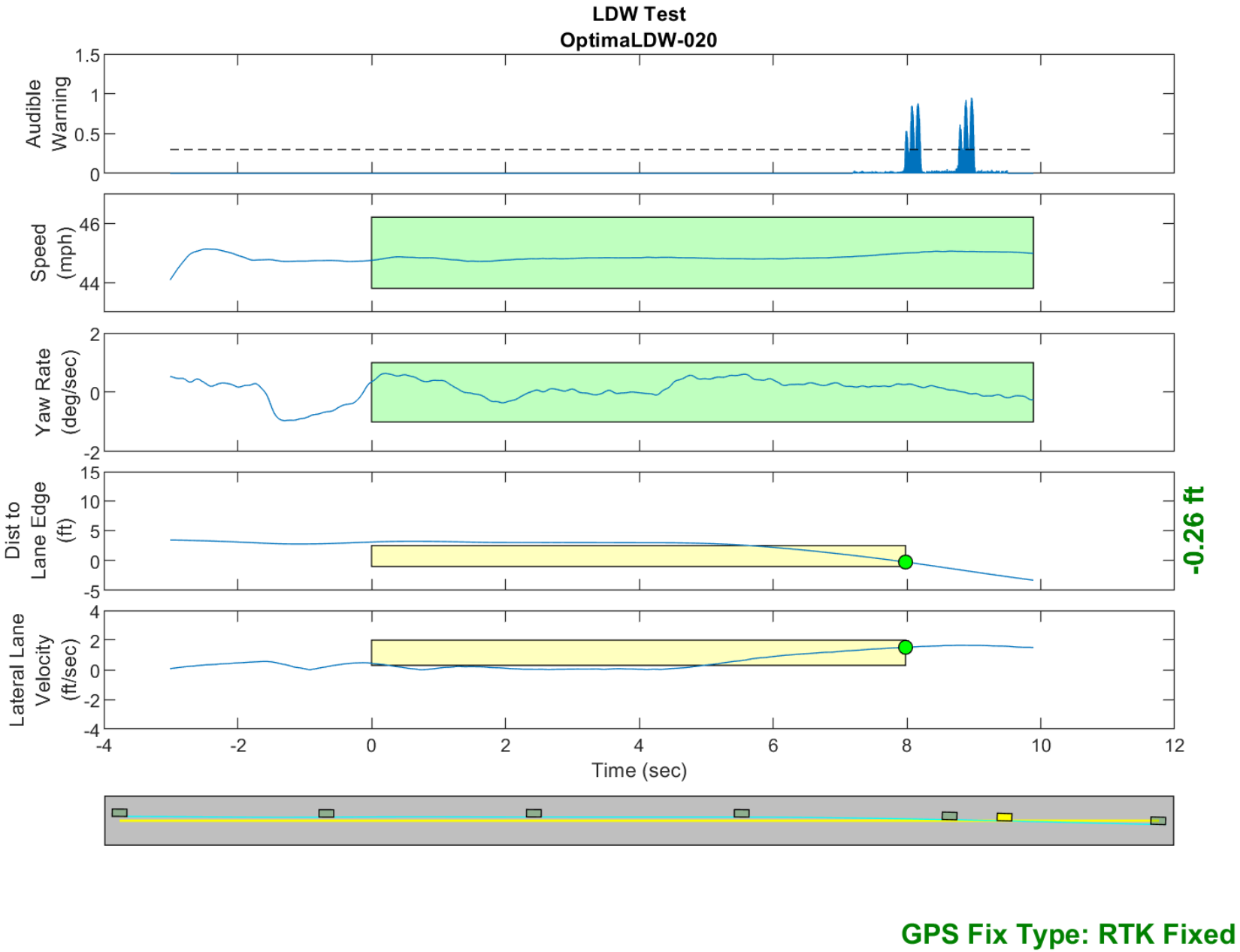

Figure D38. Time History for Run 20, Dashed Line, Right Departure, Audible Warning

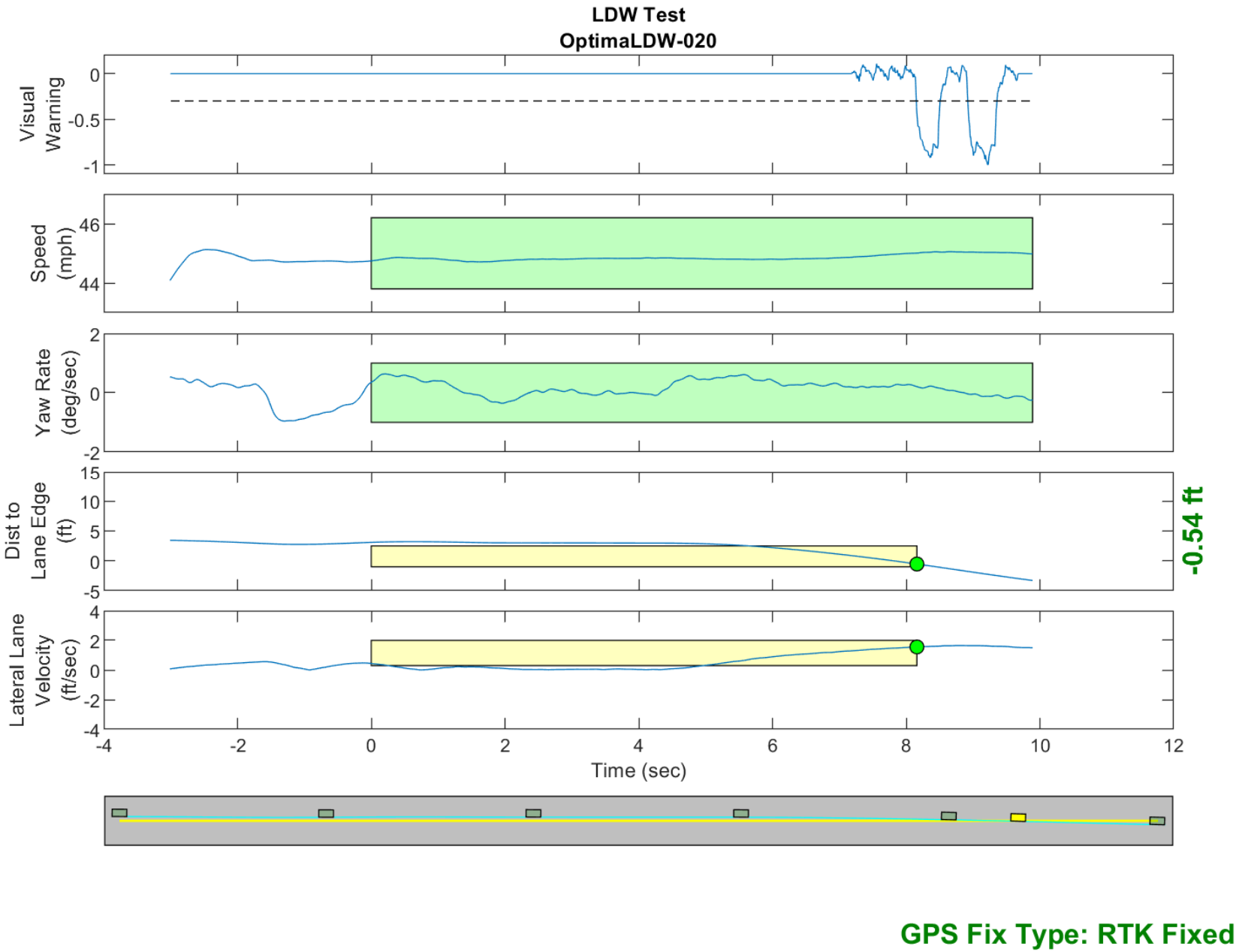

Figure D39. Time History for Run 20, Dashed Line, Right Departure, Visual Warning

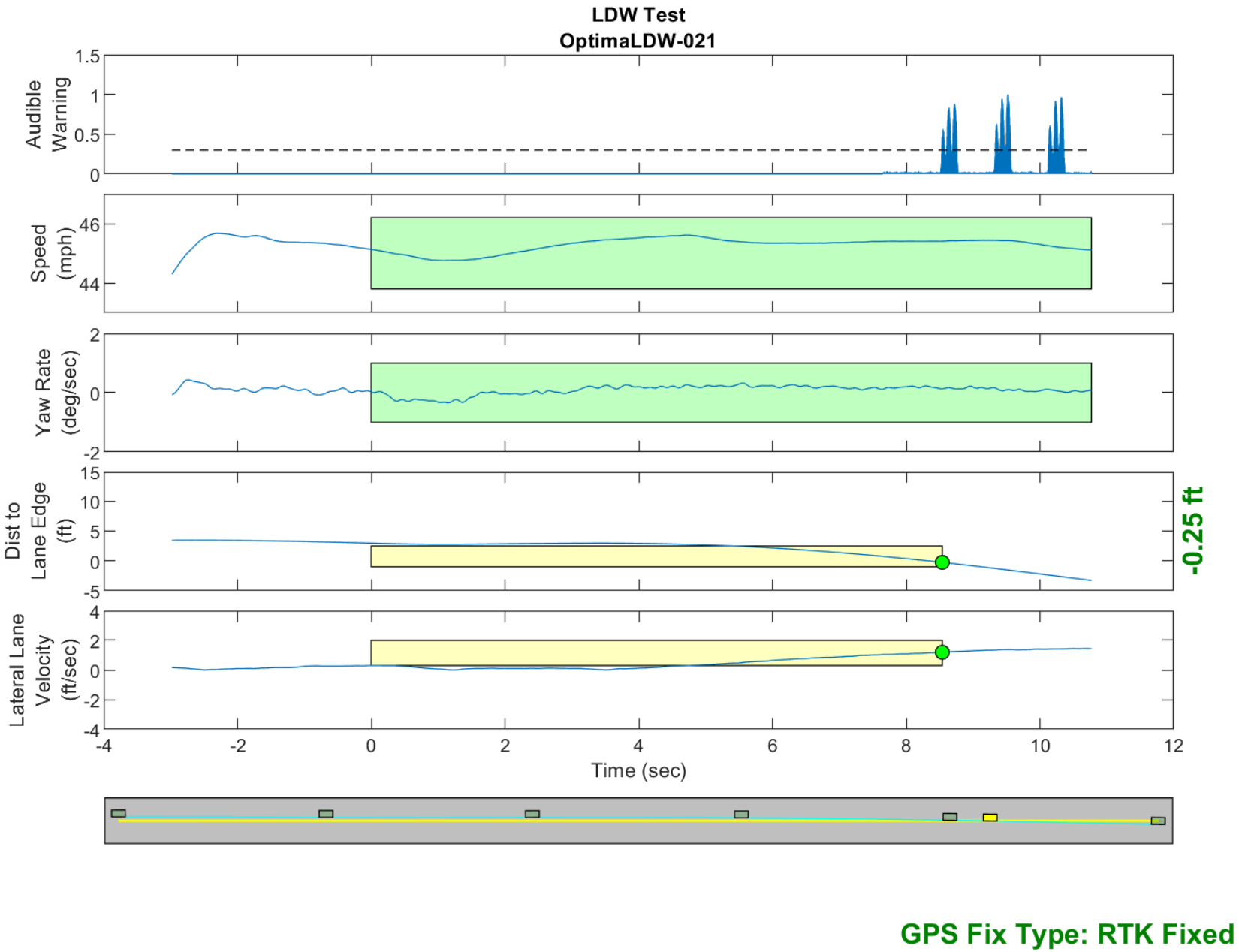

Figure D40. Time History for Run 21, Dashed Line, Right Departure, Audible Warning

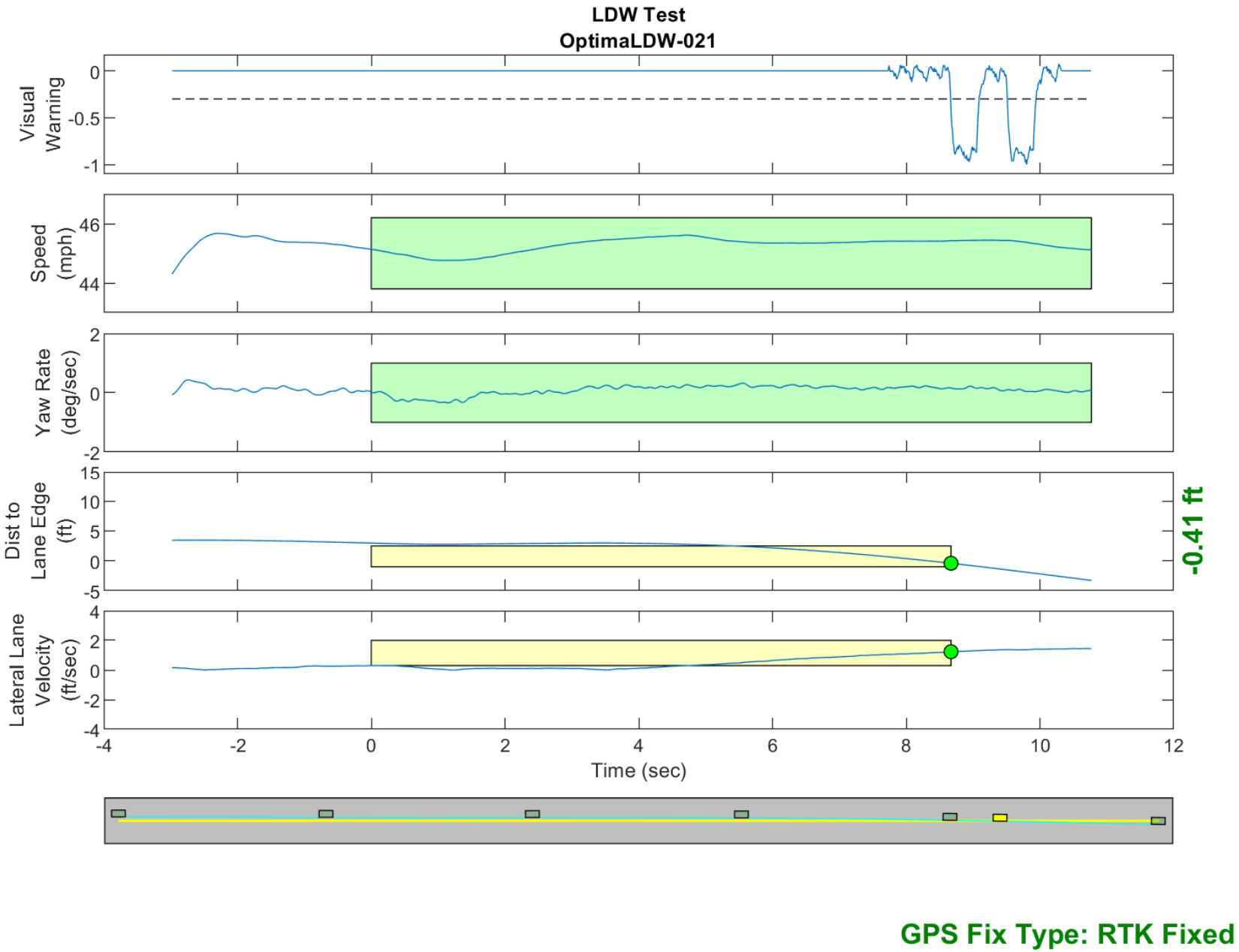

Figure D41. Time History for Run 21, Dashed Line, Right Departure, Visual Warning

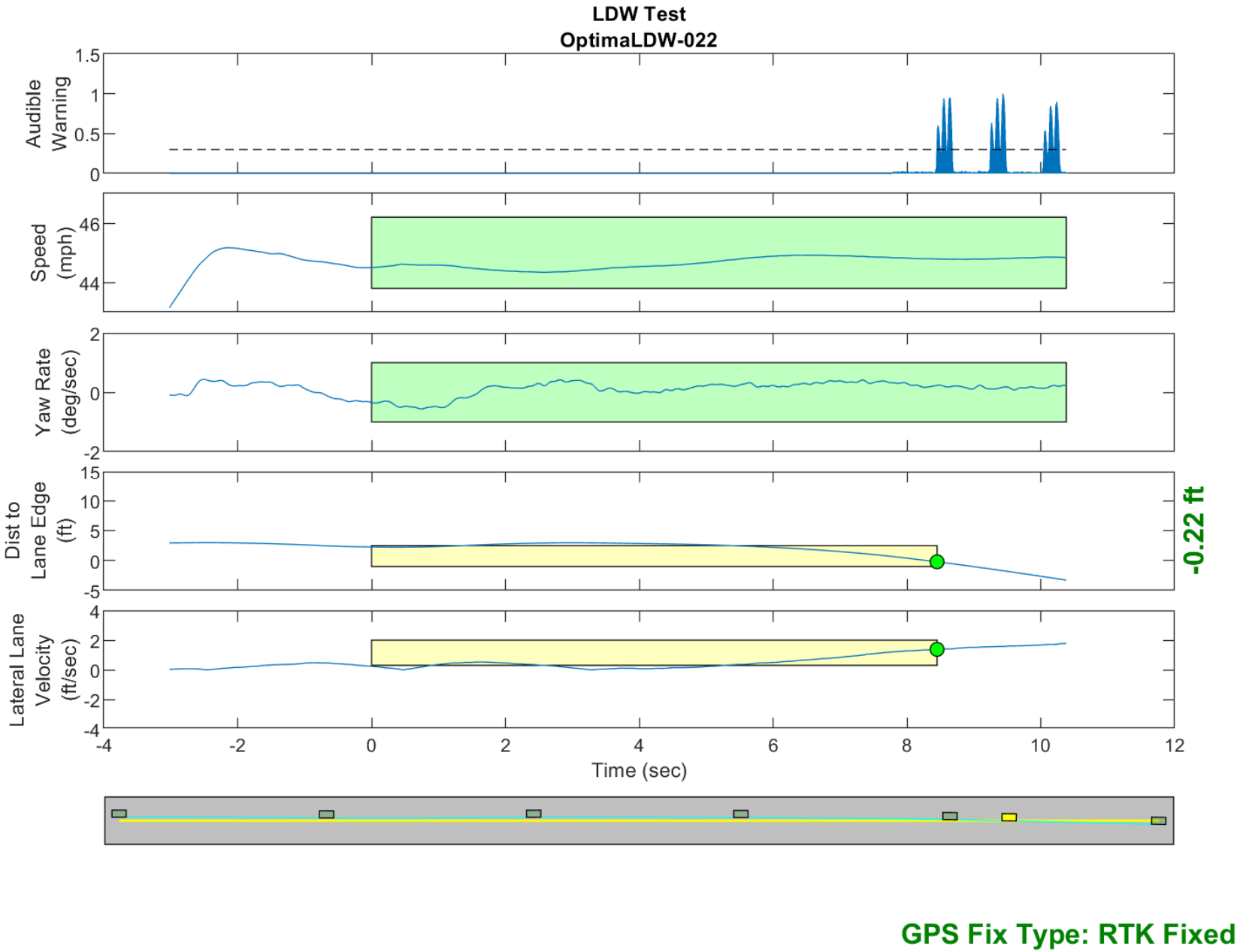

Figure D42. Time History for Run 22, Dashed Line, Right Departure, Audible Warning

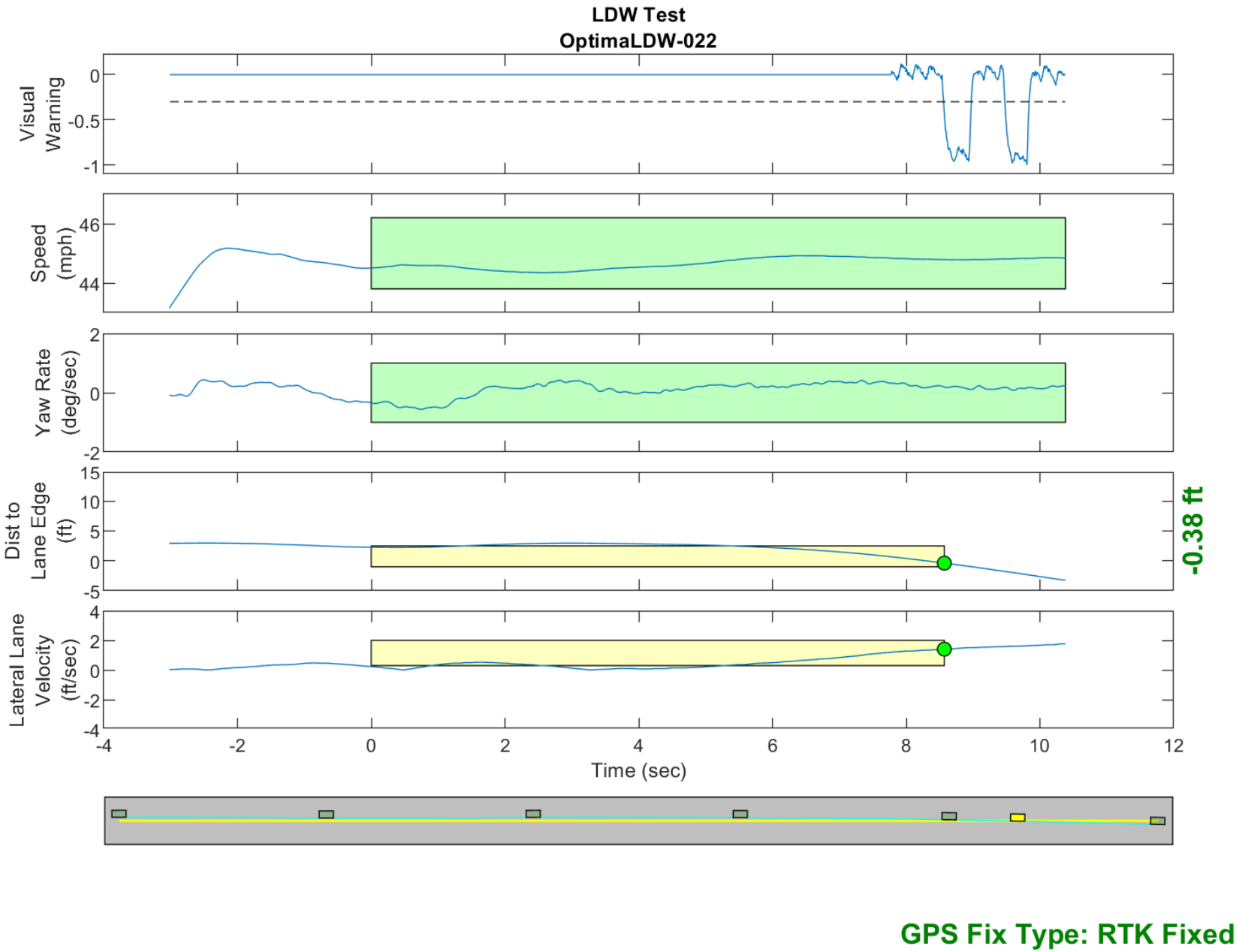

Figure D43. Time History for Run 22, Dashed Line, Right Departure, Visual Warning

