NEW CAR ASSESSMENT PROGRAM
CRASH IMMINENT BRAKING SYSTEM CONFIRMATION TEST
NCAP-DRI-CIB-22-14

2022 Subaru Forester Premium/NFF

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Draft Report

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U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
New Car Assessment Program
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16. Abstract These tests were conducted on the subject 2022 Subaru Forester Premium/NFF in accordance with the specifications of the New Car Assessment Program's (NCAP's) most current Test Procedure in docket NHTSA-2015-0006-0025; CRASH IMMINENT BRAKE SYSTEM PERFORMANCE EVALUATION FOR THE NEW CAR ASSESSMENT PROGRAM, October 2015. The vehicle passed the requirements of the test for all four CIB test scenarios and all speeds.			
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Section I

INTRODUCTION

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

The method prescribed by the National Highway Traffic Safety Administration (NHTSA) to evaluate CIB performance on the test track[1] 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 Subaru Forester Premium/NFF. 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.

[1] 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 Subaru Forester Premium/NFF

VIN: *JF2SKADC7NH41xxxx*

Test start date: *1/13/2022* Test end date: *1/13/2022*

Crash Imminent Braking System setting: *No range settings available.*

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

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2022 Subaru Forester Premium/NFF

TEST VEHICLE INFORMATION

VIN: *JF2SKADC7NH41xxxx*

Body Style: *SUV* Color: *Autumn Green Metallic*

Date Received: *1/3/2022* Odometer Reading: *5 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Subaru Corporation*

Date of manufacture: *11/21*

Vehicle Type: *MPV/VTUM*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *225/60R17*

Rear: *225/60R17*

Recommended cold tire pressure: Front: *230 kPa (33 psi)*

Rear: *220 kPa (32 psi)*

TIRES

Tire manufacturer and model: *Bridgestone Ecopia H/L 422 Plus*

Front tire designation: *225/60R17 99H*

Rear tire designation: *225/60R17 99H*

Front tire DOT prefix: *EL FC DMM*

Rear tire DOT prefix: *EL FC DMM*

CRASH IMMINENT BRAKING

DATA SHEET 3: TEST CONDITIONS

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2022 Subaru Forester Premium/NFF

GENERAL INFORMATION

Test start date: *1/13/2022* Test end date: *1/13/2022*

AMBIENT CONDITIONS

Air temperature: *12.8 C (55 F)*

Wind speed: *1.0 m/s (2.3 mph)*

X Windspeed ≤ 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: *230 kPa (33 psi)*

Rear: *220 kPa (32 psi)*

CRASH IMMINENT BRAKING

DATA SHEET 3: TEST CONDITIONS

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2022 Subaru Forester Premium/NFF

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*526.2 kg (1160 lb)*	Right Front:	*479.0 kg (1056 lb)*
Left Rear:	*376.9 kg (831 lb)*	Right Rear:	*371.9 kg (820 lb)*
		Total:	*1754.0 kg (3867 lb)*

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

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2022 Subaru Forester Premium/NFF

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

EyeSight Driver-Assist System

Type and location of sensors the system uses:

Stereo camera located at the top center of the windshield

System setting used for test (if applicable):

No range settings available.

Over what speed range is the system operational?

The EyeSight system is operational between 1 to 100 mph (Per manufacturer supplied information).

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

____ No

If yes, please provide a full description.

The EyeSight system requires the vehicle to be driven on public roads without inclement weather for about one hour to be initialized. This initialization procedure does not need to be repeated after an ignition cycle.

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

____ No

If yes, please provide a full description.

The EyeSight system will deactivate after three AEB activations without an ignition cycle and a Pre-Collision Braking System OFF indicator light located in the instrument panel will illuminate.

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

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2022 Subaru Forester Premium/NFF

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

- **X** Warning light
- **X** Buzzer or auditory alarm
- ____ Vibration
- ____ Other

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

The EyeSight system alerts the driver with a visual and auditory alert. The visual alert is displayed in the center of the instrument panel and consists of an image of two vehicles, one behind the other, lane lines, and the words "Obstacle Detected" above. The vehicle shown in front flashes on/off. The auditory alert consists of repeated beeps followed by a long continuous beep with a primary frequency of 2215 Hz.

Is there a way to deactivate the system?

- **X** Yes
- ____ No

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

A button to deactivate the EyeSight system is located on the front center ceiling control panel. Press and hold the button for approximately 2 seconds and the system will emit a single audible beep and illuminate a Pre-Collision Braking System Off indicator light when it is deactivated. Refer to the Subaru EyeSight Manual pages 61-62 shown in Appendix B pages B-14 to B-15.

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

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2022 Subaru Forester Premium/NFF

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

	Yes
X	No

If yes, please provide a full description.

There are no range settings available for the EyeSight system.

Are there other driving modes or conditions that render CIB inoperable or reduce its effectiveness?

X	Yes
	No

If yes, please provide a full description.

Refer to the Subaru EyeSight Manual pages 30-41 shown in Appendix B pages B-2 to B-13.

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.

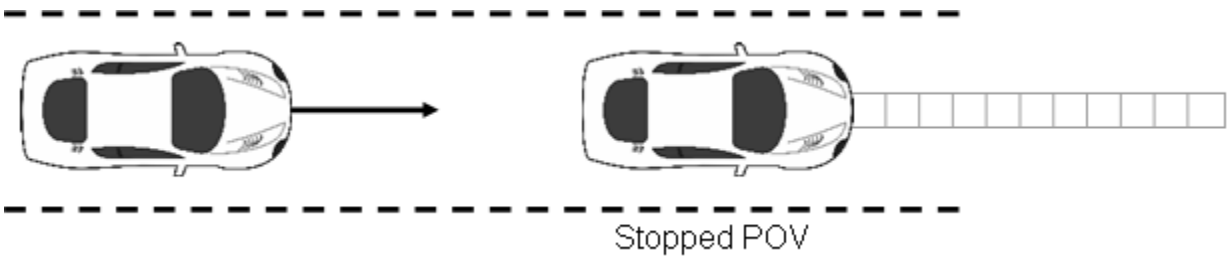

Figure 1. Depiction of Test 1

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 ±1 ft (0.3 m) during the validity period.
- The yaw rate of the SV could not deviate more than ±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} 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 ≥ 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. <u>TEST 2 – SUBJECT VEHICLE ENCOUNTERS SLOWER PRINCIPAL OTHER VEHICLE</u>

- 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.

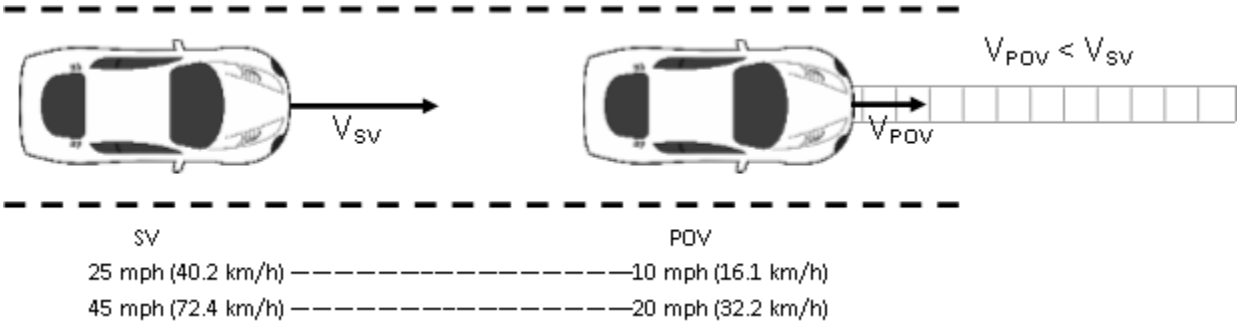

Figure 2. Depiction of Test 2

a. Procedure

The SV ignition was cycled prior to each test run. The tests were conducted two ways. In the first, the POV was driven at a constant 10.0 mph (16.1 km/h) in the center of the lane of travel while the SV was driven at 25.0 mph (40.2 km/h), in the center lane of travel, toward the slower-moving POV. In the second, the POV was driven at a constant 20.0 mph (32.2 km/h) in the center of the lane of travel while the SV was driven at 45.0 mph (72.4 km/h), in the center lane of travel, toward the slower-moving POV. In both cases, 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
- 1 second after the speed of the SV becomes less than or equal to that of the POV.

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 ±1 ft (0.3 m) during the validity period.
- The yaw rate of the SV and POV could not deviate more than ±1 deg/sec during the validity period.
- The SV speed could not deviate more than ±1.0 mph (±1.6 km/h) during an interval defined by TTC = 5.0 seconds to t_{FCW} or impact if no FCW alert was given.
- The POV speed could not deviate more than ±1.0 mph (±1.6 km/h) during the validity period.

b. Criteria

For the test series in which the initial SV speed was 25 mph, the condition for passing was that there be no SV-to-POV impact for at least five of the seven valid test trials.

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 ≥ 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.

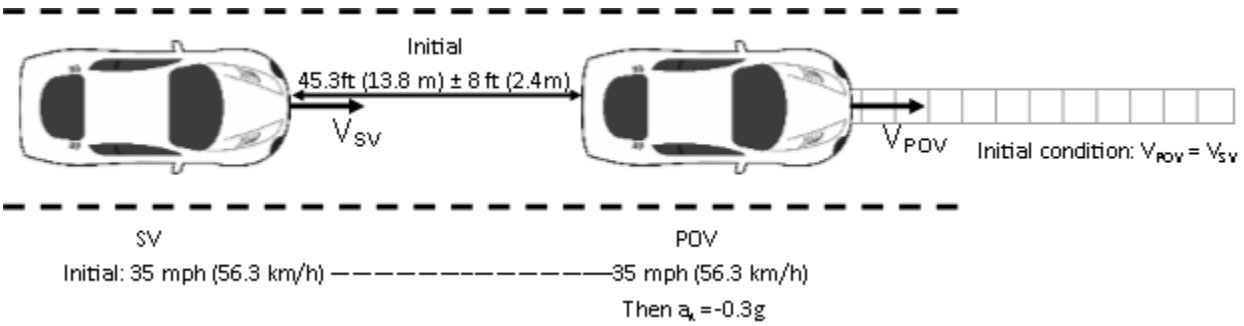

Figure 3. Depiction of Test 3

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) ± 8 ft (2.4 m). Once these conditions were met, the POV tow vehicle brakes were applied to achieve 0.3 ± 0.03 g of deceleration within 1.5 ± 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 ±1 ft (0.3 m) during the validity period.
- The yaw rate of the SV and POV could not deviate more than ±1 deg/sec during the validity period.
- The SV speed could not deviate more than ±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 ±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 ±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 ±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 ≥ 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 ±1 ft (0.3 m) during the validity period.
- The yaw rate of the SV could not deviate more than ±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 ±1.0 mph (±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 ≤ 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	5th	3 dB	60 dB	Identified Center Frequency ± 5%
Tactile	5th	3 dB	60 dB	Identified Center Frequency ± 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 ±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 ±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 ±2 in (±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: 2/10/2021 Due: 2/10/2022
Linear (string) encoder	Throttle pedal travel	10 in	0.1 in	UniMeasure LX-EP	50060726	By: DRI Date: 4/15/2021 Due: 4/15/2022
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 Paev5	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

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

Figure A3. Window Sticker (Monroney Label)

Figure A4. Vehicle Certification Label

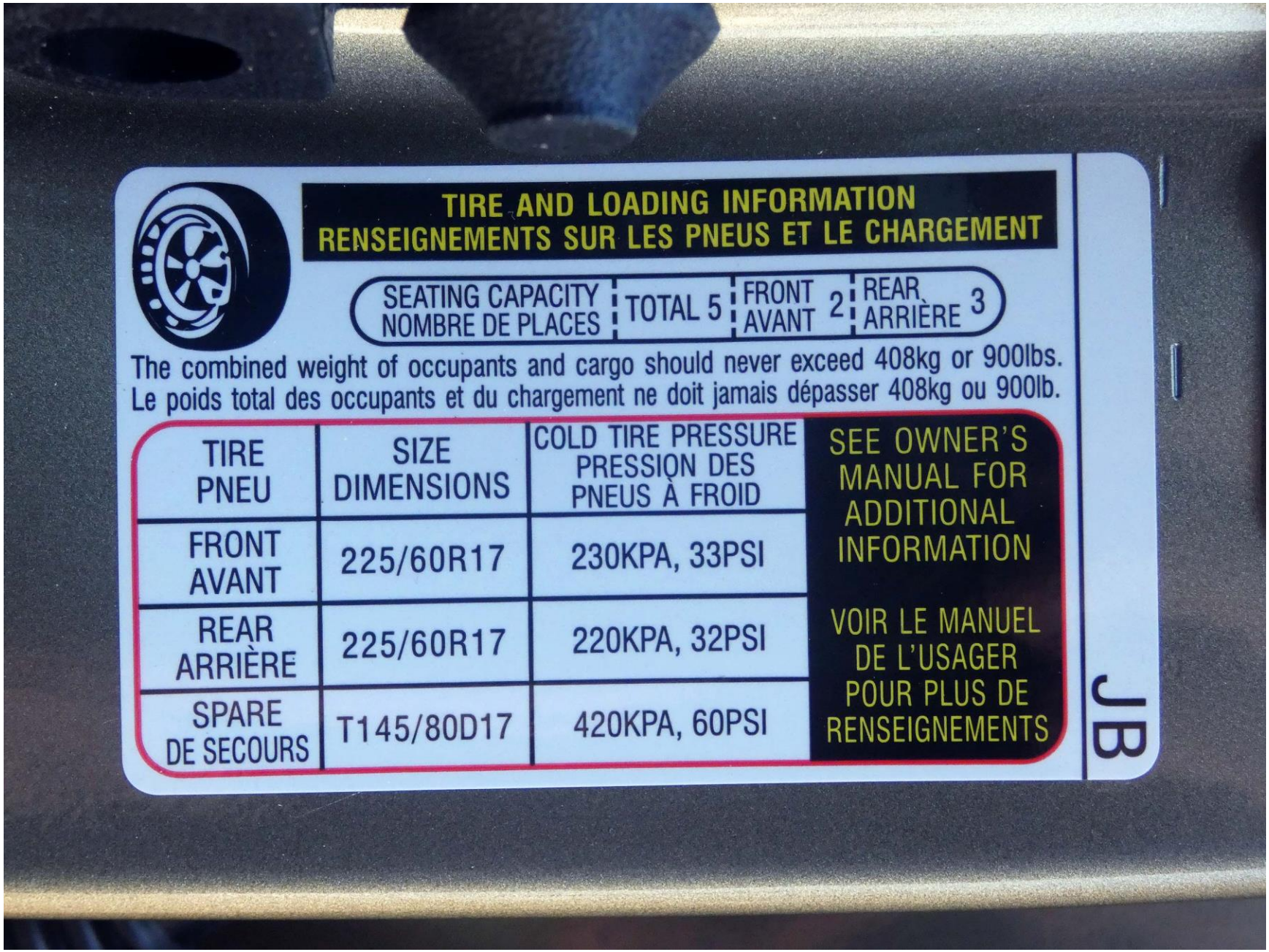

Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

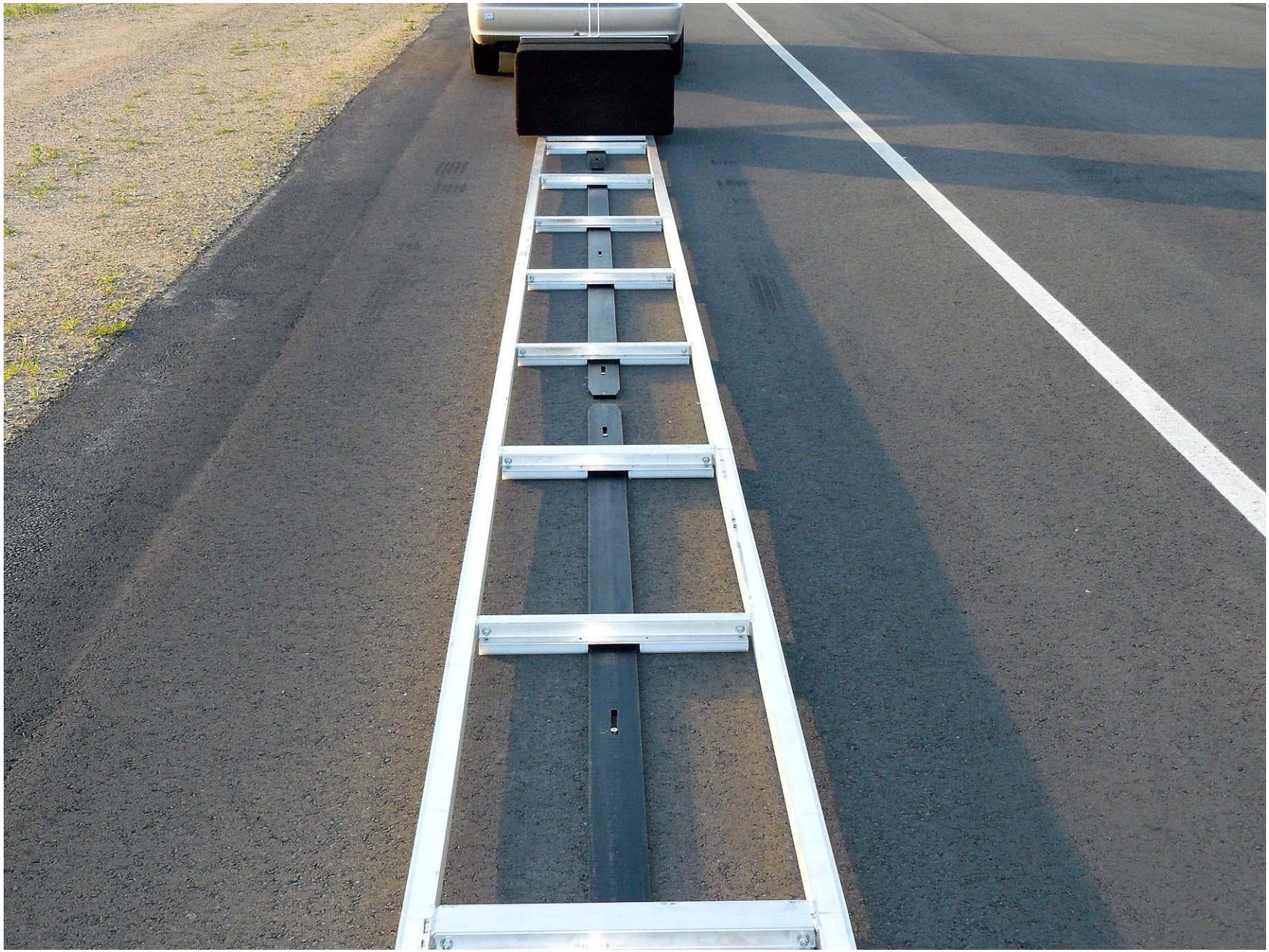

Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

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

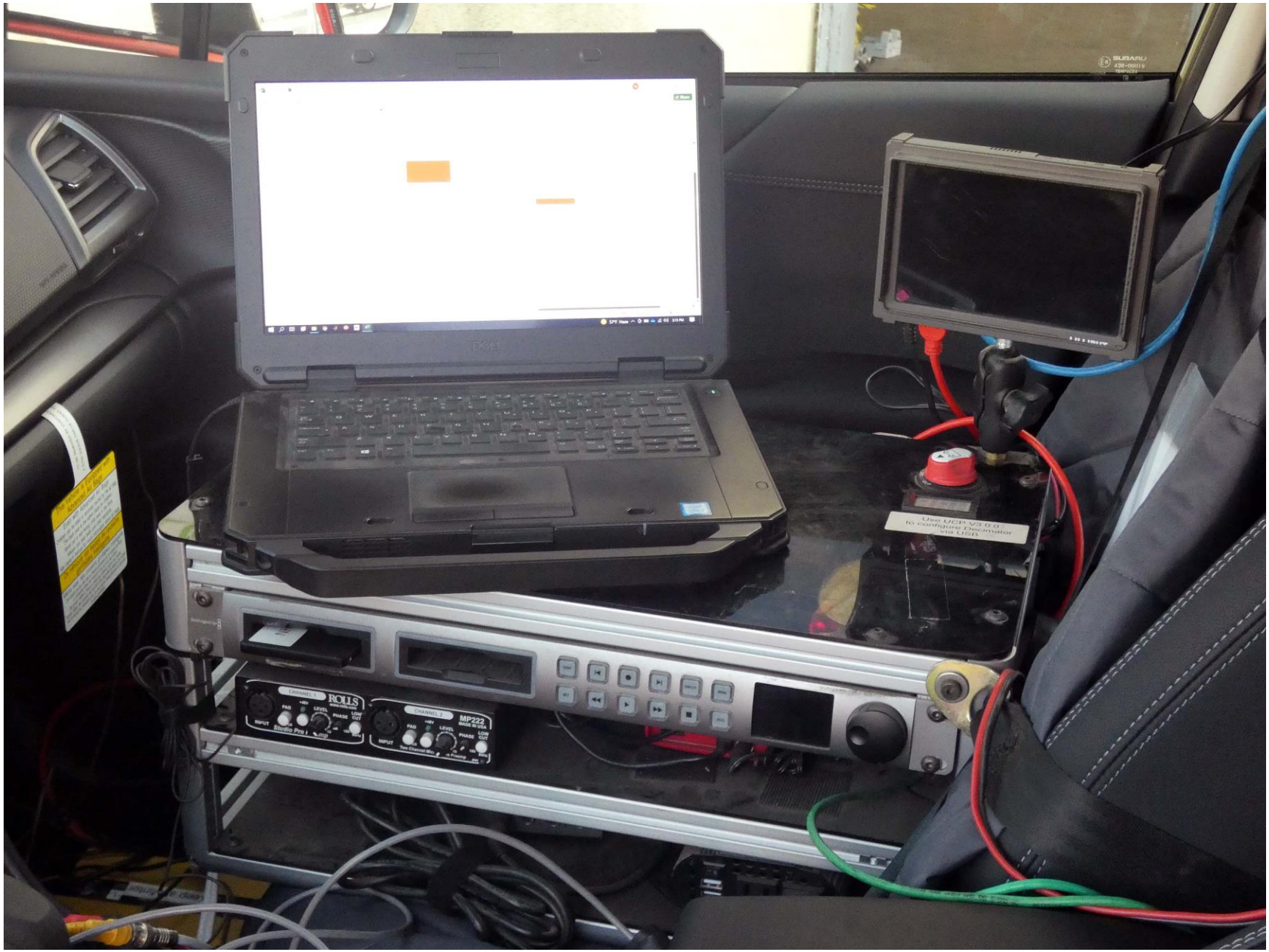

Figure A12. Computer Installed in Subject Vehicle

Figure A13. Brake Actuator Installed in POV System

Figure A14. AEB On/Off Switch Control

Figure A15. Visual Alert

APPENDIX B

Excerpts from Owner’s Manual

Pre-Collision Braking System

When there is a risk of a collision with an obstacle in front (a vehicle, pedestrian, cyclist, etc.), the EyeSight system helps to prevent or minimize a collision by warning the driver. If the driver still does not take evasive action to avoid a collision, the brakes can be automatically applied just before the collision in order to reduce impact damage, or if possible, prevent the collision. If the driver takes evasive action to avoid a collision, Pre-Collision Braking Assist will operate in order to help the driver to prevent or minimize the collision.
This system can be effective not only with direct rear-end collisions, but also with offset rear-end collisions. In addition to rear-end collisions, this system can be effective for avoiding collisions with crossing pedestrians and cyclists and with oncoming vehicles and pedestrians when turning. This function can be activated when the select lever is in the “D”, “M” (models with manual mode), “L” (models with “L” position) or “N” position.

⚠ WARNING

Pre-Collision Braking System operation

- Never use Pre-Collision Braking System and Pre-Collision Braking Assist to stop your car or avoid a collision under ordinary conditions. These functions cannot prevent collisions under all conditions. If the driver relies only on Pre-Collision Braking System for Brake operation, collisions may occur.
- When a warning is activated, pay attention to the front of the vehicle and its surroundings, and operate the brake pedal and/or take other actions if necessary.
- The EyeSight Pre-Collision Braking System is primarily designed to prevent rear-end collisions with other vehicles when possible or to minimize damage and injuries in the event of a collision. In addition to other vehicles, things such as motorbikes, cyclists and pedestrians can also be treated as obstacles. However, there may be cases when detection is not possible depending on a variety of conditions[*2]. For example, when a vehicle is viewed from the side, oncoming vehicle, vehicles approaching in reverse, small animals or children, or walls or doors are not likely to be detected.
- Pre-Collision Braking System will operate at the point when it determines that a collision cannot be avoided and is designed to apply strong braking force just before a collision. The result of this varies depending on a variety of conditions[*2]. Because of this, performance of this function will not always be the same.
- When Pre-Collision Braking System is activated, it will continue to operate even if the accelerator pedal is partially depressed. However, it will be canceled if the accelerator pedal is suddenly or fully depressed.

- If the driver depresses the brake pedal or turns the steering wheel, the system may determine that this constitutes evasive action by the driver, and the automatic braking control may not activate in order to allow the driver full control.
- If the speed difference with the obstacle is greater than approximately 37 mph (60 km/h), collisions cannot be avoided due to performance limitations of EyeSight. However, even if the speed difference is approximately 37 mph (60 km/h) or less, if an obstacle cuts in front of you or moves outside the camera's field of view, the vehicle might not be able to stop or the system might not activate when the visibility, road slipperiness, etc. do not meet the following conditions.*

*: Conditions in which Pre-Collision Braking System cannot detect obstacles:

- Distance to obstacle in front of you, speed difference, proximity conditions, lateral displacement (the amount of offset)
- Vehicle conditions (amount of load, number of occupants, etc.)
- Road conditions (grade, slipperiness, shape, bumps, etc.)
- Visibility ahead is poor (rain, snow, fog or smoke, etc.).
- The detected object is something other than a vehicle, motorcycle, cyclist or pedestrian.
  - A domestic animal or other animal (a dog or deer, etc.)
  - A guardrail, telephone pole, tree, fence or wall, etc.
- Even if the obstacle is a motorcycle, cyclist or pedestrian, depending on the brightness of the surroundings, its relative movement, its aspect, and the direction it is facing, there may be cases when the system cannot detect it.
- The system determines that operation by the driver (based on accelerator pedal operation, braking, steering wheel angle, etc.) is intended as evasive action.
- Vehicle maintenance status (brake systems, tire wear, tire pressure, whether a temporary spare tire is being used, etc.)
- A trailer or another vehicle, etc. is being towed.
- The brakes are cold due to the outside temperature being low or just after starting the engine.
- The brakes are overheated on downhill grades (braking performance is reduced).
- In rain or after washing the vehicle (the brakes are wet and braking performance is reduced.)
- Recognition conditions of the stereo camera
  In particular, the function may be unable to stop the vehicle or may not activate in the following cases.

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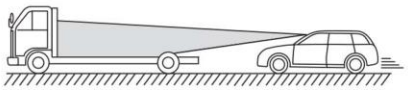
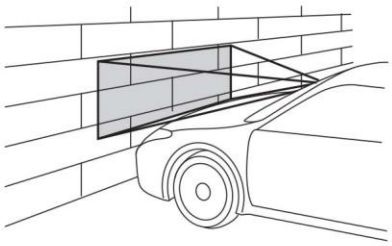
- The object moves outside the camera's field of view.
- Bad weather (for example heavy rain, a blizzard or thick fog)
- Visibility is poor due to sand, smoke or water vapor blowing in the wind, or the front vision is obscured due to water splashes, snow, dirt or dust stir up generated by the vehicle in front or oncoming traffic.
- At night or in a tunnel without the headlights on
- At night or in a tunnel when there is a vehicle in front that does not have its taillights on
- Approaching a motorcycle, cyclist or pedestrian at night
- A vehicle, motorcycle, cyclist or pedestrian is outside the area illuminated by the headlights.
- Strong light is coming from the front (for example, sunlight at dawn, sunset or headlight beams, etc.).
- The windshield has become fogged, scratched or smeared, or snow, dirt, dust or frost has adhered to it, or it is otherwise affected. These will reduce the stereo camera's field of view. Also, light is reflecting off the dirt, etc.
- Fluid has not been fully wiped off the windshield during or after washer use.
- The target cannot be correctly recognized because the stereo camera's view is obstructed by water droplets from rain or the window washer, or by the wiper blades.
- The stereo camera's field of view is obstructed (for example by a canoe on the roof of the vehicle).
- The vehicle is tilted at an extreme angle due to loaded cargo or other factors.
- It is pitch black and there are no objects in the surrounding area.
- The surrounding area is mostly the same color (for example in a snowy location).
- The rear aspect of the vehicle in front is low, small or irregular (the system may recognize another part of the vehicle as its rear and will determine operation from that).
  - There is an empty truck or trailer with no rear and/or side panels on the cargo bed.
  - Vehicles that have cargo protruding from their back ends
  - Non-standard shaped vehicles (vehicle transporters or vehicles with a sidecar fitted, etc.)
  - The height of the vehicle is low, etc.



S02133

- There is a wall, etc. in front of a stopped vehicle.
- There is another object near the vehicle.
- A vehicle, etc. has its side facing you.
- With vehicles that are backing up or with oncoming vehicles, etc.
- The size and height of an obstacle is smaller than the limitations of the stereo camera's recognition capability.
  - With small animals or children, etc.
  - With pedestrians who are sitting or lying down
- The detected object is a fence or wall, etc. with a uniform pattern (a striped pattern or brick pattern, etc.).
- There is a wall or door made of glass or a mirror in front.
- The vehicle in front suddenly swerves, accelerates, or decelerates.
- A vehicle, motorcycle, cyclist or pedestrian suddenly cuts in from the side or suddenly runs in front of you.
- Your vehicle is immediately behind an obstacle after changing lanes.
- There is a vehicle, motorcycle, cyclist or pedestrian in a location close to your vehicle's bumper.
- The speed difference between your vehicle and an obstacle is 4 mph (5 km/h) or less (As braking is performed once the obstacle is in close proximity to your vehicle, depending on the shape and size of the obstacle, there may be some cases when the obstacle is outside the range of the camera's field of view.).
- On sharp curves, steep uphill grades or steep downhill grades
- On a bumpy or unpaved road
- The brightness changes such as at a tunnel entrance or exit or when you drive under an overpass.



