

**NEW CAR ASSESSMENT PROGRAM  
CRASH IMMINENT BRAKING SYSTEM CONFIRMATION TEST  
NCAP-DRI-CIB-22-01**

**2022 Chevrolet Bolt EUV Premier**

**DYNAMIC RESEARCH, INC.**

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**6 September 2022**

**Final Report**

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

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16. Abstract These tests were conducted on the subject 2022 Chevrolet Bolt EUV Premier in accordance with the specifications of the New Car Assessment Program's (NCAP's) most current Test Procedure in docket NHTSA-2015-0006-0025; CRASH IMMINENT BRAKE SYSTEM PERFORMANCE EVALUATION FOR THE NEW CAR ASSESSMENT PROGRAM, October 2015. The vehicle passed the requirements of the test for all four CIB test scenarios and all speeds.			
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## Section I

### INTRODUCTION

Crash Imminent Braking (CIB) systems are a subset of Automatic Emergency Braking (AEB) systems. CIB systems are designed to avoid, or mitigate rear-end crashes, by automatically applying subject vehicle brakes when the system determines that, without intervention, a rear-end crash will occur. CIB systems typically work as an extension of Forward Collision Warning (FCW) systems, which alert the driver to the possibility of a collision unless driver action is taken. CIB systems employ sensors capable of detecting vehicles in the forward path. Current CIB technology typically involves RADAR, LIDAR, or vision-based (camera) sensors, and measurement of vehicle operating conditions such as speed, driver steering and brake application, etc. Algorithms in the system's Central Processing Unit (CPU) use this information to continuously monitor the likelihood of a rear-end crash and command a brake actuator to apply the brakes when necessary.

The method prescribed by the National Highway Traffic Safety Administration (NHTSA) to evaluate CIB performance on the test track<sup>1</sup> involves three rear-end type crash configurations and a "false positive" test. In the rear-end scenarios, a subject vehicle (SV) approaches a stopped, slower-moving, or decelerating principal other vehicle (POV) in the same lane of travel. For these tests, the POV is a strikeable object with the characteristics of a compact passenger car. The false positive scenarios are used to evaluate the propensity of a CIB system to inappropriately activate in a non-critical driving scenario that does not involve a forward vehicle or present a safety risk to the SV occupant(s).

The purpose of the testing reported herein was to objectively quantify the performance of a Crash Imminent Braking system installed on a 2022 Chevrolet Bolt EUV Premier. This test is part of the New Car Assessment Program to assess Crash Imminent Braking Systems sponsored by the National Highway Traffic Safety Administration under Contract No. DTNH22-14-D-00333.

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<sup>1</sup> NHTSA-2015-0006-0025; Crash Imminent Brake System Performance Evaluation for the New Car Assessment Program, October 2015.

Section II  
**DATA SHEETS**

**CRASH IMMINENT BRAKING**  
**DATA SHEET 1: TEST RESULTS SUMMARY**

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2022 Chevrolet Bolt EUV Premier

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VIN: 1G1FZ6S05N412xxxx

Test start date: 8/31/2022

Test end date: 8/31/2022

Crash Imminent Braking System setting: N/A

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

SV 25 mph: Pass

**Test 2 – Subject Vehicle Encounters  
Slower Principal Other Vehicle**

SV 25 mph POV 10 mph: Pass

SV 45 mph POV 20 mph: Pass

**Test 3 – Subject Vehicle Encounters  
Decelerating Principal Other Vehicle**

SV 35 mph POV 35 mph: Pass

**Test 4 – Subject Vehicle Encounters  
Steel Trench Plate**

SV 25 mph: Pass

SV 45 mph: Pass

**Overall: Pass**

Notes:

**CRASH IMMINENT BRAKING**  
**DATA SHEET 2: VEHICLE DATA**  
(Page 1 of 1)  
**2022 Chevrolet Bolt EUV Premier**

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**TEST VEHICLE INFORMATION**

VIN: 1G1FZ6S05N412xxxx

Body Style: SUV

Color: Cherry Red Tintcoat

Date Received: 8/19/2022

Odometer Reading: 63 mi

**DATA FROM VEHICLE'S CERTIFICATON LABEL**

Vehicle manufactured by: General Motors LLC

Date of manufacture: 05/22

Vehicle Type: Passenger Car

**DATA FROM TIRE PLACARD**

Tires size as stated on Tire Placard: Front: 215/50R17 H

Rear: 215/50R17 H

Recommended cold tire pressure: Front: 260 kPa (38 psi)

Rear: 260 kPa (38 psi)

**TIRES**

Tire manufacturer and model: Michelin Energy Saver A/S

Front tire designation: 215/50R17 91H

Rear tire designation: 215/50R17 91H

Front tire DOT prefix: 1B338 03RX

Rear tire DOT prefix: 1B338 03RX

**CRASH IMMINENT BRAKING**  
**DATA SHEET 3: TEST CONDITIONS**

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2022 Chevrolet Bolt EUV Premier

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**GENERAL INFORMATION**

Test start date: 8/31/2022

Test end date: 8/31/2022

**AMBIENT CONDITIONS**

Air temperature: 26.7 C (80 F)

Wind speed: 0.5 m/s (1.2 mph)

X Windspeed  $\leq$  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: 260 kPa (38 psi)

Rear: 260 kPa (38 psi)

**CRASH IMMINENT BRAKING**  
**DATA SHEET 3: TEST CONDITIONS**

(Page 2 of 2)

**2022 Chevrolet Bolt EUV Premier**

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**WEIGHT**

Weight of vehicle as tested including driver and instrumentation

Left Front: 519.8 kg (1146 lb)

Right Front: 494.4 kg (1090 lb)

Left Rear: 415.5 kg (916 lb)

Right Rear: 408.7 kg (901 lb)

Total: 1838.4 kg (4053 lb)

**CRASH IMMINENT BRAKING**  
**DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION**

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**2022 Chevrolet Bolt EUV Premier**

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

*“Enhanced Automatic Emergency Braking” comes with the optional “Super Cruise Package”.*

Type and location of sensors the system uses:

*The AEB system uses a long-range radar located behind the front grille emblem, a short-range radar behind the lower grille on both the driver and passenger sides of the vehicle, and a mono-camera located at the top center of the windshield.*

System setting used for test (if applicable):

*N/A*

Over what speed range is the system operational?

*The AEB system is operational from 4 km/h (2.5 mph) up to the maximum speed of the vehicle (per manufacturer supplied information).*

Does the vehicle system require an initialization sequence/procedure?  Yes

No

If yes, please provide a full description.

Will the system deactivate due to repeated CIB activations, impacts, or near-misses?  Yes

No

If yes, please provide a full description.

**CRASH IMMINENT BRAKING**

**DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION**

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2022 Chevrolet Bolt EUV Premier

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

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

The AEB system alerts the driver with a visual and auditory alert. The visual alert is displayed through a heads-up display on the windshield as a row of red flashing dots. The auditory alert consists of repeated beeps with a primary frequency of approximately 2000 Hz.

Is there a way to deactivate the system?  Yes  
 No

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

The AEB system can be turned on/off using the touch screen display in the center console. The procedure is as follows:

1. Select the "Home" button.
2. Select "Settings" -> "Vehicle" -> "Collision/Detection Systems" -> "Forward Collision System".
3. Select between "Off", "Alert", and "Alert and Brake" to turn the AEB system on/off.

When the AEB system is turned off, a warning light illuminates. The system is automatically enabled each time the engine switch is turned on.

**CRASH IMMINENT BRAKING**

**DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION**

**(Page 3 of 3)**

2022 Chevrolet Bolt EUV Premier

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

If yes, please provide a full description.

*The vehicle offers three range settings for the FCW alert (Far, Medium, Near) that can be adjusted using the buttons on the left side of the steering wheel, however this does not affect the performance of the AEB system.*

Are there other driving modes or conditions that render CIB inoperable or reduce its effectiveness?  Yes  
 No

If yes, please provide a full description.

*Refer to the owner's manual pages 194-195 shown in Appendix B pages B-2 to B-3.*

Notes:

## Section III

### TEST PROCEDURES

#### A. Test Procedure Overview

Four test scenarios were used, as follows:

Test 1. Subject Vehicle (SV) Encounters Stopped Principal Other Vehicle (POV)

Test 2. Subject Vehicle Encounters Slower Principal Other Vehicle

Test 3. Subject Vehicle Encounters Decelerating Principal Other Vehicle

Test 4. Subject Vehicle Encounters Steel Trench Plate

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 CIB system to detect and respond to a stopped lead vehicle in the immediate forward path of the SV, as depicted in Figure 1.

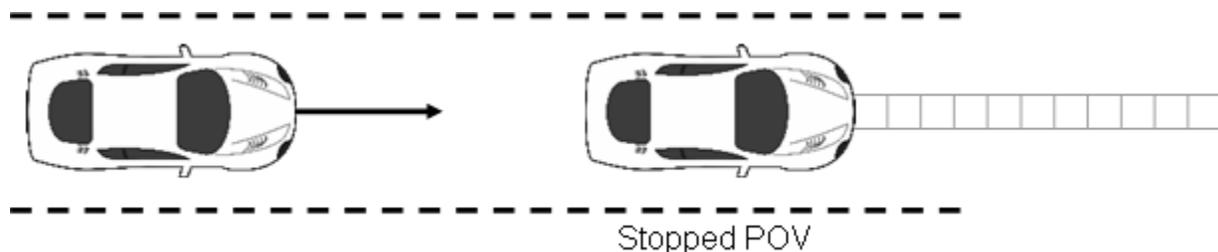


Figure 1. Depiction of Test 1

##### a. 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 approached the rear of the POV.

The SV ignition was cycled prior to each test run. The SV was driven at a nominal speed of 25 mph (40.2 km/h) in the center of the lane of travel, toward the parked POV. The SV throttle pedal was released within 500 ms after  $t_{FCW}$ , i.e. within 500 ms of the FCW alert. The test concluded when either:

- The SV came into contact with the POV or
- The SV came to a stop before making contact with the POV.

In addition to the general test validity criteria described below, for an individual test trial to be valid, the following was required throughout the test:

- The lateral distance between the centerline of the SV to the center of the travel lane could not deviate more than  $\pm 1$  ft (0.3 m) during the validity period.
- The yaw rate of the SV could not deviate more than  $\pm 1$  deg/sec during the validity period.
- The SV speed could not deviate from the nominal speed by more than  $\pm 1.0$  mph ( $\pm 1.6$  km/h) during an interval defined by a Time to Collision (TTC) = 5.1 seconds to  $t_{FCW}$  or impact if no FCW alert was given.

b. Criteria

In order to pass the test, the magnitude of the SV speed reduction attributable to CIB intervention must have been  $\geq 9.8$  mph (15.8 km/h) for at least five of seven valid test trials.

The magnitude of the SV speed reduction attributable to CIB intervention was calculated in one of two ways, depending on whether a test trial concluded with the SV colliding with the POV.

- If SV-to-POV contact occurred during a test trial, the CIB speed reduction was calculated by subtracting the SV speed at the time of SV-to-POV contact (i.e., when longitudinal range became zero) from the average SV speed calculated from  $t_{FCW} - 100$  ms to  $t_{FCW}$ .
- If SV-to-POV contact did not occur during a test trial (i.e., CIB intervention prevented the crash), the SV speed at a time of SV-to-POV contact was taken to be zero. The speed reduction is therefore equal to the SV speed at  $t_{FCW}$ .

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

- This test evaluates the ability of the CIB system to detect and respond to a slower-moving lead vehicle traveling at a constant speed in the immediate forward path of the SV, as depicted in Figure 2.



In order to pass the test series for which the initial speed of the SV was 45 mph, the magnitude of the SV speed reduction attributable to CIB intervention must have been  $\geq 9.8$  mph (15.8 km/h) for at least five of seven valid test trials. The magnitude of the SV speed reduction attributable to CIB intervention was calculated in one of two ways, depending on whether a test trial concluded with the SV colliding with the POV.

- If SV-to-POV contact occurred during a test trial, the CIB speed reduction was calculated by subtracting the SV speed at the time of SV-to-POV contact (i.e., when longitudinal range became zero) from the average SV speed calculated from  $t_{FCW} - 100$  ms to  $t_{FCW}$ .
- If SV-to-POV contact did not occur during a test trial (i.e., CIB intervention prevented the crash), the CIB speed reduction was calculated by subtracting the SV speed at the minimum longitudinal SV-to-POV range during the validity period from the SV speed at  $t_{FCW}$ .

### 3. TEST 3 – SUBJECT VEHICLE ENCOUNTERS DECELERATING PRINCIPAL OTHER VEHICLE

This test evaluates the ability of the CIB system to detect and respond to a lead vehicle slowing with a constant deceleration in the immediate forward path of the SV, as depicted in Figure 3.

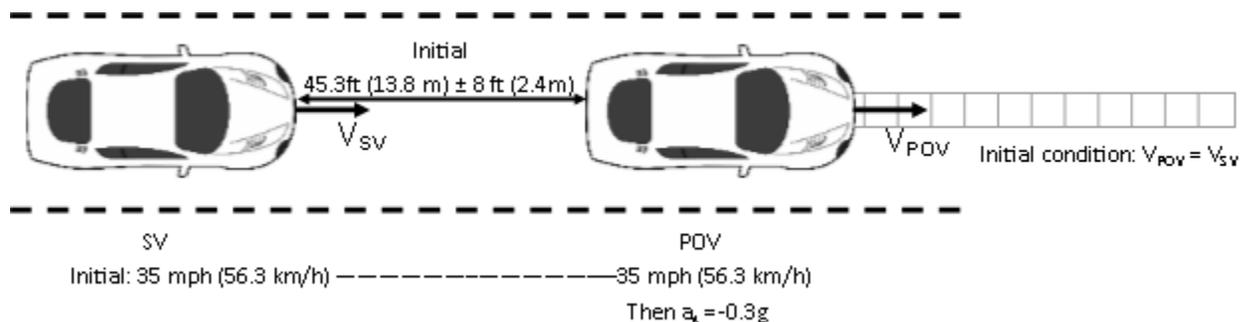


Figure 3. Depiction of Test 3

#### a. Procedure

The SV ignition was cycled prior to each test run. For this test scenario, both the POV and SV were driven at a constant 35.0 mph (56.3 km/h) in the center of the lane, with a headway of 45.3 ft (13.8 m)  $\pm$  8 ft (2.4 m). Once these conditions were met, the POV tow vehicle brakes were applied to achieve  $0.3 \pm 0.03$  g of deceleration within  $1.5 \pm 0.1$  sec. The test concluded when either:

- The SV came into contact with the POV or
- 1 second after minimum longitudinal SV-to-POV distance has occurred.

The SV driver then braked to a stop.

In addition to the general test validity criteria described below, for an individual test trial to be valid, the following was required throughout the test:

- The lateral distance between the centerline of the SV and POV to the center of the travel lane could not deviate more than  $\pm 1$  ft (0.3 m) during the validity period.
- The yaw rate of the SV and POV could not deviate more than  $\pm 1$  deg/sec during the validity period.
- The SV speed could not deviate more than  $\pm 1.0$  mph (1.6 km/h) during an interval defined by 3.0 seconds before the onset of POV braking to  $t_{FCW}$  or impact if no FCW alert was given.
- The POV speed could not deviate more than  $\pm 1.0$  mph (1.6 km/h) during an interval of 3.0 seconds before the onset of POV braking.
- The SV- POV headway distance could not deviate more than  $\pm 8$  ft (2.4 m) during an interval defined by the onset of the validity period to the onset of POV braking.
- The average POV deceleration could not deviate by more than  $\pm 0.03$  g from the nominal 0.3 g deceleration during the interval beginning at 1.5 seconds after the onset of POV braking and ending either 250 ms prior to the POV coming to a stop or the SV coming into contact with the POV.

b. Criteria

In order to pass the decelerating POV test series, the magnitude of the SV speed reduction attributable to CIB intervention must have been  $\geq 10.5$  mph (16.9 km/h) for at least five of seven valid test trials. The magnitude of the SV speed reduction attributable to CIB intervention was calculated in one of two ways, depending on whether a test trial concluded with the SV colliding with the POV.

- If SV-to-POV contact occurred during a test trial, the CIB speed reduction was calculated by subtracting the SV speed at the time of SV-to-POV contact (i.e., when longitudinal range becomes zero) from the average SV speed calculated from  $t_{FCW} - 100$  ms to  $t_{FCW}$ .
- If SV-to-POV contact did not occur during a test trial (i.e., CIB intervention prevents the crash), the CIB speed reduction was calculated by subtracting the SV speed at the minimum longitudinal SV-to-POV range during the applicable validity period from the SV speed at  $t_{FCW}$ .

#### 4. TEST 4 – FALSE POSITIVE SUPPRESSION

The false positive suppression test series evaluates the ability of a CIB system to differentiate a steel trench plate (STP) from an object presenting a genuine safety risk to the SV. Although the STP is large and metallic, it is designed to be driven over without risk of injury to the driver or damage to the SV. Therefore, in this scenario, the automatic braking available from CIB is not necessary and should be suppressed. The test condition is nearly equivalent to that previously defined for Test 1, the stopped POV condition, but

with an STP in the SV forward path in lieu of a POV.

#### a. Procedure

This test was conducted at two speeds, 25 mph (40.2 km/h) and 45 mph (72.4 km/h). The SV was driven directly towards, and over, the STP, which was positioned in the center of a travel lane, with its longest sides parallel to the road edge. The test concluded when the front most part of the SV reached a vertical plane defined by the edge of the STP first encountered by the SV.

In addition to the general test validity criteria described below, for an individual test trial to be valid, the following was required throughout the test:

- The lateral distance between the centerline of the SV to the center of the travel lane could not deviate more than  $\pm 1$  ft (0.3 m) during the validity period.
- The yaw rate of the SV could not deviate more than  $\pm 1$  deg/sec during the validity period.
- The SV speed could not deviate from the nominal speed by more than 1.0 mph (1.6 km/h) during an interval defined by a Time to Collision (TTC) = 5.1 seconds to  $t_{FCW}$  where:
  - For SV test speed of 25 mph, TTC = 5.1 seconds is taken to occur at an SV-to-STP distance of 187 ft (57 m).
  - For SV test speed of 45 mph, TTC = 5.1 seconds is taken to occur at an SV-to-STP distance of 337 ft (106 m).
- If the SV did not present an FCW alert before the end of the validity period, SV speed could not deviate more than  $\pm 1.0$  mph ( $\pm 1.6$  km/h) from TTC = 5.1 s to the end of the validity period.

If an FCW alert was presented, the driver released the throttle pedal within 500 ms of the alert. If no alert was presented, the driver did not release the throttle pedal until the end of the validity period. The SV driver then braked to a stop.

#### b. Criteria

In order to pass the False Positive test series, the magnitude of the SV deceleration reduction attributable to CIB intervention must have been  $\leq 0.50$  g for at least five of seven valid test trials.

### B. General Information

#### 1. $T_{FCW}$

The time at which the Forward Collision Warning (FCW) activation flag indicates that the system has issued an alert to the SV driver is designated as  $t_{FCW}$ . FCW alerts are typically either visual, haptic or auditory, and the onset of the alert was determined by post-

processing the test data.

For systems that implement auditory or haptic alerts, part of the pre-test instrumentation verification process was 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 was accomplished in order to identify the center frequency around which a band-pass filter was 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 was a phaseless, forward-reverse pass, elliptical (Cauer) digital filter, with filter parameters as listed in Table 1.

**Table 1. Auditory and Tactile Warning Filter Parameters**

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

## 2. GENERAL VALIDITY CRITERIA

In addition to any validity criteria described above for the individual test scenarios, for an individual trial to be valid, it must have met the following criteria throughout the test:

- The SV driver seatbelt was latched.
- If any load had been placed on the SV front passenger seat (e.g., for instrumentation), the vehicle's front passenger seatbelt was latched.
- The SV was driven at the nominal speed in the center of the travel lane, toward the POV or STP.
- The driver used the least amount of steering input necessary to maintain SV position in the center of the travel lane during the validity period; use of abrupt steering inputs or corrections was avoided.
- The yaw rate of the SV did not exceed  $\pm 1.0$  deg/s from the onset of the validity period to the instant SV deceleration exceeded 0.25 g.
- The SV driver did not apply any force to the brake pedal during the applicable validity period.
- The lateral distance between the centerline of the SV and the centerline of the POV or STP did not deviate more than  $\pm 1$  ft (0.3 m) during the applicable validity period.

### 3. VALIDITY PERIOD

The valid test interval began:

- Test 1: When the SV-to-POV TTC = 5.1 seconds
- Test 2: When the SV-to-POV TTC = 5.0 seconds
- Test 3: 3 seconds before the onset of POV braking
- Test 4: When the SV-to-STP TTC = 5.1 seconds

The valid test interval ended:

- Test 1: When either of the following occurred:
  - The SV came into contact with the POV (assessed using GPS-based range data); or
  - The SV came to a stop before making contact with the POV.
- Test 2: When either of the following occurred:
  - The SV came into contact with the POV; or
  - 1 second after the velocity of the SV became less than or equal to that of the POV.
- Test 3: When either of the following occurred:
  - The SV came into contact with the POV; or
  - 1 second after minimum longitudinal SV-to-POV distance occurred.
- Test 4: At the instant the front-most part of SV reached a vertical plane defined by the leading edge of the STP first encountered by the SV (i.e., just before it was driven onto the STP).

### 4. STATIC INSTRUMENTATION CALIBRATION

To assist in resolving uncertain test data, static calibration data was collected prior to, and immediately after each of the test series.

For Tests 1, 2, and 3, the SV, POV, POV moving platform, and tow vehicle were centered in the same travel lane with the same orientation (i.e., facing the same direction). For Test 4, the SV and STP were centered in the same travel lane.

For Tests 1, 2, and 3, the SV was positioned such that it just contacted a vertical plane that defines the rearmost location of the POV. For Test 4, the front-most location of the SV was positioned such that it just reached a vertical plane defined by the leading edge of the STP first encountered by the SV (i.e., just before it is driven onto the STP). This is the “zero position.”

If the zero position reported by the data acquisition system was found to differ by more than  $\pm 2$  in ( $\pm 5$  cm) from that measured during collection of the pre-test static calibration data file, the pre-test offset was adjusted to output zero, another pre-test static calibration data file was collected, and the test series was repeated.

## 5. NUMBER OF TRIALS

A target total of seven (7) valid trials were performed for each scenario. In cases where the test driver performed more than seven trials, the first seven trials satisfying all test tolerances were used to assess the SV performance.

## 6. TRANSMISSION

All trials were performed with SV 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. The brake lights of the POV were not illuminated.

### **C. Principal Other Vehicle**

CIB testing requires a POV that realistically represents typical vehicles, does not suffer damage or cause damage to a test vehicle in the event of collision, and can be accurately positioned and moved during the tests. The tests reported herein made use of the NHTSA developed Strikeable Surrogate Vehicle (SSV).

This SSV system was designed specifically for common rear-end crash scenarios which AEB systems address. The key components of the SSV system are:

- A POV shell which is a visually and dimensionally accurate representation of a passenger car.
- A slider and load frame assembly to which the shell is attached.
- A two-rail track on which the slider operates.
- A road-based lateral restraint track.
- A tow vehicle.

The key requirements of the POV element are to:

- Provide an accurate representation of a real vehicle to CIB sensors, including cameras and radar.
- Be resistant to damage and inflict little or no damage to the SV as a result of repeated SV-to-POV impacts.

The key requirements of the POV delivery system are to:

- Accurately control the nominal POV speed up to 35 mph (56 km/h).
- Accurately control the lateral position of the POV within the travel lane.

- Allow the POV to move away from the SV after an impact occurs.

Operationally, the POV shell is attached to the slider and load frame which includes rollers that allows the entire assembly to move longitudinally along the guide rail. The guide rail is coupled to a tow vehicle and guided by the lateral restraint track secured to the test track surface. The rail includes a provision for restraining the shell and roller assembly in the ward direction. In operation, the shell and roller assembly engage the rail assembly through detents to prevent relative motion during run-up to test speeds and deceleration of the tow vehicle. The combination of rearward stops and forward motion detents allows the test conditions, such as relative SV-to-POV headway distance, speed, etc., to be achieved and adjusted as needed in the preliminary part of a test. If during the test, the SV strikes the rear of the POV shell, the detents are overcome and the entire shell/roller assembly moves forward in a two-stage manner along the rail and away from the SV. The forward end of the rail has a cushioned stop to restrain forward motion of the shell/roller assembly. After impacting the SSV, the SV driver uses the steering wheel to maintain SV position in the center of the travel lane, thereby straddling the two-rail track. The SV driver must manually apply the SV brakes after impact. The SSV system is shown in Figures A6 through A8 and a detailed description can be found in the NHTSA report: NHTSA'S STRIKEABLE SURROGATE VEHICLE PRELIMINARY DESIGN+OVERVIEW, May 2013.

#### **D. Automatic Braking System**

The POV was equipped with an automatic braking system, which was used in Test 3. The braking system consisted of the following components:

- Electronically controlled linear actuator, mounted on the seat rail and attached to the brake pedal. The actuator can be programmed for control of stroke and rate.
- PC module programmed for control of the stroke and rate of the linear actuator.
- Switch to activate actuator.

In some cases, the SV is also equipped with an automatic braking system (E-brake) for the purpose of slowing the SV before impact with the SSV in cases where the SV is likely to fail a test. The system fires when TTC is below 0.7 sec. It is typically enabled when an SV has already impacted the SSV one or two times.

#### **E. Instrumentation**

Table 2 lists the sensors, signal conditioning, and data acquisition equipment used for these tests.

**Table 2. Test Instrumentation and Equipment**

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	< 1% error between 20 and 100 psi	Omega DPG8001	17042707002	By: DRI Date: 10/5/2021 Due: 10/5/2022
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 2/11/2022 Due: 2/11/2023
Linear (string) encoder	Throttle pedal travel	50 in	0.05 in	TE Connectivity SE1-50	K3161850	By: DRI Date: 1/18/2022 Due: 1/18/2023
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	N/A
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rate ±100 deg/s, Angle >45 deg, Velocity >200 km/h	Accels .01g, Angular Rate 0.05 deg/s, Angle 0.05 deg, Velocity 0.1 km/h	Oxford Inertial +		By: Oxford Technical Solutions
					2182	Date: 11/19/2021 Due: 11/19/2023
					2258	Date: 4/28/2021 Due: 4/28/2023

**Table 2. Test Instrumentation and Equipment (continued)**

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Real-Time Calculation of Position and Velocity Relative to POV	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: $\pm 30$ m Lateral Lane Velocity: $\pm 20$ m/sec Longitudinal Range to POV: $\pm 200$ m Longitudinal Range Rate: $\pm 50$ m/sec	Lateral Distance to Lane Marking: $\pm 2$ cm Lateral Velocity to Lane Marking: $\pm 0.02$ m/sec Longitudinal Range: $\pm 3$ cm Longitudinal Range Rate: $\pm 0.02$ m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	N/A
Microphone	Sound (to measure time at 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 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 alert)	$\pm 5g$	$\leq 3\%$ 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	$\pm 0.020$ in. $\pm 0.51$ mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2022 Due: 1/6/2023
Type	Description			Mfr, Model	Serial Number	
Data Acquisition System	Data acquisition is achieved using a dSPACE MicroAutoBox II. Data from the Oxford IMU, including Longitudinal, Lateral, and Vertical Acceleration, Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle are sent over Ethernet to the MicroAutoBox. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (listed above).			dSPACE Micro-Autobox II 1401/1513		
				Base Board		549068
				I/O Board		588523

## APPENDIX A

### Photographs

## LIST OF FIGURES

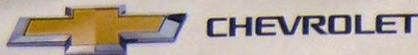
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Figure A1. Front View of Subject Vehicle



Figure A2. Rear View of Subject Vehicle



### 2022 BOLT EUV PREMIER

EXTERIOR: CHERRY RED TINTCOAT  
INTERIOR: DARK ASH GRAY / SKY  
COOL GRAY

#### STANDARD EQUIPMENT

ITEMS FEATURED BELOW ARE INCLUDED AT NO EXTRA CHARGE IN THE STANDARD VEHICLE PRICE SHOWN

#### OWNER BENEFITS

- 3 YEAR / 36,000 MILE\* BUMPER-TO-BUMPER LIMITED WARRANTY
- 8 YEAR/100,000 MILE\* ELECTRIC PROPULSION COMPONENT LIMITED WARRANTY, ROADSIDE ASSISTANCE & COURTESY TRANSPORTATION
- \*WHICHEVER COMES FIRST SEE CHEVROLET.COM OR DEALER FOR TERMS, DETAILS & LIMITS

#### PERFORMANCE & MECHANICAL

- DC FAST CHARGING PROVISIONS
- CHARGING MODULE, 11.5 KW
- ELECTRONIC PRECISION SHIFT WITH ONE-PEDAL DRIVE MODE
- DRIVE MODE CONTROL SWITCH, NORMAL/SPORT

- BATTERY RUNDOWN PROTECTION
- DUAL LEVEL CHARGE CORD

#### INTERIOR

- SEAT ADJUSTER, DRIVER 8-WAY POWER PLUS 2-WAY POWER LUMBAR
- SEAT ADJUSTER, FRONT PASSENGER 6-WAY MANUAL
- SEAT, REAR 60/40 SPLIT-FOLDING
- DRIVER & FRONT PASSENGER HEATED SEATS
- REAR SEATS, HEATED OUTBOARD
- SEATS VENTILATED, FRONT DRIVER AND PASSENGER
- LEATHER WRAP STEERING WHEEL
- DRIVER INFORMATION CENTER, 8" DIAGONAL MULTI-COLOR DISPLAY
- VISORS, DRIVER AND FRONT PASSENGER ILLUMINATED VANITY MIRRORS, COVERED, SLIDING

#### EXTERIOR

- HEADLAMPS, LED

- DAYTIME RUNNING LAMPS, LED
- WHEELS, 17" MACHINE FACE WITH CARBON FLASH PAINTED POCKETS
- LAMPS, STOP AND TAIL, LED
- FRONT WINDSHIELD WIPERS, RAIN SENSING
- MIRRORS, OUTSIDE HEATED, POWER ADJUSTABLE, INTEGRATED TURN SIGNAL INDICATORS, MANUAL FOLDING
- WIPER, REAR INTERMITTENT WITH WASHER

#### SAFETY & SECURITY

- CHEVY SAFETY ASSIST:
- AUTOMATIC EMERGENCY BRAKING
- FRONT PEDESTRIAN BRAKING
- LANE KEEP ASSIST W/ LANE DEPARTURE WARNING
- FOLLOWING DISTANCE INDICATOR
- FORWARD COLLISION ALERT
- INTELLIBEAM-AUTO HIGH BEAM

- PEDESTRIAN FRIENDLY ALERT
- HEADLAMP CONTROL AUTOMATIC ON & OFF
- TIRE PRESSURE MONITOR SYSTEM
- LANE CHANGE ALERT WITH SIDE BLIND ZONE ALERT
- TIRE FILL ALERT
- REAR CAMERA MIRROR
- HD SURROUND VISION
- REAR PARK ASSIST
- REAR CROSS TRAFFIC ALERT

#### CONNECTIVITY FEATURES

- REMOTE VEHICLE START
- CHEVROLET INFOTAINMENT 3 PLUS 10.2" DIAG HD COLOR TOUCHSCREEN, VOICE RECOGNITION
- BLUETOOTH AUDIO STREAMING
- WIRELESS APPLE CARPLAY & WIRELESS ANDROID AUTO CAPABLE, IN-VEHICLE APPS AND PERSONALIZATION CAPABLE
- WIRELESS DEVICE CHARGING

Visit us at [www.chevy.com](http://www.chevy.com)

- EFFICIENCY DISPLAY SCREENS W/ PROGRAMMABLE CHARGE TIMES
- KEYLESS OPEN/START
- ADAPTIVE CRUISE CONTROL

MANUFACTURER'S SUGGESTED RETAIL PRICE

STANDARD VEHICLE PRICE **\$38,000.00**

#### OPTIONS & PRICING

OPTIONS INSTALLED BY THE MANUFACTURER (MAY REPLACE STANDARD EQUIPMENT SHOWN)

SUN & SOUND PACKAGE: 2,495.00

- AUDIO SYSTEM, BOSE 7-SPEAKER
- SUNROOF, POWER, DUAL PANEL PANORAMIC, TILT/SLIDING WITH POWER SUNSHADE
- CHEVROLET INFOTAINMENT 3 PLUS WITH NAVIGATION

SUPER CRUISE PACKAGE: 2,200.00

- SUPER CRUISE(TM)
- INCLUDES: 3 YEARS OF SUPER CRUISE CONNECTIVITY, AFTER

WHICH A SUPER CRUISE CONNECTIVITY PLAN MUST BE PURCHASED (SUBJECT TO ONSTAR TERMS)

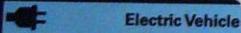
- ENHANCED AUTOMATIC EMERGENCY BRAKING

CHEVRY RED TINTCOAT 495.00  
TIRE INFLATOR KIT (DEALER INSTALLED) 95.00

TOTAL OPTIONS \$5,295.00  
TOTAL VEHICLE & OPTIONS \$43,295.00  
DESTINATION CHARGE 995.00

TOTAL VEHICLE PRICE\* **\$44,290.00**

#### EPA DOT Fuel Economy and Environment



**Fuel Economy**

**115 MPGe** Small station wagons range from 25 to 120 MPGe. The best vehicle rates 142 MPGe.

125 104 29  
combined city/hwy city highway kW-hrs per 100 miles

Driving Range When fully charged, vehicle can travel about

0 50 100 150 200 247 miles

Charge Time: 7.5 hours (240V)

You save **\$3,750** in fuel costs over 5 years compared to the average new vehicle.

