

**NEW CAR ASSESSMENT PROGRAM
CRASH IMMINENT BRAKING SYSTEM CONFIRMATION TEST
NCAP-DRI-CIB-20-08**

2020 Kia Optima EX

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11 May 2020

Final Report

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16. Abstract These tests were conducted on the subject 2020 Kia Optima EX 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 track¹ 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 2020 Kia Optima EX. 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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2020 Kia Optima EX

SUMMARY RESULTS

VIN: 5XXGU4L14LG41xxxx

Test Date: 3/24/2020

Crash Imminent Braking System setting: Early

**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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2020 Kia Optima EX

TEST VEHICLE INFORMATION

VIN: 5XXGU4L14LG41xxxx

Body Style: Sedan

Color: Ebony Black

Date Received: 3/16/2020

Odometer Reading: 23 mi

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: KIA MOTORS MANUFACTURING
GEORGIA, INC.

Date of manufacture: OCT/30/19

Vehicle Type: PASSENGER CAR

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: 215/55 R17

Rear: 215/55 R17

Recommended cold tire pressure: Front: 235 kPa (34 psi)

Rear: 235 kPa (34 psi)

TIRES

Tire manufacturer and model: KUMHO SOLUS TA31

Front tire designation: 215/55 R17 94V

Rear tire designation: 215/55 R17 94V

Front tire DOT prefix: 00099YAY1

Rear tire DOT prefix: 00099YAY1

CRASH IMMINENT BRAKING
DATA SHEET 3: TEST CONDITIONS

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2020 Kia Optima EX

GENERAL INFORMATION

Test date: 3/24/2020

AMBIENT CONDITIONS

Air temperature: 15.0 C (59 F)

Wind speed: 0.0 m/s (0.0 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: 235 kPa (34 psi)

Rear: 235 kPa (34 psi)

CRASH IMMINENT BRAKING
DATA SHEET 3: TEST CONDITIONS

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2020 Kia Optima EX

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front: 503.9 kg (1111 lb)

Right Front: 468.1 kg (1032 lb)

Left Rear: 343.4 kg (757 lb)

Right Rear: 318.9 kg (703 lb)

Total: 1634.3 kg (3603 lb)

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

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2020 Kia Optima EX

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

Forward Collision Avoidance Assist (FCA)

Type of sensors the system uses:

The system uses a mono camera located behind the windshield near the rearview mirror.

System setting used for test (if applicable): Early

What is the minimum vehicle speed at which the CIB system becomes active?

5 mph (8 km/h) (Per manufacturer supplied information)

What is the maximum vehicle speed at which the CIB system functions?

50 mph (80 km/h) (Per manufacturer supplied information)

Does the vehicle system require an initialization sequence/procedure?

 Yes
 X No

If yes, please provide a full description.

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

 Yes
 X No

If yes, please provide a full description.

See Notes on page 9.

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

 X Warning light
 X Buzzer or audible alarm
 X Vibration
Other

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

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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, audible, vibration, or combination), etc.

The visual alert depicts the rear end view of a vehicle centered between two lane lines. When the system determines that a collision with the lead vehicle is imminent the words "Collision Warning" and a triangle with an exclamation point are displayed (Appendix A, Figure A16). In some cases, "Emergency Braking" is displayed in the later stage.

The auditory warning is a tone centered at 1515 Hz and pulsed at approximately 5 times per second.

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.

FCA is activated on every ignition. After ignition is on, the driver can turn off FCA via User Select Menu (USM). Controls on the steering wheel are used to access the system menus displayed in a center LCD. The hierarchy is:

User Settings

Driver Assistance

Forward Collision-Avoidance Assist (uncheck box to disable)

See Appendix A, Figure A14.

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 driver can select the initial warning activation time on the LCD display (Appendix A, Figure A14). The hierarchy is:

User Settings

Driver Assistance

Forward Collision Warning

Select: Early/Normal/Late

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

If yes, please provide a full description.

The limitations of the system are described on pages 5-42 through 5-47 of the Owner's Manual. These pages are reproduced in Appendix B, pages B-13 through B-18.

Notes:

In general, the 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 activations or impacts, the FCA can deactivate. In this case, the system provides a diagnostic light to the driver.

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.

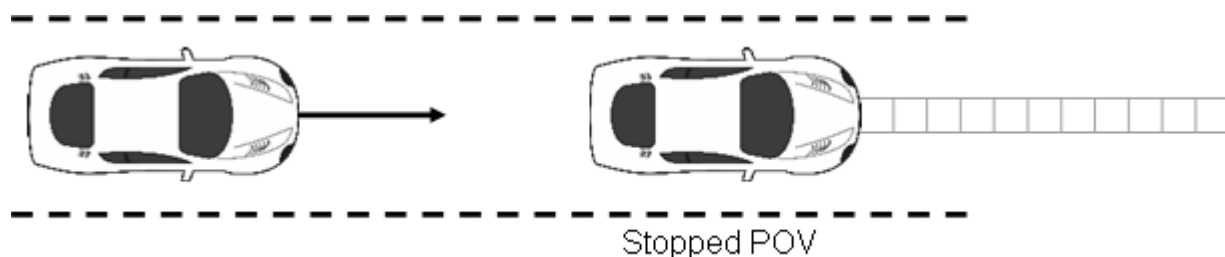


Figure 1. Depiction of Test 1

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 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} . For this test, TTC = 5.1 seconds is taken to occur at an SV-to-POV distance of 187 ft (57 m).

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. 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.

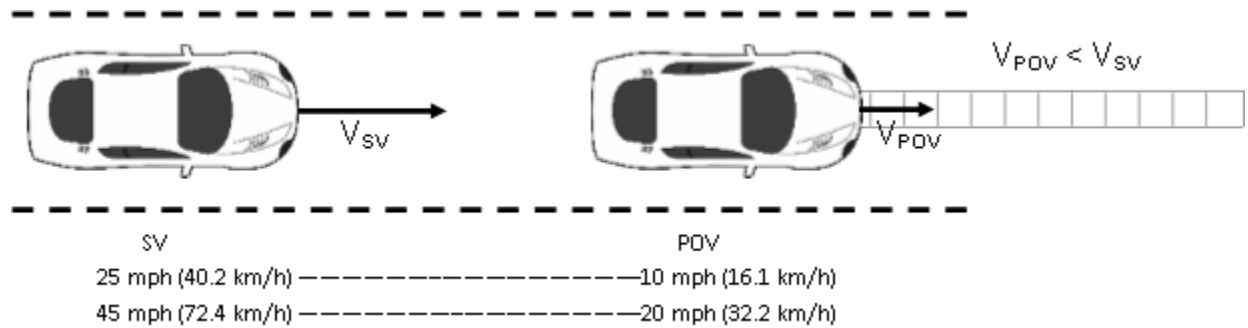


Figure 2. Depiction of Test 2

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 POV and the center of the travel lane could not deviate more than ± 1 ft (0.3 m) during the validity period.
- The lateral distance between the centerline of the SV and the center of the travel lane could not deviate more than ± 1 ft (0.3 m) 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} .
- 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-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-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.

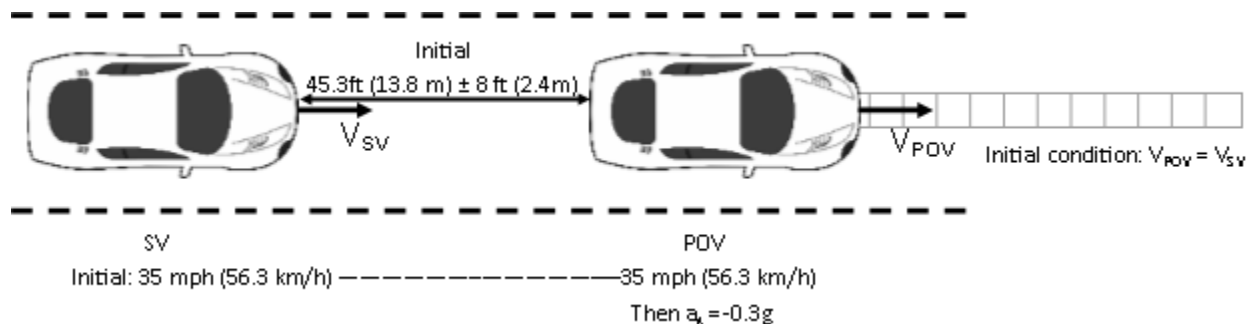


Figure 3. Depiction of Test 3 with POV Decelerating

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. The test concluded when either:

- The SV came into contact with the POV or
- For the decelerating POV, 1 second after minimal longitudinal SV-POV distance occurred or
- For the POV decelerating to stop case, 1 second after the velocity of the SV became 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 POV and the center of the travel lane could not deviate more than \pm 1 ft (0.3 m) during the validity period.
- The lateral distance between the centerline of the SV and the center of the travel lane could not deviate more than \pm 1 ft (0.3 m) during the validity period.
- The headway between the SV and POV must have been constant from the onset of the applicable validity period to the onset of POV braking.
- The SV and POV speed could not deviate more than \pm 1.0 mph (1.6 km/h) during an interval defined by the onset of the validity period to 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 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 haptic or audible, and the onset of the alert was determined by post-processing the test data.

For systems that implement audible or haptic alerts, part of the pre-test instrumentation verification process was to determine the tonal frequency of the audible warning or the vibration frequency of the tactile warning through use of the PSD (Power Spectral Density) function in Matlab. This was accomplished in order to identify the center frequency around which a band-pass filter was applied to subsequent audible or tactile warning data so that the beginning of such warnings can be programmatically determined. The band-pass filter used for these warning signal types was a phaseless, forward-reverse pass, elliptical (Cauer) digital filter, with filter parameters as listed in Table 1.

Table 1. Audible and Tactile Warning Filter Parameters

Warning Type	Filter Order	Peak-to-Peak Ripple	Minimum Stop Band Attenuation	Passband Frequency Range
Audible	5 th	3 dB	60 dB	Identified Center Frequency \pm 5%
Tactile	5 th	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 ± 1.0 deg/s from the onset of the validity period to the instant SV deceleration exceeded 0.25g.
- 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 the velocity of the SV became less than or equal to that of the POV.
- 1 second after minimal longitudinal SV-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

each of the test series.

For Tests 1, 2, and 3, the SV, POV, and 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.”

The zero position was documented prior to, and immediately after, conduct of each test series.

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 longitudinal offset was adjusted to output zero and another pre-test static calibration data file was collected. 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 post-test static calibration data file, the test trials performed between collection of that post-test static calibration data file and the last valid pre-test static calibration data file were repeated.

Static data files were collected prior to, and immediately after, conducting each of the test series. The pre-test static files were reviewed prior to test conduct to confirm that all data channels were operational and were properly configured.

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 DBS 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 POV-SV 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 subject vehicle is also equipped with an automatic braking system (E-brake) for the purpose of slowing the subject vehicle before impact with the SSV in cases where the subject vehicle 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	Omega DPG8001	17042707002	By: DRI Date: 7/3/2019 Due: 7/3/2020
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform 5338 N/	0.5% of applied load	Intercomp SWI	1110M206352	By: DRI Date: 1/6/2020 Due: 1/6/2021
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	45040532	By: DRI Date: 5/10/2019 Due: 5/10/2020
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	NA
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rat	Accels .01g, Angular Rate	Oxford Inertial +		By: Oxford Technical Solutions
					2258	Date: 5/3/2019 Due: 5/3/2021
					2176	Date: 4/11/2018 Due: 4/11/2020

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 Lane Markings (LDW) and POV (FCW)	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec Longitudinal Range to POV: ±200 m Longitudinal Range Rate: ±50 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec Longitudinal Range: ±3 cm Longitudinal Range Rate: ±0.02 m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	NA
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	NA	NA
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	NA	NA
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	NA	NA
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2020 Due: 1/6/2021
Type	Description			Mfr, Model	Serial Number	
Data Acquisition System	Data acquisition is achieved using a dSPACE MicroAutoBox II. Data from the Oxford IMU, including Longitudinal, Lateral, and Vertical Acceleration, Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle are sent over Ethernet to the MicroAutoBox. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (listed above).			dSPACE Micro-Autobox II 1401/1513		
				Base Board		549068
				I/O Board		588523

APPENDIX A

Photographs

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Figure A1. Front View of Subject Vehicle



Figure A2. Rear View of Subject Vehicle

2020 OPTIMA EX

MODEL/OPT.CODE: 54242 / 010
EXTERIOR COLOR: EBONY BLACK
INTERIOR COLOR: BLACK
VEHICLE ID NUMBER: 5XXGU4L14LG41
PORT OF ENTRY: WEST POINT

Sold To: _____ Ship To: _____

STANDARD FEATURES

STANDARD LX FEATURES

MECHANICAL

Drive Mode Select (DMS)

KIA DRIVEWISE DRIVER-ASSIST TECHNOLOGY

- Blind-Spot Collision Warning (BCW)
- Rear Cross-Traffic Collision Warning (RCCW)
- Parking Distance Warning-Reverse (PDW-R)
- Forward Collision-Avoidance Assist-Ped (FCA-Ped)
- Lane Departure Warning (LDW)
- Lane Keeping Assist-Line (LKA-L)
- Driver Attention Warning (DAW)
- High Beam Assist (HBA)

SAFETY

- Dual Front Advanced Airbags & Driver's Knee Airbag
- Dual Front Seat-Mounted Side & Full-Length Curtain Airbags
- Traction Control System (TCS) & Anti-Lock Brakes (ABS)

INTERIOR, COMFORT & CONVENIENCE

- 8" Touchscreen w/ Android Auto & Apple CarPlay
- Rear Camera with Dynamic Guidelines
- Adjustable Driver's Seat w/ Lumbar Support
- Adjustable Front Passenger's Seat w/ Height Adjuster
- Anti-Soiling Cloth Seat Trim
- Bluetooth® Wireless Technology
- USB / Auxiliary Input Jack and 12 Volt Outlet
- Steering Wheel Controls (Bluetooth/Audio/Cruise)
- Overhead Maplights & Sunglass Holder
- Remote Keyless Entry w/ Trunk Opener
- Power Windows w/ Driver's One-Touch Auto-Down

EXTERIOR

- Power, Heated Outside Mirrors w/ LED Turn Signal Indicators
- Single Projection Headlights w/ LED DRL
- 16" Alloy Wheels

WARRANTY

- 10 Year/100,000 Mile Limited Powertrain Warranty
- 5 Year/60,000 Mile Limited Basic Warranty
- 5 Year/60,000 Mile Roadside Assistance

*Ask dealer for details

MANUFACTURER'S SUGGESTED RETAIL PRICE

\$ 26,990.00

COMPARE EX FEATURES

- Added to/in place of standard LX features
- 1.6L Gas Direct-Injection Turbo Engine
- 7-Speed Dual Clutch Transmission
- Power Adj. Driver's Seat w/ Power Lumbar
- Heated Front Seats
- Leather Trimmed Seating
- Smart Key & Push Button Start
- Smart Cruise Control w/ Stop & Go
- Electronic Parking Brake w/ Auto Hold
- Dual Zone - Full Auto Temp Control (D-FATC)
- Rear Passenger Air Vents
- Wireless Phone Charger
- UVO link (1 yr trial; see owners.kia.com for details)
- Sirius/XM w/ Free 3-Month Subscription*
- Acoustic Front Door Windows
- Auto-Dimming Rearview Mirror
- LED Tail Lamps
- Projector Fog Lamps
- 17" Alloy Wheels

ADDITIONAL INSTALLED EQUIPMENT:
(In addition to or in place of standard features)
Carpeted Floor Mats

Included

Included

Included

Included

Included

Included

Included

Included

Included

Included

Included

Included

Included

Included

Included

Included

MSRP INCLUDING OPTIONS

INLAND FREIGHT AND HANDLING

TOTAL MANUFACTURER'S SUGGESTED RETAIL PRICE

\$135.00

\$ 27,125.00

\$ 925.00

\$ 28,050.00



EPA DOT Fuel Economy and Environment

Gasoline Vehicle

Fuel Economy

31 MPG
combined city/hwy
27 MPG
city
37 MPG
highway
3.2 gallons per 100 miles

MIDSIZE CARS range from 12 to 136 MPG. The best vehicle rates 136 MPG.

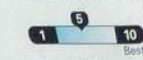
You Save **\$1,000** in fuel costs over 5 years compared to the average new vehicle.

Annual fuel cost **\$1,300**

Fuel Economy & Greenhouse Gas Rating (tailpipe only)



Smog Rating (tailpipe only)



This vehicle emits 202 grams CO₂ per mile. The best emits 6 grams per mile (tailpipe only). Producing and distributing fuel also create 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 \$7,500 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at \$ 2.70 per gallon. MPG 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



GOVERNMENT 5-STAR SAFETY RATINGS

Overall Vehicle Score ★★★★★

Based on the combined rating of frontal, side and rollover. Should ONLY be compared to other vehicles of similar size and weight.

Frontal Driver ★★★★★

Crash Passenger ★★★★★

Side Front seat ★★★★★

Crash Rear seat ★★★★★

Rollover ★★★★★

Star ratings based on the risk of injury in a frontal impact. Should ONLY be compared to other vehicles of similar size and weight. Star ratings based on the risk of injury in a side impact. Star ratings based on the risk of rollover in a single-vehicle crash.

Star ratings range from 1 to 5 stars (★★★★★) with 5 being the highest. Source: National Highway Traffic Safety Administration (NHTSA).

www.safercar.gov or 1-888-327-4236

Manufacturer's suggested retail price includes Manufacturer's recommended pre-delivery service, license and title fees, state and local taxes and other dealer installed options and accessories not included in the manufacturer's suggested retail price.

PARTS CONTENT INFORMATION

FOR VEHICLES IN THIS CAR LINE U.S./CANADIAN PARTS CONTENT: 45 %

MAJOR SOURCES OF FOREIGN PARTS: KOREA: 55%

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

FOR THIS VEHICLE FINAL ASSEMBLY POINT: WEST POINT, GA, USA

COUNTRY OF ORIGIN

ENGINE: MEXICO

TRANSMISSION: KOREA

DEALER:

STOCK NO.: 89997
VIN: LG41820
MODEL: 2020 KIA OPT
AVAIL. SERVICE AGE
OPTIONAL - ASK DEALER

EPA DOT Fuel Economy

Compare this vehicle

THIS AN FACTO

Always use a fuel information

*DEALER'S NOT THE M SUGGESTE

For Smog R Green

1

PROT

*PLUS gover charges, an

document p charge, and

fuele

Calculate e

DEALER

MR353

Mark

Prep

Pha

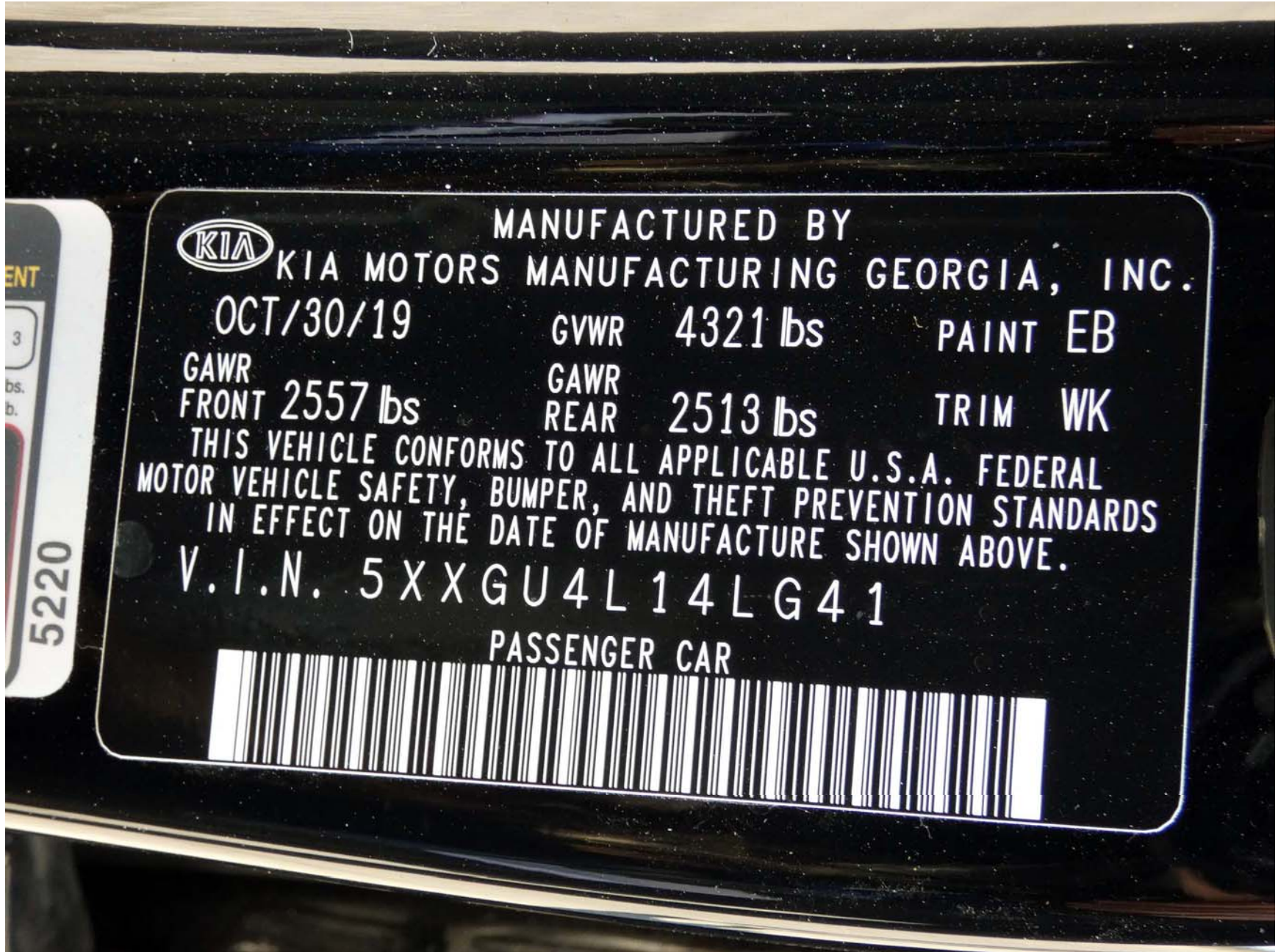
Sav

Mu

Sp

TOTAL ADDITIONAL WEIGHT: 7.3

Figure A3. Window Sticker (Monroney Label)



MANUFACTURED BY
KIA MOTORS MANUFACTURING GEORGIA, INC.

OCT/30/19

GVWR 4321 lbs

PAINT EB

GAWR
FRONT 2557 lbs

GAWR
REAR 2513 lbs

TRIM WK

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

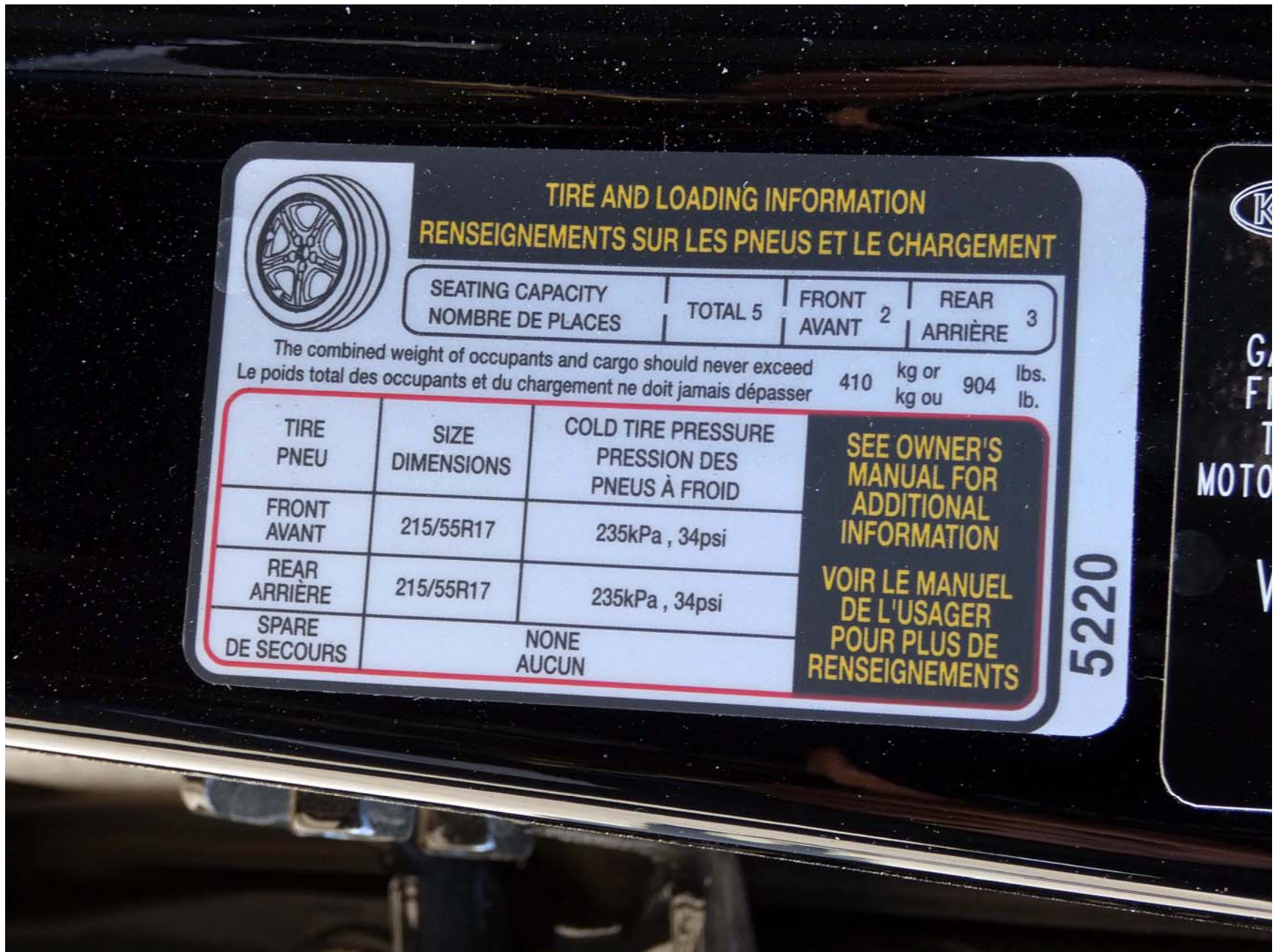
V.I.N. 5XXGU4L14LG41

PASSENGER CAR



ENT
3
bs.
b.
5220

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 410 kg or 904 lbs.
 Le poids total des occupants et du chargement ne doit jamais dépasser 410 kg ou 904 lb.