S00653

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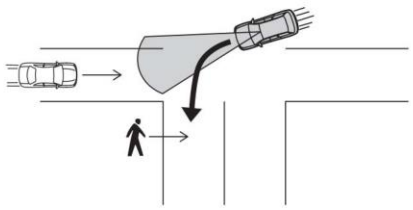
- Do not test Pre-Collision Braking System on its own. It may operate improperly and cause an accident.
- The system may not operate correctly under the conditions listed below. When these conditions occur, turn off Pre-Collision Braking System.
  ⇒ Page 61
  - The tire pressure is not correct.*1
  - The temporary spare tire is installed.*1
  - Tires that are unevenly worn or tires with uneven wear patterns are installed.*1
  - Tires that are the wrong size are installed.*1
  - A flat tire has been fixed temporarily with a tire repair kit.
  - The suspension has been modified (including a genuine SUBARU suspension that has been modified).
  - An object that obstructs the stereo camera's view is installed on the vehicle.
  - The headlights are dirty or they have snow and ice or dirt on them. (Objects are not correctly illuminated and are difficult to detect.)
  - The optical axes are not aligned correctly. (Objects are not correctly illuminated and are difficult to detect.)
  - The lights including headlights and fog lights have been modified.
  - Vehicle operation has become unstable due to an accident or malfunction.
  - The brake system warning light is illuminated.*2
  - The vehicle is tilted at an extreme angle due to loaded cargo or other factors.
  - The maximum number of occupants is exceeded.
  - The combination meter is not operating properly; such as when the lights do not illuminate, the beeps do not sound, the display is different from when it is normal, etc.*3

*1: The wheels and tires have functions that are critically important. Be sure to use the correct ones. For details, refer to the Owner's Manual for your vehicle.

*2: If the brake system warning light does not turn off, immediately pull the vehicle over in a safe place and contact a SUBARU dealer to have the system inspected. For details, refer to the Owner's Manual for your vehicle.

*3: For details about the combination meter, refer to the Owner's Manual for your vehicle.

Activation of Pre-Collision Braking System when turning



S04093

- Operation of the EyeSight Pre-Collision Braking System when making a turn is intended to avoid collisions or reduce the severity of collisions with oncoming vehicles in the neighboring oncoming lane, particularly when you are crossing the oncoming lane to make a turn at an intersection, etc. In addition to oncoming vehicles, pedestrians can also be detected, but your vehicle may not stop or the system may not activate under certain conditions*.
- If your vehicle is moving faster than approximately 16 mph (25 km/h) when you turn, the system will not activate. Also, even if your vehicle is moving approximately 16 mph (25 km/h) or slower, if the obstacle suddenly cuts in front of you or is outside the stereo camera's field of view, your vehicle may not stop or the system may not activate depending on differing conditions* such as visibility or the slipperiness of the road.

*: Conditions

- Speed difference with the oncoming vehicle, distance to the oncoming vehicle, the angle of approach, changes in the actions of the oncoming vehicle and the position of the other vehicle relative to the side of your vehicle.
- Vehicle conditions (amount of load, number of occupants, etc.)
- Road conditions (grade, slipperiness, shape, bumps, etc.)
- Visibility ahead is poor (rain, snow, fog or smoke, etc.).
- The obstacle is something other than an oncoming vehicle or pedestrian.
  - A parked vehicle or a vehicle that is traveling in the same direction as your vehicle
  - An animal, etc.
  - A guardrail, telephone pole, tree, fence or wall, etc.
- Even if an oncoming vehicle has been detected, you are not signaling to move in the direction that your vehicle is actually traveling.
- Even if the obstacle is an oncoming vehicle, it is traveling close to objects on the side of the road.
- Even if the obstacle is an oncoming vehicle, it is stopped or traveling in your lane.

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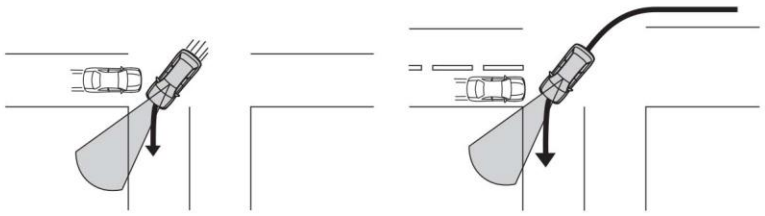
- Even if the obstacle is an oncoming vehicle, the system cannot recognize it as a target obstacle because, for example, the front of the vehicle cannot be seen or the vehicle is difficult to see because it is driving without its headlights on at night.
- Even if the obstacle is an oncoming vehicle, your vehicle moved into the oncoming vehicle's path before the system could recognize it as a target obstacle.
- Even if the obstacle is an oncoming vehicle, your vehicle is in the oncoming lane.



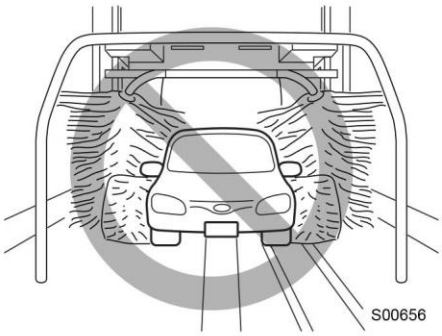
S04094

- Even if the obstacle is a pedestrian, depending on the brightness of the surroundings, its relative movement, its aspect, and the direction it is facing, there may be cases when the system cannot detect it.

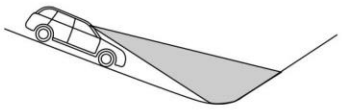
• In particular, there is a high possibility that your vehicle cannot stop or that the system will not activate in the following cases:
- Visibility is poor due to water, snow, dust, etc. kicked up by another vehicle, or due to water vapor, sand, smoke, etc. in the air.
- Approaching a pedestrian at night.
- The oncoming vehicle or pedestrian is outside the area illuminated by the headlights.
- The front aspect of the oncoming vehicle is small, low or irregular.
- The vehicle, etc. has its side facing you.
- The vehicle, etc. is backing up.
- The oncoming vehicle suddenly swerves, accelerates or decelerates.
- The oncoming vehicle or pedestrian suddenly cuts in from the side or suddenly runs in front of you.
- The oncoming vehicle or pedestrian is close to your vehicle's bumper.
- You turn the steering wheel suddenly away or back to your direction of travel.

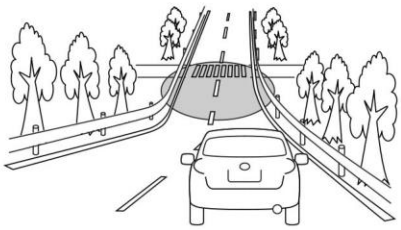
CAUTION

- In the following situations, turn off Pre-Collision Braking System. Otherwise Pre-Collision Braking System may activate unexpectedly.
  ⇒ Page 61
  - The vehicle is being towed.
  - The vehicle is being loaded onto a carrier.
  - A chassis dynamometer, free-rollers or similar equipment is being used.
  - A mechanic lifts up the vehicle, starts the engine and spins the wheels freely.
  - Passing hanging banners, flags or branches
  - Thick/tall vegetation is touching the vehicle.
  - Driving on a race track
  - In a drive-through car wash


S00656

- Pre-Collision Braking System may activate in the following situations. Therefore concentrate on safe driving.
  - Passing through an automatic gate (opening and shutting)
  - Driving close to the vehicle in front, pedestrian or cyclist
  - Driving in a location where the grade of the road changes rapidly




S01264

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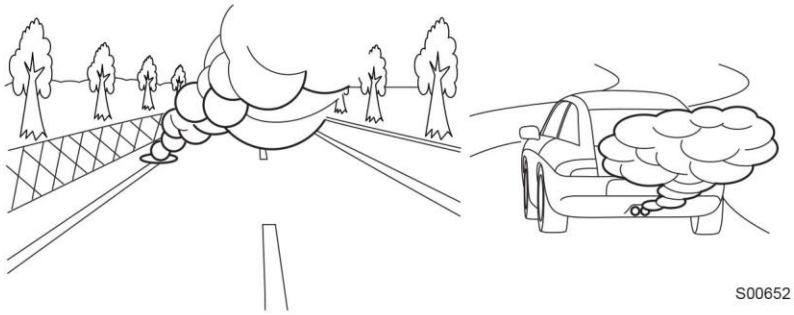
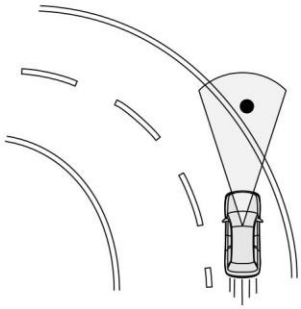
- Visibility is poor due to sand, smoke or water vapor blowing in the wind, or the front vision is obscured due to water splashes, snow, dirt or dust stir up generated by the vehicle in front or oncoming traffic.
- Passing through clouds of steam or smoke, etc.
- In adverse weather, such as heavy snow or snowstorms
- The exhaust gas emitted by the vehicle in front is clearly visible in cold weather, etc.



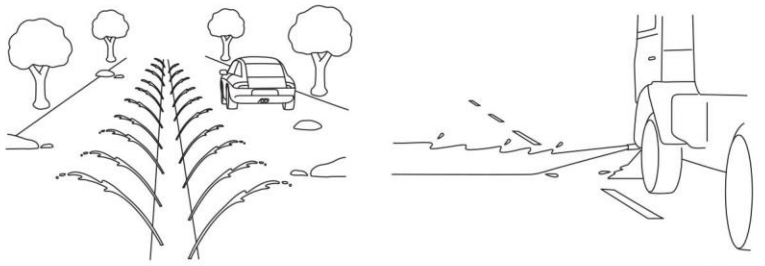
S00652

- There is an obstacle on a curve or intersection.
- You are passing close to the side of a vehicle, an obstacle or vegetation.
- Stopping very close to a wall or a vehicle in front



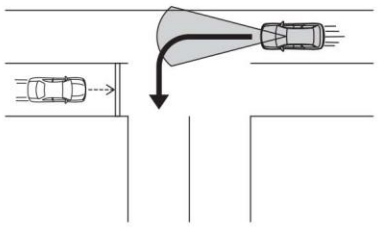
S02669

- Passing through water spray from road sprinklers or snow clearing sprinklers on the road



S02636

- If there is cargo or installed accessories, etc. that are protruding beyond the edge of the front bumper, the vehicle's length will increase and the system may not be able to prevent a collision.
- If you operate the brake pedal during automatic braking, the pedal may feel stiff. The brake pedal may also move on its own during automatic braking. However, this is normal. By depressing the brake pedal further, you can apply more braking force. Apply more braking force as necessary.
- Pre-Collision Braking System may activate in the following situations even when there is no oncoming vehicle or pedestrian approaching.
  - An oncoming vehicle decelerates or stops before an intersection just before you make a turn and enter the oncoming lane.



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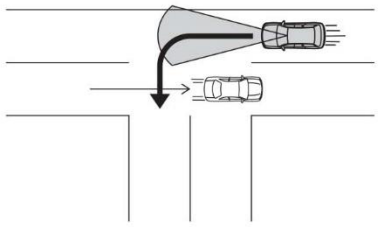
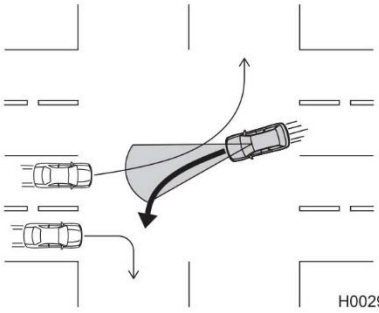
- An oncoming vehicle passes by just before you make a turn and enter the oncoming lane.



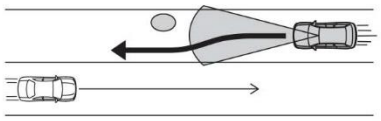
H00296

- Just before you make a turn and enter the oncoming lane, you pass by an oncoming vehicle also making a turn.



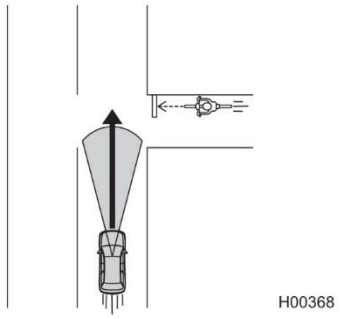
H00297

- You suddenly approach close to an oncoming vehicle while trying to change lanes or avoid an obstacle.
- When you are turning, a pedestrian crosses in front of your vehicle or just before crossing slows down or stops.

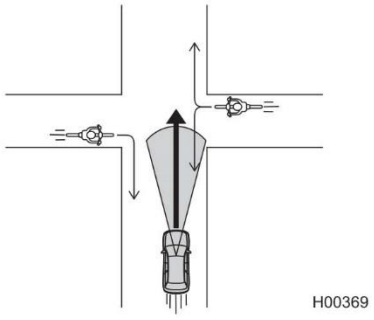


H00298

- A vehicle, motorcycle, cyclist or pedestrian slows down or stops just before crossing in front of you.



- A vehicle, motorcycle, cyclist or pedestrian changes direction to either join your lane or pass by you in the opposite direction just before crossing in front of you.



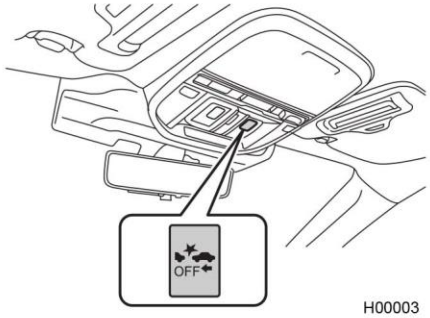
NOTE

Some unusual noises may be audible during automatic braking. This is caused by the braking control and is normal.

Turning off Pre-Collision Braking System

Press and hold the Pre-Collision Braking System OFF switch for approximately 2 seconds or longer to turn off Pre-Collision Braking System (including Pre-Collision Braking Assist and Automatic Emergency Steering (if equipped)). When 1 short beep sound emits, this control is turned off and the Pre-Collision Braking System OFF indicator light on the instrument panel illuminates.

To turn the control back on, press and hold the Pre-Collision Braking System OFF switch for approximately 2 seconds or longer again. When this control is turned on, the Pre-Collision Braking System OFF indicator light turns off.



H00003

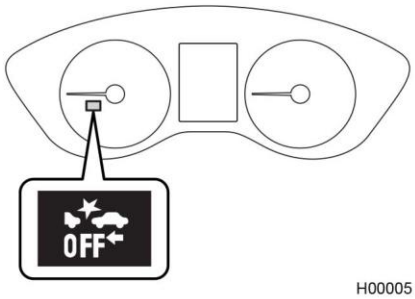
NOTE

- When Pre-Collision Braking System is turned off, the Automatic Emergency Steering (if equipped) and Pre-Collision Throttle Management Control function are also turned off.
- Even when Pre-Collision Braking System is turned off, if the engine is turned off and then restarted, Pre-Collision Braking System will be turned on. The system default setting when the vehicle is restarted is on.

■ Pre-Collision Braking System OFF indicator light

This indicator light illuminates when the ignition switch is turned to the ON position, and remains illuminated for approximately 10 seconds after the engine starts. It turns on when Pre-Collision Braking System, Automatic Emergency Steering (if equipped) and Pre-Collision Throttle Management are turned off.
It also illuminates under the following conditions.

- The EyeSight system has a malfunction.
  ⇒ Page 155
- The EyeSight system has stopped temporarily.
  ⇒ Page 157



H00005

NOTE

- If the Pre-Collision Braking System OFF indicator light illuminates, the Automatic Emergency Steering OFF indicator (if equipped) also illuminates.
  ⇒ Page 60
- When the Pre-Collision Braking System OFF indicator light is turned on, Pre-Collision Braking System (including the Pre-Collision Braking Assist function), Automatic Emergency Steering (if equipped) and Pre-Collision Throttle Management do not operate.
- For models with Automatic Emergency Steering, you cannot use Automatic Emergency Steering when BSD/RCTA is turned off. In this case, the Automatic Emergency Steering OFF indicator illuminates.

APPENDIX C

Run Log

Subject Vehicle: **2022 Subaru Forester Premium/NFF** Test start date: **1/13/2022**

Principal Other Vehicle: **SSV** Test end date: **1/13/2022**

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	**Stopped POV**	Y	2.86	5.59	24.8	1.11	1.19	Pass	
3		N							Throttle Release NG
4		Y	2.79	5.05	24.9	1.06	1.22	Pass	
5		Y	2.86	5.98	24.9	1.02	1.29	Pass	
6		Y	2.91	5.75	24.9	1.00	1.26	Pass	
7		Y	2.92	5.69	25.0	0.99	1.27	Pass	
8		Y	2.99	5.96	25.5	1.02	1.26	Pass	
9		Y	2.96	5.96	25.1	1.11	1.25	Pass	
10	Static Run								
11	**Slower POV, 25 vs 10**	Y	2.38	5.07	14.7	0.97	0.91	Pass	
12		Y	2.39	4.93	14.8	1.04	0.87	Pass	
13		Y	2.37	4.91	15.0	1.01	0.93	Pass	
14		Y	2.49	5.00	15.0	0.94	0.92	Pass	
15		Y	2.45	5.36	15.5	0.97	0.98	Pass	
16		Y	2.49	4.94	14.7	1.08	0.91	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
17		Y	2.46	4.78	14.4	1.03	0.89	Pass	
18	Static Run								
19	**Slower POV, 45 vs 20**	N							Throttle Release NG
20		Y	3.05	5.74	24.2	0.99	1.27	Pass	
21		N							Throttle Release NG
22		Y	3.06	5.72	24.5	1.02	1.28	Pass	
23		N							Throttle Release NG
24		Y	3.22	4.42	25.0	1.01	1.32	Pass	
25		Y	3.13	4.91	24.9	1.04	1.32	Pass	
26		Y	3.10	5.34	24.5	1.08	1.29	Pass	
27		Y	3.11	4.80	24.4	0.99	1.30	Pass	
28		Y	3.01	5.61	24.4	1.11	1.29	Pass	
29	Static Run								
30	**Decelerating POV, 35**	N							POV Brake
31		Y	1.89	7.44	24.1	1.10	1.00	Pass	
32		Y	1.74	8.50	22.0	1.08	1.03	Pass	
33		Y	1.61	8.69	20.2	1.04	0.98	Pass	
34		Y	1.70	7.37	21.1	1.08	0.95	Pass	
35		Y	1.80	8.30	21.6	1.09	1.01	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
36		Y	1.83	8.77	23.4	1.12	1.06	Pass	
37		Y	1.76	10.22	21.6	1.08	1.03	Pass	
38	Static Run								
39	STP - Static Run								
40	**STP False Positive, 25**	N							Did not zero headway
41	STP - Static Run								
42		Y				0.01		Pass	
43		Y				0.01		Pass	
44		Y				0.03		Pass	
45	**STP False Positive, 25**	Y				0.00		Pass	
46		Y				0.00		Pass	
47		Y				0.00		Pass	
48		Y				0.01		Pass	
49	STP - Static Run								
50		Y				0.00		Pass	
51		Y				0.01		Pass	
52	**STP False Positive, 45**	Y				0.02		Pass	
53		Y				0.02		Pass	
54		Y				0.01		Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
55		Y				0.00		Pass	
56		Y				0.01		Pass	
57	STP - Static Run								

