NEW CAR ASSESSMENT PROGRAM
FORWARD COLLISION WARNING CONFIRMATION TEST
NCAP-DRI-FCW-22-13

2022 Toyota Tundra 4x4 CrewMax

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12 July 2022

Final Report

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

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

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16. Abstract These tests were conducted on the subject 2022 Toyota Tundra 4x4 CrewMax 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 Toyota Tundra 4x4 CrewMax. 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 with the New Car Assessment Program (NCAP).

Section II

DATA SHEETS

FORWARD COLLISION WARNING

DATA SHEET 1: TEST RESULTS SUMMARY

(Page 1 of 1)

2022 Toyota Tundra 4x4 CrewMax

VIN: *5TFLA5DB9NX02xxxx*

Test start date: *7/6/2022*

Test end date: *7/6/2022*

Forward Collision Warning setting: *Early*

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 Toyota Tundra 4x4 CrewMax

TEST VEHICLE INFORMATION

VIN: *5TFLA5DB9NX02xxxx*

Body Style: *Truck* Color: *Magnetic Gray Metallic*

Date Received: *6/25/2022* Odometer Reading: *20 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Toyota Motor Manufacturing, Texas, Inc*

Date of manufacture: *03/22*

Vehicle Type: *Truck*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *265/70R18*

Rear: *265/70R18*

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

Rear: *240 kPa (35 psi)*

TIRES

Tire manufacturer and model: *Yokohama Geolander X-CV*

Front tire specification: *265/70R18 116T*

Rear tire specification: *265/70R18 116T*

Front tire DOT prefix: *4UD6 6YK*

Rear tire DOT prefix: *4UD6 6YK*

FORWARD COLLISION WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2022 Toyota Tundra 4x4 CrewMax

GENERAL INFORMATION

Test start date: *7/6/2022* Test end date: *7/6/2022*

AMBIENT CONDITIONS

Air temperature: *23.9 C (75 F)*

Wind speed: *2.6 m/s (5.8 mph)*

X Wind speed ≤ 10 m/s (22 mph).

X Tests were not performed during periods of inclement weather. This includes, but is not limited to, rain, snow, hail, fog, smoke, or ash.

X Tests were conducted during daylight hours with good atmospheric visibility (defined as an absence of fog and the ability to see clearly for more than 5000 meters). The tests were not conducted with the vehicle oriented into the sun during very low sun angle conditions, where the sun is oriented 15 degrees or less from horizontal, and camera “washout” or system inoperability results.

VEHICLE PREPARATION

Verify the following:

All non-consumable fluids at 100% capacity: **X**

Fuel tank is full: **X**

Tire pressures are set to manufacturer's recommended cold tire pressure: **X**

Front: *240 kPa (35 psi)*

Rear: *240 kPa (35 psi)*

WEIGHT

Weight of vehicle as tested including driver and instrumentation:

Left Front:	*776.1 kg (1711 lb)*	Right Front:	*772.5 kg (1703 lb)*
Left Rear:	*554.7 kg (1223 lb)*	Right Rear:	*567.9 kg (1252 lb)*
		Total:	*2671.2 kg (5889 lb)*

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

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2022 Toyota Tundra 4x4 CrewMax

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

Toyota Safety Sense 2.5: Pre-Collision System with Pedestrian Detection comes standard on this vehicle.

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

Millimeter wave radar mounted behind the front grille and a mono camera in the top center of the windshield.

Forward Collision Warning Setting used in test: *Early*

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 FCW system alerts the driver with a visual and auditory alert. The visual alert is displayed in the multi-information display located in the center of the instrument panel and consists of a red box and the word "BRAKE!". The auditory alert consists of repeated beeps with a primary frequency of approximately 2411 Hz.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

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2022 Toyota Tundra 4x4 CrewMax

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 FCW system can be turned on/off using the buttons on the left side of the steering wheel. The procedure is as follows:

1. *Press the < > button until the gear icon is selected in the multi-information display.*
2. *Scroll down until "PCS" is outlined and hold the "OK" button to select.*
3. *Within the PCS menu, scroll down to "PCS" and press "OK" to turn the FCW system on/off.*

When the FCW system is turned off, the PCS warning light illuminates, and a message is displayed in the multi-information display. 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? **X** Yes ____ No

If yes, please provide a full description.

The range setting for the FCW system can be adjusted using the buttons on the left side of the steering wheel. The procedure is as follows:

1. *Press the < > button until the gear icon is selected in the multi-information display.*
2. *Scroll down until "PCS" is outlined and hold the "OK" button to select.*
3. *Within the PCS menu, scroll down to "Sensitivity" and press the “OK” button to adjust the FCW range (Early, Middle, Late).*

The warning timing setting is retained when the engine switch is turned off. However, if the PCS system is disabled and re-enabled, the range setting for the FCW system will default to the middle setting.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 3 of 3)

2022 Toyota Tundra 4x4 CrewMax

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 235-237 shown in Appendix B pages B-4 to B-6.

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.

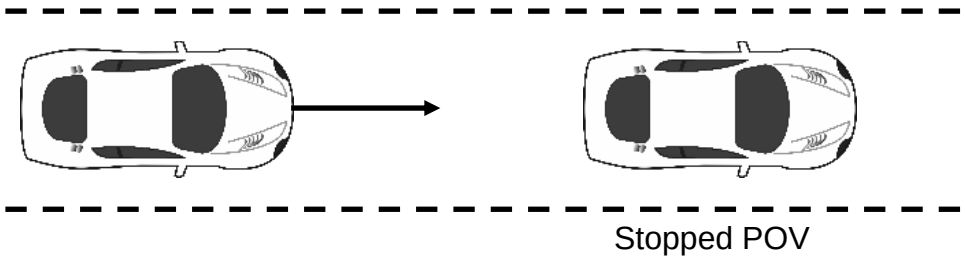


Figure 1. Depiction of Test 1

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.

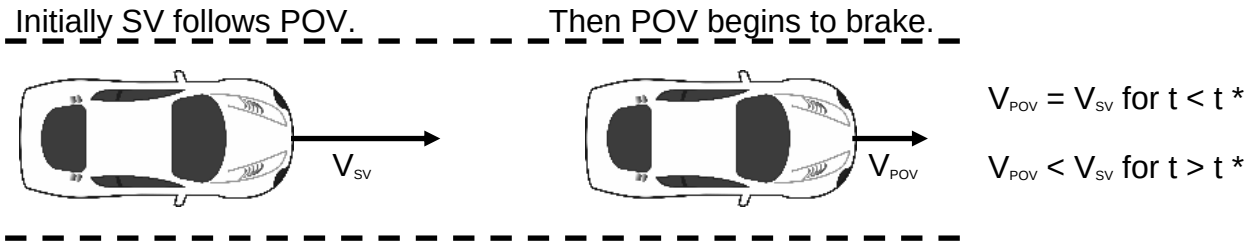


Figure 2. Depiction of Test 2

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).

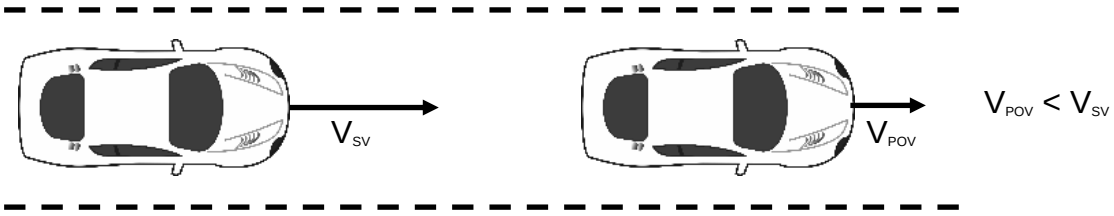


Figure 3. Depiction of Test 3

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 +	2182	Date: 11/19/2021 Due: 11/19/2023
				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

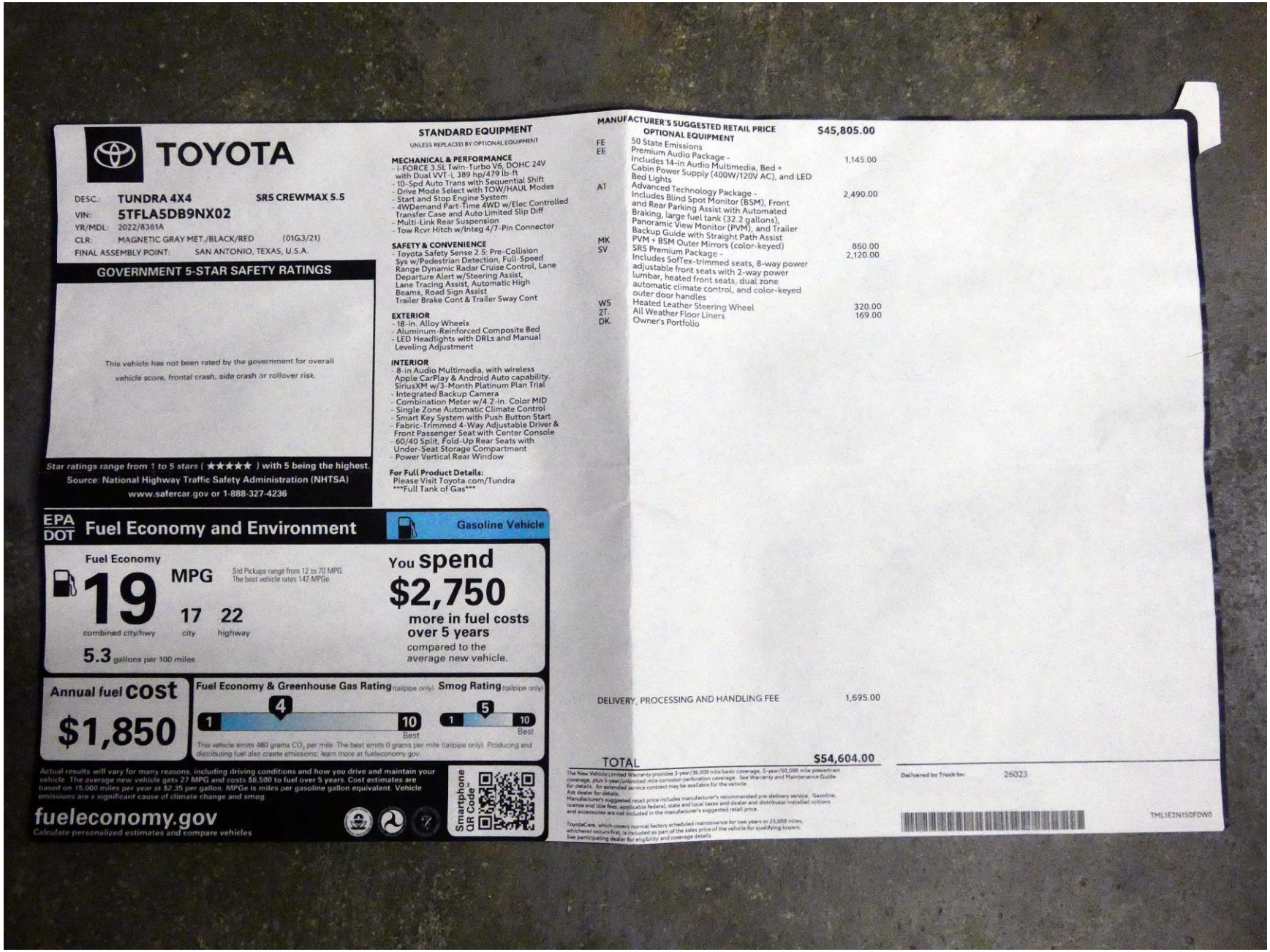


Figure A3. Window Sticker (Monroney Label)

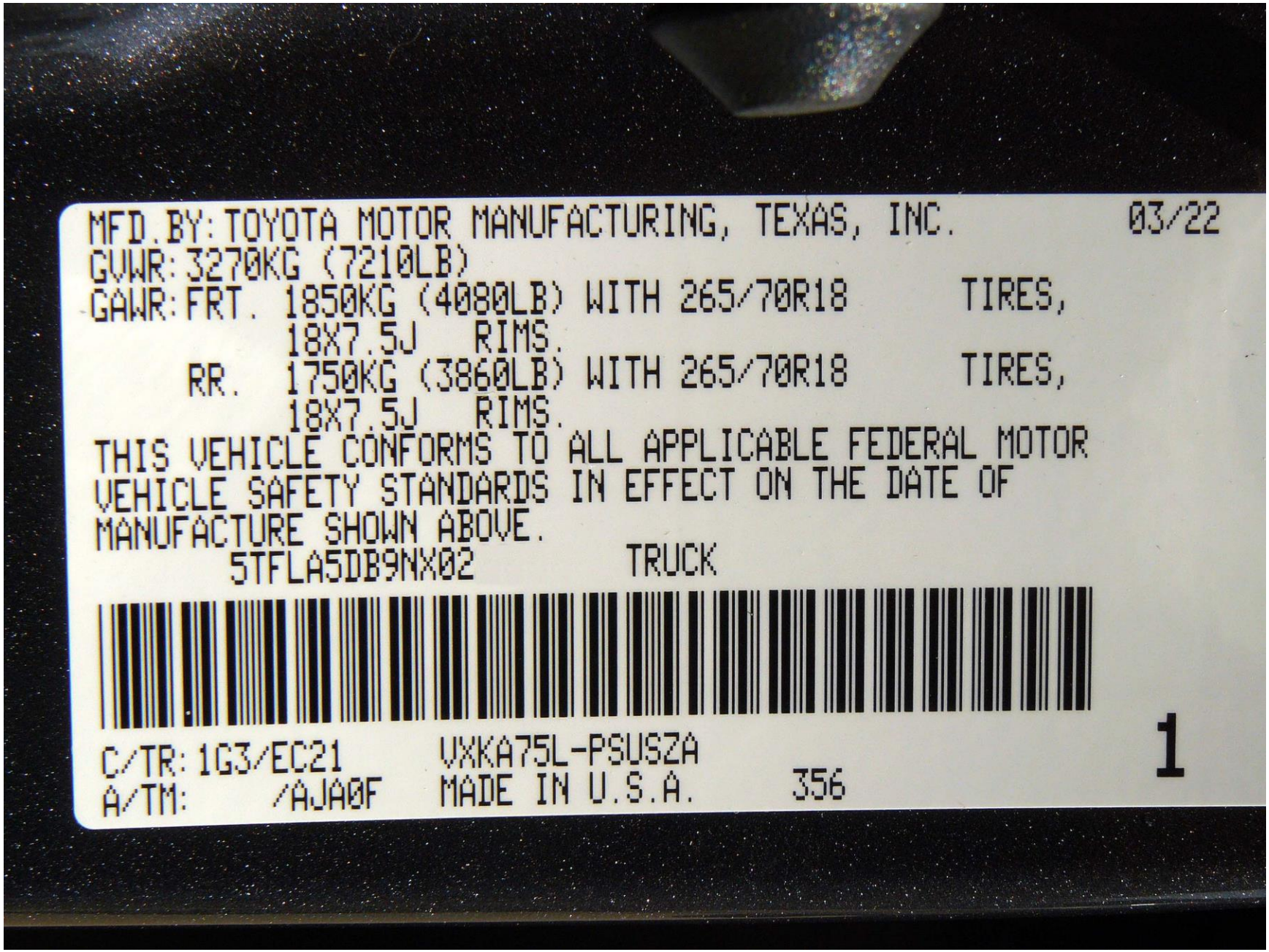


Figure A4. Vehicle Certification Label

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

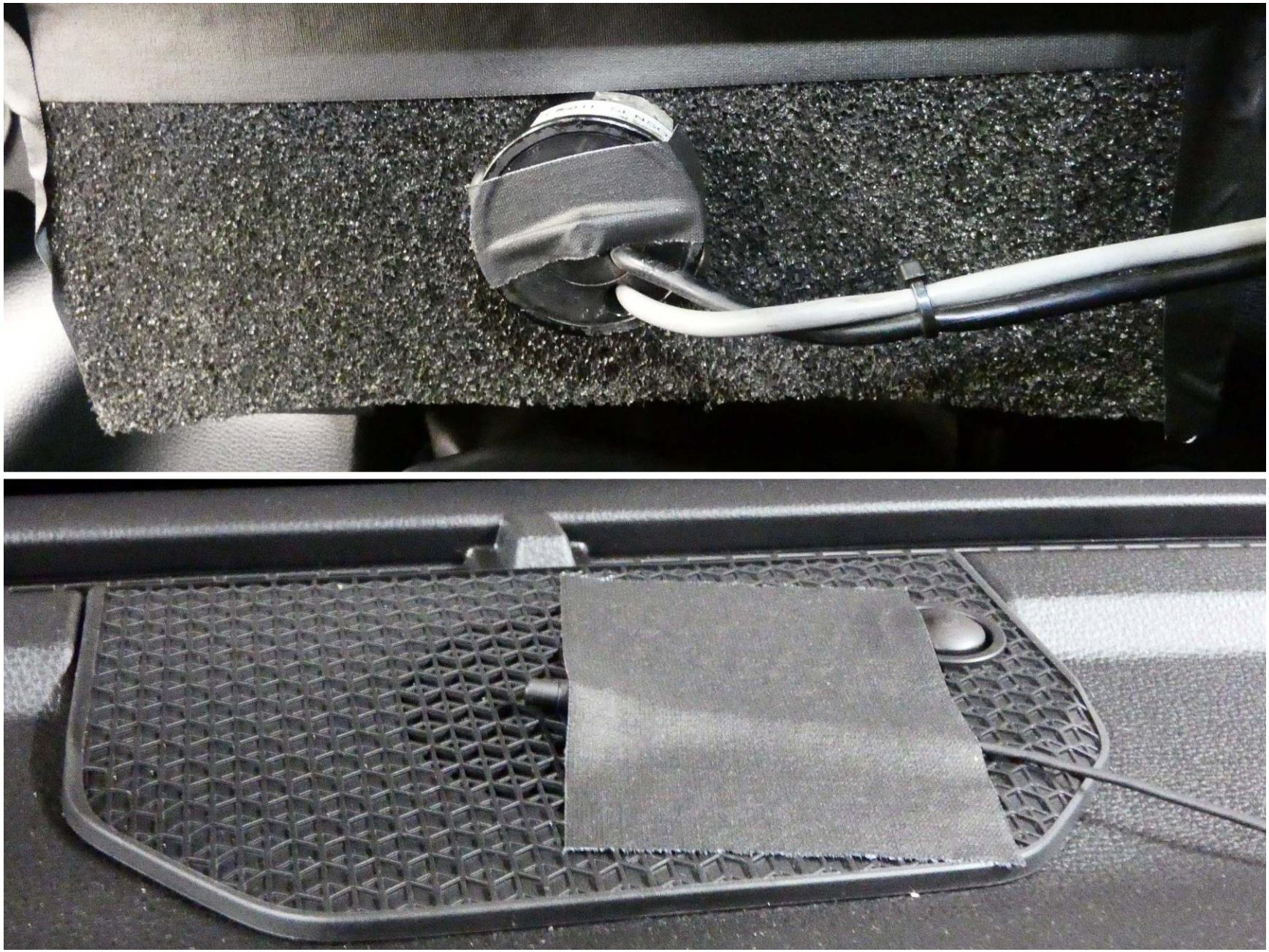


Figure A9. Sensors for Detecting Visual and Auditory Alerts

Figure A10. Computer Installed in Subject Vehicle

Figure A11. Brake Actuation System Installed in Principal Other Vehicle

Figure A12. Steering Wheel Buttons

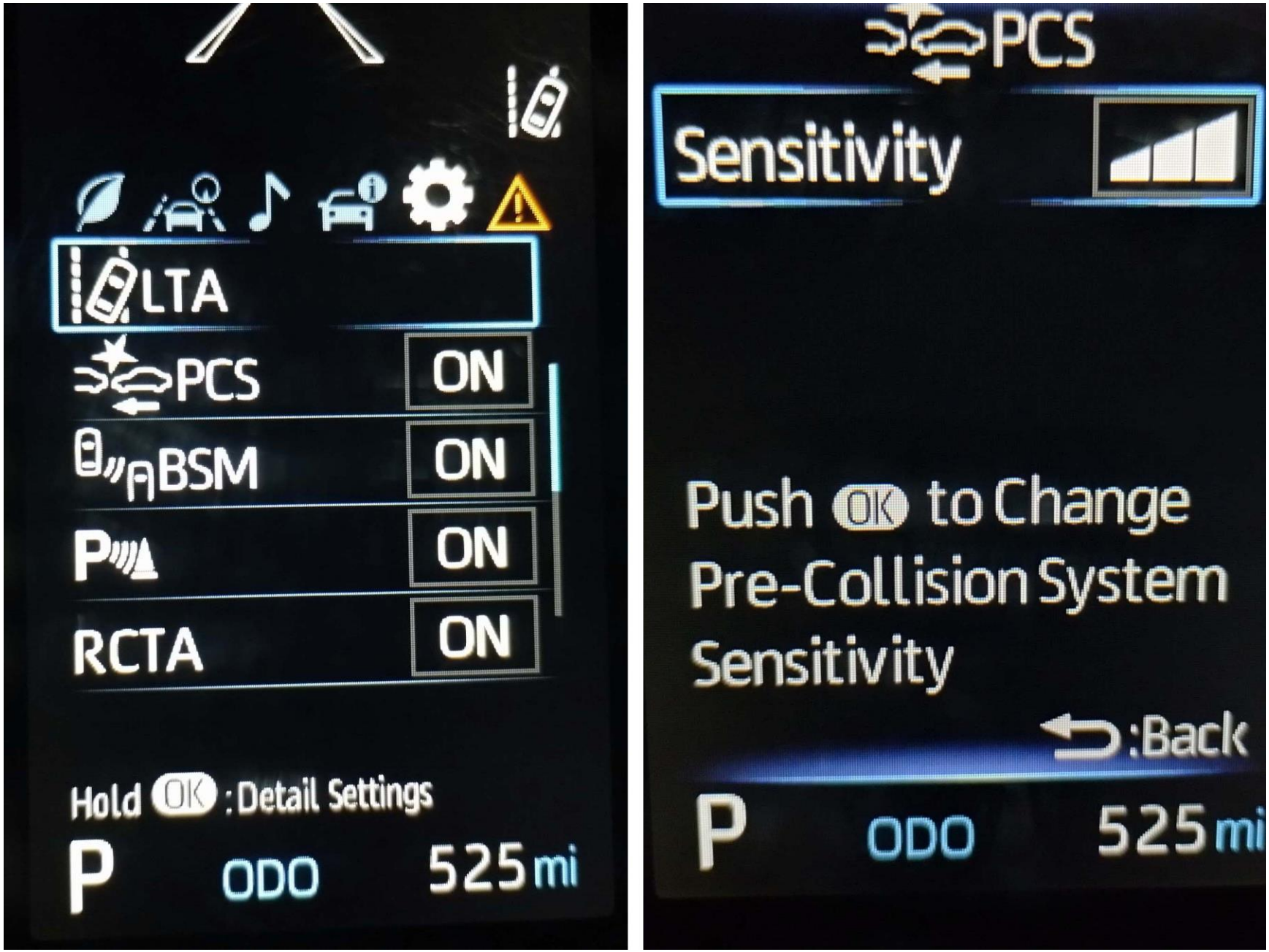


Figure A13. FCW System Warning Timing Menu

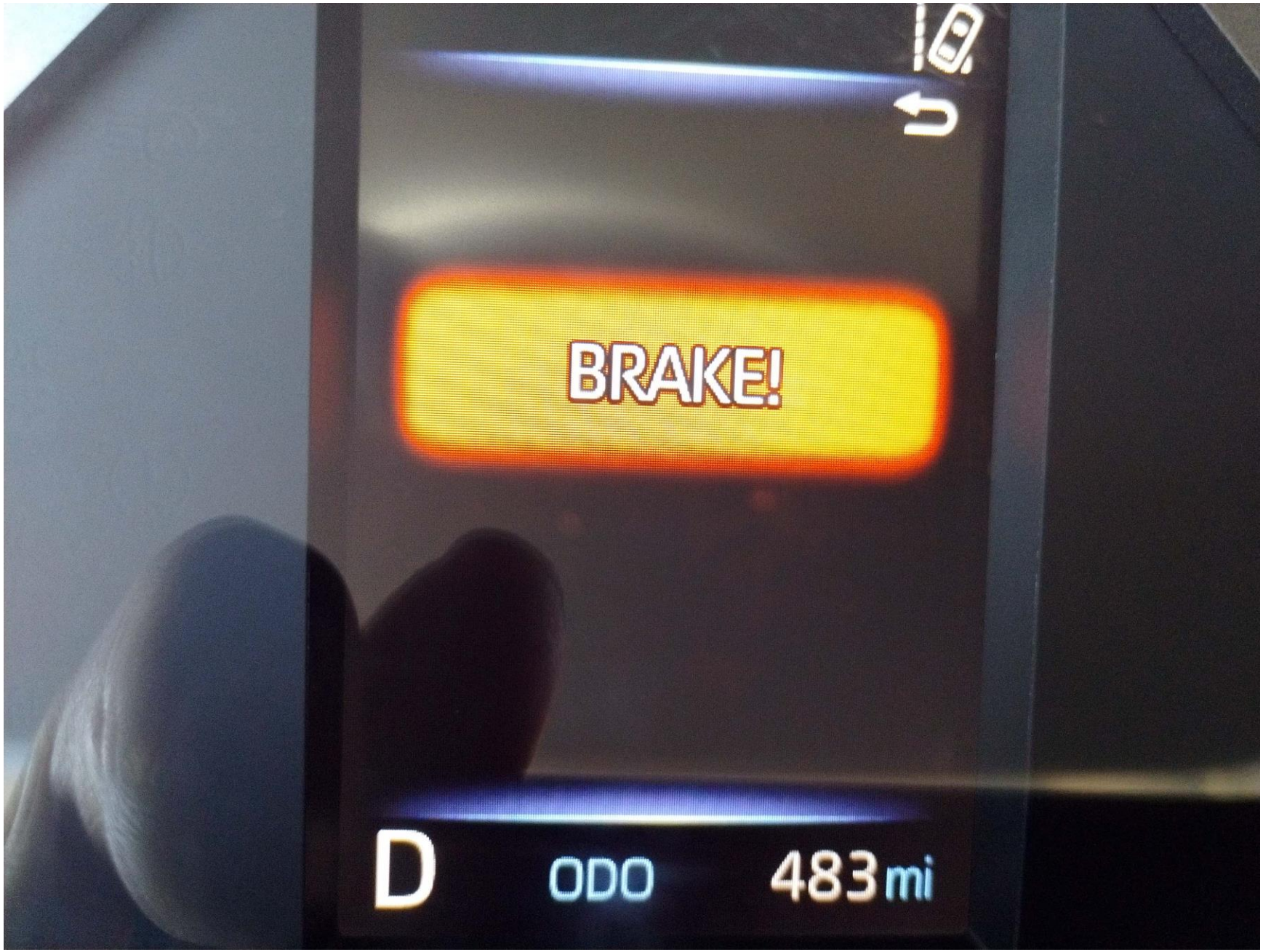


Figure A14. Visual Alert

APPENDIX B

Excerpts from Owner’s Manual

PCS (Pre-Collision System)*

*: If equipped

The pre-collision system uses a radar sensor and front camera to detect objects (→P.233) in front of the vehicle. When the system determines that the possibility of a frontal collision with an object is high, a warning operates to urge the driver to take evasive action and the potential brake pressure is increased to help the driver avoid the collision. If the system determines that the possibility of a frontal collision with an object is extremely high, the brakes are automatically applied to help avoid the collision or help reduce the impact of the collision.

The pre-collision system can be disabled/enabled and the warning timing can be changed. (→P.237)

Detectable objects

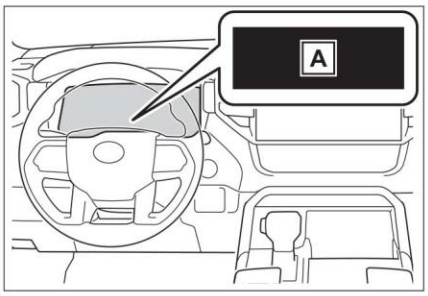
The system can detect the following (The detectable objects differs depending on the function.):

- Vehicles
- Bicyclists
- Pedestrians

System functions

■ Pre-collision warning

When the system determines that the possibility of a frontal collision is high, a buzzer will sound and a warning message will be displayed on the multi-information display to urge the driver to take evasive action.



A "BRAKE!"

■ Pre-collision brake assist

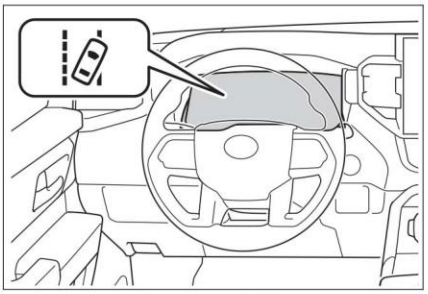
When the system determines that the possibility of a frontal collision is high, the system applies greater braking force in relation to how strongly the brake pedal is depressed.

■ Pre-collision braking

If the system determines that the possibility of a frontal collision is extremely high, the brakes are automatically applied to help avoid the collision or reduce the impact of the collision.

■ Emergency steering assist

If the system determines that the possibility of a collision with a pedestrian is high and that there is sufficient space for the vehicle to be steered into within its lane, and the driver has begun evasive maneuver or steering, emergency steering assist will assist the steering movements to help enhance the vehicle stability and for lane departure prevention. During operation, the indicator will illuminate in green.

