NEW CAR ASSESSMENT PROGRAM
FORWARD COLLISION WARNING CONFIRMATION TEST
OCAS-DRI-FCW-20-01

2020 Audi A6 45 TFSI Quattro

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27 April 2020

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 2020 Audi A6 45 TFSI Quattro in accordance with the specifications of the New Car Assessment Program's (NCAP) 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 principle 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.

Section II

DATA SHEETS

FORWARD COLLISION WARNING

DATA SHEET 1: TEST RESULTS SUMMARY

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2020 Audi A6 45 TFSI Quattro

VIN: *WAUD8AF22LN0xxxx*

Test Date: *1/23/2020*

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)

2020 Audi A6 45 TFSI Quattro

TEST VEHICLE INFORMATION

VIN: *WAUD8AF22LN0xxxx*

Body Style: *Sedan* Color: *Glacier White Metallic*

Date Received: *1/13/2020* Odometer Reading: *15 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *AUDI AG*

Date of manufacture: *07/19*

Vehicle Type: *Passenger Car*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *245/45R19*

Rear: *245/45R19*

Recommended cold tire pressure: Front: *220 kPa (32 psi)*

Rear: *240 kPa (35 psi)*

TIRES

Tire manufacturer and model: *Continental Pro Contact TX*

Front tire size: *245/45R19*

Rear tire size: *245/45R19*

Front tire DOT prefix: *AFA2WD40*

Rear tire DOT prefix: *AFA2WD40*

FORWARD COLLISION WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2020 Audi A6 45 TFSI Quattro

GENERAL INFORMATION

Test date: *1/23/2020*

AMBIENT CONDITIONS

Air temperature: *12.2 C (54 F)*

Wind speed: *0.5 m/s (1.2 mph)*

X Wind speed ≤ 10 m/s (22 mph).

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

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

VEHICLE PREPARATION

Verify the following:

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

Fuel tank is full: **X**

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

Front: *220 kPa (32 psi)*

Rear: *240 kPa (35 psi)*

FORWARD COLLISION WARNING

DATA SHEET 3: TEST CONDITIONS

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2020 Audi A6 45 TFSI Quattro

WEIGHT

Weight of vehicle as tested including driver and instrumentation:

Left Front:	*513.9 kg (1133 lb)*	Right Front:	*526.6 kg (1161 lb)*
Left Rear:	*439.1 kg (968 lb)*	Right Rear:	*453.6 kg (1000 lb)*
		Total:	*1933.2 kg (4262 lb)*

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 1 of 3)

2020 Audi A6 45 TFSI Quattro

Name of the FCW option, option package, etc.: *Pre Sense Front*

Forward Collision Warning Setting used in test: *Early*

Type and location of sensors the system uses:

Camera located behind the windshield, near the rearview mirror.

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

- **X** Warning light
- **X** Buzzer or audible alarm
- ___ Vibration
- **X** Other Brake jerk

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

The visual alert is presented in the center of the instrument cluster between the speedometer and tachometer. It is shown in Appendix A, Figure A16.

The auditory alert is presented as a single pulse tone centered at 1809 Hz.

A haptic alert is also presented as a quick momentary brake application.

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.

Pre Sense Front (FCW) can be disabled by using the vehicle settings menus. These can be accessed by two different methods.

1. Using the touch screen select

Vehicle

Driver Assistance (See Appendix A, Figure A13)

2. Press the Driver assistance setting button (Appendix A, Figure A15)

From the Driver Assistance page select the gear icon in the upper right of the screen, then

Audi pre sense

Prewarning

Toggle the top radio button for on/off (See Figure A14)

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 Pre Sense Front (FCW) sensitivity can be adjusted by using the vehicle settings menus. These can be accessed by two different methods.

1. Using the touch screen select

Vehicle

Driver Assistance (See Appendix A, Figure A13)

2. Press the Driver assistance setting button (See Appendix A, Figure A15)

From the Driver Assistance page select the gear icon in the upper right of the screen, then

Audi pre sense

Prewarning

Select Early, Medium, or Late (See Figure A14)

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

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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 system has a self-test algorithm, which will reduce the system performance or deactivate completely if the following conditions are observed:

- *Mud/dirt/snow accumulation on the sensor*
- *ESC Turned off or in sport mode*

If the system detects sensor blockage, FCW, DBS, CIB will not be available, and the system will show a notification in the vehicle cluster.

For a more comprehensive list of other driving modes or conditions that render FCW inoperable or reduce its effective, see Appendix B, Page B-2 (Owner's Manual, Page 114).

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. TEST 1 – SUBJECT VEHICLE ENCOUNTERS STOPPED PRINCIPAL OTHER VEHICLE ON A STRAIGHT ROAD

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

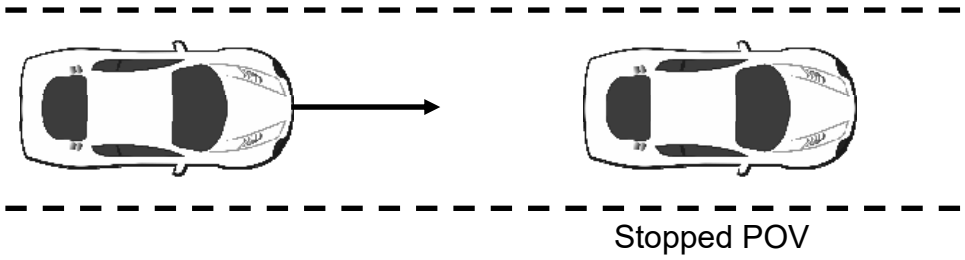

Figure 1. Depiction of Test 1

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 1.0 ft (0.3 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.

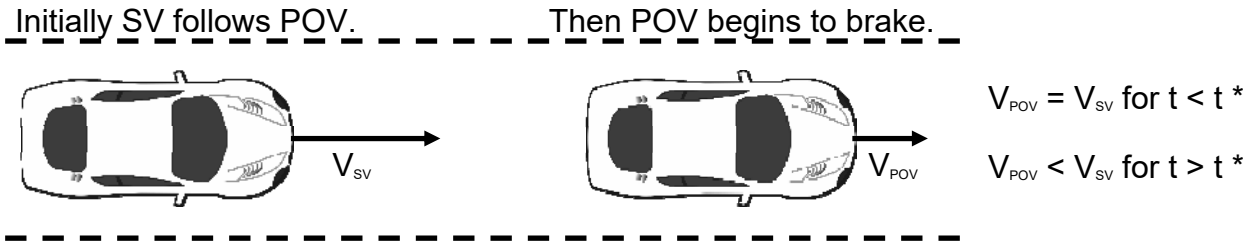

Figure 2. Depiction of Test 2

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.

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

[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).

- 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 1.0 ft (0.3 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 ±0.03g, 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).

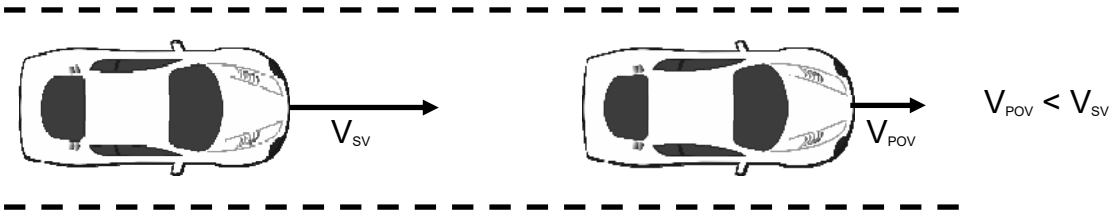

Figure 3. Depiction of Test 3

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 1.0 ft (0.3 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:

- High pressure nitrogen bottle, strapped to the front passenger seat, with regulator and pressure gauges
- Pneumatic piston-type actuator, with solenoid valve
- “Pickle” switch to activate brakes

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	Omega DPG8001	17042707002	By: DRI Date: 7/3/2019 Due: 7/3/2020
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform 5338 N/	0.5% of applied load	Intercomp SWI	1110M206352	By: DRI Date: 1/6/2020 Due: 1/6/2021
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	NA
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rat	Accels .01g, Angular Rate	Oxford Inertial +		By: Oxford Technical Solutions
					2258	Date: 5/3/2019 Due: 5/3/2021
					2176	Date: 4/11/2018 Due: 4/11/2020
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	NA

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	NA	NA
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	NA	NA
Accelerometer	Acceleration (to measure time at haptic alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	NA	NA
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2020 Due: 1/6/2021

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 audible or haptic alerts, part of the pre-test instrumentation verification process is to determine the tonal frequency of the audible warning or the vibration frequency of the tactile warning through use of the PSD (Power Spectral Density) function in Matlab. This is accomplished in order to identify the center frequency around which a band-pass filter is applied to subsequent audible or tactile warning data so that the beginning of such warnings can be programmatically determined. The 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. Audible and Tactile Warning Filter Parameters

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

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

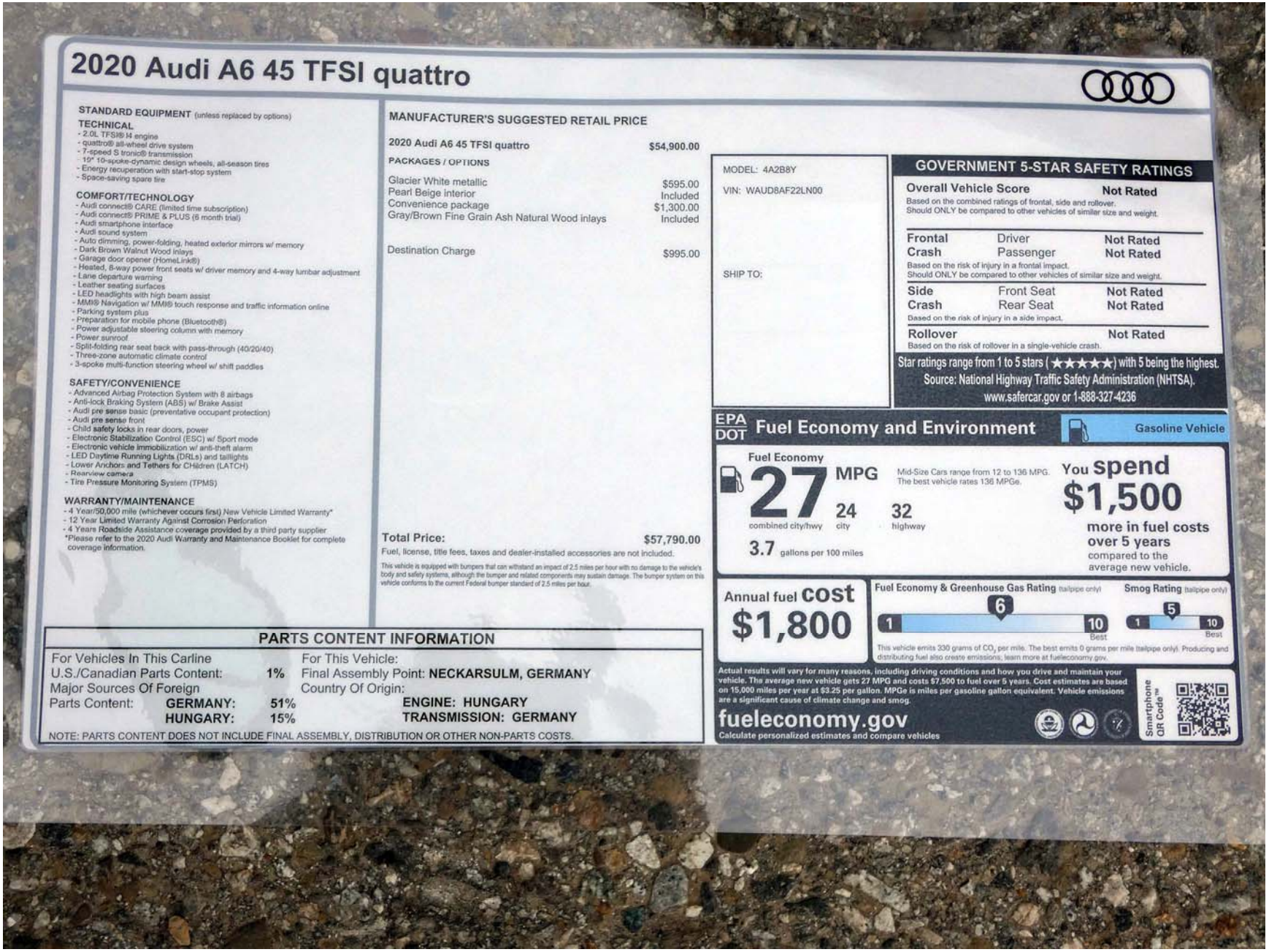

Figure A3. Window Sticker (Monroney Label)

Figure A4. Vehicle Certification Label

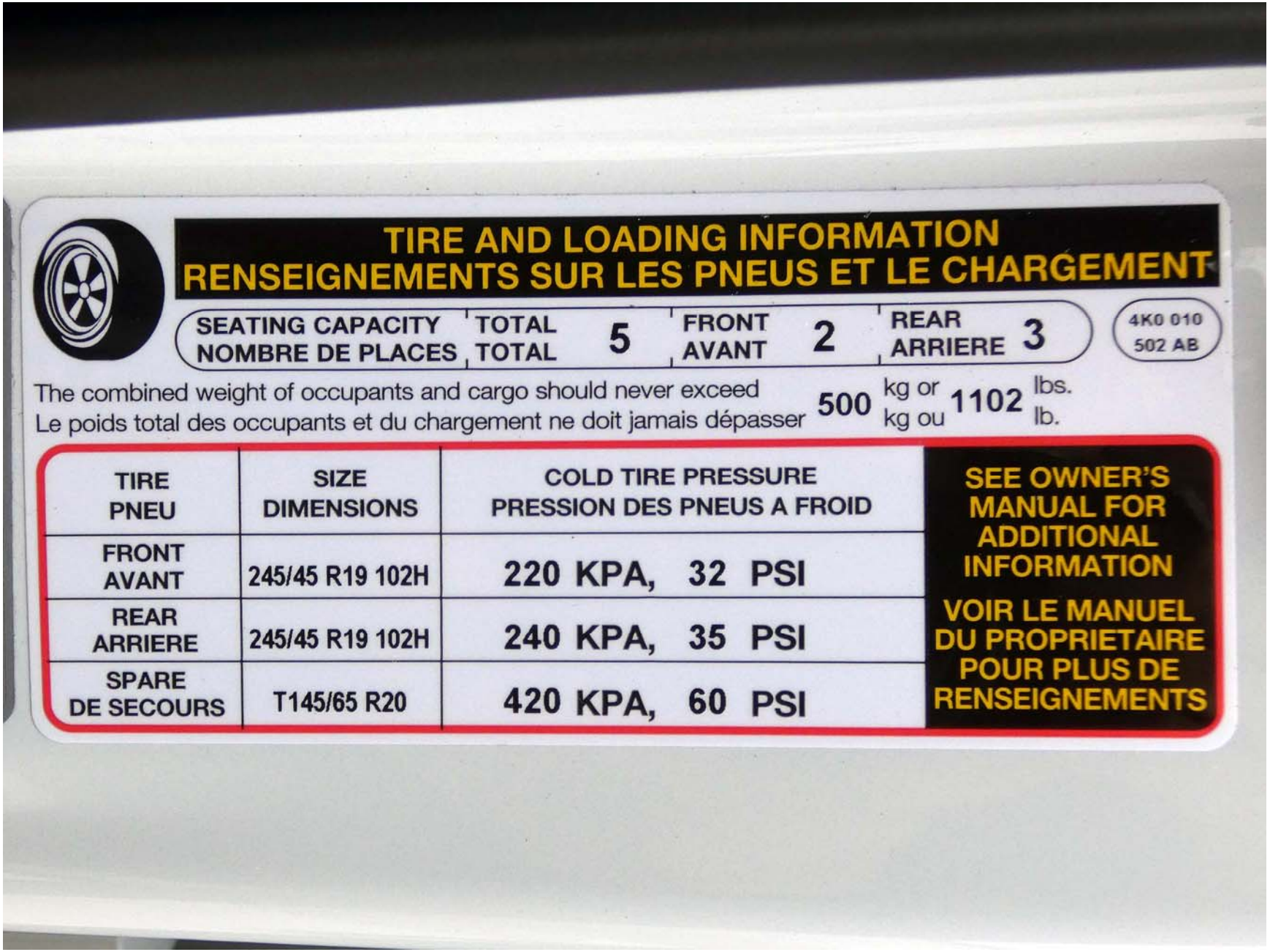

Figure A5. Tire Placard

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. Sensor for Detecting Visual Alerts

Figure A10. Sensor for Detecting Auditory Alerts

Figure A11. Computer Installed in Subject Vehicle

Figure A12. Brake Actuation System Installed in Principal Other Vehicle

Figure A13. System Setting Menus (1 of 2)

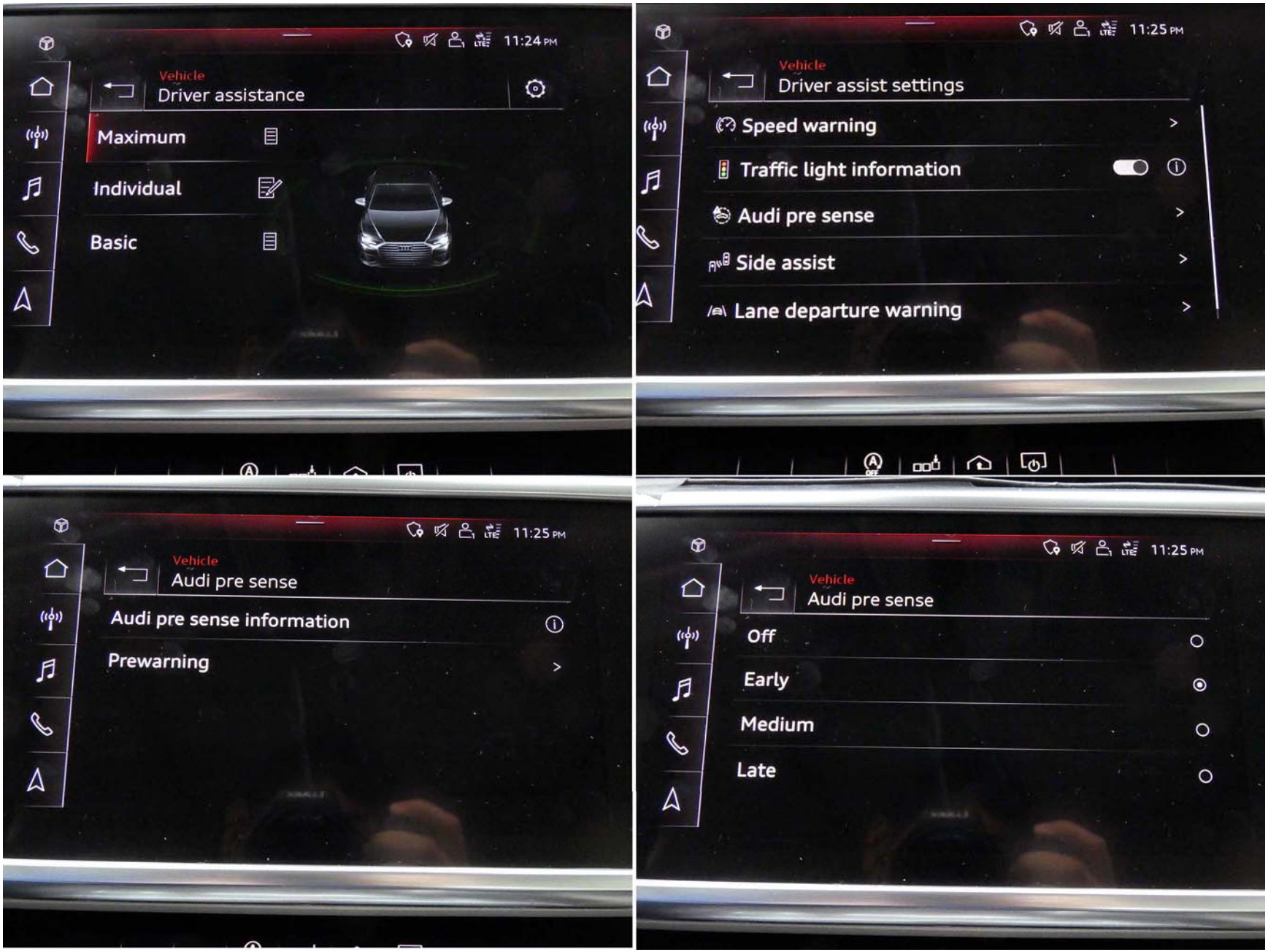

Figure A14. System Setting Menus (2 of 2)

Figure A15. Button for Directly Accessing Driver Assistance Settings Menus

Figure A16. FCW Visual Alert

APPENDIX B

Excerpts from Owner’s Manual

BRAKE	Brake system ✓ ⇨ *page 100*, ⇨ *page 102*, ⇨ *page 234*
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	Anti-lock braking system (ABS) ✓ ⇨ *page 110*
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	Tank system ⇨ *page 224*
	Electrical system ⇨ *page 235*
	Engine oil level (MIN) ⇨ *page 229*
	Engine oil level (MAX) ⇨ *page 229*
	Engine oil sensor ⇨ *page 229*
	Malfunction Indicator Lamp (MIL) ✓ ⇨ *page 226*
	Engine warm-up request ⇨ *page 229*
	Washer fluid level ⇨ *page 238*
	Windshield wipers ⇨ *page 57*
	Parking system plus ⇨ *page 153*
TPMS	Tire pressure ⇨ *page 257*
	Tire pressure ✓ ⇨ *page 257*
	Loose wheel warning ⇨ *page 254*
	Bulb failure indicator ⇨ *page 52*
	Adaptive light ⇨ *page 52*
	Light/rain sensor ⇨ *page 52*, ⇨ *page 57*
	Door lock ⇨ *page 34*
	Battery in vehicle key ⇨ *page 38*
	Night vision assist ⇨ *page 125*
	Intersection assistant ⇨ *page 149*
	Side assist ⇨ *page 147*; Exit warning ⇨ *page 148*
	Rear cross-traffic assist ⇨ *page 158*
	Adaptive cruise assist ⇨ *page 138*
	Steering intervention request ⇨ *page 135*, ⇨ *page 141*
	Lane departure warning ⇨ *page 141*
	Distance warning ⇨ *page 139*
	Audi pre sense ⇨ *page 145*
SOS	Emergency assist ⇨ *page 150*
SOS	Emergency call function ⇨ *page 180*

Other indicator lights

	Rear safety belt ✓ ⇨ *page 66*
	Start/Stop system ⇨ *page 98*
	Low beam headlight ⇨ *page 49*
	Parking light ⇨ *page 49*
	Turn signals ⇨ *page 50*
CRUISE	Cruise control system ⇨ *page 126*
	Cruise control system ⇨ *page 126*
	Efficiency assist ⇨ *page 127*
	Efficiency assist ⇨ *page 127*

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Assist systems

General information

Safety precautions

WARNING

- As the driver, you are always completely responsible for all driving tasks. The assist systems cannot replace the driver's attention. Give your full attention to driving the vehicle, and be ready to intervene in the traffic situation at all times.
- Activate the assist systems only if the surrounding conditions permit it. Always adapt your driving style to the current visual, weather, road, and traffic conditions.
- Loose objects can be thrown around the vehicle interior during sudden driving or braking maneuvers, which increases the risk of an accident. Store objects securely while driving.
- For the assist systems to be able to react correctly, the function of the sensors and cameras must not be restricted. Note the information on sensors and cameras ⇒ page 225.

Tips

- Pay attention to applicable local regulations relating to driving tasks, leaving space for emergency vehicles, vehicle distance, speed, parking location, wheel placement, etc. The driver is always responsible for following the laws that are applicable in the location where the vehicle is being operated.
- You can cancel a steering or braking intervention by the system, by braking or accelerating noticeably, steering, or deactivating the respective assist system.
- Always check the assist systems settings before driving. The settings could have been changed, for example, by other drivers or if another personal profile was used.

System limitations

WARNING

- The use of an assist system cannot overcome the natural laws of physics. A collision cannot be prevented in certain circumstances.
- Warnings, messages, or indicator lights may not be displayed or initiated on time or correctly, for example, if vehicles are approaching very fast.
- Corrective interventions by the assist systems, such as steering or braking interventions, may not be sufficient or they may not occur. Always be ready to intervene.

Tips

- Due to the system limitations when detecting the surrounding area, the systems may warn or intervene unexpectedly or too late in certain situations. The assist systems may also interpret a driving maneuver incorrectly and then warn the driver unexpectedly.
- The systems may not function as expected in unusual driving situations, such as driving offroad, on unpaved roads, on loose ground, on inclines, or on grooves in the road.
- The systems may not function correctly in unclear traffic situations, such as turning lanes, exit ramps, construction zones, rises or dips that obstruct visibility, intersections, toll stations, or city traffic.
- The detection of the surrounding area can be limited, for example by vehicles driving ahead or by rain, snow, heavy spray, or light shining into the camera.
- If accessories have been mounted on the steering wheel, the ability for the steering systems to react may be limited.

camera may be covered. Clean the area in front of the camera ⇨ *page 116, fig. 86* and try to turn on the systems again later.

If the malfunction remains, drive to an authorized Audi dealer or authorized Audi Service Facility immediately to have the malfunction corrected.

Audi pre sense

Introduction

Applies to: vehicles with Audi pre sense

Within the limits of the system, the Audi pre sense functions can initiate measures in certain driving situations to protect the vehicle occupants and other road users. Depending on the vehicle equipment, various Audi pre sense systems may be installed:

- **Audi pre sense basic** can react during emergency and dangerous braking maneuvers and unstable driving situations (such as oversteering or understeering).
- **Audi pre sense front**[1] can detect an impending frontal impact and react with warnings, braking interventions, and preemptive safety measures for the vehicle occupants.
- **Audi pre sense rear** monitors the rear traffic behind your vehicle and can react to an impending rear impact.
- **Audi pre sense side** can detect an impending side impact from cross-traffic and vehicles coming from the side, and can initiate preemptive safety measures.
- The **swerve assist** can assist during an evasive maneuver recognized as critical with steering movement and by braking individual wheels individually.
- The **turn assist** can detect vehicles in the opposite lane and react with braking maneuvers.

Audi pre sense preemptive safety measures

Applies to: vehicles with Audi pre sense

Depending on the vehicle speed and the vehicle equipment, the following functions may be initiated in certain situations:

- Visual and audio warnings
- Activation of the emergency flashers[1]
- Reversible tensioning of safety belts
- Closing the windows and panoramic glass roof
- Adjusting the seats
- Other preemptive safety measures by individual systems

WARNING

Follow the safety precautions and note the limits of the assist systems, sensors, and cameras ⇨ *page 114*.

Tips

- Depending on the risk situation that is detected and the selected Audi drive select* mode, not all preemptive safety measures may be initiated under certain circumstances. Certain functions can be adjusted or skipped if necessary.
- Audi pre sense may be restricted or unavailable under certain circumstances, for example if:
  - There are passengers with unfastened safety belts
  - It has only been several seconds since the ignition was switched on The indicator light turns on.
  - When driving in reverse
  - There is an airbag control module malfunction
  - System functions may not be available if the ESC is limited or switched off, or if there is a malfunction.

[1] This is not available in some countries.

