NEW CAR ASSESSMENT PROGRAM
FORWARD COLLISION WARNING CONFIRMATION TEST
NCAP-DRI-FCW-20-14

2020 Mazda CX-30

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

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

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

Prepared By: J. Lenkeit and N. Watanabe

Program Manager Test Engineer

Date: 27 April 2020

1. Report No. NCAP-DRI-FCW-20-14	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Final Report of Forward Collision Warning Confirmation Test of a 2020 Mazda CX-30.		5. Report Date 27 April 2020	
		6. Performing Organization Code DRI	
7. Author(s) J. Lenkeit, Program Manager N. Watanabe, Test Engineer		8. Performing Organization Report No. DRI-TM-19-182	
9. Performing Organization Name and Address Dynamic Research, Inc. 355 Van Ness Ave, STE 200 Torrance, CA 90501		10. Work Unit No.	
		11. Contract or Grant No. DTNH22-14-D-00333	
12. Sponsoring Agency Name and Address 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, D.C. 20590		13. Type of Report and Period Covered Final Test Report January – April 2020	
		14. Sponsoring Agency Code NRM-110	
15. Supplementary Notes			
16. Abstract These tests were conducted on the subject 2020 Mazda CX-30 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.			
17. Key Words Forward Collision Warning, FCW, New Car Assessment Program, NCAP		18. Distribution Statement Copies of this report are available from the following: NHTSA Technical Reference Division National Highway Traffic Safety Administration 1200 New Jersey Avenue, SE Washington, D.C. 20590	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 103	22. Price

TABLE OF CONTENTS

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

(Page 1 of 1)

2020 Mazda CX-30

VIN: *3MVDMABL6LM1xxxx*

Test Date: *1/22/2020*

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 Mazda CX-30

TEST VEHICLE INFORMATION

VIN: *3MVDMABL6LM1xxxx*

Body Style: *SUV* Color: *Snowflake White Pearl MC*

Date Received: *1/13/2020* Odometer Reading: *31 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *MAZDA MOTOR MANUFACTURING DE MEXICO S.A. DE C.V.*

Date of manufacture: *10/19*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *215/65R16*

Rear: *215/65R16*

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

Rear: *250 kPa (36 psi)*

TIRES

Tire manufacturer and model: *Bridgestone Turanza*

Front tire size: *215/65R16*

Rear tire size: *215/65R16*

Front tire DOT prefix: *1V6 6VJBV11*

Rear tire DOT prefix: *1V6 6VJBV11*

FORWARD COLLISION WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2020 Mazda CX-30

GENERAL INFORMATION

Test date: *1/22/2020*

AMBIENT CONDITIONS

Air temperature: *16.7 C (62 F)*

Wind speed: *1.3 m/s (2.9 mph)*

X Wind speed ≤ 10 m/s (22 mph).

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

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

VEHICLE PREPARATION

Verify the following:

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

Fuel tank is full: **X**

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

Front: *250 kPa (36 psi)*

Rear: *250 kPa (36 psi)*

FORWARD COLLISION WARNING

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2020 Mazda CX-30

WEIGHT

Weight of vehicle as tested including driver and instrumentation:

Left Front:	*474.5 kg (1046 lb)*	Right Front:	*455.0 kg (1003 lb)*
Left Rear:	*318.9 kg (703 lb)*	Right Rear:	*291.7 kg (643 lb)*
		Total:	*1540.1 kg (3395 lb)*

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 1 of 3)

2020 Mazda CX-30

Name of the FCW option, option package, etc.: *Smart Brake Support (SBS)*

Forward Collision Warning Setting used in test: *Early*

Type and location of sensors the system uses:

Radar and mono camera

The Forward Sensing Camera (FSC) is installed at the top of the windshield near the rearview mirror.

The front radar sensor is mounted behind the radiator grille.

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

- **X** Warning light
- **X** Buzzer or audible 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, audible, vibration, or combination), etc.

Visual warning: Symbol & Word, Red color, Flashes on/off. See Figure A15 in Appendix A.
Audial warning: Repeated Beep, High Pitch. Tone is centered at 1966 Hz pulsed 7 times/second.

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.

A multi-function control located just behind the shift lever (Figure A14) is used to access the vehicle settings.

The hierarchy for setting the SBS (FCW) system on or off is:

Settings

Safety Settings

Collision Avoidance

Smart Brake Support - checkbox to enable or disable

When the SBS is canceled, the SBS OFF indicator light turns on. The system resets to on when the ignition is cycled.

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

____ Yes

X No

If yes, please provide a full description.

A multi-function control located just behind the shift lever (Figure A14) is used to access the vehicle settings.

The hierarchy for setting the SBS (FCW) system sensitivity is:

Settings

Safety Settings

Collision Avoidance

Smart Brake Support

Alert Timing select Early, Normal, or Late

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 3 of 3)

2020 Mazda CX-30

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.

Limitations of the system are detailed in Owner's Manual, Pages 4-150 and 4-151 shown in Appendix B, Pages B-4 and B-5.

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.

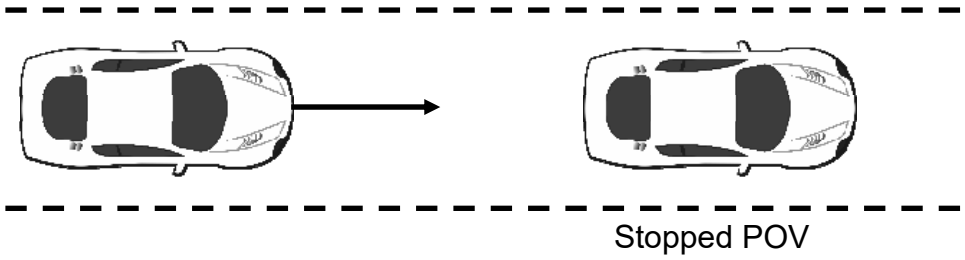


Figure 1. Depiction of Test 1

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.

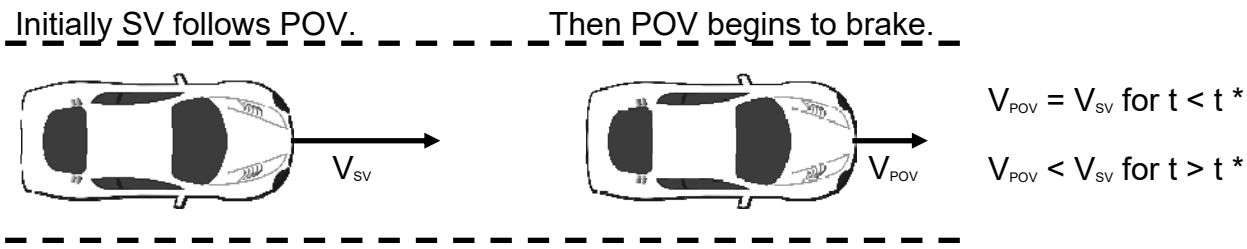


Figure 2. Depiction of Test 2

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:

- 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

[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).

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).

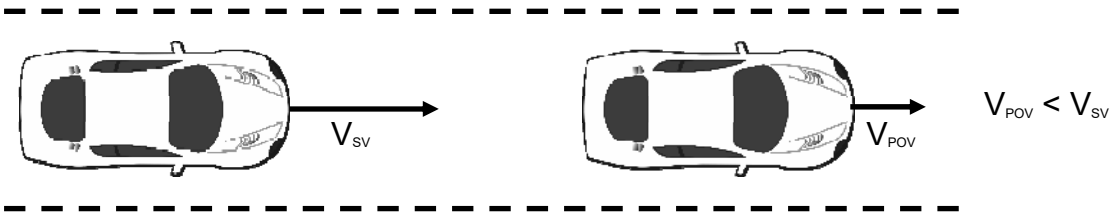


Figure 3. Depiction of Test 3

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

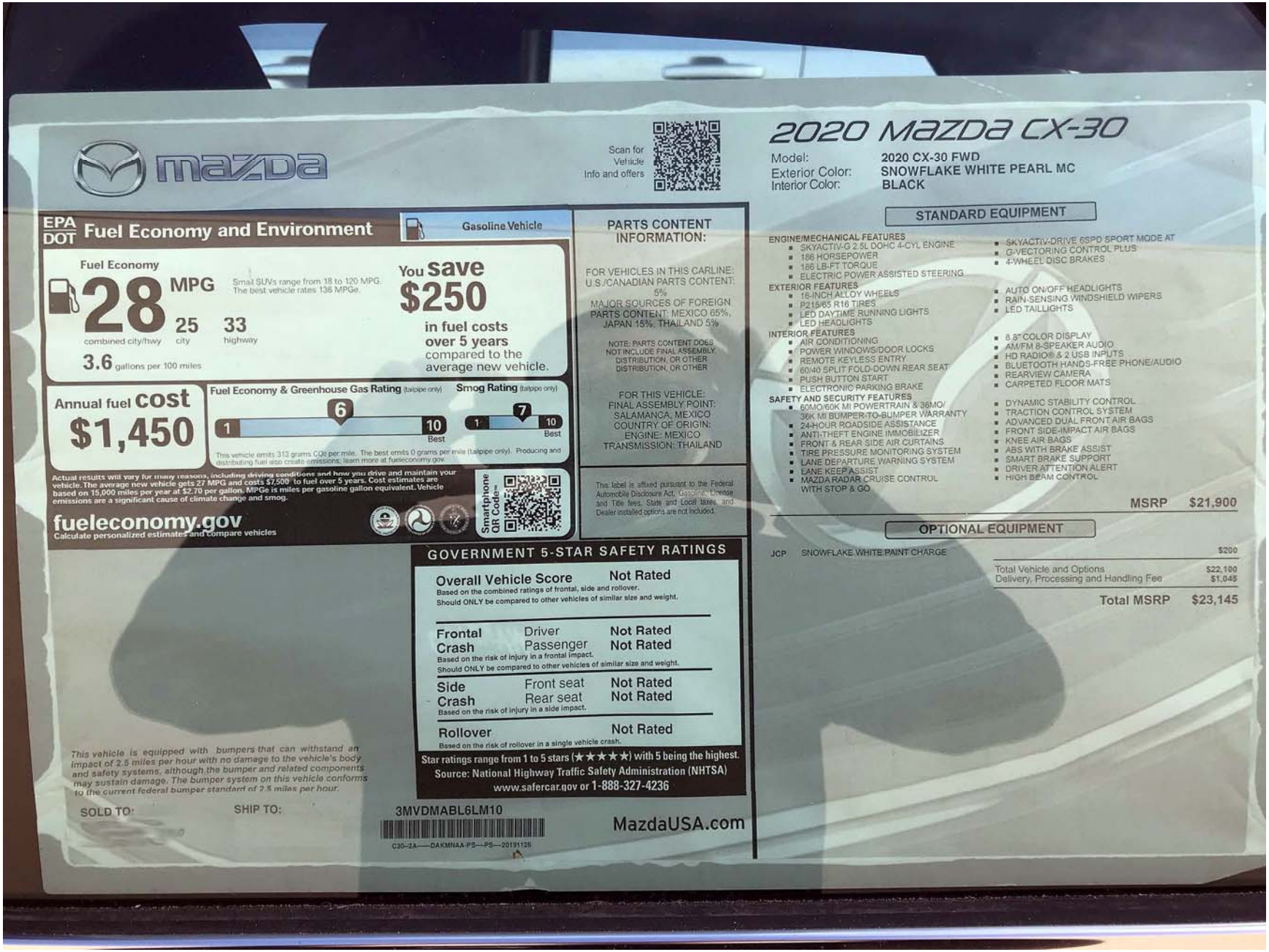


Figure A3. Window Sticker (Monroney Label)

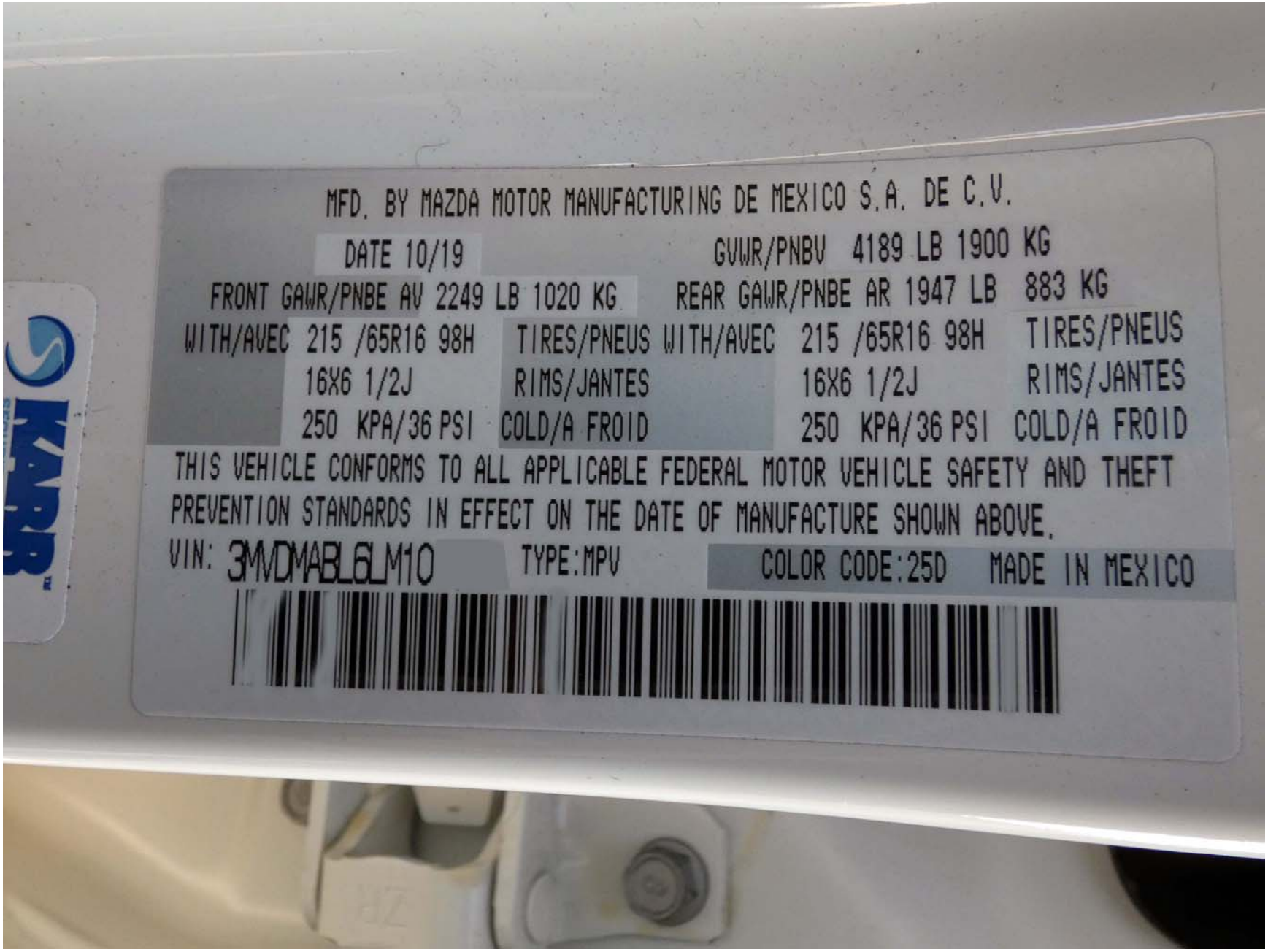


Figure A4. Vehicle Certification Label

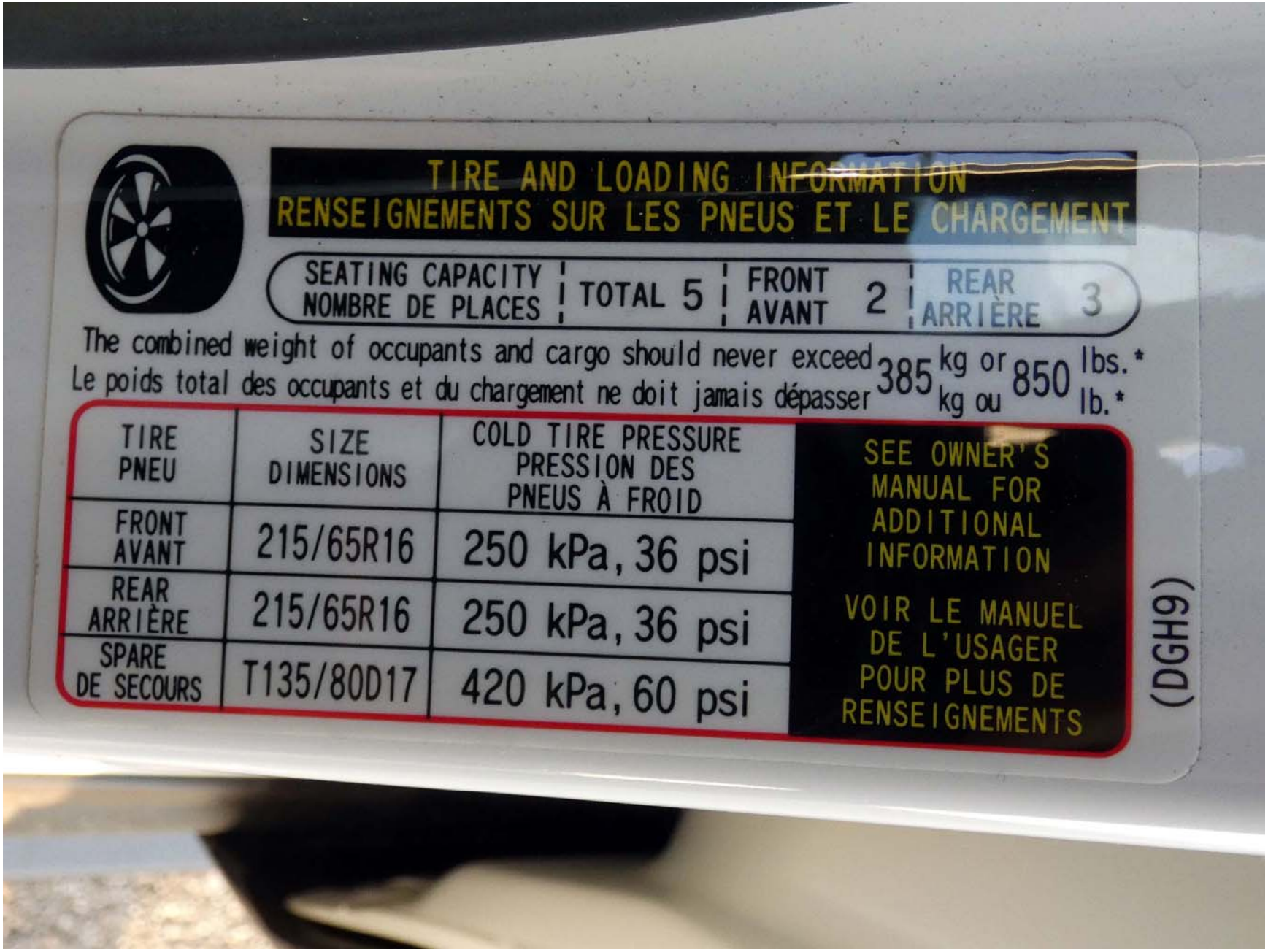


Figure A5. Tire Placard

Figure A6. Front View of Principal Other Vehicle

Figure A7. Rear View of Principal Other Vehicle

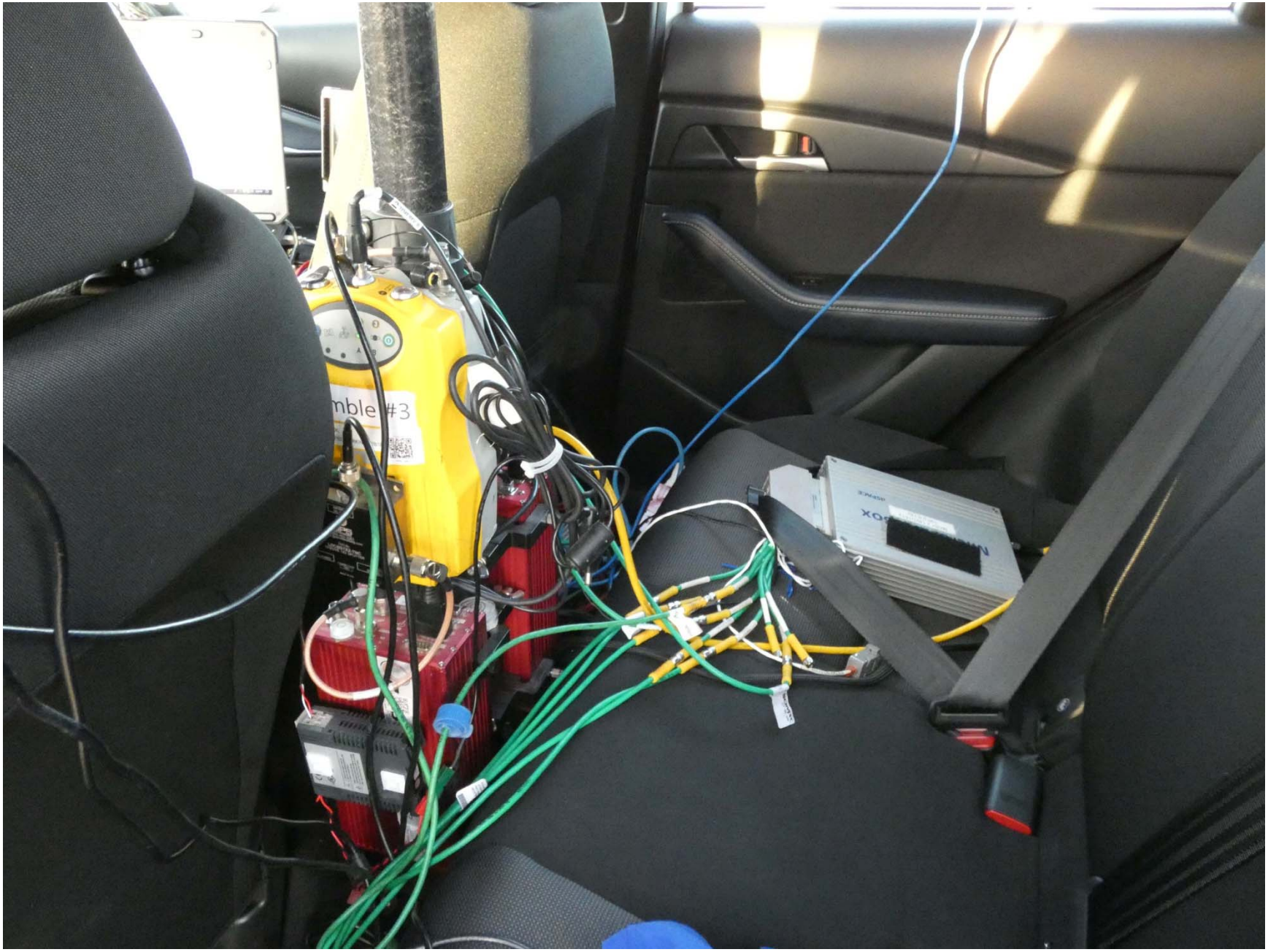


Figure A8. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

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

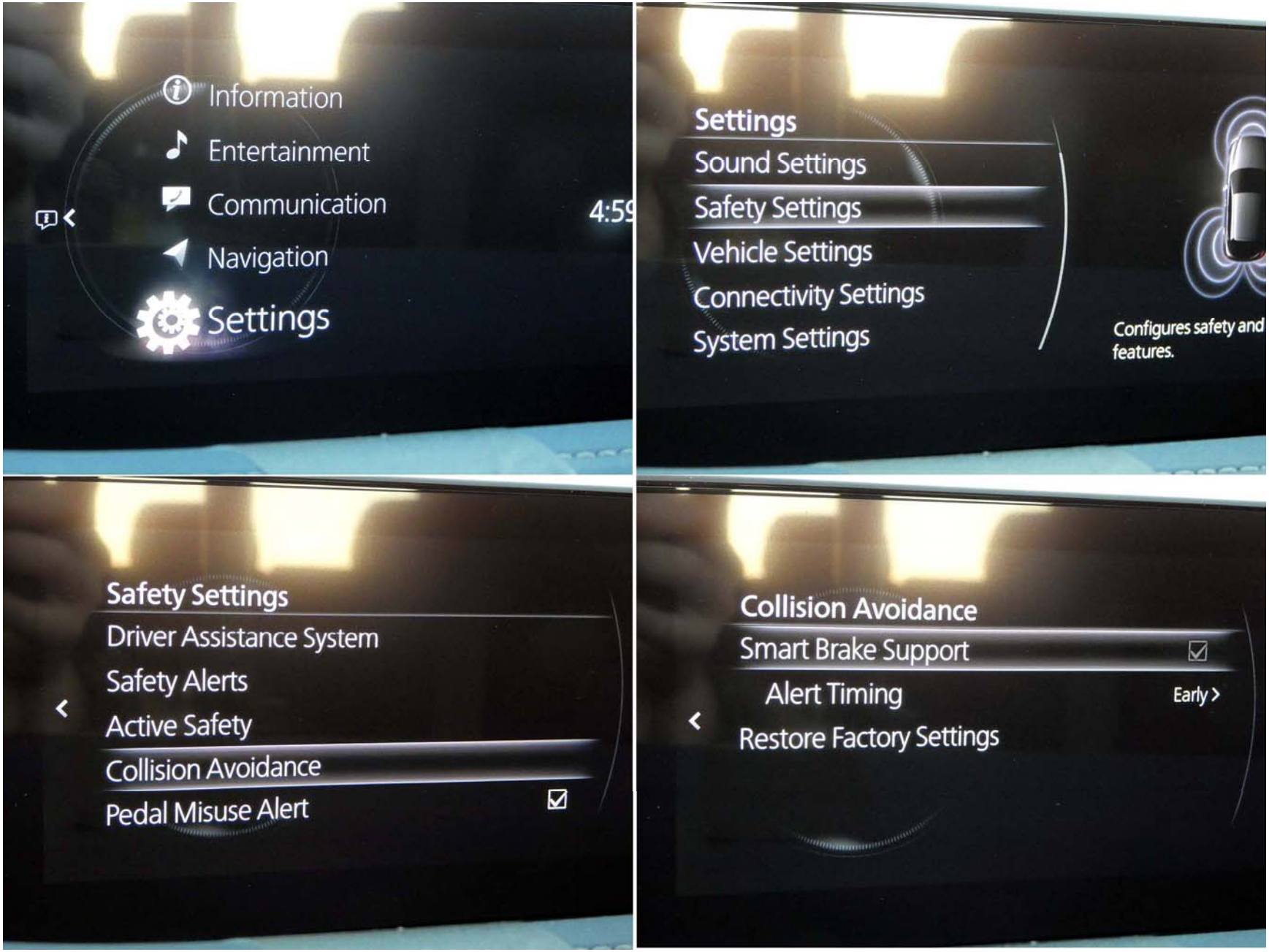


Figure A13. FCW System Setting Menus

Figure A14. Controls for Adjusting Settings

Figure A15. FCW Visual Alert

APPENDIX B

Excerpts from Owner’s Manual

Reverse driving

Smart Brake Support [Rear] (SBS-R).....page 4-152
Smart Brake Support [Rear Crossing] (SBS-RC)..... page 4-155

▼ Camera and Sensors

Forward Sensing Camera (FSC)

The Forward Sensing Camera (FSC) detects lane indications and recognizes headlights, taillights and city lights during nighttime driving. In addition, it also detects the vehicle ahead, pedestrians, or obstructions. The following systems use the Forward Sensing Camera (FSC).