Annual fuel cost **\$550**

Fuel Economy & Greenhouse Gas Rating (tailpipe only) Smog Rating (tailpipe only)

1 10 10 10 10

This vehicle emits 0 grams CO<sub>2</sub> per mile. The best emits 0 grams per mile (tailpipe only). Does not include emissions from generating electricity. Learn more at [fuelconomy.gov](http://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 \$6,550 to fuel over 5 years. Cost estimates include emissions are a significant cause of climate change and smog.

**fuelconomy.gov**  
Calculate personalized estimates and compare vehicles



#### GOVERNMENT 5-STAR SAFETY RATINGS

This vehicle has not been rated by the government for overall vehicle score, frontal crash, side crash or rollover risk.

Source: National Highway Traffic Safety Administration (NHTSA)  
[www.safercar.gov](http://www.safercar.gov) or 1-888-327-4236



Equipped with the safety and security of OnStar®  
Visit [onstar.com](http://onstar.com) for details.

**WARNING**  
Cancer and Reproductive Harm  
[www.P65Warnings.ca.gov/](http://www.P65Warnings.ca.gov/)  
passenger-vehicle  
SEE OWNER'S MANUAL

#### PARTS CONTENT INFORMATION

FOR VEHICLES IN THIS CARLINE:  
U.S./CANADIAN PARTS CONTENT: 63%  
MAJOR SOURCES OF FOREIGN PARTS CONTENT: KOREA 15%

NOTE: PARTS CONTENT DOES NOT INCLUDE FINAL ASSEMBLY, DISTRIBUTION, OR OTHER NON-PARTS COSTS.

FOR THIS VEHICLE:  
FINAL ASSEMBLY POINT:  
LAKE ORION, MI U.S.A.  
COUNTRY OF ORIGIN:  
ENGINE (MOTOR): UNITED STATES  
TRANSMISSION (ELECTRIC DRIVE UNIT): KOREA

This label has been applied pursuant to Federal law - Do not remove prior to delivery to the ultimate purchaser. Includes Manufacturer's Recommended Pre-Delivery Service. Does not include dealer installed options and accessories not listed above. Local taxes or license fees.

A California statute requires the following notice to be affixed to this vehicle: "This vehicle is equipped with bumpers that can withstand an impact of 2.5 miles per hour with no damage to the vehicle's body and safety systems, although the bumper and related components may sustain damage. The bumper system on this vehicle conforms to the current federal bumper standard of 2.5 miles per hour."

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ORDER NO ZPP02T SALES CODE E  
SALES MODEL CODE 1904  
DEALER NO 20093  
FINAL ASSEMBLY:  
LAKE ORION, MI U.S.A.  
VIN 1G1FZ6S05N412



**TD**  
1GAD918801

Figure A3. Window Sticker (Monroney Label)



MFD BY GENERAL MOTORS LLC

05/22

GVWR  
2127 KG  
4689 LB

GAWR FRT  
1069 KG  
2356 LB

GAWR RR  
1058 KG  
2333 LB



252F

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

**1G1FZ6S05N412**

TYPE: PASS CAR

MODEL: 501FG48

Figure A4. Vehicle Certification Label

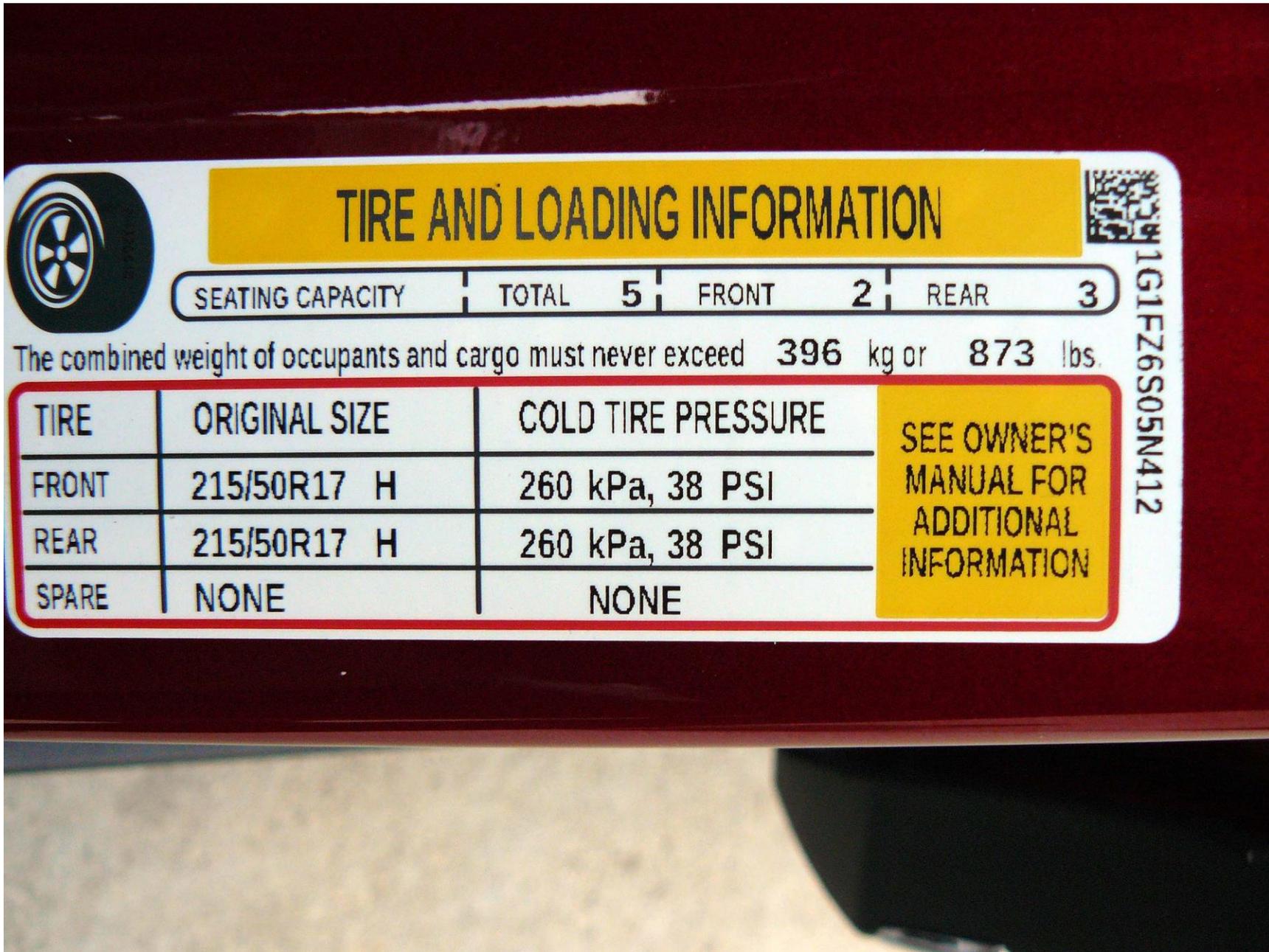


Figure A5. Tire Placard



Figure A6. Rear View of Principal Other Vehicle (SSV)



Figure A7. Load Frame/Slider of SSV

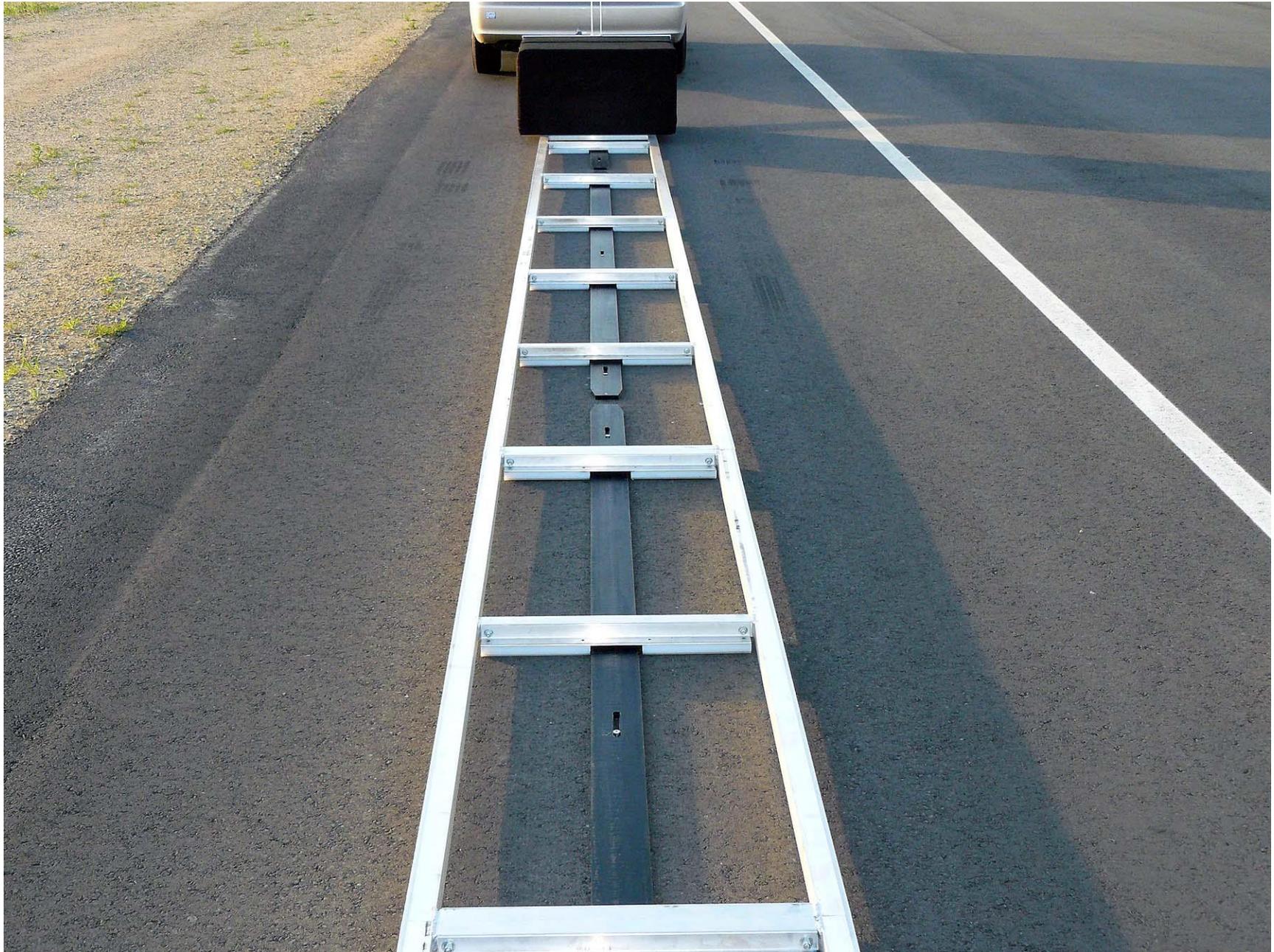


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track



Figure A9. Steel Trench Plate



Figure A10. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

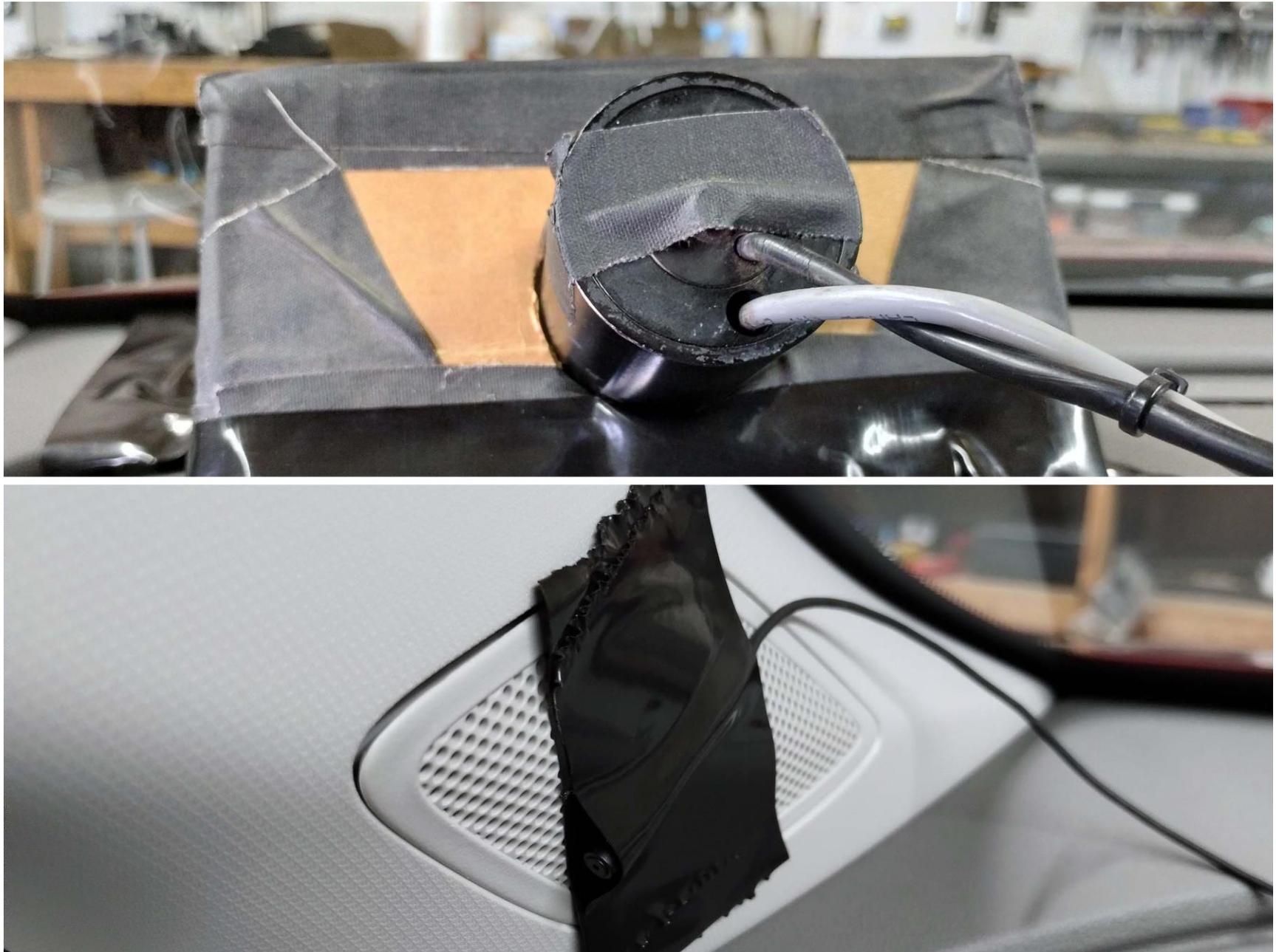


Figure A11. Sensors for Detecting Visual and Auditory Alerts



Figure A12. Computer Installed in Subject Vehicle



Figure A13. Brake Actuator Installed in POV System

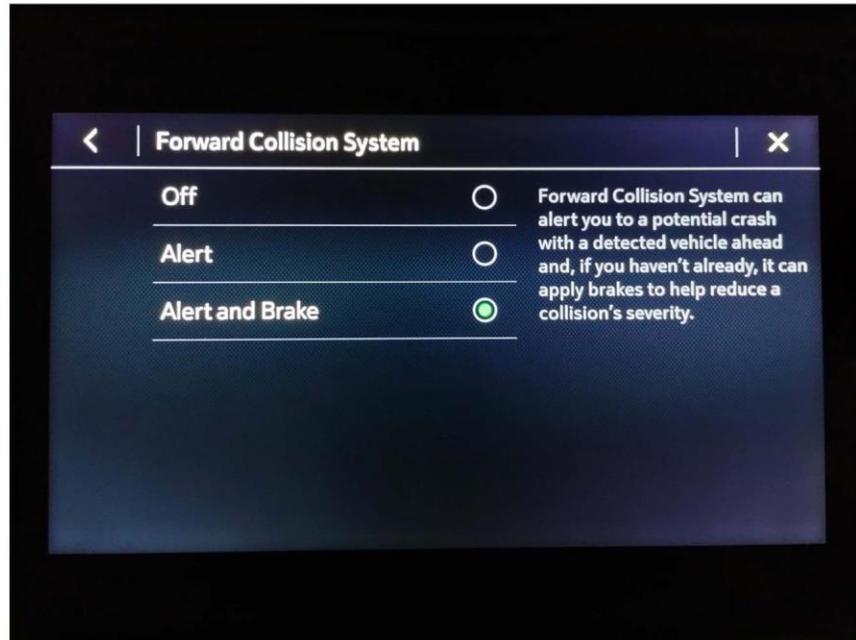
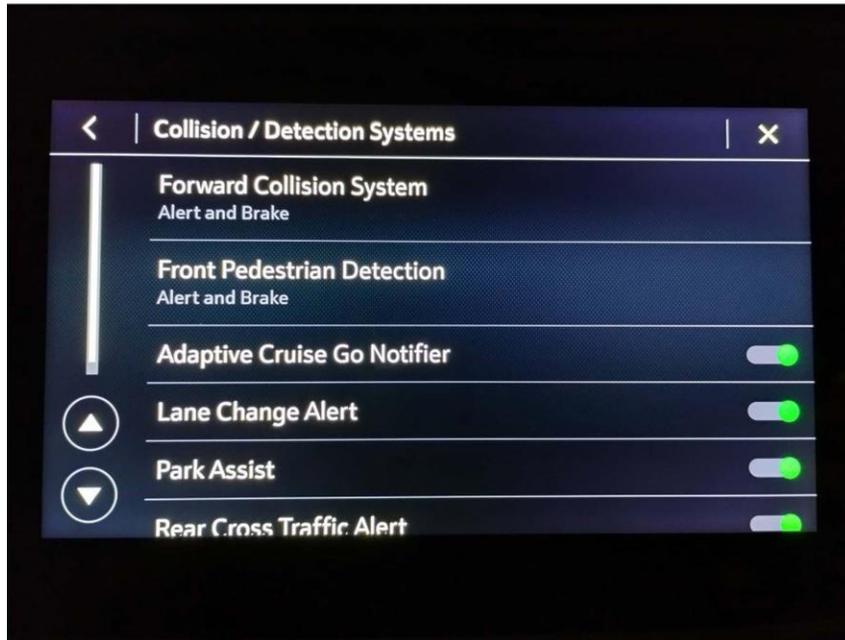


Figure A14. Menus for Turning AEB System On/Off



Figure A15. Visual Alert

## APPENDIX B

Excerpts from Owner's Manual

occur. Consider traffic and weather conditions when selecting the alert timing. The range of selectable alert timing may not be appropriate for all drivers and driving conditions.

**Following Distance Indication**

The following distance to a moving vehicle you are following is indicated in following time in seconds on the Driver Information Center (DIC).

The minimum following time is 0.5 seconds away. If there is no vehicle detected ahead, or the vehicle ahead is out of sensor range, dashes will be displayed.

**Unnecessary Alerts**

FCA may provide unnecessary alerts to turning vehicles, vehicles in other lanes, objects that are not vehicles, or shadows. These alerts are normal operation and the vehicle does not need service.

**Cleaning the System**

If the FCA system does not seem to operate properly, this may correct the issue:

- Clean the outside of the windshield in front of the rearview mirror.
- Clean the entire front of the vehicle.

- Clean the headlamps.

**Automatic Emergency Braking (AEB)**

If the vehicle has Forward Collision Alert (FCA), it also has AEB, which includes Intelligent Brake Assist (IBA). When the system detects a vehicle ahead in your path that is traveling in the same direction that you may be about to crash into, it can provide a boost to braking or automatically brake the vehicle. This can help avoid or lessen the severity of crashes when driving in a forward gear. Depending on the situation, the vehicle may automatically brake moderately or hard. This automatic emergency braking can only occur if a vehicle is detected. This is shown by the FCA vehicle ahead indicator being lit. See *Forward Collision Alert (FCA) System* ⇨ 192.

The system works when driving in a forward gear between 8 km/h (5 mph) and 80 km/h (50 mph). It can detect vehicles up to approximately 60 m (197 ft).

 **Warning**

AEB is an emergency crash preparation feature and is not designed to avoid crashes. Do not rely on AEB to brake the vehicle. AEB will not brake outside of its operating speed range and only responds to detected vehicles.

AEB may not:

- Detect a vehicle ahead on winding or hilly roads.
- Detect all vehicles, especially vehicles with a trailer, tractors, muddy vehicles, etc.
- Detect a vehicle when weather limits visibility, such as in fog, rain, or snow.
- Detect a vehicle ahead if it is partially blocked by pedestrians or other objects.

Complete attention is always required while driving, and you should be ready to take action and apply the brakes and/or steer the vehicle to avoid crashes.

AEB may slow the vehicle to a complete stop to try to avoid a potential crash. If this happens, AEB may engage the Electric

Parking Brake (EPB) to hold the vehicle at a stop. Release the EPB or firmly press the accelerator pedal.

**Warning**

AEB may automatically brake the vehicle suddenly in situations where it is unexpected and undesired. It could respond to a turning vehicle ahead, guardrails, signs, and other non-moving objects. To override AEB, firmly press the accelerator pedal, if it is safe to do so.

**Intelligent Brake Assist (IBA)**

IBA may activate when the brake pedal is applied quickly by providing a boost to braking based on the speed of approach and distance to a vehicle ahead.

Minor brake pedal pulsations or pedal movement during this time is normal and the brake pedal should continue to be applied as needed. IBA will automatically disengage only when the brake pedal is released.

**Warning**

IBA may increase vehicle braking in situations when it may not be necessary. You could block the flow of traffic. If this occurs, take your foot off the brake pedal and then apply the brakes as needed.

AEB and IBA can be disabled through vehicle personalization. See "Collision/Detection Systems" under *Vehicle Personalization* ⇨ 102.

A system unavailable message may display if:

- The front of the vehicle or windshield is not clean.
- Heavy rain or snow is interfering with object detection.
- There is a problem with the StabiliTrak system.

The AEB system does not need service.

**Front Pedestrian Braking (FPB) System**

If equipped, the FPB system may help avoid or reduce the harm caused by front-end crashes with nearby pedestrians when driving in a forward gear. FPB displays an

amber indicator, , when a pedestrian is detected ahead. When approaching a detected pedestrian too quickly, FPB provides a red flashing alert on the windshield and rapidly beeps. FPB can provide a boost to braking or automatically brake the vehicle. This system includes Intelligent Brake Assist (IBA), and the Automatic Emergency Braking (AEB) System may also respond to pedestrians. See *Automatic Emergency Braking (AEB)* ⇨ 194.

The FPB system can detect and alert to pedestrians in a forward gear at speeds between 8 km/h (5 mph) and 80 km/h (50 mph). During daytime driving, the system detects pedestrians up to a distance of approximately 40 m (131 ft). During nighttime driving, system performance is very limited.

**Warning**

FPB does not provide an alert or automatically brake the vehicle, unless it detects a pedestrian. FPB may not detect pedestrians, including children:

(Continued)

## APPENDIX C

### Run Log

Subject Vehicle: **2022 Chevrolet Bolt EUV Premier**

Test start date: **8/31/2022**

Principal Other Vehicle: **SSV**

Test end date: **8/31/2022**

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
1	Static Run								
2	<b>Stopped POV</b>	Y	2.22	4.72	25.0	1.05	0.86	Pass	
3		Y	2.27	3.62	25.5	1.05	0.85	Pass	
4		Y	2.16	3.53	25.0	1.03	0.81	Pass	
5		Y	2.23	4.87	24.5	1.04	0.85	Pass	
6		Y	2.21	3.89	25.2	1.04	0.82	Pass	
7		Y	2.17	2.38	25.0	1.06	0.79	Pass	
8		Y	2.16	4.27	25.2	1.00	0.84	Pass	
9	Static Run								
10	<b>Slower POV, 25 vs 10</b>	Y	2.25	3.31	14.9	1.08	0.63	Pass	
11		Y	2.24	4.58	15.3	1.04	0.69	Pass	
12		Y	2.22	4.65	15.0	1.01	0.69	Pass	
13		Y	2.24	4.43	14.7	1.03	0.69	Pass	
14		Y	2.27	4.53	15.6	1.07	0.69	Pass	
15		Y	2.25	4.95	15.1	1.08	0.71	Pass	
16		Y	2.23	5.43	15.5	1.00	0.75	Pass	
17	Static Run								

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
18	<b>Slower POV, 45 vs 20</b>	Y	2.93	4.10	25.1	0.78	1.14	Pass	
19		Y	2.89	7.26	24.8	0.72	1.19	Pass	
20		Y	2.98	3.23	25.3	0.78	1.13	Pass	
21		Y	2.93	3.94	26.0	0.71	1.14	Pass	
22		Y	2.84	4.88	25.4	0.78	1.19	Pass	
23		Y	2.99	4.69	25.4	0.69	1.12	Pass	
24		Y	2.95	4.25	25.4	0.66	1.12	Pass	
25	Static run								
26	<b>Decelerating POV, 35</b>	Y	2.11	0.00	31.8	1.03	1.13	Pass	
27		N							POV Braking
28		Y	2.01	0.00	33.2	1.00	1.04	Pass	
29		Y	2.10	0.00	32.8	1.02	1.01	Pass	
30		Y	2.49	0.00	29.5	0.64	1.08	Pass	
31		Y	2.52	0.00	33.2	1.01	0.98	Pass	
32		Y	2.25	1.72	27.0	1.03	1.12	Pass	
33	Y	2.29	1.14	28.7	1.00	1.06	Pass		
34	Static Run								
35	STP - Static Run								

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
36	<b>STP False Positive, 25</b>	Y				0.01		Pass	
37		Y				0.01		Pass	
38		Y				0.00		Pass	
39		Y				0.01		Pass	
40		Y				0.01		Pass	
41		Y				0.01		Pass	
42		Y				0.01		Pass	
43	STP - Static Run								
44	<b>STP False Positive, 45</b>	Y				0.00		Pass	
45		Y				0.00		Pass	
46		Y				0.01		Pass	
47		Y				0.00		Pass	
48		Y				0.00		Pass	
49		Y				0.01		Pass	
50	Y				0.00		Pass		
51	STP - Static Run								

## 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 codes indicating to which vehicle the data pertain.

### Time History Plot Description

Each time history plot consists of data relevant 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:

- Stopped POV (SV at 25 mph)
- Slower POV, 25/10 (SV at 25 mph, POV at 10 mph)
- Slower POV, 45/20 (SV at 45 mph, POV at 20 mph)
- Decelerating POV 35 mph (Both vehicles at 35 mph with 13.8 m gap, POV brakes at 0.3 g)
- False Positive STP 25 mph (Steel trench plate run over at 25 mph)
- False Positive STP 45 mph (Steel trench plate run over at 45 mph)

Time history figures include the following sub-plots:

- FCW 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 combination of the following:
  - Filtered, rectified, and normalized sound signal. The vertical scale is 0 to 1.
  - Filtered, rectified, and normalized acceleration (i.e., haptic alert, such as steering wheel vibration). The vertical scale is 0 to 1.
  - Normalized light sensor signal. The vertical scale is 0 to 1.

As only the auditory or haptic alert is perceptible by the driver during a test run, the earliest of either of these alerts is used to define the onset of the FCW alert. A vertical black bar on the plot indicates the TTC (sec) at the first moment of the warning issued by the FCW system. The FCW TTC is displayed to the right of the subplot in green. For False Positive tests, when the FCW presents a warning “FCW” is shown in red at the right edge of the FCW plot.

- Headway (ft) – Longitudinal separation (gap) between the frontmost point of the Subject Vehicle and the rearmost point of the Strikeable Surrogate Vehicle (SSV) towed by the Principal Other Vehicle. The minimum headway during the run is displayed to the right of the subplot.
- SV/POV Speed (mph) – Speed of the Subject Vehicle and Principal Other Vehicle (if any). For CIB tests, the speed reduction experienced by the Subject Vehicle is displayed to the right of the subplot.
- Yaw Rate (deg/sec) – Yaw rate of the Subject Vehicle and Principal Other Vehicle (if any).
- Lateral Offset (ft) – Lateral offset within the lane of the Subject Vehicle to the center of the lane of travel. Note that for tests involving the Strikeable Surrogate Vehicle (SSV), the associated lateral restraint track is defined to be the center of the lane of travel. If testing is done with a different POV which does not have a lateral restraint track, lateral offset is defined to be the lateral offset between the SV and POV.
- Ax (g) – Longitudinal acceleration of the Subject Vehicle and Principal Other Vehicle (if any). For CIB tests, the TTC (sec) at the moment of first CIB activation is displayed to the right of the subplot in green. Also, the peak value of Ax for the SV is shown on the subplot.
- Accelerator Pedal Position (0-1) – Normalized position of the accelerator pedal.

### **Envelopes and Thresholds**

Some of the time history plot figures 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. Such exceedances indicate either that the test was invalid or that the requirements of the test were not met (i.e., failure of the AEB system).

For plots with green envelopes, in order for the test to be valid, the time-varying data must not exceed the envelope boundaries at any time. Exceedances of a green envelope are indicated by red shading in the area between the measured time-varying data and the envelope boundaries.

For plots with yellow envelopes, in order for the test to be valid, the time-varying data must not exceed the envelope at the beginning (left edge of the boundary) and/or end (right edge), but may exceed the boundary during the time

between the left and right edges. Exceedances at the left or right extent of a yellow envelope are indicated by red asterisks.

For the headway plot, a dashed black threshold line indicating a relative headway of zero is displayed. If no impact occurs, a green circle is displayed at the moment of minimum distance. If impact occurs, a red asterisk is displayed at the moment of impact.

For the Ax plot, if the scenario is an AEB brake-to-stop scenario, a vertical dashed black line is displayed for all plots indicating the moment of first POV braking. The yellow envelope in this case is relevant to the POV braking only. The left edge of the envelope is at 1.5 seconds after the first POV braking. A solid black threshold line extends horizontally 0.5 seconds to the left of the envelope. This threshold line represents the time during which the Ax of the Principal Other Vehicle must first achieve 0.27 g (the upper edge of the envelope). A green circle or red asterisk is displayed at the moment the POV brake level achieves 0.27 g. A green circle indicates that the test was valid (the threshold was crossed during the appropriate interval) and a red asterisk indicates that the test was invalid (the threshold was crossed outside of the appropriate interval). Additionally, for the CIB tests, a dashed black threshold line indicating an Ax of -0.15 g is given to define the onset of CIB activation. When the Subject Vehicle's Ax crosses this threshold, the CIB TTC is calculated and displayed.

For the accelerator pedal position plot, a green envelope is given starting 500 ms after the onset of the FCW warning to ensure that the accelerator pedal was released at the correct time and remained off for the duration of the CIB event. For false positive runs a green dot, rather than a green envelope is displayed. The green dot indicates that at the end of the run the accelerator pedal had not been released. If the accelerator had been released a red asterisk would appear.

## 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. Individual data points
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 cross this threshold in the time period shown in order to be valid
- Black threshold (Dashed) = for reference only – this can include warning level thresholds, TTC thresholds, and acceleration thresholds

3. Individual data point 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

- 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 D9. Figures D1 through D6 show passing runs for each of the 6 test types. Figures D7 and D8 show examples of invalid runs. Figure D9 shows an example of a valid test that failed the CIB requirements.

Time history data plots for the tests of the vehicle under consideration herein are provided beginning with Figure D10.