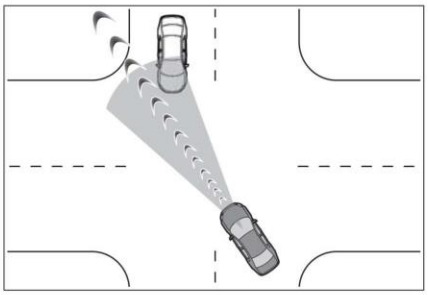


■ Intersection right/left turn assistance

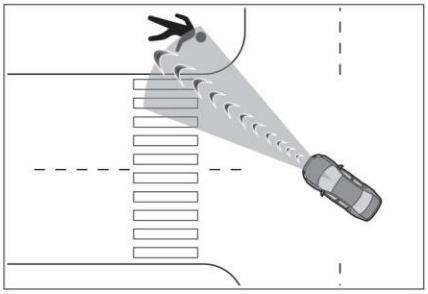
If the system determines that there is a high possibility of a collision in the following situations, it will assist with Pre-collision warning and, if necessary Pre-collision braking.

Depending on the configuration of the intersection, it may not be possible to support.

- When you turn right/left at an intersection and cross the path of an oncoming vehicle



- When you turn right/left, pedestrian is detected in the forward direction and estimated to enter your vehicle's path (bicyclists are not detected.)



■ Suspension control (vehicles with Adaptive Variable Suspension System)

When the system determines that the possibility of a frontal collision is high, the Adaptive Variable Suspension System (→P.388) will control the damping force of the shock absorbers to help maintain an appropriate vehicle posture.

WARNING

■ Limitations of the pre-collision system

- The driver is solely responsible for safe driving. Always drive safely, taking care to observe your surroundings.
  Do not use the pre-collision system instead of normal braking operations under any circumstances. This system will not prevent collisions or lessen collision damage or injury in every situation. Do not overly rely on this system. Failure to do so may lead to an accident, resulting in death or serious injury.
- Although this system is designed to help avoid a collision or help reduce the impact of the collision, its effectiveness may change according to various conditions, therefore the system may not always be able to achieve the same level of performance.
  Read the following conditions carefully. Do not overly rely on this system and always drive carefully.
  - Conditions under which the system may operate even if there is no possibility of a collision: →P.240
  - Conditions under which the system may not operate properly: →P.242
- Do not attempt to test the operation of the pre-collision system yourself.
  Depending on the objects used for testing (dummies, cardboard objects imitating detectable objects, etc.), the system may not operate properly, possibly leading to an accident.

■ Pre-collision braking

- When the pre-collision braking function is operating, a large amount of braking force will be applied.
- If the vehicle is stopped by the operation of the pre-collision braking function, the pre-collision braking function operation will be canceled after approximately 2 seconds. Depress the brake pedal as necessary.
- The pre-collision braking function may not operate if certain operations are performed by the driver. If the accelerator pedal is being depressed strongly or the steering wheel is being turned, the system may determine that the driver is taking evasive action and possibly prevent the pre-collision braking function from operating.
- In some situations, while the pre-collision braking function is operating, operation of the function may be canceled if the accelerator pedal is depressed strongly or the steering wheel is turned and the system determines that the driver is taking evasive action.
- If the brake pedal is being depressed, the system may determine that the driver is taking evasive action and possibly delay the operation timing of the pre-collision braking function.

■ Emergency steering assist

- As emergency steering assist operation will be canceled when the system determines that lane departure prevention function has been completed.

WARNING

- Emergency steering assist may not operate or may be cancel in the following cases as the system may determine the driver is taking actions.
  - If the accelerator pedal is being depressed strongly, the steering wheel is being operated sharply, the brake pedal is being depressed or the turn signal lever is being operated. In this case, the system may determine that the driver is taking evasive action and the emergency steering assist may not operate.
  - The emergency steering assist will be disabled automatically when the system judges that a trailer is connected.
  - In some situations, while the emergency steering assist is operating, operation of the function may be canceled if the accelerator pedal is depressed strongly, the steering wheel is operated sharply or the brake pedal is being depressed and the system determines that the driver is taking evasive action.
  - When the emergency steering assist is operating, if the steering wheel is held firmly or is operated in the opposite direction to that which the system is generating torque, the function may be canceled.

■When to disable the pre-collision system

In the following situations, disable the system, as it may not operate properly, possibly leading to an accident resulting in death or serious injury:

- When the vehicle is being towed
- When your vehicles is towing a trailer or another vehicle, except when the following conditions are all met
  - When the other vehicle is a trailer properly attached and connected to Toyota's official TBC ECU. (→P.184)
  - When the vehicle is not being driven on a slippery surface such as an icy road or a very wet road.
- When transporting the vehicle via truck, boat, train or similar means of transportation
- When the vehicle is raised on a lift with the engine running and the tires are allowed to rotate freely
- When inspecting the vehicle using a drum tester such as a chassis dynamometer or speedometer tester, or when using an on vehicle wheel balancer
- When a strong impact is applied to the front bumper or front grille, due to an accident or other reasons
- If the vehicle cannot be driven in a stable manner, such as when the vehicle has been in an accident or is malfunctioning
- When the vehicle is driven in a sporty manner or off-road
- When the tires are not properly inflated
- When the tires are very worn
- When tires of a size other than specified are installed
- When tire chains are installed
- When a compact spare tire or an emergency tire puncture repair kit is used

WARNING

- If equipment (snow plow, etc.) that may obstruct the radar sensor or front camera is temporarily installed to the vehicle
- When the vehicle is lifted up, except in the following cases
  - When using a Toyota official lift kit up to 4 in. (101 mm), including tire height. Aftermarket lift kits may degrade system performance.

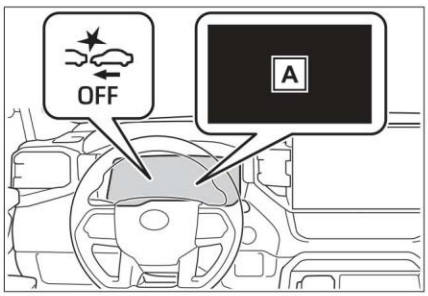
Changing settings of the pre-collision system

Enabling/disabling the pre-collision system

The pre-collision system can be enabled/disabled on ⚙ (→P.573) of the multi-information display.

The system is automatically enabled each time the engine switch is turned to ON.

If the system is disabled, the PCS warning light will turn on and a message will be displayed on the multi-information display.



A "Pre-Collision System OFF"

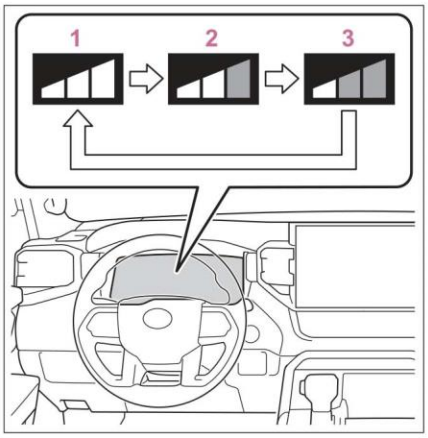
Changing the pre-collision warning timing

The pre-collision warning timing can be changed on ⚙ (→P.573) of the multi-information display.

The warning timing setting is retained when the engine switch is turned off. However, if the pre-collision system is disabled and re-enabled, the operation timing will return to the default setting (middle).

If the pre-collision warning timing is changed, emergency steering assist timing will also be changed accordingly.

If late is selected, emergency steering assist would not operate in case of an emergency.



1 Early

2 Middle

This is the default setting.

3 Late

4 Driving

■ **Operational conditions for each pre-collision function**

The pre-collision system is enabled and the system determines that the possibility of a frontal collision with a detected object is high.

The system may not operate in the following situations:

- If a battery terminal has been disconnected and reconnected and then the vehicle has not been driven for a certain amount of time
- If the shift lever is in R
- When the VSC OFF indicator is illuminated (only the pre-collision warning function will be operational)

The operation speeds and operation cancelation for each function is listed below.

● Pre-collision warning

Detectable objects	Vehicle speed	Relative speed between your vehicle and object
Vehicles	Approx. 7 to 110 mph (10 to 180 km/h)	Approx. 7 to 110 mph (10 to 180 km/h)
Bicyclists and pedestrians	Approx. 7 to 50 mph (10 to 80 km/h)	Approx. 7 to 50 mph (10 to 80 km/h)

While the pre-collision warning function is operating, if the steering wheel is operated heavily or suddenly, the pre-collision warning may be canceled.

● Pre-collision brake assist

Detectable objects	Vehicle speed	Relative speed between your vehicle and object
Vehicles	Approx. 20 to 110 mph (30 to 180 km/h)	Approx. 20 to 110 mph (30 to 180 km/h)
Bicyclists and pedestrians	Approx. 20 to 50 mph (30 to 80 km/h)	Approx. 20 to 50 mph (30 to 80 km/h)

● Pre-collision braking

Detectable objects	Vehicle speed	Relative speed between your vehicle and object
Vehicles	Approx. 7 to 110 mph (10 to 180 km/h)	Approx. 7 to 110 mph (10 to 180 km/h)
Bicyclists and pedestrians	Approx. 7 to 50 mph (10 to 80 km/h)	Approx. 7 to 50 mph (10 to 80 km/h)

If either of the following occur while the pre-collision braking function is operating, it will be canceled:

- The accelerator pedal is depressed strongly.

• The steering wheel is turned sharply or abruptly.

● Emergency steering assist

When the turn signal lights are flashing, emergency steering assist will not operate in case of an emergency.

The emergency steering assist will be disabled automatically when the system judges that a trailer is connected.

Detectable objects	Vehicle speed	Relative speed between your vehicle and object
Pedestrians	Approx. 31 to 50 mph (50 to 80 km/h)	Approx. 31 to 50 mph (50 to 80 km/h)

If any of the following occur while the emergency steering assist function is operating, it will be canceled:

• The accelerator pedal is depressed strongly.

• The steering wheel is turned sharply or abruptly.

• The brake pedal is depressed.

● Intersection right/left turn assistance (pre-collision warning)

When the turn signal lights are not flashing, support for turning left or right at an intersection which targets oncoming vehicles does not work.

When the system judges that a trailer is detected, intersection support is disabled for vehicles and pedestrians.

Detectable objects	Vehicle speed	Oncoming vehicle speed	Relative speed between your vehicle and object
Vehicles	Approx. 7 to 15 mph (10 to 25 km/h)	Approx. 20 to 35 mph (30 to 55 km/h)	Approx. 25 to 50 mph (40 to 80 km/h)
Pedestrians	Approx. 7 to 15 mph (10 to 25 km/h)	-	Approx. 7 to 15 mph (10 to 25 km/h)

● Intersection right/left turn assistance (pre-collision braking)

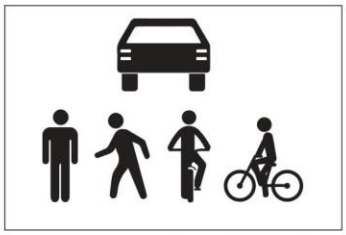
When the turn signal lights are not flashing, support for turning left or right at an intersection which targets oncoming vehicles does not work.

When the system judges that a trailer is detected, intersection support is disabled for vehicles and pedestrians.

Detectable objects	Vehicle speed	Oncoming vehicle speed	Relative speed between your vehicle and object
Vehicles	Approx. 10 to 15 mph (15 to 25 km/h)	Approx. 20 to 28 mph (30 to 45 km/h)	Approx. 28 to 43 mph (45 to 70 km/h)
Pedestrians	Approx. 7 to 15 mph (10 to 25 km/h)	-	Approx. 7 to 15 mph (10 to 25 km/h)

■ Object detection function

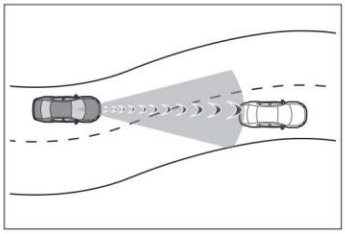
The system detects objects based on their size, profile, motion, etc. However, an object may not be detected depending on the surrounding brightness and the motion, posture, and angle of the detected object, preventing the system from operating properly. (→P.242)
The illustration shows an image of detectable objects.



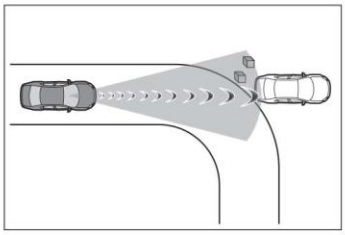
■ Conditions under which the system may operate even if there is no possibility of a collision

● In some situations such as the following, the system may determine that there is a possibility of a frontal collision and operate.

- When passing a detectable object, etc.
- When changing lanes while overtaking a detectable object, etc.
- When approaching a detectable object in an adjacent lane or on the roadside, such as when changing the course of travel or driving on a winding road

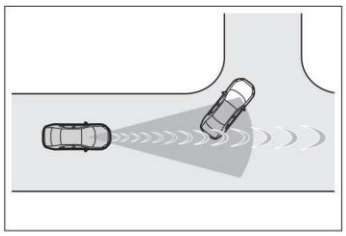


- When rapidly closing on a detectable object, etc.
- When approaching objects on the roadside, such as detectable objects, guardrails, utility poles, trees, or walls
- When there is a detectable object or other object by the roadside at the entrance of a curve

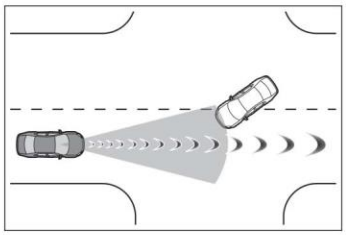


- When there are patterns or paint in front of your vehicle that may be mistaken for a detectable object
- When the front of your vehicle is hit by water, snow, dust, etc.
- When overtaking a detectable

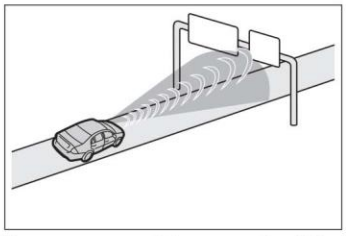
object that is changing lanes or making a right/left turn



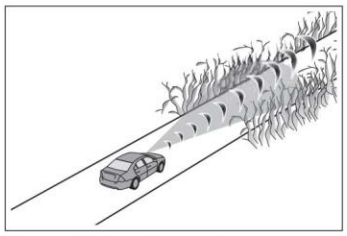
- When passing a detectable object in an oncoming lane that is stopped to make a right/left turn



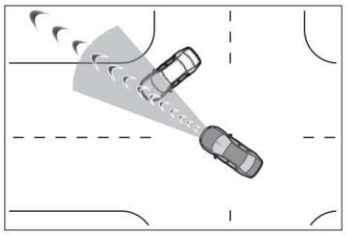
- When a detectable object approaches very close and then stops before entering the path of your vehicle
- If the front of your vehicle is raised or lowered, such as when on an uneven or undulating road surface
- When driving on a road surrounded by a structure, such as in a tunnel or on an iron bridge
- When there is a metal object (manhole cover, steel plate, etc.), steps, or a protrusion in front of your vehicle
- When passing under an object (road sign, billboard, etc.)



- When approaching an electric toll gate barrier, parking area barrier, or other barrier that opens and closes
- When using an automatic car wash
- When driving through or under objects that may contact your vehicle, such as thick grass, tree branches, or a banner



- When driving through steam or smoke
- When driving near an object that reflects radio waves, such as a large truck or guardrail
- When driving near a TV tower, broadcasting station, electric power plant, radar equipped vehicles, etc., or other location where strong radio waves or electrical noise may be present
- When there are many things which can reflect the radio waves of the radar in the vicinity (tunnels, truss bridges, gravel roads, snow covered road that have tracks, etc.)
- While making a right/left turn, when an oncoming vehicle or a crossing pedestrian has already exited the path of your vehicle
- While making a right/left turn, closely in front of an oncoming vehicle or a crossing pedestrian.
- While making a right/left turn, when an oncoming vehicle or a crossing pedestrian stops before entering the path of your vehicle
- While making a right/left turn, when an oncoming vehicle turns right/left in front of your vehicle

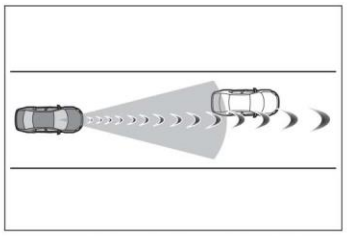


- While steering into the direction of oncoming traffic
- When the vehicle is lifted up using an aftermarket lift kit
- When the vehicle is lifted up more than 4 in. (101 mm)

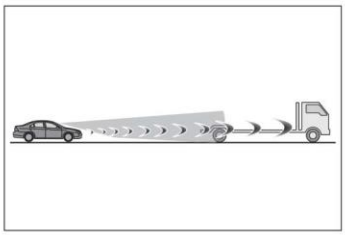
■ Situations in which the system may not operate properly

● In some situations such as the following, an object may not be detected by the radar sensor and front camera, preventing the system from operating properly:

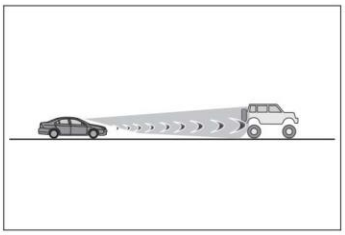
- When a detectable object is approaching your vehicle
- When your vehicle or a detectable object is wobbling
- If a detectable object makes an abrupt maneuver (such as sudden swerving, acceleration or deceleration)
- When your vehicle approaches a detectable object rapidly
- When a detectable object is not directly in front of your vehicle



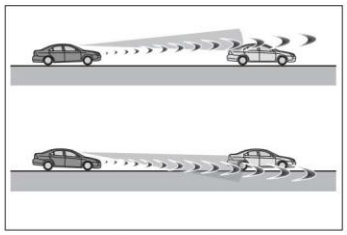
- When a detectable object is near a wall, fence, guardrail, manhole cover, vehicle, steel plate on the road, etc.
- When a detectable object is under a structure
- When part of a detectable object is hidden by an object, such as large baggage, an umbrella, or guardrail
- When there are many things which can reflect the radio waves of the radar in the vicinity (tunnels, truss bridges, gravel roads, snow covered road that have tracks, etc.)
- When there is an effect on the radio waves to the radar that is installed on another vehicle
- When multiple detectable objects are close together
- If the sun or other light is shining directly on a detectable object
- When a detectable object is a shade of white and looks extremely bright
- When a detectable object appears to be nearly the same color or brightness as its surroundings
- If a detectable object cuts or suddenly emerges in front of your vehicle
- When the front of your vehicle is hit by water, snow, dust, etc.
- When a very bright light ahead, such as the sun or the headlights of oncoming traffic, shines directly into the front camera
- When approaching the side or front of a vehicle ahead
- If a vehicle ahead is a motorcycle
- If a vehicle ahead is narrow, such as a personal mobility vehicle
- If a preceding vehicle has a small rear end, such as an unloaded truck
- If a preceding vehicle has a low rear end, such as a low bed trailer



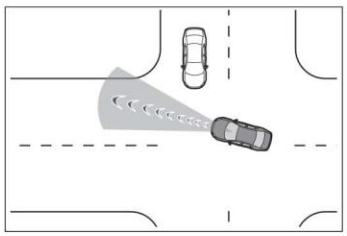
- If a vehicle ahead has extremely high ground clearance



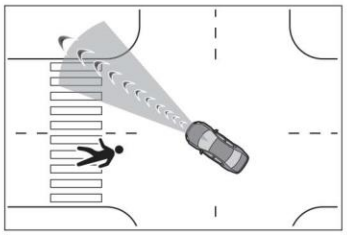
- If a vehicle ahead is carrying a load which protrudes past its rear bumper
- If a vehicle ahead is irregularly shaped, such as a tractor or side car
- If a vehicle ahead is a child sized bicycle, a bicycle that is carrying a large load, a bicycle ridden by more than one person, or a uniquely shaped bicycle (bicycle with a child seat, tandem bicycle, etc.)
- If a pedestrian/or the riding height of a bicyclist ahead is shorter than approximately 3.2 ft. (1 m) or taller than approximately 6.5 ft. (2 m)
- If a pedestrian/bicyclist is wearing oversized clothing (a rain coat, long skirt, etc.), making their silhouette obscure
- If a pedestrian is bending forward or squatting or bicyclist is bending forward
- If a pedestrian/bicyclist is moving fast
- If a pedestrian is pushing a stroller, wheelchair, bicycle or other vehicle
- When driving in inclement weather such as heavy rain, fog, snow or a sandstorm
- When driving through steam or smoke
- When the surrounding area is dim, such as at dawn or dusk, or while at night or in a tunnel, making a detectable object appear to be nearly the same color as its surroundings
- When driving in a place where the surrounding brightness changes suddenly, such as at the entrance or exit of a tunnel
- After the engine has started the vehicle has not been driven for a certain amount of time
- While making a left/right turn and for a few seconds after making a left/right turn
- While driving on a curve and for a few seconds after driving on a curve
- If your vehicle is skidding
- If the front of the vehicle is raised or lowered



- If the wheels are misaligned
- If a wiper blade is blocking the front camera
- The vehicle is being driven at extremely high speeds
- When driving on a hill
- If the radar sensor or front camera is misaligned
- When driving in a traffic lane separated by more than one lane where oncoming vehicles are driving while making a right/left turn
- When largely out of place with the opposite facing targeted oncoming vehicle during a right/left turn



- While making a right/left turn, when a pedestrian approaches from behind or side of your vehicle



- When the vehicle is lifted up using an aftermarket lift kit
- When the vehicle is lifted up more than 4 in. (101 mm)

● In addition to the above, in some situations, such as the following, the emergency steering assist may not operate.

- When the white (yellow) lane lines are difficult to see, such as when they are faint, diverging/merging, or a shadow is cast upon them
- When the lane is wider or narrower than normal
- When there is a light and dark pattern on the road surface, such as due to road repairs
- When a pedestrian is detected near the centerline of the vehicle
- When the target is too close
- When there is insufficient safe or unobstructed space for the vehicle to be steered into
- If oncoming vehicle is present
- If VSC function is operating

● In some situations such as the following, sufficient braking force or steering force may not be obtained, preventing the system from performing properly:

- If the braking functions cannot operate to their full extent, such as when the brake parts are extremely cold, extremely hot, or wet
- If the vehicle is not properly maintained (brakes or tires are excessively worn, improper tire inflation pressure, etc.)
- When the vehicle is being driven on a gravel road or other slippery surface
- When the road surface has deep wheel tracks
- When driving on a hill road
- When driving on a road that has inclines to the left or right
- When your vehicles is towing a trailer or another vehicle
- When your vehicle is lifted up

■ If VSC is disabled

● If VSC is disabled (→P.389), the pre-collision brake assist and pre-collision braking functions are also disabled.

● The PCS warning light will turn on and “VSC Turned OFF Pre-Collision Brake System Unavailable” will be displayed on the multi-information display.

APPENDIX C

Run Log

Subject Vehicle: **2022 Toyota Tundra 4x4 CrewMax** Test Date: **7/6/2022**

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	2.87	2.79	0.77	Pass	
2		Y	2.81	2.74	0.71	Pass	
3		Y	2.85	2.76	0.75	Pass	
4		Y	2.88	2.79	0.78	Pass	
5		Y	2.88	2.81	0.78	Pass	
6		Y	2.88	2.79	0.78	Pass	
7		Y	2.90	2.83	0.80	Pass	
18	**Decelerating POV, 45**	Y	2.80	2.72	0.40	Pass	
19		Y	2.74	2.67	0.34	Pass	
20		Y	2.73	2.67	0.33	Pass	
21		N					SV Speed
22		Y	2.79	2.68	0.39	Pass	
23		Y	2.79	2.69	0.39	Pass	
24		Y	2.76	2.64	0.36	Pass	
25		Y	2.83	2.81	0.43	Pass	

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
8	**Slower POV, 45 vs 20**	N					Lateral Offset
9		Y	2.70	2.59	0.70	Pass	
10		Y	2.65	2.56	0.65	Pass	
11		N					SV Acceleration
12		Y	2.64	2.54	0.64	Pass	
13		Y	2.65	2.58	0.65	Pass	
14		Y	2.72	2.63	0.72	Pass	
15		N					Lat Offset
16		Y	2.72	2.60	0.72	Pass	
17		Y	2.63	2.53	0.63	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.

