NEW CAR ASSESSMENT PROGRAM
FORWARD COLLISION WARNING CONFIRMATION TEST
NCAP-DRI-FCW-22-11

2022 Tesla Model 3 AWD

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

5 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

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Prepared By: Stephen Rhim and John Partridge

Senior Engineer Senior Engineer

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16. Abstract These tests were conducted on the subject 2022 Tesla Model 3 AWD 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 Tesla Model 3 AWD. 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 Tesla Model 3 AWD

VIN: *5YJ3E1EB9NF17xxxx*

Test start date: *3/21/2022*

Test end date: *3/21/2022*

Forward Collision Warning setting: *Medium*

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 Tesla Model 3 AWD

TEST VEHICLE INFORMATION

VIN: *5YJ3E1EB9NF17xxxx*

Body Style: *Sedan* Color: *Midnight Silver*

Date Received: *3/10/2022* Odometer Reading: *28 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *TESLA, INC.*

Date of manufacture: *02/22*

Vehicle Type: *Passenger Car*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *235/45R18*

Rear: *235/45R18*

Recommended cold tire pressure: Front: *290 kPa (42 psi)*

Rear: *290 kPa (42 psi)*

TIRES

Tire manufacturer and model: *Michelin Primacy MXM4*

Front tire specification: *235/45R18 98W*

Rear tire specification: *235/45R18 98W*

Front tire DOT prefix: *B9EL 086X*

Rear tire DOT prefix: *B9EL 086X*

FORWARD COLLISION WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2022 Tesla Model 3 AWD

GENERAL INFORMATION

Test start date: *3/21/2022* Test end date: *3/21/2022*

AMBIENT CONDITIONS

Air temperature: *17.2 C (63 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: *290 kPa (42 psi)*

Rear: *290 kPa (42 psi)*

FORWARD COLLISION WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2022 Tesla Model 3 AWD

WEIGHT

Weight of vehicle as tested including driver and instrumentation:

Left Front:	*492.1 kg (1085 lb)*	Right Front:	*487.2 kg (1074 lb)*
Left Rear:	*490.3 kg (1081 lb)*	Right Rear:	*480.4 kg (1059 lb)*
		Total:	*1950.0 kg (4299 lb)*

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 1 of 3)

2022 Tesla Model 3 AWD

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

Collision Avoidance Assist

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

Triple camera located at the top center of the windshield.

Forward Collision Warning Setting used in test: *Medium*

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 consists of an animation of the SV behind the POV shown in real time. When the visual alert activates, the POV turns red. The auditory alert consists of repeated beeps with a primary frequency of approximately 1100 Hz.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 2 of 3)

2022 Tesla Model 3 AWD

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 touch screen display in the center console. The procedure is as follows:

1. Select "Controls".

2. Select "Autopilot".

3. Select "Off" to turn the FCW system on/off.

The system does not re-enable 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 of the FCW system can be adjusted using the touch screen display in the center console. The procedure is as follows:

1. Select "Controls".

2. Select "Autopilot".

3. Select between "Late", "Medium", "Early".

The range setting is retained when the engine switch is turned off.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 3 of 3)

2022 Tesla Model 3 AWD

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.

The FCW system cannot always detect all objects, vehicles, bicycles, or pedestrians and may miss warnings or exhibit unnecessary, inaccurate, or invalid warnings. Possible reasons for this are listed in the examples below:

1. The road has sharp curves.

2. Visibility is poor (due to heavy rain, snow, fog, etc.).

3. Bright light (such as from oncoming headlights or direct sunlight) is interfering with the view of the camera(s).

4. The camera sensor is obstructed (dirty, covered, fogged over, covered by a sticker, etc.).

5. Weather conditions (heavy rain, snow, fog, or extremely hot or cold temperatures) are interfering with its operation.

Refer to the owner's manual page 114 shown in Appendix B page B-4 for additional information.

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.

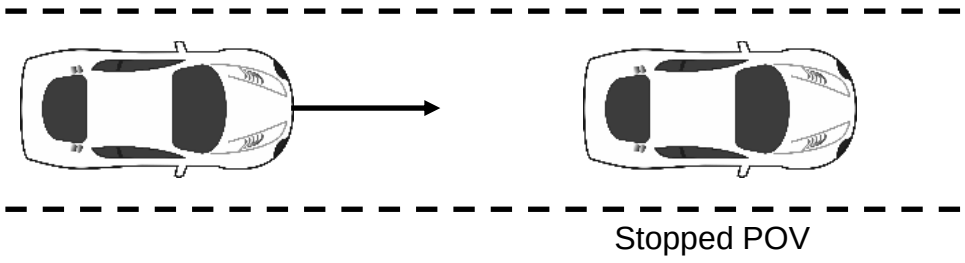

Figure 1. Depiction of Test 1

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.

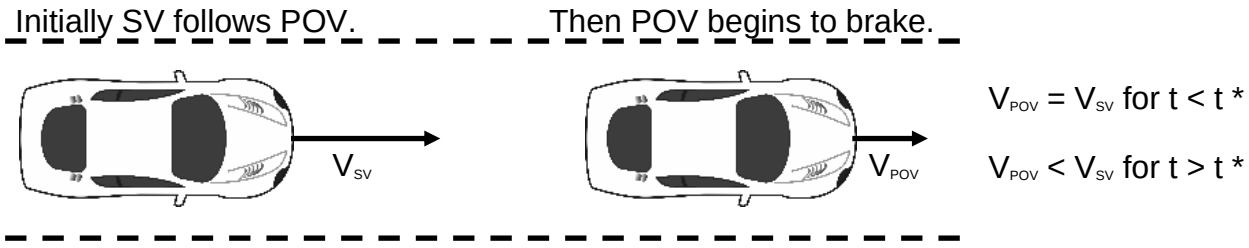

Figure 2. Depiction of Test 2

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).

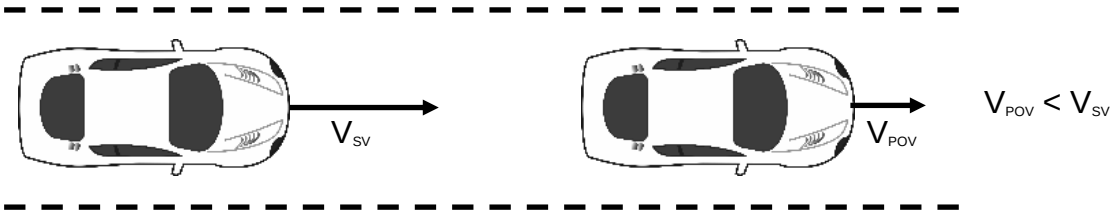

Figure 3. Depiction of Test 3

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

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Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

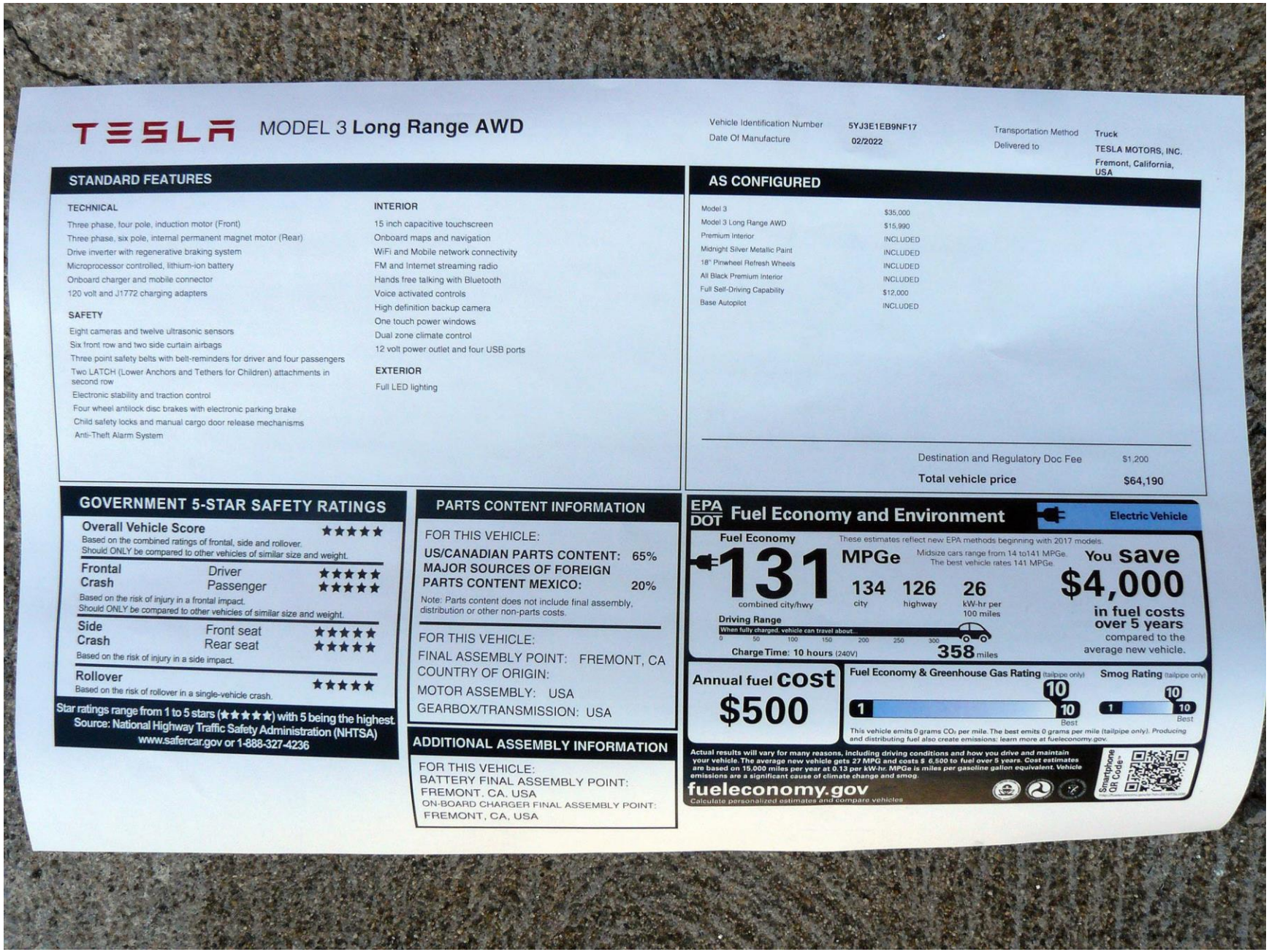


Figure A3. Window Sticker (Monroney Label)