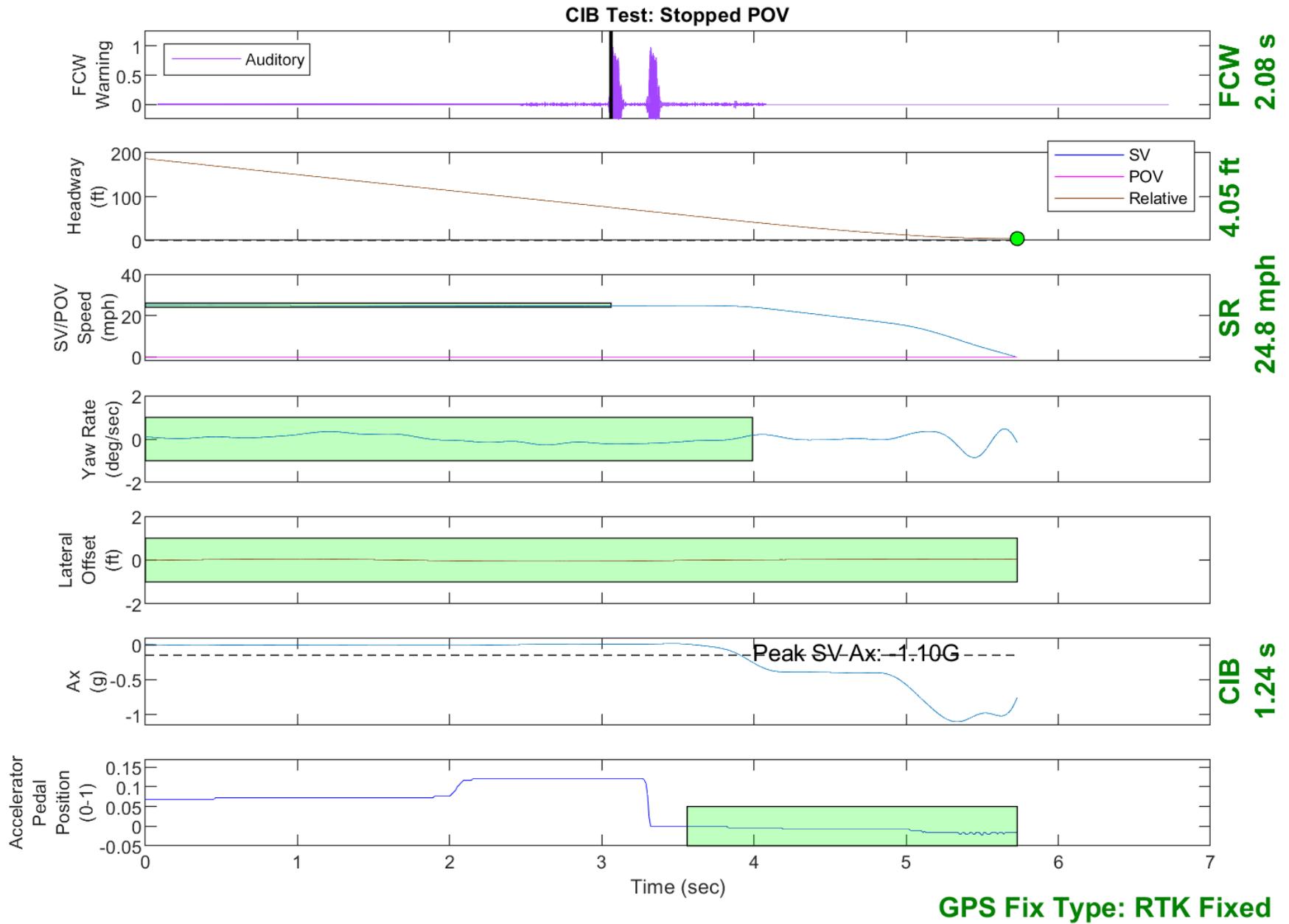


Figure D1. Example Time History for Stopped POV, Passing

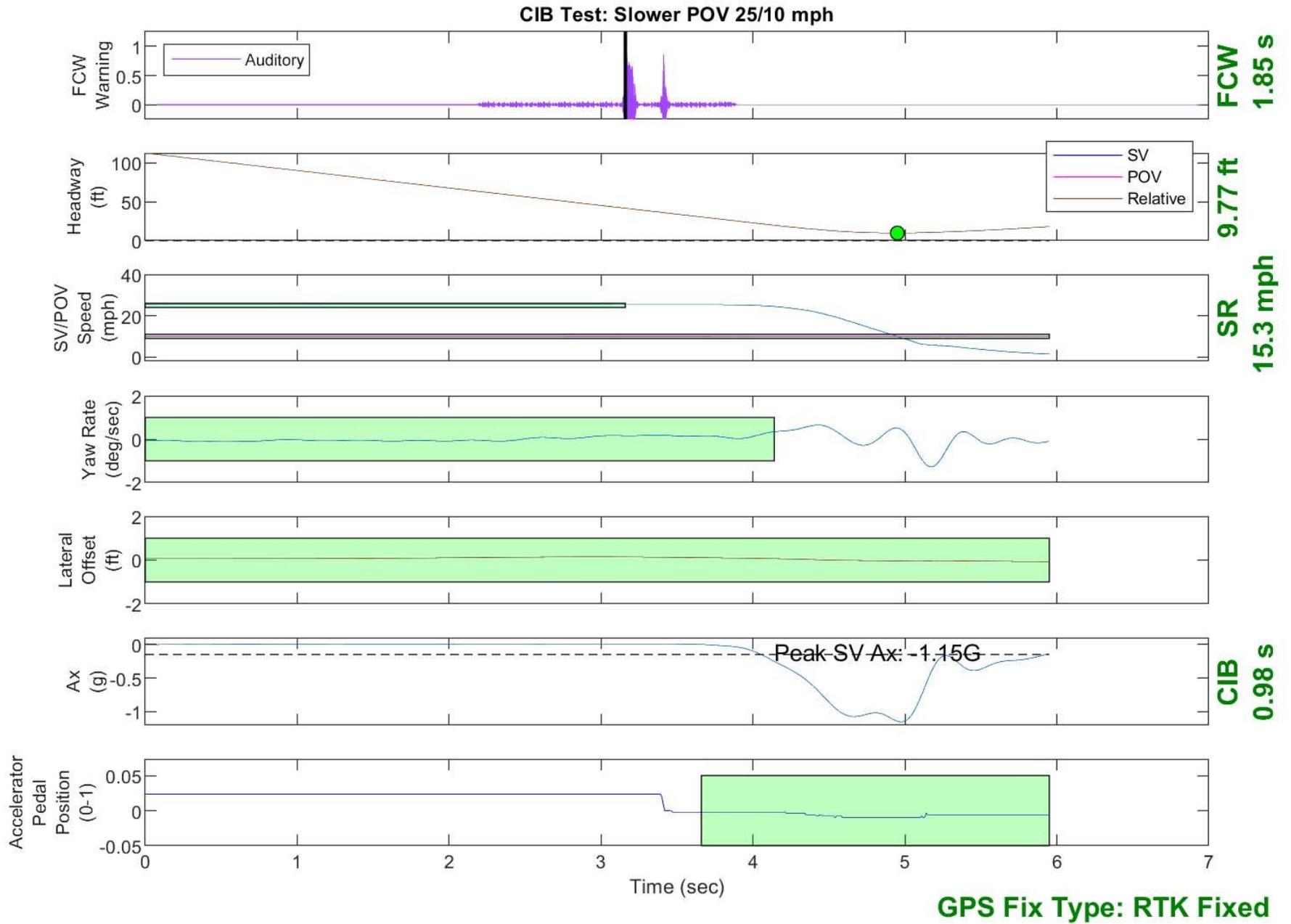


Figure D2. Example Time History for Slower POV 25 vs. 10, Passing

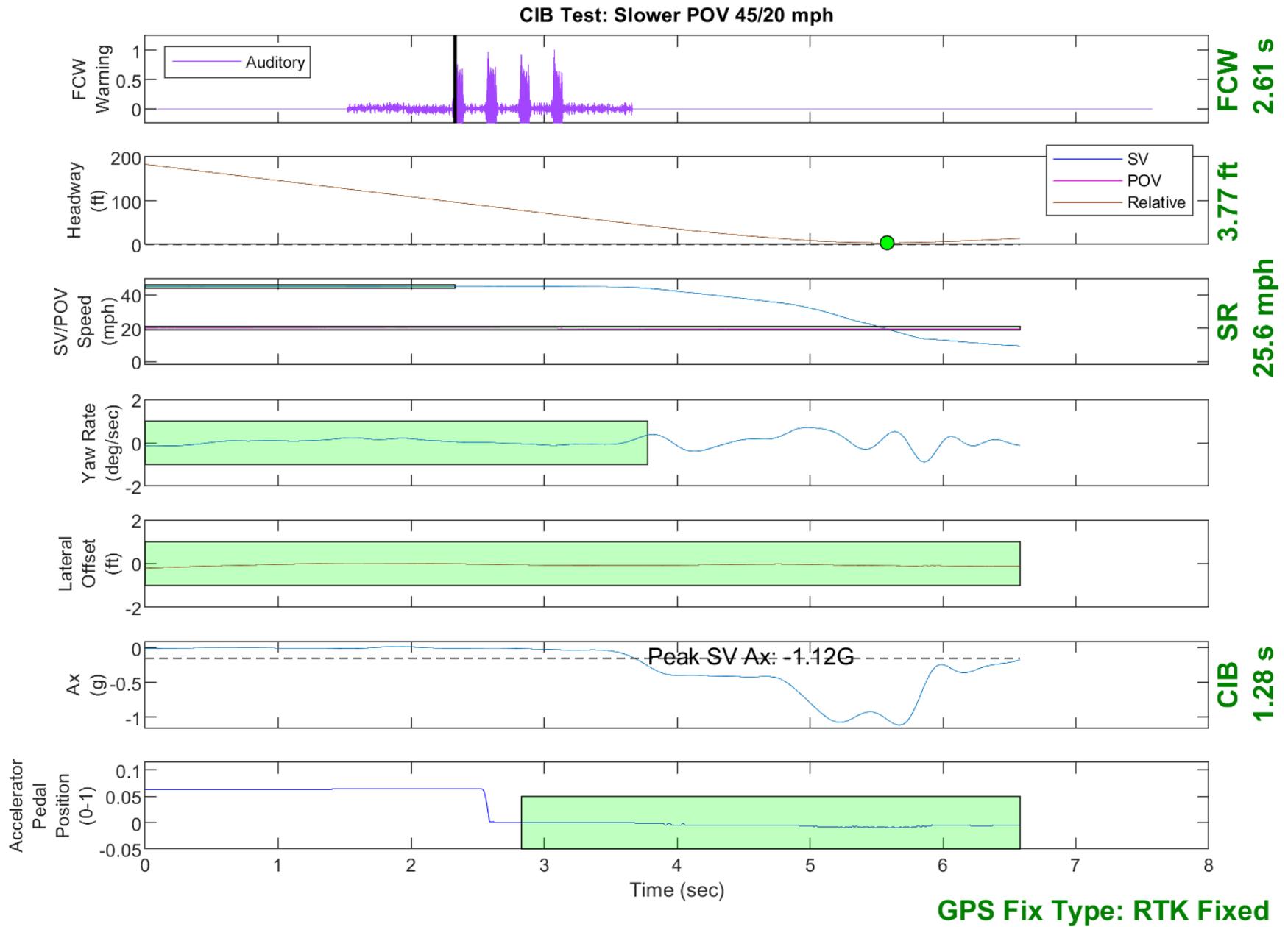


Figure D3. Example Time History for Slower POV 45 vs. 20, Passing

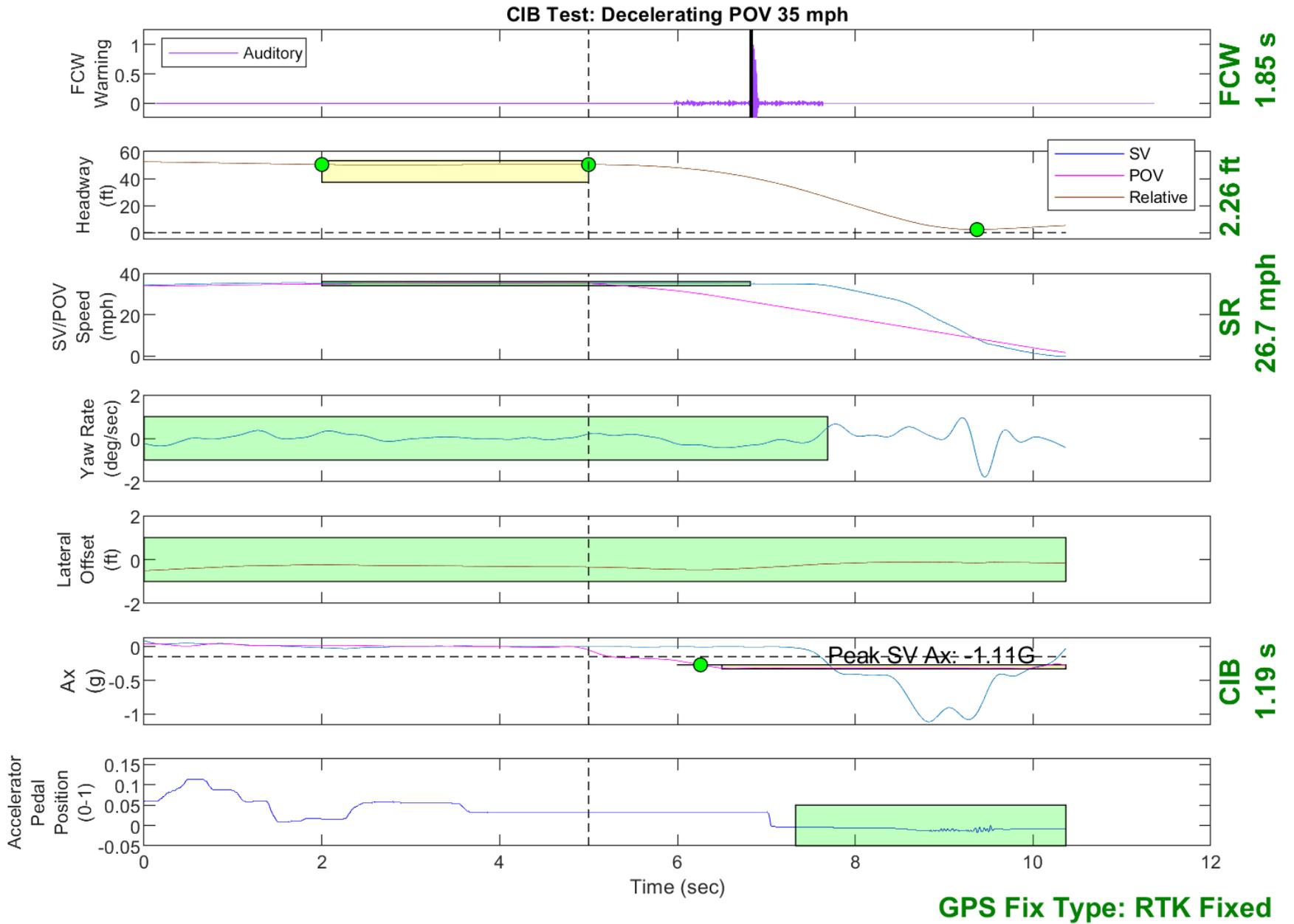


Figure D4. Example Time History for Decelerating POV 35, Passing

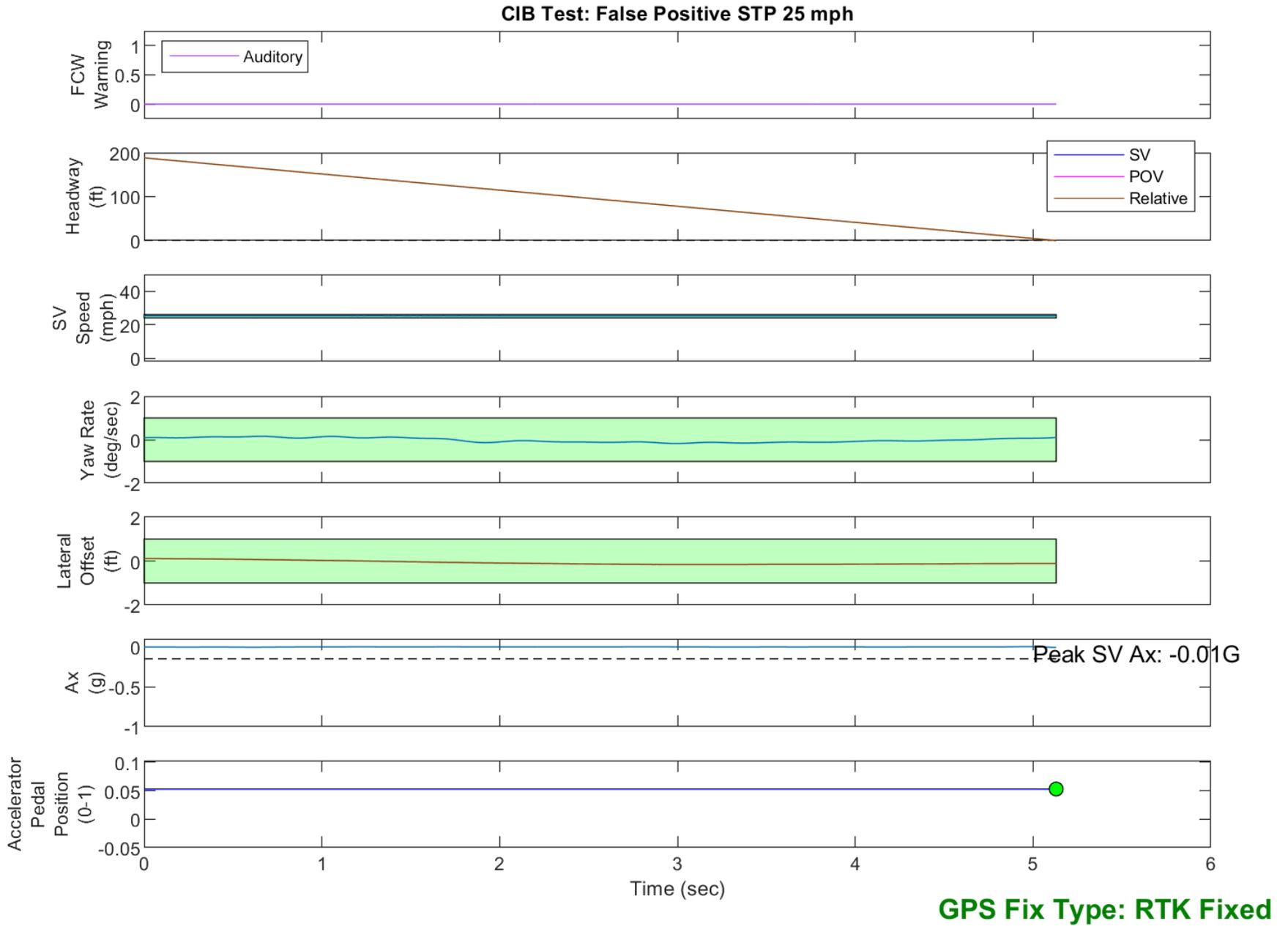


Figure D5. Example Time History for False Positive STP 25, Passing

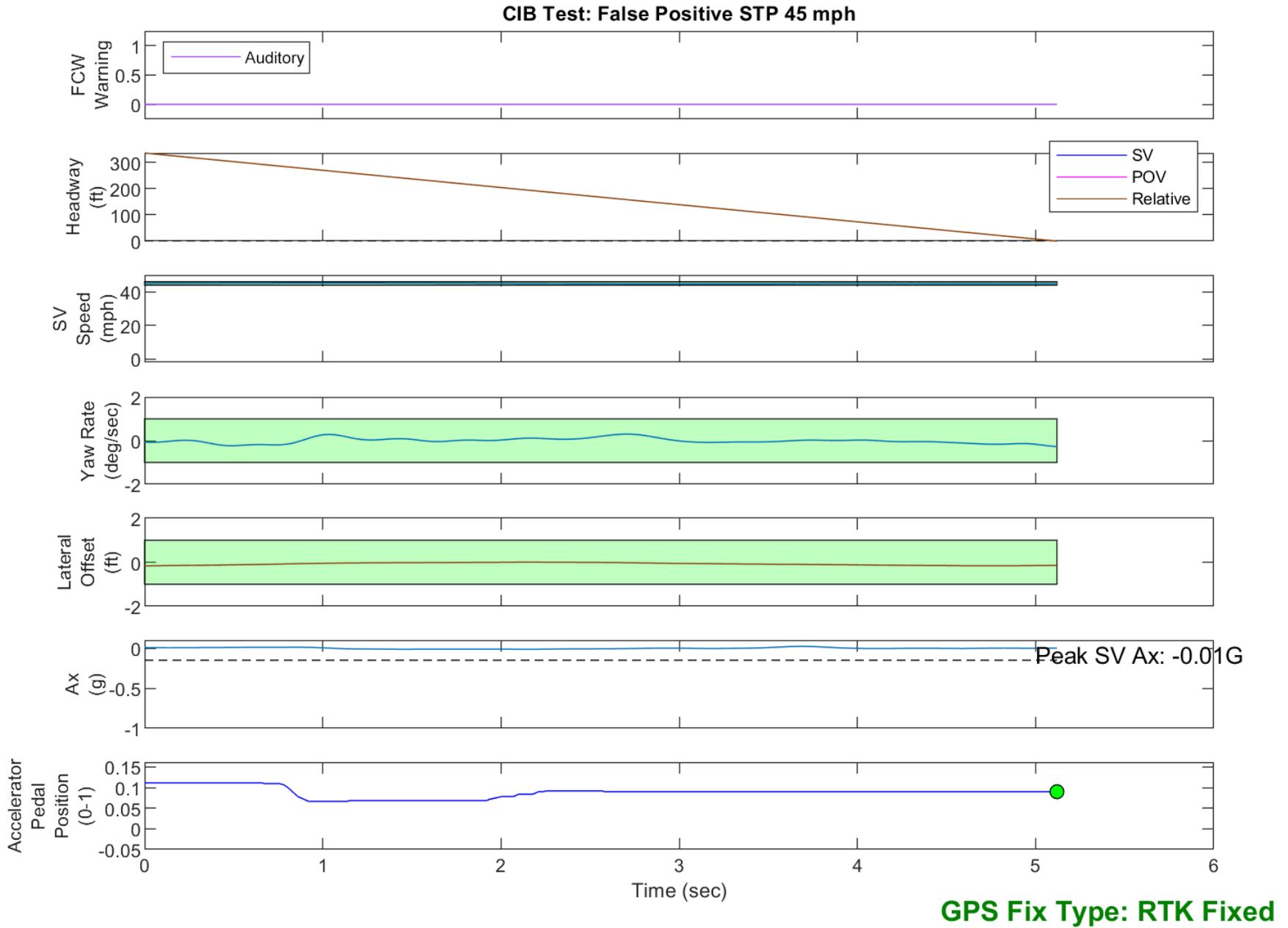


Figure D6. Example Time History for False Positive STP 45, Passing

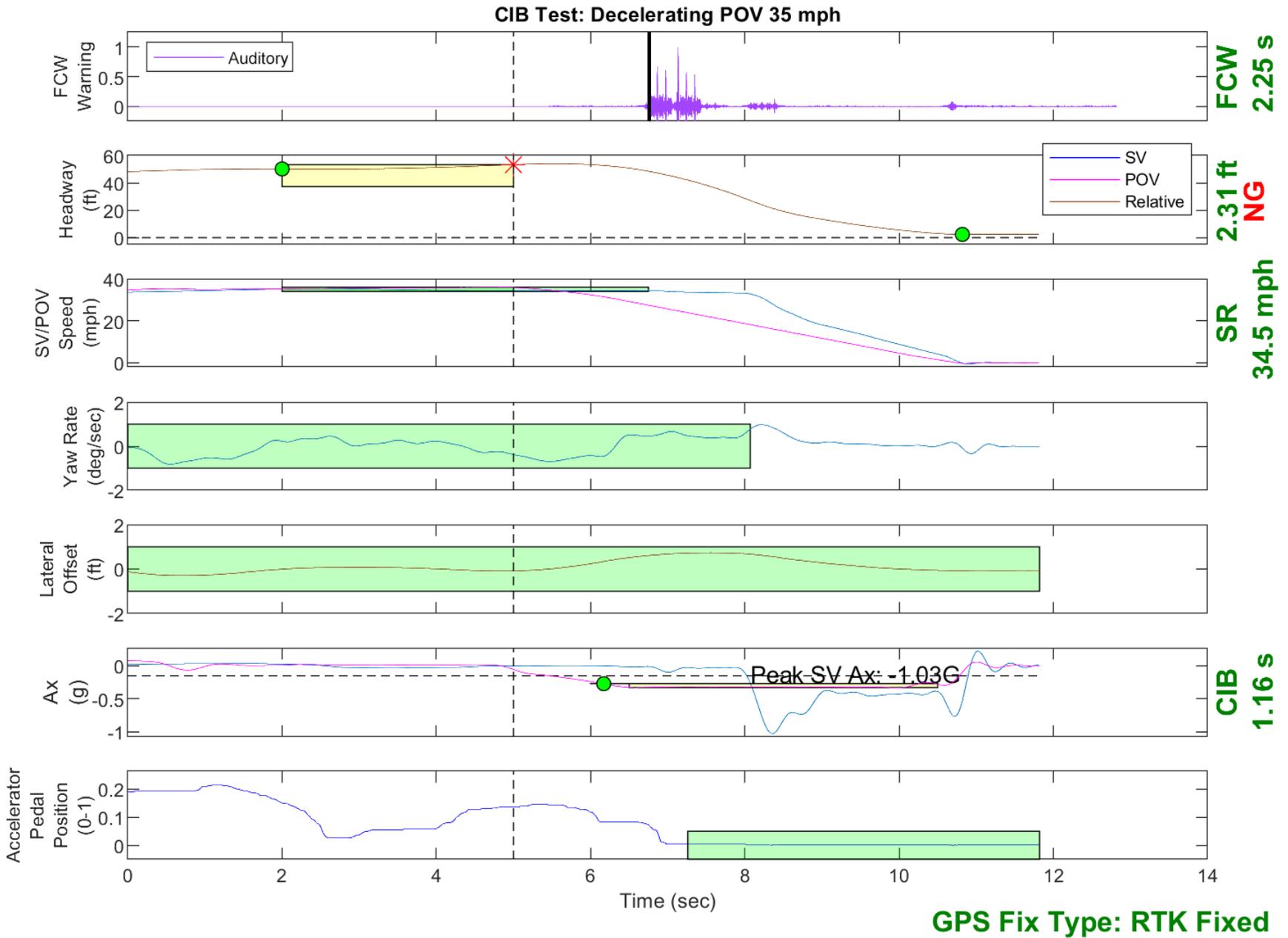


Figure D7. Example Time History Displaying Invalid Headway Criteria

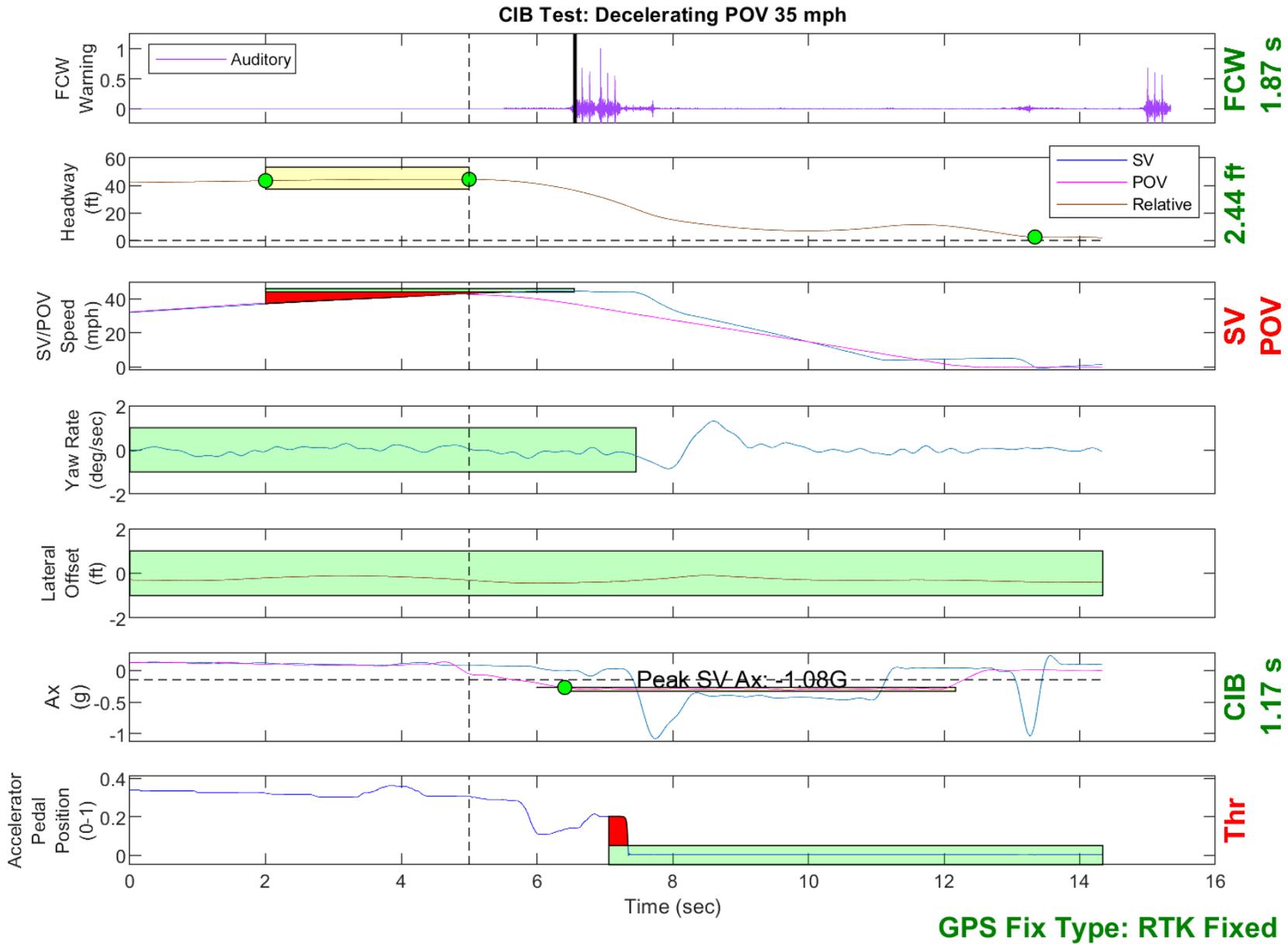


Figure D8. Example Time History Displaying Various Invalid Criteria

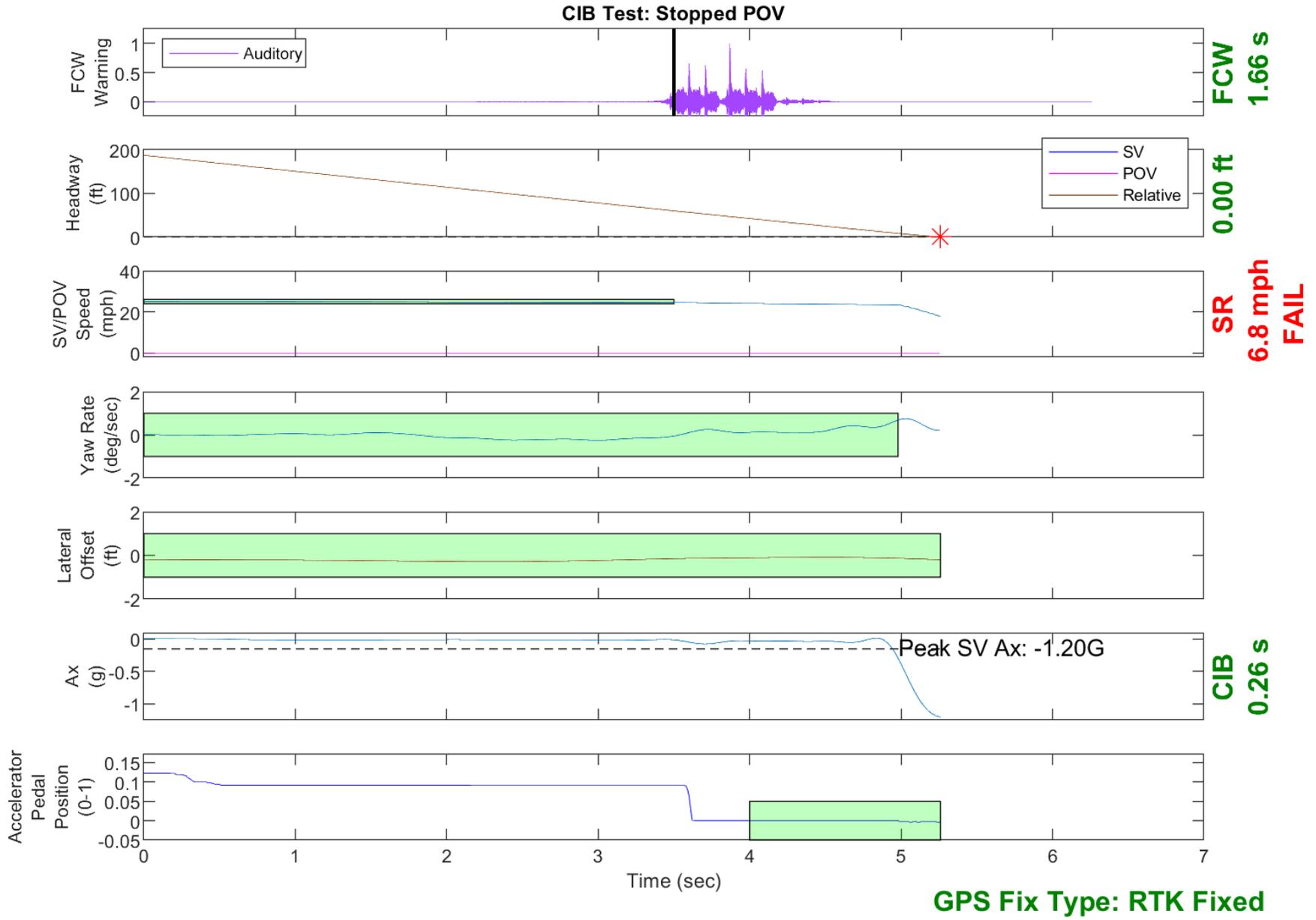


Figure D9. Example Time History for a Failed Run

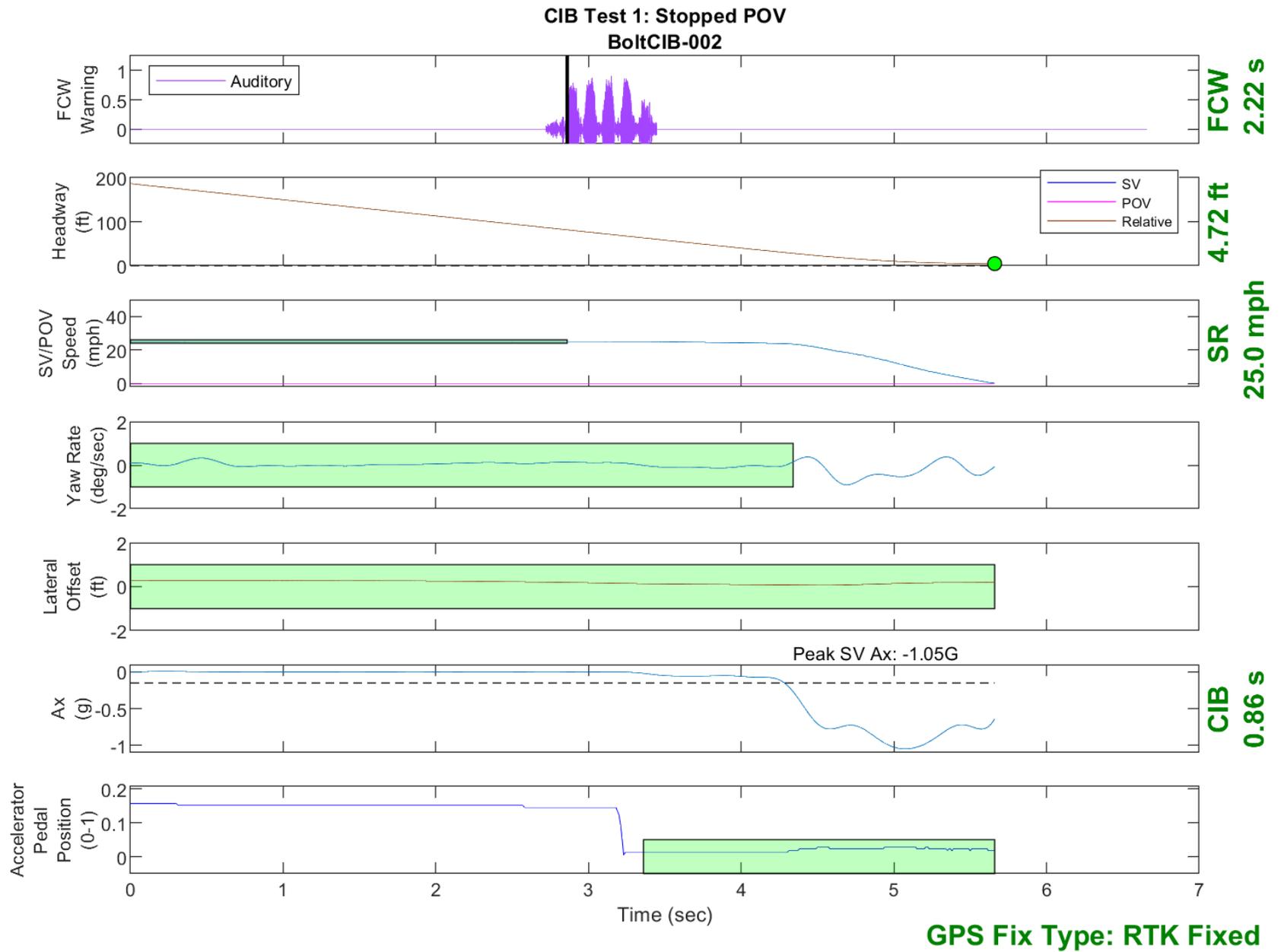