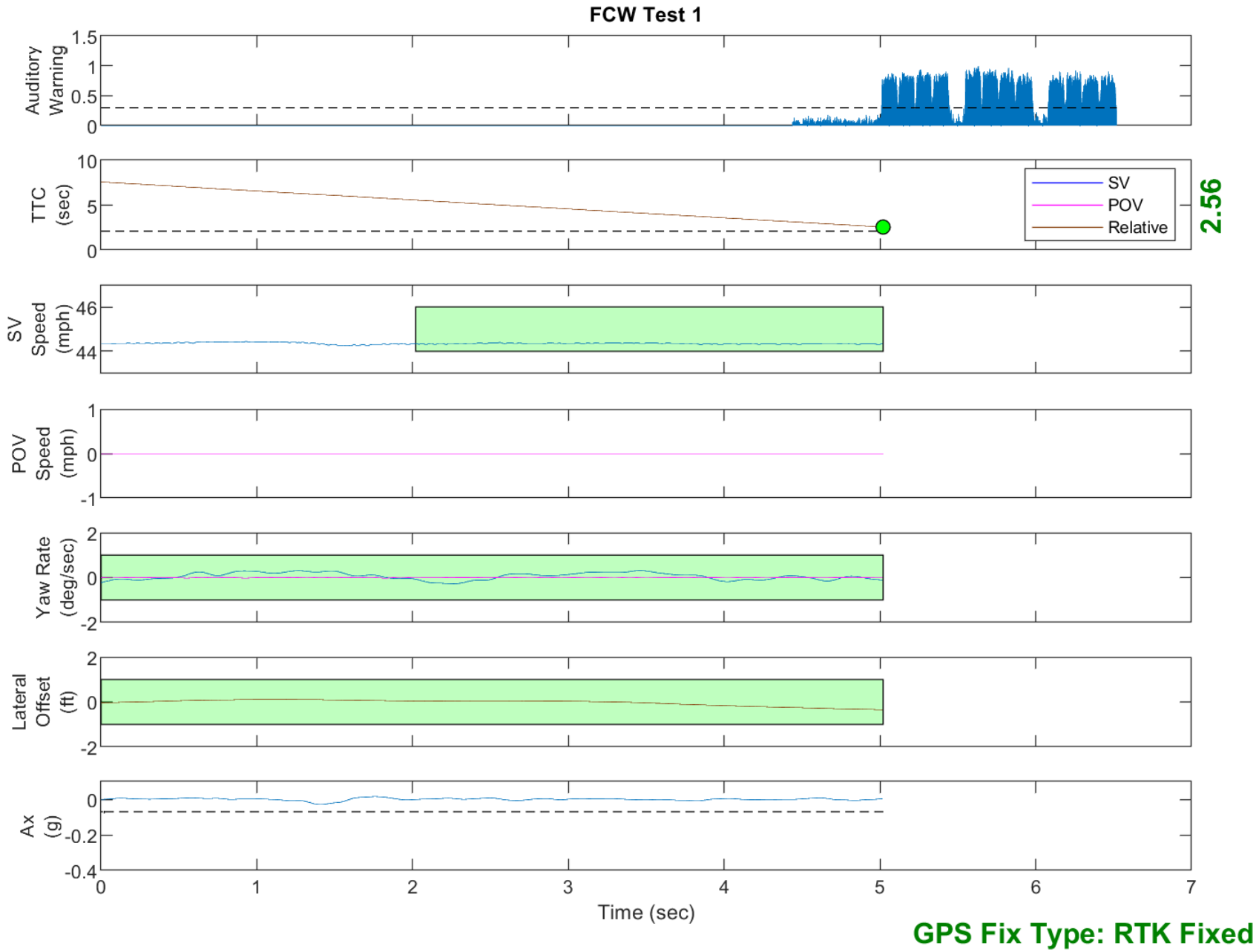


Figure D1. Example Time History for Test Type 1, Passing

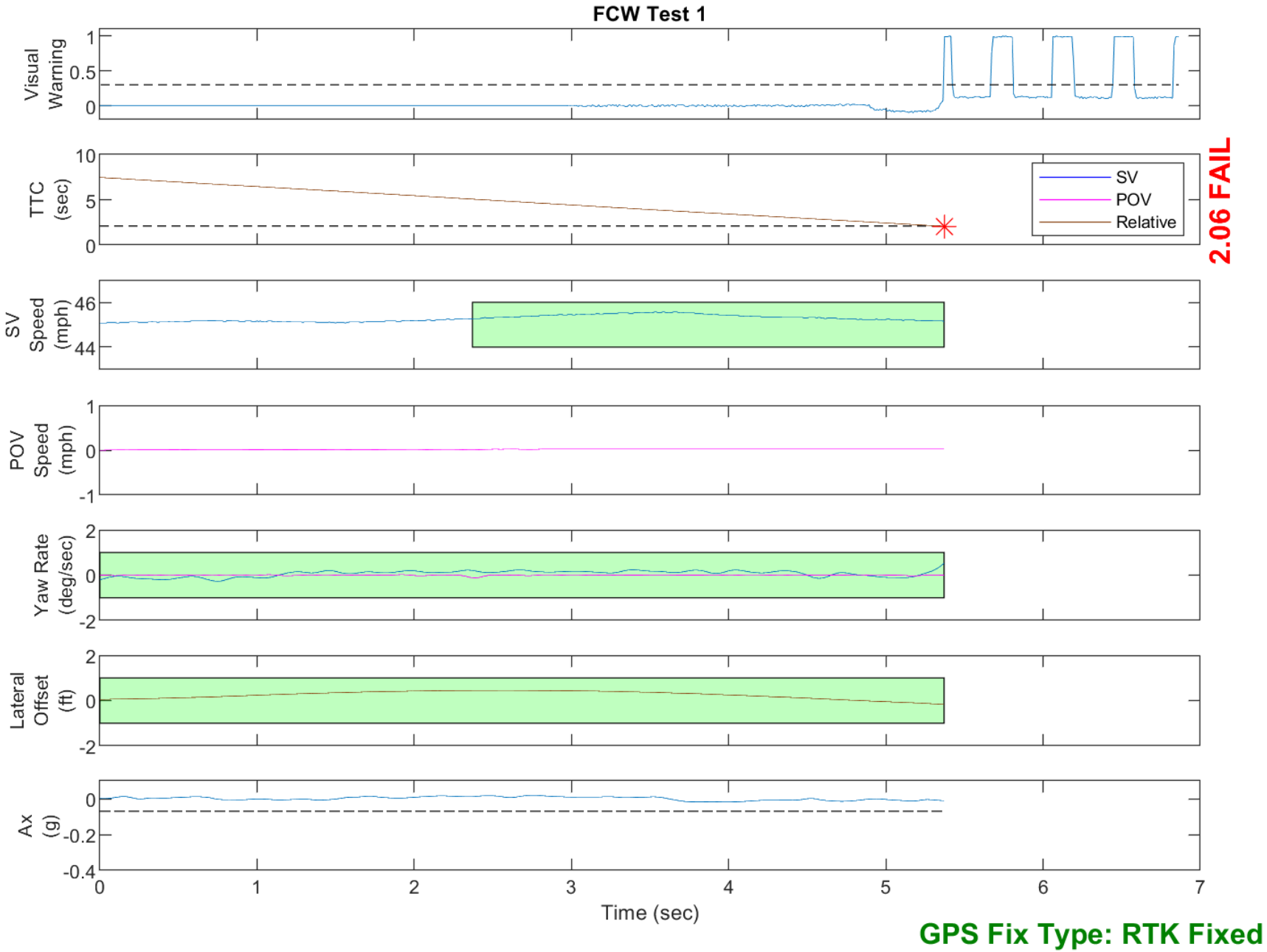


Figure D2. Example Time History for Test Type 1, Failing

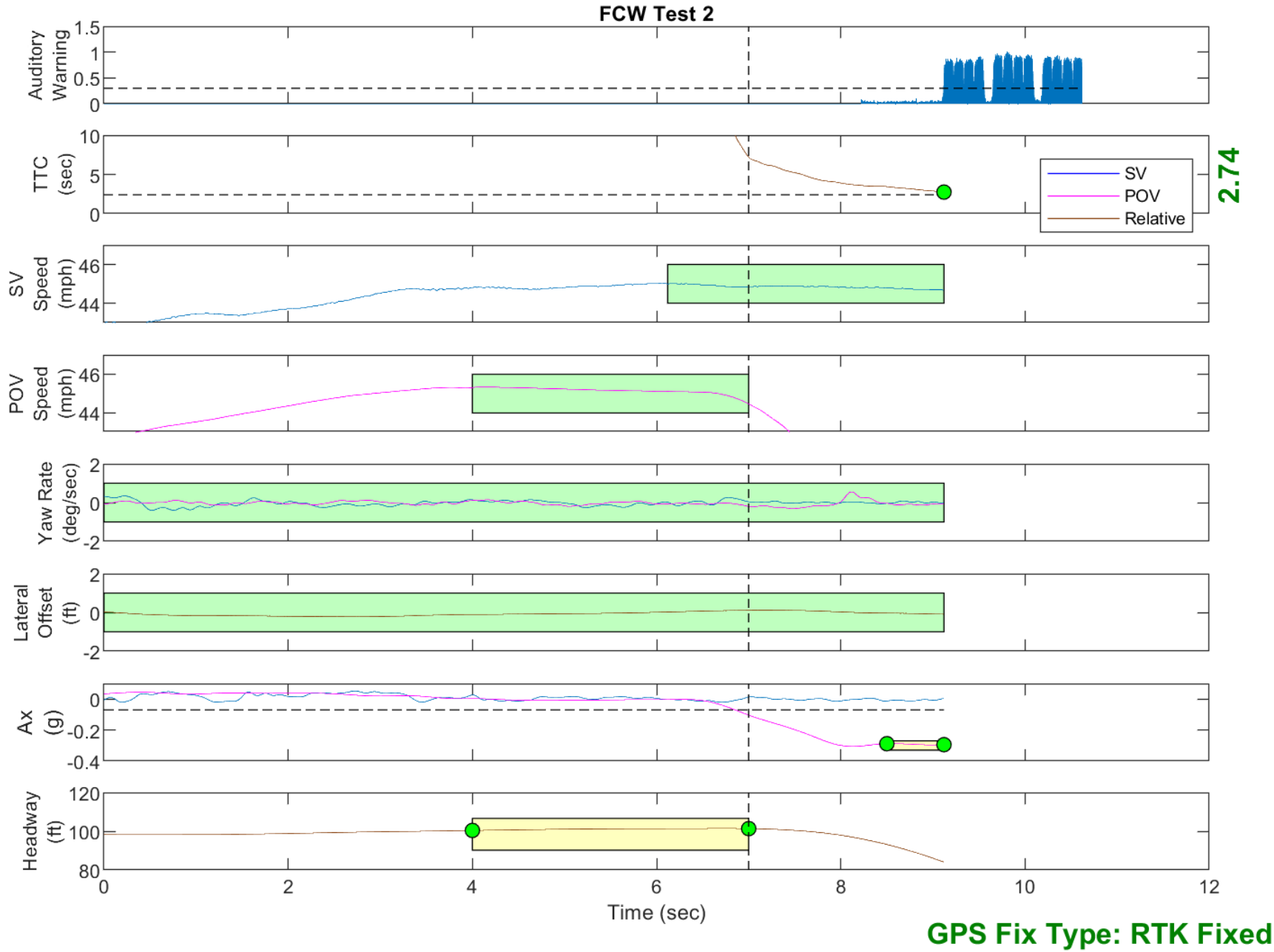


Figure D3. Example Time History for Test Type 2, Passing

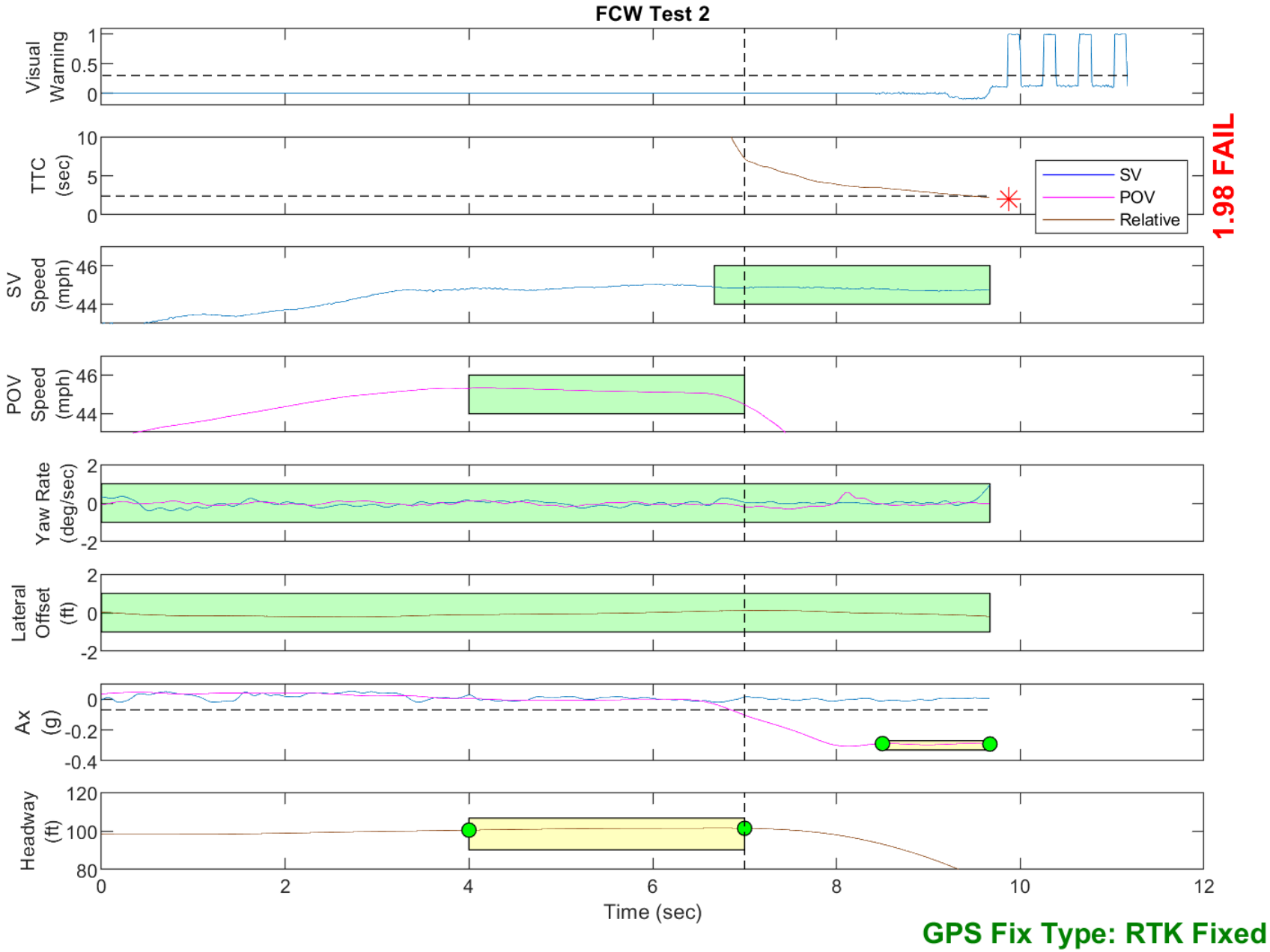


Figure D4. Example Time History for Test Type 2, Failing

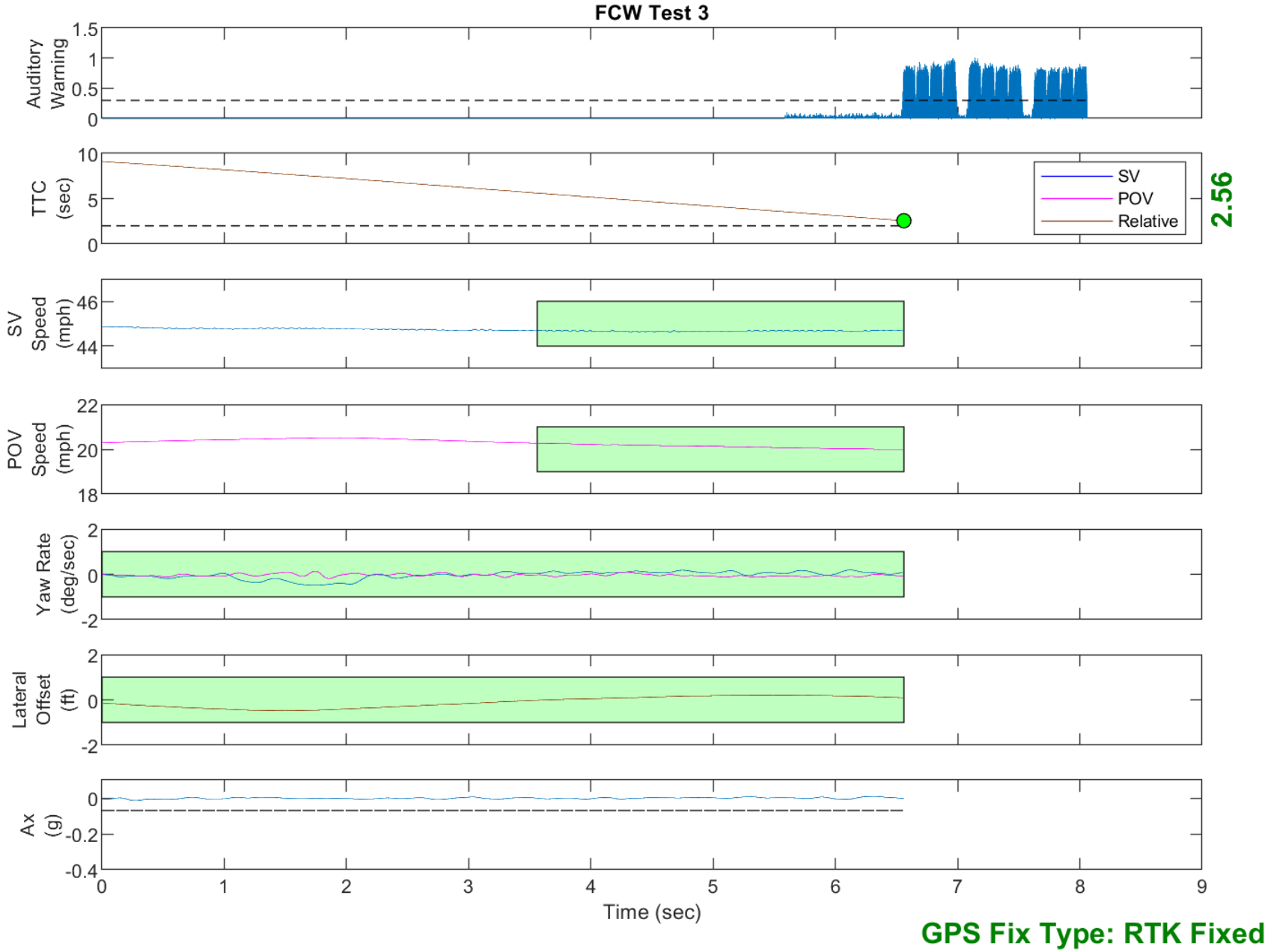


Figure D5. Example Time History for Test Type 3, Passing

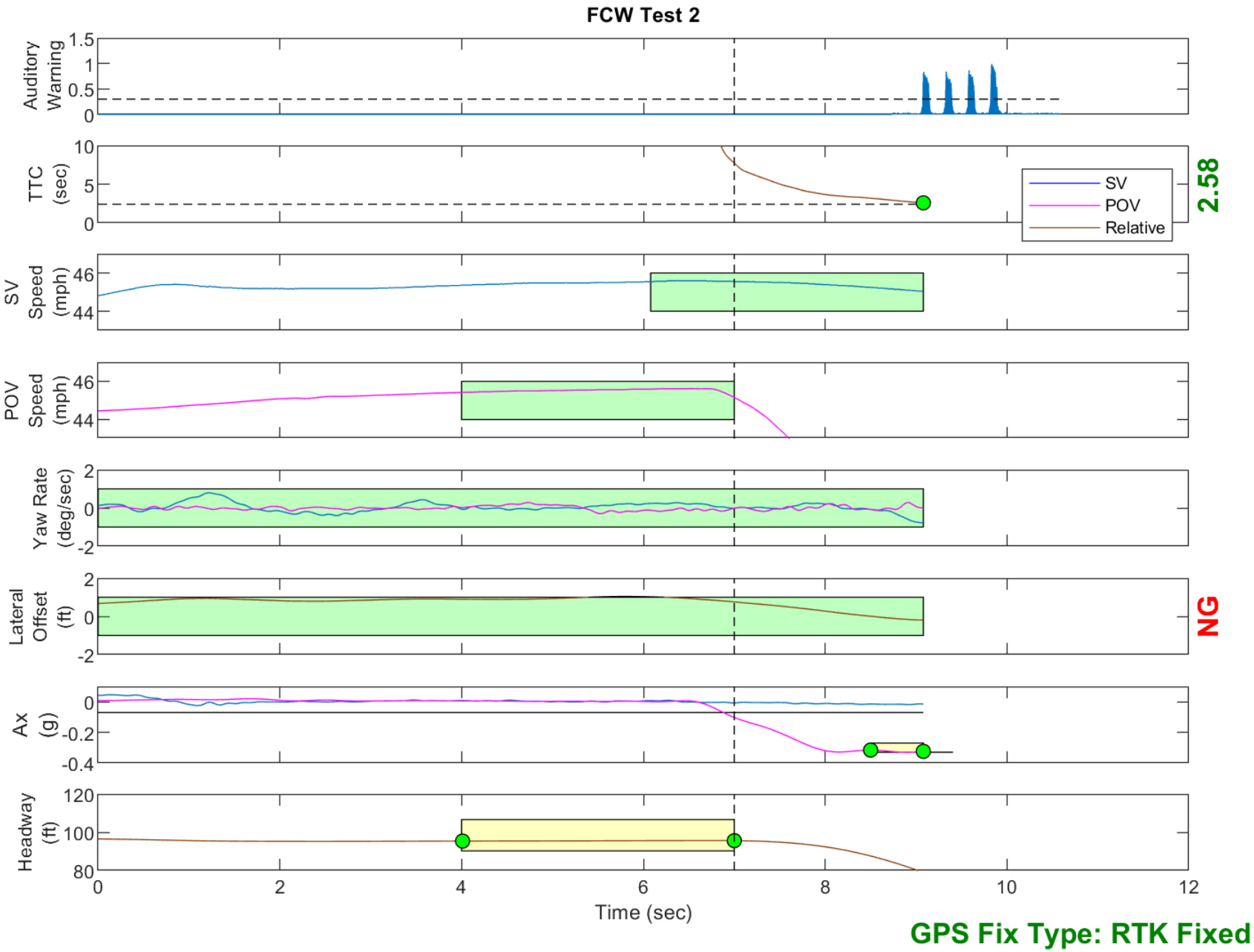


Figure D6. Example Time History Showing Invalid Lateral Offset Criteria

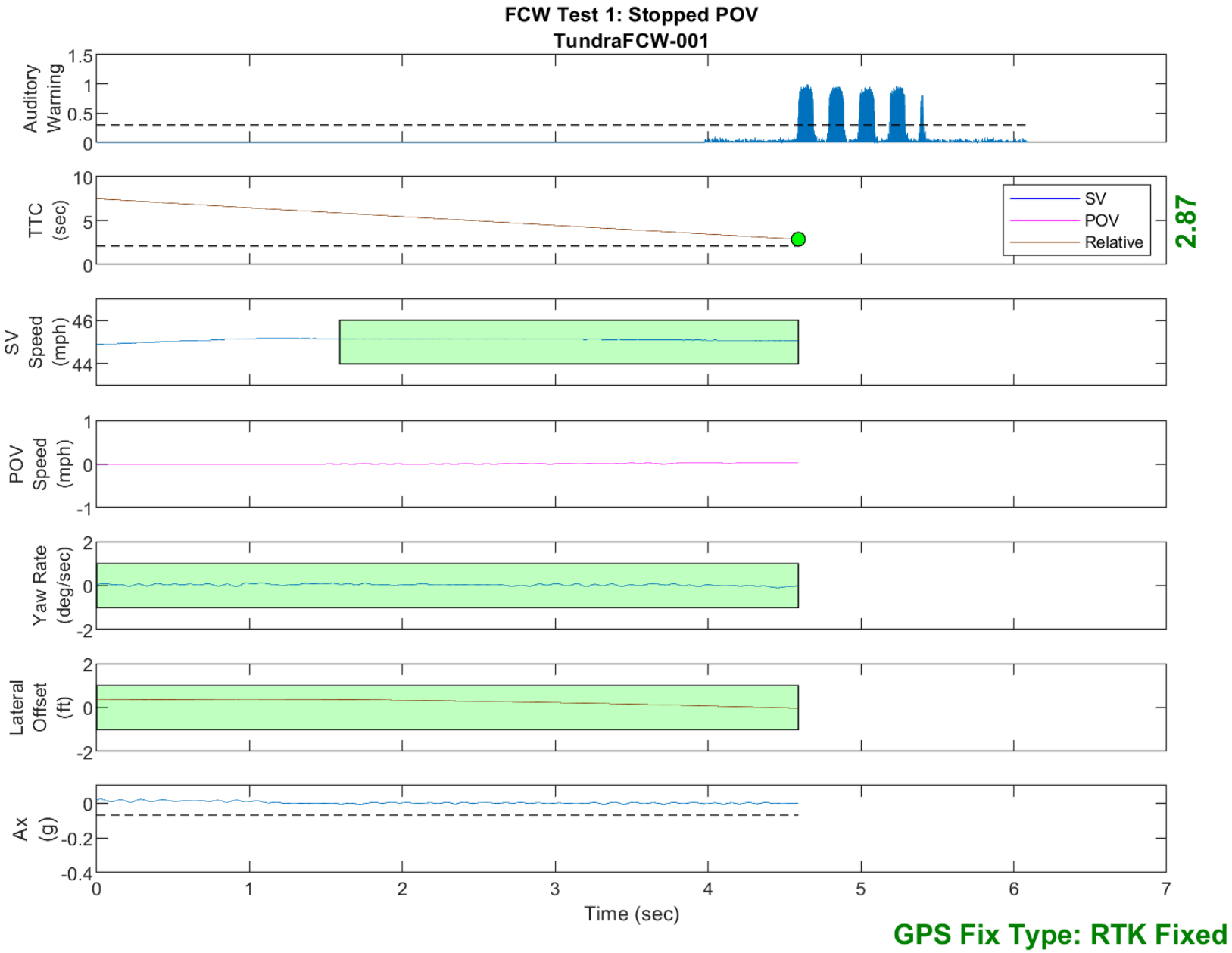


Figure D7. Time History for Run 1, Test 1 - Stopped POV, Auditory Warning

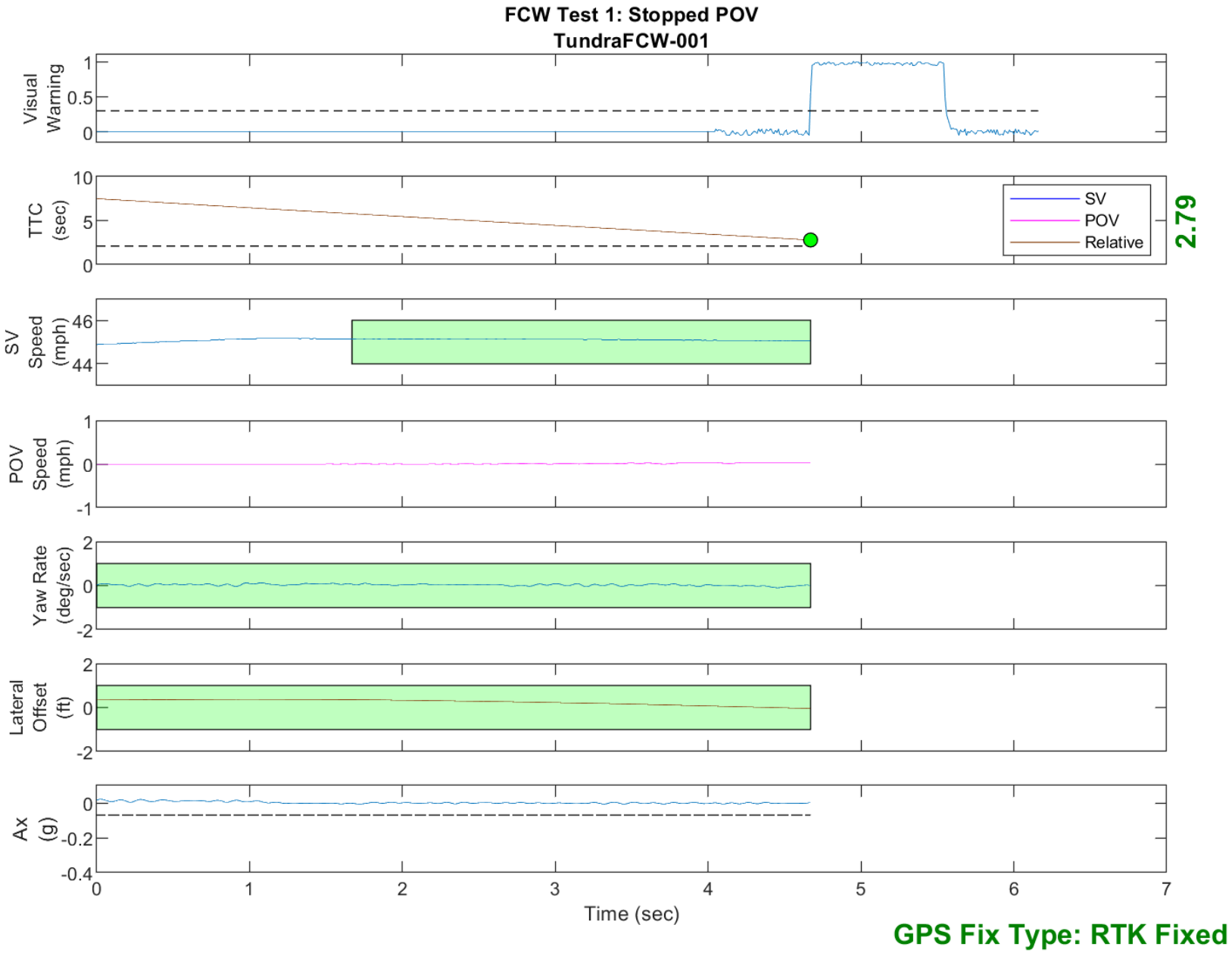


Figure D8. Time History for Run 1, Test 1 - Stopped POV, Visual Warning

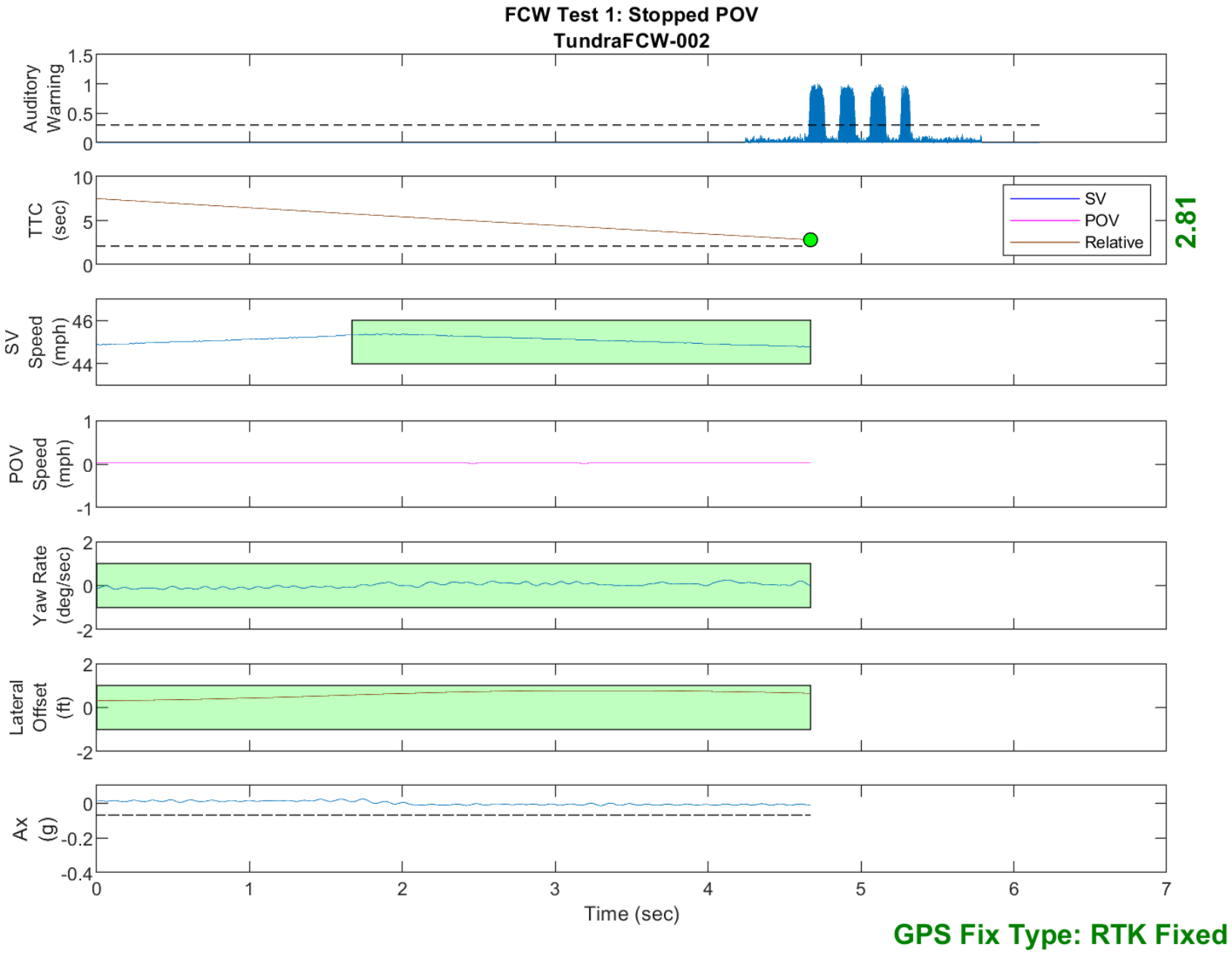


Figure D9. Time History for Run 2, Test 1 - Stopped POV, Auditory Warning