Audi pre sense basic

Applies to: vehicles with Audi pre sense basic

Audi pre sense basic is automatically active at speeds of approximately 20 mph (30 km/h) and higher. Audi pre sense basic can trigger the Audi pre sense preemptive safety measures during emergency braking and dangerous braking maneuvers as well as in unstable driving situations, such as oversteering or understeering.

WARNING

Follow the safety precautions and note the limits of the assist systems, sensors, and cameras ⇨ *page 114*.

Audi pre sense front

Applies to: vehicles with Audi pre sense front

The **Audi pre sense front** uses the data from the camera and calculates the probability of a rear-end collision. Within the limits of the system, an impending frontal impact with vehicles, pedestrians[1], or cyclists[1] may be detected in both urban and rural speed ranges.

Audi pre sense front is active at speeds of approximately 6 mph (10 km/h) and higher. It can react to pedestrians[1] or cyclists[1] at speeds up to approximately 50 mph (85 km/h), and can react to vehicles at speeds up to approximately 155 mph (250 km/h).

Early warning/acute warning

The system can recognize various dangerous situations. The **early warning** occurs if:

- A vehicle driving ahead brakes suddenly
- Your own vehicle approaches a vehicle in front of you that is traveling at a significantly slower speed or that is stationary
- A pedestrian or cyclist[1] is standing in the lane or is moving into the lane

The message **Audi pre sense** and a warning tone will warn you about the danger.

The brakes may also be applied as an **acute warning** when there is an impending collision. You will also be warned by an indicator in the instrument cluster display. When this warning occurs, it may only be possible to avoid a collision by swerving or braking strongly.

Automatic deceleration

If you do not react to the acute warning, Audi pre sense front can brake the vehicle to a full stop within the limits of the system [1]. This reduces the vehicle speed in the event of a collision.

Automatic braking force increase

If Audi pre sense determines that you are not braking strongly enough when a collision is imminent, it can increase the braking force based on the situation.

Take-over

If the message **Please take over!** appears, the vehicle has been braked to a stop by Audi pre sense and you must resume control of the vehicle.

WARNING

- Follow the safety precautions and note the limits of the assist systems, sensors, and cameras ⇨ *page 114*.
- Audi pre sense front cannot overcome natural physical laws. It is a system designed to assist and it cannot prevent a collision in every circumstance. The driver must always intervene. The driver is always responsible for braking at the correct time. Do not let the increased safety provided tempt you into taking risks. This could increase your risk of a collision.
- Audi pre sense front does not react to certain objects, such as animals, crossing or oncoming vehicles, bars, railings, or railcars.
- Audi pre sense front may be limited or unavailable when driving in curves.
- Loose objects can be thrown around the vehicle interior during sudden driving or braking maneuvers, which increases the risk of an accident. Store objects securely while driving.

[1] This is not available in some countries.

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Audi pre sense rear

Applies to: vehicles with Audi pre sense rear

Within the limits of the system, **Audi pre sense rear** uses data from radar sensors in the rear area of the vehicle and calculates the probability of a rear-end collision with the vehicle behind you.

Audi pre sense preemptive safety measures can be initiated if the risk of a collision with the vehicle behind you is detected.

WARNING

- Follow the safety precautions and note the limits of the assist systems, sensors, and cameras ⇨ *page 114*.
- Audi pre sense rear does not react to pedestrians, animals, crossing objects, and objects not detected as vehicles.

Tips

Audi pre sense rear functions may also switch off if there is a malfunction in the side assist system.

Audi pre sense side

Applies to: vehicles with Audi pre sense side

Audi pre sense side uses data from the extra radar sensors installed in the front and rear areas of the vehicle, and other sensors can react to side impacts from cross-traffic and vehicles coming from the side.

Audi pre sense side is active at speeds up to approximately 35 mph (60 km/h). The Audi pre sense preemptive safety measures can be triggered when a collision risk is detected.

WARNING

- Follow the safety precautions and note the limits of the assist systems, sensors, and cameras ⇨ *page 114*.
- Audi pre sense side does not react to pedestrians, animals, and objects not detected as vehicles.

Tips

The Audi pre sense side functions may also switch off if there is a malfunction in the intersection assistant*.

Swerve assist

Applies to: vehicles with swerve assist

The swerve assist can help you to steer the vehicle around an obstacle detected in a critical area. If you avoid an obstacle after the acute warning, then swerve assist assists you by specifically braking individual wheels and applying slight steering adjustment to correct the steering wheel angle as long as you are actively steering. The swerve assist is available at speeds between approximately 20 mph and 90 mph (30 km/h - 150 km/h) [1].

WARNING

- Follow the safety precautions and note the limits of the assist systems, sensors, and cameras ⇨ *page 114*.
- Swerve assist does not react to pedestrians, animals, crossing objects, and objects not detected as vehicles.

Tips

- System functions may not be available if the ESC is limited or switched off, or if there is a malfunction.
- An indicator in the instrument cluster will inform you when there is an intervention.

[1] In preparation at the time of printing. The speed range may be within approximately 30 mph - 90 mph (50 km/h - 150 km/h) depending on the vehicle production date.

Turn assist

Applies to: vehicles with turn assist

When your vehicle is turning

The turn assist can assist you with a braking intervention when starting to drive or when driving slowly, to reduce the risk of your vehicle colliding with an oncoming vehicle when you are making a left turn[1]. The braking intervention causes your vehicle to stay in its lane. The function is only available when the turn signal is turned on and at speeds up to maximum of 6 mph (10 km/h).

WARNING

- Follow the safety precautions and note the limits of the assist systems, sensors, and cameras ⇨ *page 114*.
- The turn assist does not react to pedestrians, animals, crossing objects, and objects not detected as vehicles.

Tips

- System functions may not be available if the ESC is limited or switched off, or if there is a malfunction.
- An indicator in the instrument cluster will inform you when there is an intervention.

Adjusting Audi pre sense

Applies to: vehicles with Audi pre sense

The system can be switched on and off in the MMI ⇨ *page 117*.

You can adjust the Audi pre sense functions to your preferences. The settings depend on the vehicle equipment.

▸ Applies to MMI: Select on the home screen: **VEHICLE** > **Driver assistance** > (⚙) > **Audi pre sense**.

Possible settings:

- **Turn assist**
- **Swerve assist**

Prewarning[2] - The prewarning can be switched off or the Audi pre sense warning time can be set (**Early/Medium/Late**).

Set the warning time for the early warning to **Early** at first. If you feel that the prewarnings appear too early, then set the warning time to **Medium**. The **Late** warning time should only be set in special circumstances.

Tips

- Switch Audi pre sense off when you are not using public streets, when loading the vehicle onto a vehicle carrier, train, ship, or other type of transportation, or when towing the vehicle. This can help to prevent an undesired intervention from the Audi pre sense system.
- If the system is switched off, it switches on again automatically once the ignition is switched on again[2].
- Certain settings are stored automatically in the active personal profile.

Messages

Applies to: vehicles with Audi pre sense

If  or is displayed when there is a malfunction, the Audi pre sense functions may be unavailable or may be limited.

A message that indicates the cause and possible solution may appear with some displays. The weather conditions may be too poor or a sensor may be covered. Clean the area in front of the sensors ⇨ *page 116, fig. 85*, ⇨ *page 116, fig. 86* and try to turn on the systems again later.

If the malfunction remains, drive to an authorized Audi dealer or authorized Audi Service Facility immediately to have the malfunction corrected.

[1] When making a right turn in countries with left-hand drive vehicles.

[2] In certain countries

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APPENDIX C

Run Log

Subject Vehicle: **2020 Audi A6 45 TFSI Quattro** Test Date: **1/23/2020**

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	2.48	2.43	0.38	Pass	
2		Y	2.42	2.37	0.32	Pass	
3		Y	2.53	2.48	0.43	Pass	
4		Y	2.49	2.42	0.39	Pass	
5		Y	2.47	2.45	0.37	Pass	
6		Y	2.40	2.36	0.30	Pass	
7		Y	2.49	2.45	0.39	Pass	
15	**Decelerating POV, 45**	Y	2.58	2.51	0.18	Pass	
16		Y	2.60	2.54	0.20	Pass	
17		Y	2.75	2.70	0.35	Pass	
18		Y	2.85	2.81	0.45	Pass	
19		Y	2.91	2.81	0.51	Pass	
20		Y	2.70	2.64	0.30	Pass	
21		Y	2.71	2.65	0.31	Pass	
8	**Slower POV, 45 vs 20**	Y	2.61	2.57	0.61	Pass	
9		Y	2.59	2.53	0.59	Pass	

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
10		Y	2.65	2.60	0.65	Pass	
11		Y	2.47	2.41	0.47	Pass	
12		Y	2.51	2.47	0.51	Pass	
13		Y	2.65	2.62	0.65	Pass	
14		Y	2.63	2.56	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 audible, 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)

Note that the minimum (worst) GPS fix type is displayed in the lower right corner of each page. The only valid fix type is RTK fixed (displayed in green). If the fix type during any portion of the test was anything other than RTK fixed, then "RTK Fixed OR LESS!!" is displayed in red.

Envelopes and Thresholds

Each of the time history plot figures can contain either green or yellow envelopes and/or black threshold lines. These envelopes and thresholds are used to programmatically and visually determine the validity of a given test run. Envelope and threshold exceedances are indicated with either red shading or red asterisks, and red text is placed to the right side of the plot indicating the type of exceedance.

Green envelopes indicate that the time-varying data should not exceed the envelope boundaries at any time within the envelope. Exceedances of a green envelope are indicated by red shading in the area between the measured time-varying data and the envelope boundaries.

Yellow envelopes indicate that the time-varying data should not exceed the envelope only at the 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.

