NEW CAR ASSESSMENT PROGRAM
LANE DEPARTURE WARNING CONFIRMATION TEST
NCAP-DRI-LDW-22-09

2022 Nissan Sentra CVT

DYNAMIC RESEARCH, INC.
355 Van Ness Avenue, STE 200
Torrance, California 90501

29 April 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
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Prepared By: Stephen Rhim and Jonathan Robel

Senior Engineer Staff Engineer

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16. Abstract These tests were conducted on the subject 2022 Nissan Sentra CVT 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 Nissan Sentra CVT. 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 Nissan Sentra CVT

VIN: *3N1AB8CV5NY25xxxx*

Test start date: *4/8/2022*

Test end date: *4/11/2022*

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 Nissan Sentra CVT

TEST VEHICLE INFORMATION

VIN: *3N1AB8CV5NY25xxxx*

Body Style: *Sedan* Color: *Brilliant Silver*

Date Received: *3/25/2022* Odometer Reading: *6 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *NISSAN MOTOR CO., LTD.*

Date of manufacture: *02/22*

Vehicle Type: *Passenger Car*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *205/60R16*

Rear: *205/60R16*

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

Rear: *230 kPa (33 psi)*

TIRES

Tire manufacturer and model: *Hankook Kinergy GT*

Front tire size: *205/60R16 92H*

Rear tire size: *205/60R16 92H*

Front tire DOT prefix: *1BC9X 1B H0*

Rear tire DOT prefix: *1BC9X 1B H0*

LANE DEPARTURE WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2022 Nissan Sentra CVT

GENERAL INFORMATION

Test start date: *4/8/2022*

Test end date: *4/11/2022*

AMBIENT CONDITIONS

Air temperature: *29.4 C (85 F)*

Wind speed: *4.1 m/s (9.2 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: *230 kPa (33 psi)*

Rear: *230 kPa (33 psi)*

LANE DEPARTURE WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2022 Nissan Sentra CVT

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*469.9 kg (1036 lb)*	Right Front:	*437.7 kg (965 lb)*
Left Rear:	*297.1 kg (655 lb)*	Right Rear:	*298.0 kg (657 lb)*
		Total:	*1502.7 kg (3313 lb)*

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

(Page 1 of 3)

2022 Nissan Sentra CVT

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

Lane Departure Warning with Haptic Steering Wheel

Type and location of sensor(s) used:

The system uses a mono camera located in 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
	Buzzer or auditory alarm
X	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 haptic alert. The visual alert consists of a flashing yellow vehicle icon with lane lines. If the vehicle information display is set to the driver assistance display, a larger image of a vehicle with lane lines is shown. A yellow lane line will flash corresponding to the side that triggered the warning. The haptic alert is provided by a vibration in the steering wheel with an approximate frequency of 35 Hz.

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 buttons on the left side of the steering wheel. The procedure is as follows:

1. *Select the Left or Right button to reach the "Settings" menu in the vehicle information display.*
2. *Select the Up or Down button to reach the "Driver Assistance" menu and press "OK".*
3. *Select "Lane" and press "OK".*
4. *Select "Lane Departure Warning" and press "OK" 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.

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

(Page 3 of 3)

2022 Nissan Sentra CVT

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 page 5-32 to 5-33 shown in Appendix B page B-6 to B-7 for additional information.

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.

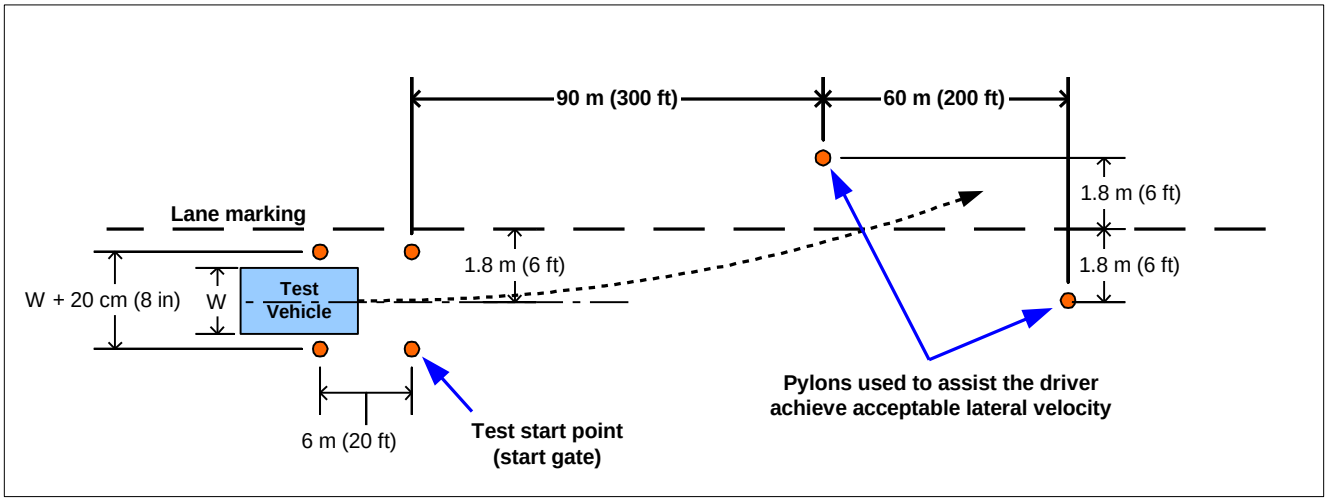

Figure 1. Position of Cones Used to Assist Driver

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.

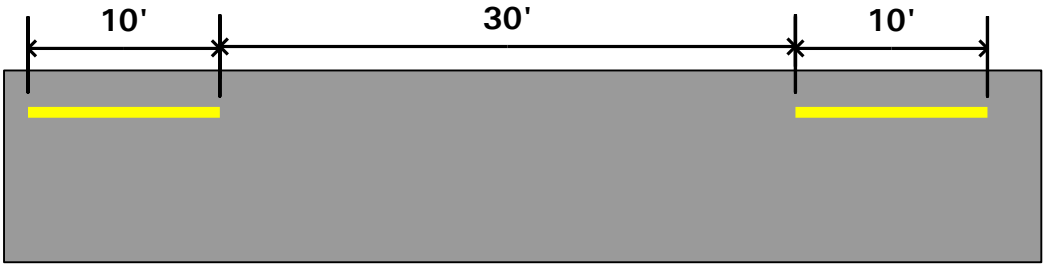

Figure 2. MUTCD Discontinuous Dashed Line Specifications

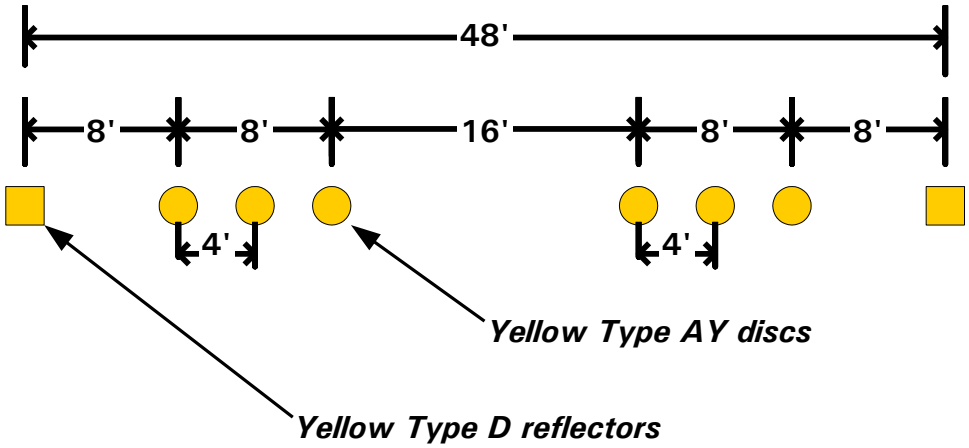

Figure 3. California Standard Plan A20A, Detail 4

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	5th	3 dB	60 dB	Identified Center Frequency ± 5%
Tactile	5th	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

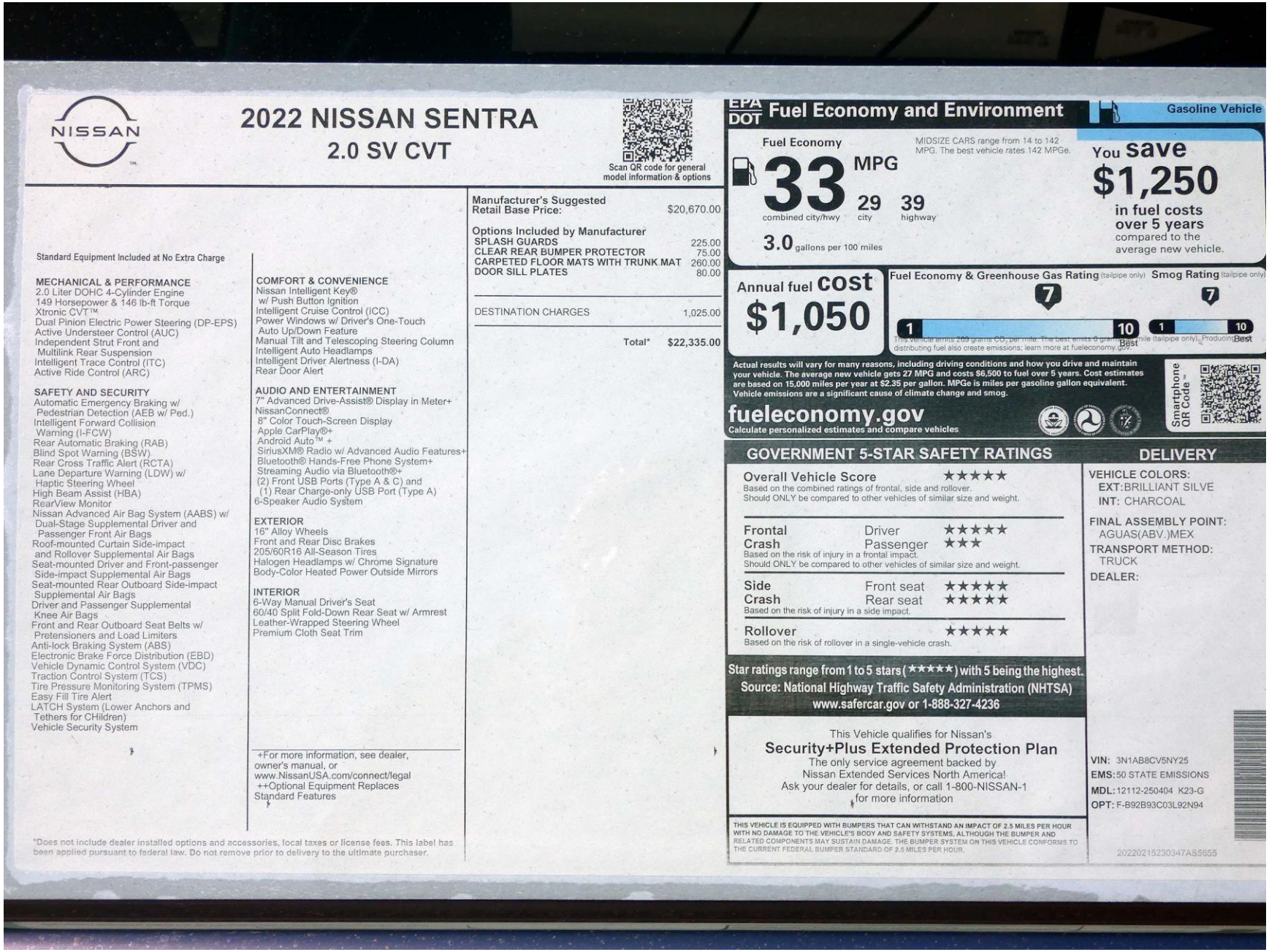


Figure A3. Window Sticker (Monroney Label)

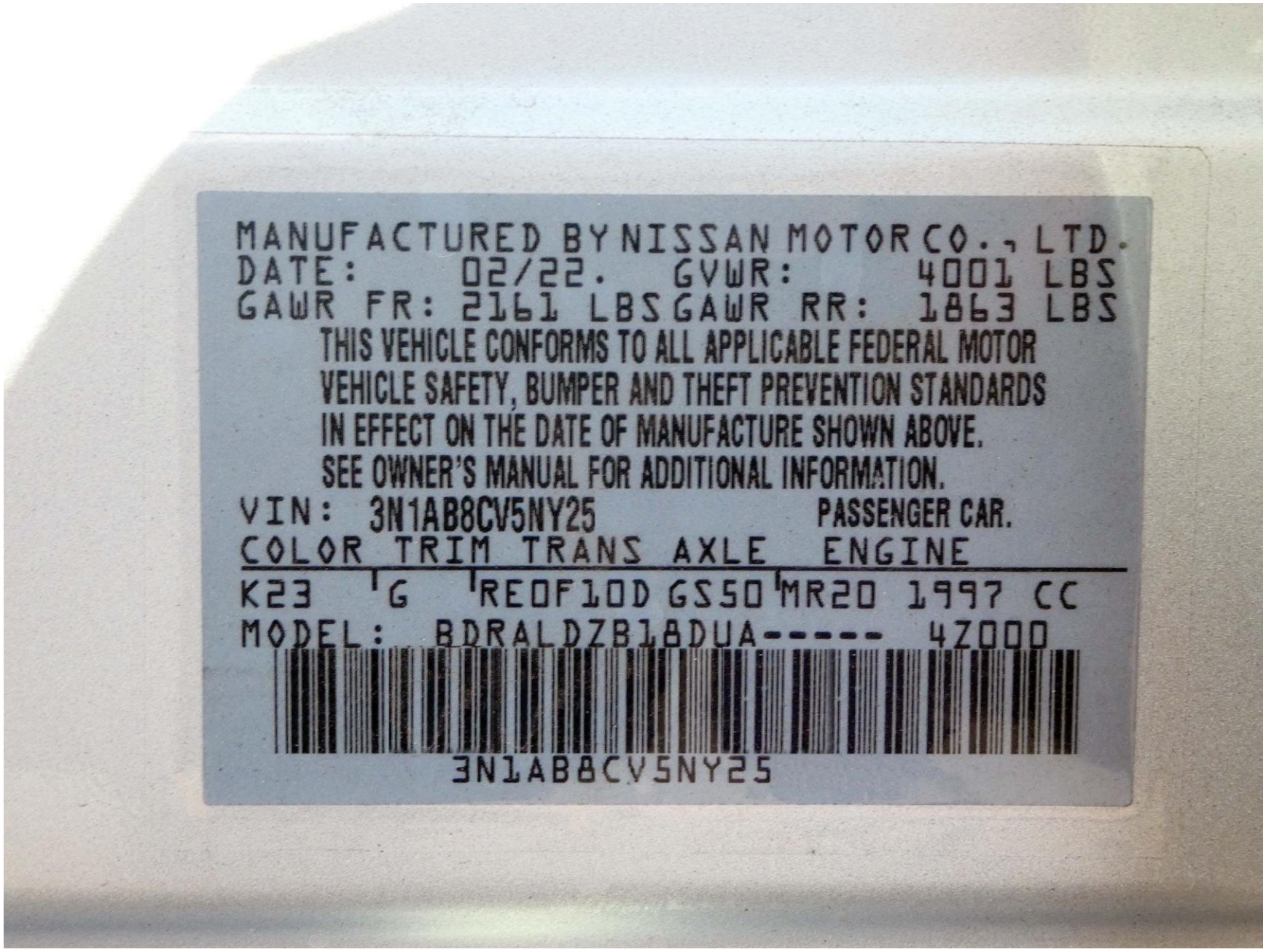


Figure A4. Vehicle Certification Label

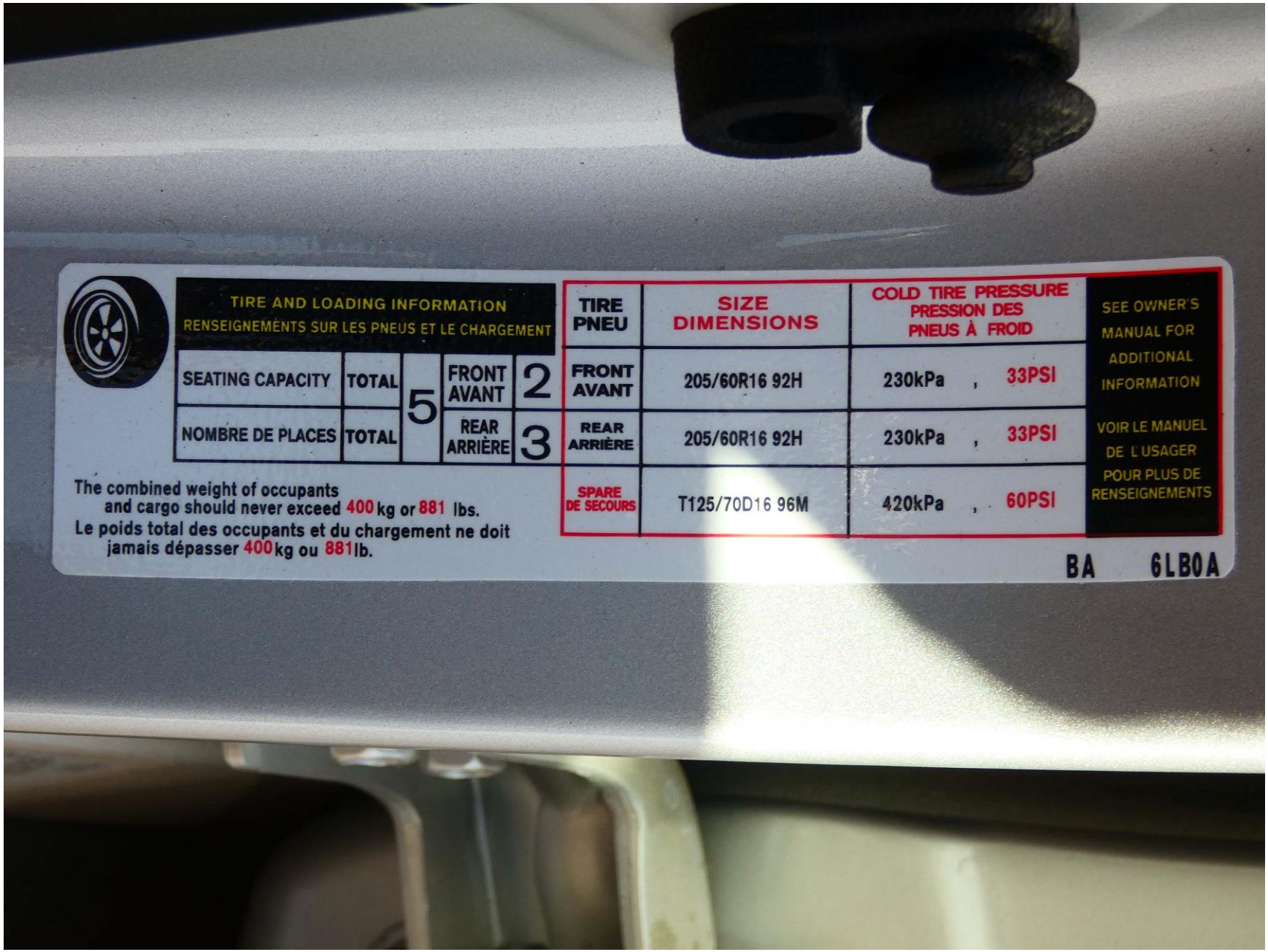


Figure A5. Tire Placard

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

Figure A7. Computer Installed in Subject Vehicle

Figure A8. Sensor for Detecting Haptic Alert

Figure A9. Sensor for Detecting Visual Alert

Figure A10. LDW System Control Buttons

Figure A11. LDW System Setup Menus

Figure A12. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

SYSTEM TEMPORARILY UNAVAILABLE

If the vehicle is parked in direct sunlight under high temperature conditions (over approximately 104°F [40°C]) and then started, the TSR system may be deactivated automatically. The "Unavailable: High Camera Temperature" warning message will appear in the vehicle information display.

Action to take:

When the interior temperature is reduced, the TSR system will resume operating automatically.

SYSTEM MALFUNCTION

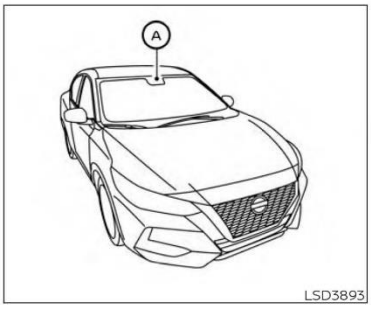
If the TSR system malfunctions, it will be turned off automatically and the system "Malfunction" warning message will appear in the vehicle information display.

Action to take:

If the TSR "Malfunction" message appears, pull off the road at a safe location and stop the vehicle. Turn the engine off and restart the engine. If the TSR "Malfunction" message continues to appear, have the system checked. It is recommended that you visit a NISSAN dealer for this service.

SYSTEM MAINTENANCE

The TSR system uses the same multi-sensing front camera unit that is used by the Lane Departure Warning (LDW) system, located in front of the interior rearview mirror. For additional information, see "System maintenance" (P. 5-34).



⚠WARNING

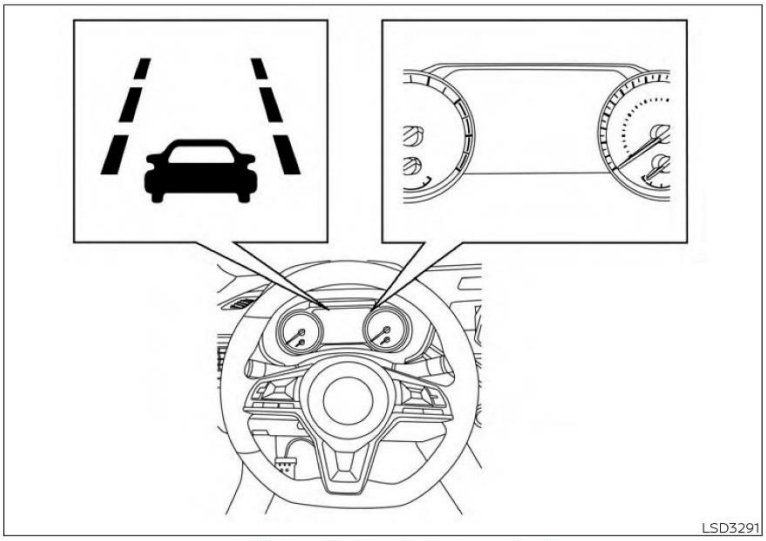
Failure to follow the warnings and instructions for proper use of the LDW system could result in serious injury or death.

- **This system is only a warning device to inform the driver of a potential unintended lane departure. It will not steer the vehicle or prevent loss of control. It is the driver's responsibility to stay alert, drive safely, keep the vehicle in the traveling lane, and be in control of the vehicle at all times.**

The LDW system will operate when the vehicle is driven at speeds of approximately 37 mph (60 km/h) and above, and only when the lane markings are clearly visible on the road.

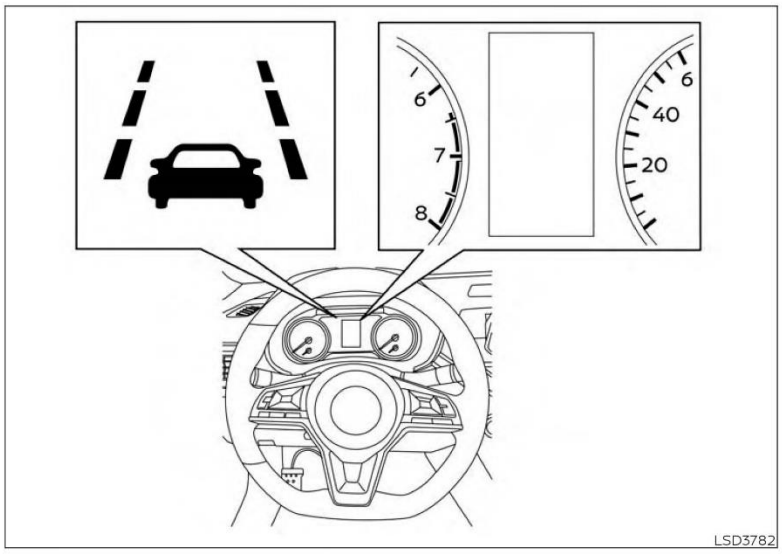
The LDW system monitors the lane markers on the traveling lane using the camera unit Ⓐ located above the inside mirror.

The LDW system warns the driver that the vehicle is beginning to leave the driving lane with an indicator and a steering wheel vibration. For additional information, see "LDW system operation" (P. 5-29).



For vehicles with the 7 inch meter display

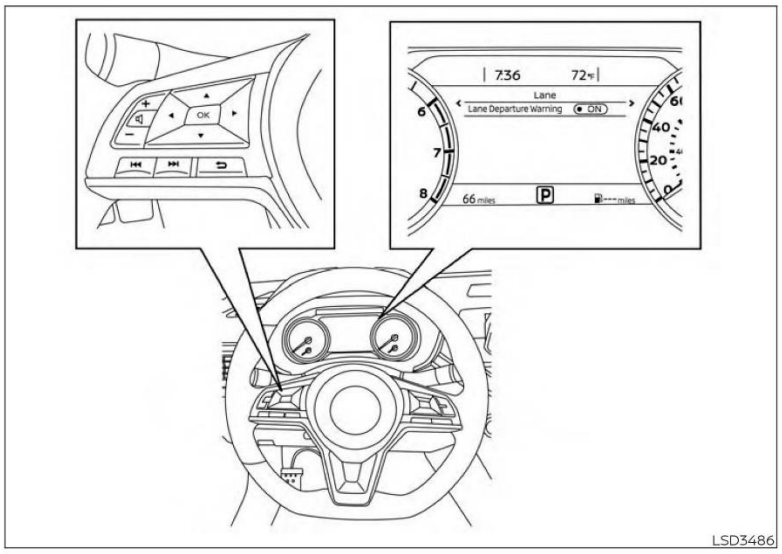
LDW SYSTEM OPERATION



For vehicles with the 4.2 inch meter display

The LDW system provides a lane departure warning function when the vehicle is driven at speeds of approximately 37 mph (60 km/h) and above and the lane markings are clear. When the vehicle approaches either the left or the right side of the traveling lane, the steering wheel will vibrate and the LDW indicator on the instrument panel will blink to alert the driver.

The warning function will stop when the vehicle returns inside of the lane markers.

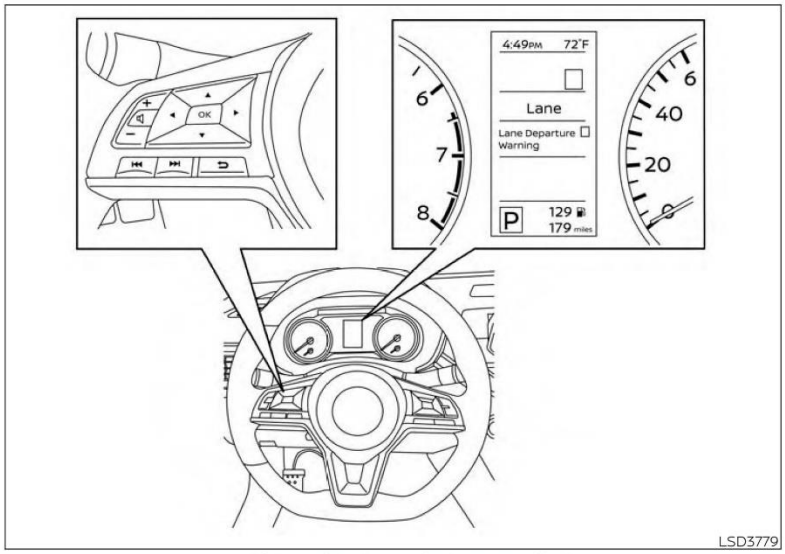


For vehicles with the 7 inch meter display

HOW TO ENABLE/DISABLE THE LDW SYSTEM

Perform the following steps to enable or disable the LDW system.

1. Press the ◀▶ button until "Settings" displays in the vehicle information display. Use the ▲▼ button to select "Driver Assistance." Then press the OK button.
2. Select "Lane" and press the OK button.
3. Select "Lane Departure Warning" and press the OK button to turn the system on or off.



For vehicles with the 4.2 inch meter display

LDW SYSTEM LIMITATIONS

⚠ WARNING

Listed below are the system limitations for the LDW system. Failure to follow the warnings and instructions for proper use of the LDW system could result in serious injury or death.

- **The system will not operate at speeds below approximately 37 mph (60 km/h) or if it cannot detect lane markers.**
- **Do not use the LDW system under the following conditions as it may not function properly:**
  - **During bad weather (rain, fog, snow, etc.).**
  - **When driving on slippery roads, such as on ice or snow.**
  - **When driving on winding or uneven roads.**
  - **When there is a lane closure due to road repairs.**
  - **When driving in a makeshift or temporary lane.**
  - **When driving on roads where the lane width is too narrow.**

- **When driving without normal tire conditions (for example, tire wear, low tire pressure, installation of spare tire, tire chains, nonstandard wheels).**
- **When the vehicle is equipped with non-original brake parts or suspension parts.**
- **When you are towing a trailer or other vehicle.**

· **The system may not function properly under the following conditions:**
- **On roads where there are multiple parallel lane markers; lane markers that are faded or not painted clearly; yellow painted lane markers; non-standard lane markers; or lane markers covered with water, dirt, snow, etc.**
- **On roads where the discontinued lane markers are still detectable.**
- **On roads where there are sharp curves.**
- **On roads where there are sharply contrasting objects, such as shadows, snow, water, wheel ruts, seams or lines remaining after road repairs. (The LDW system could detect these items as lane markers.)**
- **On roads where the traveling lane merges or separates.**
- **When the vehicle's traveling direction does not align with the lane marker.**
- **When traveling close to the vehicle in front of you, which obstructs the lane camera unit detection range.**
- **When rain, snow, dirt or an object adheres to the windshield in front of the lane camera unit.**
- **When the headlights are not bright due to dirt on the lens or if the aiming is not adjusted properly.**
- **When strong light enters the lane camera unit. (For example, the light directly shines on the front of the vehicle at sunrise or sunset.)**
- **When a sudden change in brightness occurs. (For example, when the vehicle enters or exits a tunnel or under a bridge.)**

SYSTEM TEMPORARILY UNAVAILABLE

If the vehicle is parked in direct sunlight under high temperature conditions (over approximately 104°F [40°C]) and then started, the LDW system may be deactivated automatically and the following message will appear in the vehicle information display: "Unavailable: High Cabin Temperature."

When the interior temperature is reduced, the LDW system will resume operating automatically.

The LDW system is not designed to warn under the following conditions:

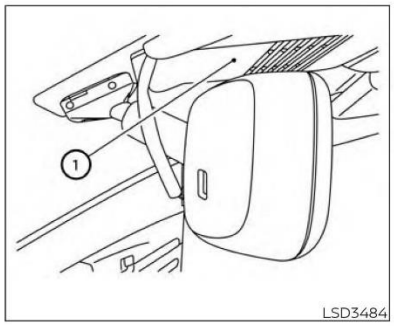
· When you operate the lane change signal and change traveling lanes in the direction of the signal. (The LDW system will become operable again approximately 2 seconds after the lane change signal is turned off.)

· When the vehicle speed lowers to less than approximately 37 mph (60 km/h).

After the above conditions have finished and the necessary operating conditions are satisfied, the LDW functions will resume.

SYSTEM MALFUNCTION

If the LDW system malfunctions, it will cancel automatically and "Not Available System Malfunction" will appear in the vehicle information display. If "Not Available System Malfunction" appears in the vehicle information display, pull off the road to a safe location and stop the vehicle. Place the shift lever in the P (Park) position and the ignition switch in the OFF position and restart the engine/motor. If "Not Available System Malfunction" continues to appear in the vehicle information display, have the system checked. It is recommended that you visit a NISSAN dealer for this service.



SYSTEM MAINTENANCE

The lane camera unit ① for the LDW system is located above the inside mirror. To keep the proper operation of the LDW system and prevent a system malfunction, be sure to observe the following:

- Always keep the windshield clean.
- Do not attach a sticker (including transparent material) or install an accessory near the camera unit.
- Do not place reflective materials, such as white paper or a mirror, on the instrument panel. The reflection of sunlight may adversely affect the camera unit's capability of detecting the lane markers.
- Do not strike or damage the areas around the camera unit. Do not touch the camera lens or remove the screw located on the camera unit. If the camera unit is damaged due to an accident, it is recommended that you visit a NISSAN dealer.

APPENDIX C

Run Log

Subject Vehicle: **2022 Nissan Sentra CVT**

Test start date: **4/8/2022**

Test end date: **4/11/2022**

Driver: **Jonathan Robel**

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

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Visual Alert (ft)	Distance at Haptic Alert (ft)	Pass/Fail	Notes
1	**Solid**	**Left**	Y	0.02	0.11	Pass	
2			Y	0.04	0.04	Pass	
3			Y	0.32	0.18	Pass	
4			Y	0.28	0.18	Pass	
5			Y	0.34	0.22	Pass	
6			Y	0.12	0.15	Pass	
7			N				Bad haptic signal
8			Y	0.13	0.17	Pass	
9	**Solid**	**Right**	Y	0.33	0.24	Pass	
10			Y	0.24	0.35	Pass	
11			Y	0.42	0.20	Pass	
12			Y	0.35	0.29	Pass	
13			Y	0.34	0.14	Pass	
14			Y	0.29	0.24	Pass	
15			Y	0.29	0.07	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Visual Alert (ft)	Distance at Haptic Alert (ft)	Pass/Fail	Notes
16	**Dashed**	**Right**	Y	0.51	0.33	Pass	
17			Y	0.40	0.27	Pass	
18			Y	0.35	0.38	Pass	
19			Y	0.48	0.28	Pass	
20			Y	0.44	0.33	Pass	
21			Y	0.55	0.46	Pass	
22			Y	0.32	0.24	Pass	
23	**Dashed**	**Left**	Y	0.18	0.05	Pass	
24			Y	0.10	0.05	Pass	
25			Y	0.16	0.05	Pass	
26			Y	0.29	0.18	Pass	
27			Y	0.12	-0.06	Pass	
28			Y	0.27	0.07	Pass	
29			Y	0.04	0.12	Pass	
30	**Botts Dots**	**Left**	Y	0.39	0.28	Pass	
31			Y	0.24	0.14	Pass	
32			Y	0.27	0.15	Pass	
33			Y	0.42	0.24	Pass	
34			Y	0.35	0.21	Pass	
35			Y	0.31	0.22	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Visual Alert (ft)	Distance at Haptic Alert (ft)	Pass/Fail	Notes
36			Y	0.29	0.20	Pass	
37	**Botts Dots**	**Right**	Y	0.37	0.33	Pass	
38			Y	0.47	0.30	Pass	
39			Y	0.29	0.30	Pass	
40			Y	0.33	0.39	Pass	
41			Y	0.38	0.21	Pass	
42			Y	0.53	0.42	Pass	
43			Y	0.38	0.28	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.

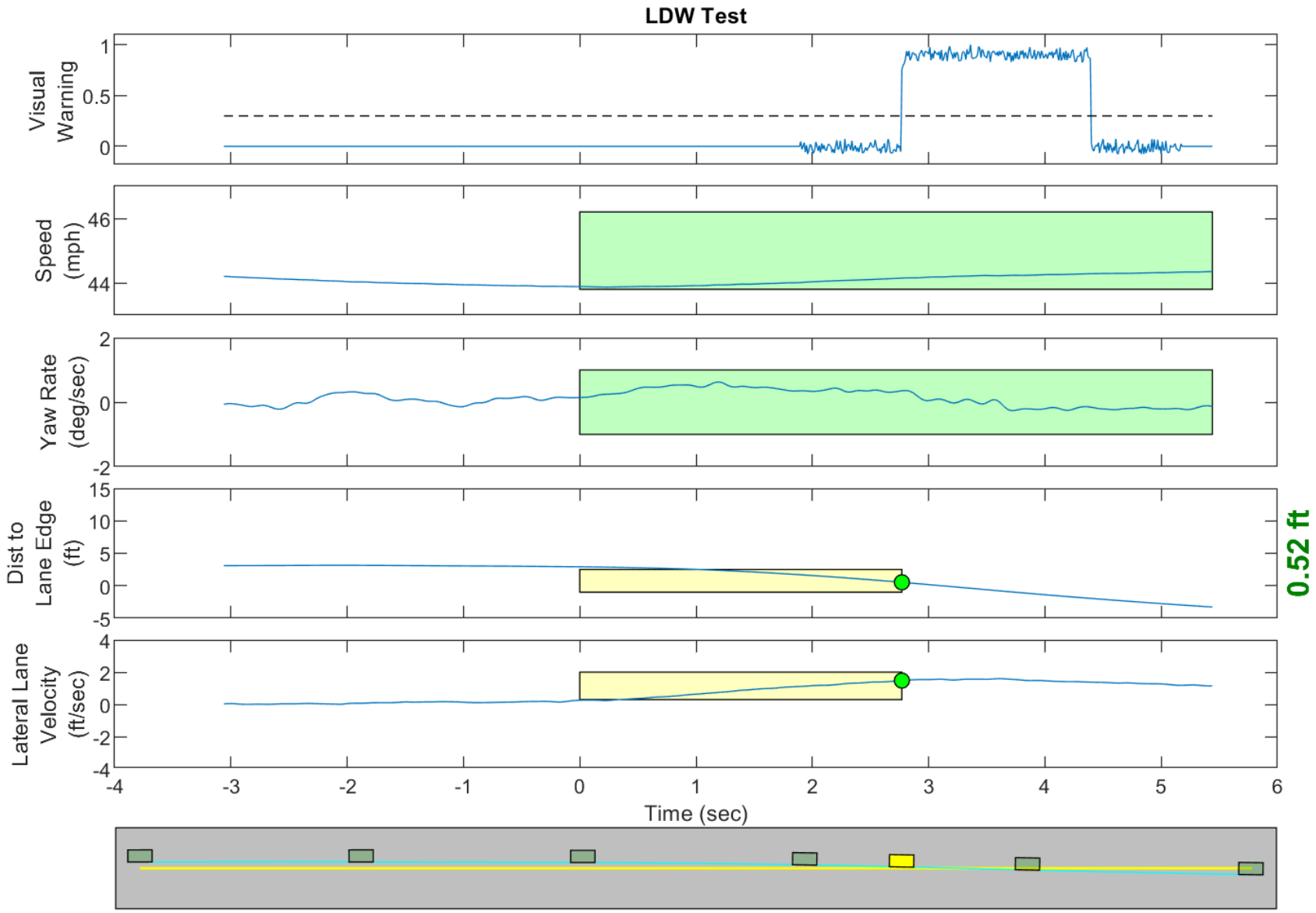

Figure D1. Example Time History for Lane Departure Warning Test, Passing

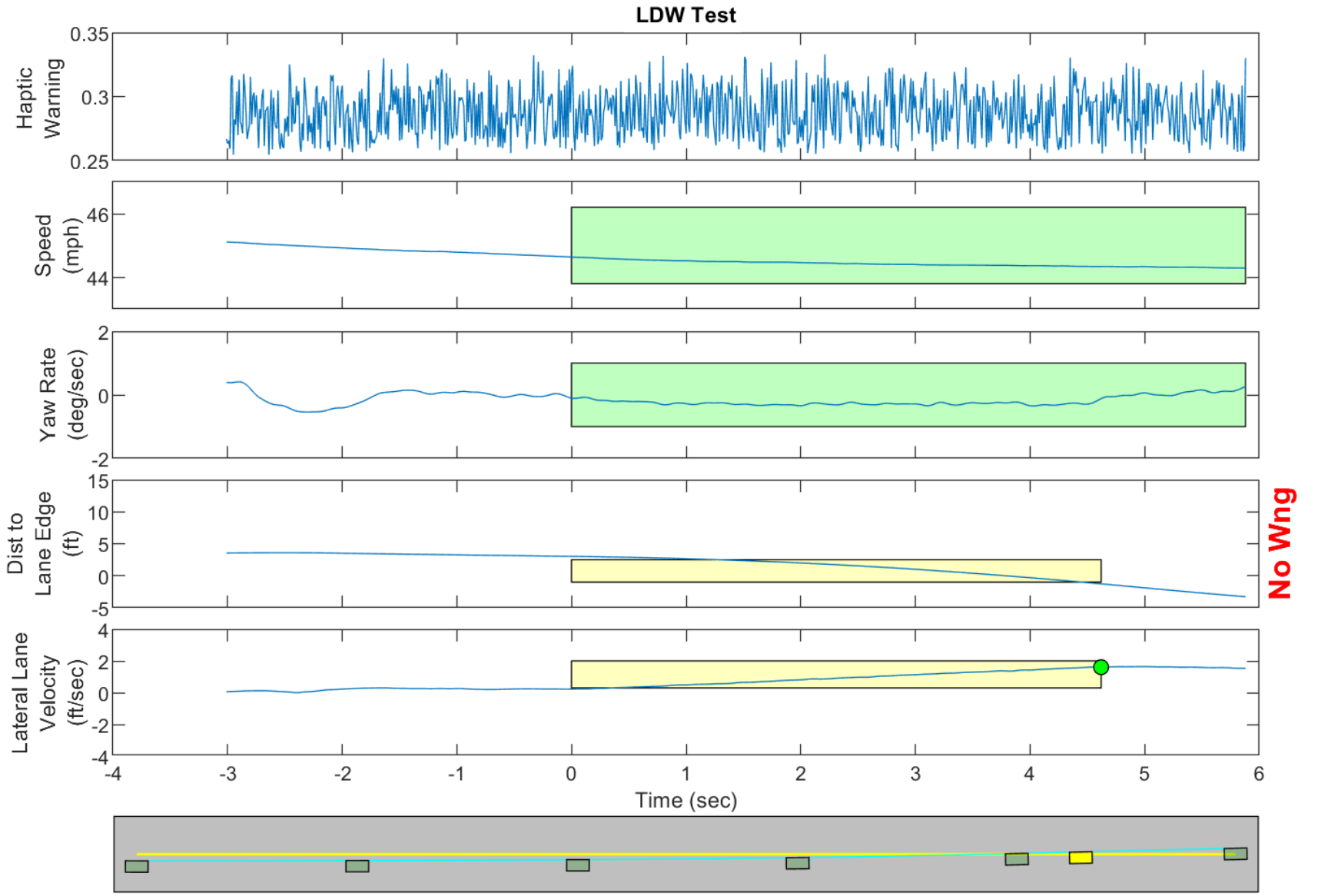

Figure D2. Example Time History for Lane Departure Warning Test, Failing, No Warning Issued

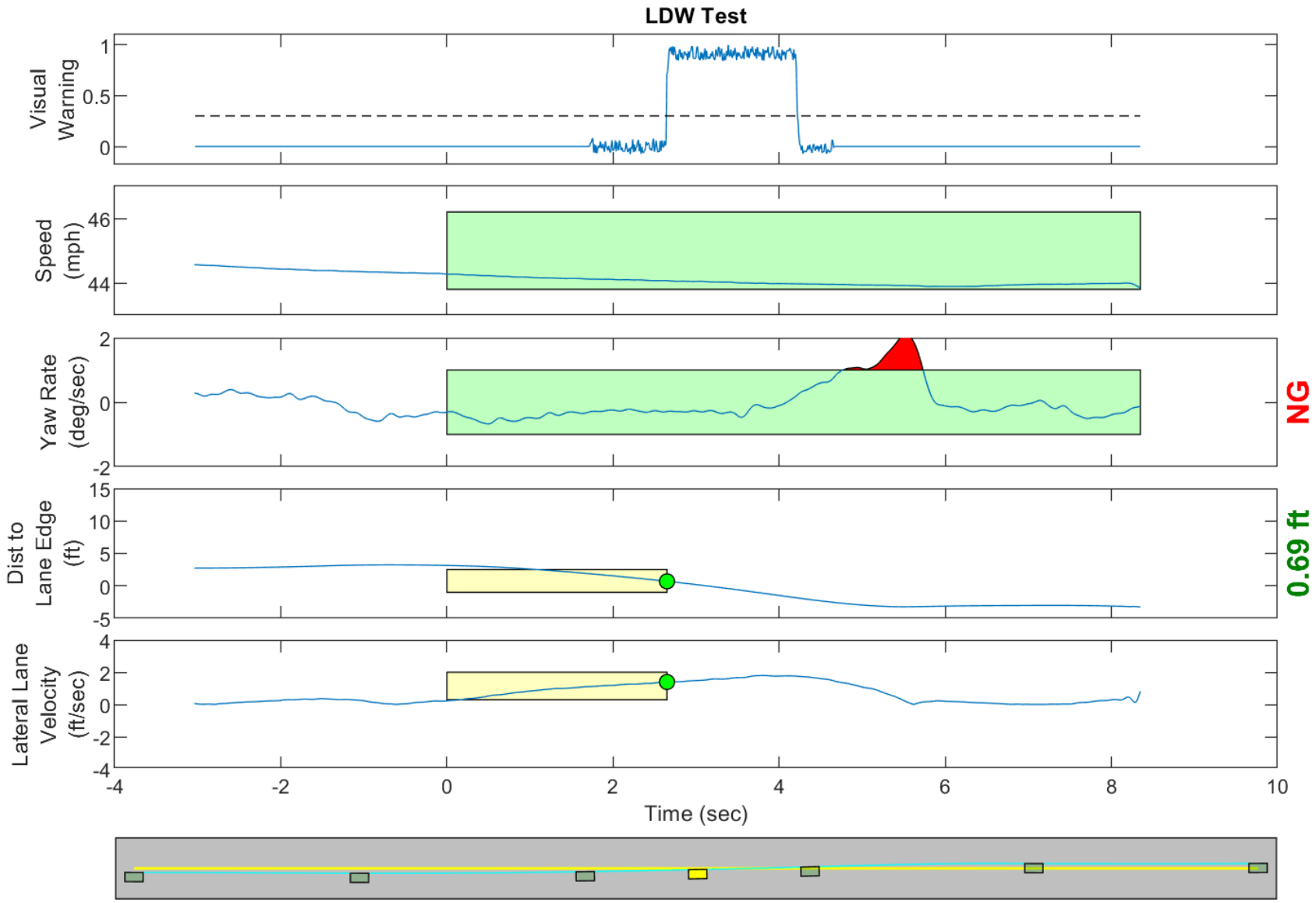

Figure D3. Example Time History for Lane Departure Warning Test, Invalid Run Due to Subject Vehicle Yaw Rate