TIRE PNEU	SIZE DIMENSIONS	COLD TIRE PRESSURE PRESSION DES PNEUS À FROID
FRONT AVANT	215/55R17	235kPa , 34psi
REAR ARRIÈRE	215/55R17	235kPa , 34psi
SPARE DE SECOURS	NONE AUCUN	

**SEE OWNER'S
 MANUAL FOR
 ADDITIONAL
 INFORMATION**
**VOIR LE MANUEL
 DE L'USAGER
 POUR PLUS DE
 RENSEIGNEMENTS**

5220

Figure A5. Tire Placard



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



Figure A7. Load Frame/Slider of SSV

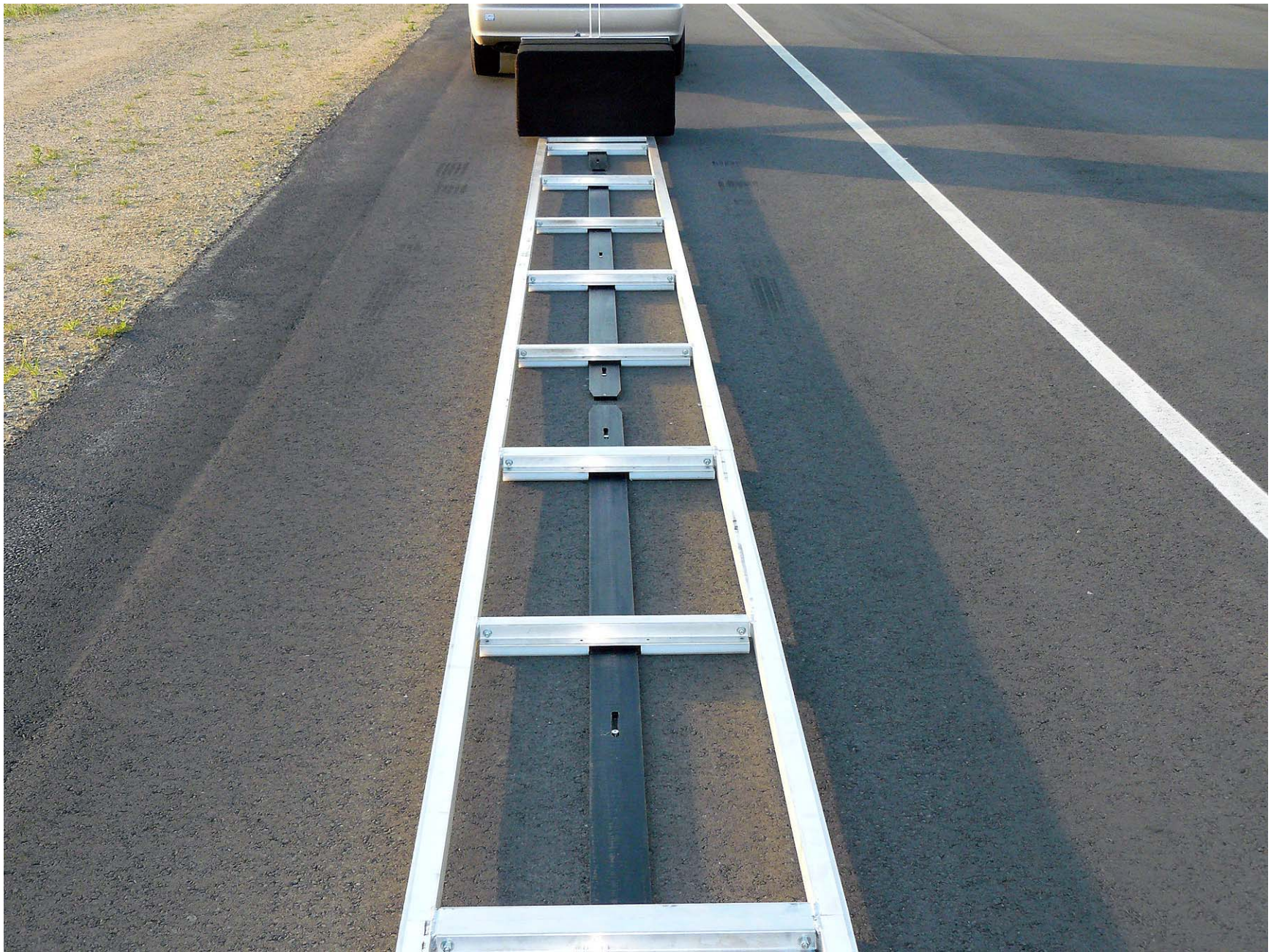


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track



Figure A9. Steel Trench Plate



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



Figure A11. Sensor for Detecting Auditory Alerts



Figure A12. Sensor for Detecting Visual Alerts



Figure A13. Brake Actuator Installed in POV System



Figure A14. AEB Setup Menus



Figure A15. Control for Changing Vehicle Parameters

APPENDIX B

Excerpts from Owner's Manual

Driver Assistance (if equipped)

- Driver Attention Warning :
 - Choose the alert stage (High sensitivity/Normal sensitivity/Off) of the Driver Attention Warning.
- *For more details, refer to "Driver Attention Warning (DAW)" in chapter 5.
- Lane Safety :
 - Active LKA : To activate the active LKA mode.
 - Standard LKA : To activate the standard LKA mode.
 - Lane Departure Warning : To activate the lane departure warning function.
- *For more details, refer to "Lane Keeping Assist (LKA) System" in chapter 5.
- Forward Collision-avoidance Assist (FCA) :
 - To activate or deactivate the FCA system.
- *For more details, refer to "Forward Collision-avoidance Assist (FCA)" in chapter 5.
- Forward Collision Warning :
 - Choose the initial warning alert time of the forward collision warning. (Late/Normal/Early)
- *For more details, refer to "Forward Collision-avoidance Assist (FCA)" in chapter 5.
- Blind-Spot Collision Warning Timing :
 - Choose the initial warning alert time of the blind-spot collision warning timing. (Normal/Late)
- *For more details, refer to "Blind-Spot Collision Warning" in chapter 5.
- Rear Cross-Traffic Collision Warning :
 - If this item is checked, the rear cross-traffic collision Warning function will be activated.
- *For more details, refer to "Blind-spot Collision Warning" in chapter 5.

Low Fuel

- This warning message illuminates if the fuel tank is nearly empty.
 - When the low fuel level warning light is illuminated, add fuel as soon as possible.
 - When the trip computer displays “--- km (or mile)” as range.

Check high beam assist system

- This warning message illuminates if the high beam assist system has a malfunction. In this case, have your vehicle inspected by an authorized Kia dealer.

Check headlight

- This warning message illuminates if there is a malfunction (burned-out bulb or circuit malfunction) with the headlamp. In this case, have your vehicle inspected by an authorized Kia dealer.

*** NOTICE**

- When replacing the bulb, use the same wattage bulb.
For more information, refer to “BULB WATTAGE” in chapter 8.
- If different wattage bulb is equipped with the vehicle, this warning message is not displayed.

Check Forward Collision-avoidance Assist system

- This warning message illuminates if there is a malfunction with the Forward Collision-avoidance Assist (FCA) system. In this case, have your vehicle inspected by an authorized Kia dealer.

*For more details, refer to “Forward Collision-avoidance Assist(FCA) system” in chapter 5.

⚠ WARNING - Low tire pressure

- **Significantly low tire pressure makes the vehicle unstable and can contribute to loss of vehicle control and increased braking distances.**
 - **Continued driving on low pressure tires will cause the tires to overheat and fail.**
- The TPMS cannot alert you to severe and sudden tire damage caused by external factors.
 - If you notice any vehicle instability, immediately take your foot off the accelerator pedal, apply the brakes gradually with light force, and slowly move to a safe position off the road.

Master Warning light (if equipped)



- This warning light informs the driver of the following situations
- Forward Collision-Avoidance Assist malfunction
- Blind-Spot Collision Warning radar blind
- Lamp malfunction
- High Beam Assist malfunction
- Tire Pressure Monitoring System (TPMS) malfunction
- Electronic Control Suspension (ECS) malfunction

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

If the warning situation is solved, the master warning light will be turned off.

Forward Collision-avoidance Assist Warning light (FCA)



This indicator light illuminates:

- When there is a malfunction with the FCA.

In this case, have the vehicle inspected by an authorized Kia dealer.

FORWARD COLLISION-AVOIDANCE ASSIST (FCA) SYSTEM - CAMERA TYPE

The Forward Collision-Avoidance Assist (FCA) system is designed to help detect and monitor the vehicle or pedestrians ahead in the roadway through camera recognition to warn the driver that a collision is imminent, and if necessary, apply emergency braking.

⚠ WARNING

Take the following precautions when using the Forward Collision-Avoidance Assist (FCA) system:

- This system is only a supplemental system and it is not intended to, nor does it replace the need for extreme care and attention of the driver. The sensing range and objects detectable by the sensors are limited. Pay attention to the road conditions at all times.
- Never drive too fast in accordance with the road conditions or while cornering.
- Always drive cautiously to prevent unexpected and sudden situations from occurring. FCA does not stop the vehicle completely and is not a collision avoidance system.

System setting and activation

System setting

- The driver can activate the FCA by placing the ignition switch to the ON position and by selecting: 'User Settings → Driver Assistance → Forward Collision-Avoidance Assist' The FCA system deactivates, when the driver cancels the system setting.



The warning light illuminates on the LCD display, when you cancel the FCA system. The driver can monitor the FCA ON/OFF status on the LCD display. Also, the warning light illuminates when the ESC (Electronic Stability Control) is turned off. When the warning light remains ON with the FCA activated, have the system checked by an authorized Kia dealer.

- The driver can select the initial warning activation time on the LCD display. Go to the 'User Settings → Driver Assistance → Forward Collision Warning → Early/Normal/Late'.

The options for the initial Forward Collision Warning includes the following:

- **EARLY** - When this condition is selected, the initial Forward Collision Warning is activated earlier than normal. This setting maximizes the amount of distance between the vehicle or pedestrians ahead before the initial warning occurs. If the 'EARLY' condition feels too sensitive, change it into 'NORMAL'.
- **NORMAL** - When this condition is selected, the initial Forward Collision Warning is activated normally. This setting allows for a smaller amount of distance between the vehicle or pedestrians ahead before the initial warning occurs compared to the EARLY mode.
- **LATE** - When this condition is selected, the initial Forward Collision Warning is activated later than normal. This setting reduces the amount of distance between the vehicle or pedestrians ahead before the initial warning occurs. Select this condition only when traffic is light, and you are driving slowly.

Prerequisite for activation

The FCA gets ready to be activated, when the FCA is selected on the LCD display, and when the following prerequisites are satisfied.

- The ESC (Electronic Stability Control) is activated.
- Vehicle speed is over 8 km/h (5 mph). (The FCA is only activated within a certain speed range.)
- The system detects a vehicle or pedestrian in front, which may collide with your vehicle. (The FCA may not be activated or may sound a warning alarm in accordance with the driving situation or vehicle condition.)

*The FCA may not operate properly according to the frontal situation, the direction and speed of pedestrian.

⚠ WARNING

- **Completely stop the vehicle on a safe location before operating the switch on the steering wheel to activate/deactivate the FCA system.**
- **The FCA automatically activates upon placing the Engine Start/Stop button to the ON position. The driver can deactivate the FCA by canceling the system setting on the LCD display. To avoid driver distractions, do not attempt to set or cancel the FCA while driving the vehicle.**
- **The FCA automatically deactivates upon canceling the ESC (Electronic Stability Control). When the ESC is canceled, the FCA cannot be activated on the LCD display. The FCA warning light will illuminate, but it does not indicate a malfunction of the system.**

FCA warning message and system control

The FCA system produces warning messages, warning alarms, and emergency braking based on the level of risk of a frontal collision, such as when a vehicle ahead suddenly brakes.

The driver can select the initial warning activation time in the User Settings in the LCD display. The options for the initial Forward Collision Warning include Early, Normal or Late initial warning time.

Collision Warning (1st warning)



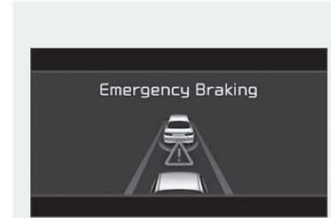
OJF058389L

This warning message appears on the LCD display with a warning chime. Additionally, some vehicle system intervention occurs by the engine management system to help decelerate the vehicle.

- Your vehicle speed may decelerate moderately.
- The FCA system limitedly controls the brakes to preemptively mitigate impact in a collision.

- It will operate if the vehicle speed is greater than 8 km/h (5 mph) and less than or equal to 60 km/h (38 mph) on a forward vehicle. (Depending on the condition of the vehicle ahead and the environment surrounding it, the possible maximum operating speed may be reduced.)

Emergency braking (2nd warning)



OJF058390L

This warning message appears on the LCD display with a warning chime. Additionally, some vehicle system intervention occurs by the engine management system to help decelerate the vehicle.

- The FCA system limitedly controls the brakes to preemptively mitigate impact in a collision. The brake control is maximized just before a collision.

- It will operate if the vehicle speed is greater than 8 km/h (5 mph) and less than or equal to 60 km/h (38 mph) on a forward vehicle. (Depending on the condition of the vehicle ahead and the environment surrounding it, the possible maximum operating speed may be reduced.)

Brake operation

- In an urgent situation, the FCA system applies the brakes.
- The FCA provides additional braking power for optimum braking performance, when the driver depresses the brake pedal.
- The braking control is automatically deactivated, when the driver sharply depresses the accelerator pedal, or when the driver abruptly operates the steering wheel.
- The FCA brake control is automatically canceled, when risk factors disappear.

CAUTION

The driver should always pay great caution to vehicle operation, even though there is no warning message or warning alarm. The warning of the FCA system may not sound while other system warning sounds.

WARNING

The FCA cannot avoid all collisions. The braking control cannot completely stop the vehicle. The driver is responsible to safely drive and control the vehicle.

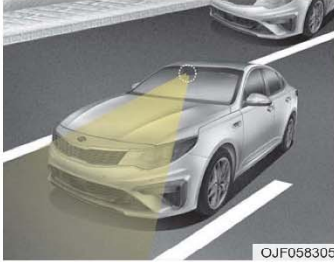
WARNING

The FCA system logic assesses the risk of a collision by monitoring several variables, such as the distance from the vehicle ahead, the speed of the vehicle ahead, and the driver's vehicle speed. Certain conditions, such as inclement weather and road conditions, may affect the operation of the FCA system.

WARNING

Never deliberately drive dangerously to activate the system.

**FCA sensor
(Front View Camera)**



In order for the FCA system to operate properly, always make sure the sensor are clean and free of dirt, snow, and debris.

Dirt, snow, or foreign substances on the sensor or its external parts may adversely affect the sensing performance of the sensor.

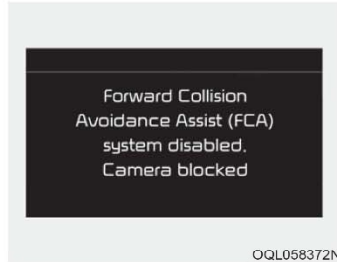
*** NOTICE**

- Never install any accessories or stickers on the front windshield, or tint the front windshield.
- Never place any reflective objects (i.e. white paper, mirror) over the dashboard. Any light reflection may cause a malfunction of the system.
- Make sure the frontal camera does not get wet.
- Never disassemble the camera assembly, or apply any impact on the camera assembly.
- Playing the vehicle audio system at high volume may prevent occupants from hearing the FCA warnings.
- Be careful not to apply unnecessary force on the sensor. If the sensor is forcibly moved out of proper alignment, the system may not operate correctly. In this case, a warning message may not be displayed. Have the vehicle inspected by an authorized Kia dealer.

*** NOTICE**

Have the vehicle inspected by an authorized Kia dealer when the windshield glass is replaced.

Warning message and warning light



When the sensor is blocked with dirt, snow, or debris, the FCA system operation may stop temporarily.

If this occurs, a warning message will appear on the LCD display.

The system will operate normally when such dirt, snow or debris is removed.

However, the FCA system may not properly operate in an area (e.g. open terrain), where any substances are not detected after turning ON the engine.

Although a warning message will not appear on the LCD display, the FCA may not properly operate.

System malfunction



- When the FCA is not working properly, the FCA warning light (⚠) will illuminate and the warning message will appear for a few seconds. After the message disappears, the master warning light (⚠) will illuminate. In this case, have the vehicle inspected by an authorized Kia dealer.
- The FCA warning message may appear along with the illumination of the ESC warning light.

⚠ WARNING

- The FCA is only a supplemental system for the driver's convenience. It is the driver's responsibility to control the vehicle operation. Do not solely depend on the FCA system. Rather, maintain a safe braking distance, and, if necessary, depress the brake pedal to reduce the driving speed or stop the vehicle.

- In certain instances and under certain driving conditions, the FCA system may activate unintentionally.

Also, due to sensing limitations, in certain situations, the front view camera recognition system may not detect the vehicle or pedestrians ahead. The FCA system may not activate and the warning message may not be displayed.

(Continued)

(Continued)

- The FCA system may not activate if the driver applies the brake pedal to avoid the risk of a collision.
- The brake control may be insufficient, possibly causing a collision, if a vehicle in front abruptly stops. Always pay extreme caution.
- The FCA system may not activate depending on road conditions, inclement weather, driving conditions or traffic conditions. Therefore, the driver should always pay attention to the road and be prepared to apply the brakes at all times.

(Continued)

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- Even if there is any problem with the brake control function of the FCA system, the vehicle's basic braking performance will operate normally. However, brake control function for avoiding collision will not activate.
- If the vehicle in front stops suddenly, you may have less control of the brake system. Therefore, always keep a safe distance between your vehicle and the vehicle in front of you.
- Occupants may get injured, if the vehicle abruptly stops by the activated FCA system. Pay extreme caution.
- The FCA system operates only to detect vehicles in front of the vehicle.
- The FCA system may not activate to all types of vehicles.

⚠ WARNING

- The FCA system does not operate when the vehicle is in reverse.
- The FCA system is not designed to detect other objects on the road such as animals.
- The FCA system does not detect vehicles in the opposite lane.
- The FCA system does not detect cross traffic vehicles that are approaching.
- The FCA system cannot detect the driver approaching the side view of a parked vehicle (for example on a dead end street.)

In these cases, you must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce the driving speed in order to maintain a safe distance.

Limitation of the system

The Forward Collision-Avoidance Assist (FCA) system is designed to monitor the vehicle or pedestrians ahead in the roadway through camera recognition to warn the driver that a collision is imminent, and if necessary, apply emergency braking.

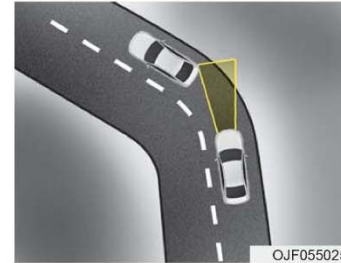
In certain situations, the camera may not be able to detect the vehicle or pedestrians ahead. In these cases, the FCA system may not operate normally. The driver must pay careful attention in the following situations where the FCA operation may be limited.

Detecting vehicles

The sensor may be limited when:

- The camera is covered object or debris
- Inclement weather such as heavy rain or snow obscures the field of view of the camera
- The camera recognition is limited
- The vehicle in front is too small to be detected (for example a motorcycle or a bicycle, etc.)
- The vehicle in front is an oversize vehicle or trailer that is too big to be detected by the camera recognition system. (for example a tractor, trailer, etc.)
- The camera's field of view is not well illuminated (either too dark or too much reflection or too much back-light that obscures the field of view)
- The vehicle in front does not have their rear lights properly turned ON or their rear lights are located unusually.
- The outside brightness changes suddenly, for example when entering or exiting a tunnel

- When light coming from a street light or an oncoming vehicle is reflected on a wet road surface such as a puddle in the road.
- The field of view in front is obstructed by sun glare or headlight of oncoming vehicle.
- The windshield glass is fogged up.
- The vehicle in front is driving erratically.
- The vehicle is on unpaved or uneven rough surfaces, or roads with sudden gradient changes.
- The vehicle is drives inside a building, such as a basement parking lot
- The camera does not recognize the entire vehicle in front.
- The camera is damaged.
- The brightness outside is too low such as when the headlamps are not on at night or the vehicle is going through a tunnel.
- Adverse road conditions cause excessive vehicle vibrations while driving
- The sensor recognition changes suddenly when passing over a speed bump
- The shadow is on the road by a median strip, trees, etc.
- The vehicle drives through a toll-gate.
- The rear part of the vehicle in front is not fully visible.
- The vehicle in front is moving vertically to the driving direction
- The vehicle in front is stopped vertically
- The vehicle in front is driving towards your vehicle or reversing
- You are on a roundabout and the vehicle in front circles



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- Driving on a curve

The performance of the FCA system may be limited when driving on a curved road.

On curved roads, the other vehicle on the same lane is not recognized and the FCA system's performance may be degraded. This may produce the warning message and the warning alarm prematurely, or it may not produce the warning message or the warning alarm at all.

Also, in certain instances the camera recognition system may not detect the vehicle traveling on a curved road.

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

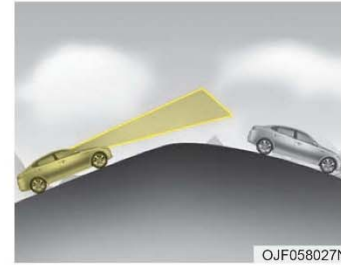


The FCA system may recognize a vehicle in the next lane when driving on a curved road.

In this case, the system may alarm the driver and apply the brake. Always pay attention to road and driving conditions while driving. If necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.

Also, when necessary depress the accelerator pedal to prevent the system from unnecessarily decelerating your vehicle.

Always check the traffic conditions around the vehicle.

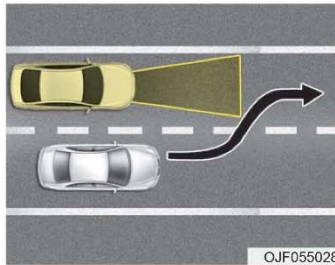


- Driving on a slope

The performance of the FCA system may be limited while driving upward or downward on a slope and may not recognize the vehicle in front in the same lane. It may prematurely produce the warning message and the warning alarm, or it may not produce the warning message and the warning alarm at all.

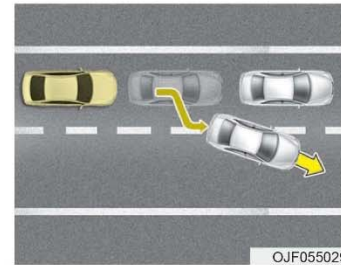
When the FCA suddenly recognizes the vehicle in front while passing over a slope, you may experience sharp deceleration.

Always keep your eyes forward while driving upward or downward on a slope, and, if necessary, depress the brake pedal to reduce your driving speed in order to maintain distance.

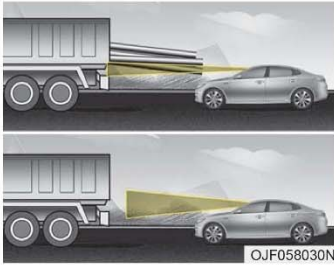


- Changing lanes

When a vehicle changes lanes in front of you, the FCA system may not immediately detect the vehicle, especially if the vehicle changes lanes abruptly. In this case, you must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.



When driving in stop-and-go traffic, and a stopped vehicle in front of you merges out of the lane, the FCA system may not immediately detect the new vehicle that is now in front of you. In this case, you must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.



- Detecting the vehicle in front of you
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. The FCA system 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, depress the brake pedal to reduce your driving speed in order to maintain distance.

Detecting pedestrians

The sensor may be limited when:

- The pedestrian is not fully detected by the camera recognition system, for example, if the pedestrian is leaning over or is not fully walking upright
- The pedestrian is moving very quickly or appears abruptly in the camera detection area
- The pedestrian is wearing clothing that easily blends into the background, making it difficult to be detected by the camera recognition system
- The outside lighting is too bright (e.g. when driving in bright sunlight or in sun glare) or too dark (e.g. when driving on a dark rural road at night)
- It is difficult to detect and distinguish the pedestrian from other objects in the surroundings, for example, when there is a group of pedestrians, or a large crowd.
- There is an item similar to a person's body structure
- The pedestrian is small
- The pedestrian has impaired mobility
- The sensor recognition is limited
- The camera is covered with a foreign object or debris
- Inclement weather such as heavy rain or snow obscures the field of view of the radar sensor or camera
- When light coming from a street light or an oncoming vehicle is reflected on a wet road surface such as a puddle in the road
- The field of view in front is obstructed by sun glare
- The windshield glass is fogged up.
- The adverse road conditions cause excessive vehicle vibrations while driving
- When the pedestrian suddenly appears in front of the vehicle
- When the construction area, rail or other metal object is near the pedestrian.

⚠ WARNING

- Do not use the Forward Collision -Avoidance Assist (FCA) system when towing a vehicle. Application of the FCA system while towing may adversely affect the safety of your vehicle or the towing vehicle.
- Use extreme caution when 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.
- The FCA system is designed to detect and monitor the vehicle ahead in the roadway through camera recognition. It is not designed to detect bicycles, motorcycles, or smaller wheeled objects such as luggage bags, shopping carts, or strollers.

(Continued)

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- Never try to test the operation of the FCA system. Doing so may cause severe injury or death.
- When front bumper or windshield glass is replaced or repaired, have the vehicle inspected by an authorized Kia dealer.

*** NOTICE**

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

This device complies with Industry Canada licence-exempt RSS standard(s).

Operation is subject to the following conditions:

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

- Playing the vehicle audio system at high volume may offset the Driver Attention Warning system warning sounds.

⚠ CAUTION

The Driver Attention Warning system may not properly operate with limited alerting in the following situations:

- *The lane detection performance is limited. (For more information, refer to “Lane Keeping Assist (LKA) system” in this chapter.)*
- *The vehicle is violently driven or is abruptly turned for obstacle avoidance (e.g. construction area, other vehicles, fallen objects, bumpy road).*
- *Forward drivability of the vehicle is severely undermined (possibly due to wide variation in tire pressures, uneven tire wear-out, toe-in/toe-out alignment).*

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- *The vehicle drives on a curvy road.*
- *The vehicle drives on a bumpy road.*
- *The vehicle drives through a windy area.*
- *The vehicle is controlled by the following driver assistance systems:*
 - *Lane Keeping Assist (LKA) system*
 - *forward collision-avoidance assist (FCA) System.*

*** NOTICE**

The Driver Attention Warning system does not detect actual driver fatigue or drowsiness. The system monitors driving and provides a warning if it detects inattentive driving practices.

APPENDIX C

Run Log

Subject Vehicle: **2020 Kia Optima EX**

Test Date: **3/24/2020**

Principal Other Vehicle: **SSV**

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	1.58	0.57	24.6	1.02	0.87	Pass	
3		Y	1.58	1.25	24.4	1.00	0.91	Pass	
4		Y	1.58	0.59	24.7	0.98	0.89	Pass	
5		Y	1.58	0.42	24.6	0.93	0.91	Pass	
6		Y	1.54	1.89	24.5	1.03	0.92	Pass	
7		Y	1.53	1.67	24.0	1.02	0.87	Pass	
8		Y	1.56	1.41	25.2	1.02	0.93	Pass	
9	Static Run								
10	Slower POV, 25 vs 10	Y	1.46	2.90	14.5	0.95	0.70	Pass	
11		Y	1.29	3.08	14.7	0.98	0.69	Pass	
12		Y	1.38	2.13	13.8	0.95	0.61	Pass	
13		Y	1.51	3.00	14.8	0.97	0.68	Pass	
14		Y	1.38	3.51	14.6	0.94	0.72	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
15		Y	1.51	2.96	14.8	0.98	0.68	Pass	
16		Y	1.61	3.33	15.4	0.99	0.70	Pass	
17	Static Run								
18	Slower POV, 45 vs 20	Y	2.65	0.00	7.7	1.10	0.73	Fail	Vehicle CIB activated at TTC shown. Driver applied additional brakes at last moment. Last minute brake actuator turned on
19		Y	2.70	3.67	25.3	0.98	0.90	Pass	
20		Y	2.71	4.02	24.7	1.00	0.90	Pass	
21		N							POV speed
22		Y	2.64	5.04	24.8	0.98	0.94	Pass	
23		Y	2.63	4.92	24.8	1.00	0.95	Pass	
24		Y	2.64	5.38	24.5	1.04	0.92	Pass	
25		Y	2.71	5.03	25.4	0.99	0.94	Pass	
26	Static run								
27	Decelerating POV, 35	Y	1.83	0.00	21.6	0.92	1.31	Pass	
28		Y	1.79	1.90	27.1	1.07	1.13	Pass	
29		Y	1.82	0.00	23.0	0.93	1.27	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
30		Y	1.68	0.00	24.7	0.91	1.33	Pass	
31		Y	1.58	0.00	27.0	0.91	1.29	Pass	
32		Y	1.73	0.00	23.3	0.94	1.34	Pass	
33		Y	1.67	0.00	21.1	0.94	1.30	Pass	
34	Static Run								
35	STP - Static Run								
36	STP False Positive, 25	Y				0.02		Pass	
37		Y				0.01		Pass	
38		Y				0.01		Pass	
39		Y				0.01		Pass	
40		Y				0.02		Pass	
41		Y				0.01		Pass	
42		Y				0.02		Pass	
43	STP - Static Run								

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
44	STP False Positive, 45	Y				0.02		Pass	
45		Y				0.01		Pass	
46		Y				0.01		Pass	
47		Y				0.02		Pass	
48		Y				0.01		Pass	
49		Y				0.01		Pass	
50		Y				0.01		Pass	
51	STP - Static Run								

APPENDIX D

Time History Plots

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Description of Time History Plots

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

Time History Plot Description

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

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

Time history figures include the following sub-plots:

- FCW Warning – Displays the Forward Collision Warning alert (which can be audible, 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 audible 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.

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

Envelopes and Thresholds

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 1 through Figure 9. Figures 1 through 6 show passing runs for each of the 6 test types. Figures 7 and 8 show examples of invalid runs. Figure 9 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 10.

