OCAS-DRI-LDW-19-01
NEW CAR ASSESSMENT PROGRAM
LANE DEPARTURE WARNING CONFIRMATION TEST

2019 Ram 1500 Crew Cab

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17 December 2019

Final Report

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U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crash Avoidance Standards
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16. Abstract These tests were conducted on the subject 2019 Ram 1500 Crew Cab in accordance with the specifications of the Office of Crash Avoidance Standards 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 2019 Ram 1500 Crew Cab. The LDW system for this vehicle provides visual 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)

2019 Ram 1500 Crew Cab

VIN: *1C6SRFHT3KN5xxxx*

Test Date: *4/4/2019*

Lane Departure Warning setting: *Medium*

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*

LANE DEPARTURE WARNING

DATA SHEET 2: GENERAL TEST AND VEHICLE PARAMETER DATA

(Page 1 of 2)

2019 Ram 1500 Crew Cab

TEST VEHICLE INFORMATION

VIN: *1C6SRFHT3KN5xxxx*

Body Style: *Crew Cab Pickup* Color: *DELMONICO RED PEARL*

Date Received: *3/21/2019* Odometer Reading: *109 mi*

Engine: *5.7 L V-8*

Transmission: *Automatic*

Final Drive: *4WD*

Is the vehicle equipped with:

ABS	X	Yes	____	No
Adaptive Cruise Control	X	Yes	____	No
Collision Mitigating Brake System	X	Yes	____	No

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *FCA US LLC*

Date of manufacture: *10-18*

DATA FROM TIRE PLACARD:

Tires size as stated on Tire Placard: Front: *285/45R22XL*

Rear: *285/45R22XL*

Recommended cold tire pressure: Front: *250 kPa (36 psi)*

Rear: *250 kPa (36 psi)*

LANE DEPARTURE WARNING

DATA SHEET 2: GENERAL TEST AND VEHICLE PARAMETER DATA

(Page 2 of 2)

2019 Ram 1500 Crew Cab

TIRES

Tire manufacturer and model: *Goodyear Eagle Touring*

Front tire size: *285/45R22XL*

Rear tire size: *285/45R22XL*

VEHICLE ACCEPTANCE

Verify the following before accepting the vehicle:

X All options listed on the "window sticker" are present on the test vehicle.

X Tires and wheel rims are the same as listed.

X There are no dents or other interior or exterior flaws.

X The vehicle has been properly prepared and is in running condition.

X Verify that spare tire, jack, lug wrench, and tool kit (if applicable) is located in the vehicle cargo area.

LANE DEPARTURE WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2019 Ram 1500 Crew Cab

GENERAL INFORMATION

Test date: *4/4/2019*

AMBIENT CONDITIONS

Air temperature: *20.0 C (68 F)*

Wind speed: *3.6 m/s (8.1 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: *250 kPa (36 psi)*

Rear: *250 kPa (36 psi)*

LANE DEPARTURE WARNING

DATA SHEET 3: TEST CONDITIONS

2019 Ram 1500 Crew Cab

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*817.4 kg (1802 lb)*	Right Front	*746.2 kg (1645 lb)*
Left Rear	*576.1 kg (1270 lb)*	Right Rear	*568.4 kg (1253 lb)*
		Total:	*2708.1 kg (5970 lb)*

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

2019 Ram 1500 Crew Cab

(Page 1 of 2)

How is the Lane Departure Warning presented to the driver? (Check all that apply)

X	Warning light
	Buzzer or audible alarm
	Vibration
X	Other

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

The warning light for the LDW system is in the center of the instrument panel to the left of the speedometer. It is a graphic of a car wandering off a lane. It is white until the car detects the lane lines, after that it turns to green. When approaching the edge of the lane line the graphic turns from green to yellow and as you cross over the lane line starts to flash.

The LDW system will also provide a haptic warning in the form of torque applied to the steering wheel to prompt the driver to remain within the lane boundaries. This occurs when both lane markings are detected and the driver unintentionally drifts out of the lane while no turn signal has been applied OR the driver departs the lane on the opposite side of the applied turn signal.

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.

Yes, there is a switch on the center of the dash above the navigation system. The button has the graphic of a car crossing the lane lines and the word "off". When pressing the button to turn off the system a yellow light will turn on when the button is pressed.

LANE DEPARTURE WARNING

DATA SHEET 4: LANE DEPARTURE WARNING SYSTEM OPERATION

2019 Ram 1500 Crew Cab

(Page 2 of 2)

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

If yes, please provide a full description.

Yes by pressing the settings button on the center touch screen display:
Settings
Safety & Driving Assistance
Lane Sense: Select Early, Medium or Late

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.

- *When enabled, the system operates above 37 mph (60 km/h) and below 112 mph (180 km/h).*
- *Use of the turn signal suppresses the warnings*
- *The system will not apply torque to the steering wheel whenever a safety system engages (anti-lock brakes, traction control system, electronic stability control, forward collision warning, etc.).*

Notes:

The Owner's Manual indicates a haptic warning but the OEM pre-test form indicated a visual warning only.

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.

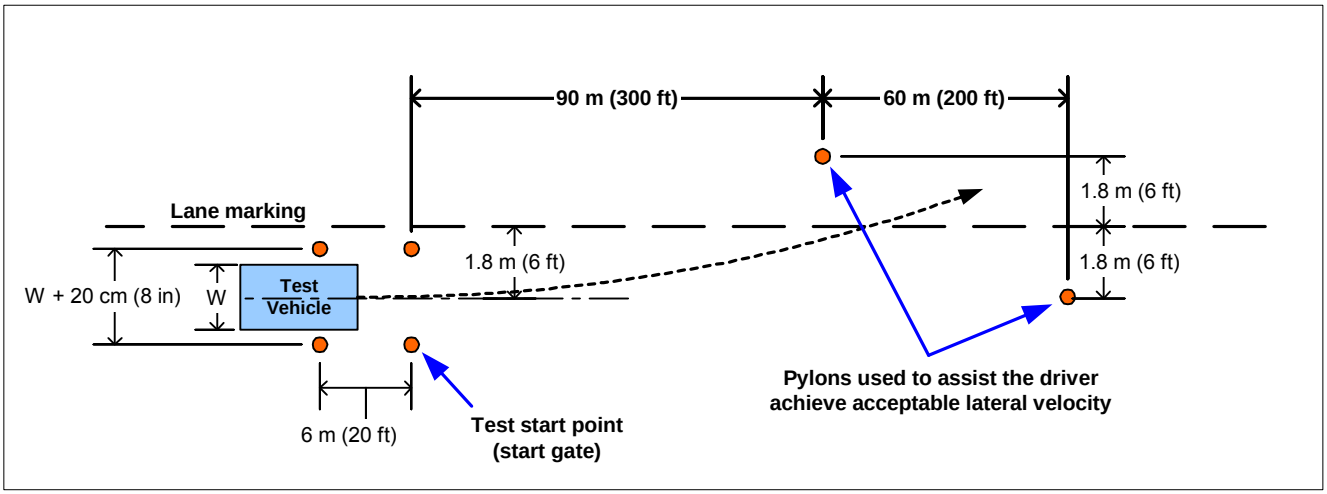

Figure 1. Position of Cones Used to Assist Driver

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 Office of Crash Avoidance Standards' 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.

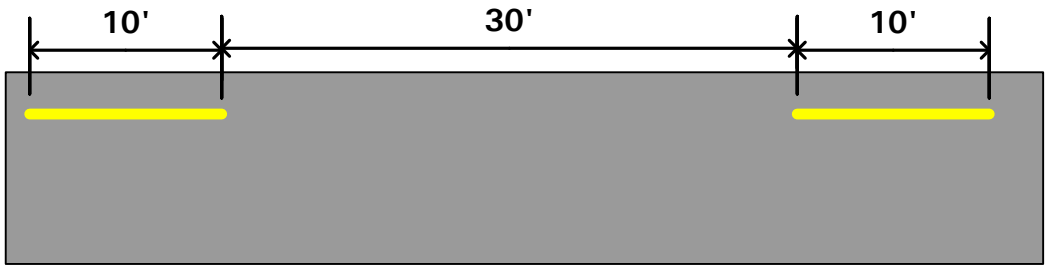

Figure 2. MUTCD Discontinuous Dashed Line Specifications

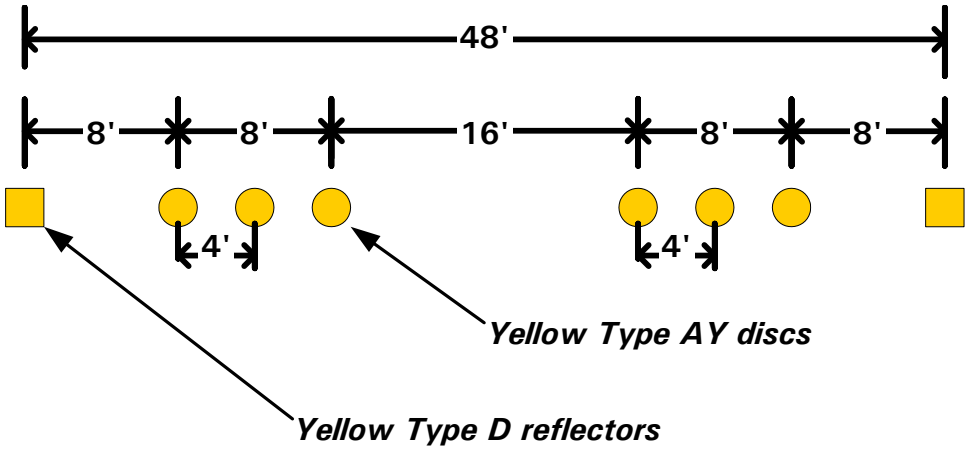

Figure 3. California Standard Plan A20A, Detail 4

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 percent), and pass 20 of the 30 trials overall (66 percent).

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: 6/21/2018 Due: 6/21/2019
Platform Scales	Vehicle Total, Wheel, and Axle Load	8000 lb 35.6 kN	±1.0% of applied load	Intercomp, SWII	1110M206352	By: DRI Date: 1/3/2019 Due: 1/3/2020
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	NA
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots Accel: ±100 m/s^2 Angular Rate: ±100 deg/s Angular Disp: ±180 deg	Position: ±2 cm Velocity: 0.05 km/h Accel: ≤ 0.01% of full range Angular Rate: ≤ 0.01% of full range Roll/Pitch Angle: ±0.03 deg Heading Angle: ±0.1 deg	Oxford Technical Solutions (OXTS), Inertial+	2182	By: Oxford Technical Solutions1 Date: 10/16/2017 Due: 10/16/2019
Real-Time Calculation of Position and Velocity Relative to Lane Markings	Distance and velocity to lane markings	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	NA

[1] Oxford Technical Solutions recommends calibration every two years.

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	NA	NA
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	NA	NA
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/2/2019 Due: 1/2/2020

Type	Description	Mfr, Model	Serial Number
Data Acquisition System	Data acquisition is achieved using a dSPACE MicroAutoBox II Data from the Oxford IMU, including Longitudinal, Lateral, and Vertical Acceleration, Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle are sent over Ethernet to the MicroAutoBox. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (listed above).	D-Space Micro-Autobox II 1401/1513	
		Base Board	549068
		I/O Board	588523

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

Table 3. Audible and Tactile Warning Filter Parameters

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

APPENDIX A

Photographs

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Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

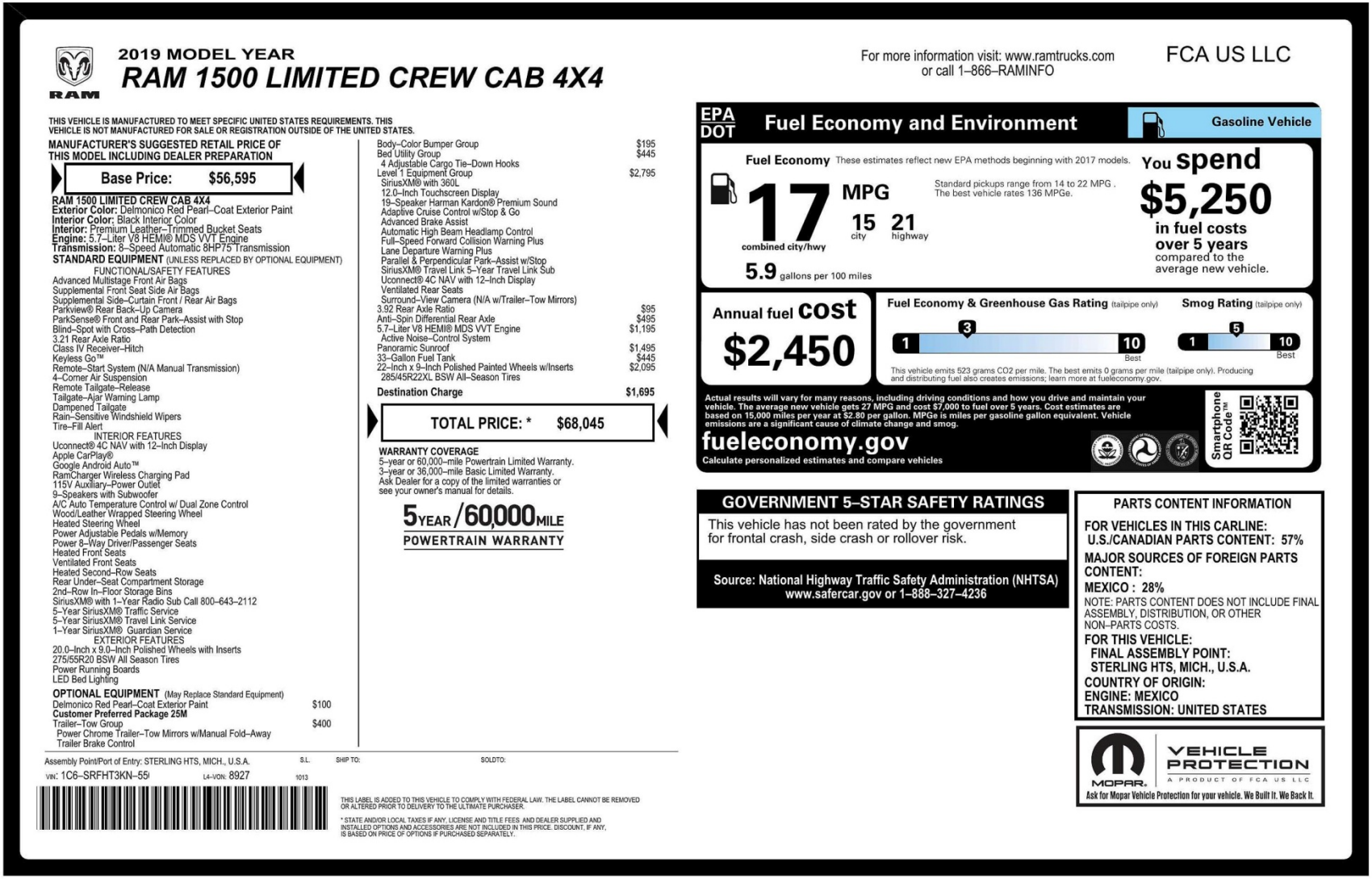


Figure A3. Window Sticker (Monroney Label)

Figure A4. Vehicle Certification Label

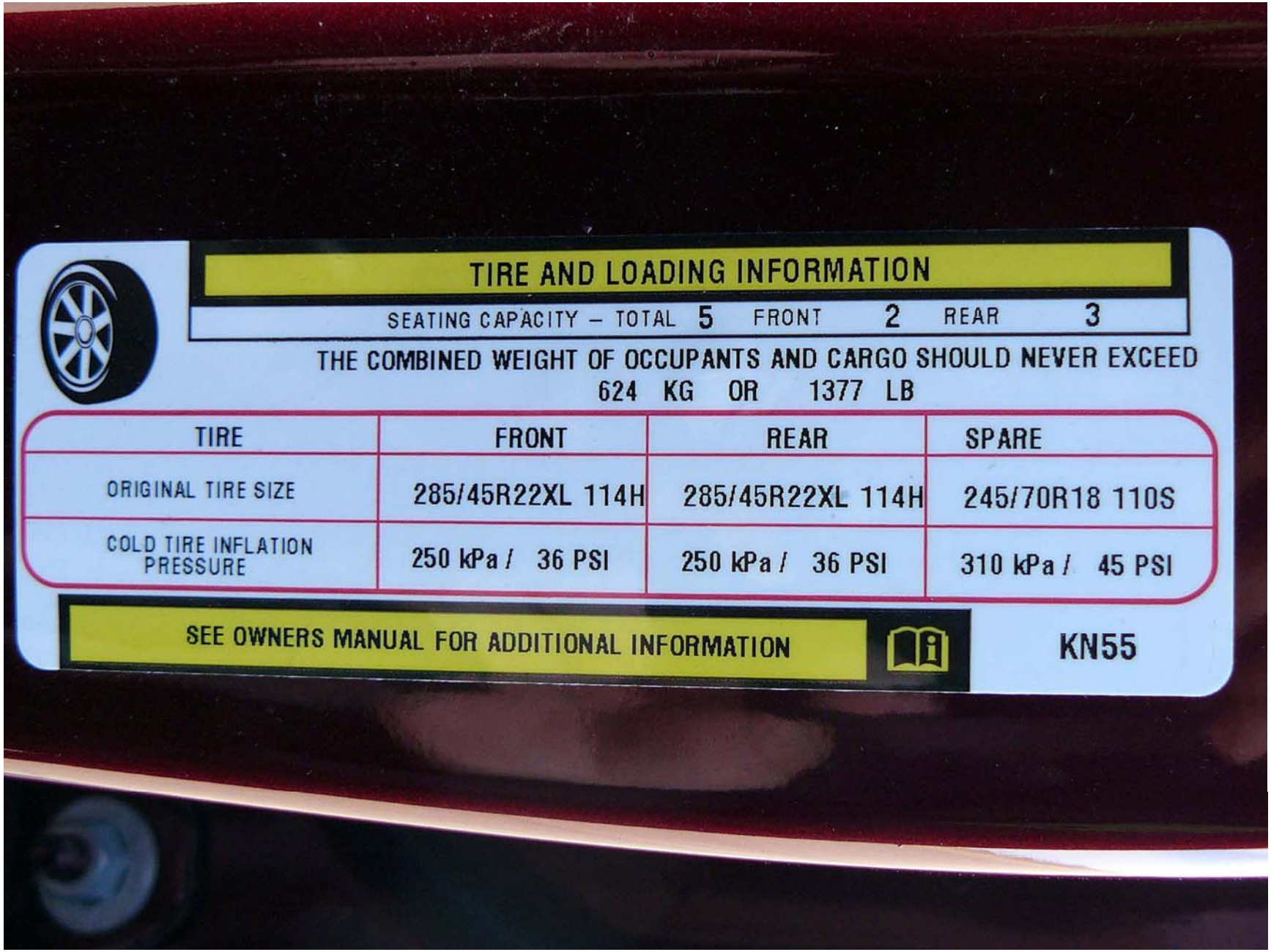


Figure A5. Tire Placard

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

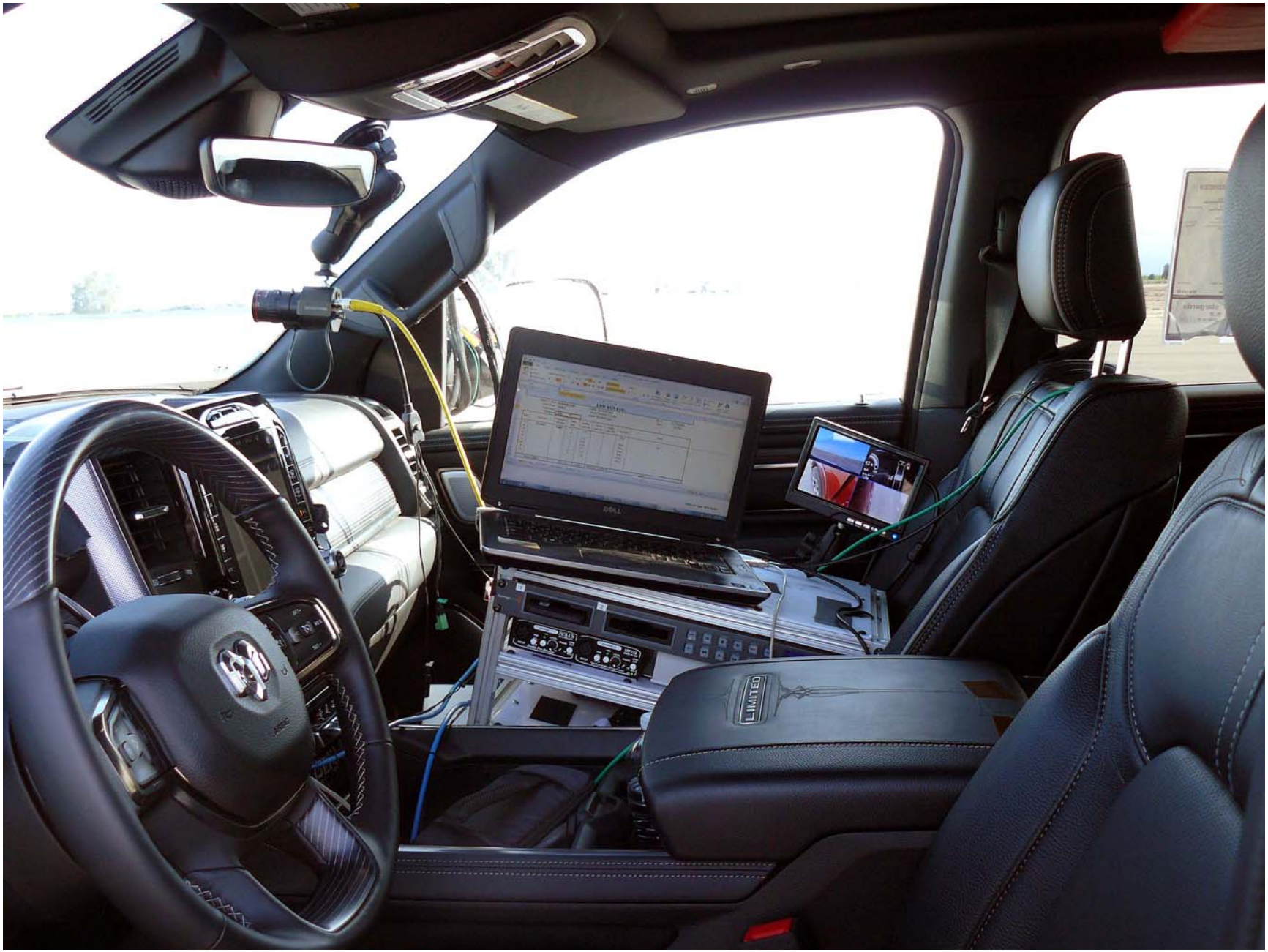


Figure A7. Computer Installed in Test Vehicle

Figure A8. Sensor for Detecting Auditory Alerts

Figure A9. Sensor for Detecting Visual Alerts

Figure A10. LDA Settings Menu Options

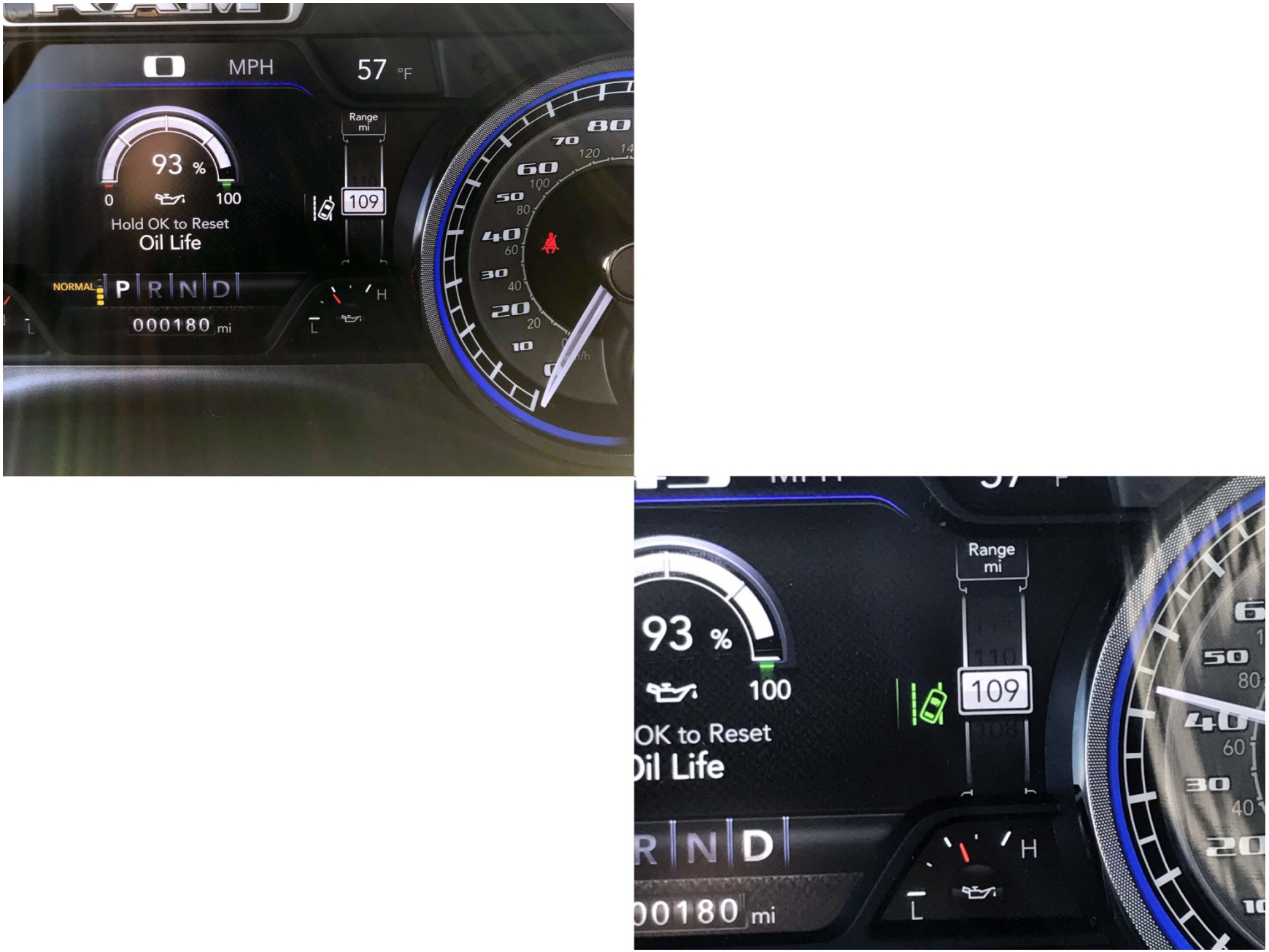


Figure A11. LDW On/Off Switch

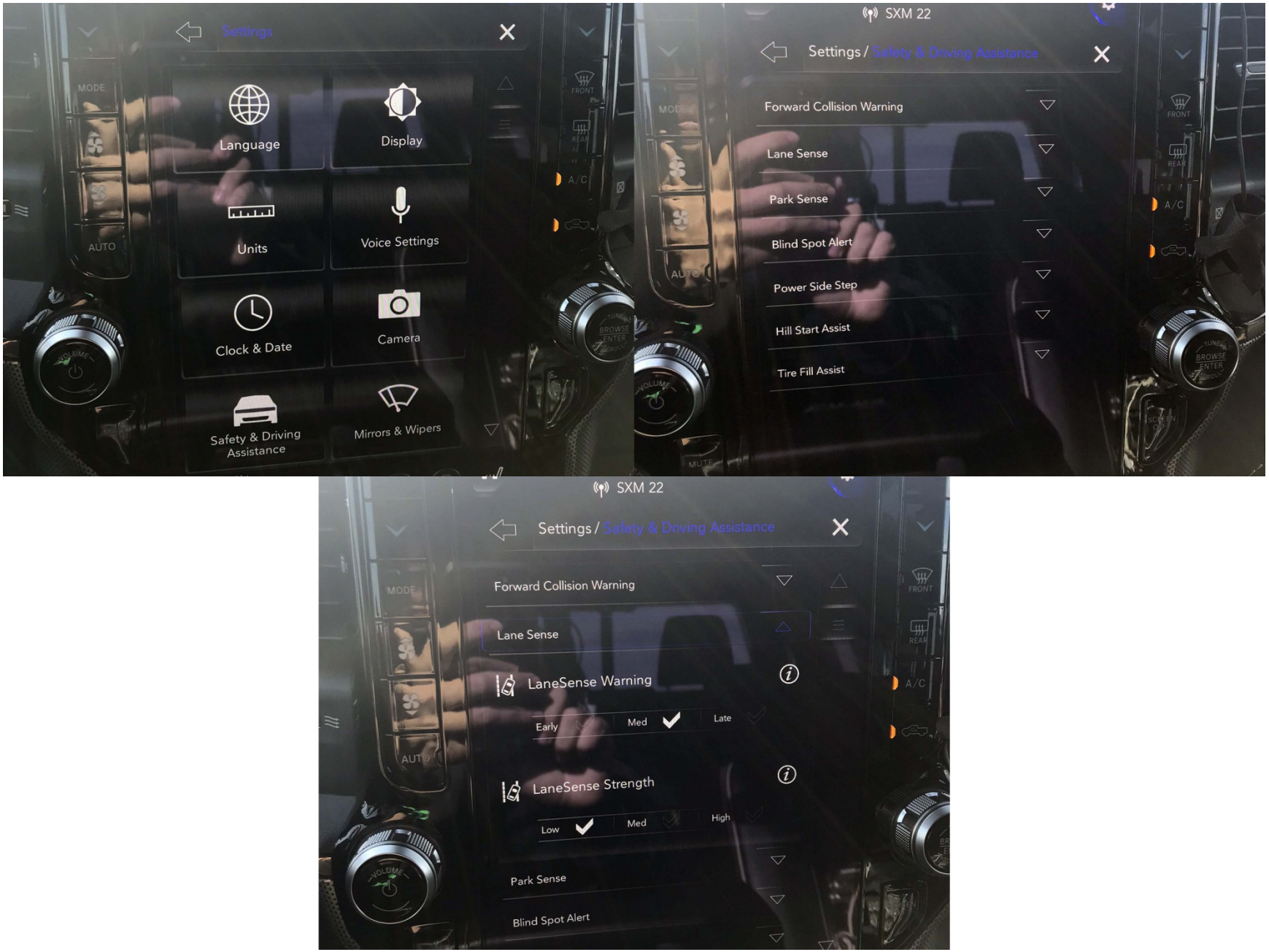


Figure A12. LDW Instrument Panel Visual Display

APPENDIX B

Excerpts from Owner's Manual

Vehicle Info

Push and release the **up** or **down** arrow button until the Vehicle Info menu icon is displayed in the instrument cluster display. Push and release the **left** or **right** arrow button to scroll through the information submenus and push and release the **OK** button to select or reset the resettable submenus.

