NEW CAR ASSESSMENT PROGRAM
FORWARD COLLISION WARNING CONFIRMATION TEST
NCAP-DRI-FCW-22-09

2022 Nissan Sentra CVT

DYNAMIC RESEARCH, INC.
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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
1200 New Jersey Avenue, SE
West Building, 4th Floor (NRM-110)
Washington, DC 20590

Prepared for the Department of Transportation, National Highway Traffic Safety Administration, under Contract No. DTNH22-14-D-00333.

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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-2006-26555-0134 to confirm the performance of a Forward Collision Warning system. The vehicle passed the requirements of the test for all three FCW test scenarios.			
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Section I

INTRODUCTION

This test evaluates the ability of a Forward Collision Warning (FCW) system to detect and alert drivers to potential hazards in the path of the vehicle as specified in the New Car Assessment Program's "Forward Collision Warning Confirmation" test procedure, dated February 2013. Three driving scenarios are utilized to assess this technology. In the first test, a Subject Vehicle (SV) approaches a stopped Principal Other Vehicle (POV) in the same lane of travel. The second test begins with the SV initially following the POV at the same constant speed. After a short while, the POV stops suddenly. The third test consists of the SV, traveling at a constant speed, approaching a slower moving POV, which is also being driven at a constant speed.

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

Section II

DATA SHEETS

FORWARD COLLISION WARNING

DATA SHEET 1: TEST RESULTS SUMMARY

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2022 Nissan Sentra CVT

VIN: *3N1AB8CV5NY25xxxx*

Test start date: *4/8/2022*

Test end date: *4/8/2022*

Forward Collision Warning setting: *N/A*

Test 1 – Subject Vehicle Encounters Stopped Principal Other Vehicle: ***Pass***

Test 2 – Subject Vehicle Encounters Decelerating Principal Other Vehicle: ***Pass***

Test 3 – Subject Vehicle Encounters Slower Principal Other Vehicle: ***Pass***

Overall: ***Pass***

Notes:

FORWARD COLLISION 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 specification: *205/60R16 92H*

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

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

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

FORWARD COLLISION WARNING

DATA SHEET 3: TEST CONDITIONS

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2022 Nissan Sentra CVT

GENERAL INFORMATION

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

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)*

FORWARD COLLISION WARNING

DATA SHEET 3: TEST CONDITIONS

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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)*

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

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2022 Nissan Sentra CVT

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

Automatic Emergency Braking with Pedestrian Detection

Type and location of sensor(s) the system uses:

The front radar is located in the grille and the front view camera is located in the upper center windshield

Forward Collision Warning Setting used in test: *N/A*

How is the Forward Collision Warning presented to the driver? (Check all that apply)

- **X** Warning light
- **X** Buzzer or auditory alarm
- ____ Vibration
- ____ Other ____

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

The AEB system alerts the driver with a visual and auditory alert. The visual alert consists of a yellow flashing vehicle icon in the top left corner of the vehicle information display. The auditory alert consists of repeated beeps with a primary frequency of 1800 Hz.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

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2022 Nissan Sentra CVT

Is the vehicle equipped with a switch whose purpose is to render FCW 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 AEB 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 "Emergency Brake" and press "OK".

4. Select "Front" and press "OK" to turn the AEB system on/off.

When the AEB system is turned off, a warning light illuminates. The system is automatically enabled each time the engine switch is turned on.

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

____ Yes

X No

If yes, please provide a full description.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

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2022 Nissan Sentra CVT

Are there other driving modes or conditions that render FCW inoperable or reduce its effectiveness?	**X**	Yes
		No

If yes, please provide a full description.

Refer to the owner's manual pages 5-108 to 5-115 shown in Appendix B pages B-7 to B-14.

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Three test procedures were used, as follows:

Test 1. Subject Vehicle (SV) Encounters Stopped Principal Other Vehicle (POV)

Test 2. Subject Vehicle Encounters Decelerating Principal Other Vehicle

Test 3. Subject Vehicle Encounters Slower Principal Other Vehicle

With the exception of trials associated with Test 1, all trials were performed with SV and POV automatic transmissions in ‘‘Drive’’ or with manual transmissions in the highest gear capable of sustaining the desired test speed. Manual transmission clutches remained engaged during all maneuvers. Except for Test 2, the brake lights of the POV were not illuminated.

In order to pass the test, if the FCW system provides a warning timing adjustment for the driver, at least one setting must meet the criterion of the test procedure. Therefore, if the vehicle was equipped with a warning timing adjustment, only the most “conservative” (earliest warning) setting was tested.

An overview of each of the test procedures follows.

1. <u>TEST 1 – SUBJECT VEHICLE ENCOUNTERS STOPPED PRINCIPAL OTHER VEHICLE ON A STRAIGHT ROAD</u>

This test evaluates the ability of the FCW function to detect a stopped lead vehicle, as depicted in Figure 1.

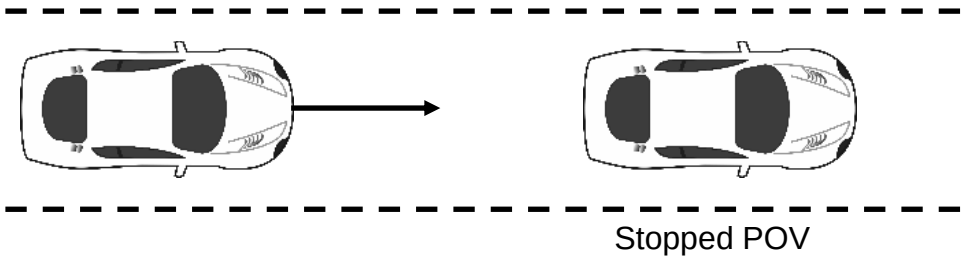


Figure 1. Depiction of Test 1

a. Alert Criteria

In order to pass the test, the FCW alert must be issued when the time-to-collision (TTC) is at least 2.1 seconds. The TTC for this test was calculated by considering the speeds of the SV and the POV at the time of the FCW alert (i.e., when the SV and POV speeds are nominally equal to 45 and 0 mph (72.4 and 0 km/h), respectively).

b. Procedure

The POV was parked in the center of a travel lane, with its longitudinal axis oriented parallel to the roadway edge and facing the same direction as the SV so that the SV approaches the rear of the POV.

The SV was driven at a nominal speed of 45 mph (72.4 km/h) in the center of the lane of travel, toward the parked POV. The test began when the SV was 492 ft (150 m) from the POV and ended when either of the following occurred:

- The required FCW alert occurred.
- The TTC to the POV fell to less than 90% of the minimum allowable range (i.e., TTC = 1.9 sec) for the onset of the required FCW alert.

The SV driver then steered and/or braked to keep the SV from striking the POV.

For an individual test trial to be valid, the following was required throughout the test:

- The SV vehicle speed could not deviate from the nominal speed by more than 1.0 mph (1.6 km/h) for a period of three seconds prior to (1) the required FCW alert or (2) before the range fell to less than 90% of the minimum allowable range for onset of the required FCW alert.
- The SV driver could not apply any force to the brake pedal before (1) the required FCW alert occurred or (2) the range fell to less than 90% of the minimum allowable range for onset of the required FCW alert.
- The lateral distance between the centerline of the SV, relative to the centerline of the POV, in road coordinates, could not exceed 2.0 ft (0.6 m).
- The yaw rate of the SV could not exceed ±1 deg/sec during the test.

Nominally, the Test 1 series was comprised of seven individual trials. The FCW system must satisfy the TTC alert criteria for at least five of the seven test trials.

2. TEST 2 – SUBJECT VEHICLE ENCOUNTERS DECELERATING PRINCIPAL OTHER VEHICLE

The SV in this test initially followed the POV at a constant time gap and then the POV suddenly decelerated, as depicted in Figure 2. The test evaluates the ability of the FCW to recognize a decelerating lead vehicle and to issue an alert to SV driver in a timely manner.

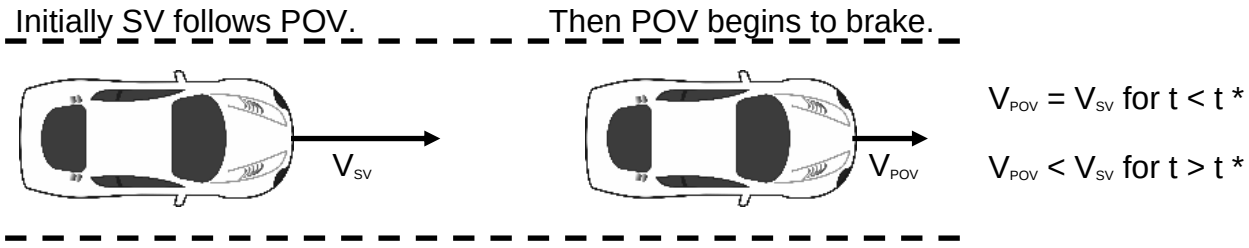


Figure 2. Depiction of Test 2

a. Alert Criteria

In order to pass the test, the FCW alert must be issued when TTC is at least 2.4 seconds. The TTC for this test, a prediction of the time it would take for the SV to collide with the POV, was calculated by considering three factors at the time of the FCW alert: (1) the speed of the SV, (2) the speed of the POV, and (3) the deceleration of the POV[1].

b. Procedure

Test 2 began with the SV and the POV traveling on a straight, flat road at a constant speed of 45.0 mph (72.4 km/h), in the center of the lane of travel. The headway from the SV to the POV was nominally maintained at 98.4 ft (30 m) until the POV braking was initiated.

The test began approximately 7 seconds before the driver of the POV started a braking maneuver in which the POV brakes were rapidly applied and modulated such that a constant deceleration of 0.3 g was achieved within 1.5 seconds after braking is initiated. The test ended when either of the following conditions was satisfied:

- The required FCW alert occurred.
- The TTC to the POV fell to less than 90% of the minimum allowable range (i.e., TTC = 2.2 sec) for the onset of the required FCW alert.

The SV driver then steered and/or braked to keep the SV from striking the POV.

[1]To simplify calculation of the TTC for Test 2, the deceleration of the POV is assumed to remain constant from the time of the FCW alert until the POV comes to a stop (i.e., a “constant” rate of slowing is assumed).

For an individual test trial to be valid, the following was required throughout the test:

- The initial POV vehicle speed could not deviate from the nominal speed by more than 1.0 mph (1.6 km/h) for a period of 3 seconds prior to the initiation of POV braking.
- The speed of the SV could not deviate from the nominal speed by more than 1.0 mph (1.6 km/h) for a period of 3 seconds prior to (1) the required FCW alert or (2) before the range fell to less than 90% of the minimum allowable range for onset of the required FCW alert.
- The lateral distance between the centerline of the SV, relative to the centerline of the POV, in road coordinates, could not exceed 2.0 ft (0.6 m).
- The yaw rates of the SV and POV could not exceed ±1 deg/sec during the test.
- The POV deceleration level was nominally required to be 0.3 g within 1.5 seconds after initiation of POV braking. The acceptable error magnitude of the POV deceleration was ±0.03 g, measured at the time the FCW alert first occurred. An initial overshoot beyond the deceleration target was acceptable, however the first local deceleration peak observed during an individual trial could not exceed 0.375 g for more than 50 ms. Additionally, the deceleration could not exceed 0.33 g over a period defined from 500 ms after the first local deceleration peak occurs, to the time when the FCW alert first occurred.
- The tolerance for the headway from the SV to the POV was ±8.2 ft (±2.5 m), measured at two instants in time: (1) three seconds prior to the time the POV brake application was initiated and (2) at the time the POV brake application was initiated.
- SV driver could not apply any force to the brake pedal before (1) the required FCW alert occurred or (2) the range fell to less than 90% of the minimum allowable range for onset of the required FCW alert.

Nominally, the Test 2 series was comprised of seven individual trials. The FCW system must satisfy the TTC alert criteria for at least five of the seven test trials.

3. TEST 3 – SUBJECT VEHICLE ENCOUNTERS SLOWER PRINCIPAL OTHER VEHICLE

This test examines the ability of the FCW system to recognize a slower lead vehicle being driven with a constant speed and to issue a timely alert. As depicted in Figure 3, the scenario was conducted with a closing speed equal to 25.0 mph (40.2 km/h).

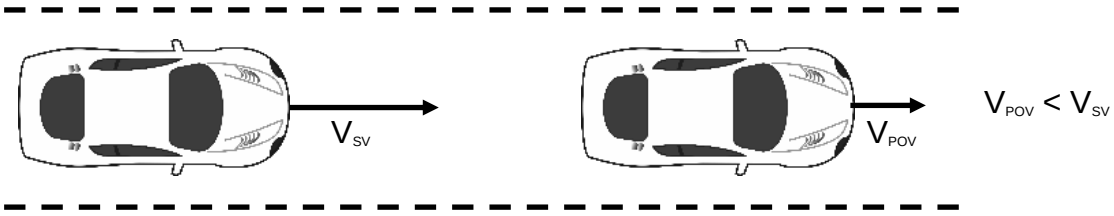


Figure 3. Depiction of Test 3

a. Alert Criteria

In order to pass the test, the FCW alert must be issued when TTC is at least 2.0 seconds. The TTC for this test, a prediction of the time it would take for the SV to collide with the POV, was calculated by considering the speeds of the SV and POV at the time of the FCW alert.

b. Procedure

Throughout the test, the POV was driven at a constant 20.0 mph (32.2 km/h) in the center of the lane of travel.

The SV was driven at 45.0 mph (72.4 km/h), in the center lane of travel, toward the slow-moving POV.

The test began when the headway from the SV to the POV was 329 ft (100 m) and ended when either of the following occurred:

- The required FCW alert occurred.
- The TTC to the POV fell to less than 90% of the minimum allowable range (i.e., TT = 1.8 sec) for the onset of the required FCW alert.

The SV driver then steered and/or braked to keep the SV from striking the POV.

For an individual test trial to be valid, the following was required throughout the test:

- The SV vehicle speed could not deviate from the nominal speed by more than 1.0 mph (1.6 km/h) for a period of 3 seconds prior to (1) the required FCW alert or (2) before the range fell to less than 90% of the minimum allowable range for onset of the required FCW alert.
- Speed of the POV could not deviate from the nominal speed by more than 1.0 mph (1.6 km/h) during the test.
- The lateral distance between the centerline of the SV, relative to the centerline of the POV, in road coordinates, could not exceed 2.0 ft (0.6 m).
- The yaw rates of the SV and POV could not exceed ±1 deg/sec during the test.
- SV driver could not apply any force to the brake pedal before (1) the required

FCW alert occurred or (2) before the range fell to less than 90% of the minimum allowable range for onset of the required FCW alert.

Nominally, the Test 3 series was comprised of seven individual trials. The FCW system must satisfy the TTC alert criteria for at least five of the seven test trials.

B. Principal Other Vehicle

The vehicle used as the Principal Other Vehicle (POV) was a 2006 Acura RL. This satisfied the test requirement that the POV be a mid-size sedan. The vehicle had a rear license plate in order to provide a suitable representative radar profile. Vehicle loading consisted of the driver plus equipment and instrumentation.

C. Automatic Braking System

The POV was equipped with an automatic braking system, which was used in Test 2. The braking system consisted of the following components:

- Electronically controlled linear actuator, mounted on the seat rail and attached to the brake pedal. The actuator can be programmed for control of stroke and rate.
- PC module programmed for control of the stroke and rate of the linear actuator.
- Switch to activate actuator.

D. Instrumentation

Table 1 lists the sensors, signal conditioning, and data acquisition equipment used for these tests.

Table 1. 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			By: Oxford Technical Solutions
				SV: Oxford Inertial +	2176	Date: 6/26/2020 Due: 6/26/2022
				POV:	2258	Date: 4/28/2021 Due: 4/28/2023
Real-Time Calculation of Position and Velocity Relative to Lane Markings (LDW) and POV (FCW)	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec Longitudinal Range to POV: ±200 m Longitudinal Range Rate: ±50 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec Longitudinal Range: ±3 cm Longitudinal Range Rate: ±0.02 m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	N/A

Table 1. Test Instrumentation and Equipment (continued)

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Microphone	Sound (to measure time at auditory 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 visual alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	N/A	N/A
Accelerometer	Acceleration (to measure time at haptic alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	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).	dSPACE 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 2.

Table 2. Auditory and Tactile Warning Filter Parameters

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

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

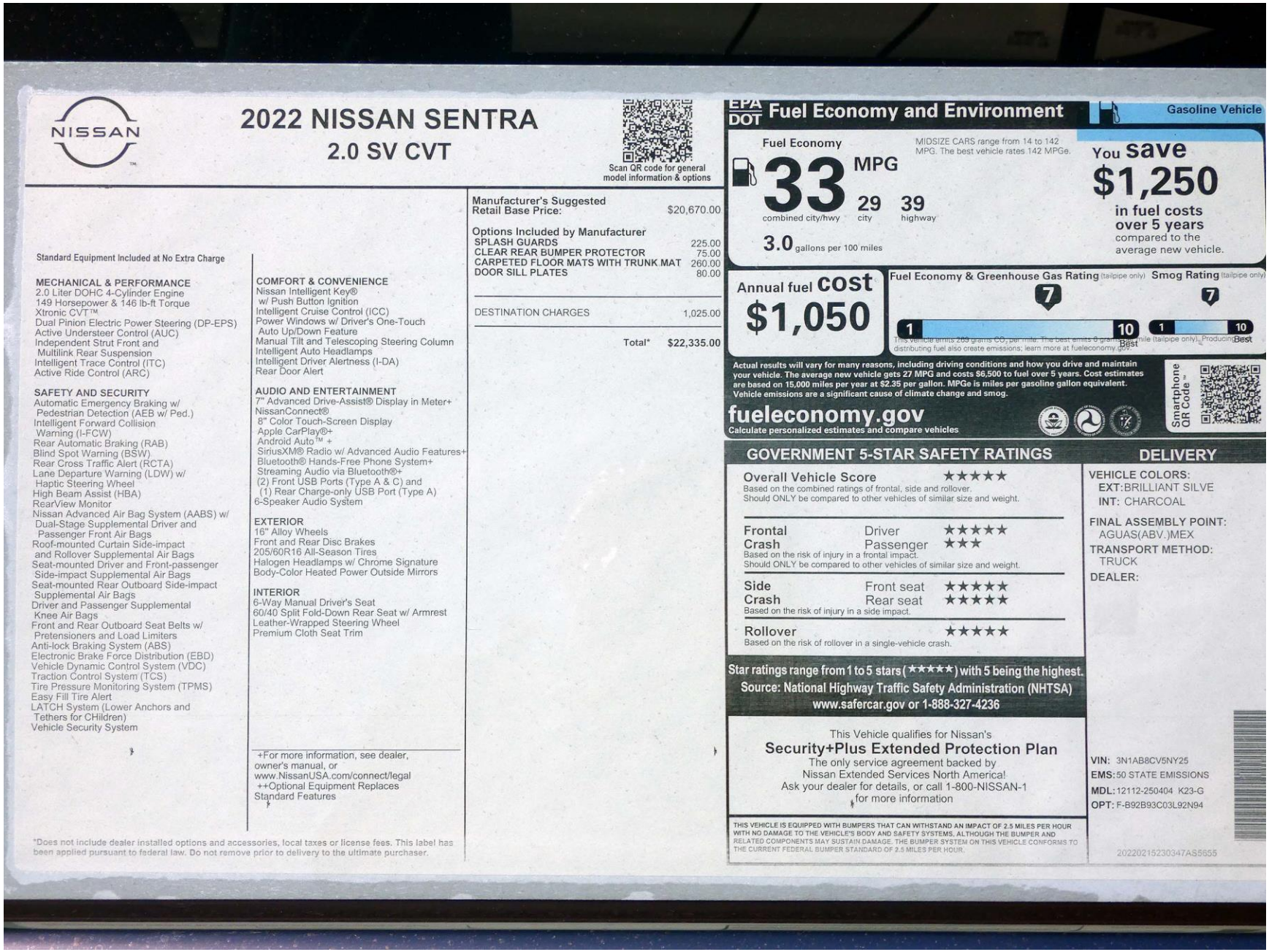


Figure A3. Window Sticker (Monroney Label)

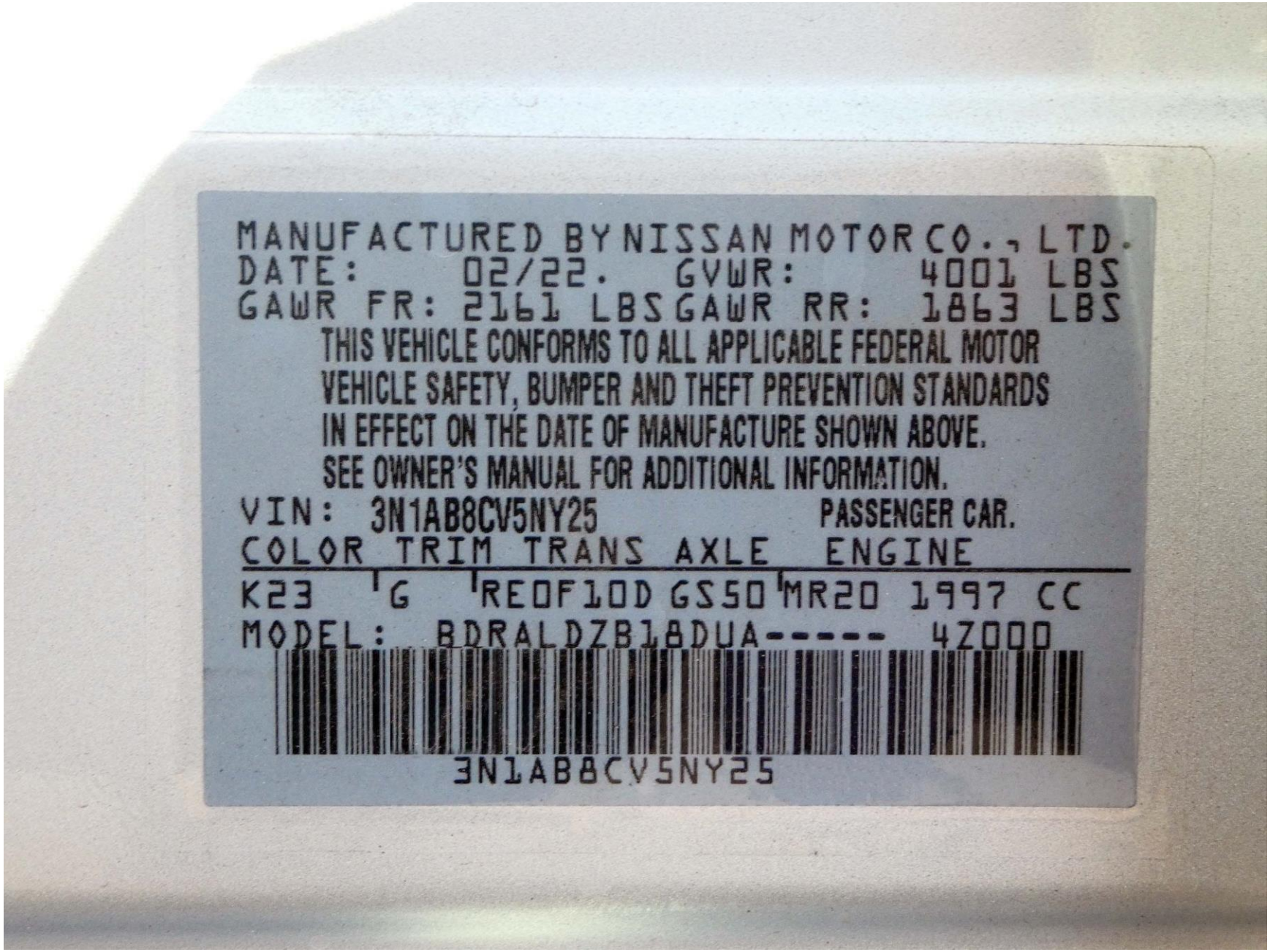


Figure A4. Vehicle Certification Label

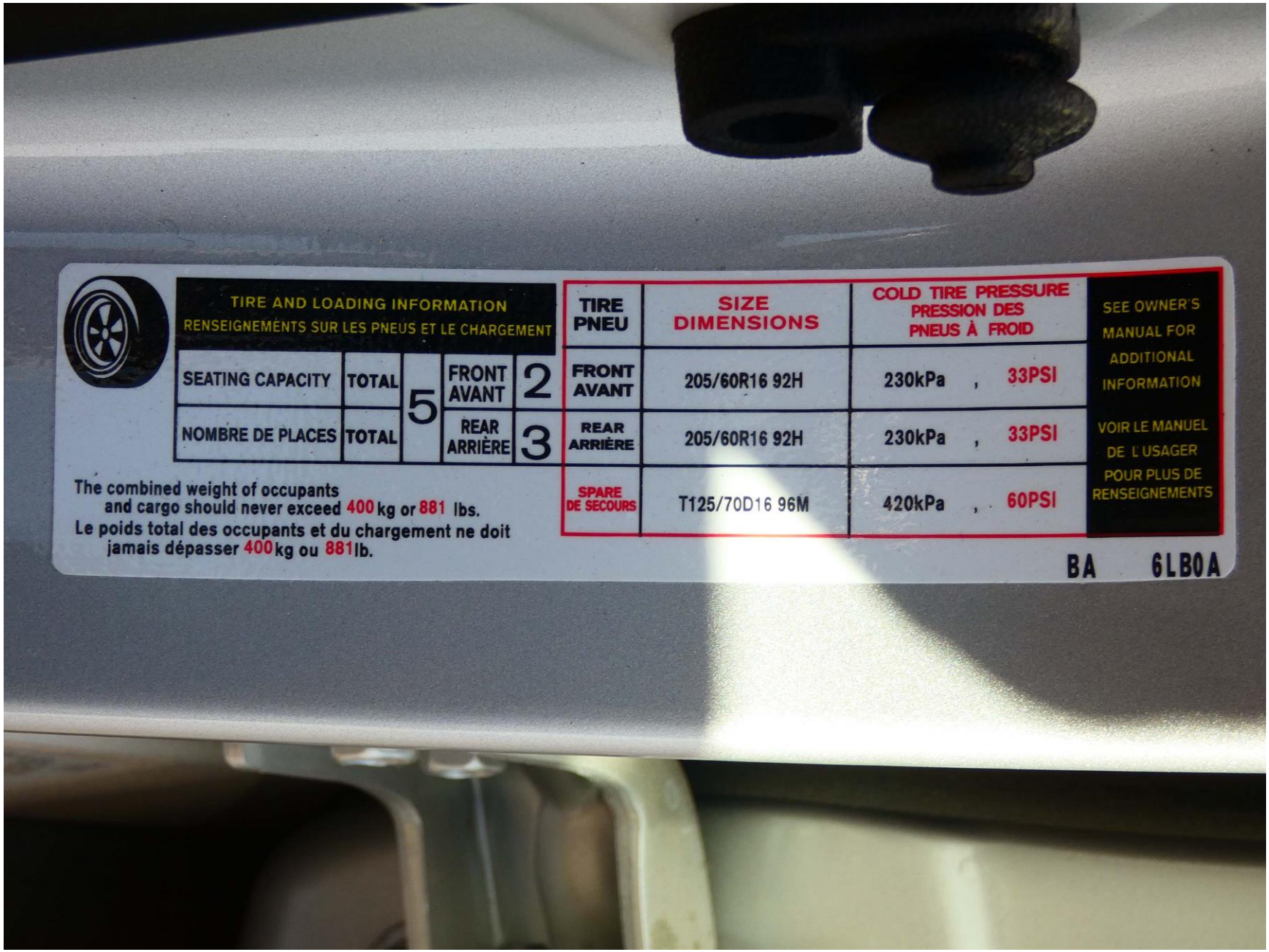


Figure A5. Tire Placard

Figure A6. Front View of Principal Other Vehicle

Figure A7. Rear View of Principal Other Vehicle

Figure A8. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

Figure A9. Sensors for Detecting Auditory and Visual Alerts

Figure A10. Computer Installed in Subject Vehicle

Figure A11. Brake Actuation System Installed in Principal Other Vehicle

Figure A12. FCW System Control Buttons

Figure A13. FCW System Setup Menu

Figure A14. Visual Alert

APPENDIX B

Excerpts from Owner’s Manual

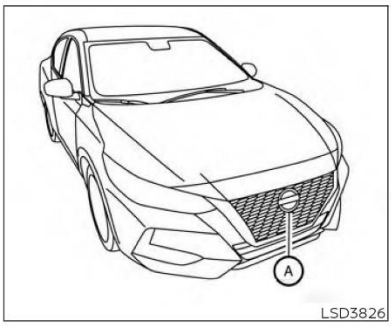
INTELLIGENT FORWARD COLLISION WARNING (I-FCW)

⚠ WARNING

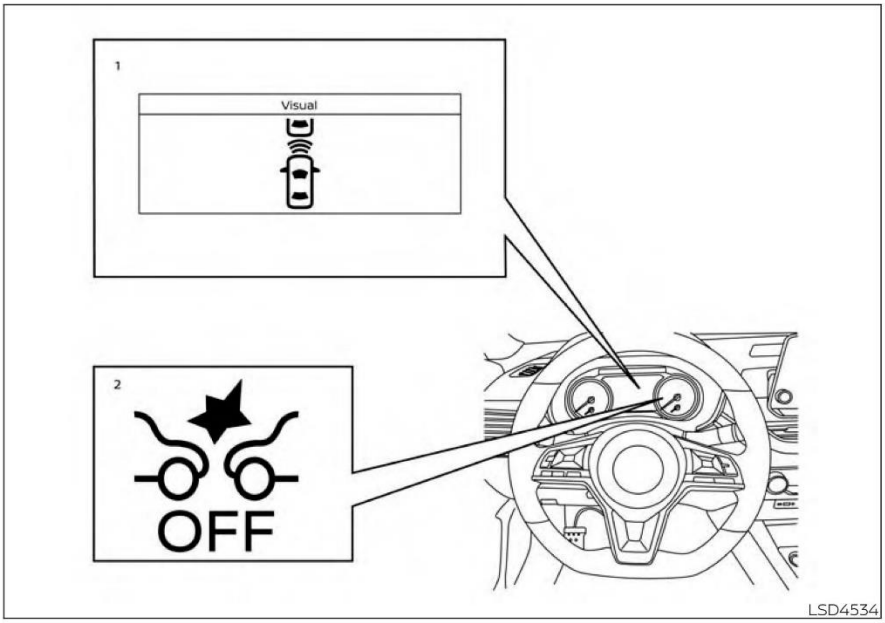
Failure to follow the warnings and instructions for proper use of the I-FCW system could result in serious injury or death.