- High Beam Control system (HBC)
- Lane Departure Warning System (LDWS)
- Traffic Sign Recognition System (TSR)
- Distance & Speed Alert (DSA)
- Driver Attention Alert (DAA)
- Mazda Radar Cruise Control (MRCC)
- Mazda Radar Cruise Control with Stop & Go function (MRCC with Stop & Go function)
- Lane-keep Assist System (LAS)
- Traffic Jam Assist (TJA)
- Smart Brake Support (SBS)

The Forward Sensing Camera (FSC) is installed at the top of the windshield near the rearview mirror.
Refer to Forward Sensing Camera (FSC) on page 4-190.

Front radar sensor

The front radar sensor detects radio waves reflected off a vehicle ahead sent from the radar sensor. The following systems use the front radar sensor.

- Distance & Speed Alert (DSA)
- Mazda Radar Cruise Control (MRCC)
- Mazda Radar Cruise Control with Stop & Go function (MRCC with Stop & Go function)
- Traffic Jam Assist (TJA)
- Smart Brake Support (SBS)

The front radar sensor is mounted behind the radiator grille.
Refer to Front Radar Sensor on page 4-194.

Front side radar sensor

The front side radar sensors detects radio waves reflected off a vehicle ahead sent from the radar sensor. The following systems use the front side radar sensor.

- Front Cross Traffic Alert (FCTA)

The front side radar sensors are installed inside the front bumper, one on the left side and one on the right side.
Refer to Front Side Radar Sensor on page 4-196.

Rear side radar sensor

The rear side radar sensors emit radio waves and detect the radio waves reflected off a vehicle approaching from the rear or an obstruction. The following systems use the rear side radar sensor.

- Blind Spot Monitoring (BSM)
- Rear Cross Traffic Alert (RCTA)
- Smart Brake Support [Rear Crossing] (SBS-RC)

The rear side radar sensors are installed inside the rear bumper, one on the left side and one on the right side.
Refer to Rear Side Radar Sensor on page 4-197.

Active driving display

NOTE
When the driver operates the steering wheel while the steering wheel operation assist is operating, the steering wheel operation assistance is canceled.

▼ System Canceling

The LAS can be set to inoperable.

- **(If only the LAS is turned off)**
  Refer to the Settings section in the Mazda Connect Owner's Manual.
- **(If the LAS is turned off by operating the i-ACTIVSENSE switch)**
  Refer to i-ACTIVSENSE Switch on page 4-85.

NOTE
If the ignition is switched OFF while you have canceled the system using the i-ACTIVSENSE switch, the system is automatically enabled the next time the ignition is switched ON. However, if the system is canceled using the personalization features, the system is not automatically enabled.

Smart Brake Support (SBS)*

▼ Smart Brake Support (SBS)

The SBS alerts the driver of a possible collision using the warning indications in the display and a warning sound if the front radar sensor and Forward Sensing Camera (FSC) determine that there is the possibility of a collision with a vehicle ahead, pedestrian, or a bicycle. Furthermore, if a collision is unavoidable, the automatic brake control is performed to reduce damage in the event of a collision. In addition, when the driver depresses the brake pedal, the brakes are applied firmly and quickly to assist.
(Vehicles with Driver Monitoring (DM))
When the SBS determines that the driver is not paying attention to the road using the driver monitoring camera and it determines that there is the possibility of a collision with an obstruction, the SBS activates the collision warning earlier than normal.

⚠ WARNING

Do not rely completely on the SBS:
The SBS is only designed to reduce damage in the event of a collision. The ability to detect obstructions is limited depending on the obstructions, weather conditions, or traffic conditions. Over reliance on the system leading to the accelerator pedal or brake pedal being mistakenly operated could result in an accident.

⚠ CAUTION

In the following cases, turn the system off to prevent an unexpected operation.

- The vehicle is being towed or when towing another vehicle.
- The vehicle is on a chassis roller.
- When driving on rough roads such as in areas of dense grass or off-road.
  See the next page on how to turn off the system.
  Refer to Stopping the Smart Brake Support (SBS) System Operation on page 4-151.

Operation conditions

The SBS operates when all of the following conditions are met.

- The ignition is switched ON.
- The SBS is on.
- The i-ACTIVSENSE warning indication/warning light is not turned on.
- **(Object is vehicle ahead)**
  The vehicle speed is about 4 km/h (2 mph) or higher.
- **(Object is a pedestrian or bicycle)**
  The vehicle speed is between about 10 to 80 km/h (6.2 to 50 mph).
- The DSC does not operate.

NOTE

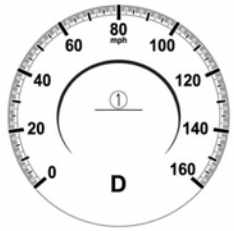
- Under the following conditions, the SBS may not operate.
  - If there is the possibility of hitting only a part of a vehicle or obstruction ahead.
  - You are driving your vehicle at the same speed as the vehicle ahead.
  - When the driver deliberately performs driving operations (accelerator operation, steering wheel operation).
  - The accelerator pedal is depressed abruptly.
  - The brake pedal is being depressed.
  - The steering wheel is being operated.
  - The selector lever is being shifted.
  - The turn signal lever is being operated.
  - When warnings and messages, such as a dirty windshield, related to the Forward Sensing Camera (FSC) or front radar sensor are being displayed on the multi-information display.
- The SBS may operate under the following conditions.
  - There is an object in the road at the entrance to a curve (including guardrails and snow banks).
  - Passing an approaching vehicle while rounding a curve.
  - When crossing a narrow bridge, and passing through low gates, narrow gates, car washing machines, or tunnels.
  - When passing through a toll gate.
  - When entering an underground parking area.
  - There is a metal object, bump, or a protruding object on the road.
  - If you suddenly come close to a vehicle ahead.
  - There is an animal, wall, or tree.
- Notifies the driver with a warning indication on the multi-information display and the active driving display (vehicles with active driving display) while the system is operating.

- If a malfunction is detected or the system temporarily stops the function due to dirty sensors (such as radar sensor or Forward Sensing Camera (FSC)), the i-ACTIVSENSE warning indication/warning light turns on and a message is displayed on the multi-information display.
- On a manual transmission vehicle, the engine stops if the clutch pedal is not depressed when the vehicle is stopped by the SBS brake operation.
- If the vehicle is stopped by the SBS brake operation and the brake pedal is not depressed, the SBS brake is automatically released after about 2 seconds.

▼ Collision Warning

When there is a possibility of a collision with a vehicle ahead, the collision warning sound is activated continuously and a warning is displayed on the multi-information display and the active driving display.

Multi-information display



1. "BRAKE!" message is displayed

Active driving display

1. "BRAKE!" message is displayed

NOTE

- The collision warning sound is activated intermittently while the SBS brake or brake assist (SBS brake assist) is operating.
- The operation distance and volume of the collision warning can be changed.
  Refer to the Settings section in the Mazda Connect Owner's Manual.

▼ Stopping the Smart Brake Support (SBS) System Operation

The SBS can be changed to inoperable. Refer to the Settings section in the Mazda Connect Owner's Manual. When the SBS is canceled, the SBS OFF indicator light turns on.

NOTE

When the ignition is switched OFF while the SBS is canceled, the SBS is automatically enabled the next time the ignition is switched ON.

Function	Available setting changes
Bose® AudioPilot[*6] Automatically adjusts the music to compensate for road noise.	Off, 1 — 3 (4 levels)

[*1] Equalizer setting saved in "Customize EQ" of the "Equalizer" item.

[*2] You can edit and save the equalizer setting manually according to your preferences.

[*3] The automatic level control (ALC) changes the audio volume automatically according to the vehicle speed. The faster the vehicle speed, the higher the volume increases. The slower the vehicle speed, the lower the volume decreases.

[*4] This function adjusts the volume automatically, therefore the volume level changes depending on the content.

[*5] Centerpoint lets vehicle owners enjoy a Bose surround sound experience.
Specifically engineered to meet the unique demands of reproducing surround sound in a vehicle.
Converts stereo signals to multiple channels allowing greater precision when reproducing the sound.
An enhanced algorithm to simultaneously create a wider, more spacious sound field.
Centerpoint is a registered trademark of Bose Corporation.

[*6] When driving, background noise can interfere with enjoying music.
AudioPilot Noise compensation technology continuously adjusts the music to compensate for background noise and vehicle speed.
It reacts only to sustained noise sources and not intermittent ones, such as speed bumps.
An enhanced DSP algorithm allows faster and more effective compensation for unusual situations, such as driving on a very rough road or at high speeds.
AudioPilot is a registered trademark of Bose Corporation.

Vehicle Notification and Warning Volume

Adjusts the alert volume for notifications and warnings.

Available setting changes
Low, Moderate, High

APPENDIX C

Run Log

Subject Vehicle: **2020 Mazda CX-30** Test Date: **1/22/2020**

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	2.89	2.87	0.79	Pass	
2		Y	2.83	2.83	0.73	Pass	
3		Y	2.88	2.87	0.78	Pass	
4		Y	2.86	2.84	0.76	Pass	
5		Y	2.91	2.91	0.81	Pass	
6		Y	2.89	2.87	0.79	Pass	
7		Y	2.61	2.59	0.51	Pass	
16	**Decelerating POV, 45**	Y	2.64	2.62	0.24	Pass	
17		N					Lateral offset
18		Y	2.90	2.88	0.50	Pass	
19		Y	2.98	2.97	0.58	Pass	
20		Y	2.99	2.98	0.59	Pass	
21		Y	2.83	2.82	0.43	Pass	
22		Y	2.93	2.91	0.53	Pass	
23		N					SV Yaw
24		Y	2.98	2.96	0.58	Pass	

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
8	**Slower POV, 45 vs 20**	Y	2.88	2.86	0.88	Pass	
9		Y	2.89	2.88	0.89	Pass	
10		Y	2.93	2.91	0.93	Pass	
11		Y	2.94	2.94	0.94	Pass	
12		Y	2.95	2.94	0.95	Pass	
13		Y	2.84	2.83	0.84	Pass	
14		N					GPS Lost RTK
15		Y	2.93	2.90	0.93	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.