- Tire Pressure
- Trans Temp (Automatic only)
- Oil Temperature
- Oil Life
- Air Suspension — If Equipped
- Coolant Temperature — If Equipped
- Oil Pressure — If Equipped
- Battery Voltage — If Equipped
- Gauge Summary — If Equipped
- Engine Hours

Driver Assist — If Equipped

The Driver Assist menu displays the status of the ACC and LaneSense systems.

Push and release the **up** or **down** arrow button until the Driver Assist menu is displayed in the instrument cluster display.

Adaptive Cruise Control (ACC) Feature

The instrument cluster display displays the current ACC system settings. The information displayed depends on ACC system status.

Push the Adaptive Cruise Control (ACC) on/off button (located on the steering wheel) until one of the following displays in the instrument cluster display:

Adaptive Cruise Control Off

When ACC is deactivated, the display will read "Adaptive Cruise Control Off."

Adaptive Cruise Control Ready

When ACC is activated but the vehicle speed setting has not been selected, the display will read "Adaptive Cruise Control Ready."

Push the SET + or the SET- button (located on the steering wheel) and the following will display in the instrument cluster display:

ACC SET

When ACC is set, the set speed will display in the instrument cluster.

The ACC screen may display once again if any ACC activity occurs, which may include any of the following:

- Distance Setting Change
- System Cancel
- Driver Override
- System Off
- ACC Proximity Warning
- ACC Unavailable Warning

For further information, refer to "Adaptive Cruise Control (ACC) — If Equipped" in "Starting And Operating."

LaneSense — If Equipped

The instrument cluster display displays the current LaneSense system settings. The information displayed depends on LaneSense system status and the conditions that need to be met. For further information, refer to "LaneSense — If Equipped" in "Starting And Operating."

Fuel Economy

Push and release the **up** or **down** arrow button until the Fuel Economy menu item is highlighted in the instrument cluster display. Push and hold the **OK** button to reset Average Fuel Economy.

- Current Fuel Economy Gauge
- Average Fuel Economy Value
- Range To Empty

Trip

Push and release the **up** or **down** arrow button until the Trip menu item is highlighted in the instrument cluster display. Push and release the **right** or **left** arrow buttons to enter the submenus of Trip A and Trip B. The Trip A or Trip B information will display the following:

- Distance
- Average Fuel Economy
- Elapsed Time

Push and hold **OK** button to reset all information.

— LaneSense Warning Light — If Equipped

The LaneSense system provides the driver with visual and steering torque warnings when the vehicle starts to drift out of its lane unintentionally without the use of a turn signal.

- When the LaneSense system senses a lane drift situation, the LaneSense indicator changes from solid green to solid yellow.
- When the LaneSense system senses the lane has been approached and is in a lane departure situation, the LaneSense indicator changes from solid white/green to flashing yellow.
- Refer to "LaneSense – If Equipped" in "Starting And Operating" for further information.

— Service LaneSense Warning Light — If Equipped

This warning light will illuminate when the LaneSense system is not operating and requires service. Please see an authorized dealer.

— Low Washer Fluid Warning Light — If Equipped

This warning light will illuminate when the windshield washer fluid is low.

— Low Fuel Warning Light

When the fuel level reaches approximately 1.5 gal (5.5 L) this light will turn on, and remain on until fuel is added.

A single warning chime will sound with Low Fuel Warning.

— Tire Pressure Monitoring System (TPMS) Warning Light

The warning light switches on and a message is displayed to indicate that the tire pressure is lower than the recommended value and/or that slow pressure loss is occurring. In these cases, optimal tire duration and fuel consumption may not be guaranteed.

Should one or more tires be in the condition mentioned above, the display will show the indications corresponding to each tire.

CAUTION!
Do not continue driving with one or more flat tires as handling may be compromised. Stop the vehicle, avoiding sharp braking and steering. If a tire puncture occurs, repair immediately using the dedicated tire repair kit and contact an authorized dealer as soon as possible.

ECO — ECO Mode Indicator Light

This light will turn on when ECO Mode is active.

— Park/Headlight On Indicator Light

This indicator light will illuminate when the park lights or headlights are turned on.

— LaneSense Indicator Light — If Equipped

The LaneSense indicator light illuminates solid green when both lane markings have been detected and the system is "armed" and ready to provide visual and torque warnings if an unintentional lane departure occurs.

Refer to "LaneSense — If Equipped" in "Starting And Operating" for further information.

— Front Fog Indicator Light — If Equipped

This indicator light will illuminate when the front fog lights are on.

— Turn Signal Indicator Lights

When the left or right turn signal is activated, the turn signal indicator will flash independently and the corresponding exterior turn signal lamps will flash. Turn signals can be activated when the multifunction lever is moved down (left) or up (right).

NOTE:

- A continuous chime will sound if the vehicle is driven more than 1 mile (1.6 km) with either turn signal on.
- Check for an inoperative outside light bulb if either indicator flashes at a rapid rate.
- If equipped with fog lamps, the fog lamp on the side of the activated turn signal will also illuminate to provide additional light when turning.

— Cruise Control SET Indicator Light — If Equipped With 7 Inch Instrument Cluster Display

This light will turn on when the speed control is set.

Refer to "Speed Control" in "Starting And Operating" for further information.

Ⓐ — Stop/Start Active Indicator Light — If Equipped

This indicator light will illuminate when the Stop/Start function is in "Autostop" mode.

— 4WD AUTO Indicator Light — If Equipped

This light alerts the driver that the vehicle is in the four-wheel drive auto mode, and the front axle is engaged, but the vehicle's power is sent to the rear wheels. Four-wheel drive will be automatically engaged when the vehicle senses a loss of traction.

For further information on four-wheel drive operation and proper use, refer to "Four-Wheel Drive Operation — If Equipped" in "Starting And Operating."

White Indicator Lights

— Adaptive Cruise Control (ACC) Ready Light — If Equipped

This light will illuminate when the vehicle equipped with Adaptive Cruise Control (ACC) has been turned on but not set.

Refer to "Adaptive Cruise Control (ACC) — If Equipped" in "Starting And Operating" for further information.

— Cruise Control Ready Indicator

This indicator light will illuminate when the cruise control is ready, but not set. Refer to "Speed Control" in "Starting And Operating" for further information.

— Speed Control SET Indicator Light — If Equipped With 3.5 Inch Instrument Cluster Display

This light will turn on when the speed control is set.

Refer to "Speed Control" in "Starting And Operating" for further information.

— Hill Descent Control (HDC) Indicator Light — If Equipped

This indicator shows when the Hill Descent Control (HDC) feature is turned on. The lamp will be on solid when HDC is armed. HDC can only be armed when the transfer case is in the "4WD LOW" position and the vehicle speed is less then 20 mph (32 km/h). If these conditions are not met while attempting to use the HDC feature, the HDC indicator light will flash on/off.

— LaneSense Indicator Light — If Equipped

When the LaneSense system is ON, but not armed, the LaneSense indicator light illuminates solid white. This occurs when only left, right, or neither lane line has been detected. If a single lane line is detected, the system is ready to provide only visual warnings if an unintentional lane departure occurs on the detected lane line.

Refer to “LaneSense — If Equipped" in “Starting And Operating” for further information.

Blue Indicator Lights

— High Beam Indicator Light

This indicator light will illuminate to indicate that the high beam headlights are on. With the low beams activated, push the multifunction lever forward (toward the front of the vehicle) to turn on the high beams. Pull the multifunction lever rearward (toward the rear of the vehicle) to turn off the high beams. If the high beams are off, pull the lever toward you for a temporary high beam on, "flash to pass" scenario.

ONBOARD DIAGNOSTIC SYSTEM — OBD II

Your vehicle is equipped with a sophisticated Onboard Diagnostic system called OBD II. This system monitors the performance of the emissions, engine, and transmission control systems. When these systems are operating properly, your vehicle will provide excellent performance and fuel economy, as well as engine emissions well within current government regulations.

If any of these systems require service, the OBD II system will turn on the Malfunction Indicator Light (MIL). It will also store diagnostic codes and other information to assist your service technician in making repairs. Although your vehicle will usually be drivable and not need towing, see an authorized dealer for service as soon as possible.

CAUTION!

- **Prolonged driving with the MIL on could cause further damage to the emission control system. It could also affect fuel economy and driveability. The vehicle must be serviced before any emissions tests can be performed.**
- **If the MIL is flashing while the vehicle is running, severe catalytic converter damage and power loss will soon occur. Immediate service is required.**

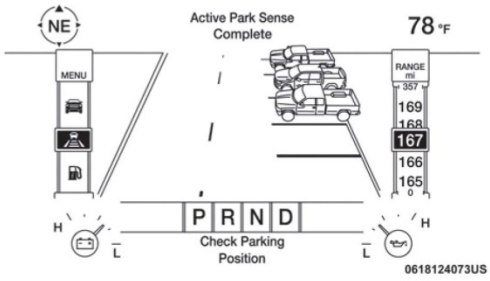
Onboard Diagnostic System (OBD II) Cybersecurity

Your vehicle is required to have an Onboard Diagnostic system (OBD II) and a connection port to allow access to information related to the performance of your emissions controls. Authorized service technicians may need to access this information to assist with the diagnosis and service of your vehicle and emissions system.

WARNING!

- **ONLY an authorized service technician should connect equipment to the OBD II connection port in order to read the VIN, diagnose, or service your vehicle.**

(Continued)



Active Park Sense Complete — Check Parking Position

WARNING!

Drivers must be careful when performing parallel or perpendicular parking maneuvers even when using the ParkSense Active Park Assist system. Always check carefully behind and in front of your vehicle, look behind and in front of you, and be sure to check for pedestrians, animals, other vehicles, obstructions, and blind spots before backing up and moving forward. You are responsible for safety and must continue to pay attention to your surroundings. Failure to do so can result in serious injury or death.

CAUTION!

- **The ParkSense Active Park Assist system is only a parking aid and it is unable to recognize every obstacle, including small obstacles. Parking curbs might be temporarily detected or not detected at all. Obstacles located above or below the sensors will not be detected when they are in close proximity.**
- **The vehicle must be driven slowly when using the ParkSense Active Park Assist system in order to be able to stop in time when an obstacle is detected. It is recommended that the driver looks over his/her shoulder when using the ParkSense Active Park Assist system.**

5

LANESENSE — IF EQUIPPED

LaneSense Operation

The LaneSense system is operational at speeds above 37 mph (60 km/h) and below 112 mph (180 km/h). It uses a forward looking camera to detect lane markings and measure vehicle position within the lane boundaries.

When both lane markings are detected and the driver unintentionally drifts out of the lane while no turn signal has been applied OR the driver departs the lane on the opposite side of the applied turn signal (if the left turn signal is applied and the vehicle departs to the right), the LaneSense system

provides a haptic warning in the form of torque applied to the steering wheel to prompt the driver to remain within the lane boundaries. The LaneSense system will also provide a visual warning through the instrument cluster display to prompt the driver to remain within the lane boundaries.

The driver may manually override the haptic warning by applying torque into the steering wheel at any time.

When only a single lane marking is detected and the driver unintentionally drifts across that lane marking (no turn signal applied), the LaneSense system provides a visual warning through the instrument cluster display to prompt the driver to remain within the lane. When only a single lane marking is detected, a haptic (torque) warning will not be provided.

NOTE:
When operating conditions have been met, the LaneSense system will monitor if the driver's hands are on the steering wheel and provides an audible and visual warning to the driver when the driver's hands are not detected on the steering wheel. The system will cancel if the driver does not return their hands to the wheel.

Turning LaneSense On Or Off

The LaneSense button is located on the switch panel below the Uconnect display.

NOTE:
If your vehicle is equipped with a 12–inch Uconnect Display screen, the LaneSense button is located above the display.

To turn the LaneSense system on, push the LaneSense button (LED turns off). A "LaneSense On" message is shown in the instrument cluster display.

Lane Sense On Message

To turn the LaneSense system off, push the LaneSense button again (LED turns on).

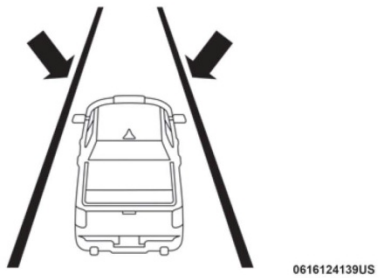
NOTE:
The LaneSense system will retain the last system state on or off from the last ignition cycle when the ignition is changed to the ON/RUN position.

LaneSense Warning Message

The LaneSense system will indicate the current lane drift condition through the instrument cluster display.

Instrument Cluster Display

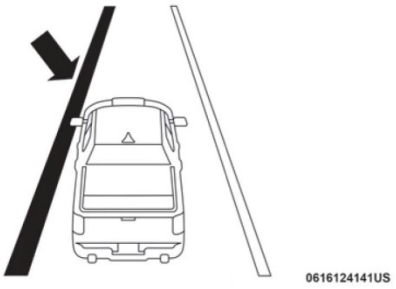
When the LaneSense system is ON; the lane lines are gray when both of the lane boundaries have not been detected and the LaneSense telltale is solid white.



System ON (Gray Lines) With White Telltale

Left Lane Departure — Only Left Lane Detected

- When the LaneSense system is ON, the LaneSense Telltale is solid white when only the left lane marking has been detected and the system is ready to provide visual warnings in the instrument cluster display if an unintentional lane departure occurs on the left side.
- When the LaneSense system senses the lane has been approached and is in a lane departure situation, the visual warning in the instrument cluster display will show the left lane line flashing yellow (on/off). The LaneSense telltale changes from solid white to flashing yellow.

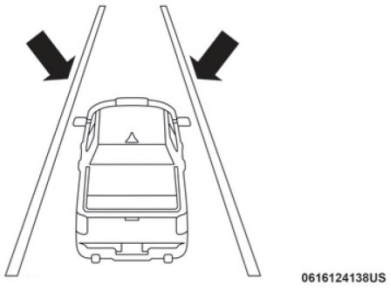


Lane Approached (Flashing Yellow Lane Line) With Yellow Telltale

NOTE:
The LaneSense system operates with the similar behavior for a right lane departure when only the right lane marking has been detected.

Left Lane Departure — Both Lane Lines Detected

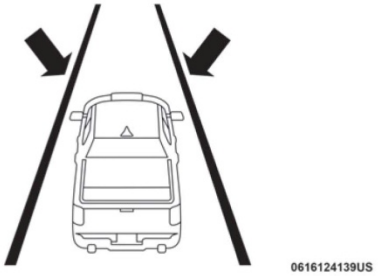
- When the LaneSense system is ON and both the lane markings have been detected, the system is "armed" to provide visual warnings in the instrument cluster display and a torque warning in the steering wheel if an unintentional lane departure occurs .The lane lines turn from gray to white and the LaneSense telltale is solid green.



Lanes Sensed (White Lines) With Green Telltale

- When the LaneSense system senses a lane drift situation, the left lane line turns solid yellow. The LaneSense telltale changes from solid green to solid yellow. At this time torque is applied to the steering wheel in the opposite direction of the lane boundary.

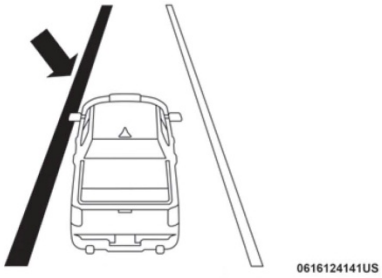
  For example: If approaching the left side of the lane the steering wheel will turn to the right.



Lane Sensed (Solid Yellow Lane Line) With Solid Yellow Telltale

- When the LaneSense system senses the lane has been approached and is in a lane departure situation, the left lane line flashes yellow (on/off). The LaneSense telltale changes from solid yellow to flashing yellow. At this time torque is applied to the steering wheel in the opposite direction of the lane boundary.

  For example: If approaching the left side of the lane the steering wheel will turn to the right.



Lane Approached (Flashing Yellow Lane Line) With Flashing Yellow Telltale

5

NOTE:
The LaneSense system operates with the similar behavior for a right lane departure.

Changing LaneSense Status

The LaneSense system has settings to adjust the intensity of the torque warning and the warning zone sensitivity (Early/Medium/Late) that you can configure through the Uconnect system screen. Refer to "Uconnect Settings" in "Multimedia" for further information.

NOTE:

- When enabled the system operates above 37 mph (60 km/h) and below 112 mph (180 km/h).
- Use of the turn signal suppresses the warnings.
- The system will not apply torque to the steering wheel whenever a safety system engages (anti-lock brakes, traction control system, electronic stability control, forward collision warning, etc.).

PARKVIEW REAR BACK UP CAMERA

The ParkView Rear Back Up Camera allows you to see an image of the rear surroundings of your vehicle whenever the gear selector is put into REVERSE or whenever it is manually activated. When the gear selector is put into REVERSE, the image will be displayed in the Uconnect screen along with a caution note to "check entire surroundings" across the top of the screen. After five seconds this note will disappear.

Manual Activation Of The Rear View Camera:

1. Press the "Controls" button located on the bottom of the Uconnect display.
2. Press the "Backup Camera" button to turn the Rear View Camera system on.

When the vehicle is shifted out of REVERSE (with Camera delay turned off), the rear Camera mode is exited and the previous screen appears again.

When the vehicle is shifted out of REVERSE (with Camera delay turned on), the rear Camera image will be displayed for up to 10 seconds after shifting to another gear, unless the vehicle speed exceeds 8 mph (13 km/h), the transmission is shifted into PARK, the ignition is switched to the OFF position, or the touchscreen button "X" to disable display of the Rear View Camera image is pressed.

Whenever the Rear View Camera image is activated through the "Backup Camera" button in the "Controls" menu, and the vehicle speed is greater than, or equal to, 8 mph (13 km/h), a display timer for the image is initiated. The image will continue to be displayed until the display timer exceeds 10 seconds.

NOTE:

- If the vehicle speed remains below 8 mph (13 km/h), the Rear View Camera image will be displayed continuously until deactivated via the touchscreen button "X", the transmission is shifted into PARK, or the ignition is cycled to the OFF position.

APPENDIX C

Run Log

Subject Vehicle: **2019 Ram 1500 Crew Cab**

Test Date: **4/4/2019**

Driver: **N. Watanabe**

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

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Visual Alert (ft)	Pass/Fail	Notes
1	**Botts**	**Left**	Y	-0.21	Pass	
2			N			lateral velocity
3			Y	-0.03	Pass	
4			N			lateral velocity, yaw rate
5			Y	-0.10	Pass	
6			Y	-0.12	Pass	
7			Y	-0.12	Pass	
8			Y	-0.15	Pass	
9			Y	-0.14	Pass	
10	Botts	Right	Y	0.11	Pass	
11			Y	0.24	Pass	
12			Y	0.06	Pass	
13			Y	0.20	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Visual Alert (ft)	Pass/Fail	Notes
14			Y	0.15	Pass	
15			Y	0.07	Pass	
16			Y	0.16	Pass	
17	**Solid**	**Right**	N			sv speed
18			Y	1.29	Pass	
19			Y	1.17	Pass	
20			Y	1.21	Pass	
21			Y	1.10	Pass	
22			Y	1.11	Pass	
23			Y	1.17	Pass	
24			Y	1.08	Pass	
25			Y	1.16	Pass	
26	**Solid**	**Left**	N			speed, yaw rate
27			Y	0.93	Pass	
28			Y	0.89	Pass	
29			Y	1.10	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Visual Alert (ft)	Pass/Fail	Notes
30			Y	0.89	Pass	
31			Y	0.87	Pass	
32			Y	1.17	Pass	
33			Y	0.91	Pass	
34			Y	0.90	Pass	
35	**Dashed**	**Left**	Y	0.85	Pass	
36			Y	0.86	Pass	
37			Y	0.79	Pass	
38			Y	0.79	Pass	
39			Y	0.72	Pass	
40			Y	0.73	Pass	
41			Y	0.82	Pass	
42	**Dashed**	**Right**	Y	1.19	Pass	
43			N			yaw rate
44			Y	1.22	Pass	
45			Y	0.95	Pass	

Run	Lane Marking Type	Departure Direction	Valid Run?	Distance at Visual Alert (ft)	Pass/Fail	Notes
46			Y	1.20	Pass	
47			Y	1.17	Pass	
48			Y	1.30	Pass	
49			Y	1.20	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. **Note:** The Bird's Eye View representation is not synchronized to the time history plots above it. It is a spatial, not temporal, representation.

Note that 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.

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

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.

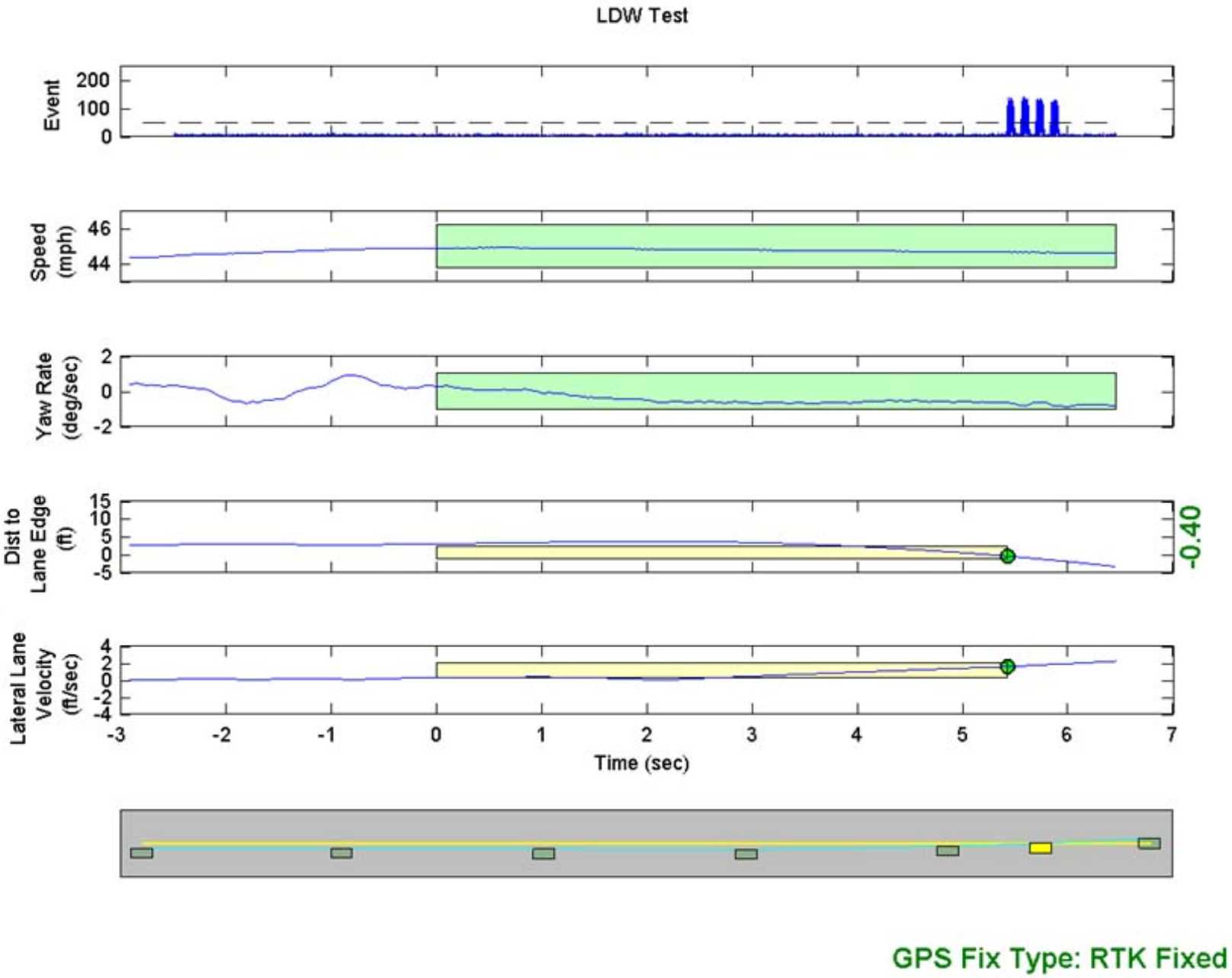

Figure D1. Example Time History for Lane Departure Warning Test, Passing

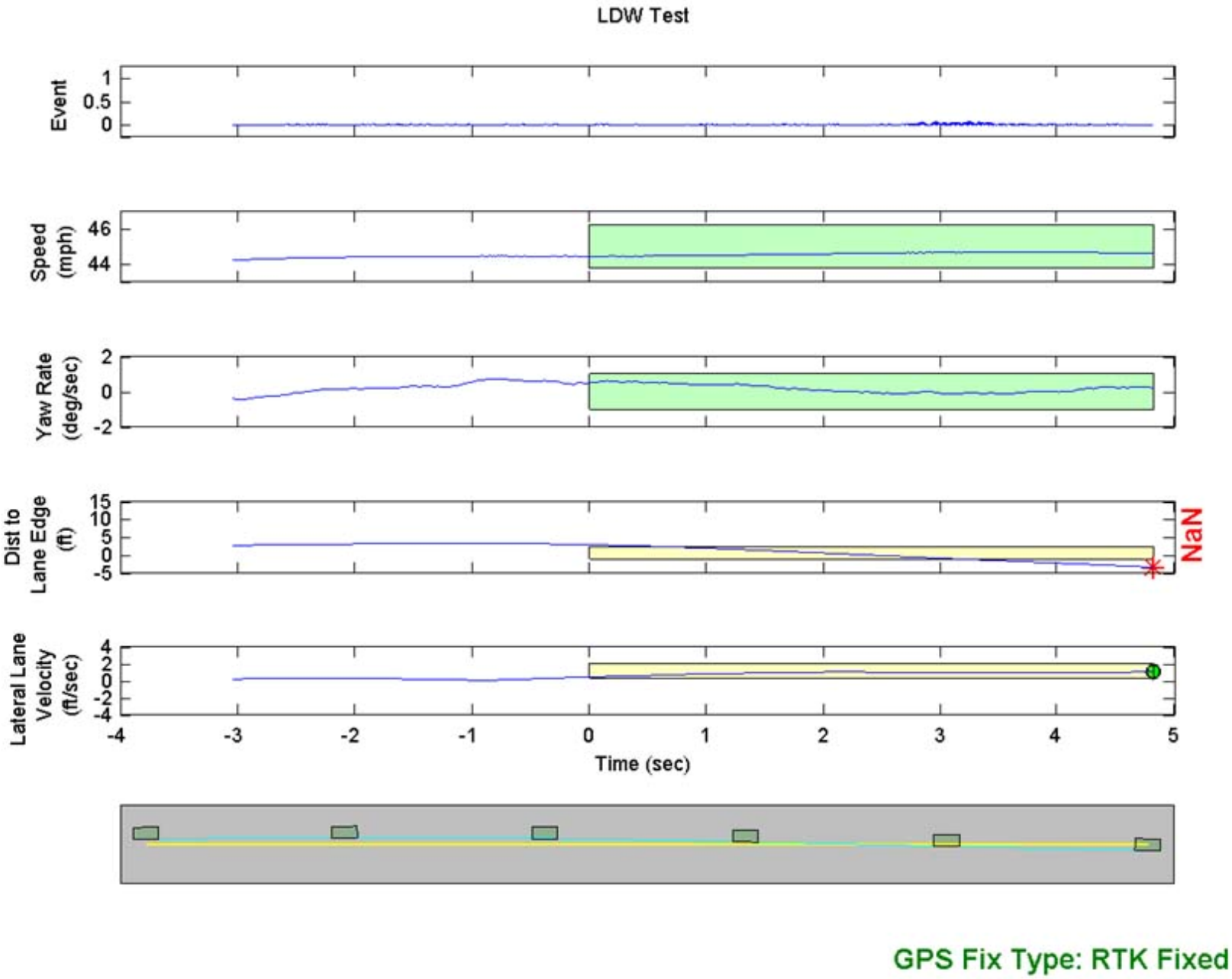

Figure D2. Example Time History for Lane Departure Warning Test, Failing, No Warning Issued