Figure D10. Time History for CIB Run 2, Test 1 - Stopped POV

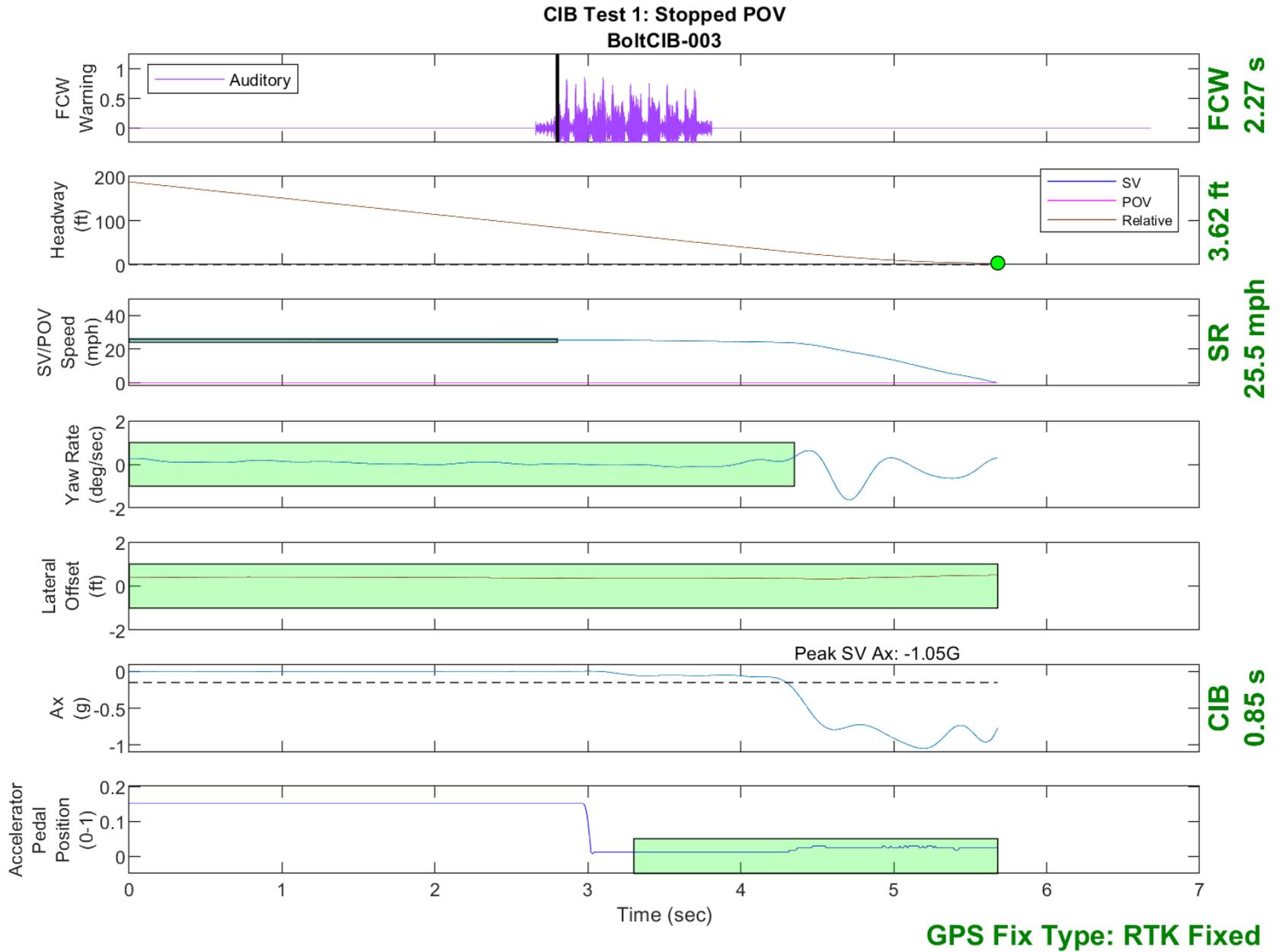


Figure D11. Time History for CIB Run 3, Test 1 - Stopped POV

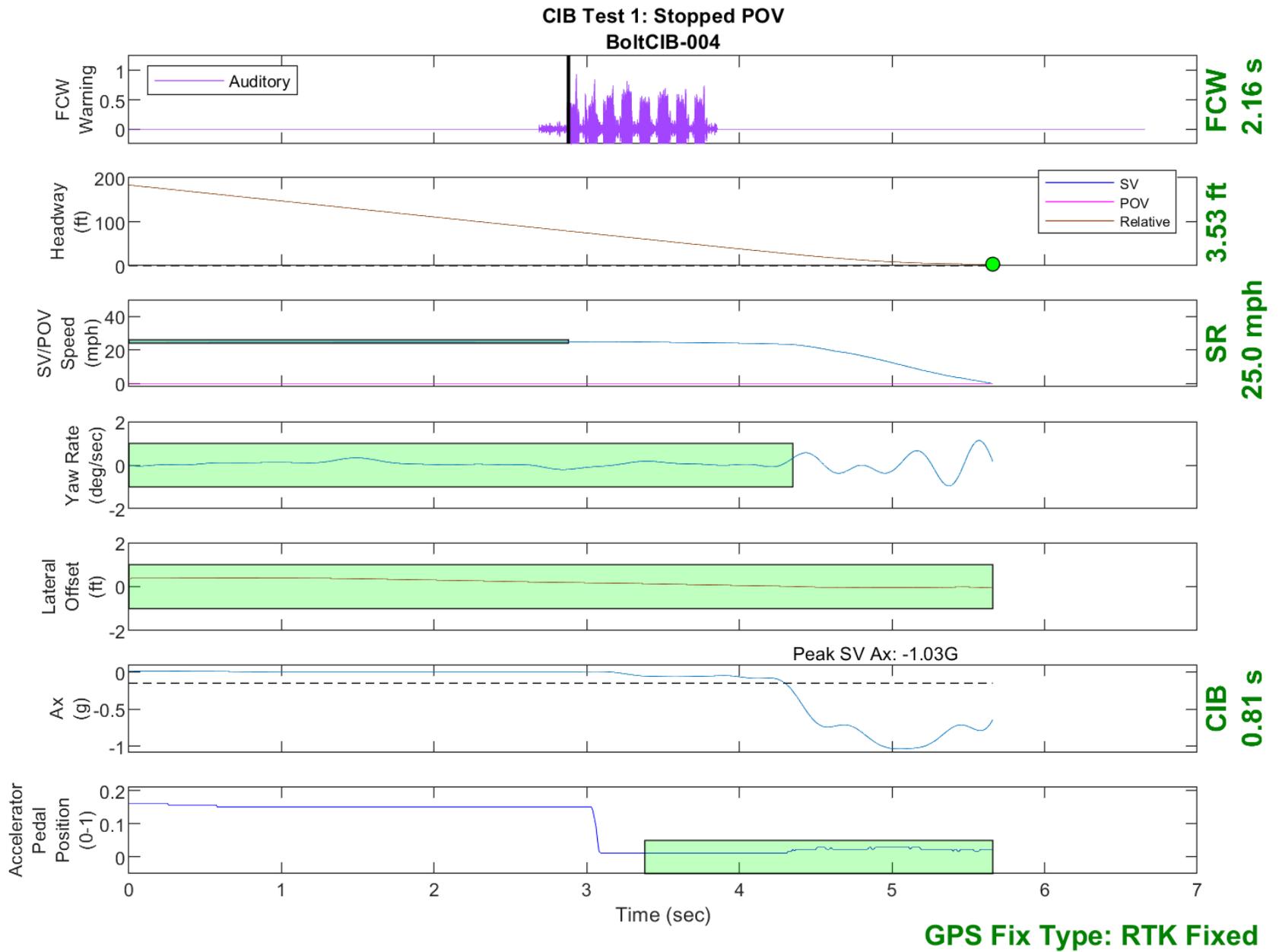


Figure D12. Time History for CIB Run 4, Test 1 - Stopped POV

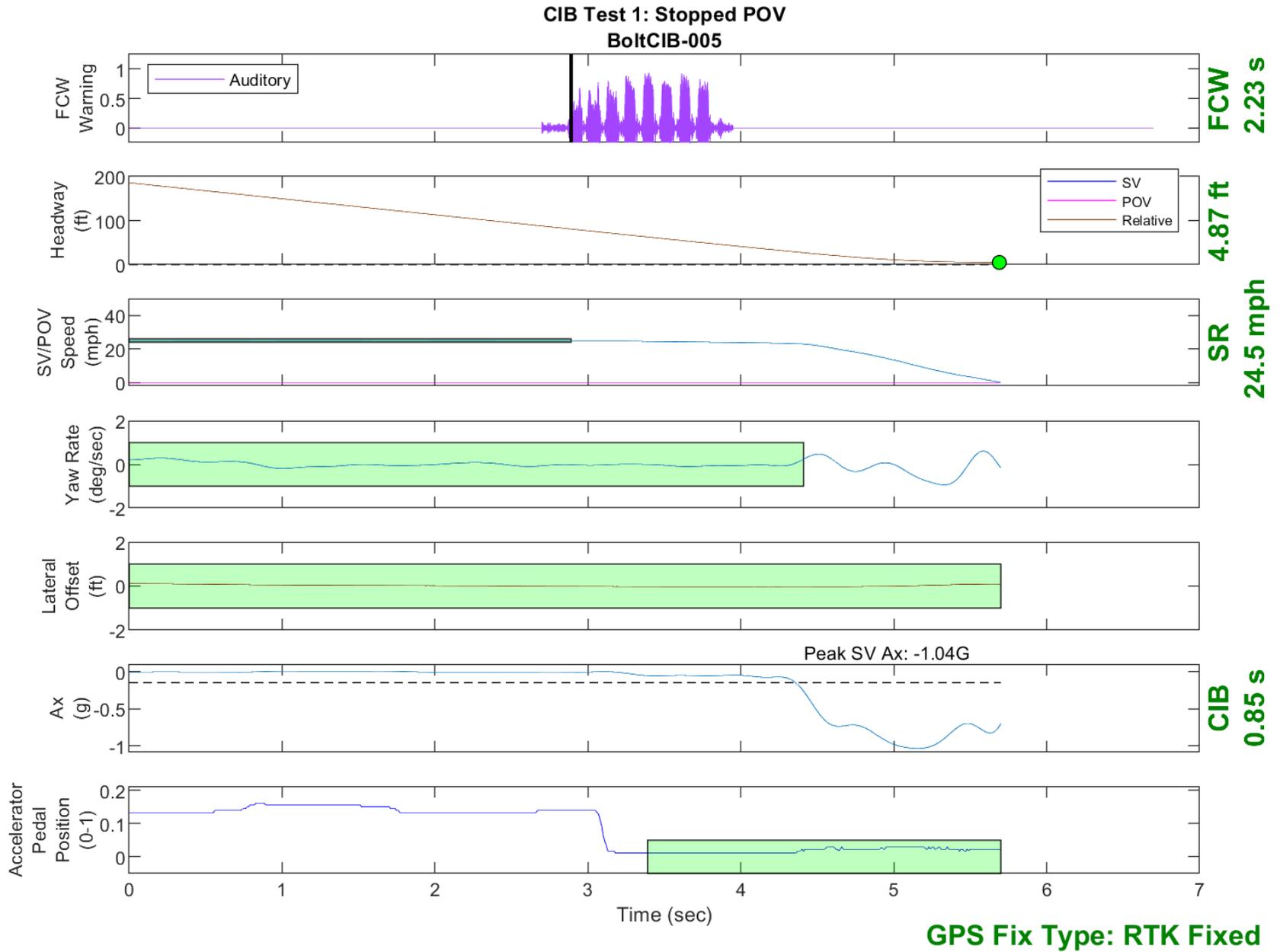


Figure D13. Time History for CIB Run 5, Test 1 - Stopped POV

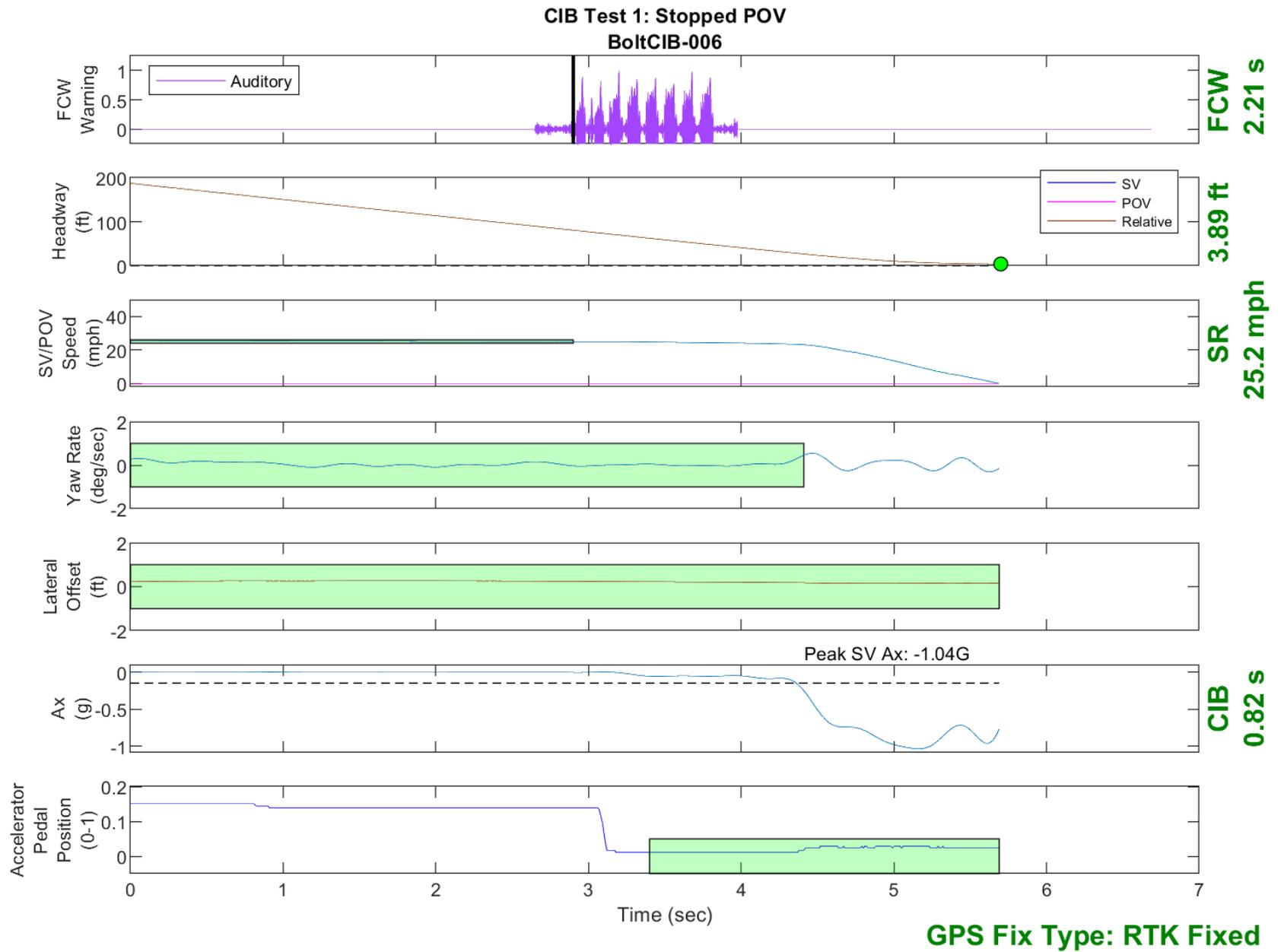


Figure D14. Time History for CIB Run 6, Test 1 - Stopped POV

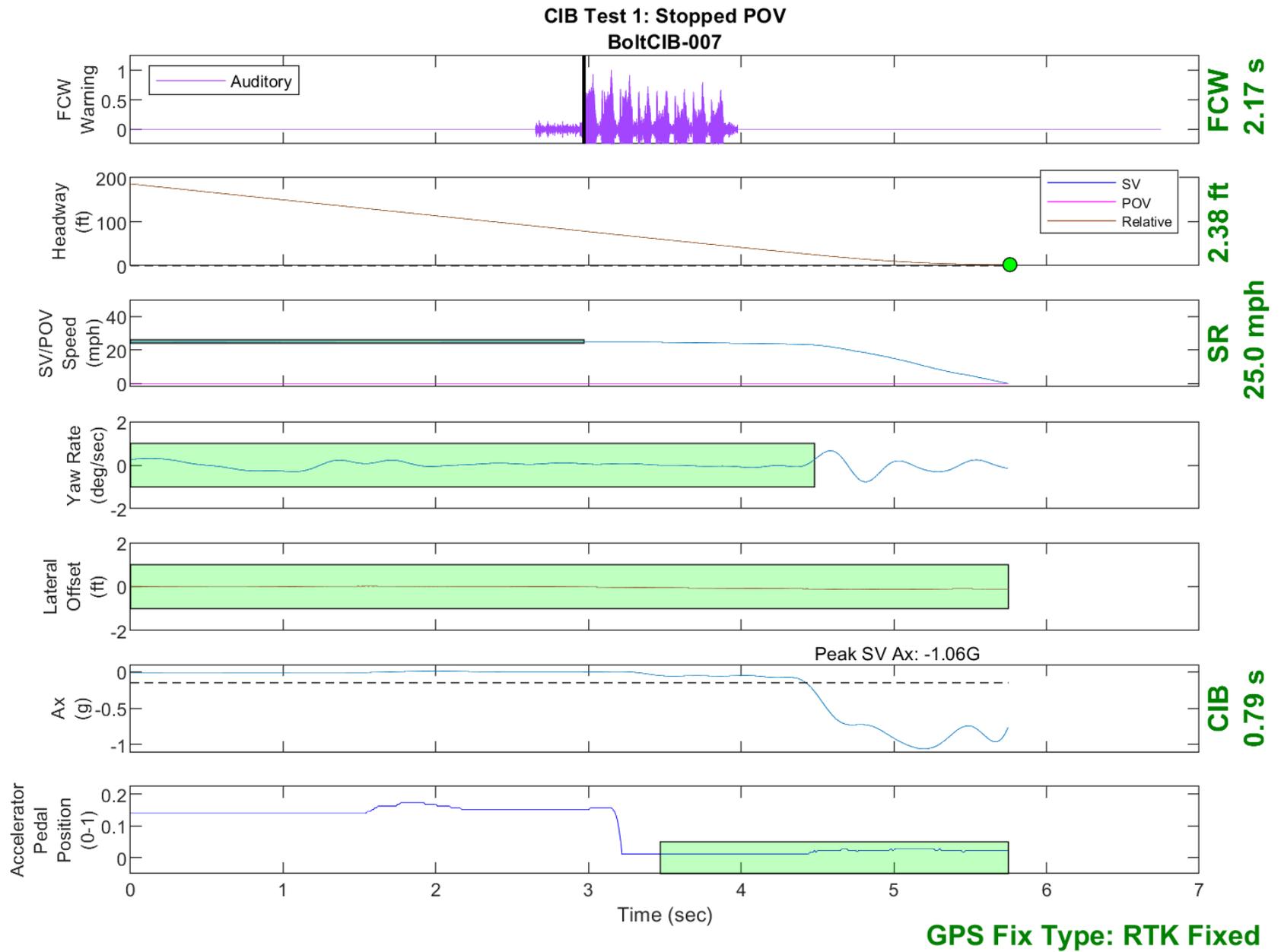


Figure D15. Time History for CIB Run 7, Test 1 - Stopped POV

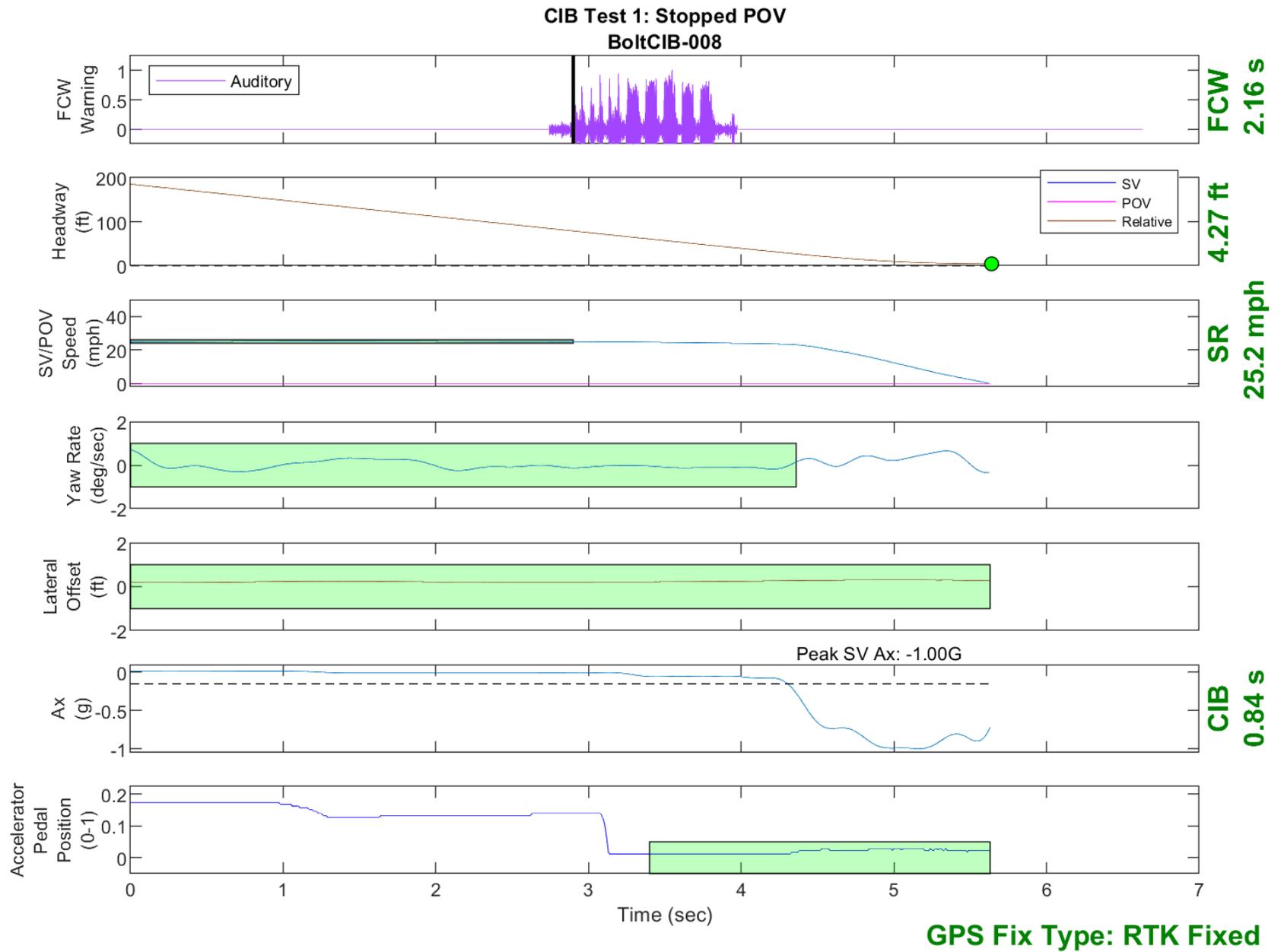


Figure D16. Time History for CIB Run 8, Test 1 - Stopped POV

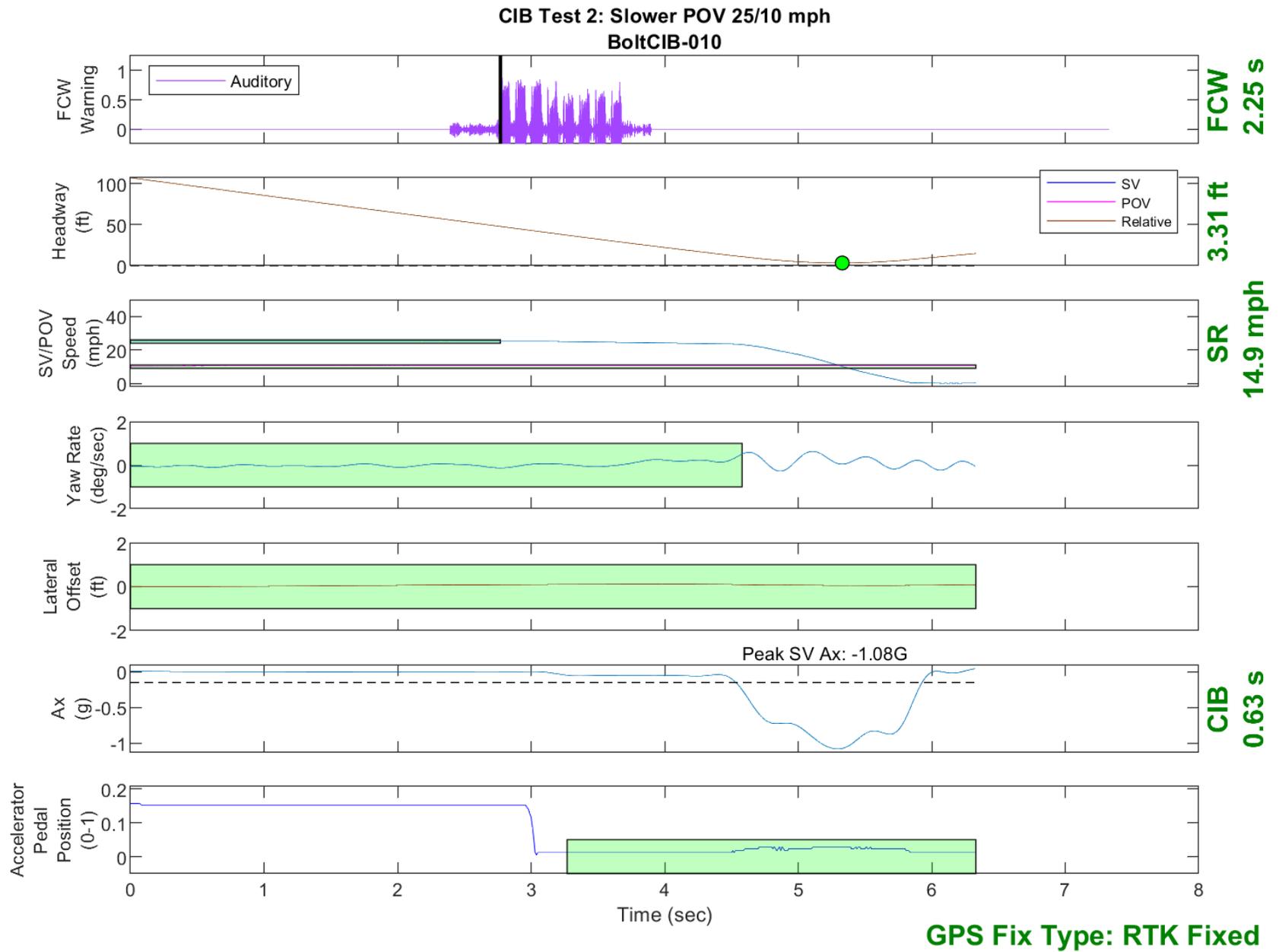


Figure D17. Time History for CIB Run 10, Test 2 - Slower Moving POV, 25/10 mph

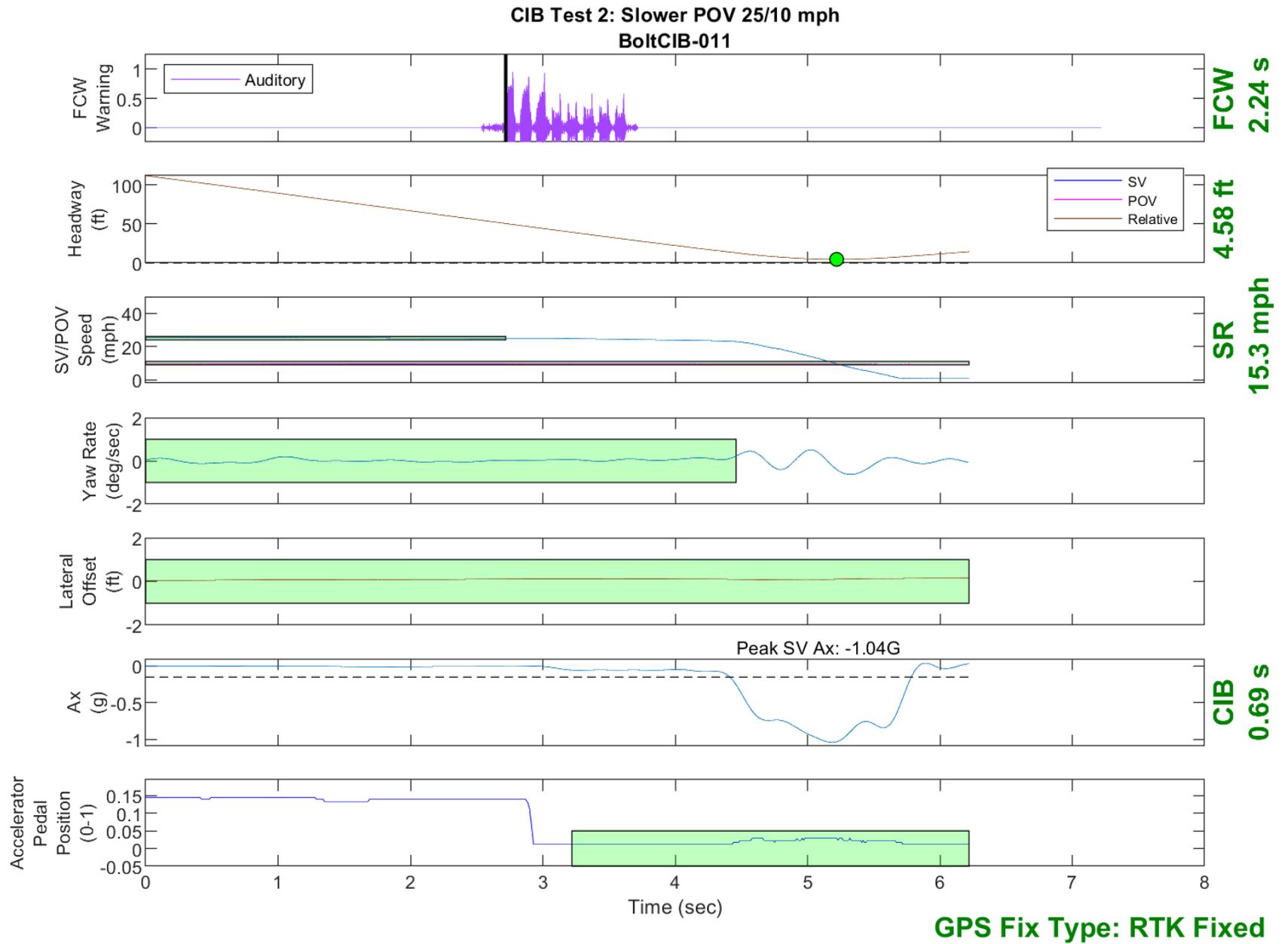


Figure D18. Time History for CIB Run 11, Test 2 - Slower Moving POV, 25/10 mph

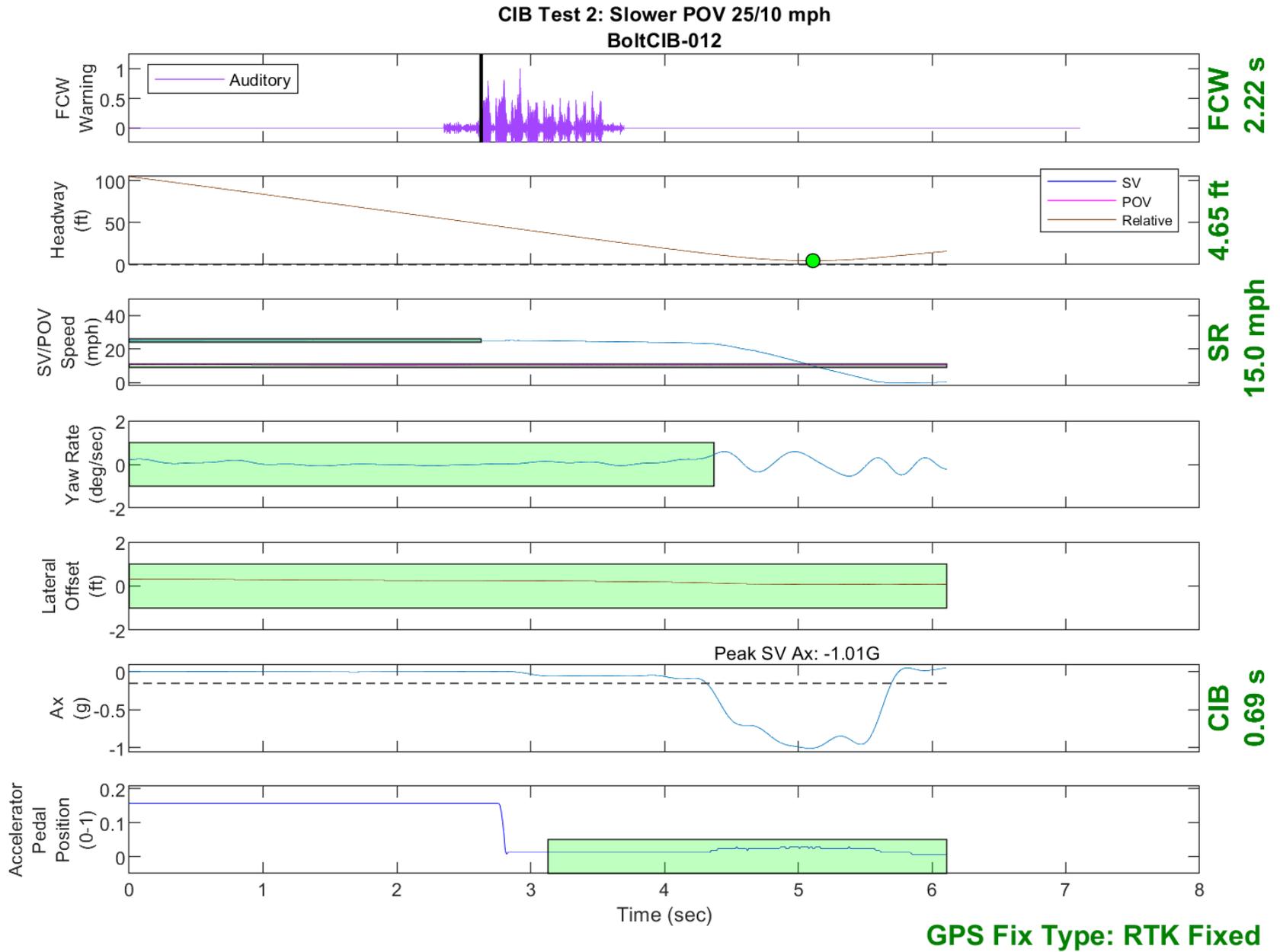