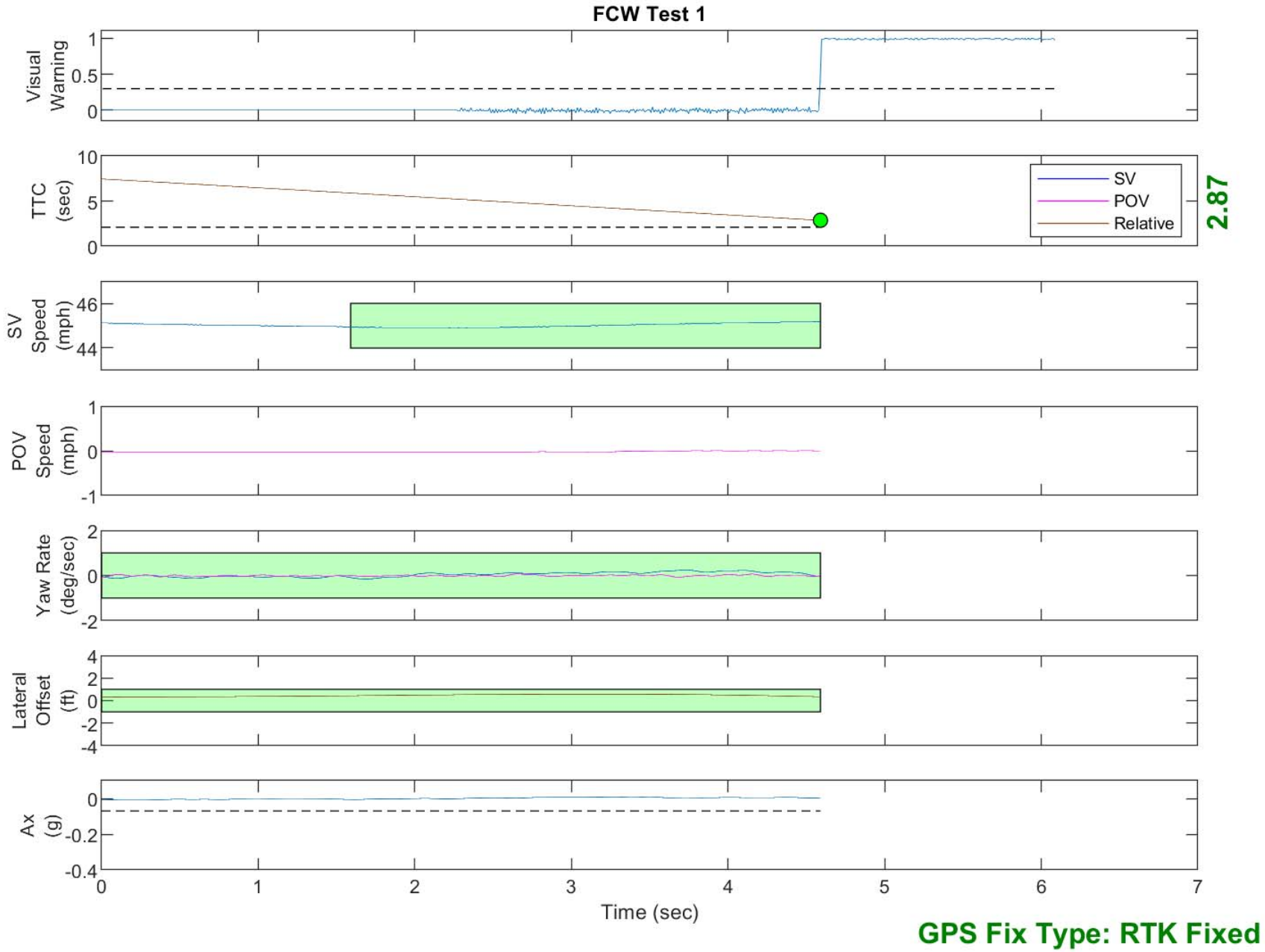


Figure D1. Example Time History for Test Type 1, Passing

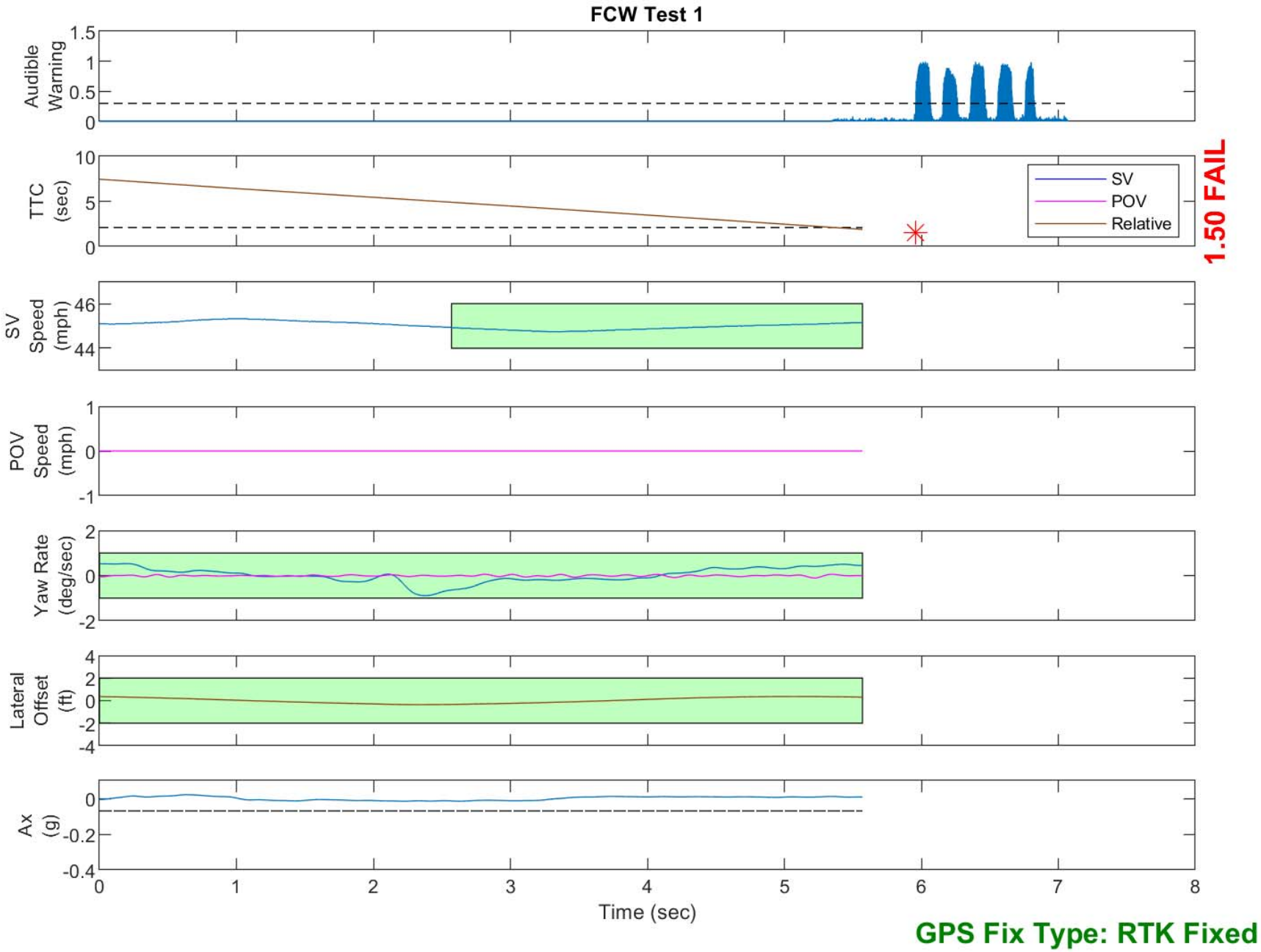


Figure D2. Example Time History for Test Type 1, Failing

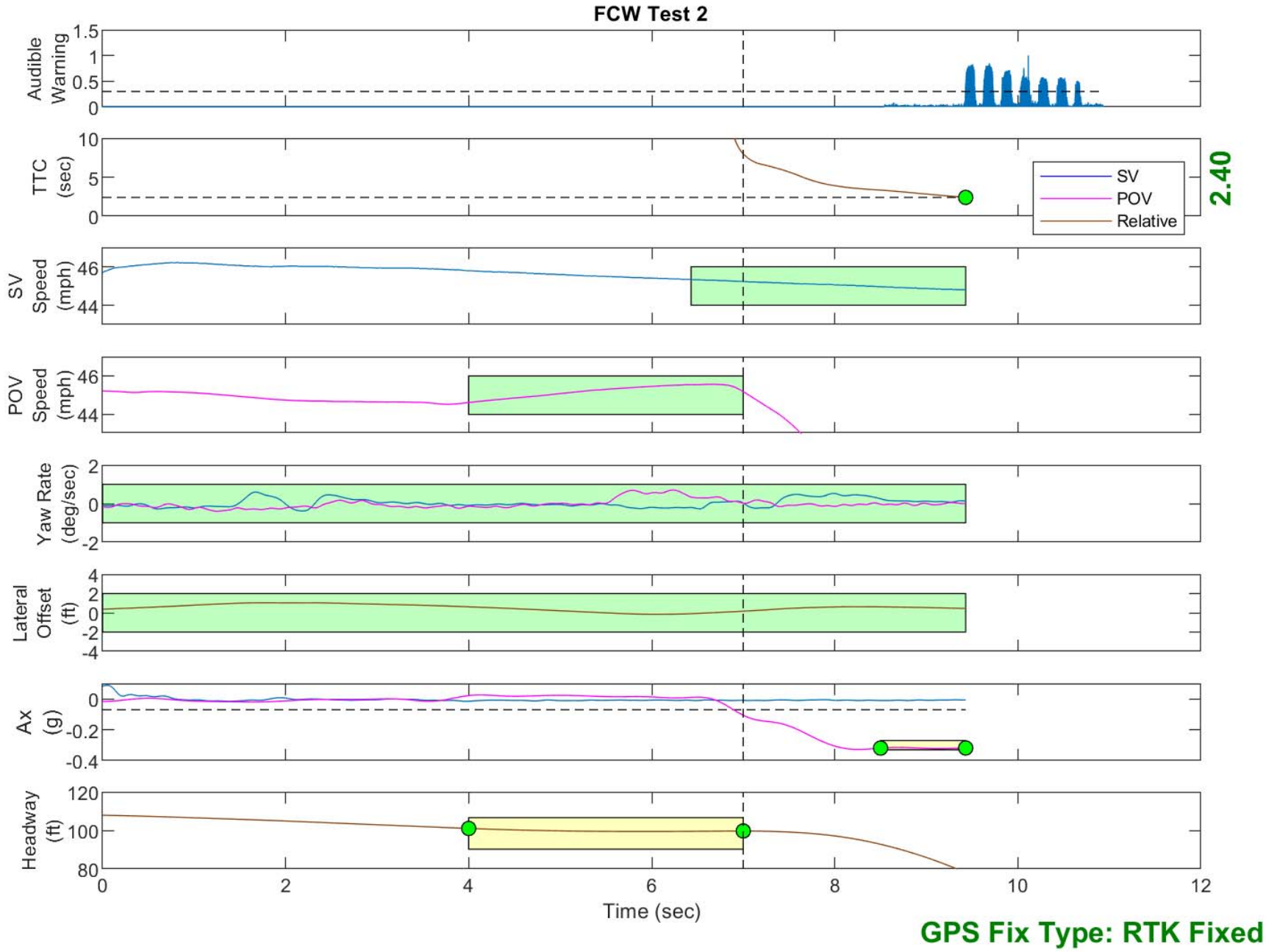


Figure D3. Example Time History for Test Type 2, Passing

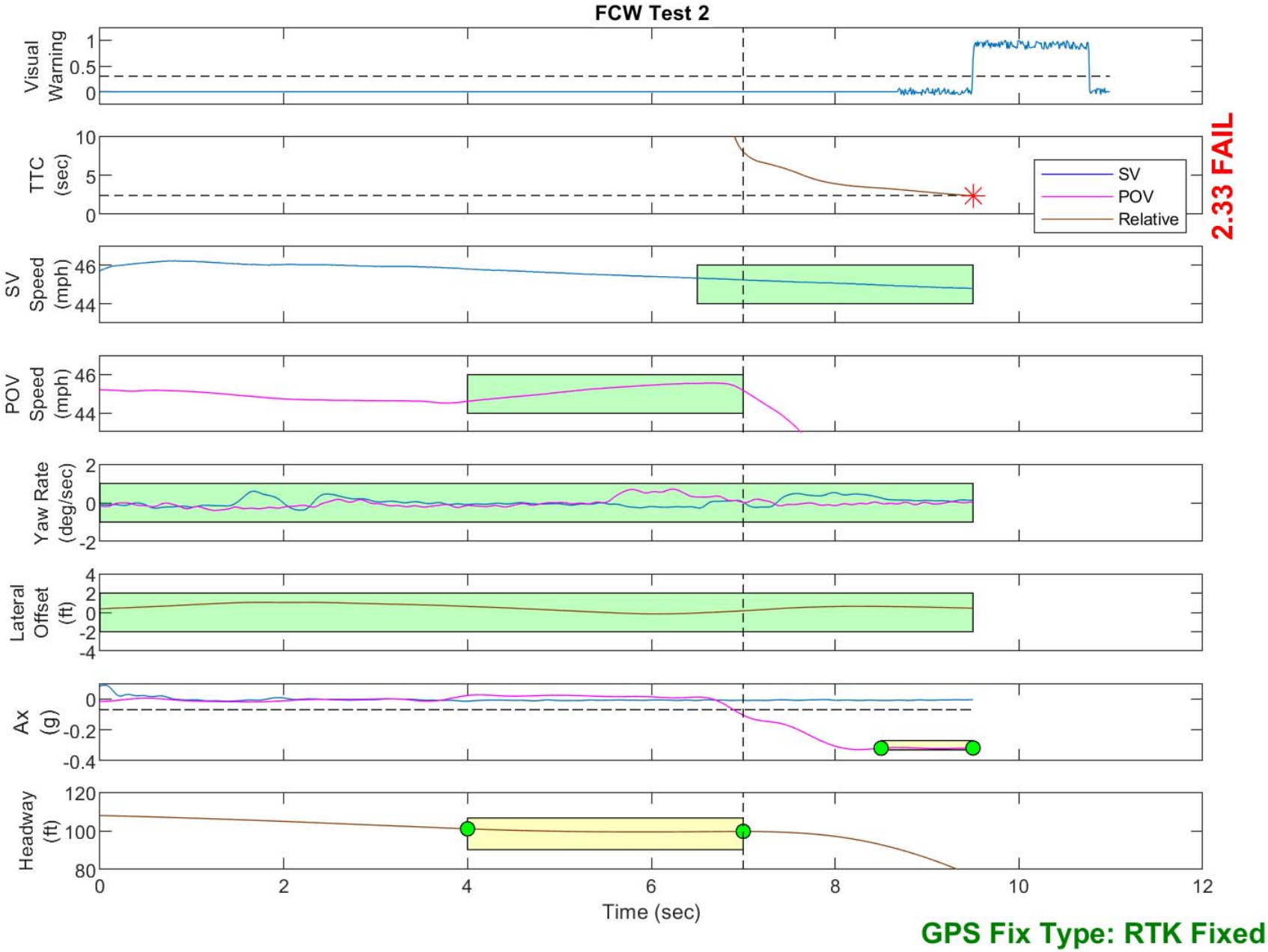


Figure D4. Example Time History for Test Type 2, Failing

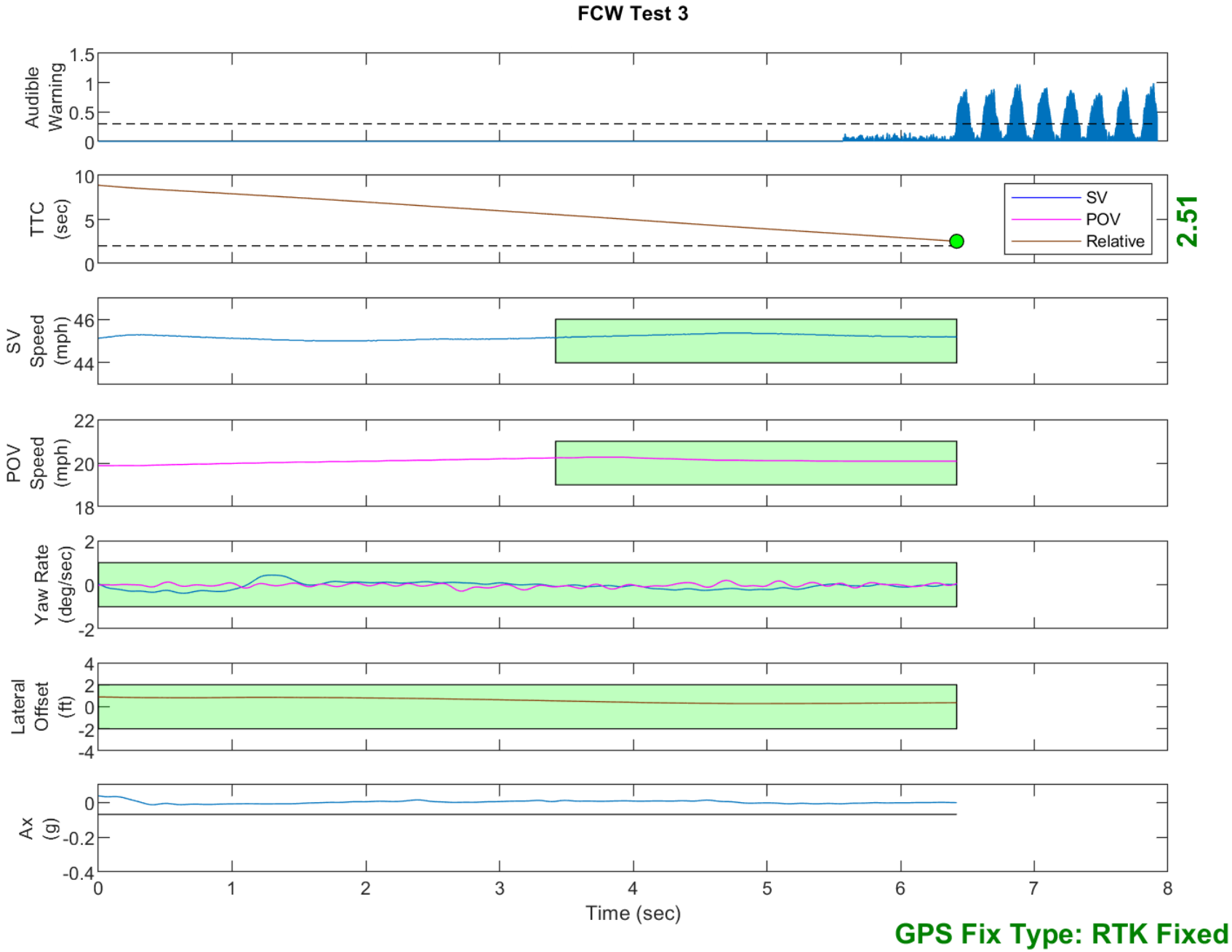


Figure D5. Example Time History for Test Type 3, Passing

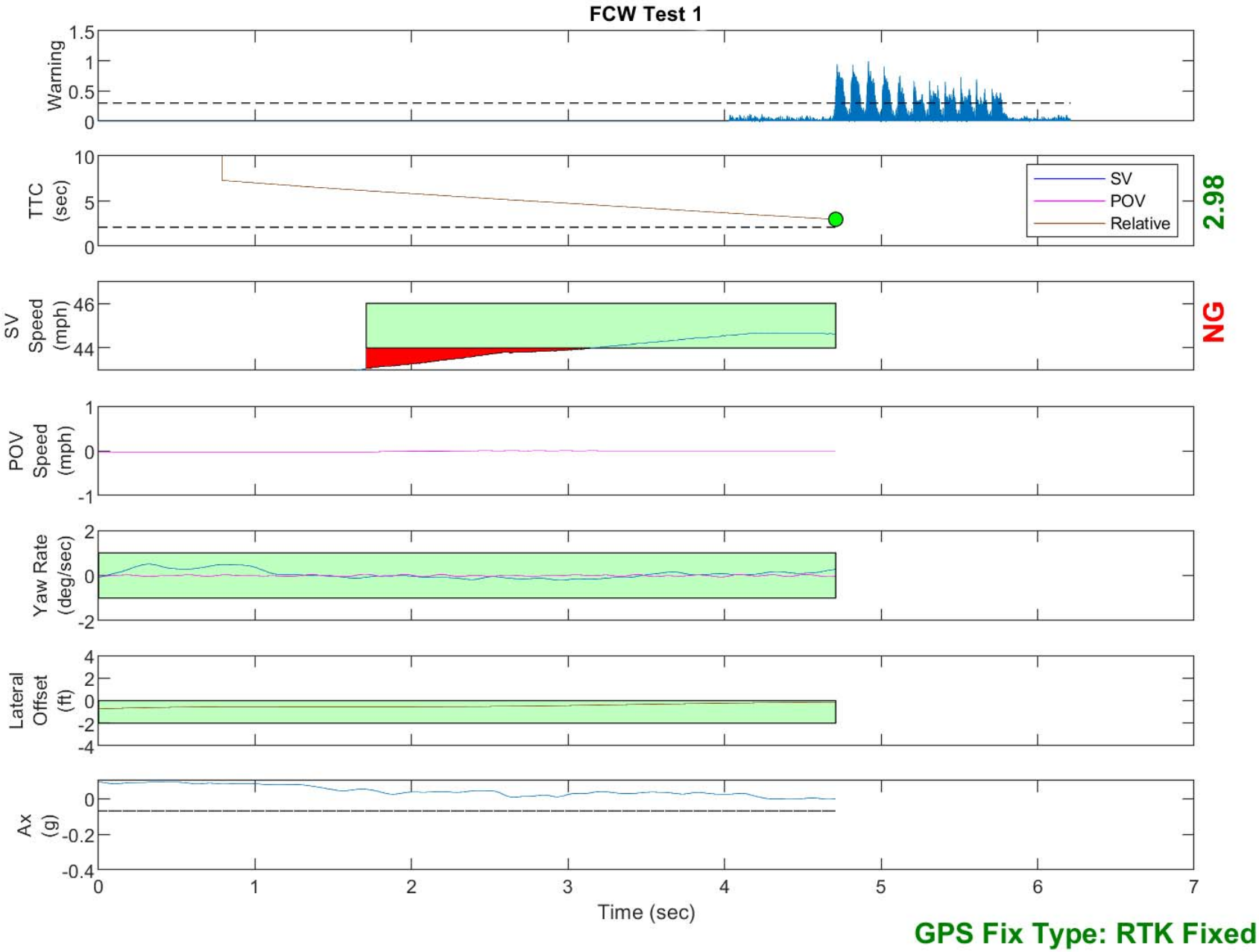


Figure D6. Example Time History for Test Type 2, Invalid Run Due to Subject Vehicle Speed