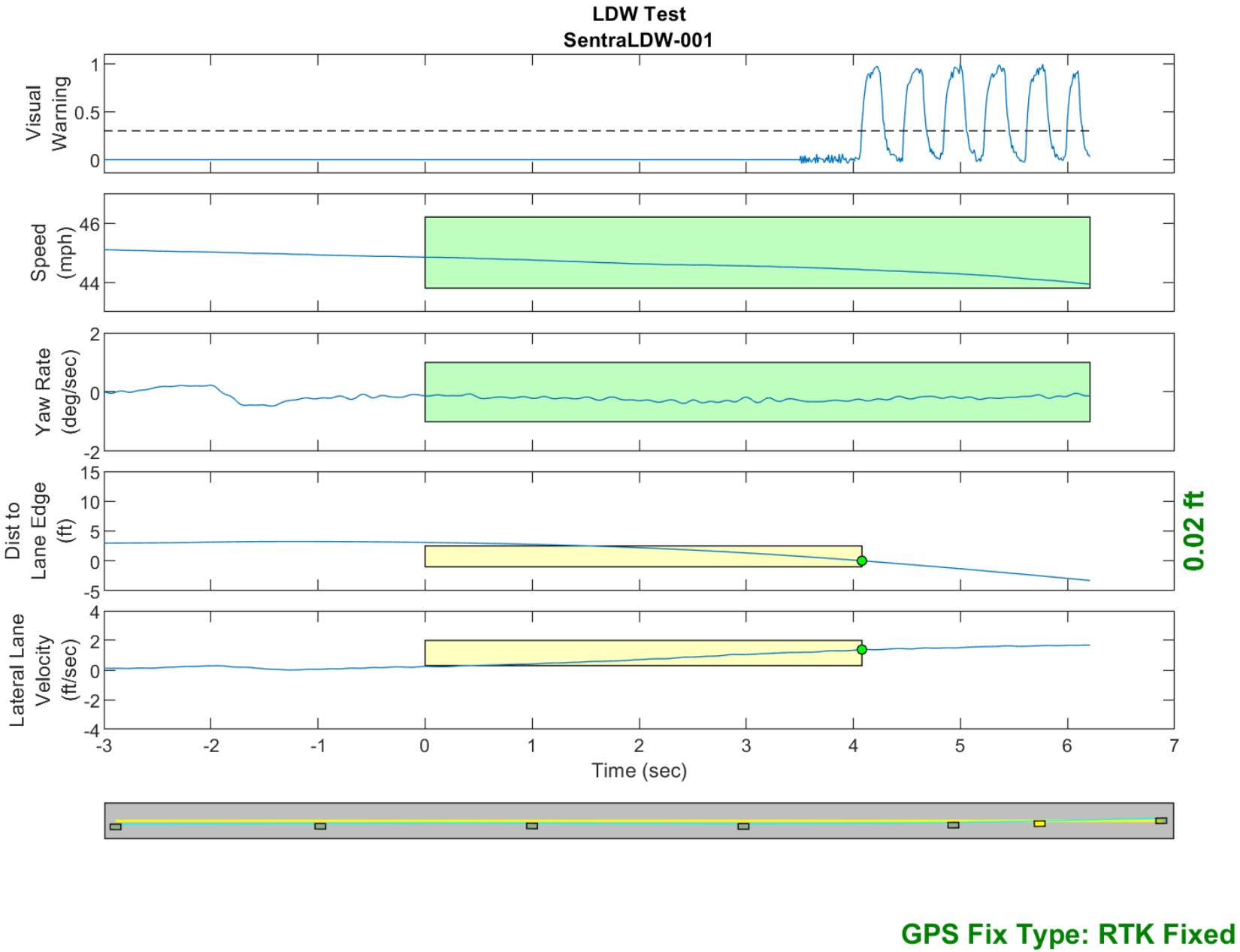

Figure D4. Time History for Run 01, Solid Line, Left Departure, Visual Warning

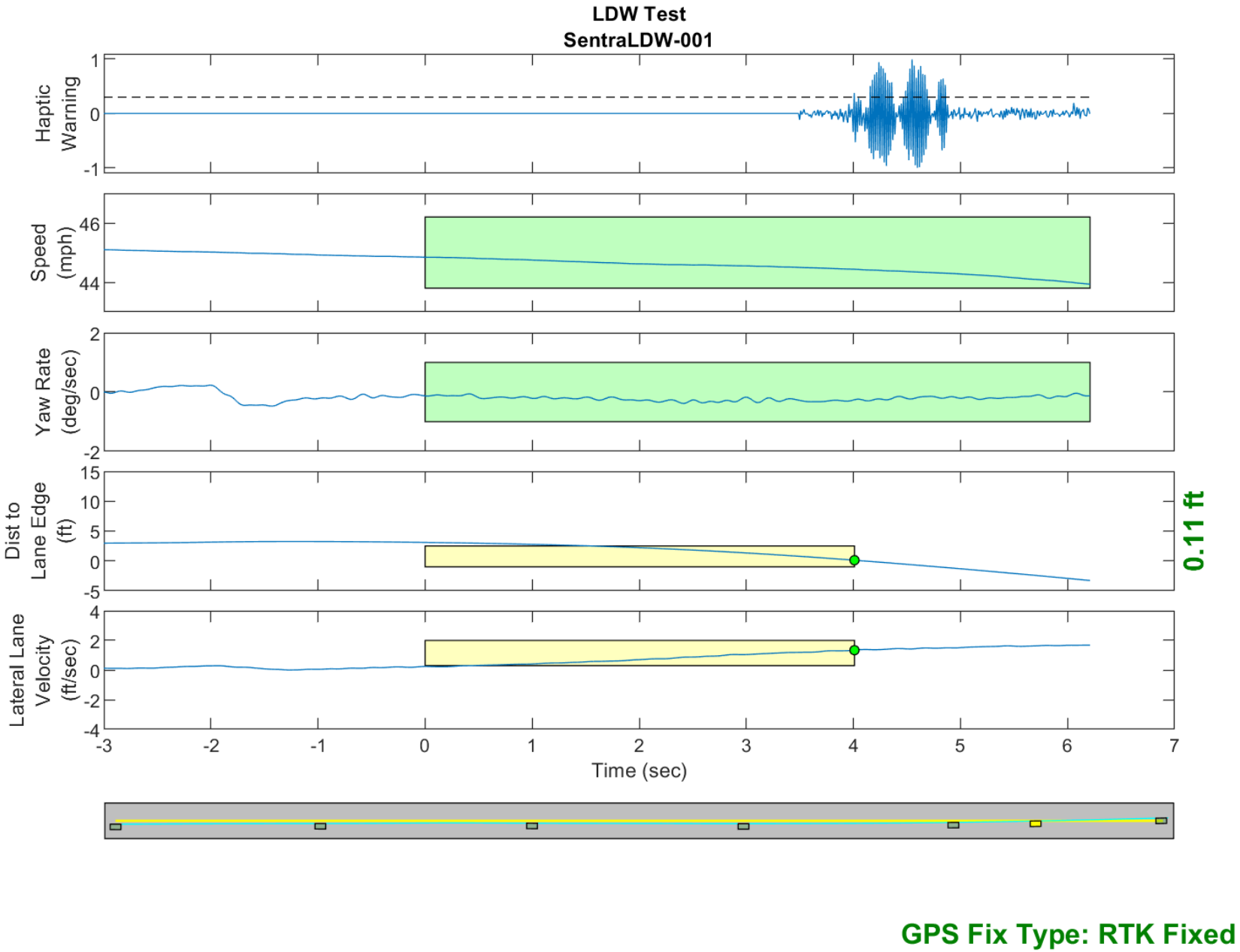

Figure D5. Time History for Run 01, Solid Line, Left Departure, Haptic Warning

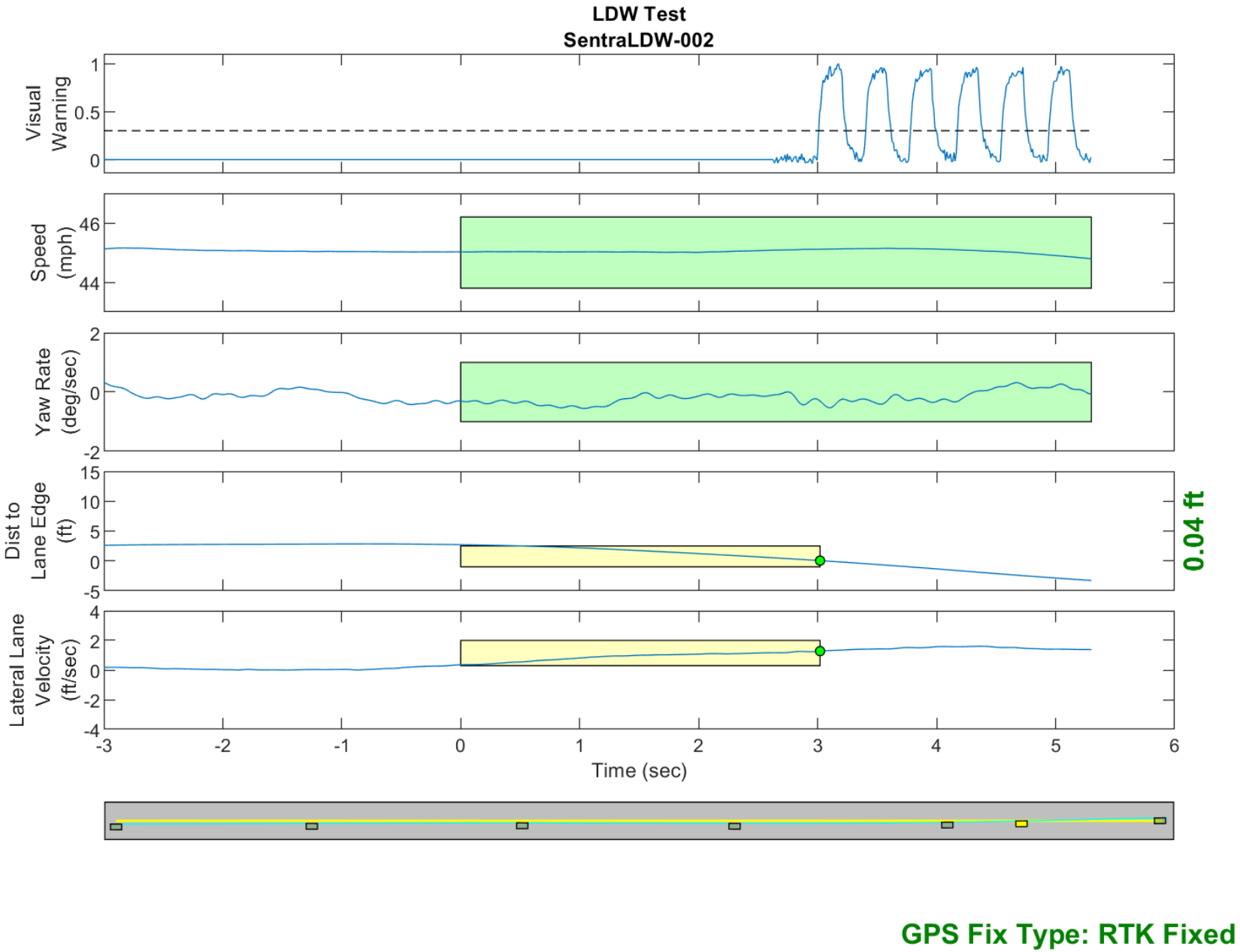

Figure D6. Time History for Run 02, Solid Line, Left Departure, Visual Warning

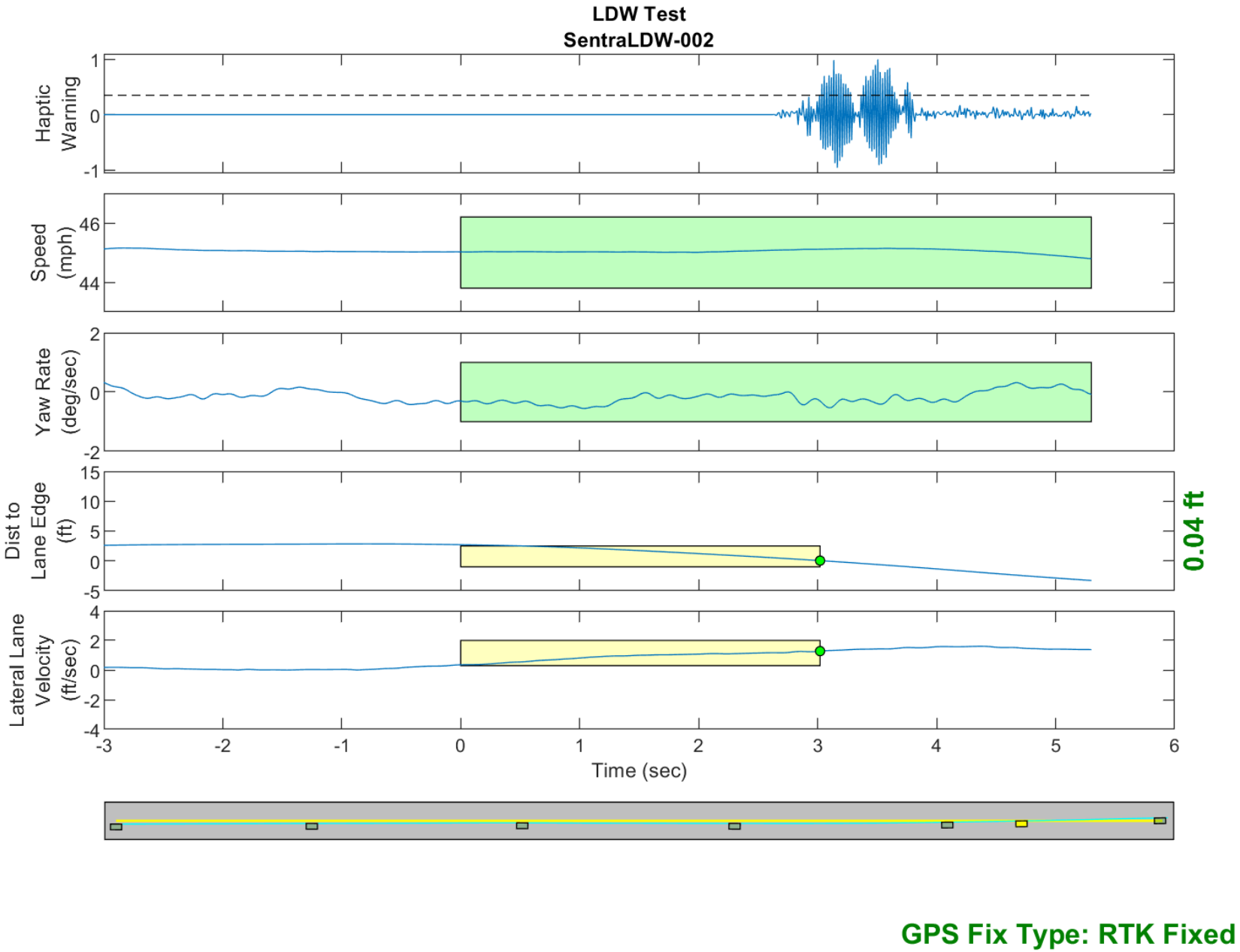

Figure D7. Time History for Run 02, Solid Line, Left Departure, Haptic Warning

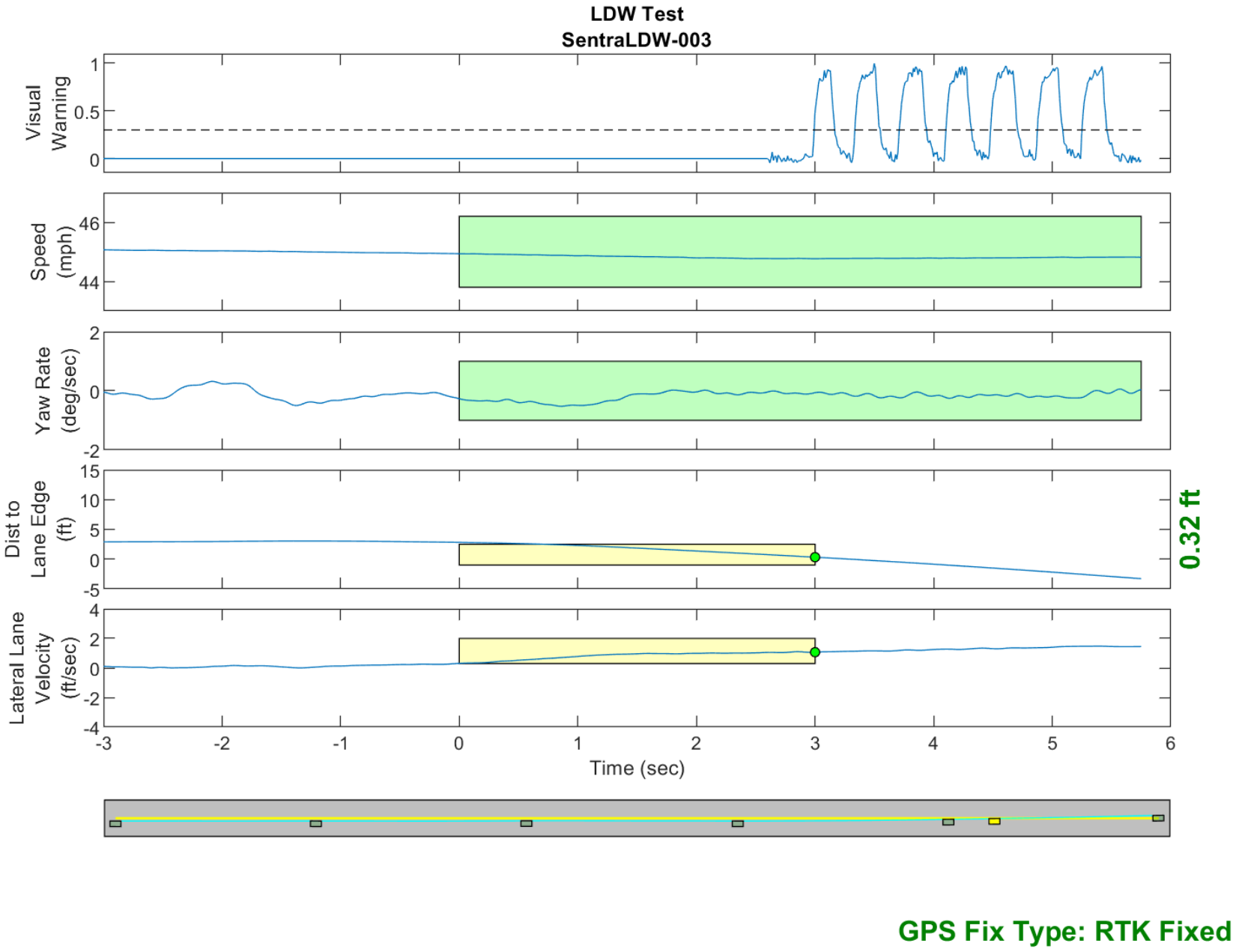

Figure D8. Time History for Run 03, Solid Line, Left Departure, Visual Warning

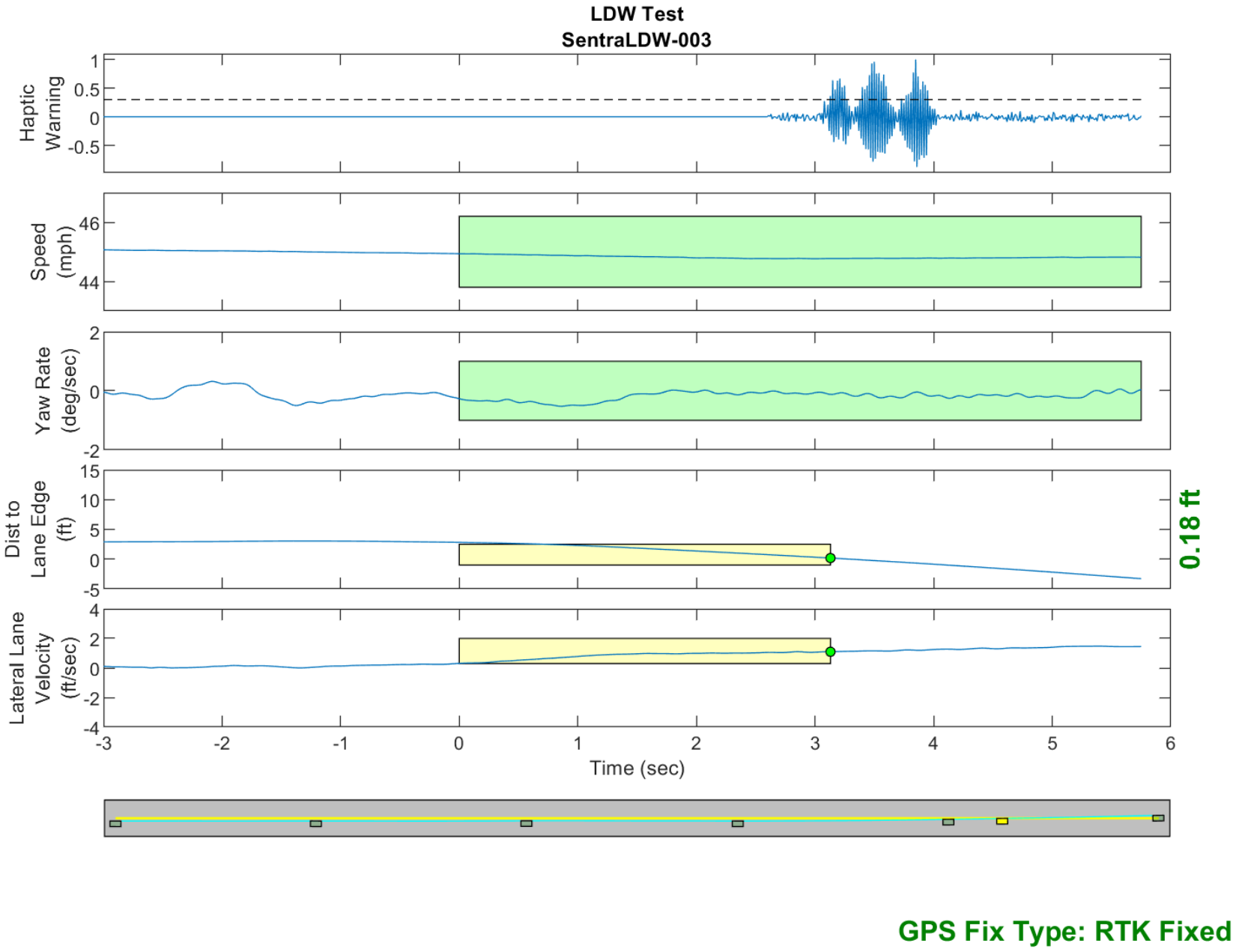

Figure D9. Time History for Run 03, Solid Line, Left Departure, Haptic Warning

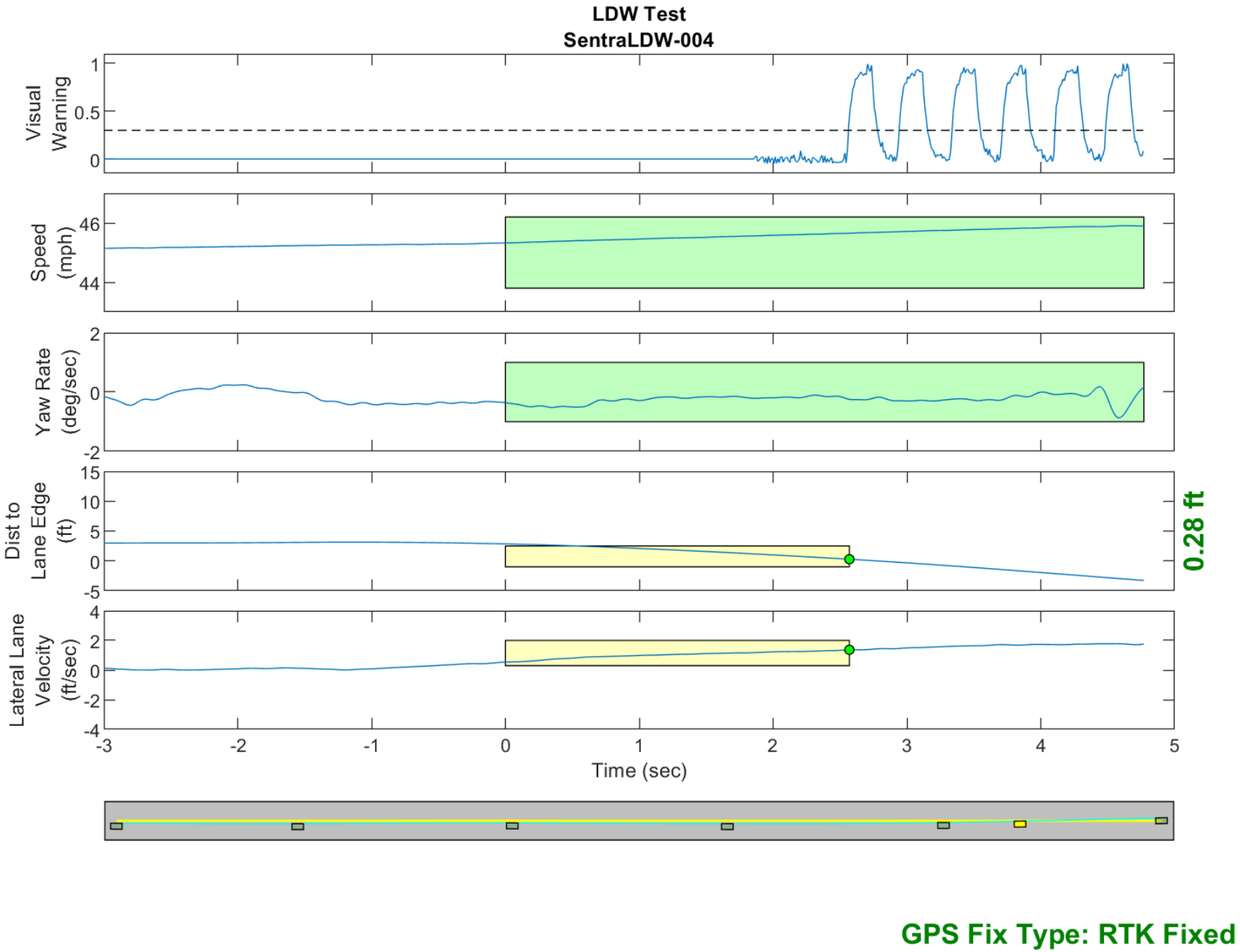

Figure D10. Time History for Run 04, Solid Line, Left Departure, Visual Warning

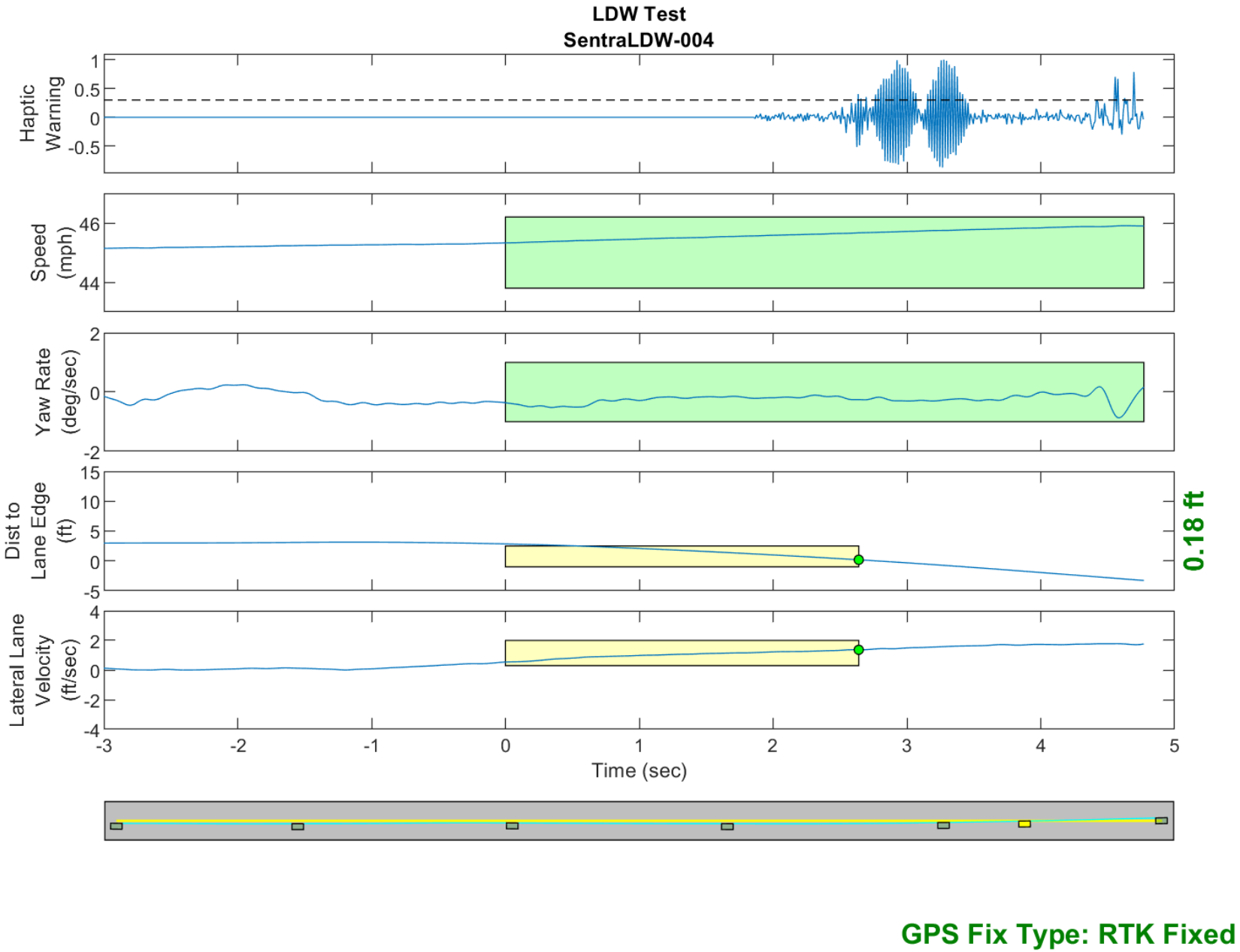

Figure D11. Time History for Run 04, Solid Line, Left Departure, Haptic Warning

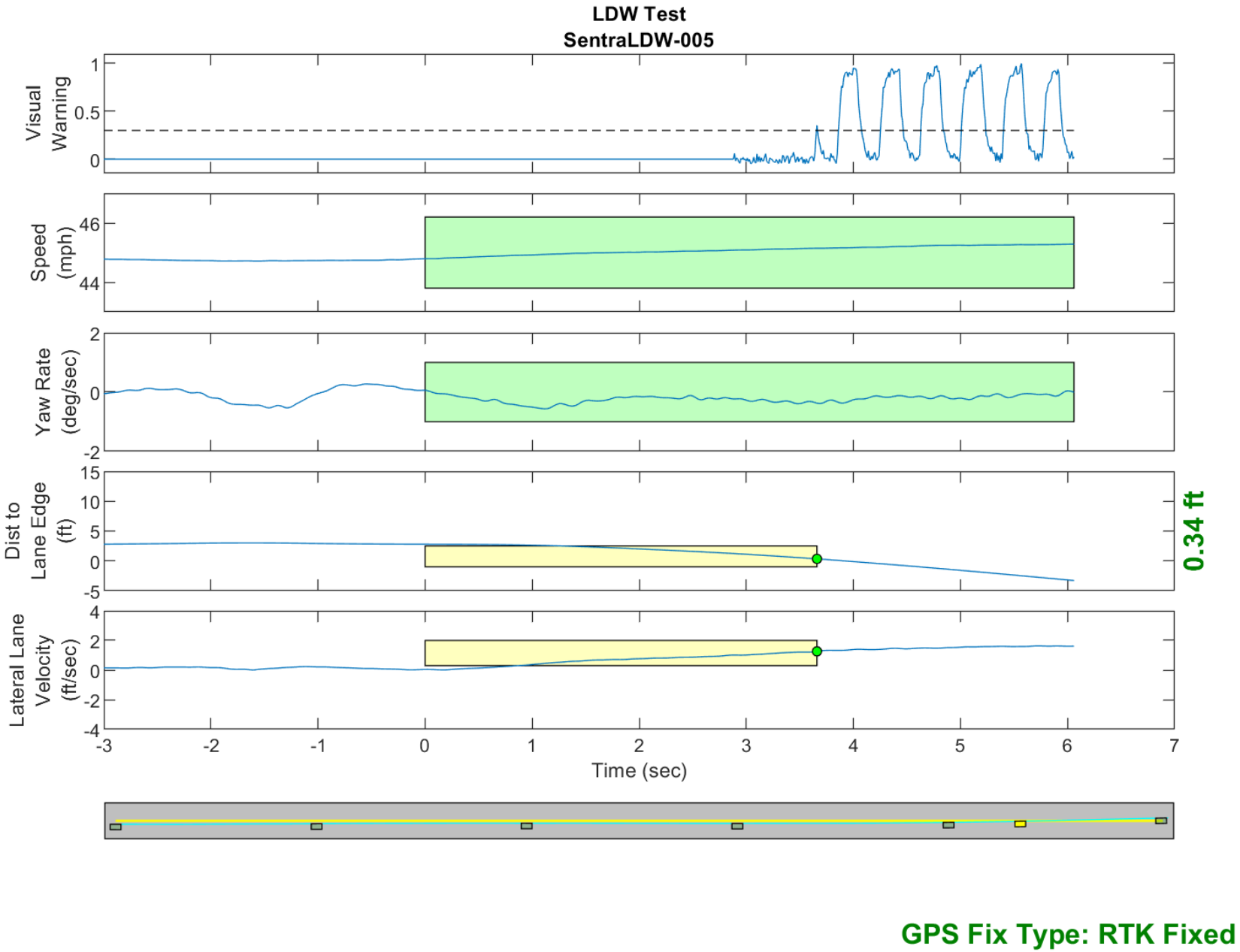

Figure D12. Time History for Run 05, Solid Line, Left Departure, Visual Warning

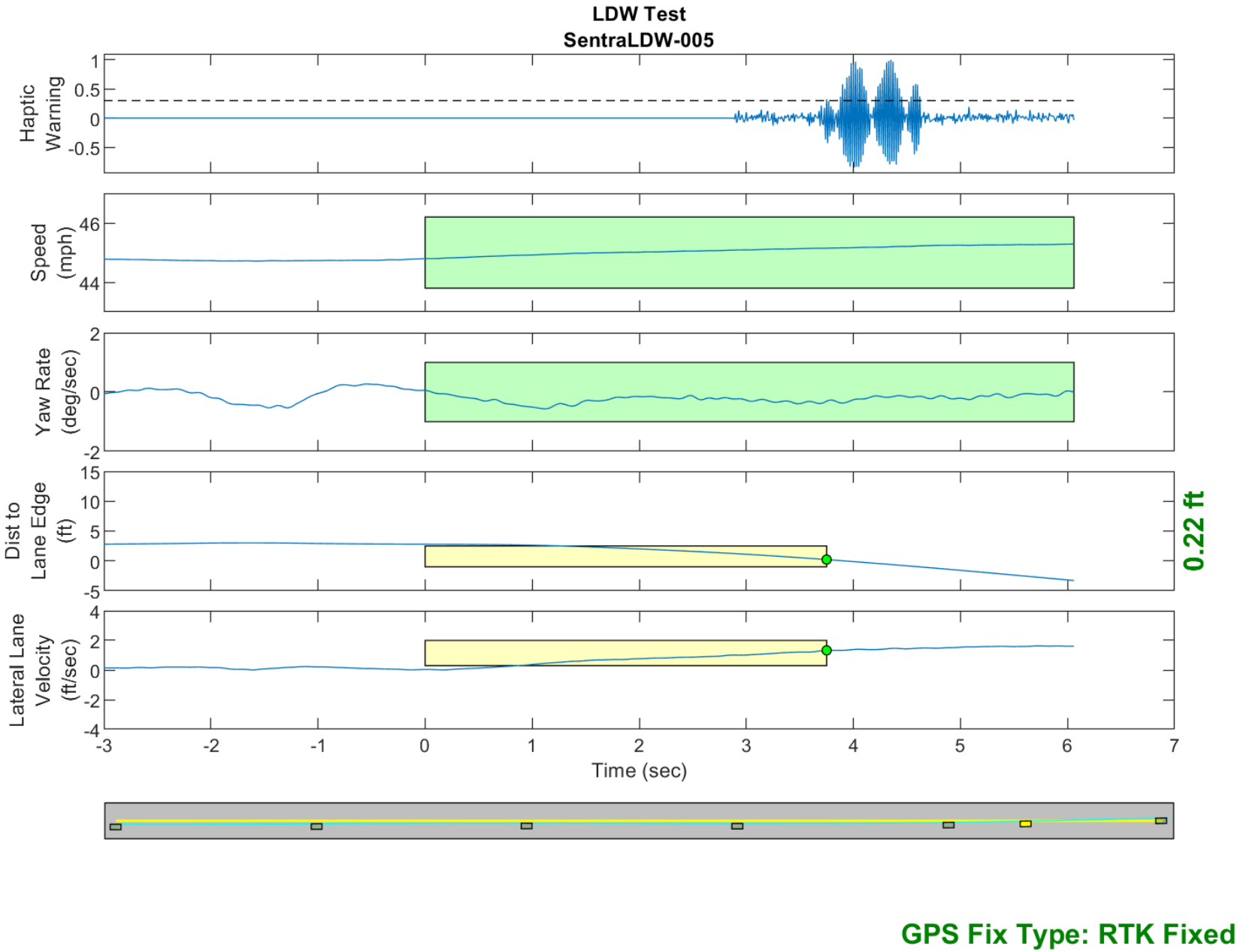

Figure D13. Time History for Run 05, Solid Line, Left Departure, Haptic Warning

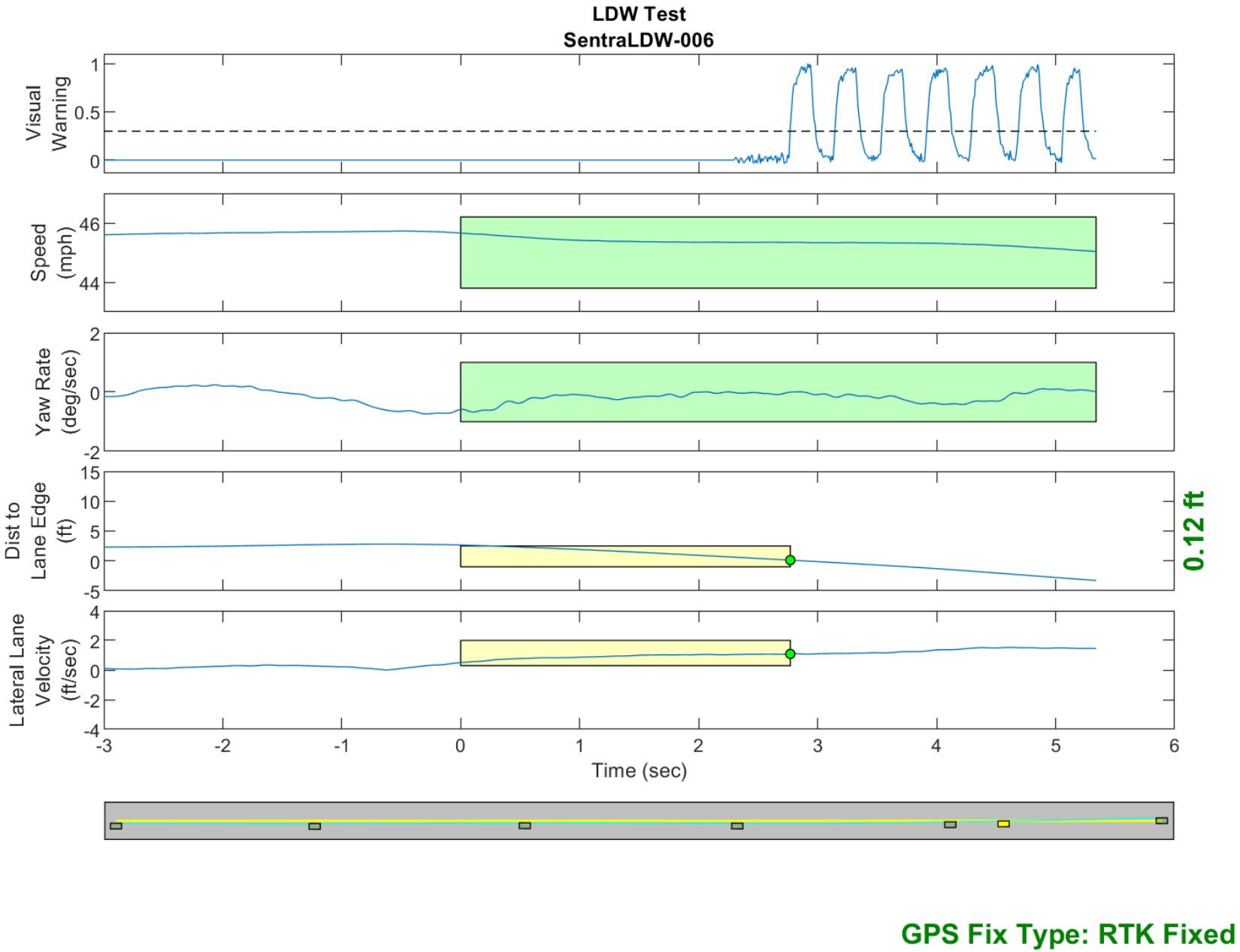

Figure D14. Time History for Run 06, Solid Line, Left Departure, Visual Warning

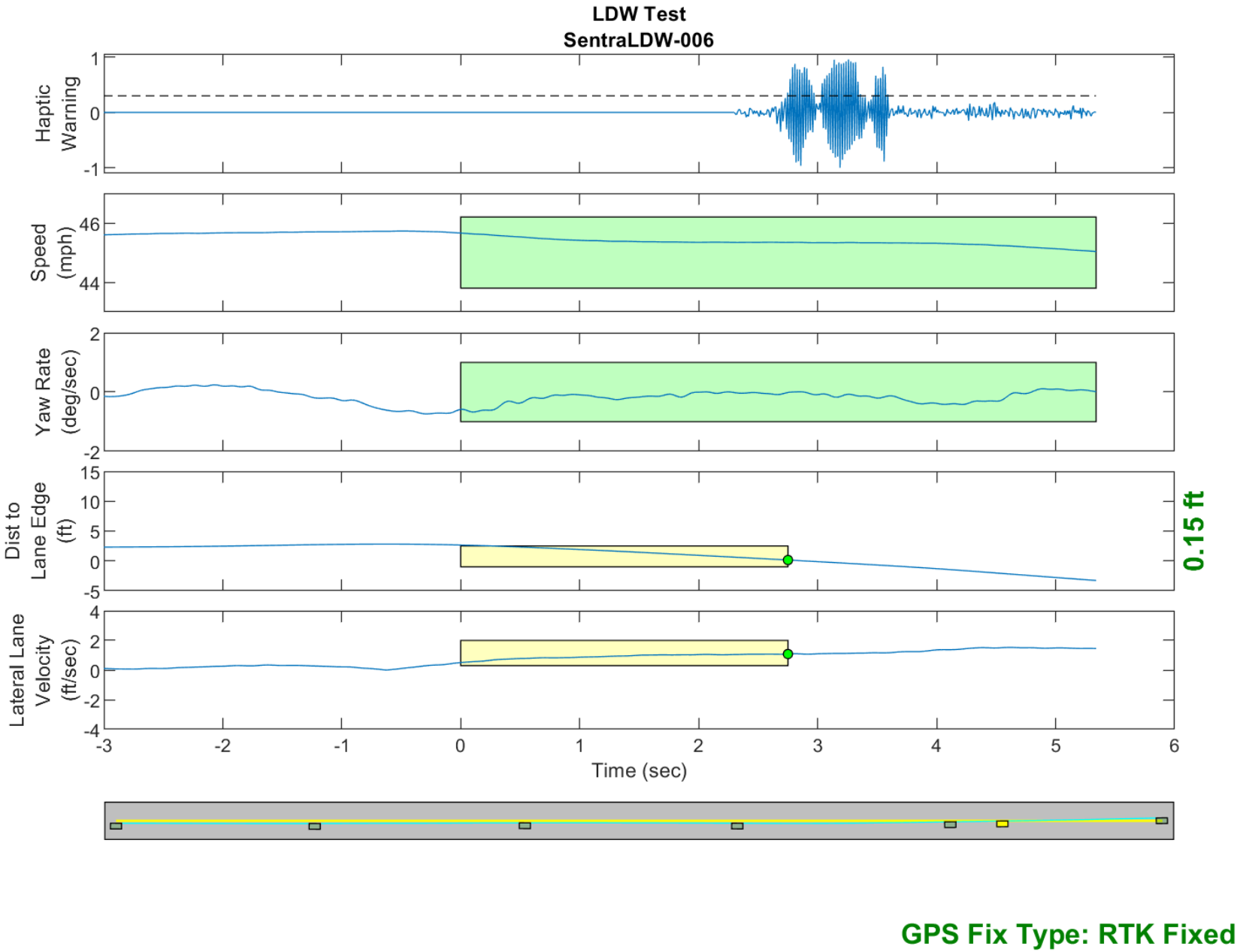

Figure D15. Time History for Run 06, Solid Line, Left Departure, Haptic Warning