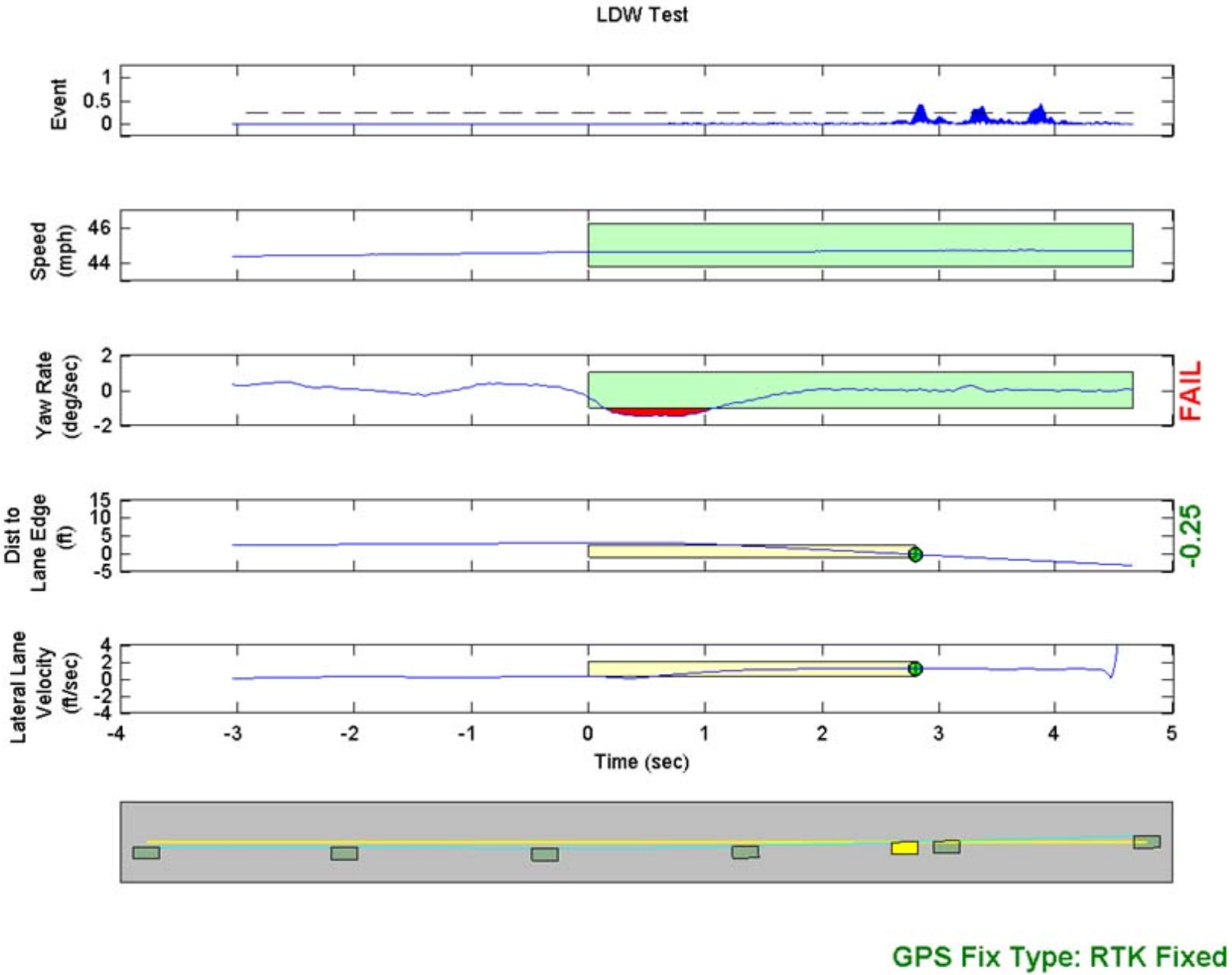

Figure D3. Example Time History for Lane Departure Warning Test, Invalid Run Due to Subject Vehicle Yaw Rate