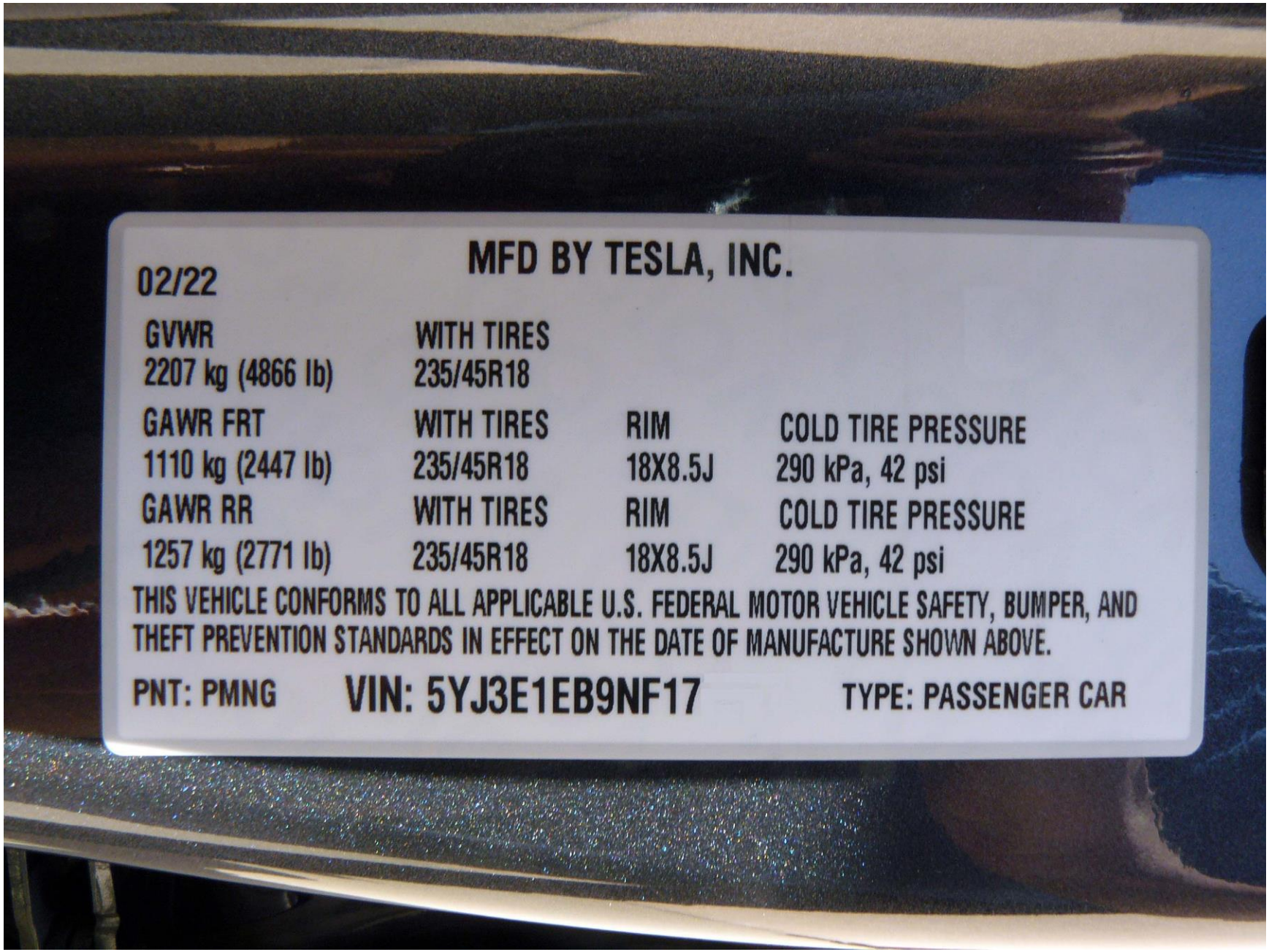


Figure A4. Vehicle Certification Label

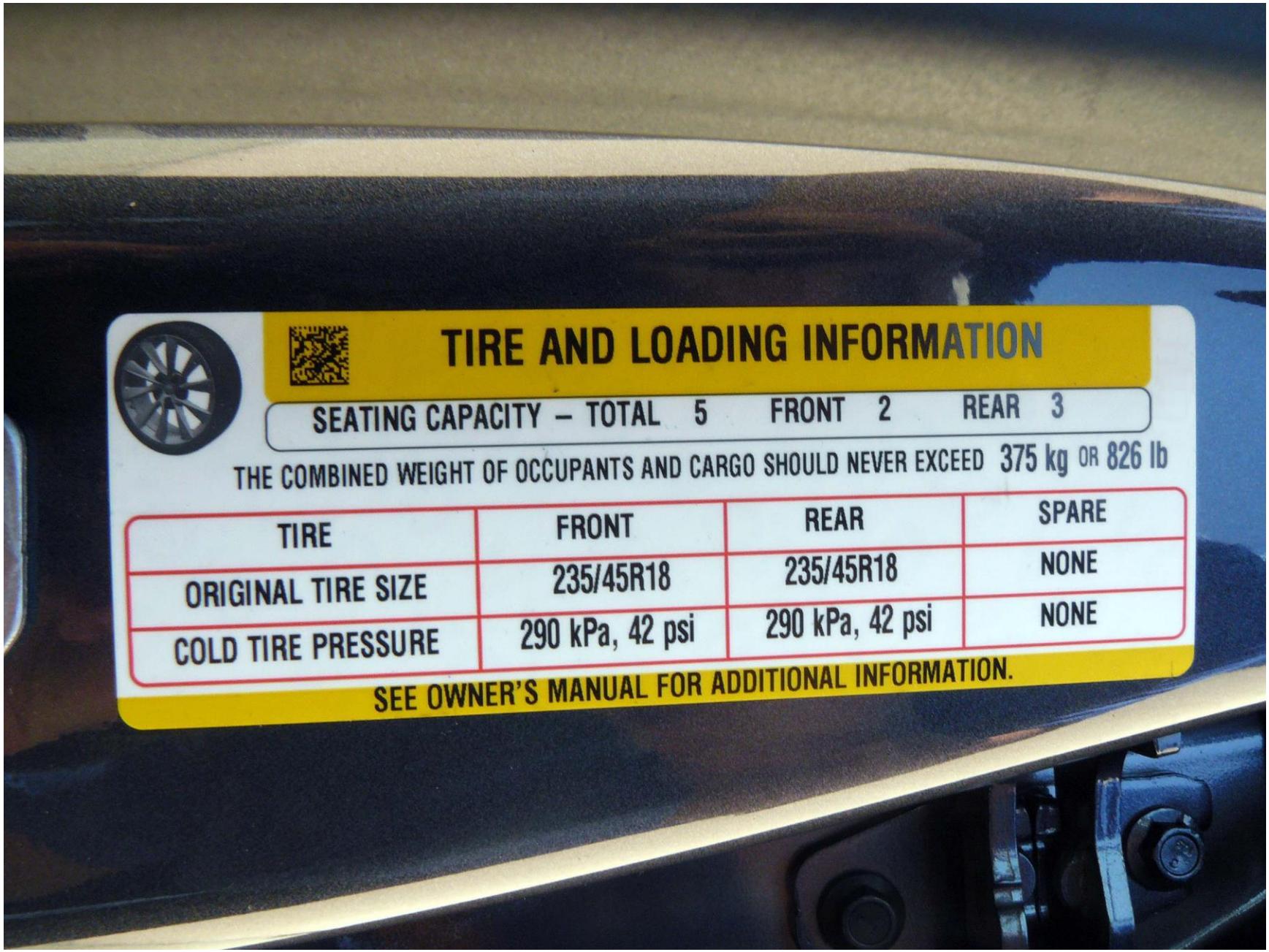


Figure A5. Tire Placard

Figure A6. Front View of Principal Other Vehicle

Figure A7. Rear View of Principal Other Vehicle

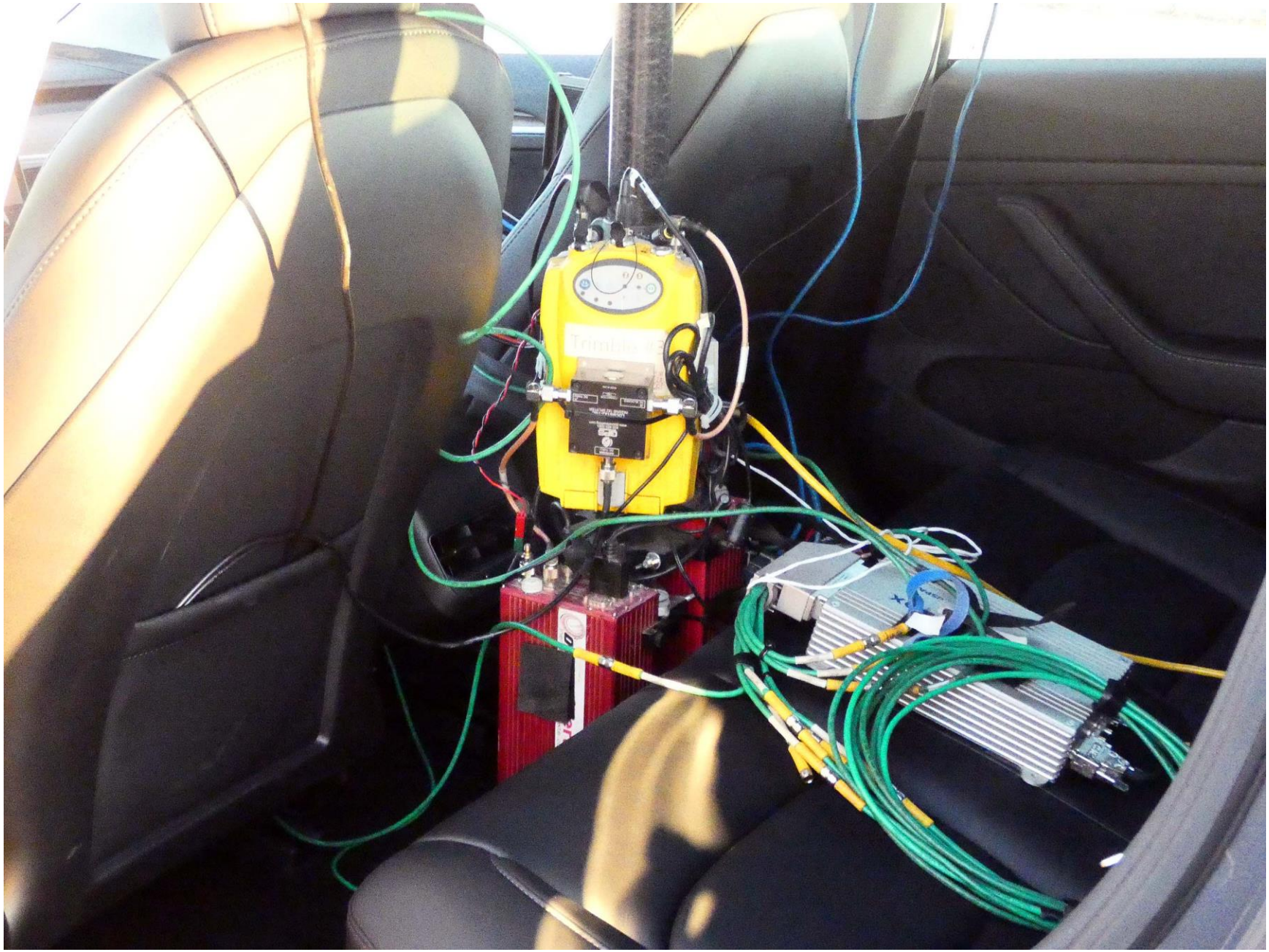


Figure A8. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

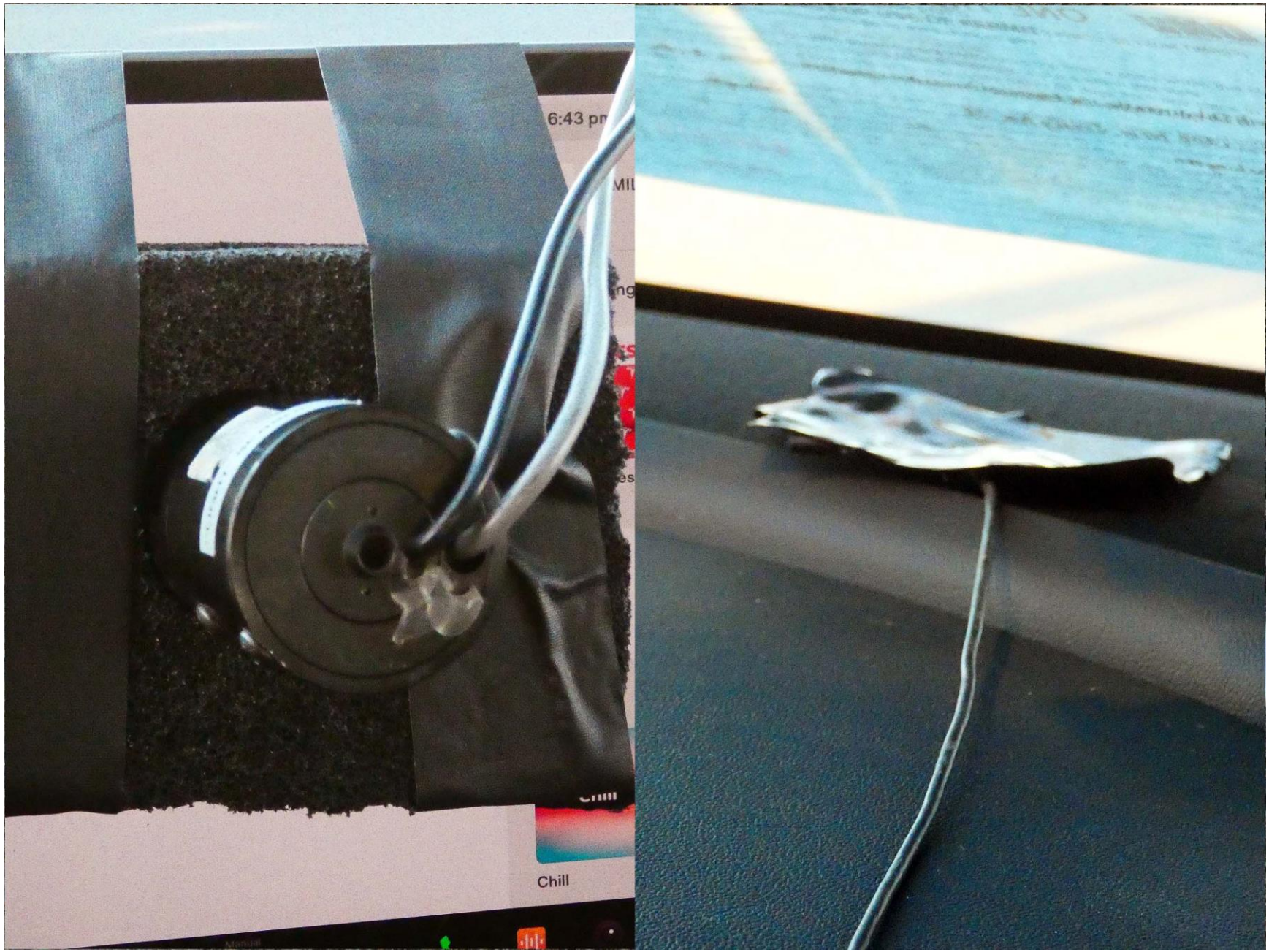


Figure A9. Sensors for Detecting Auditory and Visual Alerts

Figure A10. Computer Installed in Subject Vehicle

Figure A11. Brake Actuation System Installed in Principal Other Vehicle

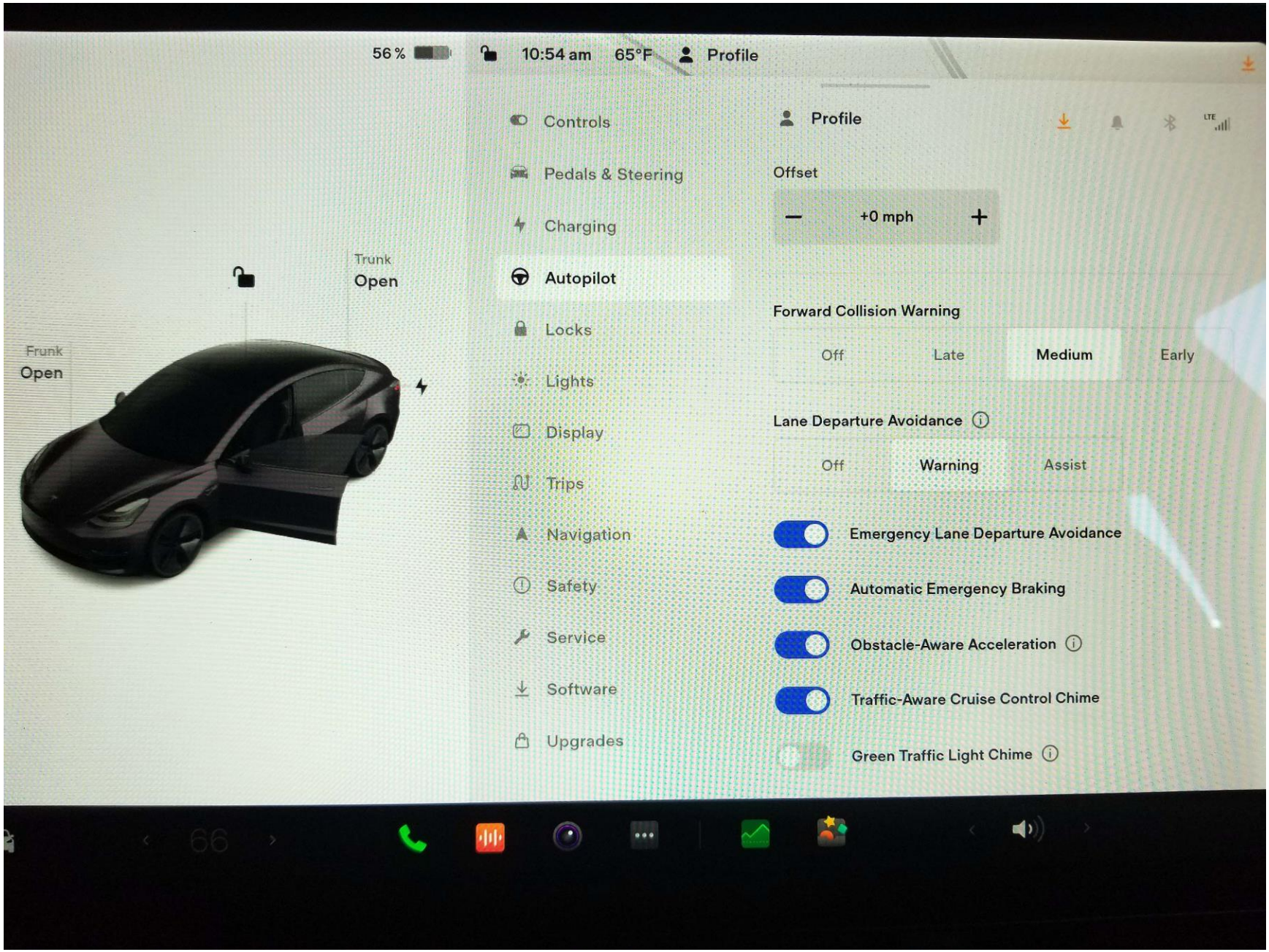


Figure A12. System Setup Menu and Alert Sensitivity

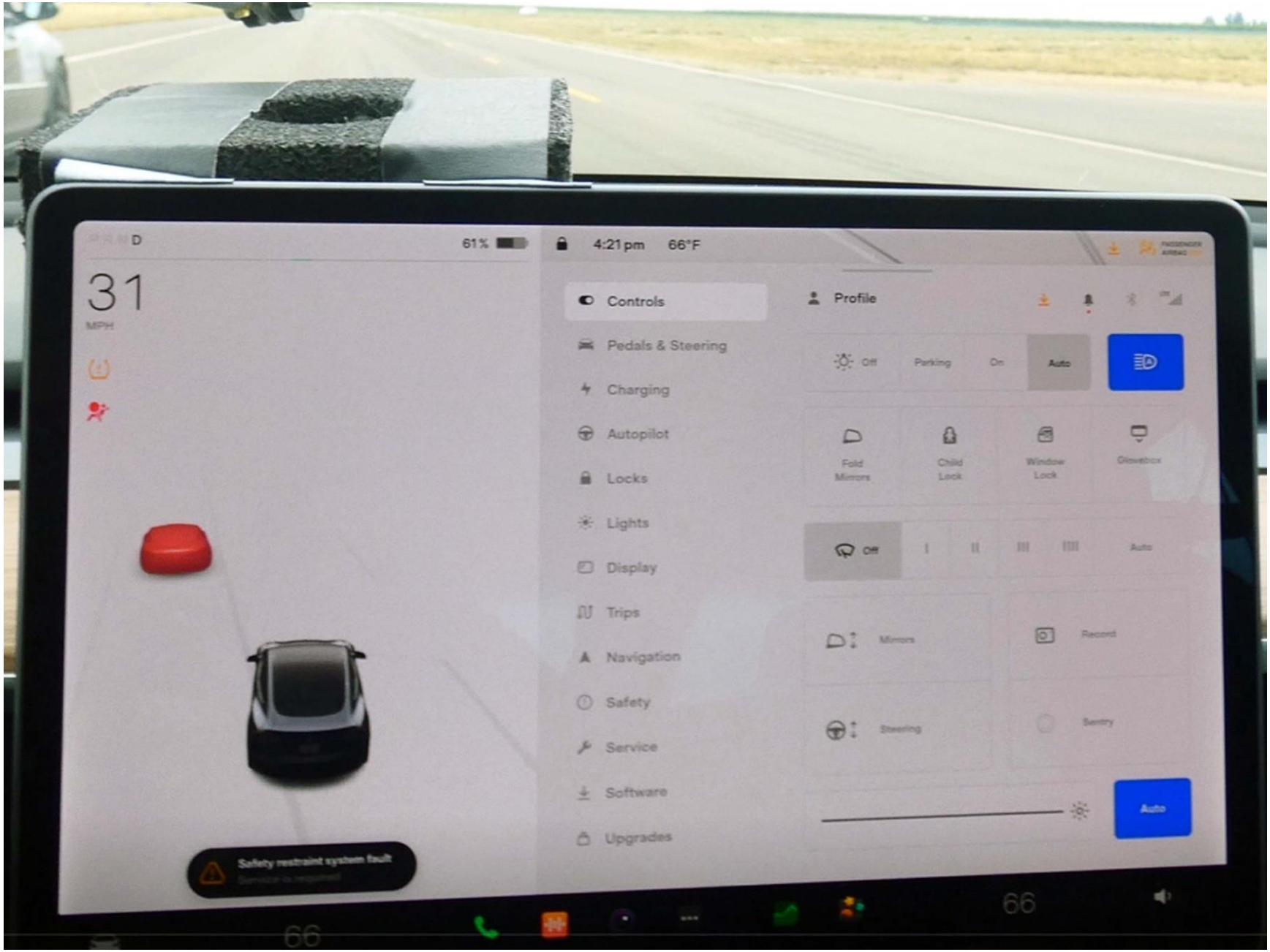


Figure A13. Visual Alert

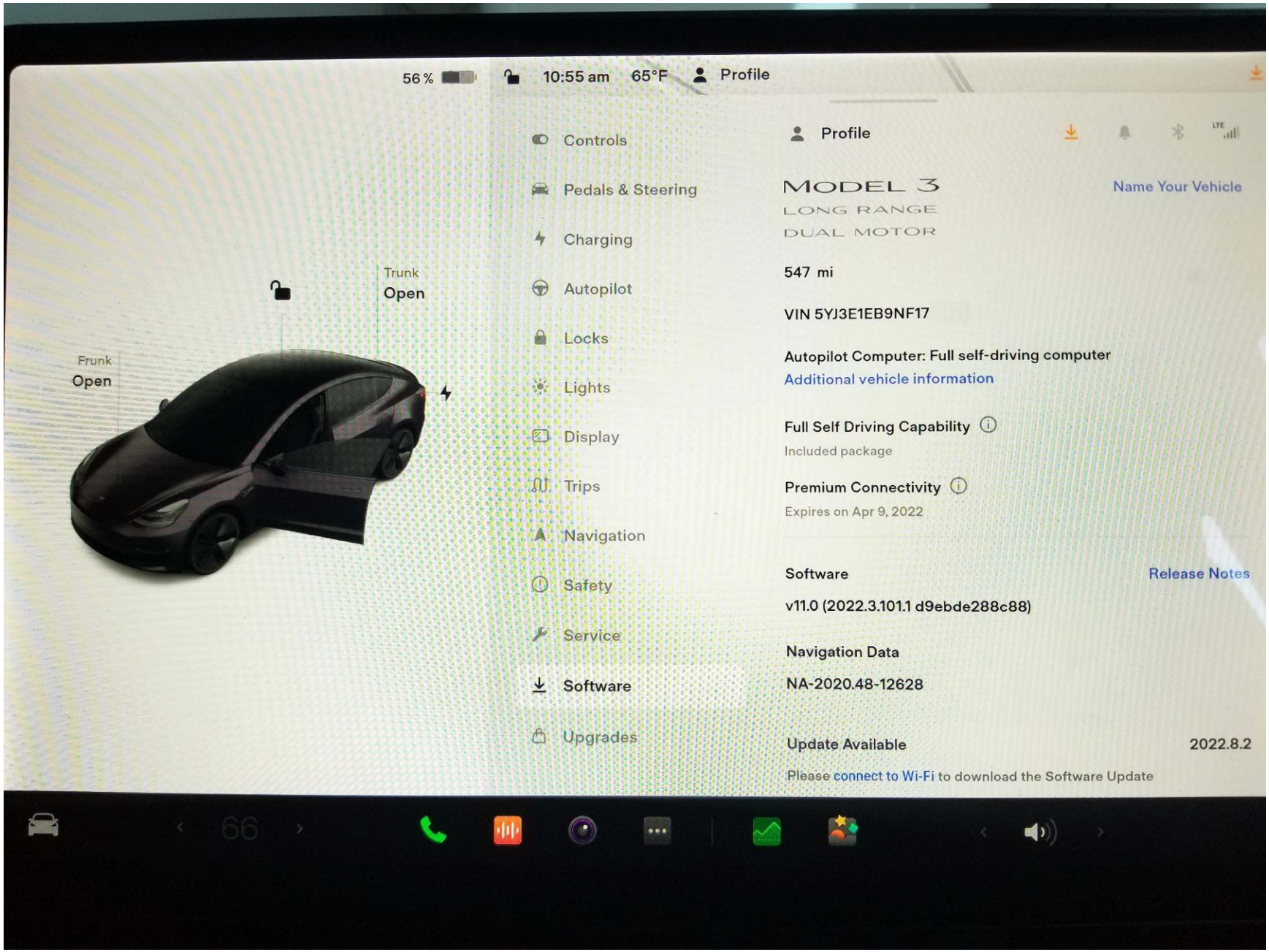


Figure A14. Software Version

APPENDIX B

Excerpts from Owner’s Manual

Collision Avoidance Assist

The following collision avoidance features are designed to increase the safety of you and your passengers:

- **Forward Collision Warning** - provides visual and audible warnings in situations when Model 3 detects that there is a high risk of a frontal collision (see Forward Collision Warning on page 112).
- **Automatic Emergency Braking** - automatically applies braking to reduce the impact of a frontal collision (see Automatic Emergency Braking on page 113).
- **Obstacle-Aware Acceleration** - reduces acceleration if Model 3 detects an object in its immediate driving path (see Obstacle-Aware Acceleration on page 113).