Figure D19. Time History for CIB Run 12, Test 2 - Slower Moving POV, 25/10 mph

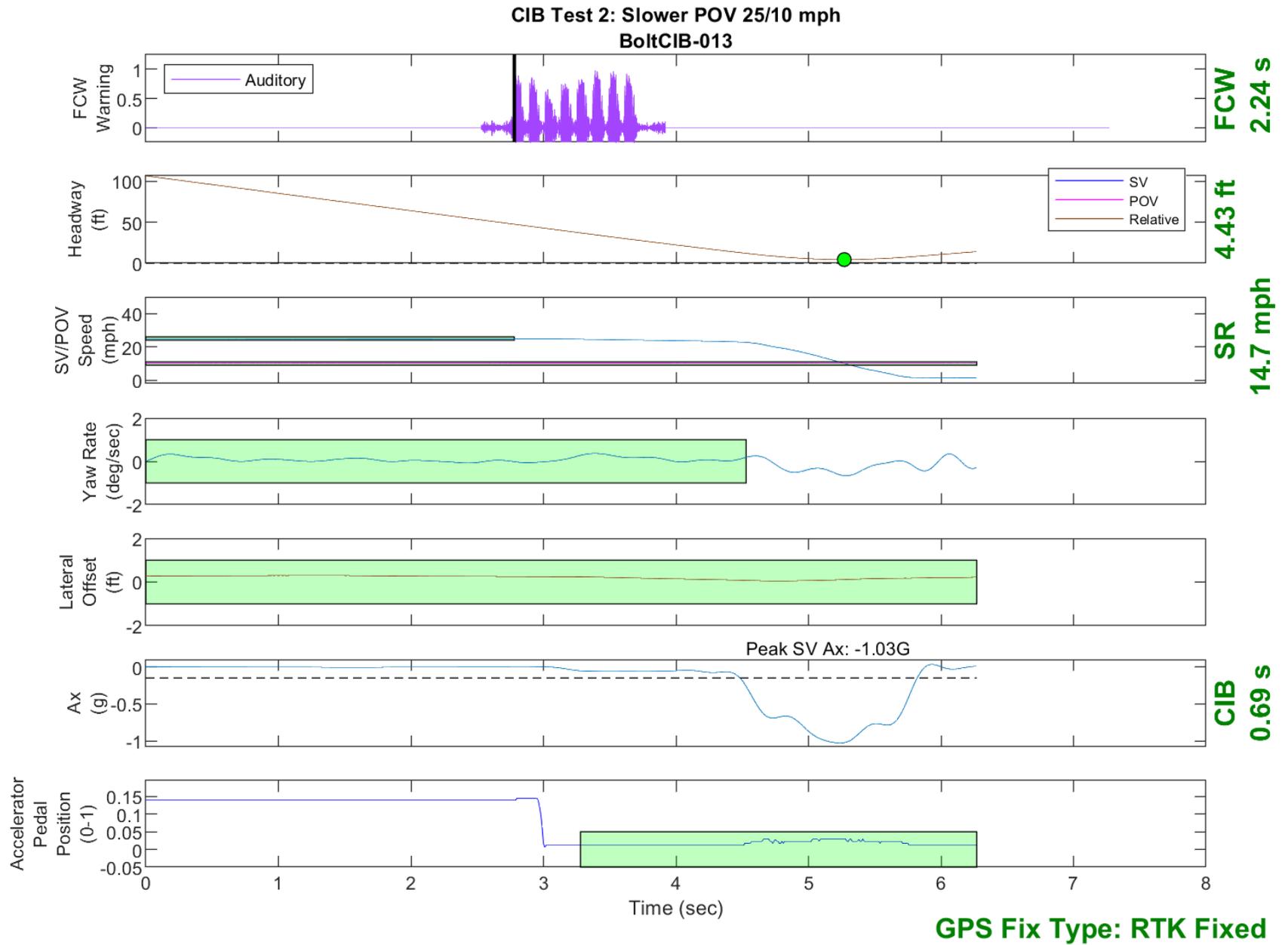


Figure D20. Time History for CIB Run 13, Test 2 - Slower Moving POV, 25/10 mph

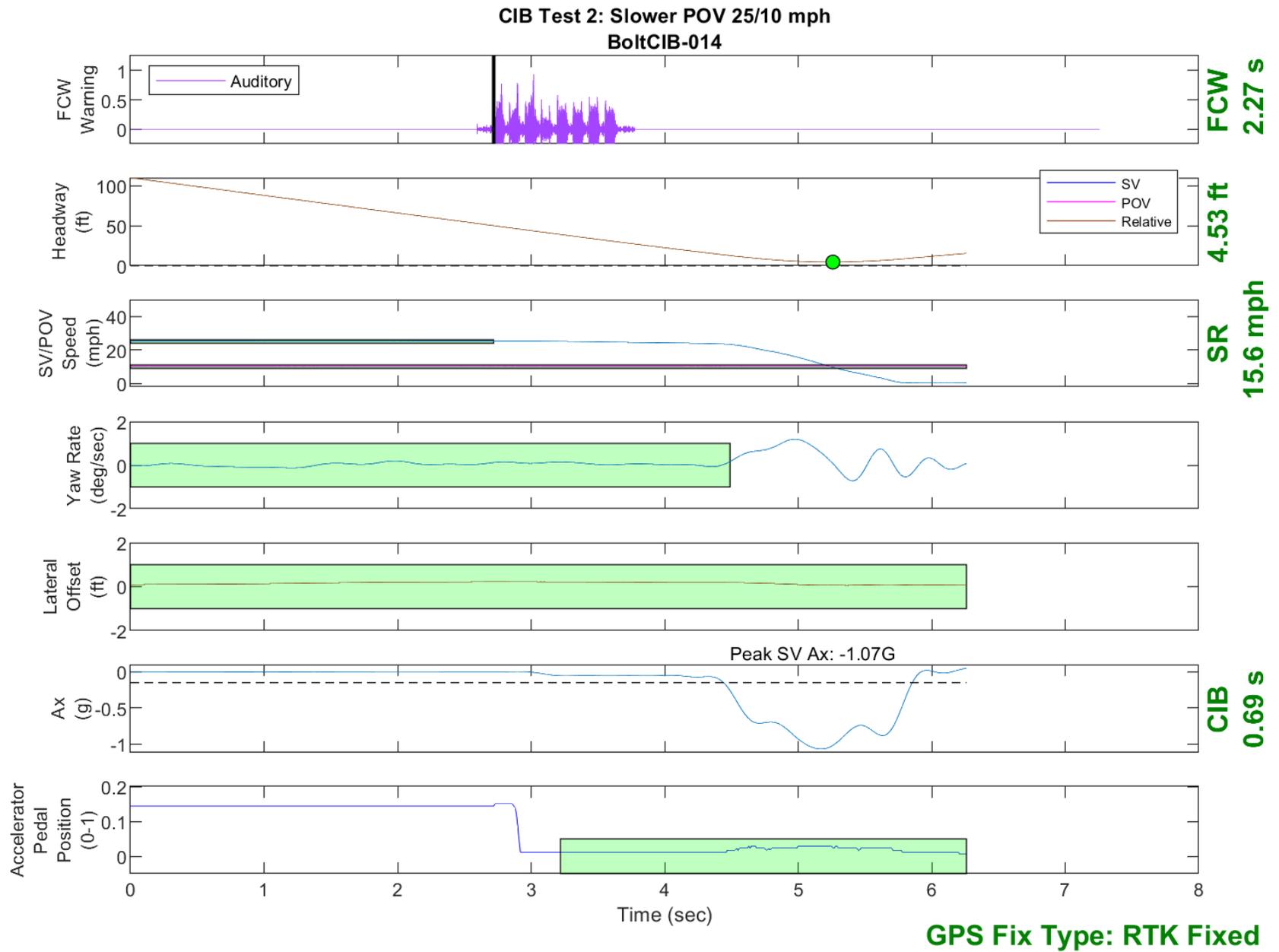


Figure D21. Time History for CIB Run 14, Test 2 - Slower Moving POV, 25/10 mph

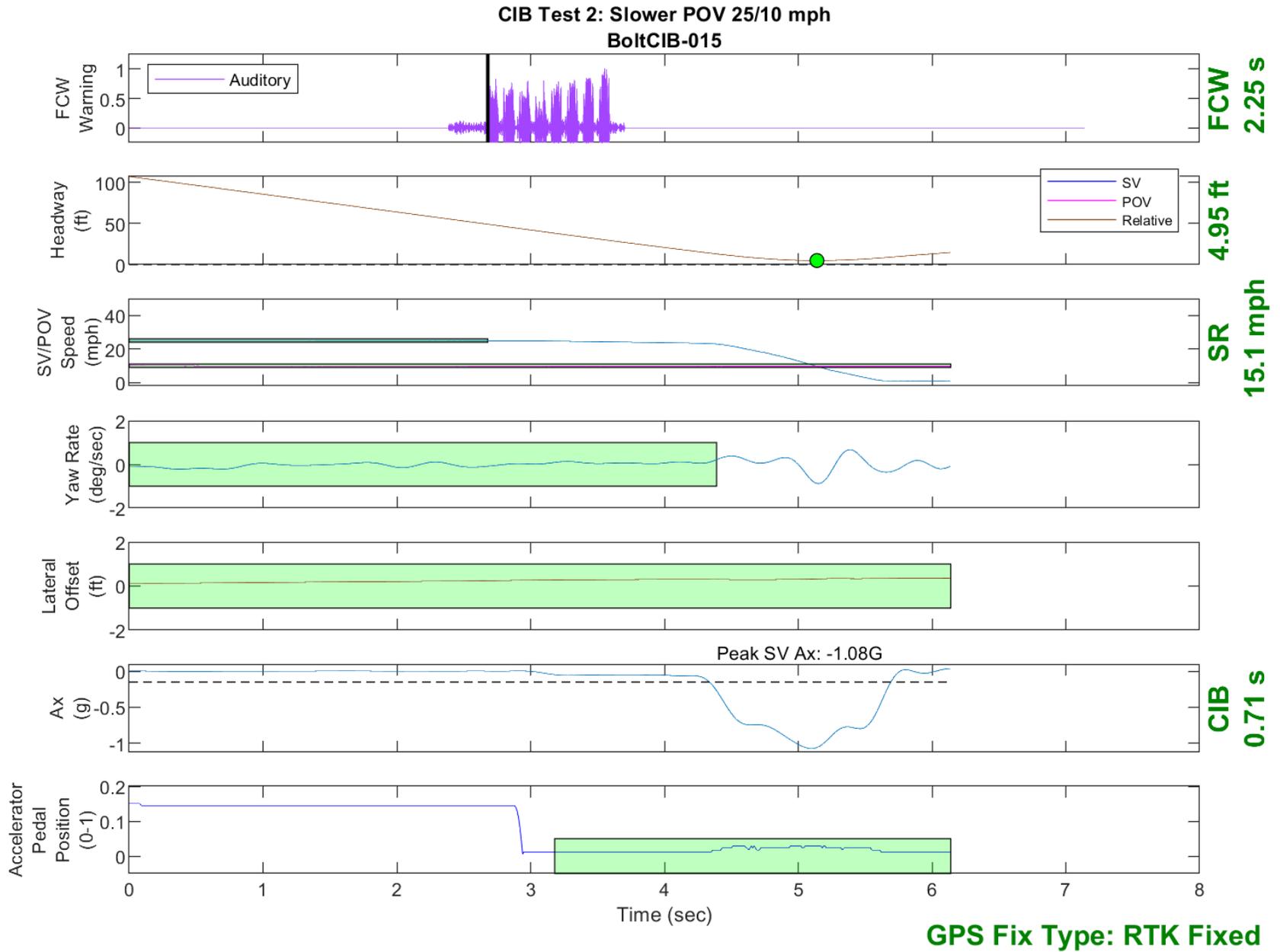


Figure D22. Time History for CIB Run 15, Test 2 - Slower Moving POV, 25/10 mph

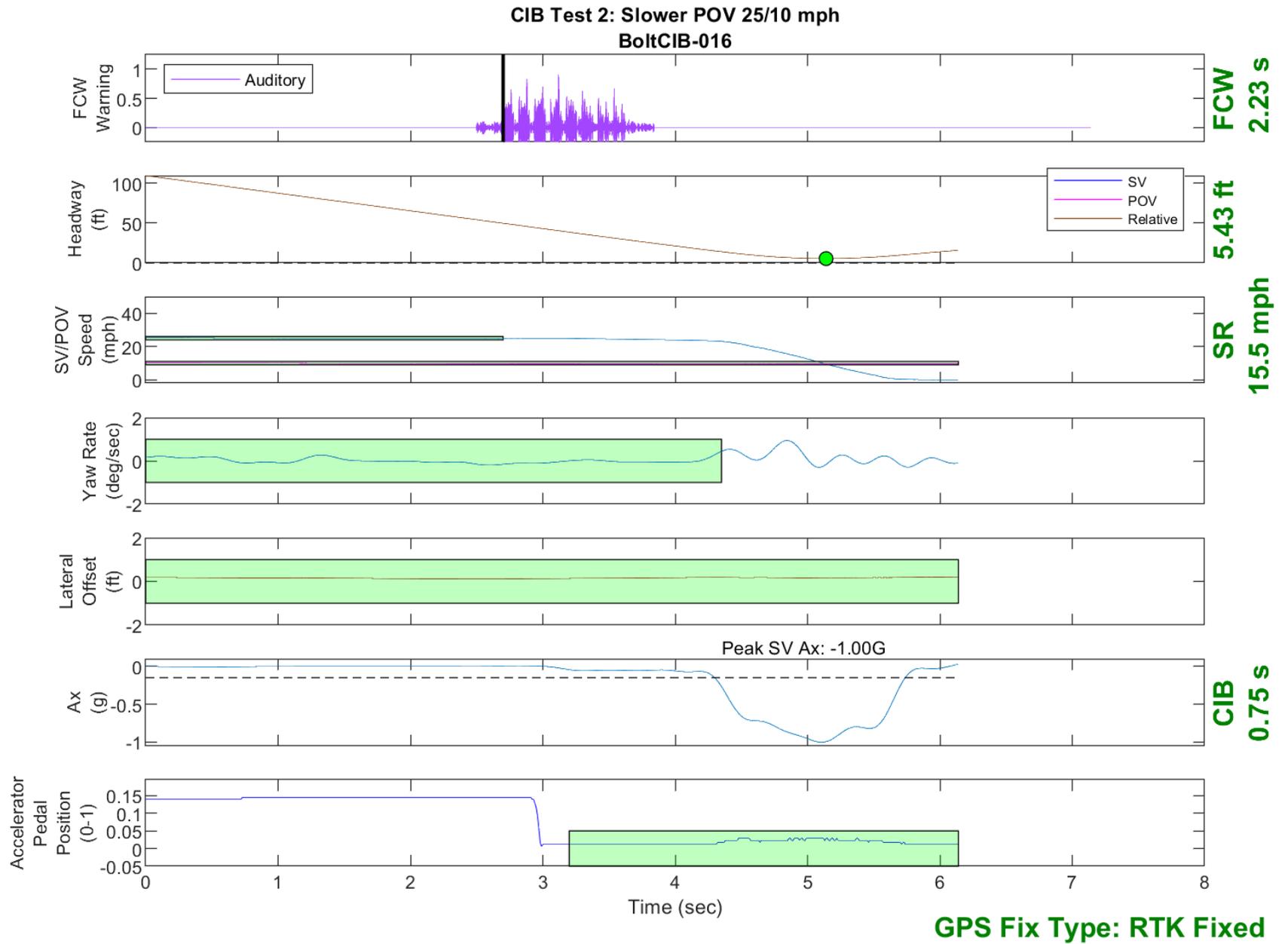


Figure D23. Time History for CIB Run 16, Test 2 - Slower Moving POV, 25/10 mph

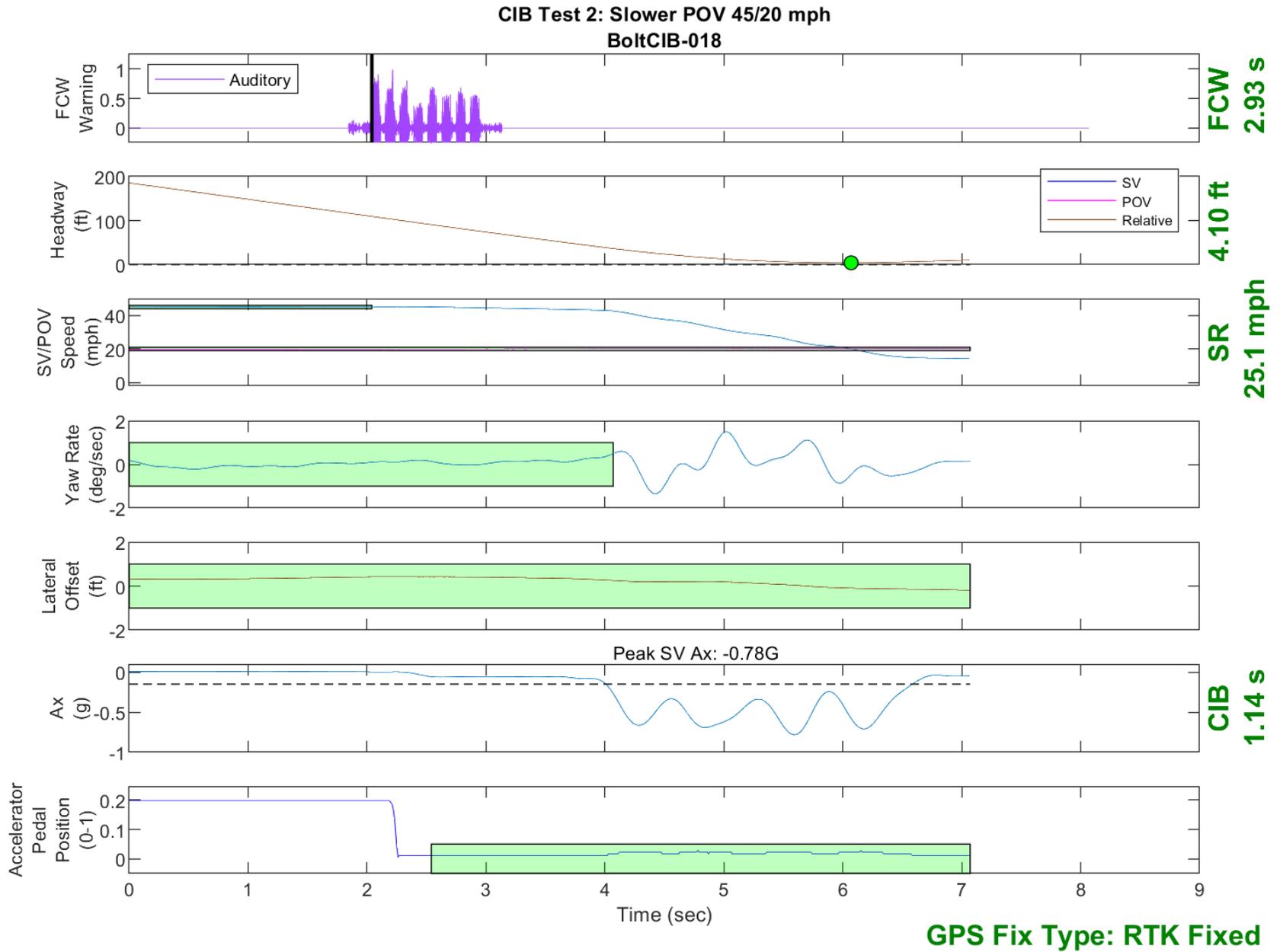


Figure D24. Time History for CIB Run 18, Test 2 - Slower Moving POV, 45/20 mph

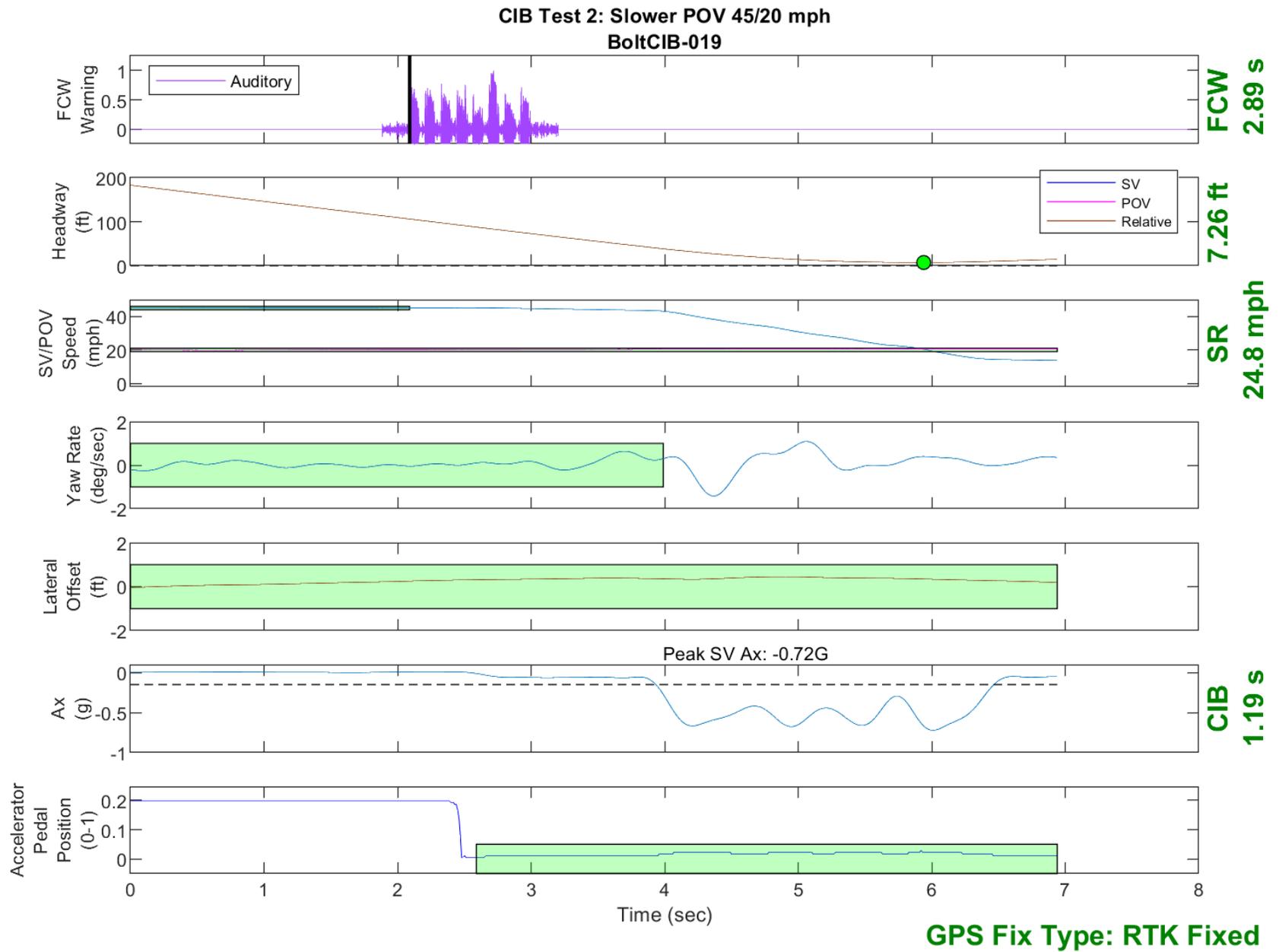


Figure D25. Time History for CIB Run 19, Test 2 - Slower Moving POV, 45/20 mph

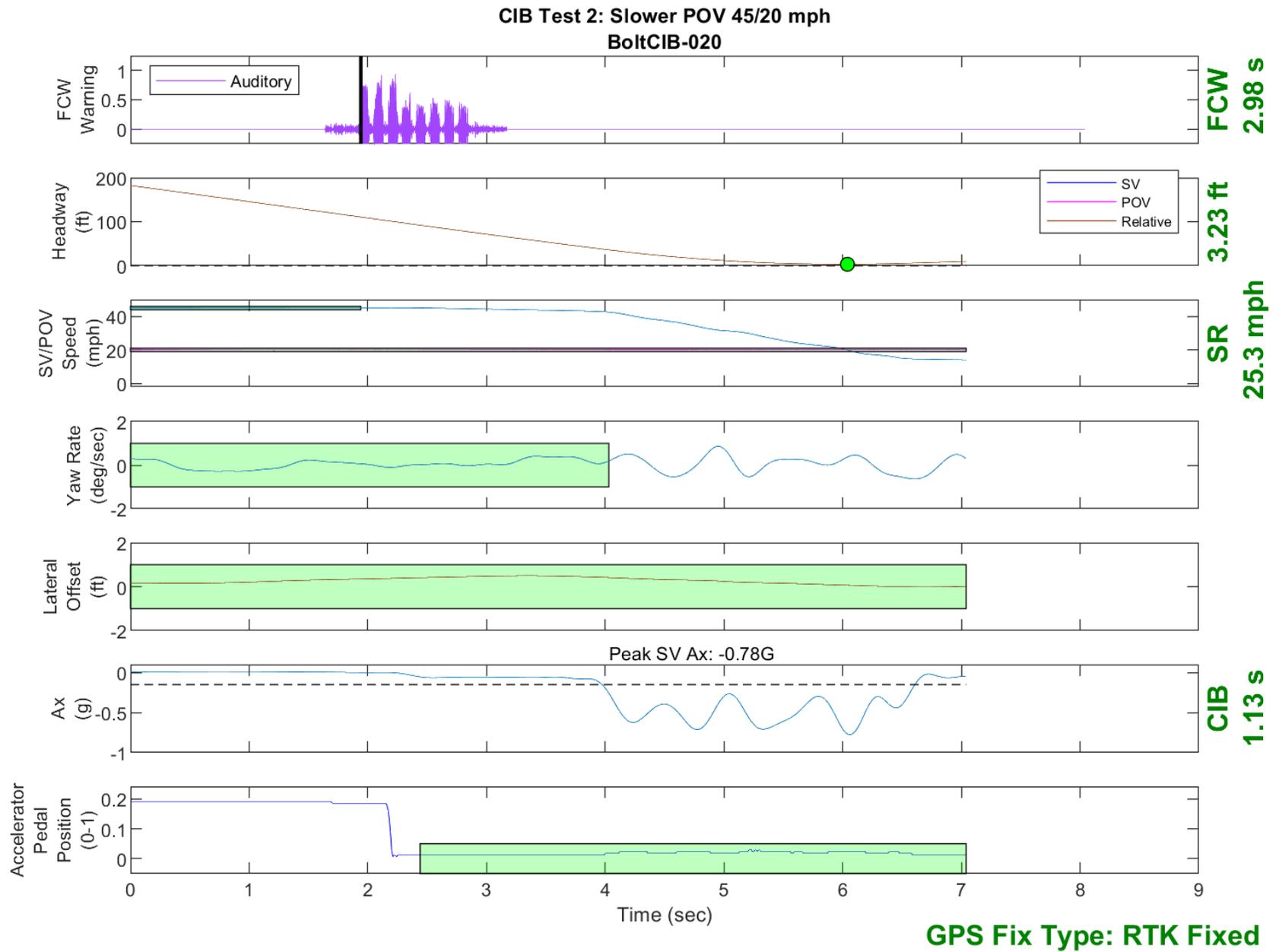


Figure D26. Time History for CIB Run 20, Test 2 - Slower Moving POV, 45/20 mph

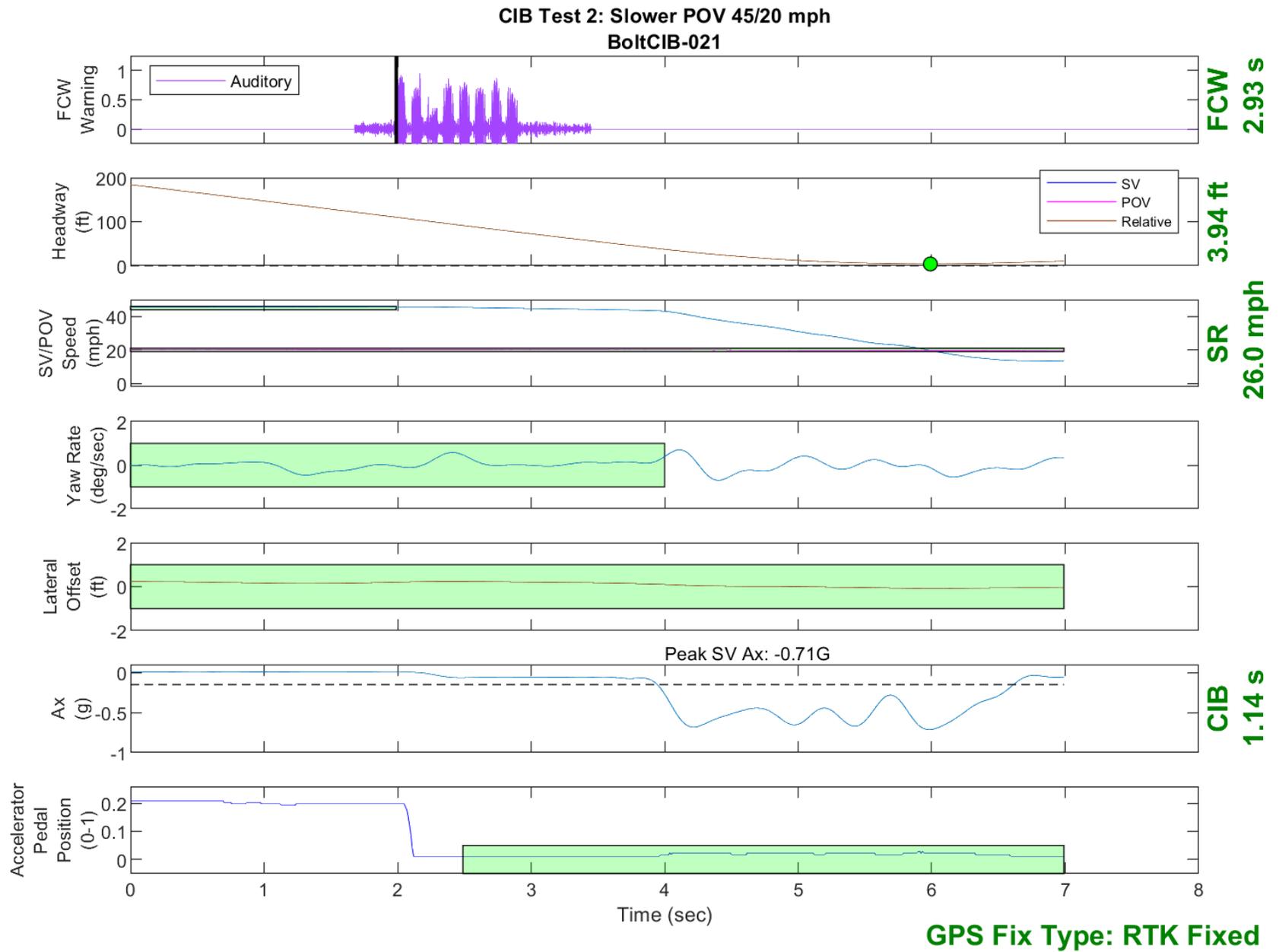