- **The I-FCW system can help warn the driver before a collision occurs but will not avoid a collision. It is the driver's responsibility to stay alert, drive safely and be in control of the vehicle at all times.**

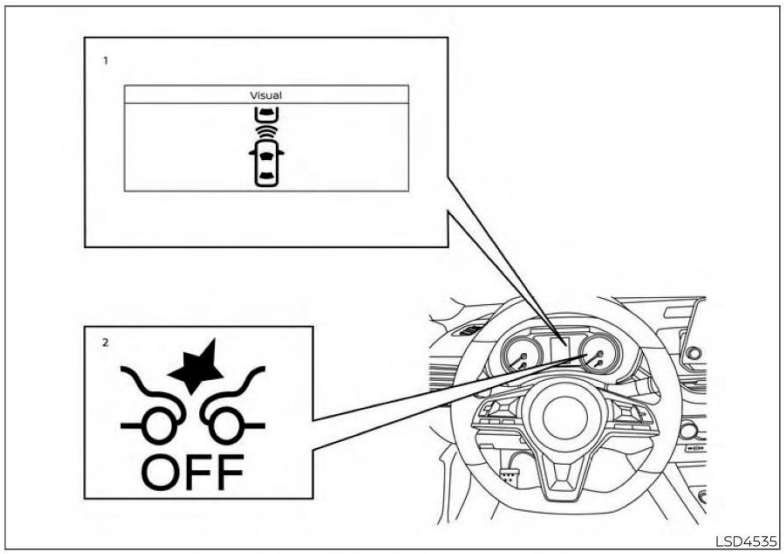
The I-FCW system can help alert the driver when there is a sudden braking of a second vehicle traveling in front of the vehicle ahead in the same lane.



The I-FCW system uses a radar sensor Ⓐ located on the front of the vehicle to measure the distance to the vehicle ahead in the same lane.

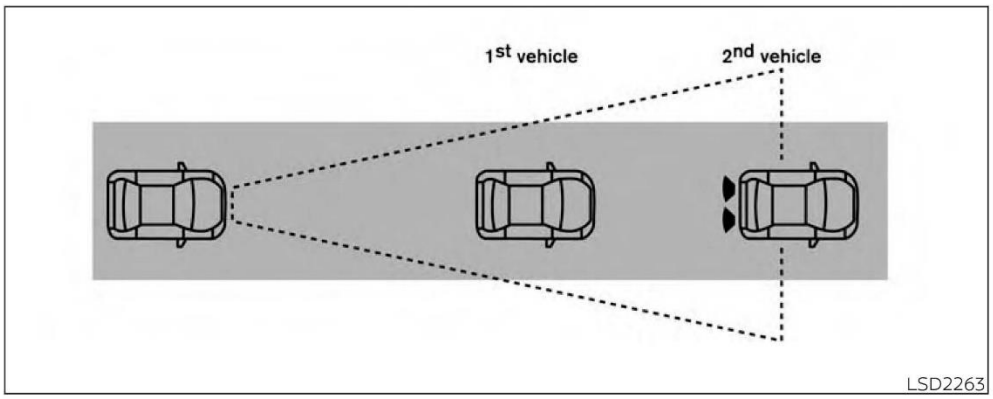


For vehicles with the 7 inch meter display



1. Vehicle ahead detection indicator
2. AEB with Pedestrian Detection system warning light

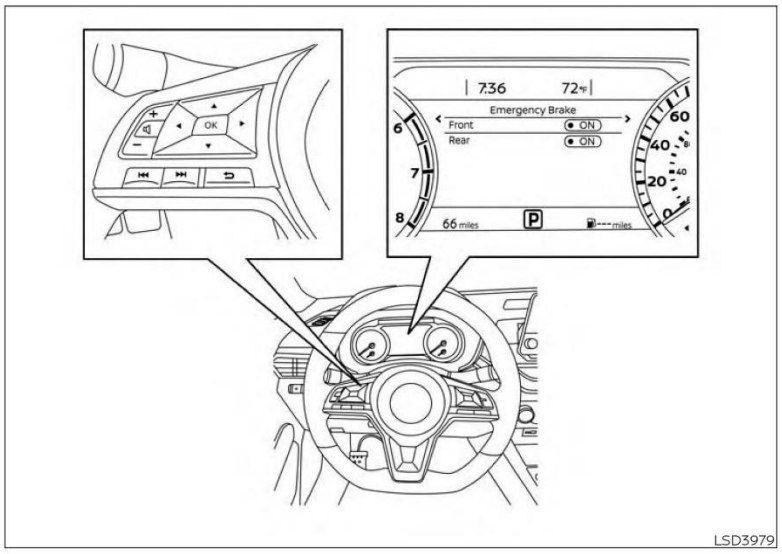
For vehicles with the 4.2 inch meter display



I-FCW SYSTEM OPERATION

The I-FCW system operates at speeds above approximately 3 mph (5 km/h).

If there is a potential risk of a forward collision, the I-FCW system will warn the driver by blinking the vehicle ahead detection indicator, and sounding an audible alert.



For vehicles with the 7 inch meter display

TURNING THE I-FCW SYSTEM ON/OFF

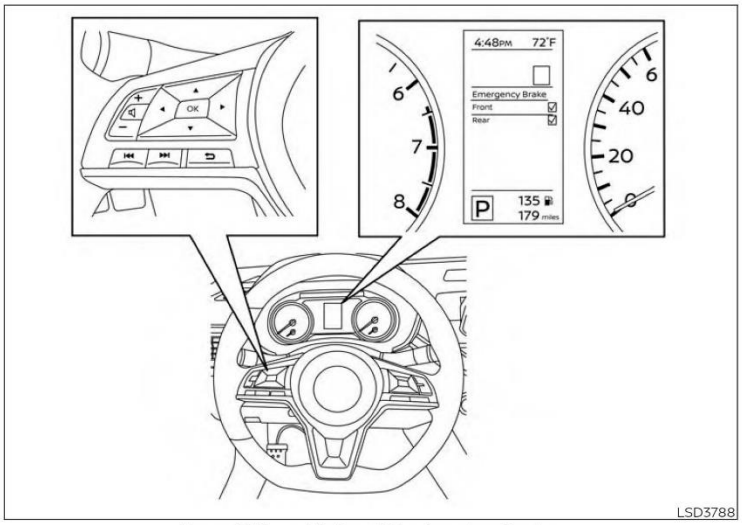
Perform the following steps to turn the I-FCW system ON or OFF.

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 "Emergency Brake" and press the OK button.
3. Select "Front" and press the OK button to turn the system on or off.

When the I-FCW system is turned off, the AEB with Pedestrian Detection system warning light illuminates.

NOTE:

- **The I-FCW system will be automatically turned on when the engine is restarted.**
- **The I-FCW system is integrated into the AEB with Pedestrian Detection system. There is not a separate selection in the vehicle information display for the I-FCW system. When the AEB with Pedestrian Detection system is turned off, the I-FCW system is also turned off.**



For vehicles with the 4.2 inch meter display

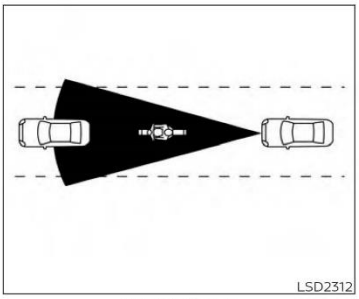


Illustration A
I-FCW SYSTEM LIMITATIONS

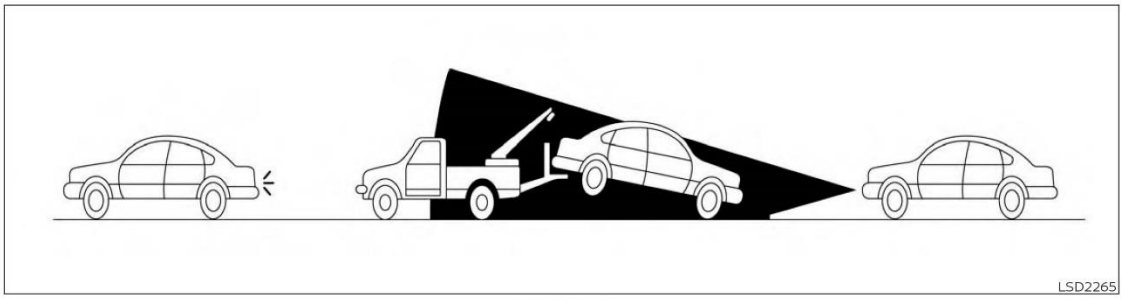


Illustration B

⚠ WARNING

Listed below are the system limitations for the I-FCW system. Failure to operate the vehicle in accordance with these system limitations could result in serious injury or death.

- **The I-FCW system cannot detect all vehicles under all conditions.**
- **The radar sensor does not detect the following objects:**
  - **Pedestrians, animals or obstacles in the roadway**
  - **Oncoming vehicles**
  - **Crossing vehicles**
- **(Illustration A) The I-FCW system does not function when a vehicle ahead is a narrow vehicle, such as a motorcycle.**
- **The radar sensor may not detect a vehicle ahead in the following conditions:**
  - **Snow or heavy rain**
  - **Dirt, ice, snow or other material covering the radar sensor.**
  - **Interference by other radar sources.**
  - **Snow or road spray from traveling vehicles.**
  - **Driving in a tunnel**
  - **(Illustration B) When the vehicle ahead is being towed.**

- (Illustration C) When the distance to the vehicle ahead is too close, the beam of the radar sensor is obstructed.
- (Illustration D) When driving on a steep downhill slope or roads with sharp curves.

- The system is designed to automatically check the sensor's functionality, within certain limitations. The system may not detect some forms of obstruction of the sensor area such as ice, snow, stickers, etc. In these cases, the system may not be able to warn the driver properly. Be sure that you check, clean and clear the sensor area regularly.
- Excessive noise will interfere with the warning chime sound, and the chime may not be heard.

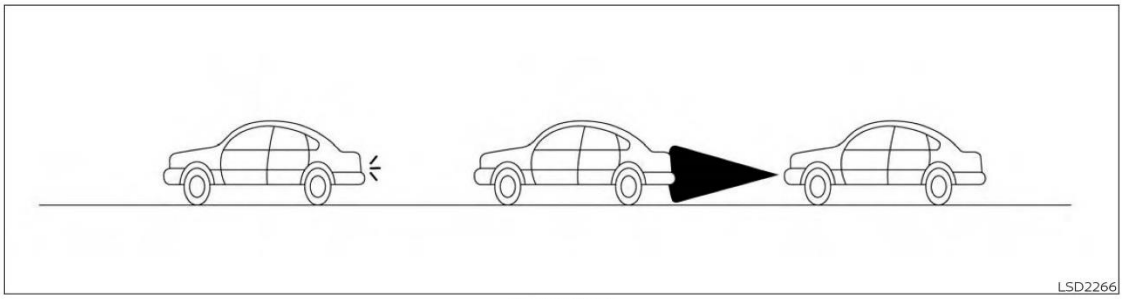


Illustration C

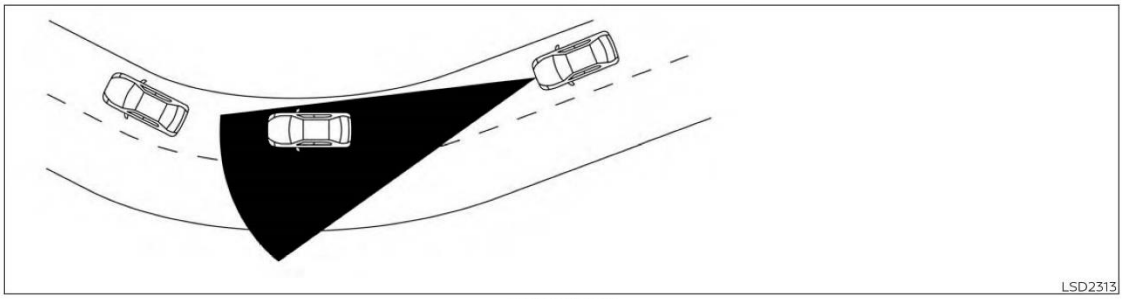
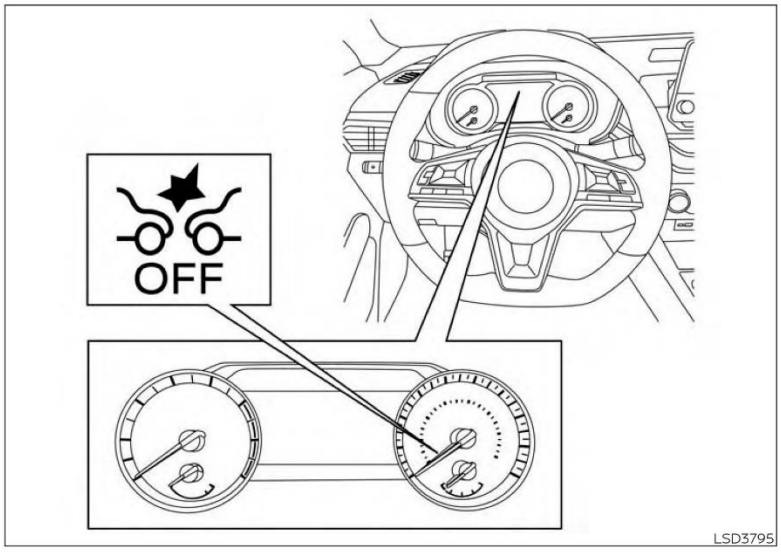


Illustration D



For vehicles with the 7 inch meter display

SYSTEM TEMPORARILY
UNAVAILABLE

Condition A

When the radar sensor picks up interference from another radar source, making it impossible to detect a vehicle ahead, the I-FCW system is automatically turned off.

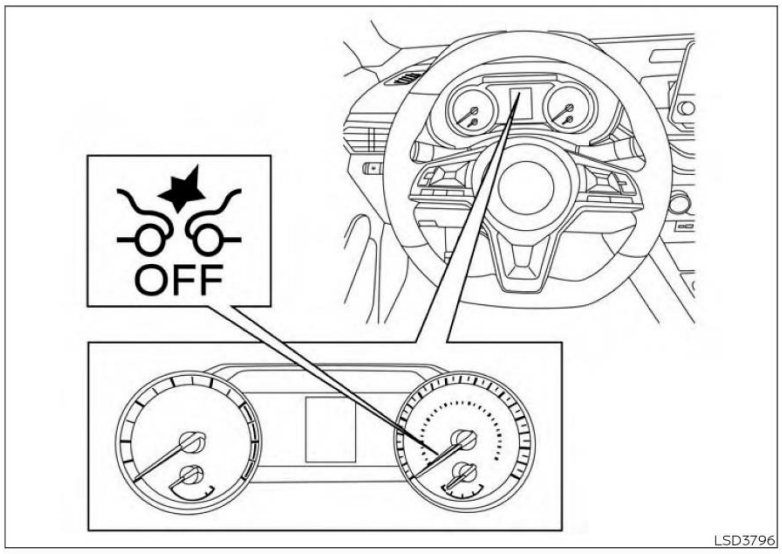
The AEB with Pedestrian Detection system warning light (orange) will illuminate.

Action to take:

When the above conditions no longer exist, the I-FCW system will resume automatically.

Condition B

When there is inclement weather (rain, fog, snow, etc.) blocking the front radar sensor, the I-FCW system will automatically be canceled. The chime will sound and the "Forward Driving Aids Temporarily Disabled Front Sensor Blocked: See Owner's Manual" or "Driving Aids Temporarily Disabled Front Sensor Blocked: See Manual" warning message will appear in the vehicle information display.



For vehicles with the 4.2 inch meter display

Action to take:

When the conditions listed above are no longer present, the warning message will no longer be available in the vehicle information display. If the "Forward Driving Aids Temporarily Disabled Front Sensor Blocked: See Owner's Manual" or "Driving Aids Temporarily Disabled Front Sensor Blocked: See Manual" warning message continues to be displayed, have the system checked. It is recommended that you visit a NISSAN dealer for this service.

Condition C

When the radar sensor of the front bumper is covered with mud, dirt, snow, ice, etc., or is obstructed, the I-FCW system will automatically be canceled, the chime will sound and the "Forward Driving Aids Temporarily Disabled Front Sensor Blocked: See Owner's Manual" or "Driving Aids Temporarily Disabled Front Sensor Blocked: See Manual" warning message will appear in the vehicle information display.

Action to take:

If the warning message appears, stop the vehicle in a safe place, place the shift lever in the P (Park) position, and turn the engine off. When the radar signal is temporarily interrupted, clean the sensor area of the front bumper and restart the engine. If the "Forward Driving Aids Temporarily Disabled Front Sensor Blocked: See Owner's Manual" or "Driving Aids Temporarily Disabled Front Sensor Blocked: See Manual" warning message continues to be displayed, have the system checked. It is recommended that you visit a NISSAN dealer for this service.

Condition D

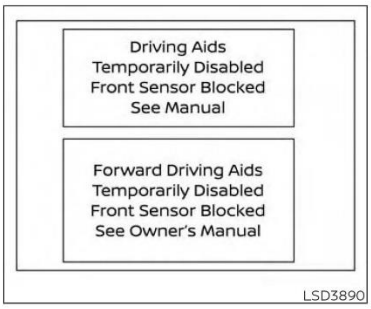
When driving on roads with limited road structures or buildings (for example, long bridges, deserts, snowfields, driving next to long walls), the system may illuminate the system warning light and display the "Forward Driving Aids Temporarily Disabled Front Sensor Blocked: See Owner's Manual" or "Driving Aids Temporarily Disabled Front Sensor Blocked: See Manual" message.

Action to take:

When the above driving conditions no longer exist, turn the system back on.

NOTE:

If the AEB with Pedestrian Detection system stops working, the I-FCW system will also stop working.



SYSTEM MALFUNCTION

If the I-FCW system malfunctions, it will be turned off automatically, a chime will sound, the AEB with Pedestrian Detection warning light (orange) will illuminate and the warning message [Malfunction] will appear in the vehicle information display.

Action to take

If the warning light (orange) comes on, stop the vehicle in a safe location, turn the engine off and restart the engine. If the warning light continues to illuminate, have the I-FCW system checked. It is recommended that you visit a NISSAN dealer for this service.

APPENDIX C

Run Log

Subject Vehicle: **2022 Nissan Sentra CVT** Test Date: **4/8/2022**

Principal Other Vehicle: **2006 Acura RL**

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
1	**Stopped POV**	Y	2.70	2.56	0.60	Pass	
2		Y	2.72	2.50	0.62	Pass	
3		Y	2.69	2.52	0.59	Pass	
4		Y	2.69	2.48	0.59	Pass	
5		Y	2.68	2.64	0.58	Pass	
6		Y	2.70	2.62	0.60	Pass	
7		Y	2.49	2.46	0.39	Pass	
19	**Decelerating POV, 45**	N					POV brakes
20		N					POV brakes
21		Y	2.72	2.67	0.32	Pass	
22		N					Lateral offset
23		Y	2.72	2.49	0.32	Pass	
24		N					Lateral offset
25		N					Lateral offset
26		N					Lateral offset
27		Y	2.69	2.64	0.29	Pass	
28		Y	2.71	2.63	0.31	Pass	

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
29		Y	2.62	2.58	0.22	Pass	
30		N					Lateral offset
31		Y	2.65	2.43	0.25	Pass	
32		N					Lateral offset
33		N					Lateral offset
34		N					Lateral offset
35		N					Lateral offset
36		N					POV brakes
37		N					Lateral offset
38		N					Lateral offset
39		Y	2.61	2.57	0.21	Pass	
8	**Slower POV, 45 vs 20**	Y	2.68	2.65	0.68	Pass	
9		N					Unable to detect auditory alert
10		N					GPS fix type
11		Y	2.67	2.63	0.67	Pass	
12		N					Lateral offset
13		N					Lateral offset
14		Y	2.66	2.62	0.66	Pass	
15		Y	2.65	2.53	0.65	Pass	
16		Y	2.65	2.40	0.65	Pass	

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
17		Y	2.62	2.38	0.62	Pass	
18		Y	2.68	2.48	0.68	Pass	

APPENDIX D

Time History Plots

LIST OF FIGURES

Description of Time History Plots

A set of time history plots is provided for each valid run in the test series. Each set of plots comprises time varying data from both the Subject Vehicle (SV) and the Principal Other Vehicle (POV), 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 indicating to which vehicle the data pertain.

Each time history plot consists of data pertinent to the test type under consideration, and therefore the data channels plotted vary according to test type. The test types (shown in the plot titles) include:

- FCW Test 1 – Stopped POV (SV at 45 mph)
- FCW Test 2 – Decelerating POV (Both vehicles at 45 mph with a 30 m gap, POV brakes at 0.3 g)
- FCW Test 3 – Slower Moving POV (SV at 45 mph, POV at 20 mph)

Time history figures include the following sub-plots:

- Warning – Displays the Forward Collision Warning Alert (which can be auditory, visual, or haptic). Depending on the type of FCW alert or instrumentation used to measure the alert, this can be any of the following:
    - Filtered, rectified, and normalized sound signal. The vertical scale is 0 to 1.
    - Filtered, rectified, and normalized acceleration (e.g., haptic alert, such as steering wheel vibration). The vertical scale is 0 to 1.
    - Light sensor signal.

- TTC (sec) – Indicates the Time to Collision as calculated up to the point of FCW alert issuance. The value of TTCW (Time to Collision at Warning) is given numerically on the right side of the figure. A passing value is indicated in green, while a failing value is indicated in red.

- SV Speed (mph) – Speed of the Subject Vehicle

- POV Speed (mph) – Speed of the Principal Other Vehicle

- Yaw Rate (deg/sec) – Yaw rate of both the Subject Vehicle and Principal Other Vehicle

- Lateral Offset (ft) – Lateral offset within the lane from the Subject Vehicle to the Principal Other Vehicle
- Ax (g) – Longitudinal acceleration of both the Subject Vehicle and Principal Other Vehicle
- Headway (ft) – Longitudinal separation between front of Subject Vehicle to rear of Principal Other Vehicle (Exclusive to test type 2)

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 left and/or right ends. Exceedances at the left or right extent of a yellow envelope are indicated by red asterisks.

For the warning plot, a dashed black threshold line indicates the threshold used to determine the onset of the FCW alert. The alert is considered on the first time the alert signal crosses this threshold line.

For the TTC plot, a dashed black threshold line indicates the minimum allowable TTC for the given test scenario. If the FCW alert occurs before this minimum allowable TTC, a green dot appears. However, if there is no alert or the alert occurs after the minimum allowable TTC, a red asterisk is shown on the plot.

For the Ax plot, a dashed black threshold line is given for at a value of -0.05 g. For a test run to be valid, the longitudinal acceleration of the Subject Vehicle must not fall below this threshold (i.e. the driver cannot apply any brakes). Additionally, for test type 2, the plot indicating the longitudinal acceleration of the Principal Other Vehicle includes a yellow envelope indicating the deceleration (0.3 g ± 0.03 g) allowed while braking. Exceedance of this threshold is indicated with red asterisks at the beginning and/or end of the threshold boundary.

Color Codes

Color codes have been adopted to easily identify which data correspond to which vehicle, as well as to indicate the types of envelopes and thresholds used in the plots.

Color codes can be broken into four categories:

1. Time-varying data
2. Validation envelopes and thresholds
3. Instantaneous samplings
4. Text

1. Time-varying data color codes:
   - Blue = Subject Vehicle data
   - Magenta = Principal Other Vehicle data
   - Brown = Relative data between SV and POV (i.e., TTC, lateral offset and headway distance)

2. 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 left and/or right ends
   - 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, TTC thresholds, and acceleration thresholds

3. 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

4. Text color codes:
   - Green = passing or valid value
   - Red = failing or invalid value

Other Notations

- ENV – For Ax plots only, indicates that the envelope for the POV braking was exceeded.
- NG – Indicates that the value for that variable was outside of bounds and therefore “No Good”.
- No Wng – No warning was detected.
- POV – Indicates that the value for the Principal Other Vehicle was out of bounds.
- SV – Indicates that the value for the Subject Vehicle was out of bounds.
- SR – Shows the speed reduction value.
- Thr – Indicates that the requirements for the throttle were not met.

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 for each test type (including passing, failing and invalid runs) are shown in Figure D1 through Figure D6. Actual time history data plots for the vehicle under consideration are provided subsequently.

Notes

When vehicles provide more than one type of alert, and when it is possible to measure the timing of these alerts, plots will be shown of each alert for each run. Because alert timing nearly always differs between alert types, a plot may indicate a valid run for one of the alerts and invalid for another. Test run validity is based on the validity window of the earliest alert, but validity determination for each individual alert is based on the timing of that alert alone. As an example, a vehicle has both visual and auditory alerts. For a particular run, the auditory alert occurs first followed by the visual alert. The validity period for the run ends when the auditory alert occurs, at which time the driver steers and/or brakes to avoid the POV. Since the visual alert occurs after the auditory alert, the run is essentially already over by the time the visual alert occurs. Depending on the relative timing gap between alerts, it may be expected that the validity criteria (yaw rate, speed, etc.) based on the timing of the visual alert could indicate an invalid run.

