NEW CAR ASSESSMENT PROGRAM
LANE DEPARTURE WARNING CONFIRMATION TEST
NCAP-DRI-LDW-22-06

2022 Kia Forte

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28 March 2022

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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16. Abstract These tests were conducted on the subject 2022 Kia Forte in accordance with the specifications of the New Car Assessment Program's (NCAP's) 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 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.

The purpose of the testing reported herein was to objectively quantify the performance of a Lane Departure Warning system installed on a 2022 Kia Forte. This test is part of the New Car Assessment Program to assess Lane Departure Warning Systems sponsored by the National Highway Traffic Safety Administration under Contract No. DTNH22-14-D-00333.

Section II

DATA SHEETS

LANE DEPARTURE WARNING

DATA SHEET 1: TEST RESULTS SUMMARY

(Page 1 of 1)

2022 Kia Forte

VIN: *3KPF54AD4NE45xxxx*

Test start date: *3/14/2022*

Test end date: *3/15/2022*

Lane Departure Warning setting: *N/A*

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)

2022 Kia Forte

TEST VEHICLE INFORMATION

VIN: *3KPF54AD4NE45xxxx*

Body Style: *Sedan* Color: *Sporty Blue*

Date Received: *2/28/2022* Odometer Reading: *60 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *KIA MEXICO S.A. DE C.V.*

Date of manufacture: *01/22*

Vehicle Type: *Passenger Car*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *225/45R17*

Rear: *225/45R17*

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

Rear: *230 kPa (33 psi)*

TIRES

Tire manufacturer and model: *Kumho Majesty Solus*

Front tire size: *225/45R17 91W*

Rear tire size: *225/45R17 91W*

Front tire DOT prefix: *000 U1YAVP*

Rear tire DOT prefix: *000 U1YAVP*

LANE DEPARTURE WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2022 Kia Forte

GENERAL INFORMATION

Test start date: *3/14/2022*

Test end date: *3/15/2022*

AMBIENT CONDITIONS

Air temperature: *21.7 C (71 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: *230 kPa (33 psi)*

Rear: *230 kPa (33 psi)*

LANE DEPARTURE WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2022 Kia Forte

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*445.9 kg (983 lb)*	Right Front:	*430.5 kg (949 lb)*
Left Rear:	*301.2 kg (664 lb)*	Right Rear:	*276.7 kg (610 lb)*
		Total:	*1454.3 kg (3206 lb)*

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

(Page 1 of 2)

2022 Kia Forte

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

Lane Departure Warning

Type and location of sensor(s) used:

The LDW system uses a camera located at the top center of the windshield.

Lane Departure Warning Setting used in test: *N/A*

How is the Lane Departure Warning presented to the driver?

(Check all that apply)

- **X** Warning light
- **X** Buzzer or auditory 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, auditory, vibration, or combination), etc.

The LDW system alerts the driver with a visual and auditory alert. The visual alert is displayed in the bottom left corner of the multi-information display and consists of a flashing green LDW icon. The auditory alert consists of set of three consecutive beeps with a primary frequency at approximately 750 Hz.

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

(Page 2 of 2)

2022 Kia Forte

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 LDW system can be turned on/off using the touch screen display on the center dash. The procedure is as follows:

1. Select "Setup" to bring up the setup menu.

2. Select "Vehicle" -> "Driver Assistance" -> "Lane Safety".

3. Select between "Assist", "Warning Only", and "Off" to turn the LDW system on/off.

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.

Refer to the owner's manual pages 5-77 to 5-78 shown in Appendix B pages B-6 to B-7.

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.

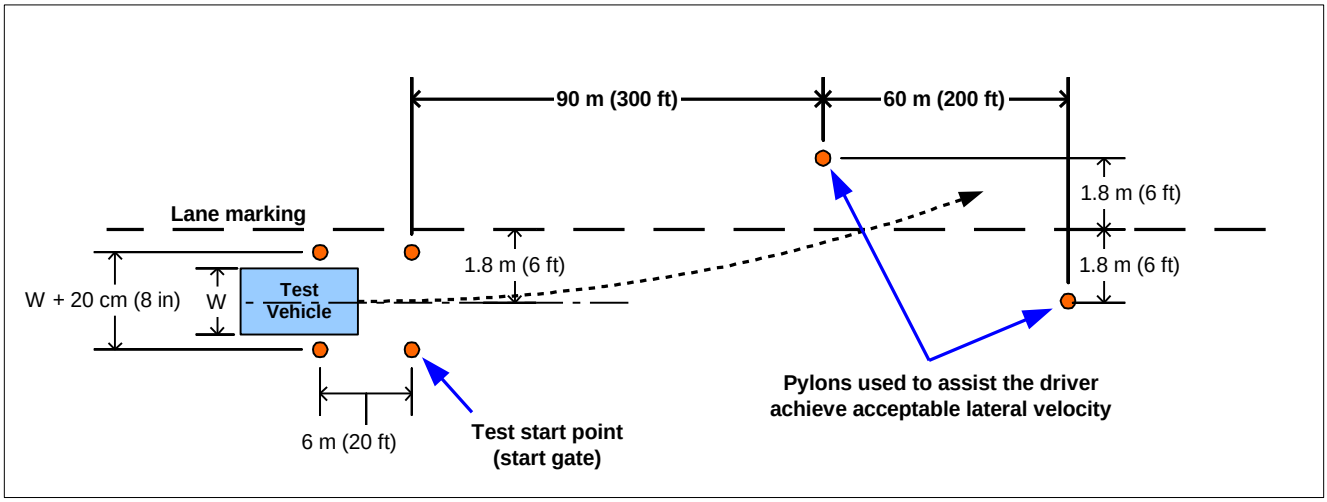

Figure 1. Position of Cones Used to Assist Driver

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.

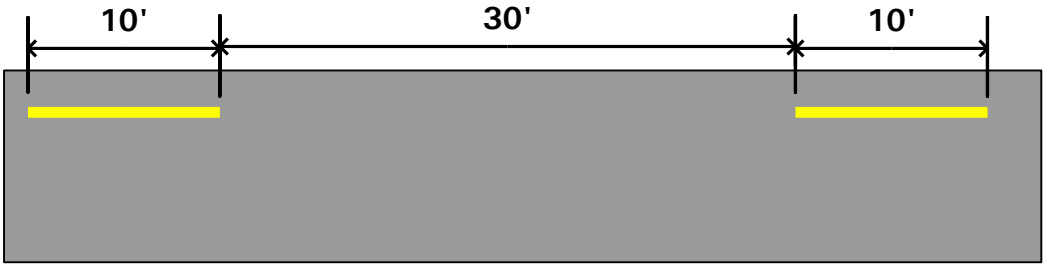

Figure 2. MUTCD Discontinuous Dashed Line Specifications

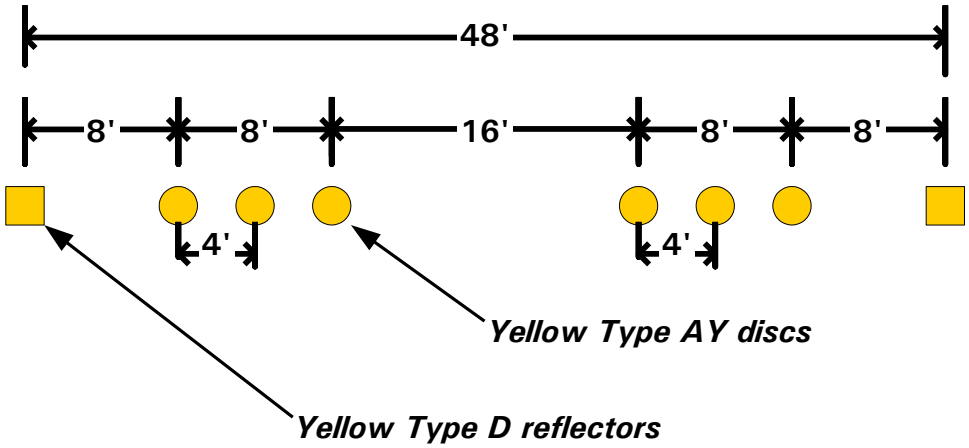

Figure 3. California Standard Plan A20A, Detail 4

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	< 1% error between 20 and 100 psi	Omega DPG8001	17042707002	By: DRI Date: 10/5/2021 Due: 10/5/2022
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 2/11/2022 Due: 2/11/2023
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	N/A
Multi-Axis Inertial Sensing System	Position: Longitudinal, Lateral, and Vertical Accels: Lateral, Longitudinal and Vertical Velocities: Roll, Pitch, Yaw Rates: Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rate ±100 deg/s, Angle >45 deg, Velocity >200 km/h	Accels .01g, Angular Rate 0.05 deg/s, Angle 0.05 deg, Velocity 0.1 km/h	Oxford Inertial +	2176	By: Oxford Technical Solutions[1] Date: 6/26/2020 Due: 6/26/2022
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	N/A

[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	N/A	N/A
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	N/A	N/A
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: 1/6/2022 Due: 1/6/2023

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 auditory or haptic alerts, part of the pre-test instrumentation verification process is to determine the tonal frequency of the auditory 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 auditory 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. Auditory and Tactile Warning Filter Parameters

Warning Type	Filter Order	Peak-to-Peak Ripple	Minimum Stop Band Attenuation	Passband Frequency Range
Auditory	5^{th}	3 dB	60 dB	Identified Center Frequency ± 5%
Tactile	5^{th}	3 dB	60 dB	Identified Center Frequency ± 20%

APPENDIX A

Photographs

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Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

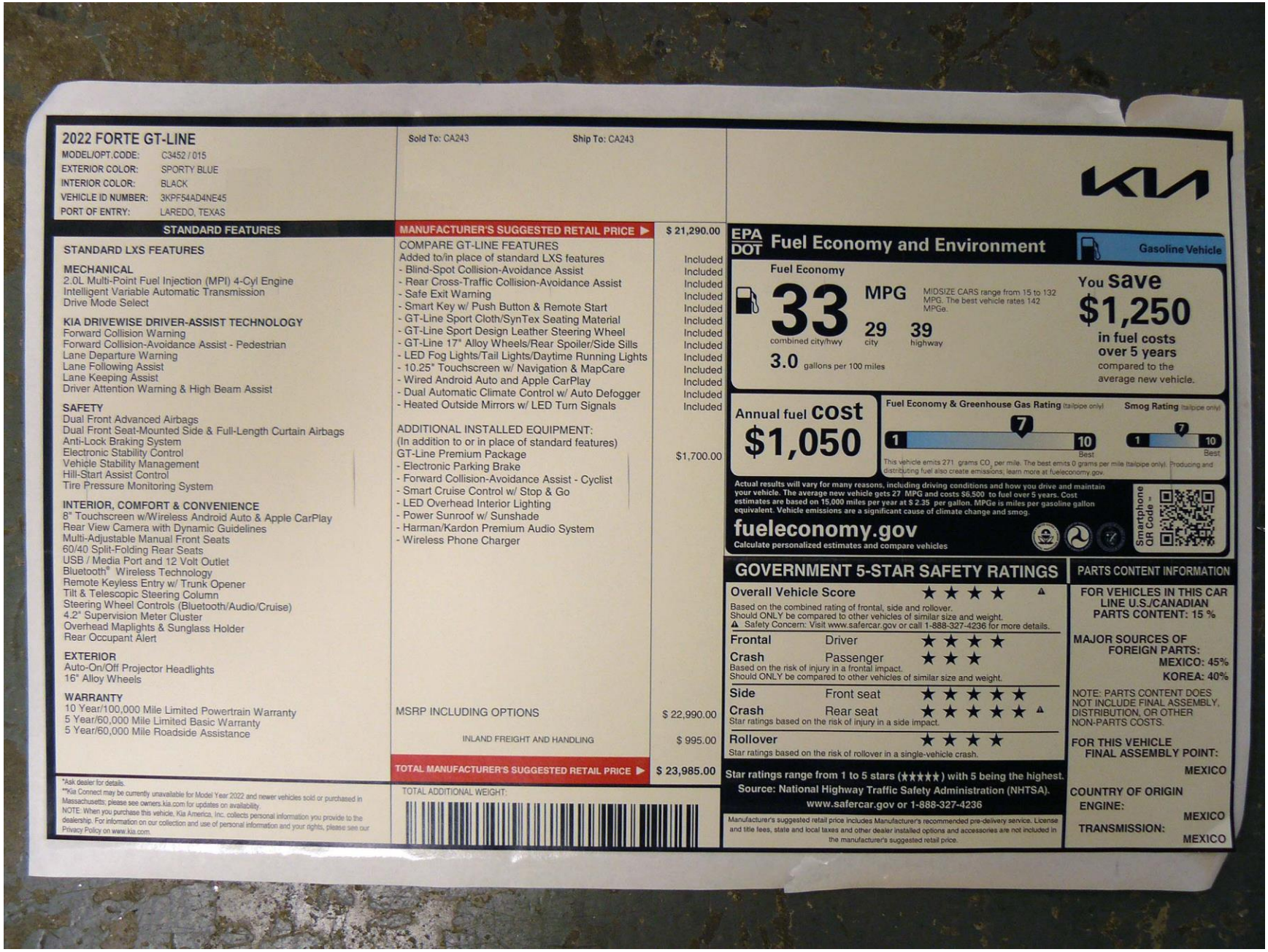


Figure A3. Window Sticker (Monroney Label)

Figure A4. Vehicle Certification Label

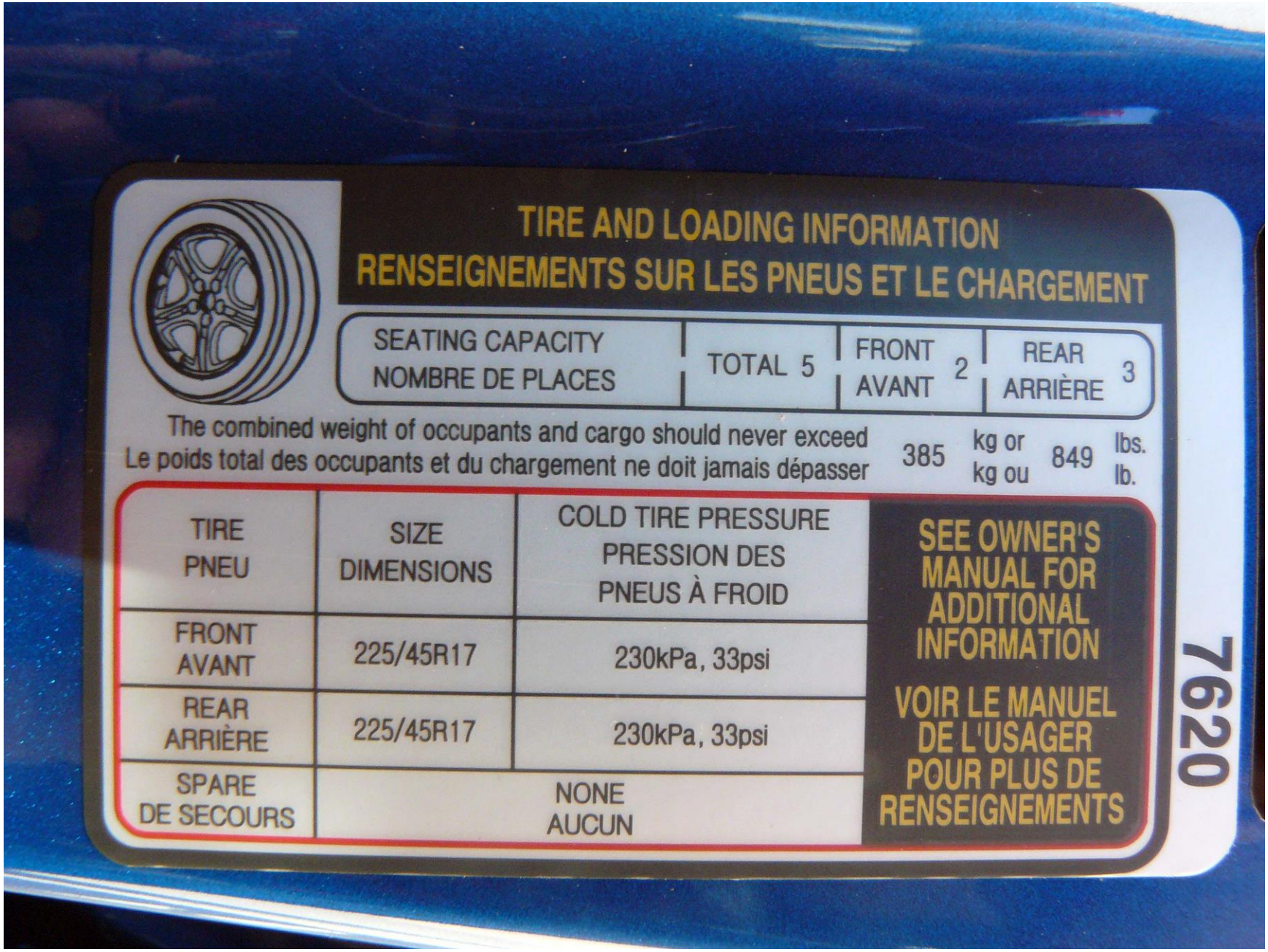


Figure A5. Tire Placard

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

Figure A7. Computer Installed in Subject Vehicle

Figure A8. Sensors for Detecting Visual and Auditory Alerts

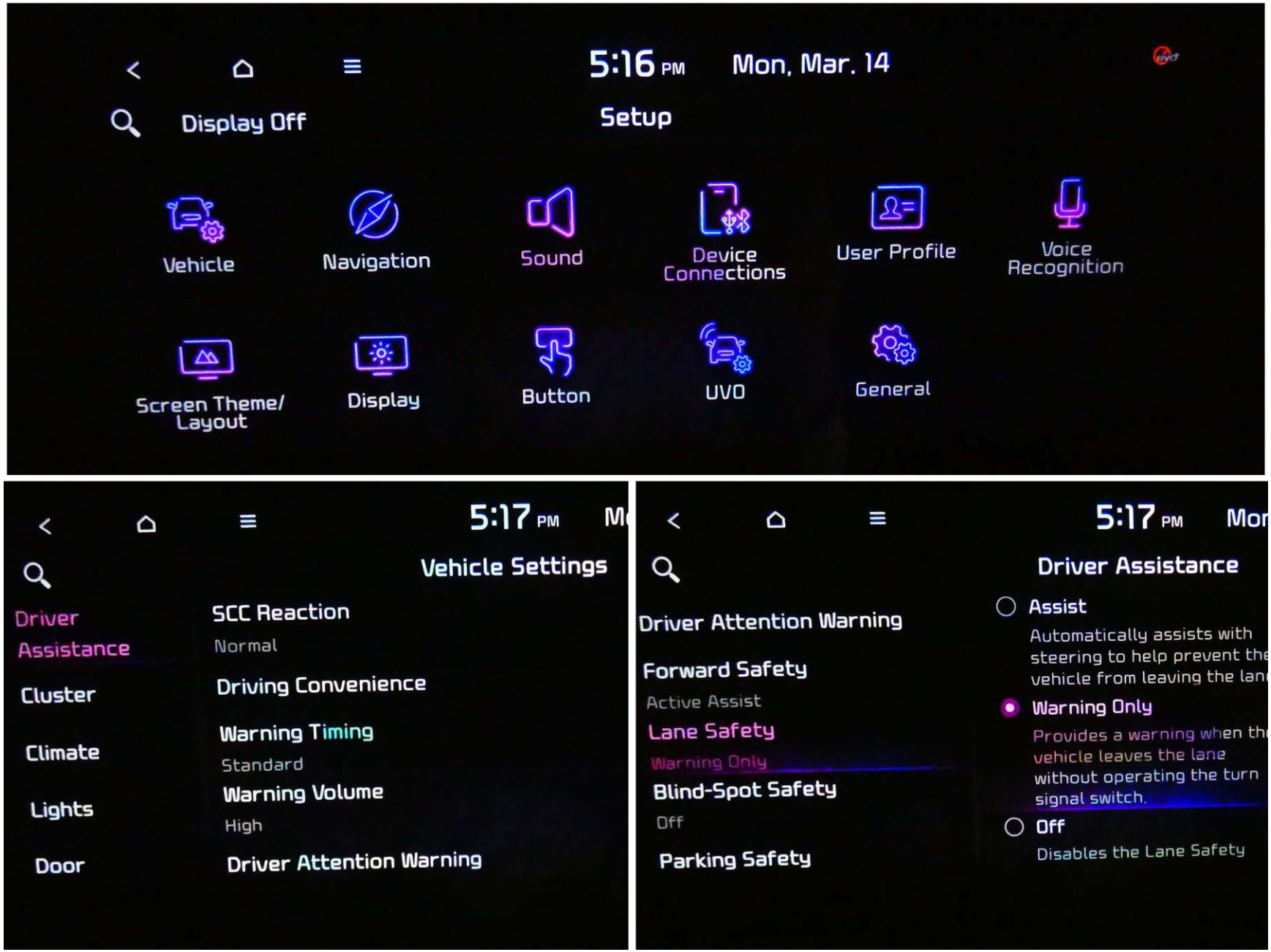


Figure A9. System Setup Menus

Figure A10. LDW Visual Alert

APPENDIX B

Excerpts from Owner’s Manual

the vehicle is started, or the front view camera is initialized.

This device complies with Part 15 of the FCC rules.

Operation is subject to the following three conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.
3. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the device.

Radio frequency radiation exposure information:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 8 in (20 cm) between the radiator and your body.This transmitter must not be colocated or operating in conjunction with any other antenna or transmitter.

Lane Keeping Assist (LKA) (if equipped)

Lane Keeping Assist is designed to help detect the lane markers while driving over a certain speed. Lane Keeping Assist will warn the driver if the vehicle leaves the lane without using the turn signal, or will automatically assist the driver's steering to help prevent the vehicle from departing the lane.

Detecting sensor

[1]: Front view camera

The front view camera is used as a detecting sensor to detect lane markings.

Refer to the picture above for the detailed location of the detecting sensor.

⚠ CAUTION

For more details on the precautions of the front view camera, refer to "Forward Collision-Avoidance Assist (FCA) (Sensor fusion) (if equipped)" on page 5-61.

Lane Keeping Assist Settings

Setting features

Lane Safety

OBD041251L

With the ignition switch or ENGINE START/STOP button in the ON position, select 'Driver Assistance → Lane Safety' from the 'User Settings (LCD display) or Setup → Vehicle (Infotainment System screen)' menu to set whether to use each function.

- If 'Assist' is selected, Lane Keeping Assist will automatically assist the driver's steering when lane departure is detected to help prevent the vehicle from moving out of its lane.
- If 'Warning Only' is selected, Lane Keeping Assist will warn the driver with an audible warning when lane departure is detected. In this mode, Lane Keeping Assist will not assist with steering the vehicle.
- If 'Off' is selected, Lane Keeping Assist will turn off. The indicator light ( ) will turn off on the cluster.

⚠ WARNING

- If 'Warning Only' is selected, steering is not assisted.
- Lane Keeping Assist does not control the steering wheel when the vehicle is driven in the middle of the lane.
- The driver should always be aware of the surroundings and steer the vehicle if 'Off' is selected.

Turning Lane Keeping Assist On/ Off

OBD051366

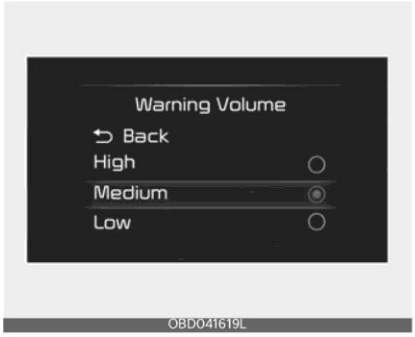
With the ignition switch or ENGINE START/STOP button in the ON position, press and hold the Lane Driving Assist button ( ) located on the steering wheel to turn off Lane Keeping Assist. Press and hold the button again to turn on the function.

The indicator ( ) in the cluster display will initially illuminate gray. If you press and hold the Lane Driving Assist button located on the steering wheel, Lane Keeping Assist will be turned off and the indicator on the cluster display will go off.

✻ NOTICE

When Lane Keeping Assist is turned off with the Lane Driving Assist button, Lane Safety settings will turn off.

Warning Volume



OBD041619L

With the ignition switch or ENGINE START/STOP button in the ON position, select 'Driver Assistance → Warning Volume' from the 'User Settings (LCD display) or Setup → Vehicle (Infotainment System screen)' menu to change the Warning Volume to 'High', 'Medium' or 'Low' for Lane Keeping Assist.

If you change the Warning Volume, the Warning Volume of other Driver Assistance systems may be changed.

Lane Keeping Assist Operation

Warning and control

Lane Keeping Assist will warn and control the vehicle with Lane Departure Warning and Lane Keeping Assist.

Lane Departure Warning

Left

OBD041263

Right

OBD041266

- To warn the driver that the vehicle is departing from the projected lane in front, the green ( ) indicator light will blink on the cluster, the lane line will blink on the cluster depending on which direction the vehicle is veering, and an audible warning will sound.
- Lane Keeping Assist will operate when your vehicle speed is between approximately 40~120 mph (60~200 km/h).

5

Lane Keeping Assist

- To warn the driver that the vehicle is departing from the projected lane in front, the green ( )indicator light will blink on the cluster, and the steering wheel will make adjustments to keep vehicle inside the lane.
- Lane Keeping Assist will operate when your vehicle speed is between approximately 40~120 mph (60~200 km/h).

Hands-off warning

OBD041236L

If the driver takes their hands off the steering wheel for several seconds, the 'Keep hands on steering wheel' warning message will appear on the cluster, and an audible warning will sound in stages.

⚠ WARNING

- The steering wheel may not be assisted if the steering wheel is held very tight or the steering wheel is steered over a certain degree.
- Lane Keeping Assist does not operate at all times. It is the responsibility of the driver to safely steer the vehicle and to maintain the vehicle in its lane.
- The hands-off warning message may appear late depending on road conditions. Always have your hands on the steering wheel while driving.
- If the steering wheel is held very lightly, the hands off warning message may appear because Lane Keeping Assist may not recognize that the driver has their hands on the steering wheel.
- If you attach objects to the steering wheel, the hands-off warning may not work properly.

✻ NOTICE

- For more details on setting the functions in the infotainment system, refer to "LCD display modes" on page 4-59.
- When lane markings are detected, the lane lines on the cluster will change from gray to the green ( ) indicator light will illuminate if Lane Keeping Assist is operable.

Lane undetected

OBDM041267L

OBD041268

- Even though the steering is assisted by Lane Keeping Assist, the driver may control the steering wheel.
- The steering wheel may feel heavier or lighter when the steering wheel is assisted by Lane Keeping Assist than when it is not.

Lane Keeping Assist Malfunction and Limitations

Lane Keeping Assist Malfunction

OMQ4050214L

When Lane Keeping Assist is not working properly, the 'Check Lane Keeping Assist (LKA) system', warning message will appear and the yellow ( ) indicator light will illuminate on the cluster. In this case, have the function inspected by an authorized Kia dealer.

Limitations of Lane Keeping Assist

Lane Keeping Assist may not operate properly or may operate unexpectedly under the following circumstances:

- The lane is contaminated or difficult to detect because,
  - The lane markings are covered with rain, snow, dirt, oil, etc.
  - The color of the lane marking is not distinguishable from the road
  - There are markings on the road near the lane or the markings on the road look similar to the lane markings
  - The lane marking is indistinct or damaged
  - The shadow is on the lane marking by a median strip, trees, guardrail, noise barriers, etc.
- There are more than two lane markings on the road
- The lane number increases or decreases, or the lane markings are crossing
- The lane markings are complicated or a structure substitutes for the lines, such as a construction area
- There are road markings, such as zig-zag lanes, crosswalk markings and road signs
- The lane suddenly disappears, such as at the intersection
- The lane is very wide or narrow
- There is a road edge without a lane
- There is a boundary structure in the roadway, such as a tollgate, sidewalk, curb, etc.
- The distance to the front vehicle is extremely short or the vehicle in front is covering the lane marking

For more details on the limitations of the front view camera, refer to "Forward Collision-Avoidance Assist (FCA) (Sensor fusion) (if equipped)" on page 5-61.

⚠ WARNING

Take the following precautions when using Lane Keeping Assist:

- The driver should hold the responsibility to safely drive and control the vehicle. Do not solely rely on Lane Keeping Assist and drive dangerously.
- The operation of Lane Keeping Assist can be cancelled or not work properly depending on road conditions and surroundings. Always be cautious while driving.
- Refer to "Limitations of Lane Keeping Assist" on page 5-77, if the lane is not detected properly.
- When you are towing a trailer or another vehicle, we recommend that Lane Keeping Assist is turned off due to safety reasons.
- If the vehicle is driven at high speed, the steering wheel will not be controlled. The driver must always follow the speed limit when using Lane Keeping Assist.
- If any other function's warning message is displayed or audible warning is generated, Lane Keeping Assist warning message may not be displayed and audible warning may not be generated.
- You may not hear the warning sound of Lane Keeping Assist if the surrounding is noisy.
- If you attach objects to the steering wheel, steering may not be assisted properly.
- Lane Keeping Assist may not operate for 15 seconds after the vehicle is started, or the front view camera is initialized.
- Lane Keeping Assist will not operate when:
  - The turn signal or hazard warning flasher is turned on
  - The vehicle is not driven in the center of the lane when Lane Keeping Assist 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 35 mph (55 km/h) or above 130 mph (210 km/h)
  - The vehicle makes sharp lane changes
  - The vehicle is suddenly stopped

APPENDIX C

Run Log

Subject Vehicle: **2022 Kia Forte**

Driver: **Stephen Rhim**

Test start date: **3/14/2022**

Test end date: **3/15/2022**

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	**Solid**	**Left**	Y	-0.45	-0.53	Pass	
2			Y	-0.52	-0.60	Pass	
3			Y	-0.44	-0.53	Pass	
4			Y	-0.51	-0.58	Pass	
5			Y	-0.54	-0.64	Pass	
6			Y	-0.59	-0.67	Pass	
7			Y	-0.43	-0.51	Pass	
8	**Solid**	**Right**	Y	-0.55	-0.65	Pass	
9			Y	-0.57	-0.64	Pass	
10			N				Speed
11			N				GPS fix type
12			N				Speed
13			Y	-0.48	-0.53	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Auditory Alert (ft)	Distance at Visual Alert (ft)	Pass/Fail	Notes
14			Y	-0.53	-0.62	Pass	
15			Y	-0.55	-0.63	Pass	
16			Y	-0.44	-0.52	Pass	
17	**Dashed**	**Right**	Y	-0.52	-0.60	Pass	
18			Y	-0.40	-0.44	Pass	
19			Y	-0.45	-0.51	Pass	
20			Y	-0.57	-0.64	Pass	
21			Y	-0.61	-0.69	Pass	
22			Y	-0.49	-0.57	Pass	
23			Y	-0.53	-0.63	Pass	
24	**Dashed**	**Left**	N				Data error
25			Y	-0.45	-0.53	Pass	
26			Y	-0.44	-0.50	Pass	
27			Y	-0.56	-0.64	Pass	
28			Y	-0.49	-0.58	Pass	
29			Y	-0.54	-0.61	Pass	
30			Y	-0.46	-0.54	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Auditory Alert (ft)	Distance at Visual Alert (ft)	Pass/Fail	Notes
31	**Botts**	**Left**	N				Data error
32			Y	-0.59	-0.69	Pass	
33			Y	-0.64	-0.78	Pass	
34			Y	-0.49	-0.58	Pass	
35			Y	-0.50	-0.58	Pass	
36			Y	-0.62	-0.71	Pass	
37			Y	-0.76	-0.82	Pass	
38	**Botts**	**Right**	N				Data error
39			Y	-0.46	-0.54	Pass	
40			Y	-0.42	-0.53	Pass	
41			Y	-0.47	-0.52	Pass	
42			Y	-0.49	-0.57	Pass	
43			Y	-0.41	-0.51	Pass	
44			Y	-0.44	-0.54	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
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.

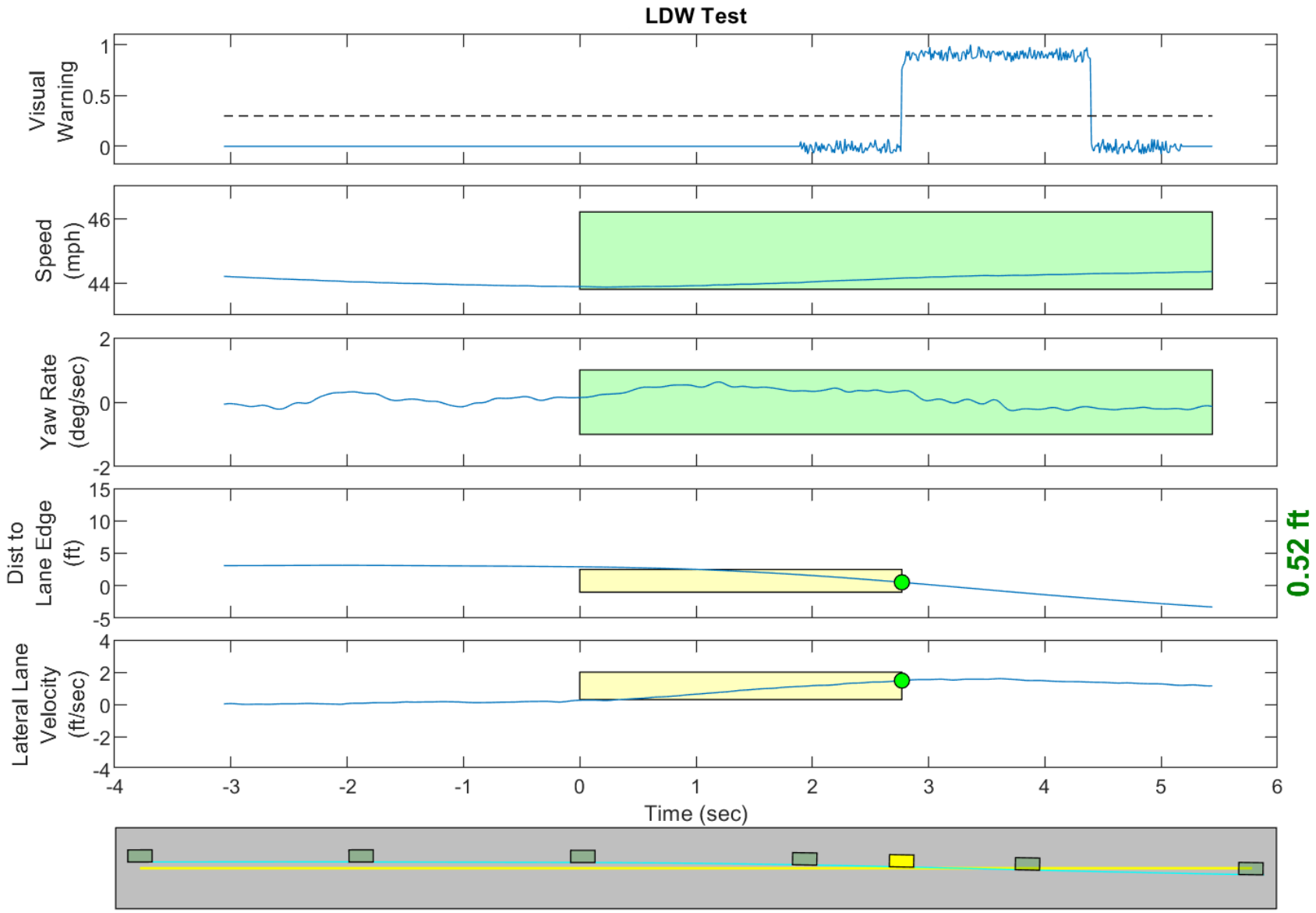


Figure D1. Example Time History for Lane Departure Warning Test, Passing

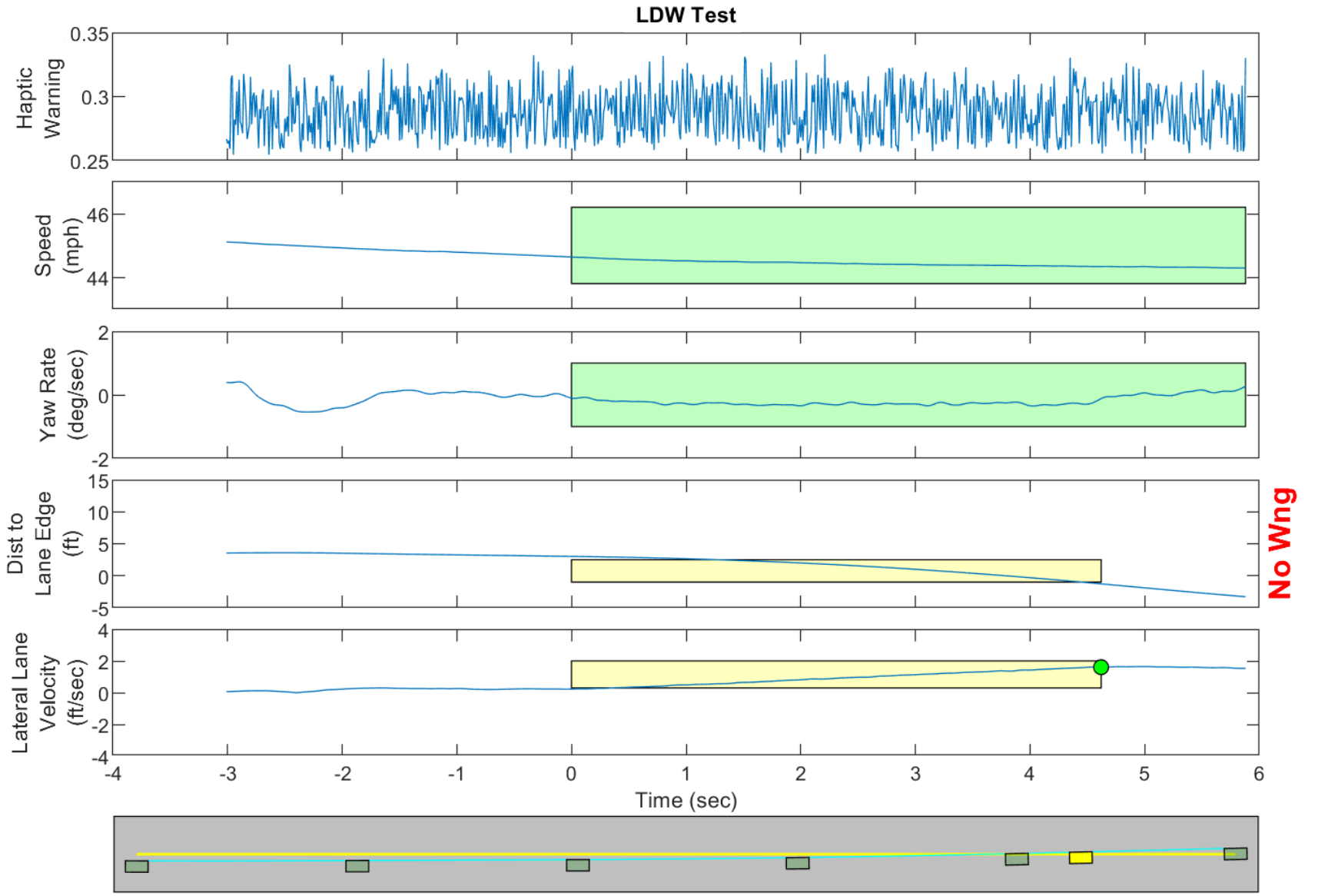


Figure D2. Example Time History for Lane Departure Warning Test, Failing, No Warning Issued

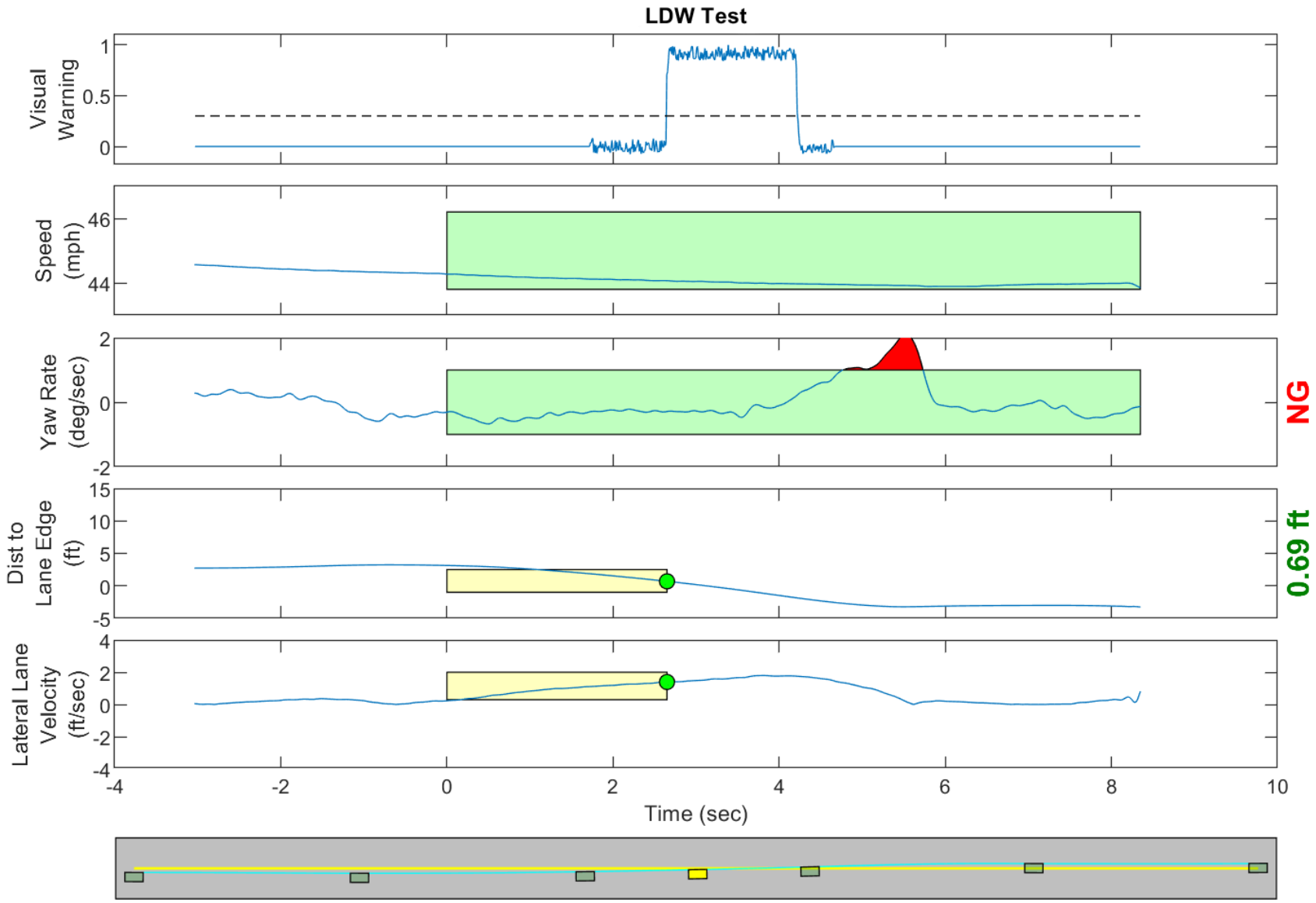


Figure D3. Example Time History for Lane Departure Warning Test, Invalid Run Due to Subject Vehicle Yaw Rate