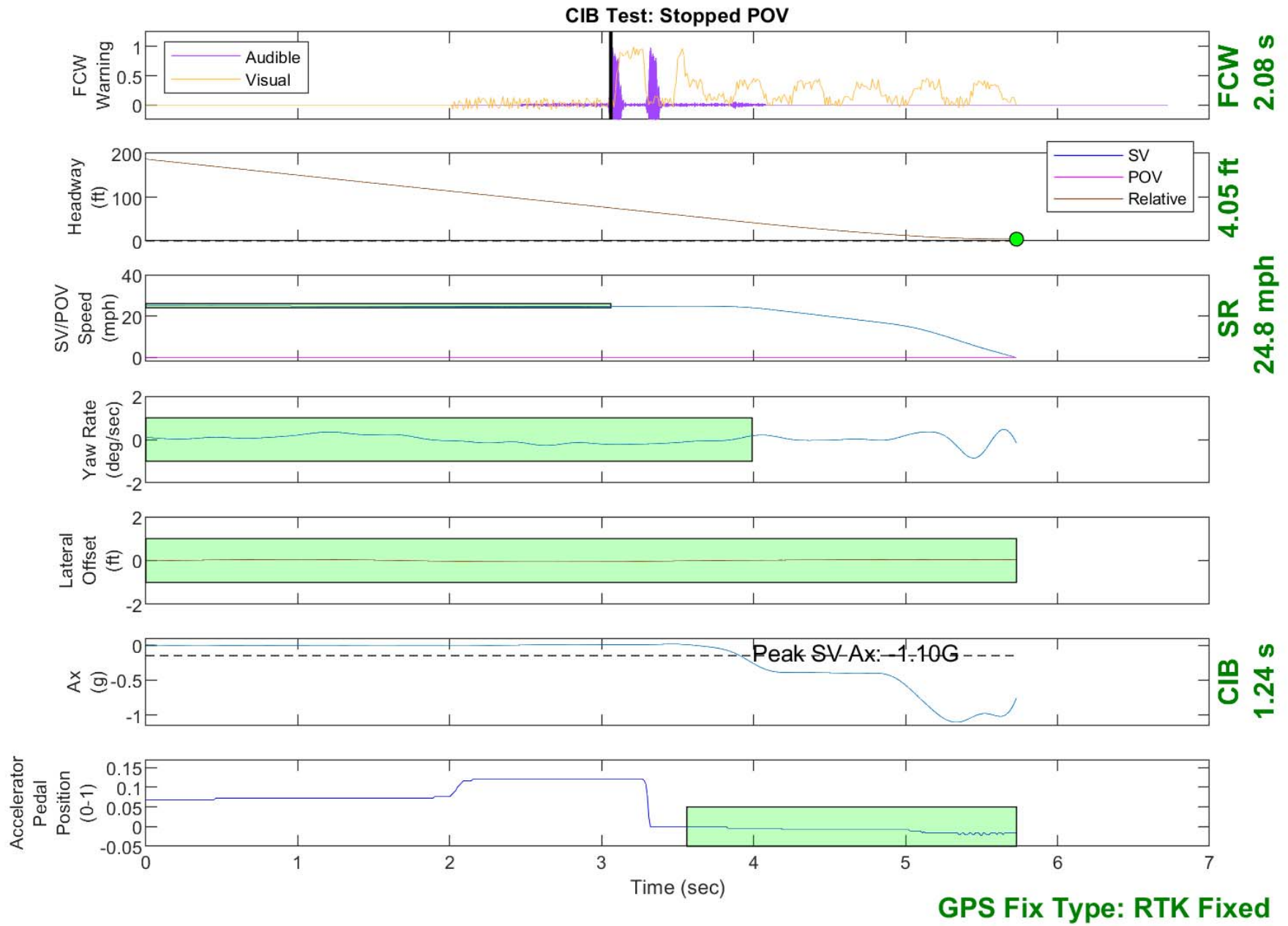


Figure D1. Example Time History for Stopped POV, Passing

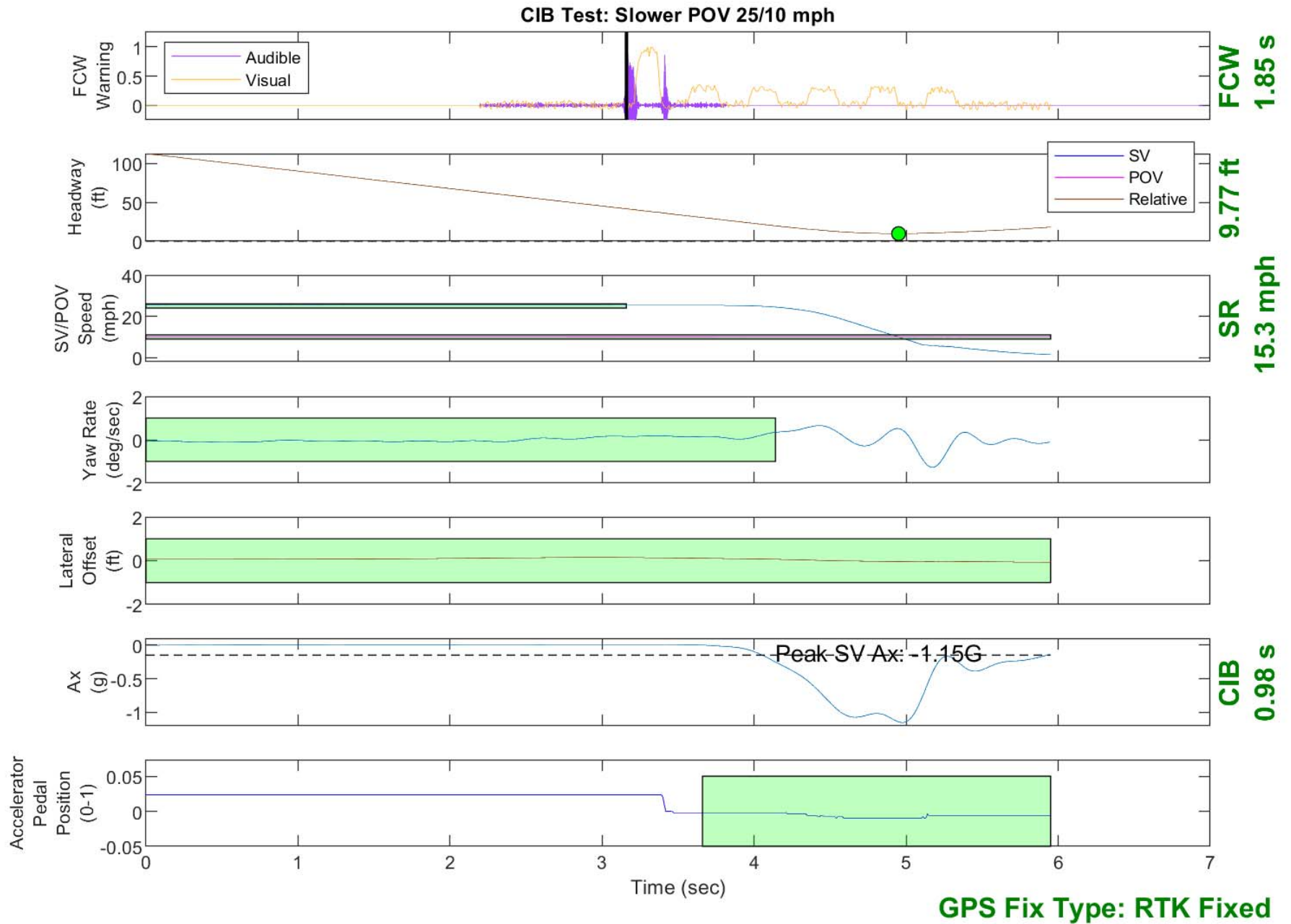


Figure D2. Example Time History for Slower POV 25 vs. 10, Passing

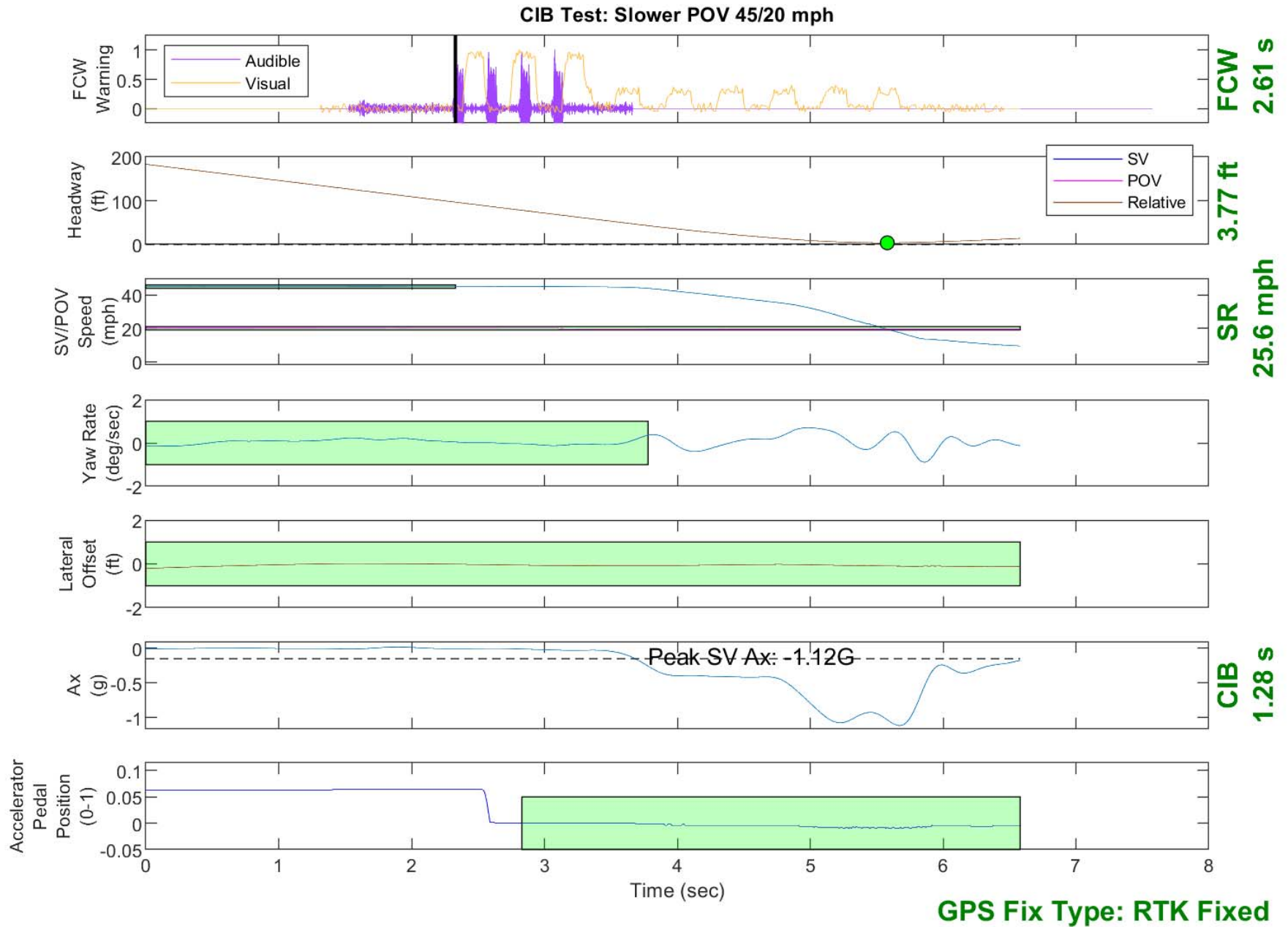


Figure D3. Example Time History for Slower POV 45 vs. 20, Passing

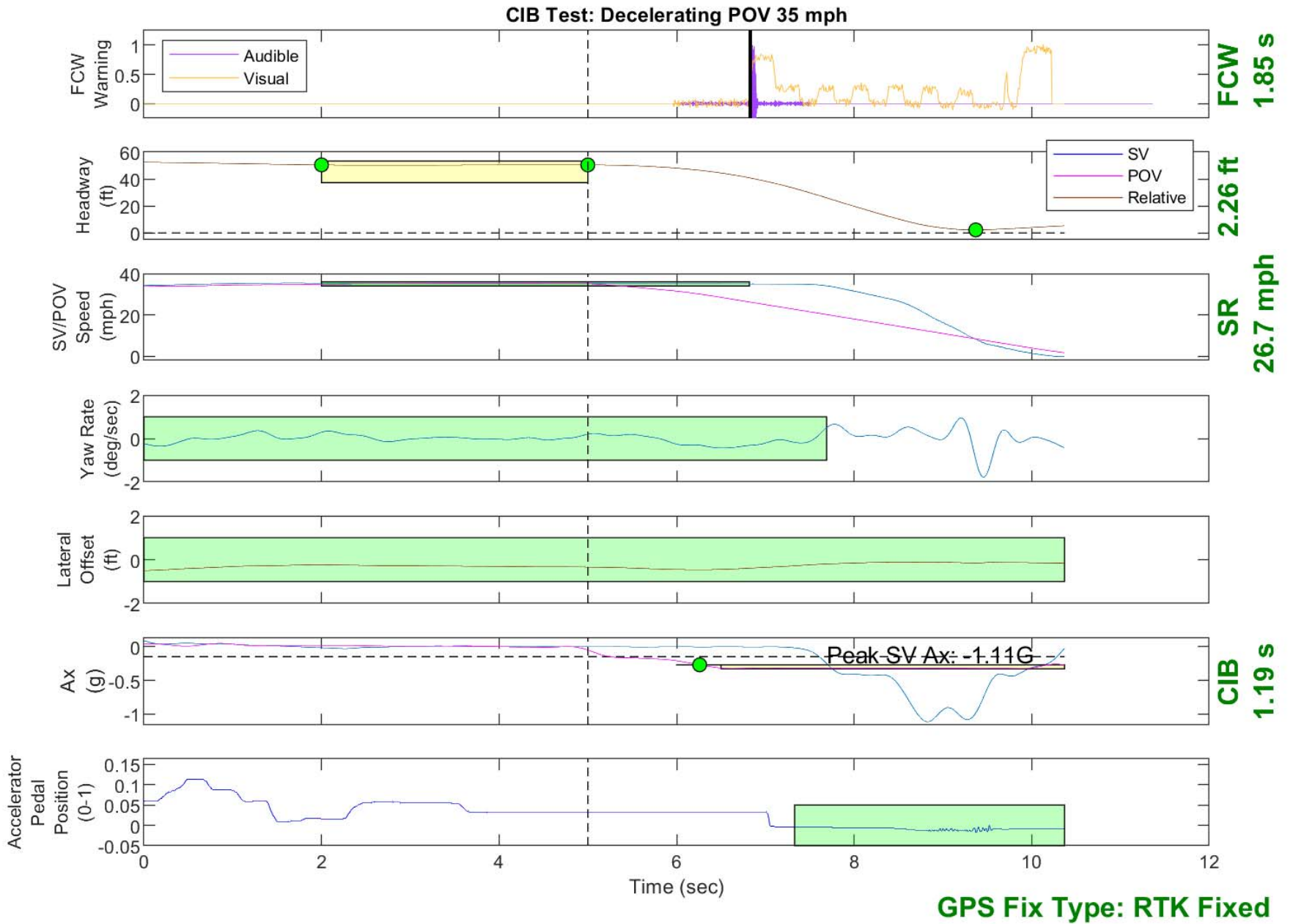


Figure D4. Example Time History for Decelerating POV 35, Passing

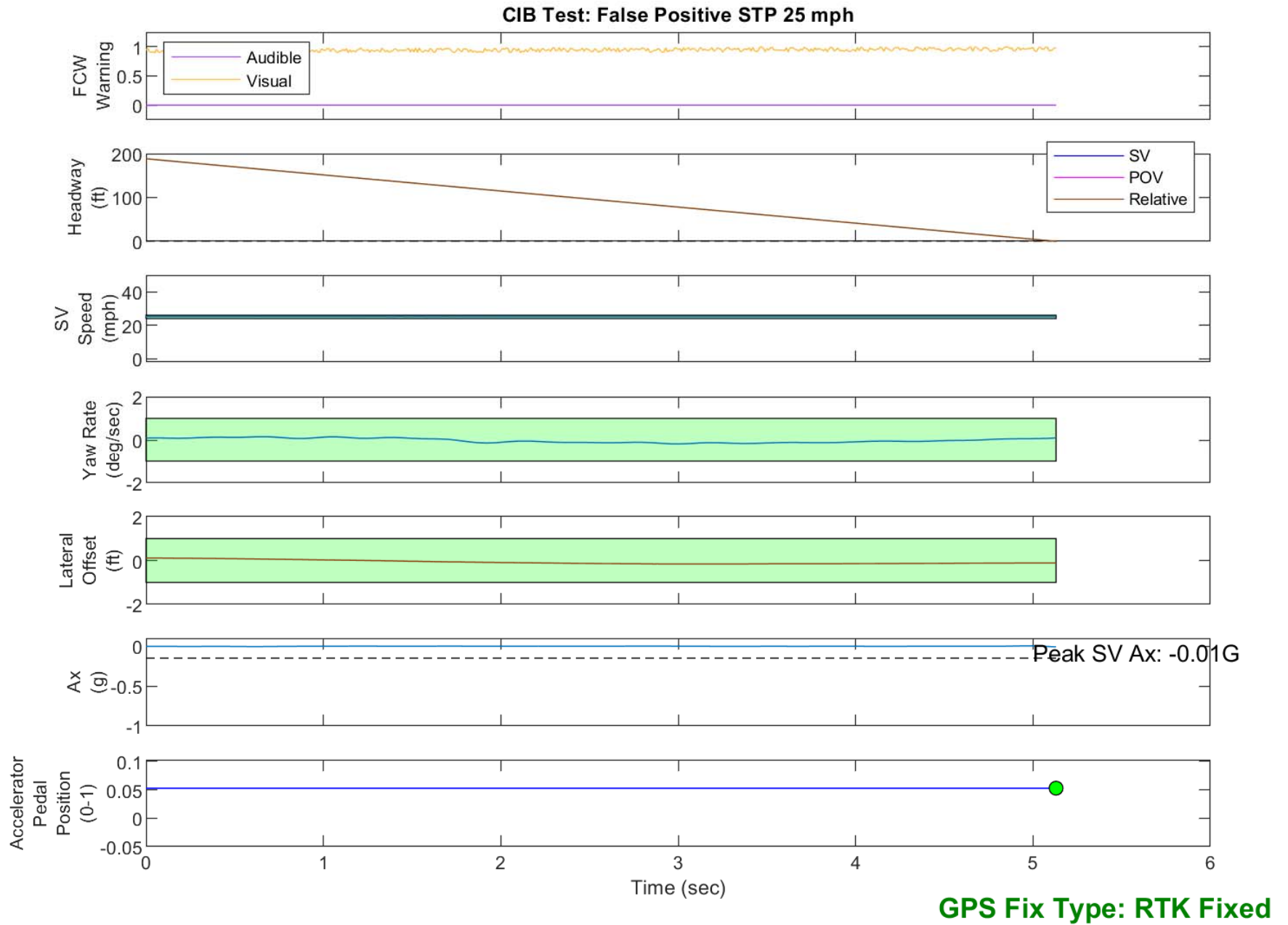


Figure D5. Example Time History for False Positive STP 25, Passing

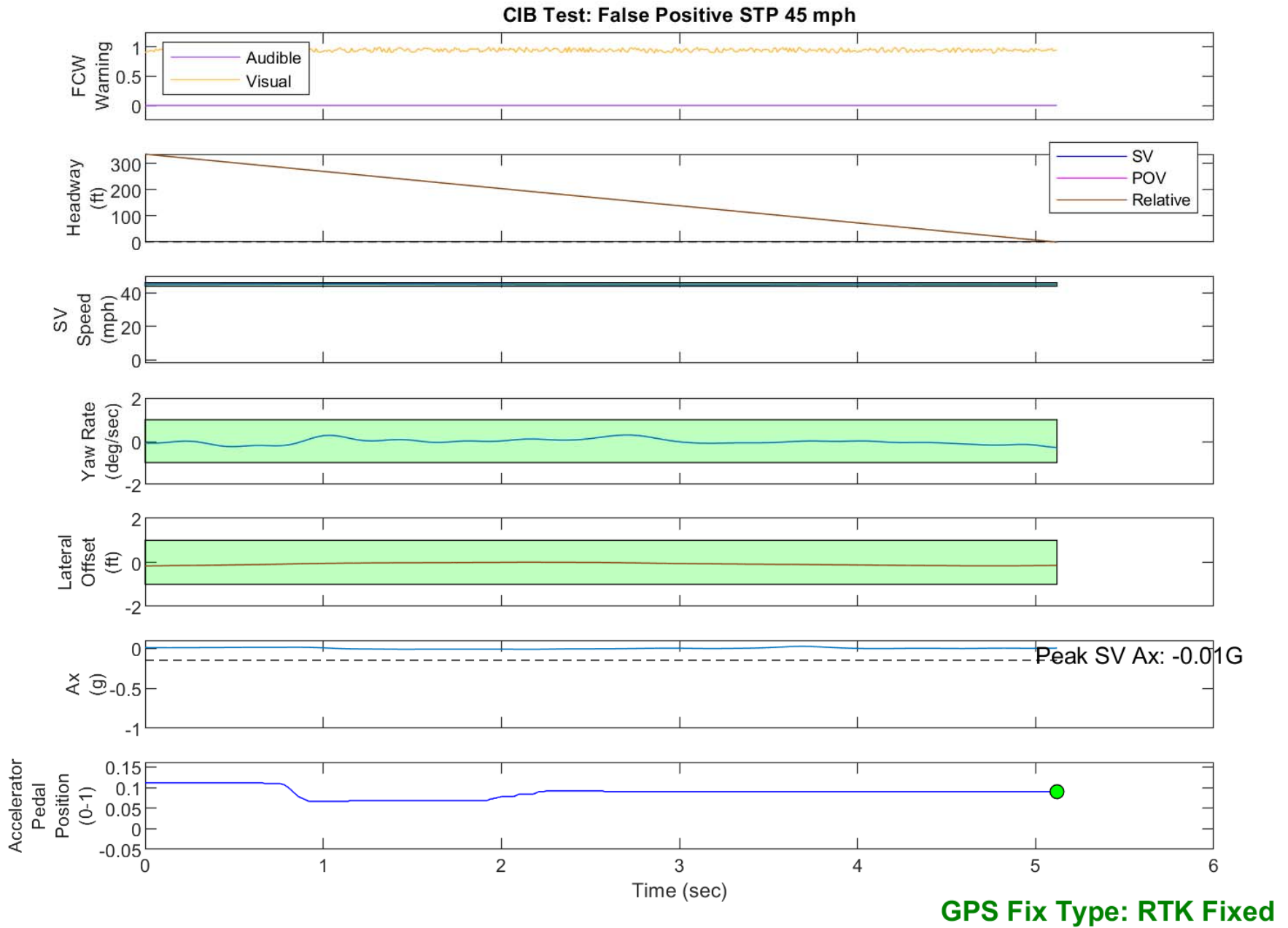


Figure D6. Example Time History for False Positive STP 45, Passing

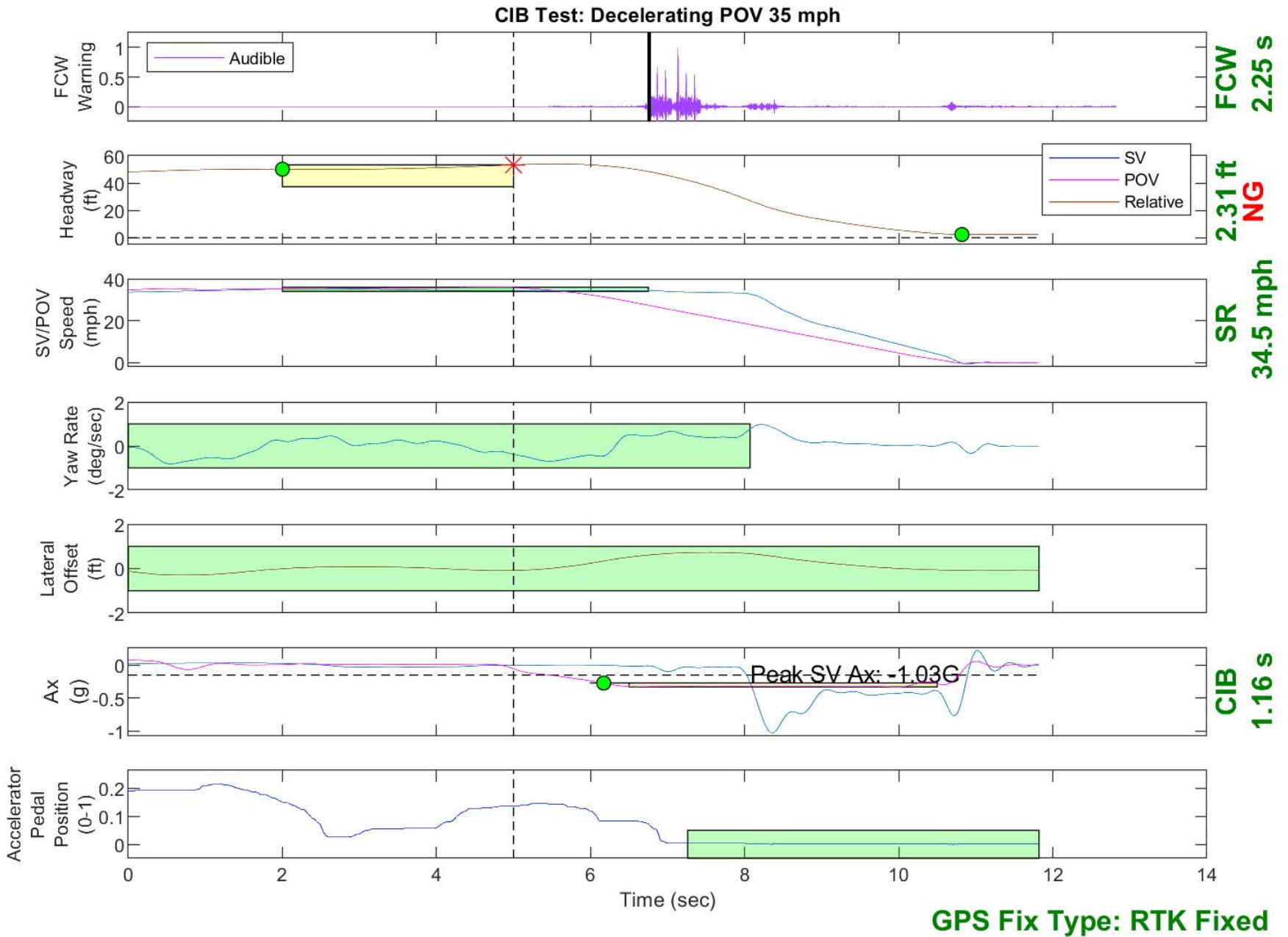


Figure D7. Example Time History Displaying Various Invalid Criteria

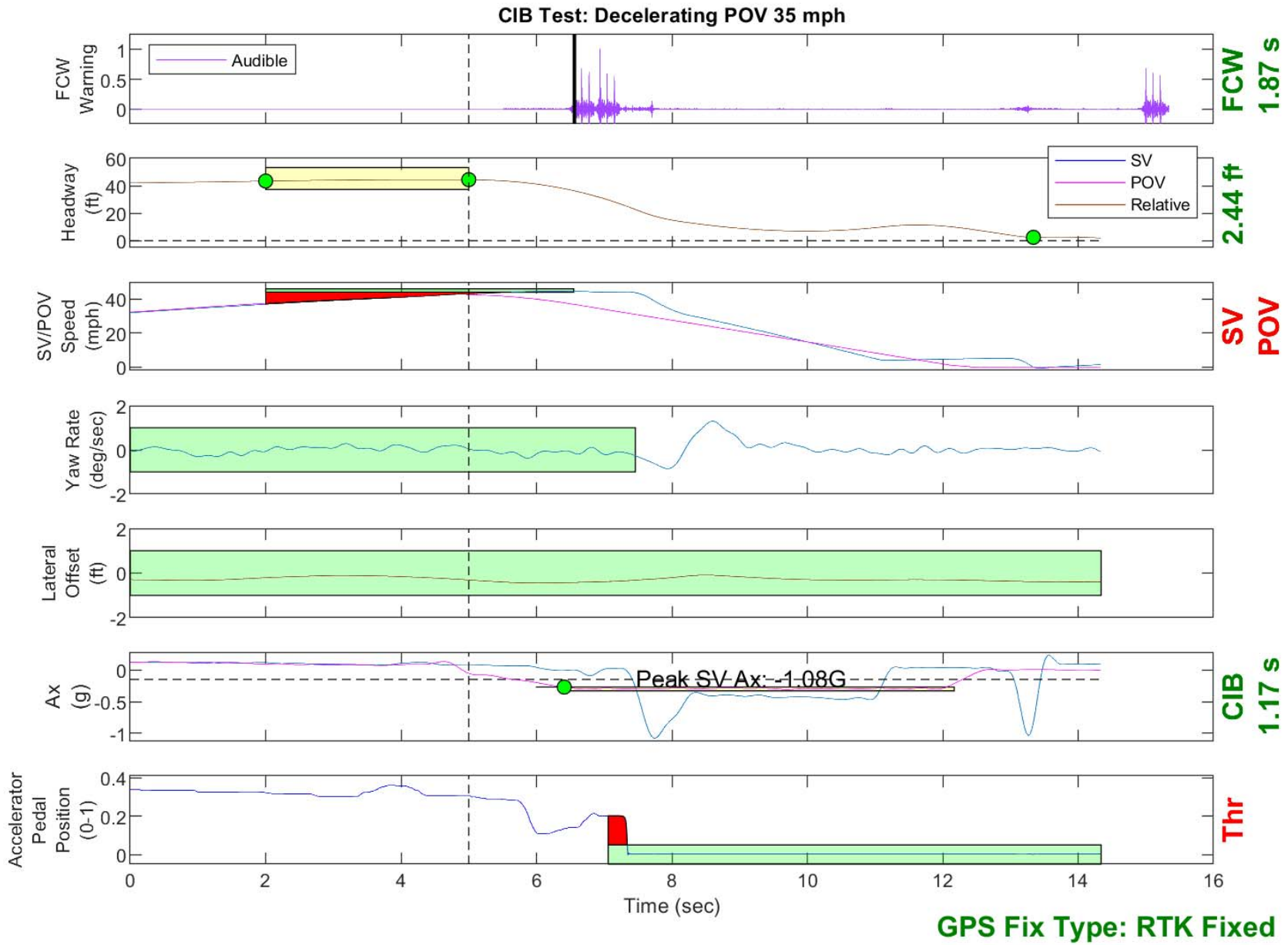


Figure D8. Example Time History Displaying Various Invalid Criteria

