NEW CAR ASSESSMENT PROGRAM
LANE DEPARTURE WARNING CONFIRMATION TEST
NCAP-DRI-LDW-21-07

2021 Hyundai Santa Fe 2.5L FWD

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16 April 2021

Final Report

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

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

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Date: 16 April 2021

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16. Abstract These tests were conducted on the subject 2021 Hyundai Santa Fe 2.5L FWD 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 2021 Hyundai Santa Fe 2.5L FWD. The LDW system for this vehicle provides both visual and auditory 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)

2021 Hyundai Santa Fe 2.5L FWD

VIN: *5NMS34AJ3MH32xxxx*

Test Date: *3/12/2021*

Lane Departure Warning setting: *Lane Safety: Warning Only*

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)

2021 Hyundai Santa Fe 2.5L FWD

TEST VEHICLE INFORMATION

VIN: *5NMS34AJ3MH32xxxx*

Body Style: *SUV* Color: *Quartz White*

Date Received: *3/1/2021* Odometer Reading: *83 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Hyundai Motor Manufacturing Alabama, LLC*

Date of manufacture: *Jan/08/21*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *235/60R18*

Rear: *235/60R18*

Recommended cold tire pressure: Front: *240 kPa (35 psi)*

Rear: *240 kPa (35 psi)*

TIRES

Tire manufacturer and model: *Kumho Crugen Premium*

Front tire size: *235/60R18 103H*

Rear tire size: *235/60R18 103H*

Front tire DOT prefix: *000 CMYANH*

Rear tire DOT prefix: *000 CMYANH*

LANE DEPARTURE WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2021 Hyundai Santa Fe 2.5L FWD

GENERAL INFORMATION

Test date: *3/12/2021*

AMBIENT CONDITIONS

Air temperature: *13.9 C (57 F)*

Wind speed: *0.5 m/s (1.2 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: *240 kPa (35 psi)*

Rear: *240 kPa (35 psi)*

LANE DEPARTURE WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2021 Hyundai Santa Fe 2.5L FWD

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*543.0 kg (1197 lb)*	Right Front:	*506.7 kg (1117 lb)*
Left Rear:	*409.1 kg (902 lb)*	Right Rear:	*396.9 kg (875 lb)*
		Total:	*1855.7 kg (4091 lb)*

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

(Page 1 of 3)

2021 Hyundai Santa Fe 2.5L FWD

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

Lane Keeping Assist, which is standard equipment.

Type and location of sensor(s) used:

Mono camera located behind the windshield near the rearview mirror.

Lane Departure Warning Setting used in test:

Lane Safety: Warning Only

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.

When the vehicle departs from the lane, the green indicator light near the tachometer will blink and the white illuminated lane line illustrations in the center of the instrument cluster will turn from solid white to flashing amber. The driver is also alerted with a short burst of repeated beep auditory warnings. See Appendix A, Figure A12.

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.

LDW can be disabled three ways:

- *With the engine on, press and hold the Lane Safety button located to the left of the steering column. See Appendix A, Figure A11.*
- *With the engine on, press and hold the Lane Driving Assist button located on the right side of the steering wheel. See Appendix A, Figure A10.*
- *A menu button on the steering wheel is used to access the system menus displayed on the center touchscreen. The hierarchy is:*

  User Settings

  Driver Assistance

  Lane Safety

  Select either "Assist", "Warning Only", or "Off"

See Appendix A, Figures A9 and A10.

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.

System limitations are described in the Owner's Manual, pages 7-22 through 7-24, shown in Appendix B, pages B-12 through 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.

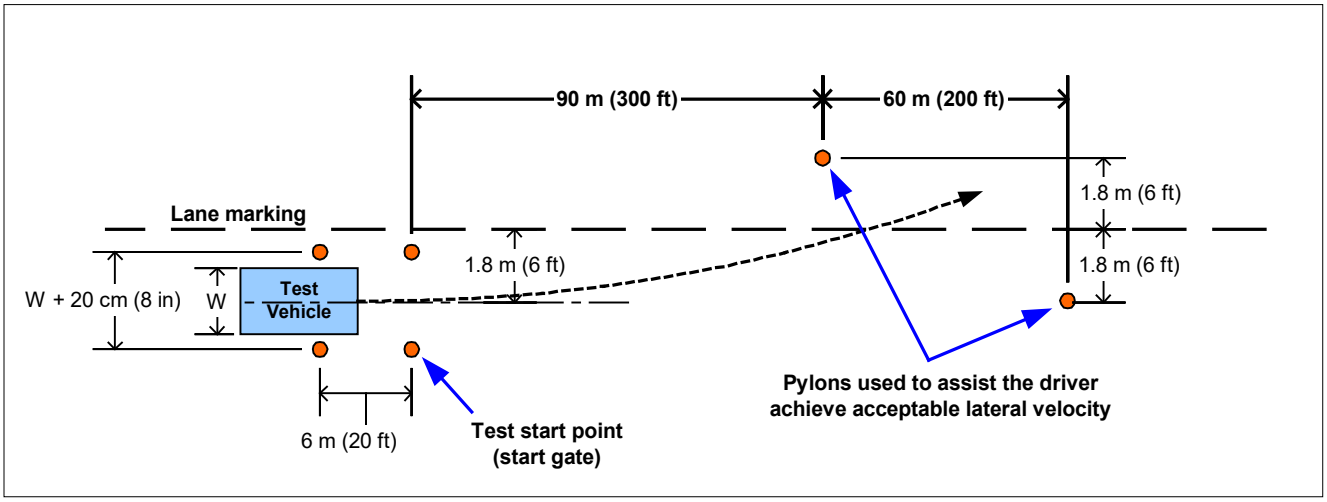


Figure 1. Position of Cones Used to Assist Driver

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.

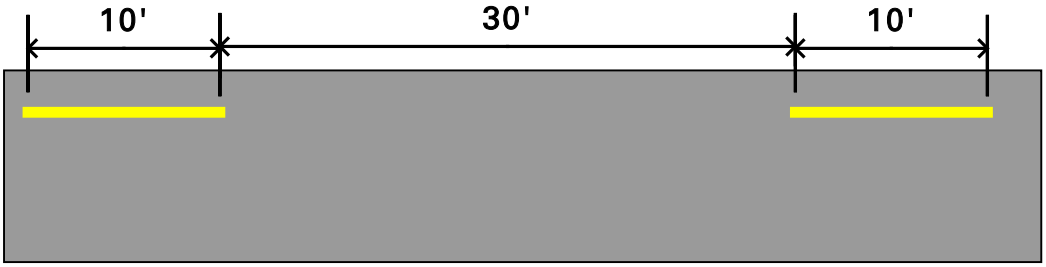


Figure 2. MUTCD Discontinuous Dashed Line Specifications

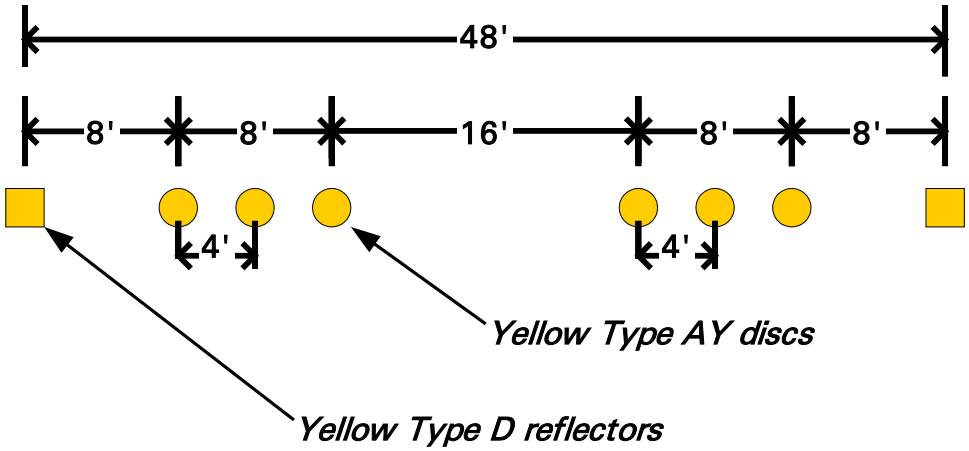


Figure 3. California Standard Plan A20A, Detail 4

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: 8/18/2020 Due: 8/18/2021
Platform Scales	Vehicle Total, Wheel, and Axle Load	8000 lb 35.6 kN	±1.0% of applied load	Intercomp, SWII	0410MN20001	By: DRI Date: 4/20/2020 Due: 4/20/2021
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	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	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots Accel: ±100 m/s^2 Angular Rate: ±100 deg/s Angular Disp: ±180 deg	Position: ±2 cm Velocity: 0.05 km/h Accel: ≤ 0.01% of full range Angular Rate: ≤ 0.01% of full range Roll/Pitch Angle: ±0.03 deg Heading Angle: ±0.1 deg	Oxford Technical Solutions (OXTS), Inertial+	2258	By: Oxford Technical Solutions[1] Date: 5/3/2019 Due: 5/3/2021
Real-Time Calculation of Position and Velocity Relative to Lane Markings	Distance and velocity to lane markings	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	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: 1/6/2021 Due: 1/6/2022

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

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

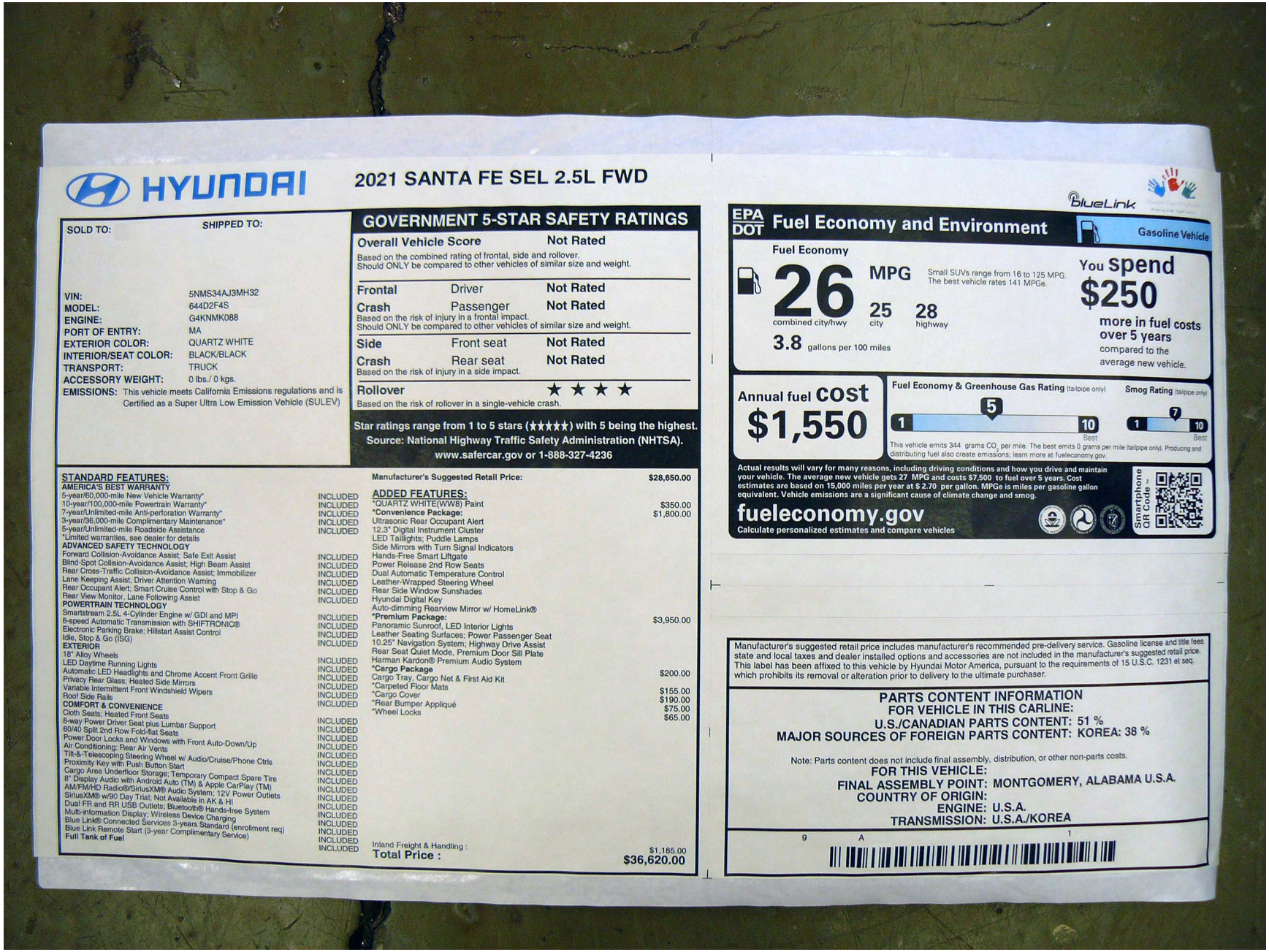


Figure A3. Window Sticker (Monroney Label)

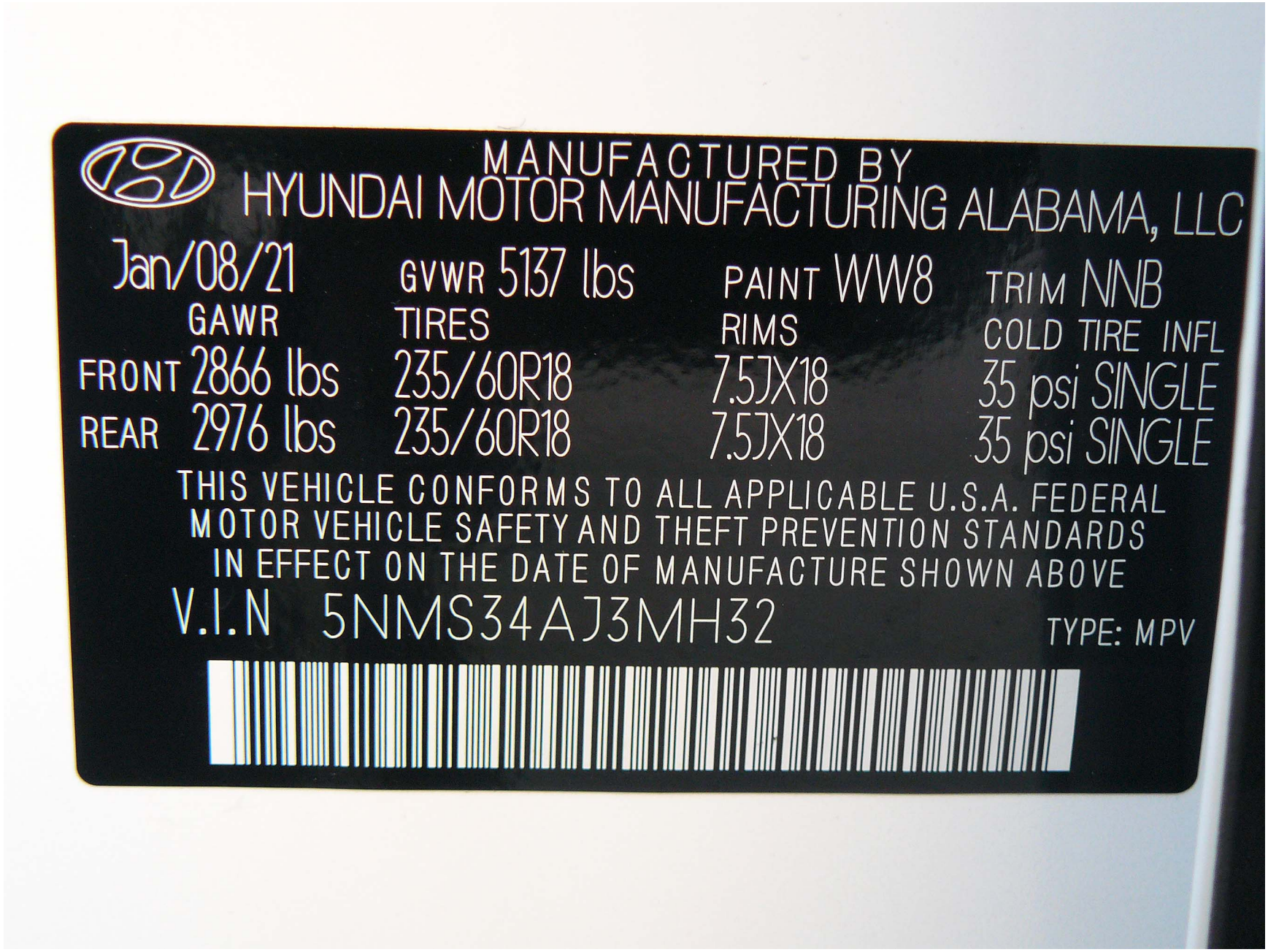


Figure A4. Vehicle Certification Label

Figure A5. Tire Placard

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

Figure A7. Sensors for Detecting Auditory and Visual Alerts

Figure A8. Computer Installed in Subject Vehicle

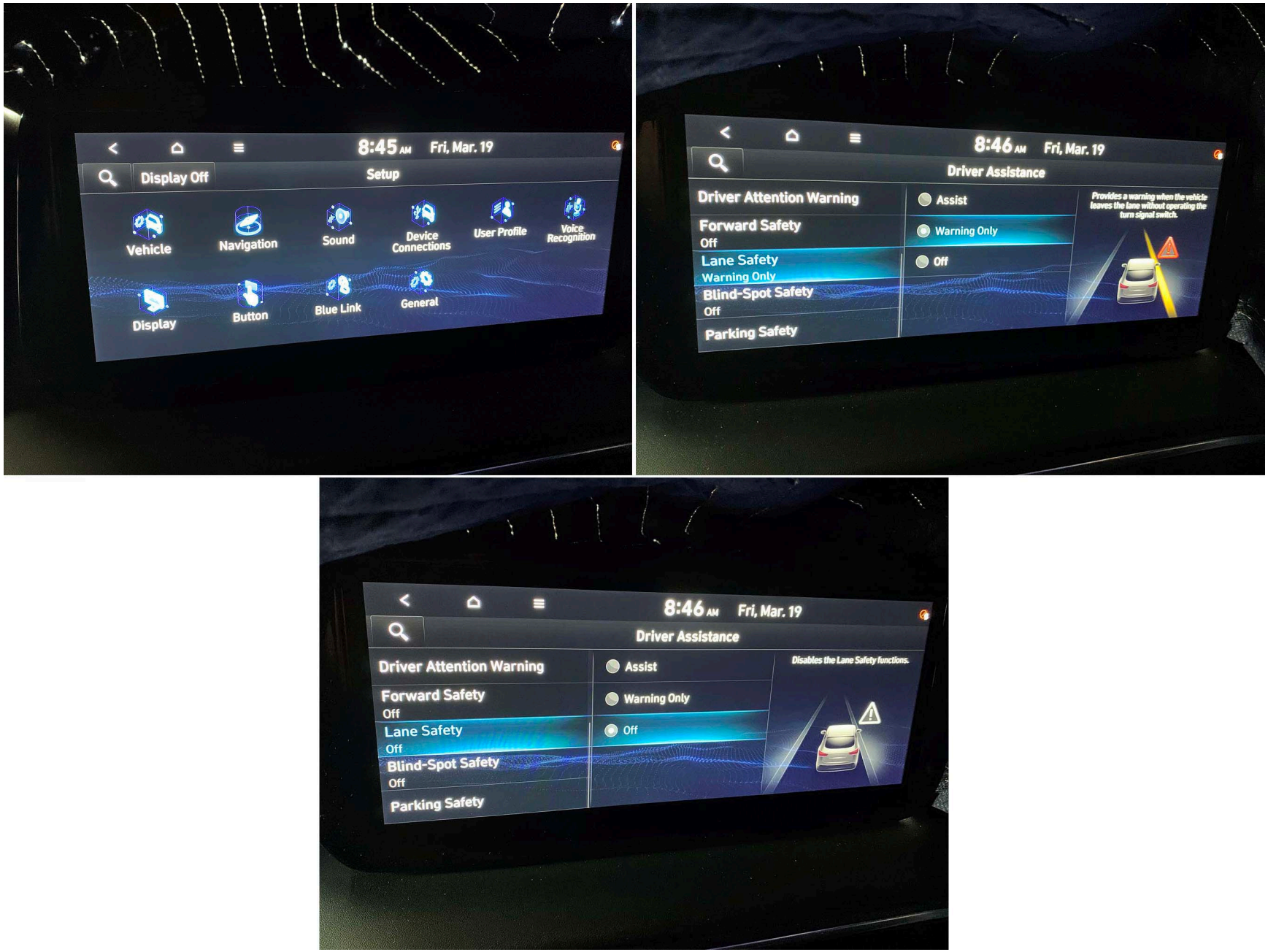


Figure A9. LDW Menus

Figure A10. Buttons for Accessing System Setup Menus and Lane Driving Assist On/Off

Figure A11. LDW On/Off Switch

Figure A12. LDW Status Indicator/Visual Alert

APPENDIX B

Excerpts from Owner’s Manual

Forward Safety warning light (if equipped)

This warning light illuminates:

- When you set the ignition switch or the Engine Start/Stop button to the ON position.
  - The Forward Safety warning light illuminates for approximately 3 seconds and then goes off.
- Whenever there is a malfunction with Forward Collision-Avoidance Assist.

If this occurs, we recommend that you have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Forward Collision-Avoidance Assist (FCA)" section in chapter 7.

Lane Safety indicator light (if equipped)

This indicator light illuminates:

- [Green] When the system operating conditions are satisfied.
- [White] When the system operating conditions are not satisfied.
- [Yellow] Whenever there is a malfunction with Lane Keeping Assist.

  If this occurs, we recommend that you have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Lane Keeping Assist (LKA)" section in chapter 7.

4 Wheel Drive (4WD) warning light

This warning light illuminates:

Whenever there is a malfunction with the 4WD system.

If this occurs, we recommend that you have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "4 Wheel Drive (4WD)" section in chapter 6.

Check Forward Collision-Avoidance Assist system (if equipped)

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

For more details, refer to “Forward Collision-Avoidance Assist (FCA)” in chapter 6.

Check Lane Keeping Assist system (if equipped)

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

For more details, refer to “Lane Keeping Assist (LKA)” in chapter 6.

Check Blind-Spot Collision Warning system (if equipped)

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

For more details, refer to “Blind-Spot Collision Warning (BCW) ” in chapter 6.

Check Driver Attention Warning system (if equipped)

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

For more details, refer to “Driver Attention Warning (DAW)” in chapter 6.

Check High Beam Assist system (if equipped)

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

For more details, refer to “High Beam Assist (HBA)” in chapter 5.

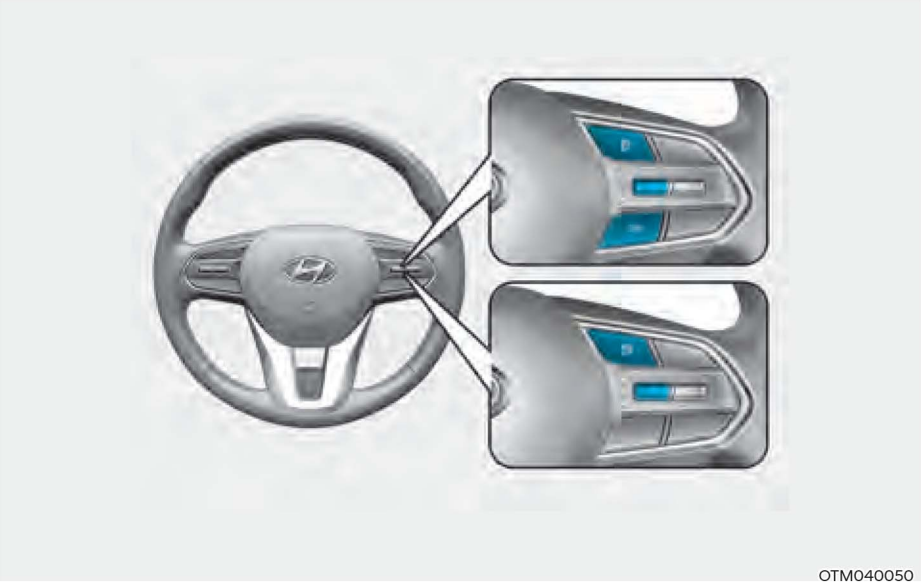
Check Smart Cruise Control system (if equipped)

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

For more details, refer to “Smart Cruise Control (SCC)” in chapter 6.

LCD DISPLAY

LCD display control



OTM040050

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

Switch	Function
	MODE button for changing modes
∧, ∨	MOVE switch for changing items
OK	SELECT/RESET button for setting or resetting the selected item

Information

When the infotainment system is applied, only the User's Setting mode on the infotainment system is supported but the User's Setting mode on the instrument cluster is not supported.

View modes

View modes	Symbol	Explanation
Driving Assist		This mode displays the state of : - Smart Cruise Control (SCC) - Highway Driving Assist (HDA) - Lane Keeping Assist (LKA) - Driver Attention Warning (DAW) **For more information, refer to "Smart Cruise Control (SCC) ", "Highway Driving Assist (HDA) ", "Lane Keeping Assist (LKA) ", "Driver Attention Warning (DAW) " in chapter 7 and "4 Wheel Drive (4WD)" in chapter 6.**
Trip Computer		This mode displays driving information such as the tripmeter, fuel economy, etc. **For more details, refer to "Trip Computer" in this chapter.**
Turn By Turn (TBT)		This mode displays the state of the navigation.
User Settings		In this mode, you can change settings of the doors, lamps, etc.
Warning		The Warning mode displays warning messages related to the vehicle when one or more systems are not operating normally.

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

Trip computer mode

OTMA060011

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

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

Turn By Turn (TBT) mode

OIK047147N

Turn-by-turn navigation, distance/time to destination information is displayed when Turn by Turn view is selected.

Driving Assist mode

OTMA040003

SCC/HDA/LKA

This mode displays the state of the Smart Cruise Control (SCC), Highway Driving Assist (HDA) and Lane Keeping Assist (LKA).

For more details, refer to each system information in chapter 7.

OIG059288L

Driver Attention Warning

This mode displays the state of the Driver Attention Warning (DAW).

For more details, refer to “Driver Attention Warning (DAW)” in chapter 7.

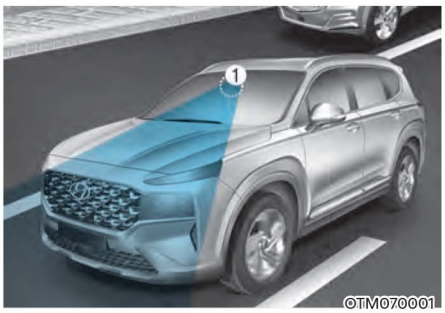
1. Driver Assistance

Items	Explanation
SCC Reaction	To adjust the sensitivity of the Smart Cruise Control system. • Fast/Normal/Slow **For more details, refer to "Smart Cruise Control (SCC)" in chapter 7.**
Driving Convenience	• Lane Following Assist To activate or deactivate the Lane Following Assist. **For more details, refer to the "Lane Following Assist (LFA)" in chapter 7.** • Highway Driving Assist To activate or deactivate the Highway Driving Assist. **For more details, refer to the "Highway Driving Assist (HDA)" in chapter 7.** • Auto Highway Speed Control To activate or deactivate the Auto Highway Speed Control. **For more details, refer to the "Navigation-based Smart Cruise Control (NSCC)" in chapter 7.**
Warning Timing	To adjust the warning timing of the driver assistance system. • Normal / Later
Warning Volume	To adjust the warning volume of the driver assistance system. • High / Medium / Low / Off
Driver Attention Warning	• Leading vehicle departure alert To activate or deactivate the Leading vehicle departure alert. **For more details, refer to the "Leading vehicle departure alert" in chapter 7.** • Inattentive Driving Warning To alert the driver's inattentive driving. **For more details, refer to the "Driver attention Warning (DAW)" in chapter 7.**
Forward safety	To adjust the Forward Collision-Avoidance Assist (FCA) • Active Assist • Warning Only • Off **For more details, refer to the "Forward Collision-Avoidance Assist (FCA)" in chapter 7.**
Lane safety	To adjust the Lane Keeping Assist (LKA) function. • Assist • Warning Only • Off **For more details, refer to the "Lane Keeping Assist (LKA)" in chapter 7.**

LANE KEEPING ASSIST (LKA)

Lane Keeping Assist is designed to help detect lane markings (or road edges) while driving over a certain speed. The system 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 (or road edges).

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)" section in chapter 7.

System settings

Setting functions for the system

Lane Safety

With the engine on, select 'Driver Assistance → Lane Safety' from the Settings menu to set whether or not to use each function.

- If 'Assist' is selected, the system 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, the system will warn the driver with an audible warning when lane departure is detected. The driver must steer the vehicle.
- If 'Off' is selected, the system 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 the system On/Off (Lane Safety button)

With the engine on, press and hold the Lane Safety button located on the instrument panel to turn on Lane Keeping Assist. The white indicator light will illuminate on the cluster.

Press and hold the button again to turn off the system.

If the engine is restarted, Lane Keeping Assist will maintain the last setting.

Information

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

Turning the system On/Off (Lane Driving Assist button)

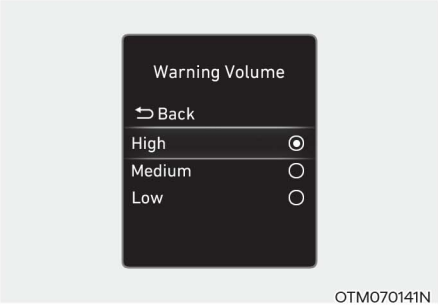
With the engine on, press and hold the Lane Driving Assist button located on the steering wheel to turn on Lane Keeping Assist. The white indicator light will illuminate on the cluster.

Press and hold the button again to turn off the system.

If the engine is restarted, Lane Keeping Assist will maintain the last setting.

CAUTION

When the Lane Driving Assist button is pressed shortly, Lane Following Assist will turn on and off.



OTM070141N

Warning Volume

With the engine on, select 'Driver Assistance → Warning Volume' from the Settings 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.

System operation

System warning and control

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

■ Left

OTM070027

■ Right

OTM070028

Lane Departure Warning

- 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.
- The system will operate when your vehicle speed is between approximately 40~120 mph (60~200 km/h).

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 the vehicle inside the lane.
- The system will operate when your vehicle speed is between approximately 40~120 mph (60~200 km/h).

■ Type A

OTM070037N

■ Type B

OTM070037L

Hands-off warning

If the driver takes their hands off the steering wheel for several seconds, the 'Place hands on the steering wheel' (or 'Keep hands on the 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 the system 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.**

Information

- **You may change settings from the instrument cluster (User Settings) or infotainment system (Vehicle Settings), whichever option that is provided with your vehicle. For more details, see "User Settings" section in chapter 4, or "Vehicle Settings" section in supplied Infotainment Manual.**
- **When lane markings (or road edges) are detected, the lane lines on the cluster will change from grey to white and the green indicator light will illuminate.**

■ Lane undetected

OTM070025

■ Lane detected

OTM070026

- **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.**

System malfunction and limitations

System malfunction

■ Type A

OTM070035N

■ Type B

OTM070035L

When Lane Keeping Assist is not working properly, the 'Check Lane Keeping Assist (LKA) system' (or 'Check LKA (Lane Keeping Assist) system') warning message will appear and the yellow indicator light will illuminate on the cluster. If this occurs, we recommend that the system be inspected by an authorized HYUNDAI dealer.

Limitations of the system

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

- The lane is contaminated or difficult to distinguish because,
  - The lane markings (or road edge) is covered with rain, snow, dirt, oil, etc.
  - The color of the lane marking (or road edge) is not distinguishable from the road
  - There are markings (or road edges) on the road near the lane or the markings (or road edges) on the road looks similar to the lane markings (or road edge)
  - The lane marking (or road edge) is indistinct or damaged
  - The shadow is on the lane marking (or road edge) by a median strip, trees, guardrail, noise barriers, etc.
- There are more than two lane markings (or road edges) on the road
- The lane number increases or decreases, or the lane markings (or road edges) are crossing
- The lane markings (or road edges) are complicated or a structure substitutes for the lines, such as a construction area
- There are road markings, such as zigzag lanes, crosswalk markings and road signs
- The lane suddenly disappears, such as at the intersection
- The lane (or road width) 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 (or road edge)

For more details on the limitations of the front view camera, refer to "Forward Collision-Avoidance Assist (FCA)" section in chapter 7.

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 the system 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 the System" 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 the system.**

- **If any other system'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 the system is turned on or right after changing a lane**
  - **ESC (Electronic Stability Control) or VSM (Vehicle Stability Management) is activated**
  - **The vehicle is driven on a sharp curve**
  - **35 mph (55 km/h) or above 130 mph (210 km/h)**
  - **The vehicle makes sharp lane changes**
  - **The vehicle brakes suddenly**

APPENDIX C

Run Log

Subject Vehicle: **2021 Hyundai Santa Fe 2.5L FWD** Test Date: **3/12/2021**

Driver: **K. Nagao** **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	**Dashed**	**Left**	N				GPS float
2			Y	-0.66	-0.74	Pass	
3			Y	-0.52	-0.58	Pass	
4			Y	-0.82	-0.90	Pass	
5			Y	-0.72	-0.81	Pass	
6			N				Yaw
7			Y	-0.59	-0.67	Pass	
8			N				GPS float
9			Y	-0.70	-0.78	Pass	
10			Y	-0.52	-0.59	Pass	
11	**Dashed**	**Right**	Y	-0.44	-0.51	Pass	
12			Y	-0.36	-0.45	Pass	
13			Y	-0.46	-0.53	Pass	
14			Y	-0.47	-0.53	Pass	
15			N				Unclear visual warning
16			Y	-0.45	-0.53	Pass	
17			Y	-0.42	-0.50	Pass	
18			Y	-0.45	-0.50	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Auditory Alert (ft)	Distance at Visual Alert (ft)	Pass/Fail	Notes
19	**Solid**	**Right**	Y	-0.52	-0.60	Pass	
20			Y	-0.41	-0.50	Pass	
21			Y	-0.43	-0.51	Pass	
22			Y	-0.38	-0.44	Pass	
23			Y	-0.42	-0.47	Pass	
24			Y	-0.52	-0.61	Pass	
25			Y	-0.41	-0.49	Pass	
26	**Solid**	**Left**	Y	-0.45	-0.57	Pass	
27			Y	-0.50	-0.59	Pass	
28			Y	-0.49	-0.61	Pass	
29			Y	-0.54	-0.63	Pass	
30			Y	-0.52	-0.61	Pass	
31			Y	-0.55	-0.62	Pass	
32			Y	-0.51	-0.59	Pass	
33	**Botts**	**Left**	Y	-0.71	-0.78	Pass	
34			Y	-0.56	-0.65	Pass	
35			Y	-0.42	-0.49	Pass	
36			Y	-0.18	-0.28	Pass	
37			Y	-0.63	-0.71	Pass	
38			Y	-0.13	-0.24	Pass	
39			Y	-0.49	-0.60	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Auditory Alert (ft)	Distance at Visual Alert (ft)	Pass/Fail	Notes
40	**Botts**	**Right**	Y	-0.58	-0.66	Pass	
41			Y	-0.50	-0.63	Pass	
42			Y	-0.38	-0.48	Pass	
43			Y	-0.48	-0.57	Pass	
44			Y	-0.32	-0.40	Pass	
45			Y	-0.53	-0.64	Pass	
46			Y	-0.54	-0.64	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.

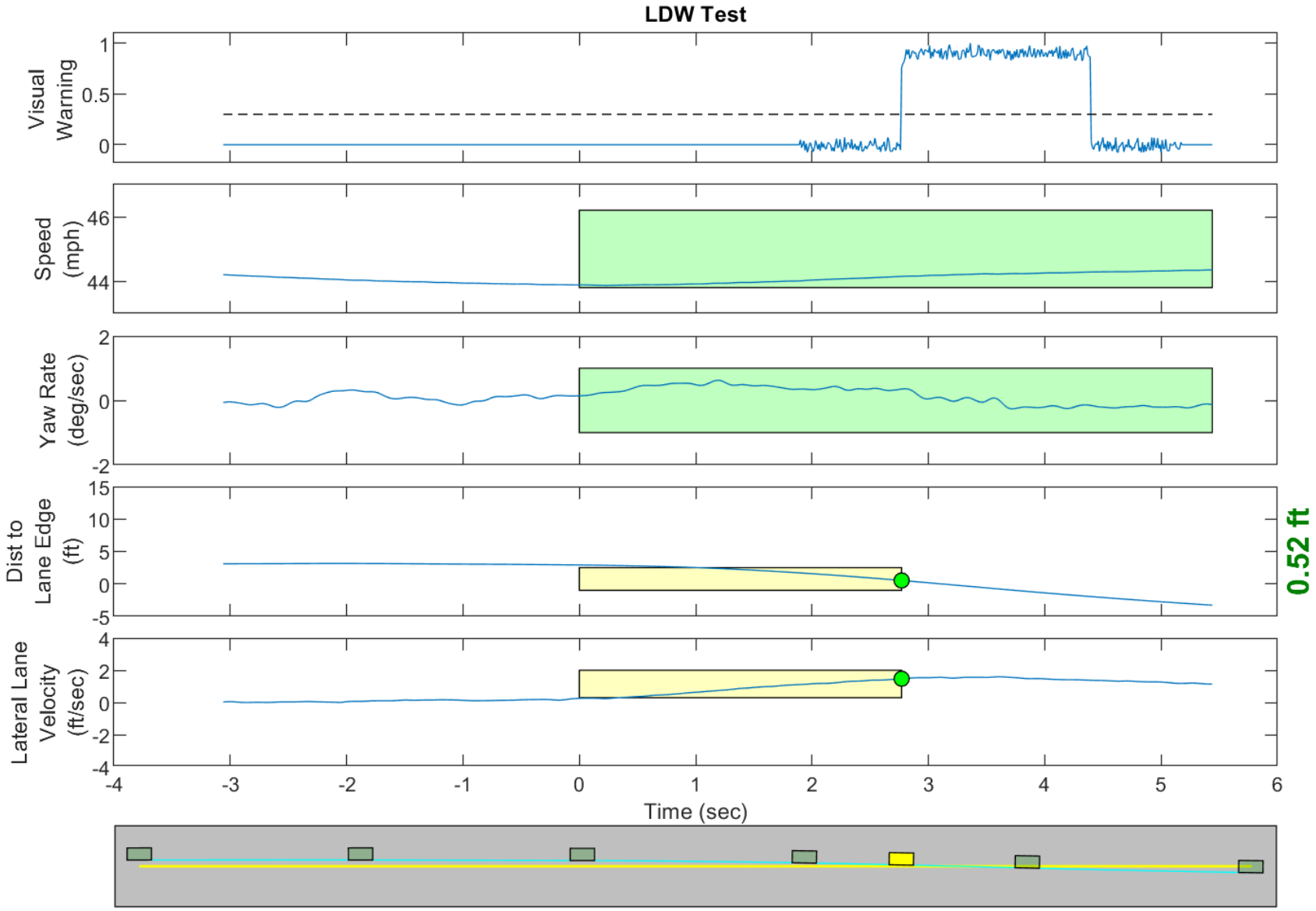


Figure D1. Example Time History for Lane Departure Warning Test, Passing

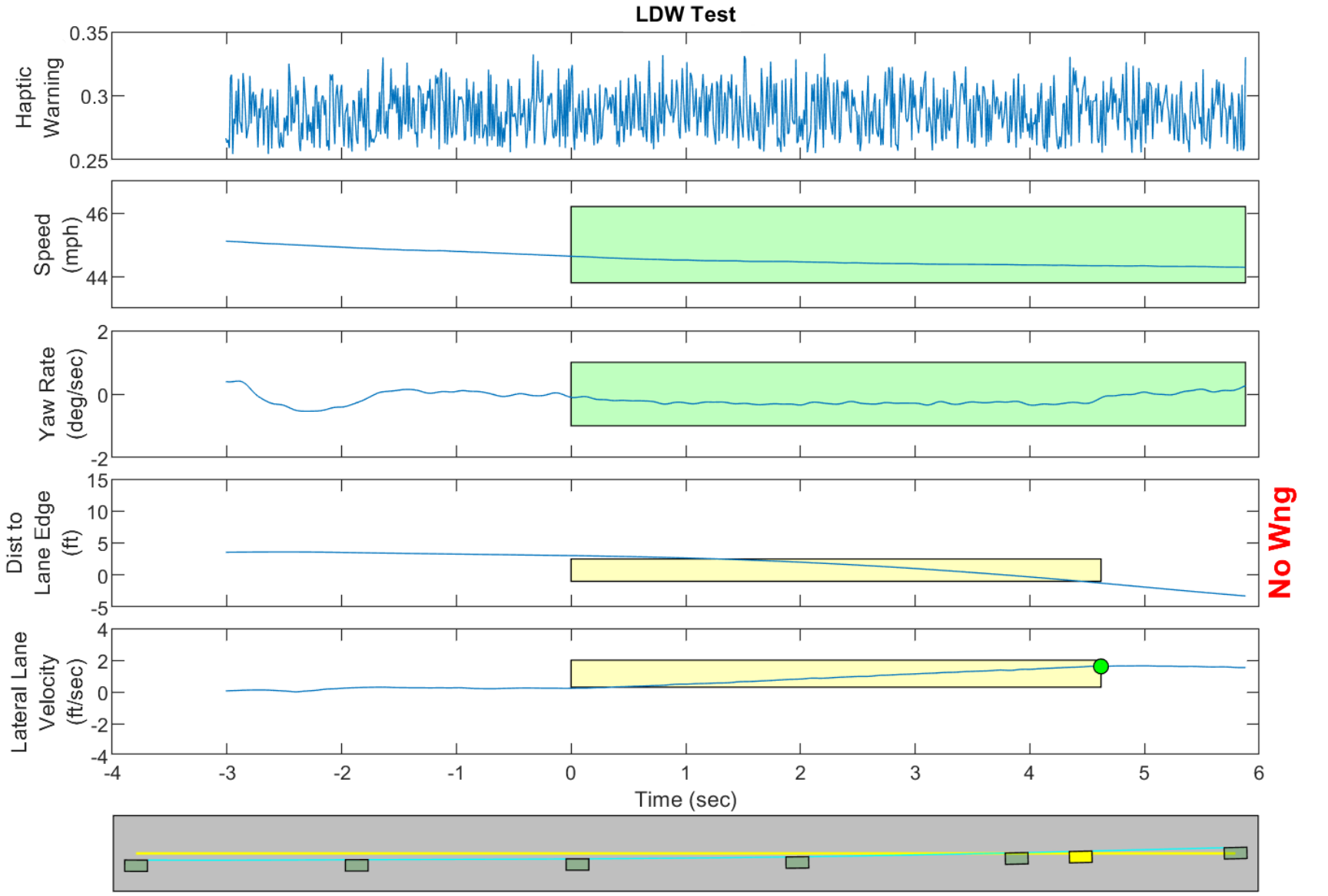


Figure D2. Example Time History for Lane Departure Warning Test, Failing, No Warning Issued

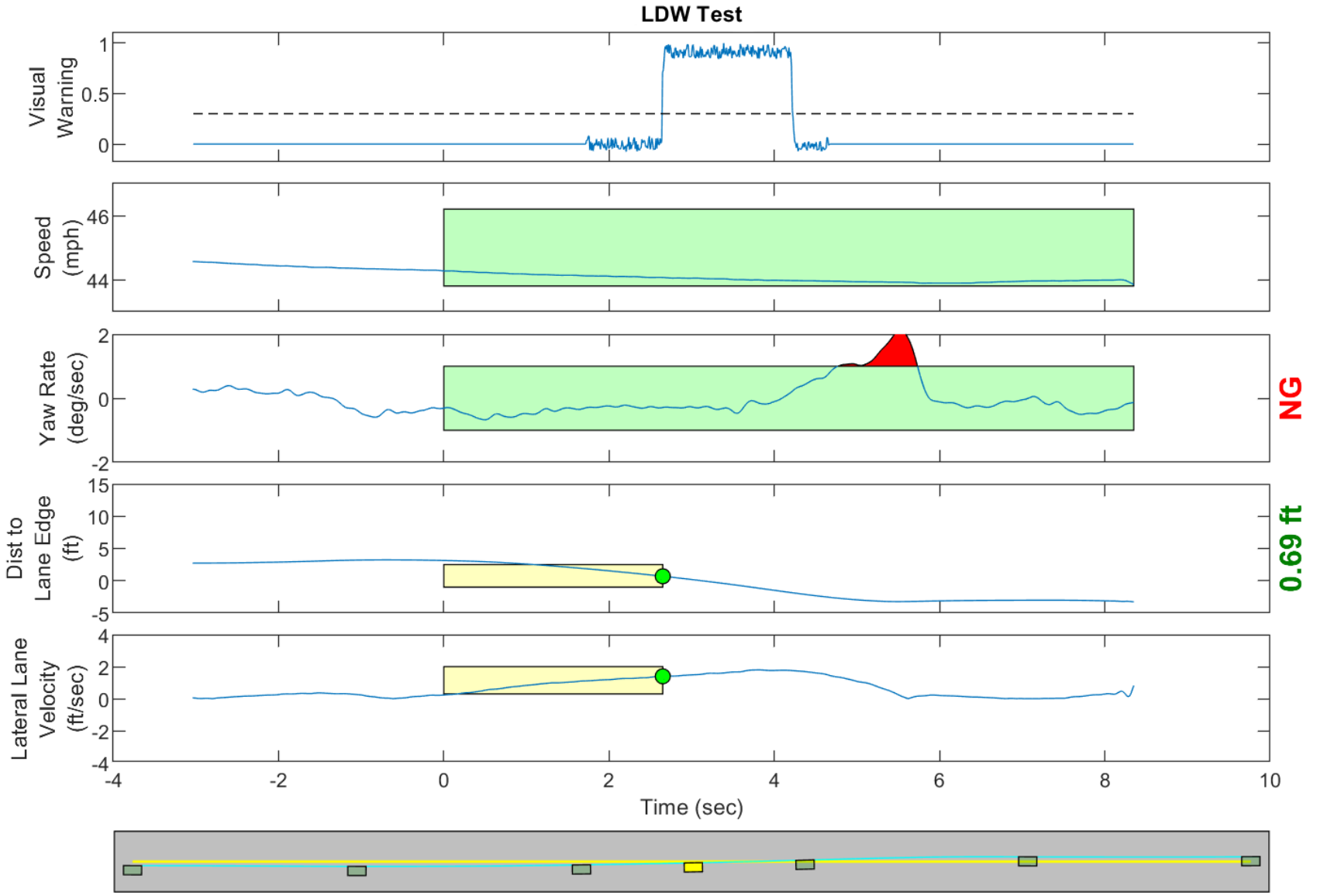


Figure D3. Example Time History for Lane Departure Warning Test, Invalid Run Due to Subject Vehicle Yaw Rate