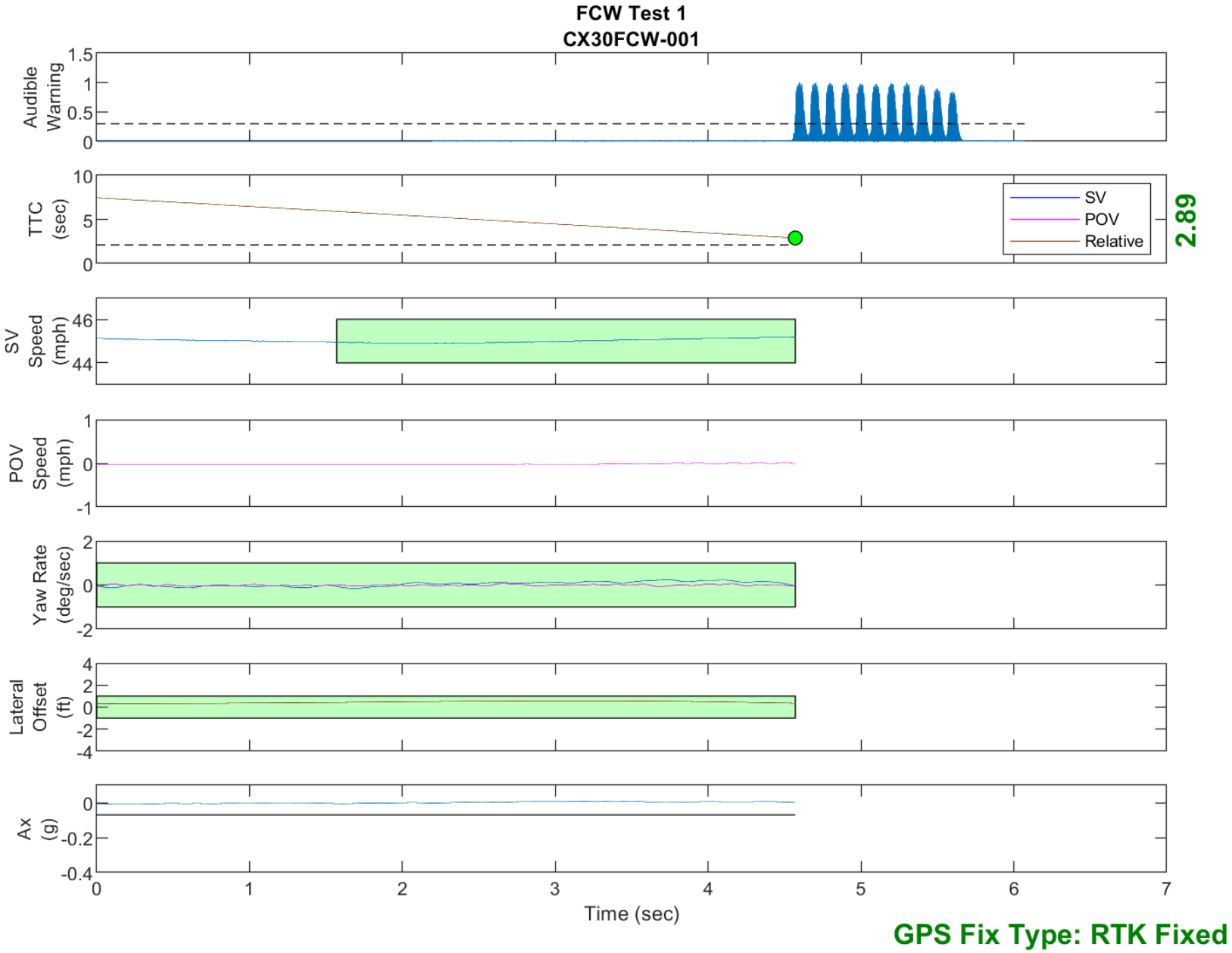


Figure D7. Time History for Run 1, FCW Test 1, Audible Warning

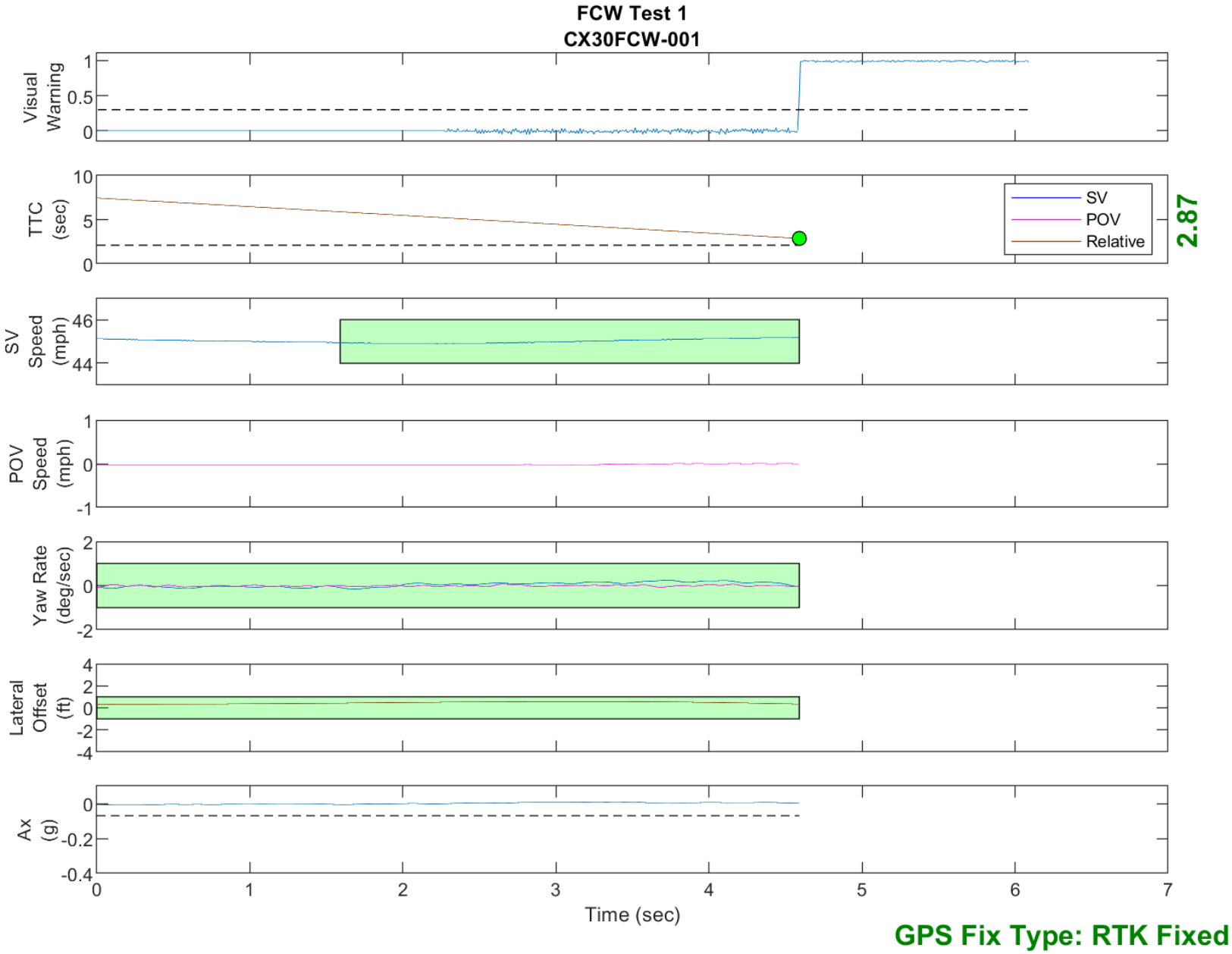


Figure D8. Time History for Run 1, FCW Test 1, Visual Warning

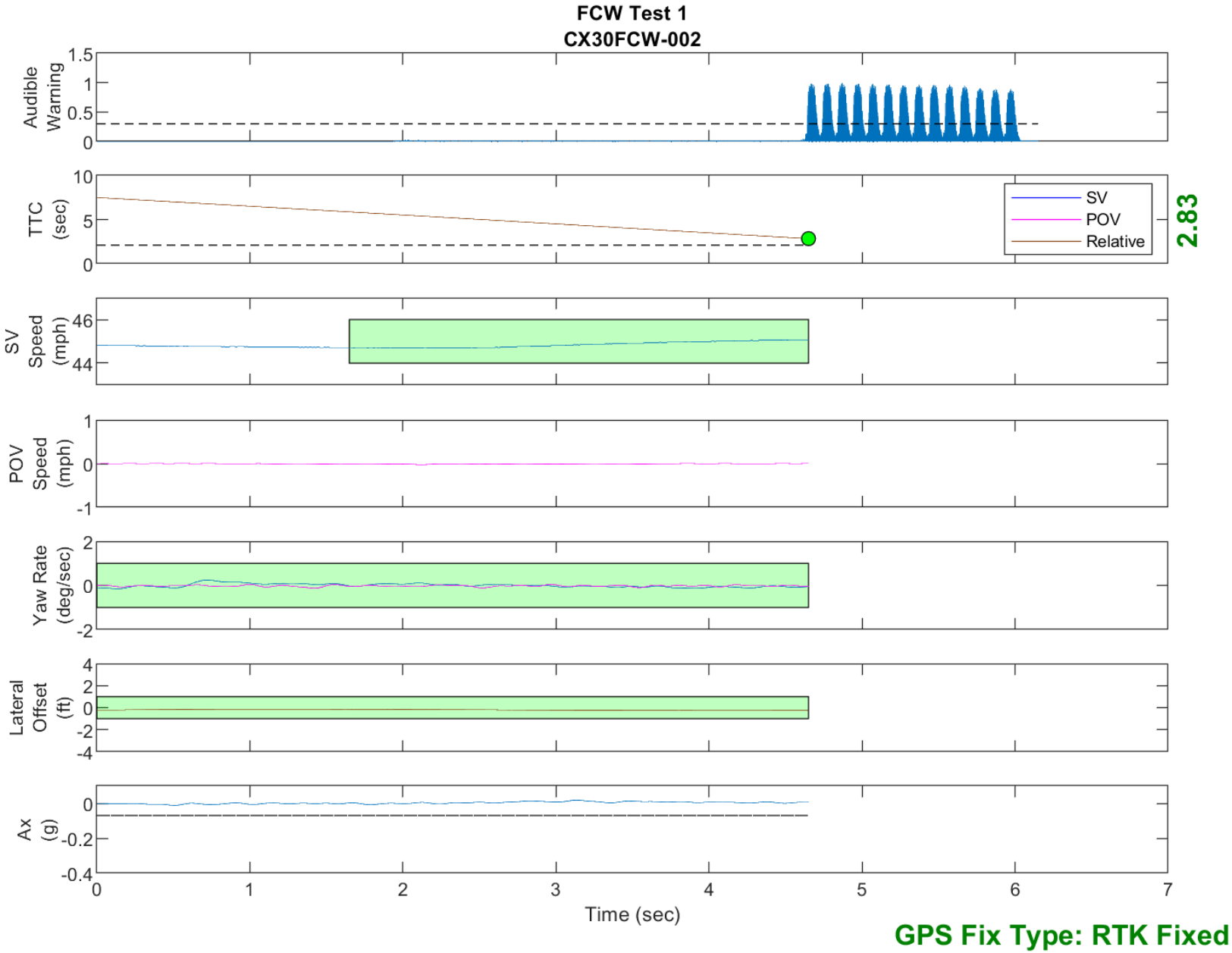


Figure D9. Time History for Run 2, FCW Test 1, Audible Warning

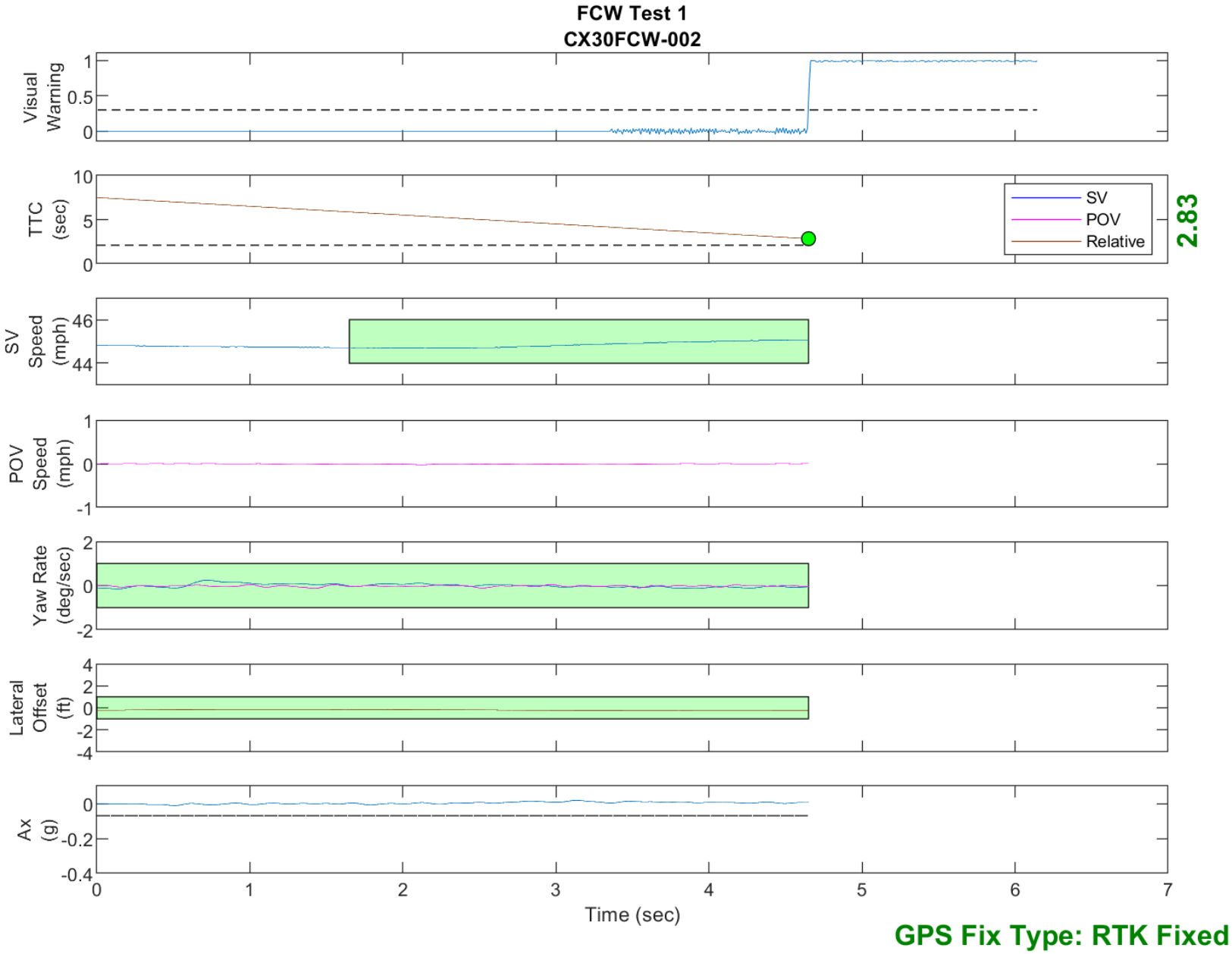


Figure D10. Time History for Run 2, FCW Test 1, Visual Warning

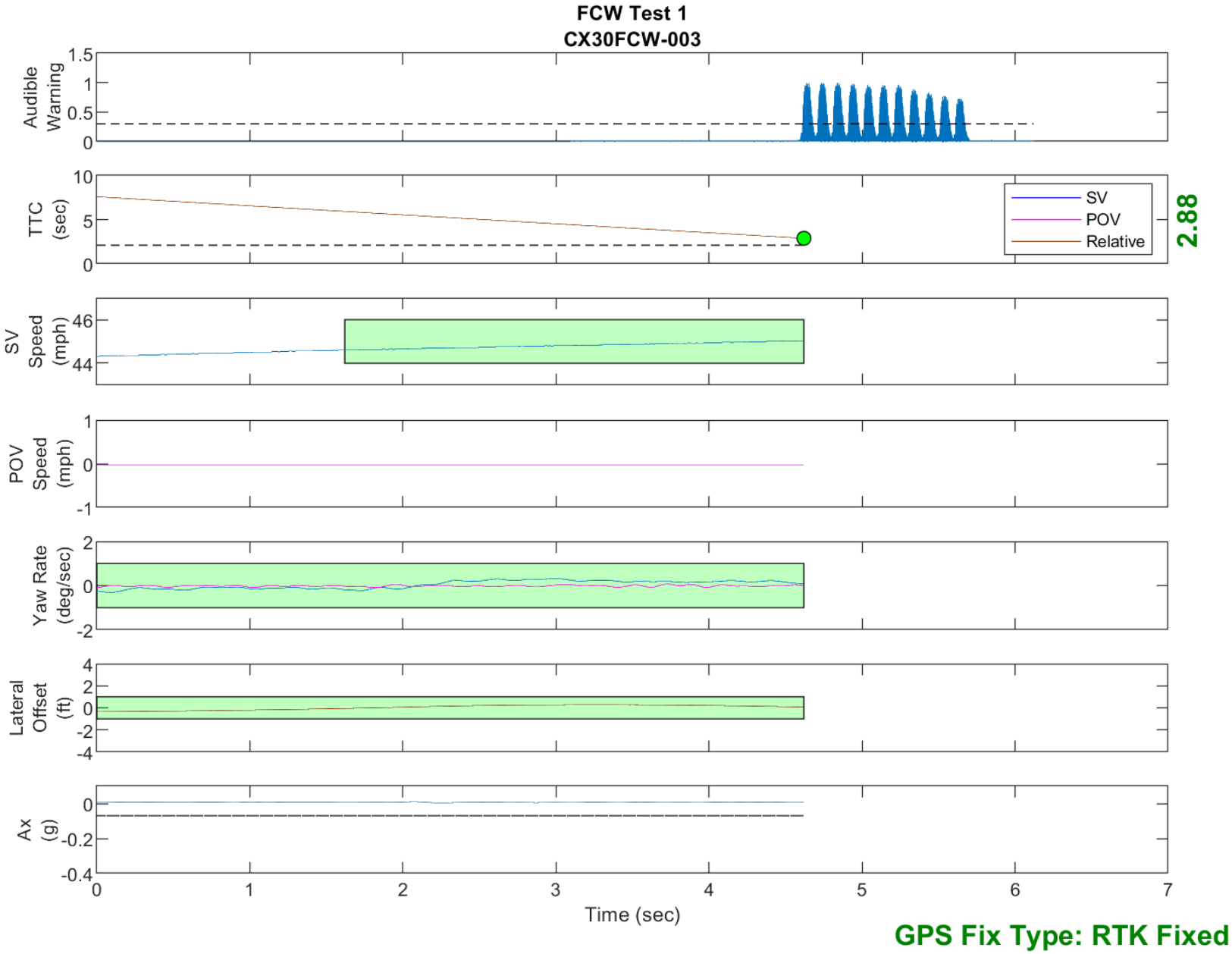


Figure D11. Time History for Run 3, FCW Test 1, Audible Warning

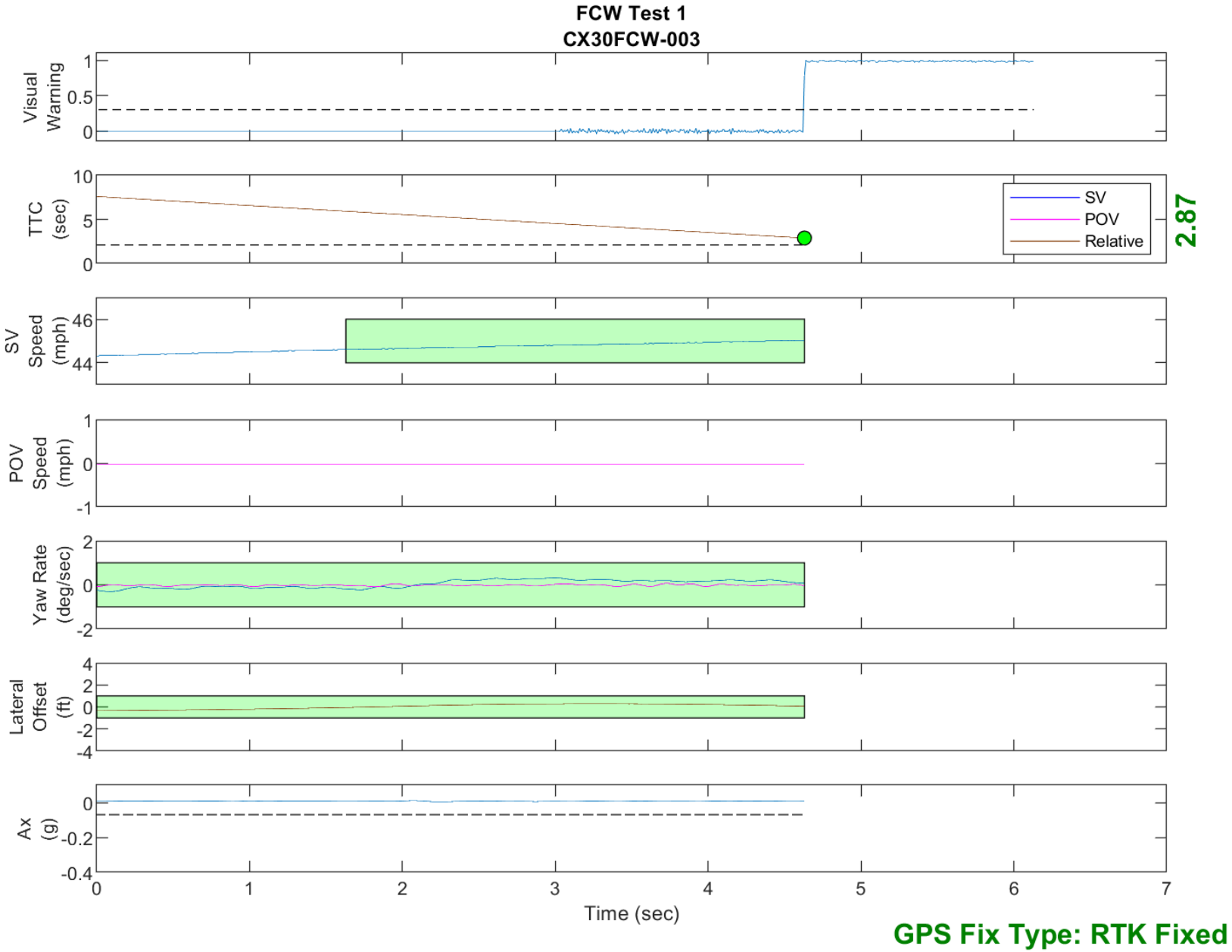


Figure D12. Time History for Run 3, FCW Test 1, Visual Warning

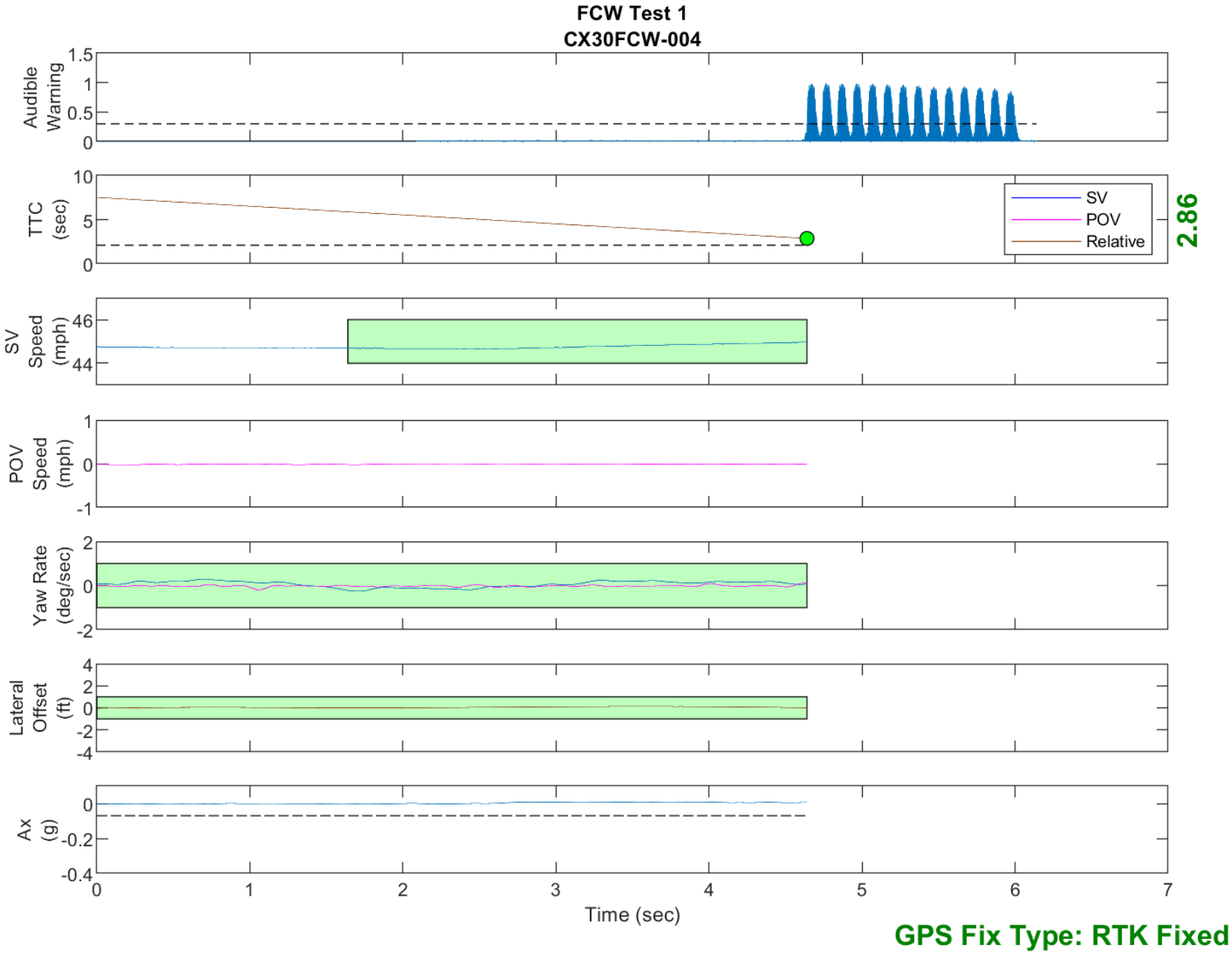


Figure D13. Time History for Run 4, FCW Test 1, Audible Warning

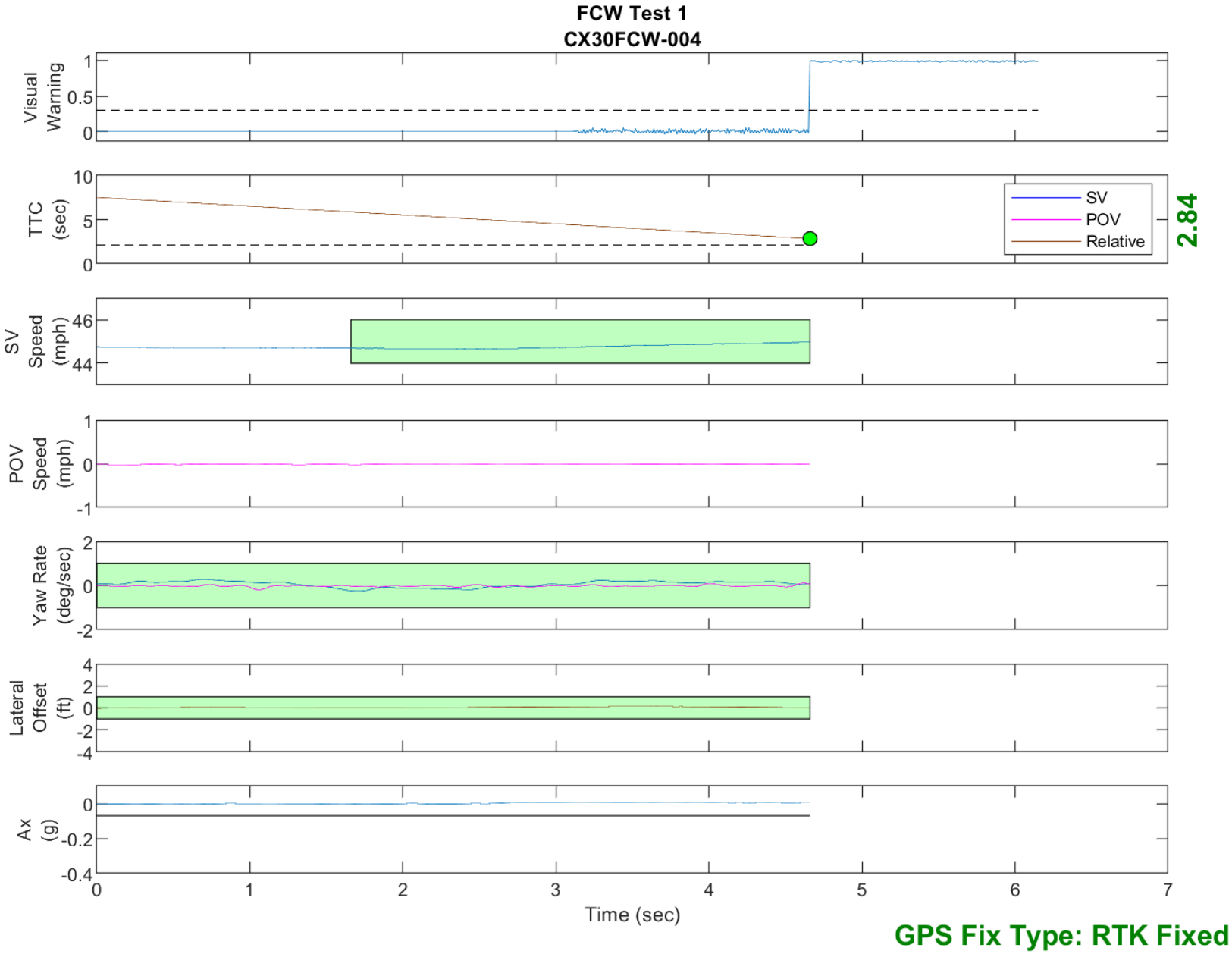


Figure D14. Time History for Run 4, FCW Test 1, Visual Warning

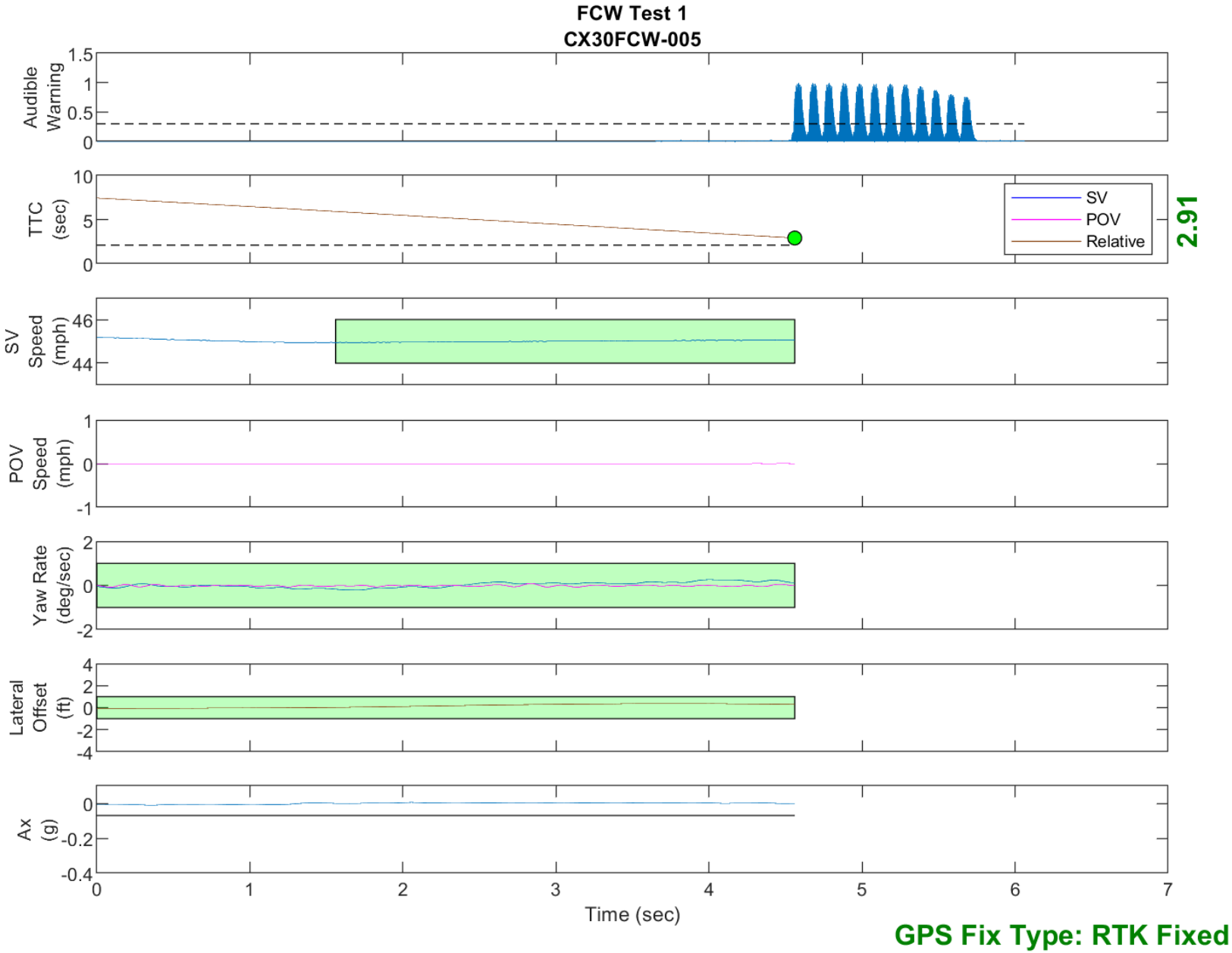


