

**NEW CAR ASSESSMENT PROGRAM
FORWARD COLLISION WARNING CONFIRMATION TEST
NCAP-DRI-FCW-21-06**

2021 Hyundai Santa Fe 2.5L FWD

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15 April 2021

Final Report

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National Highway Traffic Safety Administration
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1200 New Jersey Avenue, SE
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Date: 15 April 2021

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16. Abstract These tests were conducted on the subject 2021 Hyundai Santa Fe 2.5L FWD 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 Principal Other Vehicle (POV) in the same lane of travel. The second test begins with the SV initially following the POV at the same constant speed. After a short while, the POV stops suddenly. The third test consists of the SV, traveling at a constant speed, approaching a slower moving POV, which is also being driven at a constant speed.

Section II
DATA SHEETS

FORWARD COLLISION WARNING
DATA SHEET 1: TEST RESULTS SUMMARY

(Page 1 of 1)

2021 Hyundai Santa Fe 2.5L FWD

VIN: 5NMS34AJ3MH32xxxx

Test Date: 3/11/2021

Forward Collision Warning settings:

Forward Safety Active Assist: Warning Only

Warning Timing: Normal

Warning Volume: Medium

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

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

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

Overall: **Pass**

Notes:

FORWARD COLLISION WARNING

DATA SHEET 2: VEHICLE DATA

(Page 1 of 1)

2021 Hyundai Santa Fe 2.5L FWD

TEST VEHICLE INFORMATION

VIN: 5NMS34AJ3MH32xxxx

Body Style: SUV

Color: Quartz White

Date Received: 3/1/2021

Odometer Reading: 83 mi

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: Hyundai Motor Manufacturing Alabama, LLC

Date of manufacture: Jan/08/21

Vehicle Type: MPV

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: 235/60R18

Rear: 235/60R18

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

Rear: 240 kPa (35 psi)

TIRES

Tire manufacturer and model: Kumho Crugen Premium

Front tire specification: 235/60R18 103H

Rear tire specification: 235/60R18 103H

Front tire DOT prefix: 000 CMYANH

Rear tire DOT prefix: 000 CMYANH

FORWARD COLLISION WARNING
DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2021 Hyundai Santa Fe 2.5L FWD

GENERAL INFORMATION

Test date: 3/11/2021

AMBIENT CONDITIONS

Air temperature: 13.3 C (56 F)

Wind speed: 3.6 m/s (8.1 mph)

X Wind speed \leq 10 m/s (22 mph).

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

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

VEHICLE PREPARATION

Verify the following:

All non-consumable fluids at 100% capacity: X

Fuel tank is full: X

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

Front: 240 kPa (35 psi)

Rear: 240 kPa (35 psi)

FORWARD COLLISION WARNING
DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2021 Hyundai Santa Fe 2.5L FWD

WEIGHT

Weight of vehicle as tested including driver and instrumentation:

Left Front: 543.0 kg (1197 lb)

Right Front: 506.7 kg (1117 lb)

Left Rear: 409.1 kg (902 lb)

Right Rear: 396.9 kg (875 lb)

Total: 1855.7 kg (4091 lb)

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 1 of 3)

2021 Hyundai Santa Fe 2.5L FWD

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

Forward Collision-Avoidance Assist (FCA). It is standard equipment.

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

Sensor fusion (radar and mono camera)

Front camera: behind the back mirror

Front radar: on center of the radiator grille

Forward Collision Warning Setting used in test:

Forward Safety Active Assist: Warning Only

Warning Timing: Normal

Warning Volume: Medium

How is the Forward Collision Warning presented to the driver? Warning light
(Check all that apply) Buzzer or auditory alarm
 Vibration
 Other _____

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

See Appendix A, Figure A15. The visual warning is presented in the center of the instrument cluster. It depicts the upper rear view of a passenger car following a lead passenger car. The initial alert (FCW) shows the words "Collision Warning" and a triangle with an exclamation point. When braking is initiated, the words change to "Emergency Braking". The auditory alert is a 1008 Hz tone pulsed at approximately 8 Hz.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 2 of 3)

2021 Hyundai Santa Fe 2.5L FWD

Is the vehicle equipped with a switch whose purpose is to render FCW inoperable? Yes
 No

If yes, please provide a full description including the switch location and method of operation, any associated instrument panel indicator, etc.

See Appendix A, Figures A12 and A14.

A menu button on the steering wheel is used to access the system menus displayed on the center touchscreen. The hierarchy is:

Vehicle Settings

Driver Assistance

Forward Safety

Select either "Active Assist", "Warning Only", or "Off"

FCA is reactivated on each ignition cycle.

Is the vehicle equipped with a control whose purpose is to adjust the range setting or otherwise influence the operation of FCW? Yes
 No

If yes, please provide a full description.

See Appendix A, Figures A13 and A14.

A menu button on the steering wheel is used to access the system menus displayed on the center touchscreen. The hierarchy is:

Vehicle Settings

Driver Assistance

Warning Timing

Select either "Normal" or "Late"

The warning volume can be adjusted in a similar manner.

FORWARD COLLISION WARNING

DATA SHEET 4: FORWARD COLLISION WARNING SYSTEM OPERATION

(Page 3 of 3)

2021 Hyundai Santa Fe 2.5L FWD

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 described in the Owner's Manual, pages 7-11 through 7-17, shown in Appendix B, pages B-17 through B-23.

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.

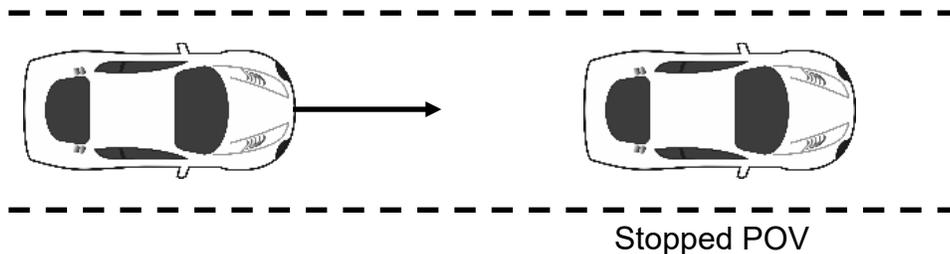


Figure 1. Depiction of Test 1

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 2.0 ft (0.6 m).
- The yaw rate of the SV could not exceed ± 1 deg/sec during the test.

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

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

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

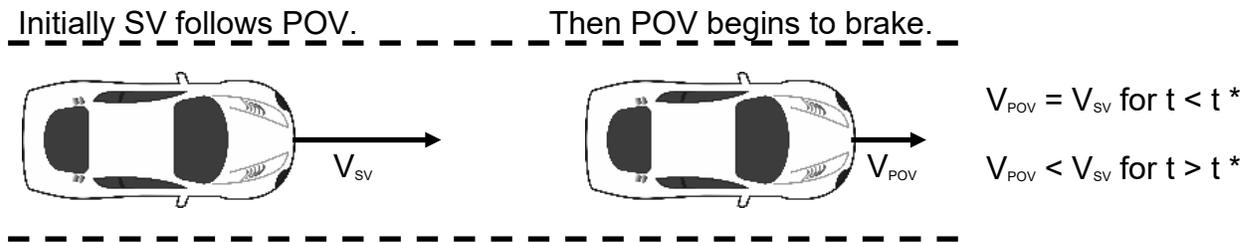


Figure 2. Depiction of Test 2

a. Alert Criteria

In order to pass the test, the FCW alert must be issued when TTC is at least 2.4 seconds. The TTC for this test, a prediction of the time it would take for the SV to collide with the POV, was calculated by considering three factors at the time of the FCW alert: (1) the speed of the SV, (2) the speed of the POV, and (3) the deceleration of the POV¹.

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.

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

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

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

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

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

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

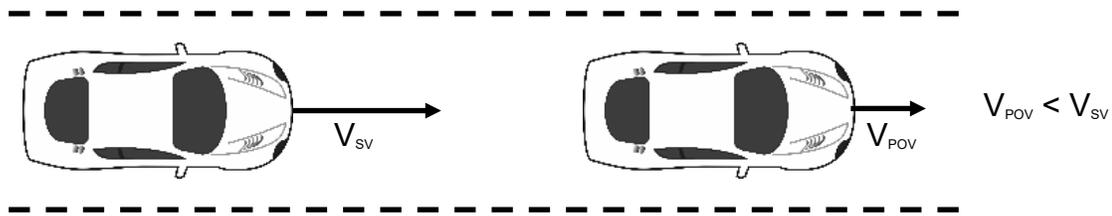


Figure 3. Depiction of Test 3

a. Alert Criteria

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

b. Procedure

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

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

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

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

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

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

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

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

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

B. Principal Other Vehicle

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

C. Automatic Braking System

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

- 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 100 psi	Omega DPG8001	17042707002	By: DRI Date: 8/18/2020 Due: 8/18/2021
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 4/20/2020 Due: 4/20/2021
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	N/A
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rate ±100 deg/s, Angle >45 deg, Velocity >200 km/h	Accels .01g, Angular Rate 0.05 deg/s, Angle 0.05 deg, Velocity 0.1 km/h			By: Oxford Technical Solutions
				SV: Oxford Inertial +	2258	Date: 5/3/2019 Due: 5/3/2021
				POV:	2182	Date: 9/16/2019 Due: 9/16/2021
Real-Time Calculation of Position and Velocity Relative to Lane Markings (LDW) and POV (FCW)	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec Longitudinal Range to POV: ±200 m Longitudinal Range Rate: ±50 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec Longitudinal Range: ±3 cm Longitudinal Range Rate: ±0.02 m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	N/A

Table 1. Test Instrumentation and Equipment (continued)

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Microphone	Sound (to measure time at auditory alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	N/A	N/A
Light Sensor	Light intensity (to measure time at visual alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	N/A	N/A
Accelerometer	Acceleration (to measure time at haptic alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	N/A	N/A
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2021 Due: 1/6/2022
Type	Description			Mfr, Model	Serial Number	
Data Acquisition System	Data acquisition is achieved using a dSPACE MicroAutoBox II. Data from the Oxford IMU, including Longitudinal, Lateral, and Vertical Acceleration, Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle are sent over Ethernet to the MicroAutoBox. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (listed above).			dSPACE Micro-Autobox II 1401/1513		
				Base Board	549068	
				I/O Board	588523	

For systems that implement auditory or haptic alerts, part of the pre-test instrumentation verification process is to determine the tonal frequency of the auditory warning or the vibration frequency of the tactile warning through use of the PSD (Power Spectral Density) function in Matlab. This is accomplished in order to identify the center frequency around which a band-pass filter is applied to subsequent auditory or tactile warning data so that the beginning of such warnings can be programmatically determined. The band-pass filter used for these warning signal types is a phaseless, forward-reverse pass, elliptical (Cauer) digital filter, with filter parameters as listed in Table 2.

Table 2. Auditory and Tactile Warning Filter Parameters

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

APPENDIX A

Photographs

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Figure A1. Front View of Subject Vehicle



Figure A2. Rear View of Subject Vehicle



2021 SANTA FE SEL 2.5L FWD

SOLD TO: _____ SHIPPED TO: _____

VIN: 5NMS34AJ3MH32
 MODEL: 644D2F4S
 ENGINE: G4KNMK08B
 PORT OF ENTRY: MA
 EXTERIOR COLOR: QUARTZ WHITE
 INTERIOR/SEAT COLOR: BLACK/BLACK
 TRANSPORT: TRUCK
 ACCESSORY WEIGHT: 0 lbs./ 0 kgs.
 EMISSIONS: This vehicle meets California Emissions regulations and is Certified as a Super Ultra Low Emission Vehicle (SULEV)

GOVERNMENT 5-STAR SAFETY RATINGS

Overall Vehicle Score		Not Rated
Based on the combined rating of frontal, side and rollover. Should ONLY be compared to other vehicles of similar size and weight.		
Frontal	Driver	Not Rated
Crash	Passenger	Not Rated
Based on the risk of injury in a frontal impact. Should ONLY be compared to other vehicles of similar size and weight.		
Side	Front seat	Not Rated
Crash	Rear seat	Not Rated
Based on the risk of injury in a side impact.		
Rollover		★★★★
Based on the risk of rollover in a single-vehicle crash.		

Star ratings range from 1 to 5 stars (★★★★) with 5 being the highest.
 Source: National Highway Traffic Safety Administration (NHTSA).
www.safercar.gov or 1-888-327-4236

STANDARD FEATURES:
AMERICA'S BEST WARRANTY
 5-year/60,000-mile New Vehicle Warranty*
 10-year/100,000-mile Powertrain Warranty*
 7-year/Unlimited-mile Anti-perforation Warranty*
 3-year/36,000-mile Complimentary Maintenance*
 5-year/Unlimited-mile Roadside Assistance
 *Limited warranties, see dealer for details
ADVANCED SAFETY TECHNOLOGY
 Forward Collision-Avoidance Assist, Safe Exit Assist
 Blind-Spot Collision-Avoidance Assist, High Beam Assist
 Rear Cross-Traffic Collision-Avoidance Assist, Immobilizer
 Lane Keeping Assist, Driver Attention Warning
 Rear Occupant Alert, Smart Cruise Control with Stop & Go
 Rear View Monitor, Lane Following Assist
POWERTRAIN TECHNOLOGY
 Smartstream 2.5L 4-Cylinder Engine w/ GDI and MPI
 8-speed Automatic Transmission with SHIFTRONIC®
 Electronic Parking Brake, Hillstart Assist Control
 Idle, Stop & Go (ISG)
EXTERIOR
 18" Alloy Wheels
 LED Daytime Running Lights
 Automatic LED Headlights and Chrome Accent Front Grille
 Privacy Rear Glass, Heated Side Mirrors
 Variable Intermittent Front Windshield Wipers
 Roof Side Rails
COMFORT & CONVENIENCE
 Cloth Seats, Heated Front Seats
 8-way Power Driver Seat plus Lumbar Support
 60/40 Split 2nd Row Fold-flat Seats
 Power Door Locks and Windows with Front Auto-Down/Up
 Air Conditioning, Rear Air Vents
 TB- & Telescoping Steering Wheel w/ Audio/Cruise/Phone Ctl's
 Proximity Key with Push Button Start
 Cargo Area Underfloor Storage, Temporary Compact Spare Tire
 8" Display Audio with Android Auto (TM) & Apple CarPlay (TM)
 AM/FM/HD Radio/SiriusXM® Audio System, 12V Power Outlets
 SiriusXM® w/90 Day Trial, Not Available in AK & HI
 Dual FR and RR USB Outlets, Bluetooth® Hands-free System
 Multi-Information Display, Wireless Device Charging
 Blue Link® Connected Services 3-years Standard (enrollment req)
 Blue Link Remote Start (3-year Complimentary Service)
 Full Tank of Fuel

Manufacturer's Suggested Retail Price:	\$28,650.00
ADDED FEATURES:	
*QUARTZ WHITE(W/W) Paint	\$350.00
*Convenience Package:	\$1,800.00
Ultrasonic Rear Occupant Alert	
12.3" Digital Instrument Cluster	
LED Taillights, Puddle Lamps	
Side Mirrors with Turn Signal Indicators	
Hands-Free Smart Liftgate	
Power Release 2nd Row Seats	
Dual Automatic Temperature Control	
Leather-Wrapped Steering Wheel	
Rear Side Window Sunshades	
Hyundai Digital Key	
Auto-dimming Rearview Mirror w/ HomeLink®	
*Premium Package:	\$3,950.00
Panoramic Sunroof, LED Interior Lights	
Leather Seating Surfaces, Power Passenger Seat	
10.25" Navigation System, Highway Drive Assist	
Rear Seat Quiet Mode, Premium Door Sill Plate	
Hamam Kardon® Premium Audio System	
*Cargo Package	\$200.00
Cargo Tray, Cargo Net & First Aid Kit	
*Carpeted Floor Mats	\$155.00
*Cargo Cover	\$190.00
*Rear Bumper Appliqué	\$75.00
*Wheel Locks	\$65.00
Inland Freight & Handling:	\$1,185.00
Total Price :	\$36,620.00



EPA DOT Fuel Economy and Environment Gasoline Vehicle

Fuel Economy

26 MPG
 combined city/hwy

25 city
 28 highway

3.8 gallons per 100 miles

Small SUVs range from 16 to 125 MPG. The best vehicle rates 141 MPGe.

You spend \$250
 more in fuel costs over 5 years compared to the average new vehicle.

Annual fuel cost \$1,550

Fuel Economy & Greenhouse Gas Rating (tailpipe only) **5**

Smog Rating (tailpipe only) **7**

This vehicle emits 344 grams CO₂ per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel also create emissions; learn more at fuelconomy.gov.

Actual results will vary for many reasons, including driving conditions and how you drive and maintain your vehicle. The average new vehicle gets 27 MPG and costs \$7,500 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at \$2.70 per gallon. MPGe is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

fuelconomy.gov
 Calculate personalized estimates and compare vehicles

Smartphone QR Code

Manufacturer's suggested retail price includes manufacturer's recommended pre-delivery service. Gasoline license and title fees state and local taxes and dealer installed options and accessories are not included in the manufacturer's suggested retail price. This label has been affixed to this vehicle by Hyundai Motor America, pursuant to the requirements of 15 U.S.C. 1231 et seq. which prohibits its removal or alteration prior to delivery to the ultimate purchaser.

PARTS CONTENT INFORMATION FOR VEHICLE IN THIS CARLINE:
U.S./CANADIAN PARTS CONTENT: 51 %
MAJOR SOURCES OF FOREIGN PARTS CONTENT: KOREA: 38 %

Note: Parts content does not include final assembly, distribution, or other non-parts costs.

FOR THIS VEHICLE:
FINAL ASSEMBLY POINT: MONTGOMERY, ALABAMA U.S.A.
COUNTRY OF ORIGIN:
ENGINE: U.S.A.
TRANSMISSION: U.S.A./KOREA

9 A 1

Figure A3. Window Sticker (Monroney Label)



MANUFACTURED BY
HYUNDAI MOTOR MANUFACTURING ALABAMA, LLC

Jan/08/21	GVWR 5137 lbs	PAINT WW8	TRIM NNB
GAWR	TIRES	RIMS	COLD TIRE INFL
FRONT 2866 lbs	235/60R18	7.5JX18	35 psi SINGLE
REAR 2976 lbs	235/60R18	7.5JX18	35 psi SINGLE

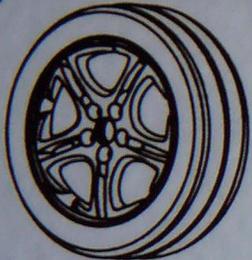
THIS VEHICLE CONFORMS TO ALL APPLICABLE U.S.A. FEDERAL
MOTOR VEHICLE SAFETY AND THEFT PREVENTION STANDARDS
IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE

V.I.N 5NMS34AJ3MH32

TYPE: MPV



Figure A4. Vehicle Certification Label



TIRE AND LOADING INFORMATION
RENSEIGNEMENTS SUR LES PNEUS ET LE CHARGEMENT

SEATING CAPACITY NOMBRE DE PLACES	TOTAL 5	FRONT AVANT 2	REAR ARRIÈRE 3
--------------------------------------	---------	------------------	-------------------

The combined weight of occupants and cargo should never exceed 480 kg or 1058 lbs.
 Le poids total des occupants et du chargement ne doit jamais dépasser 480 kg ou 1058 lb.

TIRE PNEU	SIZE DIMENSIONS	COLD TIRE PRESSURE PRESSION DES PNEUS À FROID
FRONT AVANT	235/60R18	240kPa, 35psi
REAR ARRIÈRE	235/60R18	240kPa, 35psi
SPARE PNEU DE SECOURS	T135/90D17	420kPa, 60psi

SEE OWNER'S
MANUAL FOR
ADDITIONAL
INFORMATION

VOIR LE MANUEL
DE L'USAGER
POUR PLUS DE
RENSEIGNEMENTS



CAUTION: LOAD CARRYING CAPACITY REDUCED
 Modifications to this vehicle have reduced
 the original load carrying capacity by: _____ kg or _____ lbs

Figure A5. Tire Placard



Figure A6. Front View of Principal Other Vehicle



Figure A7. Rear View of Principal Other Vehicle



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



Figure A9. Sensors for Detecting Auditory and Visual Alerts



Figure A10. Computer Installed in Subject Vehicle



Figure A11. Brake Actuation System Installed in Principal Other Vehicle



Figure A12. System Setup Menus (page 1 of 2)



Figure A13. System Setup Menus (page 2 of 2)



Figure A14. Button for Accessing System Setup Menus



Figure A15. FCW Visual Alert

APPENDIX B

Excerpts from Owner's Manual

**Forward Safety warning light
(if equipped)**



This warning light illuminates:

- When you set the ignition switch or the Engine Start/Stop button to the ON position.
 - The Forward Safety warning light illuminates for approximately 3 seconds and then goes off.
- Whenever there is a malfunction with Forward Collision-Avoidance Assist.

If this occurs, we recommend that you have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to “Forward Collision-Avoidance Assist (FCA)” section in chapter 7.

**Lane Safety indicator light
(if equipped)**



This indicator light illuminates:

- [Green] When the system operating conditions are satisfied.
- [White] When the system operating conditions are not satisfied.
- [Yellow] Whenever there is a malfunction with Lane Keeping Assist. If this occurs, we recommend that you have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to “Lane Keeping Assist (LKA)” section in chapter 7.

**4 Wheel Drive (4WD) warning
light**



This warning light illuminates:

Whenever there is a malfunction with the 4WD system.

If this occurs, we recommend that you have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to “4 Wheel Drive (4WD)” section in chapter 6.

**SPORT Mode Indicator Light
(if equipped)**



This indicator light illuminates

When you select "SPORT" mode as drive mode.

For more details, refer to "Drive Mode Integrated Control System" in chapter 6.

**SMART Mode Indicator Light
(if equipped)**



This indicator light illuminates:

When you select "SMART" mode as drive mode.

For more details, refer to "Drive Mode Integrated Control System" in chapter 6.

Master warning light



This warning light illuminates:

When there is a malfunction in operation in any of the following systems:

- Forward Collision-Avoidance Assist malfunction (if equipped)
- Forward Collision-Avoidance Assist radar blocked (if equipped)
- Blind-Spot Collision Warning malfunction (if equipped)
- Blind-Spot Collision Warning radar blocked (if equipped)
- LED headlamp malfunction (if equipped)
- High Beam Assist malfunction (if equipped)
- Smart Cruise Control with Stop & Go malfunction (if equipped)
- Smart Cruise Control with Stop & Go radar blocked (if equipped)
- Tire Pressure Monitoring System (TPMS) malfunction

To identify the details of the warning, look at the LCD display.

Check Forward Collision-Avoidance Assist system (if equipped)

This warning message is displayed if there is a problem with Forward Collision-Avoidance Assist. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to “Forward Collision-Avoidance Assist (FCA)” in chapter 6.

Check Lane Keeping Assist system (if equipped)

This warning message is displayed if there is a problem with Lane Keeping Assist. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to “Lane Keeping Assist (LKA)” in chapter 6.

Check Blind-Spot Collision Warning system (if equipped)

This warning message is displayed if there is a problem with Blind-Spot Collision Warning. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to “Blind-Spot Collision Warning (BCW)” in chapter 6.

Check Driver Attention Warning system (if equipped)

This warning message is displayed if there is a problem with Driver Attention Warning. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to “Driver Attention Warning (DAW)” in chapter 6.

Check High Beam Assist system (if equipped)

This warning message is displayed if there is a problem with the High Beam Assist. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to “High Beam Assist (HBA)” in chapter 5.

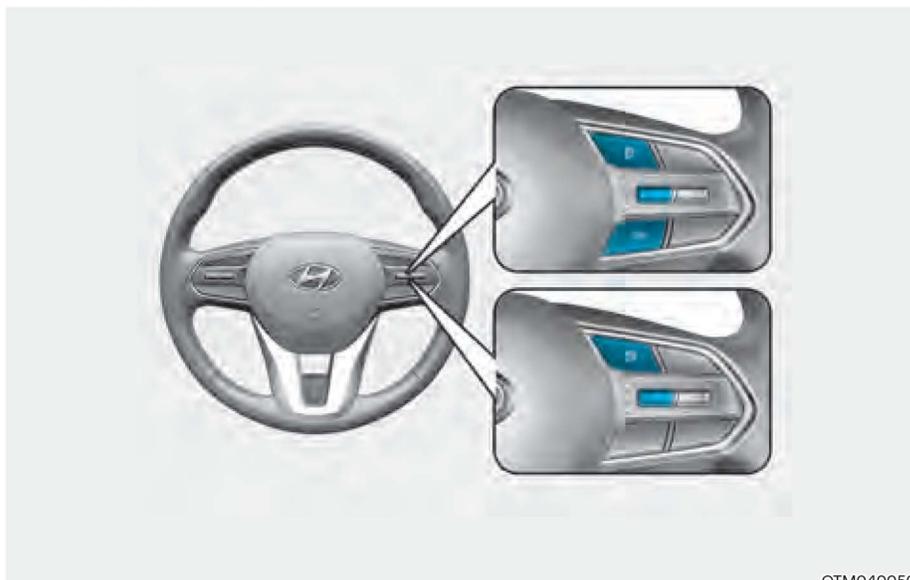
Check Smart Cruise Control system (if equipped)

This warning message is displayed if there is a problem with Smart Cruise Control. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to “Smart Cruise Control (SCC)” in chapter 6.

LCD DISPLAY

LCD display control



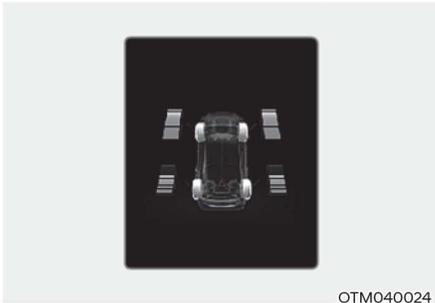
OTM040050

The LCD display modes can be changed by using the control buttons.

Switch	Function
	MODE button for changing modes
	MOVE switch for changing items
OK	SELECT/RESET button for setting or resetting the selected item

Information

When the infotainment system is applied, only the User's Setting mode on the infotainment system is supported but the User's Setting mode on the instrument cluster is not supported.



OTM040024

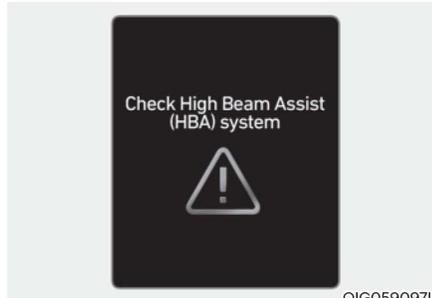
Driving force distribution (4WD)

This mode displays information related to 4WD driving force.

If the vehicle is in 4WD lock state, this mode is not displayed.

For detailed information, refer to the "Four Wheel Drive" in the chapter 6.

Master warning group



OIG059097L

This warning light informs the driver the following situations.

- Forward Collision-Avoidance Assist malfunction (if equipped)
- Forward Collision-Avoidance Assist radar blocked (if equipped)
- Blind-Spot Collision Warning malfunction (if equipped)
- Blind-Spot Collision Warning radar blocked (if equipped)
- LED headlamp malfunction (if equipped)
- High Beam Assist malfunction (if equipped)
- Smart Cruise Control malfunction (if equipped)
- Smart Cruise Control radar blocked (if equipped)
- Tire Pressure Monitoring System (TPMS) malfunction

The Master Warning Light illuminates if one or more of the above warning situations occur.

At this time, a Master Warning icon (⚠) will appear beside the User Settings icon (⚙), on the LCD display.

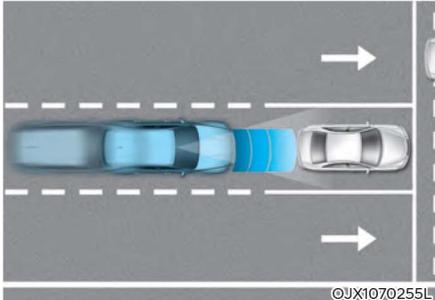
If the warning situation is solved, the master warning light will be turned off and the Master Warning icon will disappear.

1. Driver Assistance

Items	Explanation
SCC Reaction	To adjust the sensitivity of the Smart Cruise Control system. <ul style="list-style-type: none"> • Fast/Normal/Slow For more details, refer to "Smart Cruise Control (SCC)" in chapter 7.
Driving Convenience	<ul style="list-style-type: none"> • Lane Following Assist To activate or deactivate the Lane Following Assist. For more details, refer to the "Lane Following Assist (LFA)" in chapter 7. <ul style="list-style-type: none"> • Highway Driving Assist To activate or deactivate the Highway Driving Assist. For more details, refer to the "Highway Driving Assist (HDA)" in chapter 7. <ul style="list-style-type: none"> • Auto Highway Speed Control To activate or deactivate the Auto Highway Speed Control. For more details, refer to the "Navigation-based Smart Cruise Control (NSCC)" in chapter 7.
Warning Timing	To adjust the warning timing of the driver assistance system. <ul style="list-style-type: none"> • Normal / Later
Warning Volume	To adjust the warning volume of the driver assistance system. <ul style="list-style-type: none"> • High / Medium / Low / Off
Driver Attention Warning	<ul style="list-style-type: none"> • Leading vehicle departure alert To activate or deactivate the Leading vehicle departure alert. For more details, refer to the "Leading vehicle departure alert" in chapter 7. <ul style="list-style-type: none"> • Inattentive Driving Warning To alert the driver's inattentive driving. For more details, refer to the "Driver attention Warning (DAW)" in chapter 7.
Forward safety	To adjust the Forward Collision-Avoidance Assist (FCA) <ul style="list-style-type: none"> • Active Assist • Warning Only • Off For more details, refer to the "Forward Collision-Avoidance Assist (FCA)" in chapter 7.
Lane safety	To adjust the Lane Keeping Assist (LKA) function. <ul style="list-style-type: none"> • Assist • Warning Only • Off For more details, refer to the "Lane Keeping Assist (LKA)" in chapter 7.