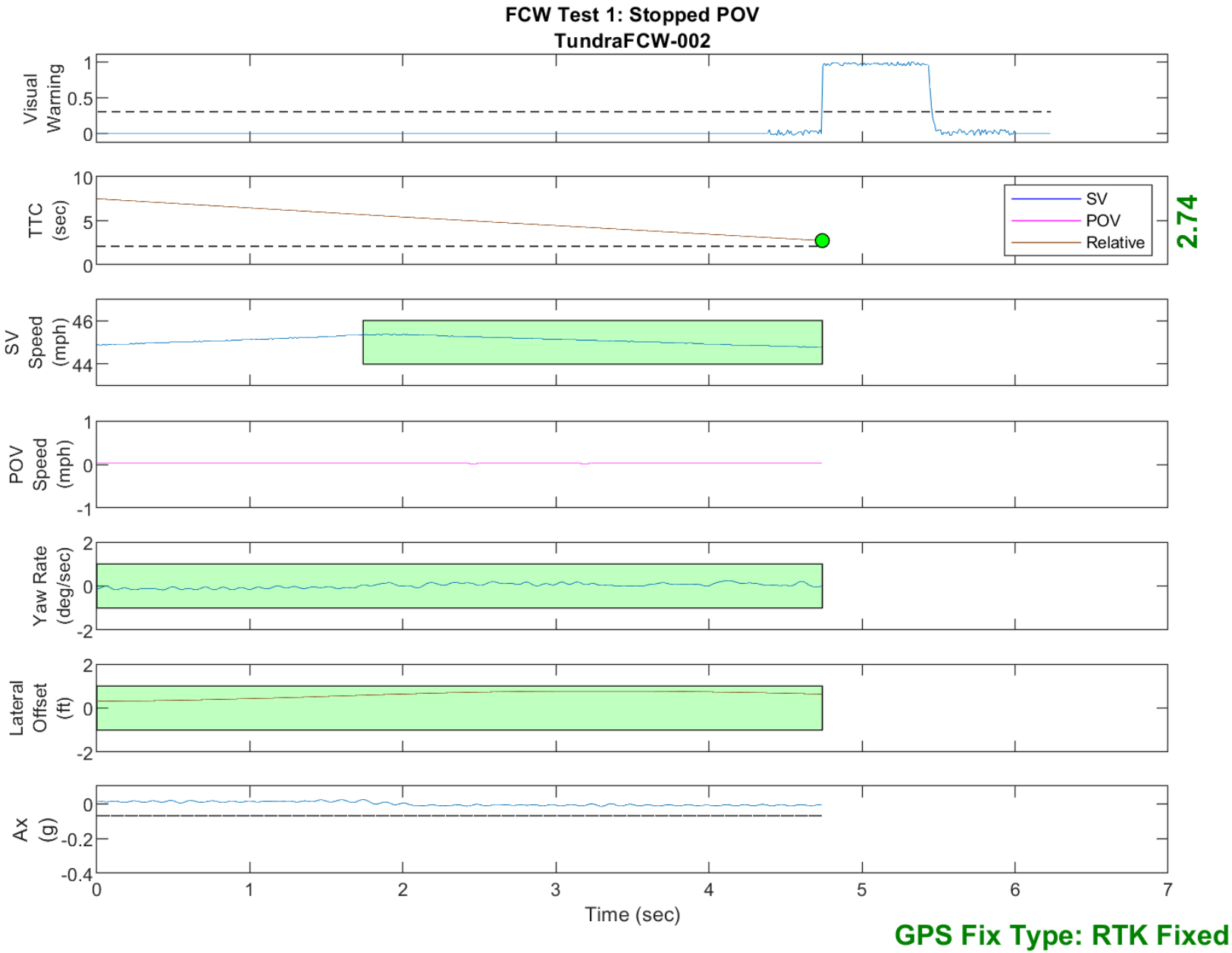


Figure D10. Time History for Run 2, Test 1 - Stopped POV, Visual Warning

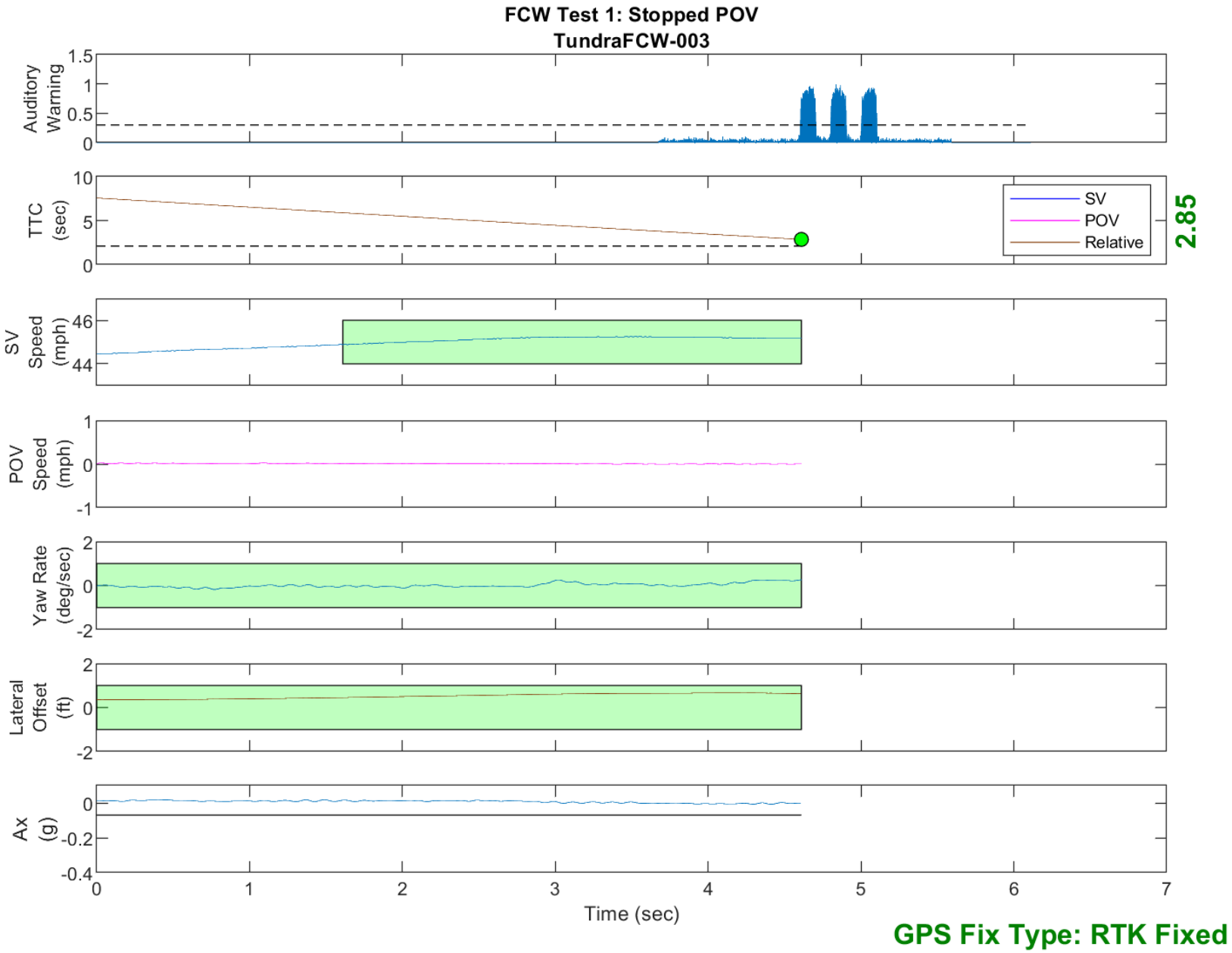


Figure D11. Time History for Run 3, Test 1 - Stopped POV, Auditory Warning

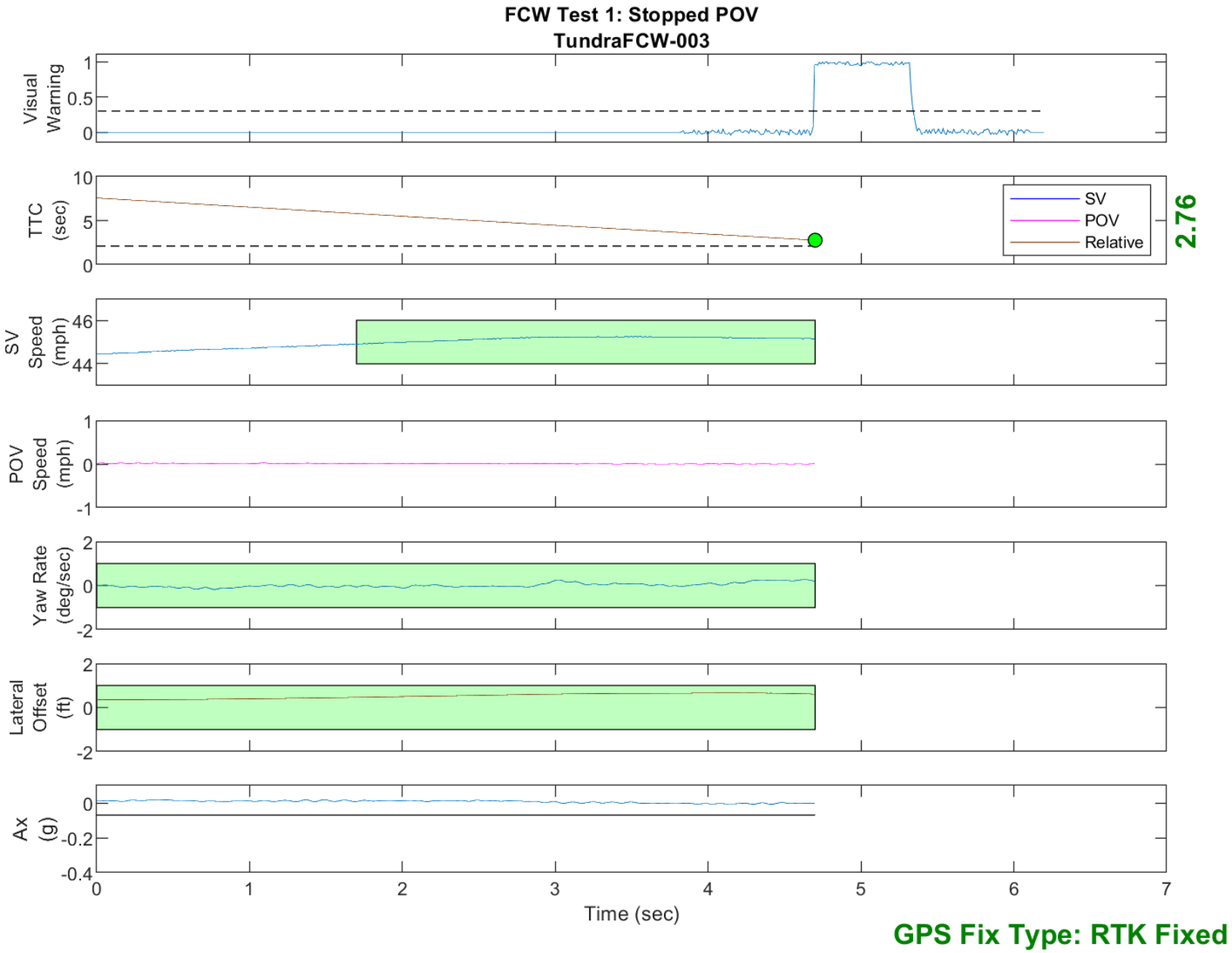


Figure D12. Time History for Run 3, Test 1 - Stopped POV, Visual Warning

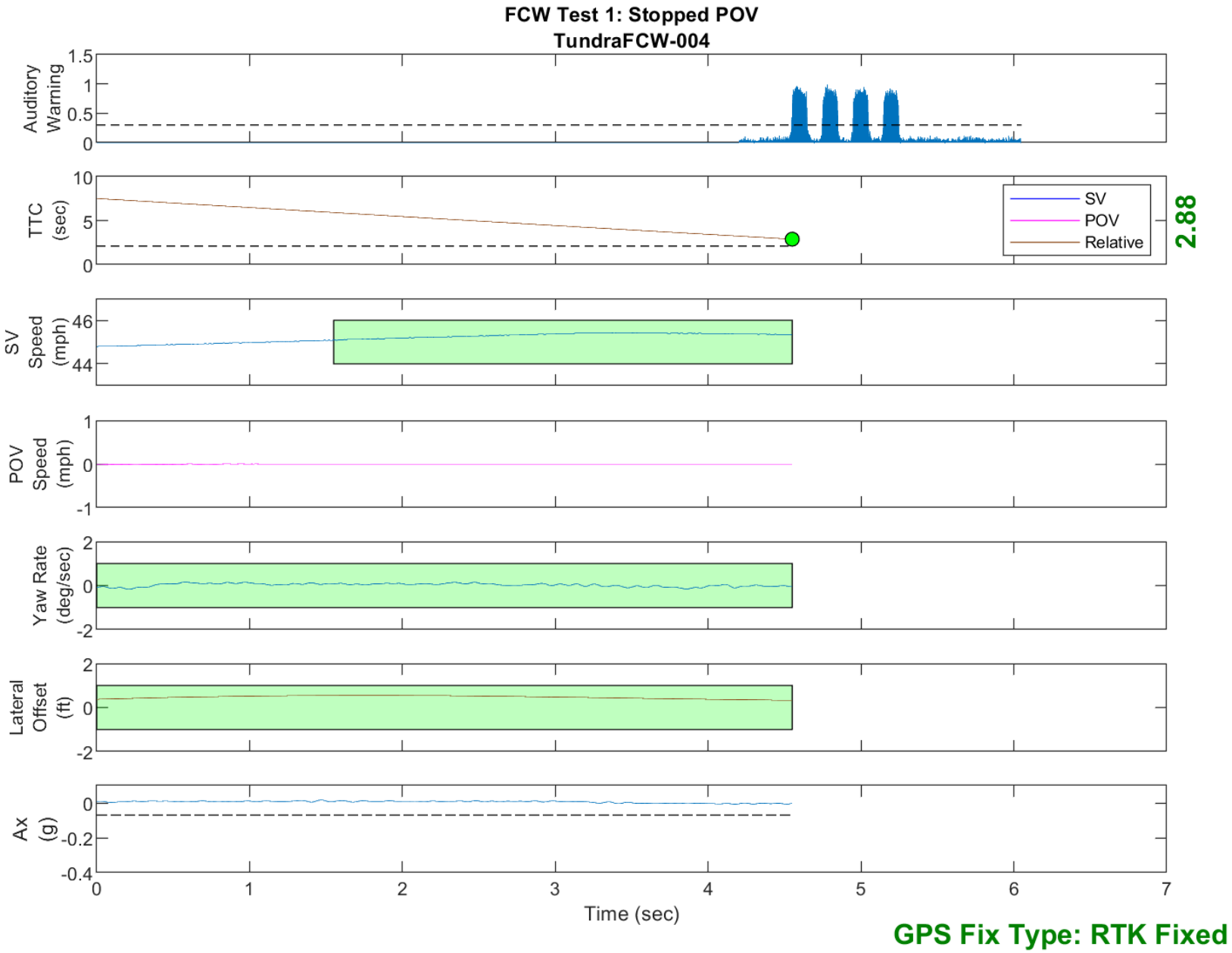


Figure D13. Time History for Run 4, Test 1 - Stopped POV, Auditory Warning

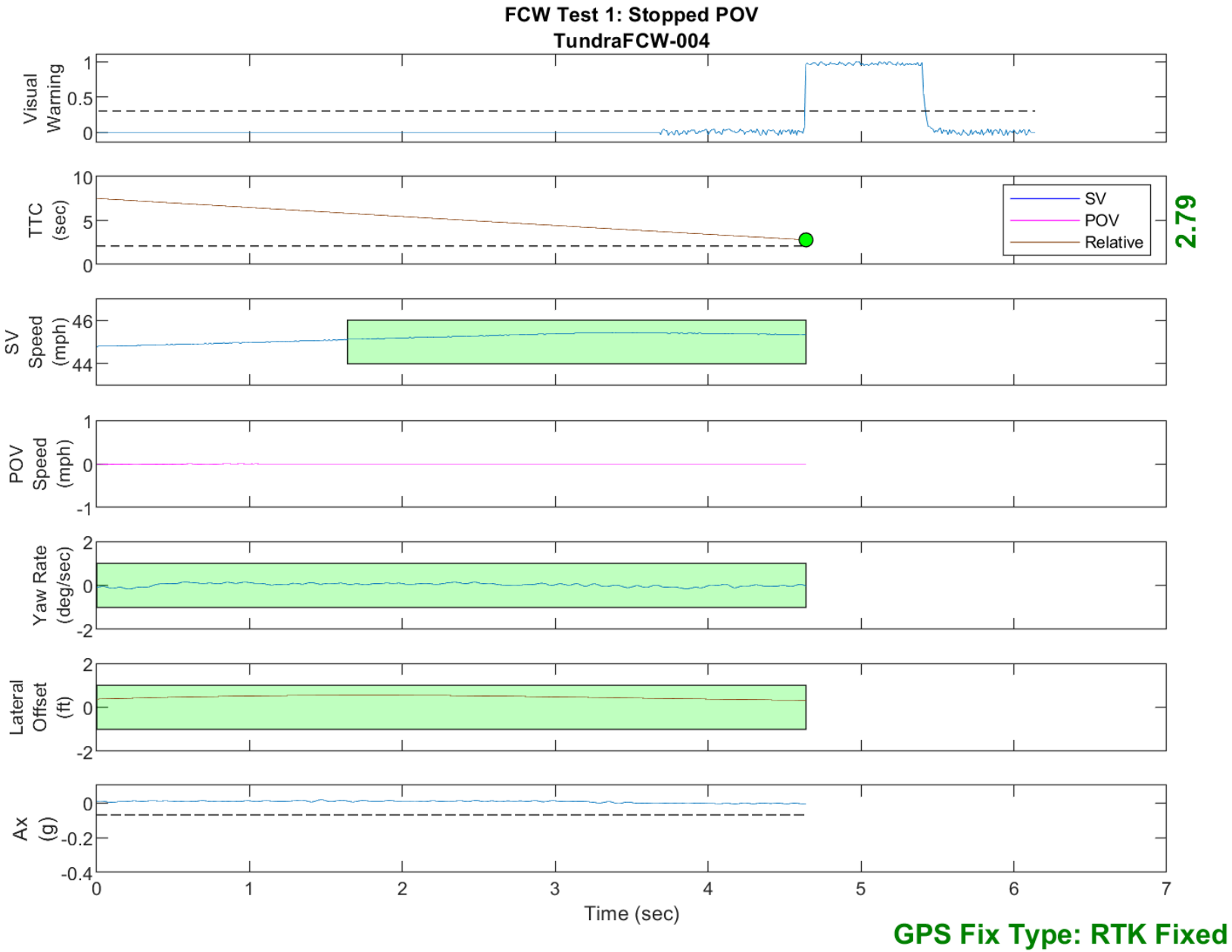


Figure D14. Time History for Run 4, Test 1 - Stopped POV, Visual Warning

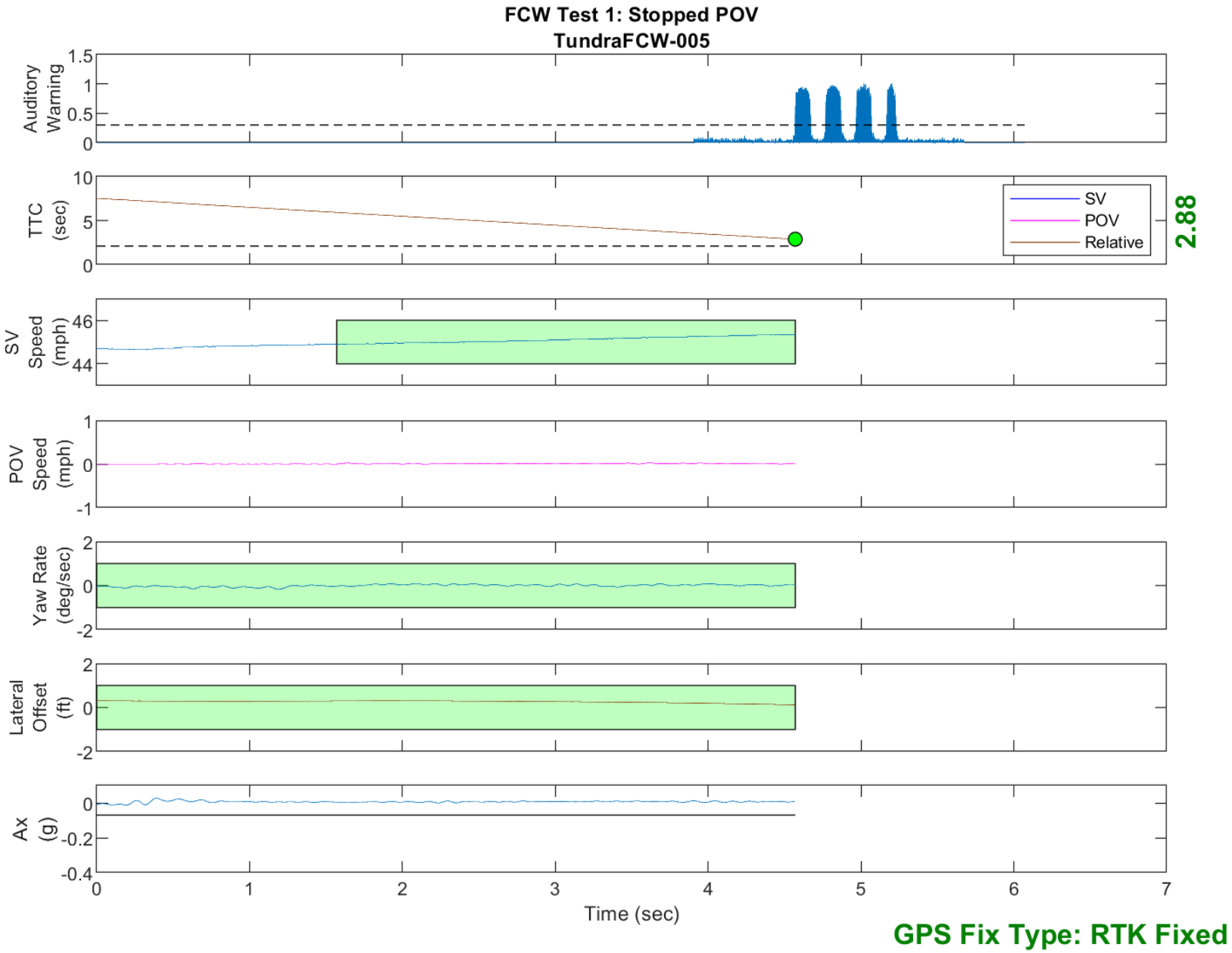


Figure D15. Time History for Run 5, Test 1 - Stopped POV, Auditory Warning

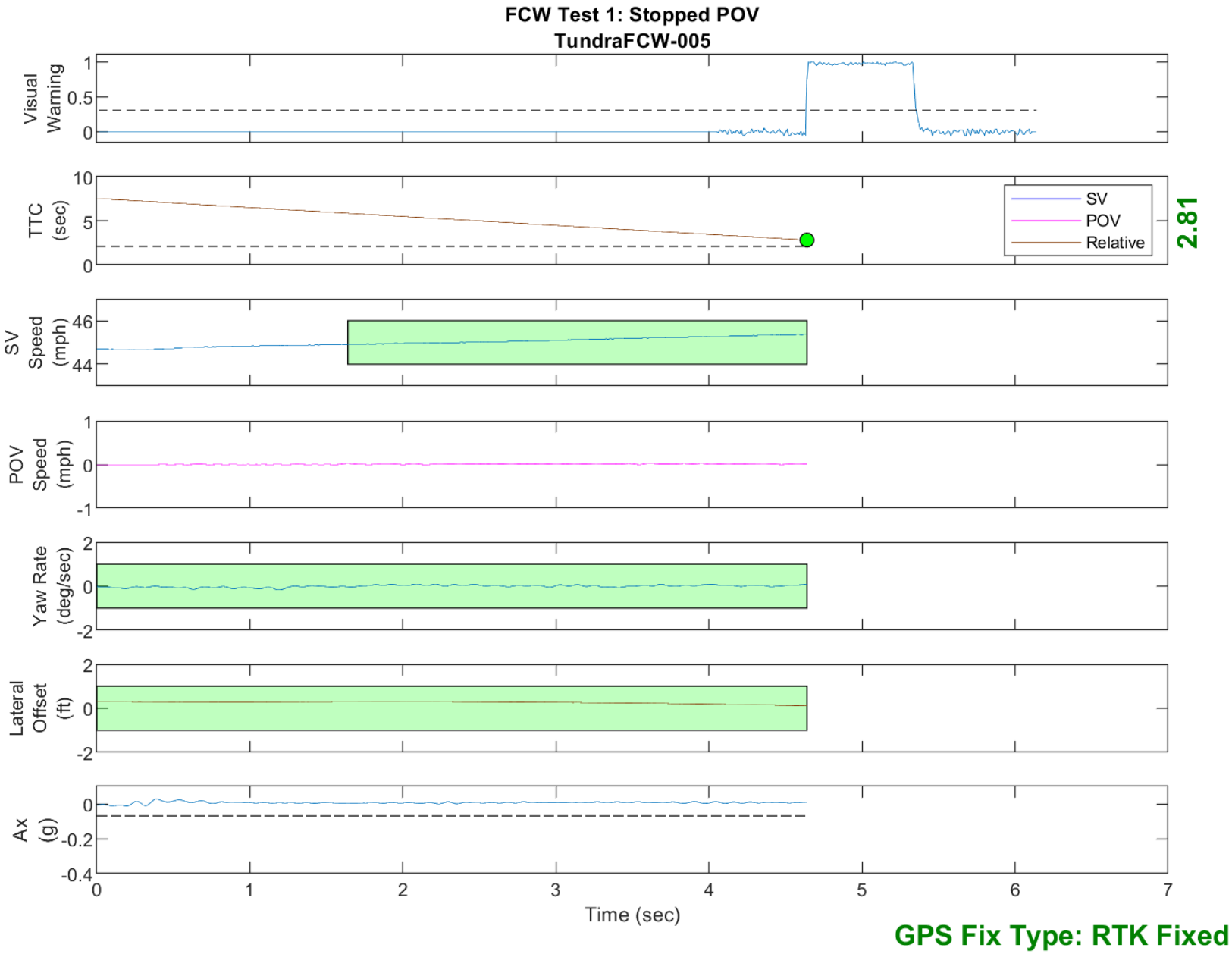


Figure D16. Time History for Run 5, Test 1 - Stopped POV, Visual Warning

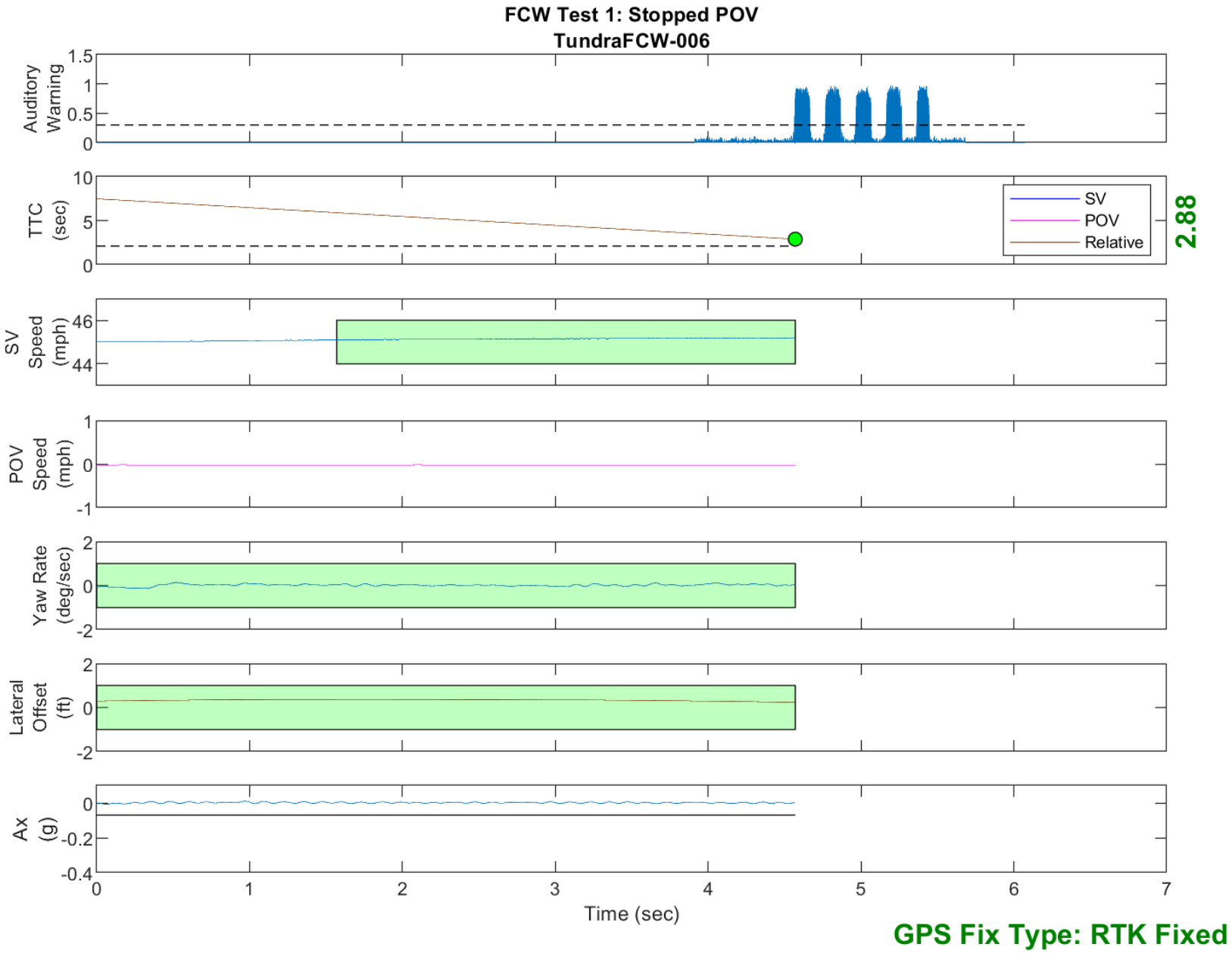


Figure D17. Time History for Run 6, Test 1 - Stopped POV, Auditory Warning

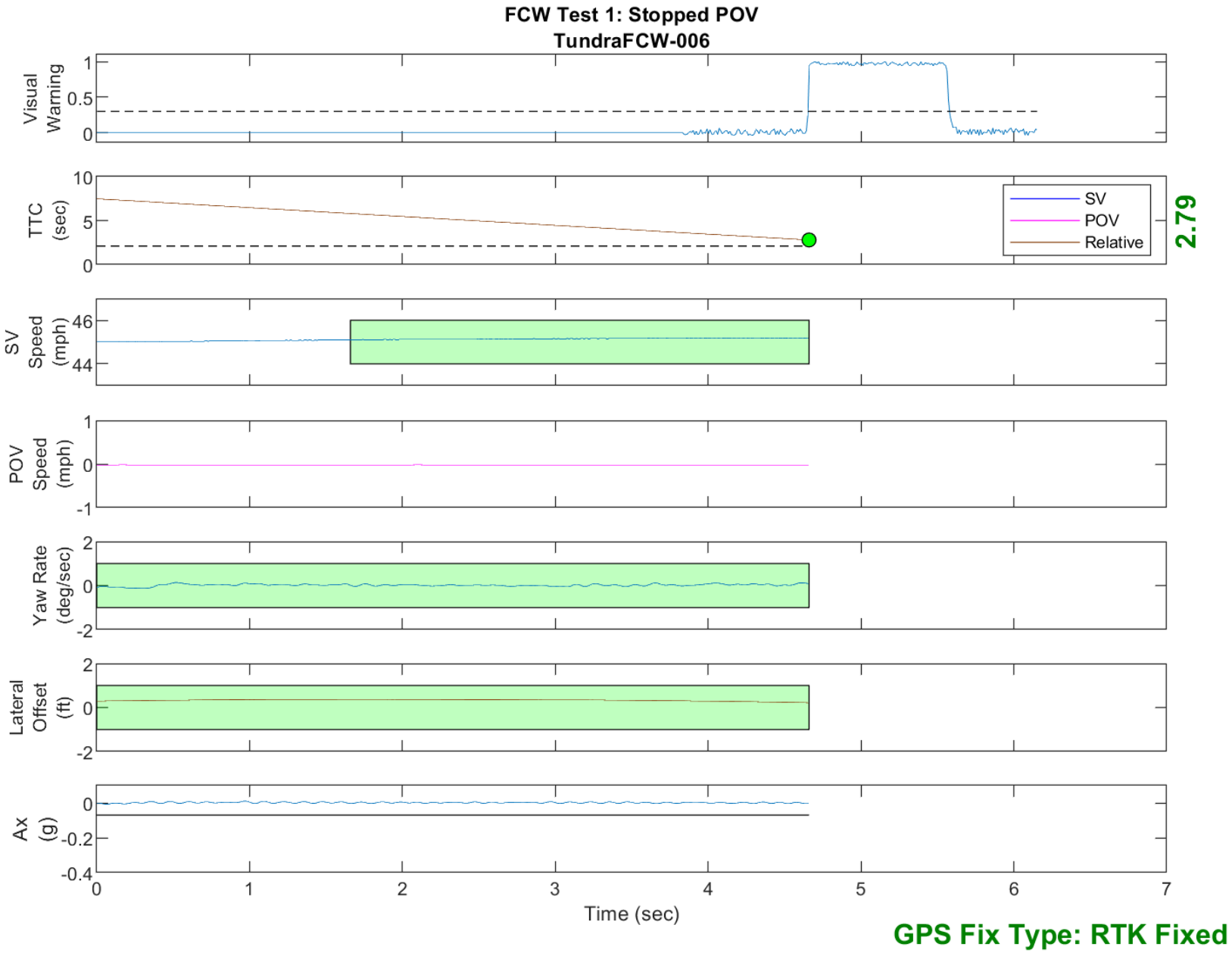