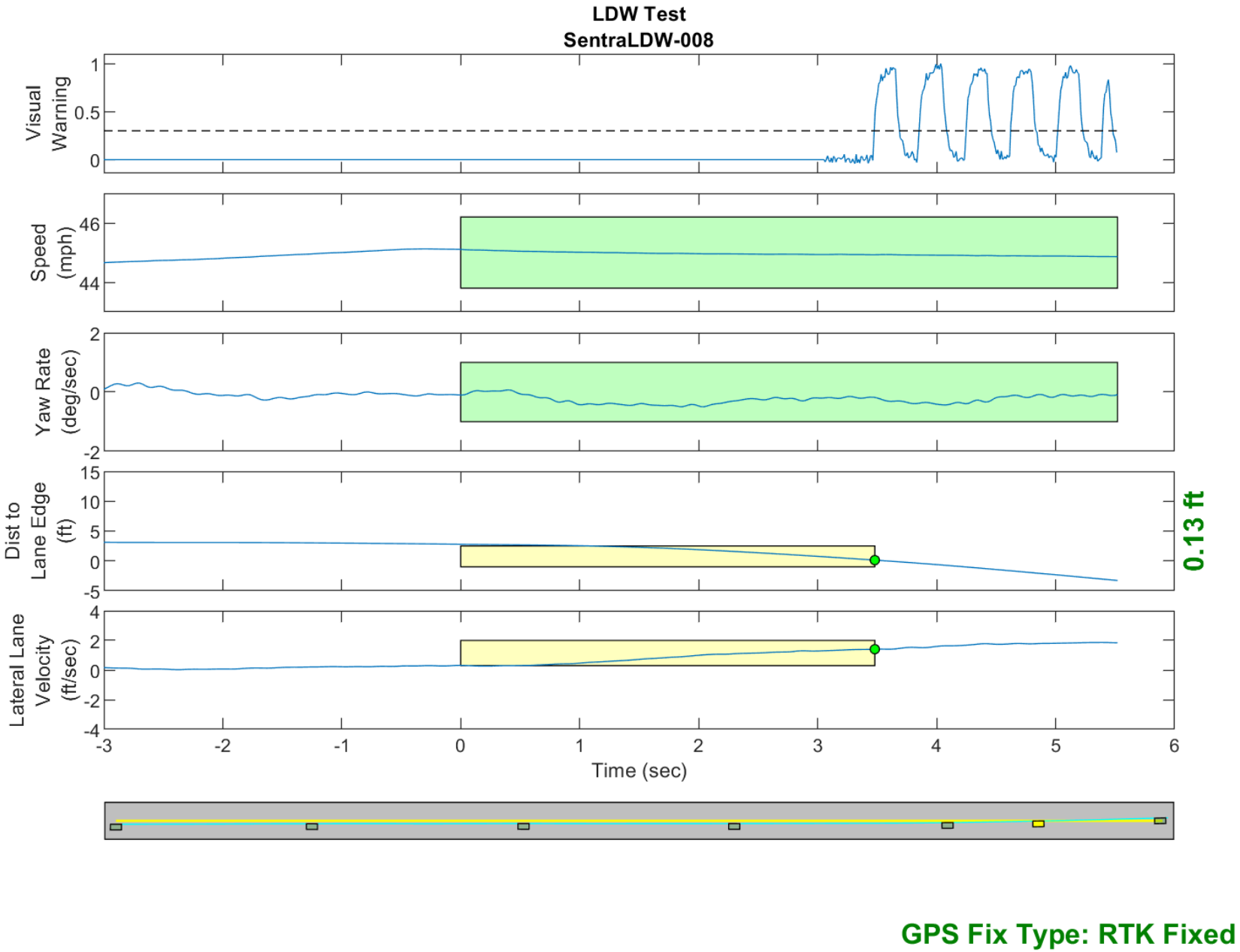

Figure D16. Time History for Run 08, Solid Line, Left Departure, Visual Warning

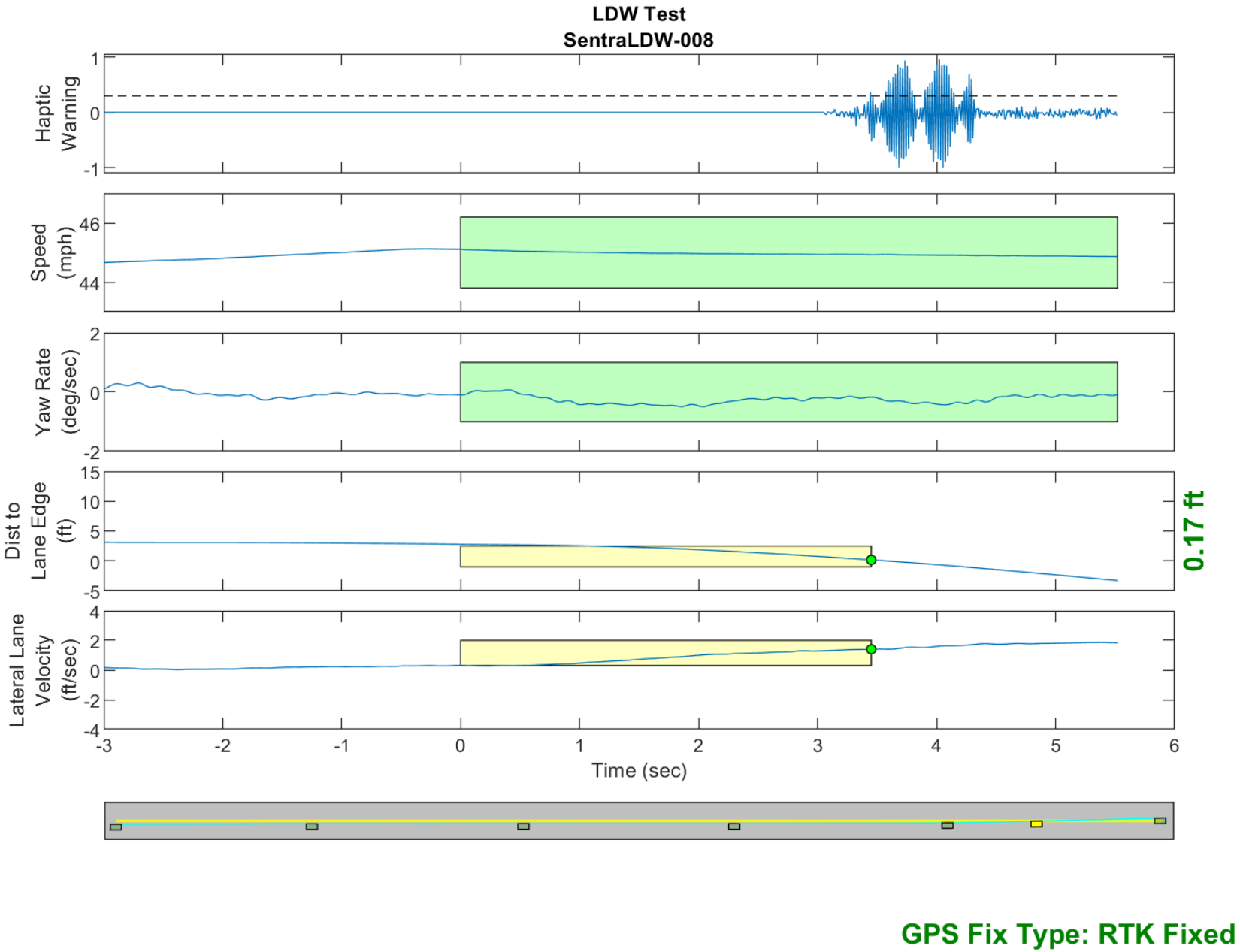

Figure D17. Time History for Run 08, Solid Line, Left Departure, Haptic Warning

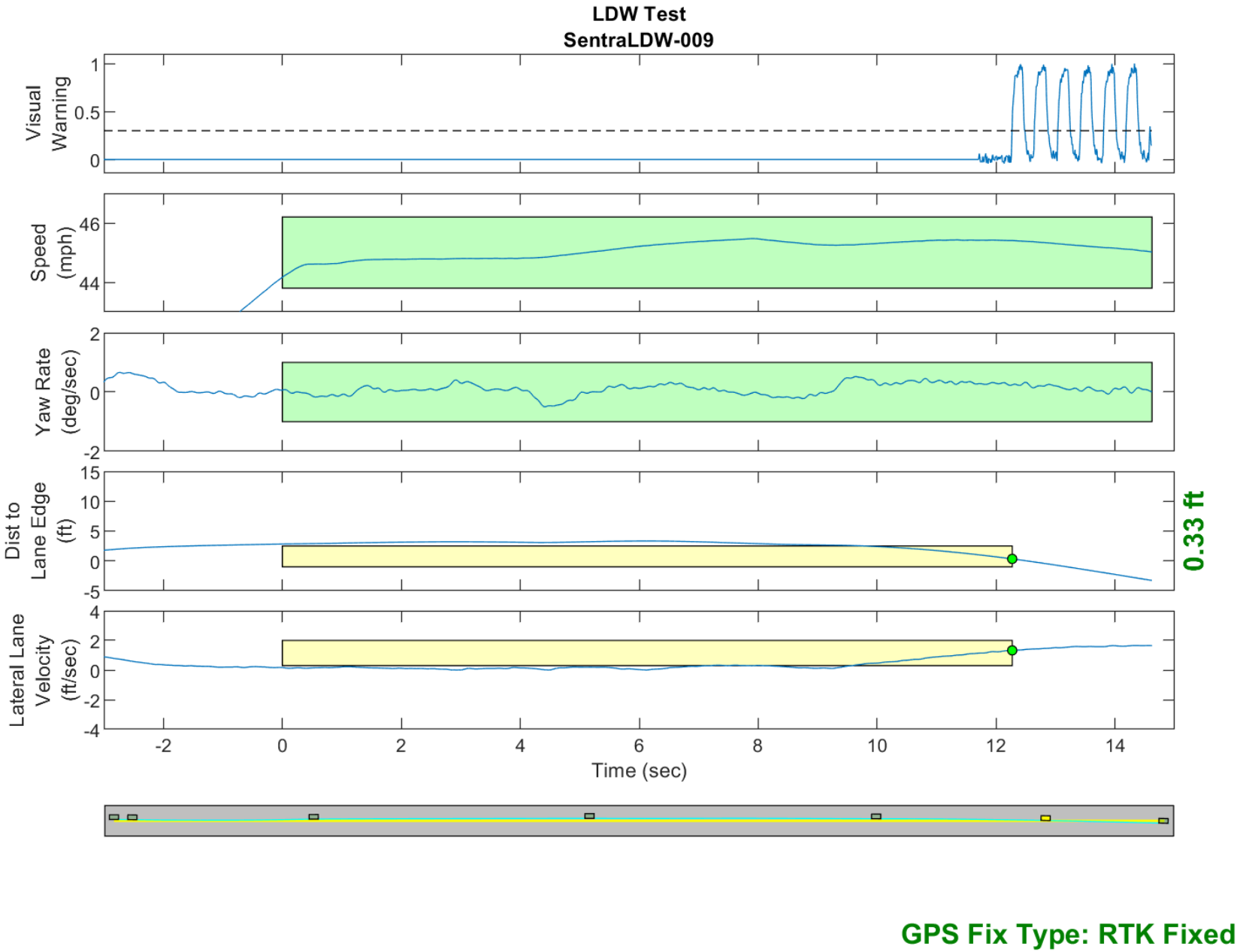

Figure D18. Time History for Run 09, Solid Line, Right Departure, Visual Warning

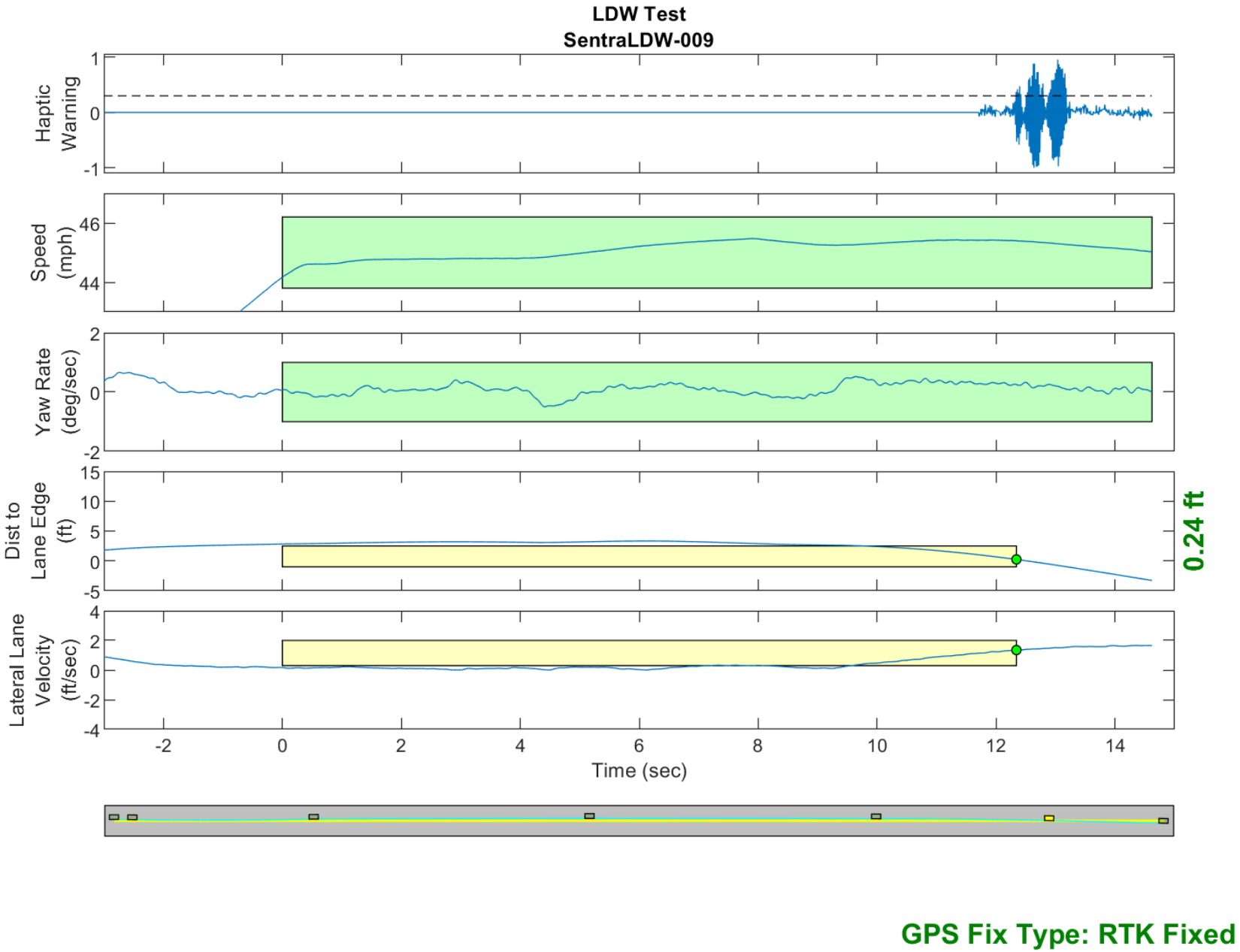

Figure D19. Time History for Run 09, Solid Line, Right Departure, Haptic Warning

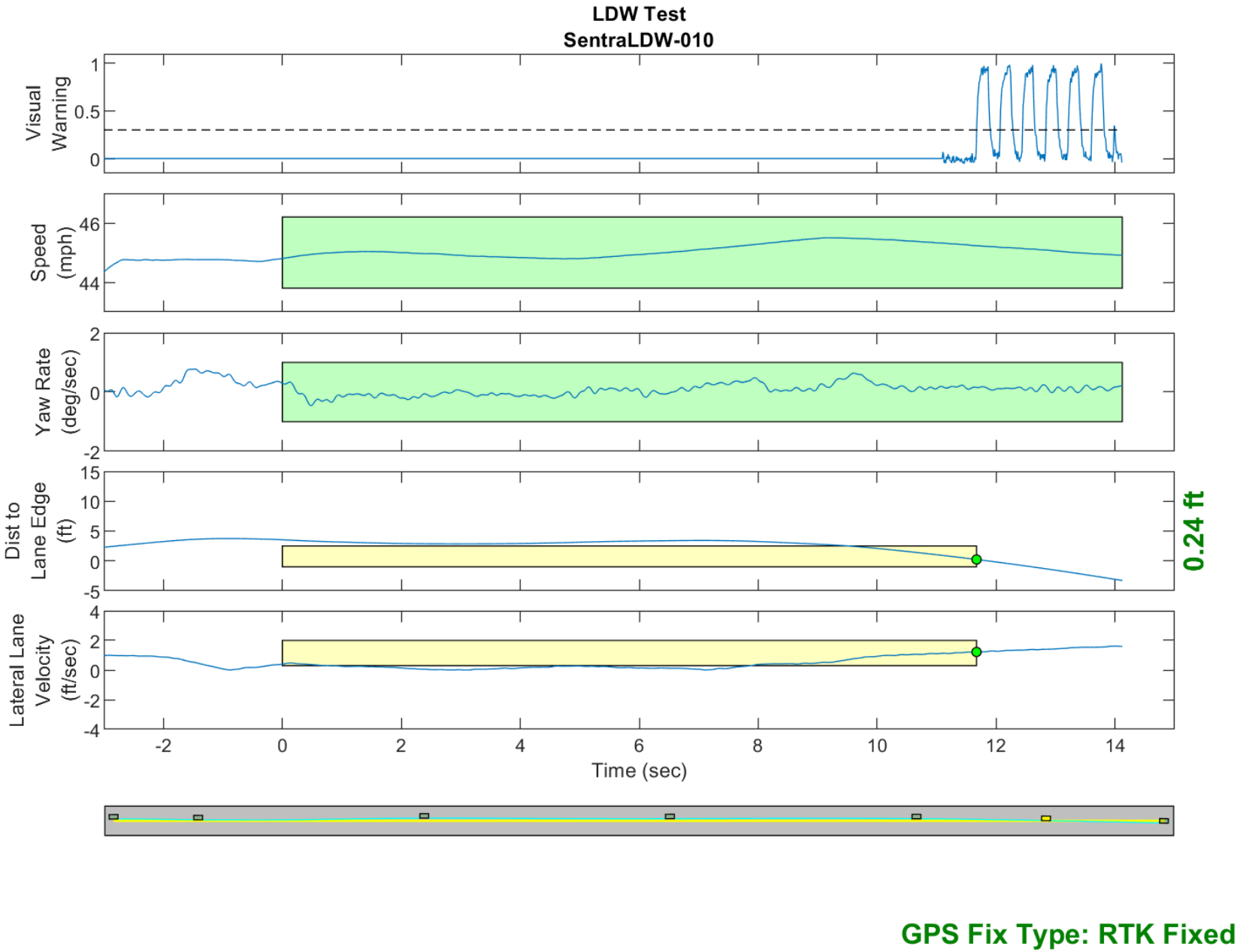

Figure D20. Time History for Run 10, Solid Line, Right Departure, Visual Warning

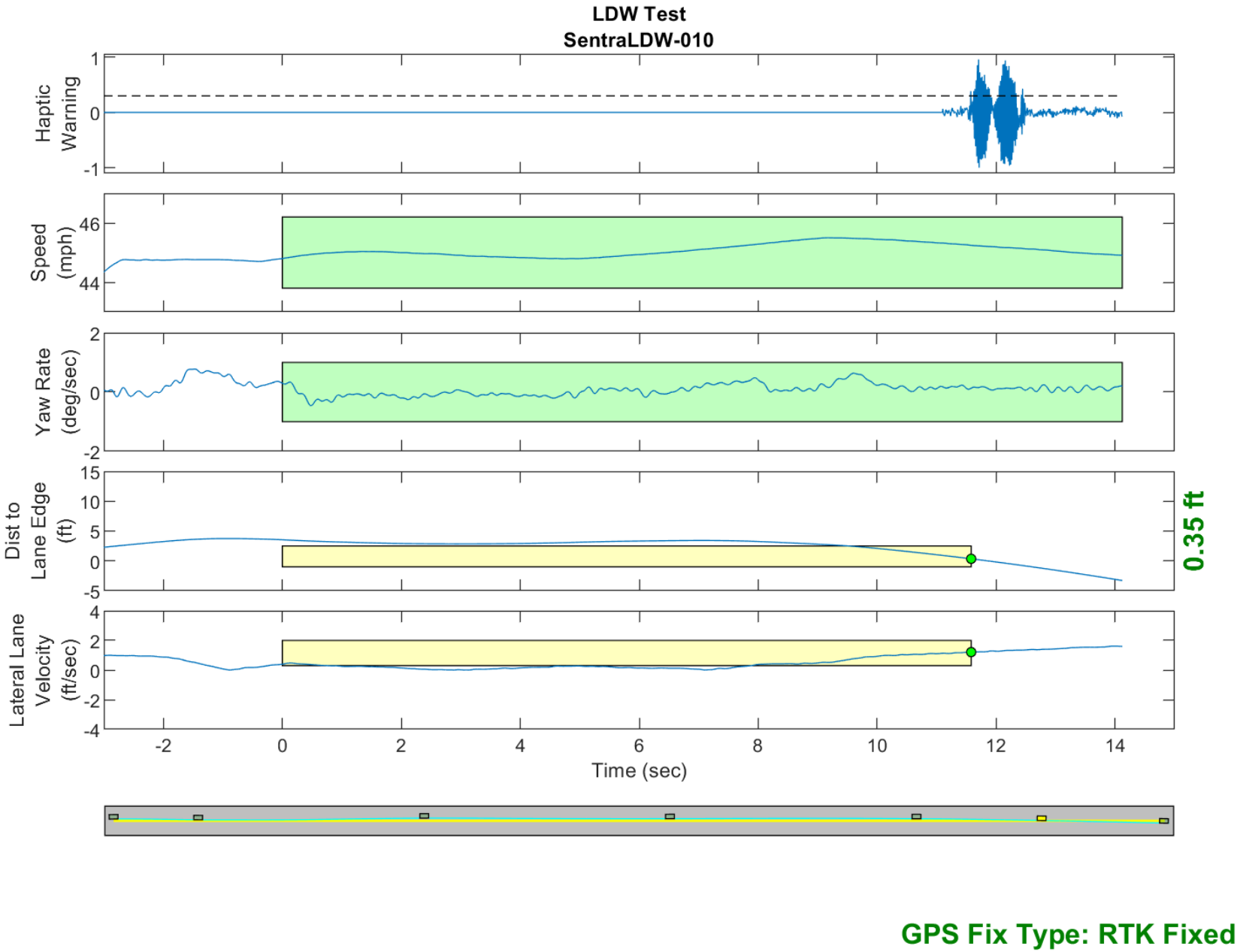

Figure D21. Time History for Run 10, Solid Line, Right Departure, Haptic Warning

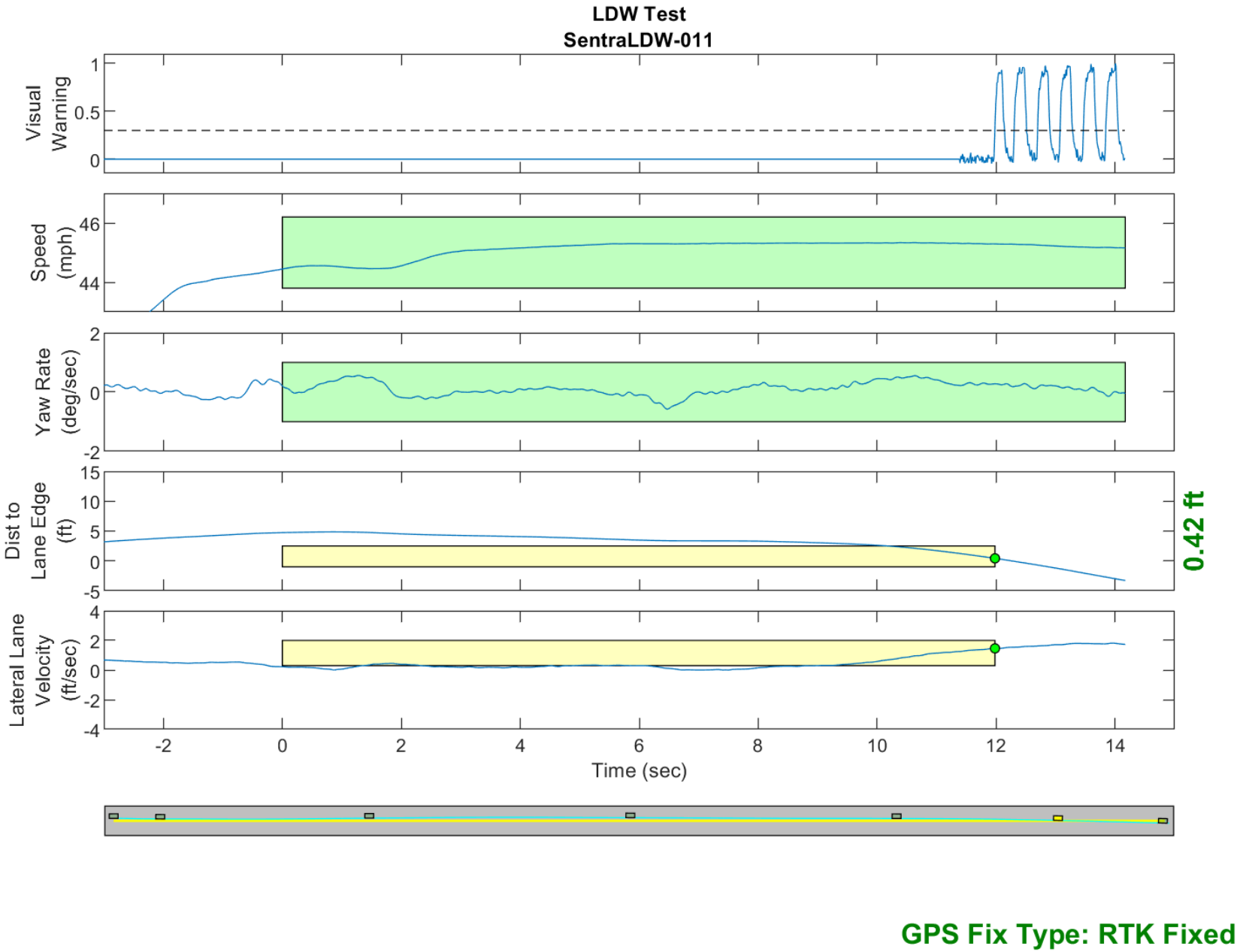

Figure D22. Time History for Run 11, Solid Line, Right Departure, Visual Warning

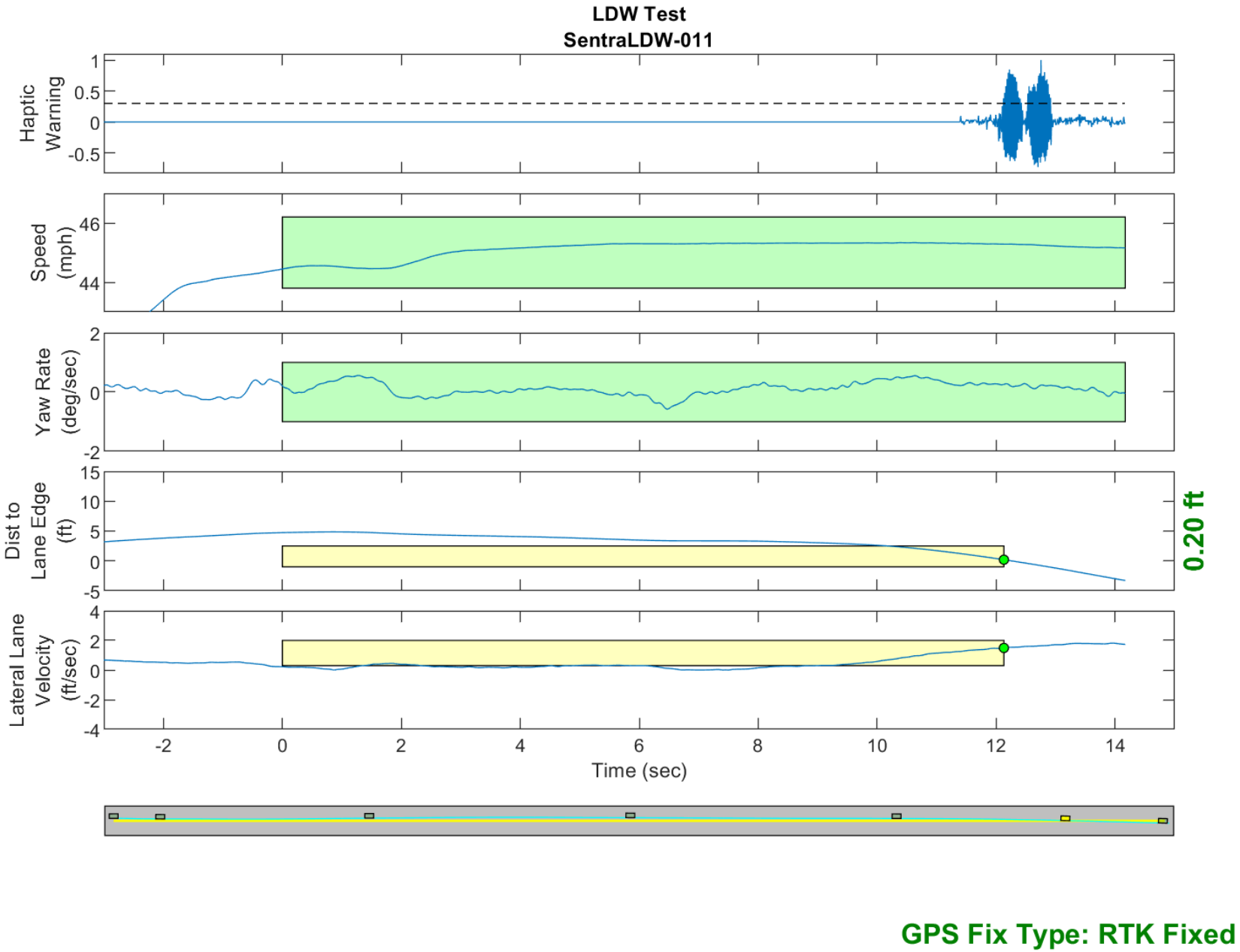

Figure D23. Time History for Run 11, Solid Line, Right Departure, Haptic Warning

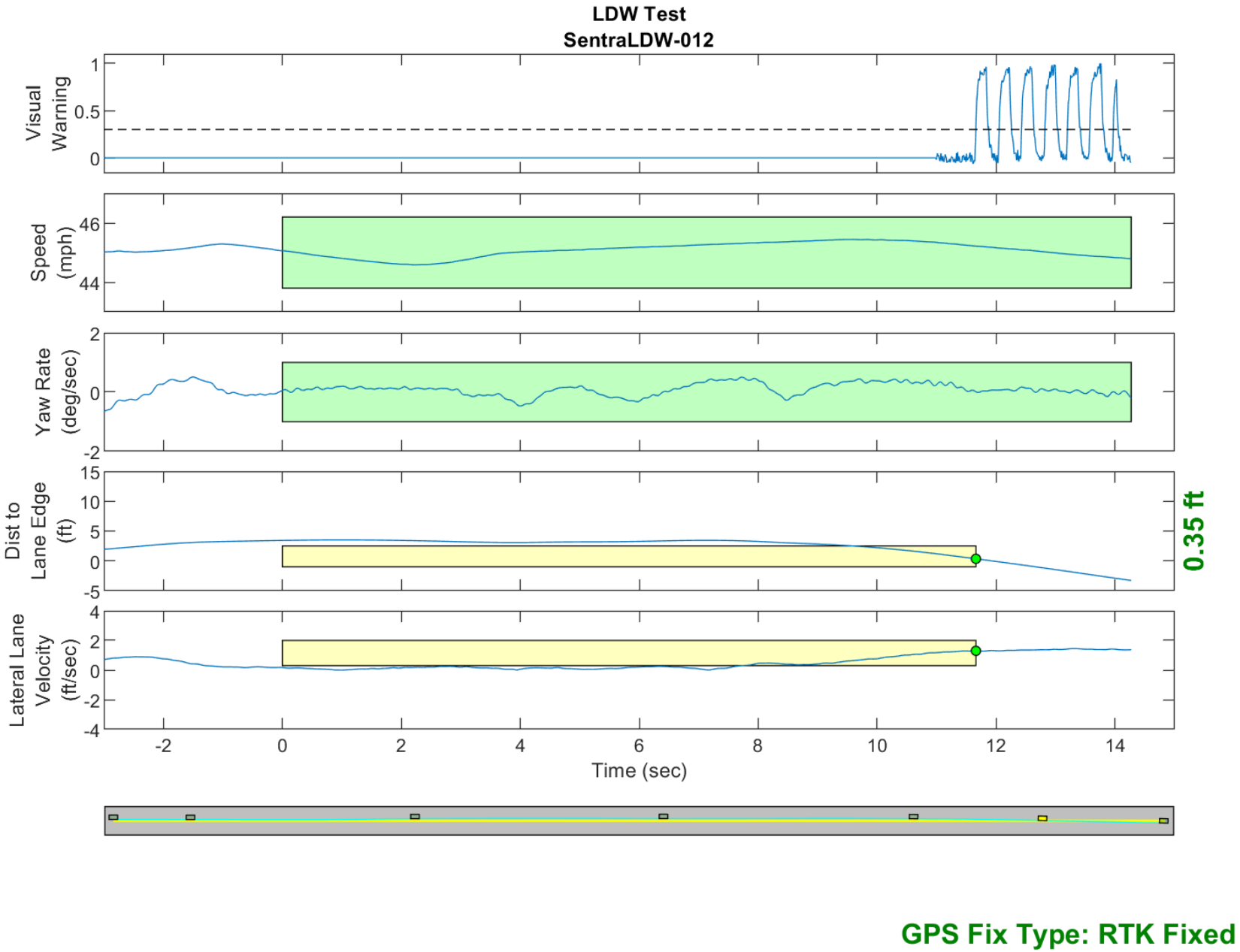

Figure D24. Time History for Run 12, Solid Line, Right Departure, Visual Warning

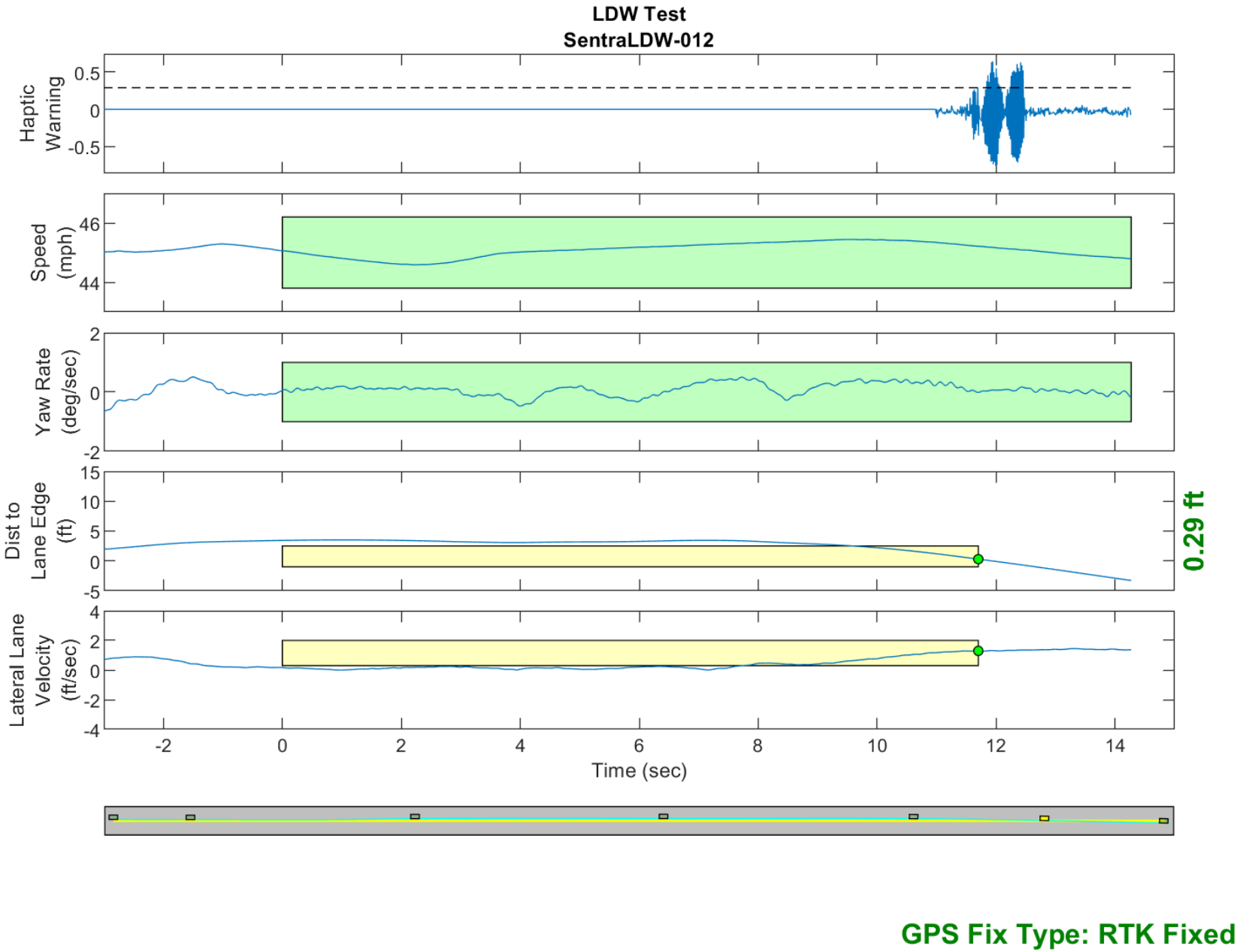

Figure D25. Time History for Run 12, Solid Line, Right Departure, Haptic Warning

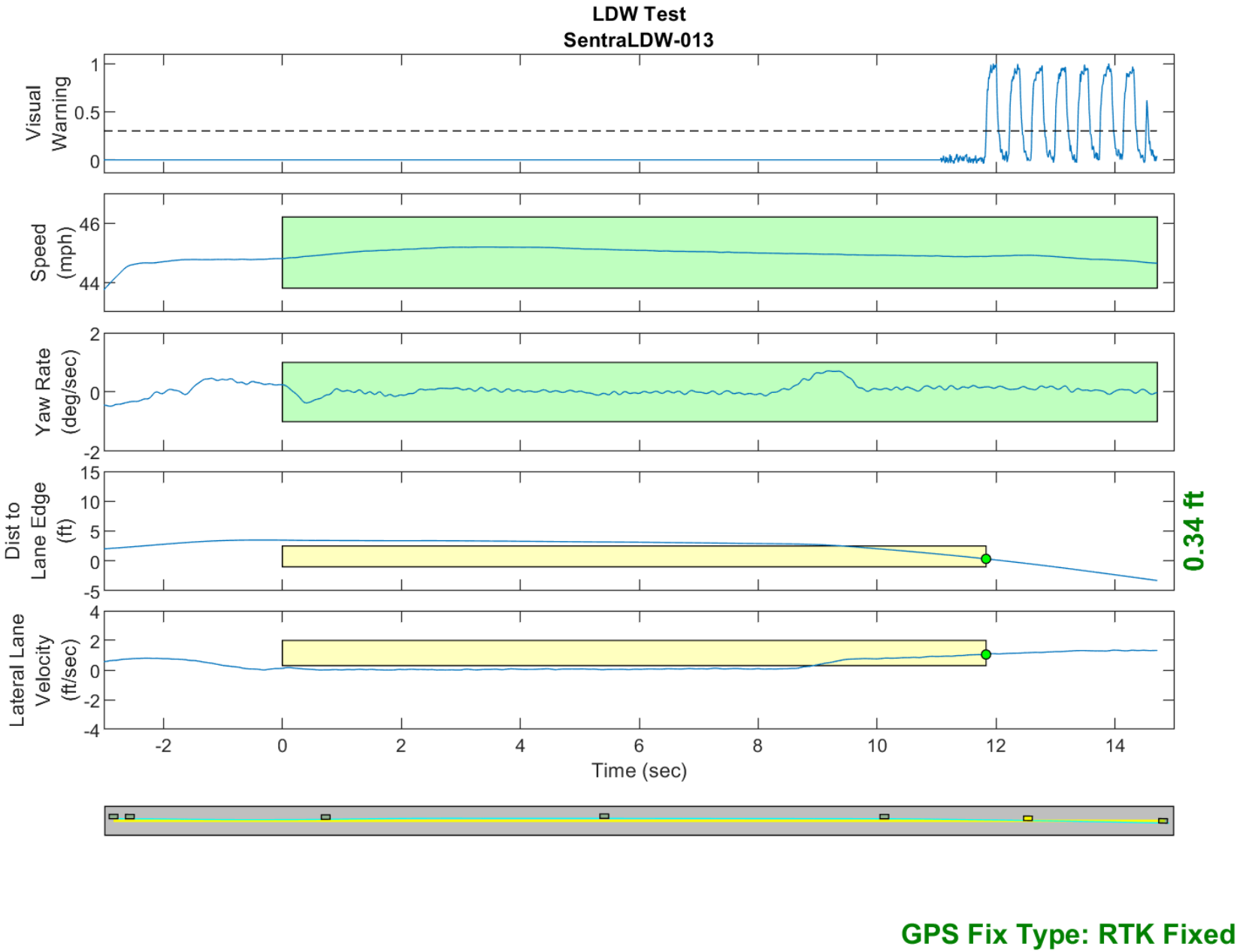

Figure D26. Time History for Run 13, Solid Line, Right Departure, Visual Warning

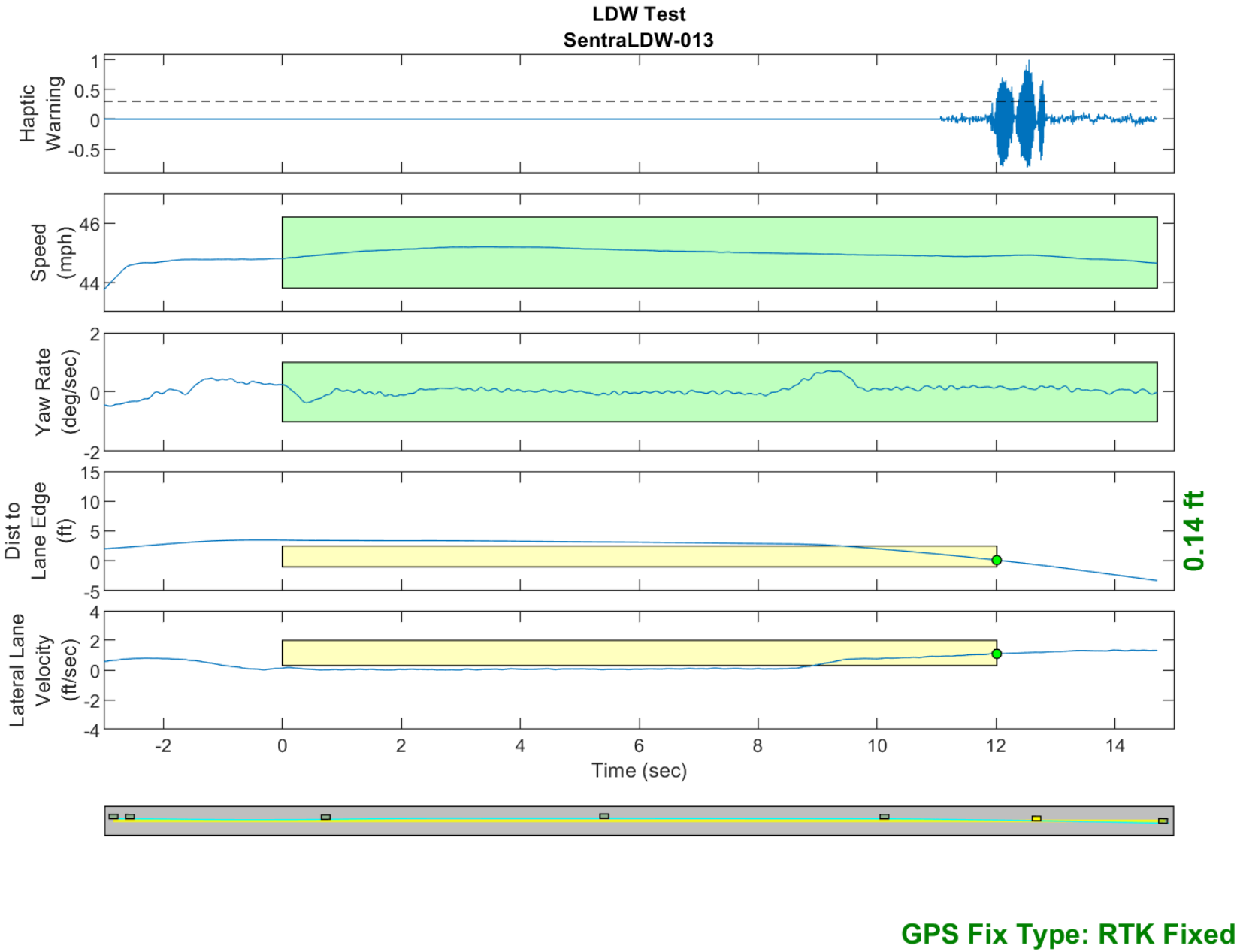

Figure D27. Time History for Run 13, Solid Line, Right Departure, Haptic Warning