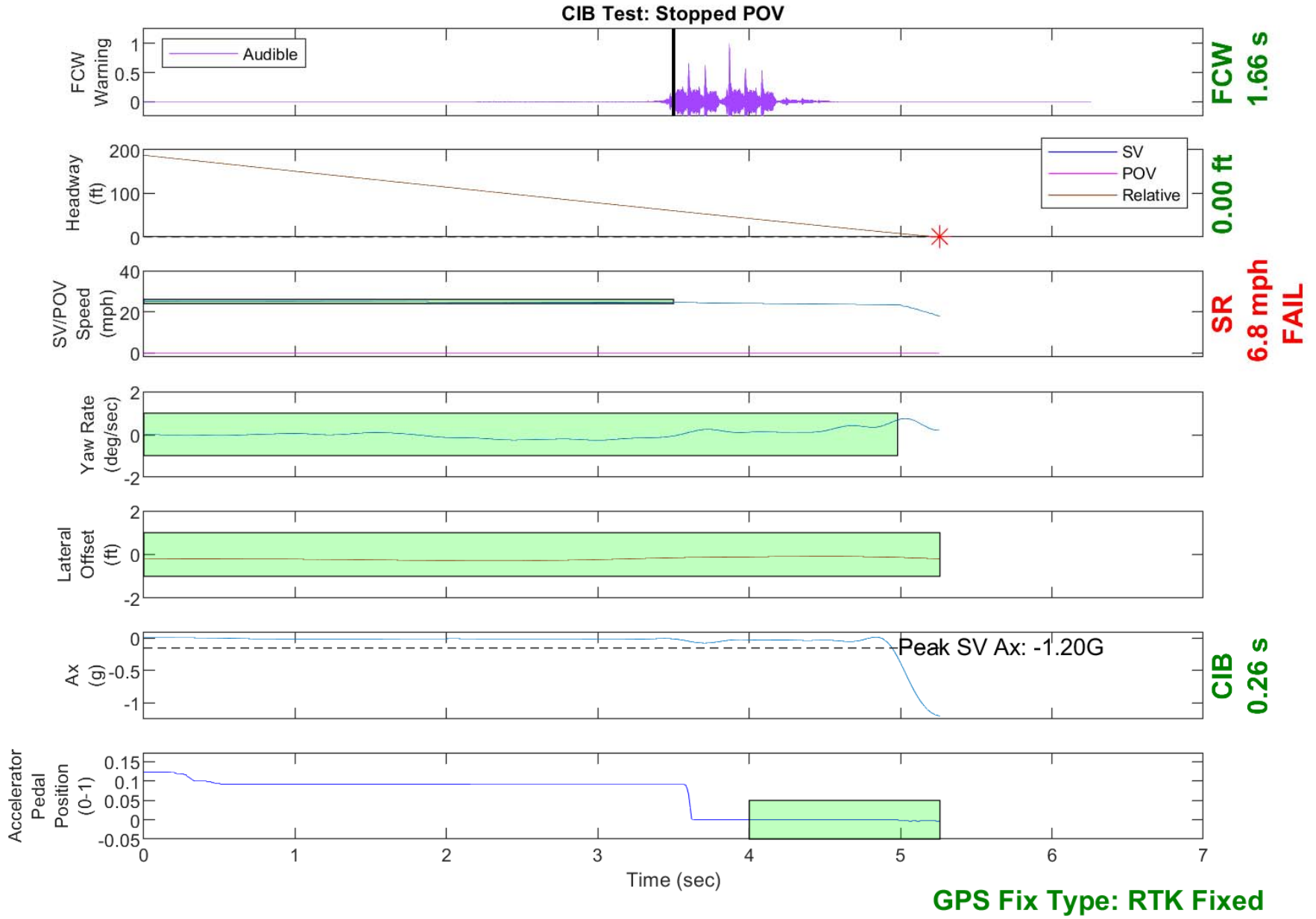


Figure D9. Example Time History for a Failed Run

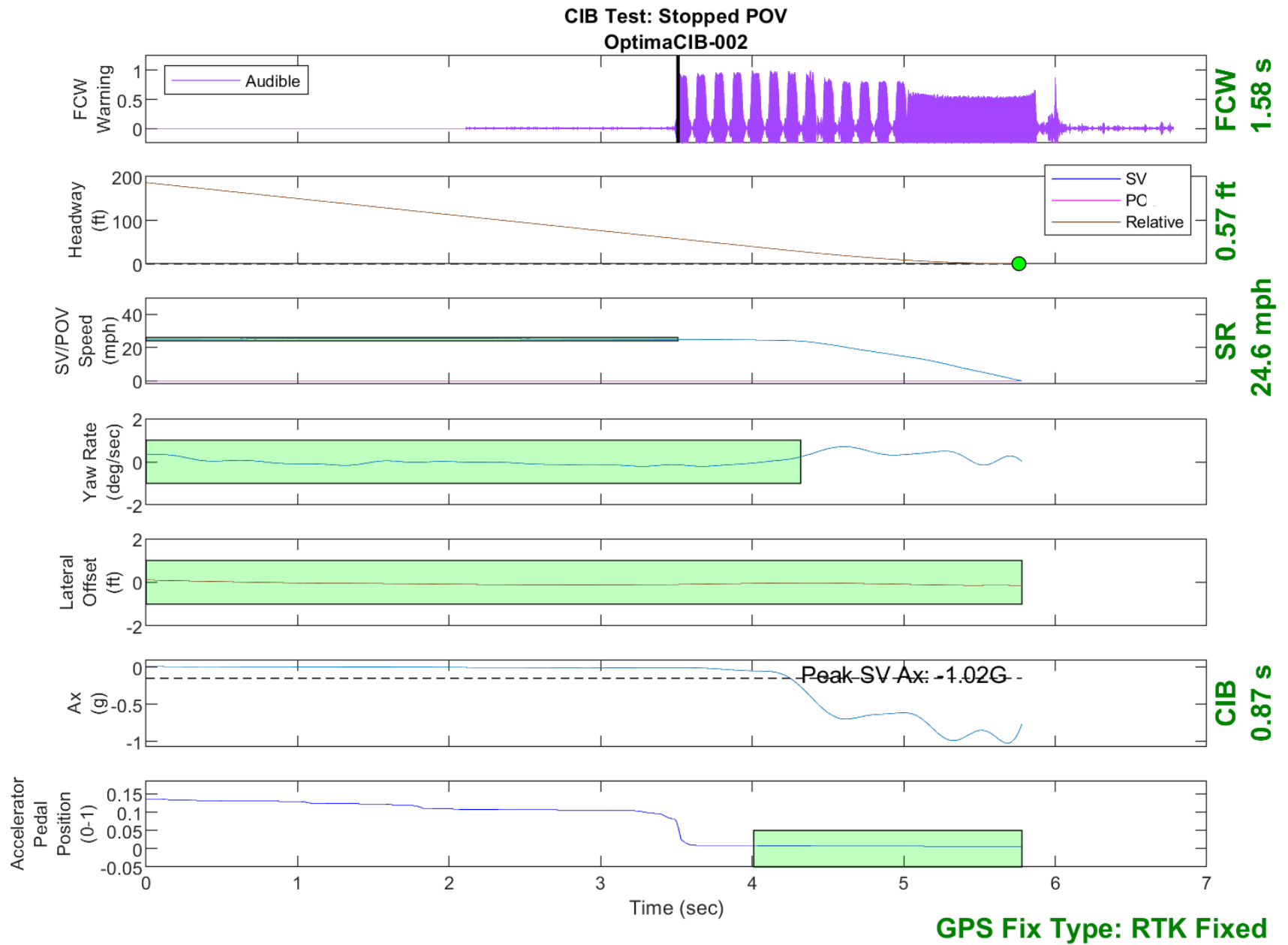


Figure D10. Time History for CIB Run 2, SV Encounters Stopped POV

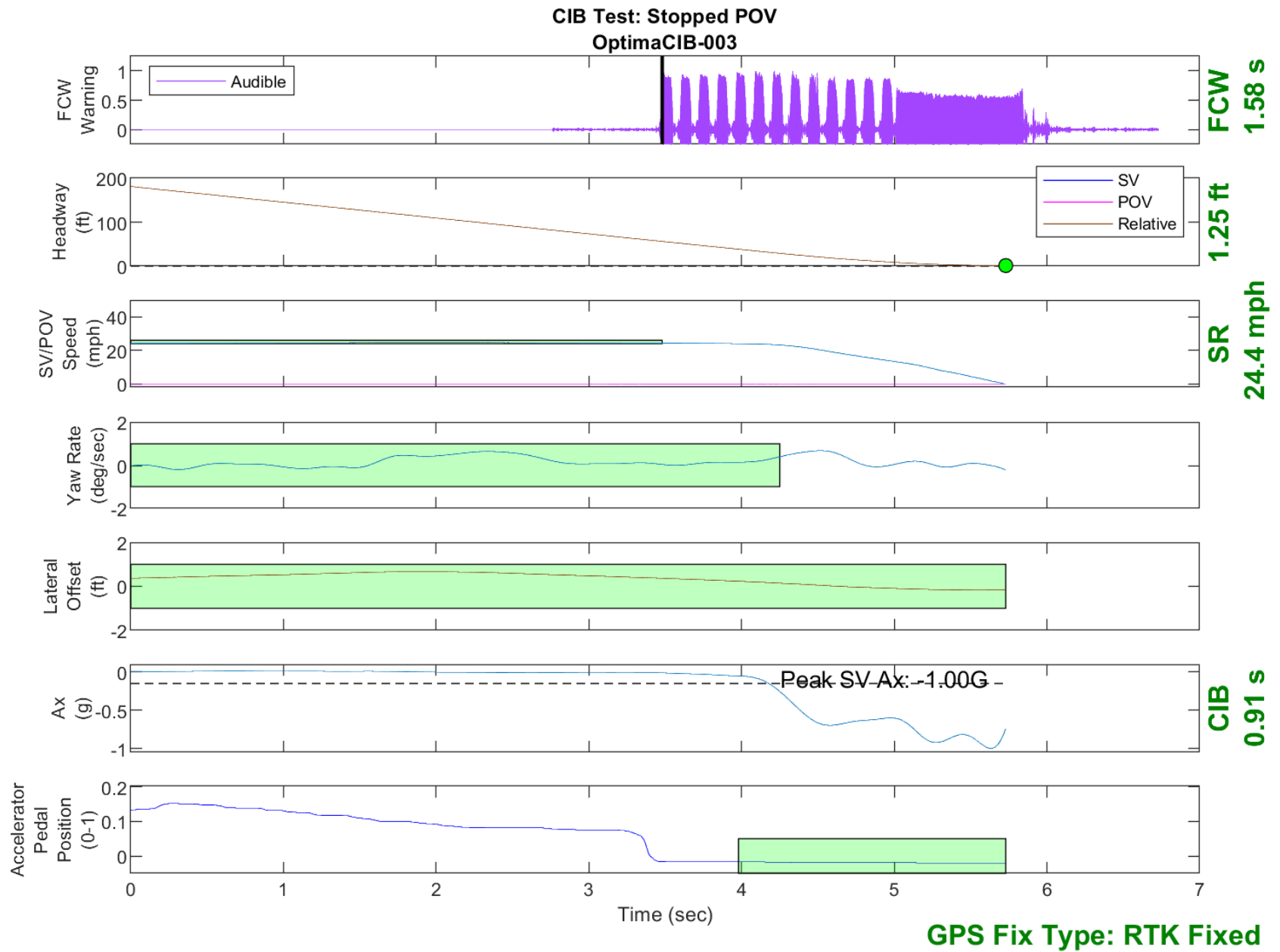


Figure D11. Time History for CIB Run 3, SV Encounters Stopped POV

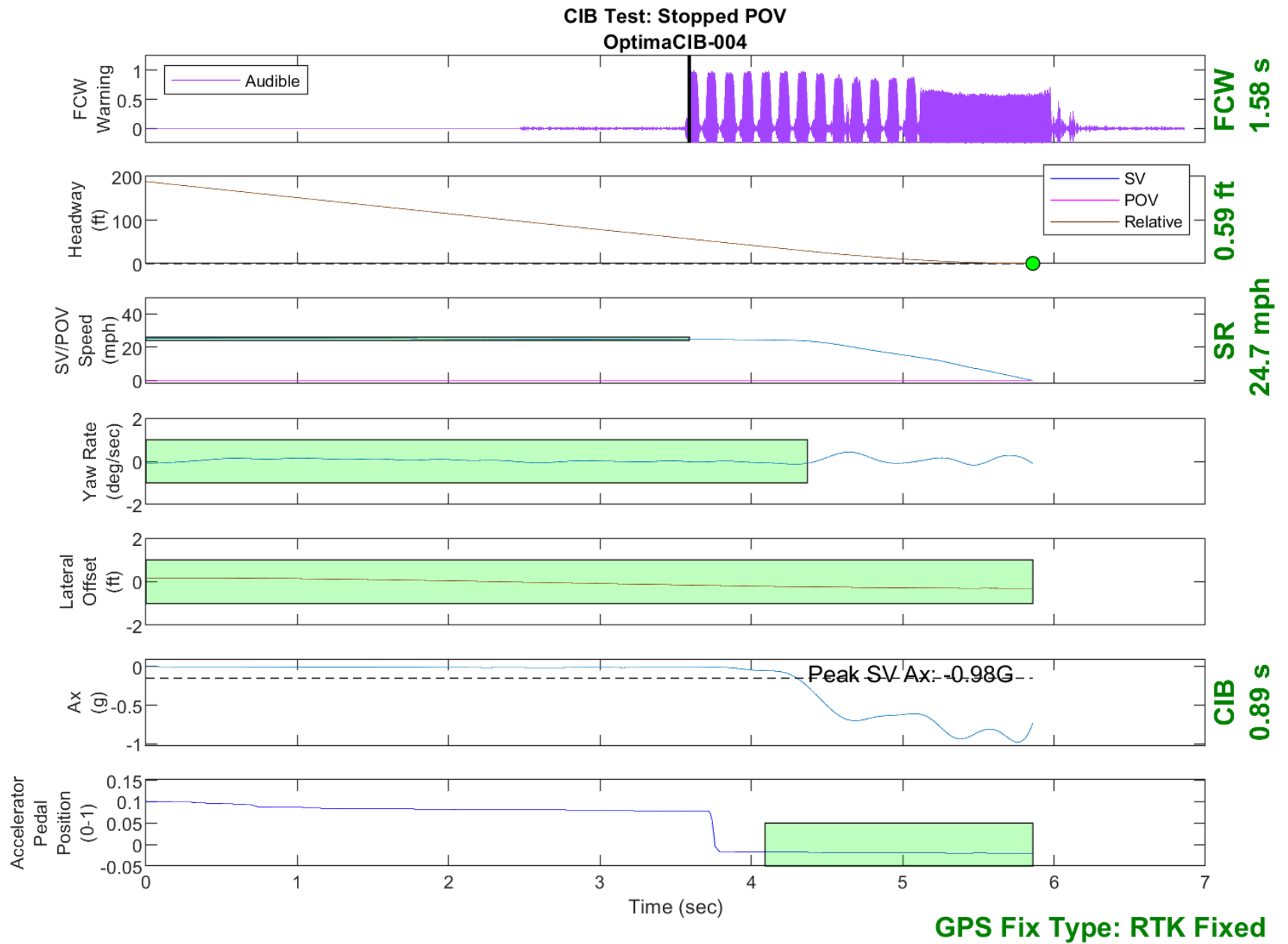


Figure D12. Time History for CIB Run 4, SV Encounters Stopped POV

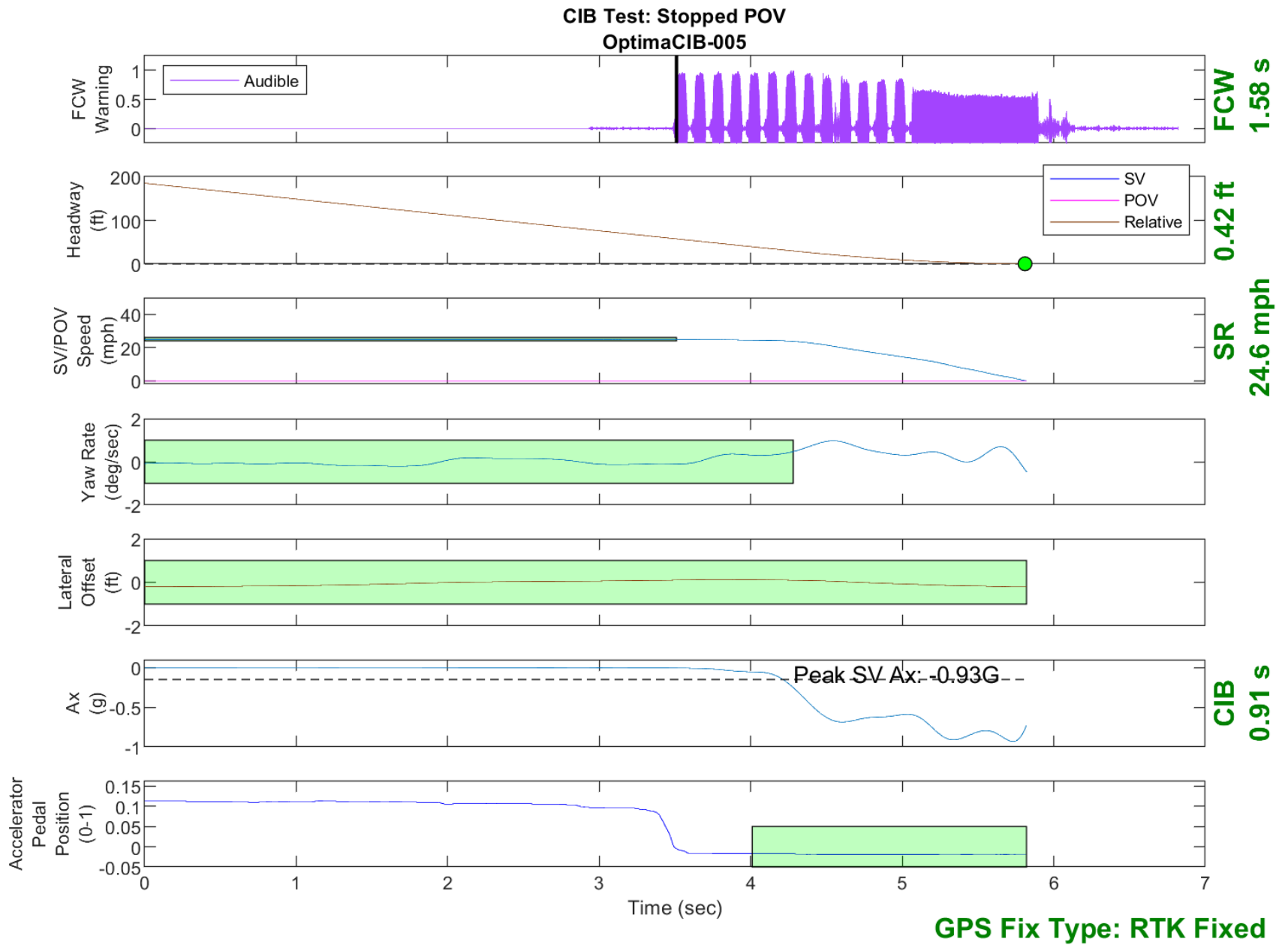


Figure D13. Time History for CIB Run 5, SV Encounters Stopped POV

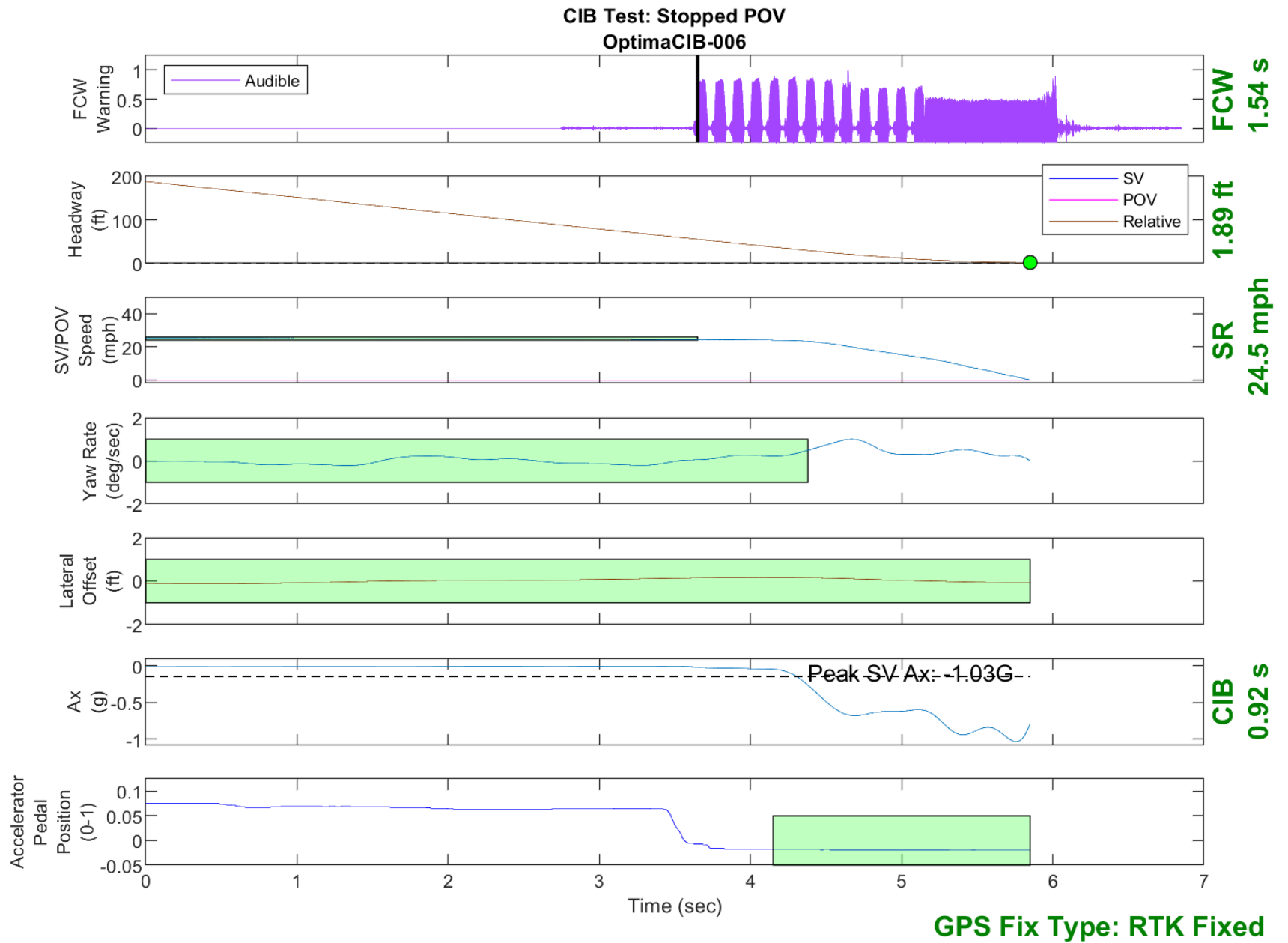


Figure D14. Time History for CIB Run 6, SV Encounters Stopped POV

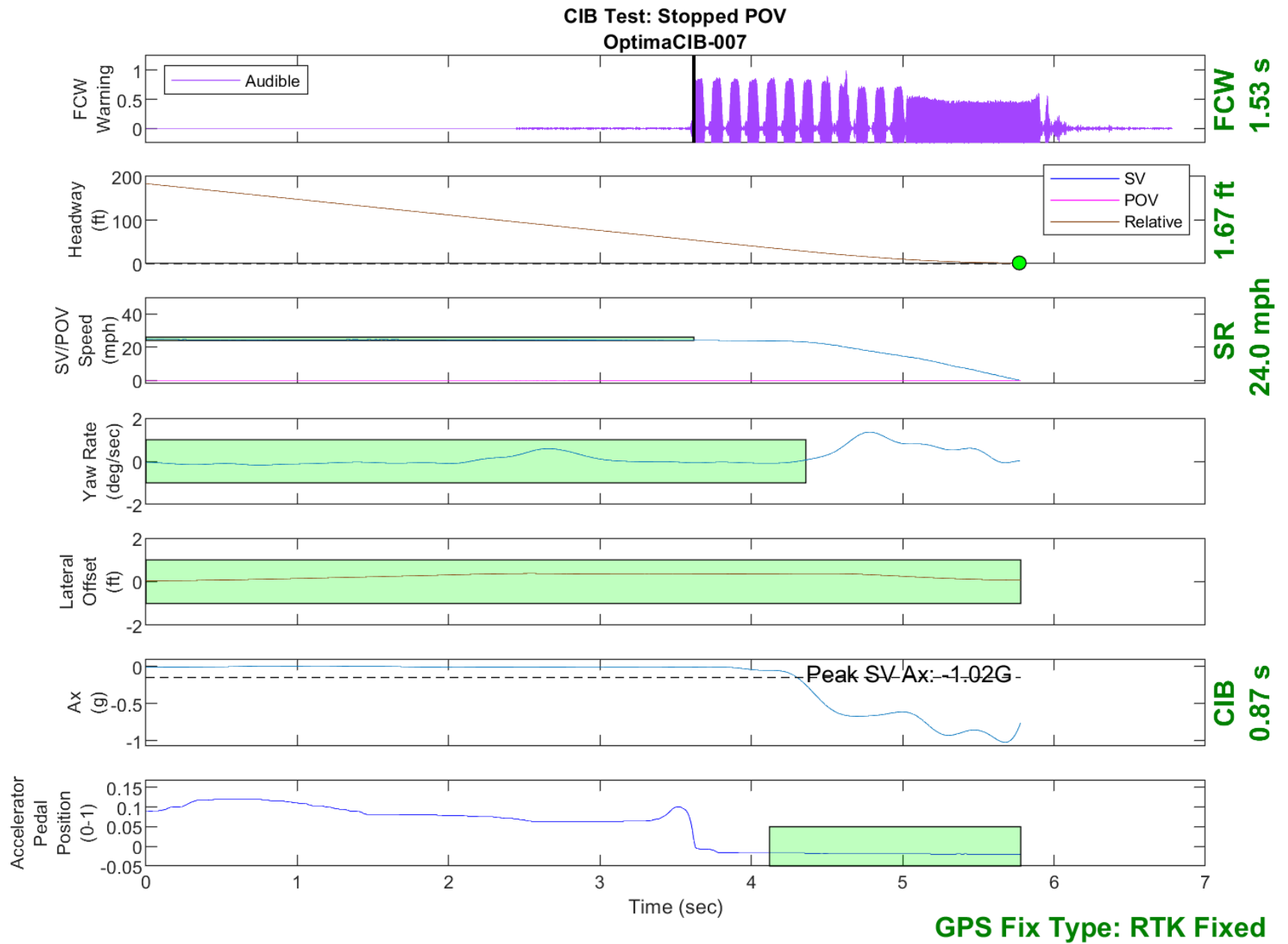


Figure D15. Time History for CIB Run 7, SV Encounters Stopped POV

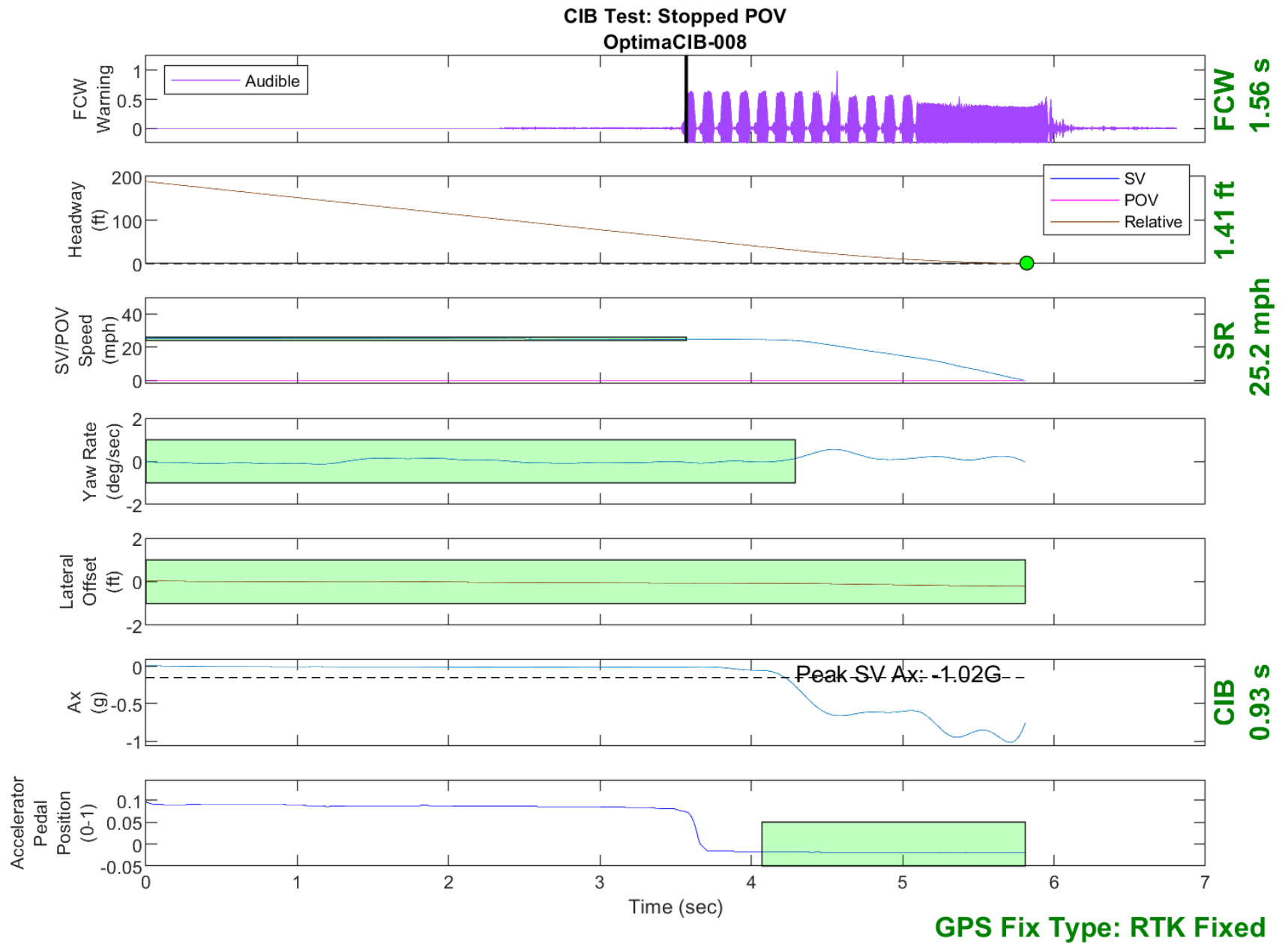