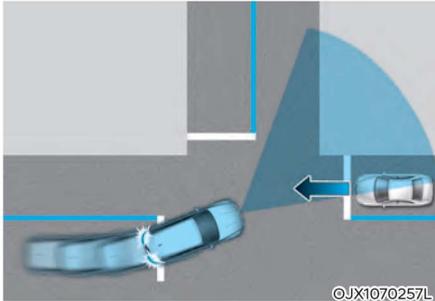
FORWARD COLLISION-AVOIDANCE ASSIST (FCA) (SENSOR FUSION)

Basic function



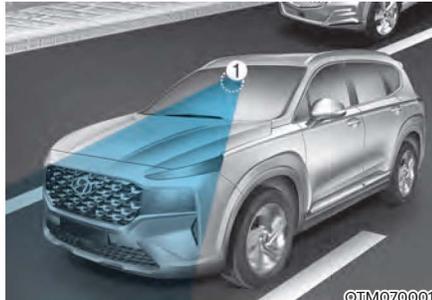
Forward Collision-Avoidance Assist is designed to help detect and monitor the vehicle ahead or help detect a pedestrian or cyclist in the roadway and warn the driver that a collision is imminent with a warning message and an audible warning, and if necessary, apply emergency braking.

Junction Turning function (if equipped)



Junction Turning function will help avoid a collision with an oncoming vehicle in an adjacent lane when turning left at a crossroad with the turn signal on by applying emergency braking.

Detecting sensor



[1] : Front view camera,
[2] : Front radar

Refer to the picture above for the detailed location of the detecting sensors.

**CAUTION**

Take the following precautions to maintain optimal performance of the detecting sensor:

- Never disassemble the detecting sensor or sensor assembly, or apply any impact on it.
- If the detecting sensors have been replaced or repaired, we recommend that you have your vehicle inspected by an authorized HYUNDAI dealer.
- Never install any accessories or stickers on the front windshield, or tint the front windshield.
- Pay extreme caution to keep the front view camera dry.
- Never place any reflective objects (i.e. white paper, mirror) over the dashboard. Any light reflection may prevent the system from functioning properly.
- Do not apply license plate frame or objects, such as a bumper sticker, film or a bumper guard, near the front radar cover.
- Always keep the front radar and cover clean and free of dirt and debris.

Use only a soft cloth to wash the vehicle. Do not spray pressurized water directly on the sensor or sensor cover.

- If unnecessary force has been applied to the radar or around the radar, Forward Collision-Avoidance Assist may not properly operate even though a warning message does not appear on the cluster. We recommend that the vehicle be inspected by an authorized HYUNDAI dealer.
- Use only genuine parts to repair or replace a damaged front radar cover. Do not apply paint to the front radar cover.

System settings

Setting functions for the system



Forward Safety

With the engine on, select 'Driver Assistance → Forward Safety' from the Settings menu to set whether or not to use each function.

- If 'Active Assist' is selected, the system will warn the driver with a warning message and an audible warning depending on the collision risk levels. Braking assist will be applied depending on the collision risk.
- If 'Warning Only' is selected, the system will warn the driver with a warning message and an audible warning depending on the collision risk levels. Braking will not be assisted.
- If 'Off' is selected, the system will turn off. The  warning light will illuminate on the cluster.

The driver can monitor Forward Collision-Avoidance Assist ON/OFF status from the Settings menu. If the  warning light remains ON when the system is ON, we recommend that the system be inspected by an authorized HYUNDAI dealer.

WARNING

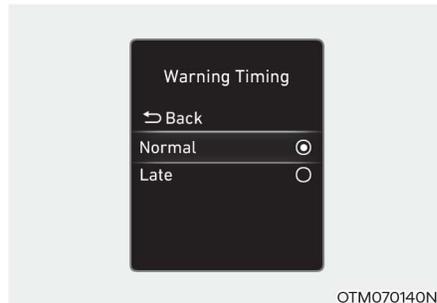
When the engine is restarted, Forward Collision-Avoidance Assist will always turn on. However, if 'Off' is selected after the engine is restarted, the driver should always be aware of the surroundings and drive safely.

CAUTION

- If 'Warning Only' is selected, braking is not assisted.
- The settings for Forward Safety include 'Basic function' and 'Junction Turning' (if equipped).

Information

Forward Collision-Avoidance Assist will turn off when ESC is turned off by pressing and holding the ESC OFF button for more than 3 seconds. The  warning light will illuminate on the cluster.

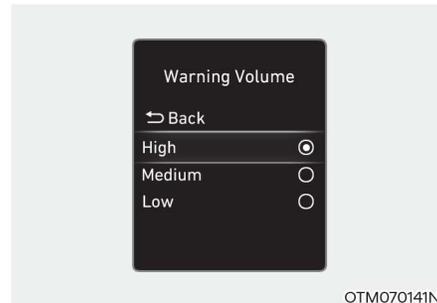


OTM070140N

Warning Timing

With the engine on, select 'Driver Assistance → Warning Timing' from the Settings menu to change the initial warning activation time for Forward Collision-Avoidance Assist.

When the vehicle is first delivered, Warning Timing is set to 'Normal'. If you change the Warning Timing, the warning time of other Driver Assistance systems may change.



OTM070141N

Warning Volume

With the engine on, select 'Driver Assistance → Warning Volume' from the Settings menu to change the Warning Volume to 'High', 'Medium' or 'Low' for Forward Collision-Avoidance Assist.

If you change the warning volume, the Warning Volume of other Driver Assistance systems may change.



CAUTION

- The setting of the Warning Timing and Warning Volume applies to all functions of Forward Collision-Avoidance Assist.
- Even though 'Normal' is selected for Warning Timing, if the front vehicle suddenly stops, the initial warning activation time may seem late.
- Select 'Late' for Warning Timing when traffic is light and when driving speed is slow.



Information

If the engine is restarted, Warning Timing and Warning Volume will maintain the last setting.

System operation

Basic function

System warning and control

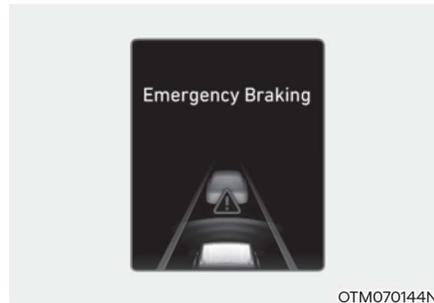
The basic function for Forward Collision-Avoidance Assist is to help warn and control the vehicle depending on the collision level: 'Collision Warning', 'Emergency Braking' and 'Stopping vehicle and ending brake control'.



OTM070143N

Collision Warning

- To warn the driver of a collision, the 'Collision Warning' warning message will appear on the cluster and an audible warning will sound.
- If a vehicle is detected in front, the system will operate when your vehicle speed is between approximately 6~112 mph (10~180 km/h).
- If a pedestrian or cyclist is detected in front, the system will operate when your vehicle speed is between approximately 6~53 mph (10~85 km/h).
- If 'Active Assist' is selected, braking may be assisted.



OTM070144N

Emergency Braking

- To warn the driver that emergency braking will be assisted, the 'Emergency Braking' warning message will appear on the cluster and an audible warning will sound.
- If a vehicle is detected in front, the system will operate when your vehicle speed is between approximately 6~47 mph (10~75 km/h).
- If a pedestrian or cyclist is detected in front, the system will operate when your vehicle speed is between approximately 6~40 mph (10~65 km/h).
- In emergency braking situation, braking is assisted with strong braking power by the system to help prevent collision with the vehicle, pedestrian or cyclist ahead.



OTM070059L

Stopping vehicle and ending brake control

- When the vehicle is stopped due to emergency braking, the 'Drive carefully' warning message will appear on the cluster.
For your safety, the driver should depress the brake pedal immediately and check the surroundings.
- Brake control will end after the vehicle is stopped by emergency braking for approximately 2 seconds.

Junction Turning function (if equipped)

System warning and control

Junction Turning function will help warn and control the vehicle depending on the collision level: 'Collision Warning', 'Emergency Braking' and 'Stopping vehicle and ending brake control'

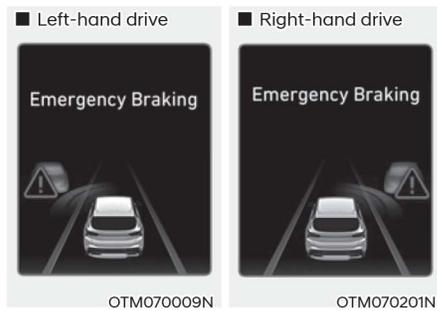


OTM070008N

OTM070200N

Collision Warning

- To warn the driver of a collision, the 'Collision Warning' warning message will appear on the cluster and an audible warning will sound.
- The system will operate when your vehicle speed is between approximately 6~19 mph (10~30 km/h) and the oncoming vehicle speed is between approximately 19~44 mph (30~70 km/h).
- If 'Active Assist' is selected, braking may be assisted.



Emergency Braking

- To warn the driver that emergency braking will be assisted, the 'Emergency Braking' warning message will appear on the cluster and an audible warning will sound.
- The system will operate when your vehicle speed is between approximately 6~19 mph (10~30 km/h) and the oncoming vehicle speed is between approximately 19~44 mph (30~70 km/h).
- In emergency braking situation, braking is assisted with strong braking power by the system to help prevent collision with the oncoming vehicle.

i Information

If the driver's seat is on the left side, Junction Turning function will operate only when the driver turns left. If the driver's seat position is on right side, the function will operate only when you turn right.



Stopping vehicle and ending brake control

- When the vehicle is stopped due to emergency braking, the 'Drive carefully' warning message will appear on the cluster.
For your safety, the driver should depress the brake pedal immediately and check the surroundings.
- Brake control will end after the vehicle is stopped by emergency braking for approximately 2 seconds.

**WARNING**

Take the following precautions when using Forward Collision-Avoidance Assist:

- For your safety, change the Settings after parking the vehicle at a safe location.
- With 'Active Assist' or 'Warning Only' selected, when ESC is turned off by pressing and holding the ESC OFF button for more than 3 seconds, Forward Collision-Avoidance Assist will turn off automatically. In this case, the system cannot be set from the Settings menu and the  warning light will illuminate on the cluster which is normal. If ESC is turned on by pressing the ESC OFF button, Forward Collision-Avoidance Assist will maintain the last setting.
- Forward Collision-Avoidance Assist does not operate in all situations or cannot avoid all collisions.
- The driver should hold the responsibility to control the vehicle. Do not solely depend on Forward Collision-Avoidance Assist. Rather, maintain a safe braking distance, and if necessary, depress the brake pedal to reduce driving speed or to stop the vehicle.
- Never deliberately operate Forward Collision-Avoidance Assist on people, animal, objects, etc. It may cause serious injury or death.
- Forward Collision-Avoidance Assist may not operate if the driver depresses the brake pedal to avoid collision.
- Depending on the road and driving conditions, Forward Collision-Avoidance Assist may warn the driver late or may not warn the driver.
- During Forward Collision-Avoidance Assist operation, the vehicle may stop suddenly injuring passengers and shifting loose objects. Always have the seat belt on and keep loose objects secured.
- If any other system's warning message is displayed or audible warning is generated, Forward Collision-Avoidance Assist warning message may not be displayed and audible warning may not be generated.
- You may not hear the warning sound of Forward Collision-Avoidance Assist if the surrounding is noisy.
- Forward Collision-Avoidance Assist may turn off or may not operate properly or may operate unnecessarily depending on the road conditions and the surroundings.

**WARNING**

- Even if there is a problem with Forward Collision-Avoidance Assist, the vehicle's basic braking performance will operate normally.
- During emergency braking, braking control by the system will automatically cancel when the driver excessively depresses the accelerator pedal or sharply steers the vehicle.

 **CAUTION**

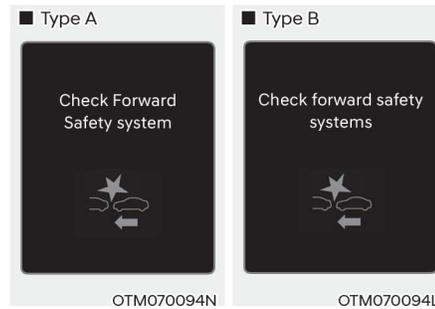
- Forward Collision-Avoidance Assist operating speed range may reduce due to the conditions of the vehicle or pedestrian in front or surroundings. Depending on the speed, the system may only warn the driver, or the system may not operate.
- Forward Collision-Avoidance Assist will operate under certain conditions by judging the risk level based on the condition of the oncoming vehicle, driving direction, speed and surroundings.

 **Information**

In a situation where collision is imminent, braking may be assisted by Forward Collision-Avoidance Assist when braking is insufficient by the driver.

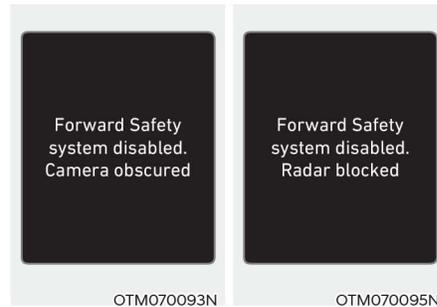
System malfunction and limitations

System malfunction



When Forward Collision-Avoidance Assist is not working properly, the 'Check Forward Safety system(s)' warning message will appear, and the  and  warning lights will illuminate on the cluster. We recommend that the system be inspected by an authorized HYUNDAI dealer.

System disabled



When the front windshield where the front view camera is located, front radar cover or sensor is covered with foreign material, such as snow or rain, it can reduce the detecting performance and temporarily limit or disable Forward Collision-Avoidance Assist.

If this occurs the 'Forward Safety system(s) disabled. Camera obscured' or the 'Forward Safety system(s) disabled. Radar blocked' warning message, and the  and  warning lights will illuminate on the cluster.

The system will operate normally when such snow, rain or foreign material is removed.

If the system does not operate normally after obstruction (snow, rain, or foreign material) is removed, we recommend that the system be inspected by an authorized HYUNDAI dealer.

WARNING

- Even though the warning message or warning light does not appear on the cluster, Forward Collision-Avoidance Assist may not properly operate.
- Forward Collision-Avoidance Assist may not properly operate in an area (e.g. open terrain), where any substance are not detected after turning ON the engine.

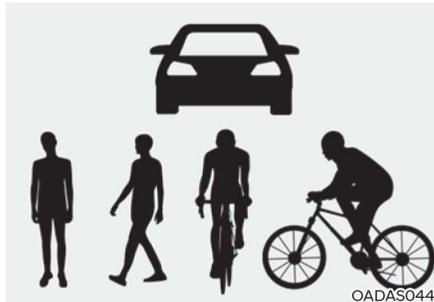
Limitations of the system

Forward Collision-Avoidance Assist may not operate normally, or the system may operate unexpectedly under the following circumstances:

- The detecting sensor or the surroundings are contaminated or damaged
- The temperature around the front view camera is high or low
- The camera lens is contaminated due to tinted, filmed or coated windshield, damaged glass, or stuck of foreign material (sticker, bug, etc.) on the glass
- Moisture is not removed or frozen on the windshield
- Washer fluid is continuously sprayed, or the wiper is on
- Driving in heavy rain or snow, or thick fog
- The field of view of the front view camera is obstructed by sun glare
- Street light or light from an oncoming vehicle is reflected on the wet road surface, such as a puddle on the road
- An object is placed on the dashboard

- Your vehicle is being towed
- The surrounding is very bright
- The surrounding is very dark, such as in a tunnel, etc.
- The brightness changes suddenly, for example when entering or exiting a tunnel
- The brightness outside is low, and the headlamps are not on or are not bright
- Driving through steam, smoke or shadow
- Only part of the vehicle, pedestrian or cyclist is detected
- The vehicle in front is a bus, heavy truck, truck with a unusually shaped luggage, trailer, etc.
- The vehicle in front has no tail lights, tail lights are located unusually, etc.
- The brightness outside is low, and the tail lamps are not on or are not bright
- The rear of the front vehicle is small or the vehicle does not look normal, such as when the vehicle is tilted, overturned, or the side of the vehicle is visible, etc.
- The front vehicle's ground clearance is low or high
- A vehicle, pedestrian or cyclist suddenly cuts in front
- The bumper around the front radar is impacted, damaged or the front radar is out of position
- The temperature around the front radar is high or low
- Driving through a tunnel or iron bridge
- Driving in large areas where there are few vehicles or structures (i.e. desert, meadow, suburb, etc.)
- Driving near areas containing metal substances, such as a construction zone, railroad, etc.
- A material is near that reflects very well on the front radar, such as a guardrail, nearby vehicle, etc.
- The cyclist in front is on a bicycle made of material that does not reflect on the front radar
- The vehicle in front is detected late
- The vehicle in front is suddenly blocked by an obstacle
- The vehicle in front suddenly changes lane or suddenly reduces speed
- The vehicle in front is bent out of shape
- The front vehicle's speed is fast or slow
- The vehicle in front steers in the opposite direction of your vehicle to avoid a collision
- With a vehicle in front, your vehicle changes lane at low speed
- The vehicle in front is covered with snow
- You are departing or returning to the lane
- Unstable driving
- You are on a roundabout and the vehicle in front is not detected
- You are continuously driving in a circle
- The vehicle in front has an unusual shape
- The vehicle in front is driving uphill or downhill

- The pedestrian or cyclist is not fully detected, for example, if the pedestrian is leaning over or is not fully walking upright
- The pedestrian or cyclist is wearing clothing or equipment that makes it difficult to detect as a pedestrian or cyclist

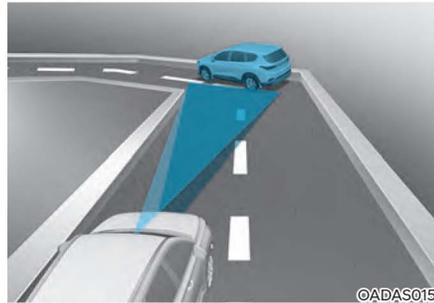
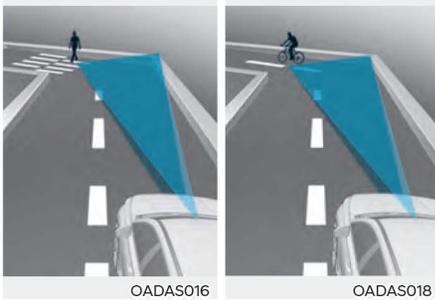
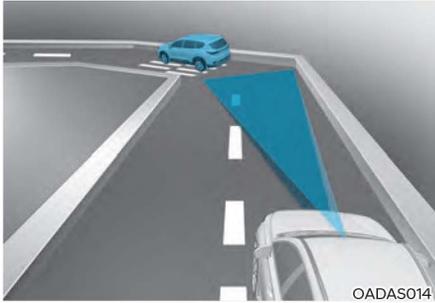


The illustration above shows the image the front view camera is capable of detecting as a vehicle, pedestrian and cyclist.

- The pedestrian or cyclist in front is moving very quickly
- The pedestrian or cyclist in front is short or is posing a low posture
- The pedestrian or cyclist in front has impaired mobility
- The pedestrian or cyclist in front is moving intersected with the driving direction
- There is a group of pedestrians, cyclists or a large crowd in front
- The pedestrian or cyclist is wearing clothing that easily blends into the background, making it difficult to detect
- The pedestrian or cyclist is difficult to distinguish from the similar shaped structure in the surroundings
- You are driving by a pedestrian, cyclist, traffic sign, structure, etc. near the intersection
- Driving in a parking lot
- Driving through a tollgate, construction area, unpaved road, partial paved road, uneven road, speed bumps, etc.
- Driving on an incline road, curved road, etc.
- Driving through a roadside with trees or streetlights
- The adverse road conditions cause excessive vehicle vibrations while driving
- Your vehicle height is low or high due to heavy loads, abnormal tire pressure, etc.
- Driving through a narrow road where trees or grass are overgrown
- There is interference by electromagnetic waves, such as driving in an area with strong radio waves or electrical noise

 **WARNING**

- Driving on a curve



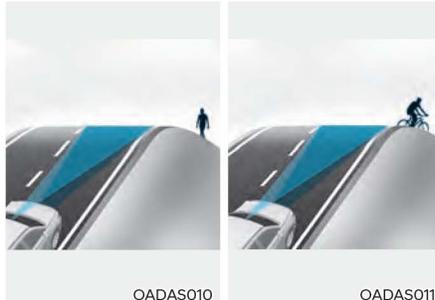
Forward Collision-Avoidance Assist may not detect other vehicles, pedestrians or cyclists in front of you on curved roads adversely affecting the performance of the sensors. This may result in no warning or braking assist when necessary.

When driving on a curve, you must maintain a safe braking distance, and if necessary, steer the vehicle and depress the brake pedal to reduce your driving speed in order to maintain a safe distance.

Forward Collision-Avoidance Assist may detect a vehicle, pedestrian or cyclist in the next lane or outside the lane when driving on a curved road.

If this occurs, the system may unnecessarily warn the driver and control the brake. Always check the traffic conditions around the vehicle.

- Driving on a slope



Forward Collision-Avoidance Assist may not detect other vehicles, pedestrians or cyclists in front of you while driving uphill or downhill adversely affecting the performance of the sensors.

This may result in unnecessary warning or braking assist, or no warning or braking assist when necessary.

Also, vehicle speed may rapidly decrease when a vehicle, pedestrian or cyclist ahead is suddenly detected.

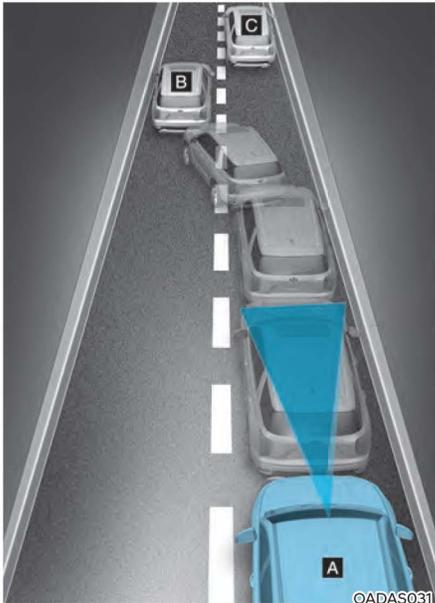
Always have your eyes on the road while driving uphill or downhill and if necessary, steer your vehicle and depress the brake pedal to reduce your driving speed in order to maintain a safe distance.

- Changing lanes



[A] : Your vehicle,
[B] : Lane changing vehicle

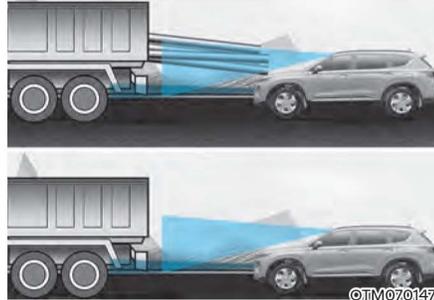
When a vehicle moves into your lane from an adjacent lane, it cannot be detected by the sensor until it is in the sensor's detection range. Forward Collision-Avoidance Assist may not immediately detect the vehicle when the vehicle changes lanes abruptly. In this case, you must maintain a safe braking distance, and if necessary, steer your vehicle and depress the brake pedal to reduce your driving speed in order to maintain a safe distance.



[A] : Your vehicle, [B] : Lane changing vehicle,
[C] : Same lane vehicle

When a vehicle in front of you merges out of the lane, Forward Collision-Avoidance Assist may not immediately detect the vehicle that is now in front of you. In this case, you must maintain a safe braking distance, and if necessary, steer your vehicle and depress the brake pedal to reduce your driving speed in order to maintain a safe distance.

- **Detecting vehicle**



If the vehicle in front of you has cargo that extends rearward from the cab, or when the vehicle in front of you has higher ground clearance, additional special attention is required. Forward Collision-Avoidance Assist may not be able to detect the cargo extending from the vehicle. In these instances, you must maintain a safe braking distance from the rearmost object, and if necessary, steer your vehicle and depress the brake pedal to reduce your driving speed in order to maintain distance.

 **WARNING**

- When you are towing a trailer or another vehicle, we recommend that Forward Collision-Avoidance Assist is turned off due to safety reasons.
- Forward Collision-Avoidance Assist may operate if objects that are similar in shape or characteristics to vehicles, pedestrians and cyclists are detected.
- Forward Collision-Avoidance Assist does not operate on bicycles, motorcycles, or smaller wheeled objects, such as luggage bags, shopping carts, or strollers.
- Forward Collision-Avoidance Assist may not operate normally if interfered by strong electromagnetic waves.
- Forward Collision-Avoidance Assist may not operate for 15 seconds after the vehicle is started, or the front view camera is initialized.

 **Information**

In some instances, FCA system may be cancelled when subjected to electromagnetic interference.

 **Information**

This device complies with Part 15 of the FCC rules.

Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

APPENDIX C

Run Log

Subject Vehicle: **2021 Hyundai Santa Fe 2.5L FWD**

Test Date: **3/11/2021**

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	2.78	2.47	0.68	Pass	
2		Y	2.71	2.32	0.61	Pass	
3		Y	2.76	2.40	0.66	Pass	
4		Y	2.73	2.42	0.63	Pass	
5		Y	2.71	2.39	0.61	Pass	
6		Y	2.72	2.38	0.62	Pass	
7		Y	2.73	2.35	0.63	Pass	
15	Decelerating POV	Y	2.51	2.13	0.11	Pass	
16		Y	2.47	2.12	0.07	Pass	
17		Y	2.51	2.18	0.11	Pass	
18		Y	2.50	2.16	0.10	Pass	
19		Y	2.42	2.05	0.02	Pass	
20		Y	2.31	1.97	-0.09	Fail	
21		Y	2.50	2.14	0.10	Pass	

Run	Test Type	Valid Run?	TTCW Sound (sec)	TTCW Light (sec)	TTCW Margin (sec)	Pass/Fail	Notes
8	Slower POV	Y	2.33	1.97	0.33	Pass	
9		Y	2.32	1.94	0.32	Pass	
10		Y	2.33	1.95	0.33	Pass	
11		Y	2.33	1.99	0.33	Pass	
12		Y	2.36	2.04	0.36	Pass	
13		Y	2.39	2.05	0.39	Pass	
14		Y	2.40	2.10	0.40	Pass	

APPENDIX D

Time History Plots

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Description of Time History Plots

A set of time history plots is provided for each valid run in the test series. Each set of plots comprises time varying data from both the Subject Vehicle (SV) and the Principal Other Vehicle (POV), as well as pass/fail envelopes and thresholds. The following is a description of data types shown in the time history plots, as well as a description of the color code indicating to which vehicle the data pertain.

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

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

Time history figures include the following sub-plots:

- Warning – Displays the Forward Collision Warning Alert (which can be auditory, visual, or haptic). Depending on the type of FCW alert or instrumentation used to measure the alert, this can be any of the following:
 - Filtered, rectified, and normalized sound signal. The vertical scale is 0 to 1.
 - Filtered, rectified, and normalized acceleration (e.g., haptic alert, such as steering wheel vibration). The vertical scale is 0 to 1.
 - Light sensor signal.
- TTC (sec) – Indicates the Time to Collision as calculated up to the point of FCW alert issuance. The value of TTCW (Time to Collision at Warning) is given numerically on the right side of the figure. A passing value is indicated in green, while a failing value is indicated in red.
- SV Speed (mph) – Speed of the Subject Vehicle
- POV Speed (mph) – Speed of the Principal Other Vehicle
- Yaw Rate (deg/sec) – Yaw rate of both the Subject Vehicle and Principal Other Vehicle

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

Envelopes and Thresholds

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

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

Yellow envelopes indicate that the time-varying data should not exceed the envelope only at the left and/or right ends. Exceedances at the left or right extent of a yellow envelope are indicated by red asterisks.