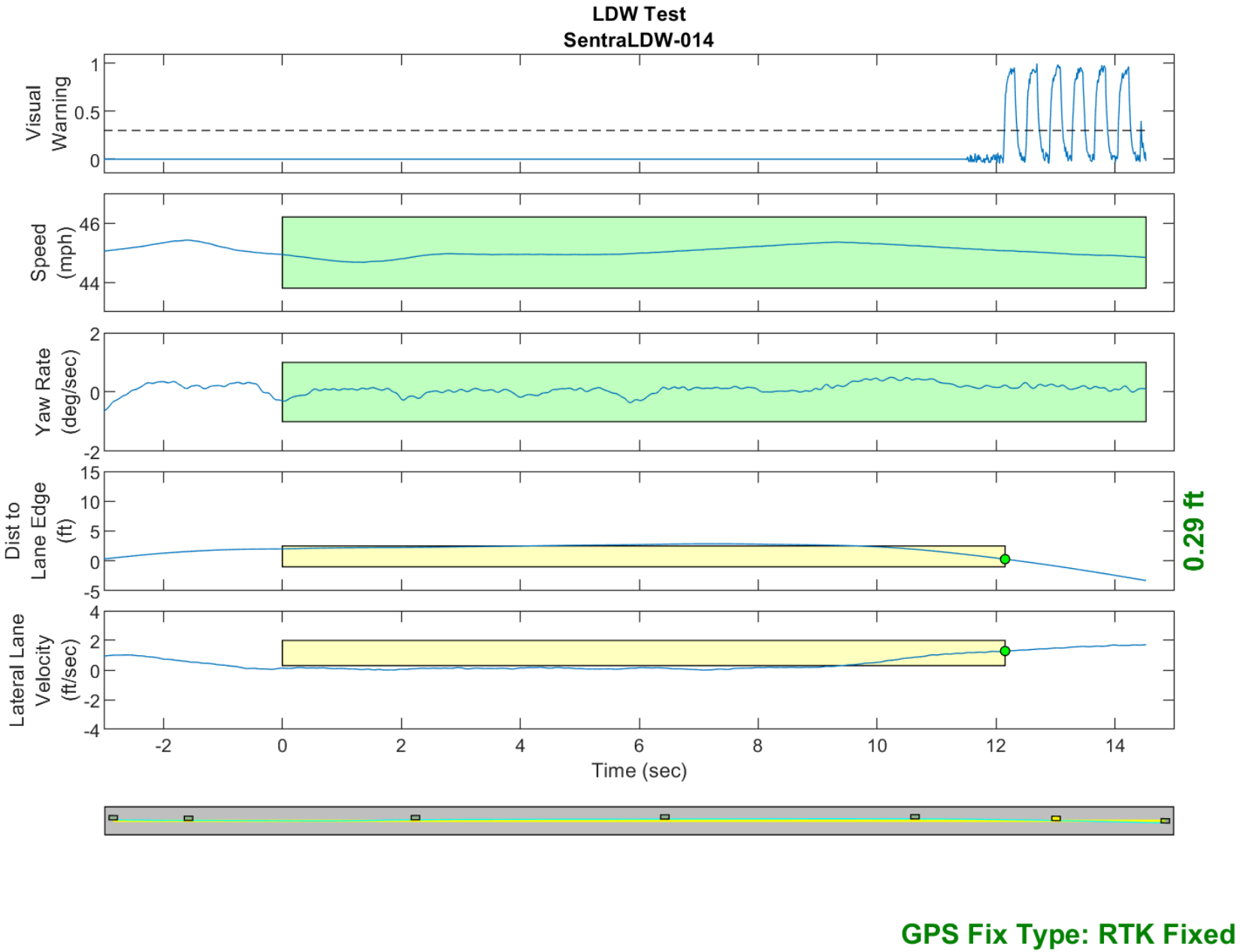

Figure D28. Time History for Run 14, Solid Line, Right Departure, Visual Warning

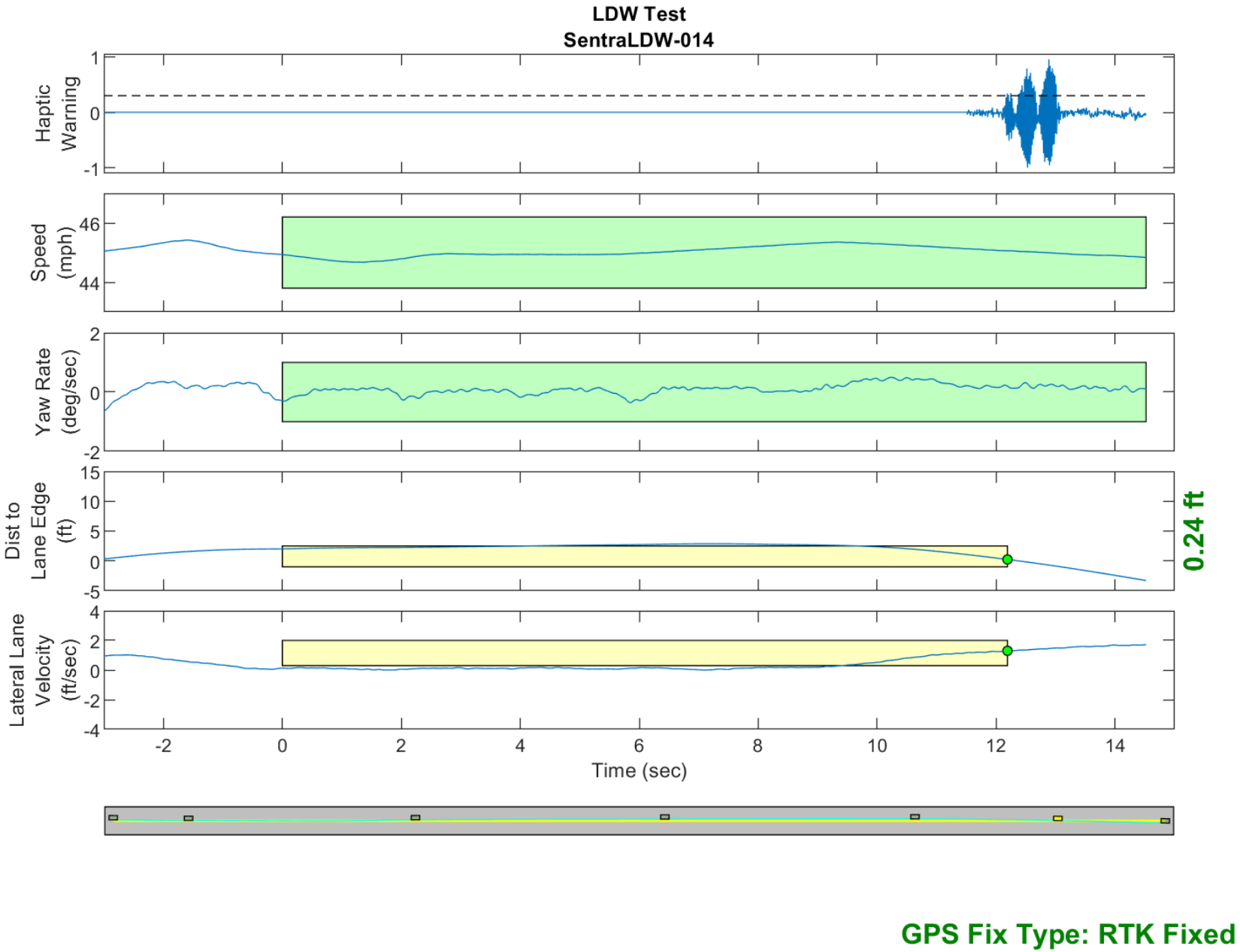

Figure D29. Time History for Run 14, Solid Line, Right Departure, Haptic Warning

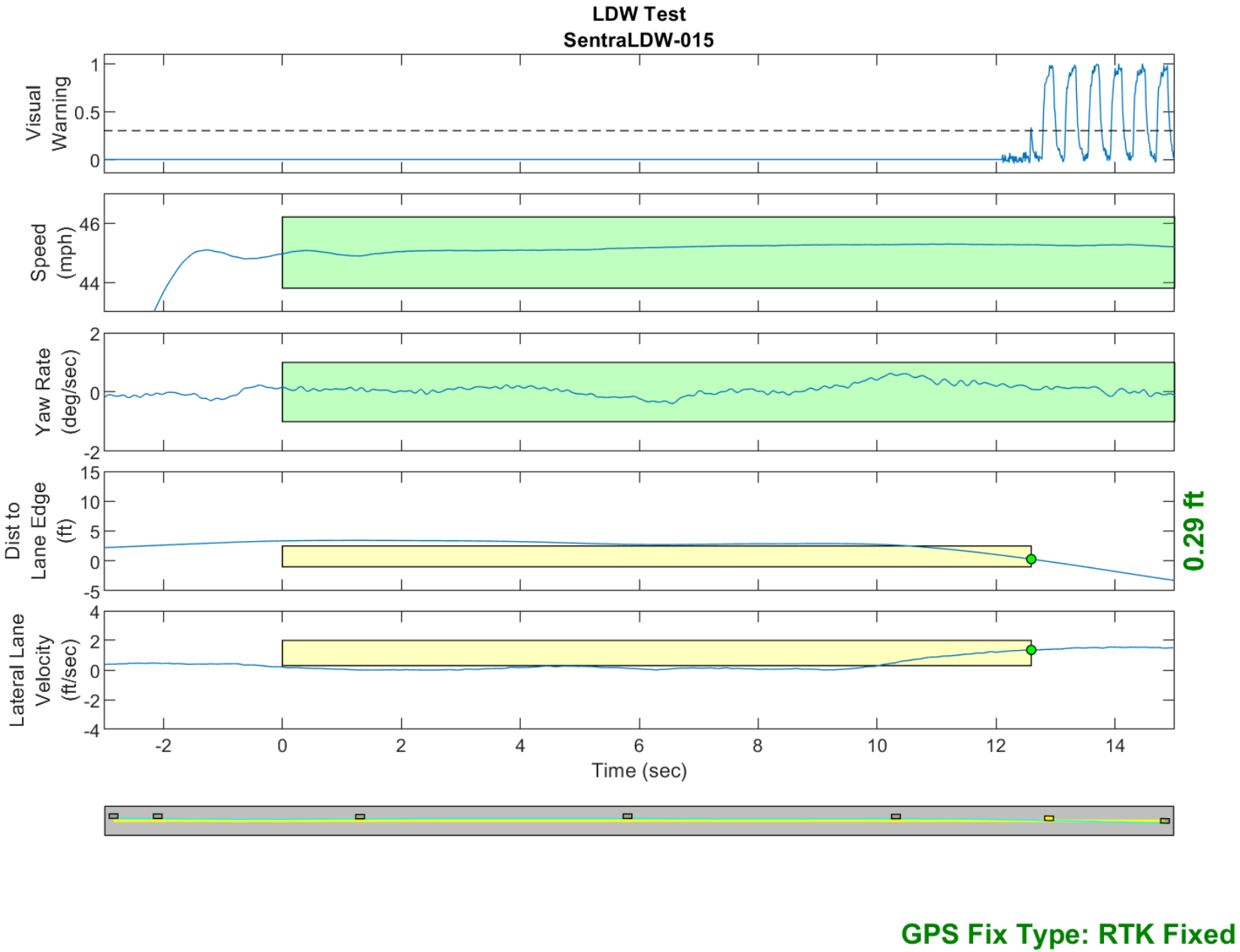

Figure D30. Time History for Run 15, Solid Line, Right Departure, Visual Warning

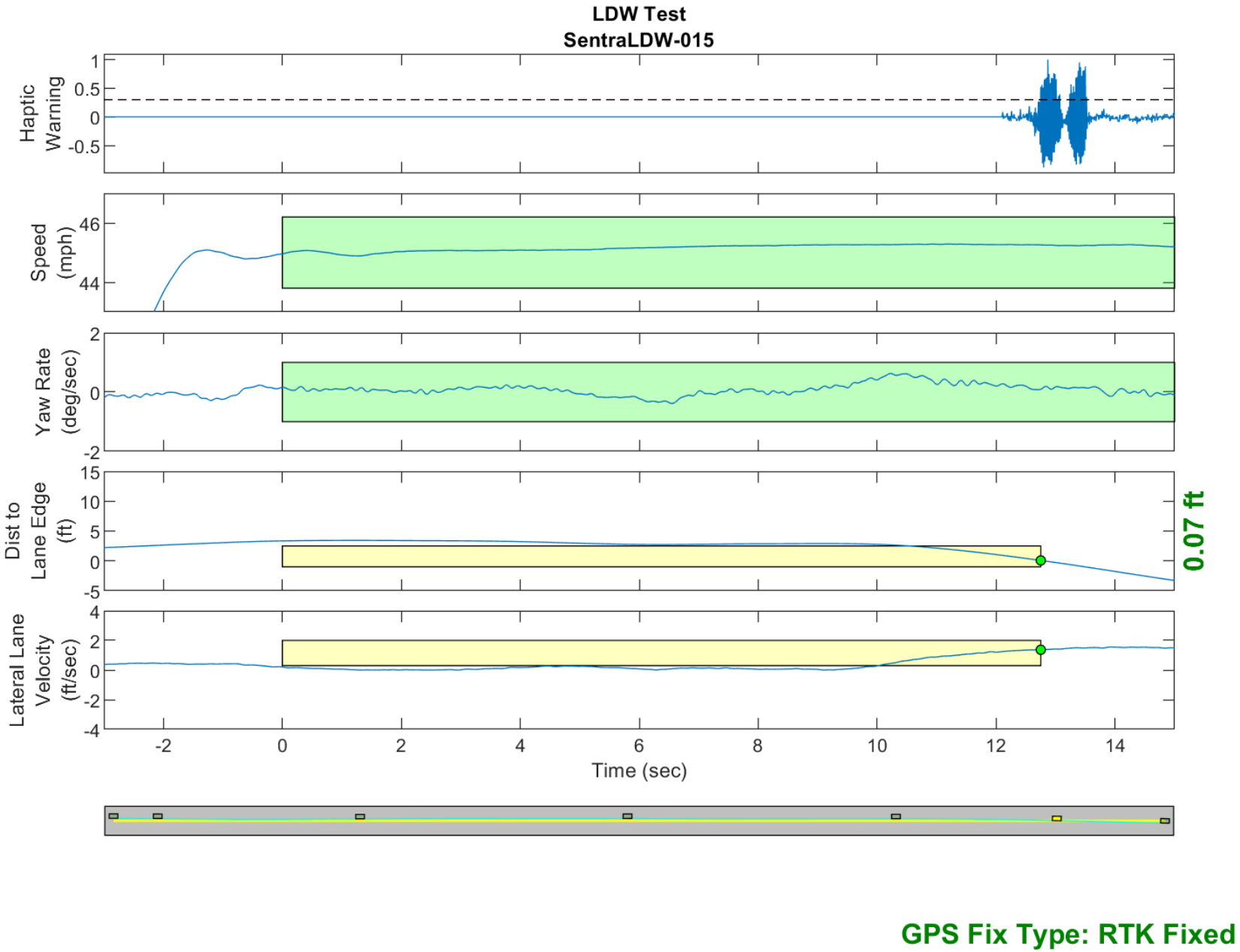

Figure D31. Time History for Run 15, Solid Line, Right Departure, Haptic Warning

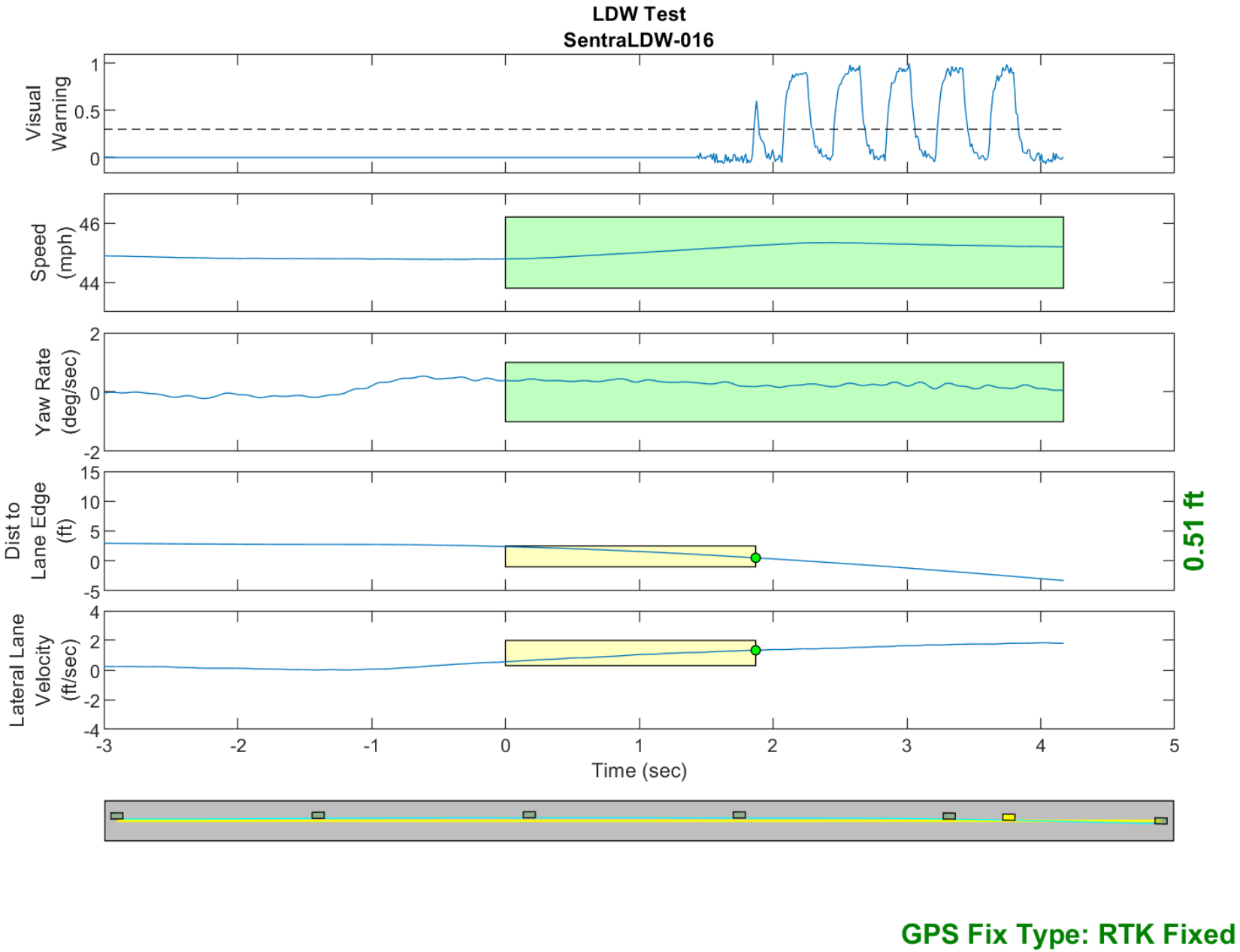

Figure D32. Time History for Run 16, Dashed Line, Right Departure, Visual Warning

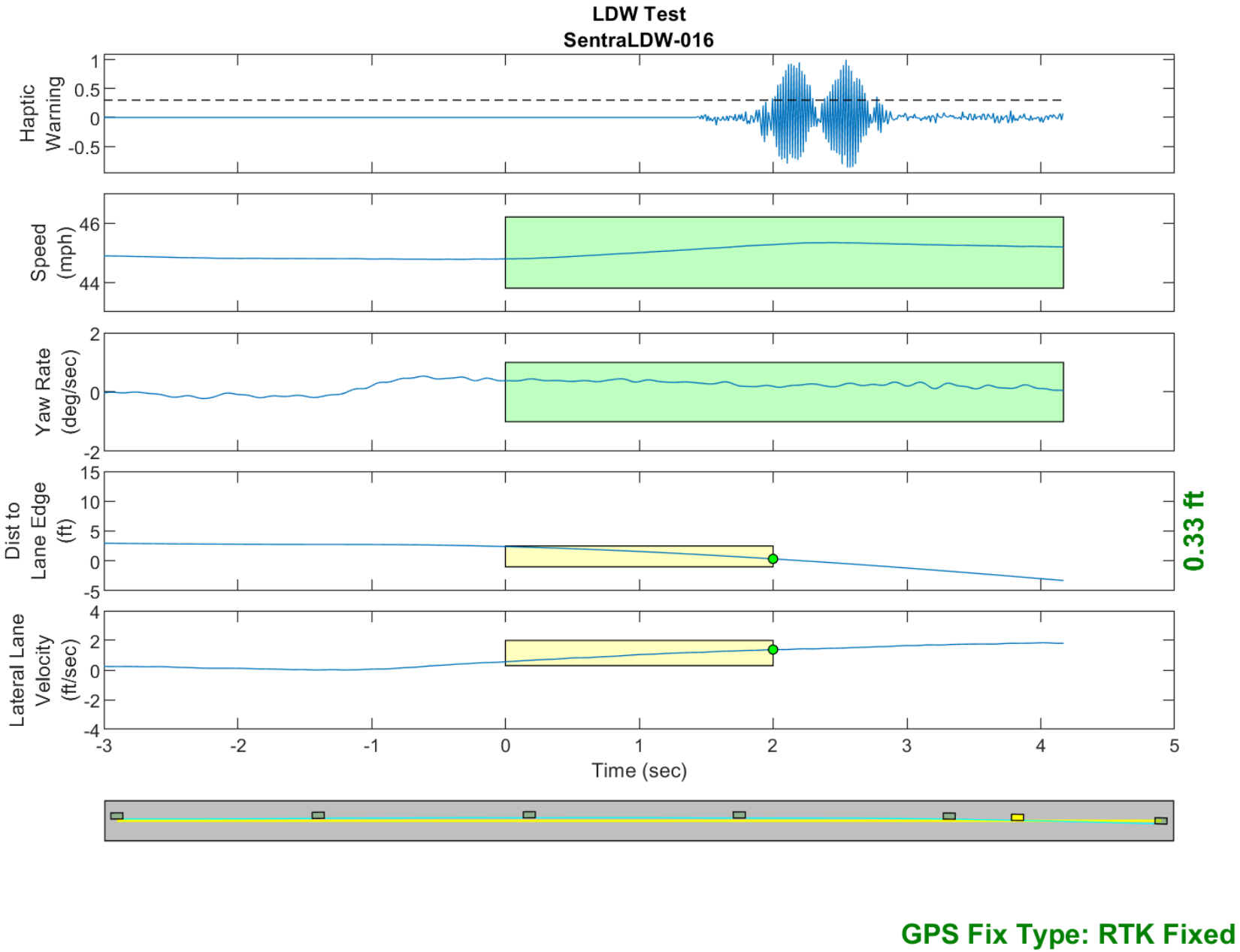

Figure D33. Time History for Run 16, Dashed Line, Right Departure, Haptic Warning

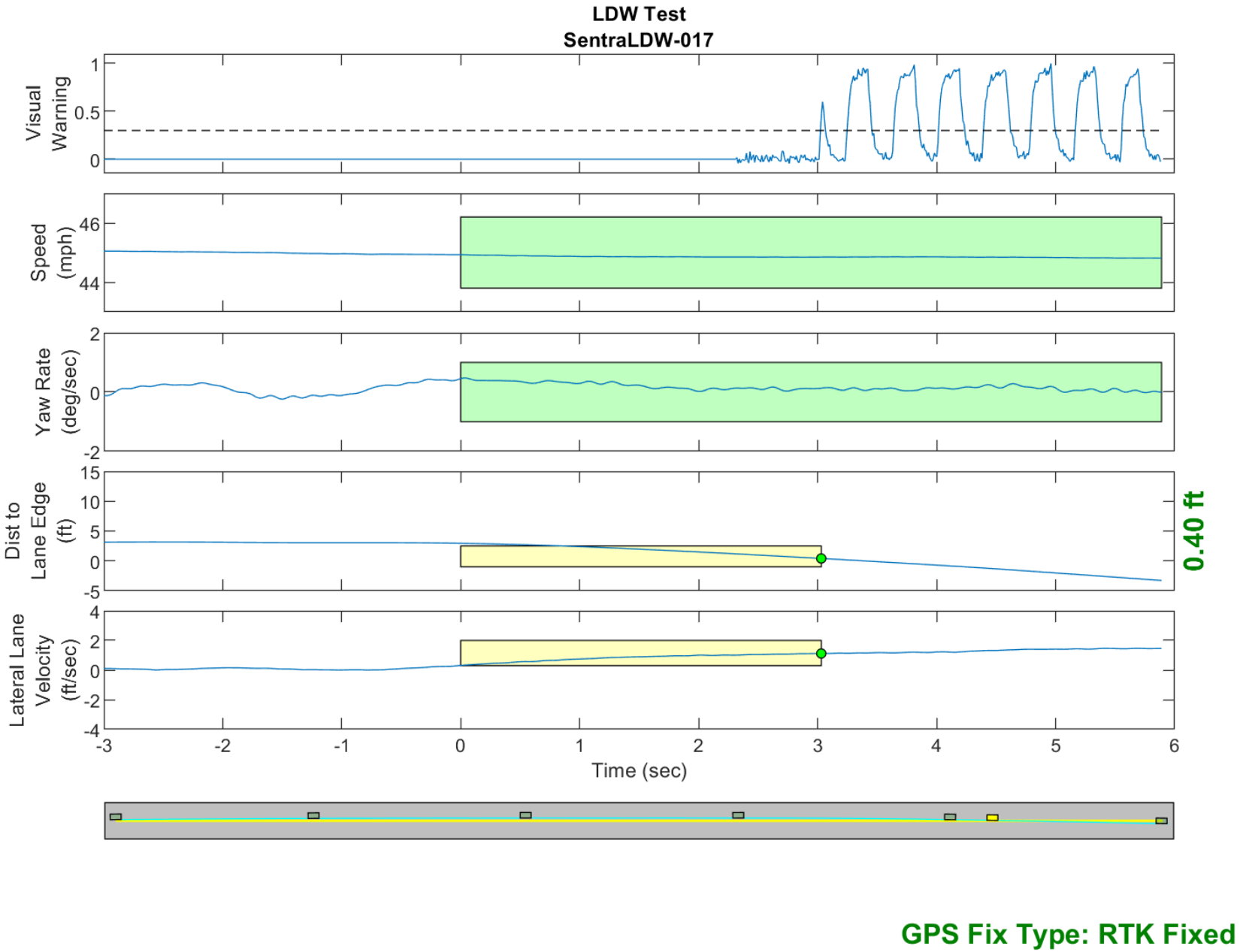

Figure D34. Time History for Run 17, Dashed Line, Right Departure, Visual Warning

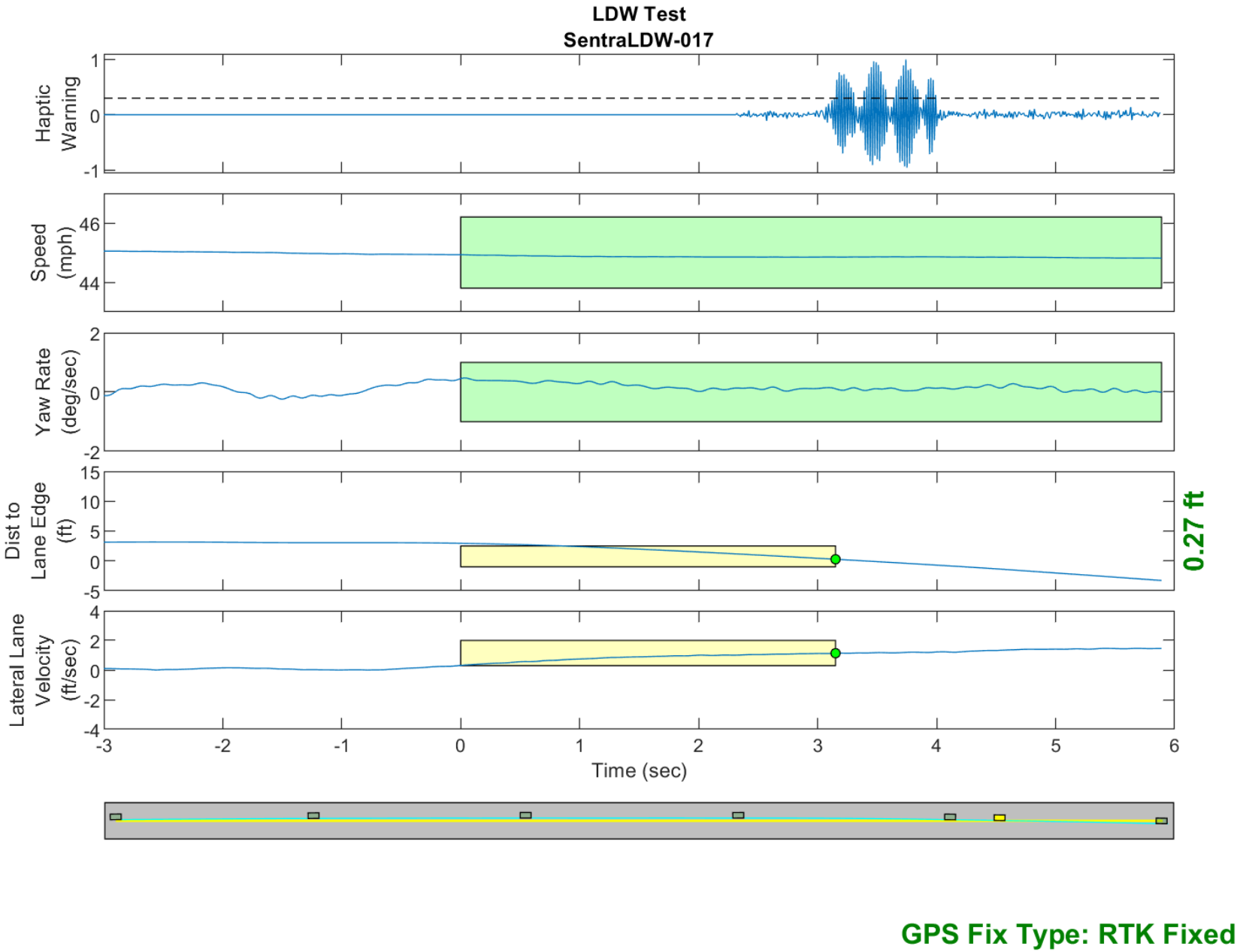

Figure D35. Time History for Run 17, Dashed Line, Right Departure, Haptic Warning

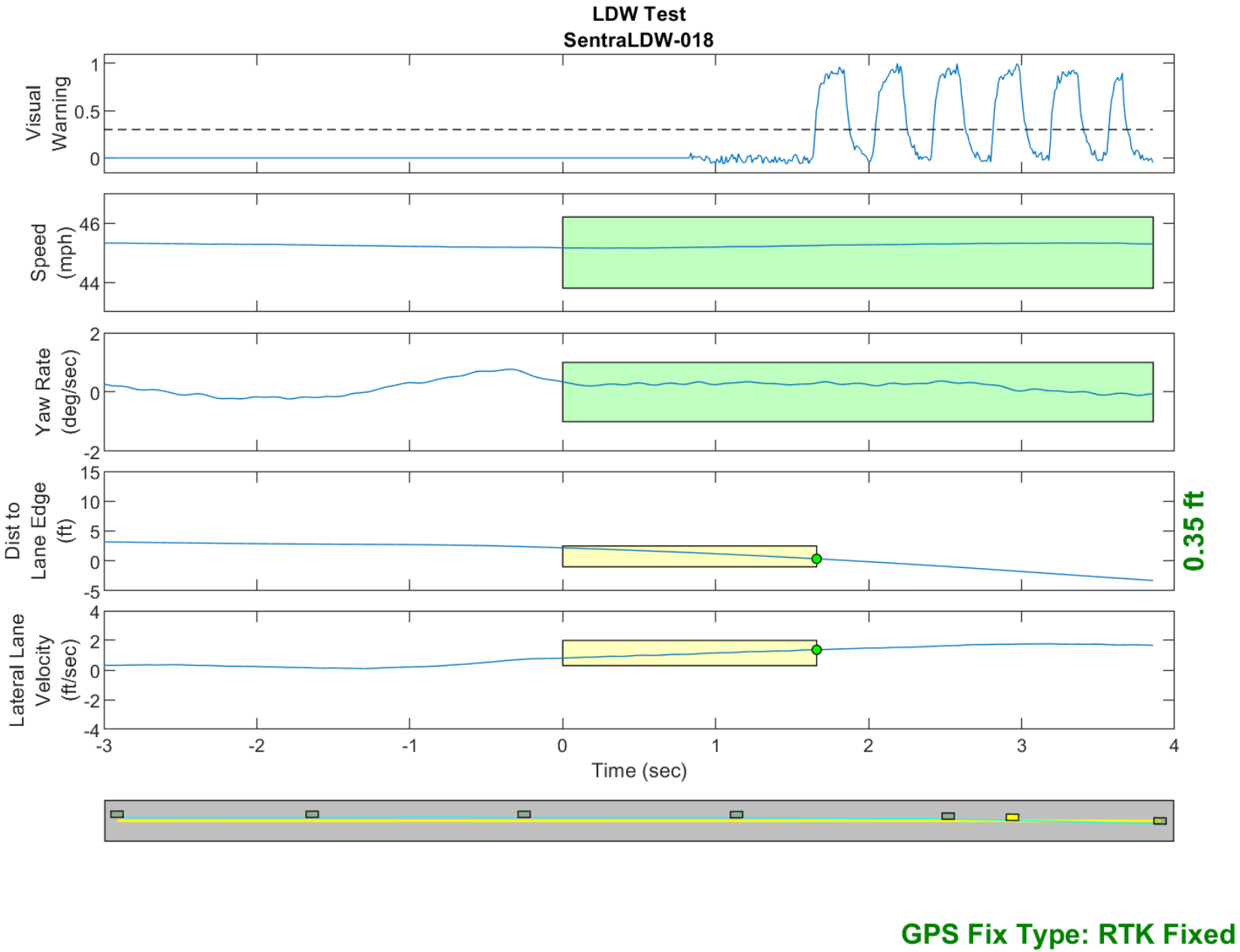

Figure D36. Time History for Run 18, Dashed Line, Right Departure, Visual Warning

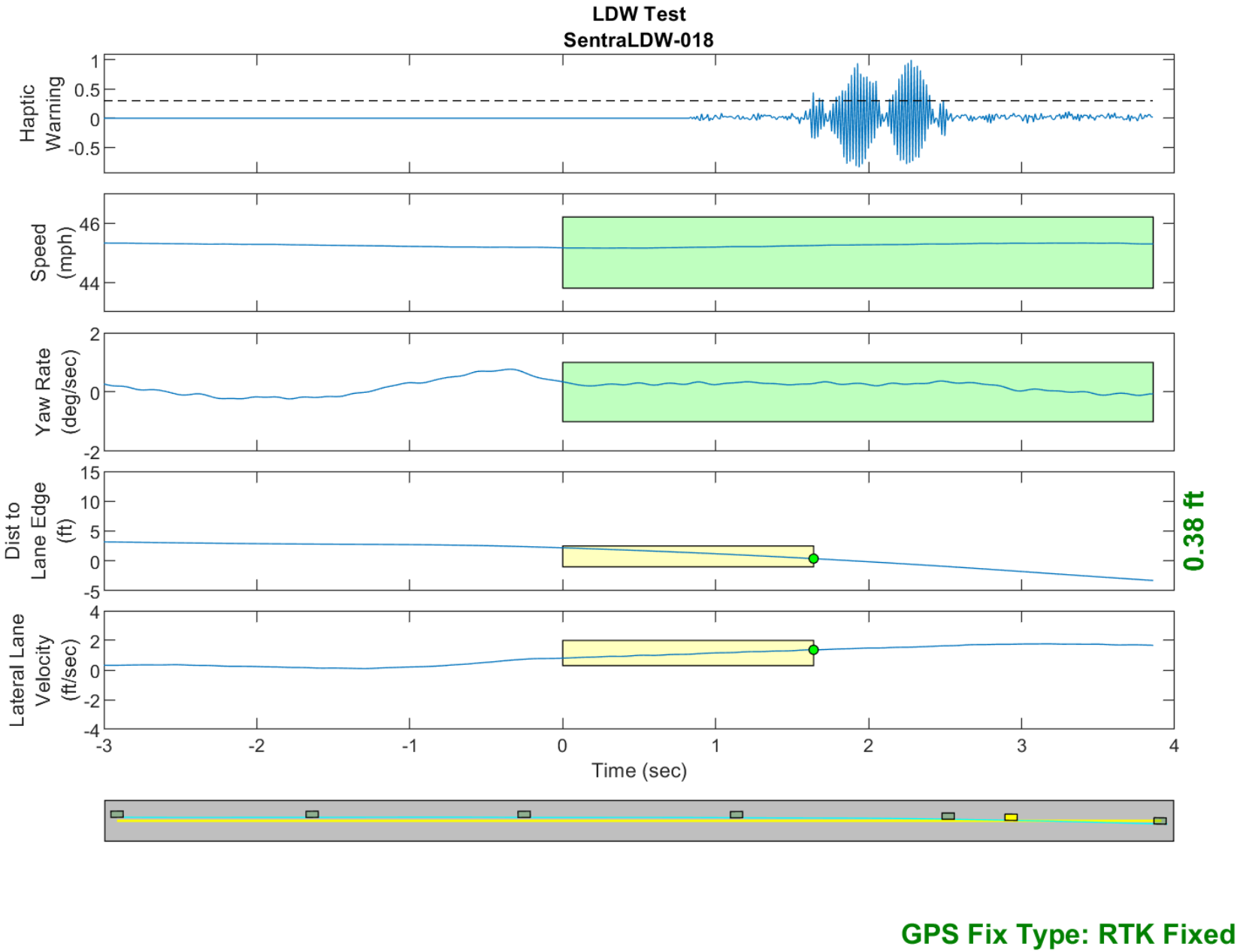

Figure D37. Time History for Run 18, Dashed Line, Right Departure, Haptic Warning

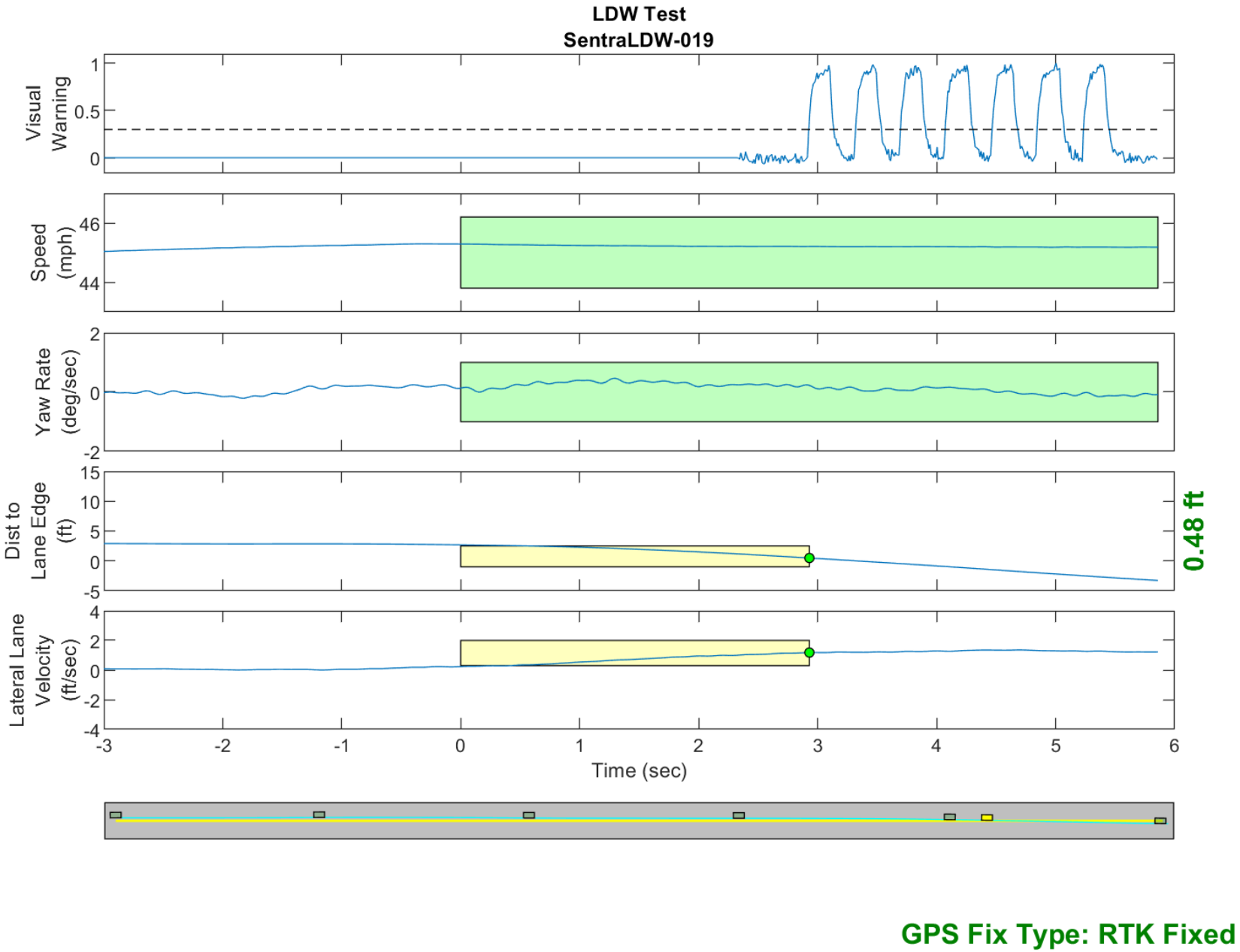

Figure D38. Time History for Run 19, Dashed Line, Right Departure, Visual Warning

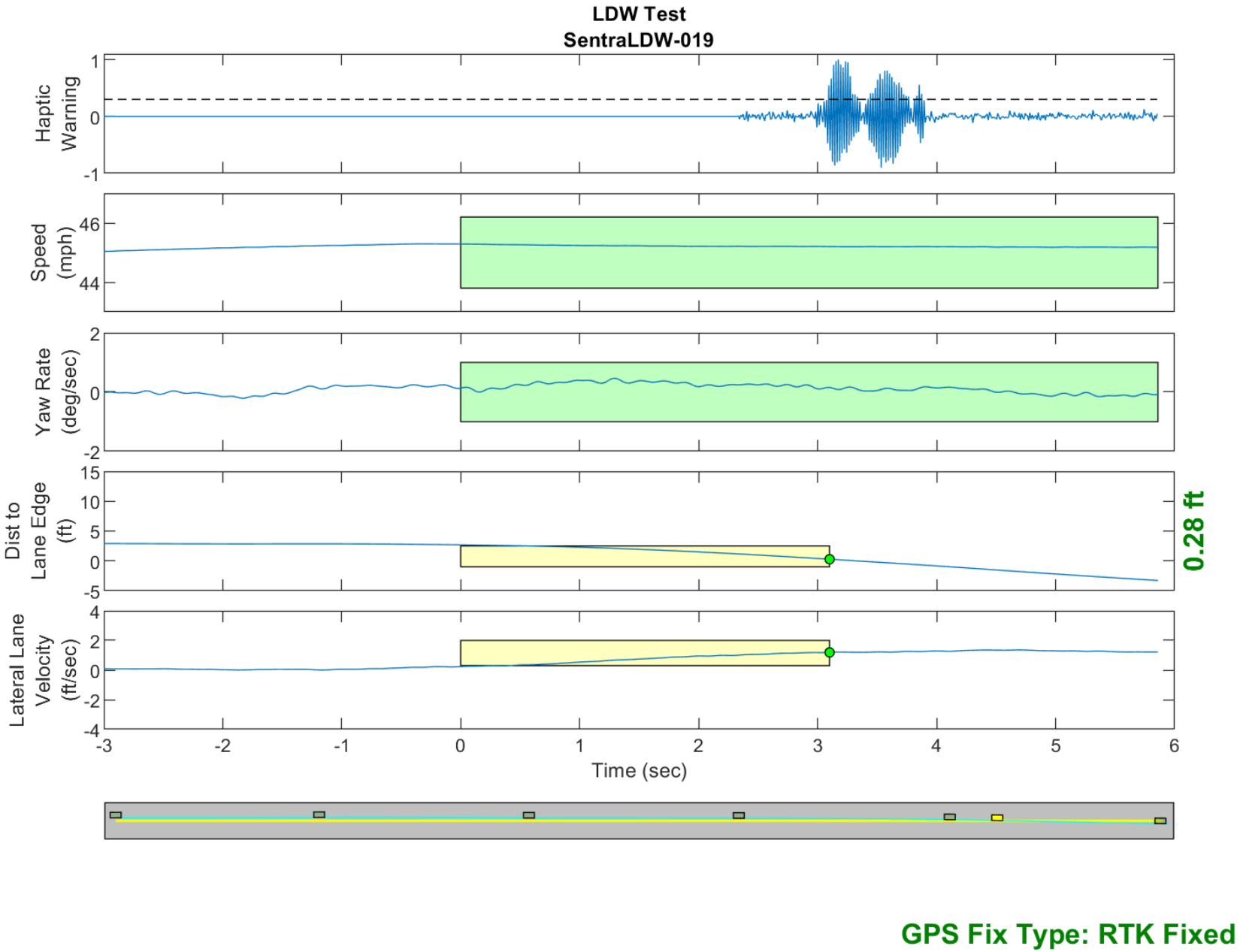

Figure D39. Time History for Run 19, Dashed Line, Right Departure, Haptic Warning