Figure D27. Time History for CIB Run 21, Test 2 - Slower Moving POV, 45/20 mph

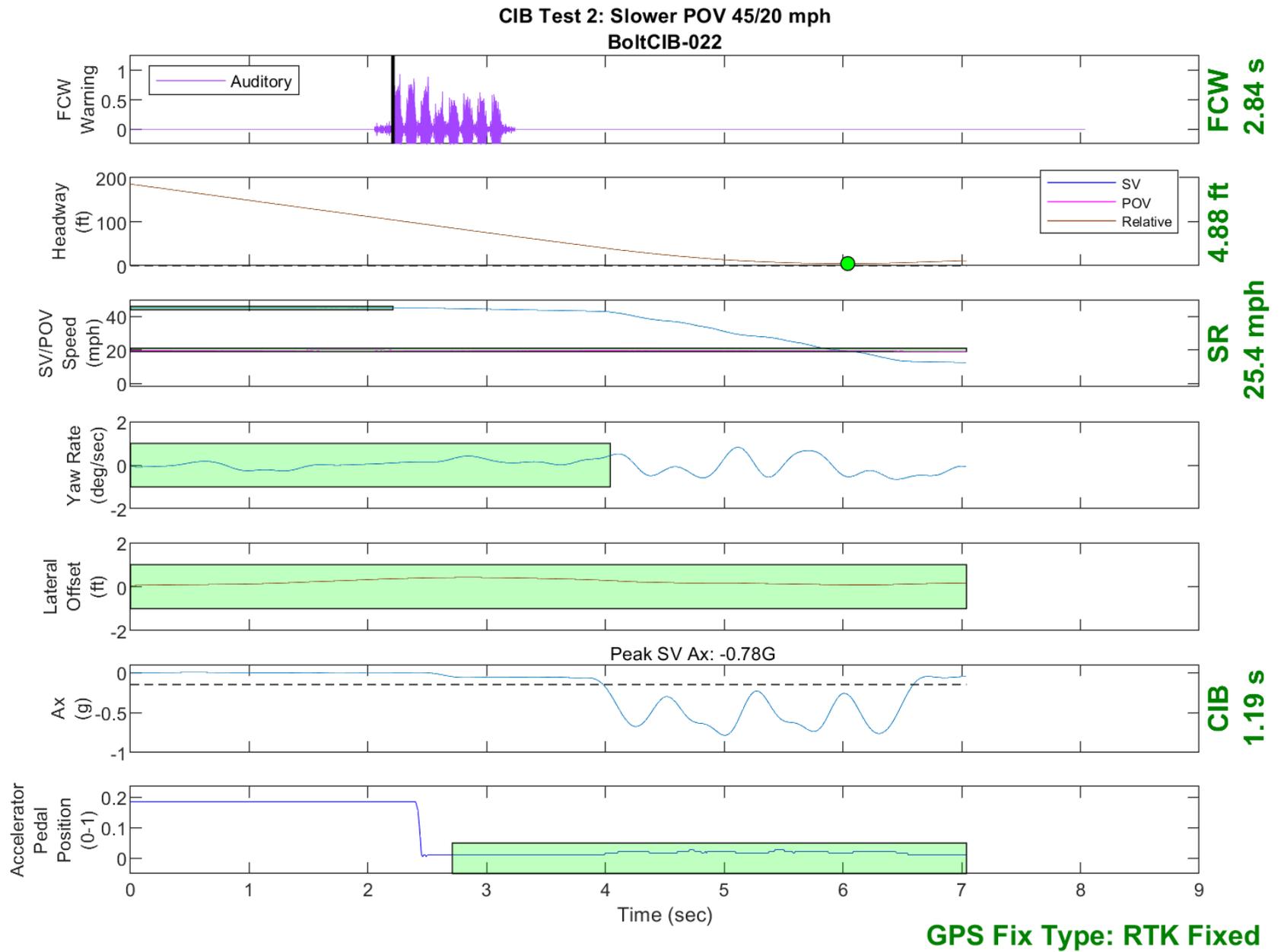


Figure D28. Time History for CIB Run 22, Test 2 - Slower Moving POV, 45/20 mph

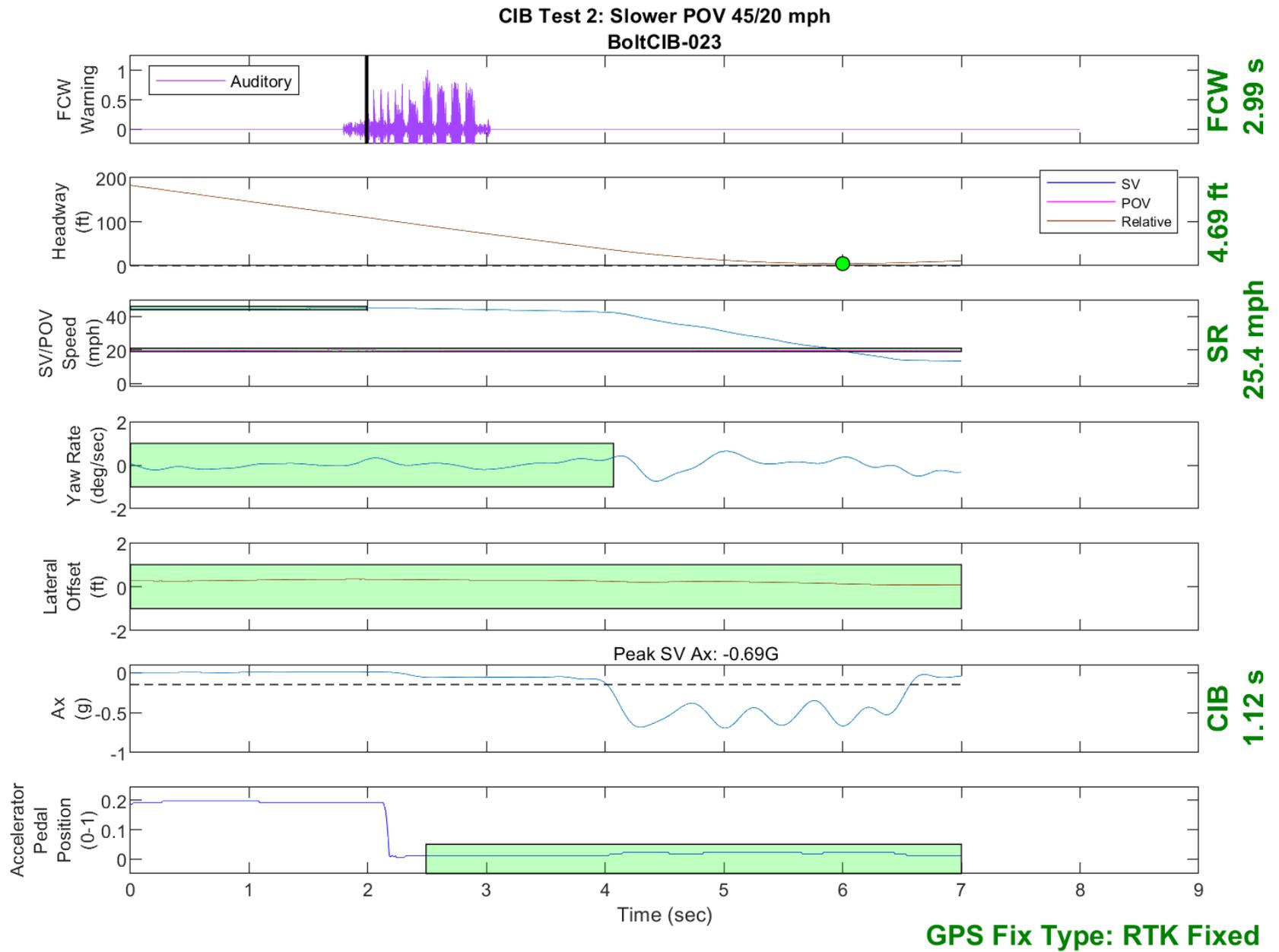


Figure D29. Time History for CIB Run 23, Test 2 - Slower Moving POV, 45/20 mph

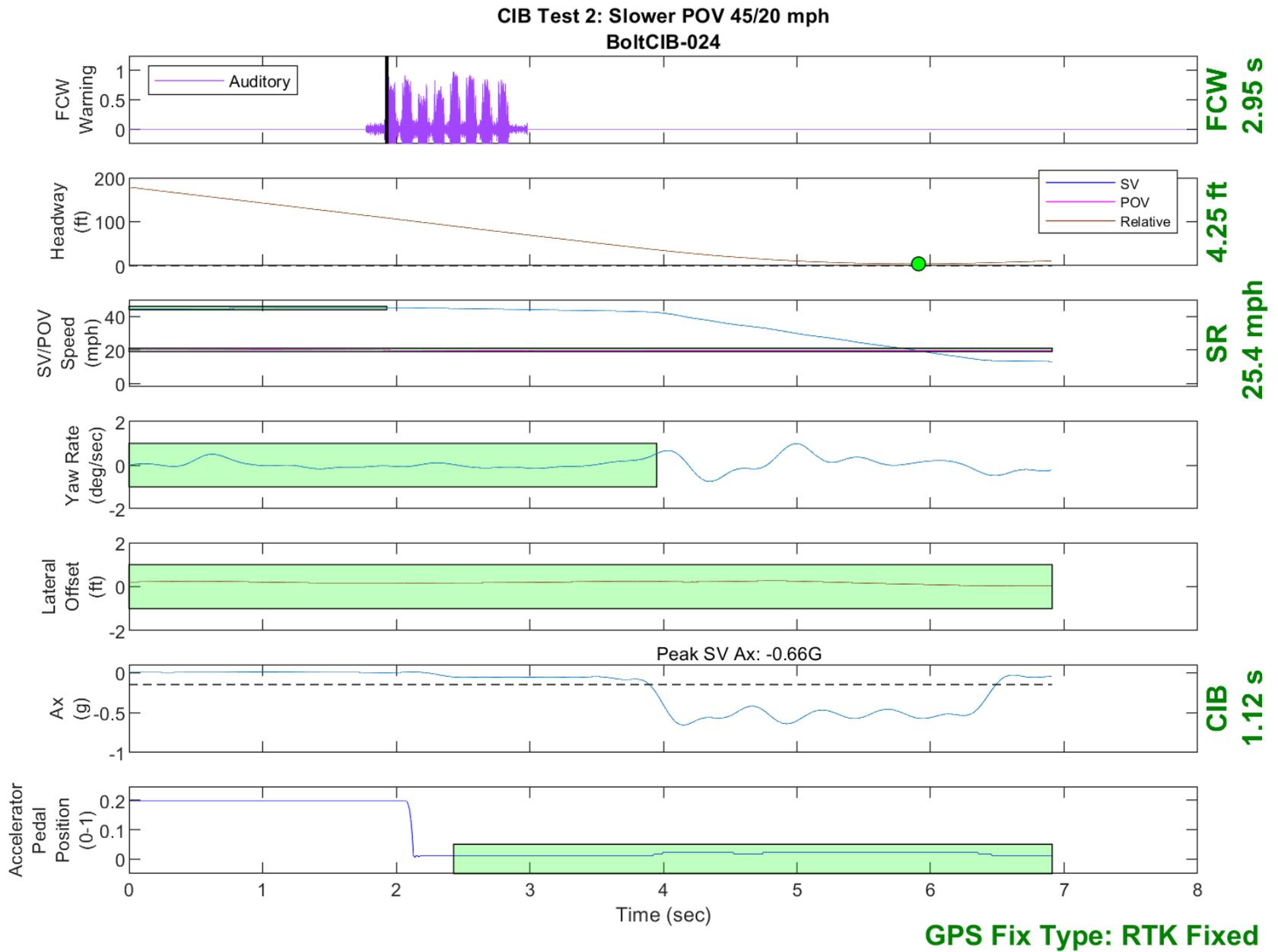


Figure D30. Time History for CIB Run 24, Test 2 - Slower Moving POV, 45/20 mph

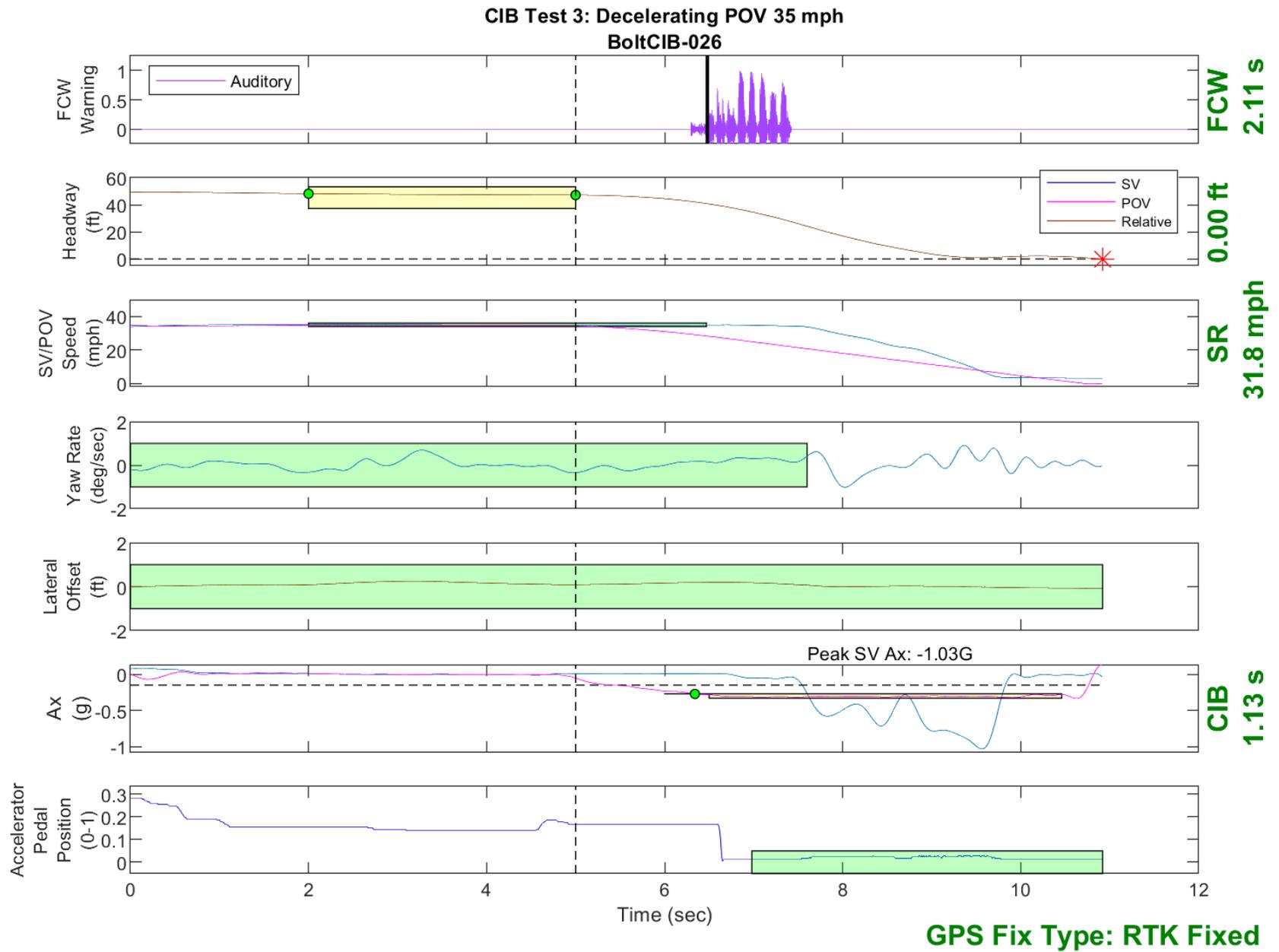


Figure D31. Time History for CIB Run 26, Test 3 - Decelerating POV 35 mph

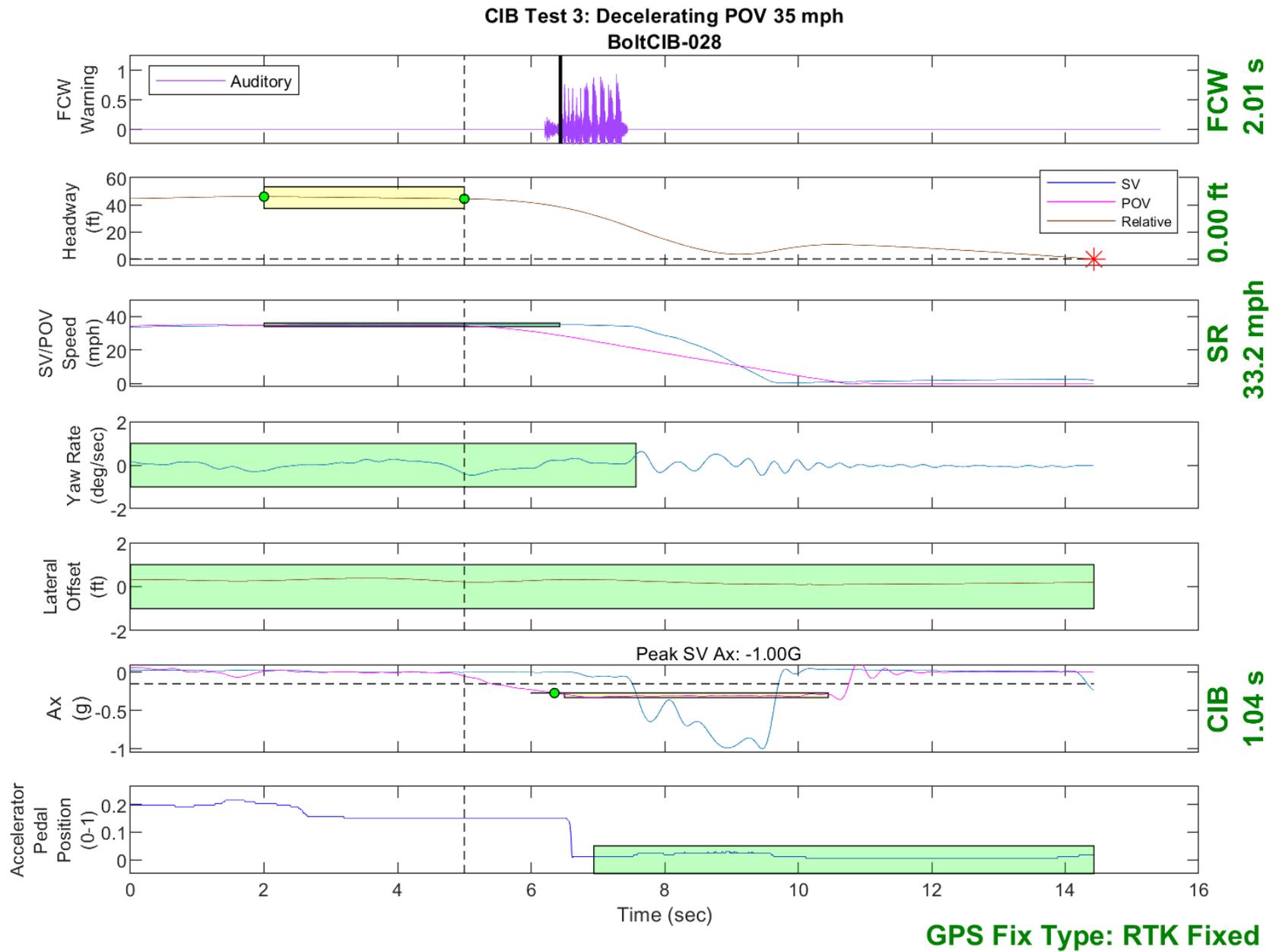


Figure D32. Time History for CIB Run 28, Test 3 - Decelerating POV 35 mph

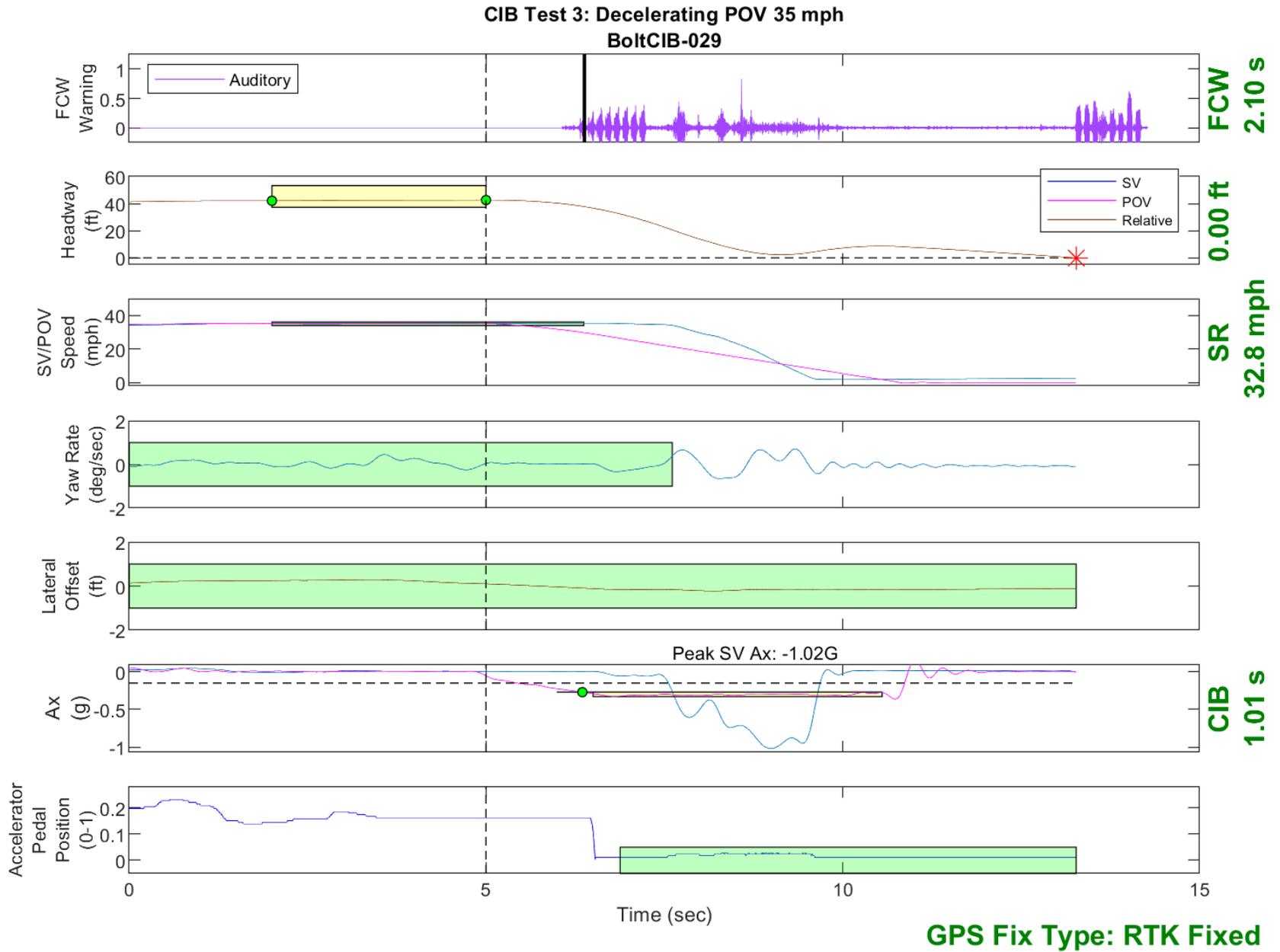


Figure D33. Time History for CIB Run 29, Test 3 - Decelerating POV 35 mph

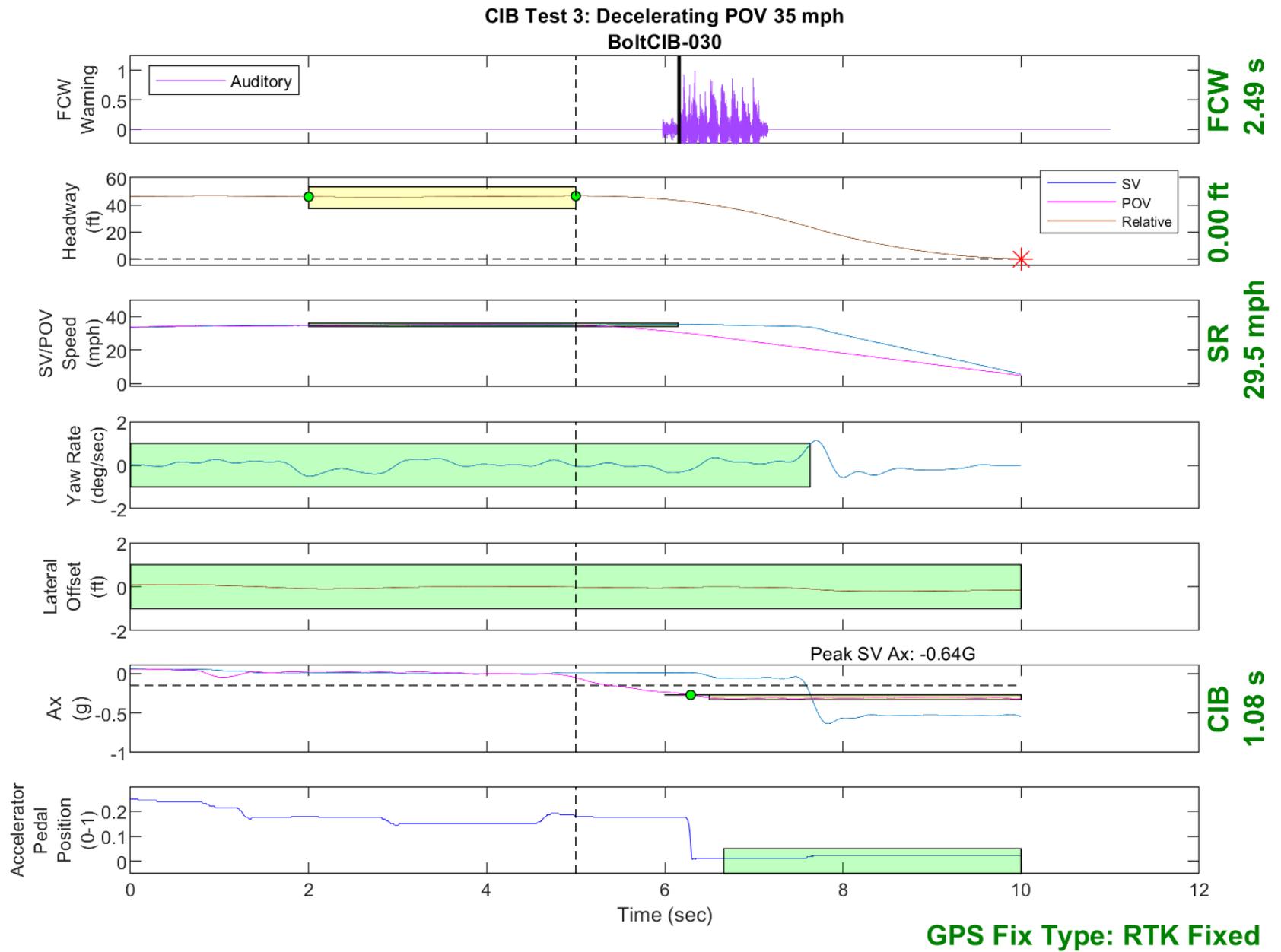


Figure D34. Time History for CIB Run 30, Test 3 - Decelerating POV 35 mph

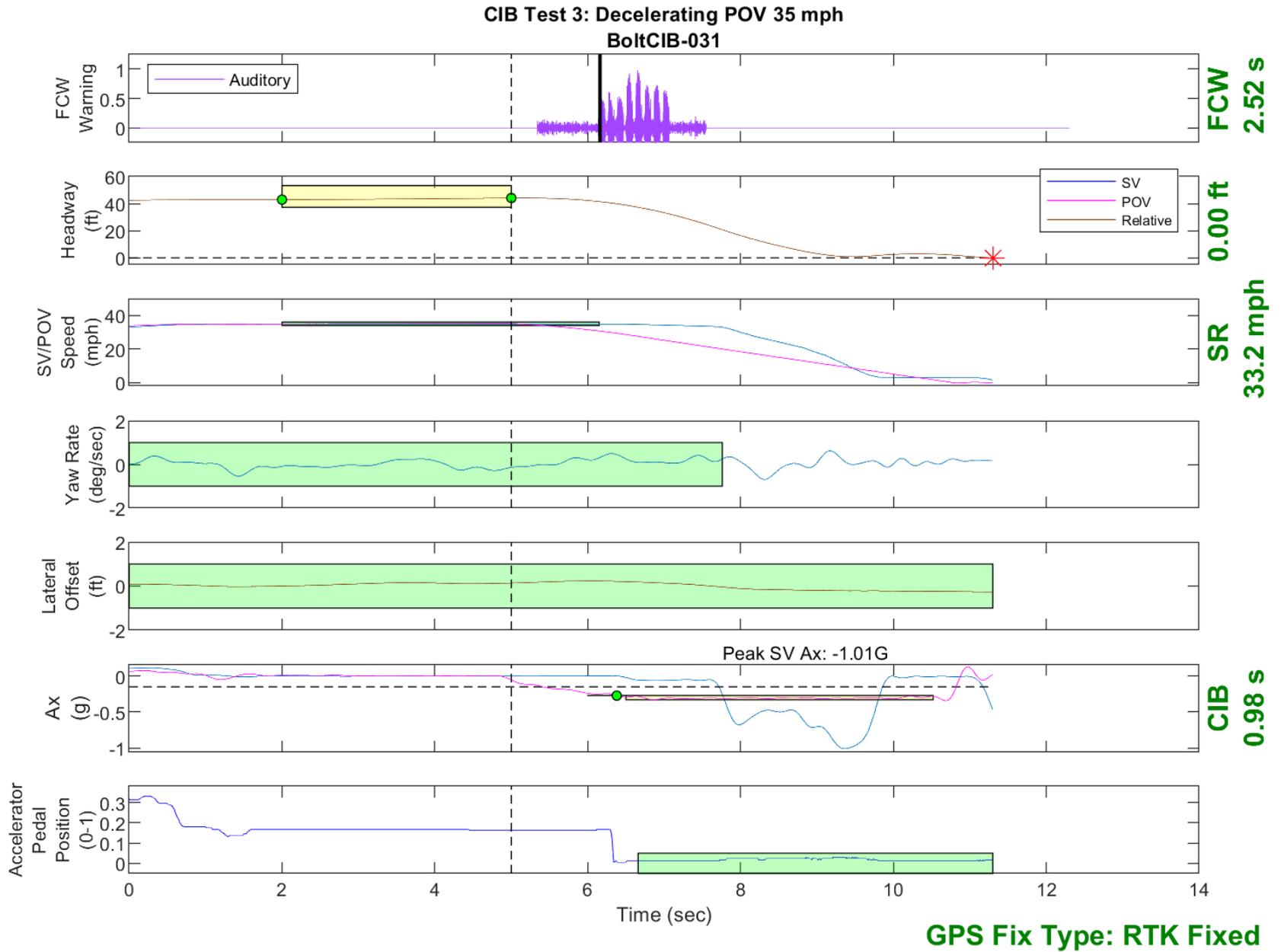