APPENDIX D

Time History Plots

LIST OF FIGURES

Description of Time History Plots

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

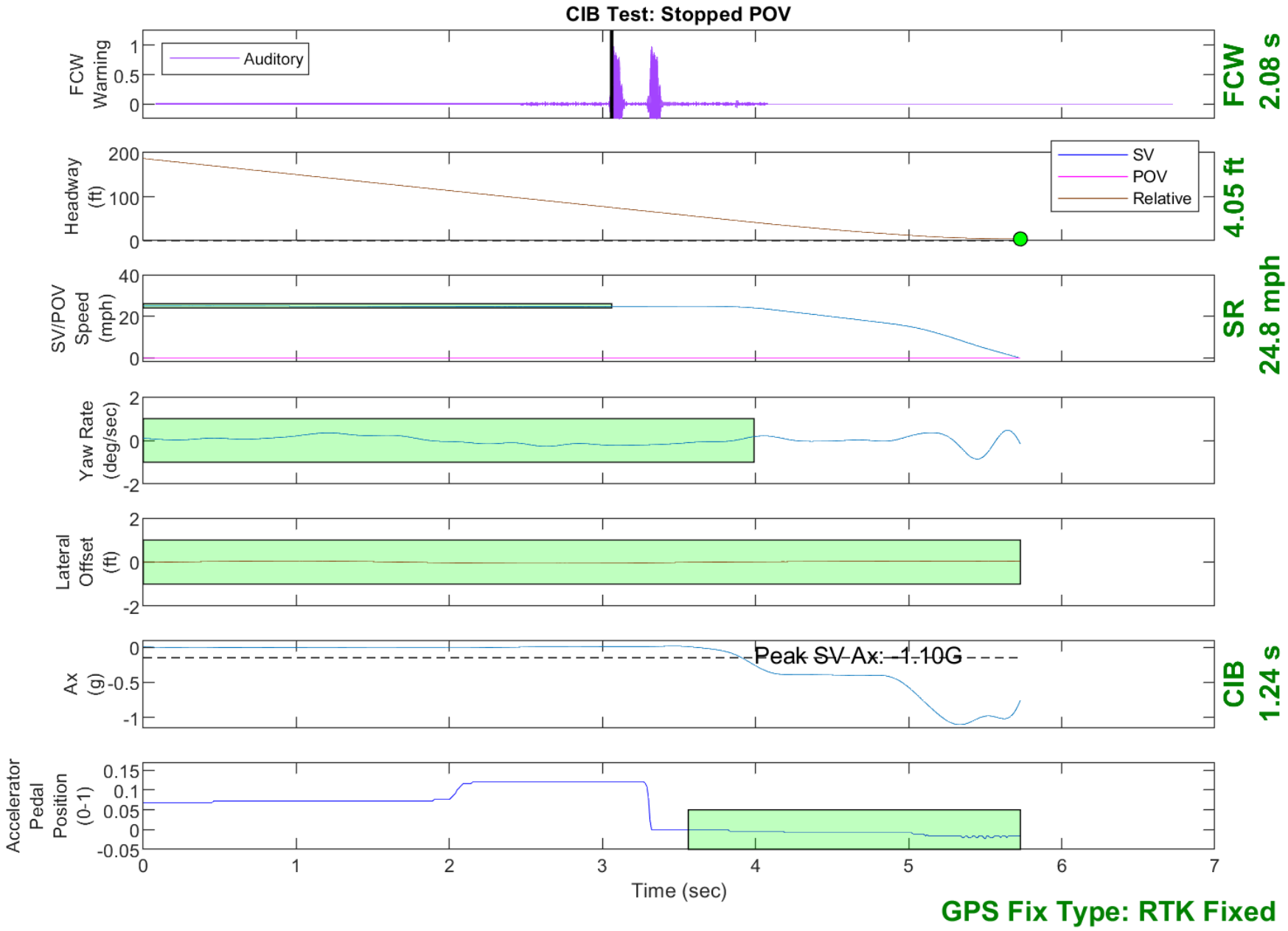


Figure D1. Example Time History for Stopped POV, Passing

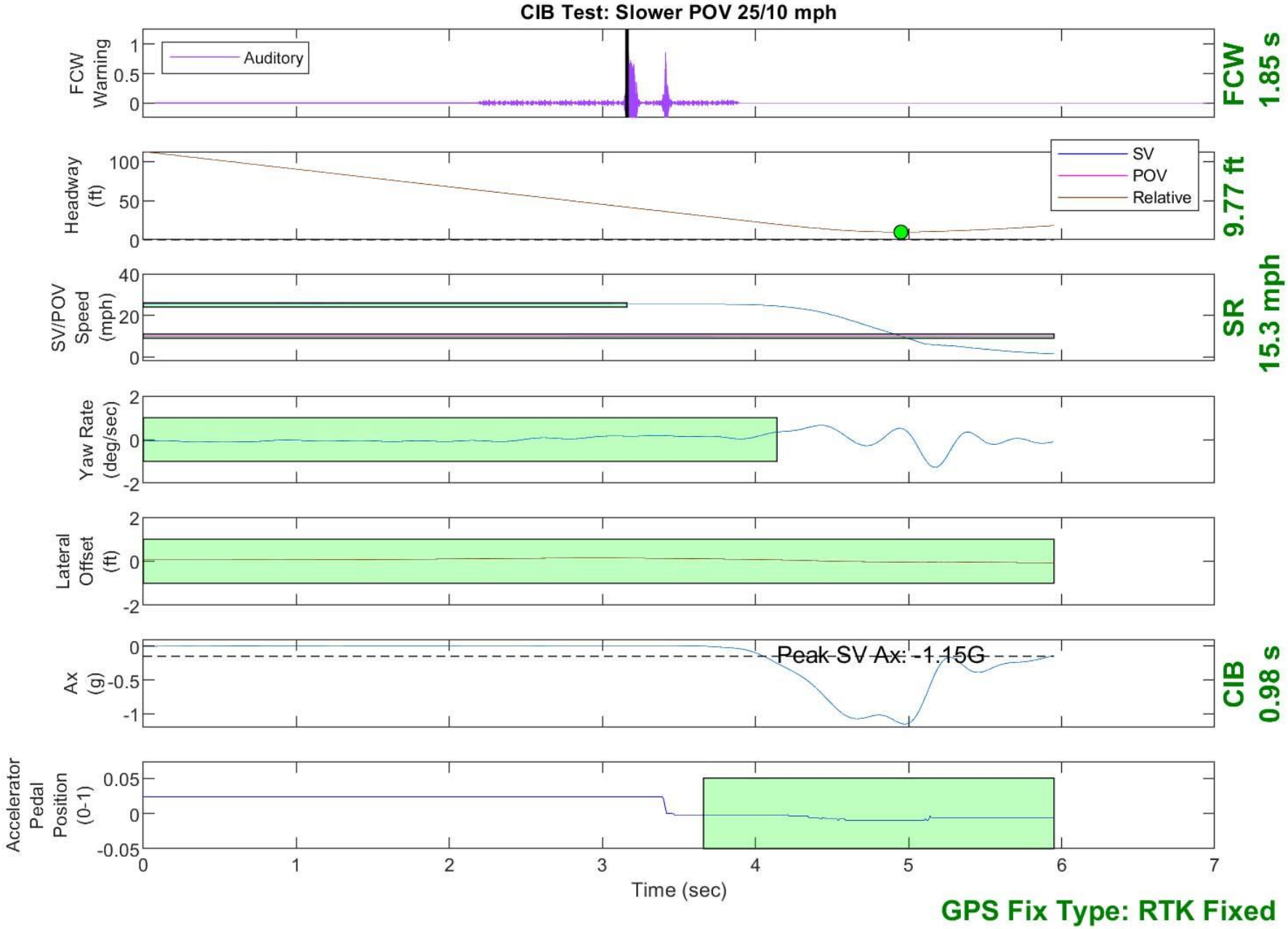


Figure D2. Example Time History for Slower POV 25 vs. 10, Passing

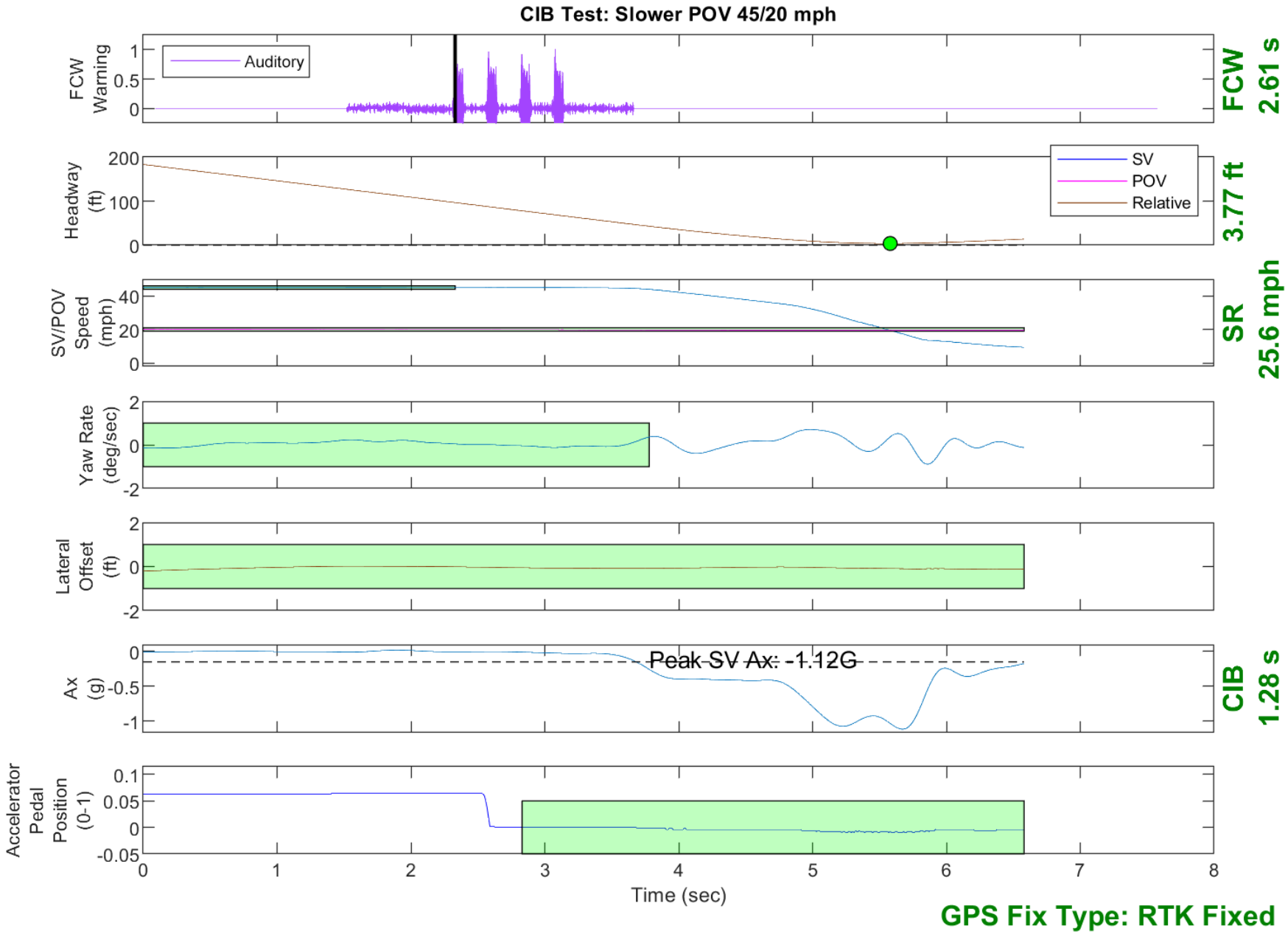


Figure D3. Example Time History for Slower POV 45 vs. 20, Passing

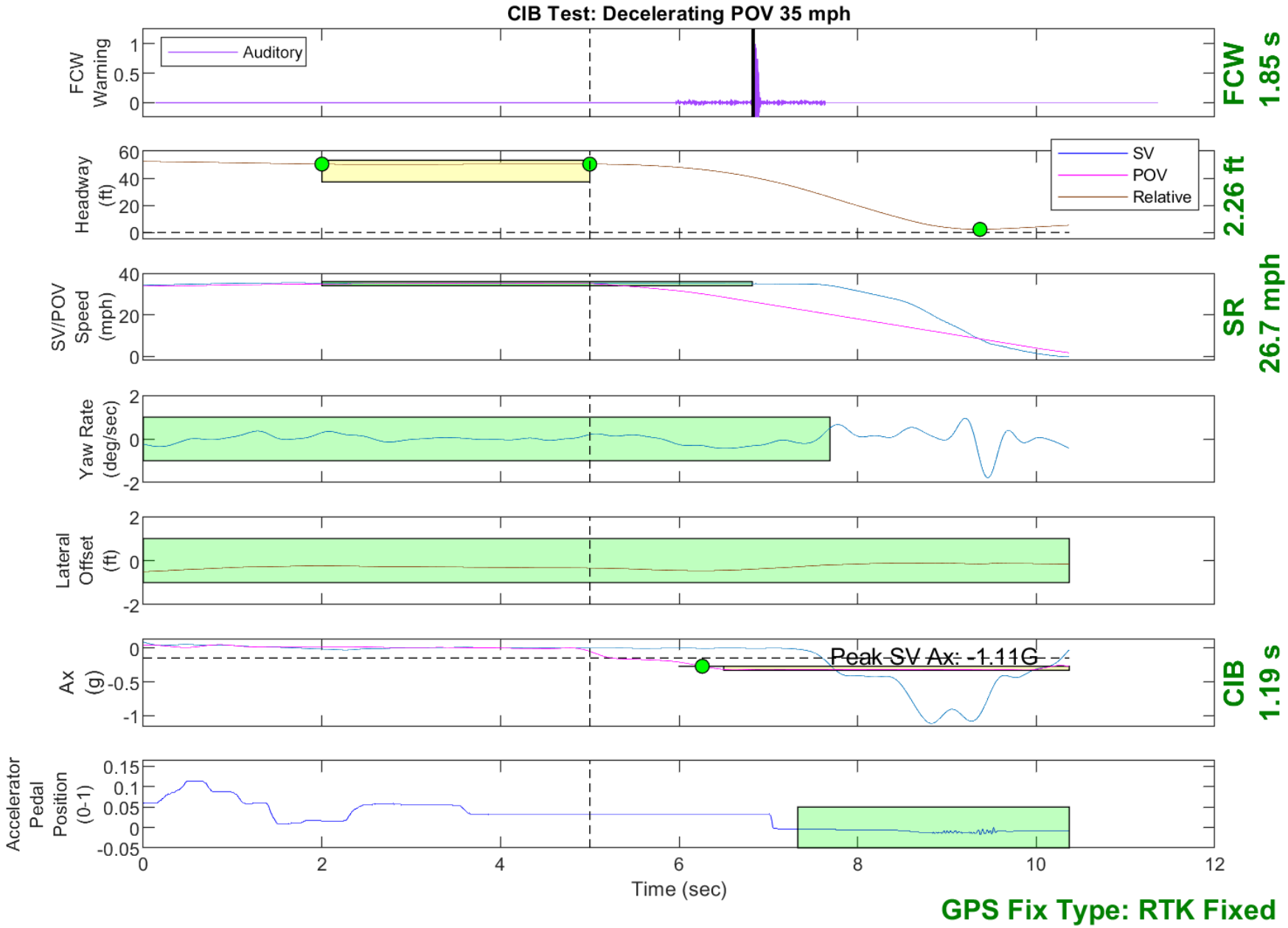


Figure D4. Example Time History for Decelerating POV 35, Passing

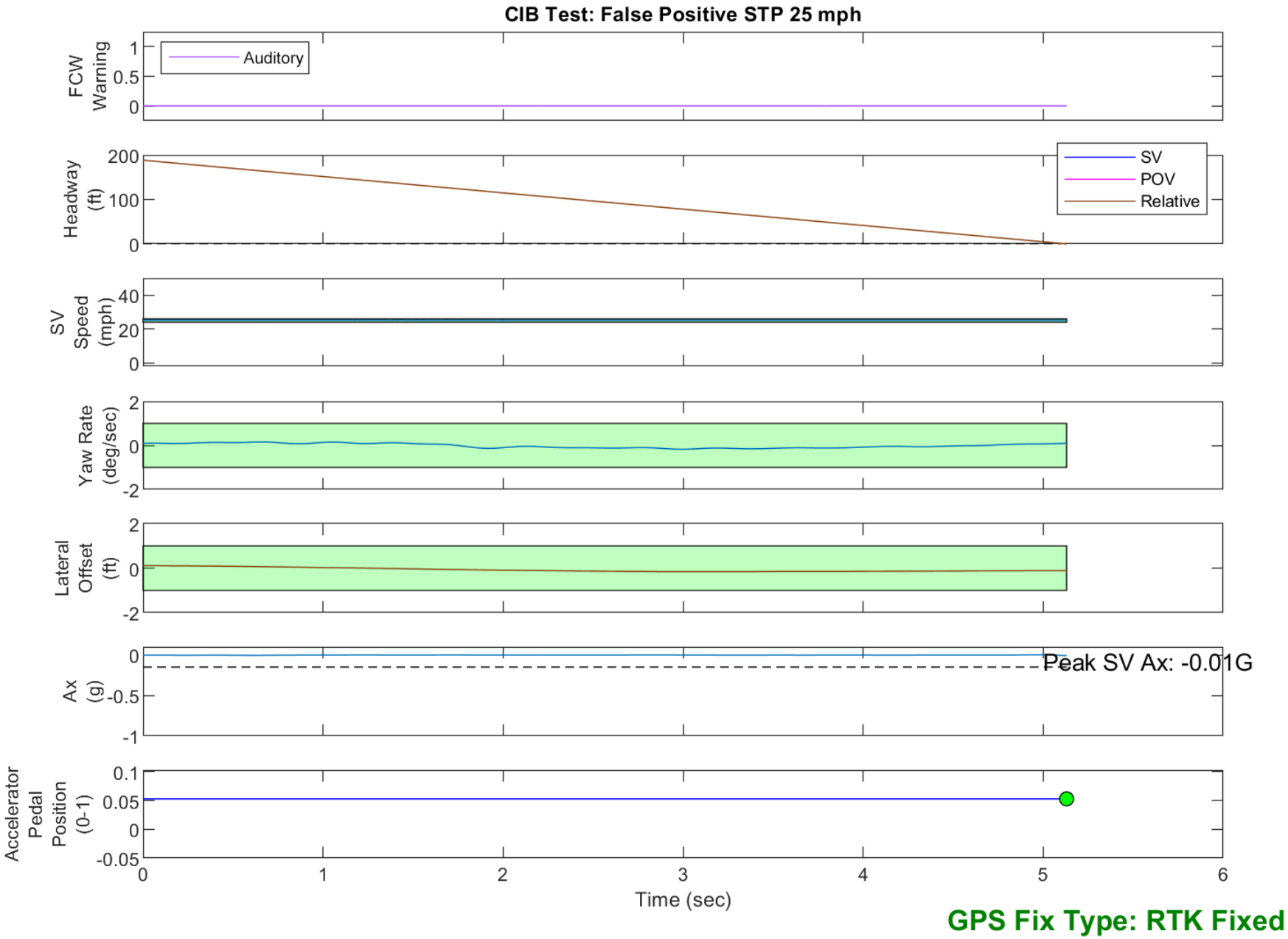


Figure D5. Example Time History for False Positive STP 25, Passing

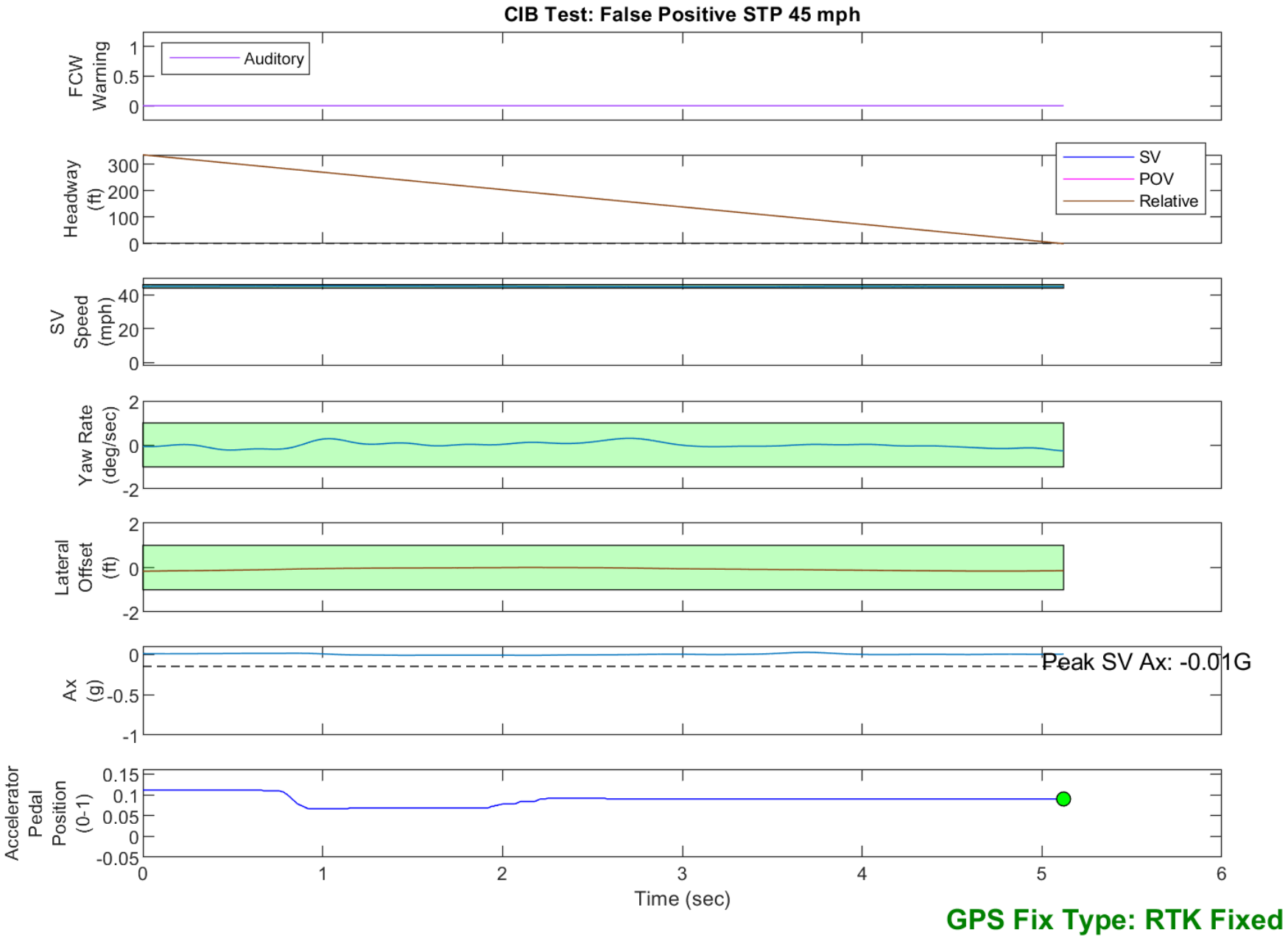


Figure D6. Example Time History for False Positive STP 45, Passing

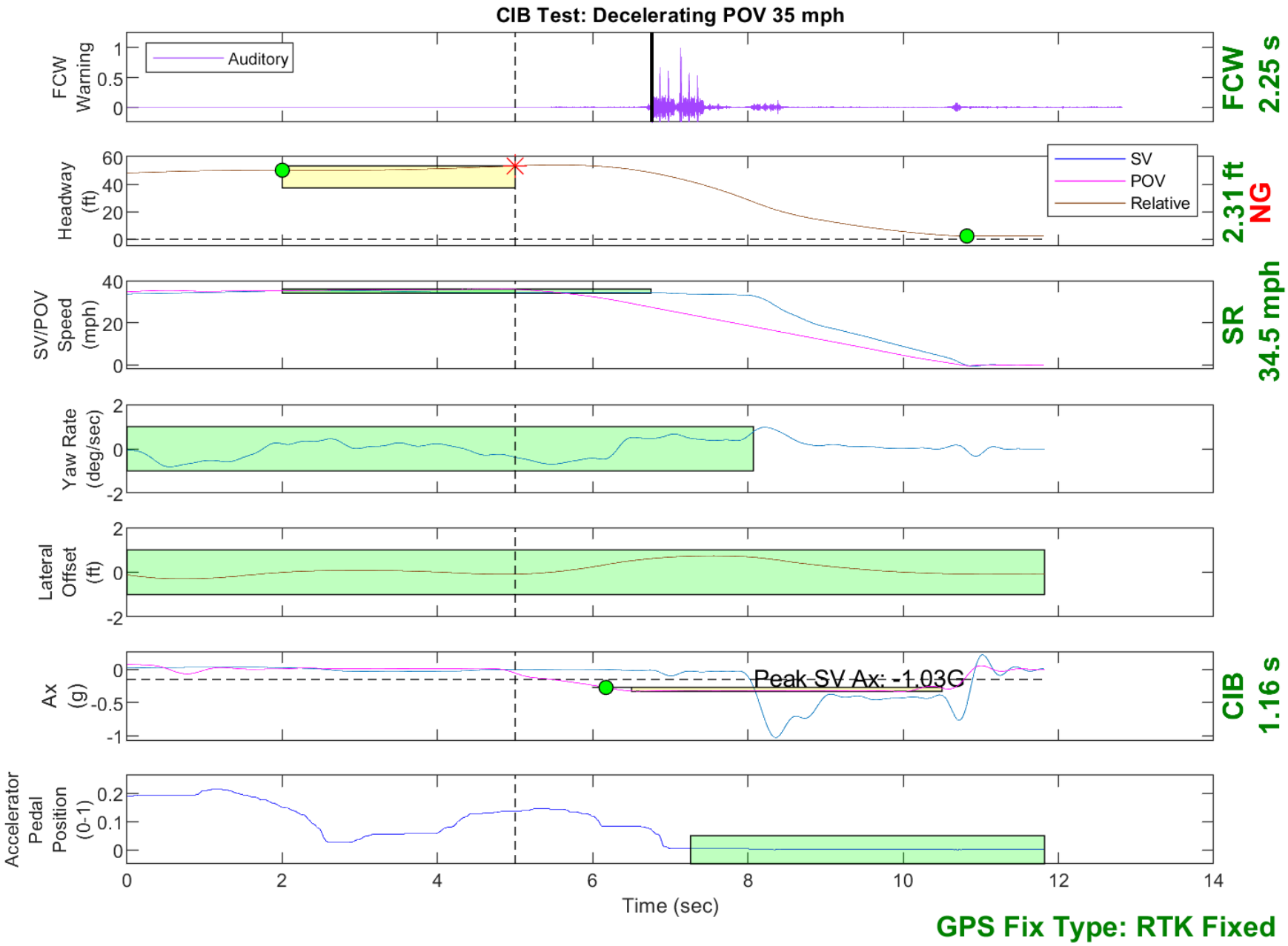


Figure D7. Example Time History Displaying Invalid Headway Criteria

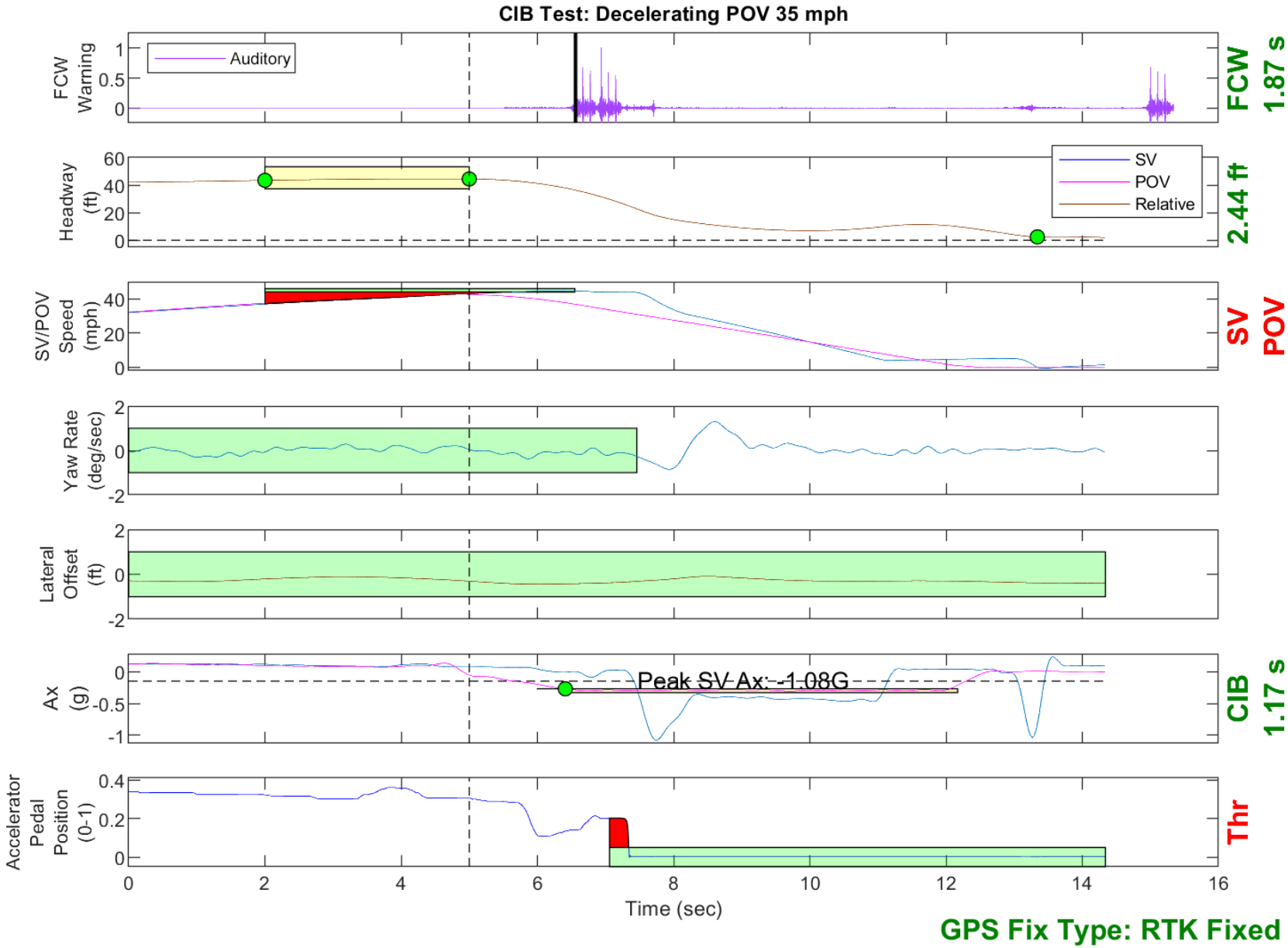


Figure D8. Example Time History Displaying Various Invalid Criteria