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

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

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

Color Codes

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

Color codes can be broken into four categories:

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

1. Time-varying data color codes:

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

2. Validation envelope and threshold color codes:

- Green envelope = time varying data must be within the envelope at all times in order to be valid
- Yellow envelope = time varying data must be within limits at left and/or right ends
- Black threshold (Solid) = time varying data must not exceed this threshold in order to be valid
- Black threshold (Dashed) = for reference only – this can include warning level thresholds, TTC thresholds, and acceleration thresholds

3. Instantaneous sampling color codes:

- Green circle = passing or valid value at a given moment in time
- Red asterisk = failing or invalid value at a given moment in time

4. Text color codes:

- Green = passing or valid value
- Red = failing or invalid value

Other Notations

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

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

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

Notes

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

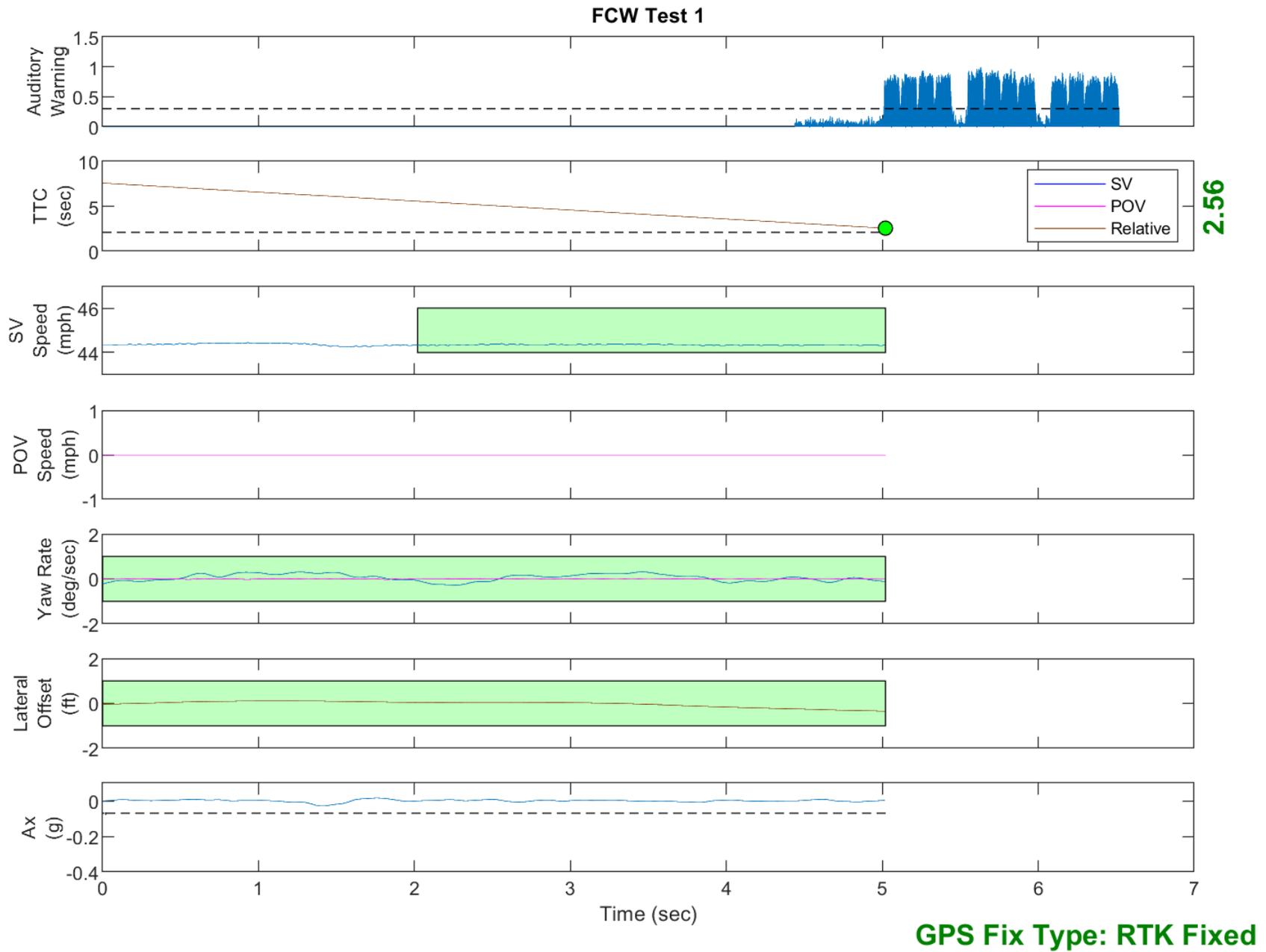
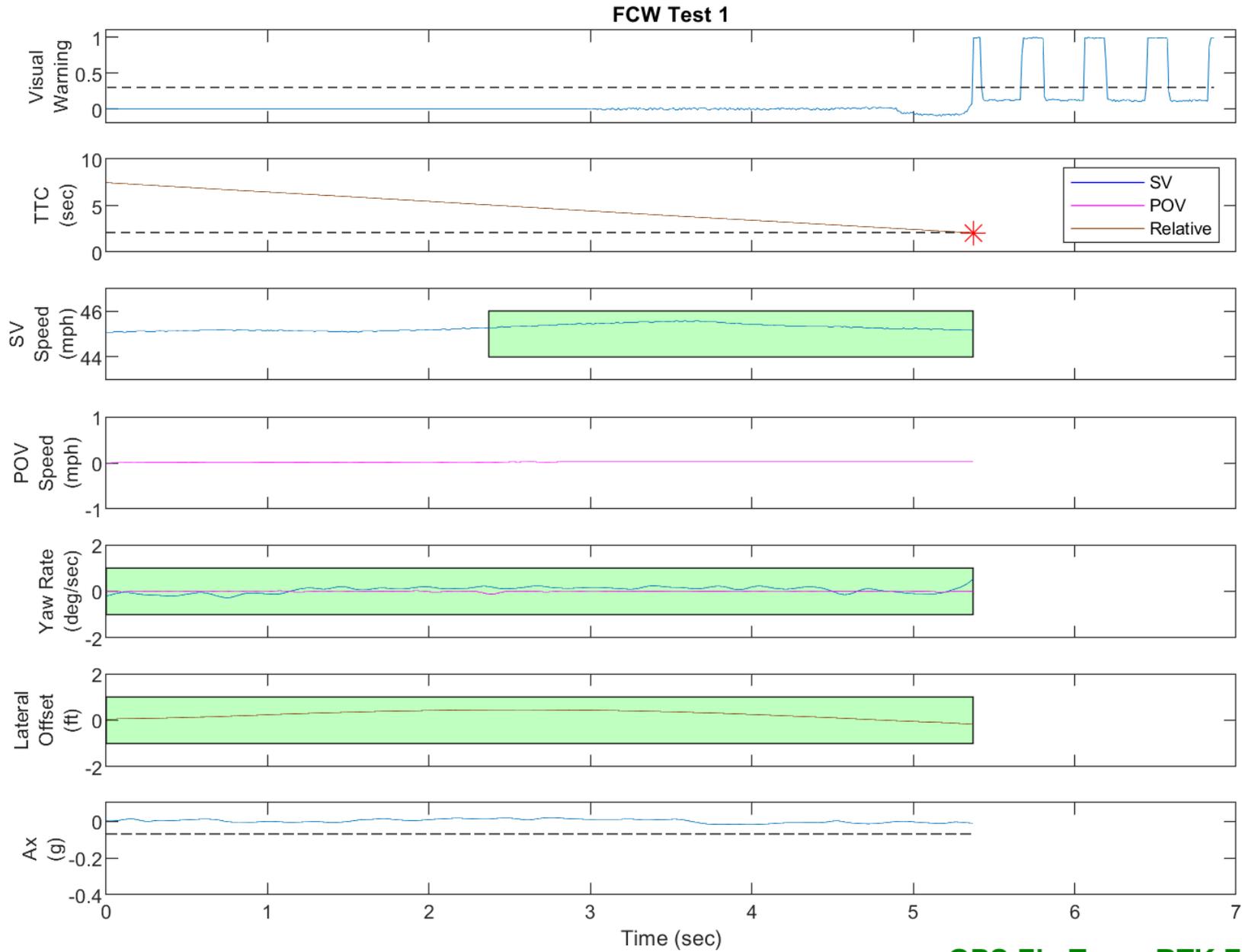


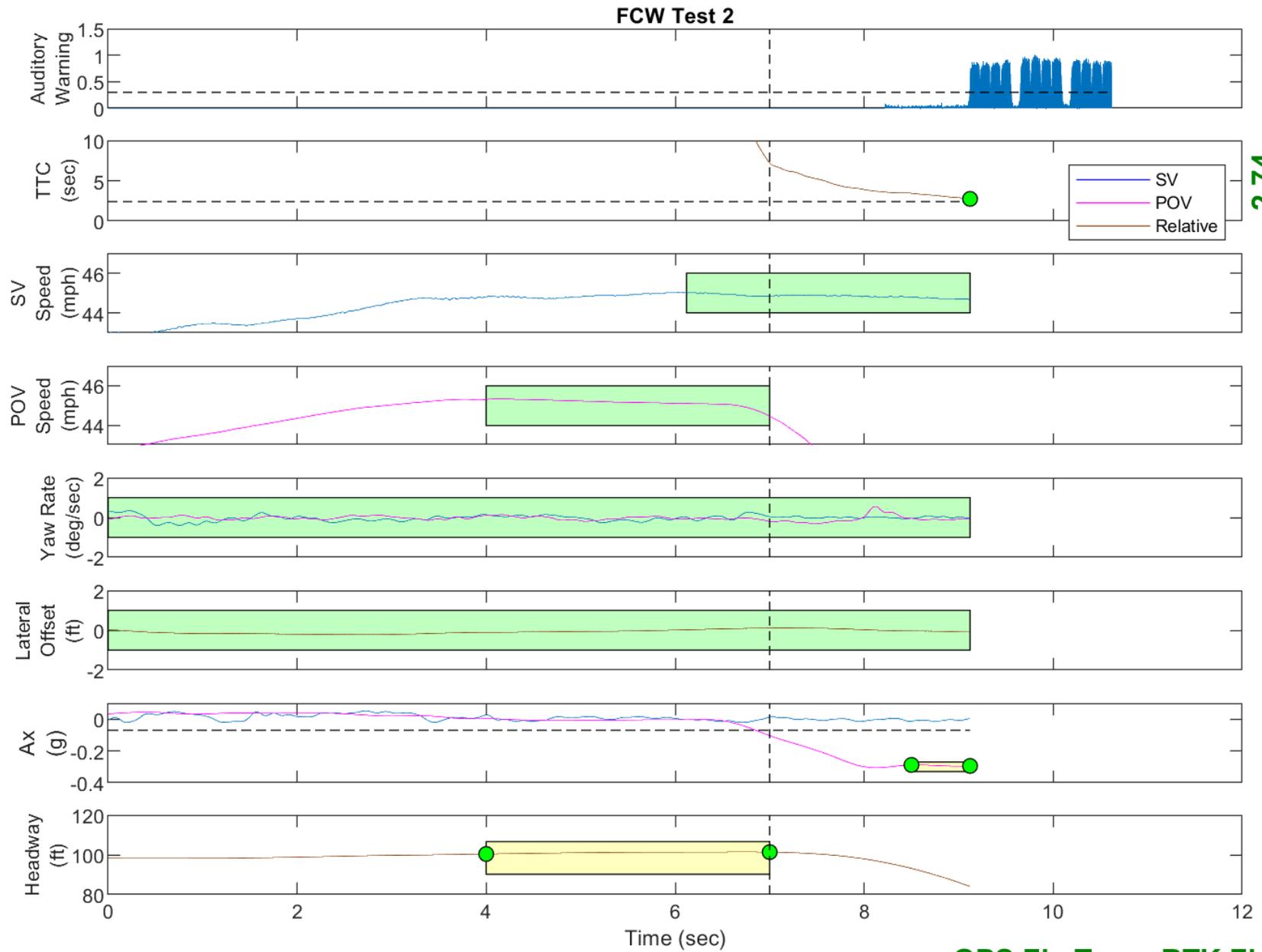
Figure D1. Example Time History for Test Type 1, Passing



2.06 FAIL

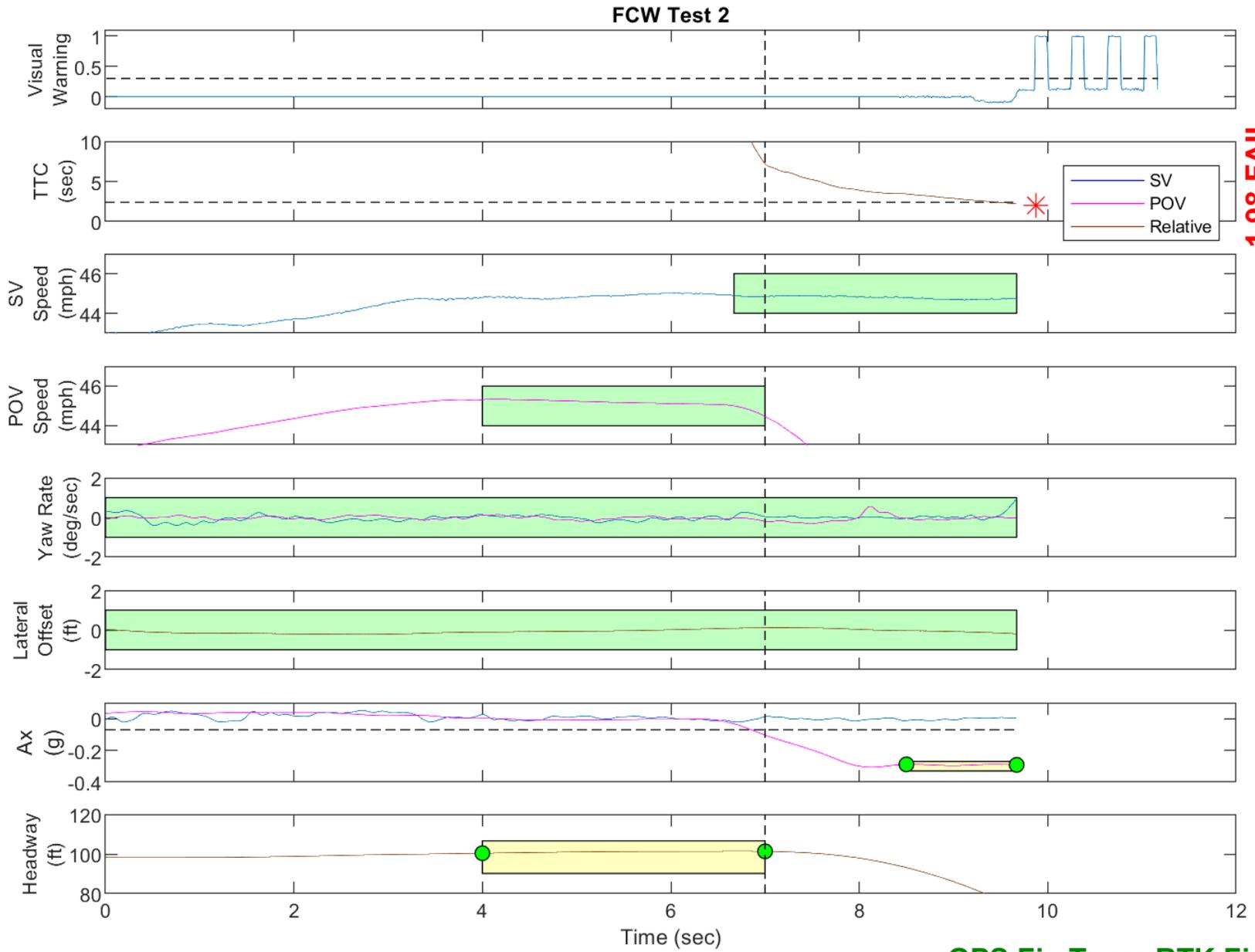
GPS Fix Type: RTK Fixed

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



GPS Fix Type: RTK Fixed

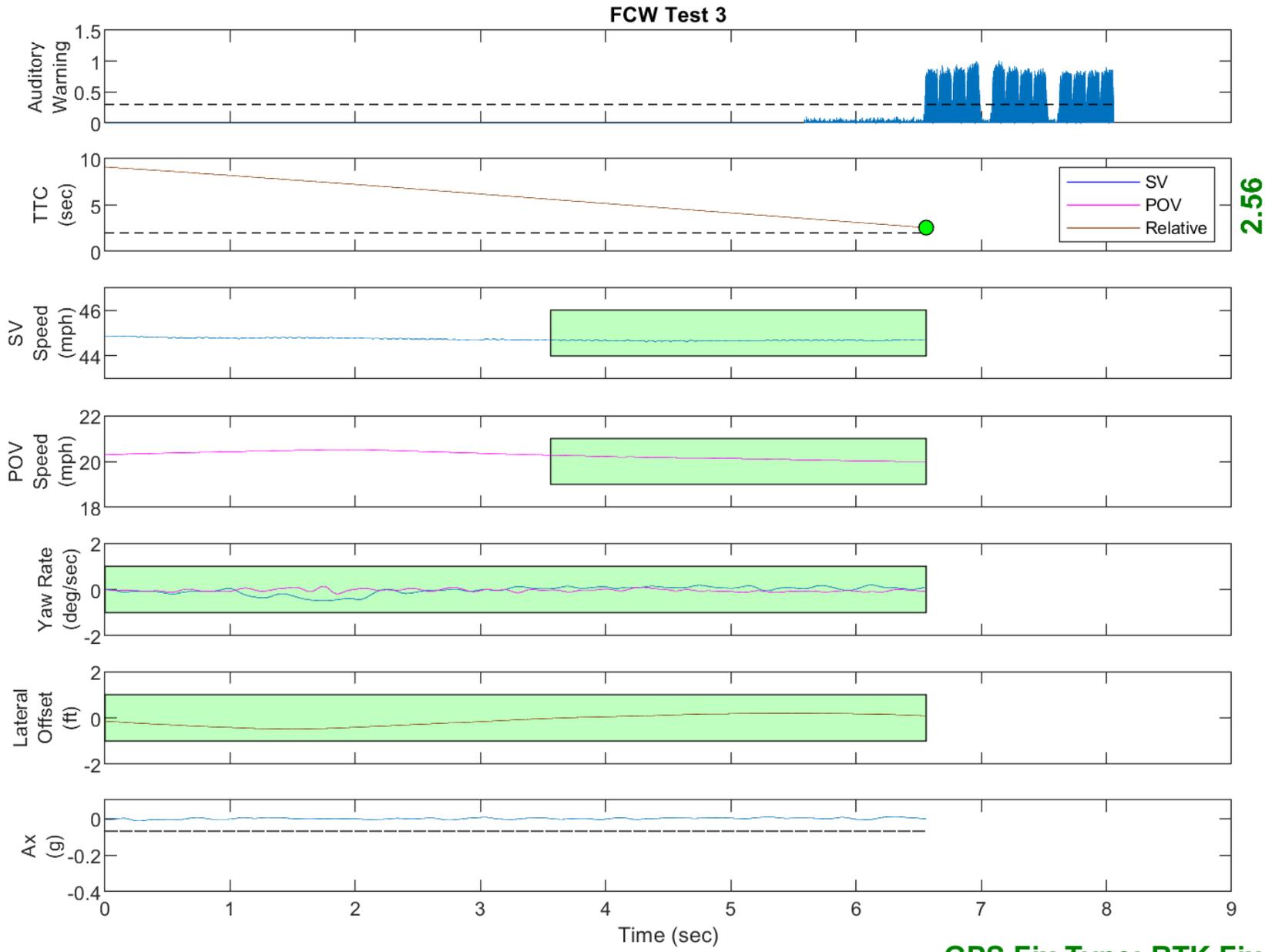
Figure D3. Example Time History for Test Type 2, Passing



