

**NEW CAR ASSESSMENT PROGRAM  
CRASH IMMINENT BRAKING SYSTEM CONFIRMATION TEST  
NCAP-DRI-CIB-22-08**

**2022 Hyundai Santa Cruz AWD**

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**2 May 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 Hyundai Santa Cruz AWD in accordance with the specifications of the New Car Assessment Program'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 Hyundai Santa Cruz AWD. 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 Hyundai Santa Cruz AWD

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VIN: 5NTJEDAF4NH01xxxx

Test start date: 4/26/2022

Test end date: 4/27/2022

Crash Imminent Braking System setting: Standard

**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 Hyundai Santa Cruz AWD

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**TEST VEHICLE INFORMATION**

VIN: 5NTJEDAF4NH01xxxx

Body Style: Truck

Color: Phantom Black

Date Received: 4/15/2022

Odometer Reading: 51 mi

**DATA FROM VEHICLE'S CERTIFICATON LABEL**

Vehicle manufactured by: HYUNDAI MOTOR MANUFACTURING ALABAMA, LLC

Date of manufacture: Dec/23/21

Vehicle Type: Truck

**DATA FROM TIRE PLACARD**

Tires size as stated on Tire Placard: Front: 245/50R20

Rear: 245/50R20

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

Rear: 240 kPa (35 psi)

**TIRES**

Tire manufacturer and model: Michelin Primacy LTX

Front tire designation: 245/50R20 102V

Rear tire designation: 245/50R20 102V

Front tire DOT prefix: DOT 1AP JD 00TX

Rear tire DOT prefix: DOT 1AP JD 00TX

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

(Page 1 of 2)

2022 Hyundai Santa Cruz AWD

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**GENERAL INFORMATION**

Test start date: 4/26/2022

Test end date: 4/27/2022

**AMBIENT CONDITIONS**

Air temperature: 25.6 C (78 F)

Wind speed: 1.0 m/s (2.3 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: 240 kPa (35 psi)

Rear: 240 kPa (35 psi)

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

(Page 2 of 2)

2022 Hyundai Santa Cruz AWD

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**WEIGHT**

Weight of vehicle as tested including driver and instrumentation

Left Front: 585.1 kg (1290 lb)

Right Front: 551.1 kg (1215 lb)

Left Rear: 438.2 kg (966 lb)

Right Rear: 421.8 kg (930 lb)

Total: 1996.2 kg (4401 lb)

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

(Page 1 of 3)

2022 Hyundai Santa Cruz AWD

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

Forward Collision-Avoidance Assist (FCA)

Type and location of sensors the system uses:

Front radar located in the lower grille and front view camera located in the upper center windshield.

System setting used for test (if applicable):

Standard

Over what speed range is the system operational?

The AEB system is operational between 10-75 km/h (6-112 mph) 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.

In general, FCA does not deactivate due to repeated FCA activations or impacts. However, if the brake actuator or radar/camera sensors are damaged or have problems due to repeated FCA activations or impacts, FCA can deactivate.

**CRASH IMMINENT BRAKING**

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

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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 two-stage visual and auditory alert. The visual alert is displayed in the multi-information display located in the center of the instrument panel. The first stage consists of an image of two vehicles between lane lines with the words "Collision Warning" and the words change to "Emergency Braking" in the second stage. The auditory alert consists of repeated beeps for the first stage, and then a continuous beep for the second stage. The primary frequency for both alerts is approximately 1000 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 on the center dash. The procedure is as follows:

1. Select "Setup" to bring up the setup menu.
2. Select "Vehicle" -> "Driver Assistance" -> "Forward Safety".
3. Select between "Active Assist", "Warning Only", and "Off" to turn the AEB system on/off.

When the AEB system is turned off, the FCA off 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**

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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 range setting can be adjusted using the touch screen display on the center dash. The procedure is as follows:

1. Select "Setup" to bring up the setup menu.
2. Select "Vehicle" -> "Driver Assistance" -> "Warning Timing".
3. Select between "Standard" and "Late".

The warning timing setting is retained when the engine switch is turned off.

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 7-21 to 7-29 shown in Appendix B pages B-9 to B-17.

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.

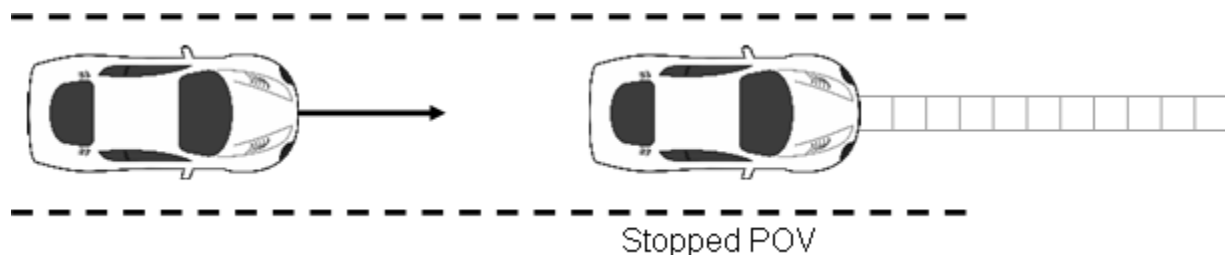


Figure 1. Depiction of Test 1

##### 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.

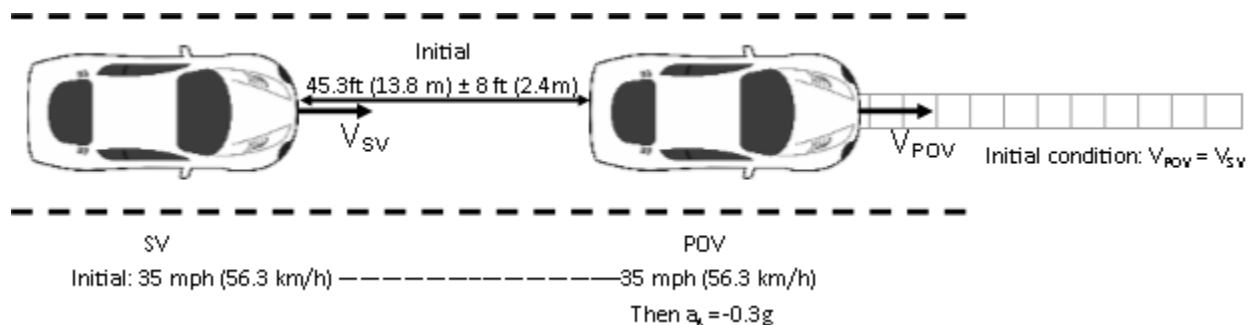


Figure 3. Depiction of Test 3

#### 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.

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 (SV-to-POV contact was assessed by using GPS-based range data or by measurement of direct contact sensor output); or
- The SV came to a stop before making contact with the POV.

Tests 2 and 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	K3161858	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
					2176	Date: 6/26/2020 Due: 6/26/2022
					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: ±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
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)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	N/A	N/A
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2022 Due: 1/6/2023
Type	Description			Mfr, Model	Serial Number	
Data Acquisition System	Data acquisition is achieved using a dSPACE MicroAutoBox II. Data from the Oxford IMU, including Longitudinal, Lateral, and Vertical Acceleration, Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle are sent over Ethernet to the MicroAutoBox. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (listed above).			dSPACE Micro-Autobox II 1401/1513		
				Base Board		549068
				I/O Board		588523

## APPENDIX A

### Photographs

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Figure A1. Front View of Subject Vehicle





Figure A2. Rear View of Subject Vehicle





# 2022 SANTA CRUZ LIMITED AWD

SOLD TO: CA275 SHIPPED TO: CA275

VIN: 5NTJEDAF4NH01  
 MODEL: 90472AT5  
 ENGINE: G4KPMK103651  
 PORT OF ENTRY: MA  
 EXTERIOR COLOR: PHANTOM BLACK  
 INTERIOR/SEAT COLOR: BLACK/BLACK  
 TRANSPORT: TRUCK  
 ACCESSORY WEIGHT: 7 lbs. / 3 kgs.  
 EMISSIONS: This vehicle is certified to meet emission requirements in all 50 states

## 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 or 1-888-327-4236

### STANDARD FEATURES:

**AMERICA'S BEST WARRANTY**  
 5-year/100,000-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  
 Lane Keeping Assist, Lane Following Assist  
 Driver Attention Warning, Rear Occupant Alert  
 Blind Spot Collision-Avoidance Assist  
 Rear Cross-Traffic Collision-Avoidance Assist  
 Safe Exit Warning, Immobilizer  
 Electronic Stability Control (ESC) w/ Traction Control  
 ABS w/ Electronic Brake-Force Distribution  
 Downhill Brake Control, Hillstart Assist Control  
 Front, Front Side & Side-Curtain Airbags w/ Rollover Sensors  
 Tire Pressure Monitoring System w/ Individual Tire Indicator

**POWERTRAIN TECHNOLOGY**  
 Smartstream 2.0L Turbocharged 4-Cylinder Engine w/ GDI & MPI  
 8-Speed Wet Dual-Clutch Transmission w/ SHIFTRONIC®  
 Self-Leveling Rear Suspension  
 Drive Mode Select, Paddle Shifters  
 HTRAC All-Wheel Drive

**EXTERIOR**  
 20-inch Alloy Wheels, Temporary Compact Spare Tire  
 LED Daytime Running Lights, LED Tail Lights  
 Automatic LED Headlights, High Beam Assist  
 Premium-Finish Dark Chrome Grille & Tailgate Handle  
 Power Sunroof, Roof Side Rails  
 LED Bed Lighting, Adjustable C-Channel Cleat Rail System  
 Rear Sliding Glass w/ Defroster  
 Integrated Tonneau Cover  
 Sheet Molded Composite Bed  
 Under-Bed & Side-wall Storage Compartments  
 Rear Bumper Corner Steps  
 Heated Side Mirrors with Turn Signals

**COMFORT & CONVENIENCE**  
 Leather Trimmed Seats  
 Smart Cruise Control w/ Stop & Go  
 Dual Automatic Temperature Control, Rain-Sensing Wipers  
 Hyundai Digital Key  
 Proximity Key w/ Push Button Start

### COMFORT & CONVENIENCE(cont.)

Remote Engine Start  
 Power Driver's Seat w/ Lumbar Support  
 LED Interior Lights, Ambient Interior Lighting  
 Heated & Ventilated Front Seats  
 Leather-Wrapped Steering Wheel and Shift Knob  
 Heated Steering Wheel, Rear Air Vents  
 Auto-Dimming Mirror w/ HomeLink®  
 60/40 Flip-Up Rear Seats w/ Storage Bin  
 10.25-inch Digital Instrument Cluster  
 10.25-inch Navigation w/ Android Auto (TM) & Apple CarPlay (TM)  
 Rearview Monitor w/ Parking Guidance  
 Surround View Monitor, Blind View Monitor  
 Dual Front USB Outlets, HD Radio®  
 Wireless Device Charging  
 115V AC Power Inverter in Bed  
 Bose® Premium Audio System  
 SiriusXM Radio w/90 Day Platinum trial subscription;  
 Not Available in AK & HI  
 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:** \$39,720.00

**ADDED FEATURES:**  
 \*Carpeted Floor Mats \$195.00

Inland Freight & Handling: \$1,225.00  
**Total Price:** \$41,140.00

## EPA DOT Fuel Economy and Environment



**Fuel Economy**  
**22** MPG  
 combined city/hwy  
 4.5 gallons per 100 miles

Small SUVs range from 16 to 125 MPG. The best vehicle rates 142 MPGe.

**You spend \$1,500 more in fuel costs over 5 years** compared to the average new vehicle.

**Annual fuel cost \$1,600**

**Fuel Economy & Greenhouse Gas Rating (tailpipe only)**  
 1 5 10 Best

**Smog Rating (tailpipe only)**  
 1 5 10 Best

This vehicle emits 403 grams CO<sub>2</sub> per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel also creates emissions; learn more at fueleconomy.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 \$6,500 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at \$ 2.35 per gallon. MPGe is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

**fueleconomy.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: 53 %  
 MAJOR SOURCES OF FOREIGN PARTS CONTENT: KOREA: 35 %

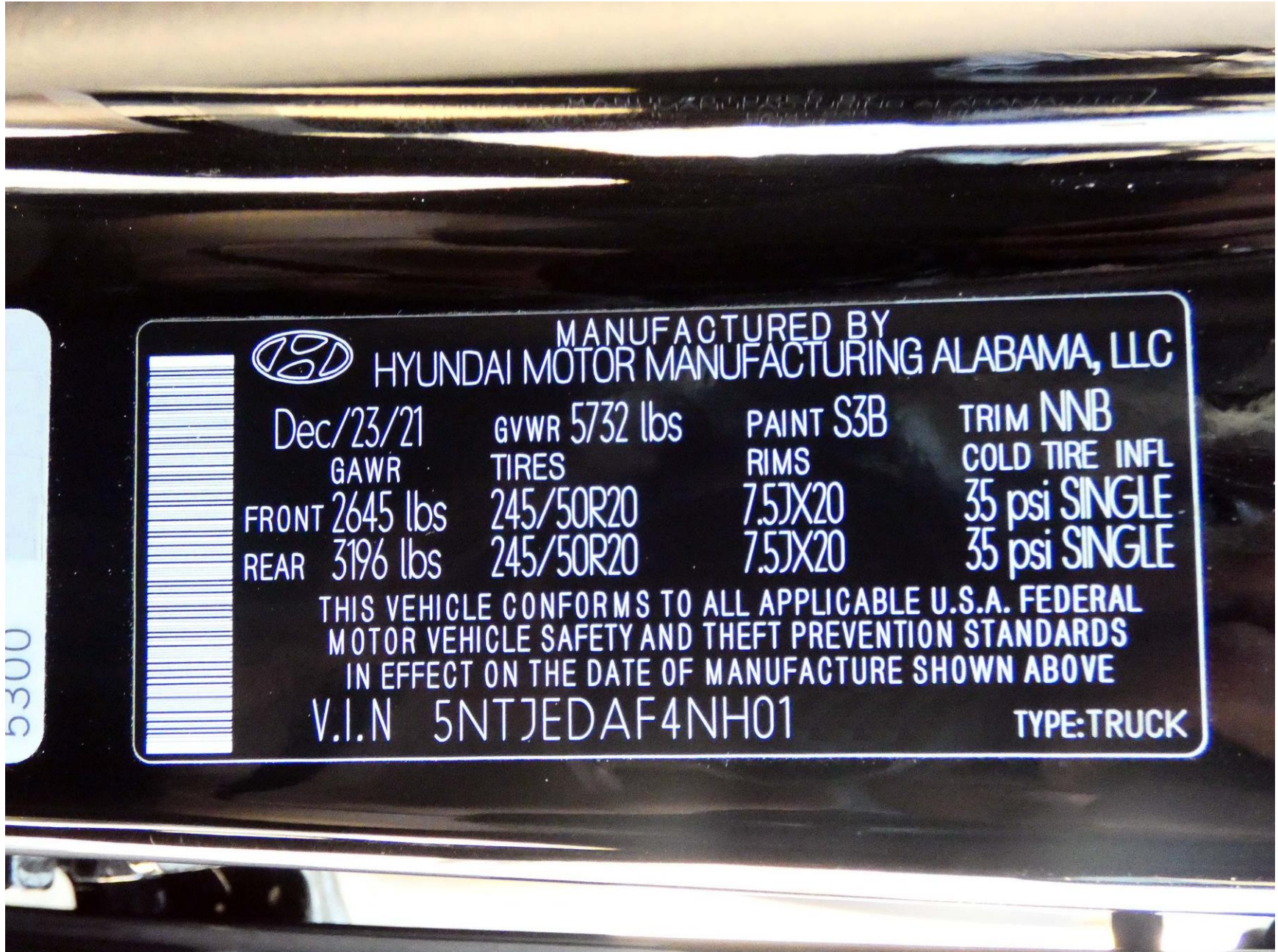
Note: Parts content does not include final assembly, distribution, or other non-parts costs.

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

3 A 1

Figure A3. Window Sticker (Monroney Label)





 MANUFACTURED BY  
HYUNDAI MOTOR MANUFACTURING ALABAMA, LLC

	Dec/23/21	GVWR 5732 lbs	PAINT S3B	TRIM NNB
	GAWR	TIRES	RIMS	COLD TIRE INFL
	FRONT 2645 lbs	245/50R20	7.5JX20	35 psi SINGLE
	REAR 3196 lbs	245/50R20	7.5JX20	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 5NTJEDAF4NH01 TYPE:TRUCK

5300

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 640 kg or 1,411 lbs.  
Le poids total des occupants et du chargement ne doit jamais dépasser 640 kg ou 1,411 lb.

TIRE PNEU	SIZE DIMENSIONS	COLD TIRE PRESSURE PRESSION DES PNEUS À FROID	SEE OWNER'S MANUAL FOR ADDITIONAL INFORMATION  VOIR LE MANUEL DE L'USAGER POUR PLUS DE RENSEIGNEMENTS
FRONT AVANT	245/50R20	240kPa, 35psi	
REAR ARRIÈRE	245/50R20	240kPa, 35psi	
SPARE DE SECOURS	T135/80D18	420kPa, 60psi	



5300

Figure A5. Tire Placard





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





Figure A7. Load Frame/Slider of SSV



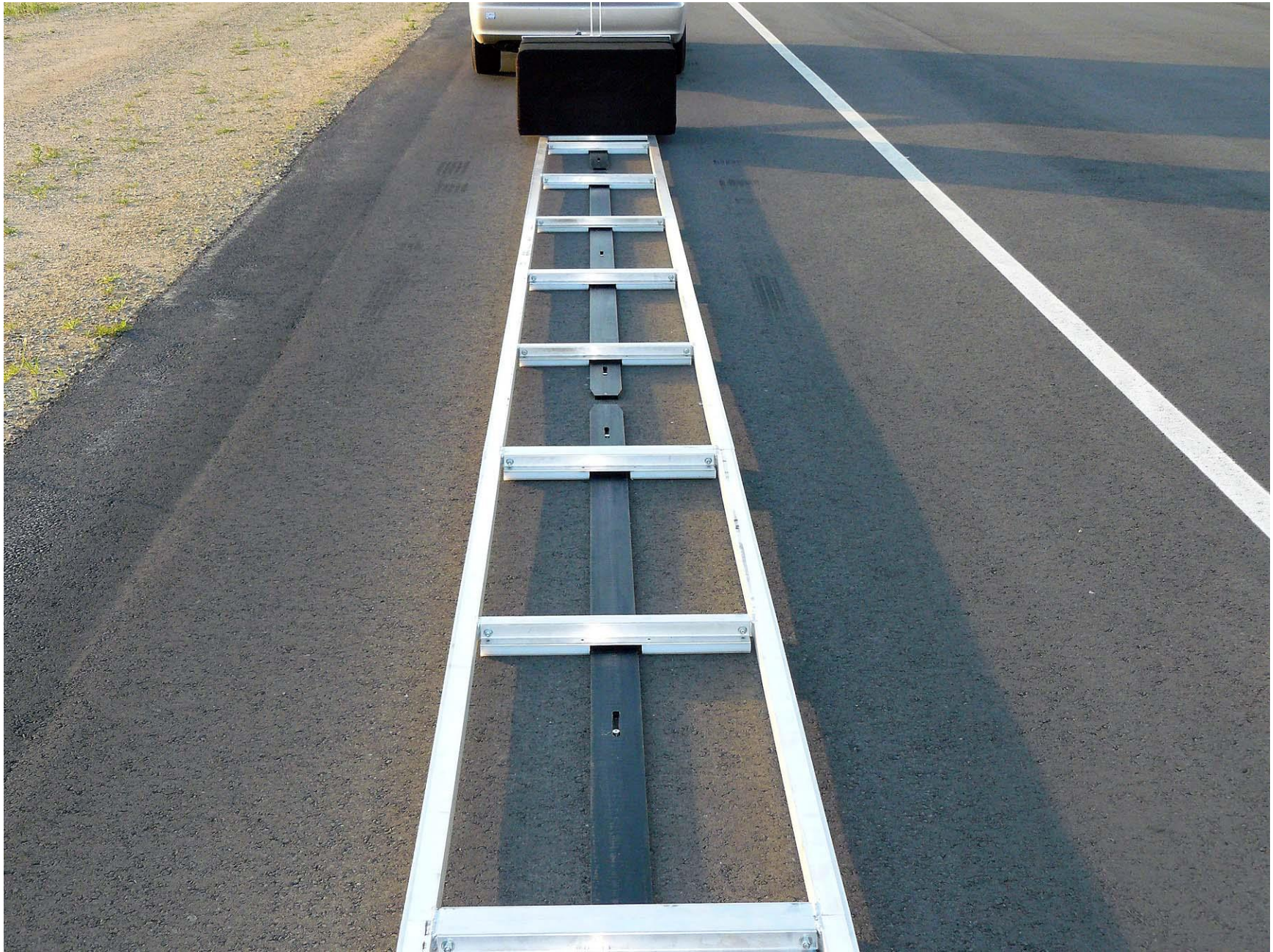


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track





Figure A9. Steel Trench Plate



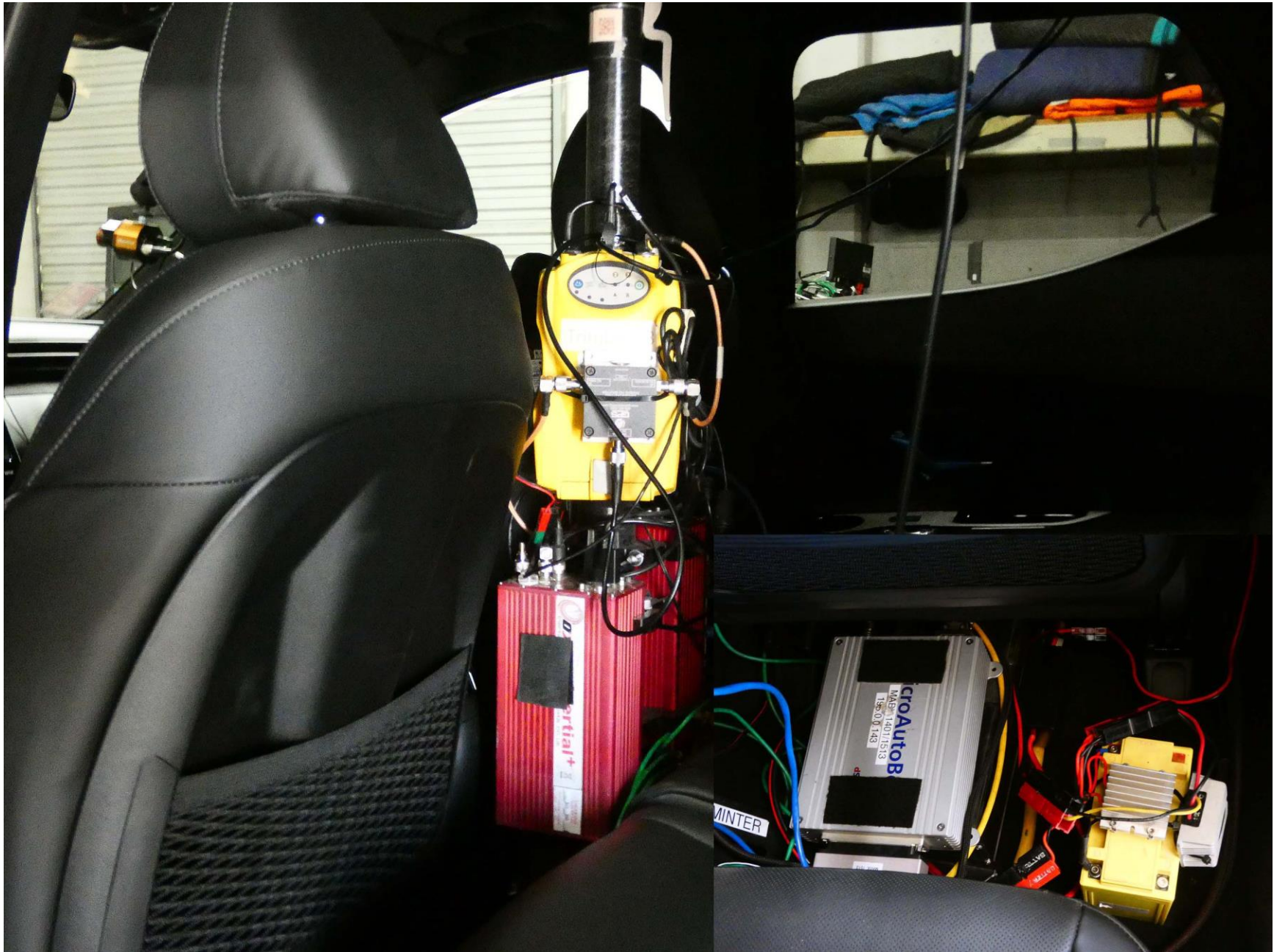


Figure A10. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle





Figure A11. Sensor for Detecting Auditory and Visual Alerts





Figure A12. Computer Installed in Subject Vehicle





Figure A13. Brake Actuator Installed in POV System



Figure A14. AEB System Warning Timing Setup





Figure A15. AEB System On/Off



Figure A16. First Stage Visual Alert





Figure A17. Second Stage Visual Alert

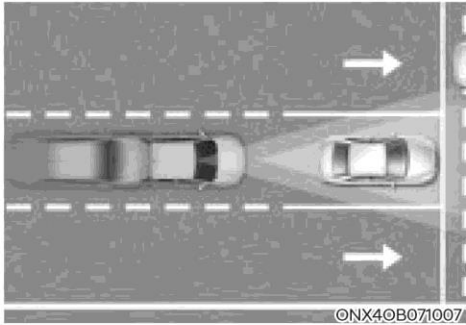


## APPENDIX B

Excerpts from Owner's Manual

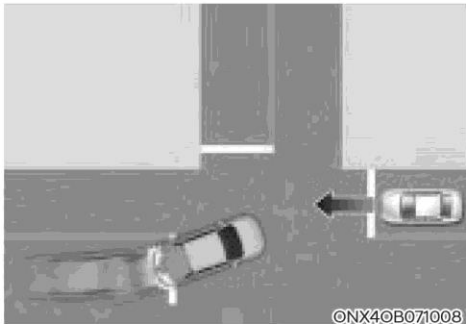
## FORWARD COLLISION-AVOIDANCE ASSIST (FCA) (SENSOR FUSION) (IF EQUIPPED)

### Basic function



Forward Collision Avoidance Assist is designed to help detect and monitor a vehicle on the roadway ahead or help detect if a pedestrian or cyclist is in the roadway. Forward Collision Avoidance Assist will warn the driver with an audible warning and a message in the LCD cluster if it determines that a collision is imminent. In certain cases, emergency braking may be applied.

### Junction Turning function



The Junction Turning function can help avoid a collision with an oncoming vehicle when attempting to make a left hand turn at an intersection. If the function detects that a collision is imminent, a warning message occurs and in certain cases, emergency braking may be applied.

### 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 cause any damage to it.
  - If the detecting sensors have been replaced or repaired, have the 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 (for example, white paper, mirror) over the dashboard.
  - 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 the radar or around the radar has been damaged or impacted in any way, Forward Collision-Avoidance Assist may not properly operate even though a warning message does not appear on the cluster. Have the vehicle 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.


## Forward Collision-Avoidance Assist Settings


### Setting features



#### Forward Safety

With the engine on, select 'Driver Assistance → Forward Safety' from the Settings menu to set whether to use each function.

- If 'Active Assist' is selected, Forward Collision-Avoidance Assist warns the driver with a warning message and an audible warning depending on the collision risk levels. Braking assist is applied depending on the collision risk levels.
- If 'Warning Only' is selected, Forward Collision-Avoidance Assist warns the driver with a warning message and an audible warning depending on the collision risk levels. Braking is not assisted. The driver must apply the brake pedal if necessary.
- If 'Off' is selected, Forward Collision-Avoidance Assist turns off. The  warning light illuminates 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 Forward Collision-Avoidance Assist is on, have the vehicle inspected by an authorized HYUNDAI dealer.


#### WARNING

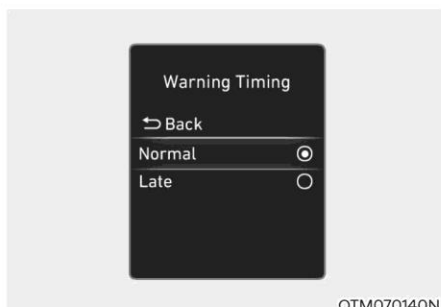
When the engine is restarted, Forward Collision-Avoidance Assist will always turn on. However, if 'Off' is selected after the engine is restarted, note that Forward Collision Avoidance will not be active. The driver must take extra precaution while driving and always be aware of the vehicle surroundings.

#### CAUTION

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

#### Information

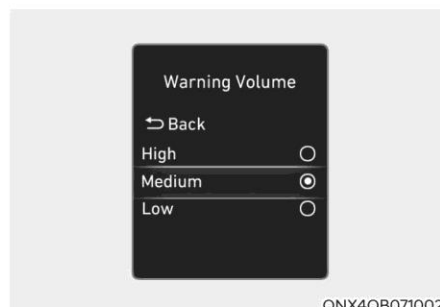
Forward Collision-Avoidance Assist will turn off when ESC is turned off by pressing and holding the ESC OFF button. The  warning light illuminates on the cluster.



### 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 Timing of other Driver Assistance systems may change.



### 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 warning may seem late.
- Select 'Late' for Warning Timing when traffic is light and when driving speed is slow.



### Information

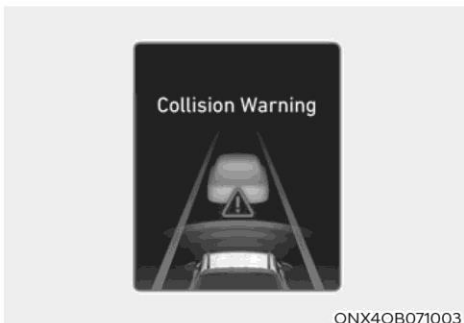
If the engine is restarted, Warning Timing and Warning Volume will maintain the last setting.