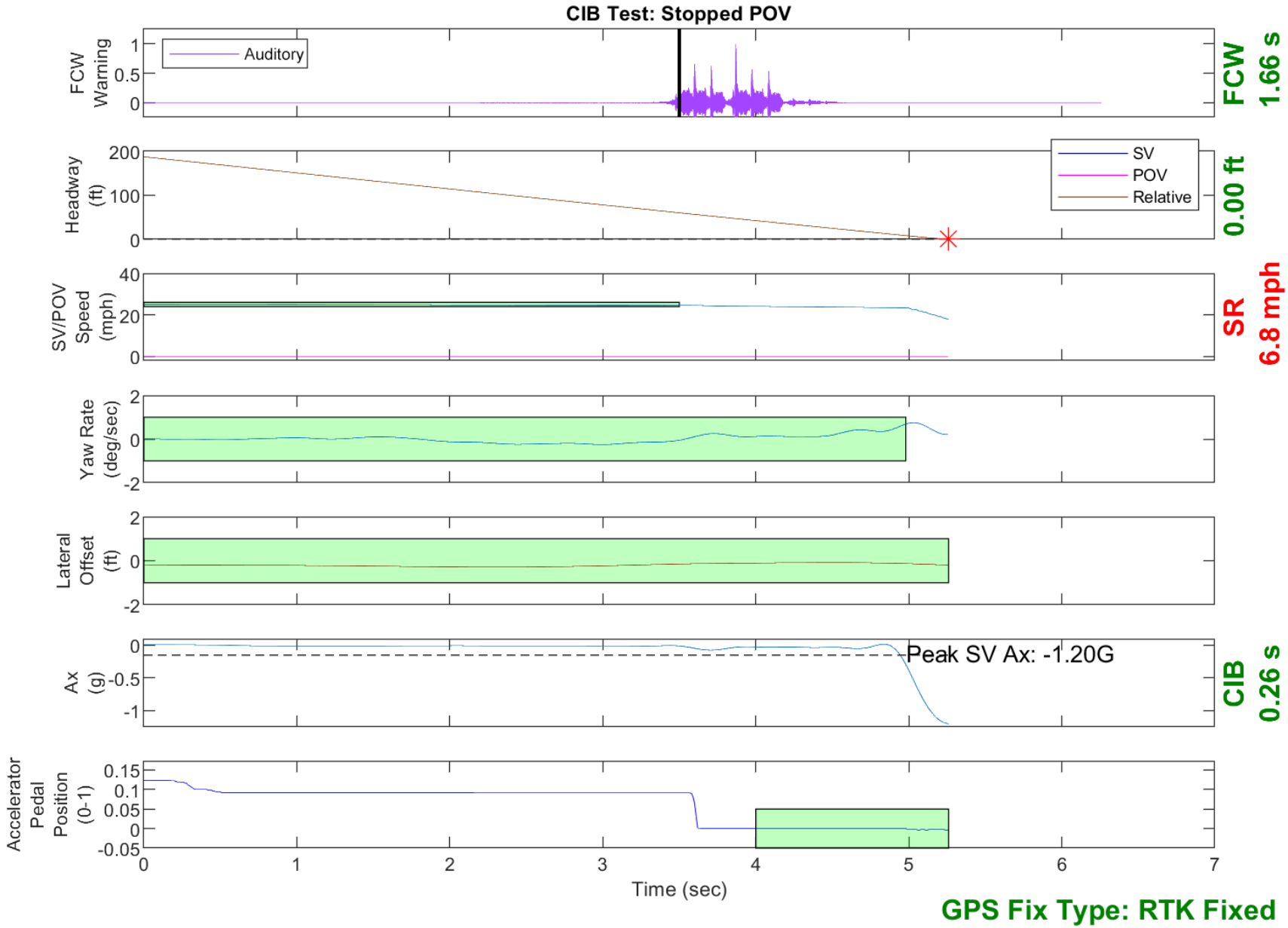


Figure D9. Example Time History for a Failed Run

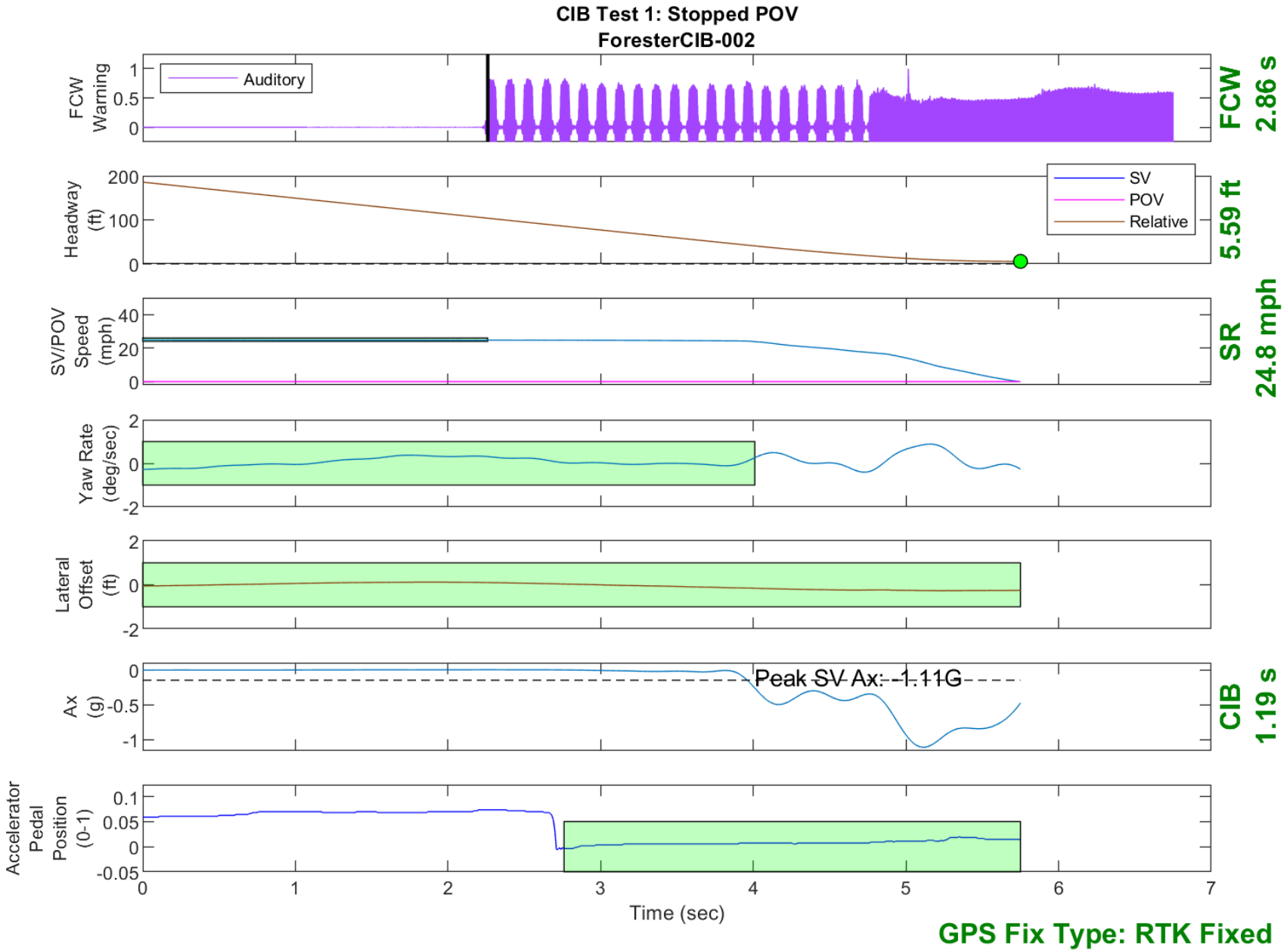


Figure D10. Time History for CIB Run 2, Test 1 - Stopped POV

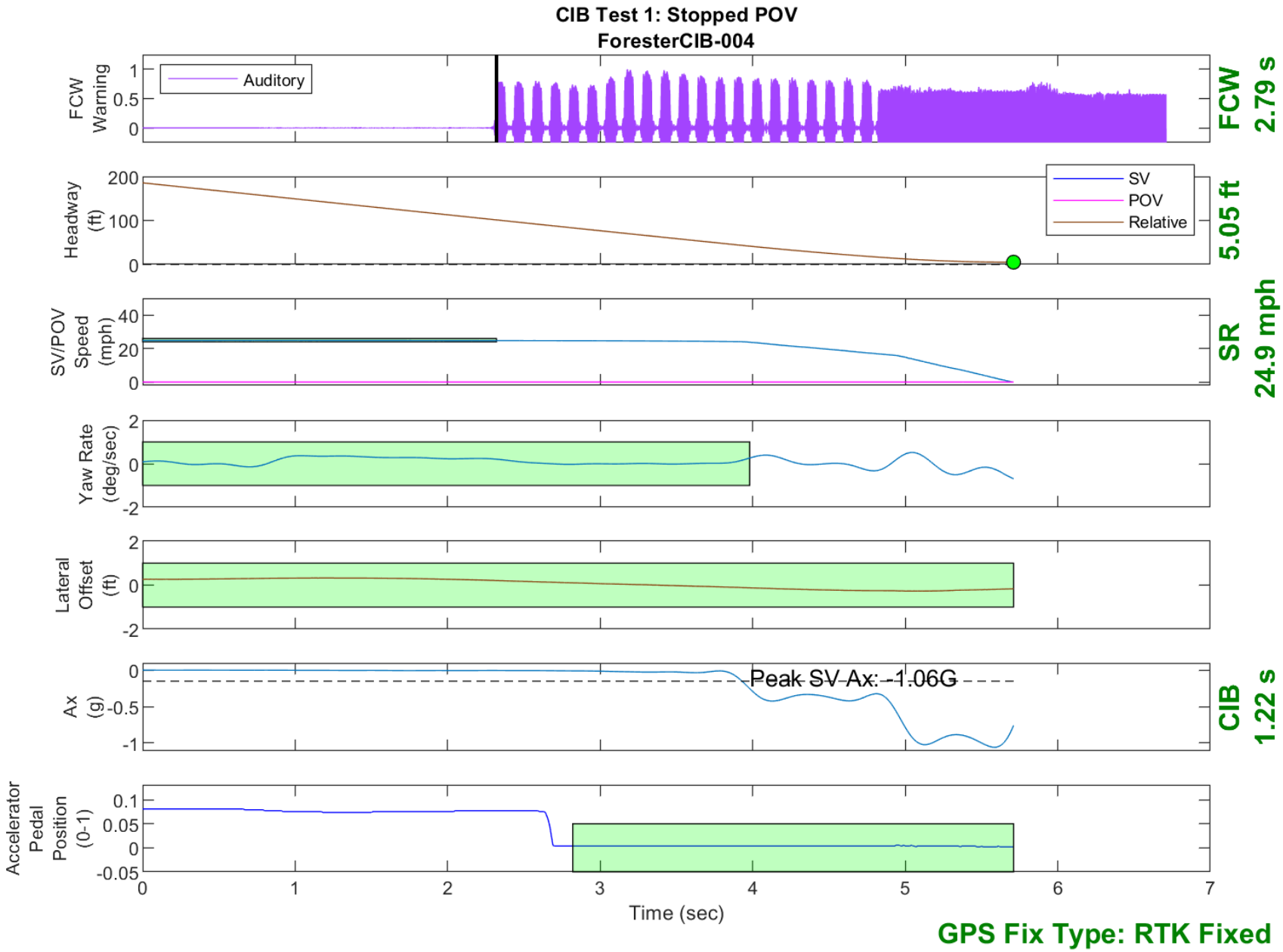


Figure D11. Time History for CIB Run 4, Test 1 - Stopped POV

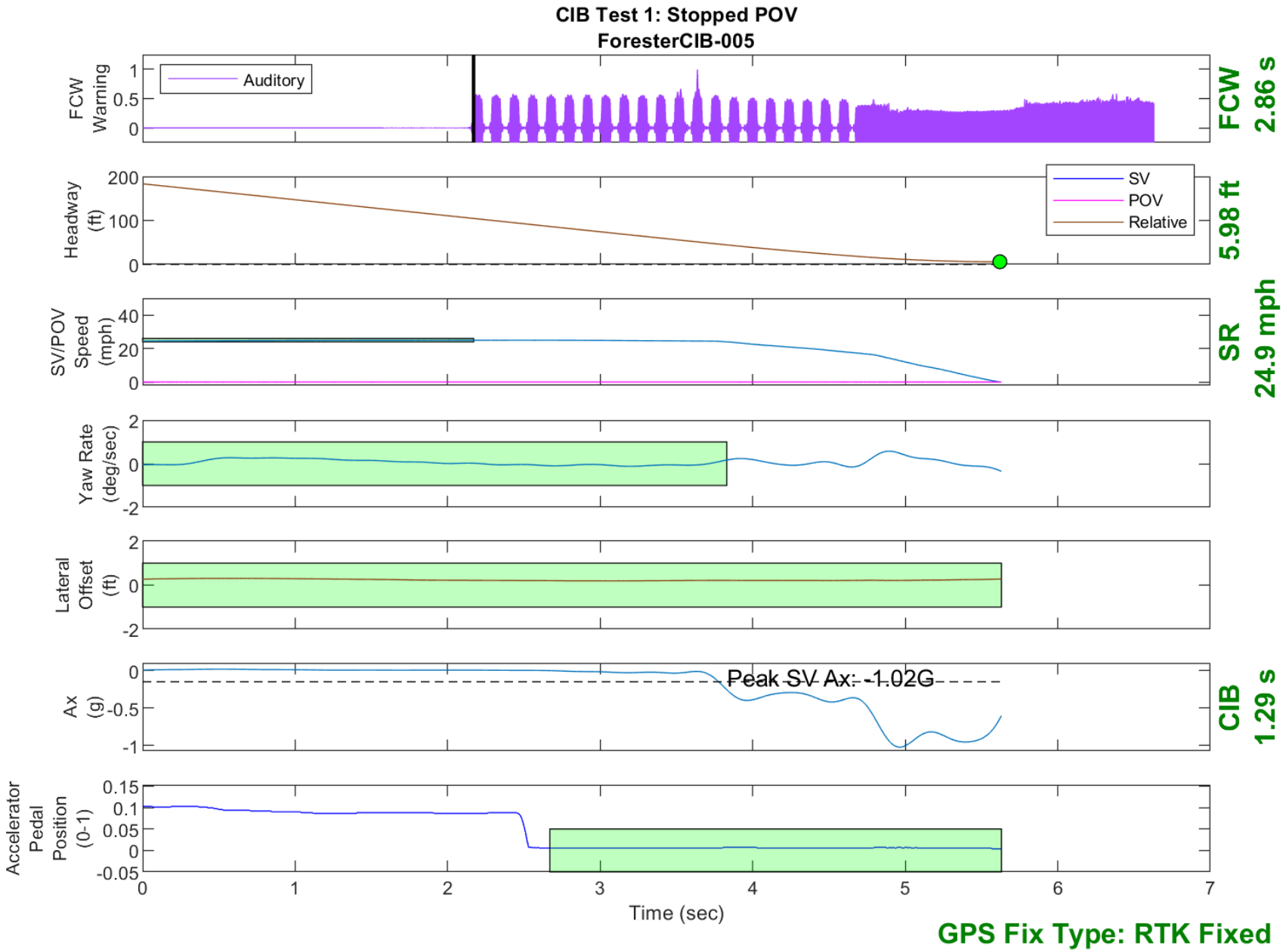


Figure D12. Time History for CIB Run 5, Test 1 - Stopped POV

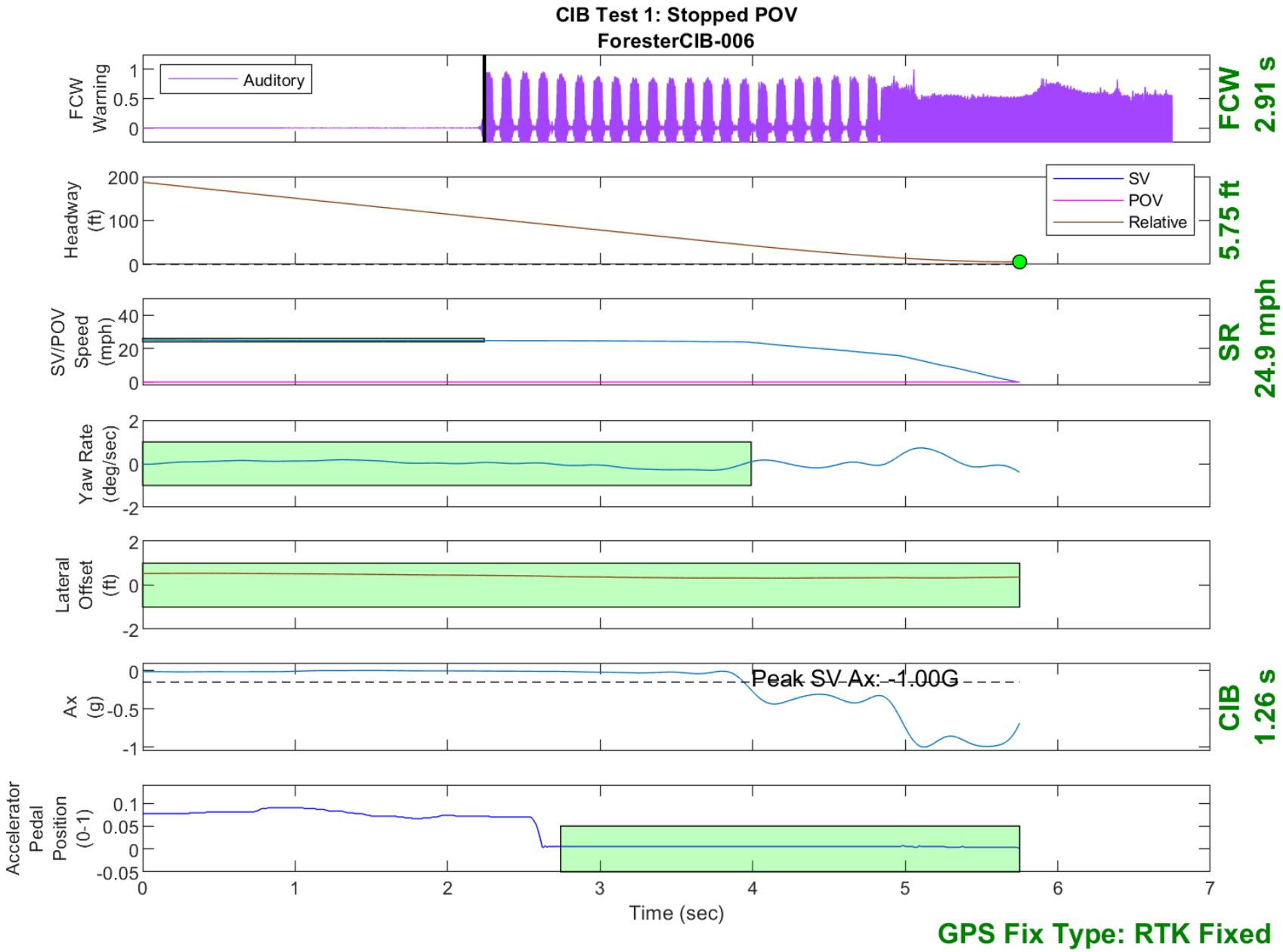


Figure D13. Time History for CIB Run 6, Test 1 - Stopped POV

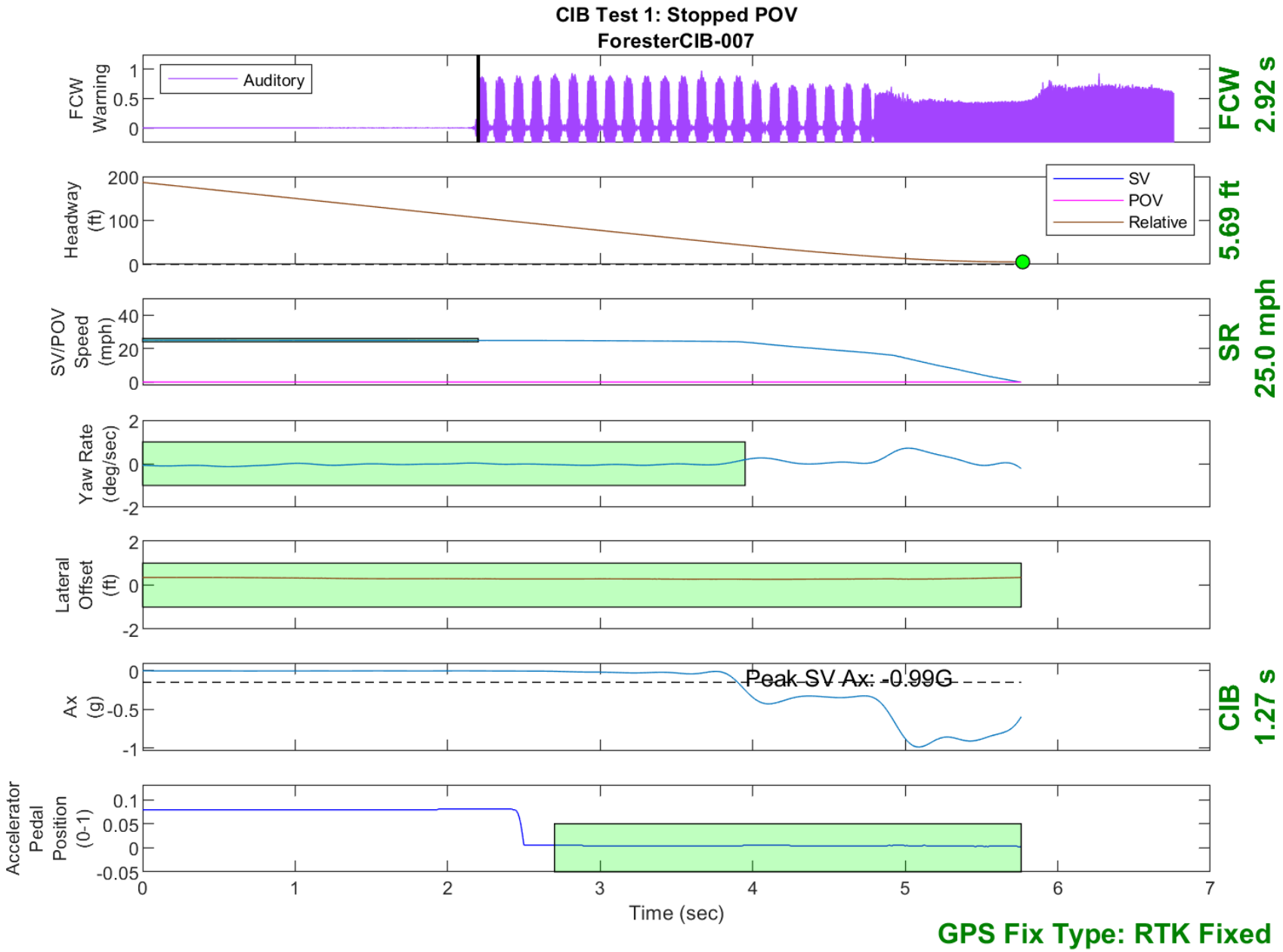


Figure D14. Time History for CIB Run 7, Test 1 - Stopped POV

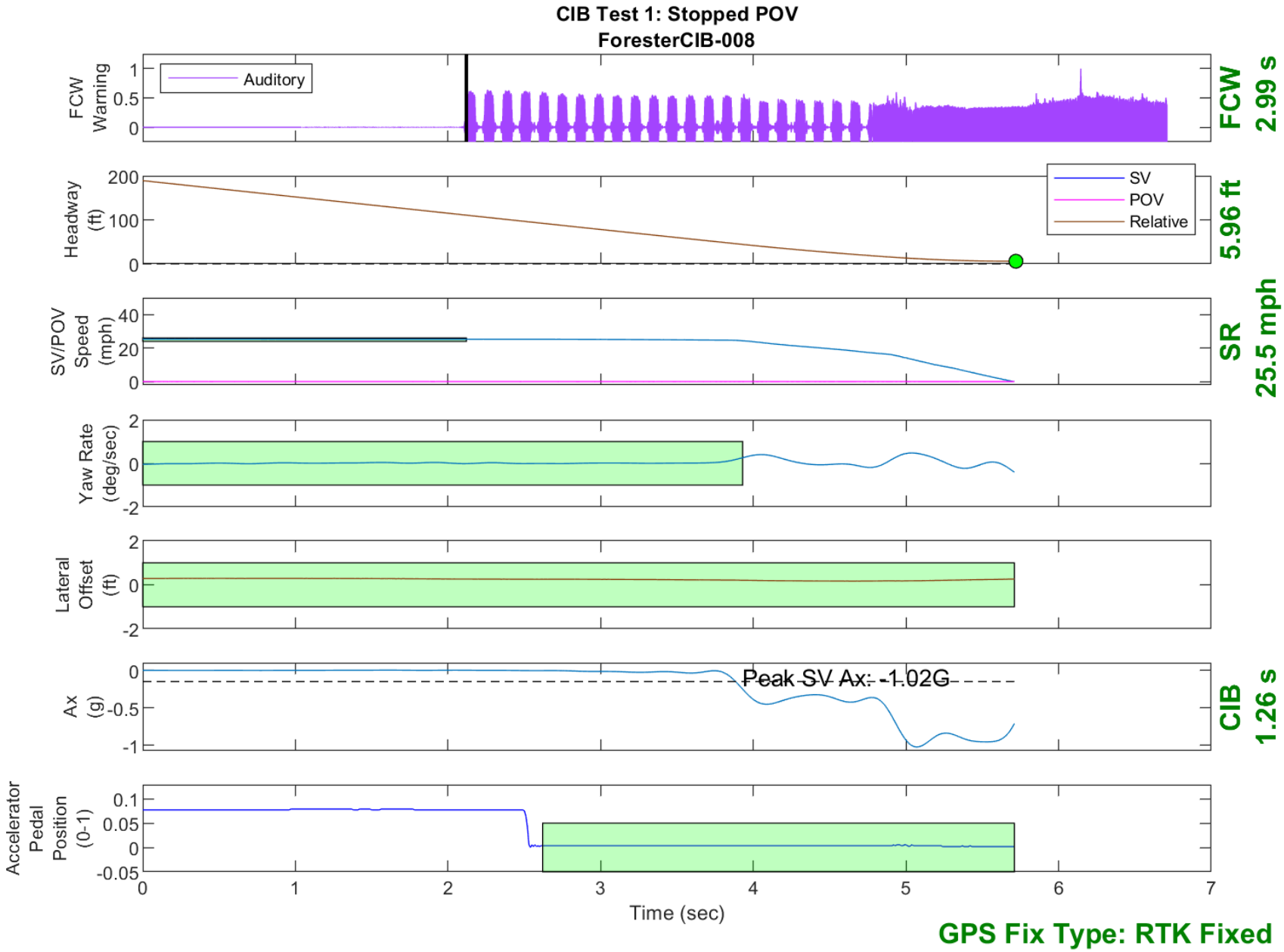


Figure D15. Time History for CIB Run 8, Test 1 - Stopped POV

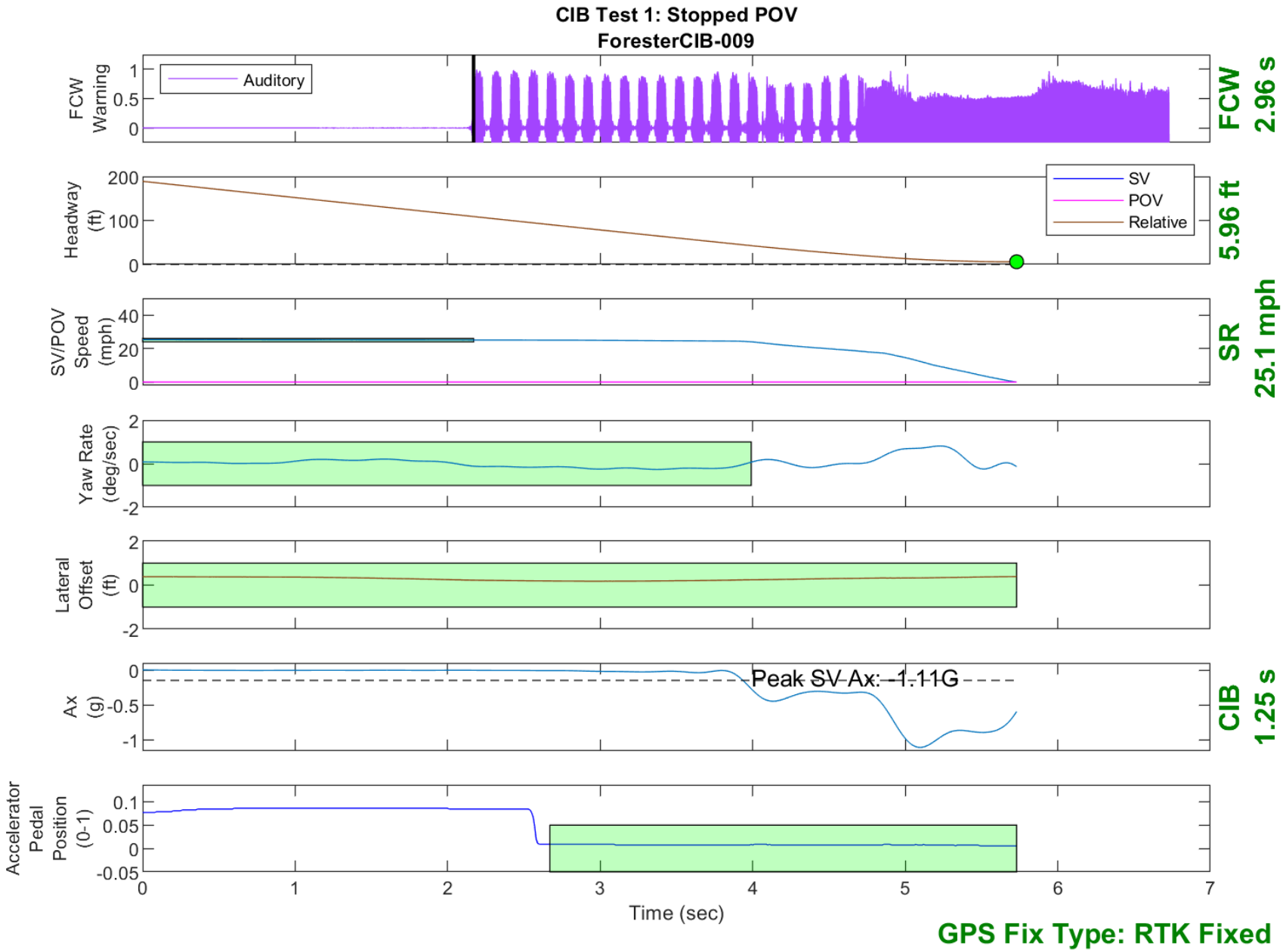


Figure D16. Time History for CIB Run 9, Test 1 - Stopped POV

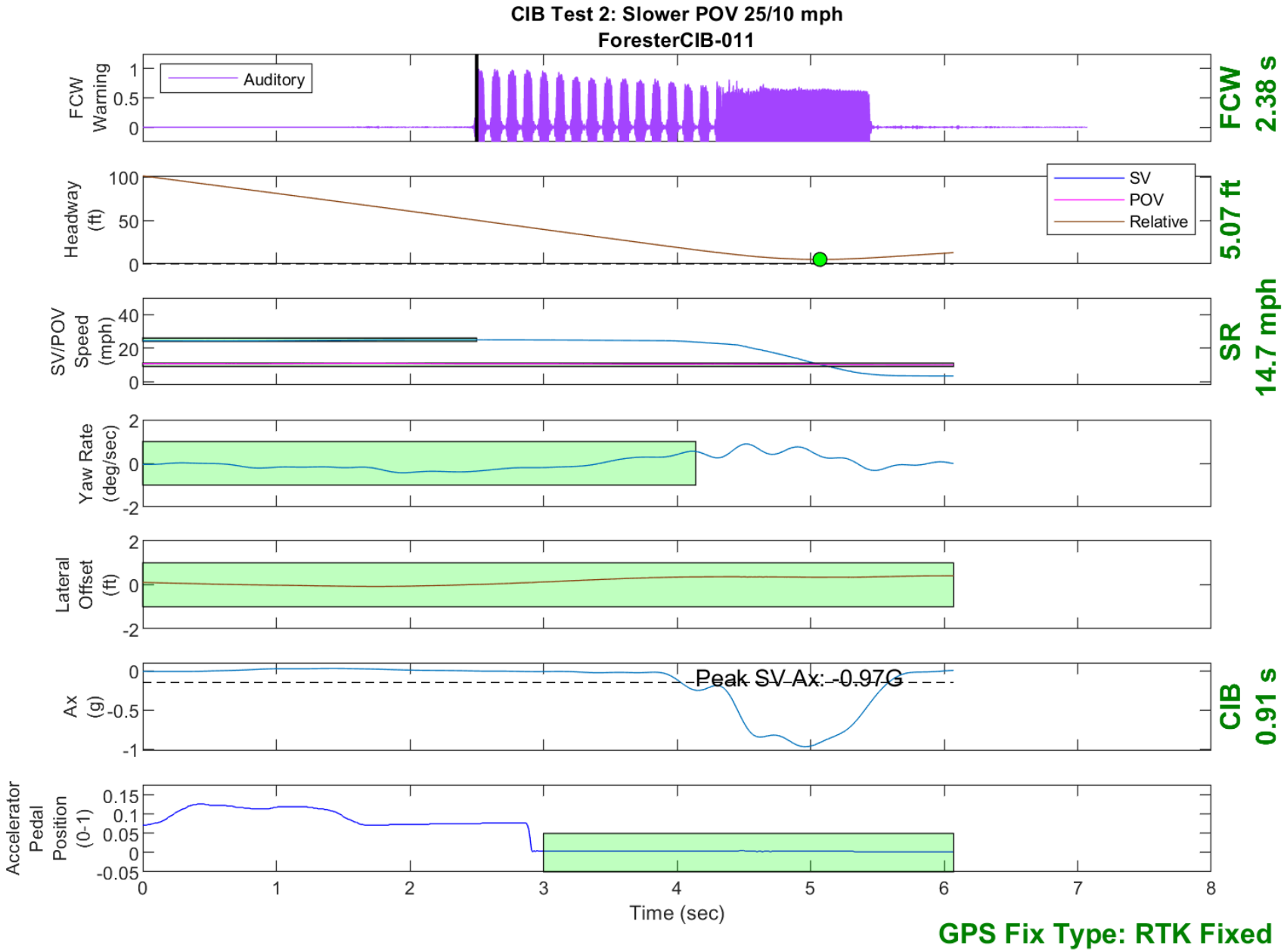


Figure D17. Time History for CIB Run 11, Test 2 - Slower Moving POV, 25/10 mph

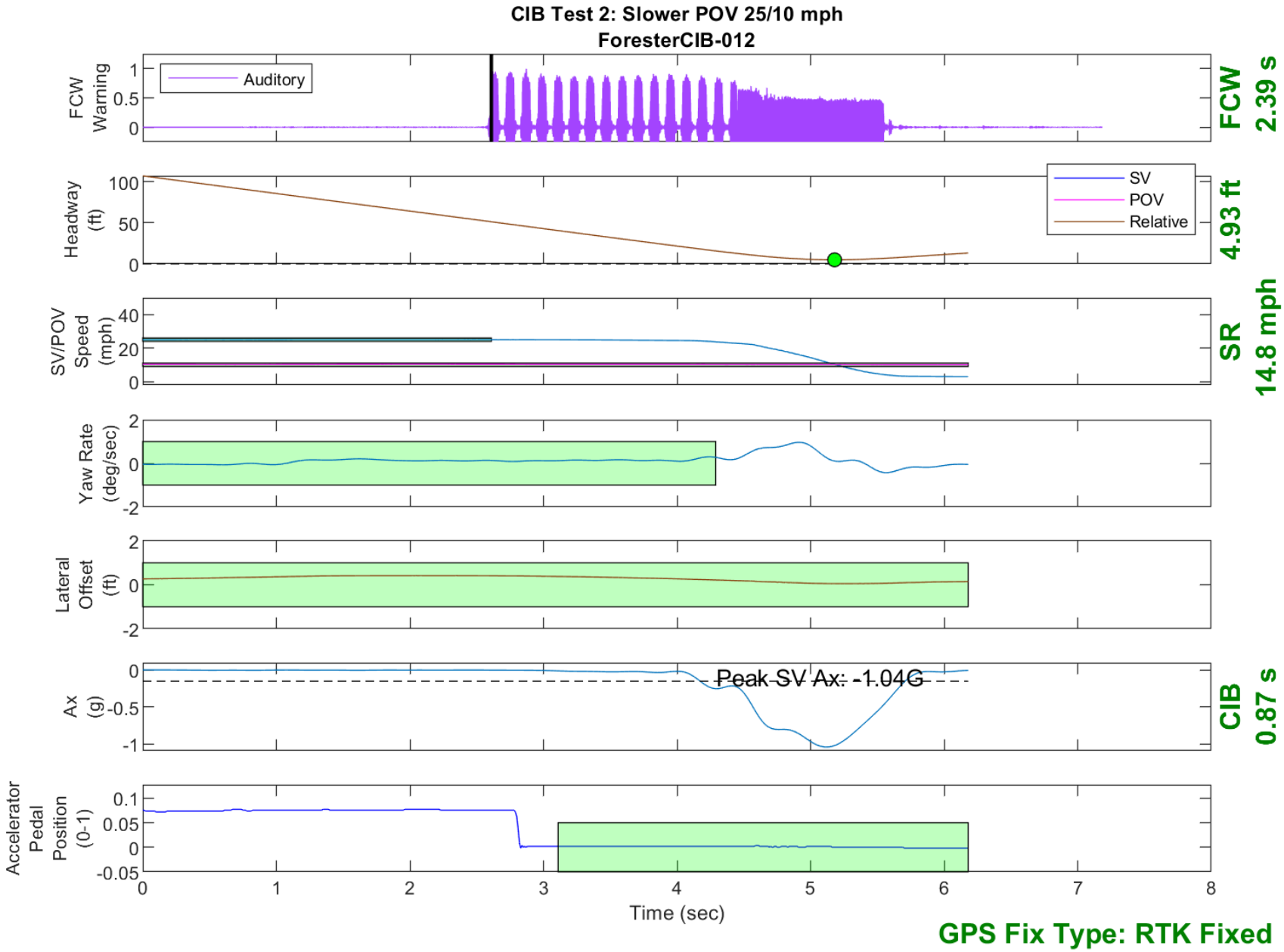