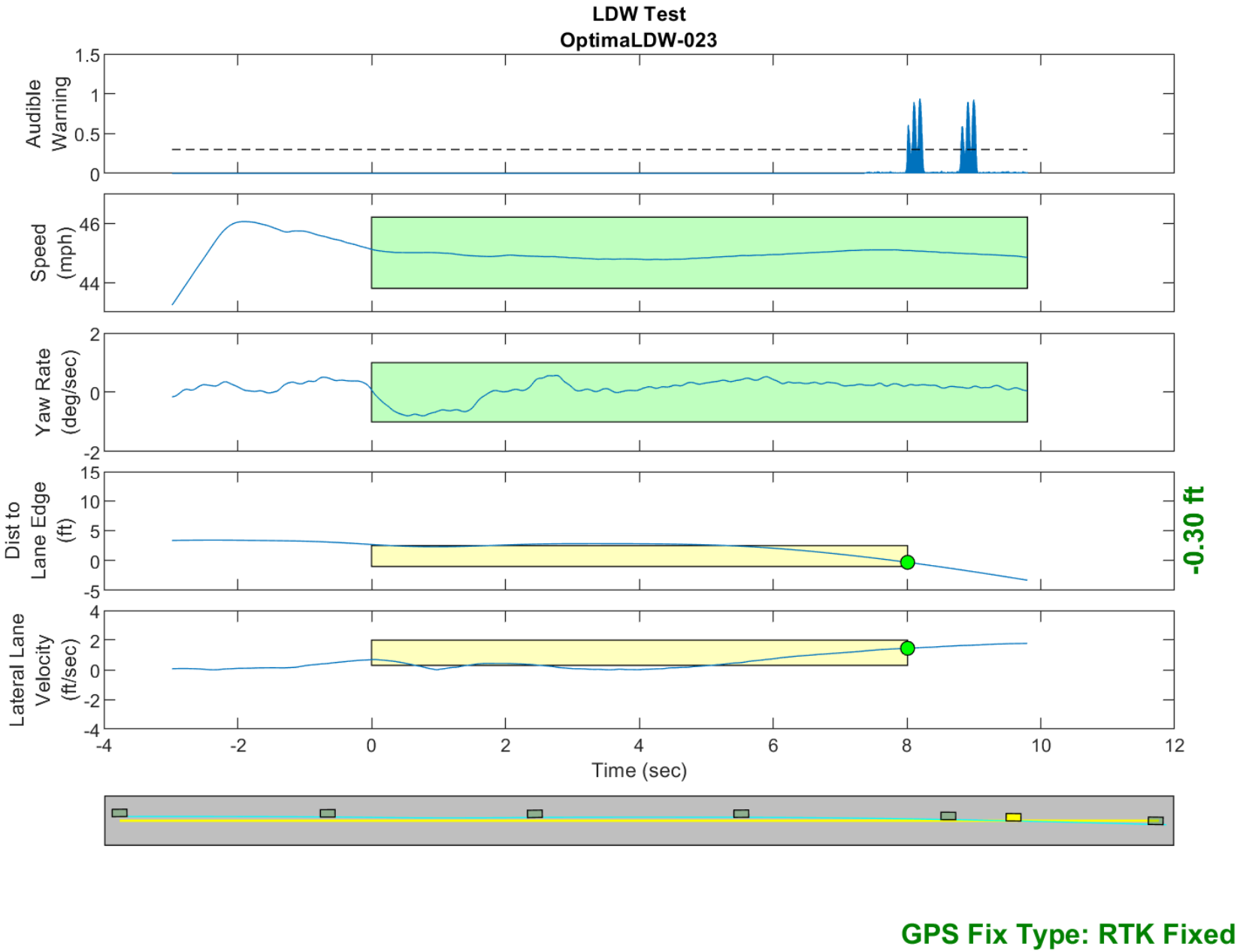

Figure D44. Time History for Run 23, Dashed Line, Right Departure, Audible Warning

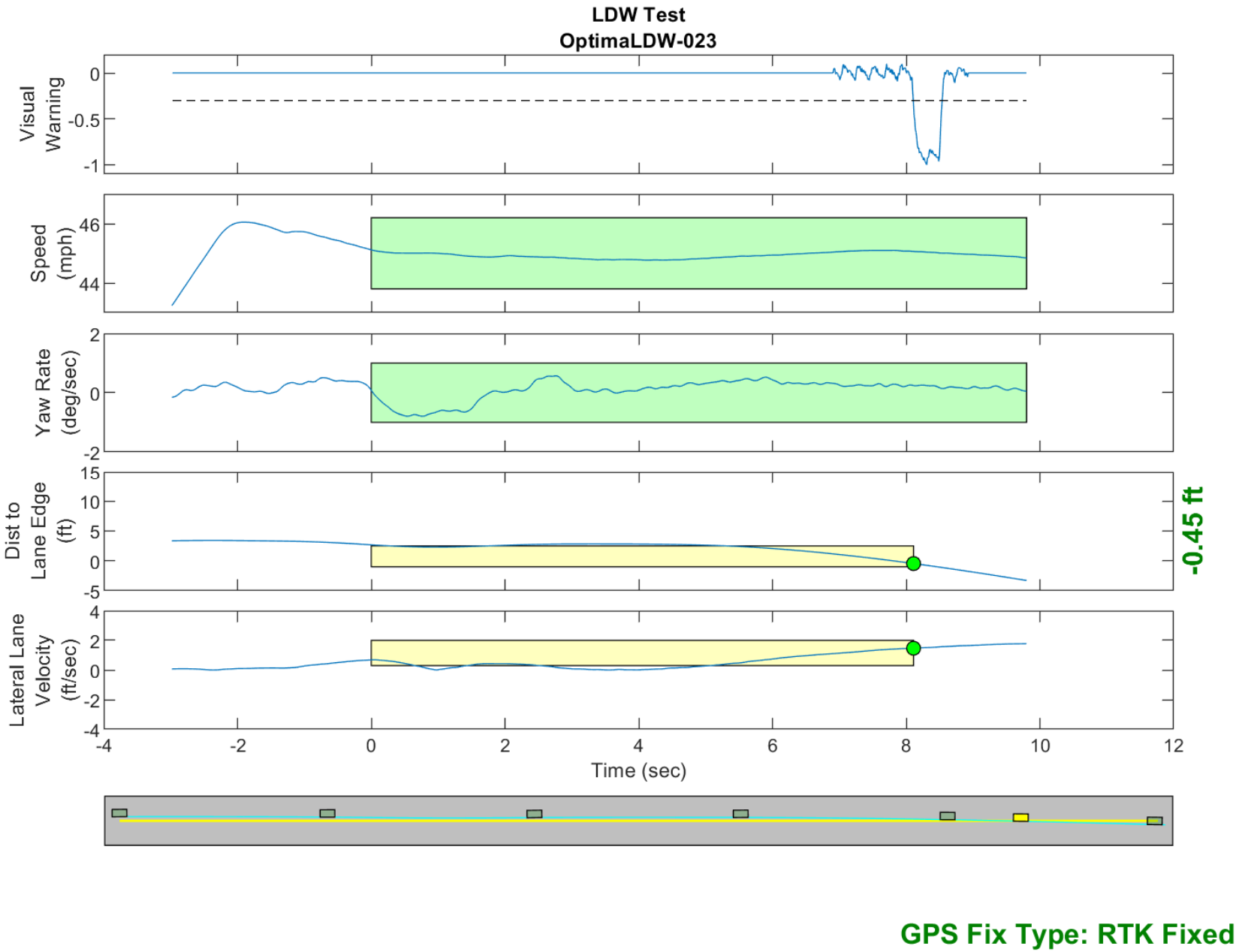

Figure D45. Time History for Run 23, Dashed Line, Right Departure, Visual Warning

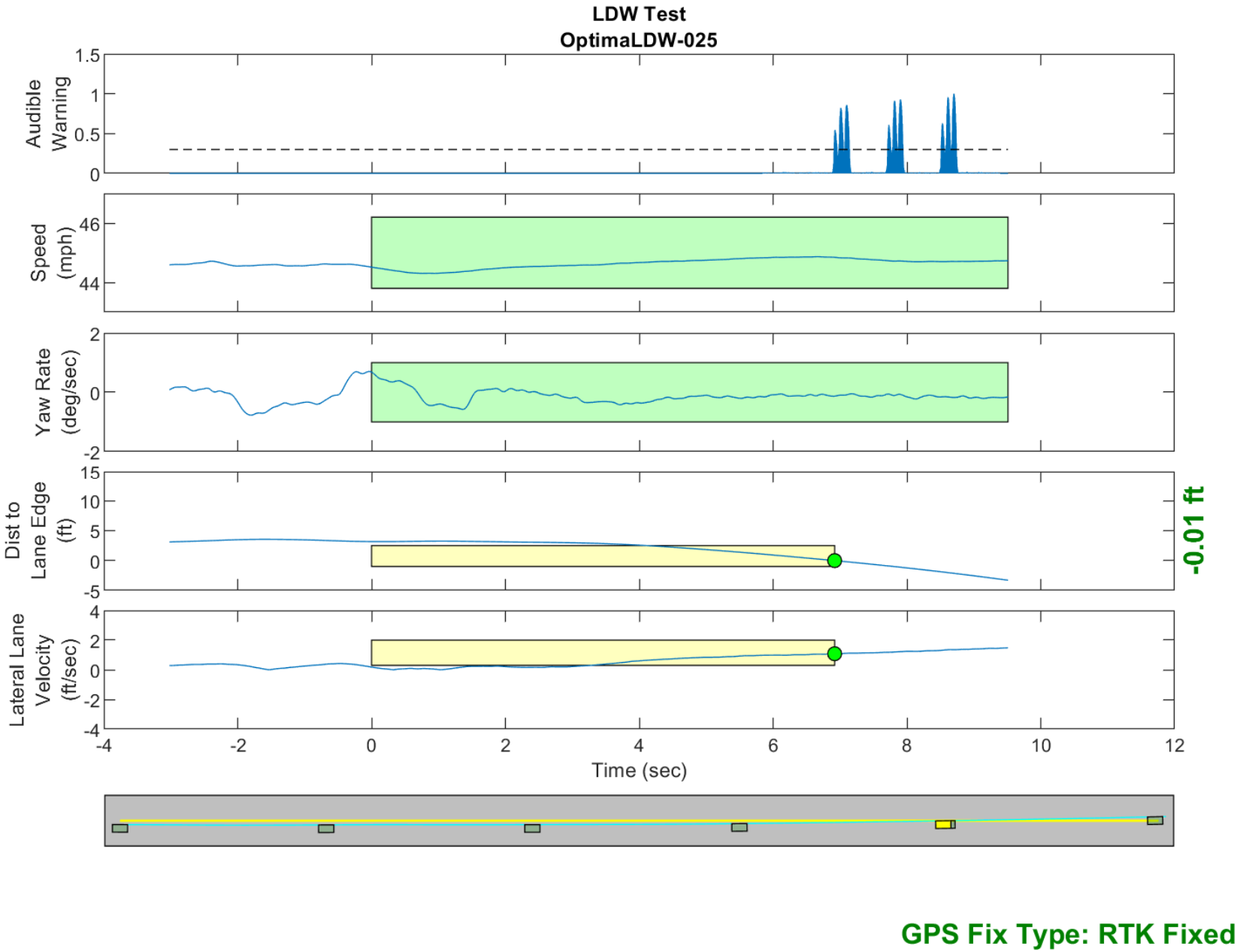

Figure D46. Time History for Run 25, Dashed Line, Left Departure, Audible Warning

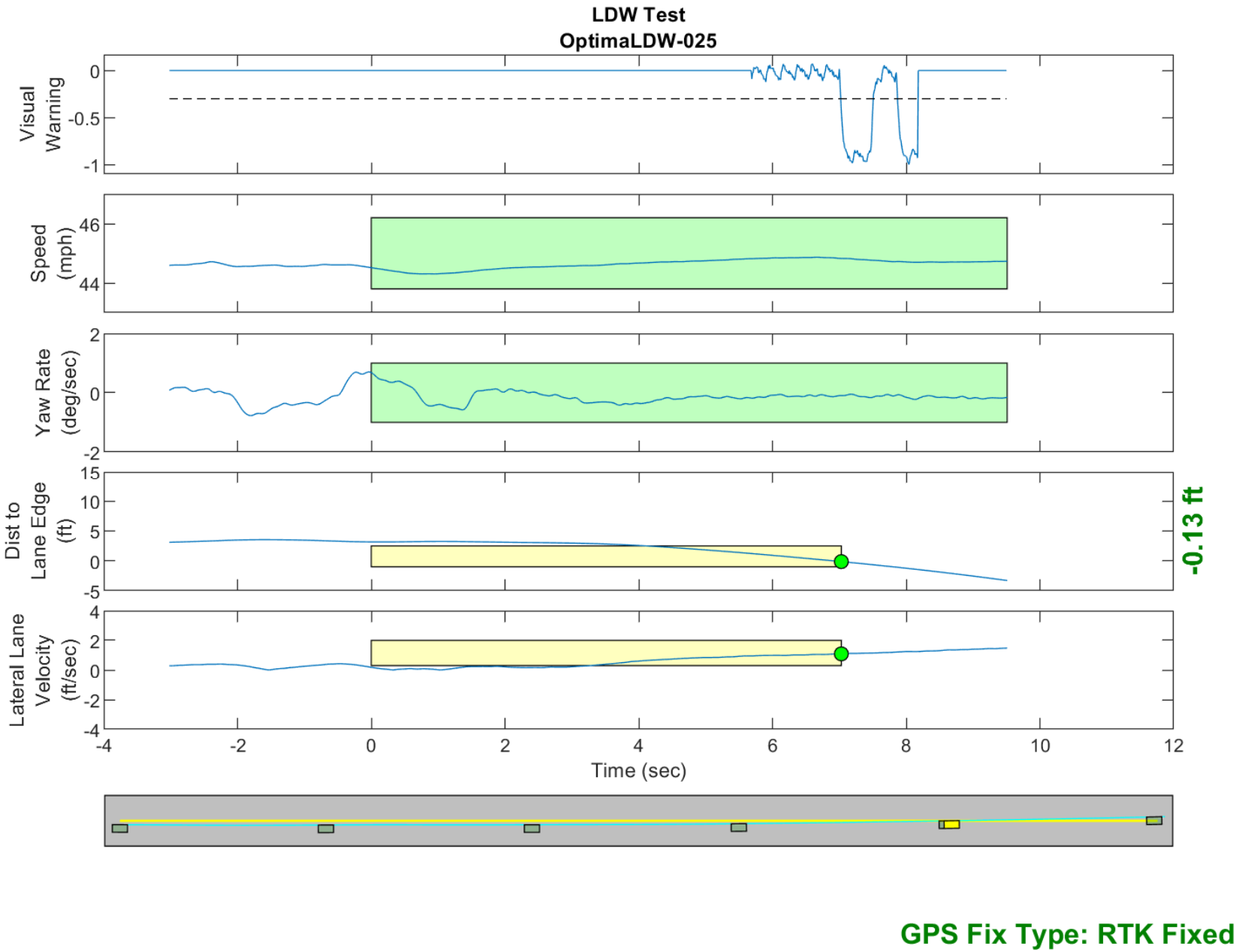

Figure D47. Time History for Run 25, Dashed Line, Left Departure, Visual Warning

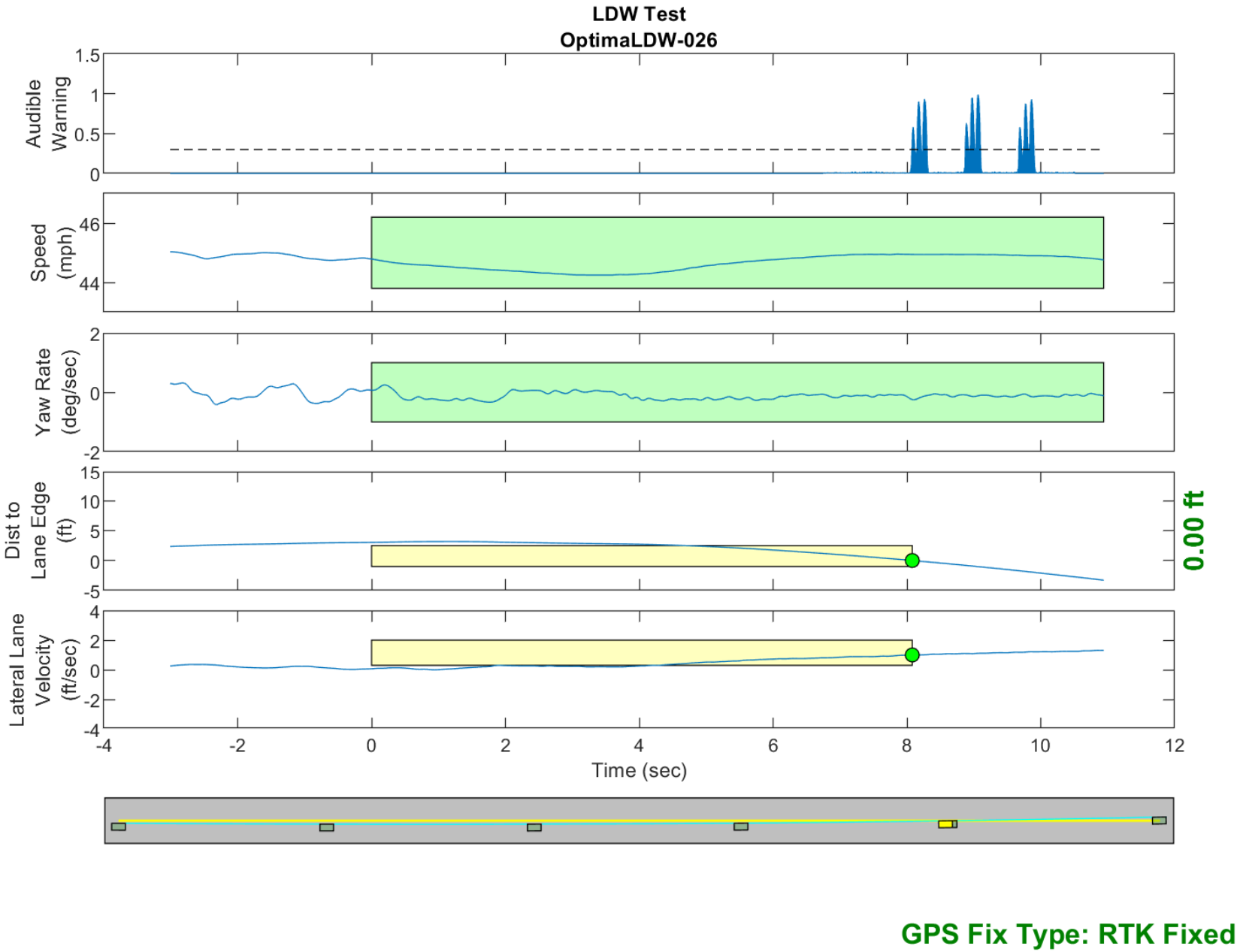

Figure D48. Time History for Run 26, Dashed Line, Left Departure, Audible Warning

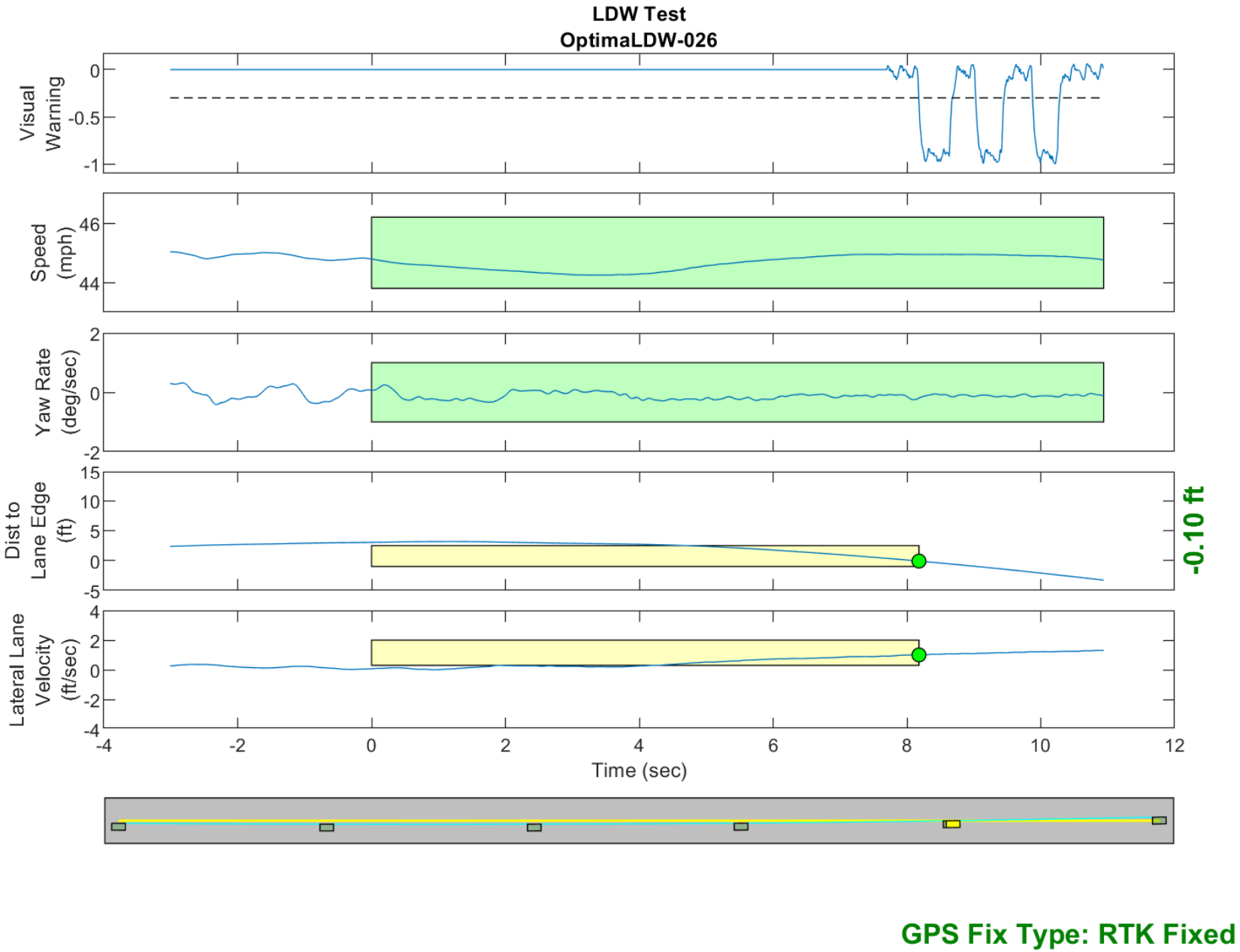

Figure D49. Time History for Run 26, Dashed Line, Left Departure, Visual Warning

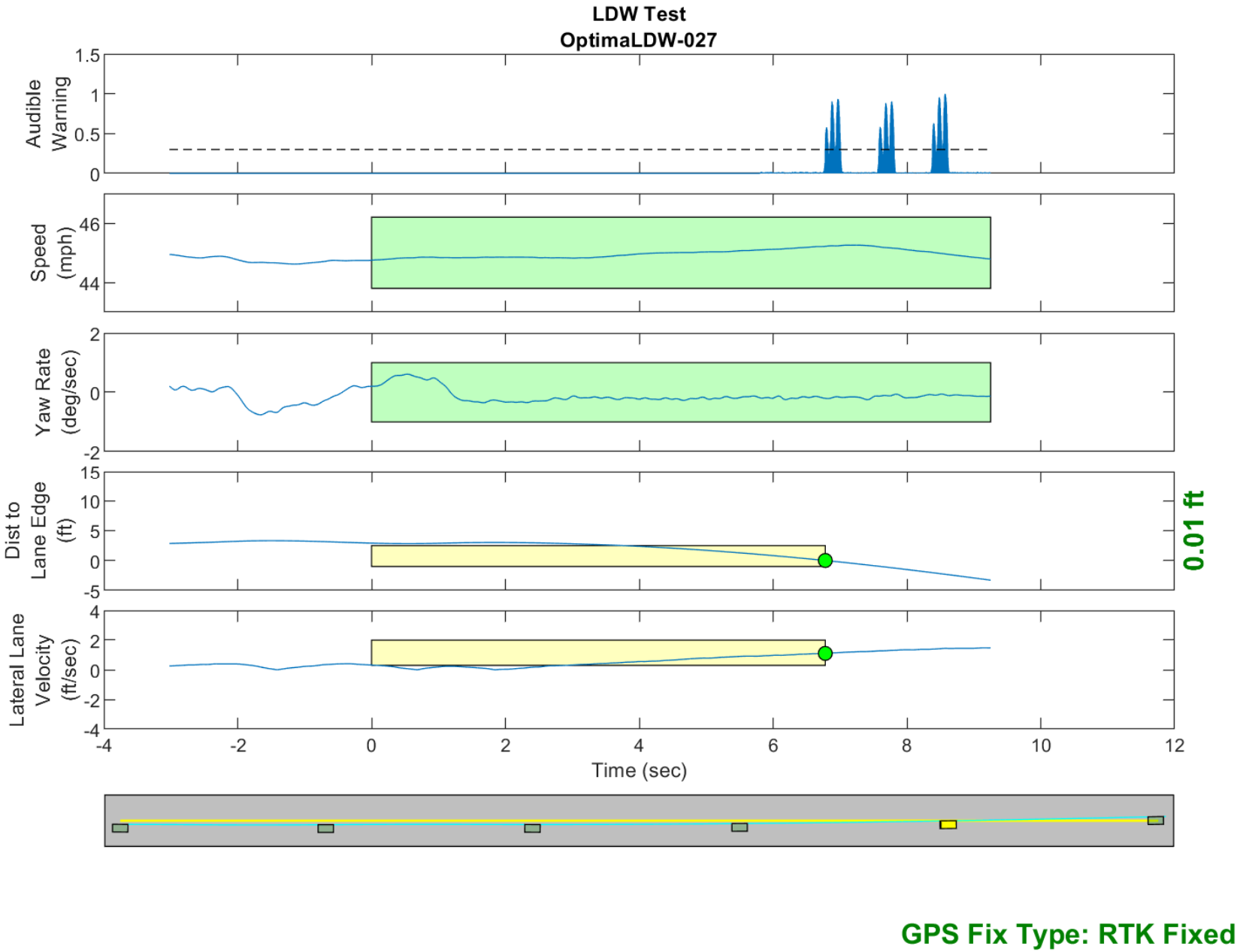

Figure D50. Time History for Run 27, Dashed Line, Left Departure, Audible Warning