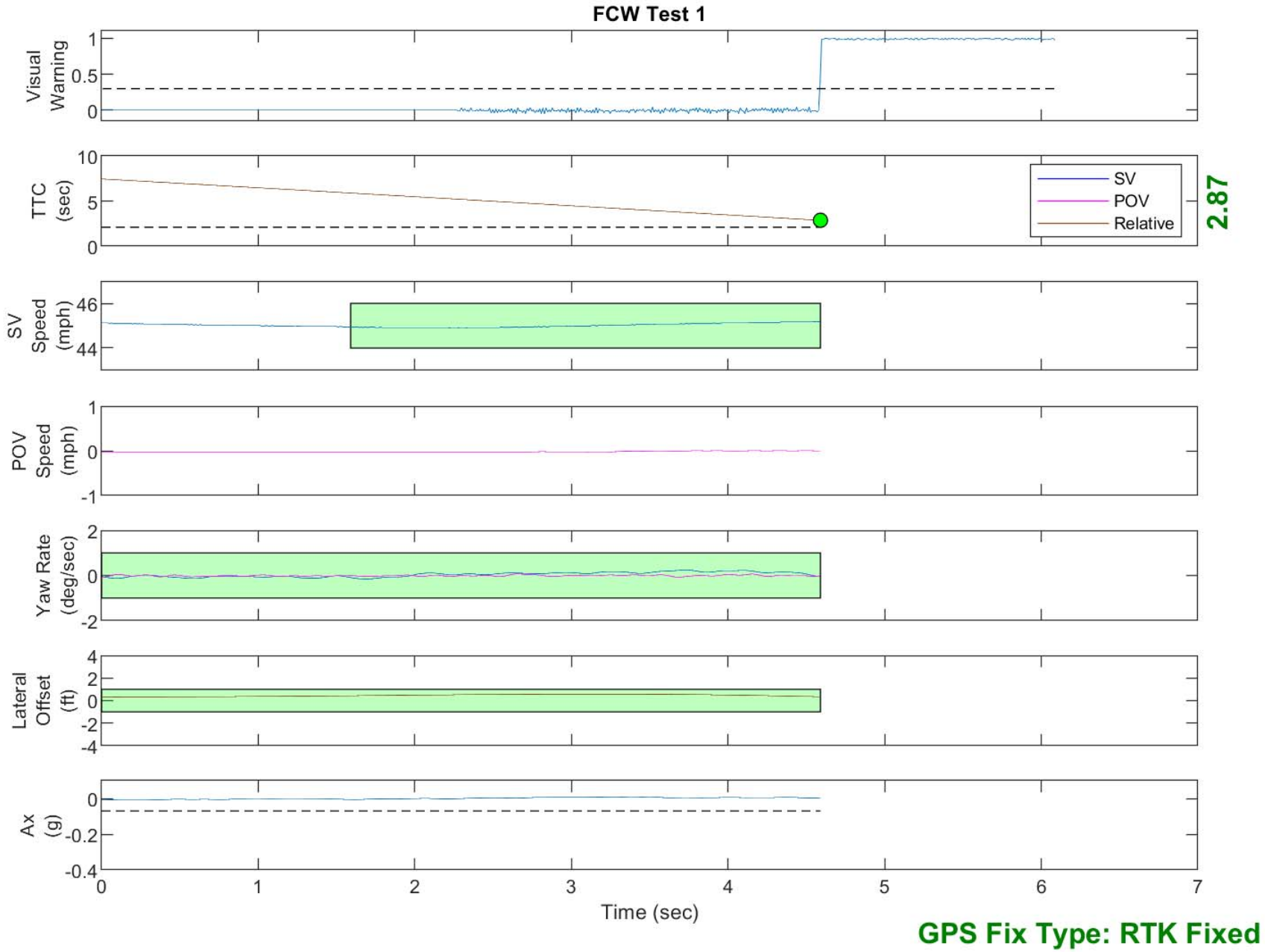

Figure D1. Example Time History for Test Type 1, Passing

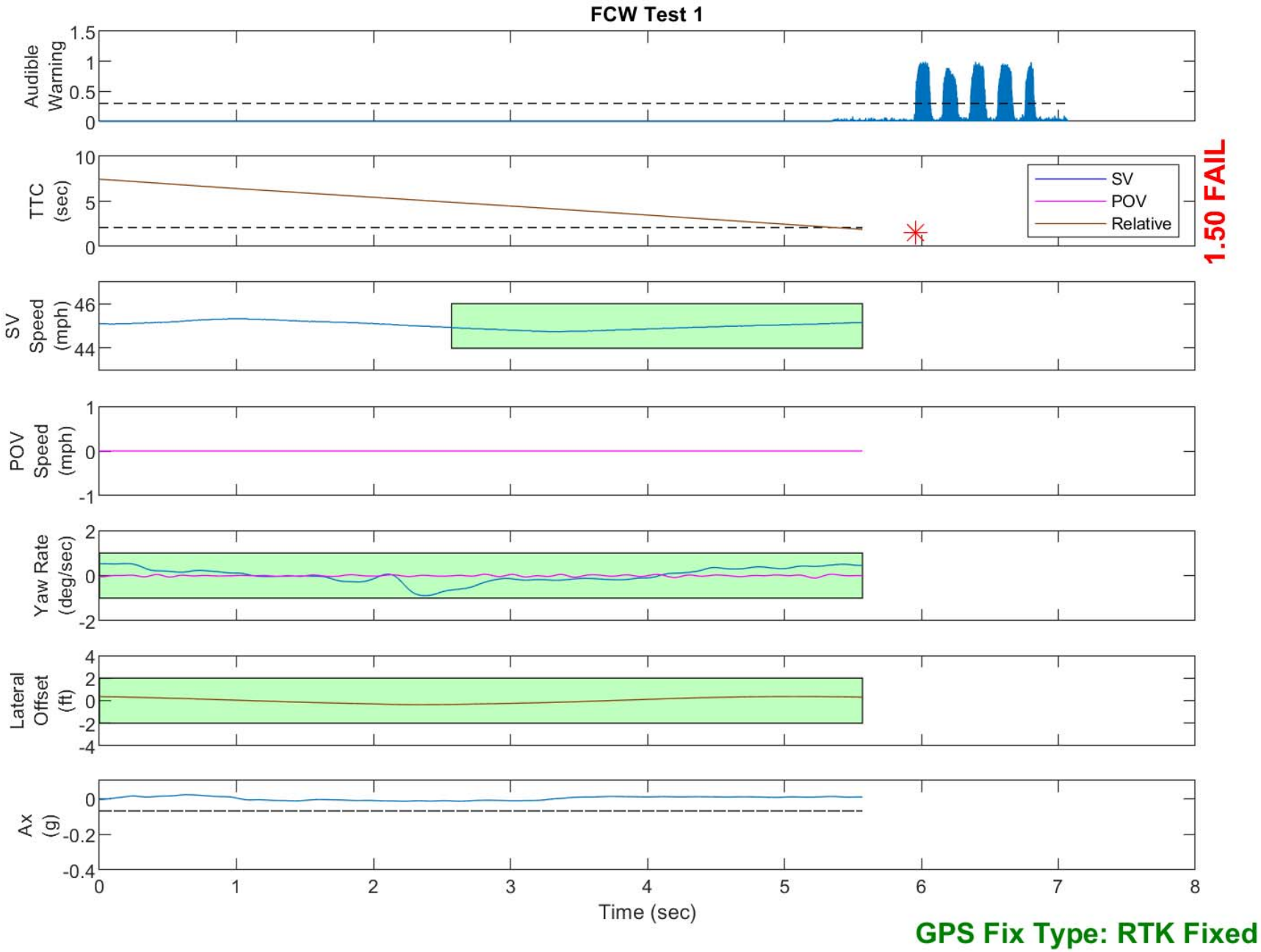

Figure D2. Example Time History for Test Type 1, Failing

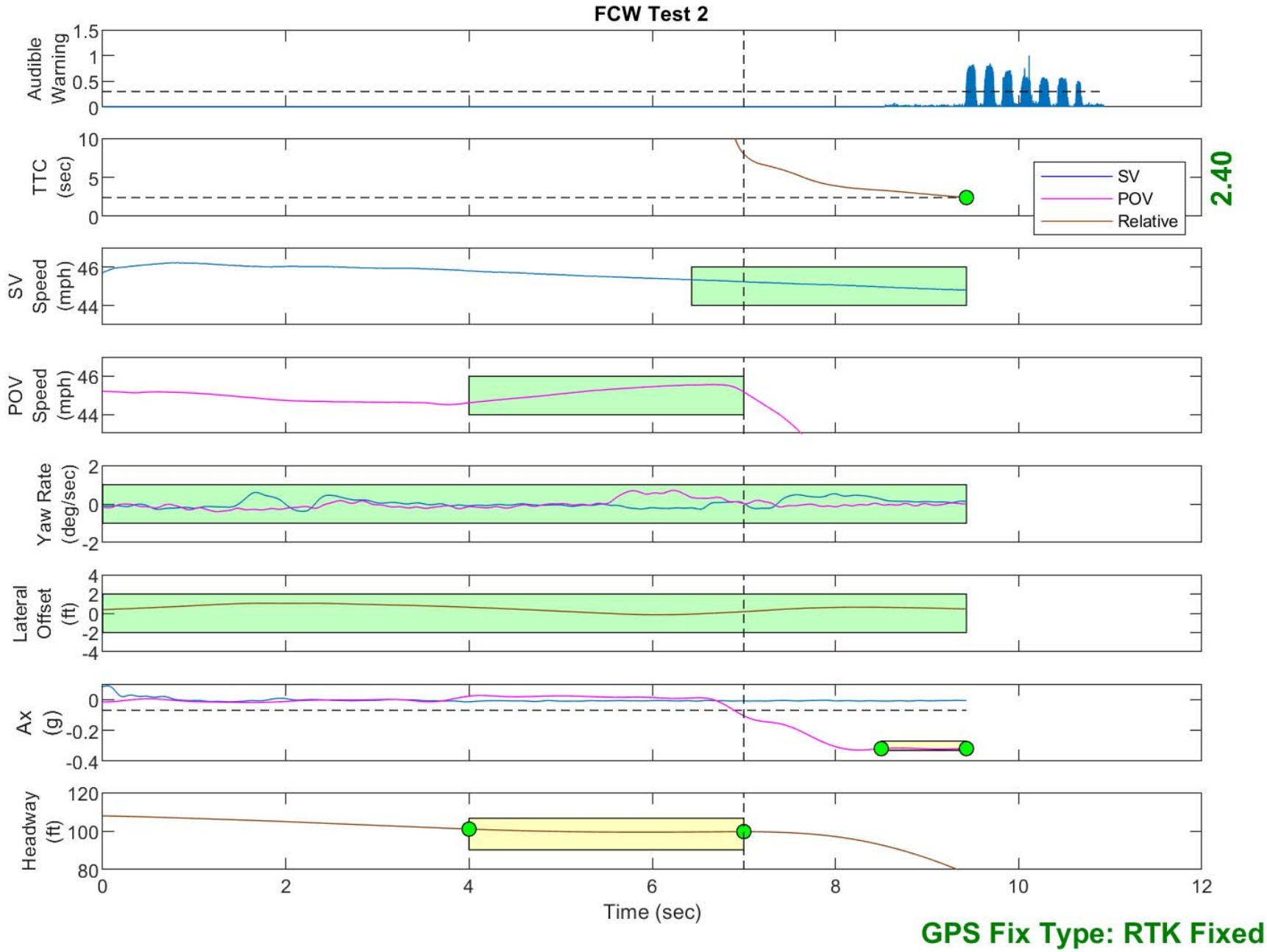

Figure D3. Example Time History for Test Type 2, Passing

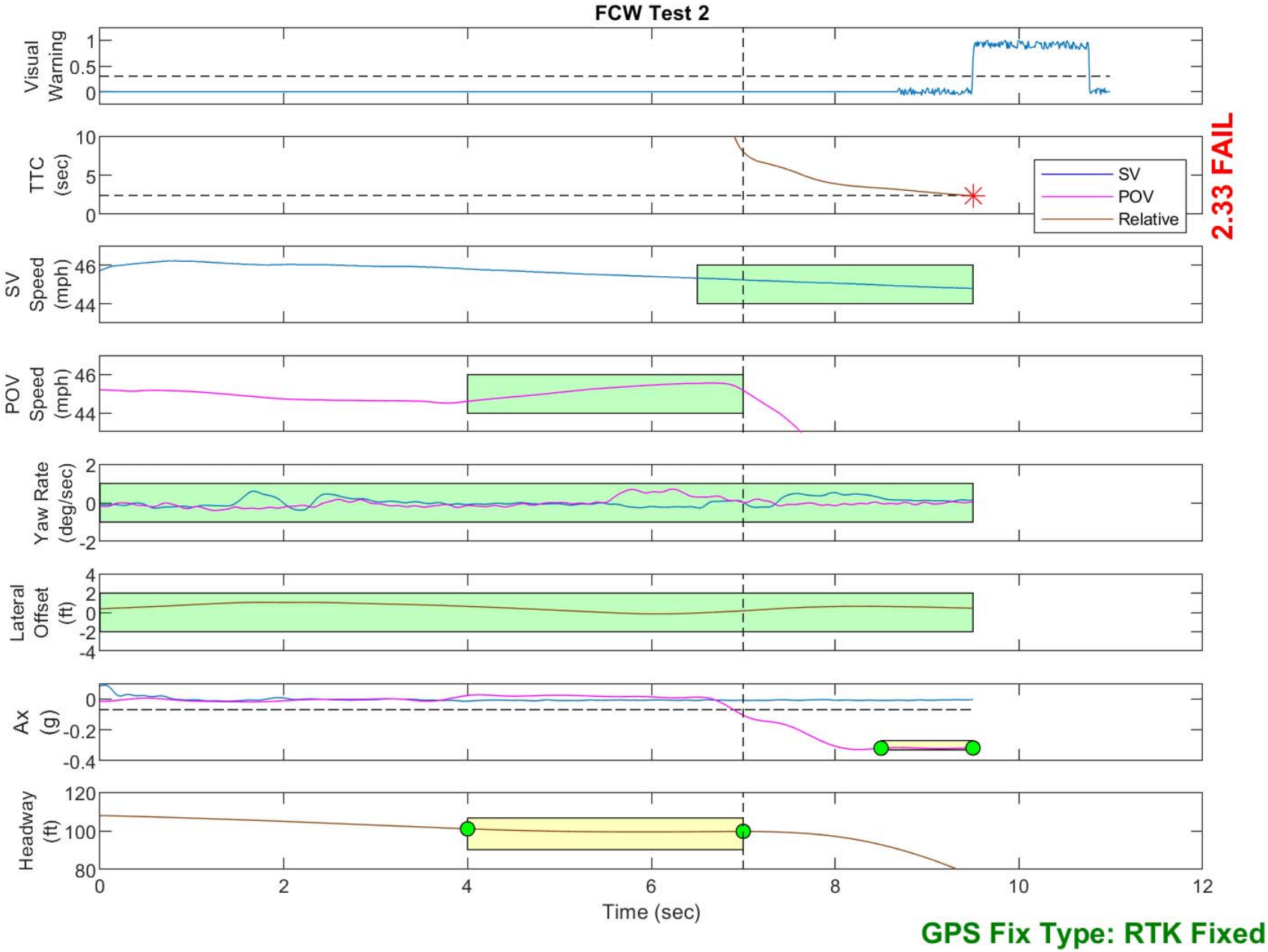

Figure D4. Example Time History for Test Type 2, Failing

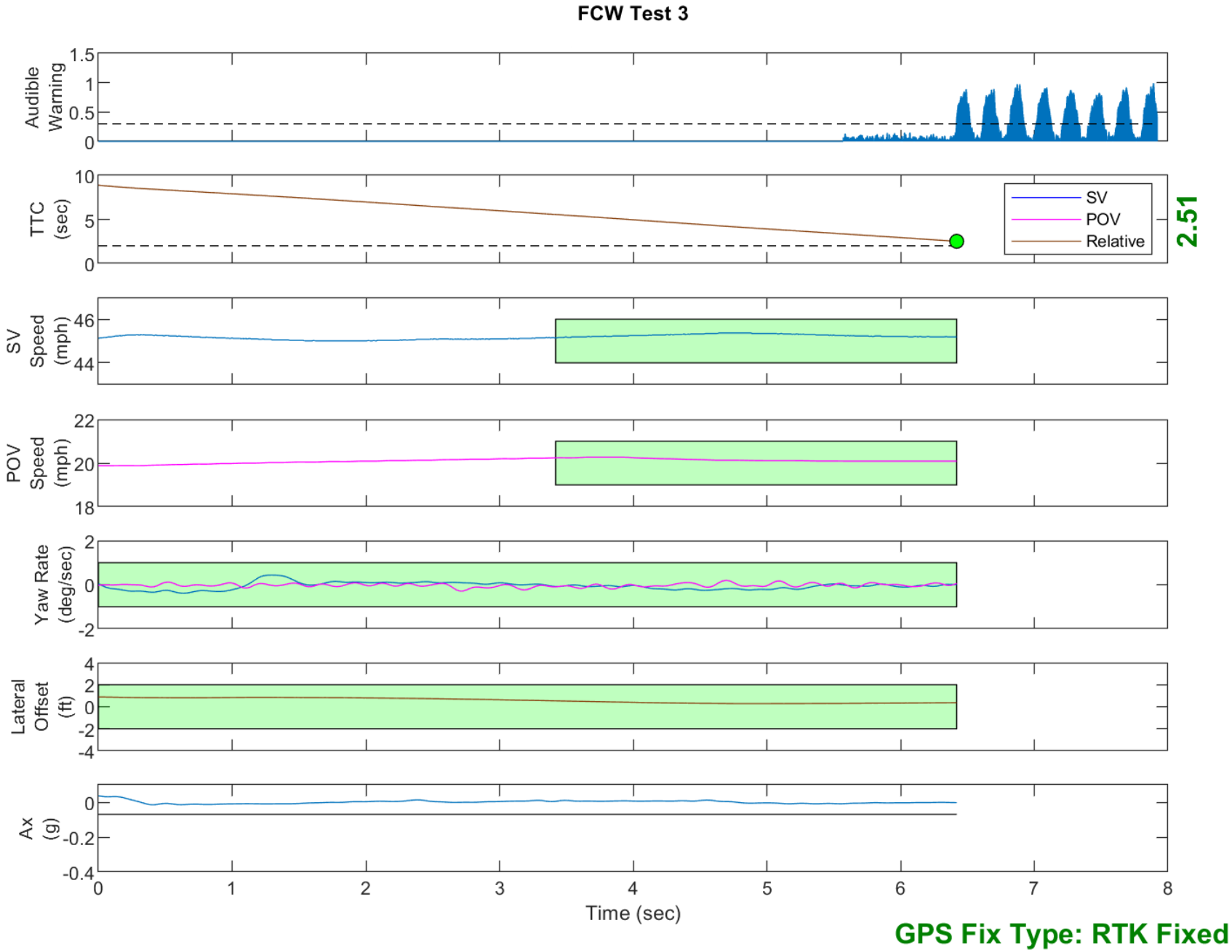

Figure D5. Example Time History for Test Type 3, Passing

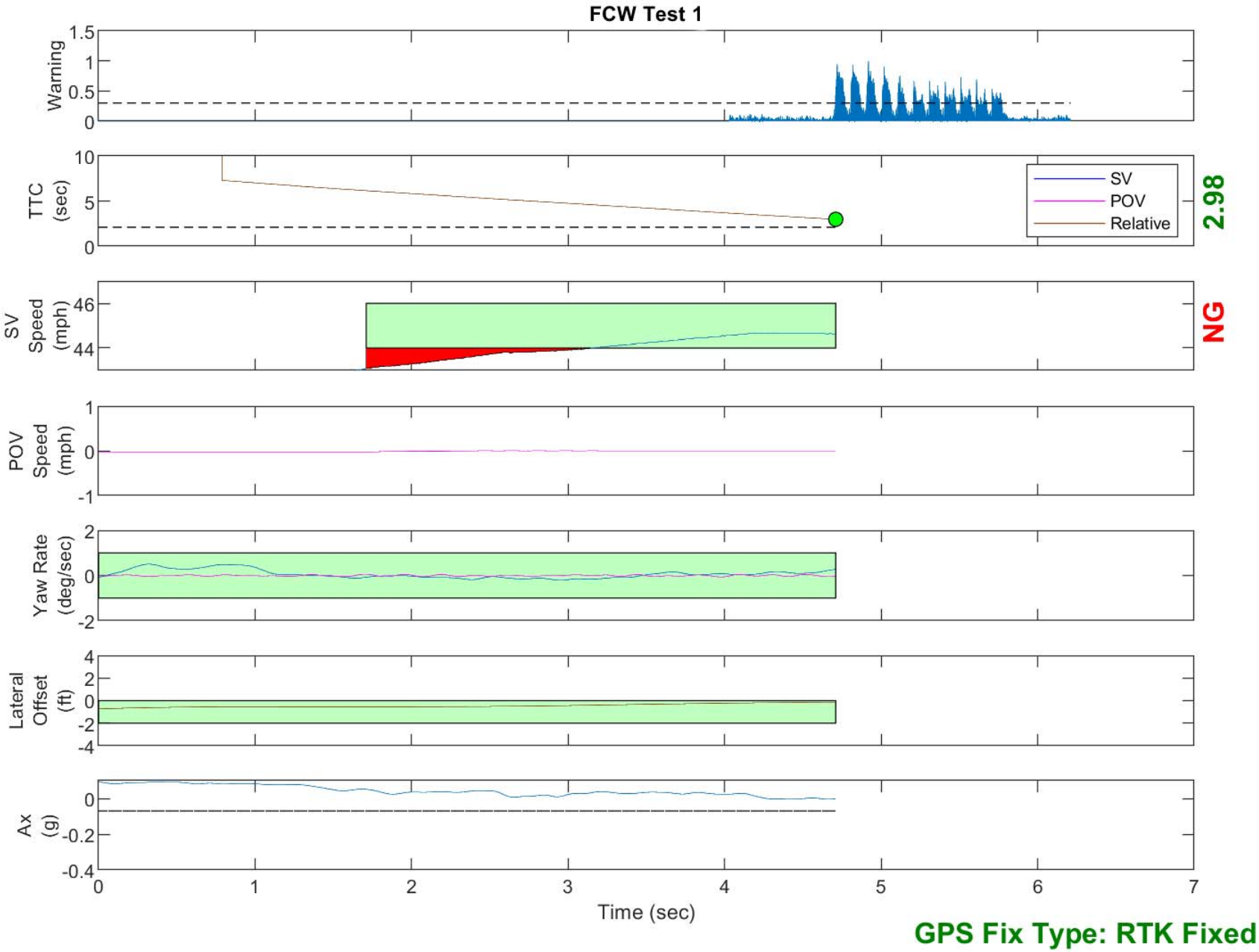

Figure D6. Example Time History for Test Type 2, Invalid Run Due to Subject Vehicle Speed