Figure D18. Time History for CIB Run 12, Test 2 - Slower Moving POV, 25/10 mph

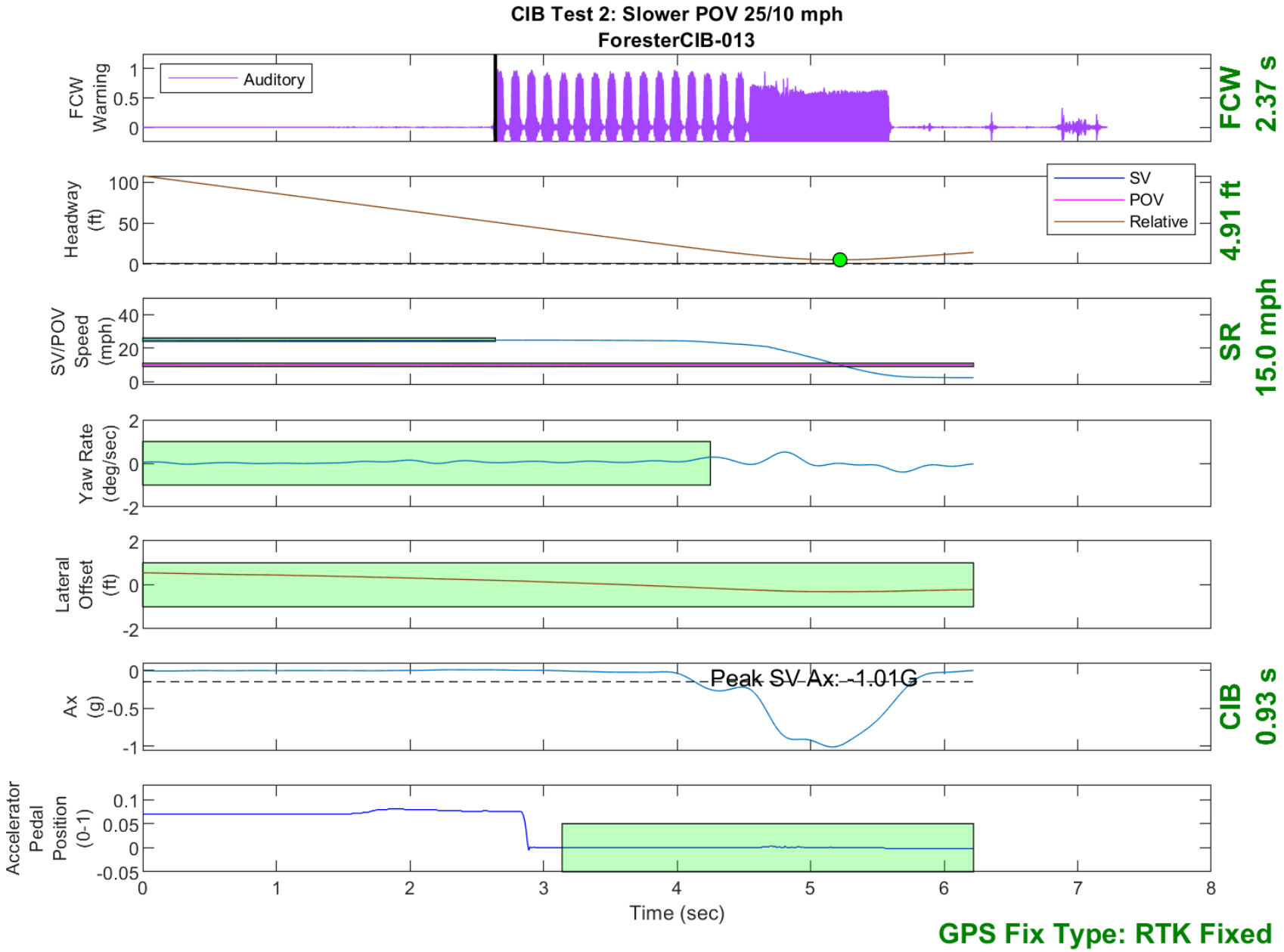


Figure D19. Time History for CIB Run 13, Test 2 - Slower Moving POV, 25/10 mph

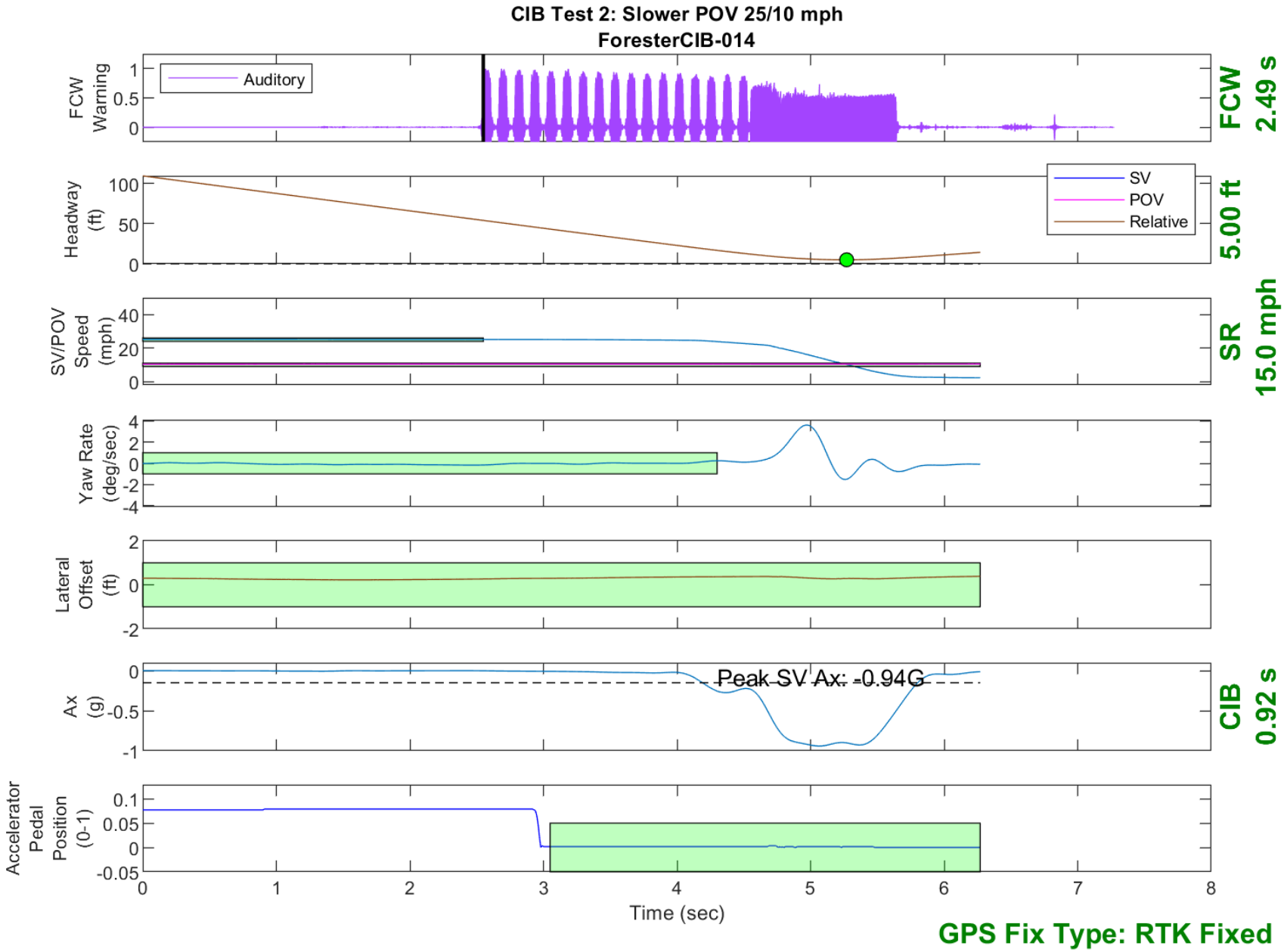


Figure D20. Time History for CIB Run 14, Test 2 - Slower Moving POV, 25/10 mph

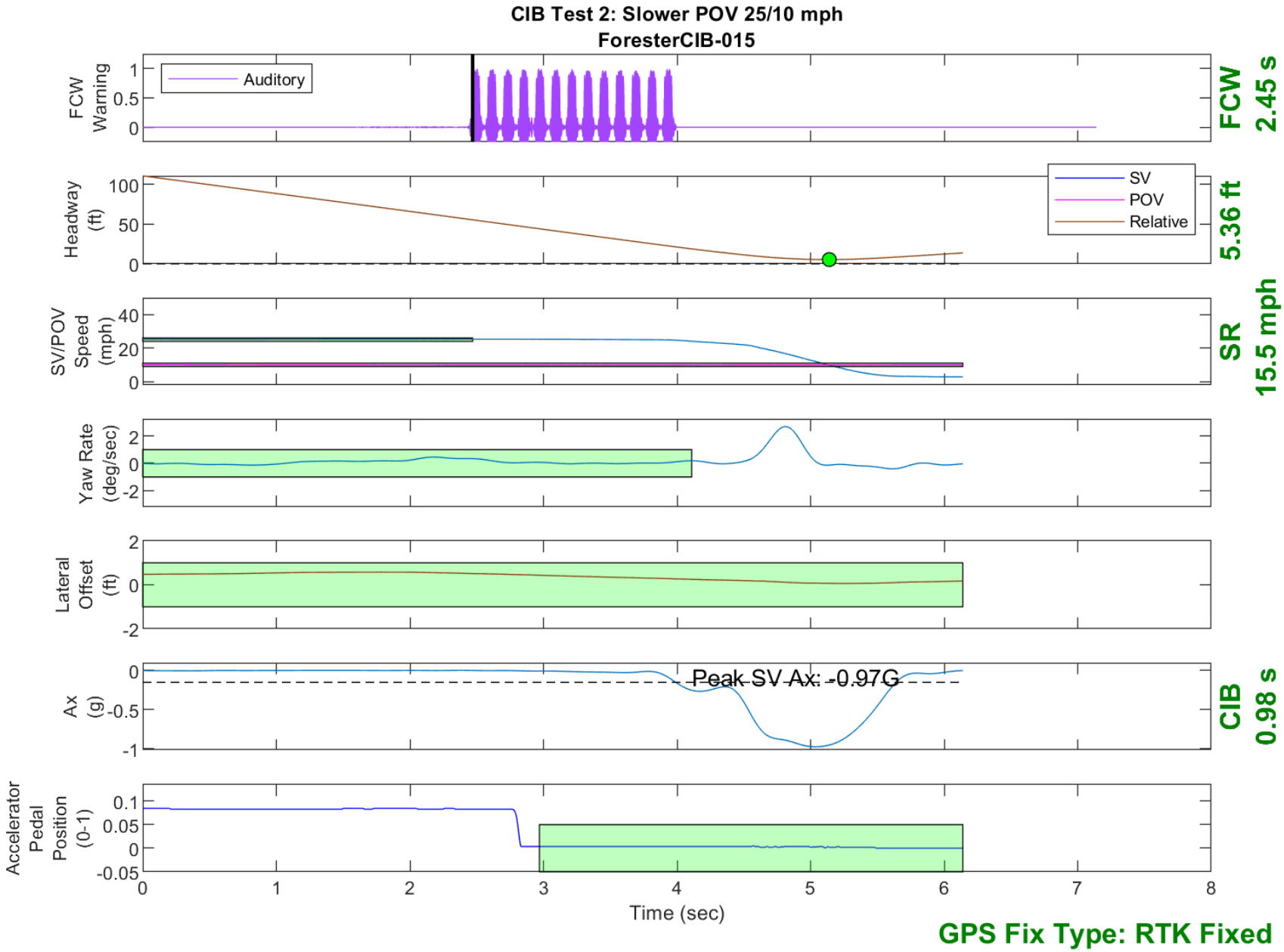


Figure D21. Time History for CIB Run 15, Test 2 - Slower Moving POV, 25/10 mph

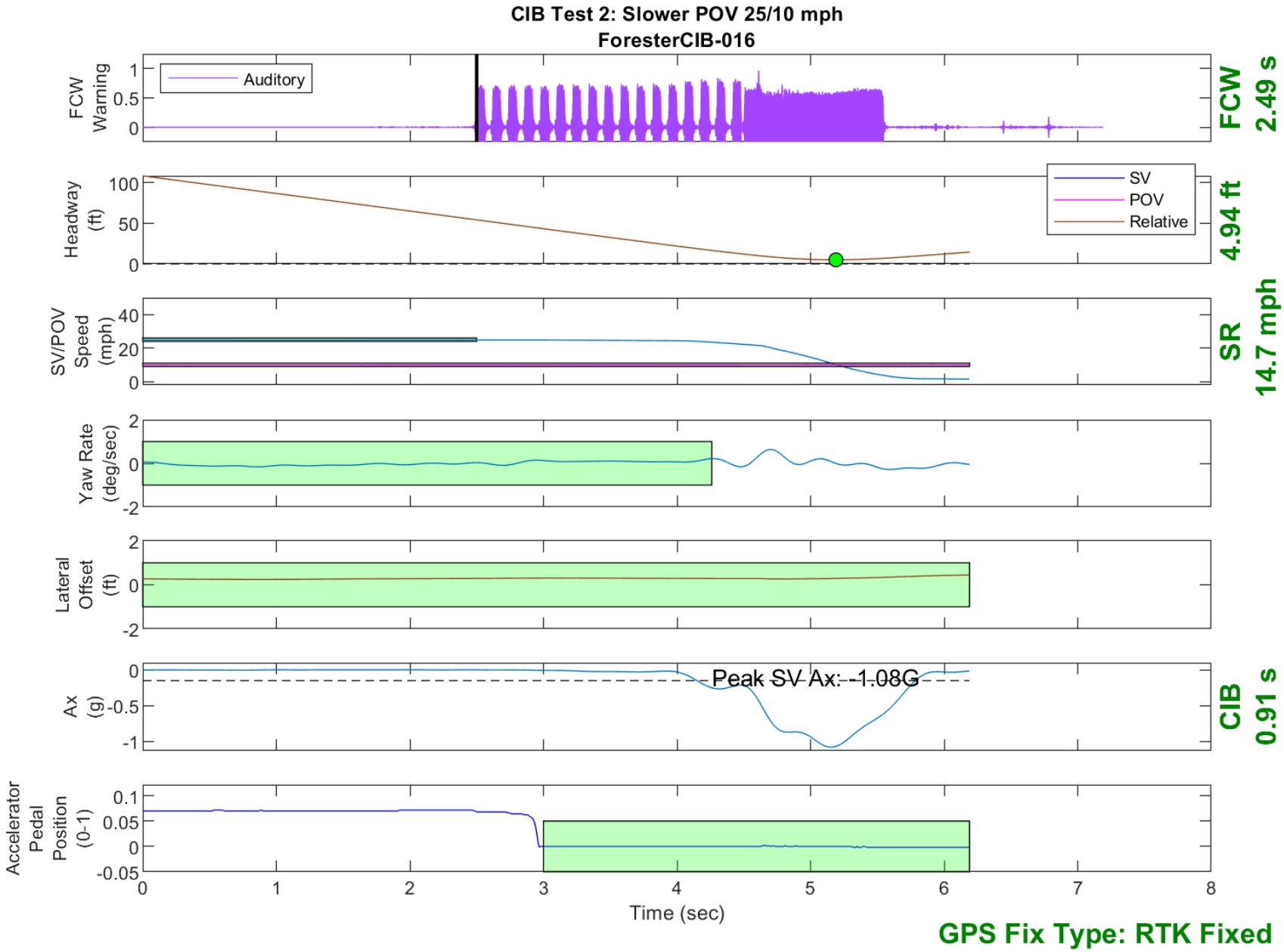


Figure D22. Time History for CIB Run 16, Test 2 - Slower Moving POV, 25/10 mph

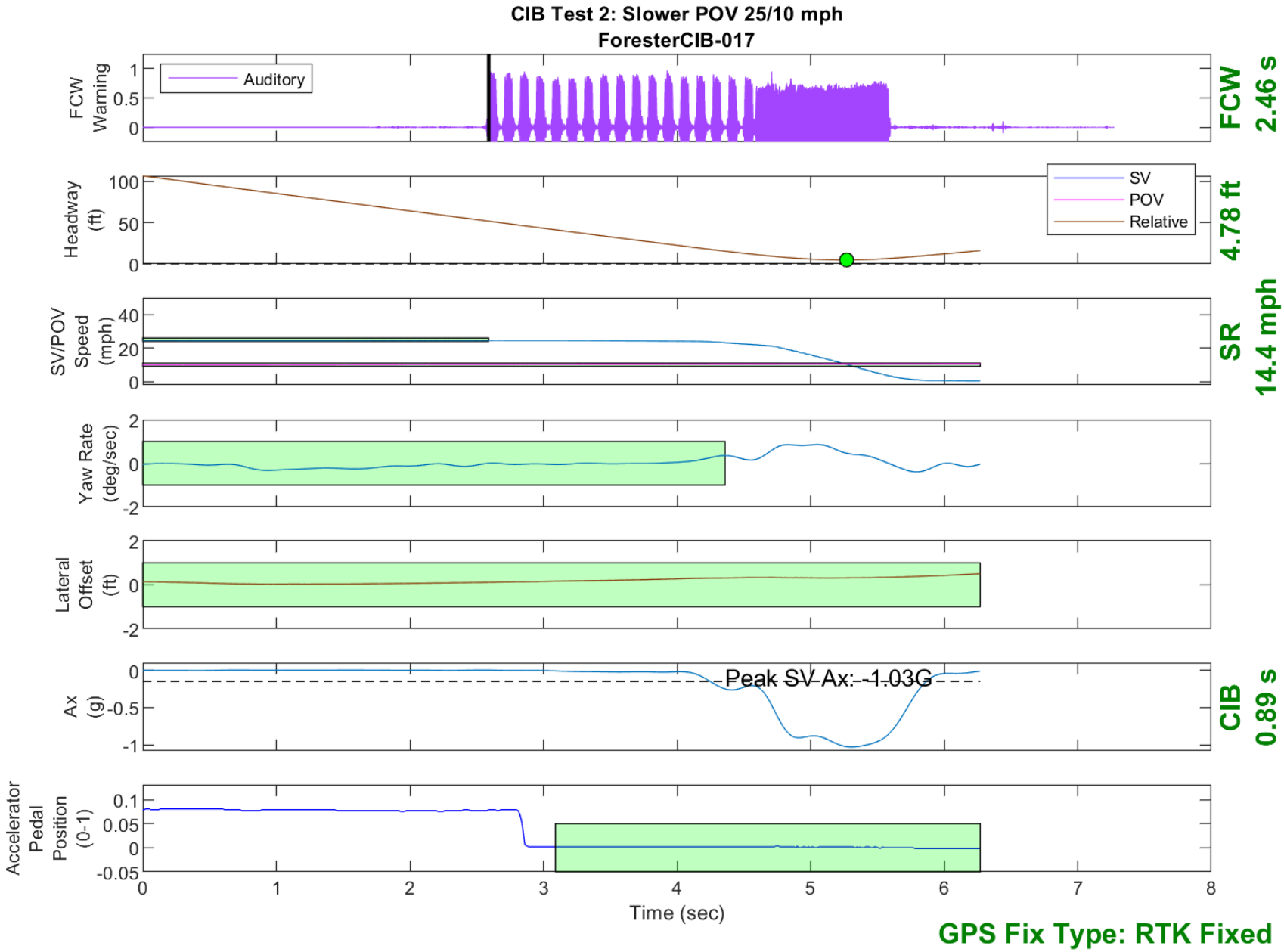


Figure D23. Time History for CIB Run 17, Test 2 - Slower Moving POV, 25/10 mph

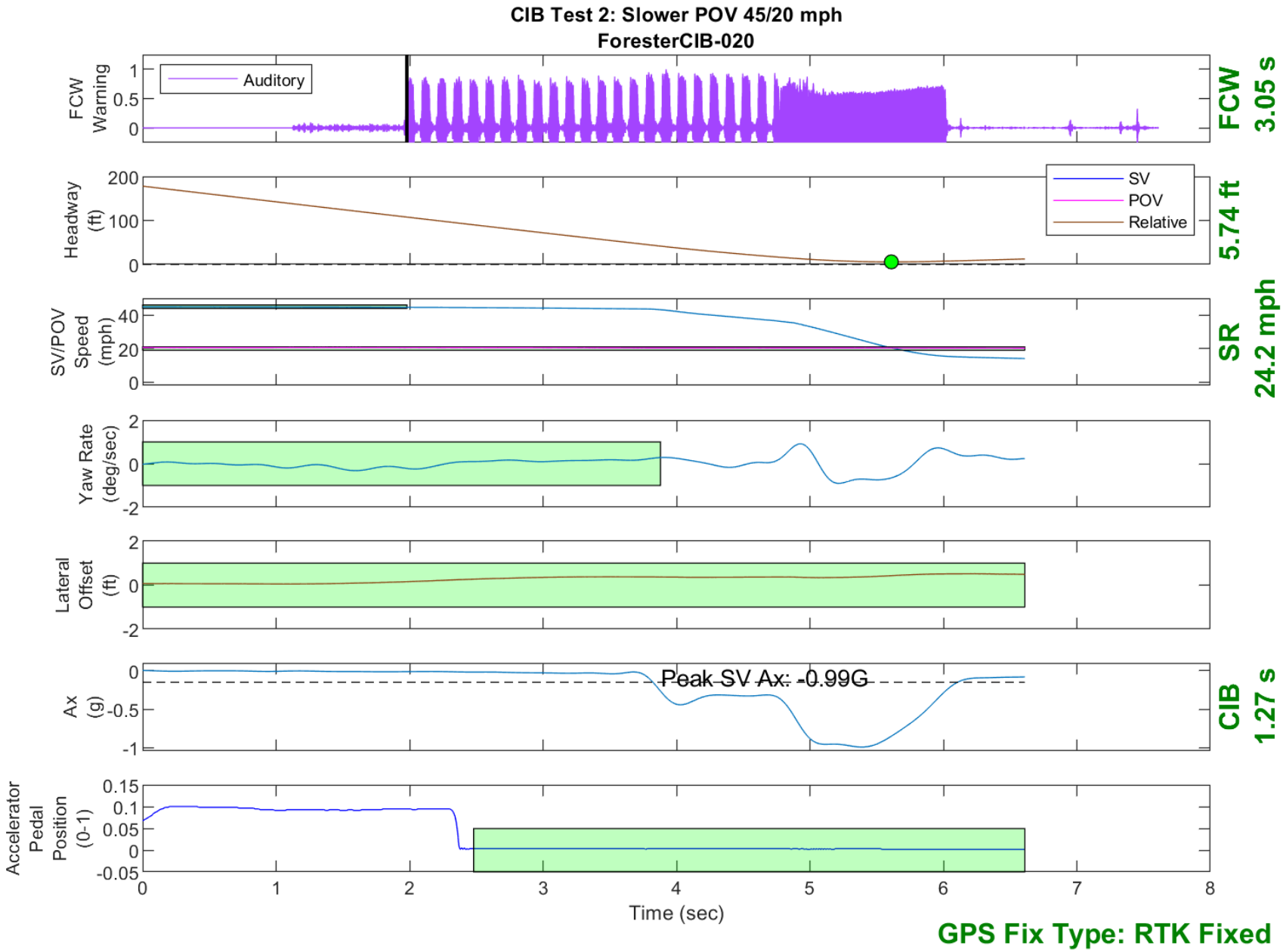


Figure D24. Time History for CIB Run 20, Test 2 - Slower Moving POV, 45/20 mph

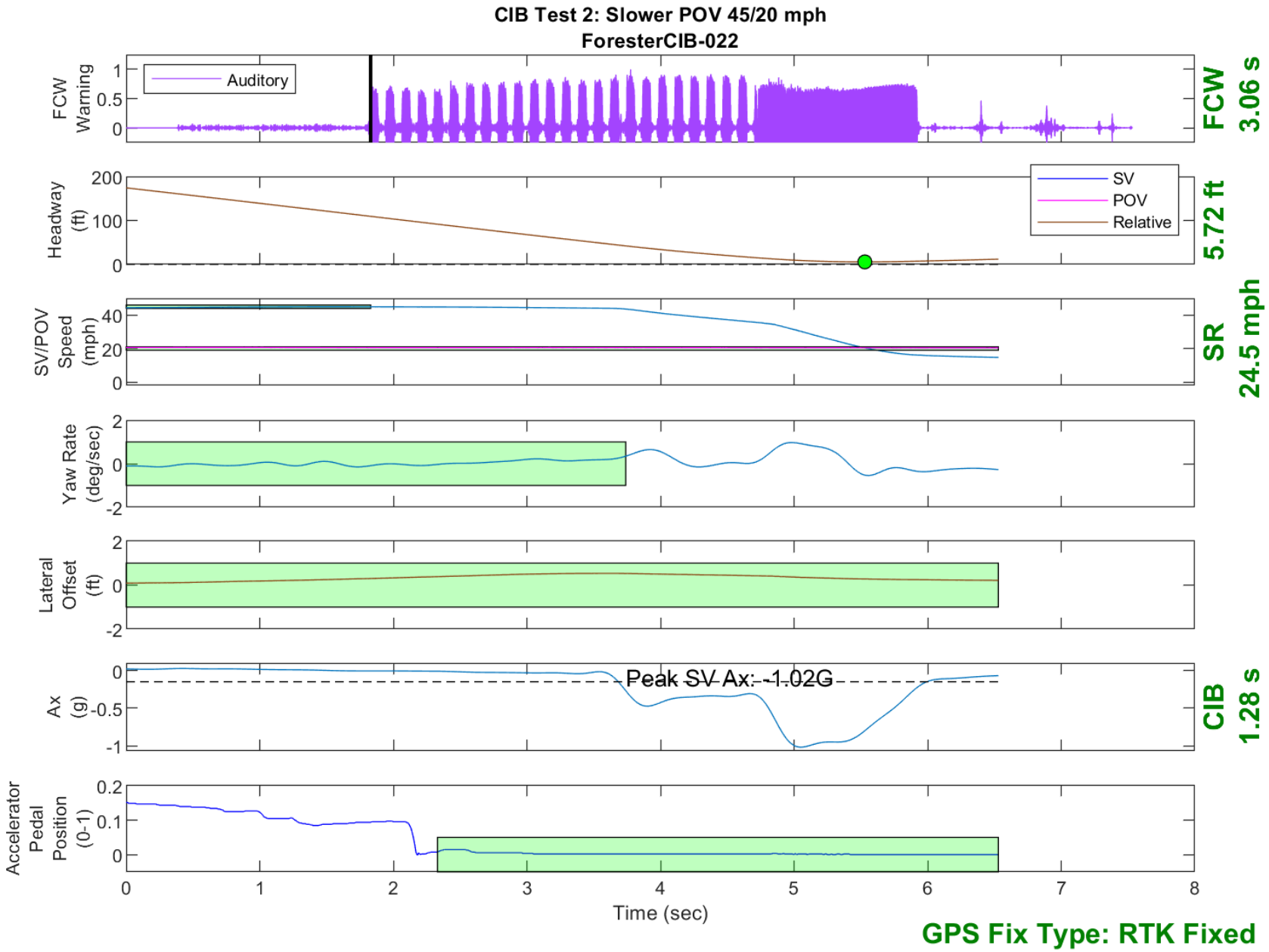


Figure D25. Time History for CIB Run 22, Test 2 - Slower Moving POV, 45/20 mph

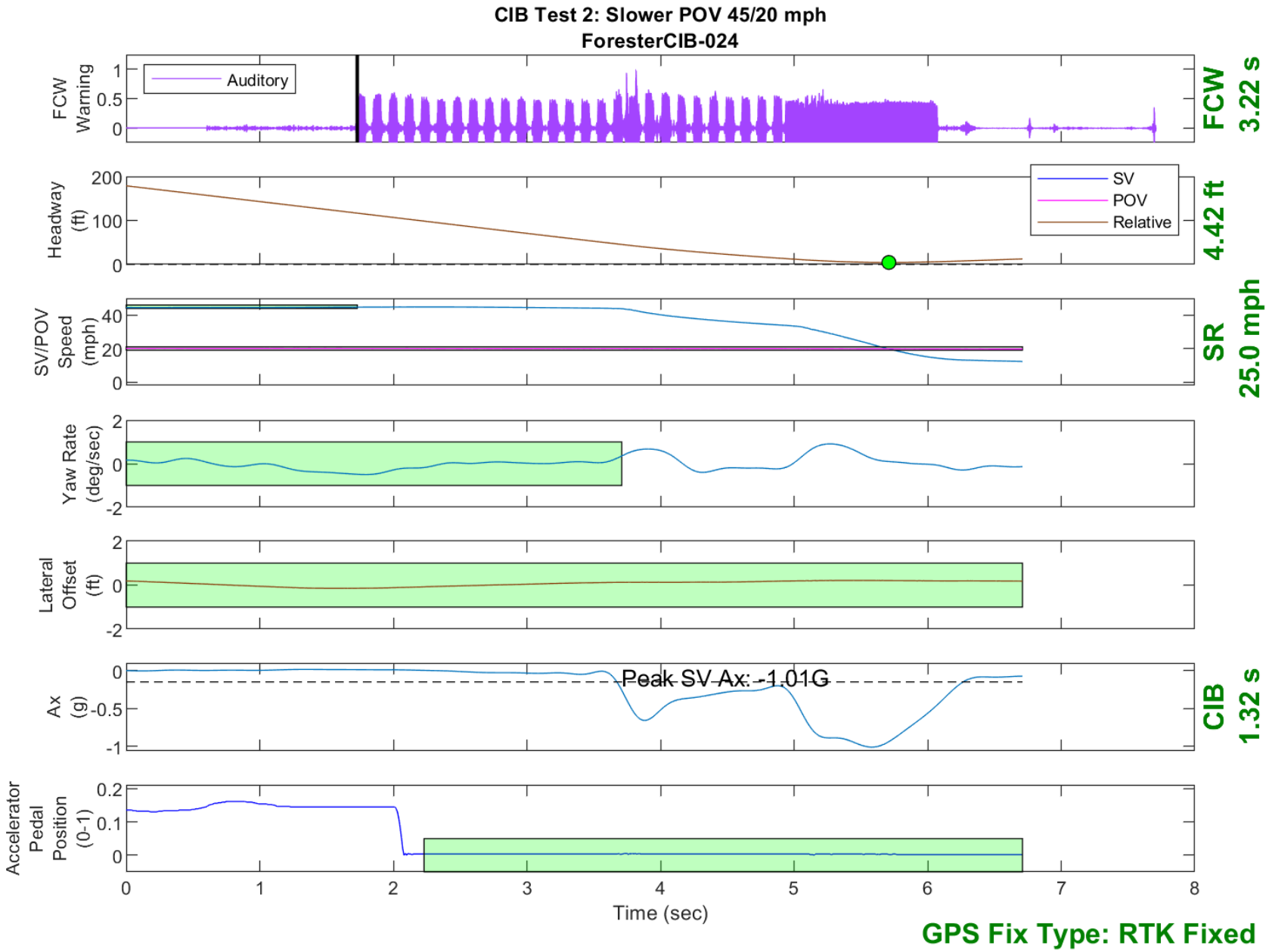


Figure D26. Time History for CIB Run 24, Test 2 - Slower Moving POV, 45/20 mph