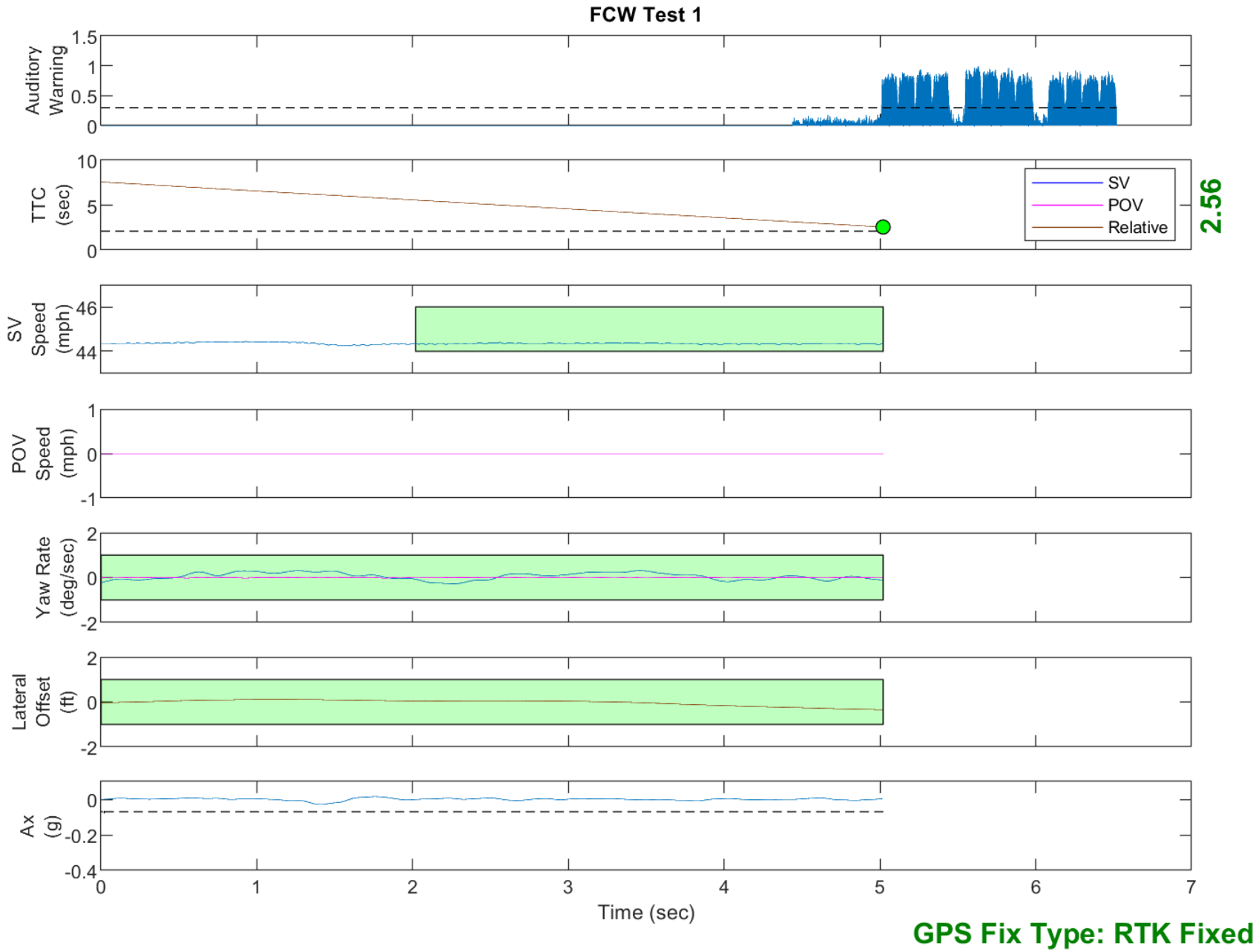


Figure D1. Example Time History for Test Type 1, Passing

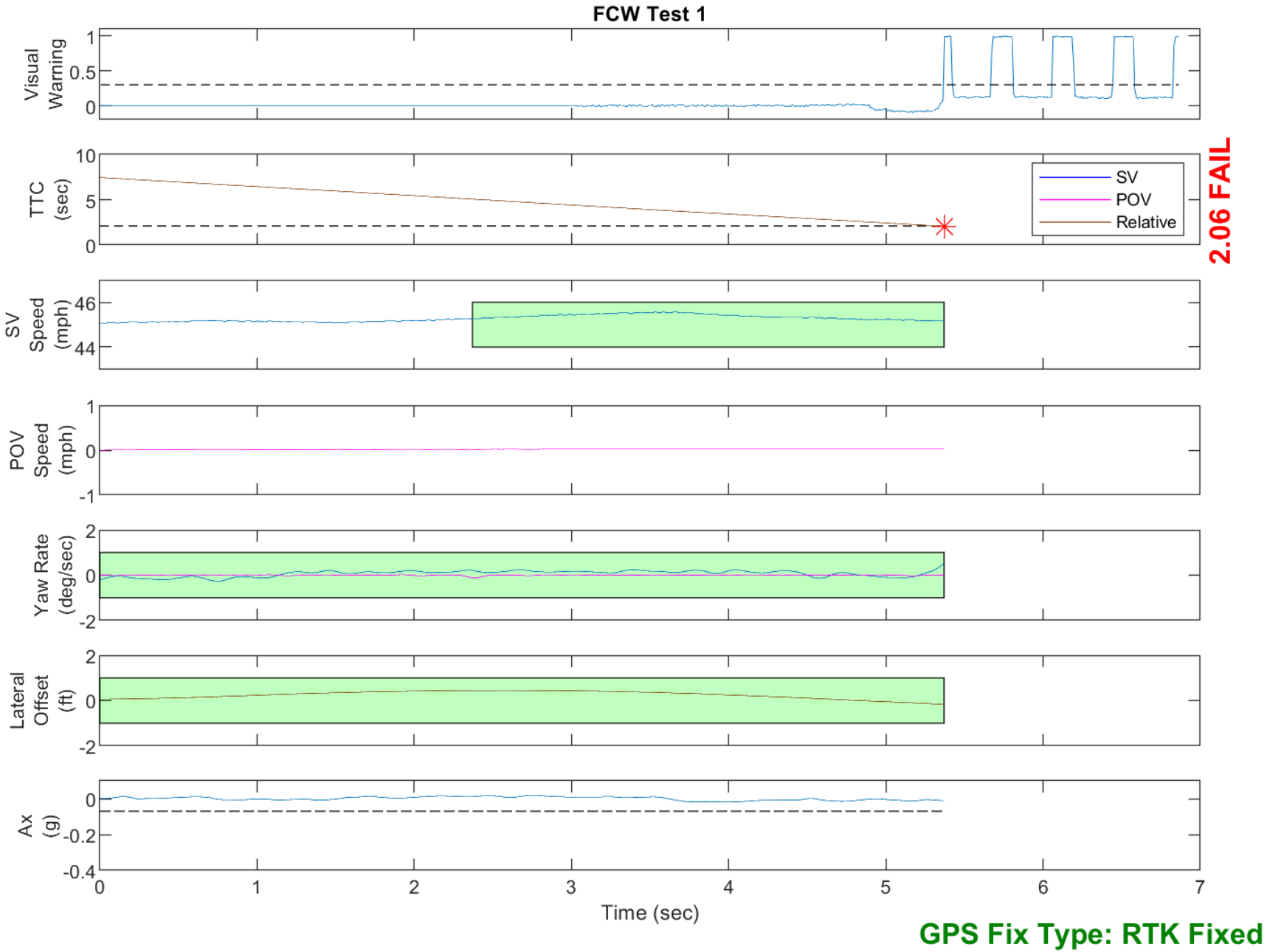


Figure D2. Example Time History for Test Type 1, Failing

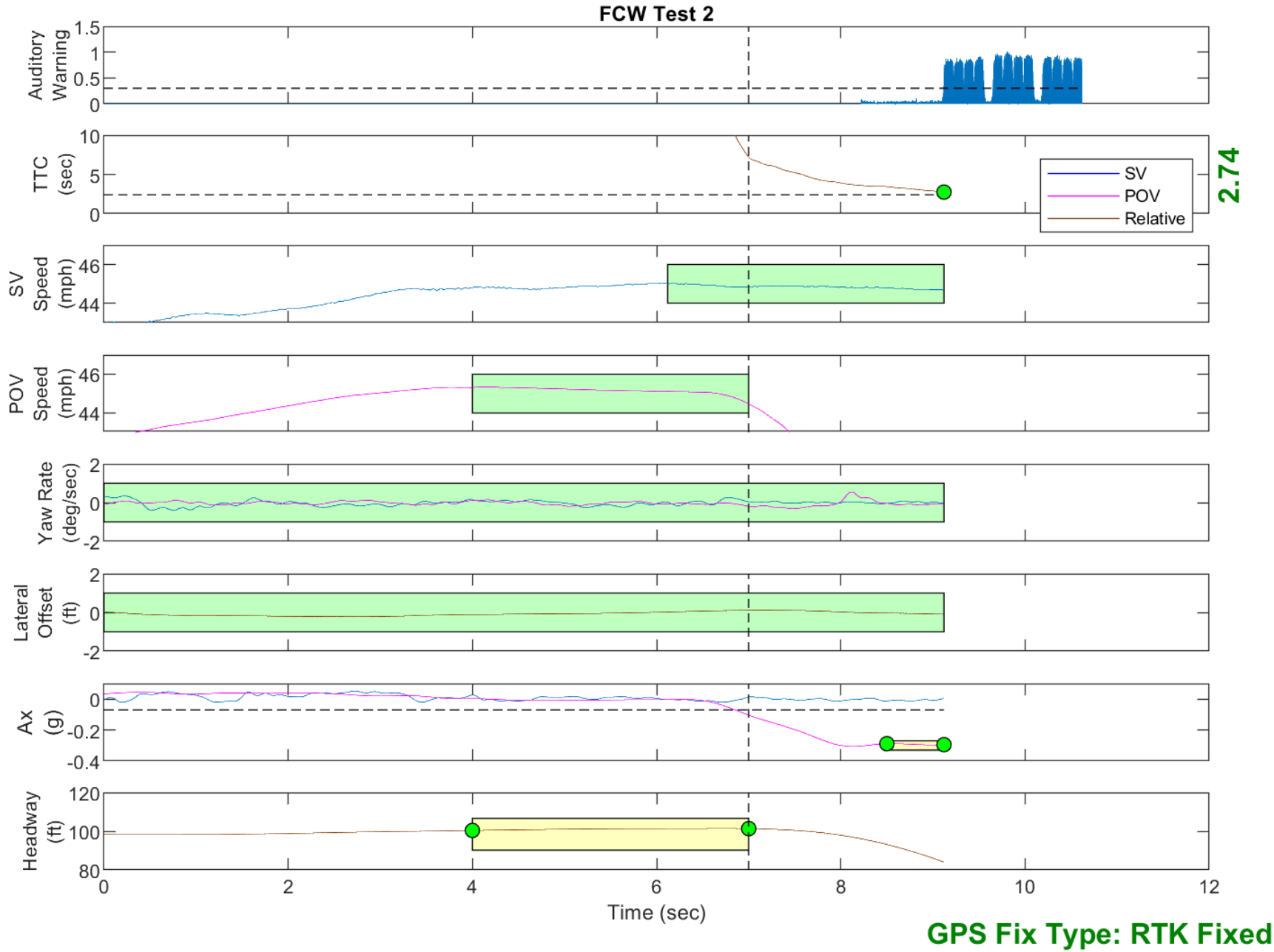


Figure D3. Example Time History for Test Type 2, Passing

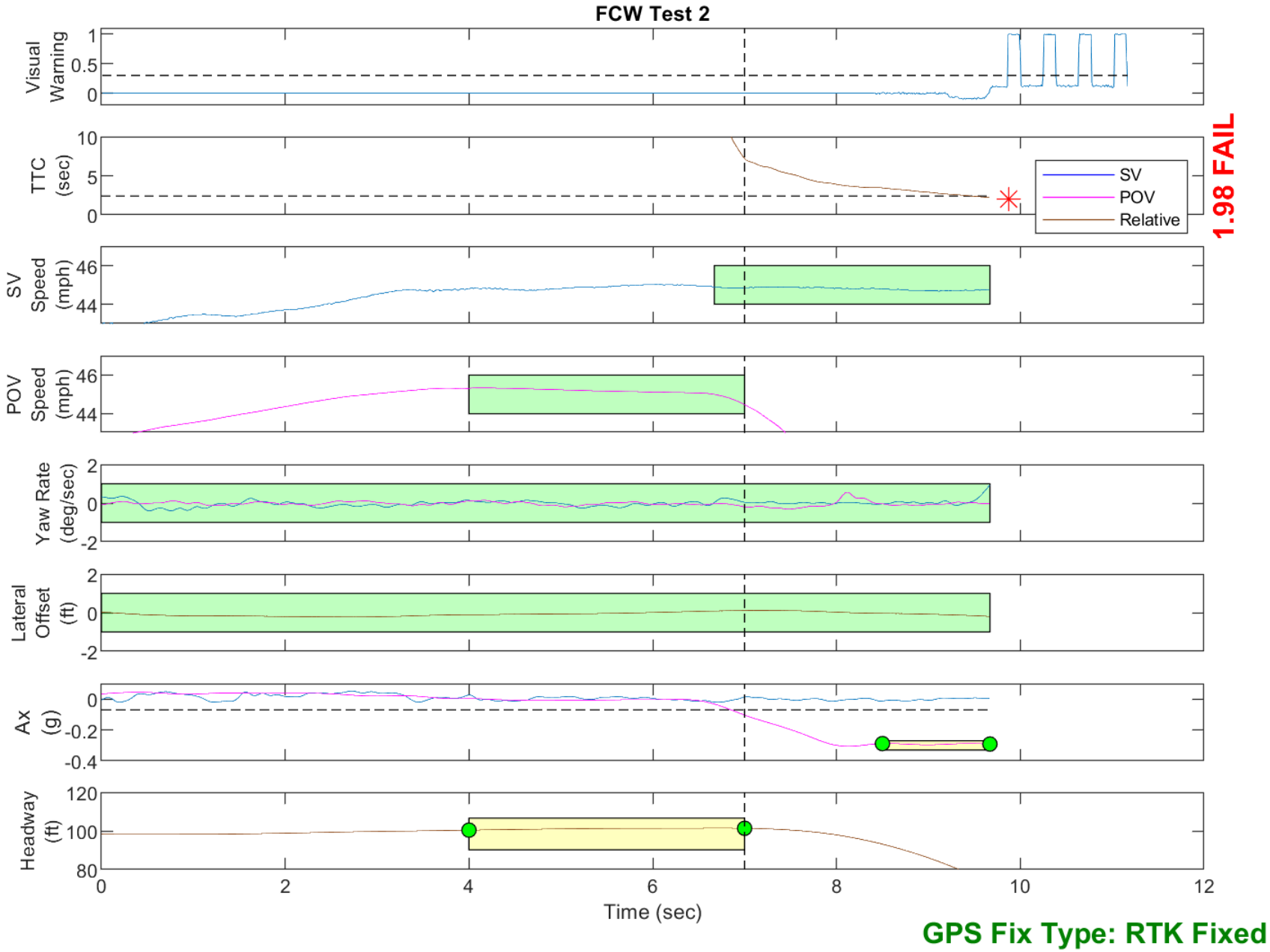


Figure D4. Example Time History for Test Type 2, Failing

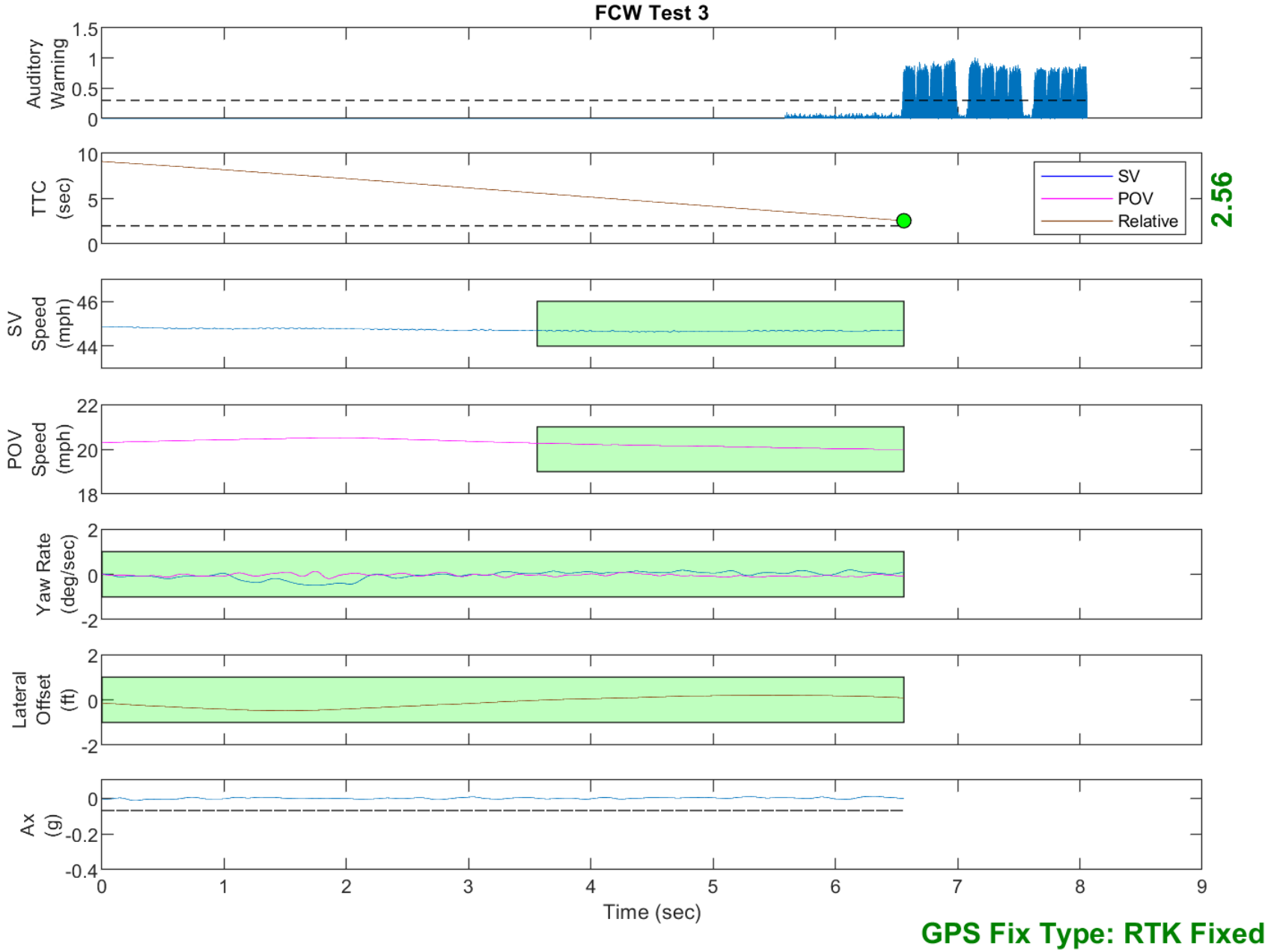


Figure D5. Example Time History for Test Type 3, Passing

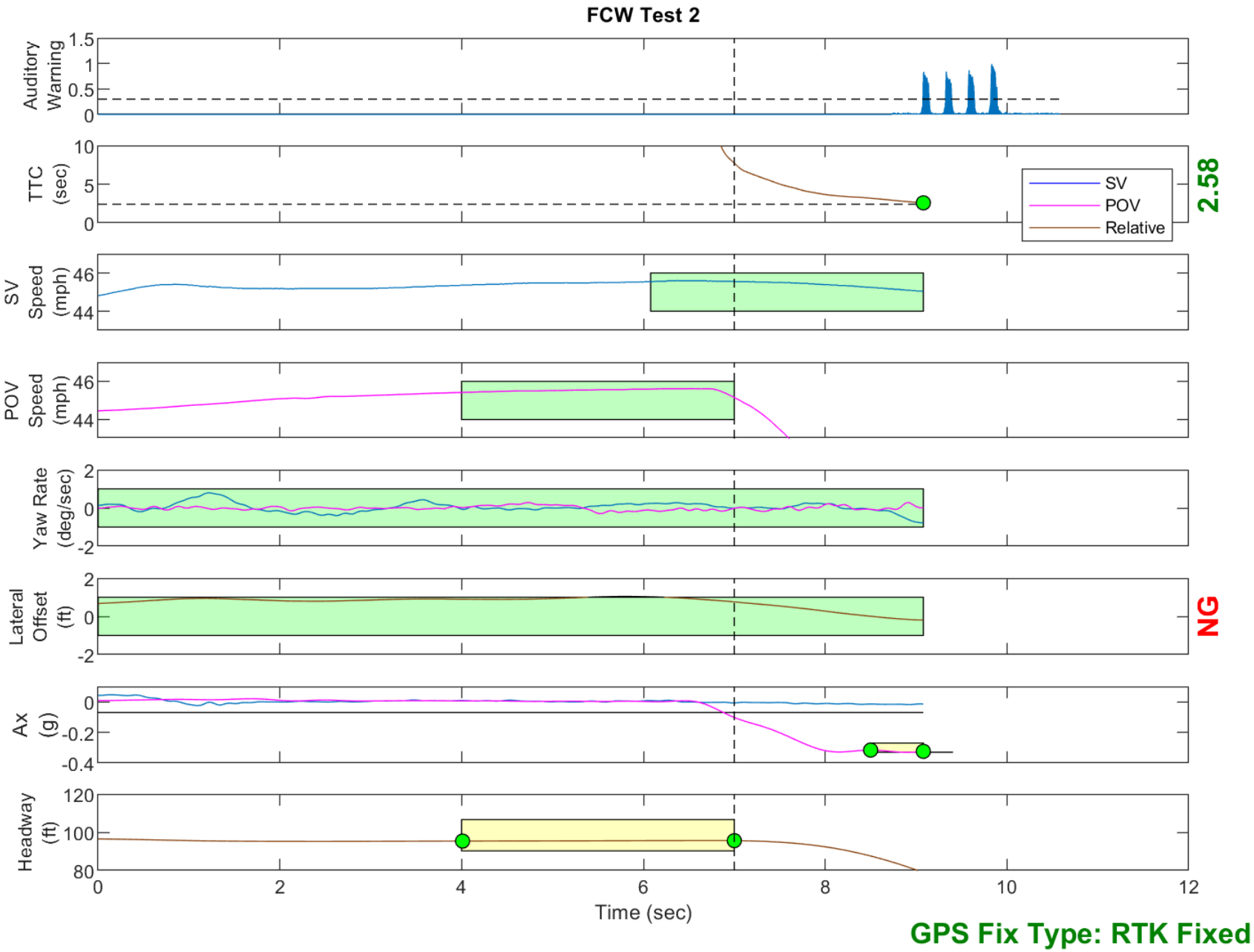


Figure D6. Example Time History Showing Invalid Lateral Offset Criteria

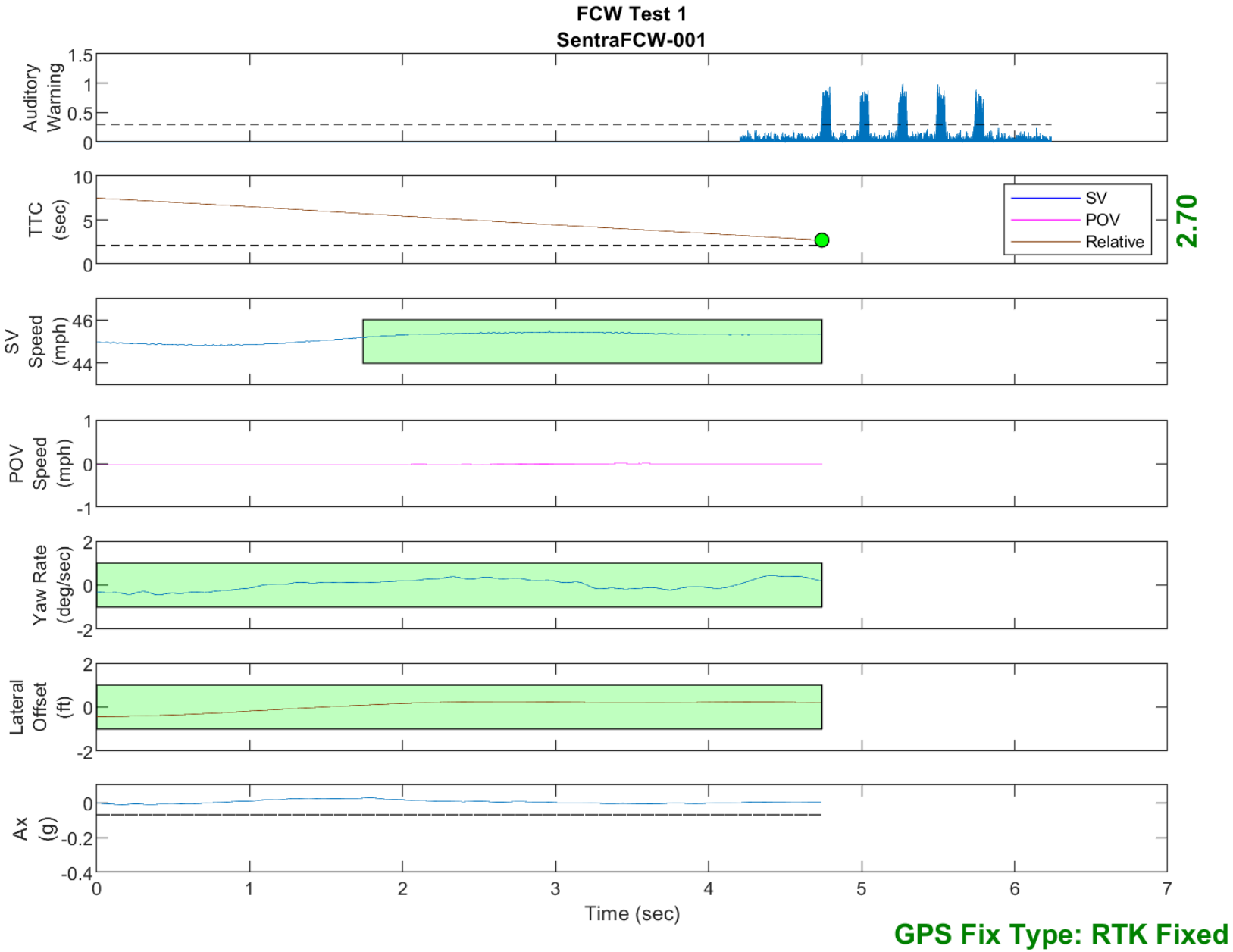


Figure D7. Time History for Run 1, Test 1 - Stopped POV, Auditory Warning

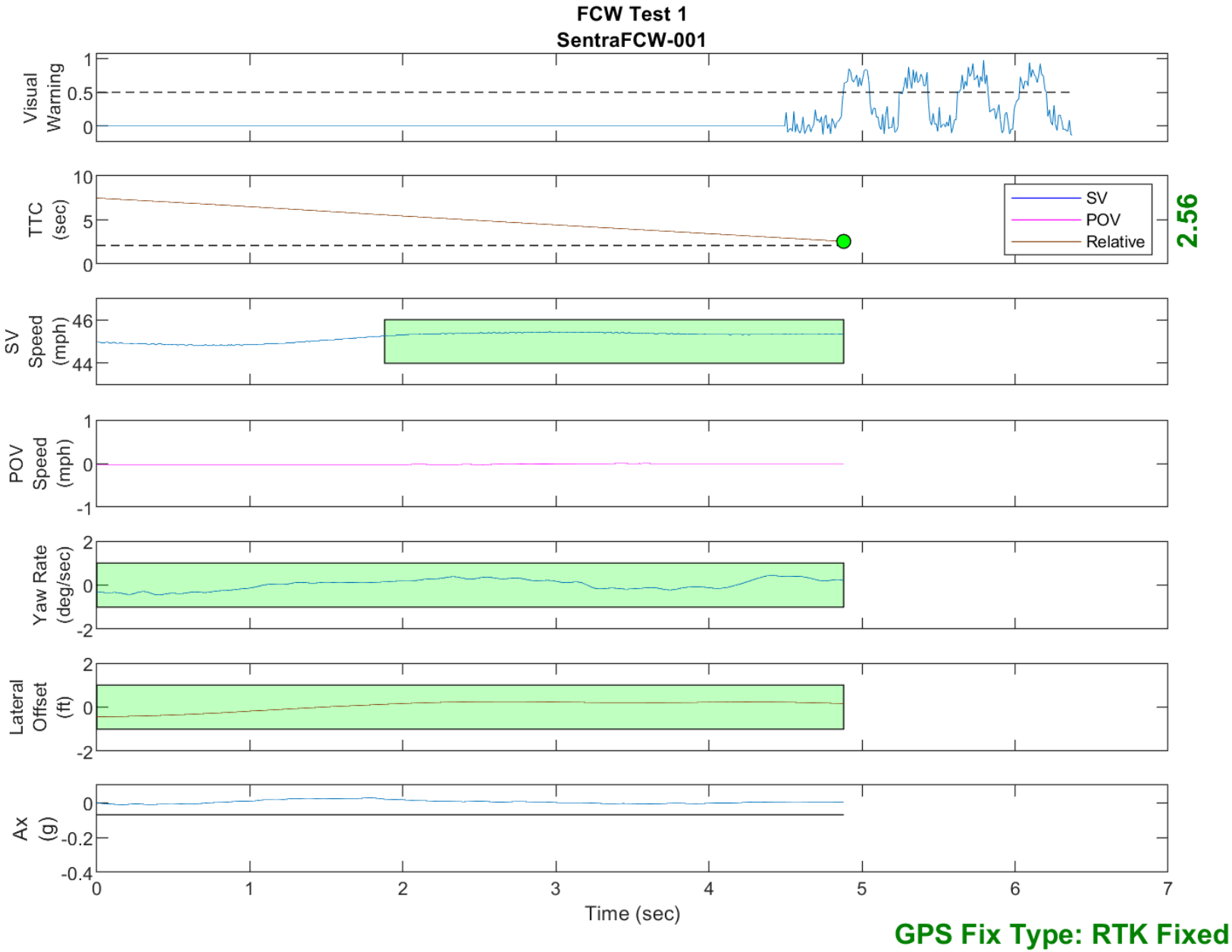


Figure D8. Time History for Run 1, Test 1 - Stopped POV, Visual Warning

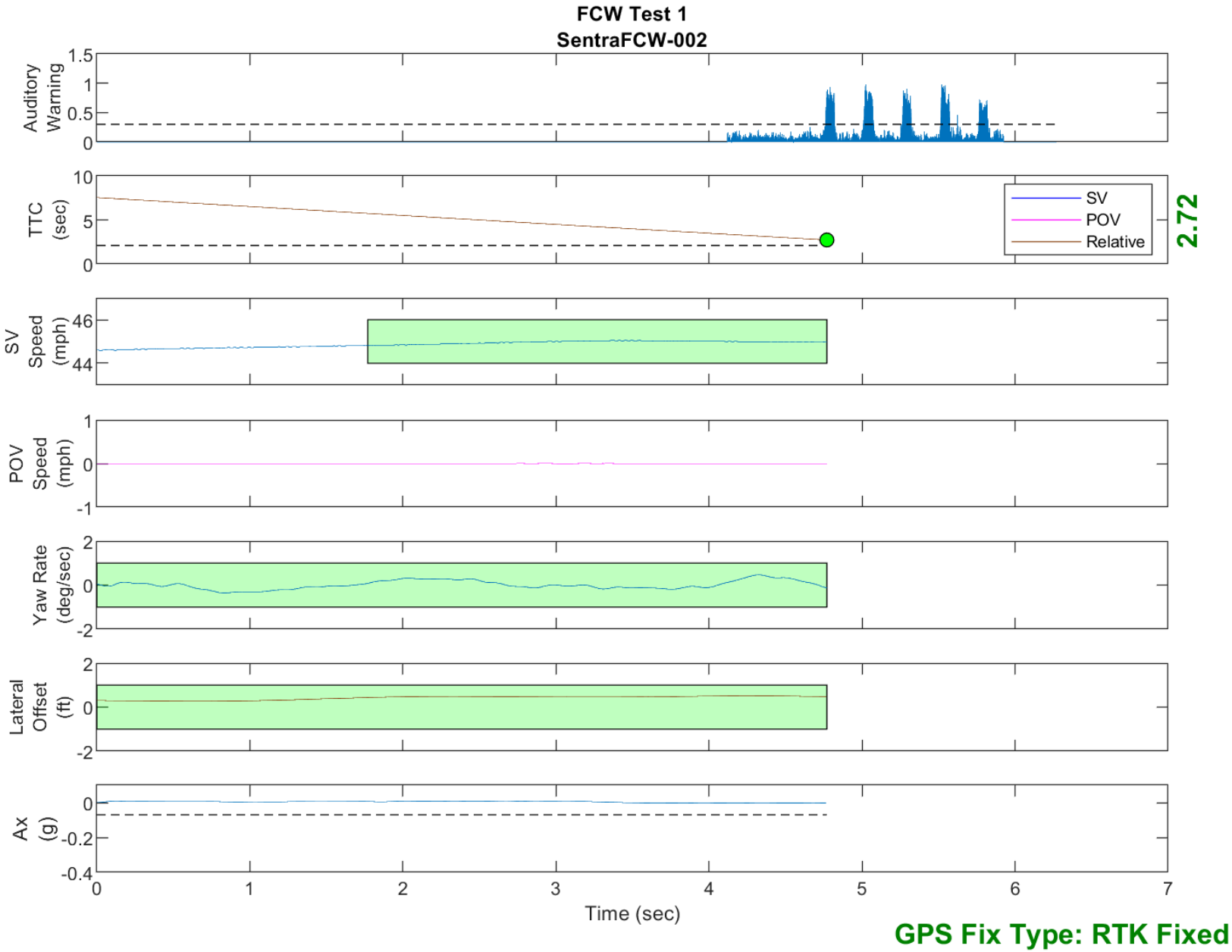


Figure D9. Time History for Run 2, Test 1 - Stopped POV, Auditory Warning