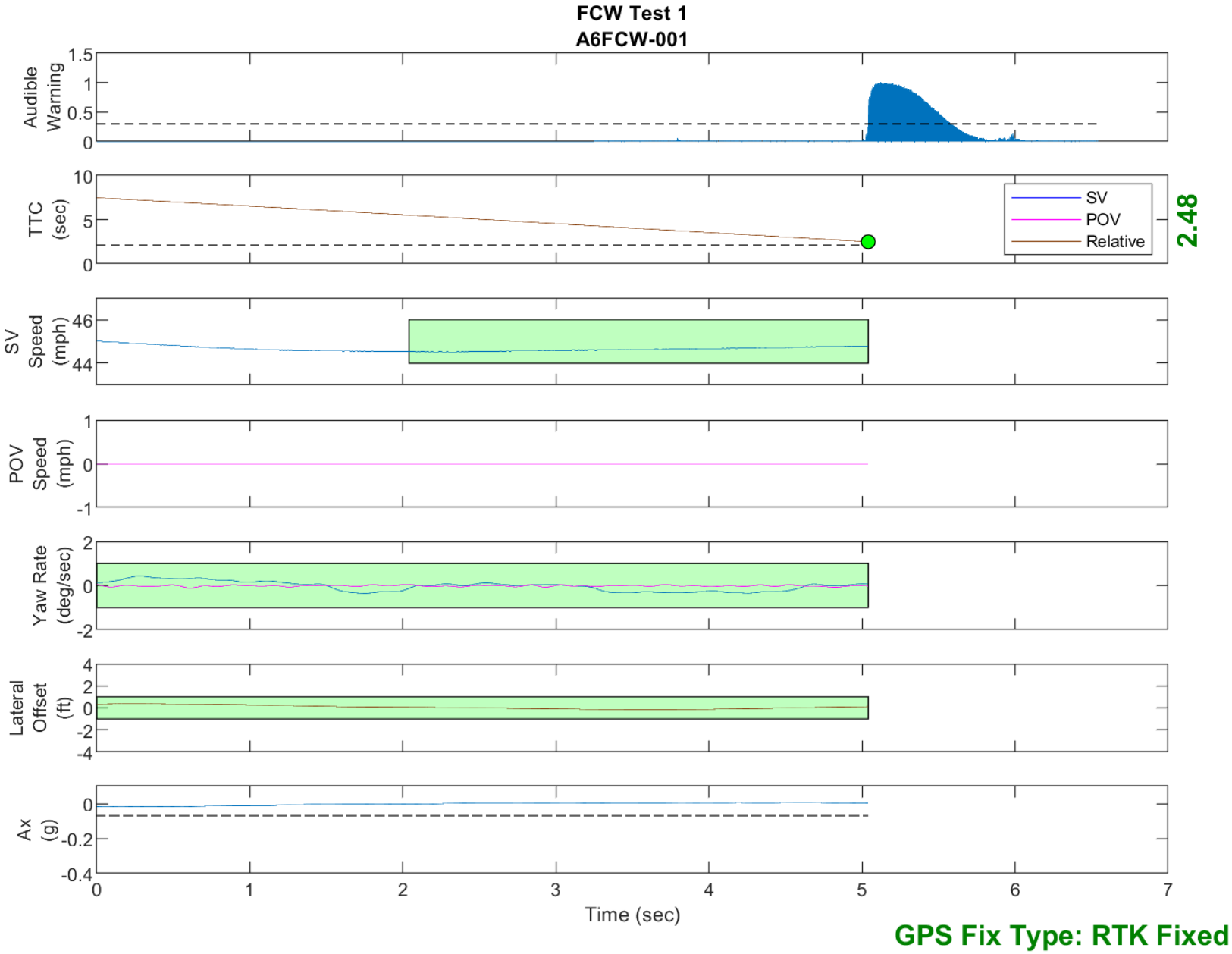

Figure D7. Time History for Run 1, FCW Test 1, Audible Warning

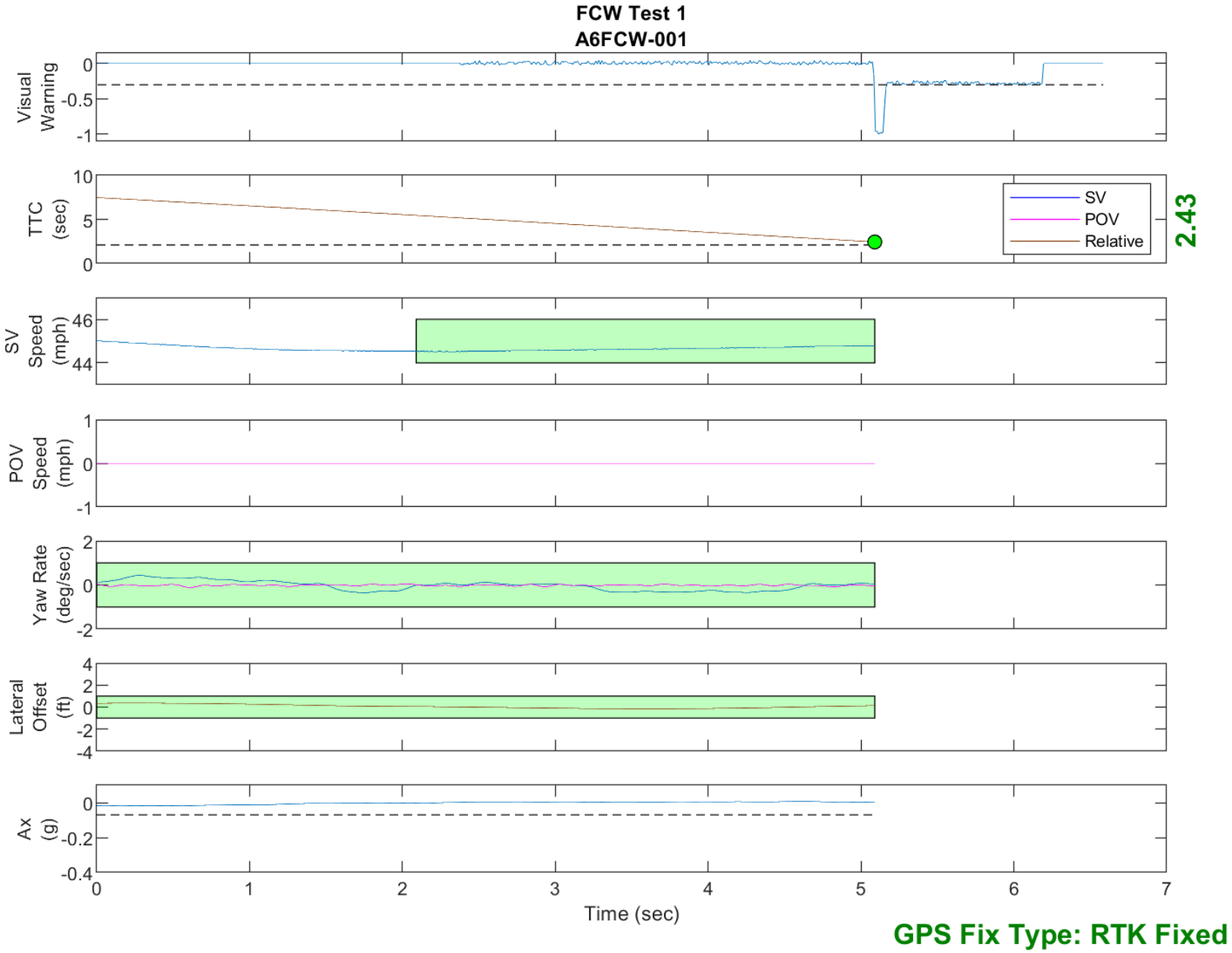

Figure D8. Time History for Run 1, FCW Test 1, Visual Warning

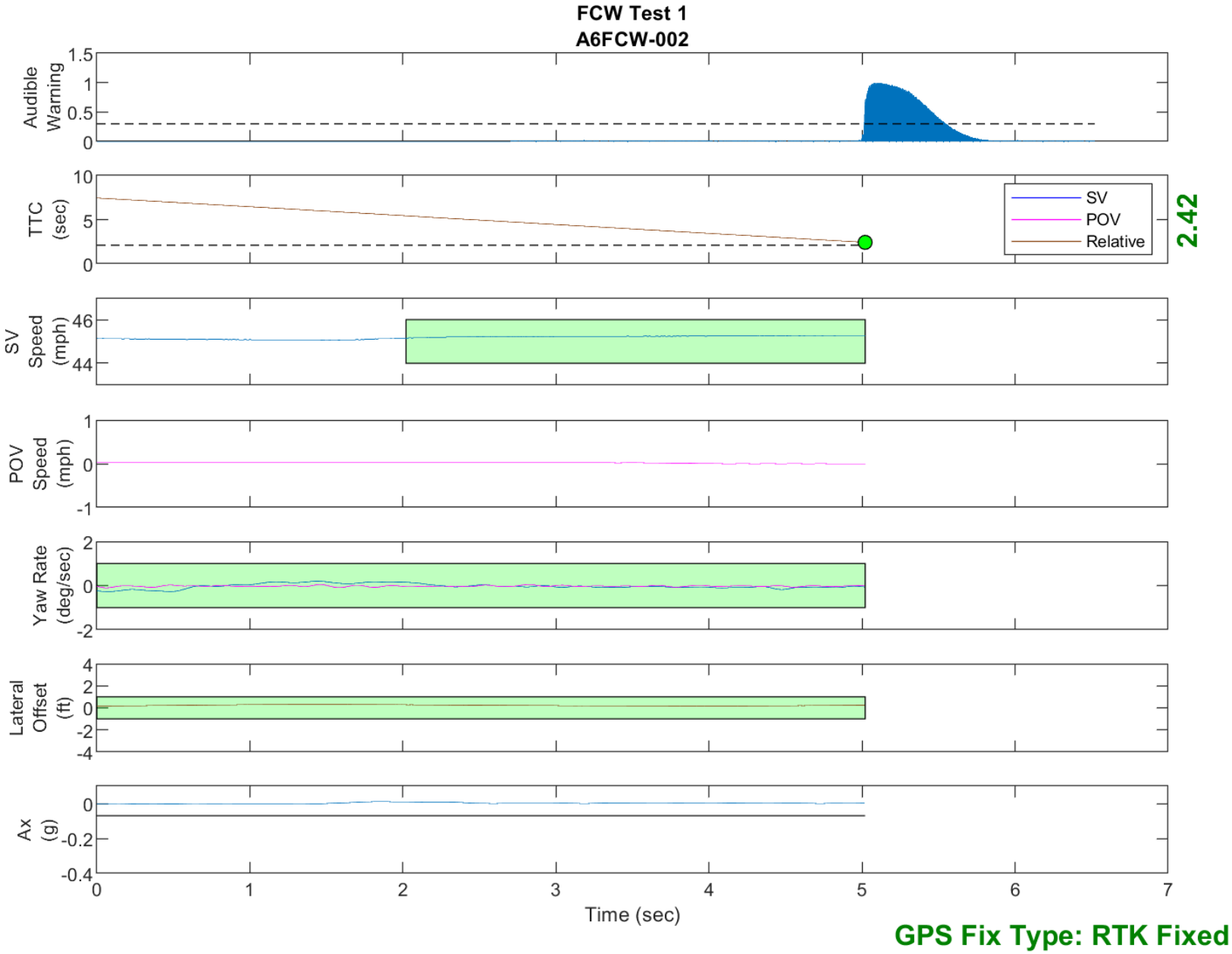

Figure D9. Time History for Run 2, FCW Test 1, Audible Warning

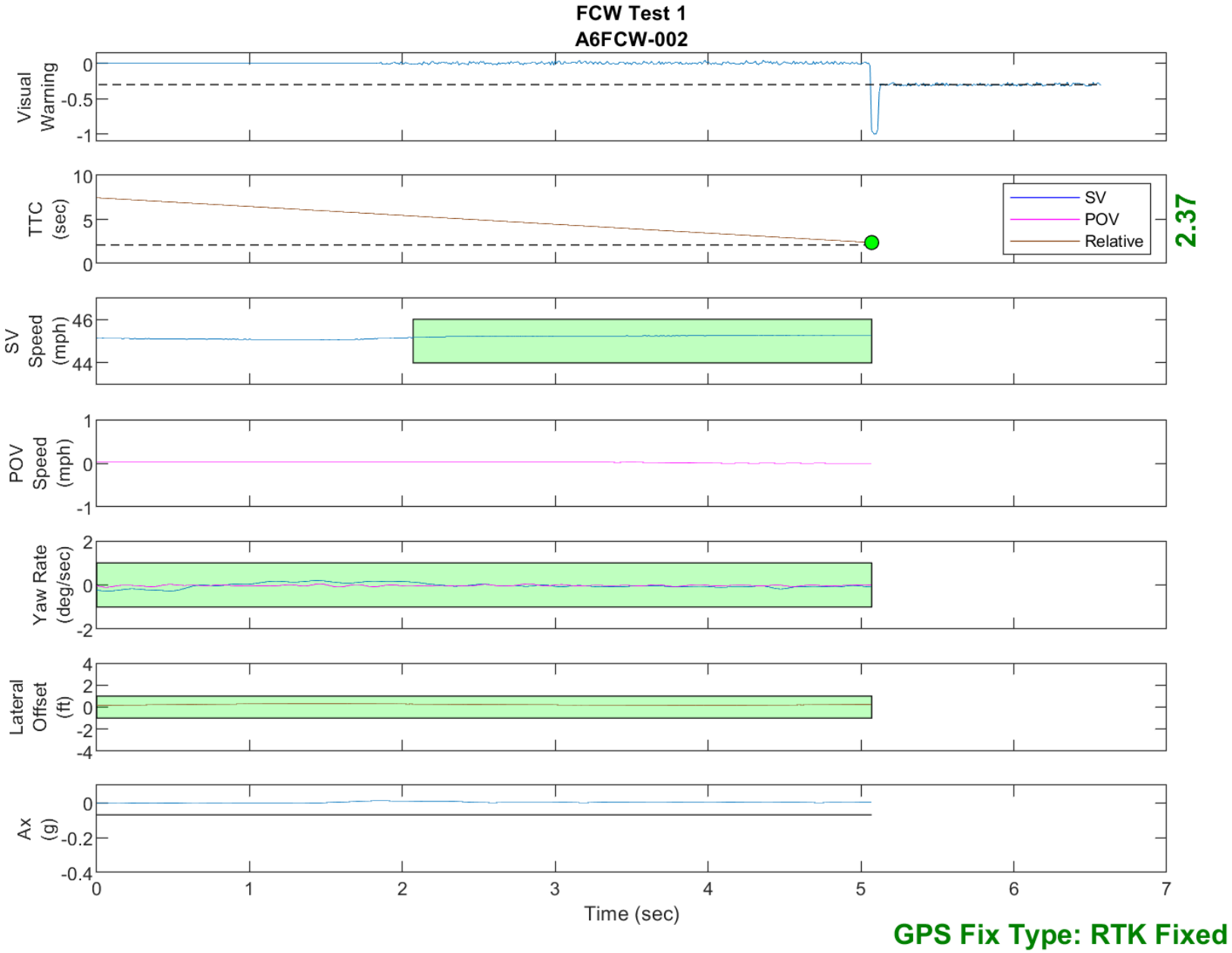

Figure D10. Time History for Run 2, FCW Test 1, Visual Warning

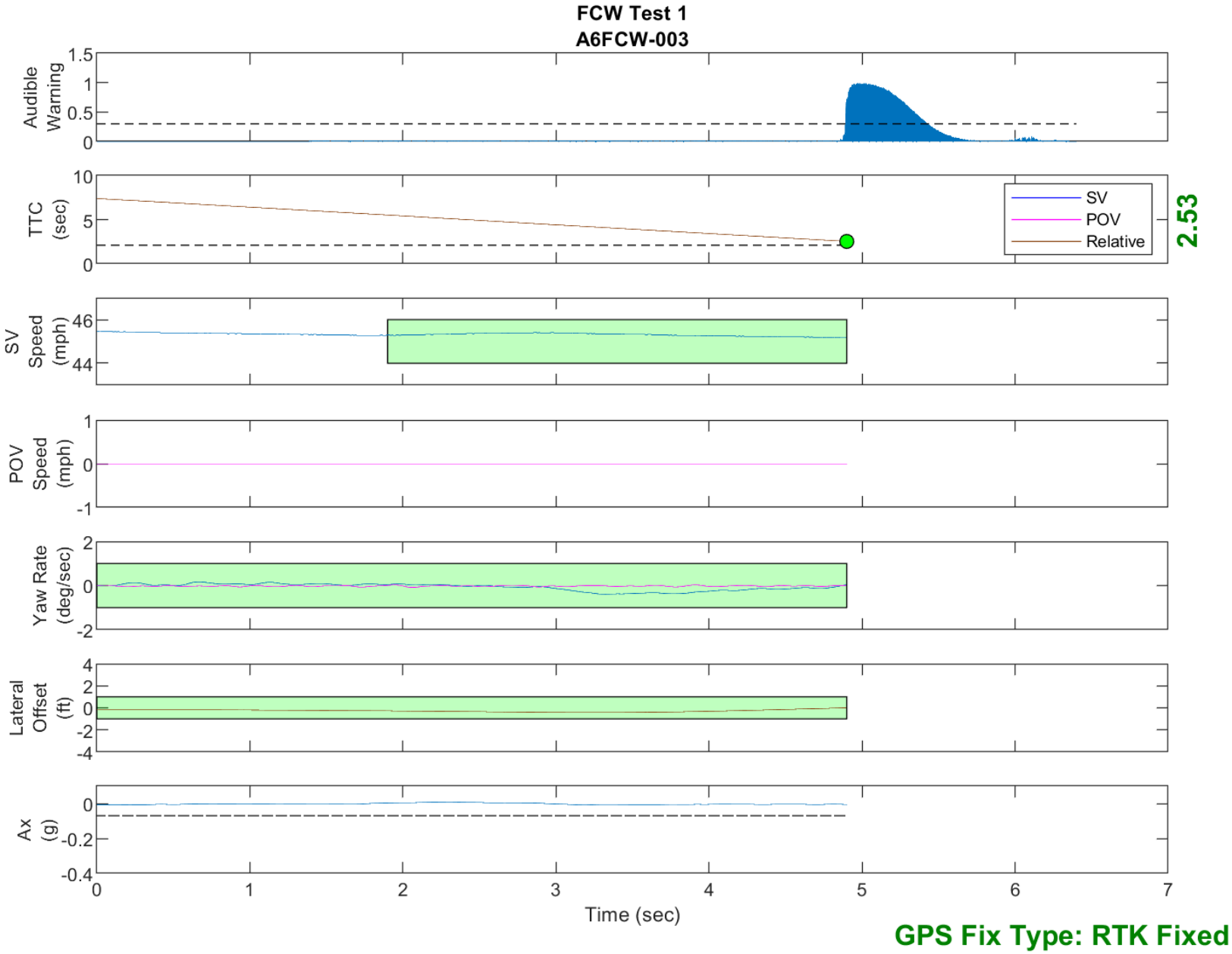

Figure D11. Time History for Run 3, FCW Test 1, Audible Warning

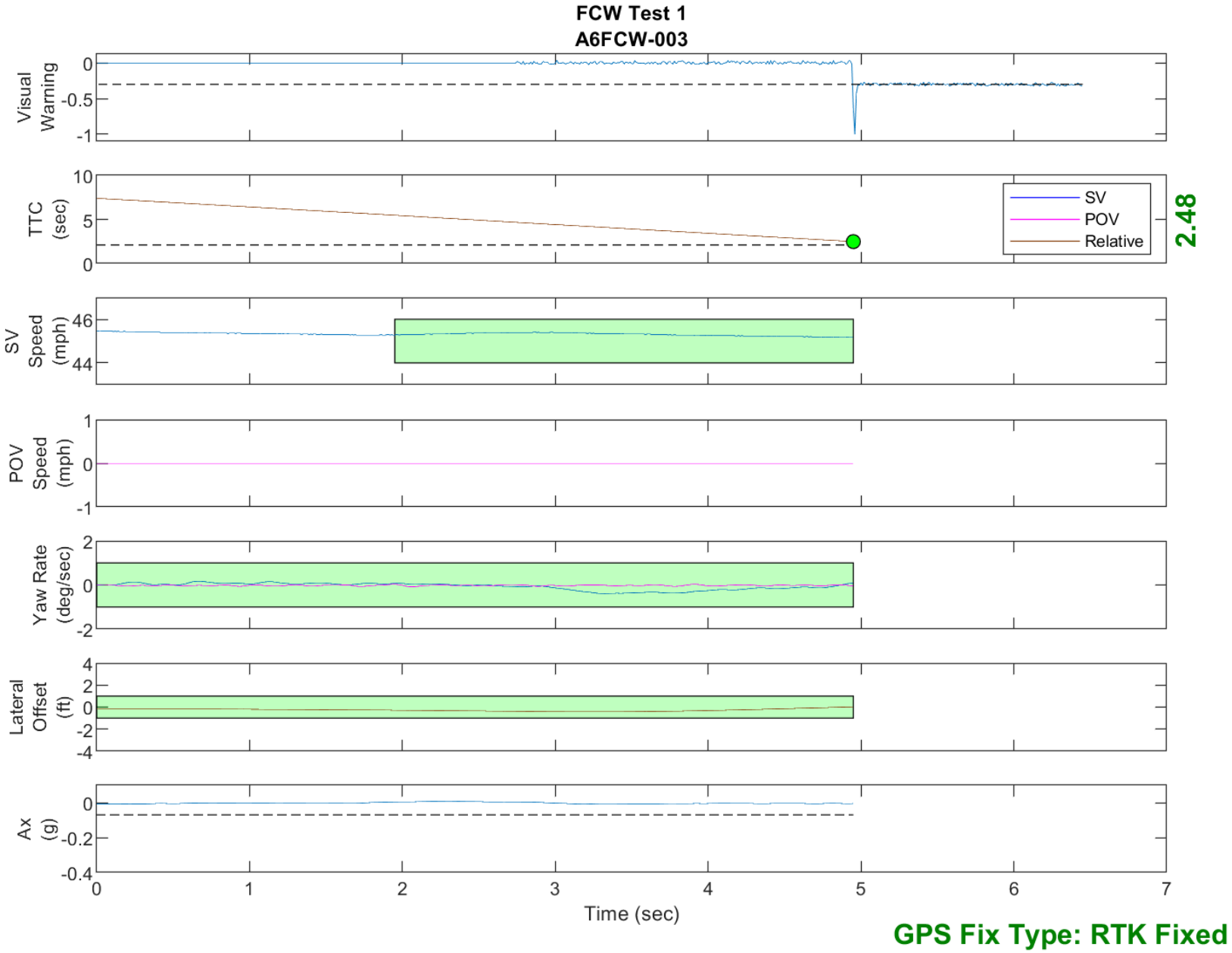

Figure D12. Time History for Run 3, FCW Test 1, Visual Warning

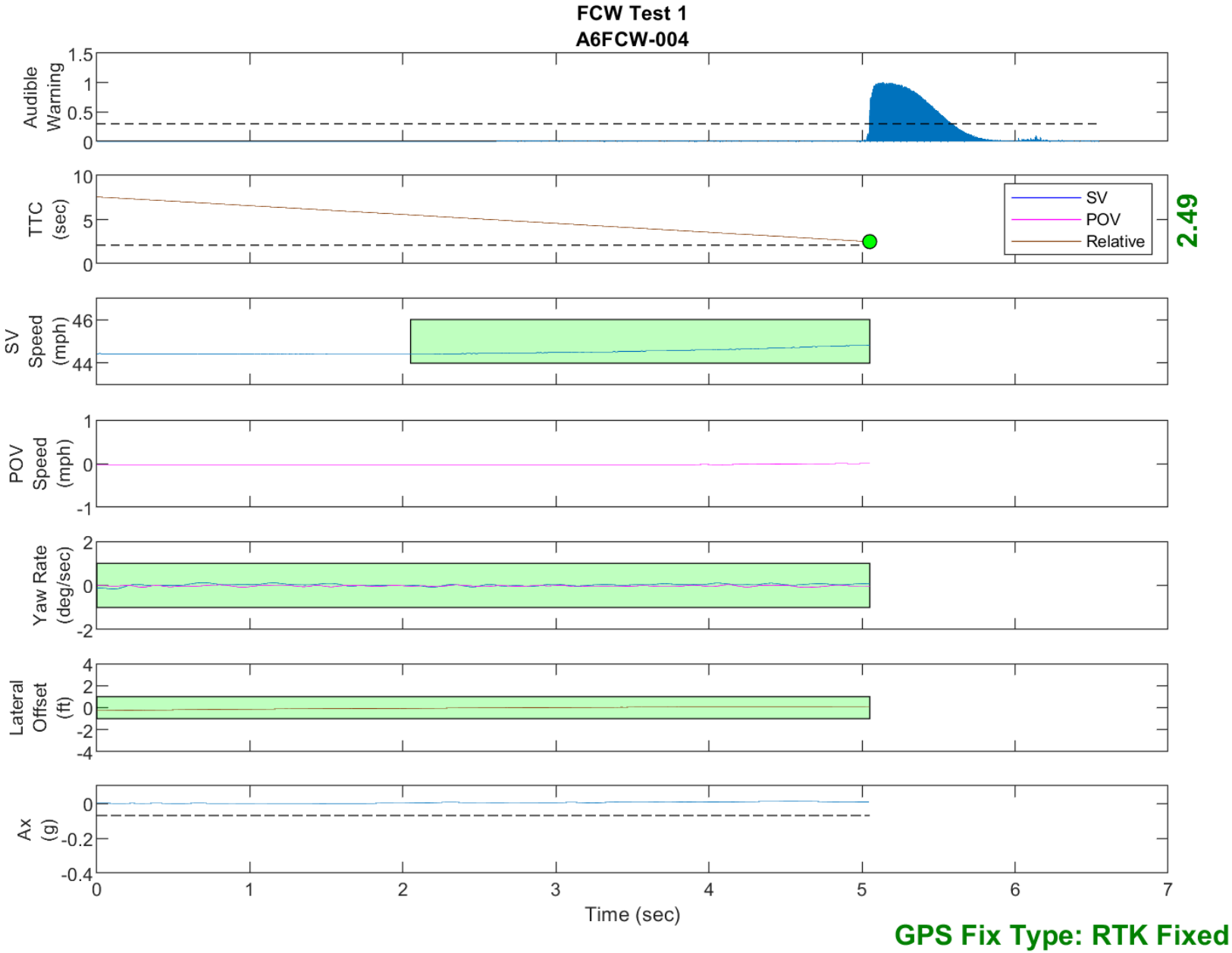

Figure D13. Time History for Run 4, FCW Test 1, Audible Warning

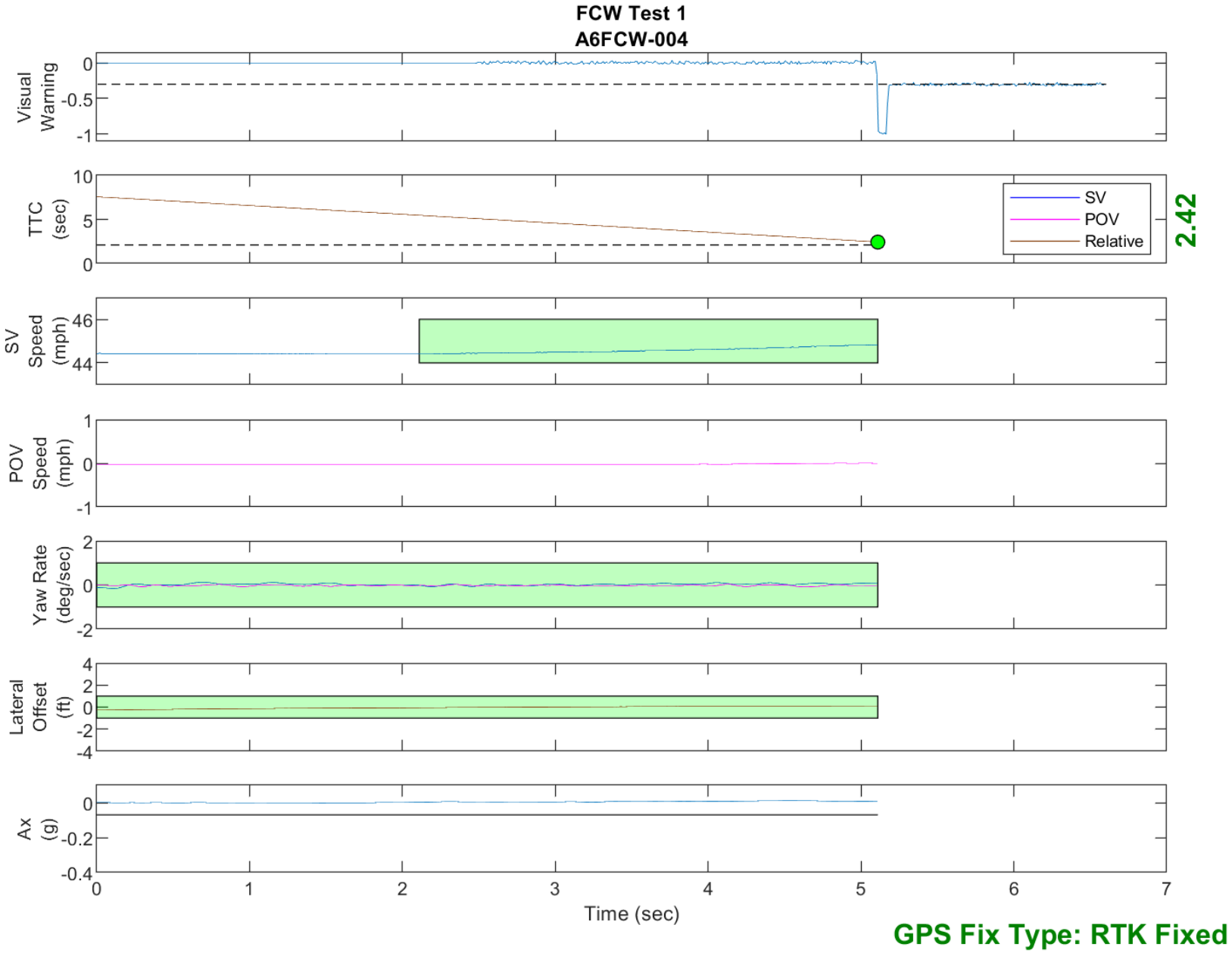

Figure D14. Time History for Run 4, FCW Test 1, Visual Warning

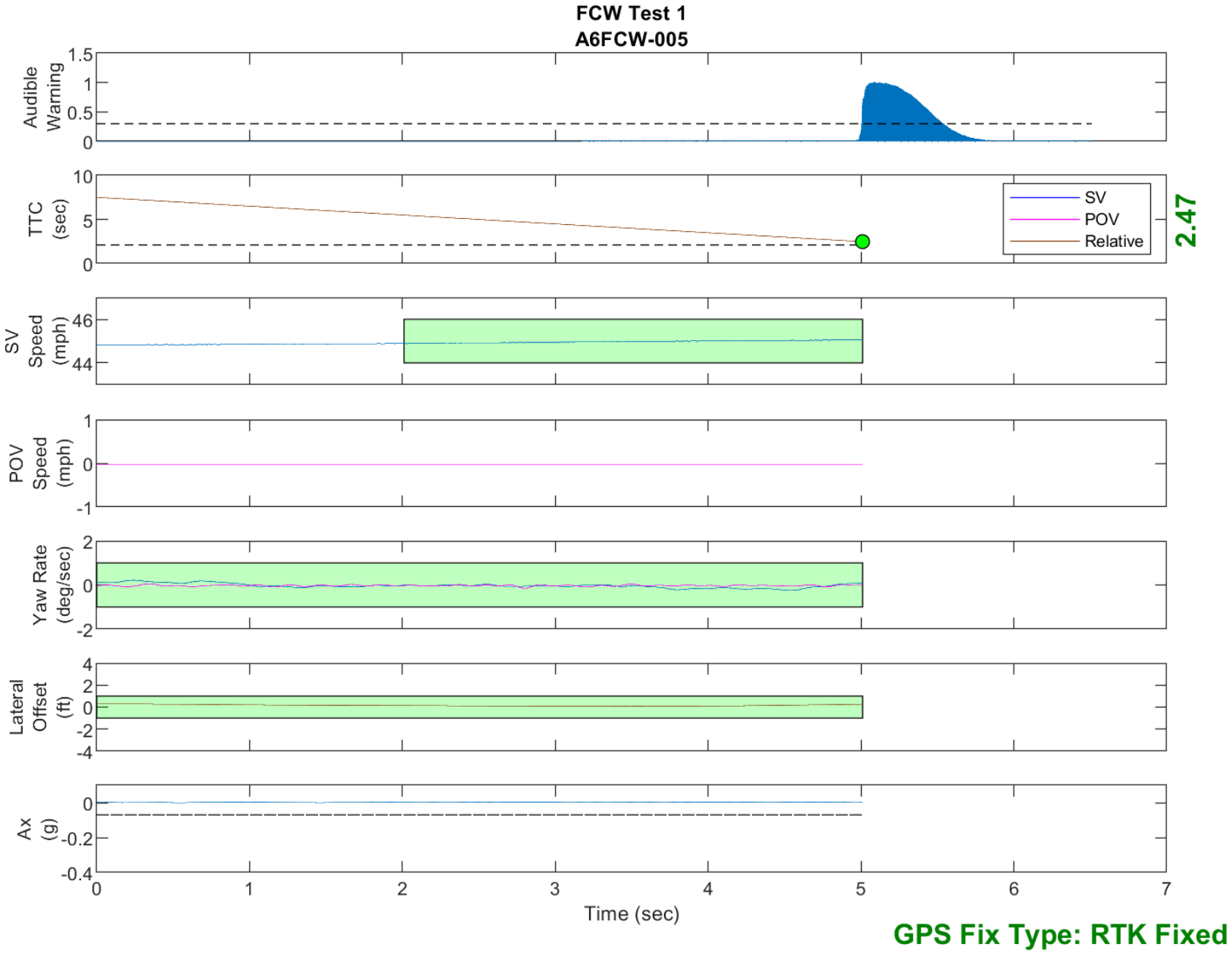