Figure D15. Time History for Run 5, FCW Test 1, Audible Warning

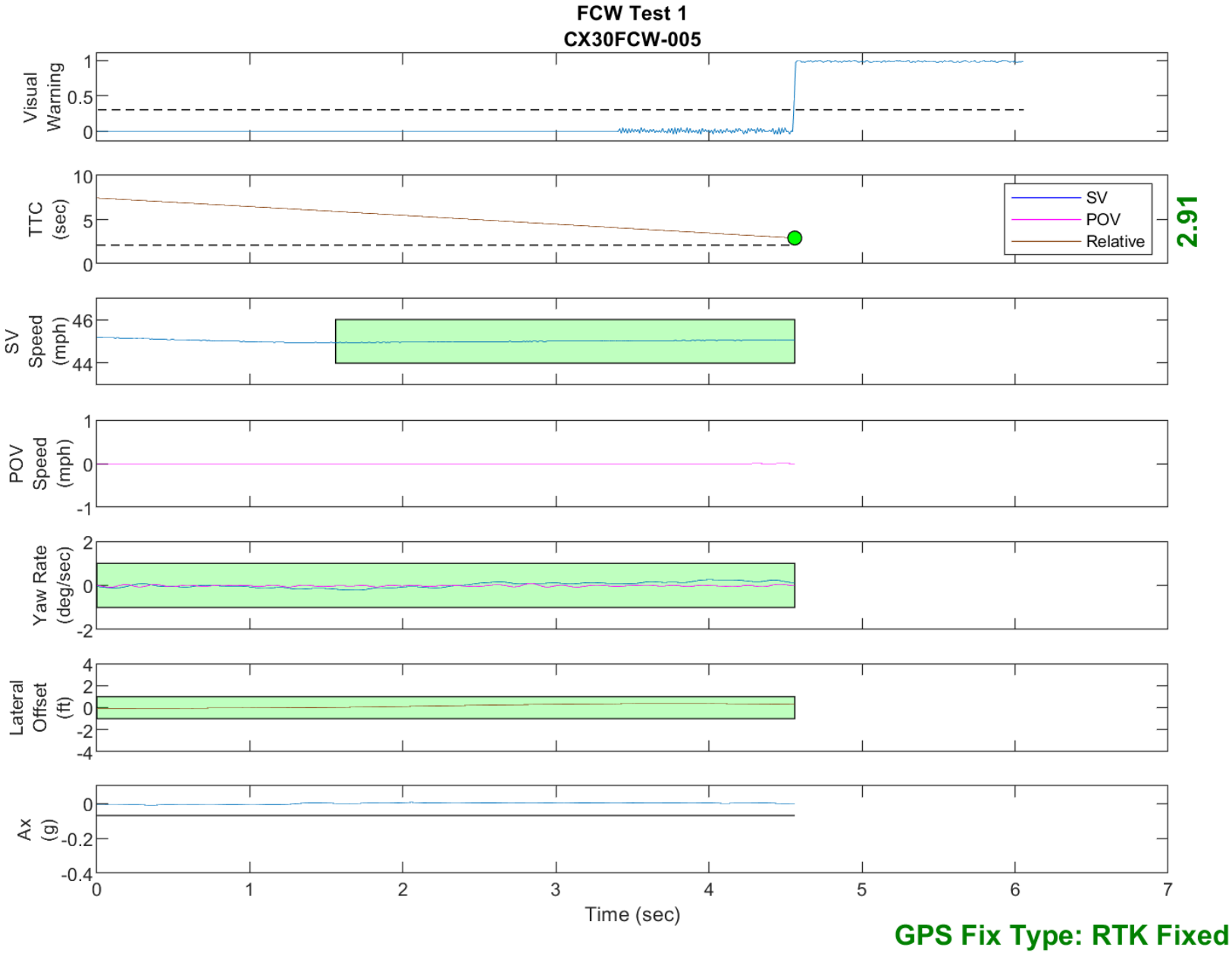


Figure D16. Time History for Run 5, FCW Test 1, Visual Warning

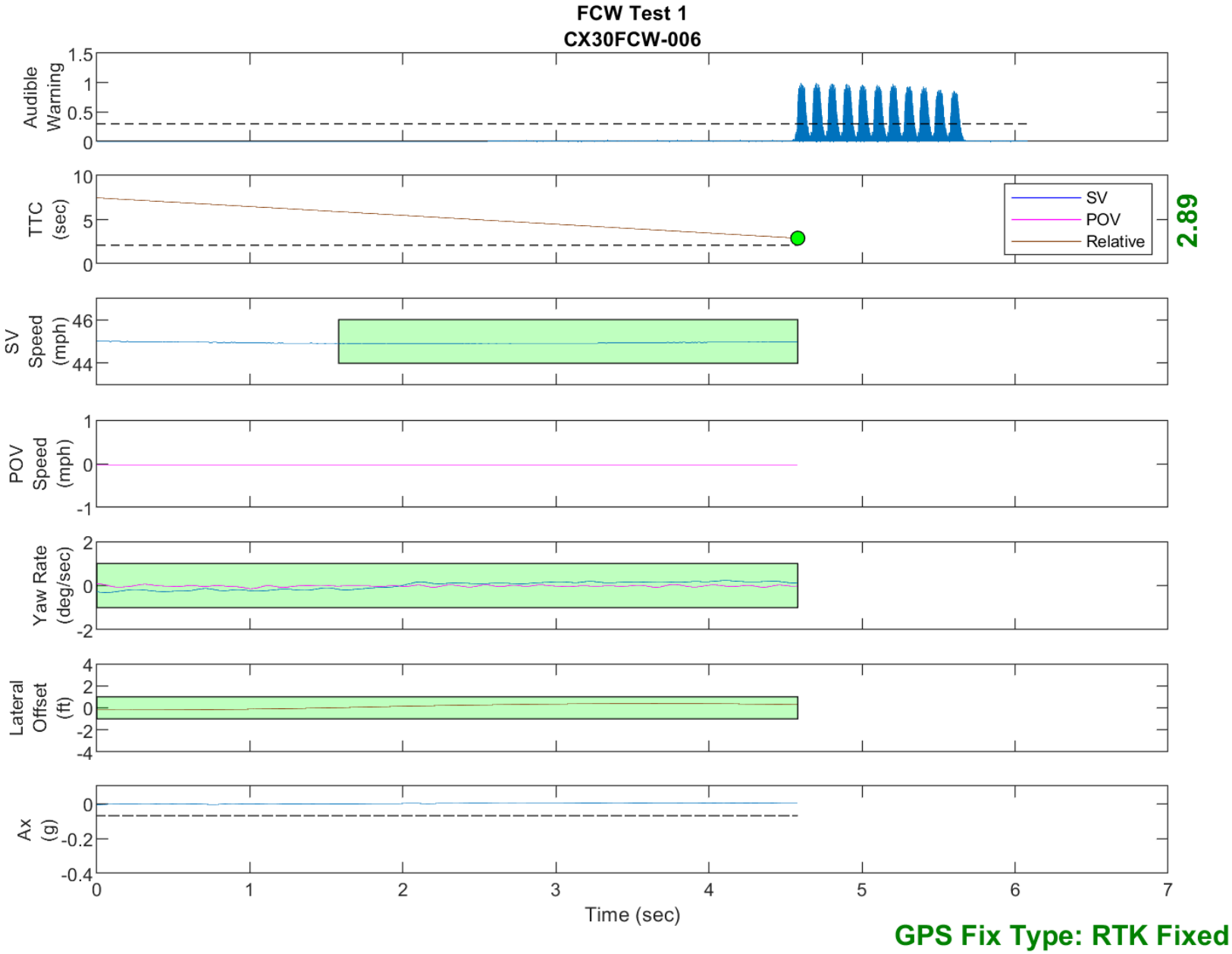


Figure D17. Time History for Run 6, FCW Test 1, Audible Warning

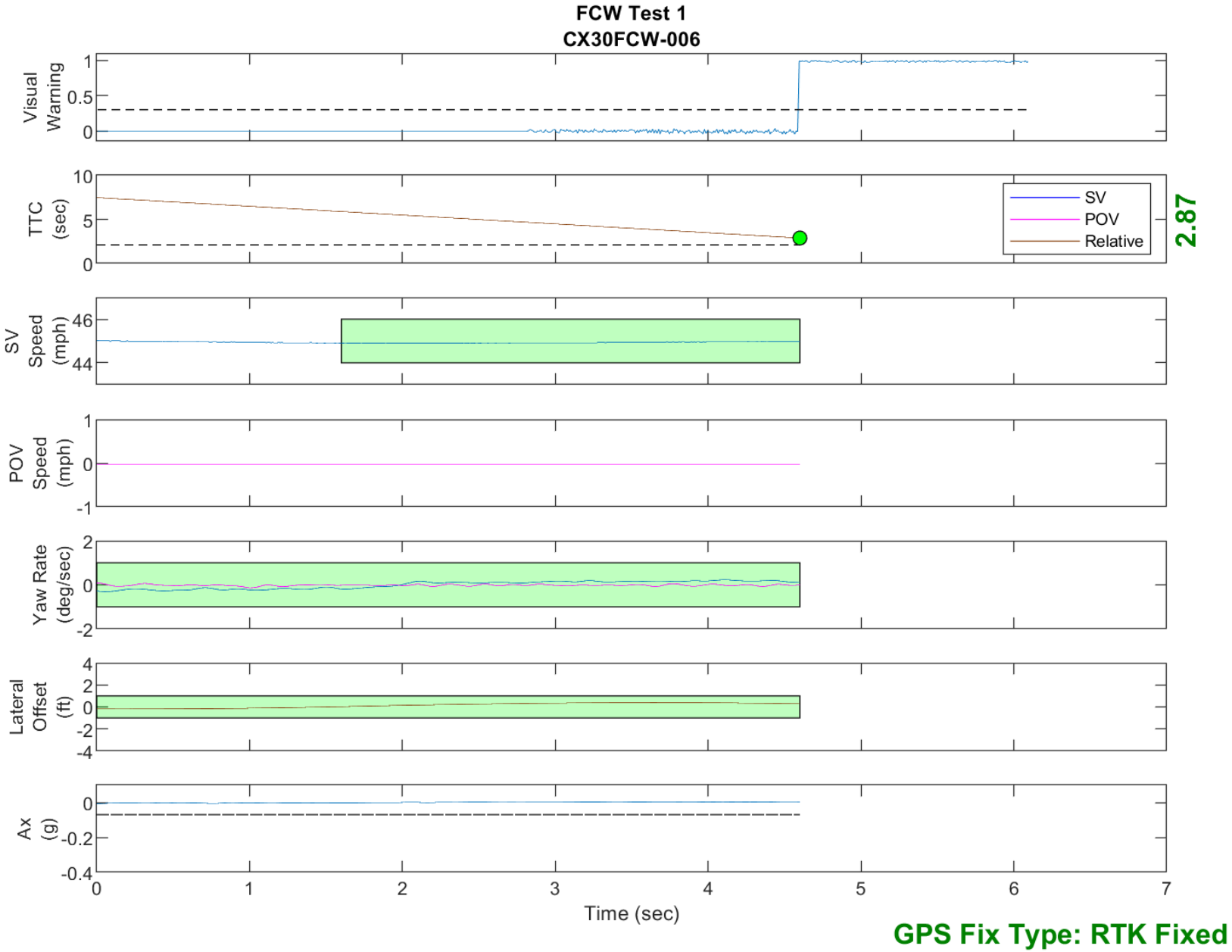


Figure D18. Time History for Run 6, FCW Test 1, Visual Warning

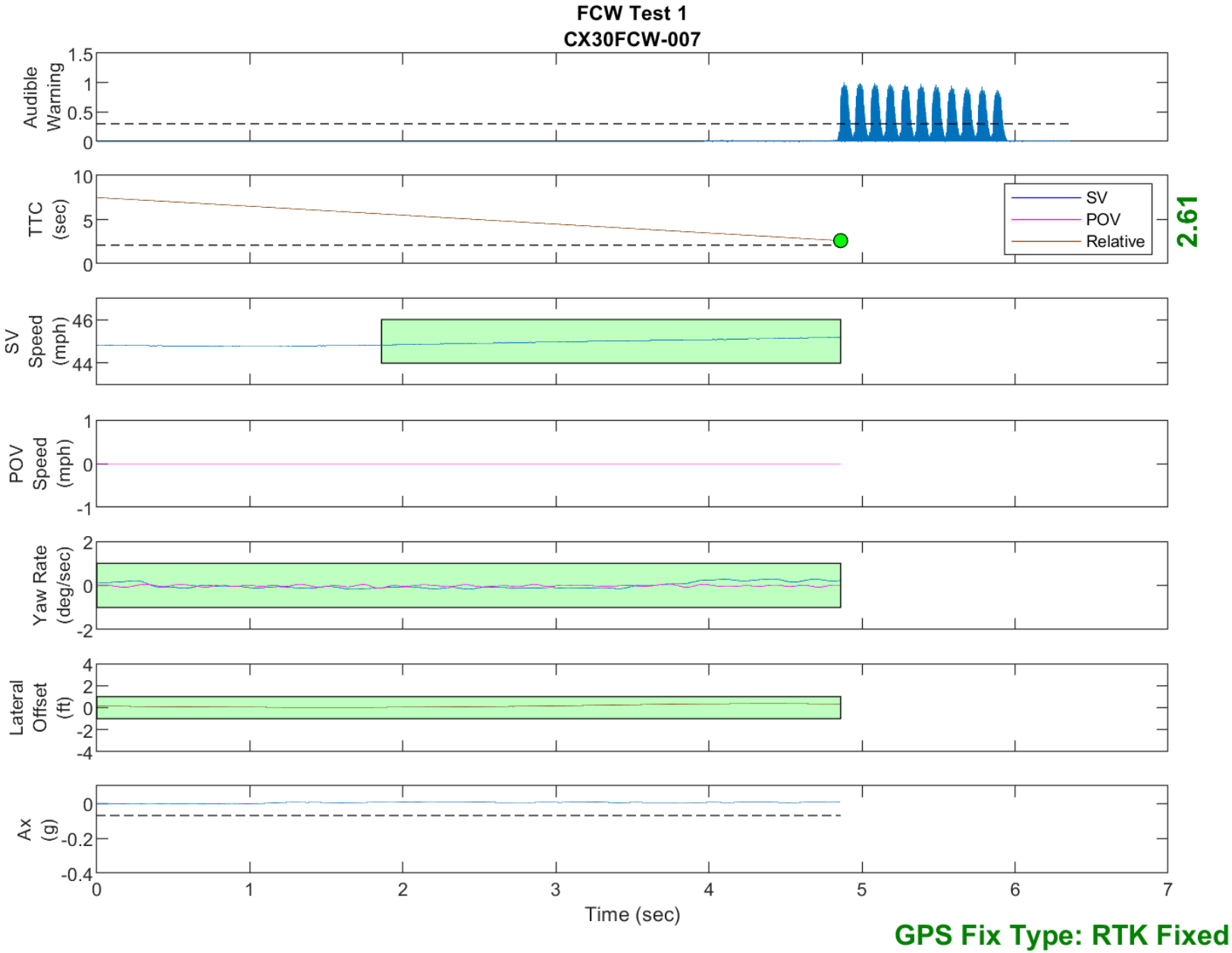


Figure D19. Time History for Run 7, FCW Test 1, Audible Warning

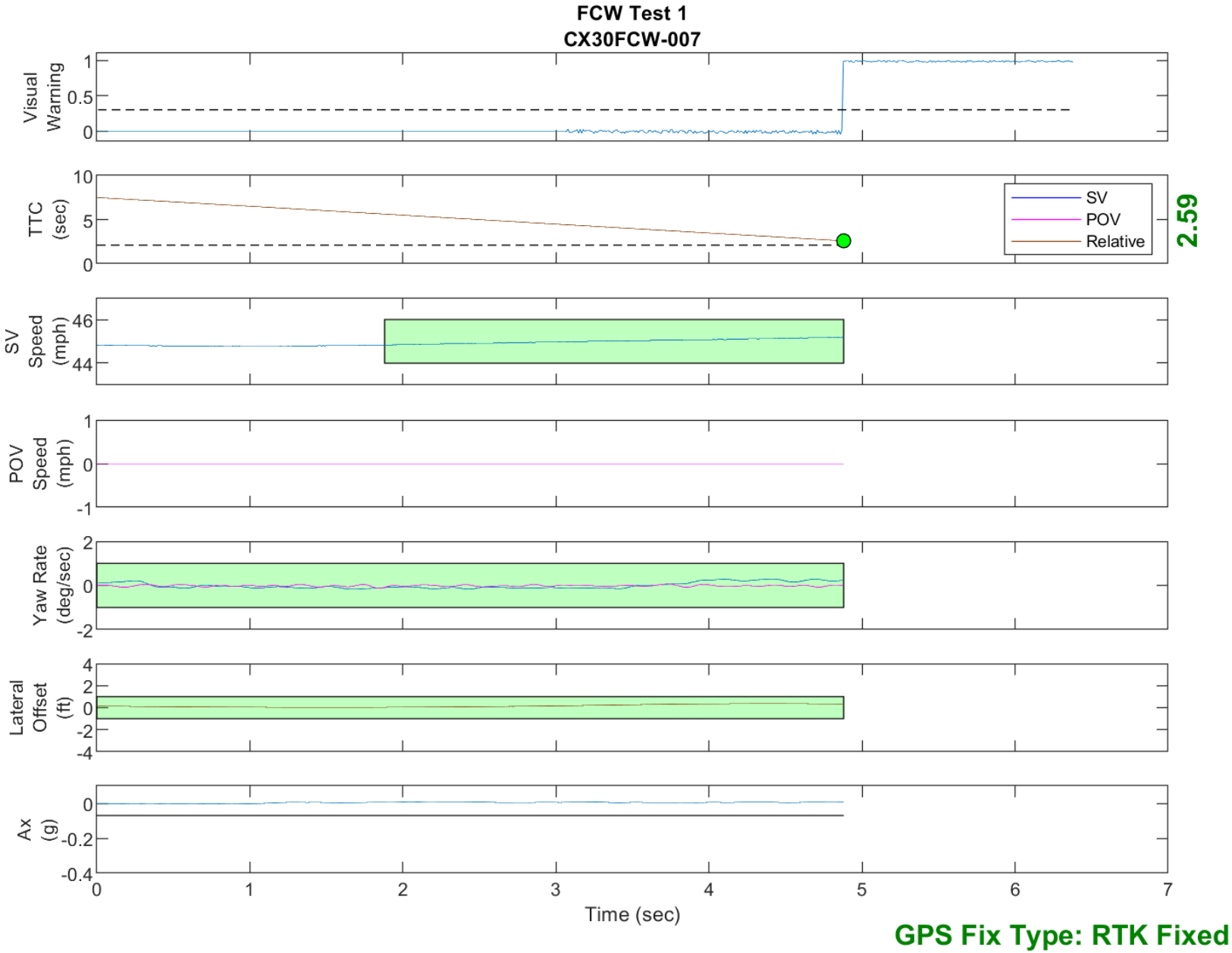


Figure D20. Time History for Run 7, FCW Test 1, Visual Warning

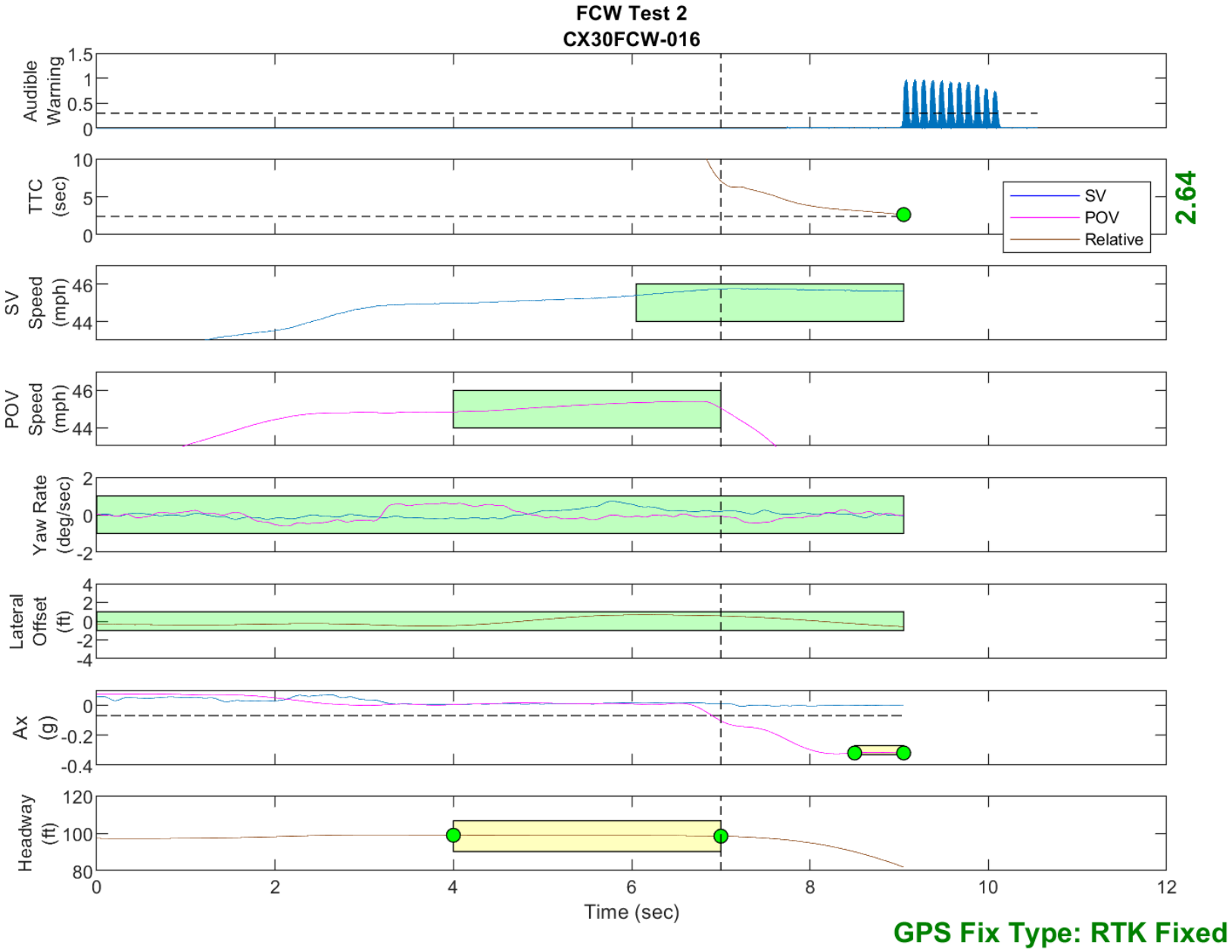


Figure D21. Time History for Run 16, FCW Test 2, Audible Warning

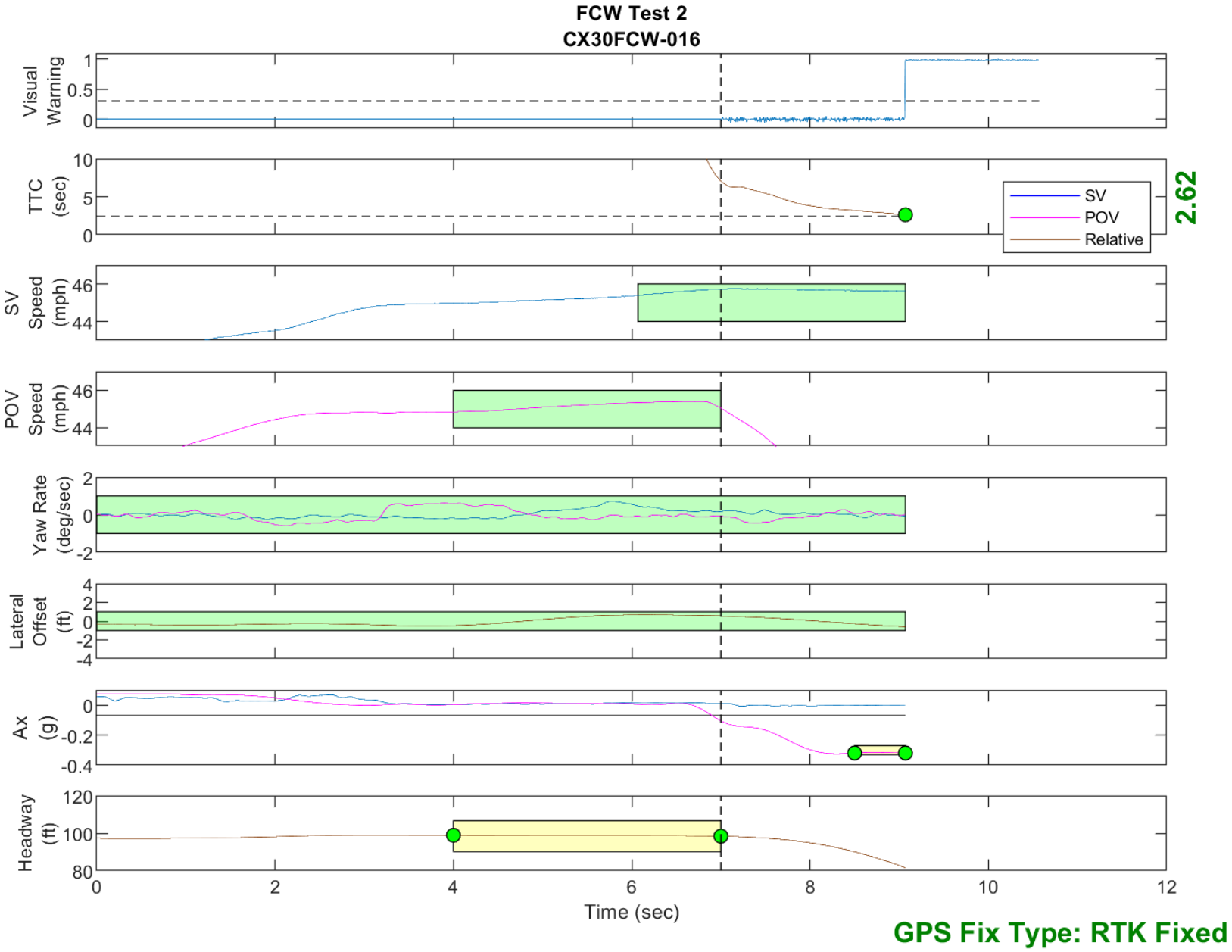


Figure D22. Time History for Run 16, FCW Test 2, Visual Warning

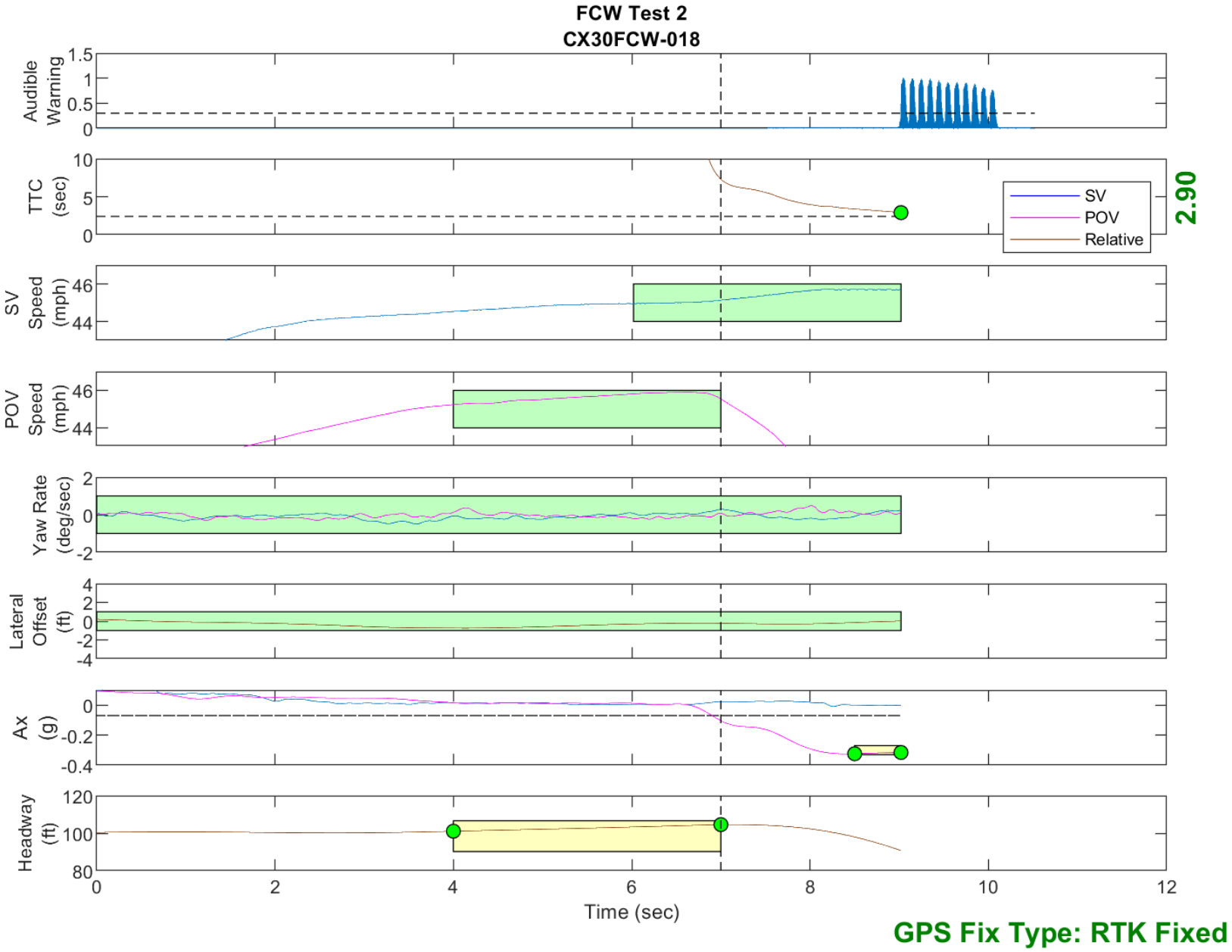


Figure D23. Time History for Run 18, FCW Test 2, Audible Warning