CAUTION: Ensure all cameras and sensors are clean. Dirty cameras and sensors, as well as environmental conditions such as rain and faded lane markings, can affect performance.

WARNING: Forward Collision Warning is for guidance purposes only and is not a substitute for attentive driving and sound judgment. Keep your eyes on the road when driving and never depend on Forward Collision Warning to warn you of a potential collision. Several factors can reduce or impair performance, causing either unnecessary, invalid, inaccurate, or missed warnings. Depending on Forward Collision Warning to warn you of a potential collision can result in serious injury or death.

WARNING: Automatic Emergency Braking is not designed to prevent all collisions. In certain situations, it can minimize the impact of a frontal collision by attempting to reduce your driving speed. Depending on Automatic Emergency Braking to avoid a collision can result in serious injury or death.

WARNING: Obstacle-Aware Acceleration is not designed to prevent a collision. In certain situations, it can minimize the impact of a collision. Depending on Obstacle-Aware Acceleration to avoid a collision can result in serious injury or death.

Forward Collision Warning

Model 3 monitors the area in front of it for the presence of an object such as a vehicle, motorcycle, bicycle, or pedestrian. If a collision is considered likely unless you take immediate corrective action, Forward Collision Warning is designed to sound a chime and highlight the vehicle in front of you in red on the touchscreen. If this happens, **TAKE IMMEDIATE CORRECTIVE ACTION!**

Warnings cancel automatically when the risk of a collision has been reduced (for example, you have decelerated or stopped Model 3, or the object in front of your vehicle has moved out of your driving path).

If immediate action is not taken when Model 3 issues a Forward Collision Warning, Automatic Emergency Braking (if enabled) may automatically apply the brakes if a collision is considered imminent (see Automatic Emergency Braking on page 113).

By default, Forward Collision Warning is turned on. To turn it off or adjust its sensitivity, touch **Controls** > **Autopilot** > **Forward Collision Warning**. Instead of the default warning level of **Medium**, you can turn the warning **Off**, or you can choose to be warned **Late** or **Early**.

NOTE: Your chosen setting for Forward Collision Warning is retained until you manually change it.

WARNING: The camera(s) and sensors associated with Forward Collision Warning are designed to monitor an approximate area of up to 525 feet (160 meters) in your driving path. The area being monitored by Forward Collision Warning can be adversely affected by road and weather conditions. Use appropriate caution when driving.

WARNING: Forward Collision Warning is designed only to provide visual and audible alerts. It does not attempt to apply the brakes or decelerate Model 3. When seeing and/or hearing a warning, it is the driver's responsibility to take immediate corrective action.

WARNING: Forward Collision Warning may provide a warning in situations where the likelihood of collision may not exist. Stay alert and always pay attention to the area in front of Model 3 so you can anticipate whether any action is required.

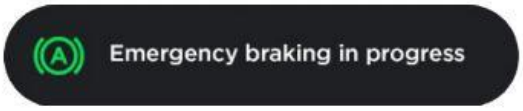
Forward Collision Warning operates only when driving between approximately 3 mph (5 km/h) and 90 mph (150 km/h).

WARNING: Forward Collision Warning does not provide a warning when the driver is already applying the brake.

Automatic Emergency Braking

Model 3 is designed to determine the distance from a detected object traveling in front of it. When a frontal collision is considered unavoidable, Automatic Emergency Braking is designed to apply the brakes to reduce the vehicle's speed and therefore, the severity of the impact. The amount of speed that is reduced depends on many factors, including driving speed and environment.

When Automatic Emergency Braking applies the brakes, the touchscreen displays a visual warning and sounds a chime. You may also notice abrupt downward movement of the brake pedal. The brake lights turn on to alert other road users that you are slowing down.



Automatic Emergency Braking operates only when driving between approximately 3 mph (5 km/h) and 90 mph (150 km/h).

Automatic Emergency Braking does not apply the brakes, or stops applying the brakes, when:

- You turn the steering wheel sharply.
- You press and release the brake pedal while Automatic Emergency Braking is applying the brakes.
- You accelerate hard while Automatic Emergency Braking is applying the brakes.
- The vehicle, motorcycle, bicycle, or pedestrian is no longer detected ahead.

Automatic Emergency Braking is always enabled when you start Model 3. To disable it for your current drive, touch **Controls** > **Autopilot** > **Automatic Emergency Braking**.

WARNING: It is strongly recommended that you do not disable Automatic Emergency Braking. If you disable it, Model 3 does not automatically apply the brakes in situations where a collision is considered likely.

WARNING: Automatic Emergency Braking is designed to reduce the severity of an impact. It is not designed to avoid a collision.

WARNING: Several factors can affect the performance of Automatic Emergency Braking, causing either no braking or inappropriate or untimely braking, such as when a vehicle is partially in the path of travel or there is road debris. It is the driver's responsibility to drive safely and remain in control of the vehicle at all times. Never depend on Automatic Emergency Braking to avoid or reduce the impact of a collision.

WARNING: Automatic Emergency Braking is designed to reduce the impact of frontal collisions only and does not function when Model 3 is in Reverse.

WARNING: Automatic Emergency Braking is not a substitute for maintaining a safe traveling distance between you and the vehicle in front of you.

WARNING: The brake pedal moves downward abruptly during automatic braking events. Always ensure that the brake pedal can move freely. Do not place material under or on top of the driver's floor mat (including an additional mat) and always ensure that the driver's floor mat is properly secured. Failure to do so can impede the ability of the brake pedal to move freely.

Obstacle-Aware Acceleration

Obstacle-Aware Acceleration is designed to reduce the impact of a collision by reducing motor torque and in some cases applying the brakes, if Model 3 detects an object in its driving path. The touchscreen displays a visual warning and sounds a chime when the brakes are automatically applied. For example, Model 3, while parked in front of a closed garage door with the Drive gear engaged, detects that you have pressed hard on the accelerator pedal. Although Model 3 still accelerates and hits the garage door, the reduced torque may result in less damage.

Obstacle-Aware Acceleration is designed to operate only when all of these conditions are simultaneously met:

- A driving gear is engaged (Drive or Reverse).
- Model 3 is stopped or traveling less than 10 mph (16 km/h).
- Model 3 detects an object in its immediate driving path.

To disable Obstacle-Aware Acceleration, touch **Controls** > **Autopilot** > **Obstacle-Aware Acceleration**.

WARNING: Obstacle-Aware Acceleration is designed to reduce the severity of an impact. It is not designed to avoid a collision.

WARNING: Obstacle-Aware Acceleration may not limit torque in all situations. Several factors, including environmental conditions, distance from an obstacle, and a driver's actions, can limit, delay, or inhibit Obstacle-Aware Acceleration.

WARNING: Obstacle-Aware Acceleration may not limit torque when performing a sharp turn, such as into a parking space.

WARNING: Do not rely on Obstacle-Aware Acceleration to control acceleration or to avoid, or limit, the severity of a collision, and do not attempt to test Obstacle-Aware Acceleration. Doing so can result in serious property damage, injury, or death.

WARNING: Several factors can affect the performance of Obstacle-Aware Acceleration, causing an inappropriate or untimely reduction in motor torque. It is the driver's responsibility to drive safely and remain in control of Model 3 at all times.

Limitations and Inaccuracies

Collision Avoidance features cannot always detect all objects, vehicles, bikes, or pedestrians, and you may experience unnecessary, inaccurate, invalid, or missed warnings for many reasons, particularly if:

- The road has sharp curves.
- Visibility is poor (due to heavy rain, snow, fog, etc.).
- Bright light (such as from oncoming headlights or direct sunlight) is interfering with the view of the camera(s).
- The camera or radar sensor (if equipped) is obstructed (dirty, covered, fogged over, covered by a sticker, etc.).
- One or more of the ultrasonic sensors is damaged, dirty, or obstructed (such as by mud, ice, or snow, or by a vehicle bra, excessive paint, or adhesive products such as wraps, stickers, rubber coating, etc.).
- Weather conditions (heavy rain, snow, fog, or extremely hot or cold temperatures) are interfering with sensor operation.
- The sensors are affected by other electrical equipment or devices that generate ultrasonic waves.

WARNING: The limitations previously described do not represent an exhaustive list of situations that may interfere with proper operation of Collision Avoidance Assist features. These features may fail to provide their intended function for many other reasons. It is the driver's responsibility to avoid collisions by staying alert, paying attention, and taking corrective action as early as possible.

CAUTION: If a fault occurs with a Collision Avoidance Assist feature, Model 3 displays an alert. Contact Tesla Service.

APPENDIX C

Run Log

Subject Vehicle: **2022 Tesla Model 3 AWD** Test Date: **3/21/2022**

Principal Other Vehicle: **2006 Acura RL**

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Margin (sec)	Pass/Fail	Notes
Due to the continuously changing visual display, the FCW visual alert was not able to be detected accurately. Only the auditory alert was captured for this test.						
1	**Stopped POV**	Y	3.05	0.95	Pass	
2		Y	3.07	0.97	Pass	
3		Y	3.08	0.98	Pass	
4		Y	3.03	0.93	Pass	
5		Y	3.09	0.99	Pass	
6		Y	3.01	0.91	Pass	
7		Y	3.03	0.93	Pass	
19	**Decelerating POV, 45**	N				POV Brakes, Lateral Offset
20		N				POV Brakes
21		Y	2.94	0.54	Pass	
22		N				Lateral Offset
23		Y	2.78	0.38	Pass	
24		Y	2.83	0.43	Pass	
25		Y	2.87	0.47	Pass	
26		Y	3.02	0.62	Pass	

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Margin (sec)	Pass/Fail	Notes
27		N				Lateral Offset
28		N				POV Speed
29		Y	3.02	0.62	Pass	
30		N				Lateral Offset
31		Y	2.95	0.55	Pass	
8	**Slower POV, 45 vs 20**	Y	3.00	1.00	Pass	
9		Y	3.09	1.09	Pass	
10		Y	3.01	1.01	Pass	
11		N				Lateral Offset
12		N				Lateral Offset
13		Y	2.95	0.95	Pass	
14		Y	2.88	0.88	Pass	
15		Y	3.03	1.03	Pass	
16		N				Lateral Offset
17		N				POV Speed
18		Y	2.67	0.67	Pass	

APPENDIX D

Time History Plots

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Figure D3. Example Time History for Test Type 2, Passing D-9
Figure D4. Example Time History for Test Type 2, Failing D-10
Figure D5. Example Time History for Test Type 3, Passing D-11
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Figure D26. Time History for Run 15, Test 3 - Slower Moving POV, Auditory Warning D-32
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Description of Time History Plots

A set of time history plots is provided for each valid run in the test series. Each set of plots comprises time varying data from 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.