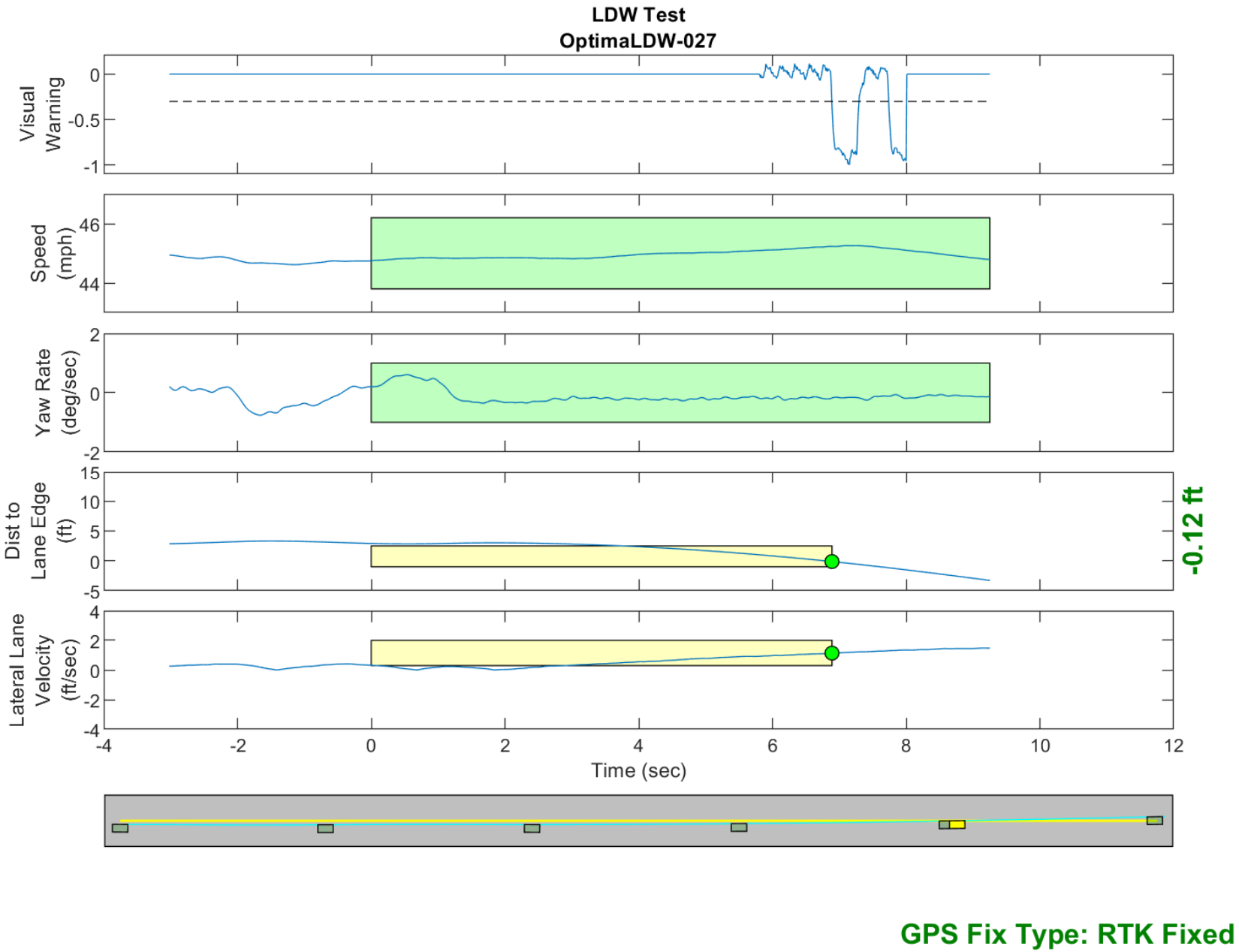

Figure D51. Time History for Run 27, Dashed Line, Left Departure, Visual Warning

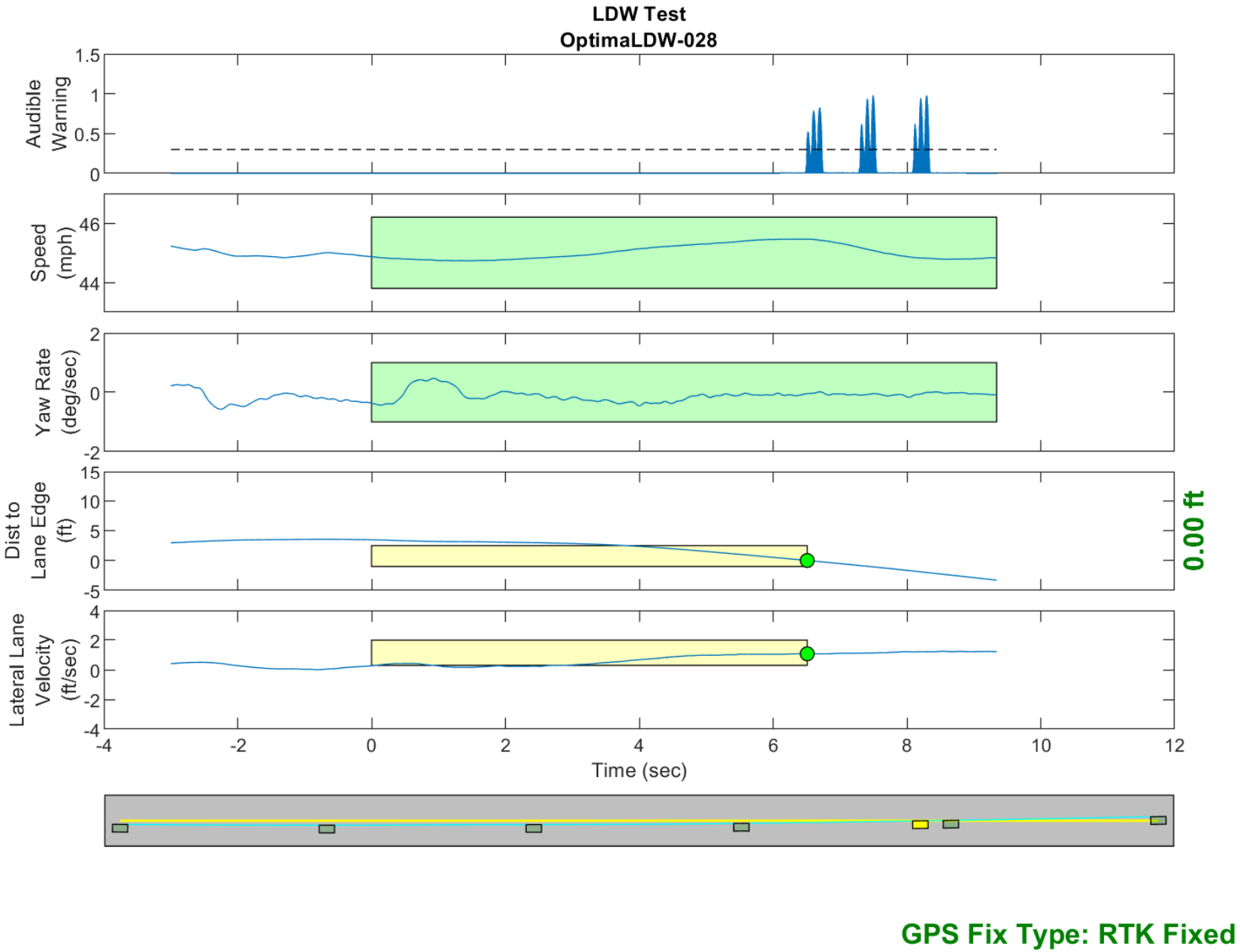

Figure D52. Time History for Run 28, Dashed Line, Left Departure, Audible Warning

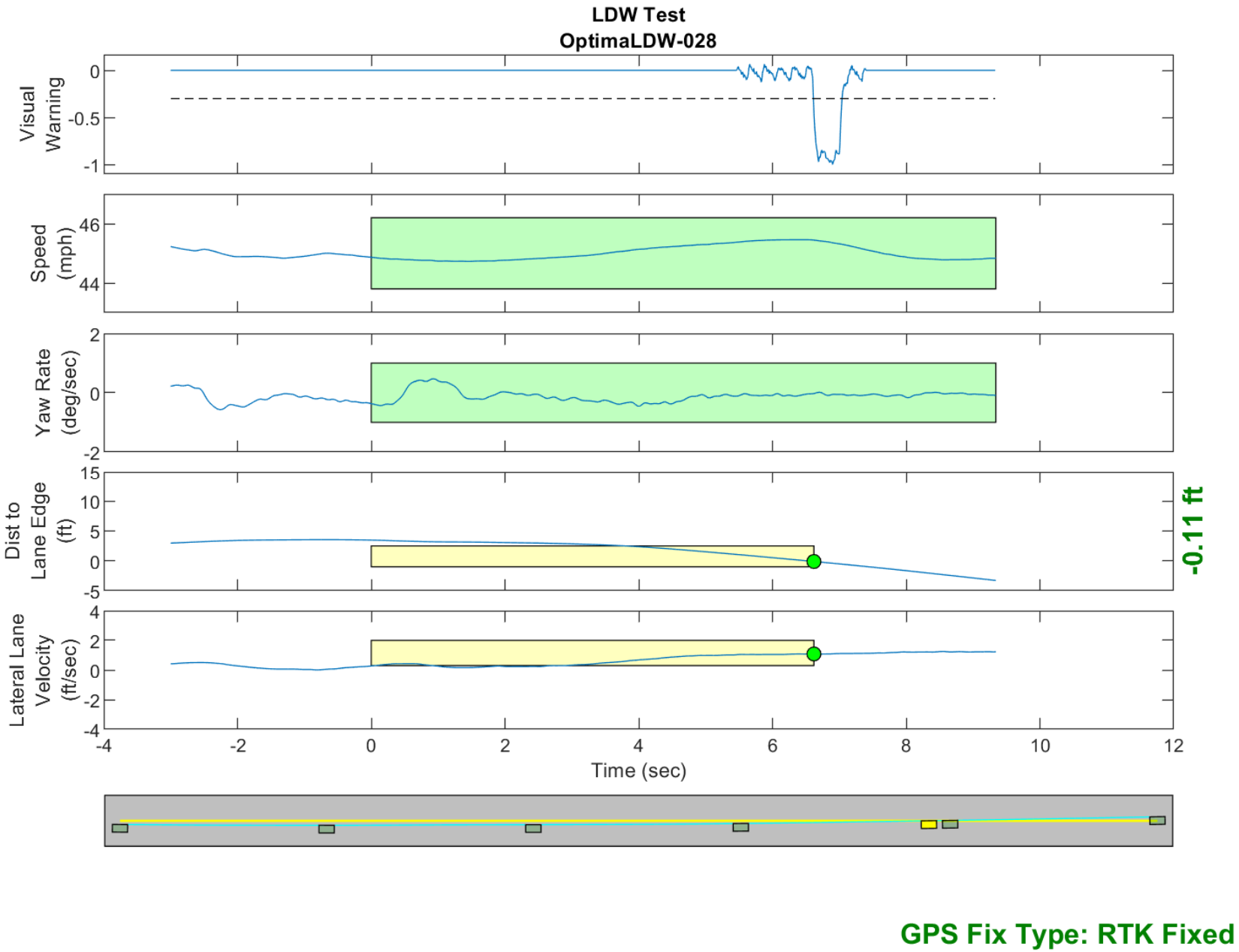

Figure D53. Time History for Run 28, Dashed Line, Left Departure, Visual Warning

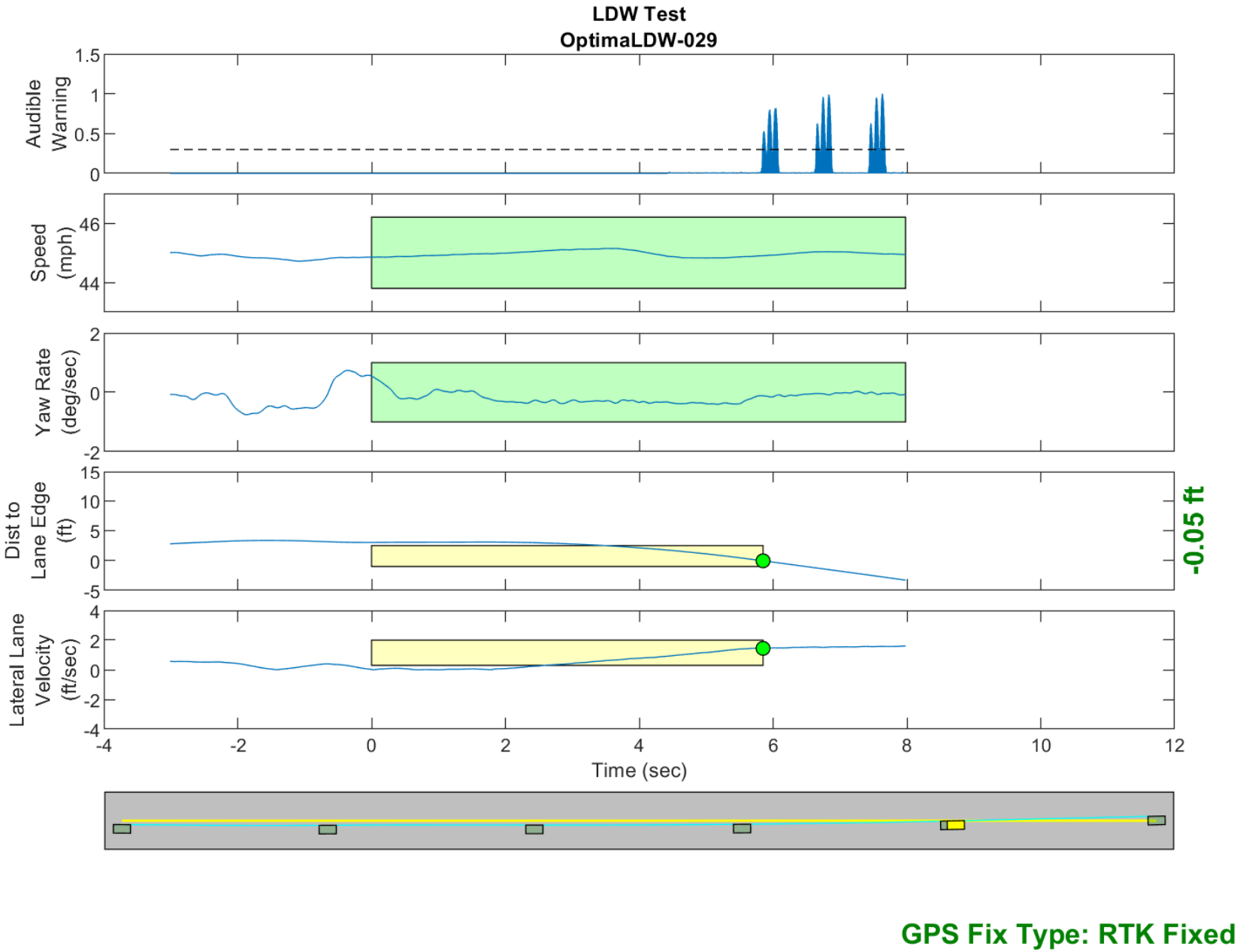

Figure D54. Time History for Run 29, Dashed Line, Left Departure, Audible Warning

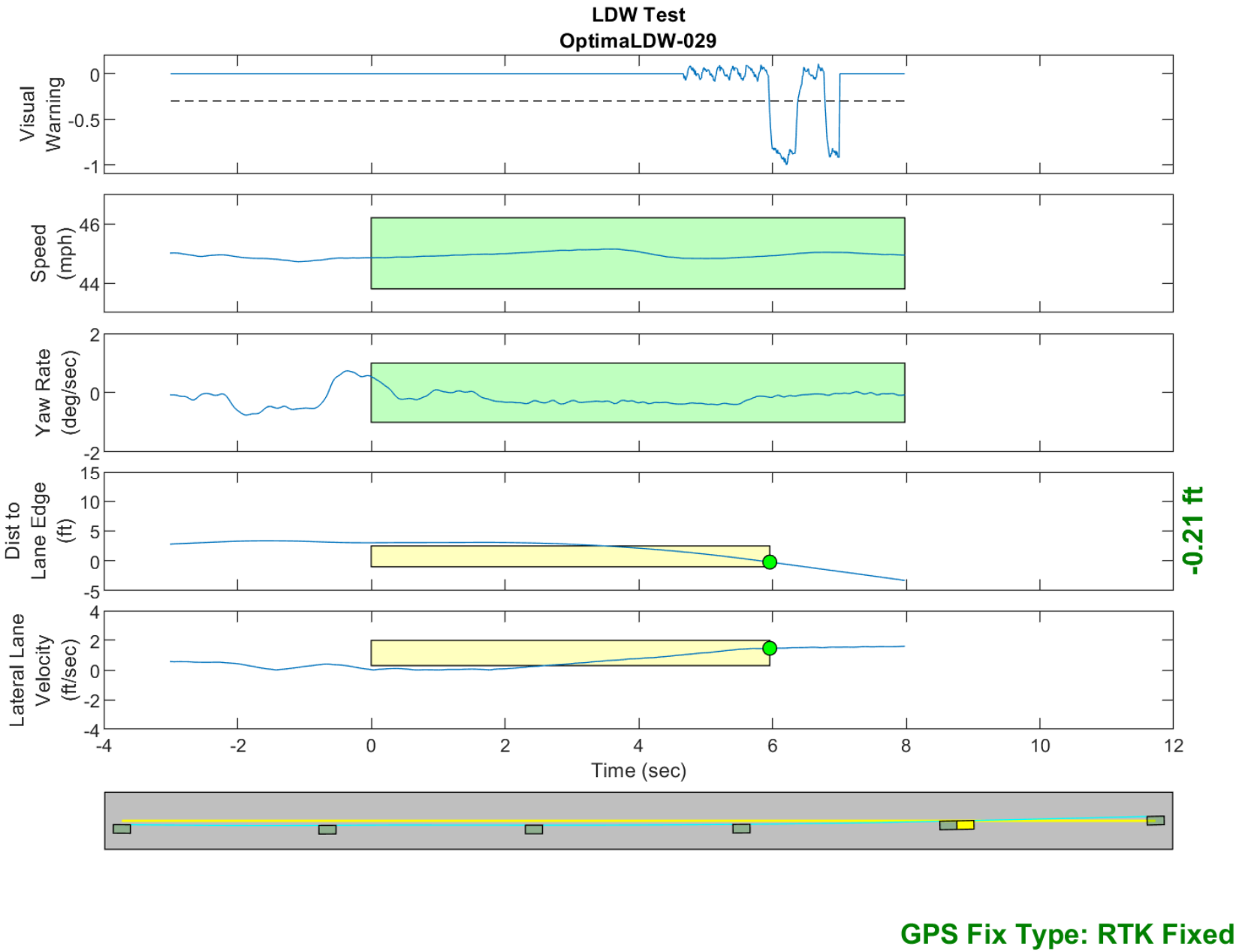

Figure D55. Time History for Run 29, Dashed Line, Left Departure, Visual Warning

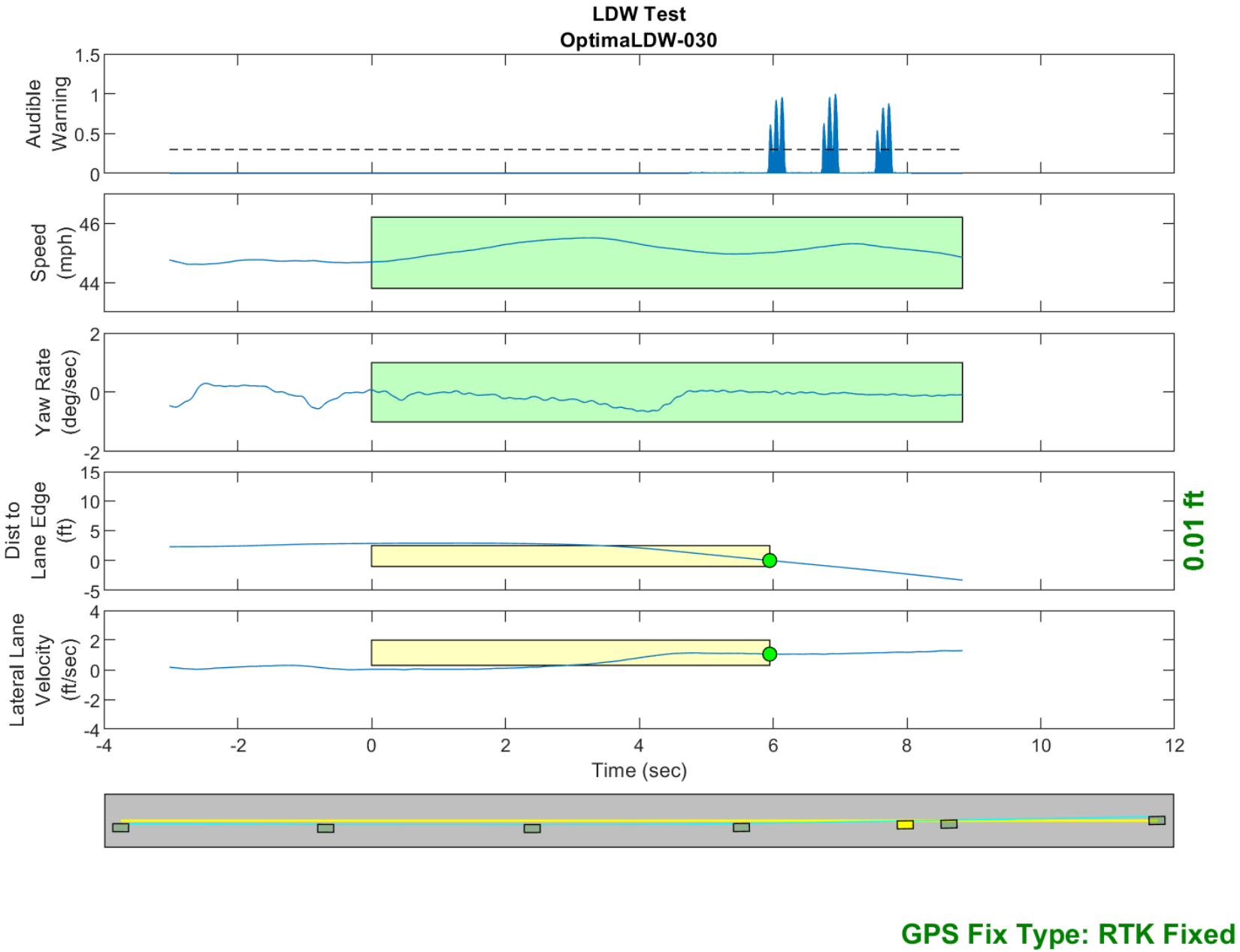

Figure D56. Time History for Run 30, Dashed Line, Left Departure, Audible Warning