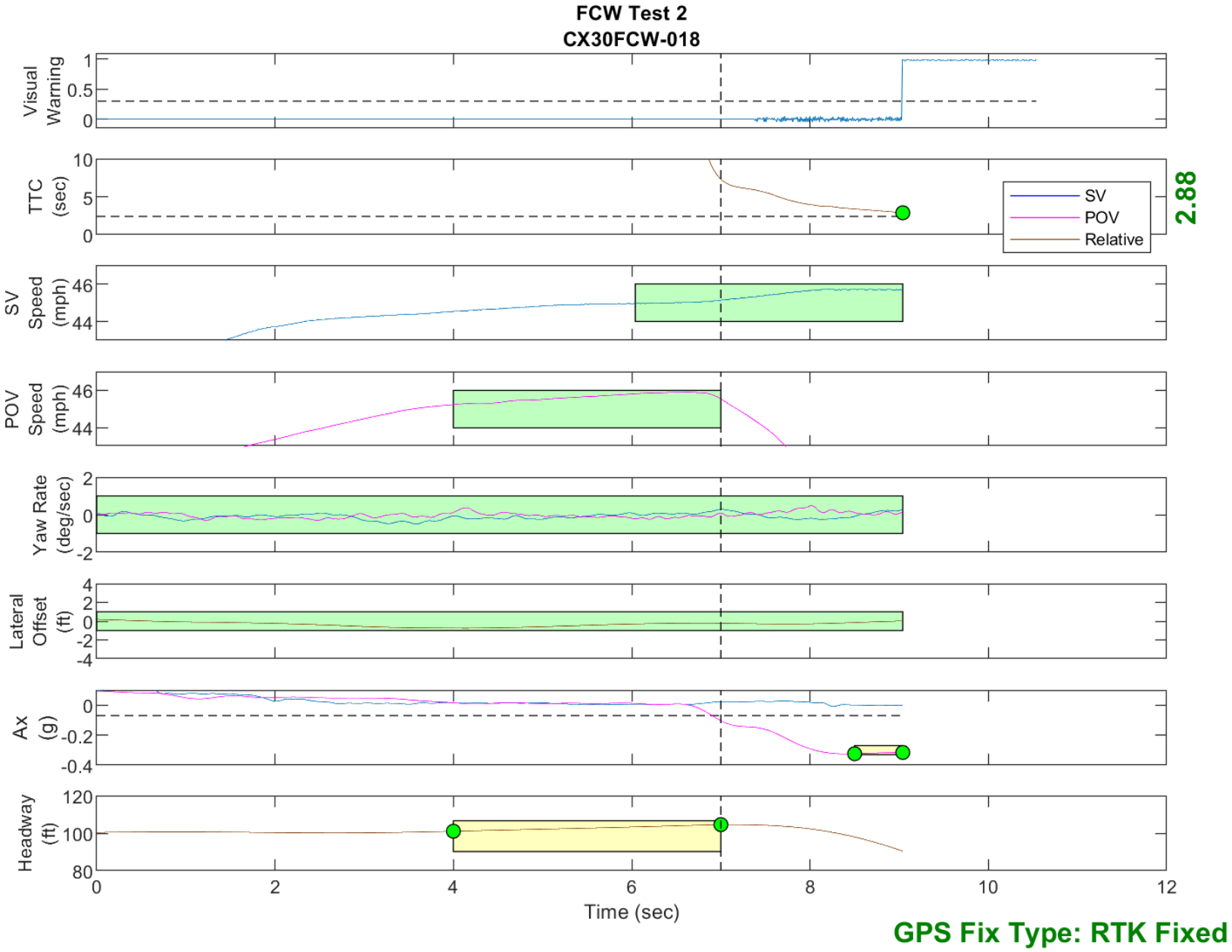


Figure D24. Time History for Run 18, FCW Test 2, Visual Warning

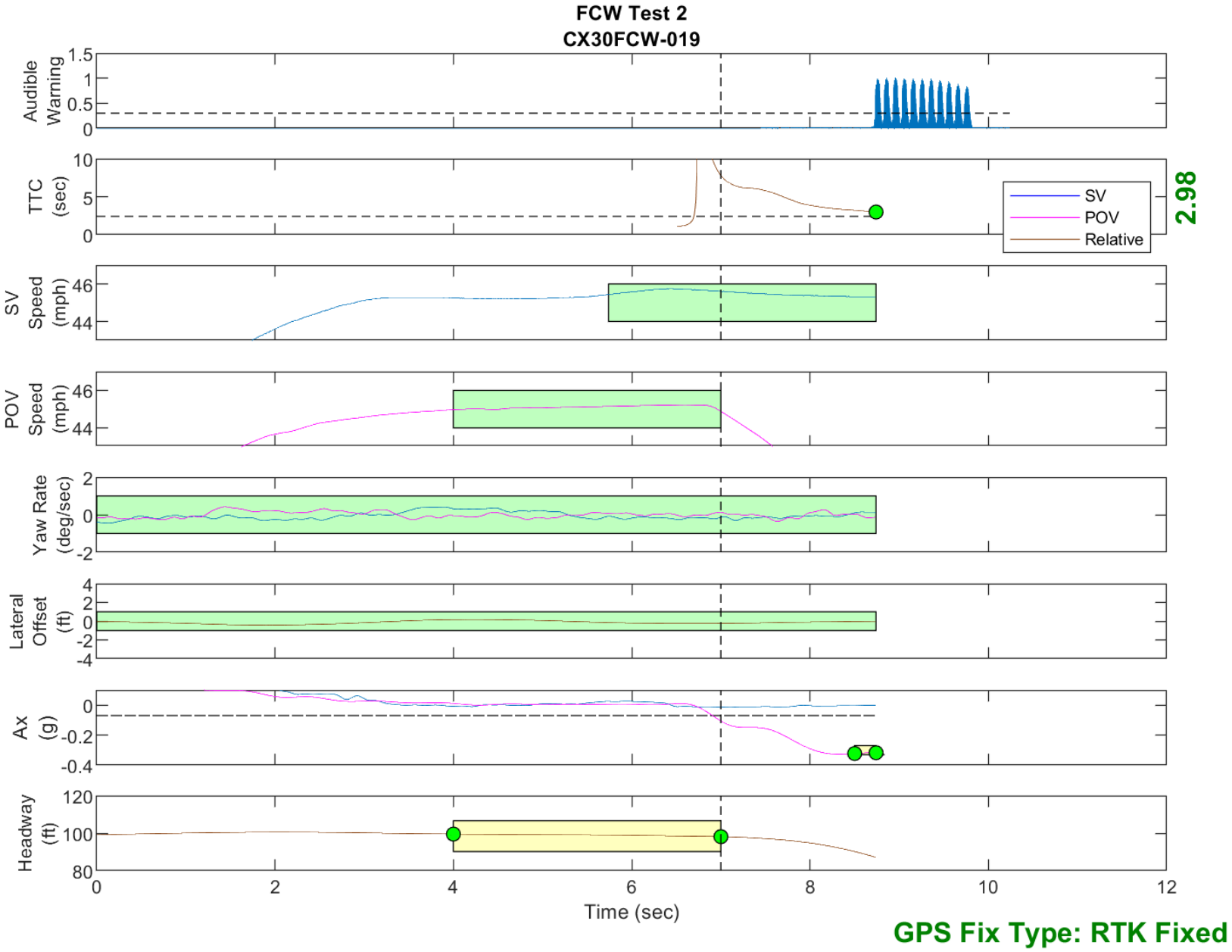


Figure D25. Time History for Run 19, FCW Test 2, Audible Warning

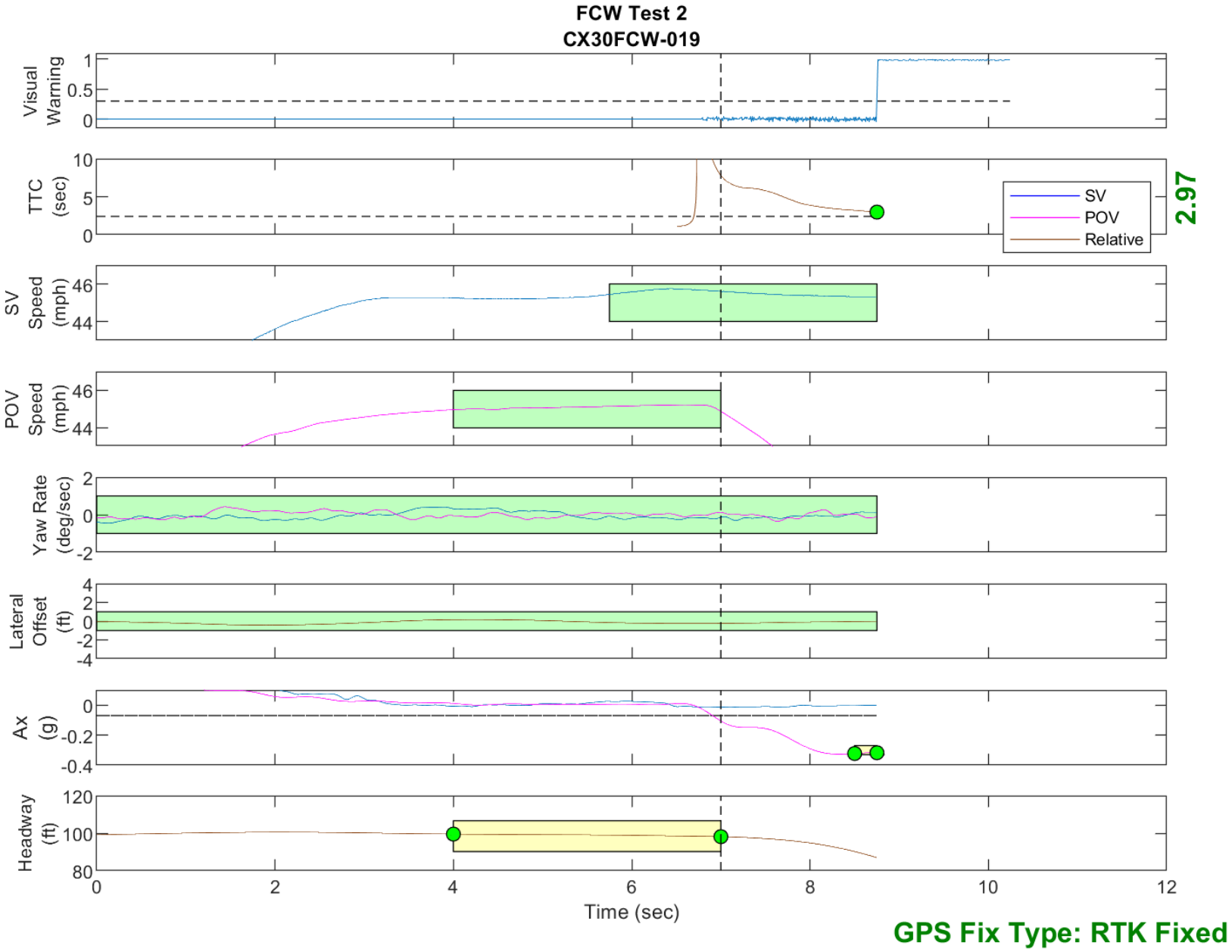


Figure D26. Time History for Run 19, FCW Test 2, Visual Warning

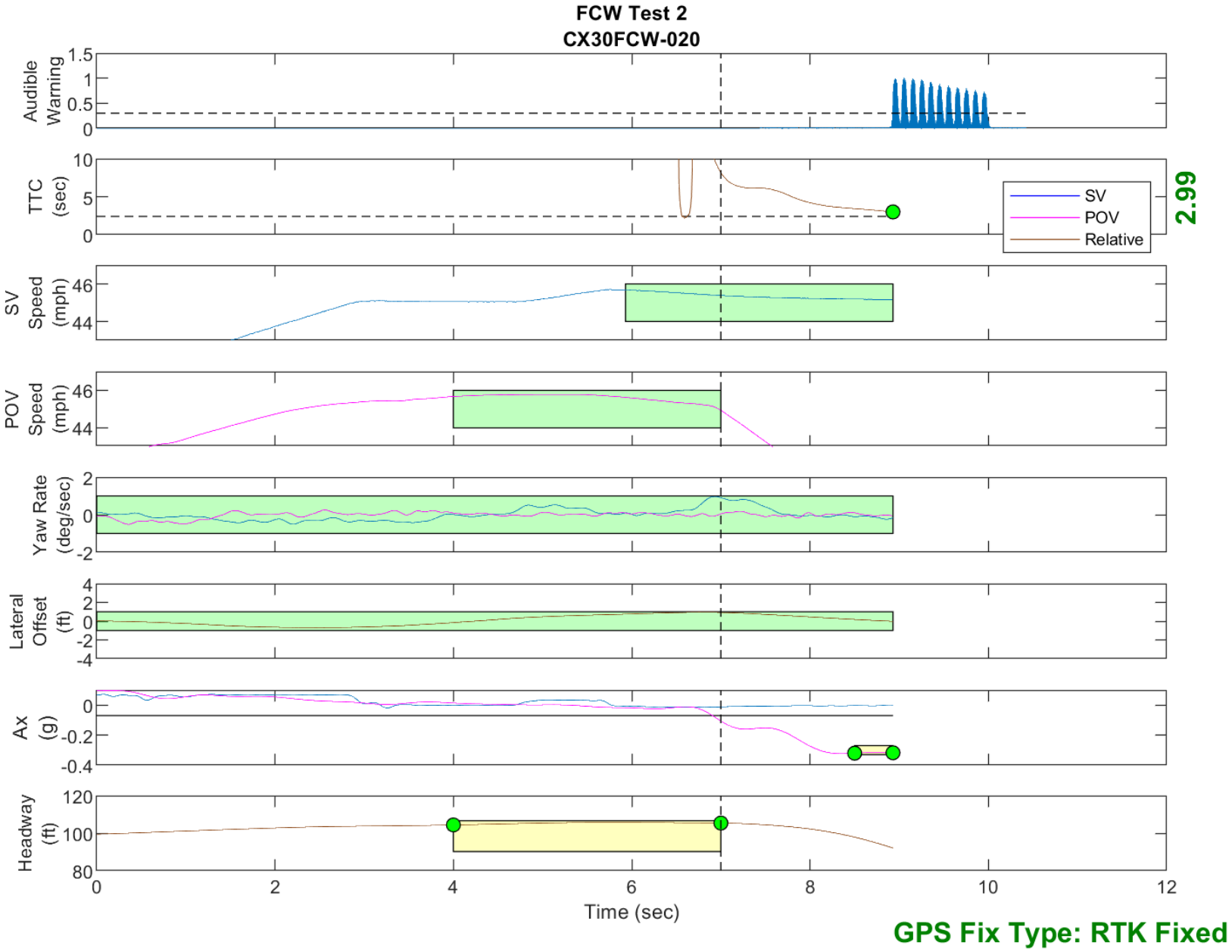


Figure D27. Time History for Run 20, FCW Test 2, Audible Warning

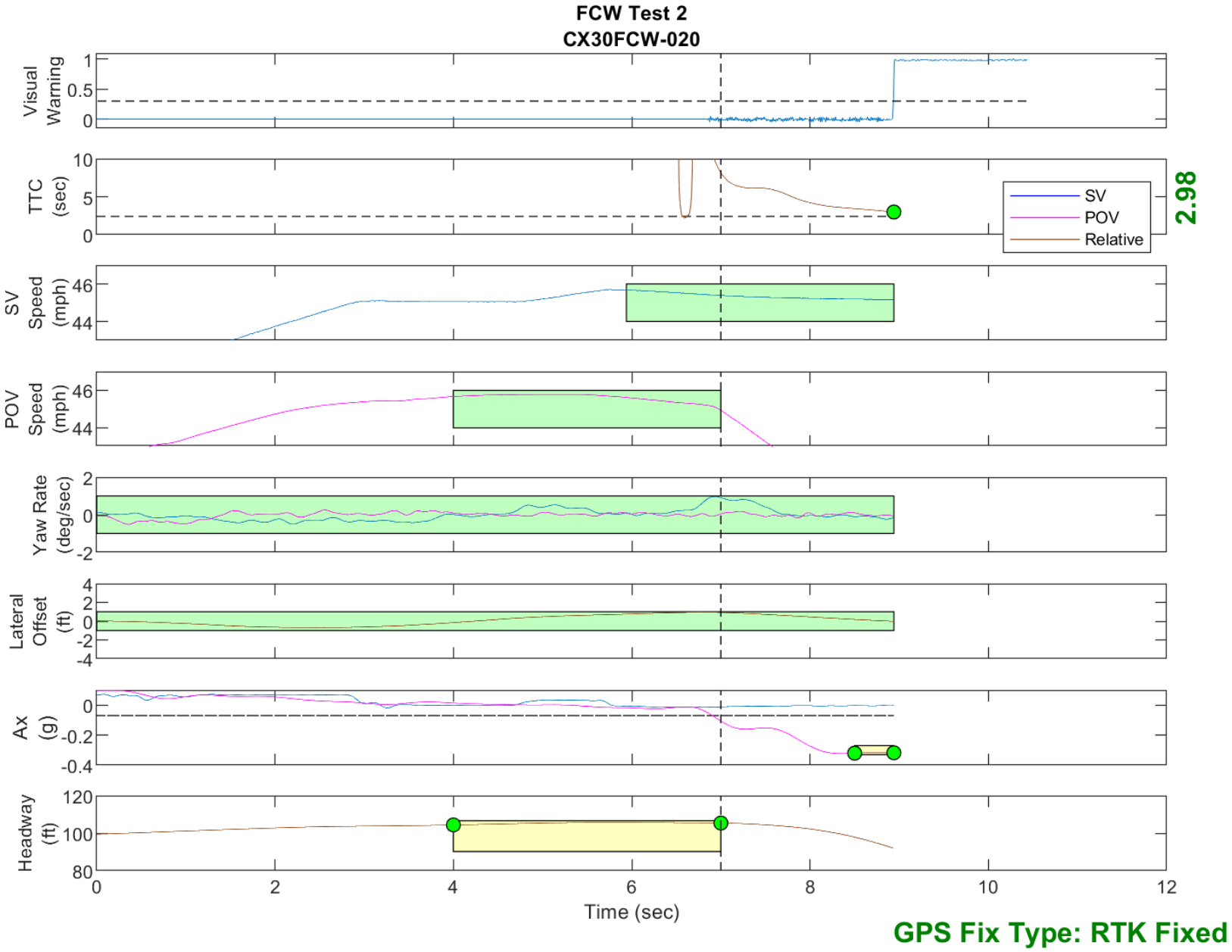


Figure D28. Time History for Run 20, FCW Test 2, Visual Warning

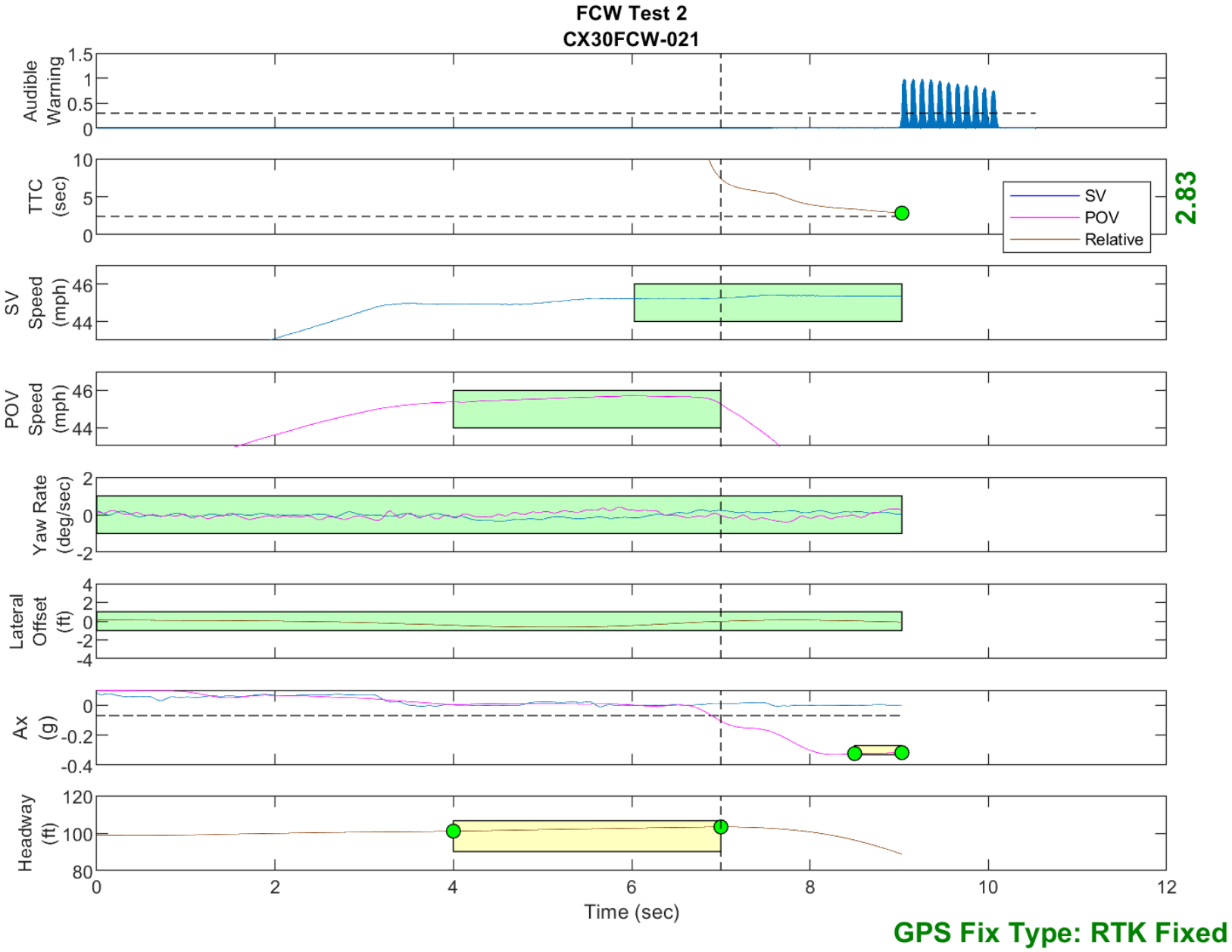


Figure D29. Time History for Run 21, FCW Test 2, Audible Warning

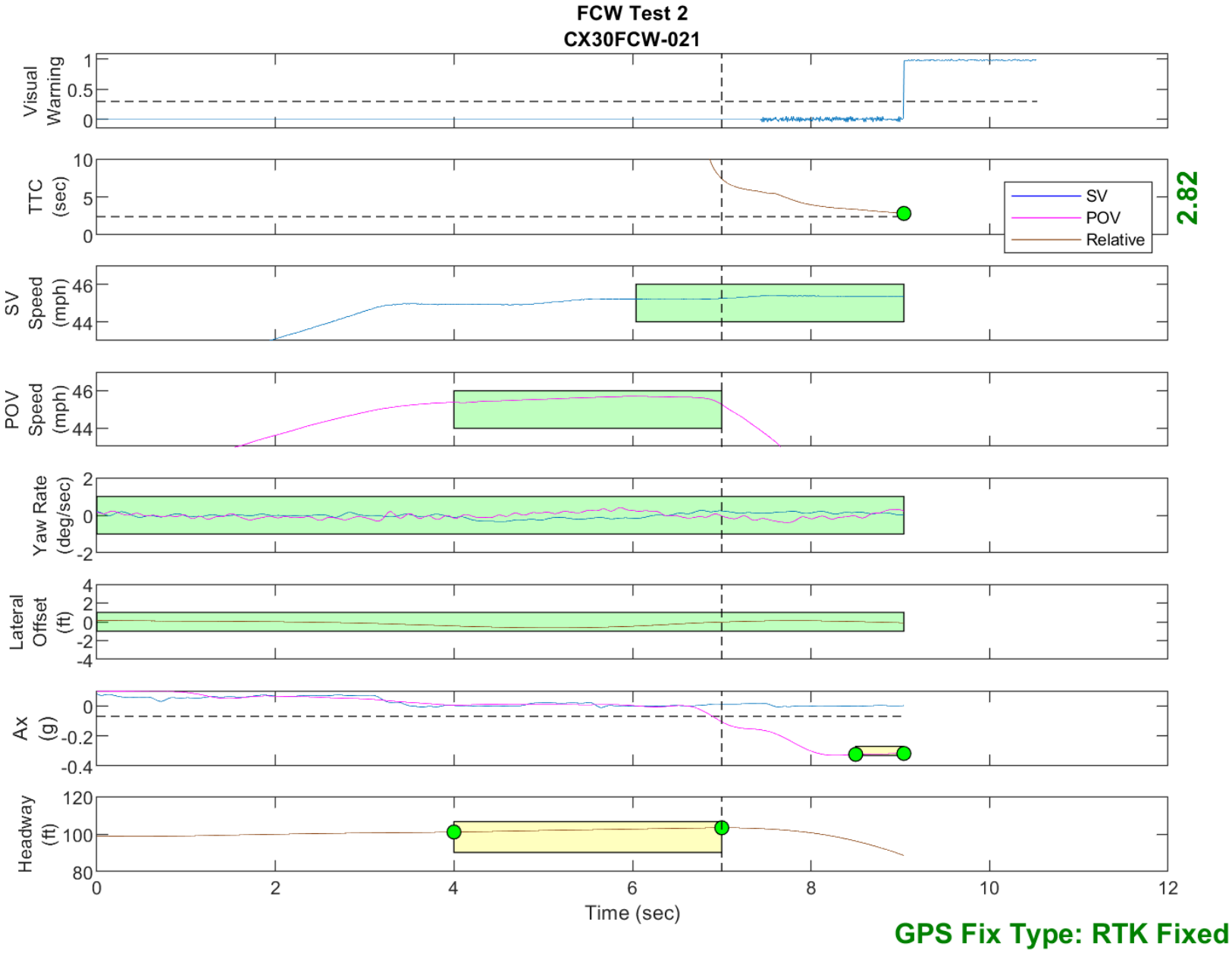


Figure D30. Time History for Run 21, FCW Test 2, Visual Warning

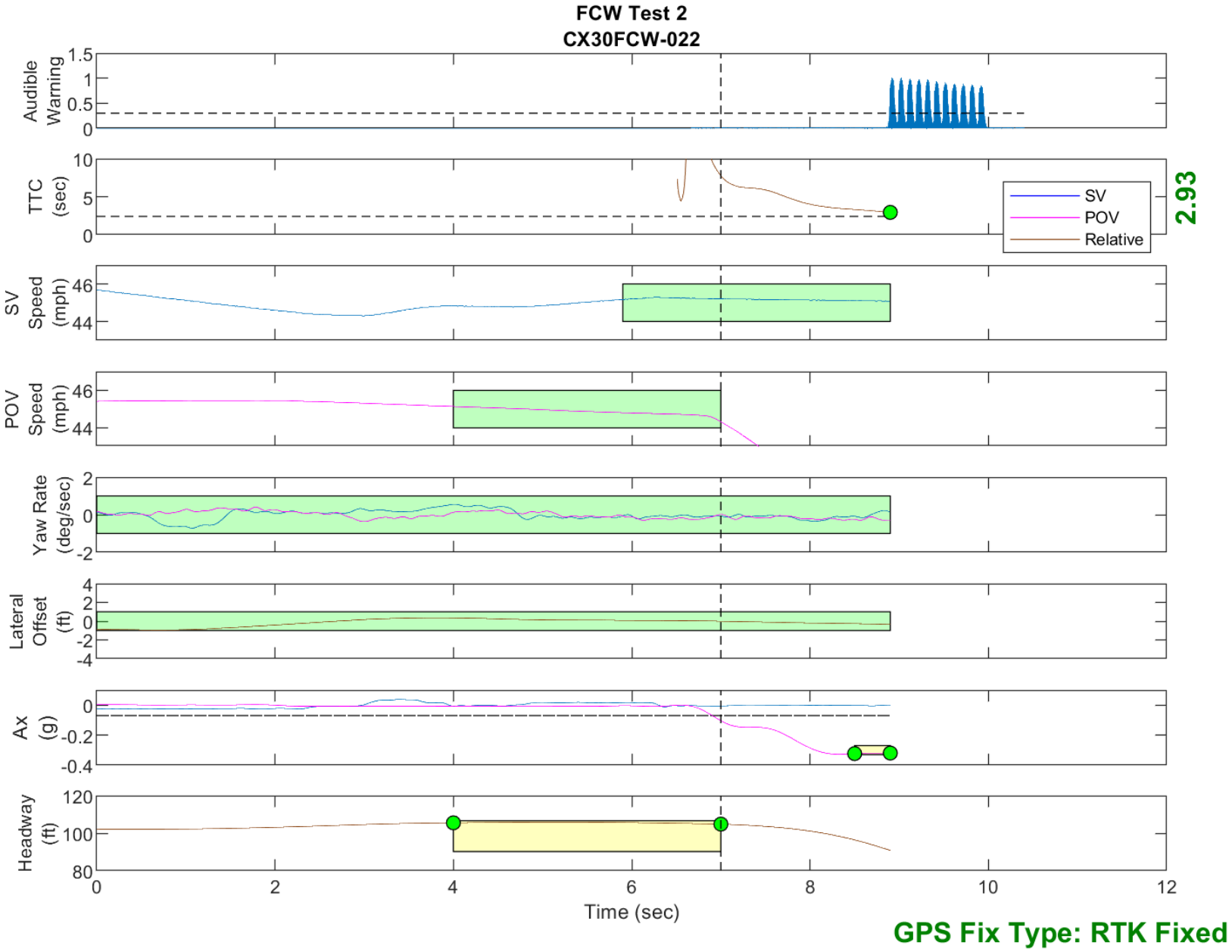


Figure D31. Time History for Run 22, FCW Test 2, Audible Warning

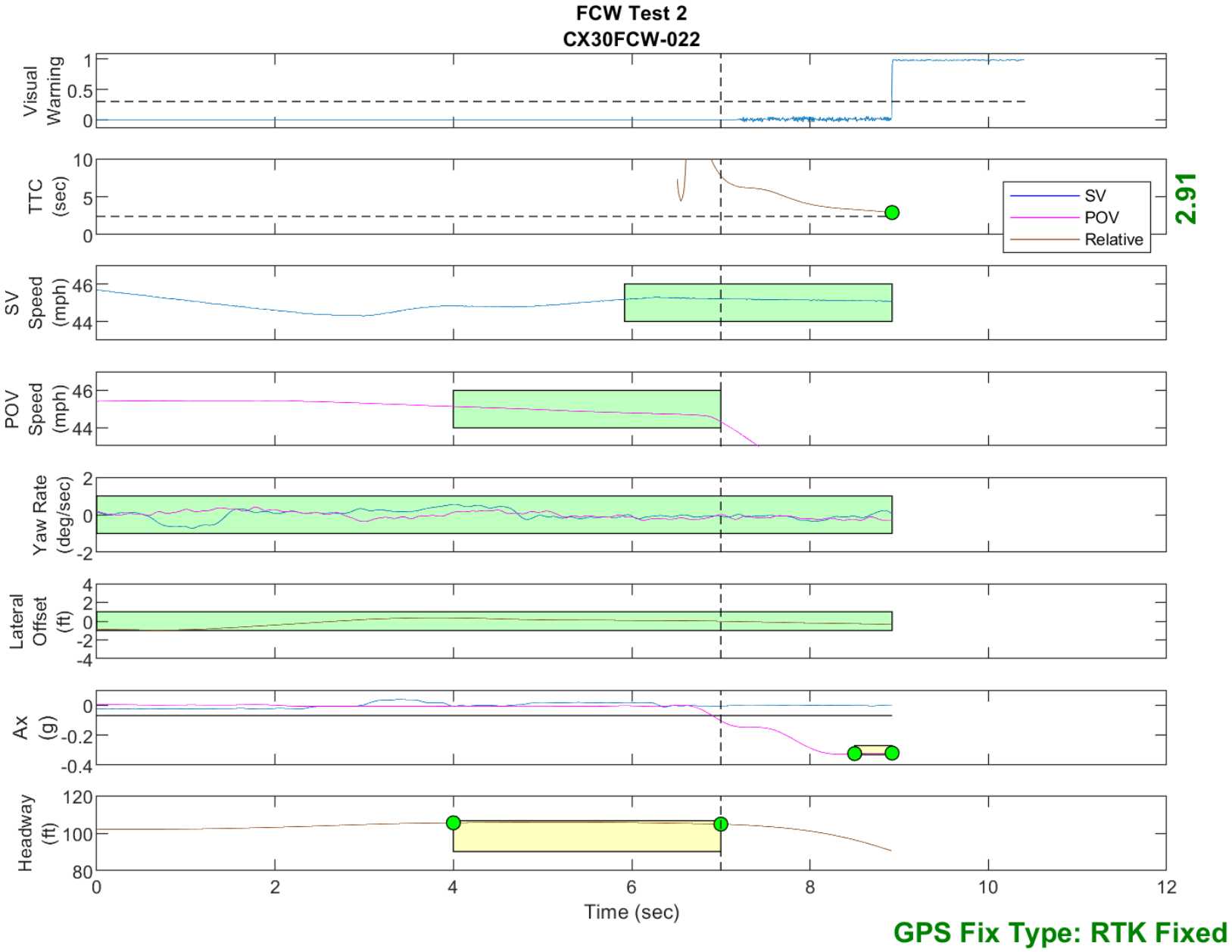