Figure D18. Time History for Run 6, Test 1 - Stopped POV, Visual Warning

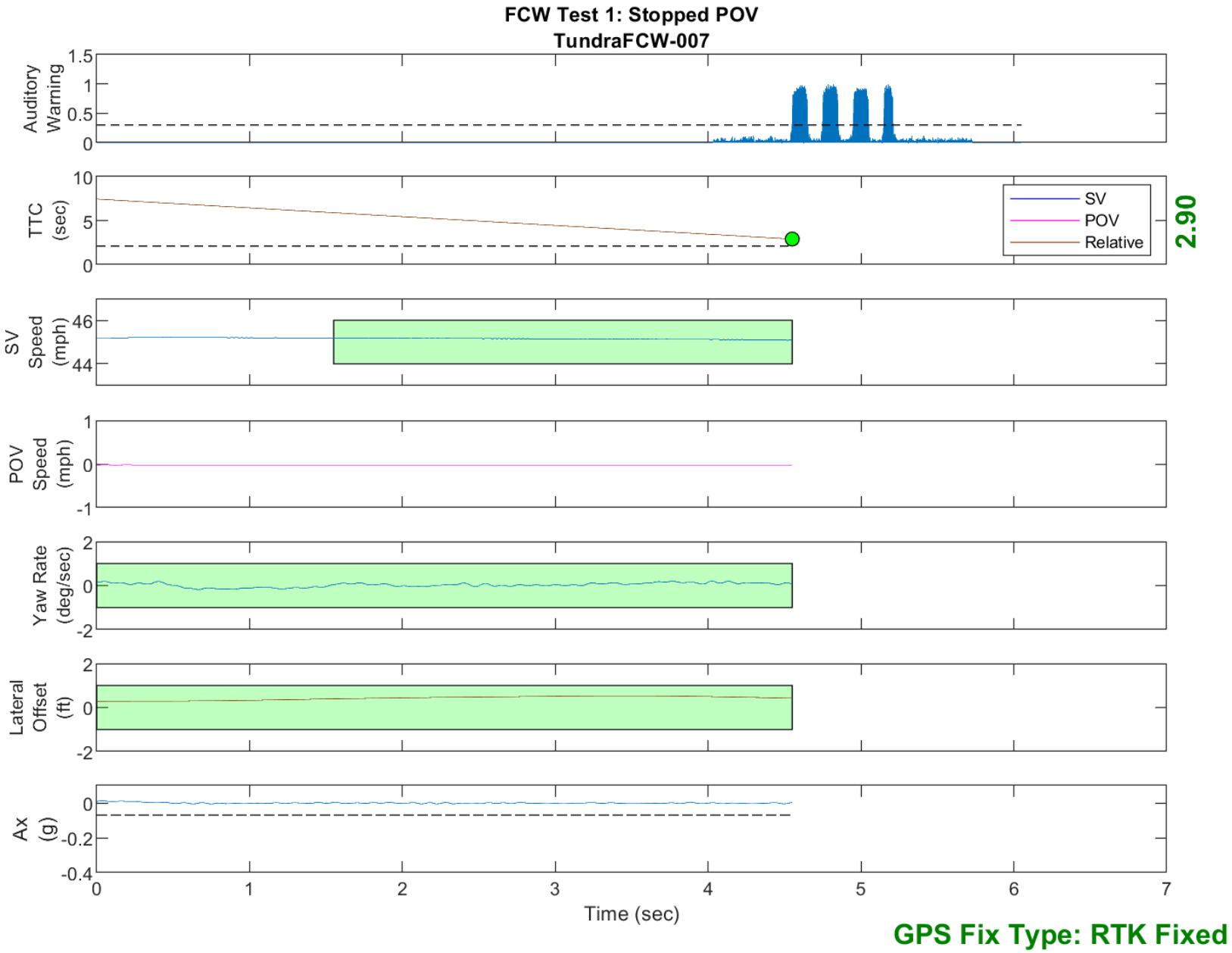


Figure D19. Time History for Run 7, Test 1 - Stopped POV, Auditory Warning

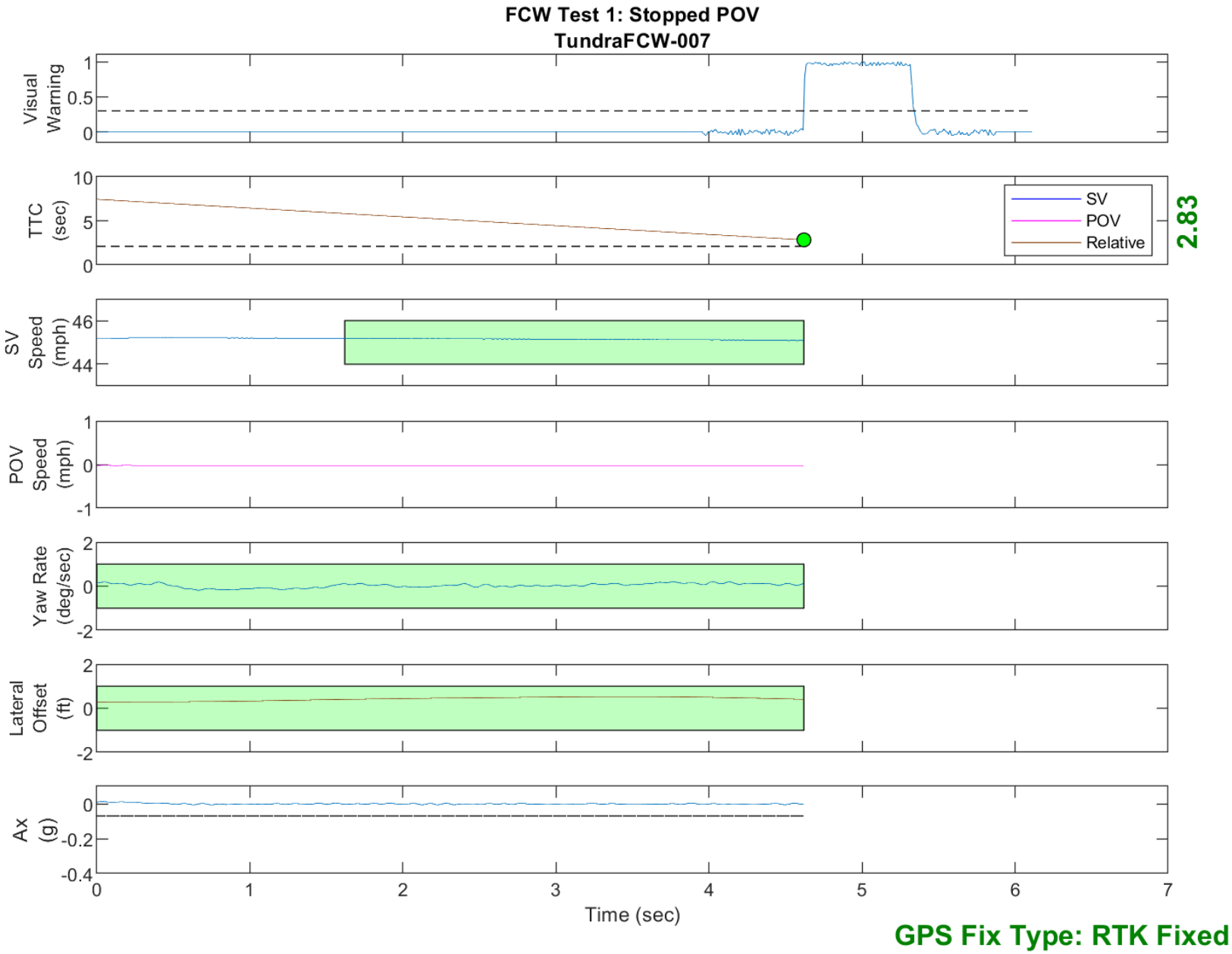


Figure D20. Time History for Run 7, Test 1 - Stopped POV, Visual Warning

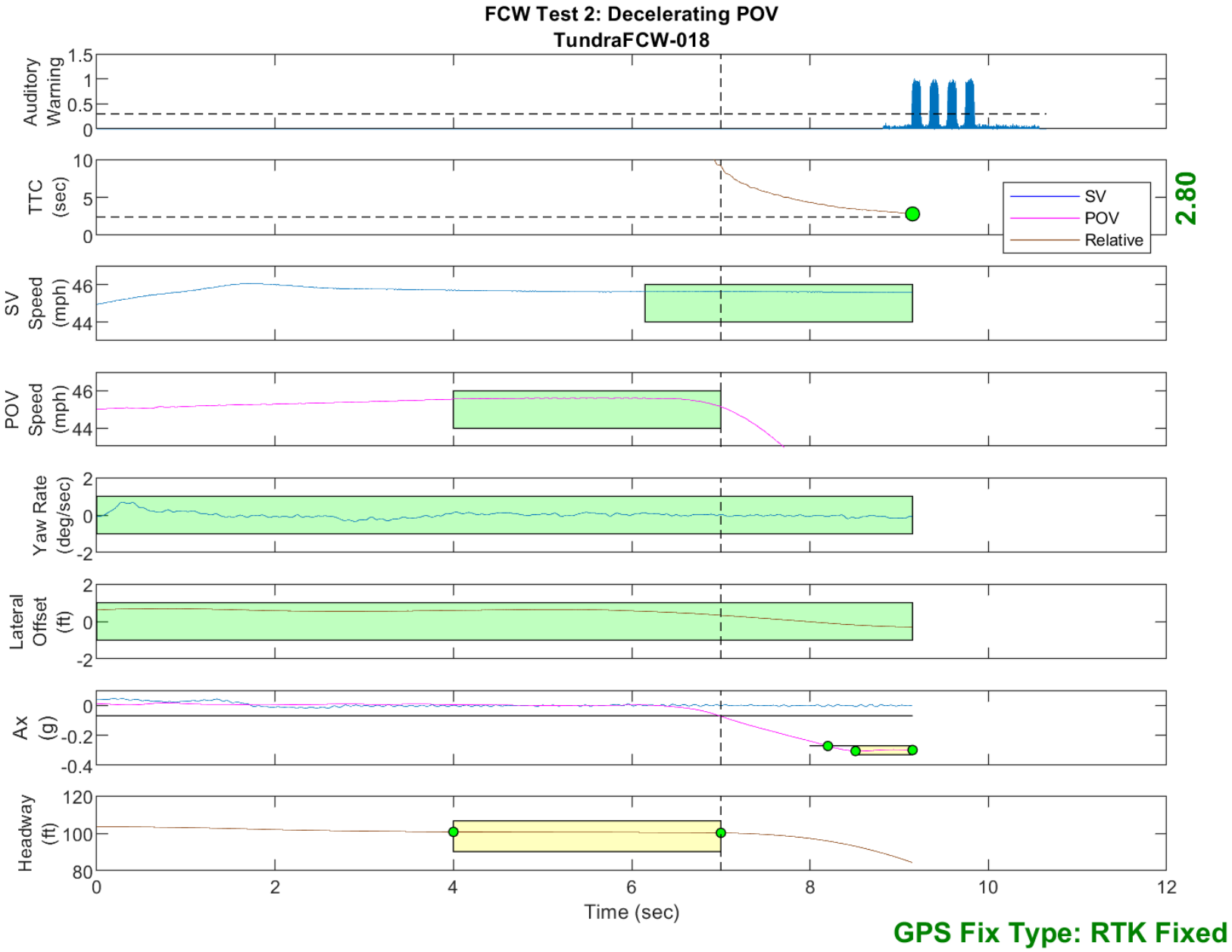


Figure D21. Time History for Run 18, Test 2 - Decelerating POV, Auditory Warning

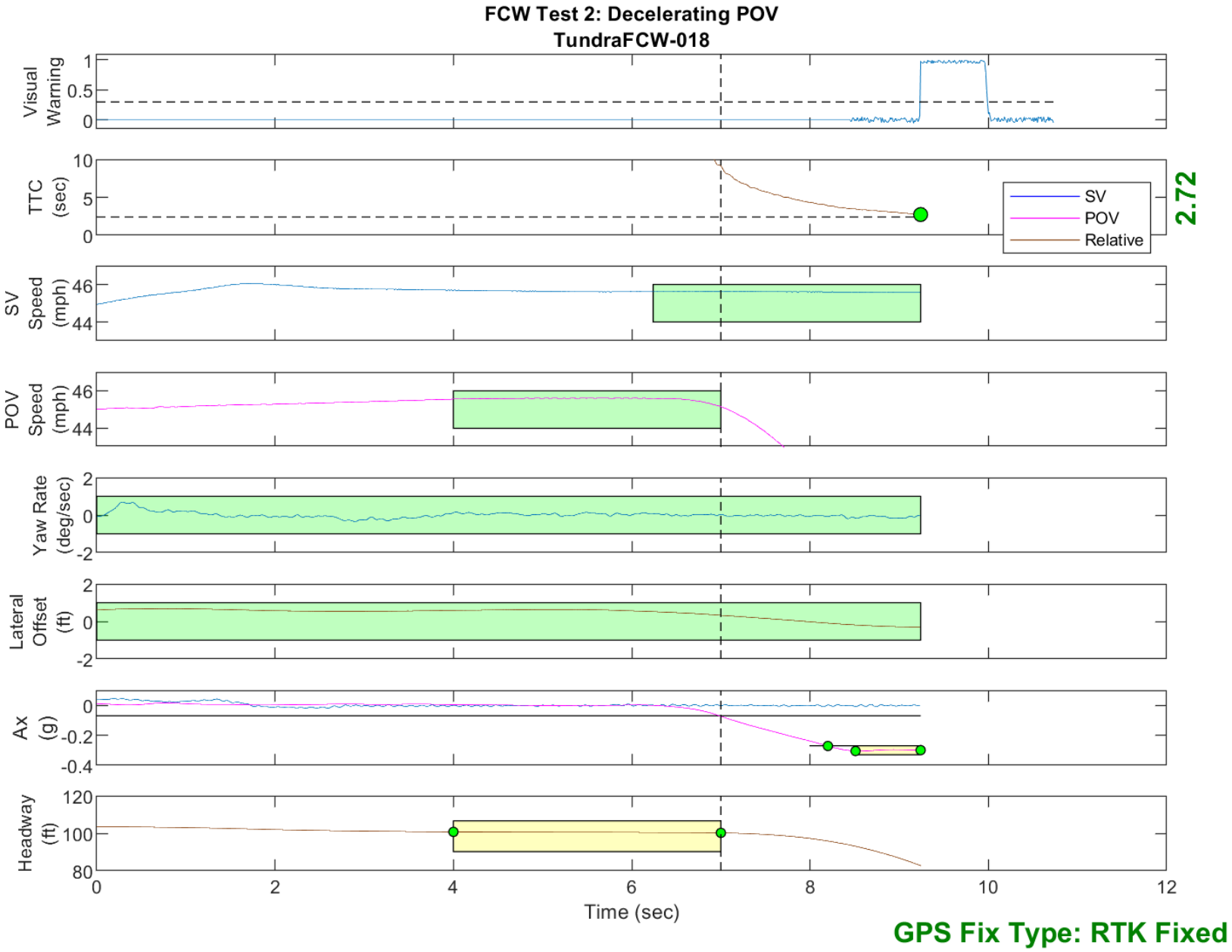


Figure D22. Time History for Run 18, Test 2 - Decelerating POV, Visual Warning

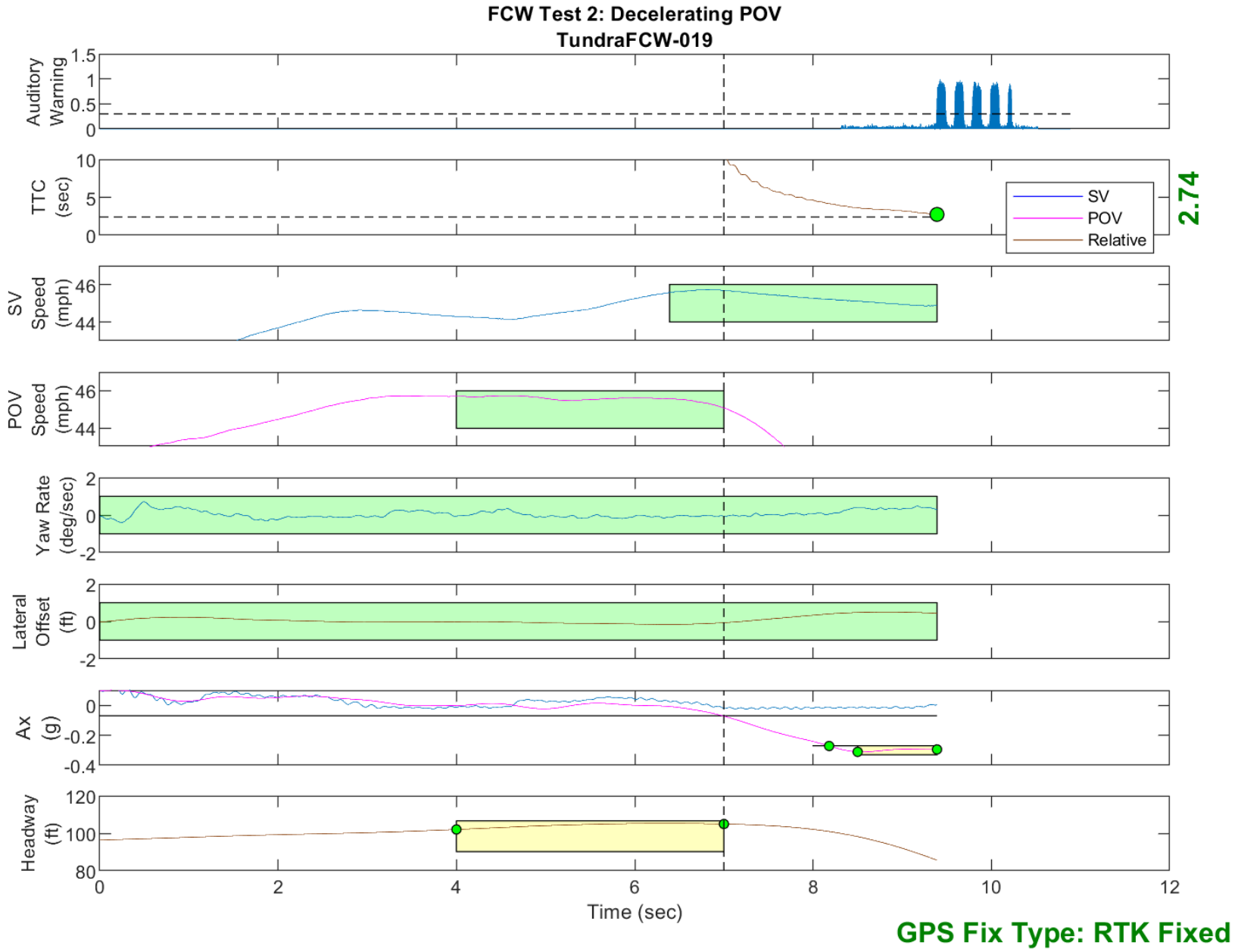


Figure D23. Time History for Run 19, Test 2 - Decelerating POV, Auditory Warning

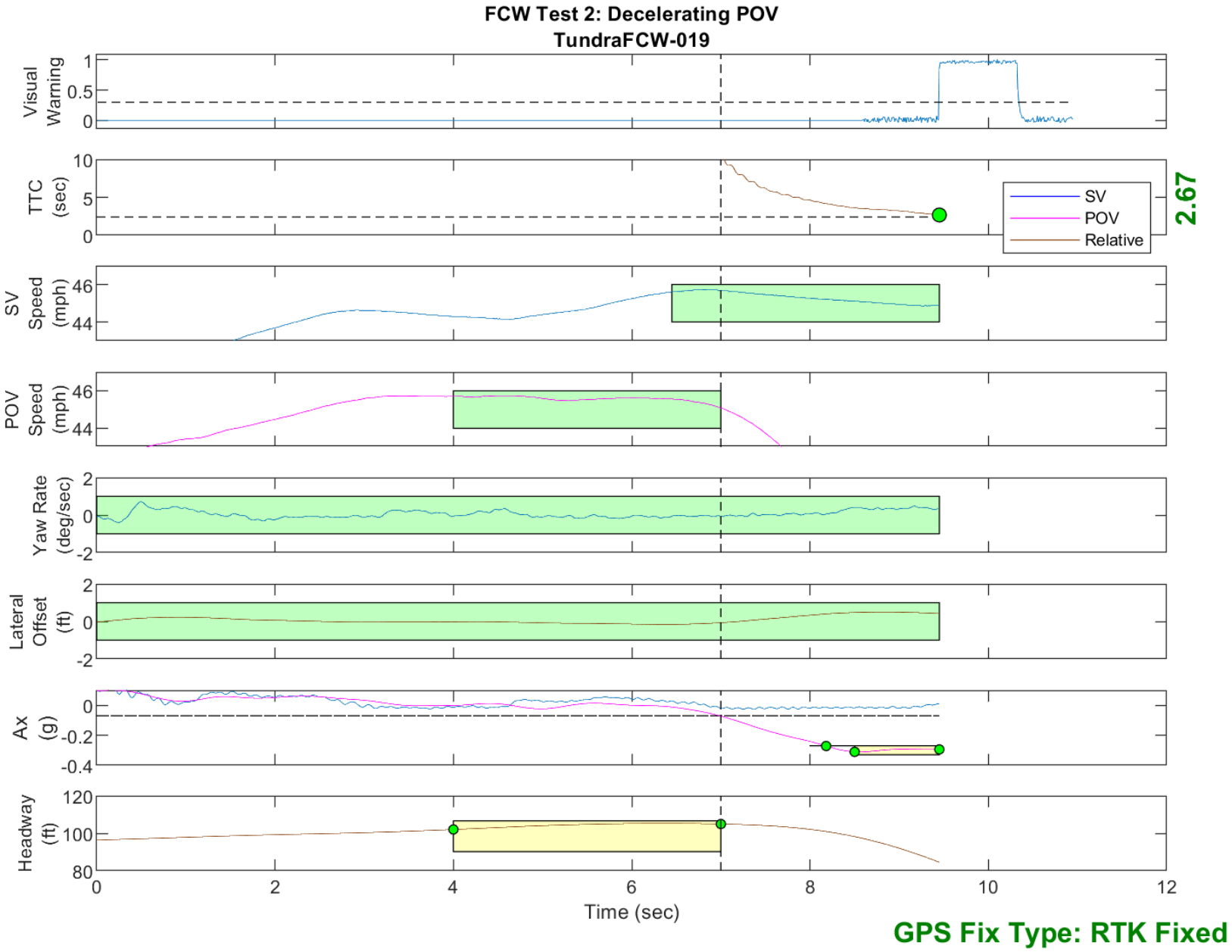


Figure D24. Time History for Run 19, Test 2 - Decelerating POV, Visual Warning

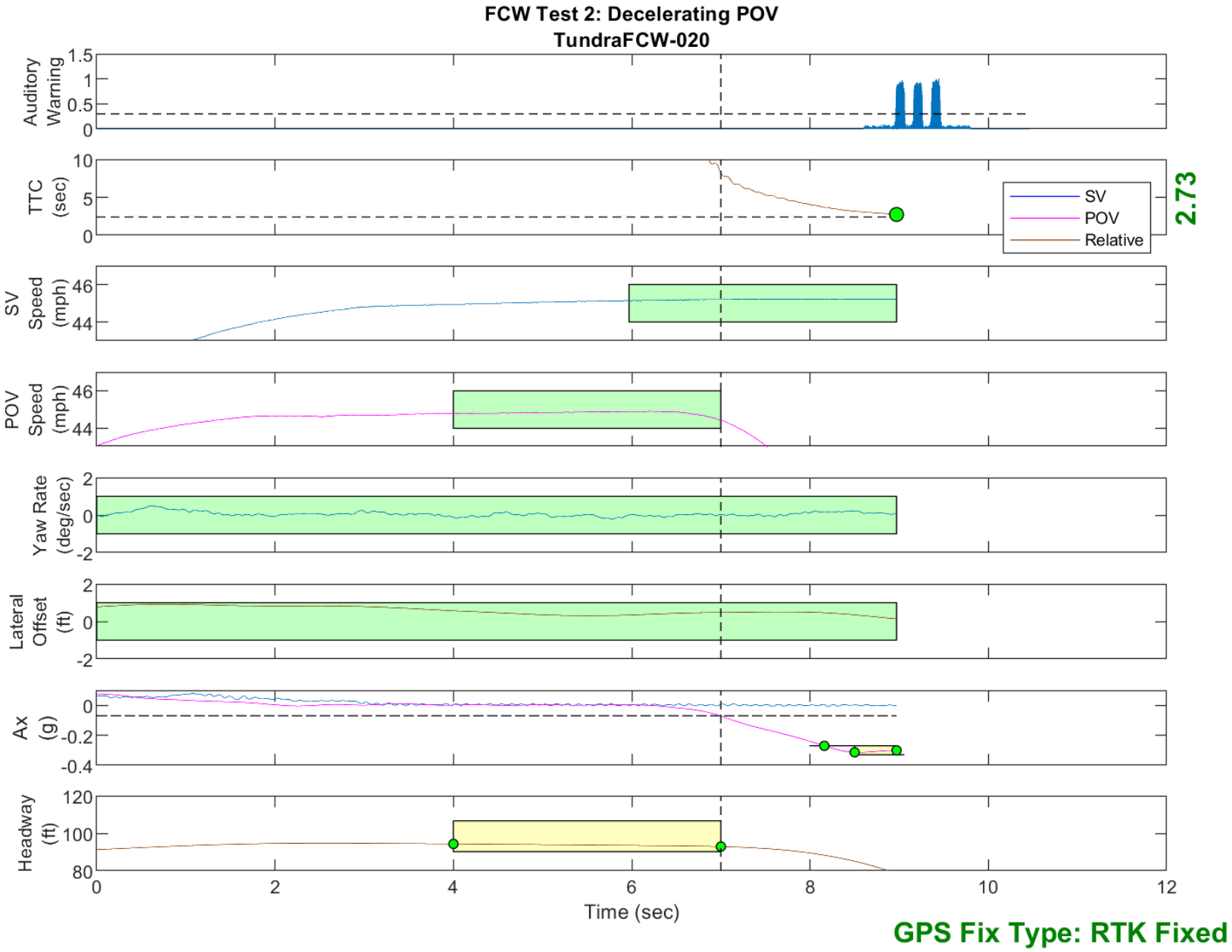


Figure D25. Time History for Run 20, Test 2 - Decelerating POV, Auditory Warning

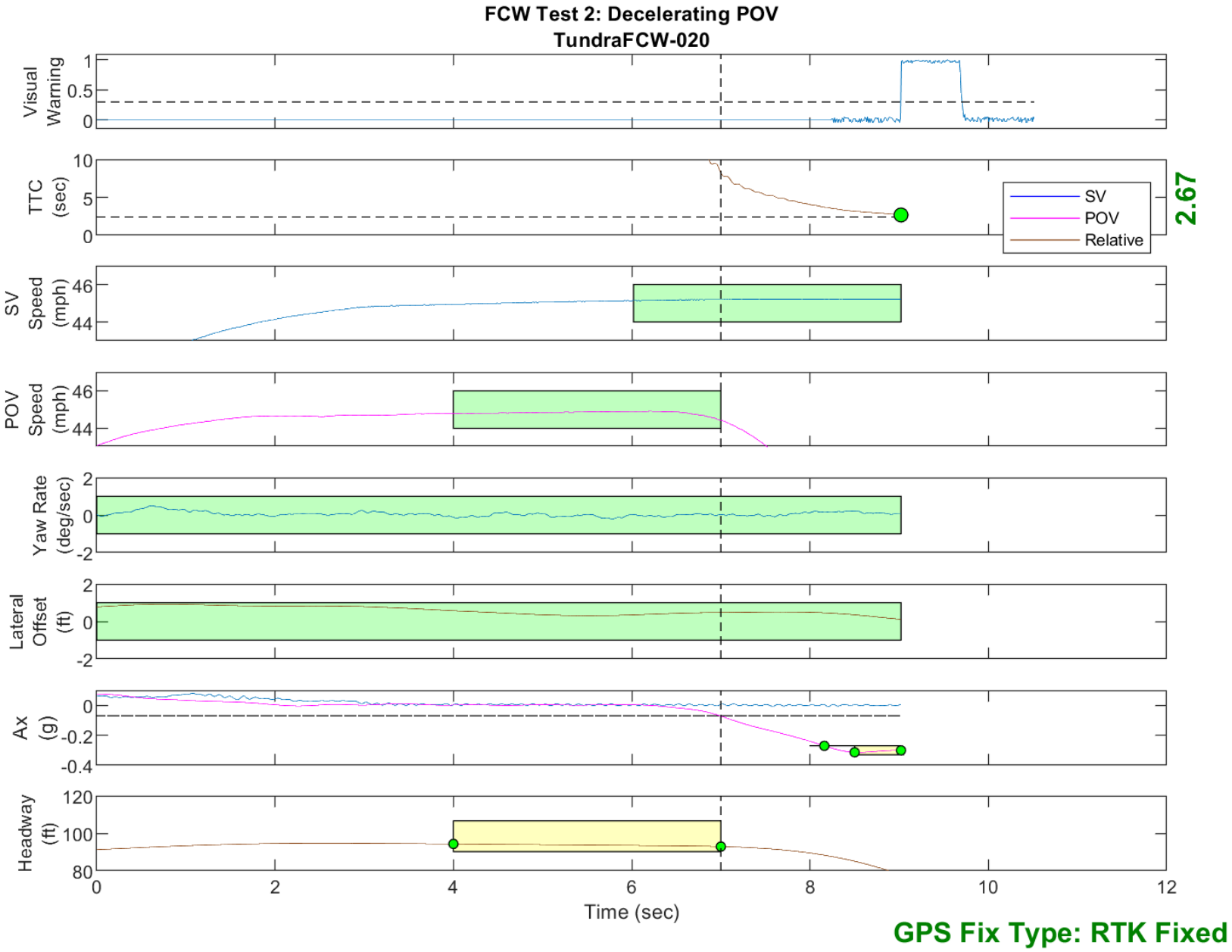