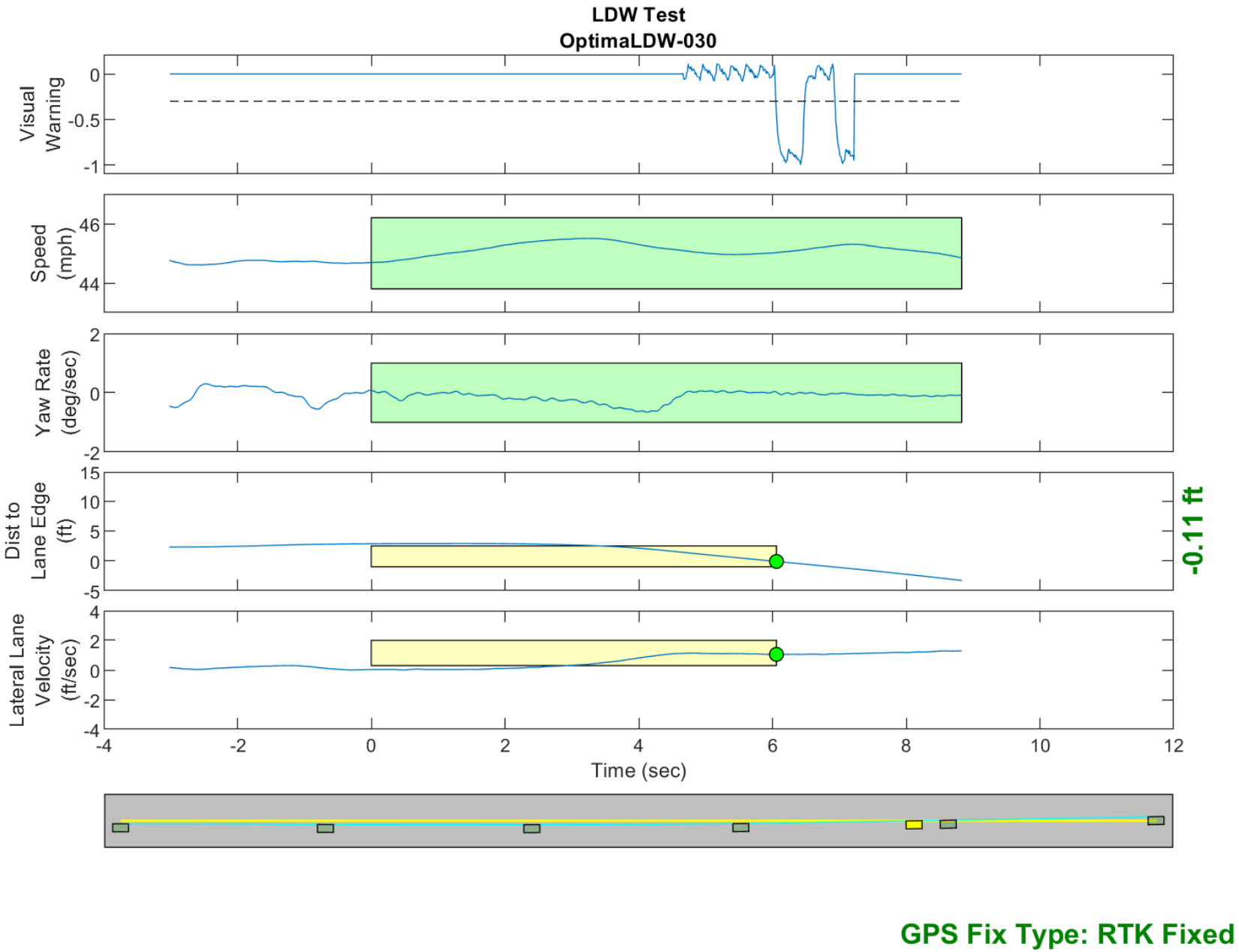

Figure D57. Time History for Run 30, Dashed Line, Left Departure, Visual Warning

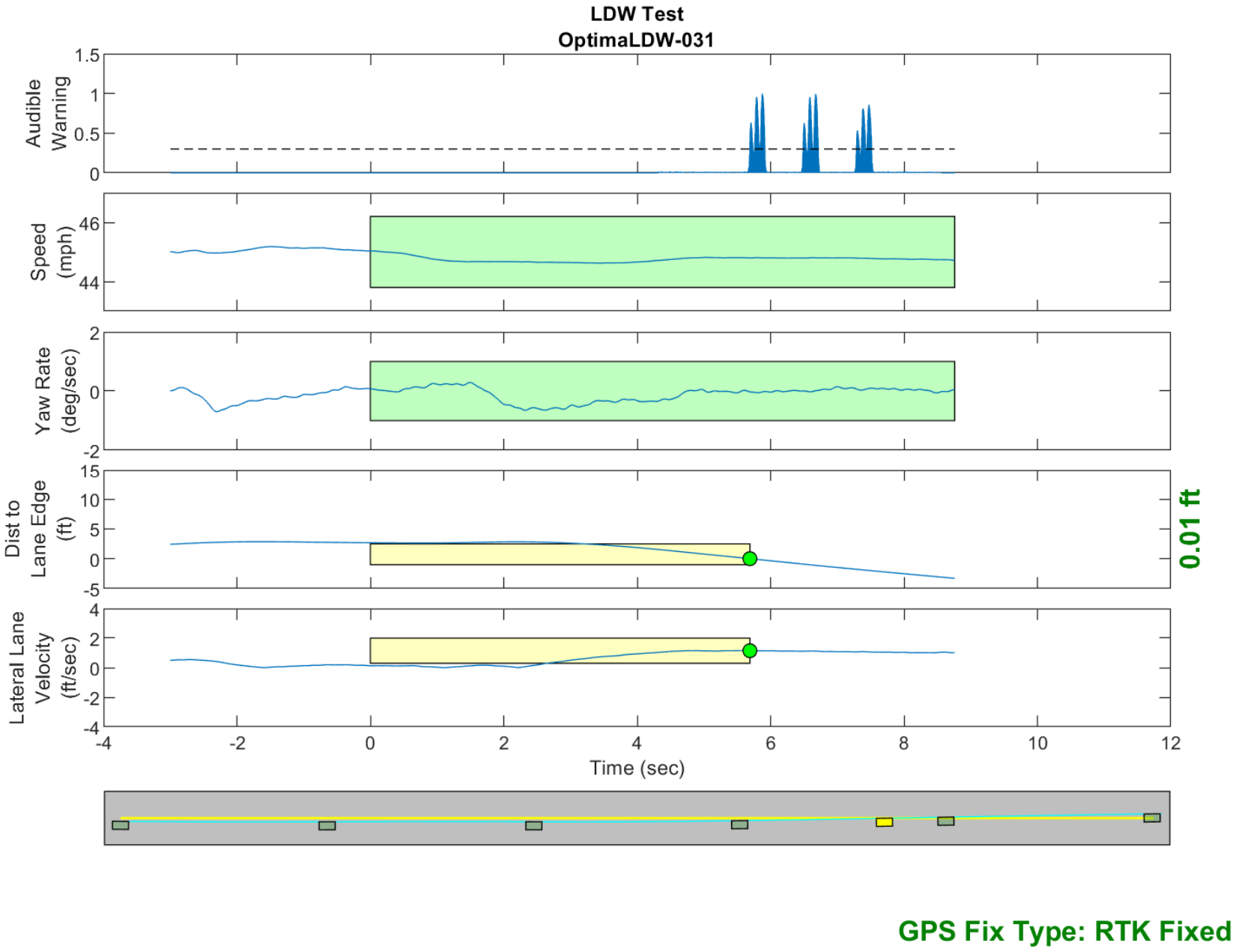

Figure D58. Time History for Run 31, Dashed Line, Left Departure, Audible Warning