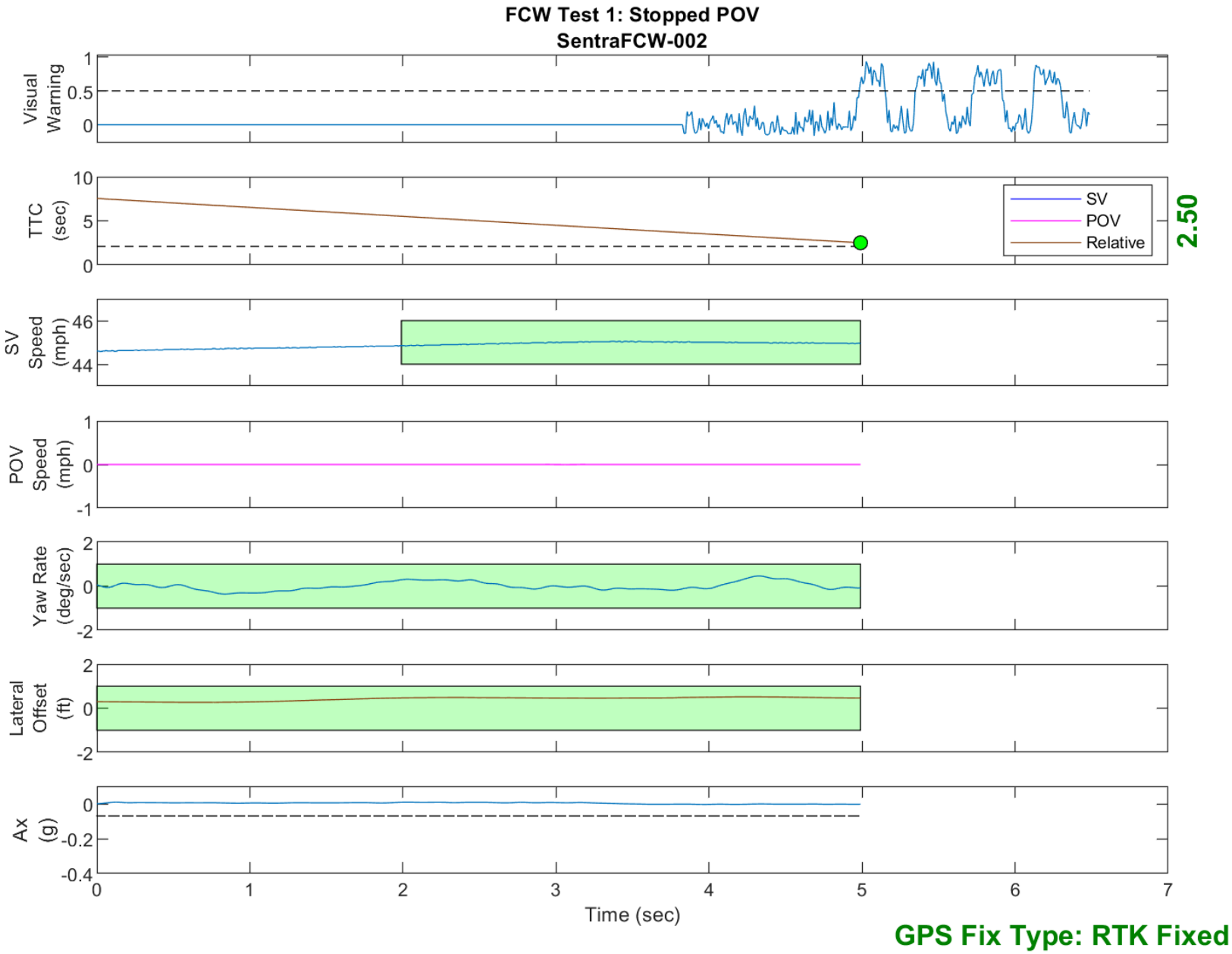


Figure D10. Time History for Run 2, Test 1 - Stopped POV, Visual Warning

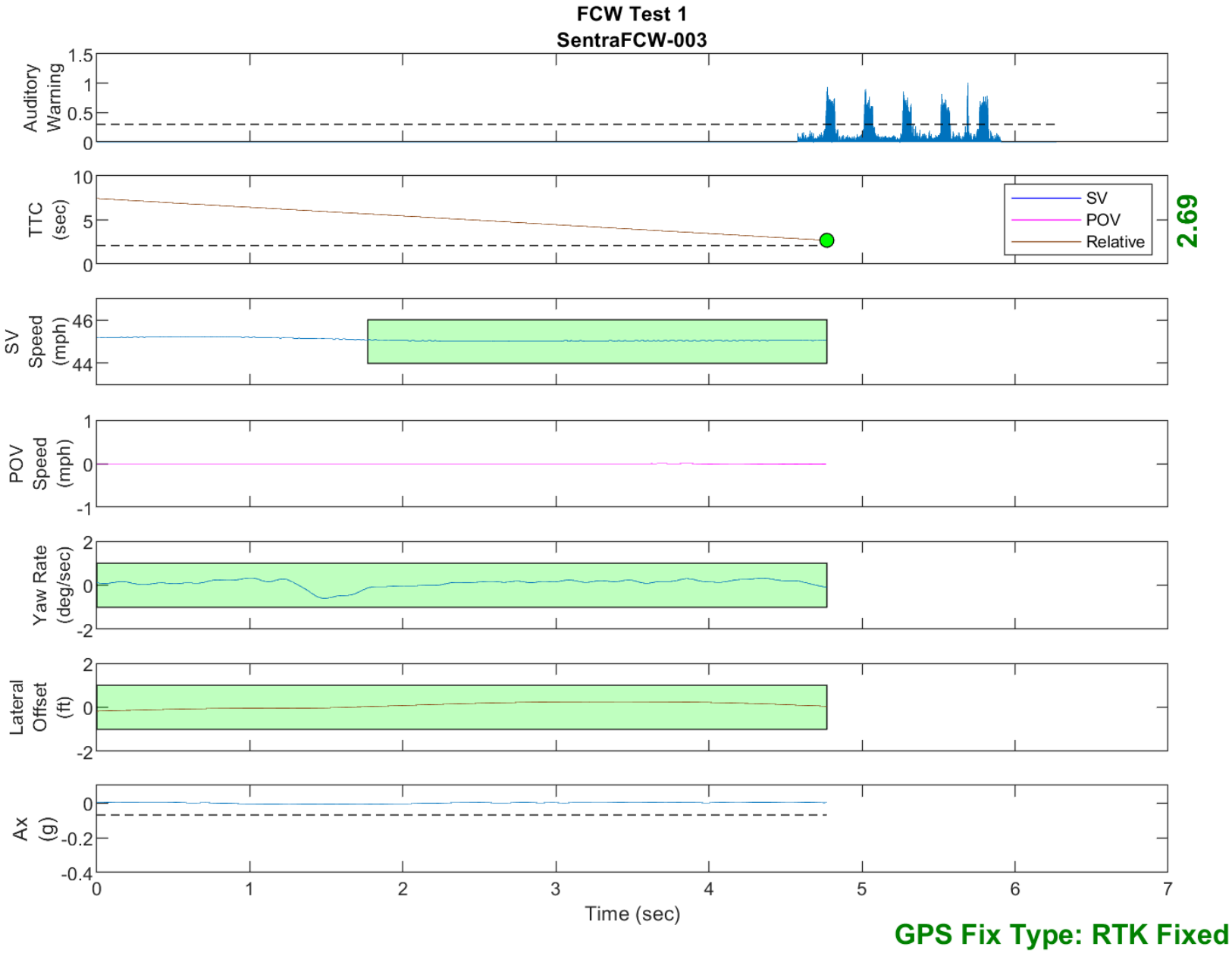


Figure D11. Time History for Run 3, Test 1 - Stopped POV, Auditory Warning

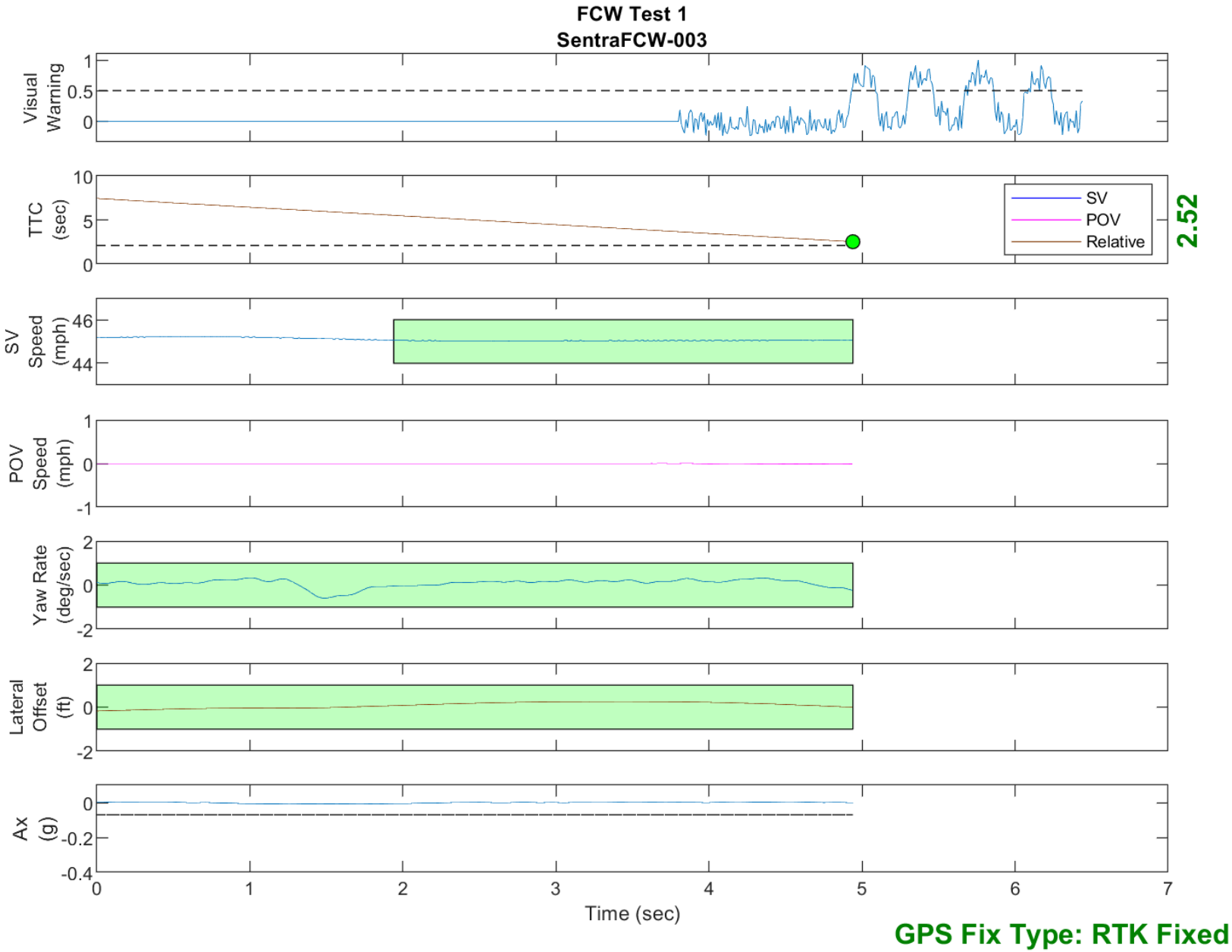


Figure D12. Time History for Run 3, Test 1 - Stopped POV, Visual Warning

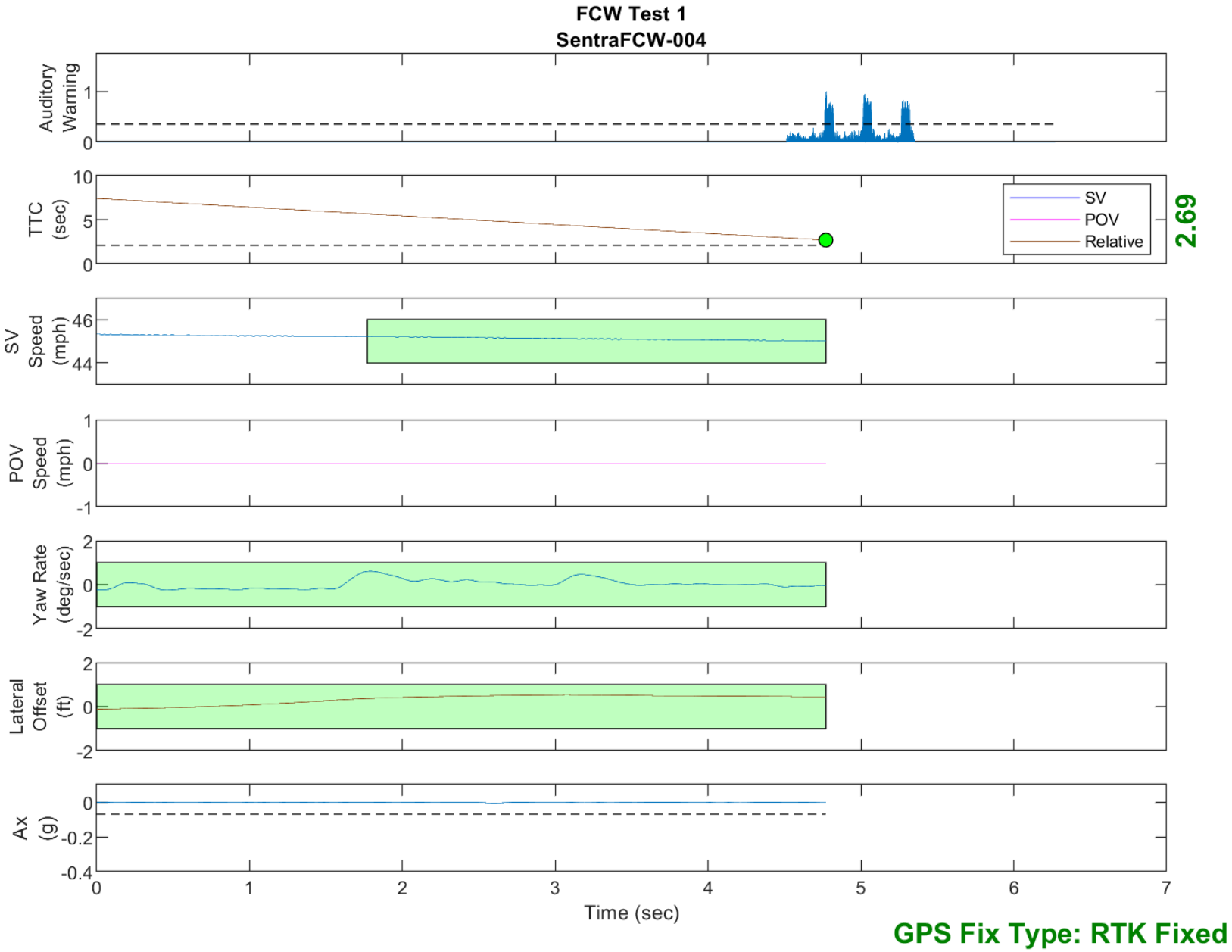


Figure D13. Time History for Run 4, Test 1 - Stopped POV, Auditory Warning

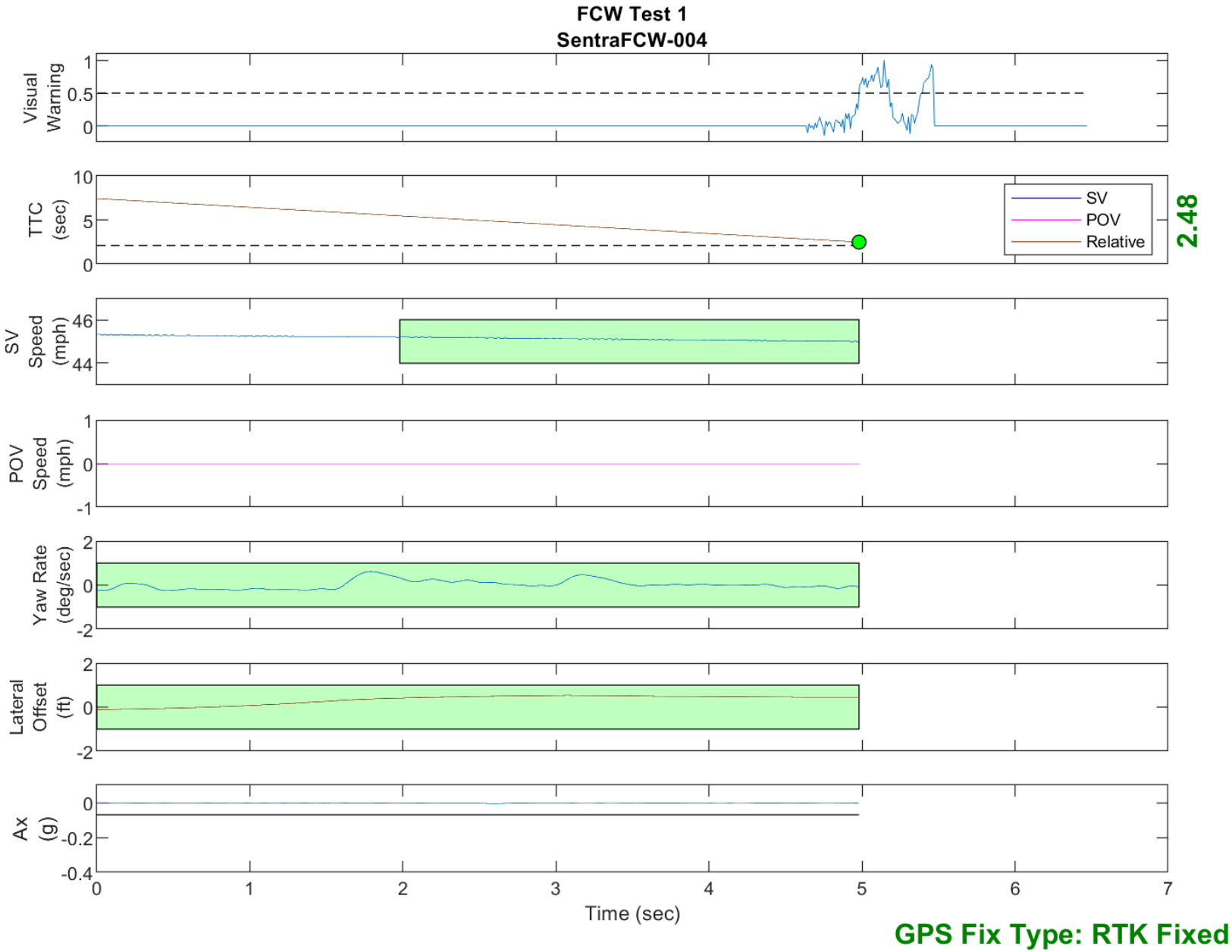


Figure D14. Time History for Run 4, Test 1 - Stopped POV, Visual Warning

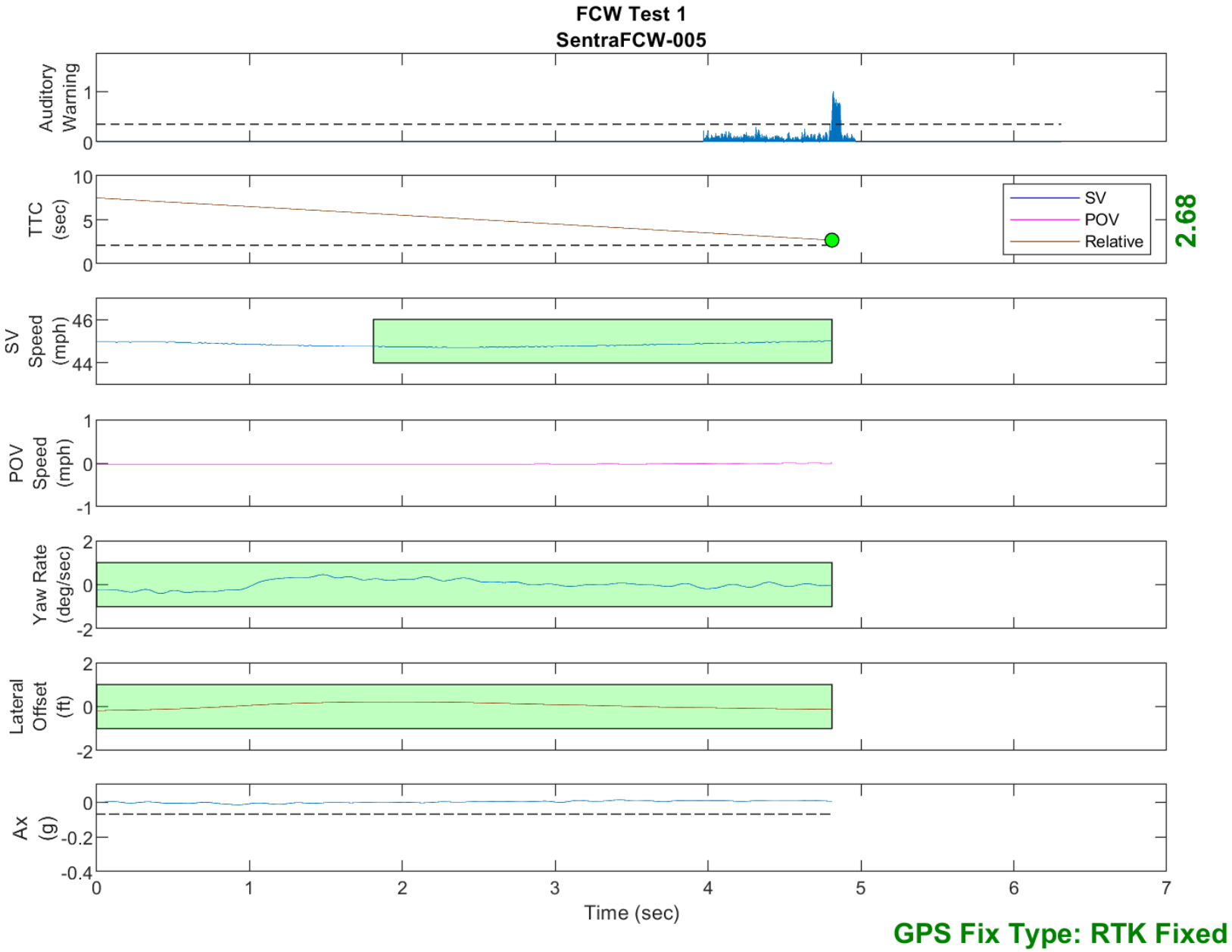


Figure D15. Time History for Run 5, Test 1 - Stopped POV, Auditory Warning

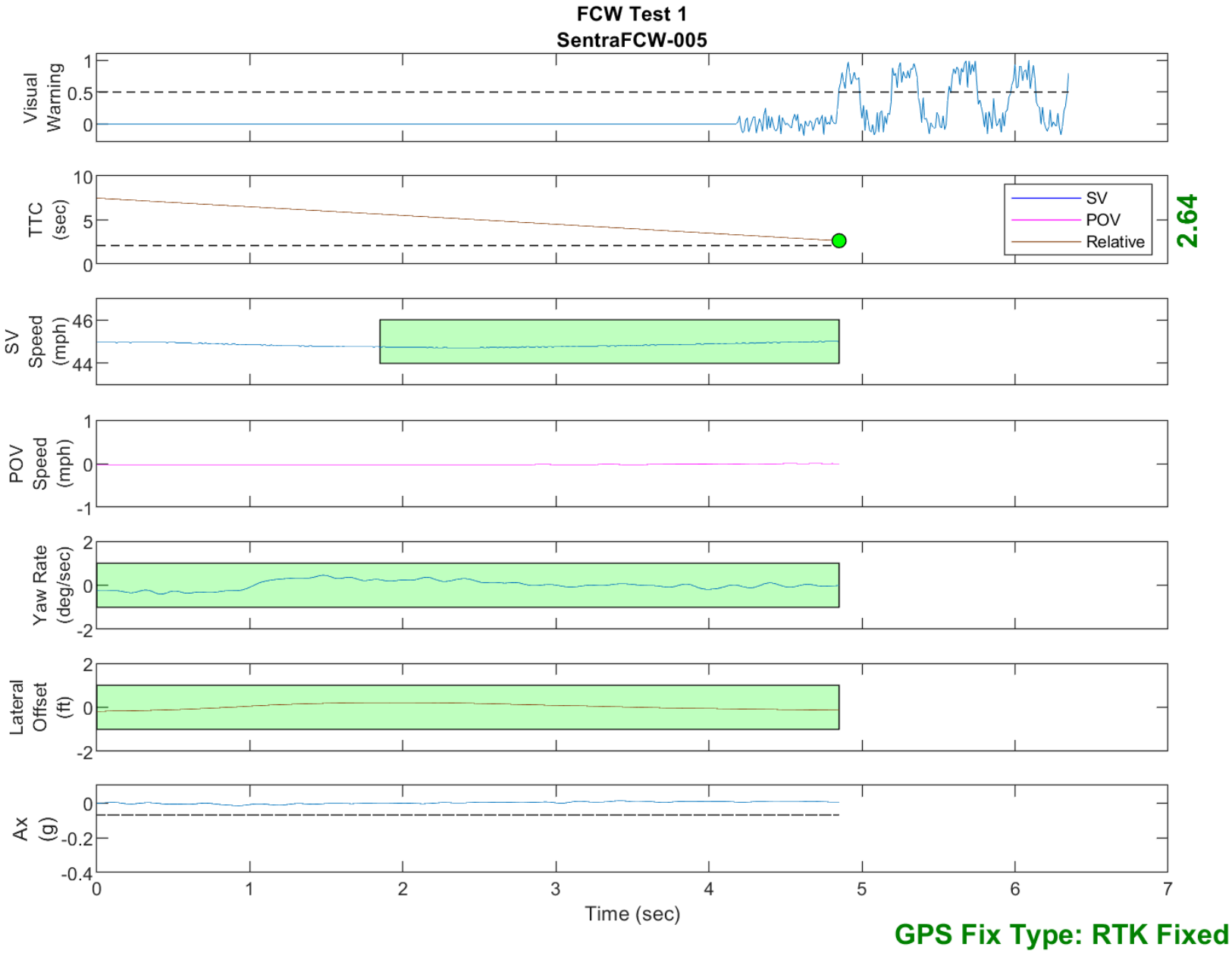


Figure D16. Time History for Run 5, Test 1 - Stopped POV, Visual Warning

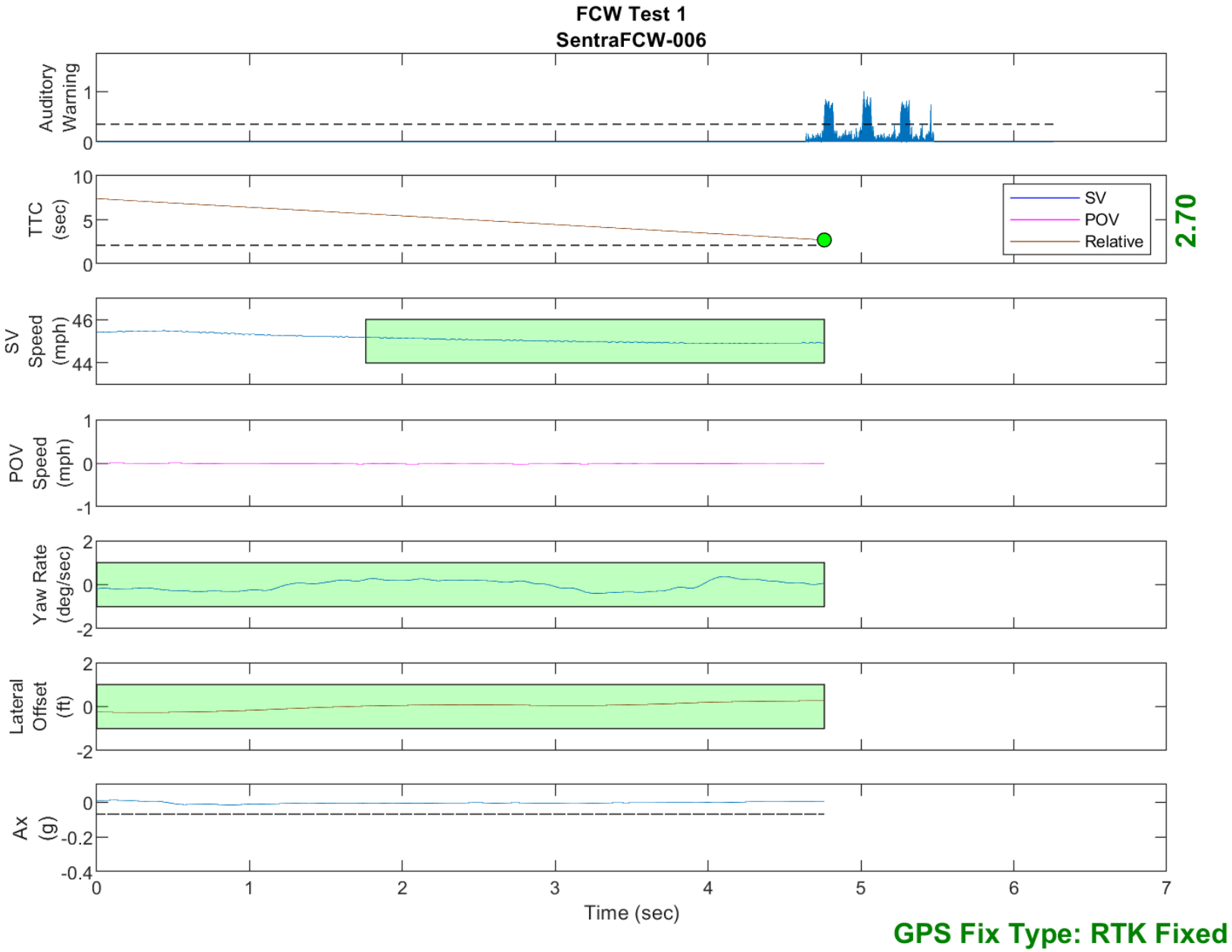


Figure D17. Time History for Run 6, Test 1 - Stopped POV, Auditory Warning

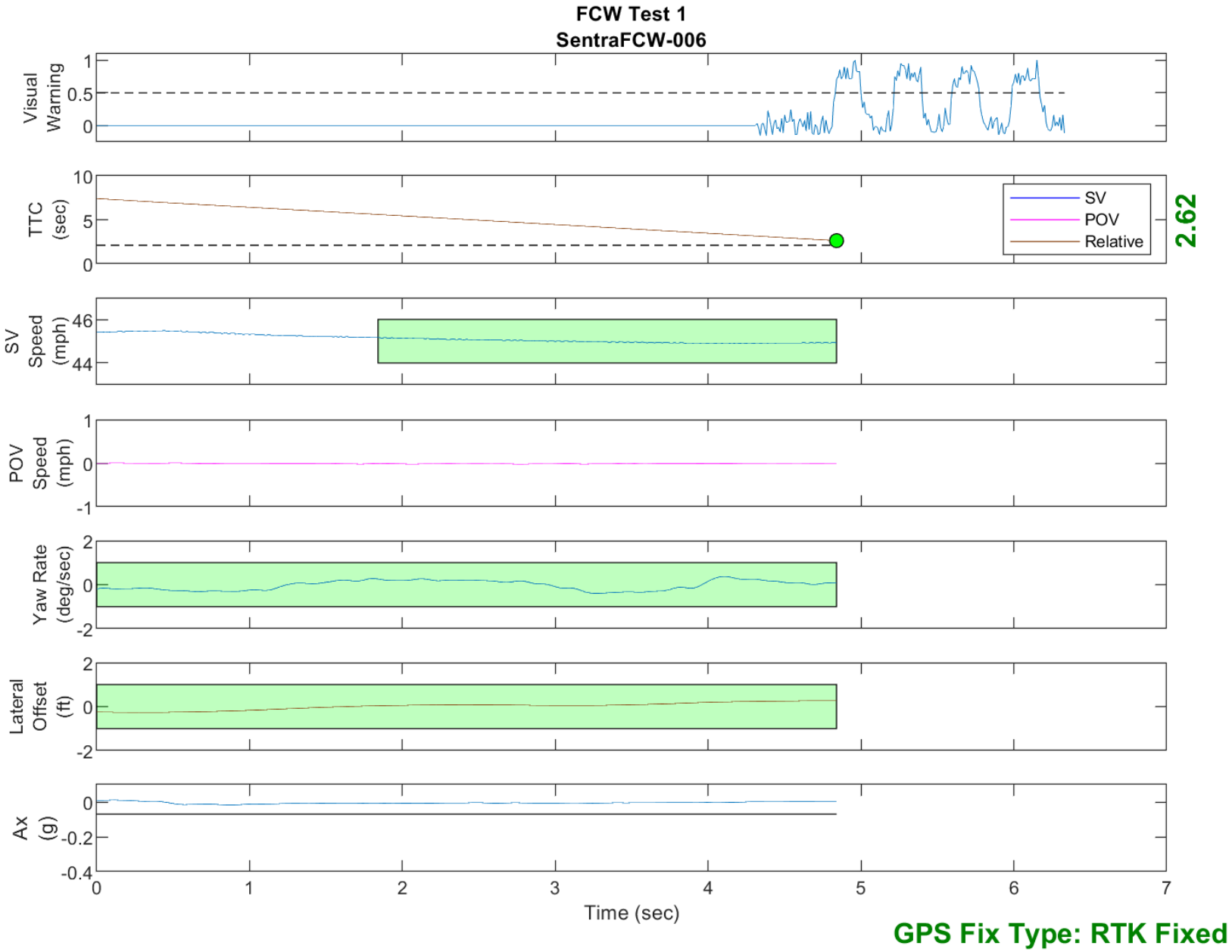