Figure D26. Time History for Run 20, Test 2 - Decelerating POV, Visual Warning

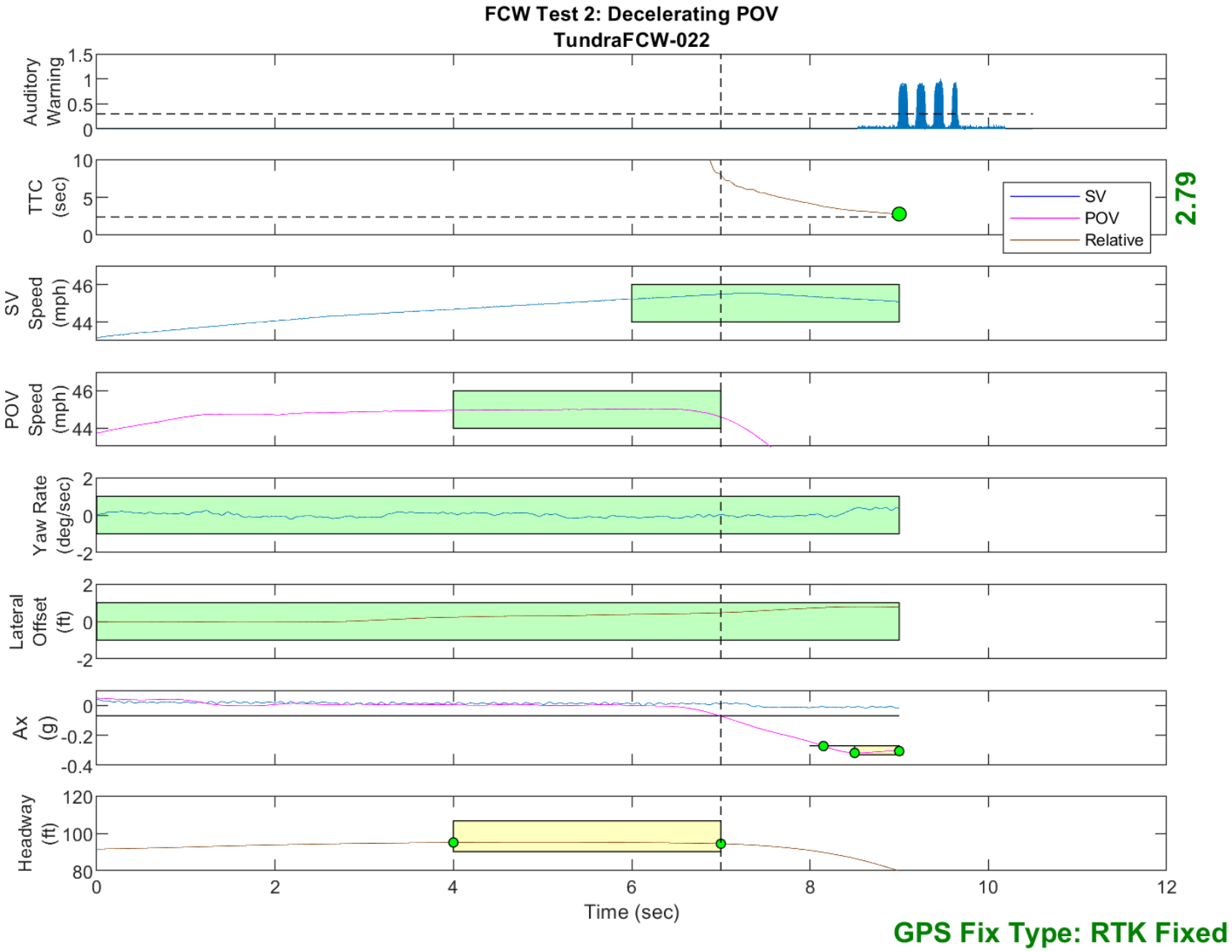


Figure D27. Time History for Run 22, Test 2 - Decelerating POV, Auditory Warning

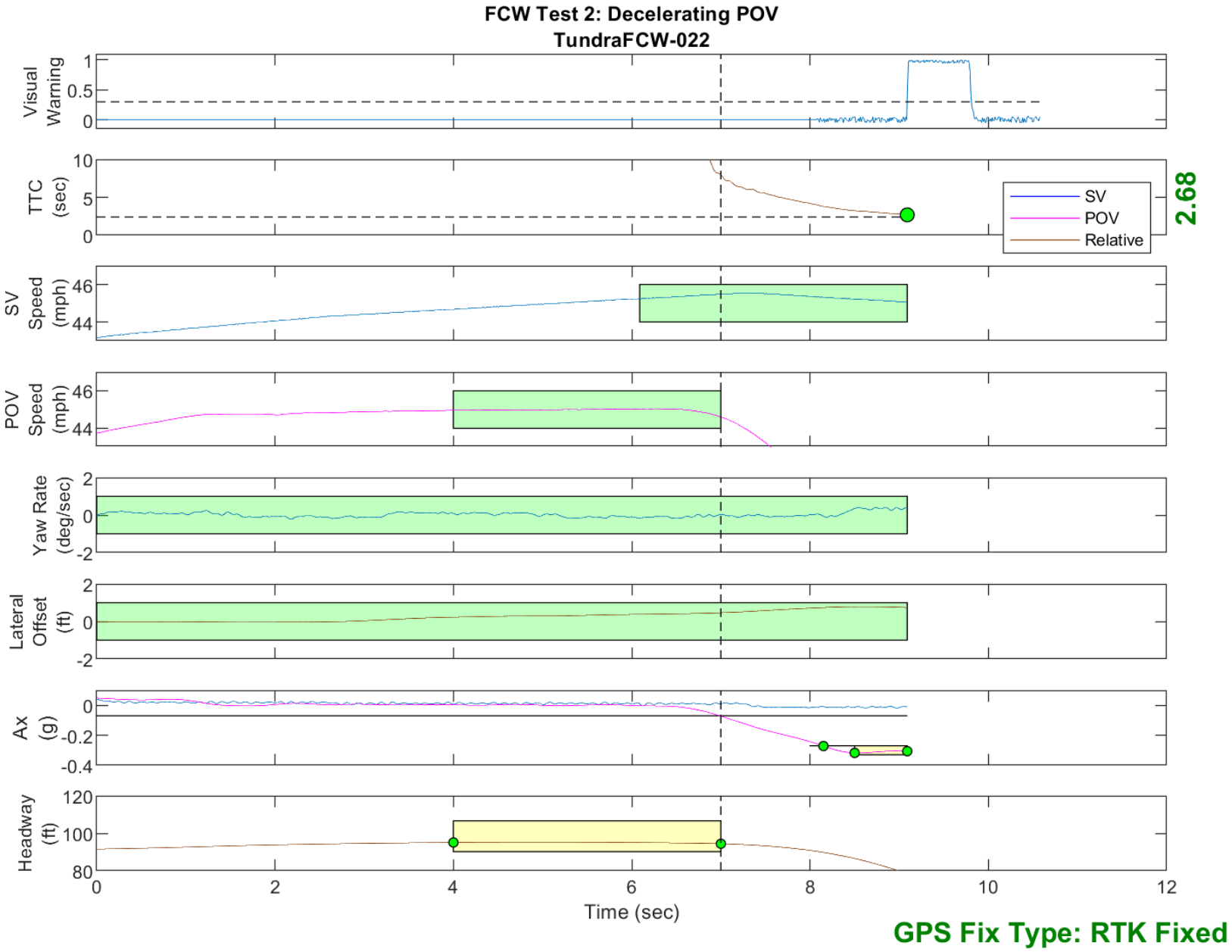


Figure D28. Time History for Run 22, Test 2 - Decelerating POV, Visual Warning

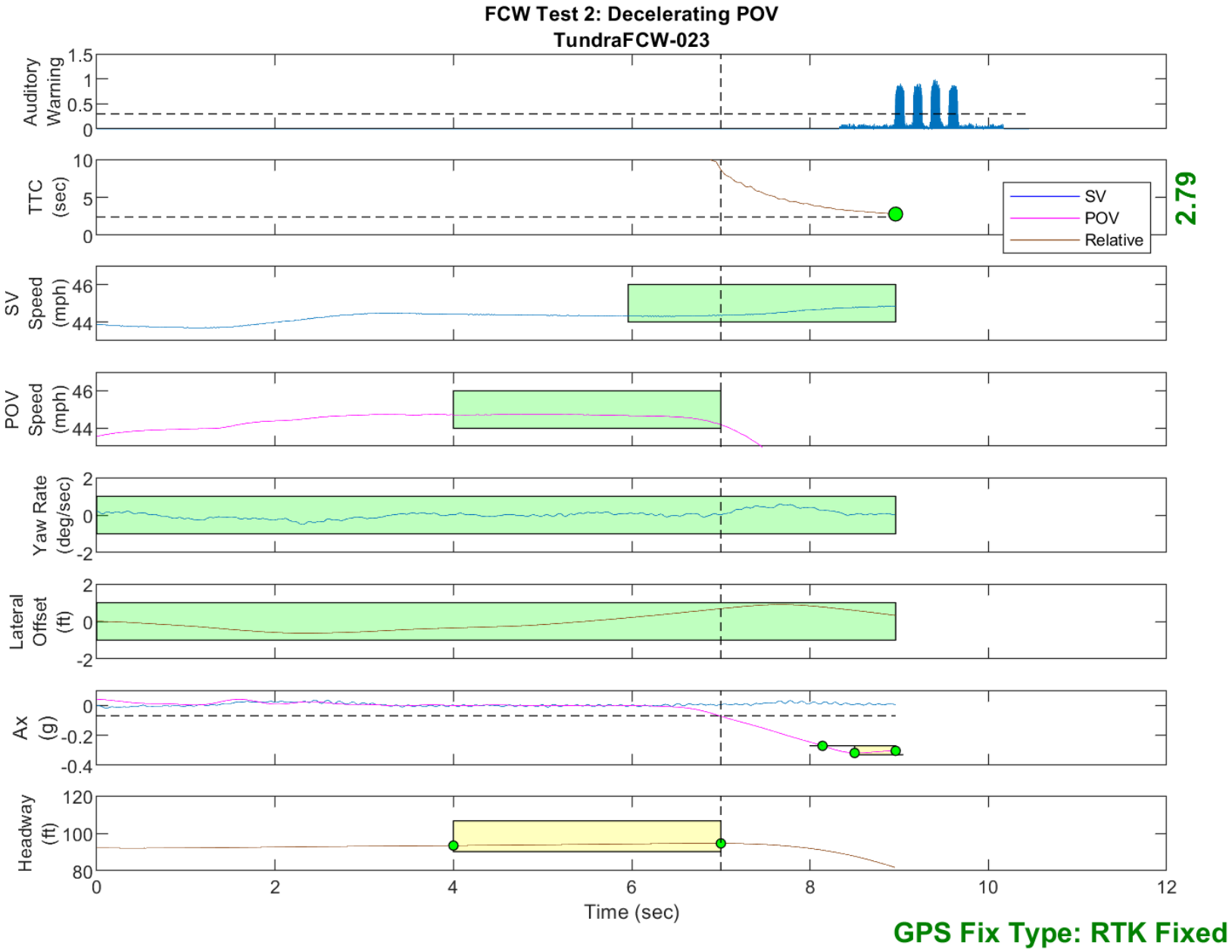


Figure D29. Time History for Run 23, Test 2 - Decelerating POV, Auditory Warning

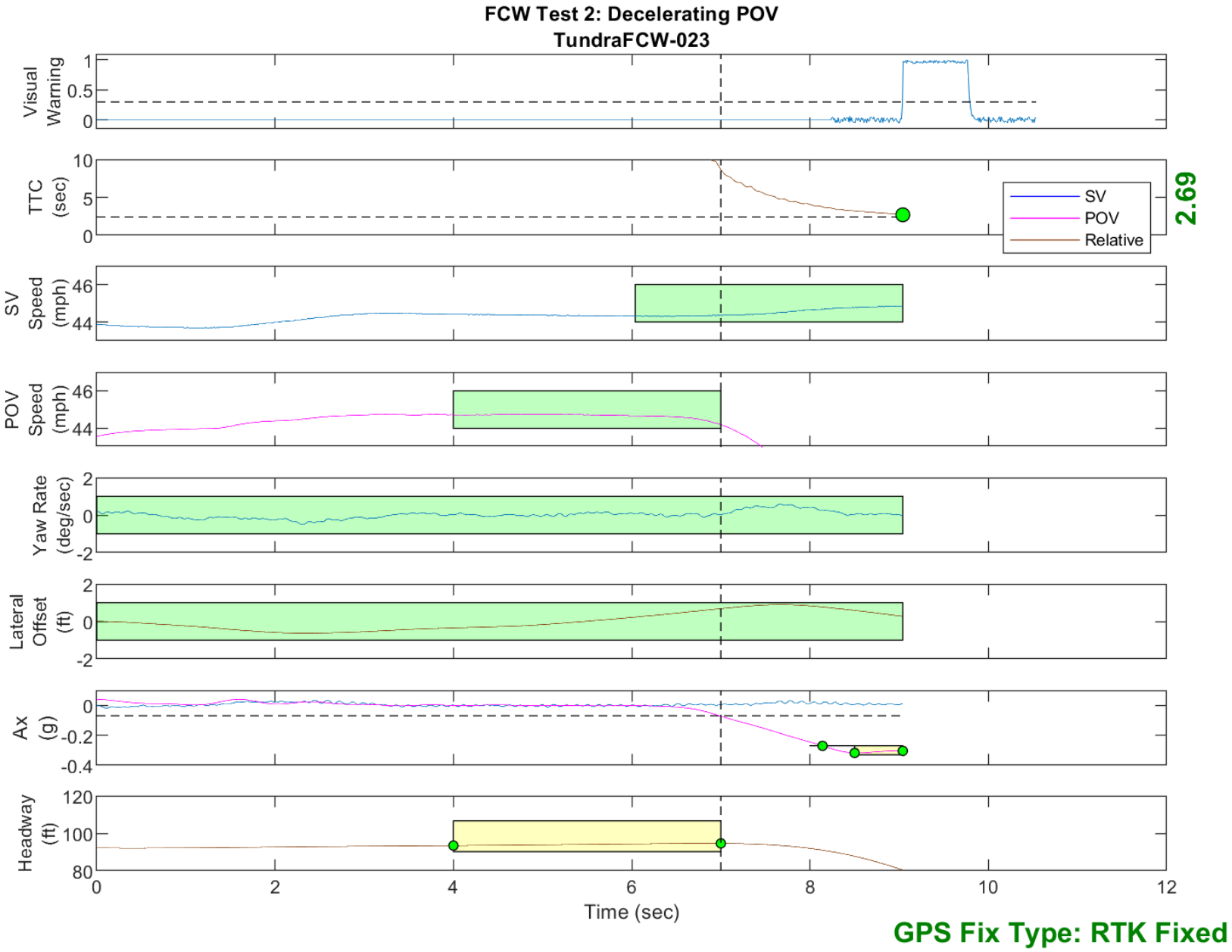


Figure D30. Time History for Run 23, Test 2 - Decelerating POV, Visual Warning

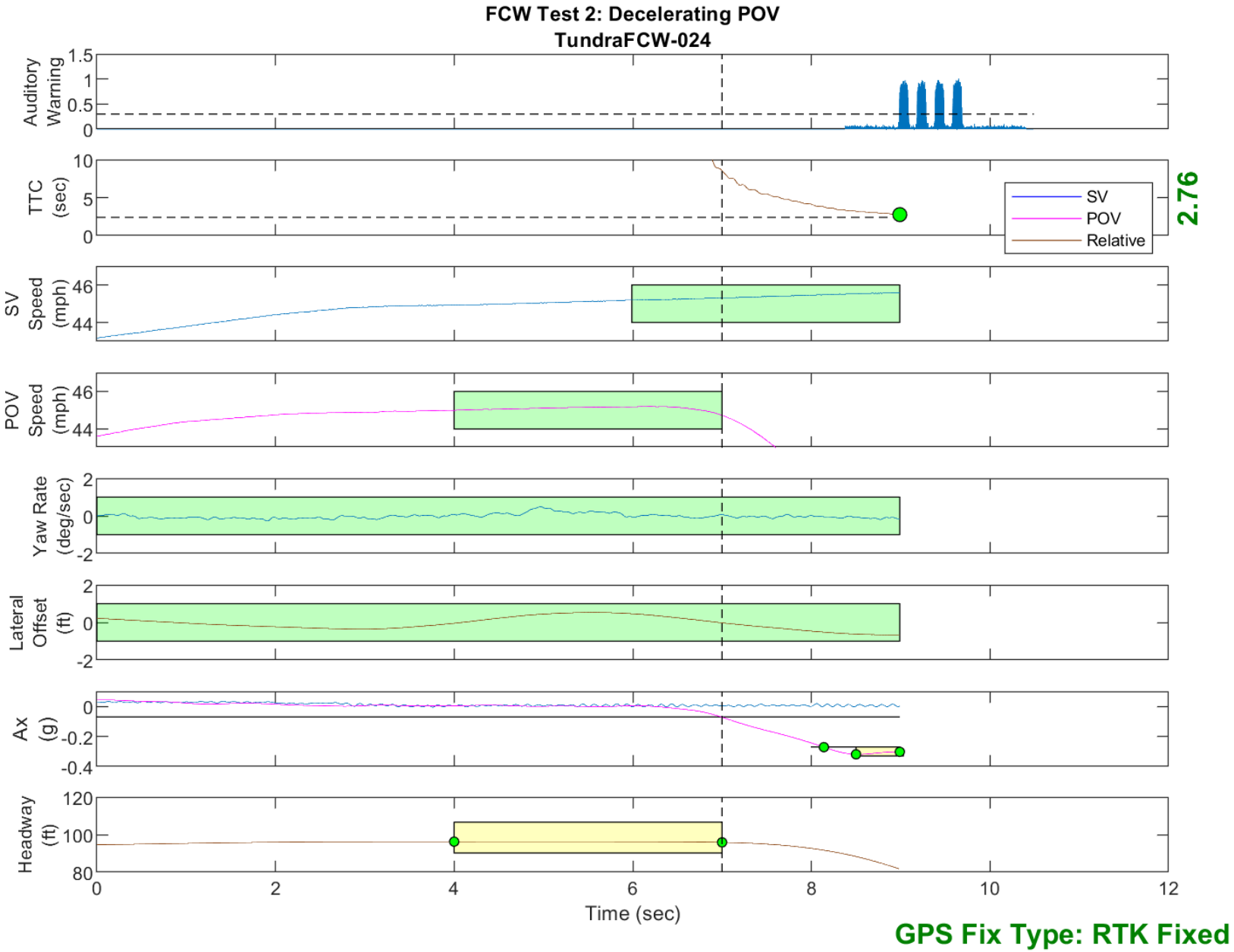


Figure D31. Time History for Run 24, Test 2 - Decelerating POV, Auditory Warning

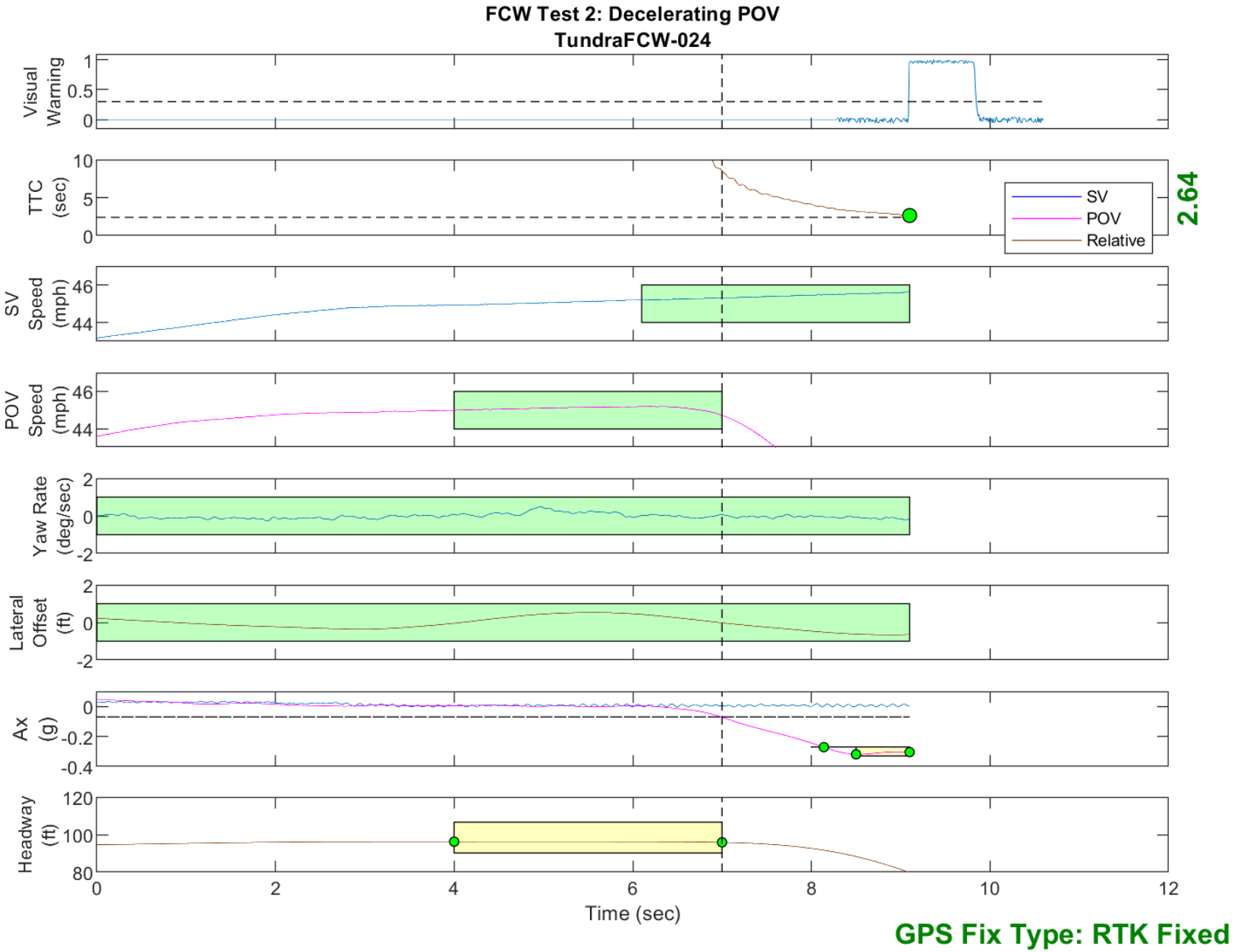


Figure D32. Time History for Run 24, Test 2 - Decelerating POV, Visual Warning

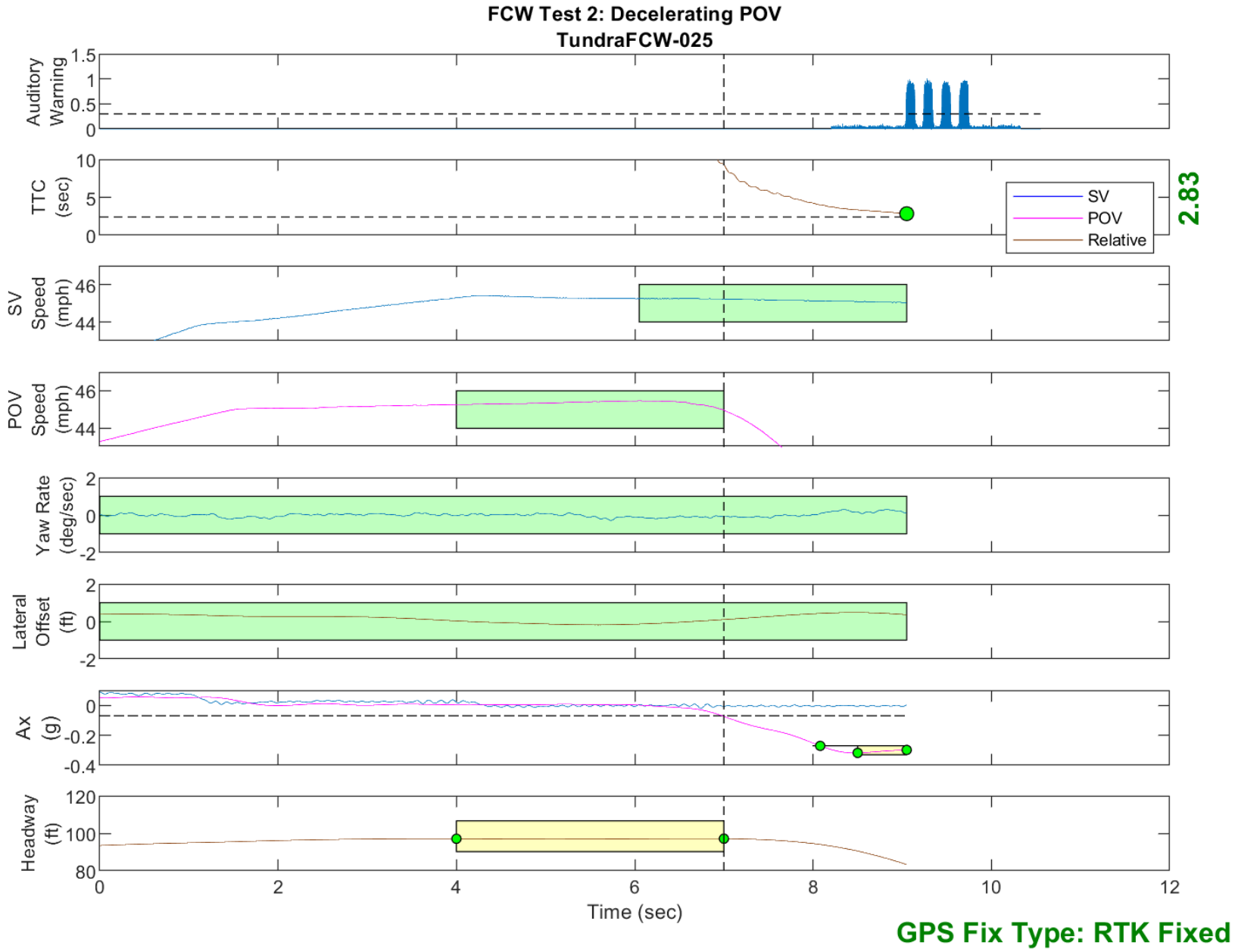


Figure D33. Time History for Run 25, Test 2 - Decelerating POV, Auditory Warning