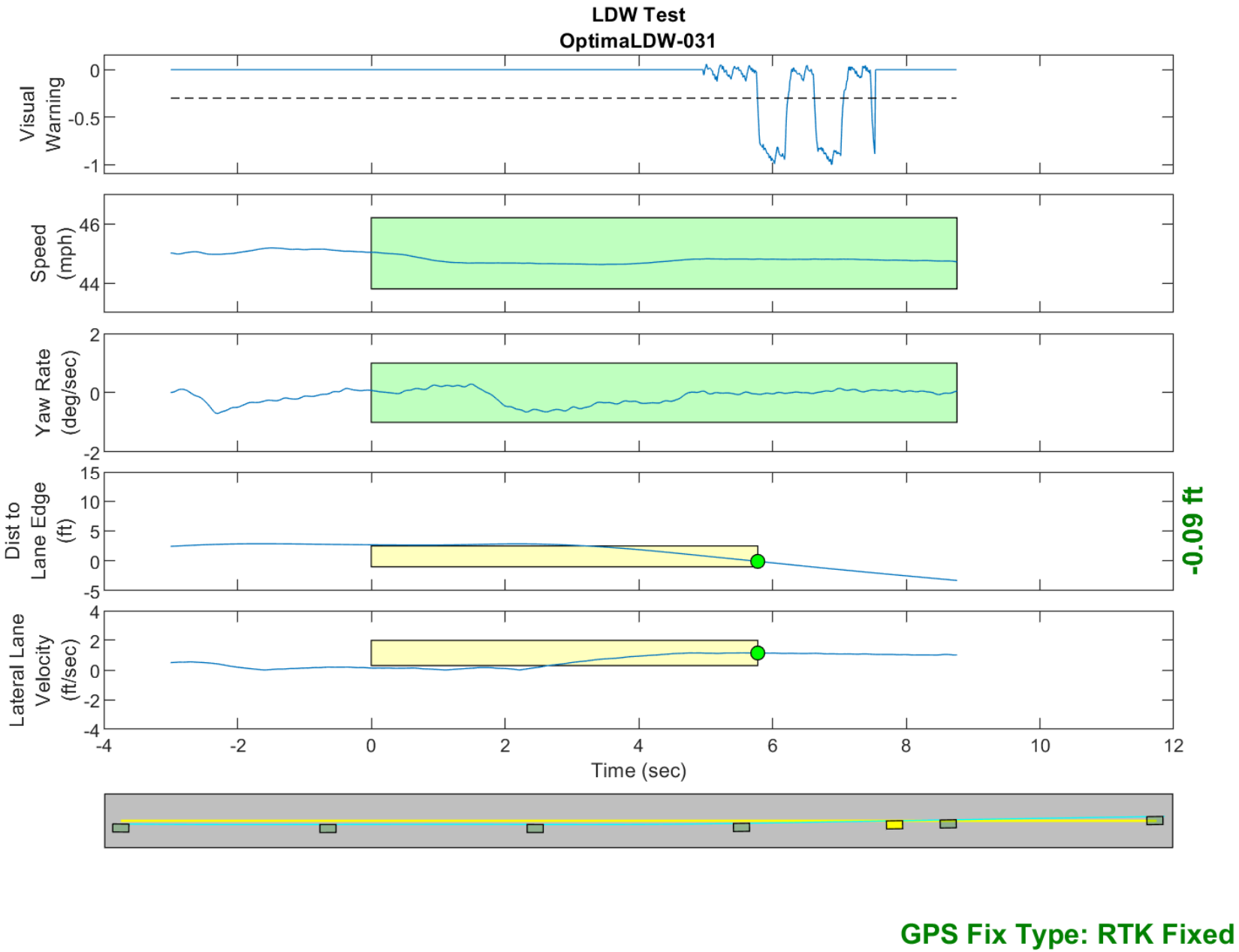

Figure D59. Time History for Run 31, Dashed Line, Left Departure, Visual Warning

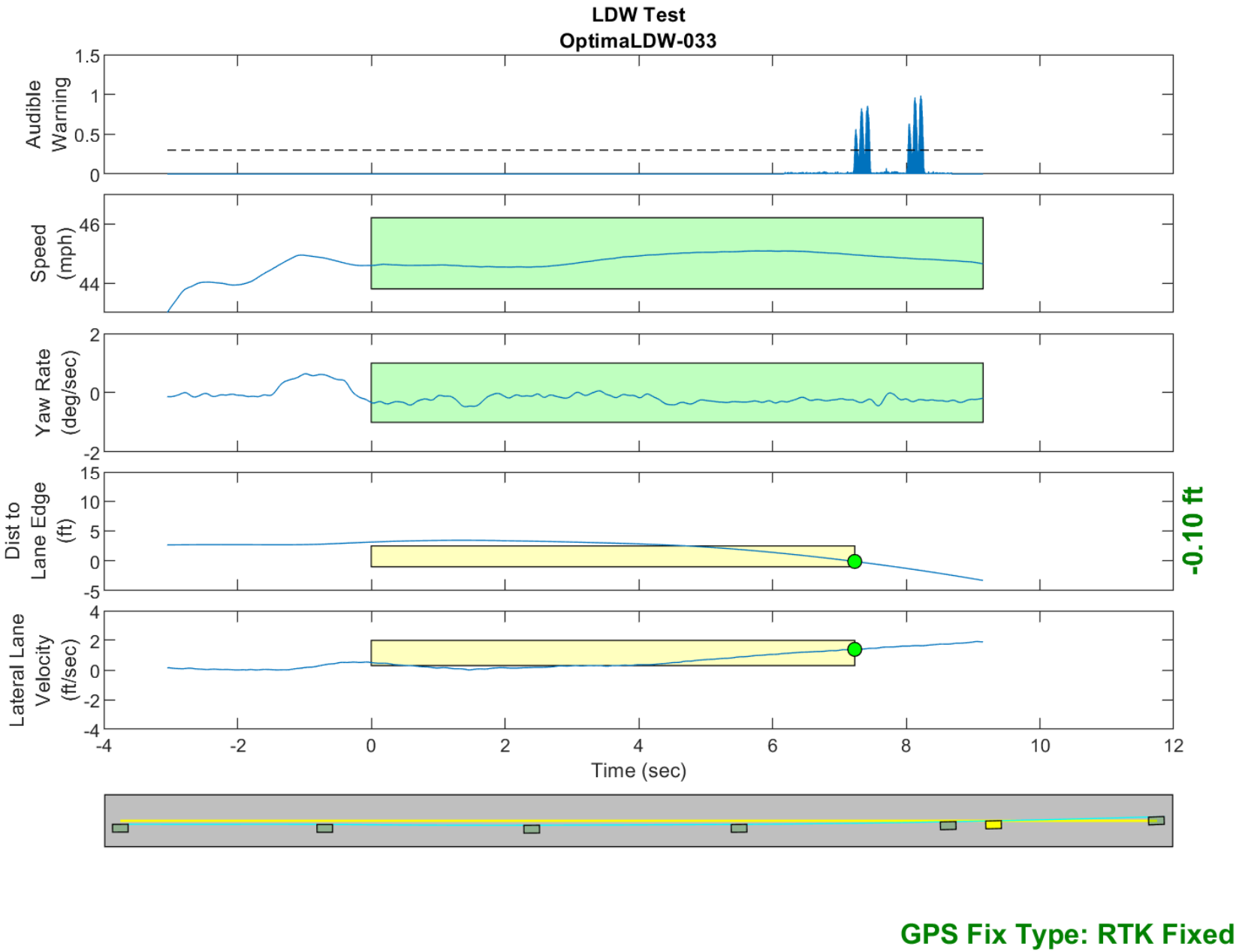

Figure D60. Time History for Run 33, Botts Dots, Left Departure, Audible Warning

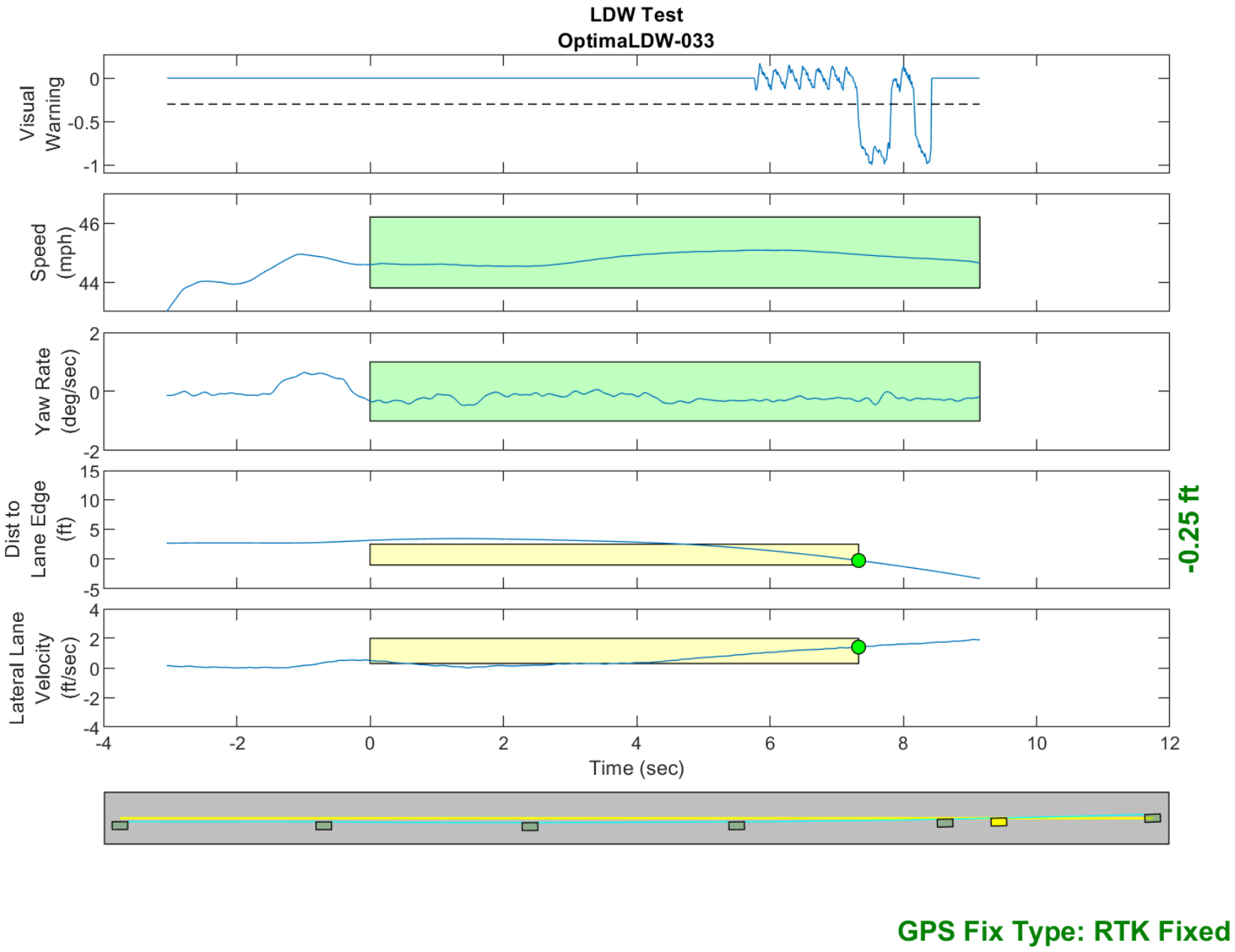

Figure D61. Time History for Run 33, Botts Dots, Left Departure, Visual Warning

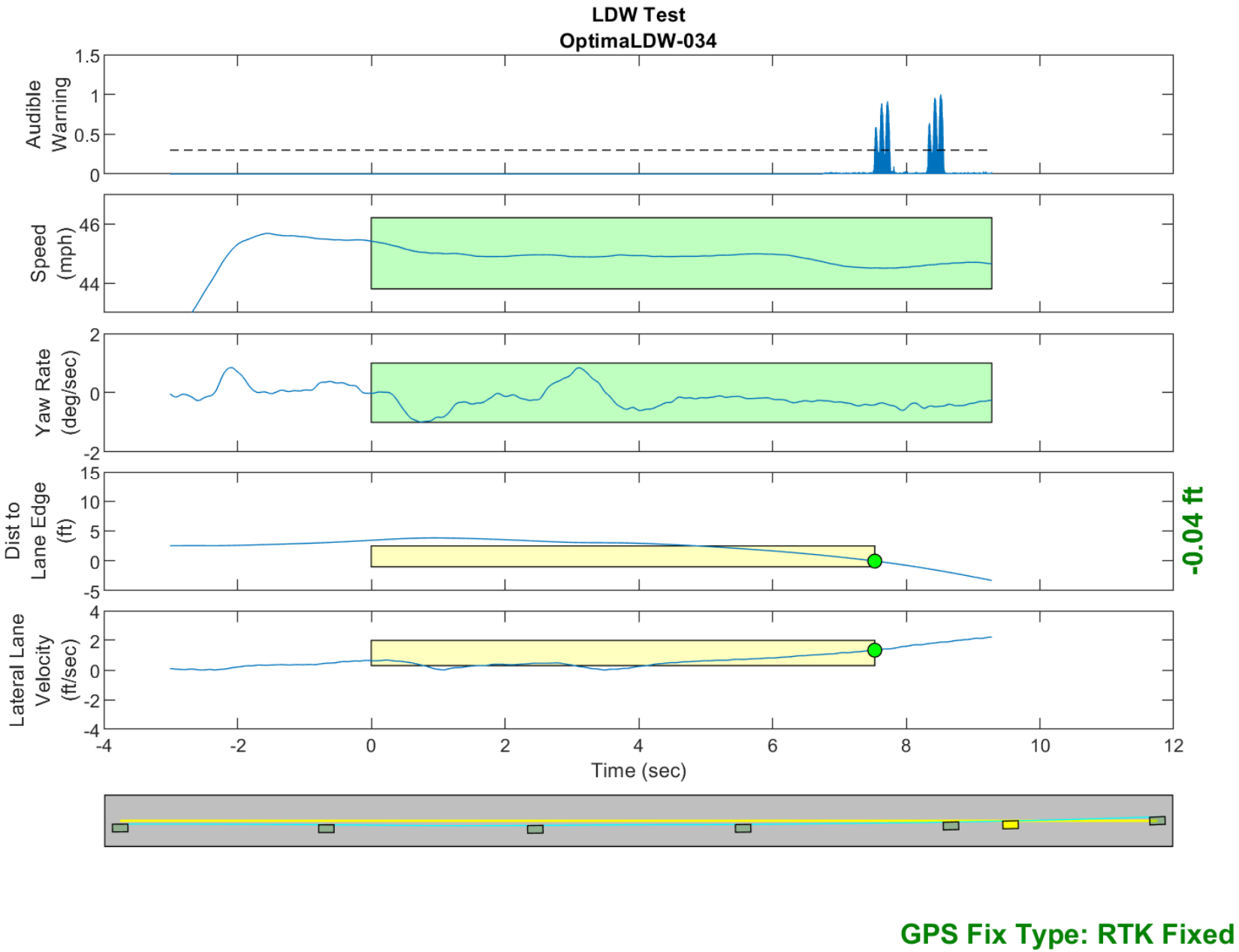

Figure D62. Time History for Run 34, Botts Dots, Left Departure, Audible Warning

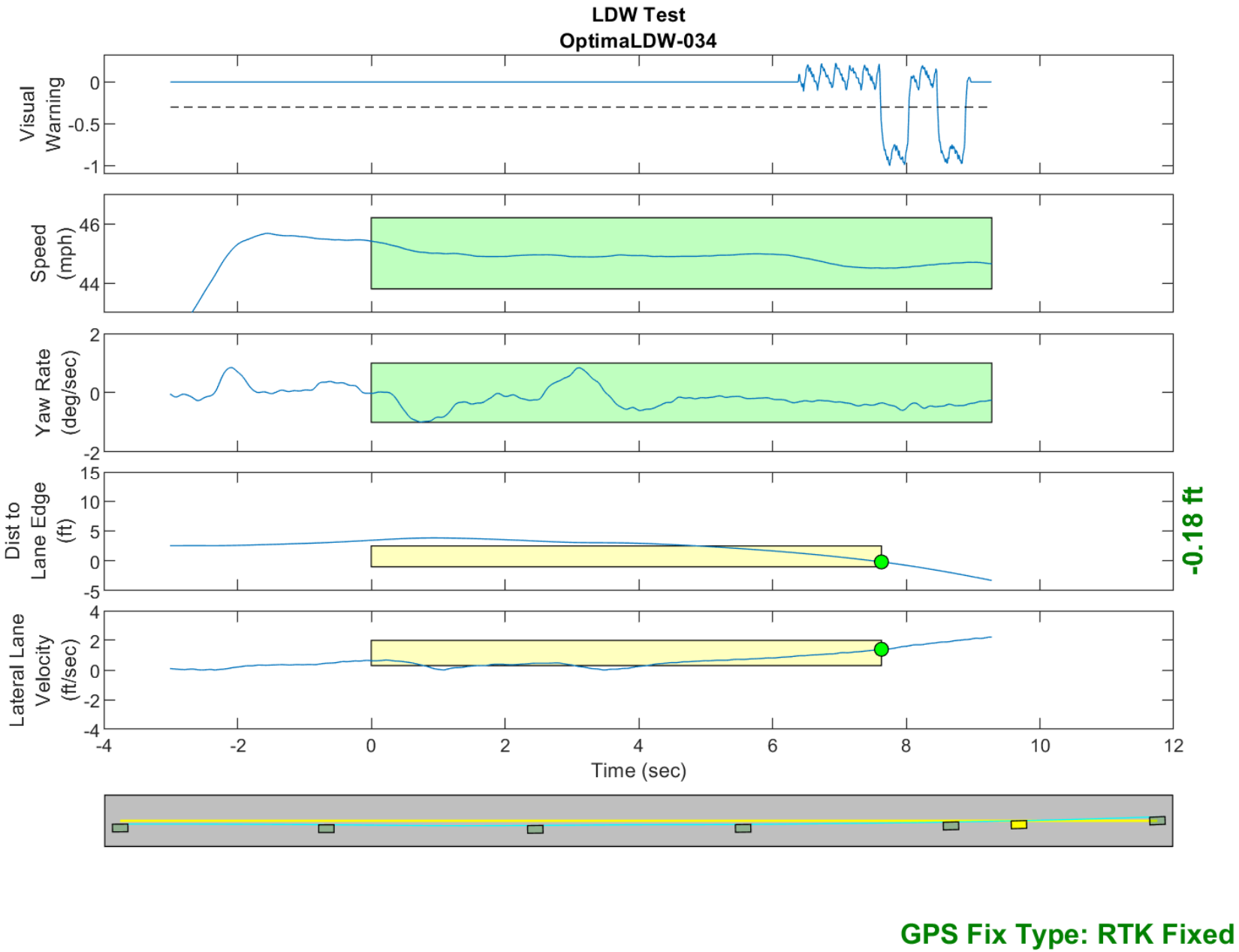

Figure D63. Time History for Run 34, Botts Dots, Left Departure, Visual Warning

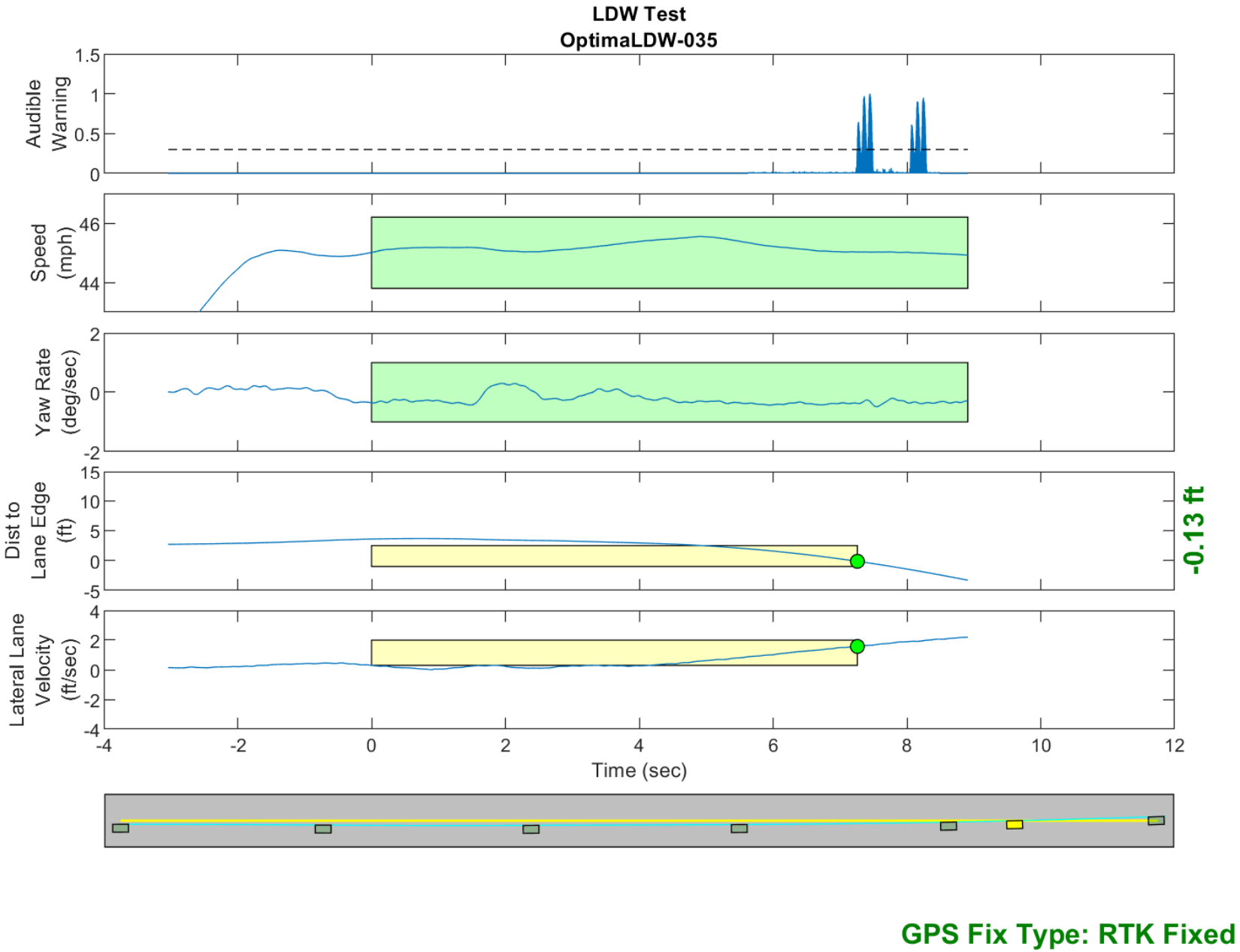

Figure D64. Time History for Run 35, Botts Dots, Left Departure, Audible Warning

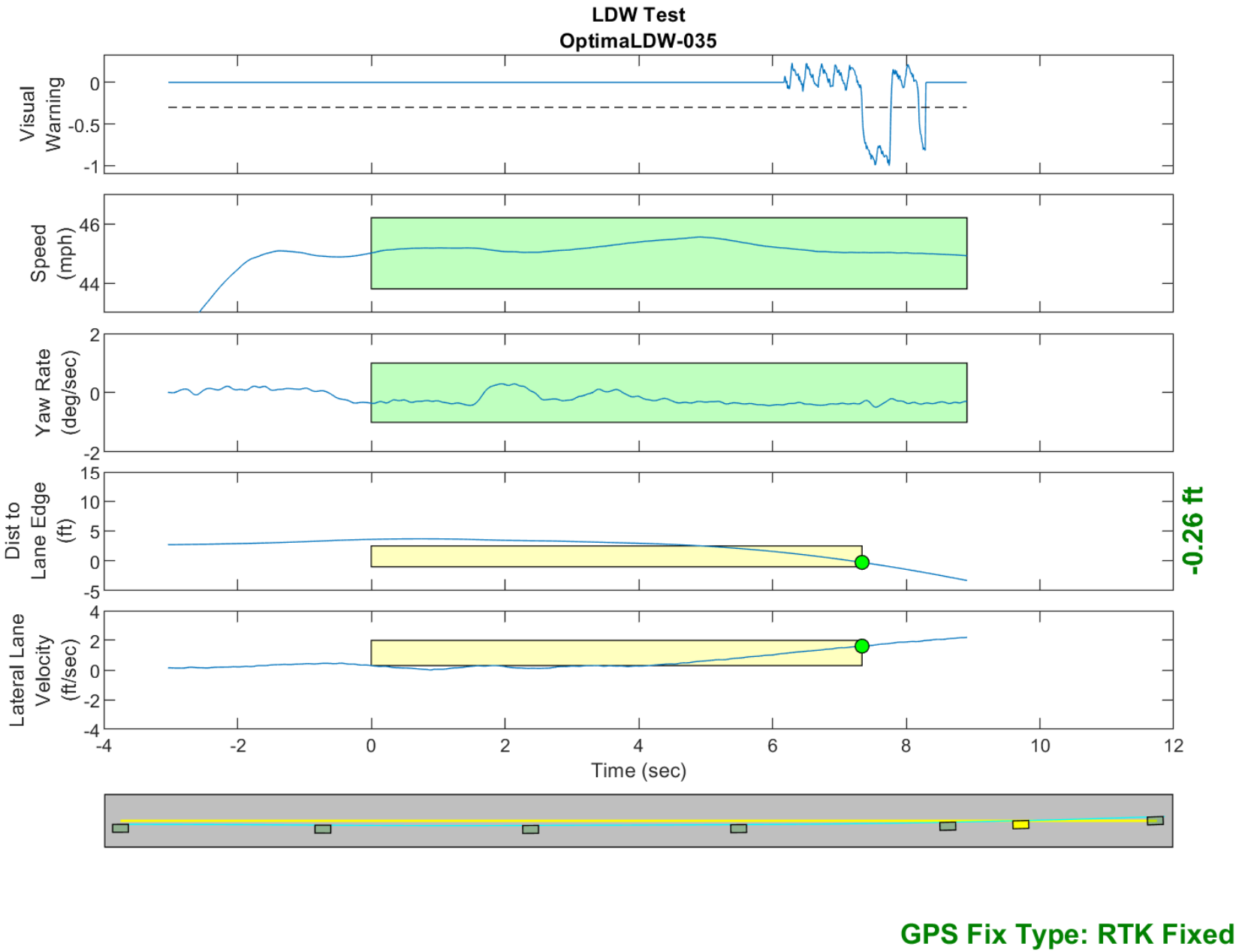

Figure D65. Time History for Run 35, Botts Dots, Left Departure, Visual Warning

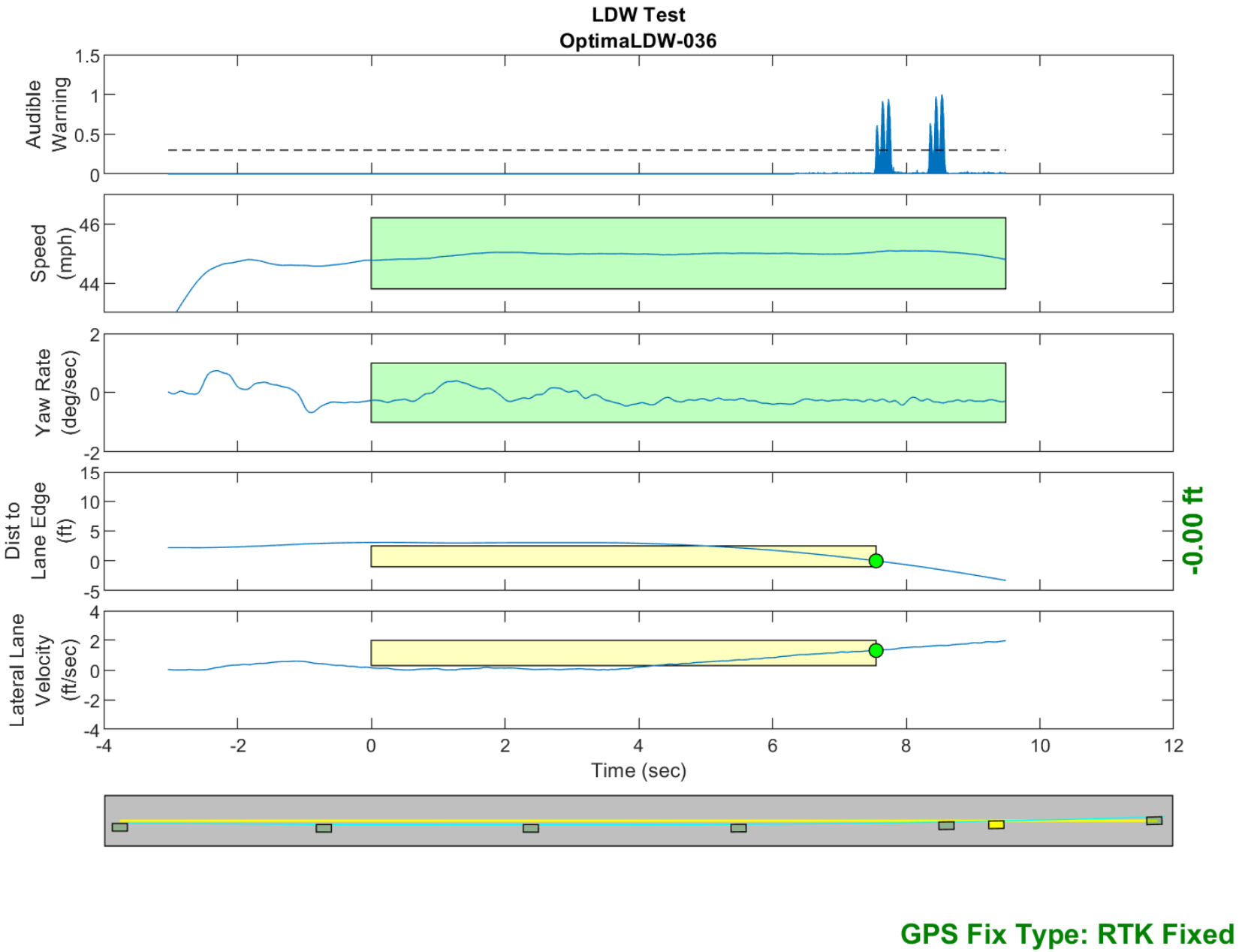

Figure D66. Time History for Run 36, Botts Dots, Left Departure, Audible Warning