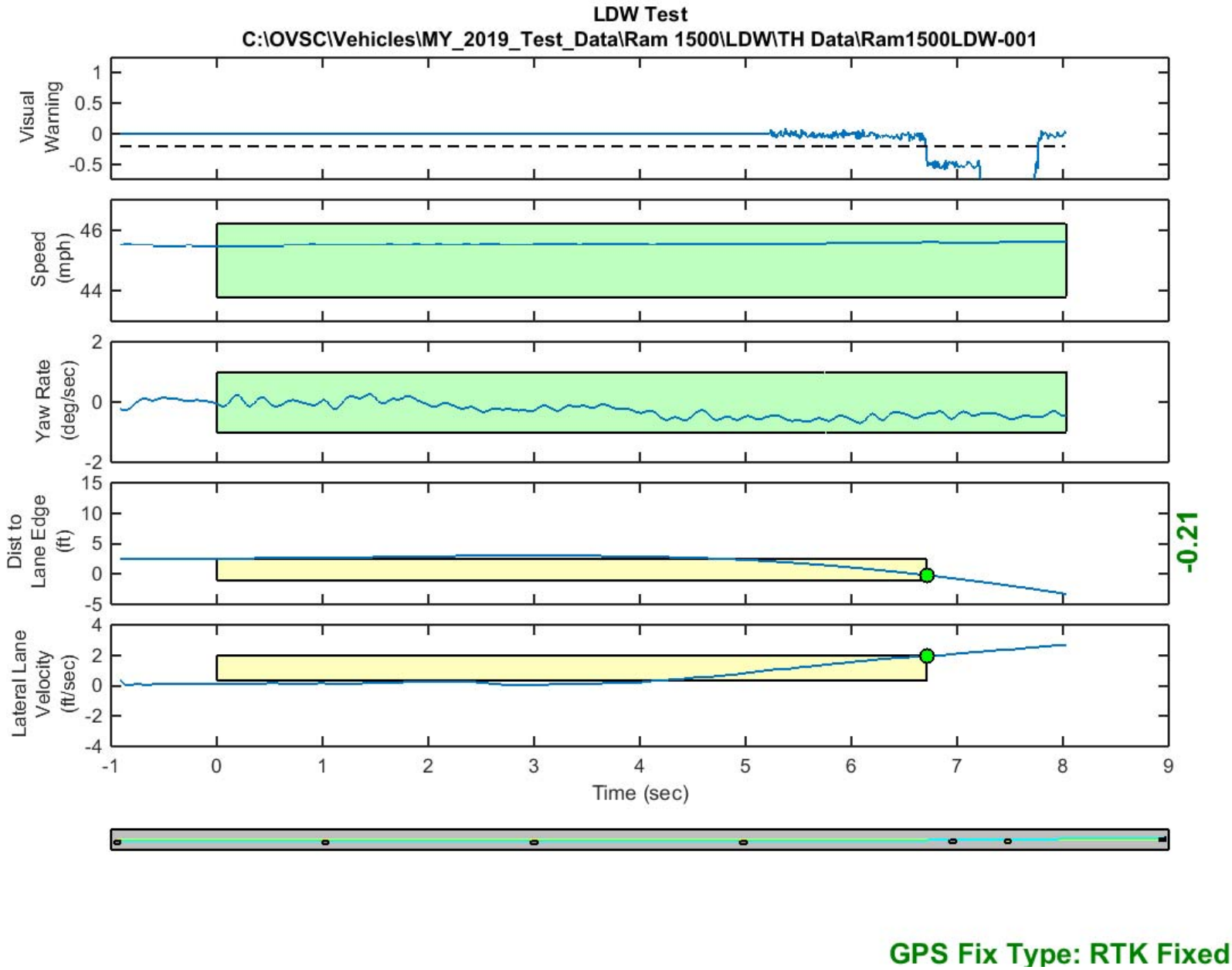

Figure D4. Time History for Run 01, Botts Dots, Left Departure, Visual Warning

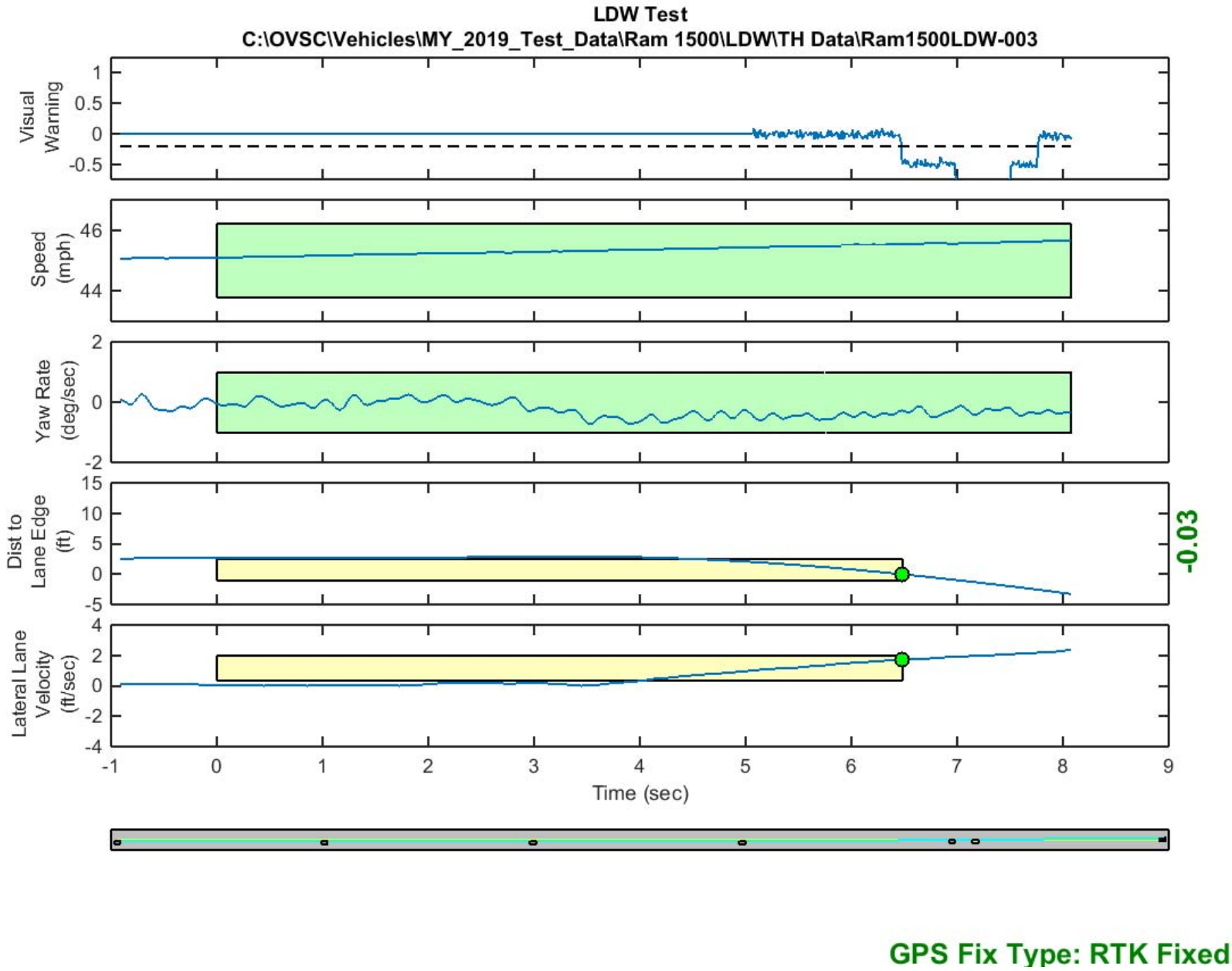

Figure D5. Time History for Run 03, Botts Dots, Left Departure, Visual Warning

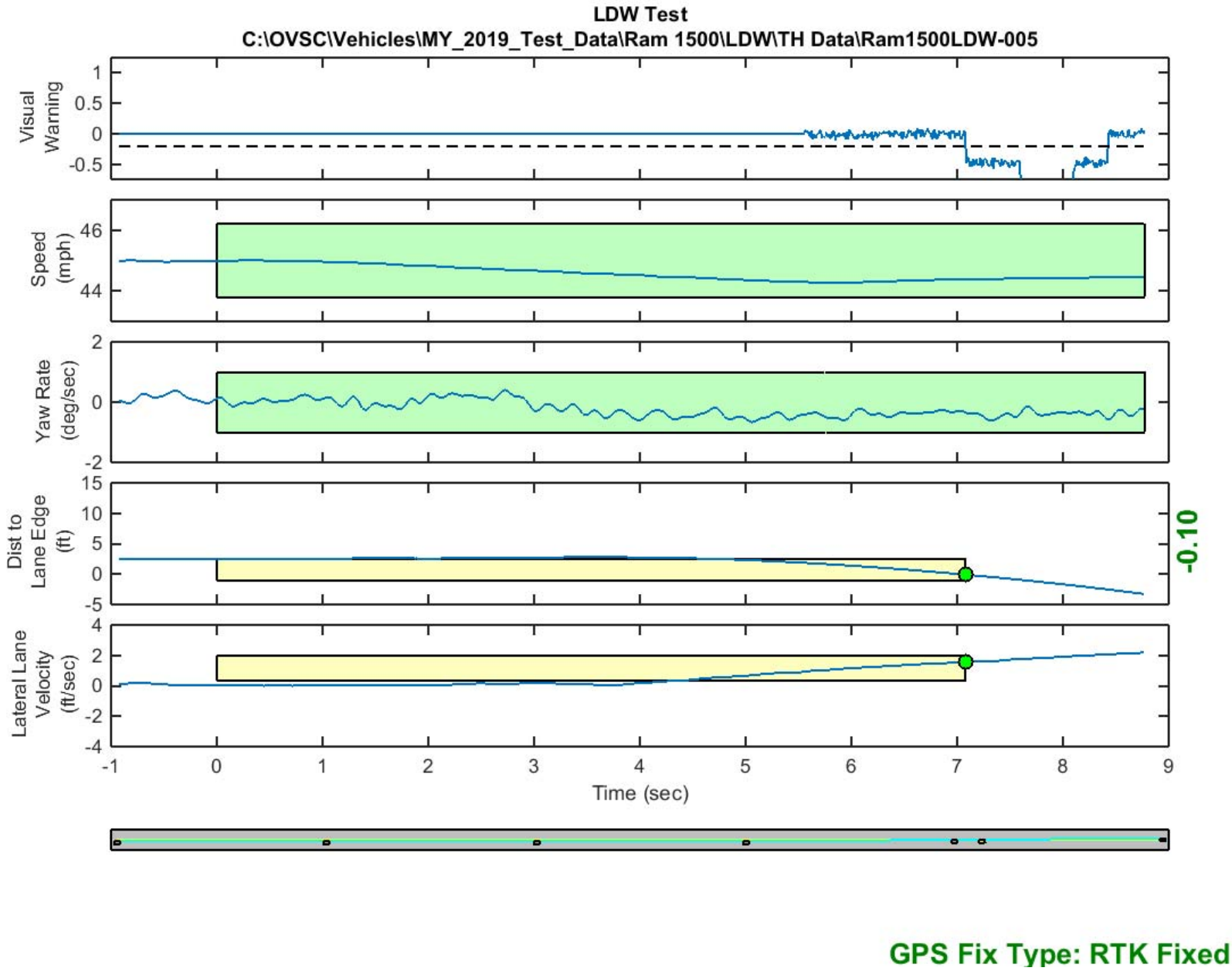

Figure D6. Time History for Run 05, Botts Dots, Left Departure, Visual Warning

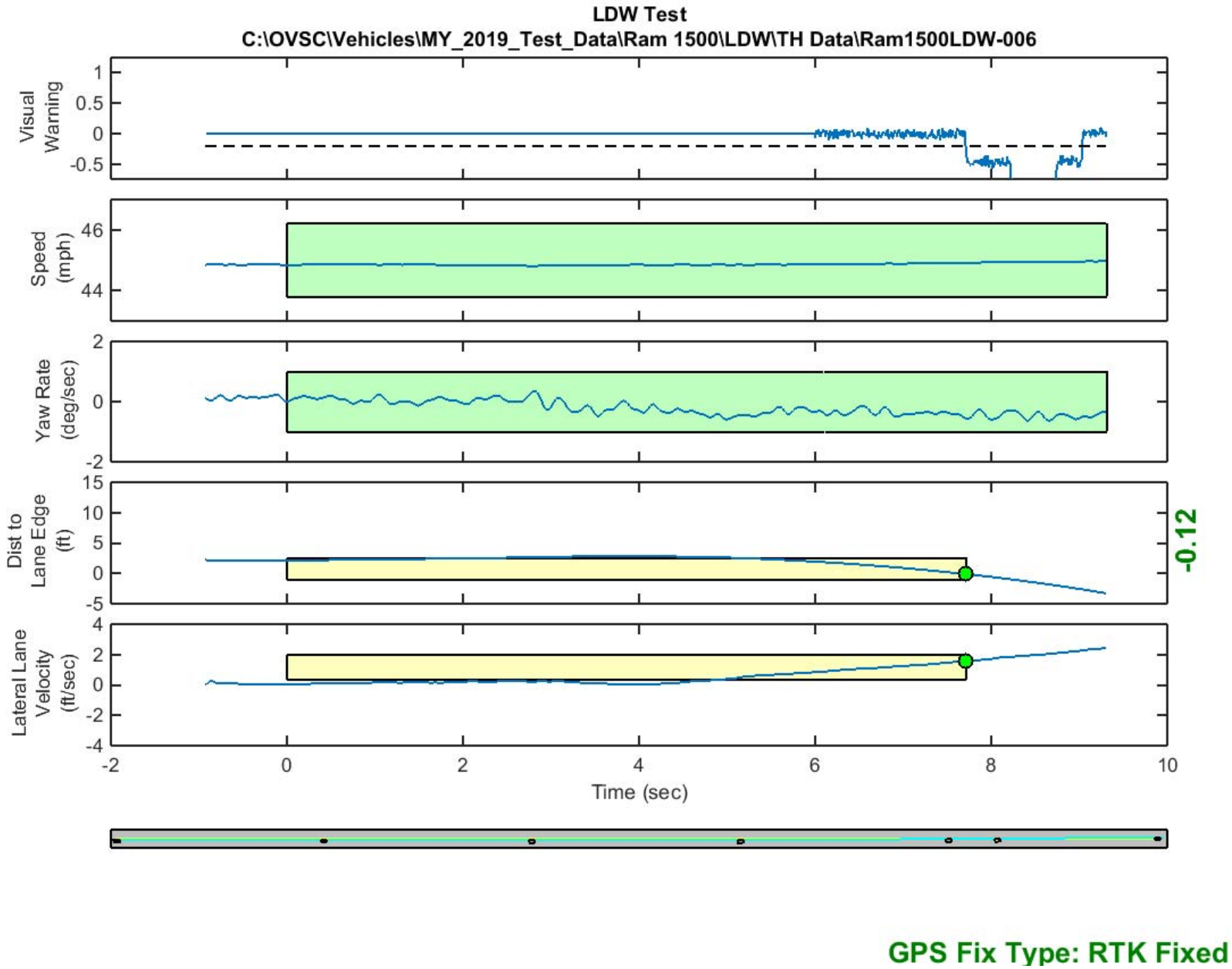

Figure D7. Time History for Run 06, Botts Dots, Left Departure, Visual Warning

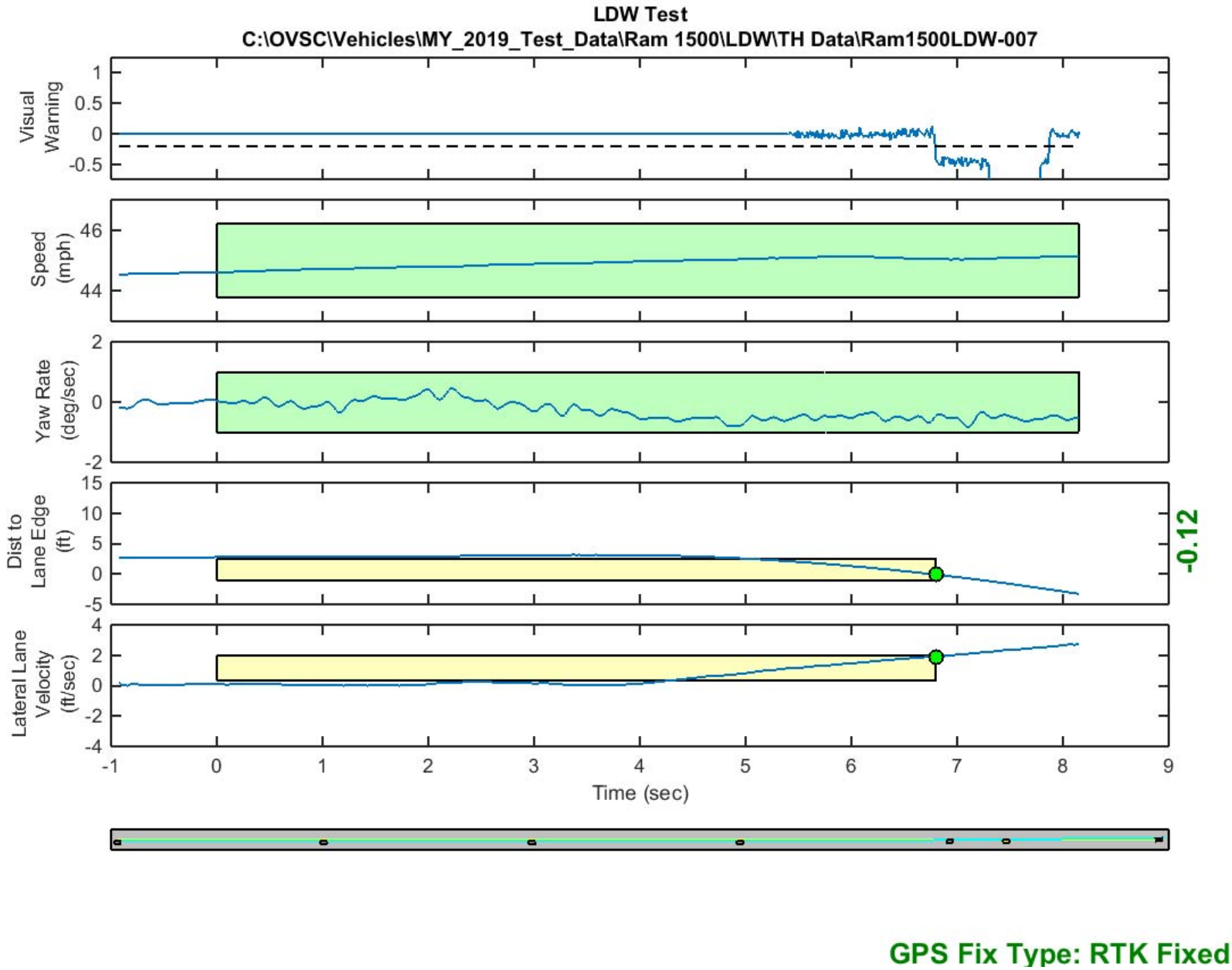

Figure D8. Time History for Run 07, Botts Dots, Left Departure, Visual Warning

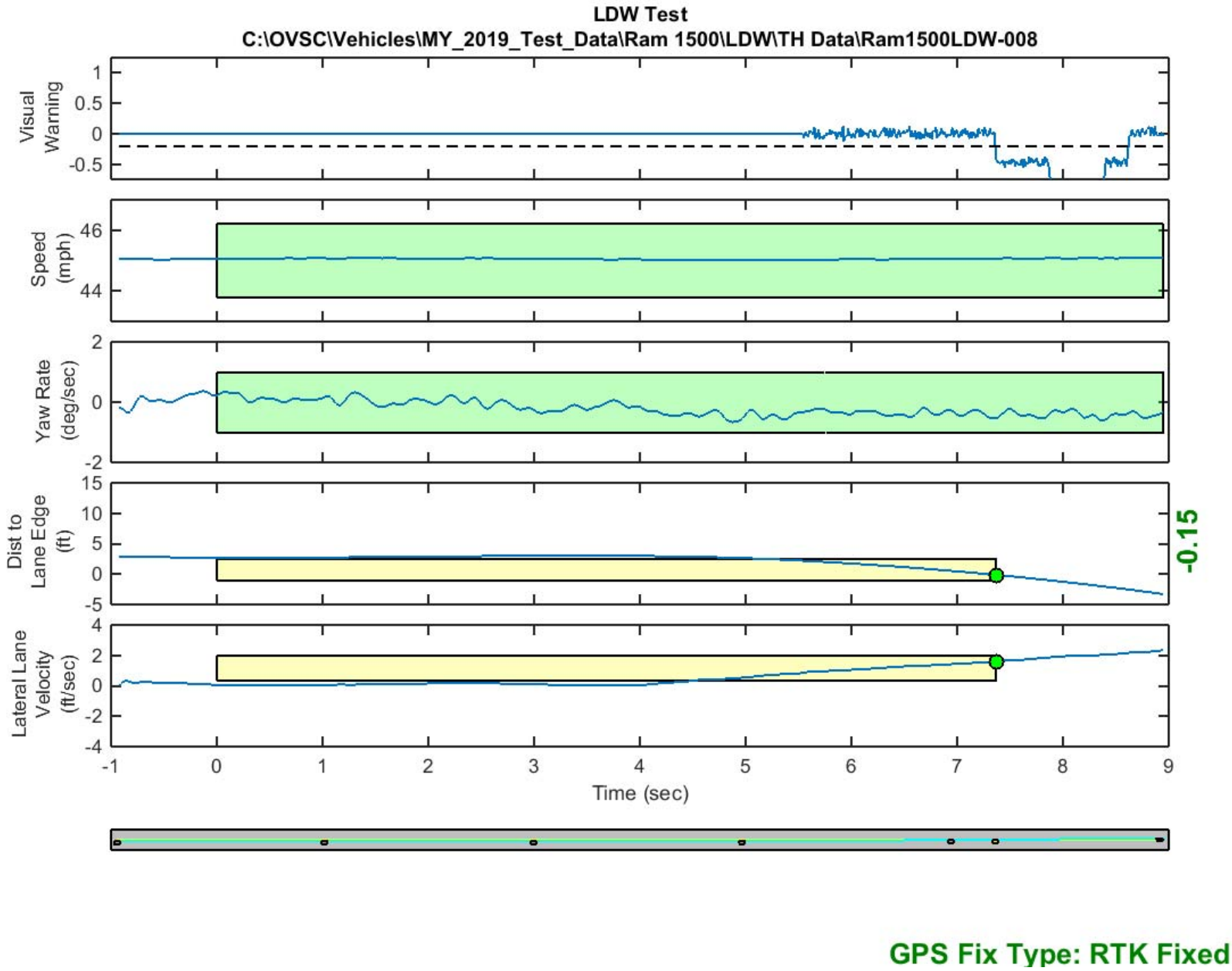

Figure D9. Time History for Run 08, Botts Dots, Left Departure, Visual Warning

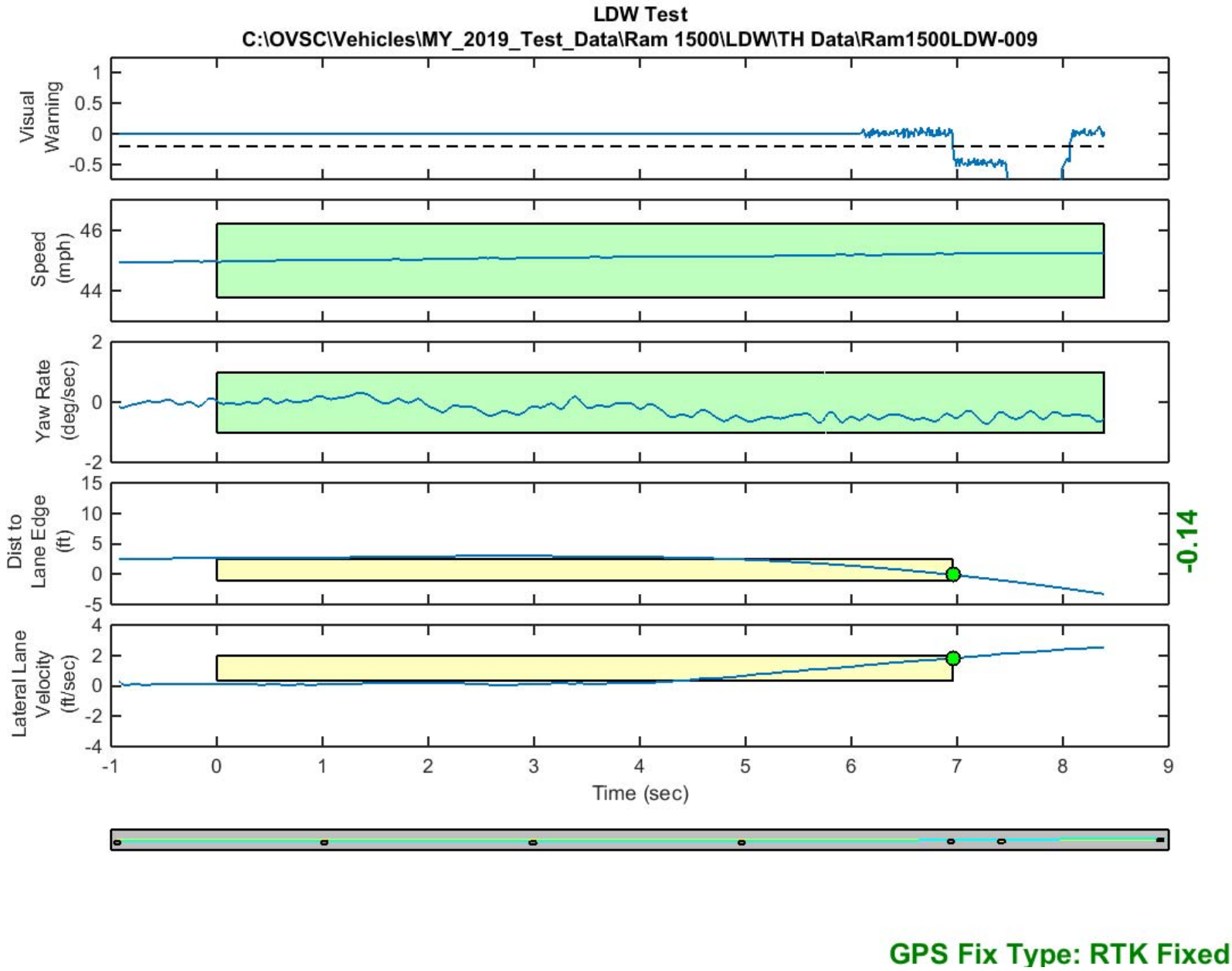

Figure D10. Time History for Run 09, Botts Dots, Left Departure, Visual Warning

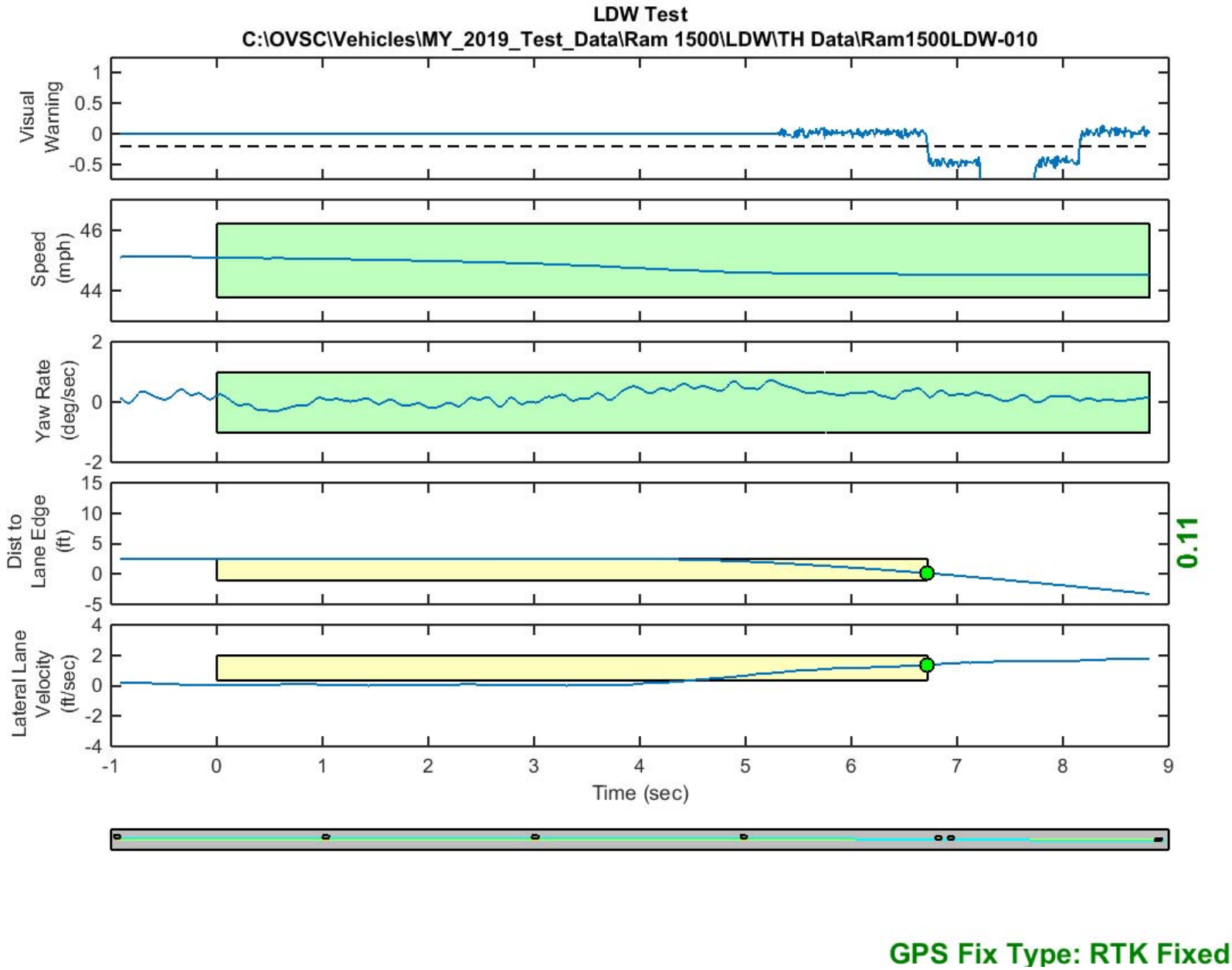

Figure D11. Time History for Run 10, Botts Dots, Right Departure, Visual Warning

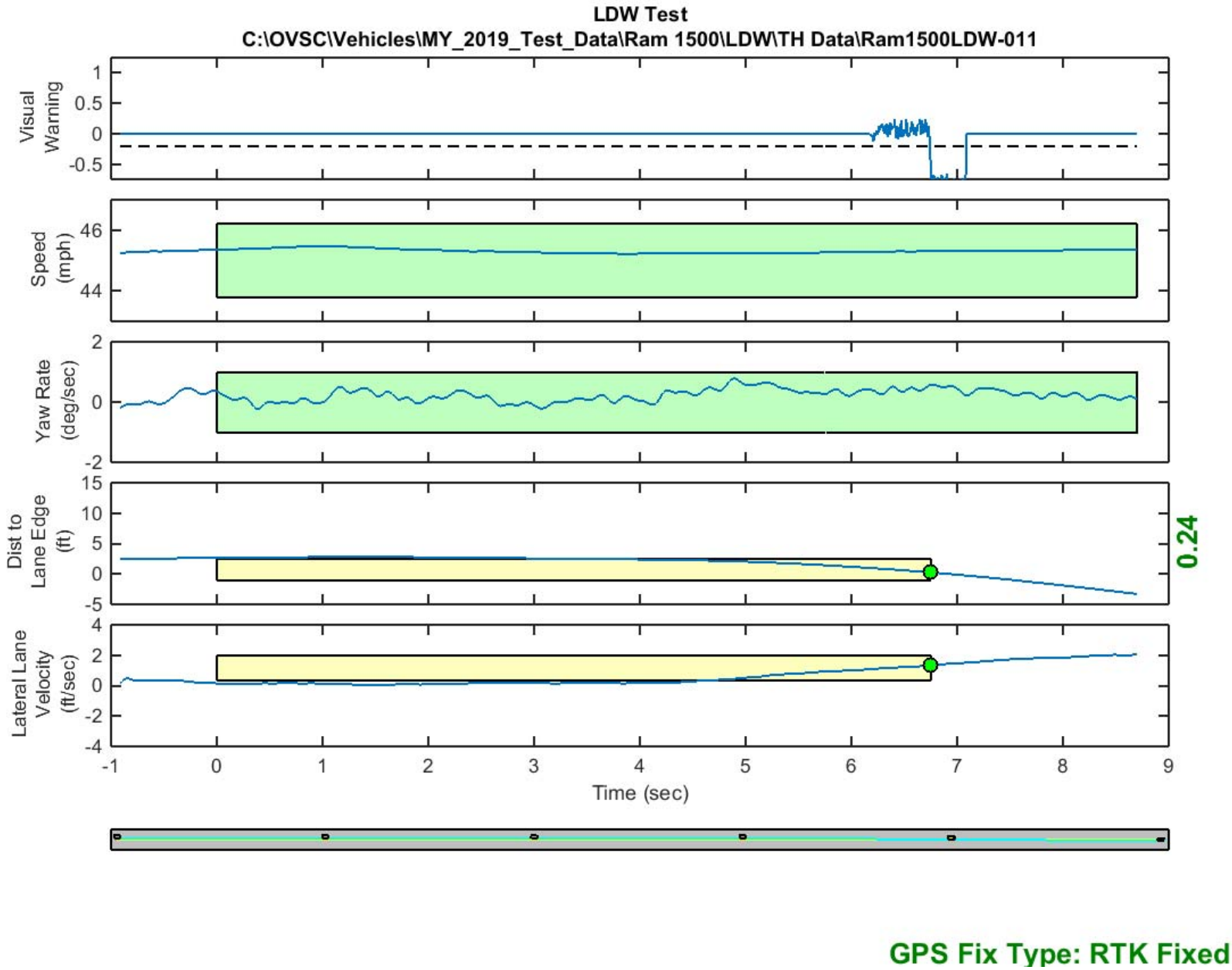

Figure D12. Time History for Run 11, Botts Dots, Right Departure, Visual Warning