## Forward Collision-Avoidance Assist Operation

### Basic function

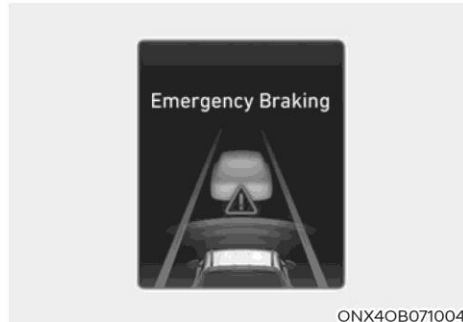
#### Warning and control

The basic function of Forward Collision Avoidance Assist is to help warn the driver and, if necessary, control the vehicle to help mitigate a collision. The following warning messages may be displayed depending on the collision risk level.



#### Collision Warning

- To warn the driver of a collision, the 'Collision Warning' warning message appears on the cluster and an audible warning sounds.
- If a vehicle is detected in front, the function 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 function operates when your vehicle speed is between approximately 6-53 mph (10-85 km/h).
- If 'Active Assist' is selected, braking may be assisted.



#### Emergency Braking

- To warn the driver that emergency braking is assisted, the 'Emergency Braking' warning message appears on the cluster and an audible warning sounds.
- If a vehicle is detected in front, the function operates when your vehicle speed is between approximately 6-47 mph (10-75 km/h).
- If a pedestrian or cyclist is detected in front, the function operates 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 function to help prevent collision with the vehicle, pedestrian or cyclist ahead.



ONX4OB071005

#### Stopping vehicle and ending brake control

- When the vehicle is stopped due to emergency braking, the 'Drive carefully' warning message appears on the cluster.

For your safety, the driver should depress the brake pedal immediately and check the surroundings.

- Brake control ends after the vehicle is stopped by emergency braking for approximately 2 seconds.

### Junction Turning function

#### Warning and control

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



ONX4OB071010

#### Collision Warning

- To warn the driver of a collision, the 'Collision Warning' warning message appears on the cluster and an audible warning sounds.
- The function operates 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 is assisted, the 'Emergency Braking' warning message appears on the cluster and an audible warning sounds.
- The function operates 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 function to help prevent collision with the oncoming vehicle.




### Stopping vehicle and ending brake control

- When the vehicle is stopped due to emergency braking, the 'Drive carefully' warning message appears on the cluster.  
For your safety, the driver should depress the brake pedal immediately and check the surroundings.
- Brake control ends 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, Forward Collision-Avoidance Assist will turn off automatically. In this case, Forward Collision-Avoidance Assist cannot be set from the Settings menu and the  warning light illuminates 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 properly.
- During emergency braking, braking control by Forward Collision-Avoidance Assist will automatically cancel when the driver excessively depresses the accelerator pedal or sharply steers the vehicle.

 **CAUTION**

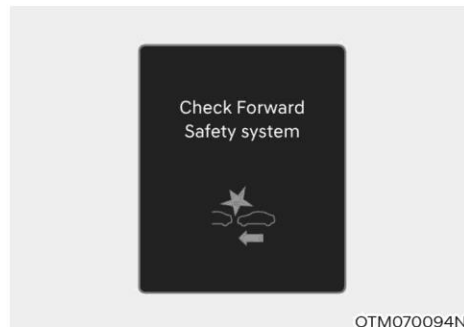
- Depending on the condition of the vehicle and pedestrian in front and the surroundings, the speed range to operate Forward Collision-Avoidance Assist may reduce. Forward Collision-Avoidance Assist may only warn the driver, or it may not operate.
- Forward Collision-Avoidance Assist will operate under 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.
- The images and colors in the cluster may differ depending on the cluster type or theme selected from the cluster.

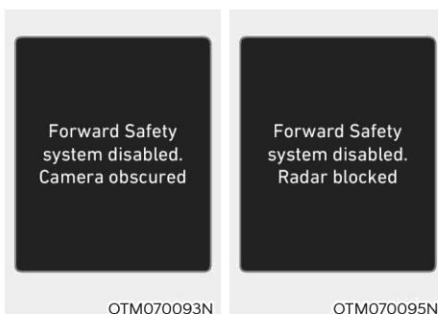
**Forward Collision-Avoidance Assist Malfunction and Limitations**

***Forward Collision-Avoidance Assist malfunction***





When Forward Collision-Avoidance Assist is not working properly, the 'Check Forward Safety system' warning message appears, and the  and  warning lights illuminate on the cluster. If this occurs, have the vehicle inspected by an authorized HYUNDAI dealer.

### Forward Collision-Avoidance Assist 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 disabled. Camera obscured' or the 'Forward Safety system disabled. Radar blocked' warning message, and the  and  warning lights illuminate on the cluster.

Forward Collision-Avoidance Assist will operate properly when when such snow, rain or foreign material is removed.

If Forward Collision-Avoidance Assist does not operate properly after obstruction (snow, rain, or foreign material) is removed, have the vehicle 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 (for example, open terrain), where any objects are not detected after turning ON the engine.

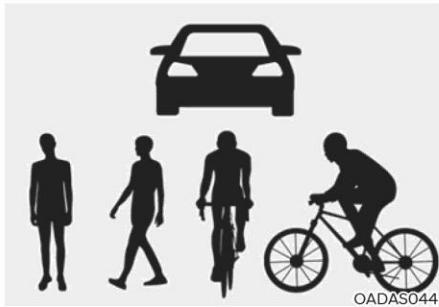
### Limitations of Forward Collision-Avoidance Assist

Forward Collision-Avoidance Assist may not operate properly, or it 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 due to surrounding environment
- The camera lens is contaminated due to tinted, filmed or coated windshield, damaged glass, or sticky 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 traffic 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 an unusually shaped cargo, 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 vast where there are few vehicles or structures for example, 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

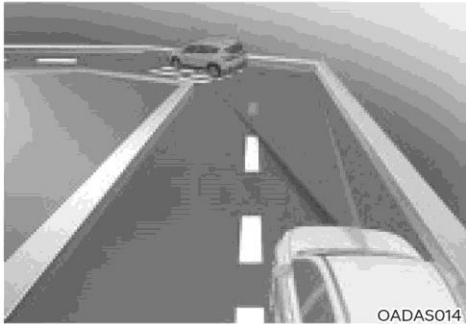


The illustration above shows the image the front view camera and front radar are capable of detecting as a vehicle, pedestrian and cyclist.

- 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 similarly 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 curved road

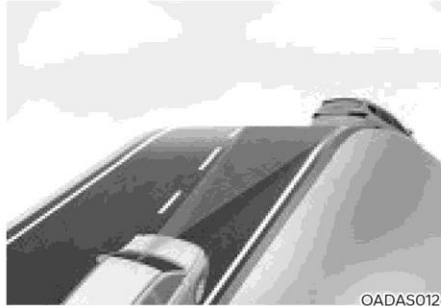


Forward Collision-Avoidance Assist may not detect other vehicles, pedestrians or cyclists in front of you on curved roads adversely affecting the performance of the sensors. This may result in no warning or braking assist when necessary.

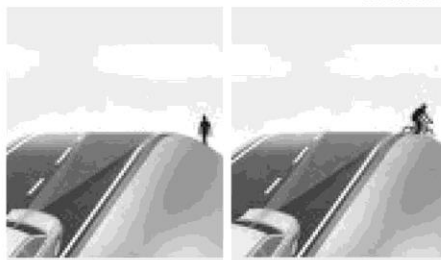
When driving on a curved road, you must maintain a safe braking distance, and if necessary, steer the vehicle and depress the brake pedal to reduce your driving speed in order to maintain a safe distance.

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, Forward Collision-Avoidance Assist may unnecessarily warn the driver and control the brake. Always check the traffic conditions around the vehicle.

- Driving on an inclined road



OADAS012



OADAS010

OADAS011

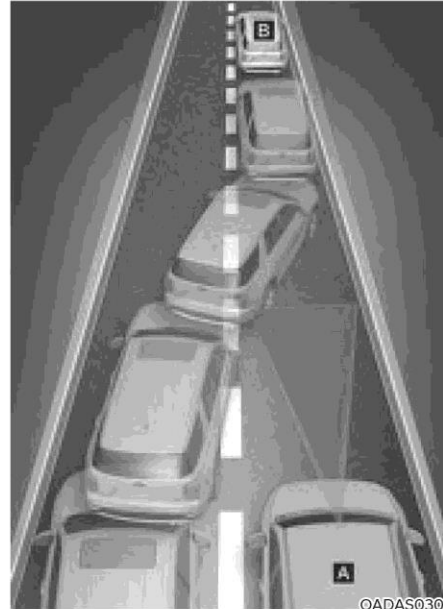
**Forward Collision-Avoidance Assist may not detect other vehicles, pedestrians or cyclists in front of you while driving uphill or downhill adversely affecting the performance of the sensors.**

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

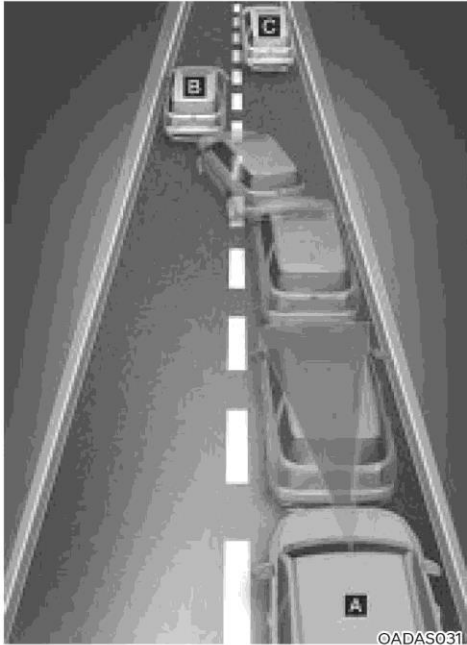


OADAS030

[A] : Your vehicle,

[B] : Lane changing vehicle

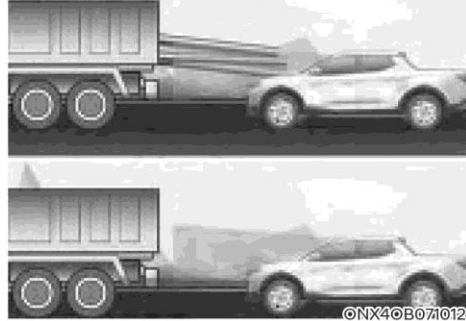
**When a vehicle moves into your lane from an adjacent lane, it cannot be detected by the sensor until it is in the sensor's detection range. Forward Collision-Avoidance Assist may not immediately detect the vehicle when the vehicle changes lanes abruptly. In this case, you must maintain a safe braking 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 properly 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**

This device complies with Part 15 of the FCC rules.

Operation is subject to the following three conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.
3. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the device.

 **Information**

Radio frequency radiation exposure information:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment.

This equipment should be installed and operated with minimum distance of 8 in. (20 cm) between the radiator (antenna) and your body.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

## APPENDIX C

### Run Log

Subject Vehicle: **2022 Hyundai Santa Cruz AWD**

Test start date: **4/26/2022**

Principal Other Vehicle: **SSV**

Test end date: **4/27/2022**

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	1.67	1.04	24.9	0.99	0.89	Pass	
3		Y	1.64	1.01	25.7	0.96	0.89	Pass	
4		Y	1.64	1.60	24.9	1.05	0.86	Pass	
5		Y	1.61	2.54	25.0	1.07	0.87	Pass	
6		Y	1.66	0.72	25.7	1.02	0.88	Pass	
7		Y	1.62	0.88	24.9	1.05	0.88	Pass	
8		Y	1.62	1.22	25.1	1.06	0.88	Pass	
9	Static Run								
10	<b>Slower POV, 25 vs 10</b>	Y	1.57	3.02	14.7	0.94	0.66	Pass	
11		Y	1.57	2.70	15.6	0.97	0.67	Pass	
12		Y	1.66	2.65	15.0	0.95	0.66	Pass	
13		Y	1.71	3.72	15.5	0.93	0.72	Pass	
14		Y	1.61	3.22	15.1	0.96	0.68	Pass	
15		Y	1.63	3.12	15.7	0.95	0.68	Pass	
16	Y	1.64	3.22	15.0	0.96	0.68	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	2.74	4.18	24.7	0.95	0.91	Pass	
19		Y	2.72	2.31	25.3	0.97	0.87	Pass	
20		Y	2.74	2.72	25.4	0.95	0.90	Pass	
21		N							POV Speed
22		Y	2.73	2.94	25.4	0.98	0.88	Pass	
23		Y	2.77	3.26	25.5	0.98	0.91	Pass	
24		Y	2.74	2.66	25.2	1.00	0.88	Pass	
25		Y	2.72	3.64	25.8	0.99	0.93	Pass	
26	Static run								
27	<b>Decelerating POV, 35</b>	N							POV Brakes
28		Y	1.68	1.00	23.5	1.05	1.43	Pass	
29		N							POV Brakes
30		N							POV Brakes
31		N							Sound Recorder Malfunction
32		N							POV Brakes
33		N							POV Brakes
34		Y	1.73	0.00	16.8	0.90	1.53	Pass	
35		Y	1.76	0.00	15.9	0.89	1.46	Pass	
36		Y	1.76	1.43	24.8	1.07	1.16	Pass	
37		Y	1.82	0.00	18.5	0.93	1.49	Pass	
38		Y	1.84	0.00	14.8	0.95	1.49	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
39		Y	1.72	0.00	24.0	0.95	1.43	Pass	
40	Static Run								
41	STP - Static Run								
42	<b>STP False Positive, 25</b>	Y				0.01		Pass	
43		Y				0.02		Pass	
44		Y				0.01		Pass	
45		Y				0.02		Pass	
46		Y				0.01		Pass	
47		Y				0.01		Pass	
48		Y				0.01		Pass	
49	STP - Static Run								
50	<b>STP False Positive, 45</b>	Y				0.02		Pass	
51		Y				0.01		Pass	
52		Y				0.01		Pass	
53		Y				0.01		Pass	
54		Y				0.02		Pass	
55		Y				0.01		Pass	
56		Y				0.01		Pass	
57	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.