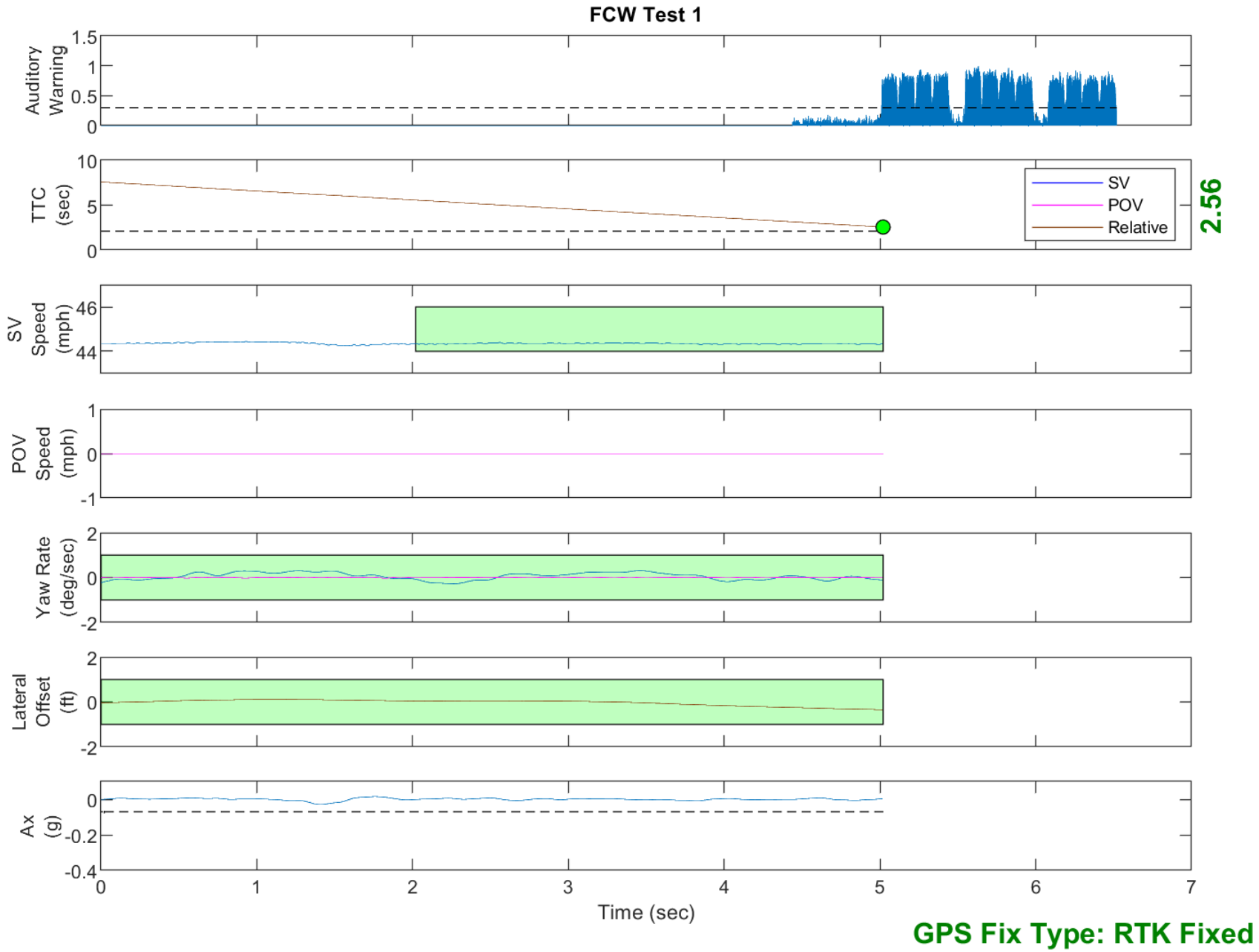

Figure D1. Example Time History for Test Type 1, Passing

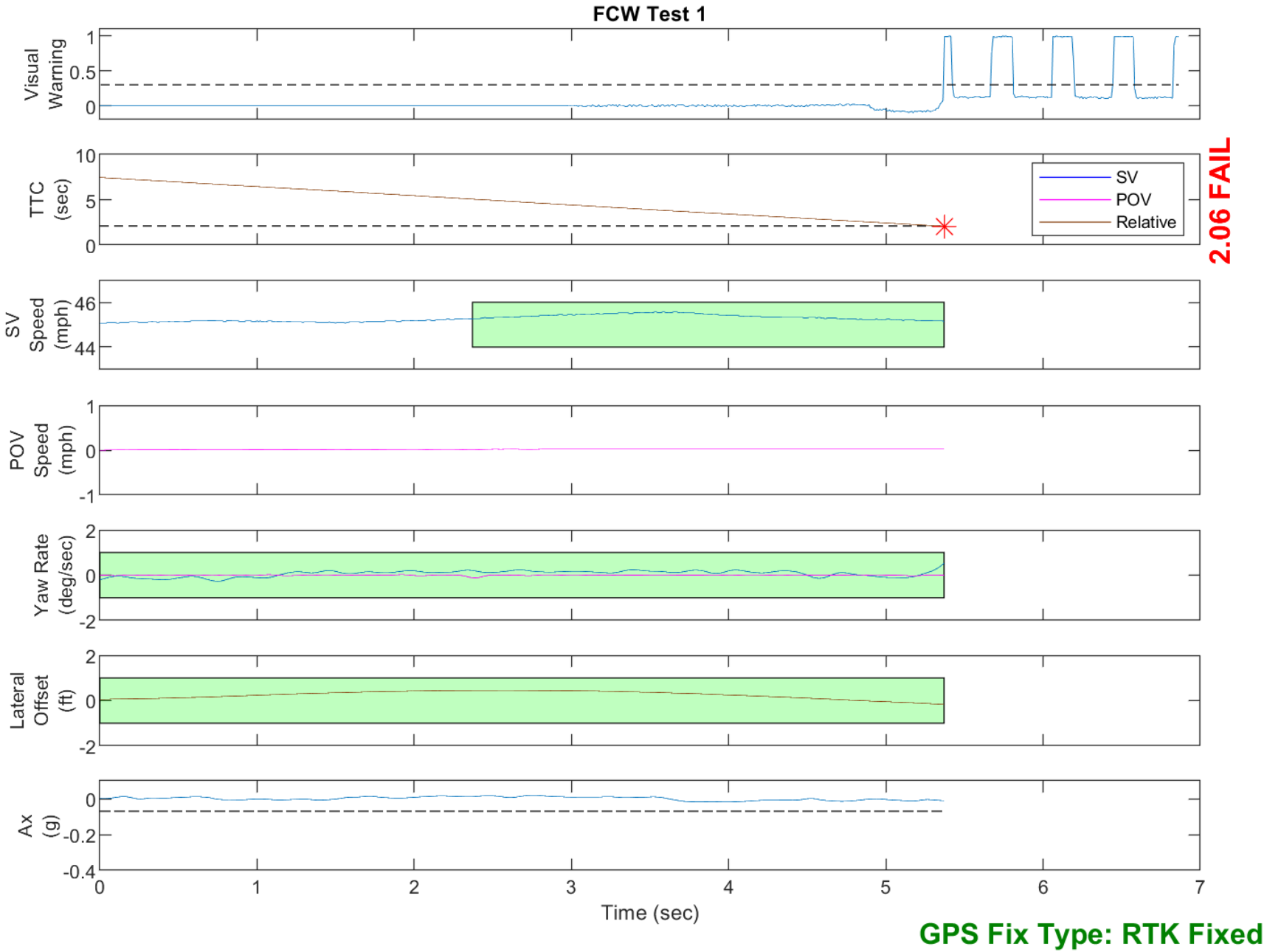

Figure D2. Example Time History for Test Type 1, Failing

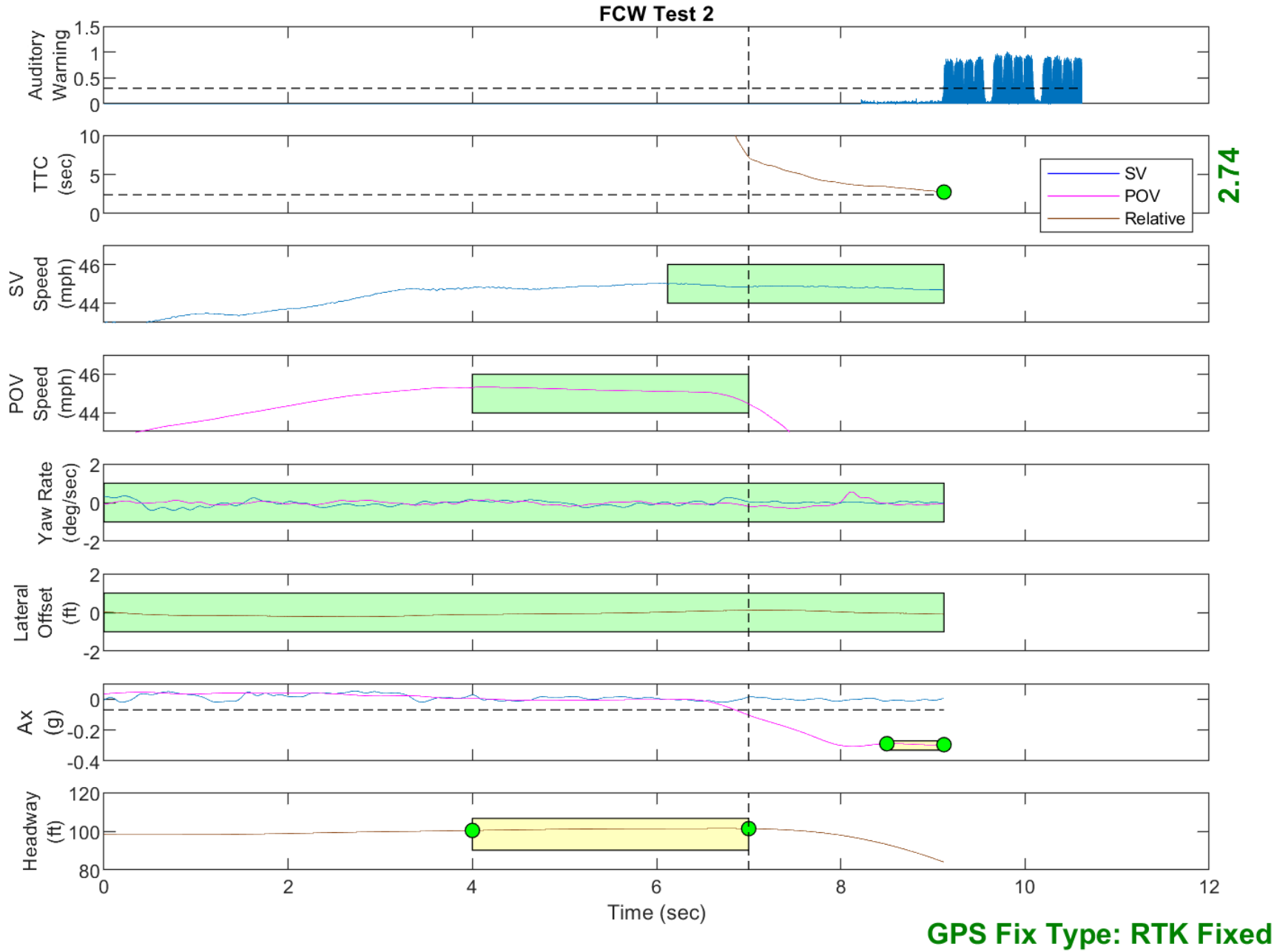

Figure D3. Example Time History for Test Type 2, Passing

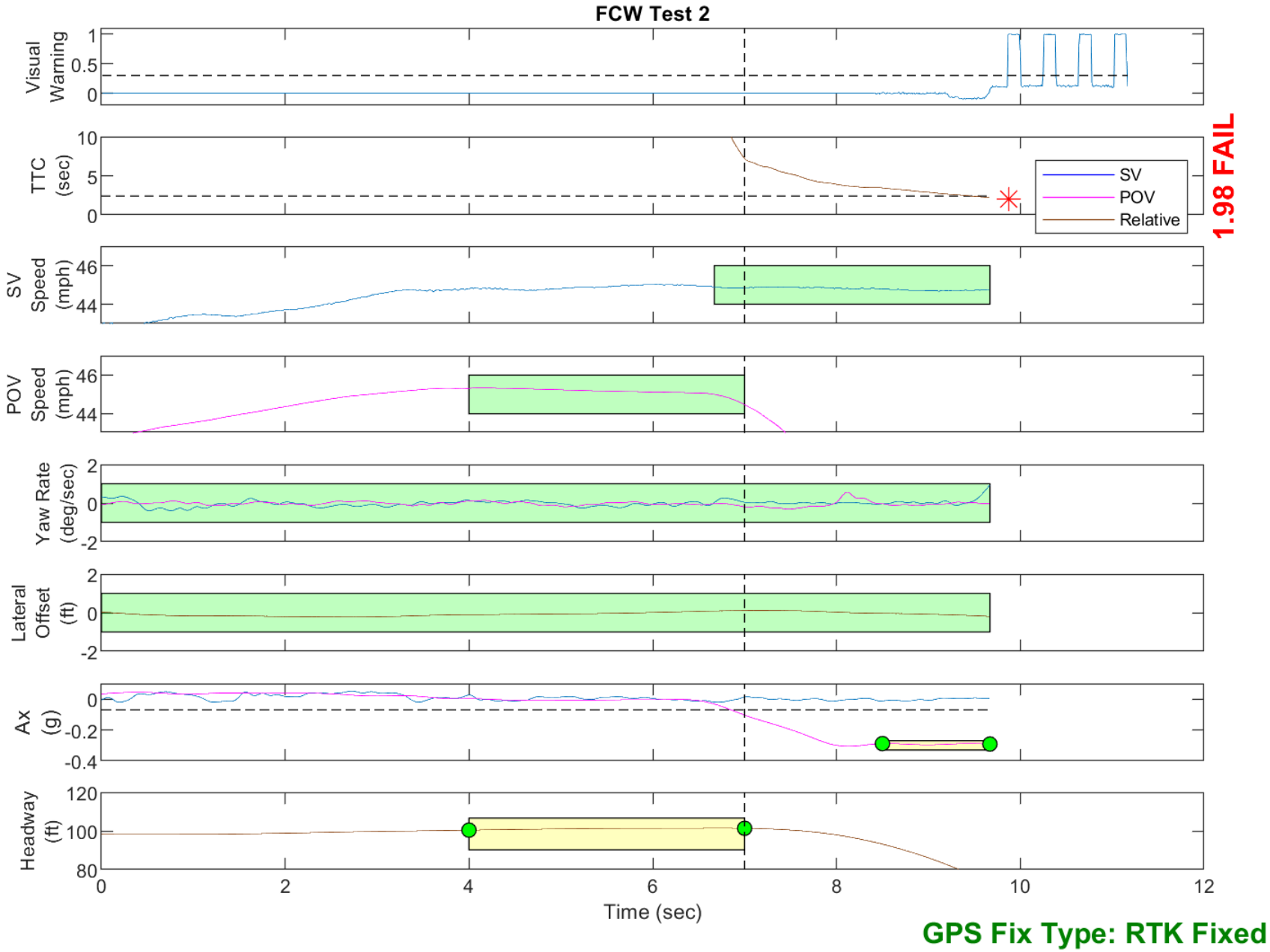

Figure D4. Example Time History for Test Type 2, Failing

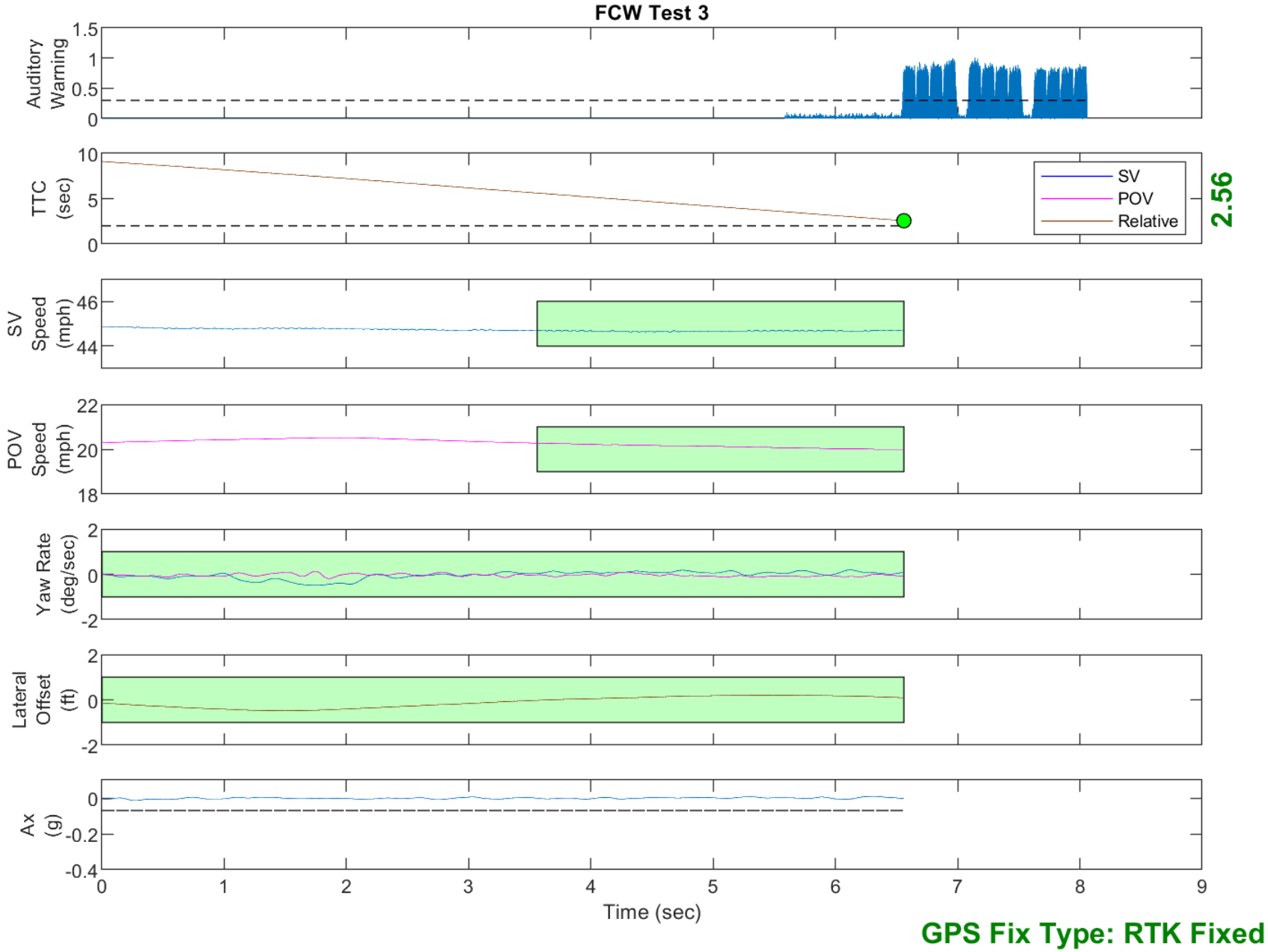

Figure D5. Example Time History for Test Type 3, Passing

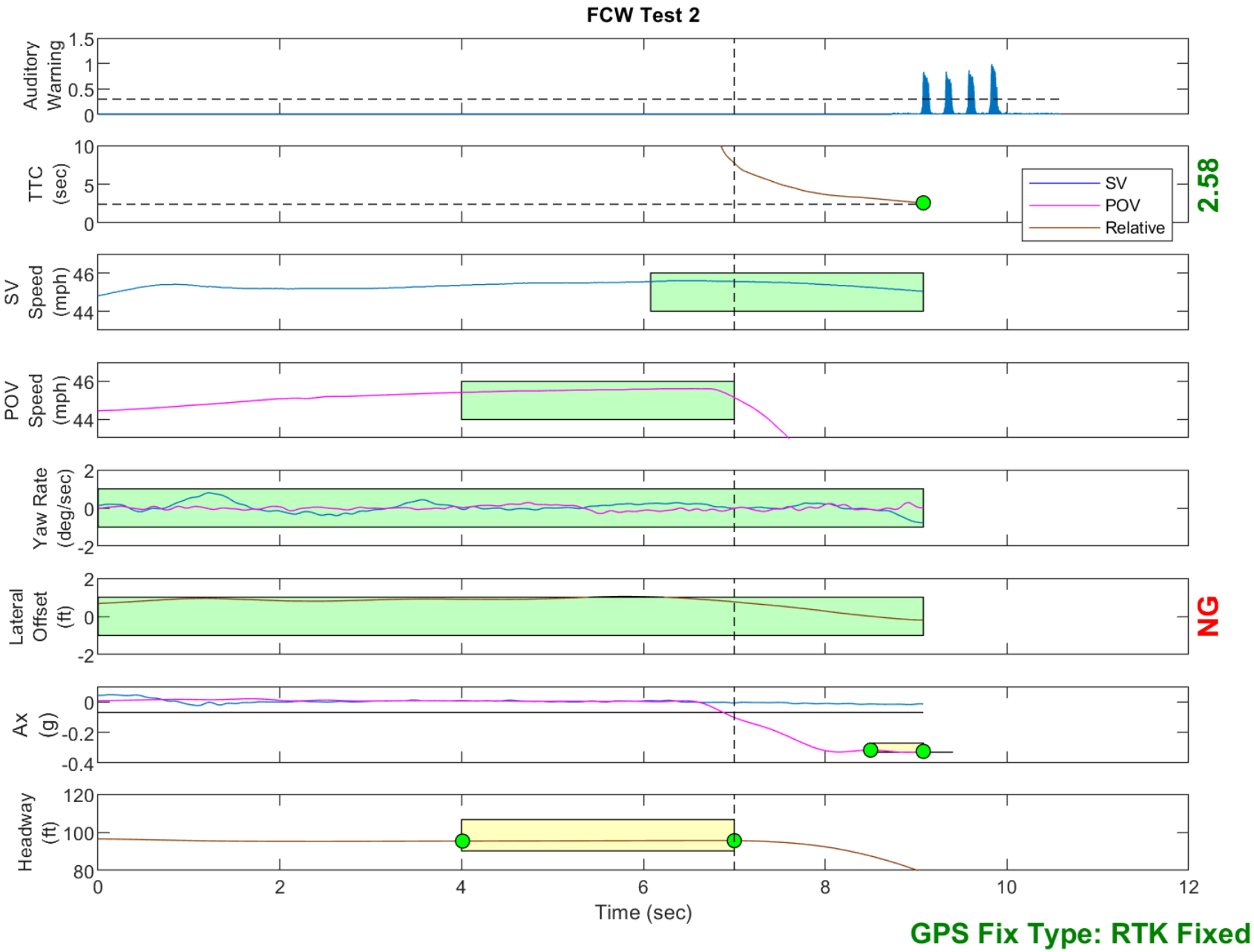

Figure D6. Example Time History Showing Invalid Lateral Offset Criteria