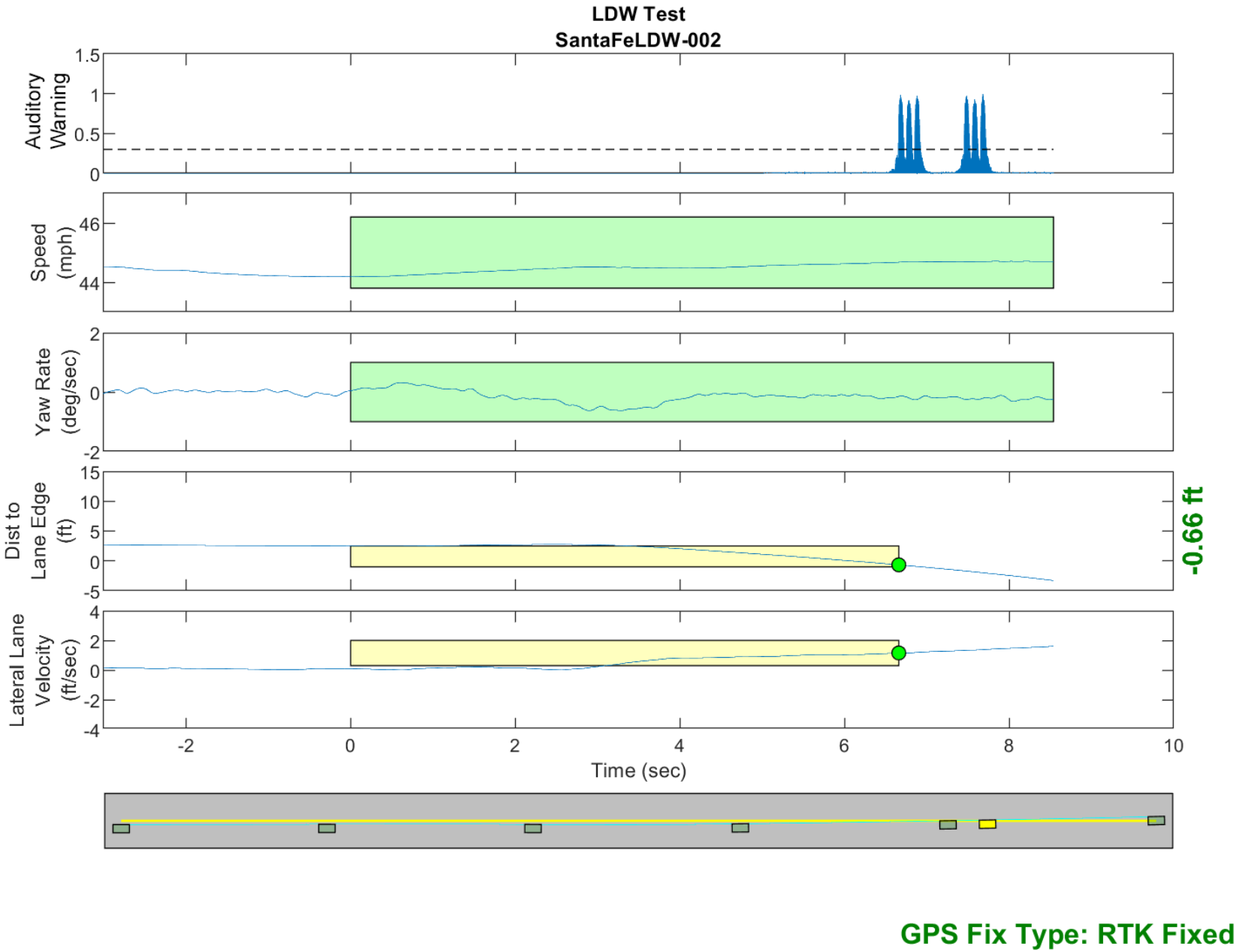


Figure D4. Time History for Run 02, Dashed Line, Left Departure, Auditory Warning

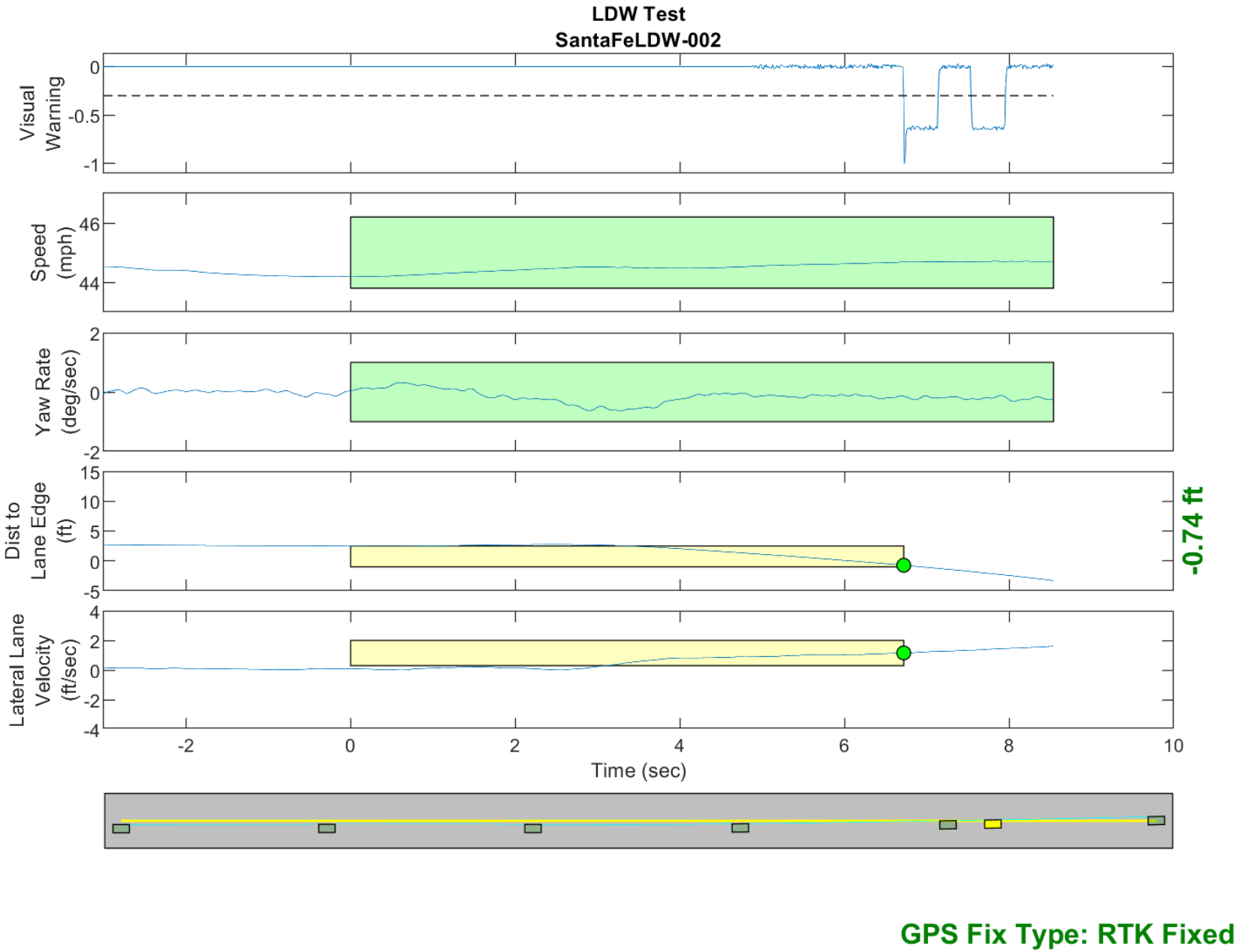


Figure D5. Time History for Run 02, Dashed Line, Left Departure, Visual Warning

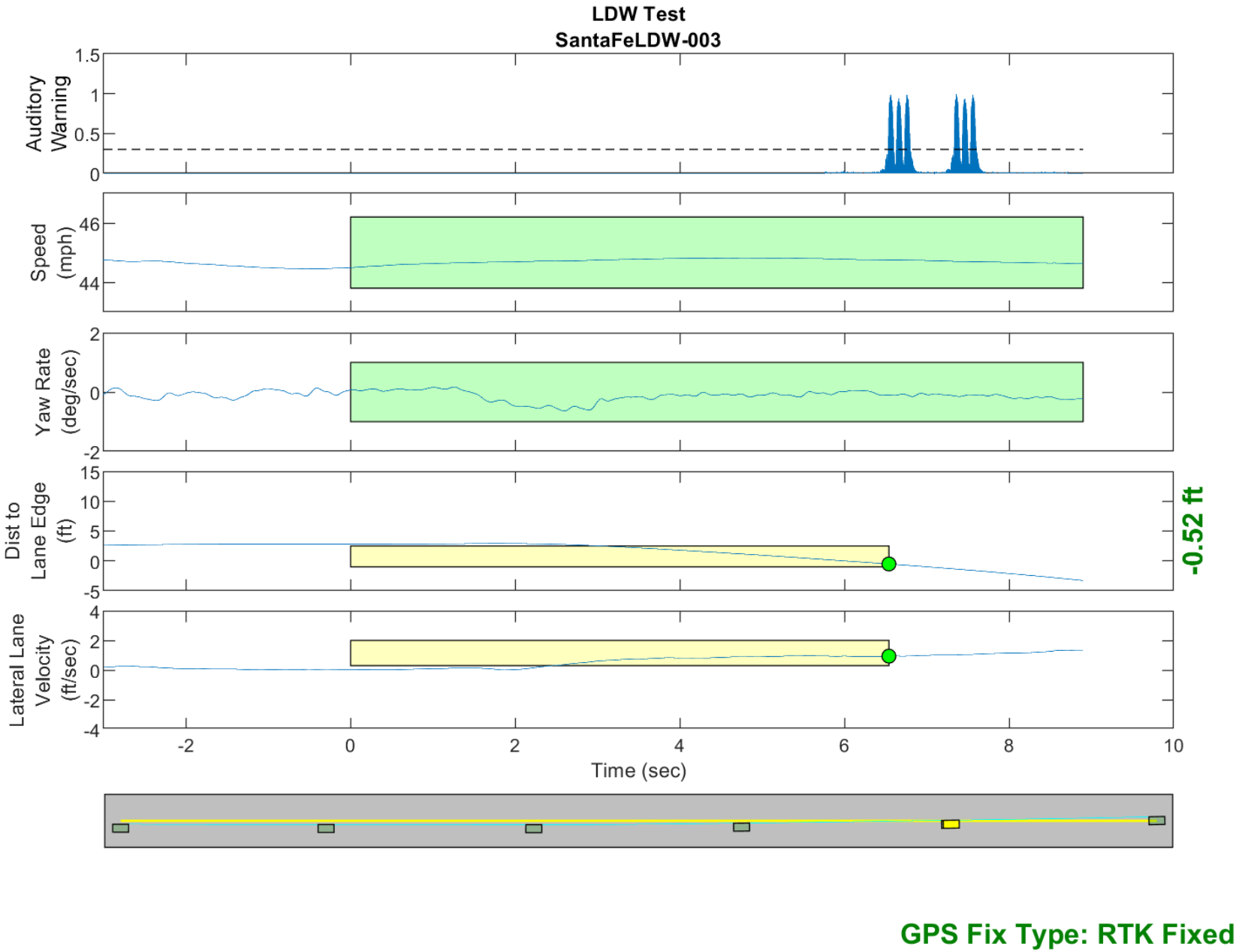


Figure D6. Time History for Run 03, Dashed Line, Left Departure, Auditory Warning

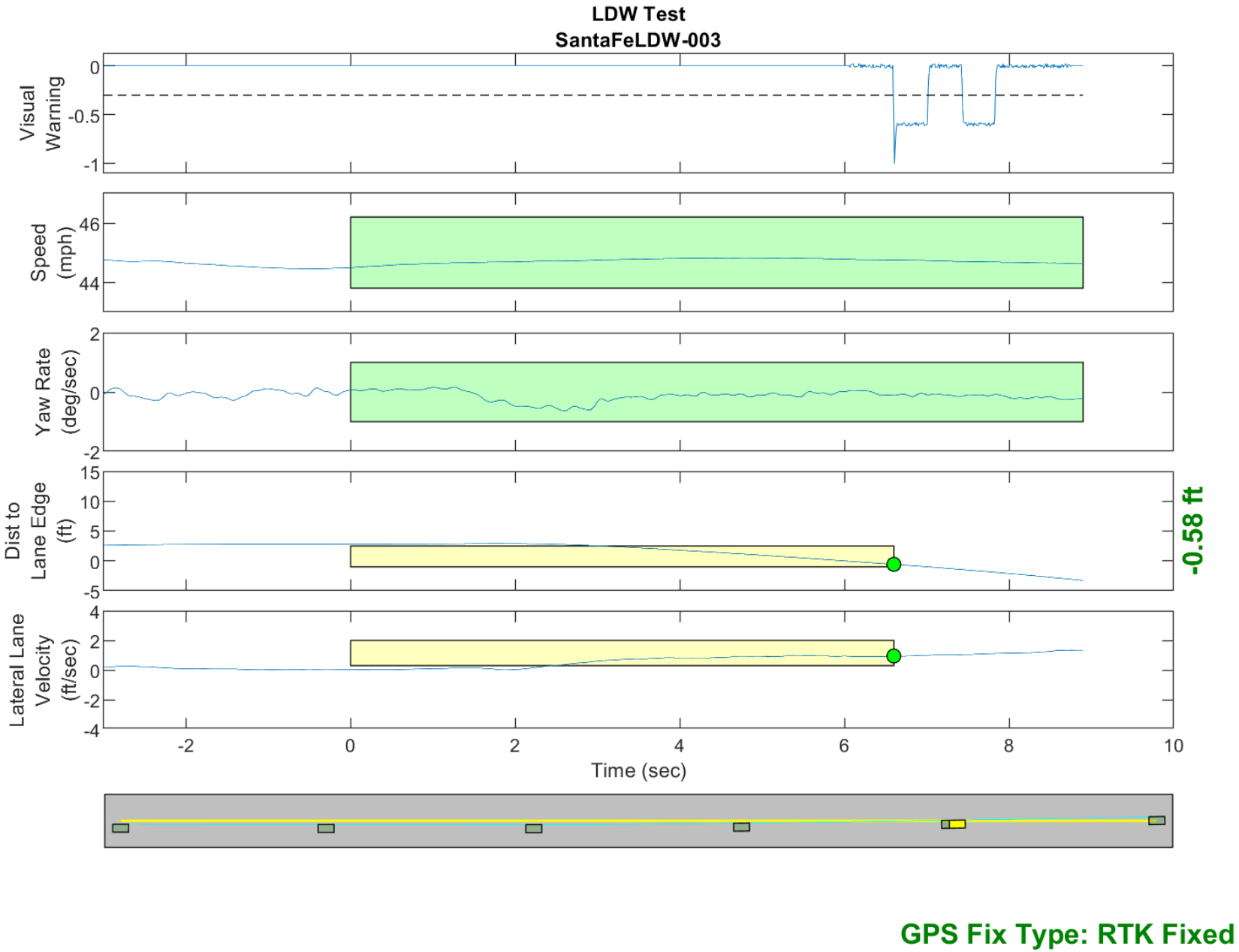


Figure D7. Time History for Run 03, Dashed Line, Left Departure, Visual Warning

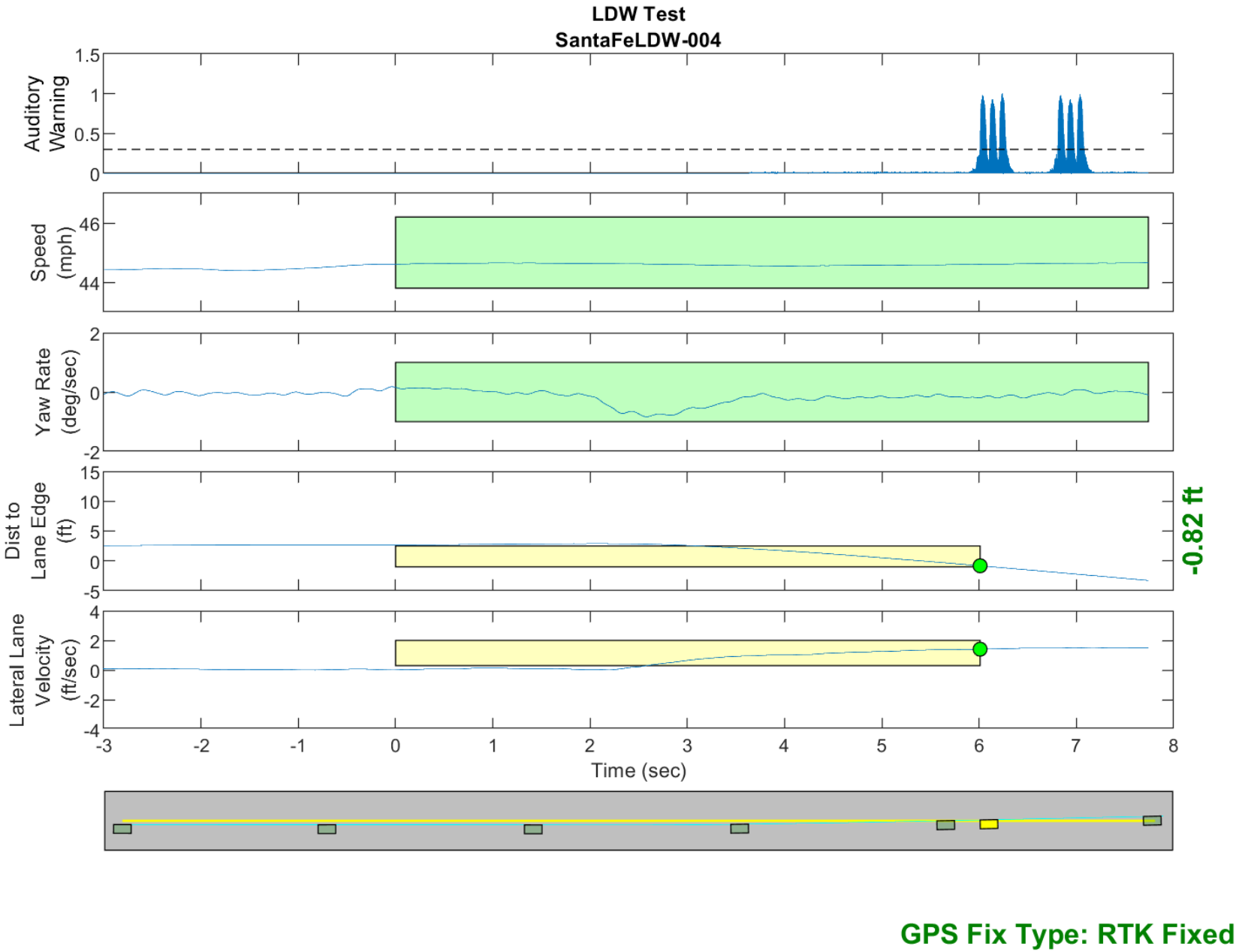


Figure D8. Time History for Run 04, Dashed Line, Left Departure, Auditory Warning

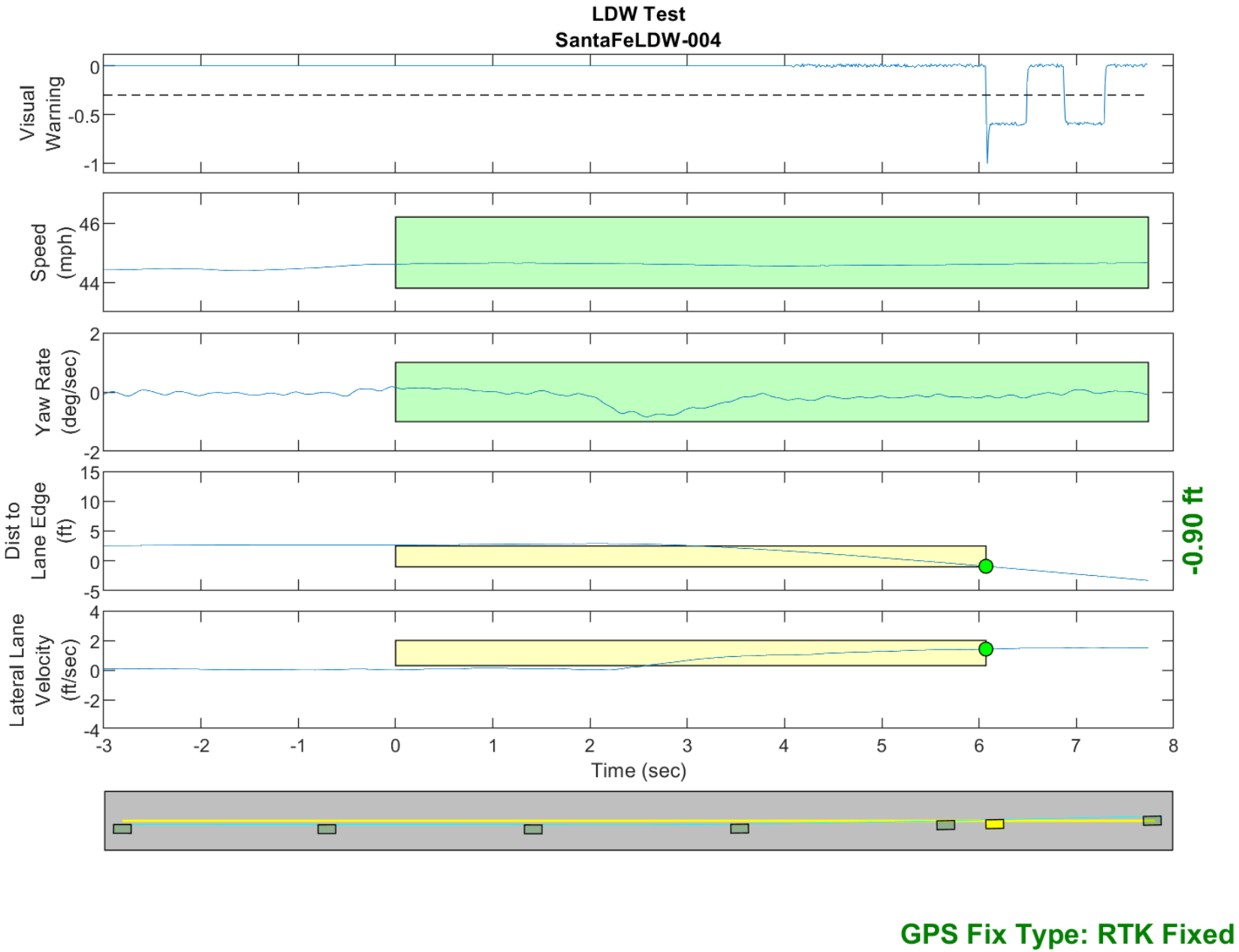


Figure D9. Time History for Run 04, Dashed Line, Left Departure, Visual Warning

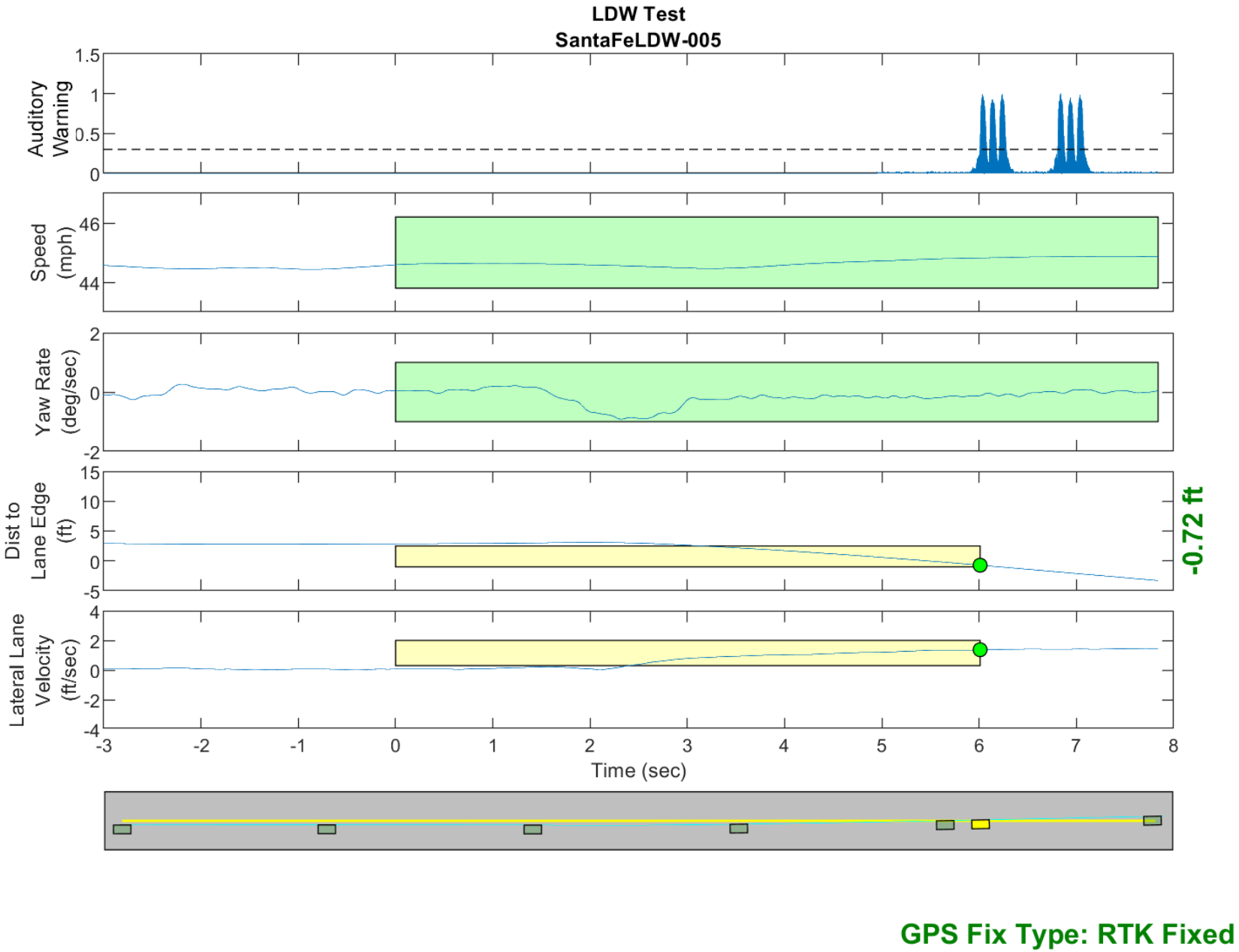


Figure D10. Time History for Run 05, Dashed Line, Left Departure, Auditory Warning

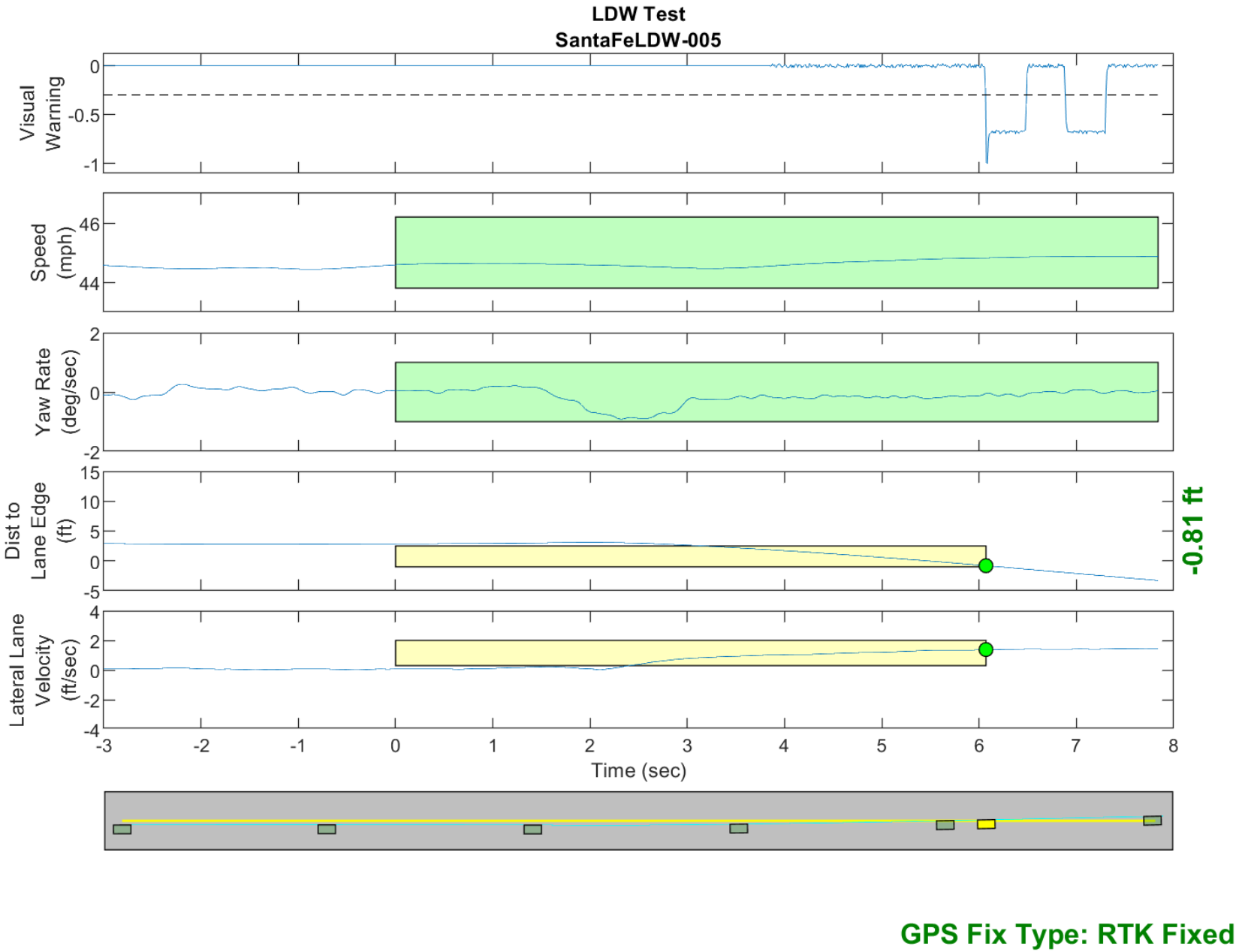


Figure D11. Time History for Run 05, Dashed Line, Left Departure, Visual Warning

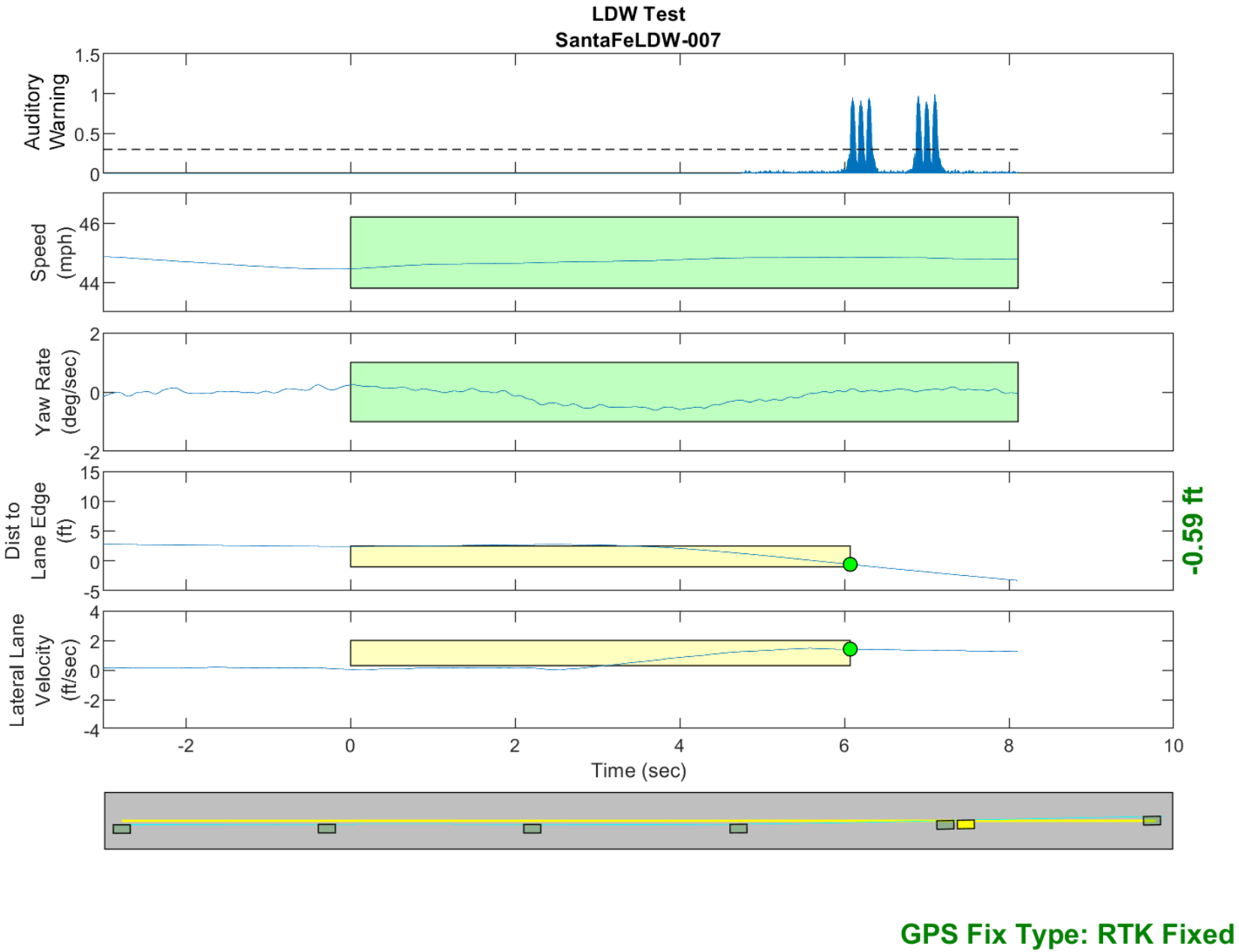


Figure D12. Time History for Run 07, Dashed Line, Left Departure, Auditory Warning

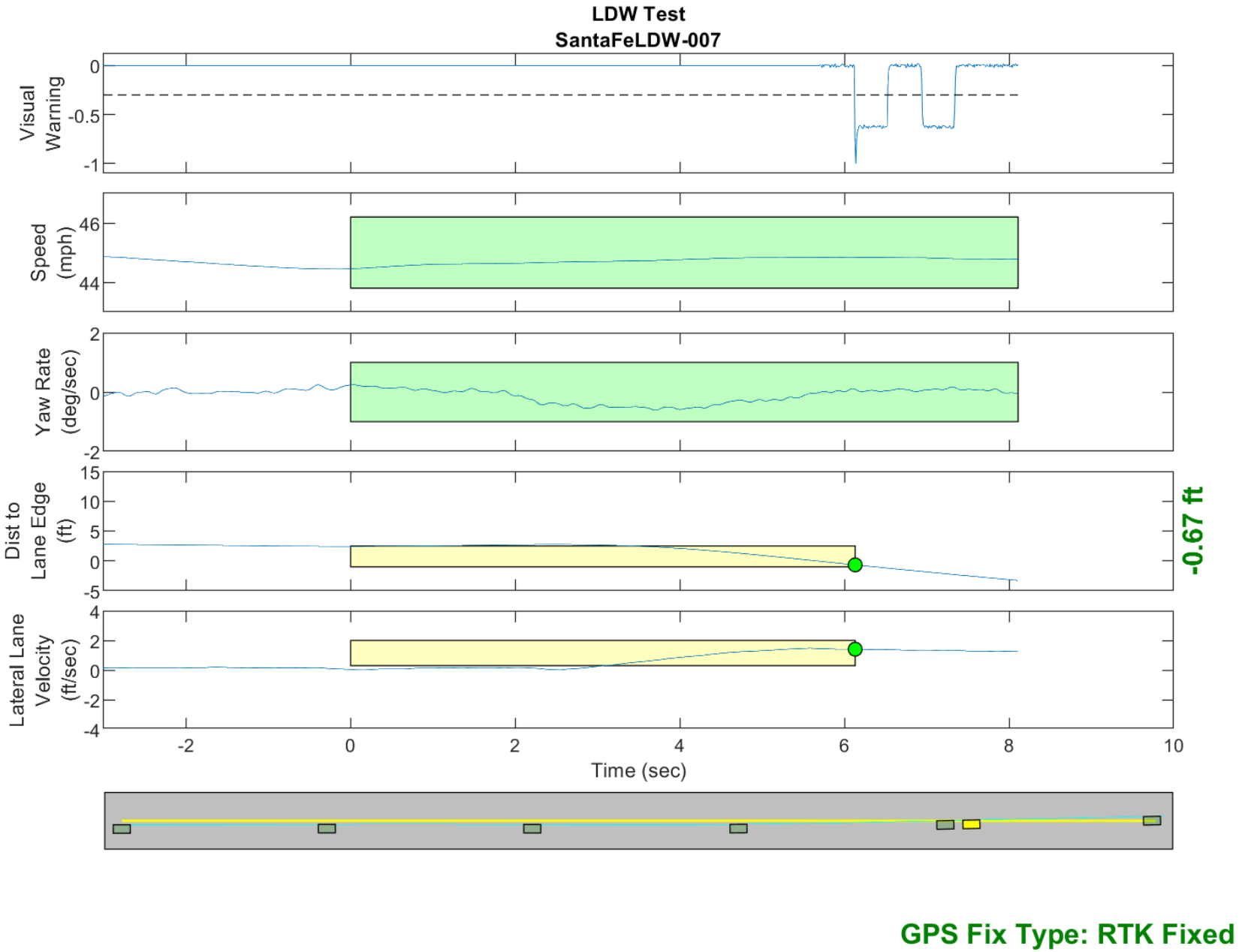


Figure D13. Time History for Run 07, Dashed Line, Left Departure, Visual Warning

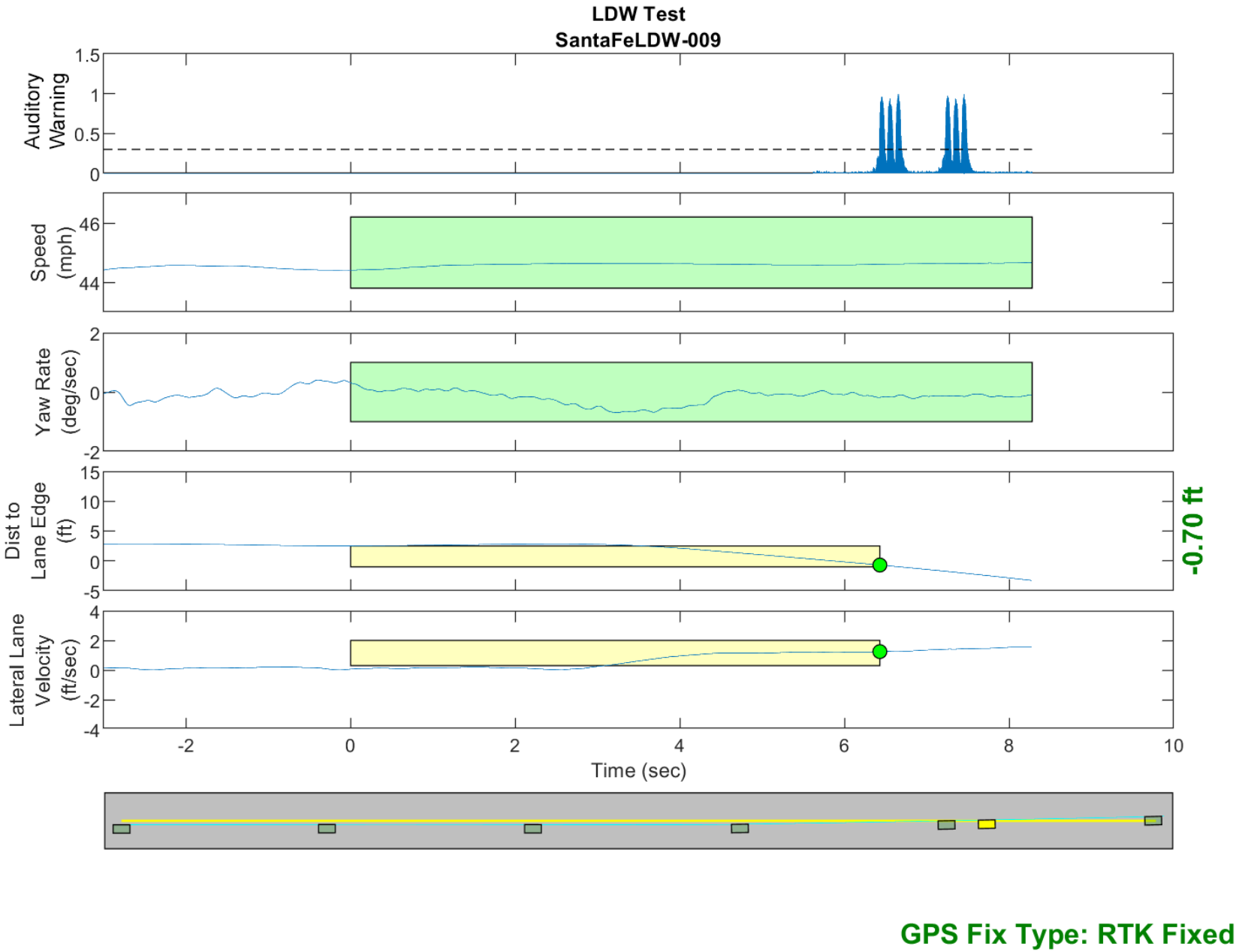


Figure D14. Time History for Run 09, Dashed Line, Left Departure, Auditory Warning