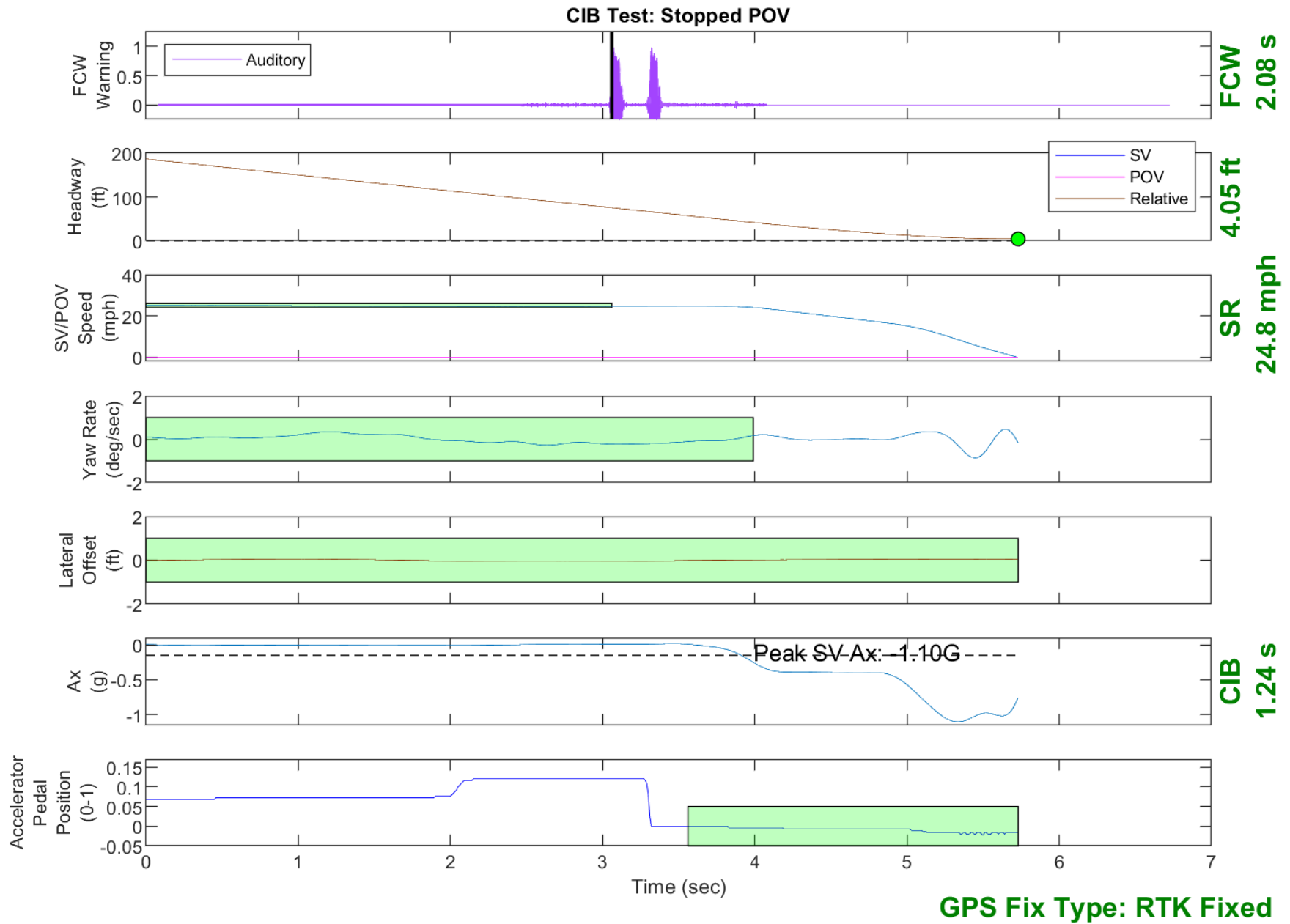


Figure D1. Example Time History for Stopped POV, Passing

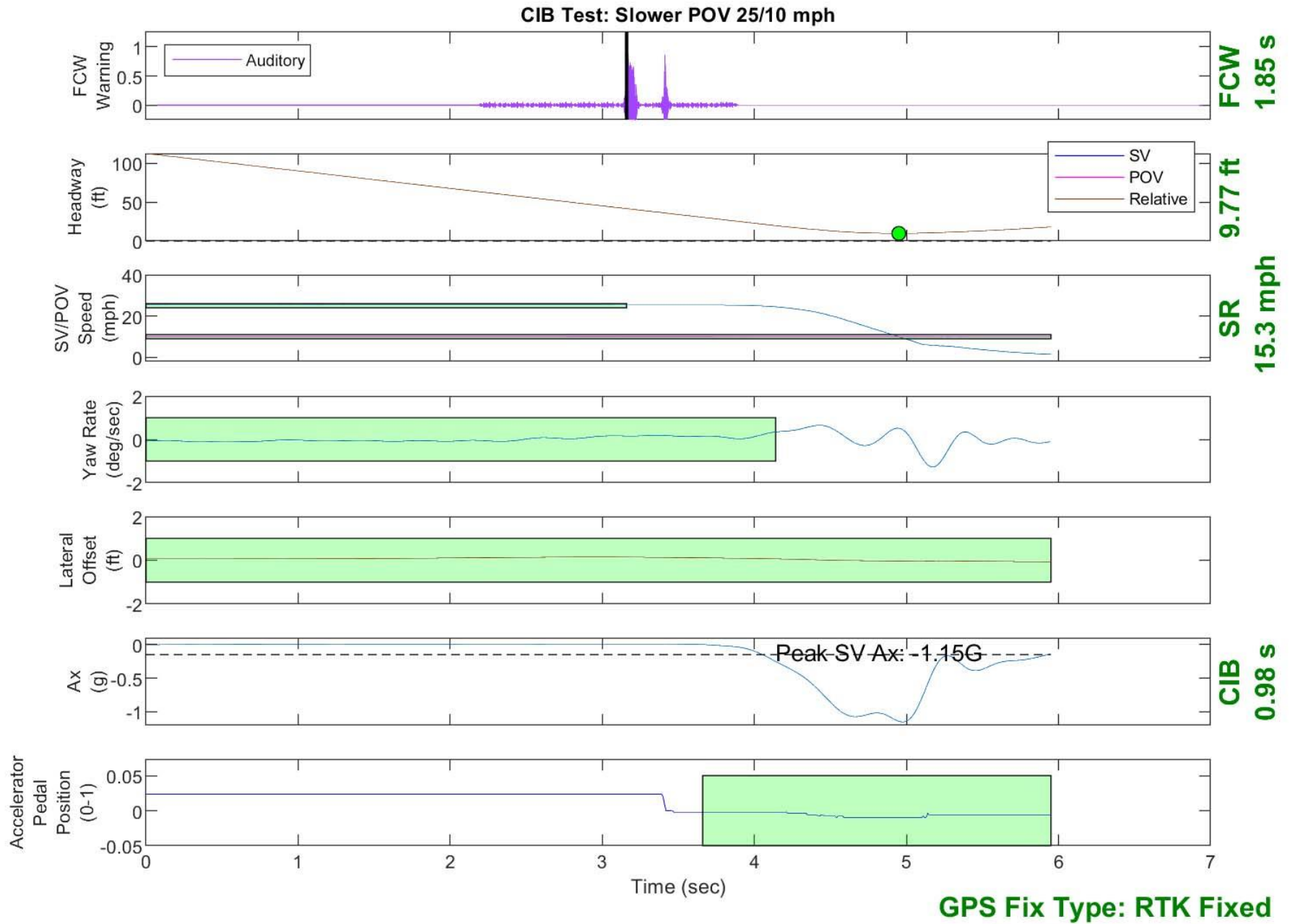


Figure D2. Example Time History for Slower POV 25 vs. 10, Passing

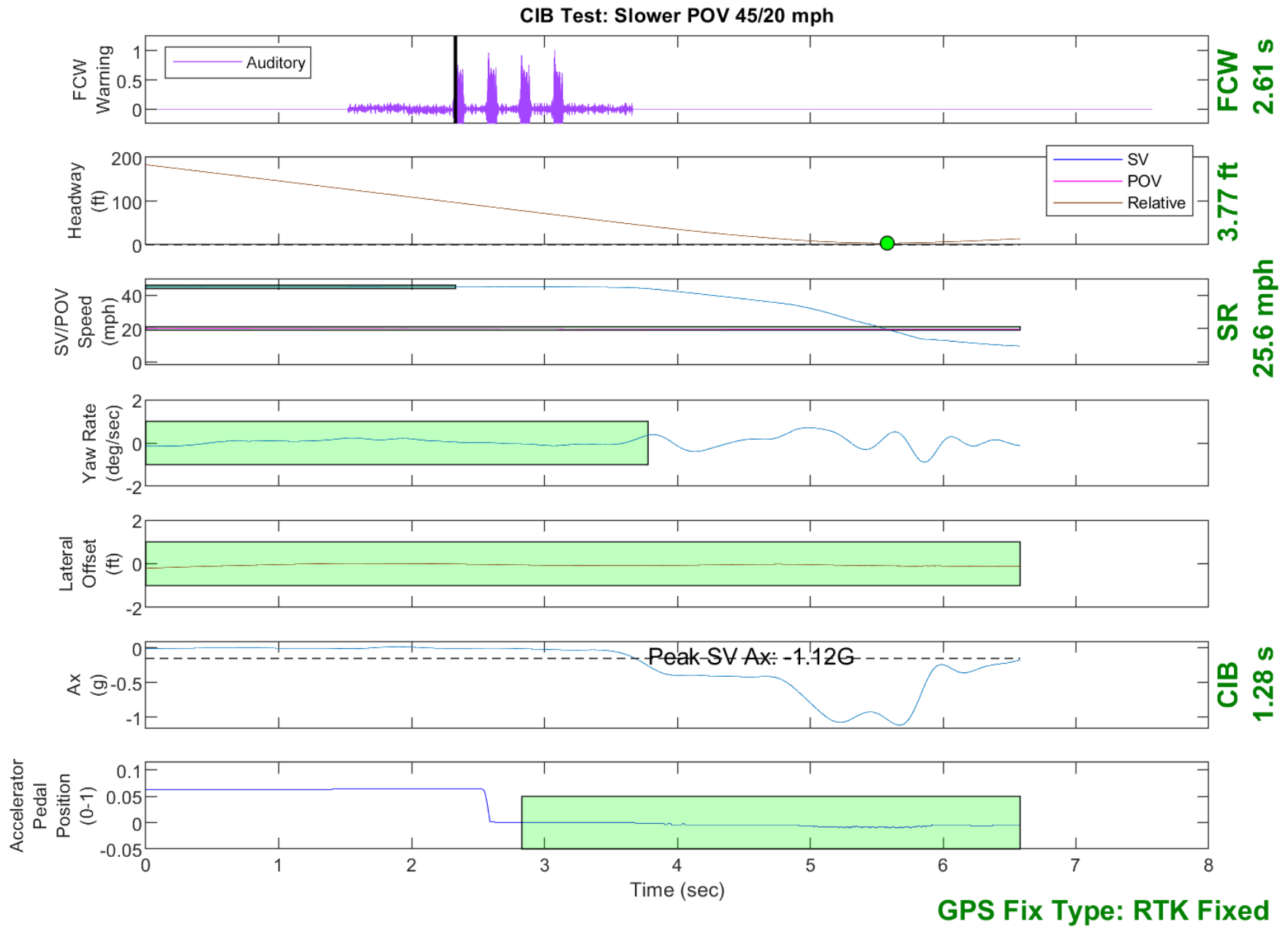


Figure D3. Example Time History for Slower POV 45 vs. 20, Passing



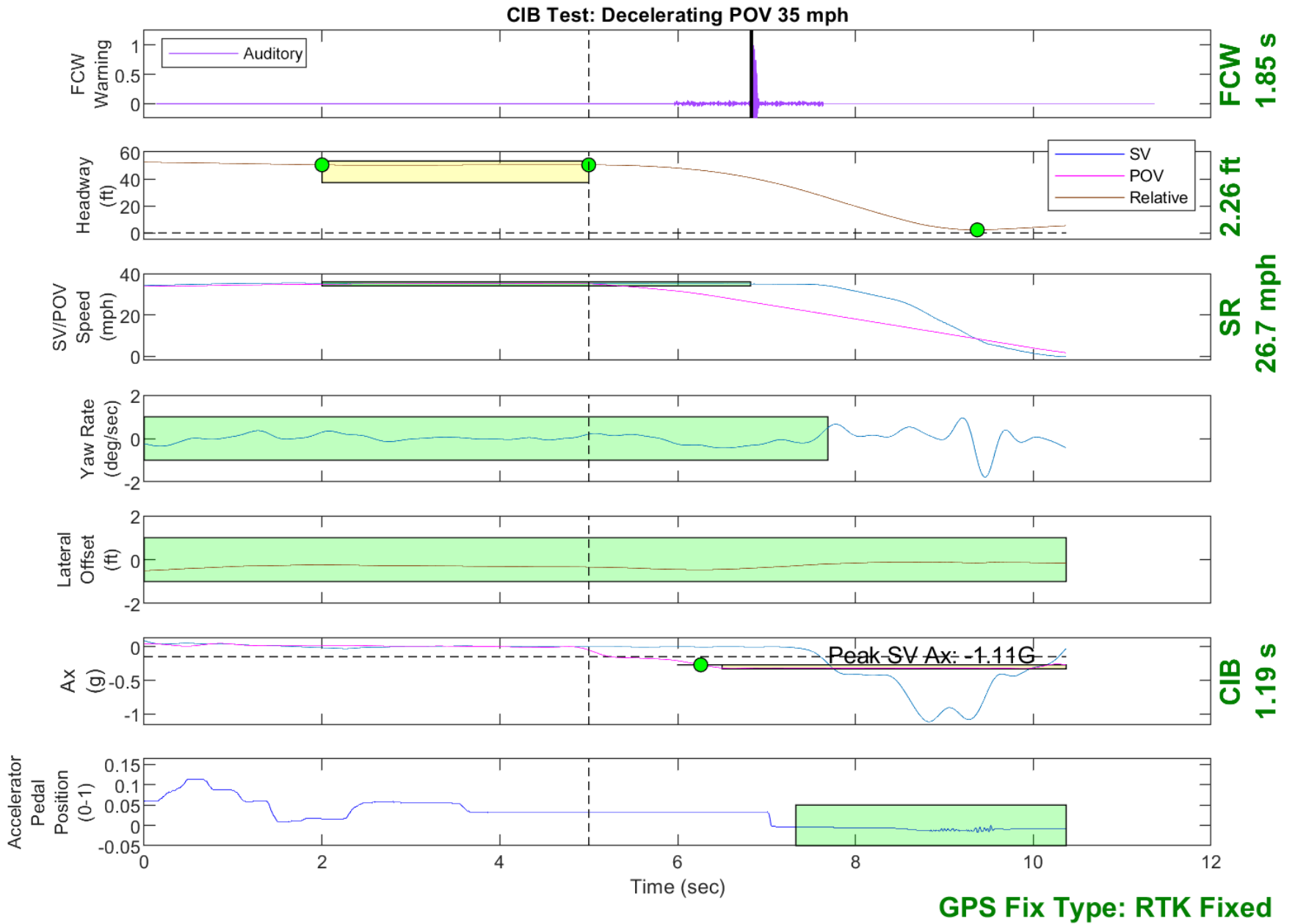


Figure D4. Example Time History for Decelerating POV 35, Passing

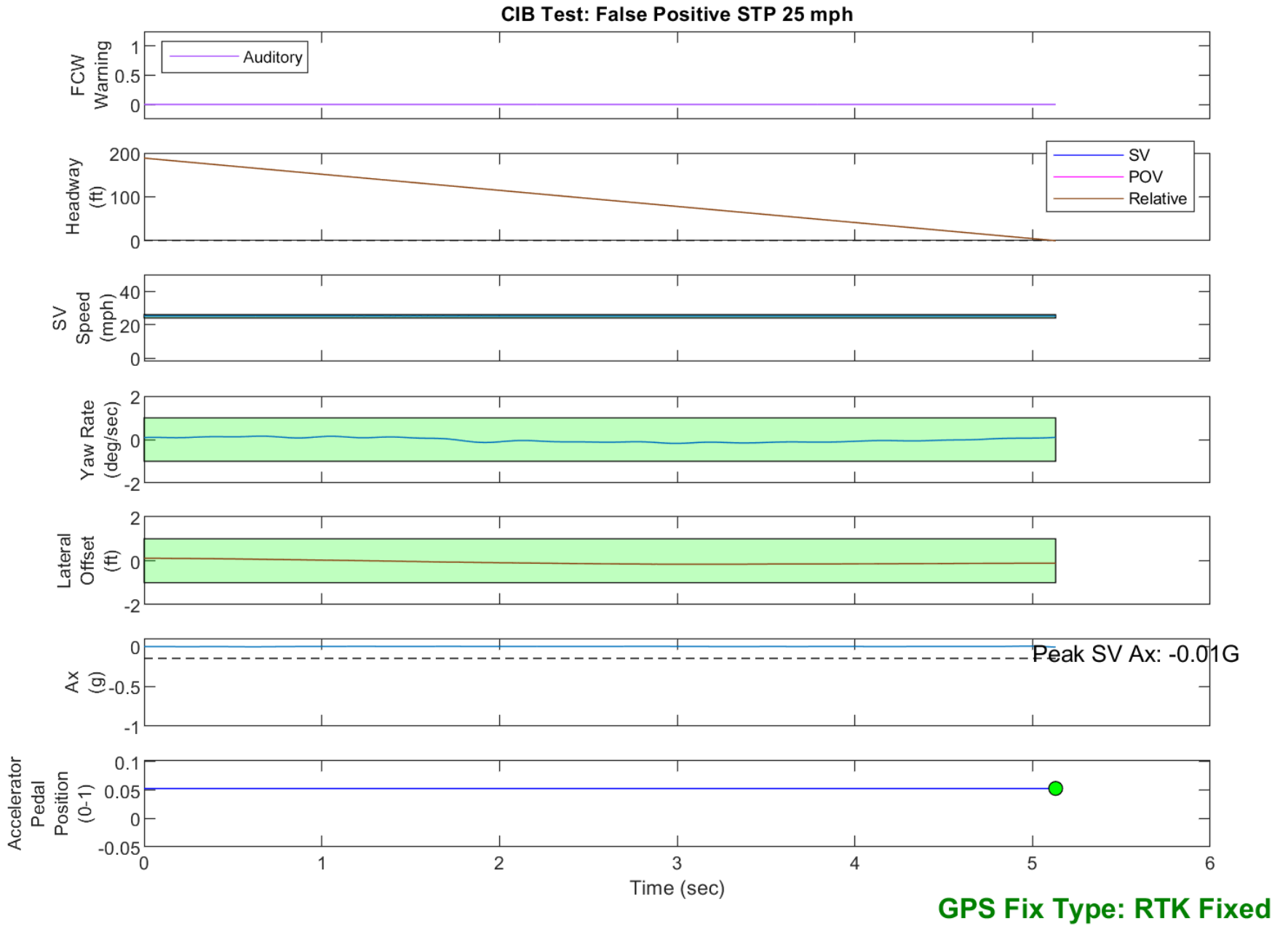


Figure D5. Example Time History for False Positive STP 25, Passing

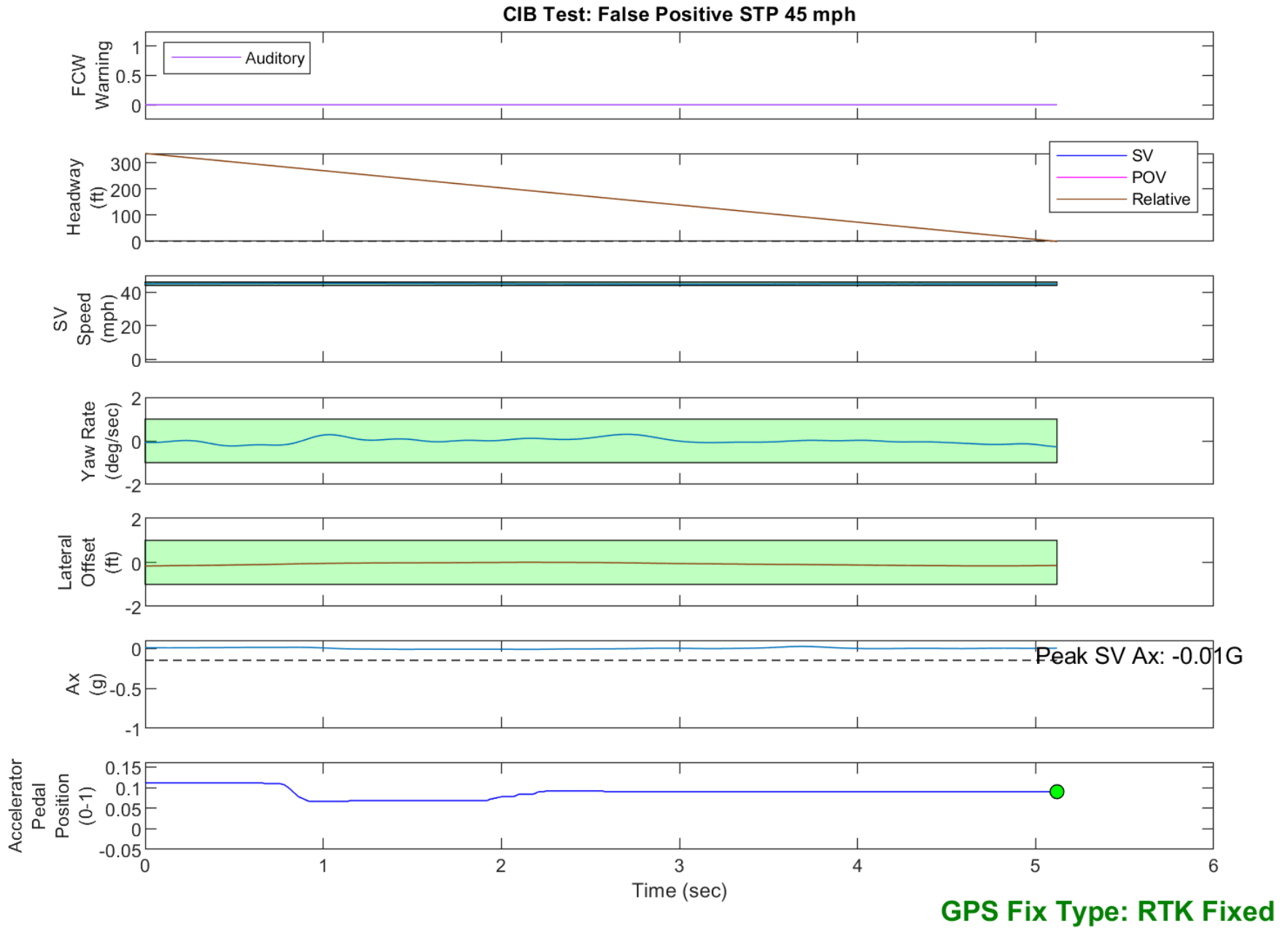


Figure D6. Example Time History for False Positive STP 45, Passing

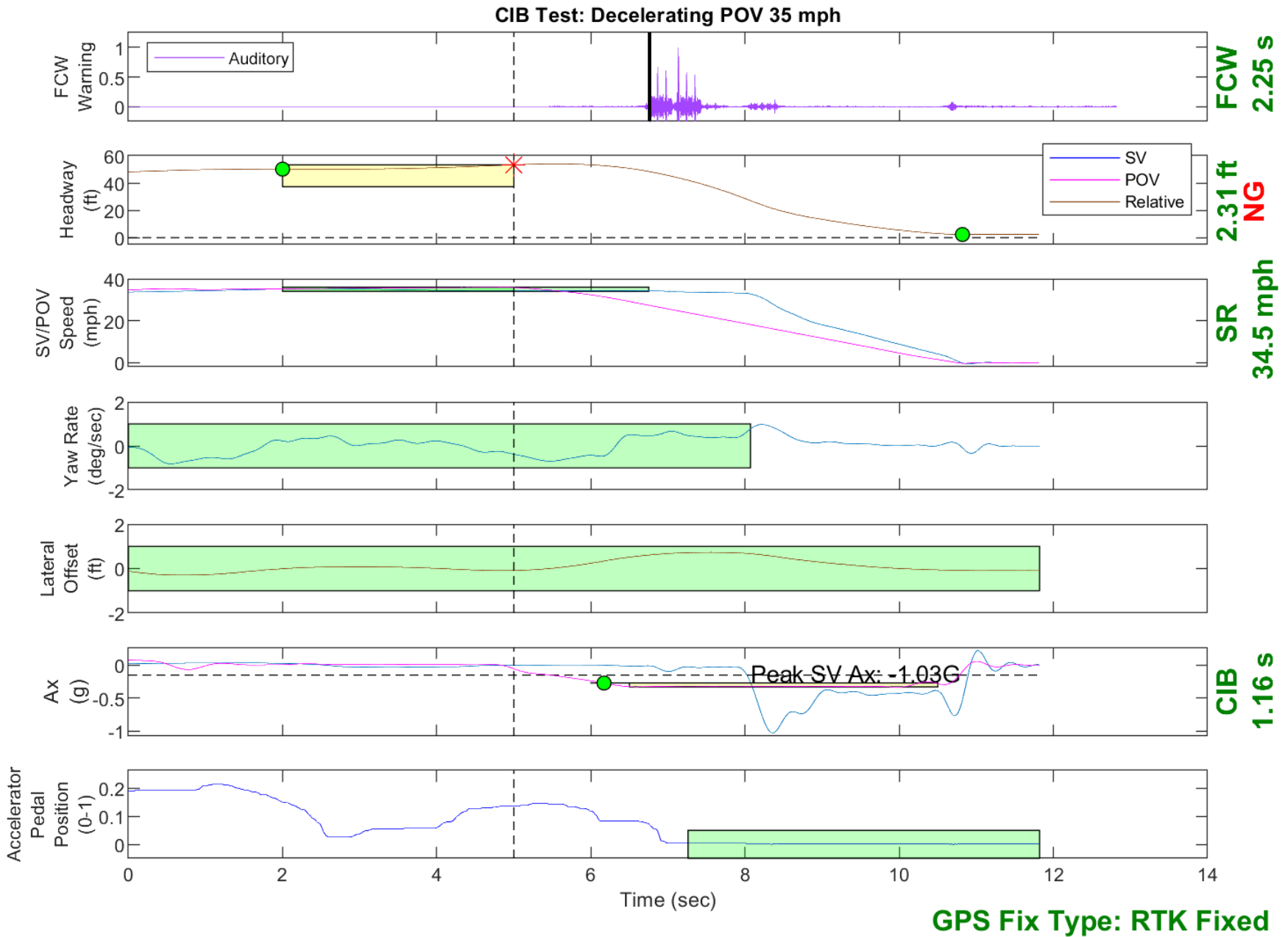


Figure D7. Example Time History Displaying Invalid Headway Criteria

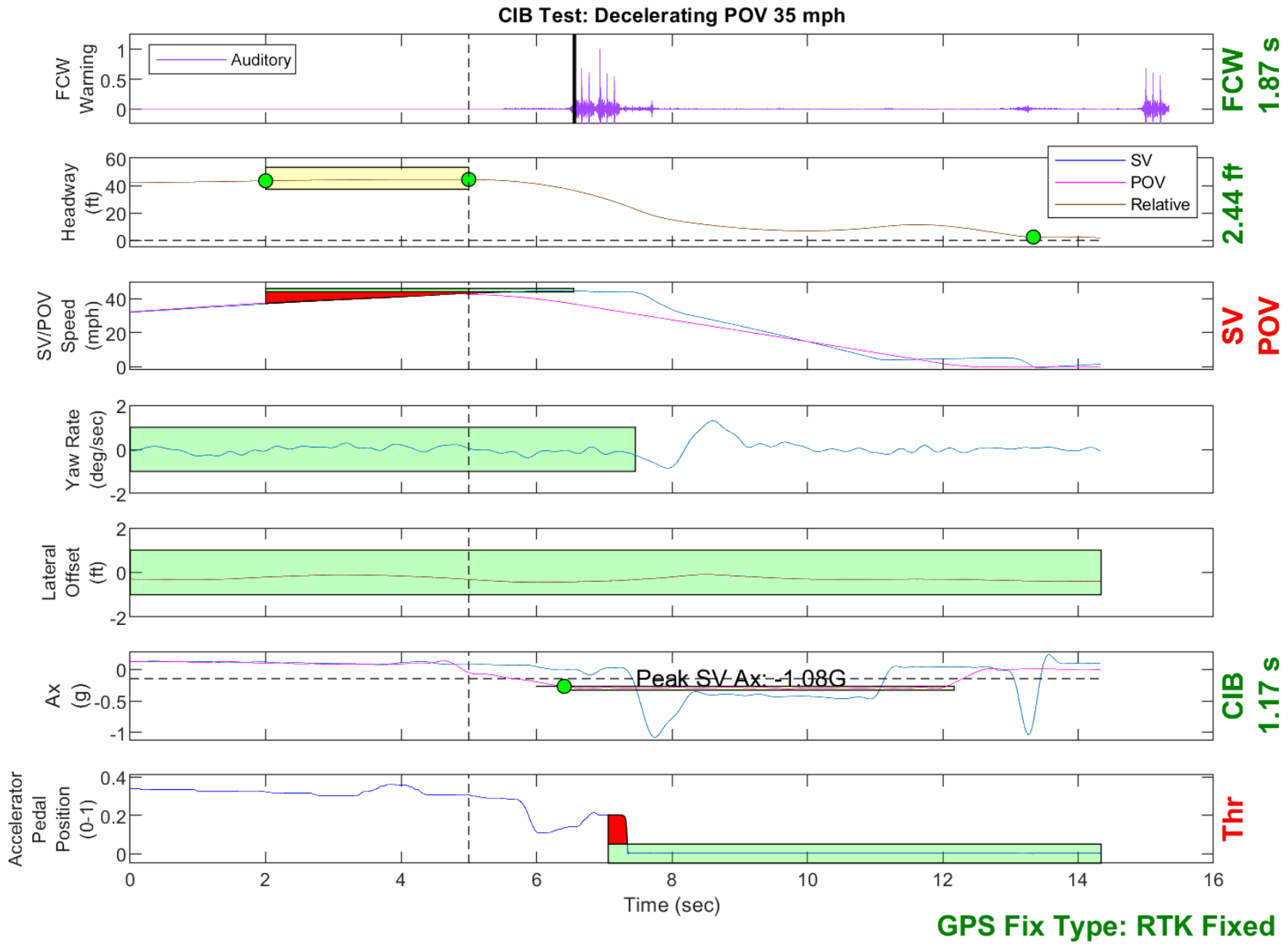


Figure D8. Example Time History Displaying Various Invalid Criteria

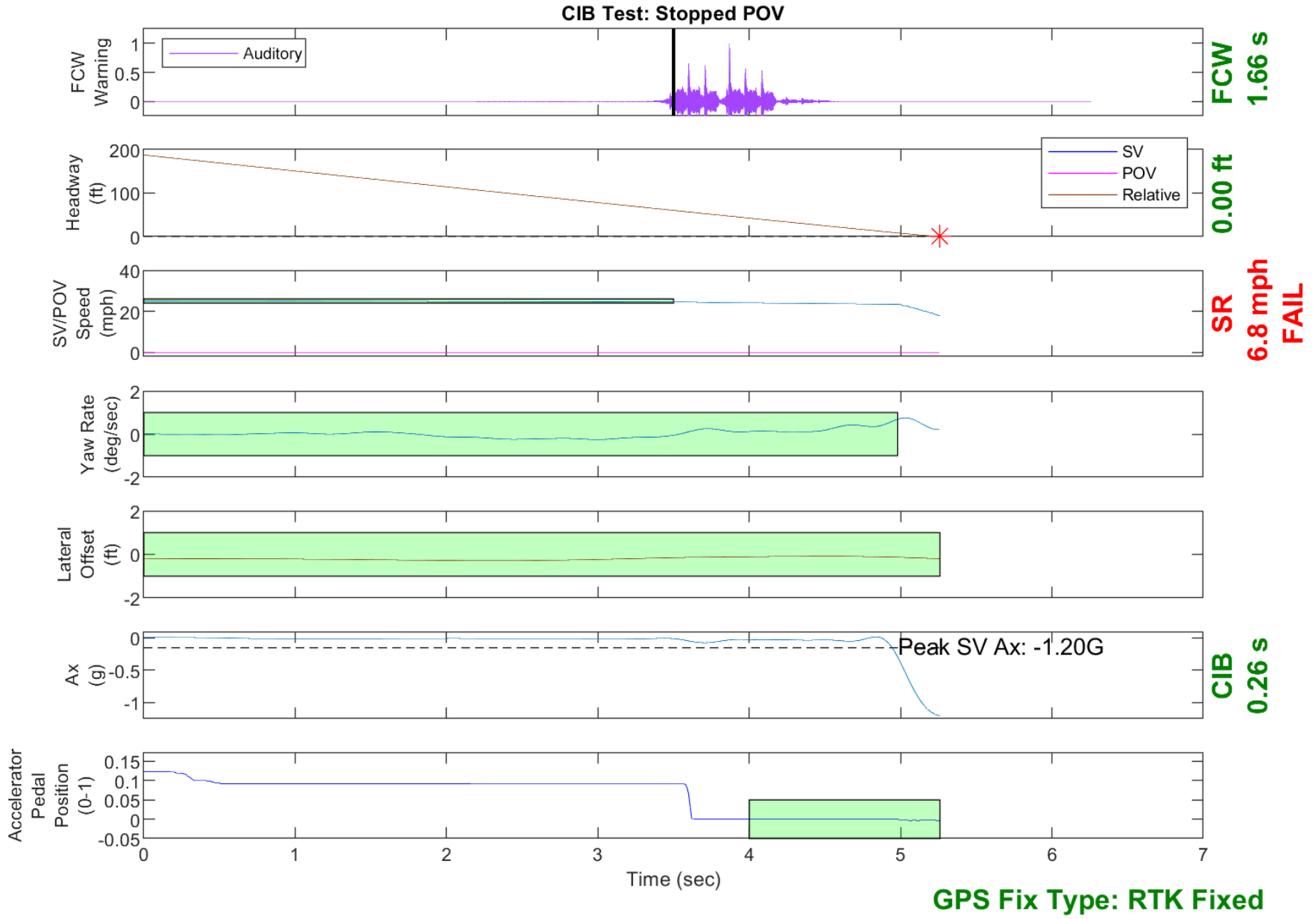


Figure D9. Example Time History for a Failed Run