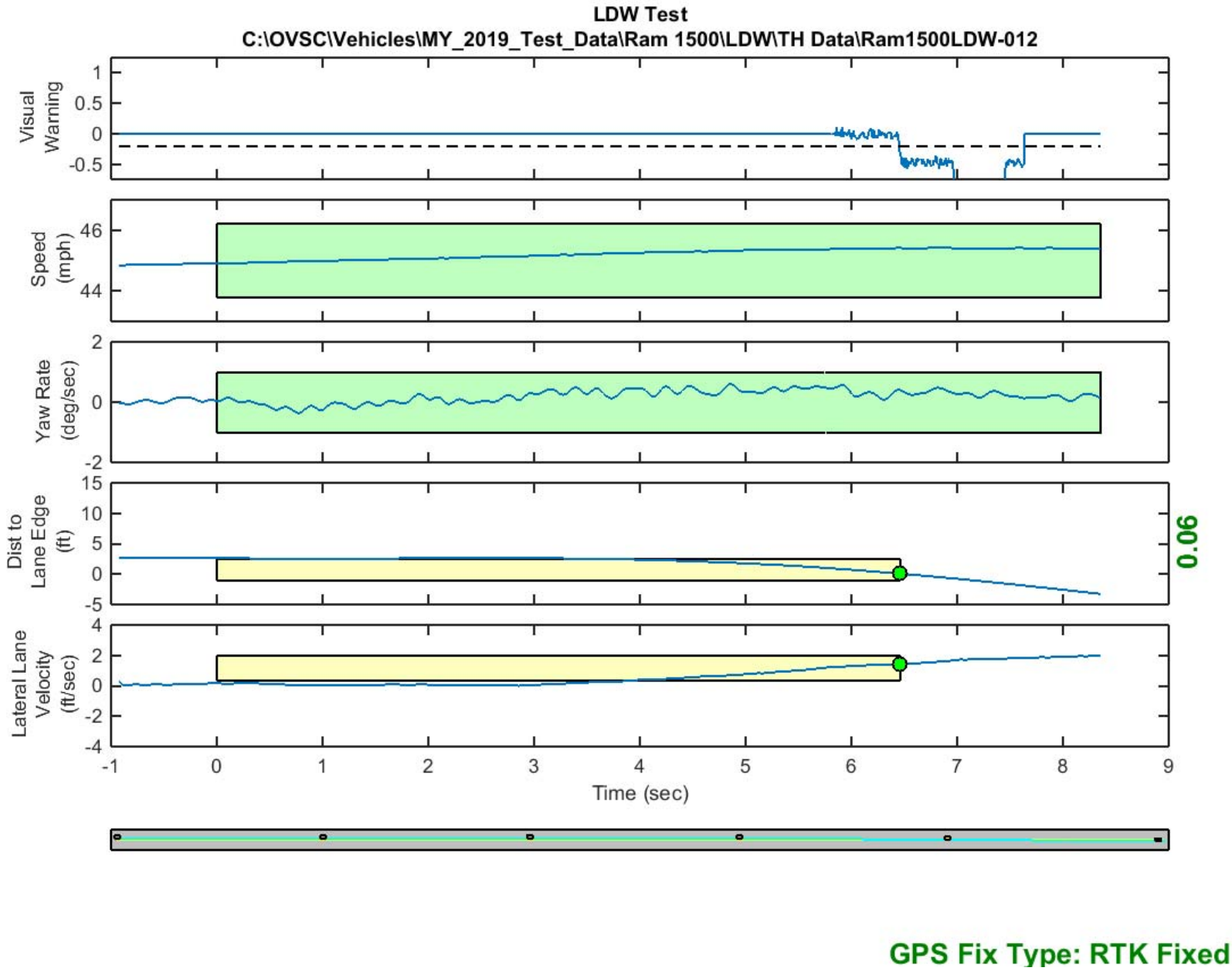

Figure D13. Time History for Run 12, Botts Dots, Right Departure, Visual Warning

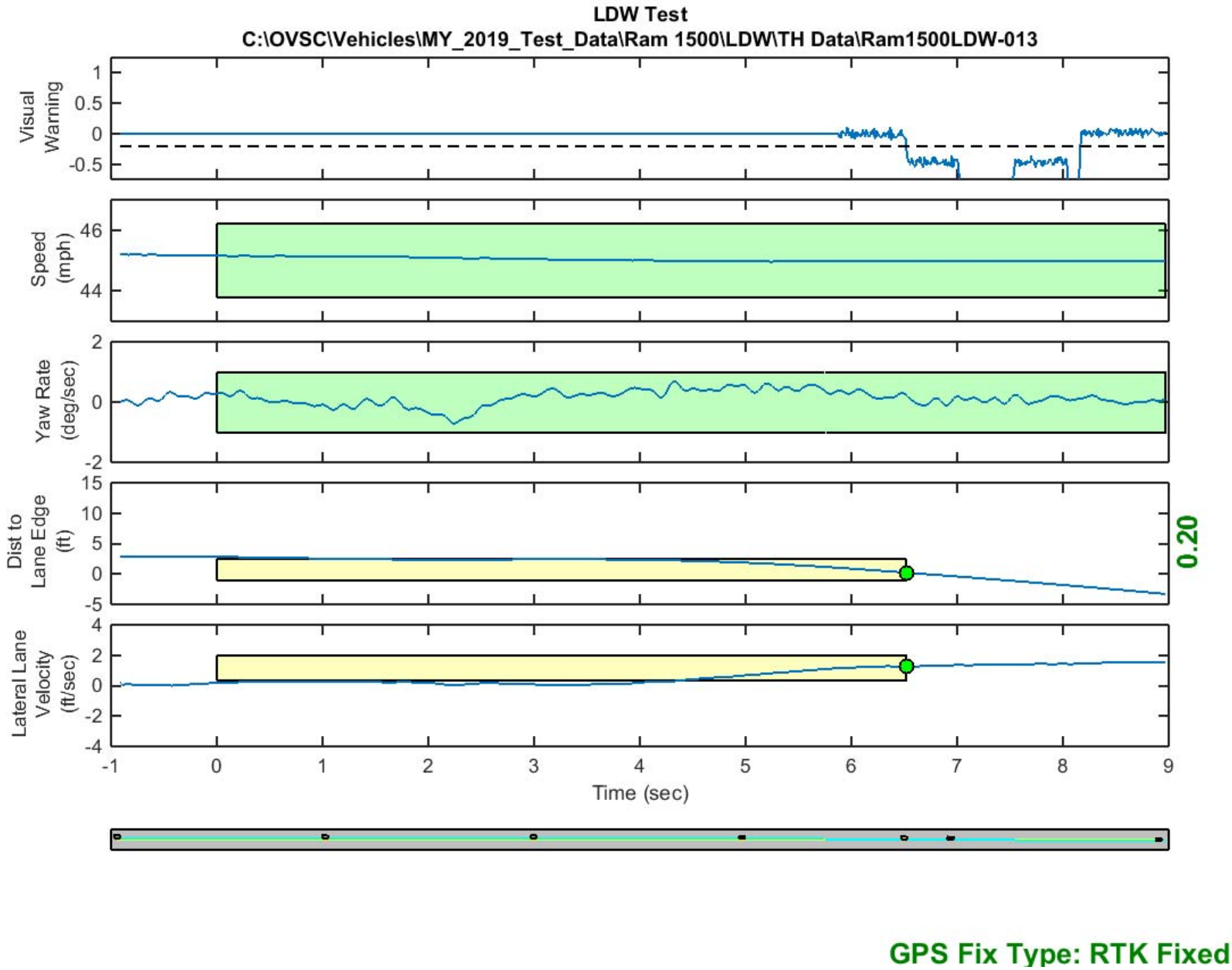

Figure D14. Time History for Run 13, Botts Dots, Right Departure, Visual Warning

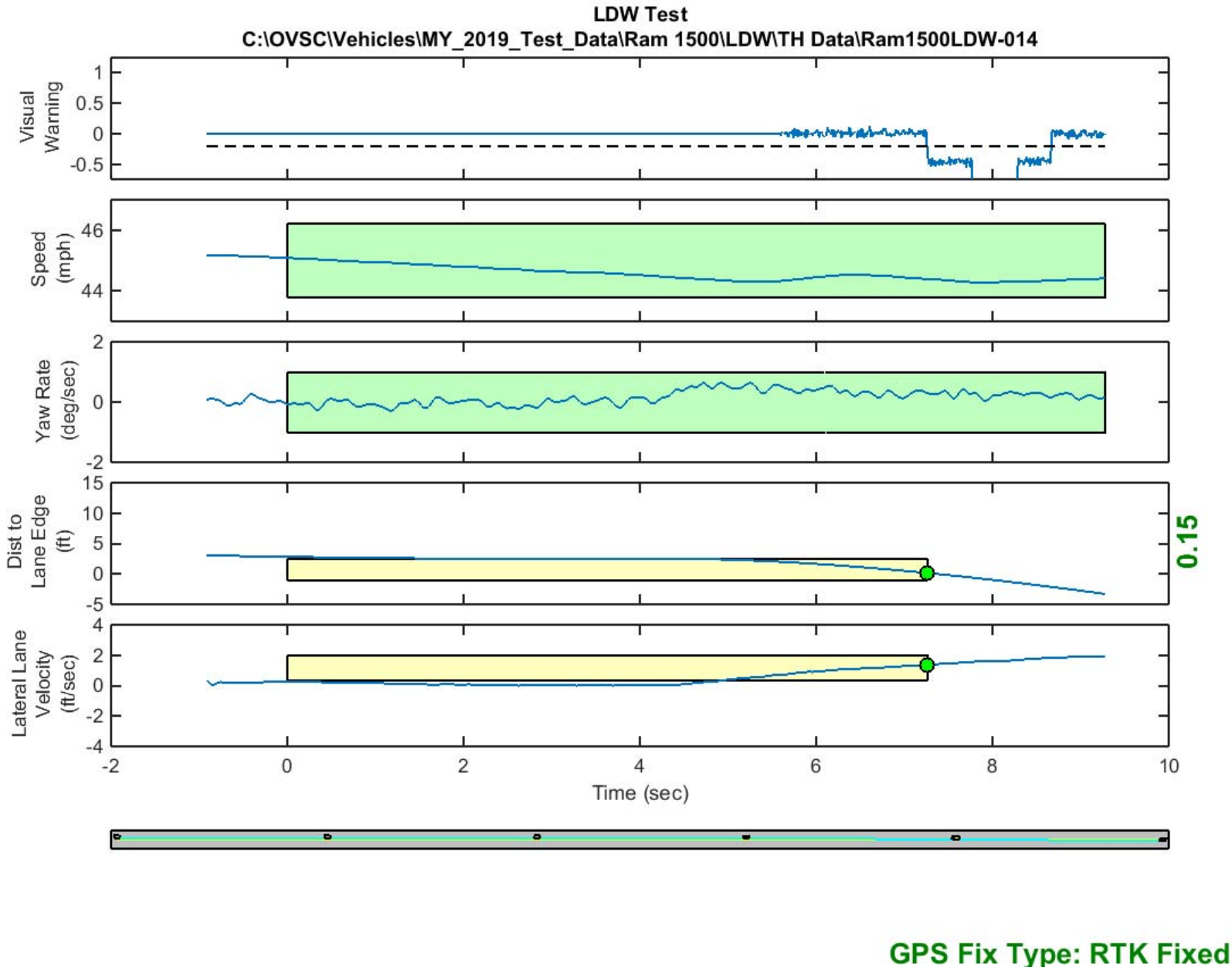

Figure D15. Time History for Run 14, Botts Dots, Right Departure, Visual Warning

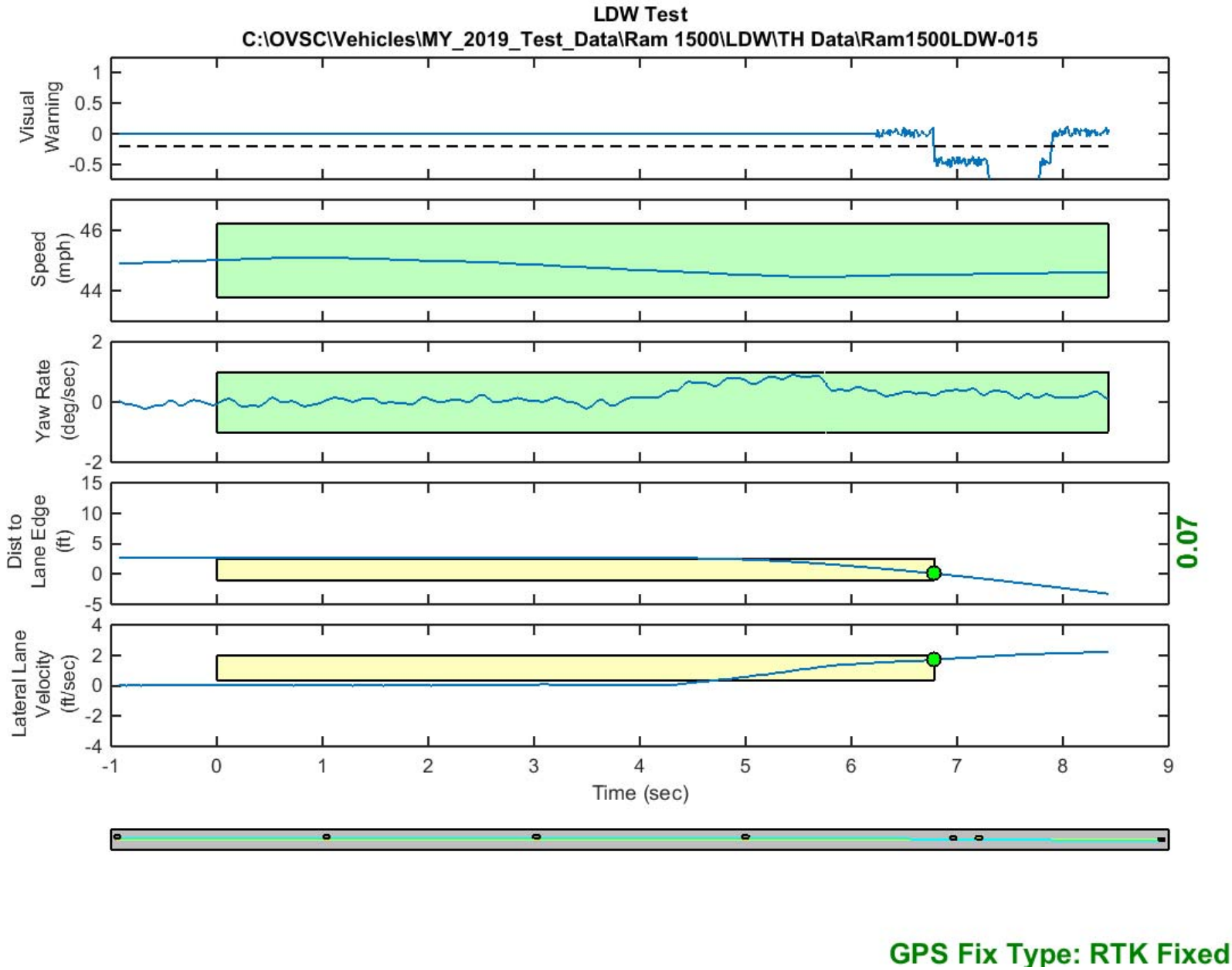

Figure D16. Time History for Run 15, Botts Dots, Right Departure, Visual Warning

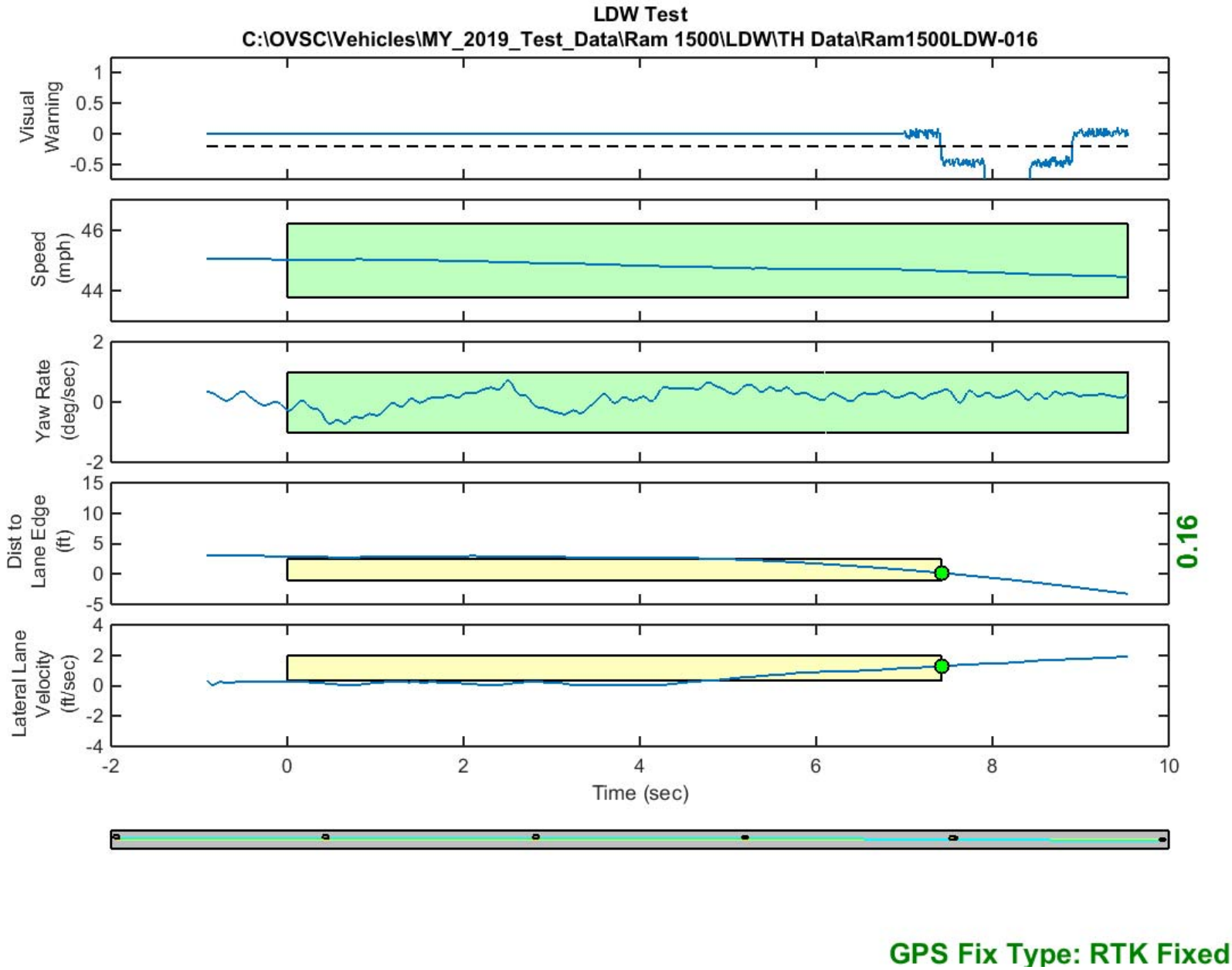

Figure D17. Time History for Run 16, Botts Dots, Right Departure, Visual Warning

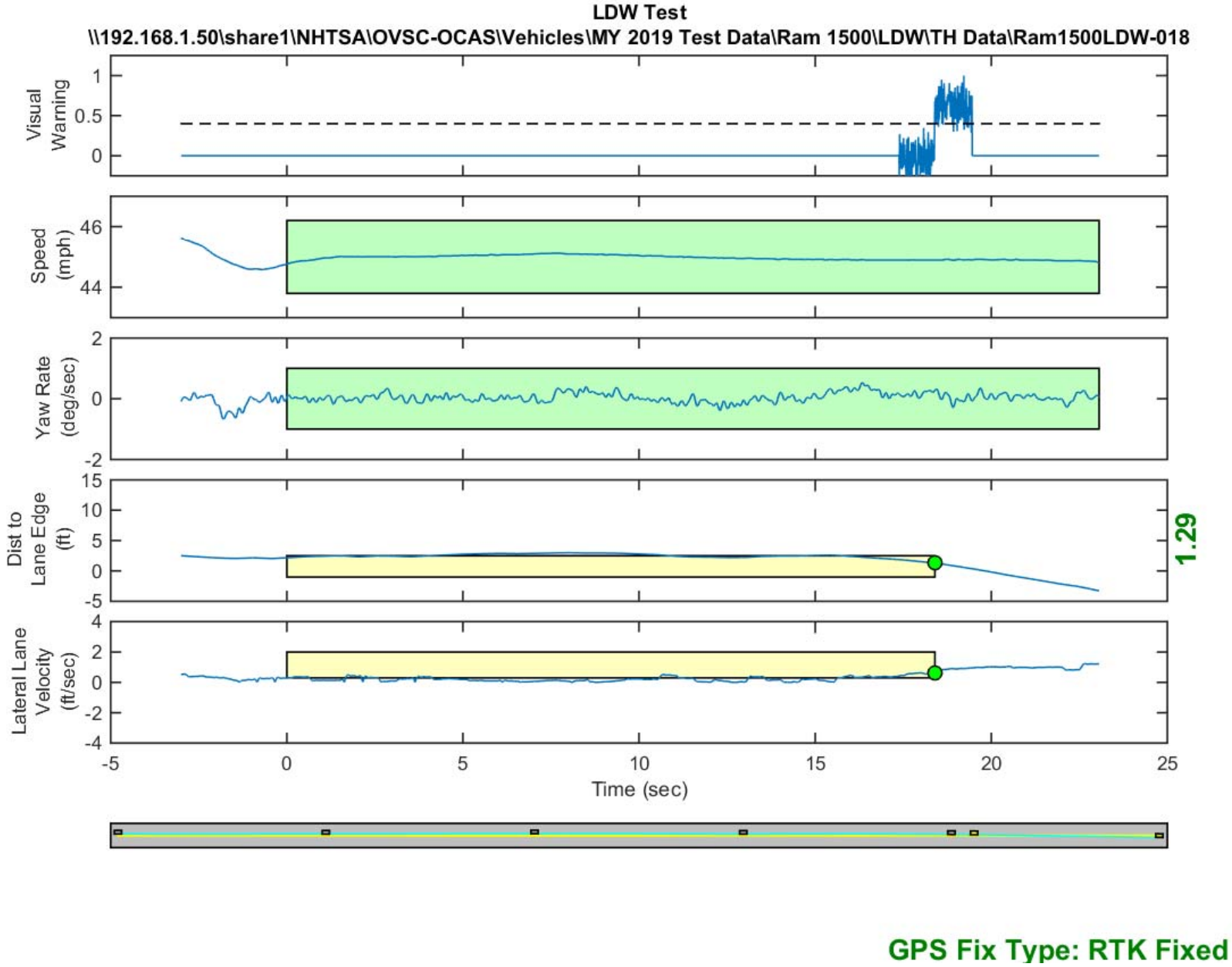

Figure D18. Time History for Run 18, Solid Line, Right Departure, Visual Warning

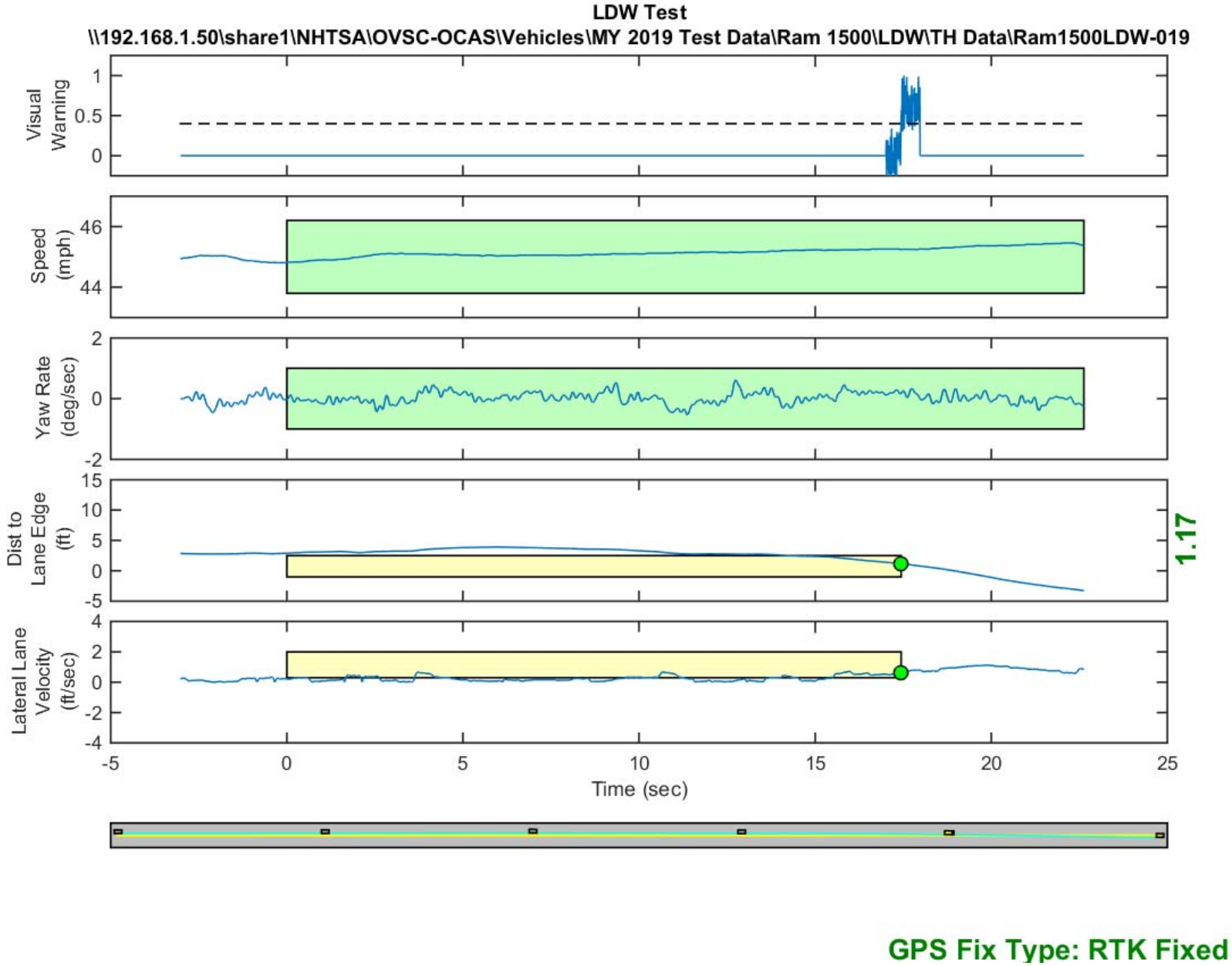

Figure D19. Time History for Run 19, Solid Line, Right Departure, Visual Warning

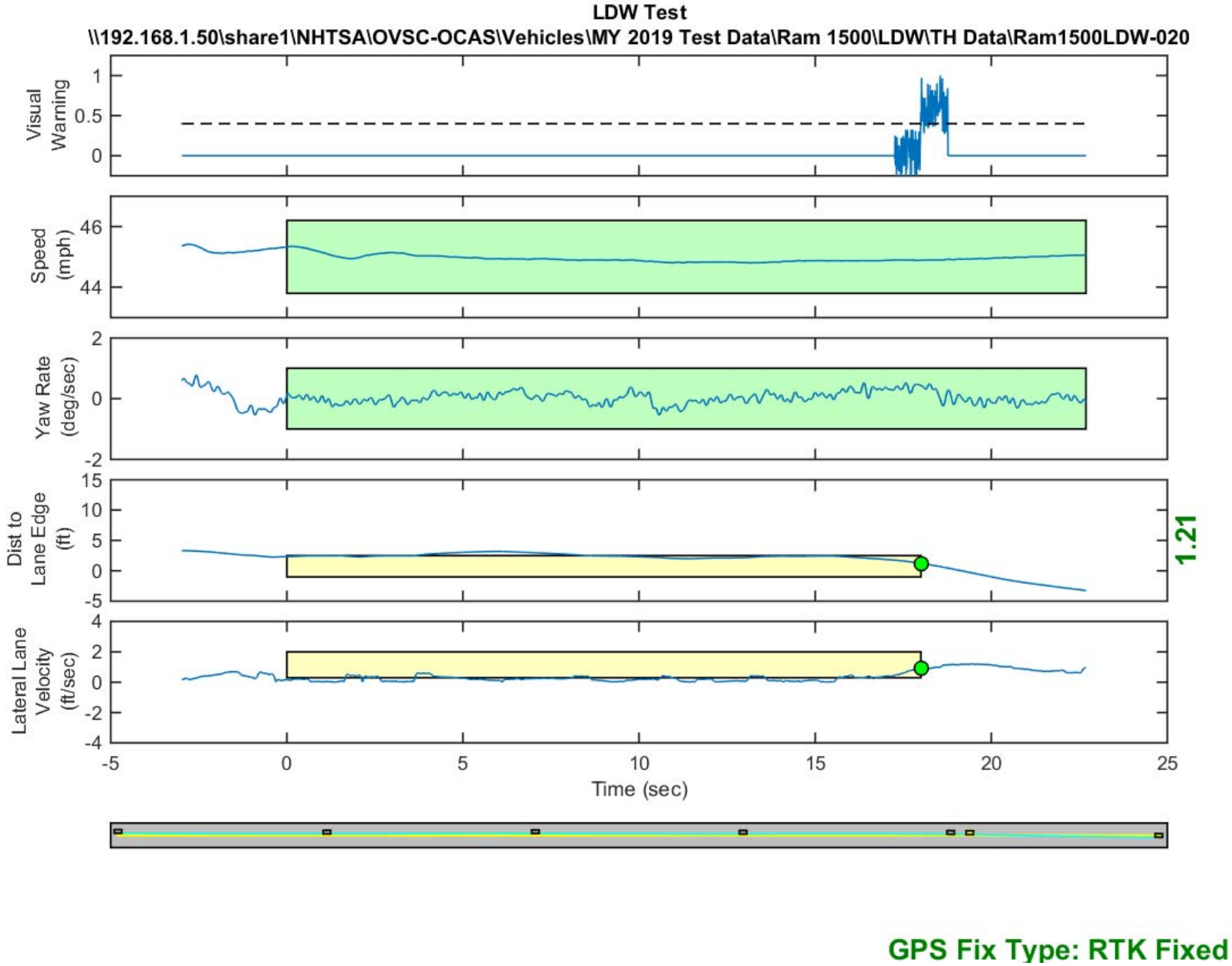

Figure D20. Time History for Run 20, Solid Line, Right Departure, Visual Warning

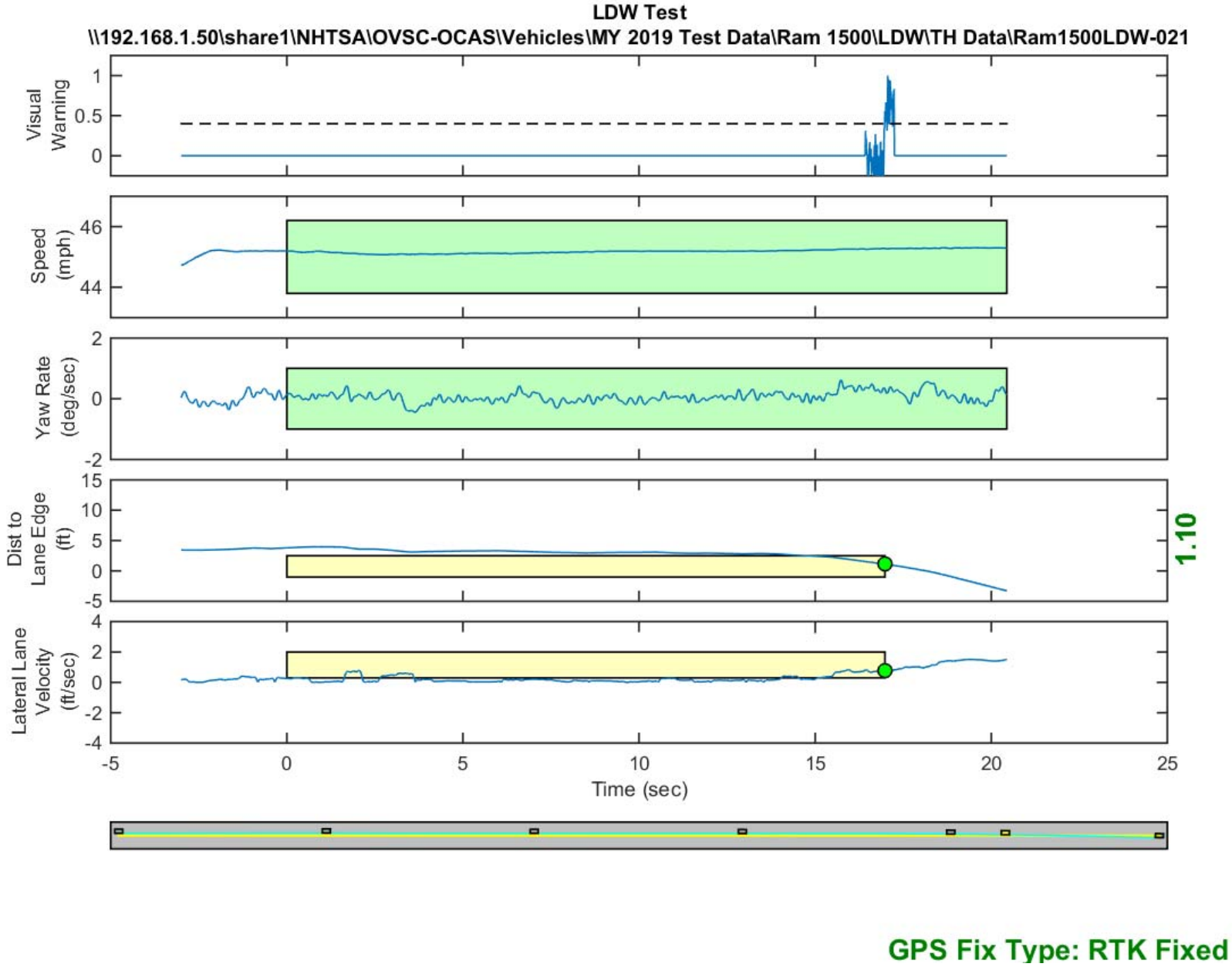