Figure D15. Time History for Run 5, FCW Test 1, Audible Warning

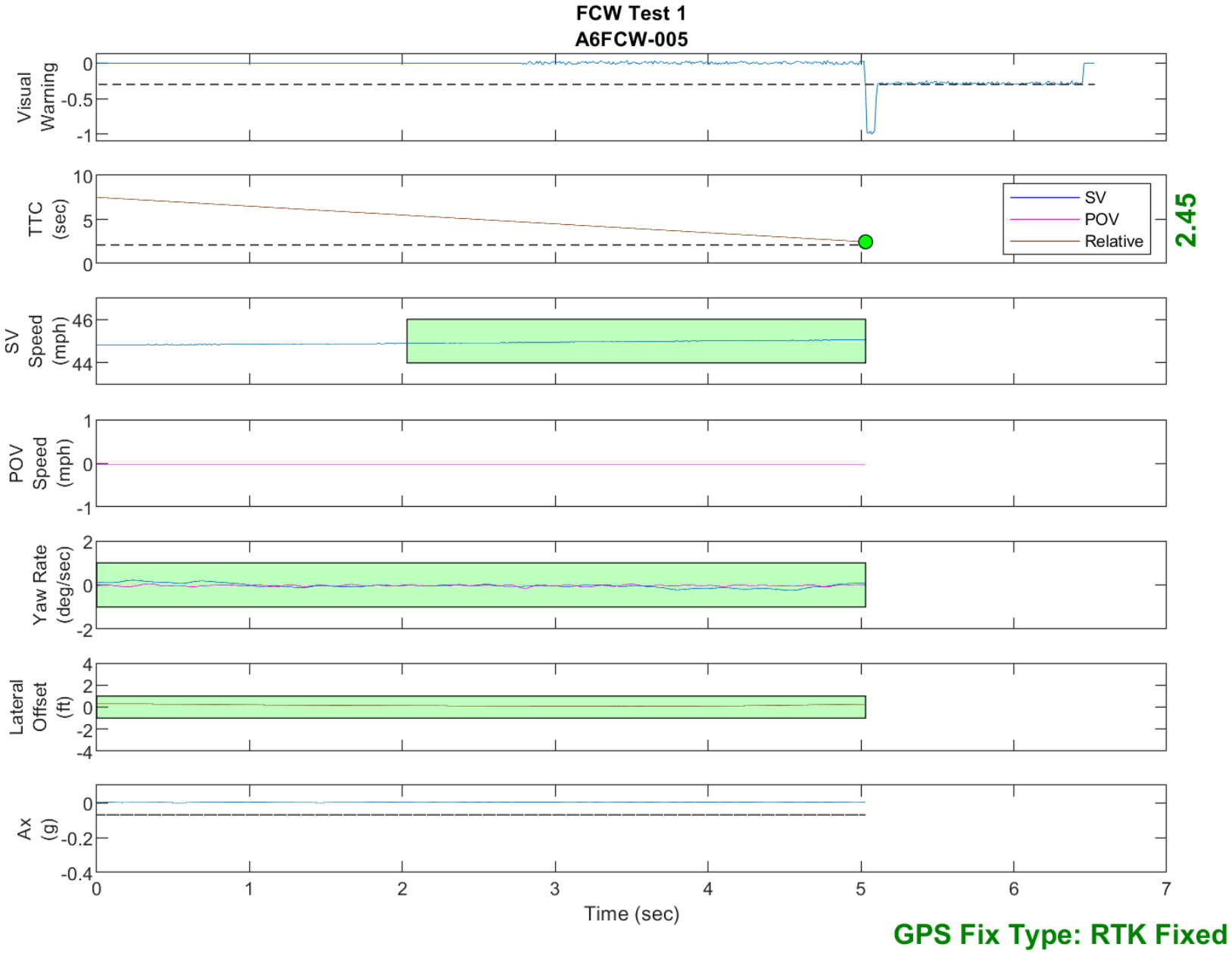

Figure D16. Time History for Run 5, FCW Test 1, Visual Warning

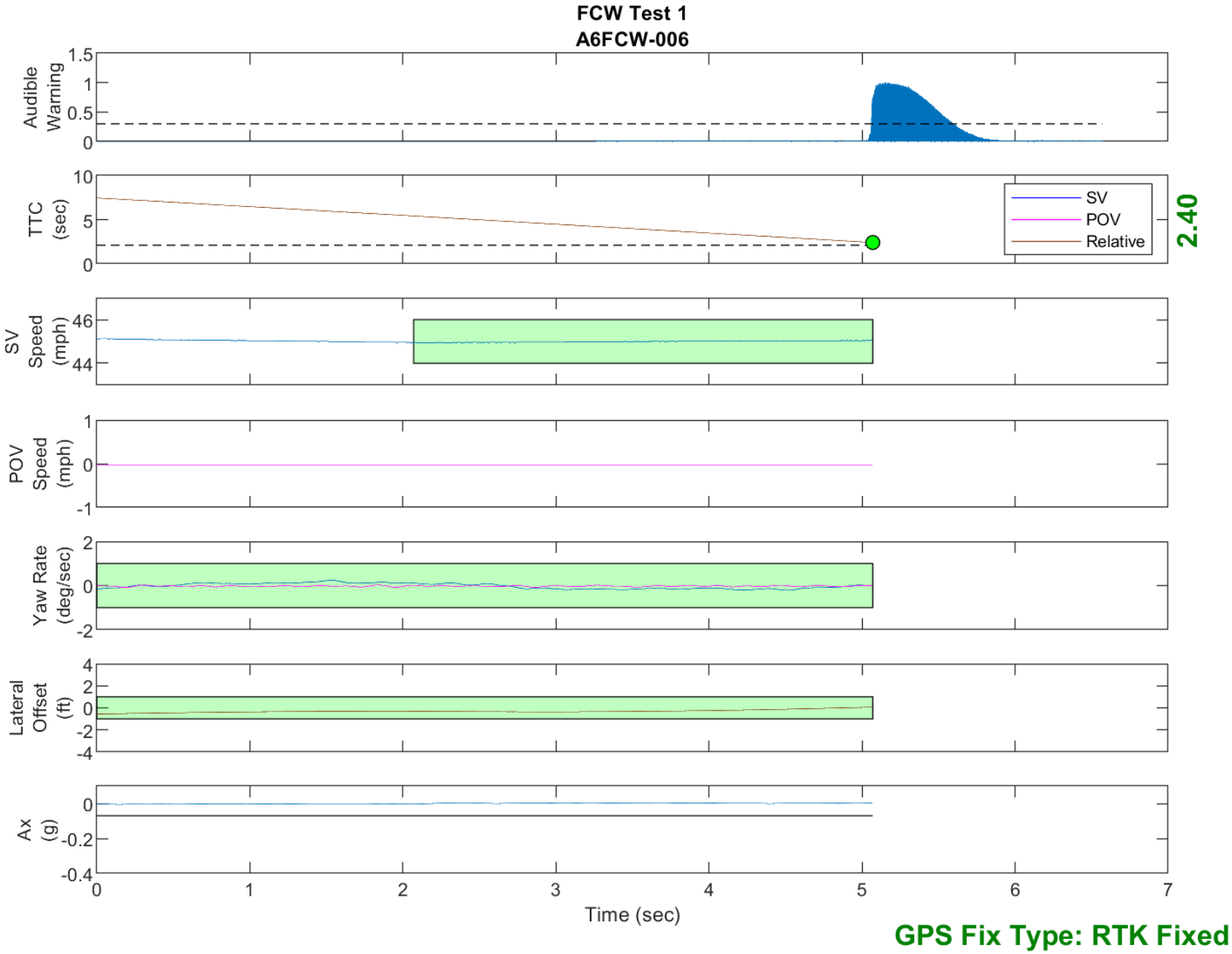

Figure D17. Time History for Run 6, FCW Test 1, Audible Warning

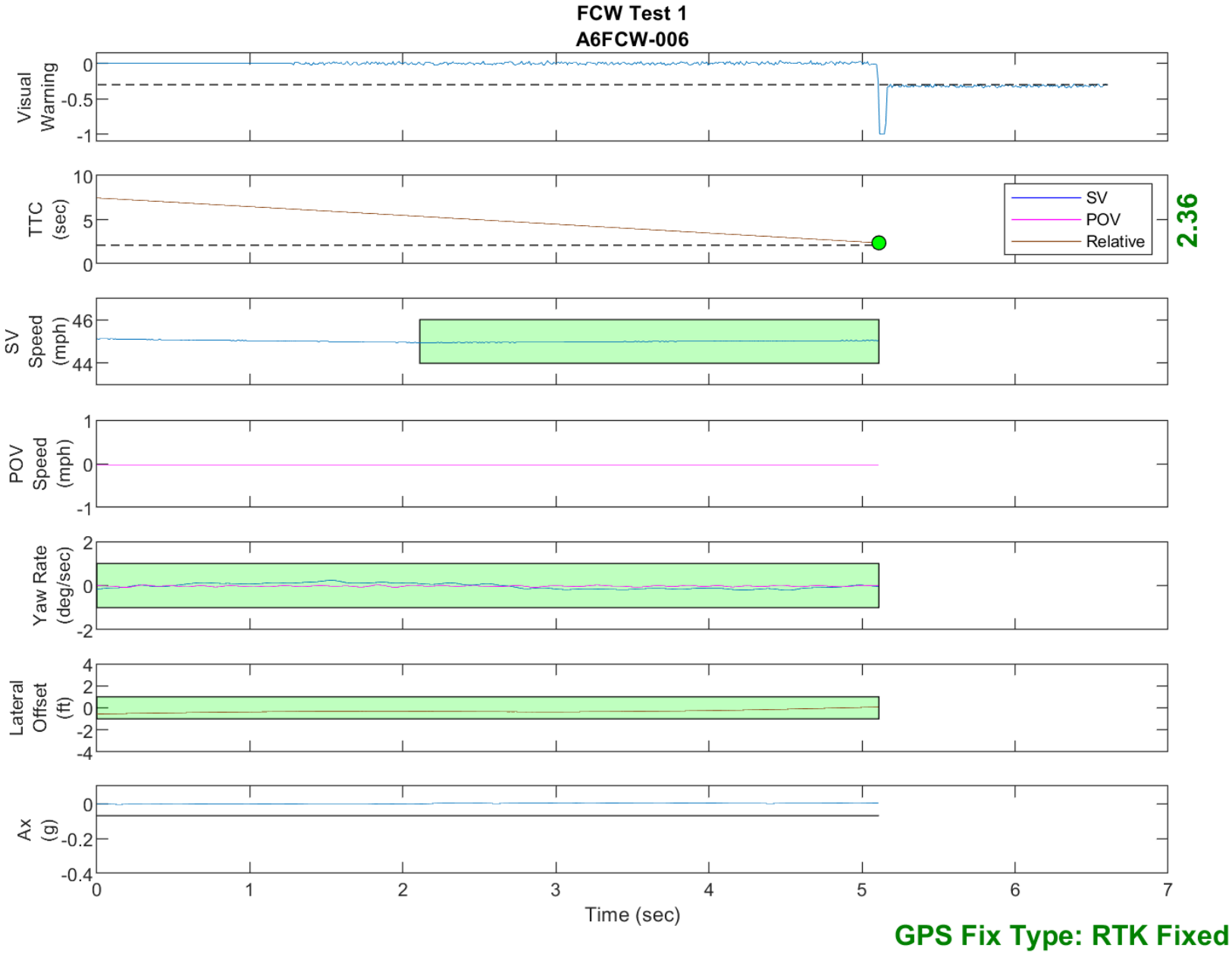

Figure D18. Time History for Run 6, FCW Test 1, Visual Warning

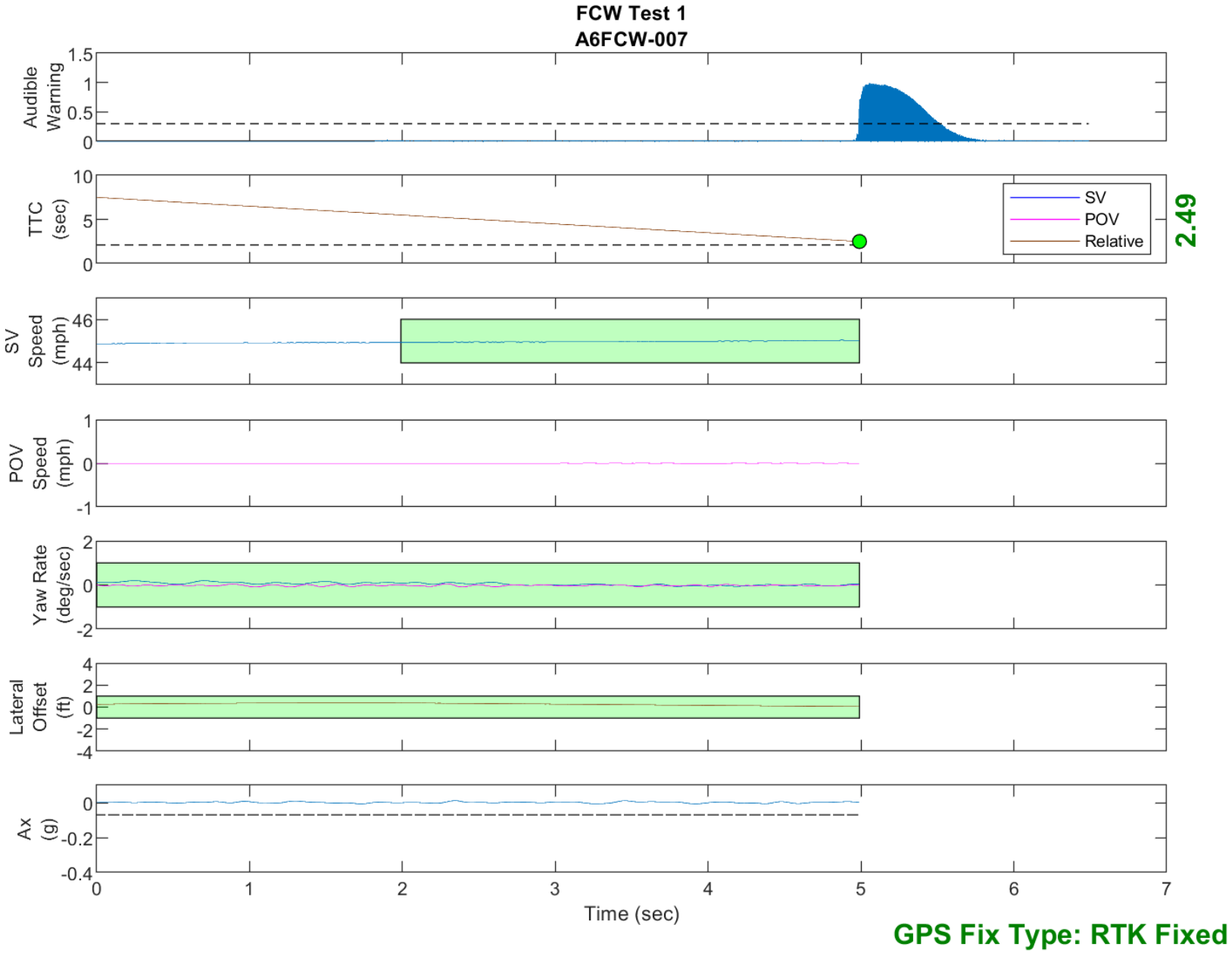

Figure D19. Time History for Run 7, FCW Test 1, Audible Warning

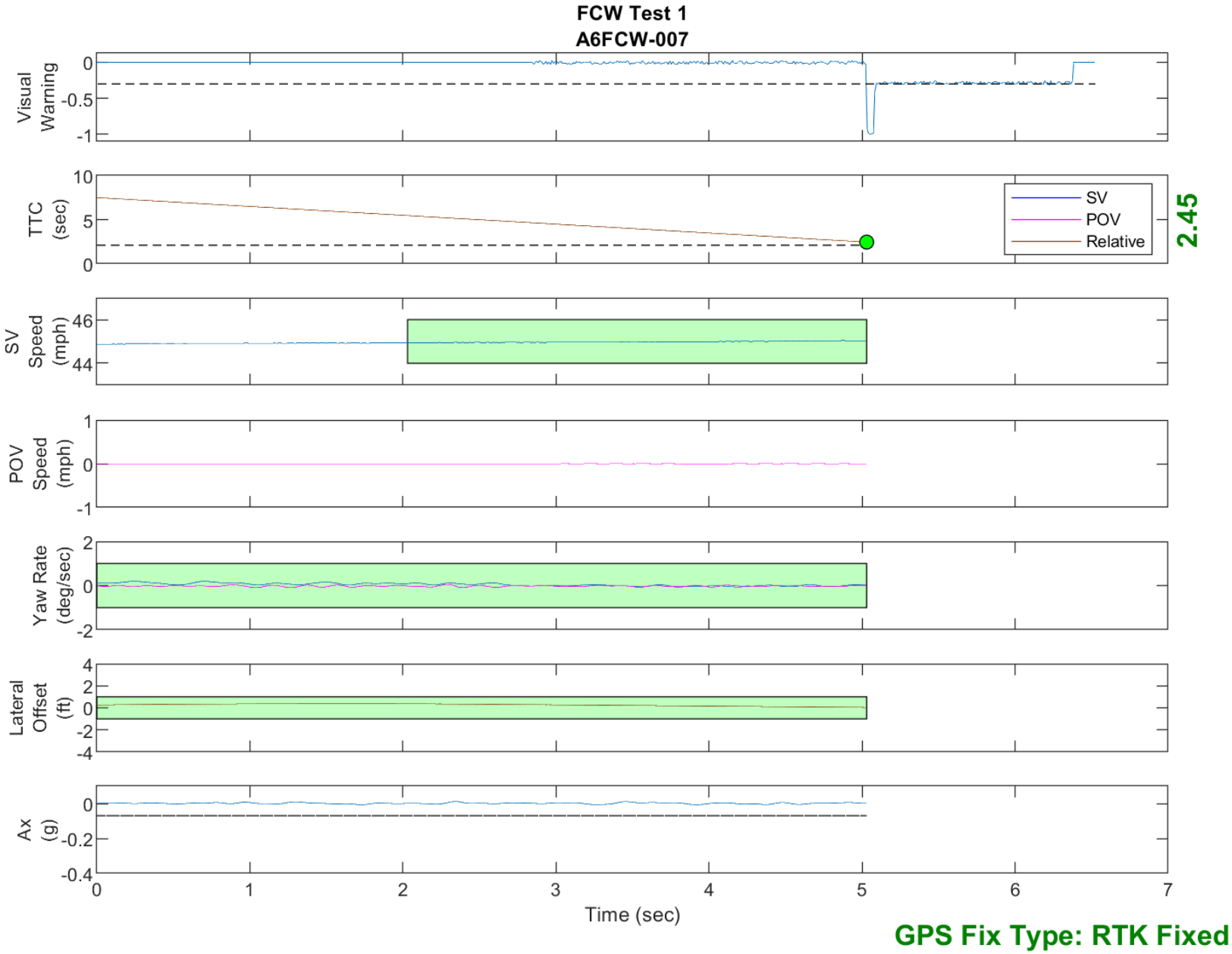

Figure D20. Time History for Run 7, FCW Test 1, Visual Warning

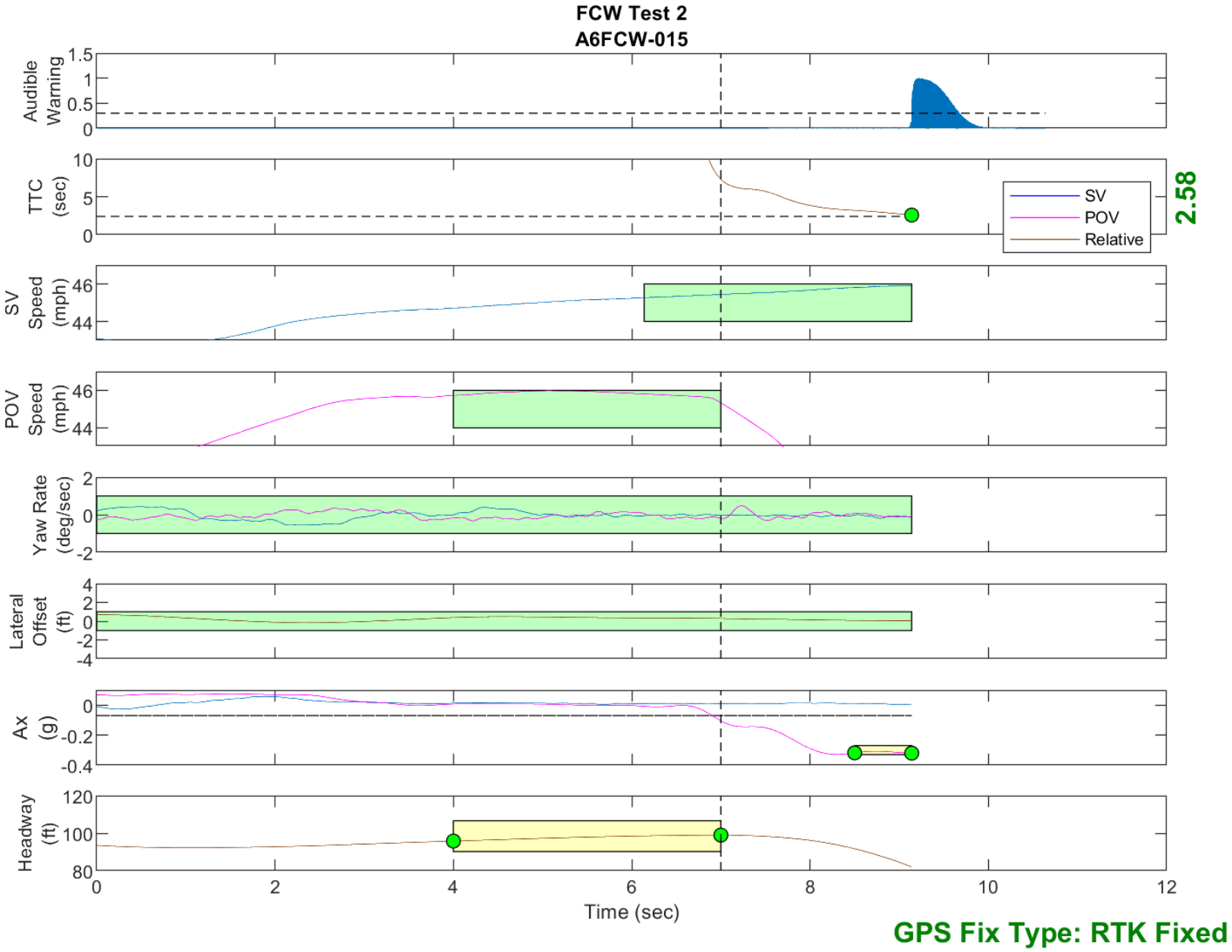

Figure D21. Time History for Run 15, FCW Test 2, Audible Warning

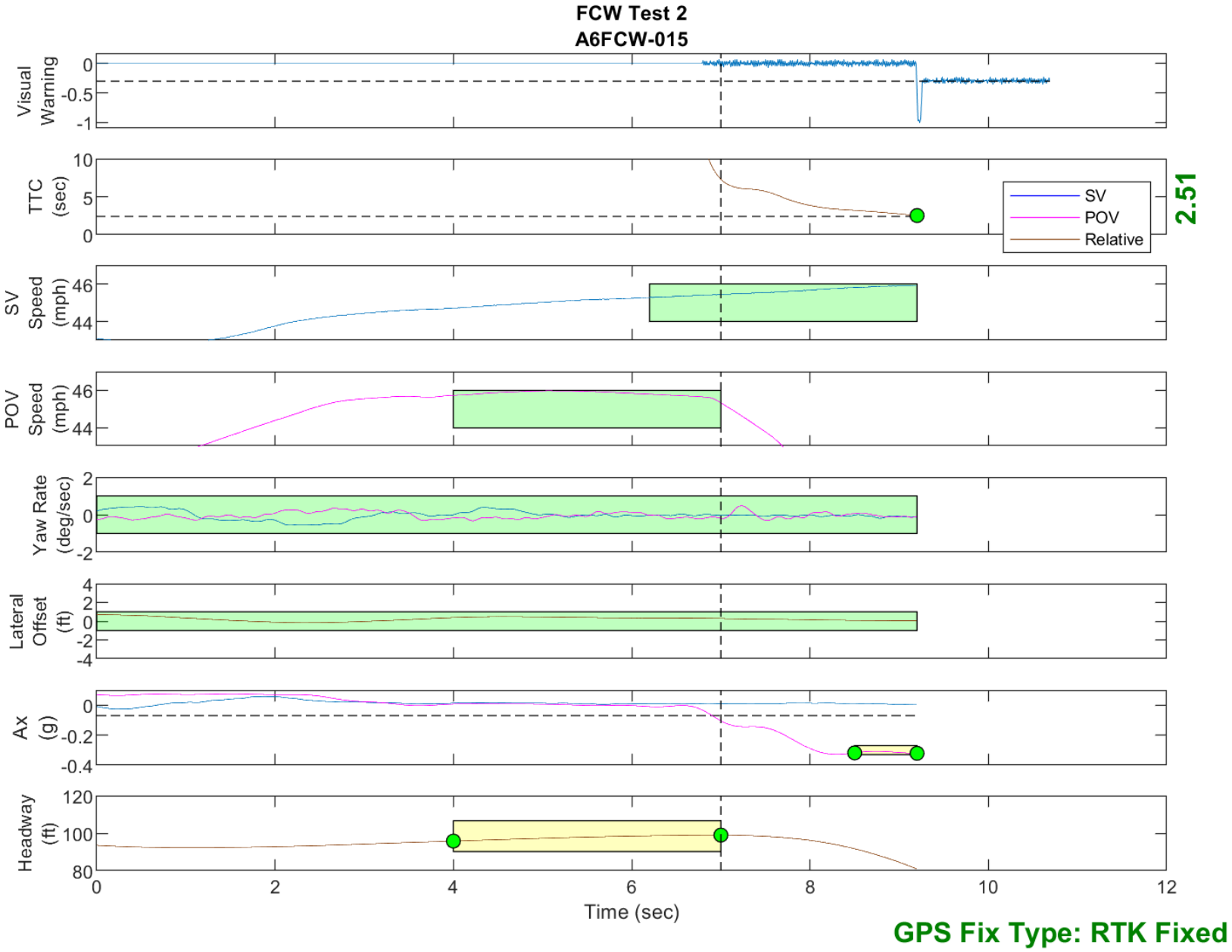

Figure D22. Time History for Run 15, FCW Test 2, Visual Warning

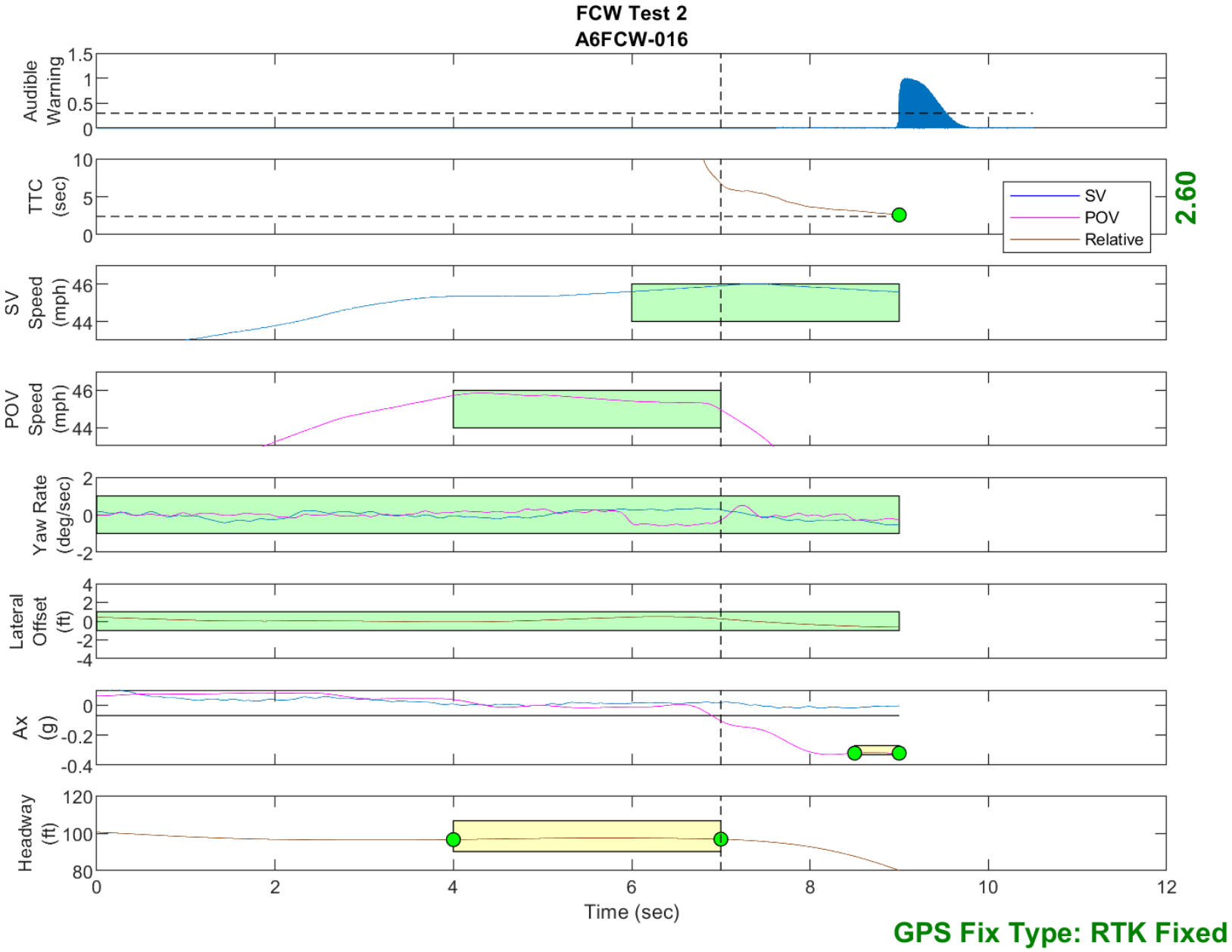

Figure D23. Time History for Run 16, FCW Test 2, Audible Warning