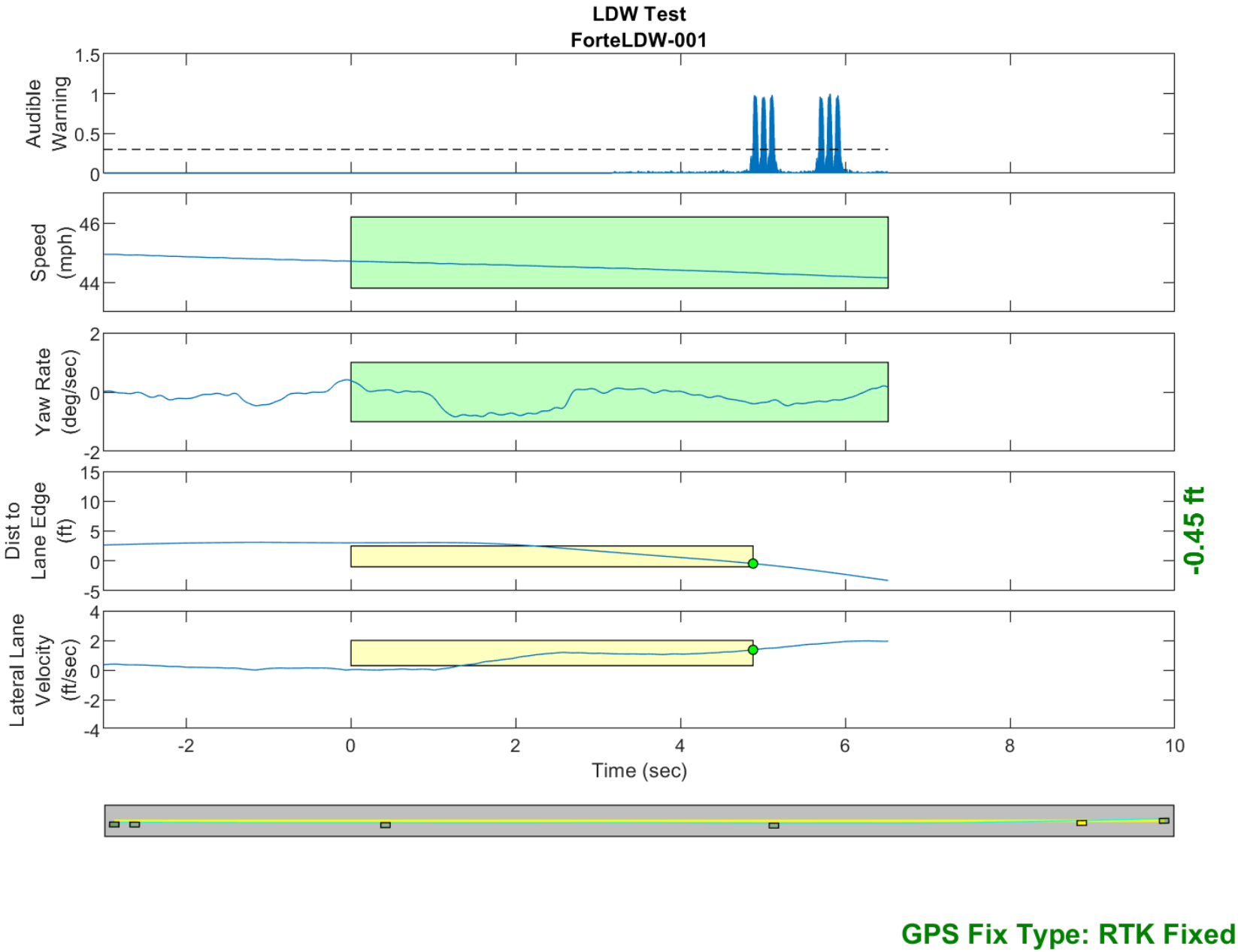
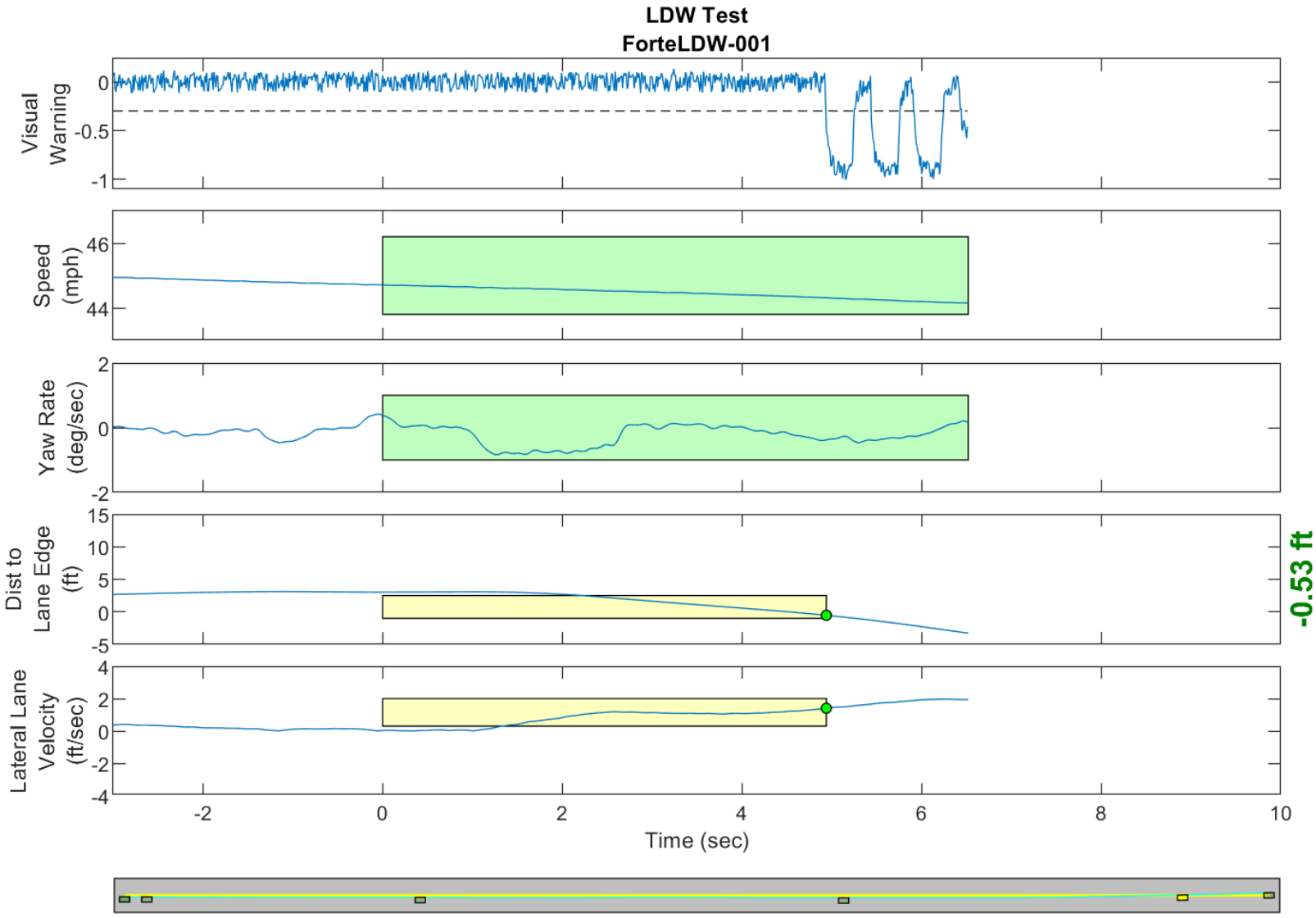


Figure D4. Time History for Run 01, Solid Line, Left Departure, Auditory Warning



GPS Fix Type: RTK Fixed

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

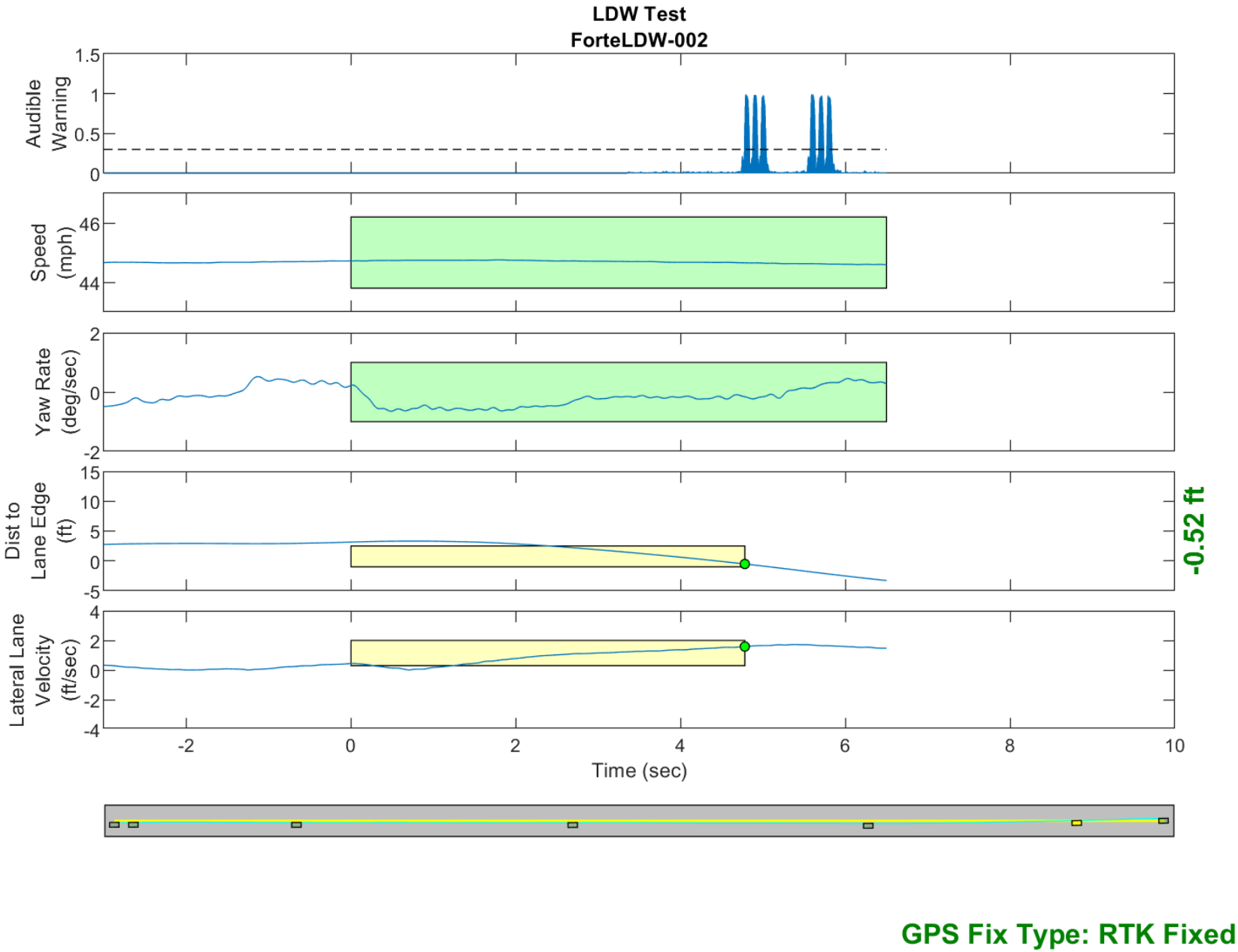


Figure D6. Time History for Run 02, Solid Line, Left Departure, Auditory Warning

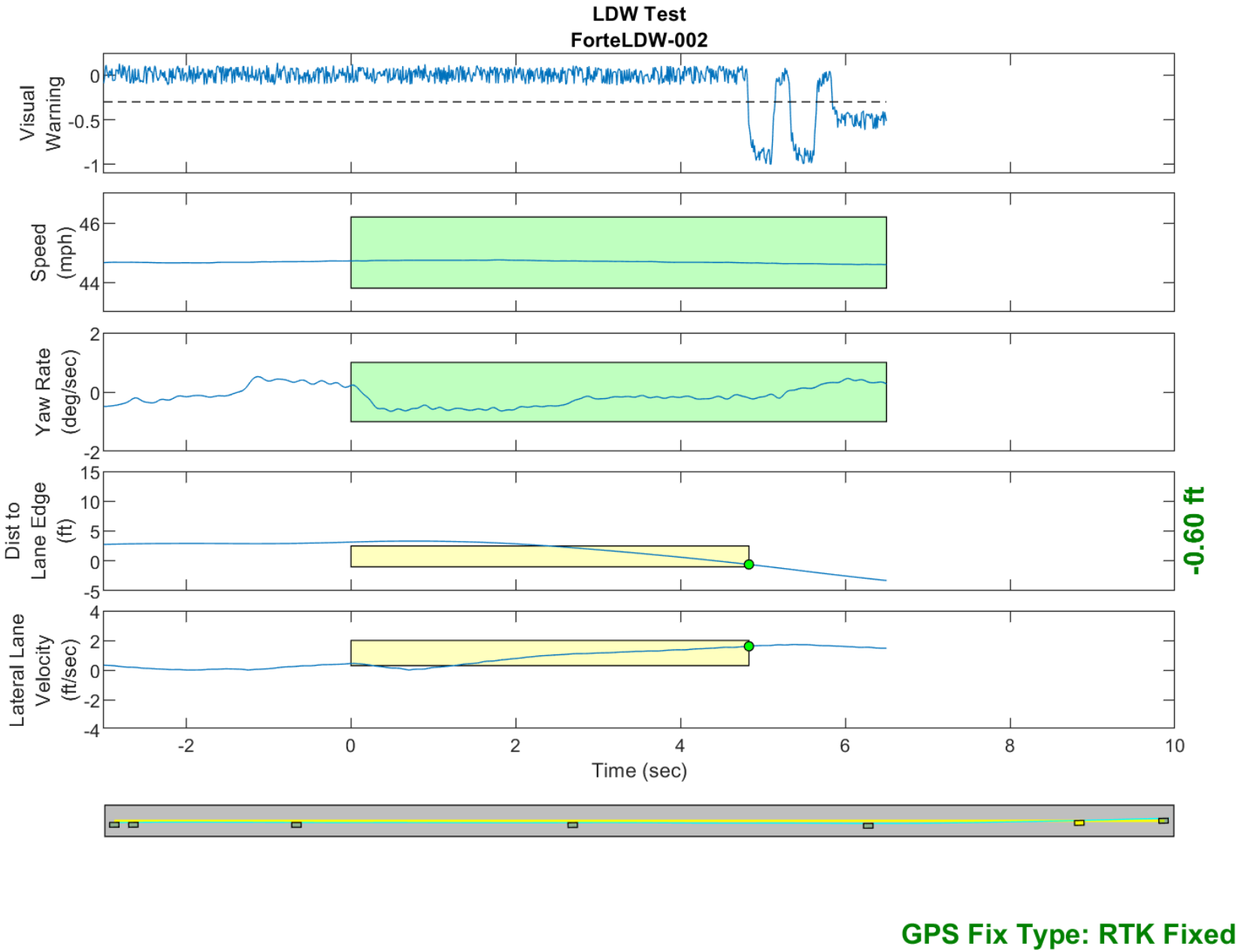


Figure D7. Time History for Run 02, Solid Line, Left Departure, Visual Warning

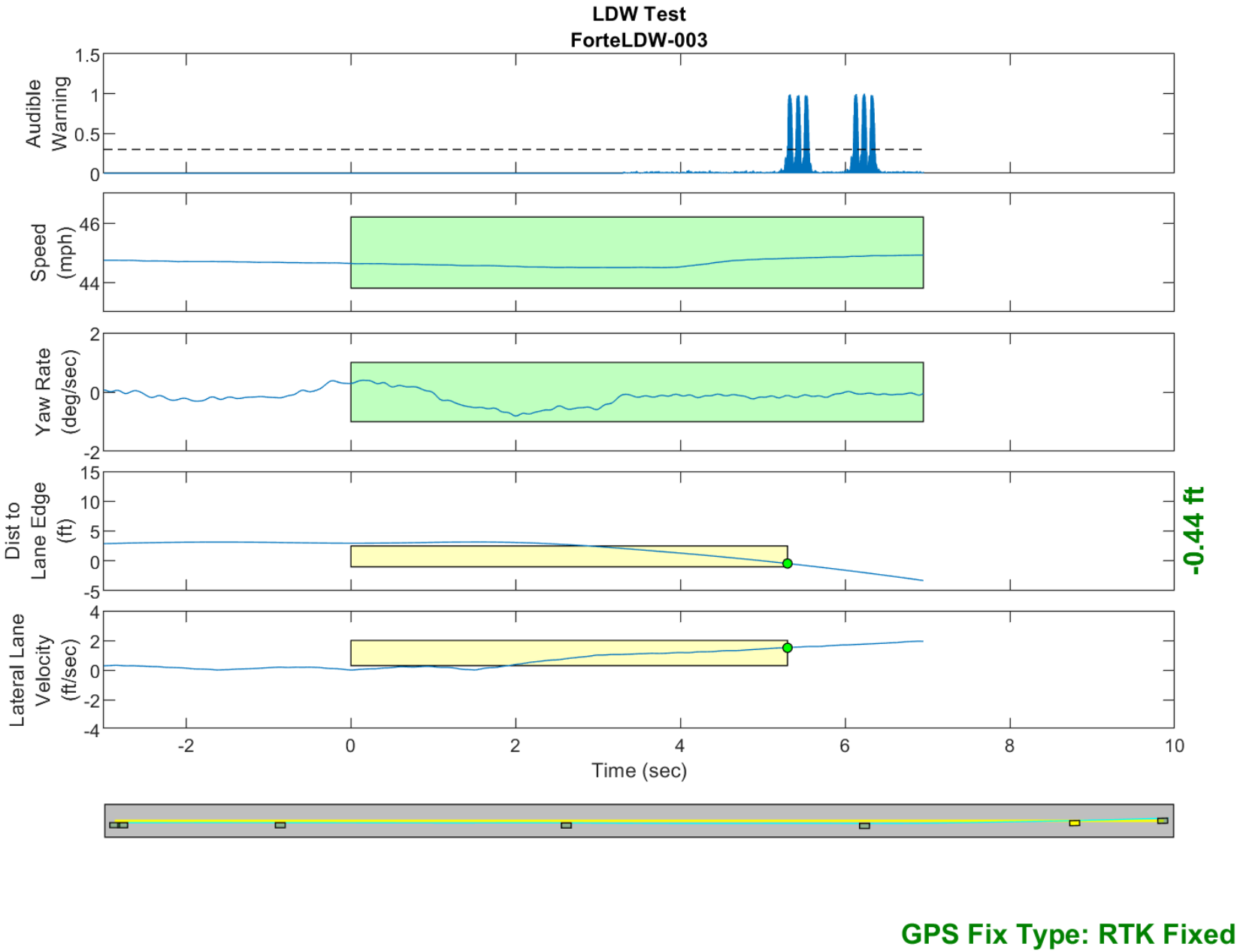


Figure D8. Time History for Run 03, Solid Line, Left Departure, Auditory Warning

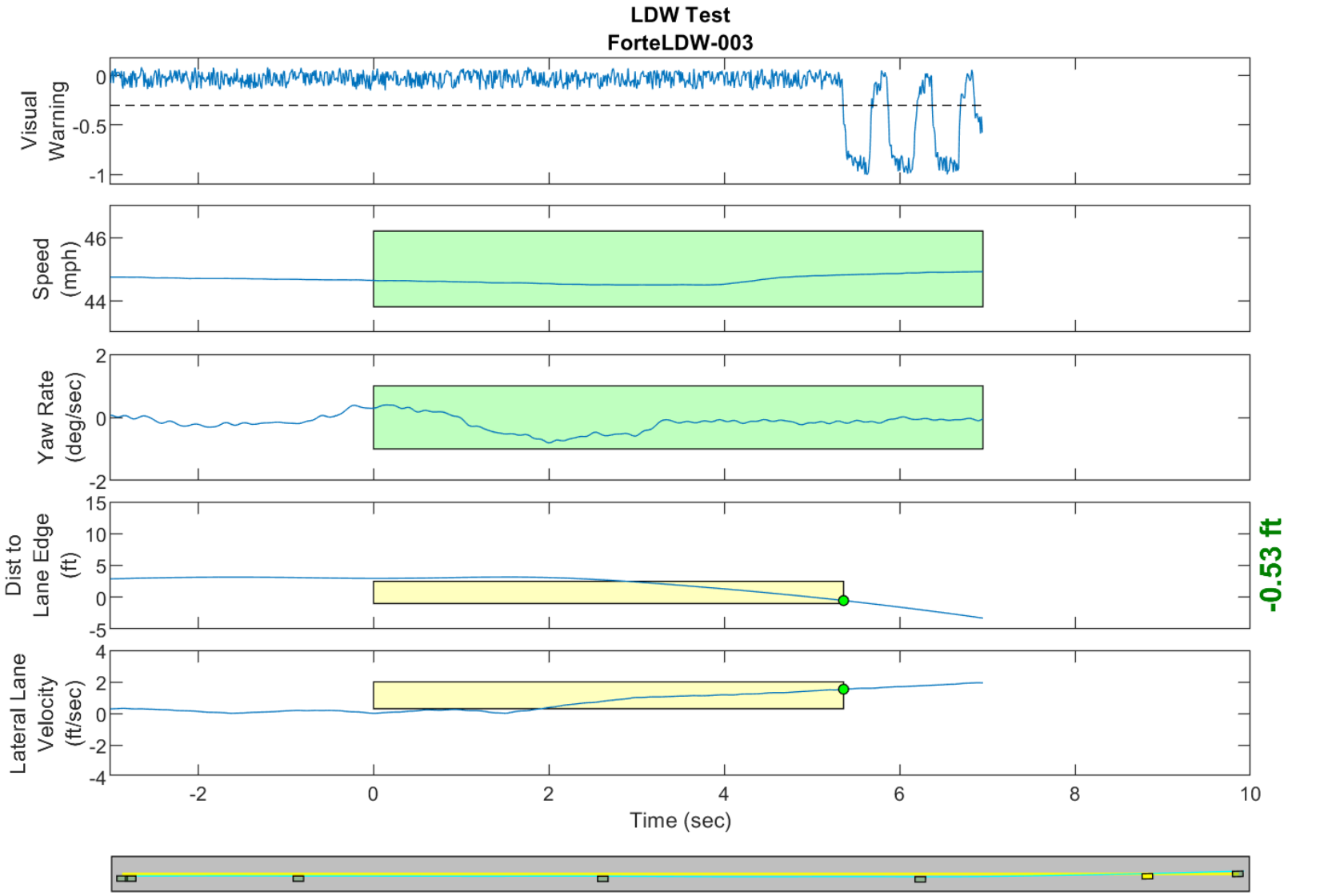


Figure D9. Time History for Run 03, Solid Line, Left Departure, Visual Warning

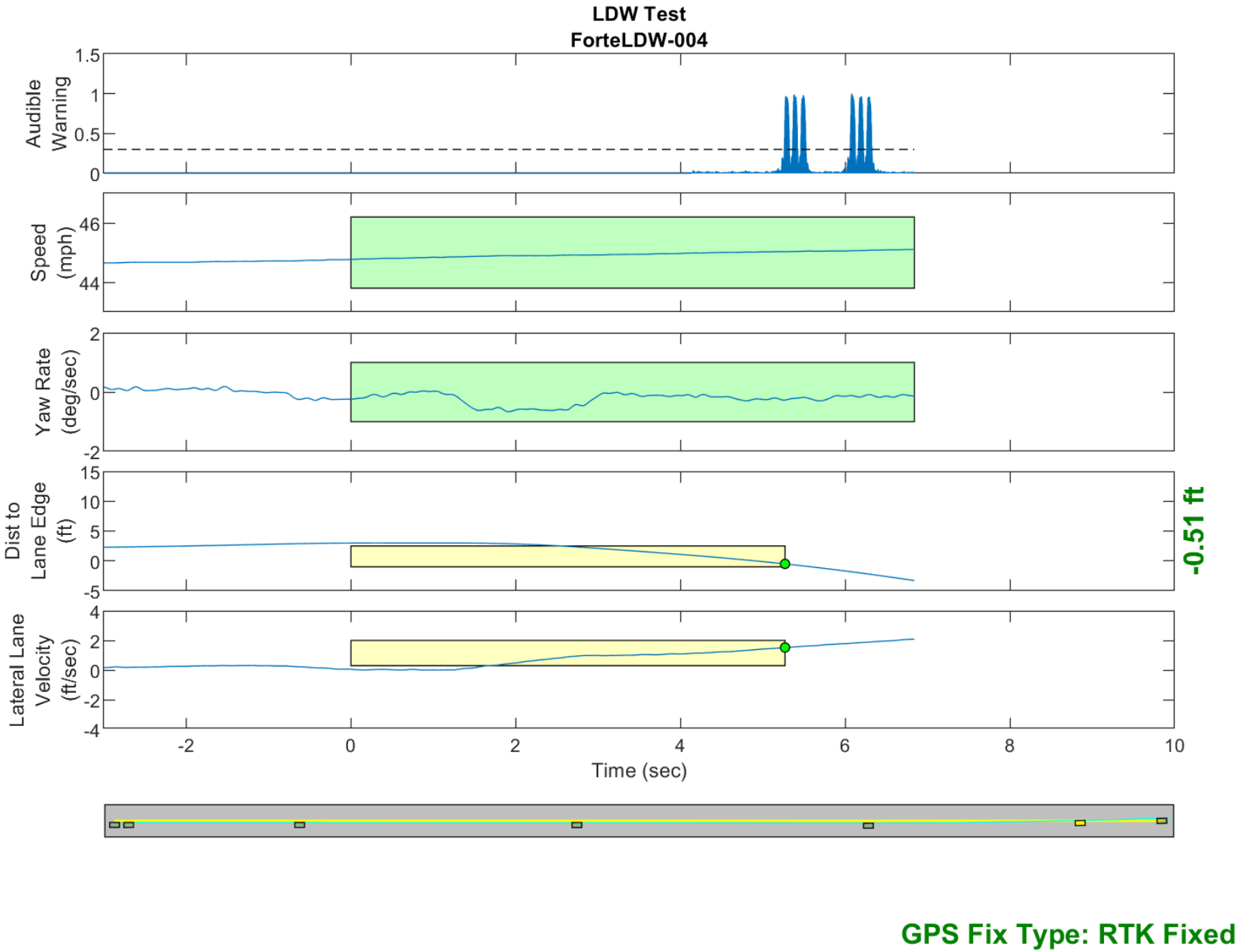


Figure D10. Time History for Run 04, Solid Line, Left Departure, Auditory Warning

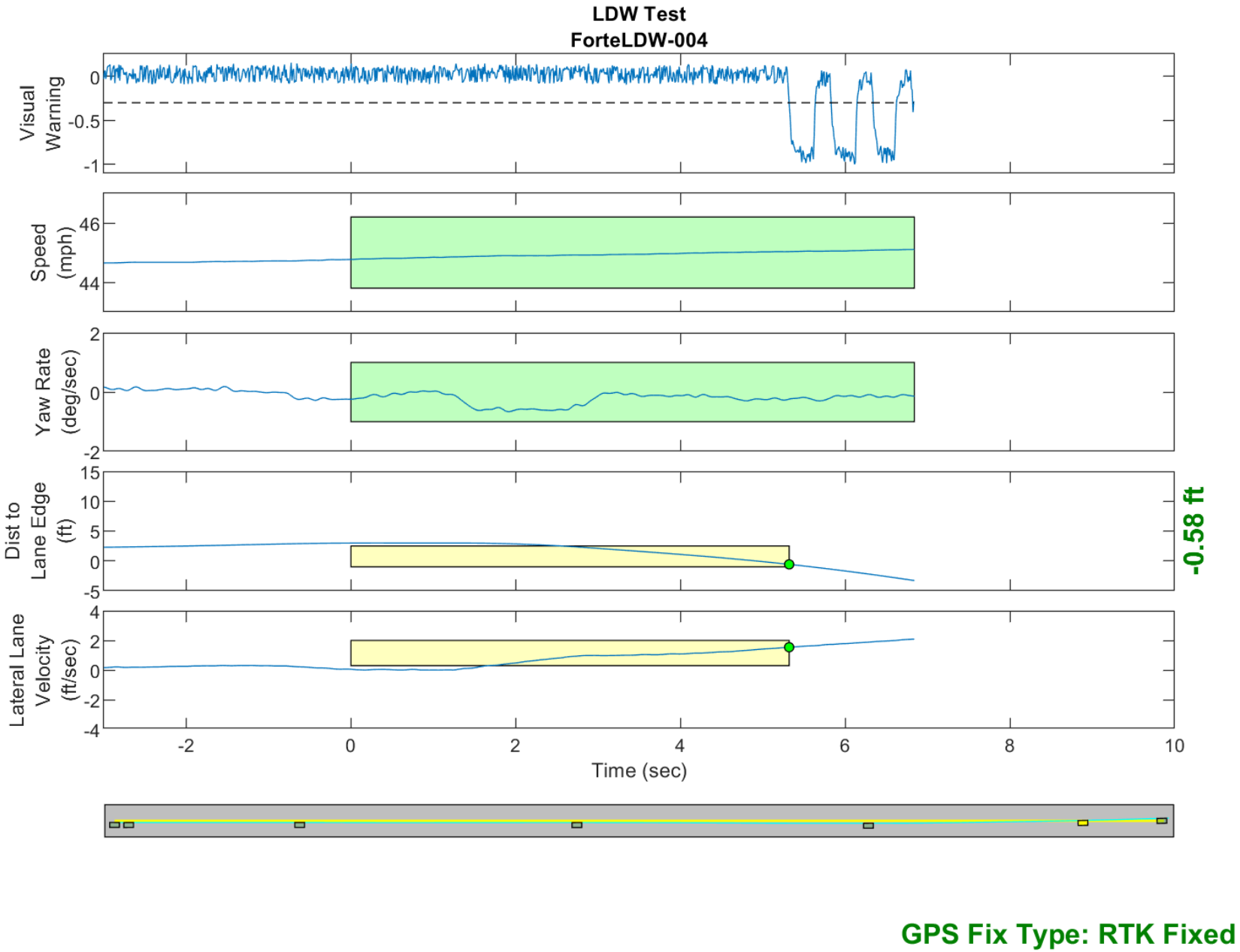


Figure D11. Time History for Run 04, Solid Line, Left Departure, Visual Warning

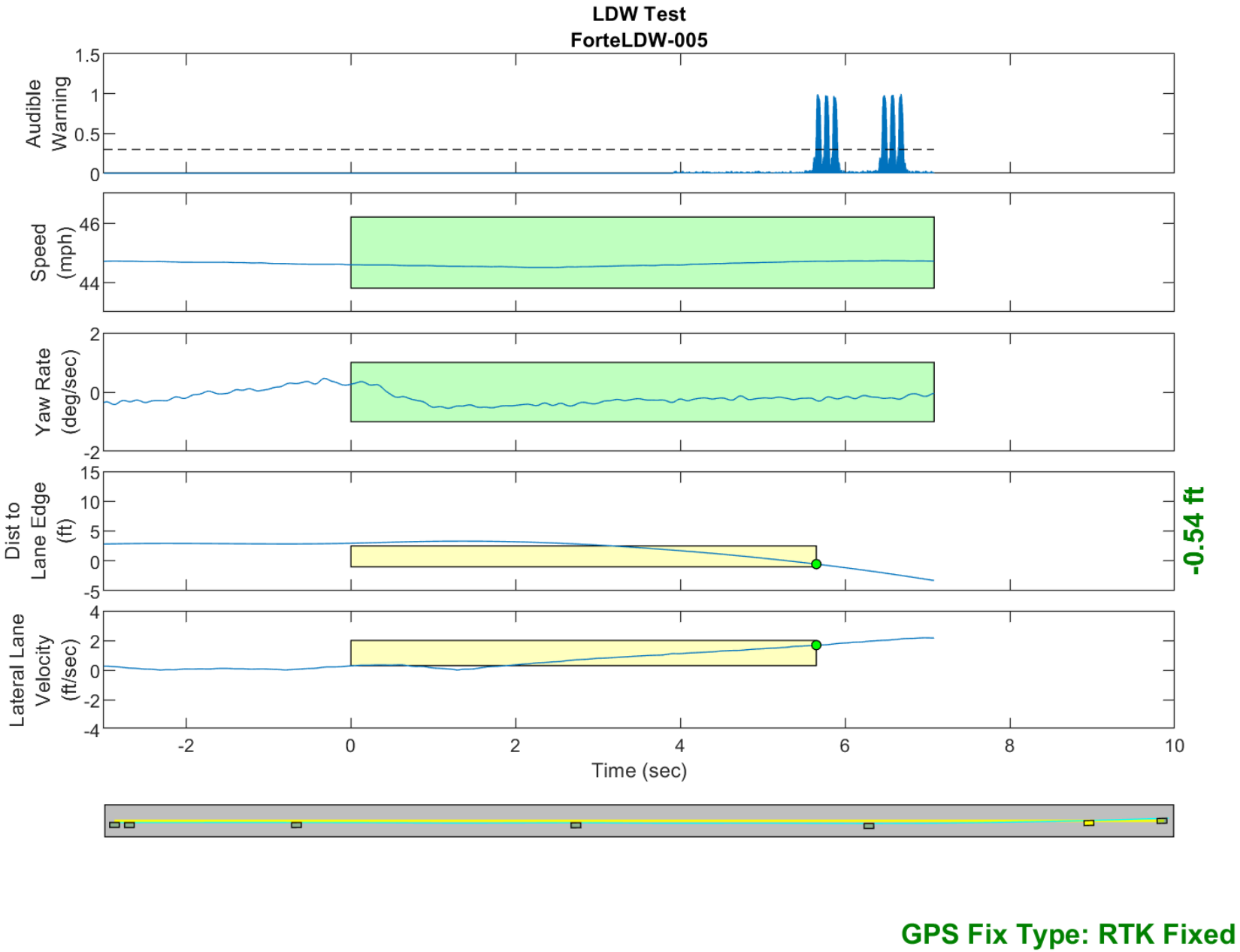


Figure D12. Time History for Run 05, Solid Line, Left Departure, Auditory Warning

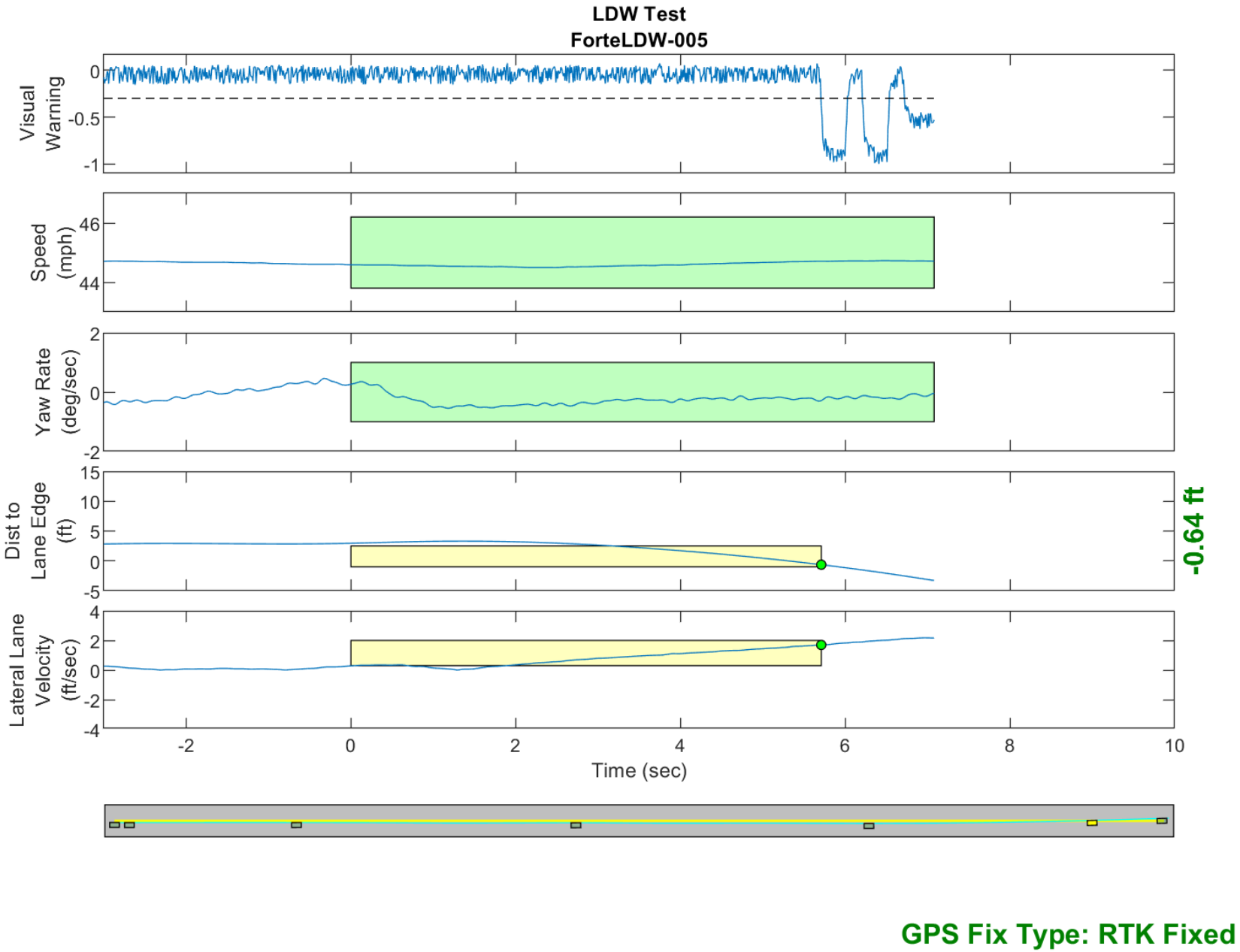


Figure D13. Time History for Run 05, Solid Line, Left Departure, Visual Warning

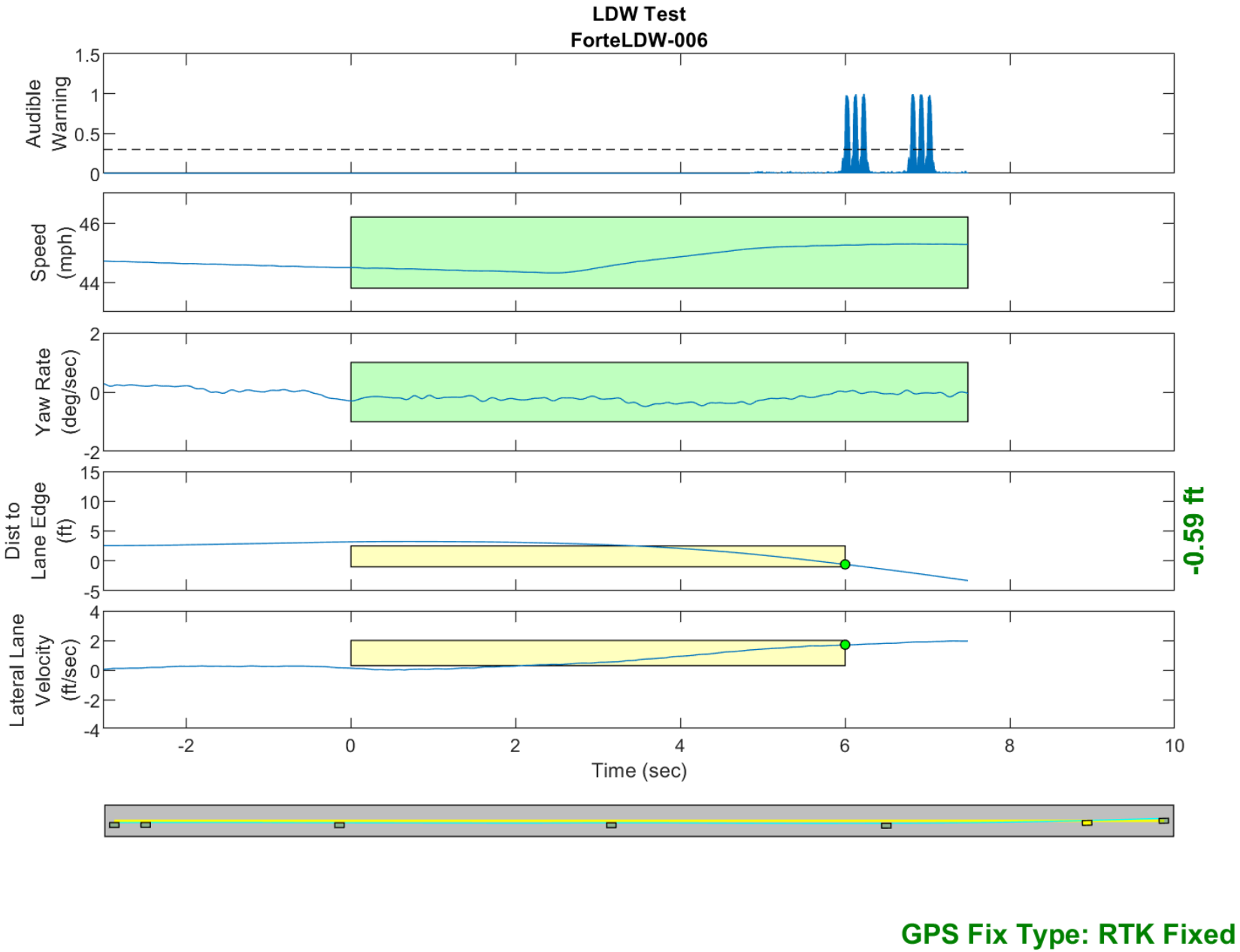


Figure D14. Time History for Run 06, Solid Line, Left Departure, Auditory Warning