Figure D21. Time History for Run 21, Solid Line, Right Departure, Visual Warning

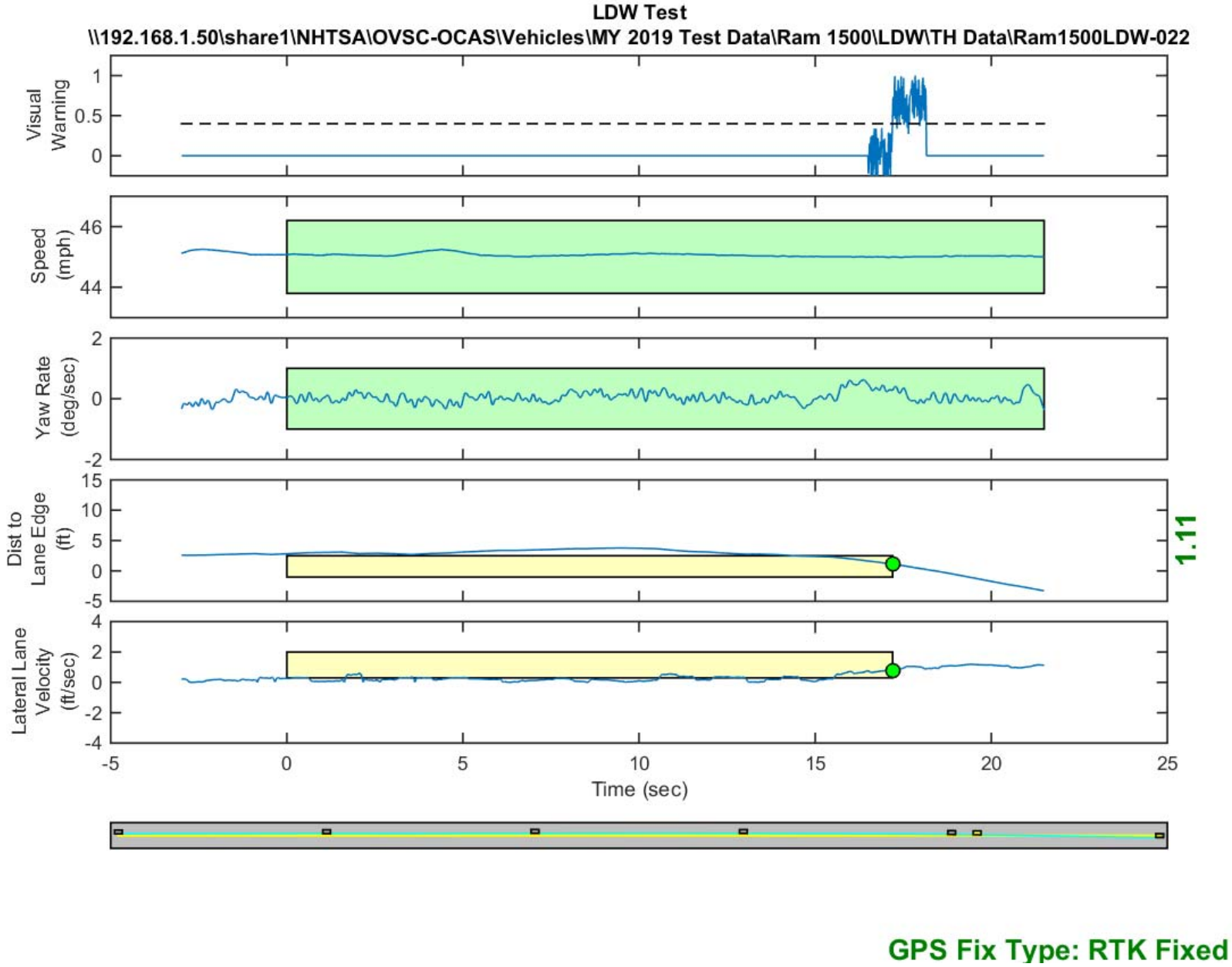

Figure D22. Time History for Run 22, Solid Line, Right Departure, Visual Warning

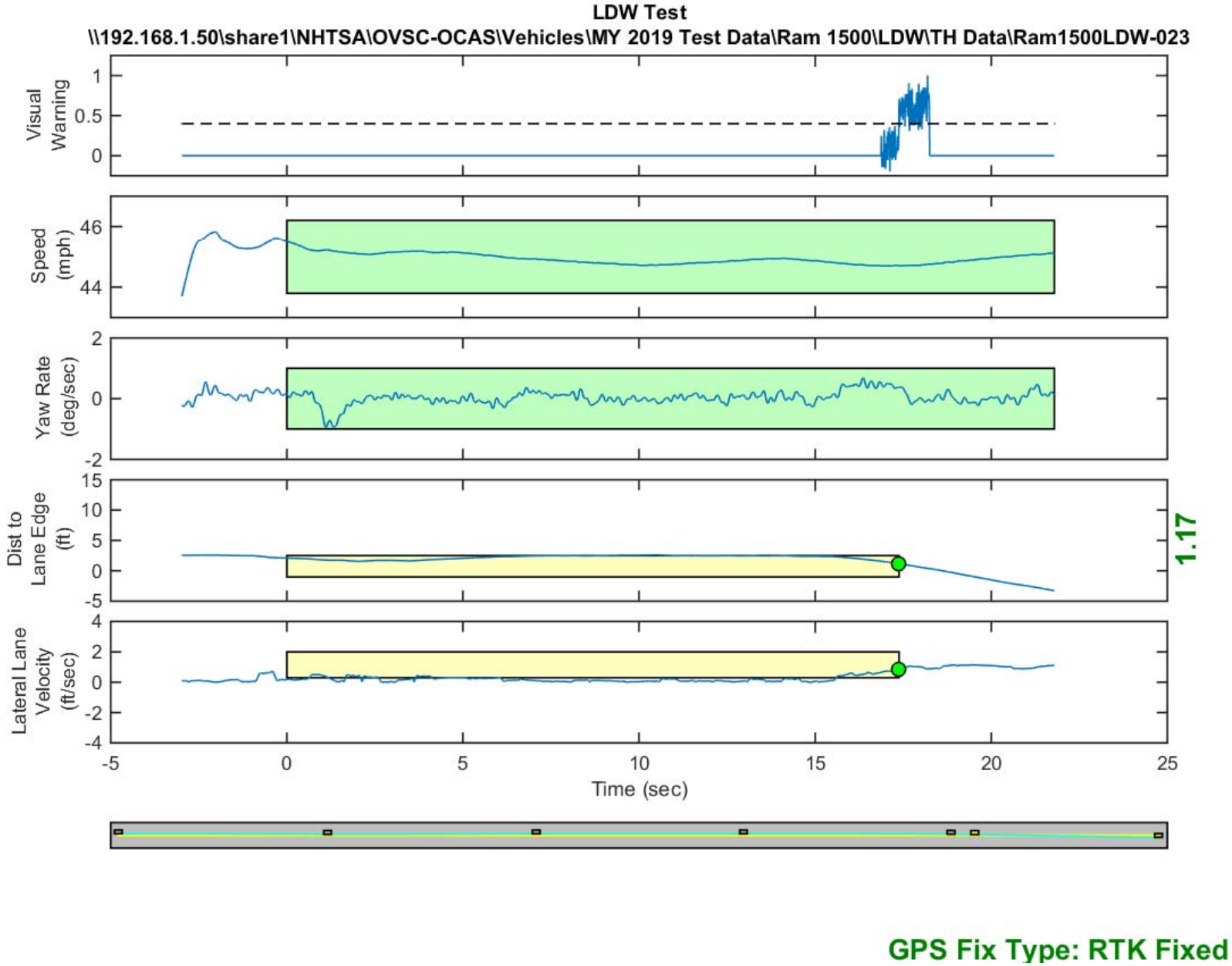

Figure D23. Time History for Run 23, Solid Line, Right Departure, Visual Warning

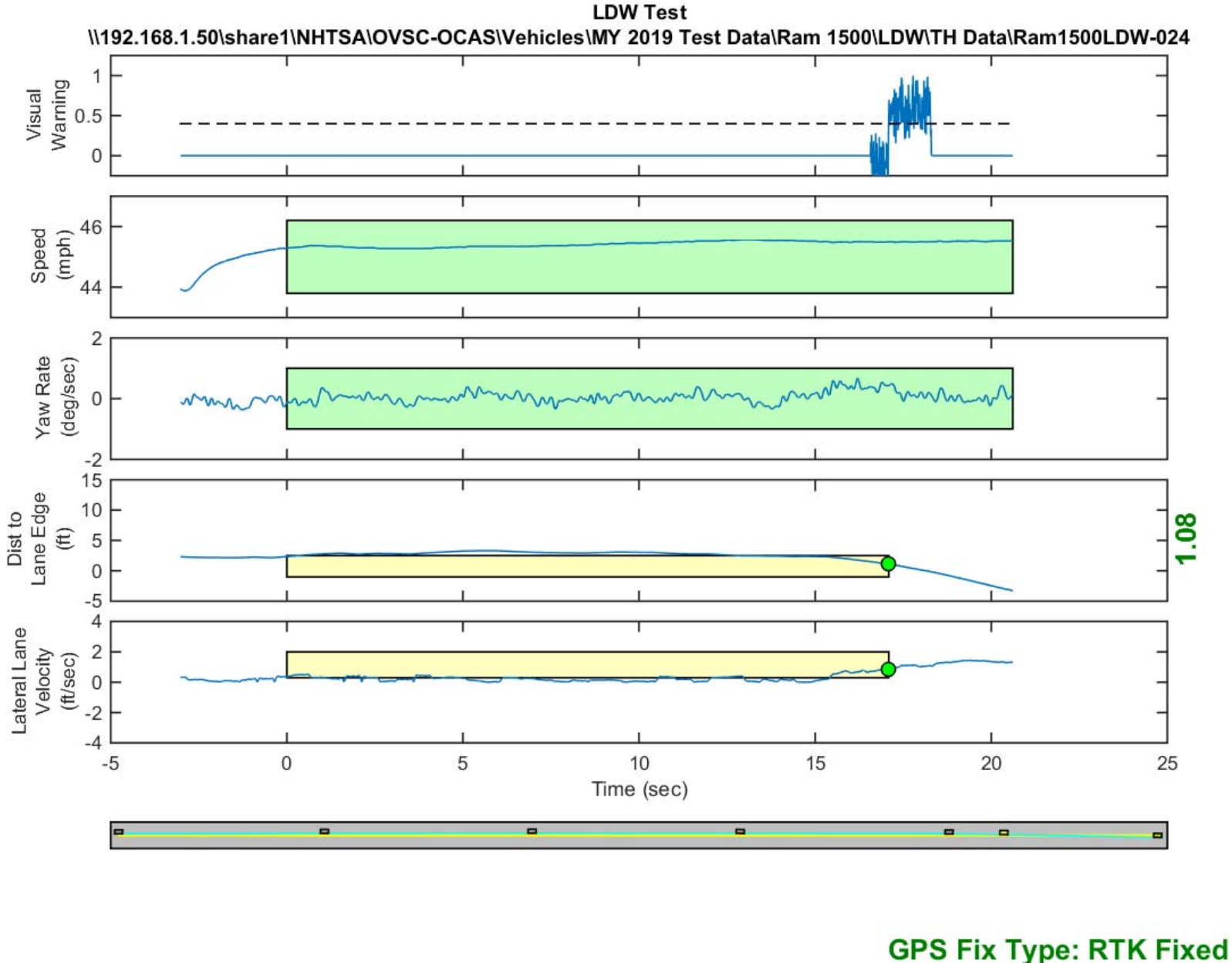

Figure D24. Time History for Run 24, Solid Line, Right Departure, Visual Warning

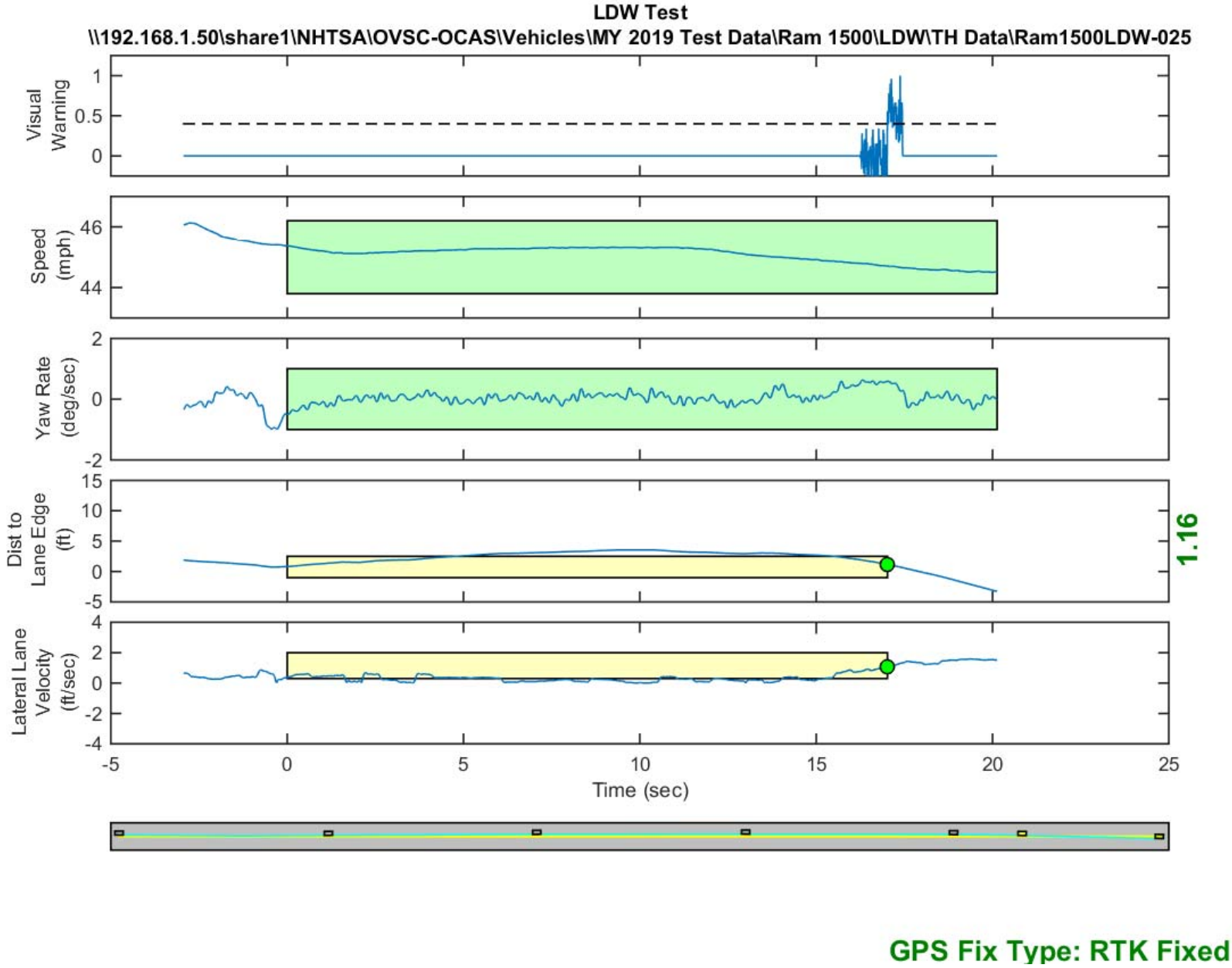

Figure D25. Time History for Run 25, Solid Line, Right Departure, Visual Warning

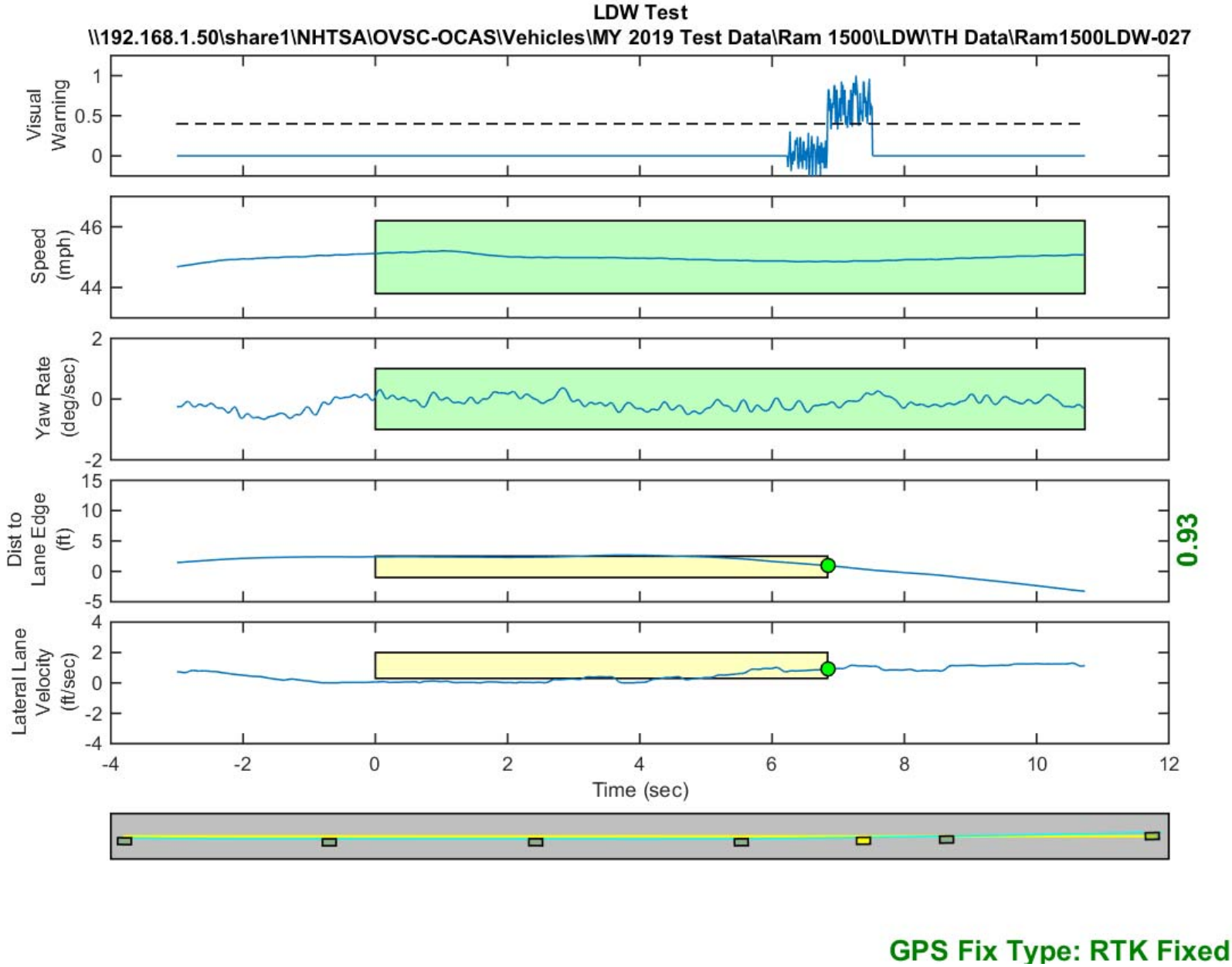

Figure D26. Time History for Run 27, Solid Line, Left Departure, Visual Warning

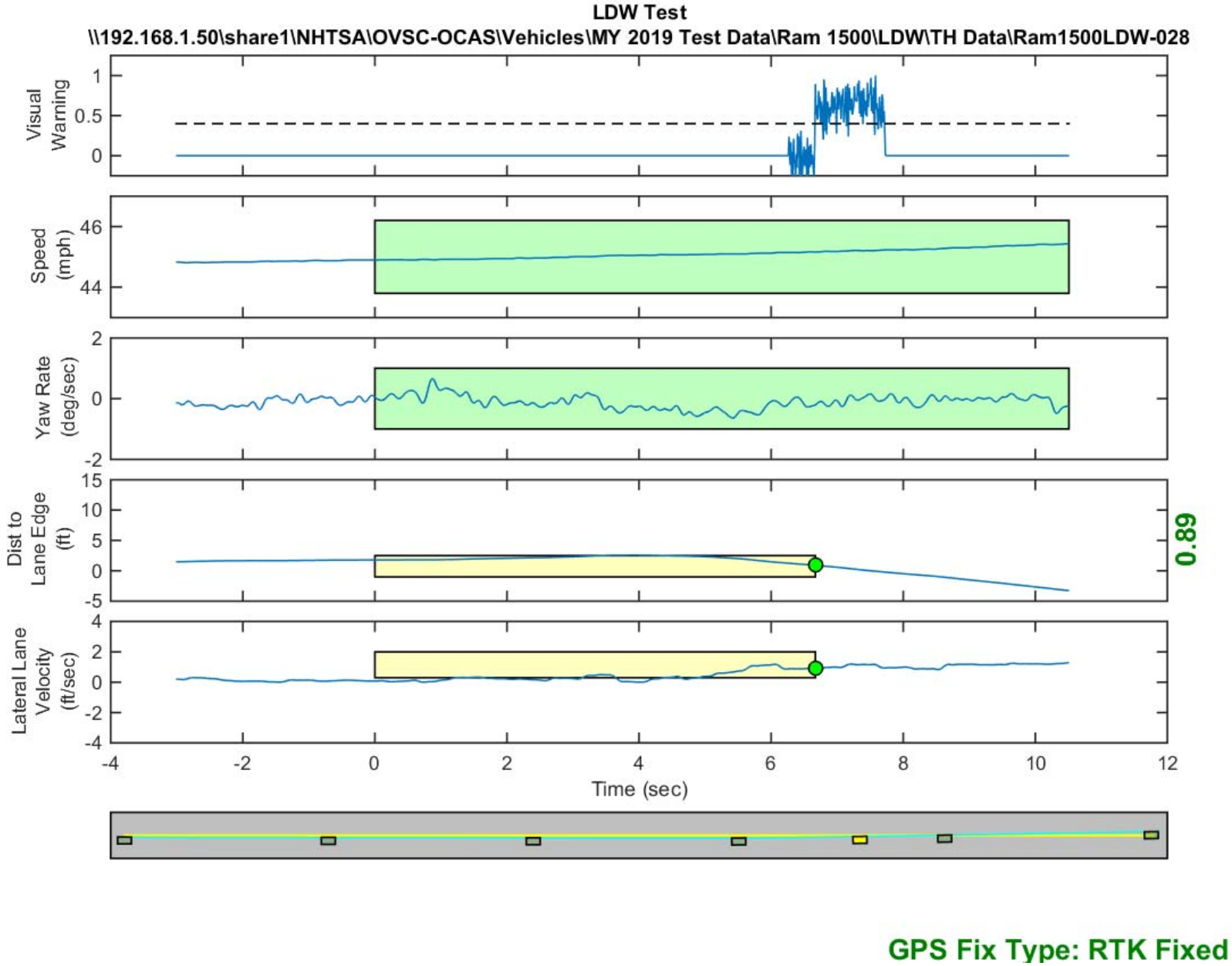

Figure D27. Time History for Run 28, Solid Line, Left Departure, Visual Warning

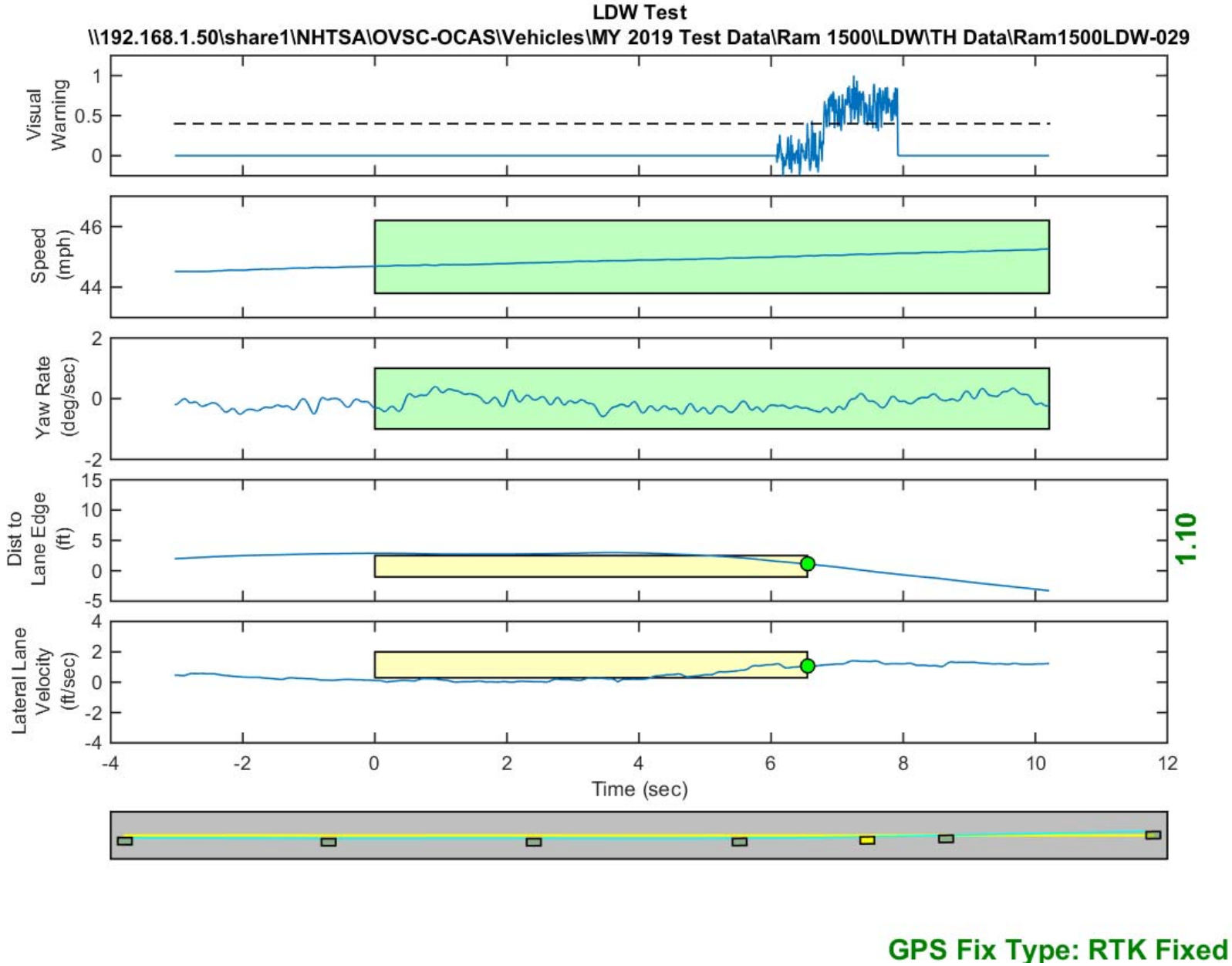

Figure D28. Time History for Run 29, Solid Line, Left Departure, Visual Warning

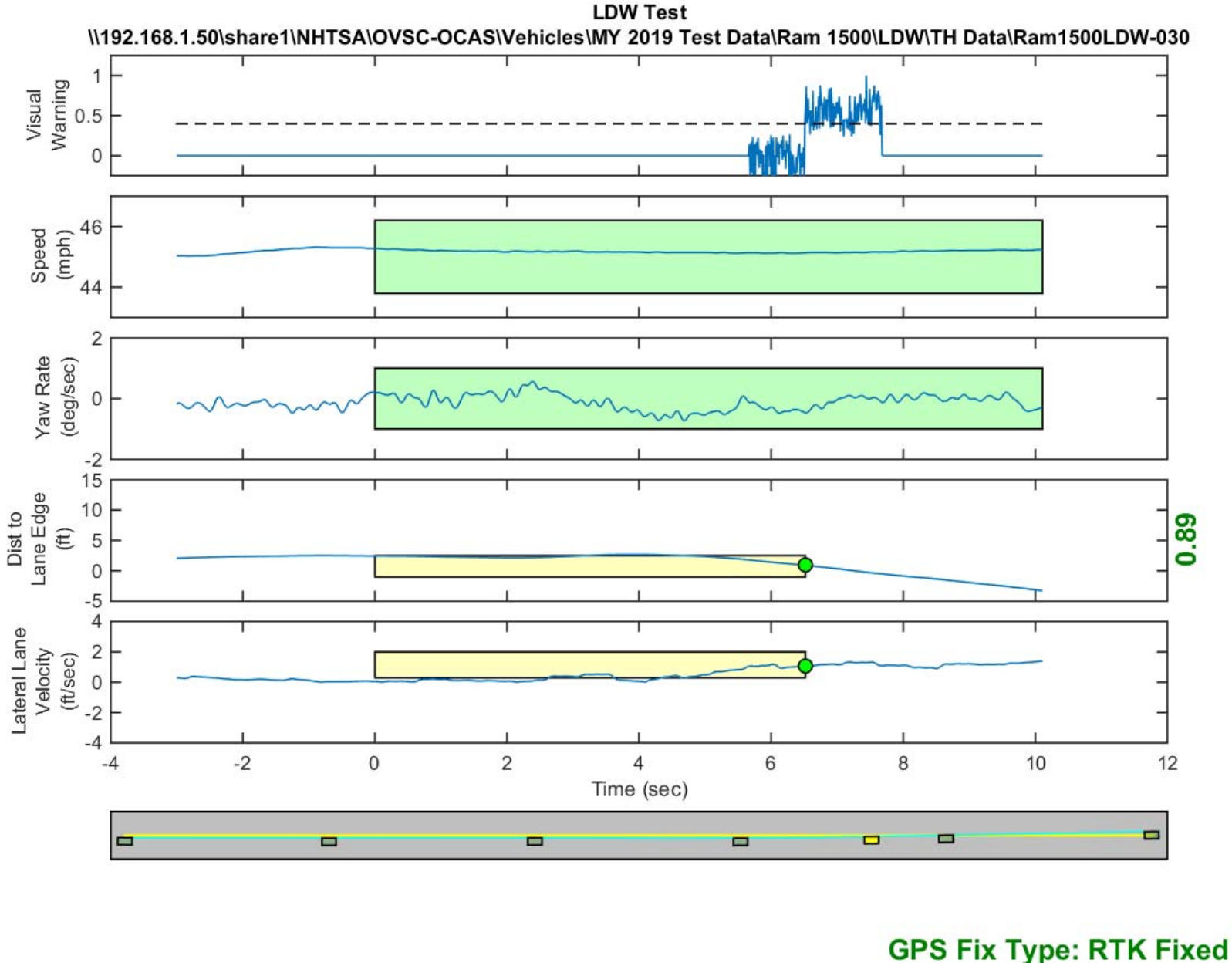

Figure D29. Time History for Run 30, Solid Line, Left Departure, Visual Warning

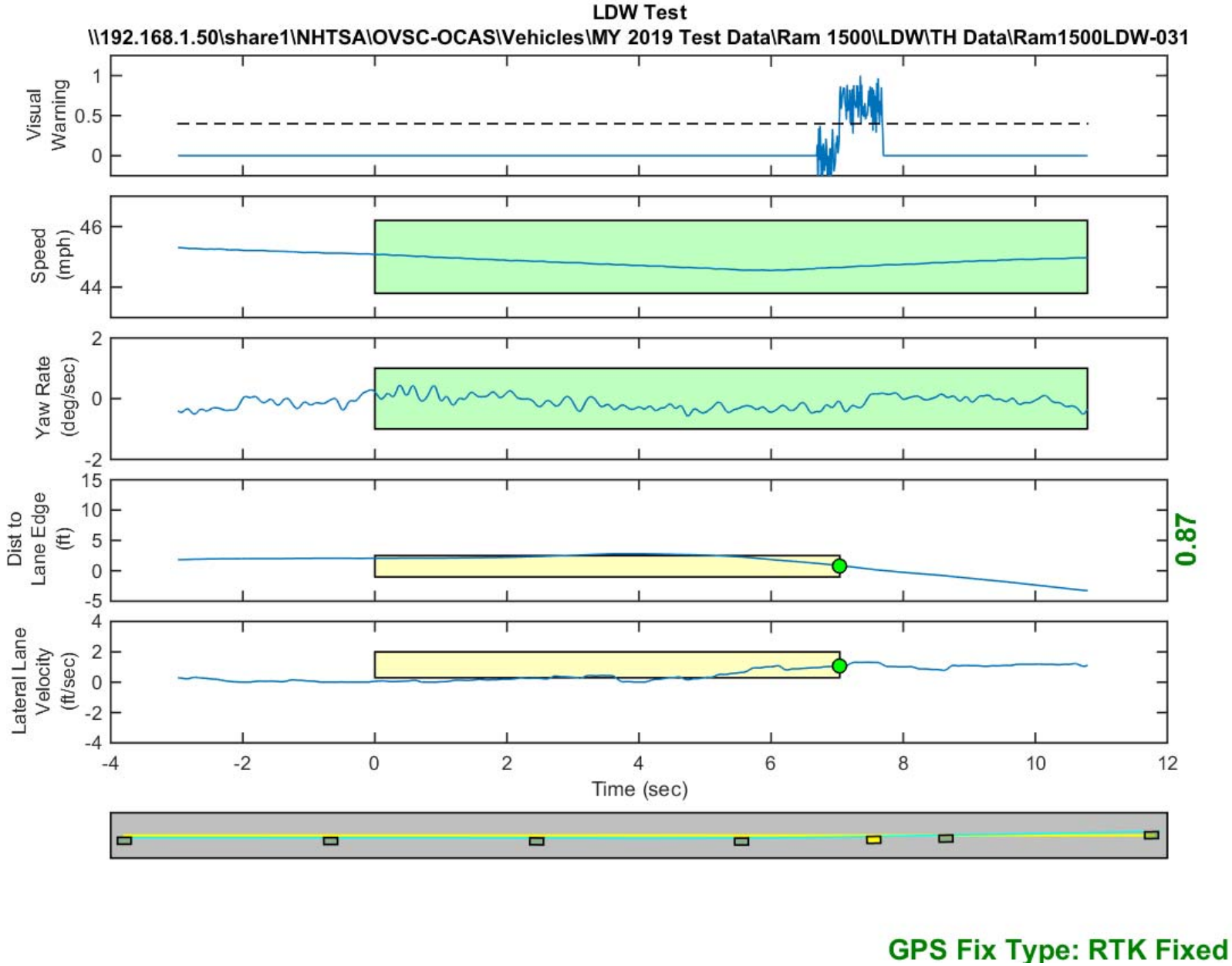