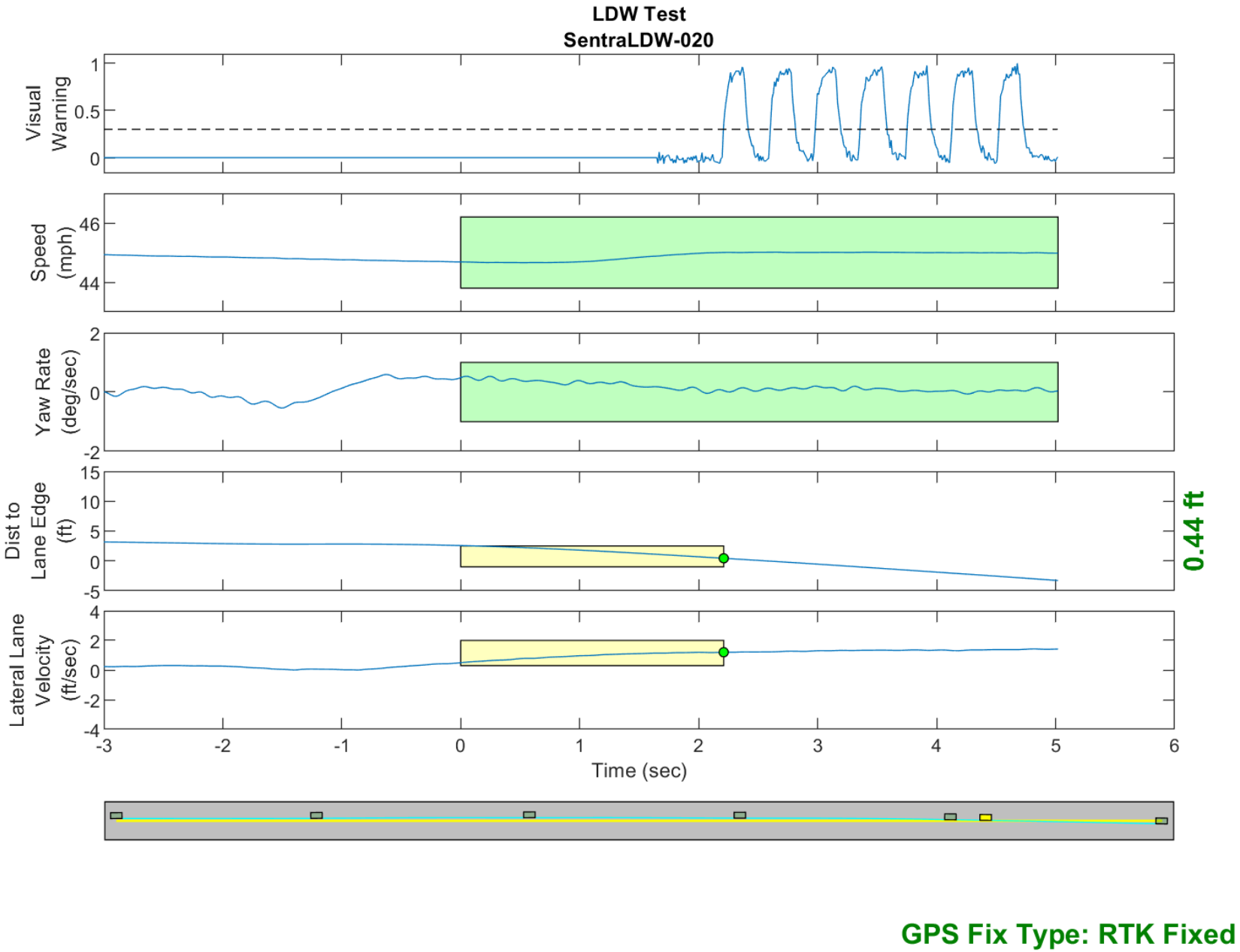

Figure D40. Time History for Run 20, Dashed Line, Right Departure, Visual Warning

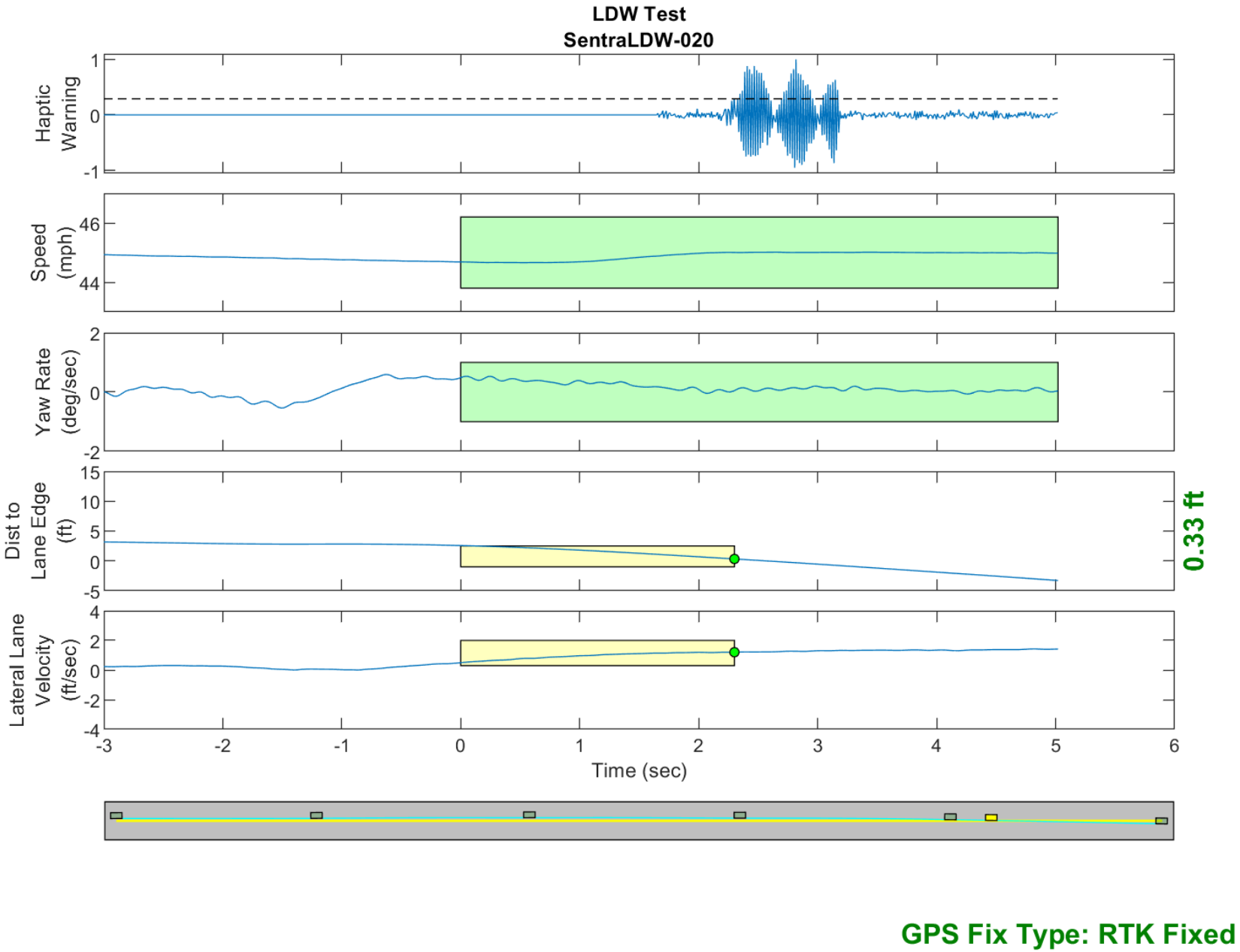

Figure D41. Time History for Run 20, Dashed Line, Right Departure, Haptic Warning

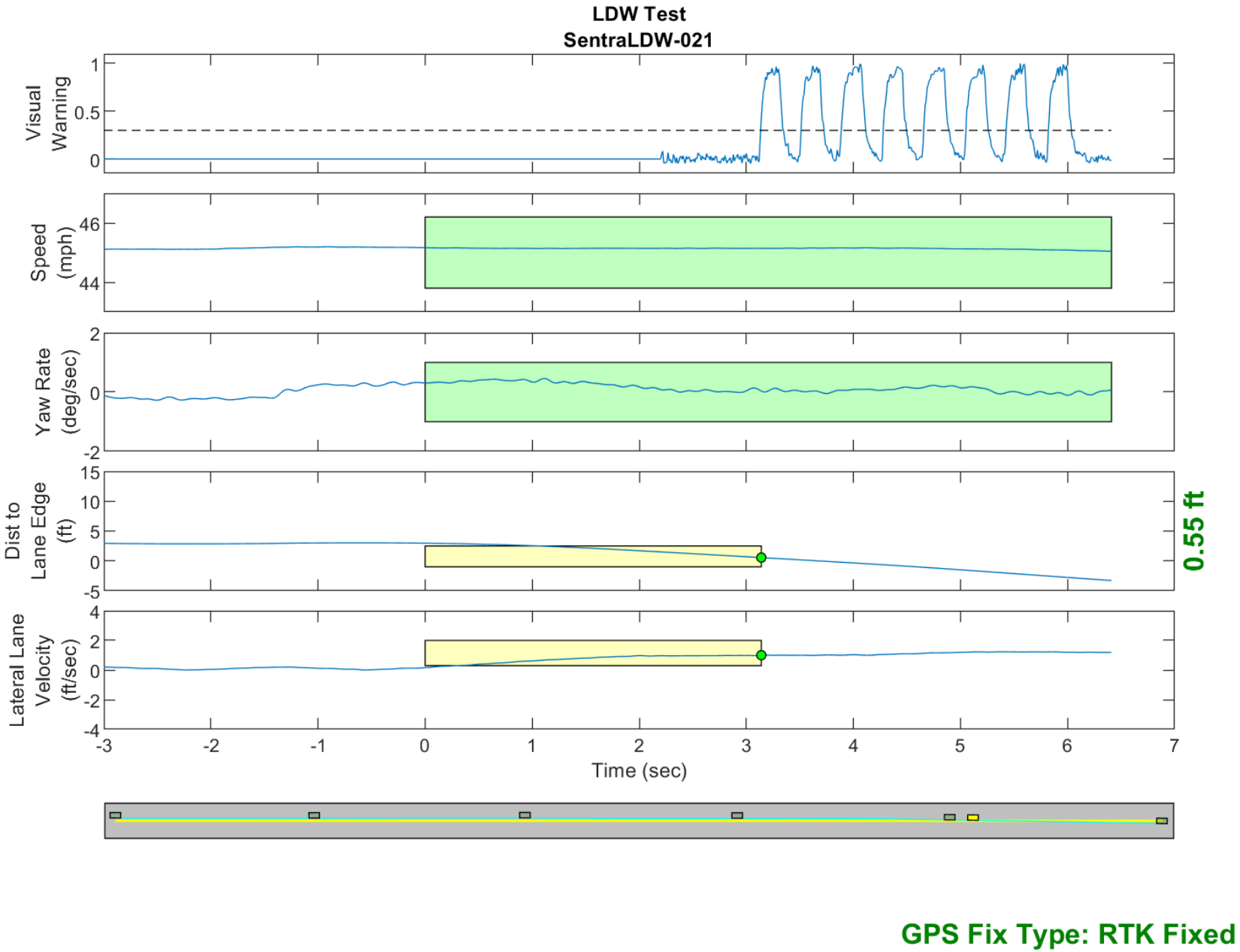

Figure D42. Time History for Run 21, Dashed Line, Right Departure, Visual Warning

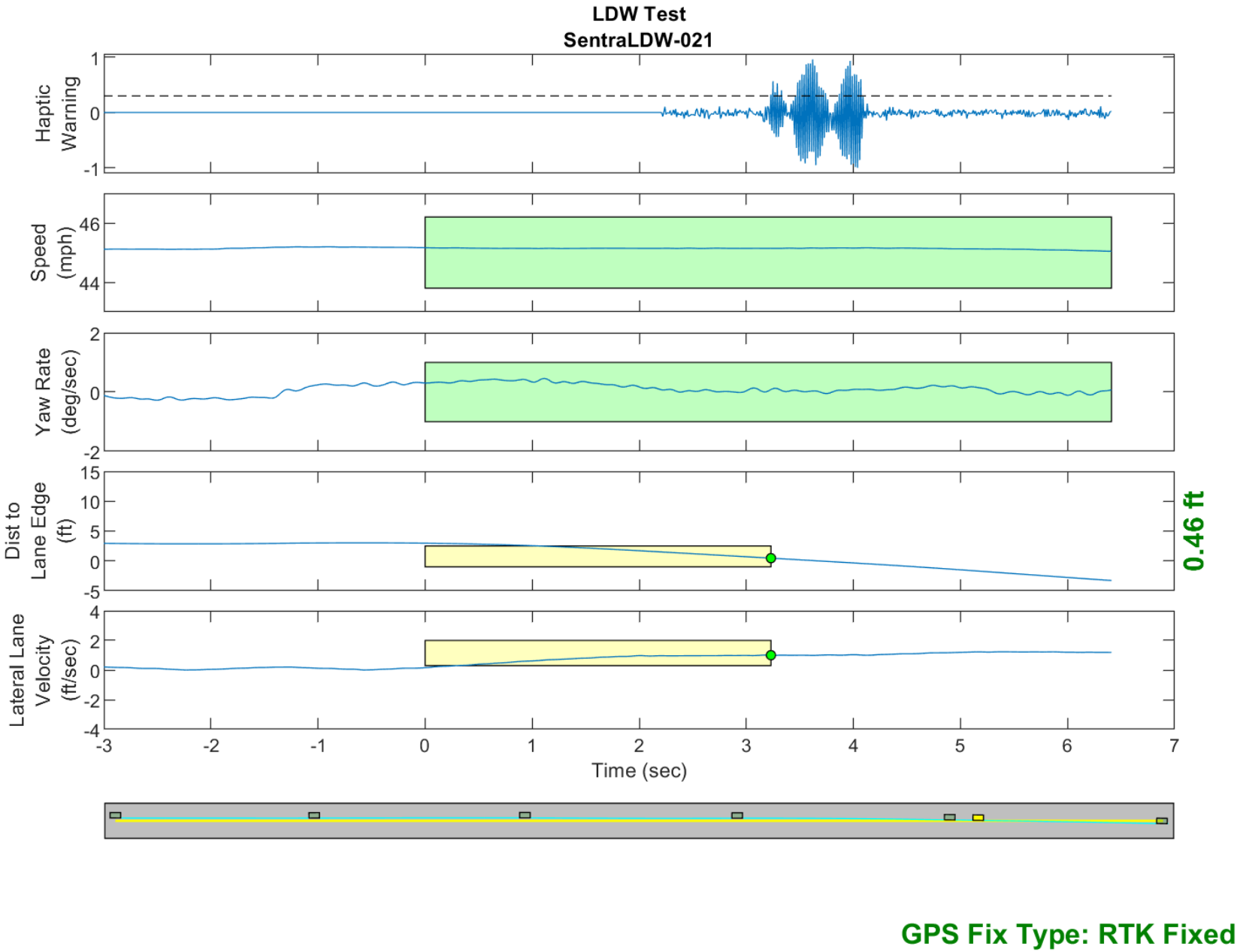

Figure D43. Time History for Run 21, Dashed Line, Right Departure, Haptic Warning

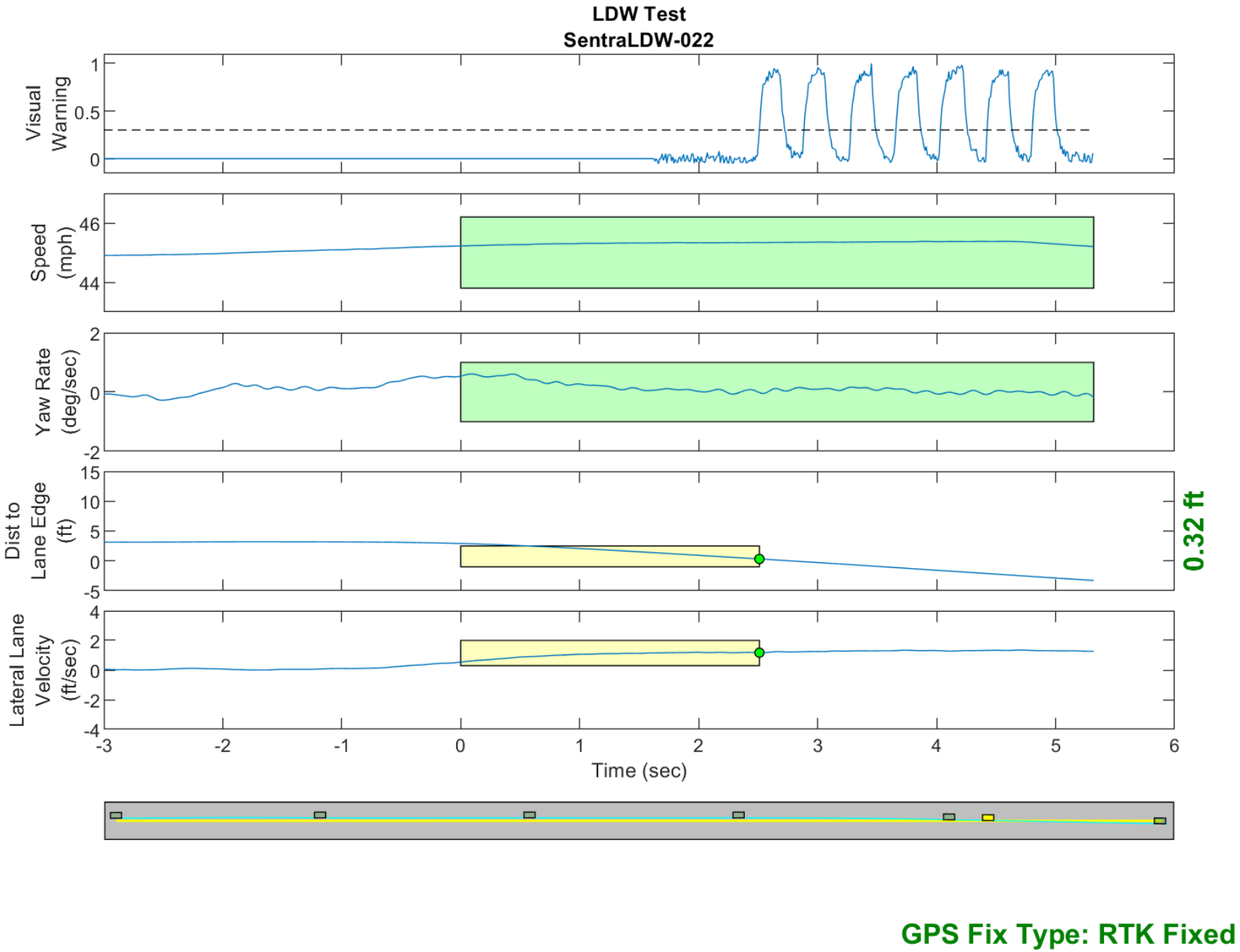

Figure D44. Time History for Run 22, Dashed Line, Right Departure, Visual Warning

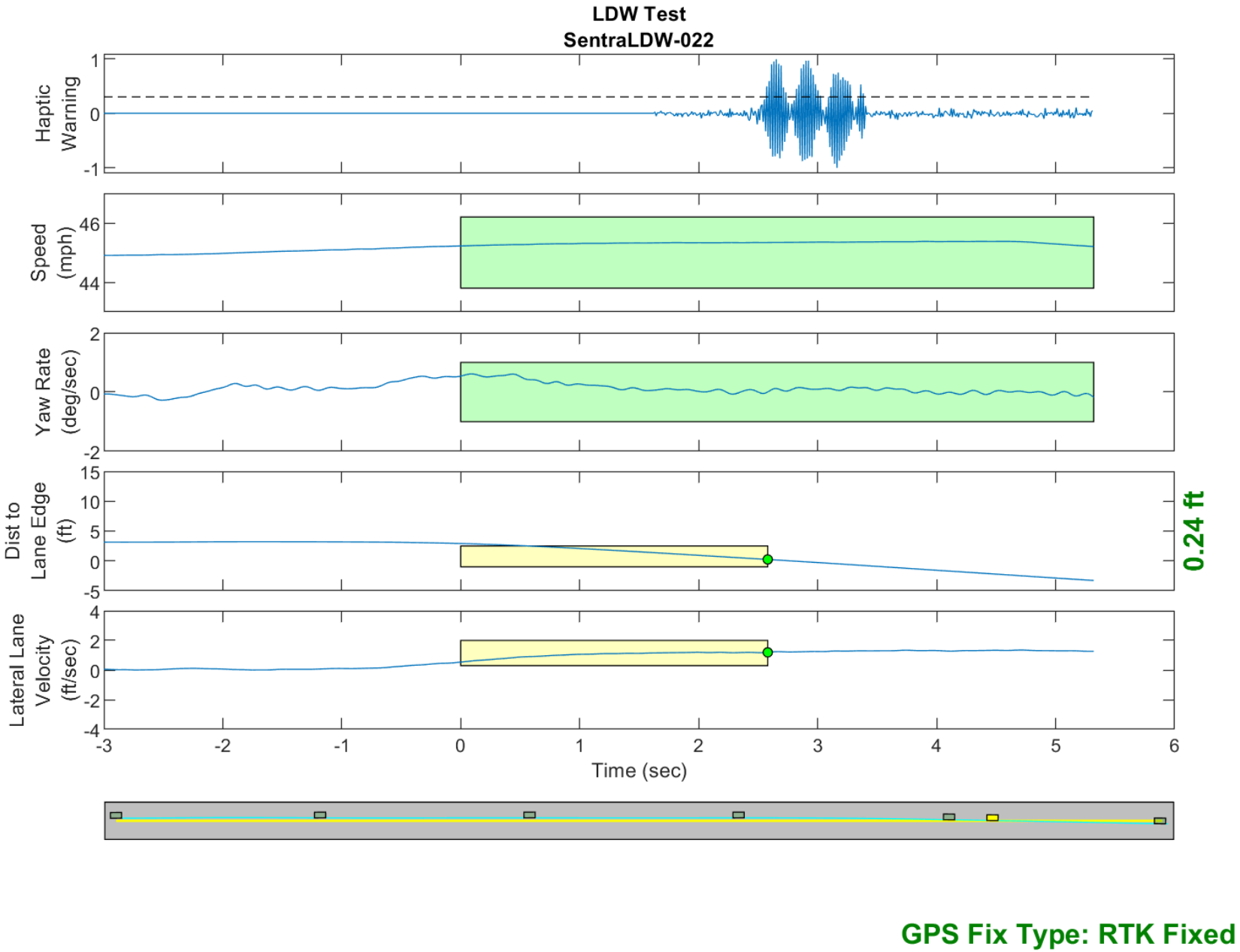

Figure D45. Time History for Run 22, Dashed Line, Right Departure, Haptic Warning