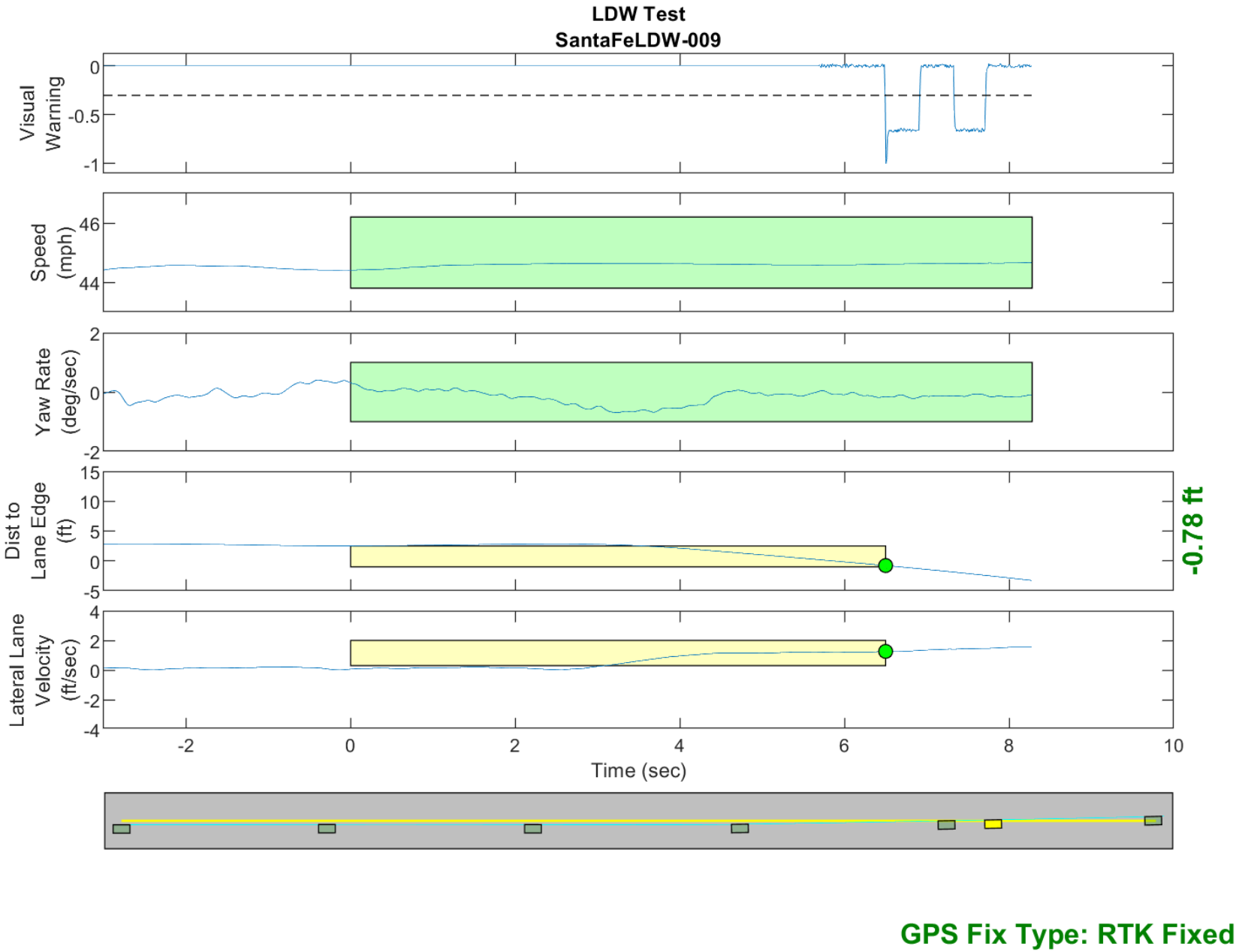


Figure D15. Time History for Run 09, Dashed Line, Left Departure, Visual Warning

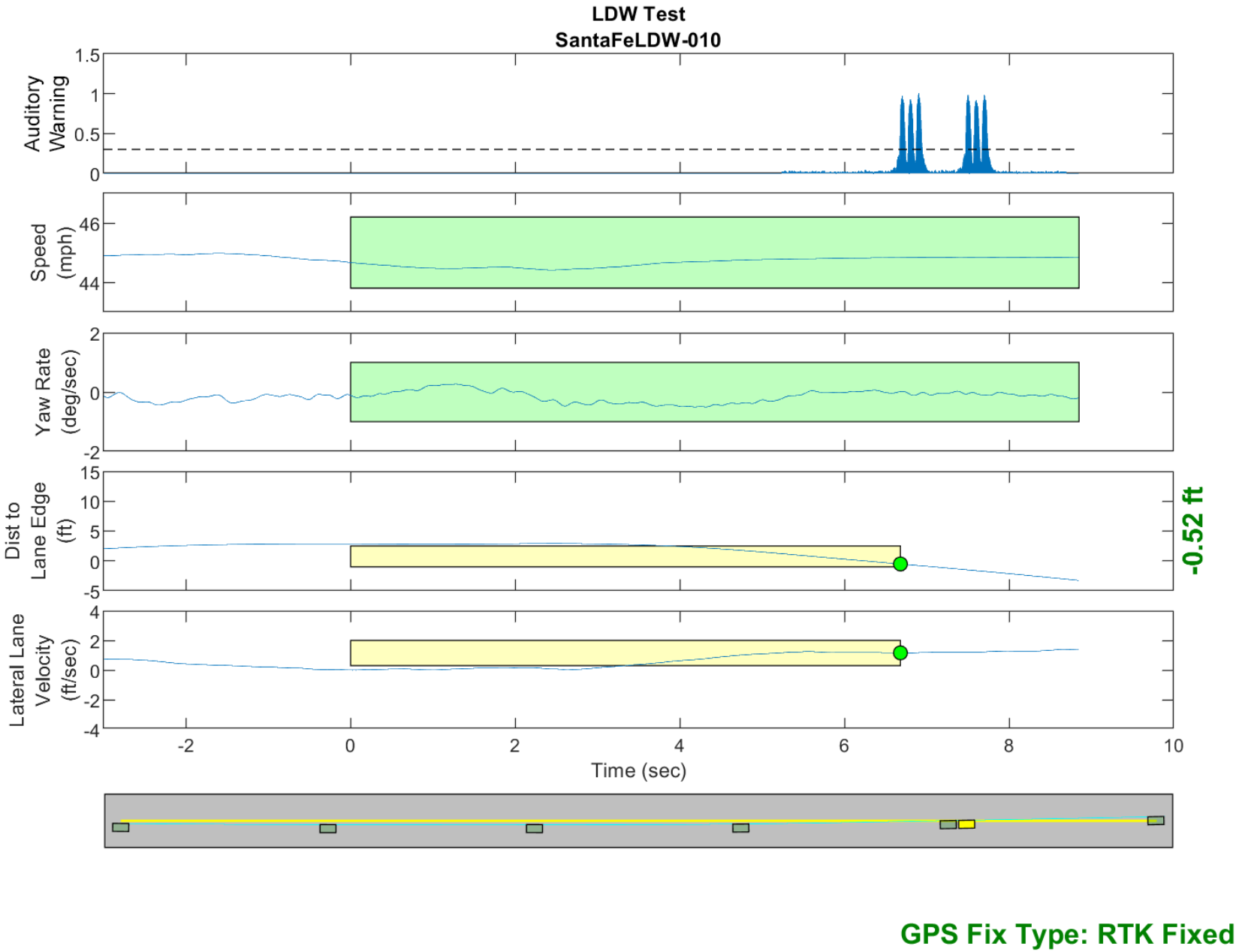


Figure D16. Time History for Run 10, Dashed Line, Left Departure, Auditory Warning

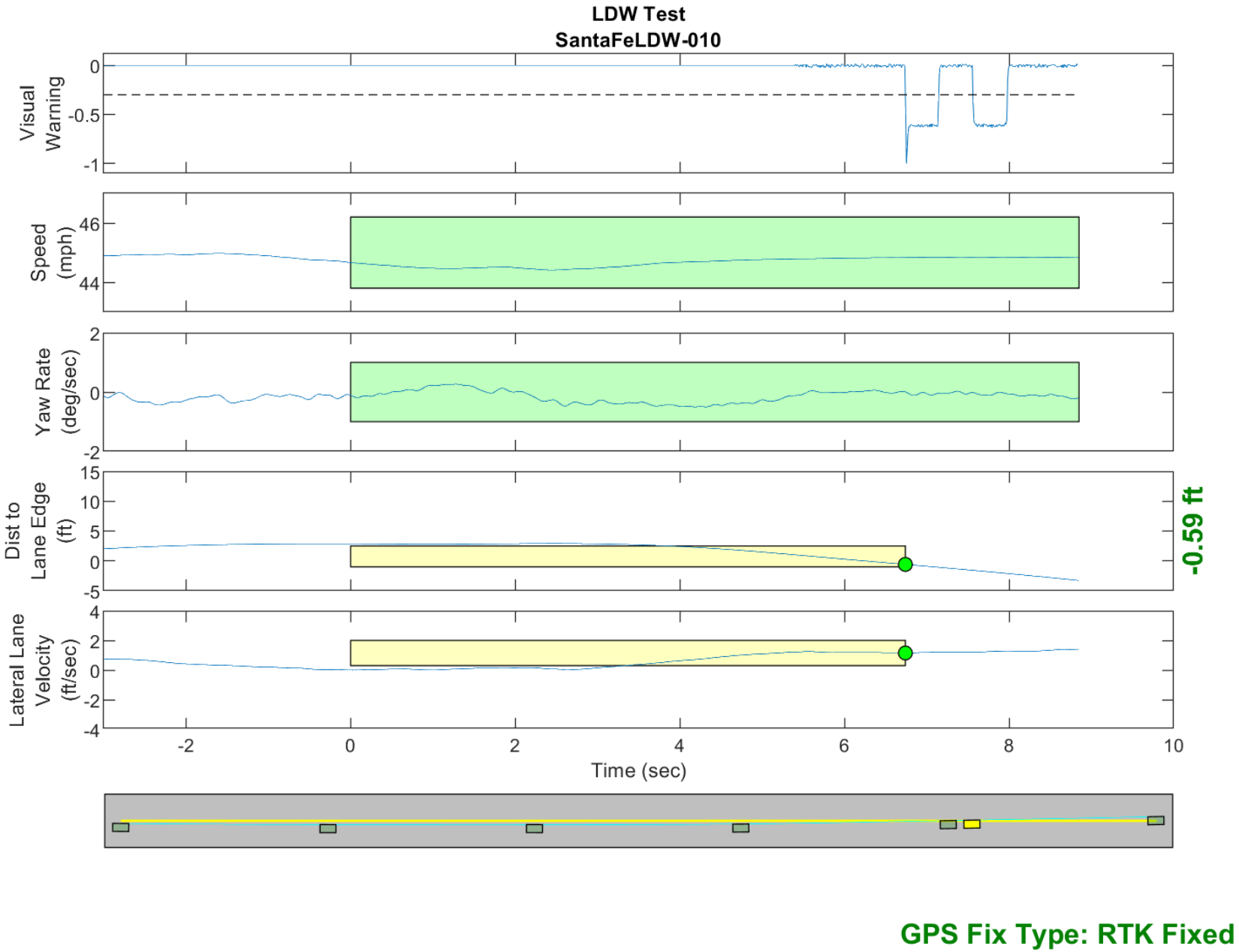


Figure D17. Time History for Run 10, Dashed Line, Left Departure, Visual Warning

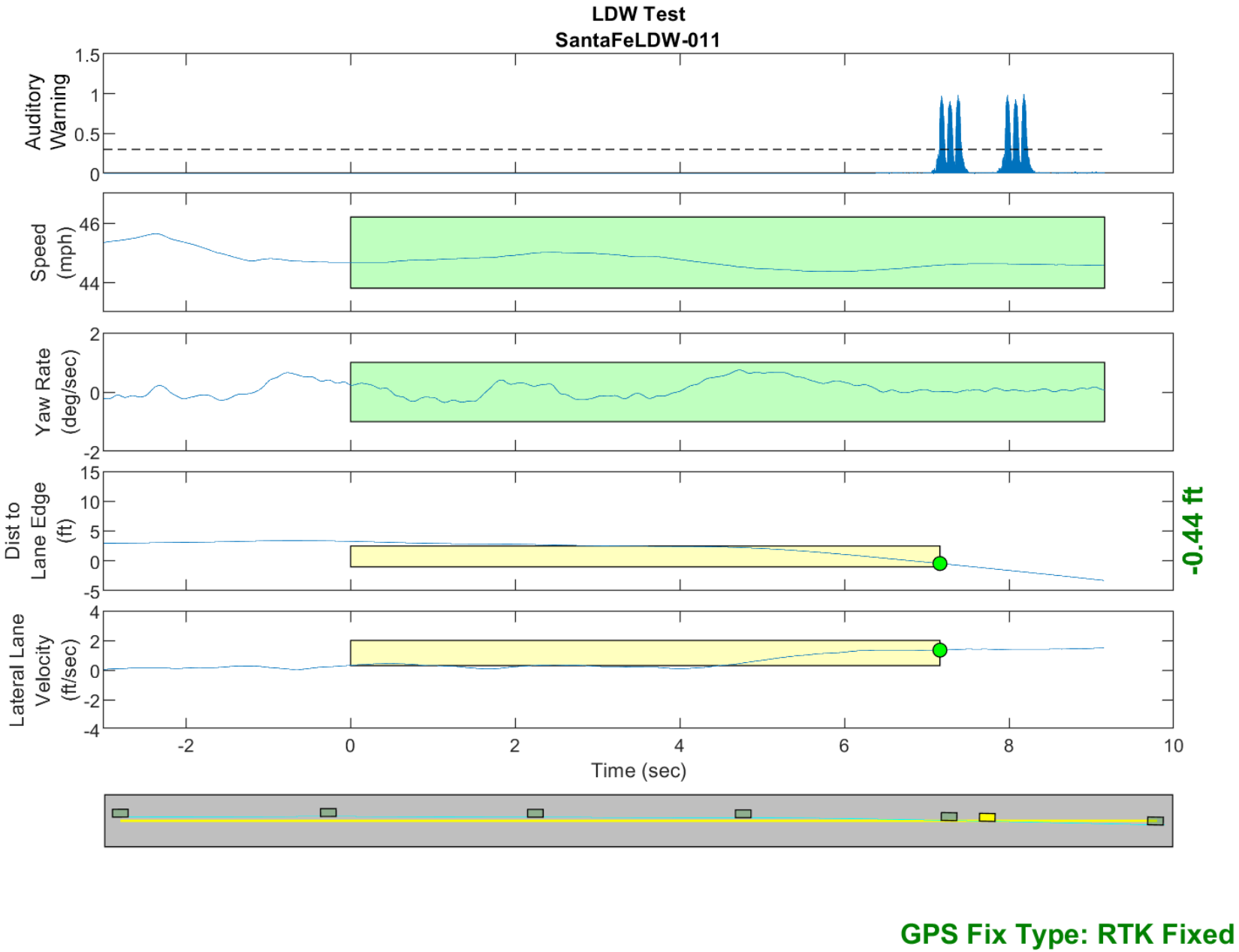


Figure D18. Time History for Run 11, Dashed Line, Right Departure, Auditory Warning

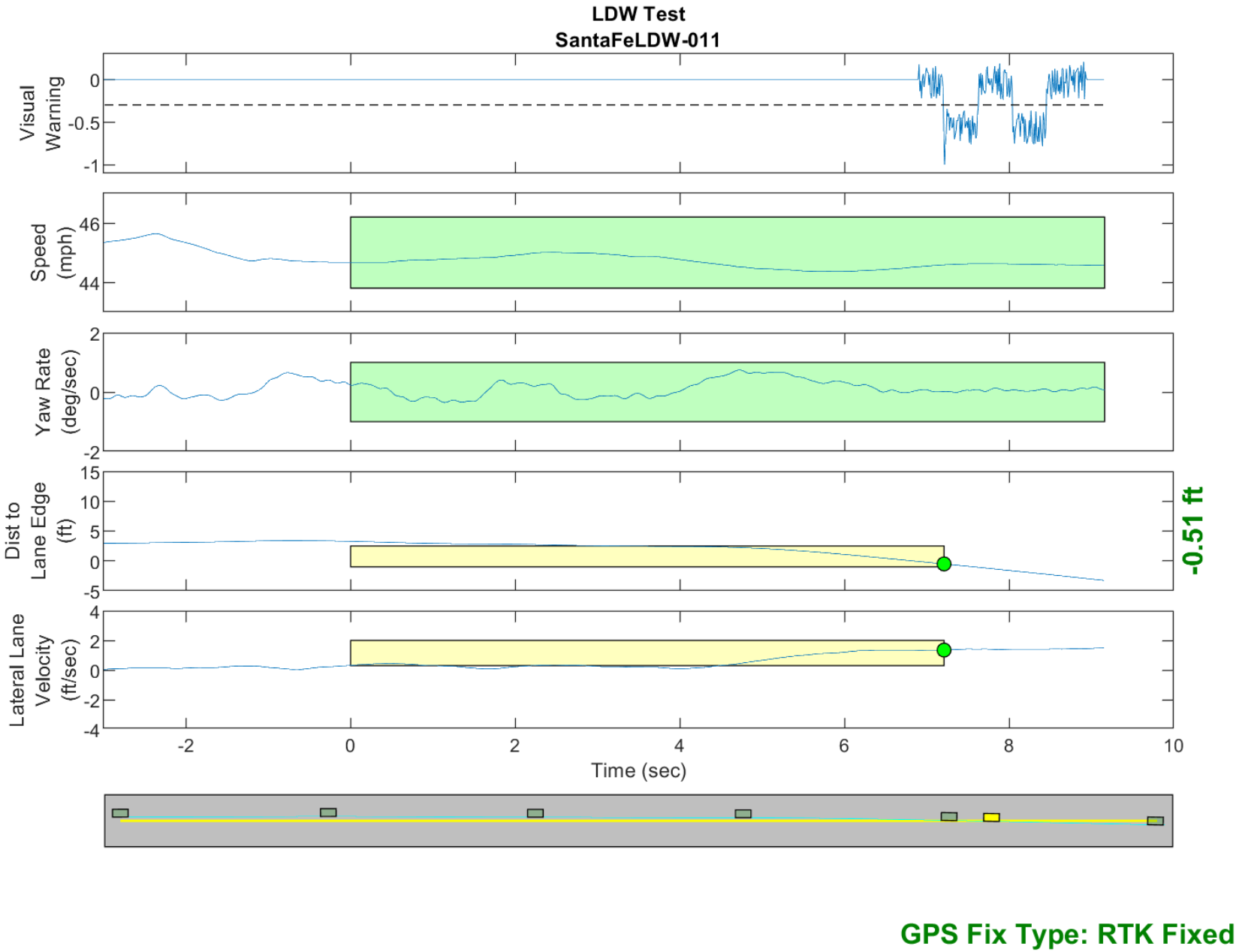


Figure D19. Time History for Run 11, Dashed Line, Right Departure, Visual Warning

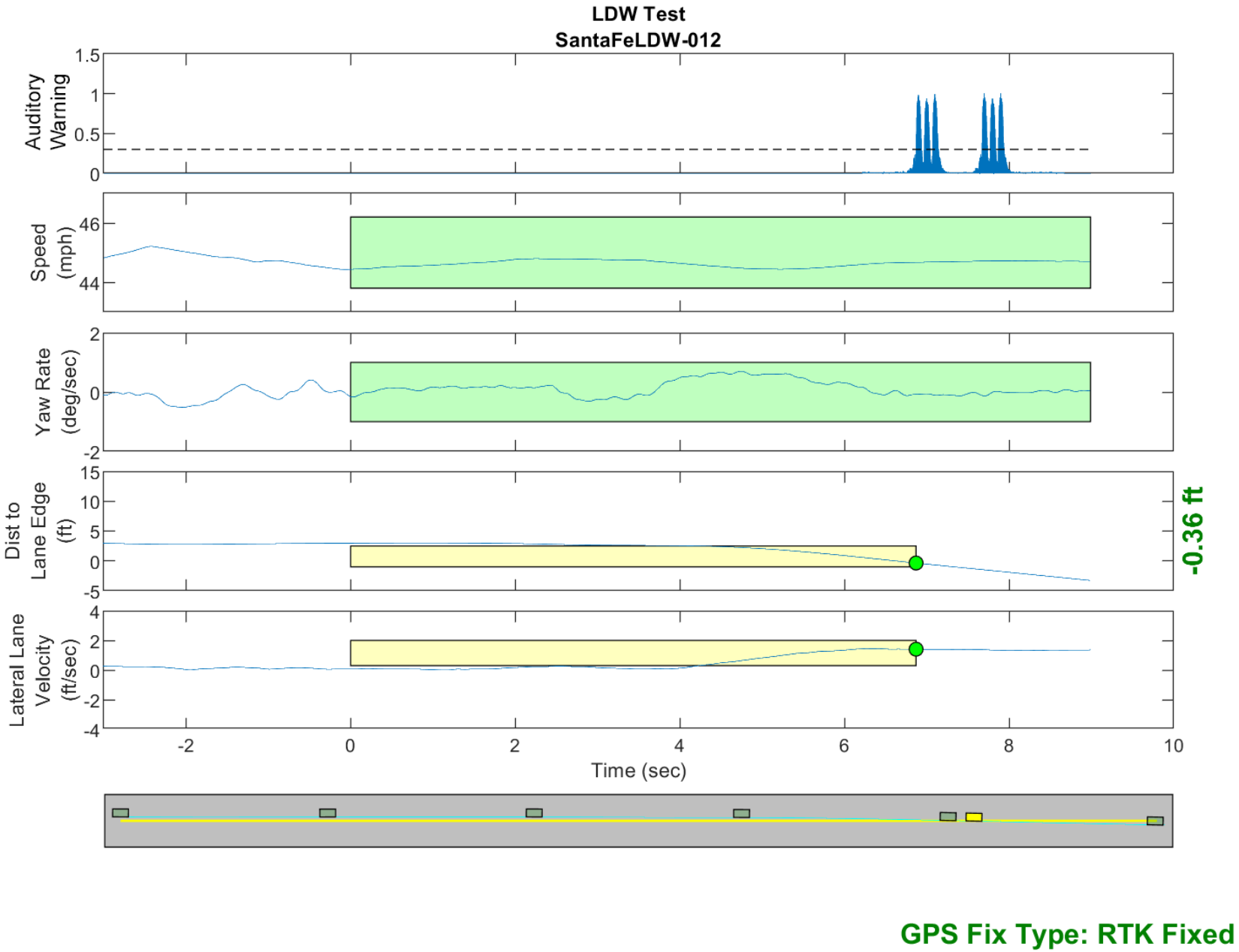


Figure D20. Time History for Run 12, Dashed Line, Right Departure, Auditory Warning

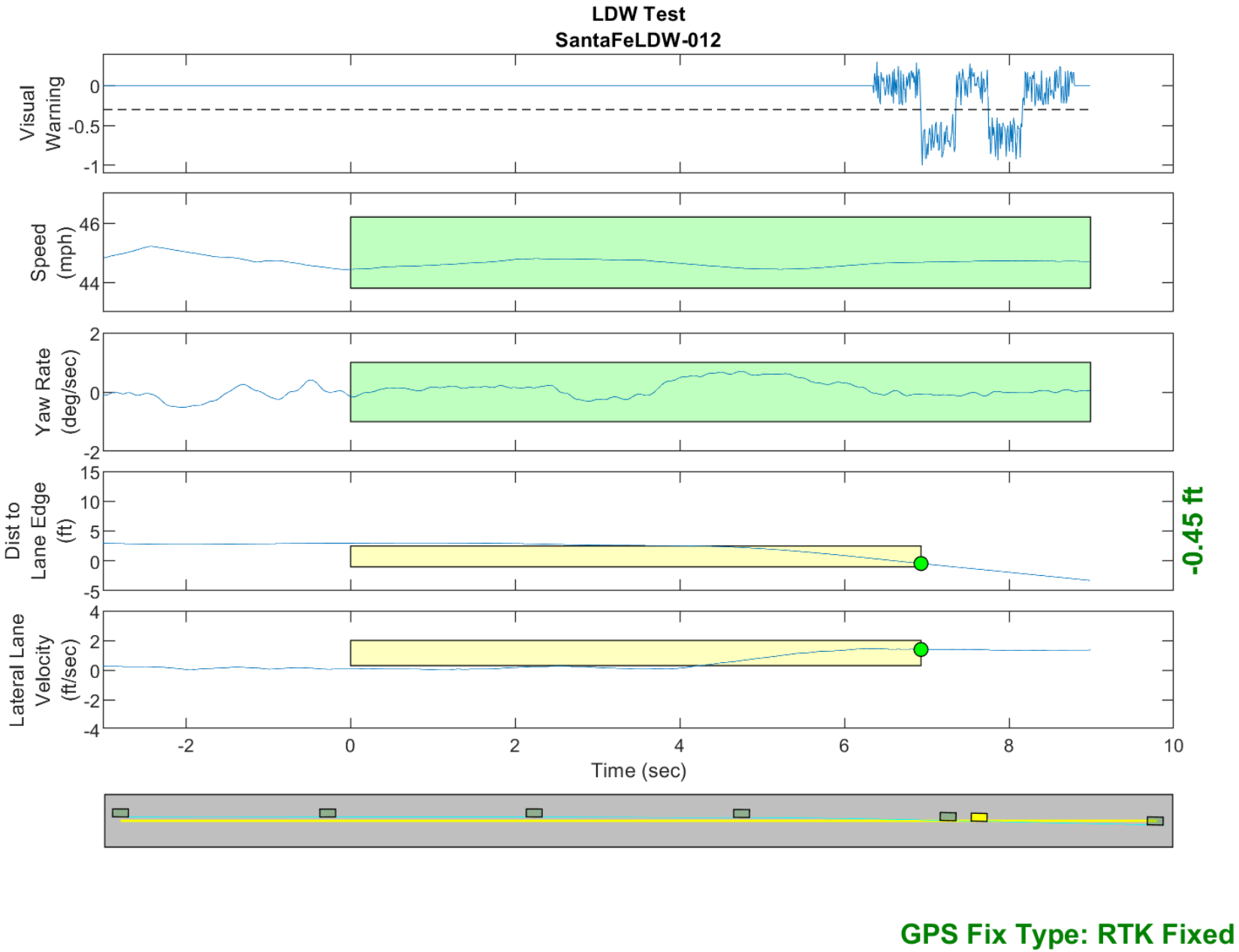


Figure D21. Time History for Run 12, Dashed Line, Right Departure, Visual Warning

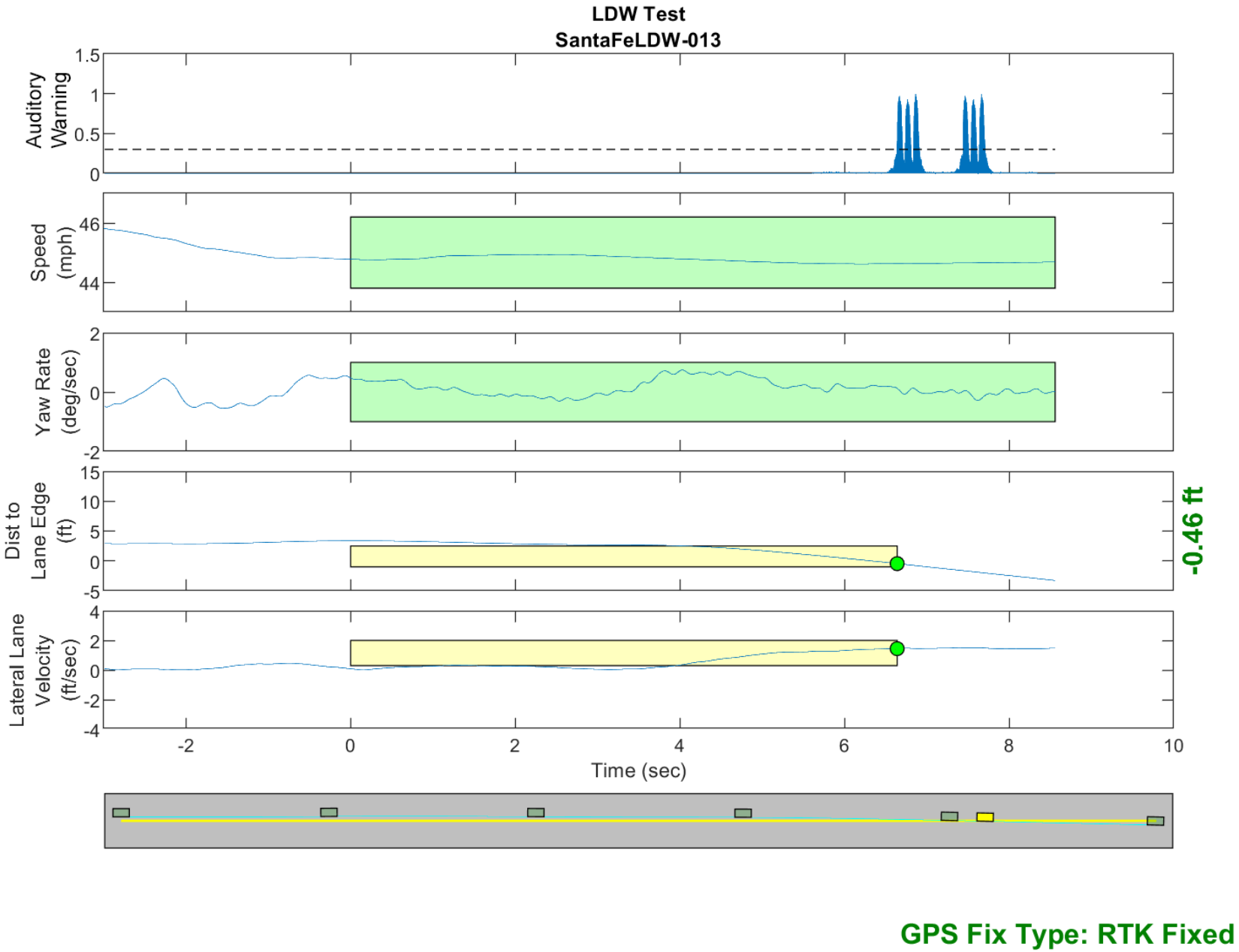


Figure D22. Time History for Run 13, Dashed Line, Right Departure, Auditory Warning

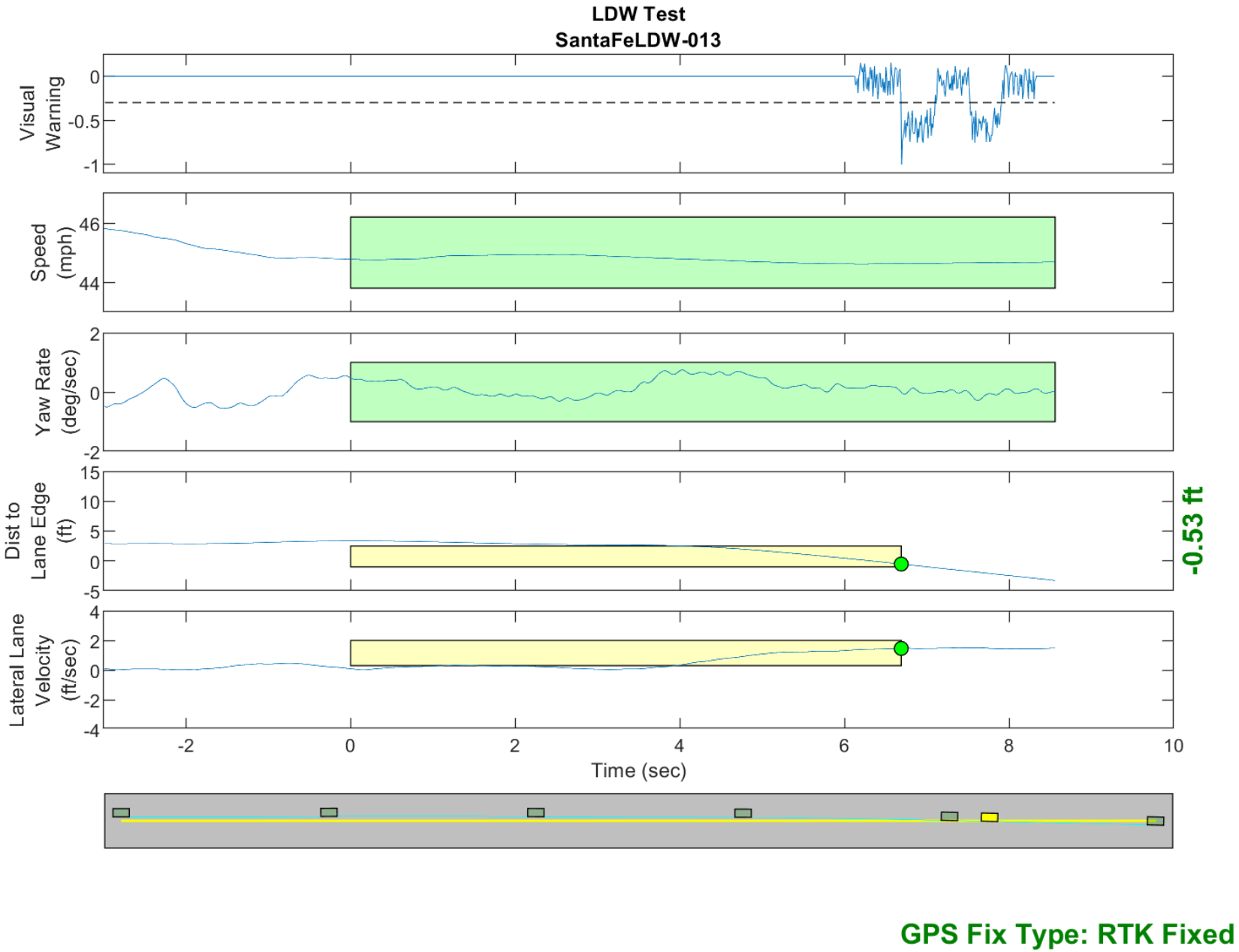


Figure D23. Time History for Run 13, Dashed Line, Right Departure, Visual Warning

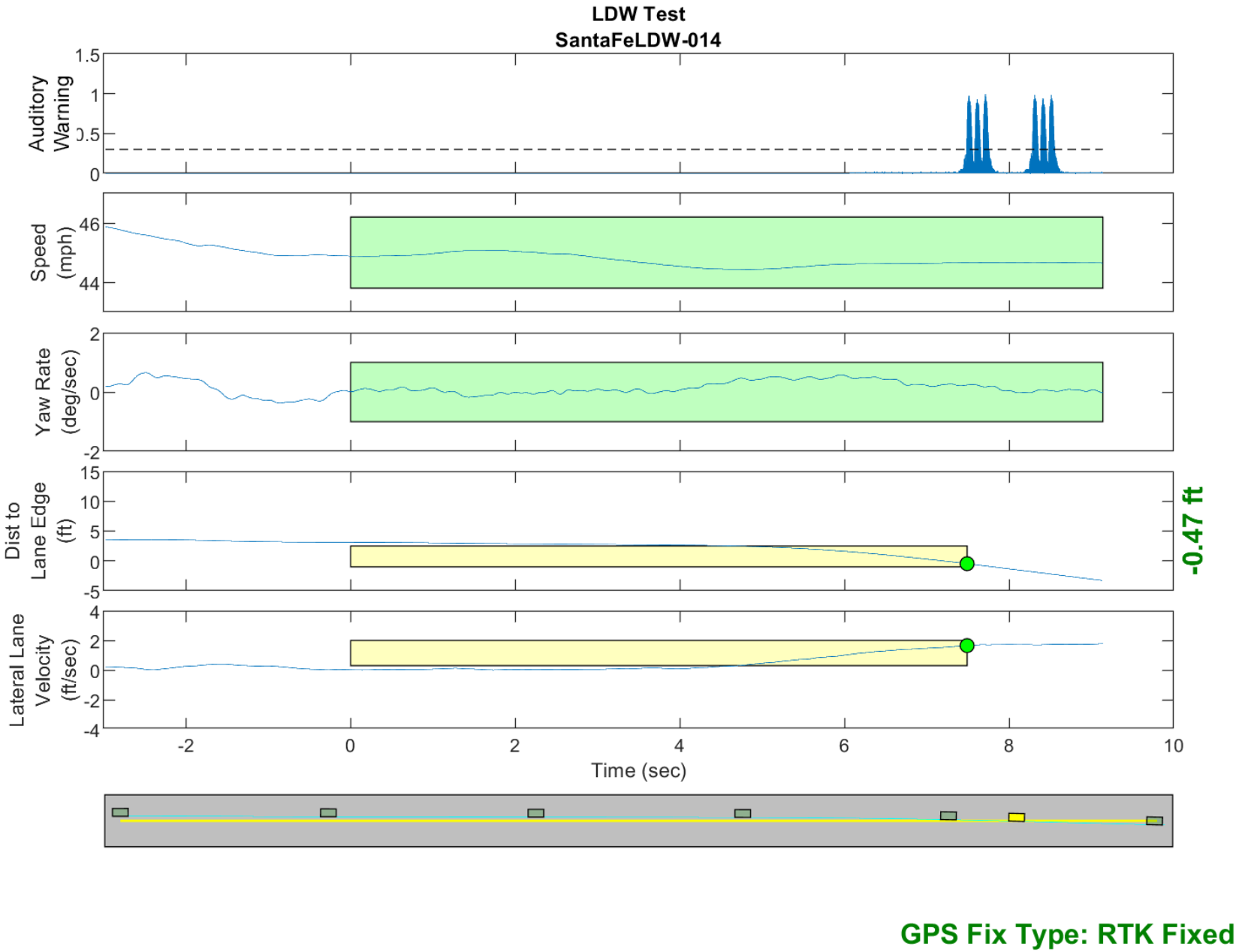


Figure D24. Time History for Run 14, Dashed Line, Right Departure, Auditory Warning

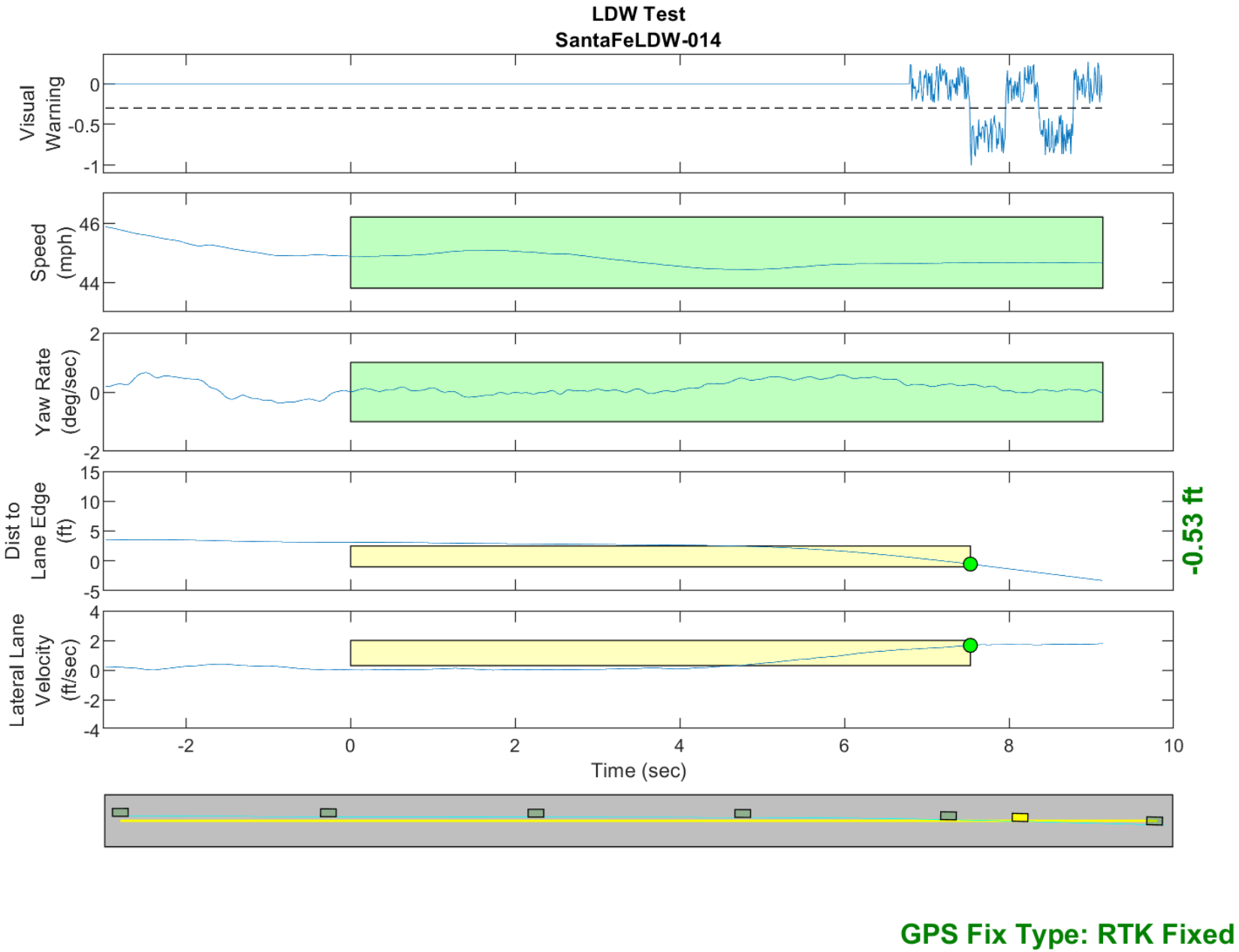


Figure D25. Time History for Run 14, Dashed Line, Right Departure, Visual Warning

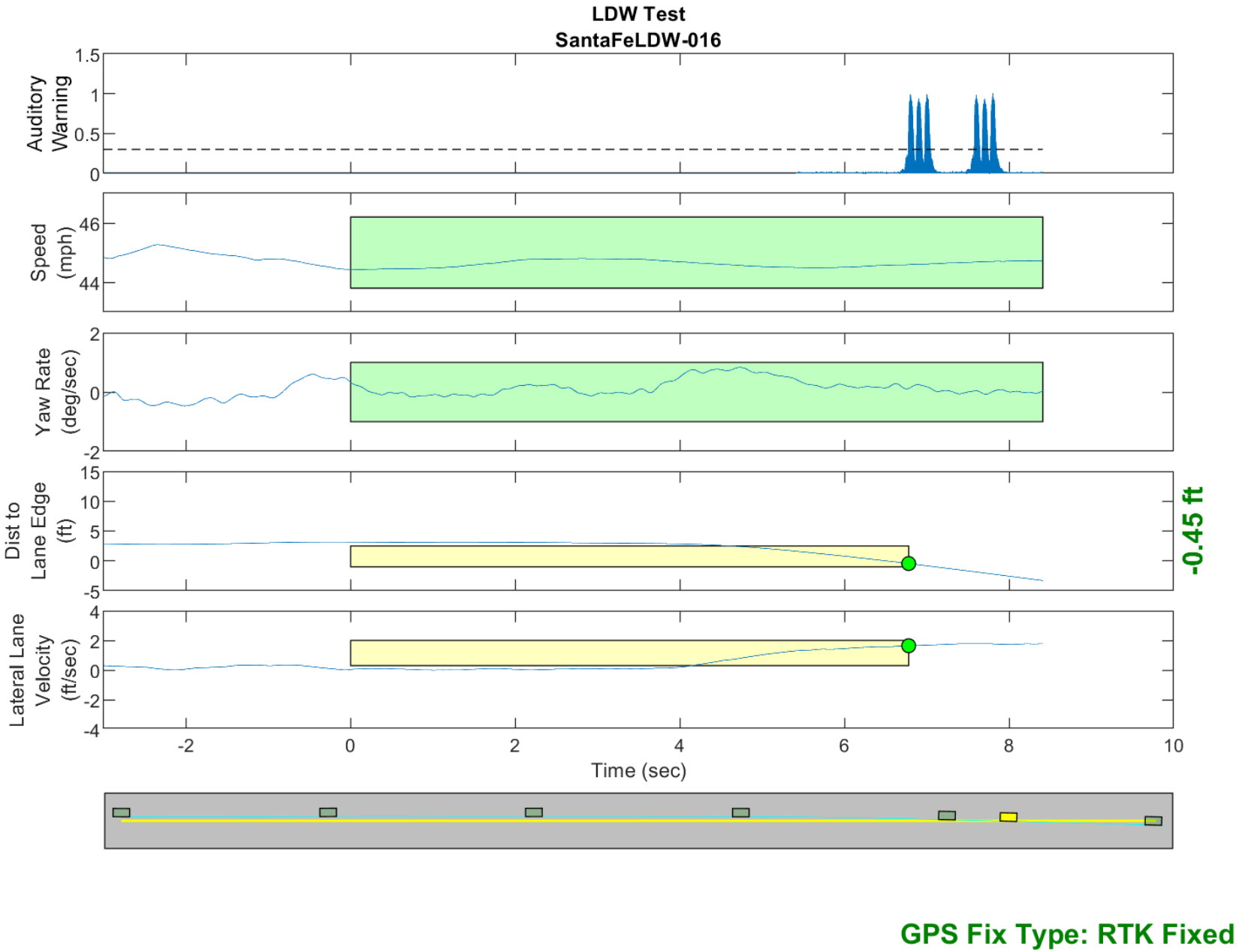


Figure D26. Time History for Run 16, Dashed Line, Right Departure, Auditory Warning

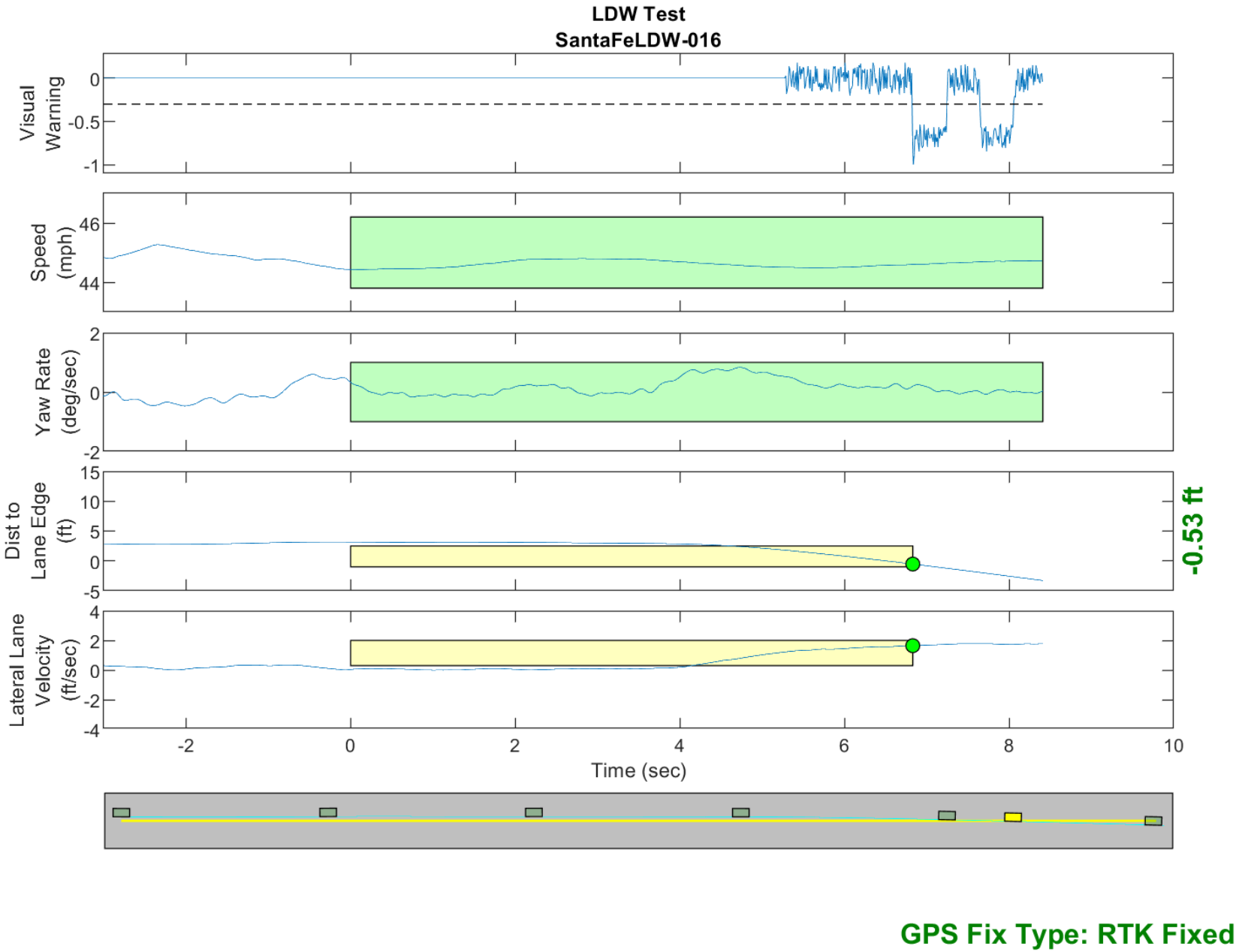


Figure D27. Time History for Run 16, Dashed Line, Right Departure, Visual Warning