Figure D16. Time History for CIB Run 8, SV Encounters Stopped POV

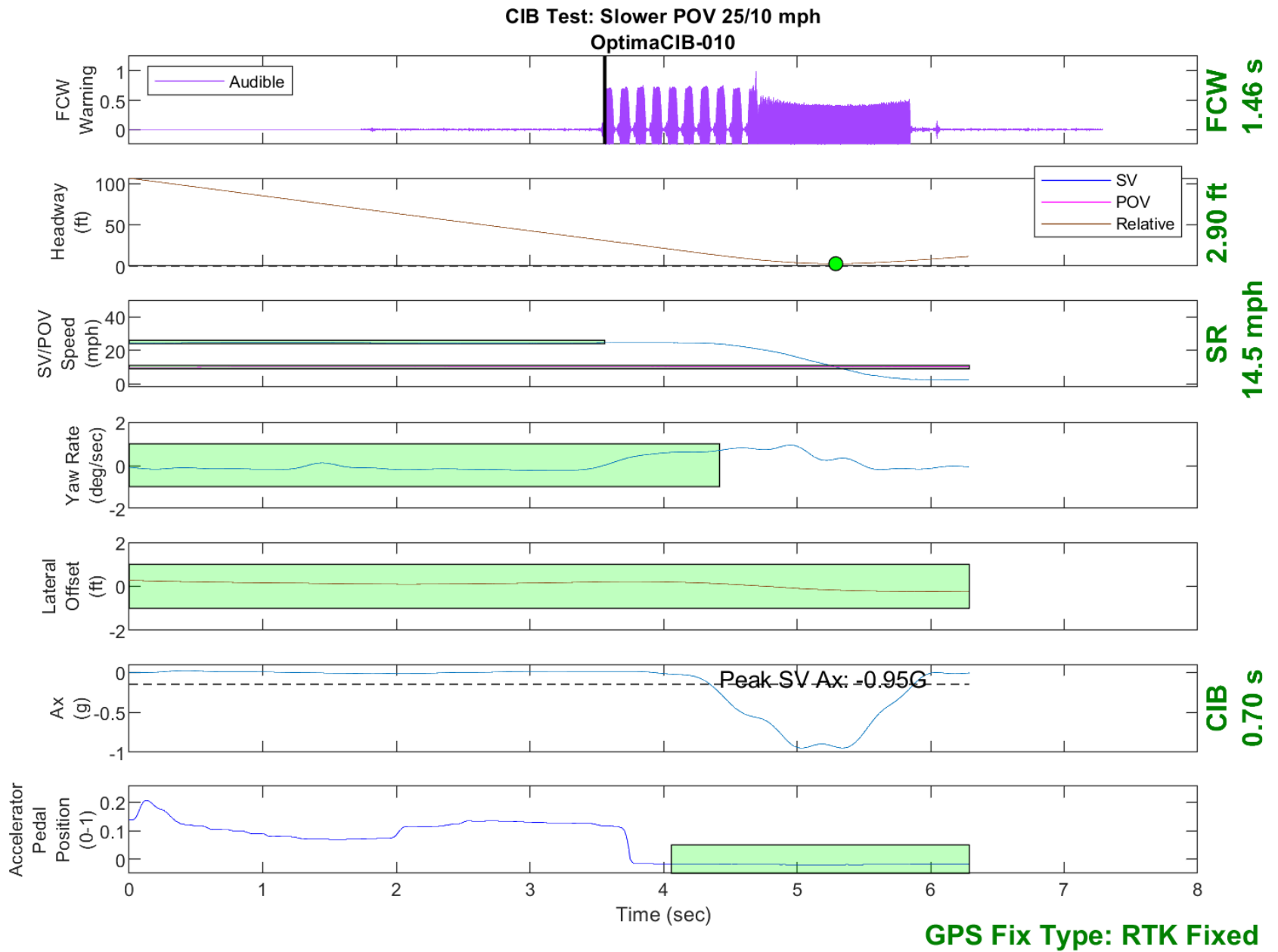


Figure D17. Time History for CIB Run 10, SV Encounters Slower POV, SV 25 mph, POV 10 mph

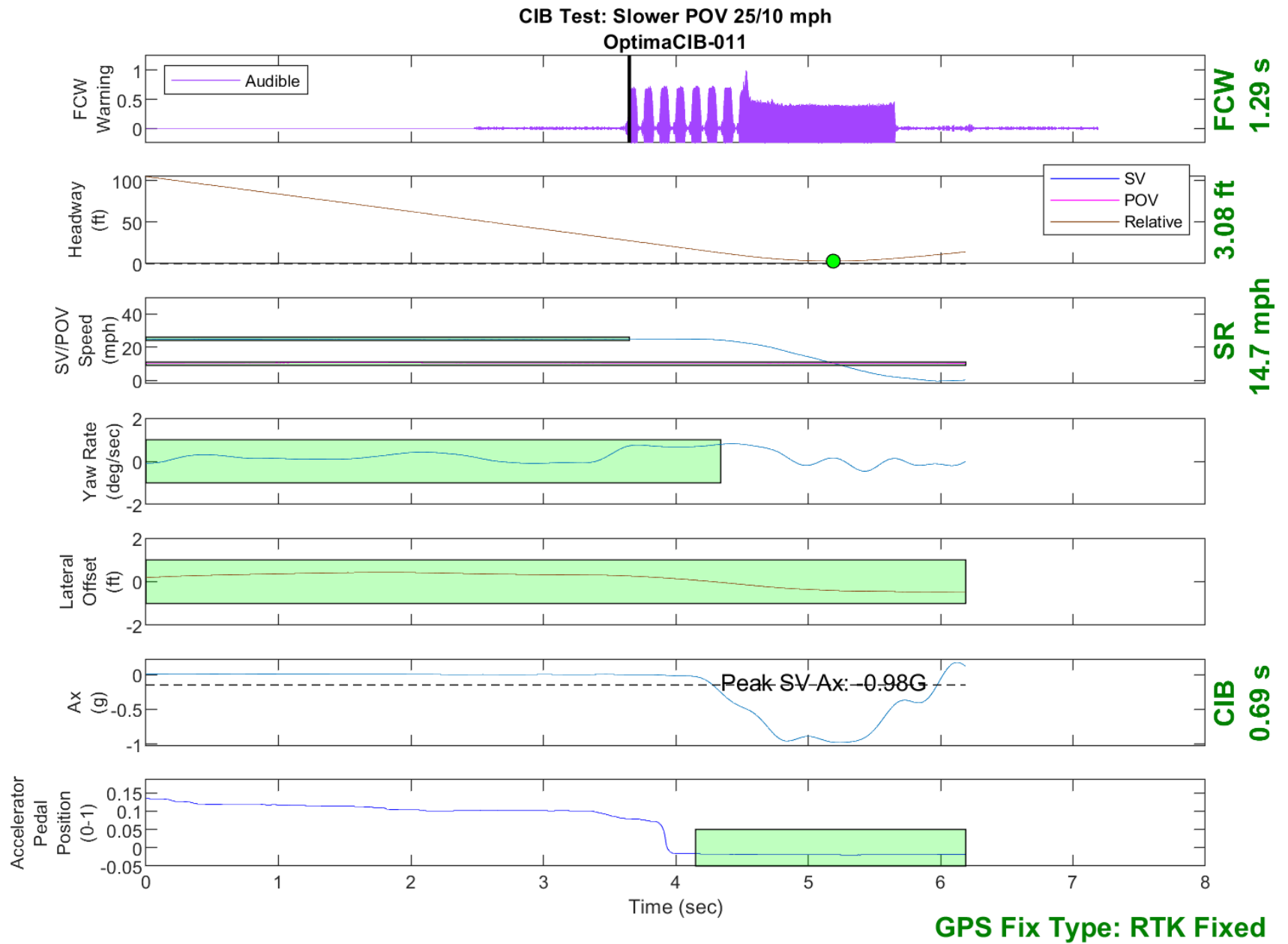


Figure D18. Time History for CIB Run 11, SV Encounters Slower POV, SV 25 mph, POV 10 mph

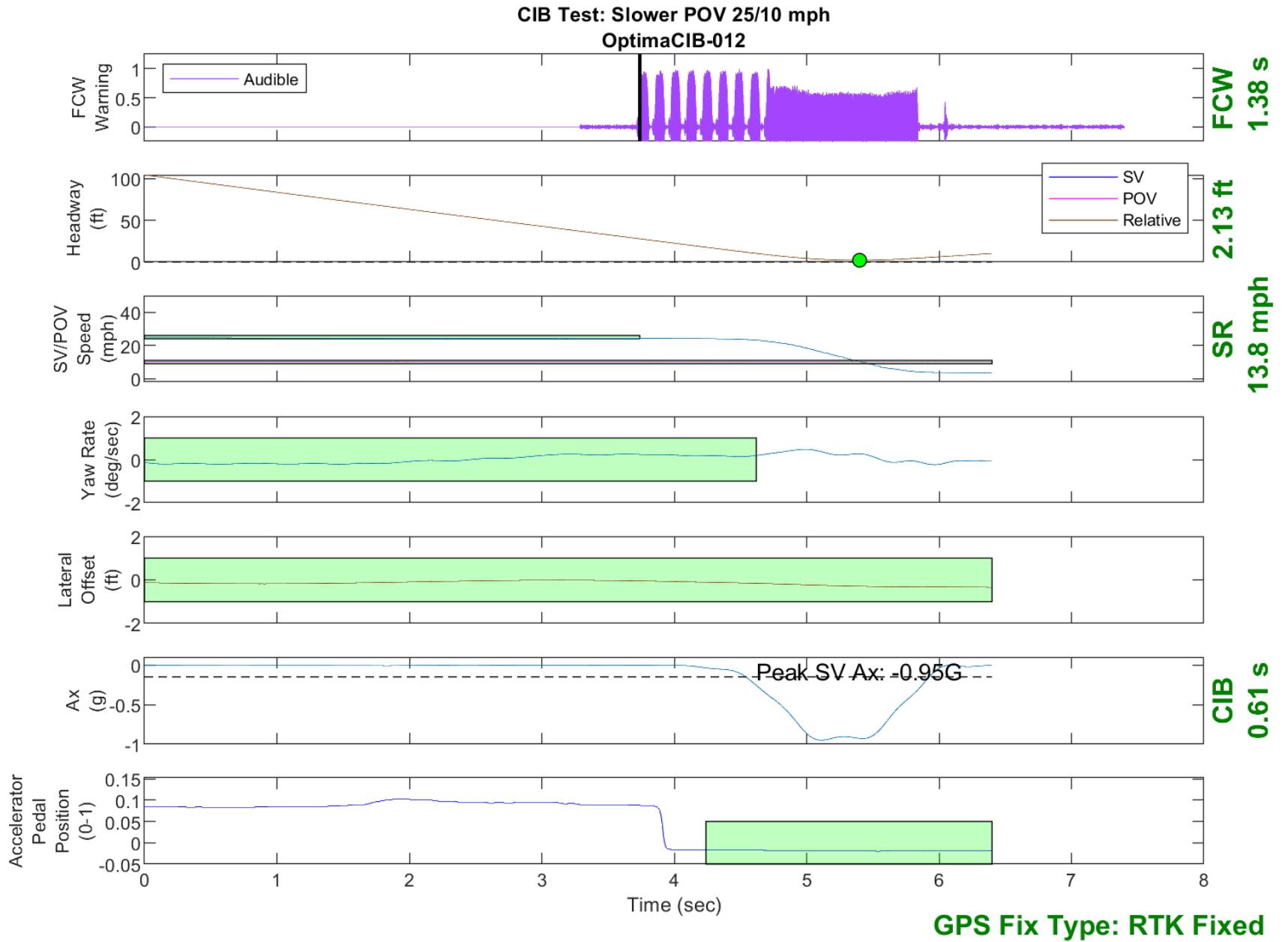


Figure D19. Time History for CIB Run 12, SV Encounters Slower POV, SV 25 mph, POV 10 mph

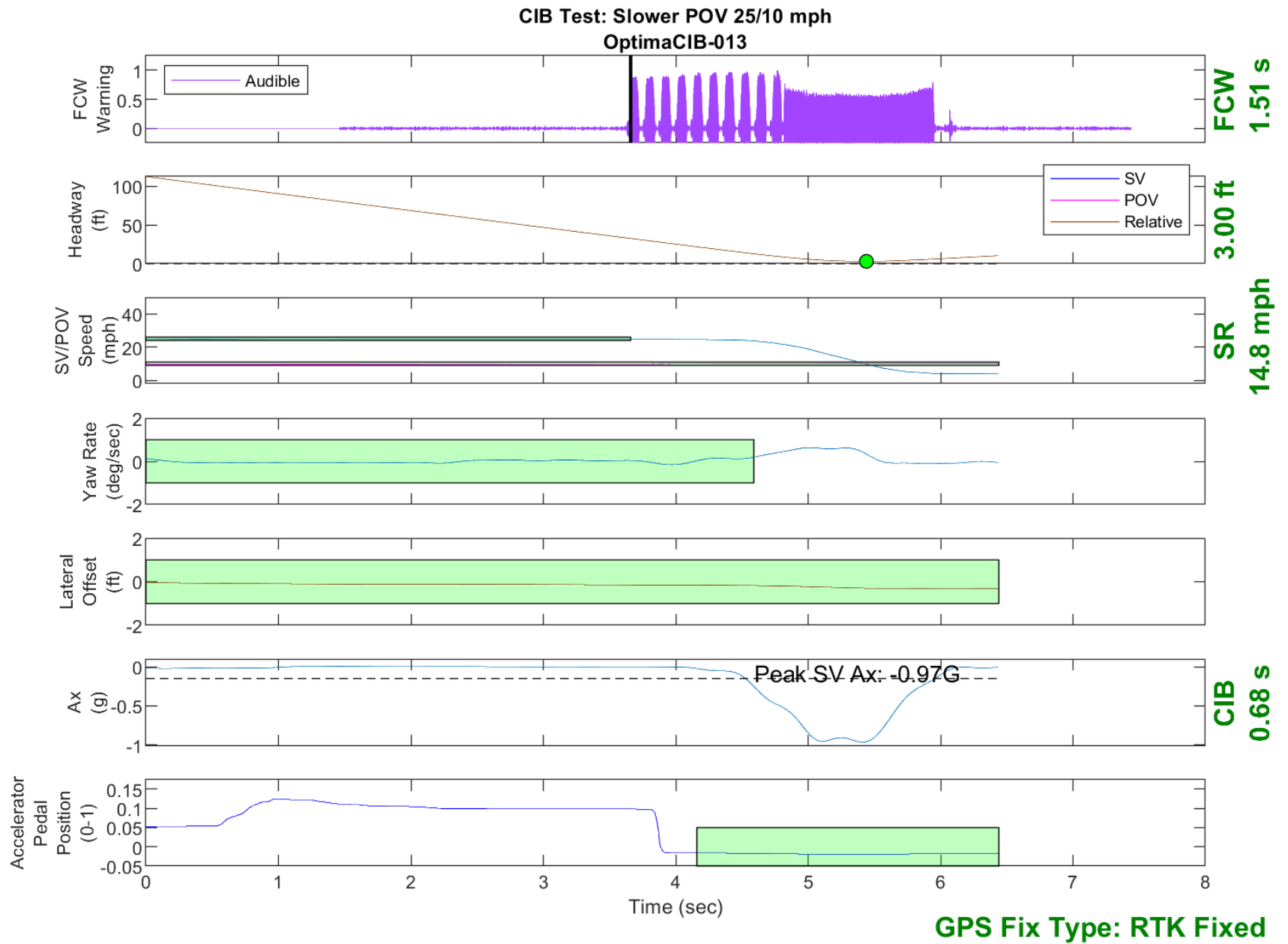


Figure D20. Time History for CIB Run 13, SV Encounters Slower POV, SV 25 mph, POV 10 mph

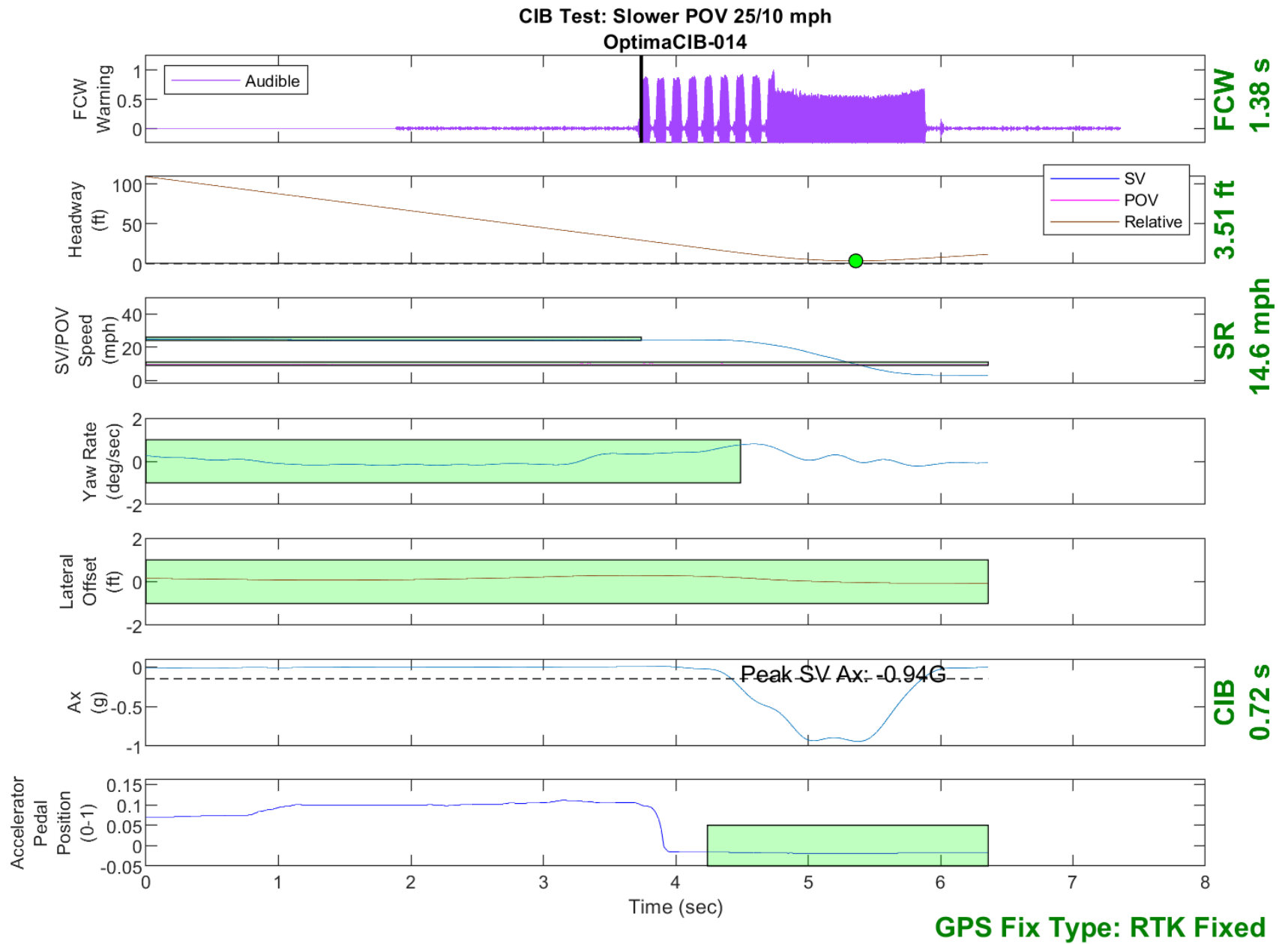


Figure D21. Time History for CIB Run 14, SV Encounters Slower POV, SV 25 mph, POV 10 mph

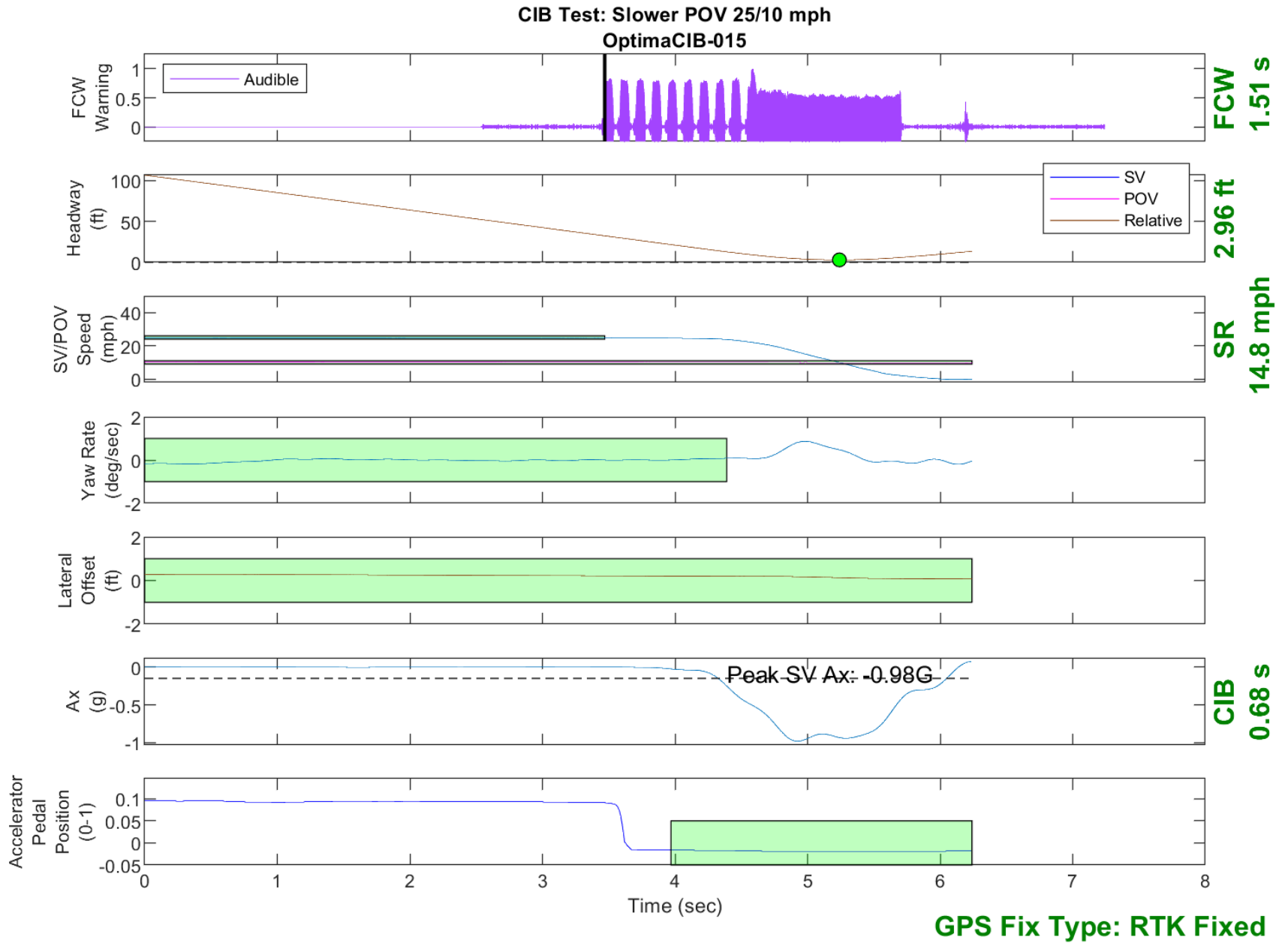


Figure D22. Time History for CIB Run 15, SV Encounters Slower POV, SV 25 mph, POV 10 mph