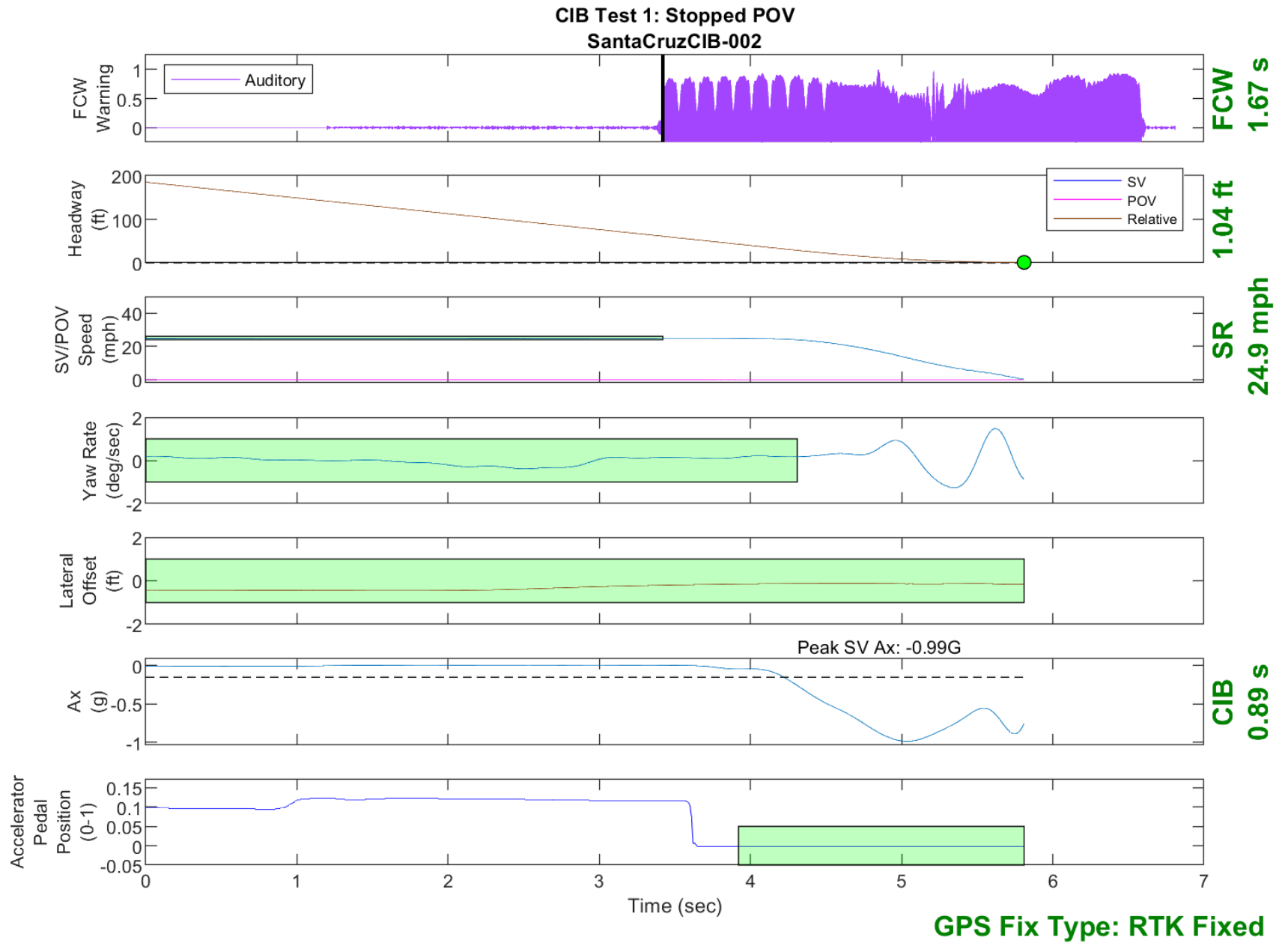


Figure D10. Time History for CIB Run 2, Test 1 - Stopped POV

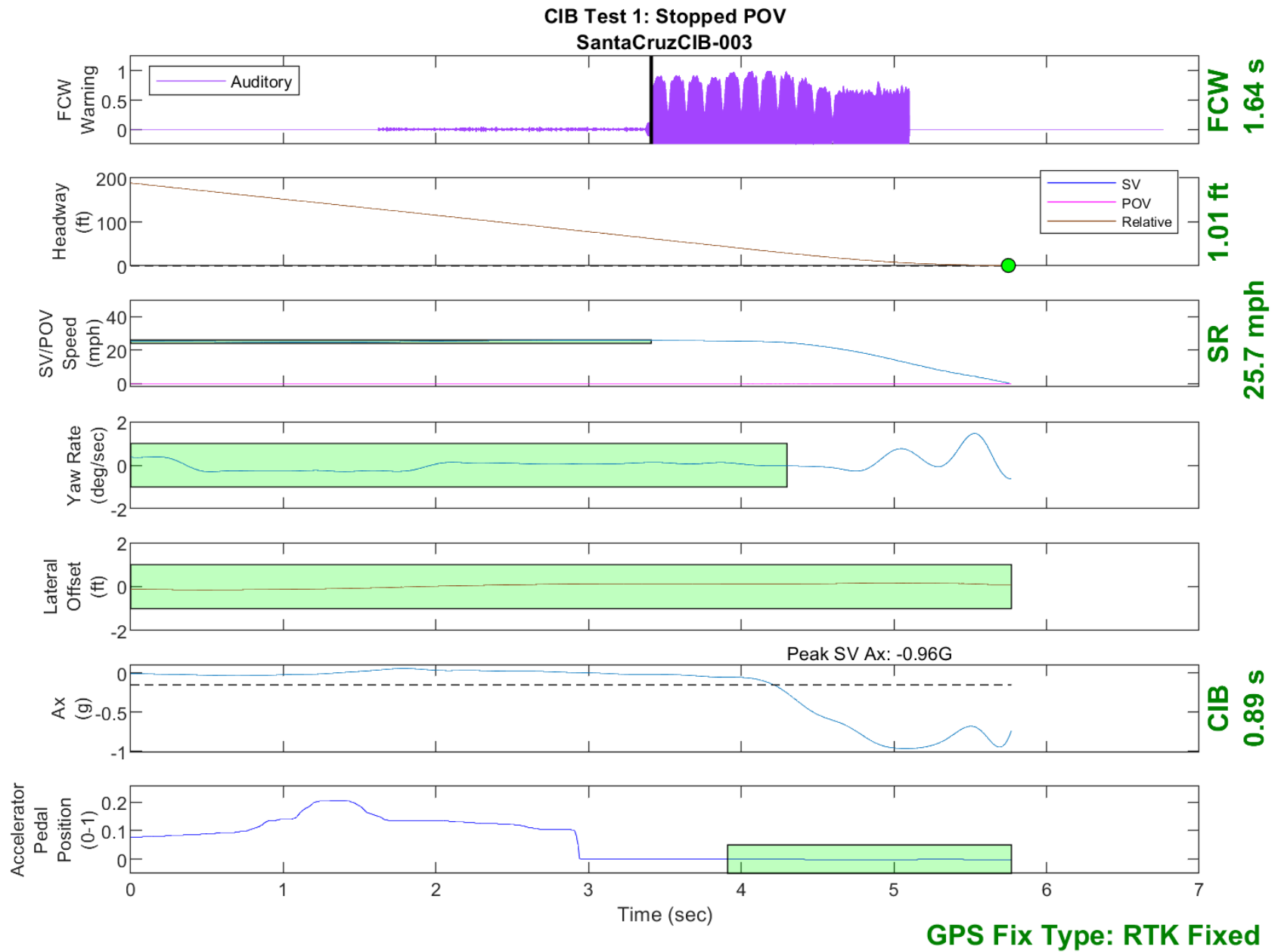


Figure D11. Time History for CIB Run 3, Test 1 - Stopped POV

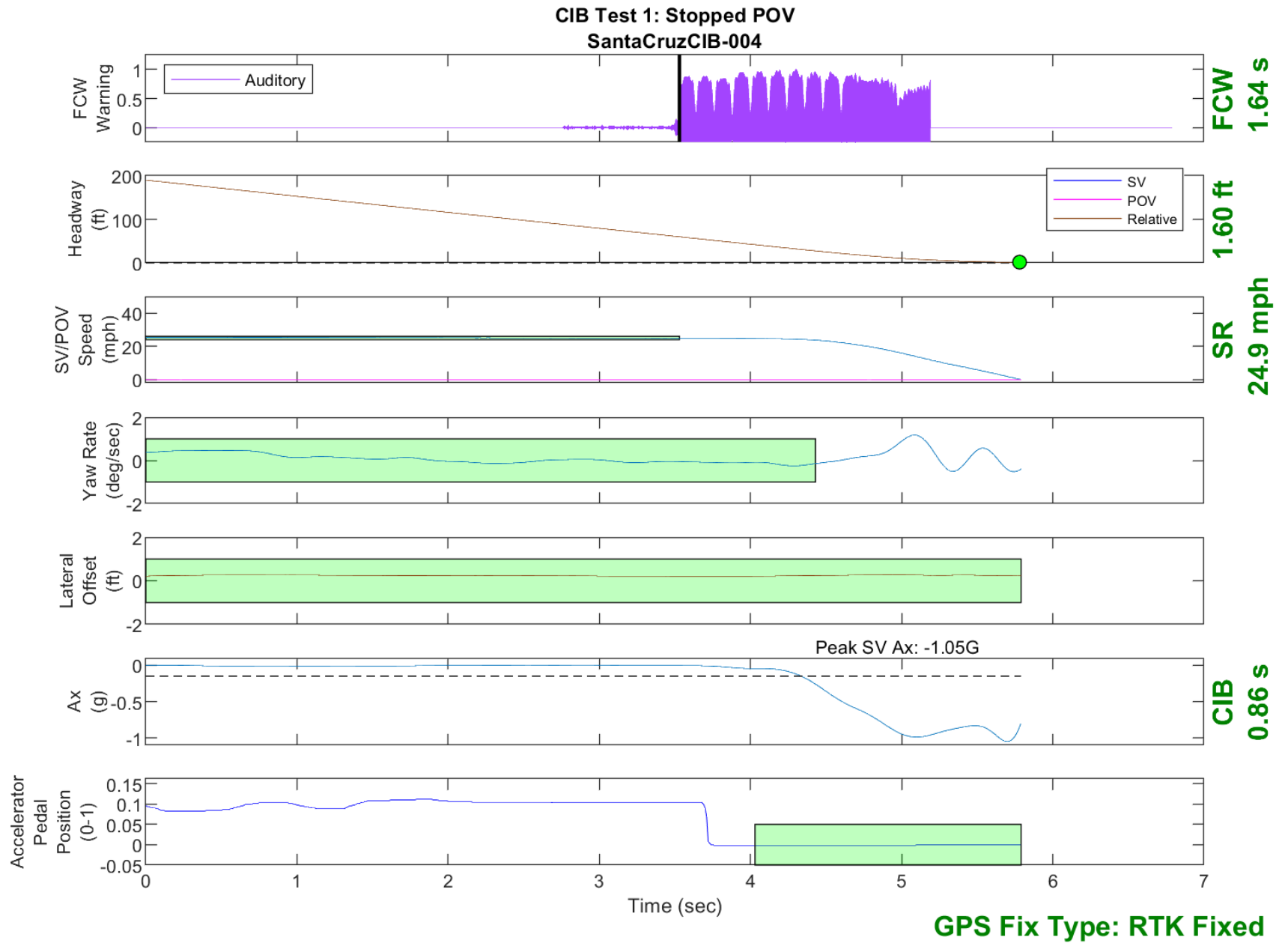


Figure D12. Time History for CIB Run 4, Test 1 - Stopped POV

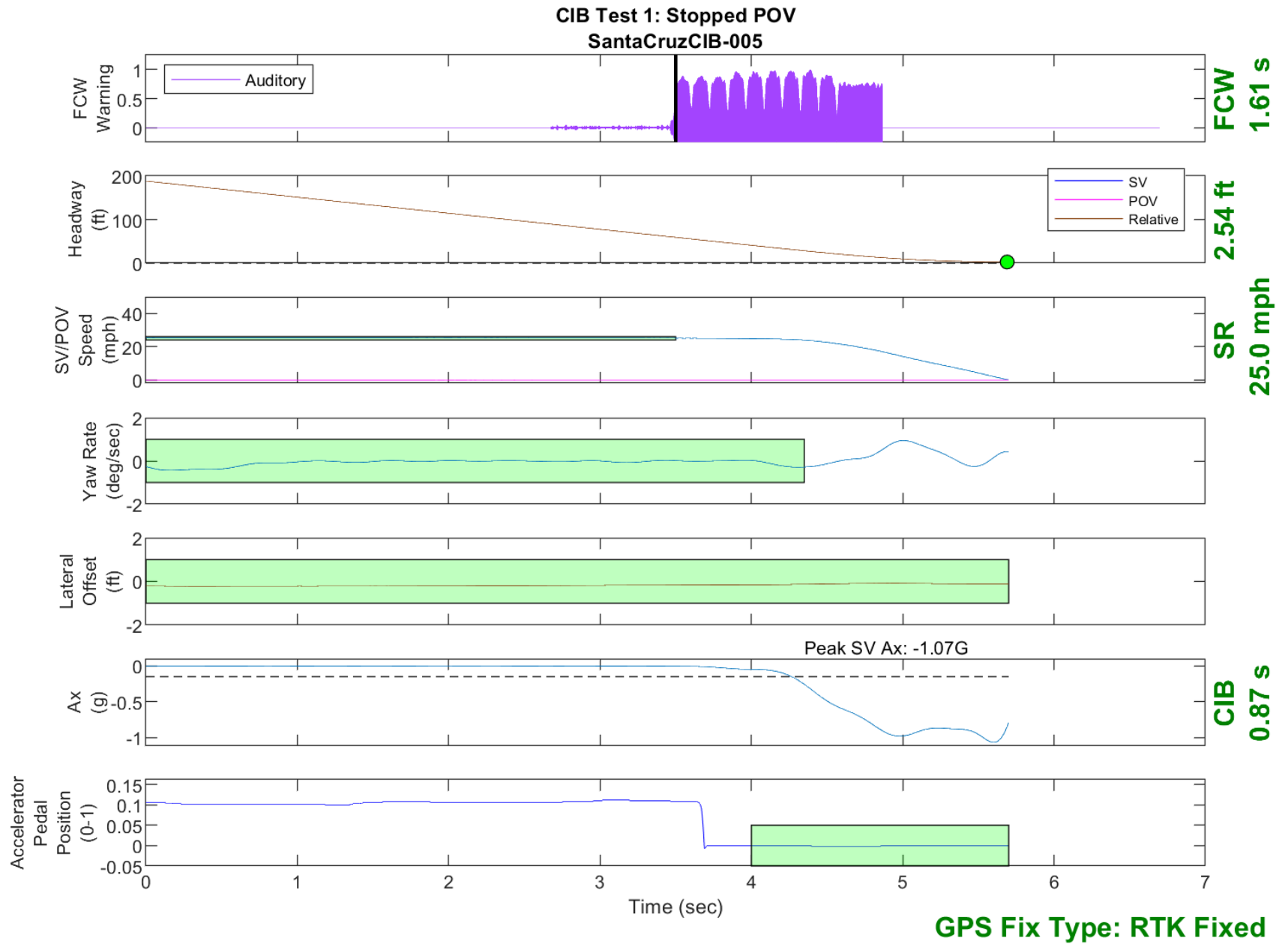


Figure D13. Time History for CIB Run 5, Test 1 - Stopped POV

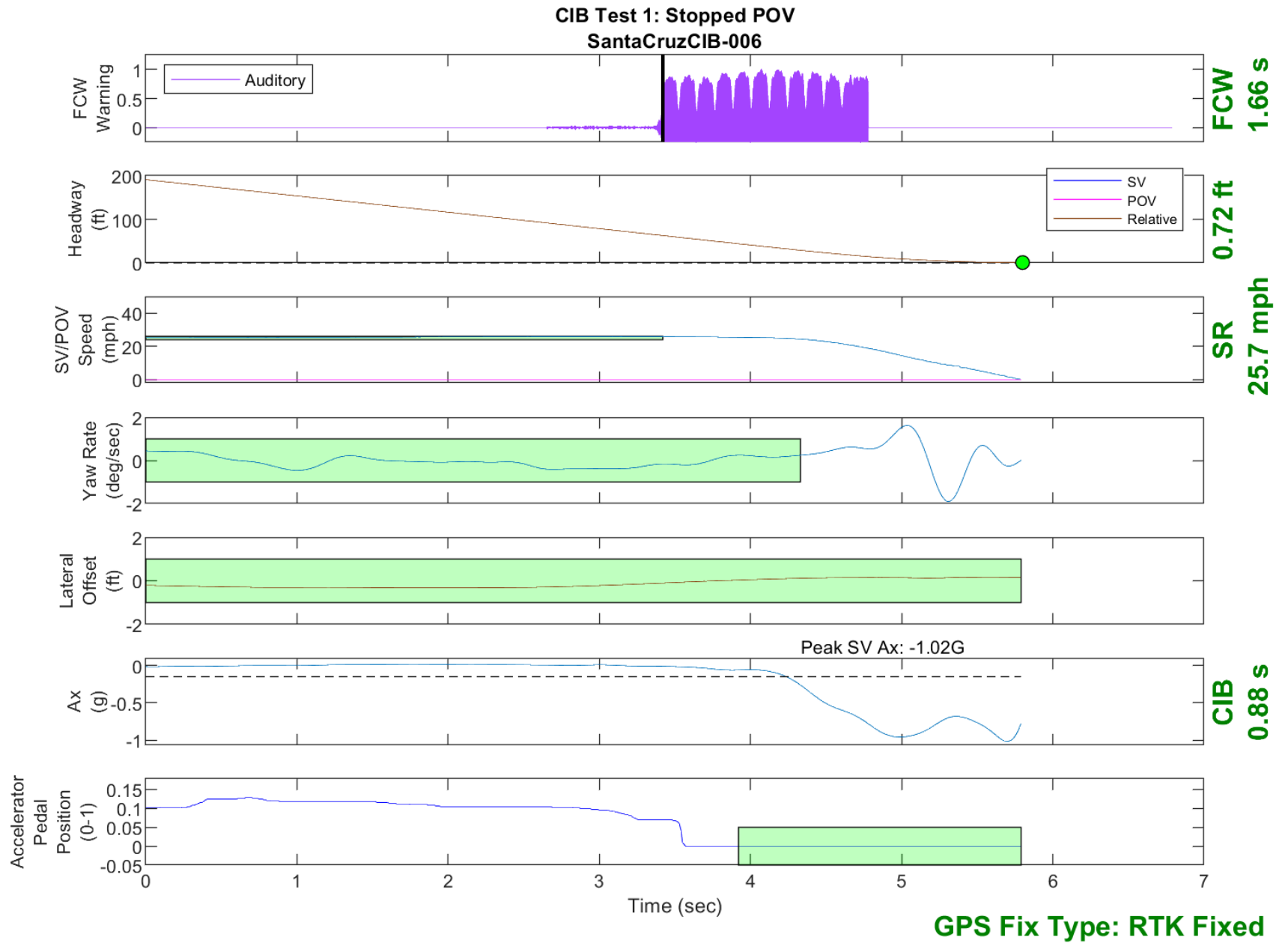


Figure D14. Time History for CIB Run 6, Test 1 - Stopped POV



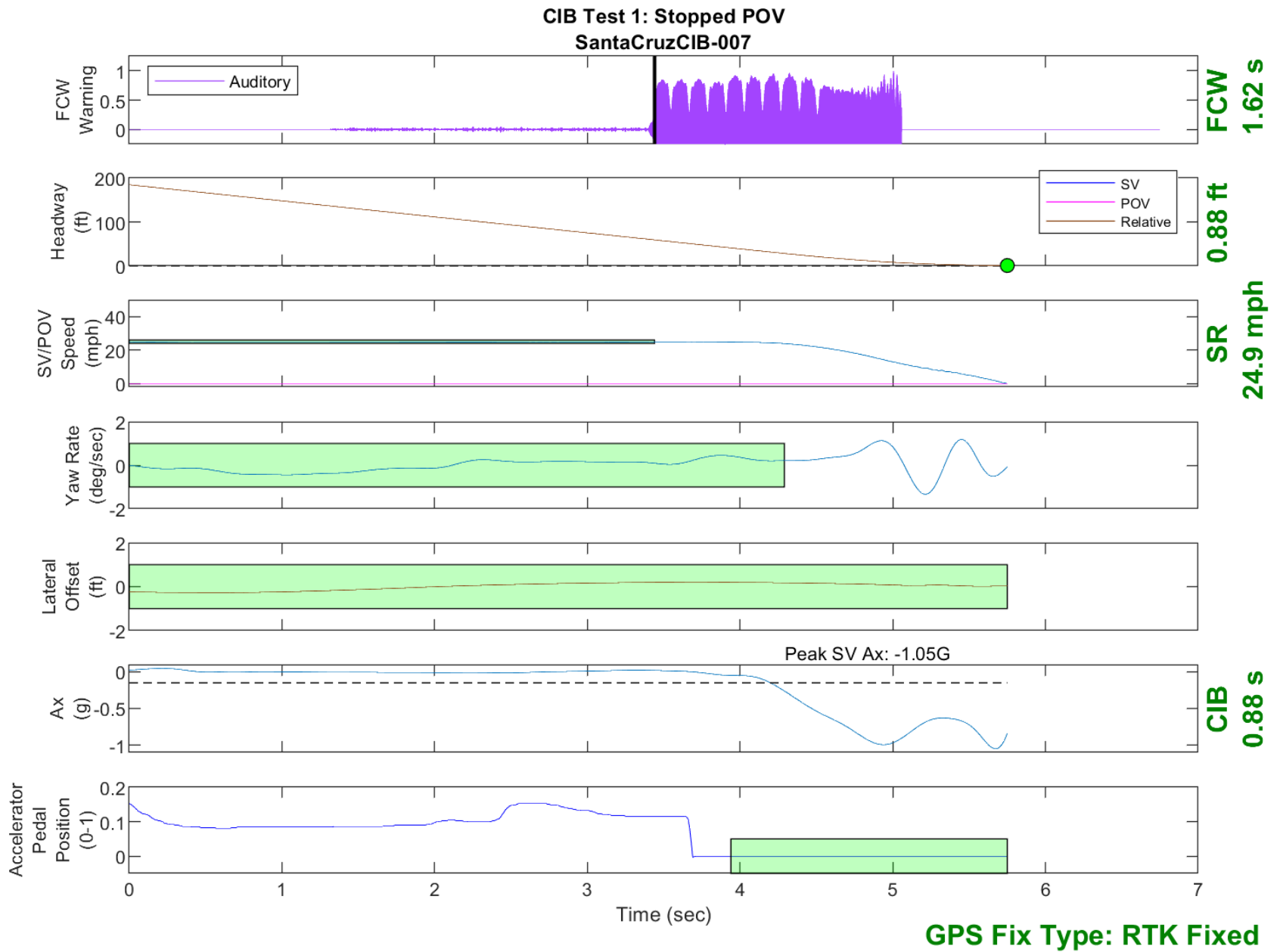


Figure D15. Time History for CIB Run 7, Test 1 - Stopped POV

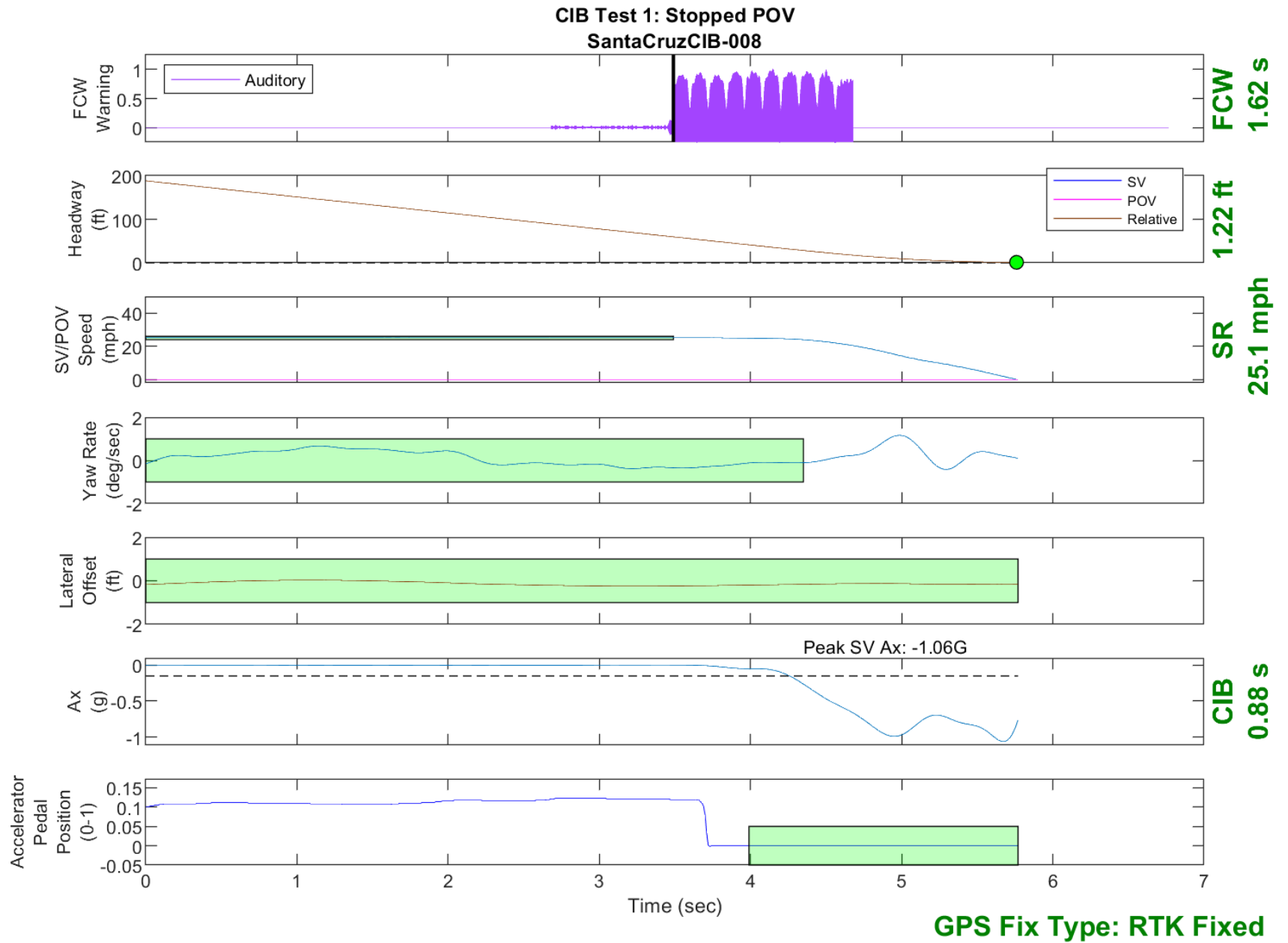


Figure D16. Time History for CIB Run 8, Test 1 - Stopped POV

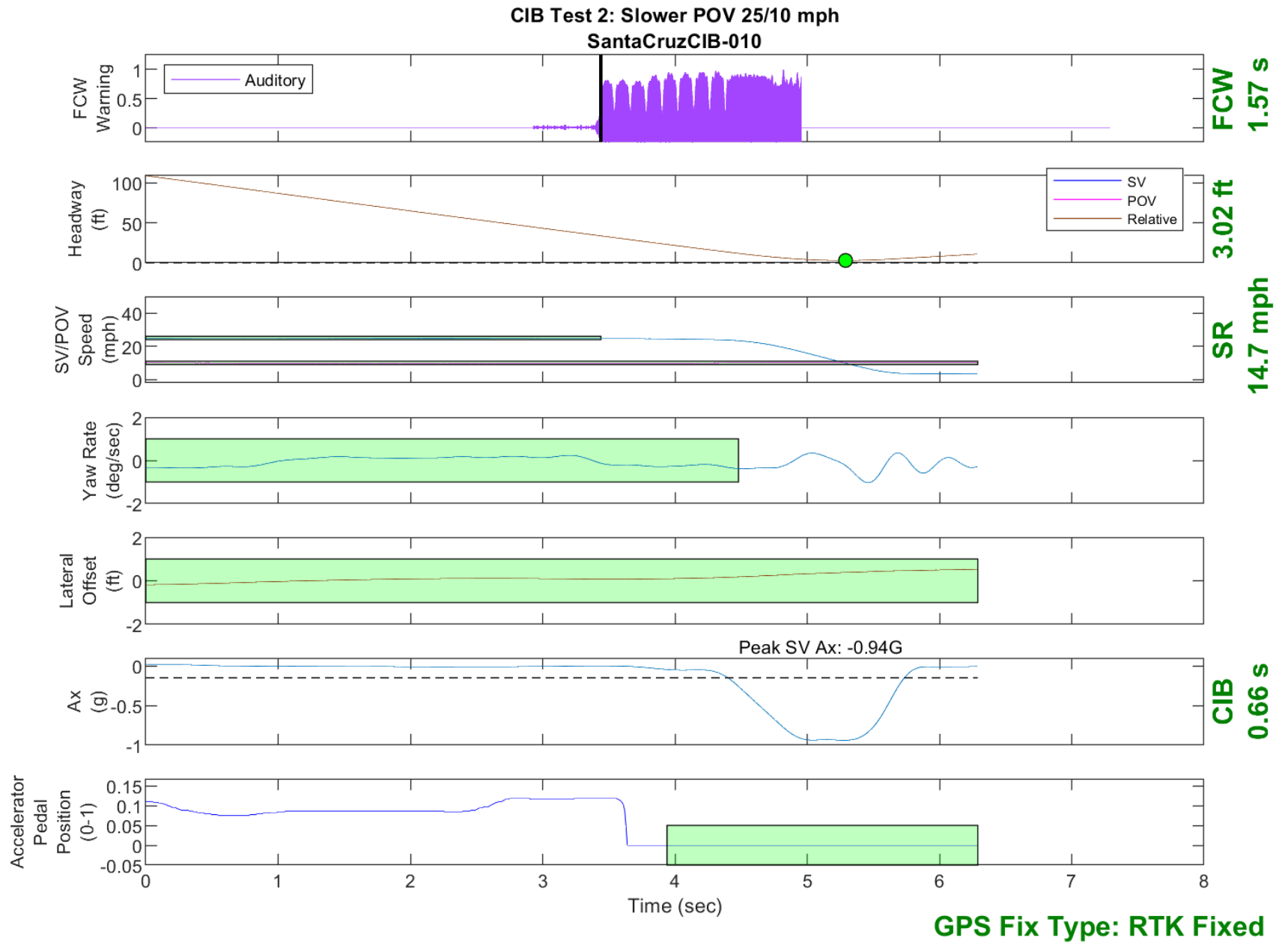


Figure D17. Time History for CIB Run 10, Test 2 - Slower Moving POV, 25/10 mph

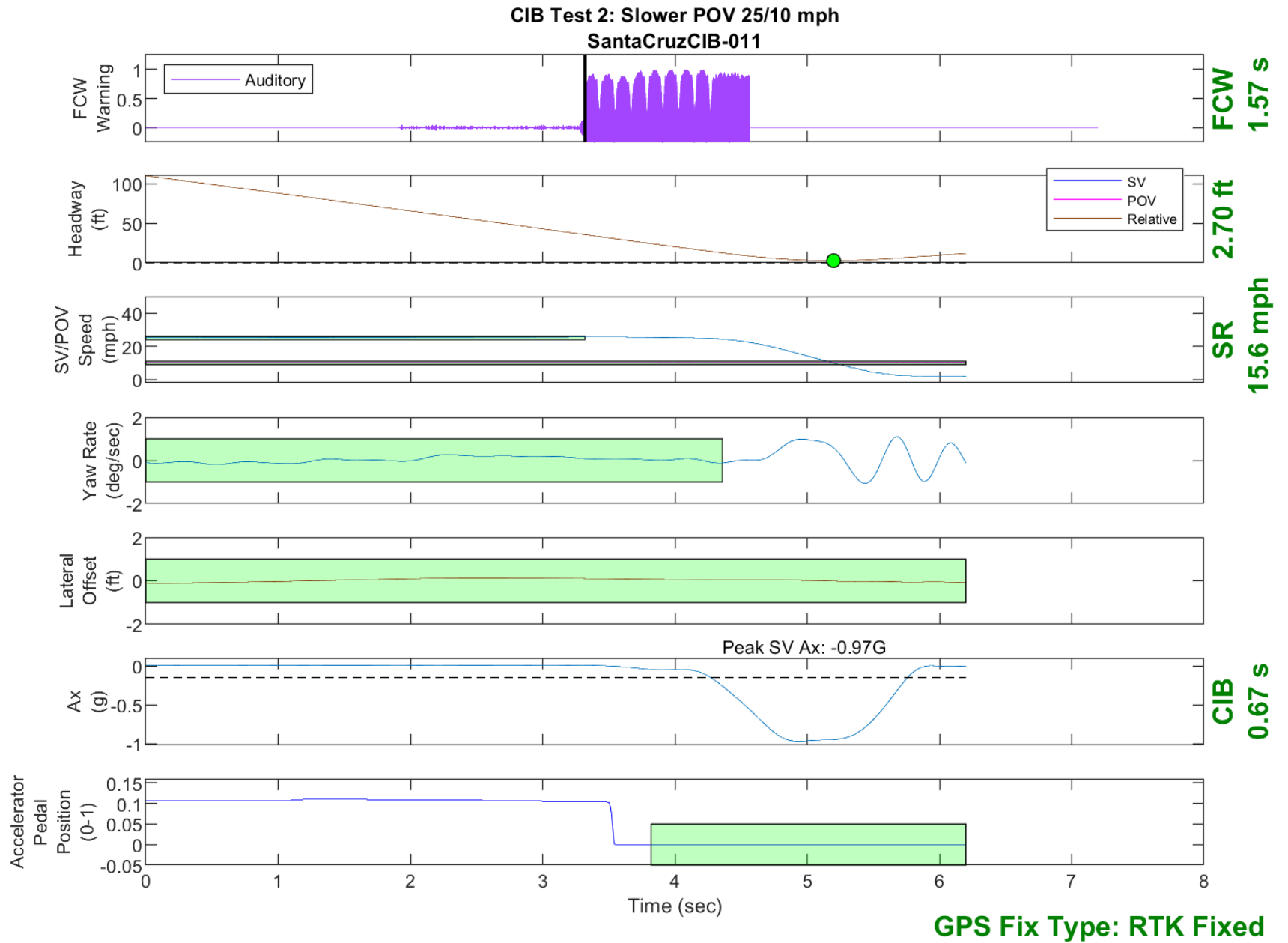


Figure D18. Time History for CIB Run 11, Test 2 - Slower Moving POV, 25/10 mph