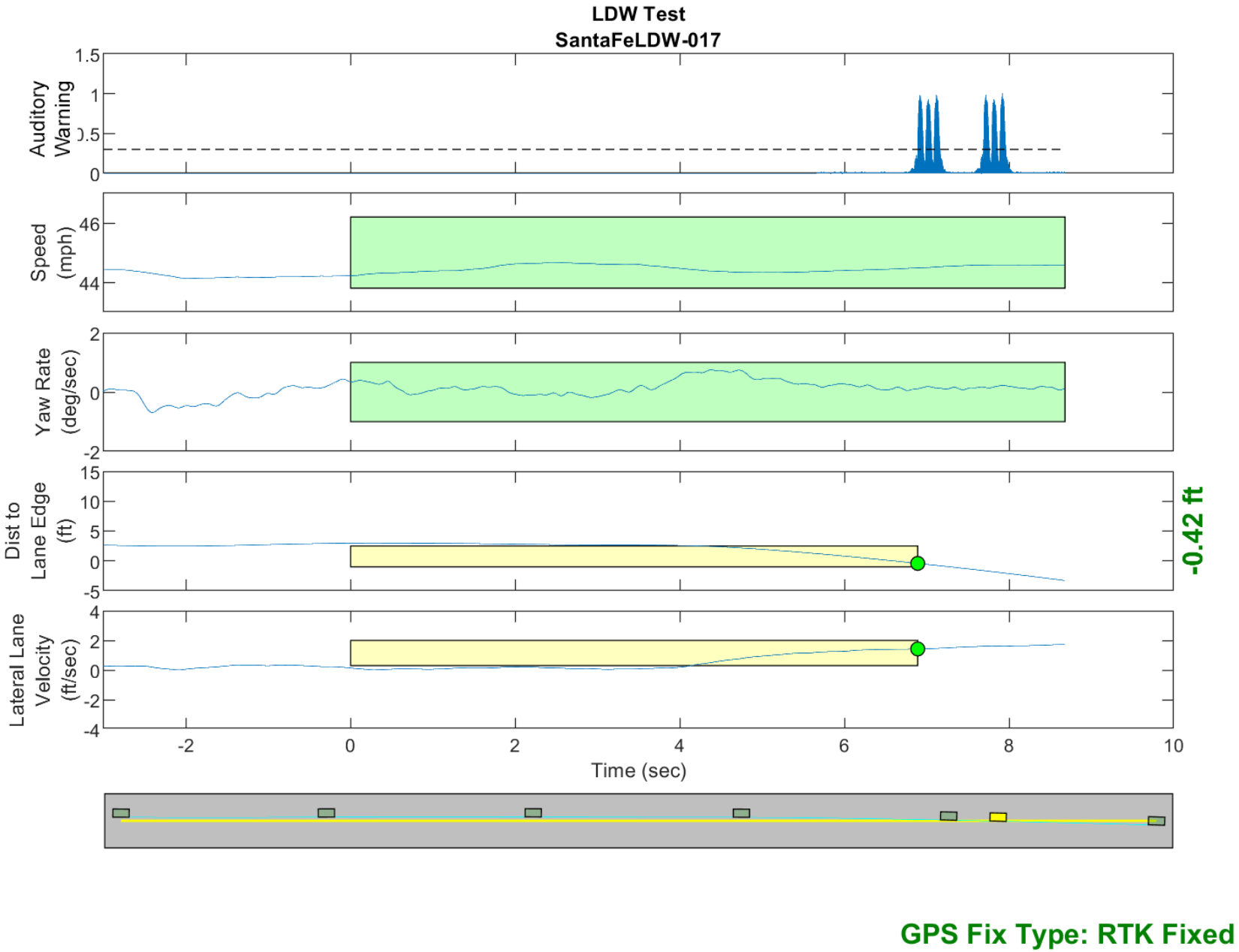


Figure D28. Time History for Run 17, Dashed Line, Right Departure, Auditory Warning

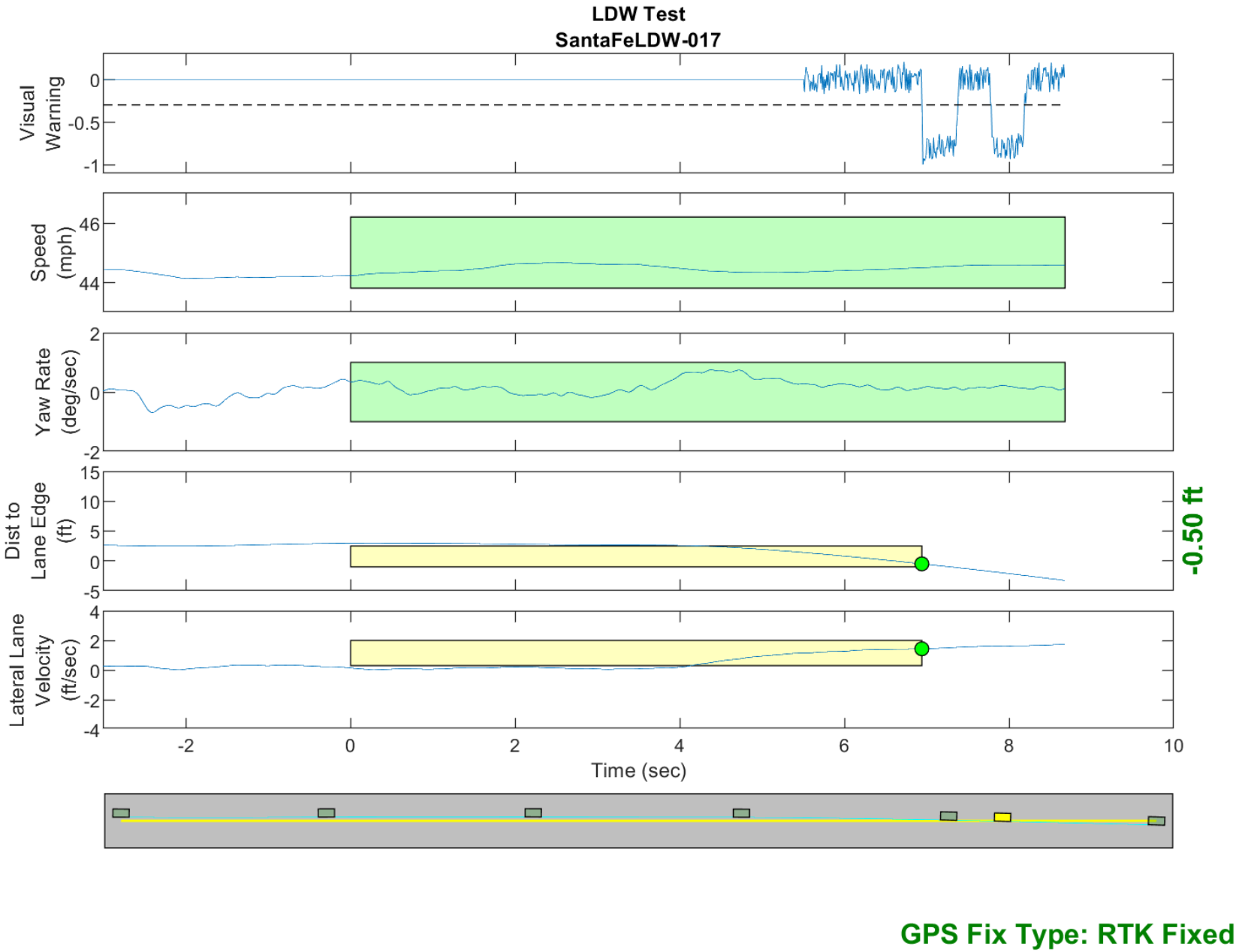


Figure D29. Time History for Run 17, Dashed Line, Right Departure, Visual Warning

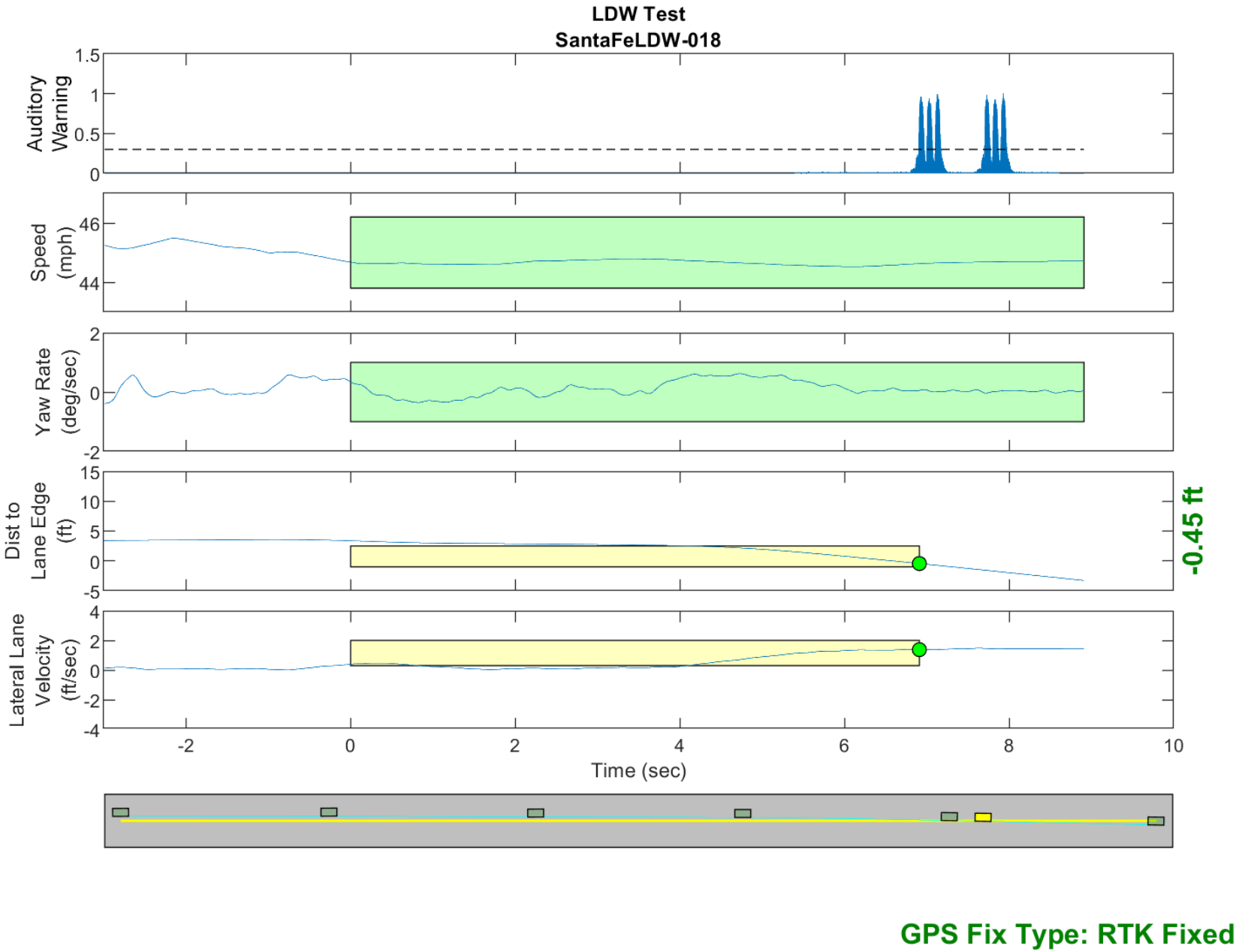


Figure D30. Time History for Run 18, Dashed Line, Right Departure, Auditory Warning

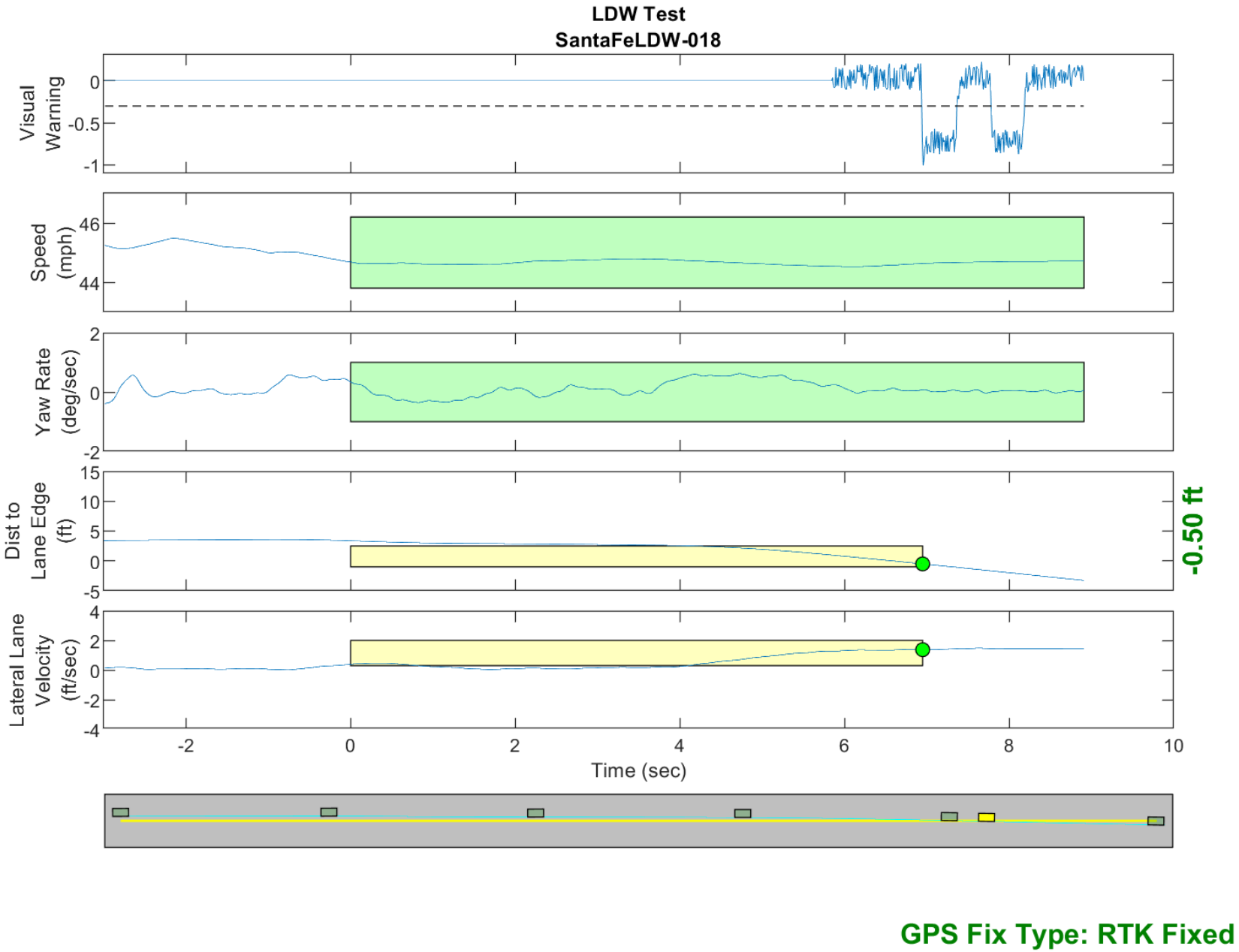


Figure D31. Time History for Run 18, Dashed Line, Right Departure, Visual Warning

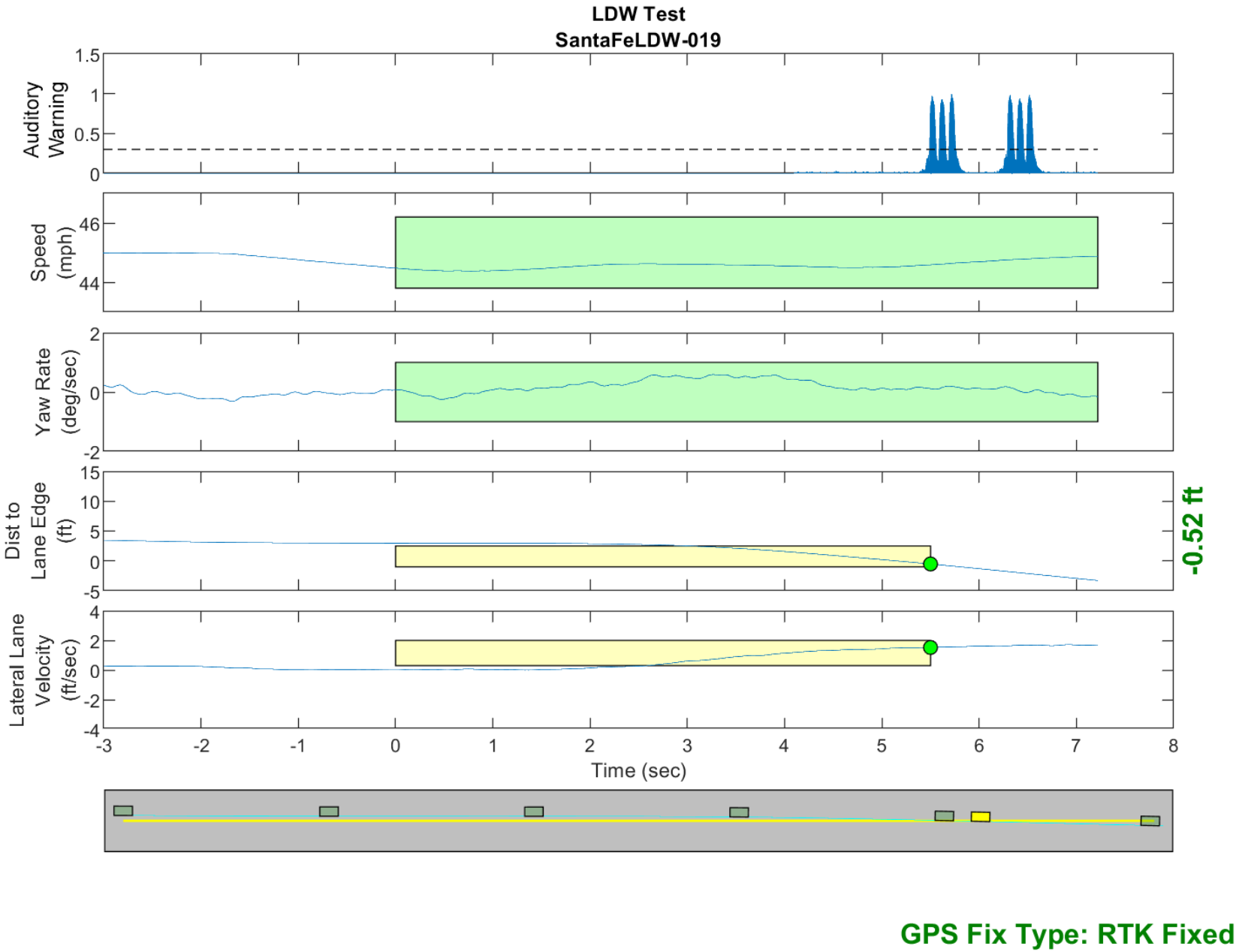


Figure D32. Time History for Run 19, Solid Line, Right Departure, Auditory Warning

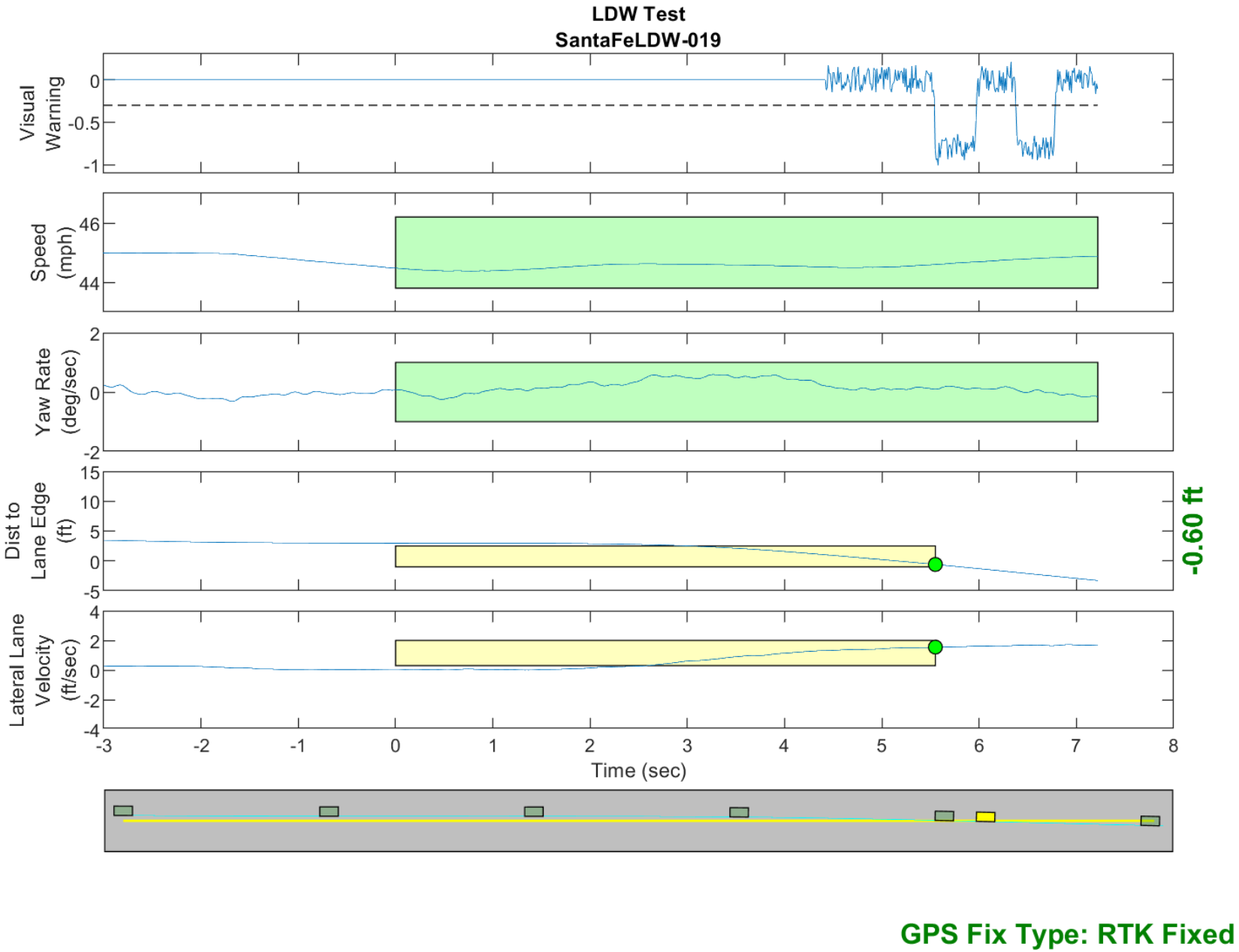


Figure D33. Time History for Run 19, Solid Line, Right Departure, Visual Warning

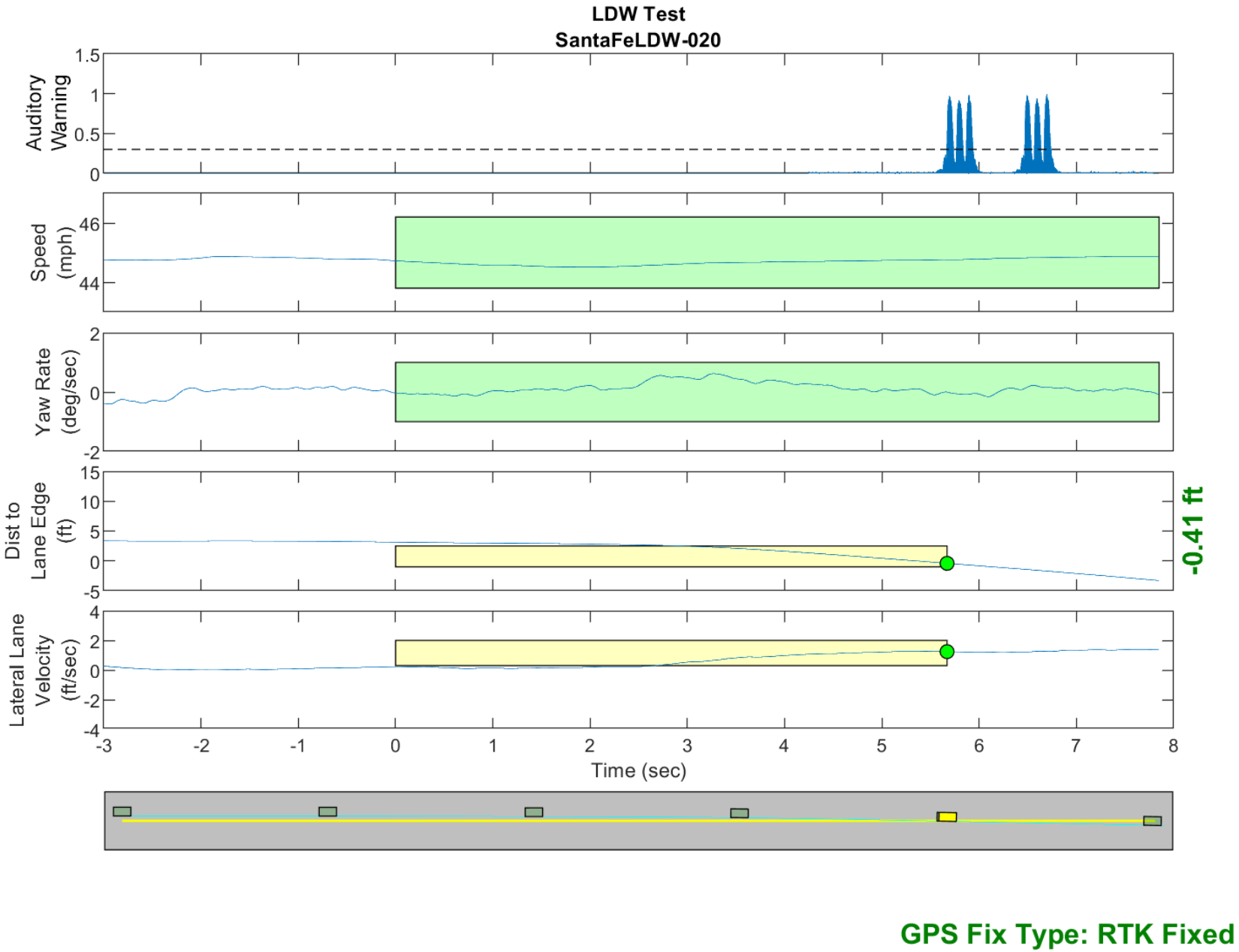


Figure D34. Time History for Run 20, Solid Line, Right Departure, Auditory Warning

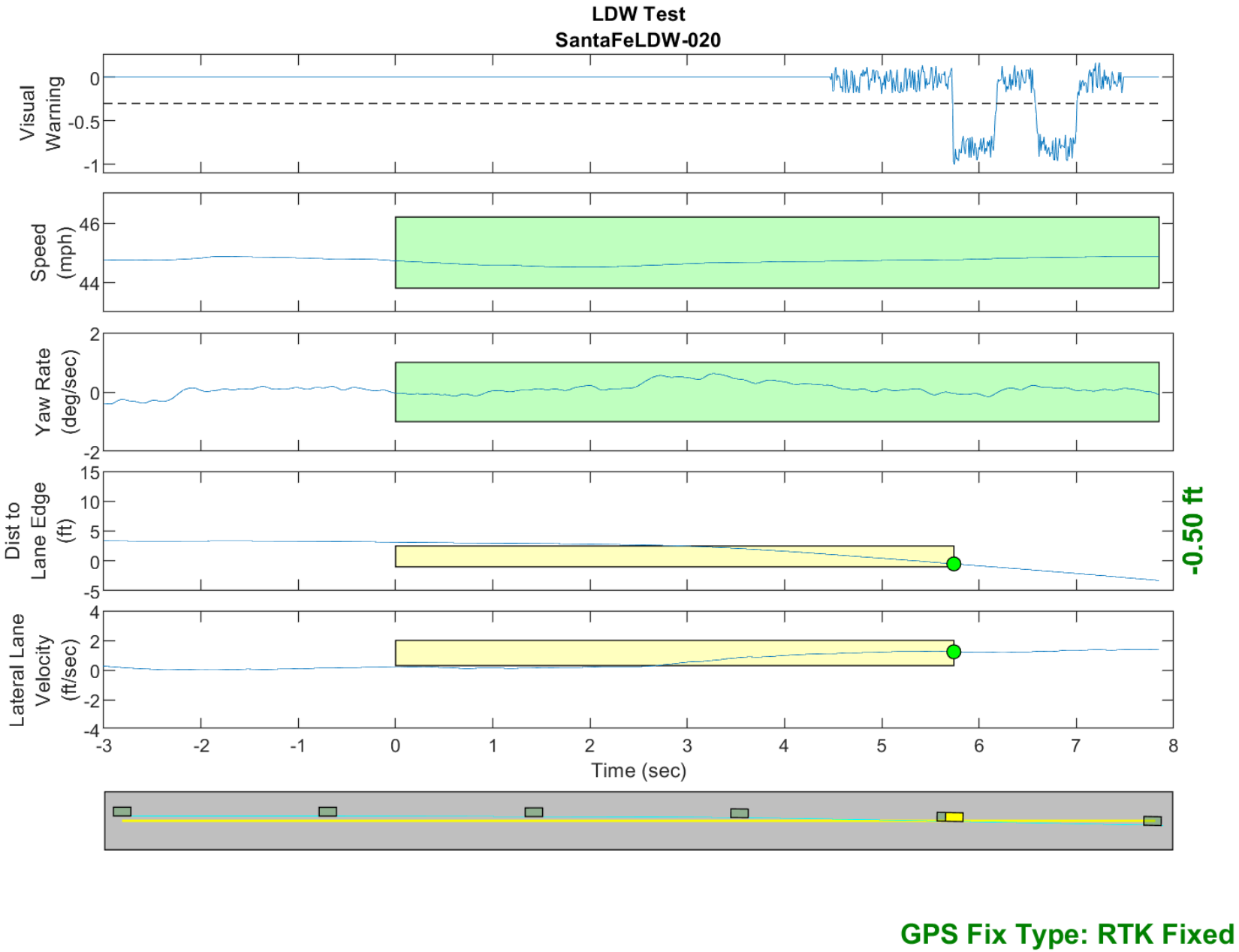


Figure D35. Time History for Run 20, Solid Line, Right Departure, Visual Warning

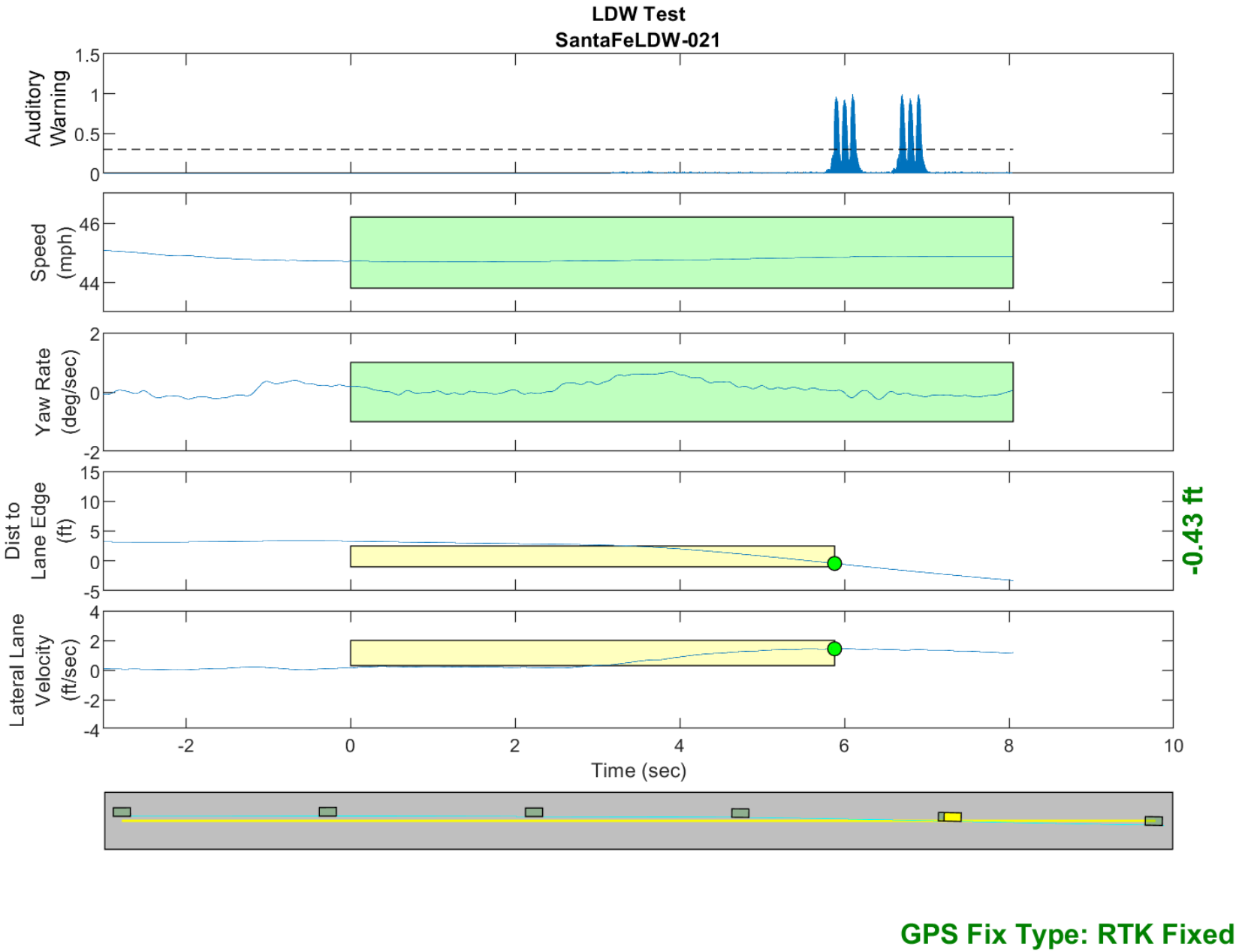


Figure D36. Time History for Run 21, Solid Line, Right Departure, Auditory Warning

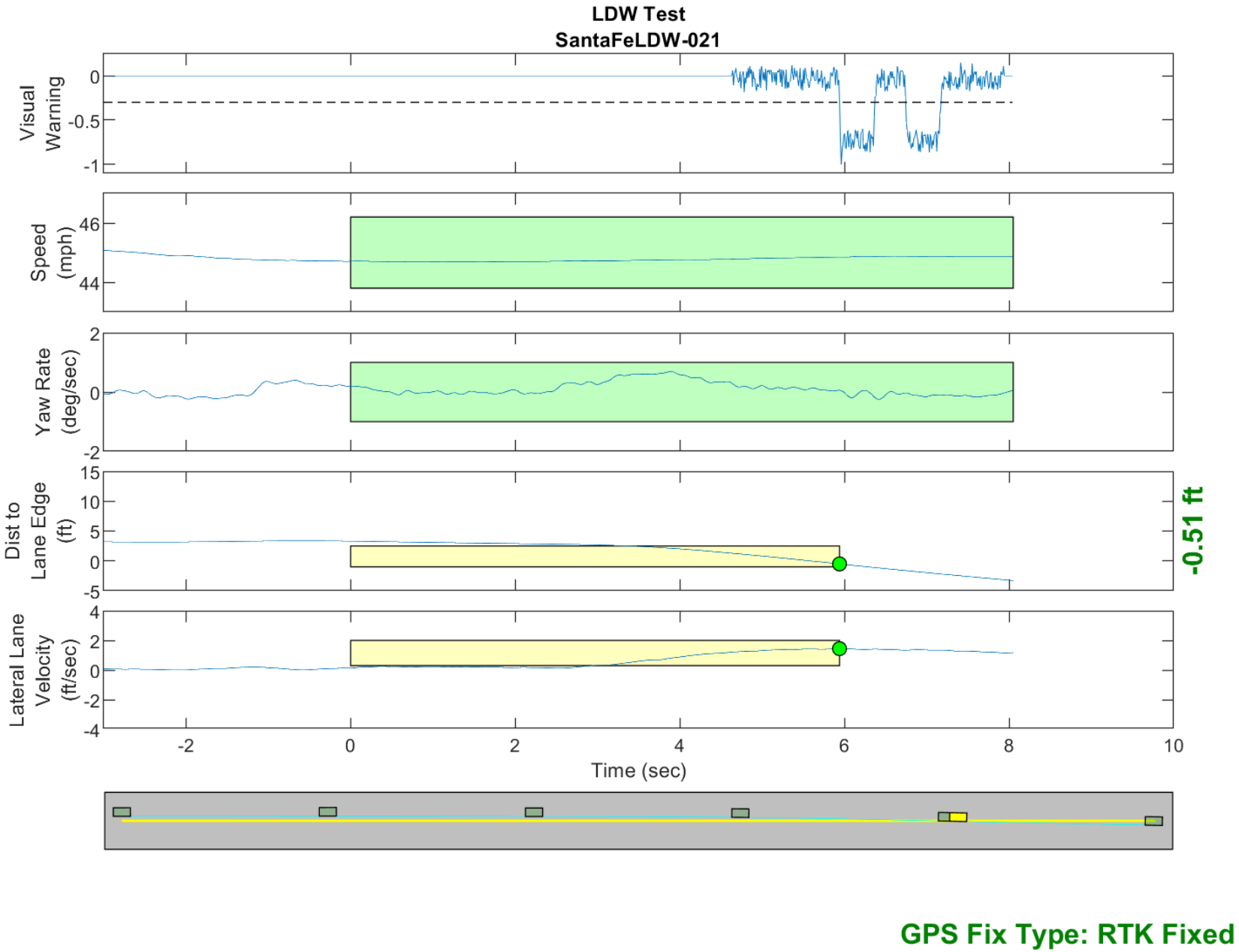


Figure D37. Time History for Run 21, Solid Line, Right Departure, Visual Warning

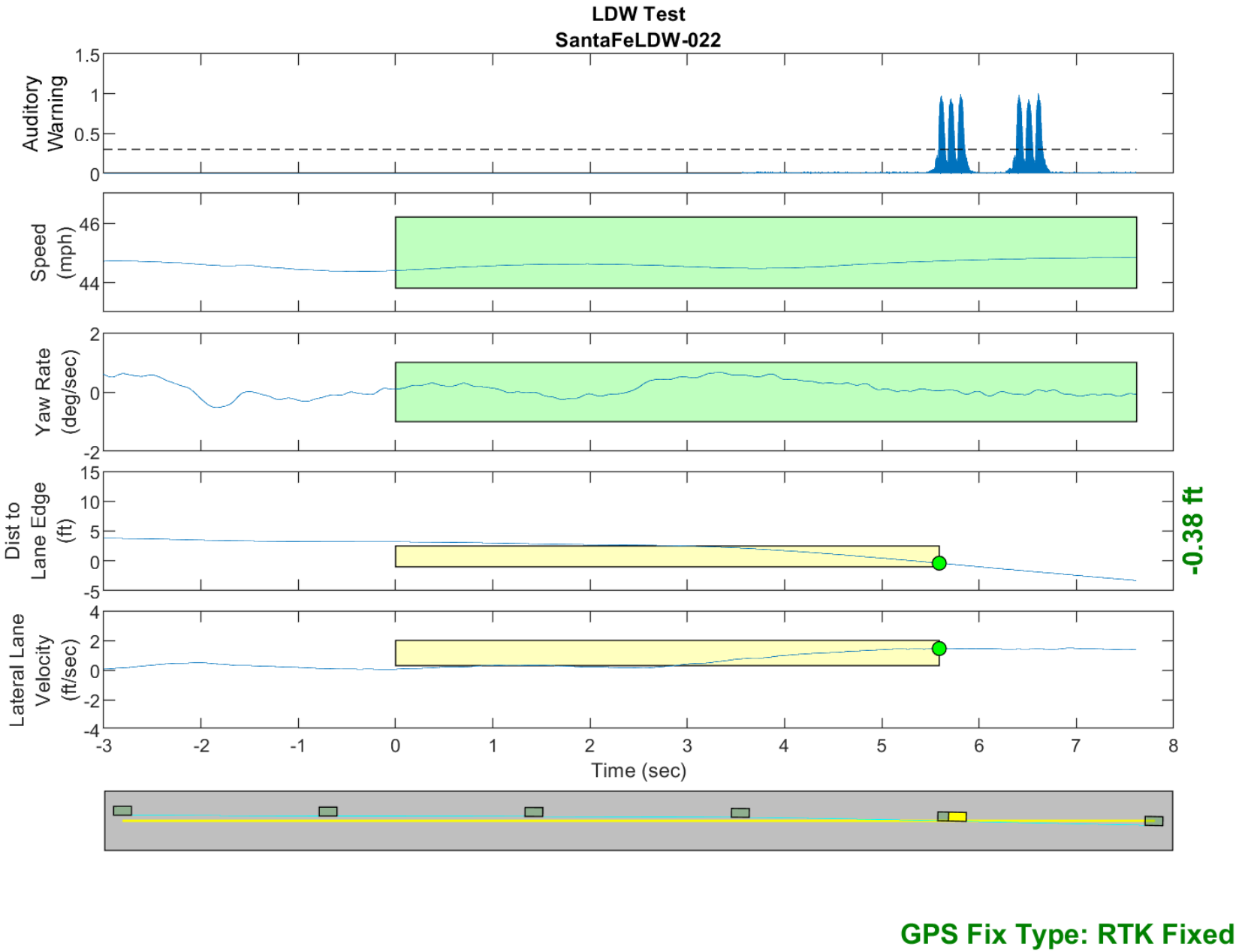


Figure D38. Time History for Run 22, Solid Line, Right Departure, Auditory Warning