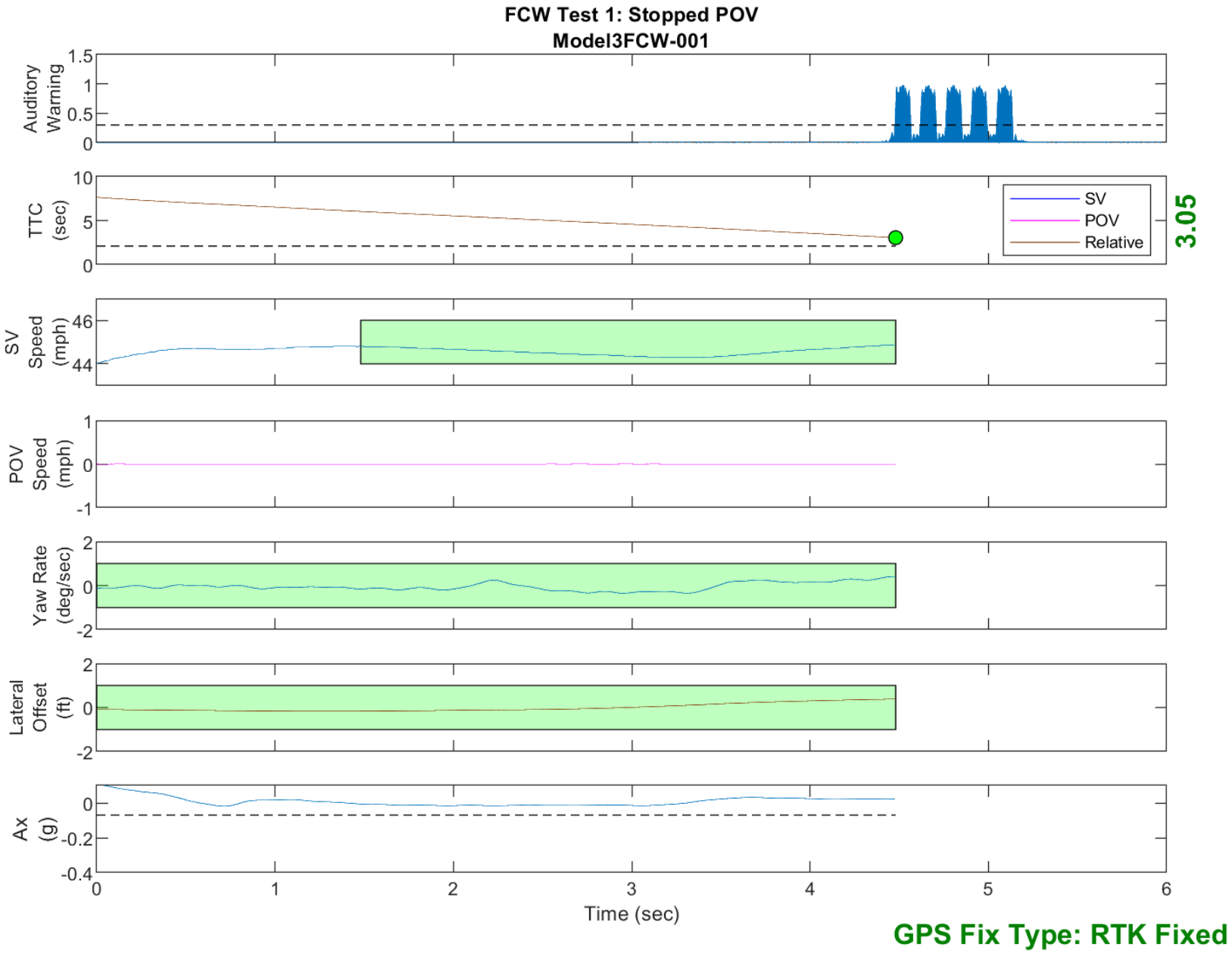

Figure D7. Time History for Run 1, Test 1 - Stopped POV, Auditory Warning

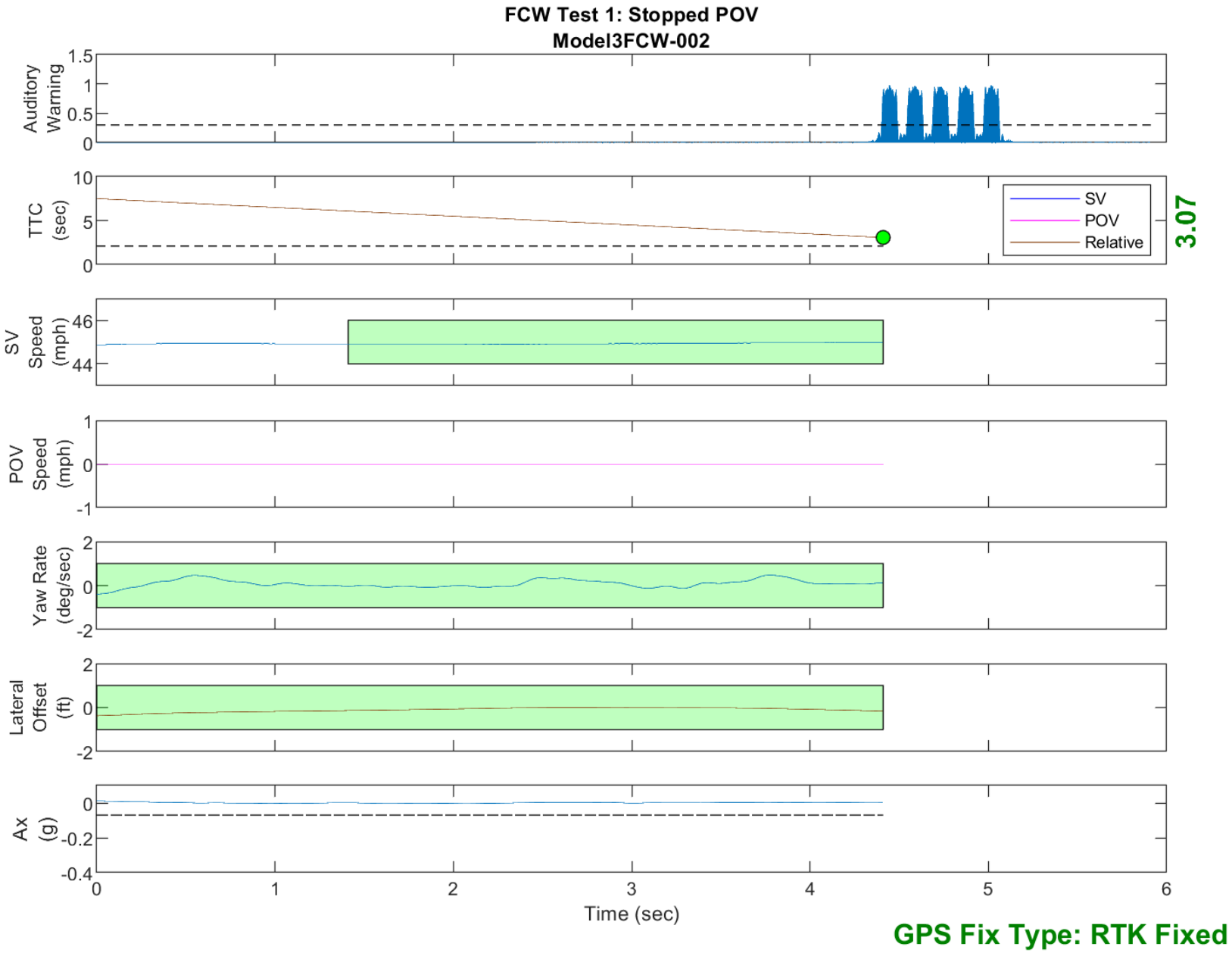

Figure D8. Time History for Run 2, Test 1 - Stopped POV, Auditory Warning

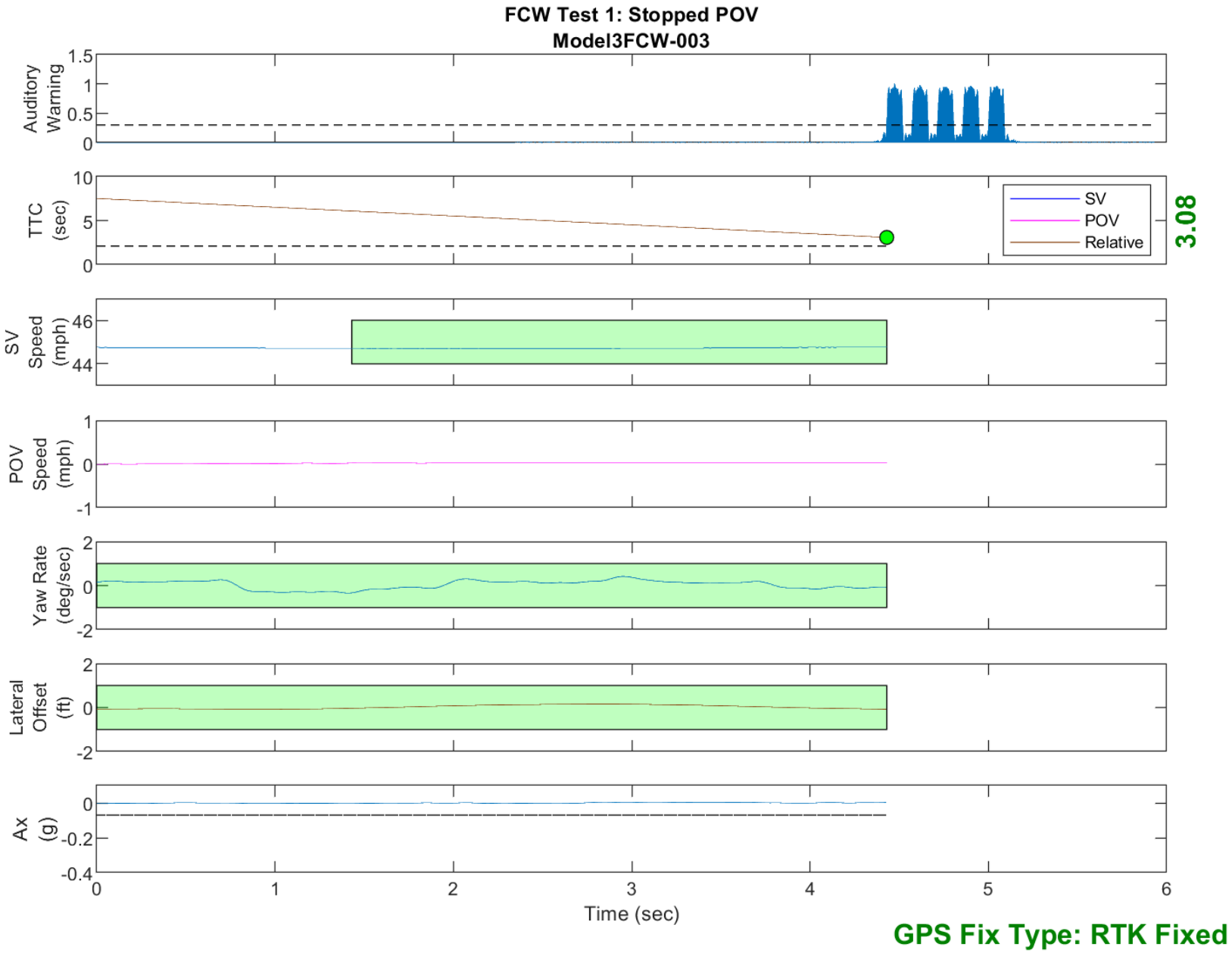

Figure D9. Time History for Run 3, Test 1 - Stopped POV, Auditory Warning

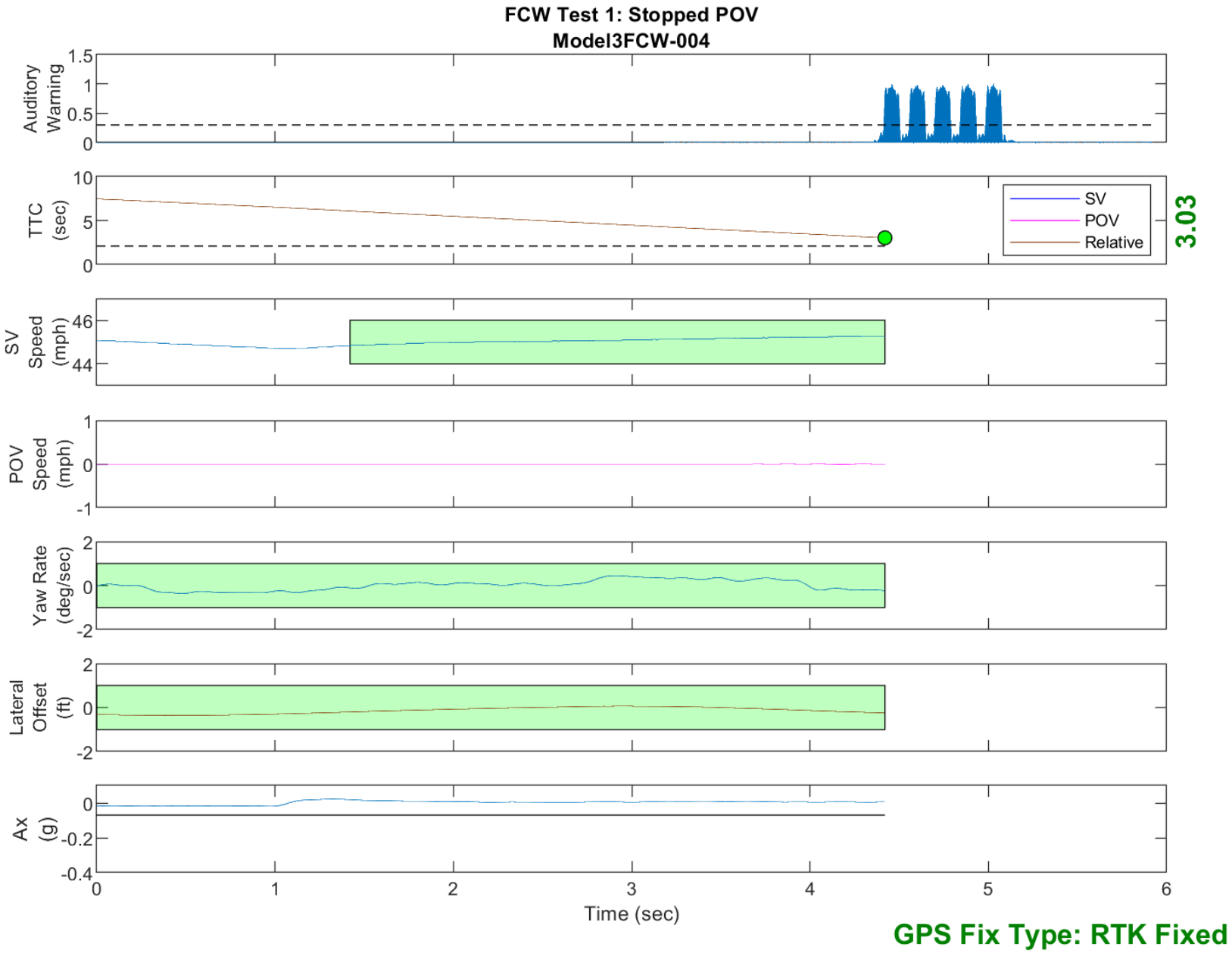

Figure D10. Time History for Run 4, Test 1 - Stopped POV, Auditory Warning

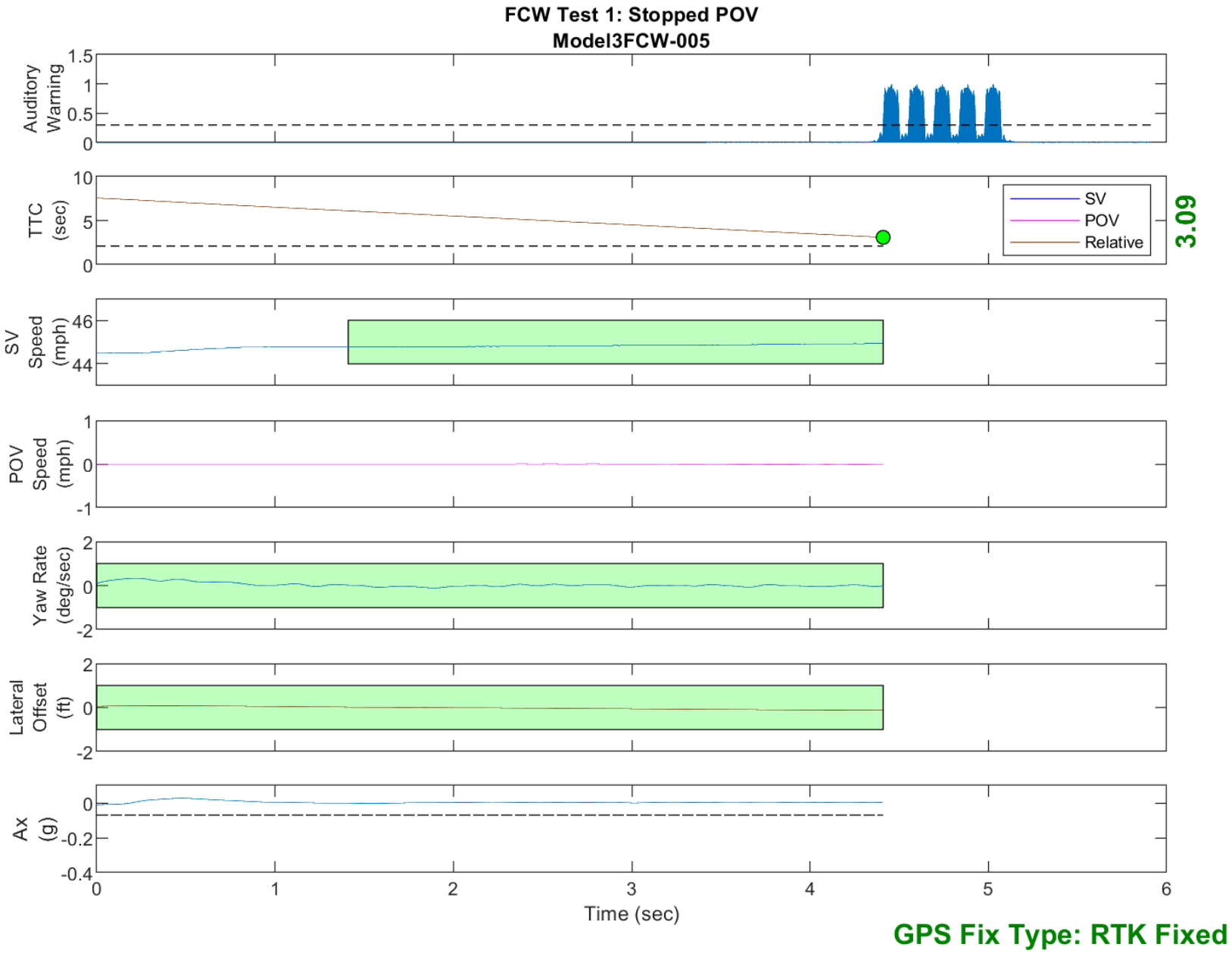

Figure D11. Time History for Run 5, Test 1 - Stopped POV, Auditory Warning

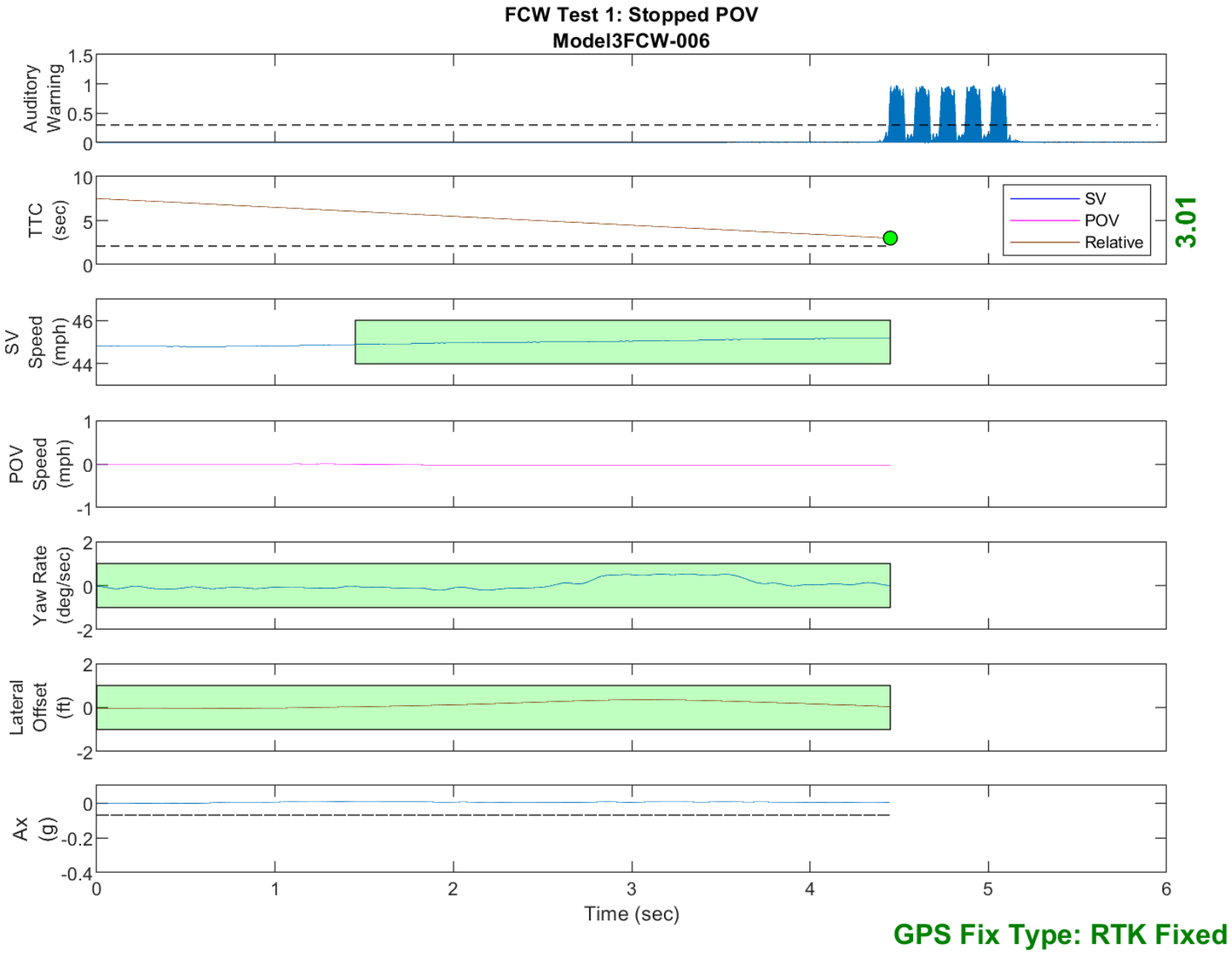