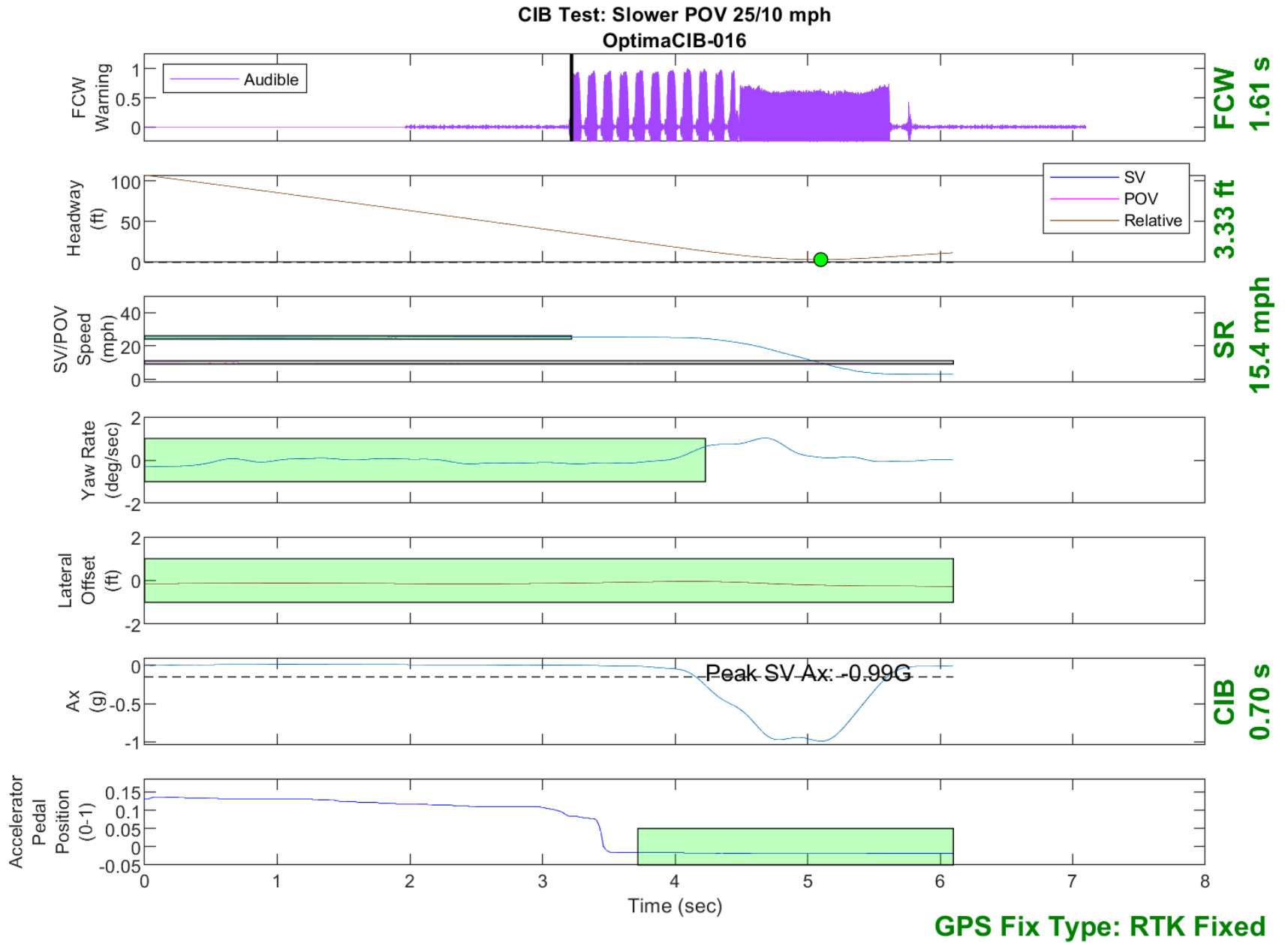


Figure D23. Time History for CIB Run 16, SV Encounters Slower POV, SV 25 mph, POV 10 mph

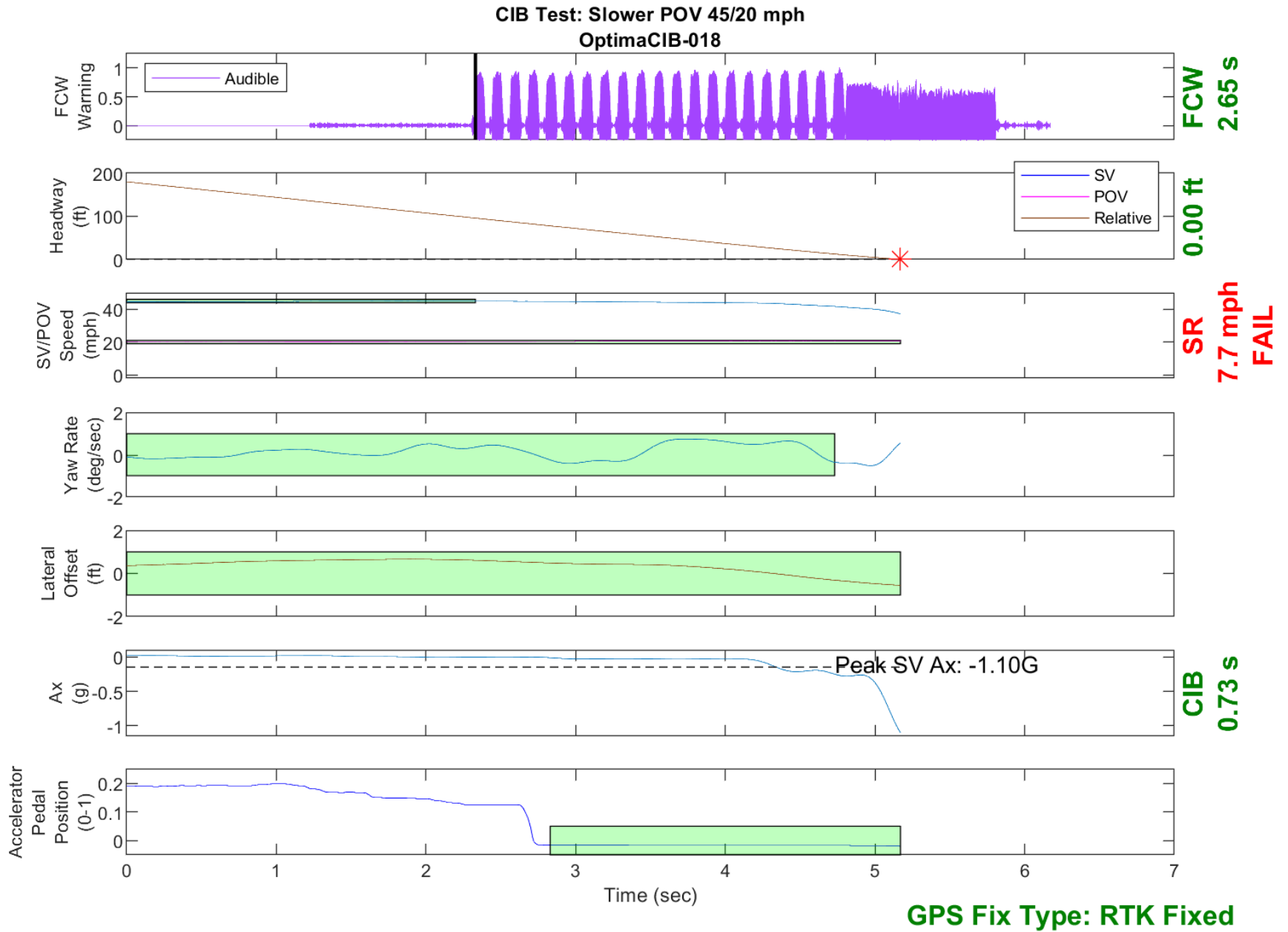


Figure D24. Time History for CIB Run 18, SV Encounters Slower POV, SV 45 mph, POV 20 mph

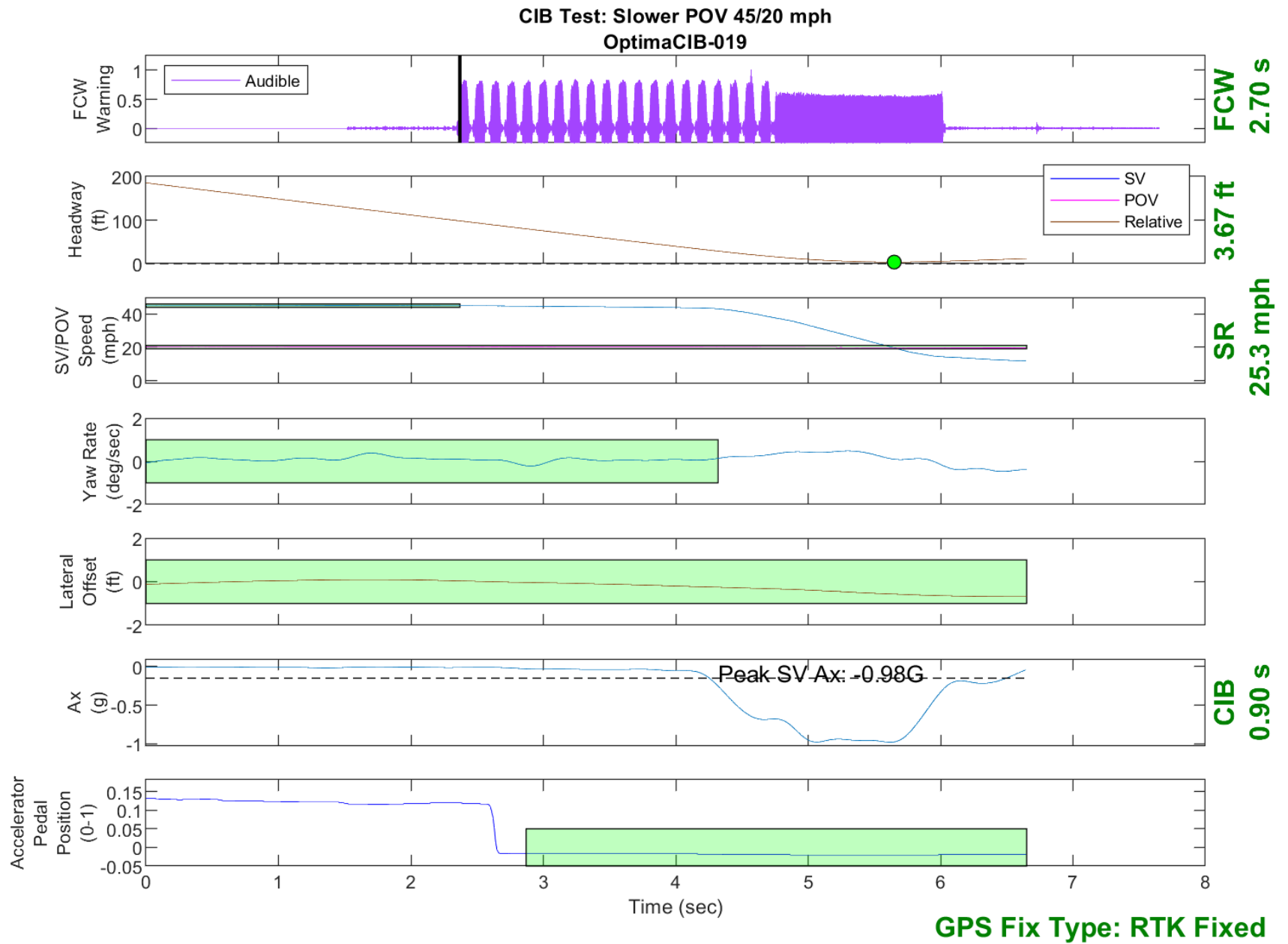


Figure D25. Time History for CIB Run 19, SV Encounters Slower POV, SV 45 mph, POV 20 mph

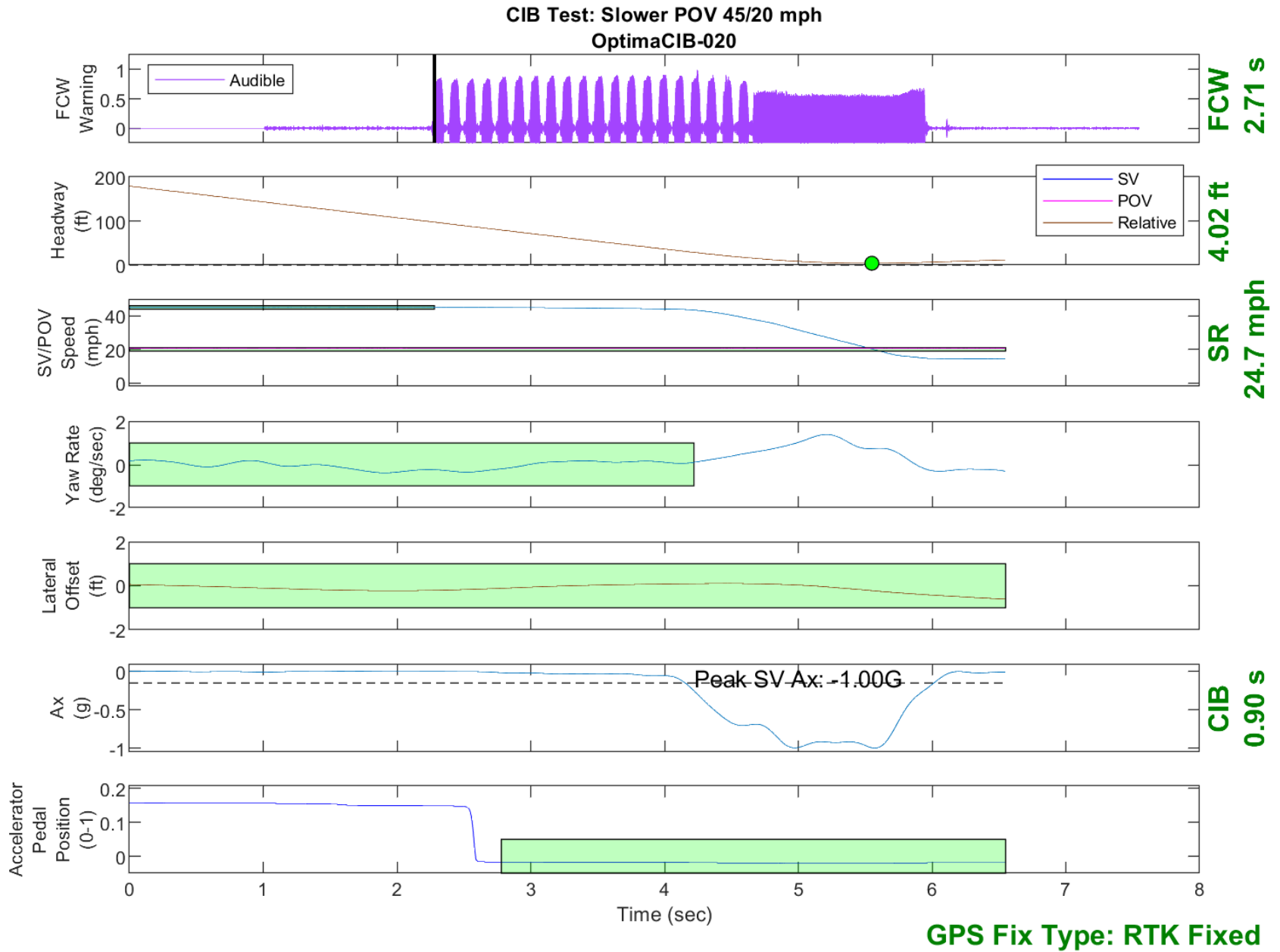


Figure D26. Time History for CIB Run 20, SV Encounters Slower POV, SV 45 mph, POV 20 mph

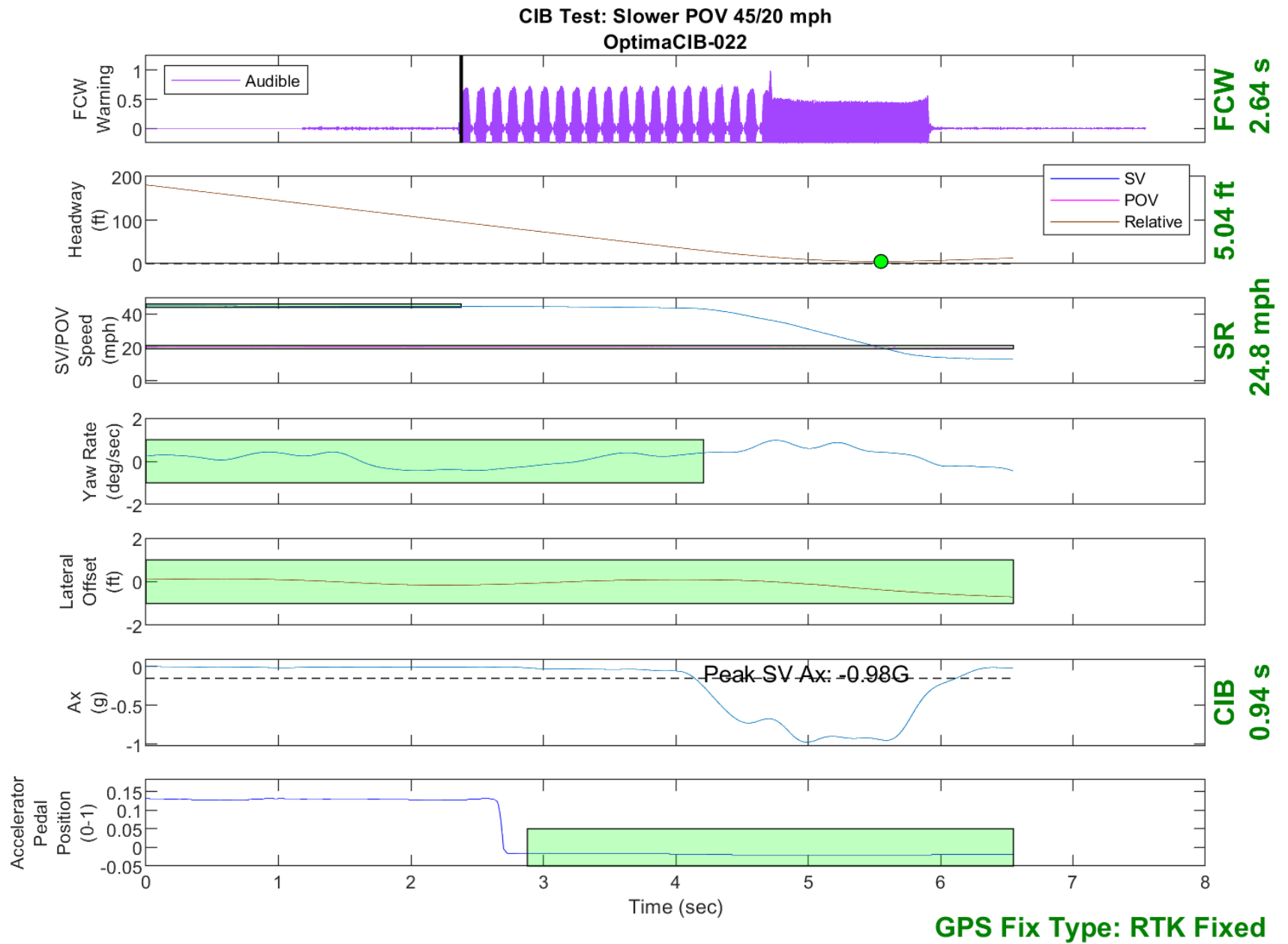


Figure D27. Time History for CIB Run 22, SV Encounters Slower POV, SV 45 mph, POV 20 mph

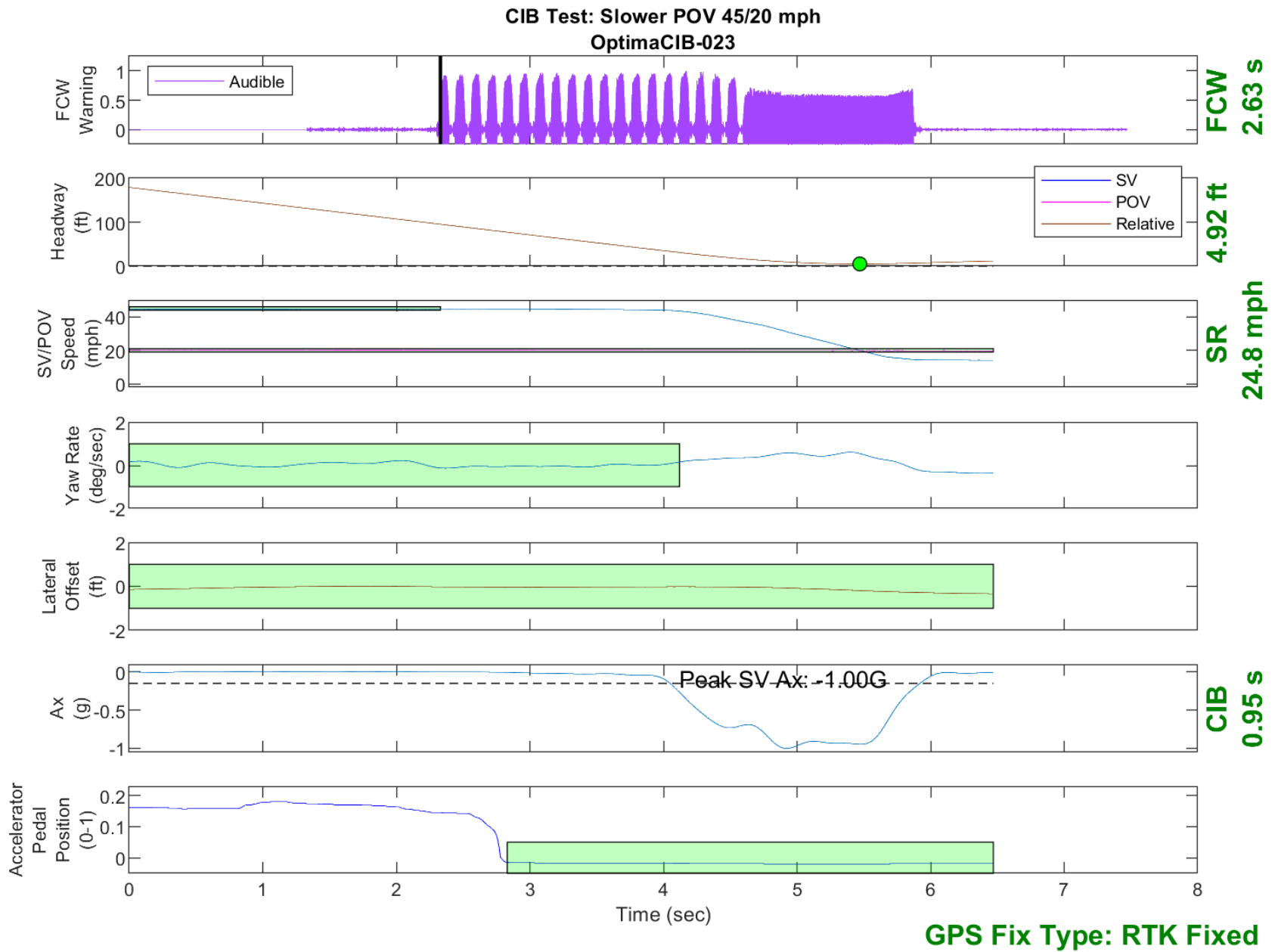


Figure D28. Time History for CIB Run 23, SV Encounters Slower POV, SV 45 mph, POV 20 mph

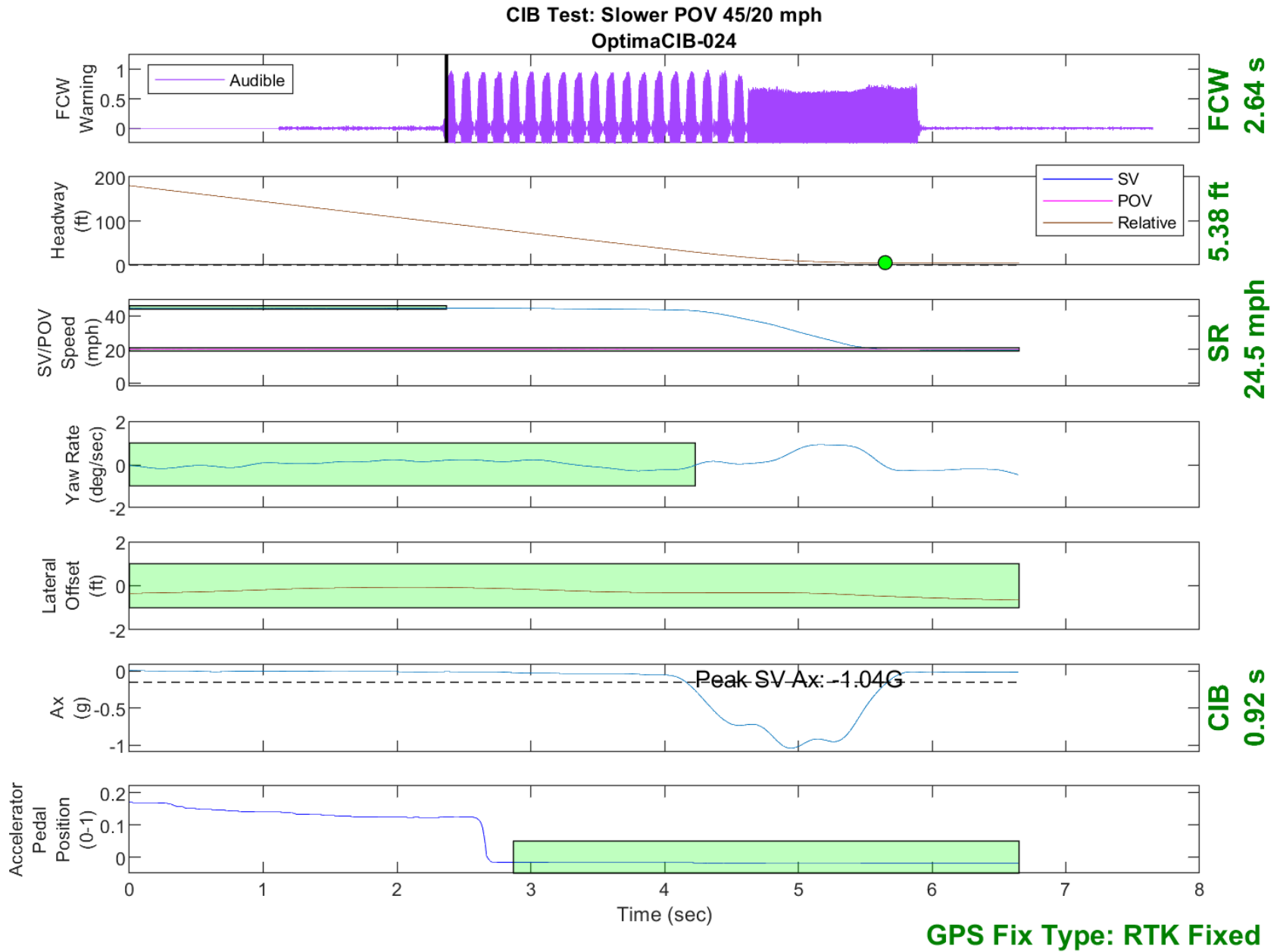


Figure D29. Time History for CIB Run 24, SV Encounters Slower POV, SV 45 mph, POV 20 mph