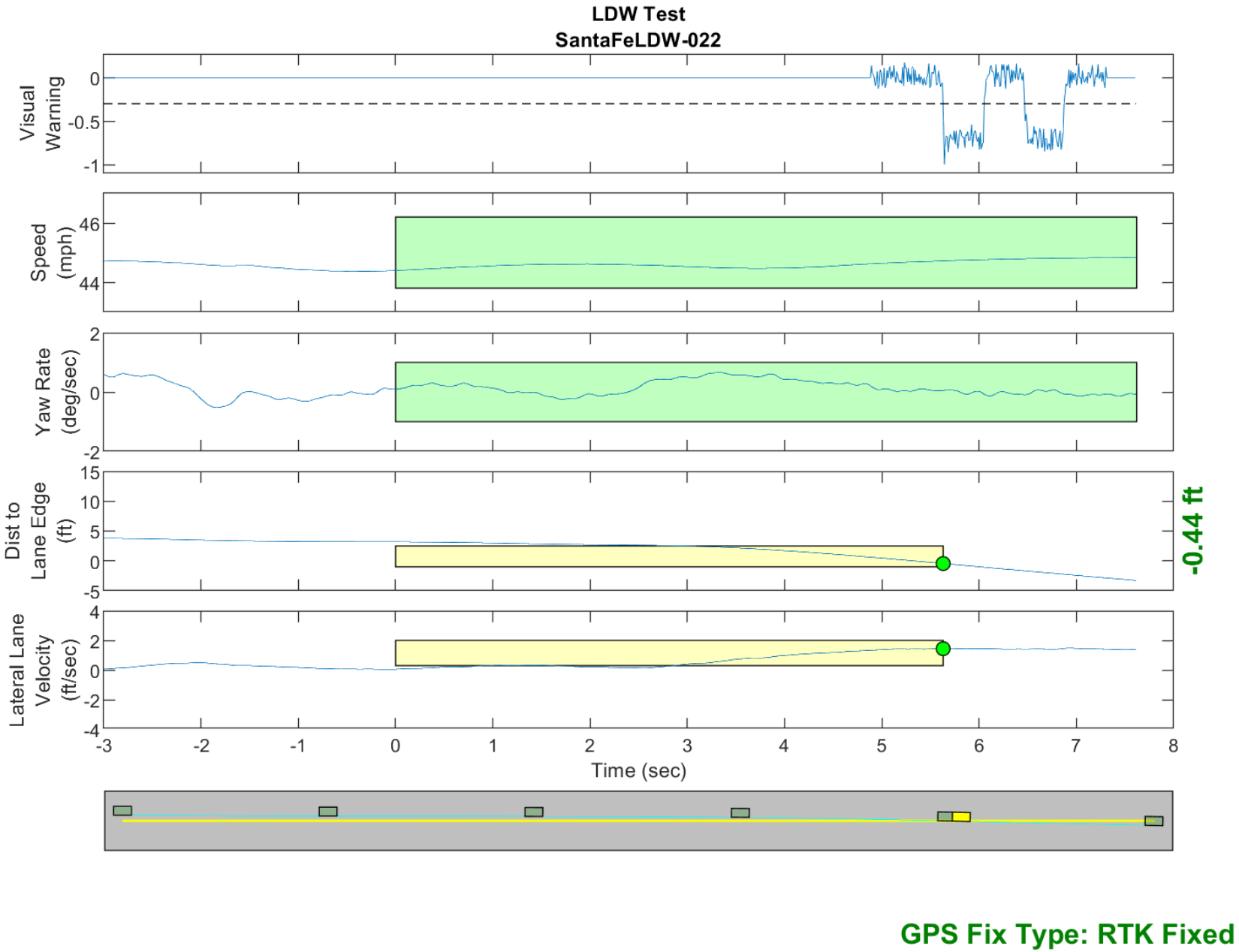


Figure D39. Time History for Run 22, Solid Line, Right Departure, Visual Warning

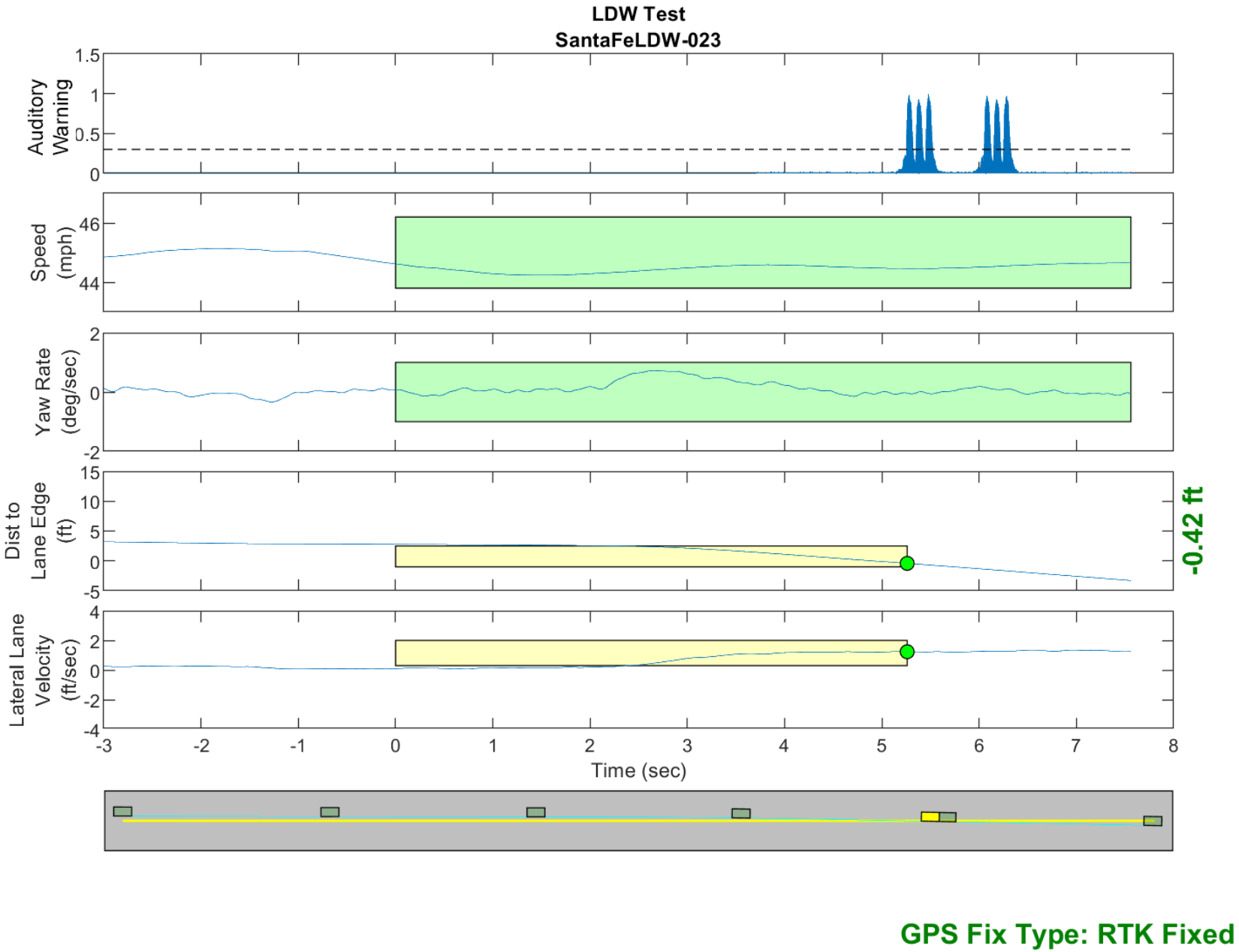


Figure D40. Time History for Run 23, Solid Line, Right Departure, Auditory Warning

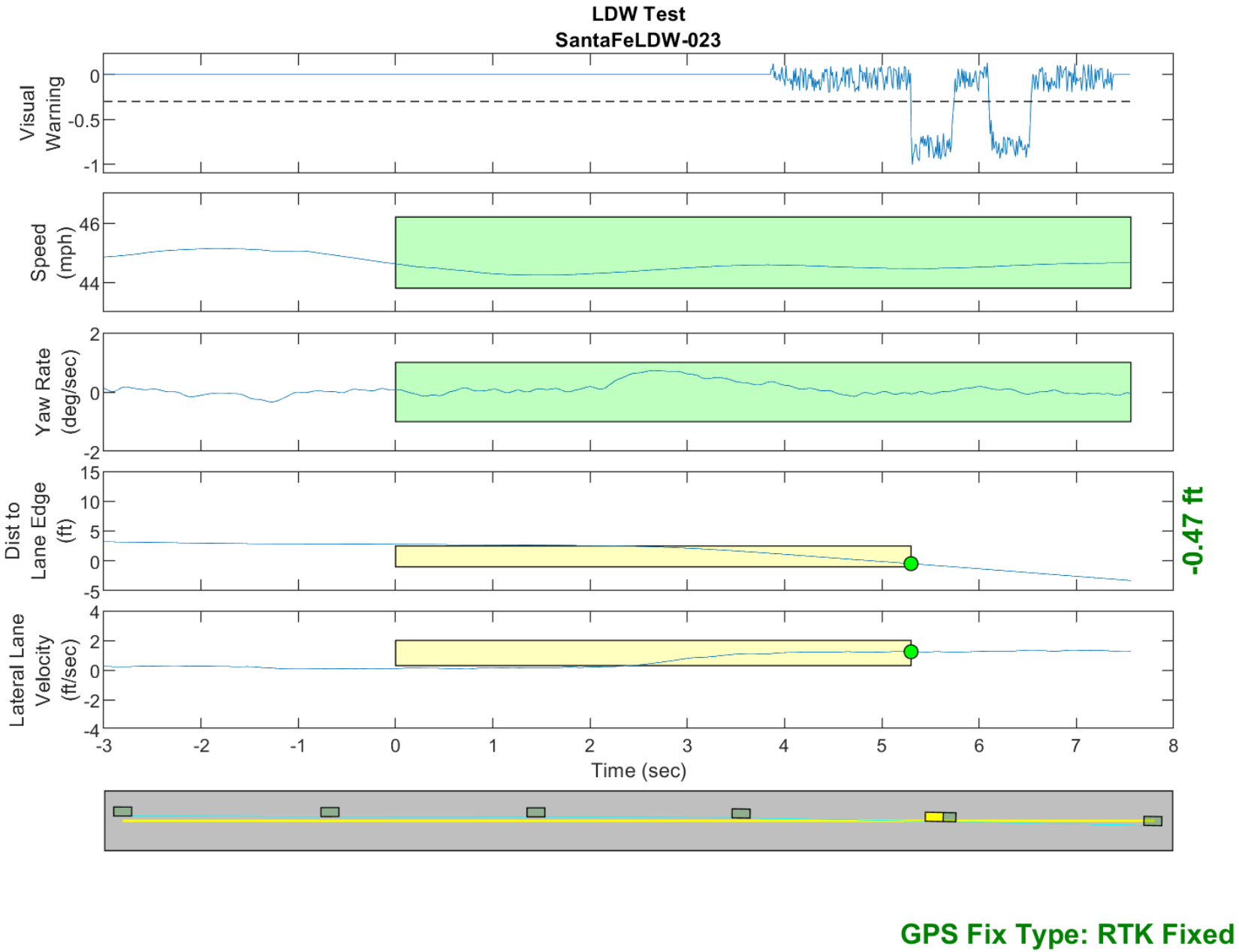


Figure D41. Time History for Run 23, Solid Line, Right Departure, Visual Warning

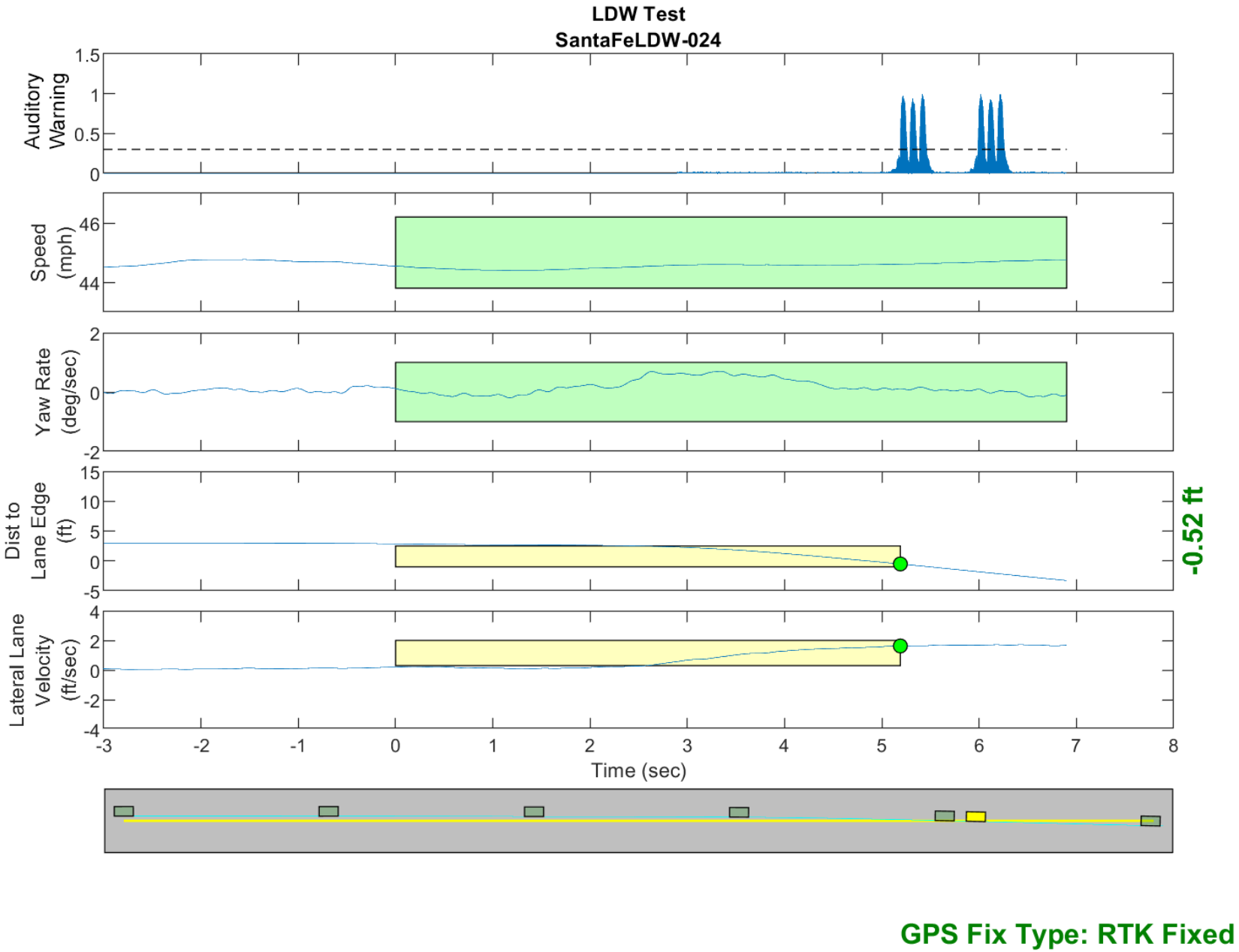


Figure D42. Time History for Run 24, Solid Line, Right Departure, Auditory Warning

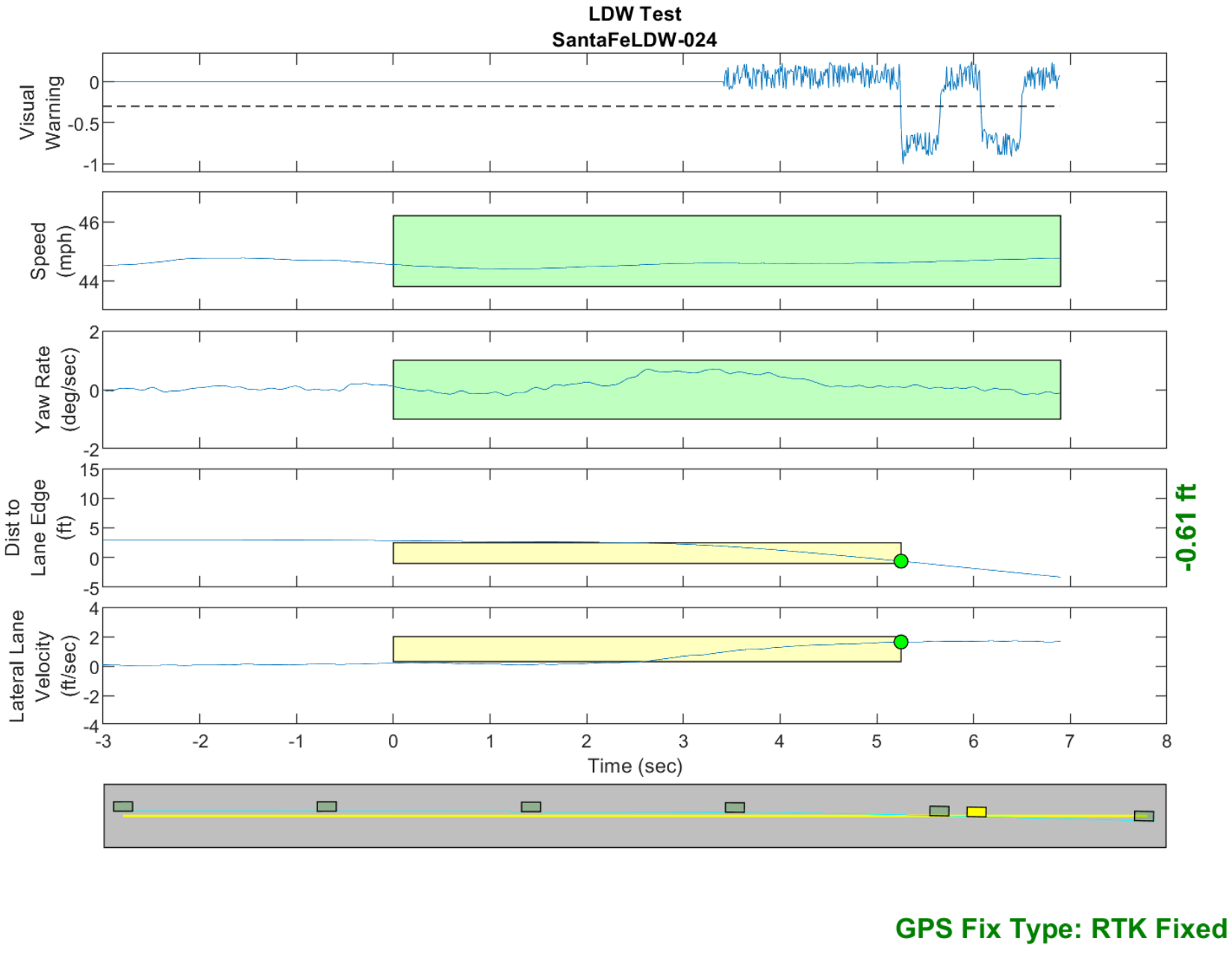


Figure D43. Time History for Run 24, Solid Line, Right Departure, Visual Warning

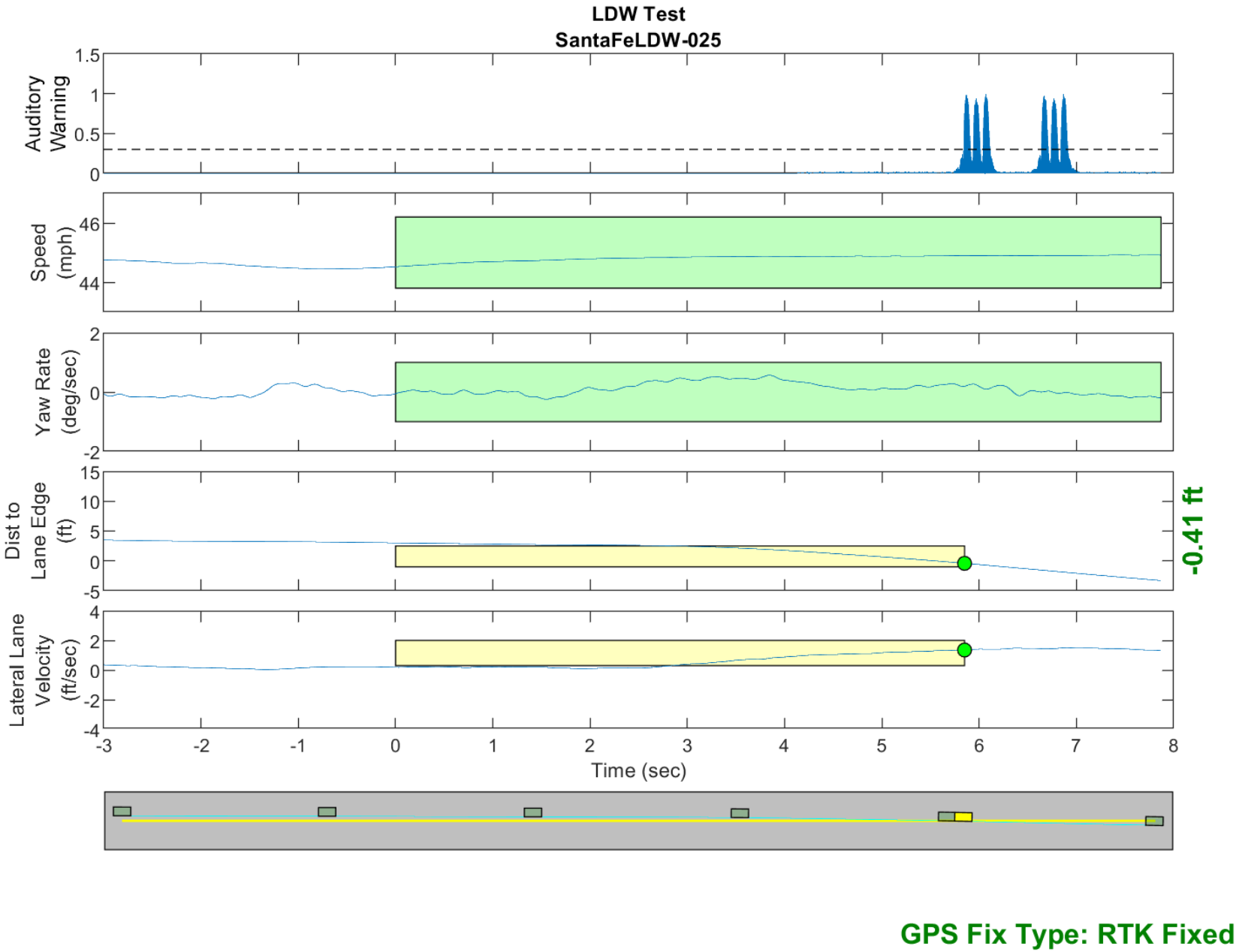


Figure D44. Time History for Run 25, LDW Test, Auditory Warning

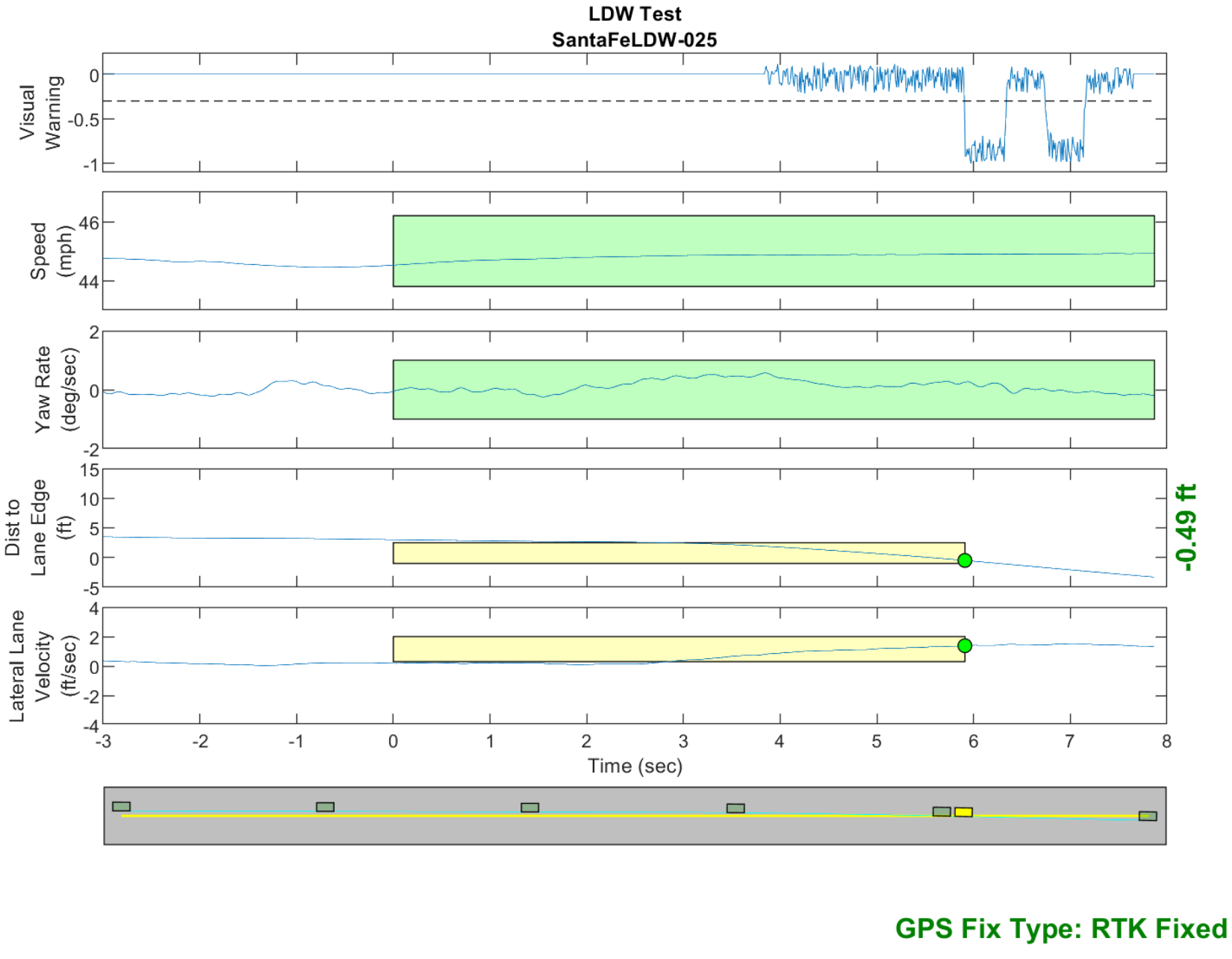


Figure D45. Time History for Run 25, LDW Test, Visual Warning

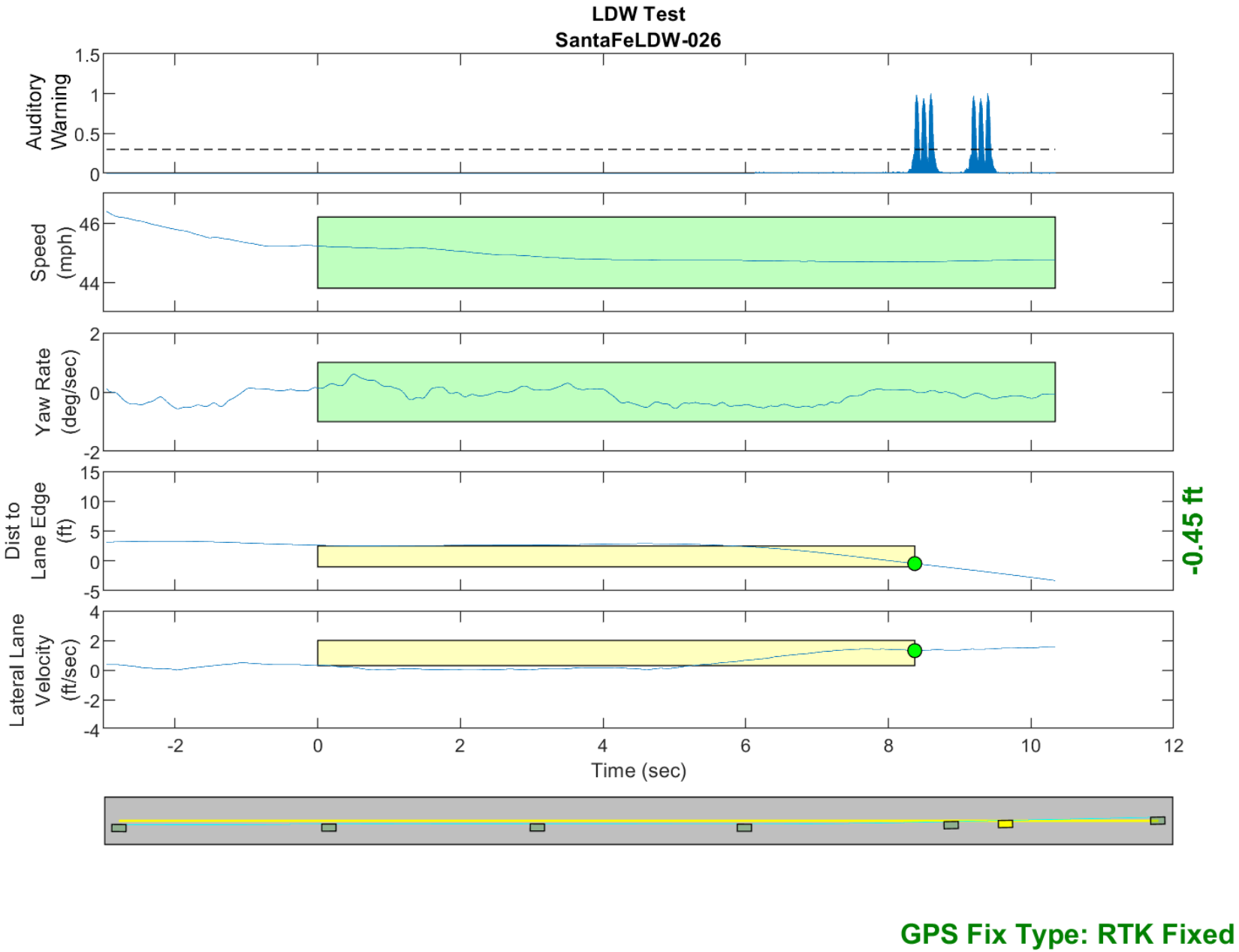


Figure D46. Time History for Run 26, Solid Line, Left Departure, Auditory Warning

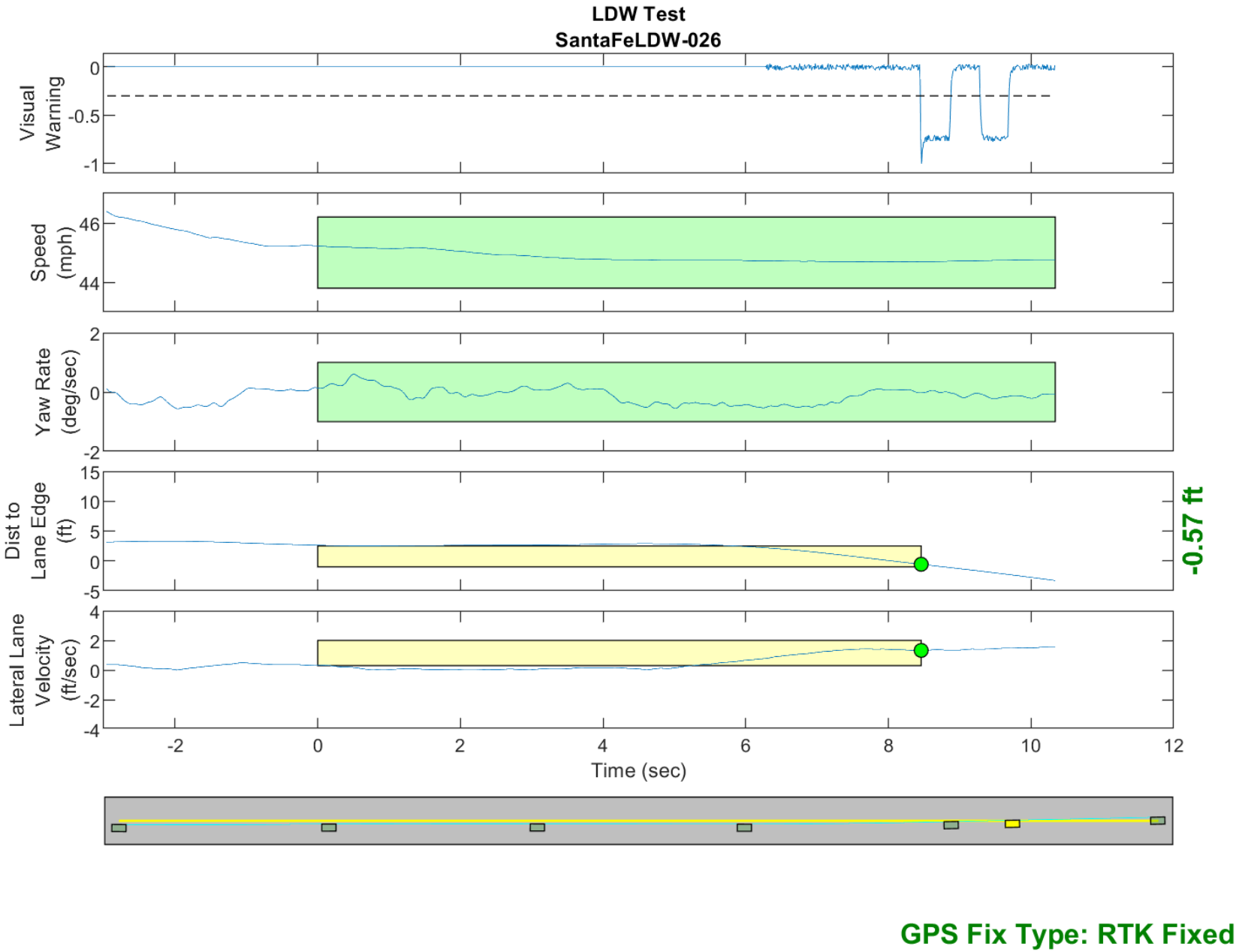


Figure D47. Time History for Run 26, Solid Line, Left Departure, Visual Warning

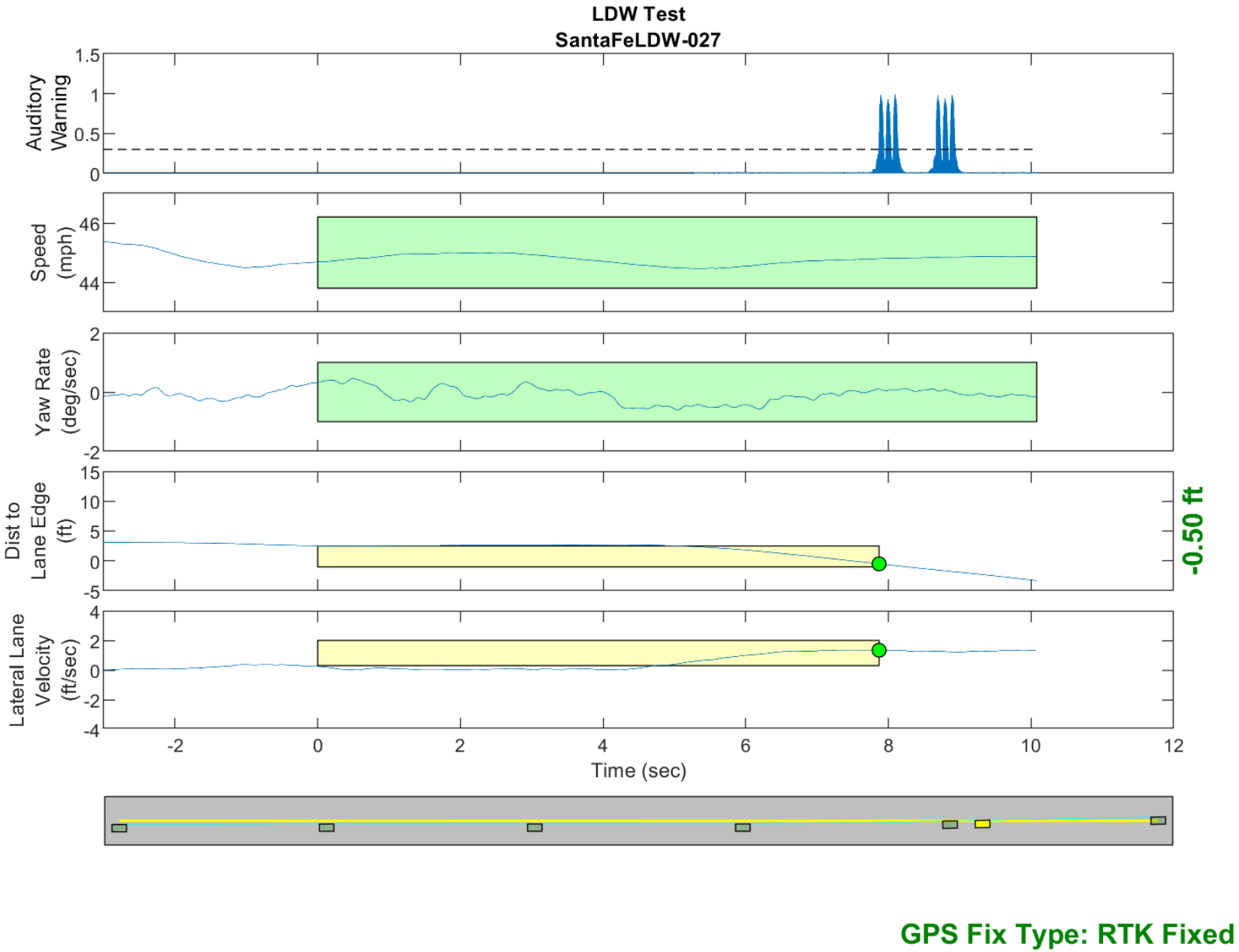


Figure D48. Time History for Run 27, Solid Line, Left Departure, Auditory Warning

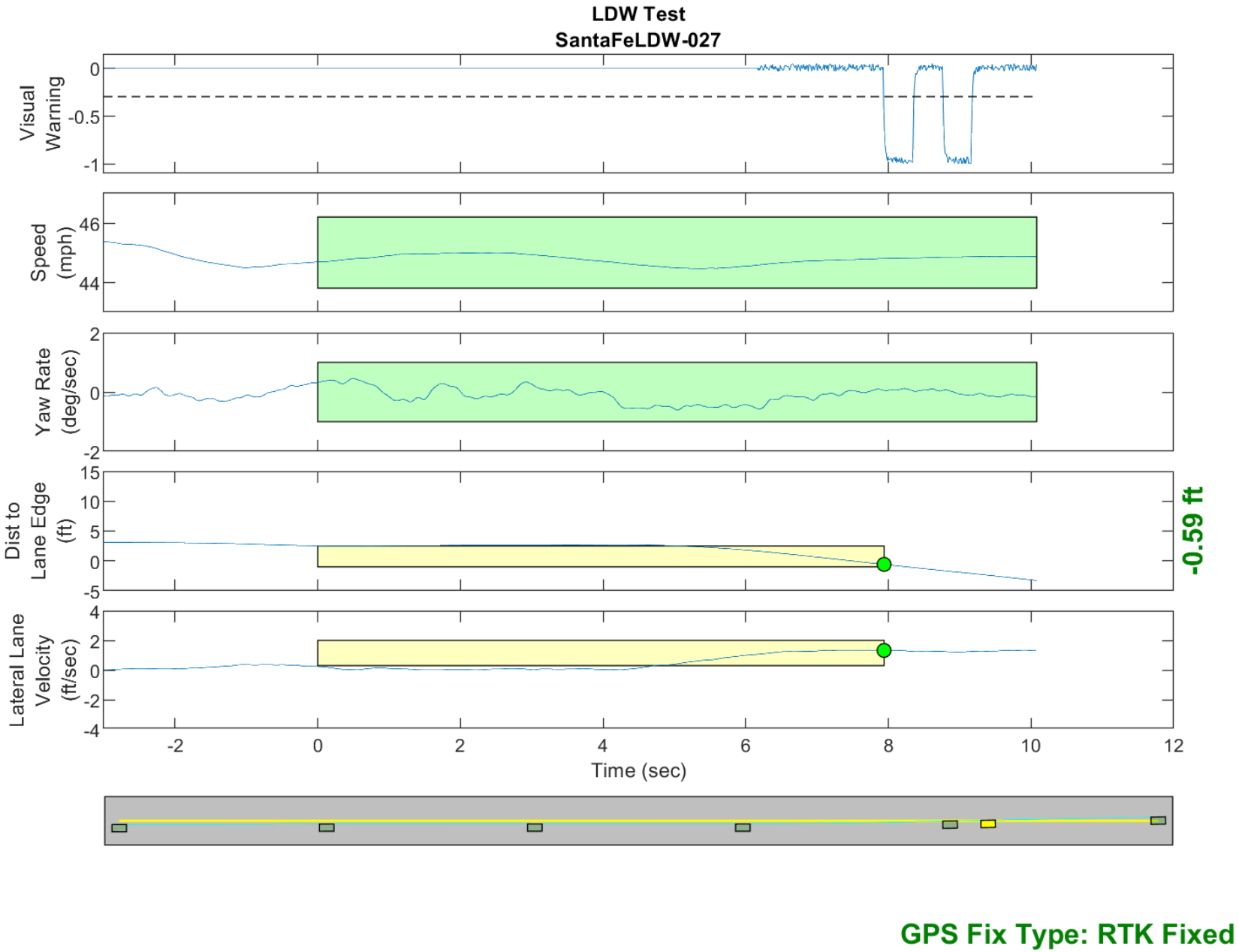


Figure D49. Time History for Run 27, Solid Line, Left Departure, Visual Warning

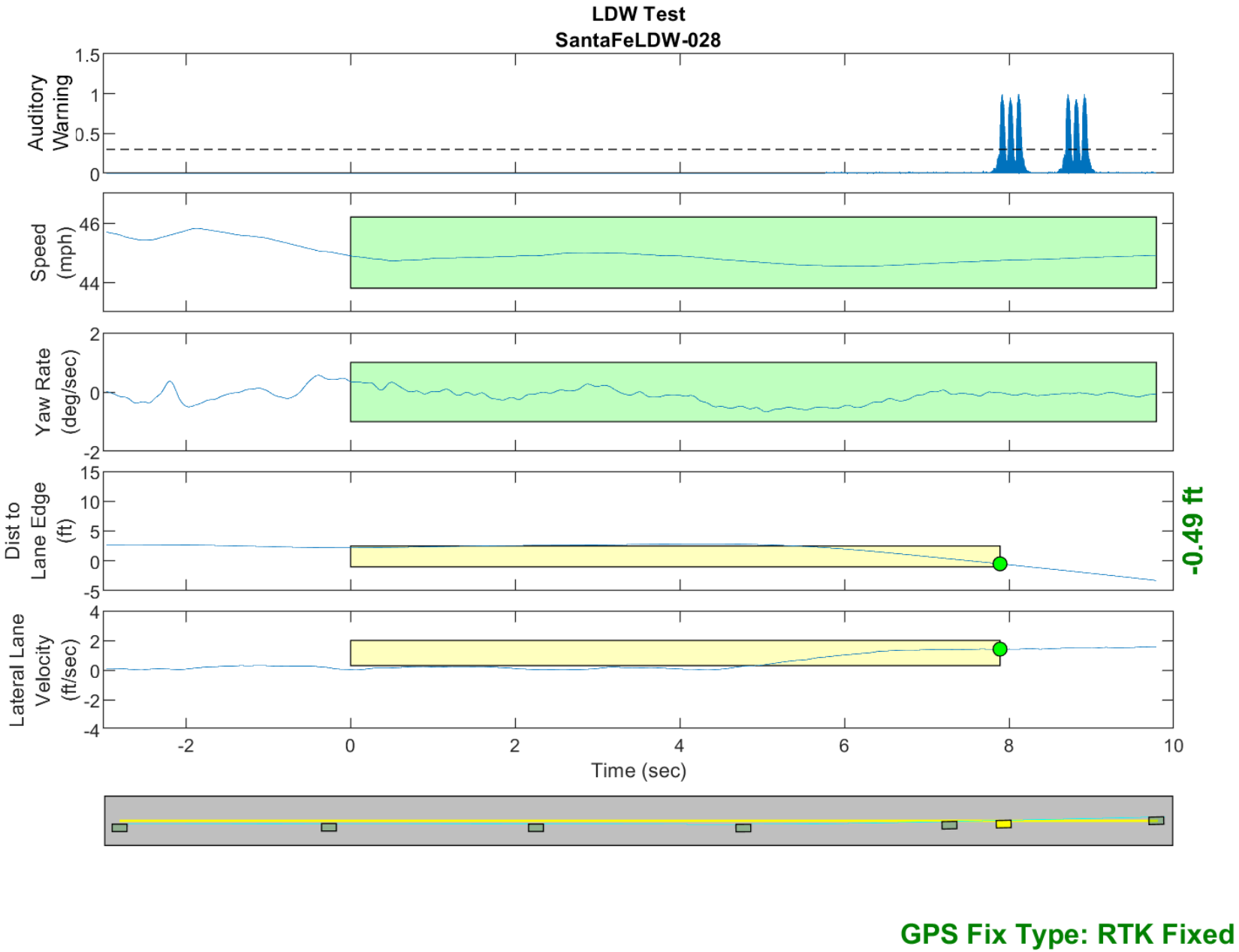


Figure D50. Time History for Run 28, Solid Line, Left Departure, Auditory Warning