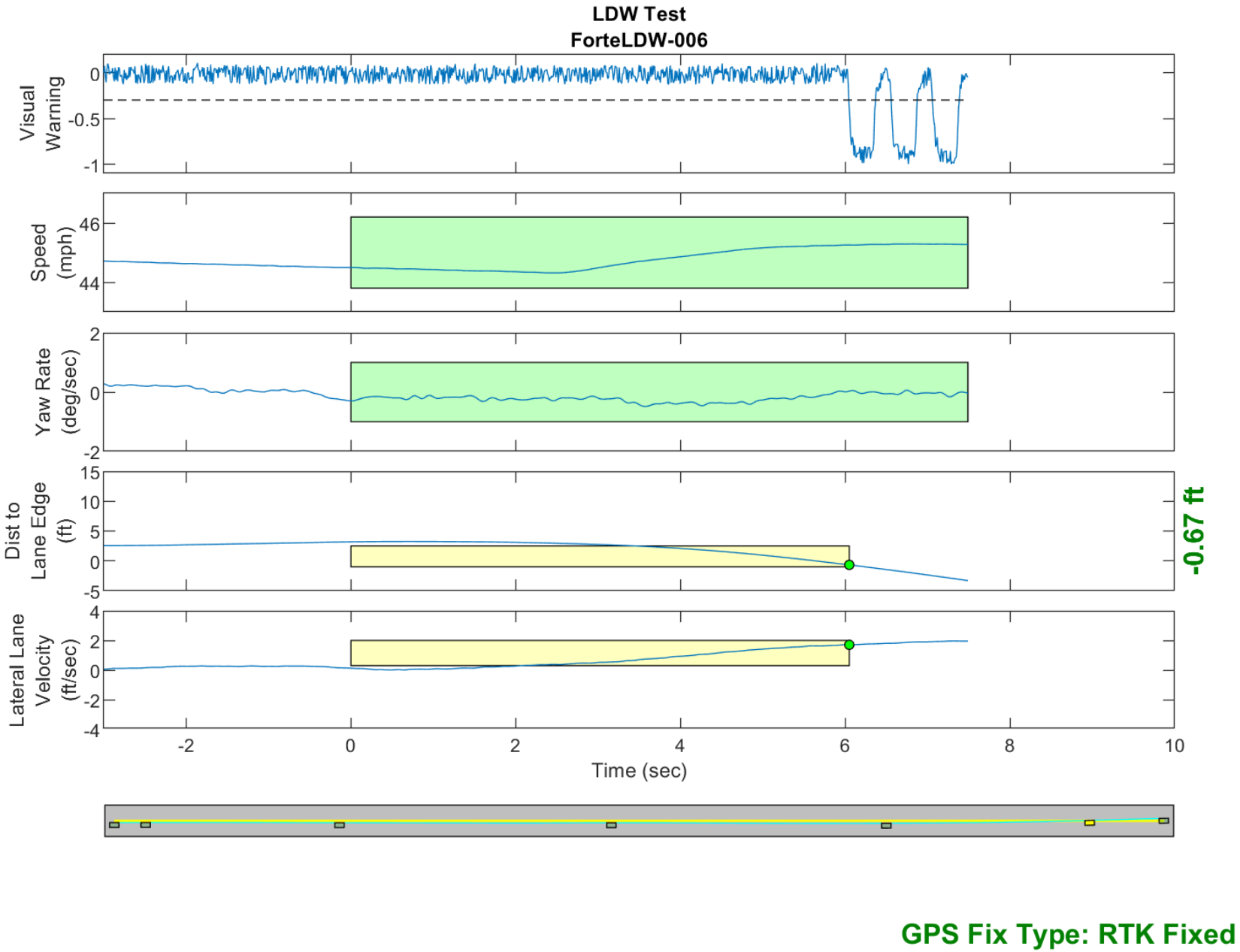


Figure D15. Time History for Run 06, Solid Line, Left Departure, Visual Warning

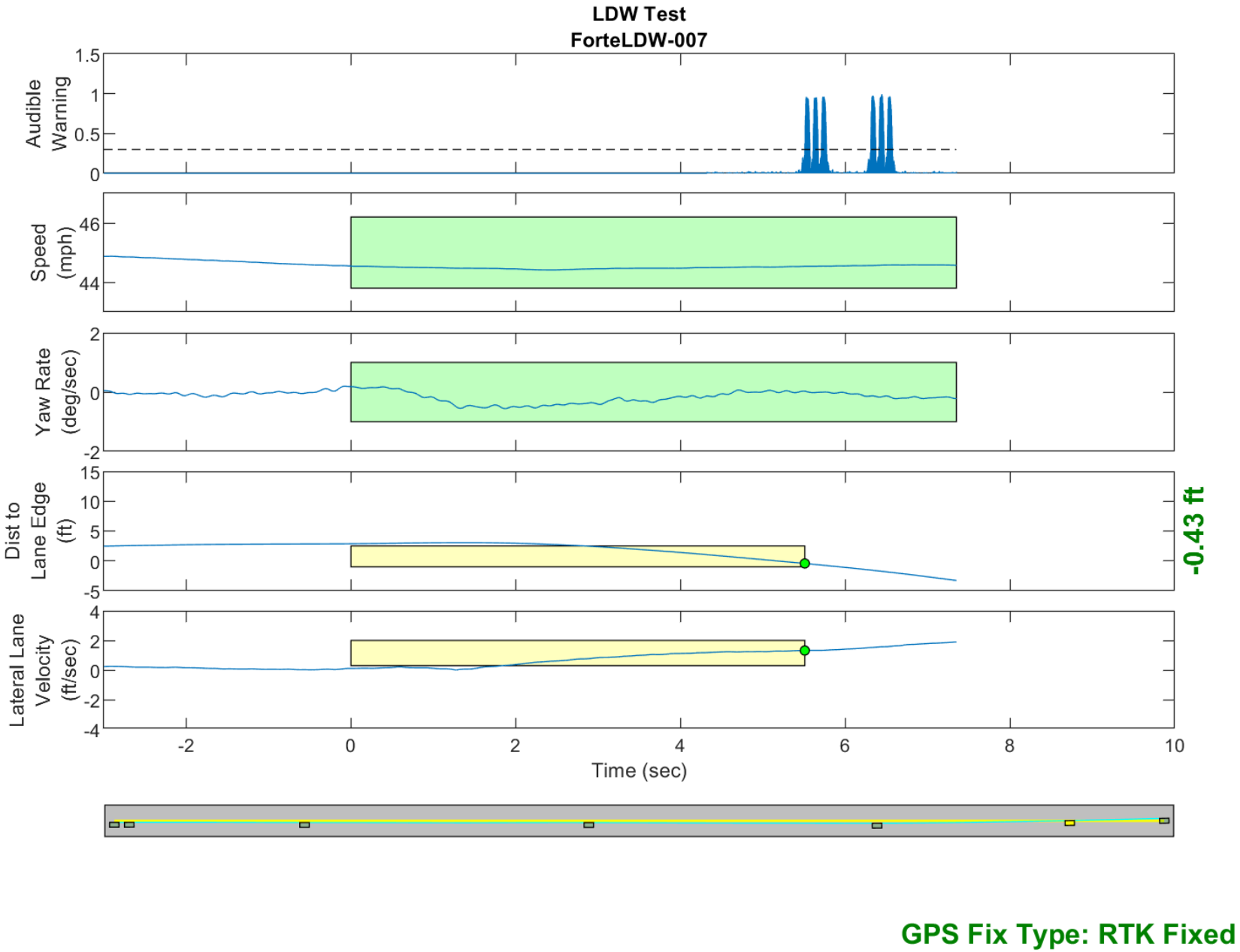


Figure D16. Time History for Run 07, Solid Line, Left Departure, Auditory Warning

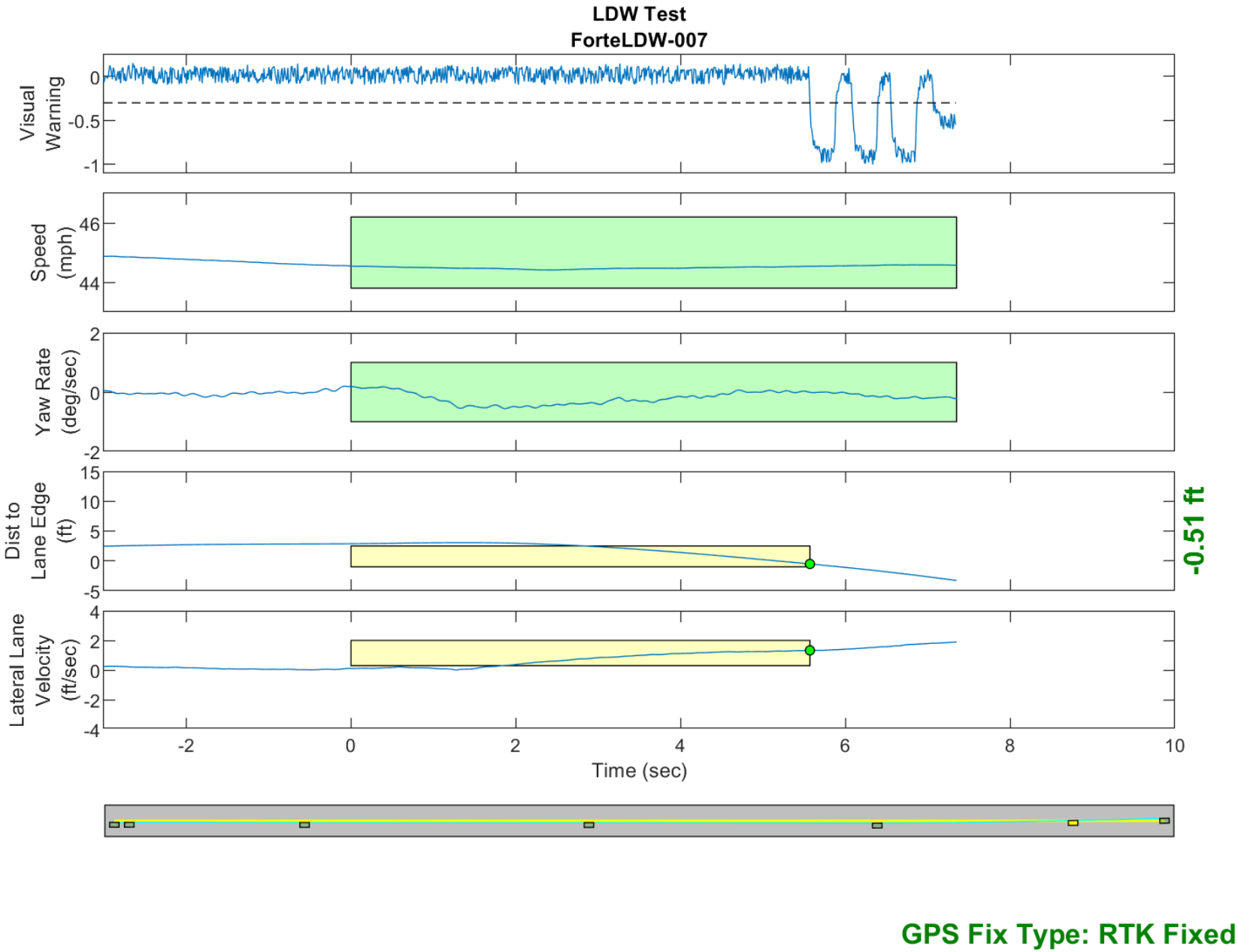


Figure D17. Time History for Run 07, Solid Line, Left Departure, Visual Warning

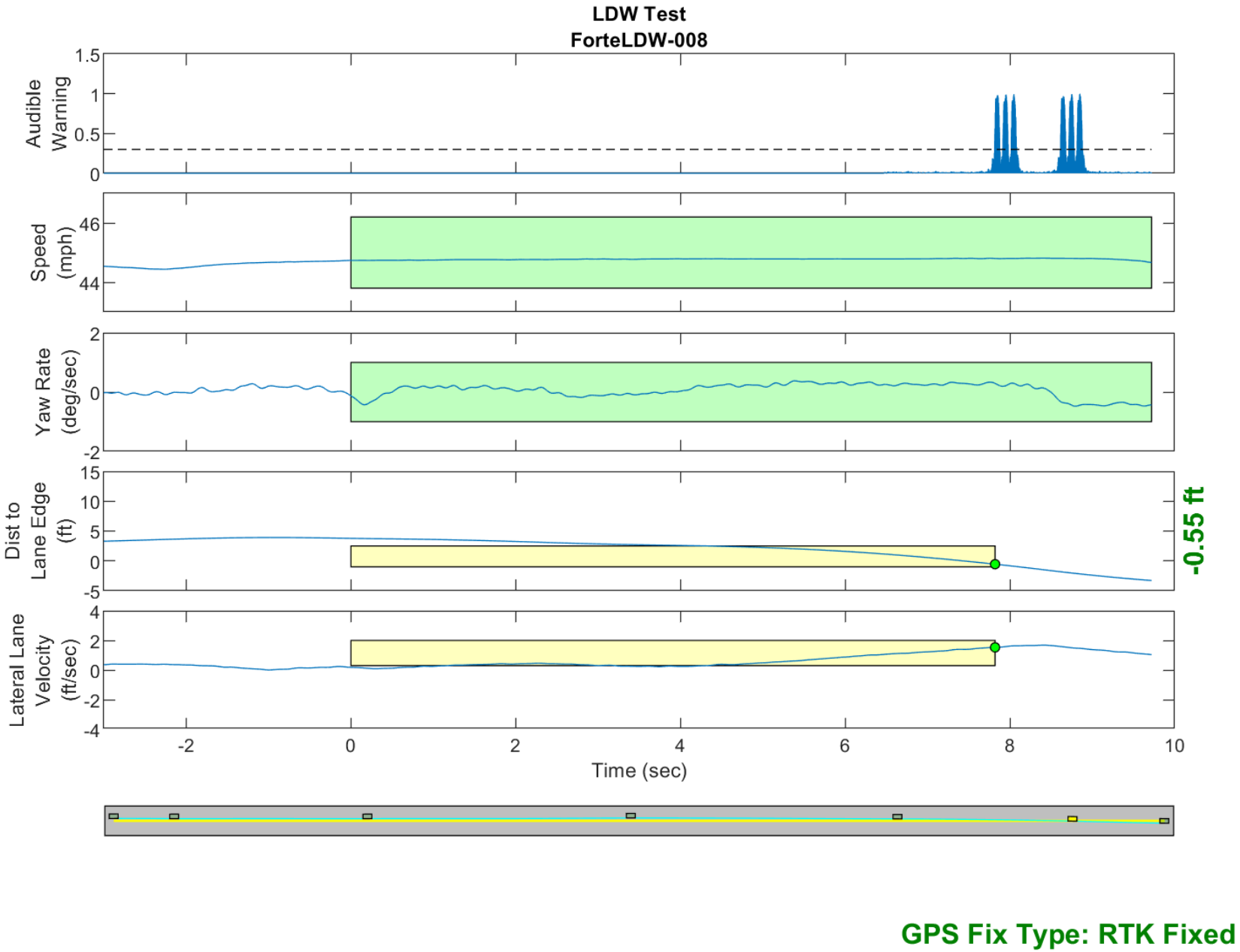


Figure D18. Time History for Run 08, Solid Line, Right Departure, Auditory Warning

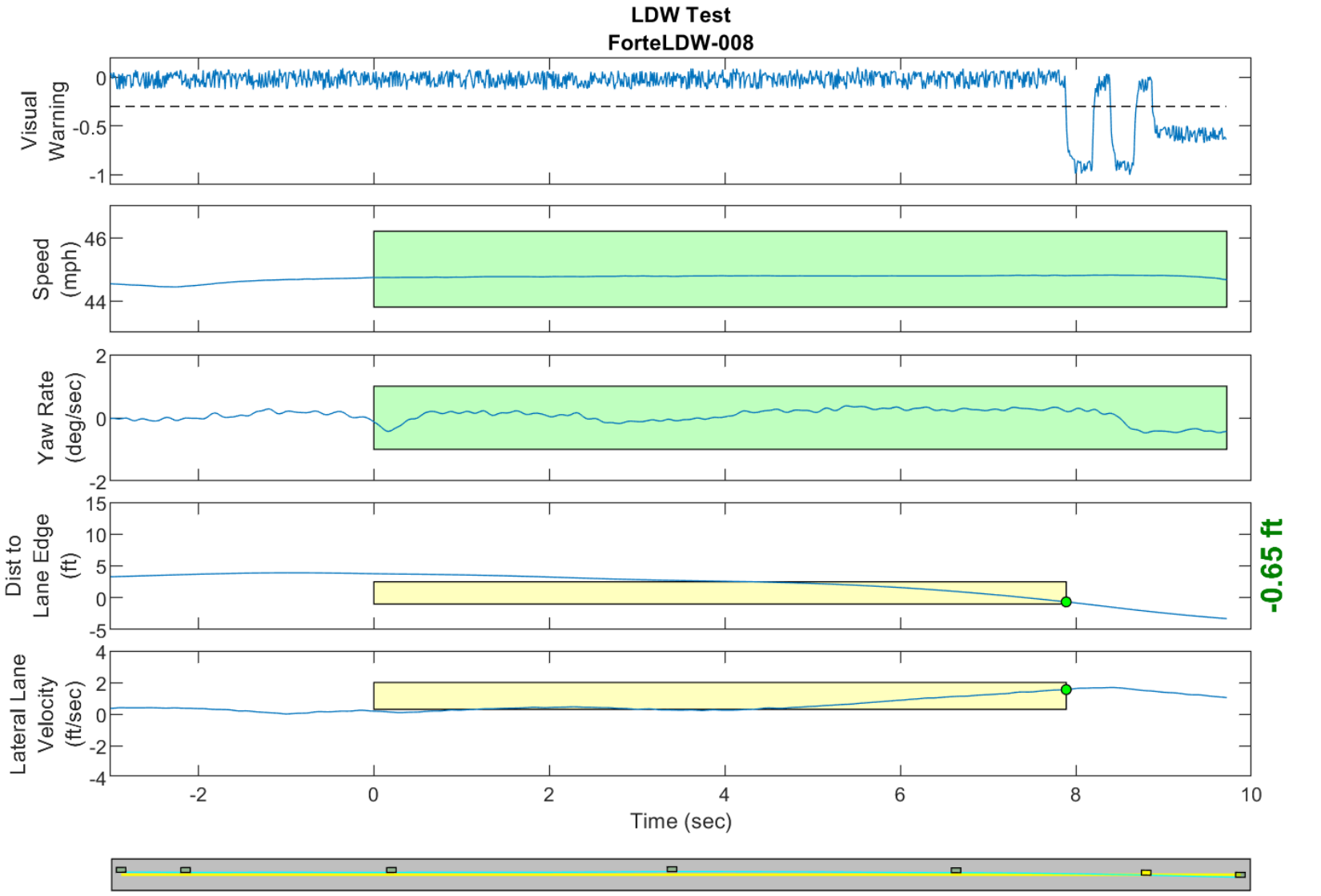


Figure D19. Time History for Run 08, Solid Line, Right Departure, Visual Warning

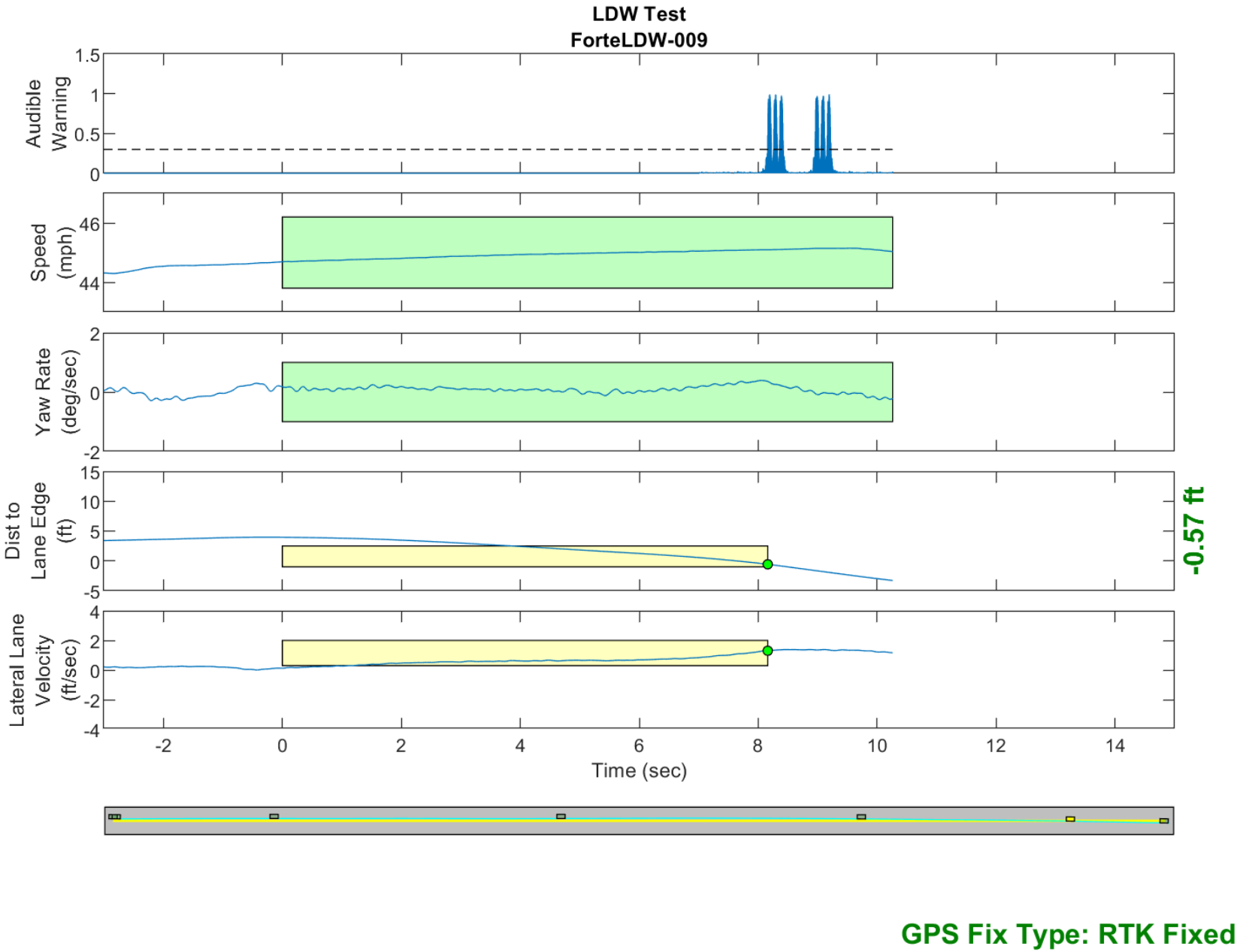


Figure D20. Time History for Run 09, Solid Line, Right Departure, Auditory Warning

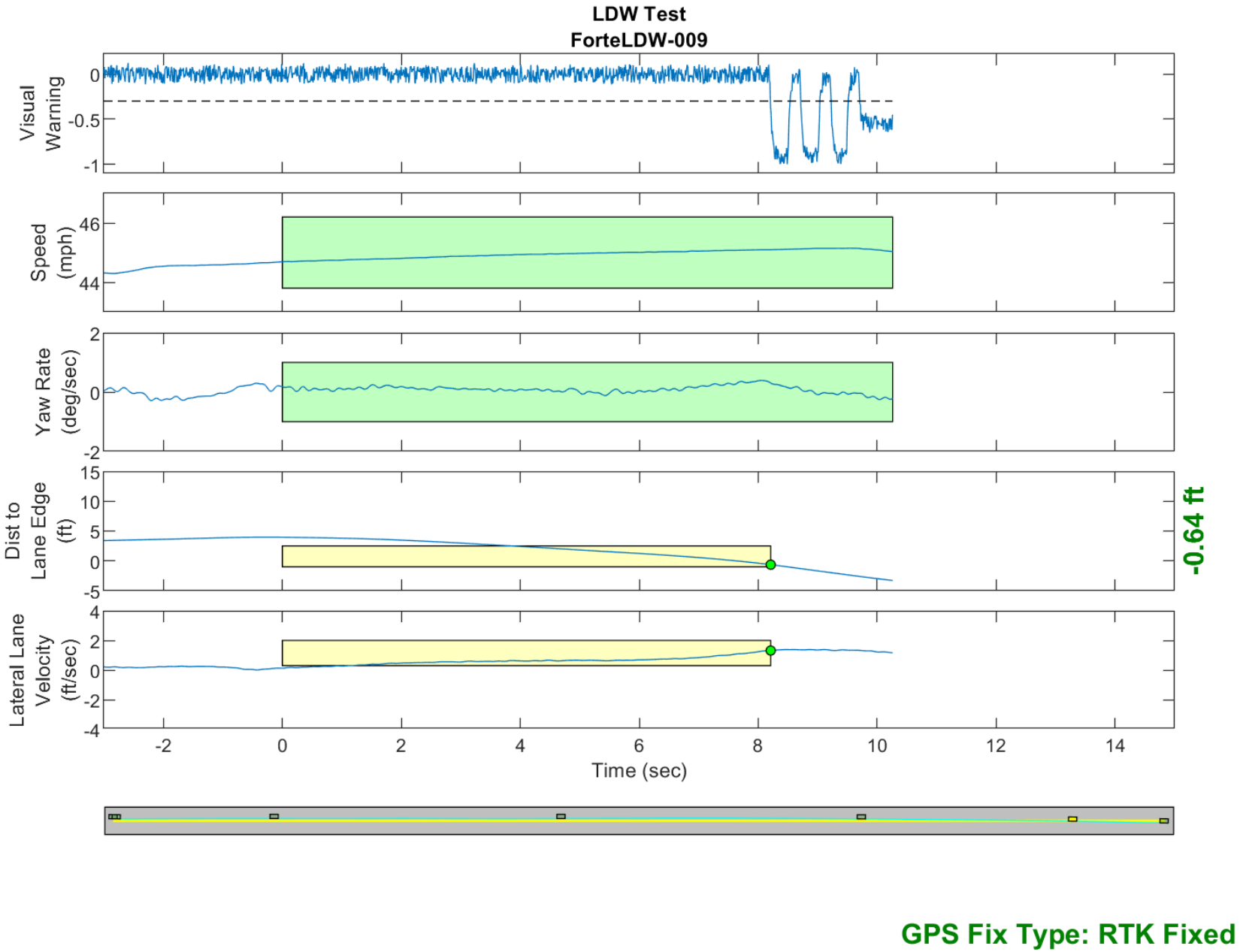


Figure D21. Time History for Run 09, Solid Line, Right Departure, Visual Warning

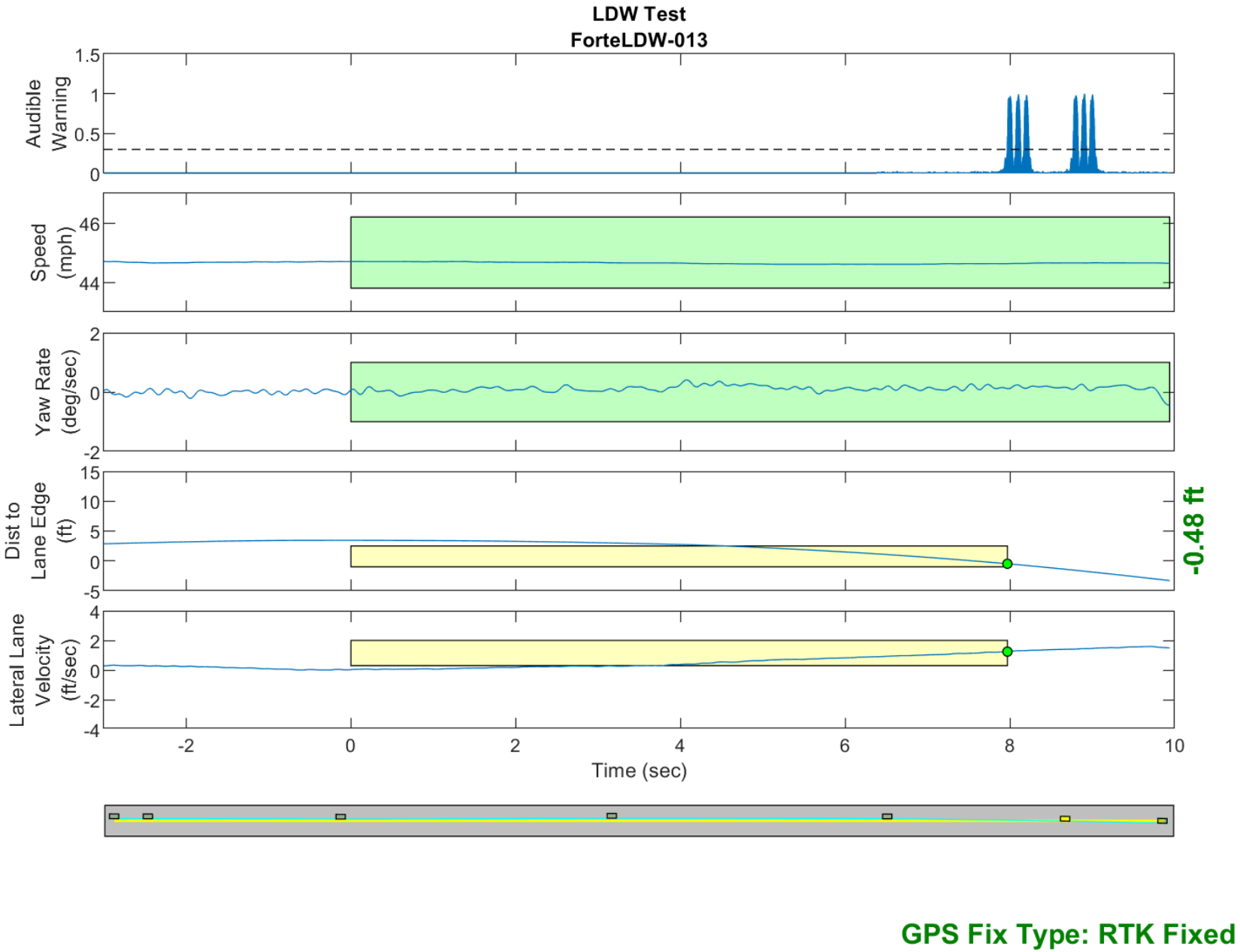


Figure D22. Time History for Run 13, Solid Line, Right Departure, Auditory Warning

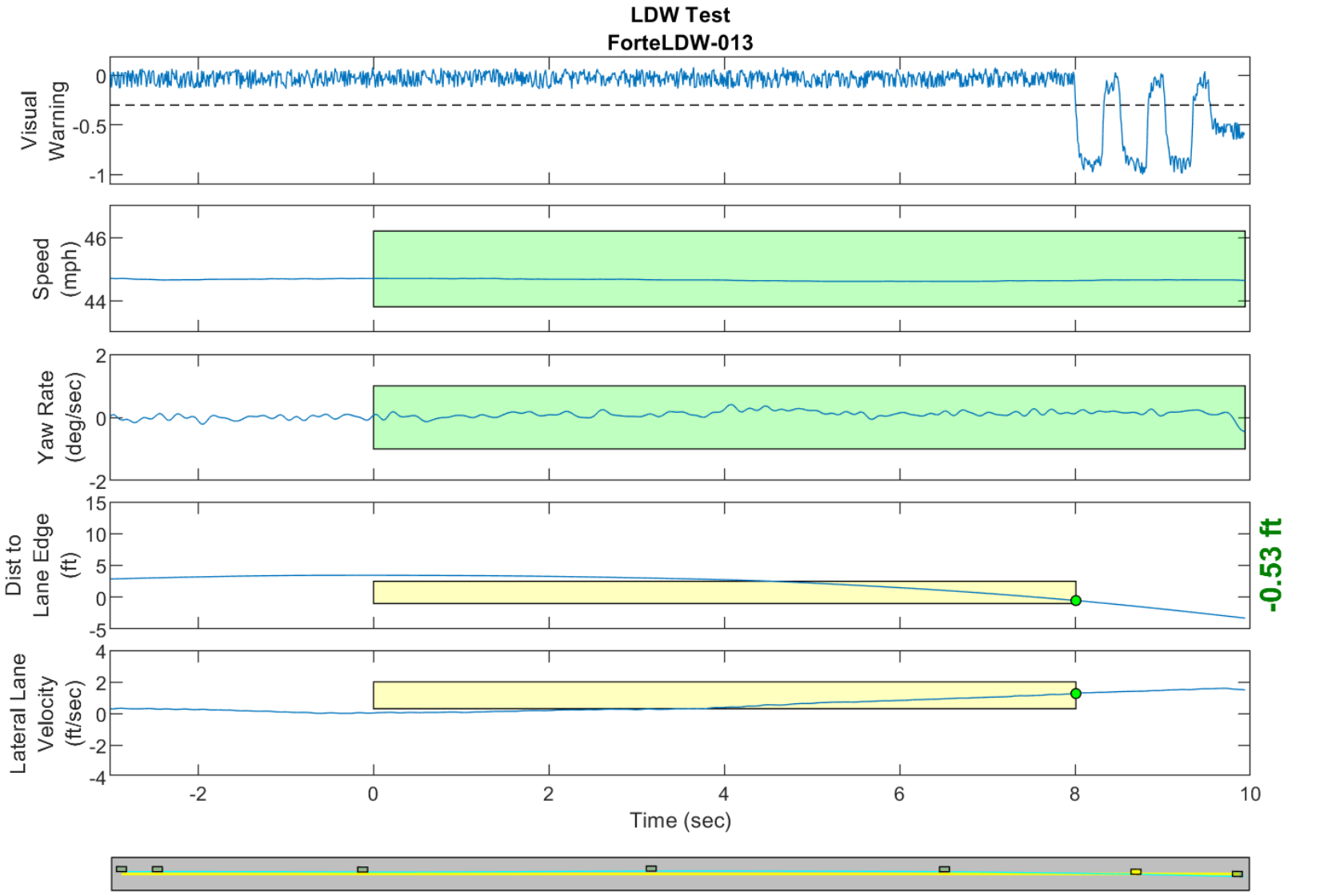


Figure D23. Time History for Run 13, Solid Line, Right Departure, Visual Warning

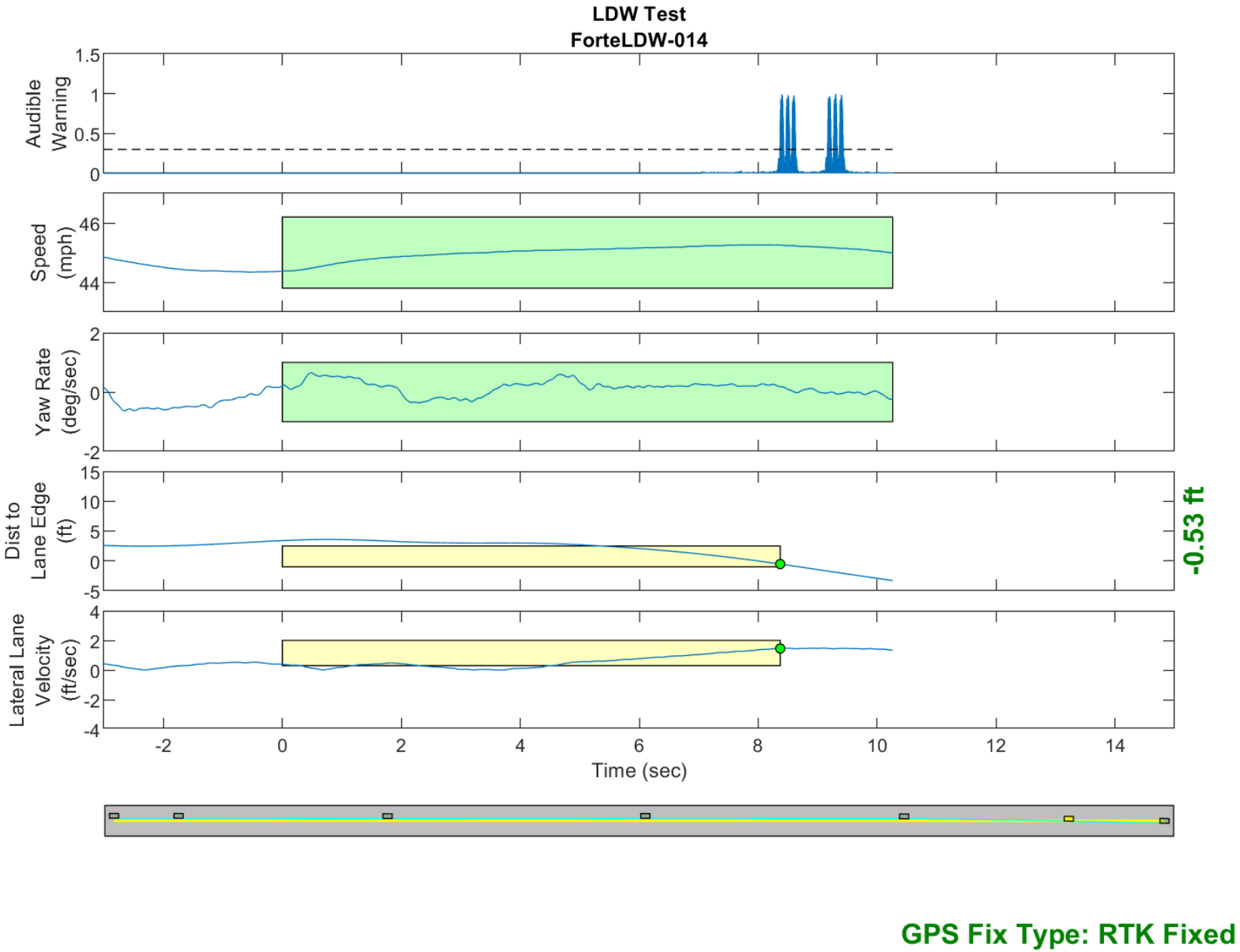


Figure D24. Time History for Run 14, Solid Line, Right Departure, Auditory Warning