1.98 FAIL

GPS Fix Type: RTK Fixed

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



GPS Fix Type: RTK Fixed

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

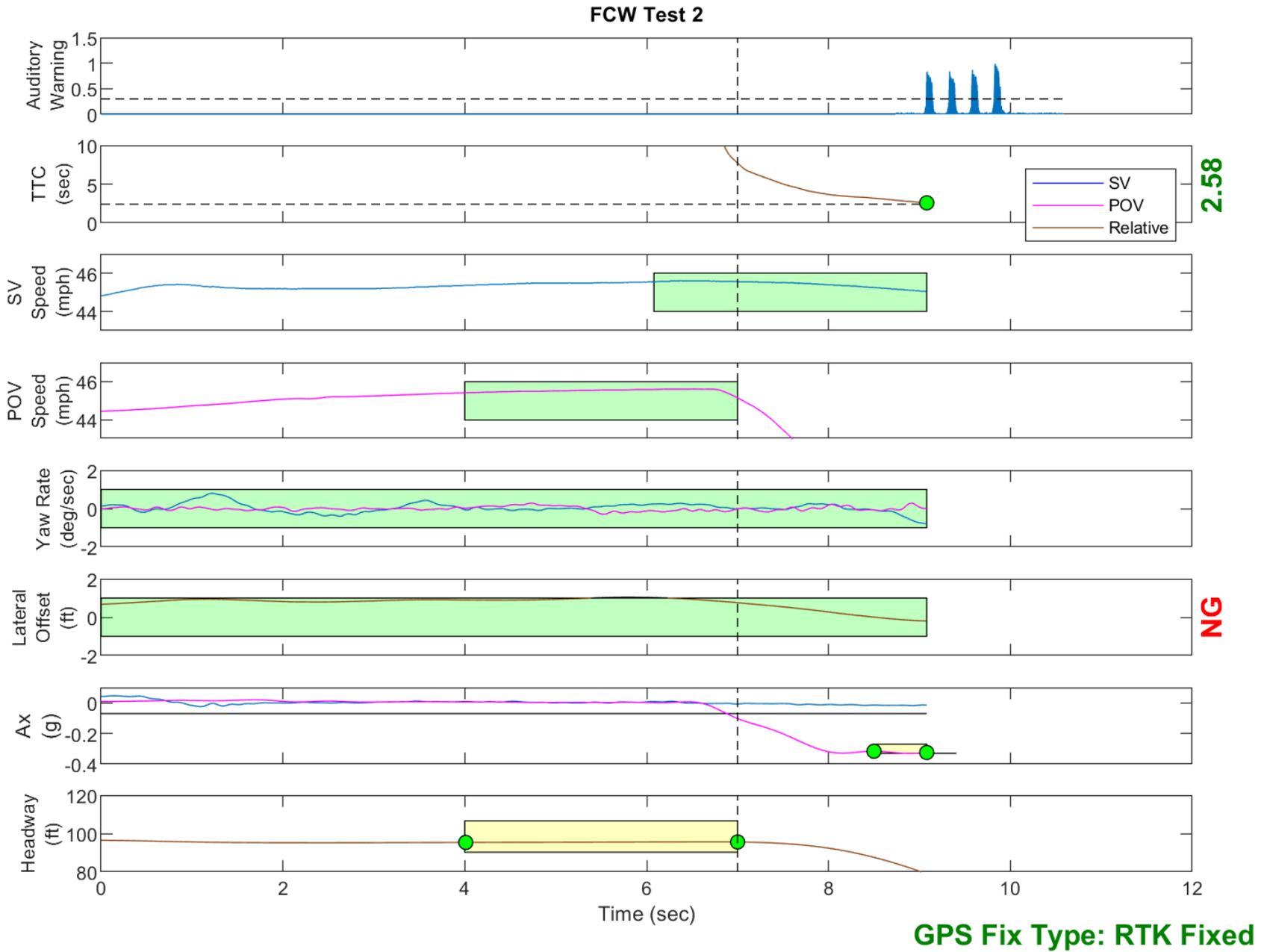


Figure D6. Example Time History Showing Invalid Lateral Offset Criteria

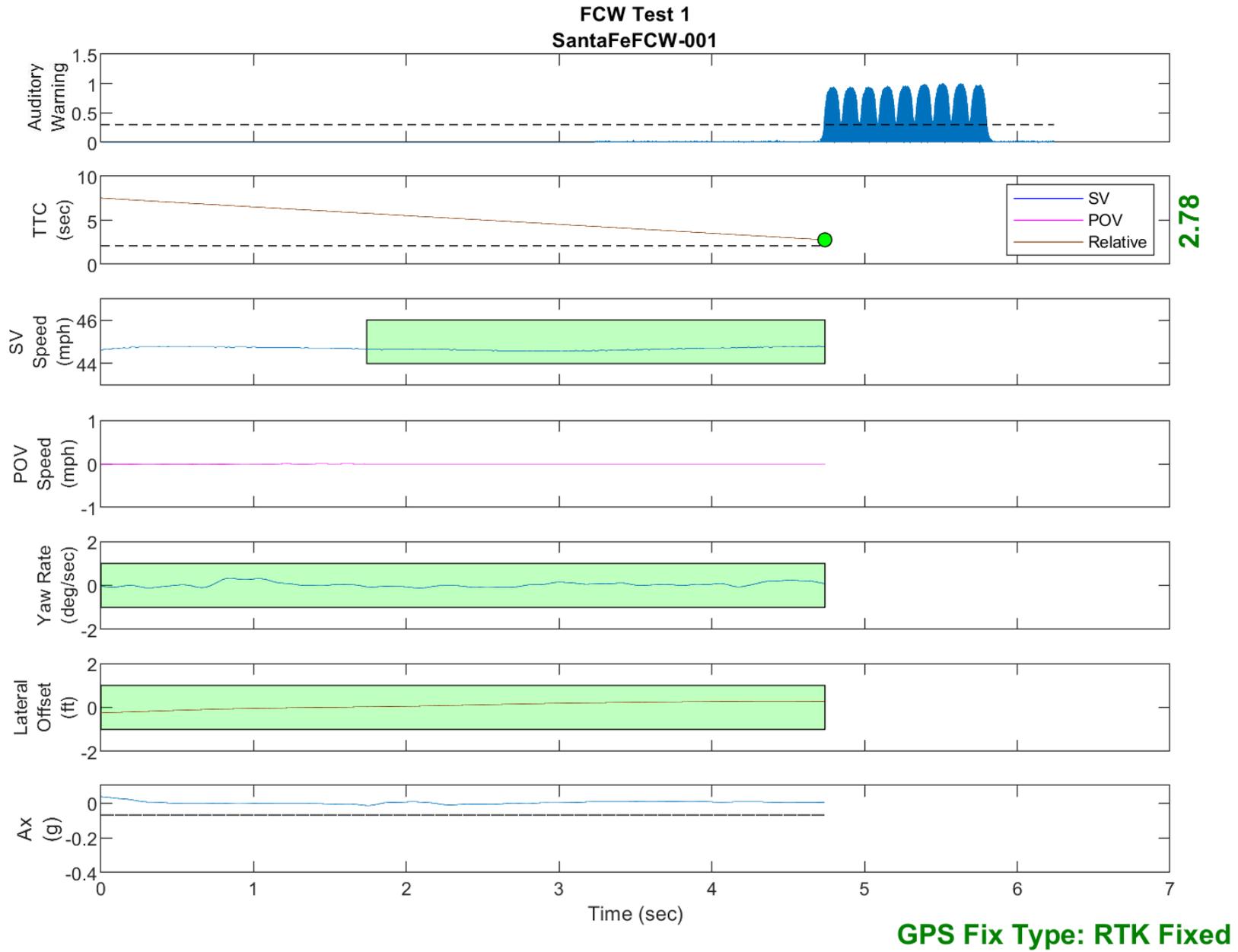


Figure D7. Time History for Run 1, FCW Test 1, Auditory Warning

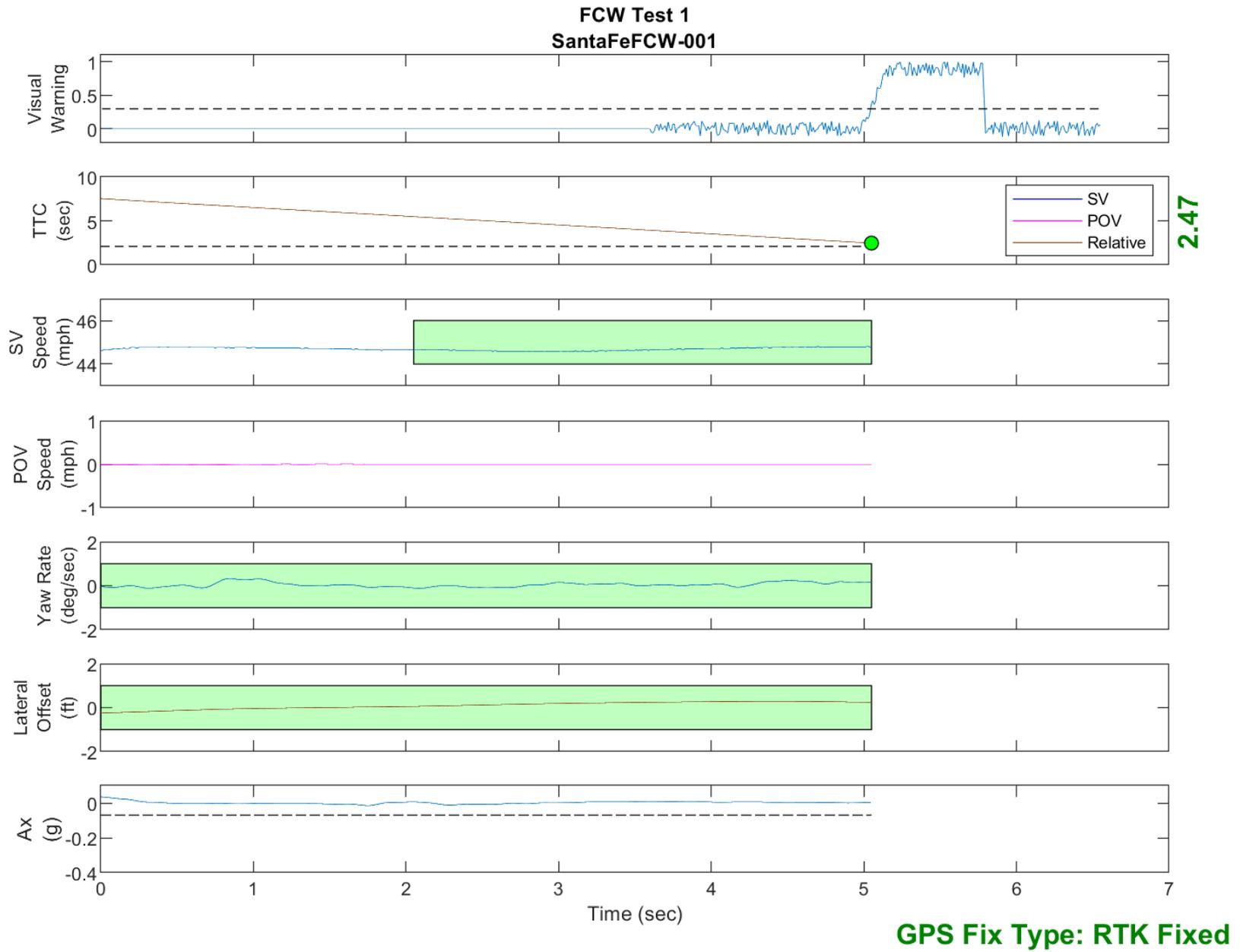


Figure D8. Time History for Run 1, FCW Test 1, Visual Warning

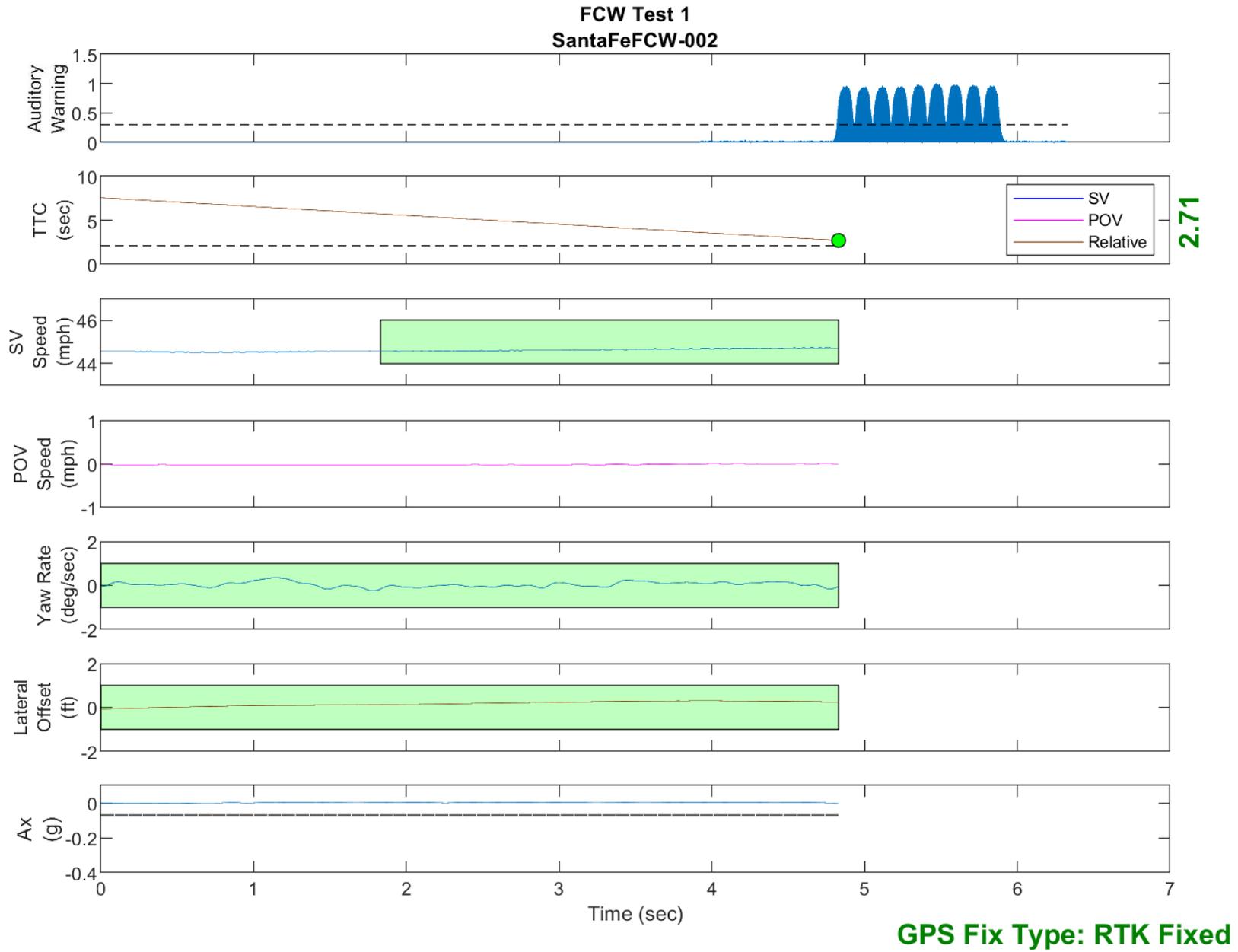


Figure D9. Time History for Run 2, FCW Test 1, Auditory Warning

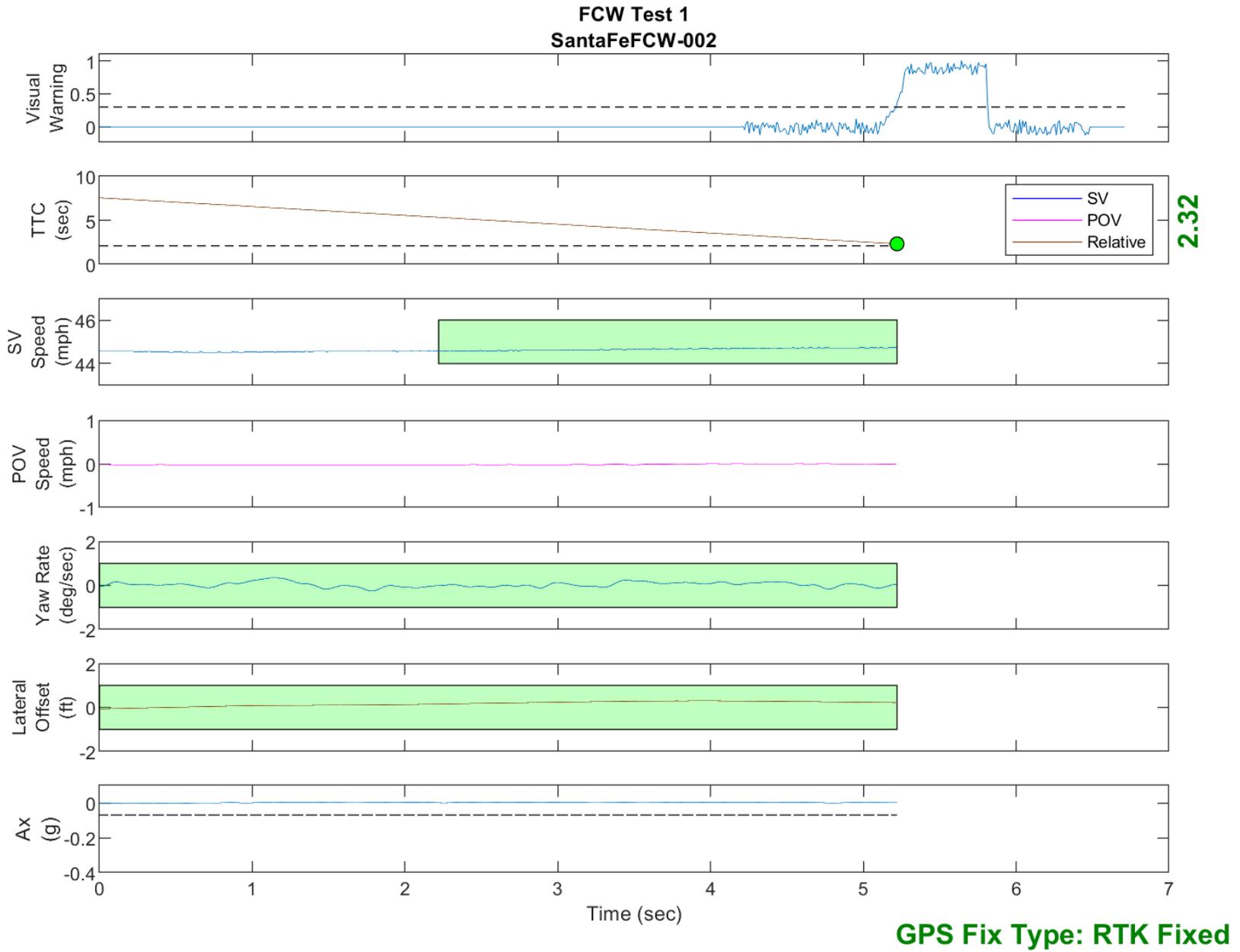


Figure D10. Time History for Run 2, FCW Test 1, Visual Warning

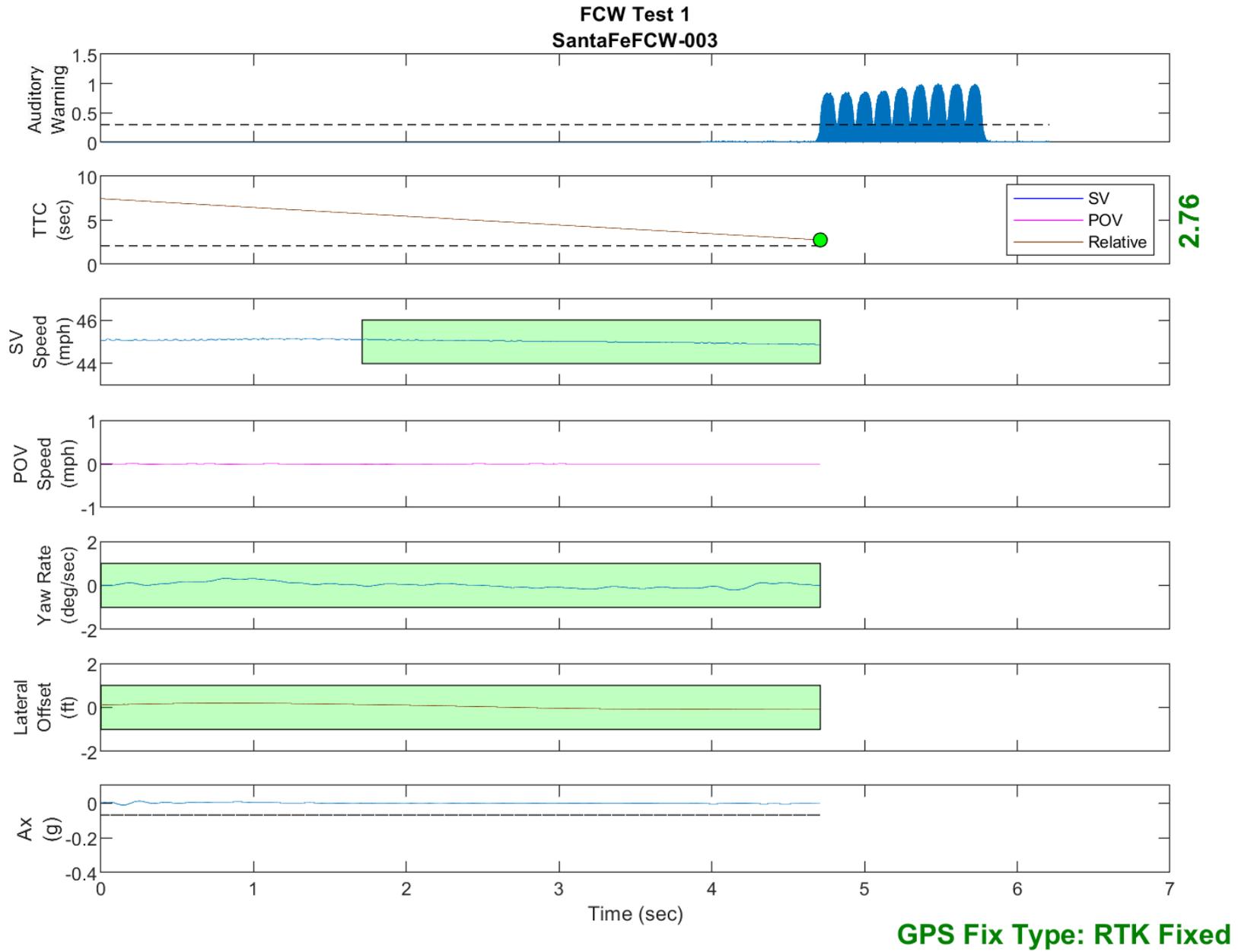


Figure D11. Time History for Run 3, FCW Test 1, Auditory Warning

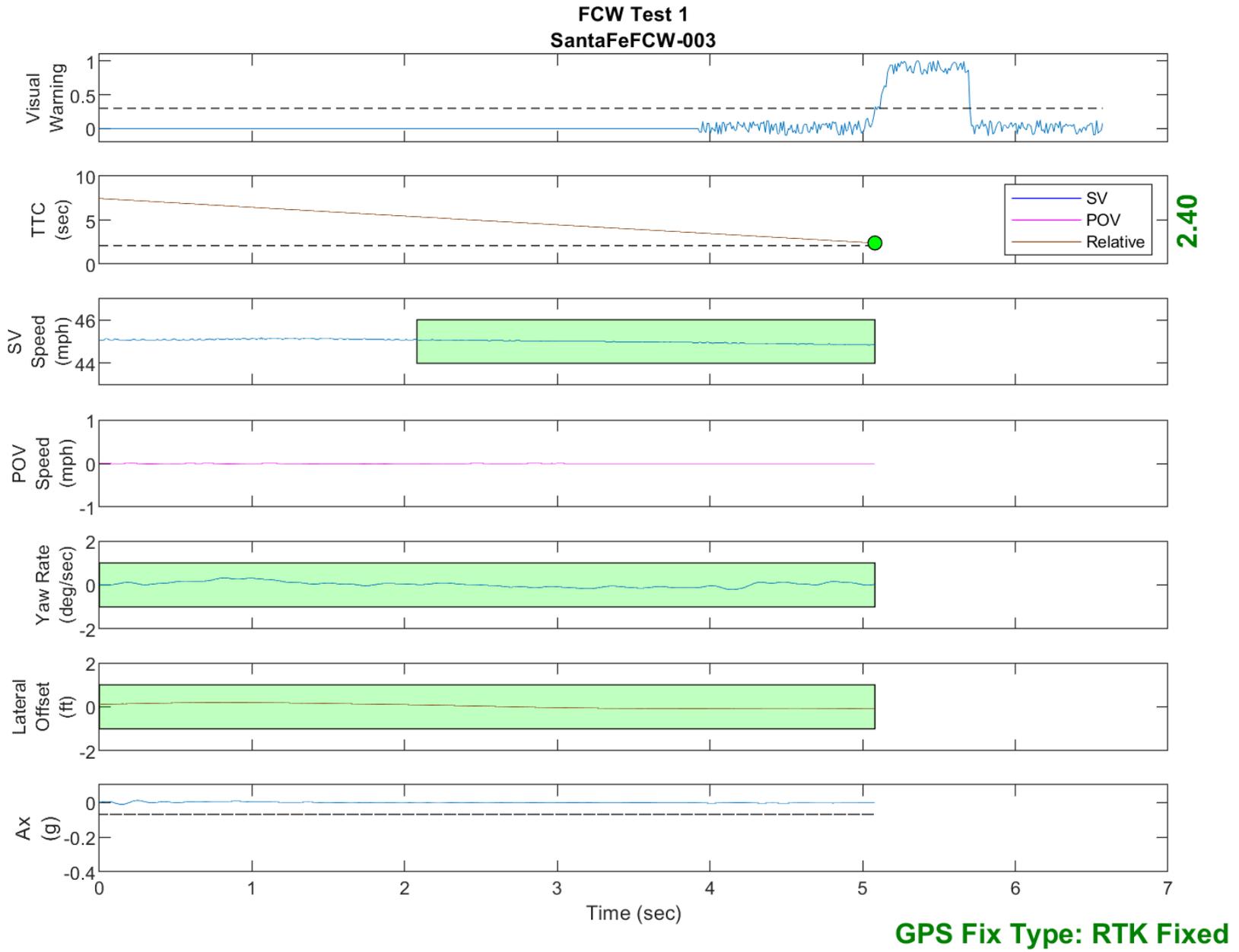


Figure D12. Time History for Run 3, FCW Test 1, Visual Warning

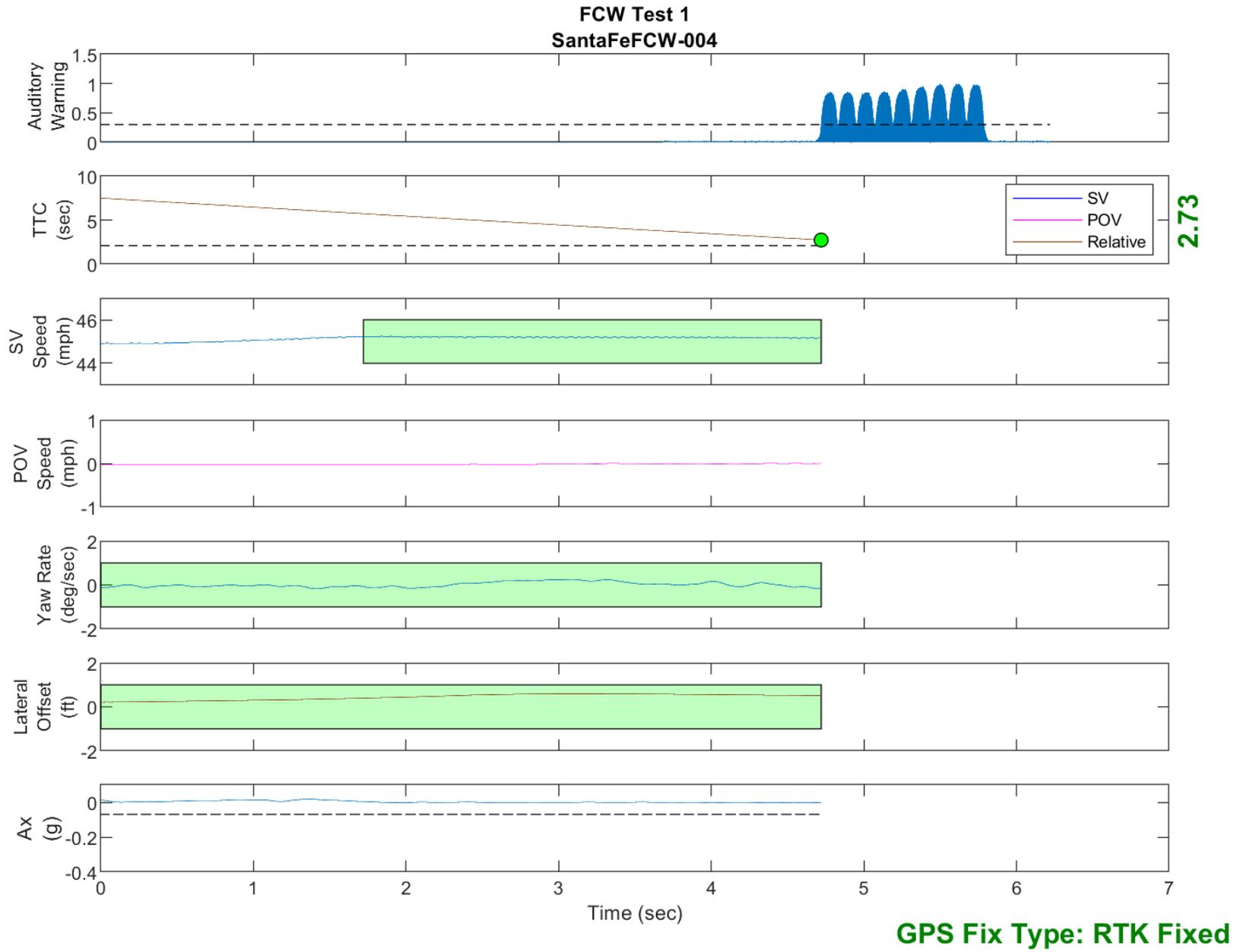