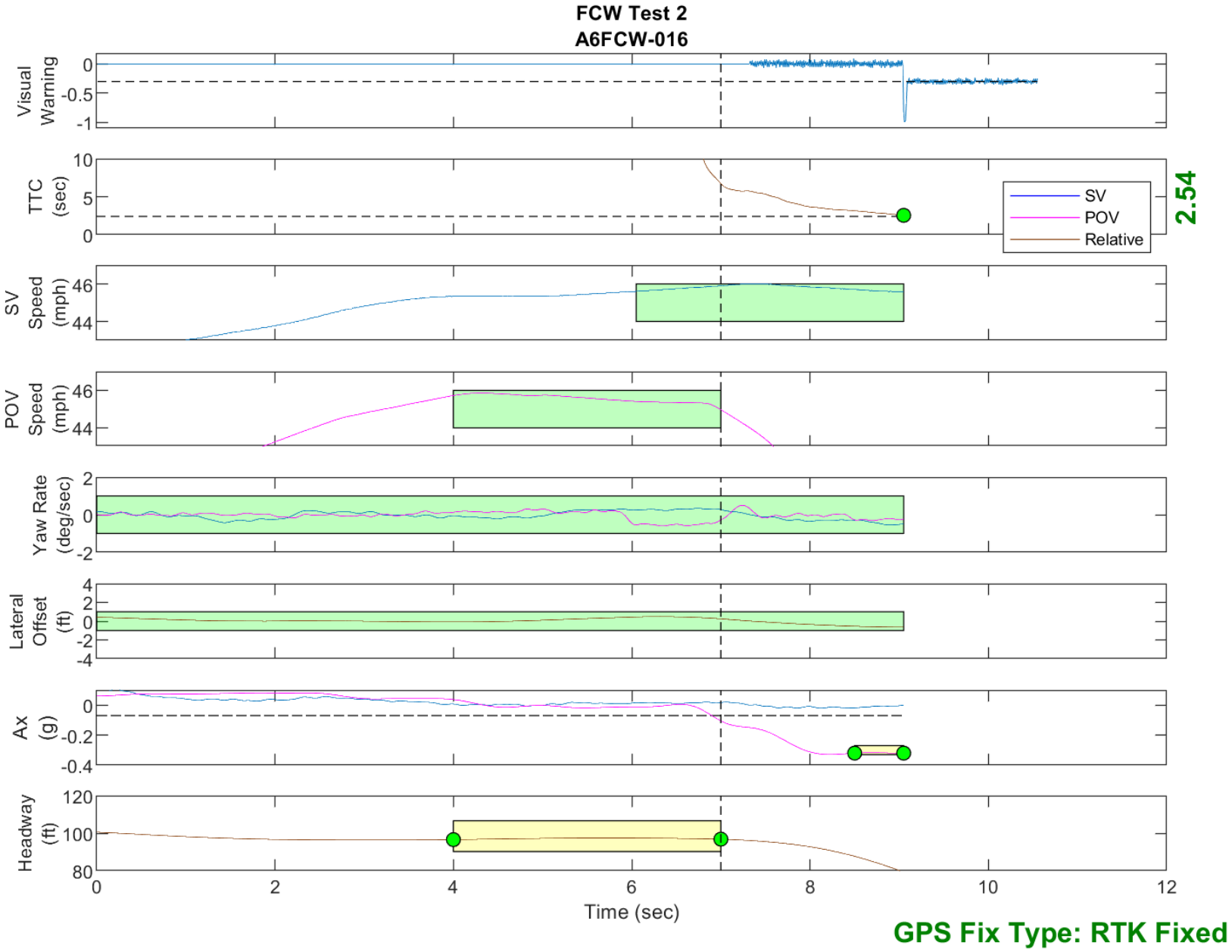

Figure D24. Time History for Run 16, FCW Test 2, Visual Warning

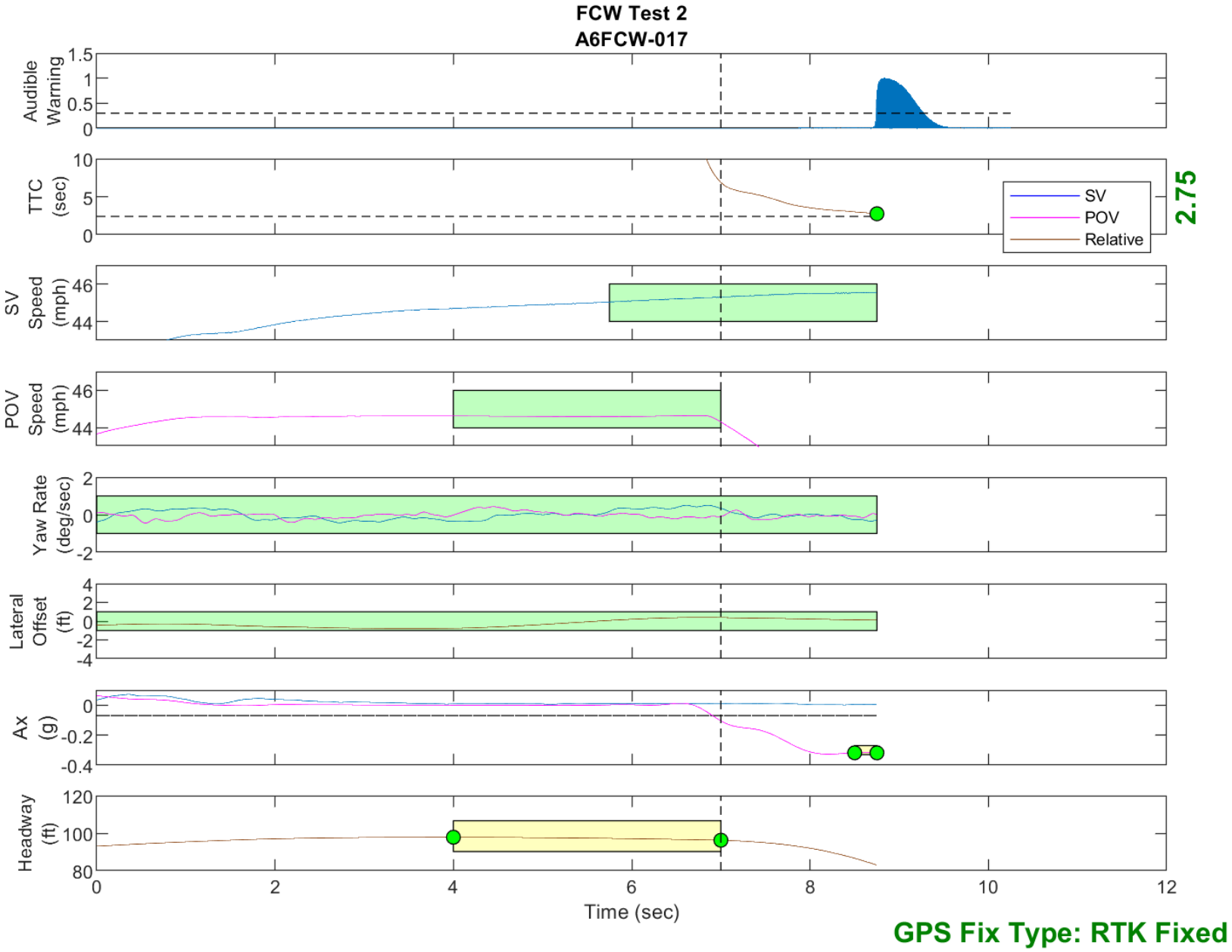

Figure D25. Time History for Run 17, FCW Test 2, Audible Warning

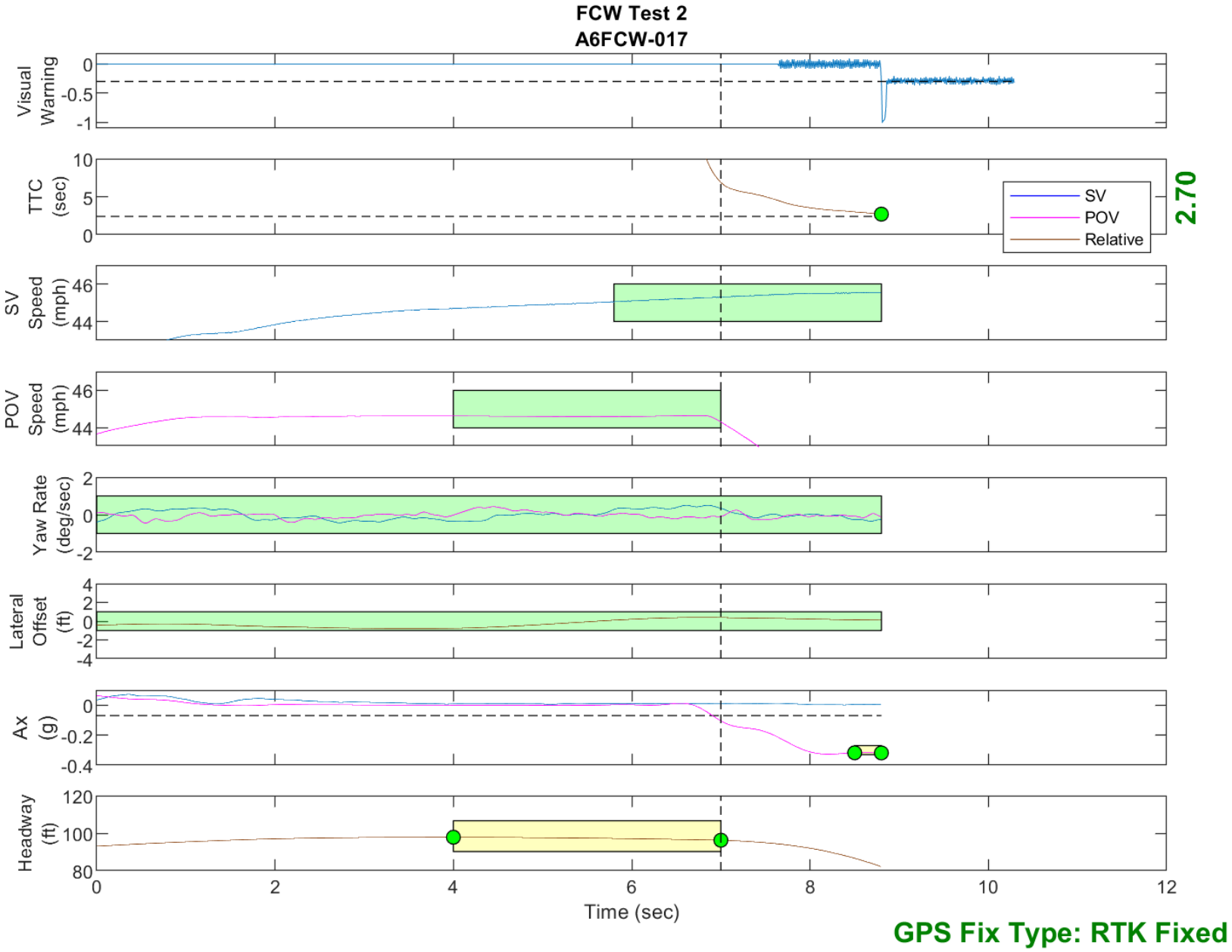

Figure D26. Time History for Run 17, FCW Test 2, Visual Warning

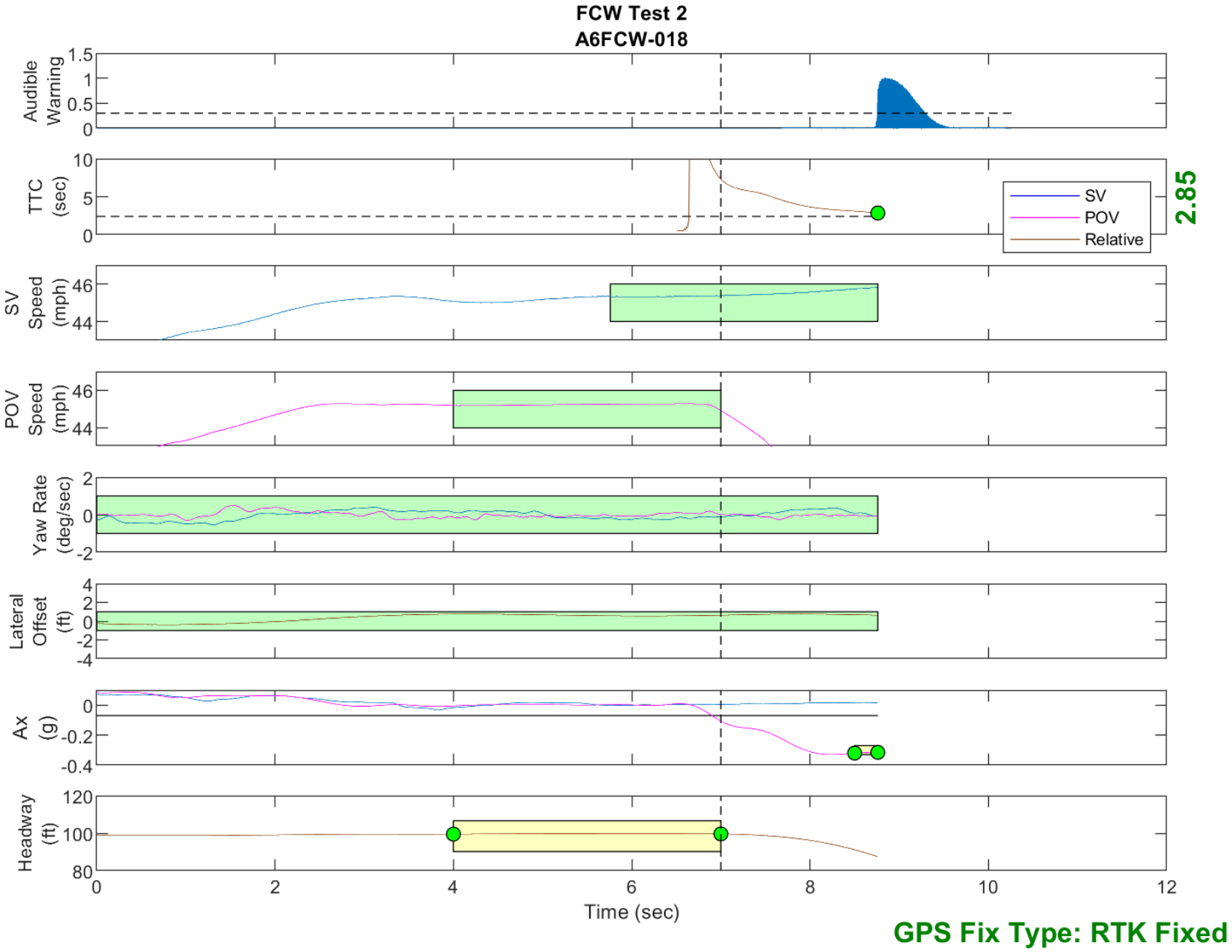

Figure D27. Time History for Run 18, FCW Test 2, Audible Warning

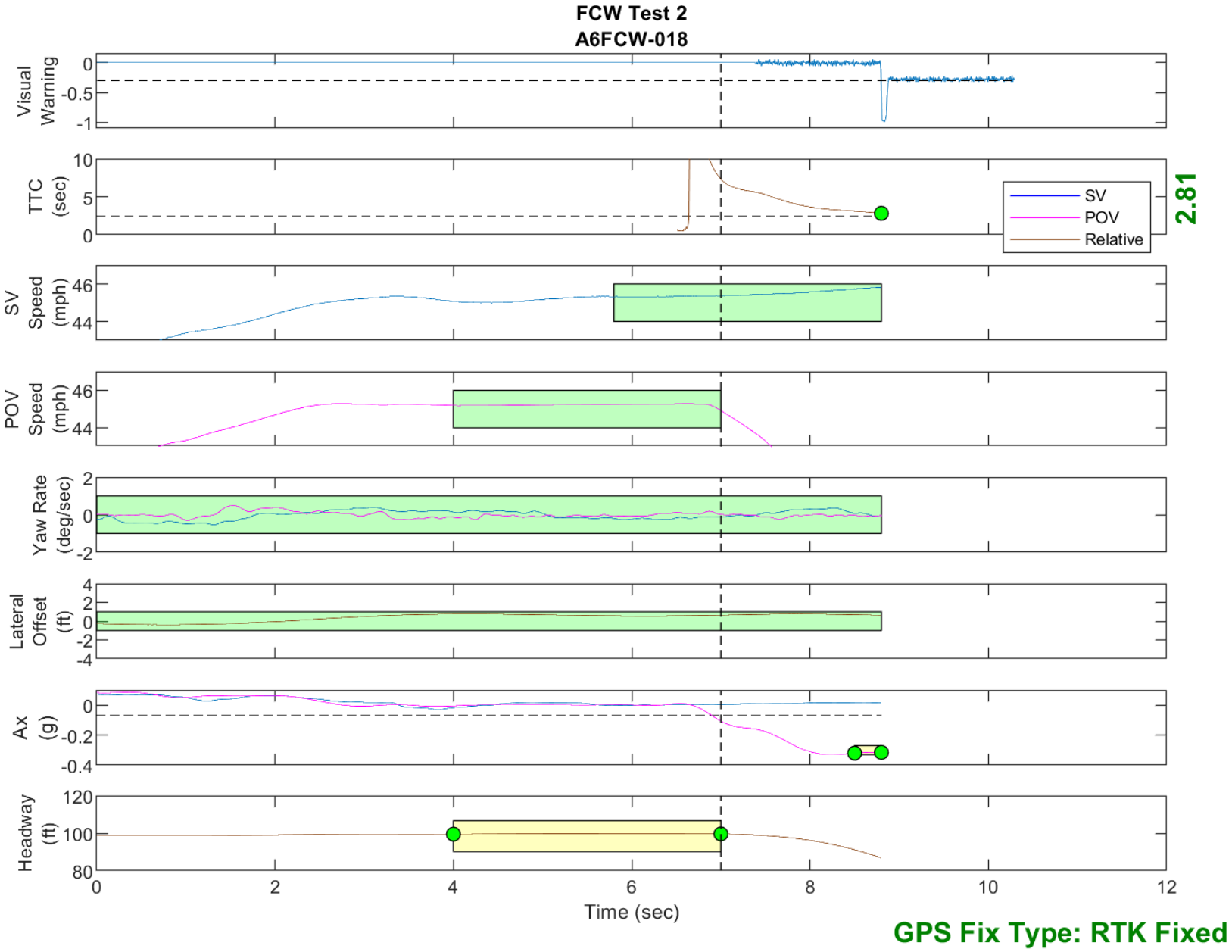

Figure D28. Time History for Run 18, FCW Test 2, Visual Warning

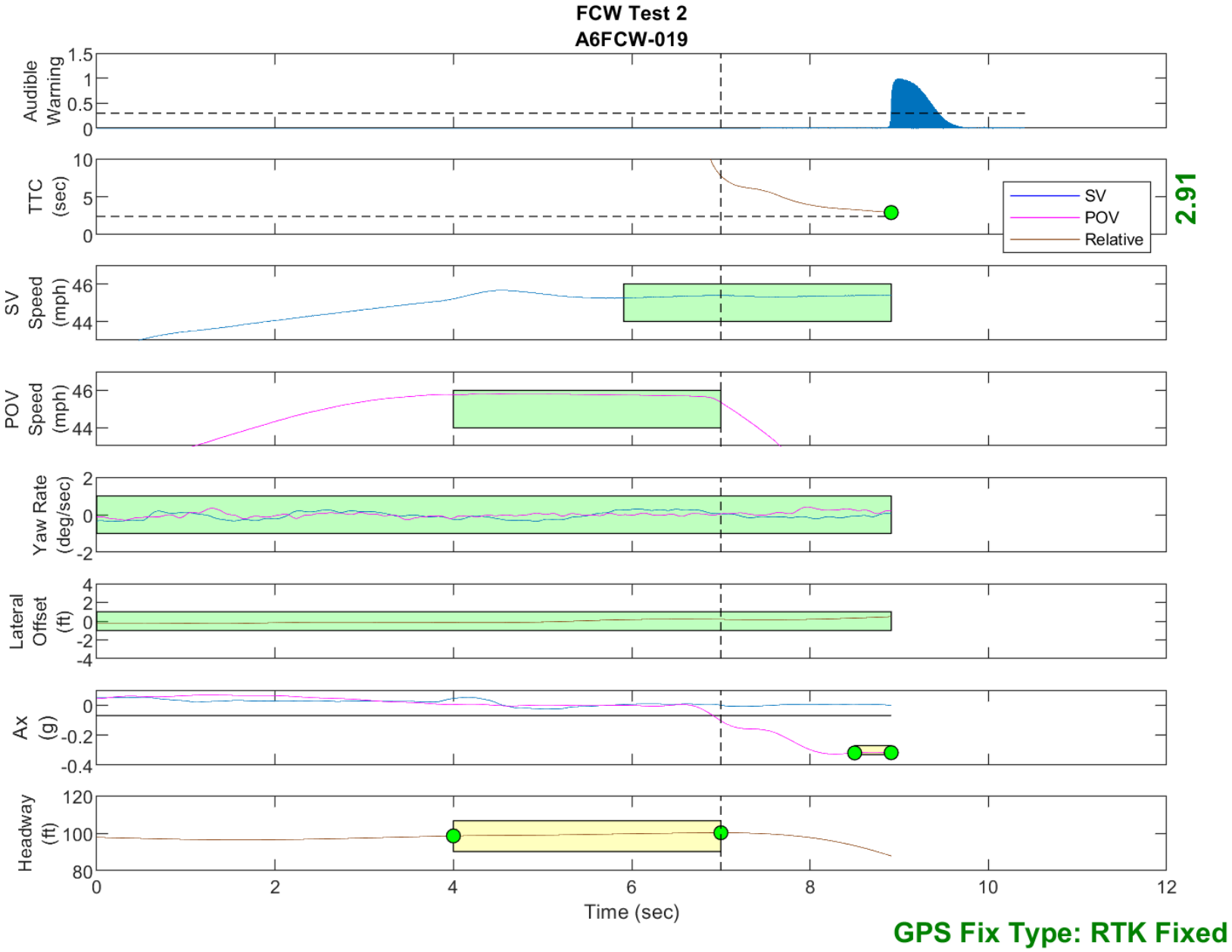

Figure D29. Time History for Run 19, FCW Test 2, Audible Warning

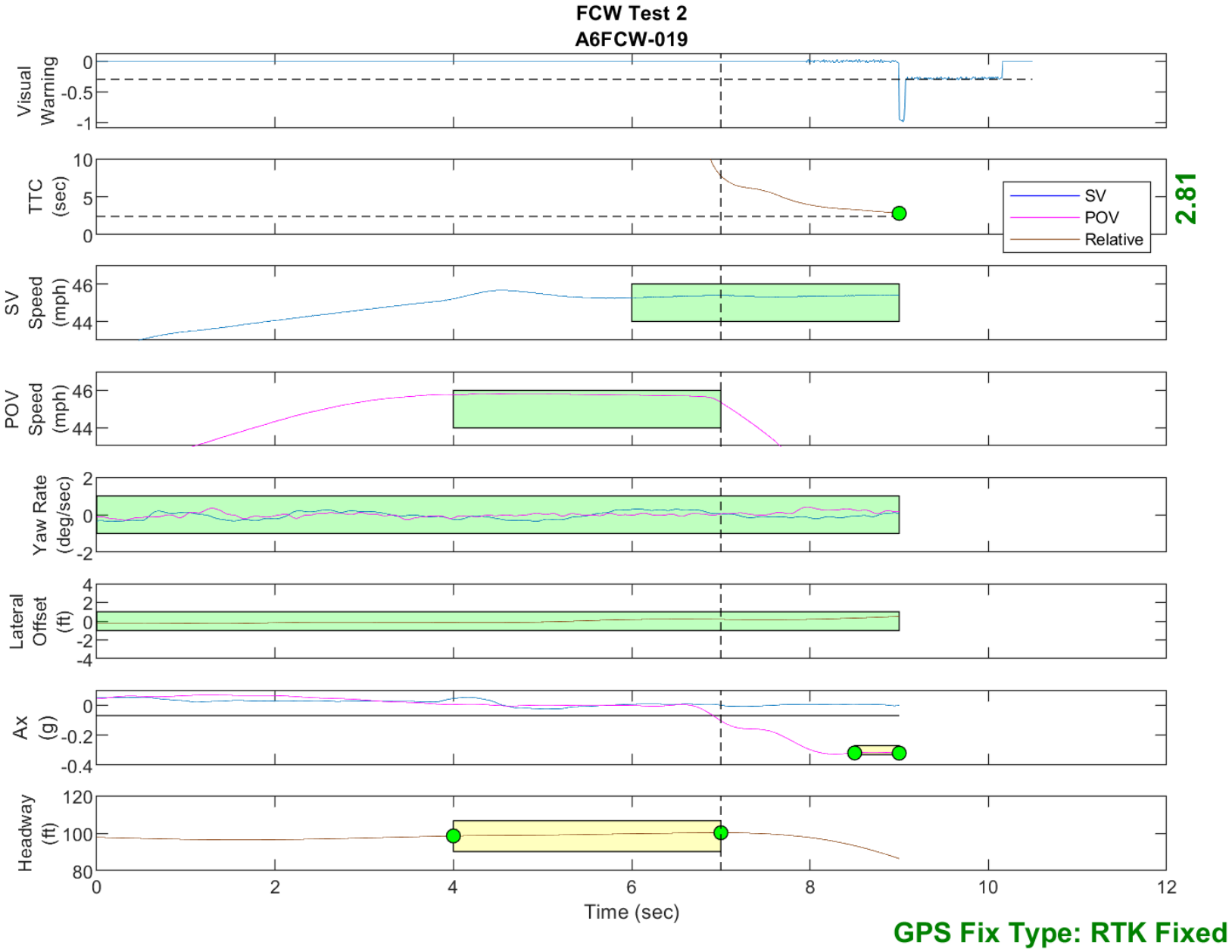

Figure D30. Time History for Run 19, FCW Test 2, Visual Warning

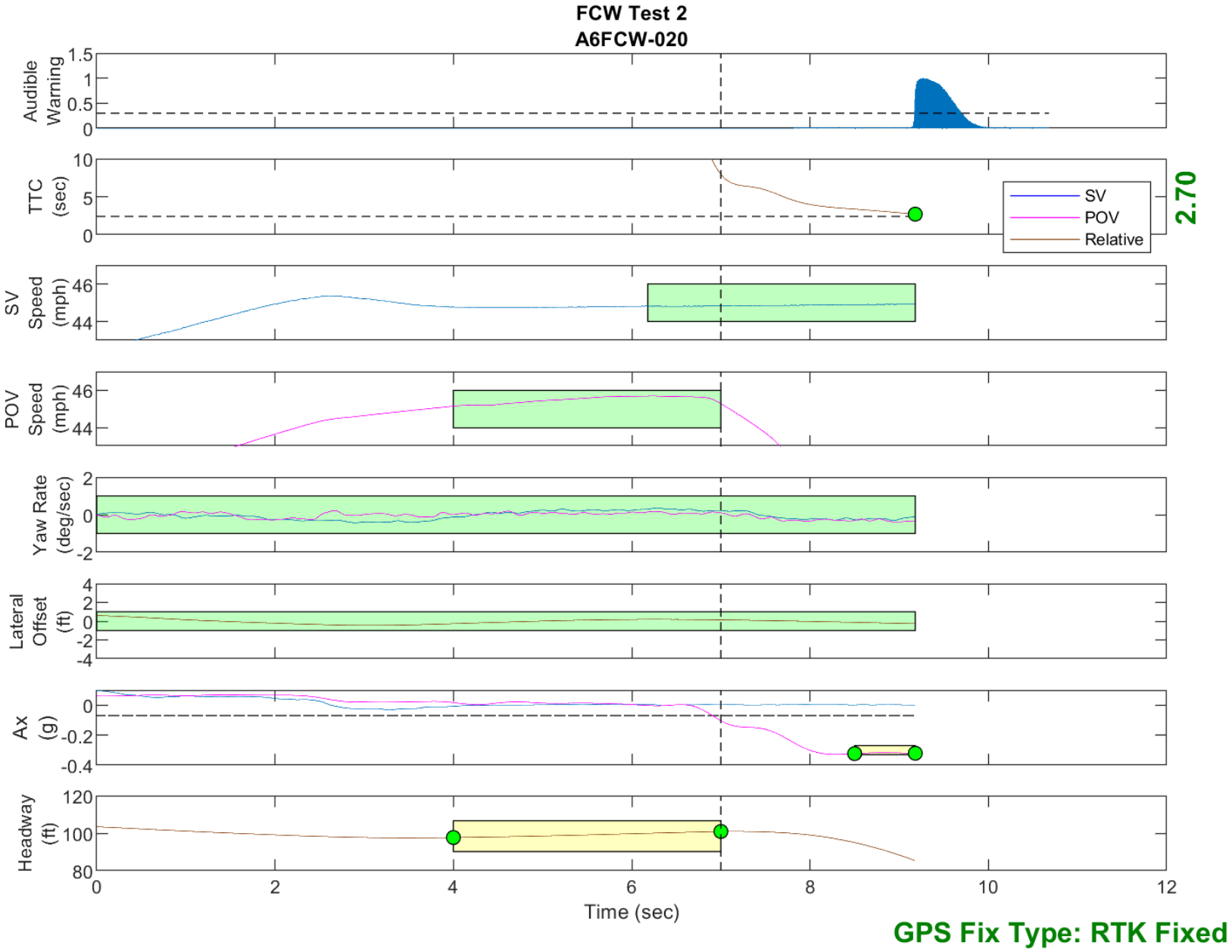

Figure D31. Time History for Run 20, FCW Test 2, Audible Warning

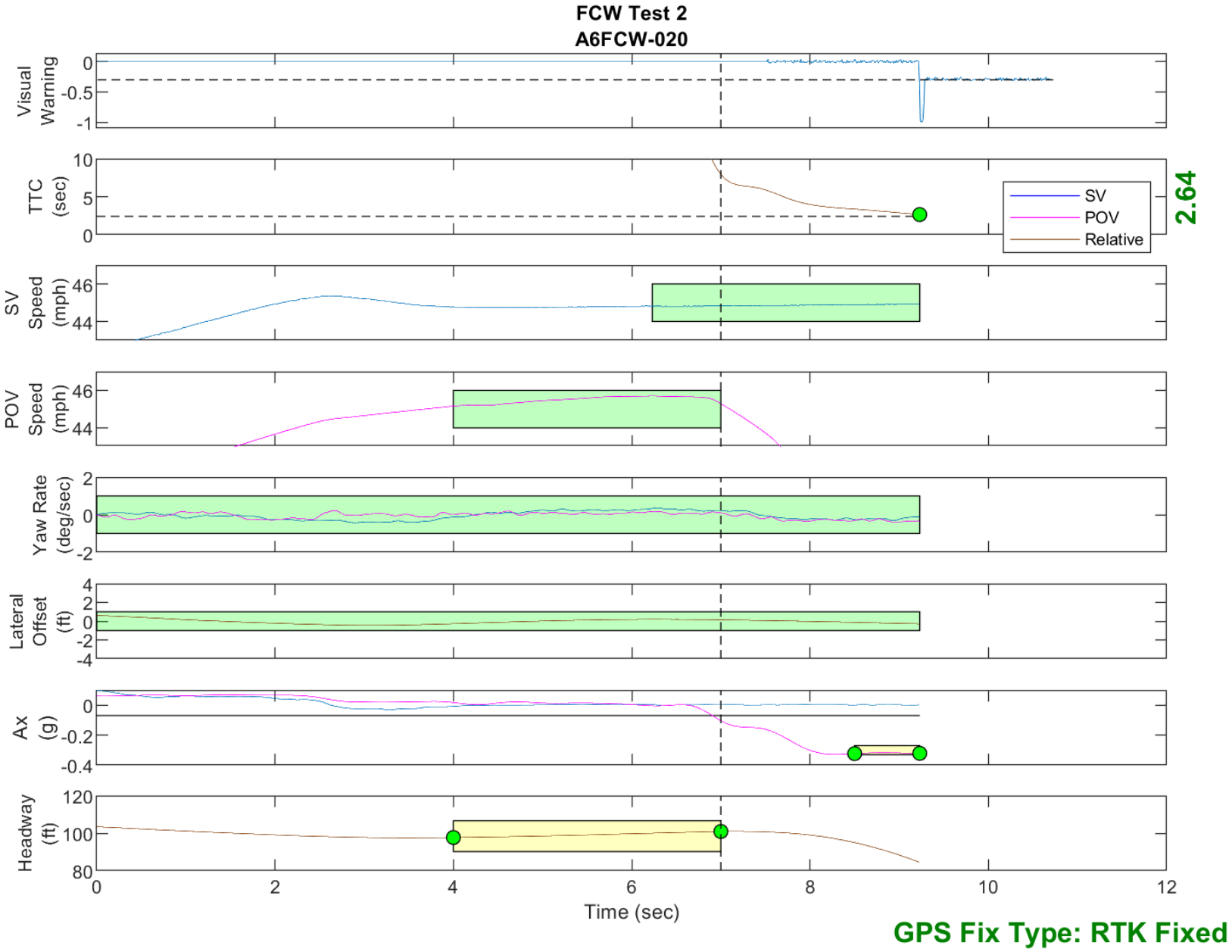