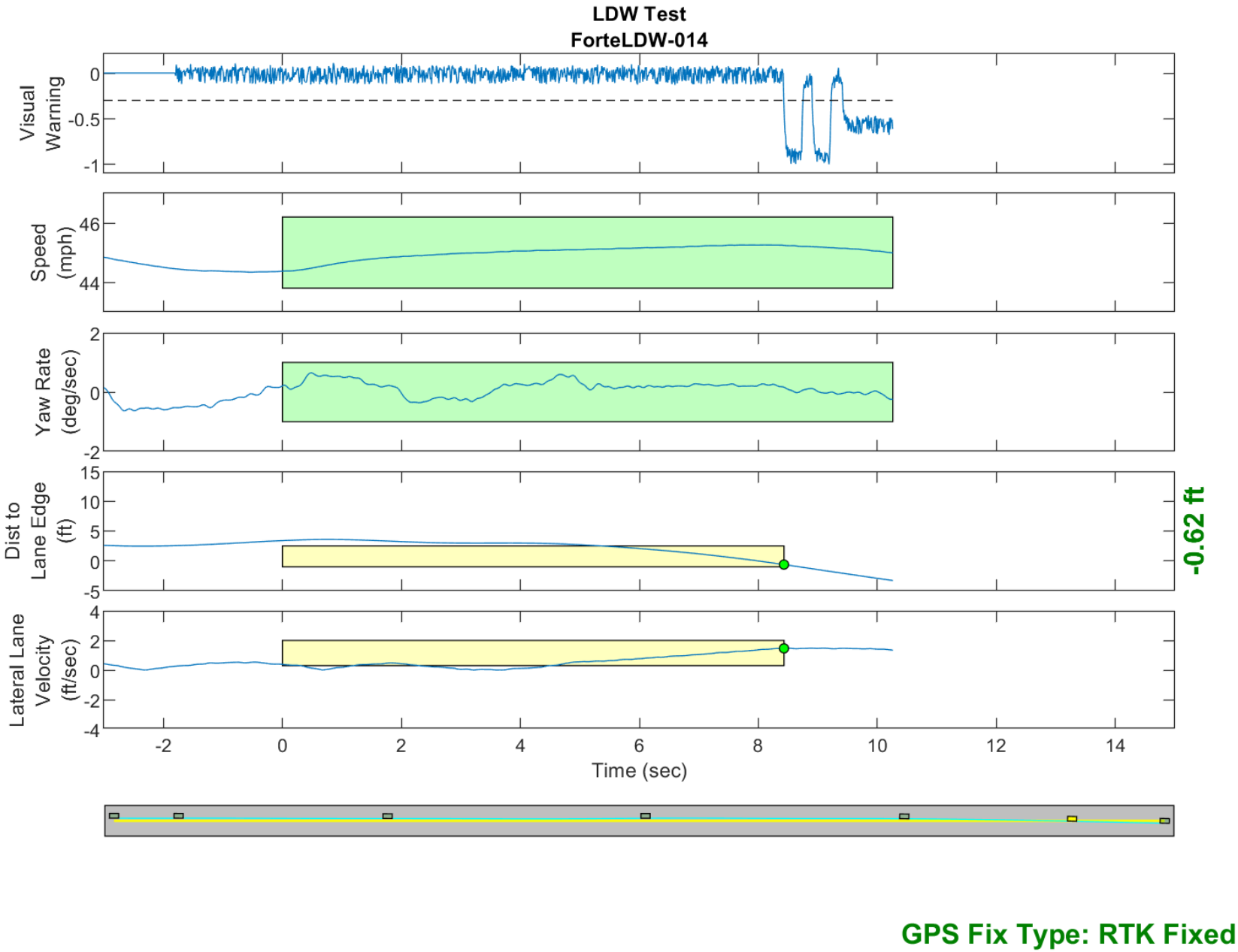


Figure D25. Time History for Run 14, Solid Line, Right Departure, Visual Warning

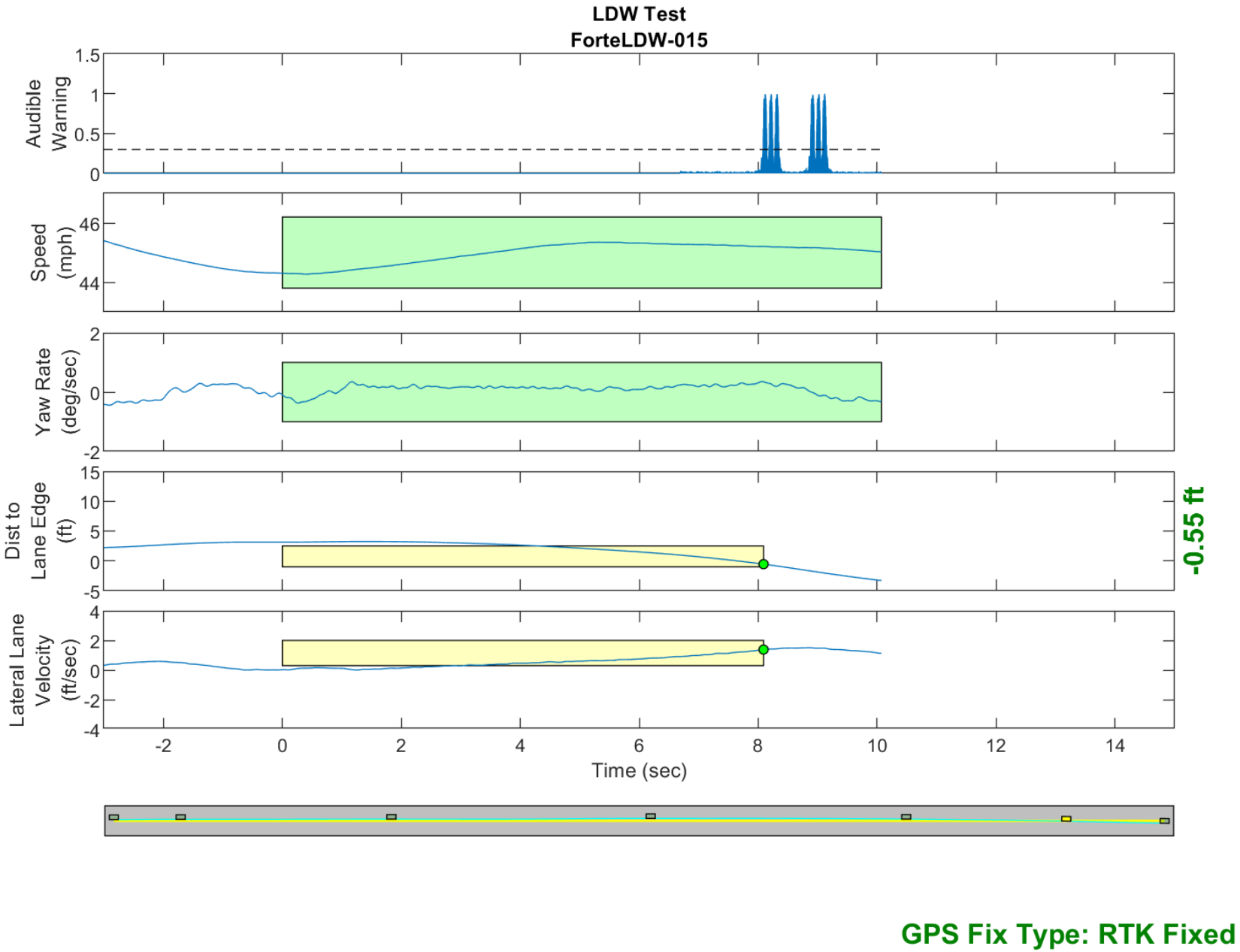


Figure D26. Time History for Run 15, Solid Line, Right Departure, Auditory Warning

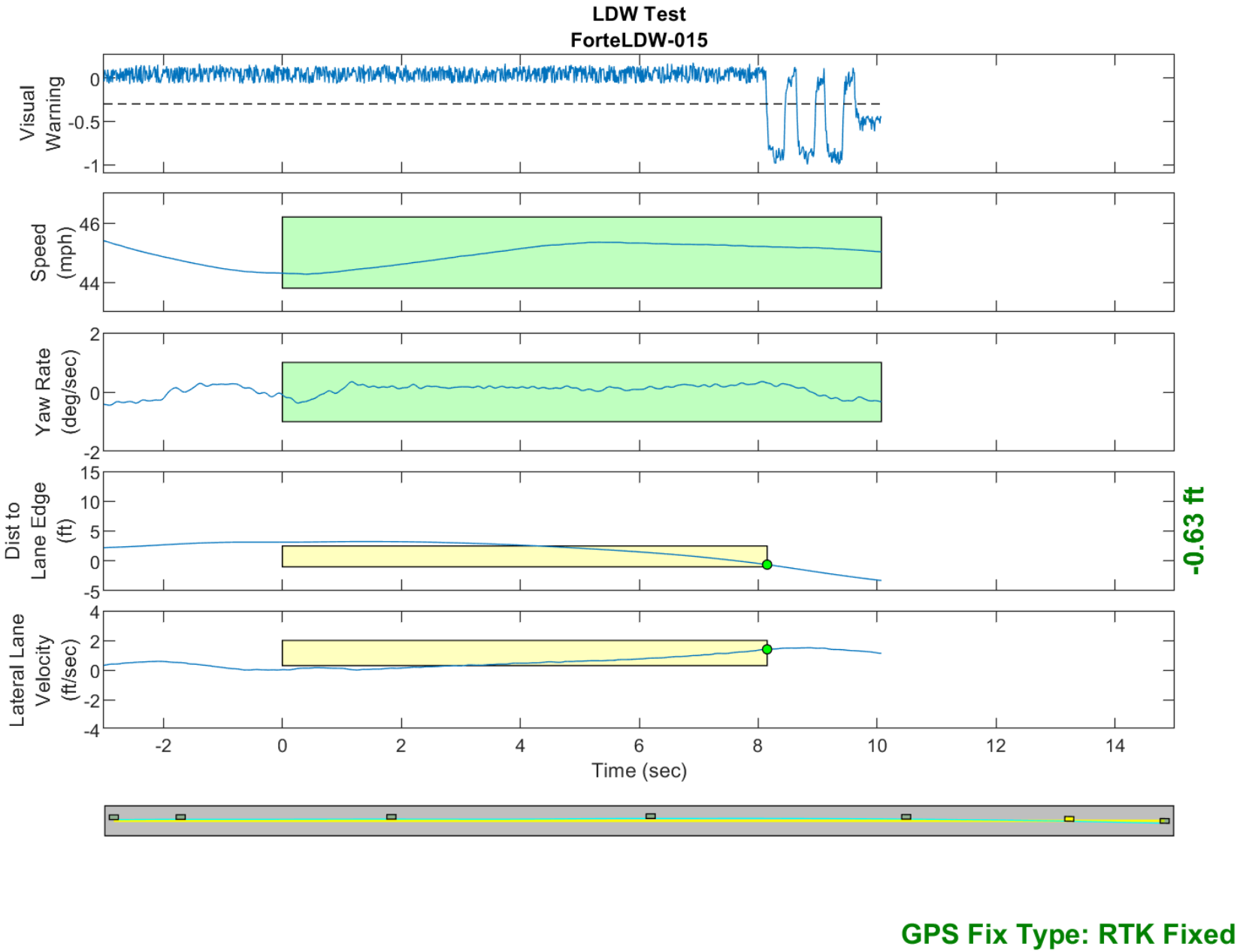


Figure D27. Time History for Run 15, Solid Line, Right Departure, Visual Warning

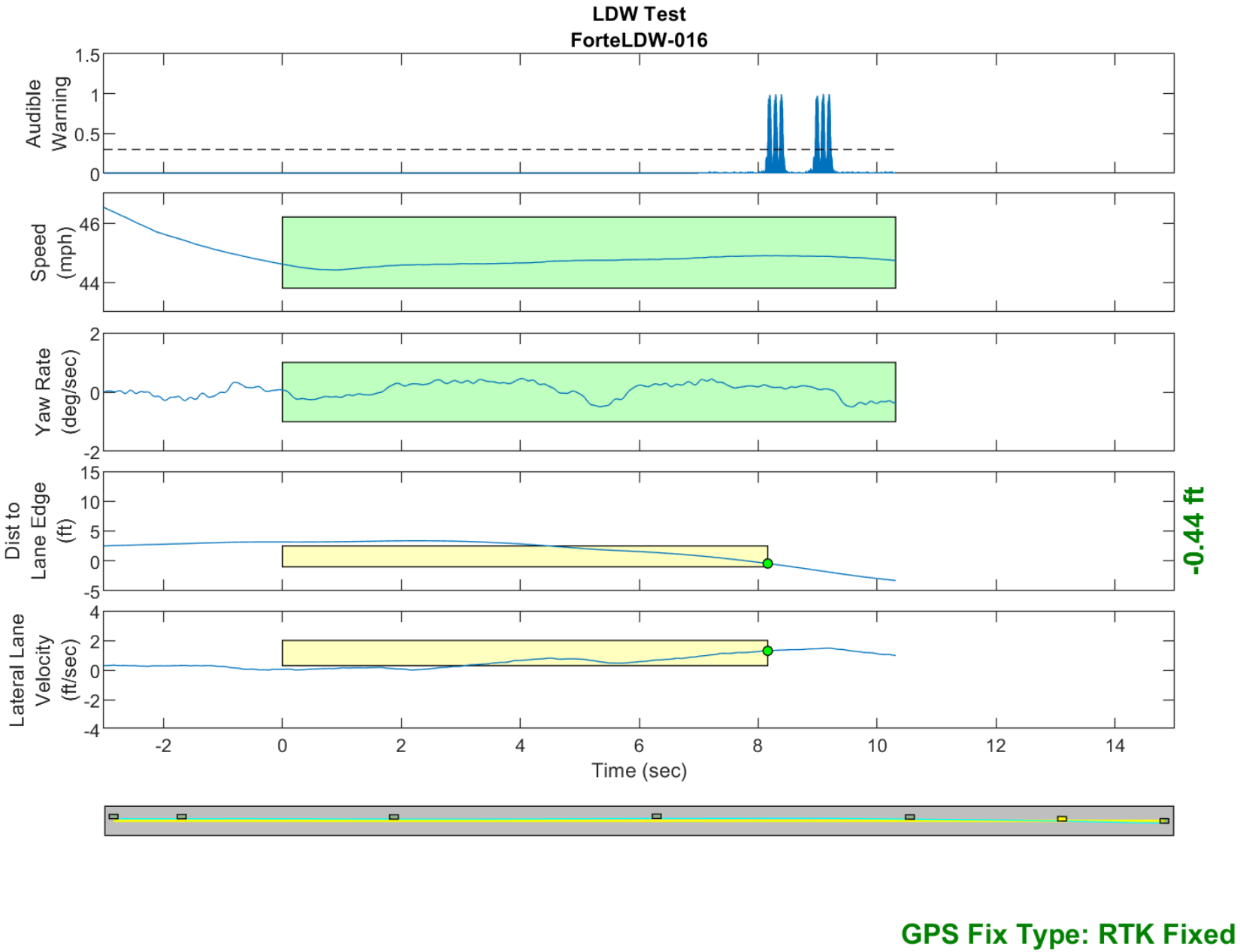


Figure D28. Time History for Run 16, Solid Line, Right Departure, Auditory Warning

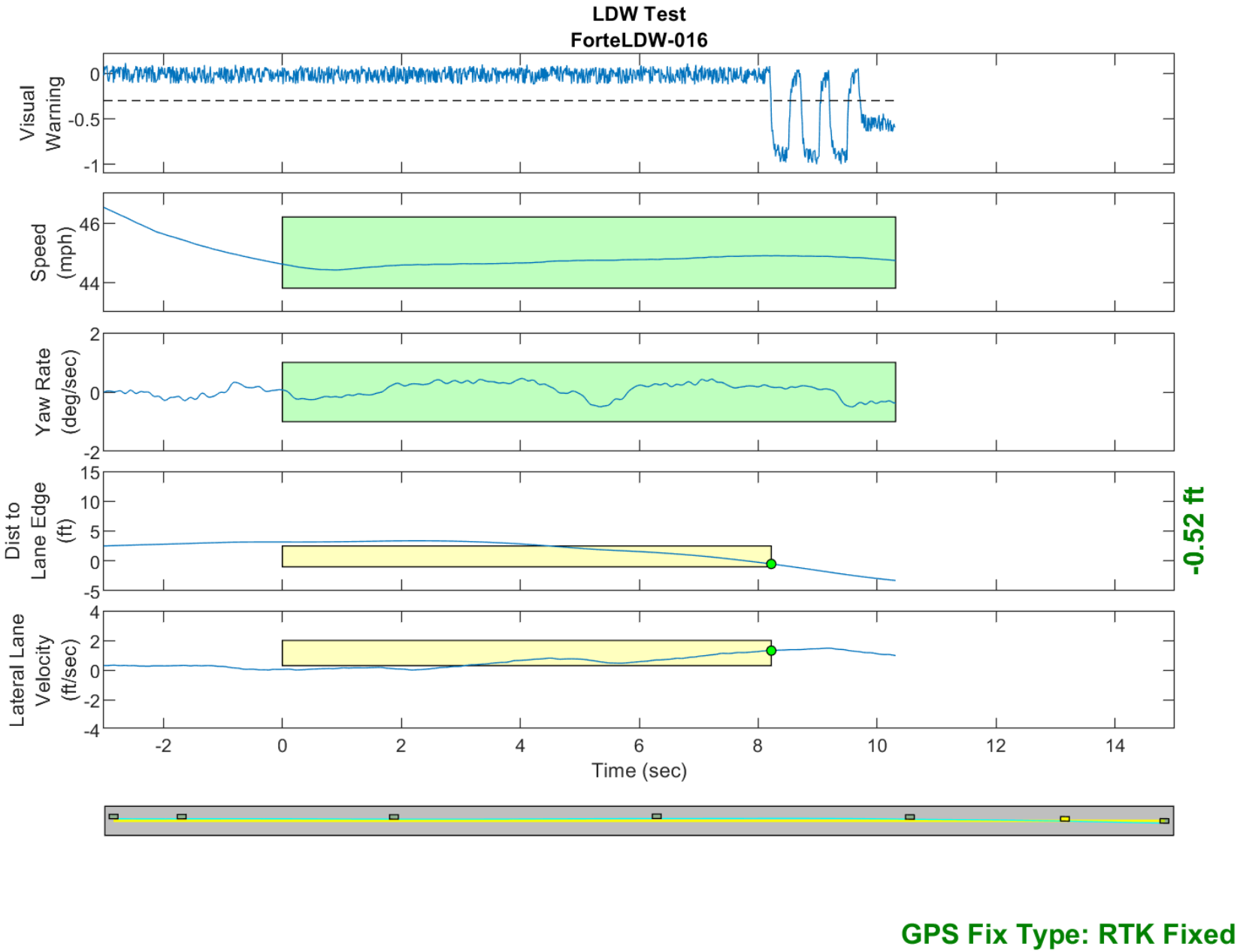


Figure D29. Time History for Run 16, Solid Line, Right Departure, Visual Warning

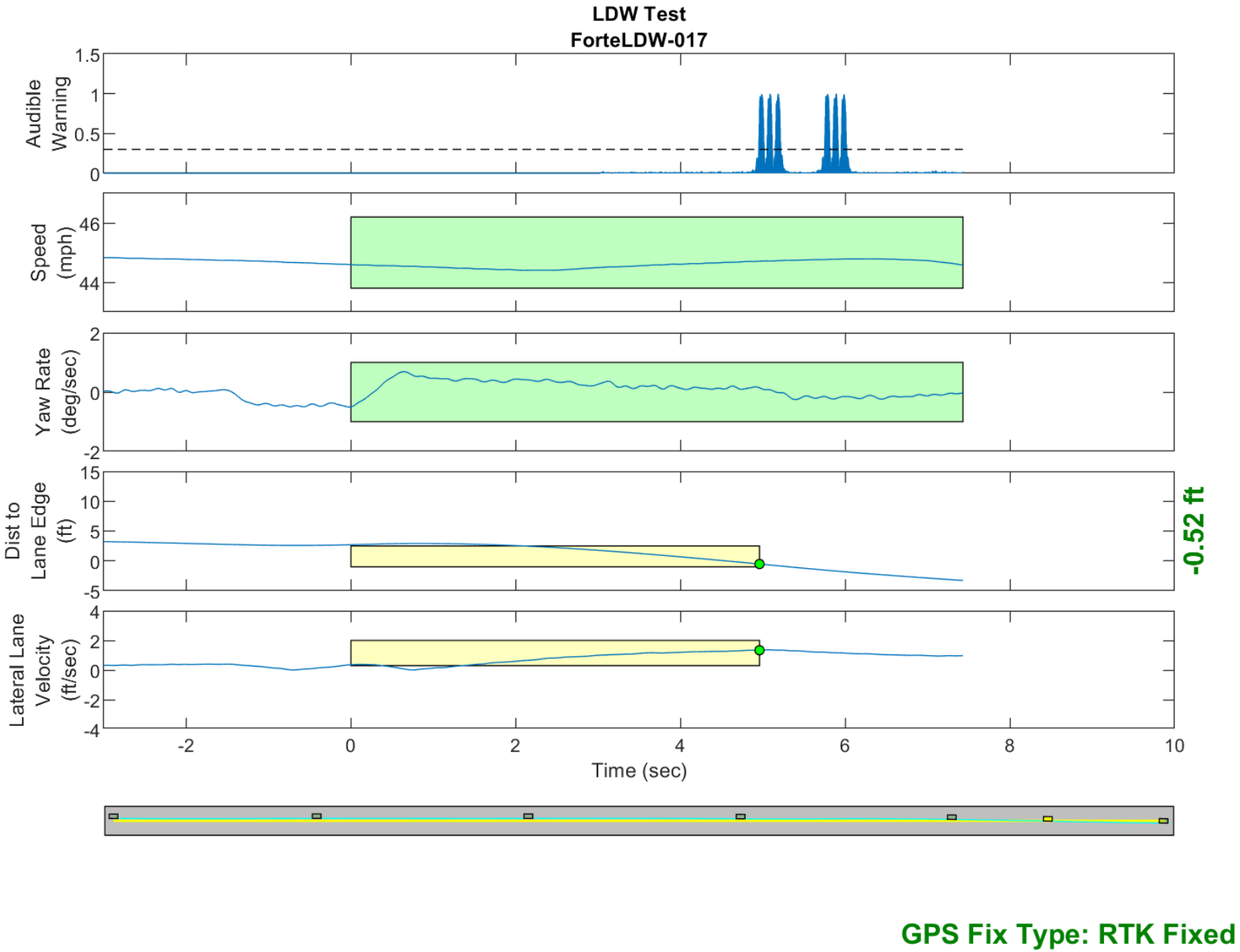


Figure D30. Time History for Run 17, Dashed Line, Right Departure, Auditory Warning

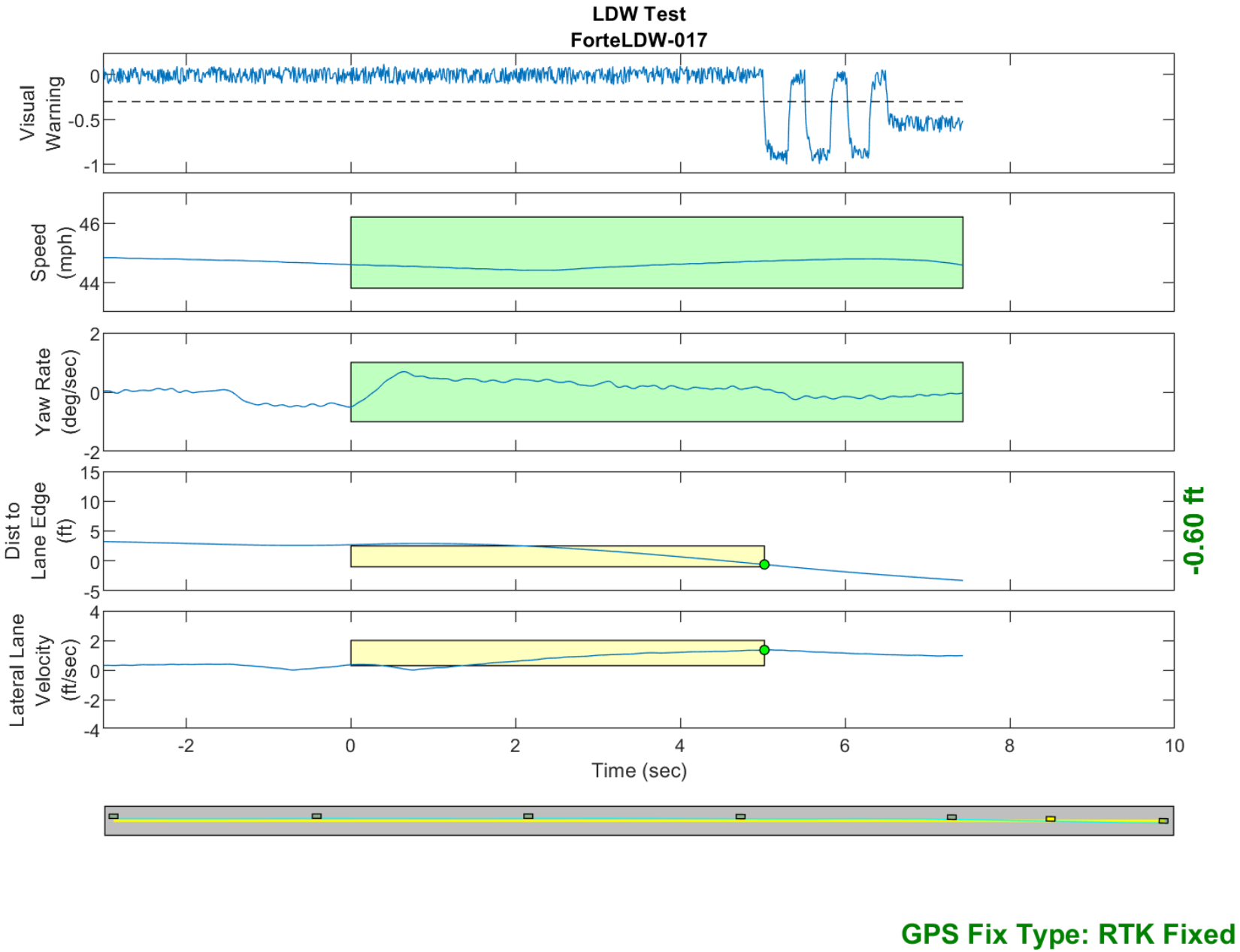


Figure D31. Time History for Run 17, Dashed Line, Right Departure, Visual Warning

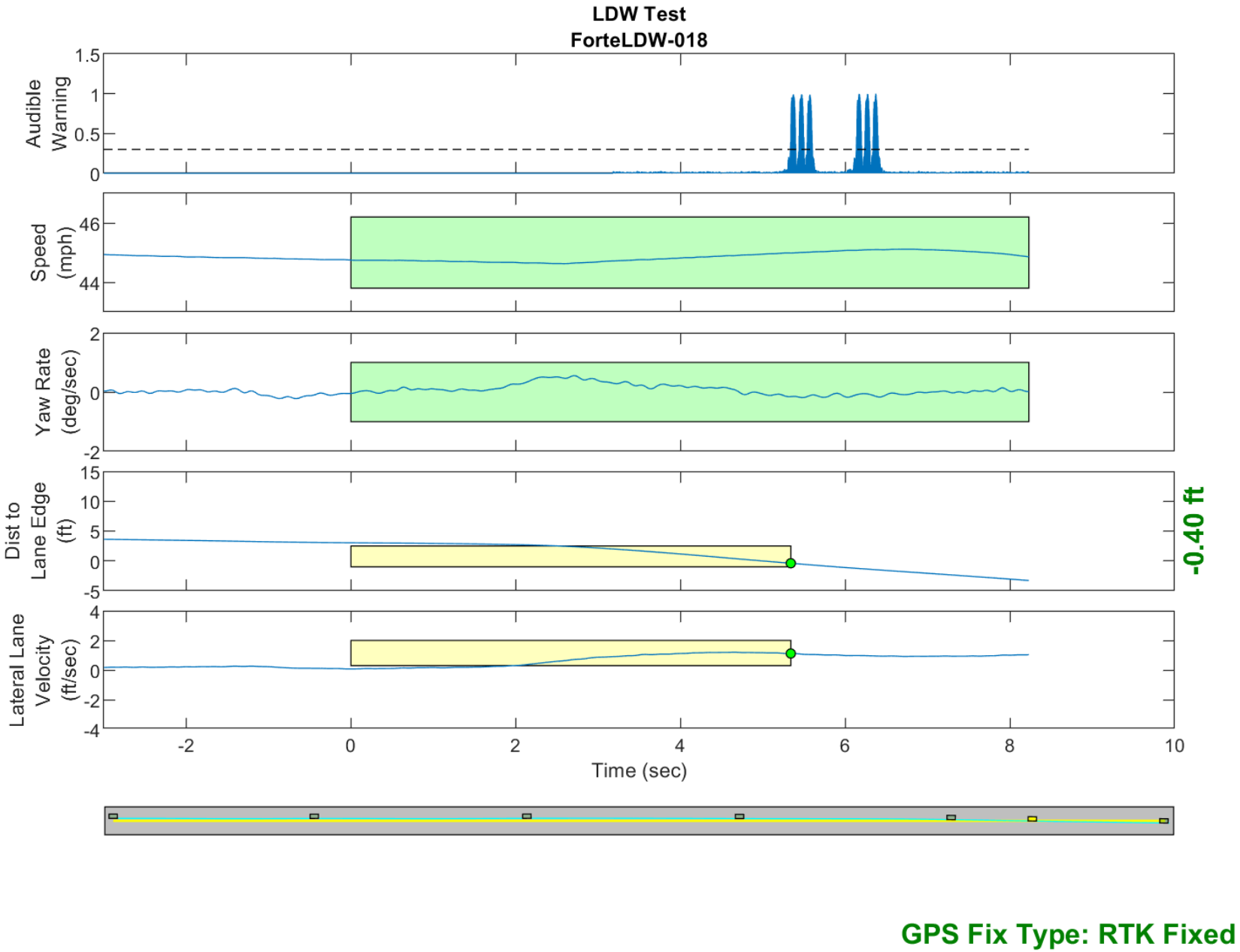


Figure D32. Time History for Run 18, Dashed Line, Right Departure, Auditory Warning

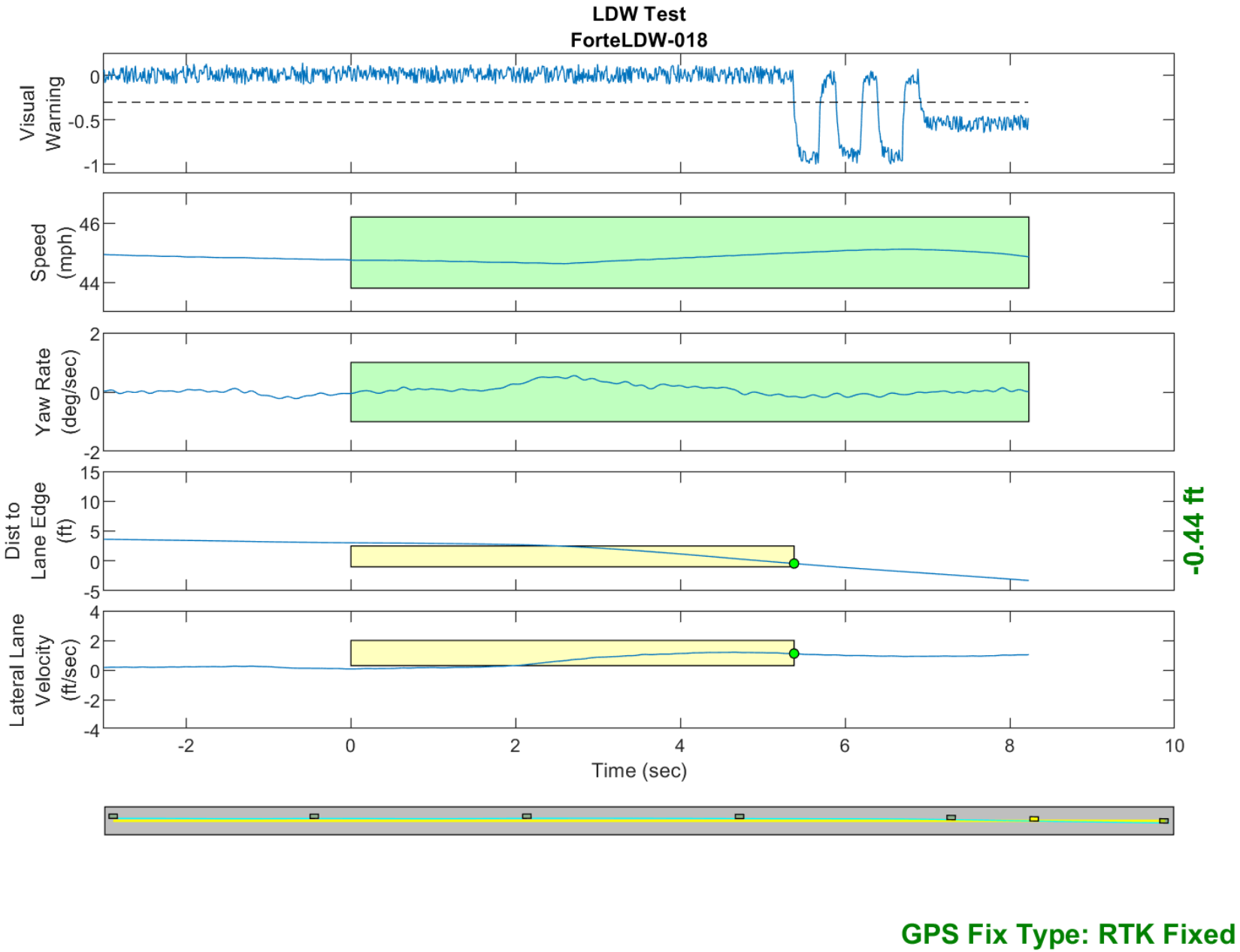


Figure D33. Time History for Run 18, Dashed Line, Right Departure, Visual Warning

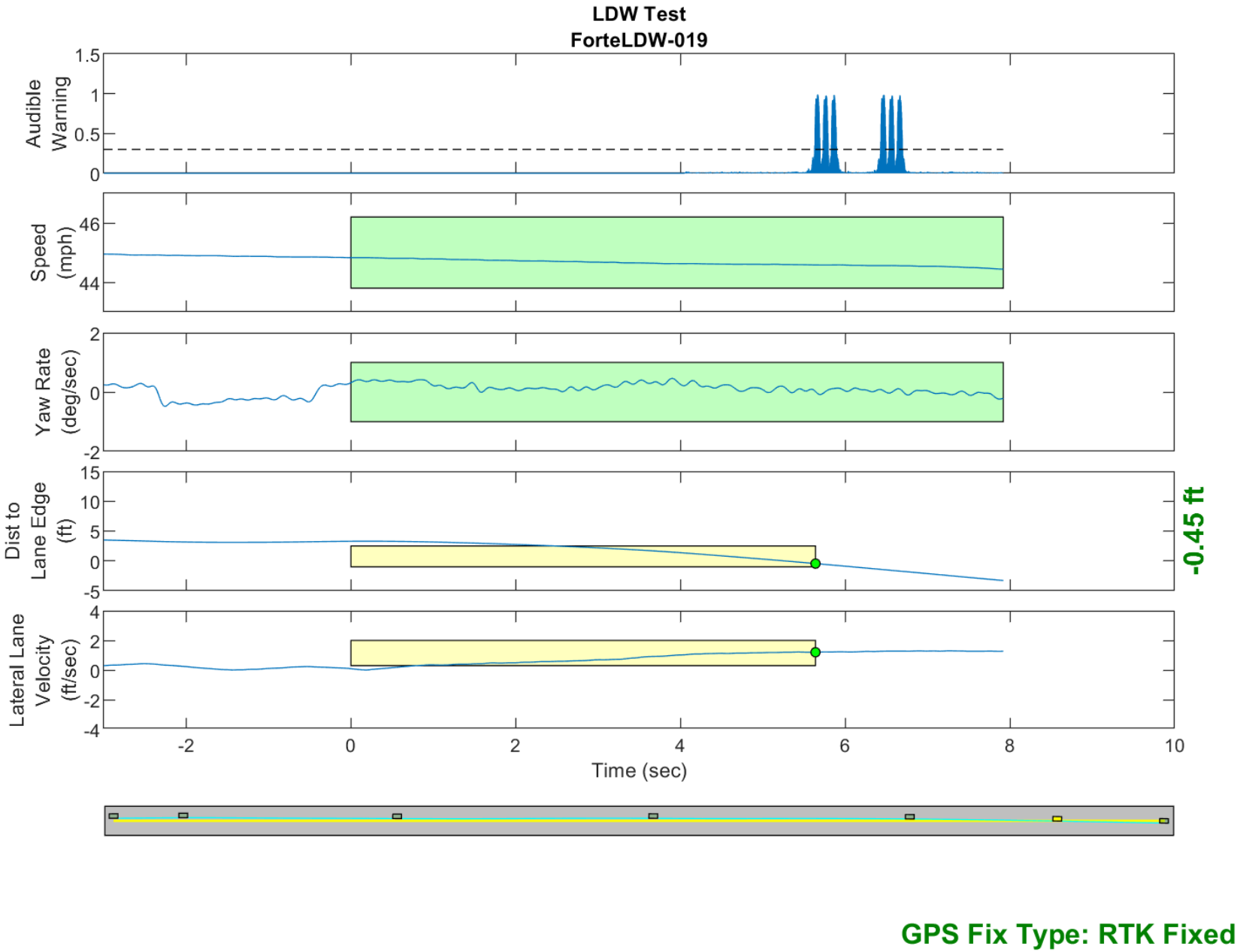


Figure D34. Time History for Run 19, Dashed Line, Right Departure, Auditory Warning

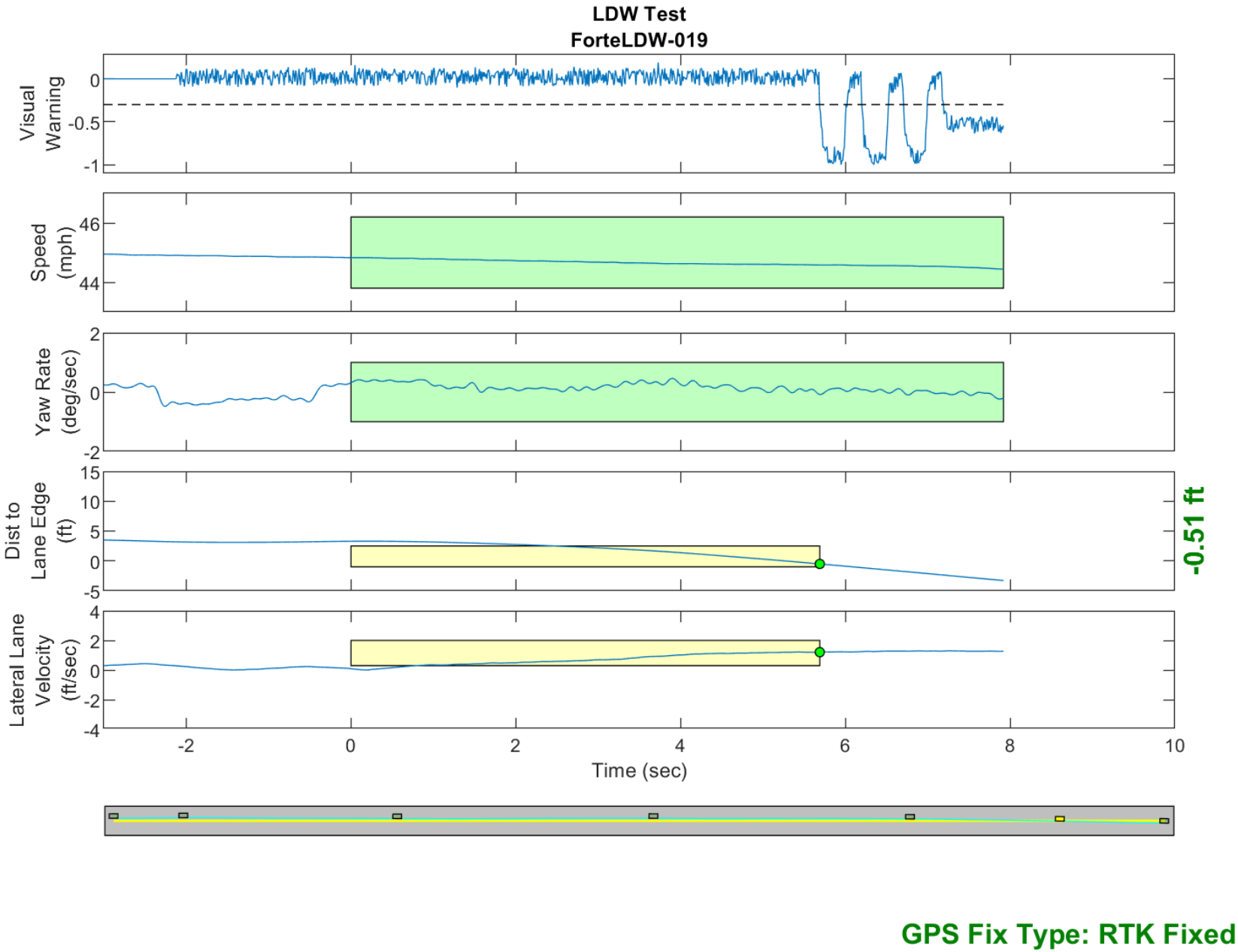


Figure D35. Time History for Run 19, Dashed Line, Right Departure, Visual Warning