Figure D12. Time History for Run 6, Test 1 - Stopped POV, Auditory Warning

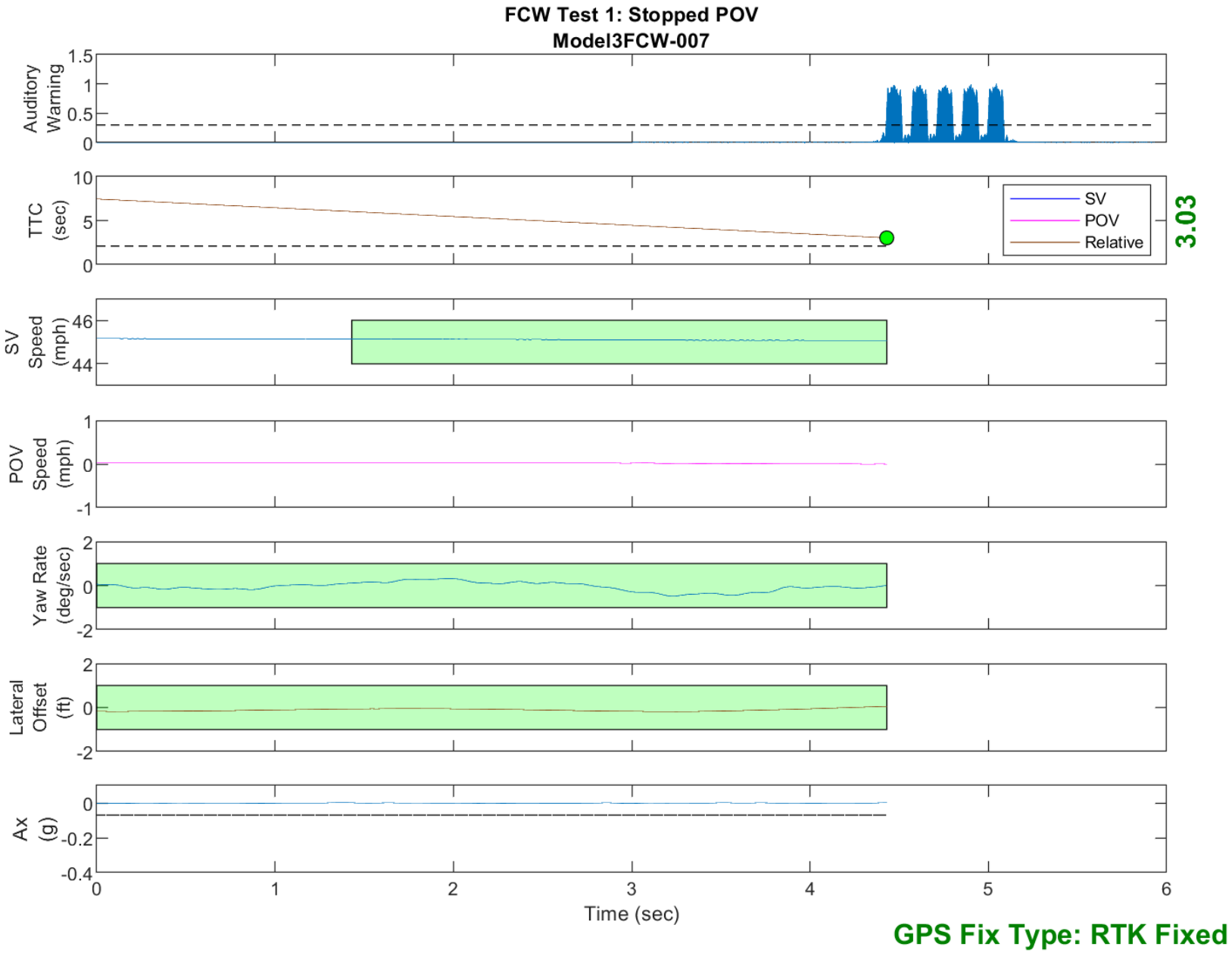

Figure D13. Time History for Run 7, Test 1 - Stopped POV, Auditory Warning

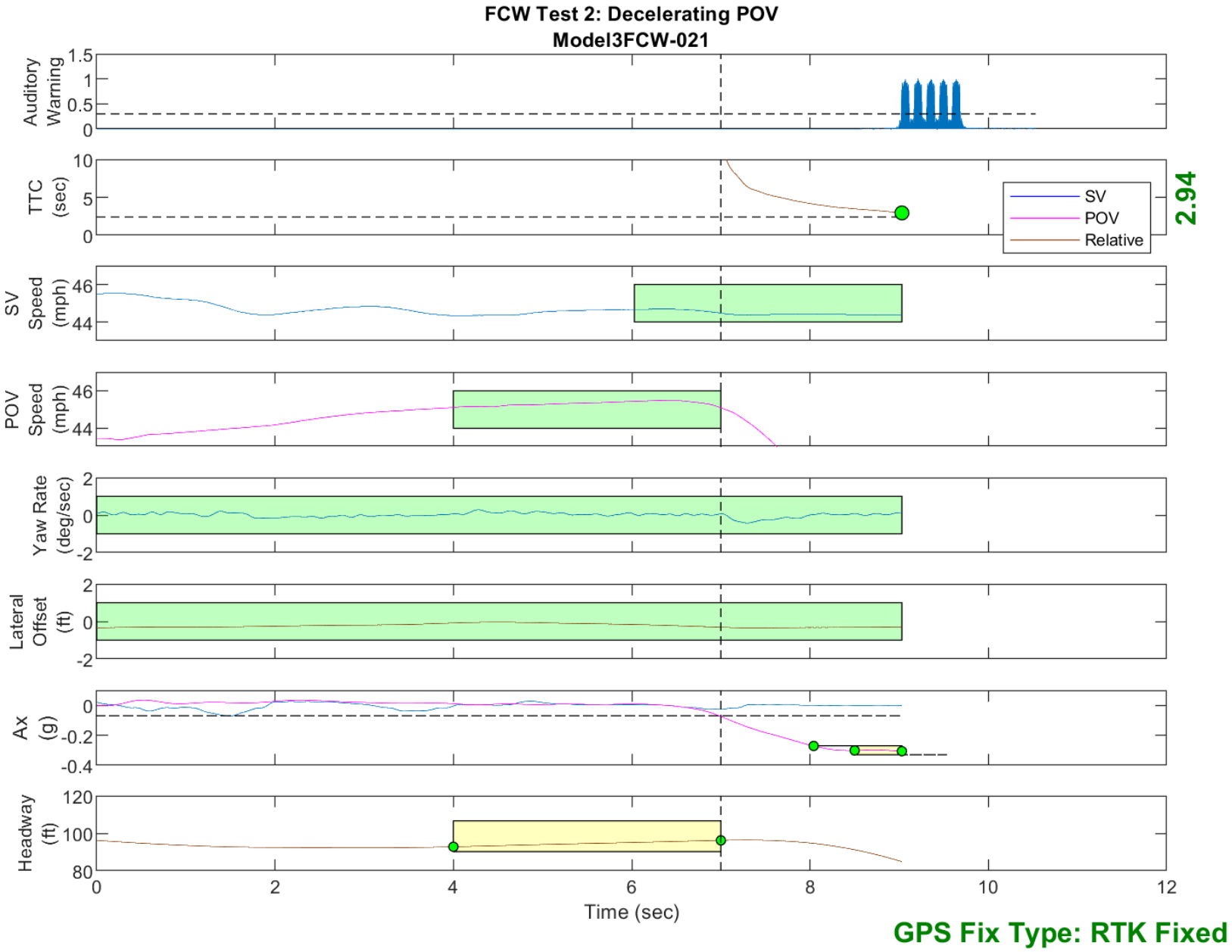

Figure D14. Time History for Run 21, Test 2 - Decelerating POV, Auditory Warning

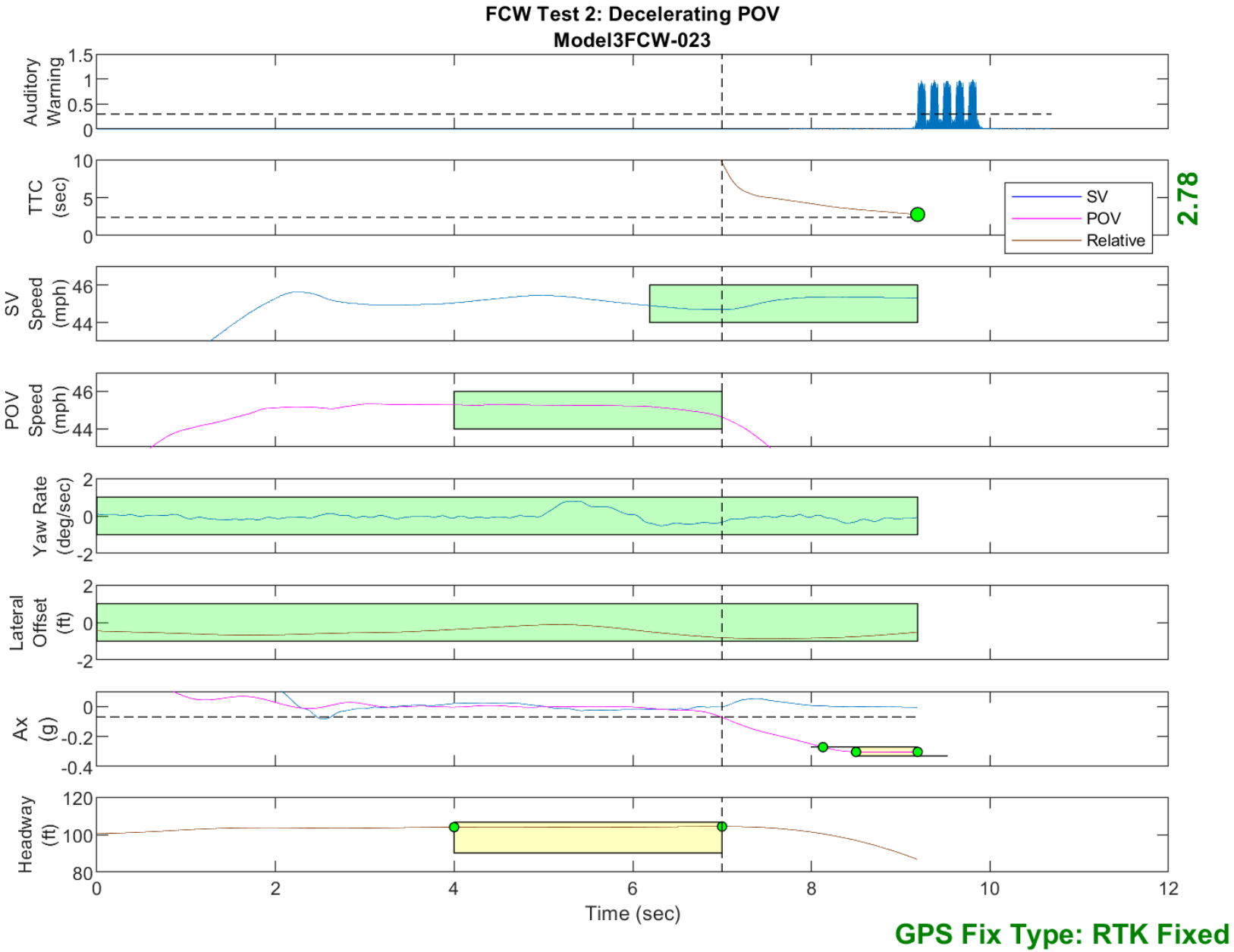

Figure D15. Time History for Run 23, Test 2 - Decelerating POV, Auditory Warning

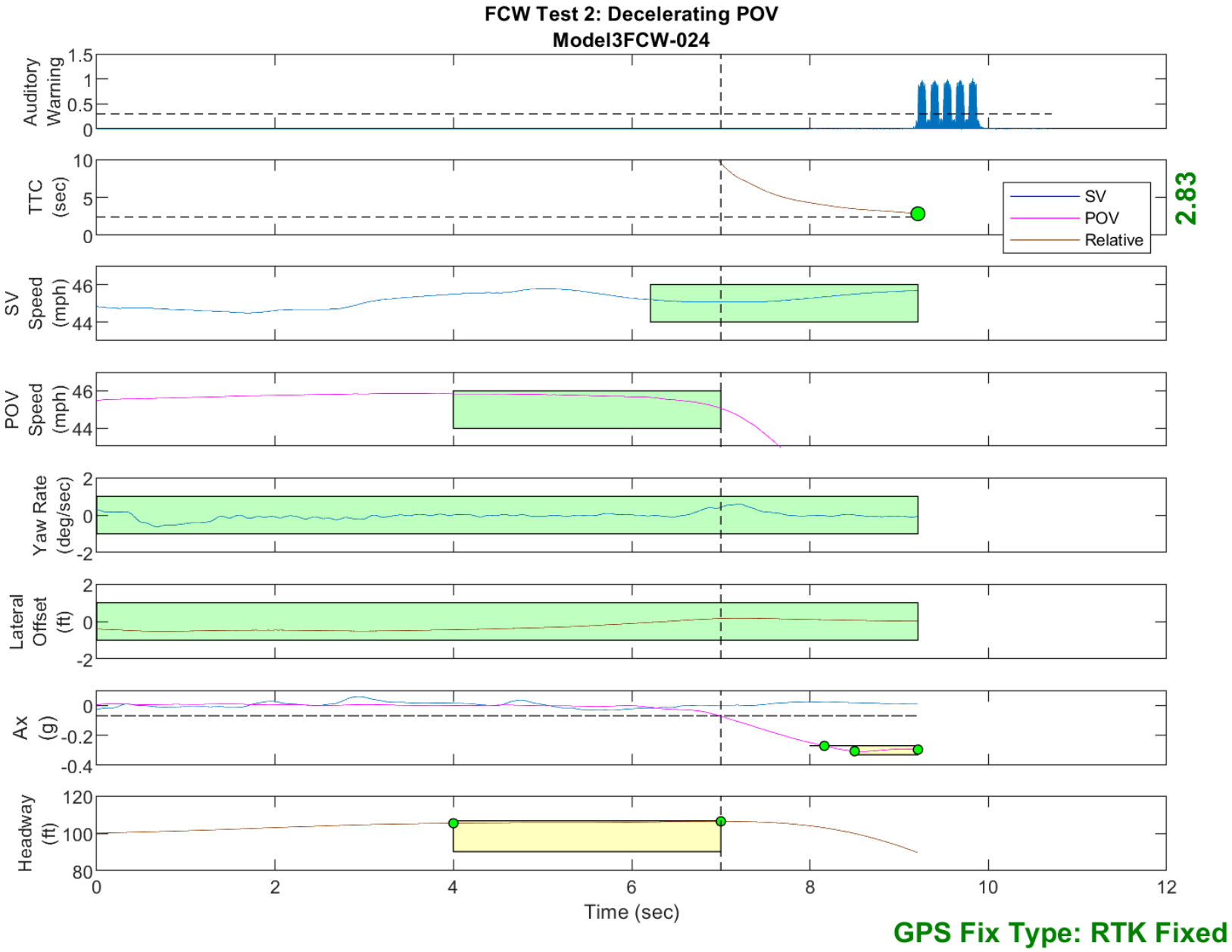

Figure D16. Time History for Run 24, Test 2 - Decelerating POV, Auditory Warning

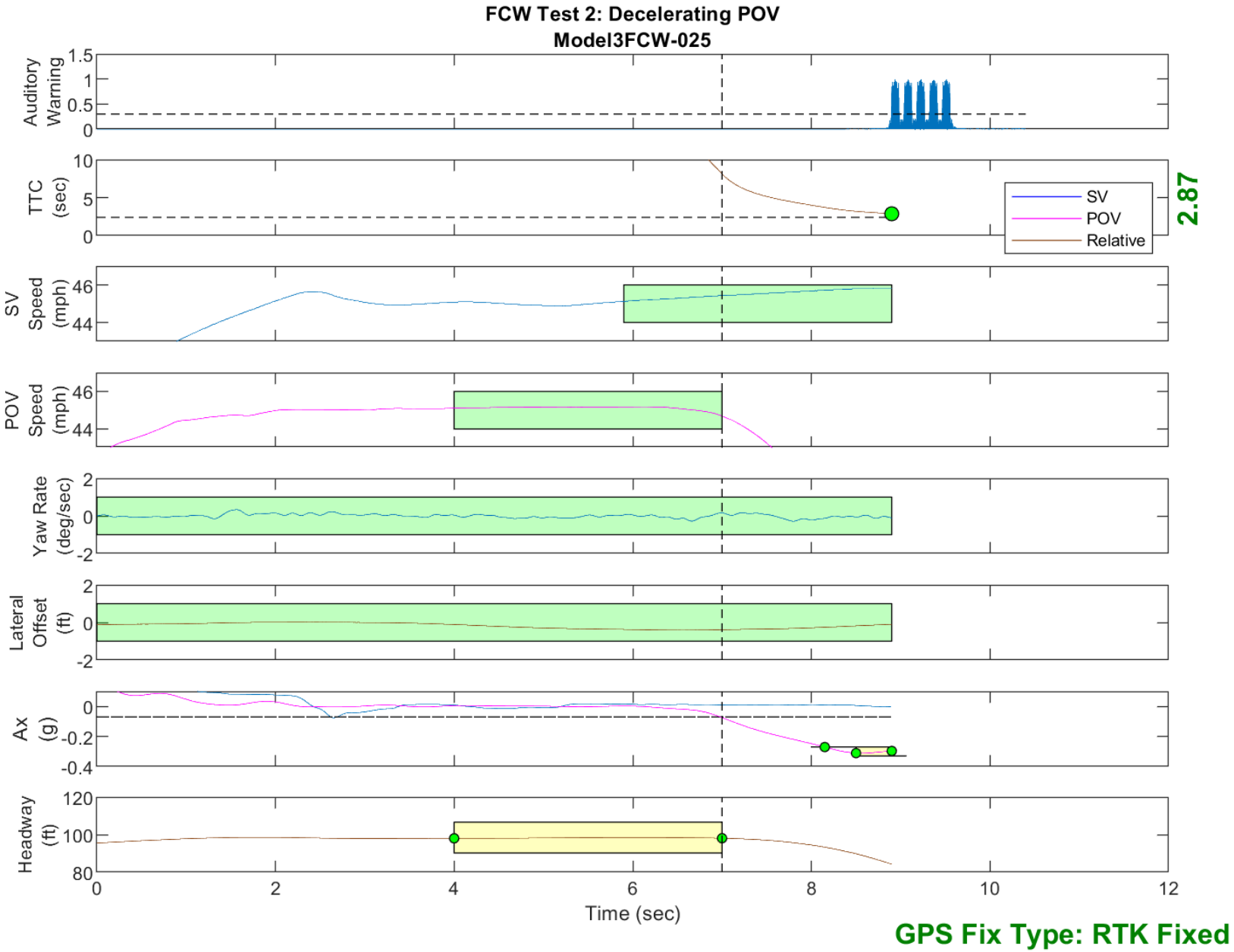

Figure D17. Time History for Run 25, Test 2 - Decelerating POV, Auditory Warning