Figure D35. Time History for CIB Run 31, Test 3 - Decelerating POV 35 mph

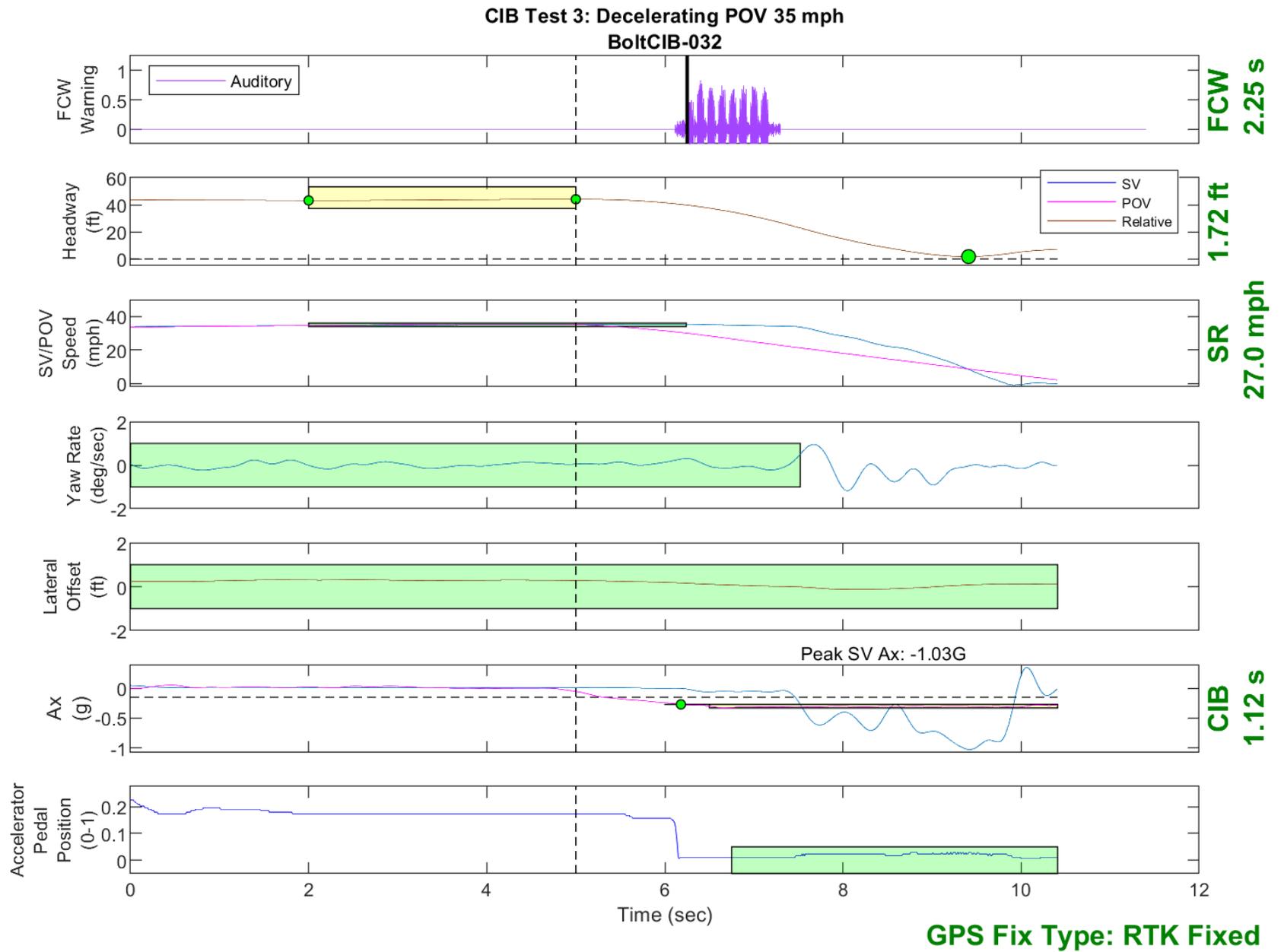


Figure D36. Time History for CIB Run 32, Test 3 - Decelerating POV 35 mph

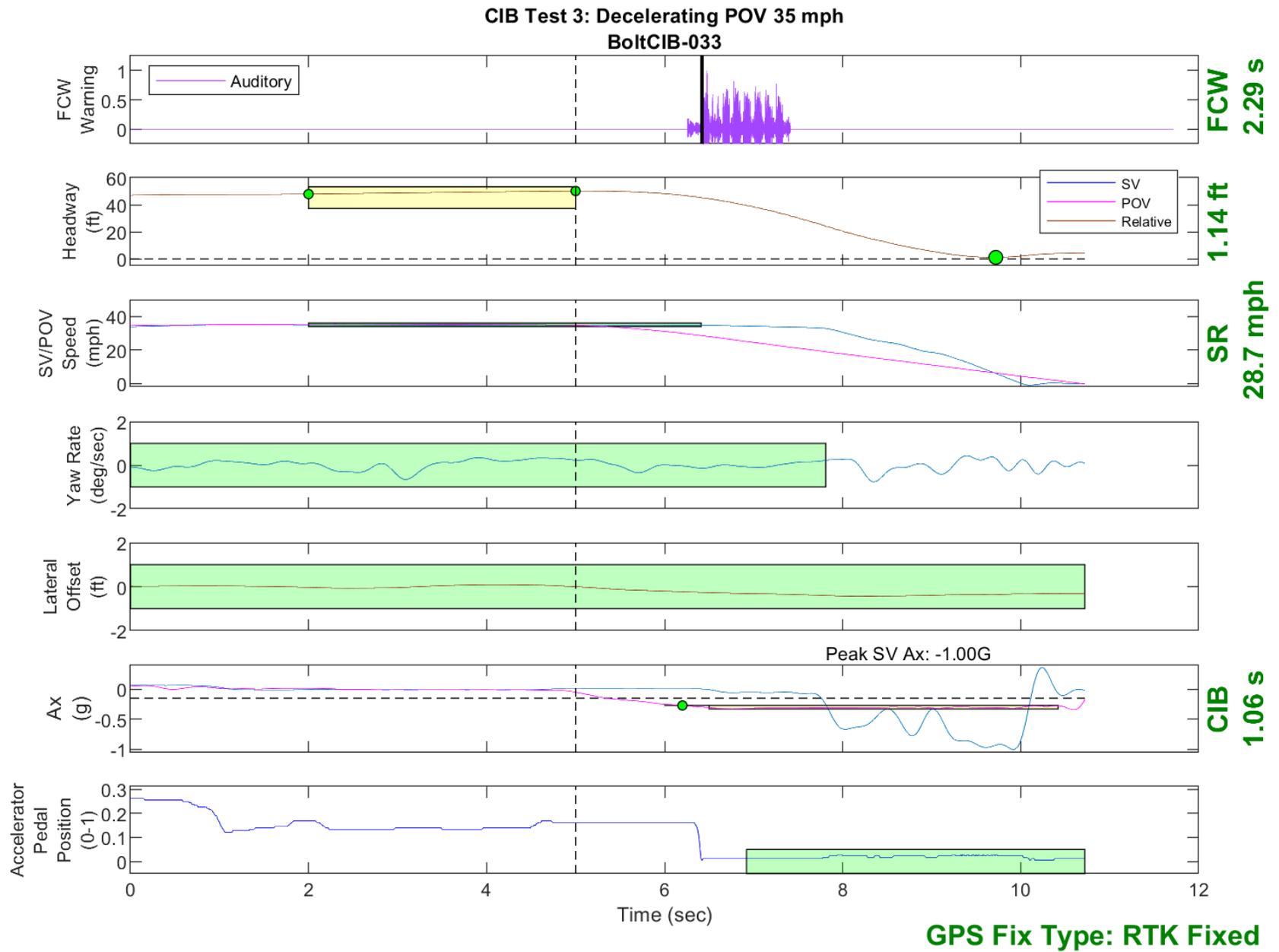


Figure D37. Time History for CIB Run 33, Test 3 - Decelerating POV 35 mph

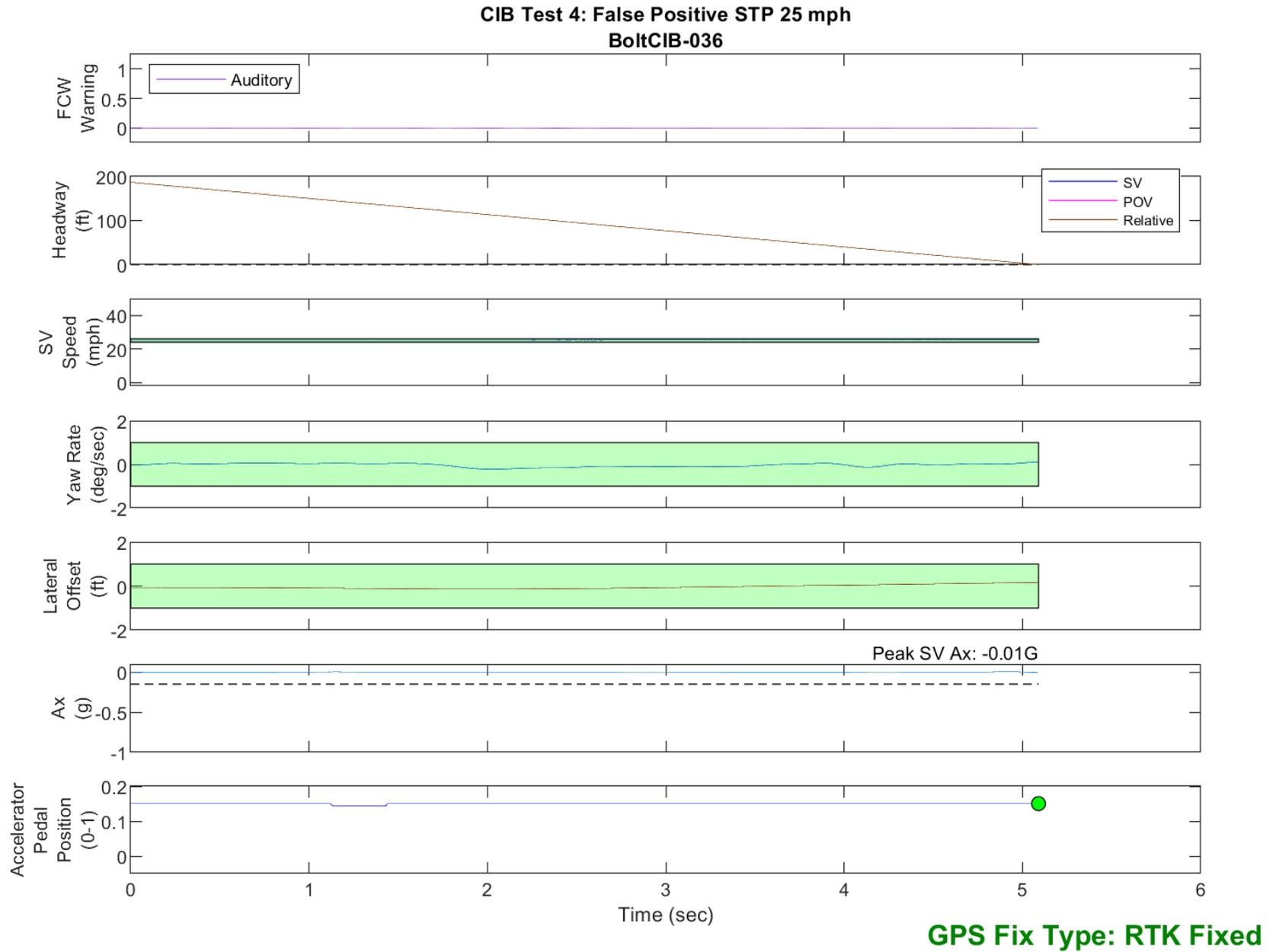


Figure D38. Time History for CIB Run 36, Test 4 - False Positive STP, 25 mph

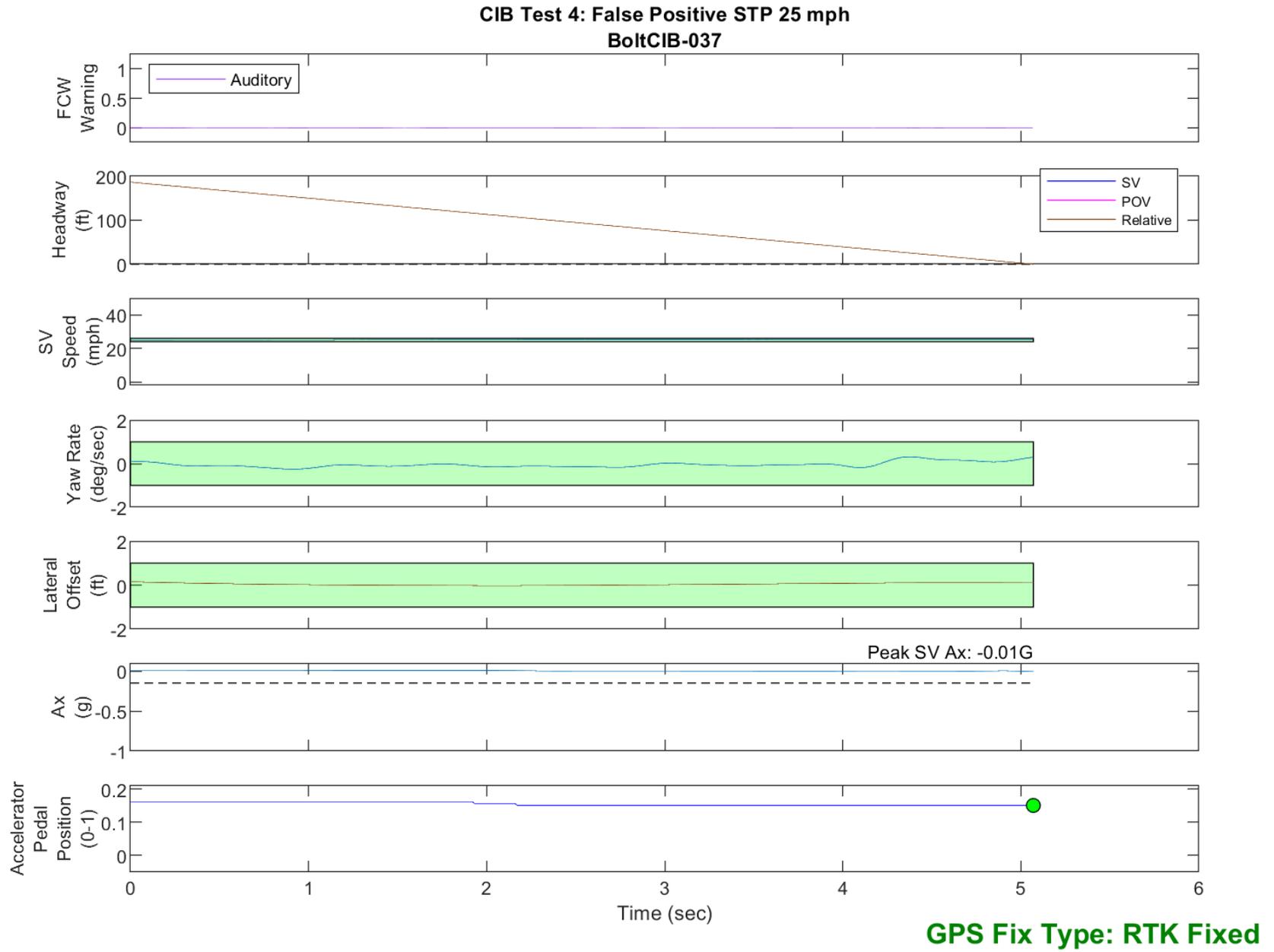


Figure D39. Time History for CIB Run 37, Test 4 - False Positive STP, 25 mph

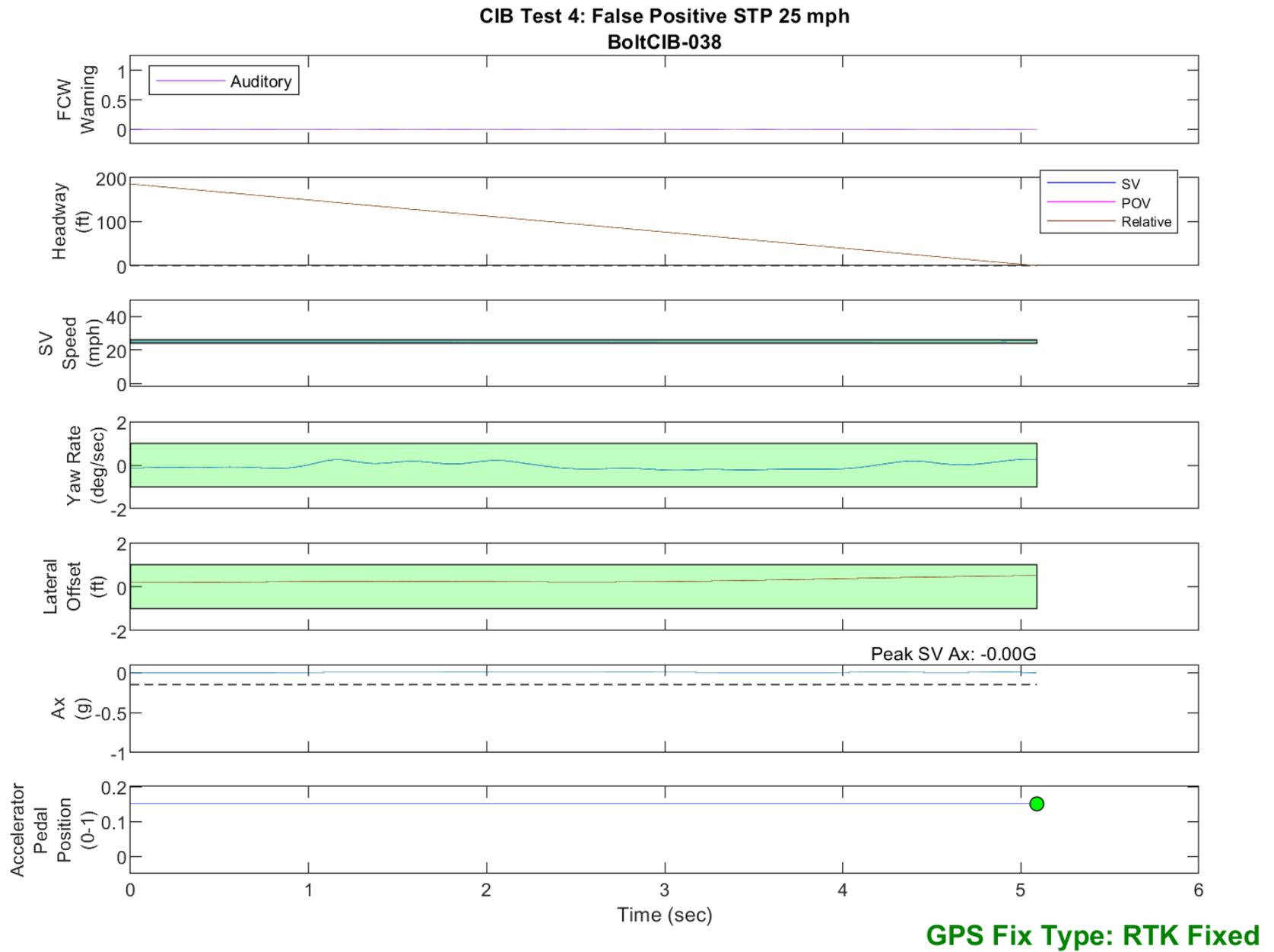


Figure D40. Time History for CIB Run 38, Test 4 - False Positive STP, 25 mph

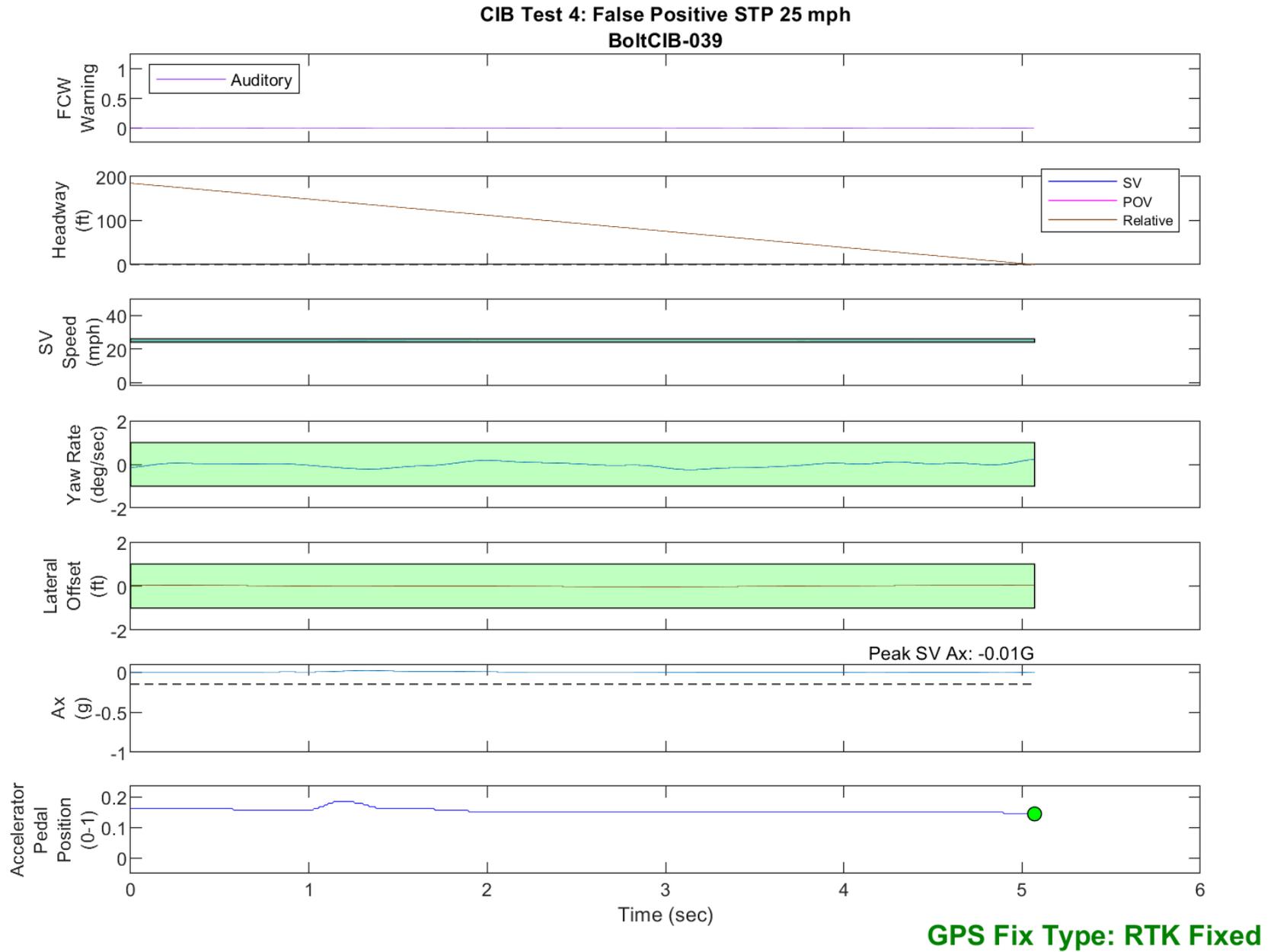


Figure D41. Time History for CIB Run 39, Test 4 - False Positive STP, 25 mph

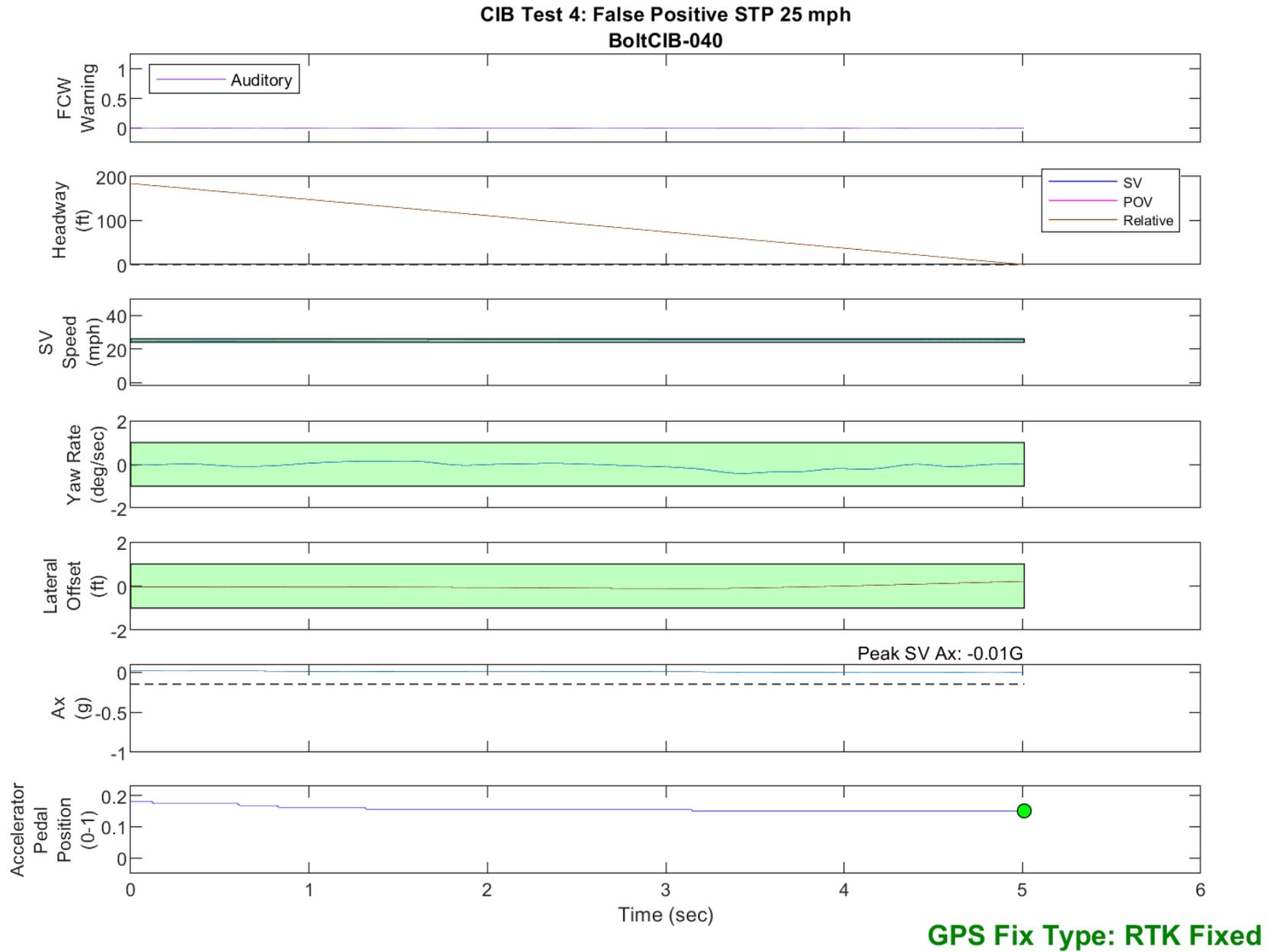


Figure D42. Time History for CIB Run 40, Test 4 - False Positive STP, 25 mph

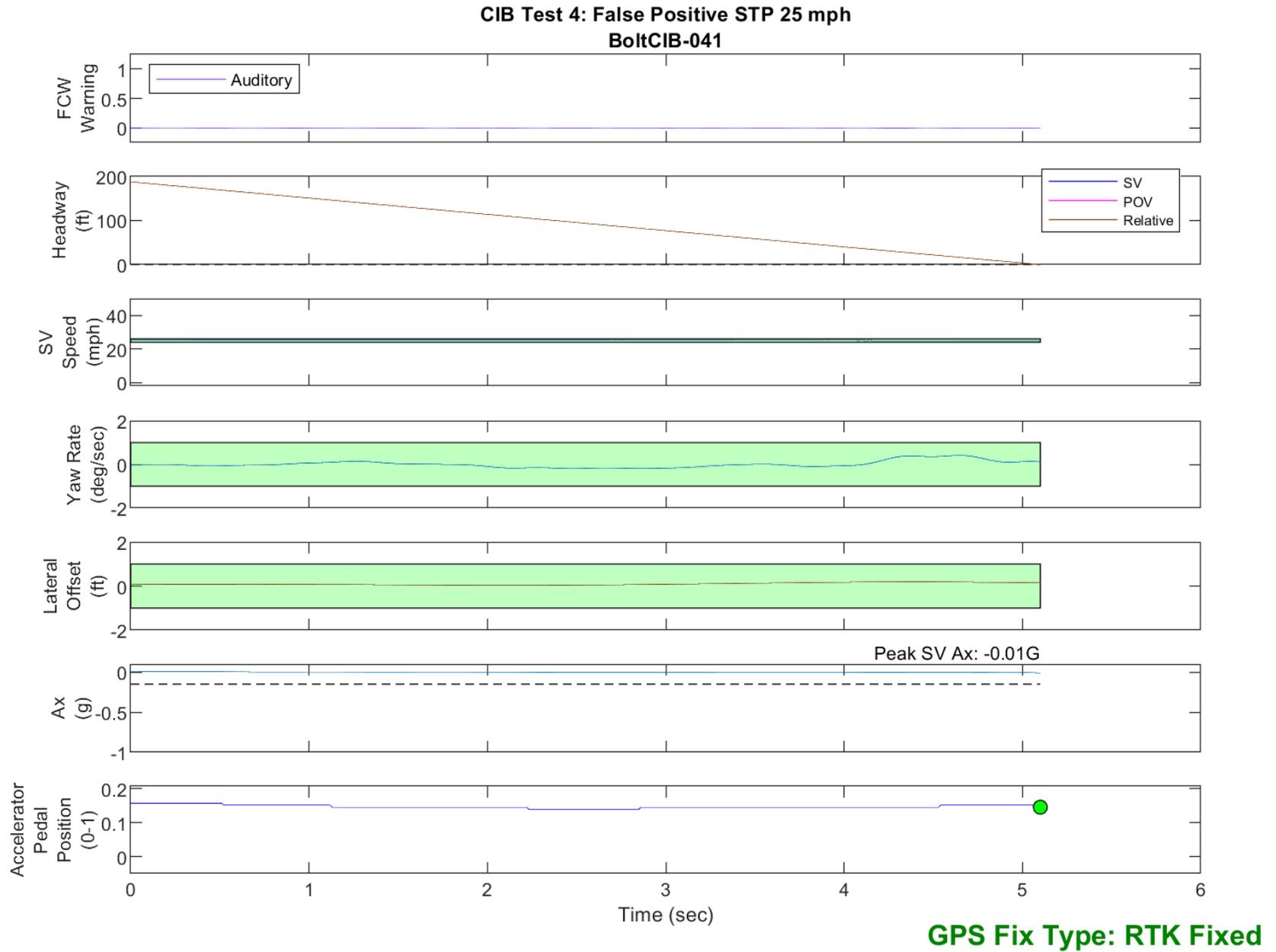


Figure D43. Time History for CIB Run 41, Test 4 - False Positive STP, 25 mph