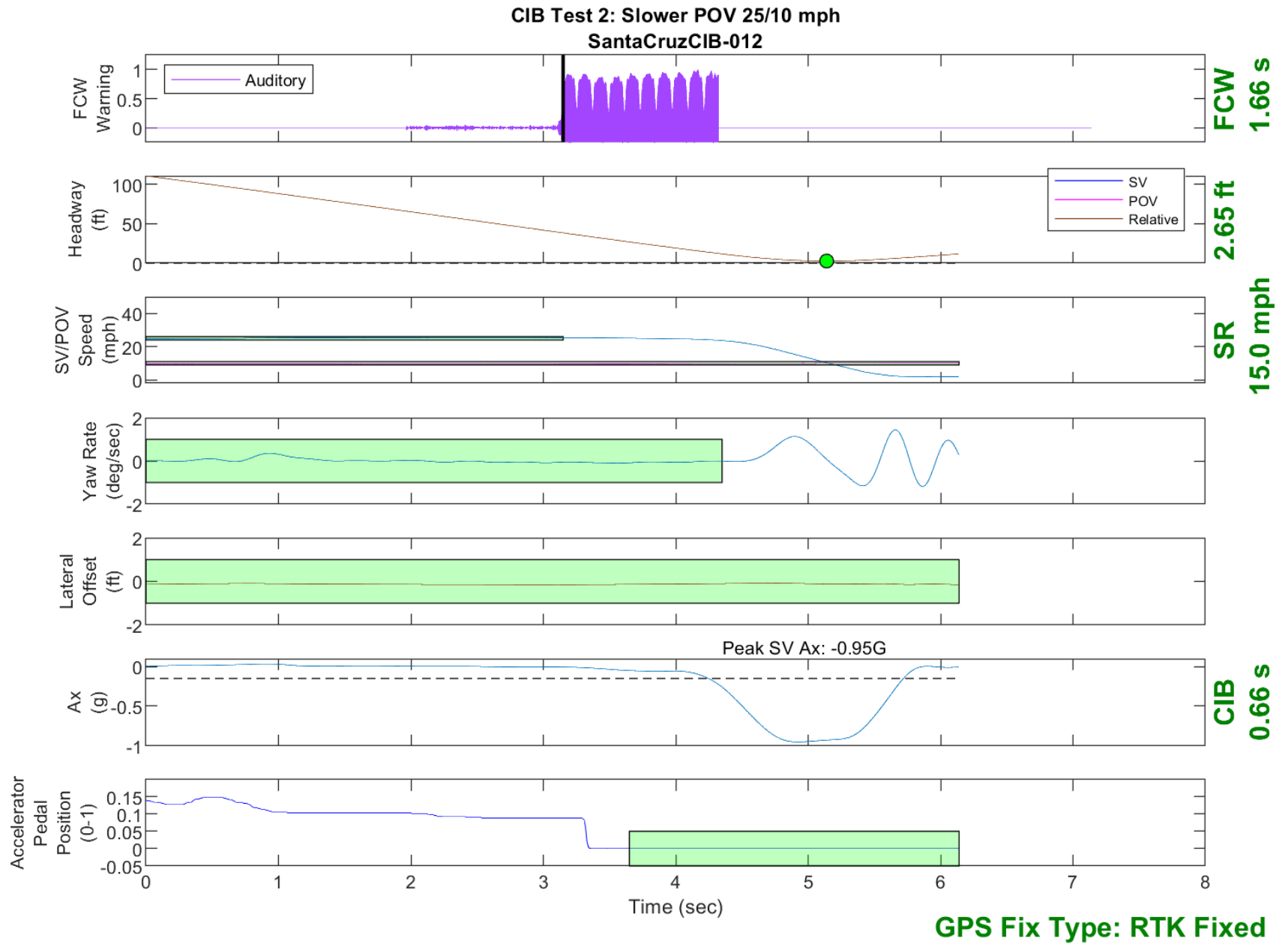


Figure D19. Time History for CIB Run 12, Test 2 - Slower Moving POV, 25/10 mph



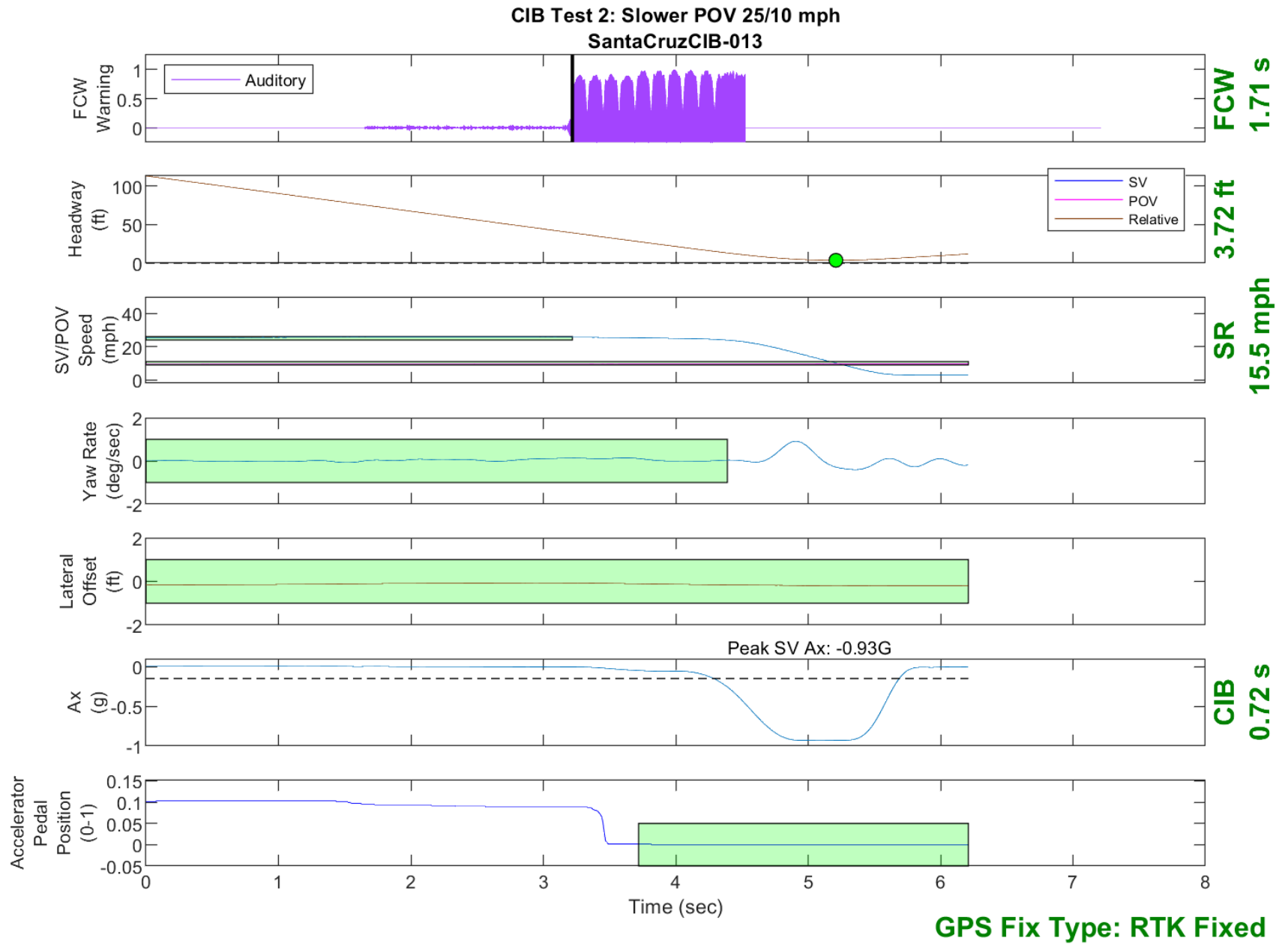


Figure D20. Time History for CIB Run 13, Test 2 - Slower Moving POV, 25/10 mph

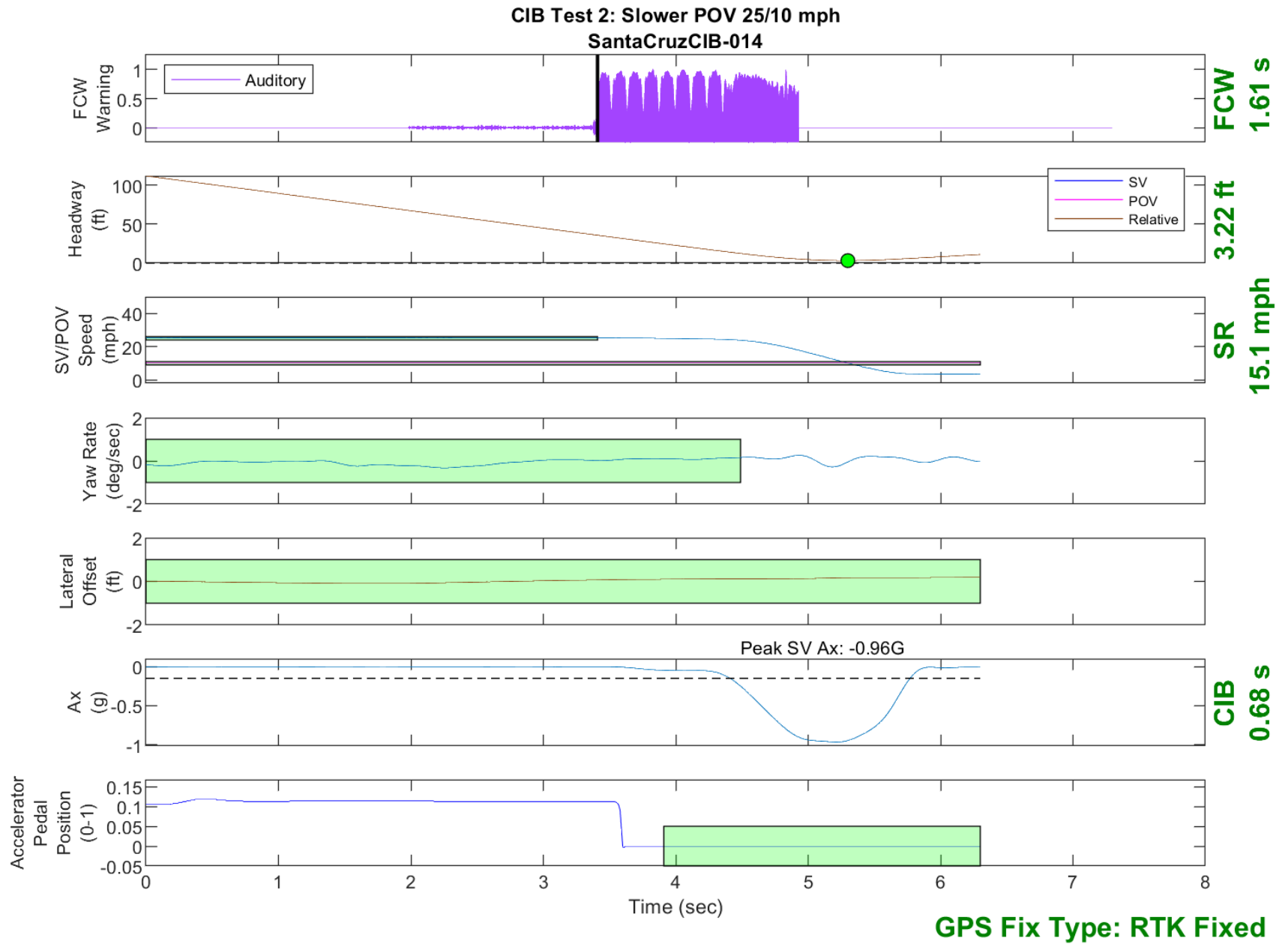


Figure D21. Time History for CIB Run 14, Test 2 - Slower Moving POV, 25/10 mph



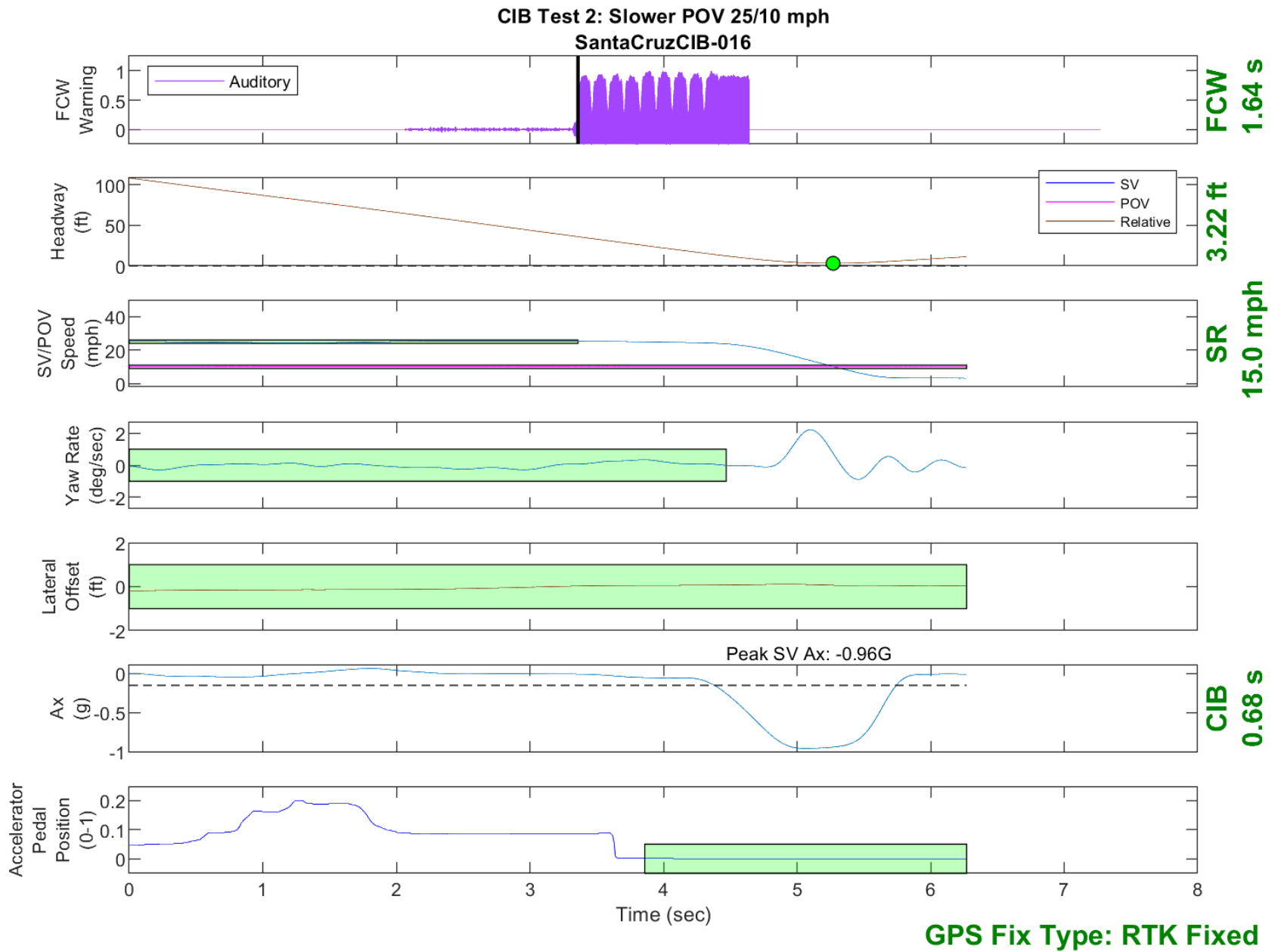


Figure D23. Time History for CIB Run 16, Test 2 - Slower Moving POV, 25/10 mph

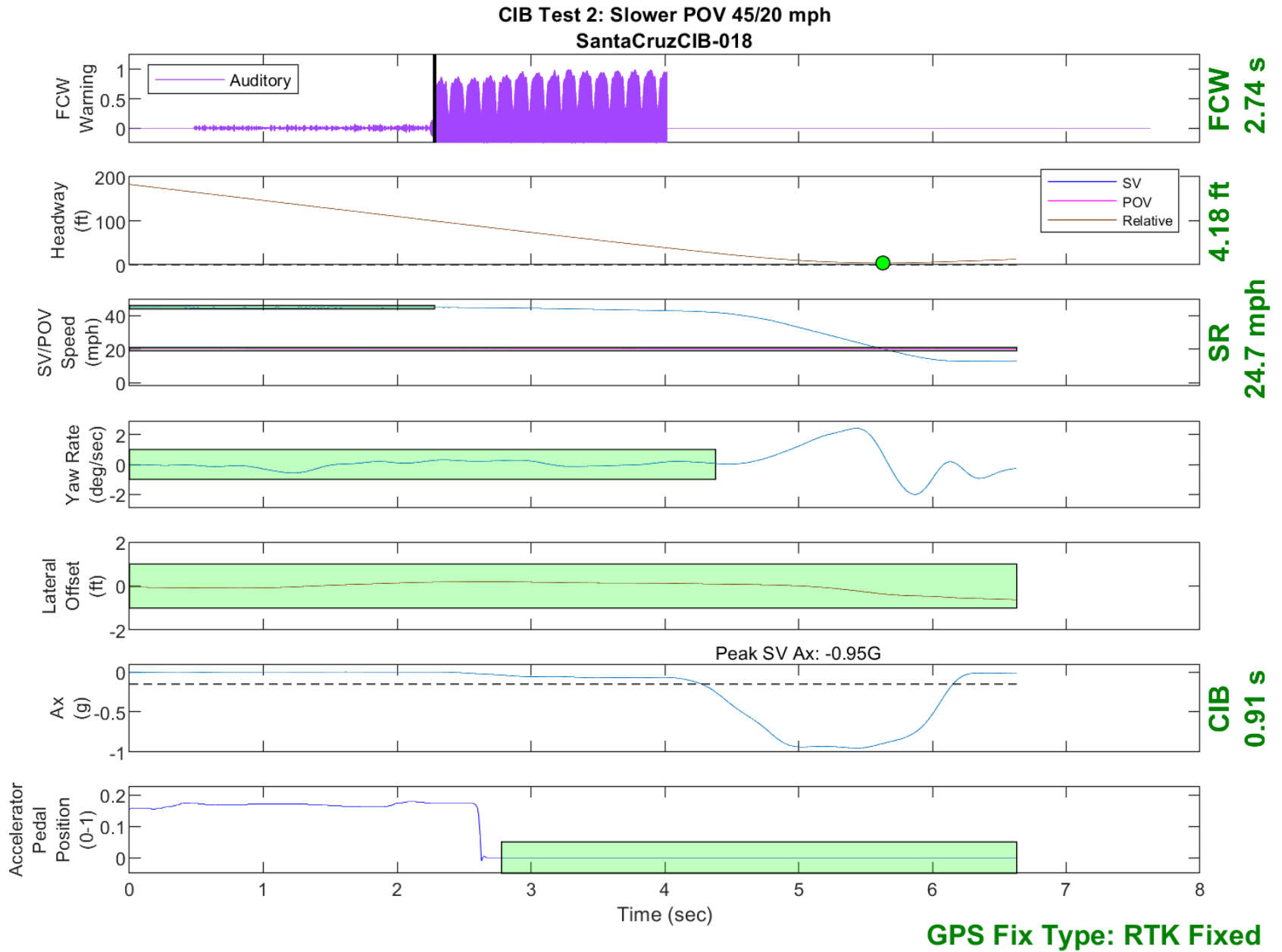


Figure D24. Time History for CIB Run 18, Test 2 - Slower Moving POV, 45/20 mph

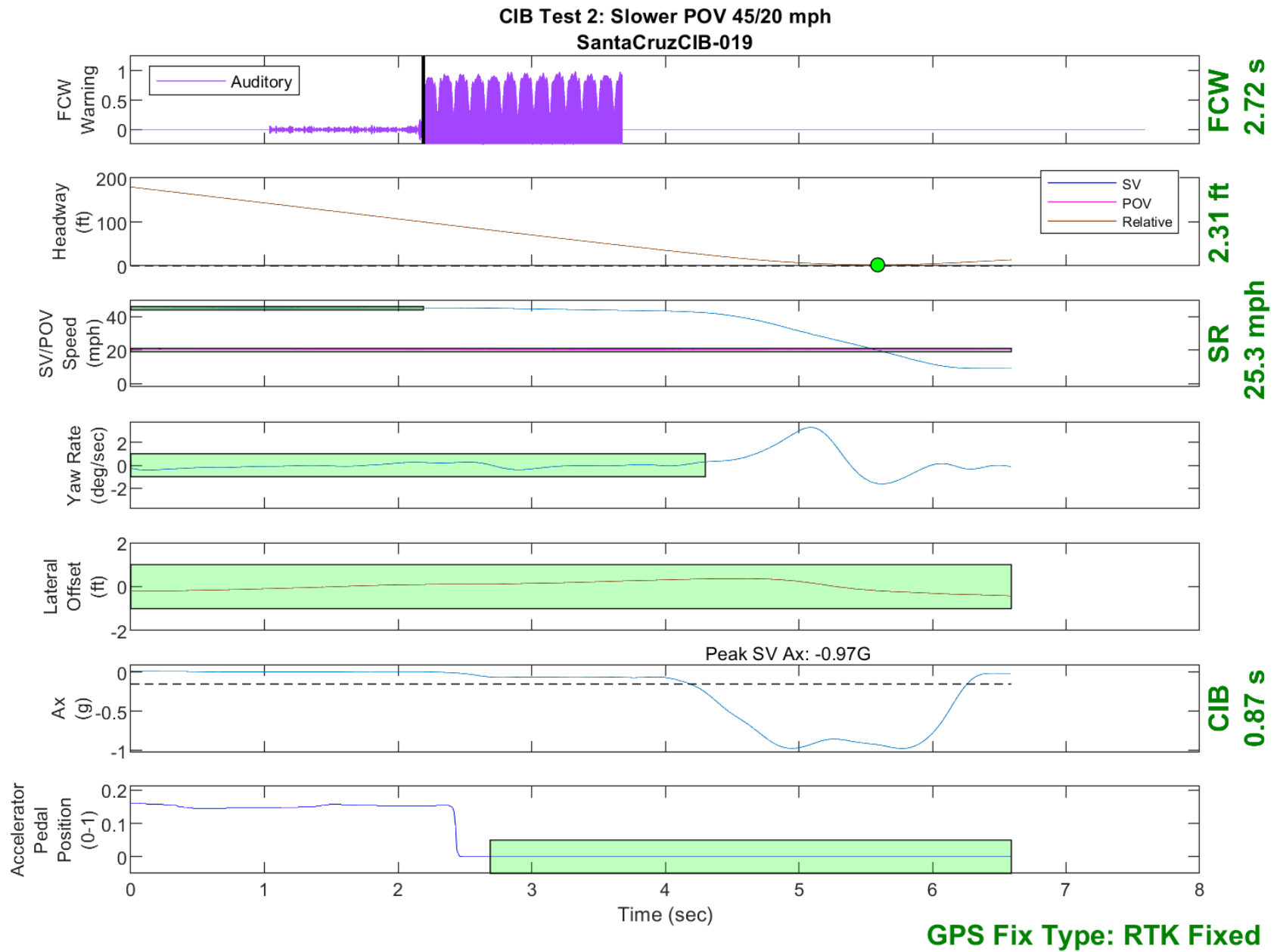


Figure D25. Time History for CIB Run 19, Test 2 - Slower Moving POV, 45/20 mph



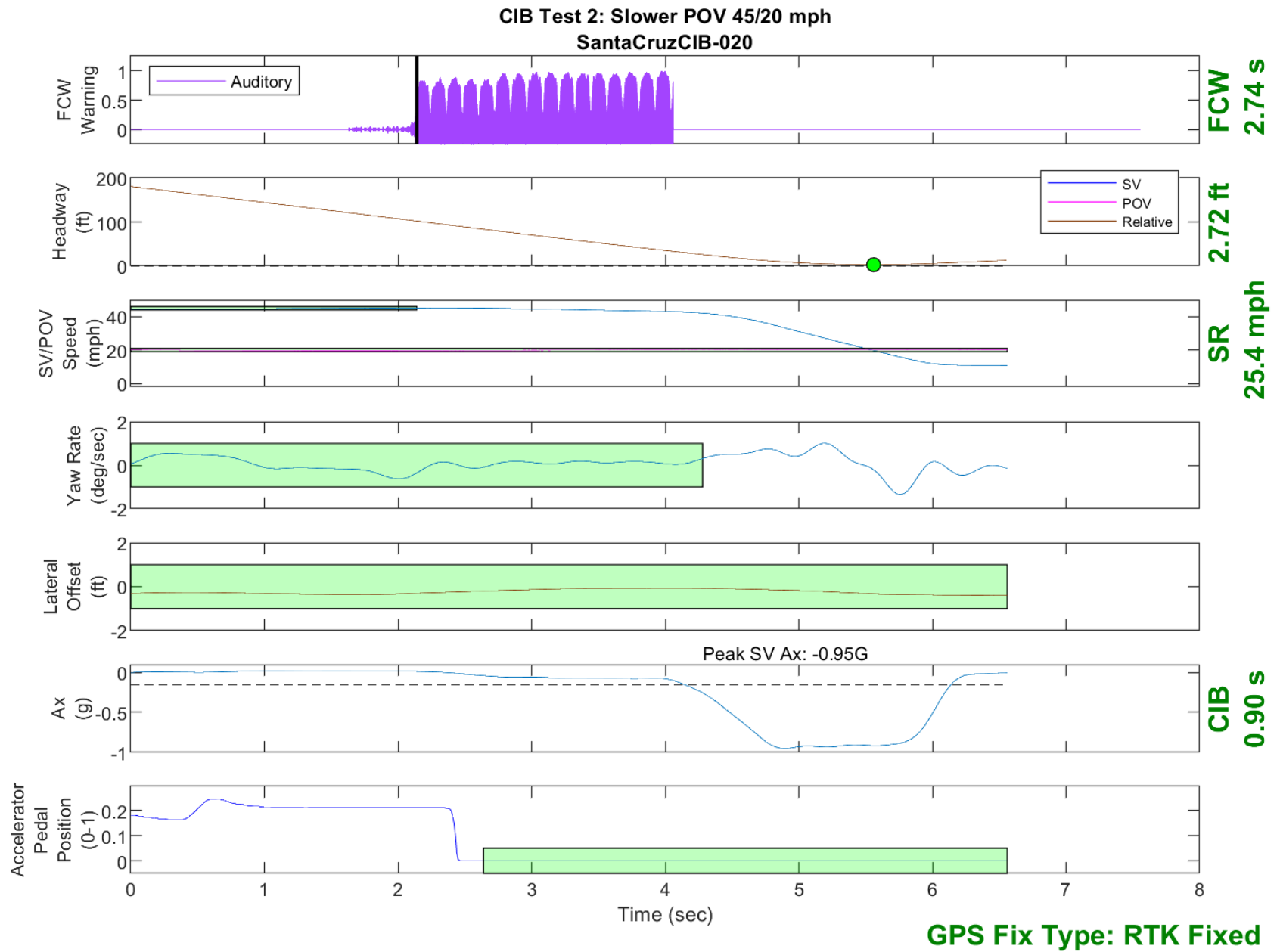


Figure D26. Time History for CIB Run 20, Test 2 - Slower Moving POV, 45/20 mph

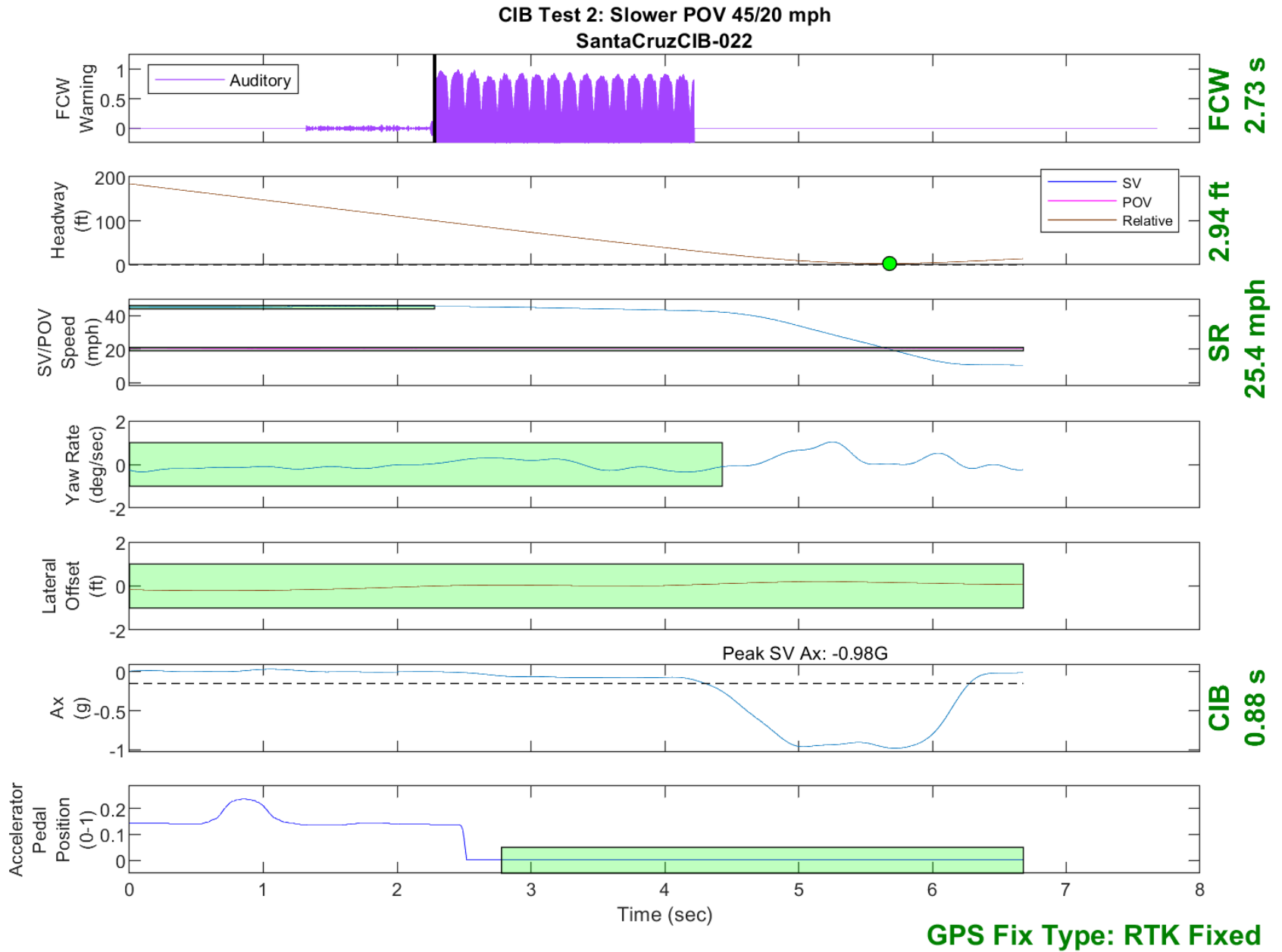


Figure D27. Time History for CIB Run 22, Test 2 - Slower Moving POV, 45/20 mph