Figure D18. Time History for Run 6, Test 1 - Stopped POV, Visual Warning

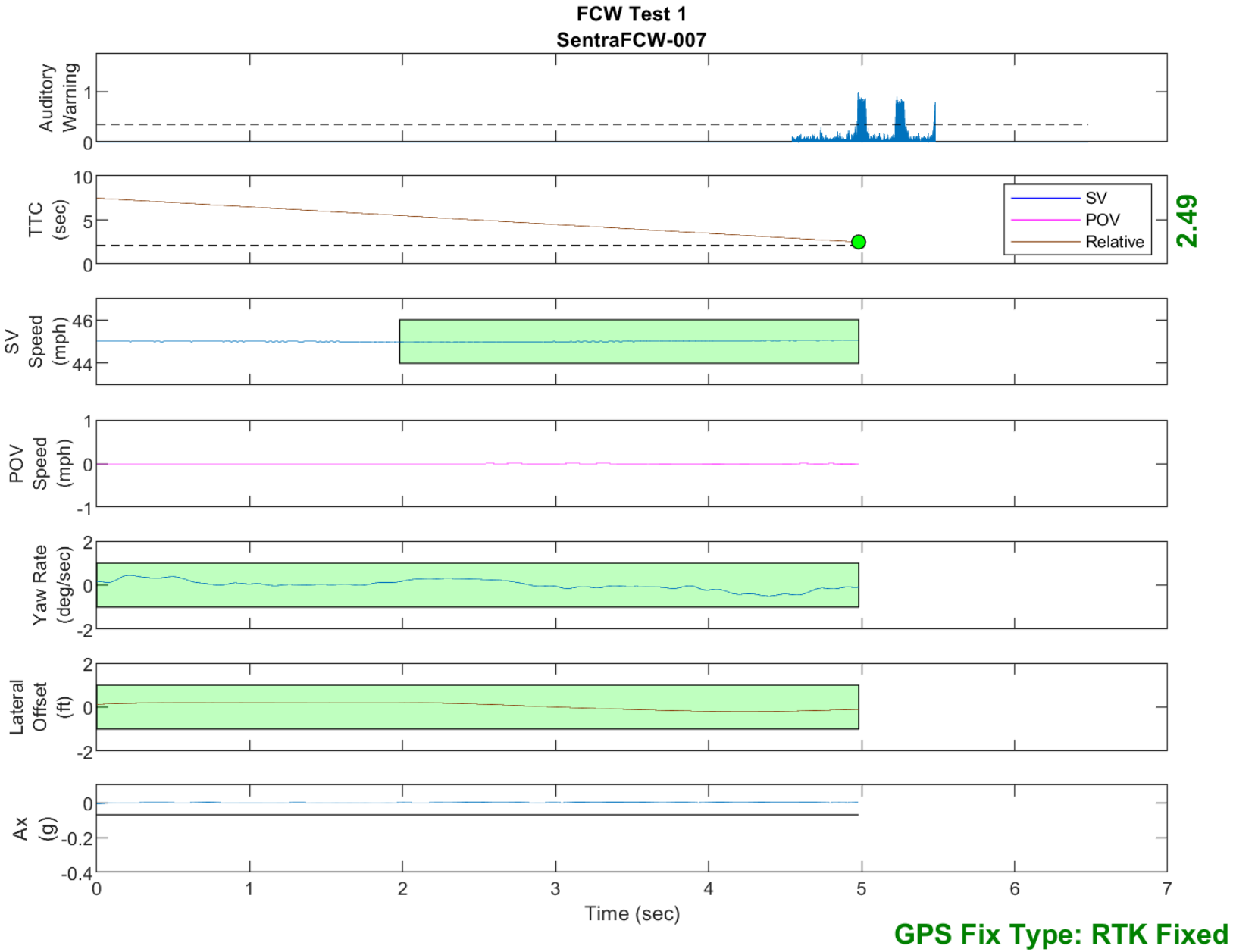


Figure D19. Time History for Run 7, Test 1 - Stopped POV, Auditory Warning

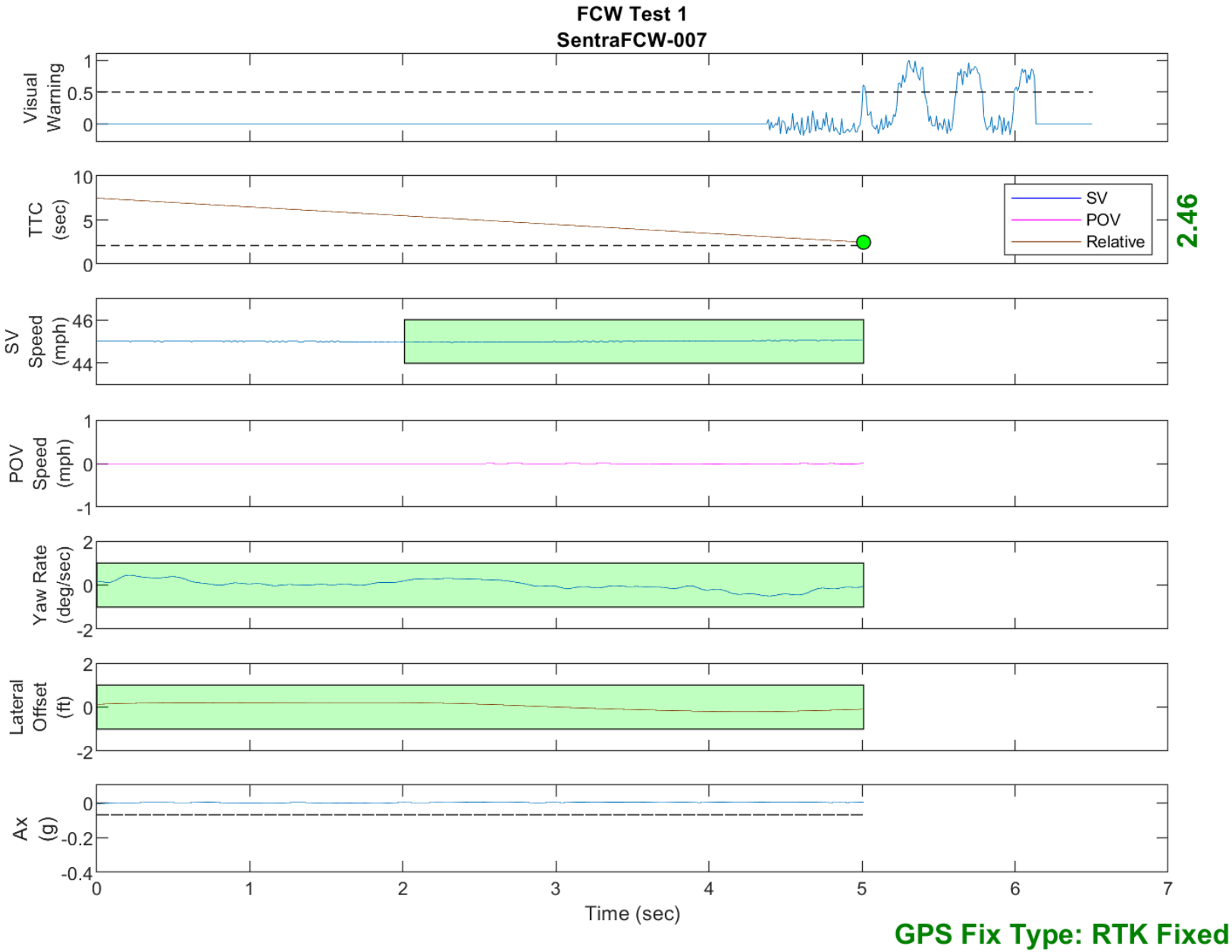


Figure D20. Time History for Run 7, Test 1 - Stopped POV, Visual Warning

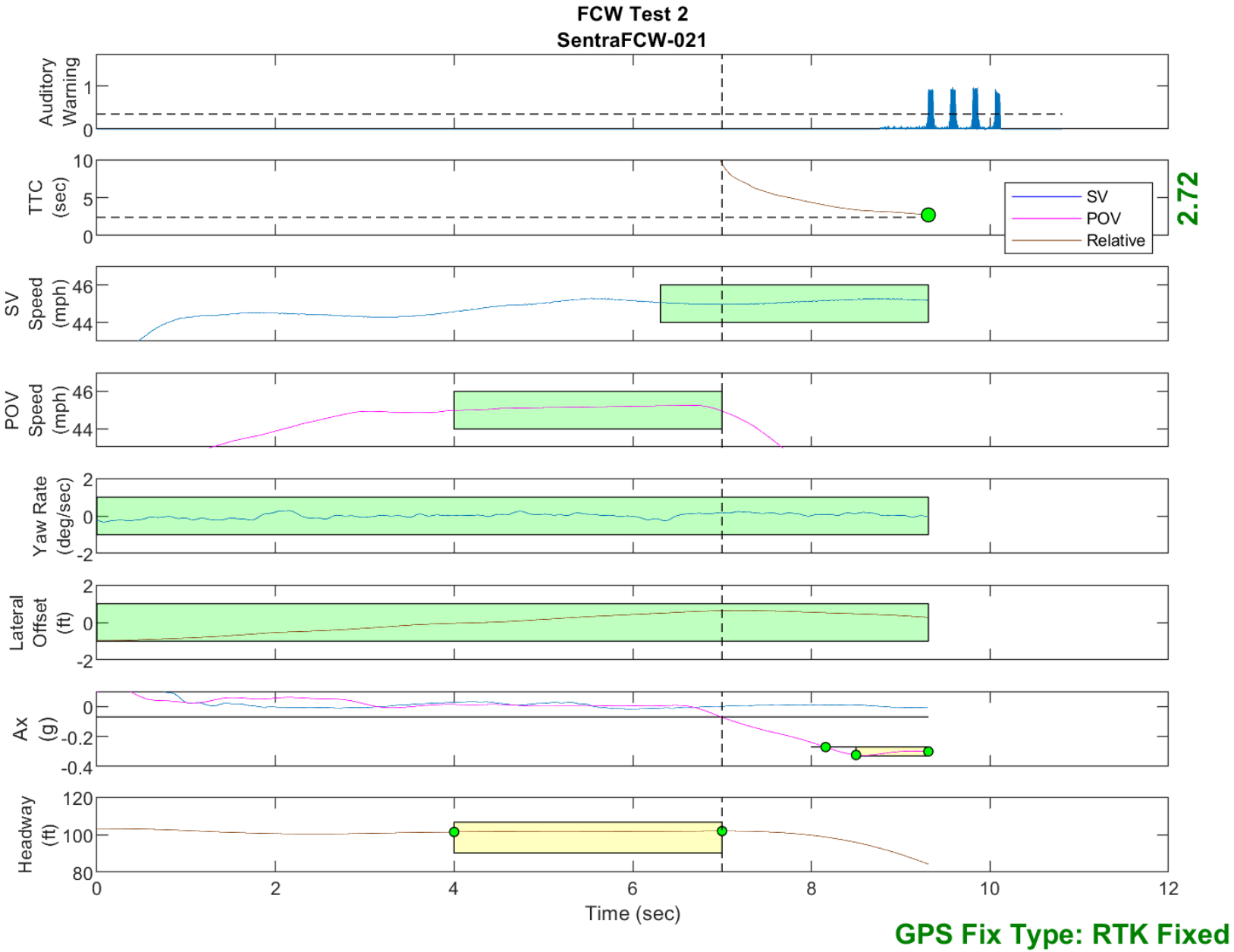


Figure D21. Time History for Run 21, Test 2 - Decelerating POV, Auditory Warning

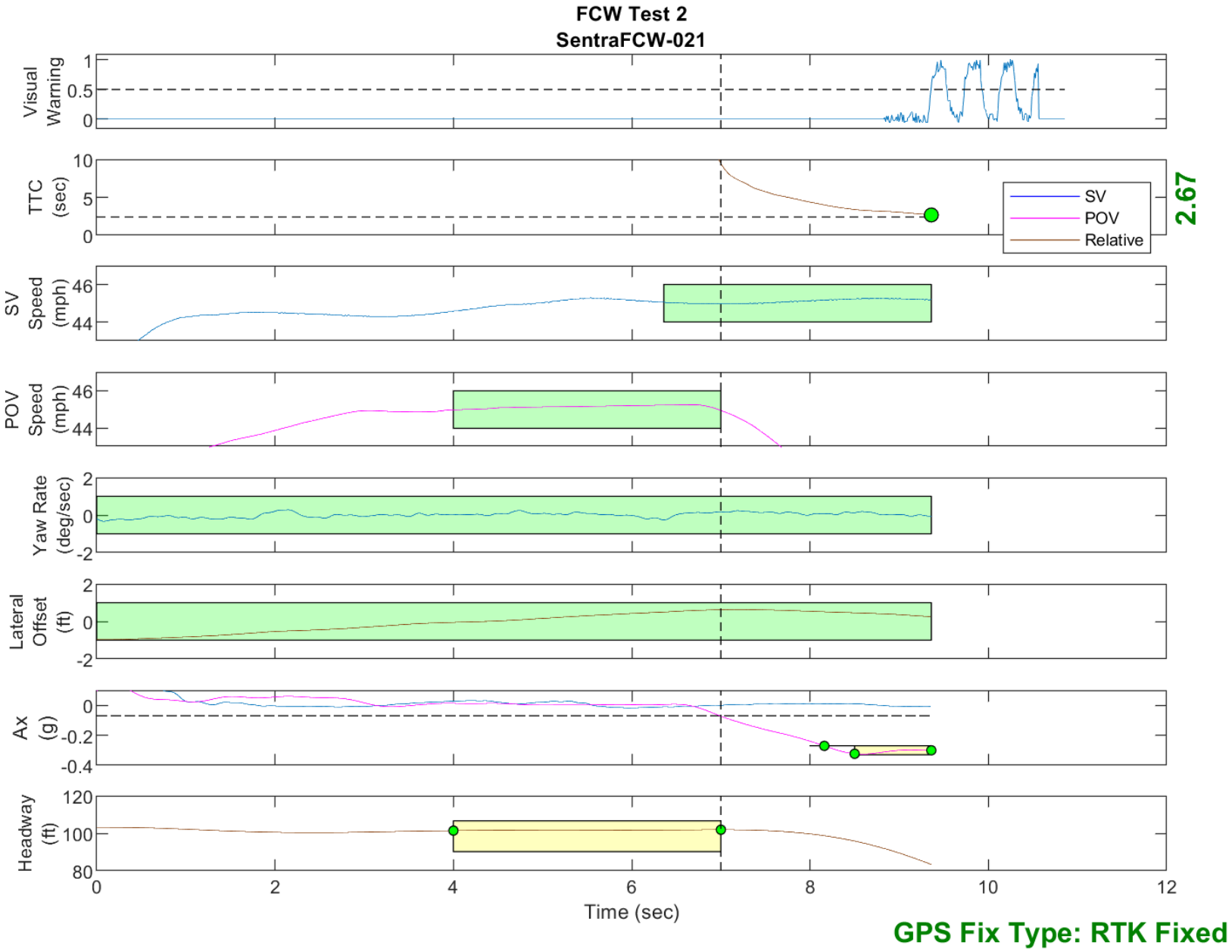


Figure D22. Time History for Run 21, Test 2 - Decelerating POV, Visual Warning

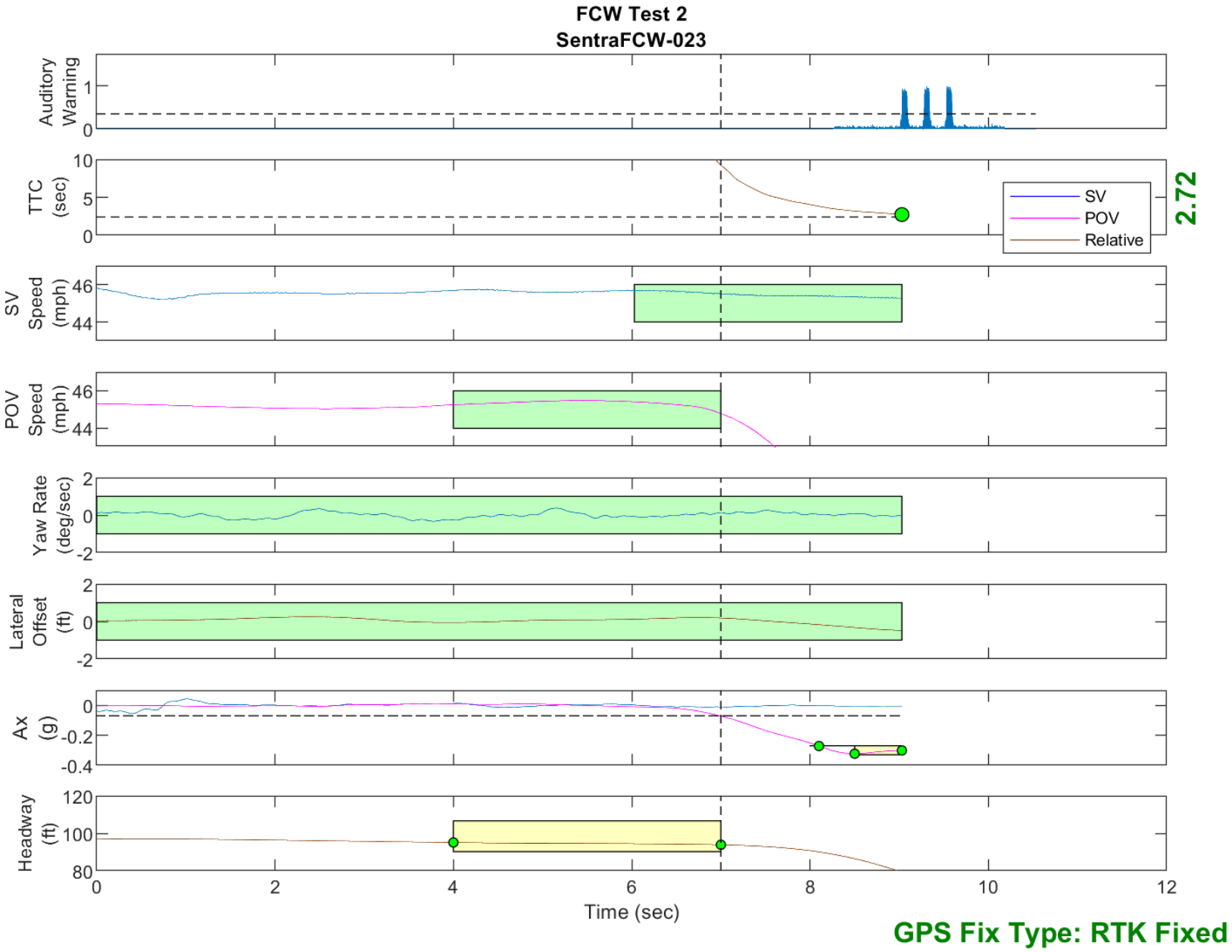


Figure D23. Time History for Run 23, Test 2 - Decelerating POV, Auditory Warning

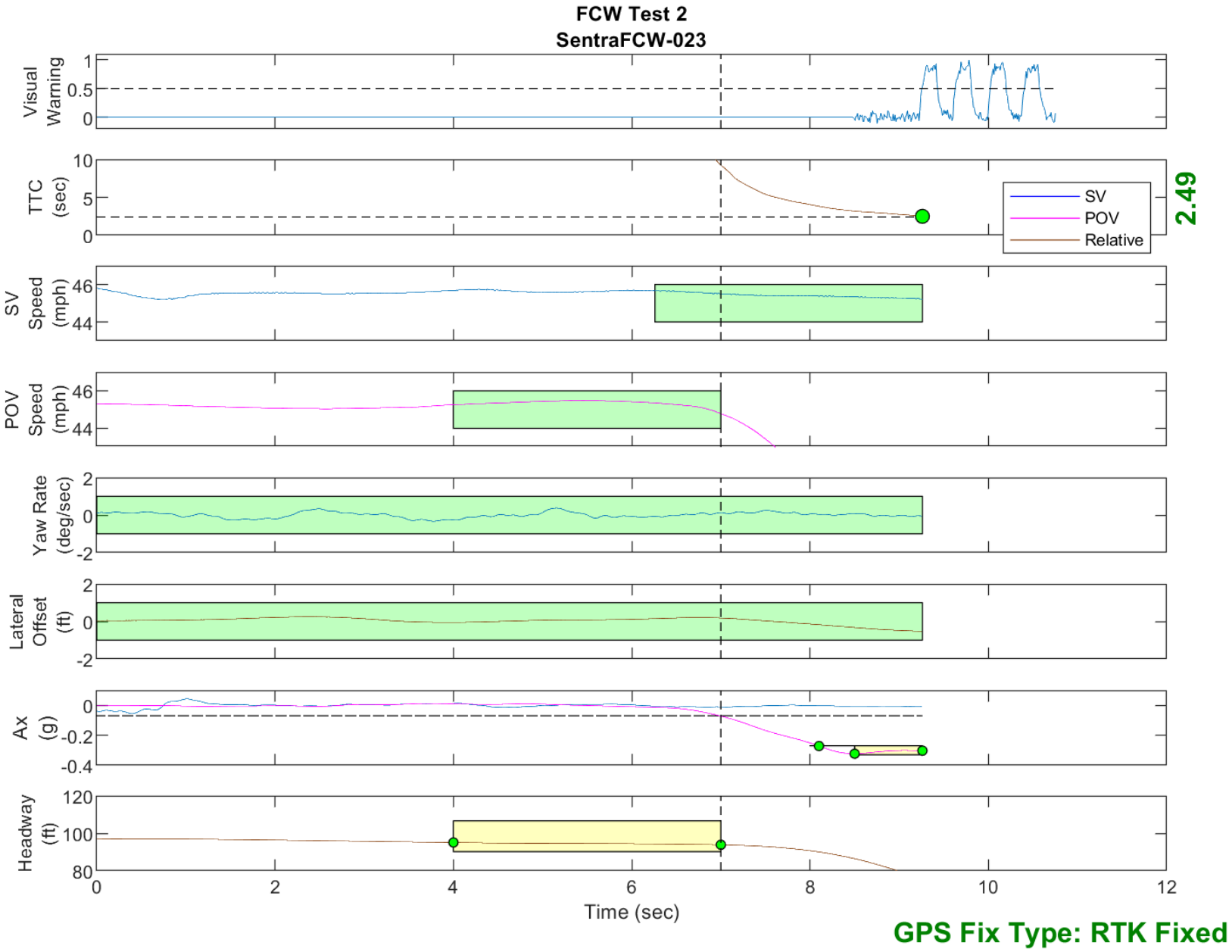


Figure D24. Time History for Run 23, Test 2 - Decelerating POV, Visual Warning

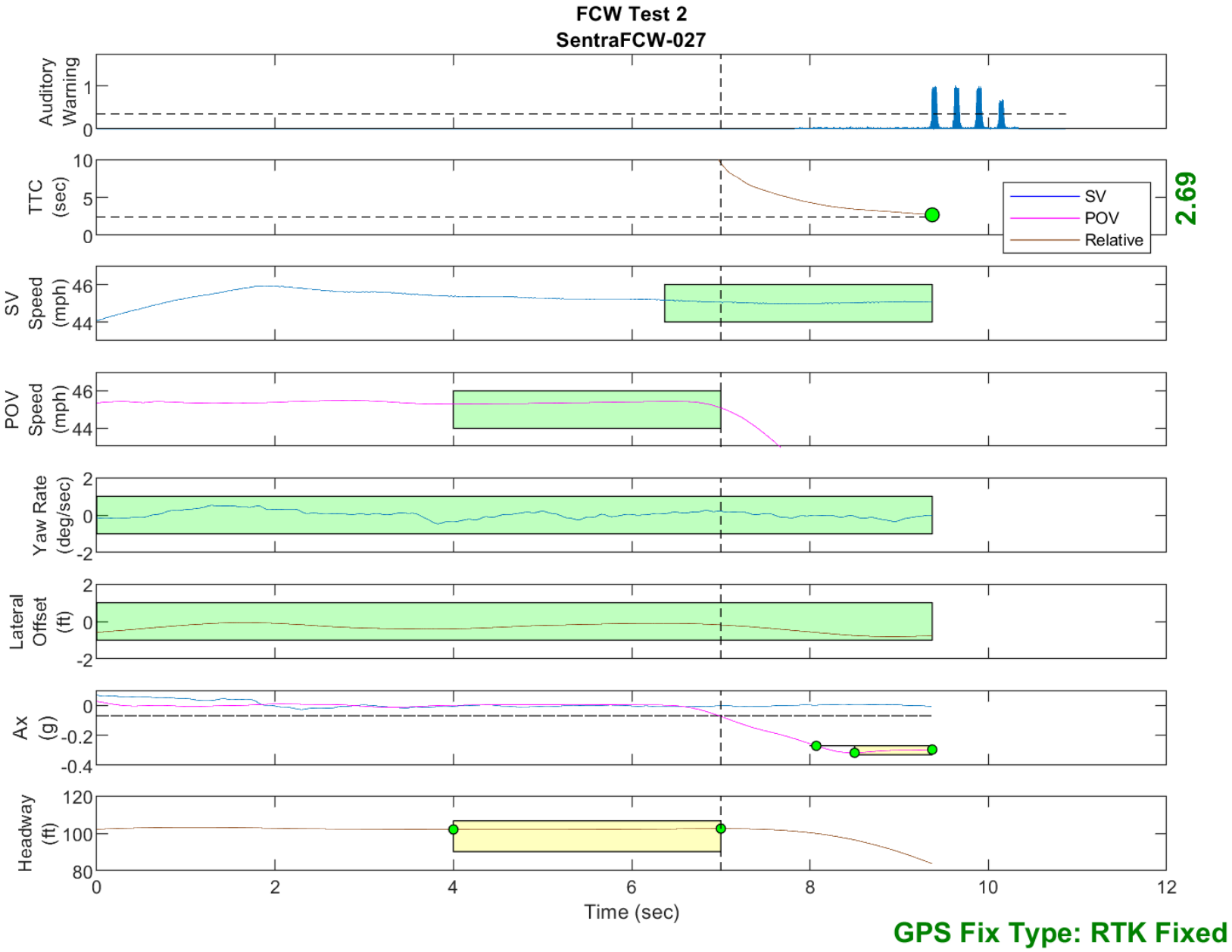


Figure D25. Time History for Run 27, Test 2 - Decelerating POV, Auditory Warning

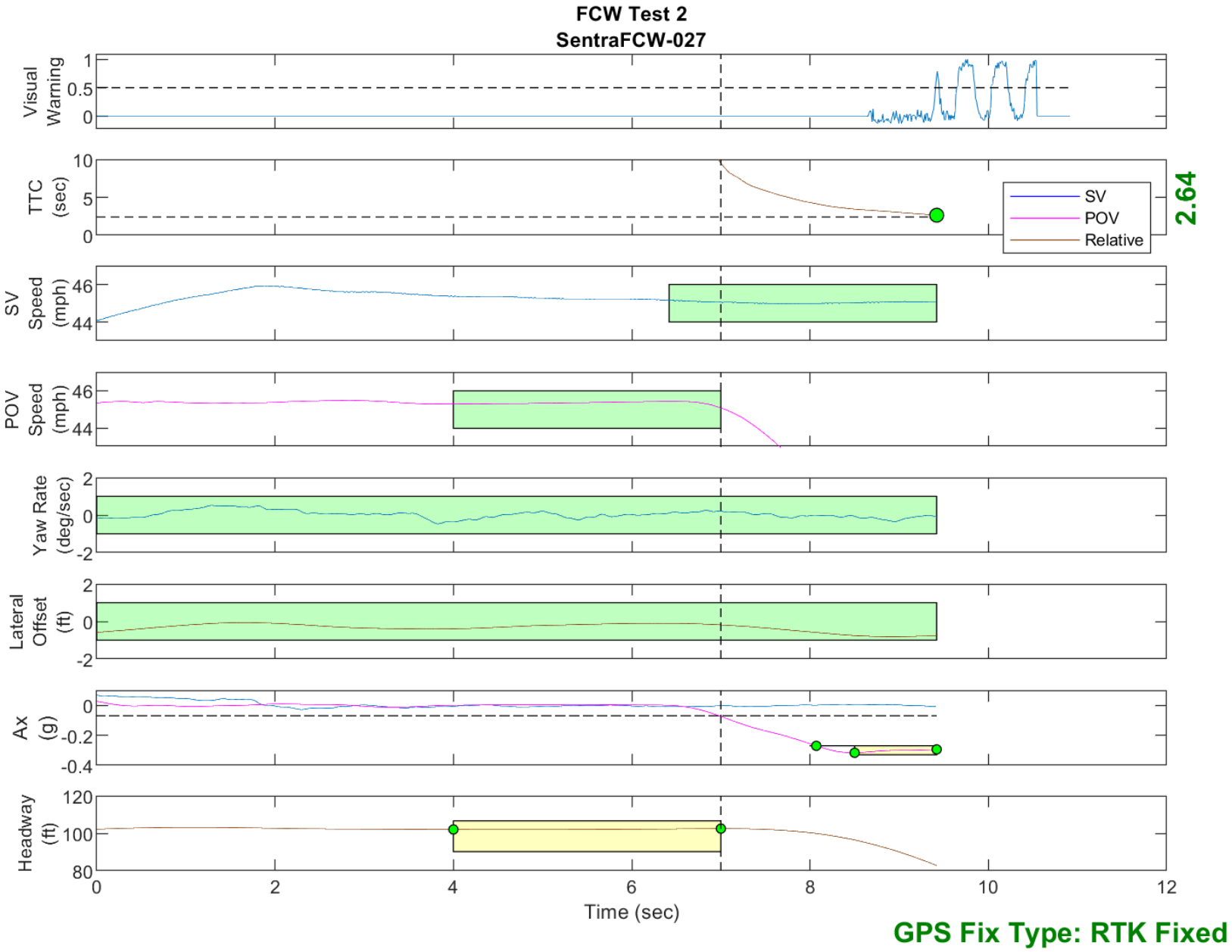