Figure D32. Time History for Run 20, FCW Test 2, Visual Warning

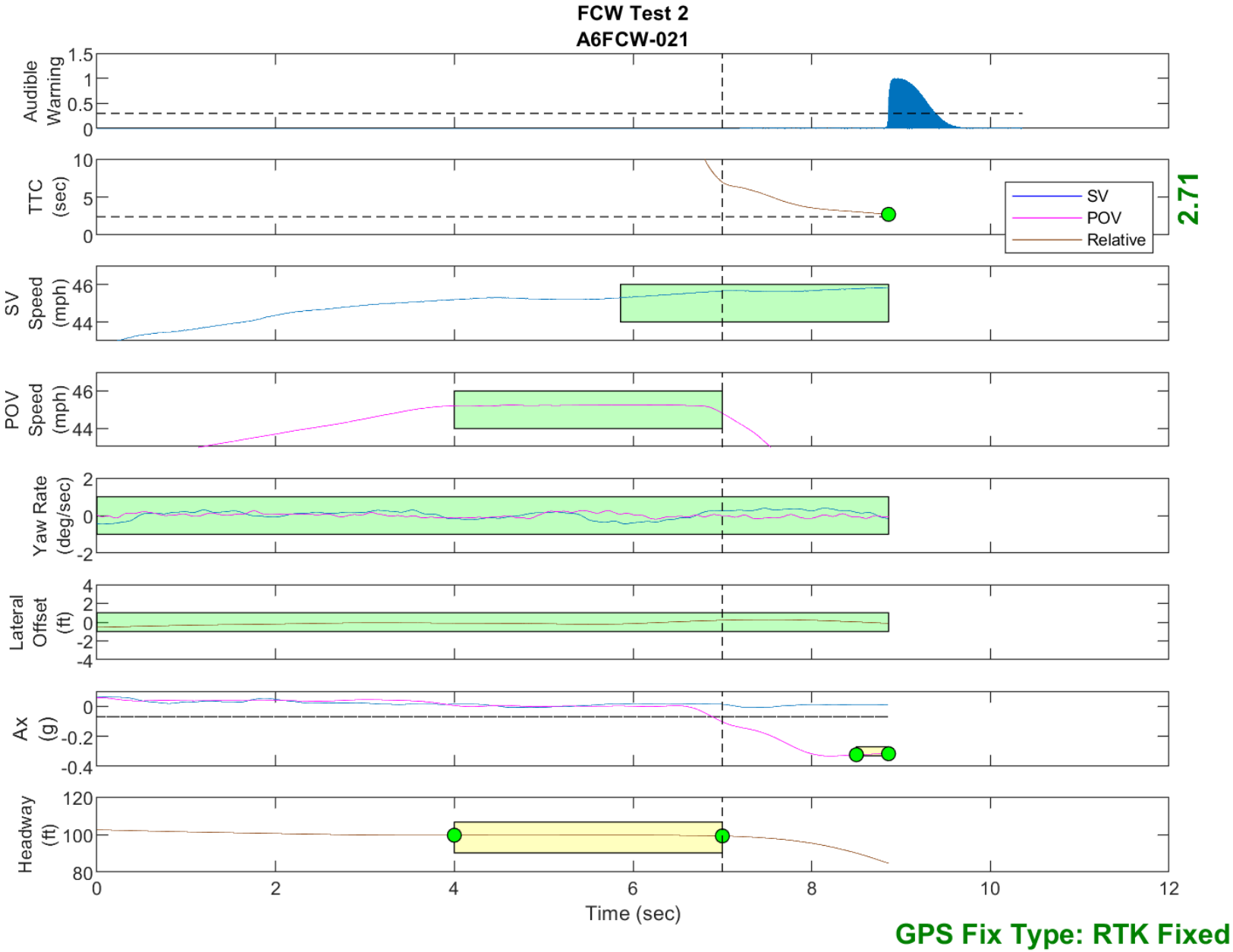

Figure D33. Time History for Run 21, FCW Test 2, Audible Warning

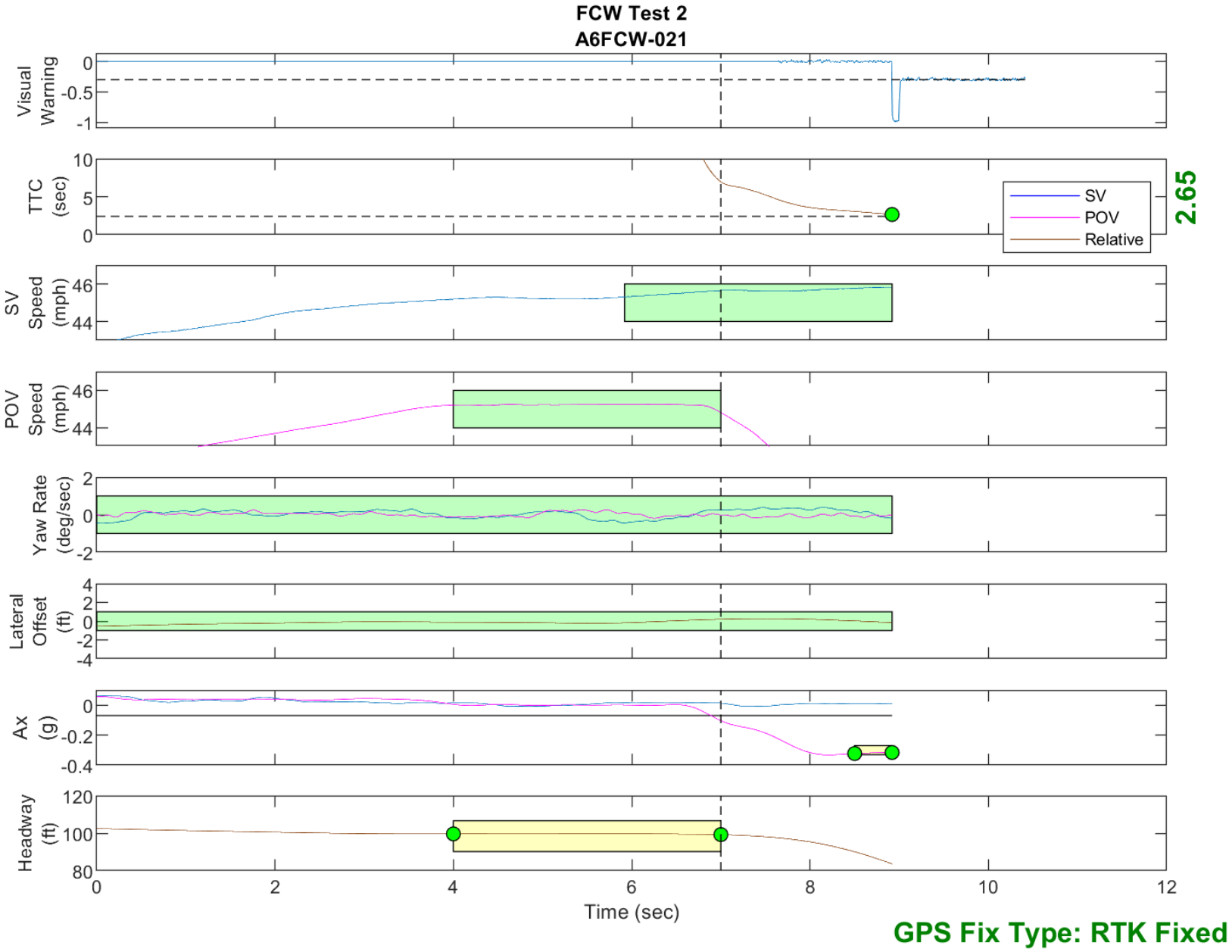

Figure D34. Time History for Run 21, FCW Test 2, Visual Warning

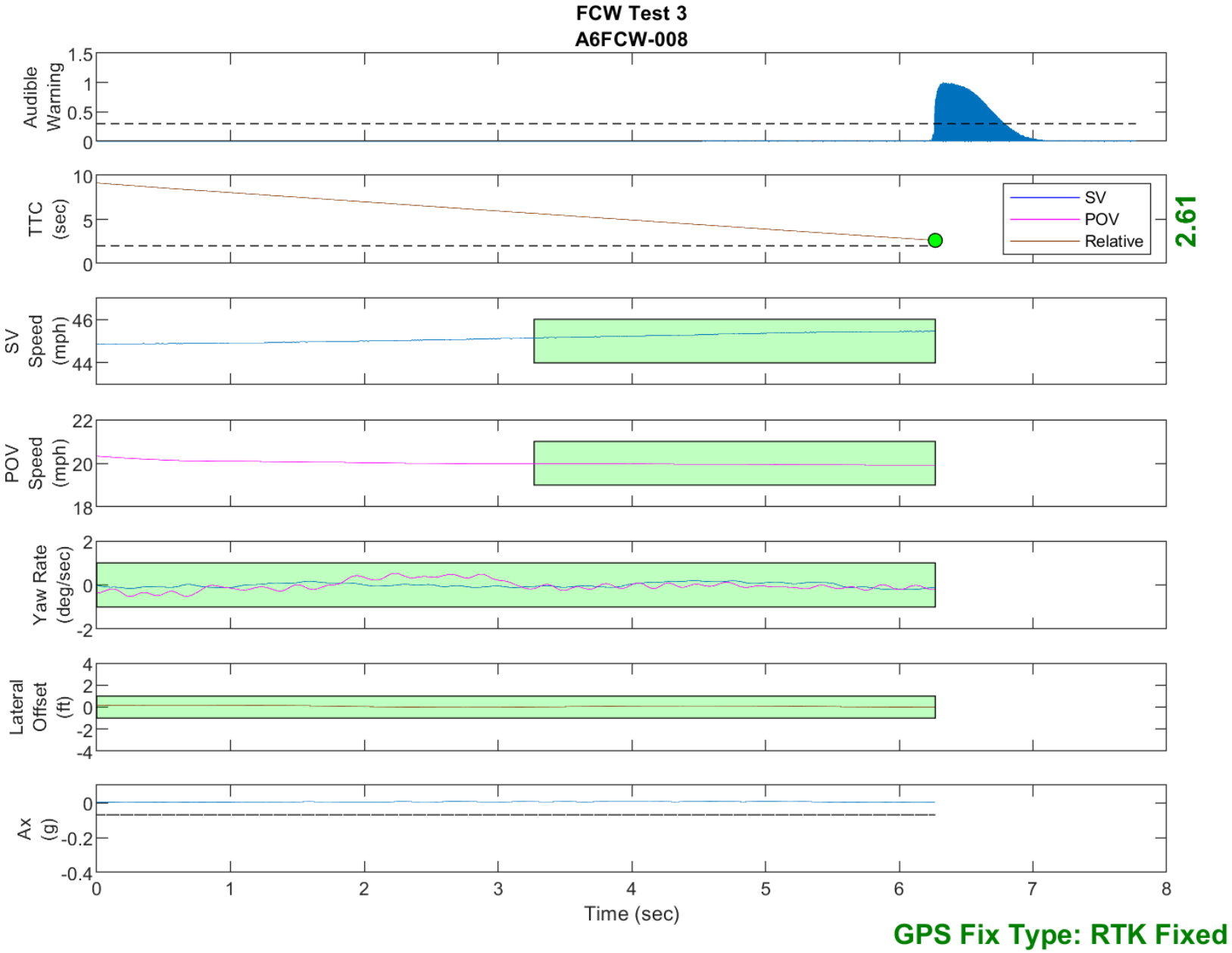

Figure D35. Time History for Run 8, FCW Test 3, Audible Warning

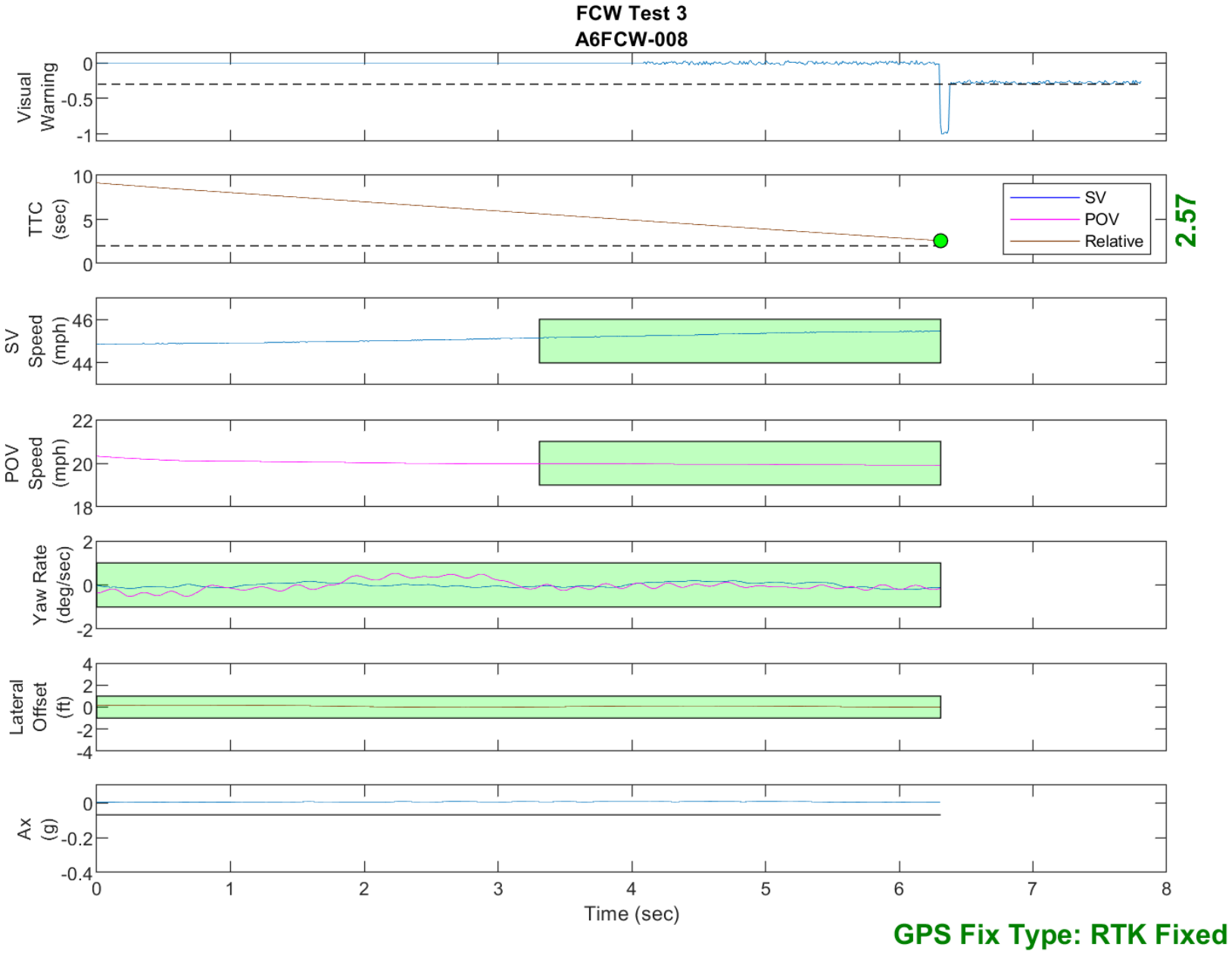

Figure D36. Time History for Run 8, FCW Test 3, Visual Warning

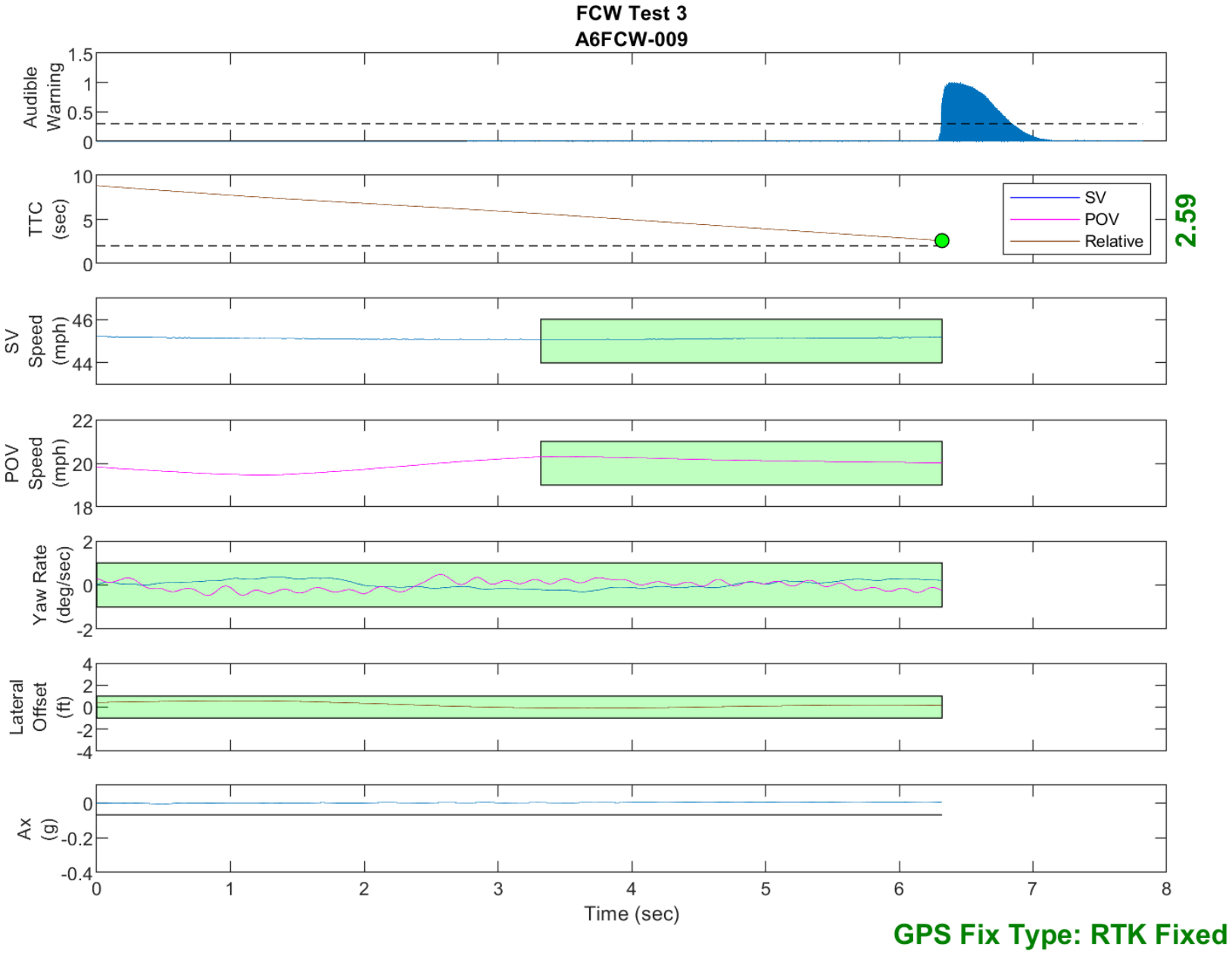

Figure D37. Time History for Run 9, FCW Test 3, Audible Warning

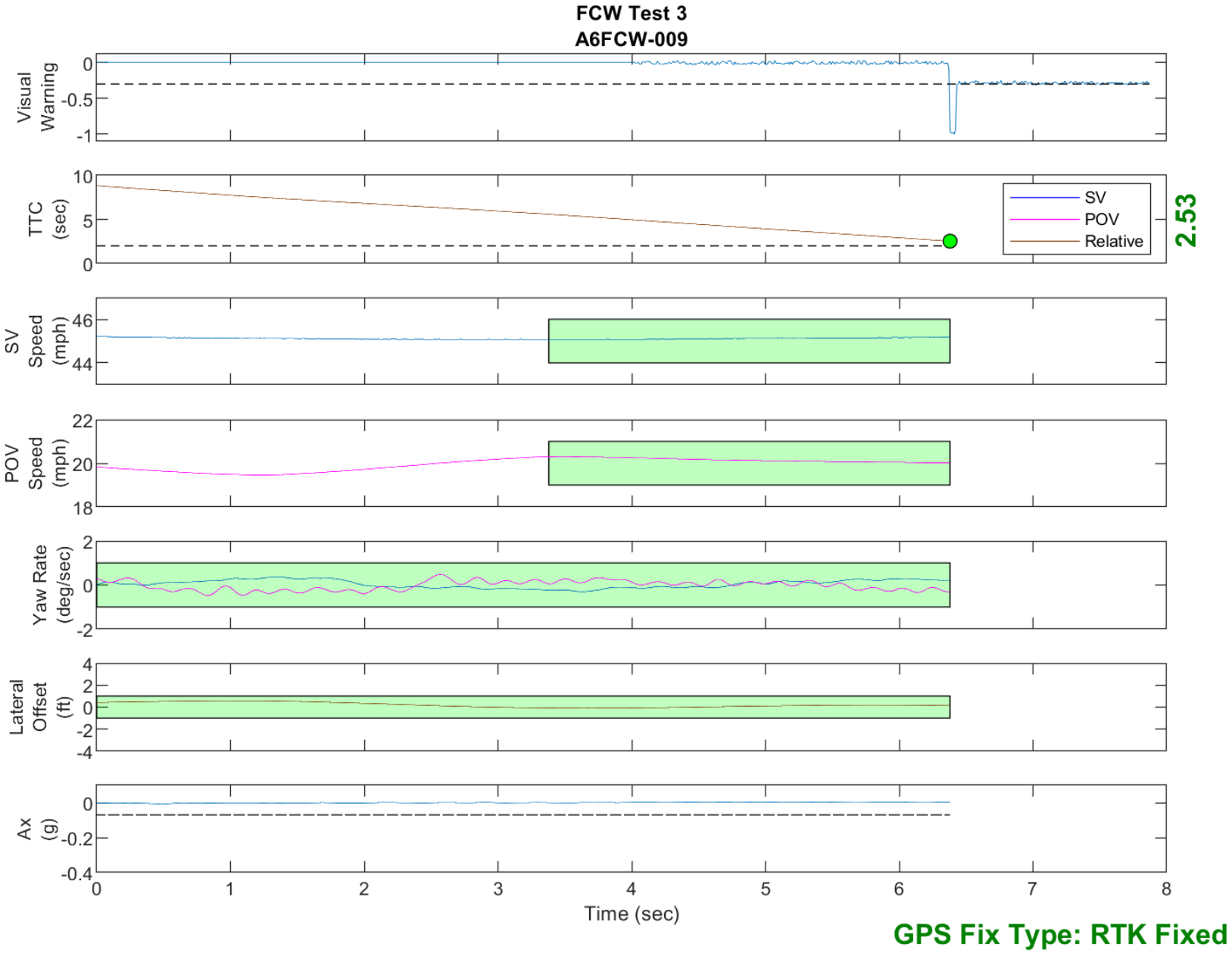

Figure D38. Time History for Run 9, FCW Test 3, Visual Warning

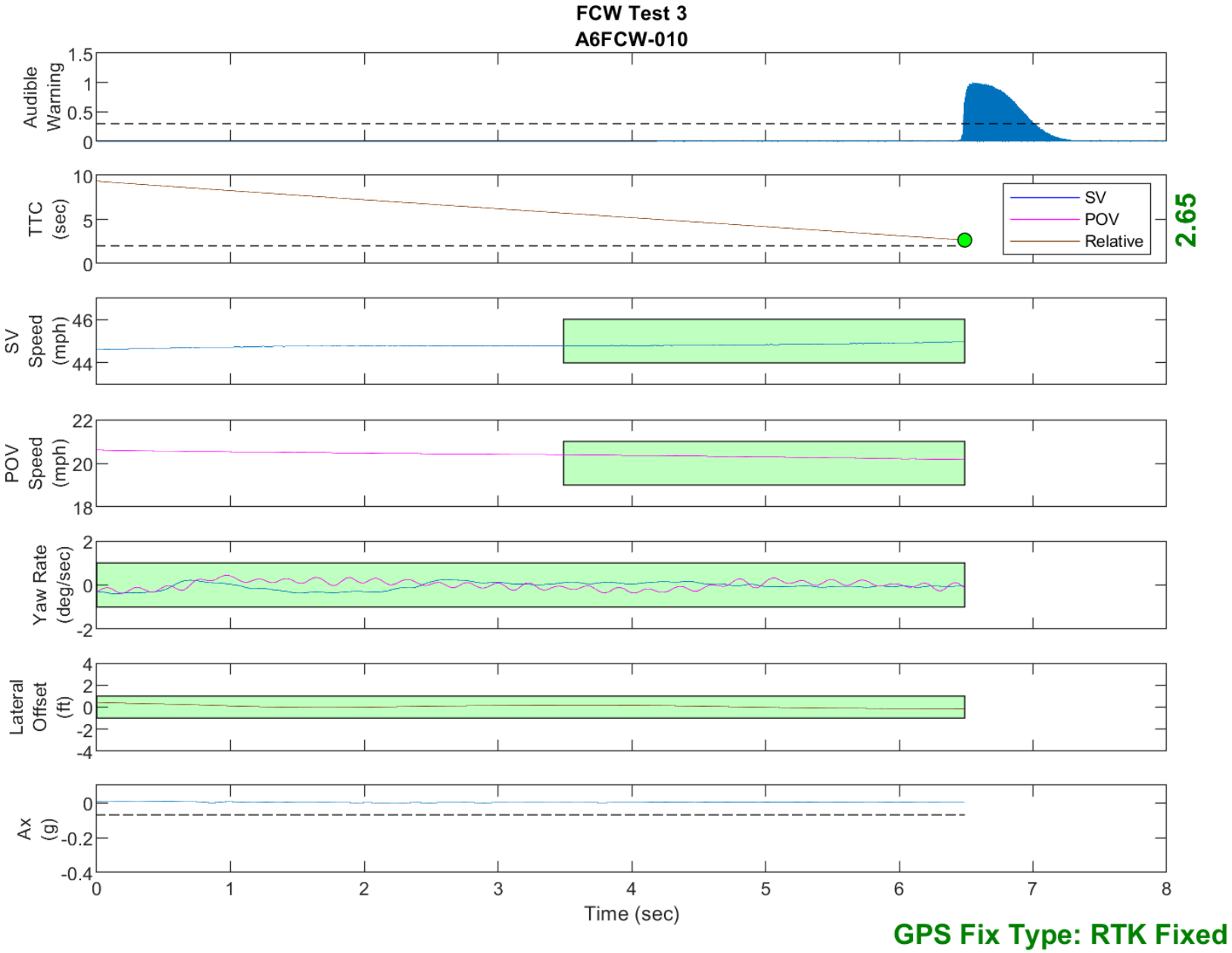

Figure D39. Time History for Run 10, FCW Test 3, Audible Warning

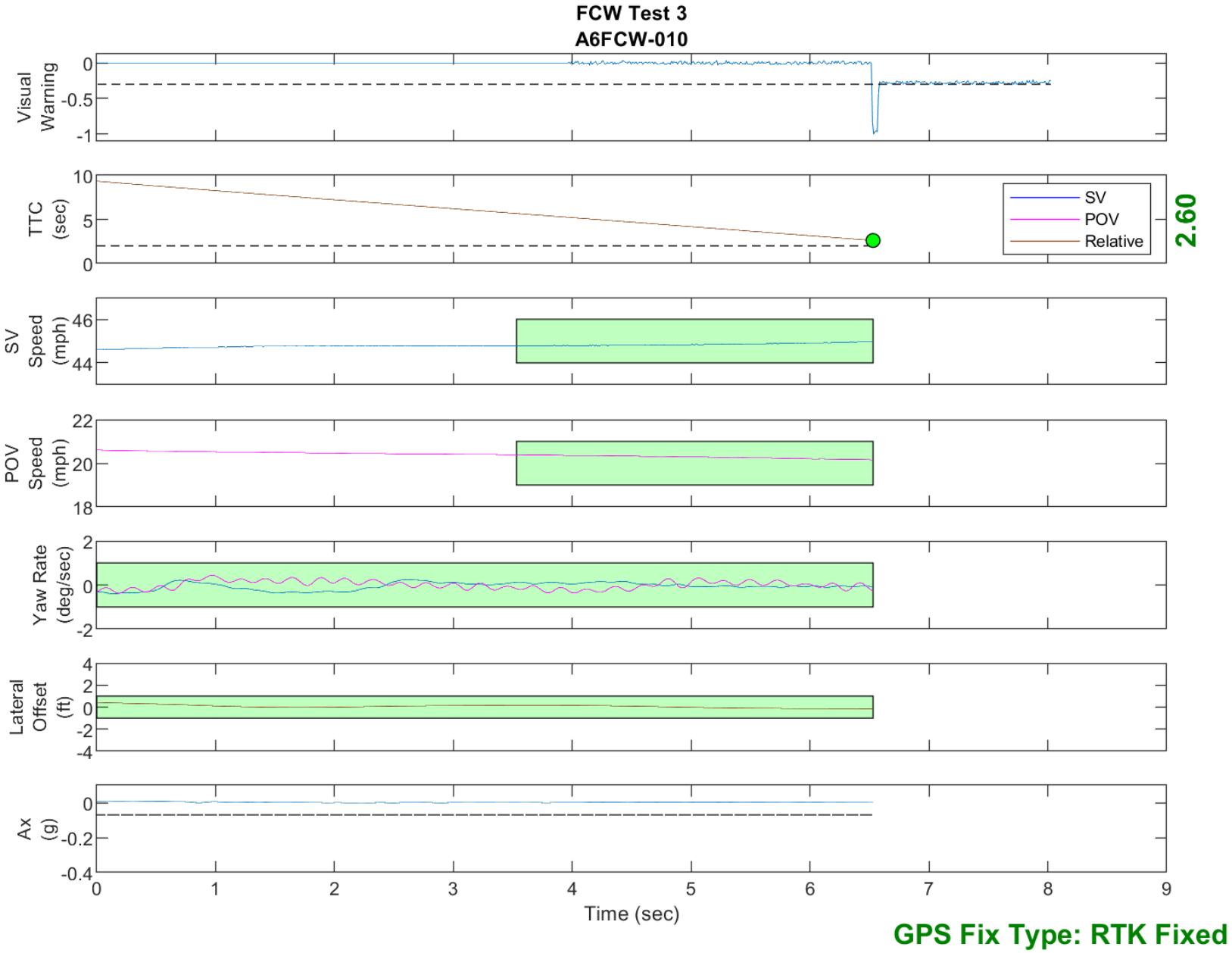