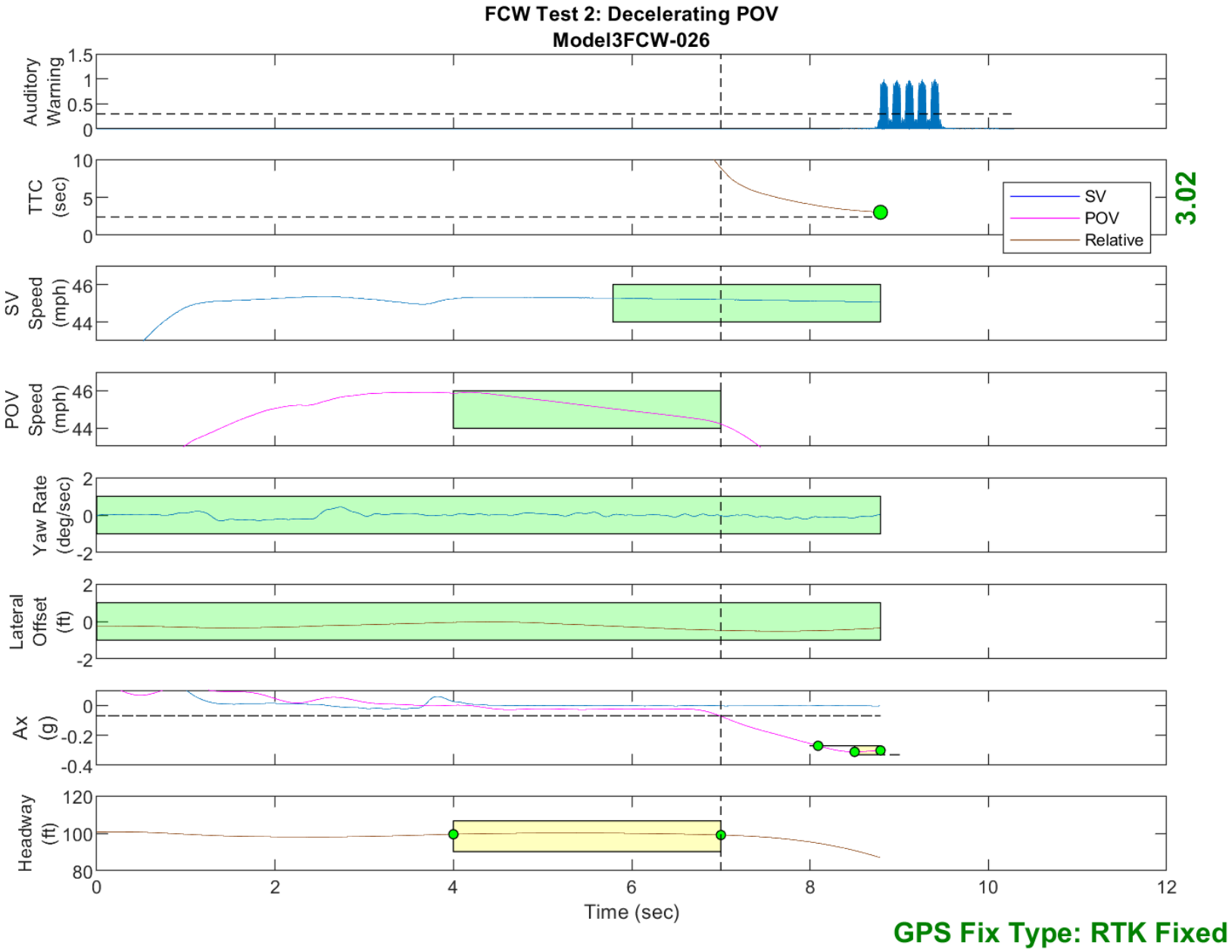

Figure D18. Time History for Run 26, Test 2 - Decelerating POV, Auditory Warning

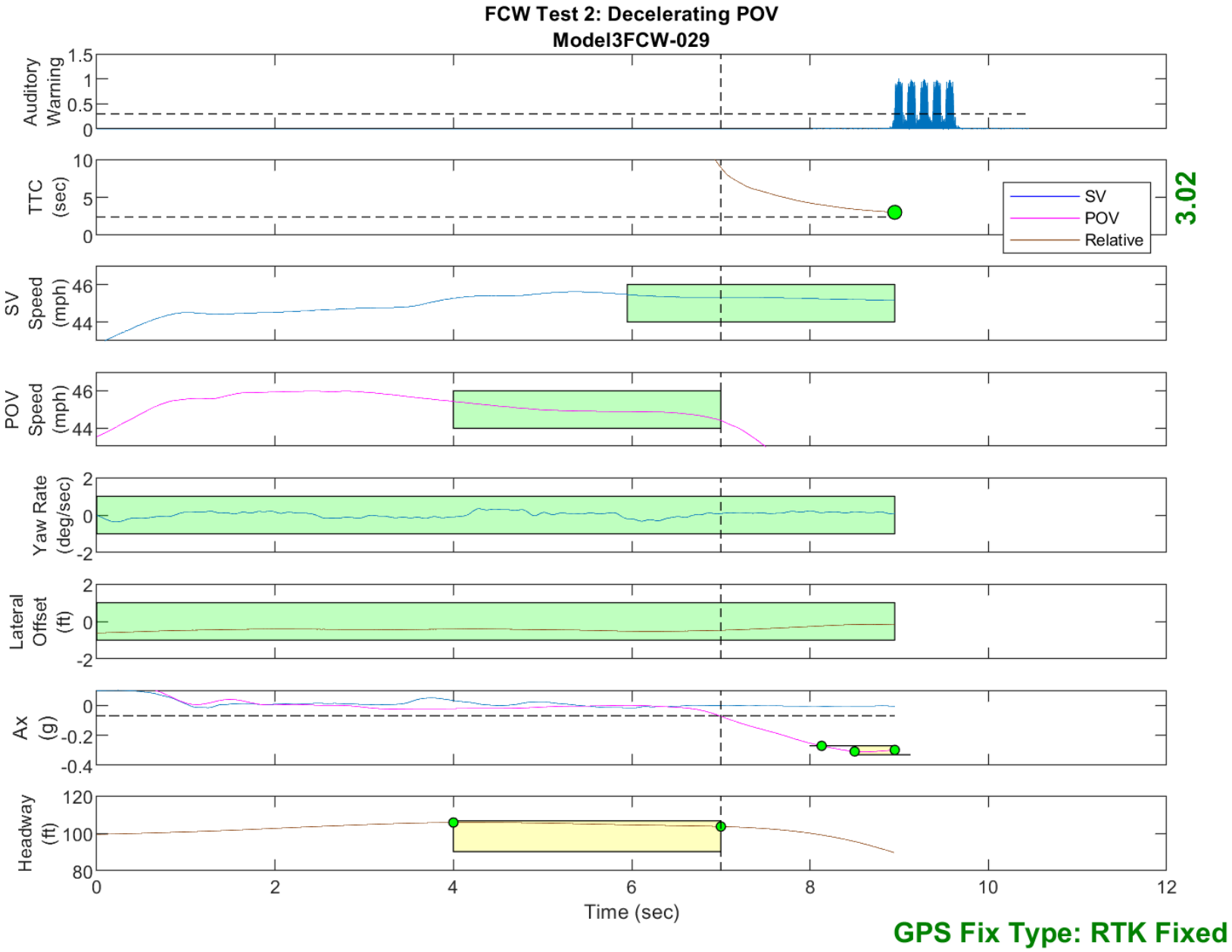

Figure D19. Time History for Run 29, Test 2 - Decelerating POV, Auditory Warning

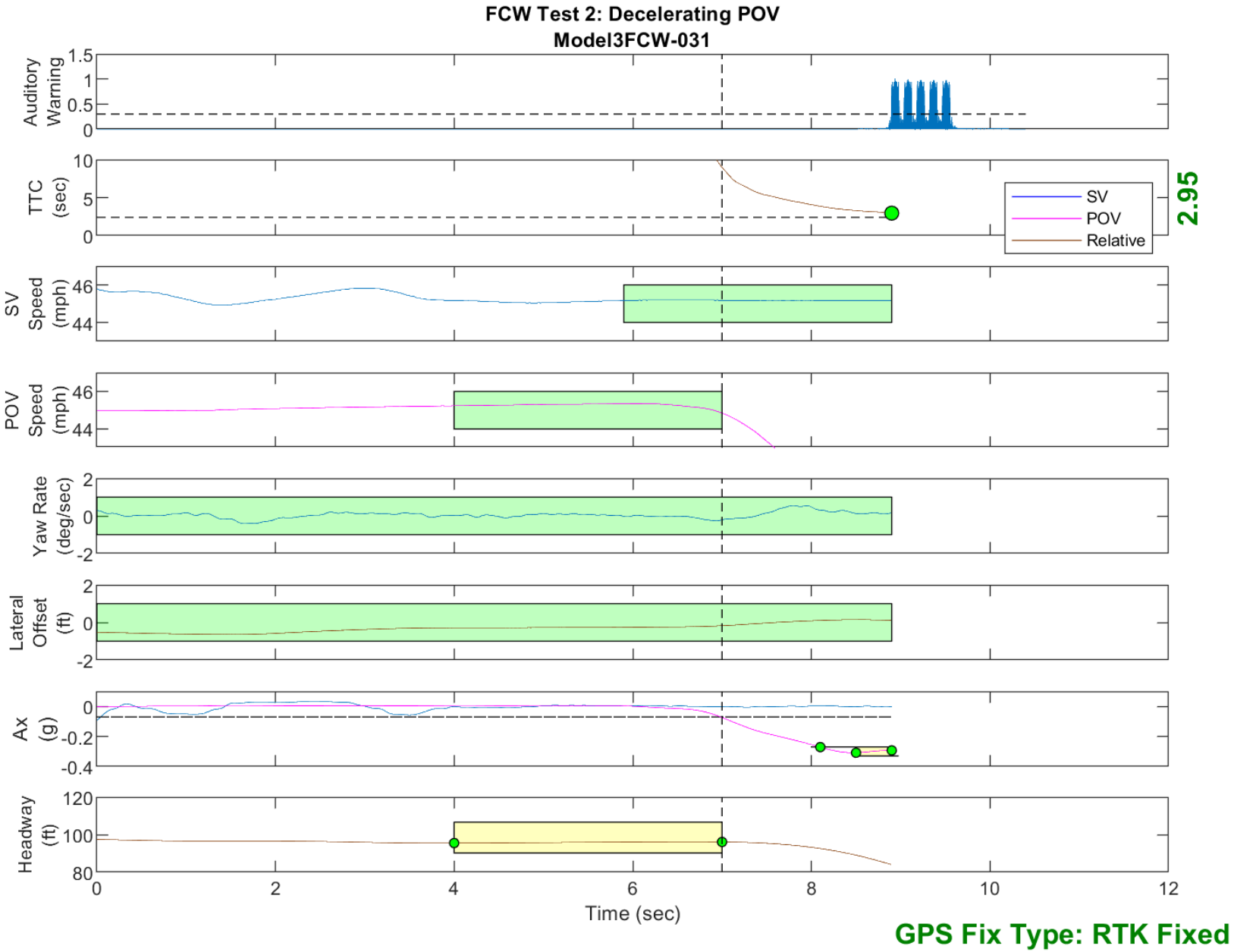

Figure D20. Time History for Run 31, Test 2 - Decelerating POV, Auditory Warning

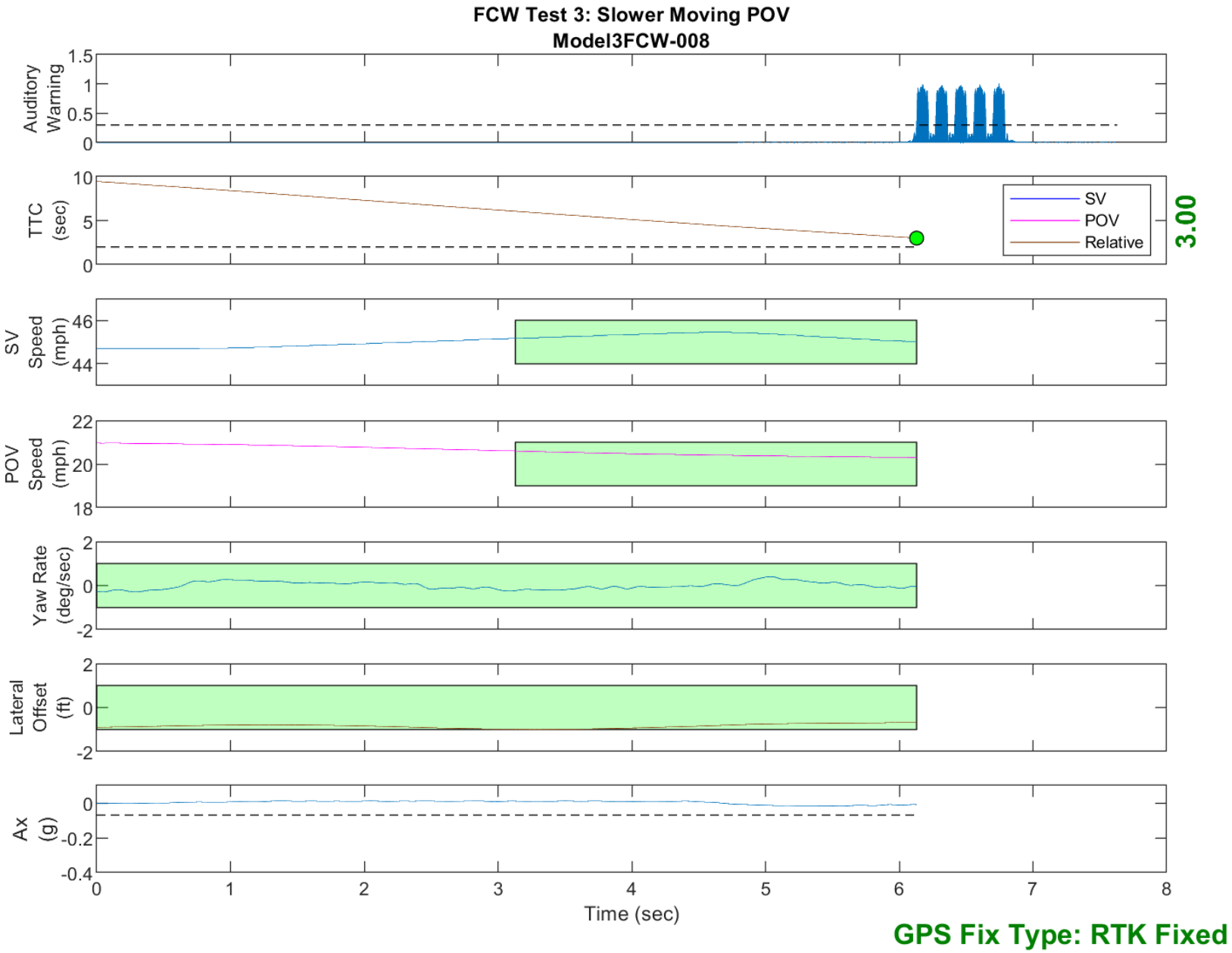

Figure D21. Time History for Run 8, Test 3 - Slower Moving POV, Auditory Warning

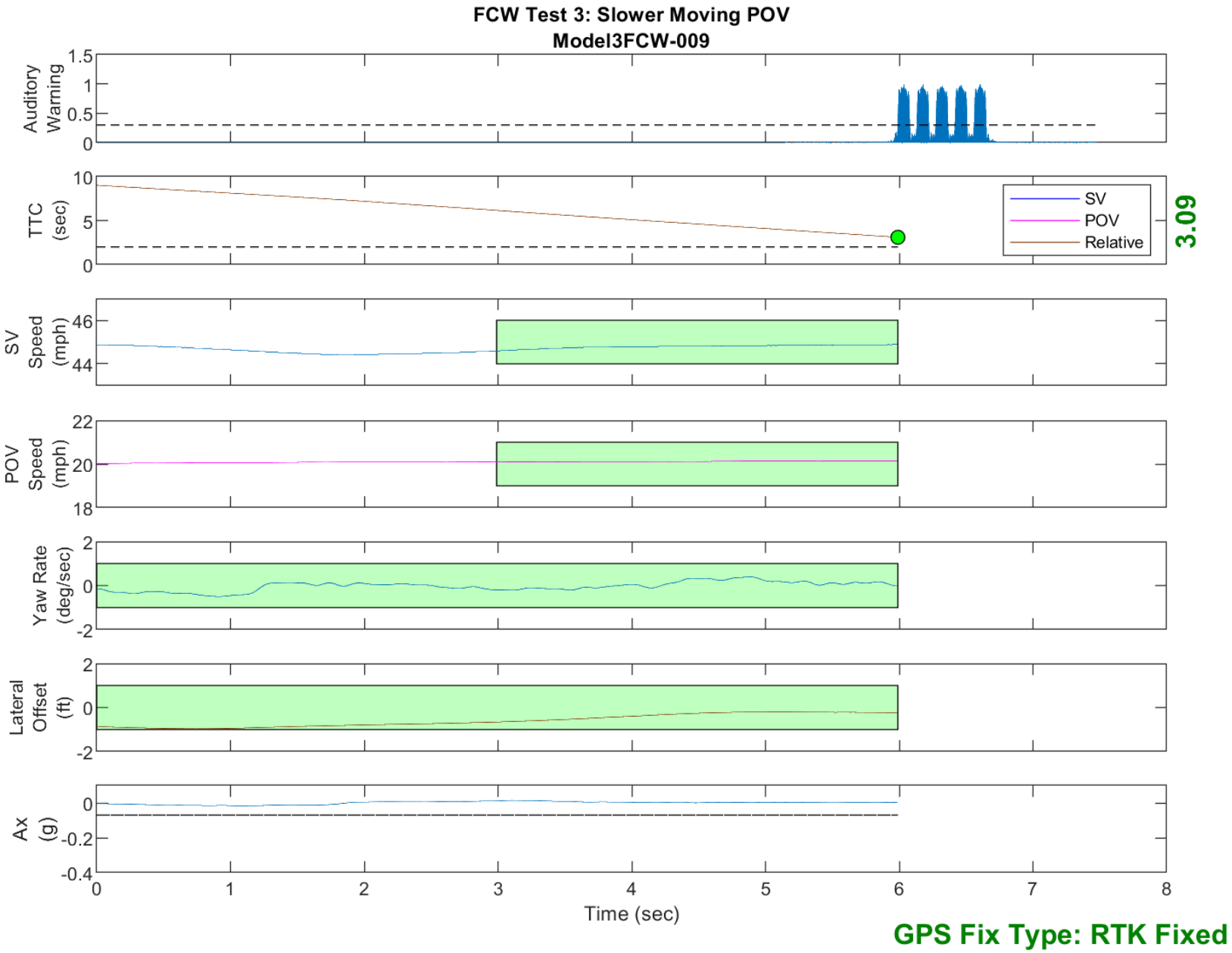

Figure D22. Time History for Run 9, Test 3 - Slower Moving POV, Auditory Warning