Figure D26. Time History for Run 27, Test 2 - Decelerating POV, Visual Warning

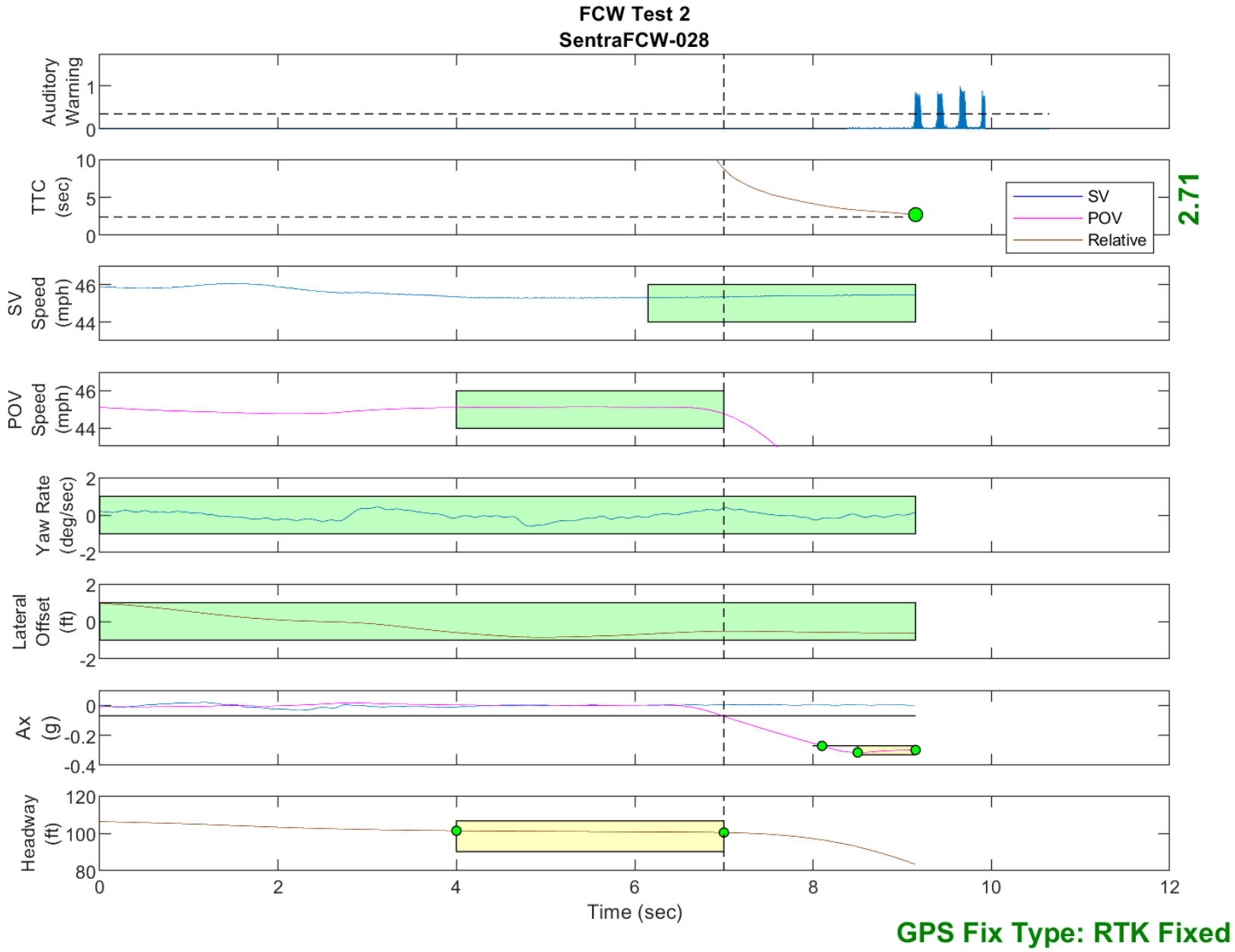


Figure D27. Time History for Run 28, Test 2 - Decelerating POV, Auditory Warning

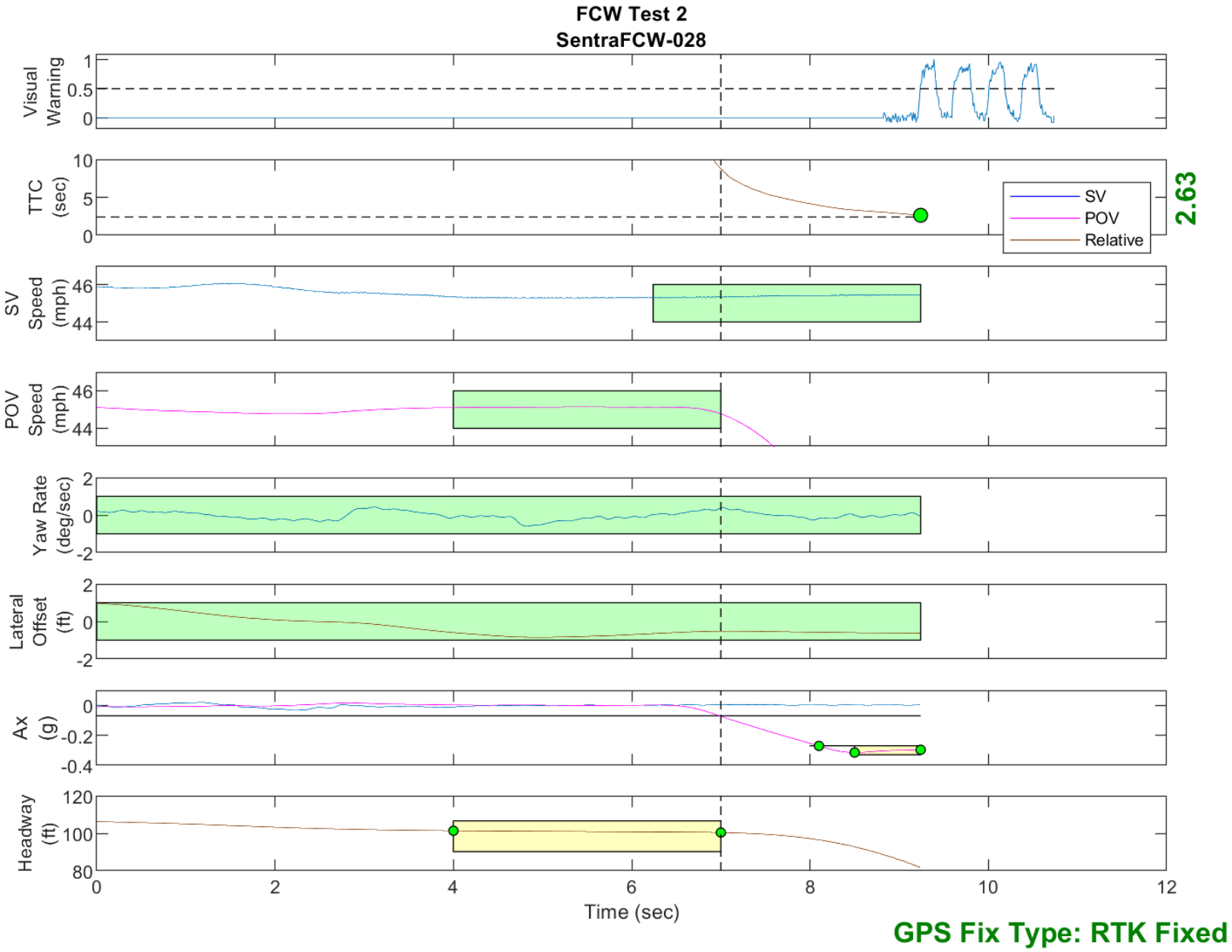


Figure D28. Time History for Run 28, Test 2 - Decelerating POV, Visual Warning

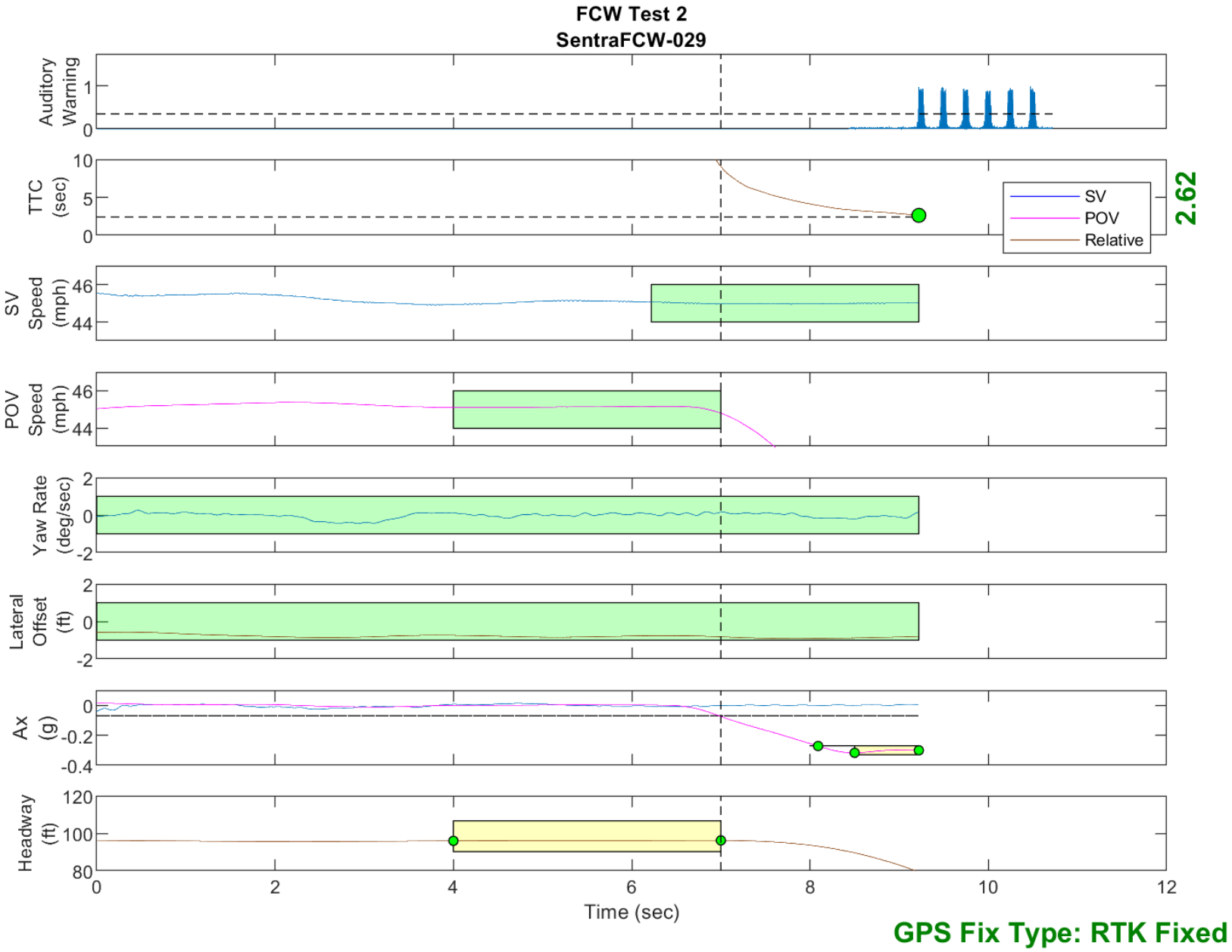


Figure D29. Time History for Run 29, Test 2 - Decelerating POV, Auditory Warning

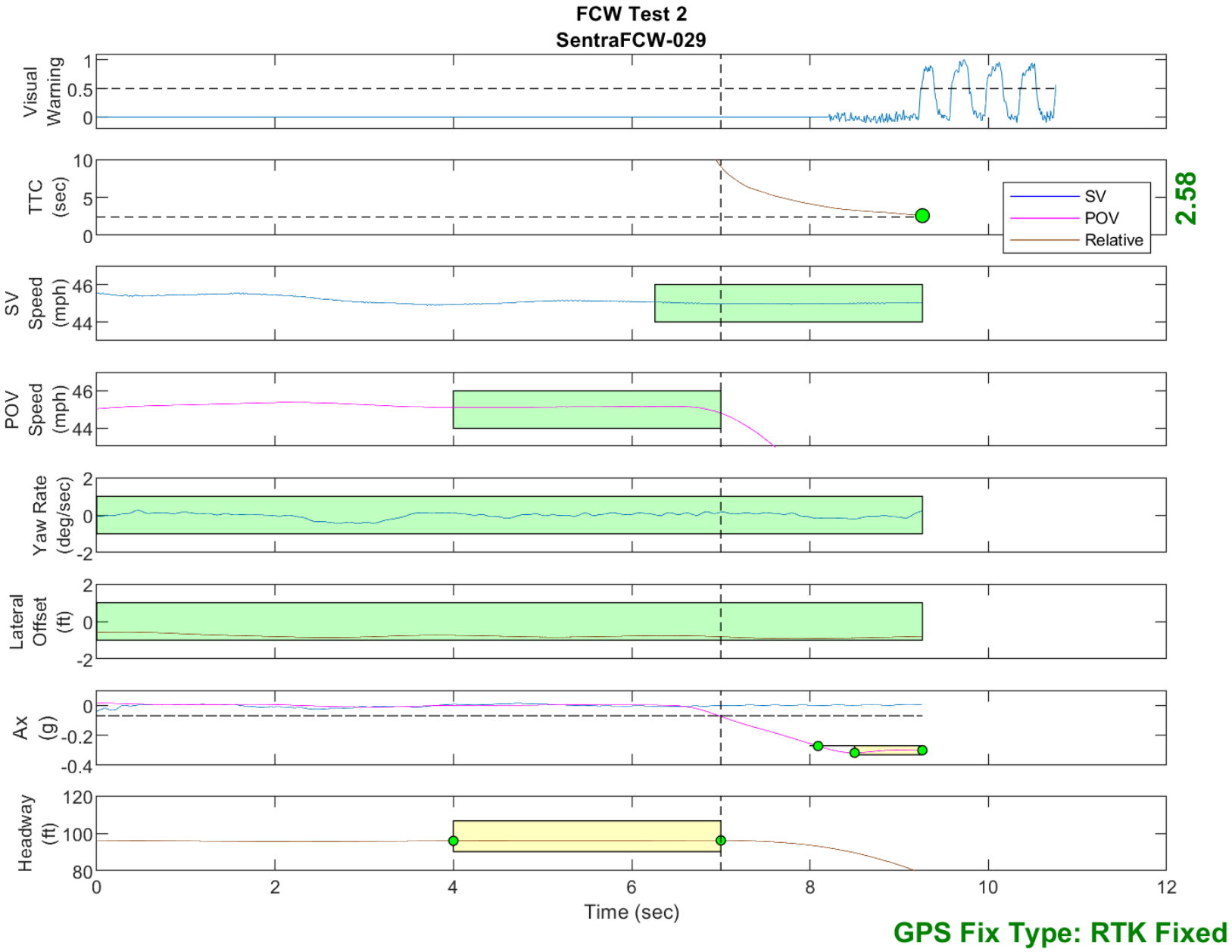


Figure D30. Time History for Run 29, Test 2 - Decelerating POV, Visual Warning

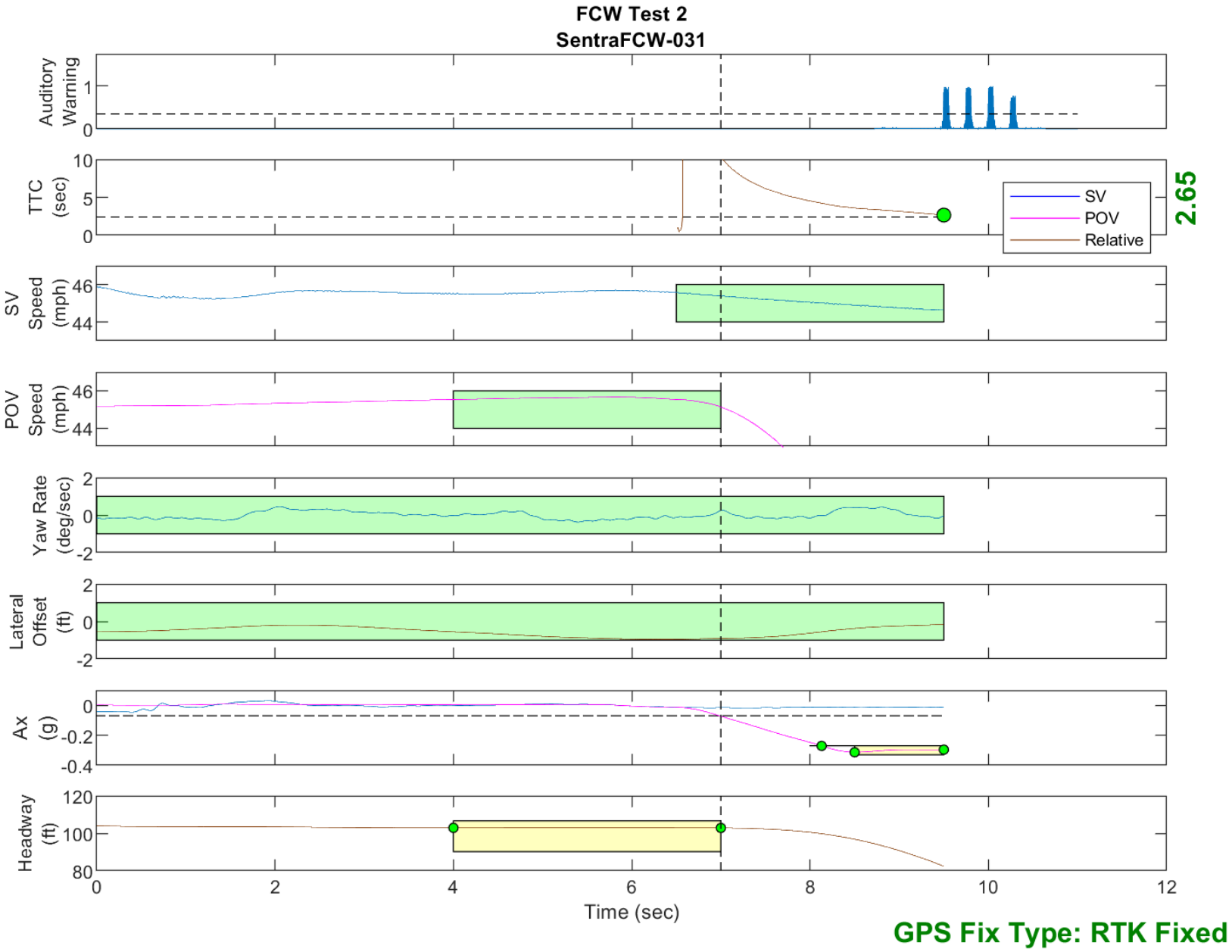


Figure D31. Time History for Run 31, Test 2 - Decelerating POV, Auditory Warning

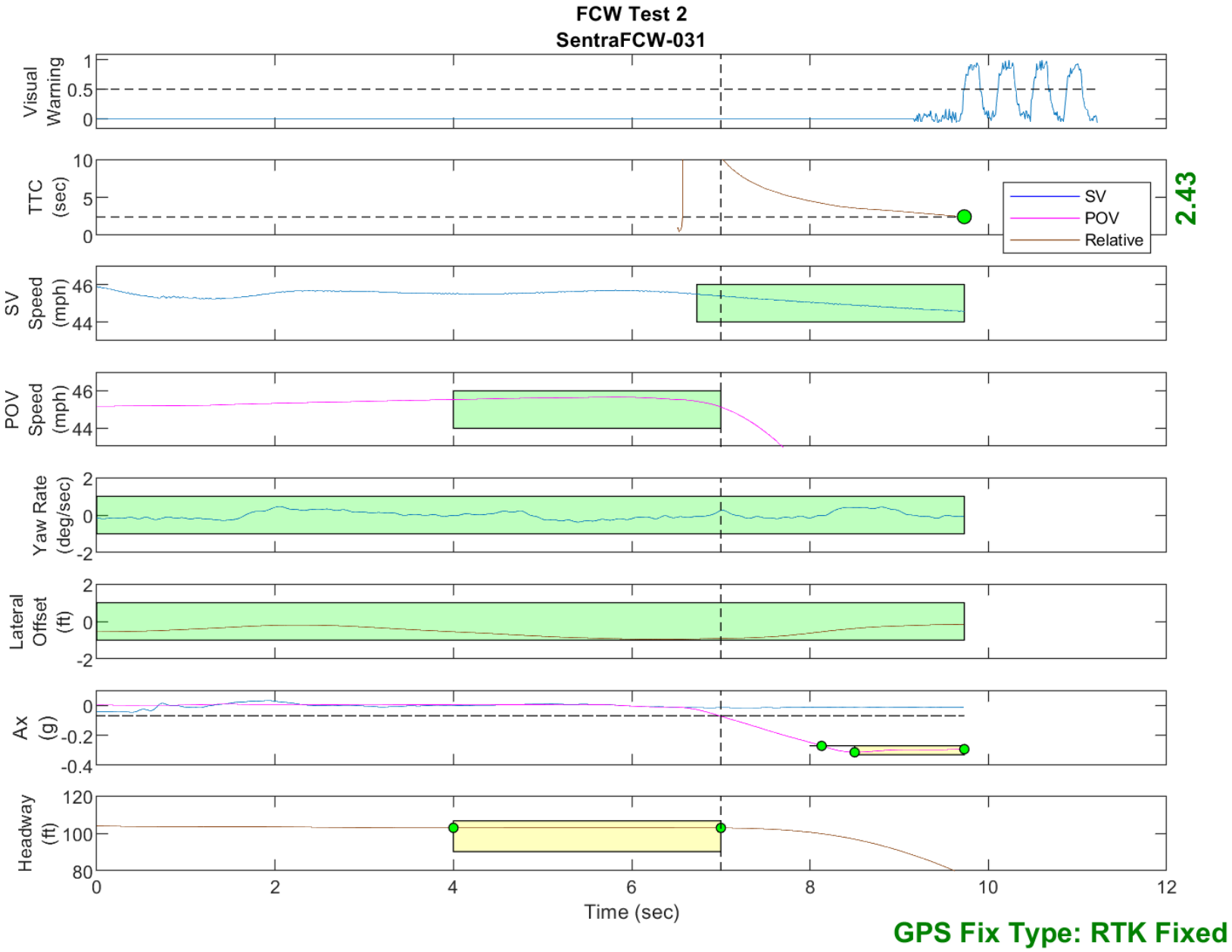


Figure D32. Time History for Run 31, Test 2 - Decelerating POV, Visual Warning

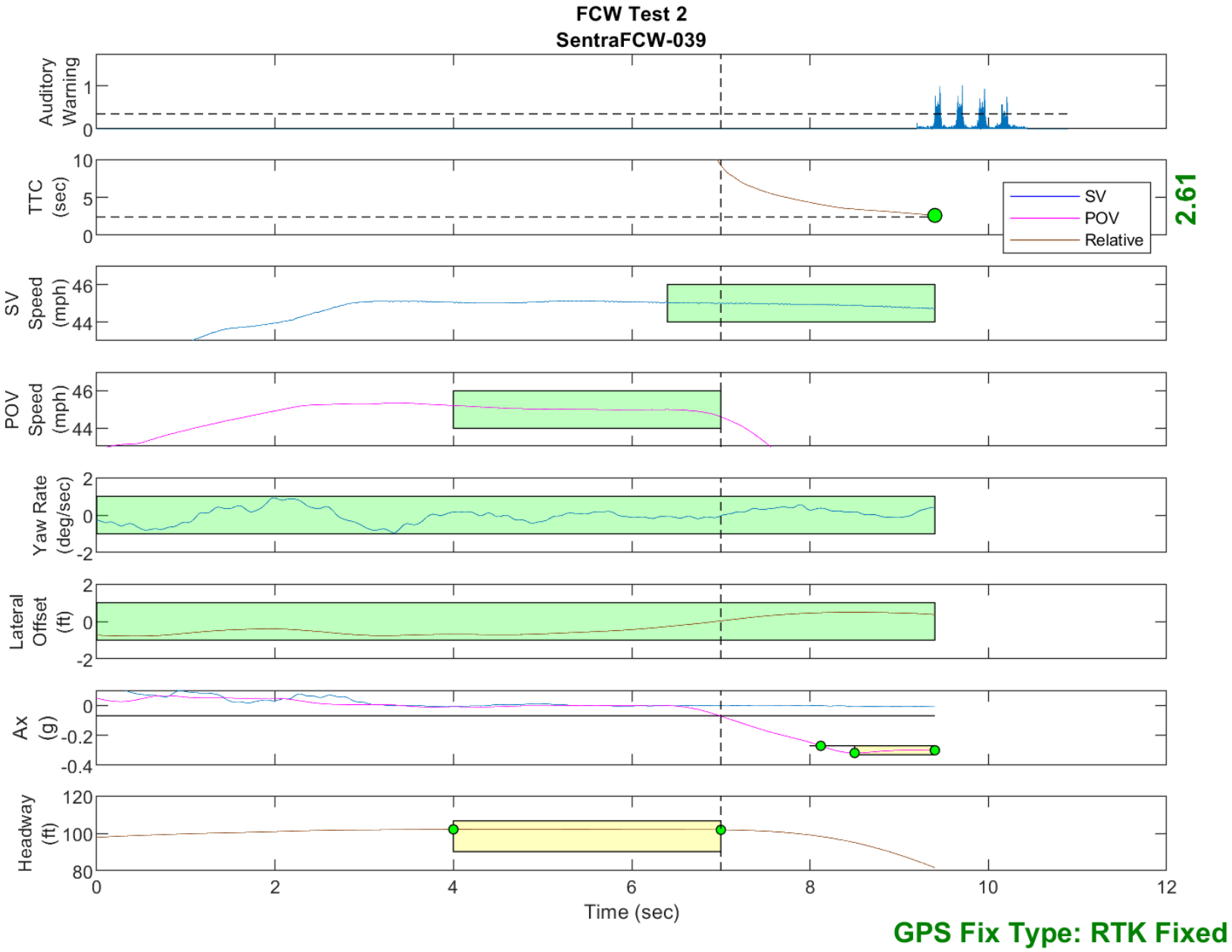


Figure D33. Time History for Run 39, Test 2 - Decelerating POV, Auditory Warning