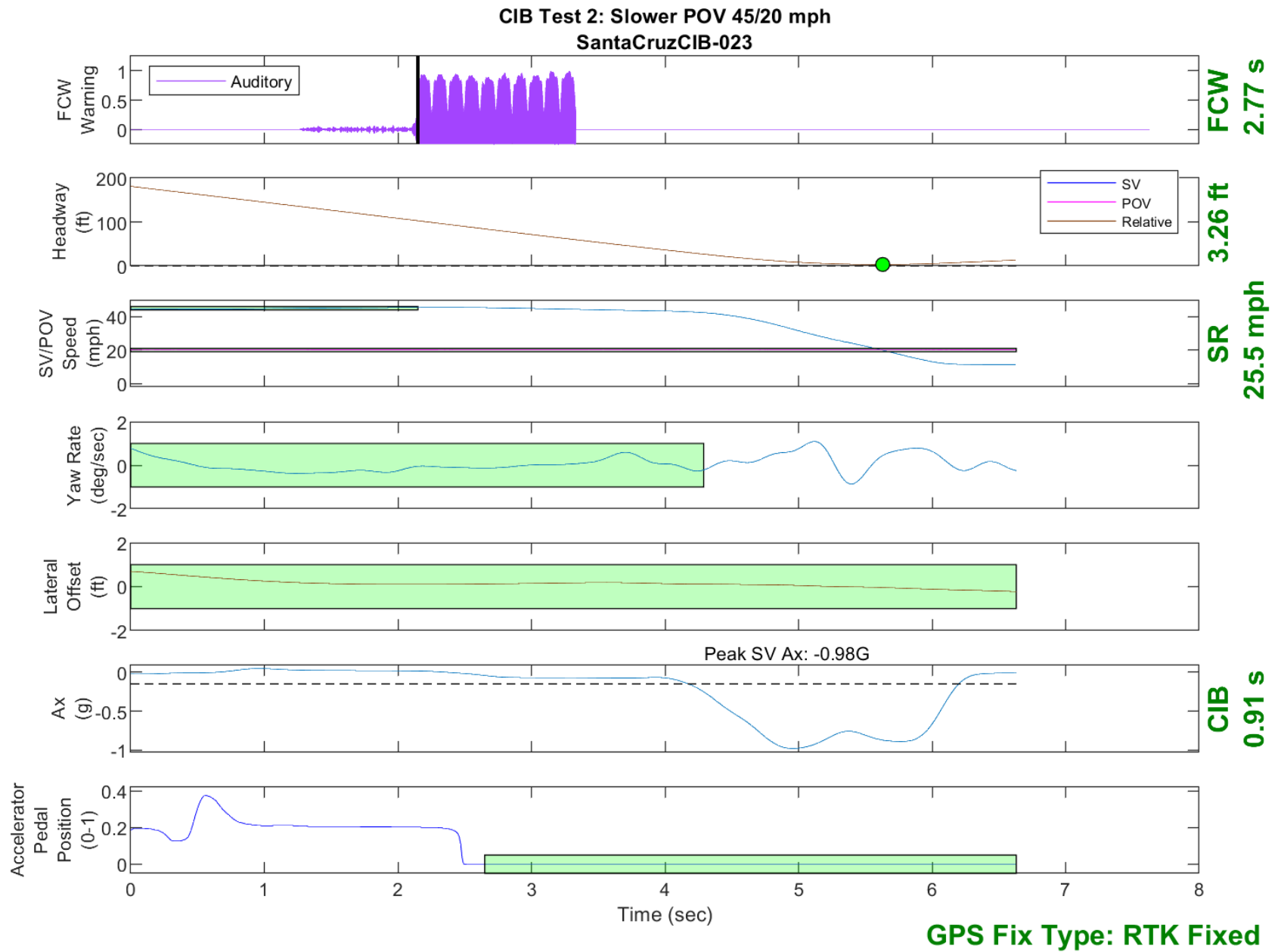


Figure D28. Time History for CIB Run 23, Test 2 - Slower Moving POV, 45/20 mph

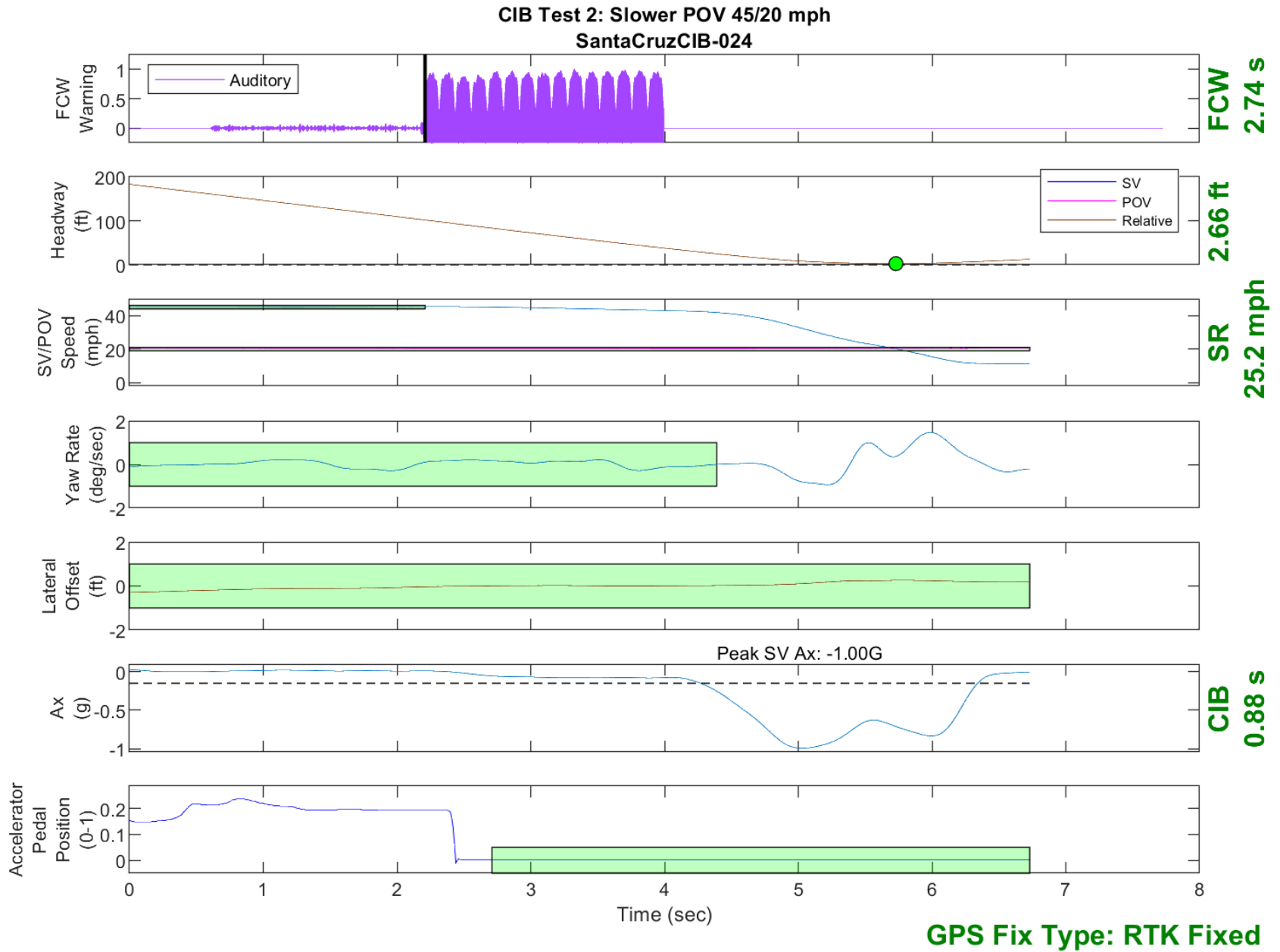


Figure D29. Time History for CIB Run 24, Test 2 - Slower Moving POV, 45/20 mph

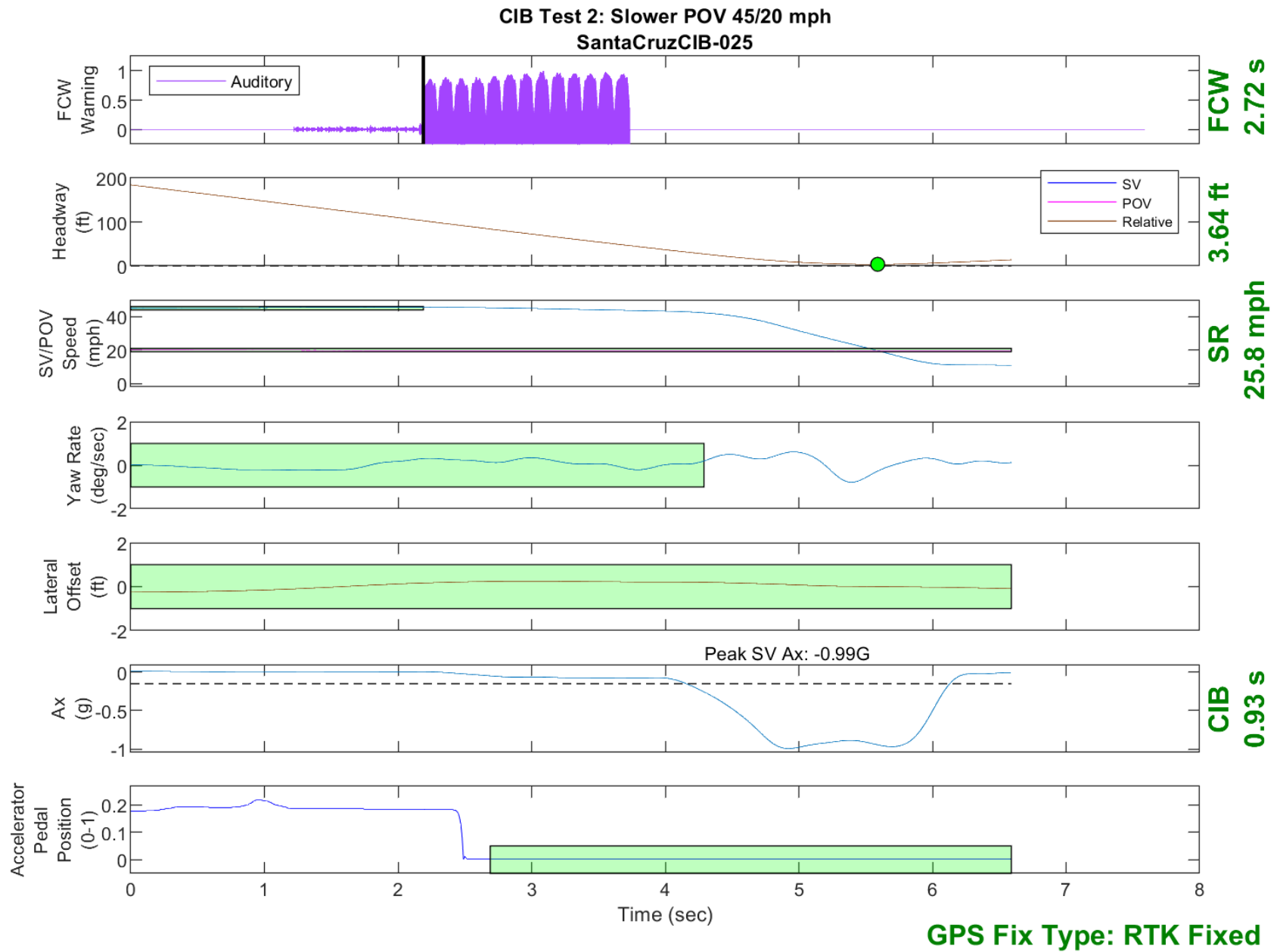


Figure D30. Time History for CIB Run 25, Test 2 - Slower Moving POV, 45/20 mph

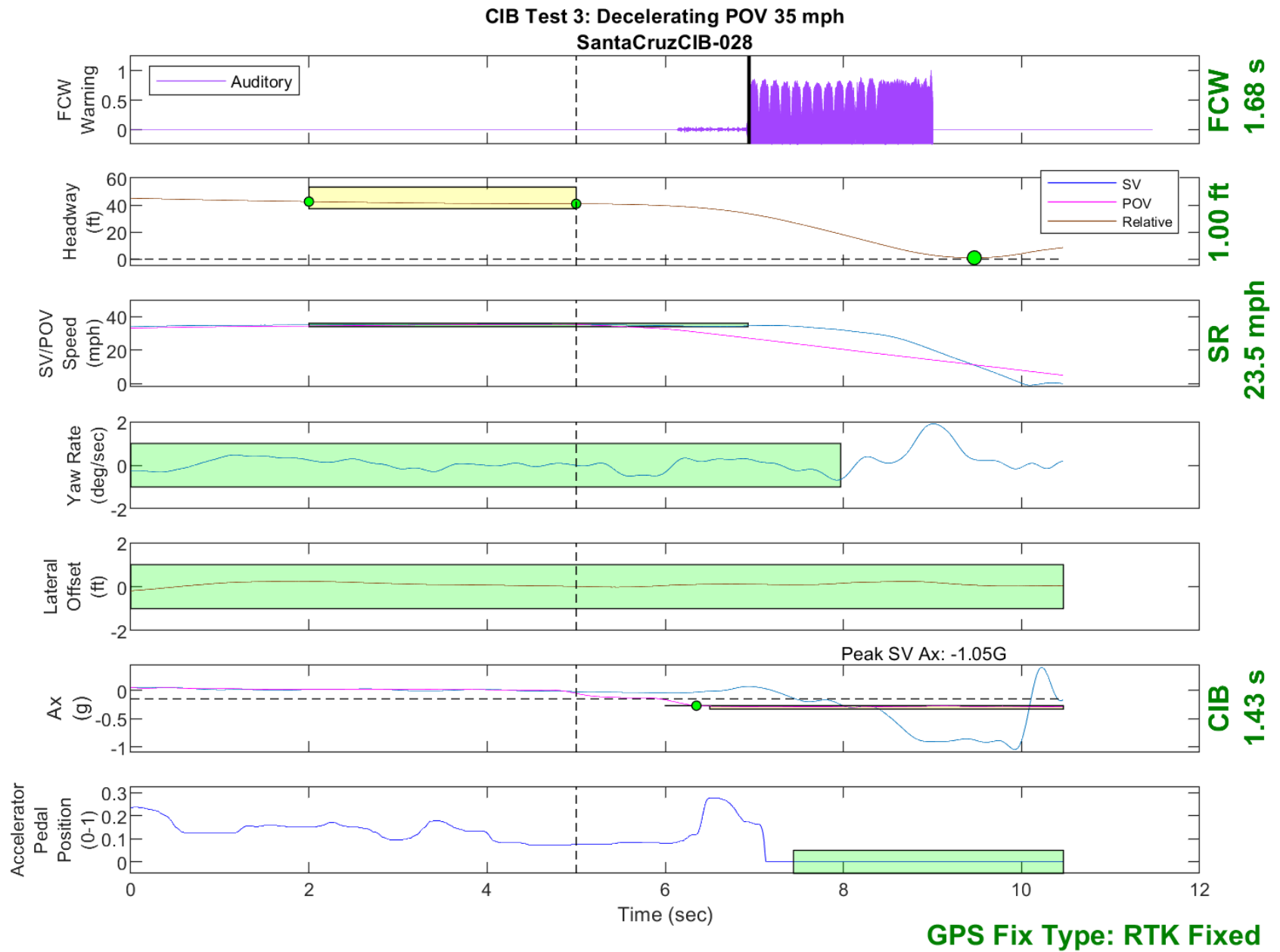


Figure D31. Time History for CIB Run 28, Test 3 - Decelerating POV 35 mph



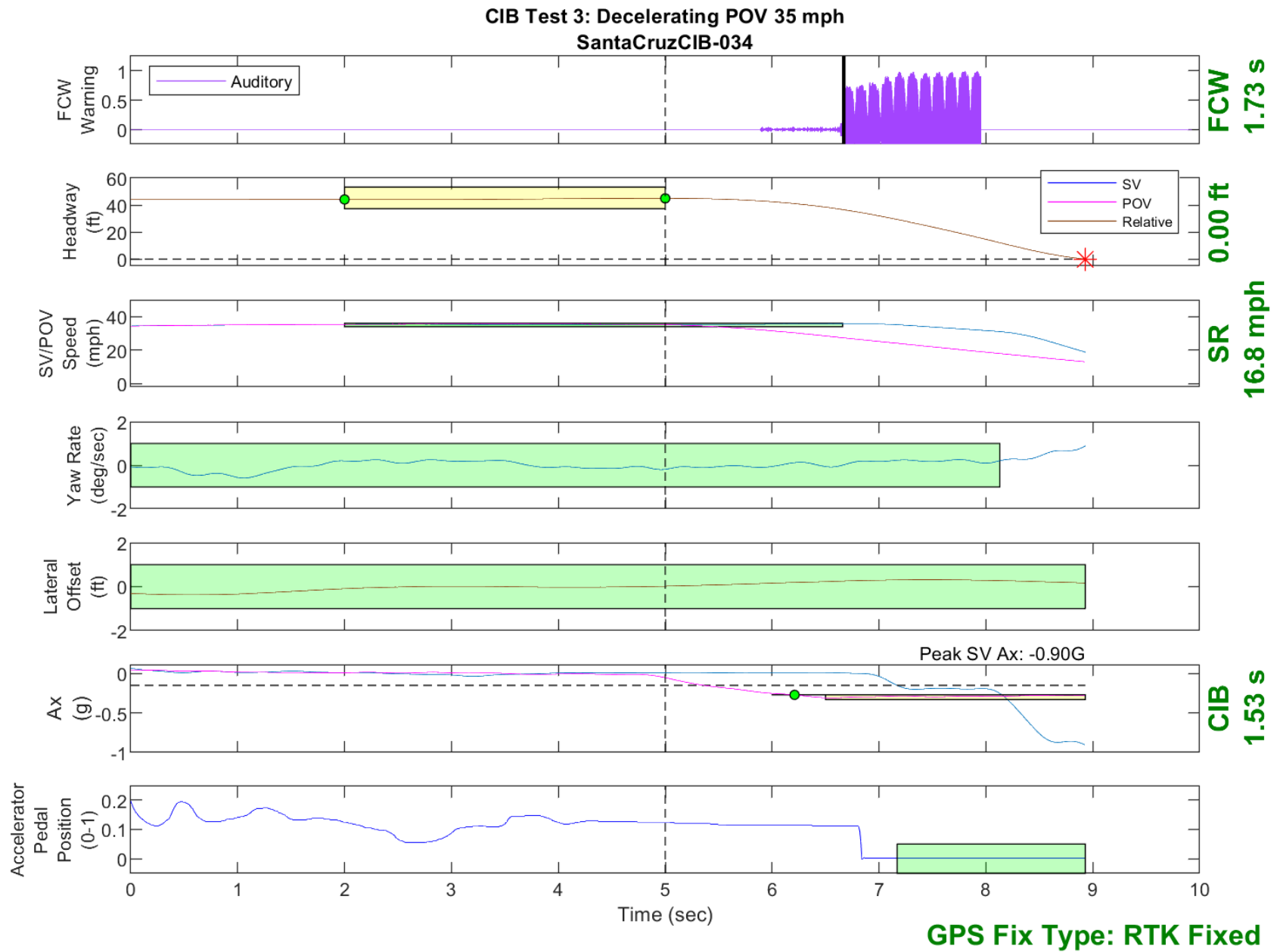


Figure D32. Time History for CIB Run 34, Test 3 - Decelerating POV 35 mph

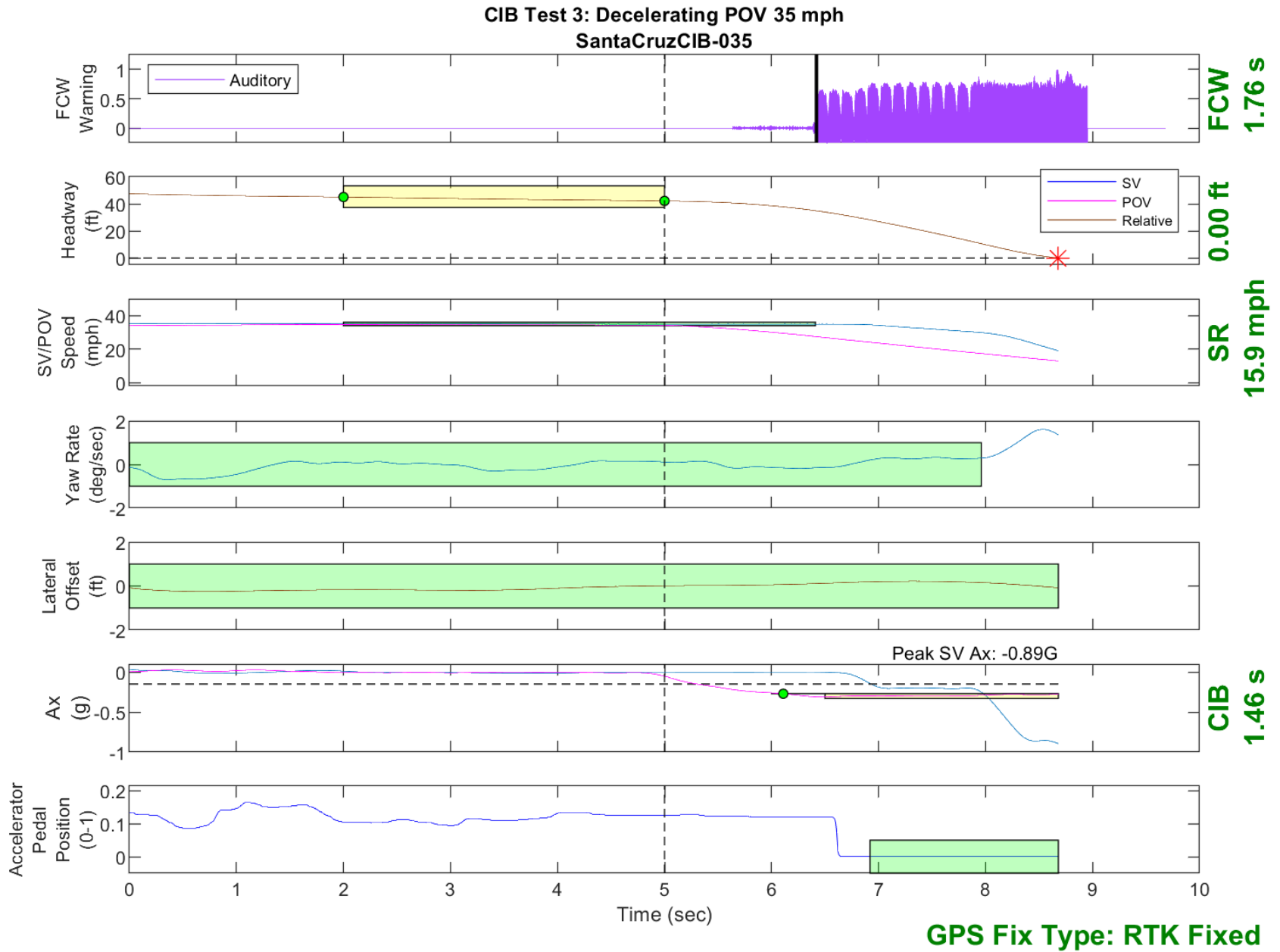


Figure D33. Time History for CIB Run 35, Test 3 - Decelerating POV 35 mph

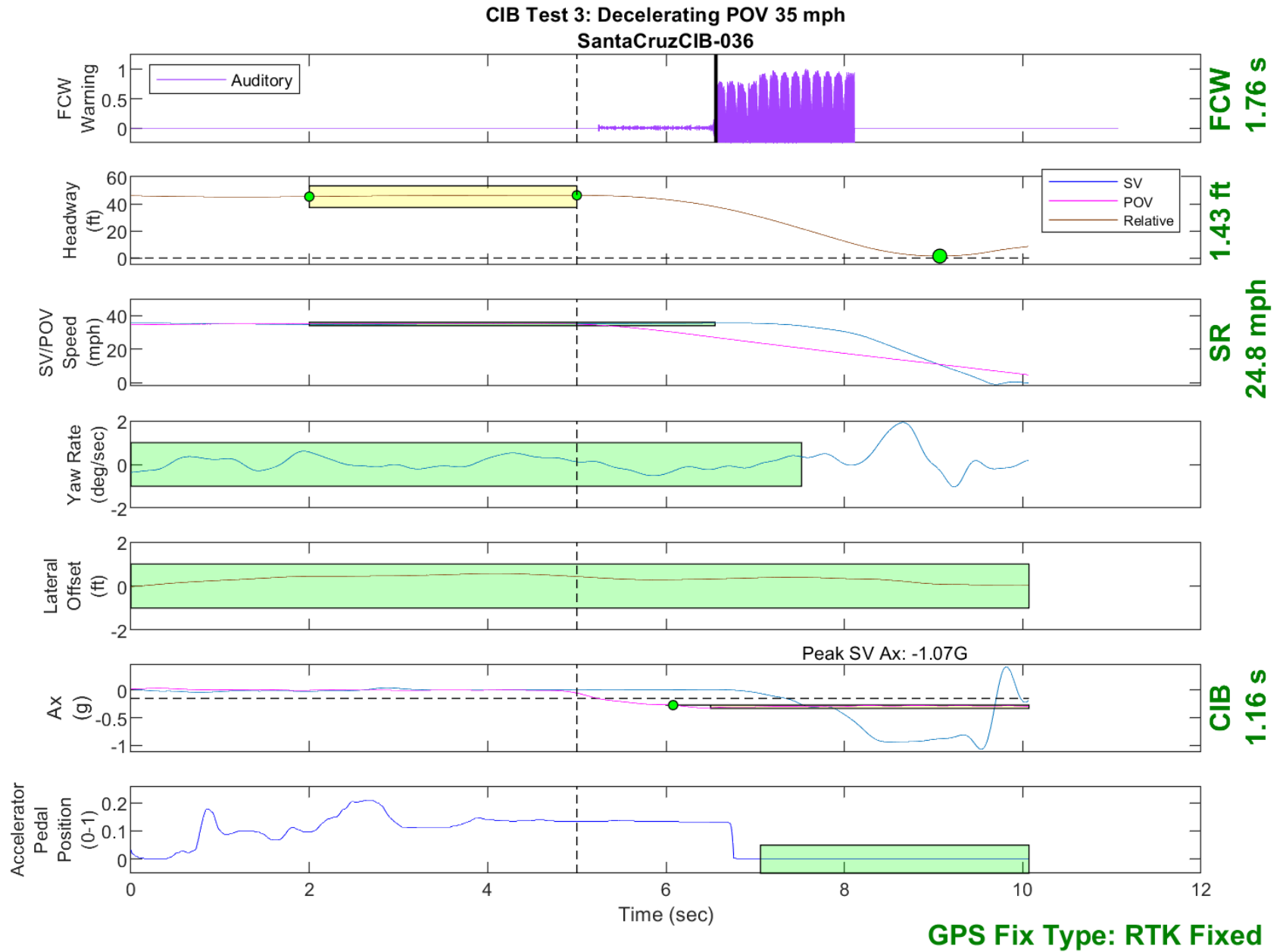


Figure D34. Time History for CIB Run 36, Test 3 - Decelerating POV 35 mph

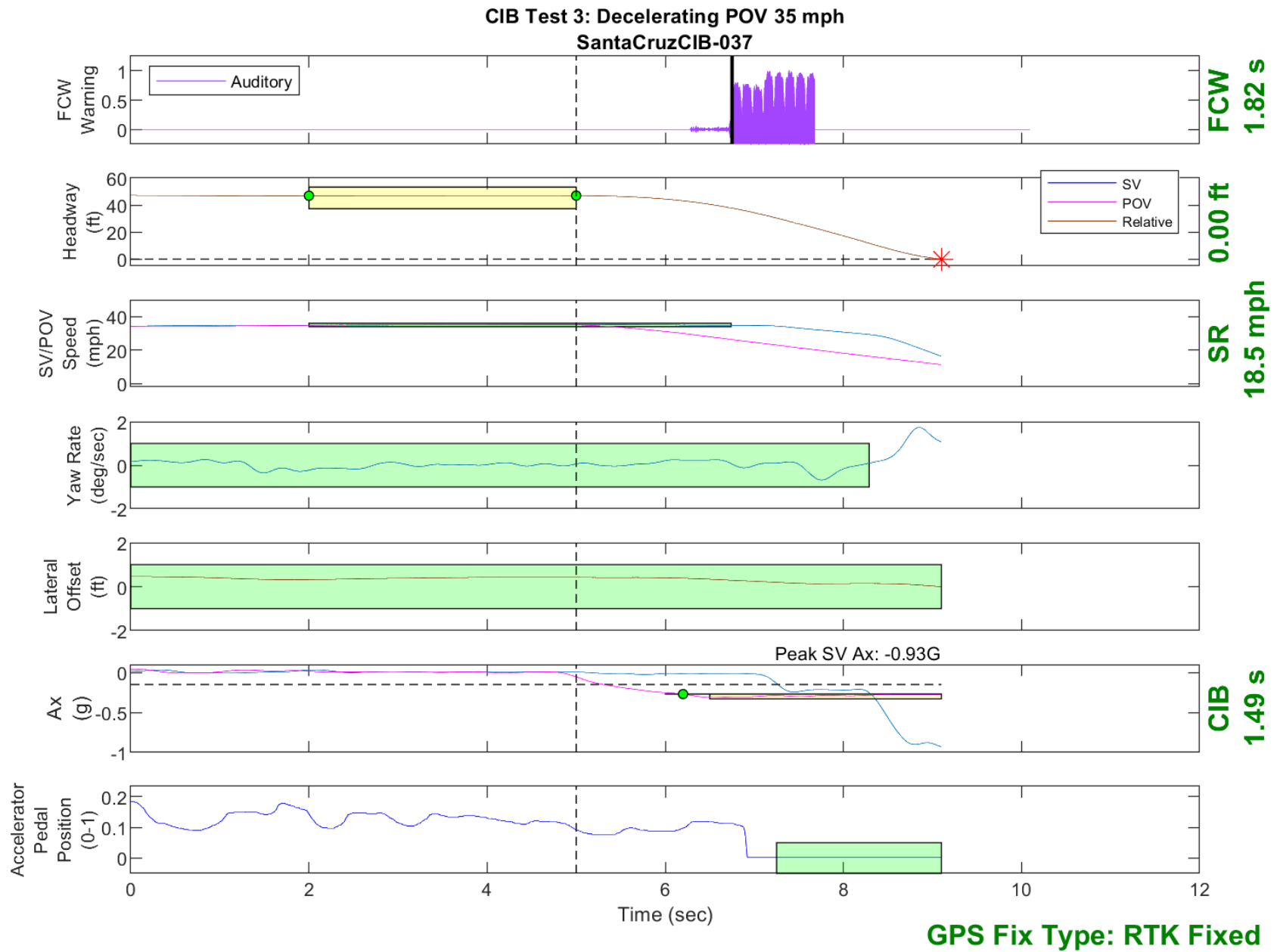


Figure D35. Time History for CIB Run 37, Test 3 - Decelerating POV 35 mph