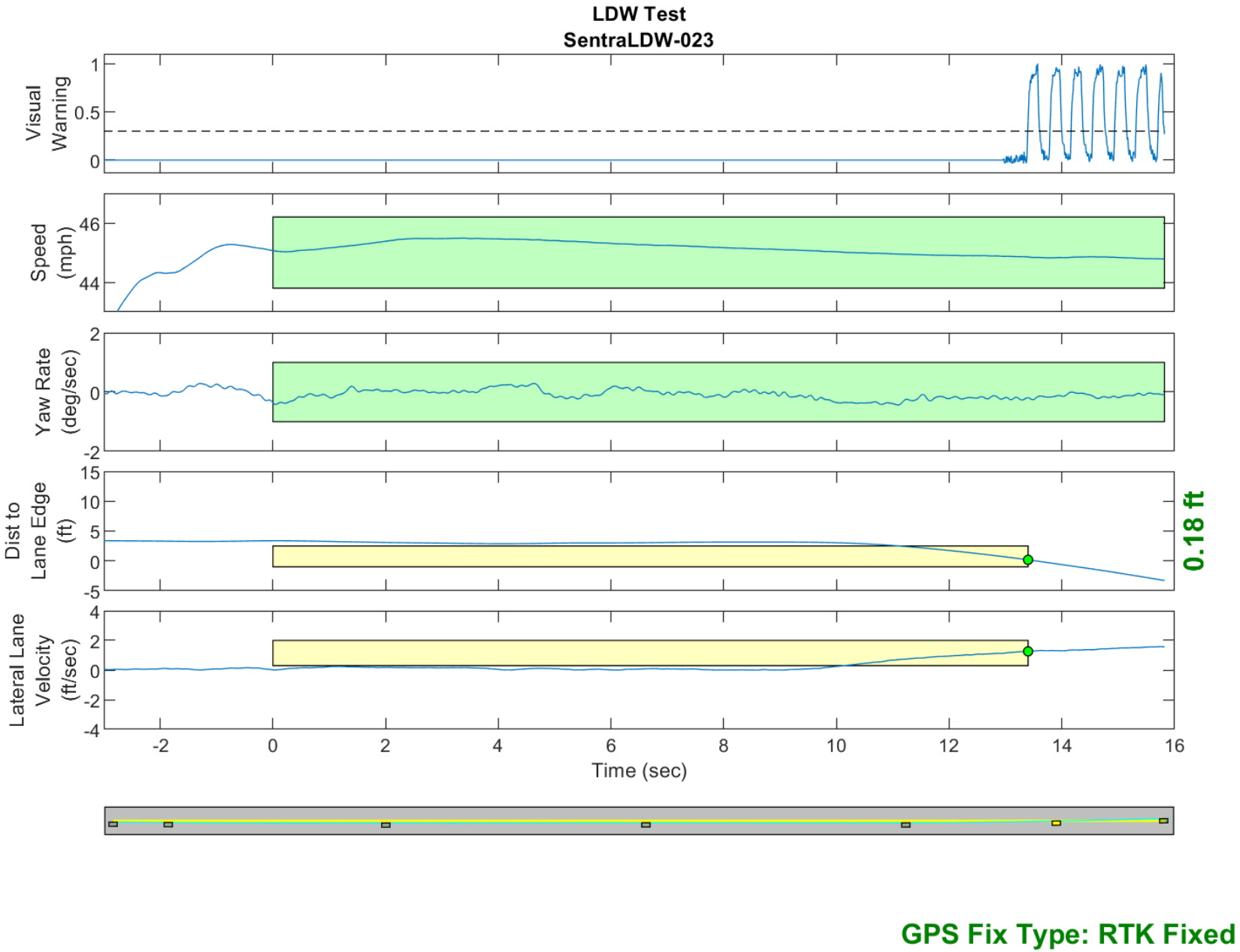

Figure D46. Time History for Run 23, Dashed Line, Left Departure, Visual Warning

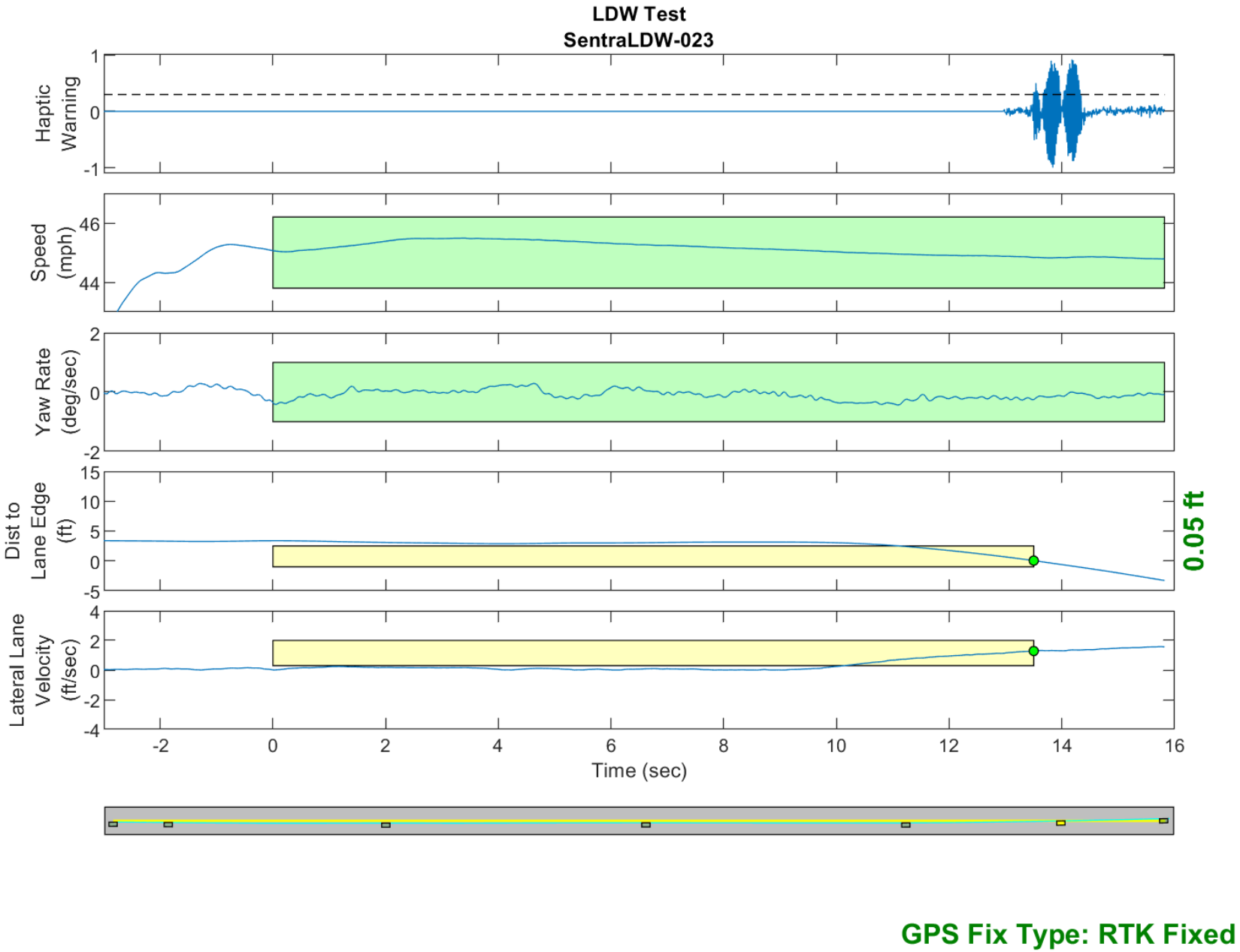

Figure D47. Time History for Run 23, Dashed Line, Left Departure, Haptic Warning

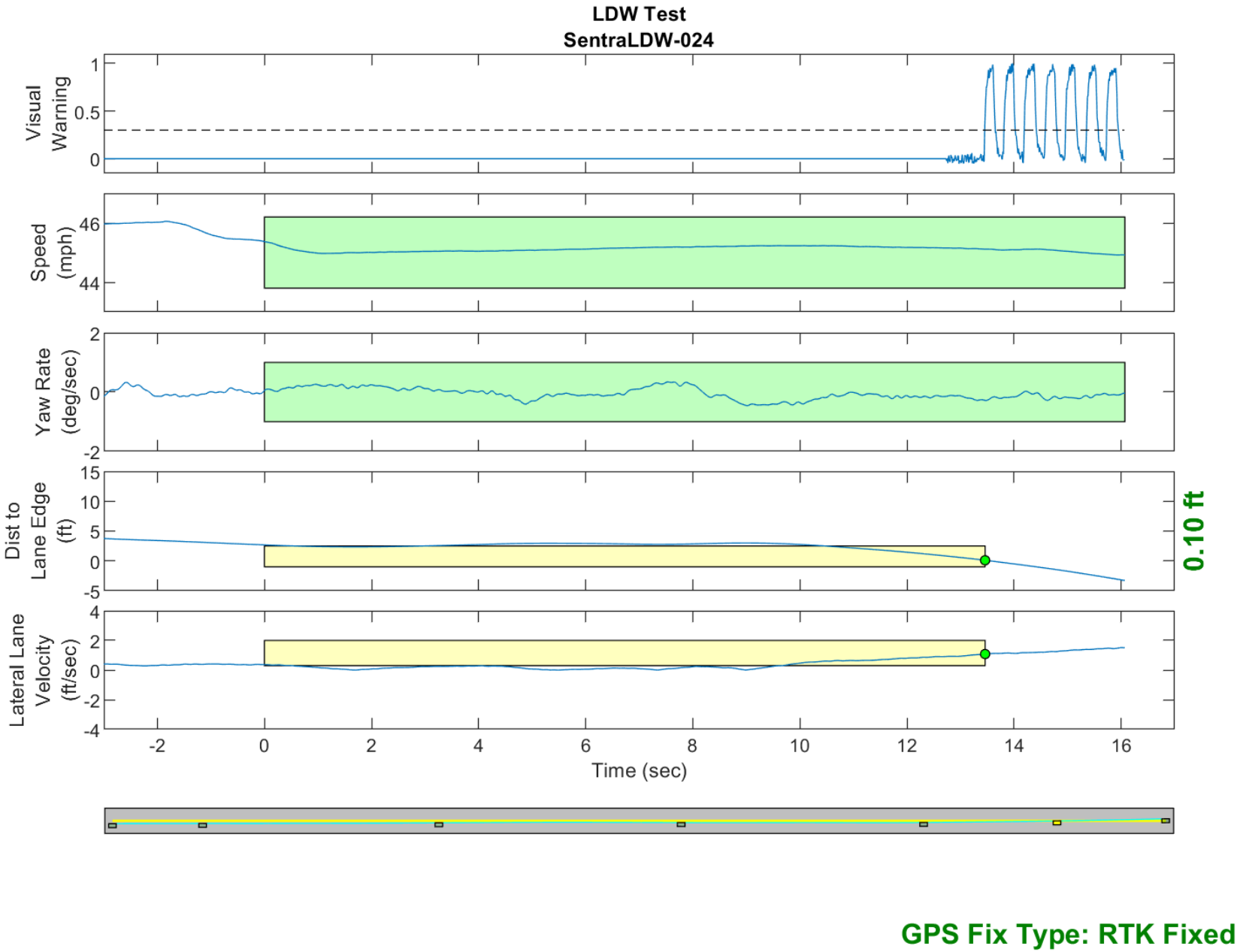

Figure D48. Time History for Run 24, Dashed Line, Left Departure, Visual Warning

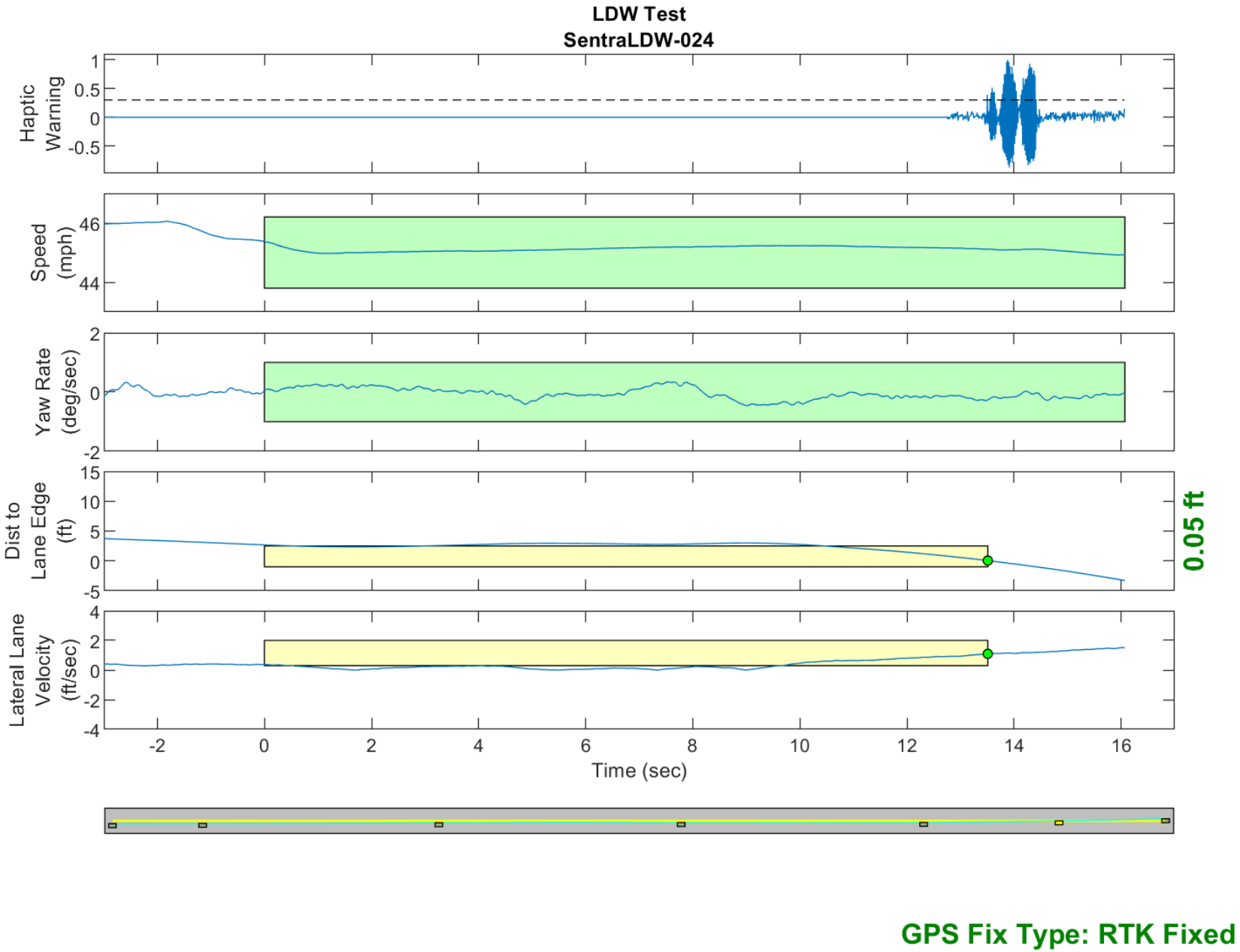

Figure D49. Time History for Run 24, Dashed Line, Left Departure, Haptic Warning

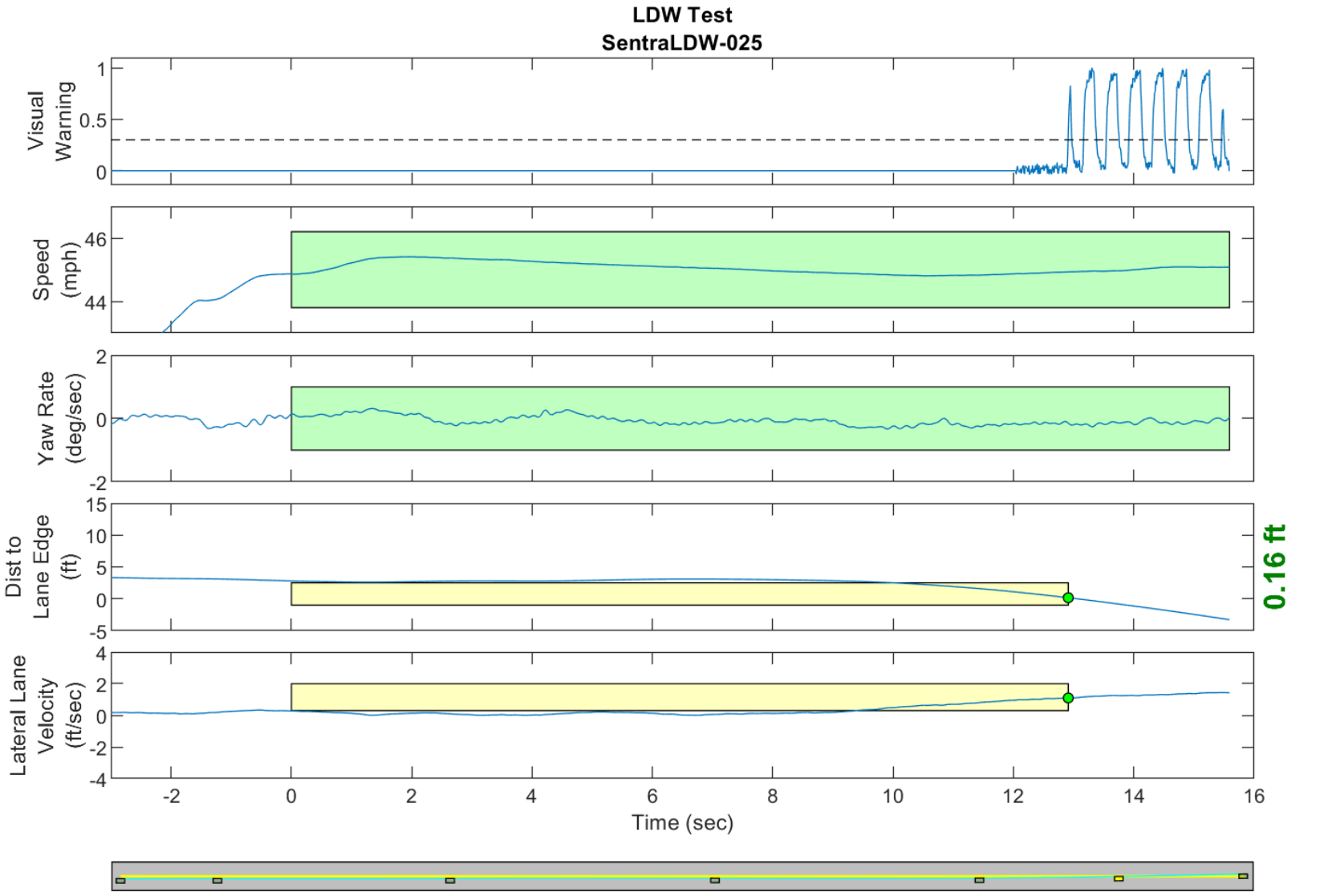

Figure D50. Time History for Run 25, Dashed Line, Left Departure, Visual Warning

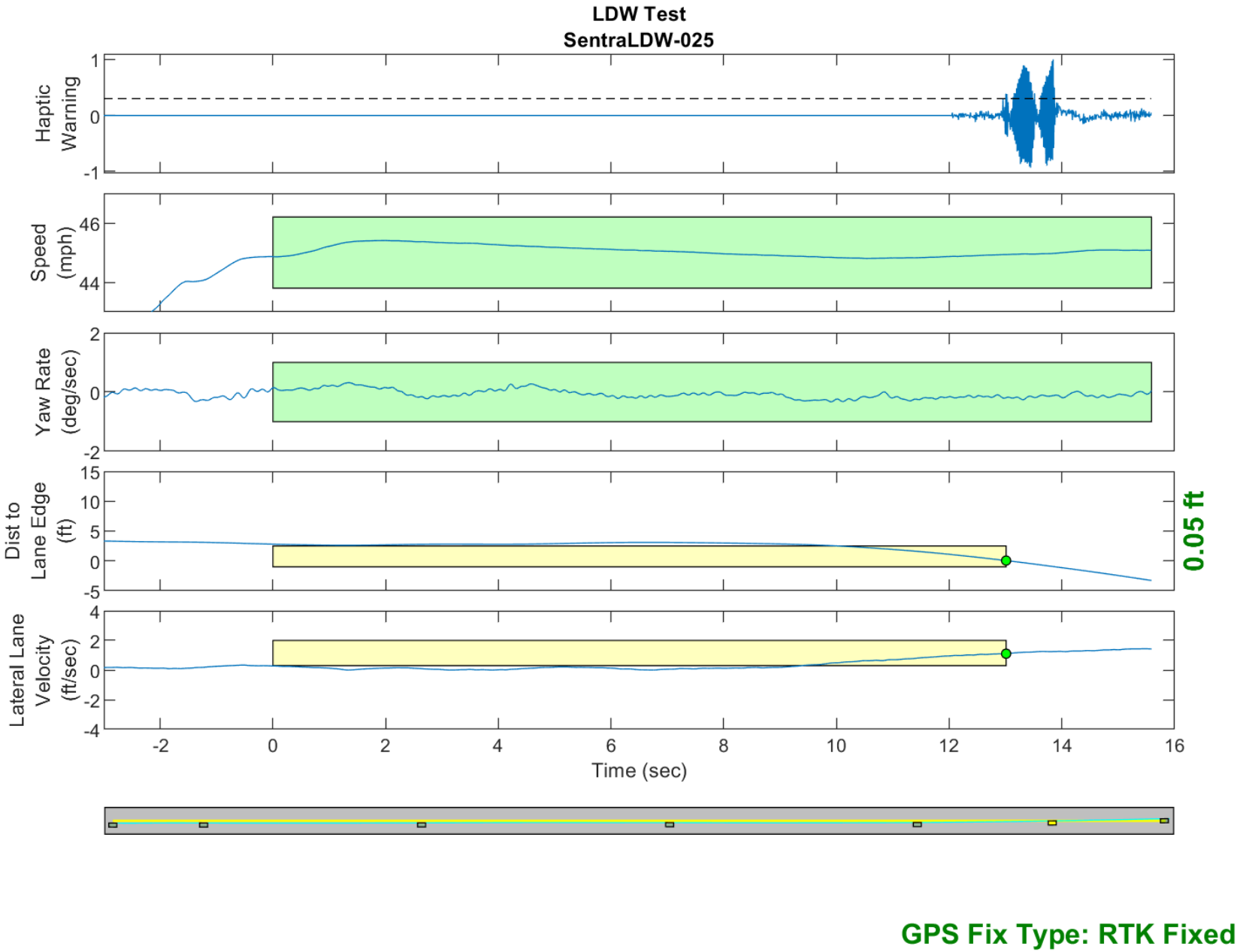

Figure D51. Time History for Run 25, Dashed Line, Left Departure, Haptic Warning

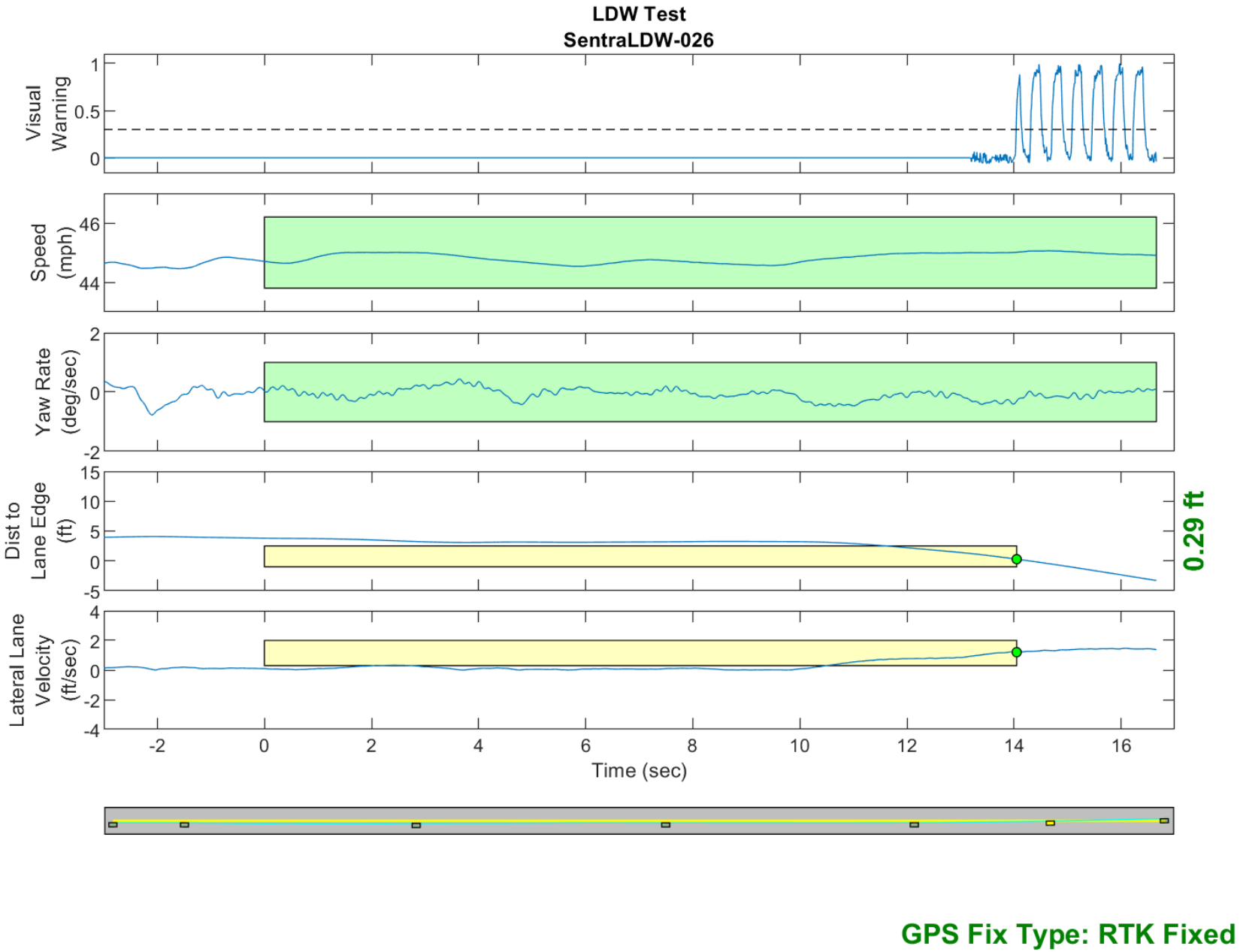

Figure D52. Time History for Run 26, Dashed Line, Left Departure, Visual Warning

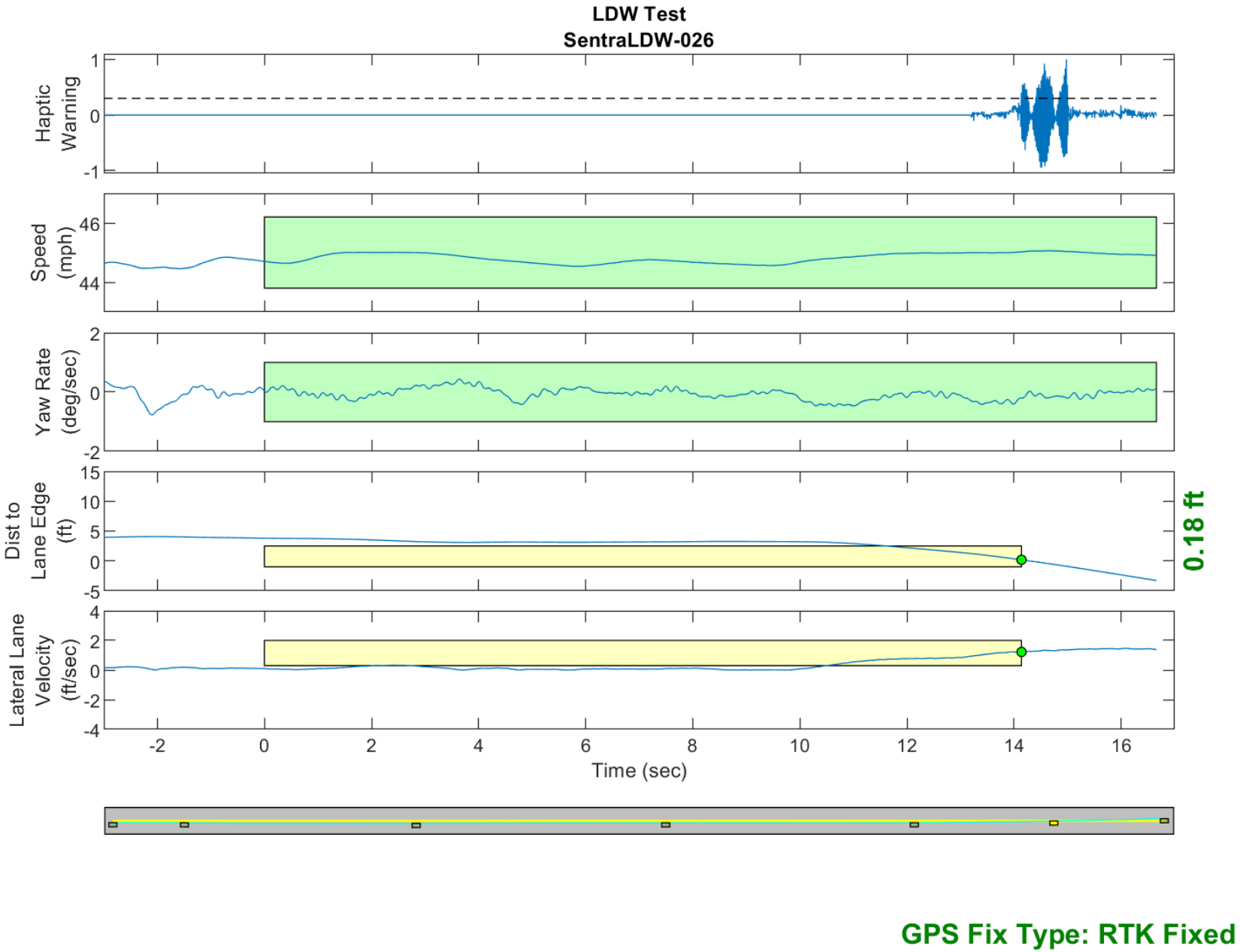

Figure D53. Time History for Run 26, Dashed Line, Left Departure, Haptic Warning

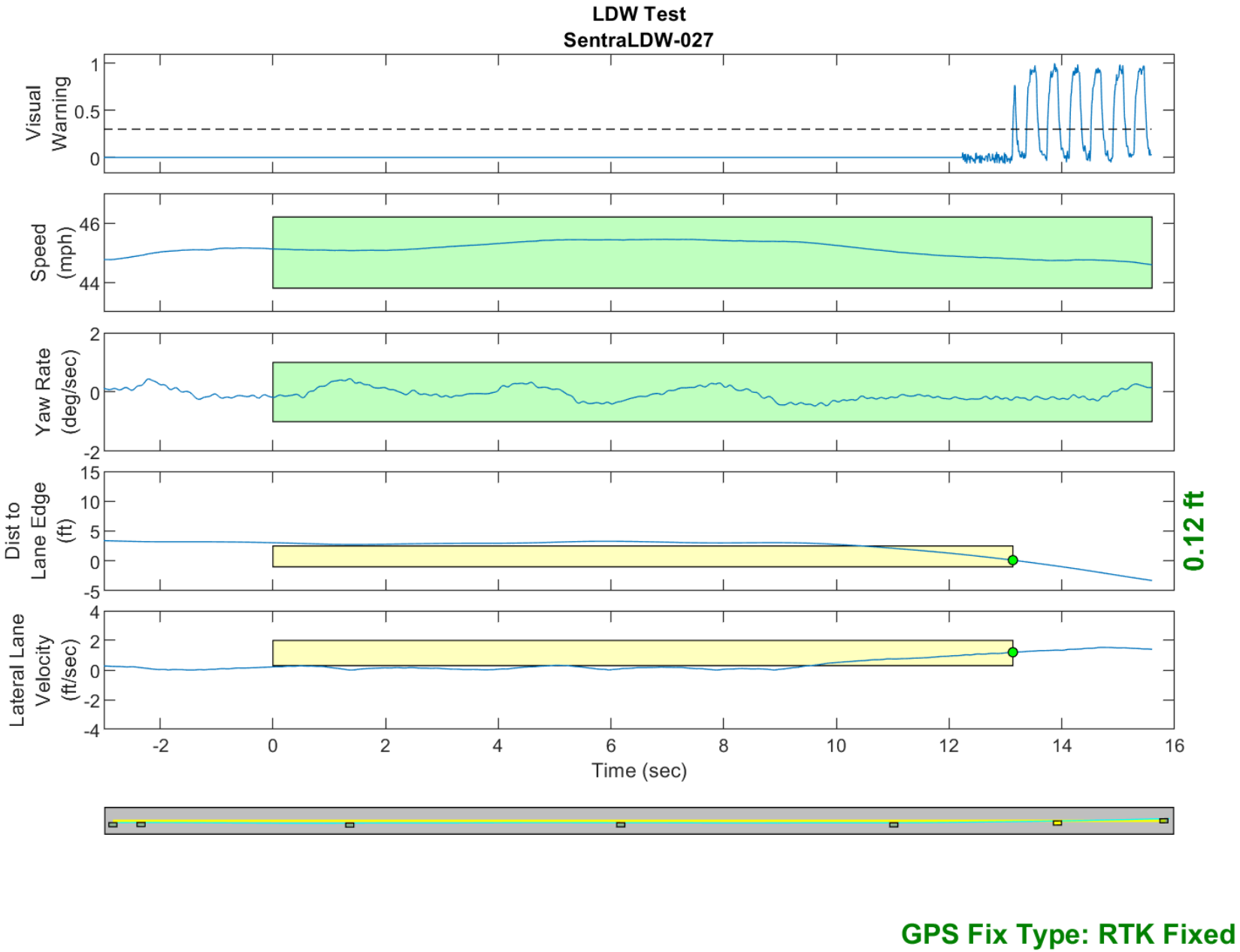

Figure D54. Time History for Run 27, Dashed Line, Left Departure, Visual Warning

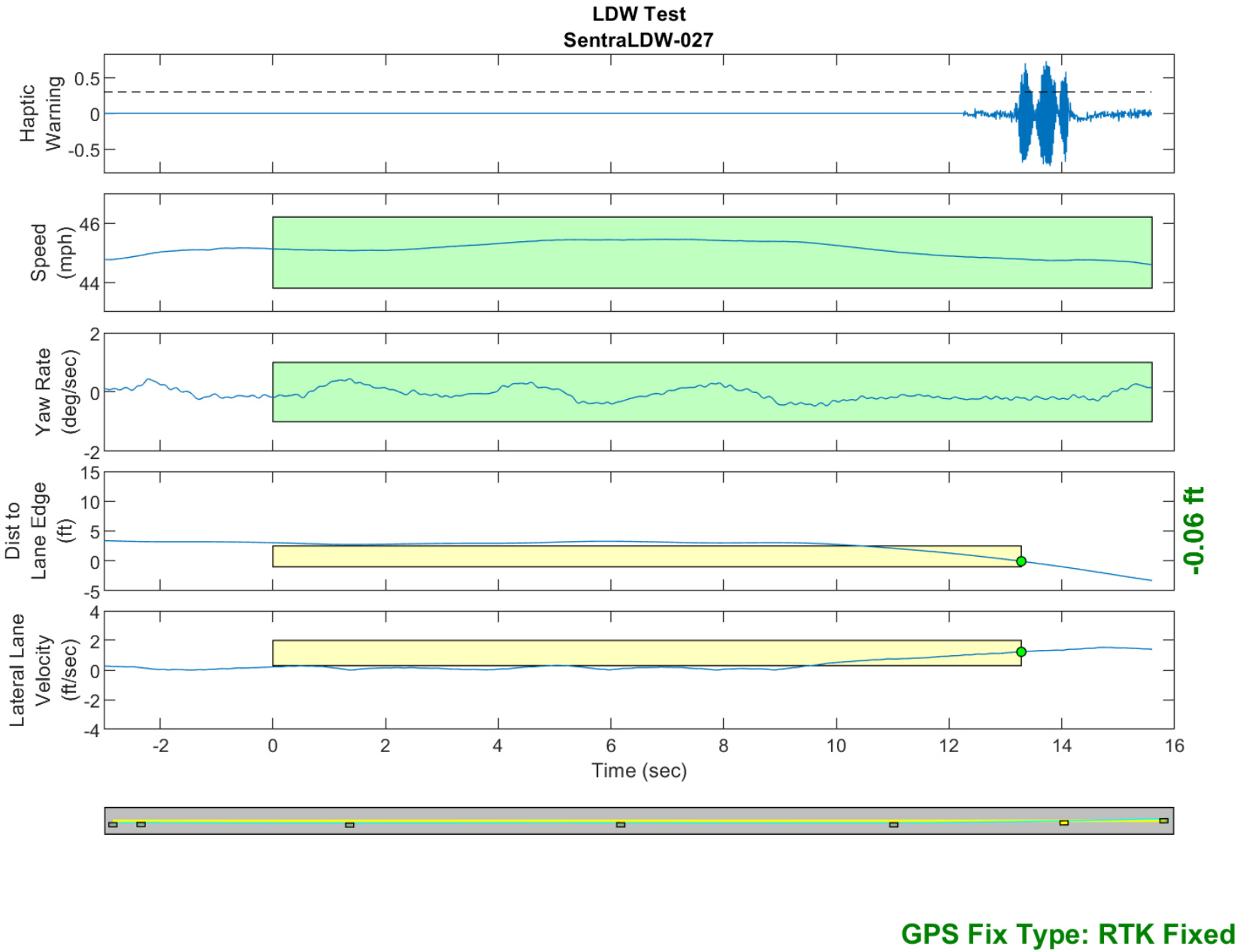

Figure D55. Time History for Run 27, Dashed Line, Left Departure, Haptic Warning

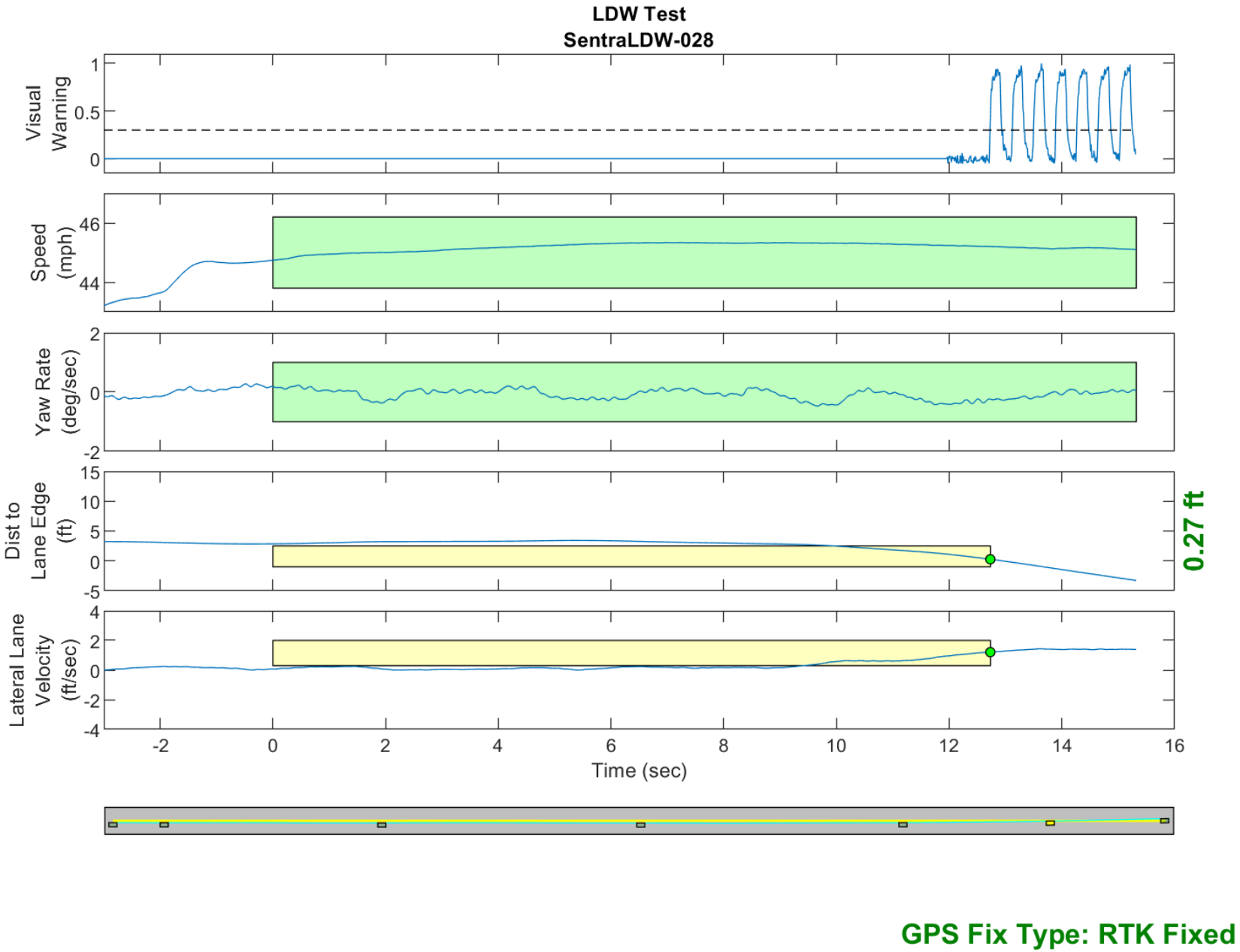

Figure D56. Time History for Run 28, Dashed Line, Left Departure, Visual Warning

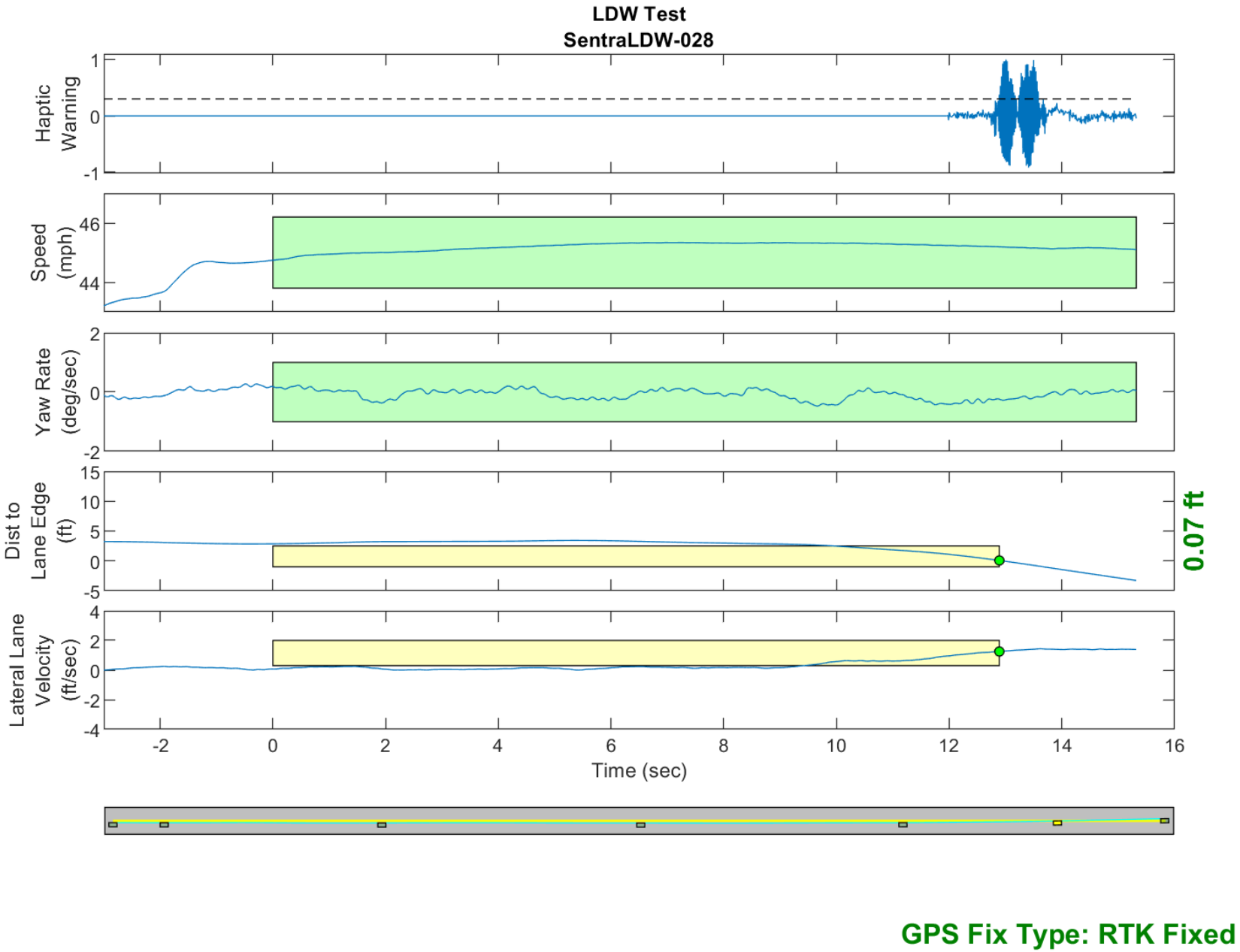

Figure D57. Time History for Run 28, Dashed Line, Left Departure, Haptic Warning

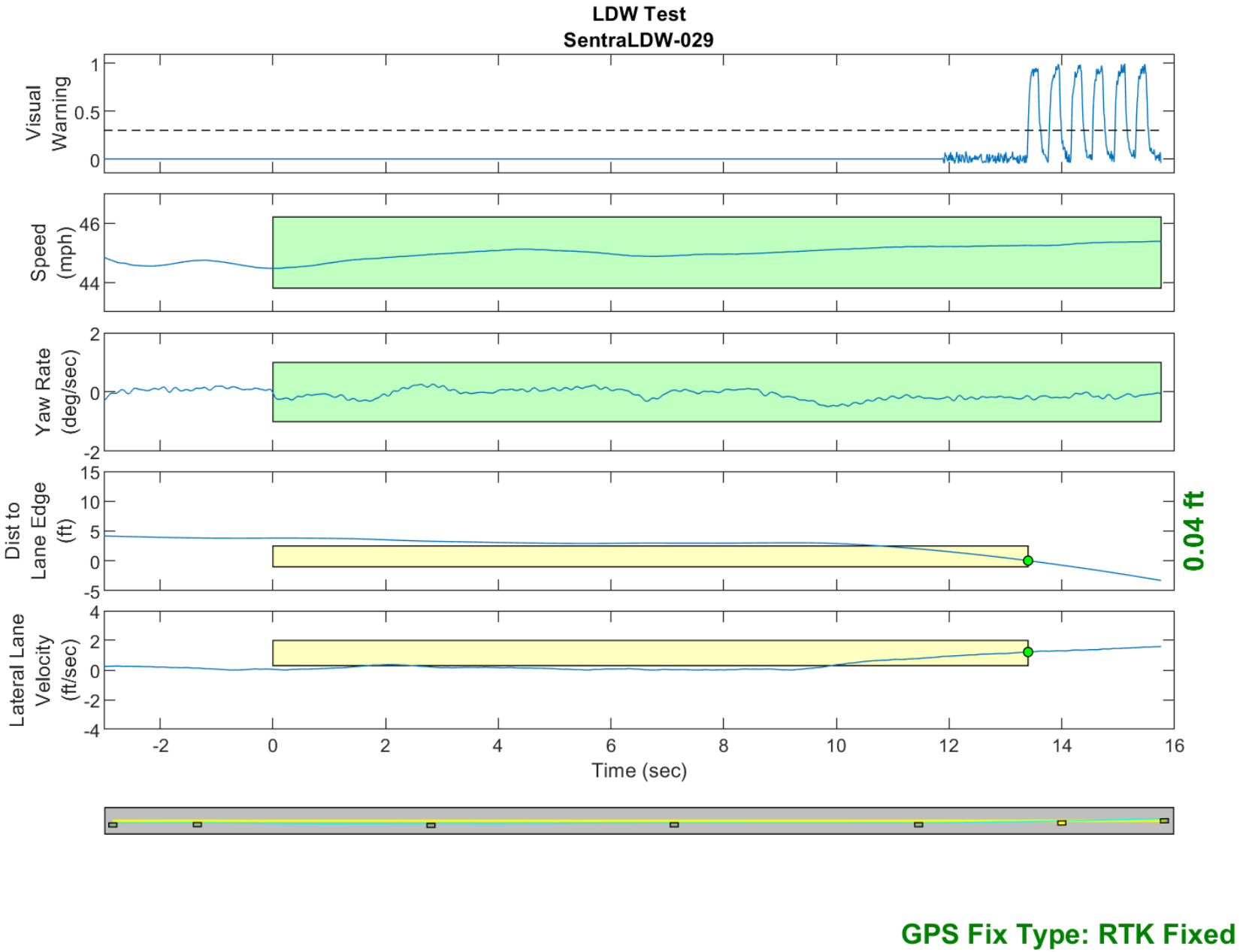

Figure D58. Time History for Run 29, Dashed Line, Left Departure, Visual Warning

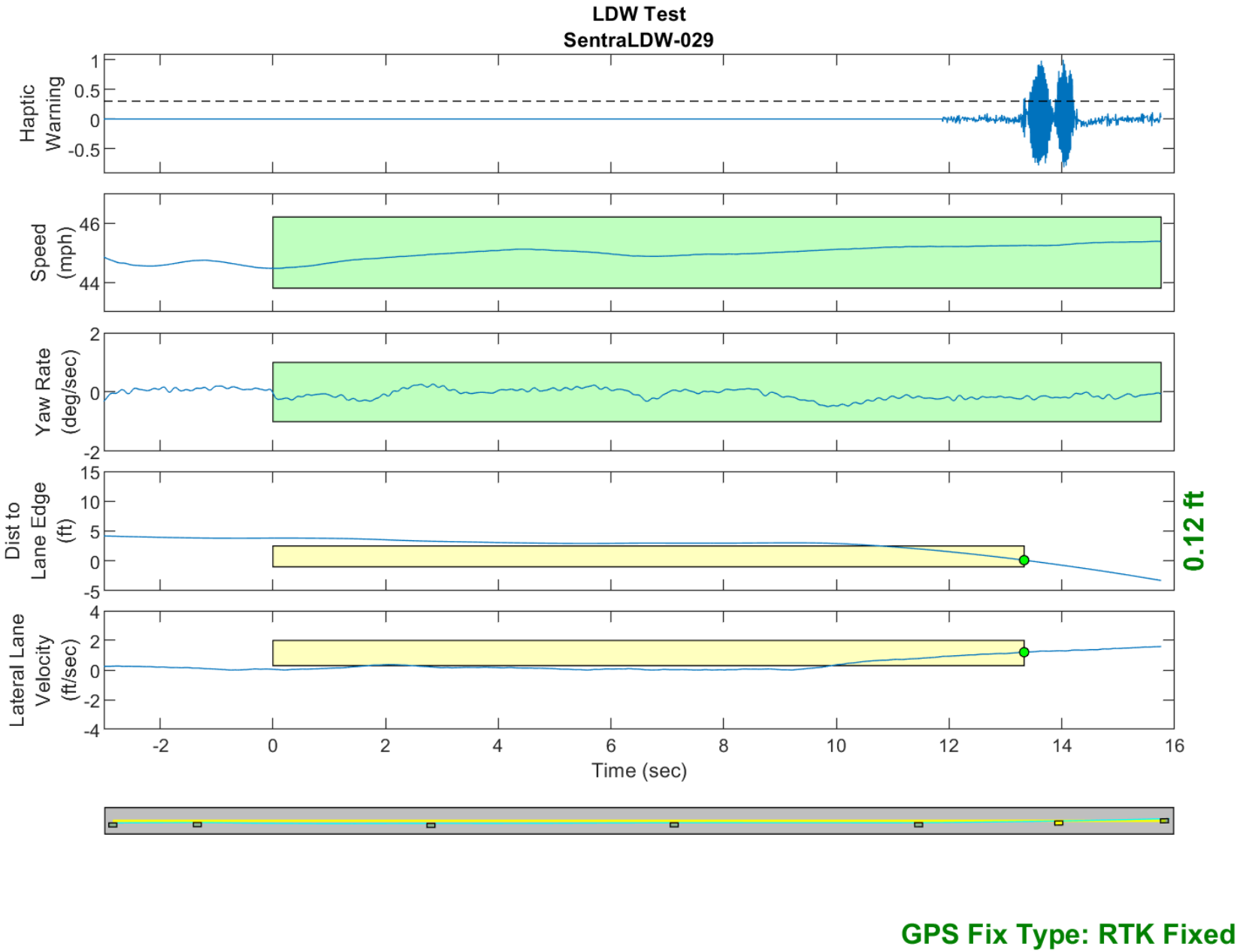

Figure D59. Time History for Run 29, Dashed Line, Left Departure, Haptic Warning