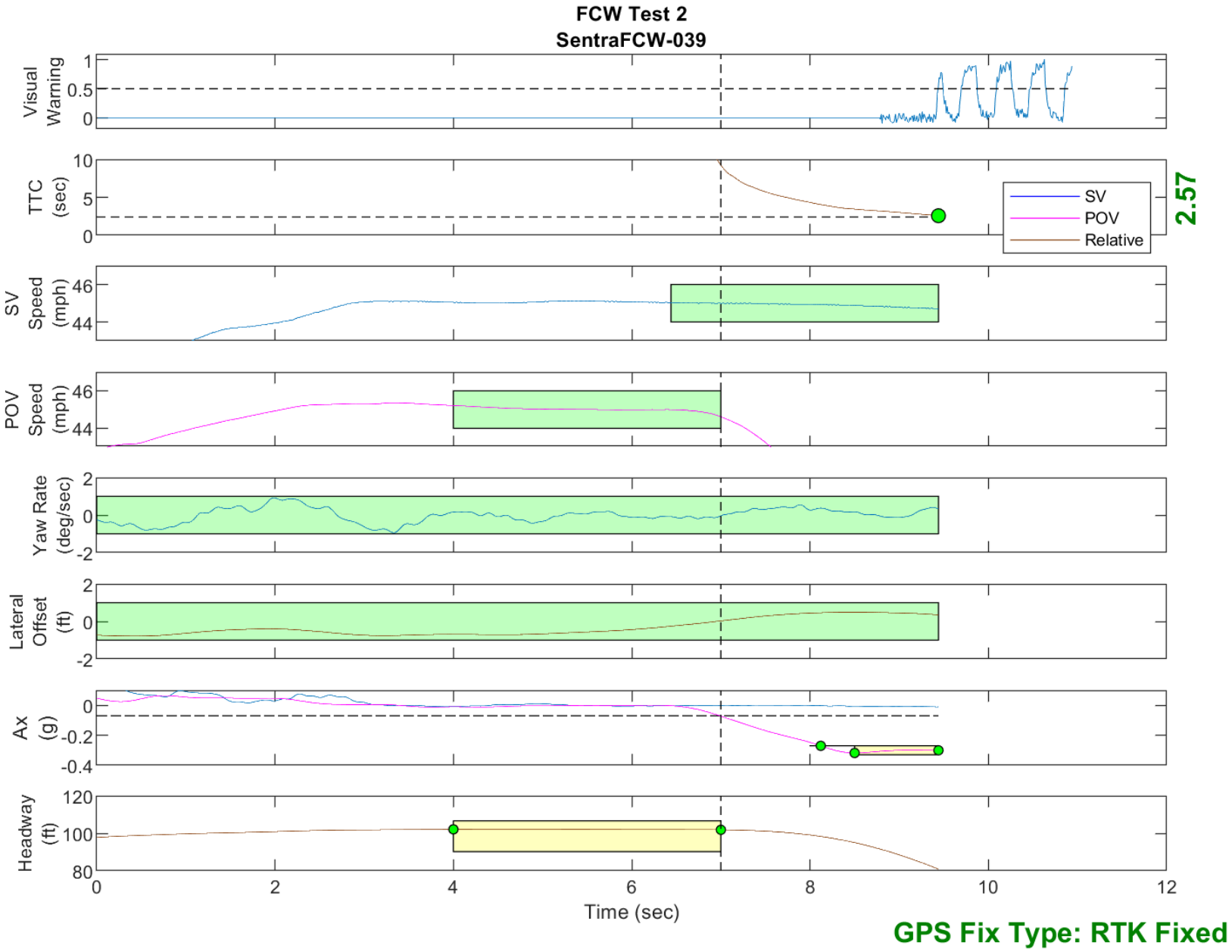


Figure D34. Time History for Run 39, Test 2 - Decelerating POV, Visual Warning

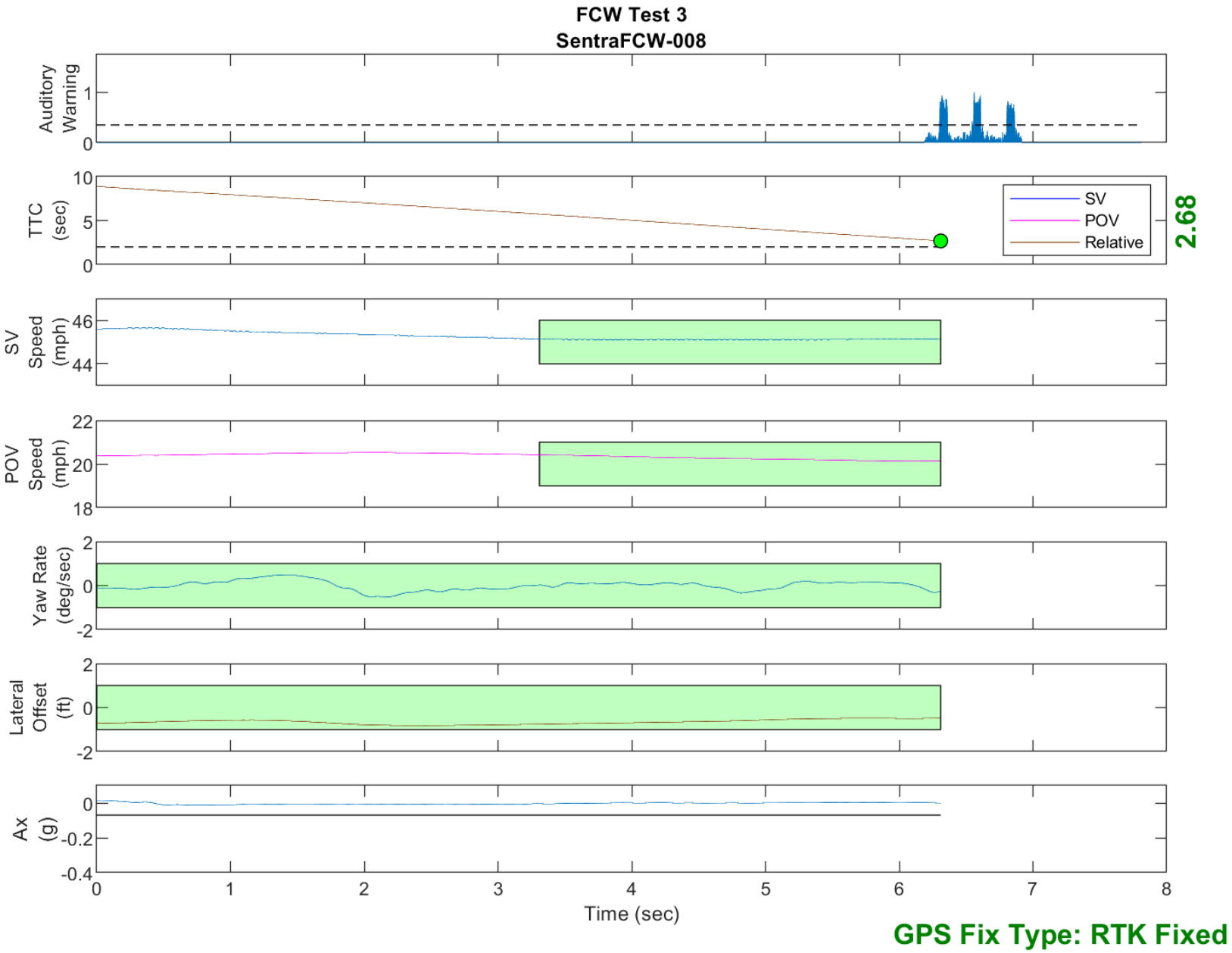


Figure D35. Time History for Run 8, Test 3 - Slower Moving POV, Auditory Warning

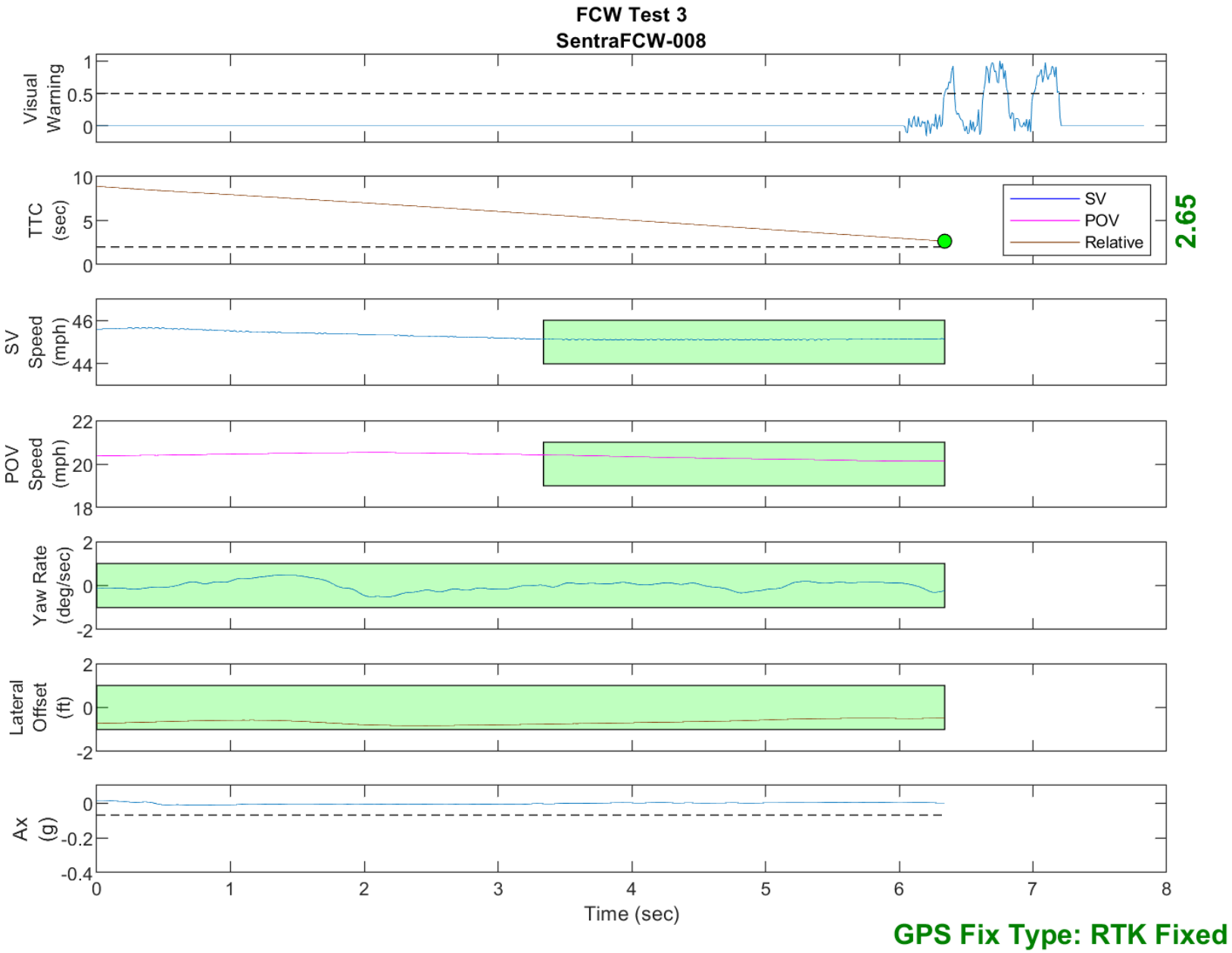


Figure D36. Time History for Run 8, Test 3 - Slower Moving POV, Visual Warning

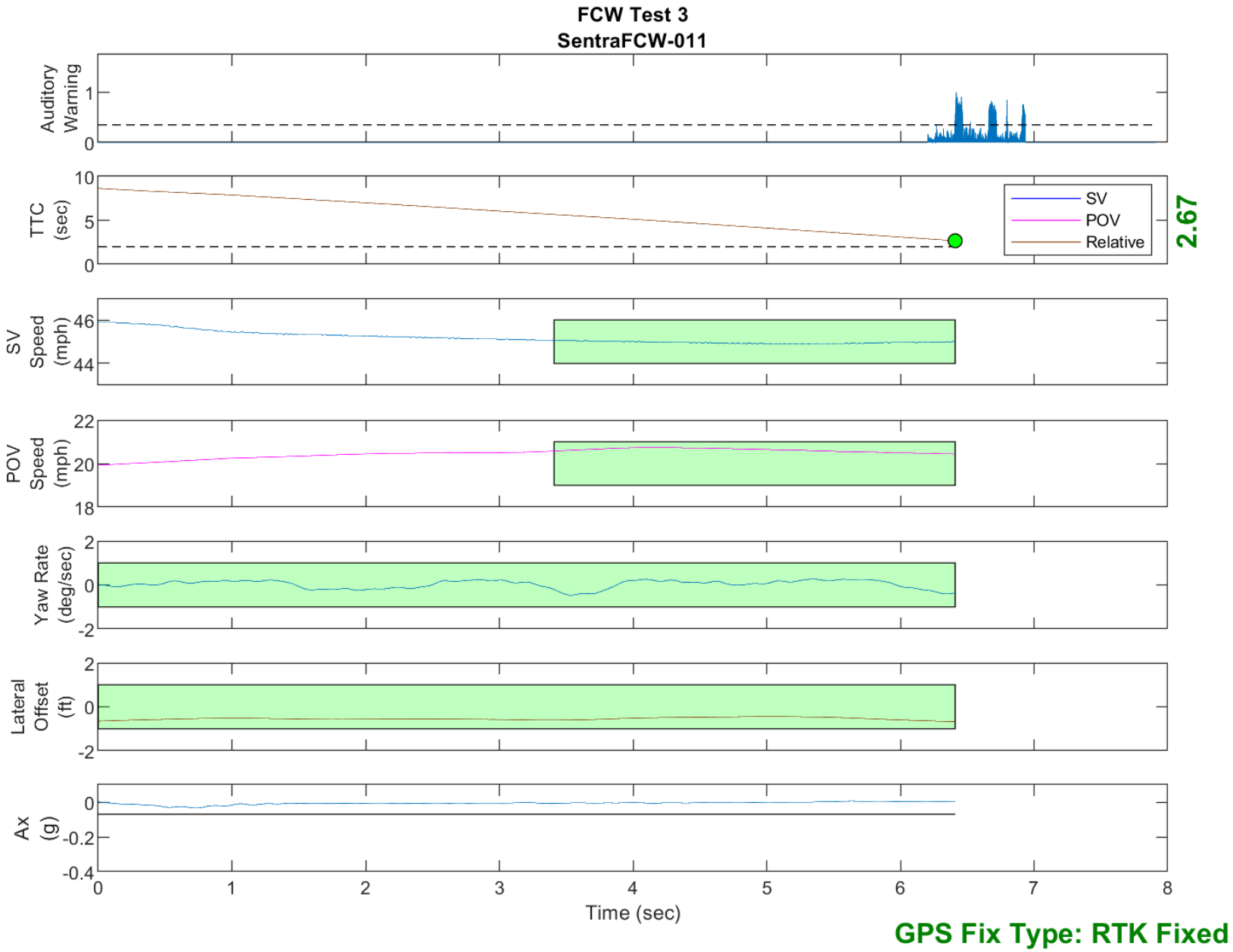


Figure D37. Time History for Run 11, Test 3 - Slower Moving POV, Auditory Warning

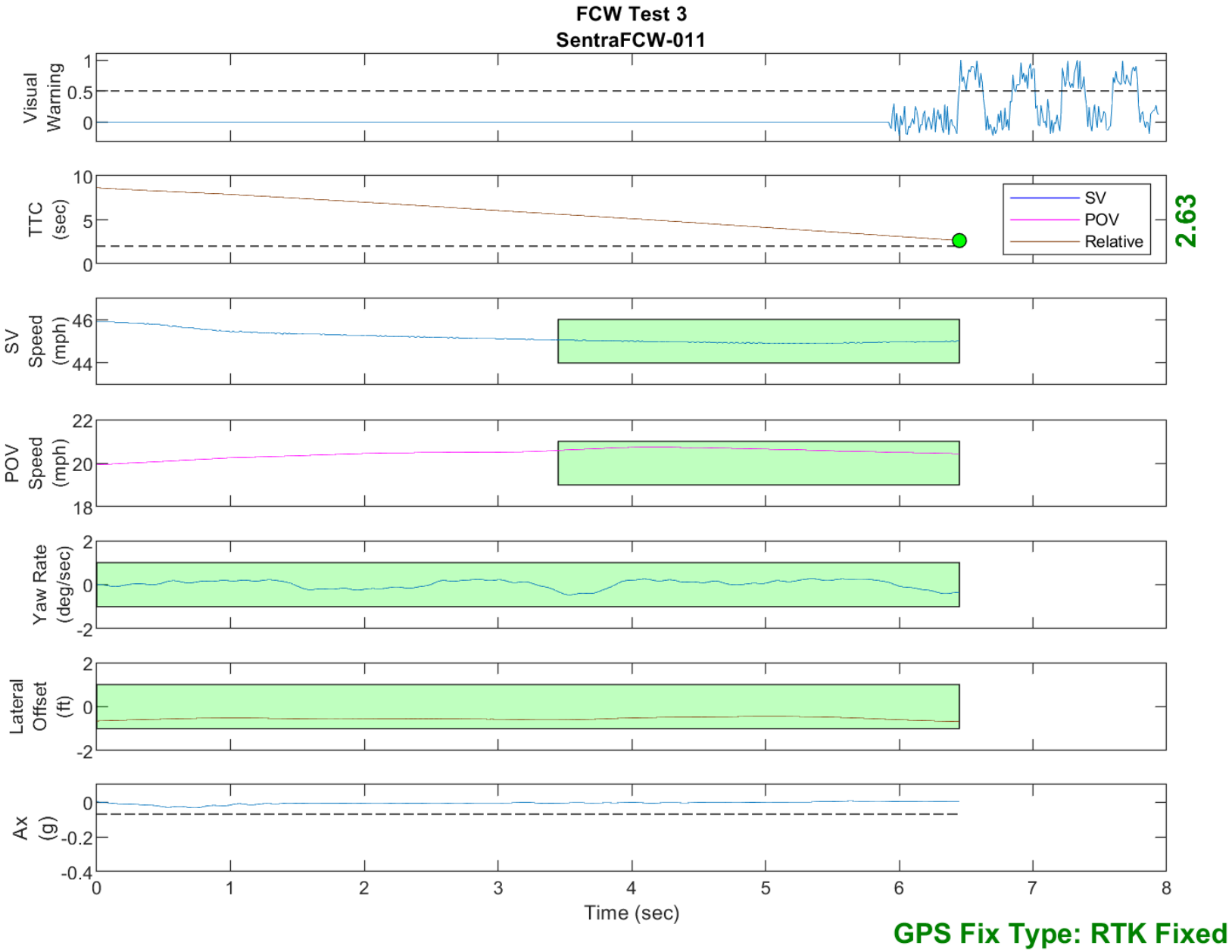


Figure D38. Time History for Run 11, Test 3 - Slower Moving POV, Visual Warning

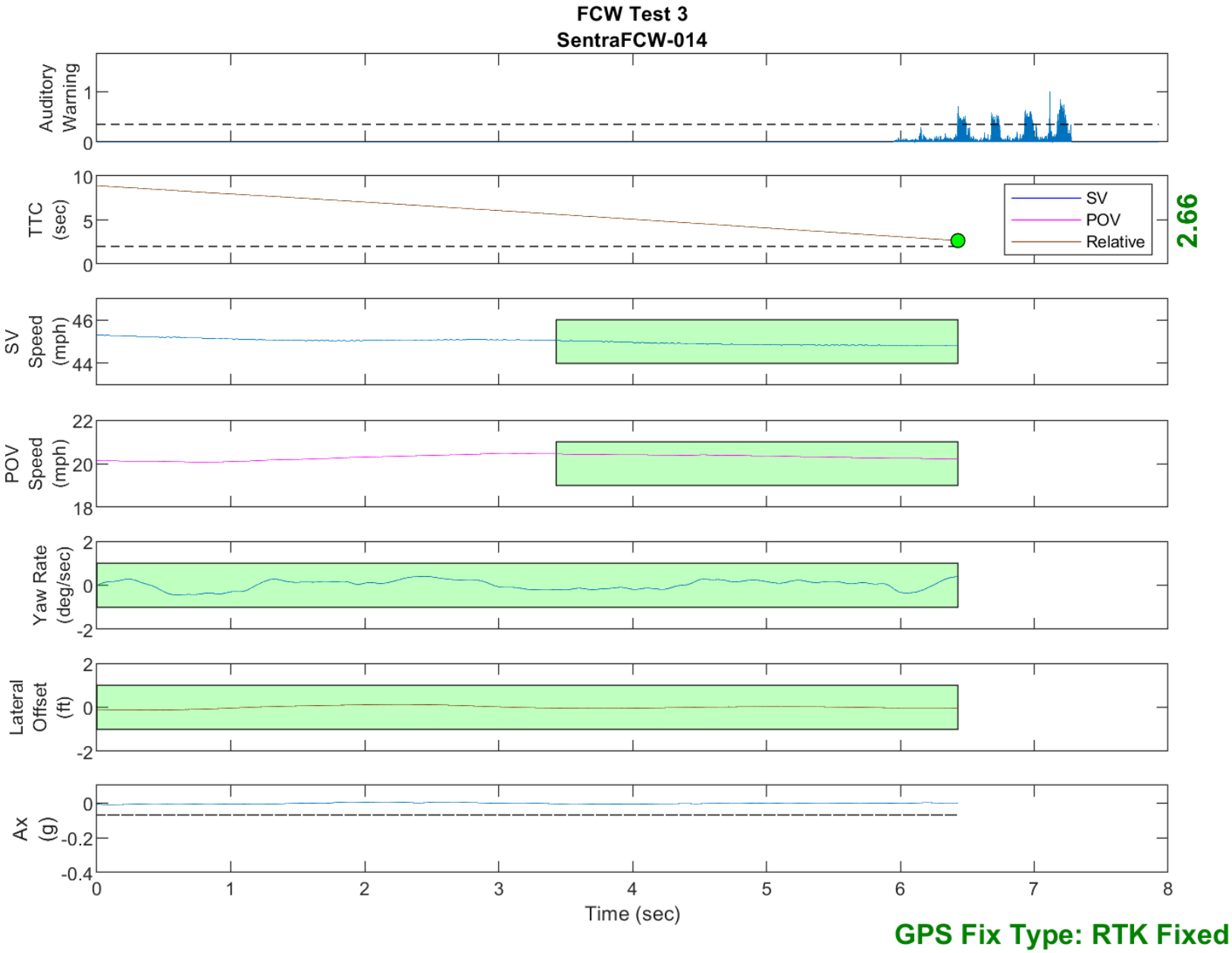


Figure D39. Time History for Run 14, Test 3 - Slower Moving POV, Auditory Warning

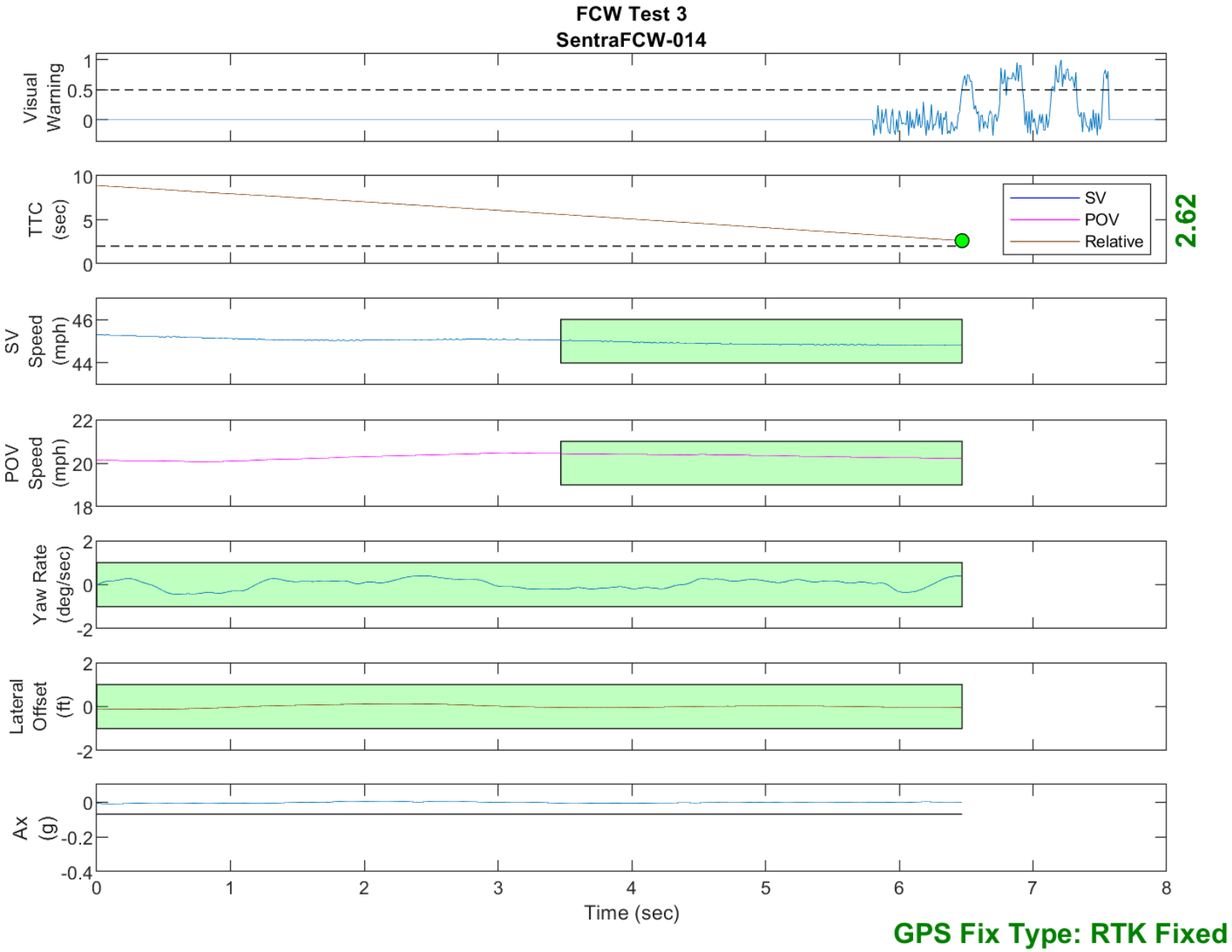


Figure D40. Time History for Run 14, Test 3 - Slower Moving POV, Visual Warning

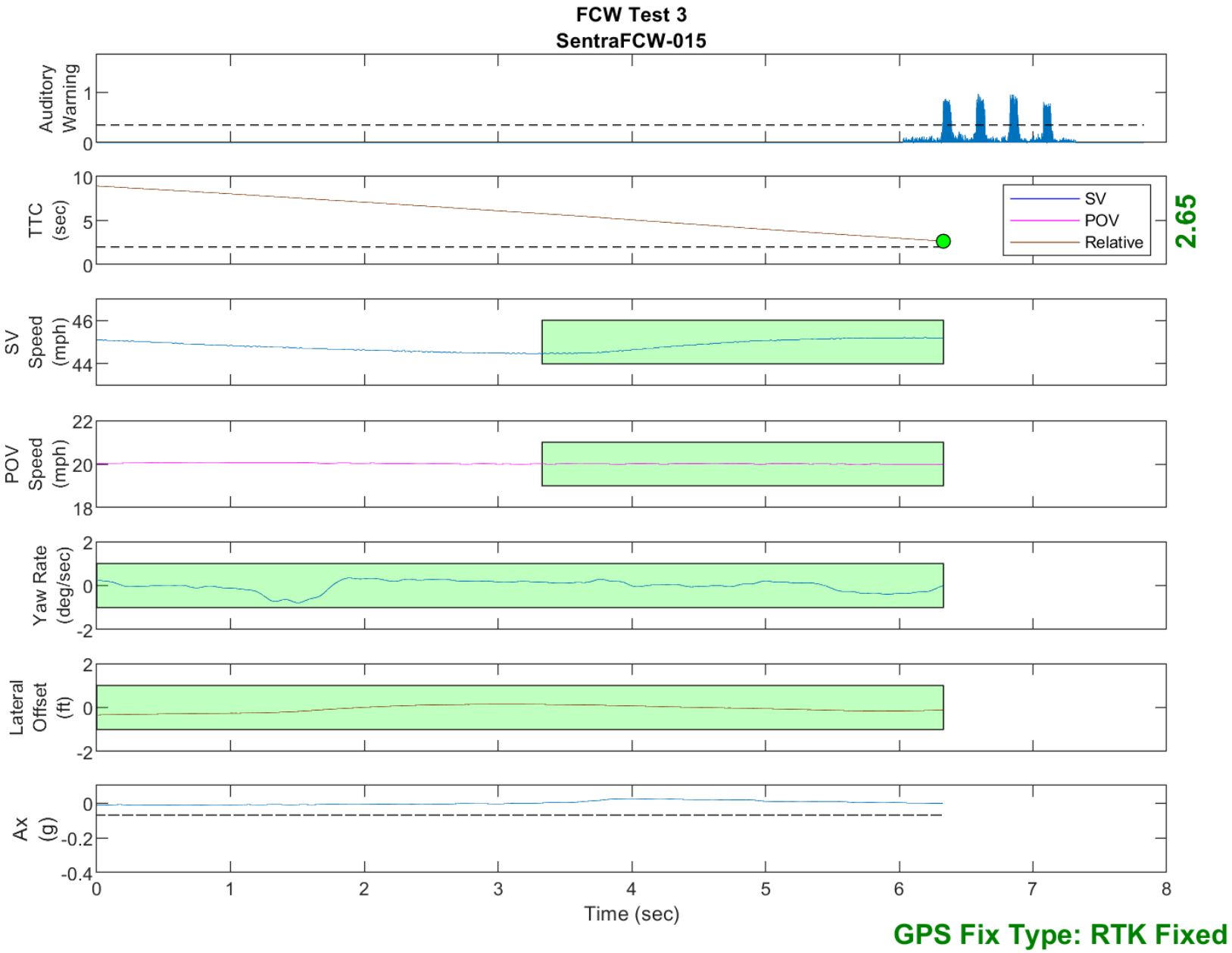


Figure D41. Time History for Run 15, Test 3 - Slower Moving POV, Auditory Warning