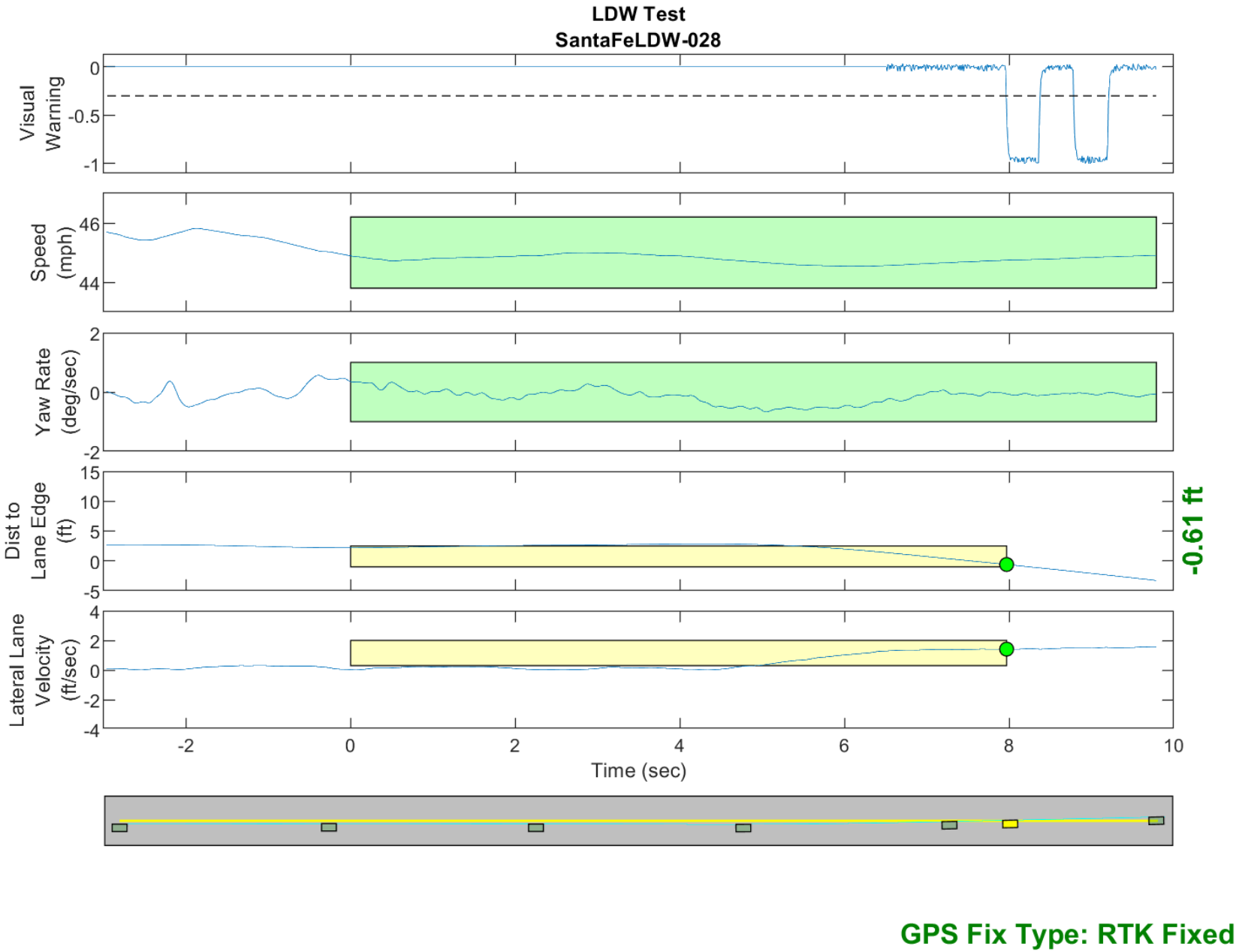


Figure D51. Time History for Run 28, Solid Line, Left Departure, Visual Warning

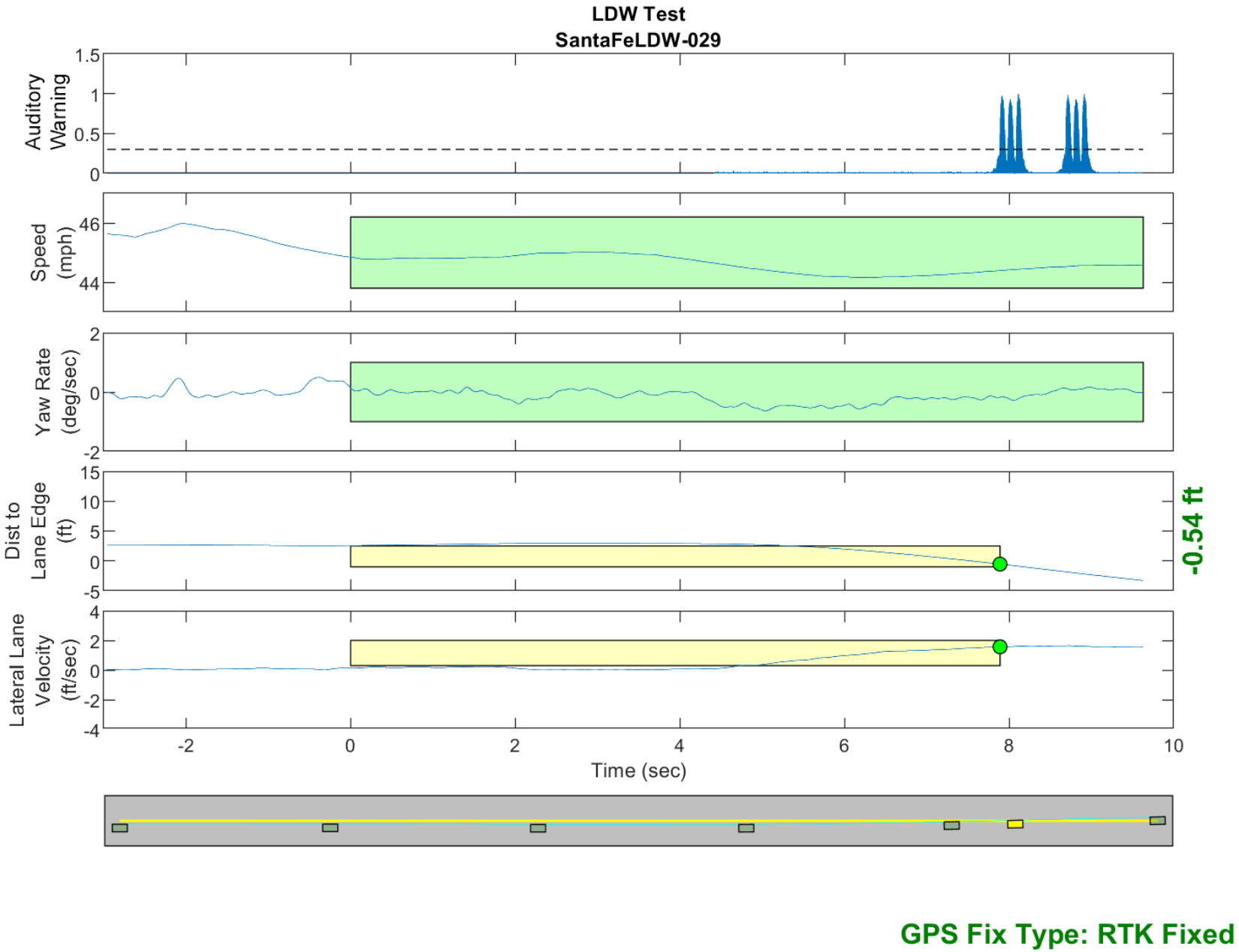


Figure D52. Time History for Run 29, Solid Line, Left Departure, Auditory Warning

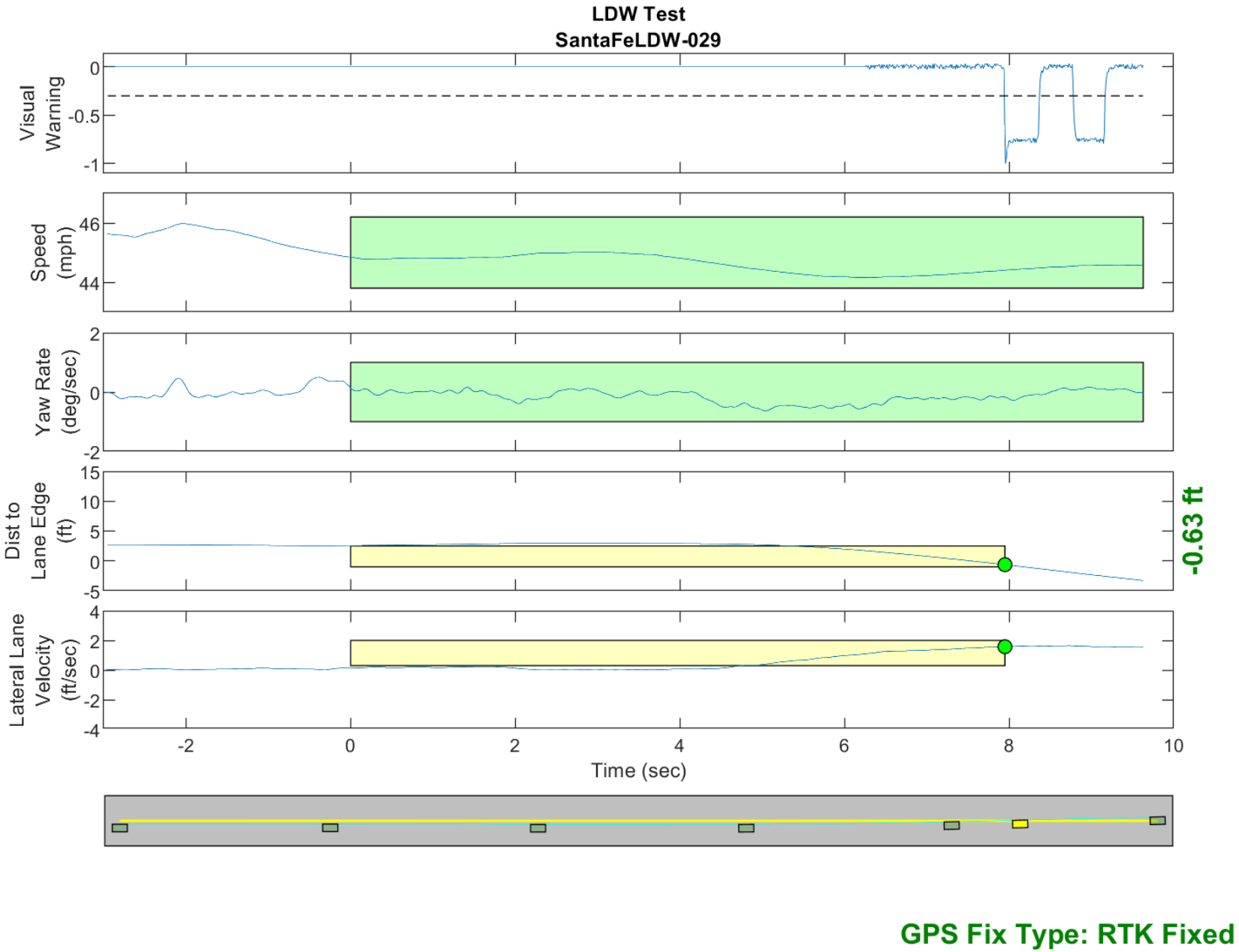


Figure D53. Time History for Run 29, Solid Line, Left Departure, Visual Warning

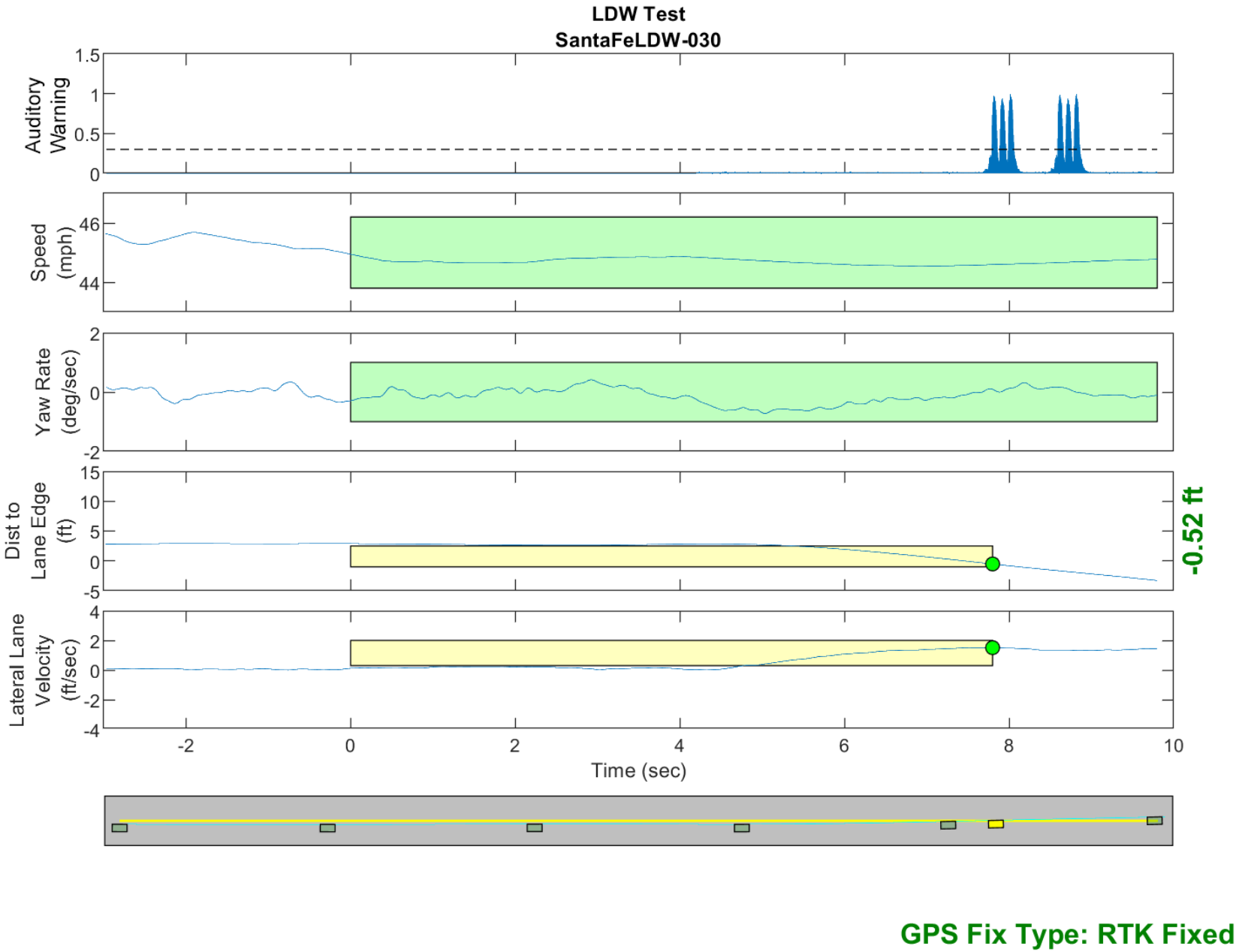


Figure D54. Time History for Run 30, Solid Line, Left Departure, Auditory Warning

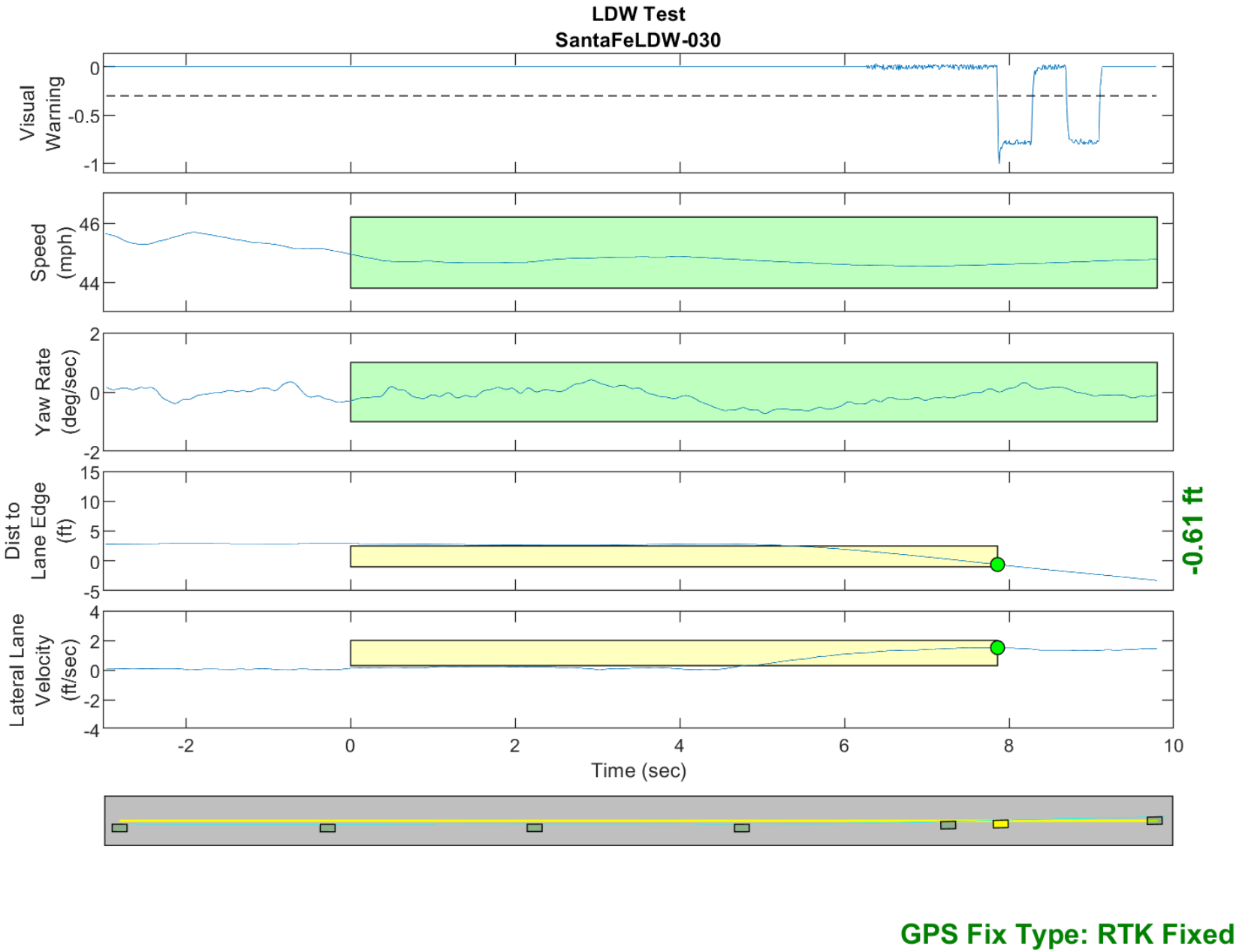


Figure D55. Time History for Run 30, Solid Line, Left Departure, Visual Warning

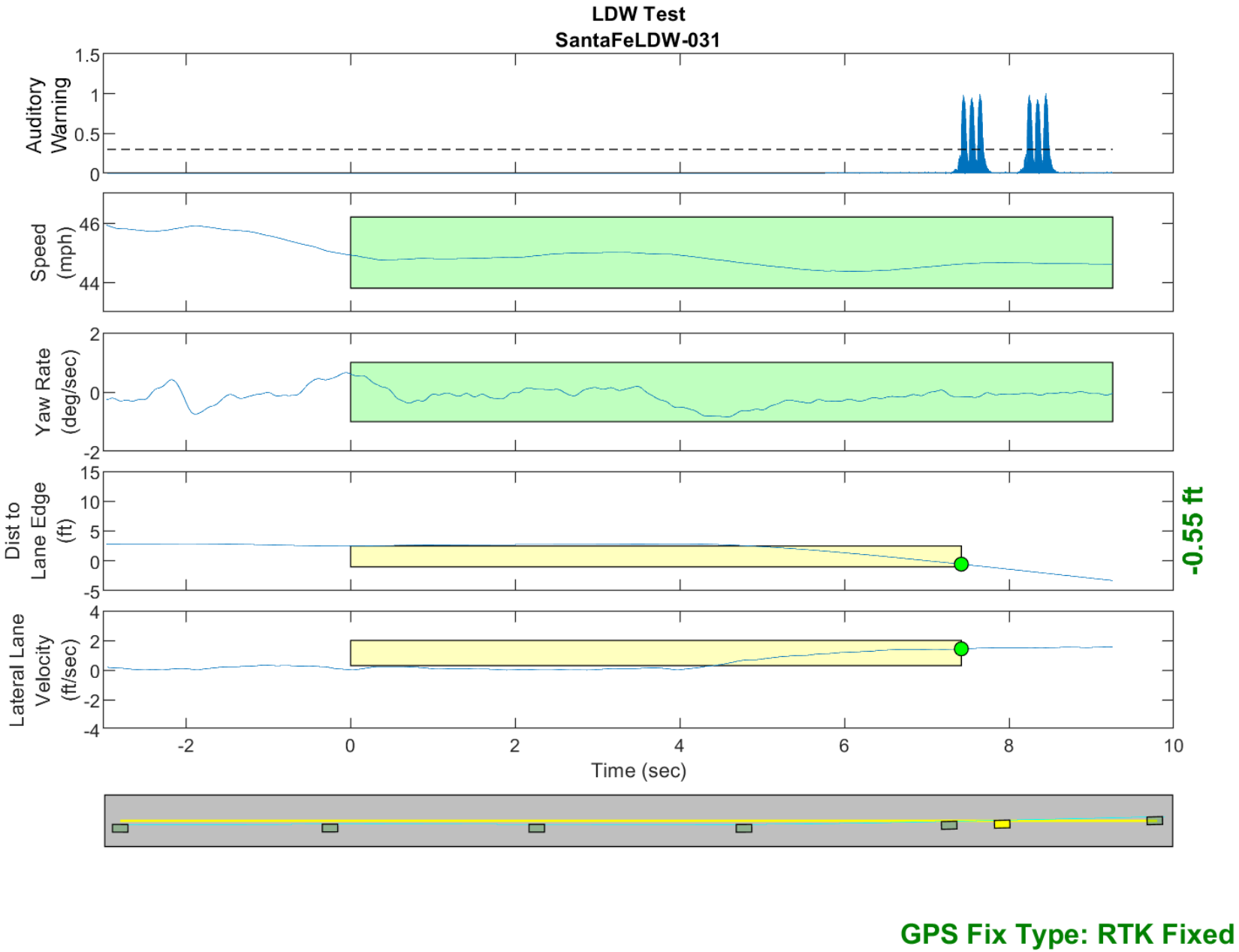


Figure D56. Time History for Run 31, Solid Line, Left Departure, Auditory Warning

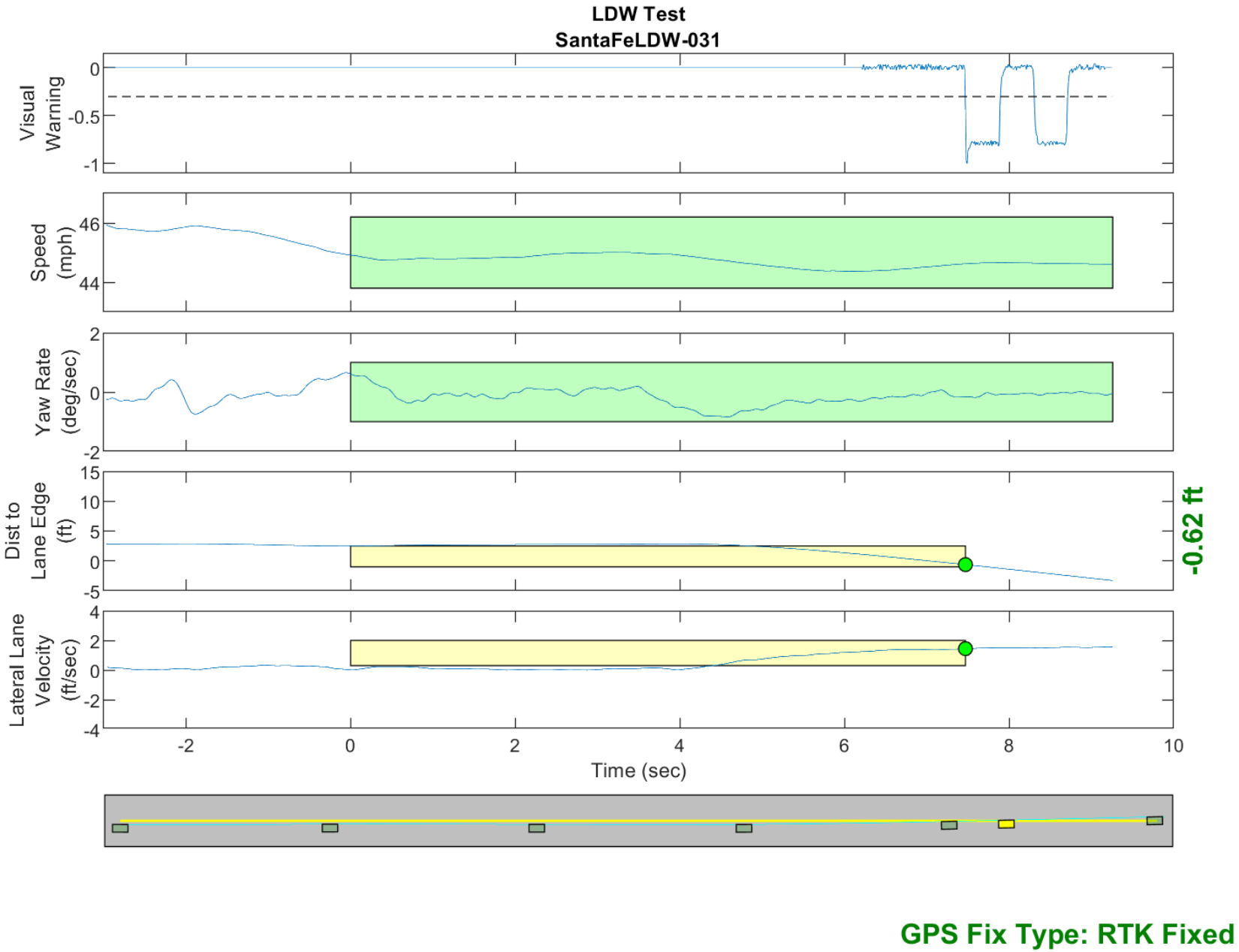


Figure D57. Time History for Run 31, Solid Line, Left Departure, Visual Warning

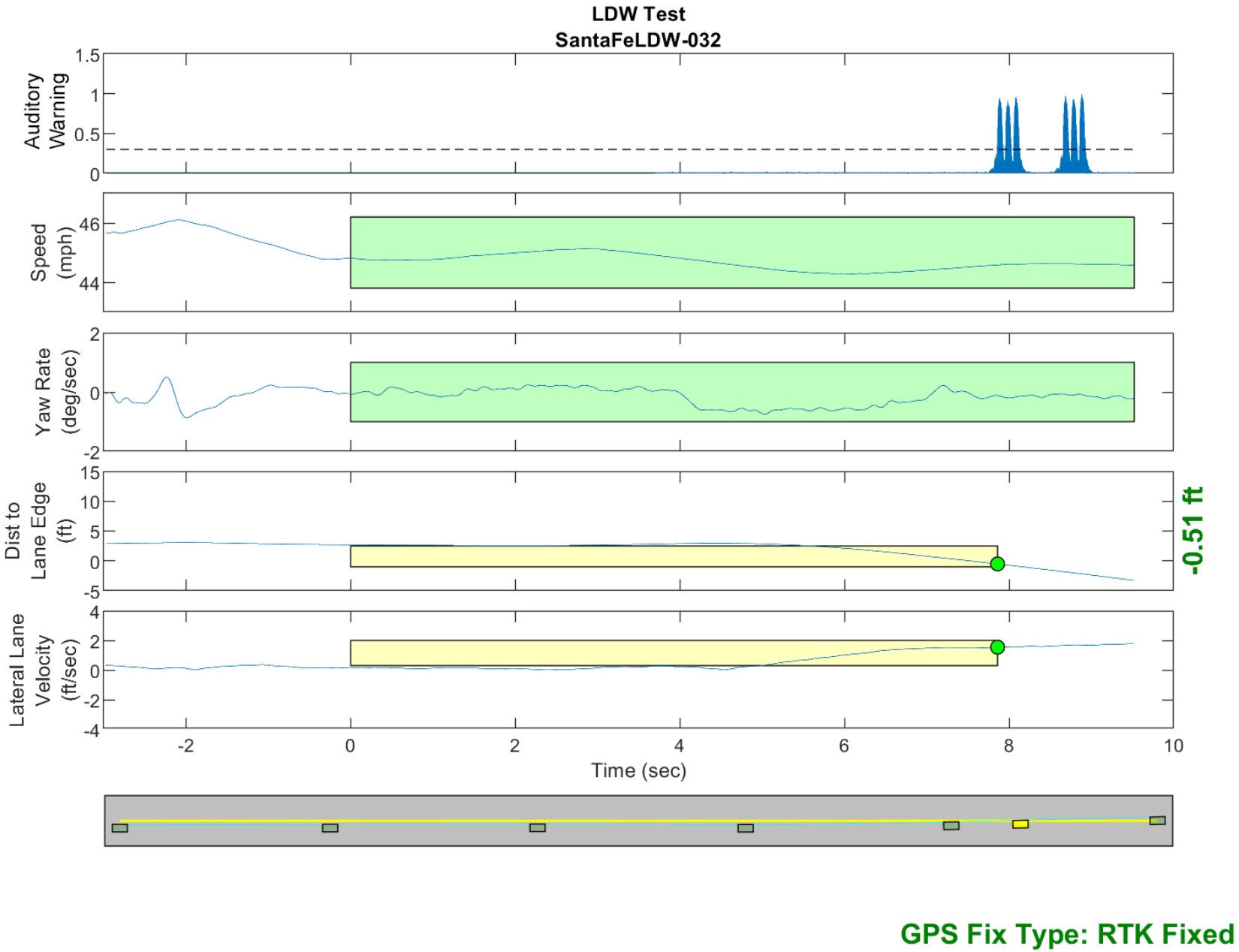


Figure D58. Time History for Run 32, Solid Line, Left Departure, Auditory Warning

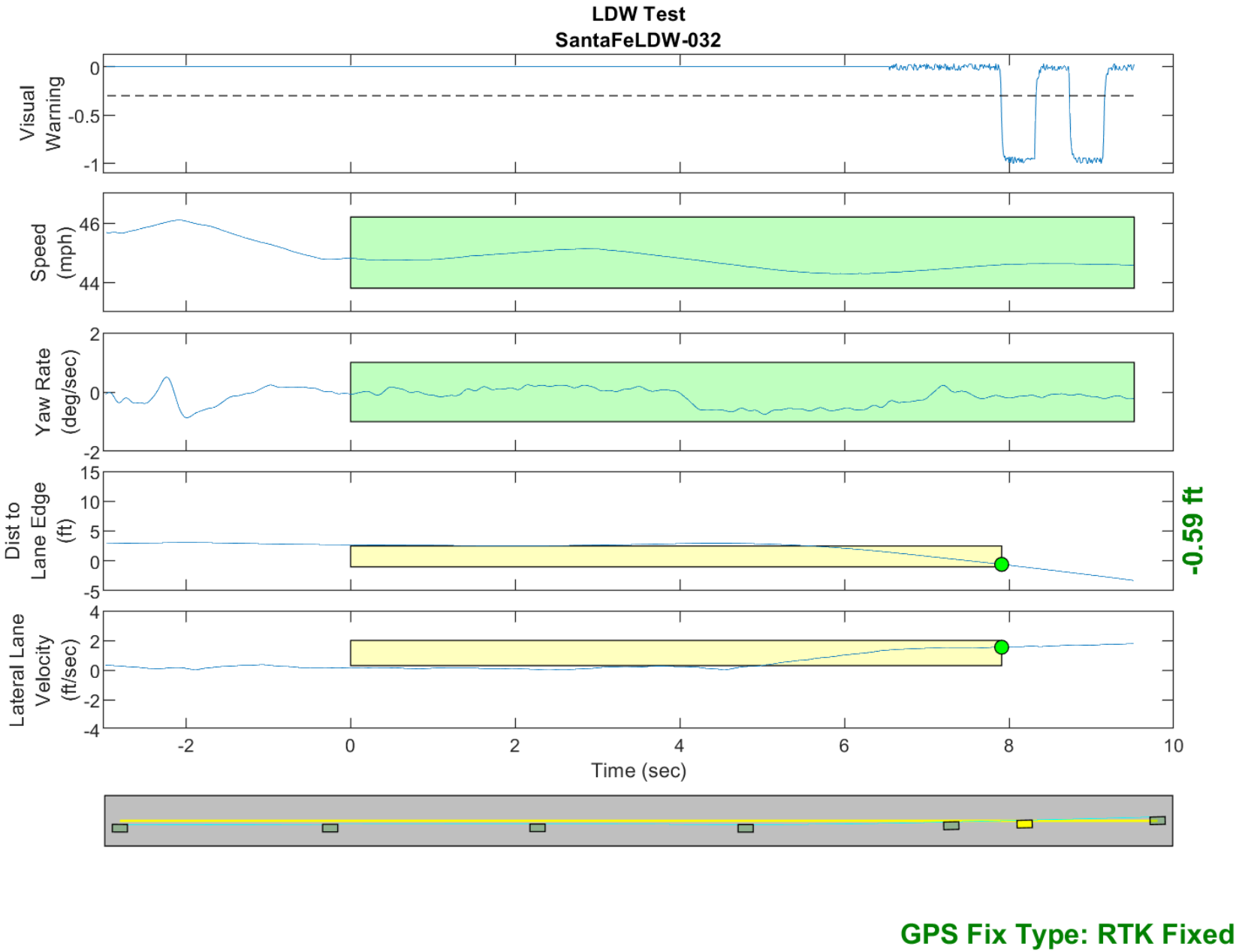


Figure D59. Time History for Run 32, Solid Line, Left Departure, Visual Warning

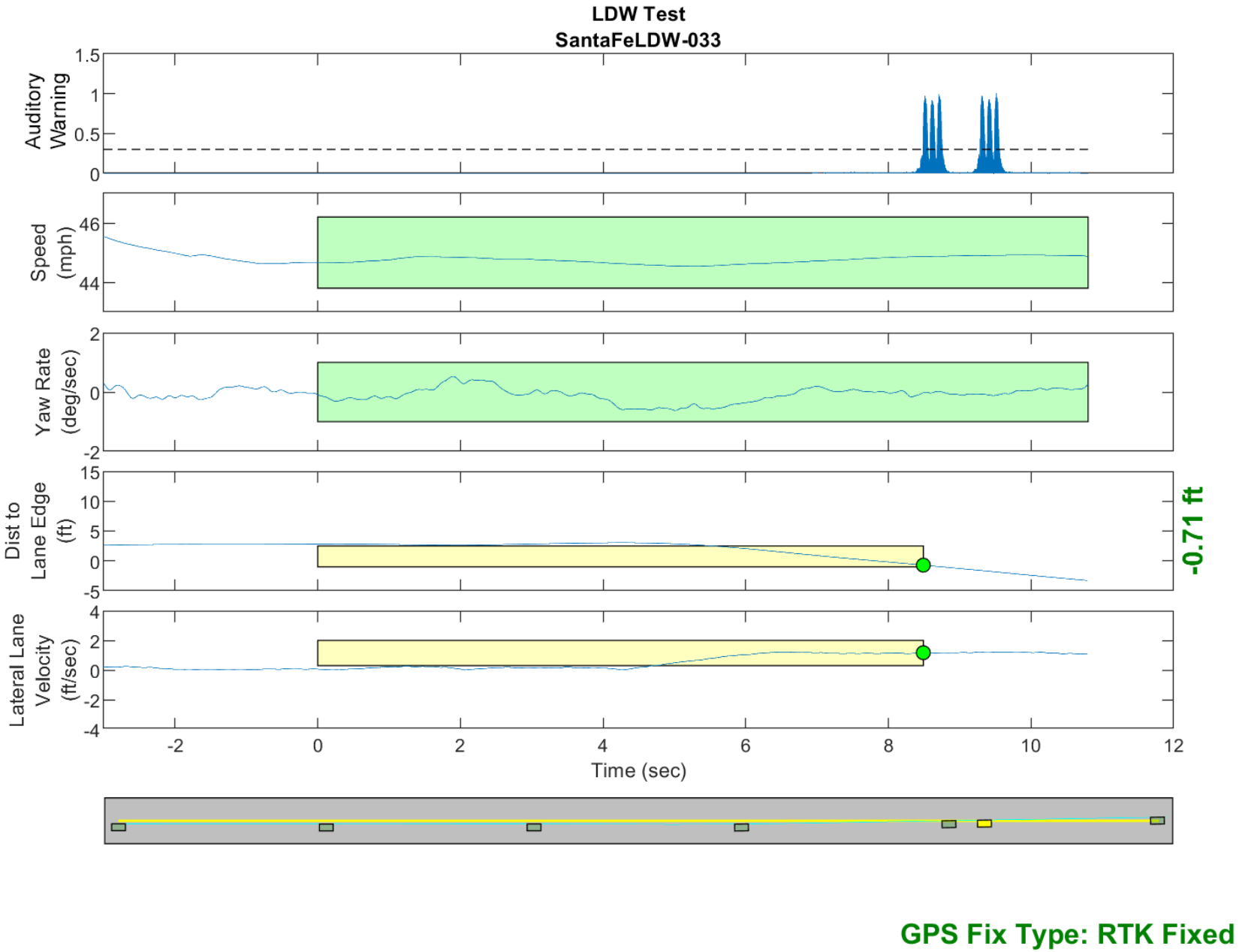


Figure D60. Time History for Run 33, Botts Dots, Left Departure, Auditory Warning

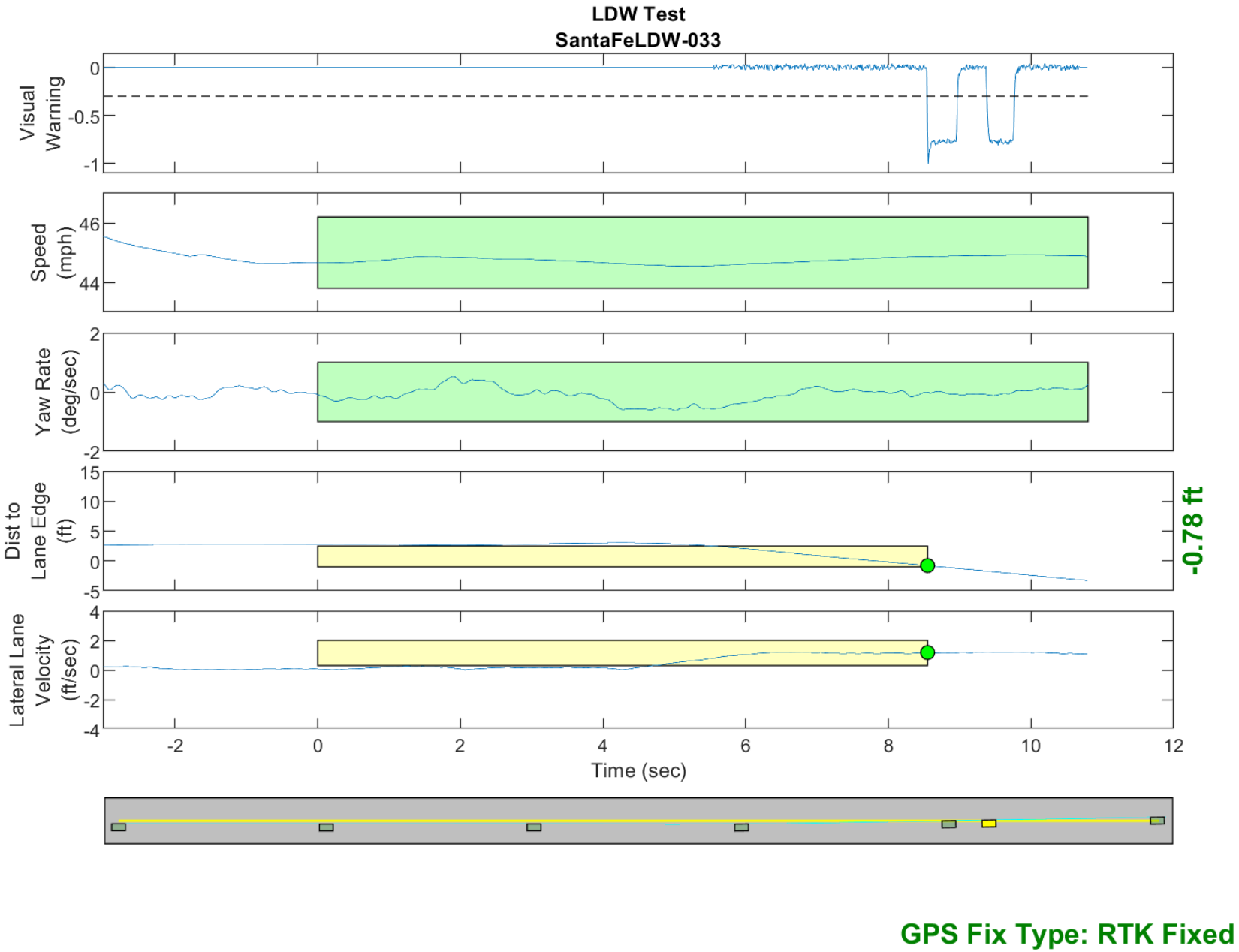


Figure D61. Time History for Run 33, Botts Dots, Left Departure, Visual Warning

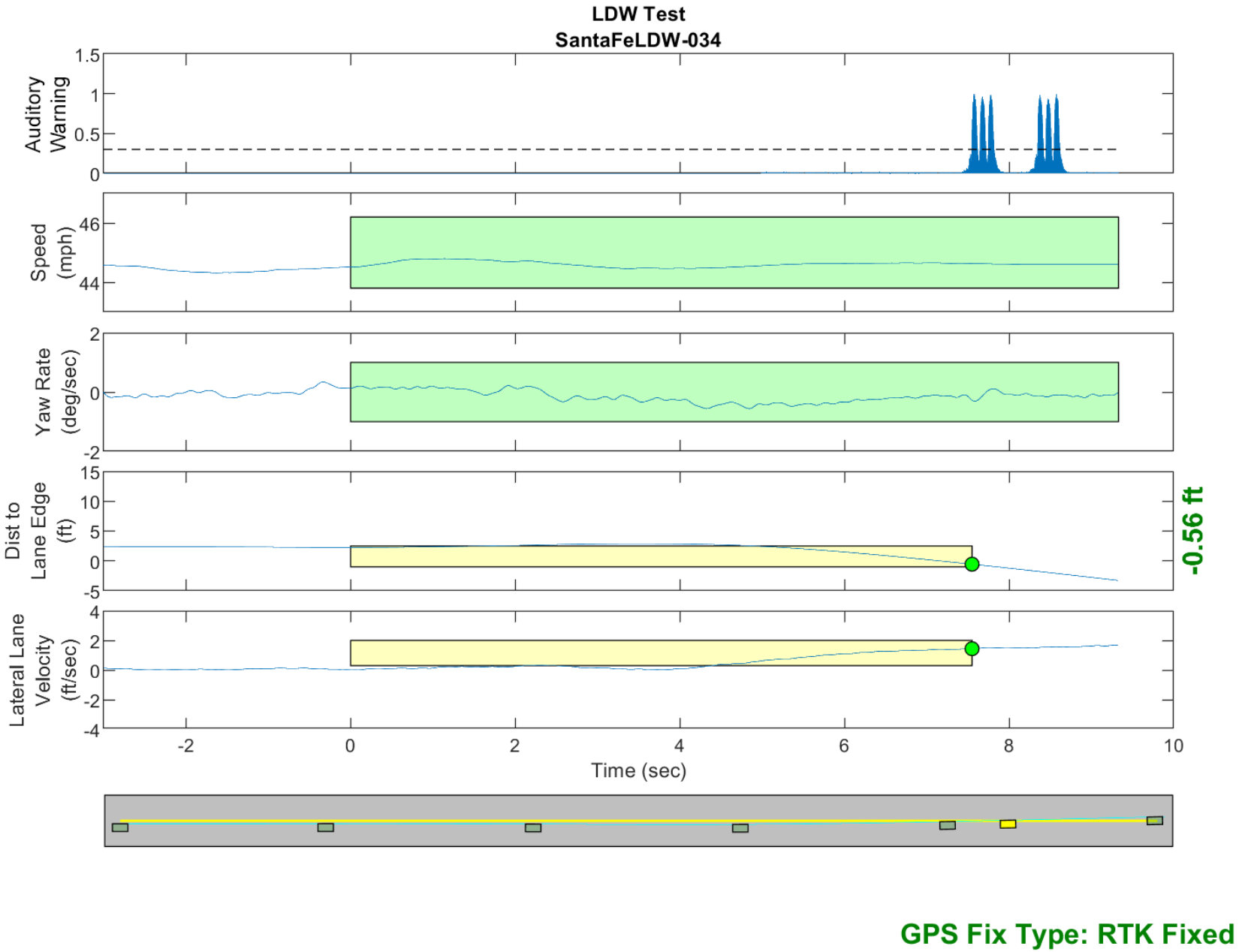


Figure D62. Time History for Run 34, Botts Dots, Left Departure, Auditory Warning