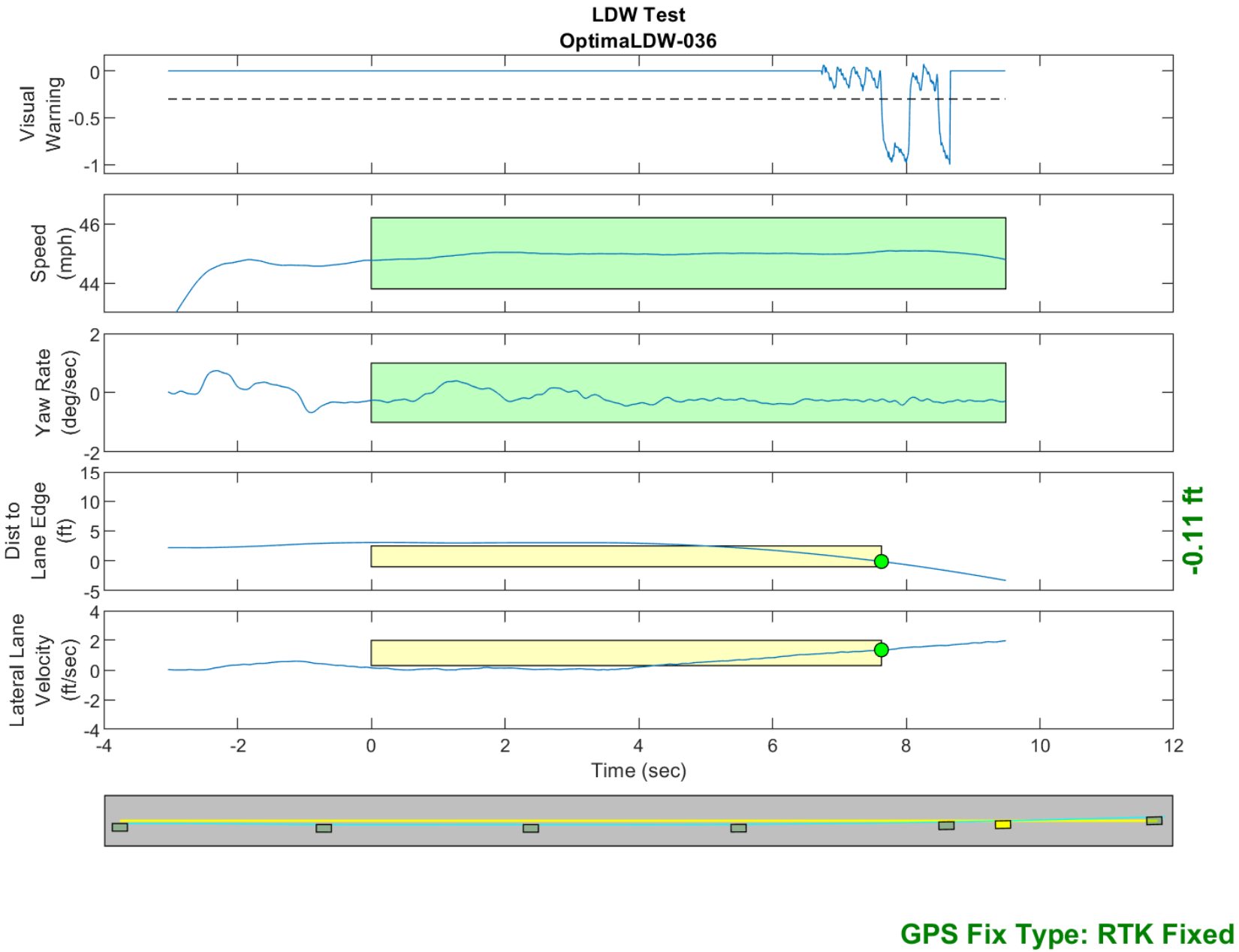

Figure D67. Time History for Run 36, Botts Dots, Left Departure, Visual Warning

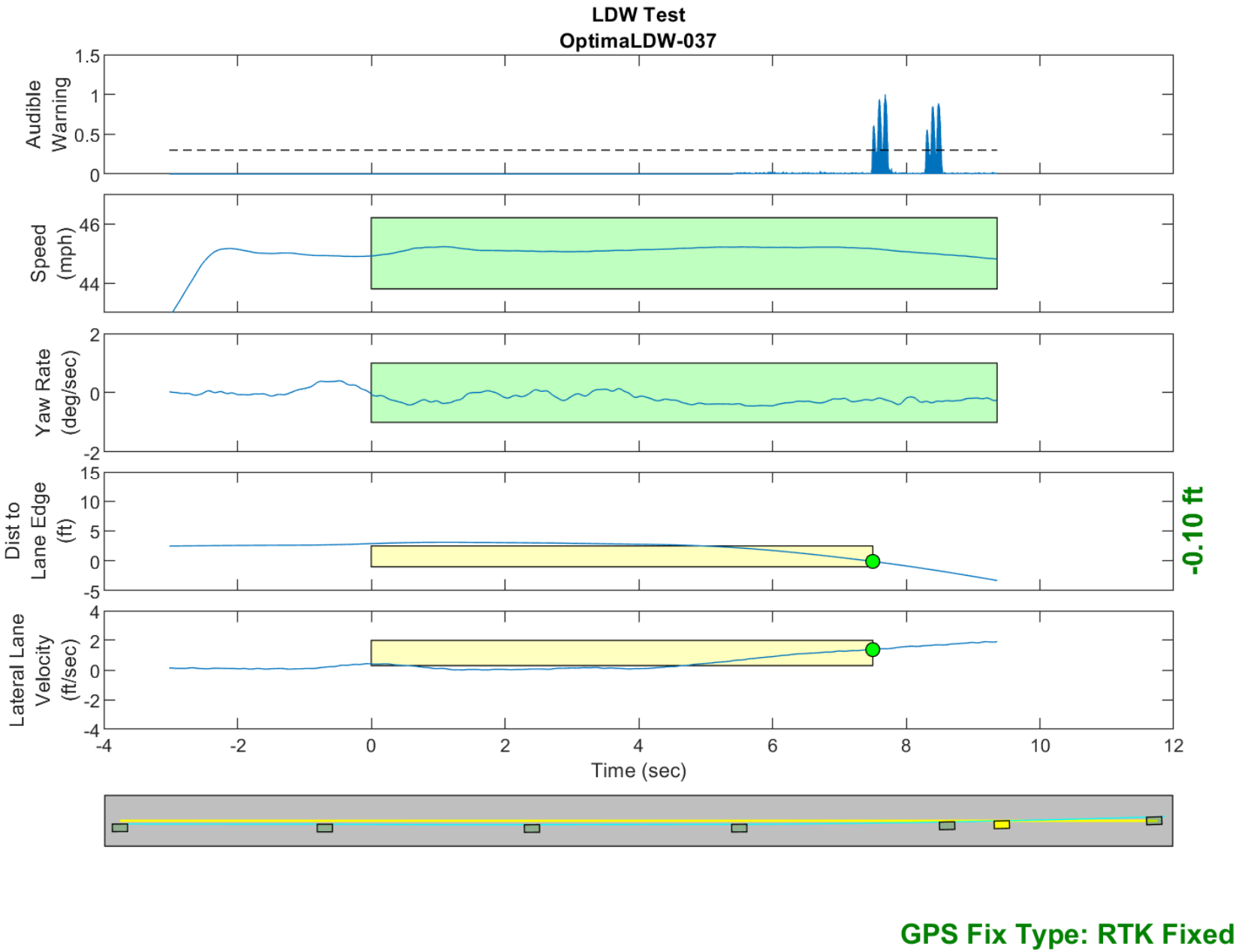

Figure D68. Time History for Run 37, Botts Dots, Left Departure, Audible Warning

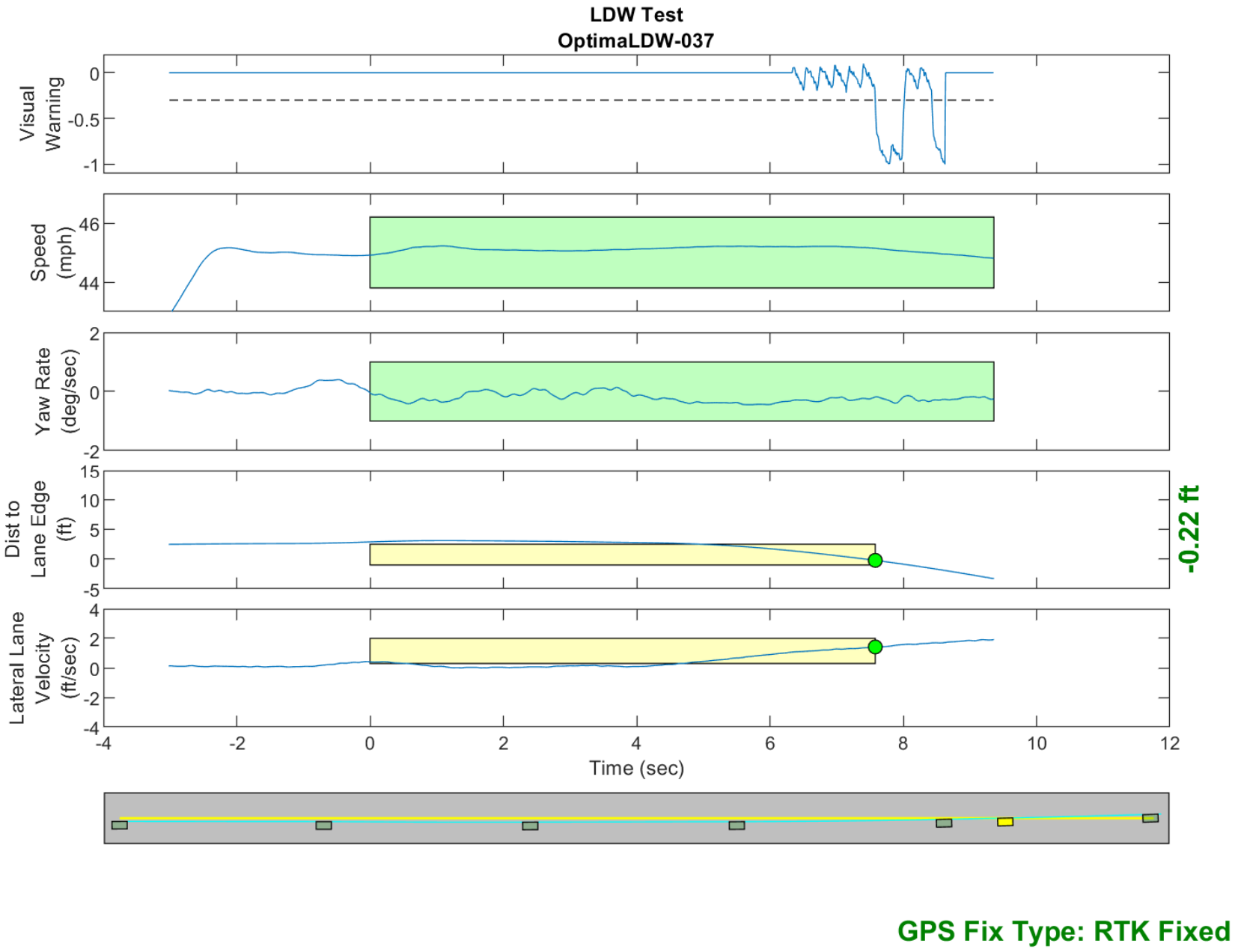

Figure D69. Time History for Run 37, Botts Dots, Left Departure, Visual Warning

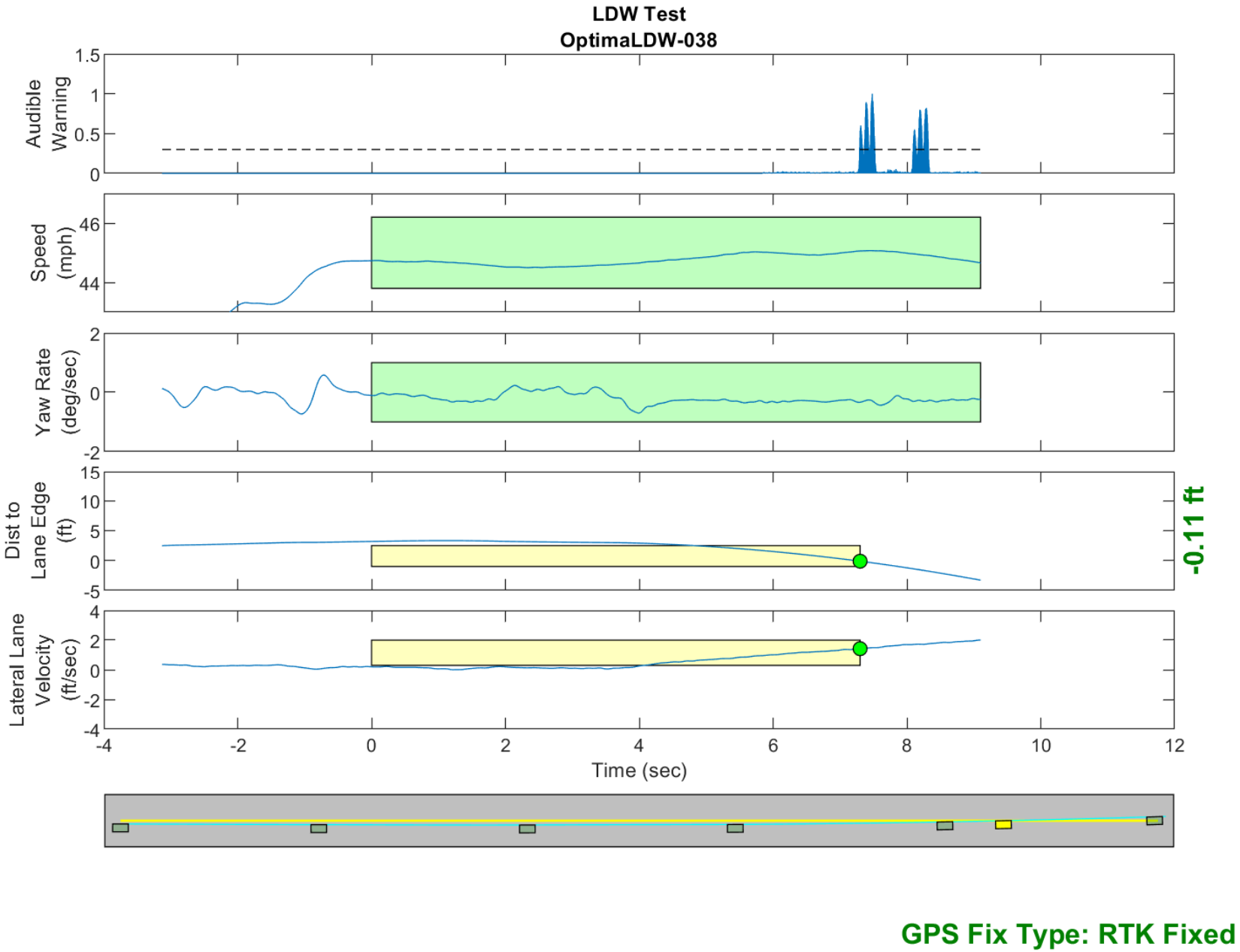

Figure D70. Time History for Run 38, Botts Dots, Left Departure, Audible Warning

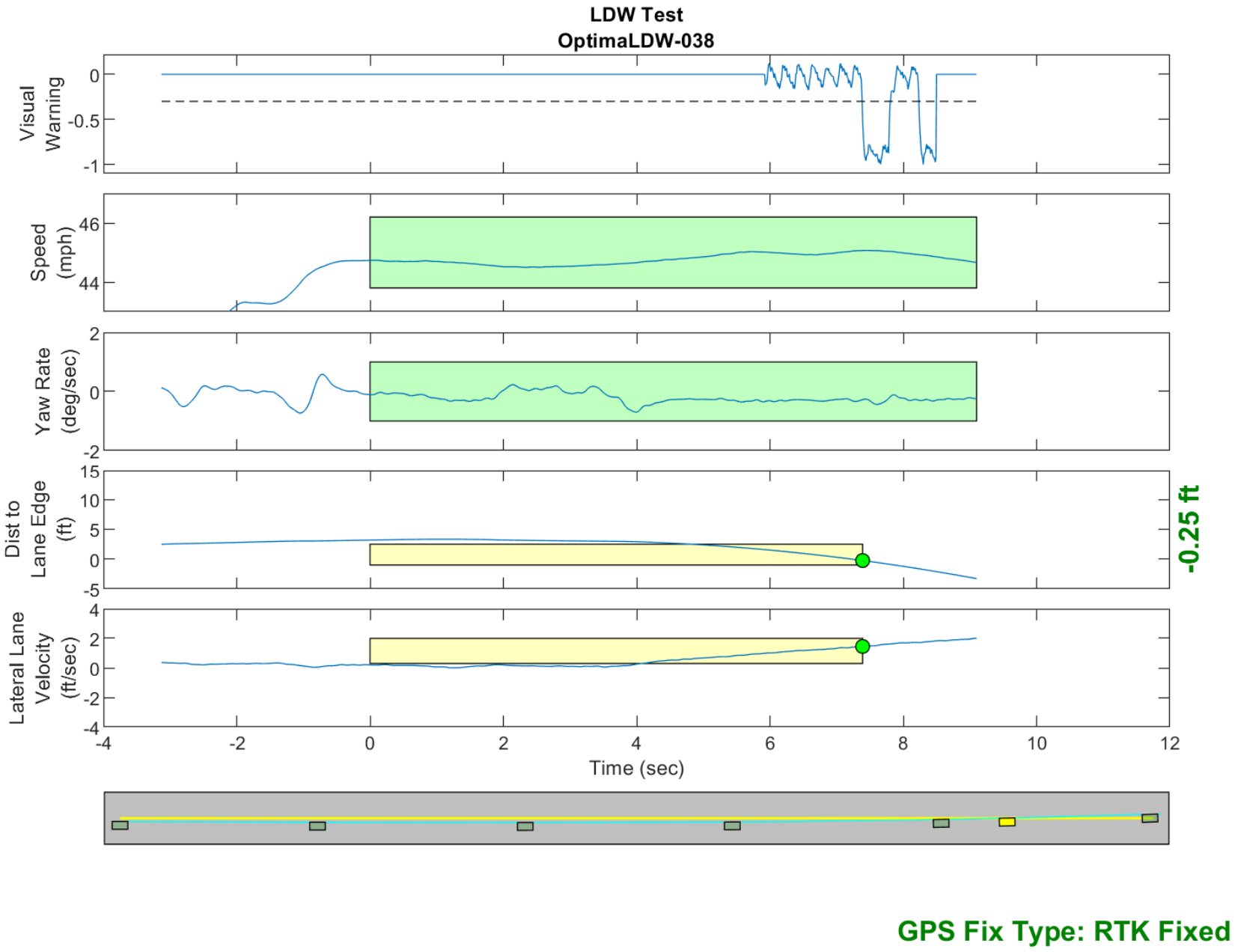

Figure D71. Time History for Run 38, Botts Dots, Left Departure, Visual Warning

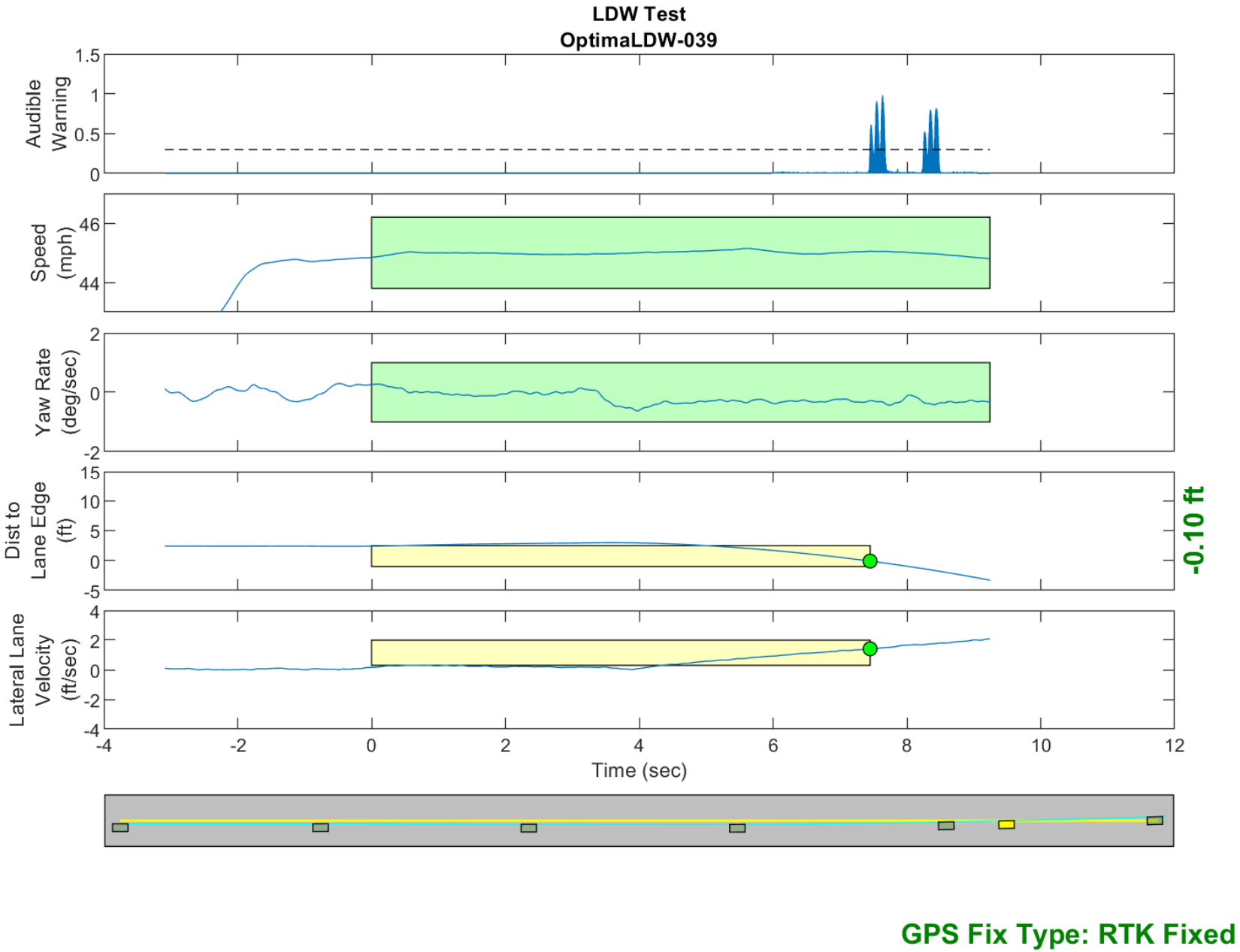

Figure D72. Time History for Run 39, Botts Dots, Left Departure, Audible Warning

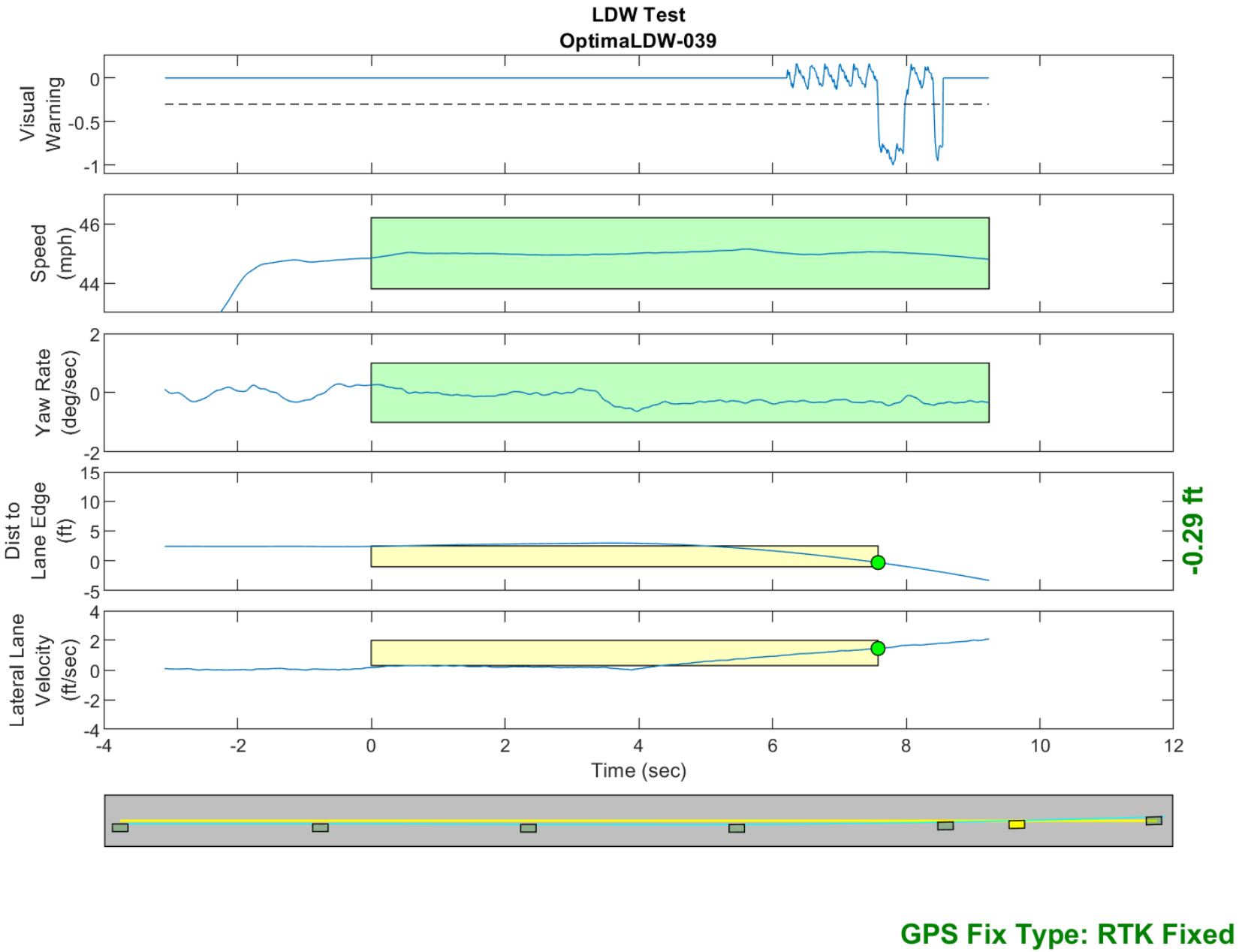

Figure D73. Time History for Run 39, Botts Dots, Left Departure, Visual Warning

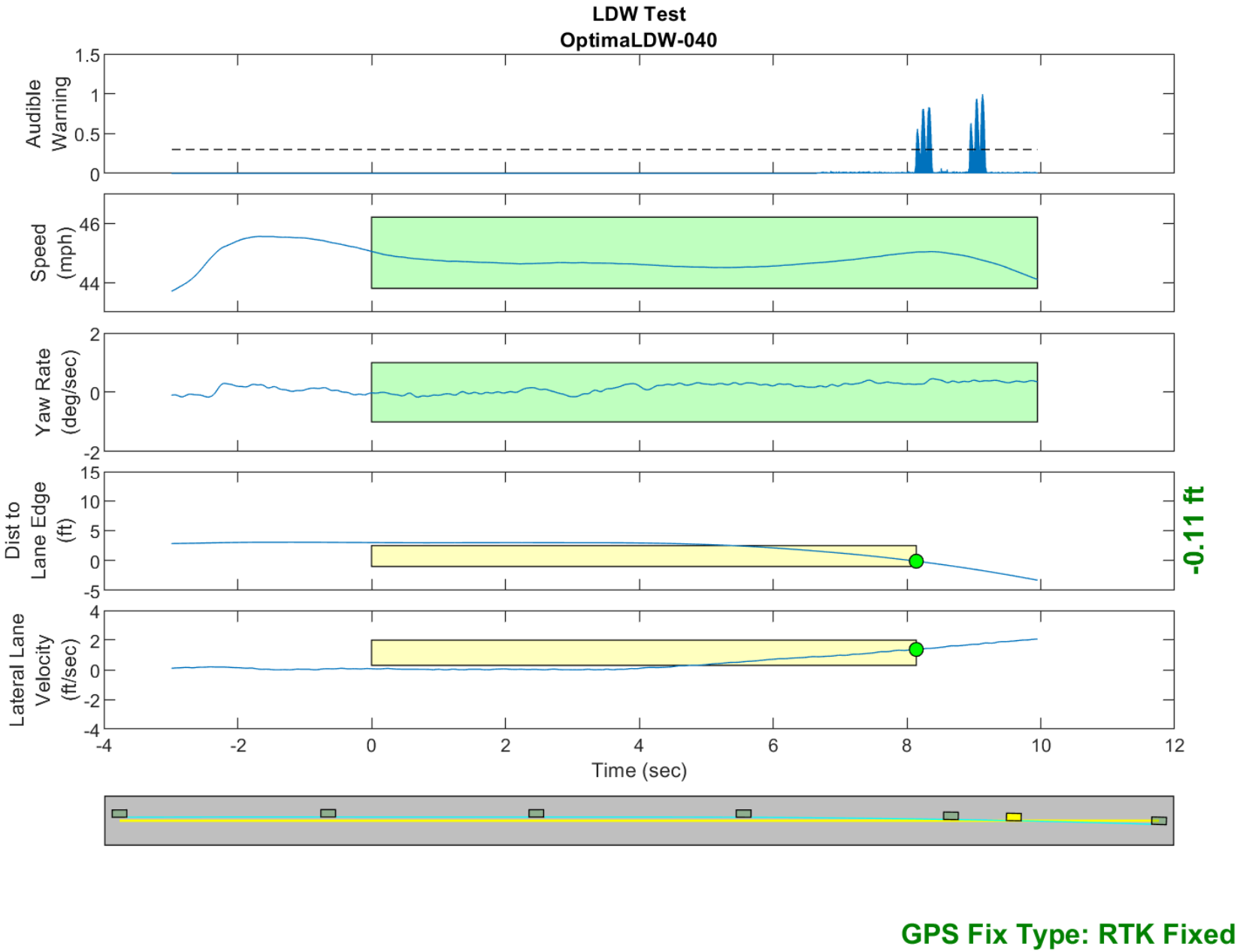

Figure D74. Time History for Run 40, Botts Dots, Right Departure, Audible Warning