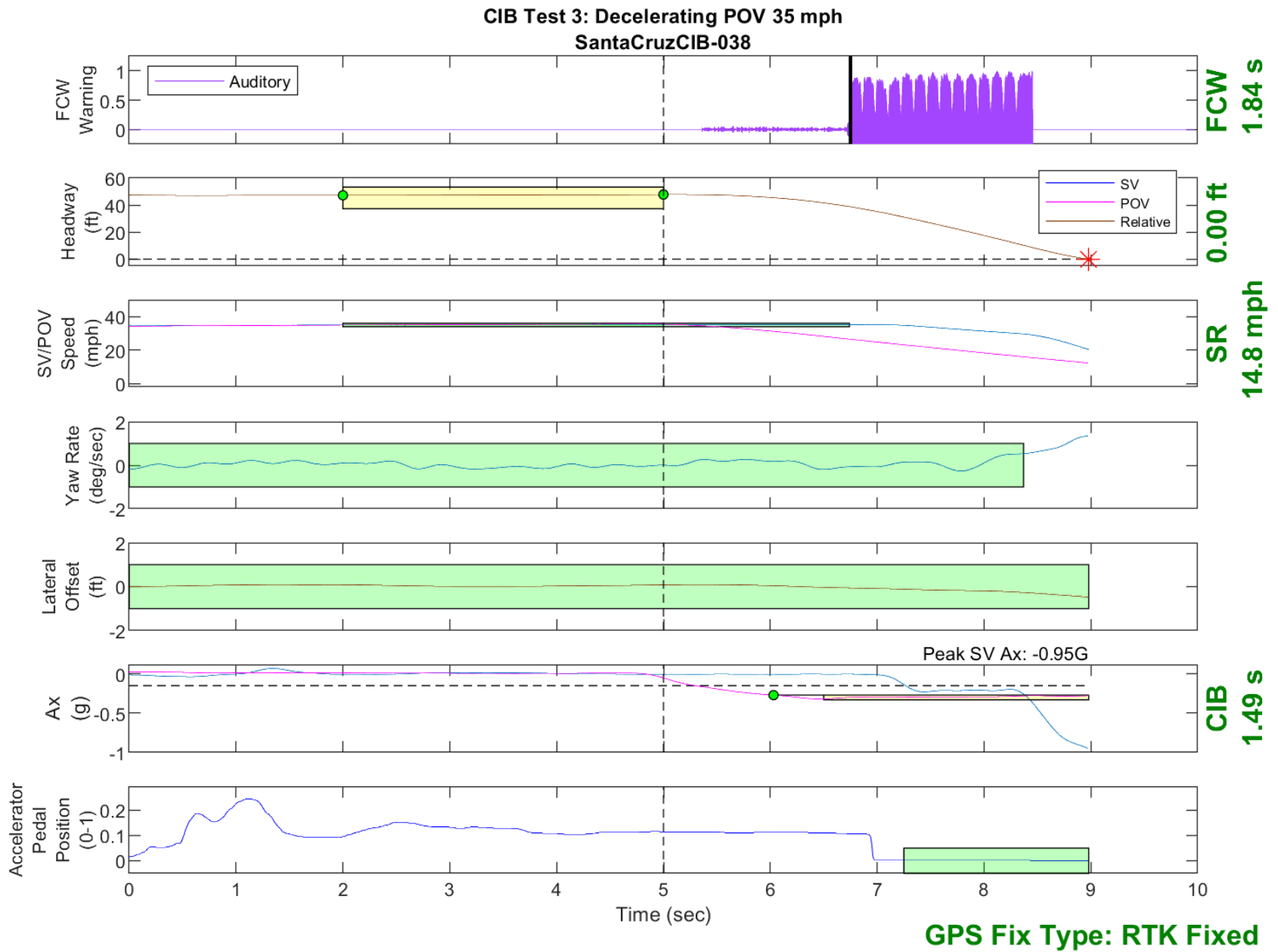


Figure D36. Time History for CIB Run 38, Test 3 - Decelerating POV 35 mph

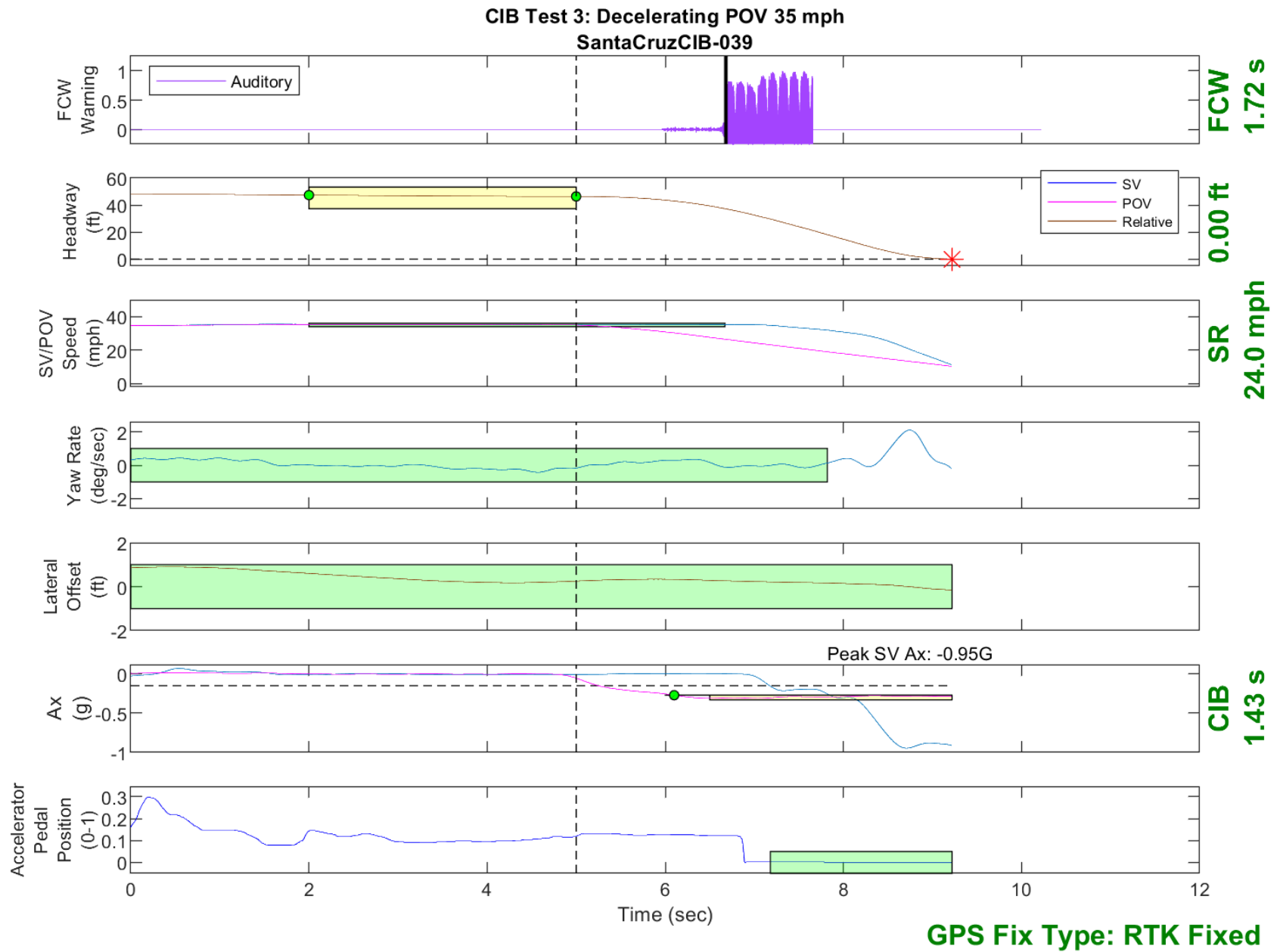


Figure D37. Time History for CIB Run 39, Test 3 - Decelerating POV 35 mph



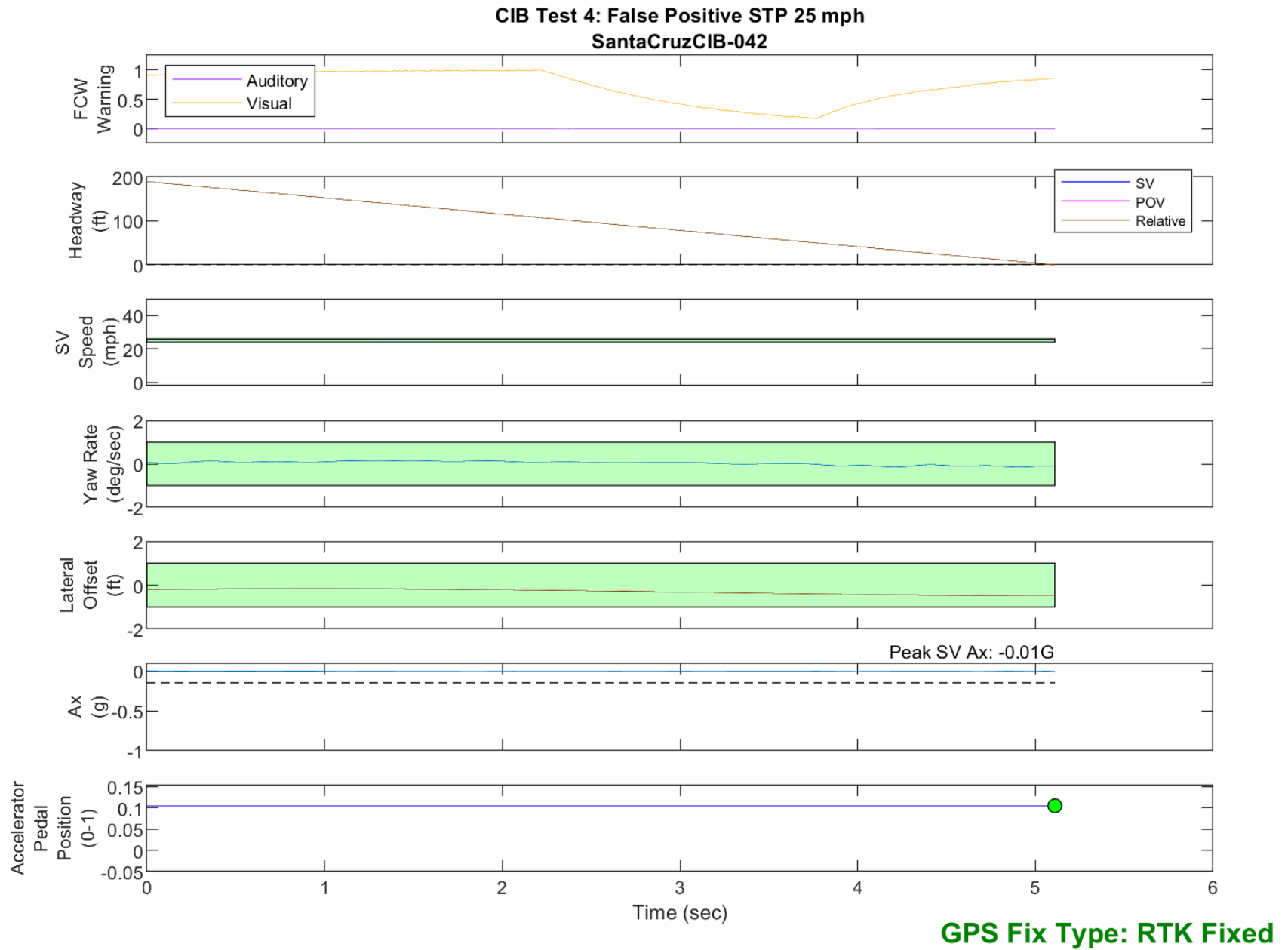


Figure D38. Time History for CIB Run 42, Test 4 - False Positive STP, 25 mph

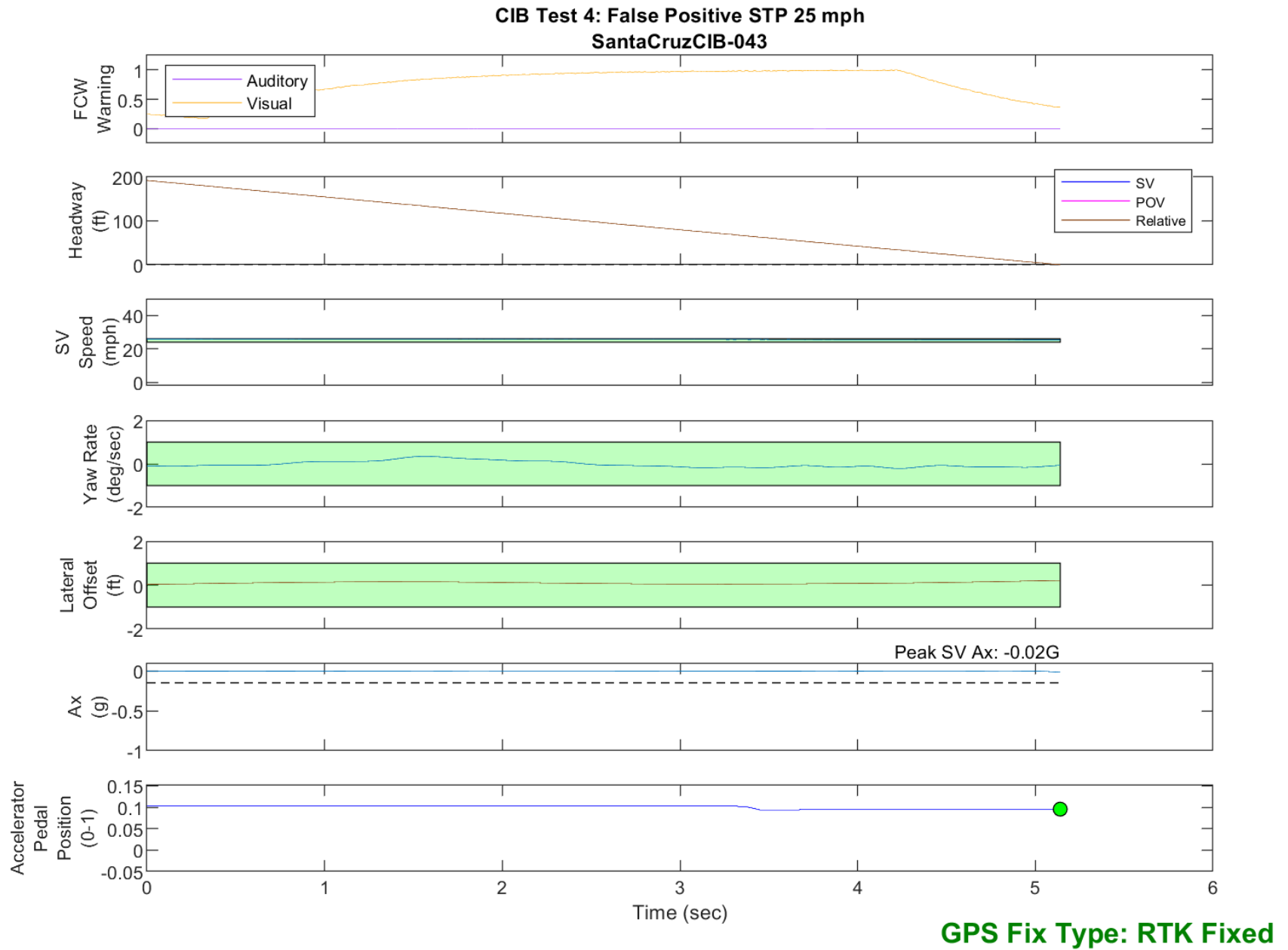


Figure D39. Time History for CIB Run 43, Test 4 - False Positive STP, 25 mph

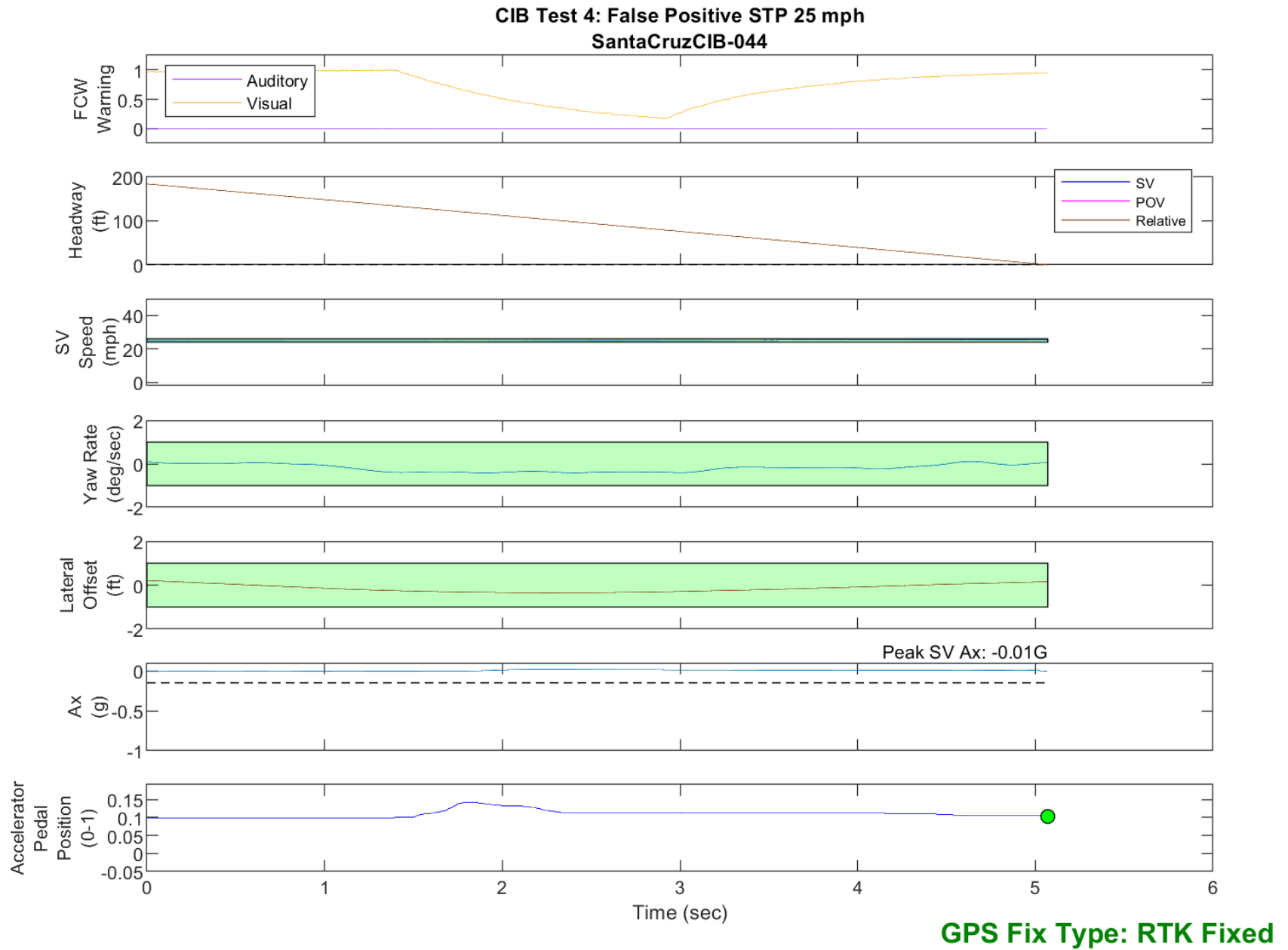


Figure D40. Time History for CIB Run 44, Test 4 - False Positive STP, 25 mph

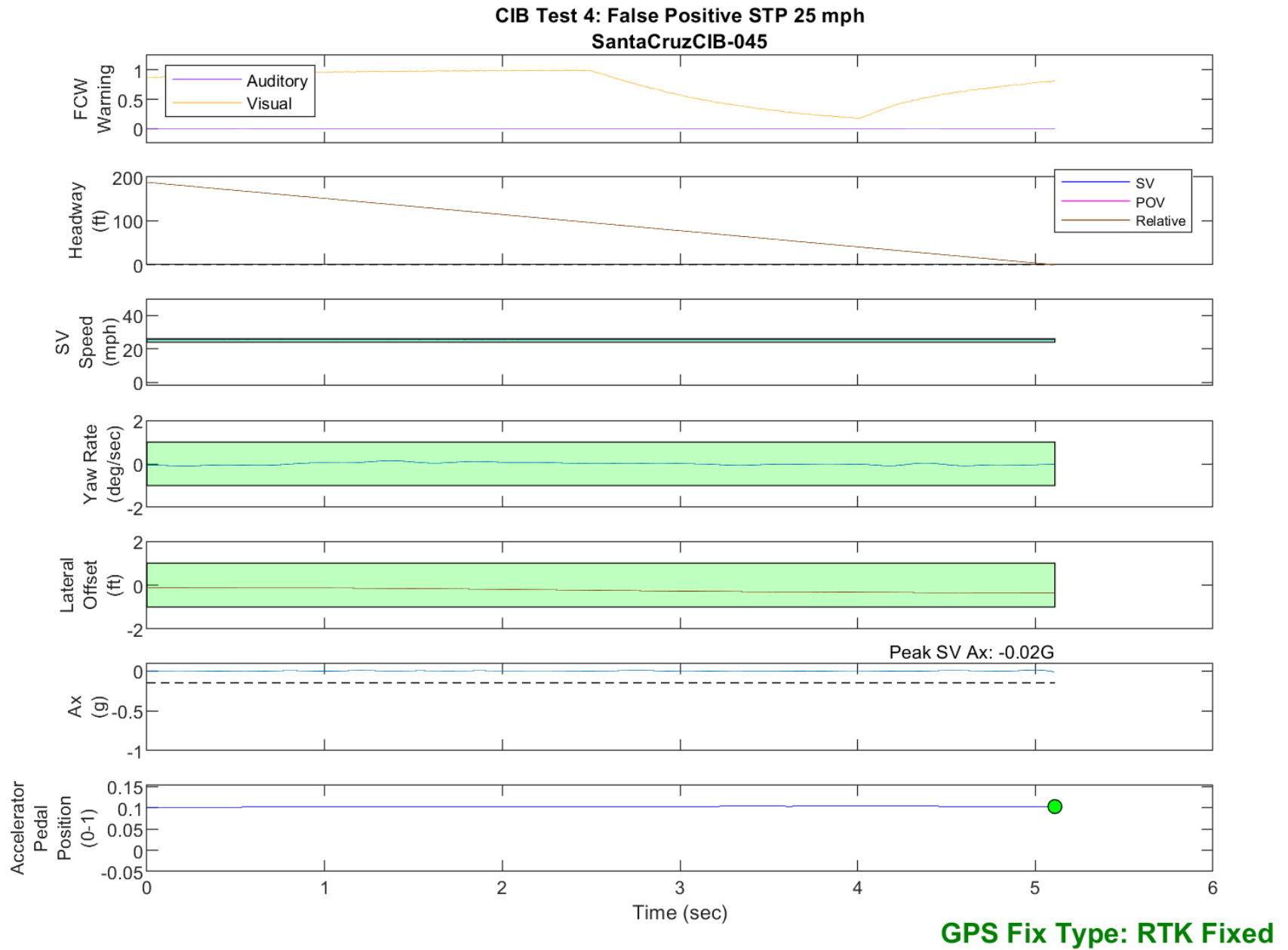


Figure D41. Time History for CIB Run 45, Test 4 - False Positive STP, 25 mph

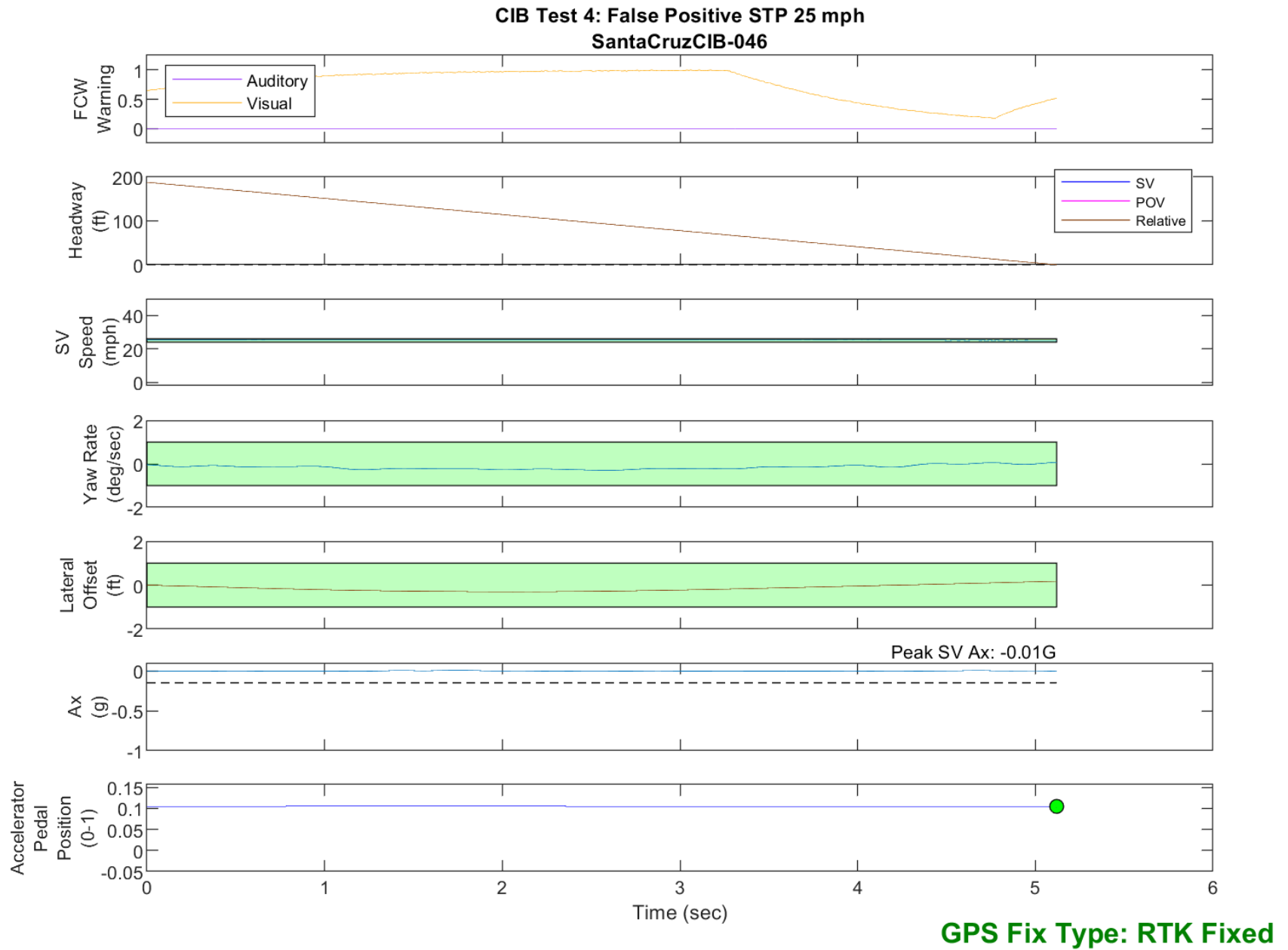


Figure D42. Time History for CIB Run 46, Test 4 - False Positive STP, 25 mph

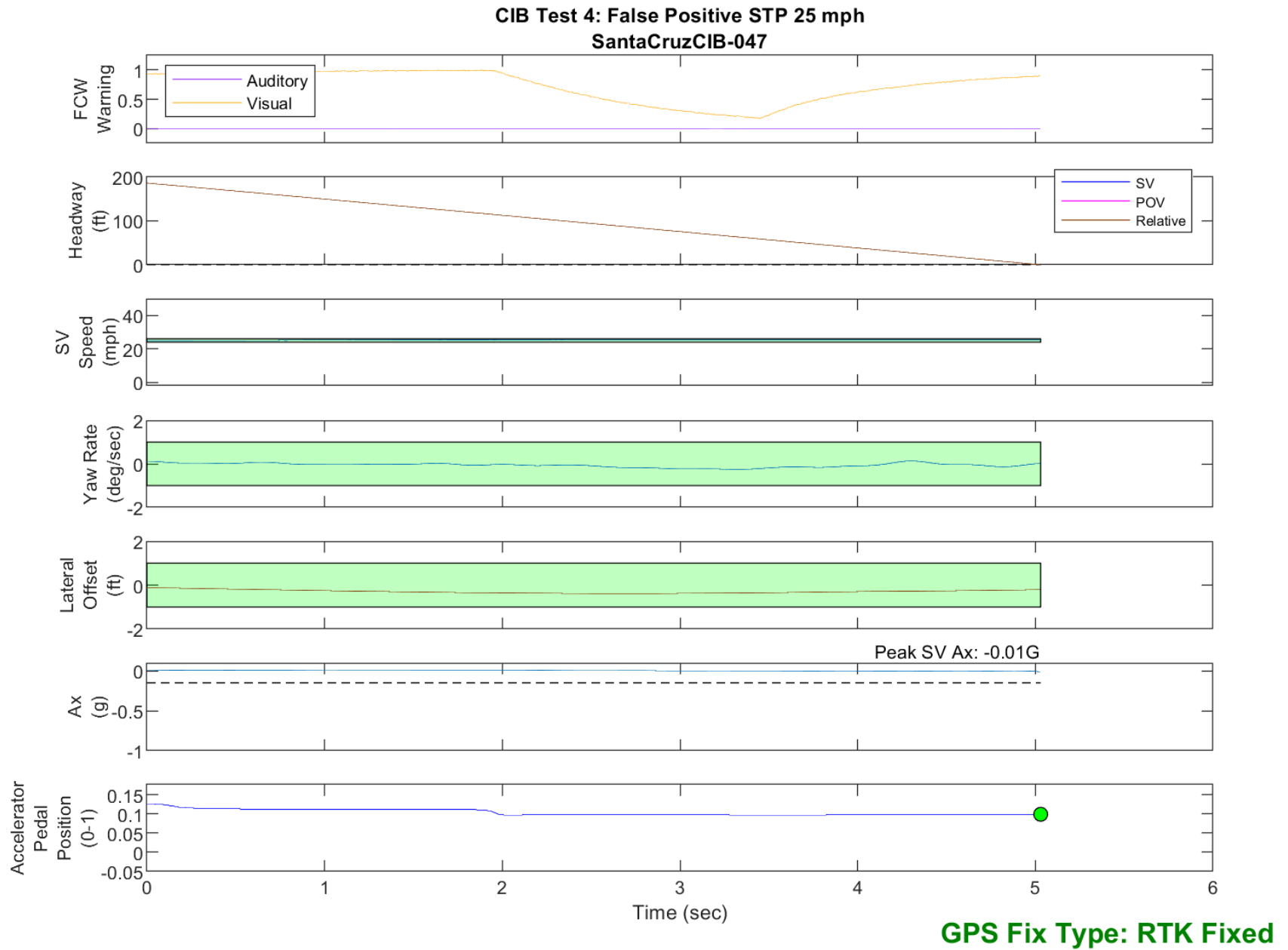


Figure D43. Time History for CIB Run 47, Test 4 - False Positive STP, 25 mph