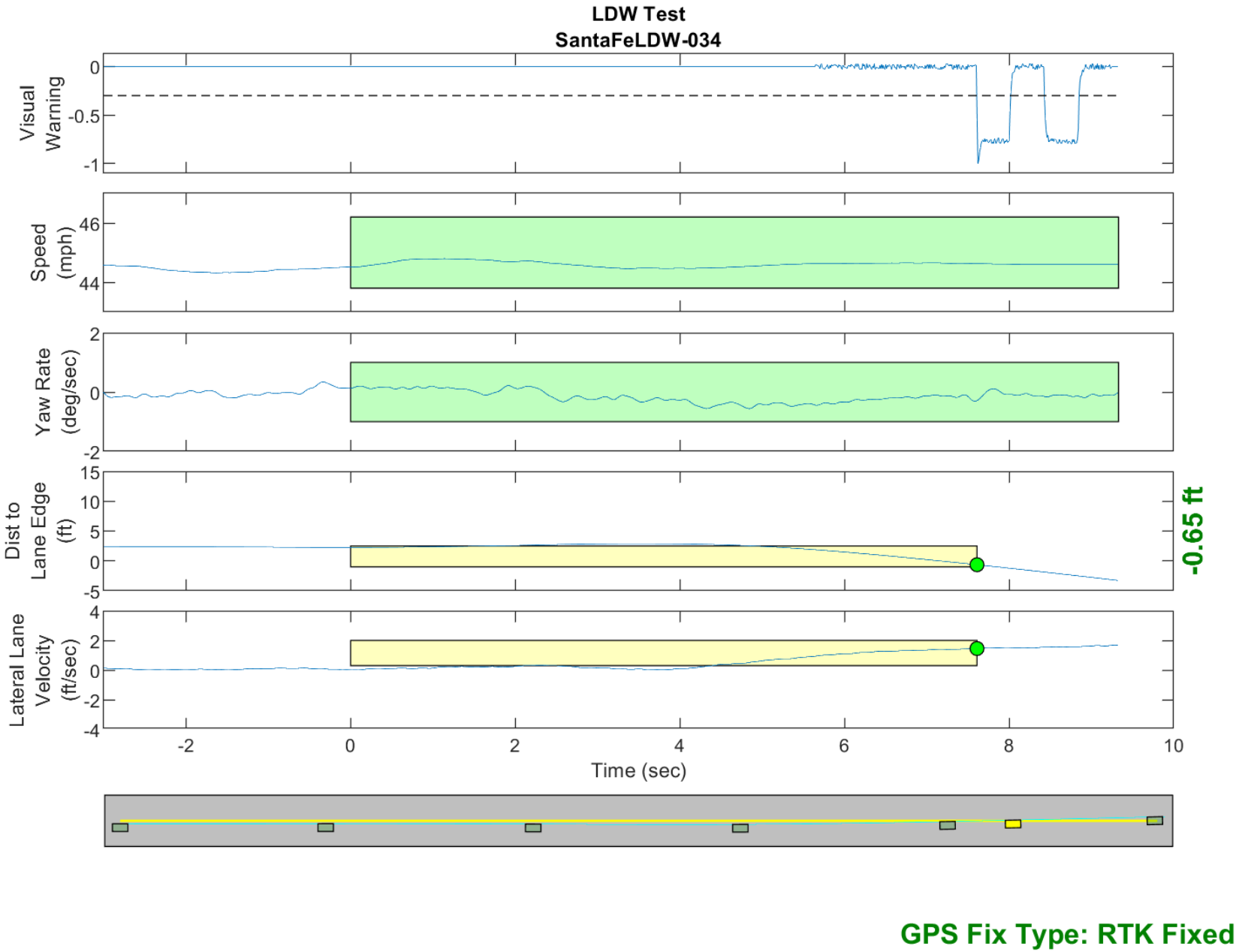


Figure D63. Time History for Run 34, Botts Dots, Left Departure, Visual Warning

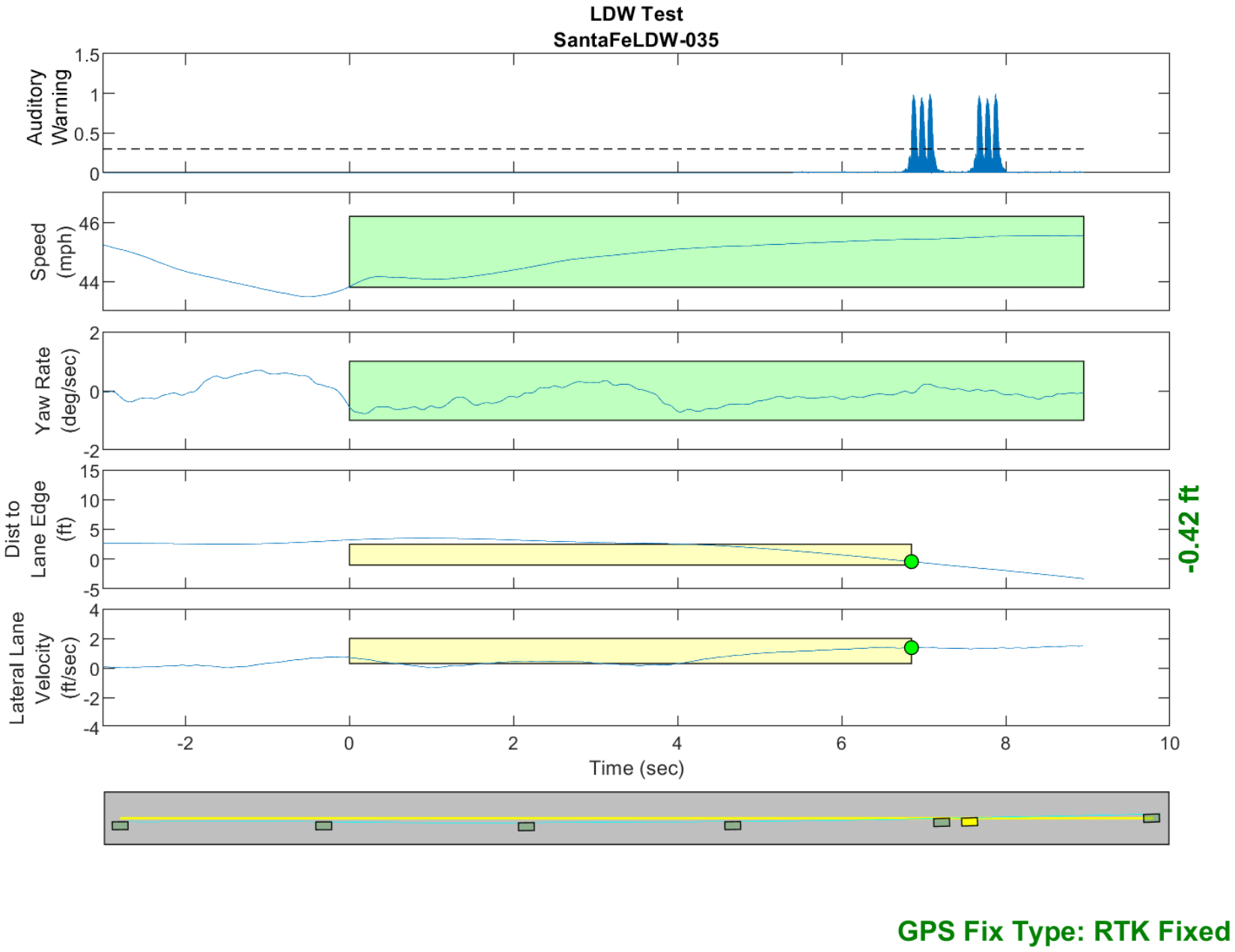


Figure D64. Time History for Run 35, Botts Dots, Left Departure, Auditory Warning

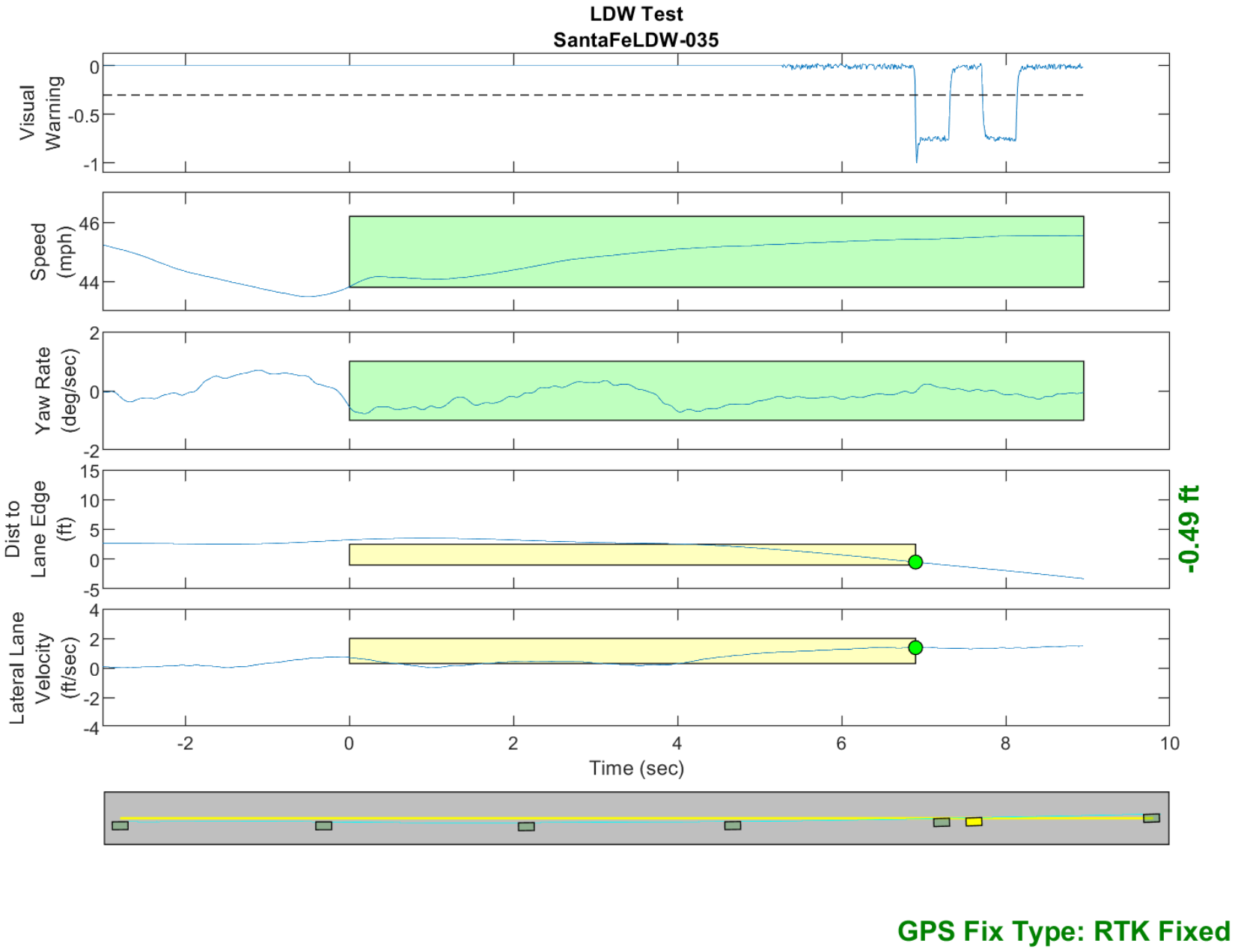


Figure D65. Time History for Run 35, Botts Dots, Left Departure, Visual Warning

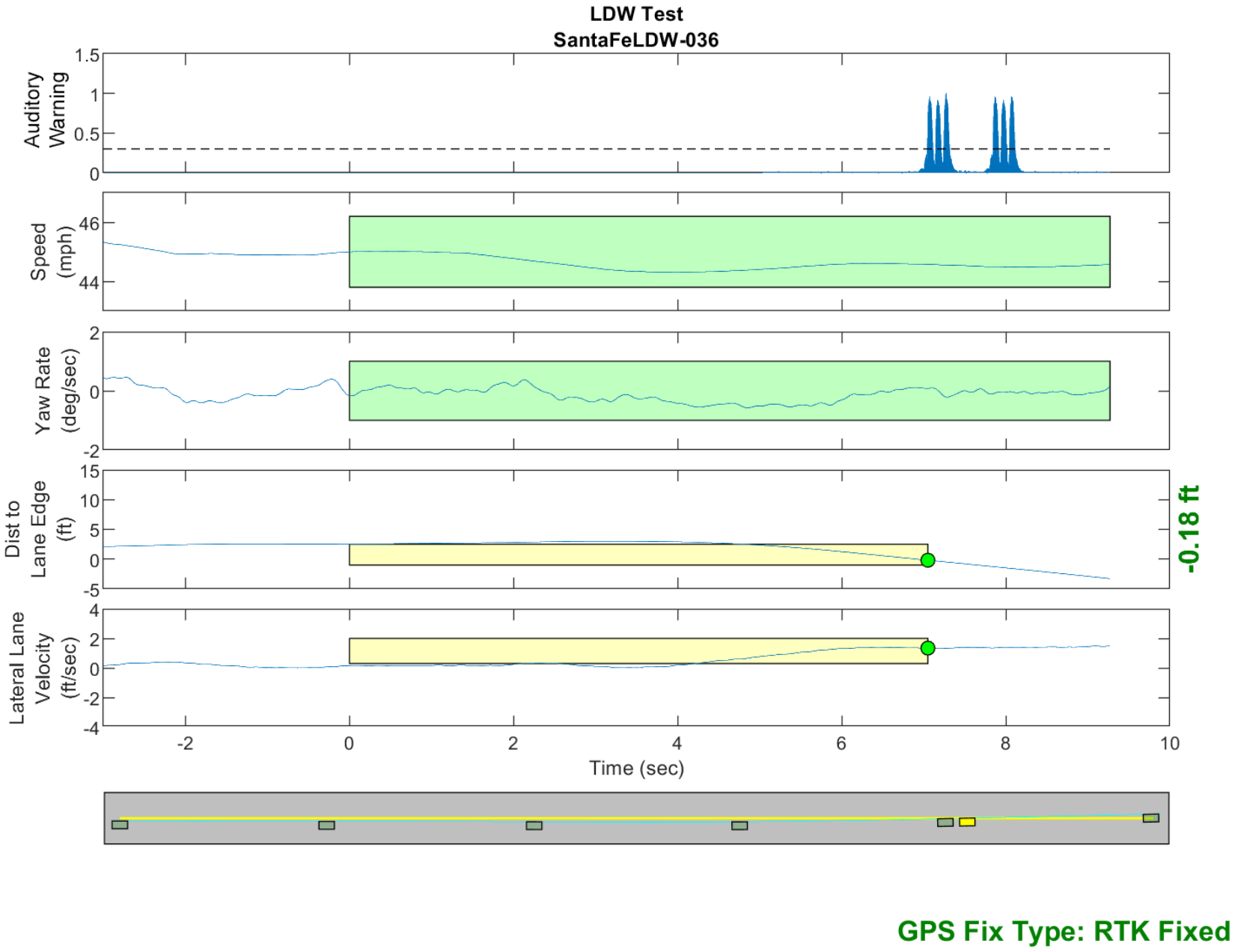


Figure D66. Time History for Run 36, Botts Dots, Left Departure, Auditory Warning

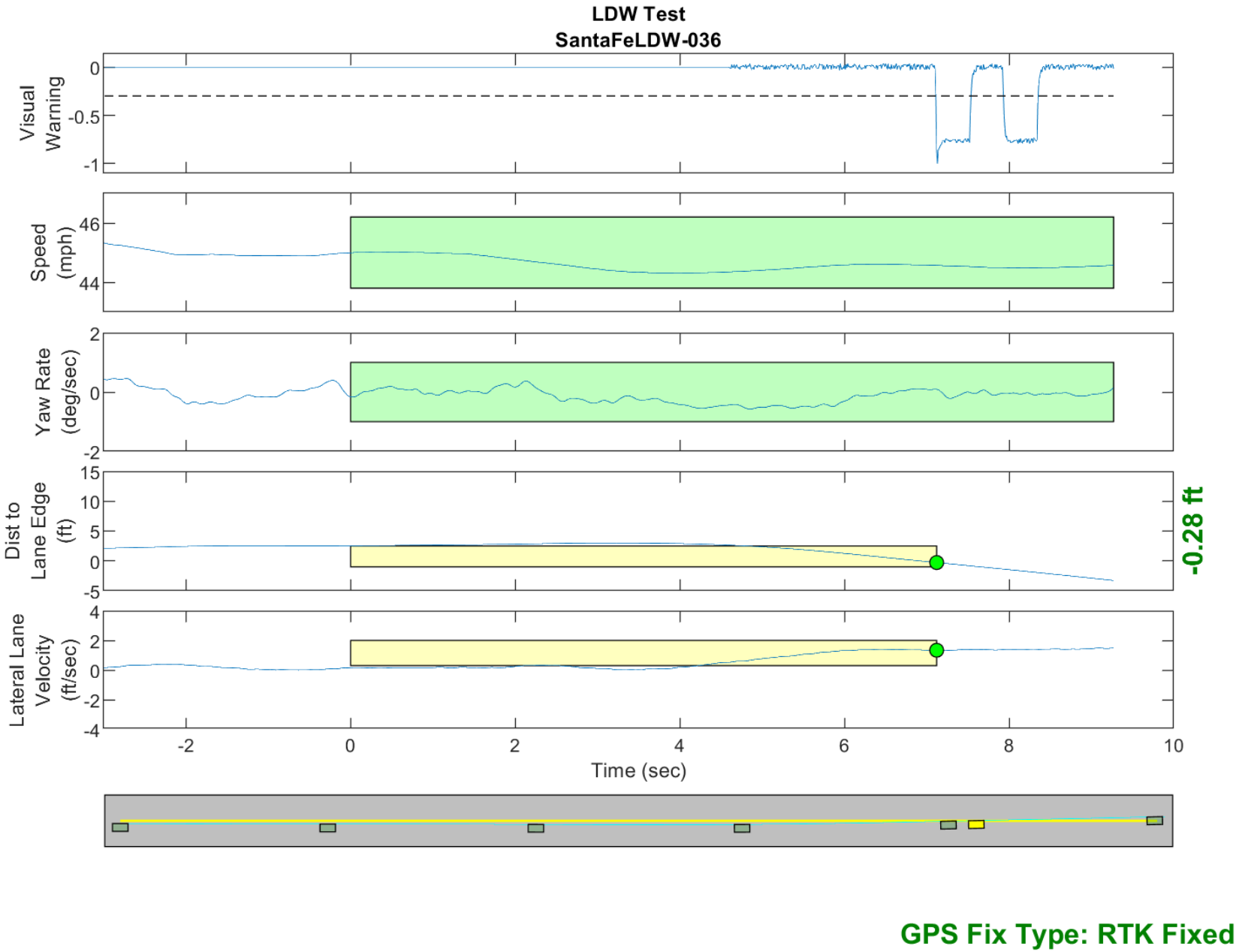


Figure D67. Time History for Run 36, Botts Dots, Left Departure, Visual Warning

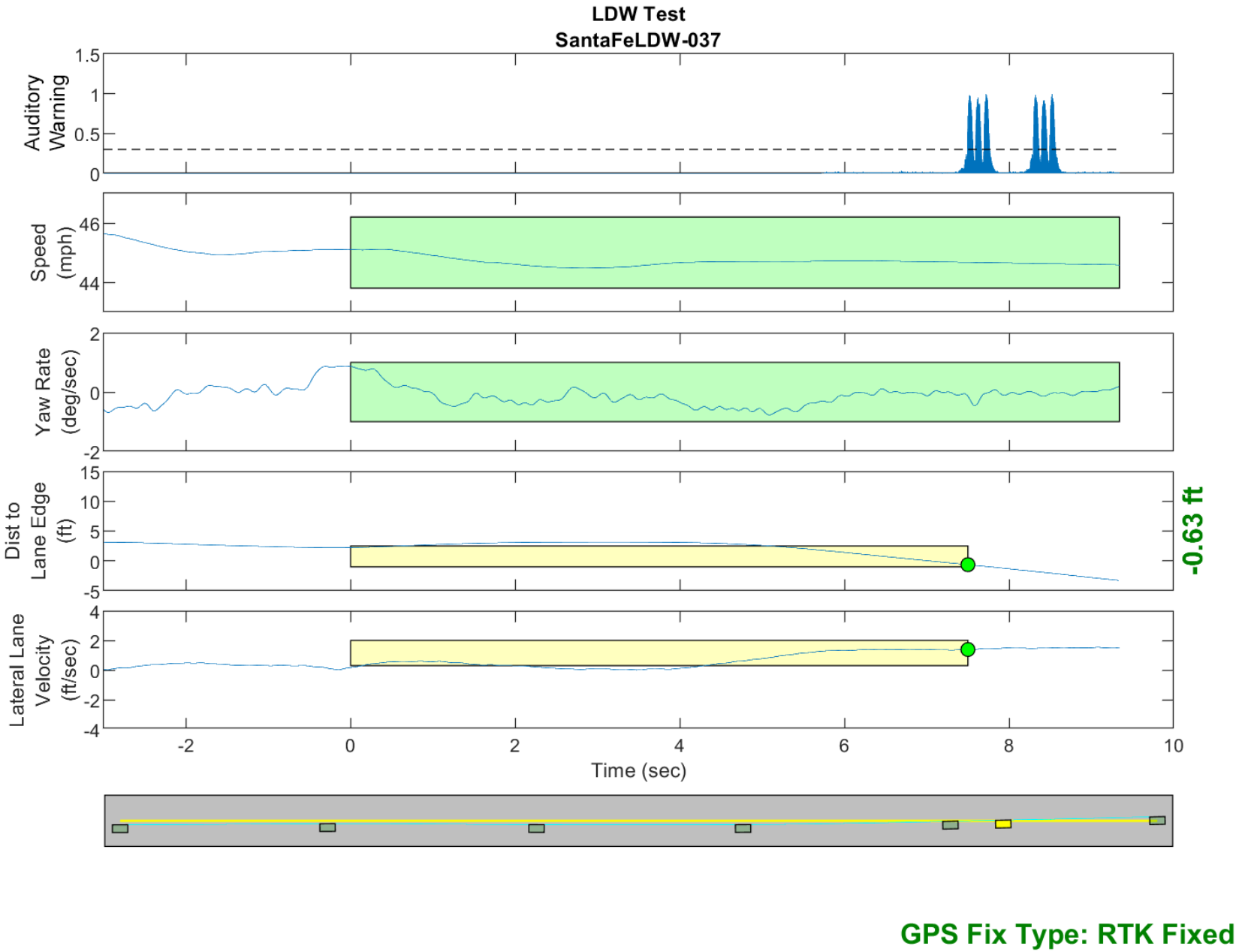


Figure D68. Time History for Run 37, Botts Dots, Left Departure, Auditory Warning

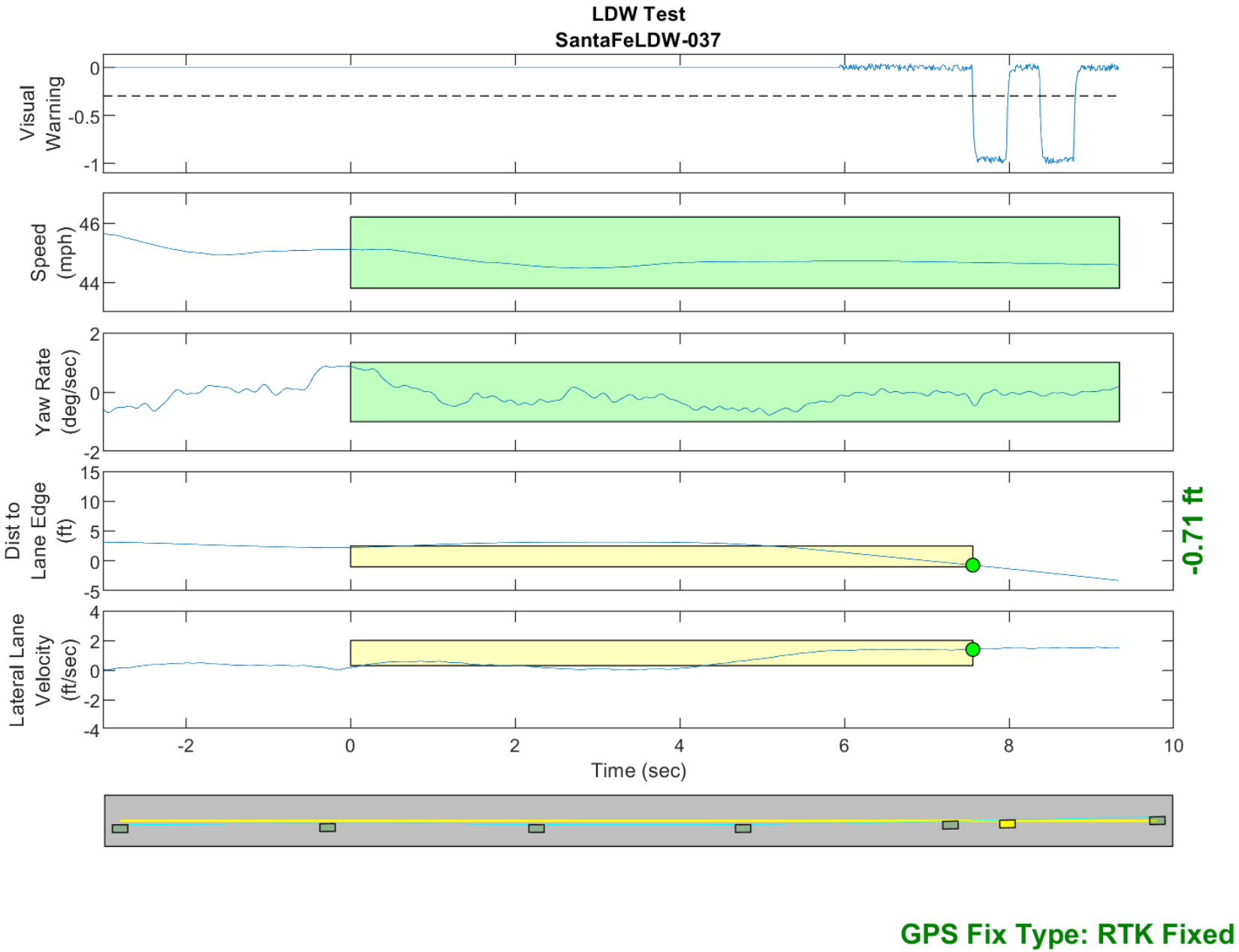


Figure D69. Time History for Run 37, Botts Dots, Left Departure, Visual Warning

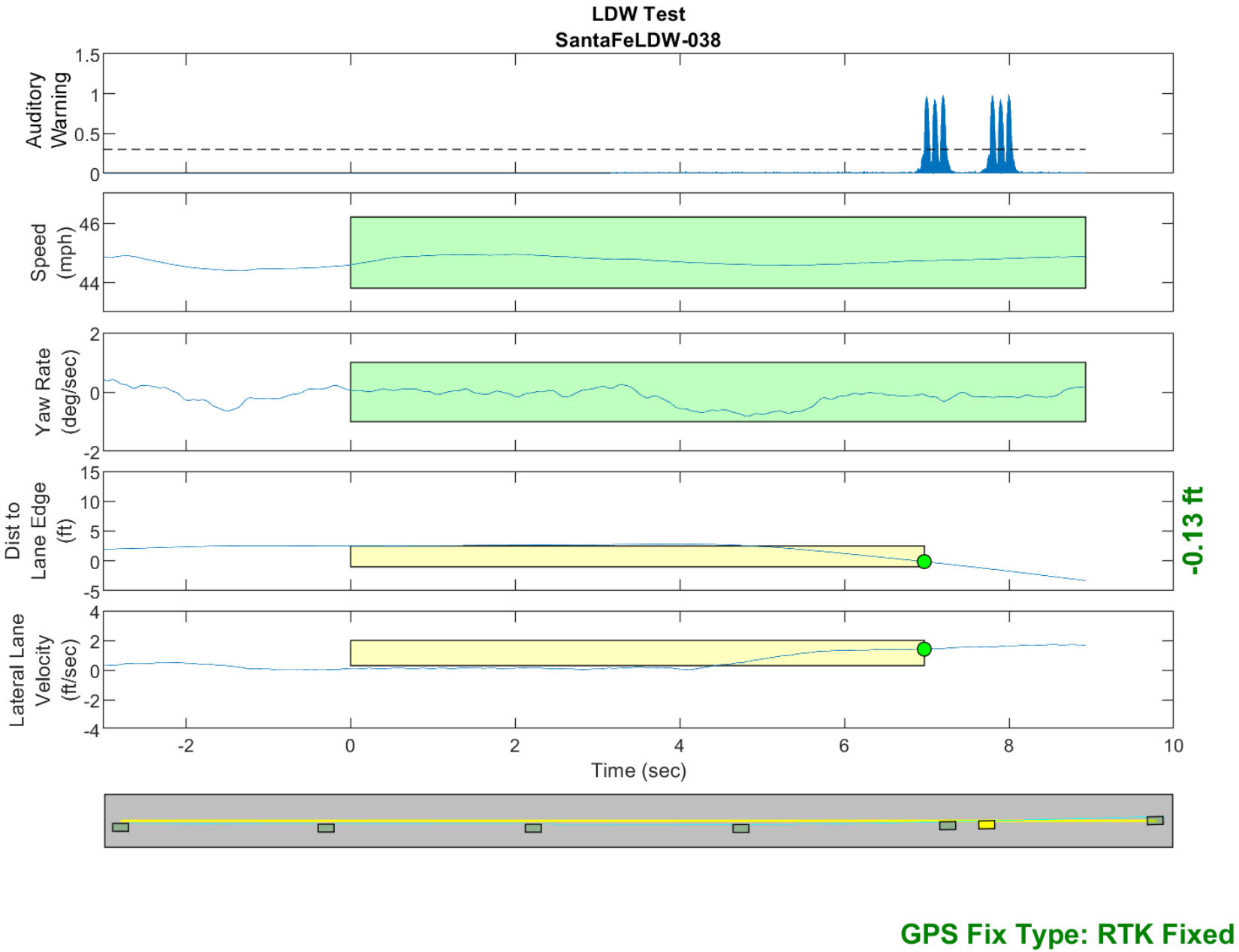


Figure D70. Time History for Run 38, Botts Dots, Left Departure, Auditory Warning

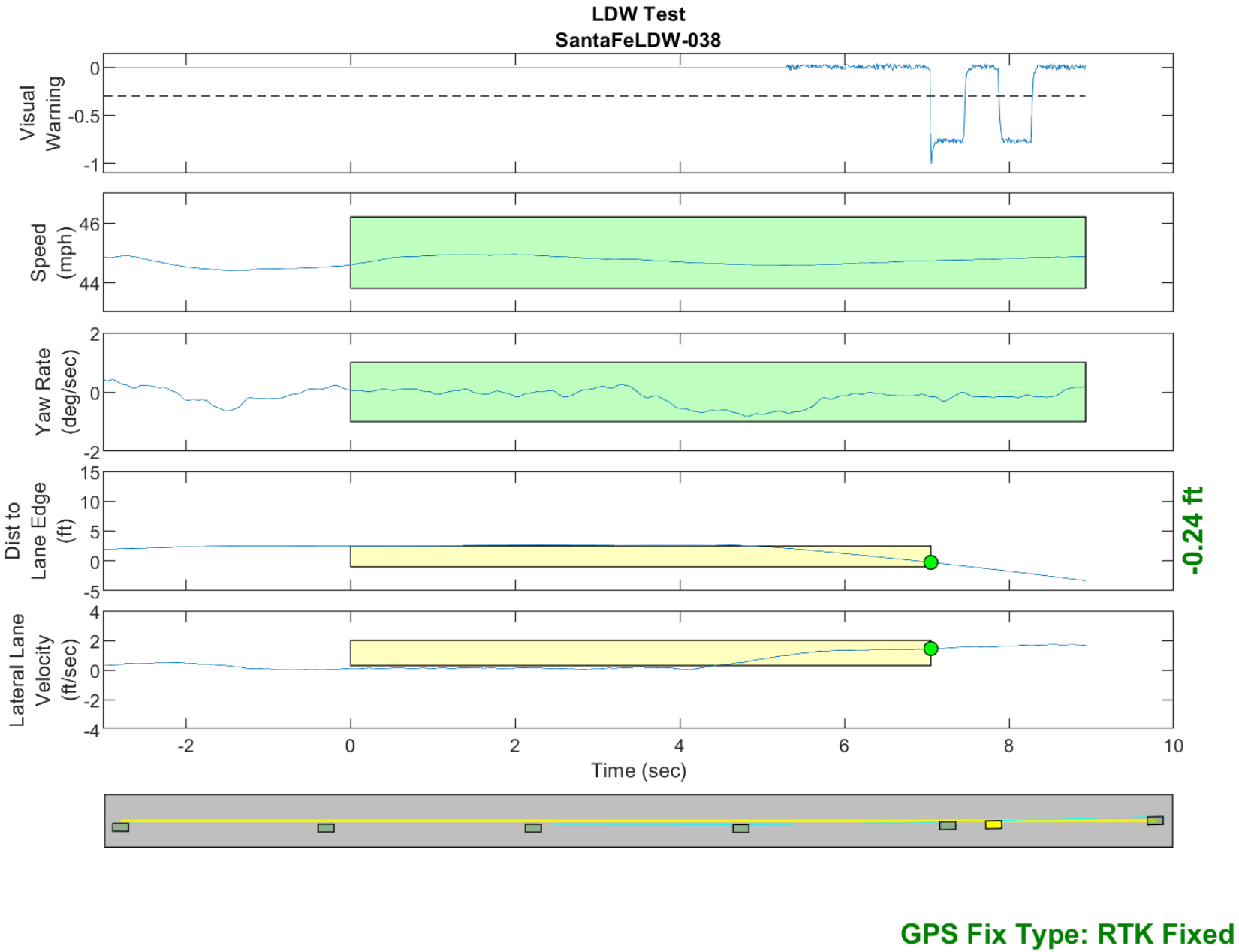


Figure D71. Time History for Run 38, Botts Dots, Left Departure, Visual Warning

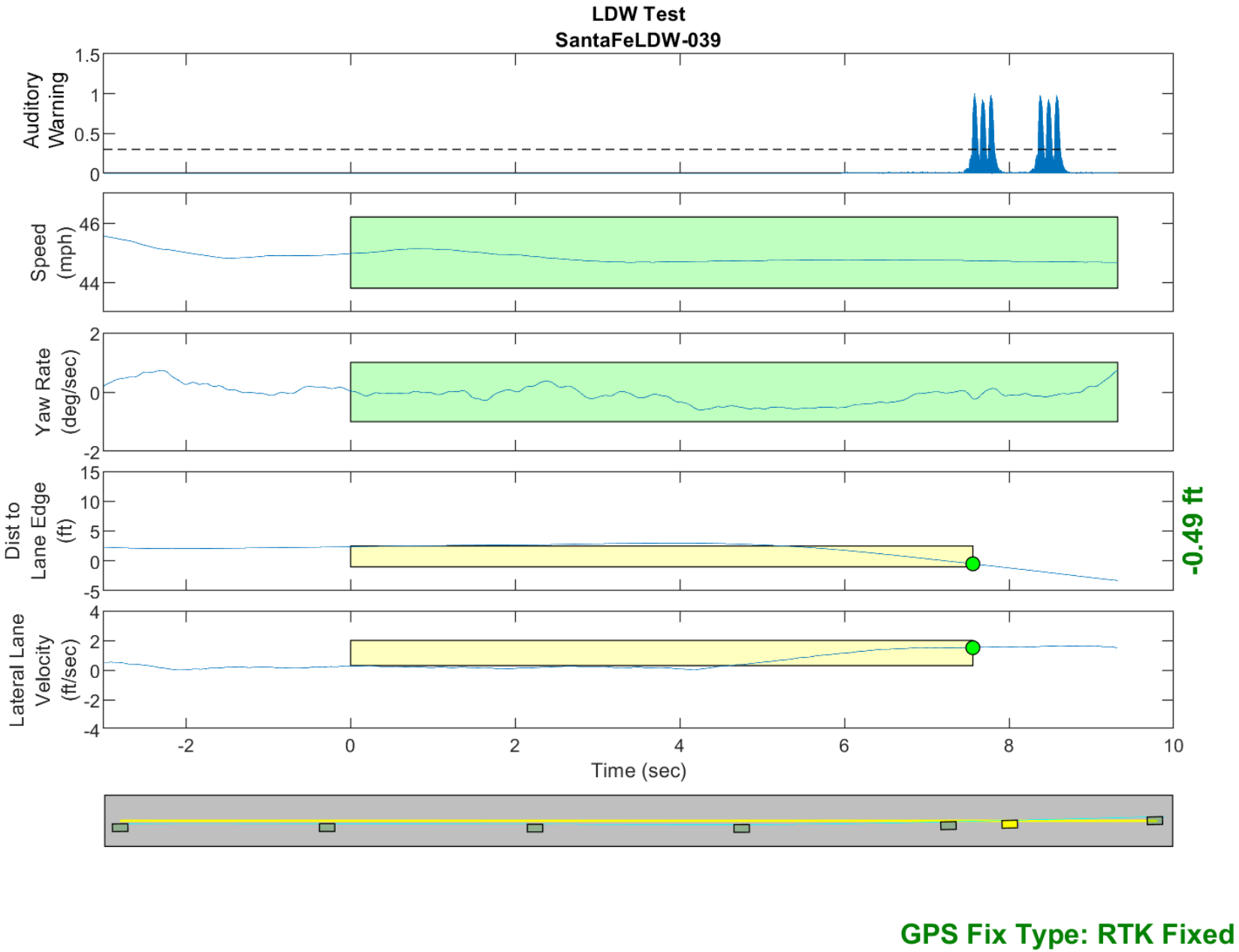


Figure D72. Time History for Run 39, Botts Dots, Left Departure, Auditory Warning

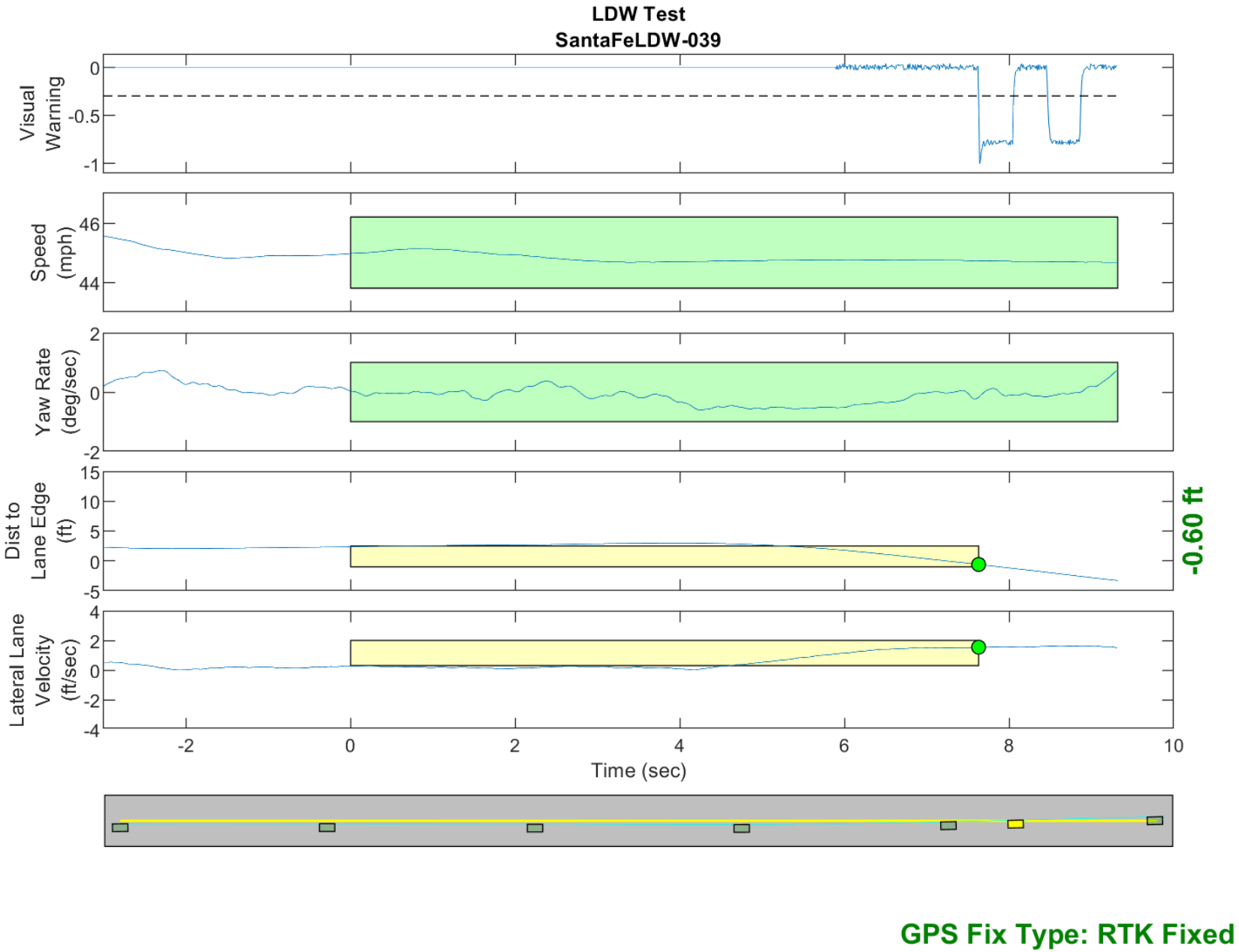


Figure D73. Time History for Run 39, Botts Dots, Left Departure, Visual Warning

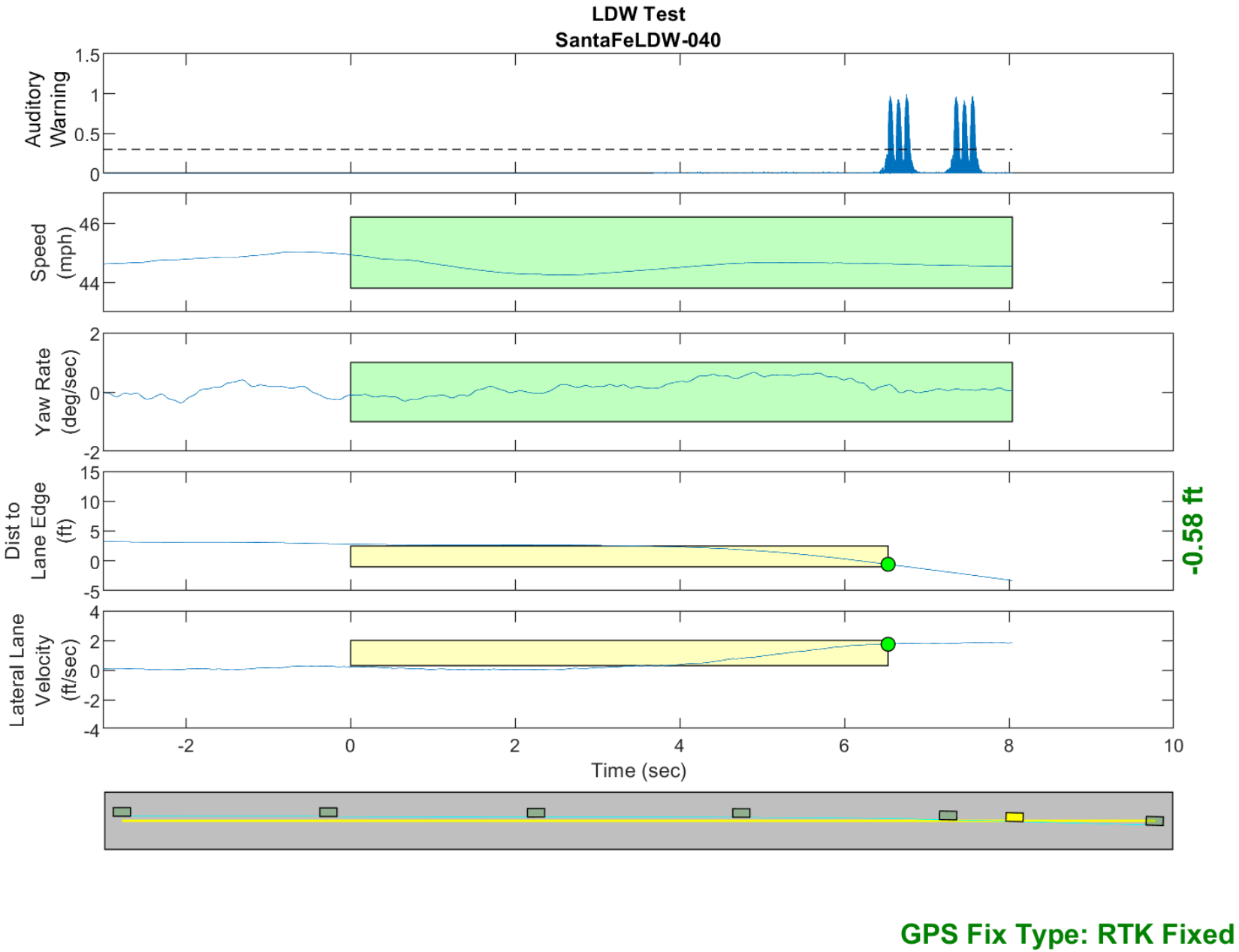


Figure D74. Time History for Run 40, Botts Dots, Right Departure, Auditory Warning