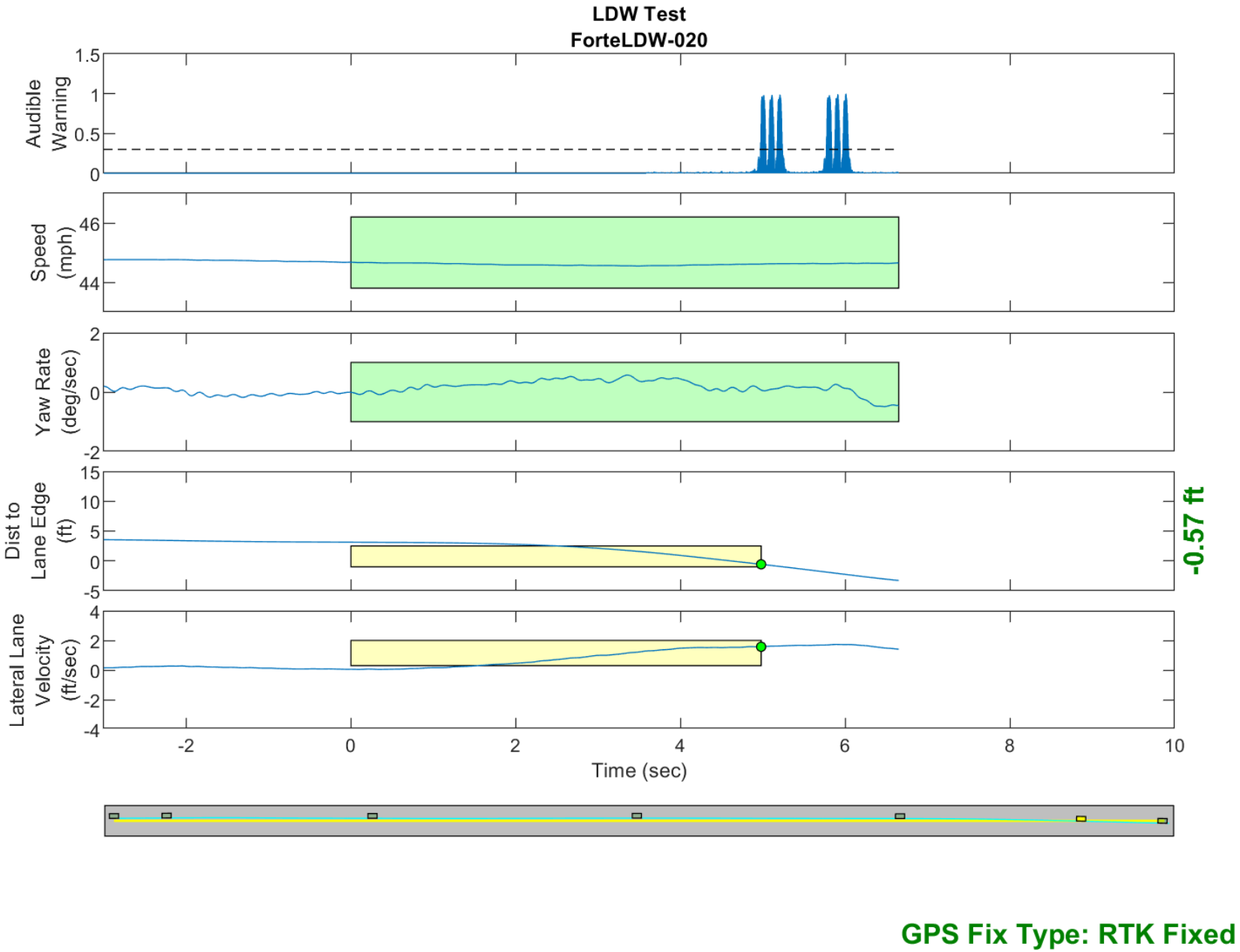


Figure D36. Time History for Run 20, Dashed Line, Right Departure, Auditory Warning

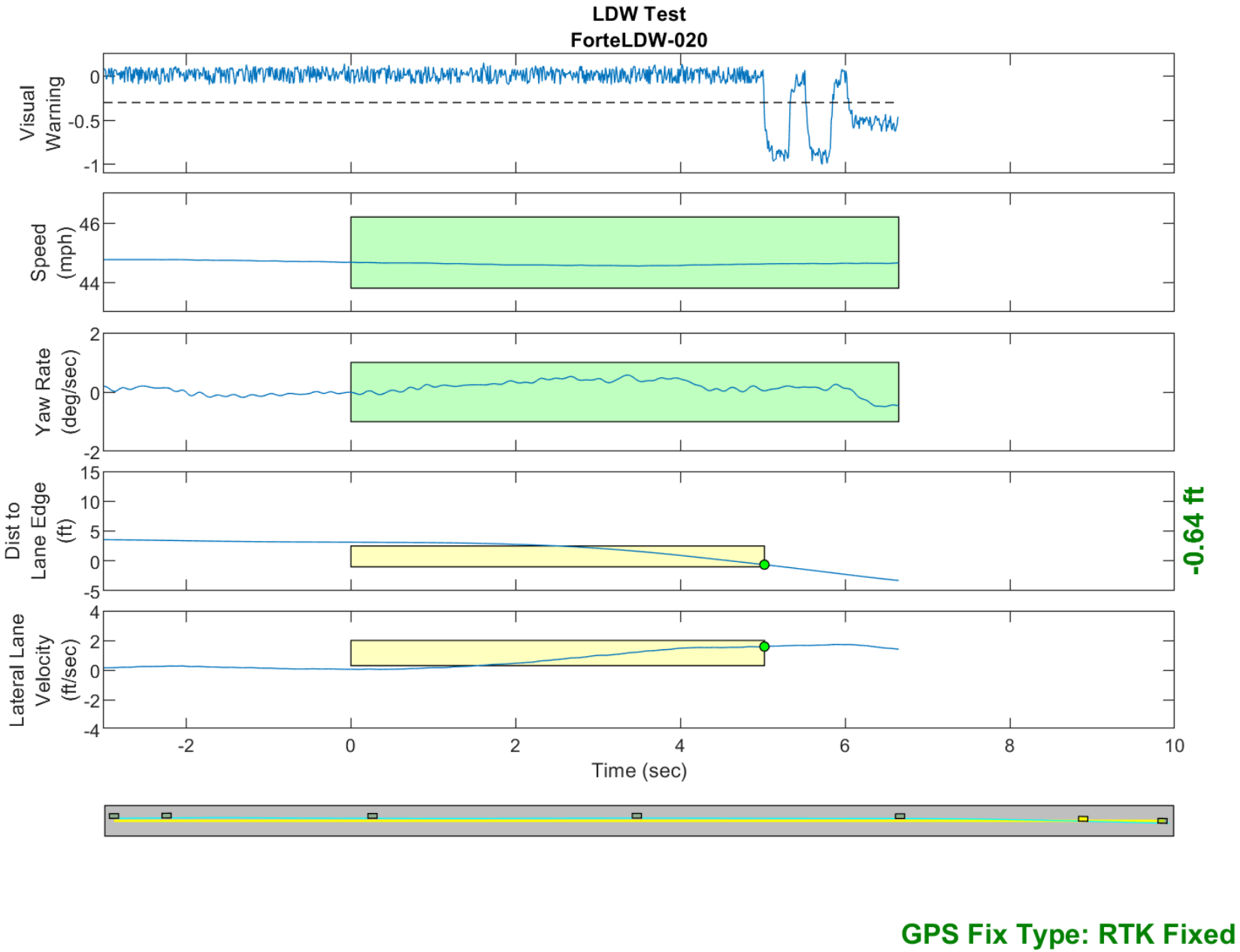


Figure D37. Time History for Run 20, Dashed Line, Right Departure, Visual Warning

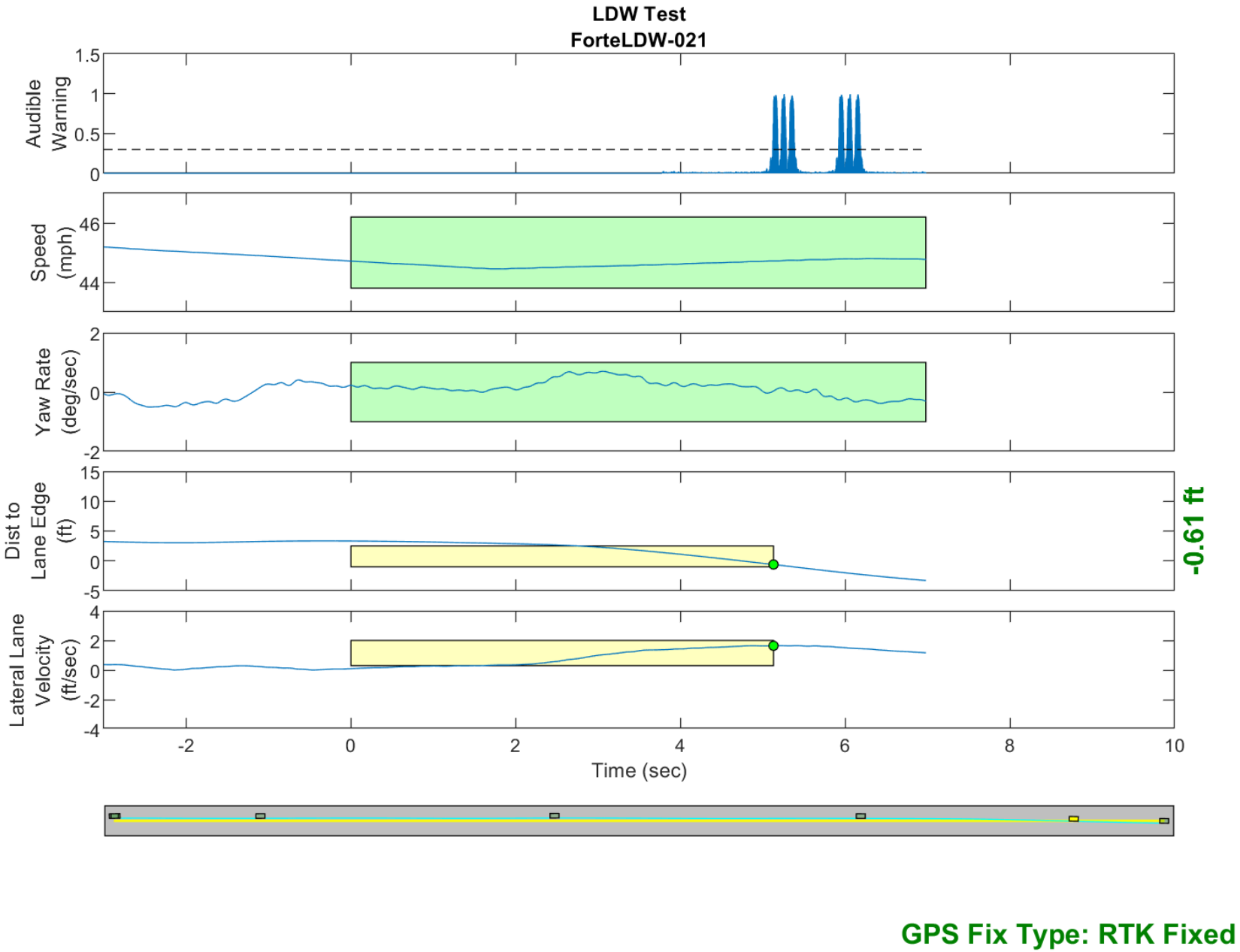


Figure D38. Time History for Run 21, Dashed Line, Right Departure, Auditory Warning

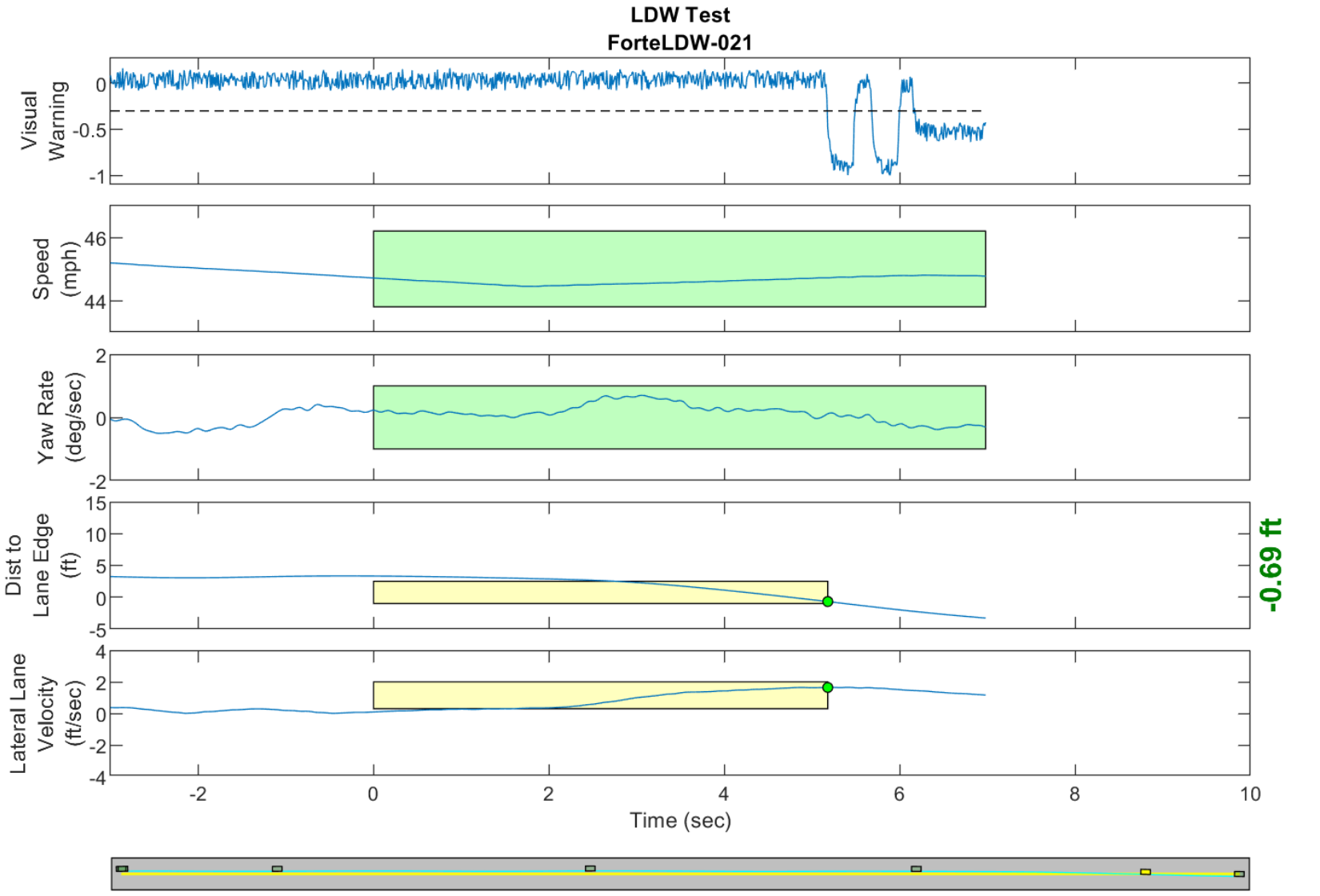


Figure D39. Time History for Run 21, Dashed Line, Right Departure, Visual Warning

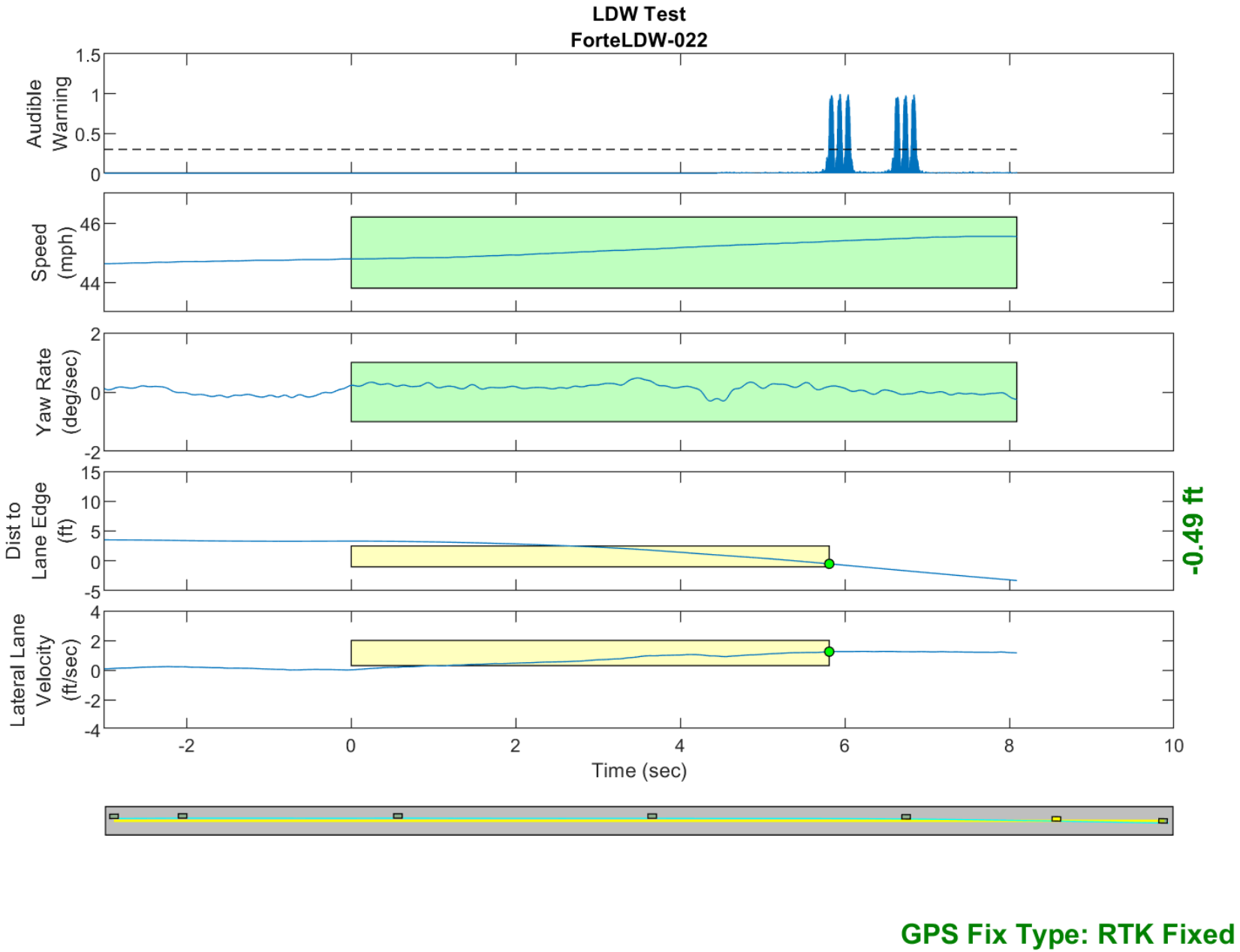
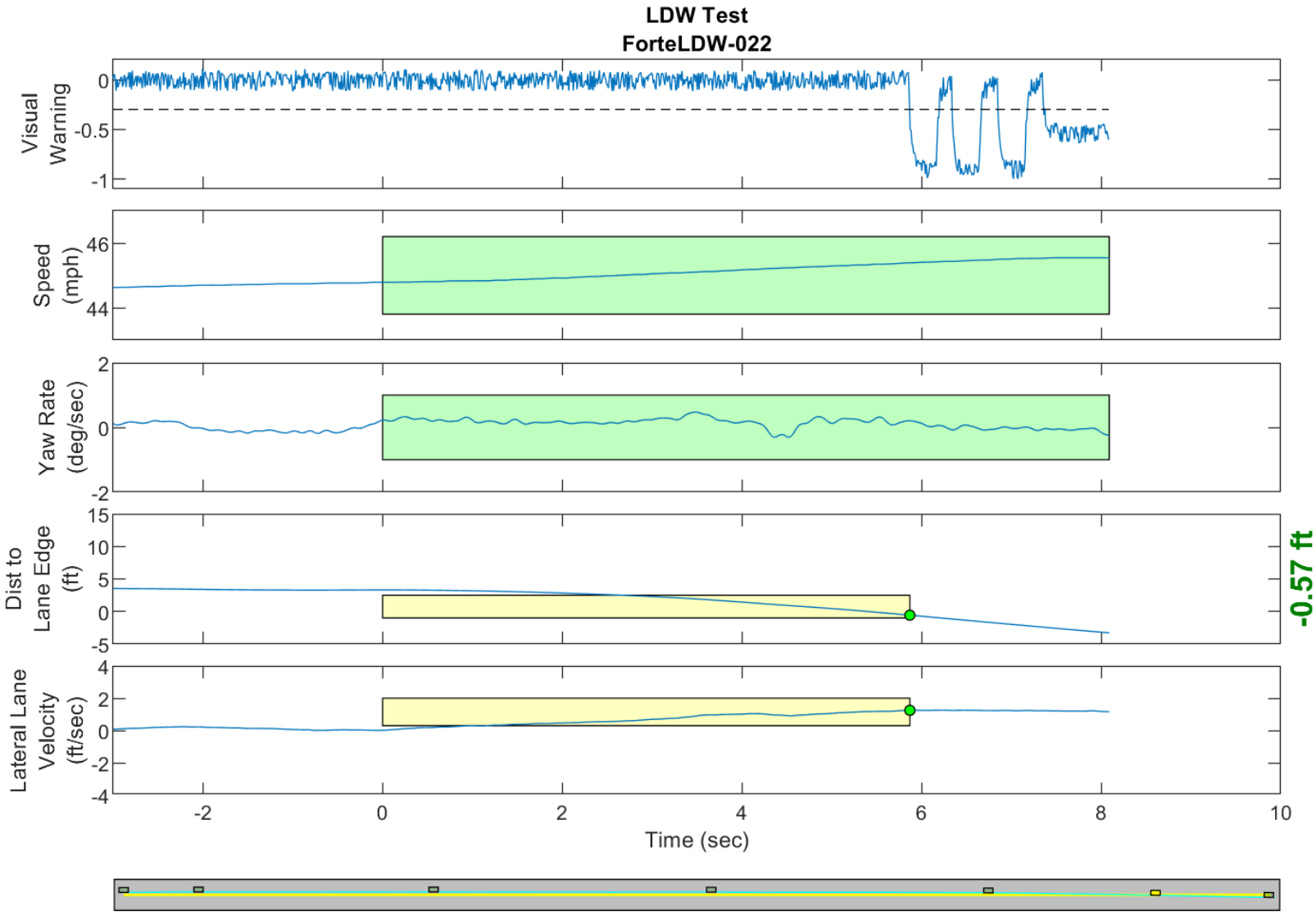


Figure D40. Time History for Run 22, Dashed Line, Right Departure, Auditory Warning



GPS Fix Type: RTK Fixed

Figure D41. Time History for Run 22, Dashed Line, Right Departure, Visual Warning

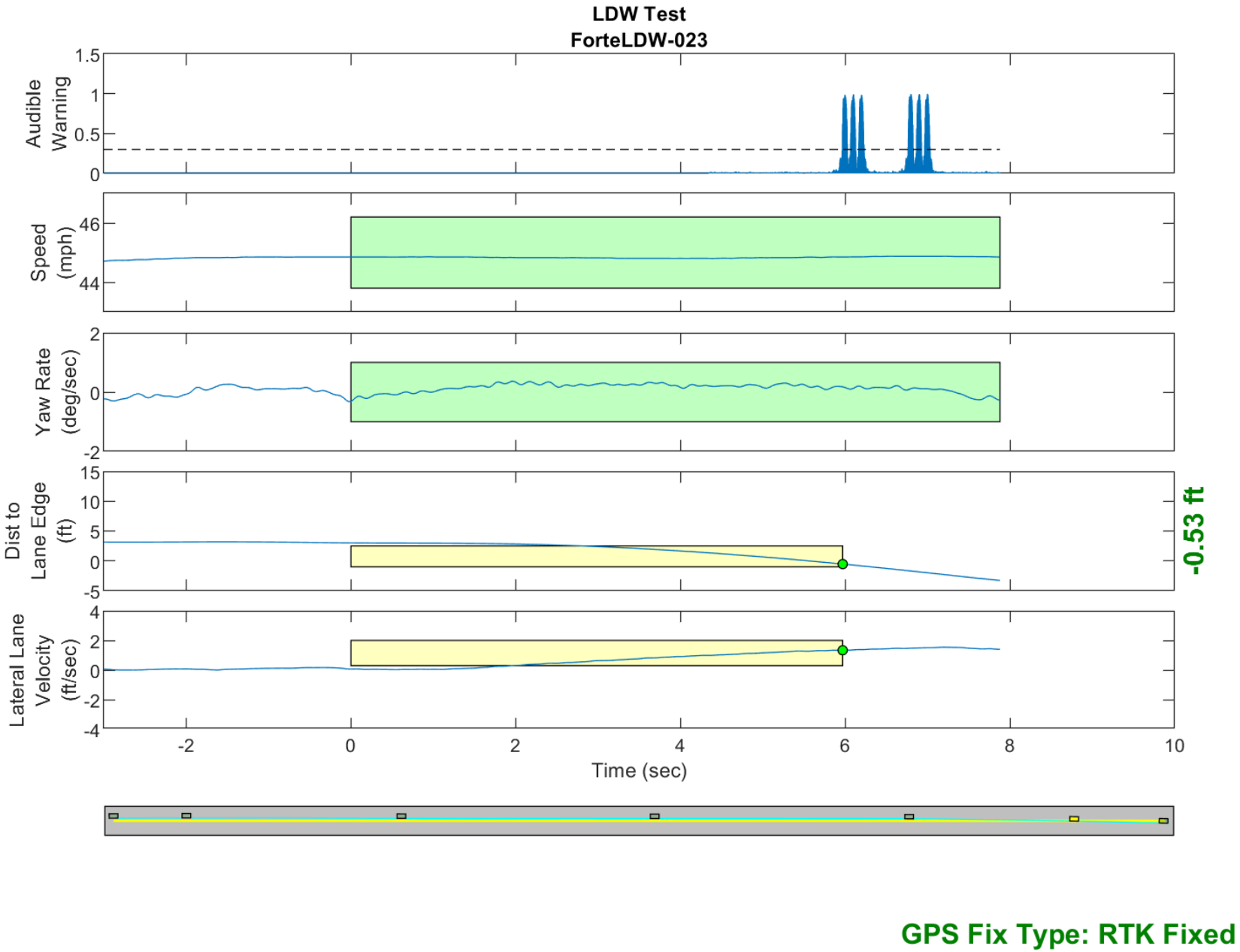


Figure D42. Time History for Run 23, Dashed Line, Right Departure, Auditory Warning

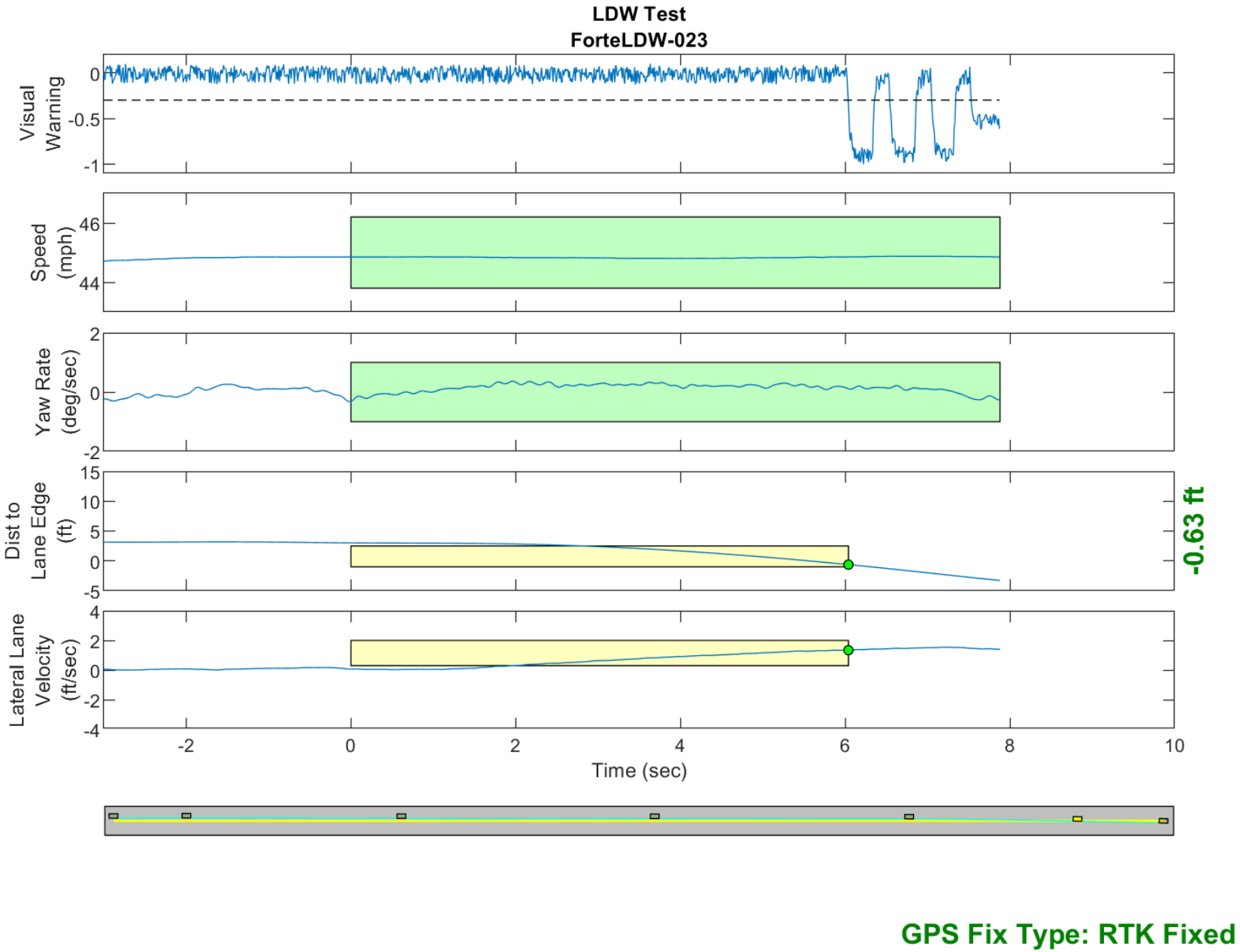


Figure D43. Time History for Run 23, Dashed Line, Right Departure, Visual Warning

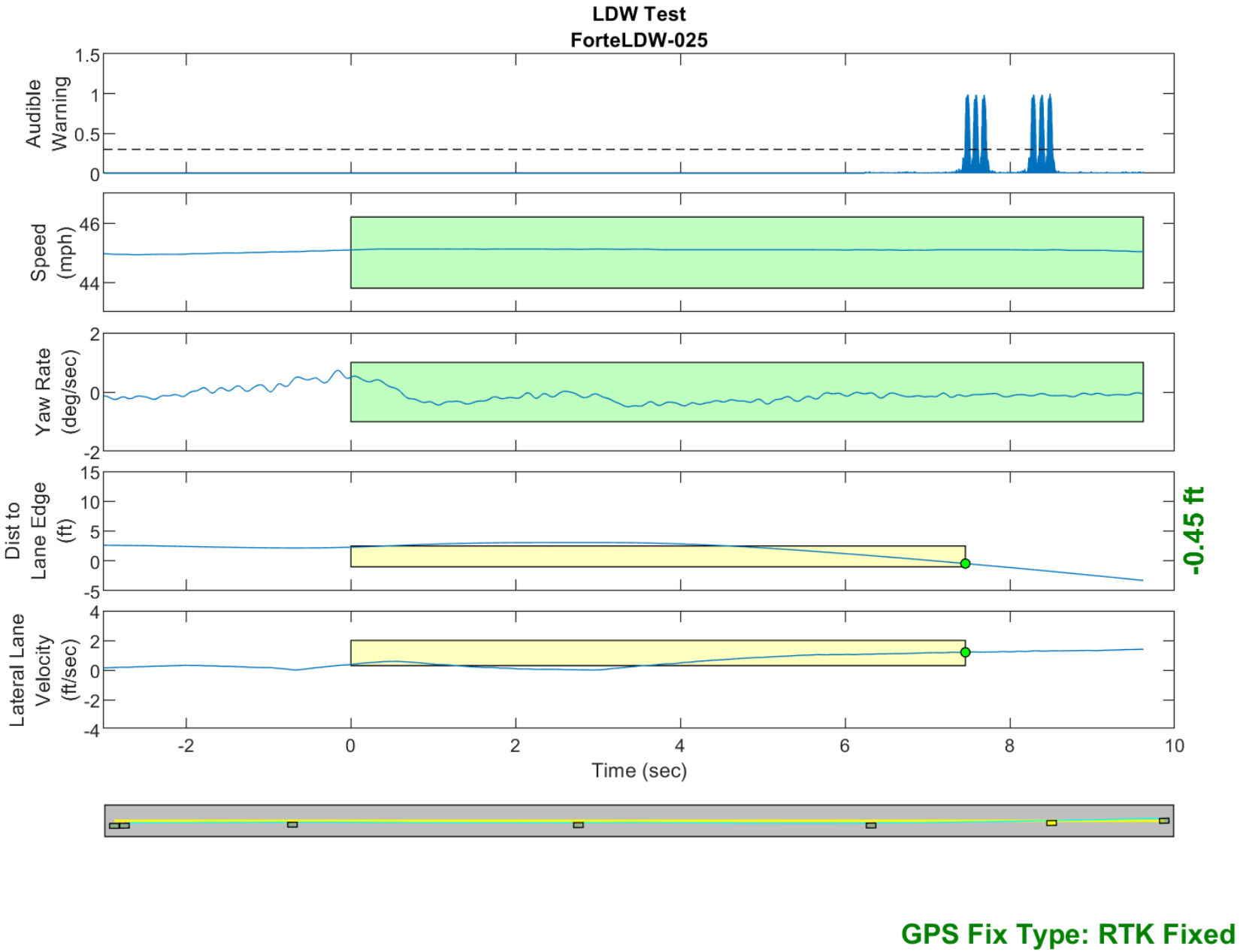


Figure D44. Time History for Run 25, Dashed Line, Left Departure, Auditory Warning

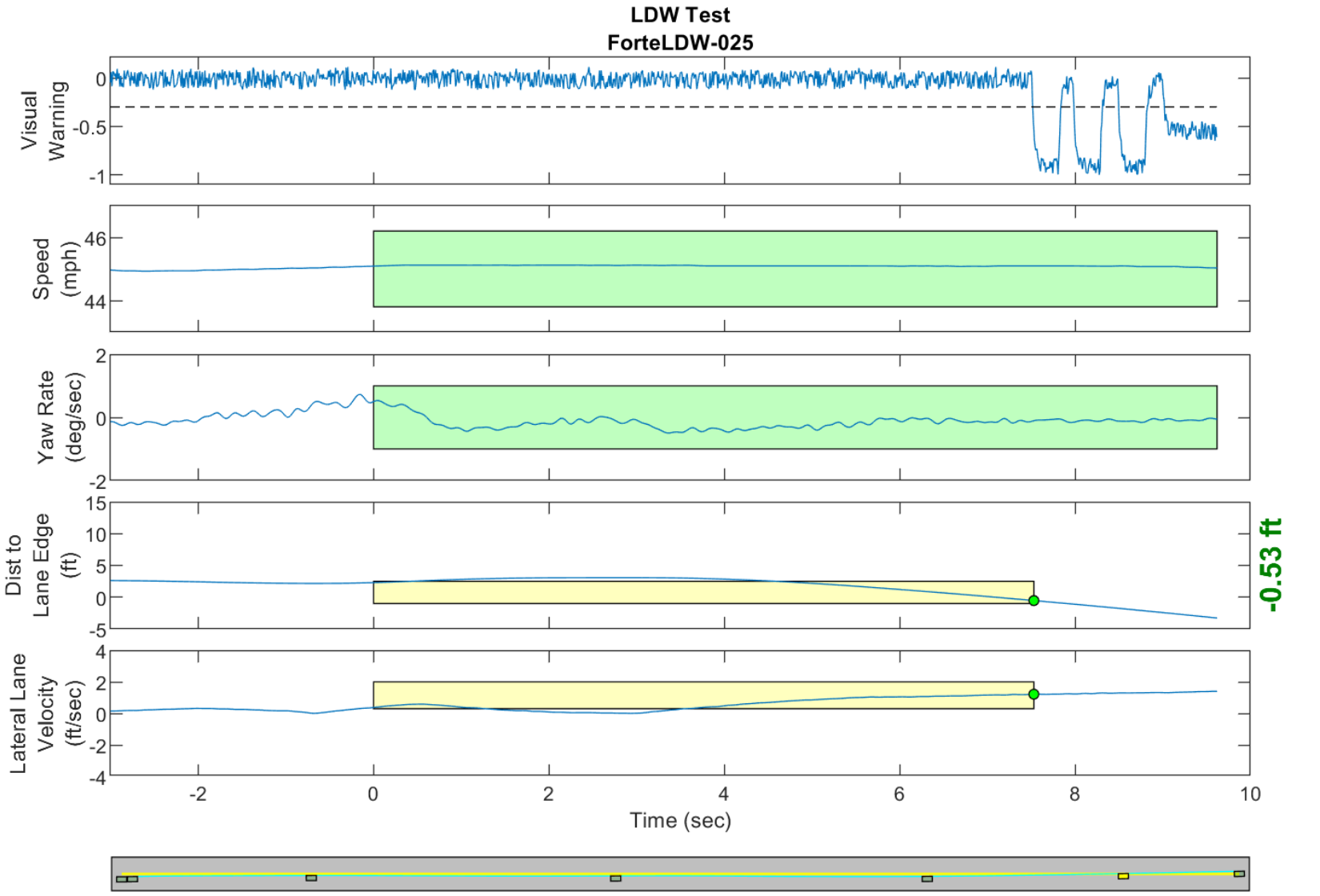


Figure D45. Time History for Run 25, Dashed Line, Left Departure, Visual Warning

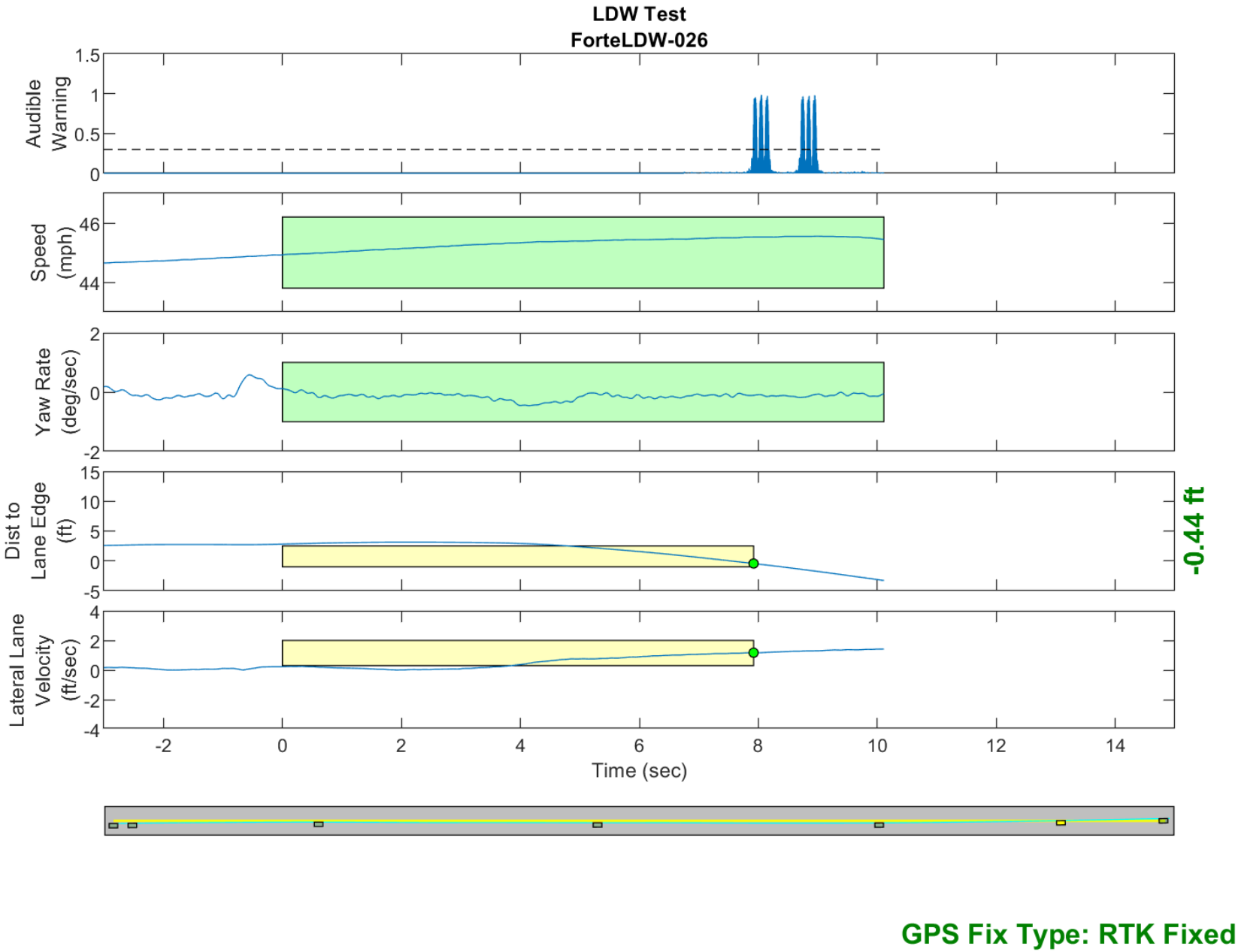


Figure D46. Time History for Run 26, Dashed Line, Left Departure, Auditory Warning