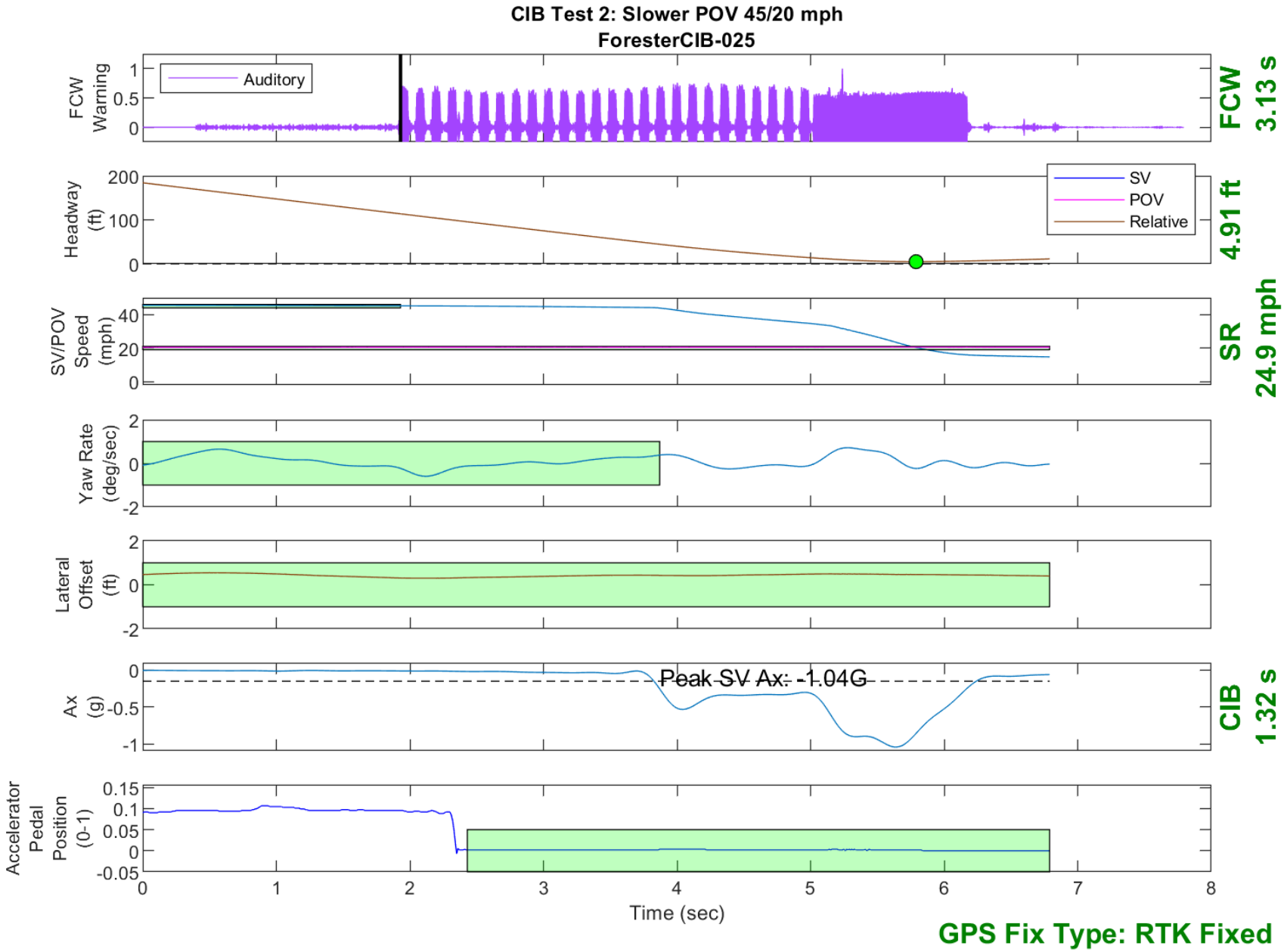


Figure D27. Time History for CIB Run 25, Test 2 - Slower Moving POV, 45/20 mph

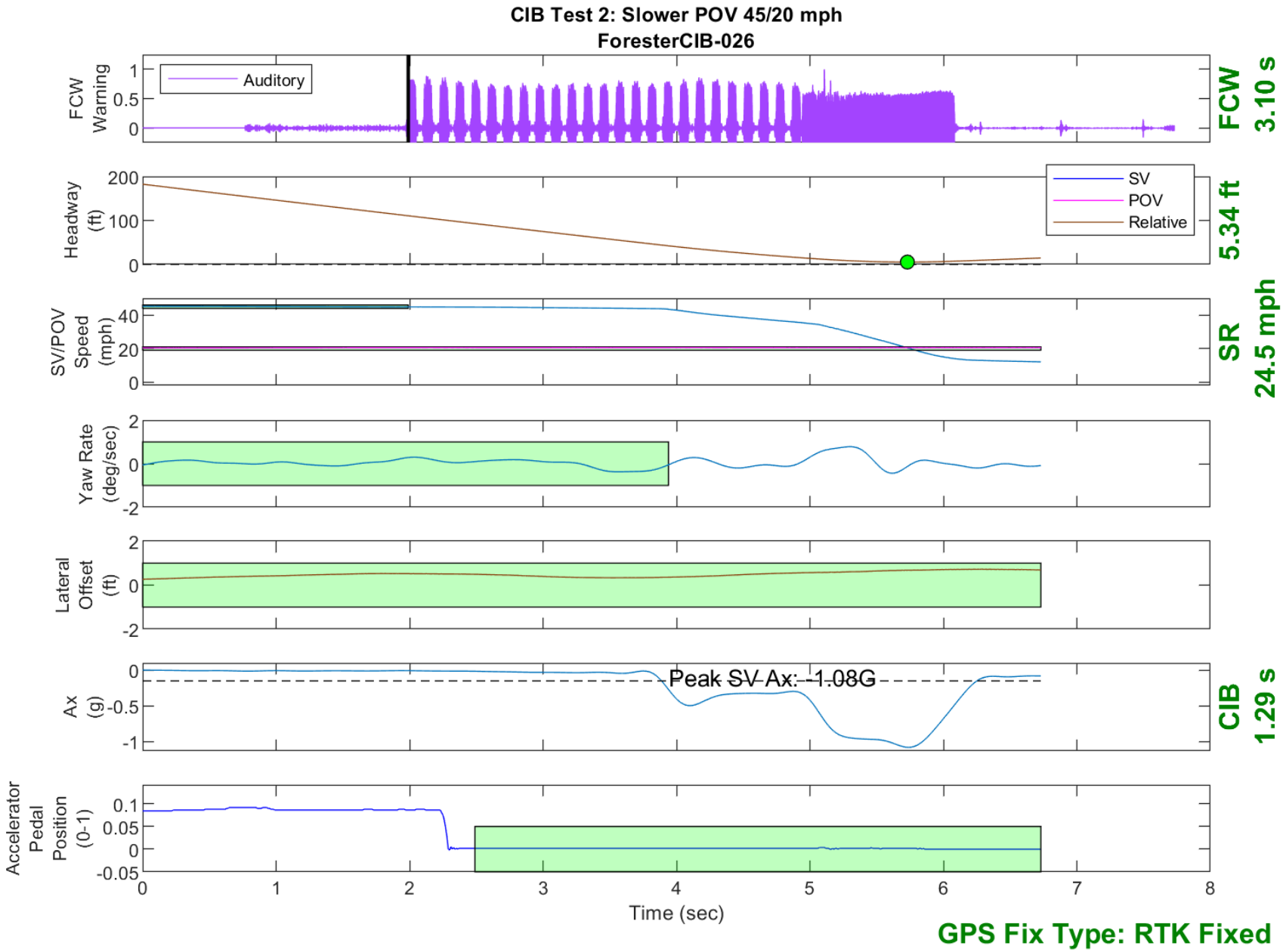


Figure D28. Time History for CIB Run 26, Test 2 - Slower Moving POV, 45/20 mph

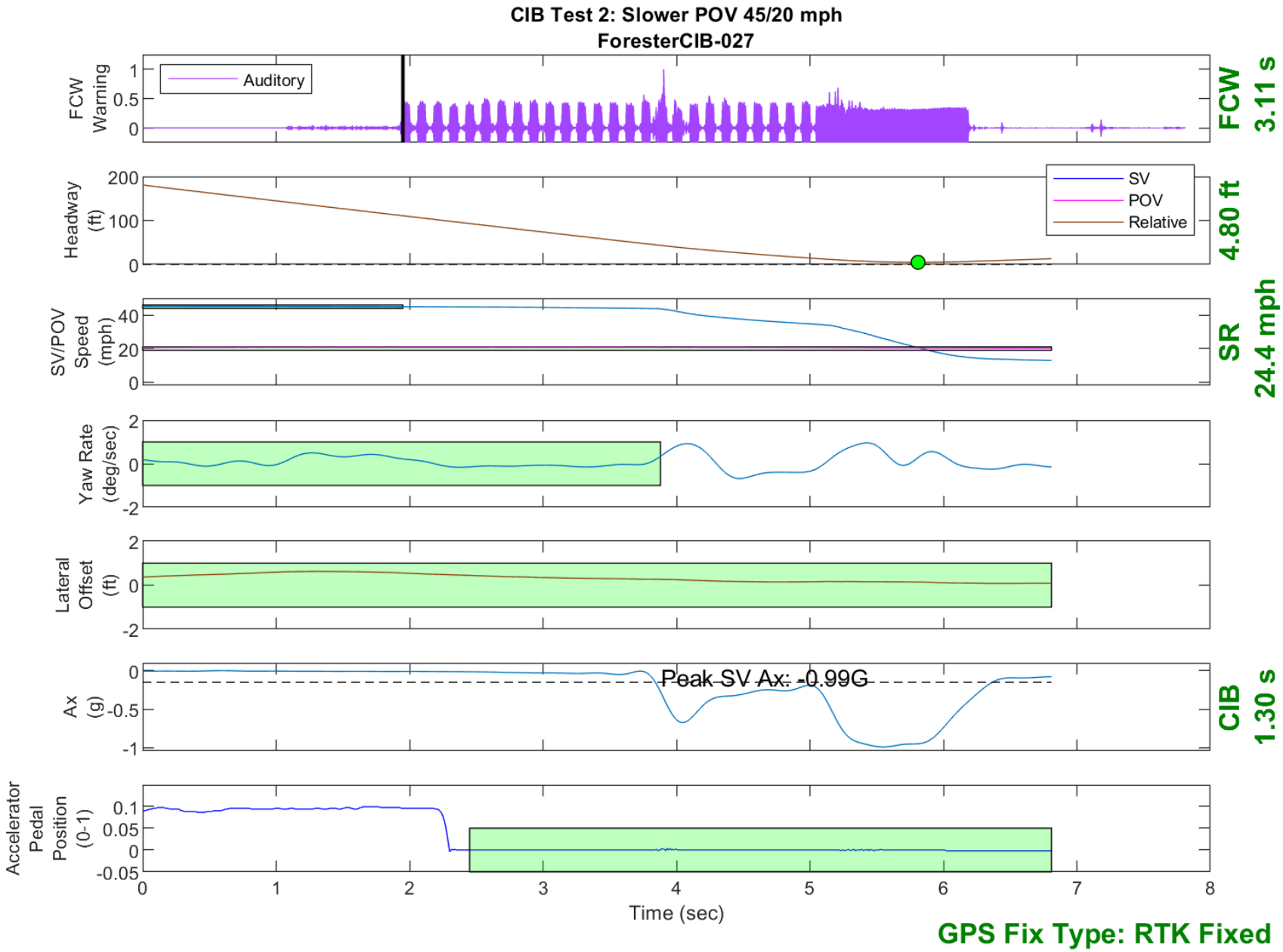


Figure D29. Time History for CIB Run 27, Test 2 - Slower Moving POV, 45/20 mph

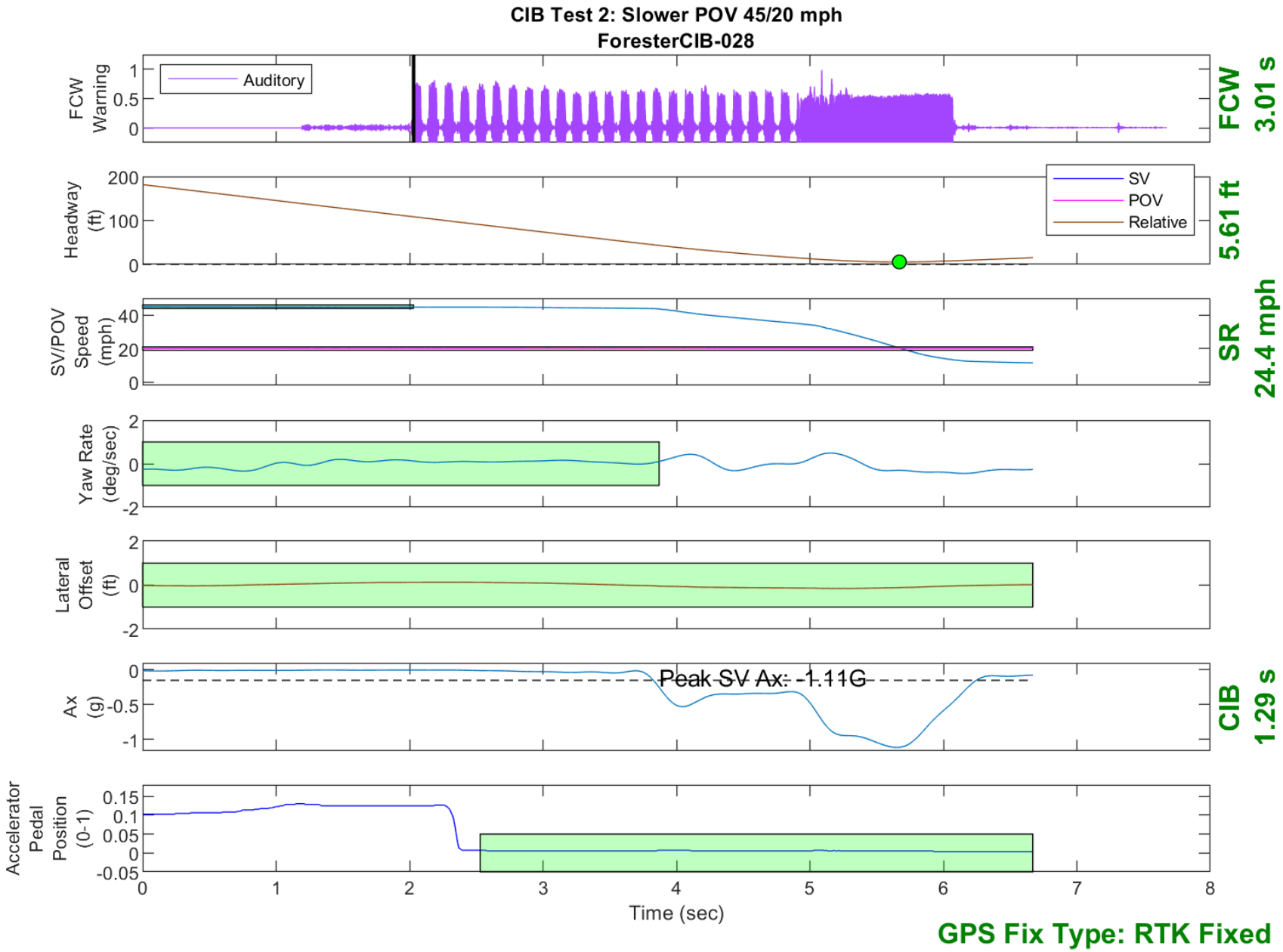


Figure D30. Time History for CIB Run 28, Test 2 - Slower Moving POV, 45/20 mph

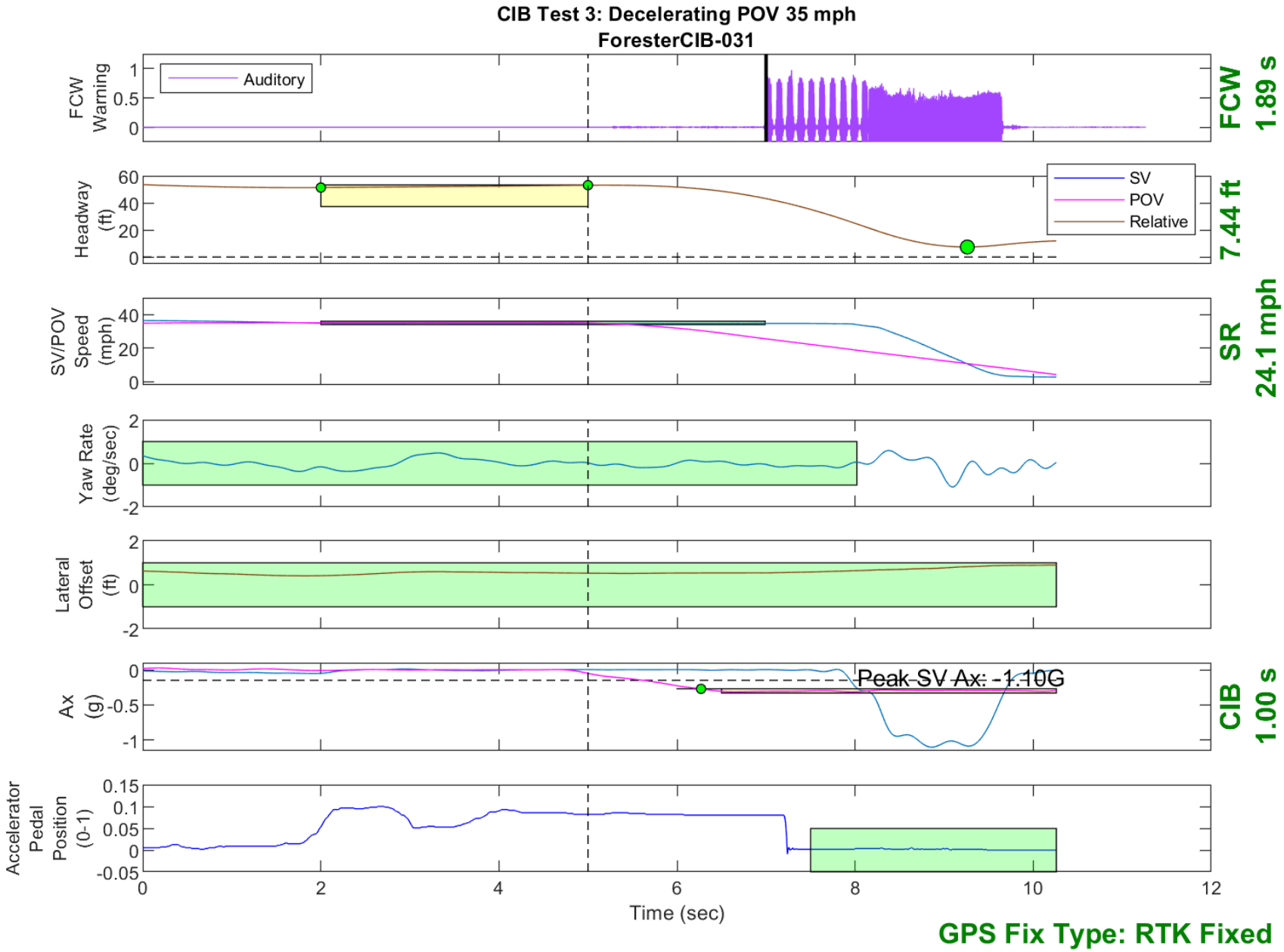


Figure D31. Time History for CIB Run 31, Test 3 - Decelerating POV 35 mph

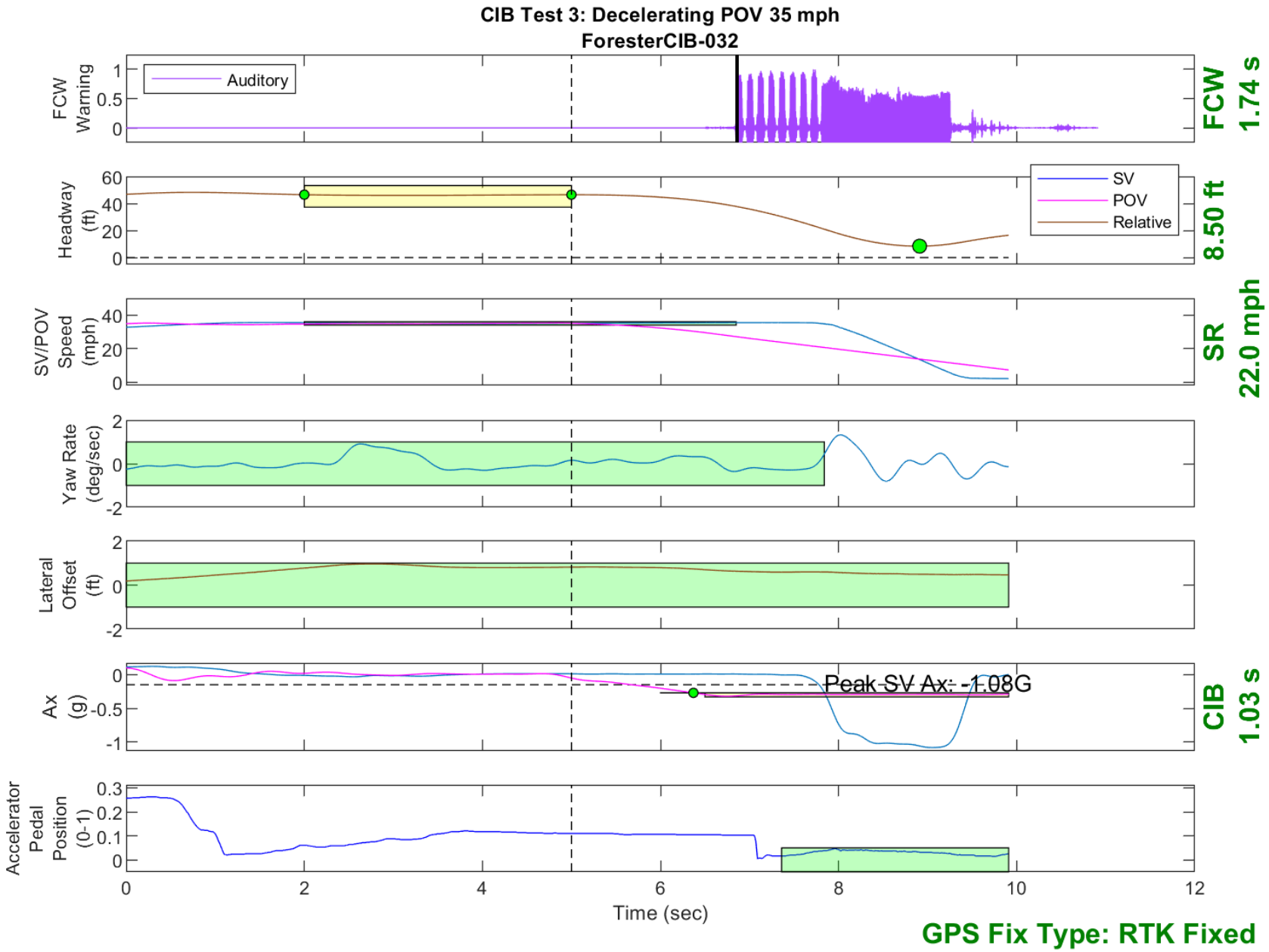


Figure D32. Time History for CIB Run 32, Test 3 - Decelerating POV 35 mph

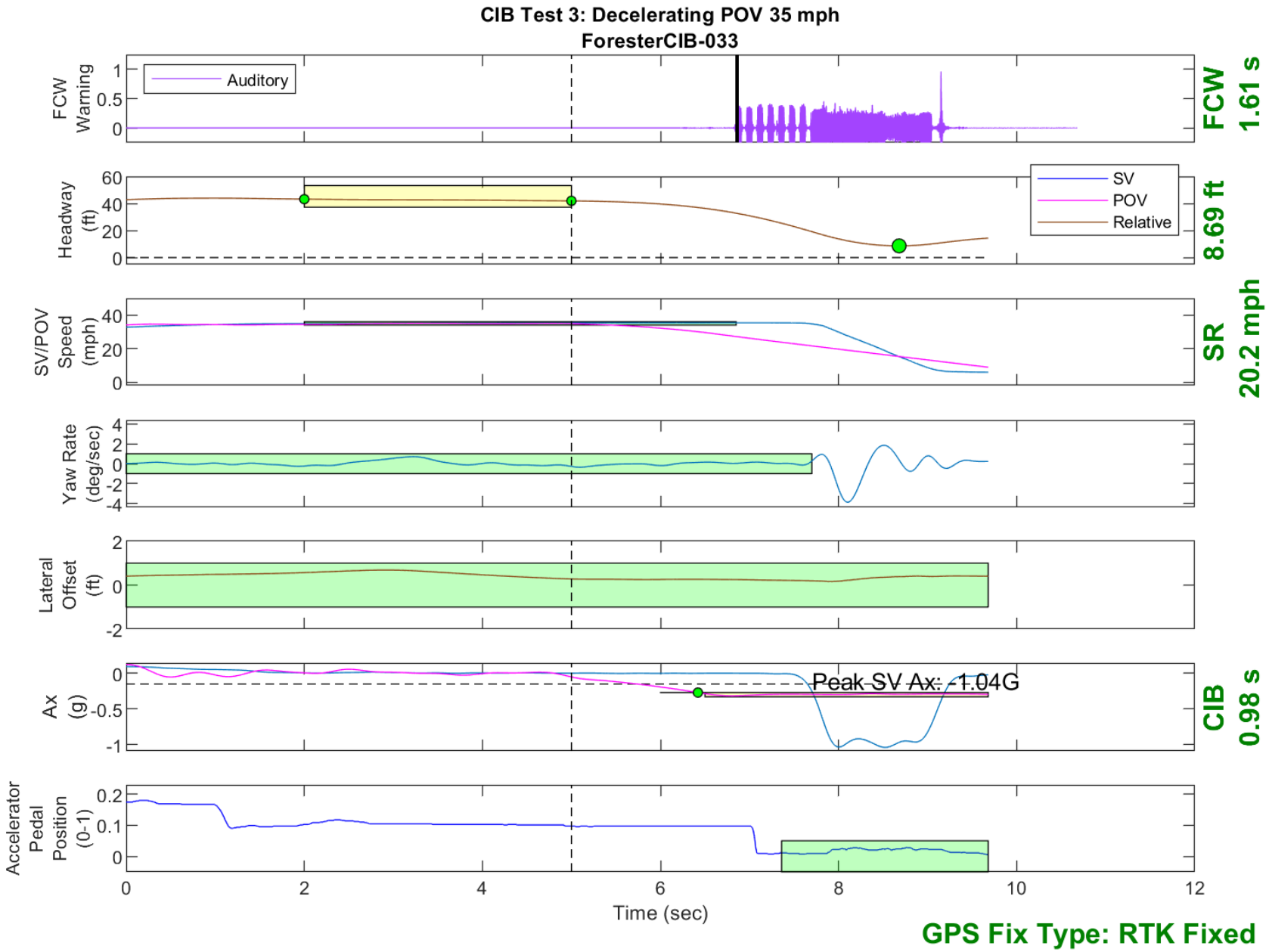


Figure D33. Time History for CIB Run 33, Test 3 - Decelerating POV 35 mph

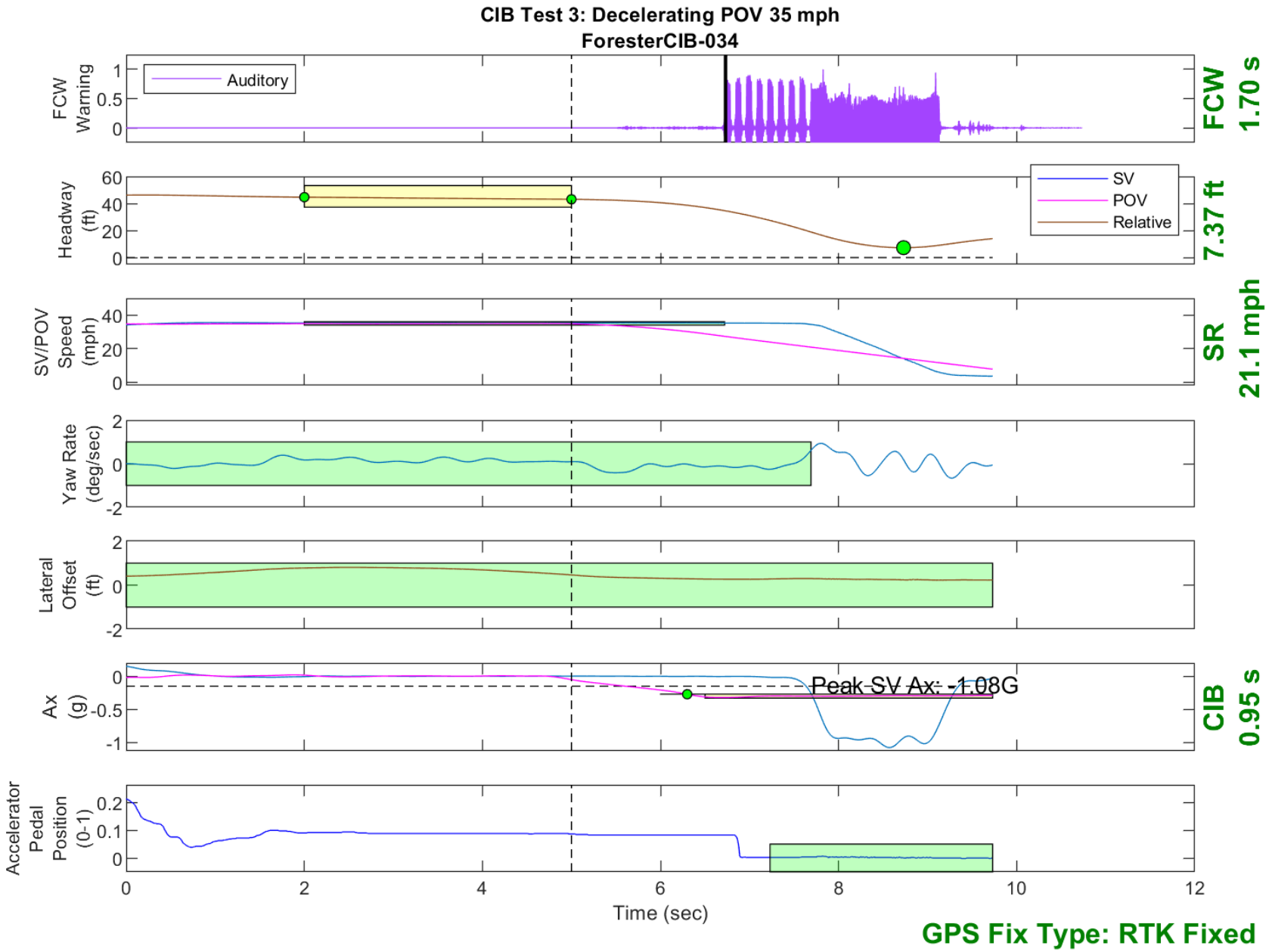


Figure D34. Time History for CIB Run 34, Test 3 - Decelerating POV 35 mph