Figure D13. Time History for Run 4, FCW Test 1, Auditory Warning

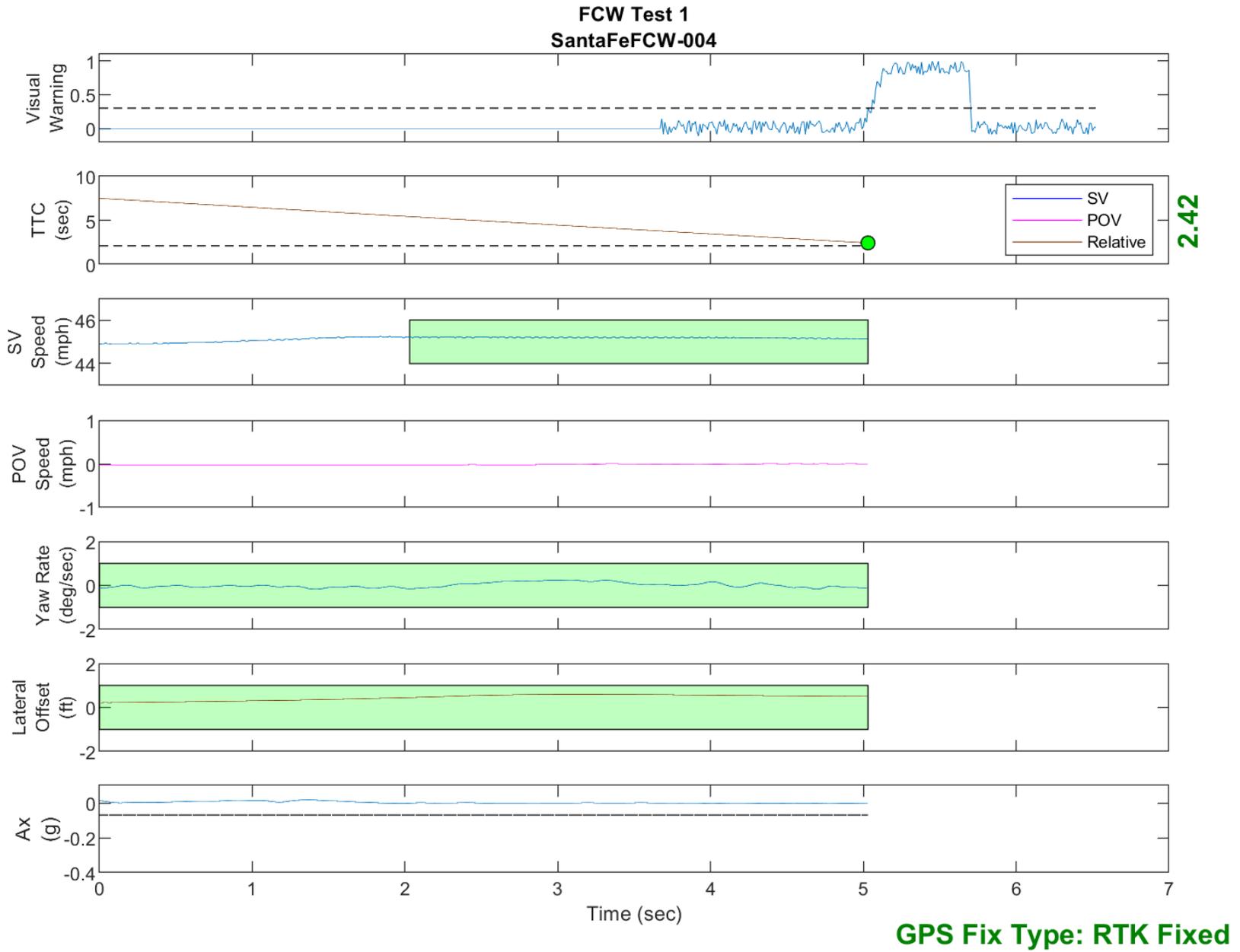


Figure D14. Time History for Run 4, FCW Test 1, Visual Warning

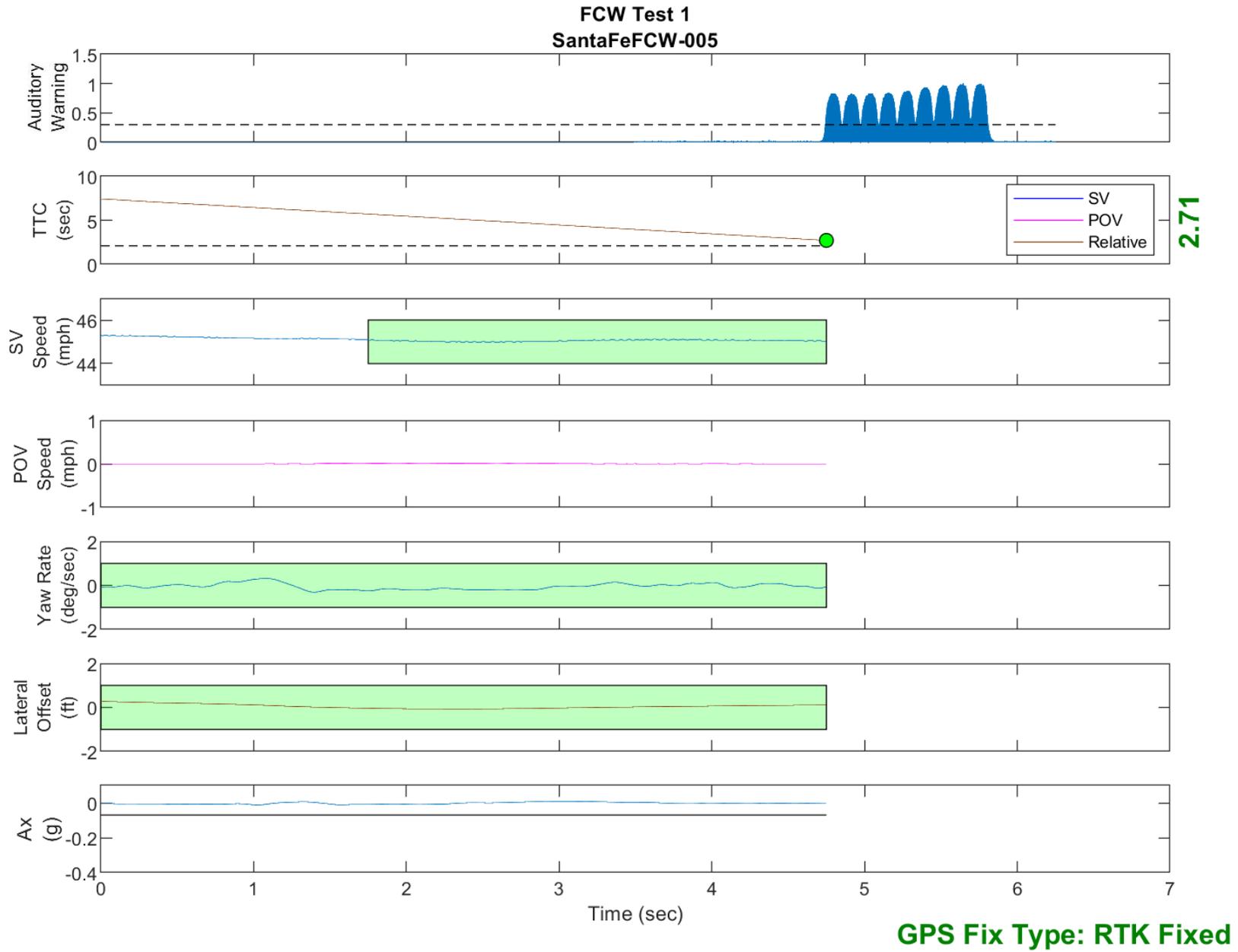


Figure D15. Time History for Run 5, FCW Test 1, Auditory Warning

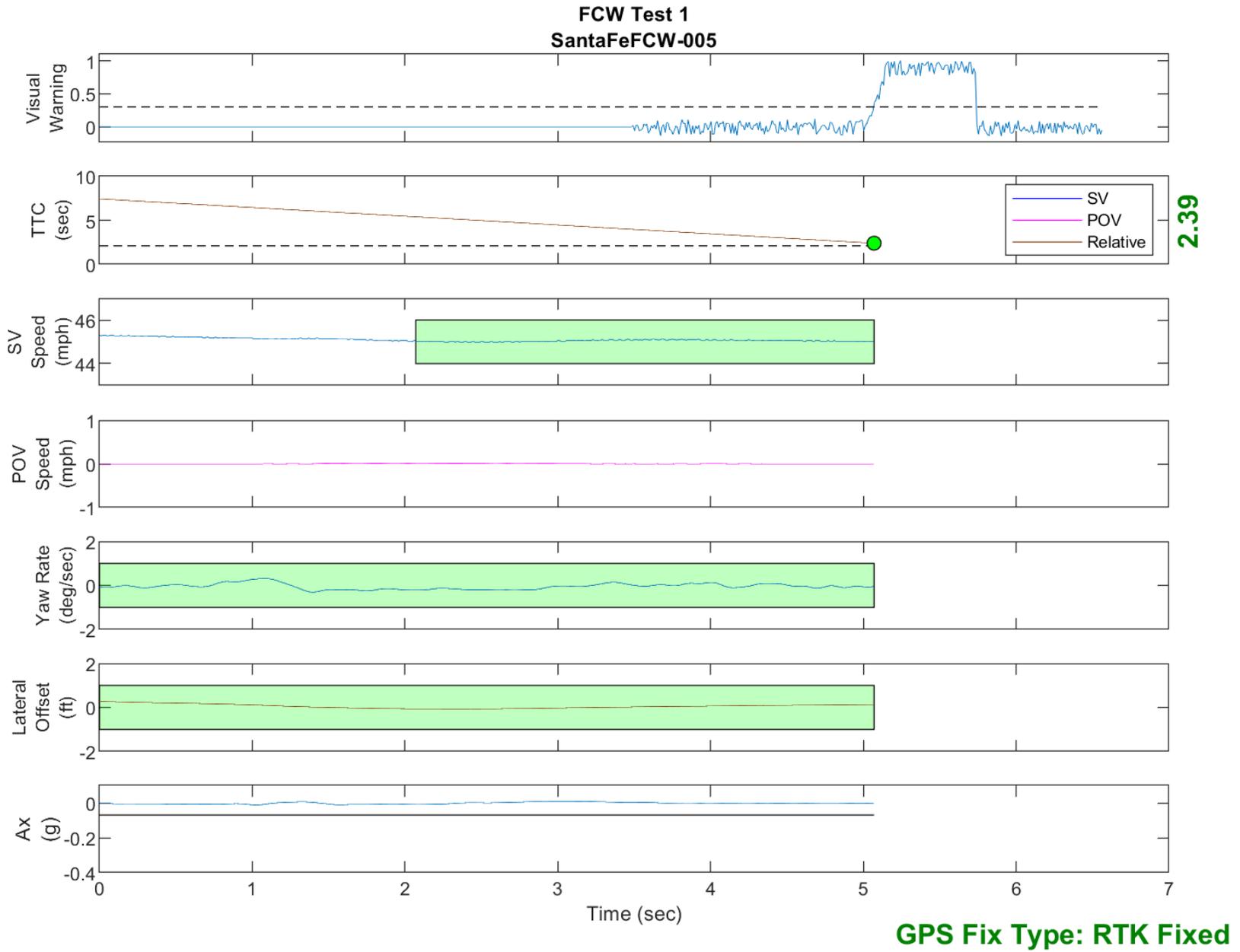


Figure D16. Time History for Run 5, FCW Test 1, Visual Warning

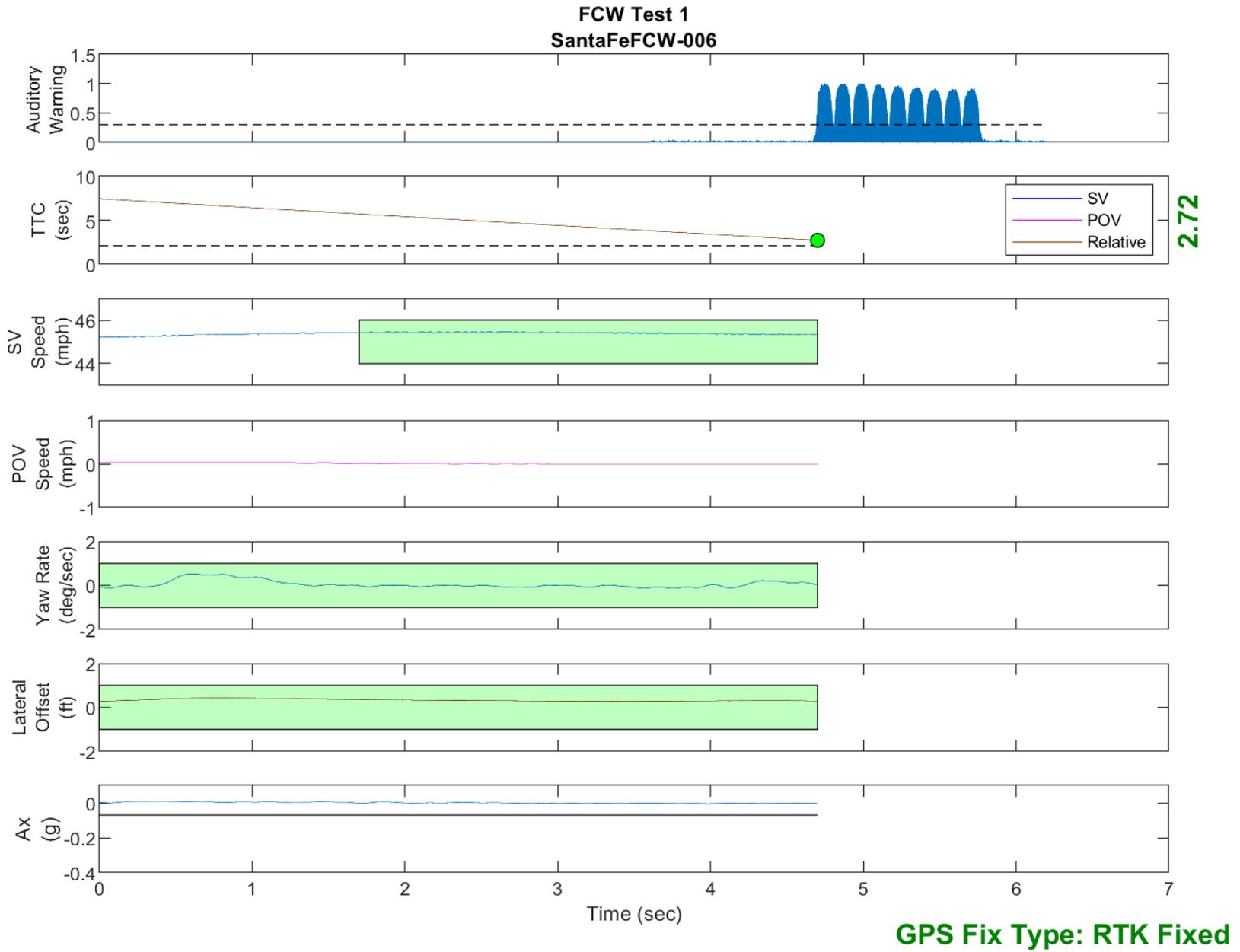


Figure D17. Time History for Run 6, FCW Test 1, Auditory Warning

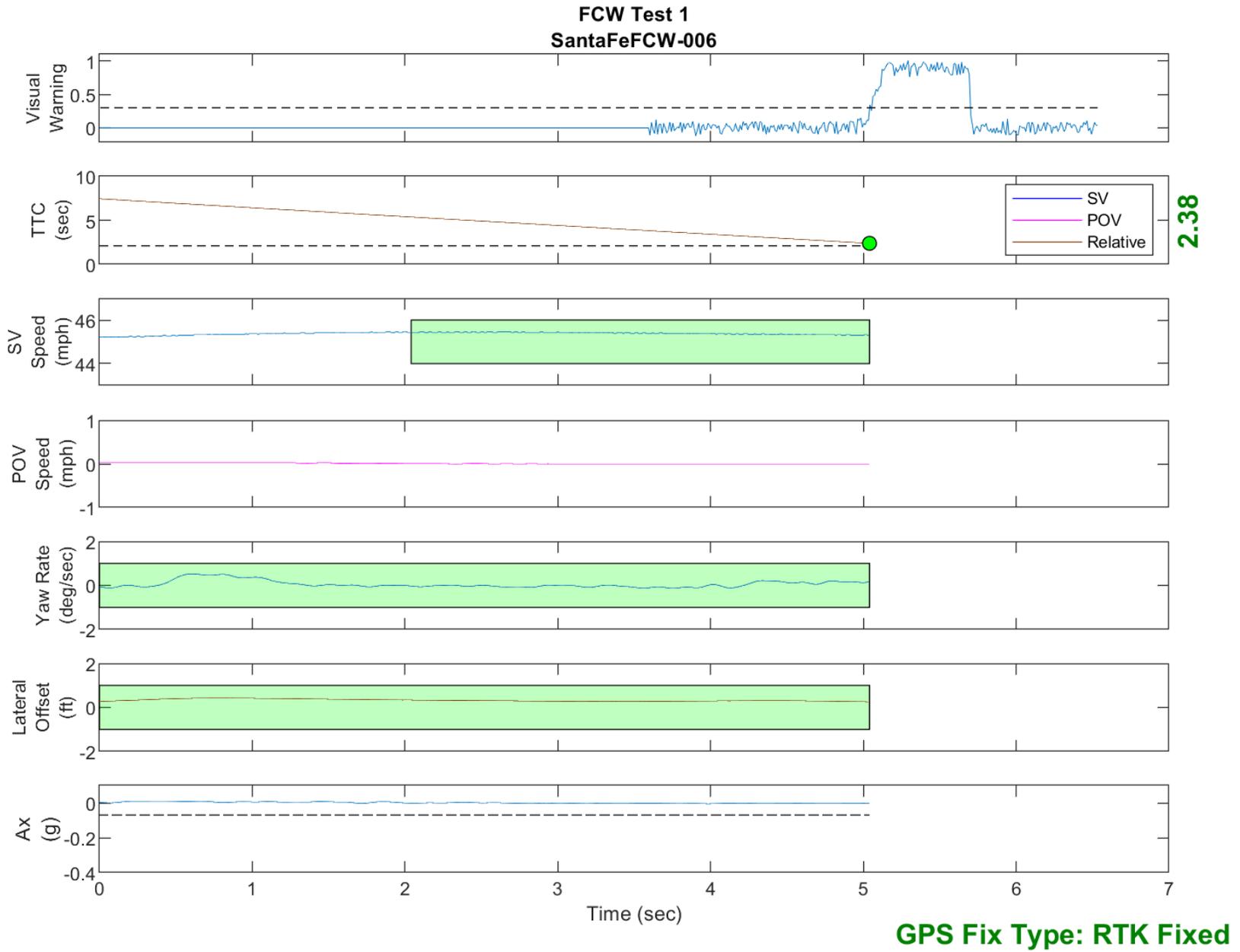


Figure D18. Time History for Run 6, FCW Test 1, Visual Warning

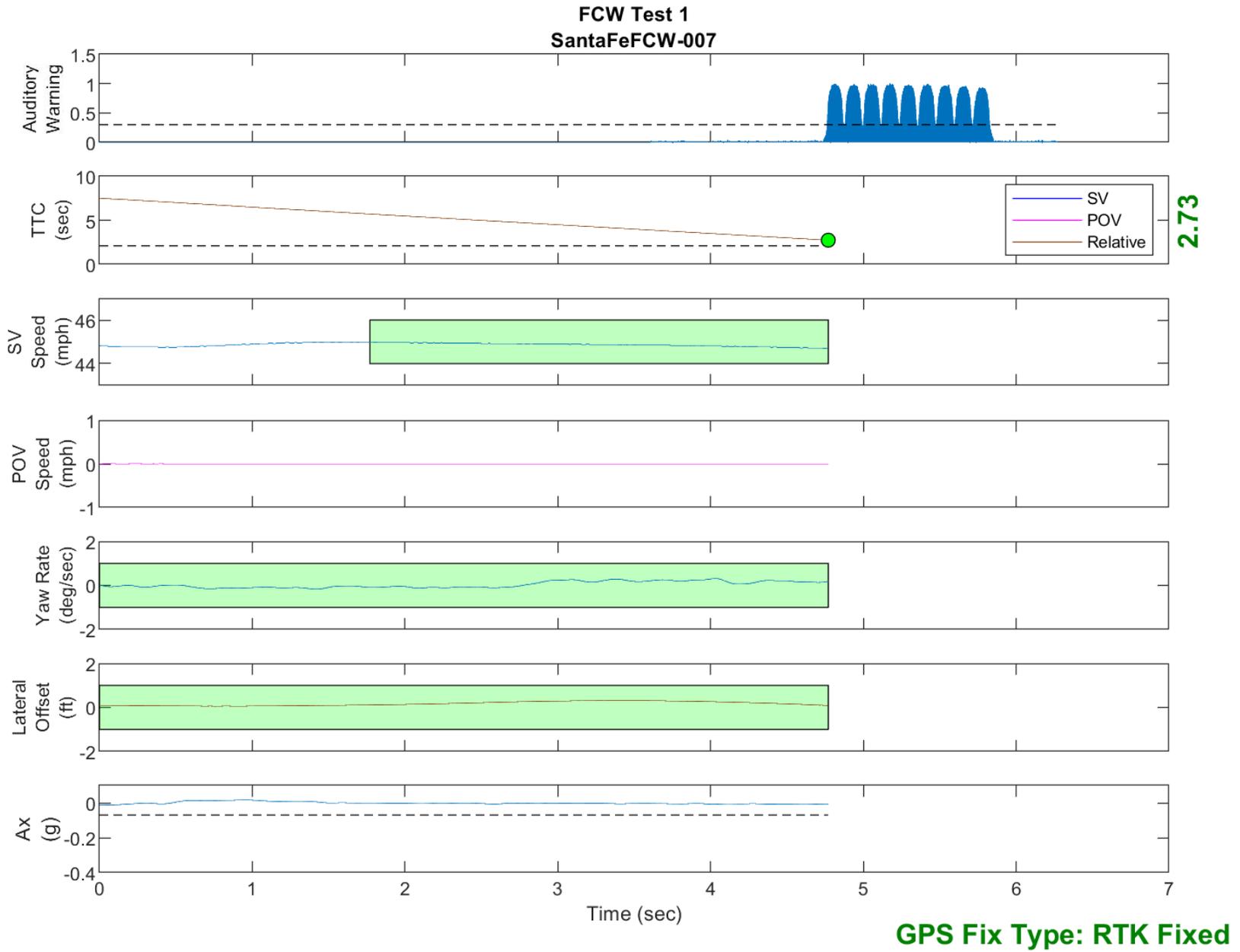


Figure D19. Time History for Run 7, FCW Test 1, Auditory Warning

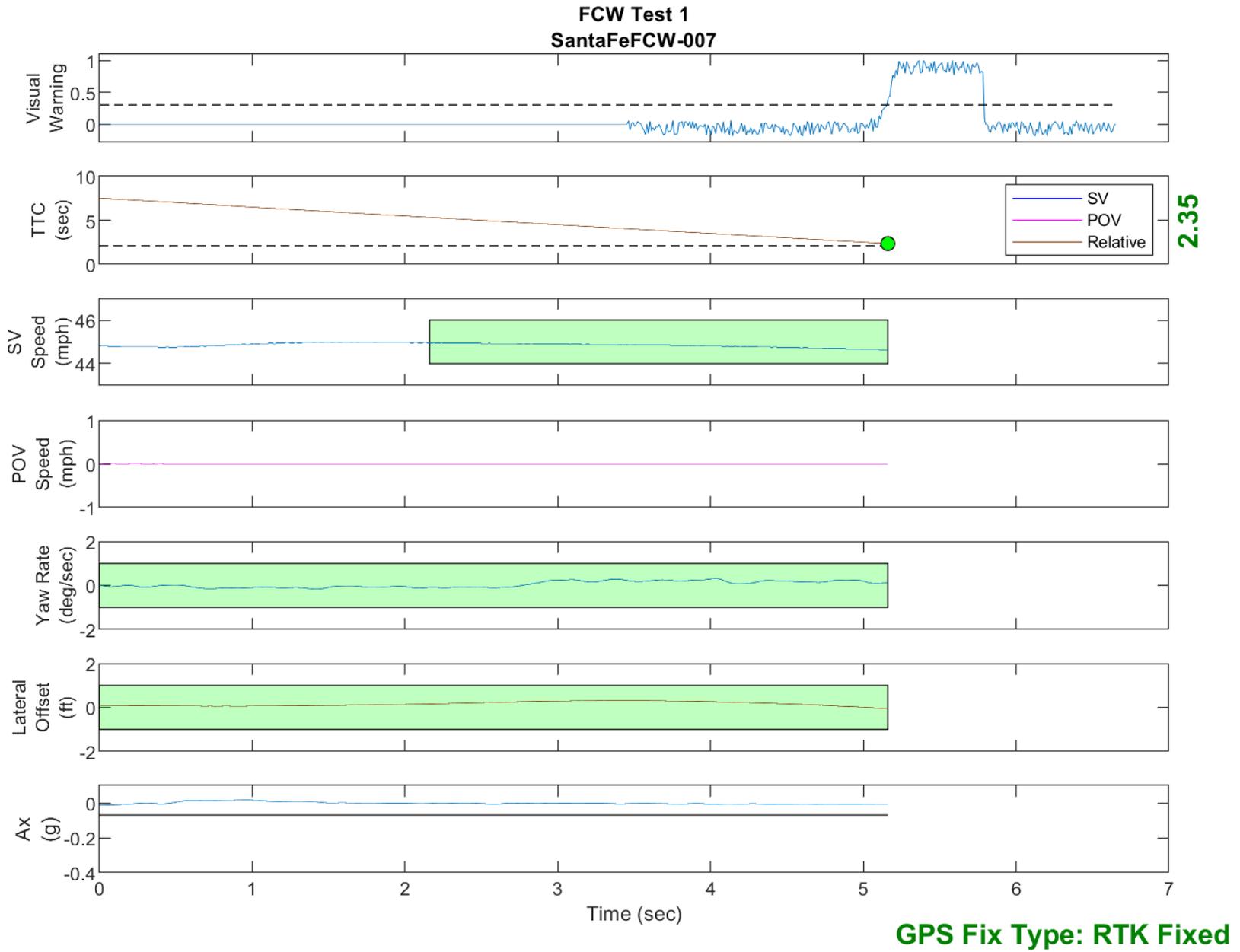


Figure D20. Time History for Run 7, FCW Test 1, Visual Warning

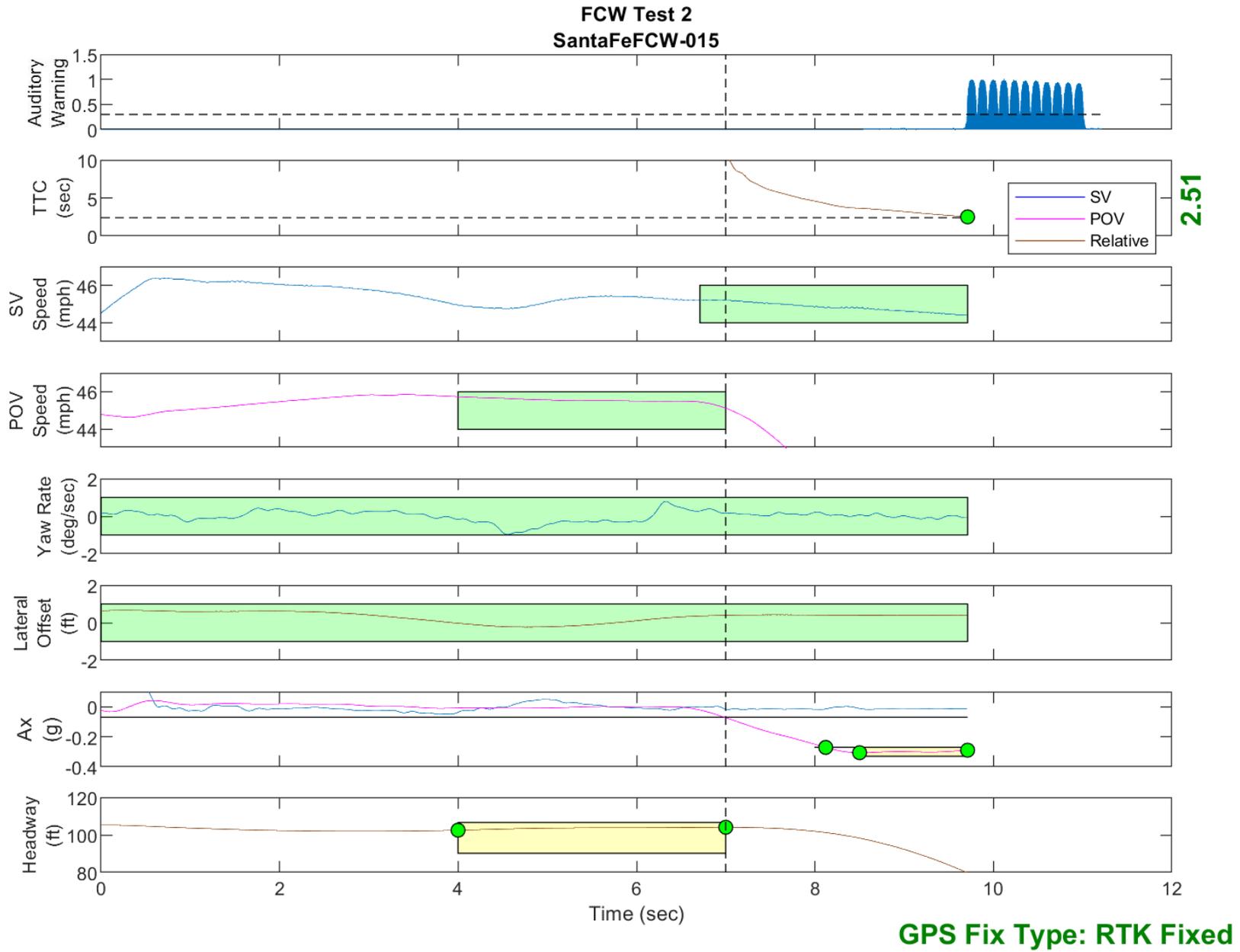


Figure D21. Time History for Run 15, FCW Test 2, Auditory Warning

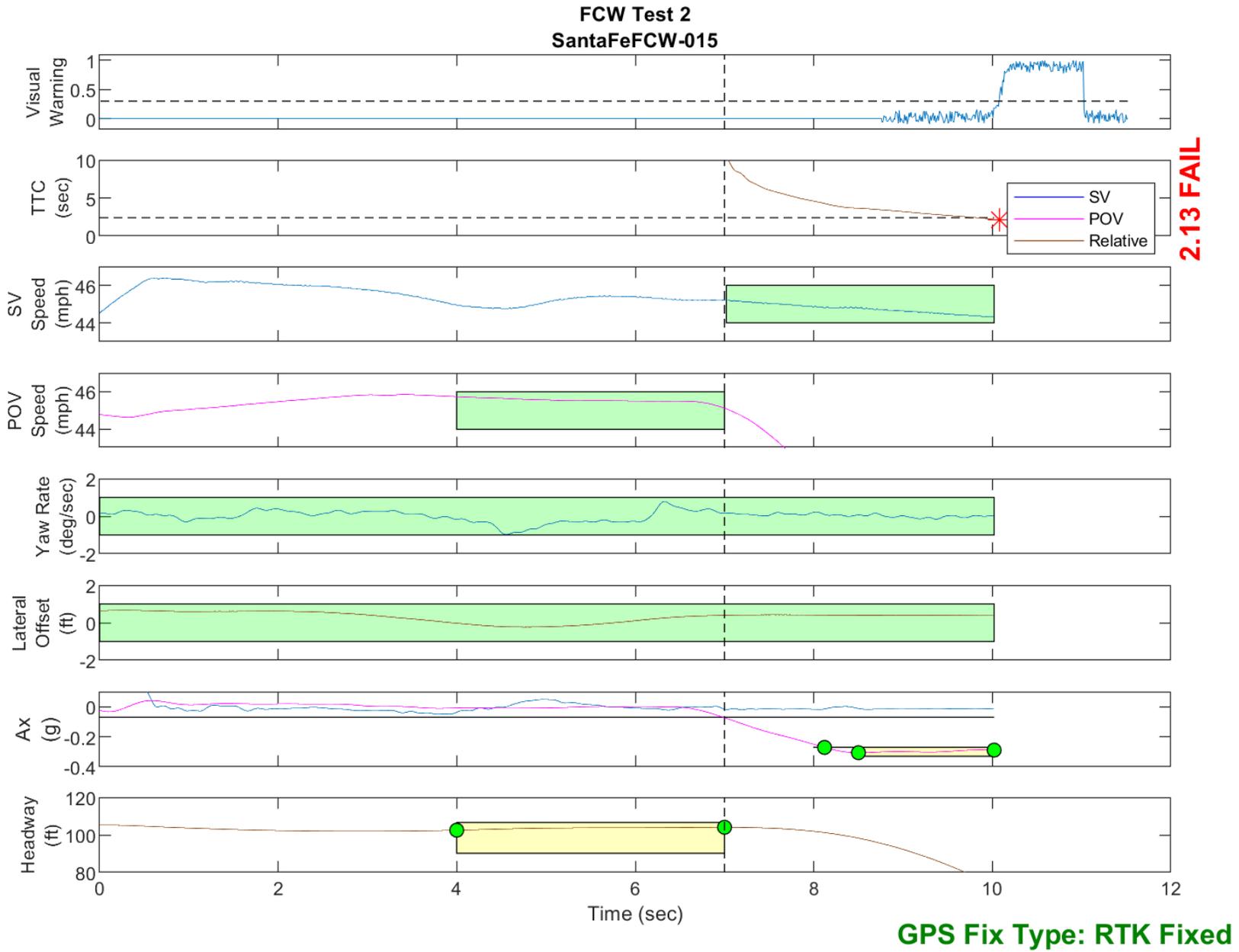