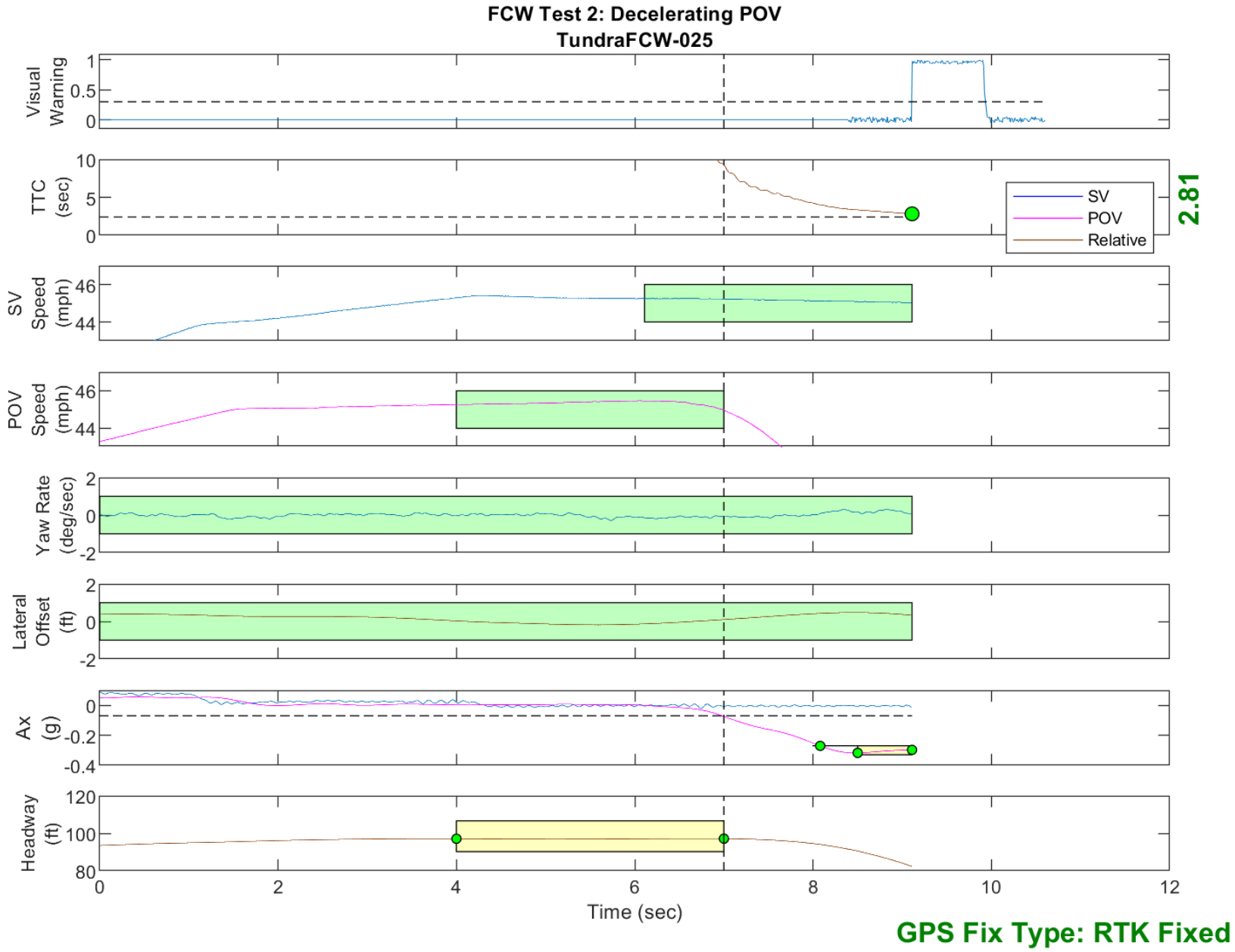


Figure D34. Time History for Run 25, Test 2 - Decelerating POV, Visual Warning

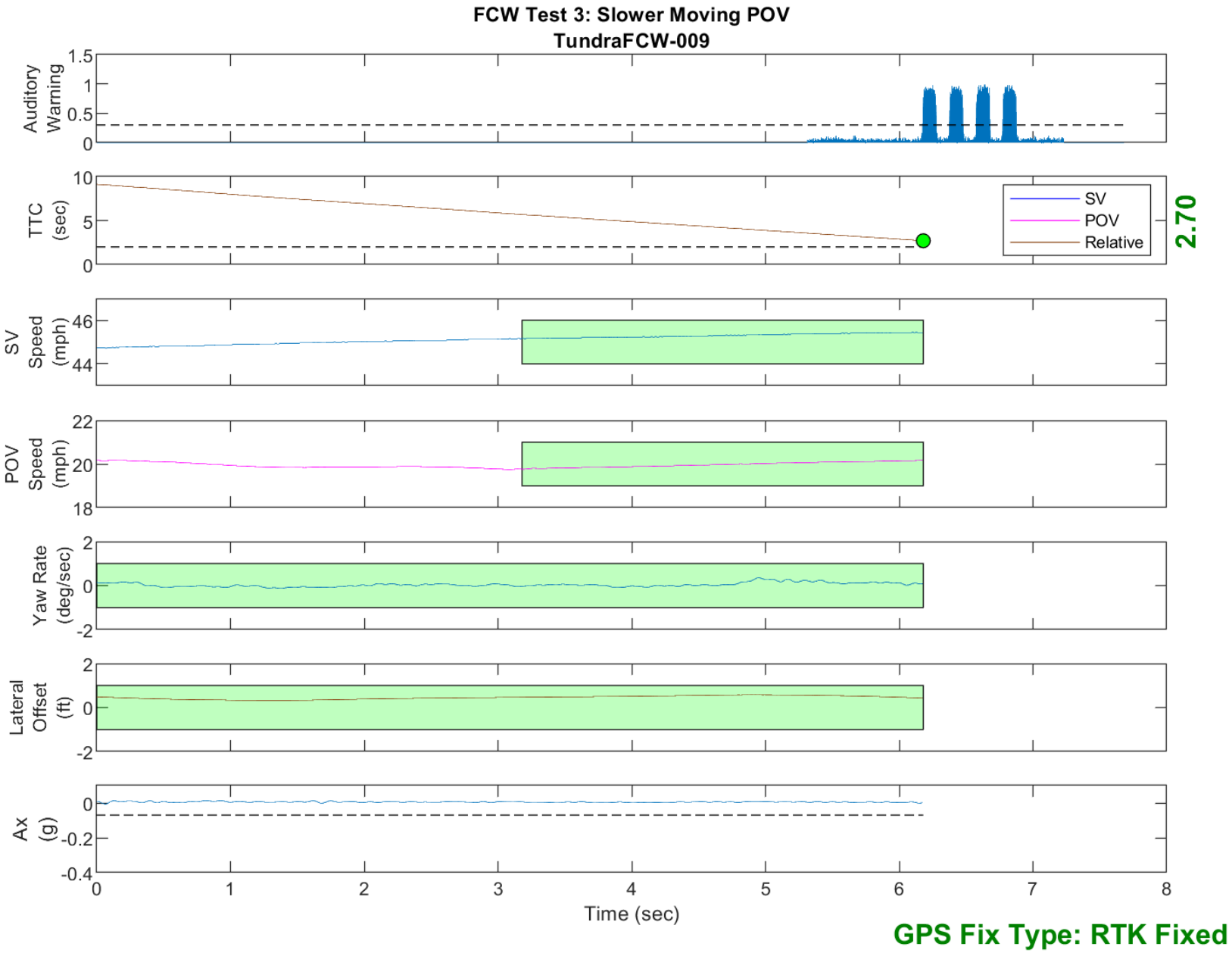


Figure D35. Time History for Run 9, Test 3 - Slower Moving POV, Auditory Warning

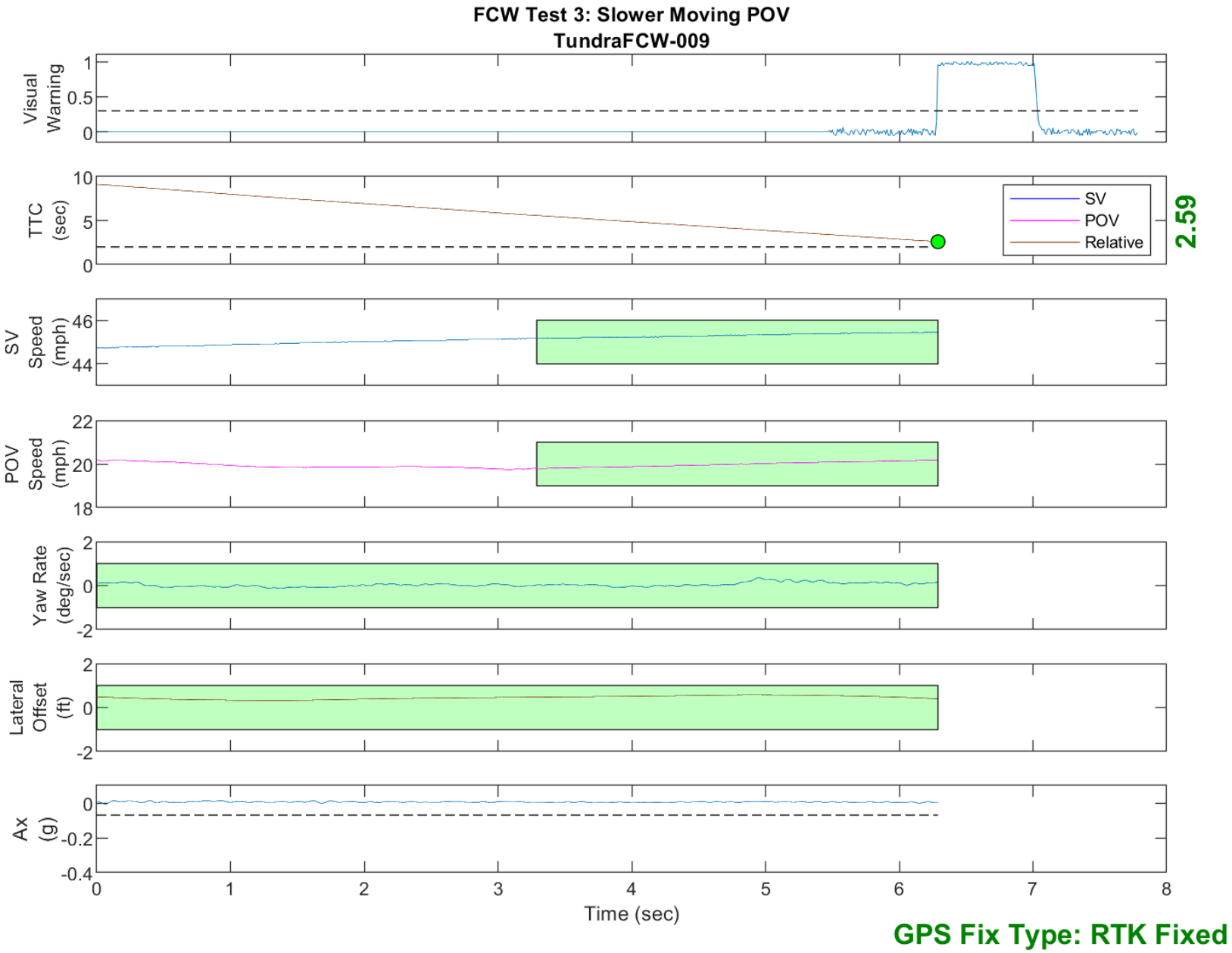


Figure D36. Time History for Run 9, Test 3 - Slower Moving POV, Visual Warning

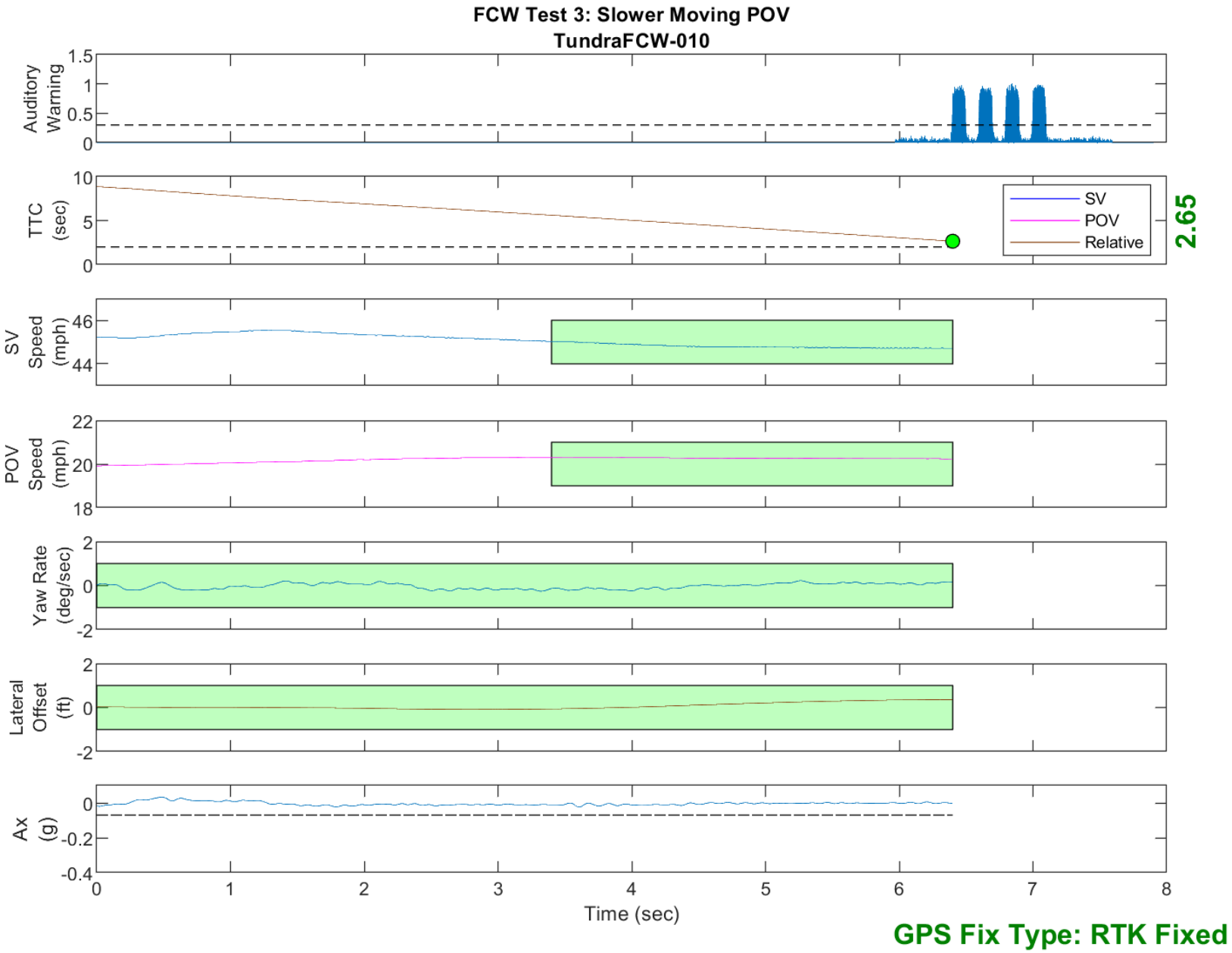


Figure D37. Time History for Run 10, Test 3 - Slower Moving POV, Auditory Warning

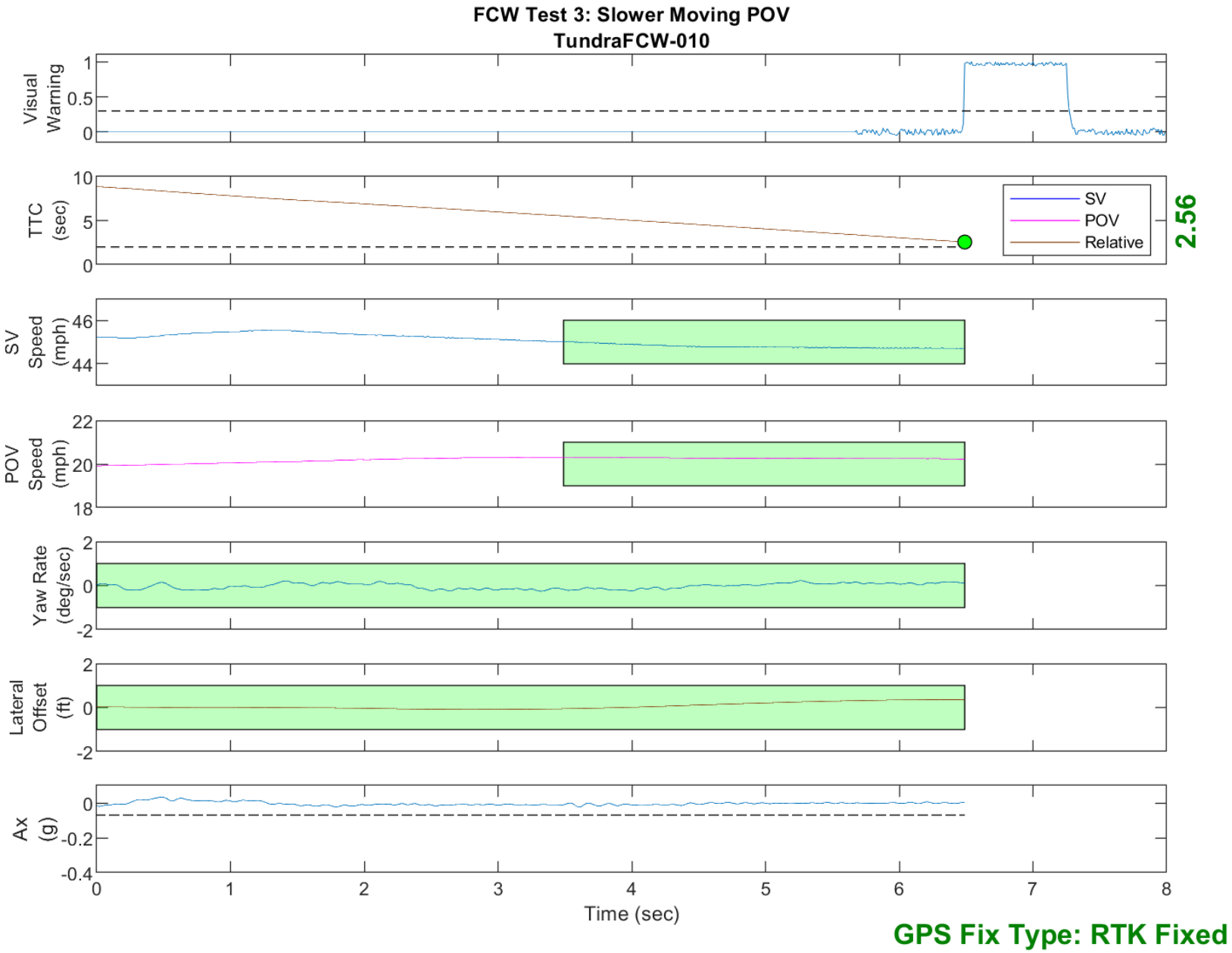


Figure D38. Time History for Run 10, Test 3 - Slower Moving POV, Visual Warning

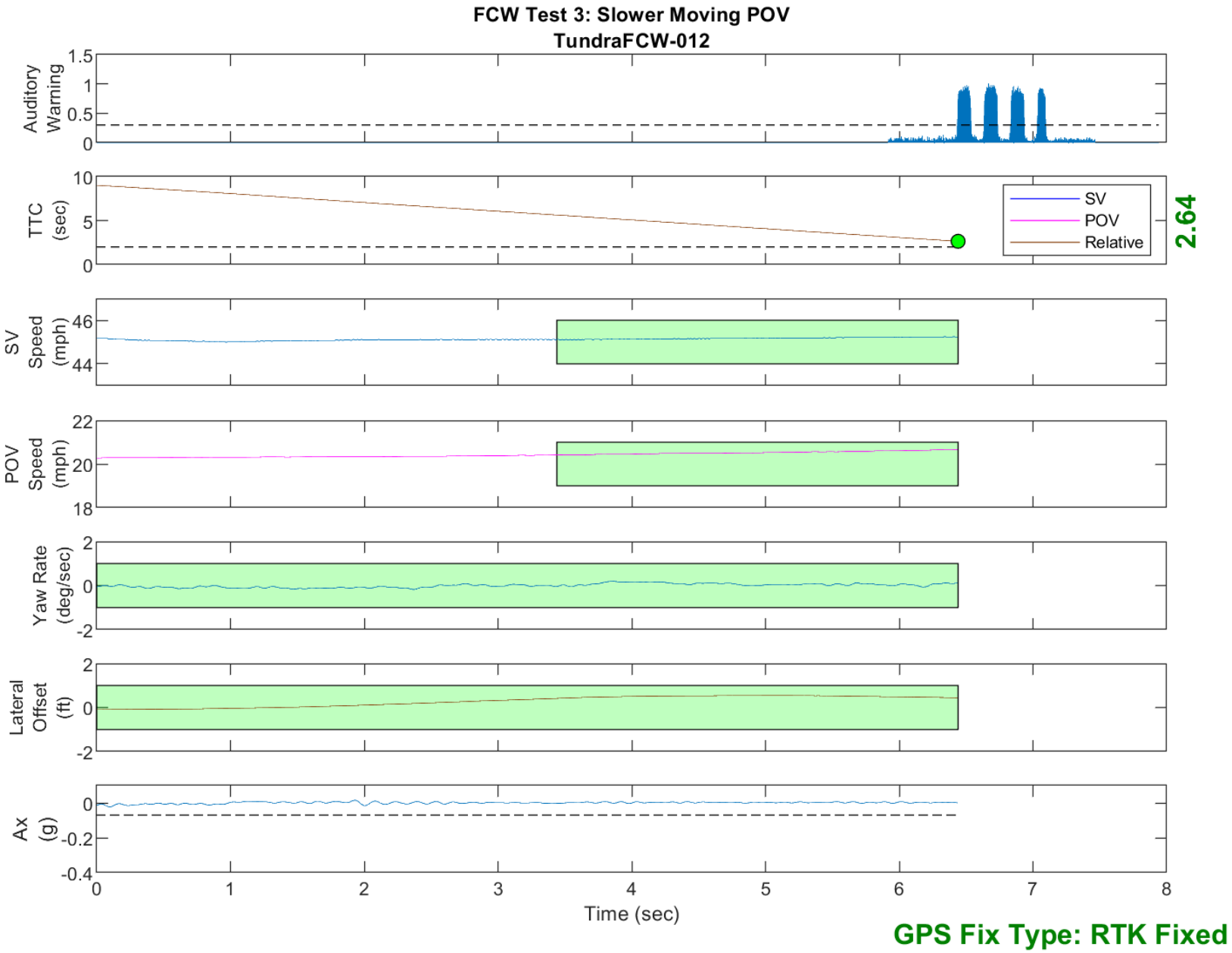


Figure D39. Time History for Run 12, Test 3 - Slower Moving POV, Auditory Warning

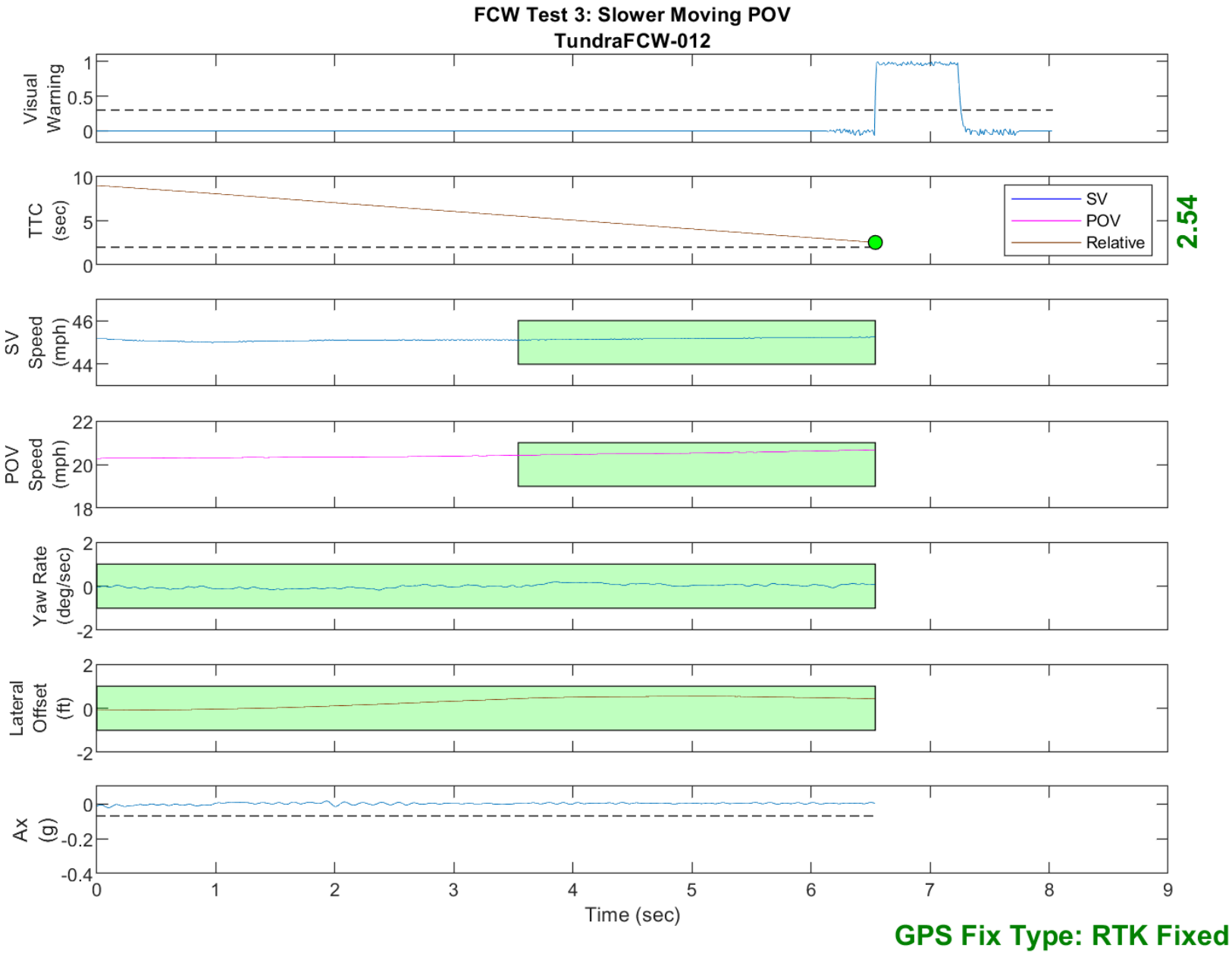


Figure D40. Time History for Run 12, Test 3 - Slower Moving POV, Visual Warning

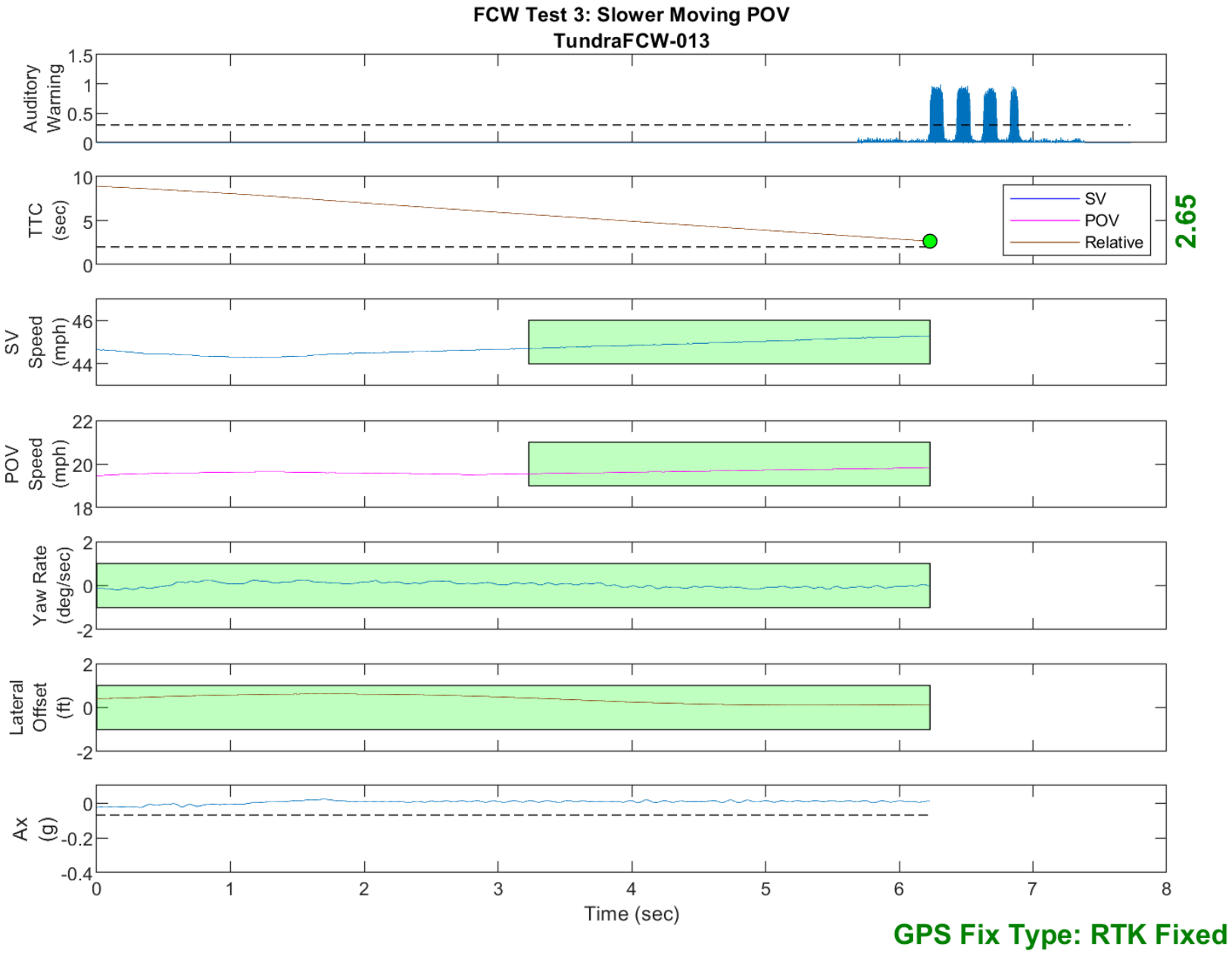


Figure D41. Time History for Run 13, Test 3 - Slower Moving POV, Auditory Warning