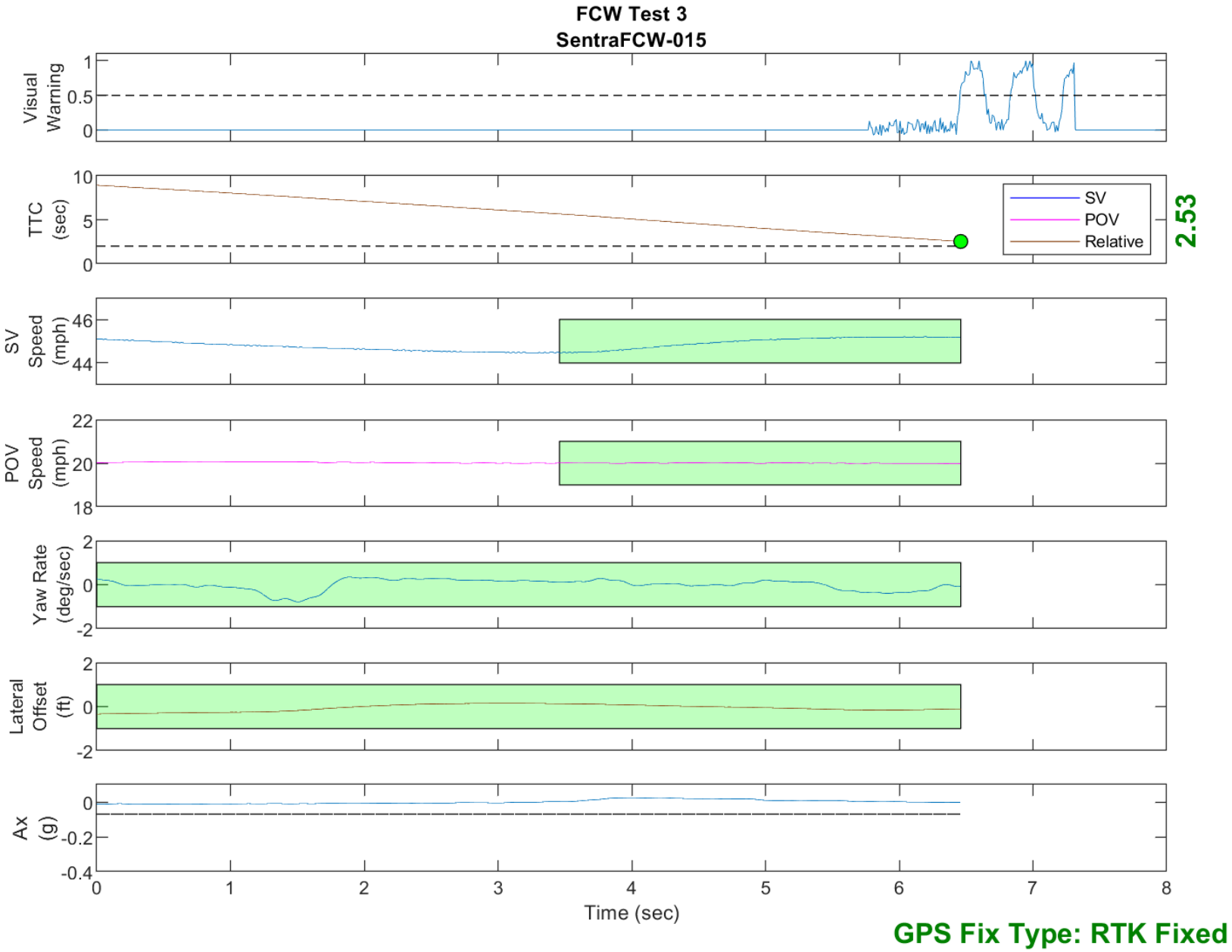


Figure D42. Time History for Run 15, Test 3 - Slower Moving POV, Visual Warning

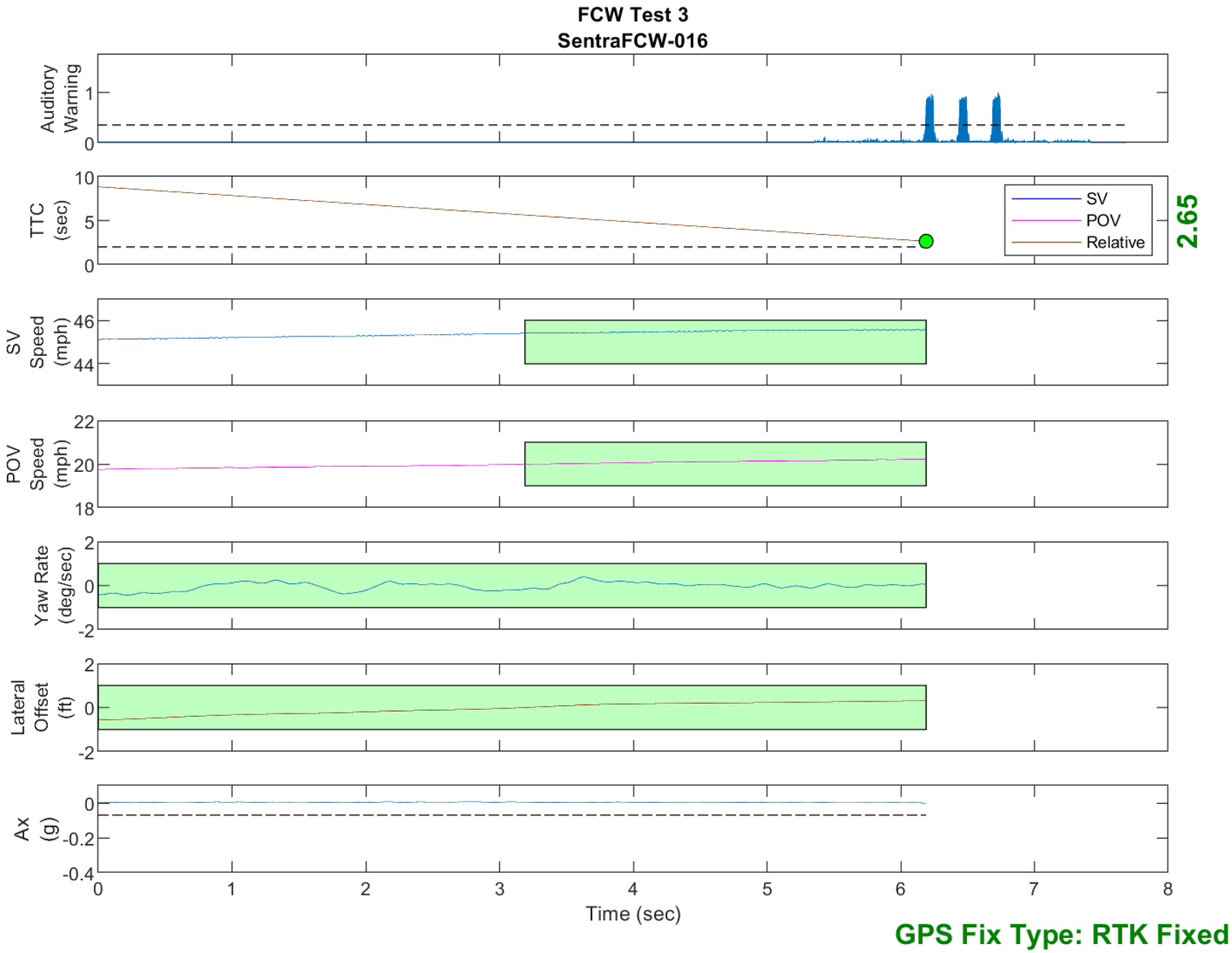


Figure D43. Time History for Run 16, Test 3 - Slower Moving POV, Auditory Warning

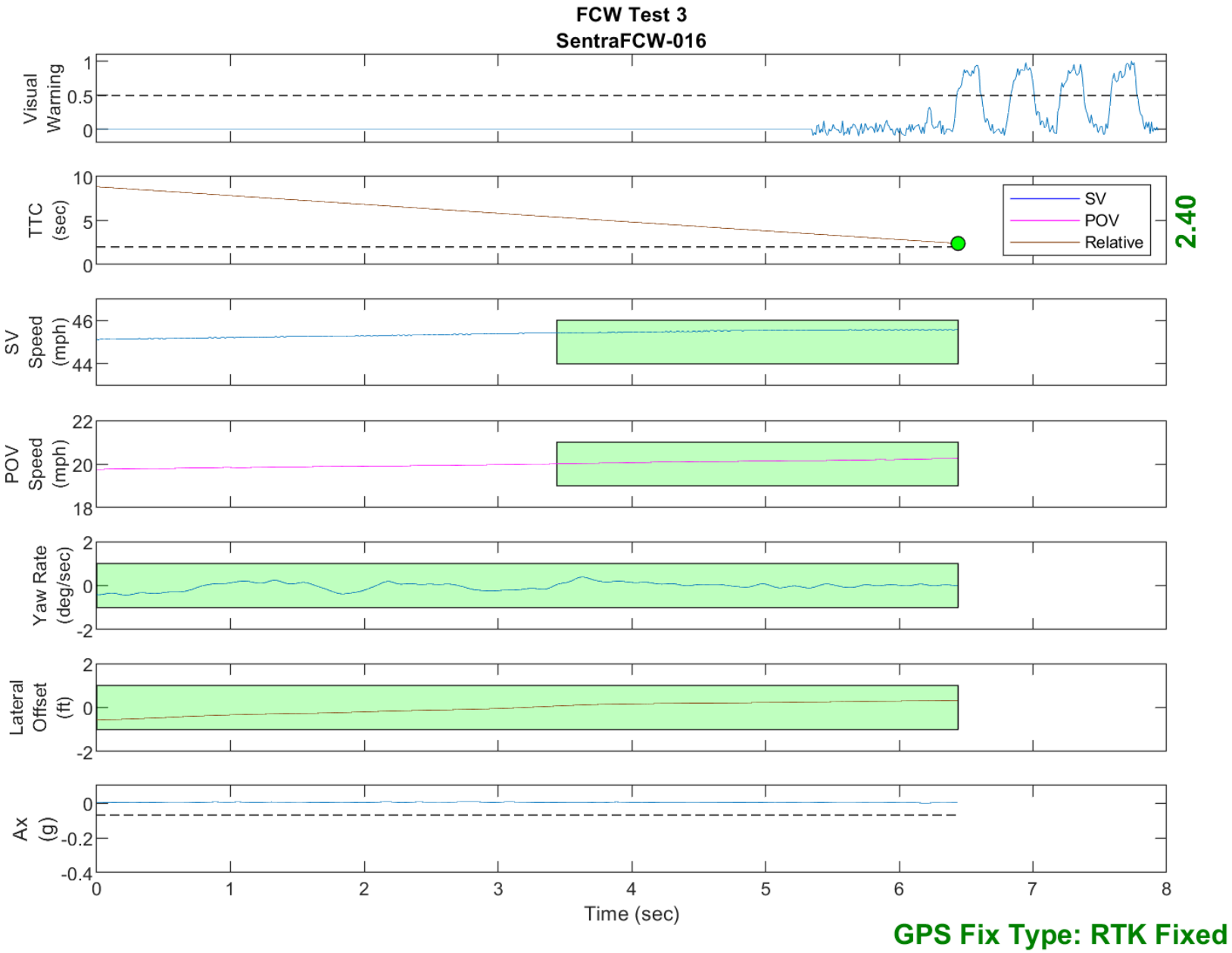


Figure D44. Time History for Run 16, Test 3 - Slower Moving POV, Visual Warning

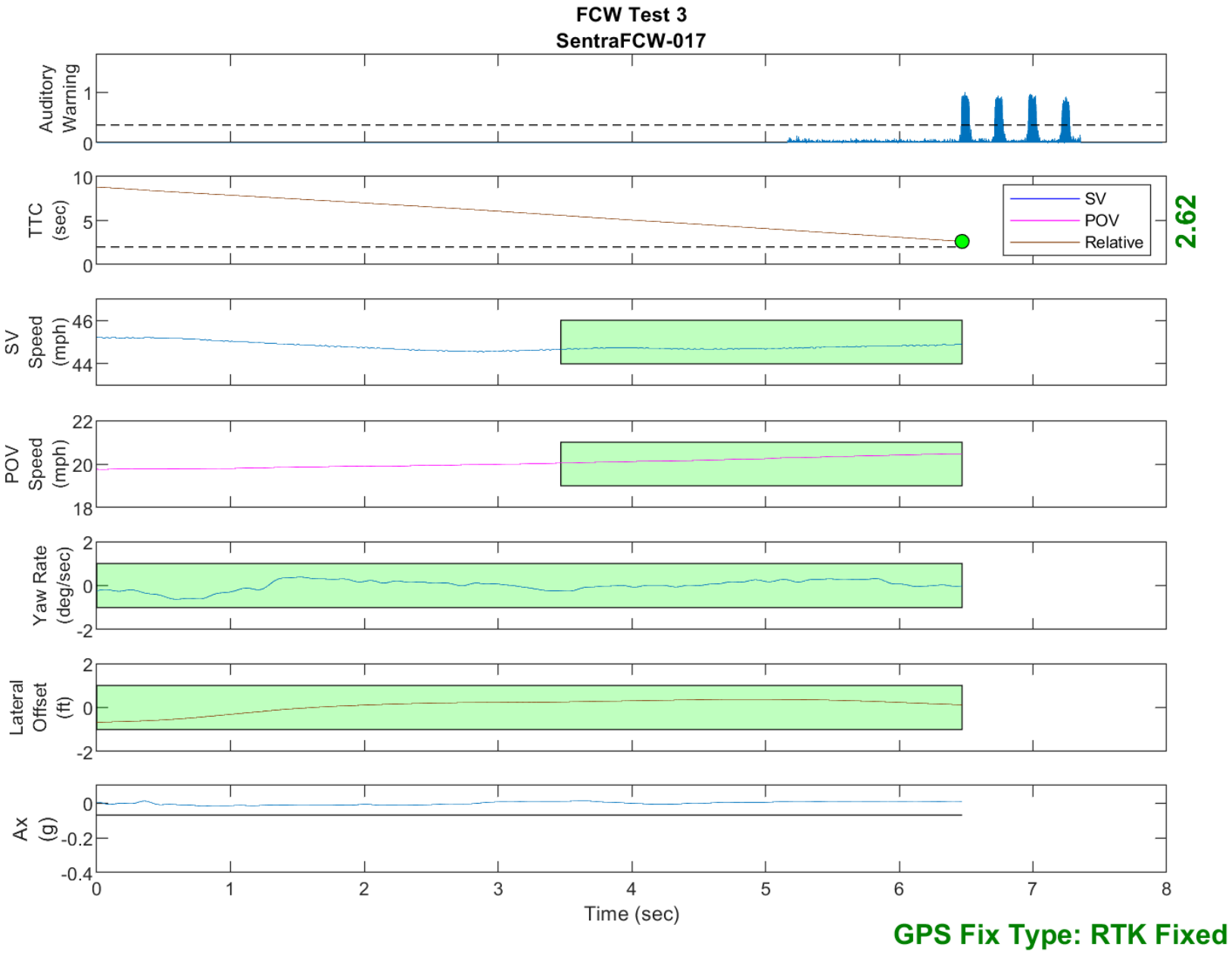


Figure D45. Time History for Run 17, Test 3 - Slower Moving POV, Auditory Warning

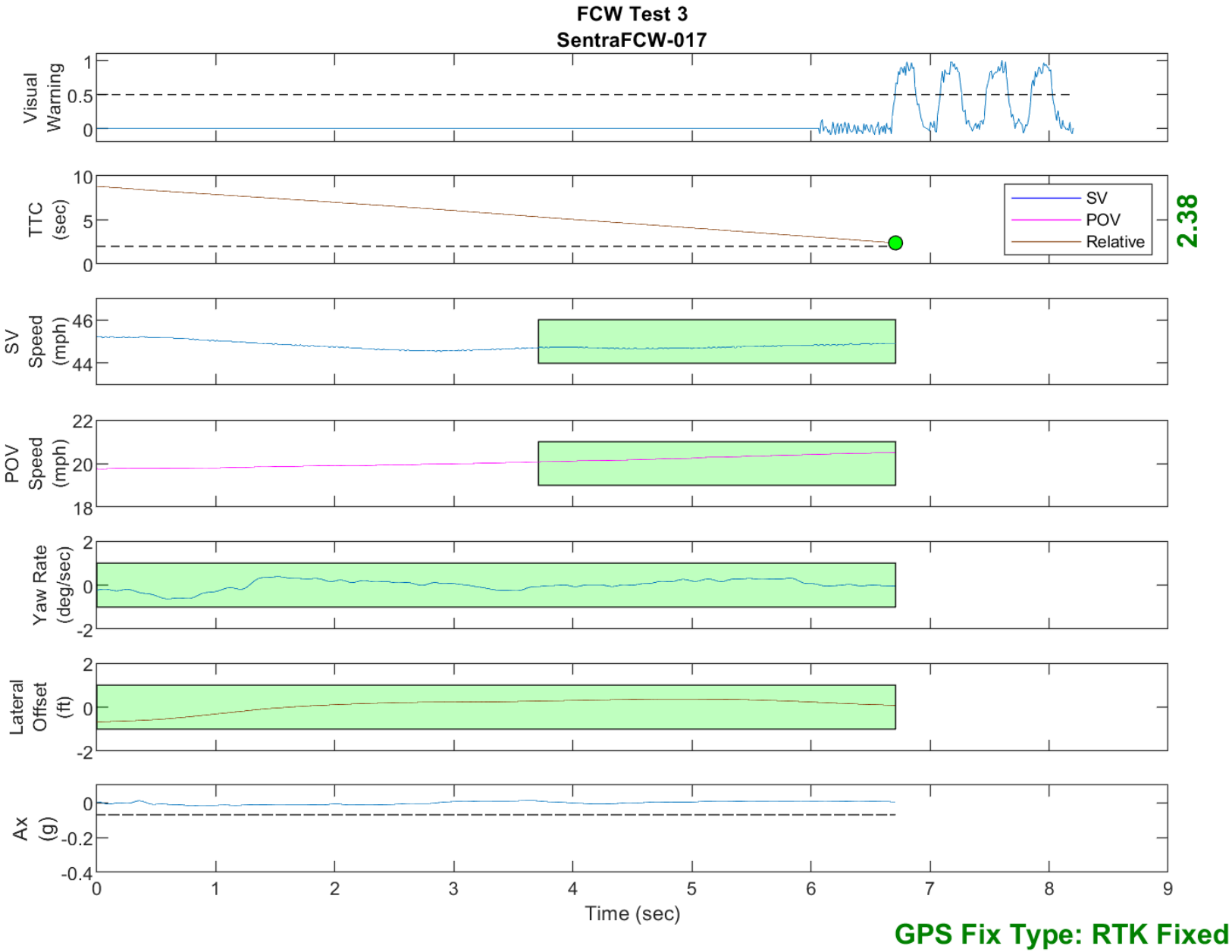


Figure D46. Time History for Run 17, Test 3 - Slower Moving POV, Visual Warning

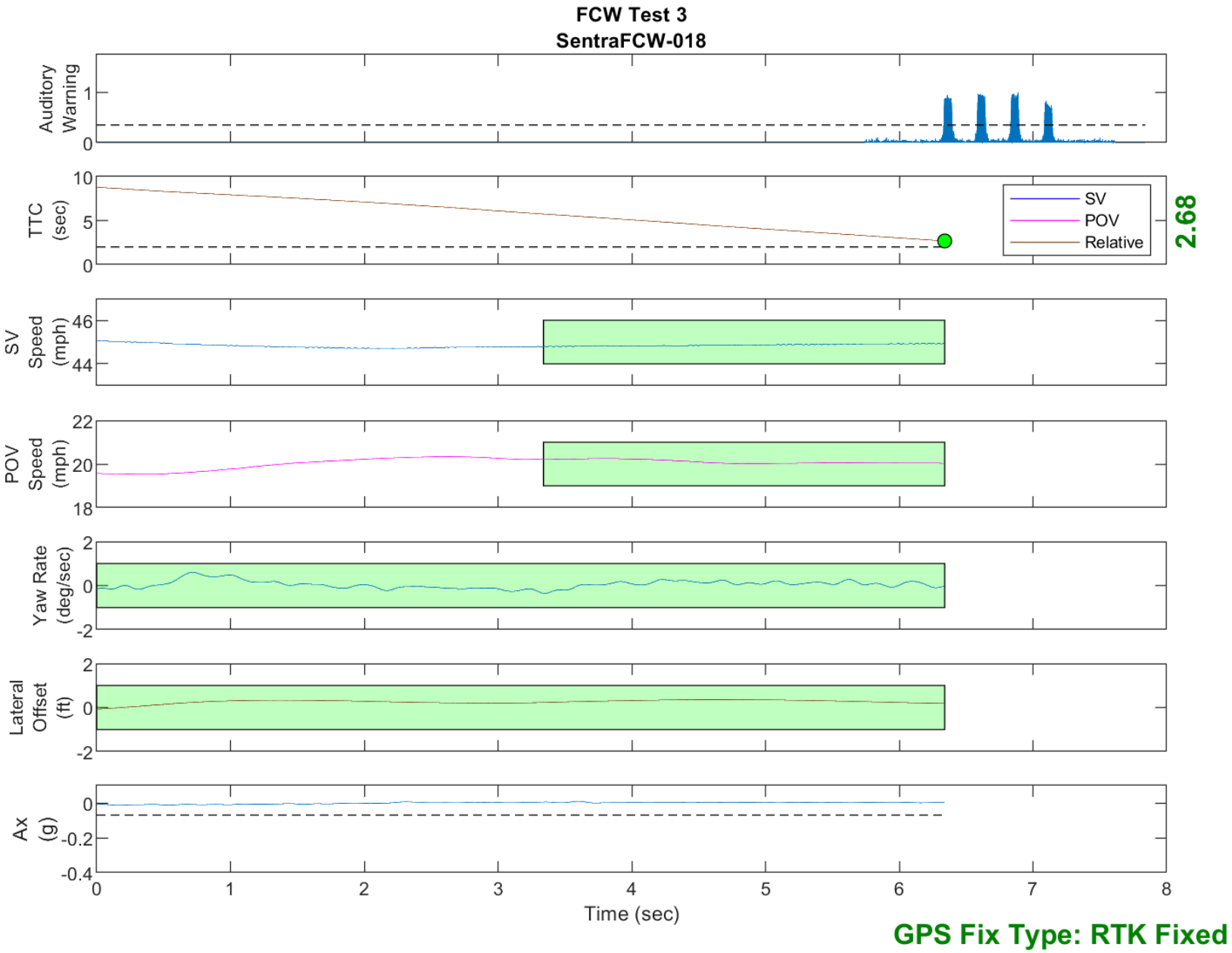


Figure D47. Time History for Run 18, Test 3 - Slower Moving POV, Auditory Warning

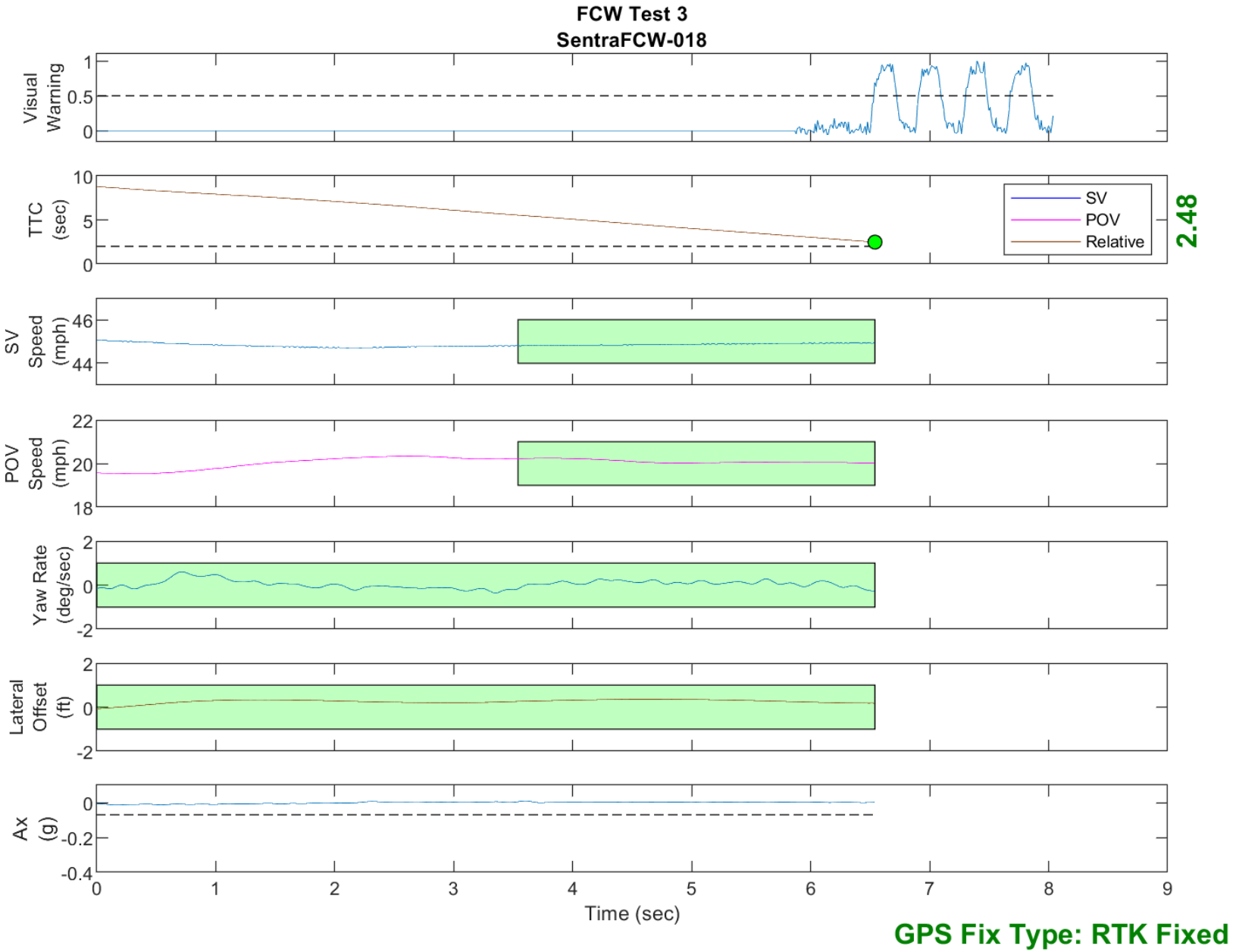


Figure D48. Time History for Run 18, Test 3 - Slower Moving POV, Visual Warning