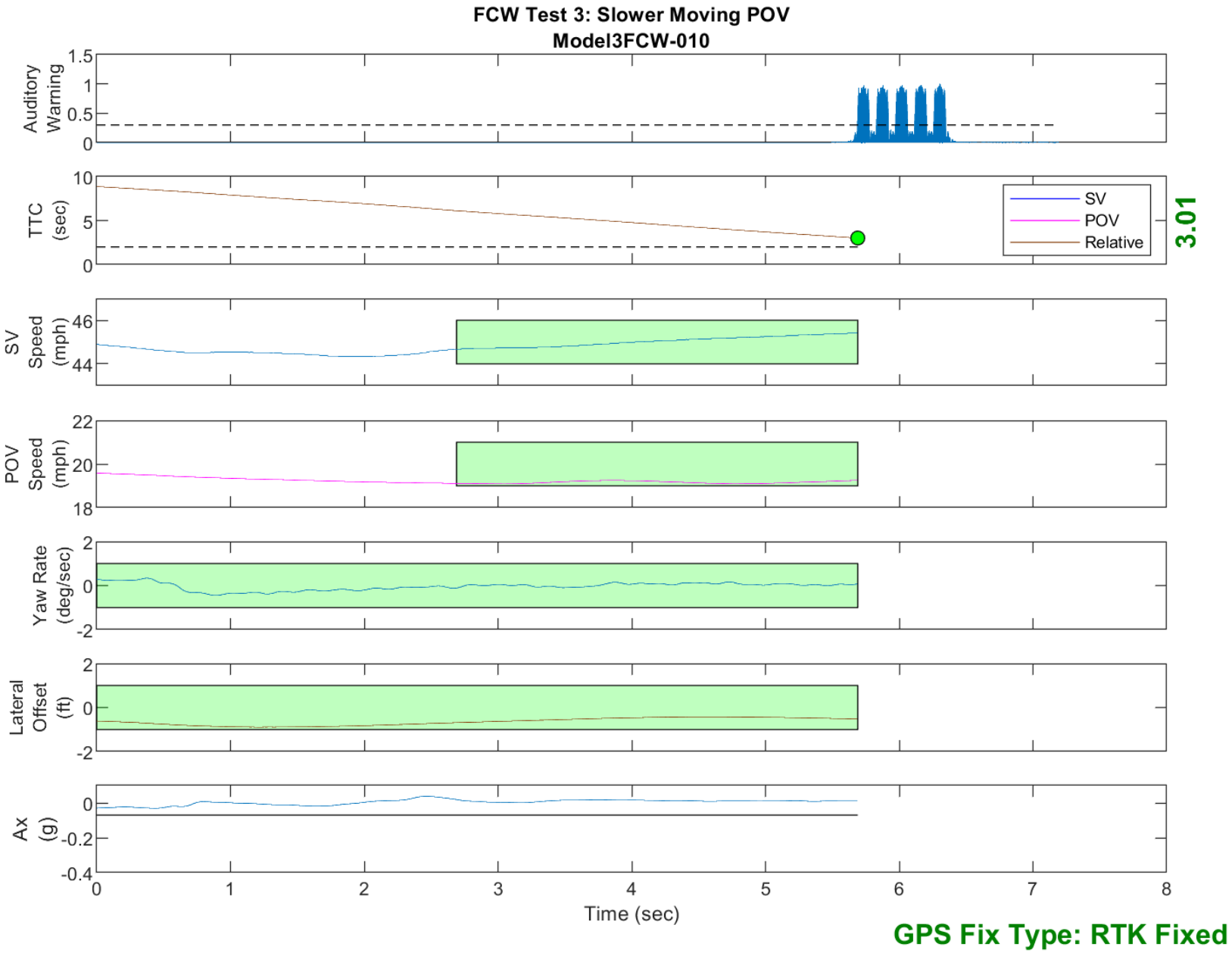

Figure D23. Time History for Run 10, Test 3 - Slower Moving POV, Auditory Warning

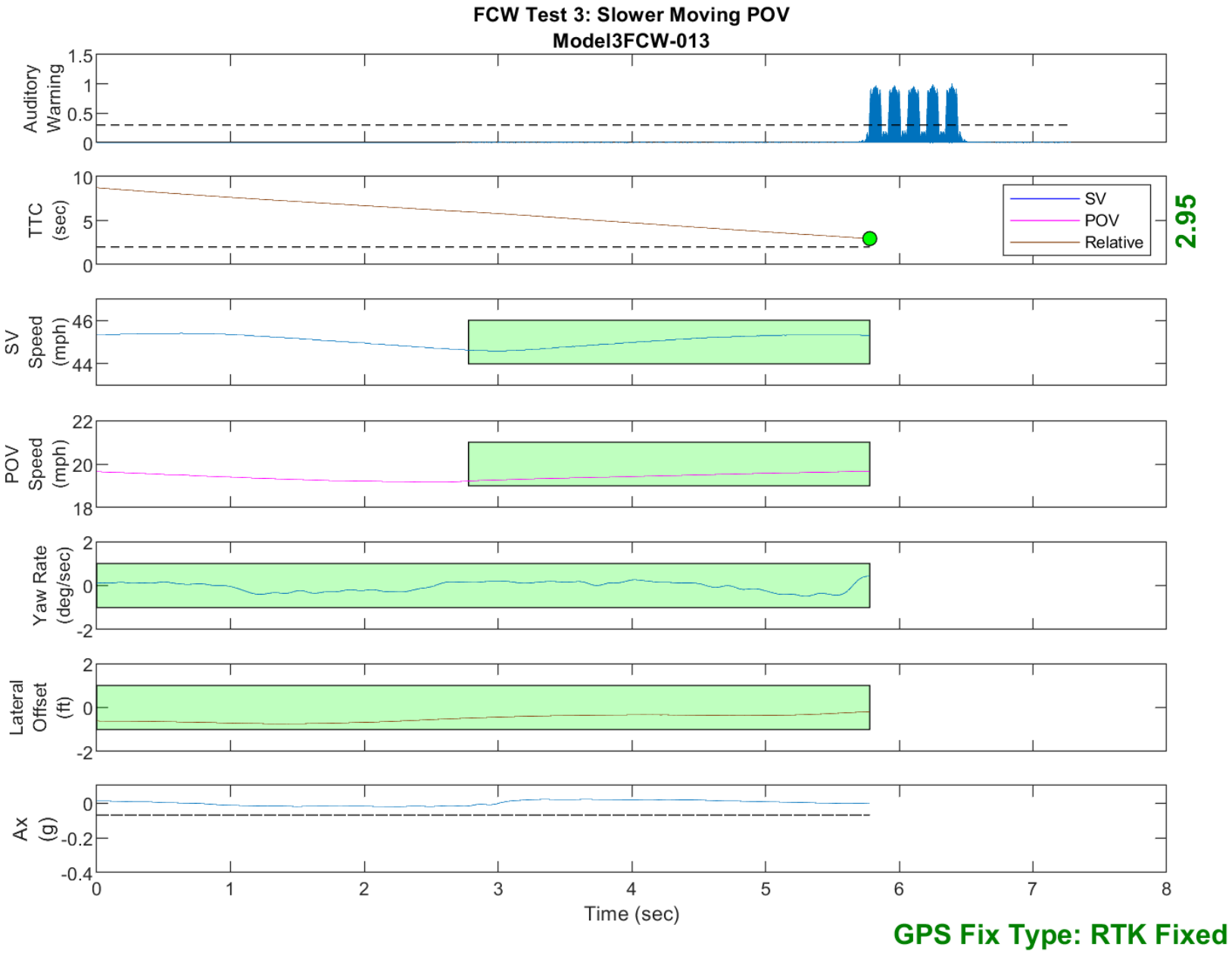

Figure D24. Time History for Run 13, Test 3 - Slower Moving POV, Auditory Warning

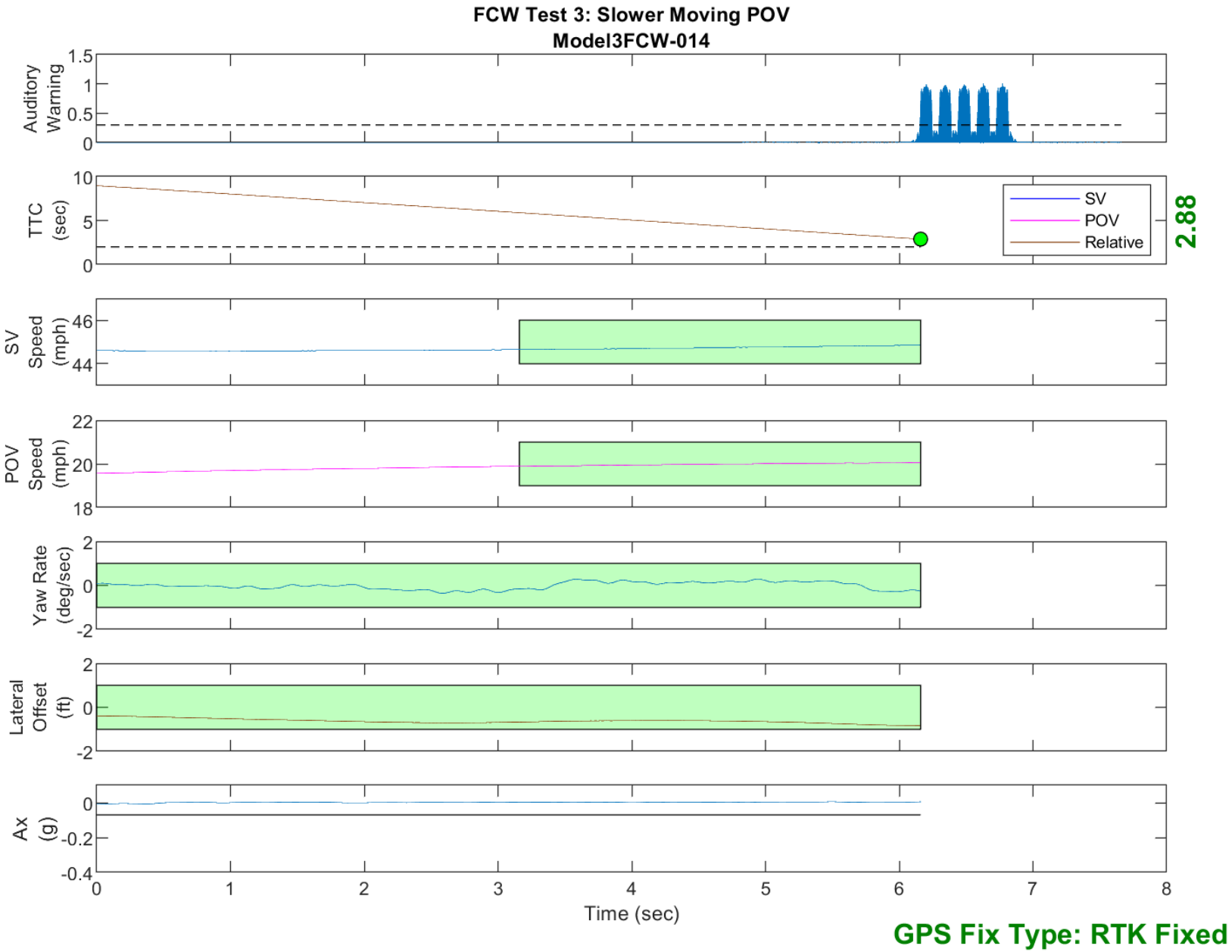

Figure D25. Time History for Run 14, Test 3 - Slower Moving POV, Auditory Warning

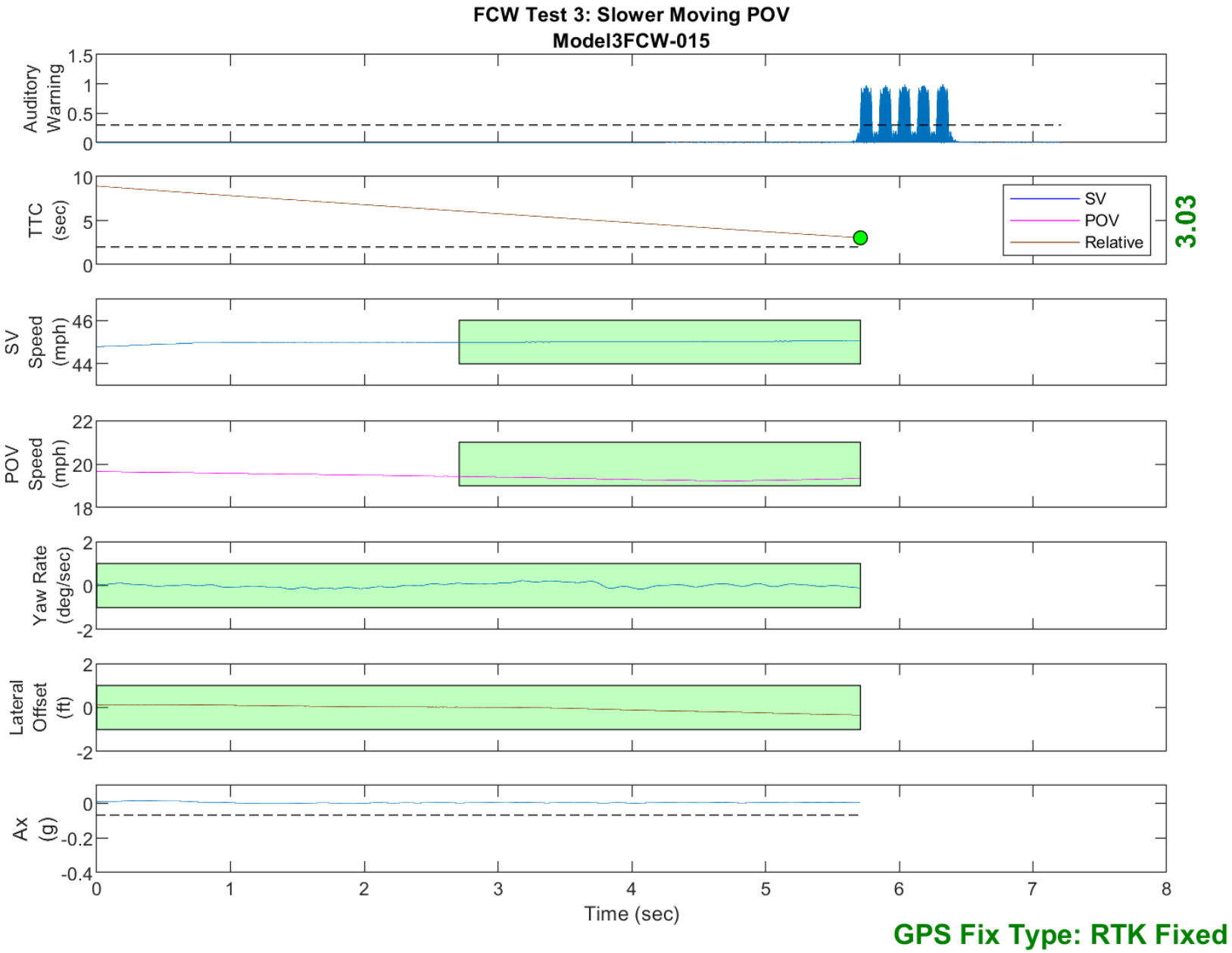

Figure D26. Time History for Run 15, Test 3 - Slower Moving POV, Auditory Warning

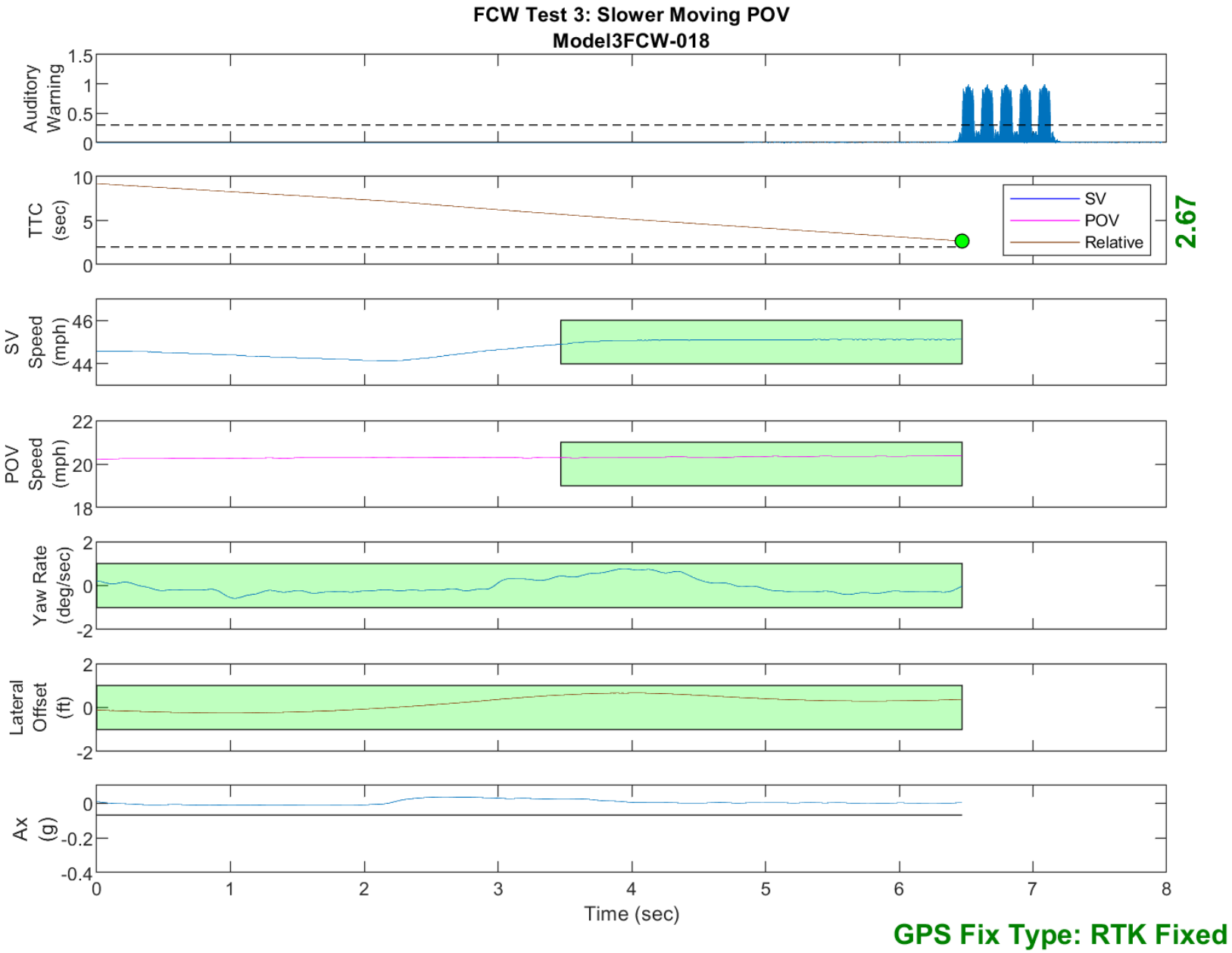

Figure D27. Time History for Run 18, Test 3 - Slower Moving POV, Auditory Warning