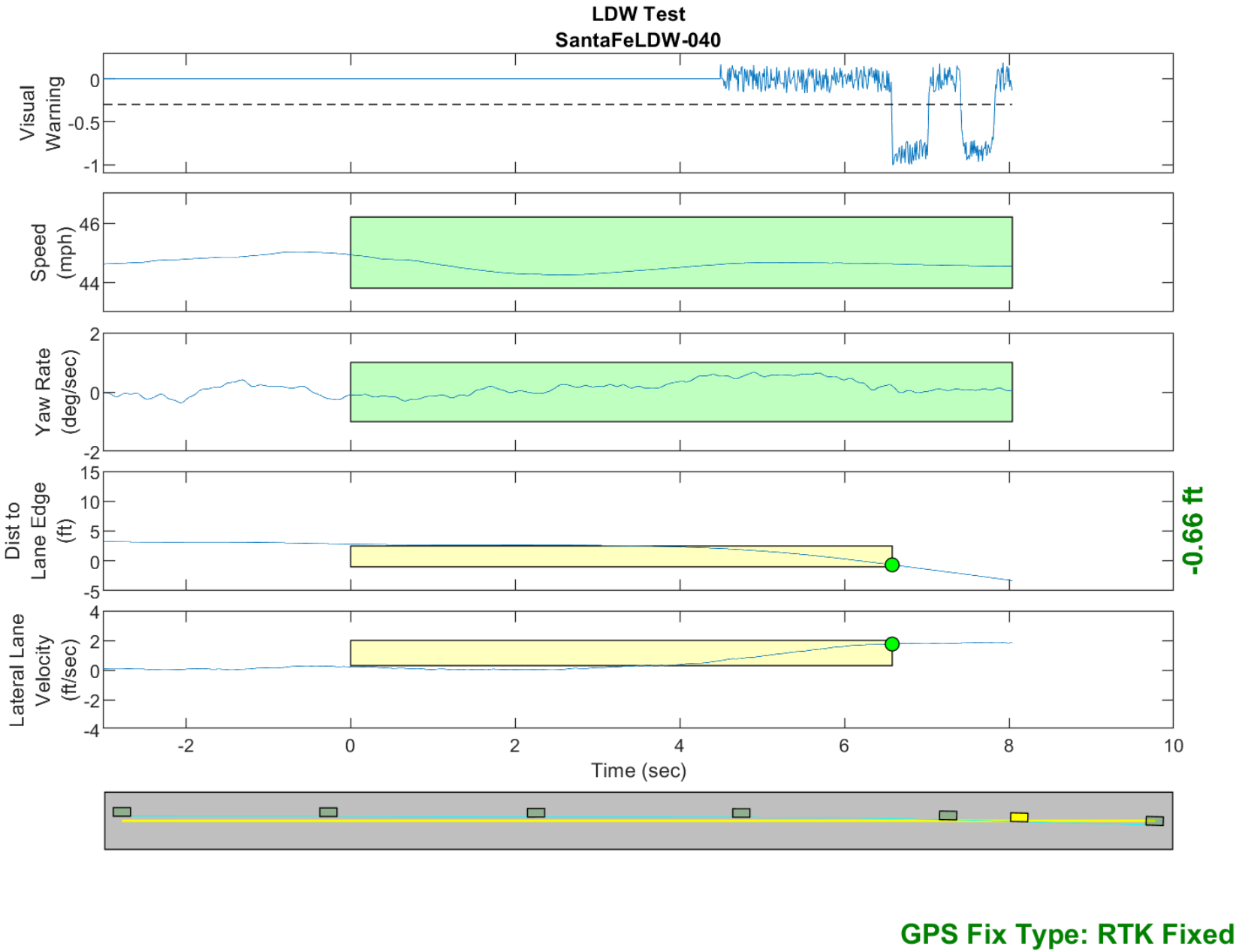


Figure D75. Time History for Run 40, Botts Dots, Right Departure, Visual Warning

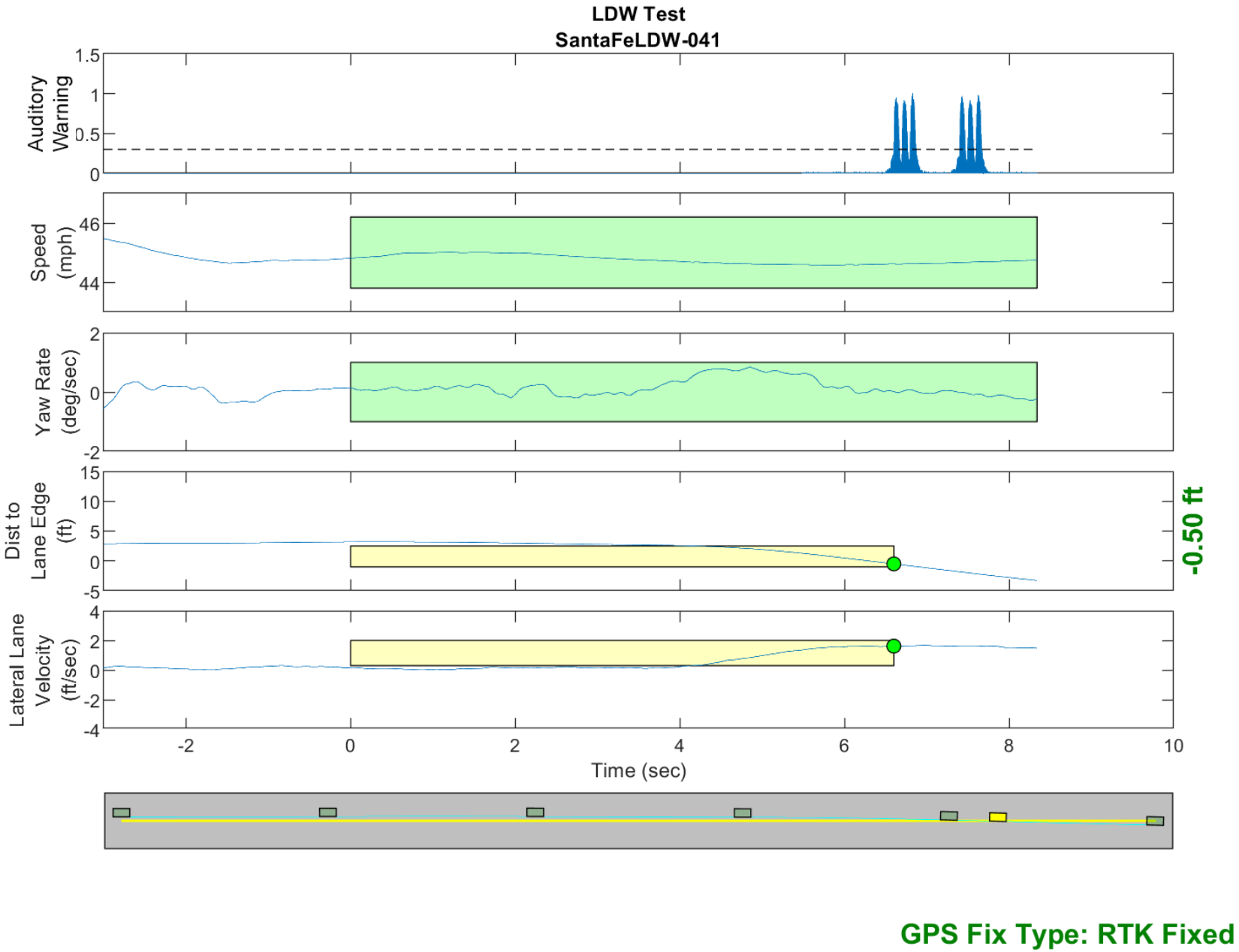


Figure D76. Time History for Run 41, Botts Dots, Right Departure, Auditory Warning

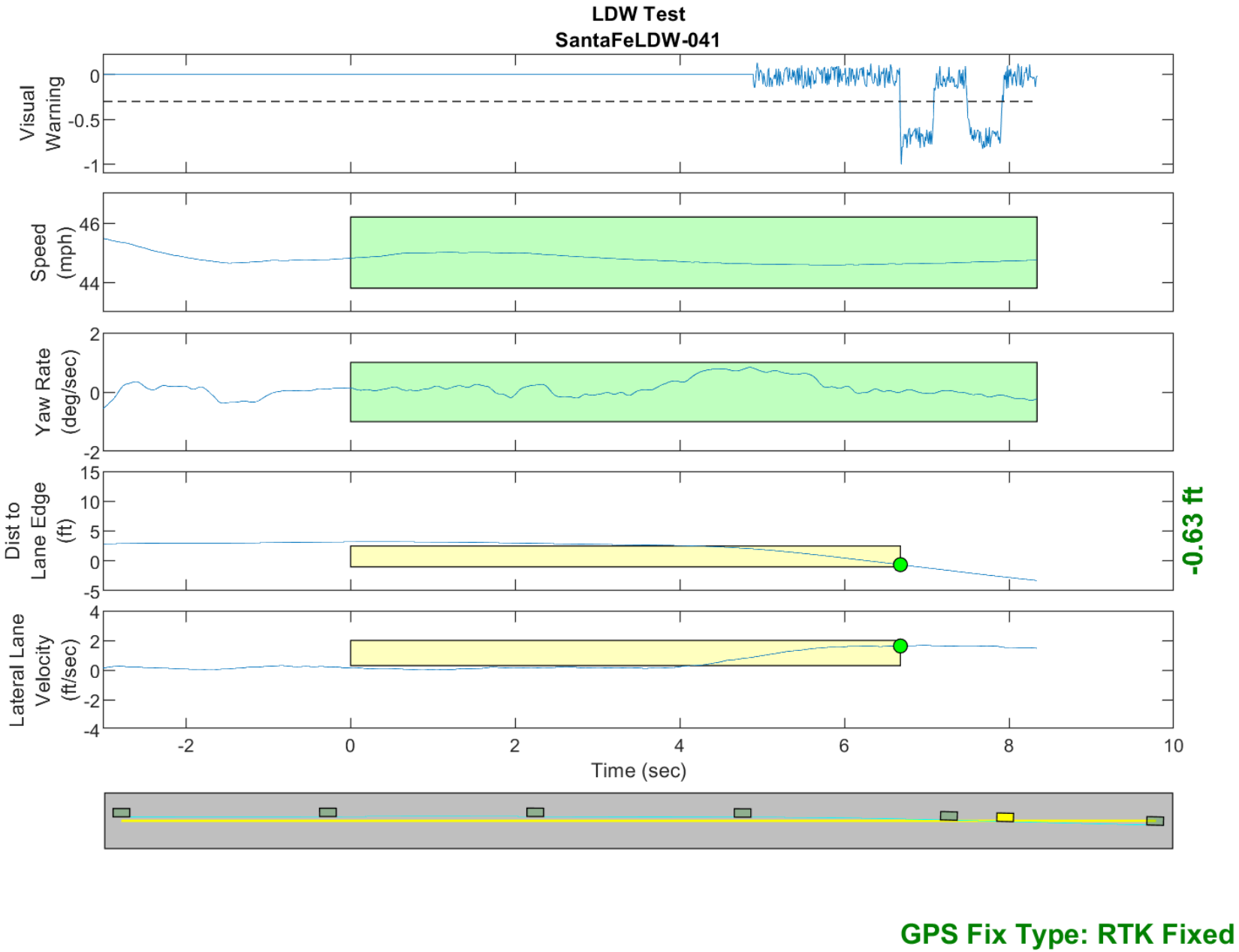


Figure D77. Time History for Run 41, Botts Dots, Right Departure, Visual Warning

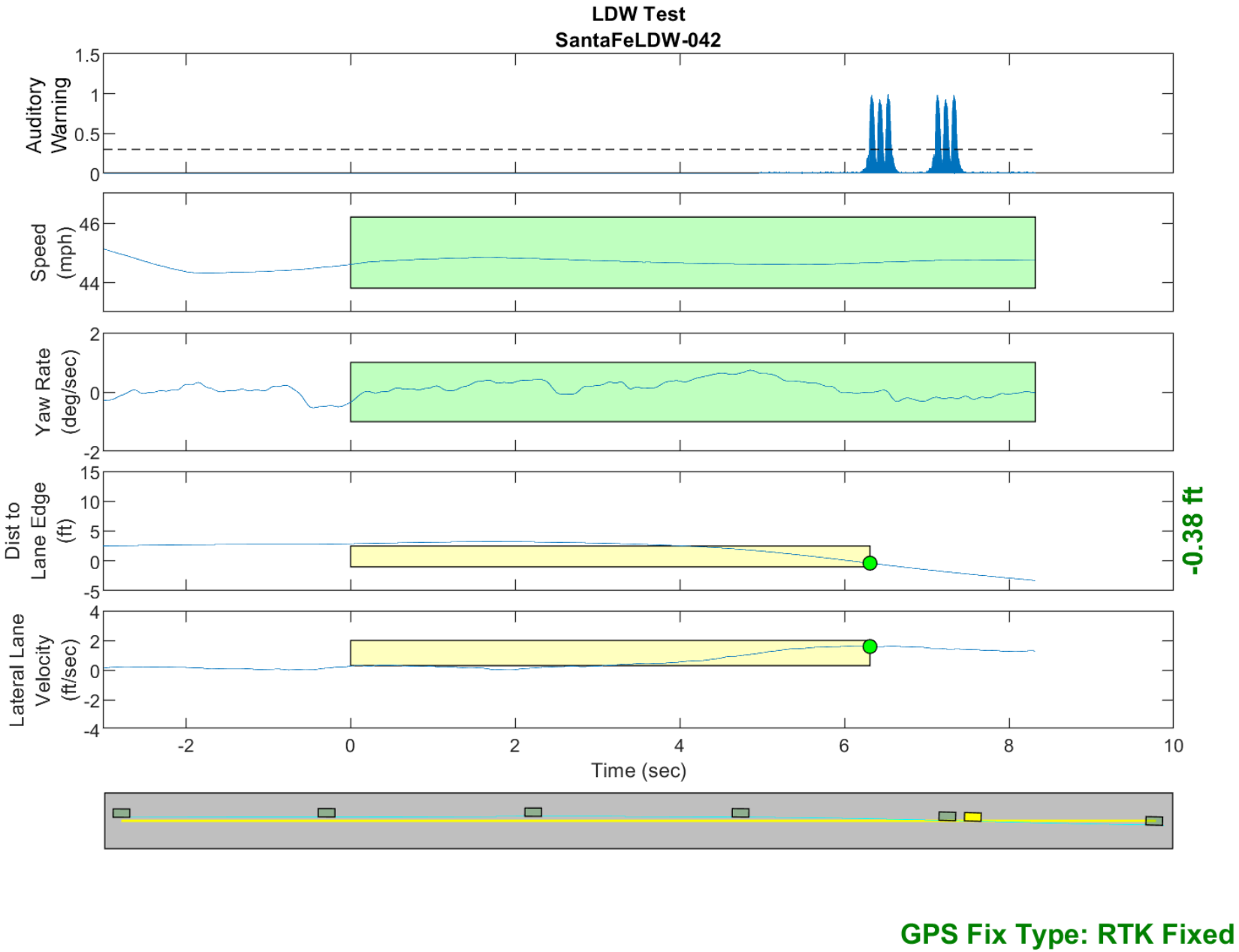


Figure D78. Time History for Run 42, Botts Dots, Right Departure, Auditory Warning

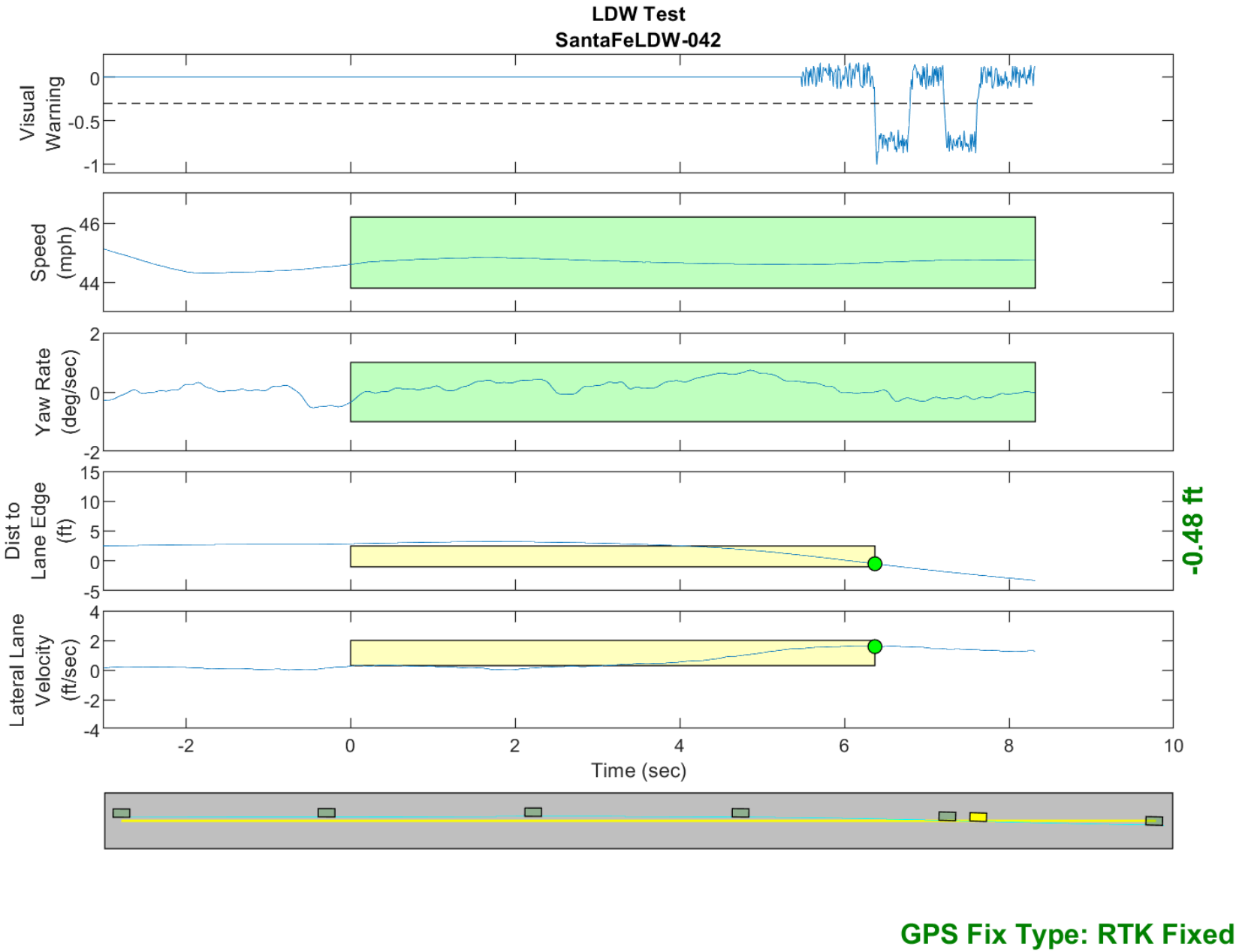


Figure D79. Time History for Run 42, Botts Dots, Right Departure, Visual Warning

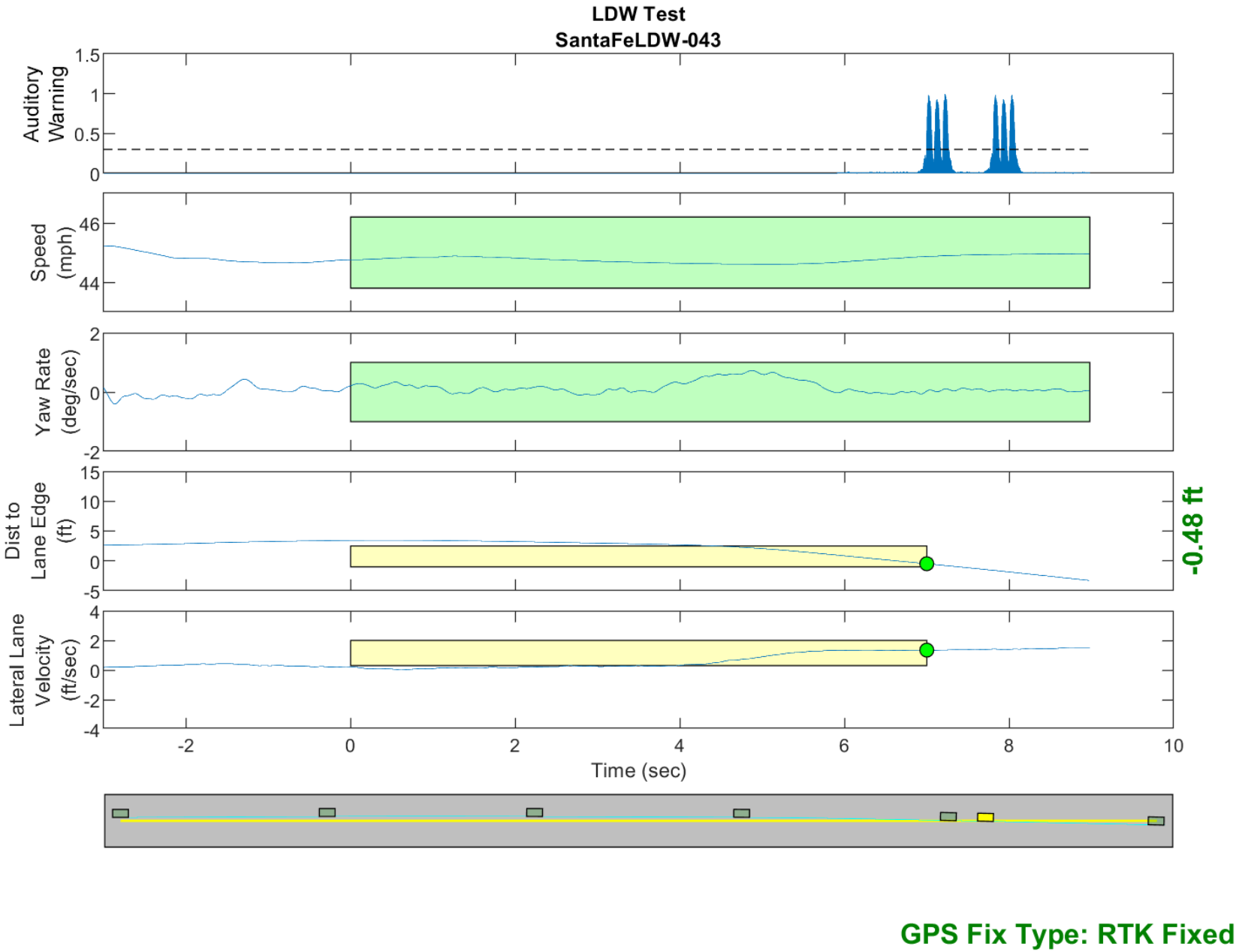


Figure D80. Time History for Run 43, Botts Dots, Right Departure, Auditory Warning

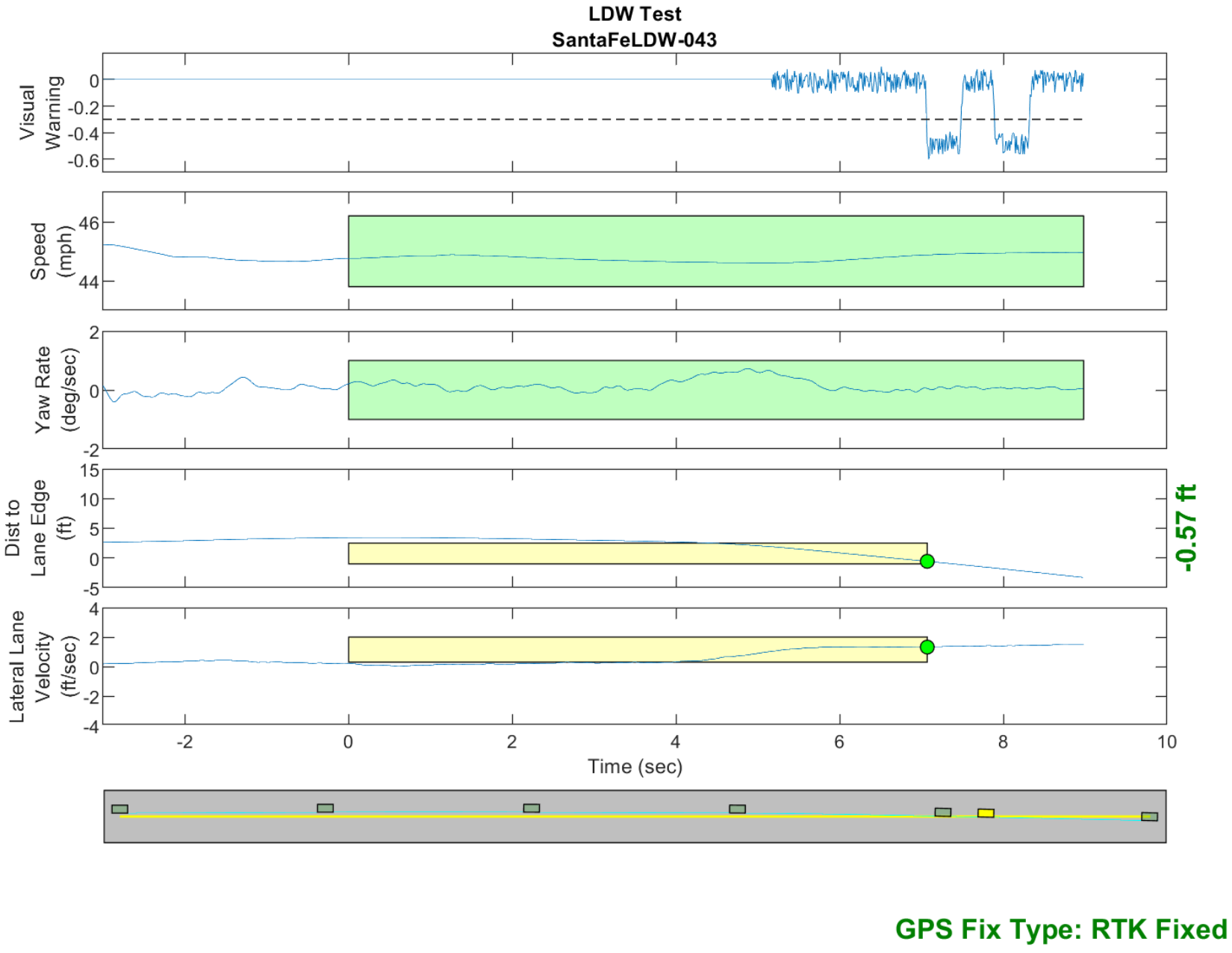


Figure D81. Time History for Run 43, Botts Dots, Right Departure, Visual Warning

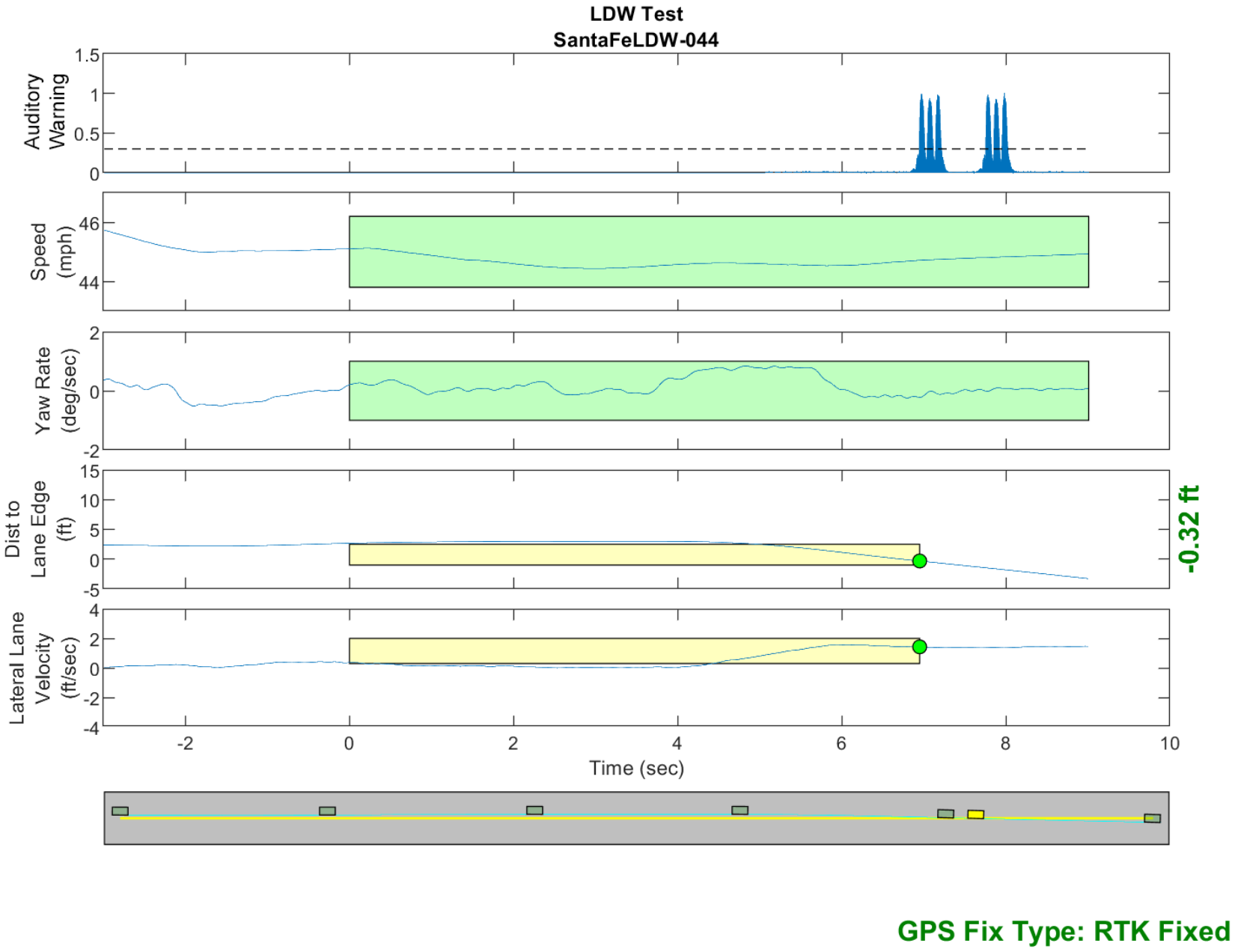


Figure D82. Time History for Run 44, Botts Dots, Right Departure, Auditory Warning

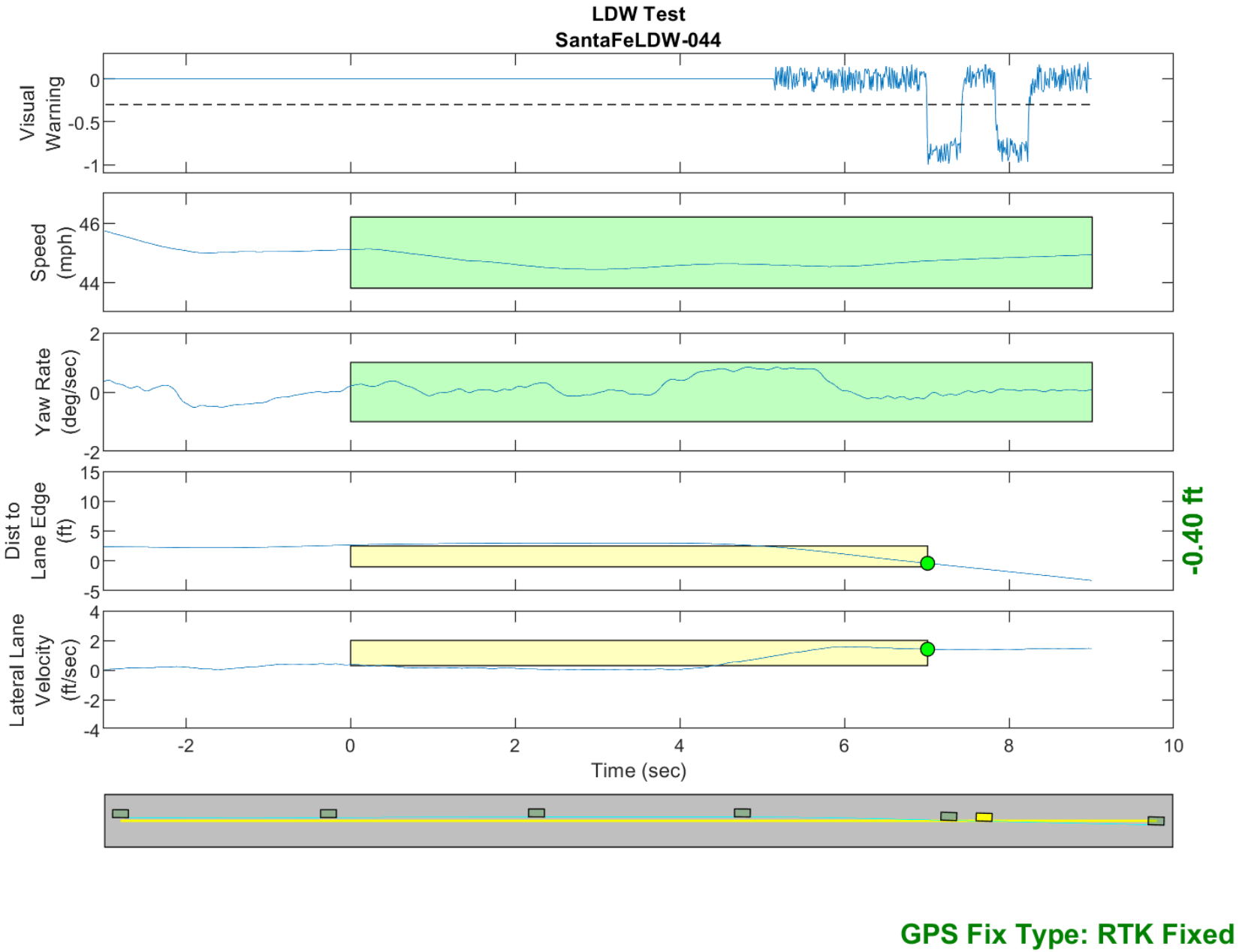


Figure D83. Time History for Run 44, Botts Dots, Right Departure, Visual Warning

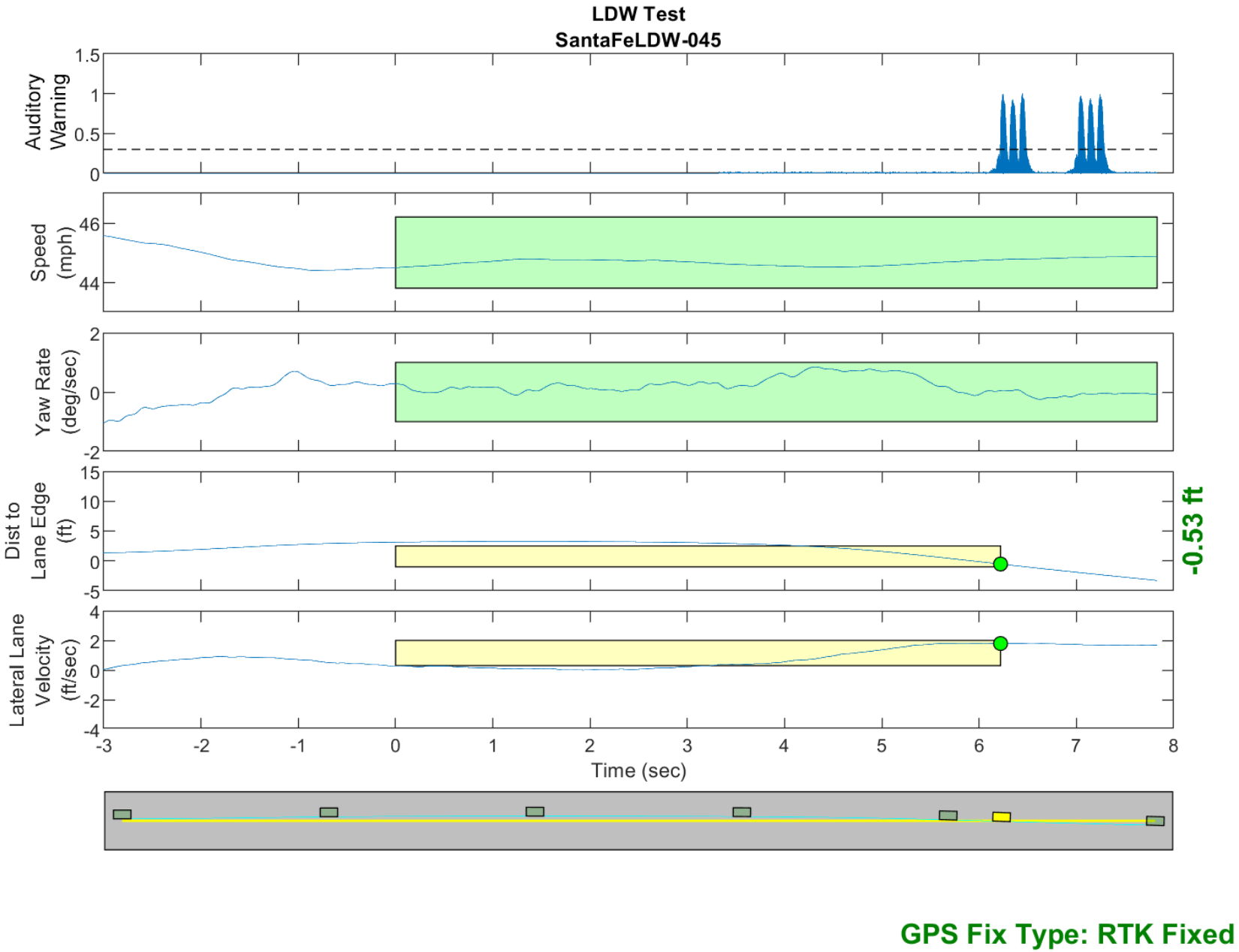


Figure D84. Time History for Run 45, Botts Dots, Right Departure, Auditory Warning

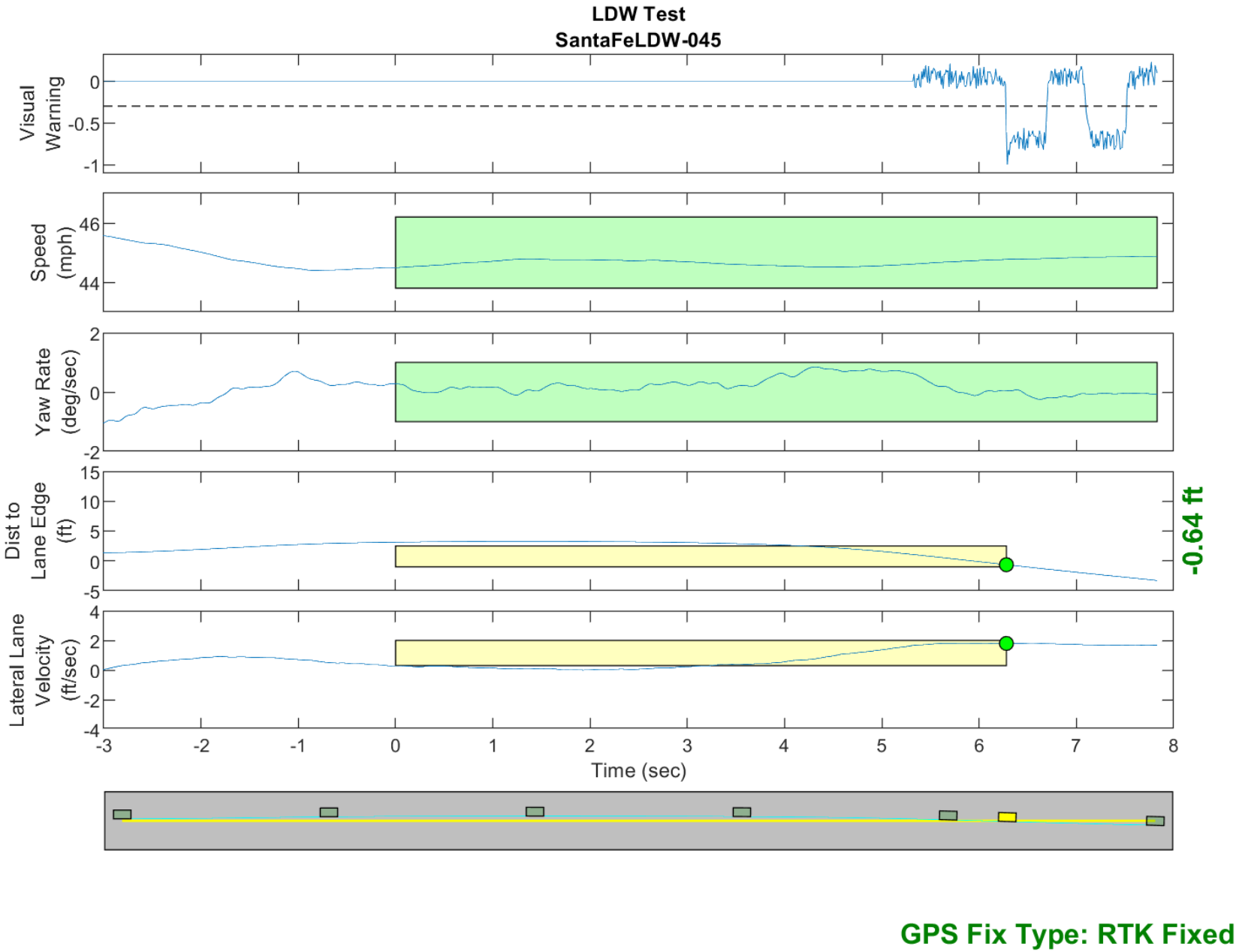


Figure D85. Time History for Run 45, Botts Dots, Right Departure, Visual Warning

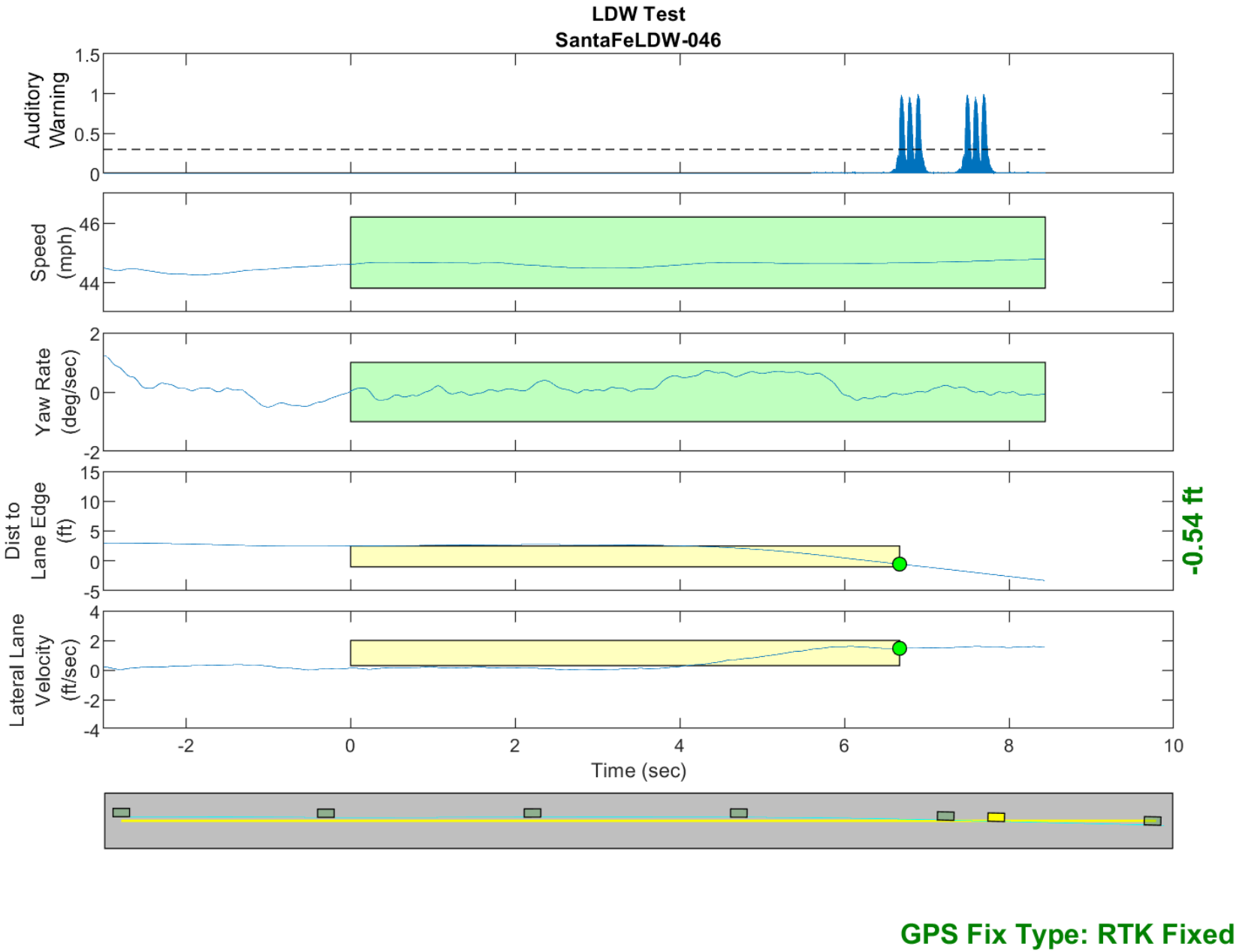


Figure D86. Time History for Run 46, Botts Dots, Right Departure, Auditory Warning

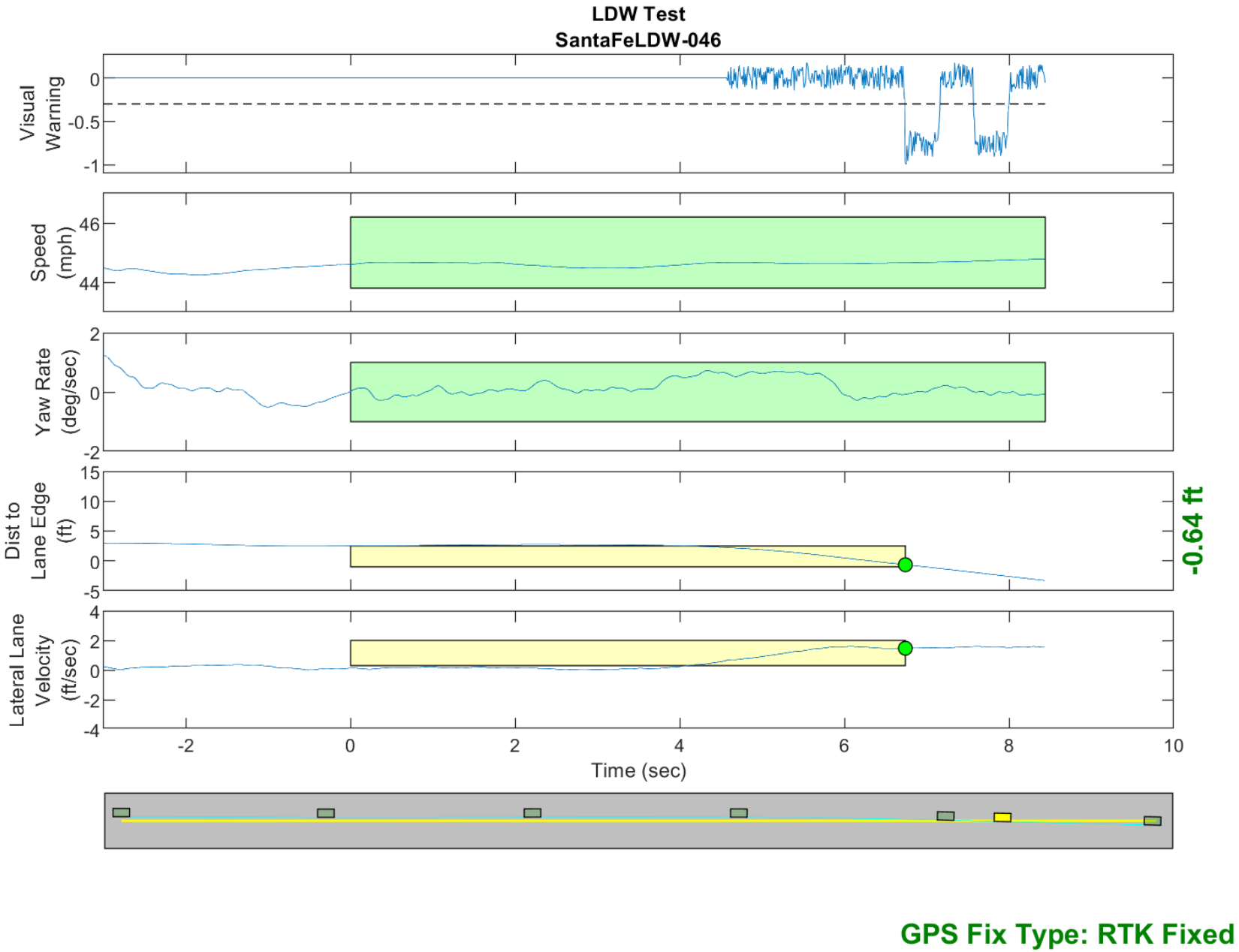


Figure D87. Time History for Run 46, Botts Dots, Right Departure, Visual Warning