Figure D22. Time History for Run 15, FCW Test 2, Visual Warning

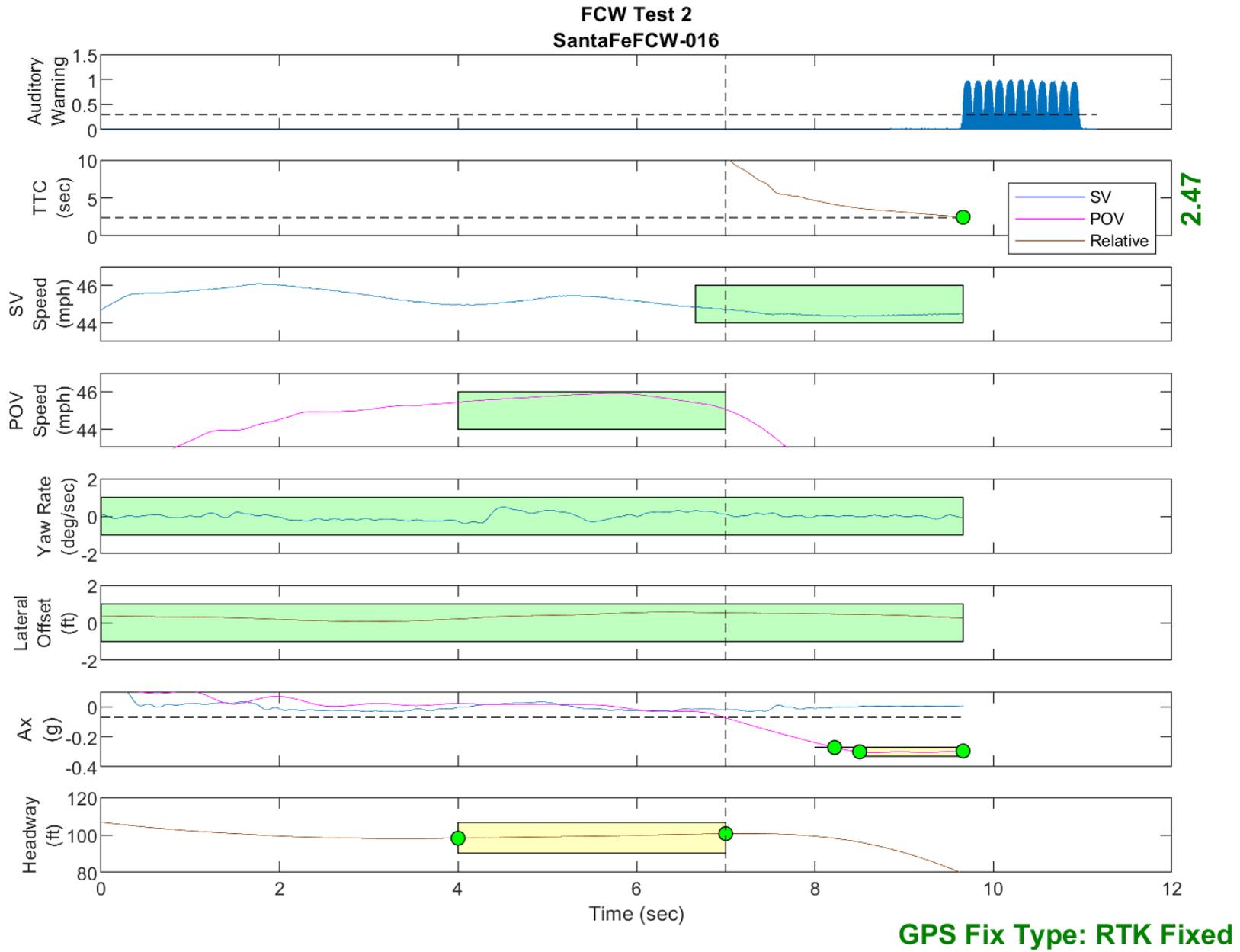


Figure D23. Time History for Run 16, FCW Test 2, Auditory Warning

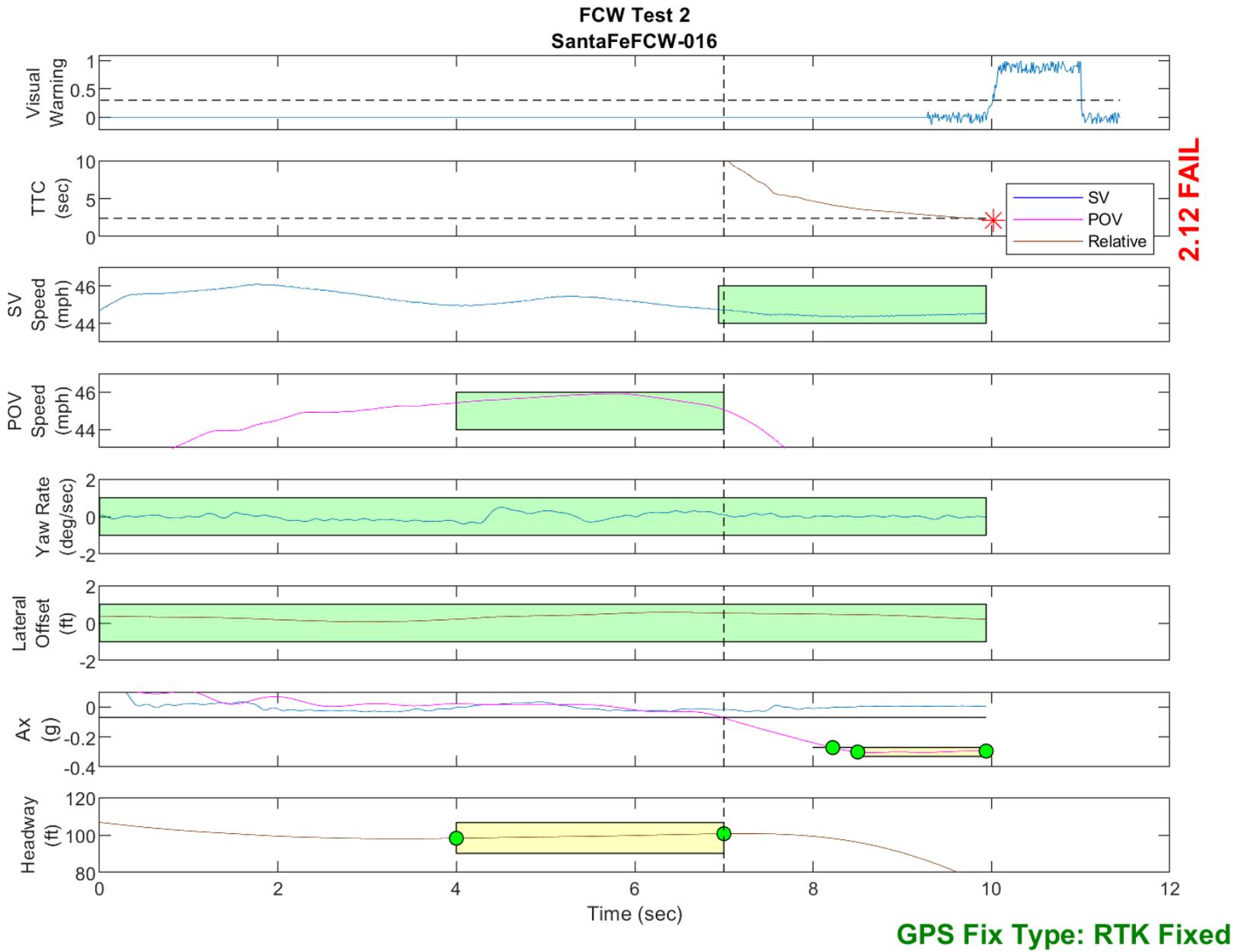


Figure D24. Time History for Run 16, FCW Test 2, Visual Warning

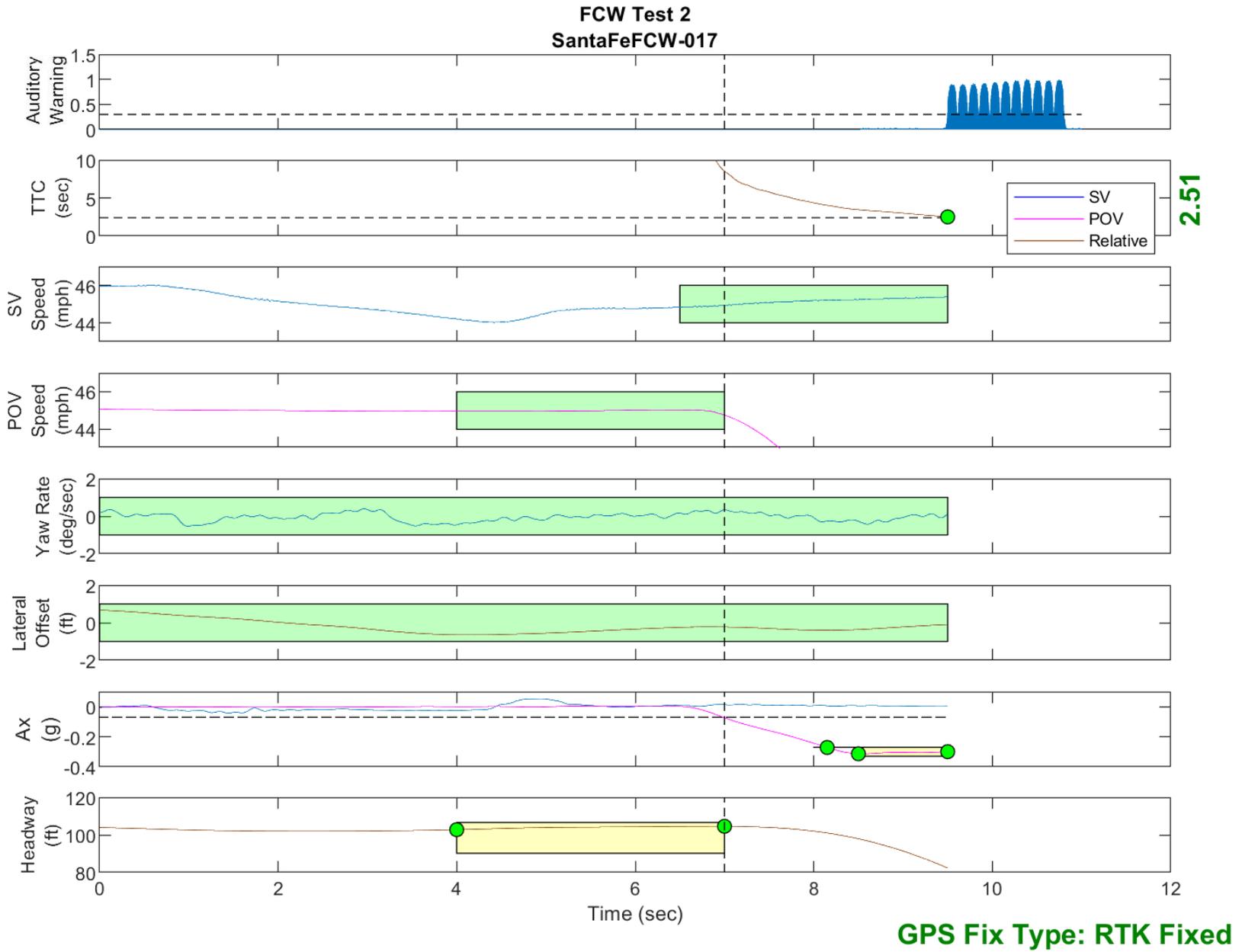


Figure D25. Time History for Run 17, FCW Test 2, Auditory Warning

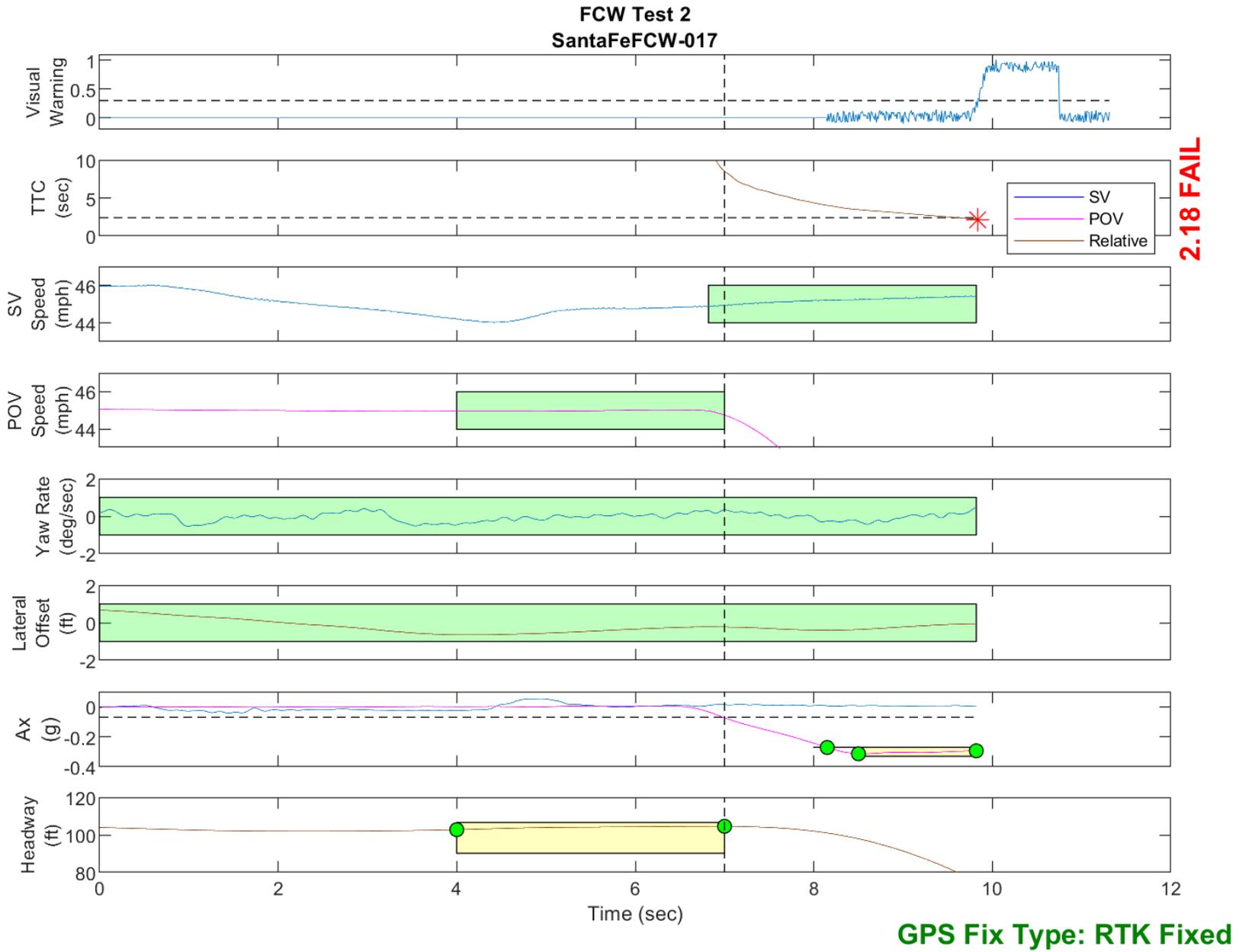


Figure D26. Time History for Run 17, FCW Test 2, Visual Warning

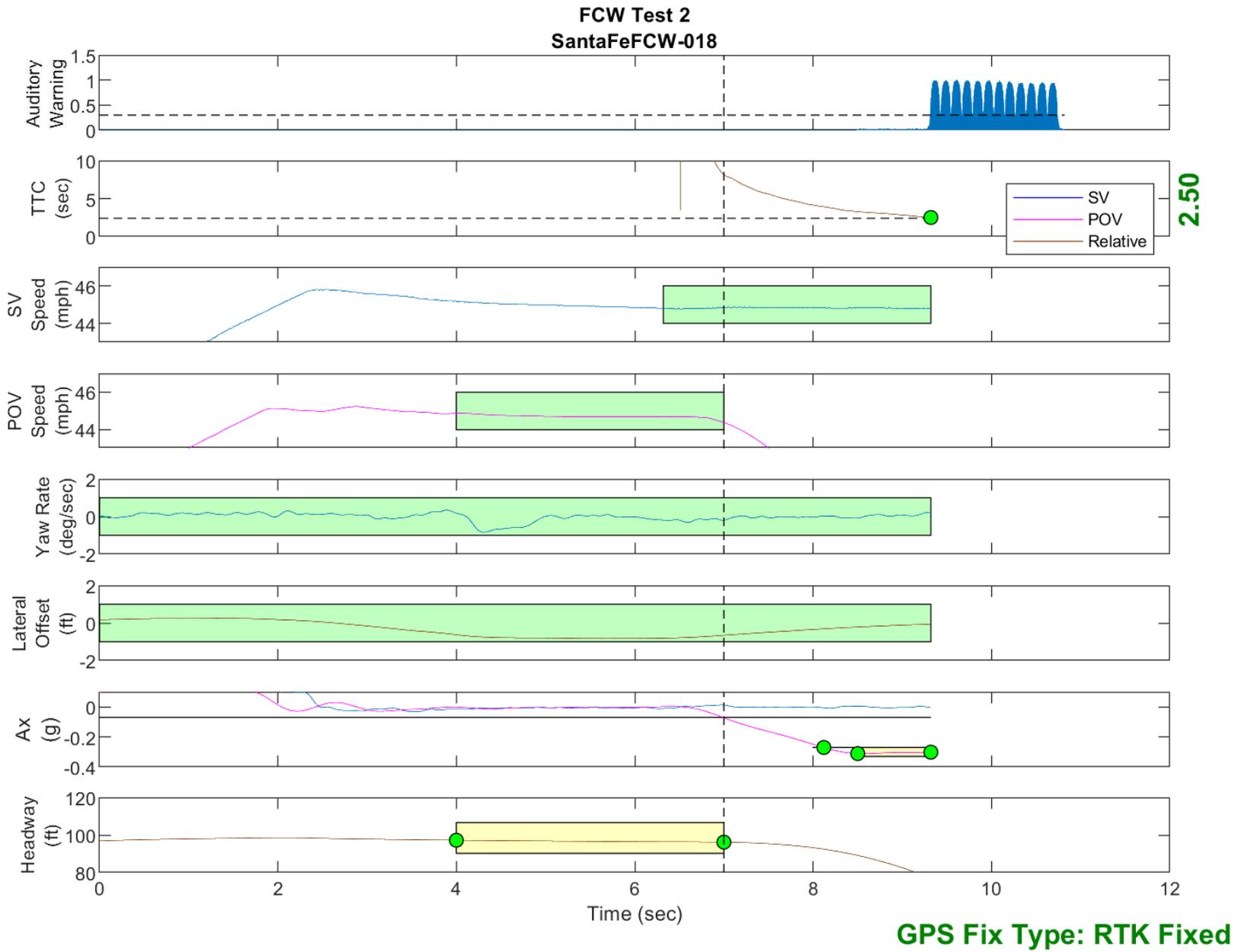


Figure D27. Time History for Run 18, FCW Test 2, Auditory Warning

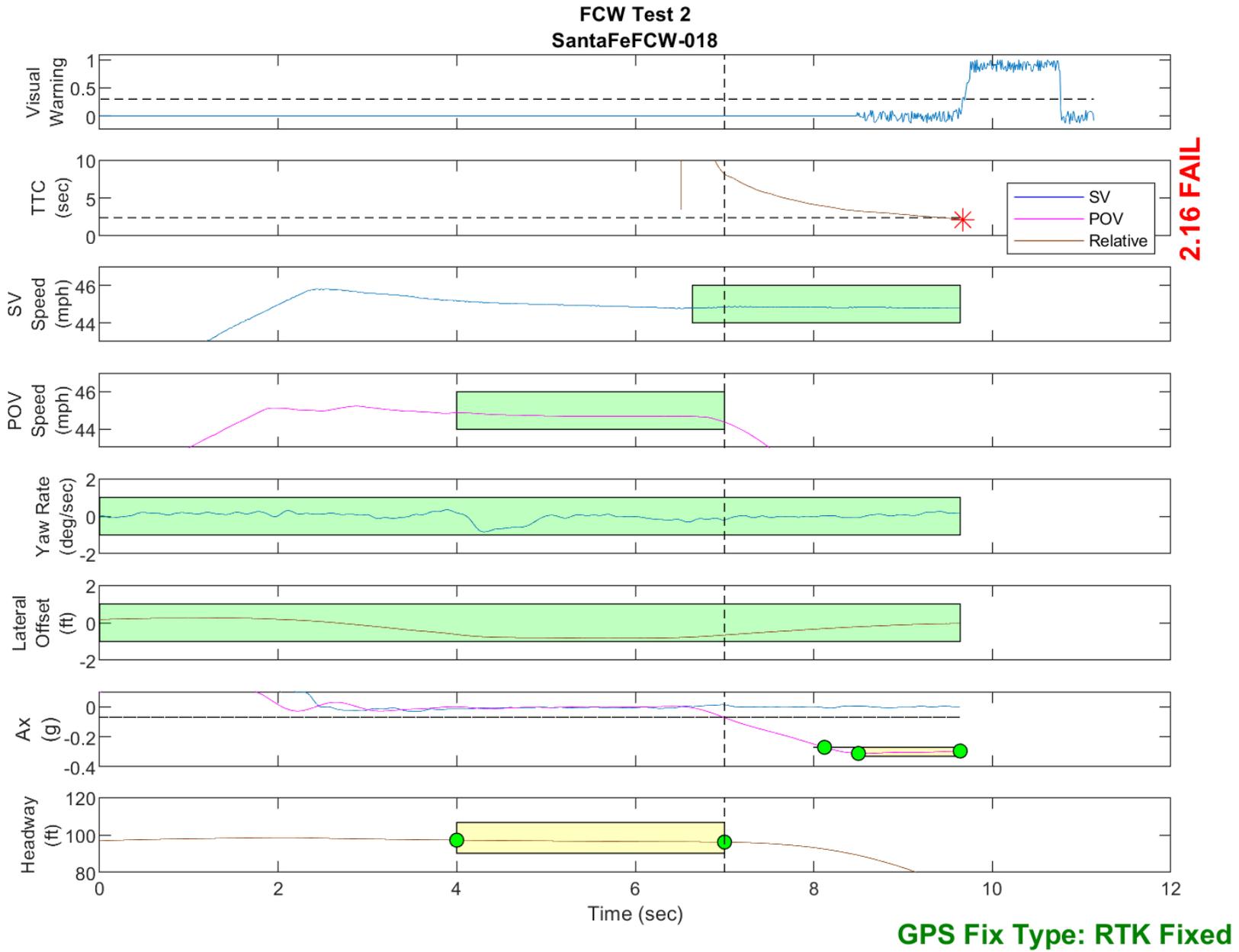


Figure D28. Time History for Run 18, FCW Test 2, Visual Warning

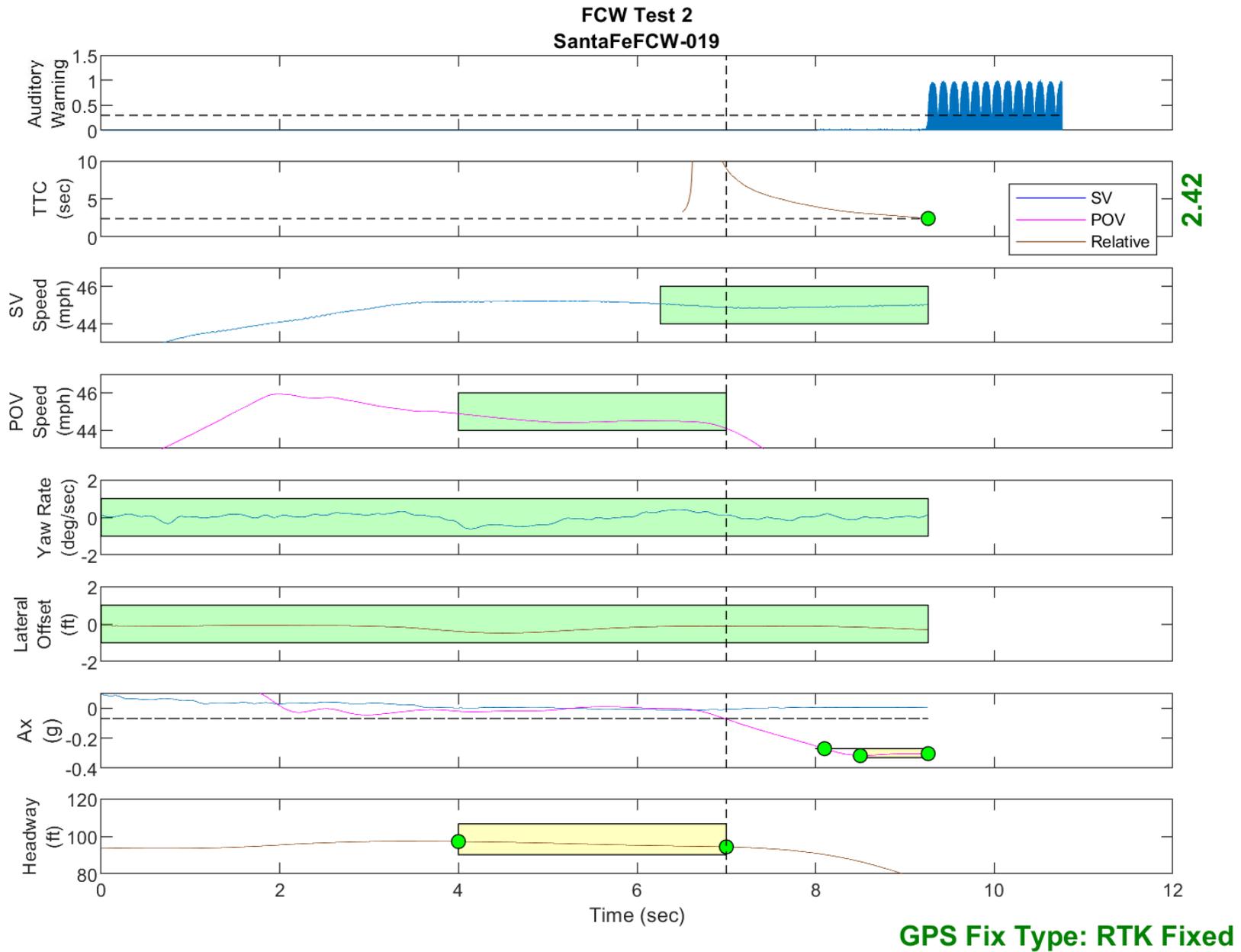


Figure D29. Time History for Run 19, FCW Test 2, Auditory Warning

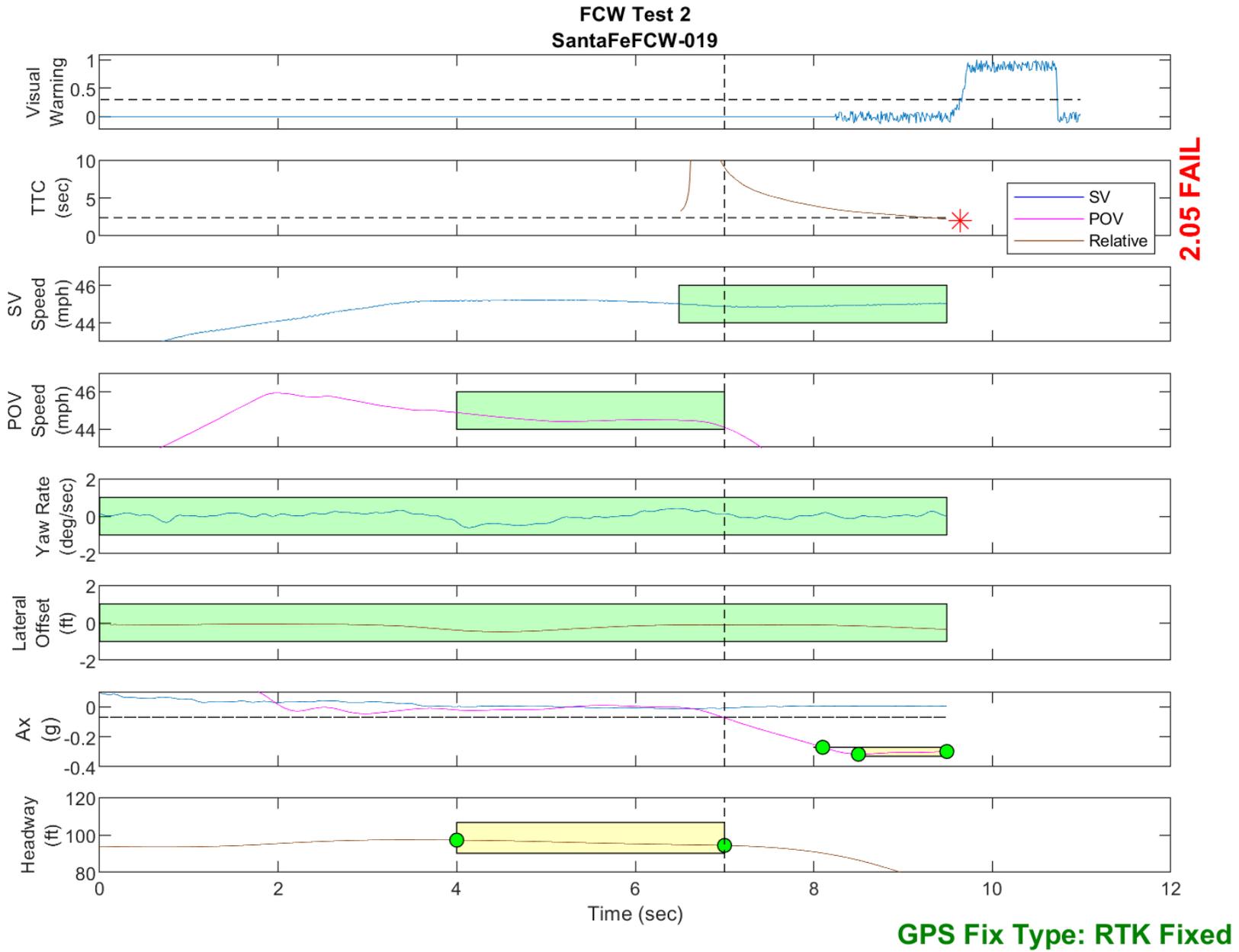


Figure D30. Time History for Run 19, FCW Test 2, Visual Warning