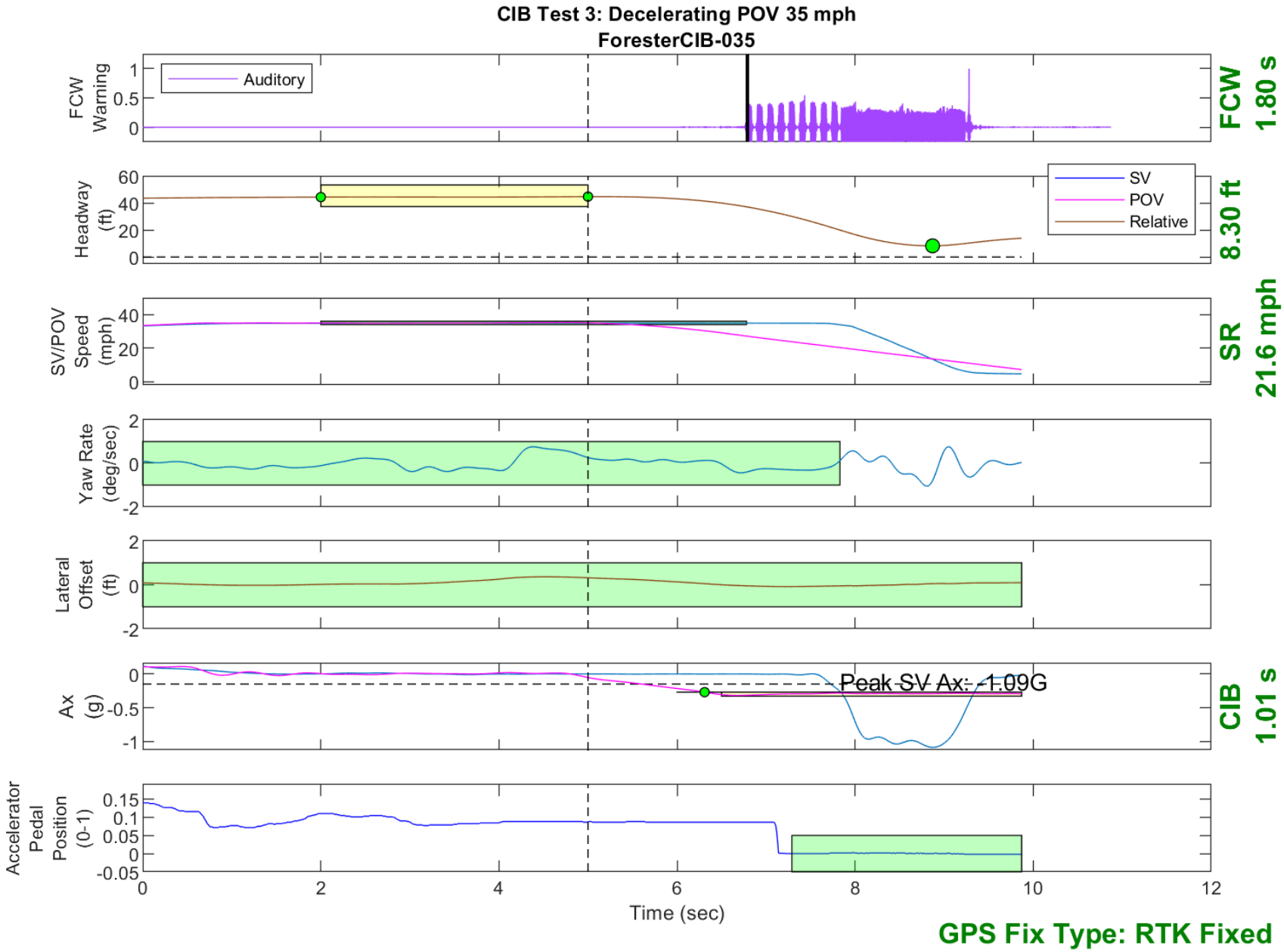


Figure D35. Time History for CIB Run 35, Test 3 - Decelerating POV 35 mph

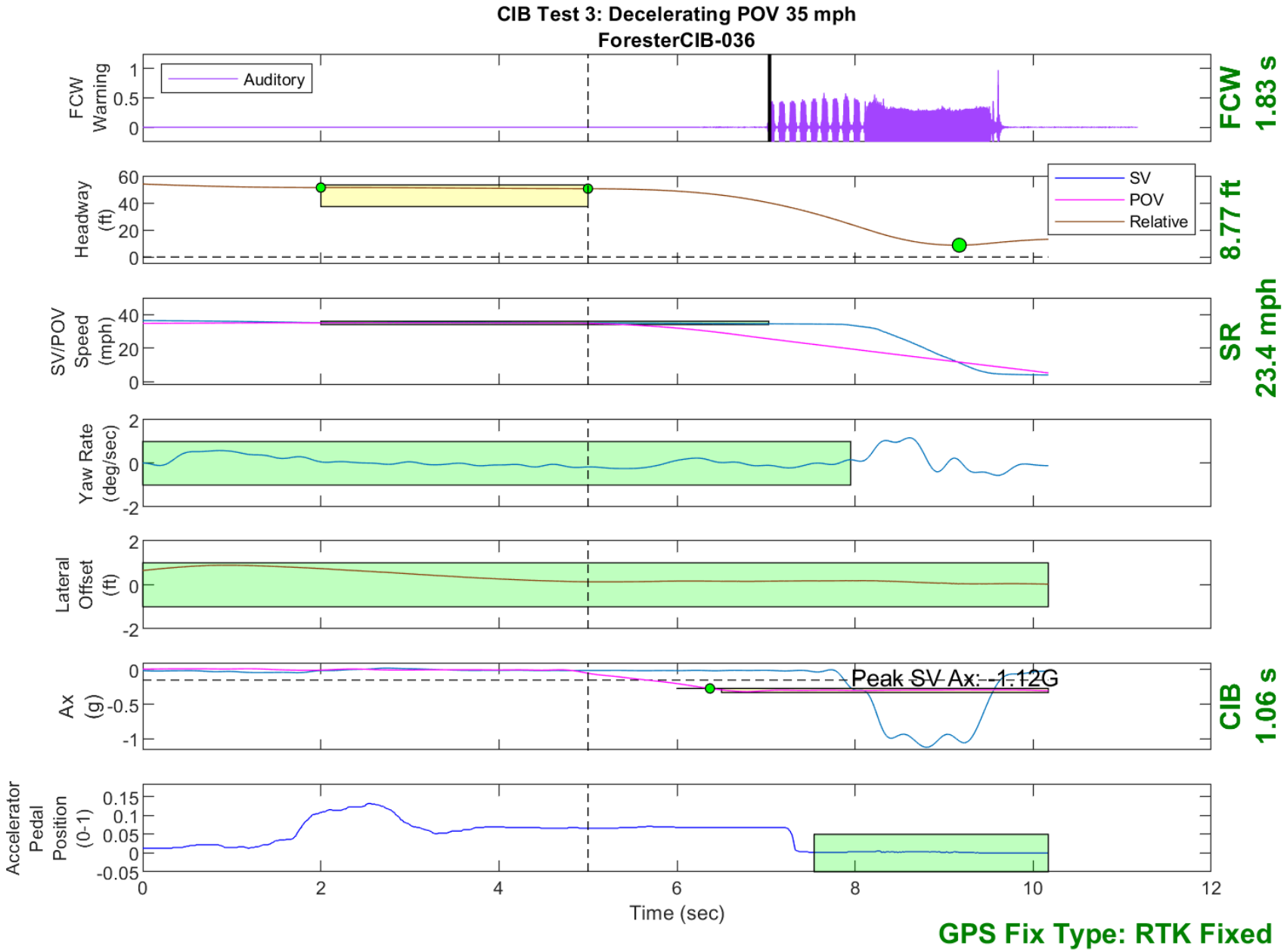


Figure D36. Time History for CIB Run 36, Test 3 - Decelerating POV 35 mph

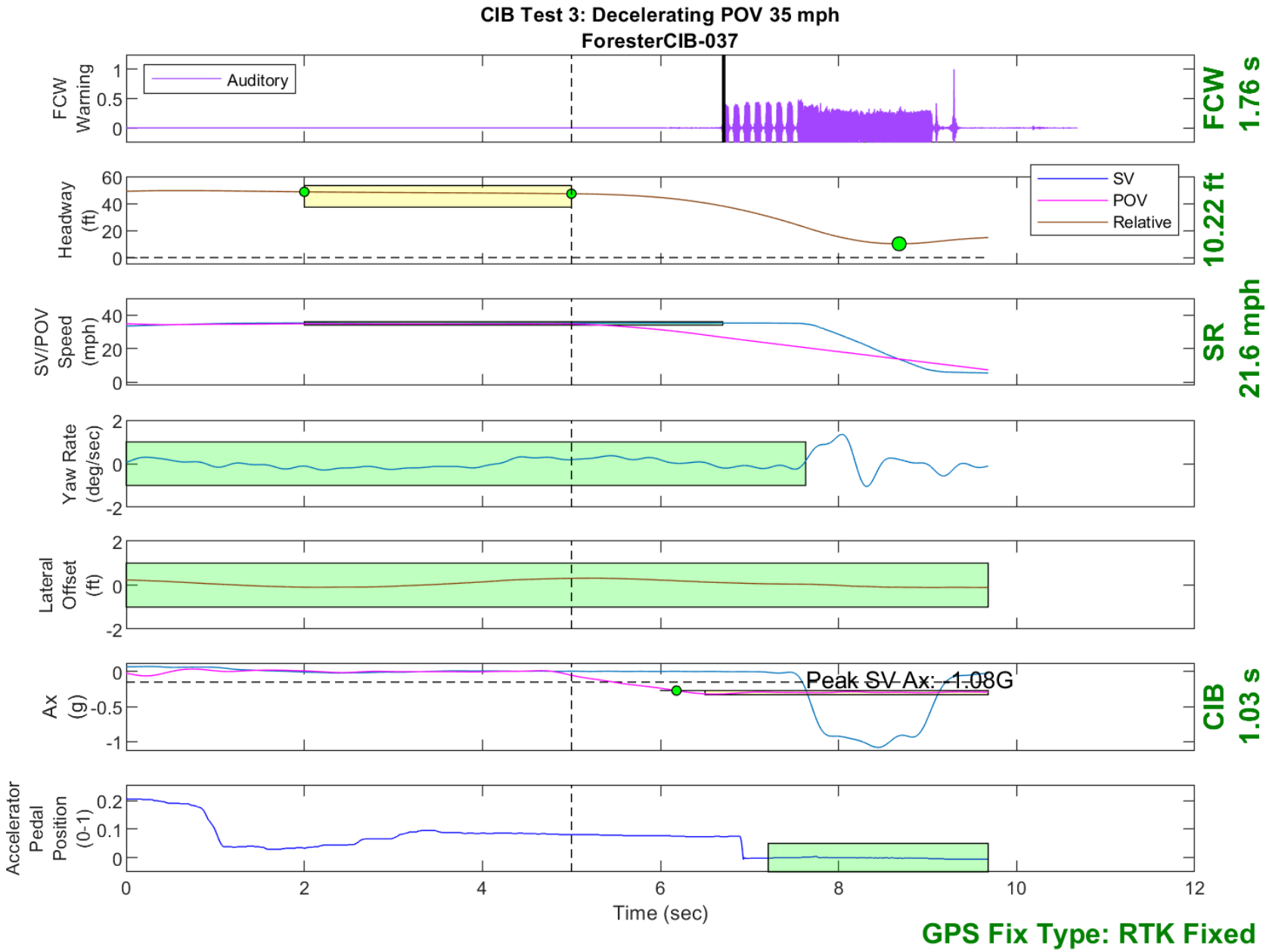


Figure D37. Time History for CIB Run 37, Test 3 - Decelerating POV 35 mph

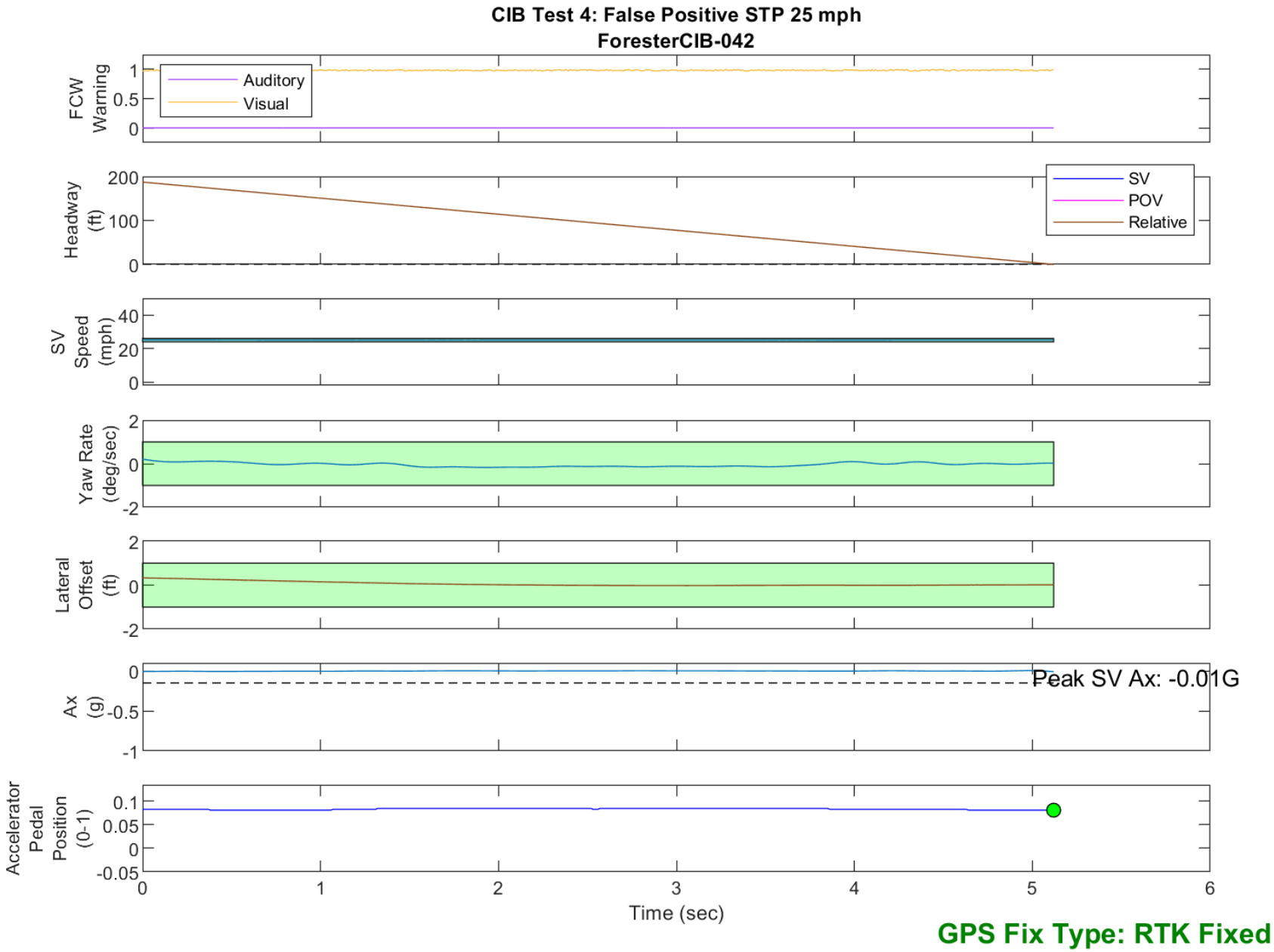


Figure D38. Time History for CIB Run 42, Test 4 - False Positive STP, 25 mph

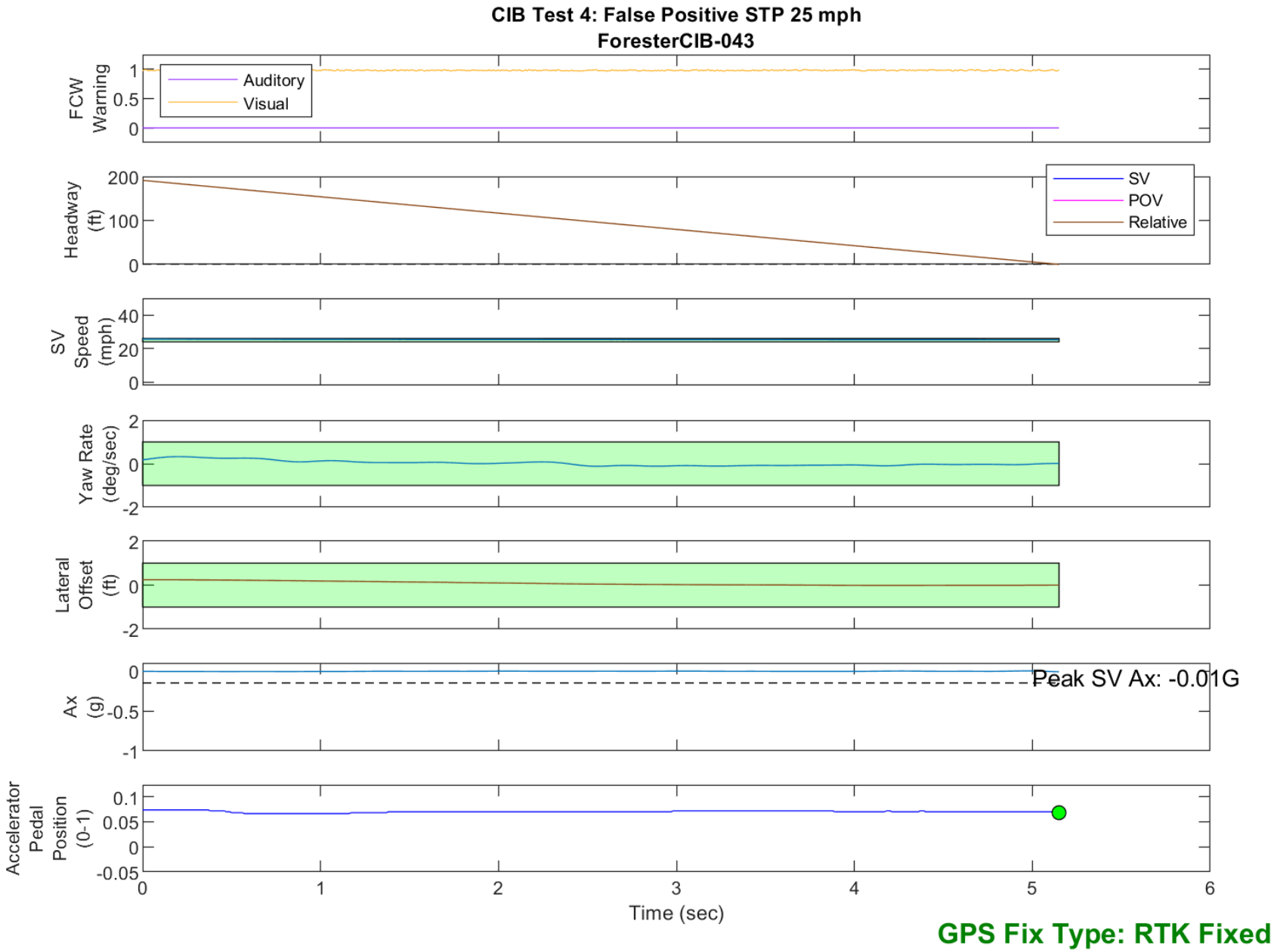


Figure D39. Time History for CIB Run 43, Test 4 - False Positive STP, 25 mph

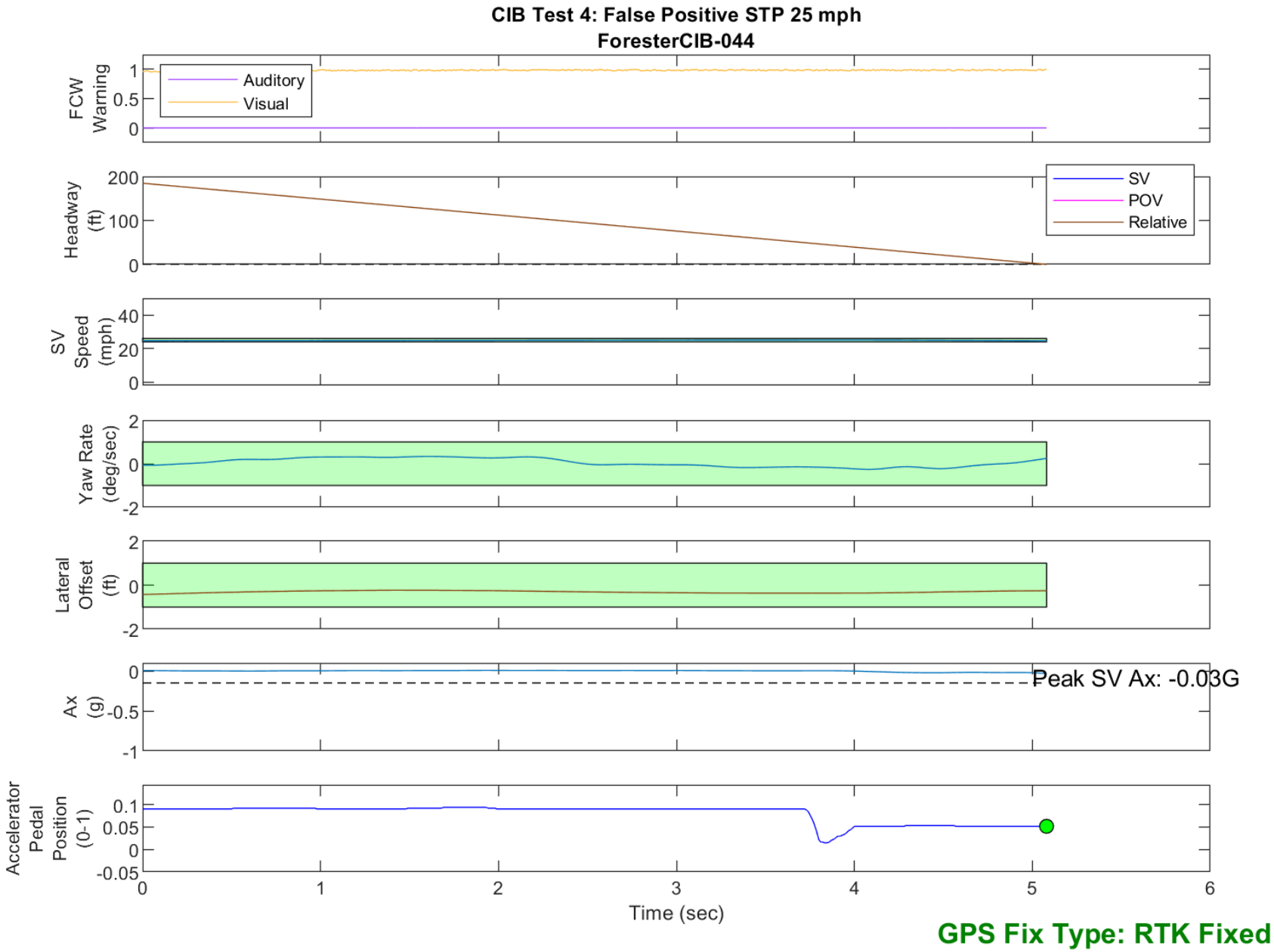


Figure D40. Time History for CIB Run 44, Test 4 - False Positive STP, 25 mph

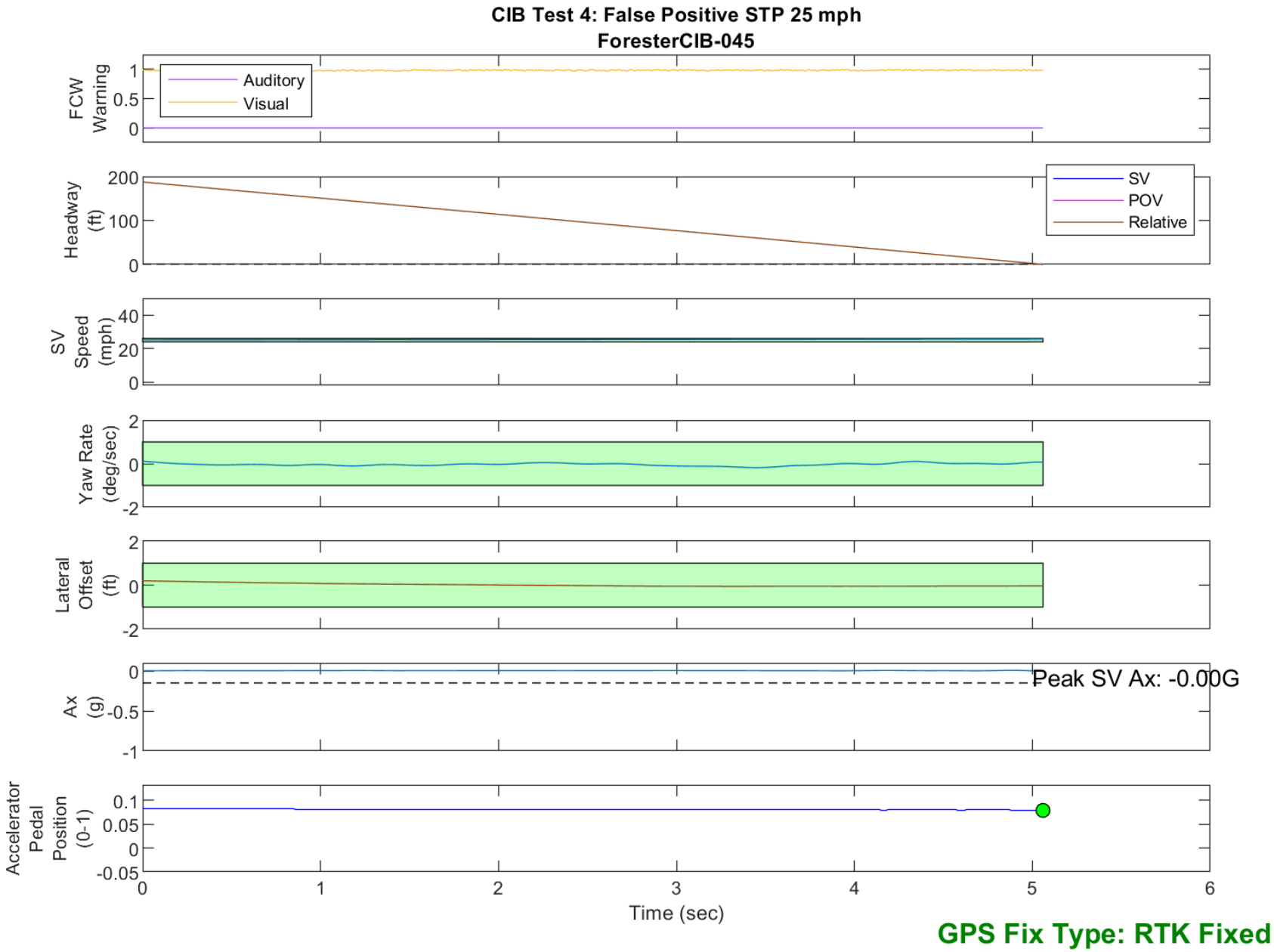


Figure D41. Time History for CIB Run 45, Test 4 - False Positive STP, 25 mph

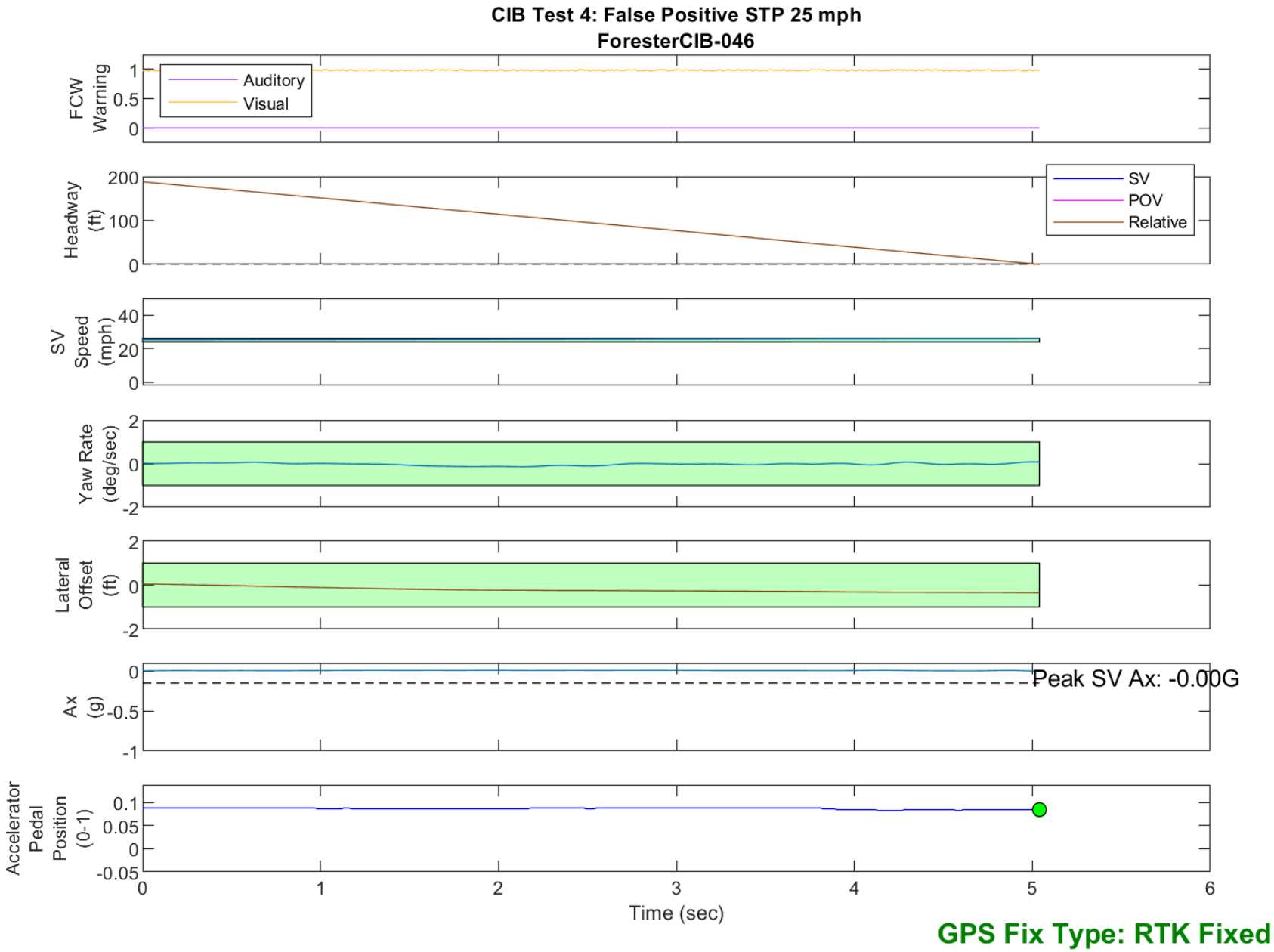


Figure D42. Time History for CIB Run 46, Test 4 - False Positive STP, 25 mph

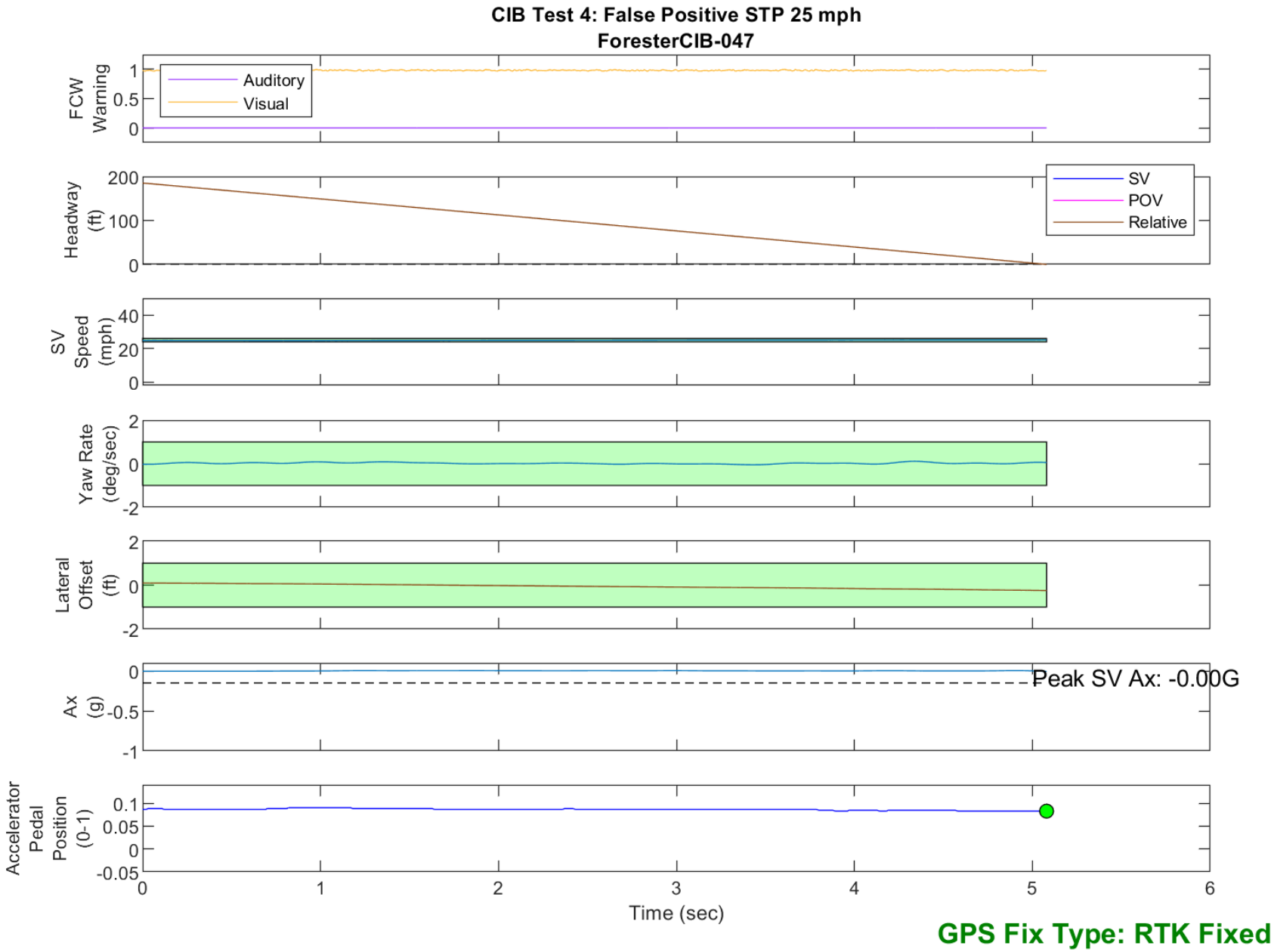