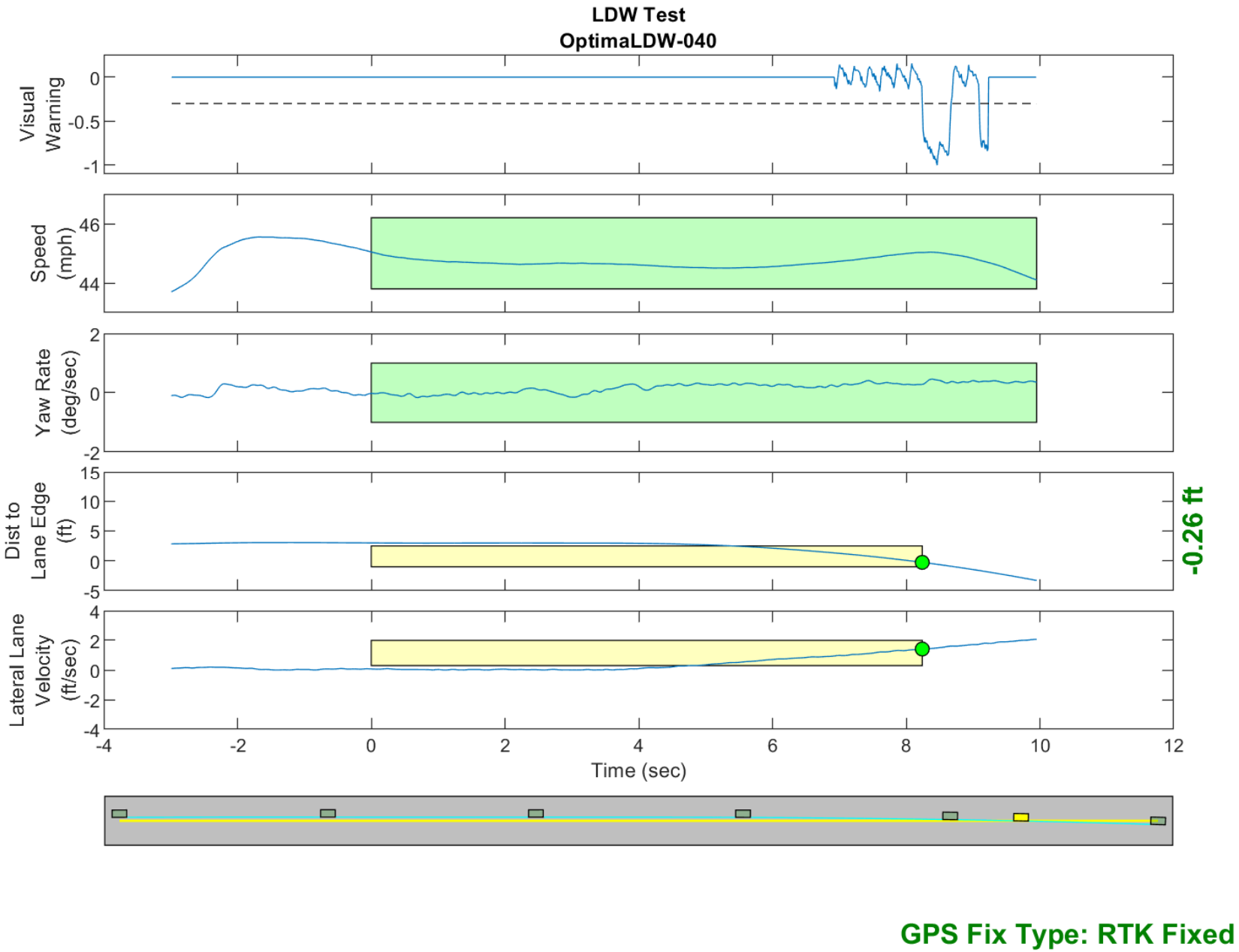

Figure D75. Time History for Run 40, Botts Dots, Right Departure, Visual Warning

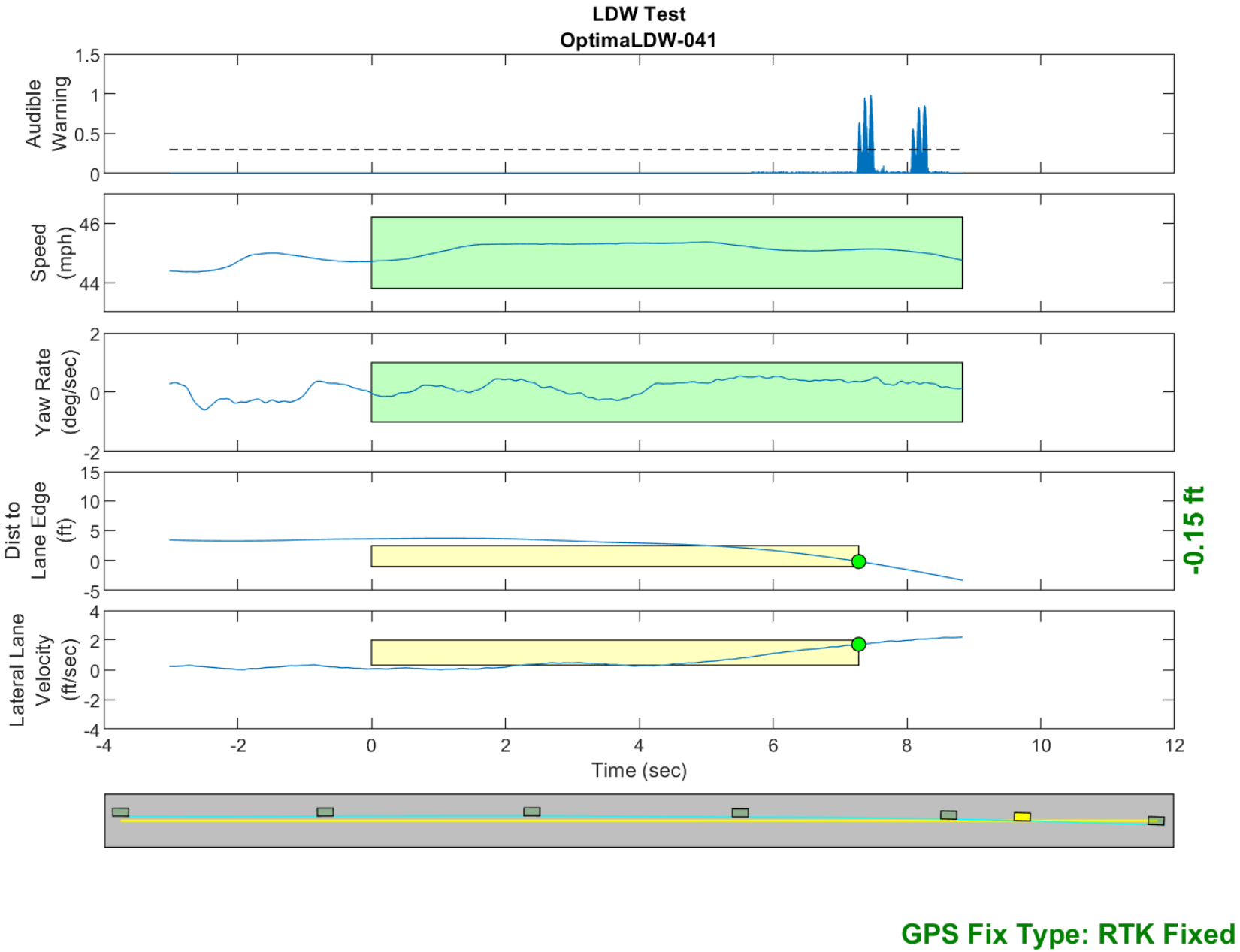

Figure D76. Time History for Run 41, Botts Dots, Right Departure, Audible Warning

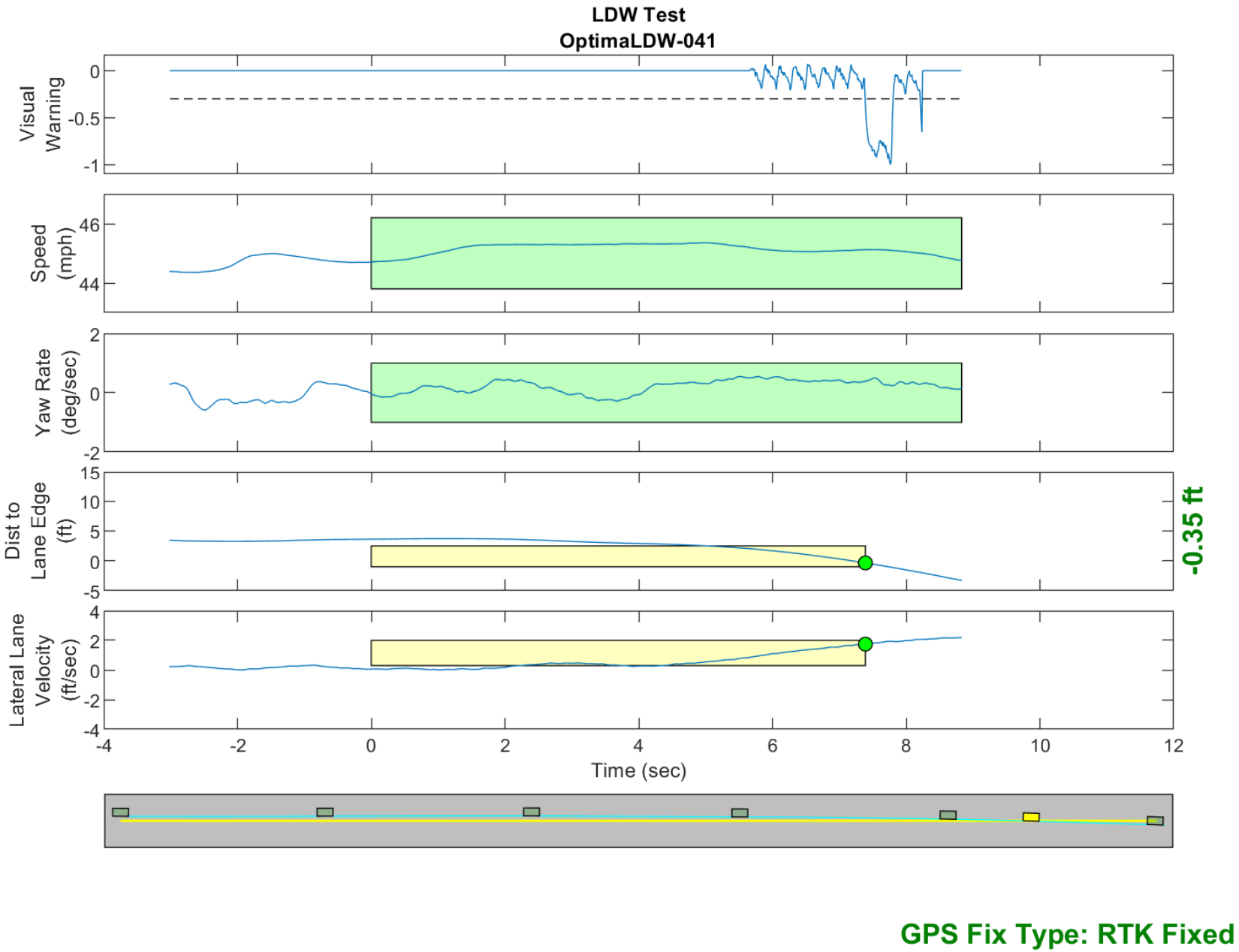

Figure D77. Time History for Run 41, Botts Dots, Right Departure, Visual Warning

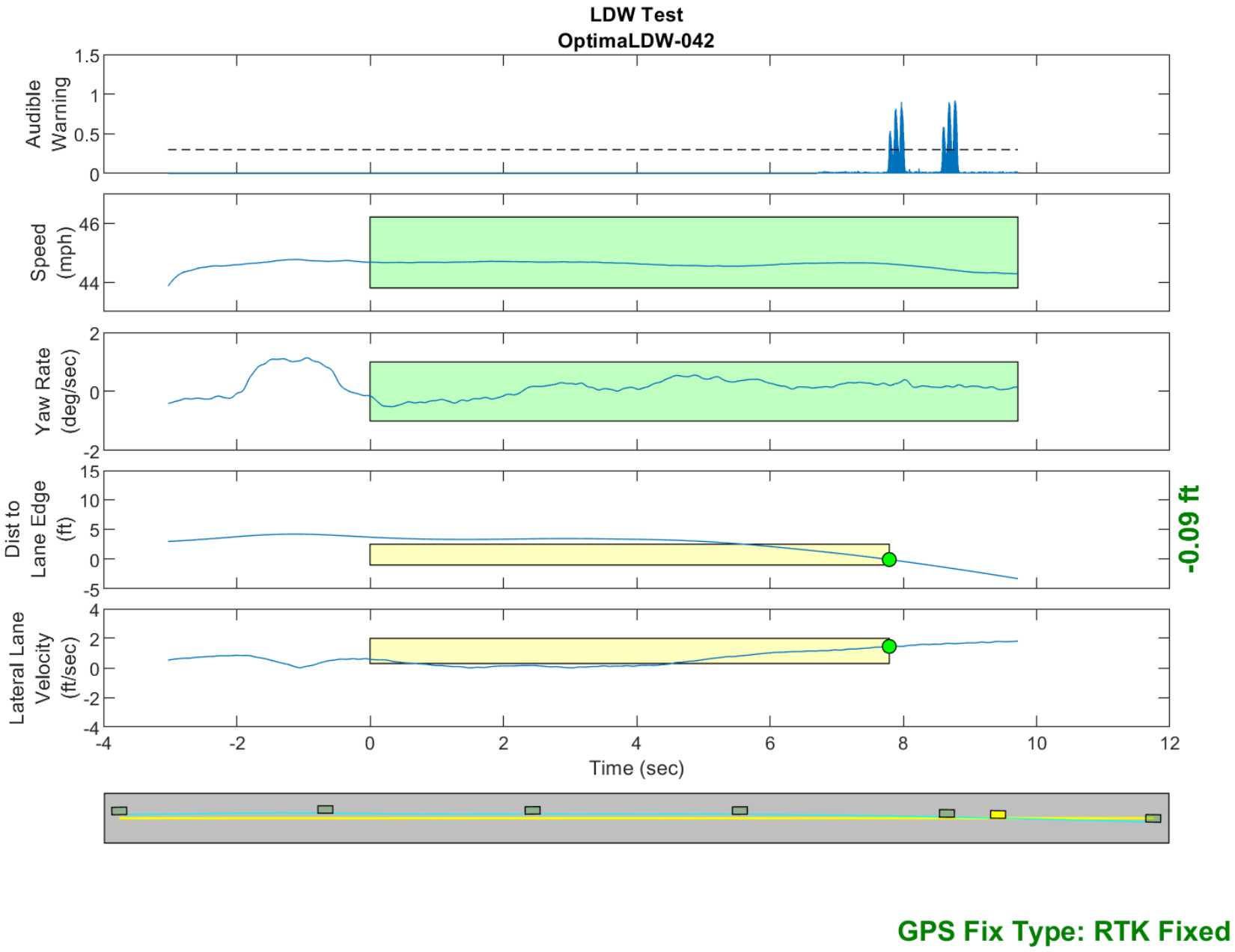

Figure D78. Time History for Run 42, Botts Dots, Right Departure, Audible Warning

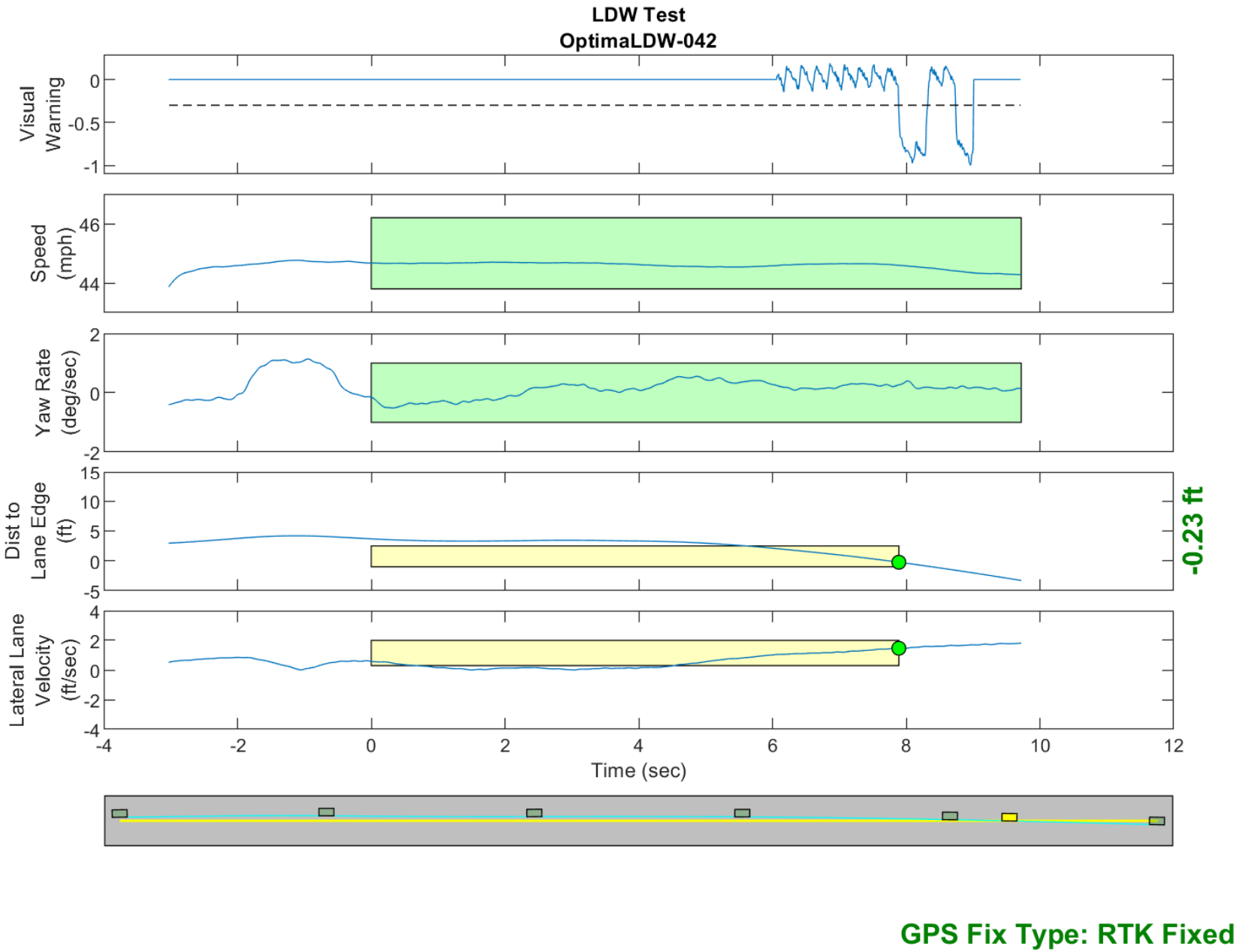

Figure D79. Time History for Run 42, Botts Dots, Right Departure, Visual Warning

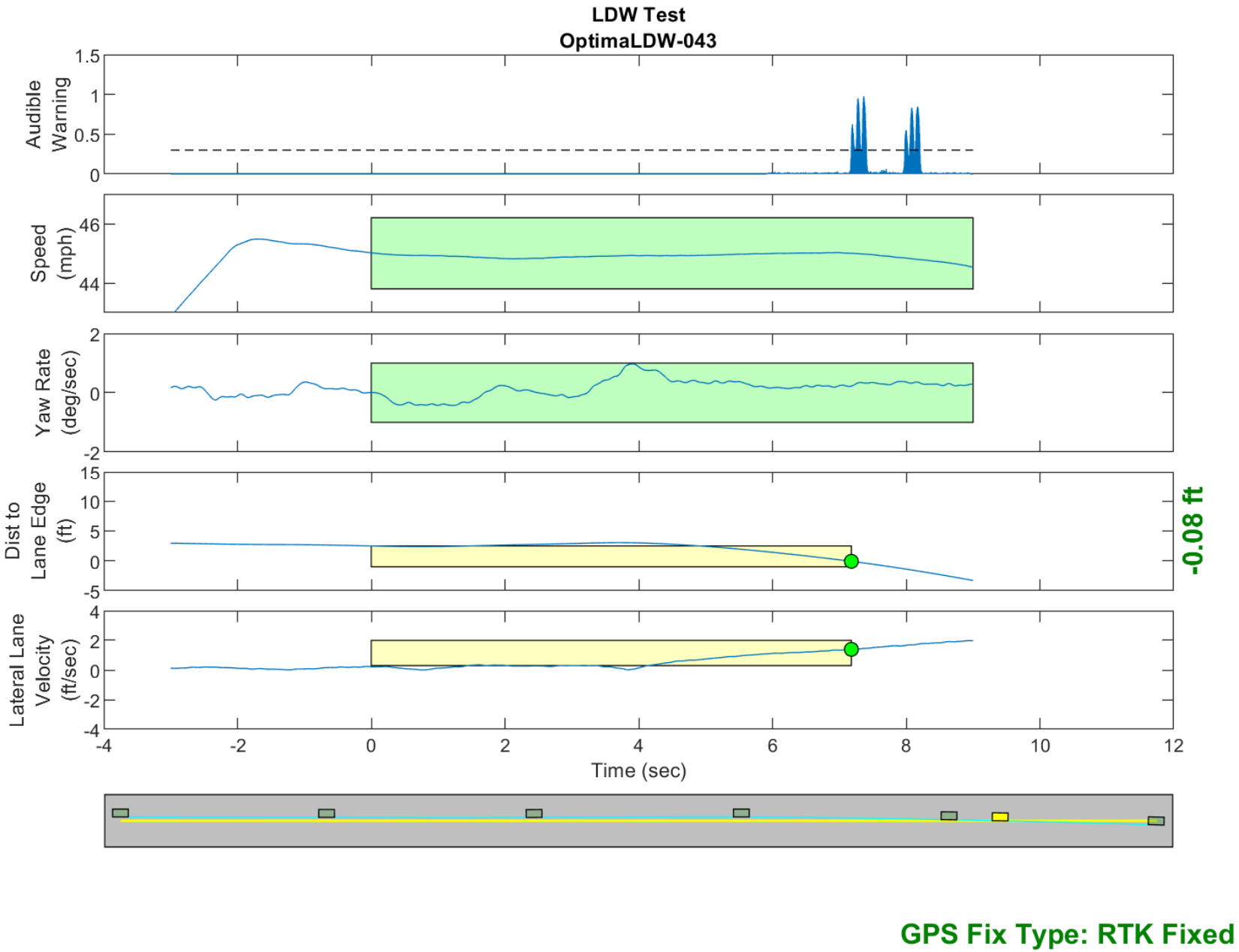

Figure D80. Time History for Run 43, Botts Dots, Right Departure, Audible Warning