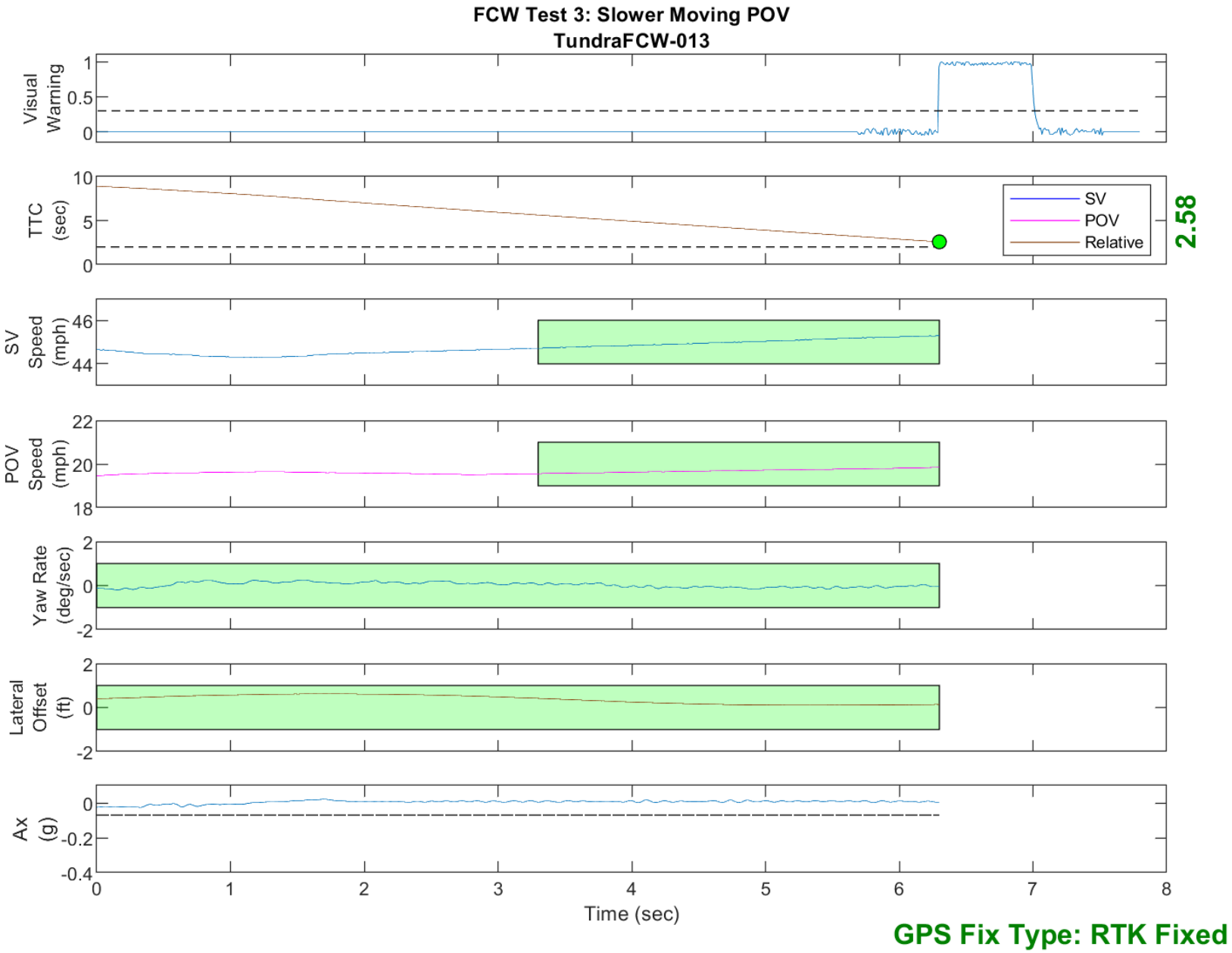


Figure D42. Time History for Run 13, Test 3 - Slower Moving POV, Visual Warning

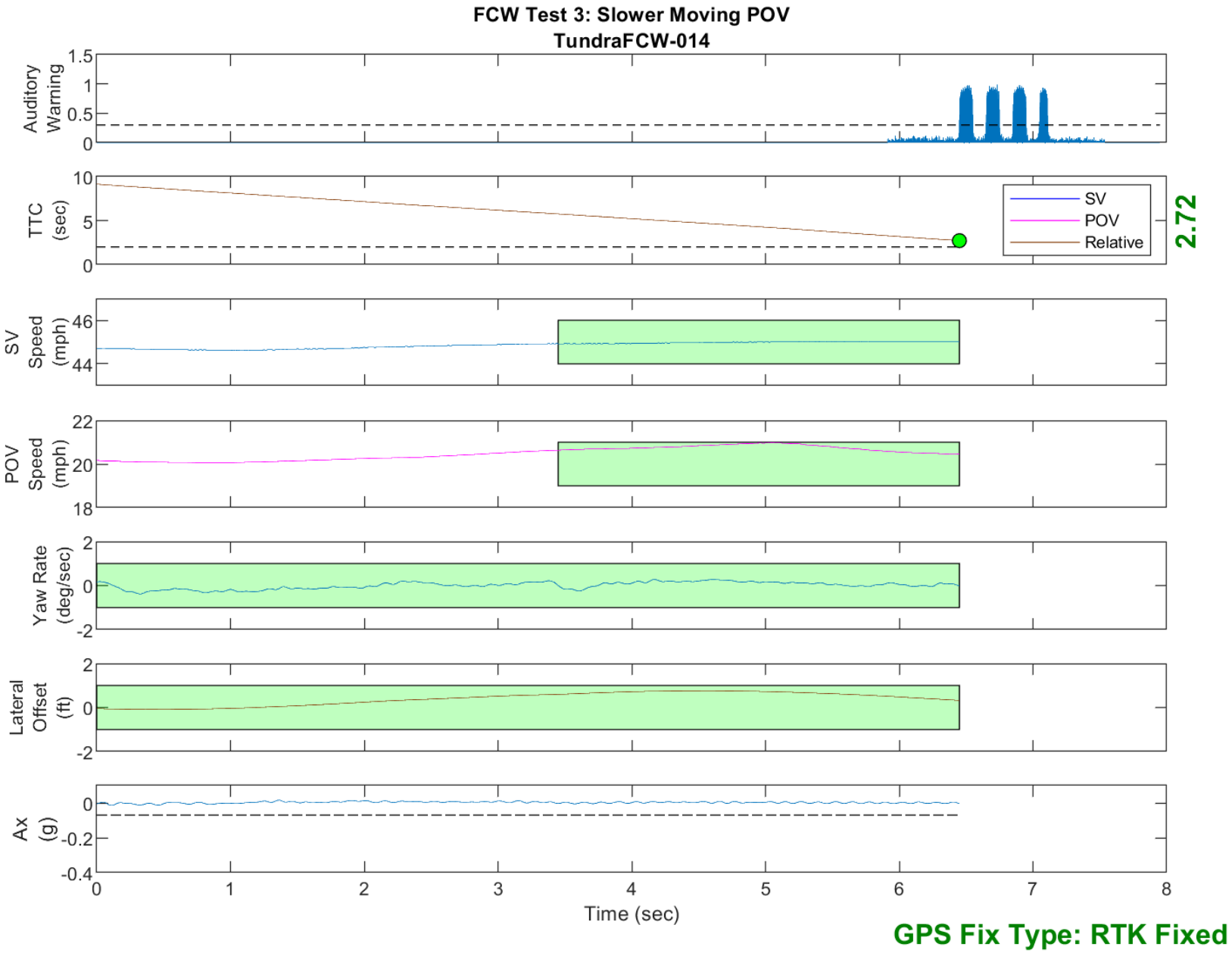


Figure D43. Time History for Run 14, Test 3 - Slower Moving POV, Auditory Warning

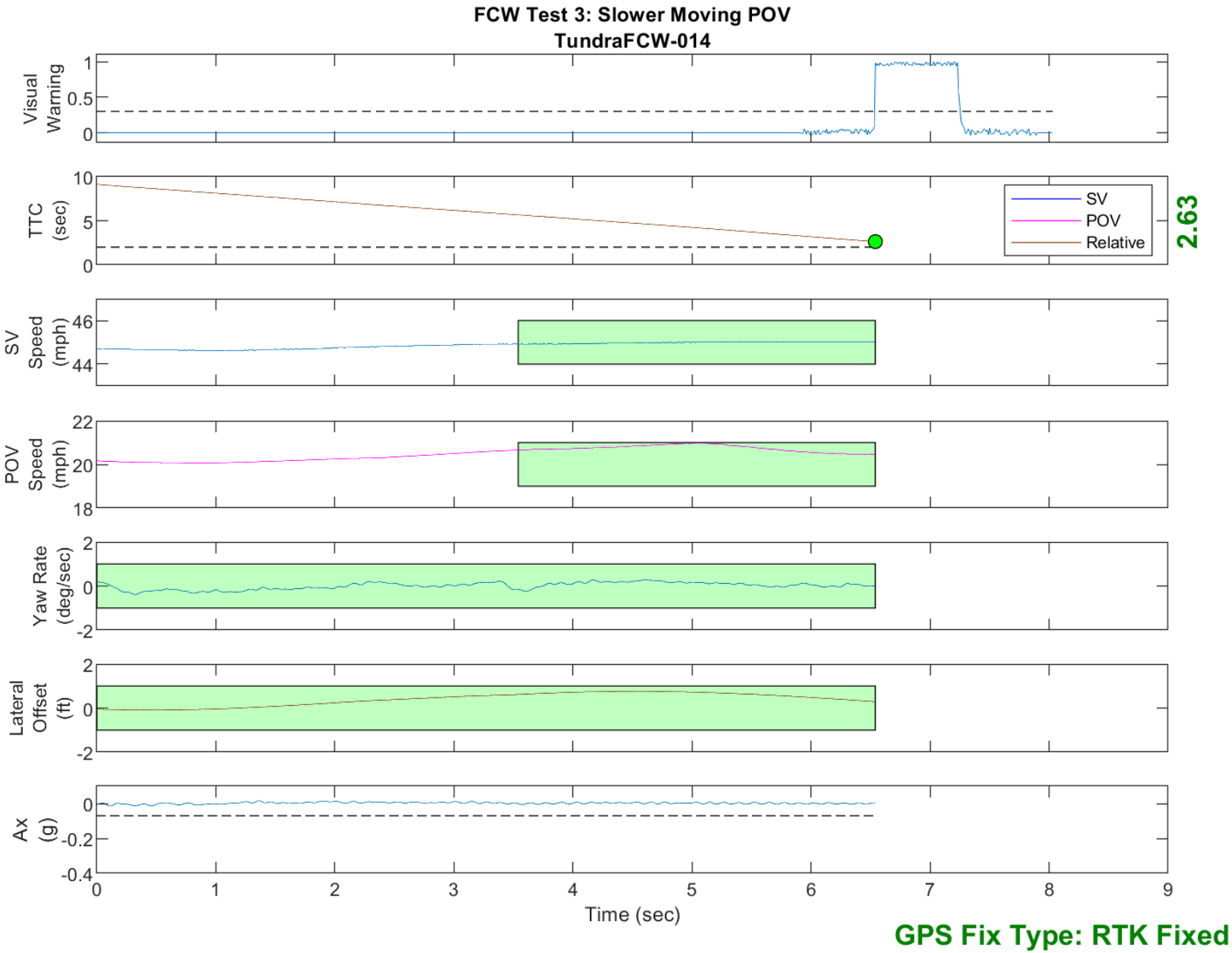


Figure D44. Time History for Run 14, Test 3 - Slower Moving POV, Visual Warning

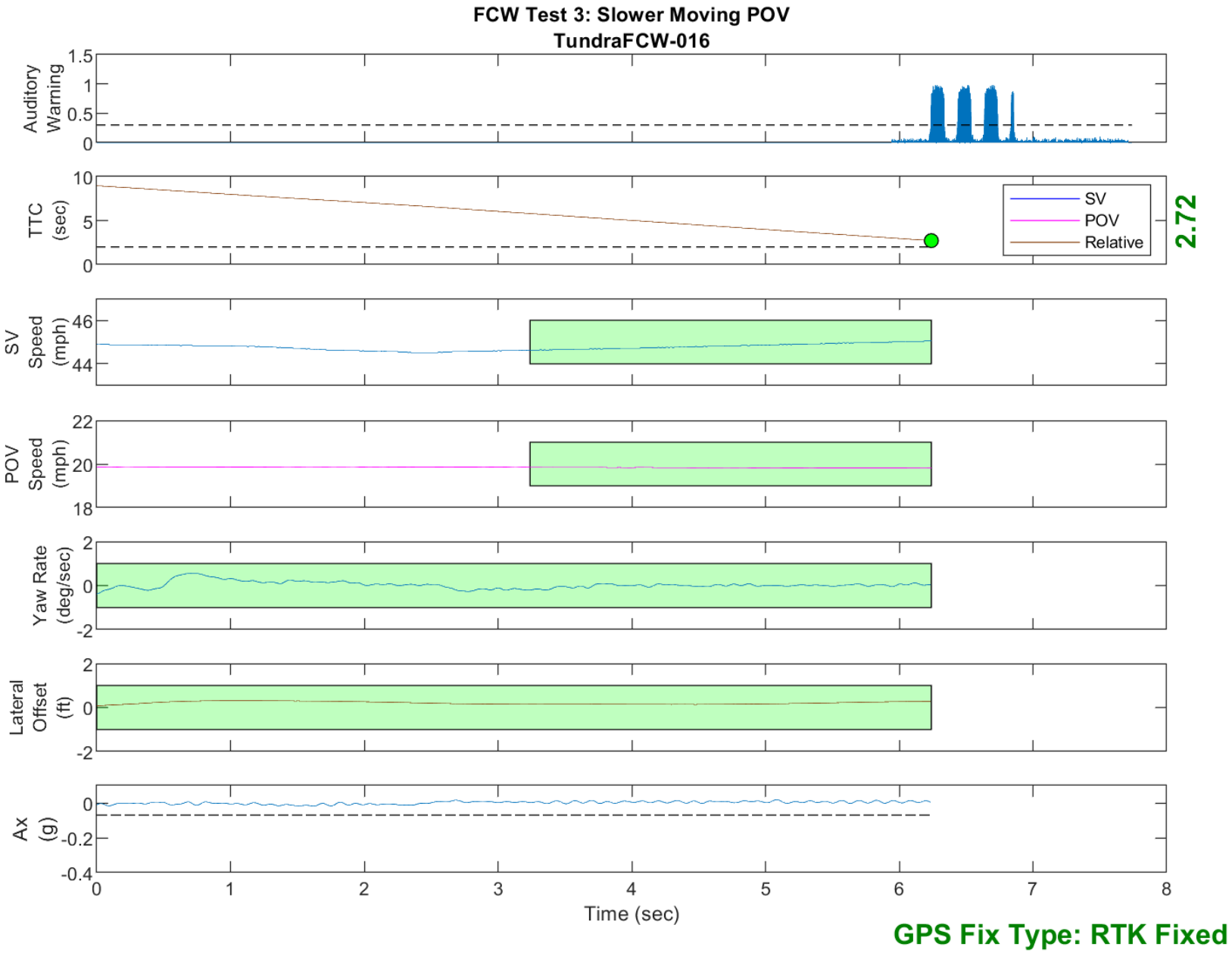


Figure D45. Time History for Run 16, Test 3 - Slower Moving POV, Auditory Warning

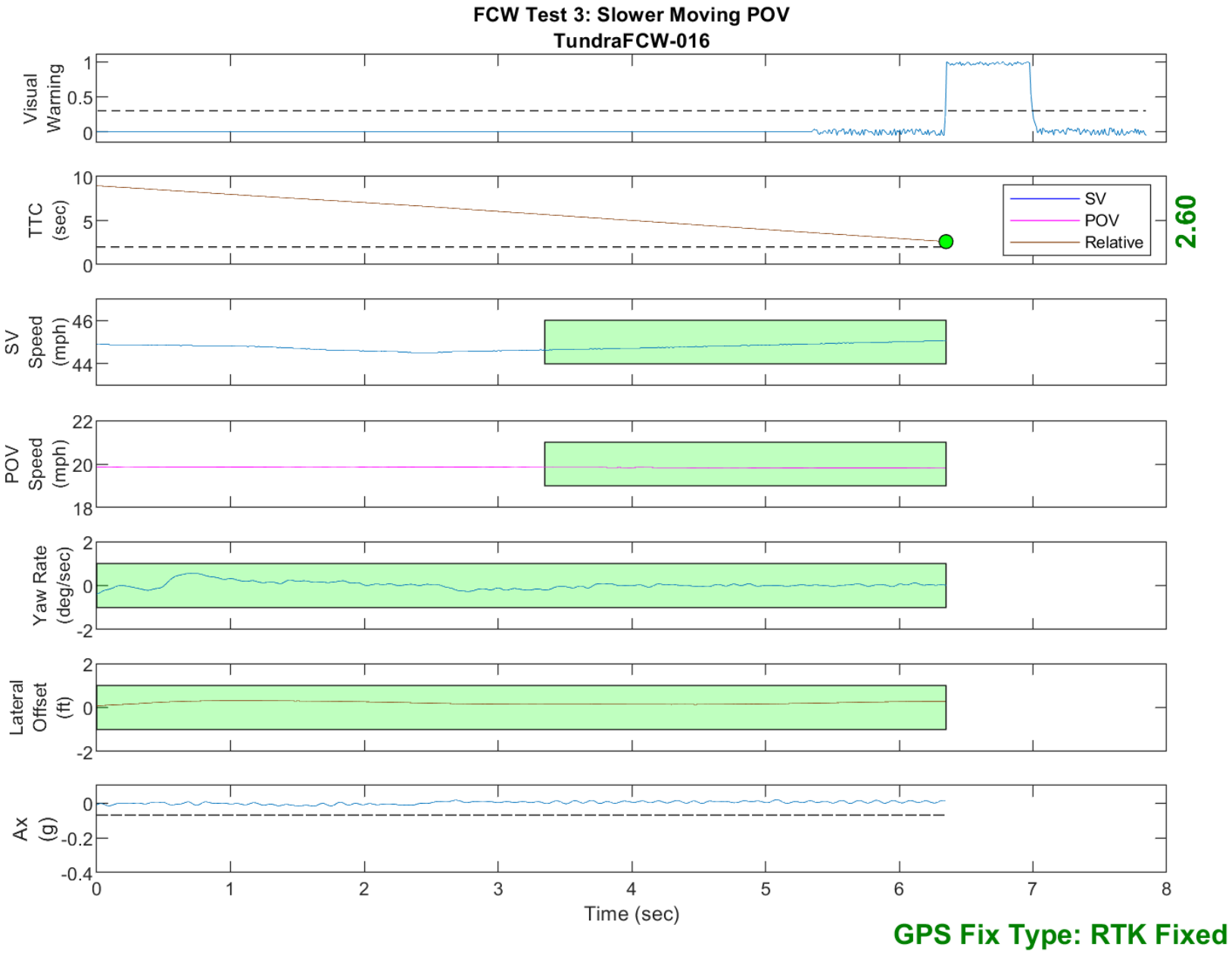


Figure D46. Time History for Run 16, Test 3 - Slower Moving POV, Visual Warning

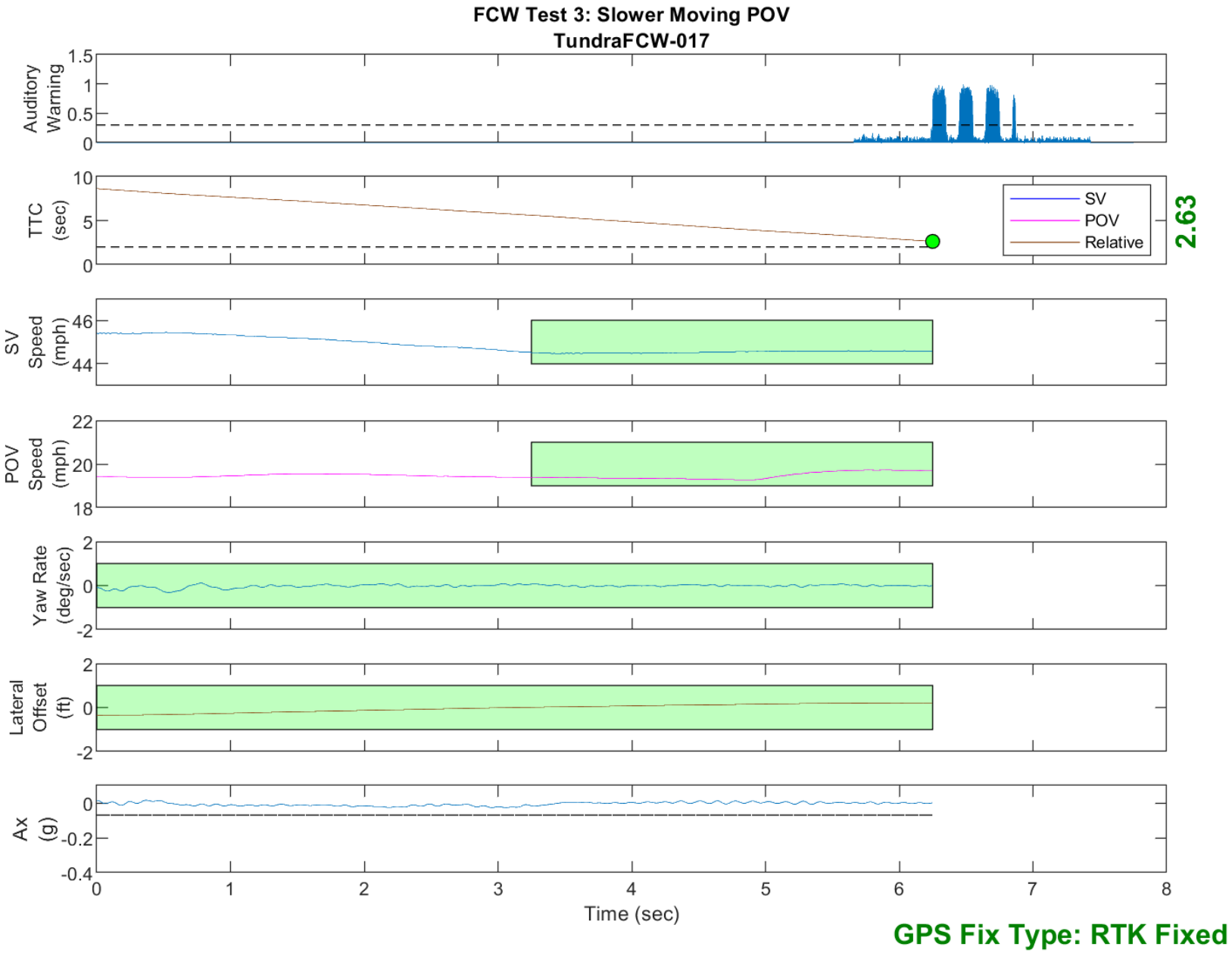


Figure D47. Time History for Run 17, Test 3 - Slower Moving POV, Auditory Warning

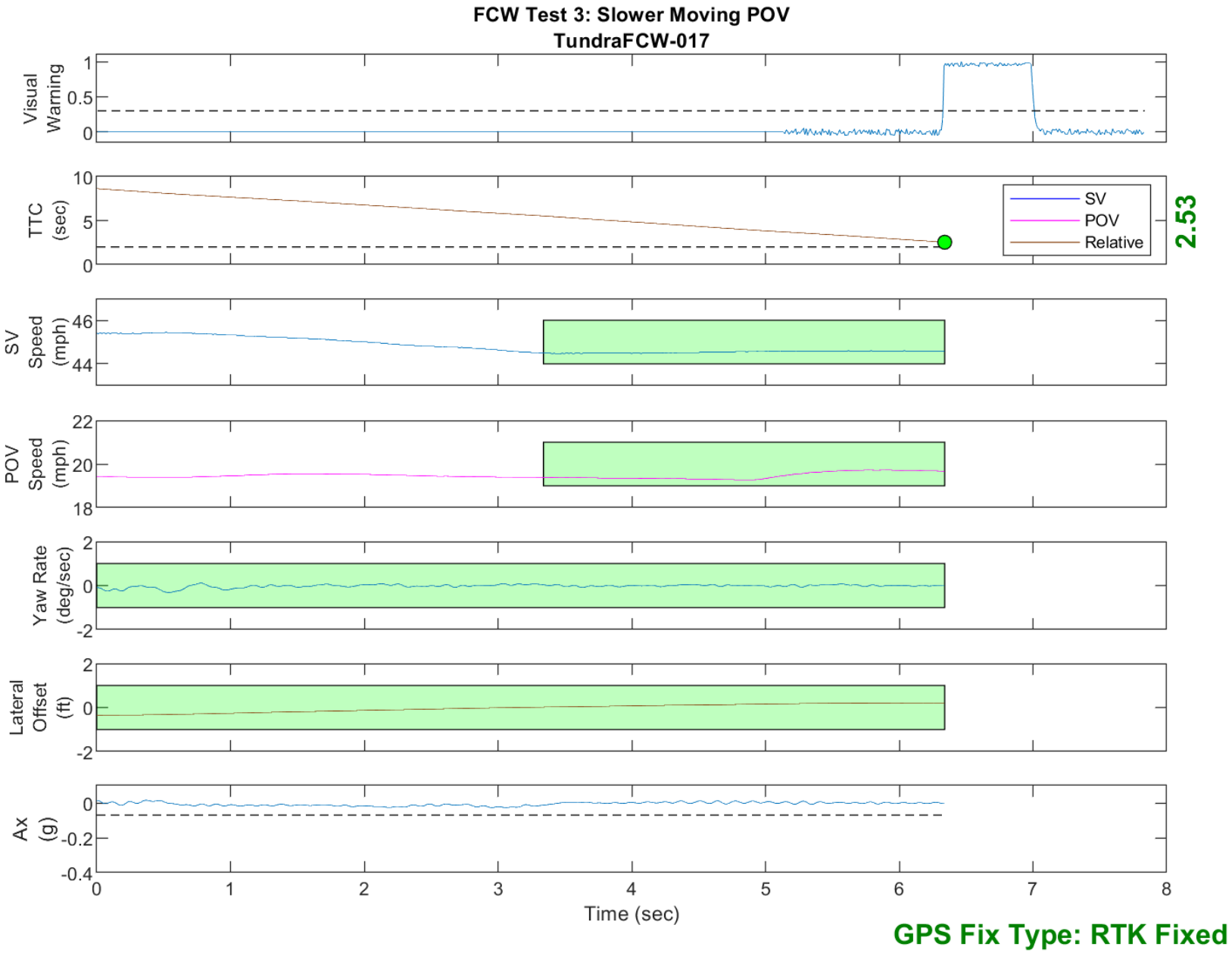


Figure D48. Time History for Run 17, Test 3 - Slower Moving POV, Visual Warning