Figure D30. Time History for Run 31, Solid Line, Left Departure, Visual Warning

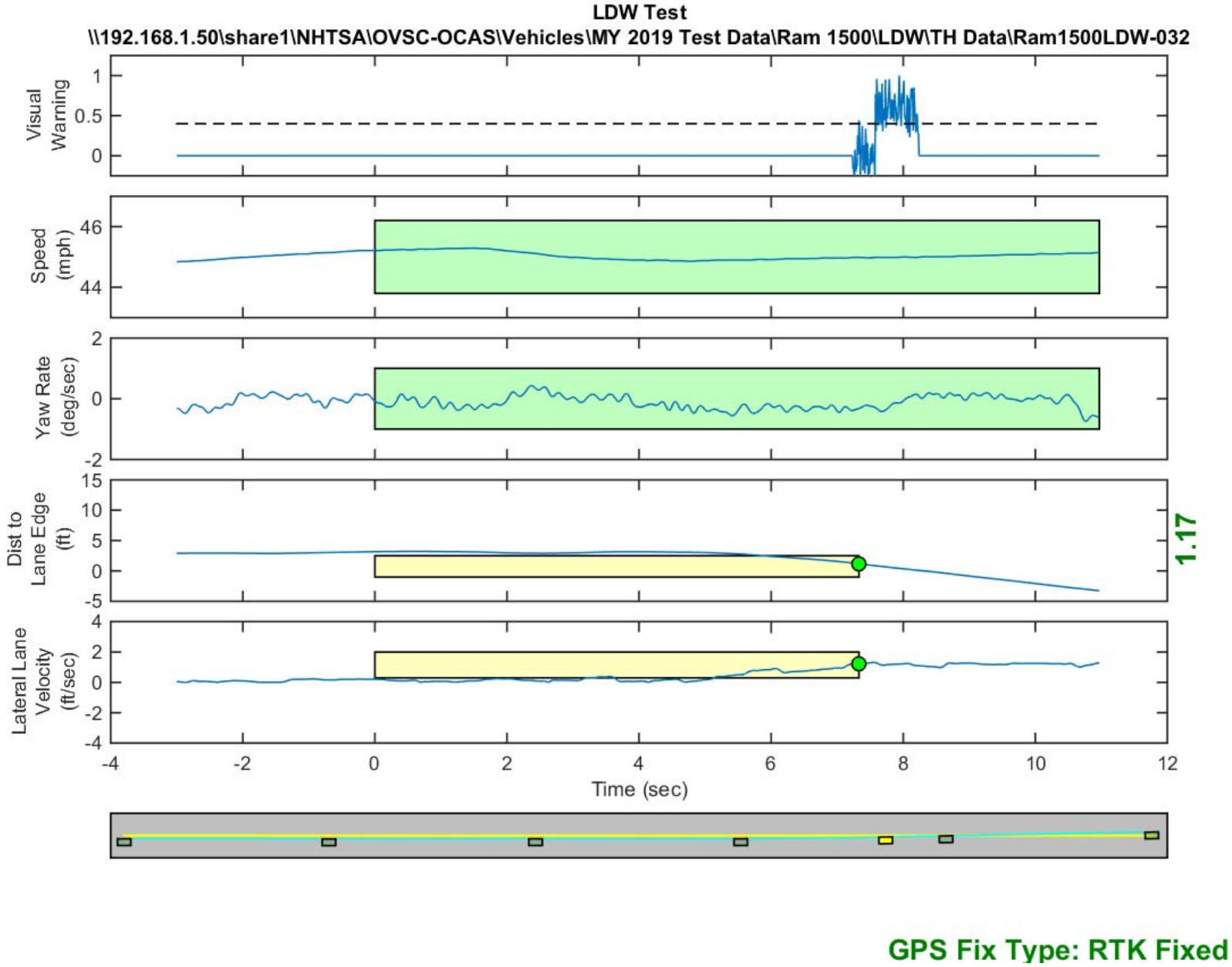

Figure D31. Time History for Run 32, Solid Line, Left Departure, Visual Warning

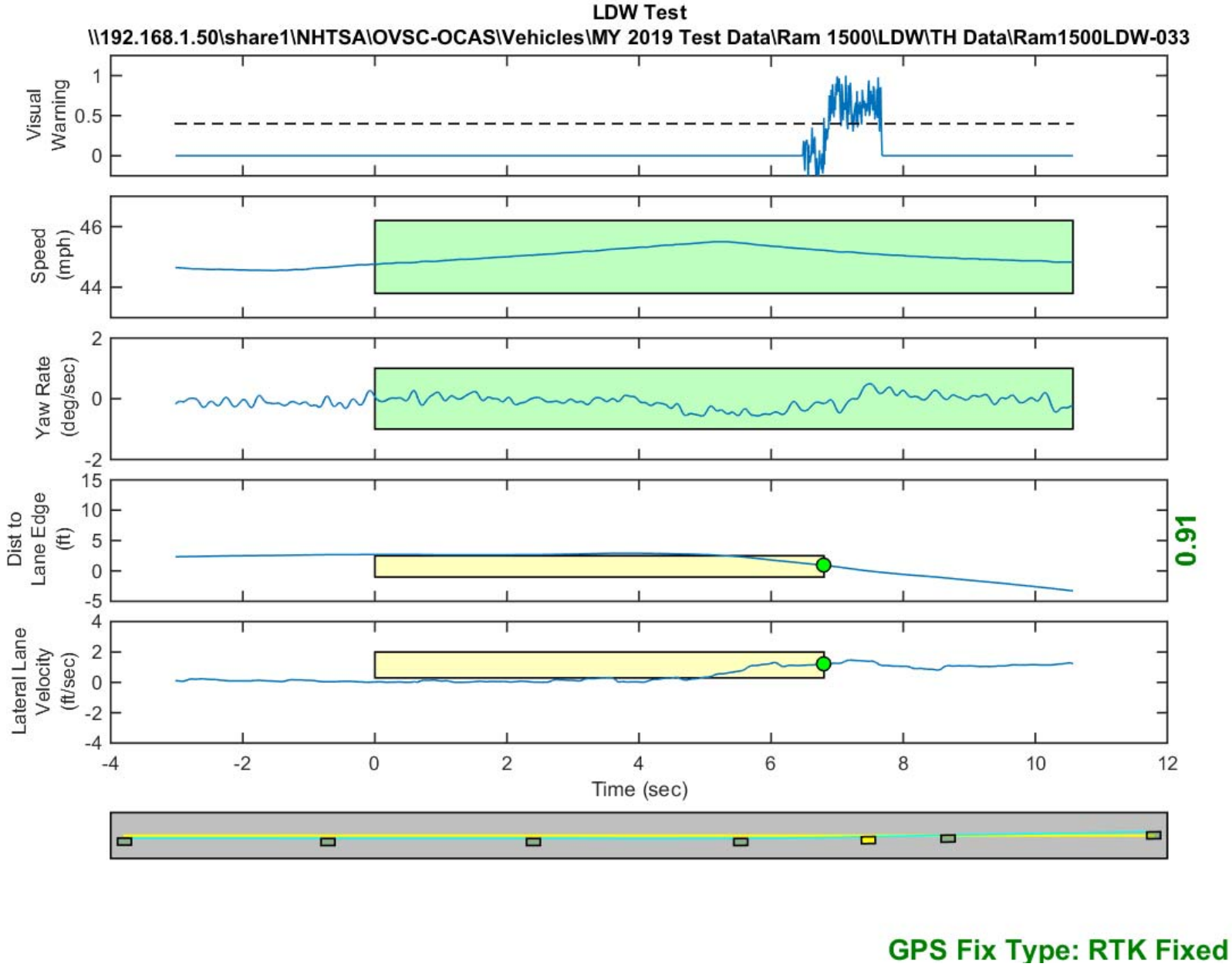

Figure D32. Time History for Run 33, Solid Line, Left Departure, Visual Warning

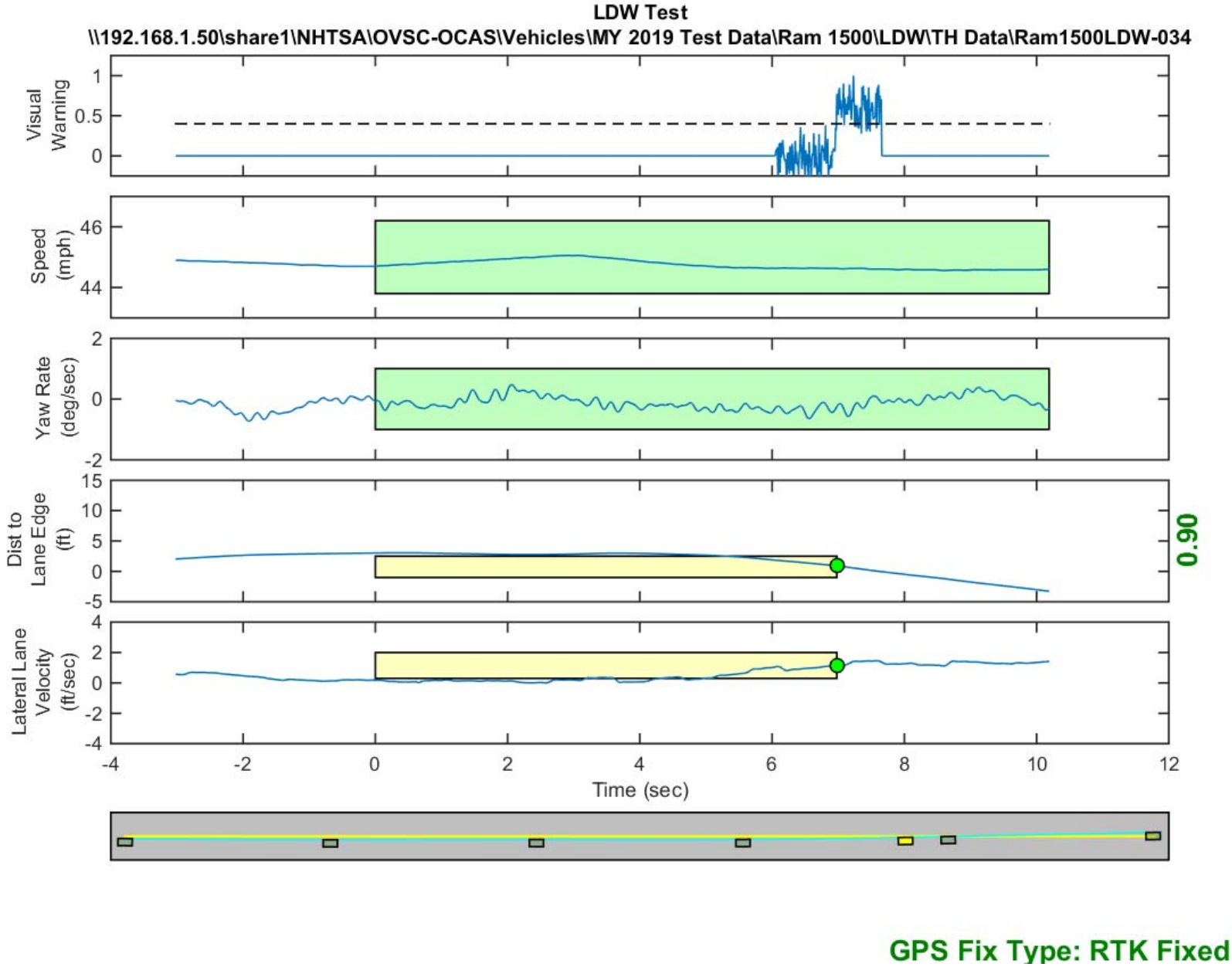

Figure D33. Time History for Run 34, Solid Line, Left Departure, Visual Warning

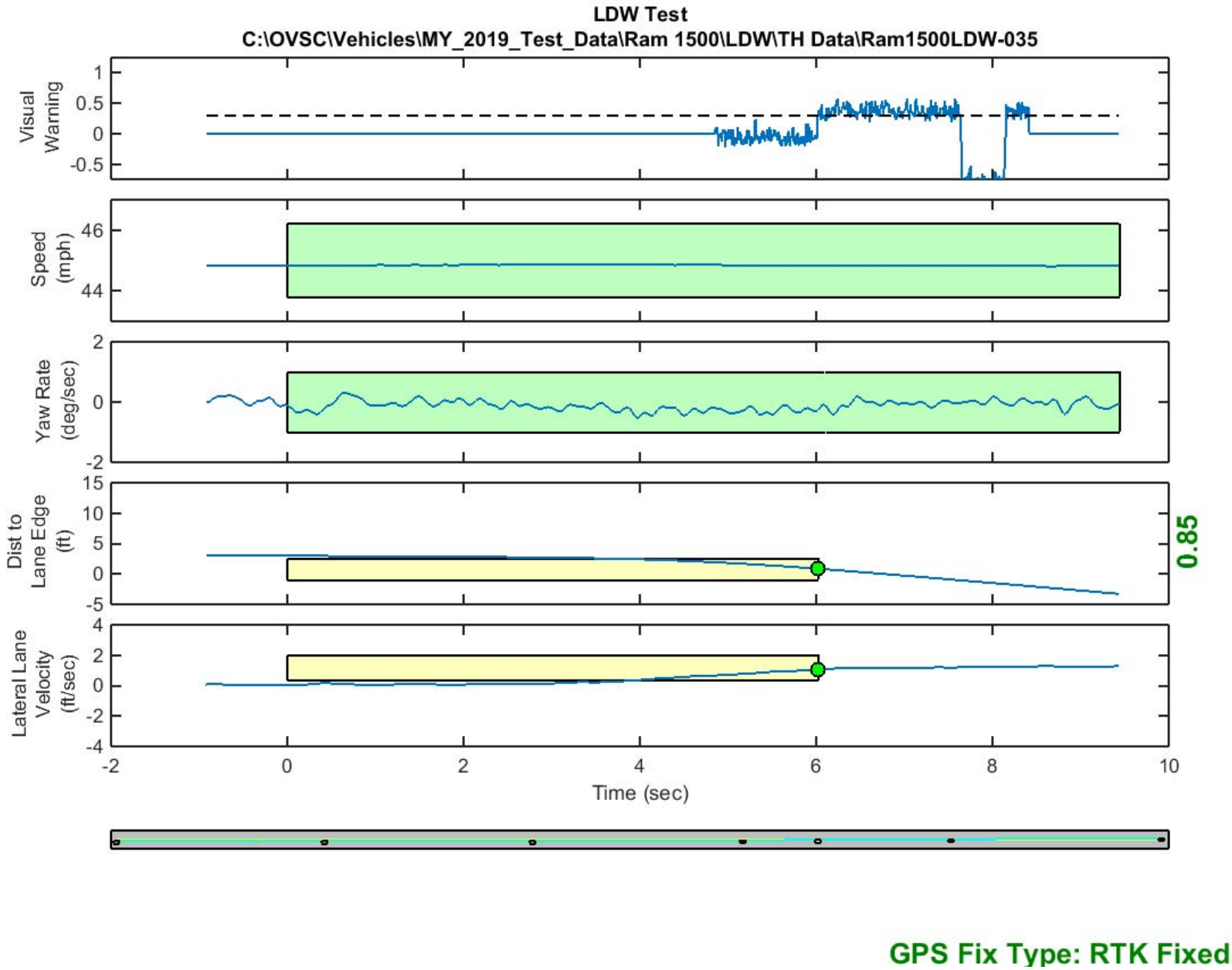

Figure D34. Time History for Run 35, Dashed Line, Left Departure, Visual Warning

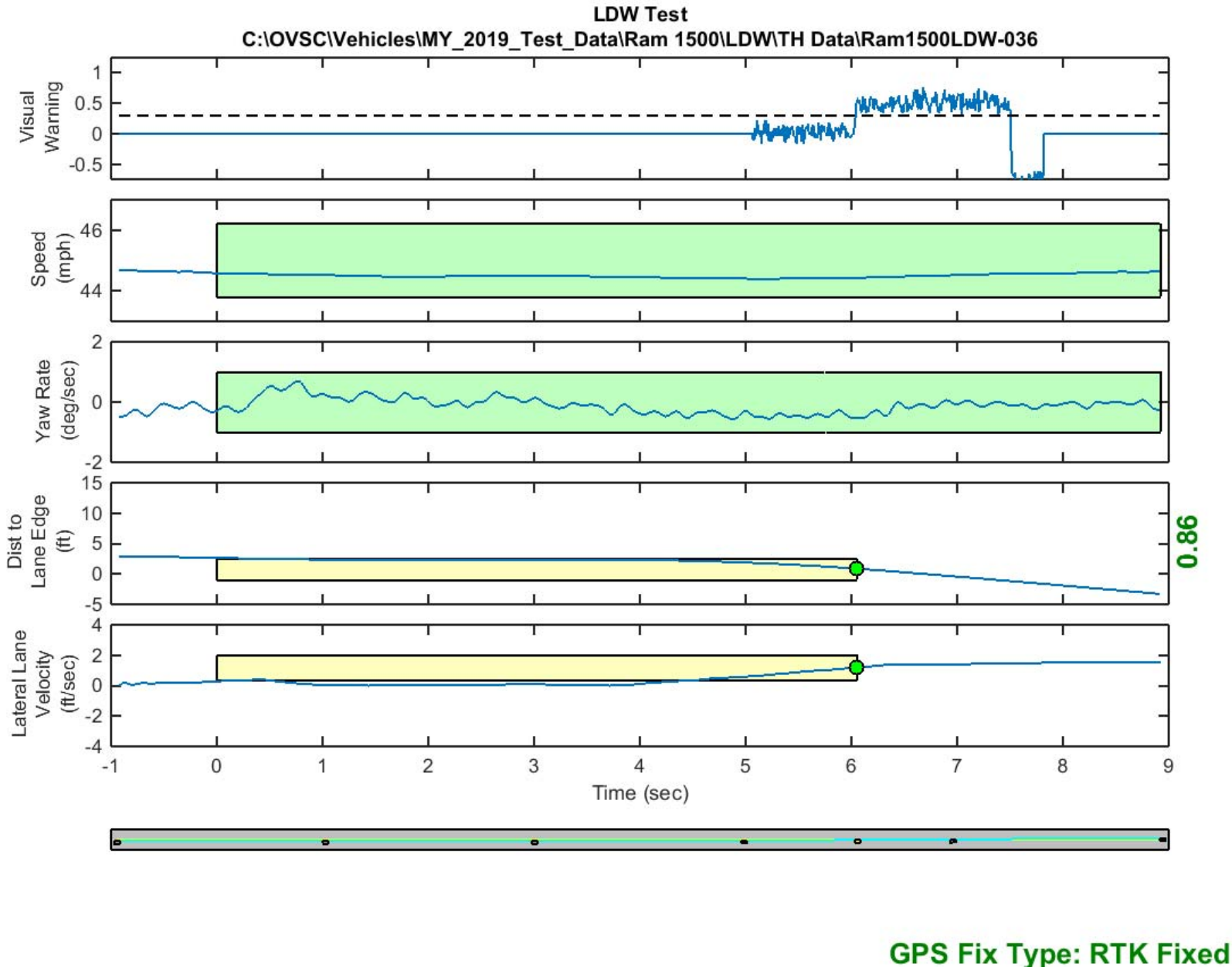

Figure D35. Time History for Run 36, Dashed Line, Left Departure, Visual Warning

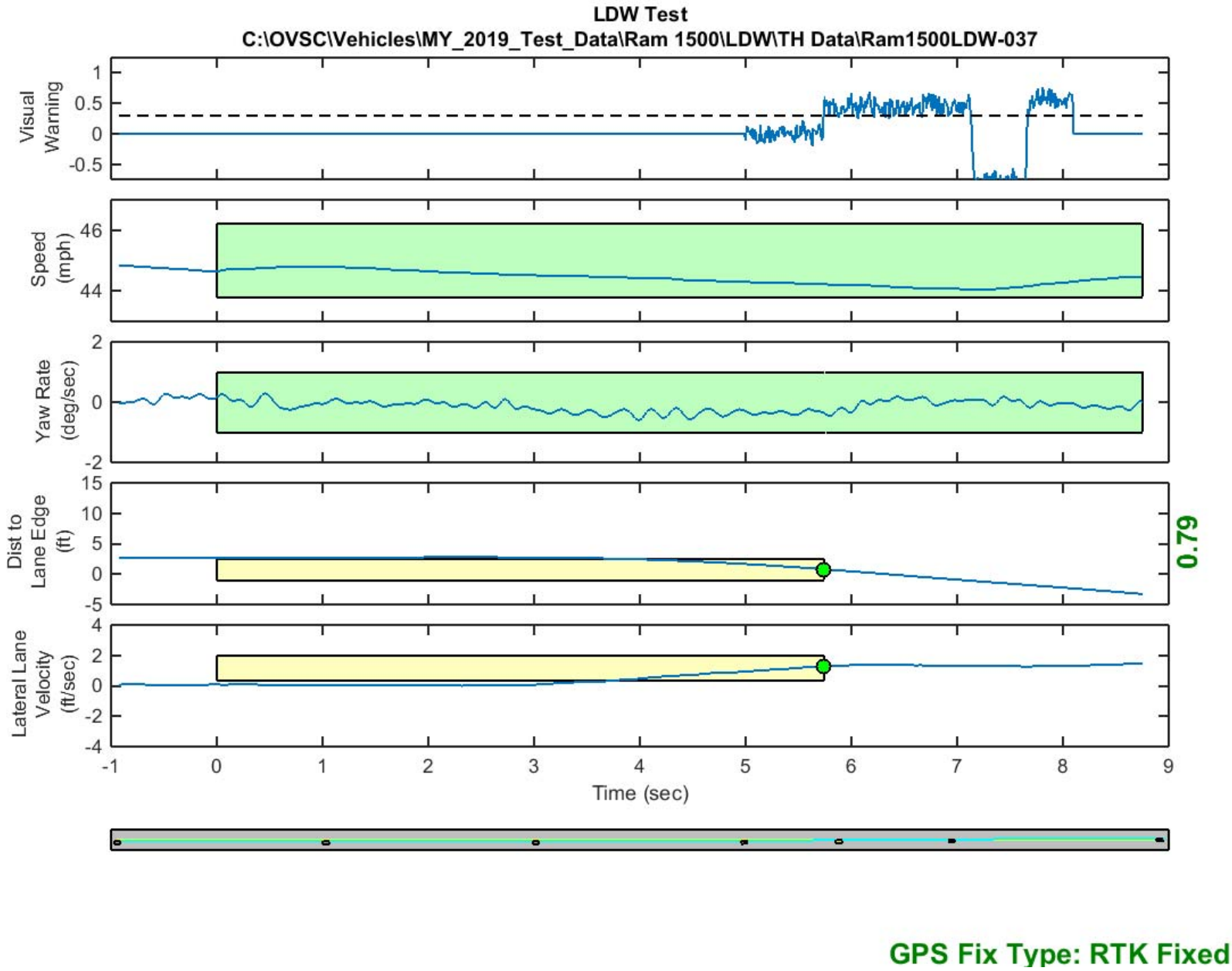

Figure D36. Time History for Run 37, Dashed Line, Left Departure, Visual Warning

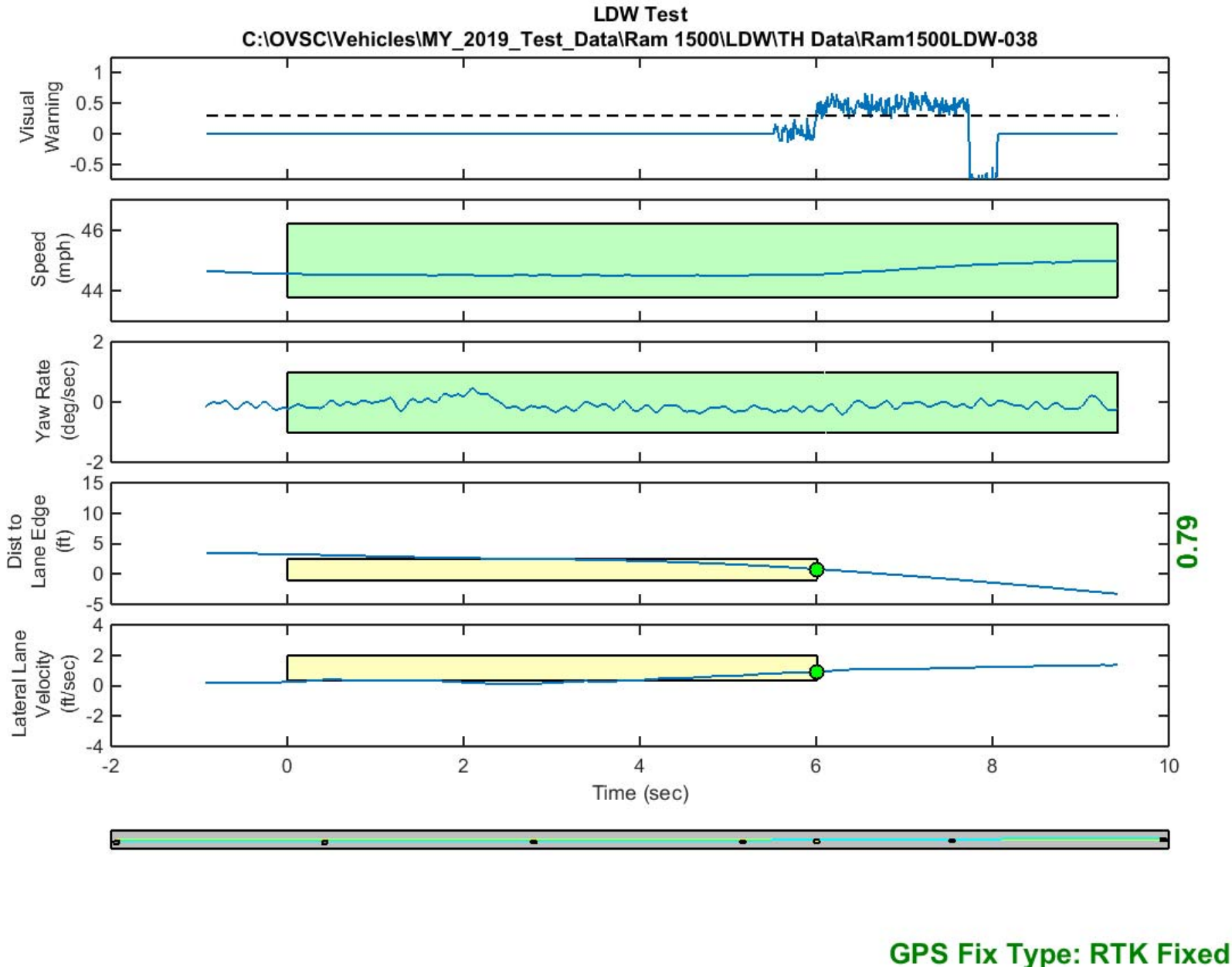

Figure D37. Time History for Run 38, Dashed Line, Left Departure, Visual Warning

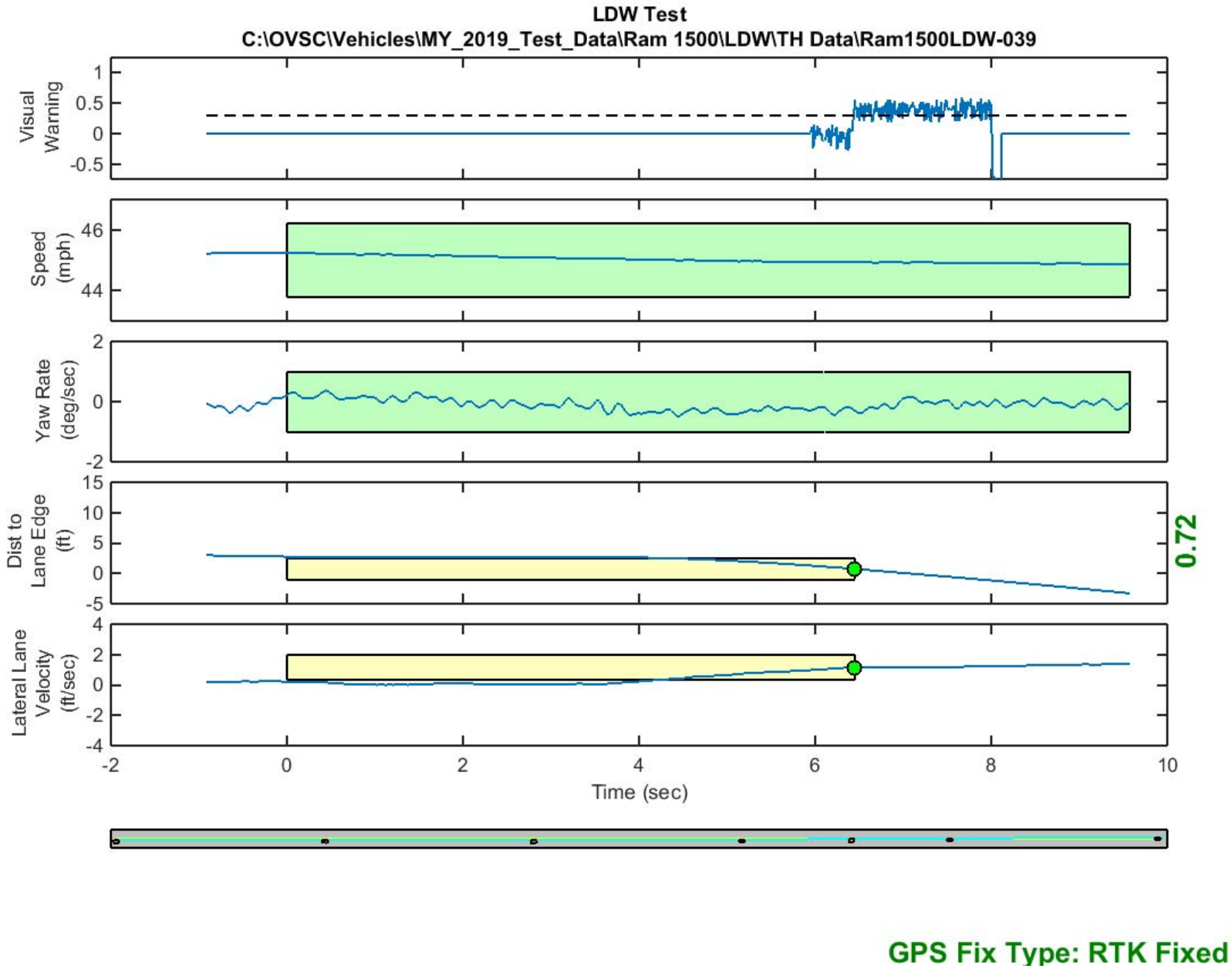

Figure D38. Time History for Run 39, Dashed Line, Left Departure, Visual Warning

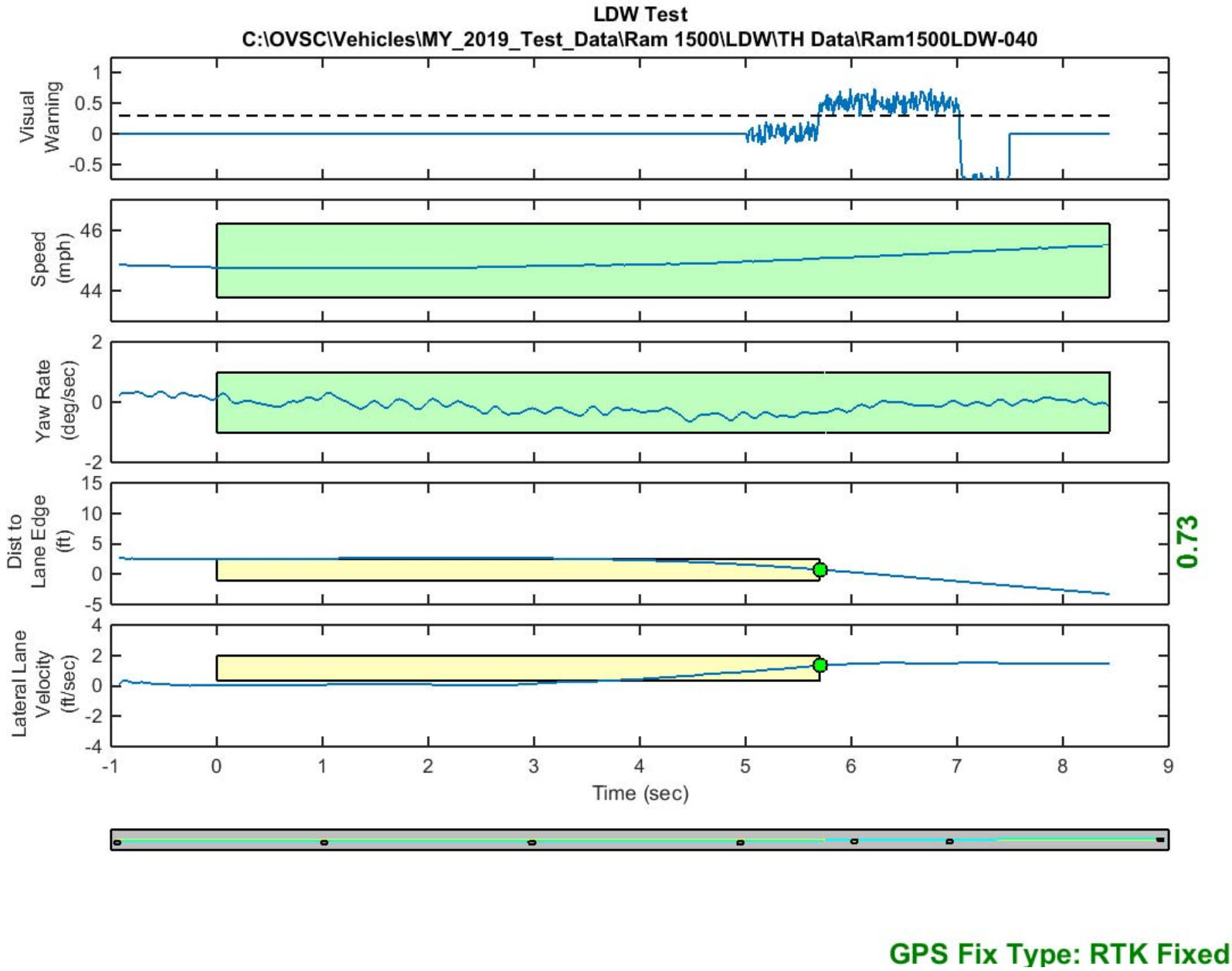