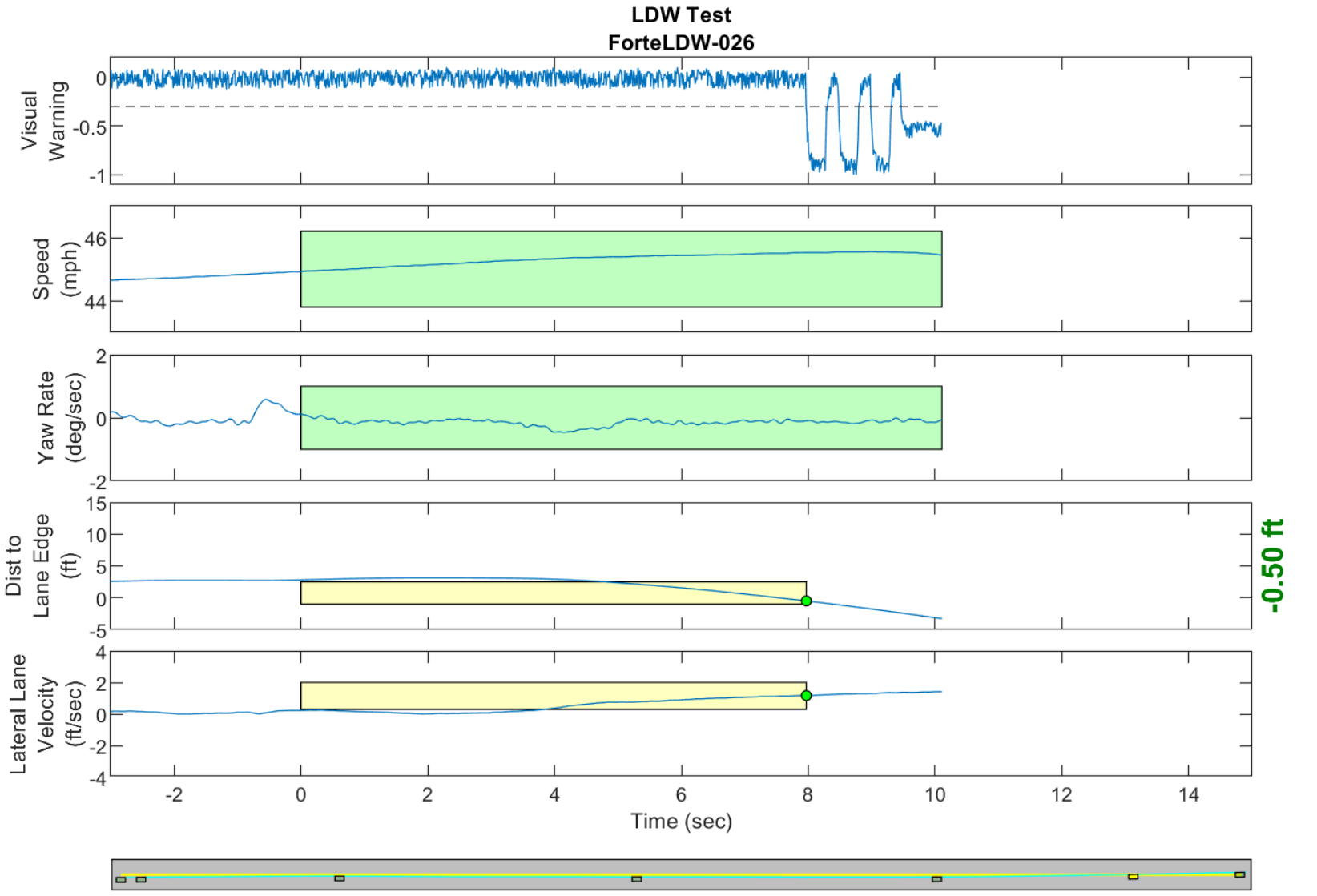


Figure D47. Time History for Run 26, Dashed Line, Left Departure, Visual Warning

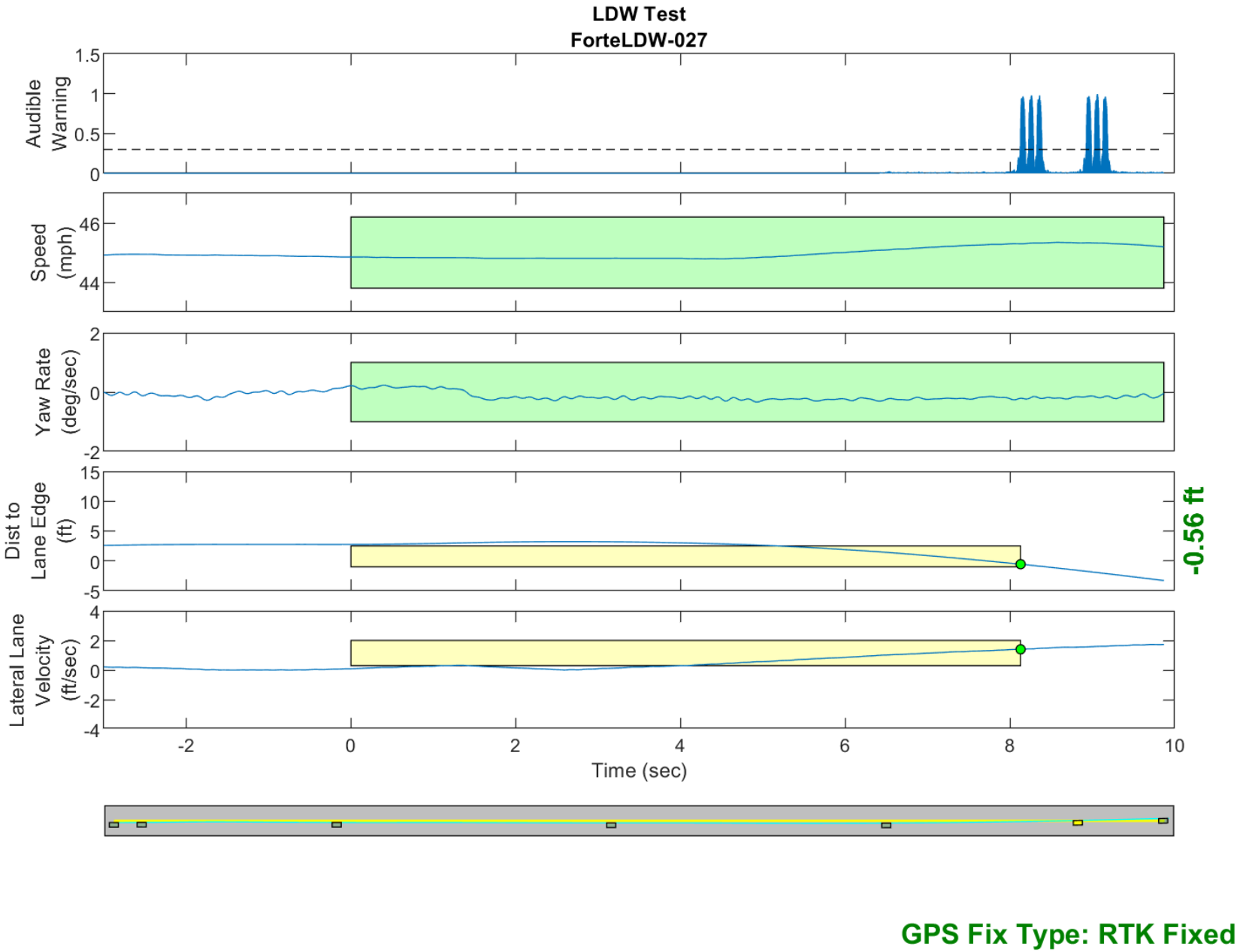


Figure D48. Time History for Run 27, Dashed Line, Left Departure, Auditory Warning

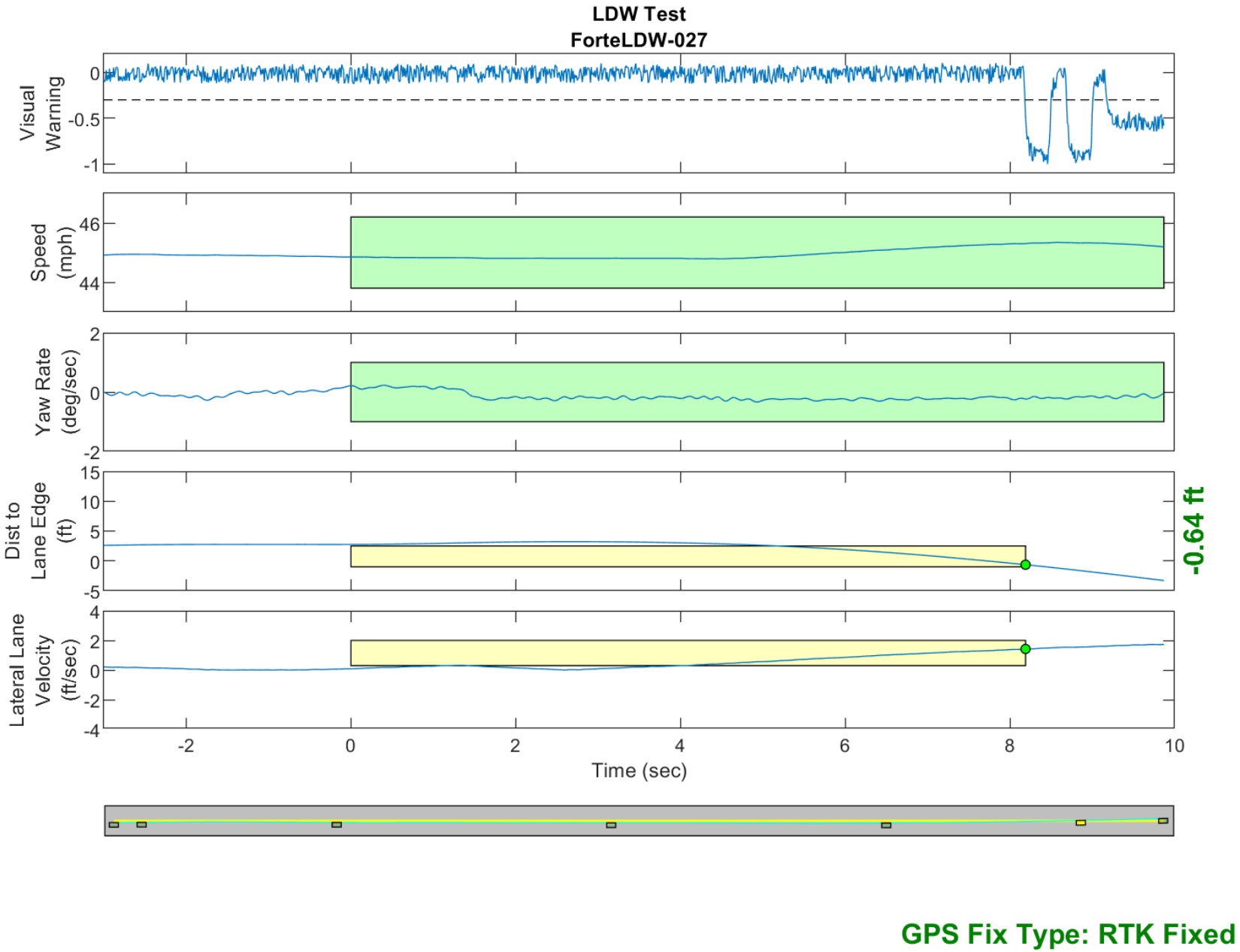


Figure D49. Time History for Run 27, Dashed Line, Left Departure, Visual Warning

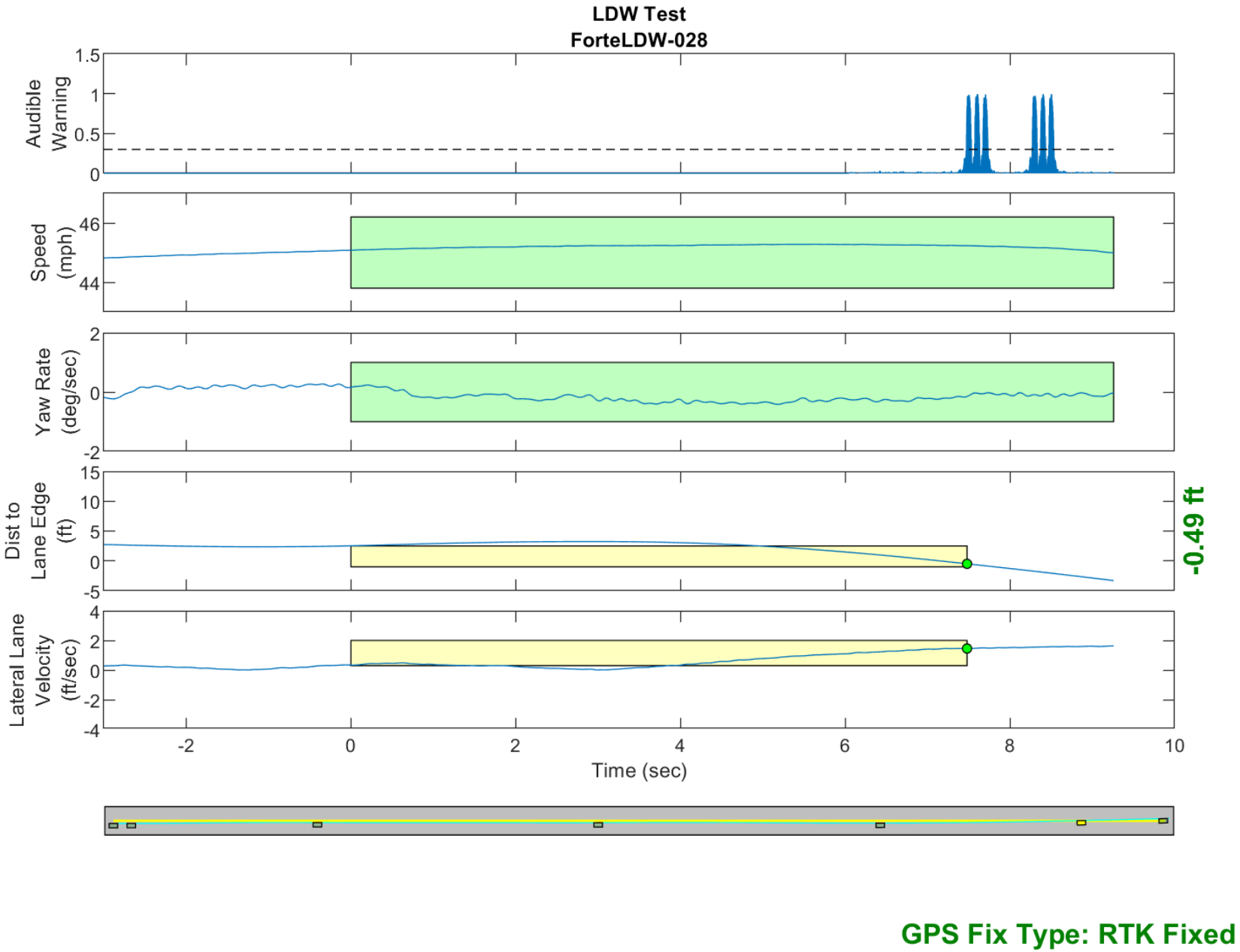


Figure D50. Time History for Run 28, Dashed Line, Left Departure, Auditory Warning

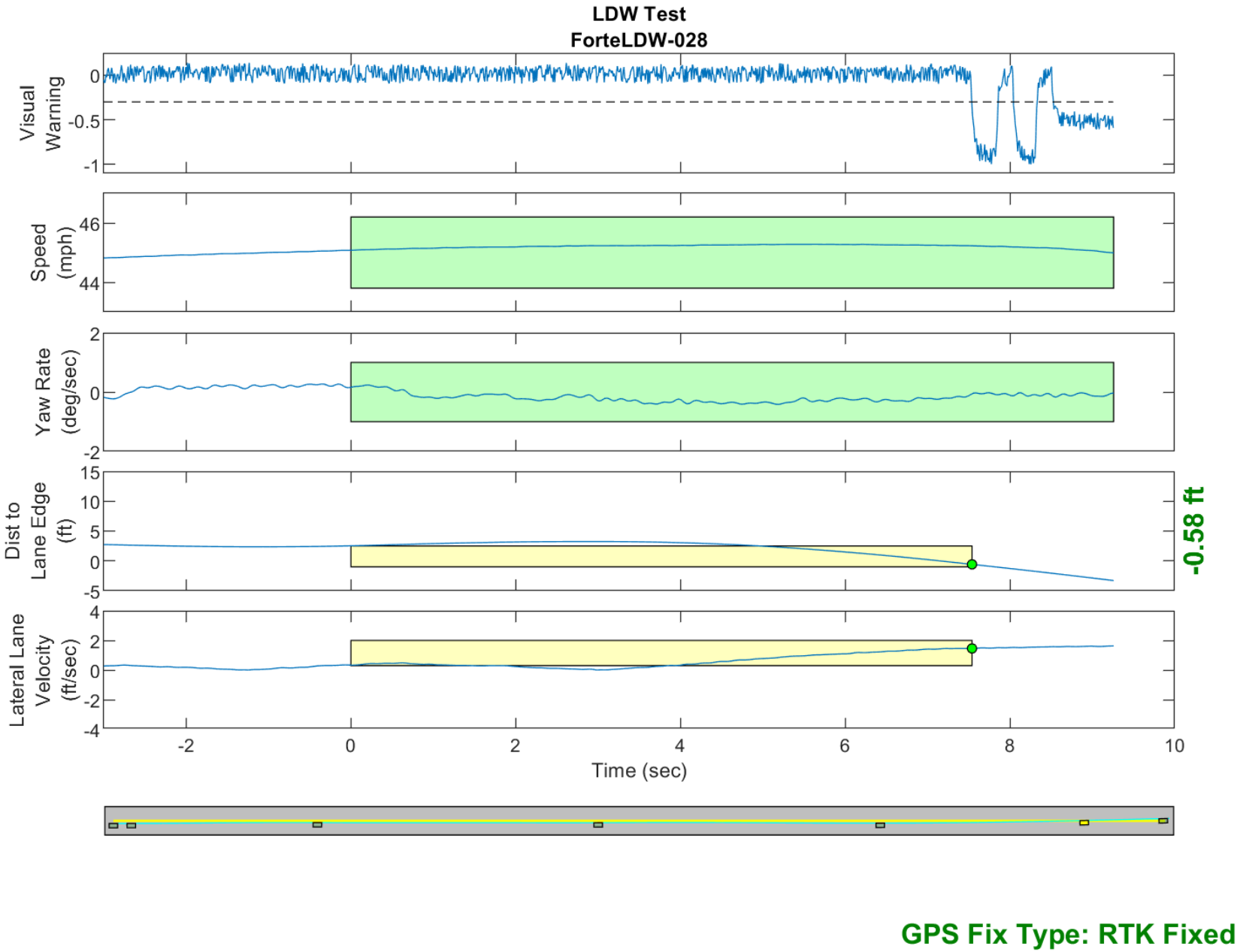


Figure D51. Time History for Run 28, Dashed Line, Left Departure, Visual Warning

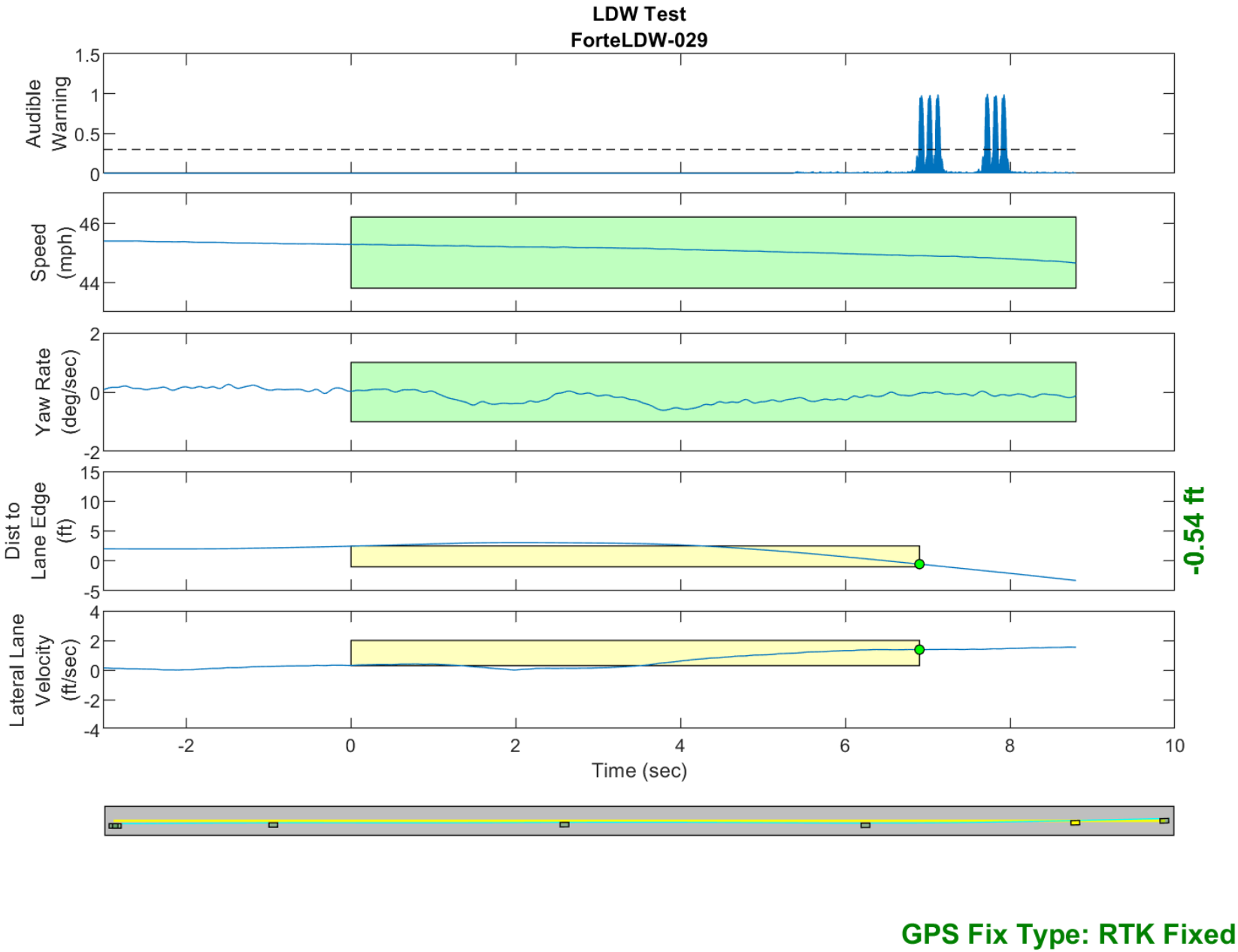
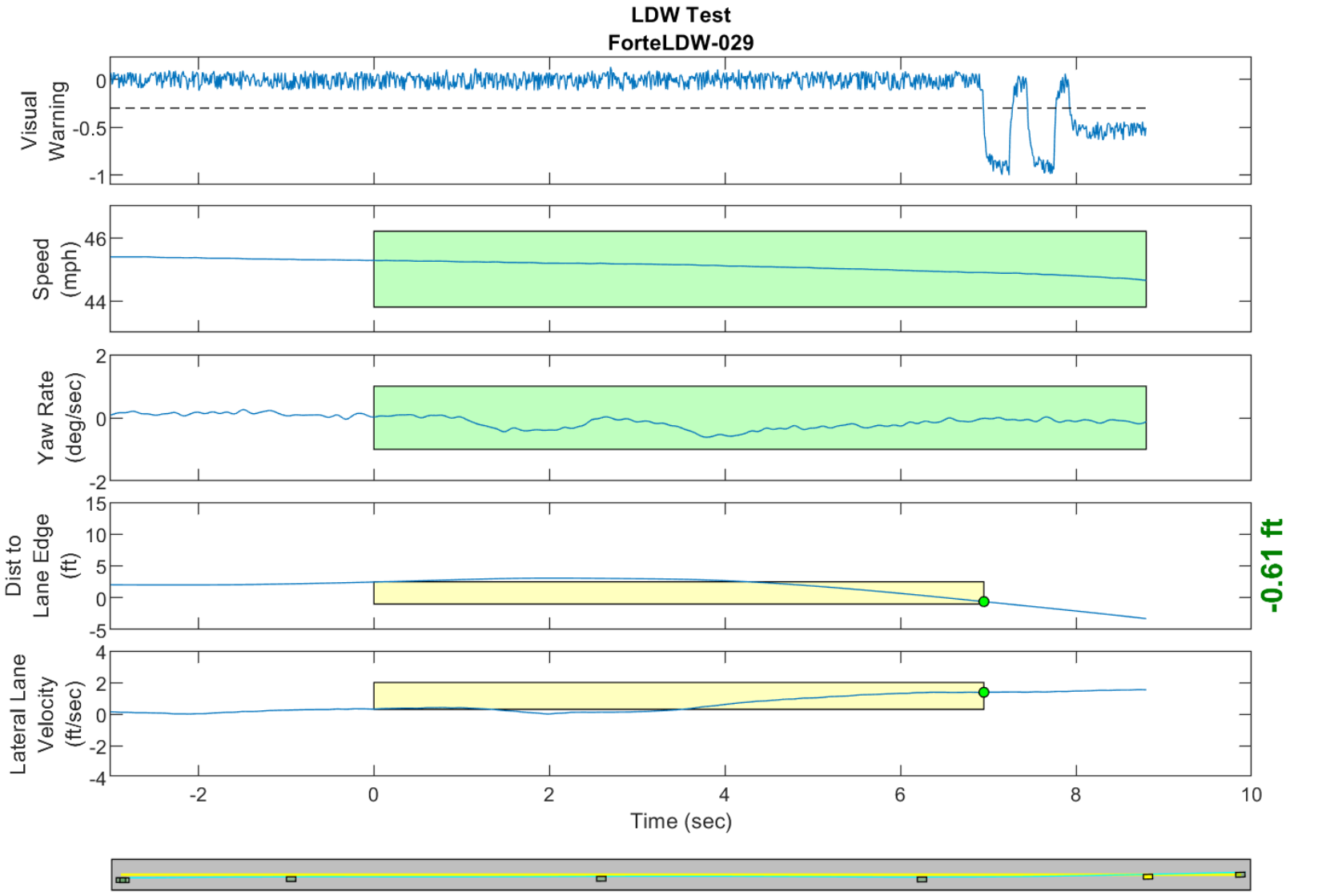


Figure D52. Time History for Run 29, Dashed Line, Left Departure, Auditory Warning



GPS Fix Type: RTK Fixed

Figure D53. Time History for Run 29, Dashed Line, Left Departure, Visual Warning

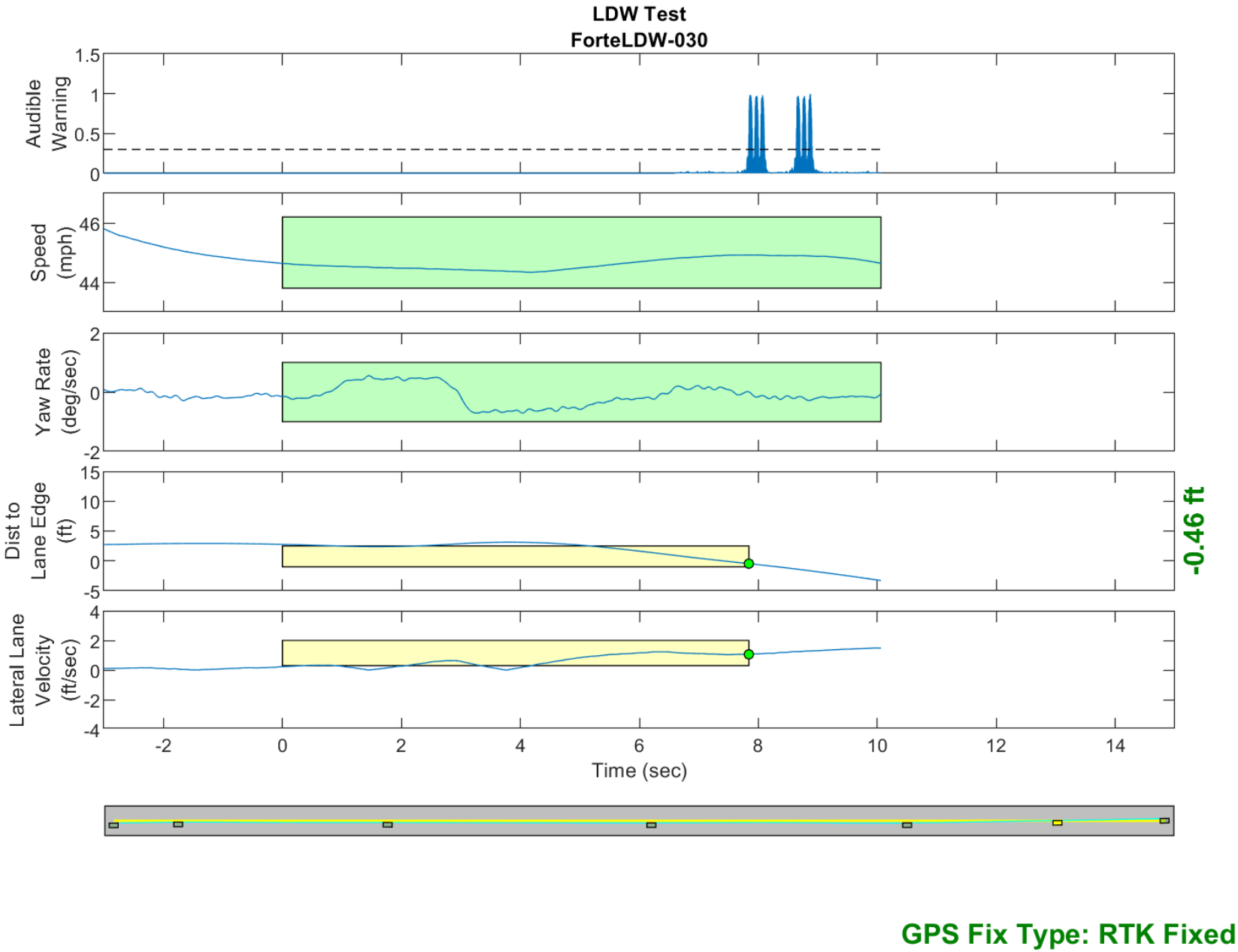


Figure D54. Time History for Run 30, Dashed Line, Left Departure, Auditory Warning

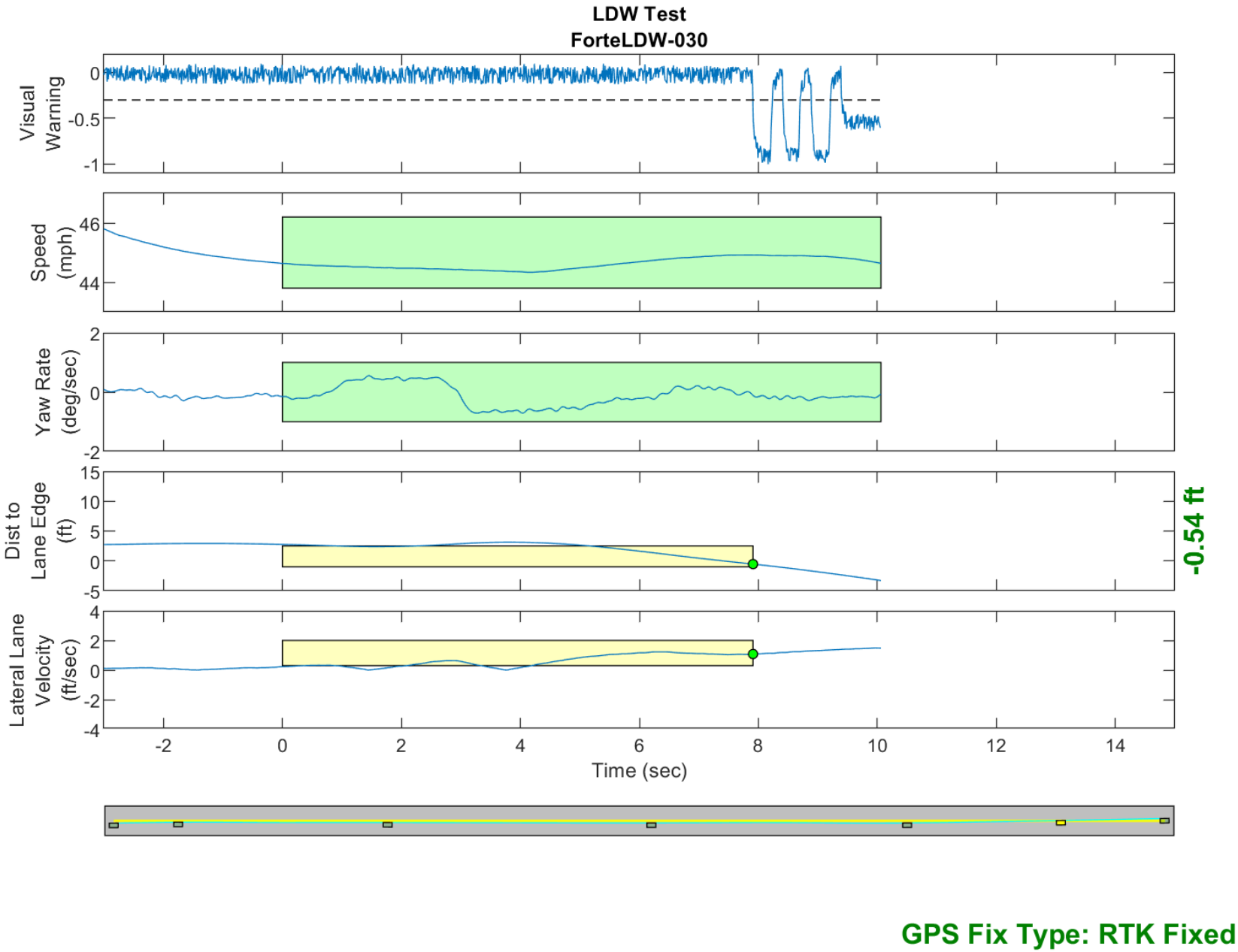


Figure D55. Time History for Run 30, Dashed Line, Left Departure, Visual Warning

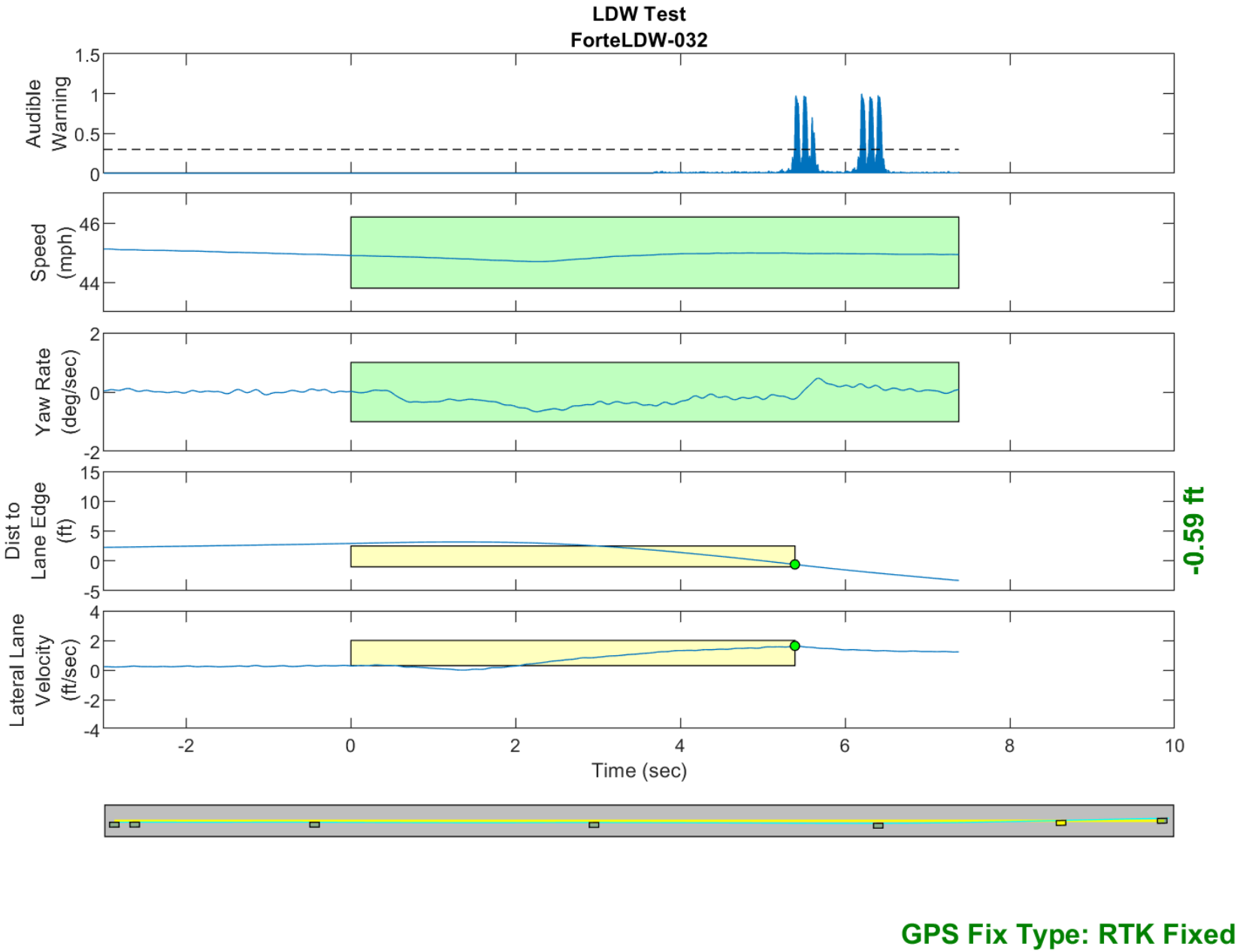


Figure D56. Time History for Run 32, Botts Dots, Left Departure, Auditory Warning

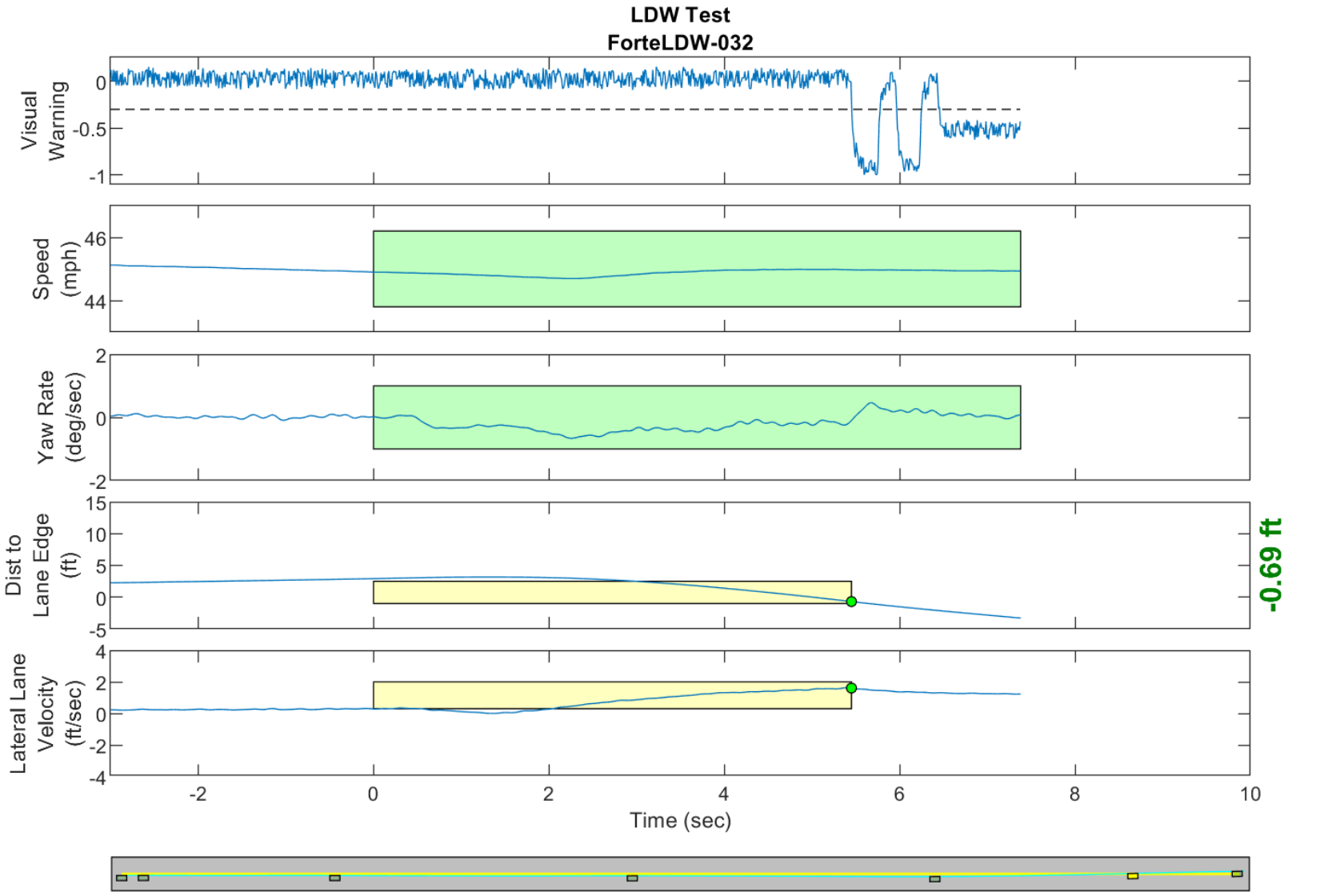


Figure D57. Time History for Run 32, Botts Dots, Left Departure, Visual Warning

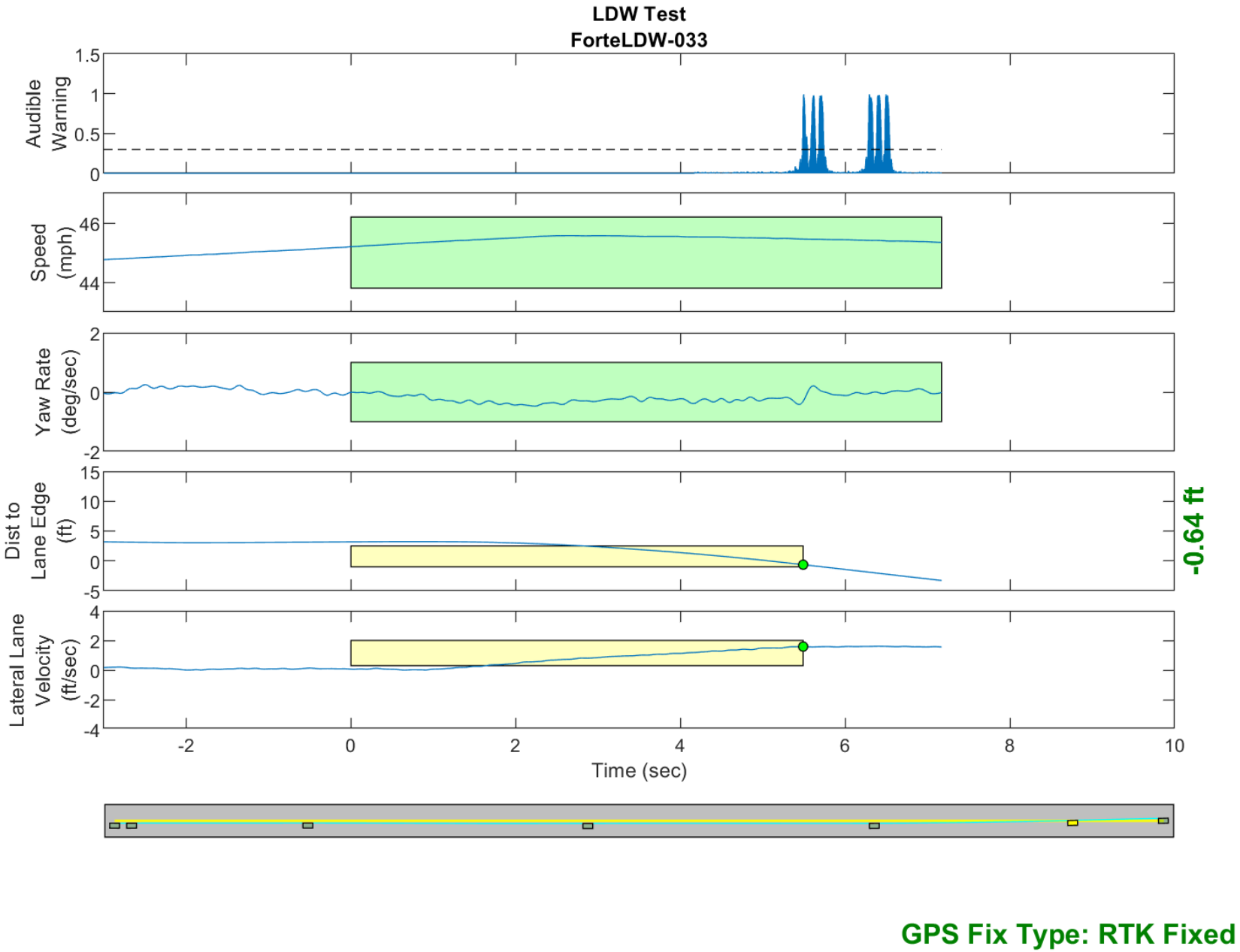


Figure D58. Time History for Run 33, Botts Dots, Left Departure, Auditory Warning