Figure D40. Time History for Run 10, FCW Test 3, Visual Warning

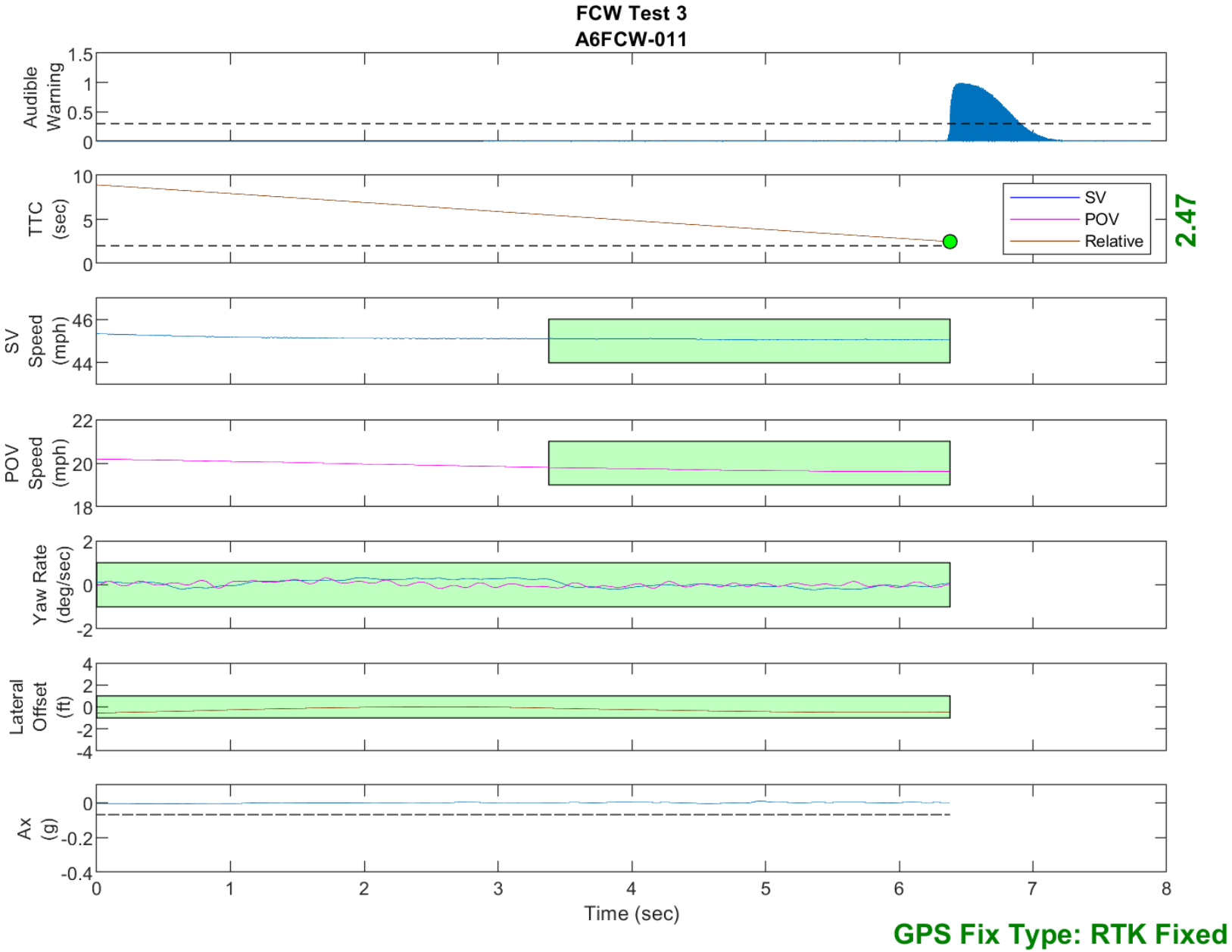

Figure D41. Time History for Run 11, FCW Test 3, Audible Warning

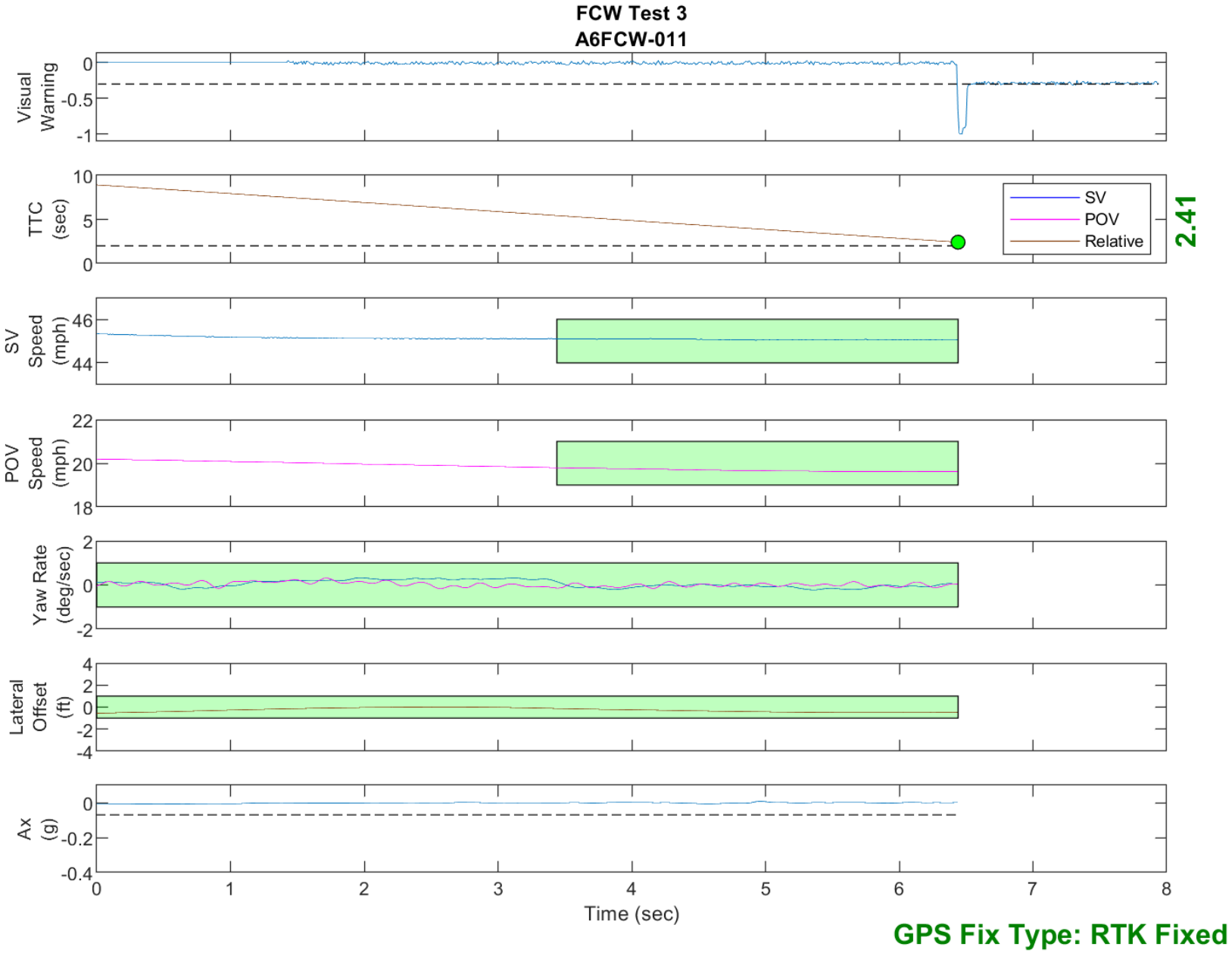

Figure D42. Time History for Run 11, FCW Test 3, Visual Warning

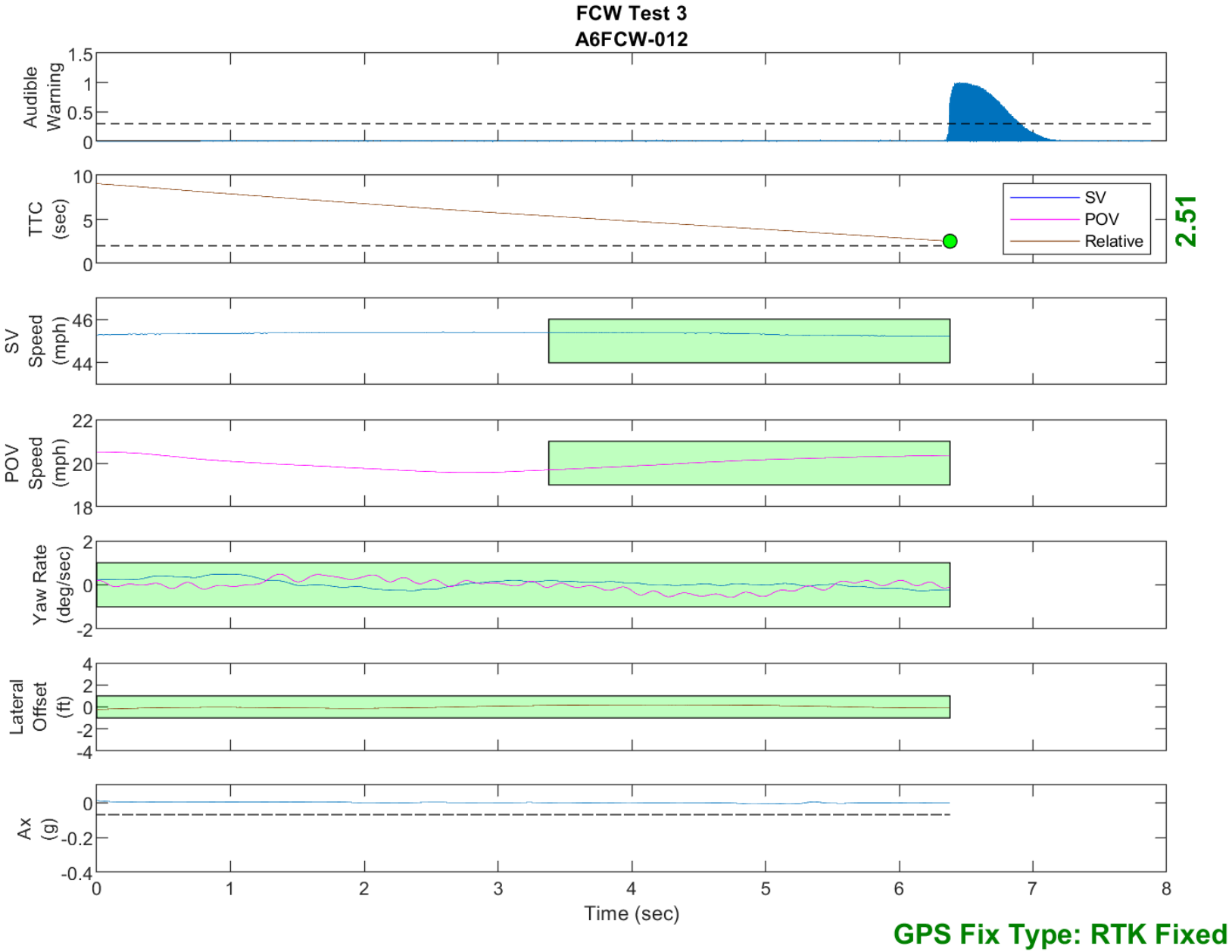

Figure D43. Time History for Run 12, FCW Test 3, Audible Warning

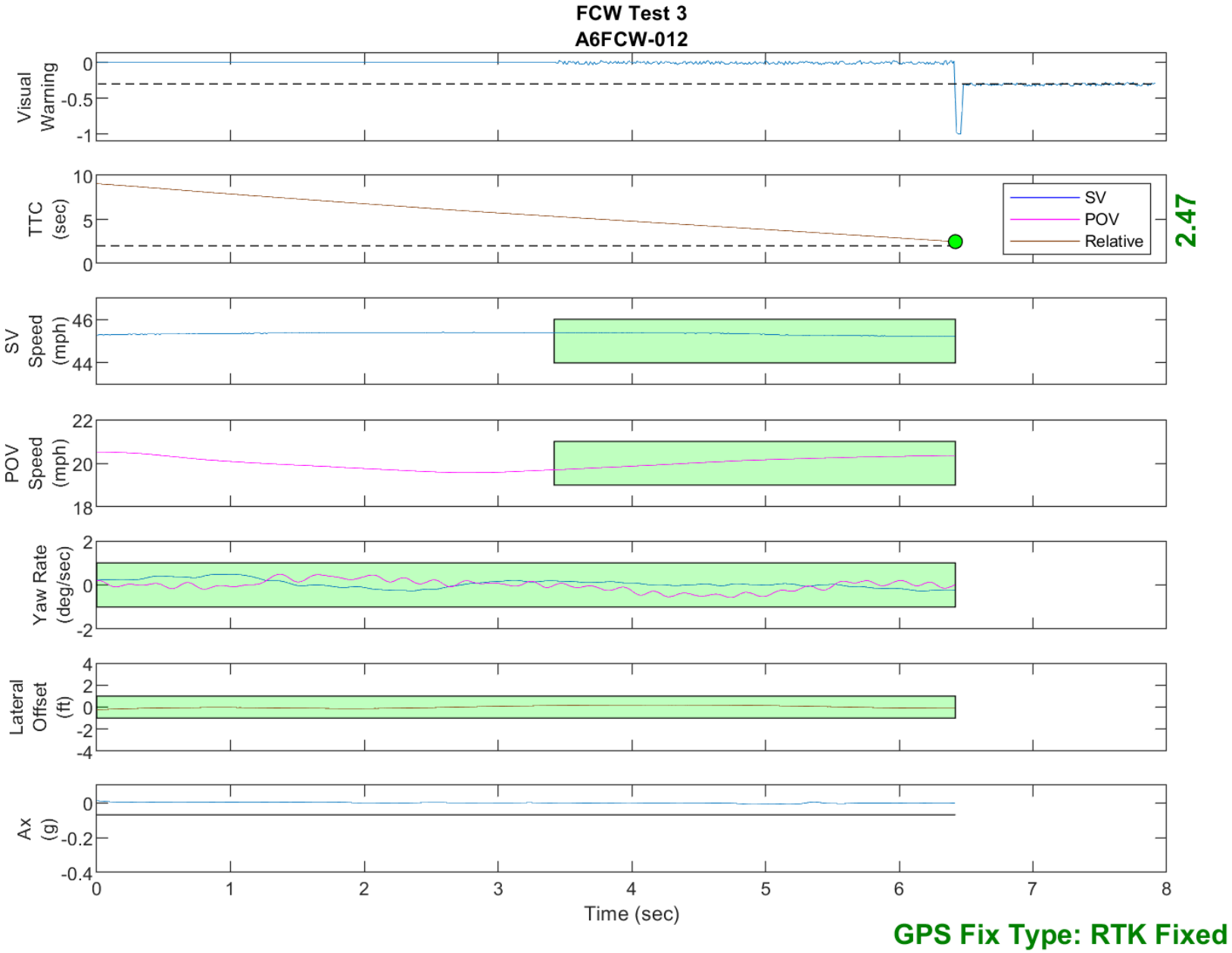

Figure D44. Time History for Run 12, FCW Test 3, Visual Warning

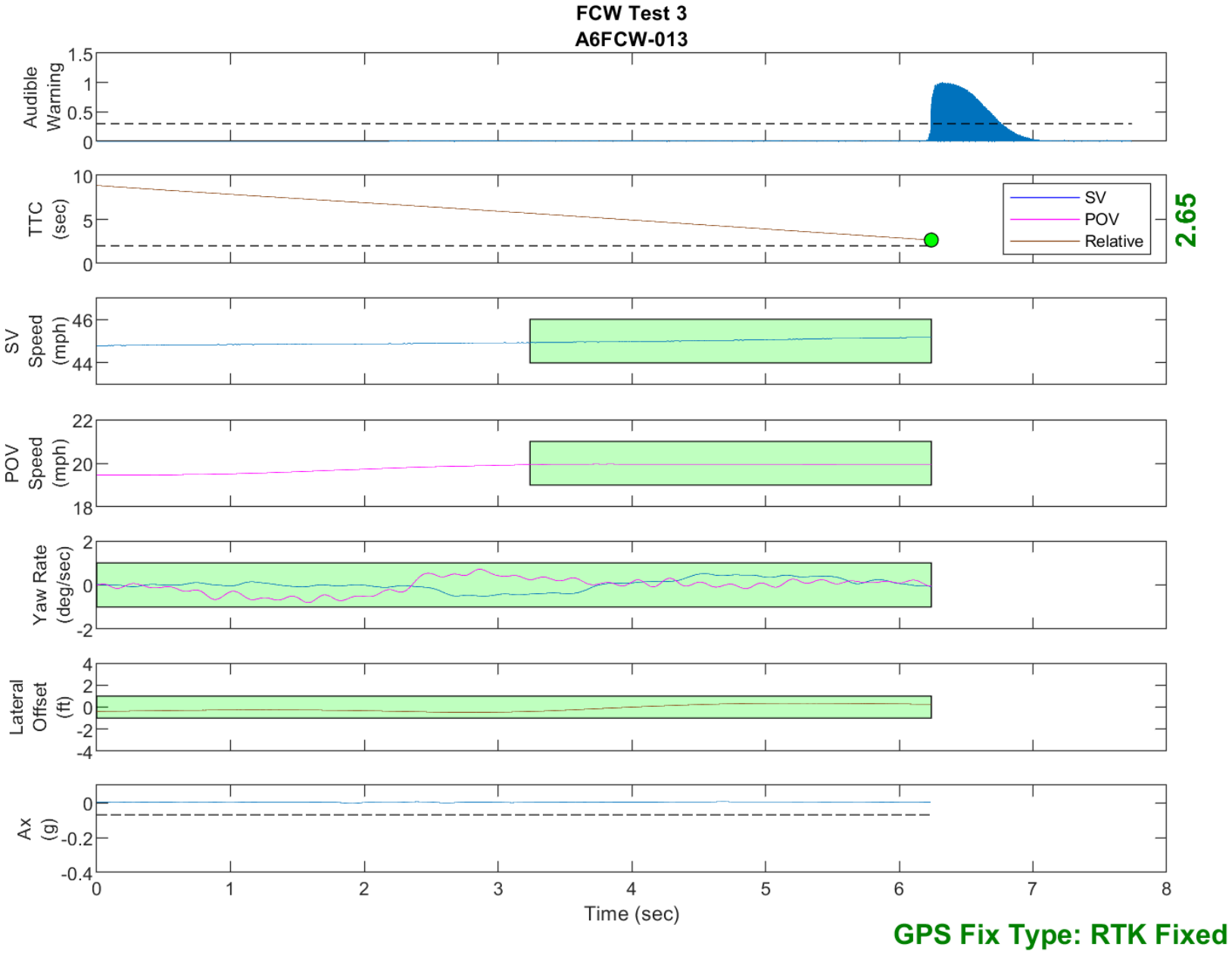

Figure D45. Time History for Run 13, FCW Test 3, Audible Warning

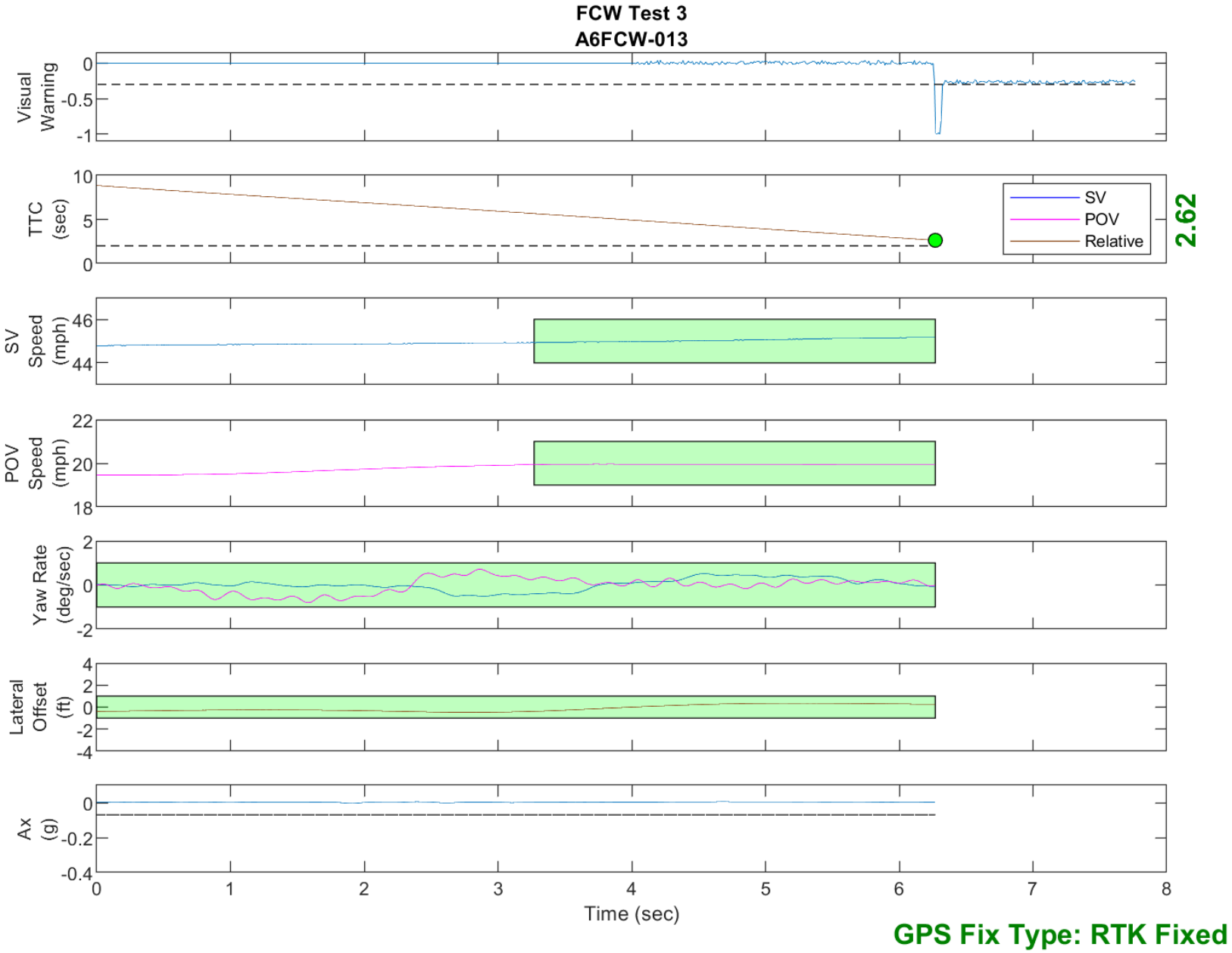

Figure D46. Time History for Run 13, FCW Test 3, Visual Warning

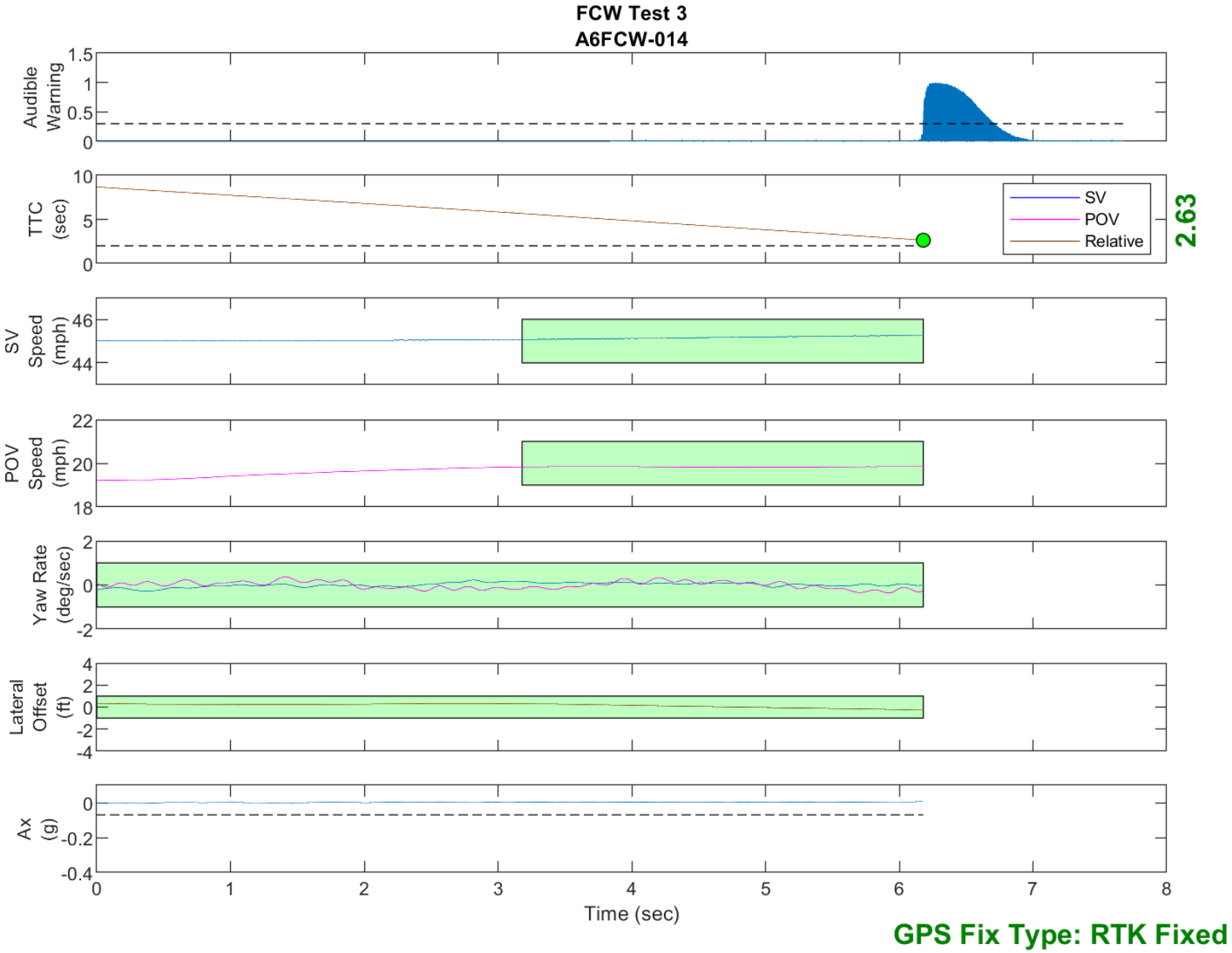

Figure D47. Time History for Run 14, FCW Test 3, Audible Warning

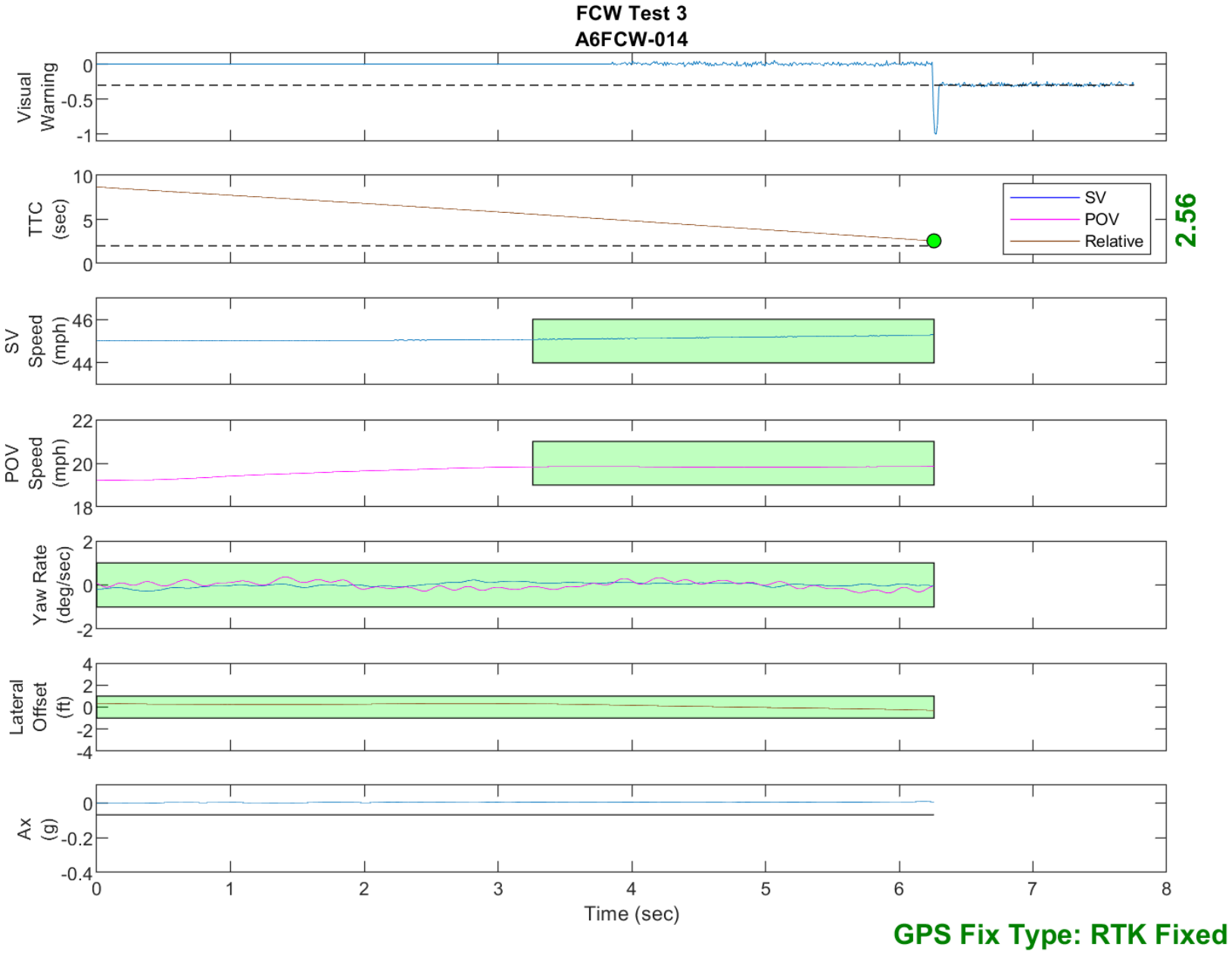

Figure D48. Time History for Run 14, FCW Test 3, Visual Warning