Figure D39. Time History for Run 40, Dashed Line, Left Departure, Visual Warning

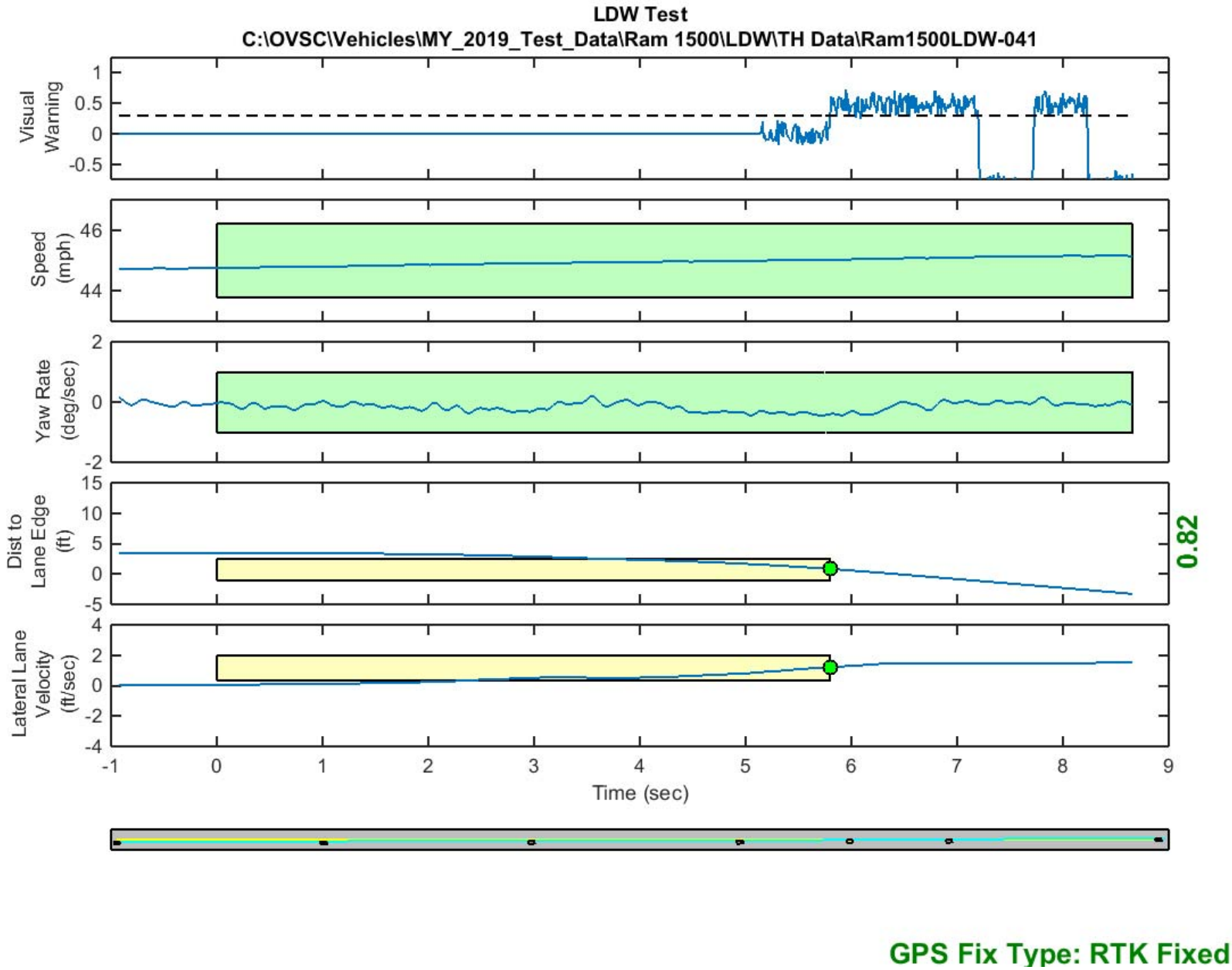

Figure D40. Time History for Run 41, Dashed Line, Left Departure, Visual Warning

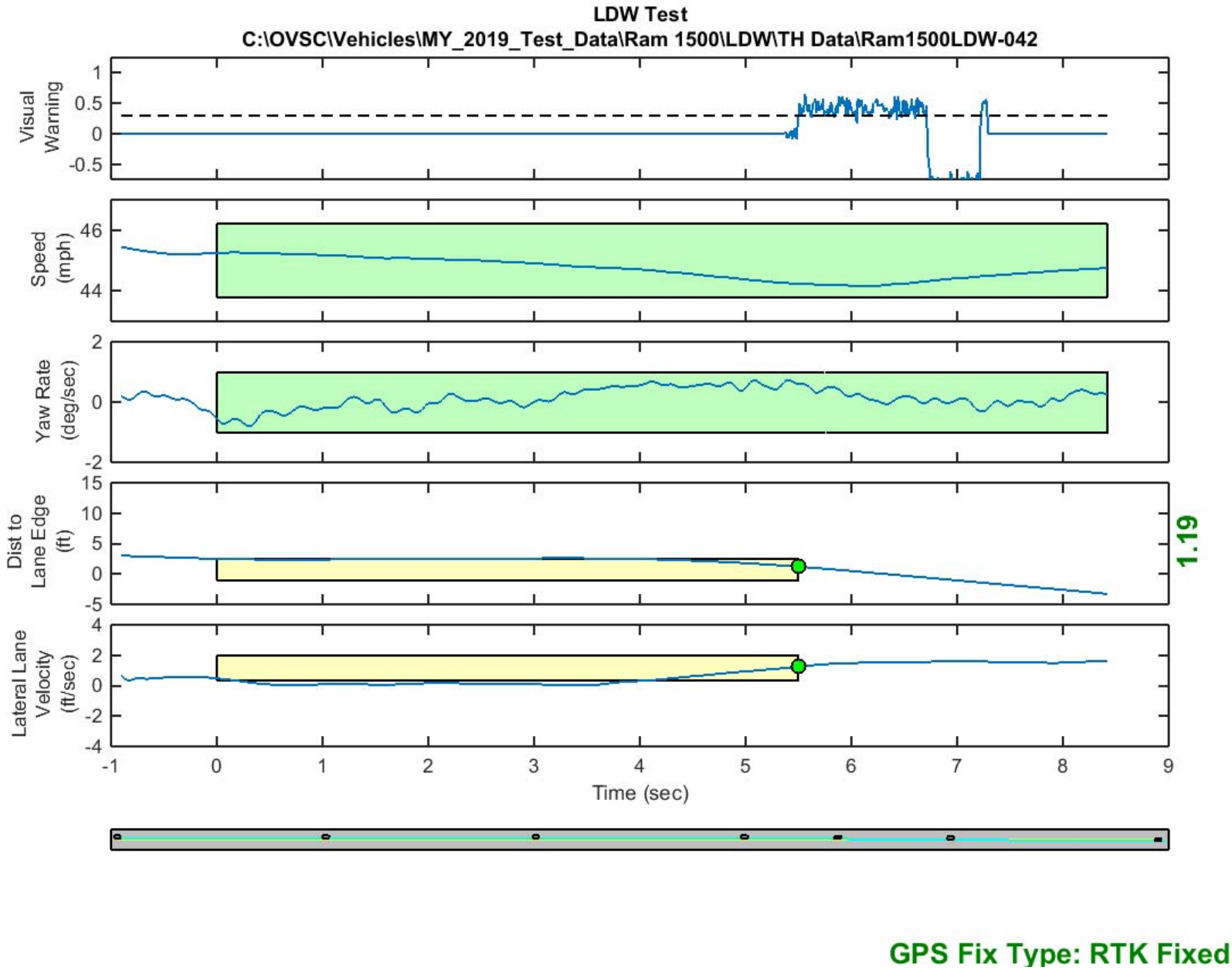

Figure D41. Time History for Run 42, Dashed Line, Right Departure, Visual Warning

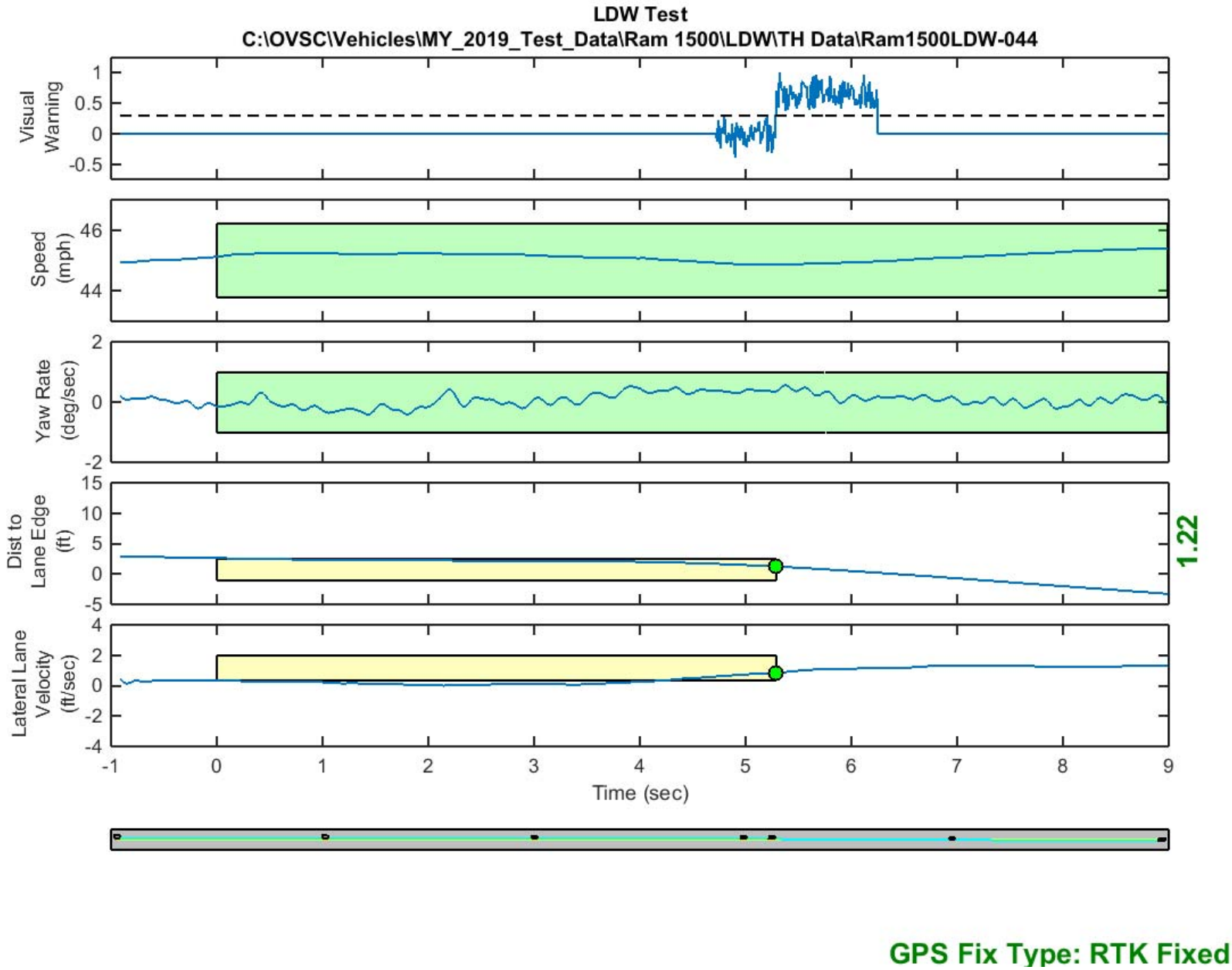

Figure D42. Time History for Run 44, Dashed Line, Right Departure, Visual Warning

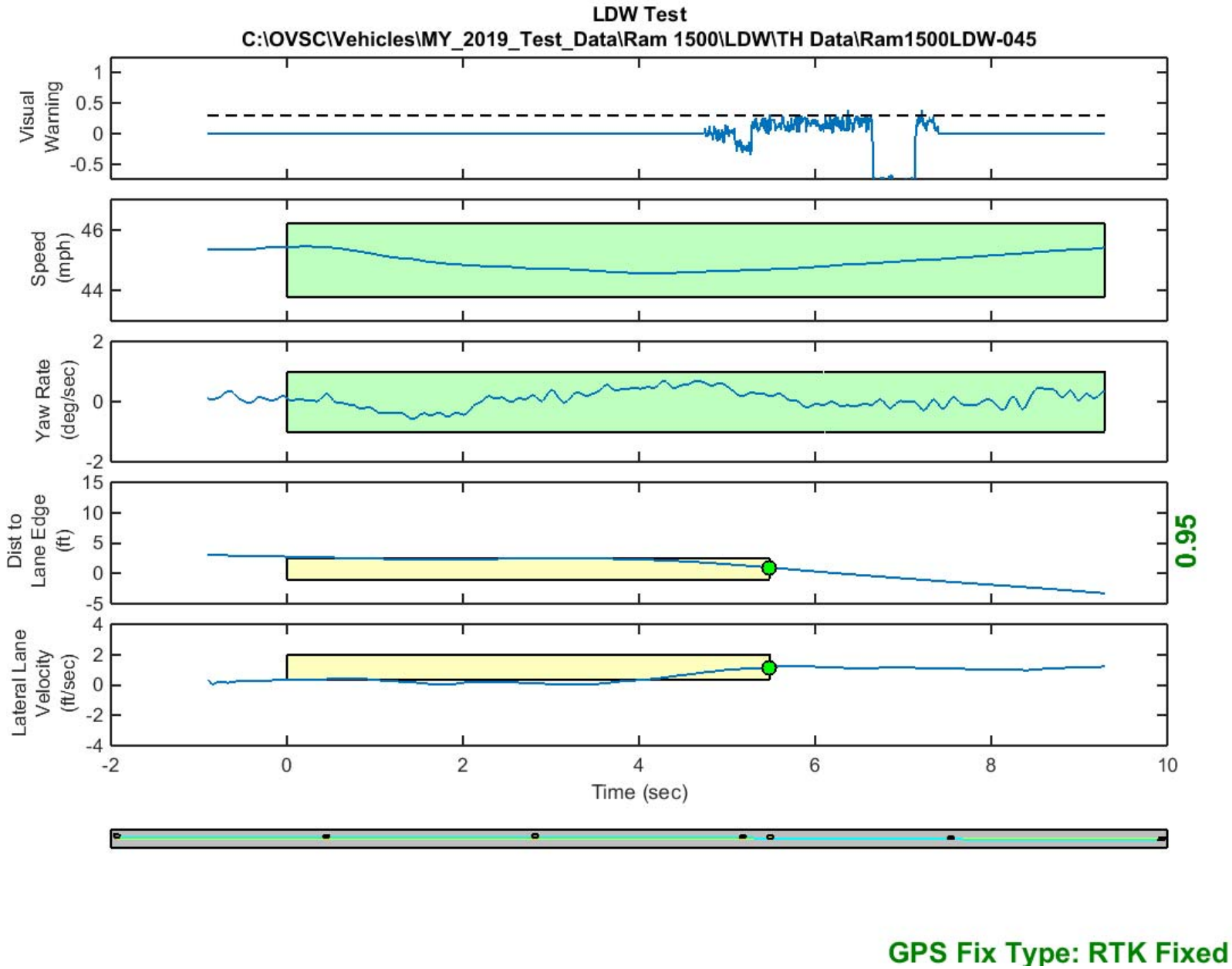

Figure D43. Time History for Run 45, Dashed Line, Right Departure, Visual Warning

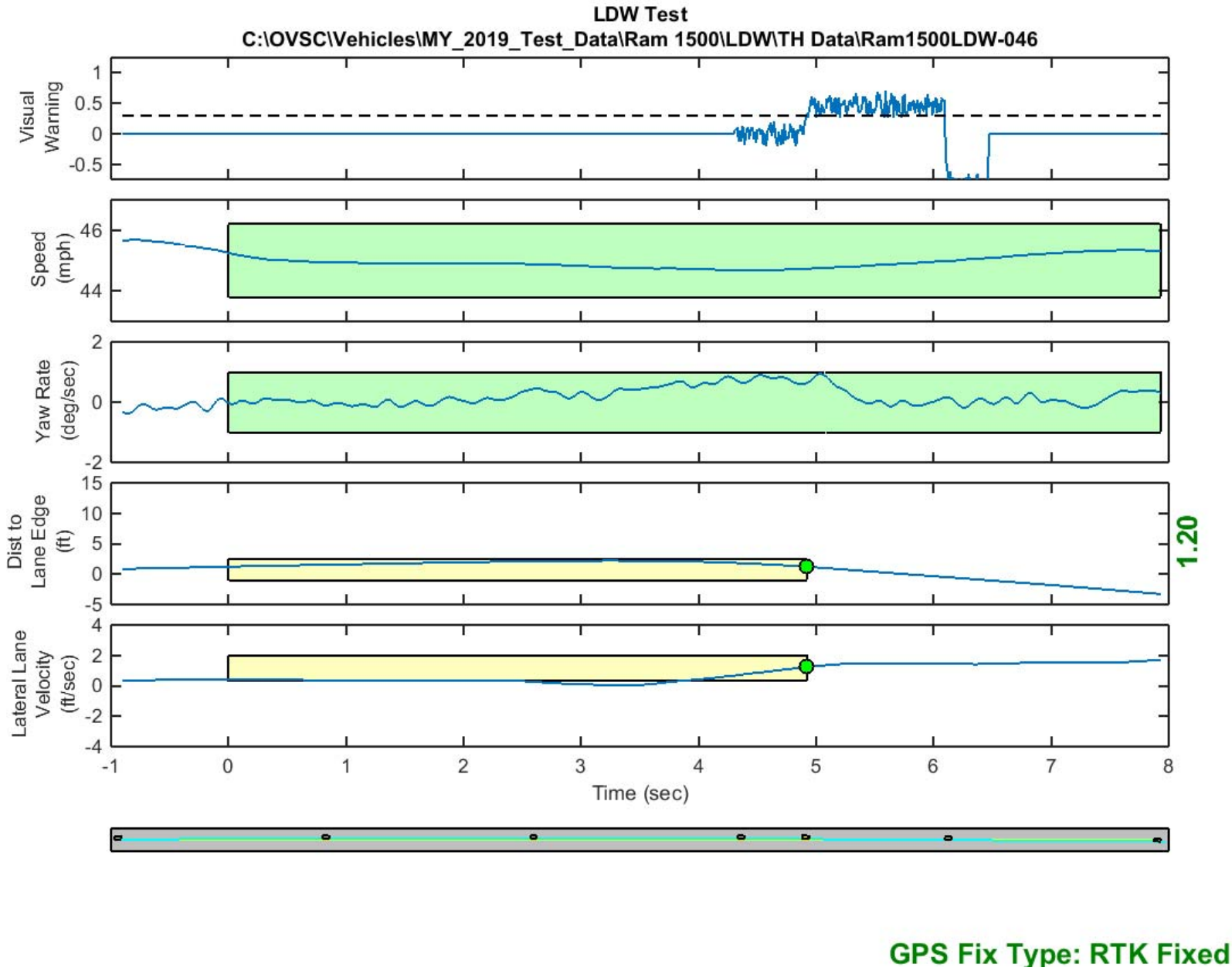

Figure D44. Time History for Run 46, Dashed Line, Right Departure, Visual Warning

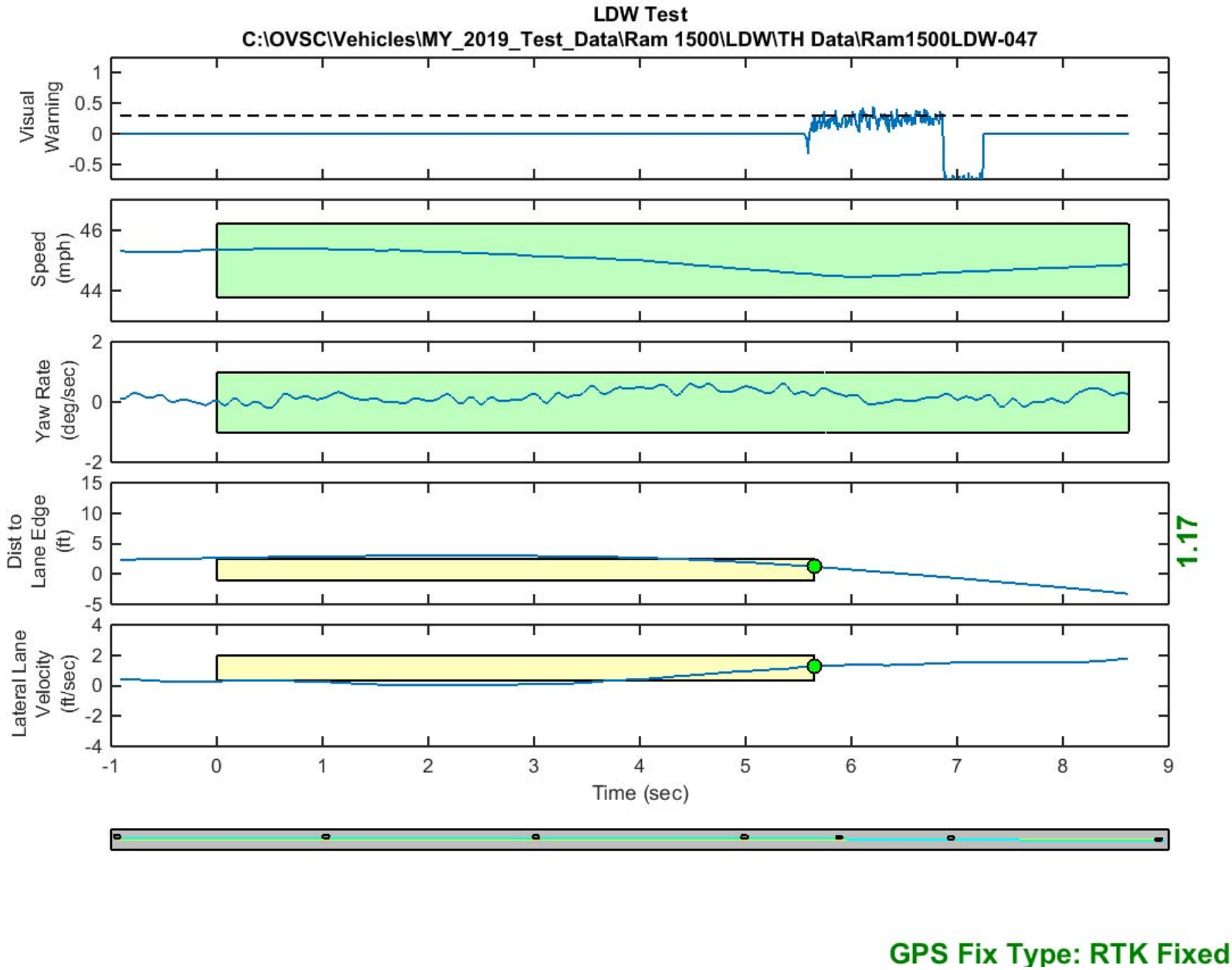

Figure D45. Time History for Run 47, Dashed Line, Right Departure, Visual Warning

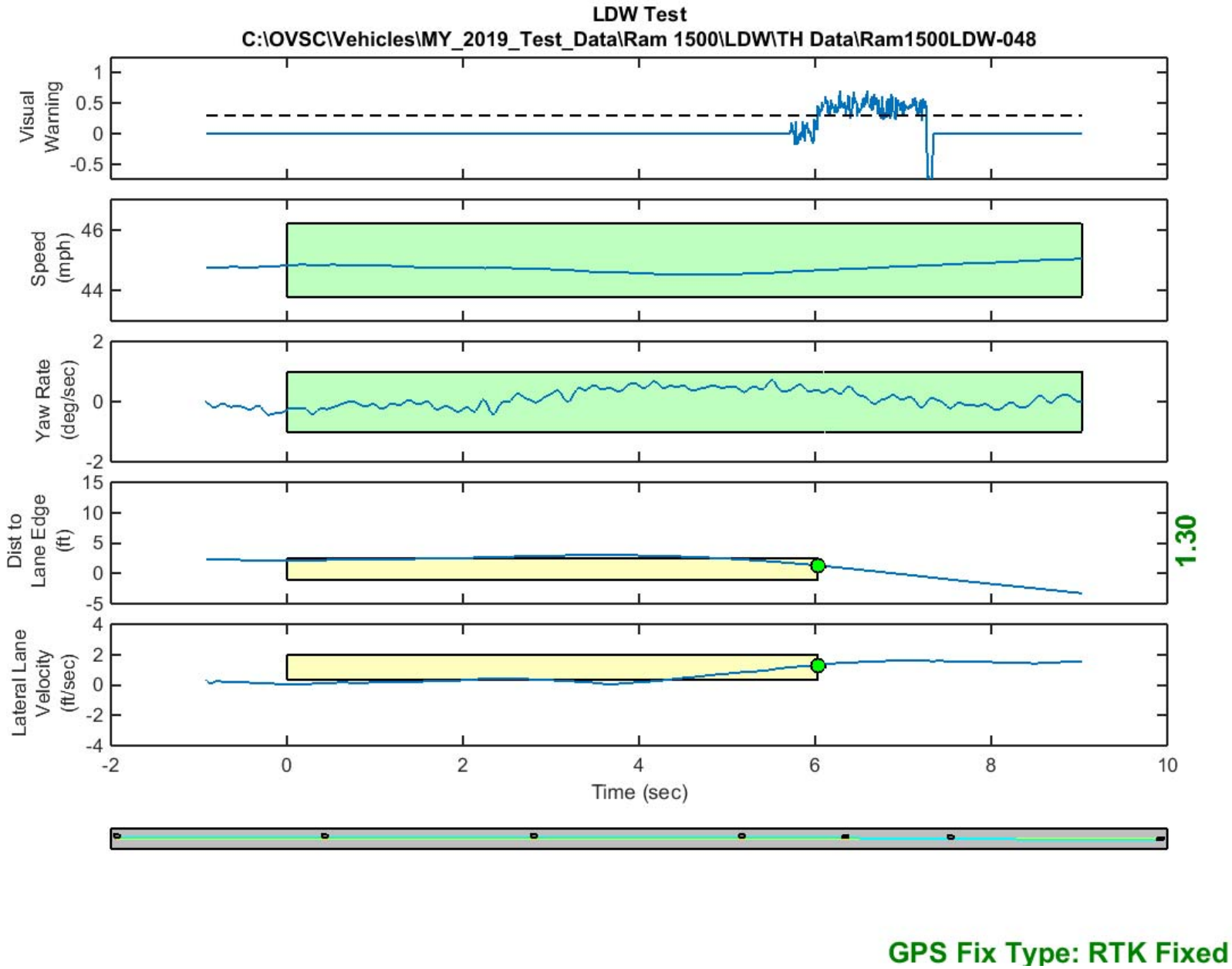

Figure D46. Time History for Run 48, Dashed Line, Right Departure, Visual Warning

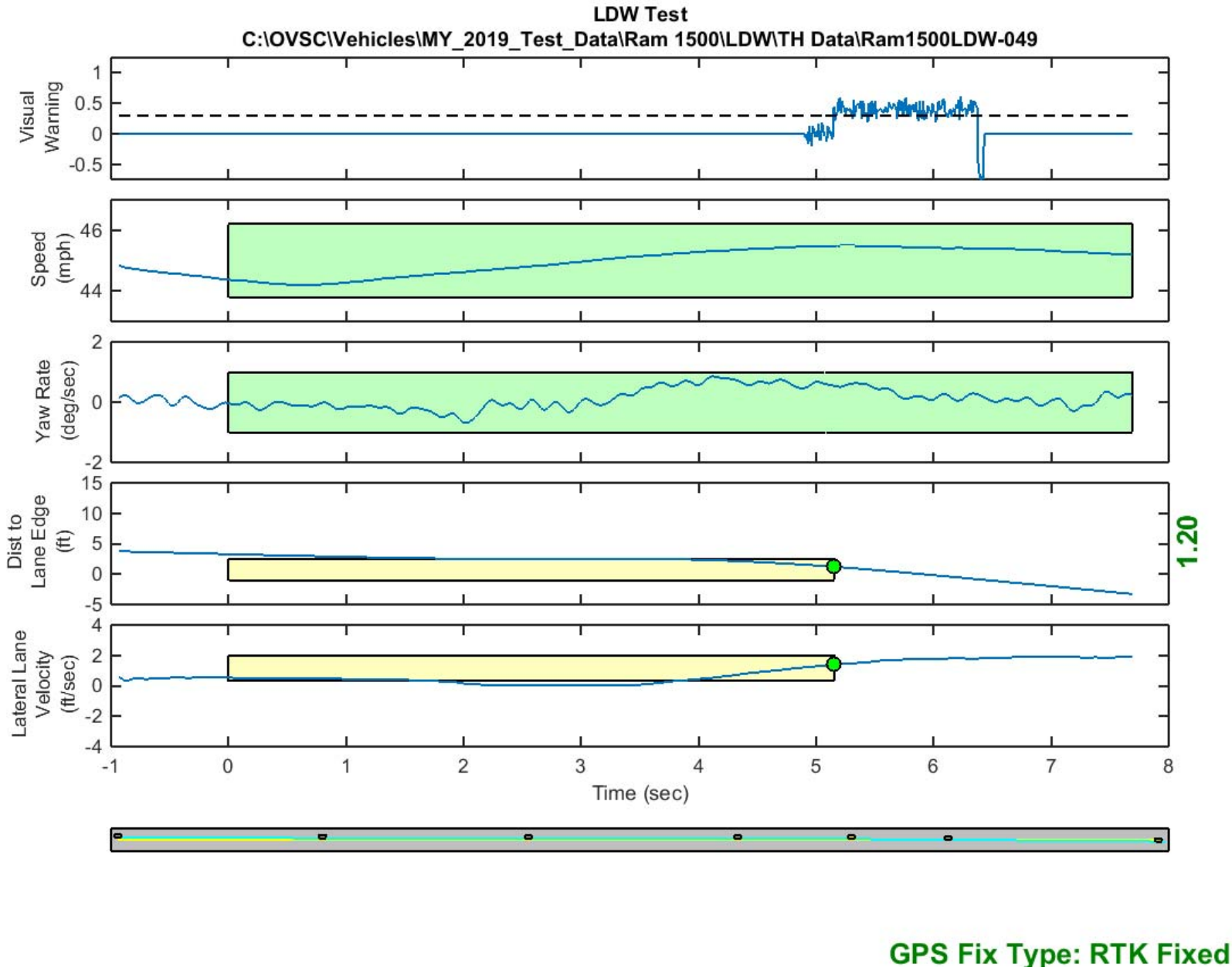

Figure D47. Time History for Run 49, Dashed Line, Right Departure, Visual Warning