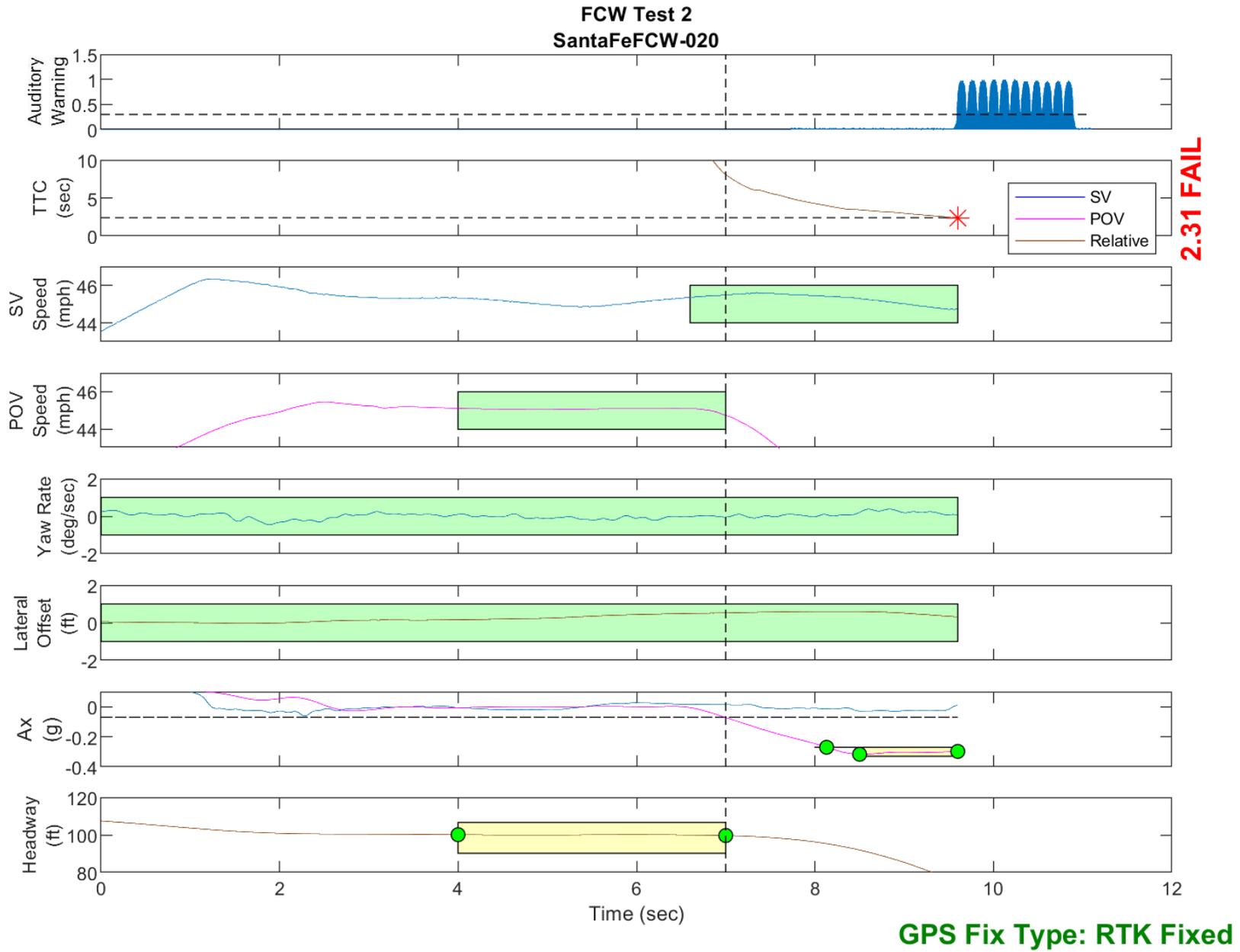


Figure D31. Time History for Run 20, FCW Test 2, Auditory Warning

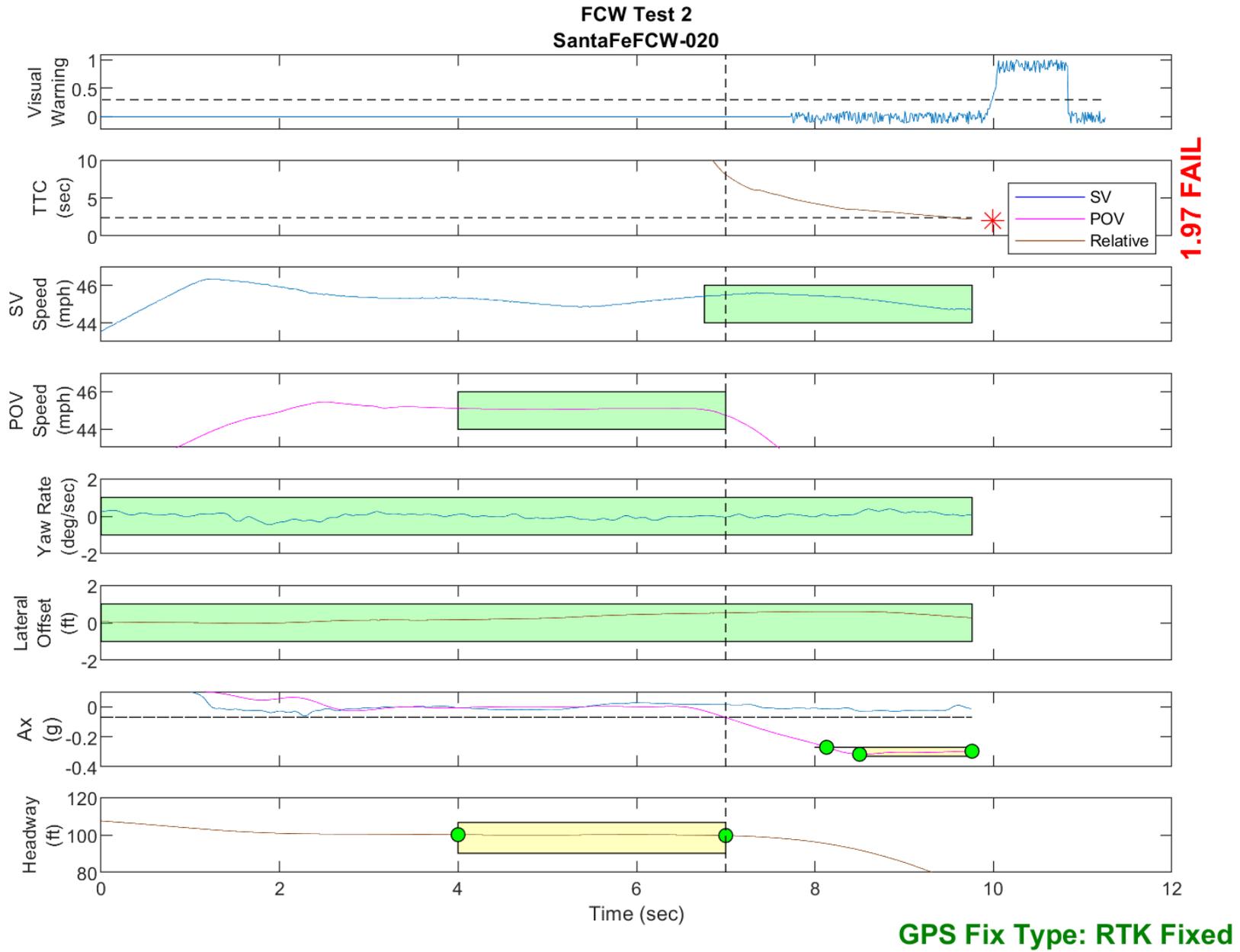


Figure D32. Time History for Run 20, FCW Test 2, Visual Warning

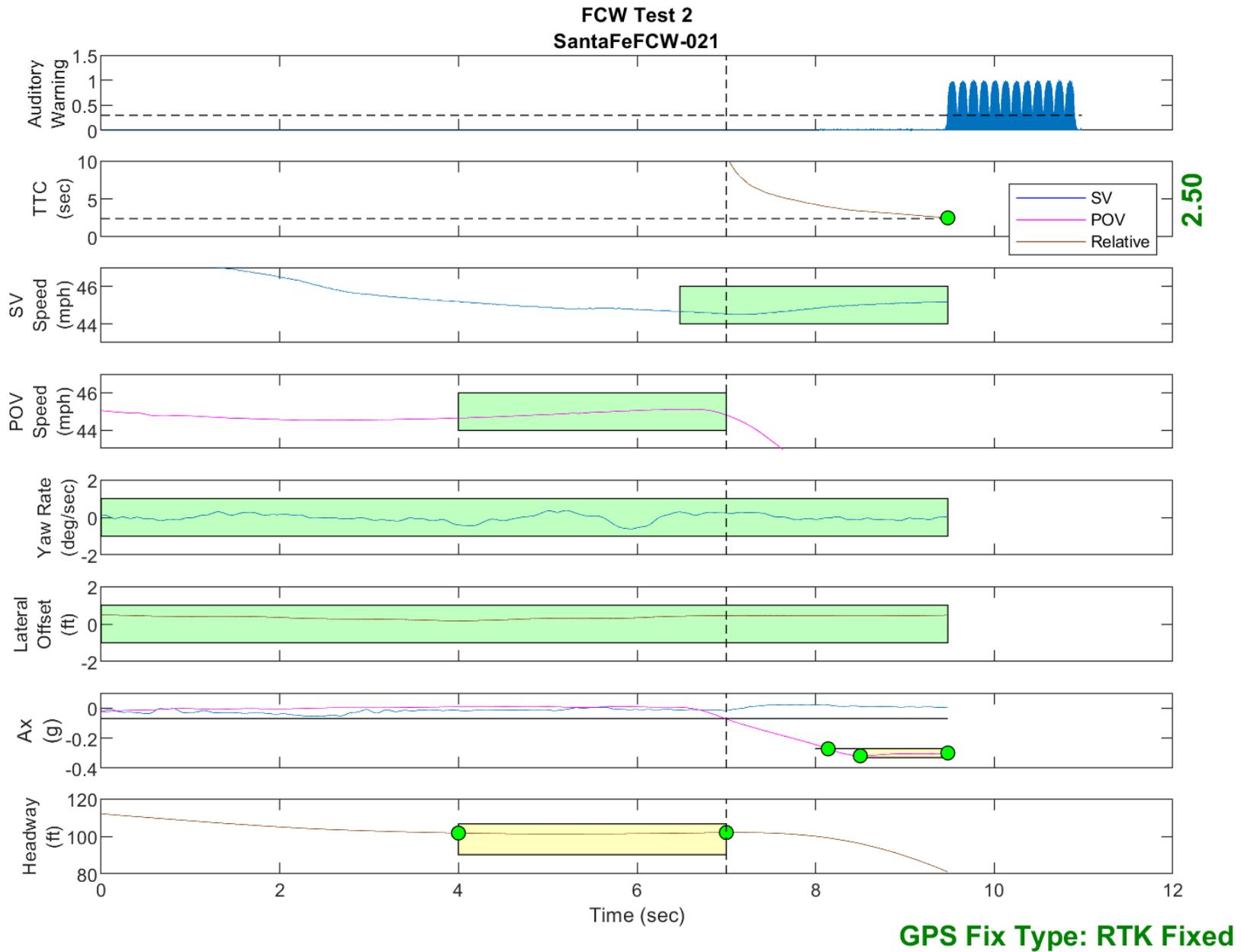


Figure D33. Time History for Run 21, FCW Test 2, Auditory Warning

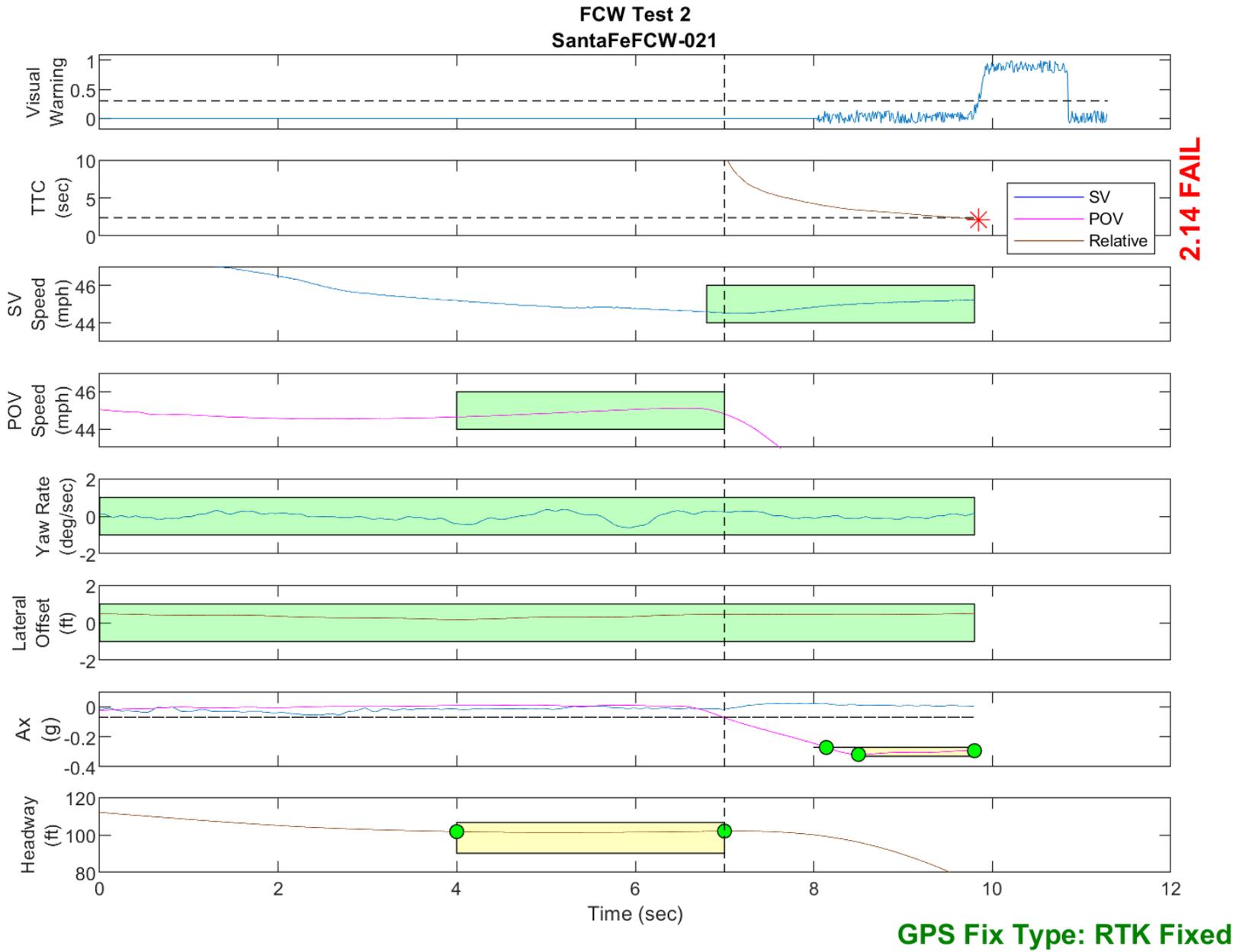


Figure D34. Time History for Run 21, FCW Test 2, Visual Warning

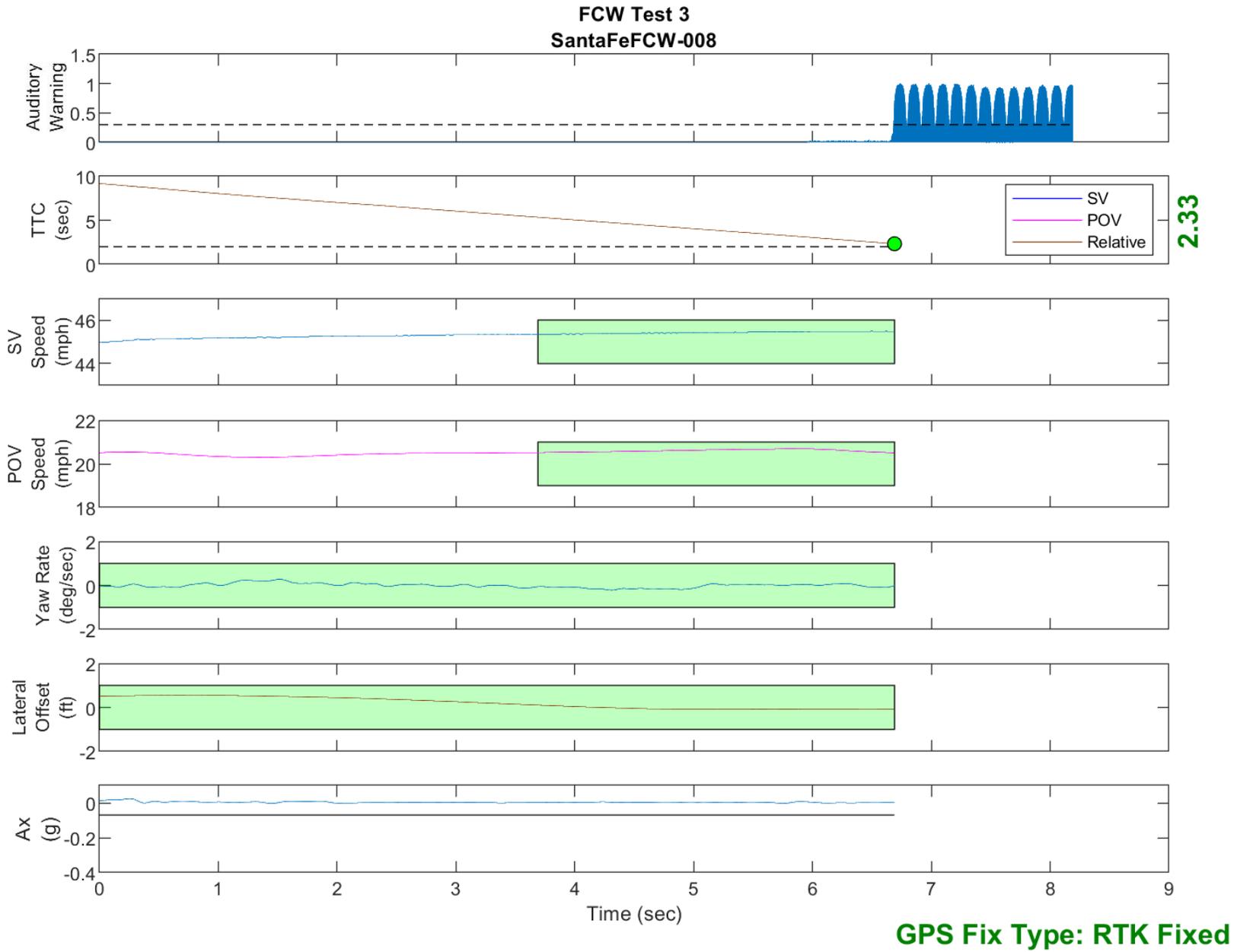


Figure D35. Time History for Run 8, FCW Test 3, Auditory Warning

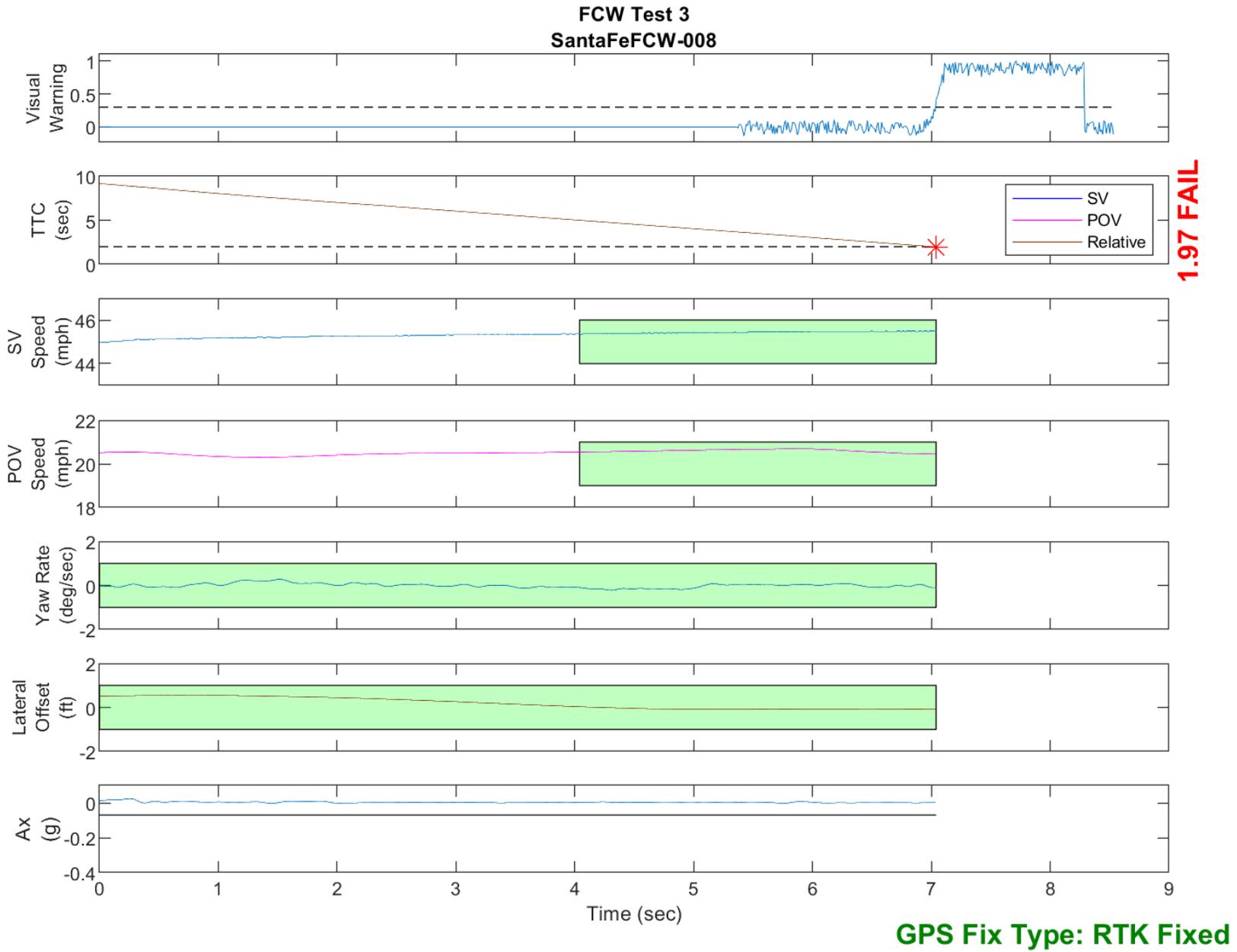


Figure D36. Time History for Run 8, FCW Test 3, Visual Warning

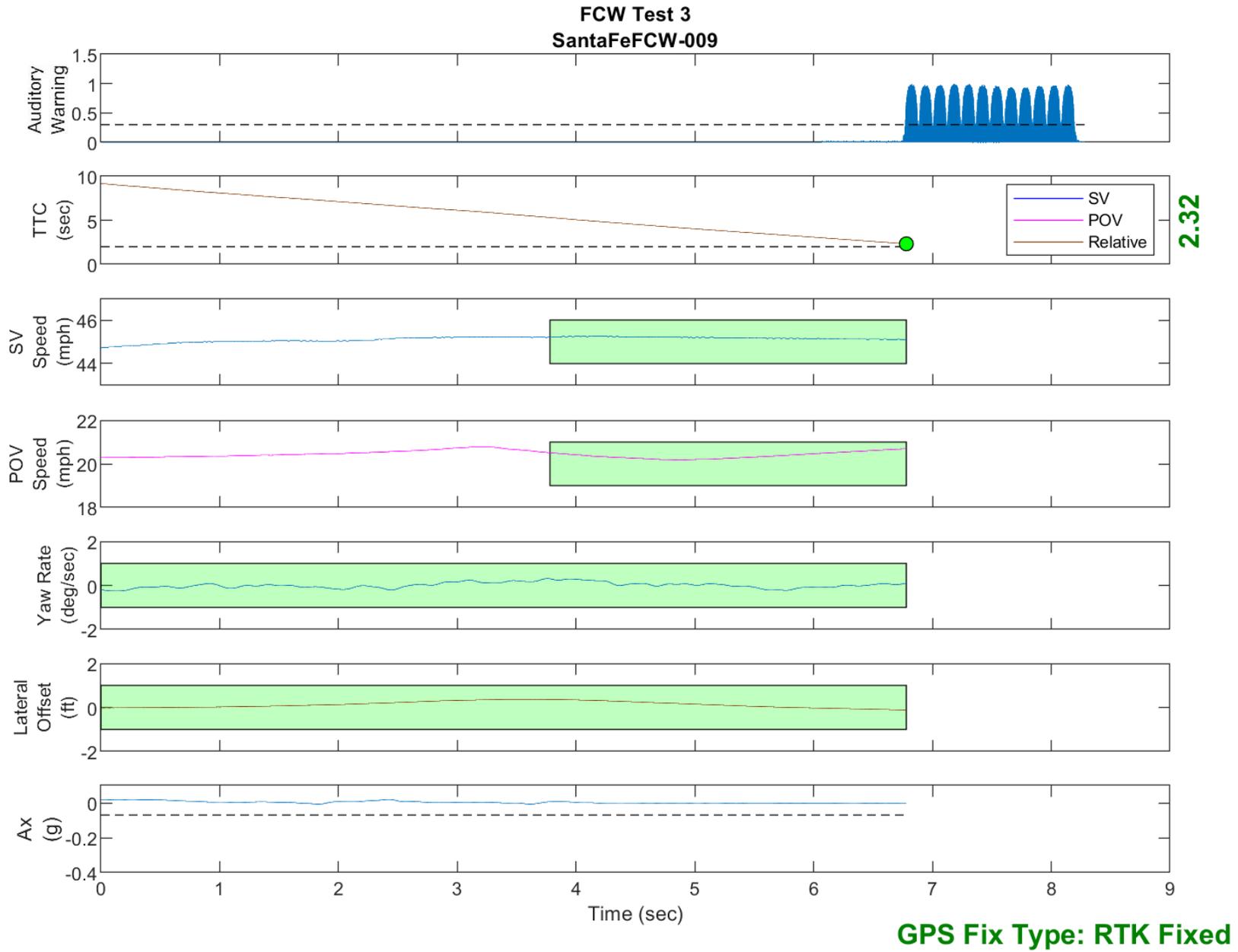


Figure D37. Time History for Run 9, FCW Test 3, Auditory Warning

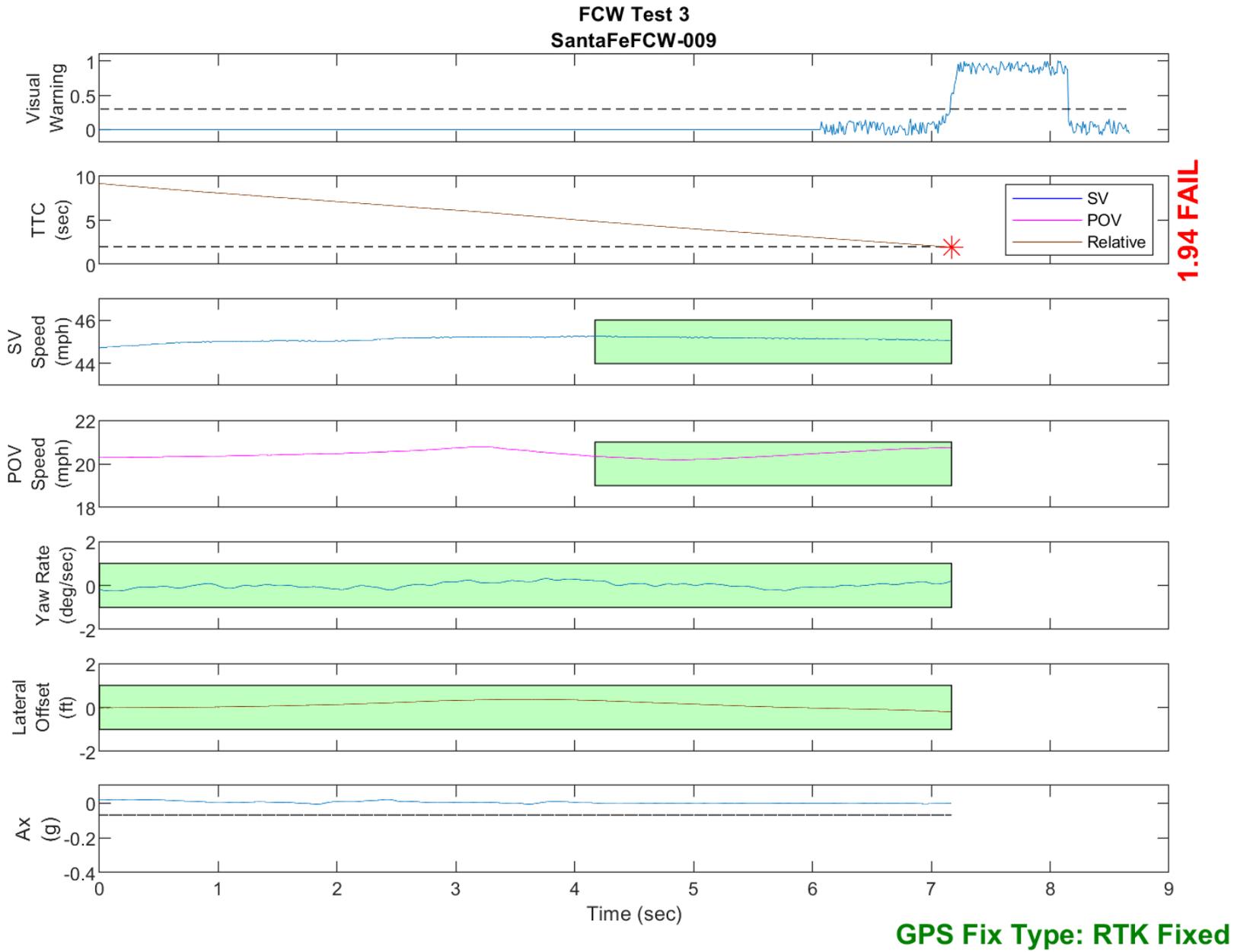


Figure D38. Time History for Run 9, FCW Test 3, Visual Warning

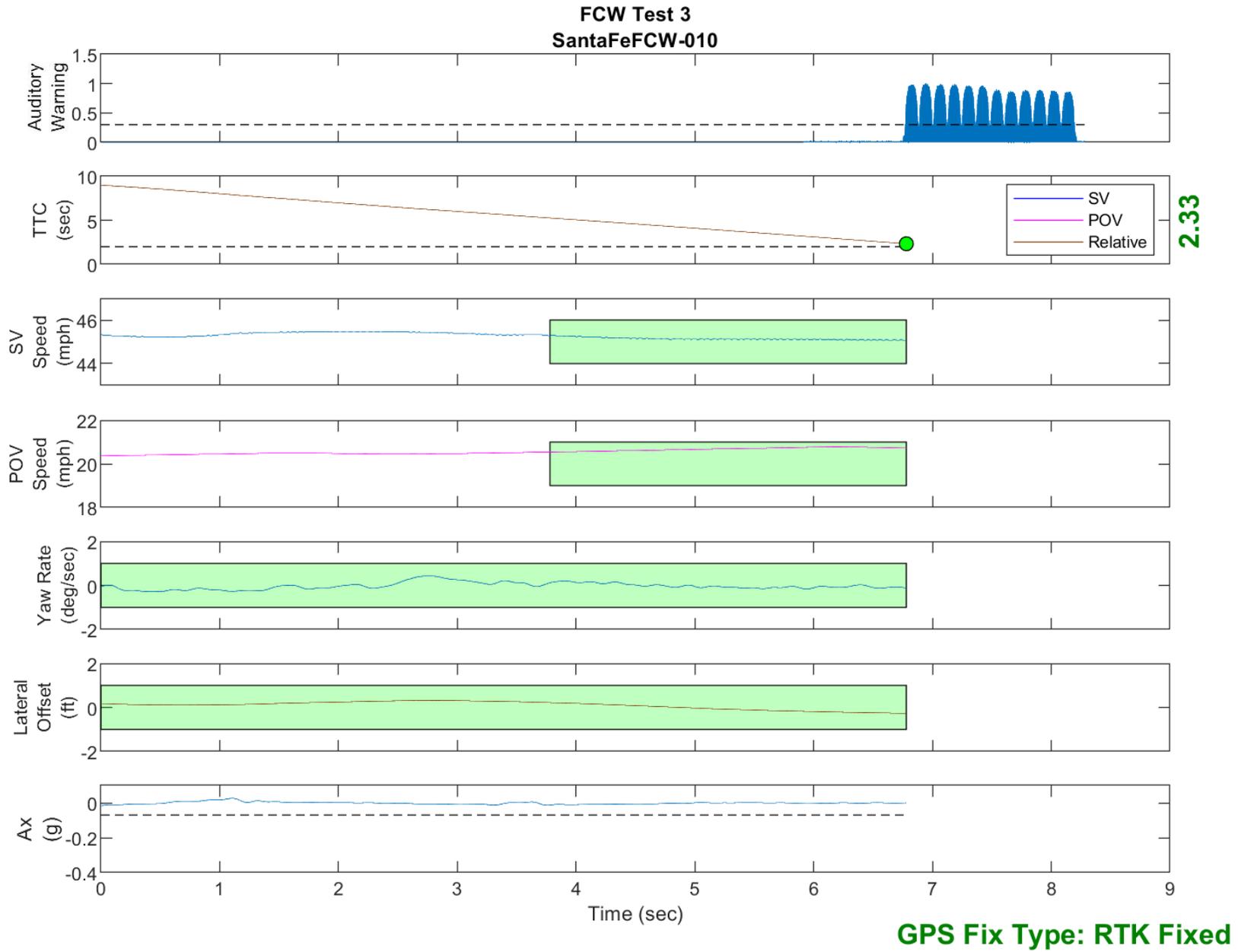


Figure D39. Time History for Run 10, FCW Test 3, Auditory Warning