Figure D43. Time History for CIB Run 47, Test 4 - False Positive STP, 25 mph

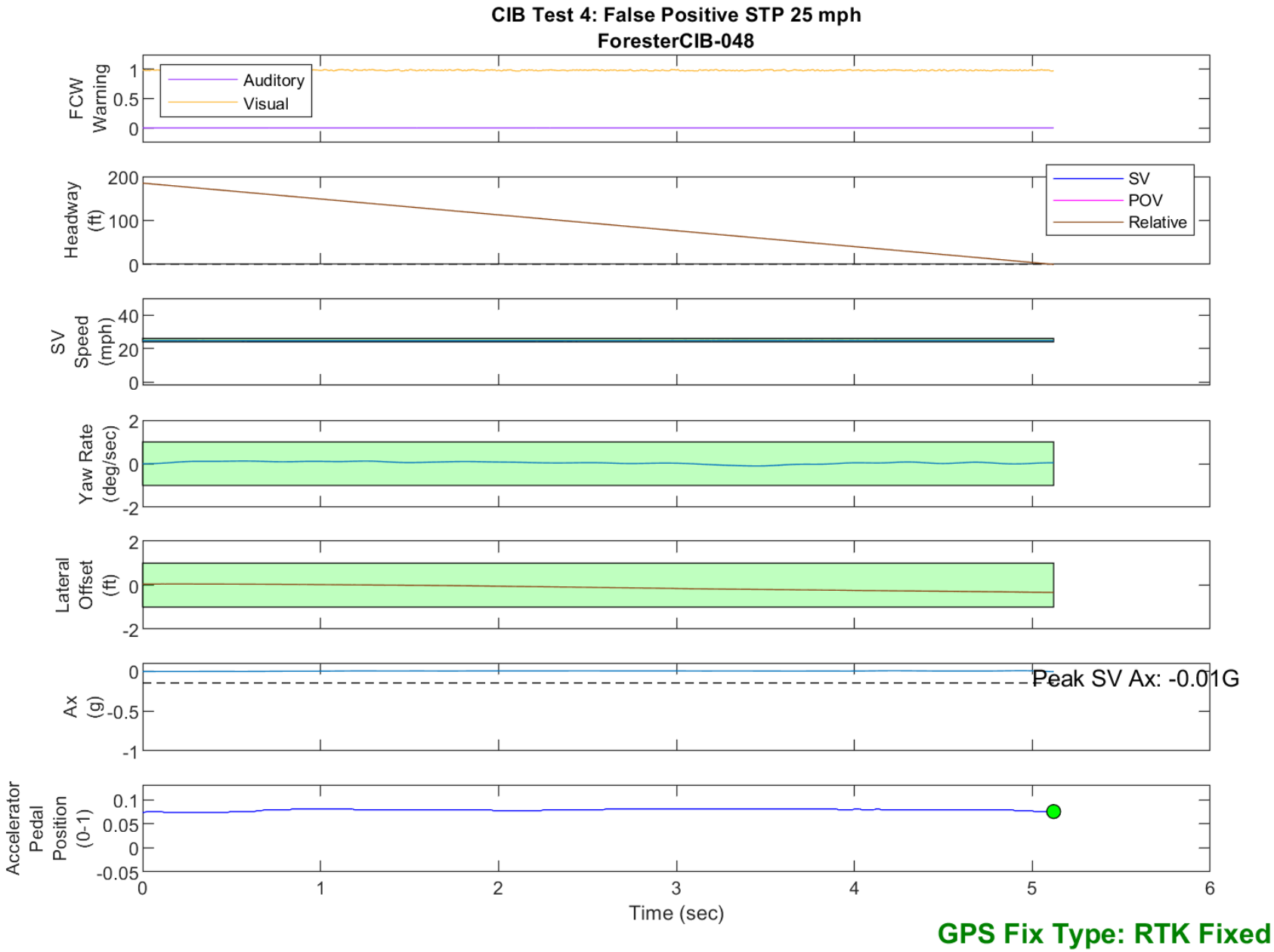


Figure D44. Time History for CIB Run 48, Test 4 - False Positive STP, 25 mph

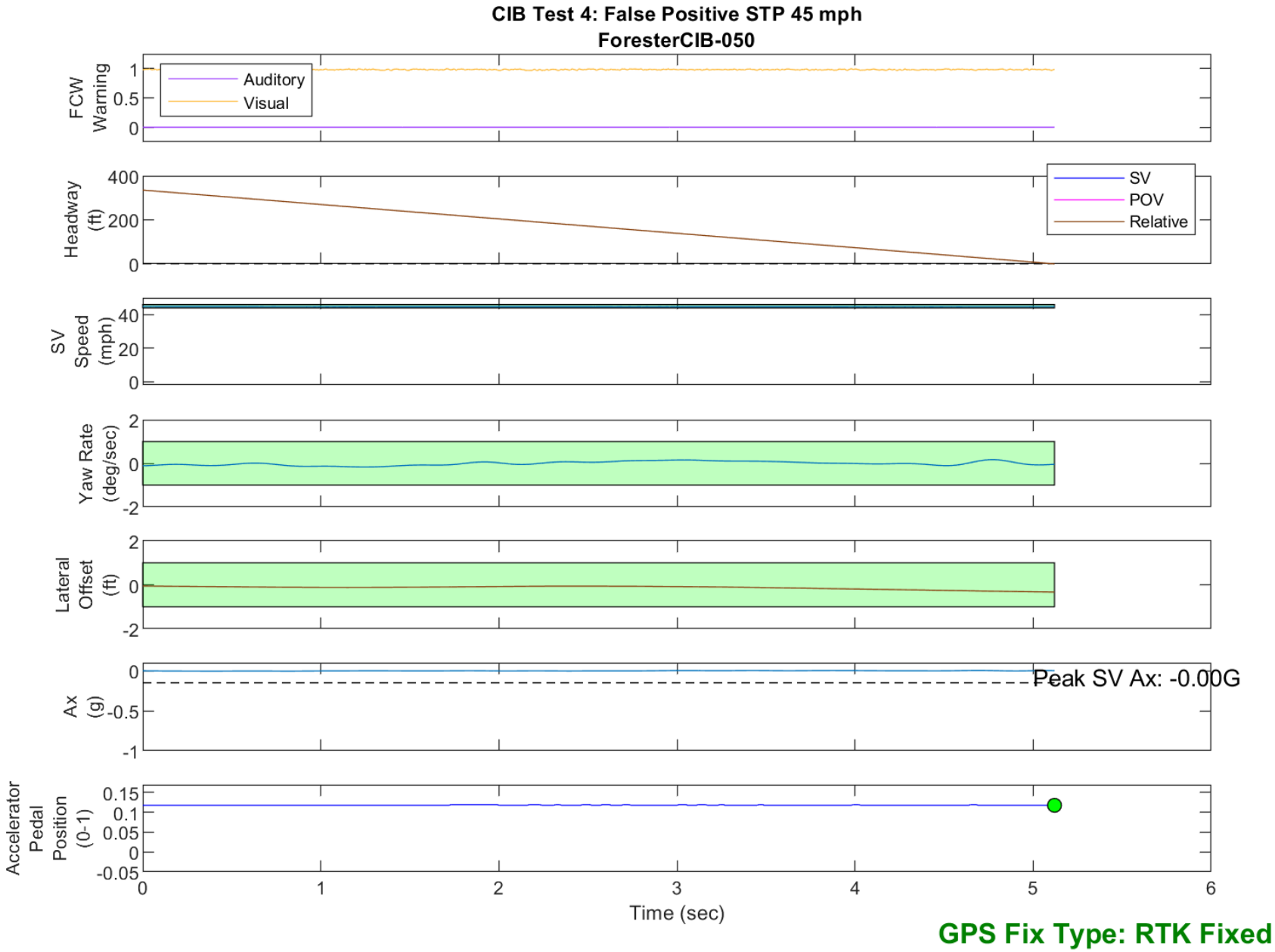


Figure D45. Time History for CIB Run 50, Test 4 - False Positive STP, 45 mph

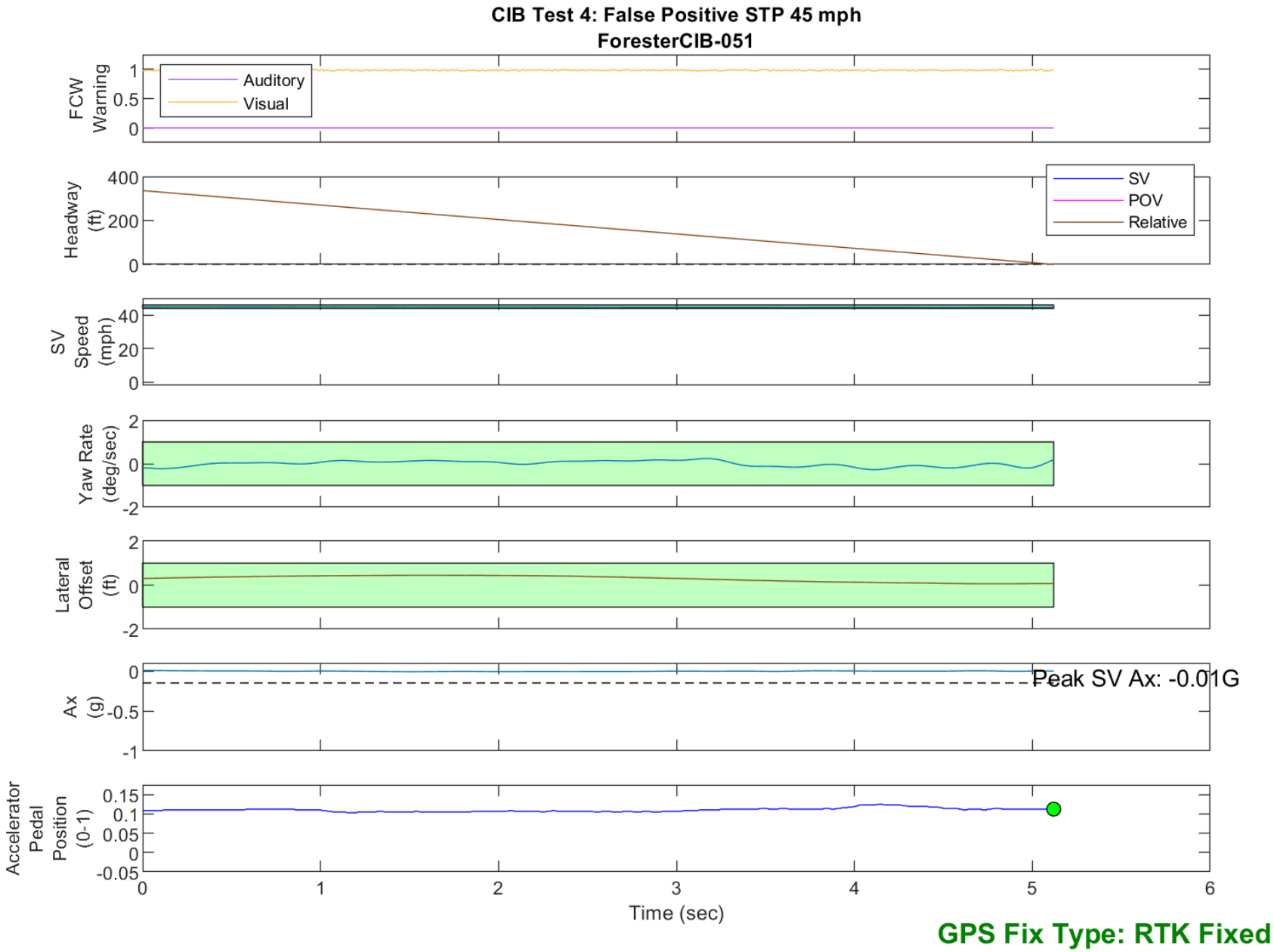


Figure D46. Time History for CIB Run 51, Test 4 - False Positive STP, 45 mph

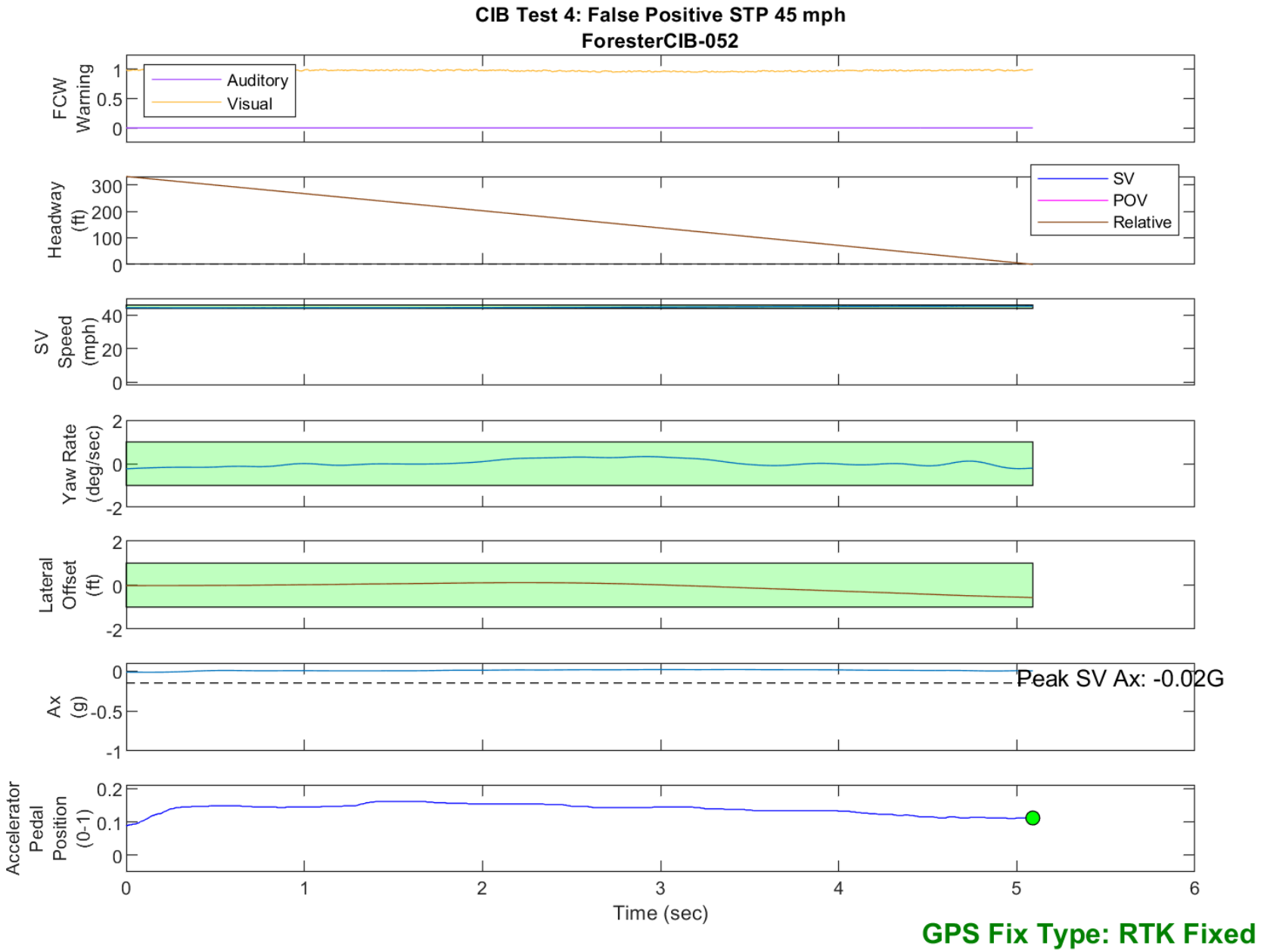


Figure D47. Time History for CIB Run 52, Test 4 - False Positive STP, 45 mph

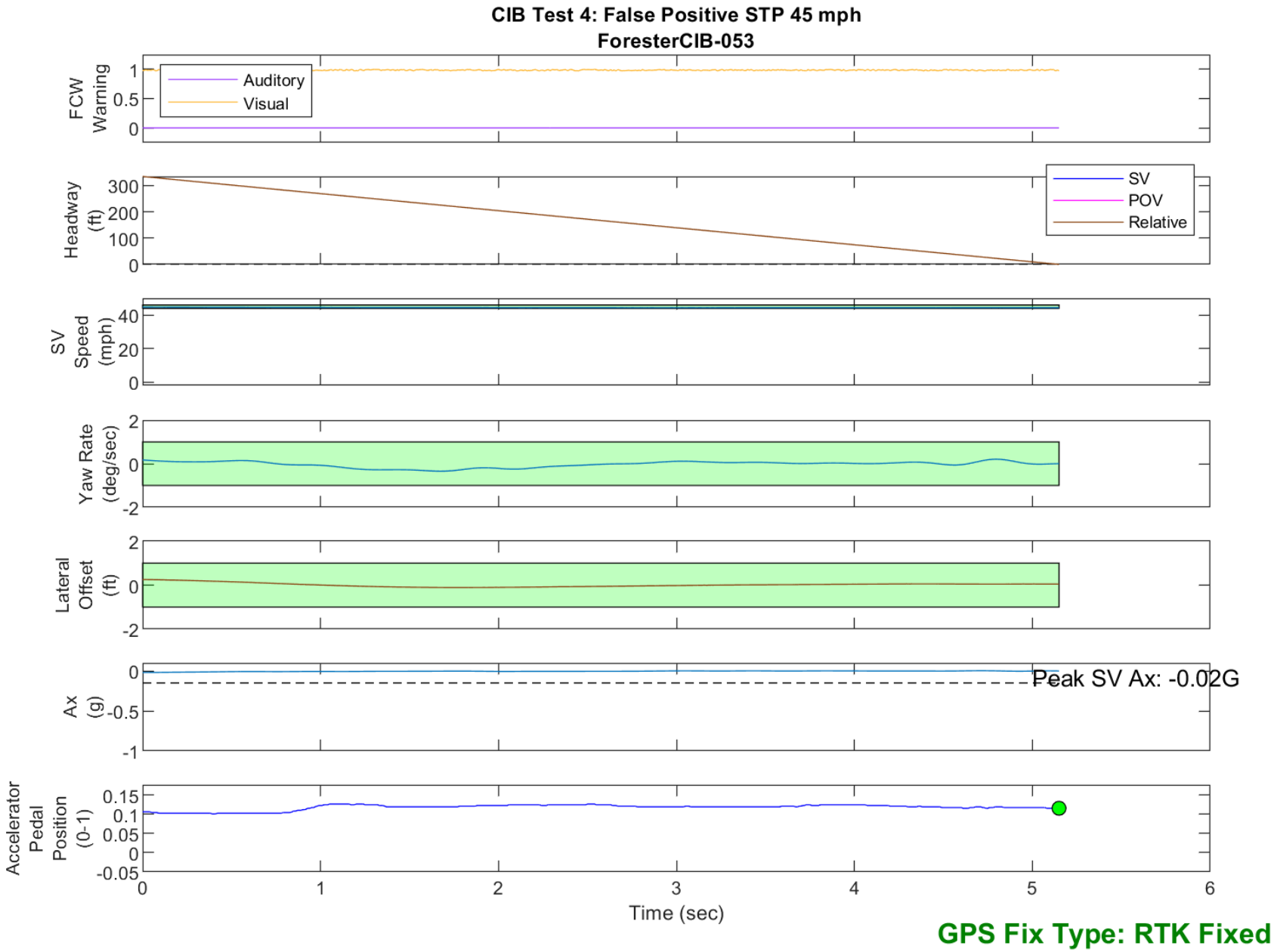


Figure D48. Time History for CIB Run 53, Test 4 - False Positive STP, 45 mph

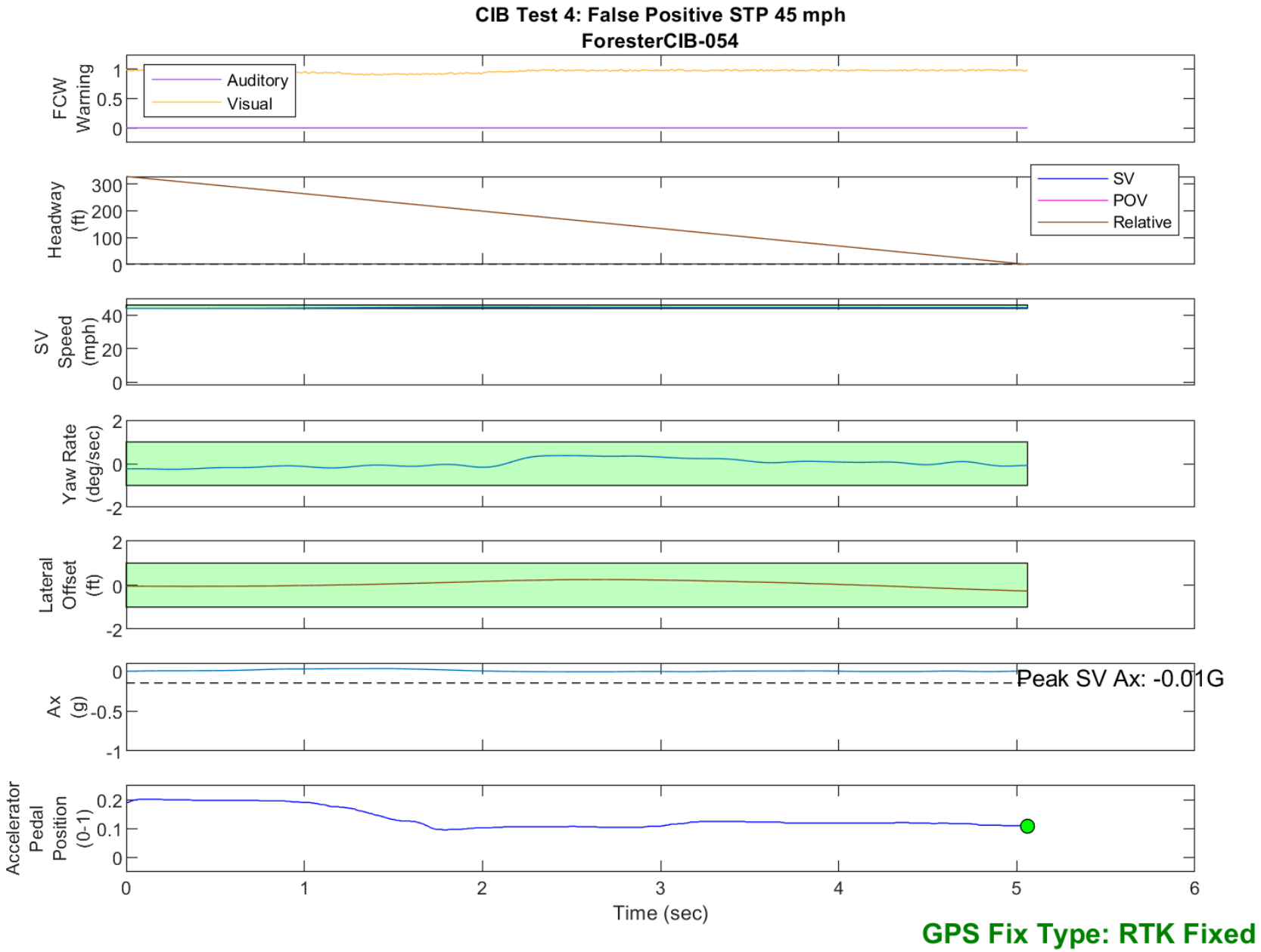


Figure D49. Time History for CIB Run 54, Test 4 - False Positive STP, 45 mph

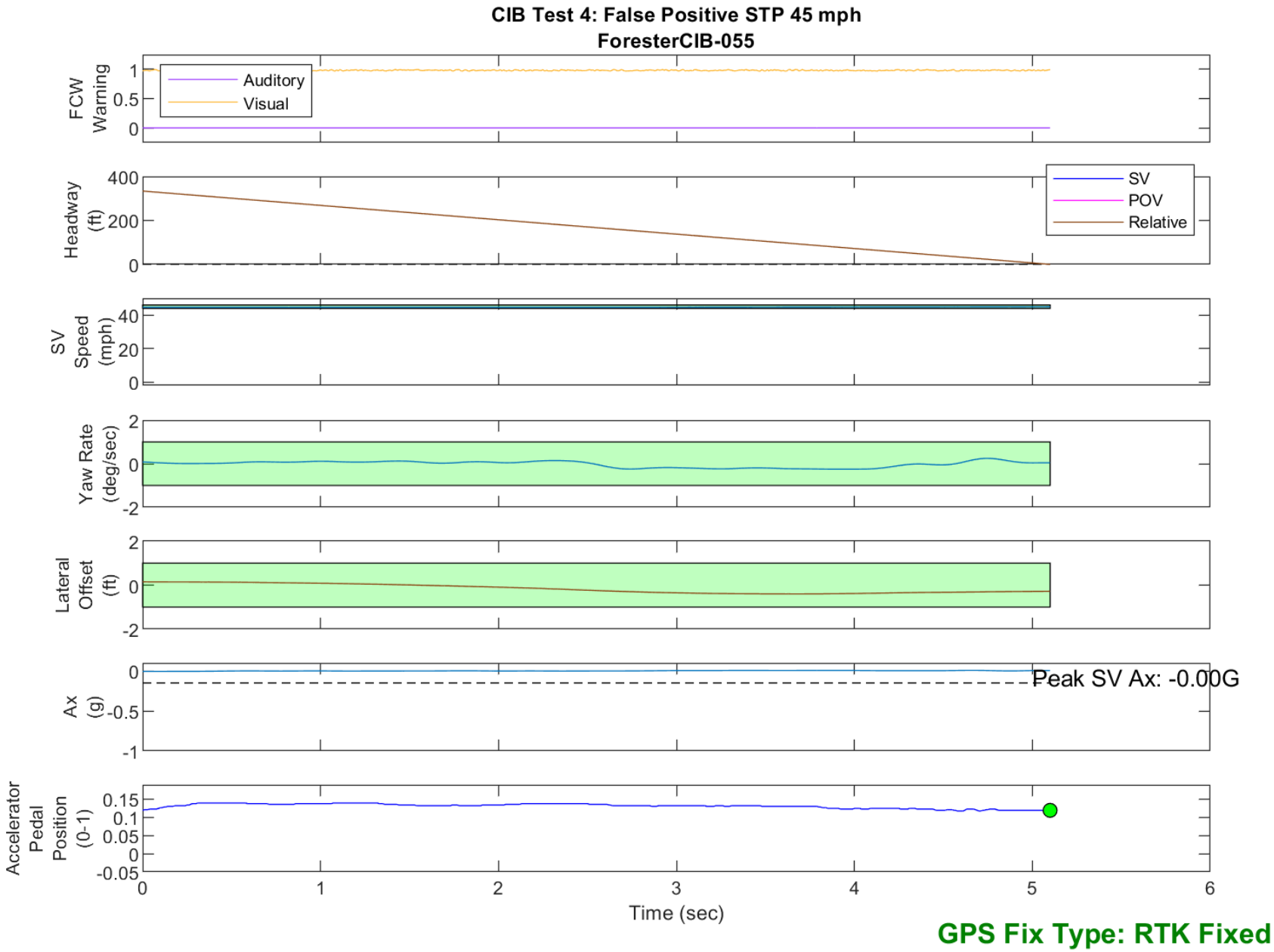


Figure D50. Time History for CIB Run 55, Test 4 - False Positive STP, 45 mph

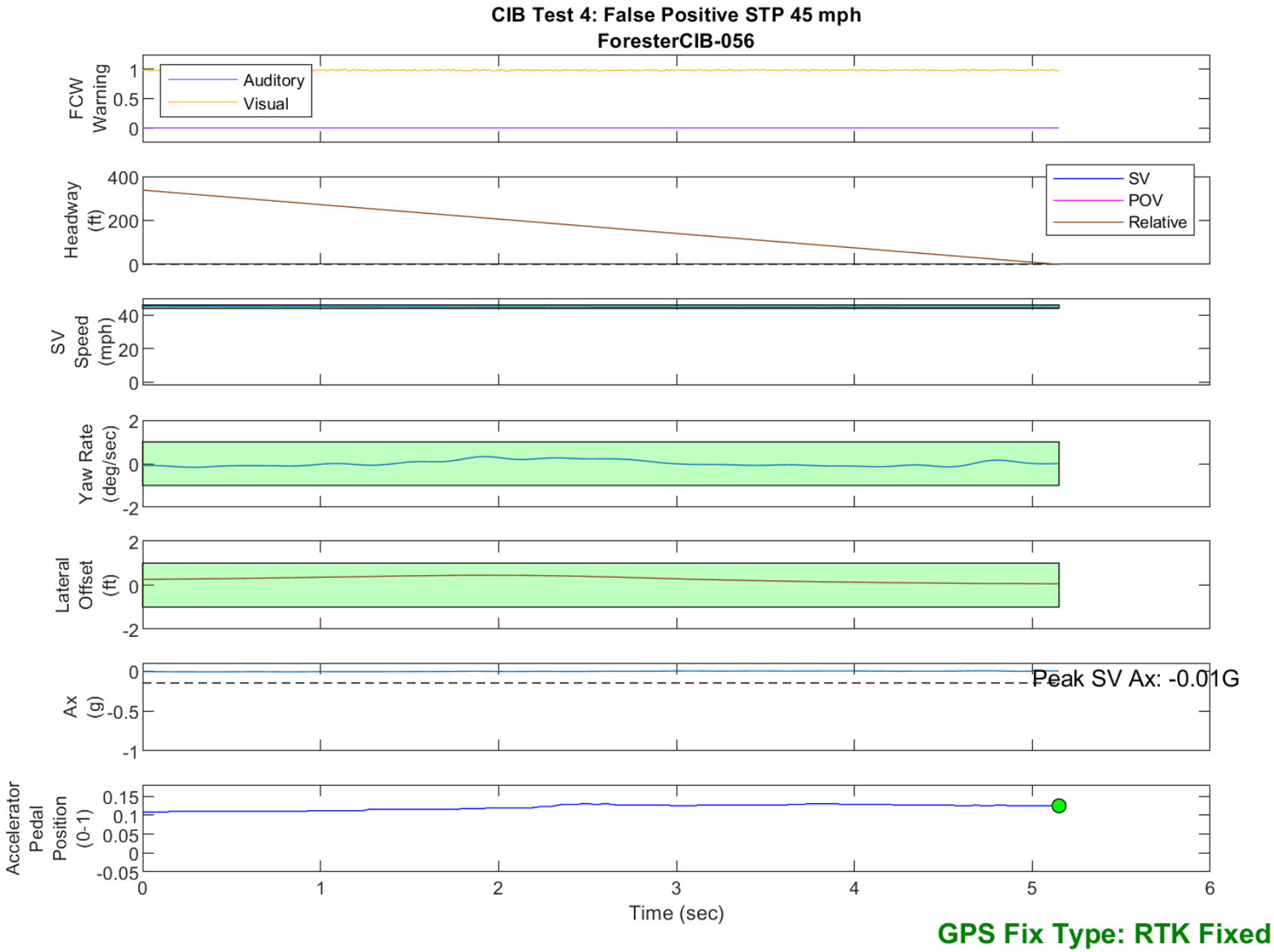


Figure D51. Time History for CIB Run 56, Test 4 - False Positive STP, 45 mph