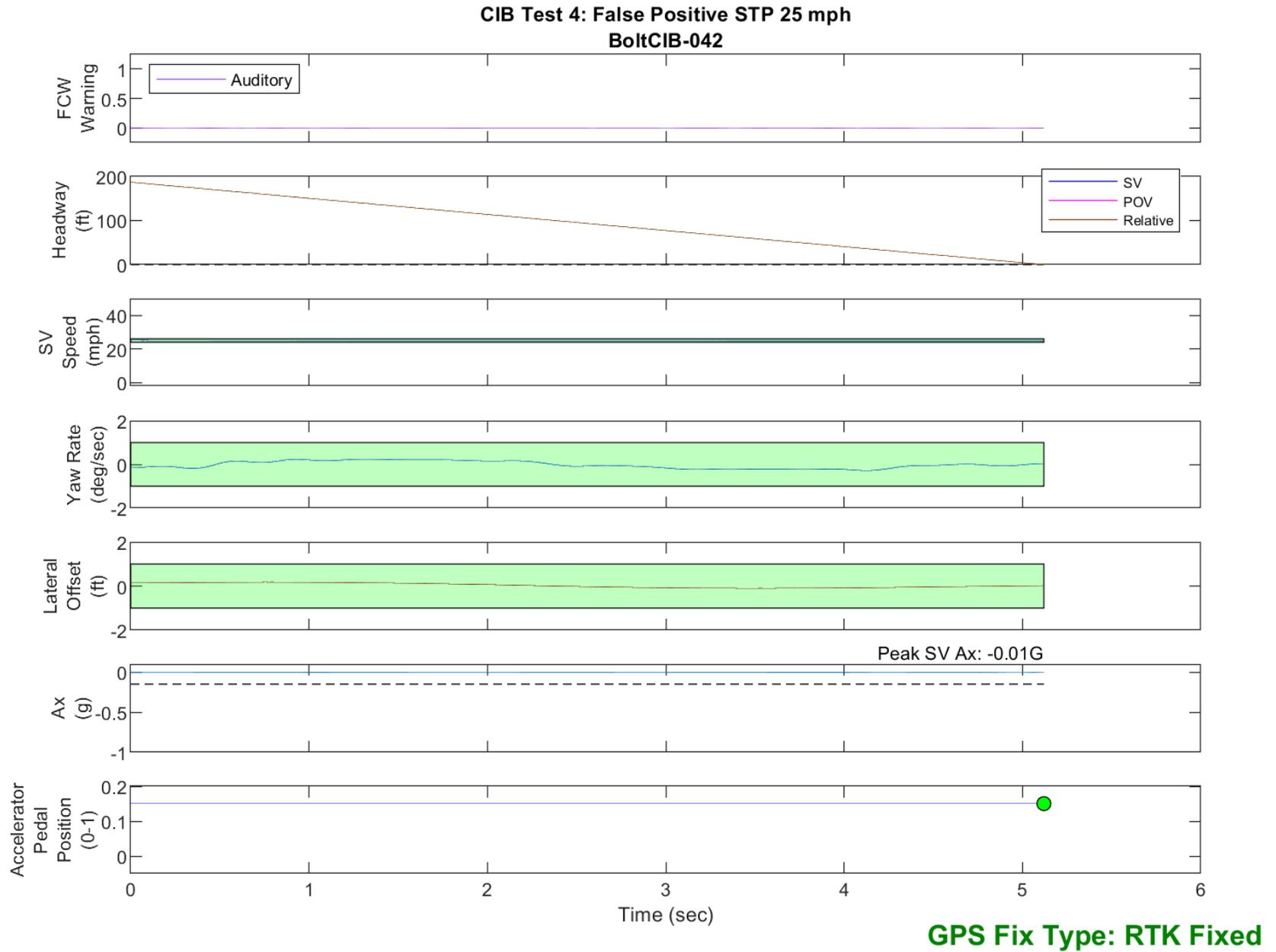


Figure D44. Time History for CIB Run 42, Test 4 - False Positive STP, 25 mph

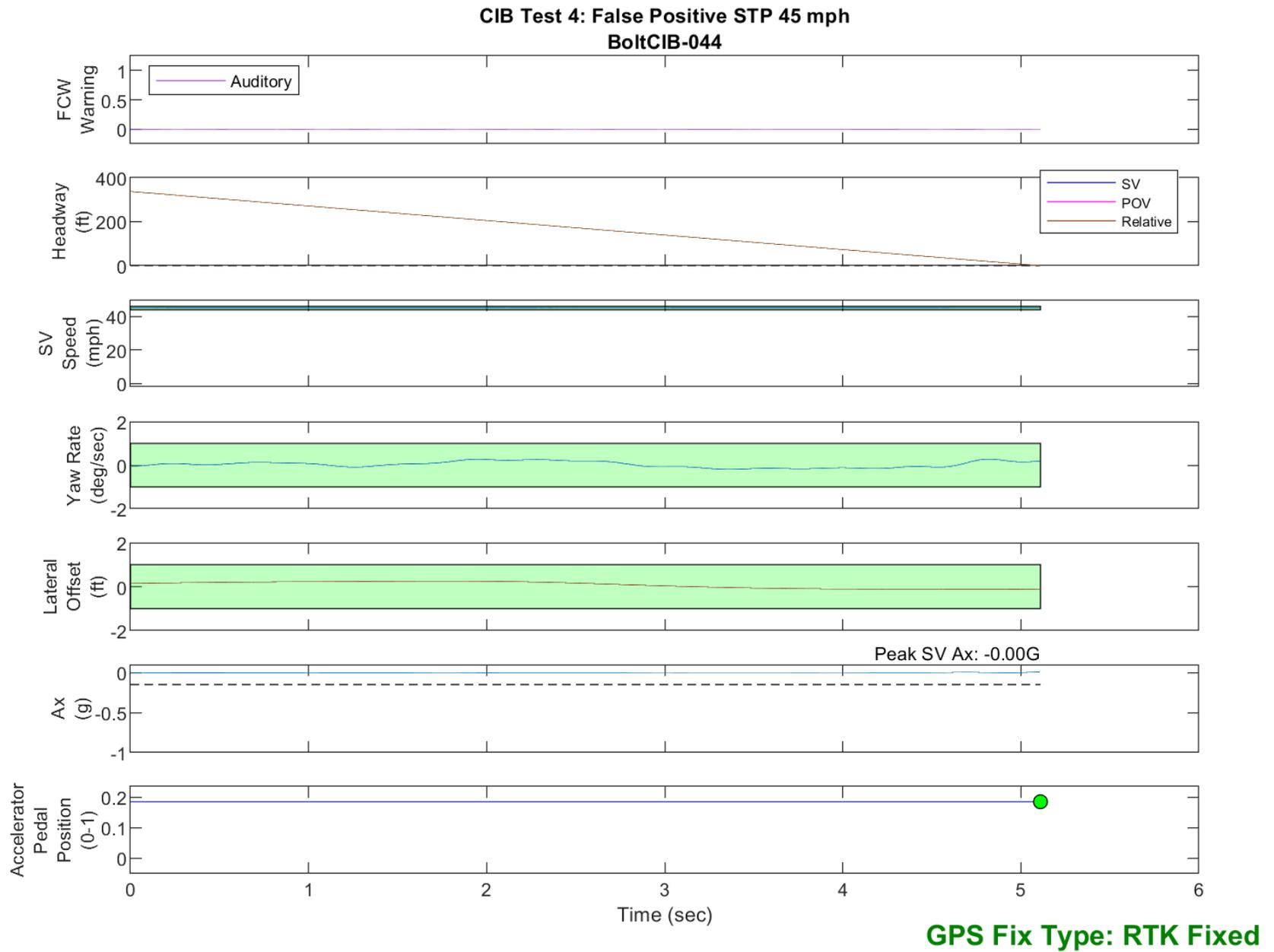


Figure D45. Time History for CIB Run 44, Test 4 - False Positive STP, 45 mph

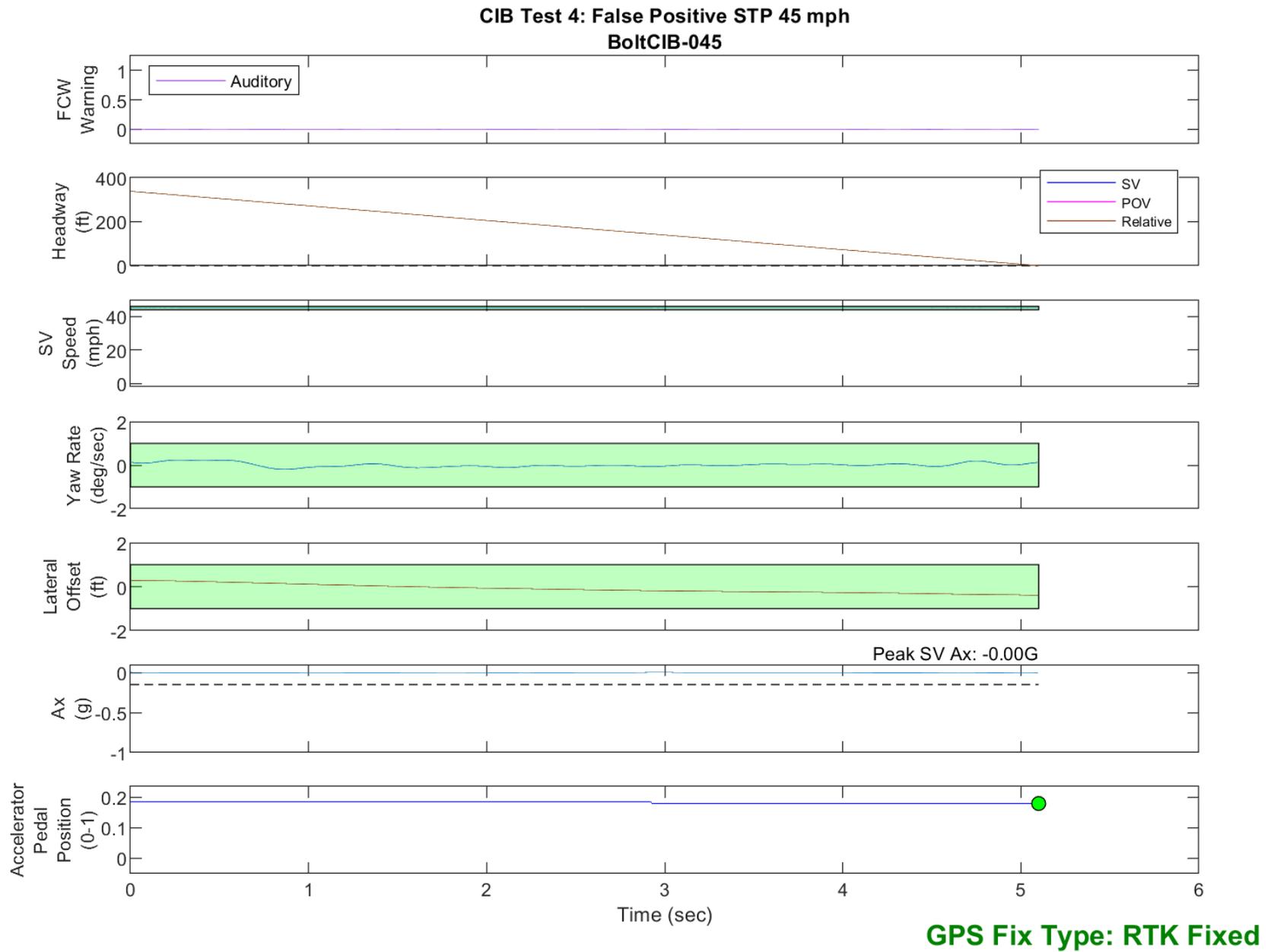


Figure D46. Time History for CIB Run 45, Test 4 - False Positive STP, 45 mph

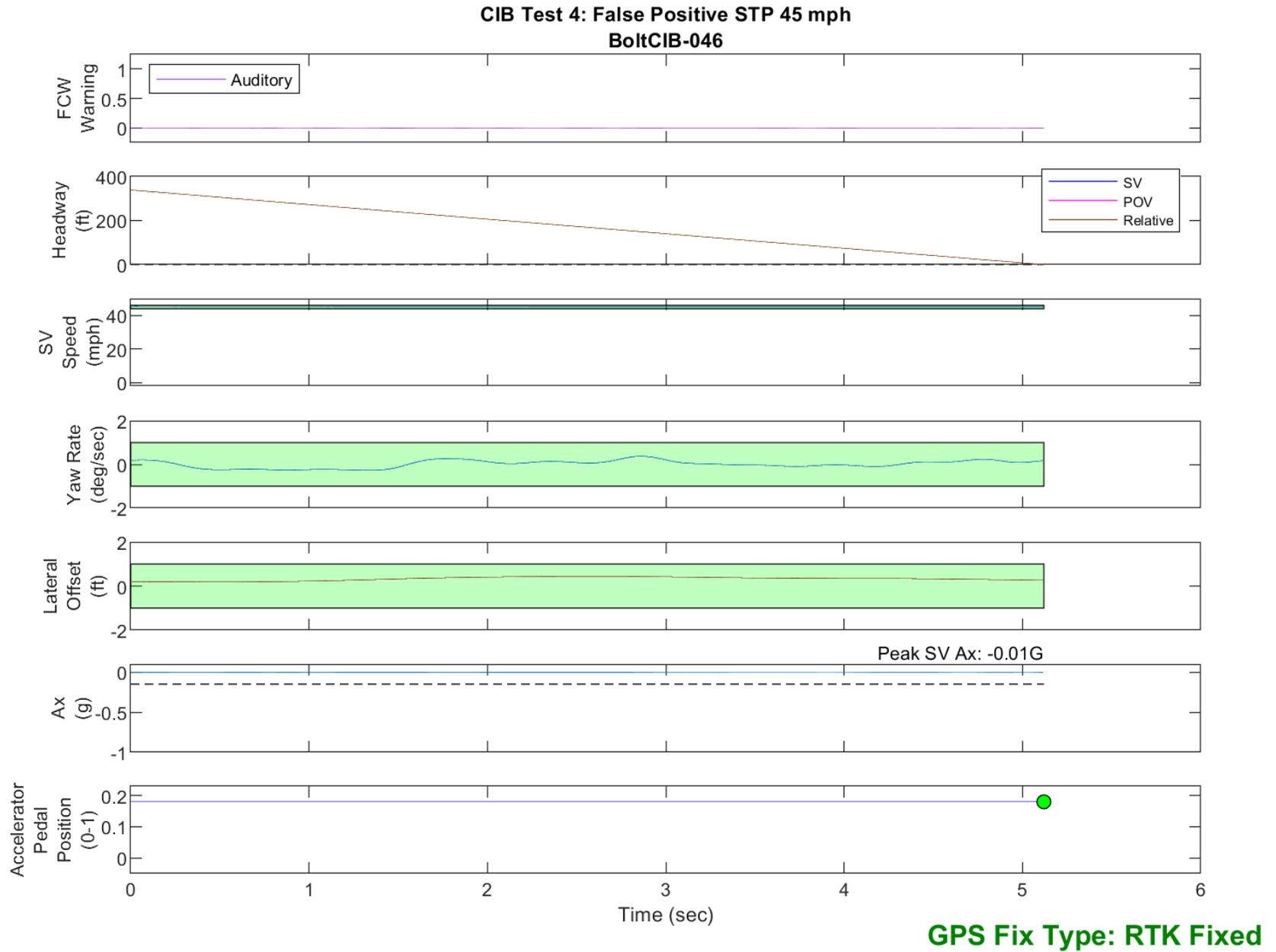


Figure D47. Time History for CIB Run 46, Test 4 - False Positive STP, 45 mph

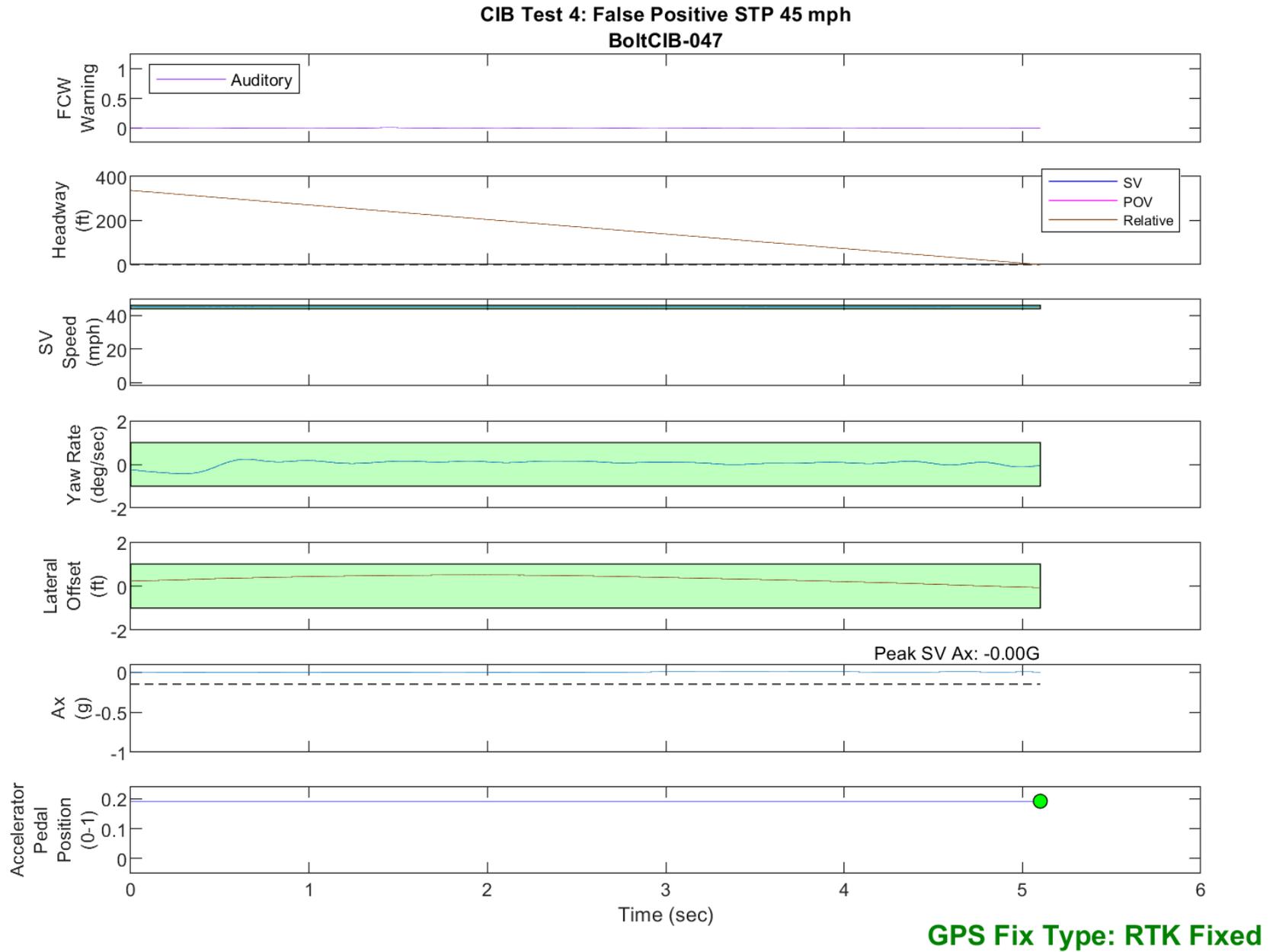


Figure D48. Time History for CIB Run 47, Test 4 - False Positive STP, 45 mph

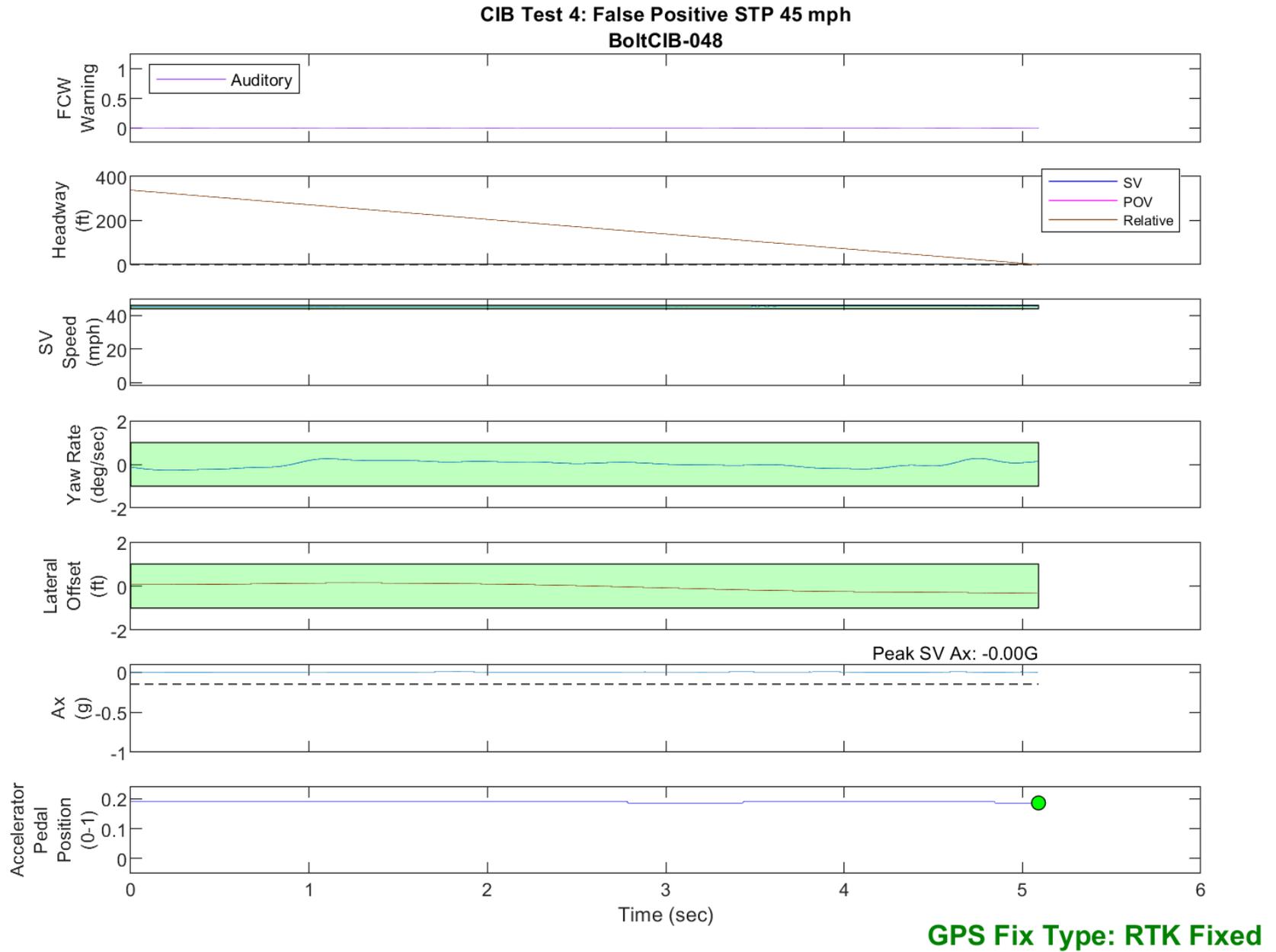


Figure D49. Time History for CIB Run 48, Test 4 - False Positive STP, 45 mph

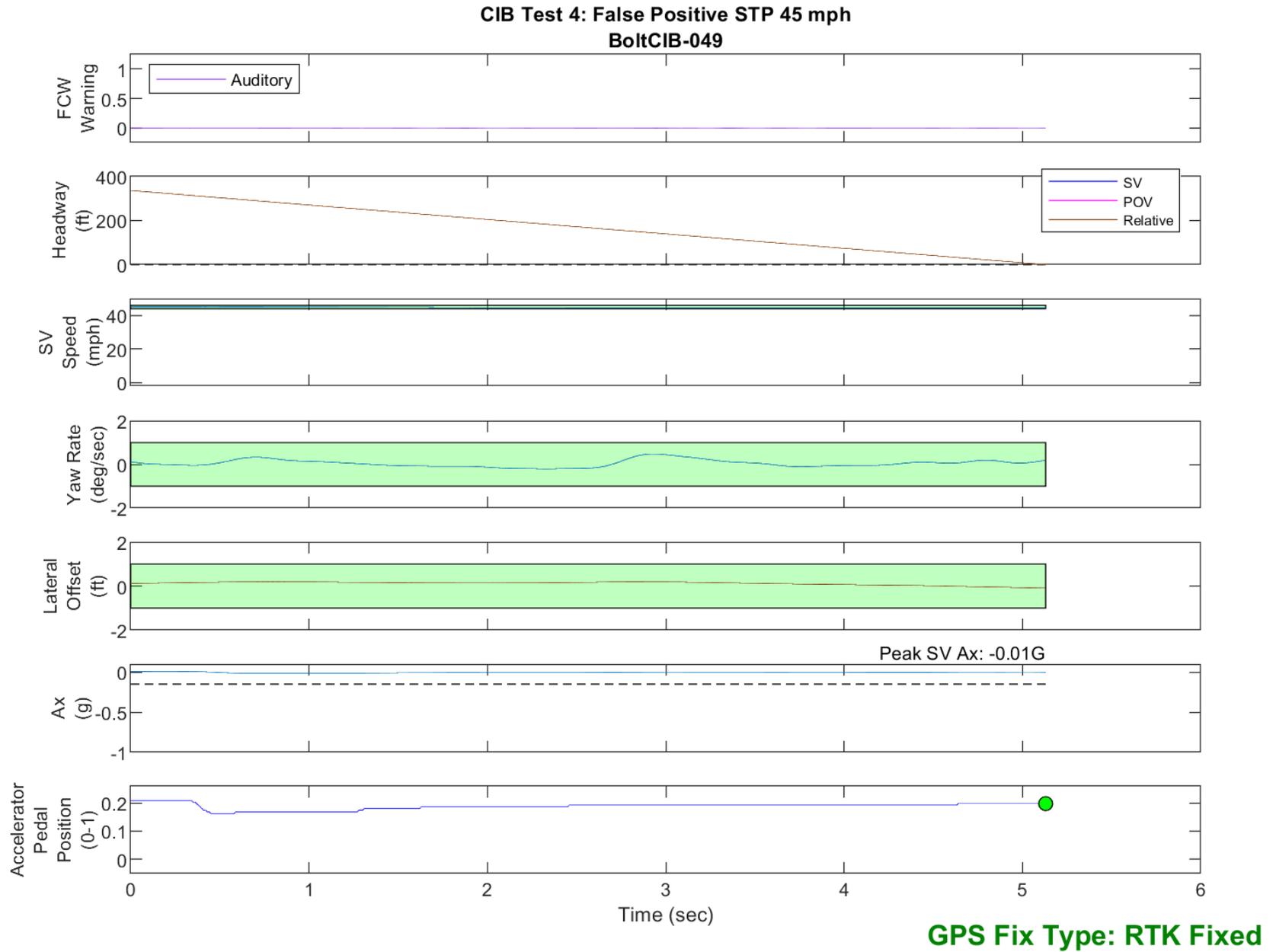


Figure D50. Time History for CIB Run 49, Test 4 - False Positive STP, 45 mph

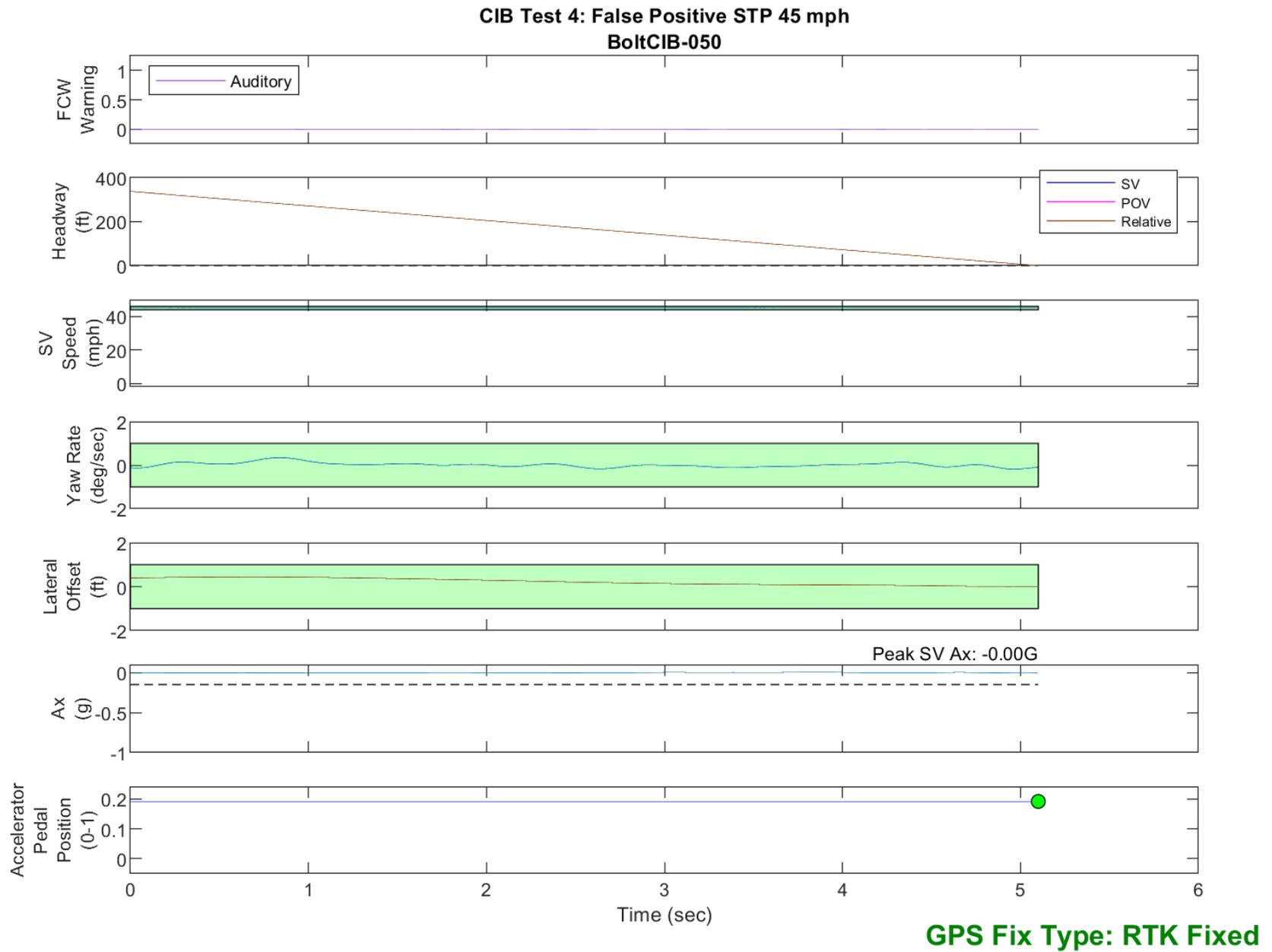


Figure D51. Time History for CIB Run 50, Test 4 - False Positive STP, 45 mph