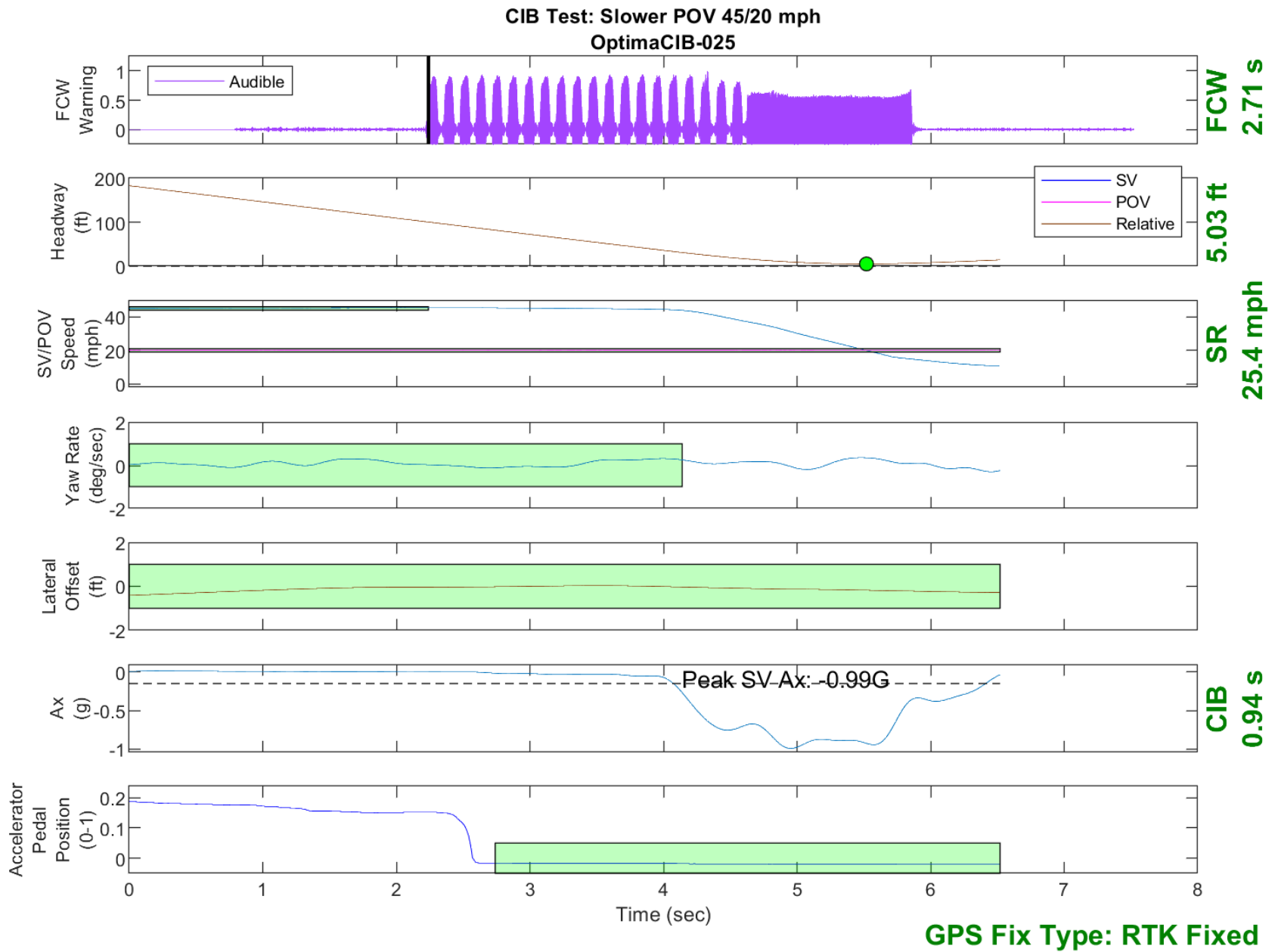


Figure D30. Time History for CIB Run 25, SV Encounters Slower POV, SV 45 mph, POV 20 mph

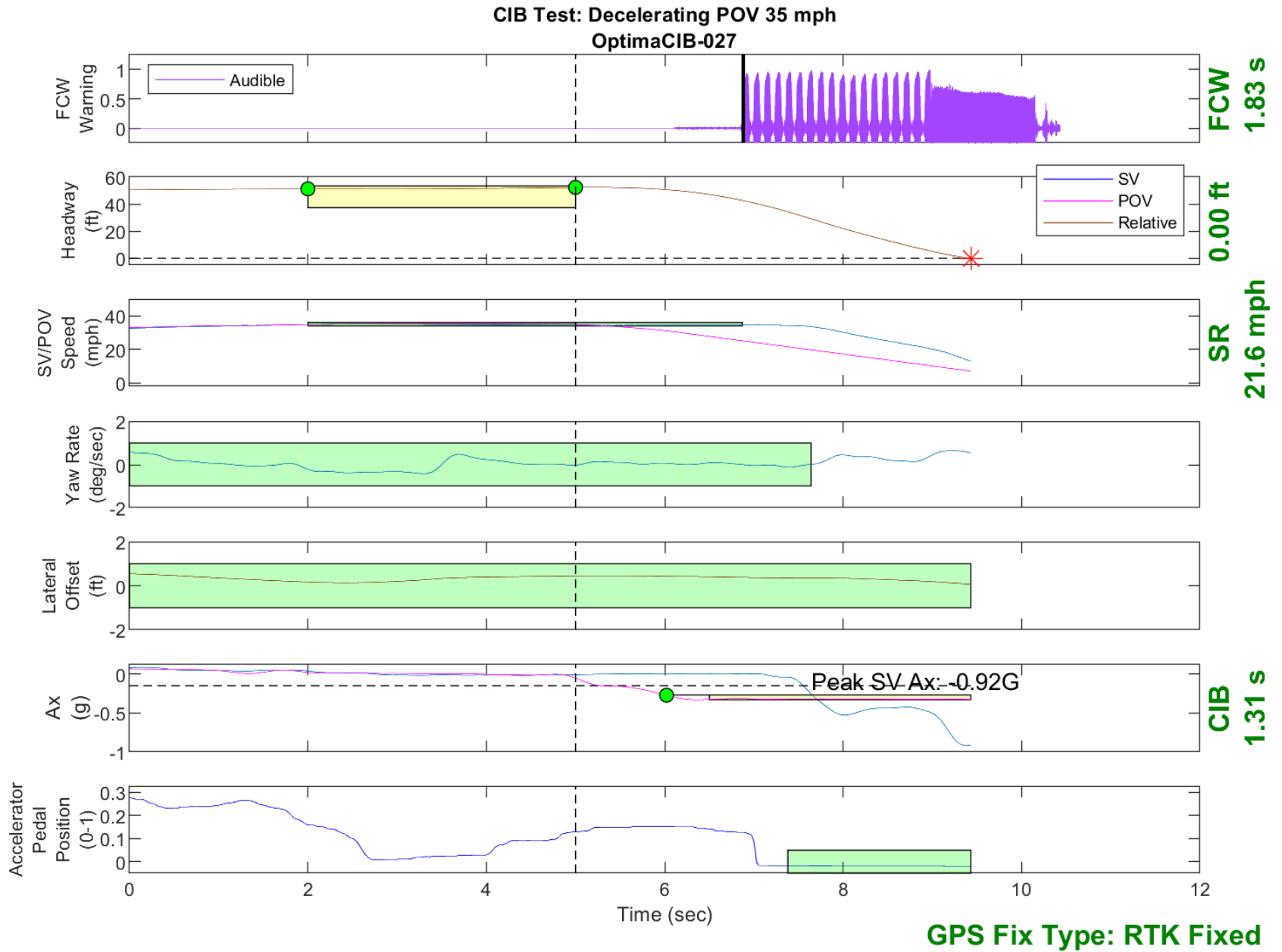


Figure D31. Time History for CIB Run 27, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

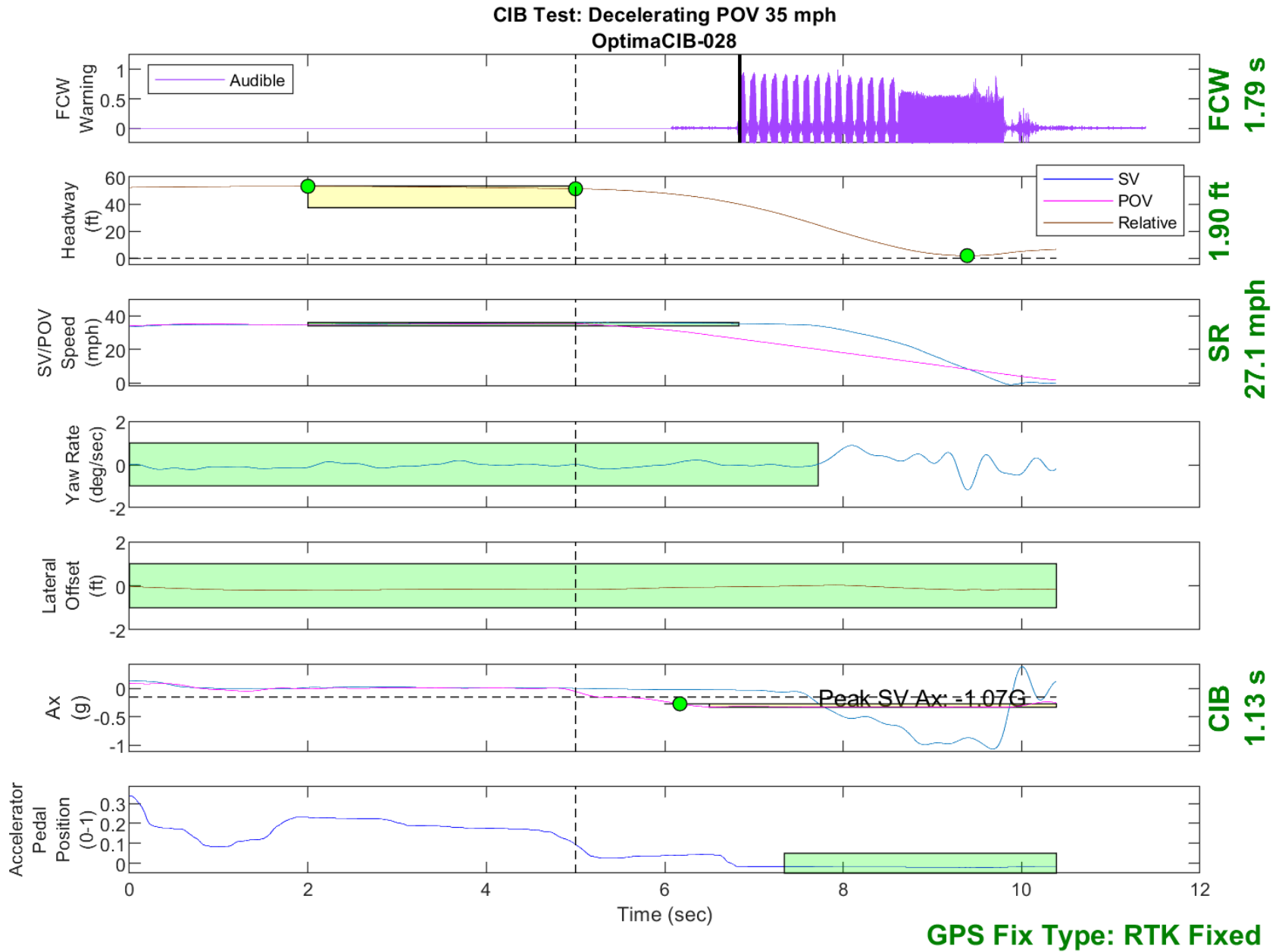


Figure D32. Time History for CIB Run 28, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

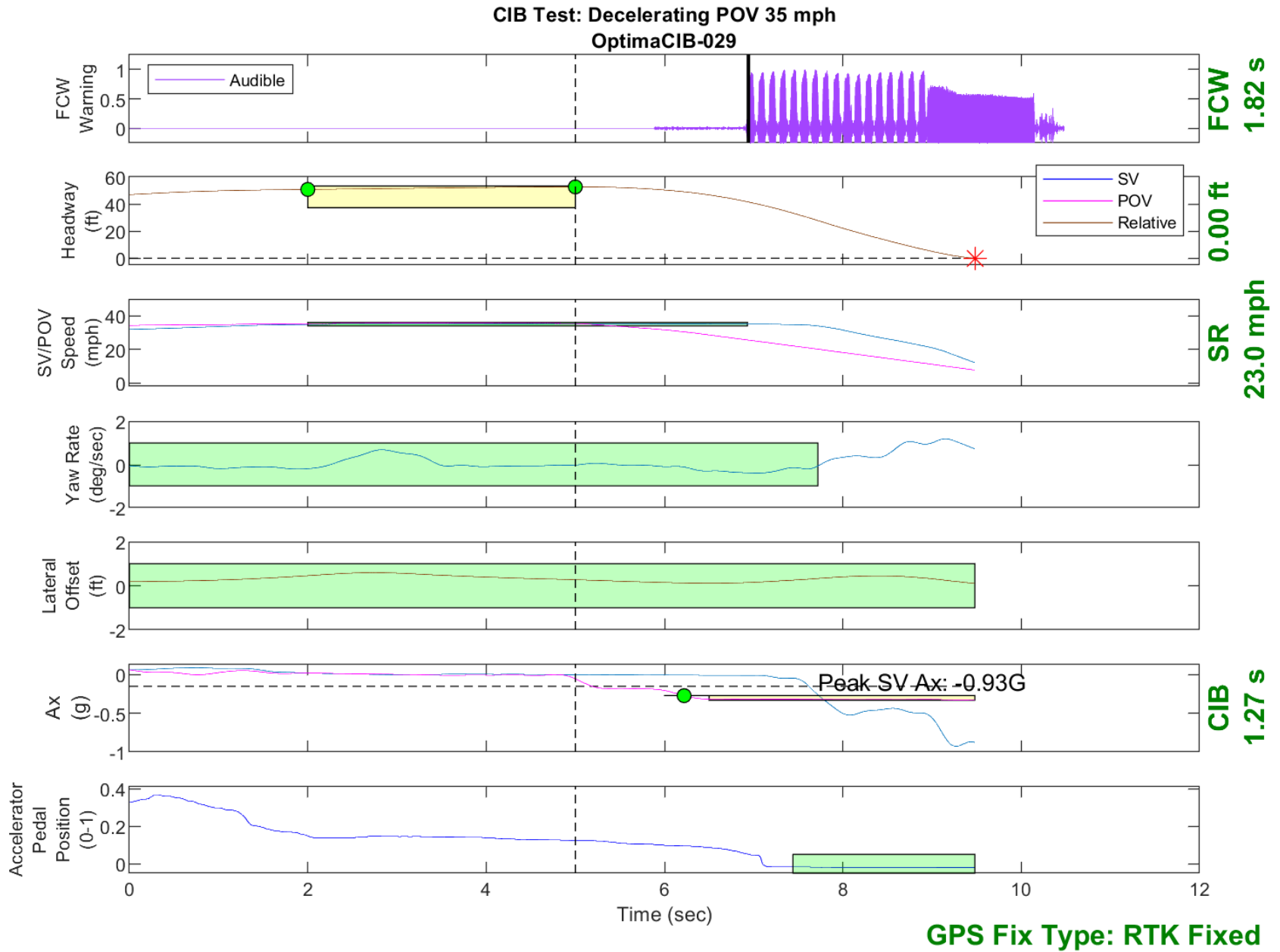


Figure D33. Time History for CIB Run 29, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

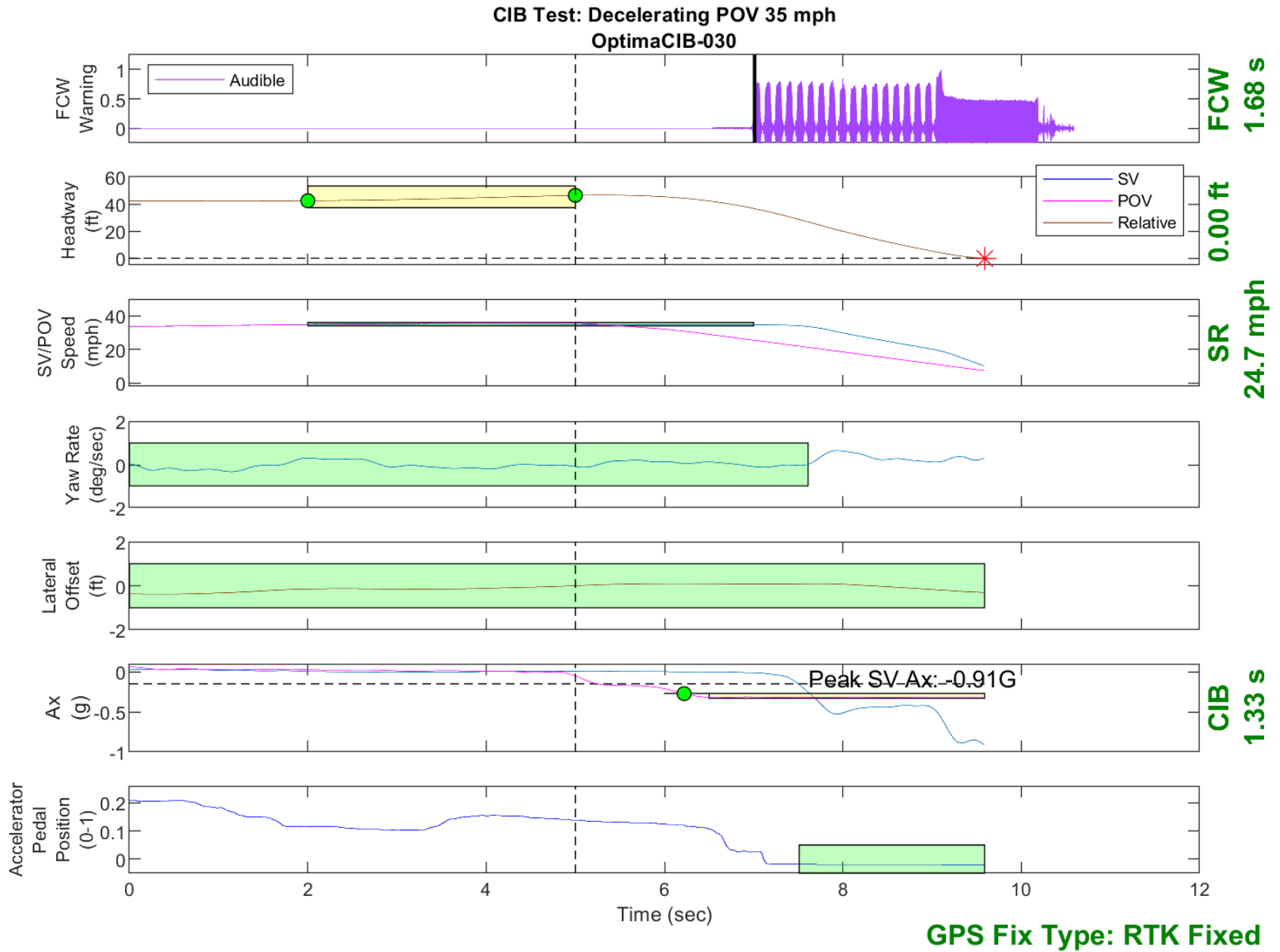


Figure D34. Time History for CIB Run 30, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

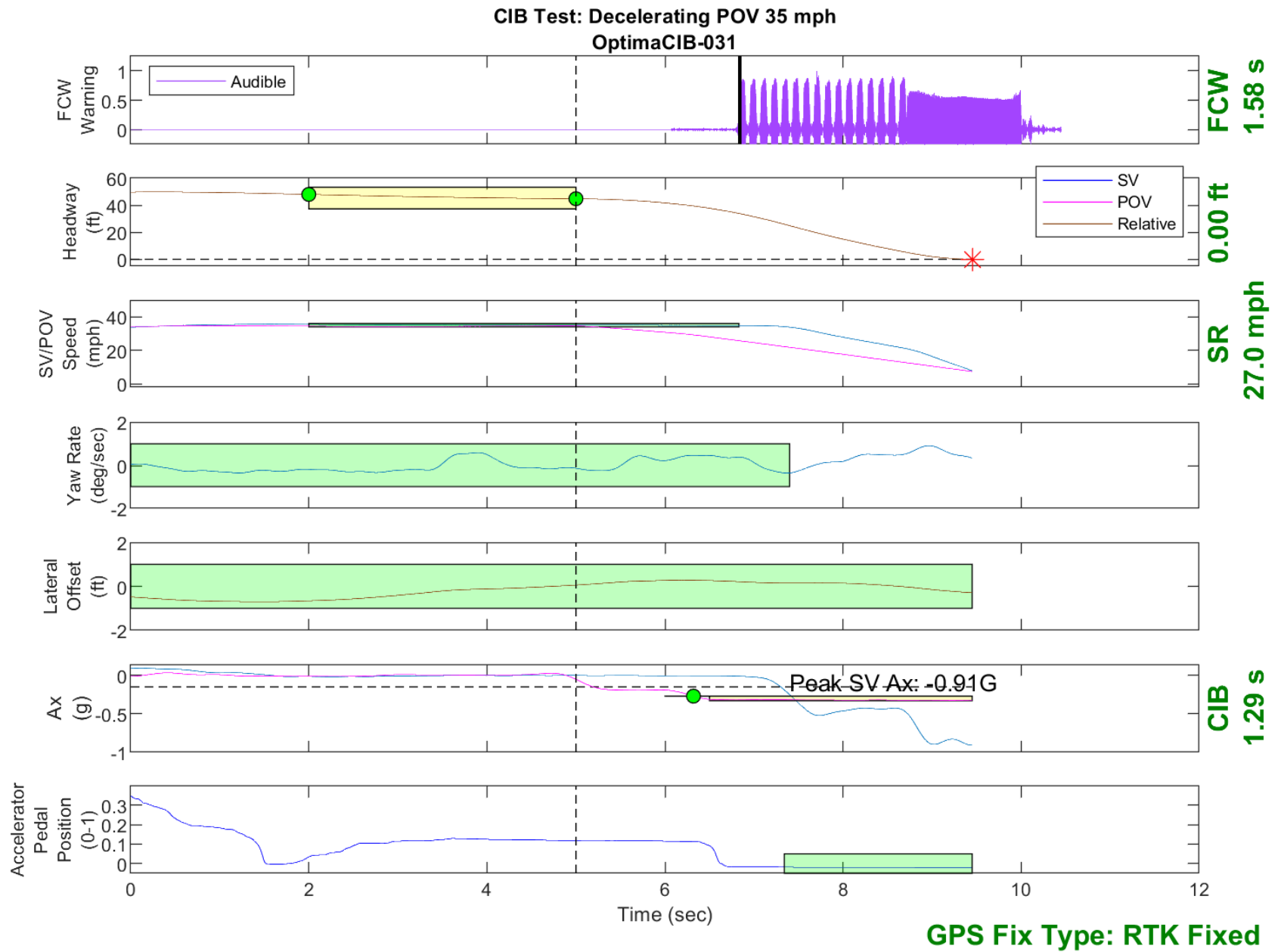


Figure D35. Time History for CIB Run 31, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

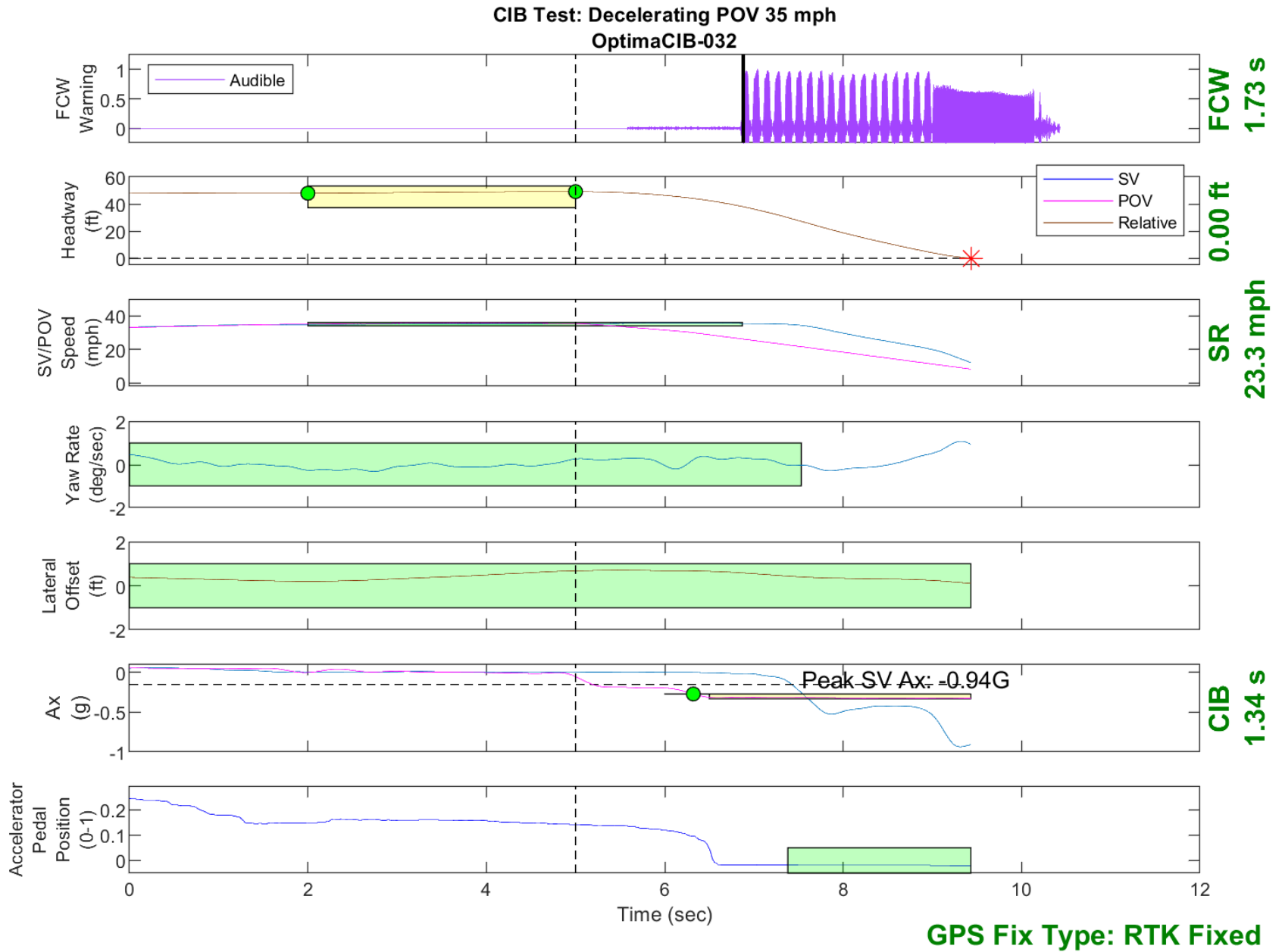


Figure D36. Time History for CIB Run 32, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

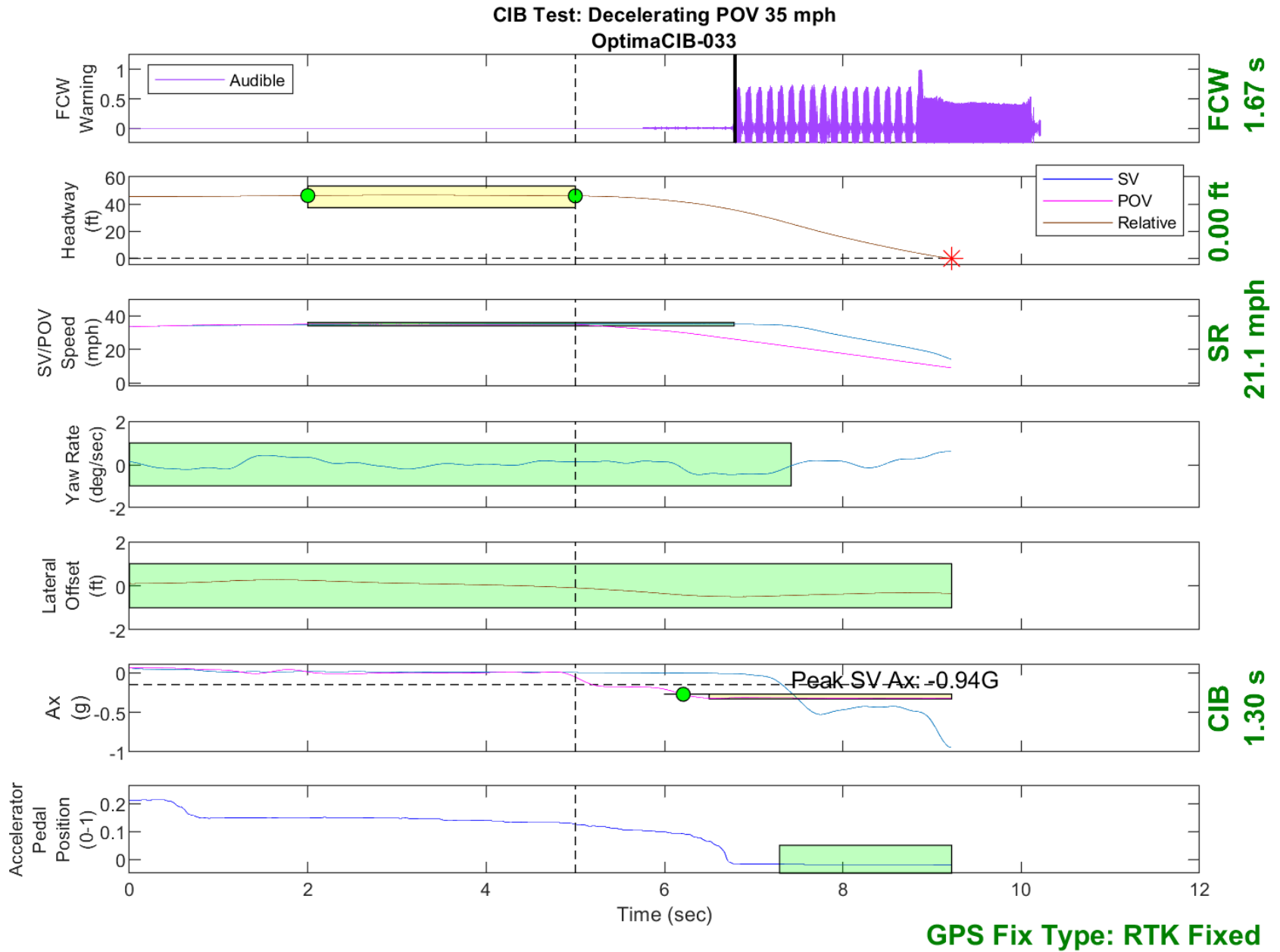


Figure D37. Time History for CIB Run 33, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