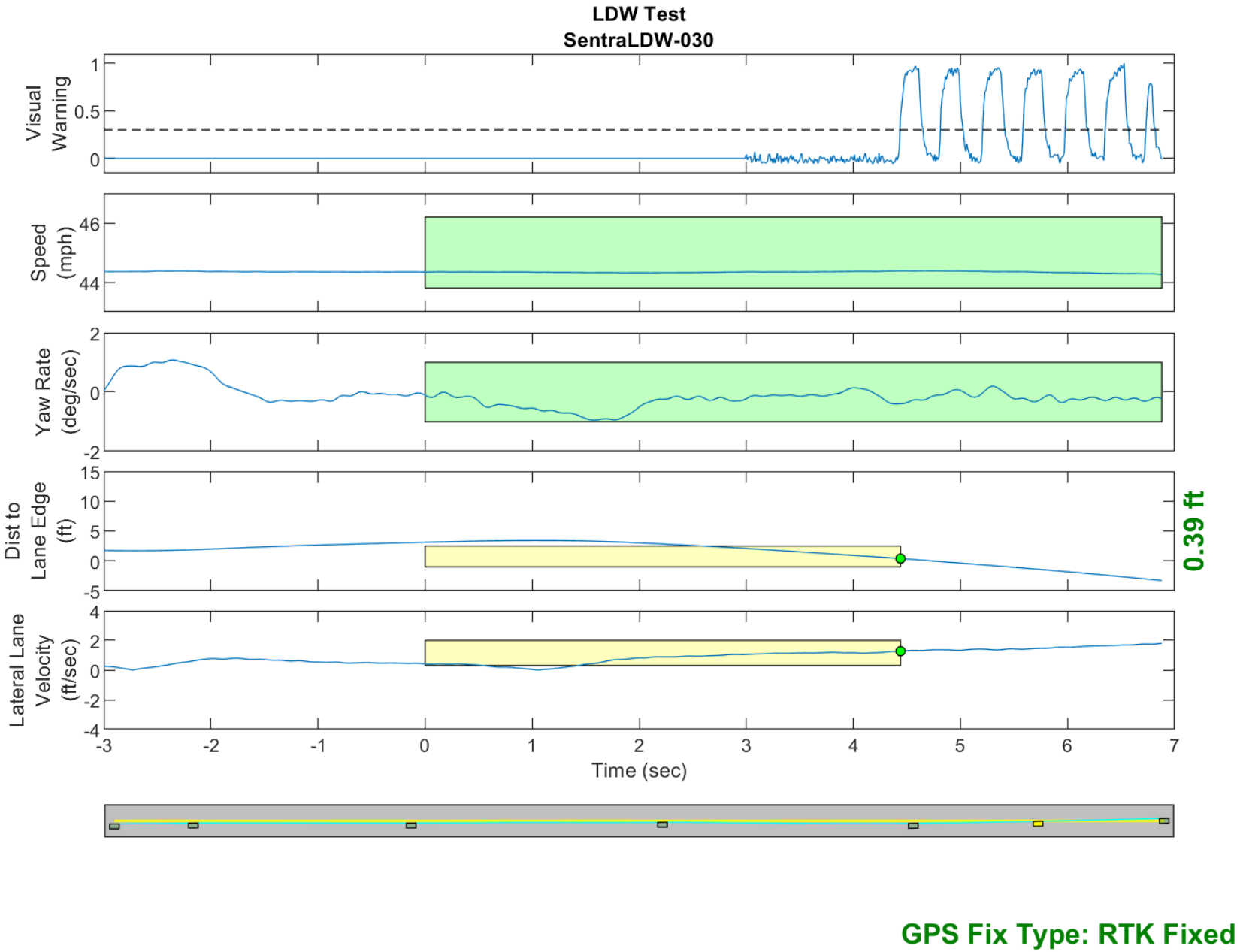

Figure D60. Time History for Run 30, Botts Dots, Left Departure, Visual Warning

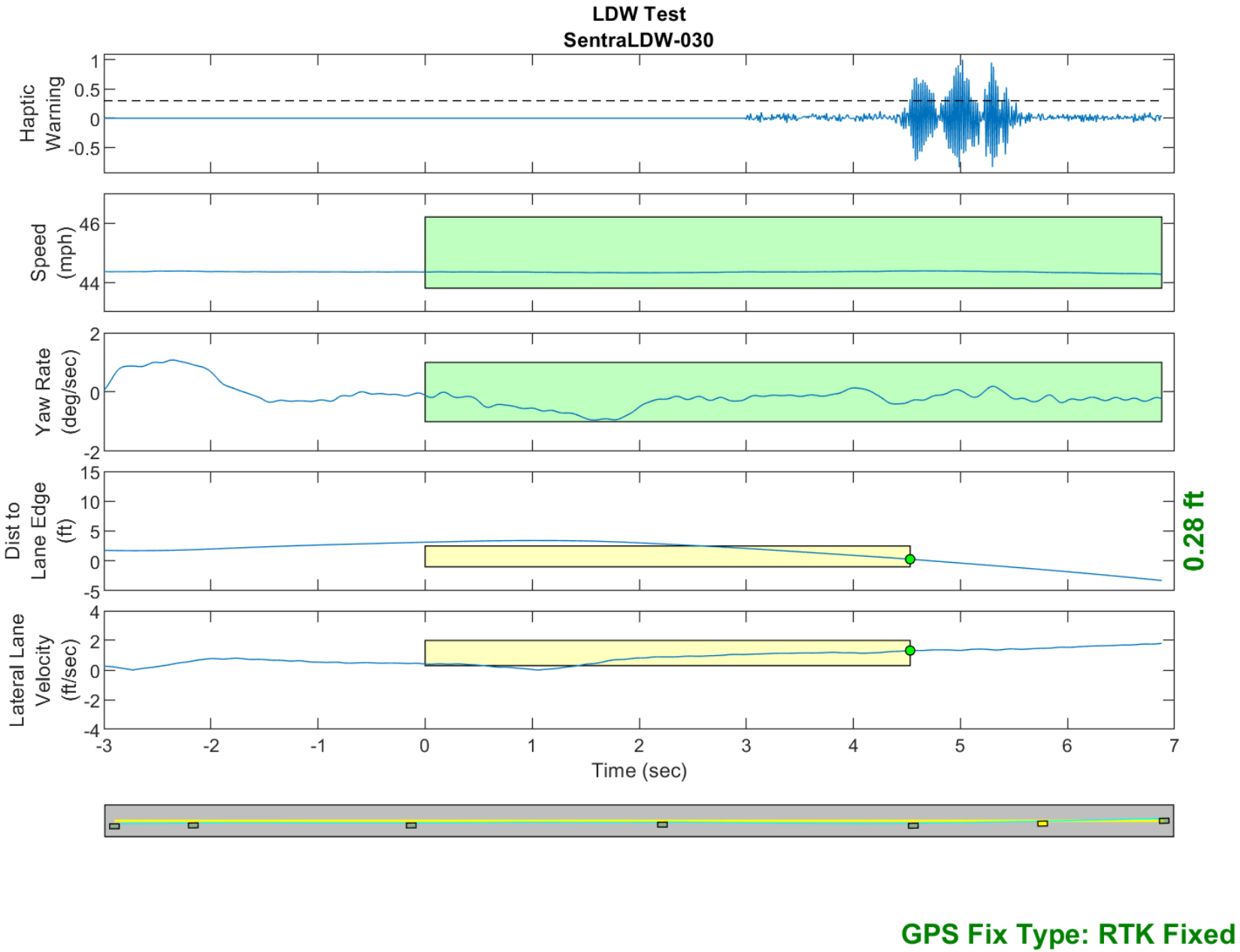

Figure D61. Time History for Run 30, Botts Dots, Left Departure, Haptic Warning

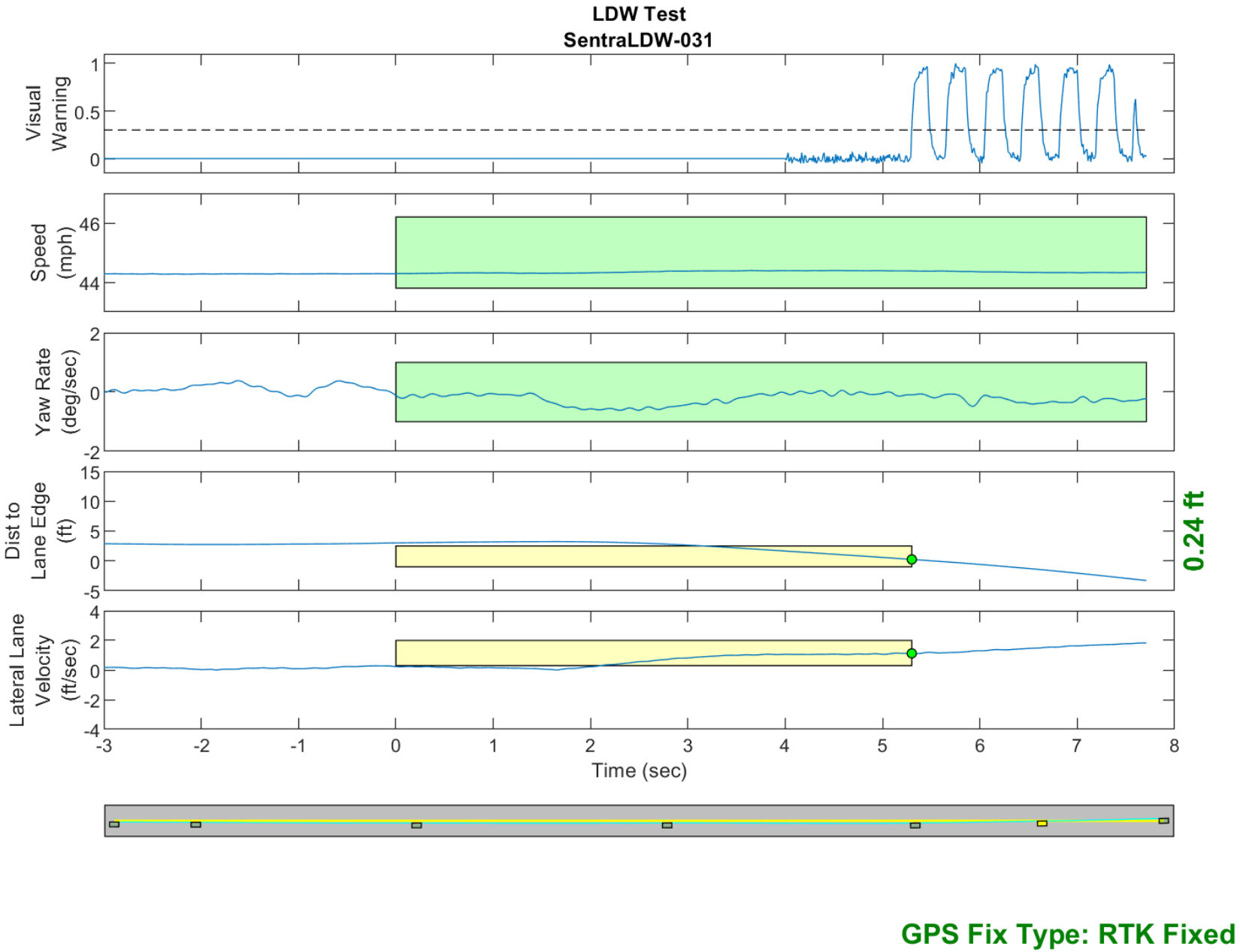

Figure D62. Time History for Run 31, Botts Dots, Left Departure, Visual Warning

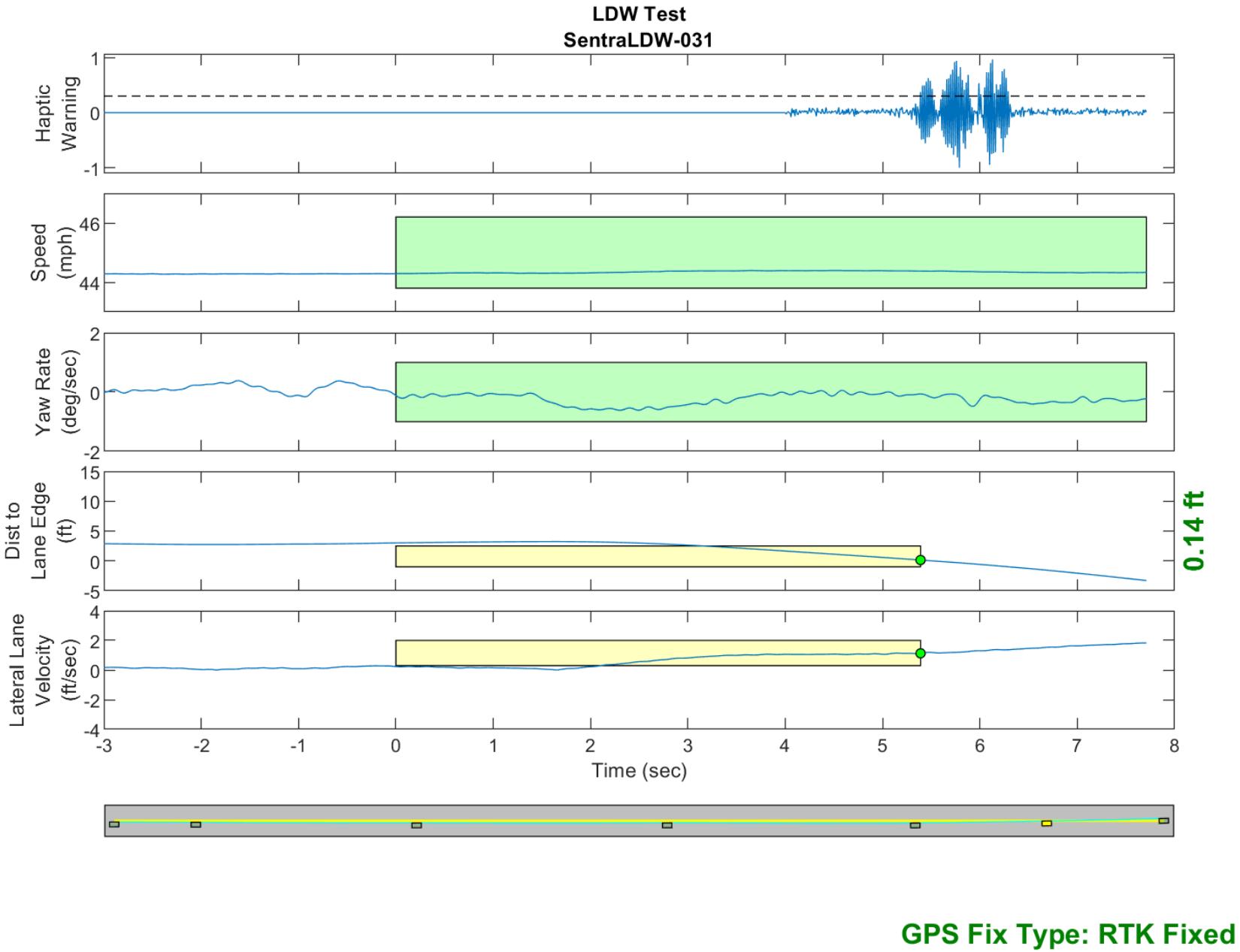

Figure D63. Time History for Run 31, Botts Dots, Left Departure, Haptic Warning

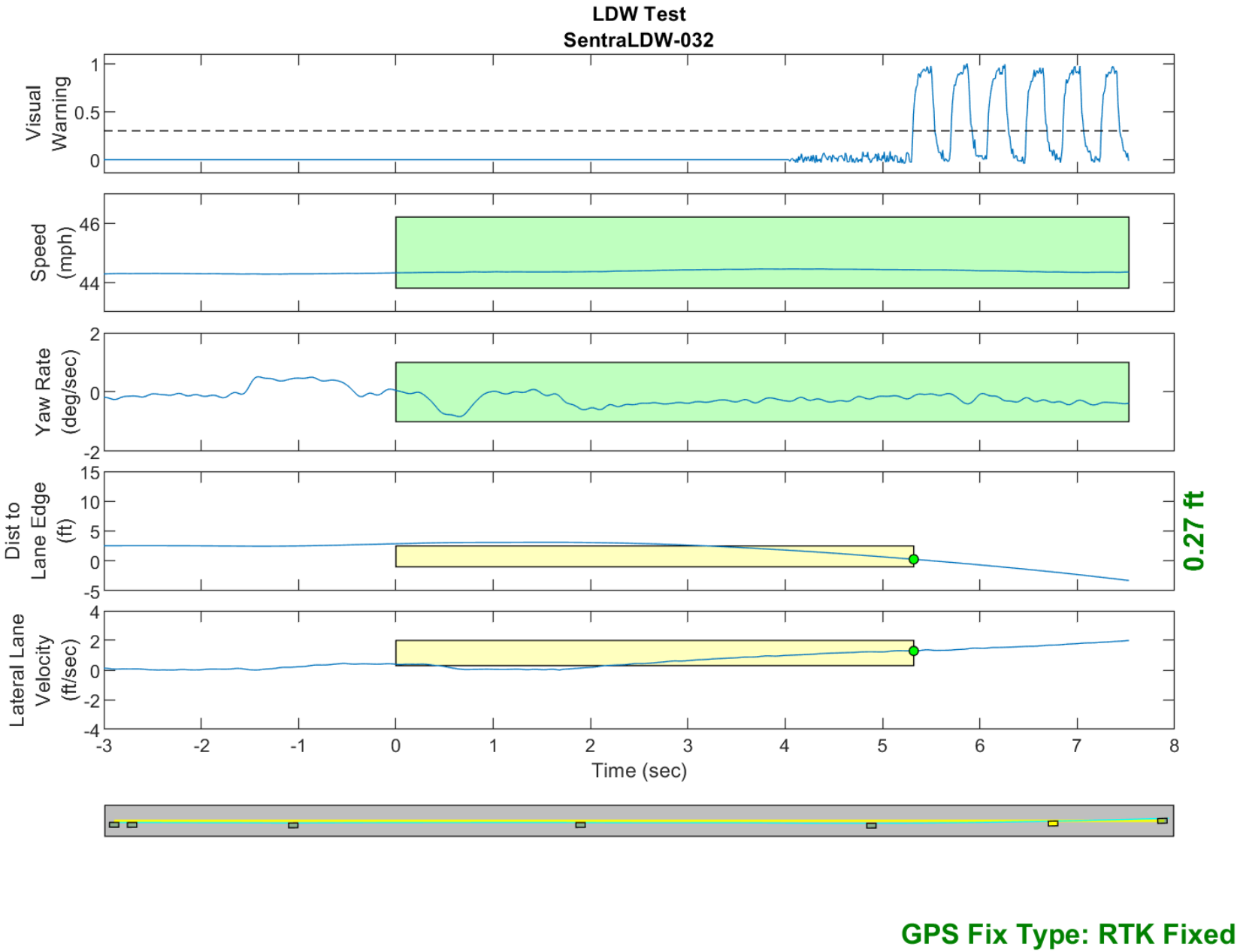

Figure D64. Time History for Run 32, Botts Dots, Left Departure, Visual Warning

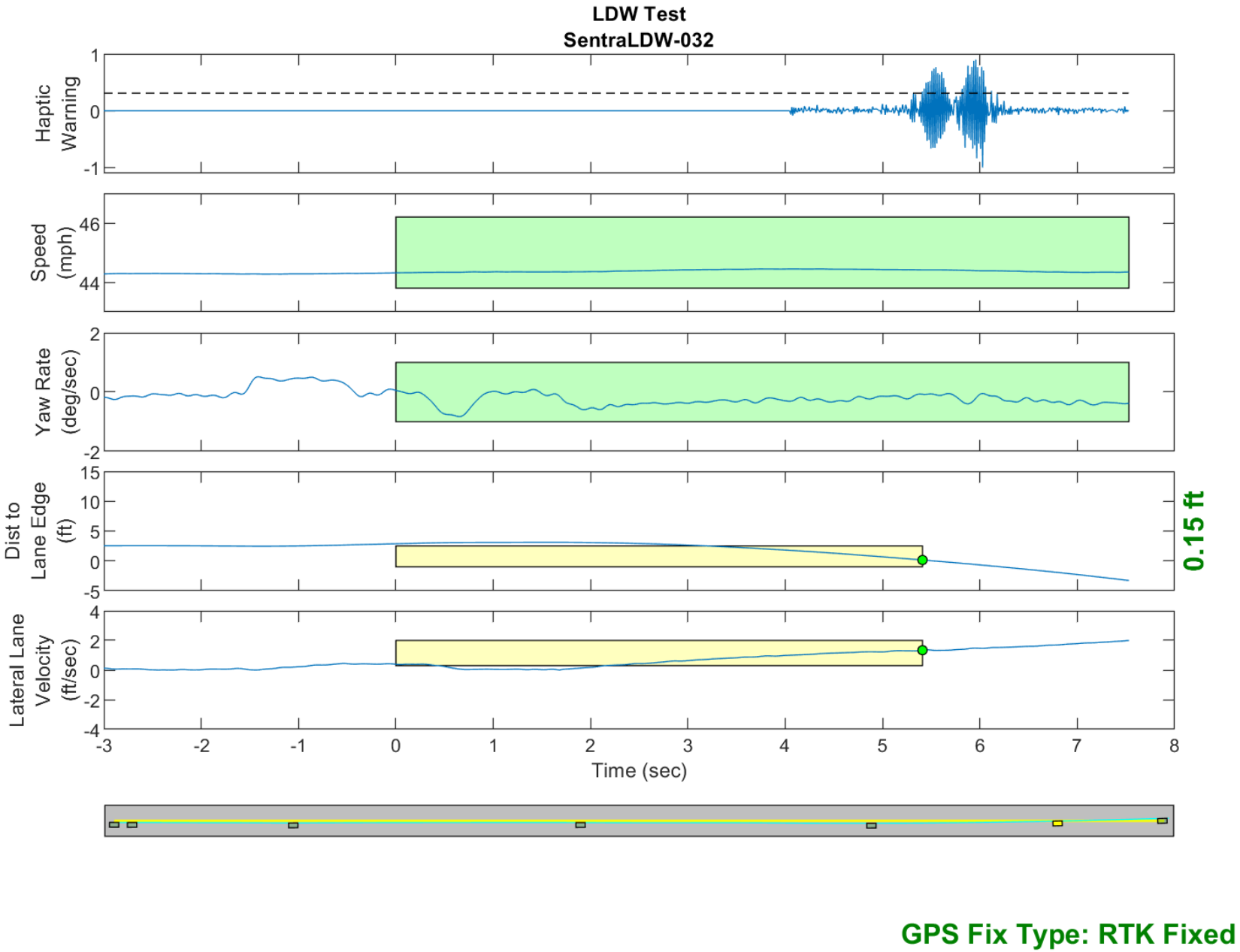

Figure D65. Time History for Run 32, Botts Dots, Left Departure, Haptic Warning

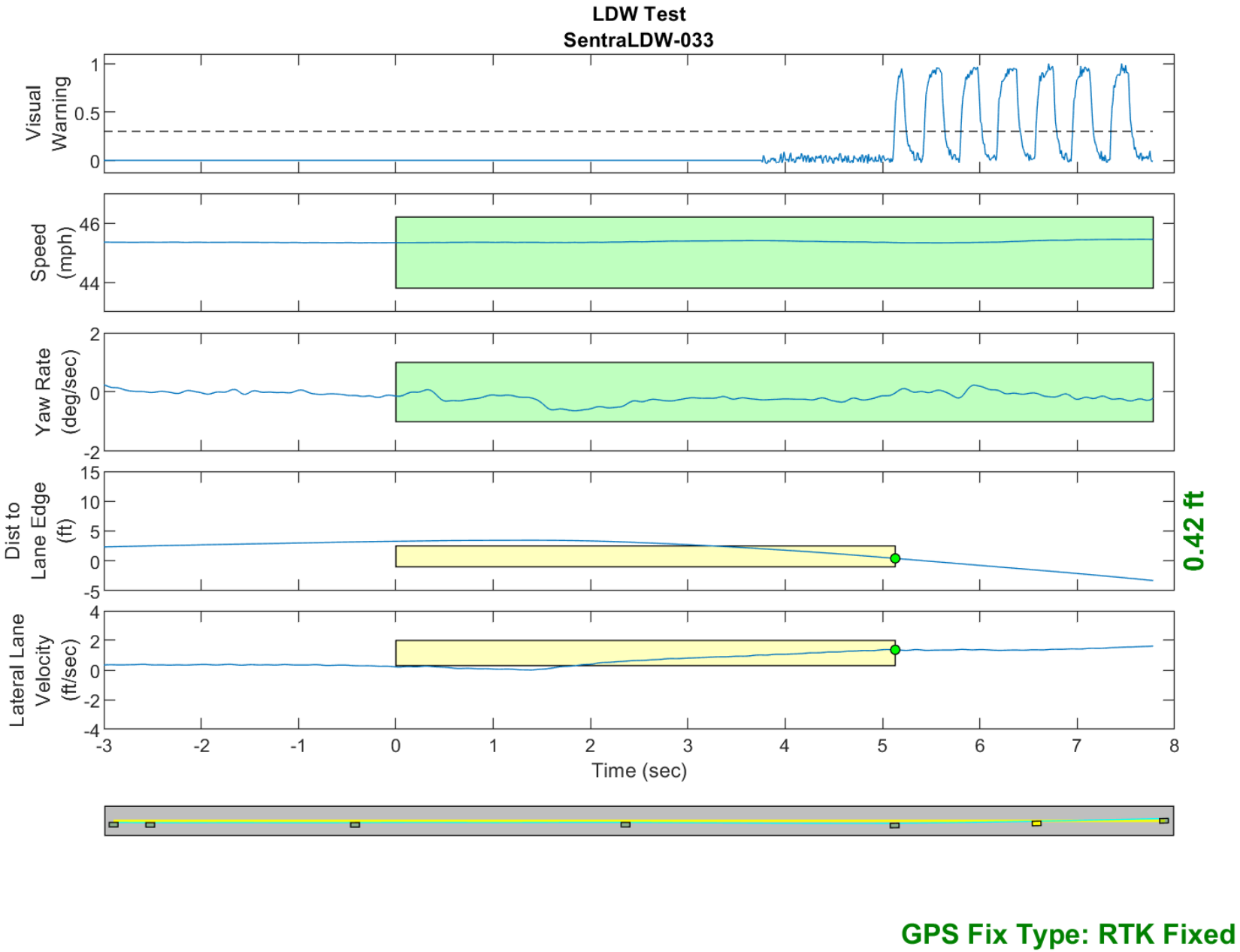

Figure D66. Time History for Run 33, Botts Dots, Left Departure, Visual Warning

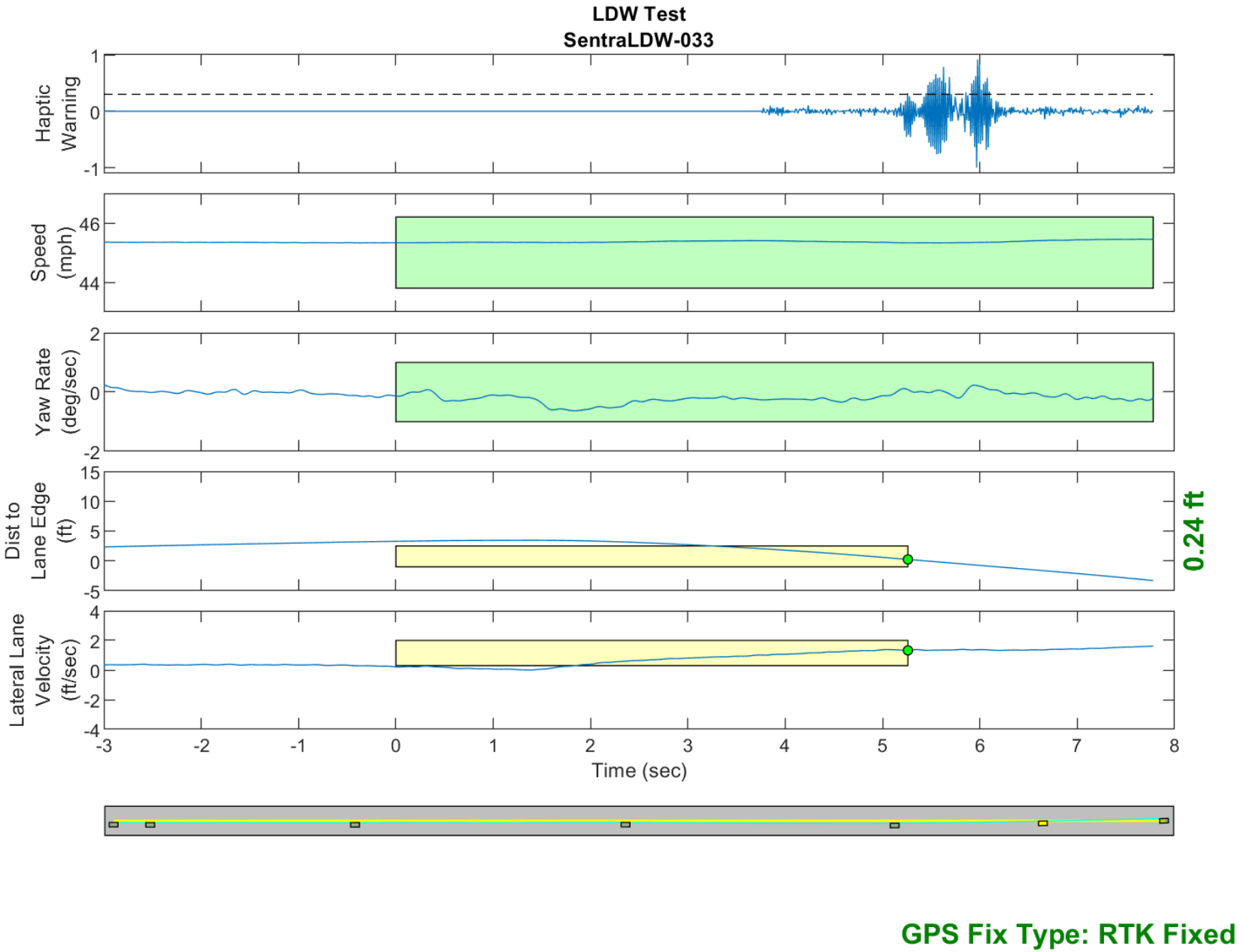

Figure D67. Time History for Run 33, Botts Dots, Left Departure, Haptic Warning

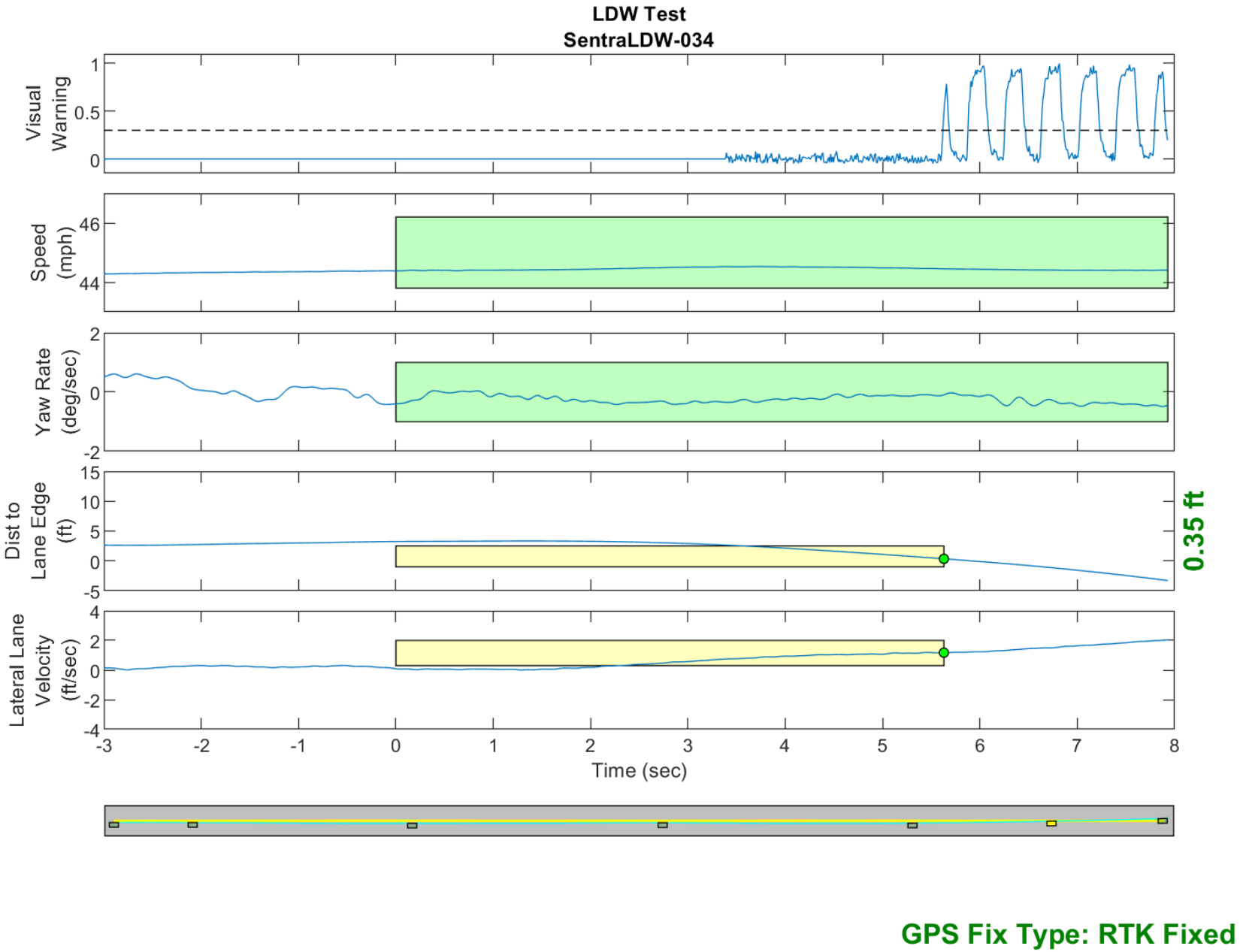

Figure D68. Time History for Run 34, Botts Dots, Left Departure, Visual Warning

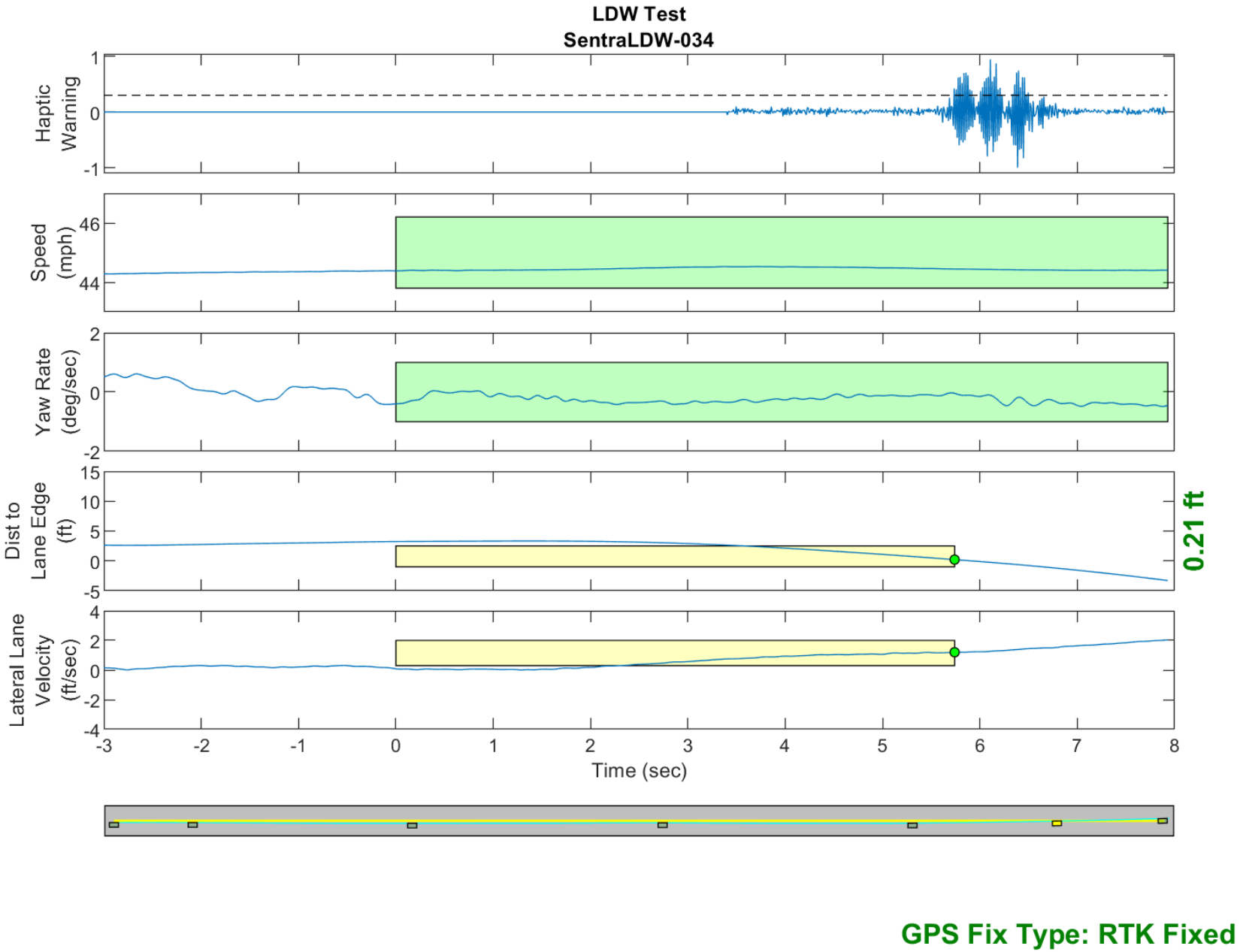

Figure D69. Time History for Run 34, Botts Dots, Left Departure, Haptic Warning

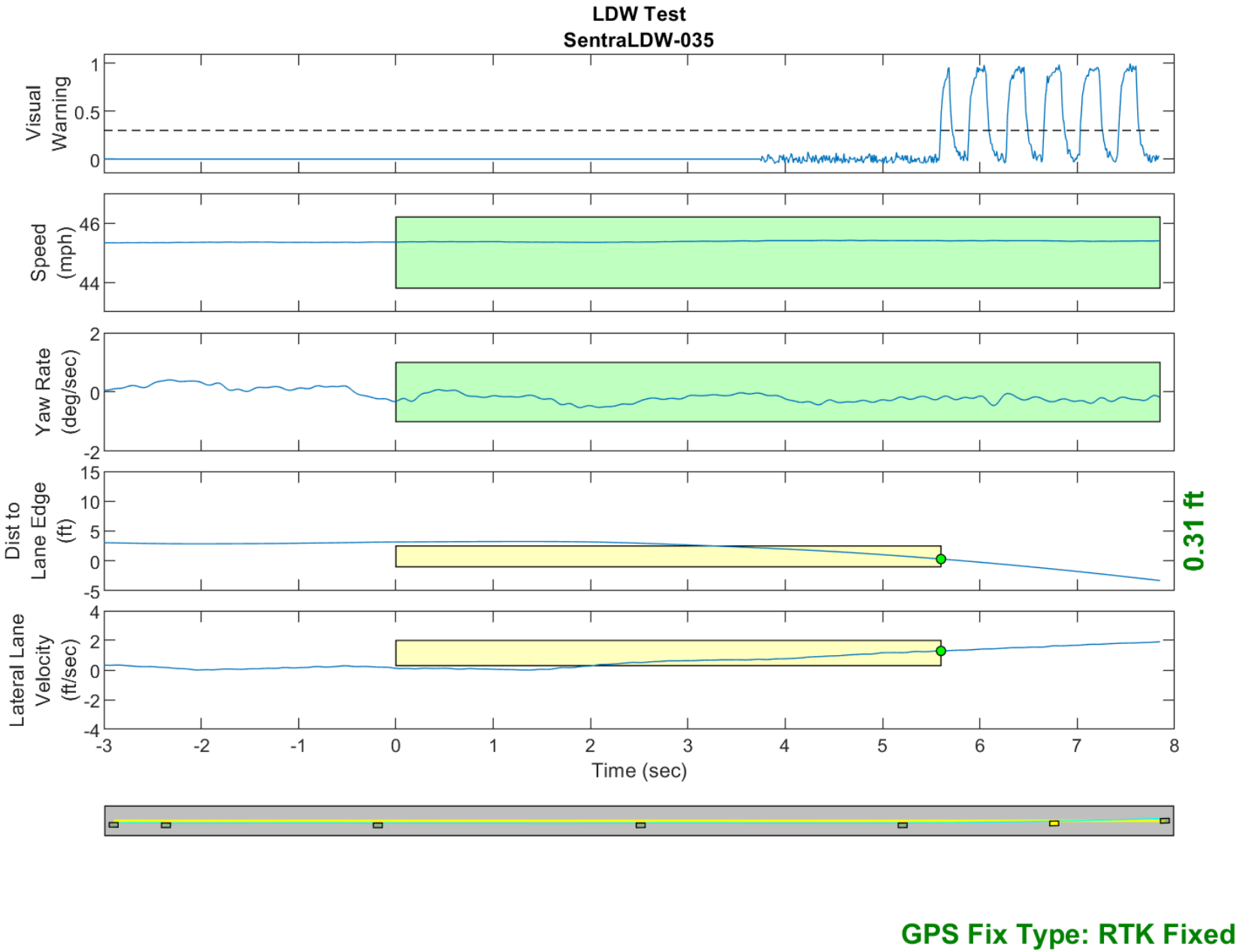

Figure D70. Time History for Run 35, Botts Dots, Left Departure, Visual Warning

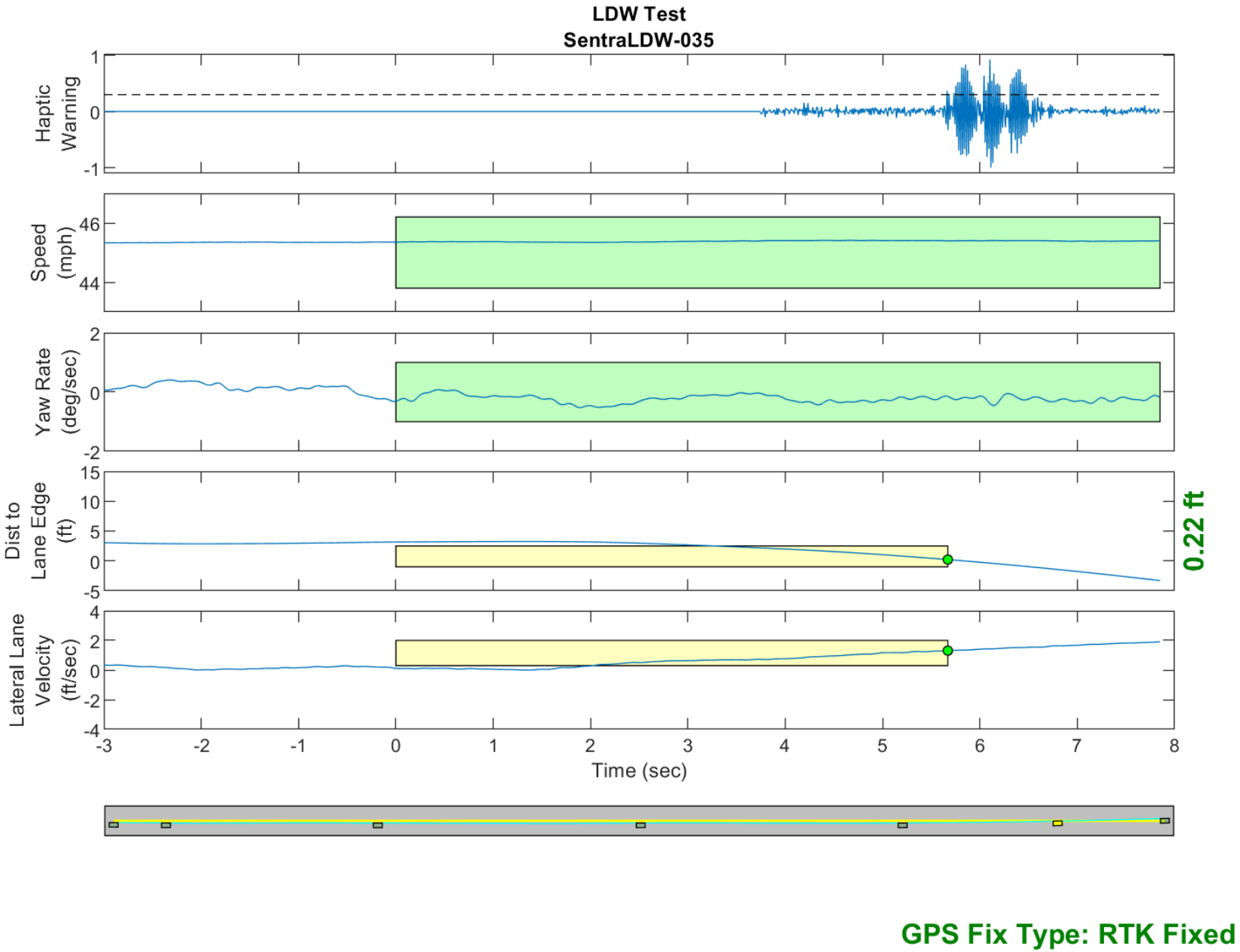

Figure D71. Time History for Run 35, Botts Dots, Left Departure, Haptic Warning

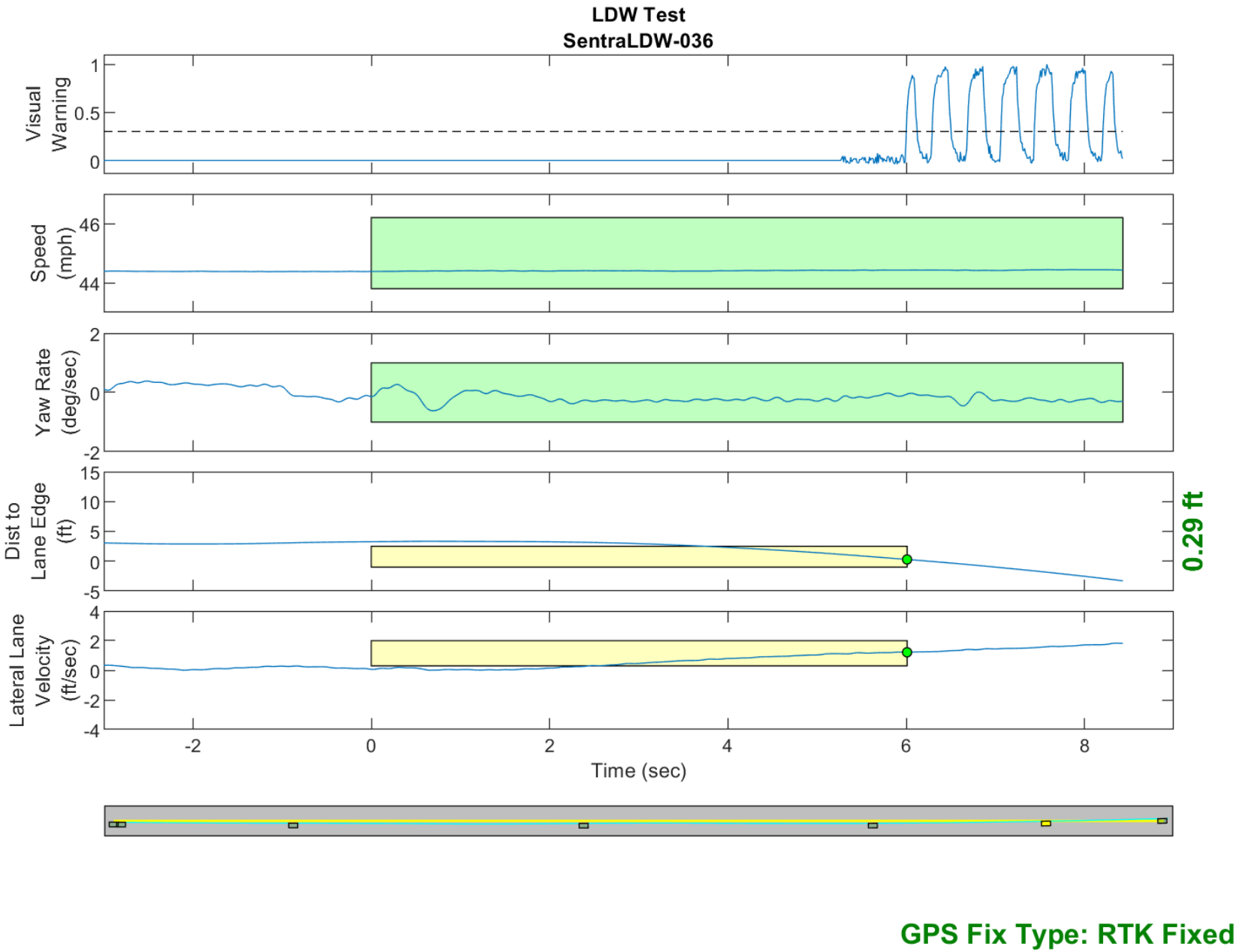

Figure D72. Time History for Run 36, Botts Dots, Left Departure, Visual Warning

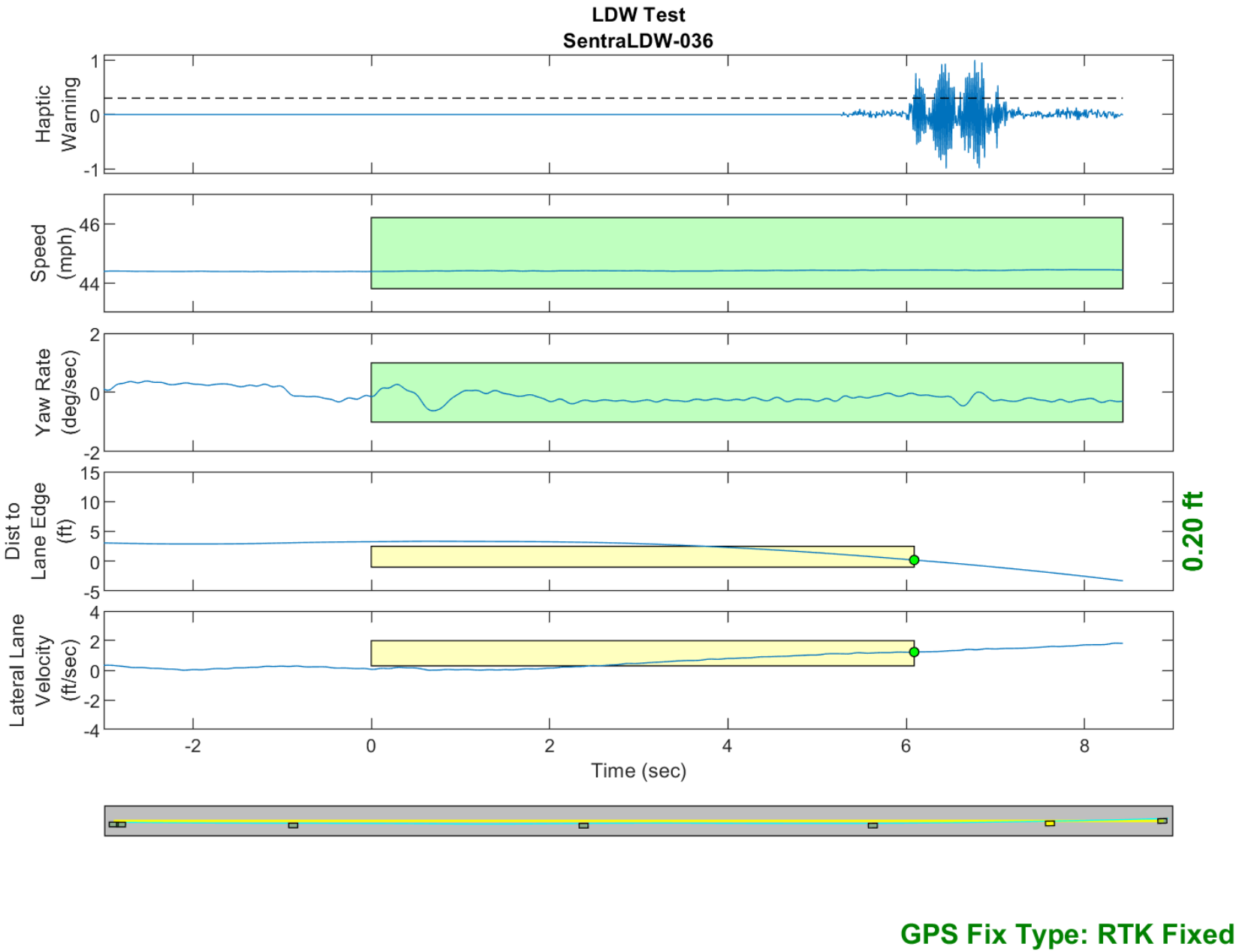

Figure D73. Time History for Run 36, Botts Dots, Left Departure, Haptic Warning