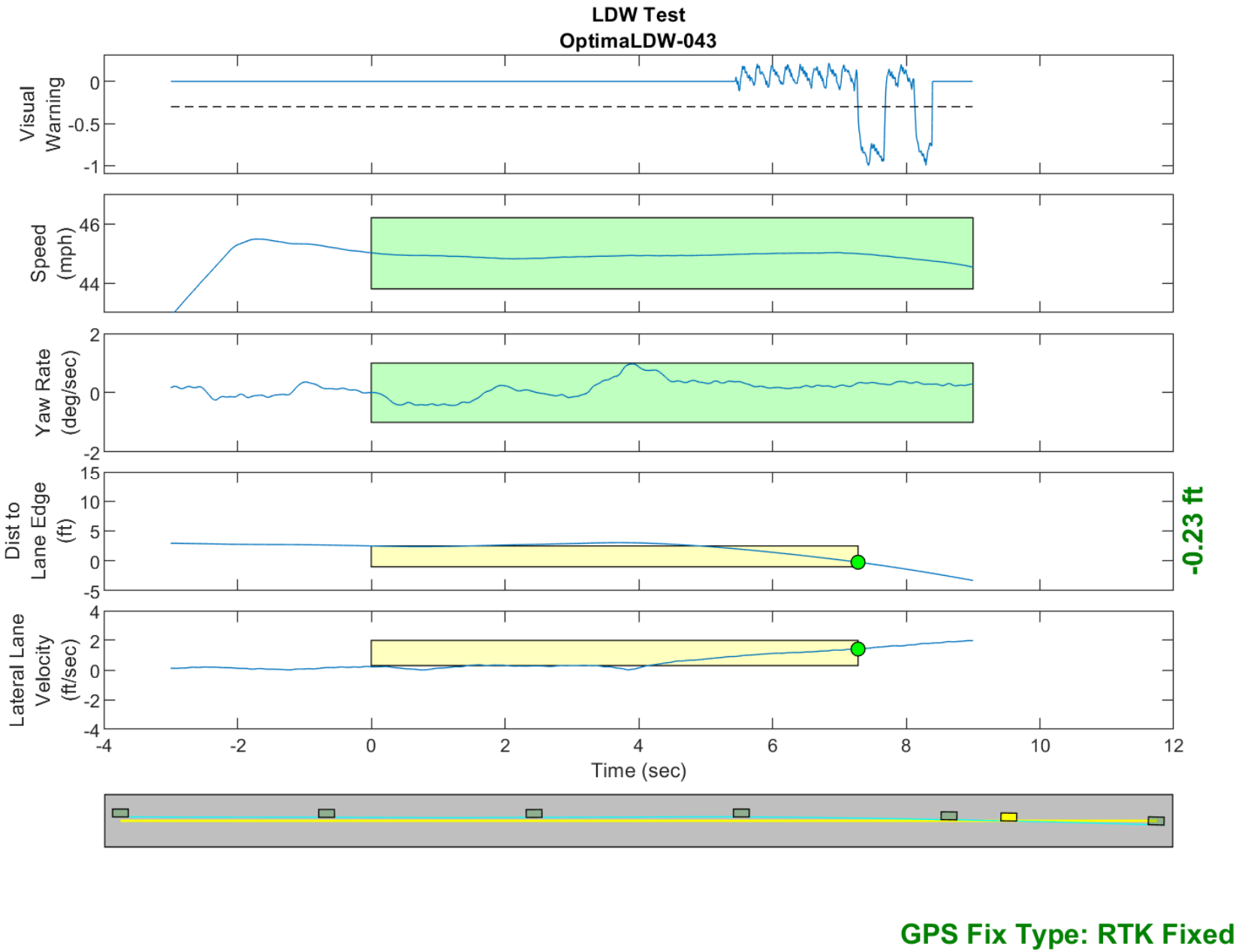

Figure D81. Time History for Run 43, Botts Dots, Right Departure, Visual Warning

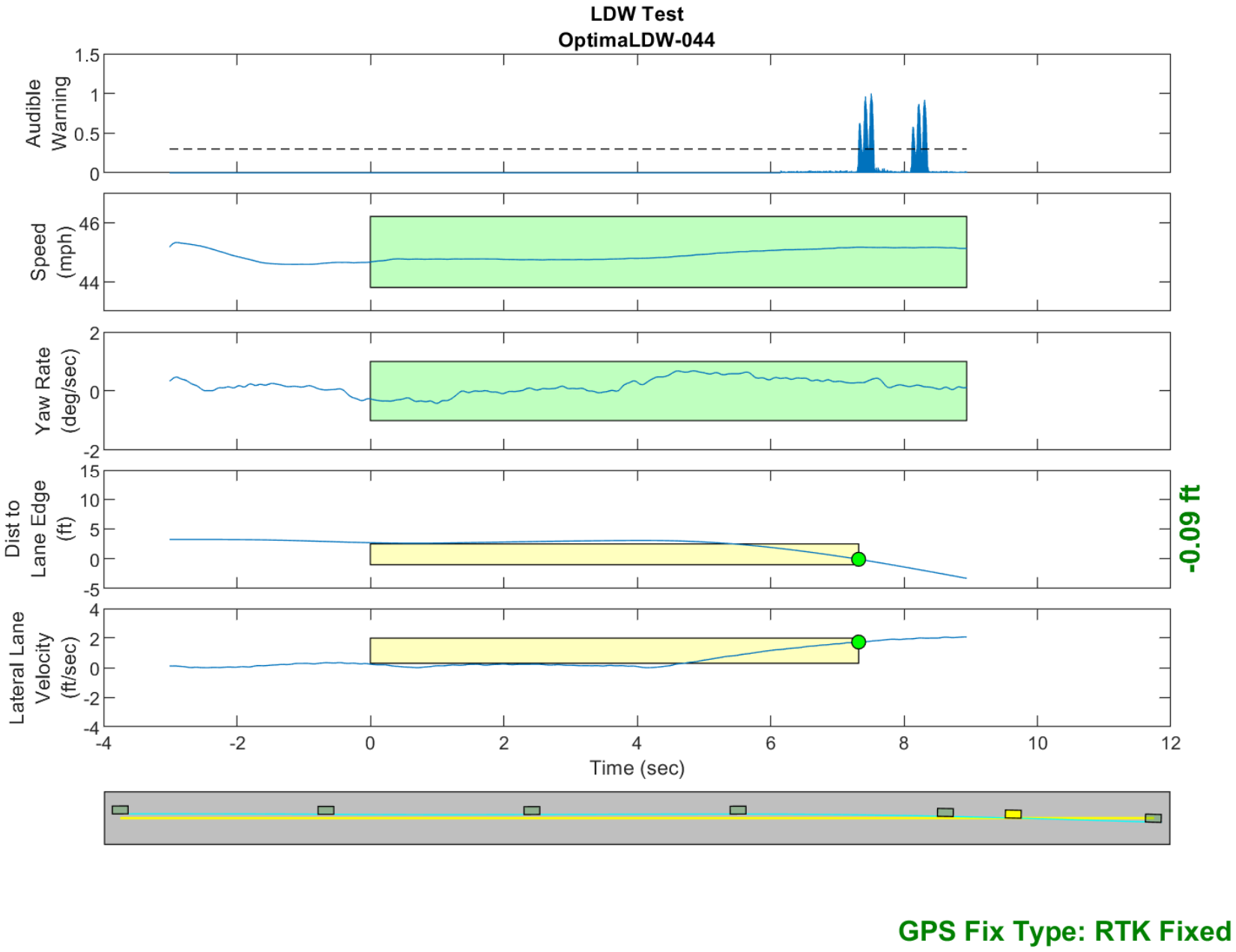

Figure D82. Time History for Run 44, Botts Dots, Right Departure, Audible Warning

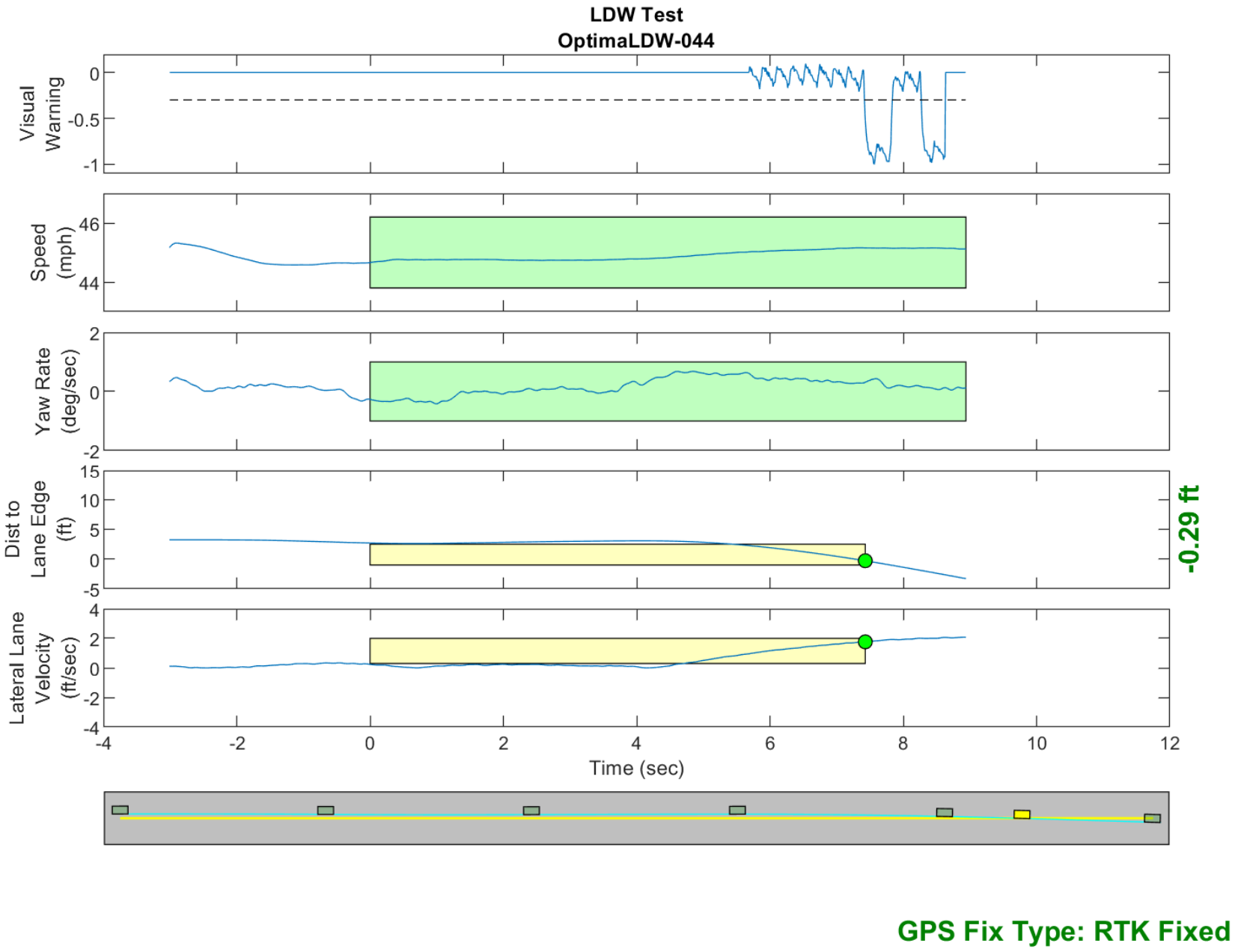

Figure D83. Time History for Run 44, Botts Dots, Right Departure, Visual Warning

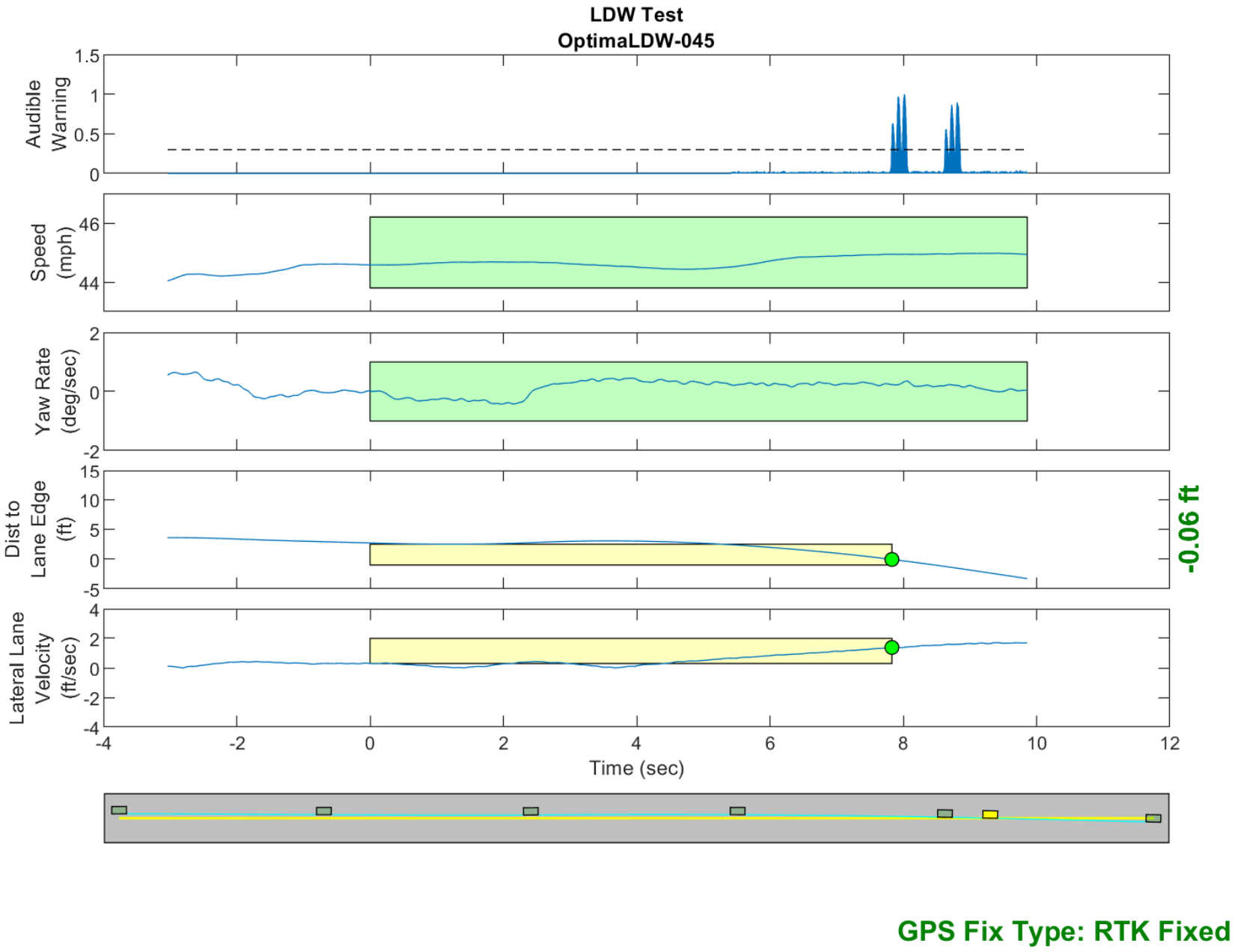

Figure D84. Time History for Run 45, Botts Dots, Right Departure, Audible Warning

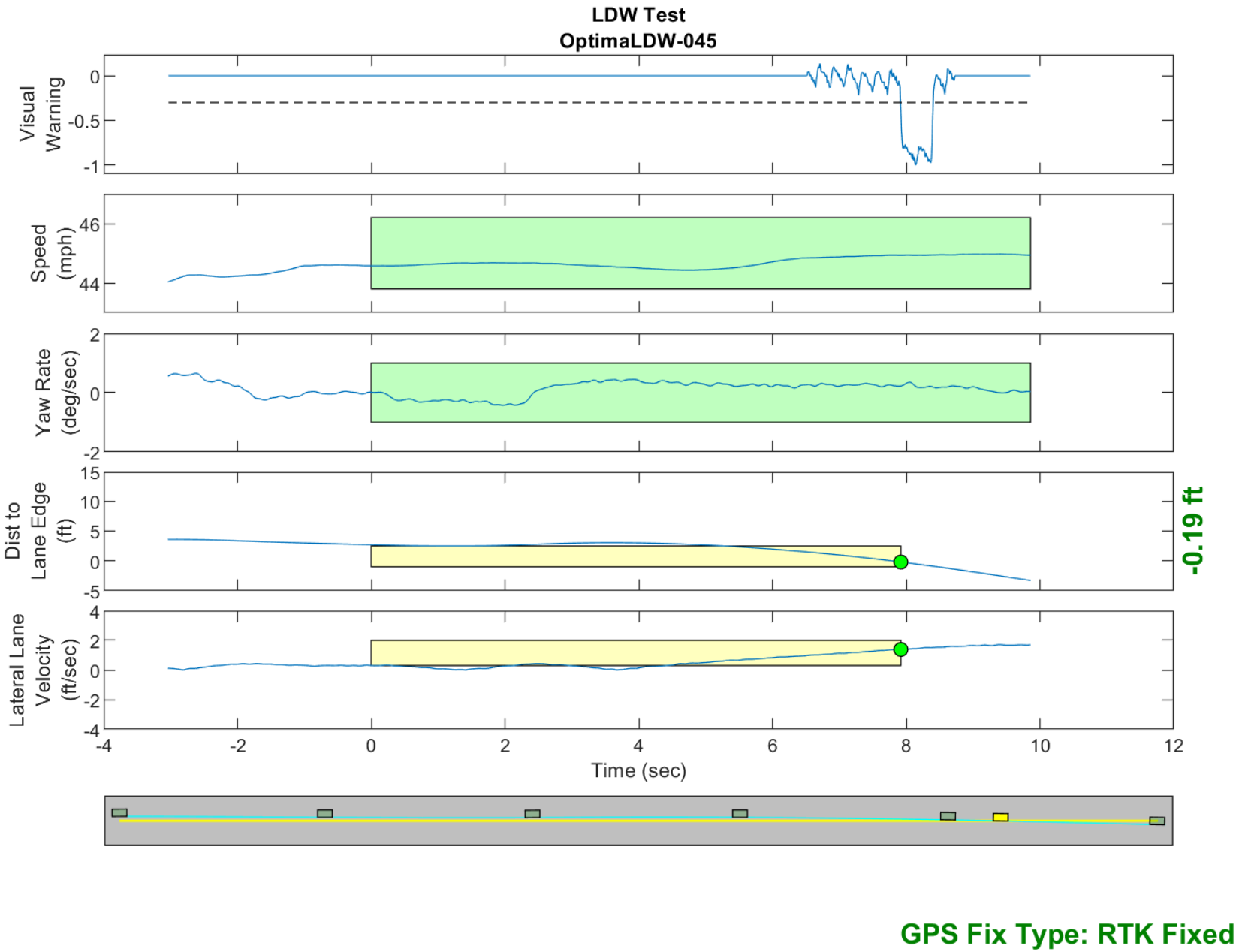

Figure D85. Time History for Run 45, Botts Dots, Right Departure, Visual Warning

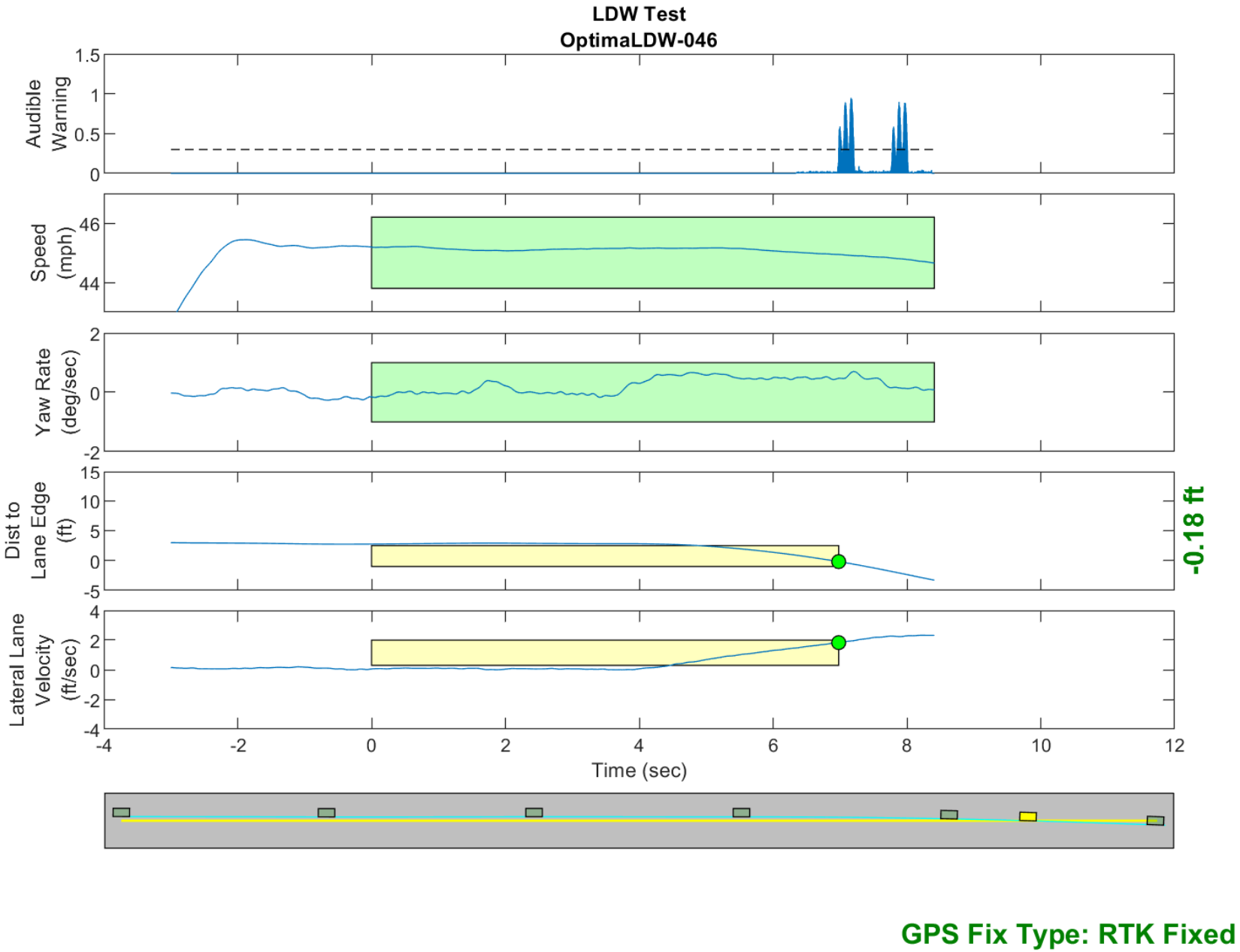

Figure D86. Time History for Run 46, Botts Dots, Right Departure, Audible Warning

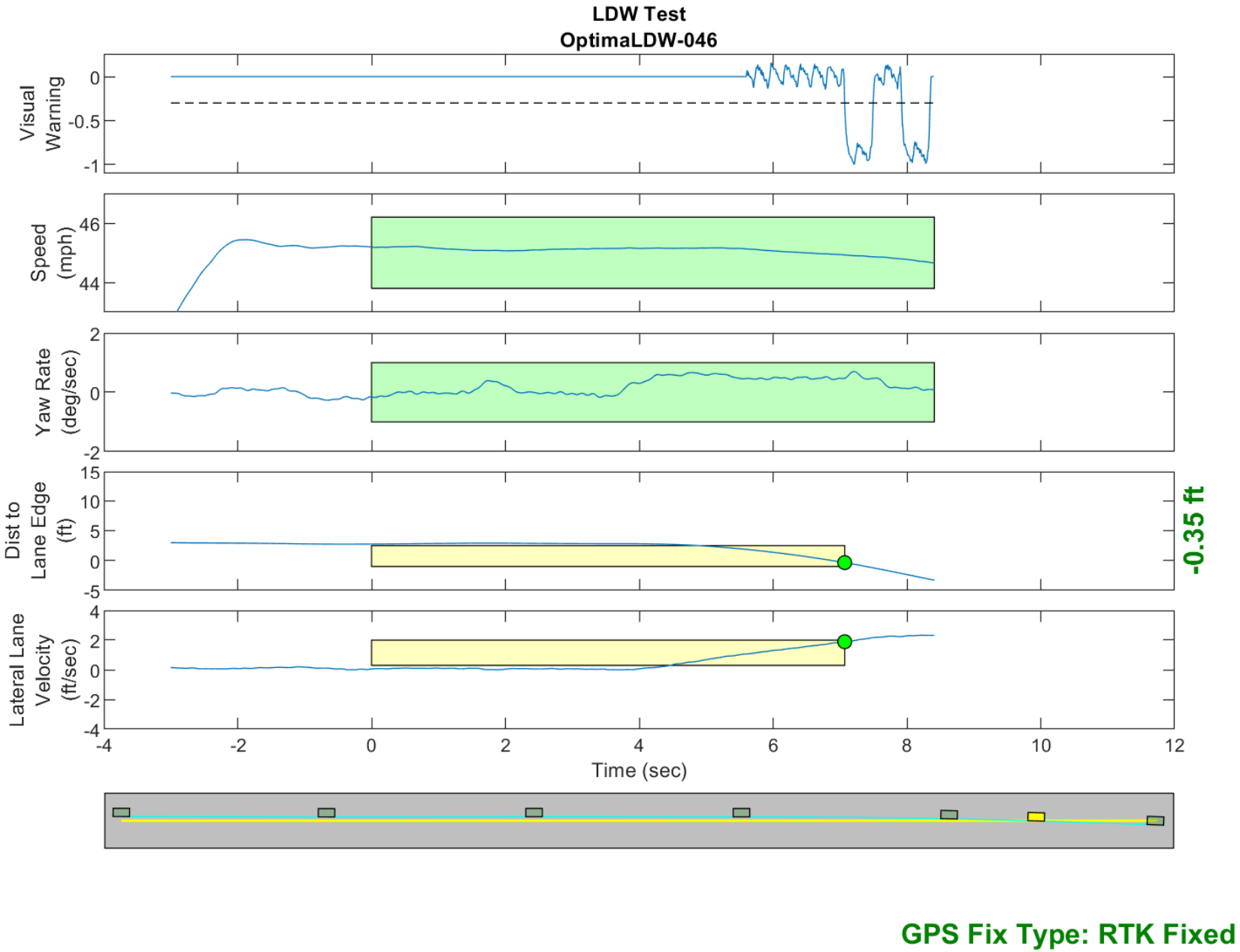

Figure D87. Time History for Run 46, Botts Dots, Right Departure, Visual Warning