Figure D32. Time History for Run 22, FCW Test 2, Visual Warning

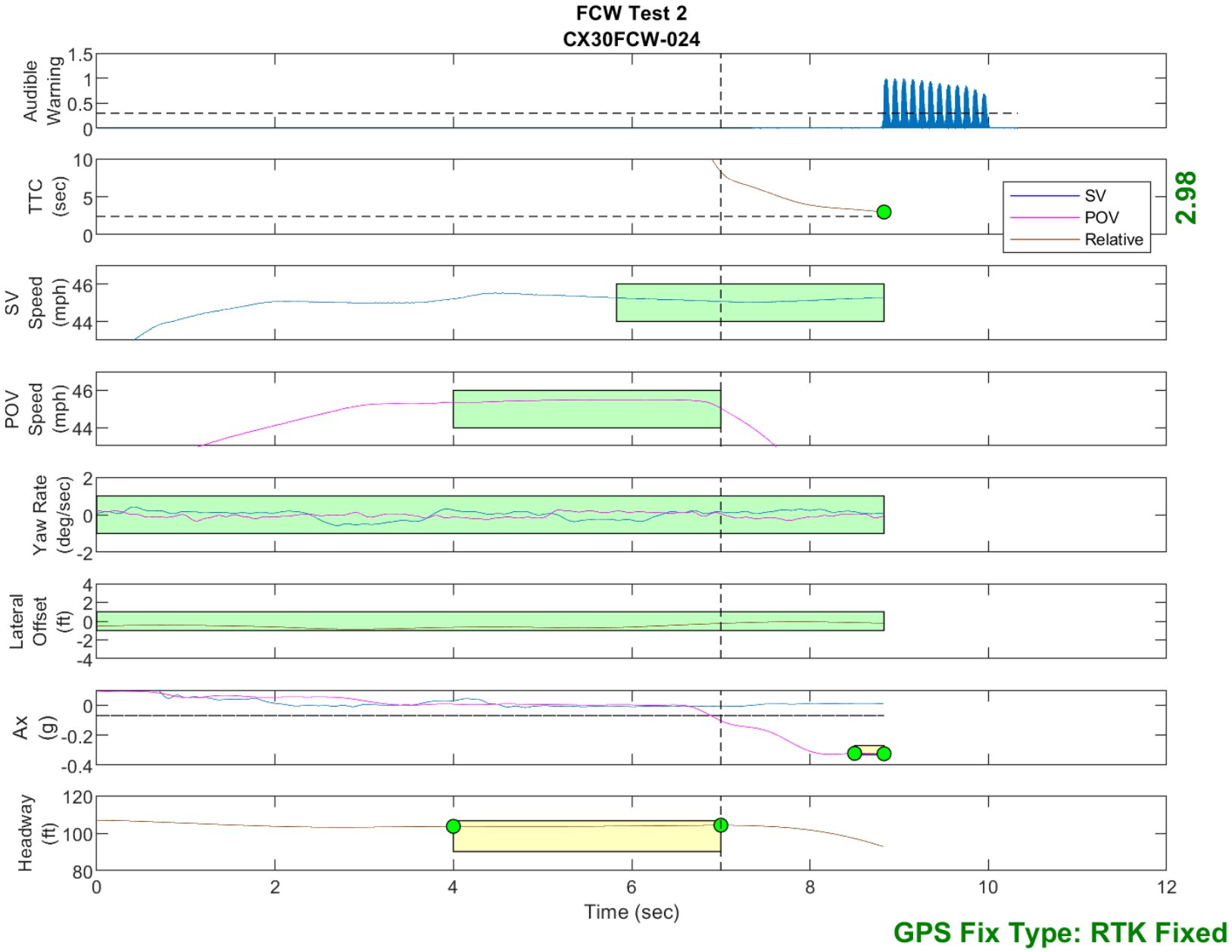


Figure D33. Time History for Run 24, FCW Test 2, Audible Warning

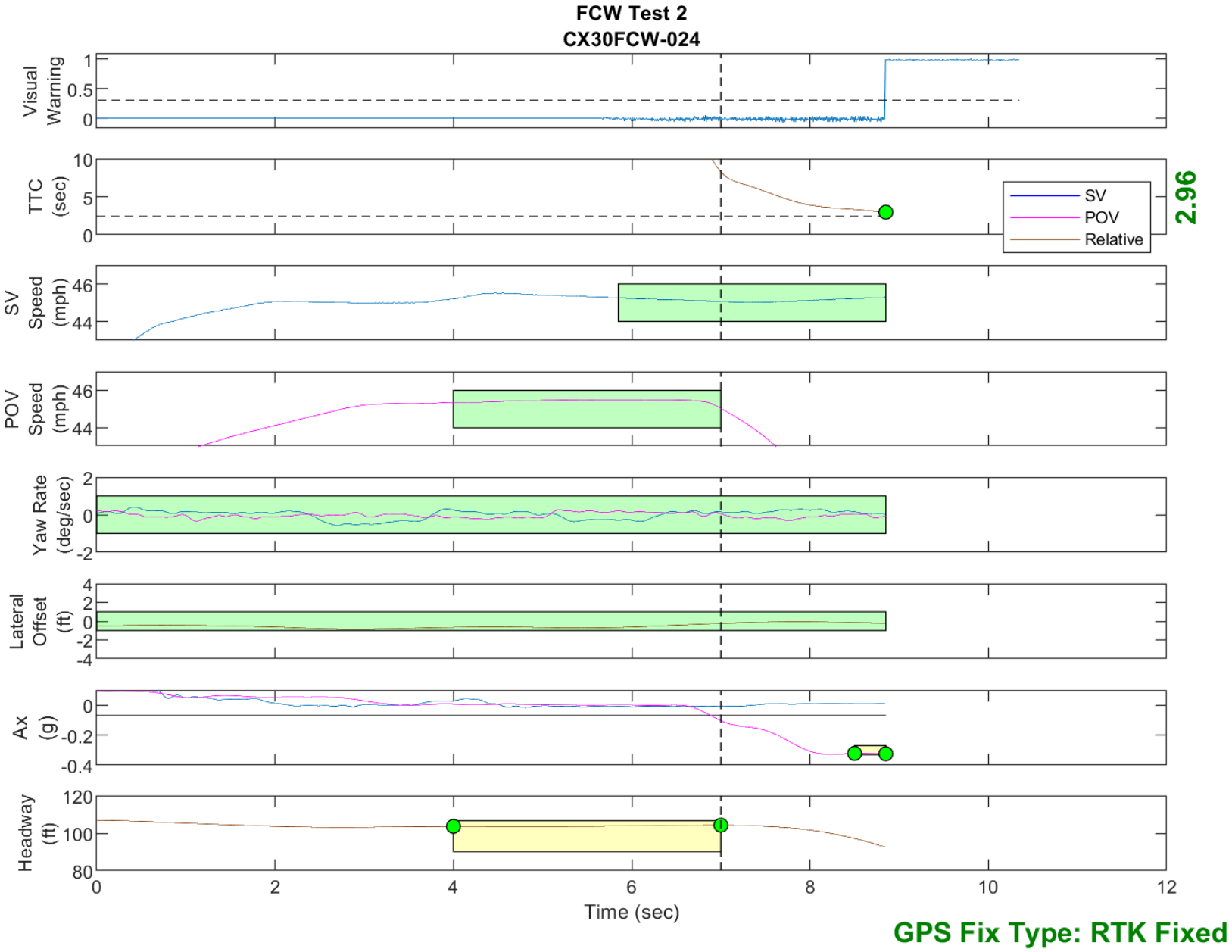


Figure D34. Time History for Run 24, FCW Test 2, Visual Warning

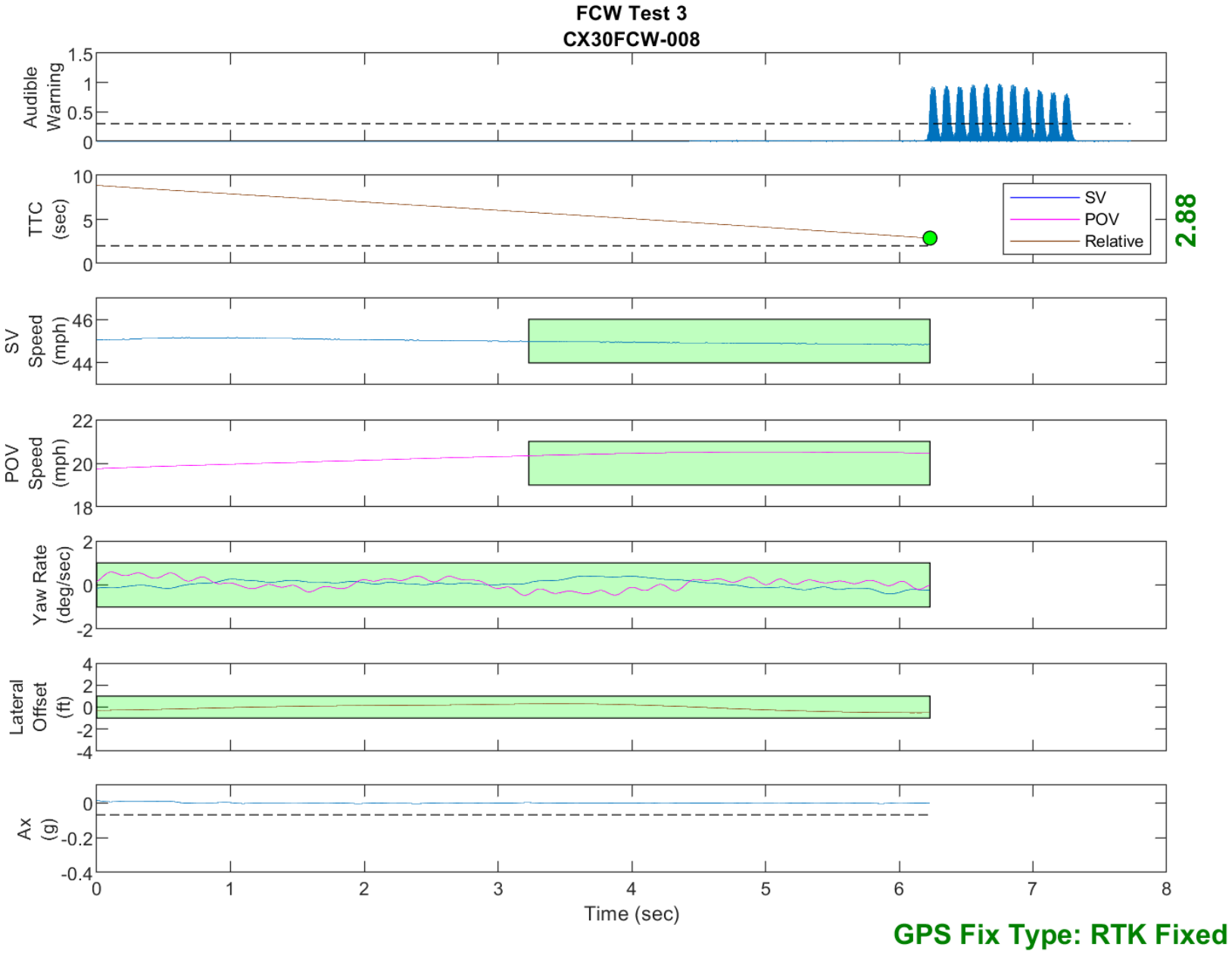


Figure D35. Time History for Run 8, FCW Test 3, Audible Warning

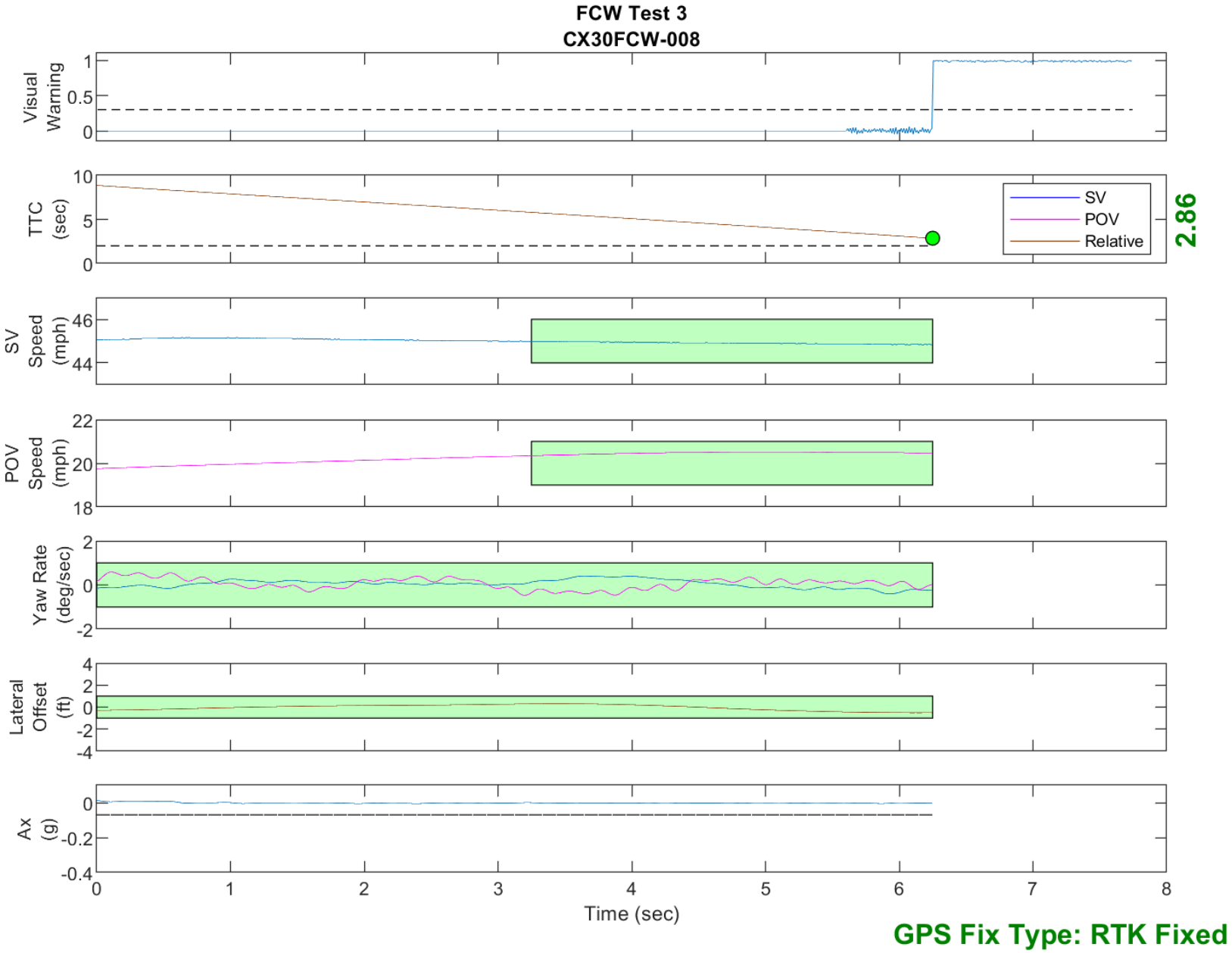


Figure D36. Time History for Run 8, FCW Test 3, Visual Warning

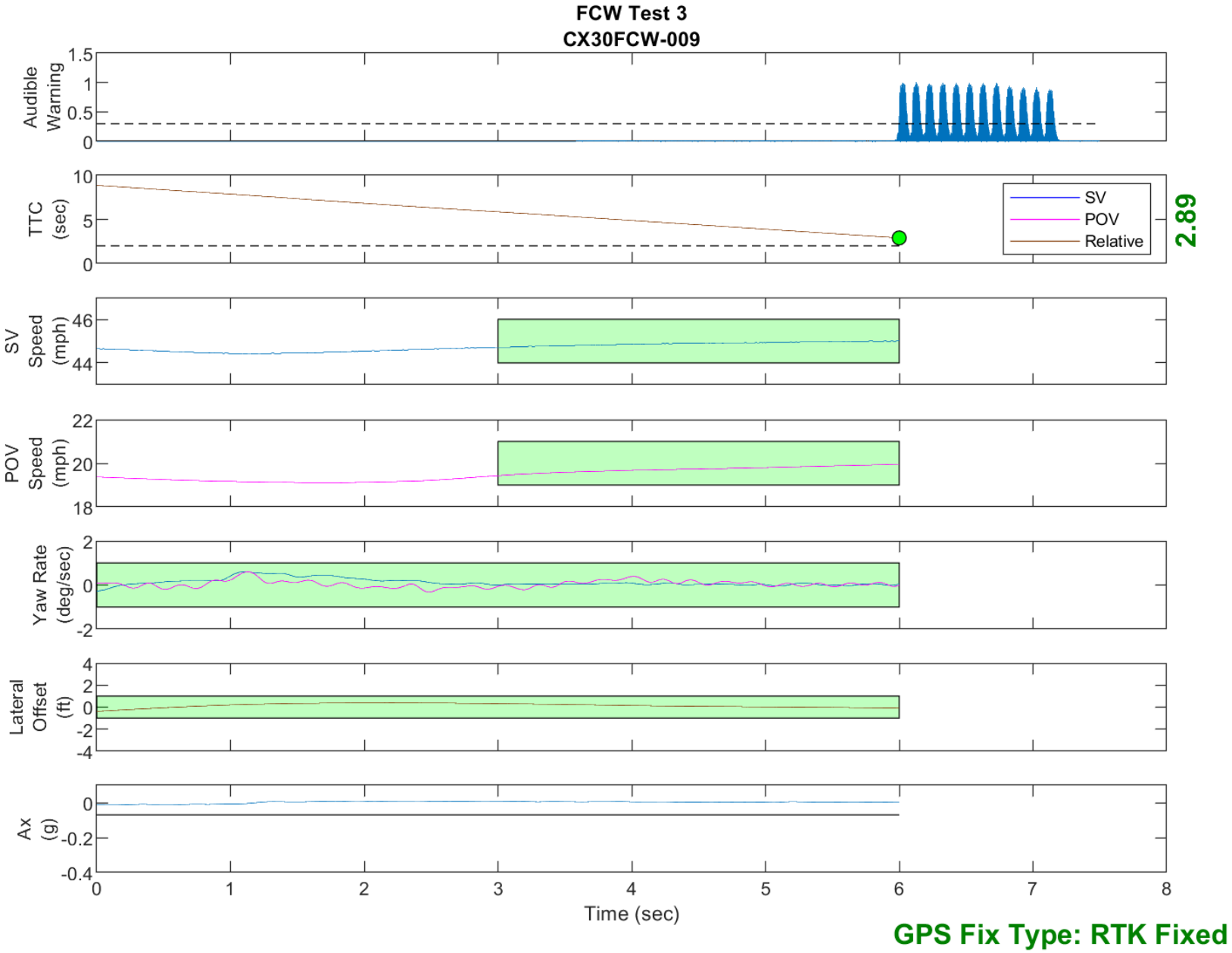


Figure D37. Time History for Run 9, FCW Test 3, Audible Warning

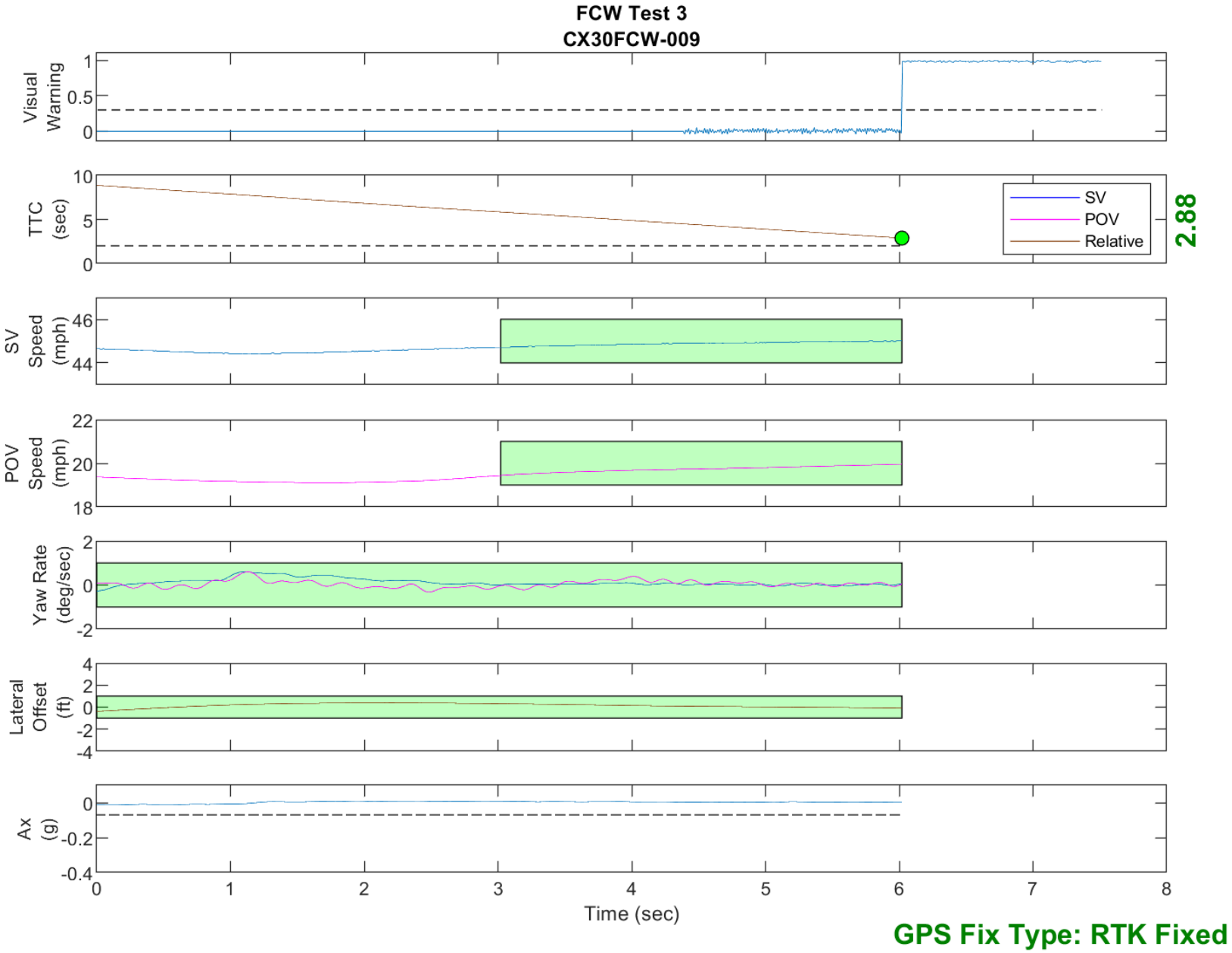


Figure D38. Time History for Run 9, FCW Test 3, Visual Warning

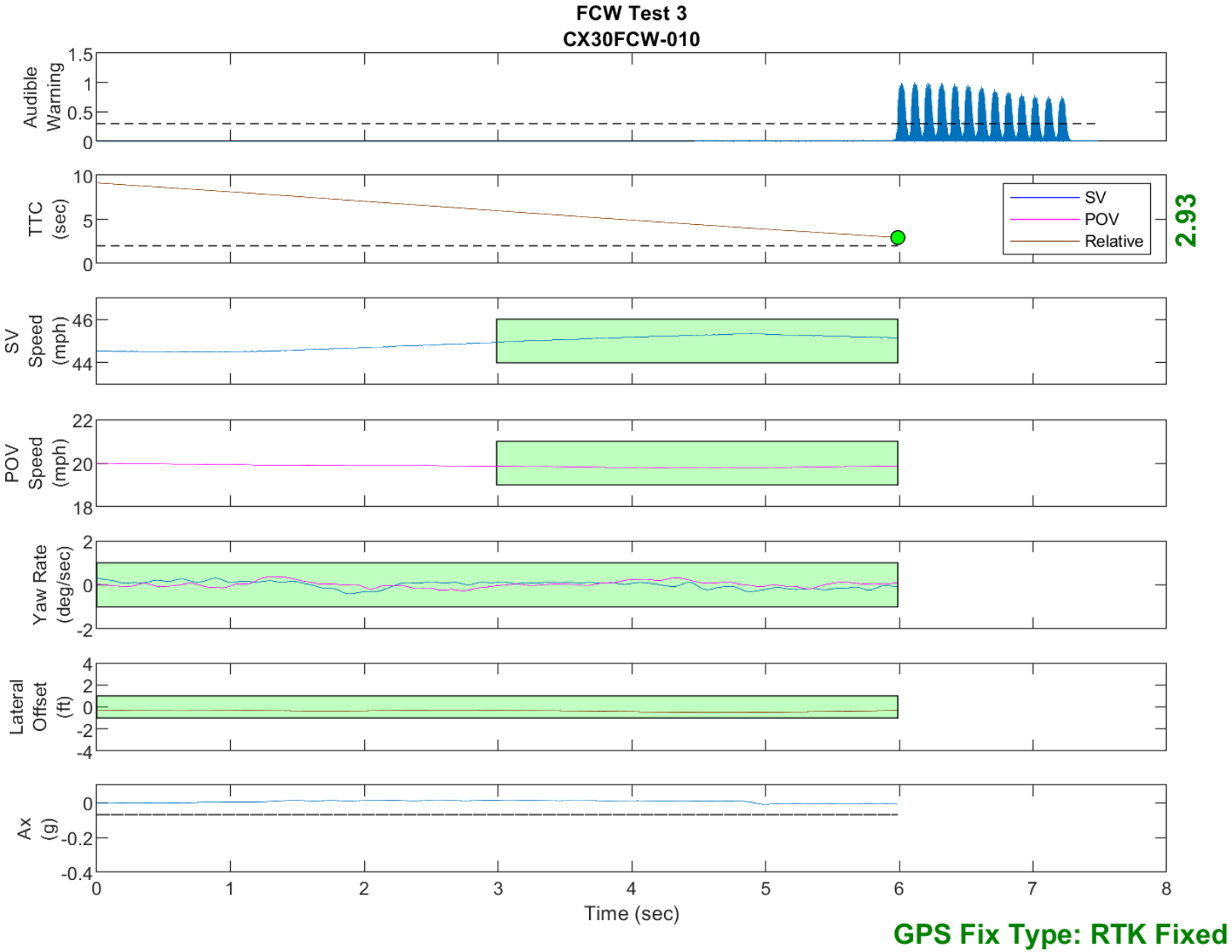


Figure D39. Time History for Run 10, FCW Test 3, Audible Warning

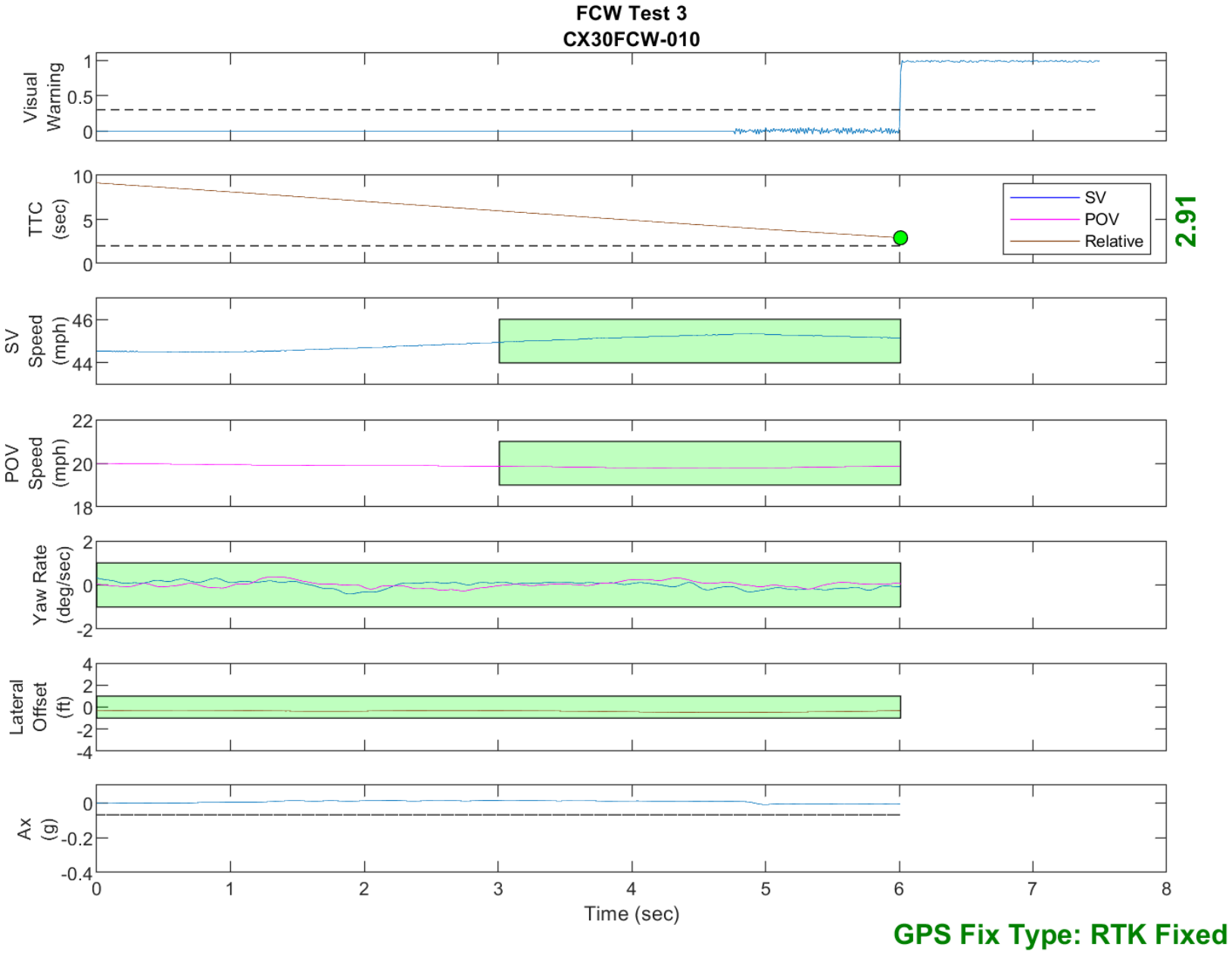