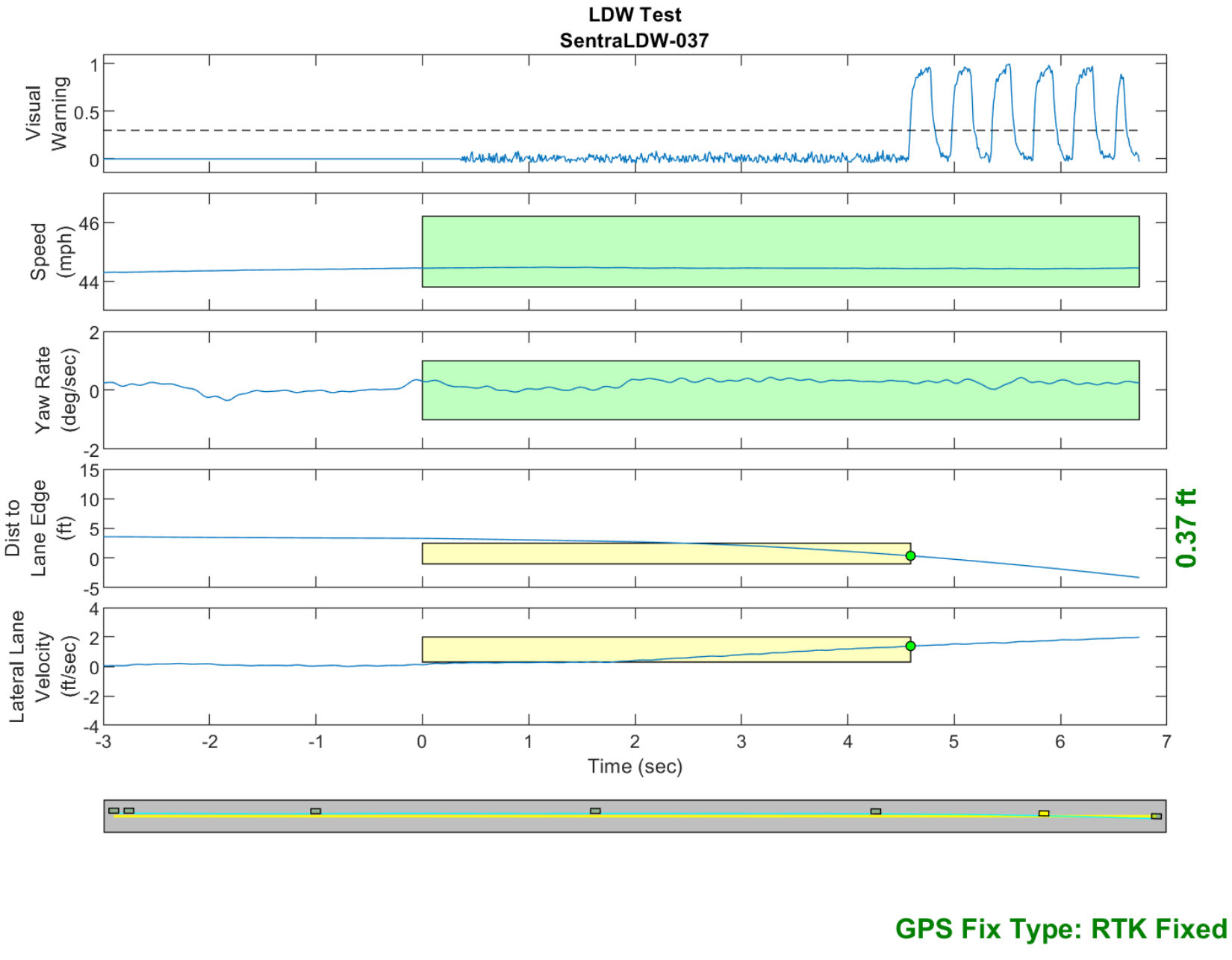

Figure D74. Time History for Run 37, Botts Dots, Right Departure, Visual Warning

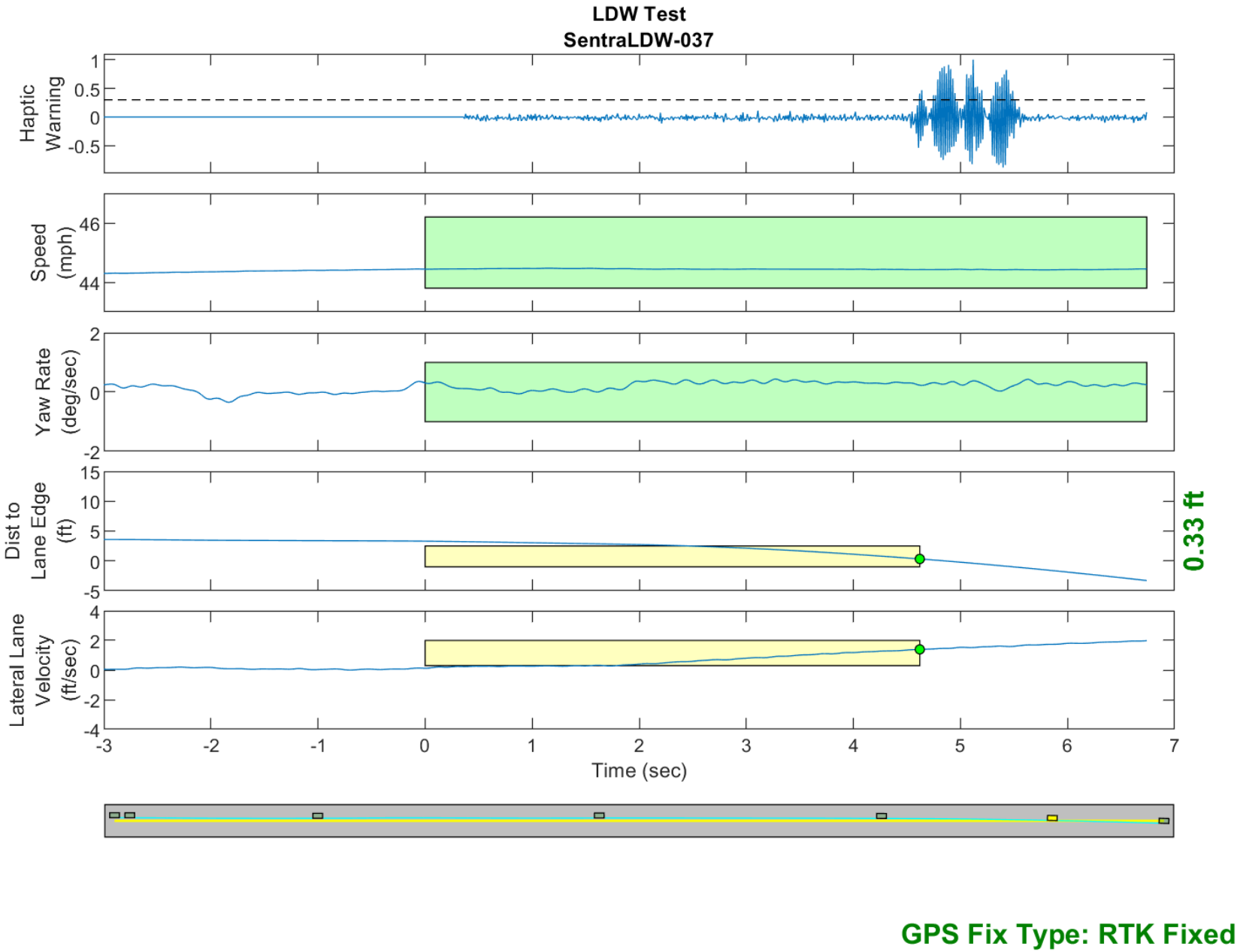

Figure D75. Time History for Run 37, Botts Dots, Right Departure, Haptic Warning

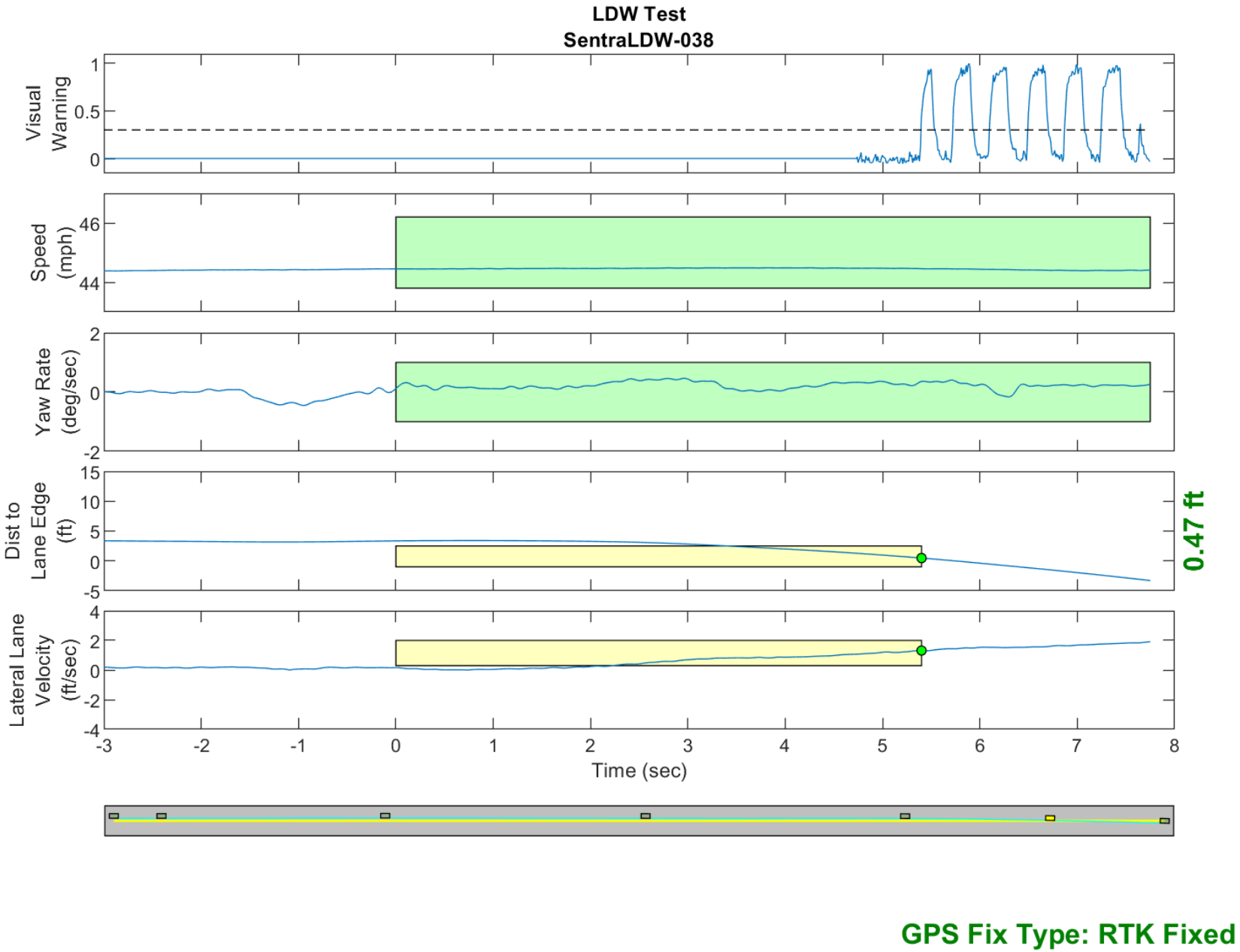

Figure D76. Time History for Run 38, Botts Dots, Right Departure, Visual Warning

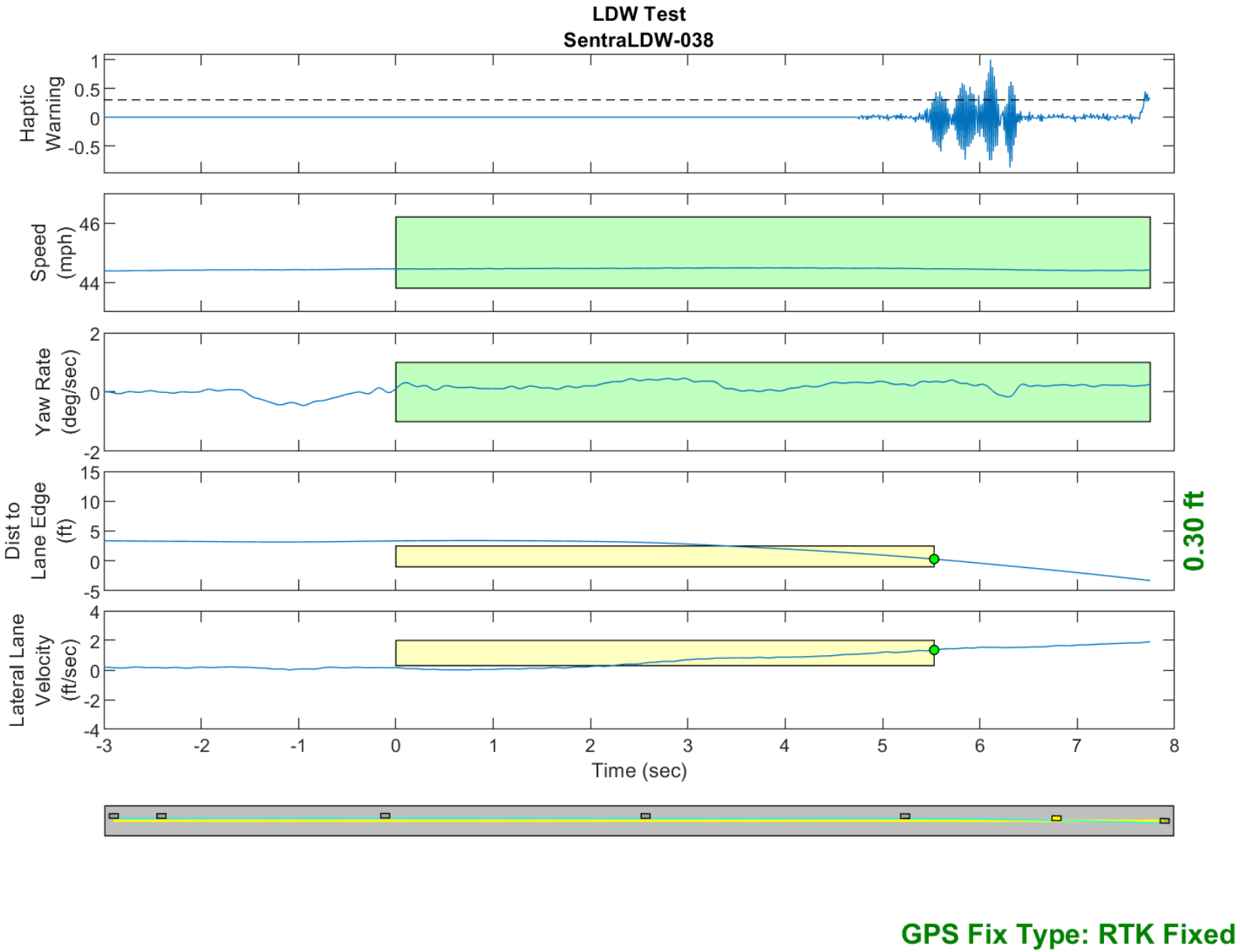

Figure D77. Time History for Run 38, Botts Dots, Right Departure, Haptic Warning

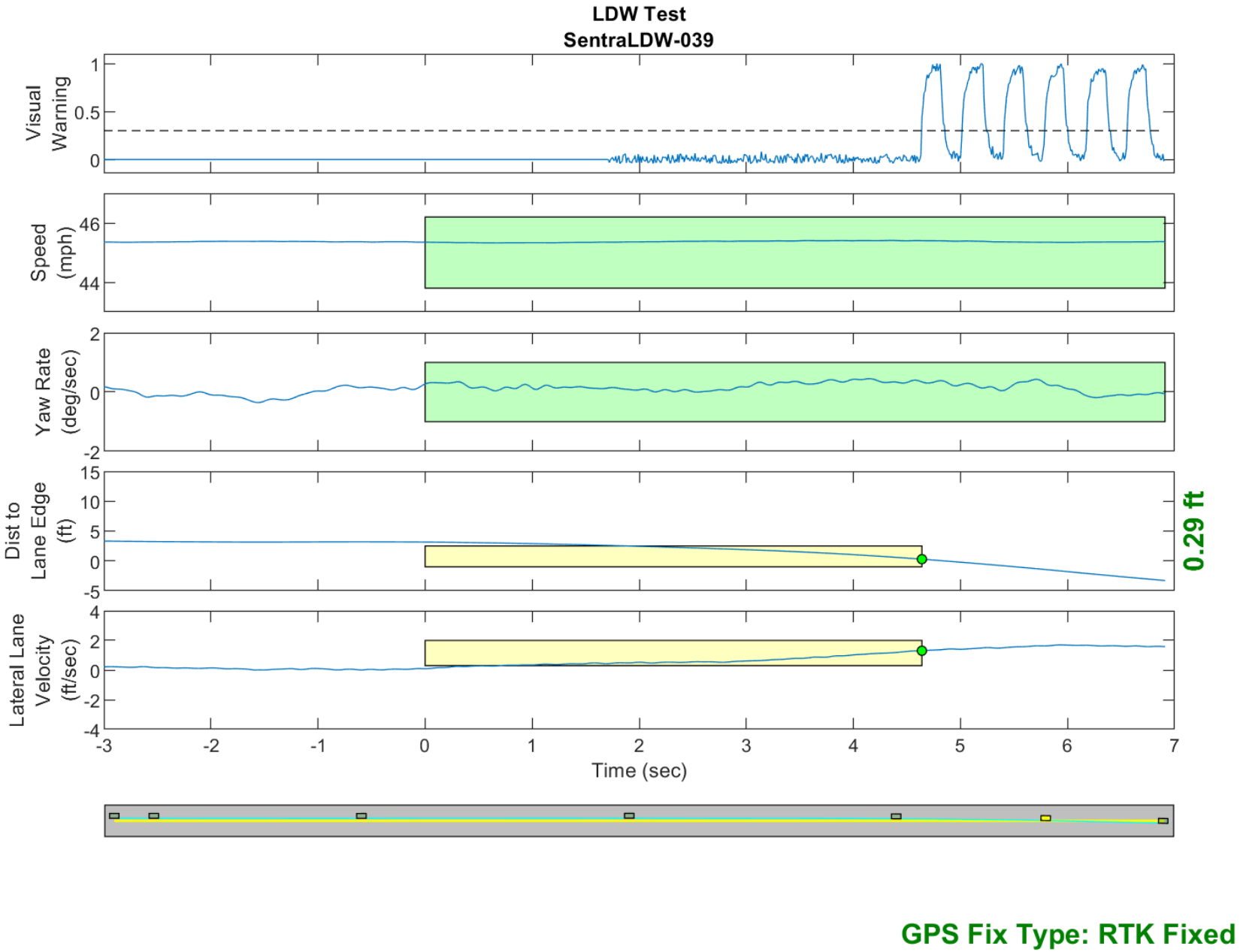

Figure D78. Time History for Run 39, Botts Dots, Right Departure, Visual Warning

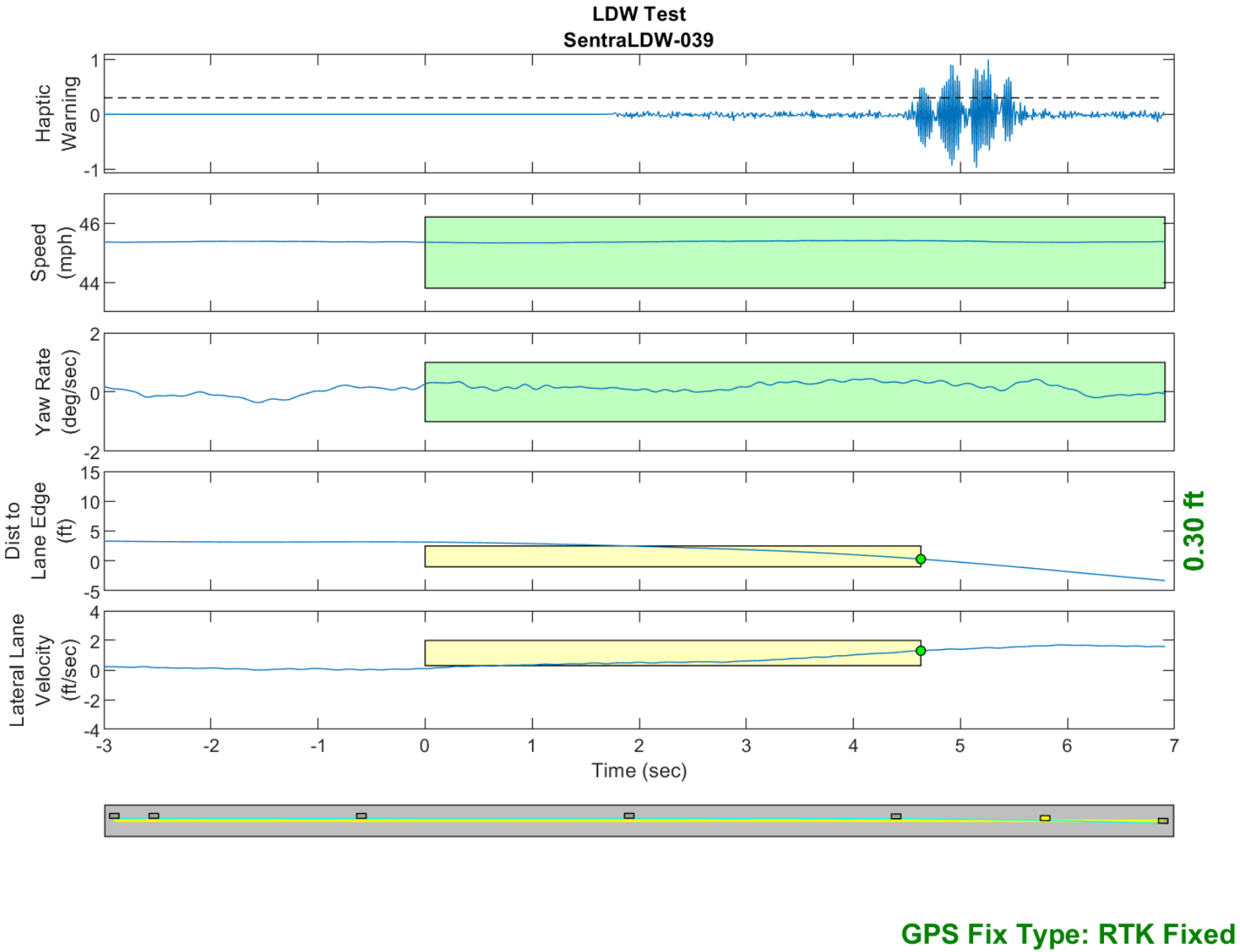

Figure D79. Time History for Run 39, Botts Dots, Right Departure, Haptic Warning

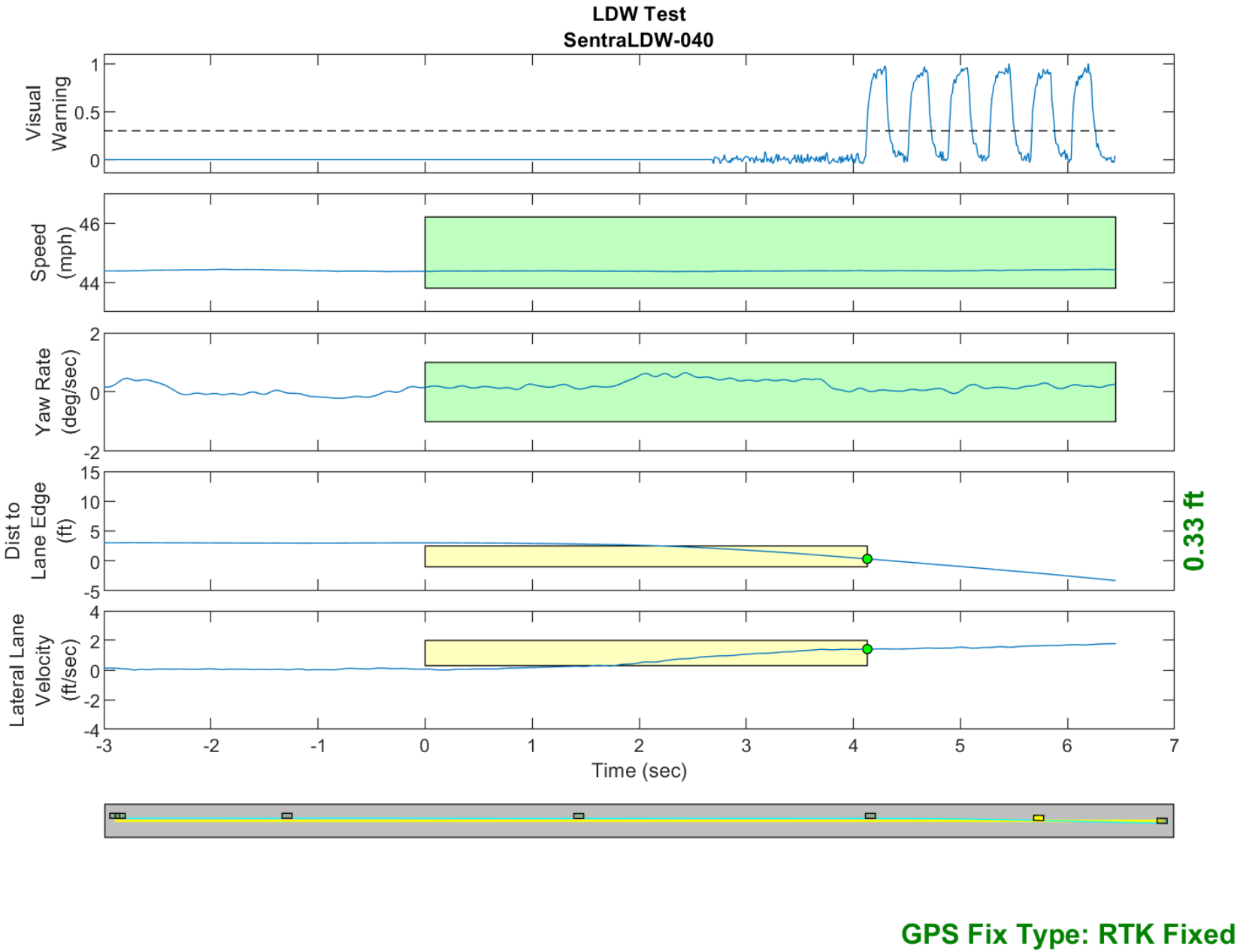

Figure D80. Time History for Run 40, Botts Dots, Right Departure, Visual Warning

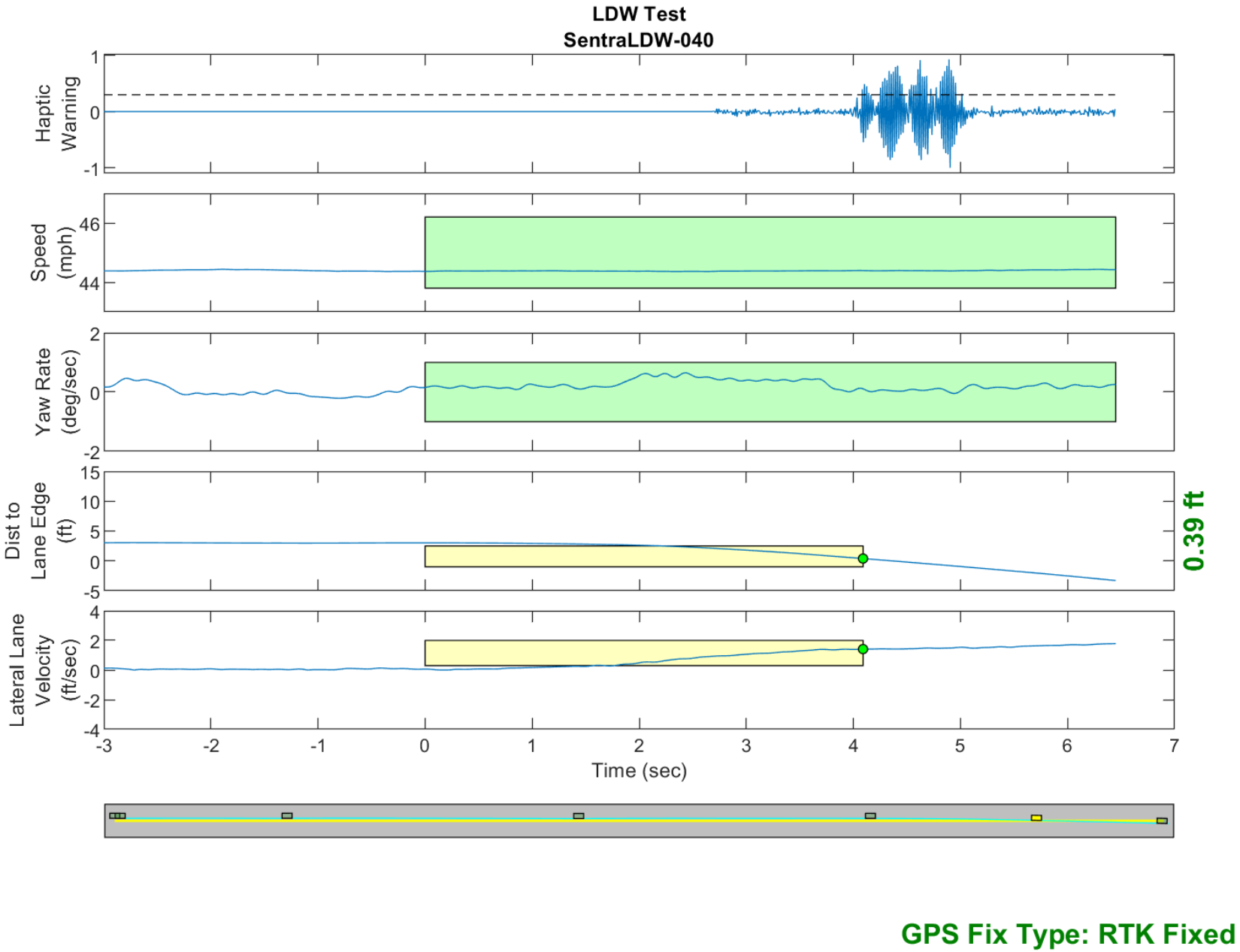

Figure D81. Time History for Run 40, Botts Dots, Right Departure, Haptic Warning

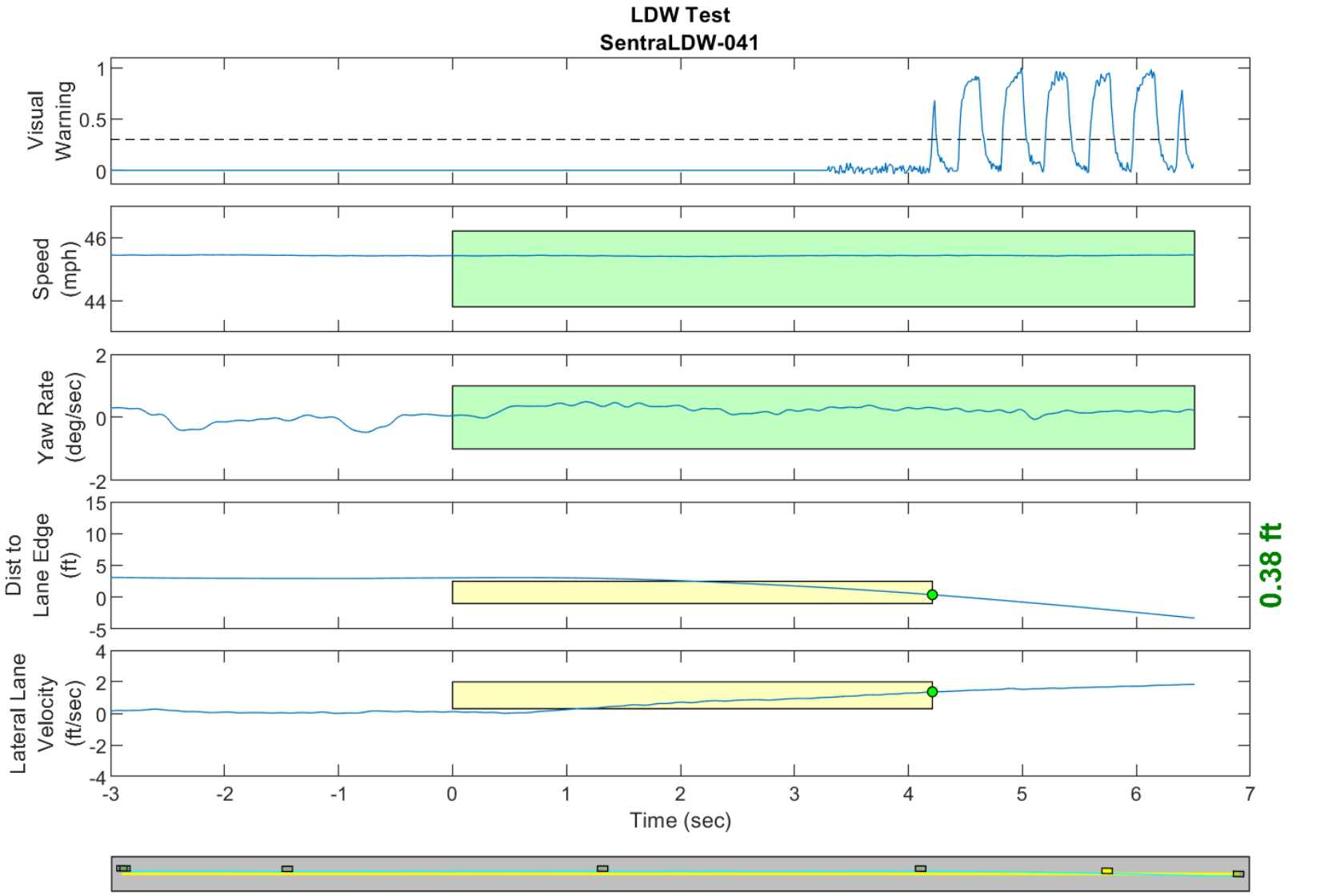

Figure D82. Time History for Run 41, Botts Dots, Right Departure, Visual Warning

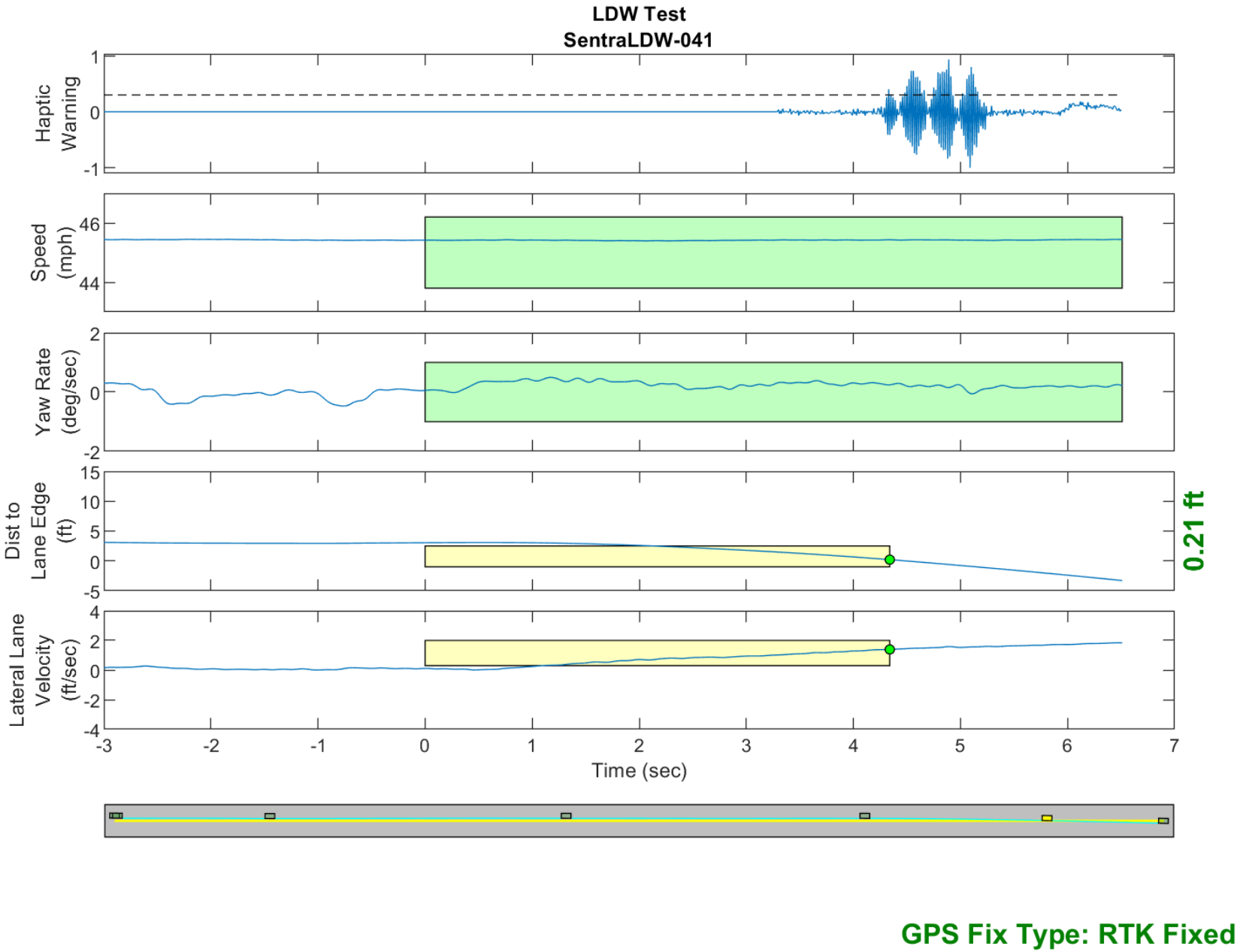

Figure D83. Time History for Run 41, Botts Dots, Right Departure, Haptic Warning

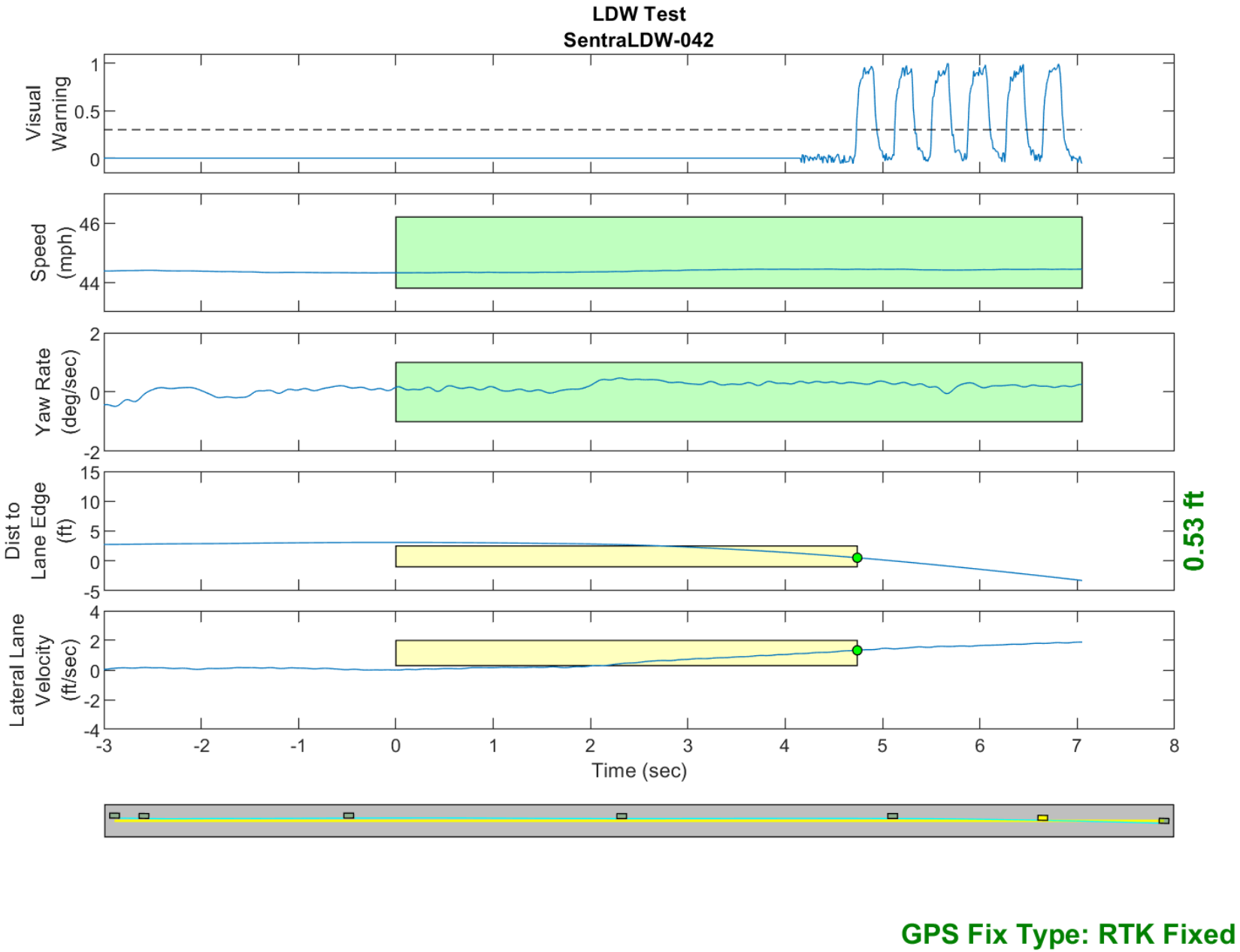

Figure D84. Time History for Run 42, Botts Dots, Right Departure, Visual Warning

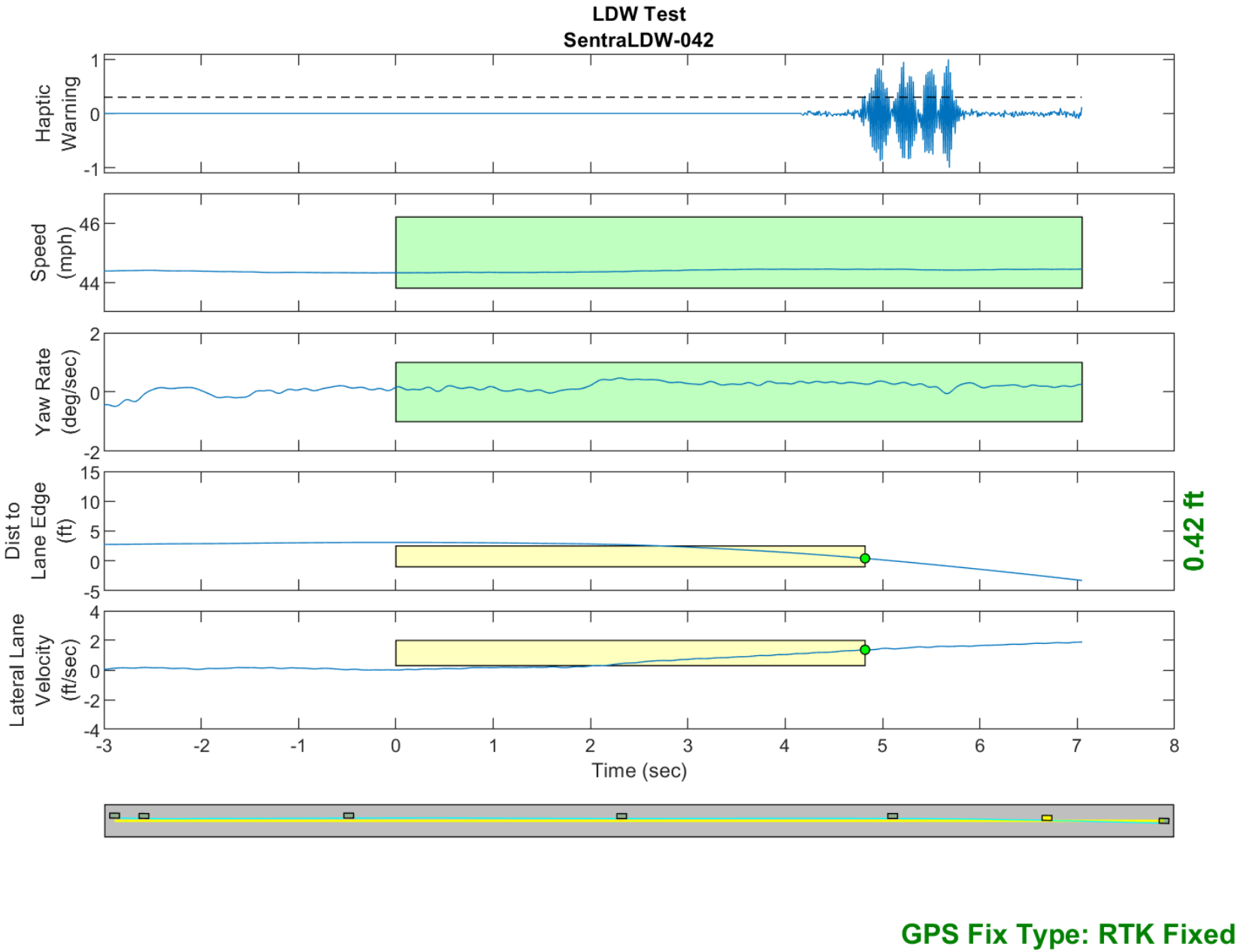

Figure D85. Time History for Run 42, Botts Dots, Right Departure, Haptic Warning

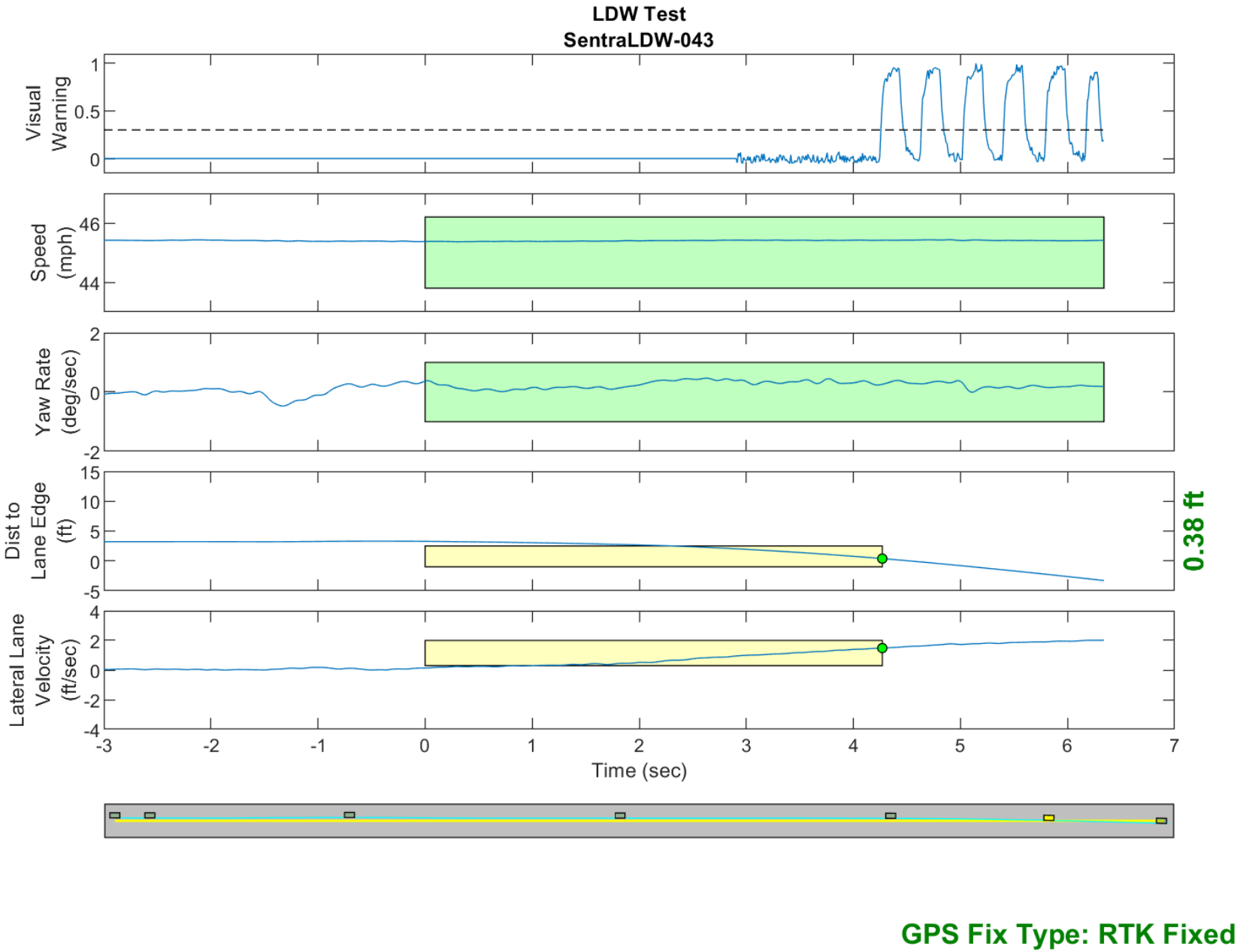

Figure D86. Time History for Run 43, Botts Dots, Right Departure, Visual Warning

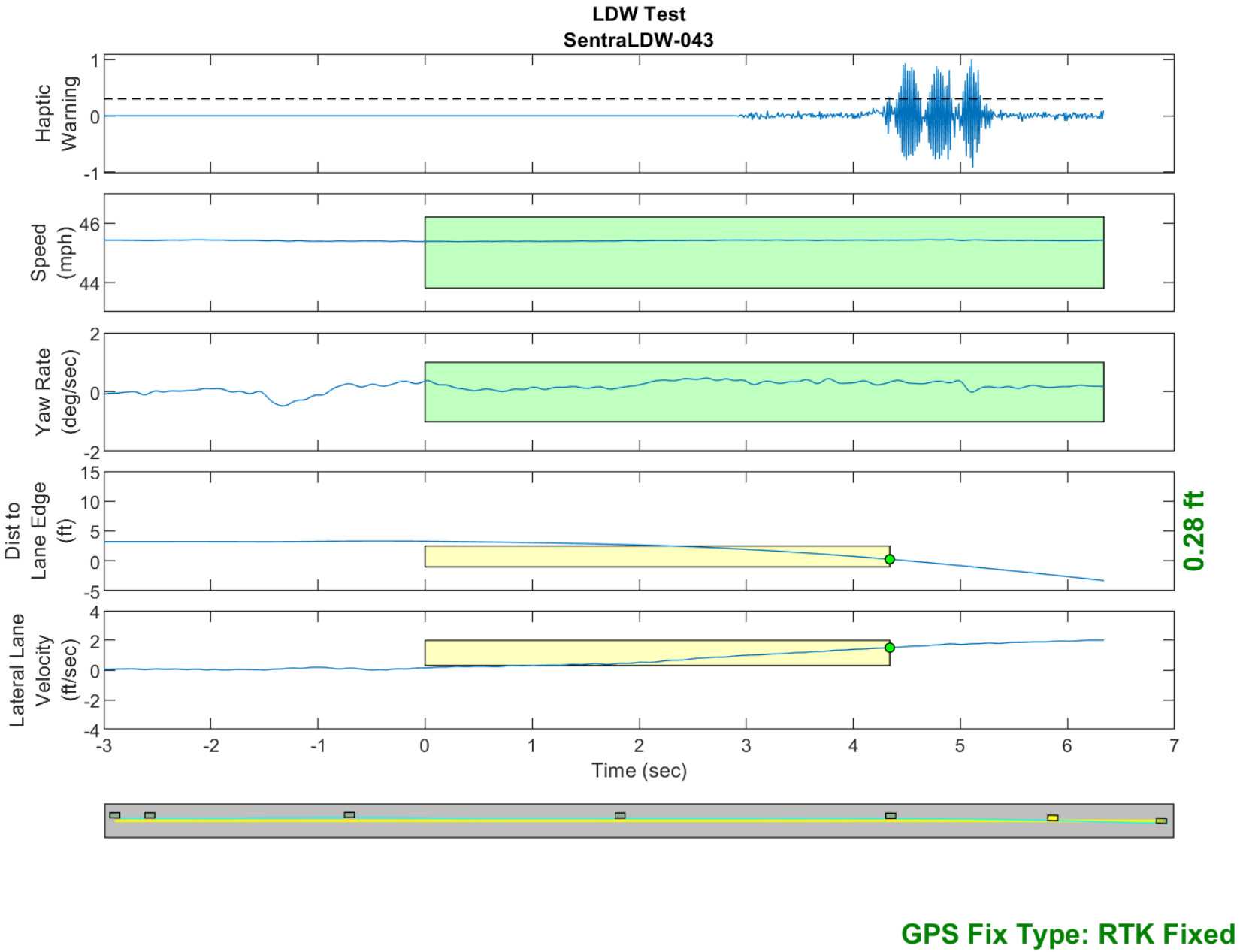

Figure D87. Time History for Run 43, Botts Dots, Right Departure, Haptic Warning