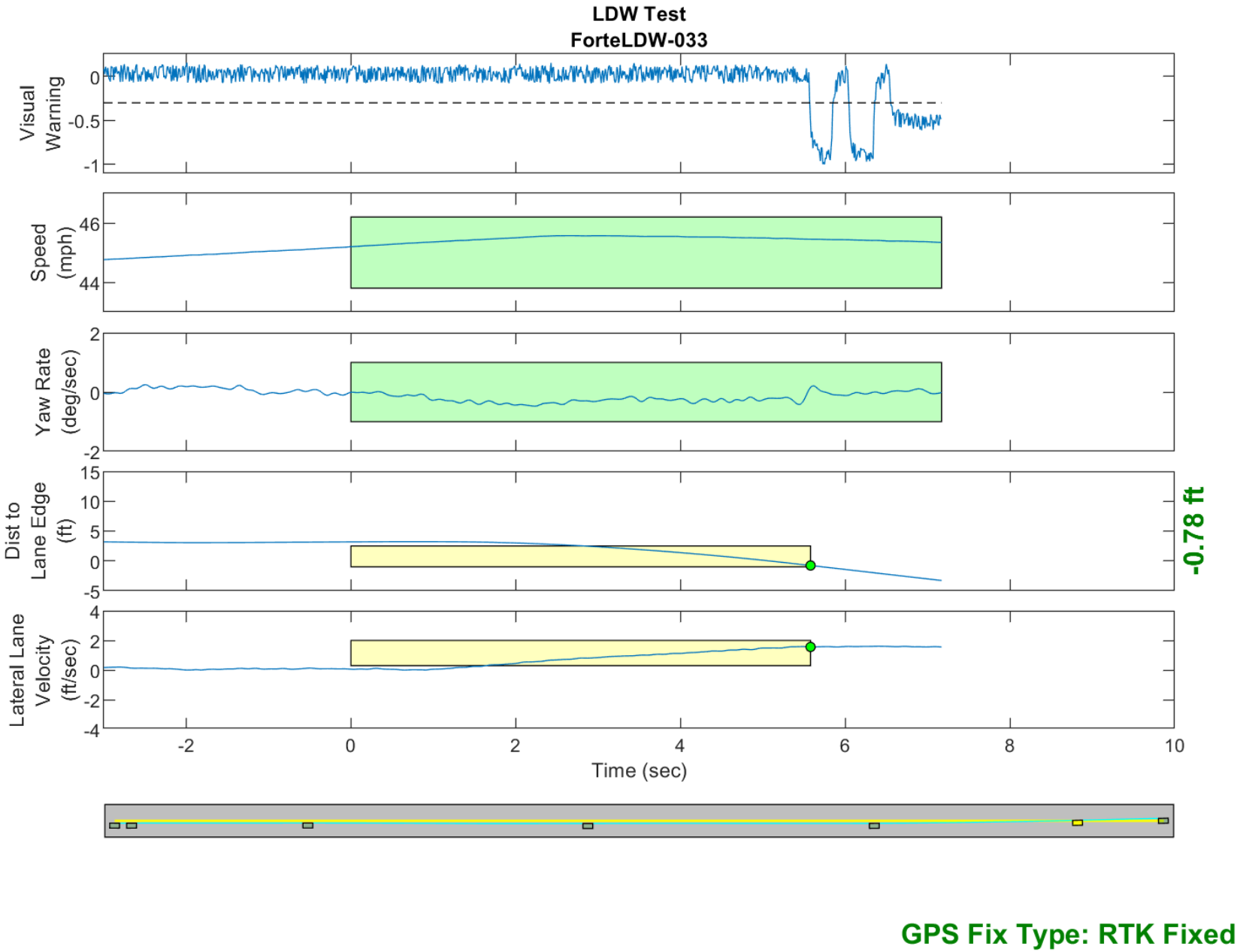


Figure D59. Time History for Run 33, Botts Dots, Left Departure, Visual Warning

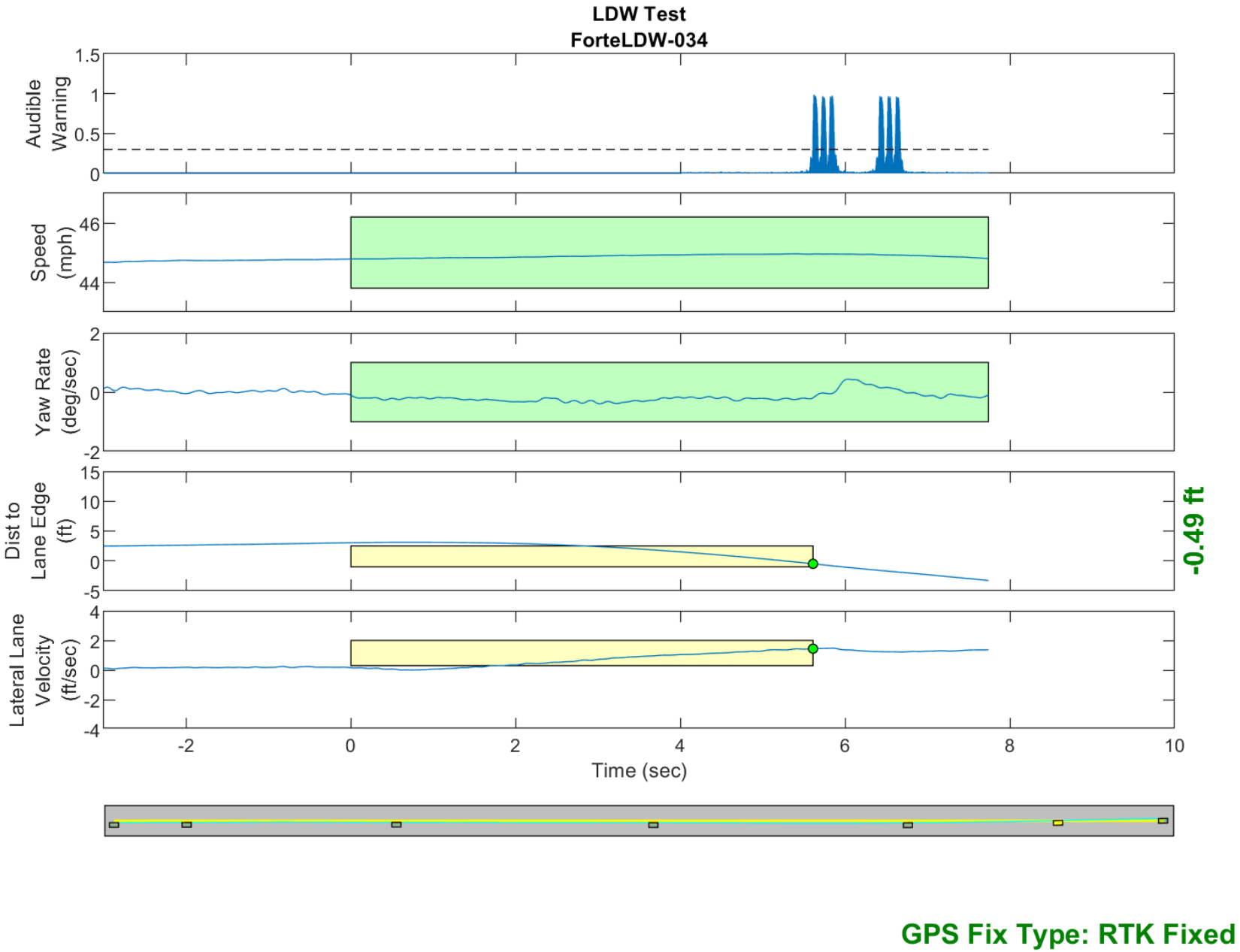


Figure D60. Time History for Run 34, Botts Dots, Left Departure, Auditory Warning

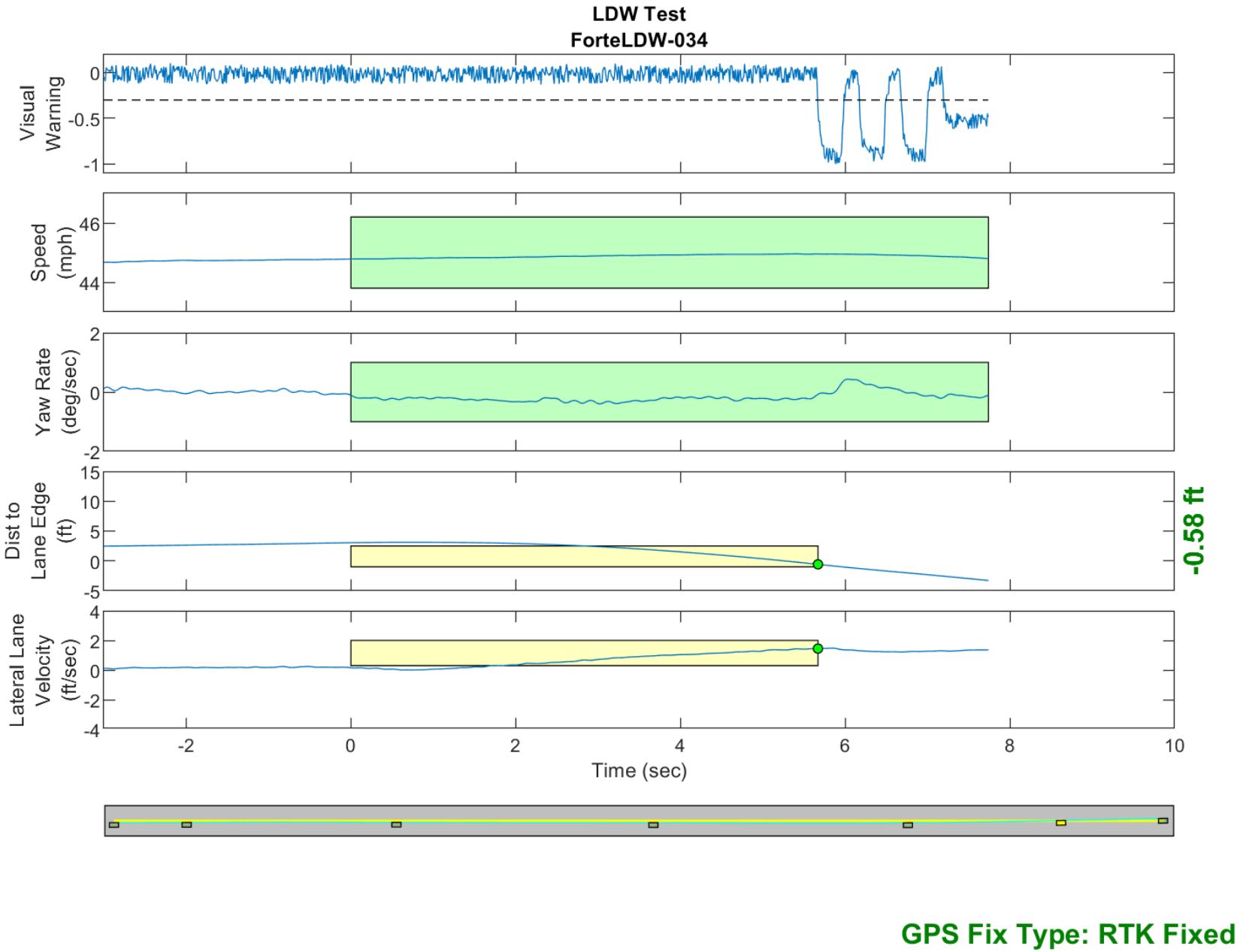


Figure D61. Time History for Run 34, Botts Dots, Left Departure, Visual Warning

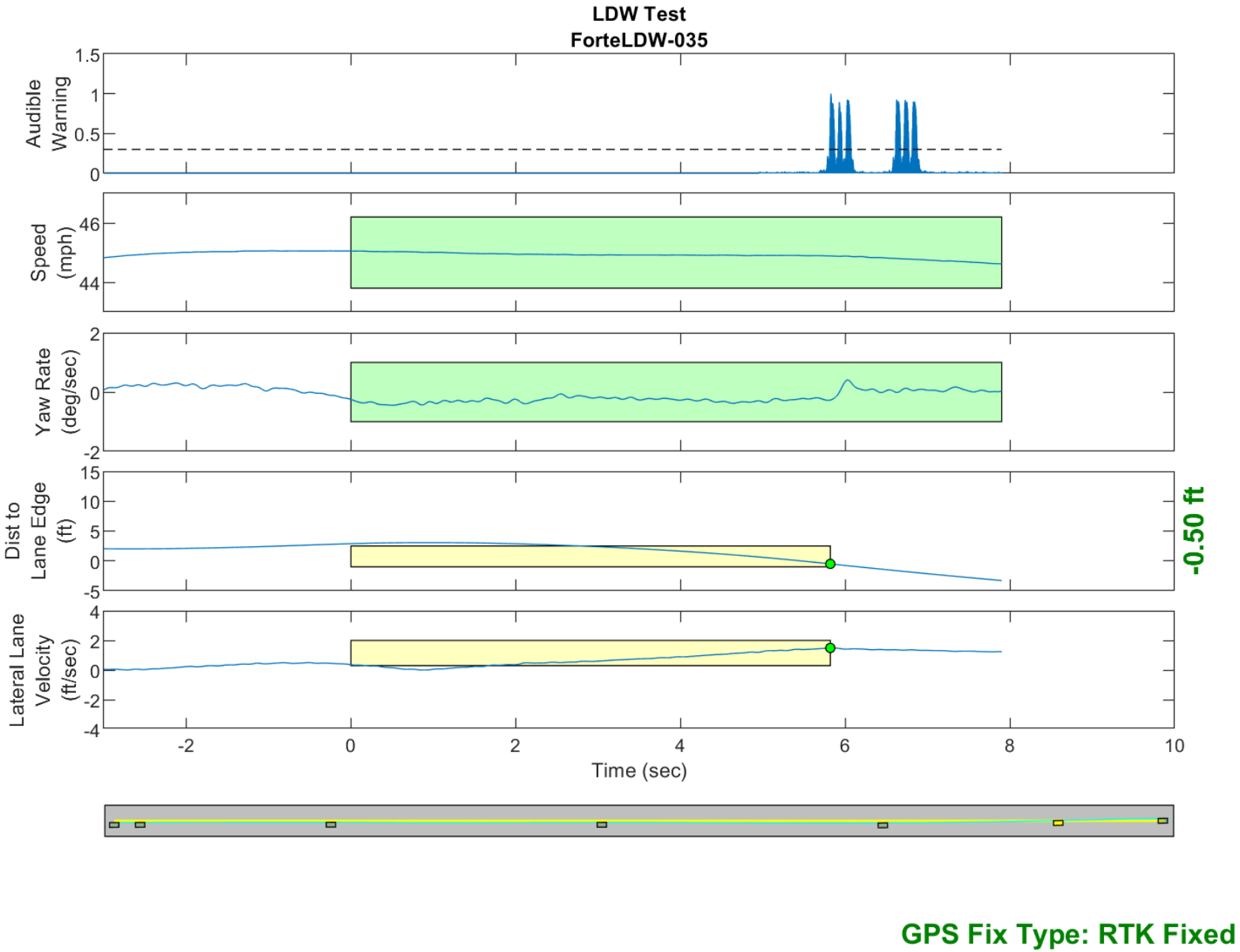


Figure D62. Time History for Run 35, Botts Dots, Left Departure, Auditory Warning

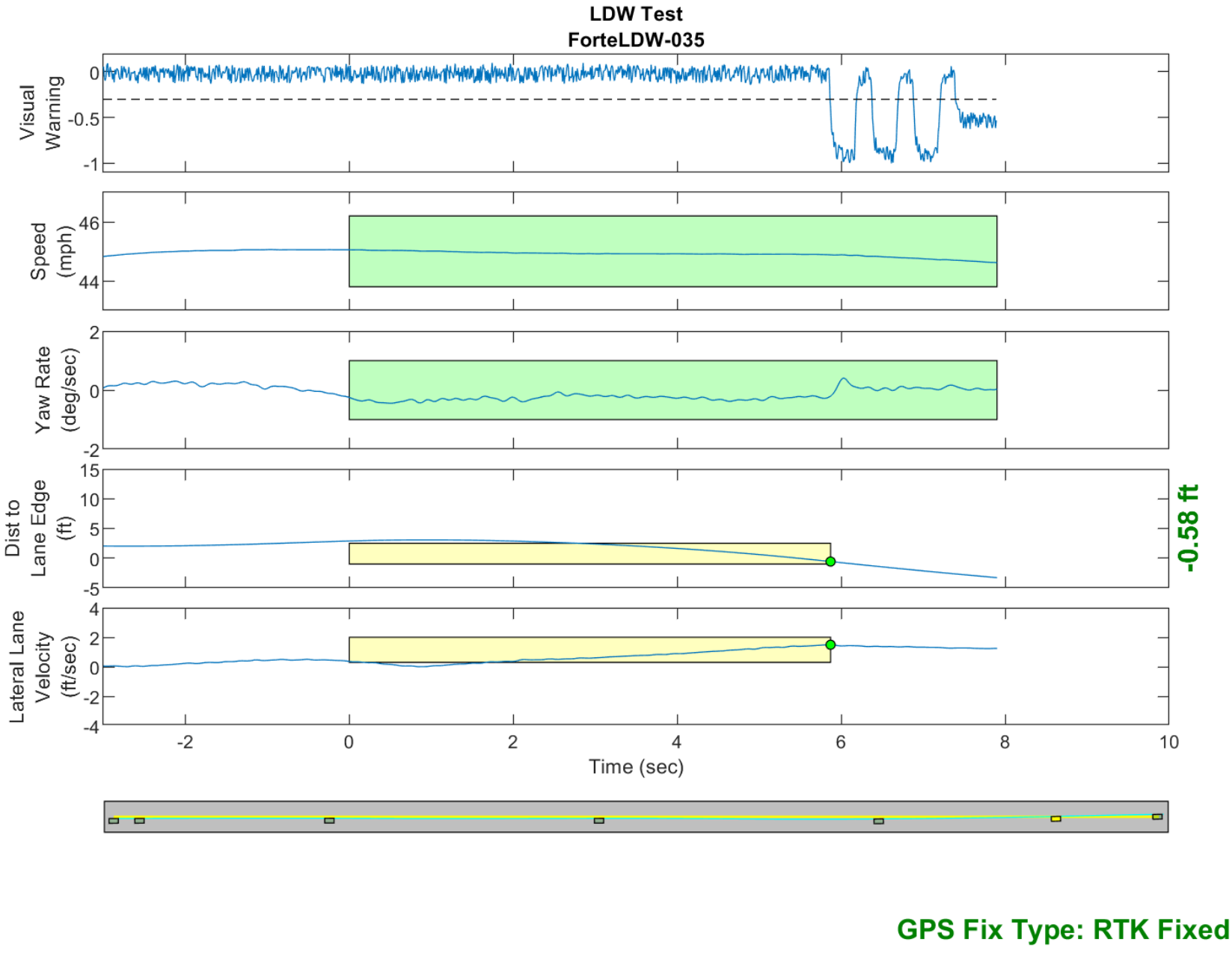


Figure D63. Time History for Run 35, Botts Dots, Left Departure, Visual Warning

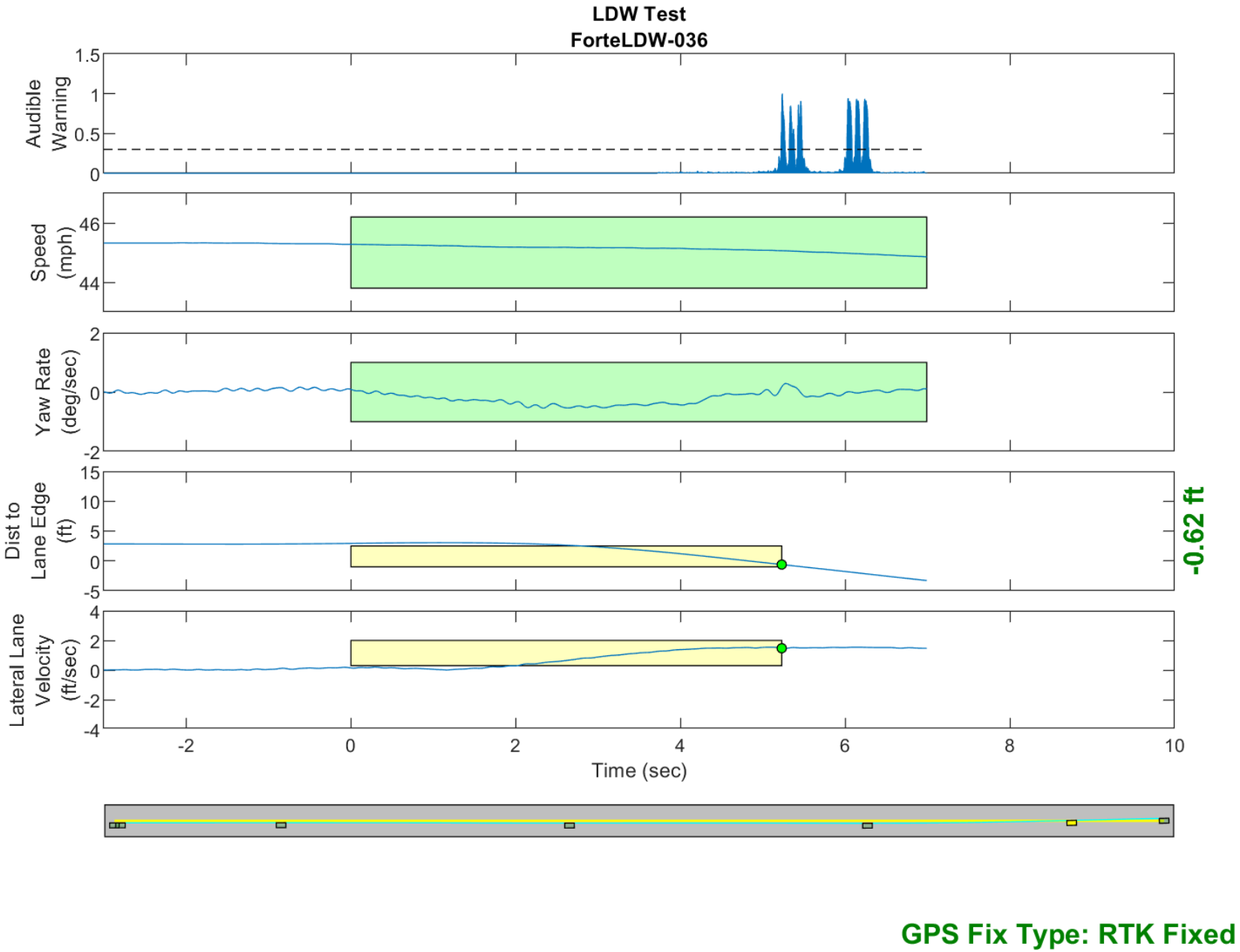
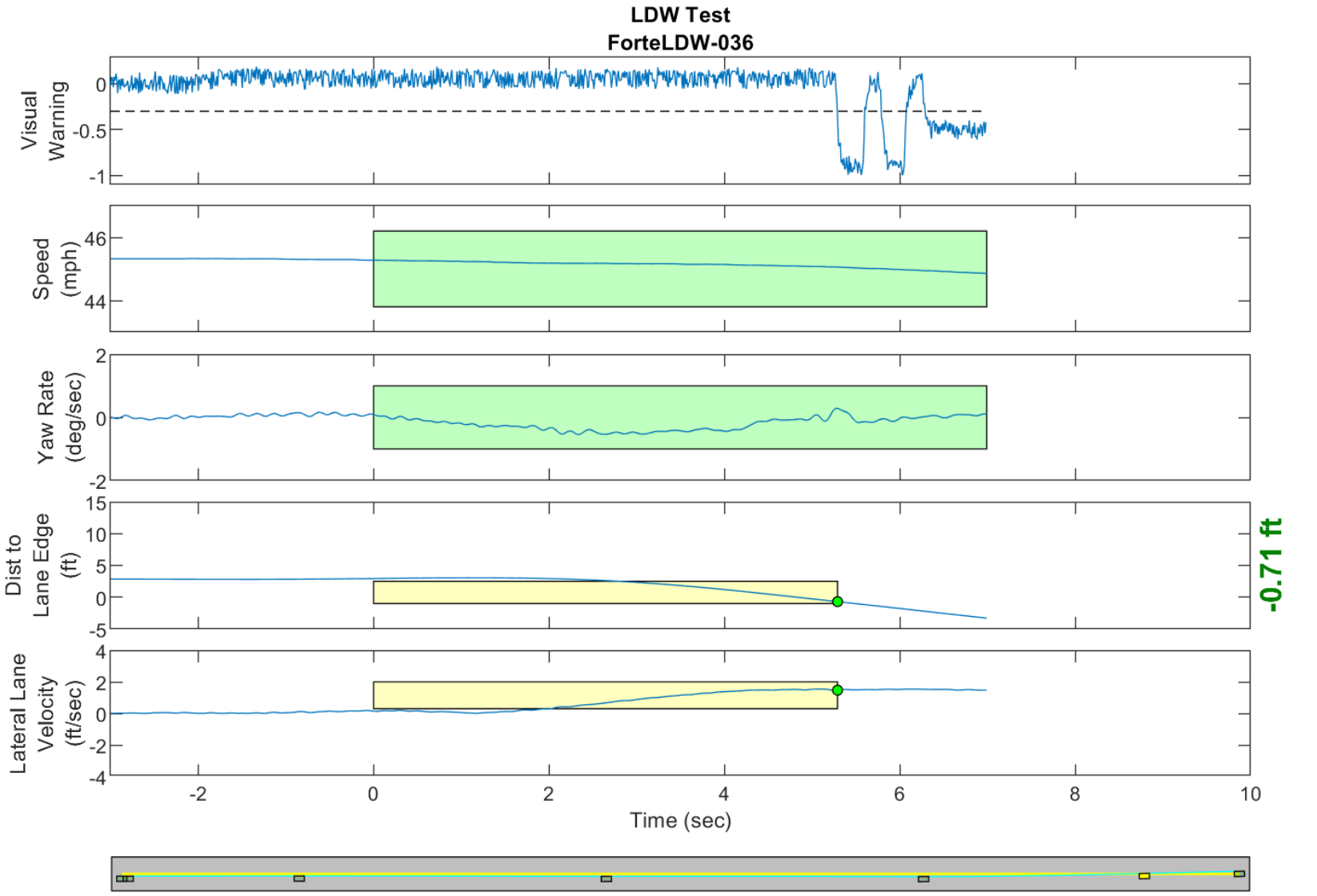


Figure D64. Time History for Run 36, Botts Dots, Left Departure, Auditory Warning



GPS Fix Type: RTK Fixed

Figure D65. Time History for Run 36, Botts Dots, Left Departure, Visual Warning

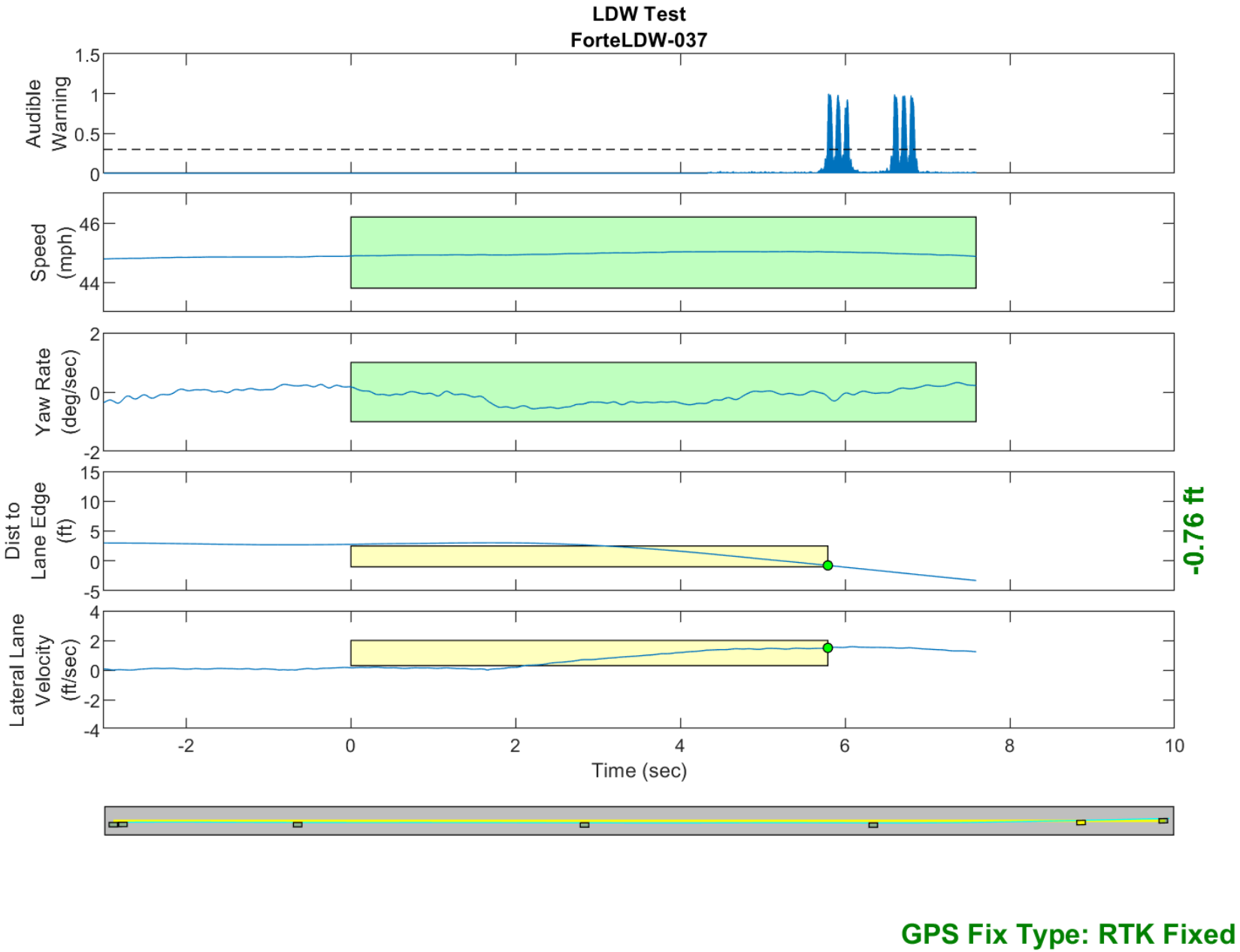


Figure D66. Time History for Run 37, Botts Dots, Left Departure, Auditory Warning

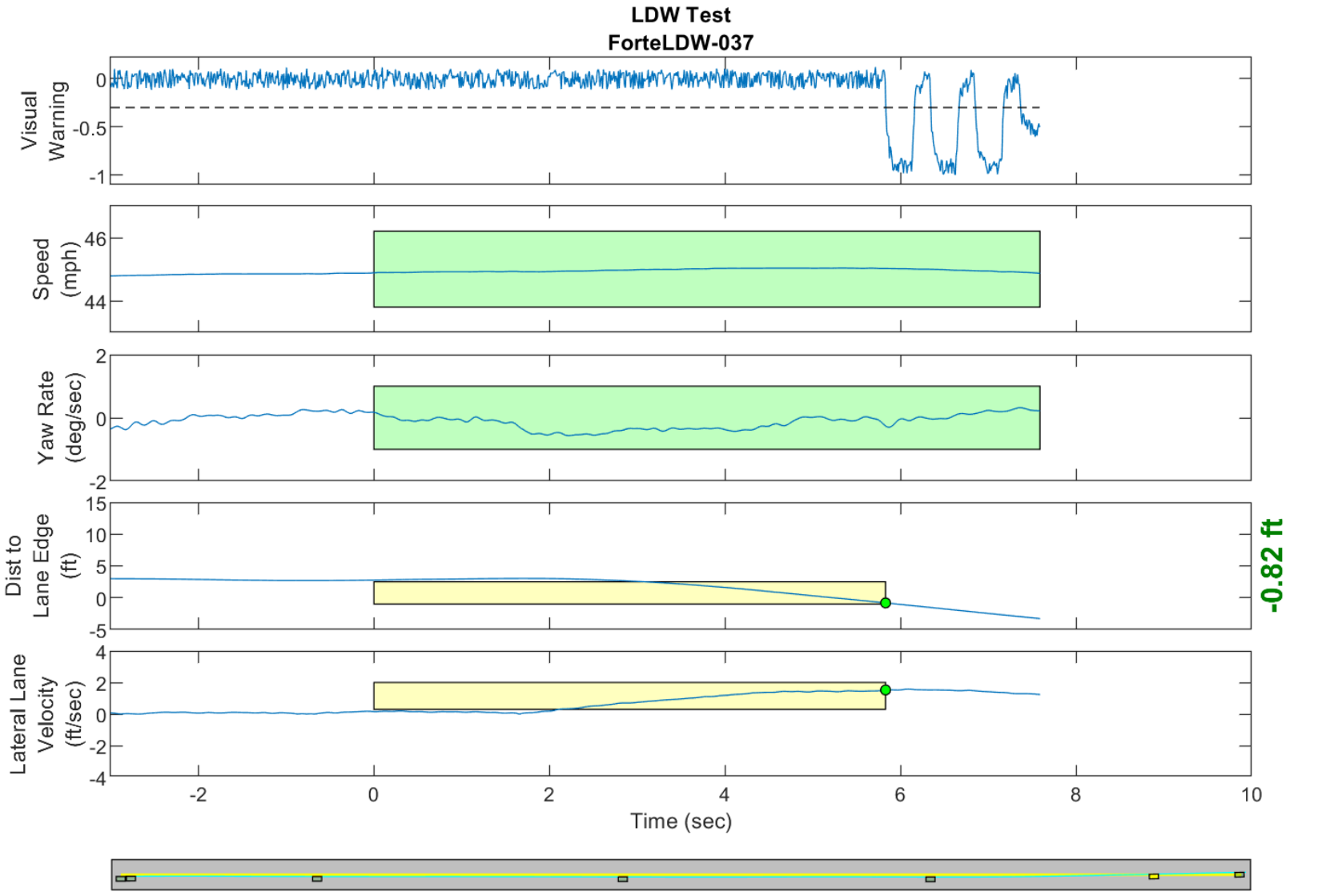


Figure D67. Time History for Run 37, Botts Dots, Left Departure, Visual Warning

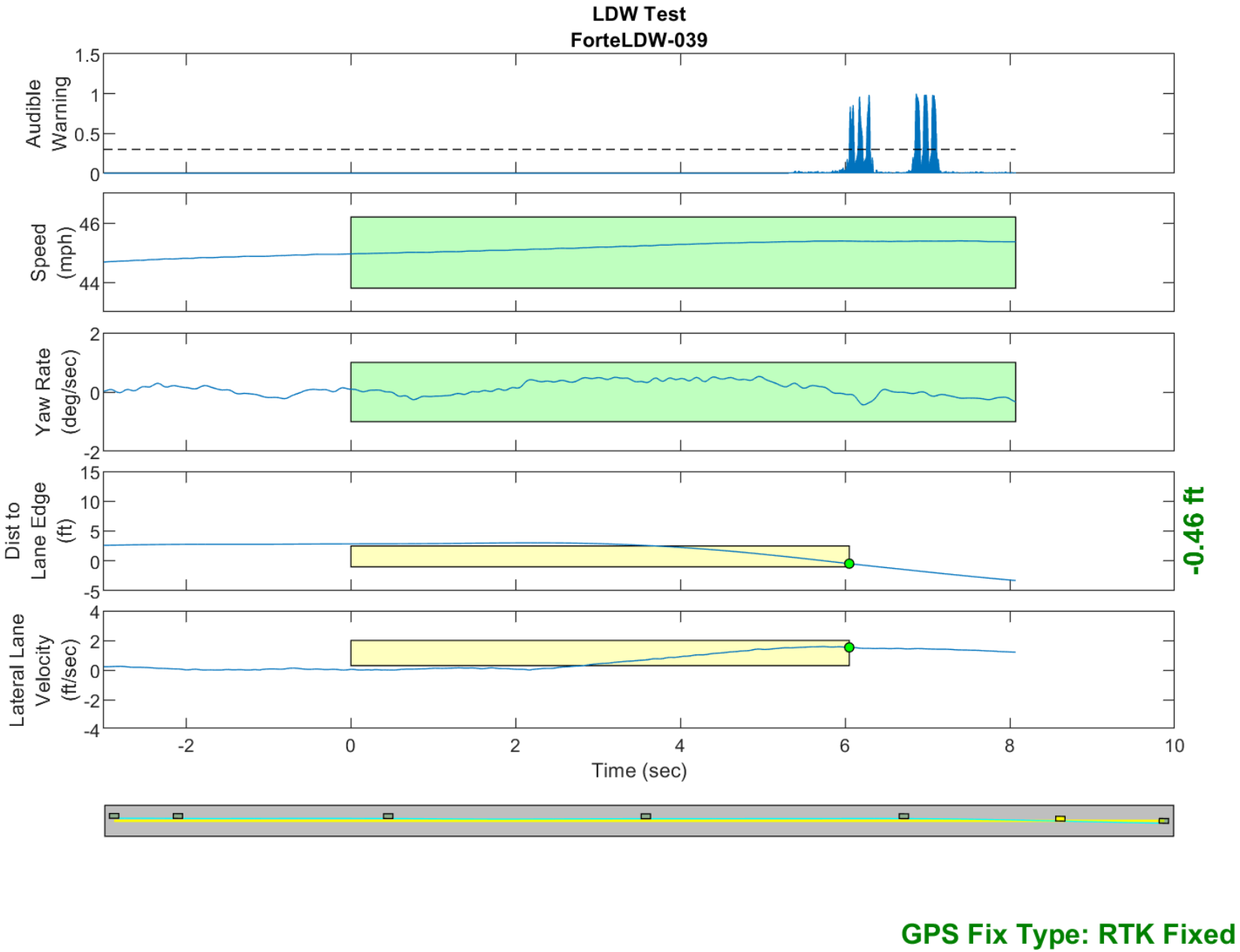


Figure D68. Time History for Run 39, Botts Dots, Right Departure, Auditory Warning