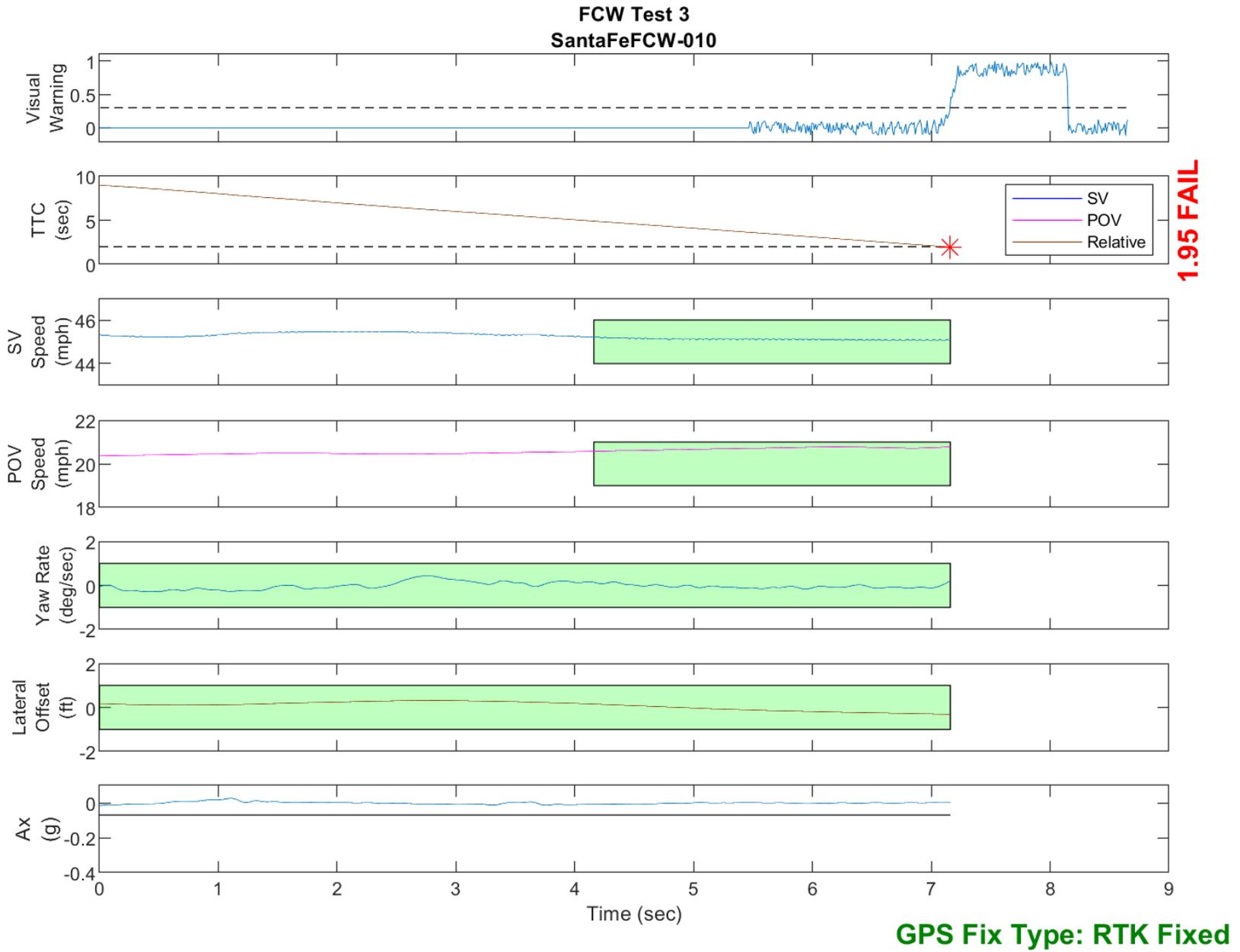


Figure D40. Time History for Run 10, FCW Test 3, Visual Warning

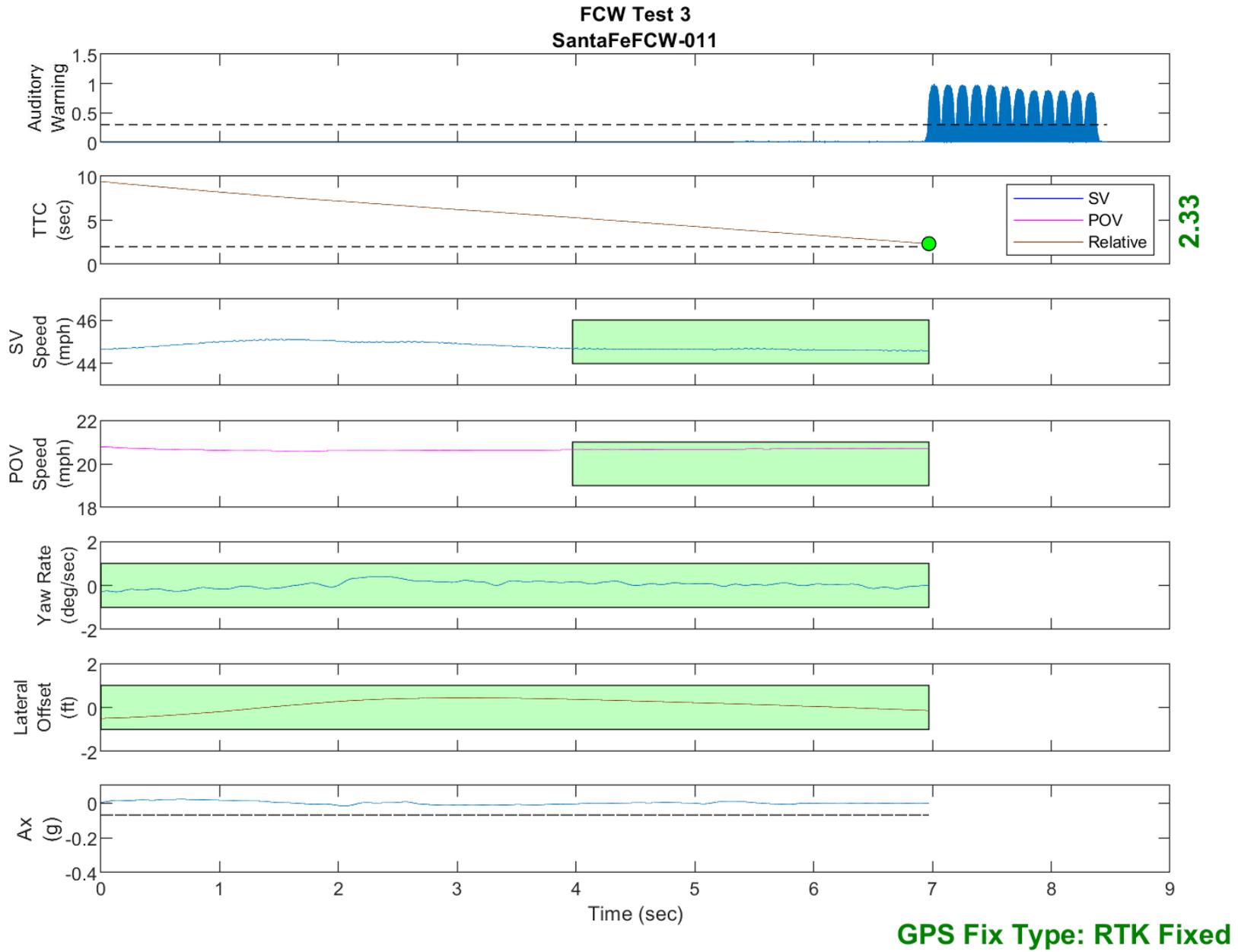


Figure D41. Time History for Run 11, FCW Test 3, Auditory Warning

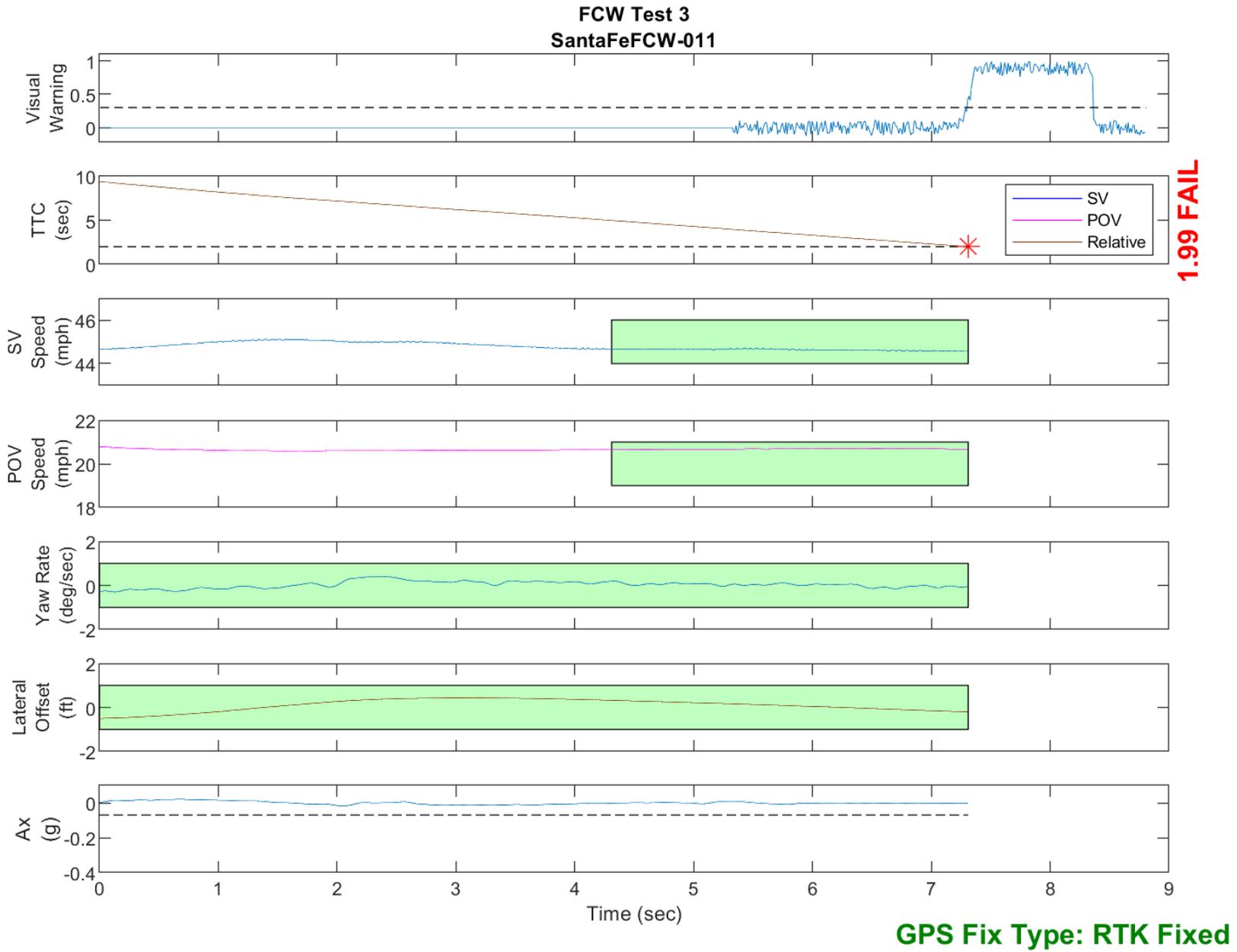


Figure D42. Time History for Run 11, FCW Test 3, Visual Warning

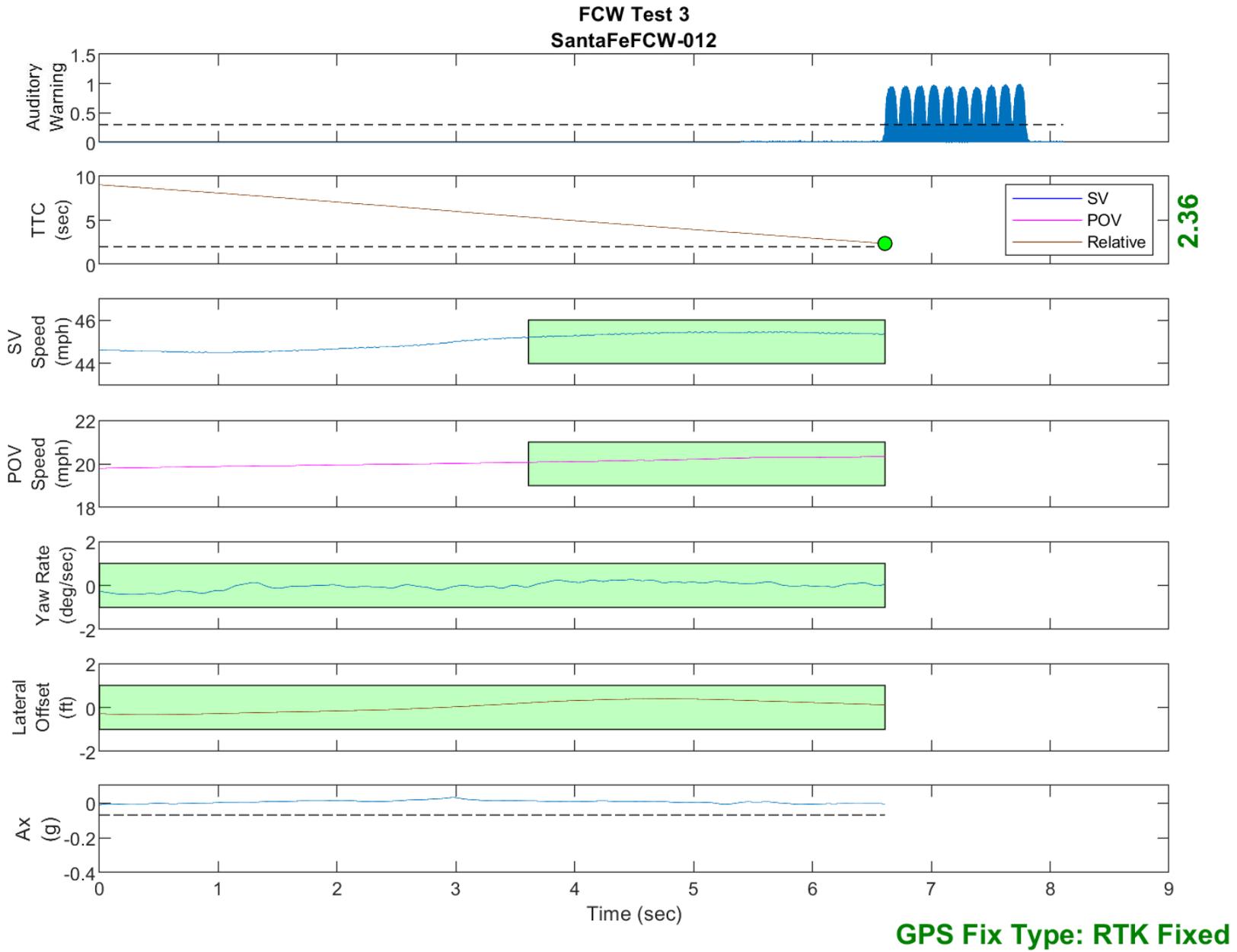


Figure D43. Time History for Run 12, FCW Test 3, Auditory Warning

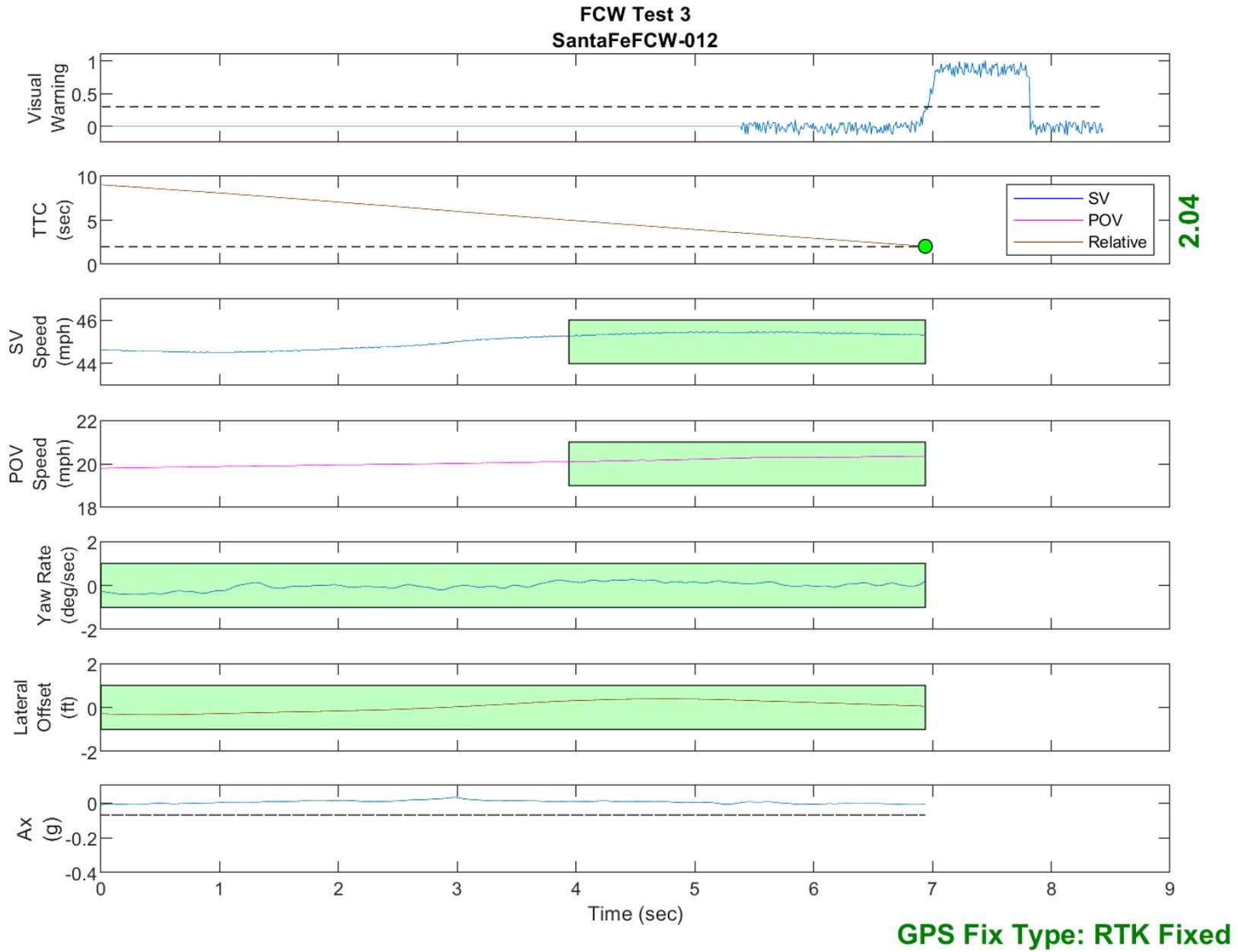


Figure D44. Time History for Run 12, FCW Test 3, Visual Warning

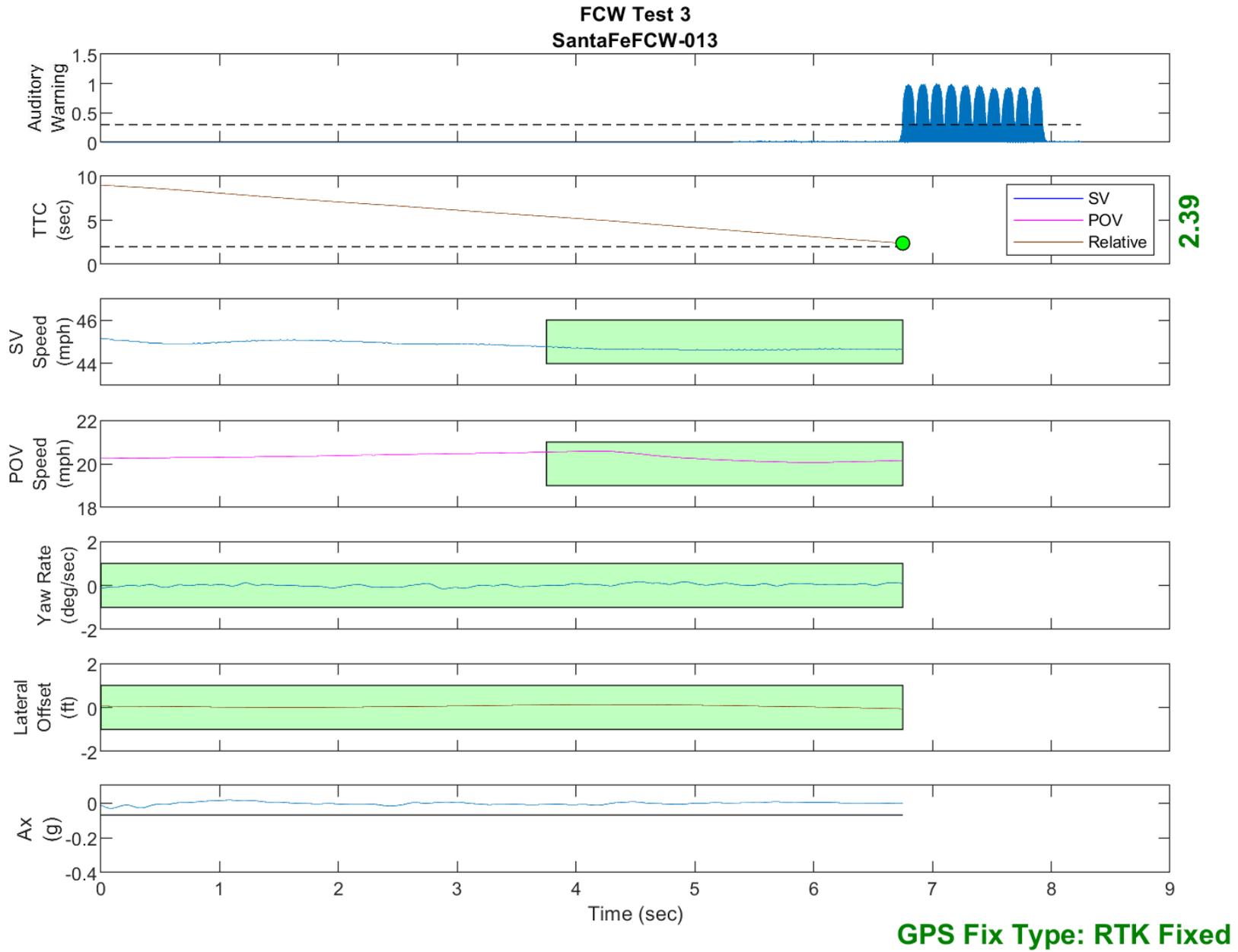


Figure D45. Time History for Run 13, FCW Test 3, Auditory Warning

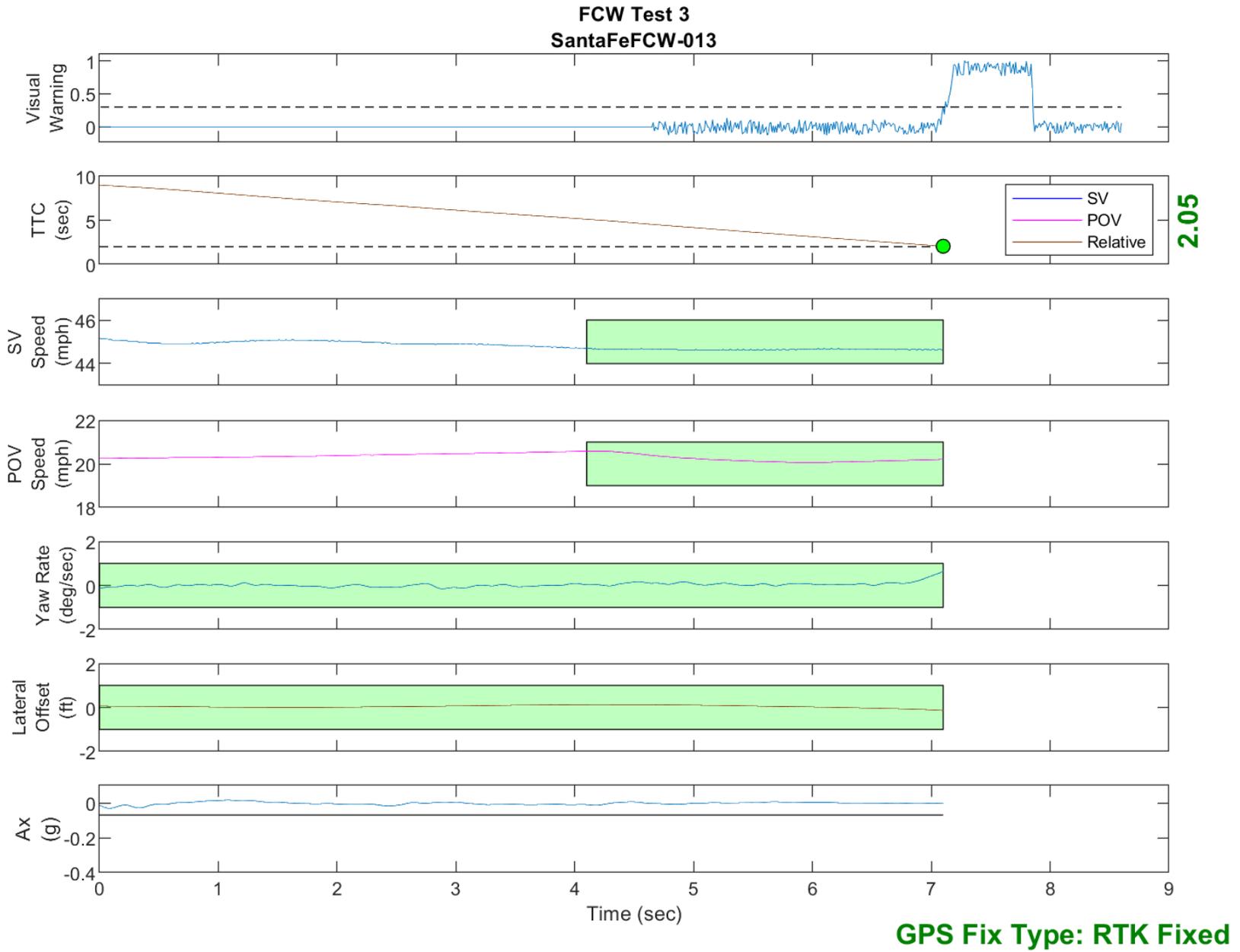


Figure D46. Time History for Run 13, FCW Test 3, Visual Warning

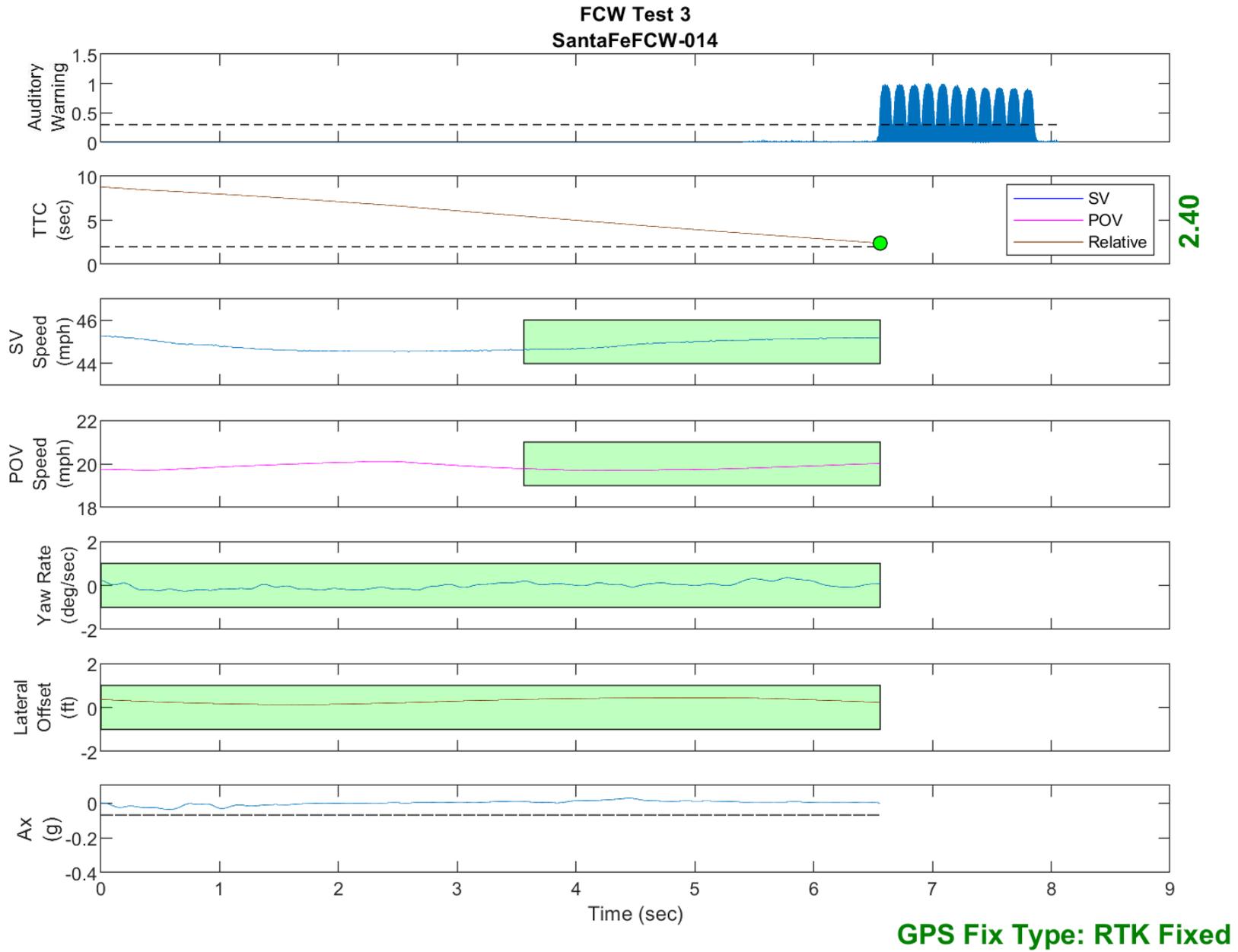


Figure D47. Time History for Run 14, FCW Test 3, Auditory Warning

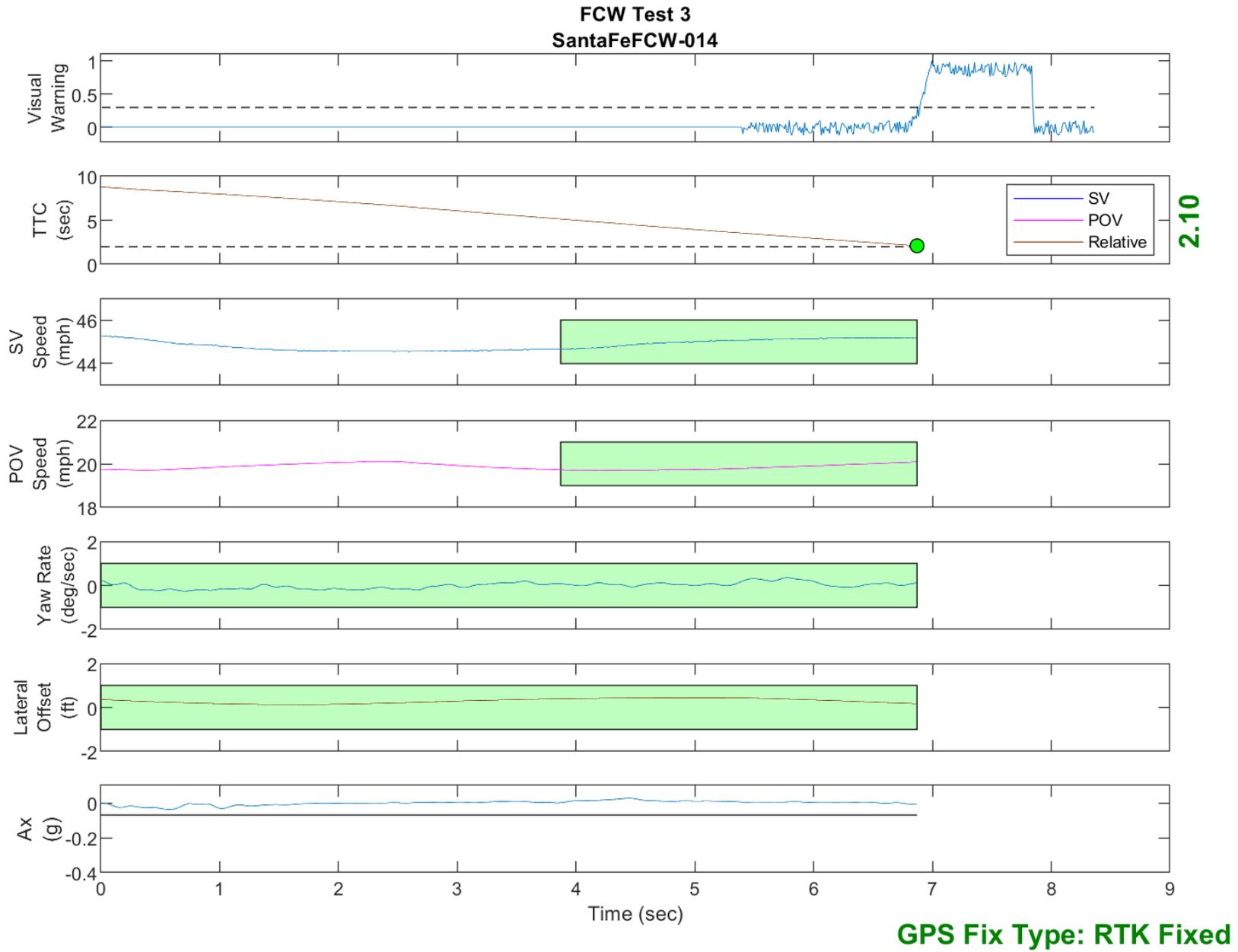


Figure D48. Time History for Run 14, FCW Test 3, Visual Warning