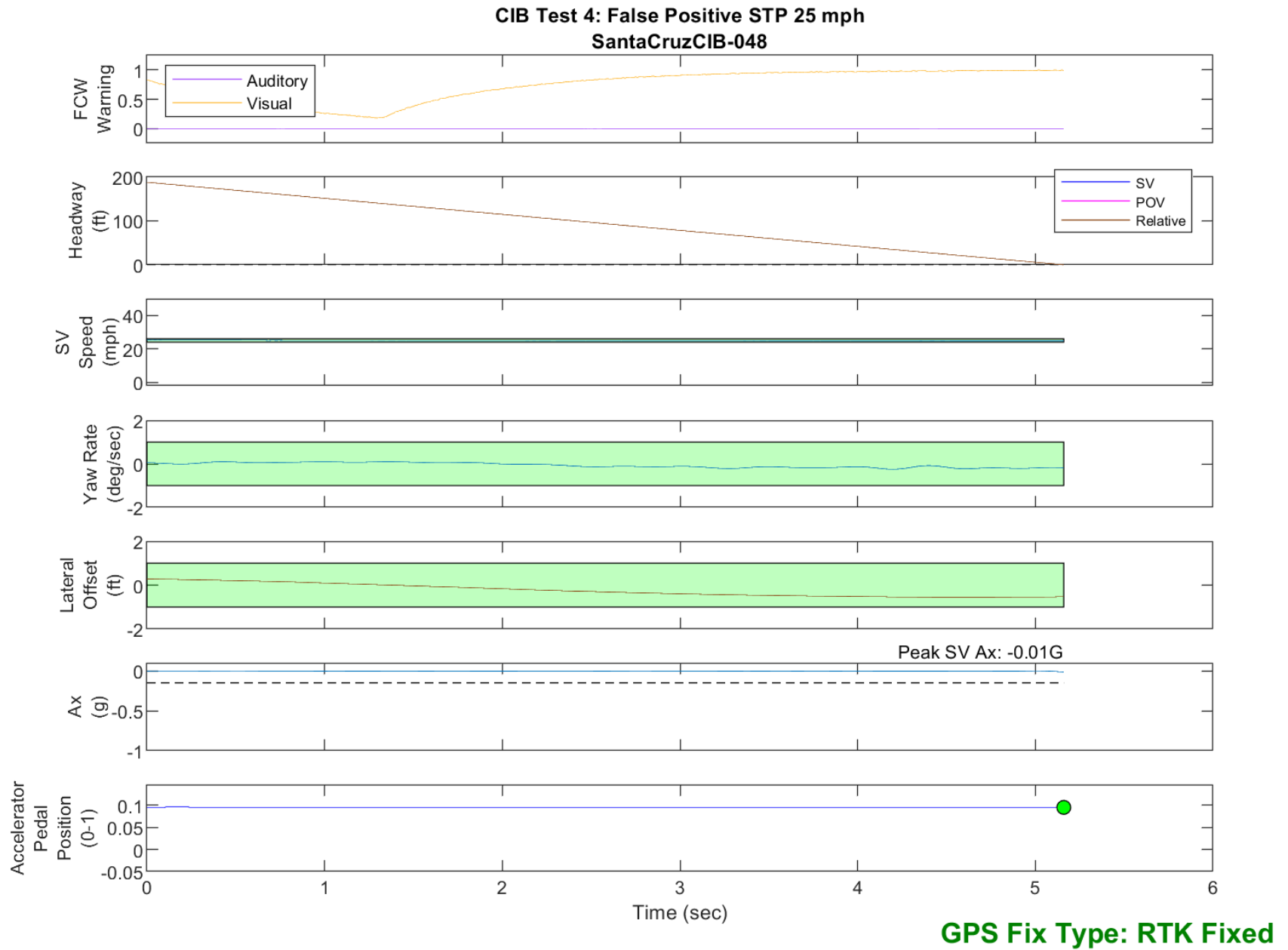


Figure D44. Time History for CIB Run 48, Test 4 - False Positive STP, 25 mph



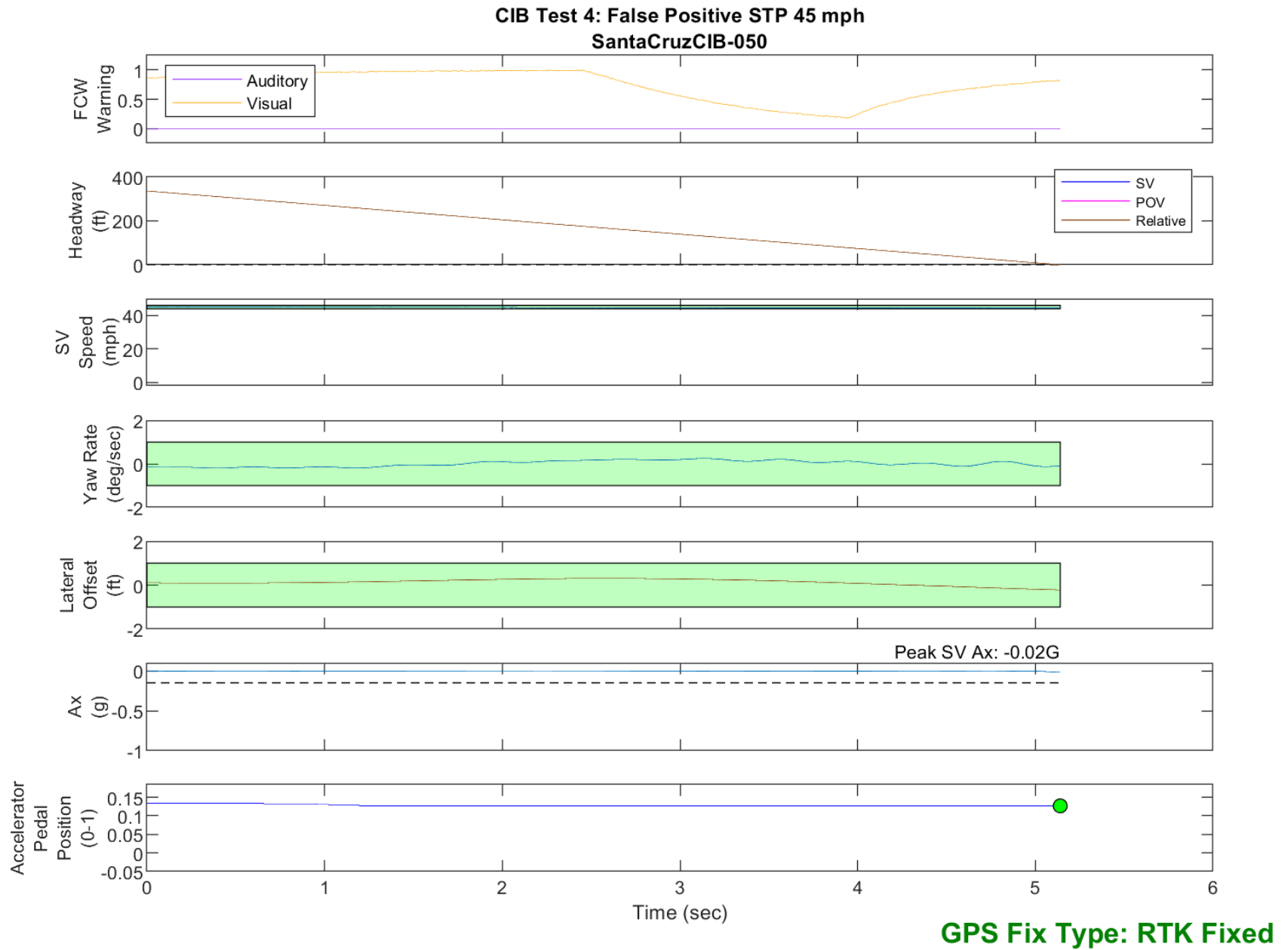


Figure D45. Time History for CIB Run 50, Test 4 - False Positive STP, 45 mph

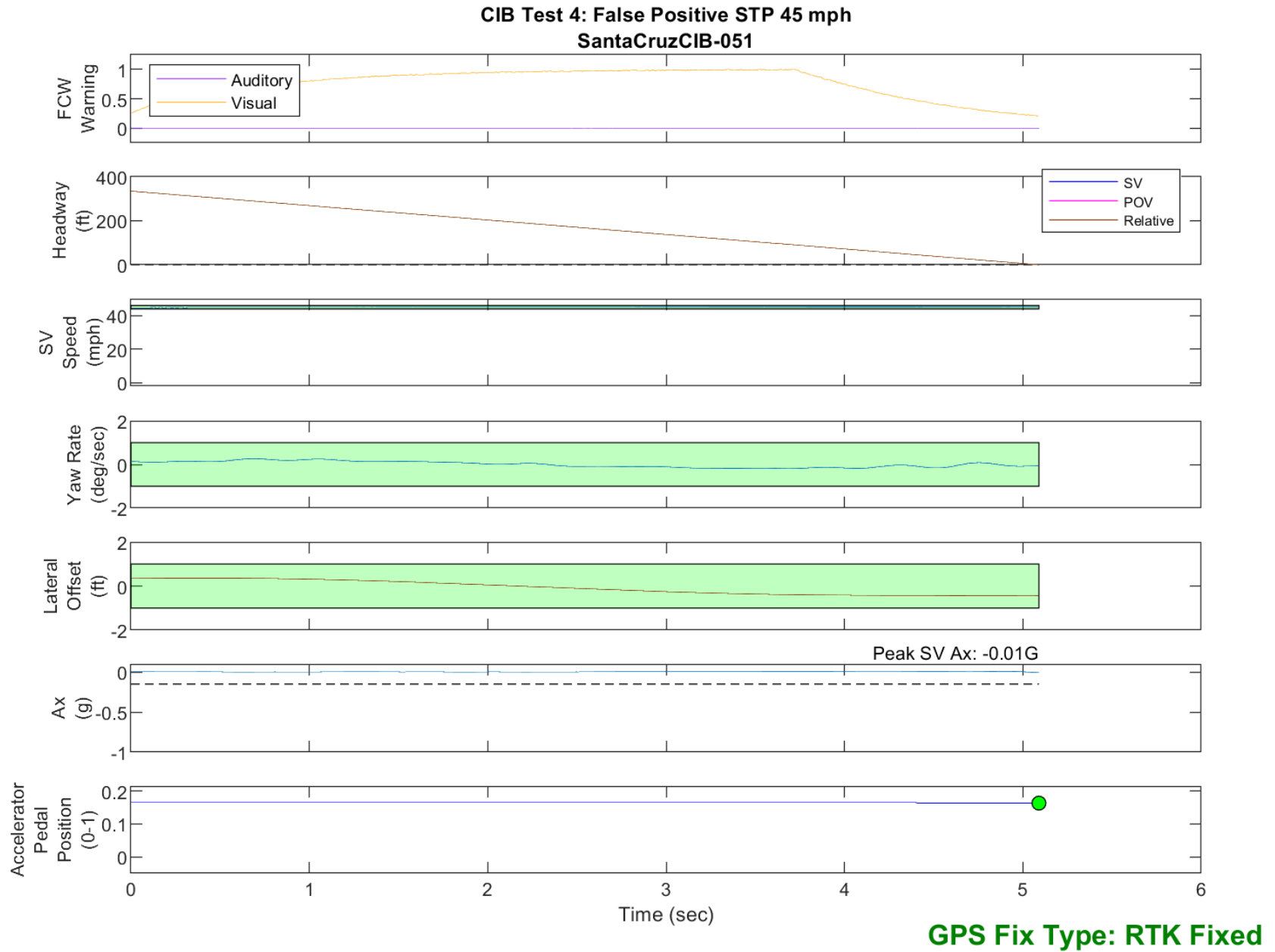


Figure D46. Time History for CIB Run 51, Test 4 - False Positive STP, 45 mph

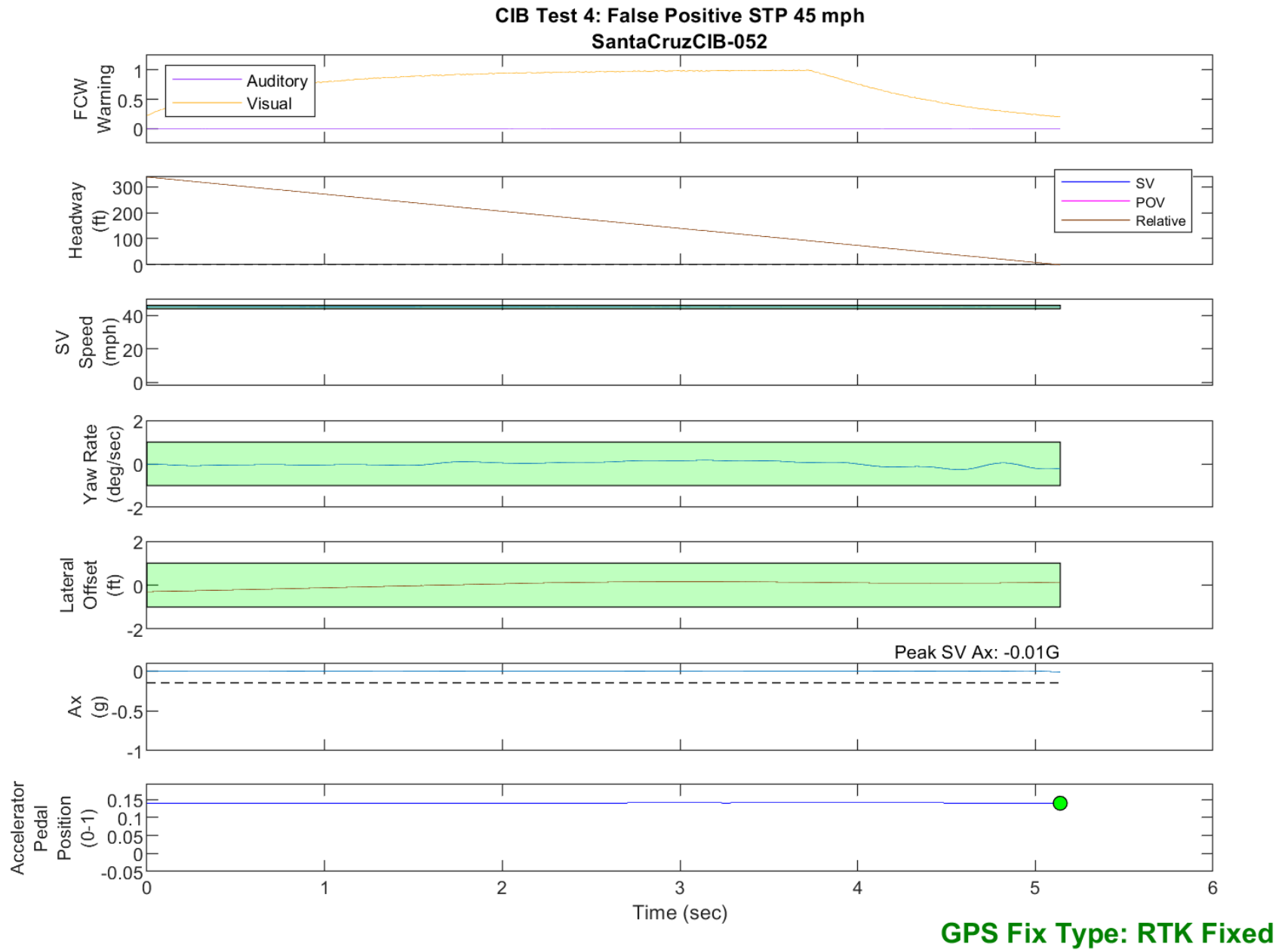


Figure D47. Time History for CIB Run 52, Test 4 - False Positive STP, 45 mph

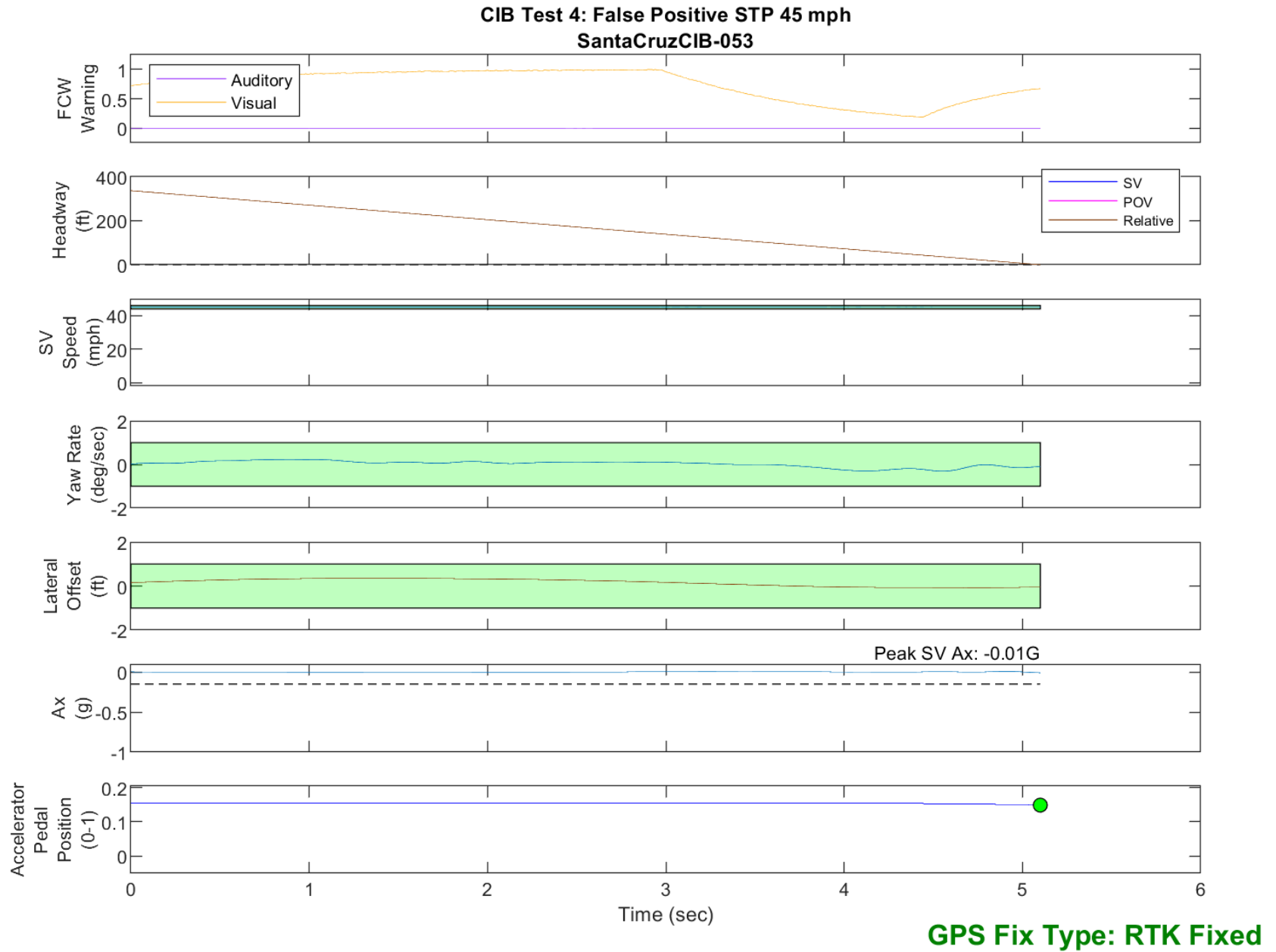


Figure D48. Time History for CIB Run 53, Test 4 - False Positive STP, 45 mph

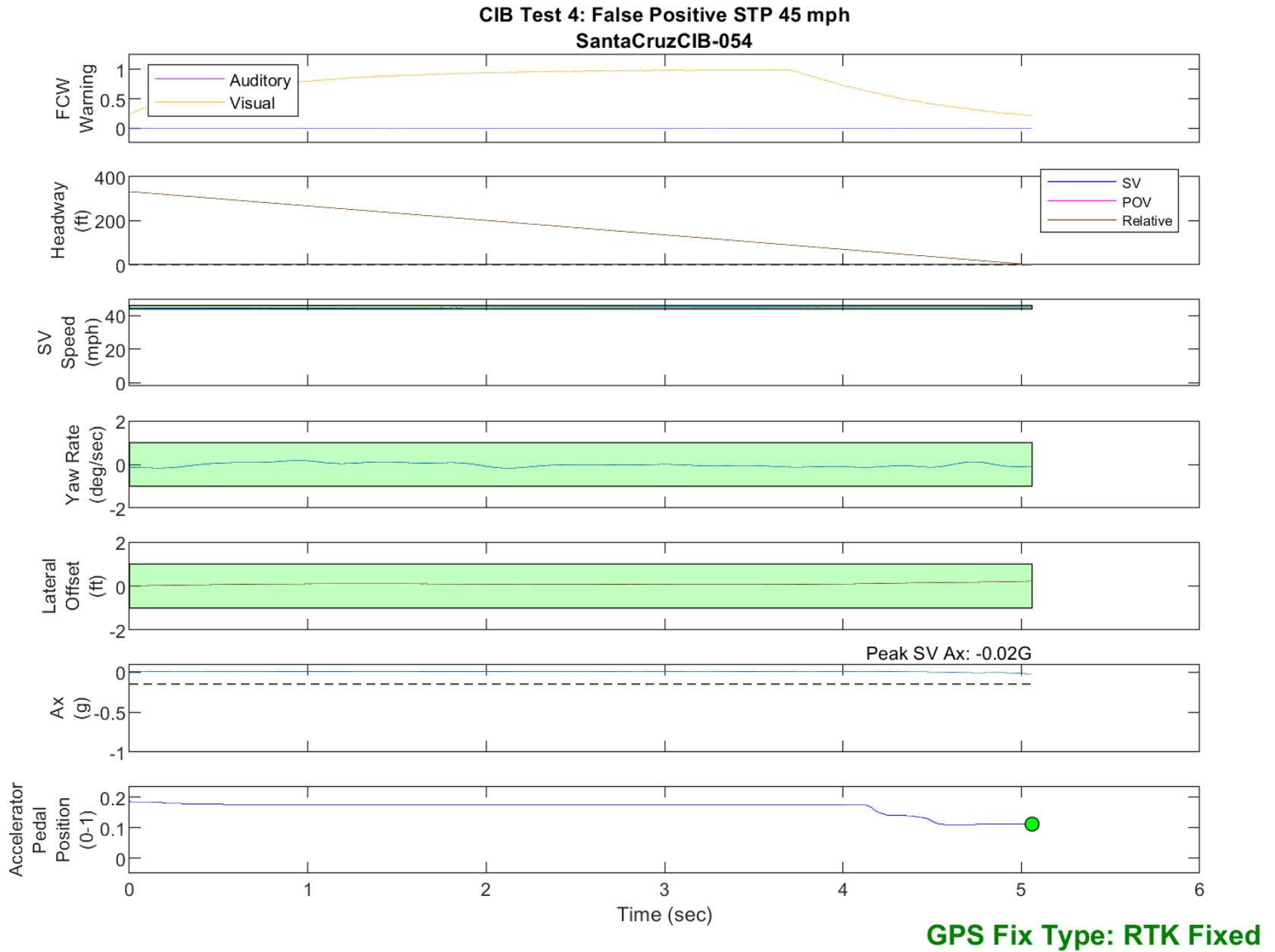


Figure D49. Time History for CIB Run 54, Test 4 - False Positive STP, 45 mph

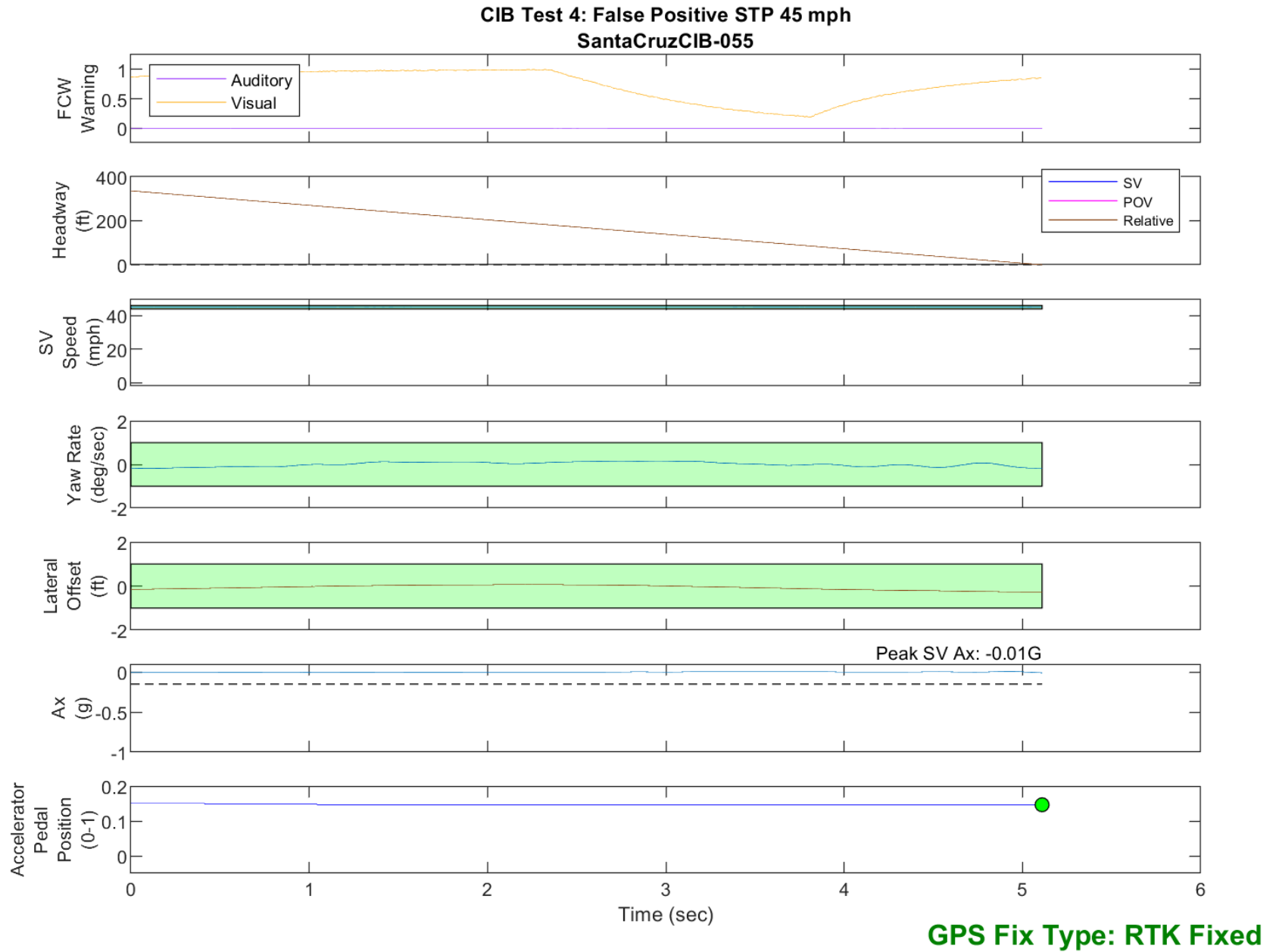


Figure D50. Time History for CIB Run 55, Test 4 - False Positive STP, 45 mph

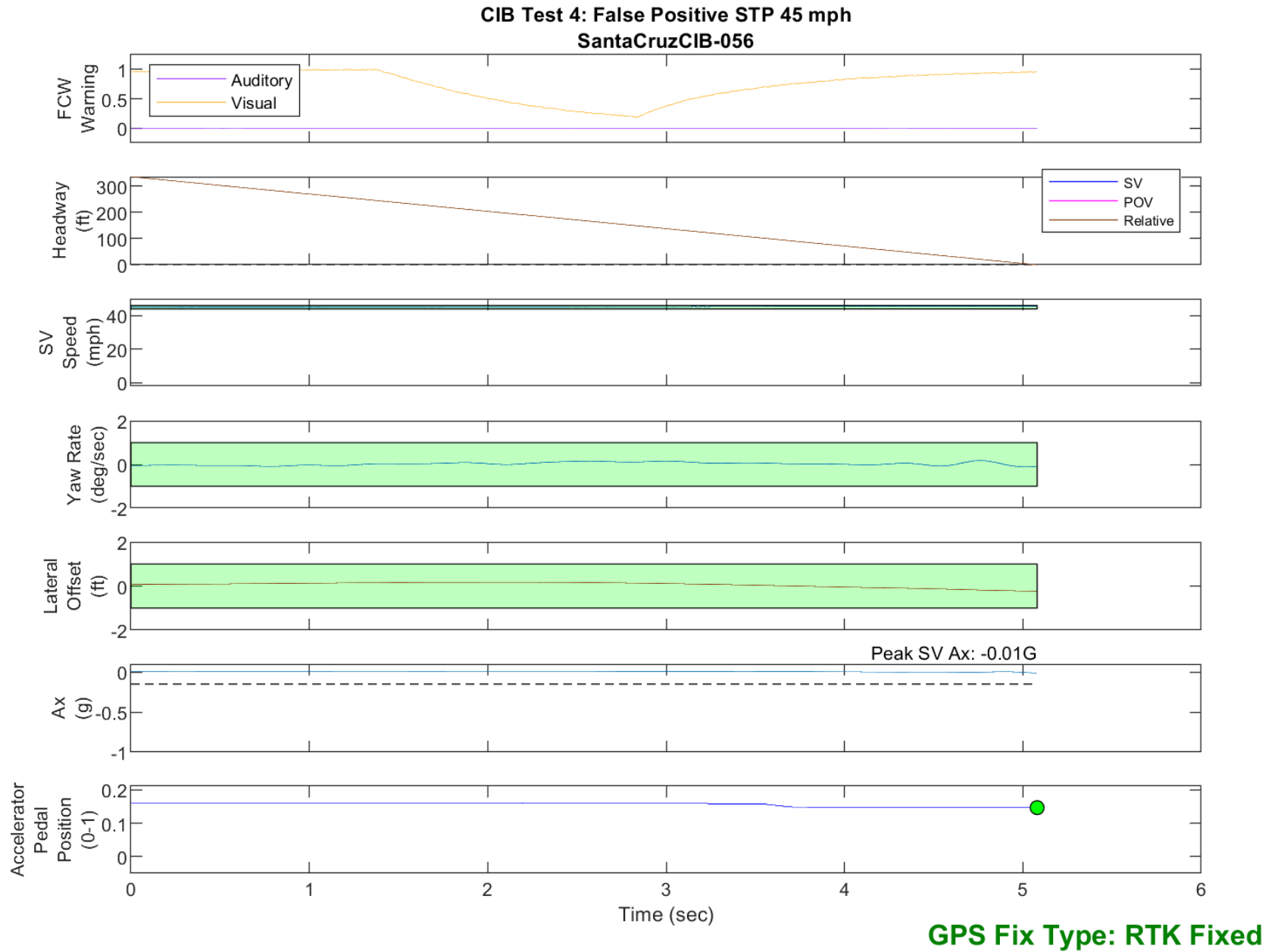


Figure D51. Time History for CIB Run 56, Test 4 - False Positive STP, 45 mph