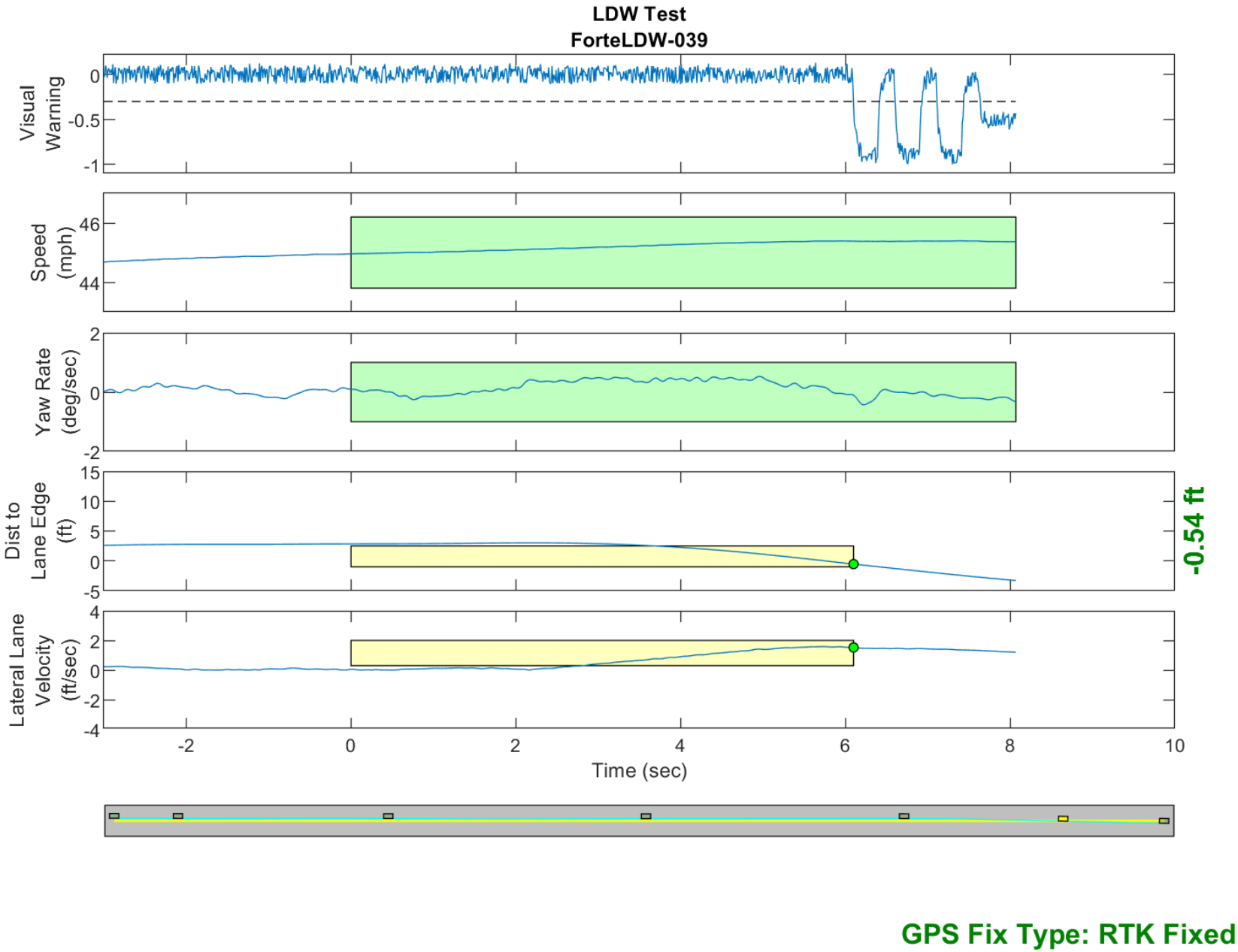


Figure D69. Time History for Run 39, Botts Dots, Right Departure, Visual Warning

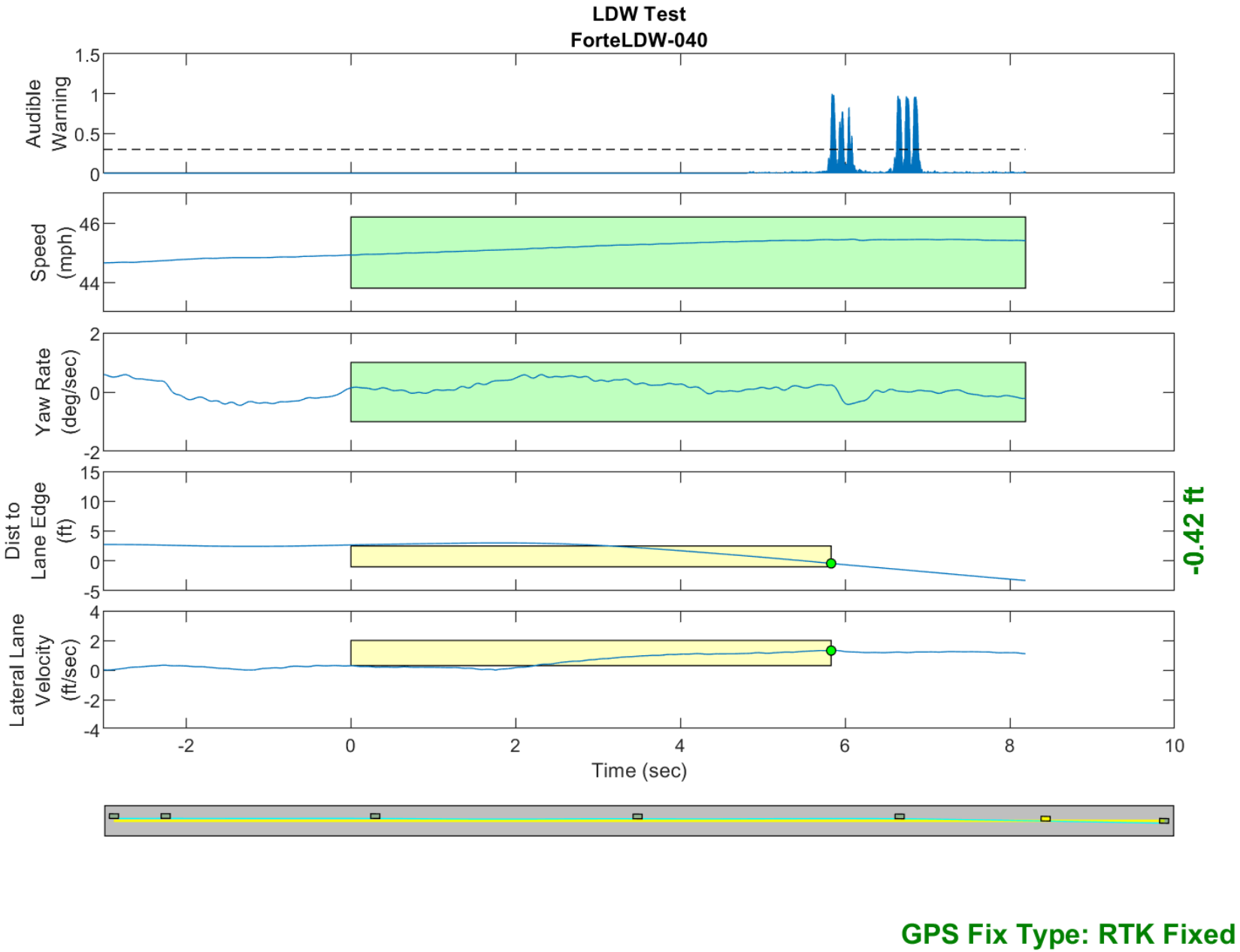


Figure D70. Time History for Run 40, Botts Dots, Right Departure, Auditory Warning

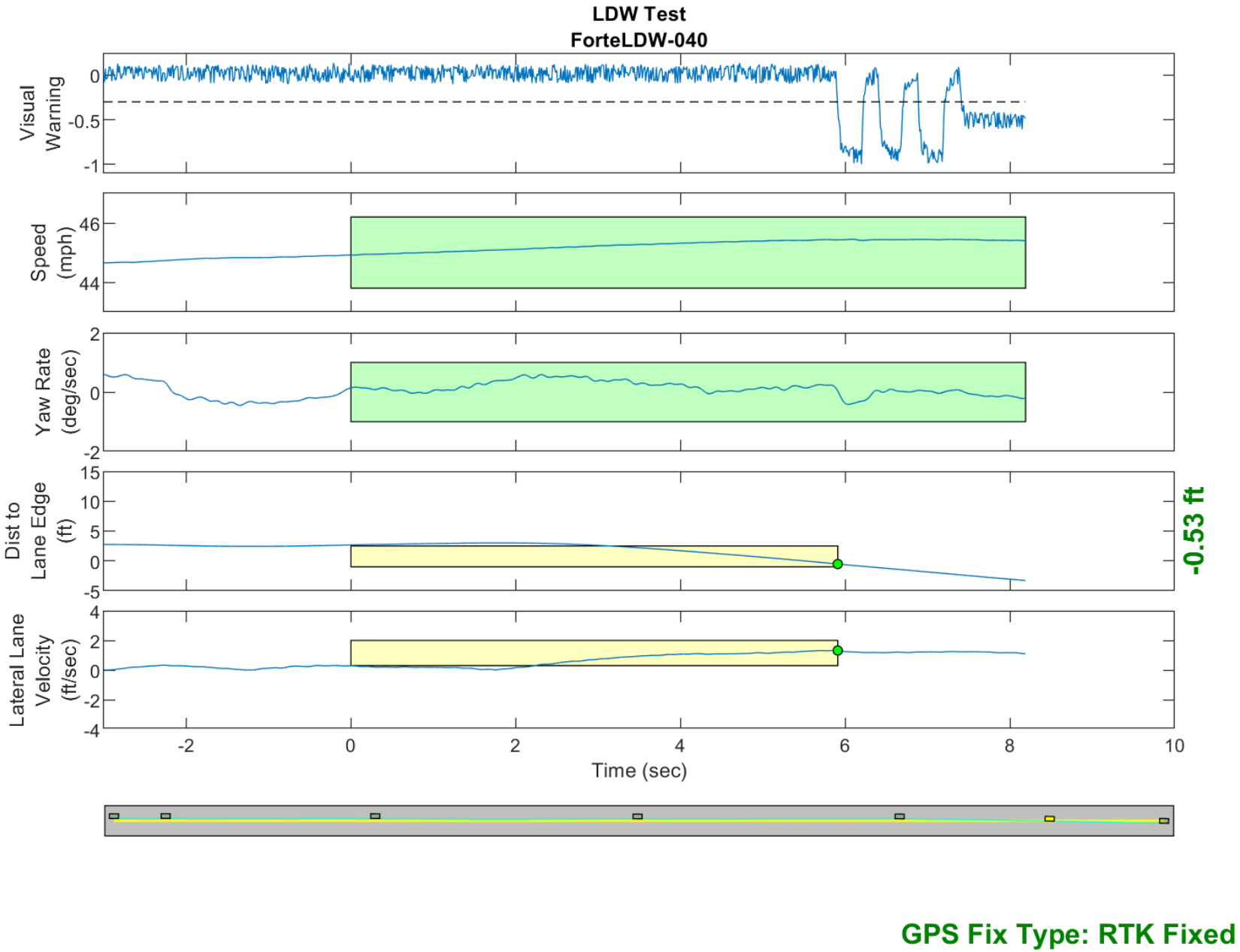


Figure D71. Time History for Run 40, Botts Dots, Right Departure, Visual Warning

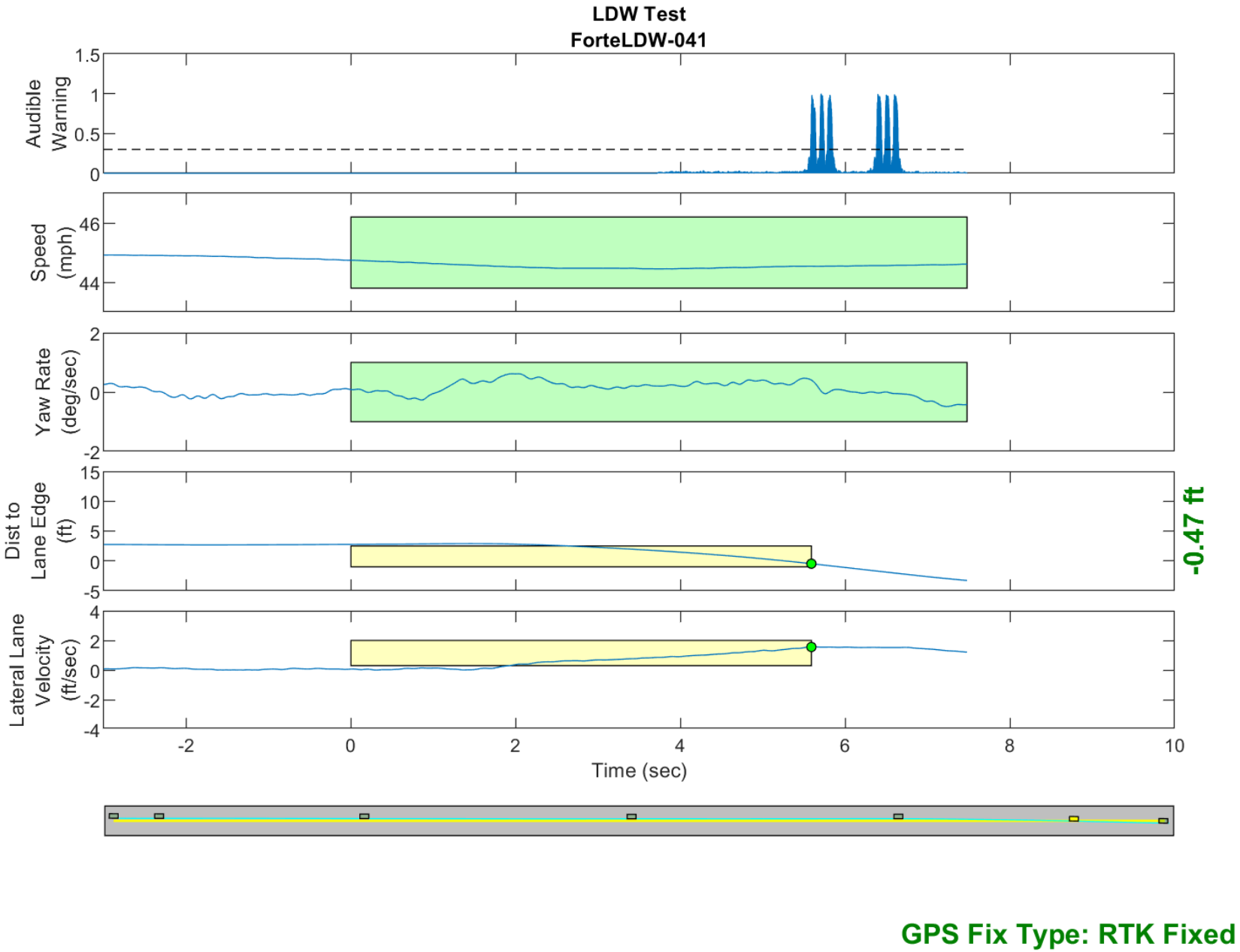


Figure D72. Time History for Run 41, Botts Dots, Right Departure, Auditory Warning

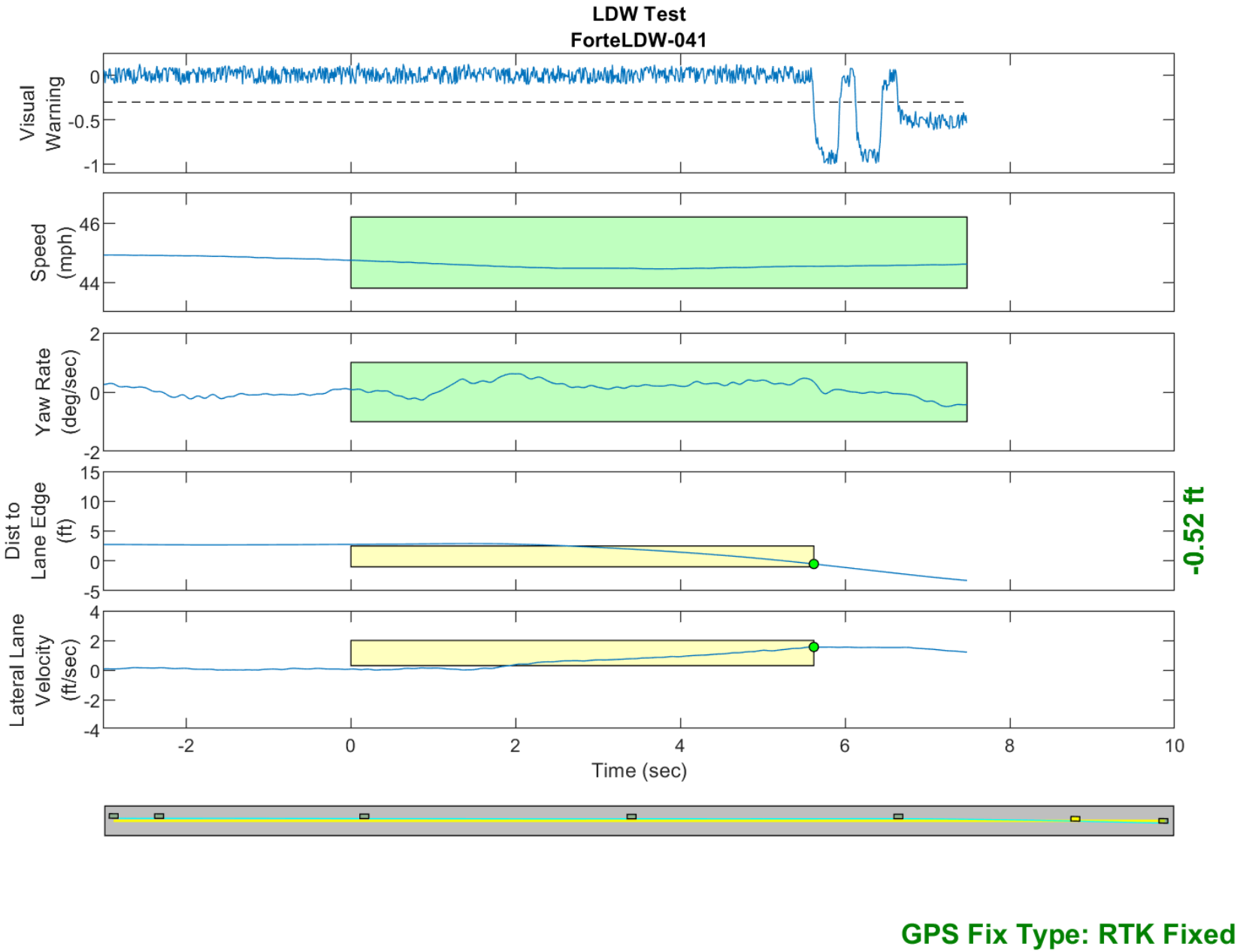


Figure D73. Time History for Run 41, Botts Dots, Right Departure, Visual Warning

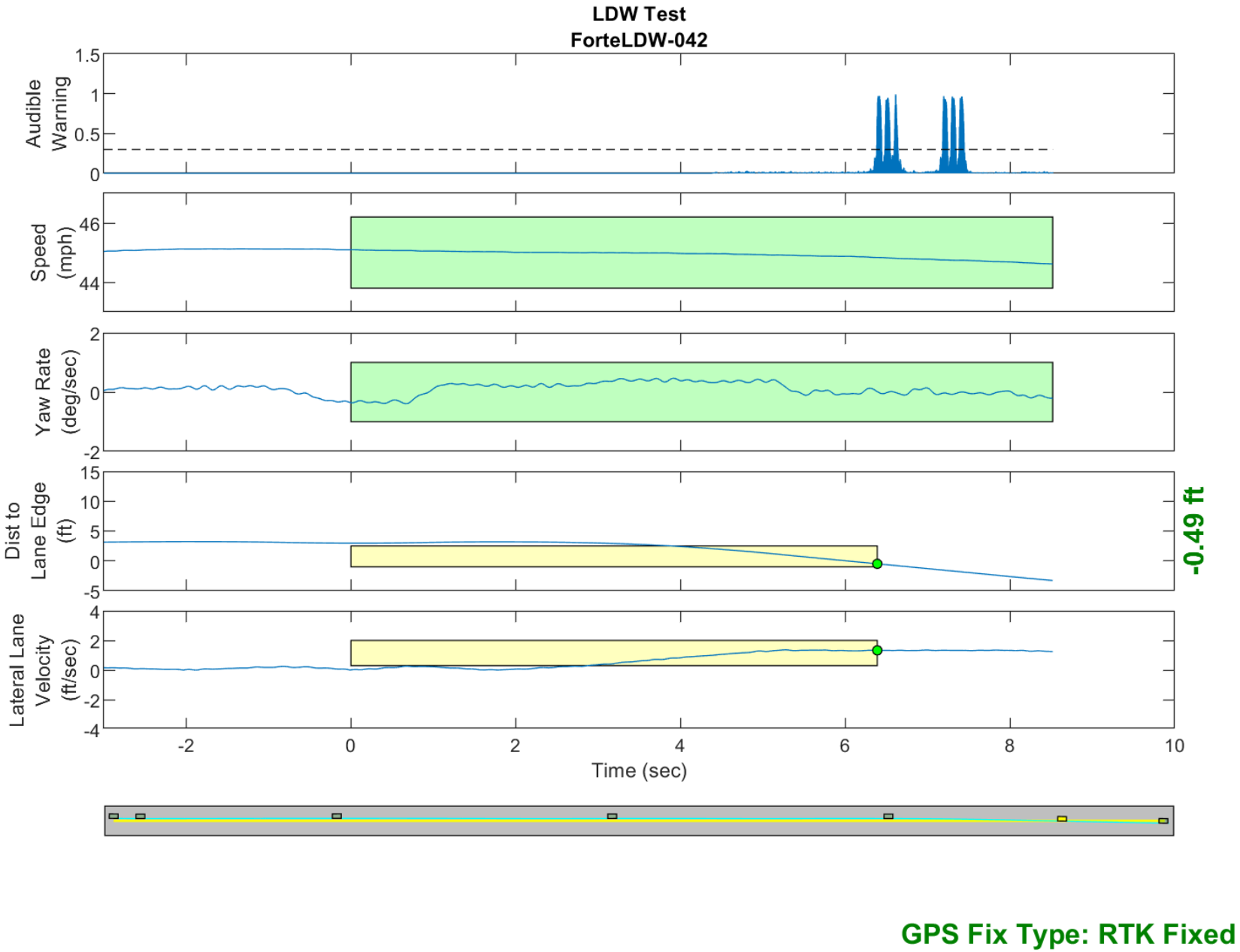


Figure D74. Time History for Run 42, Botts Dots, Right Departure, Auditory Warning

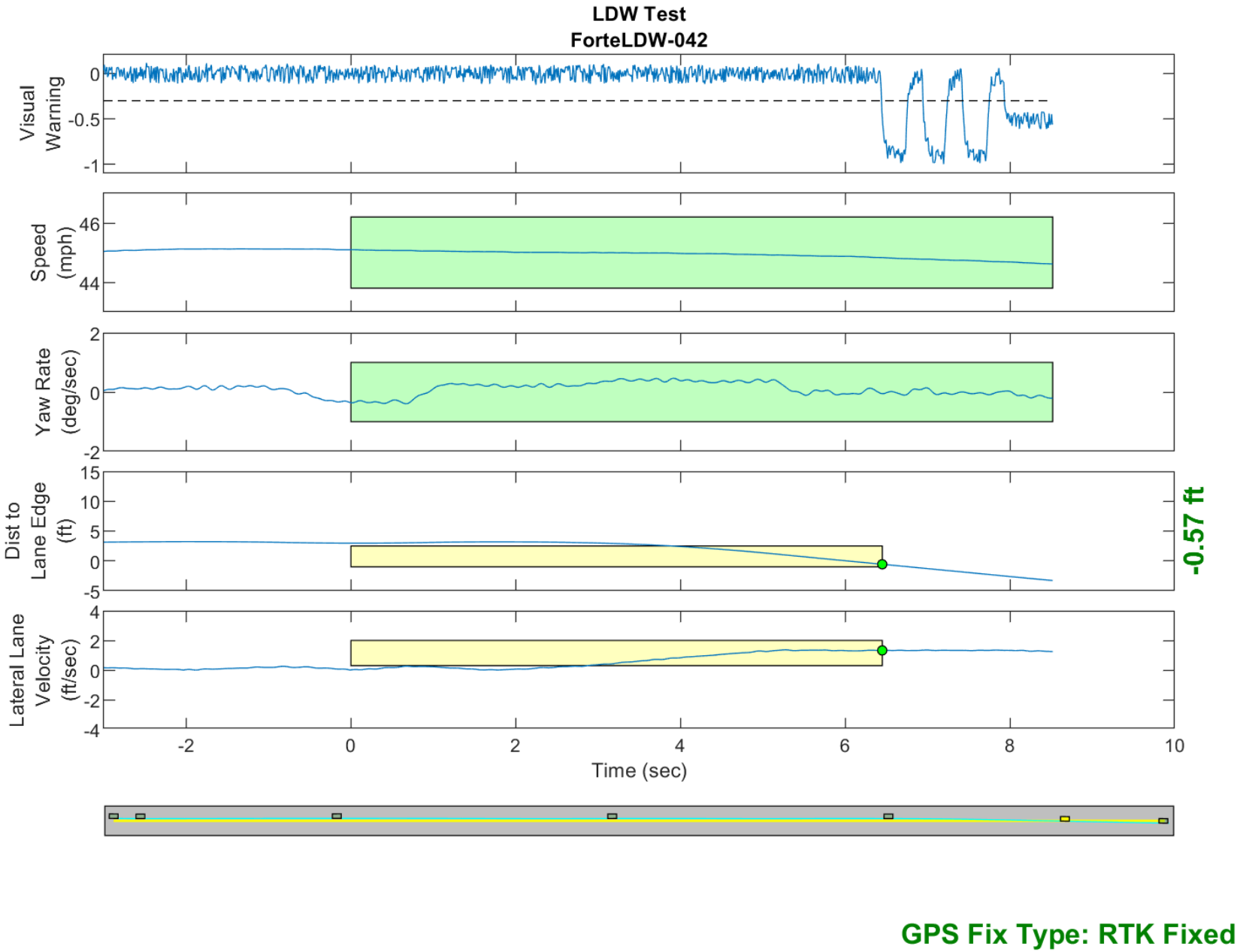


Figure D75. Time History for Run 42, Botts Dots, Right Departure, Visual Warning

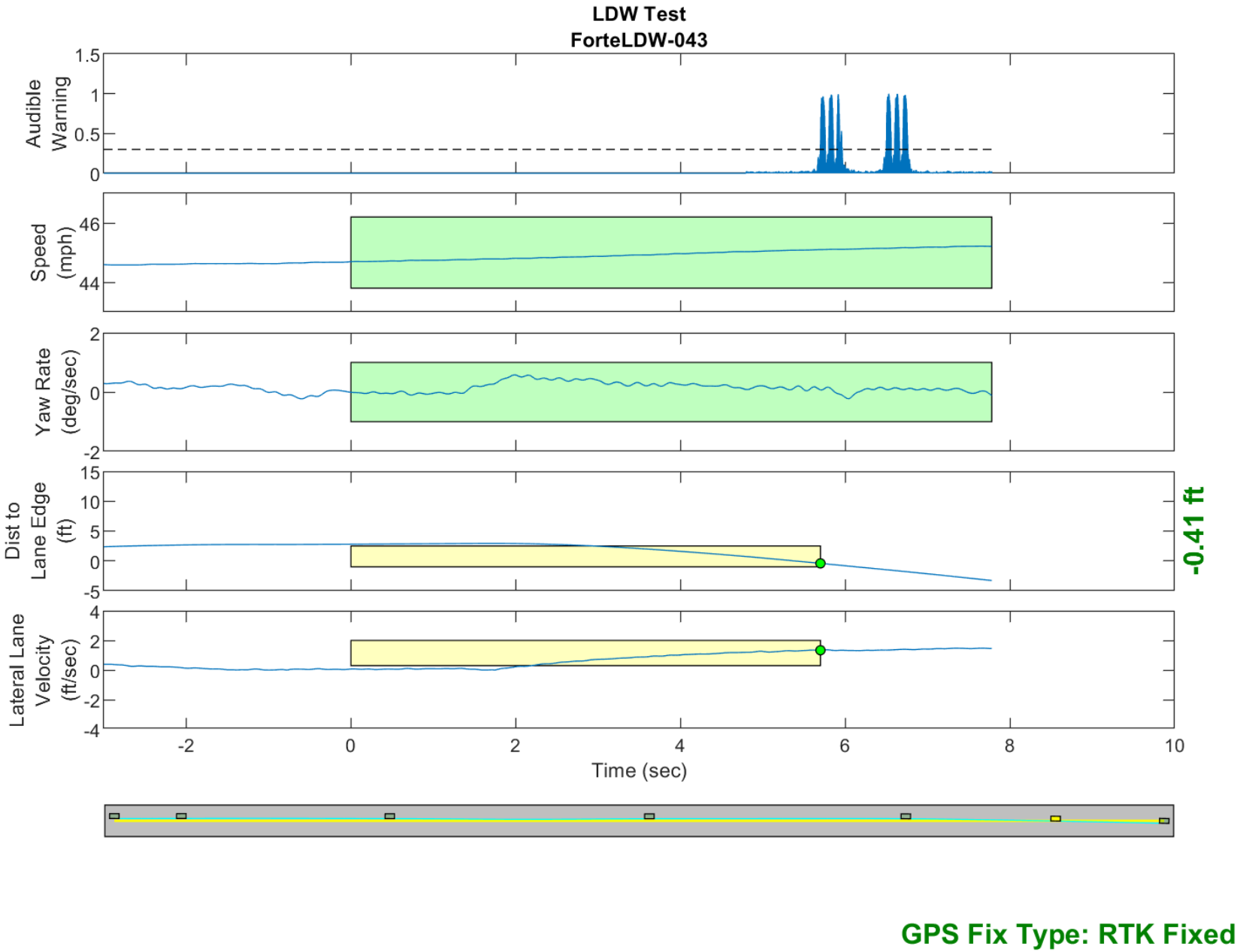


Figure D76. Time History for Run 43, Botts Dots, Right Departure, Auditory Warning

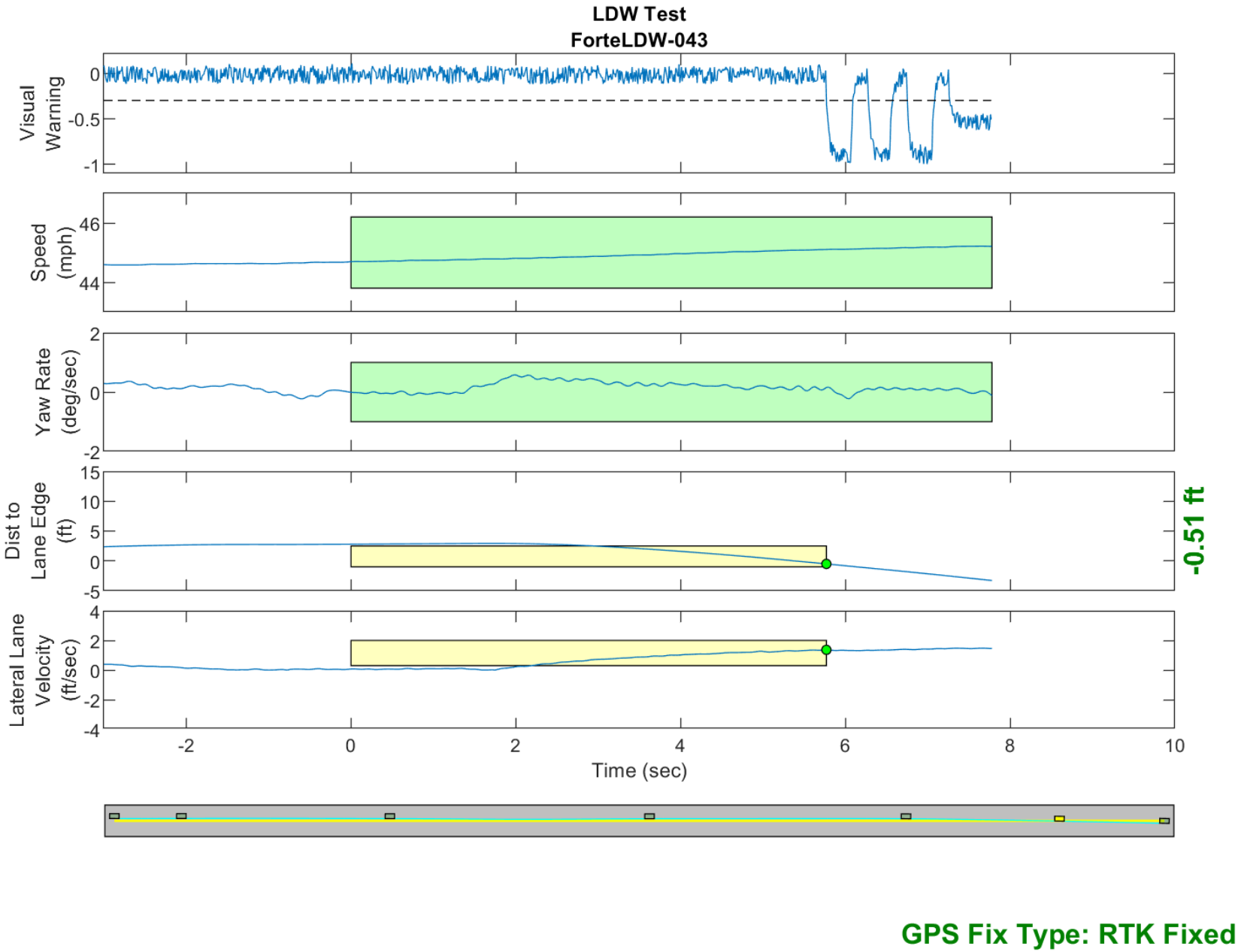


Figure D77. Time History for Run 43, Botts Dots, Right Departure, Visual Warning

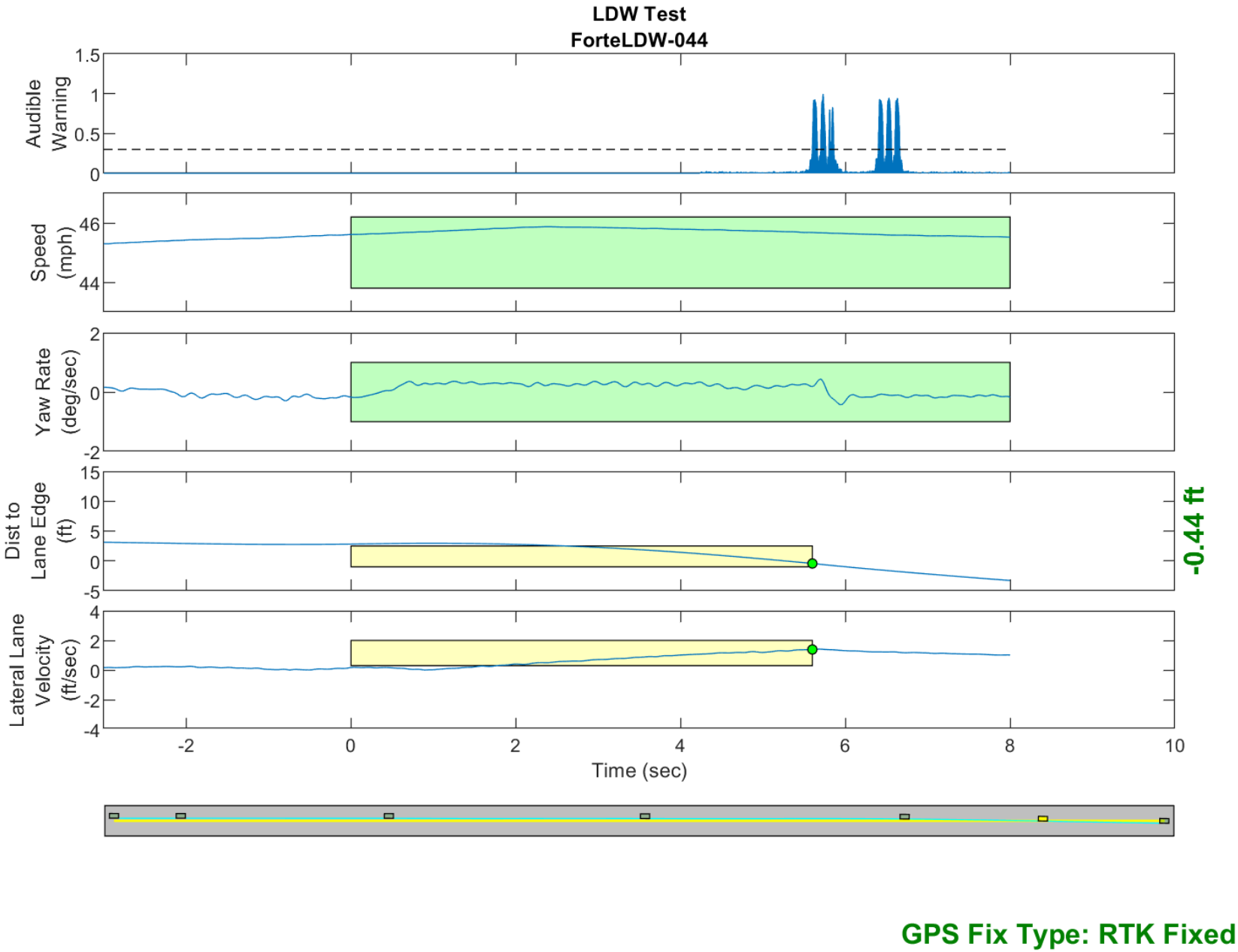


Figure D78. Time History for Run 44, Botts Dots, Right Departure, Auditory Warning

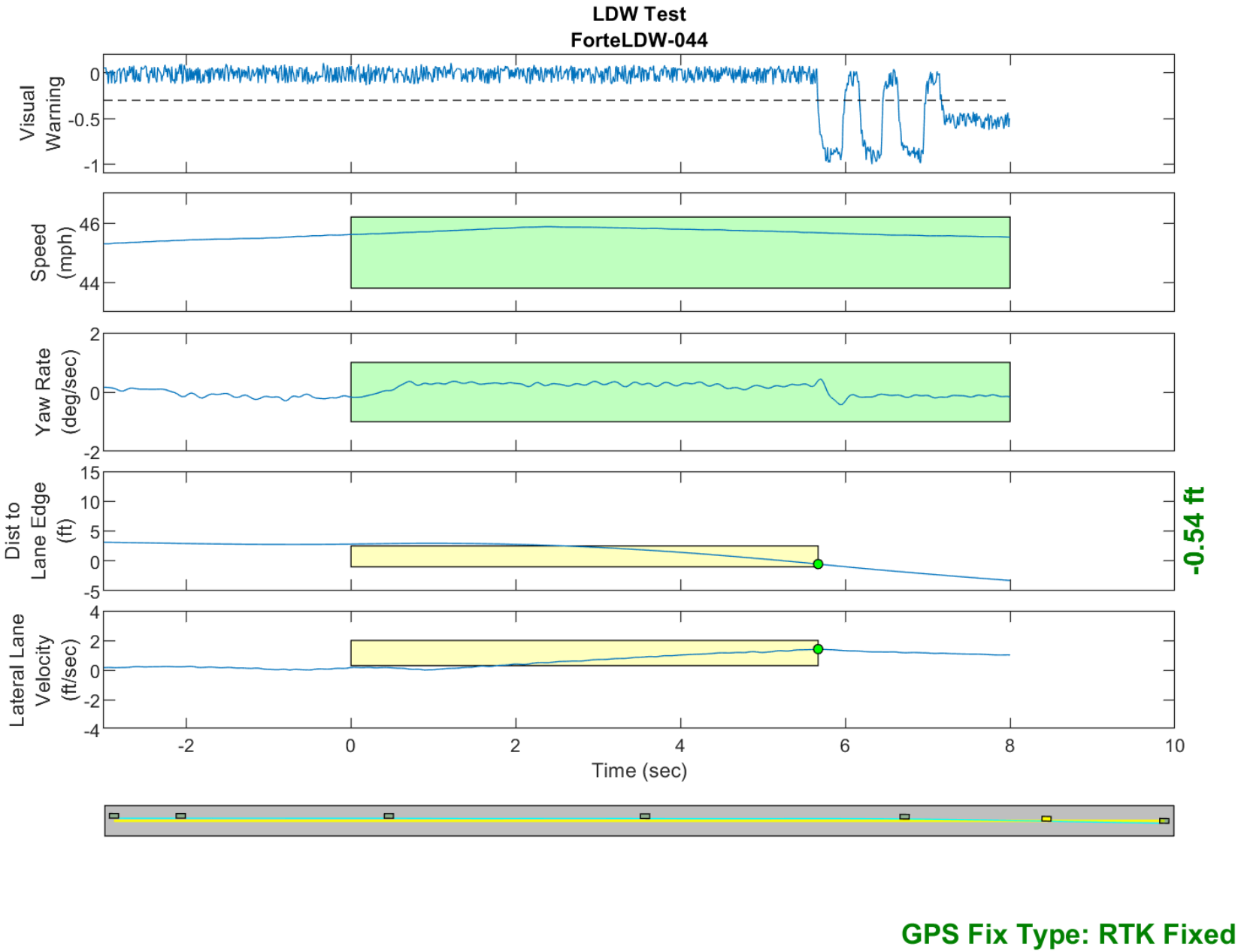


Figure D79. Time History for Run 44, Botts Dots, Right Departure, Visual Warning