Figure D40. Time History for Run 10, FCW Test 3, Visual Warning

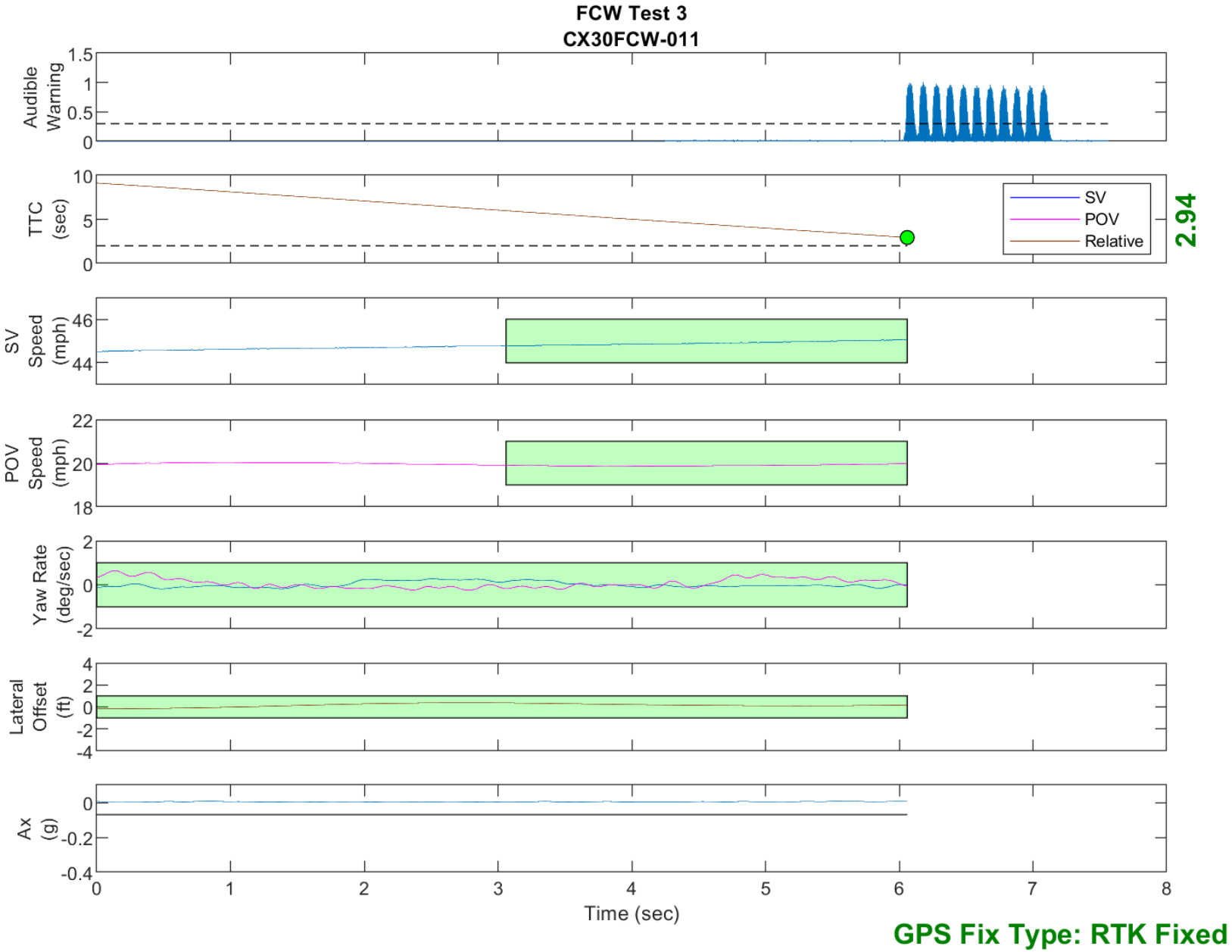


Figure D41. Time History for Run 11, FCW Test 3, Audible Warning

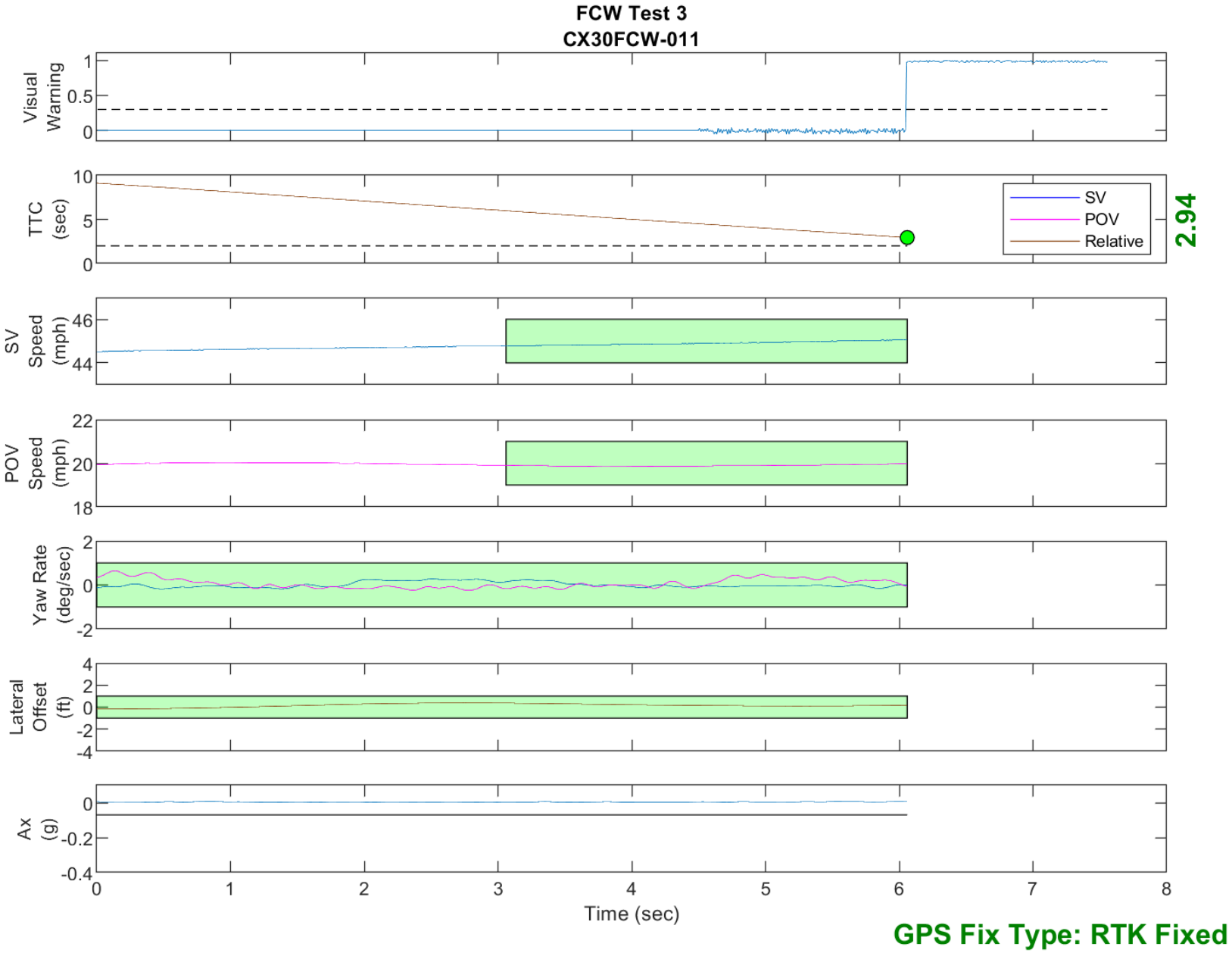


Figure D42. Time History for Run 11, FCW Test 3, Visual Warning

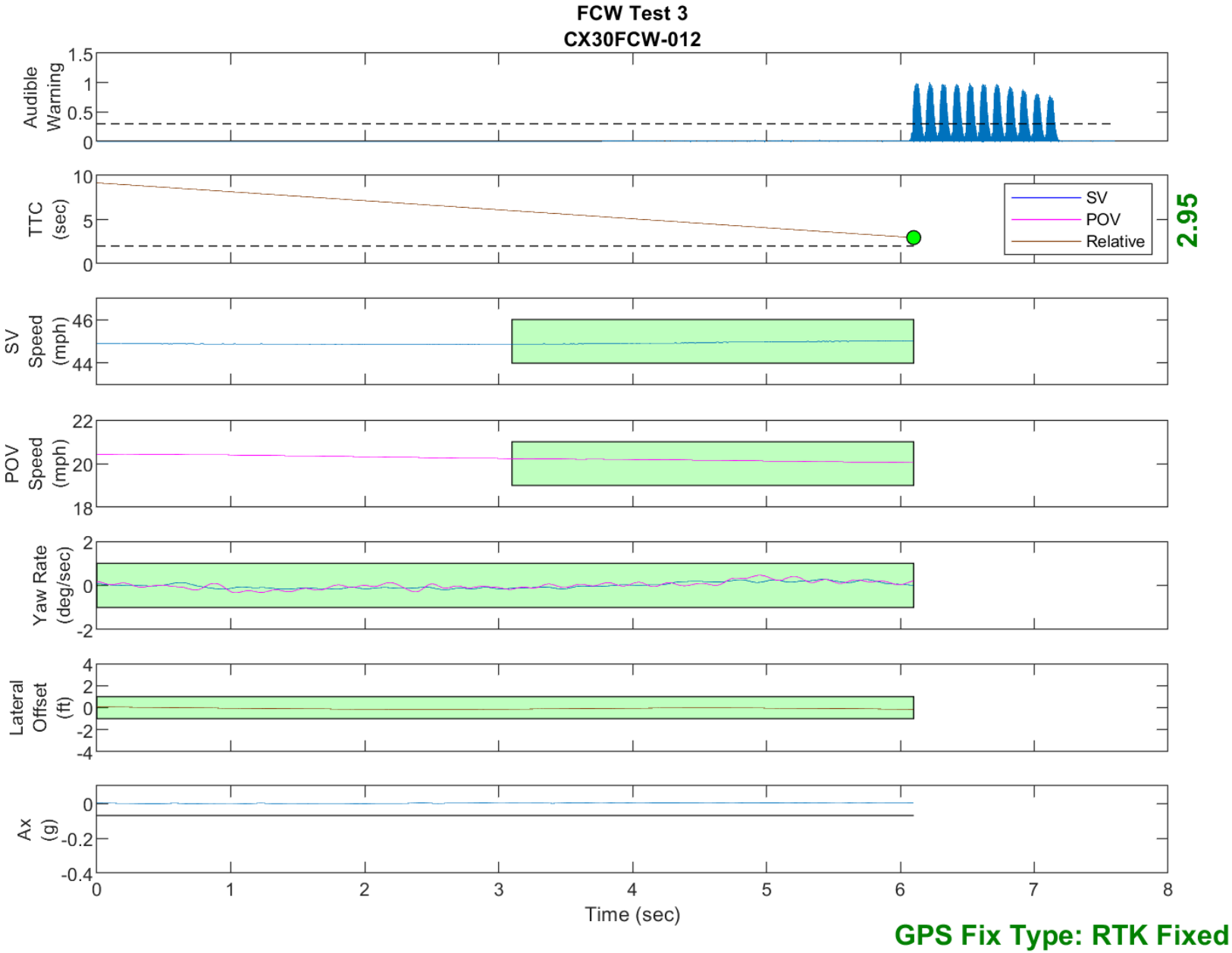


Figure D43. Time History for Run 12, FCW Test 3, Audible Warning

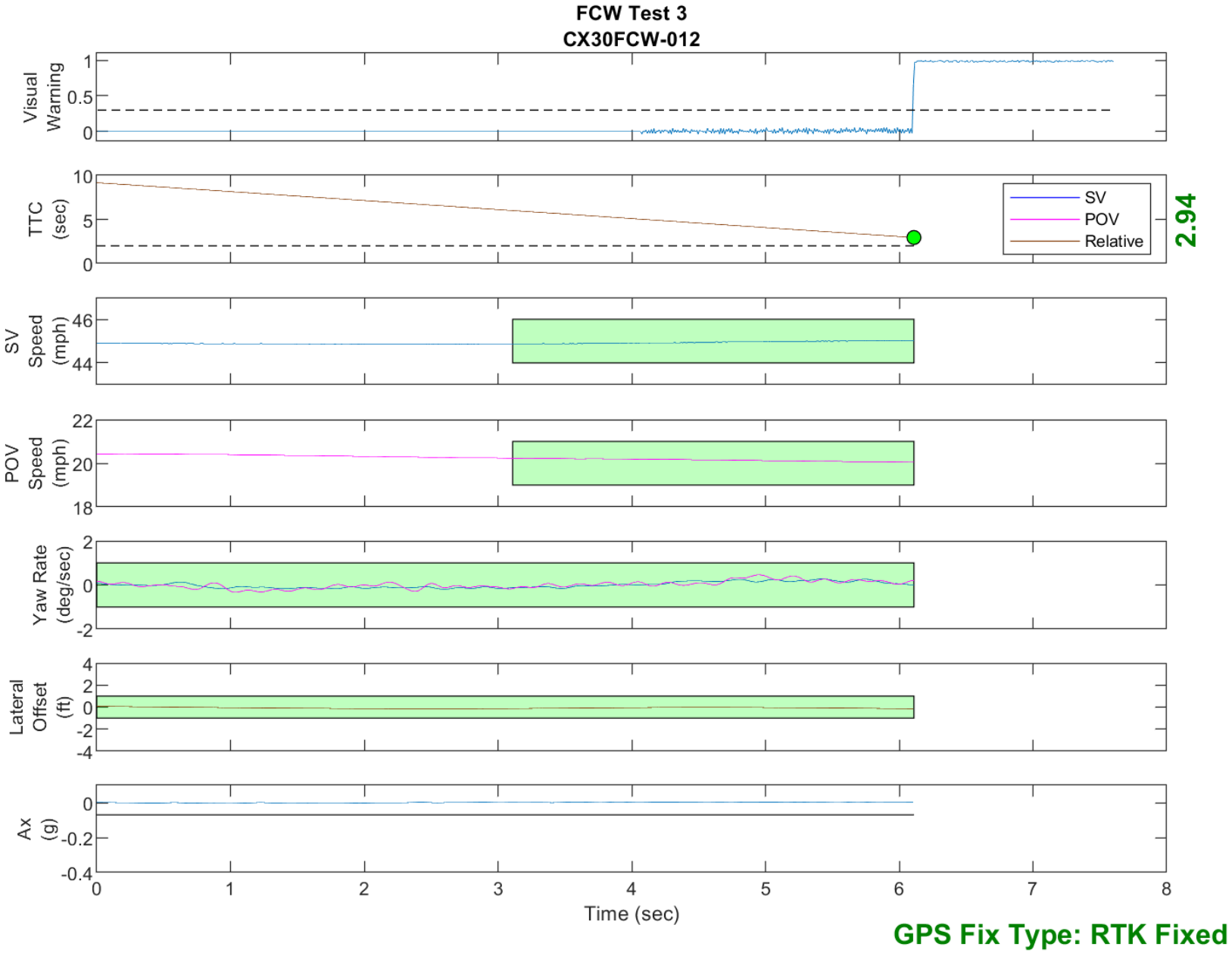


Figure D44. Time History for Run 12, FCW Test 3, Visual Warning

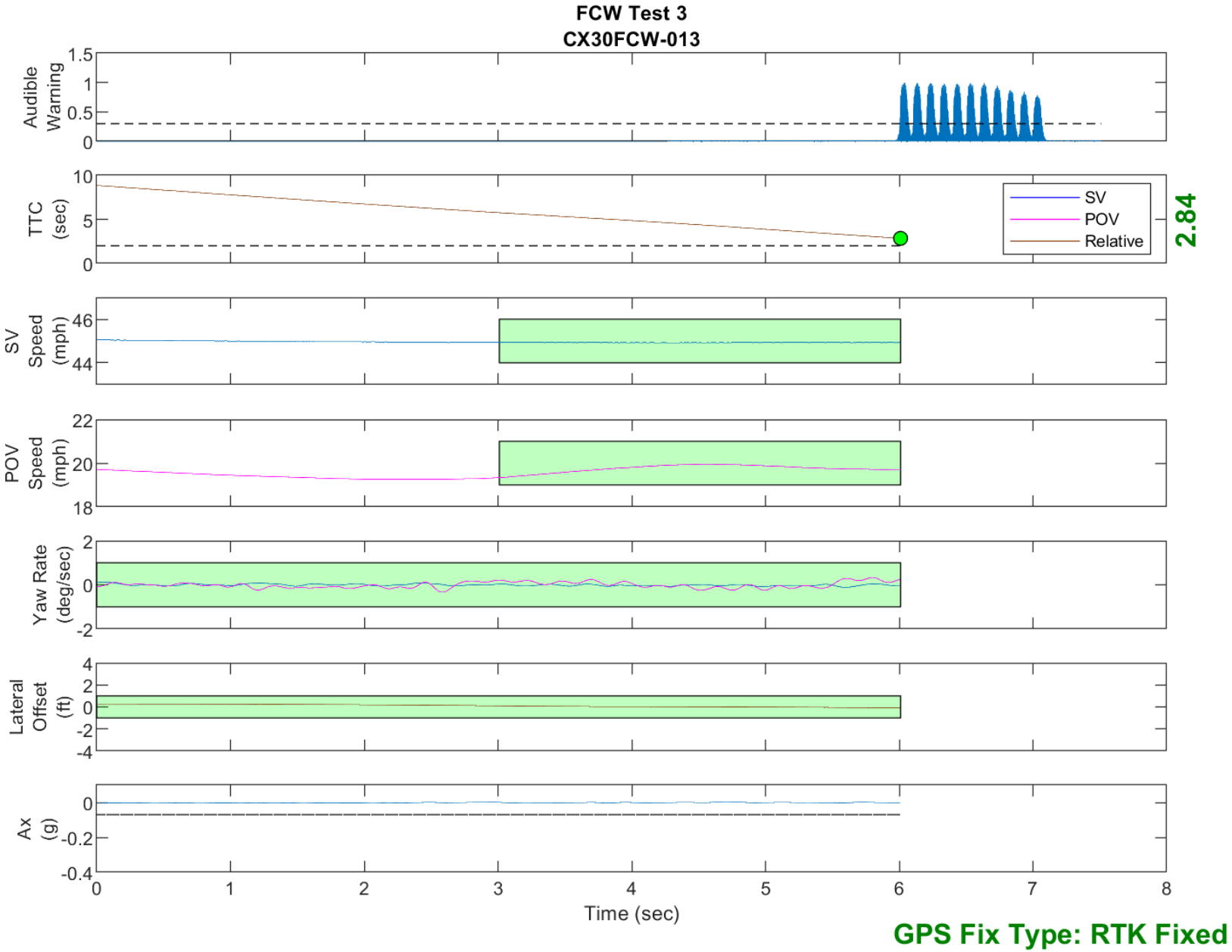


Figure D45. Time History for Run 13, FCW Test 3, Audible Warning

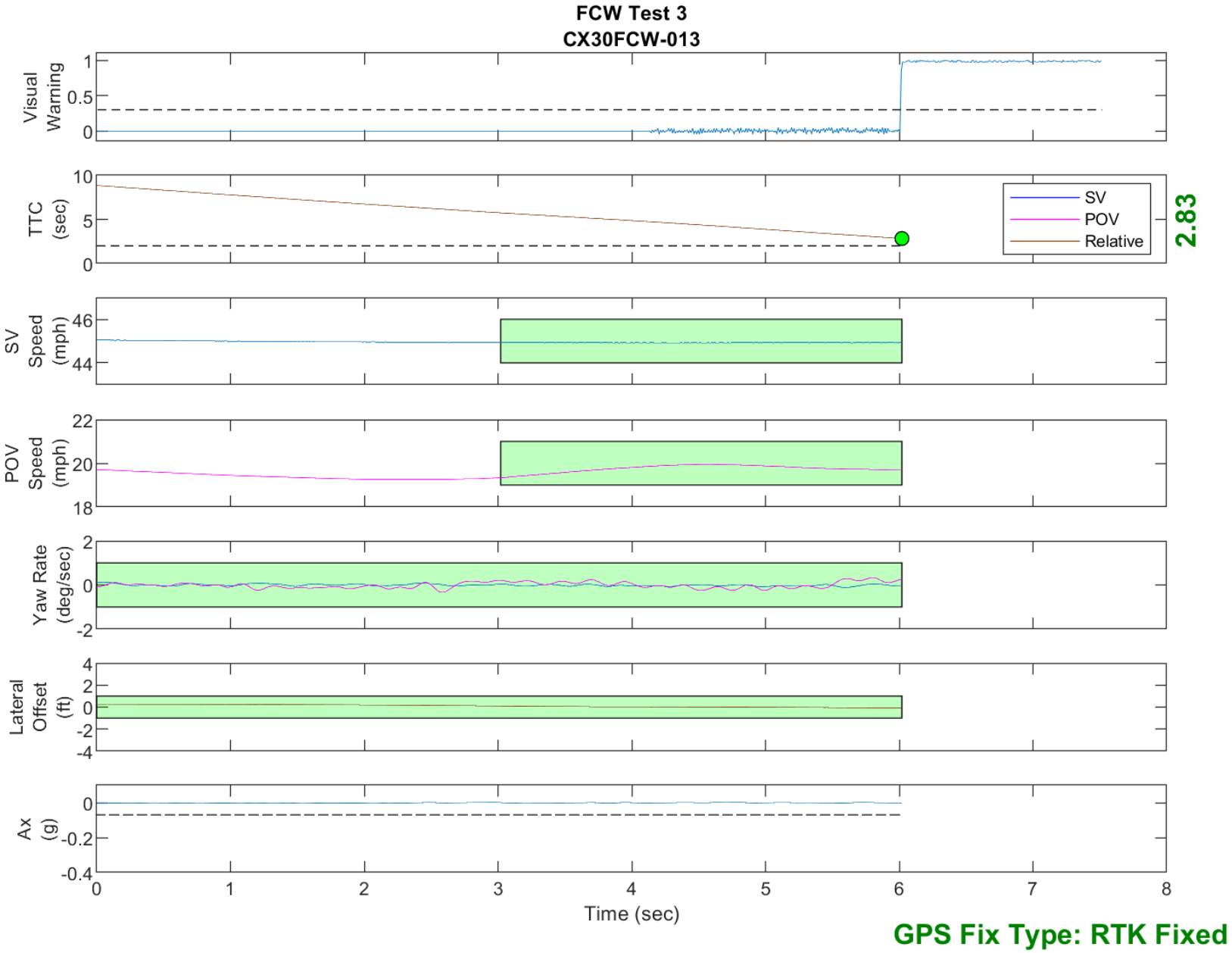


Figure D46. Time History for Run 13, FCW Test 3, Visual Warning

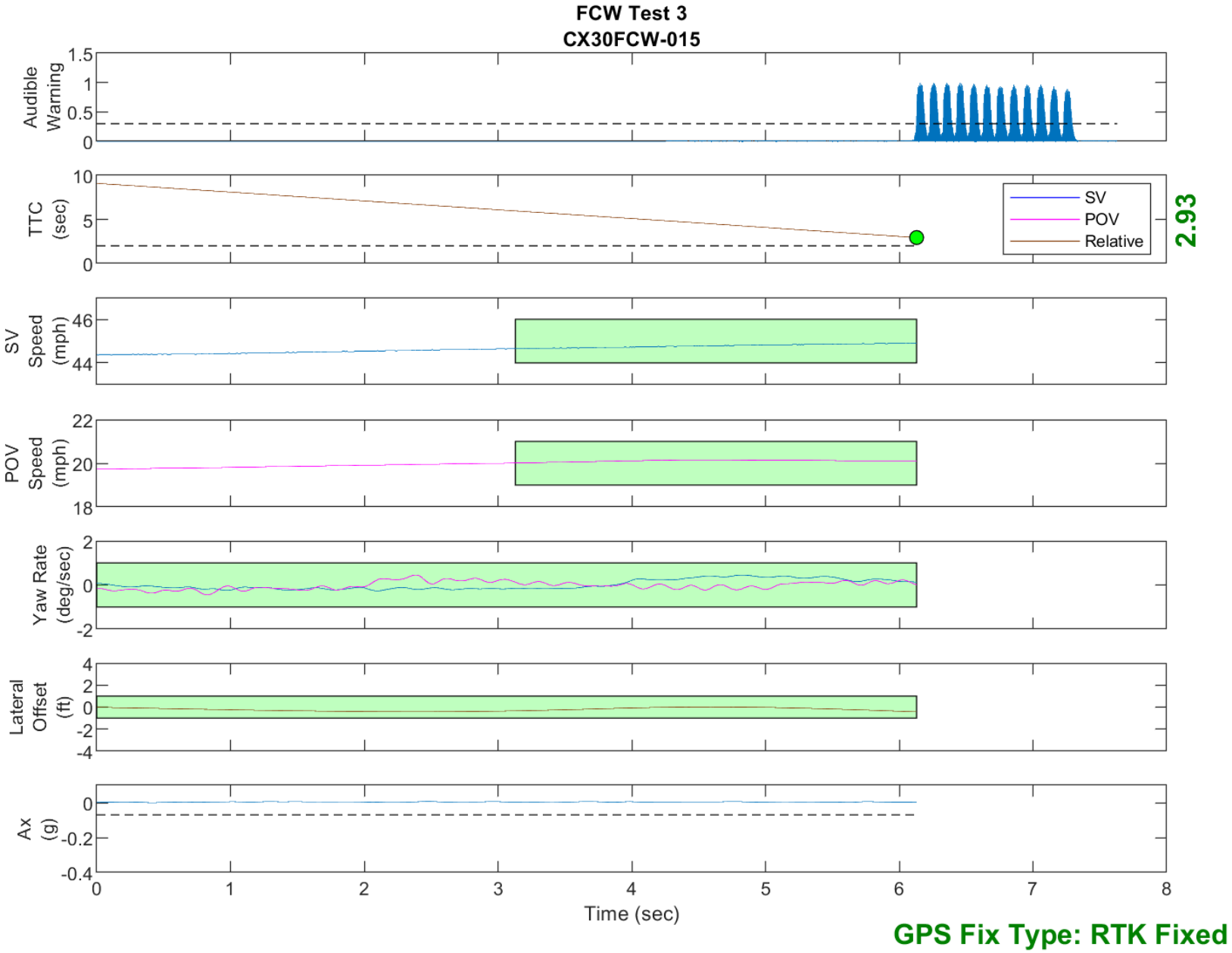


Figure D47. Time History for Run 15, FCW Test 3, Audible Warning

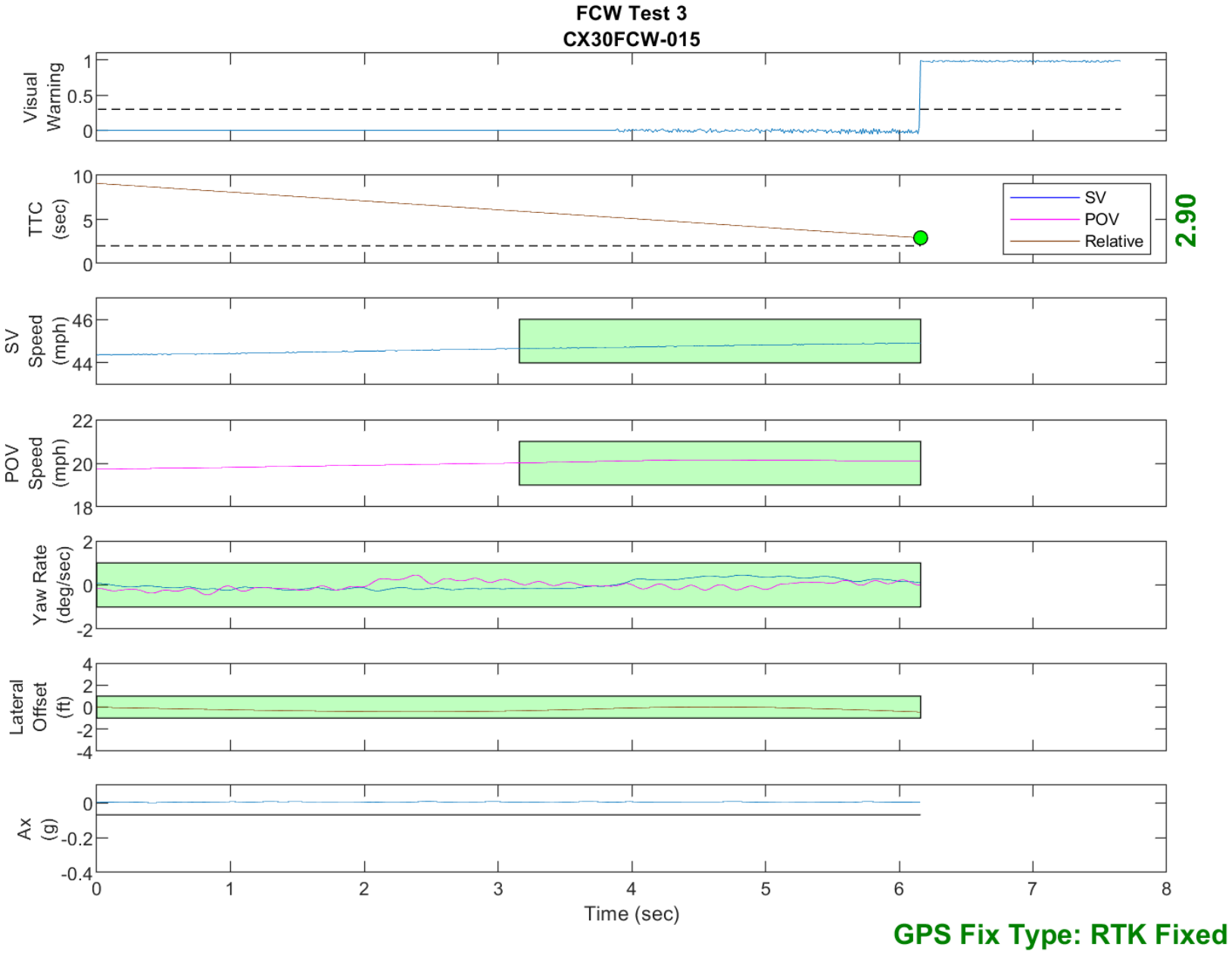


Figure D48. Time History for Run 15, FCW Test 3, Visual Warning