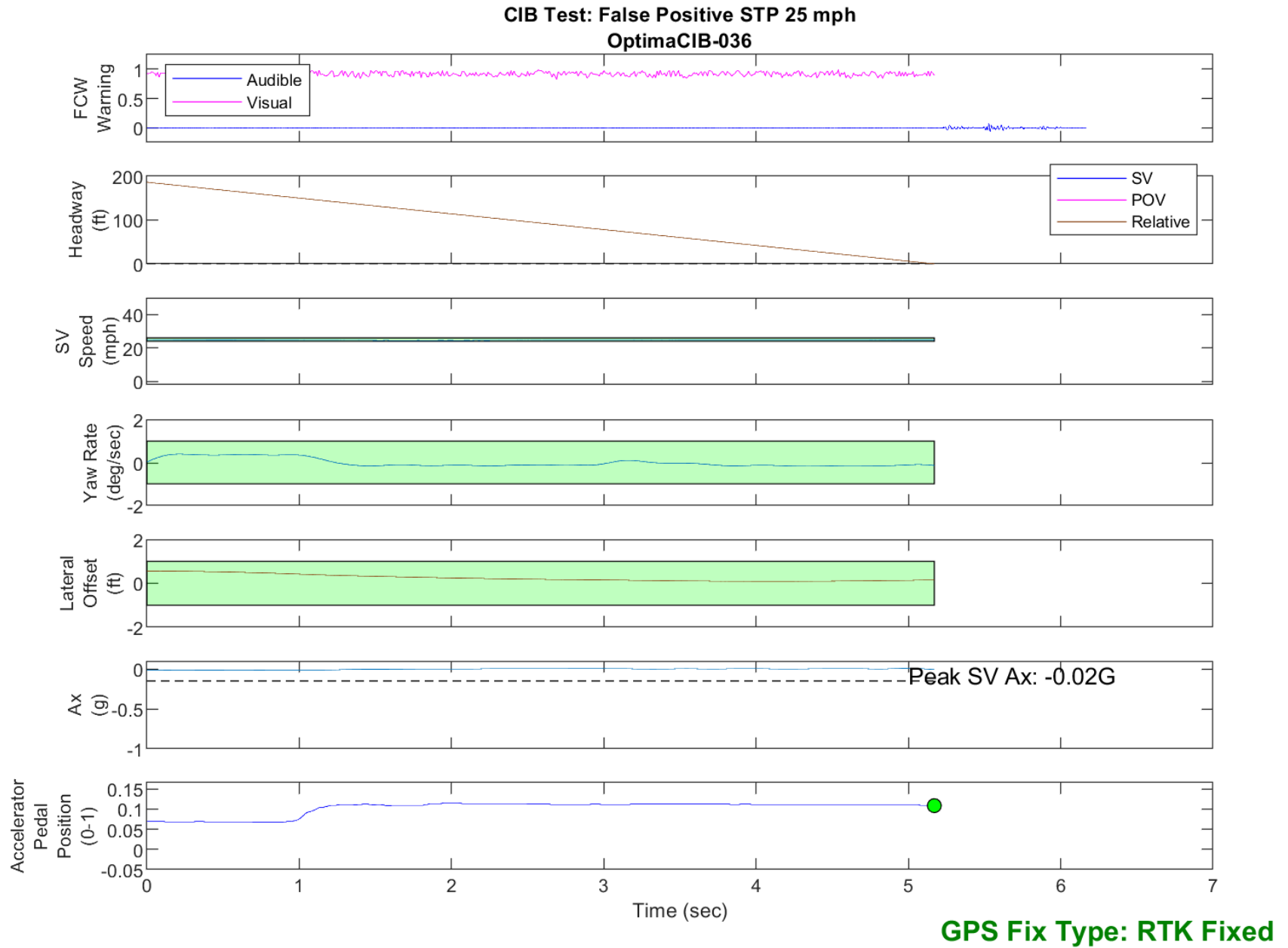


Figure D38. Time History for CIB Run 36, SV Encounters Steel Trench Plate, SV 25 mph

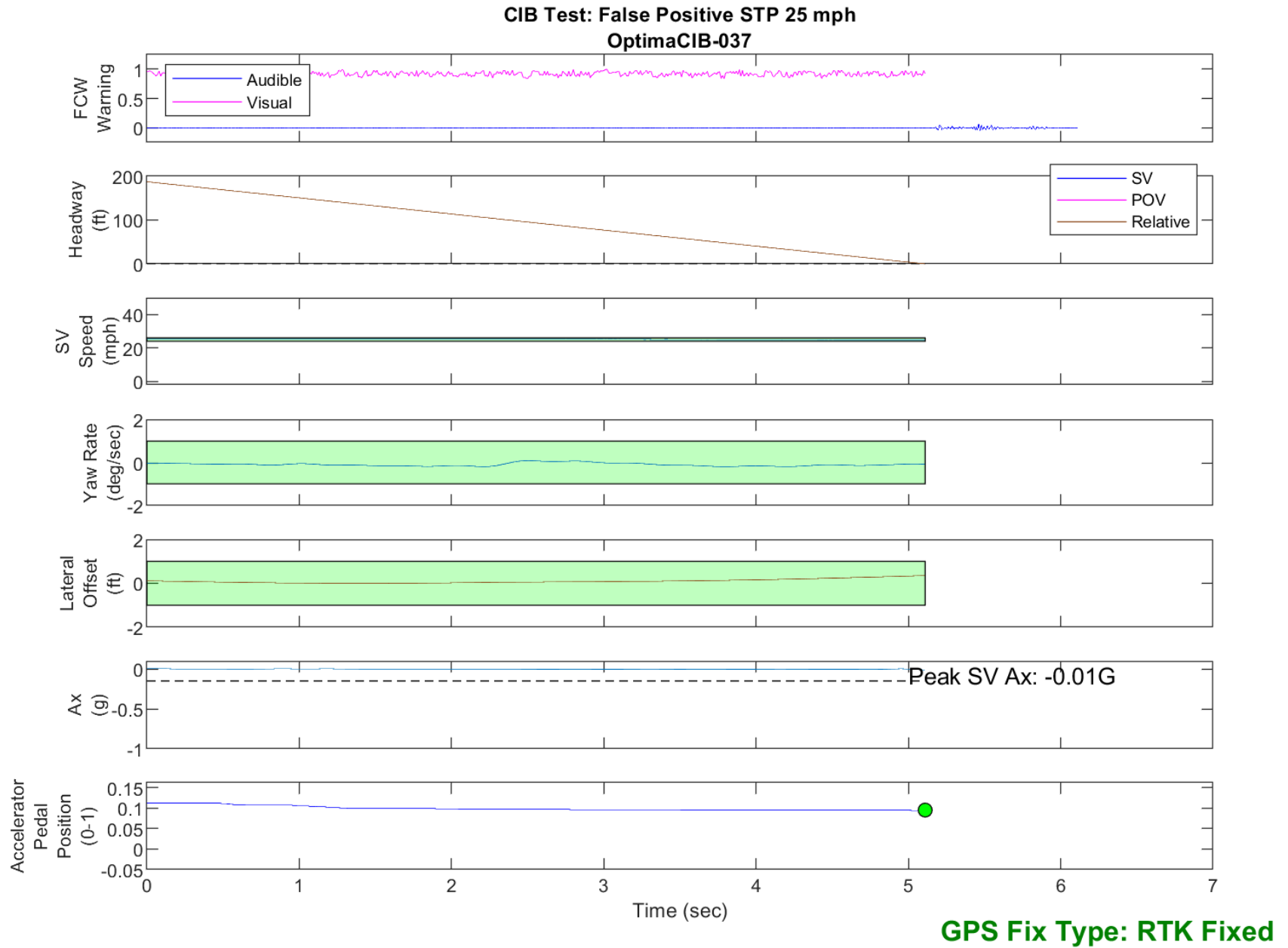


Figure D39. Time History for CIB Run 37, SV Encounters Steel Trench Plate, SV 25 mph

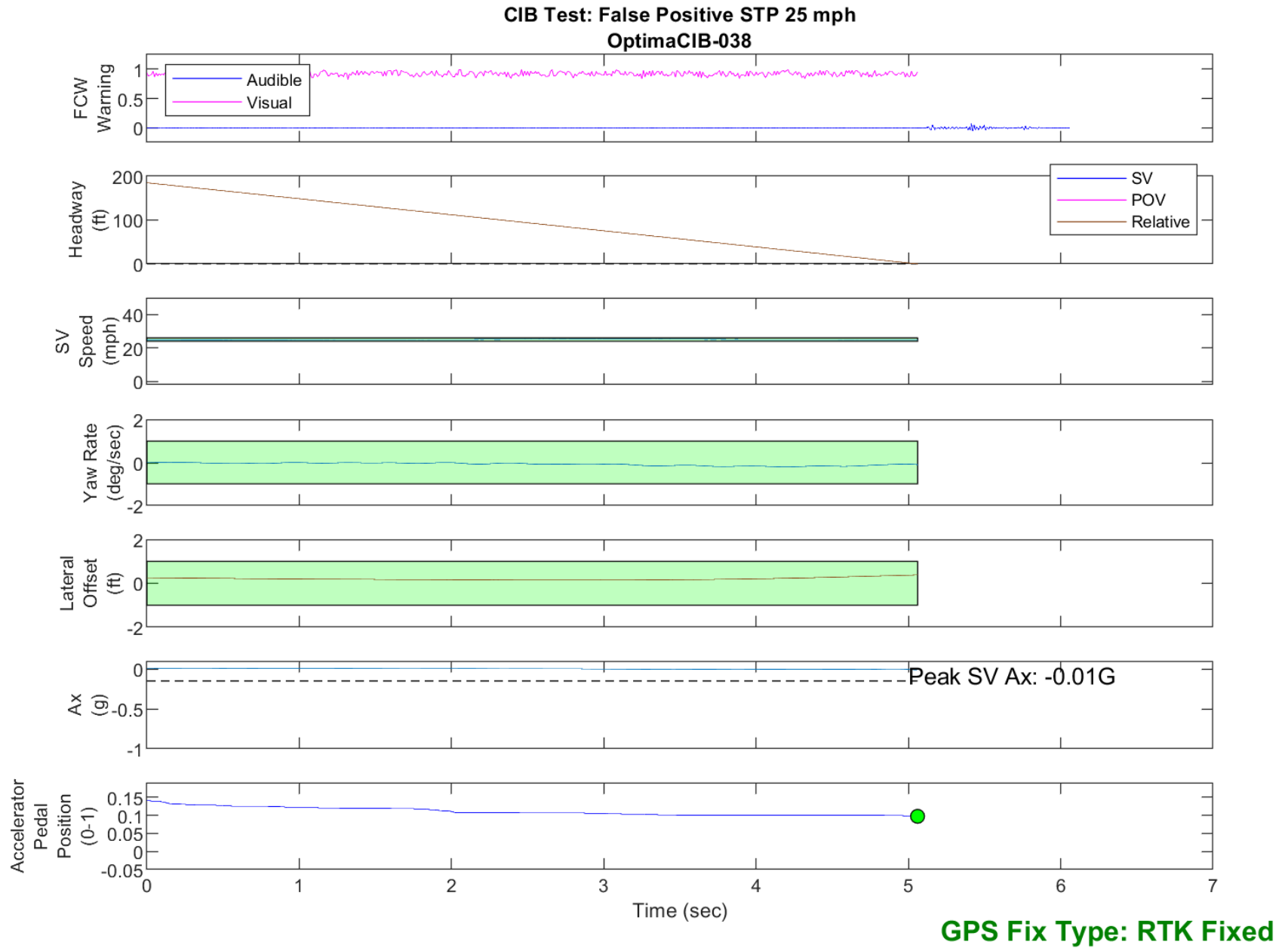


Figure D40. Time History for CIB Run 38, SV Encounters Steel Trench Plate, SV 25 mph

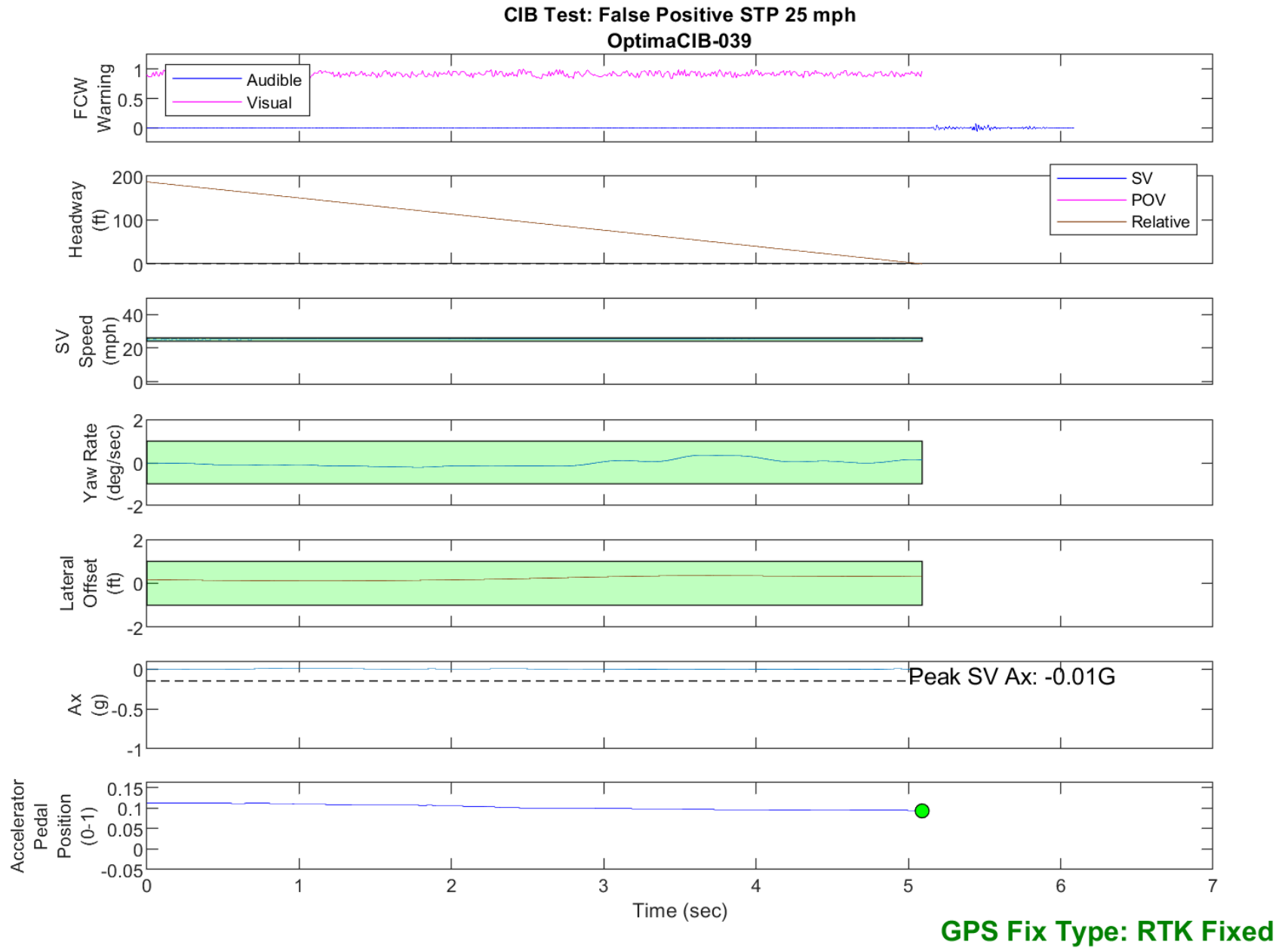


Figure D41. Time History for CIB Run 39, SV Encounters Steel Trench Plate, SV 25 mph

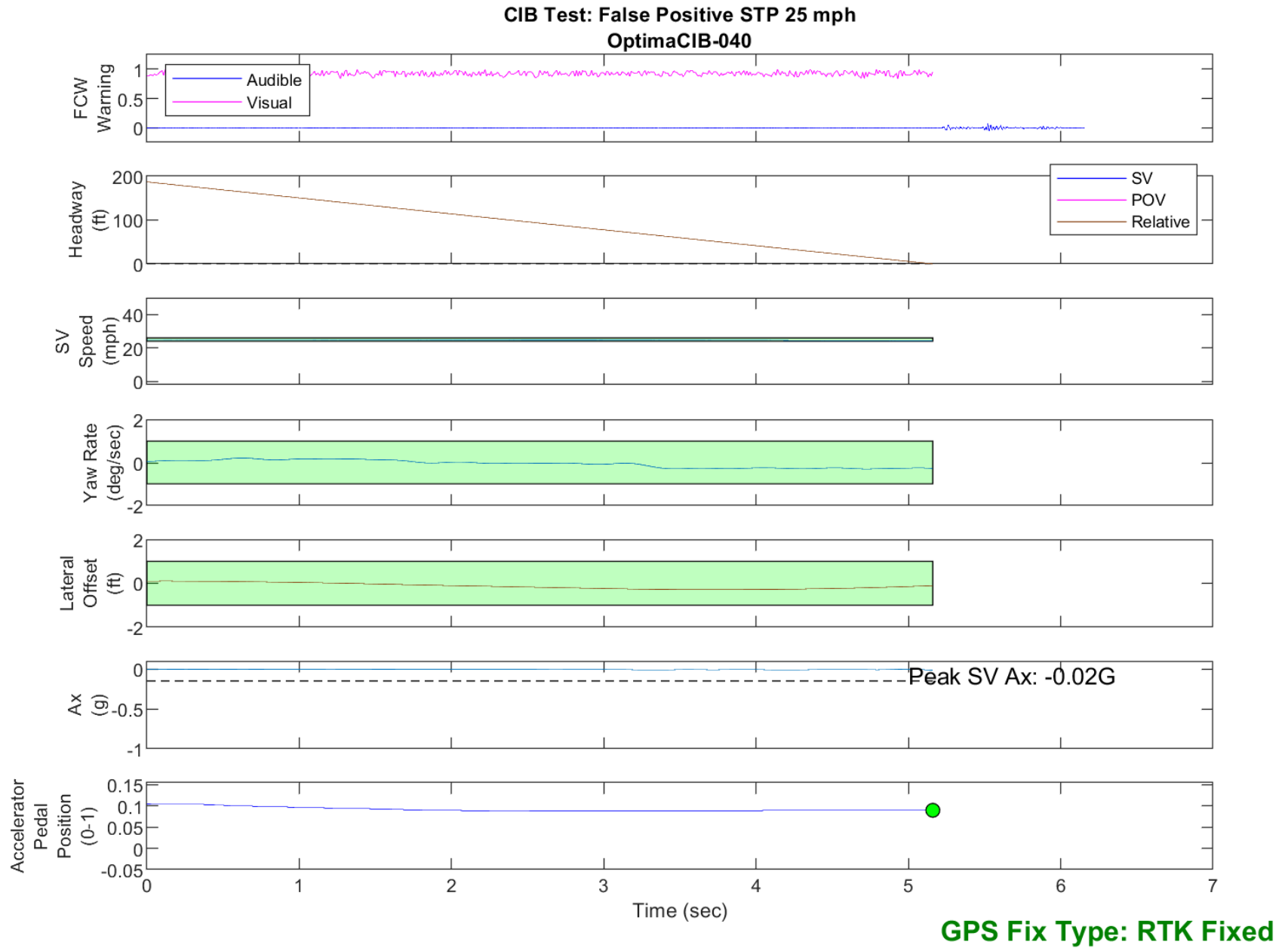


Figure D42. Time History for CIB Run 40, SV Encounters Steel Trench Plate, SV 25 mph

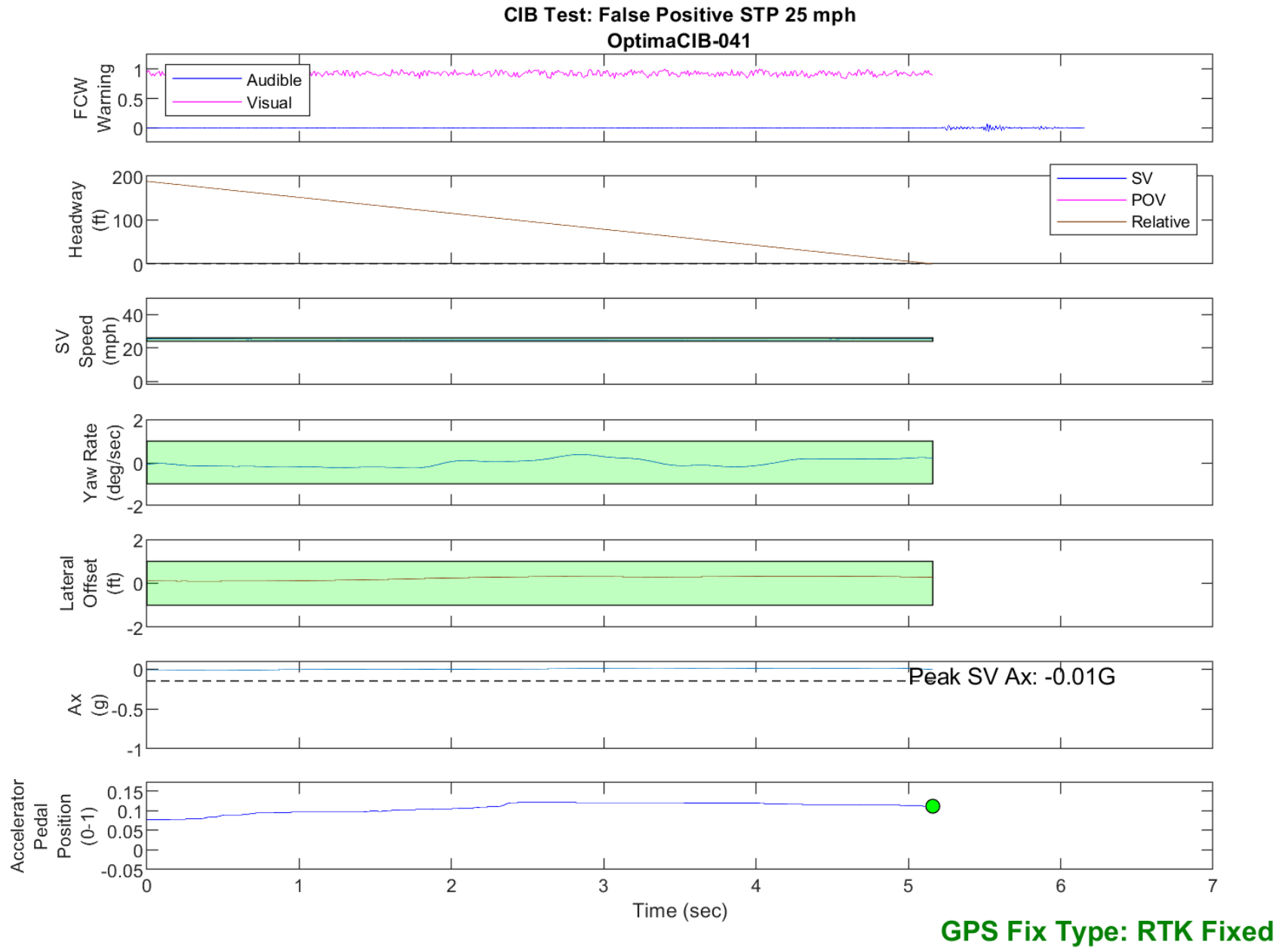


Figure D43. Time History for CIB Run 41, SV Encounters Steel Trench Plate, SV 25 mph

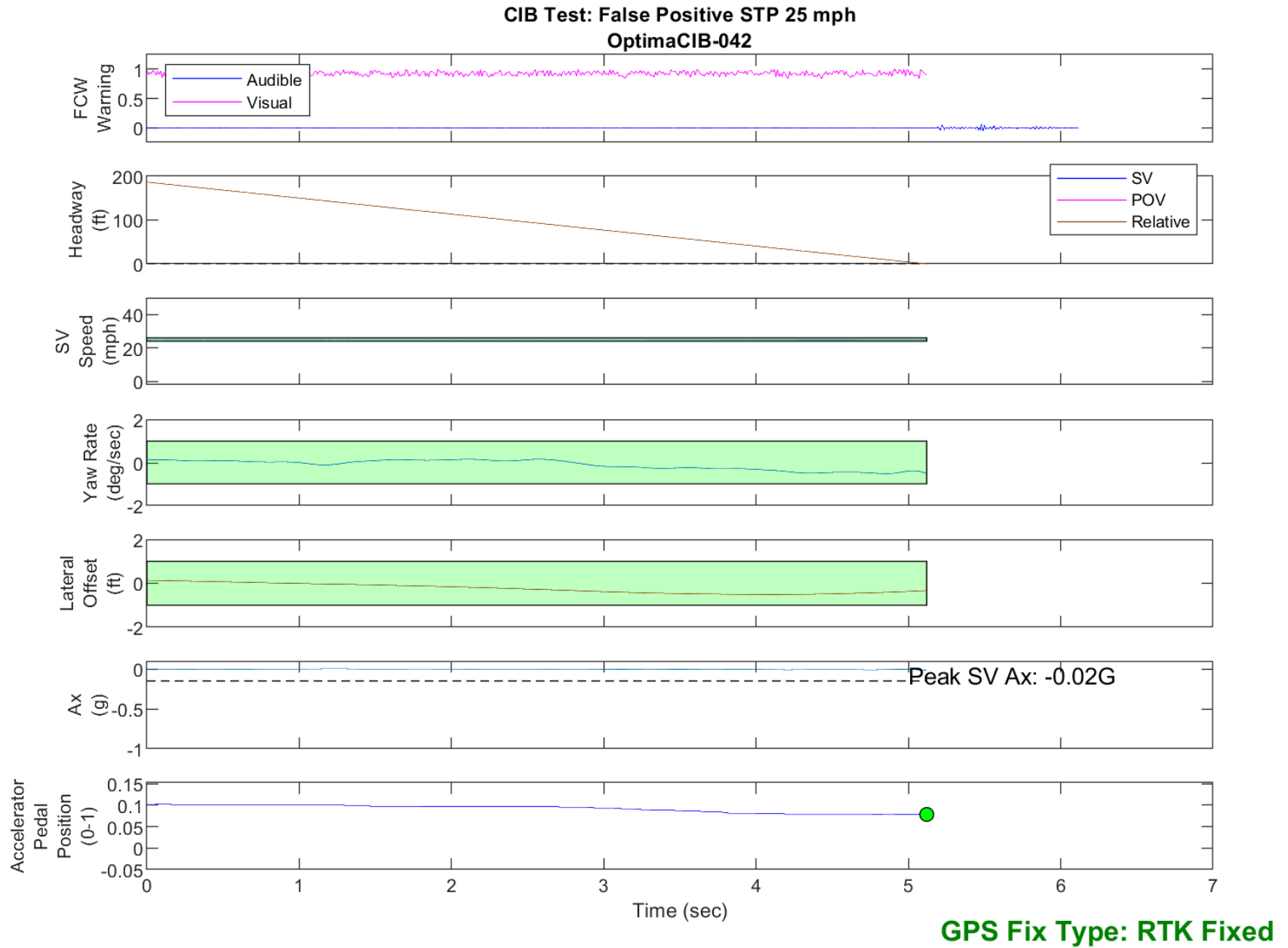


Figure D44. Time History for CIB Run 42, SV Encounters Steel Trench Plate, SV 25 mph

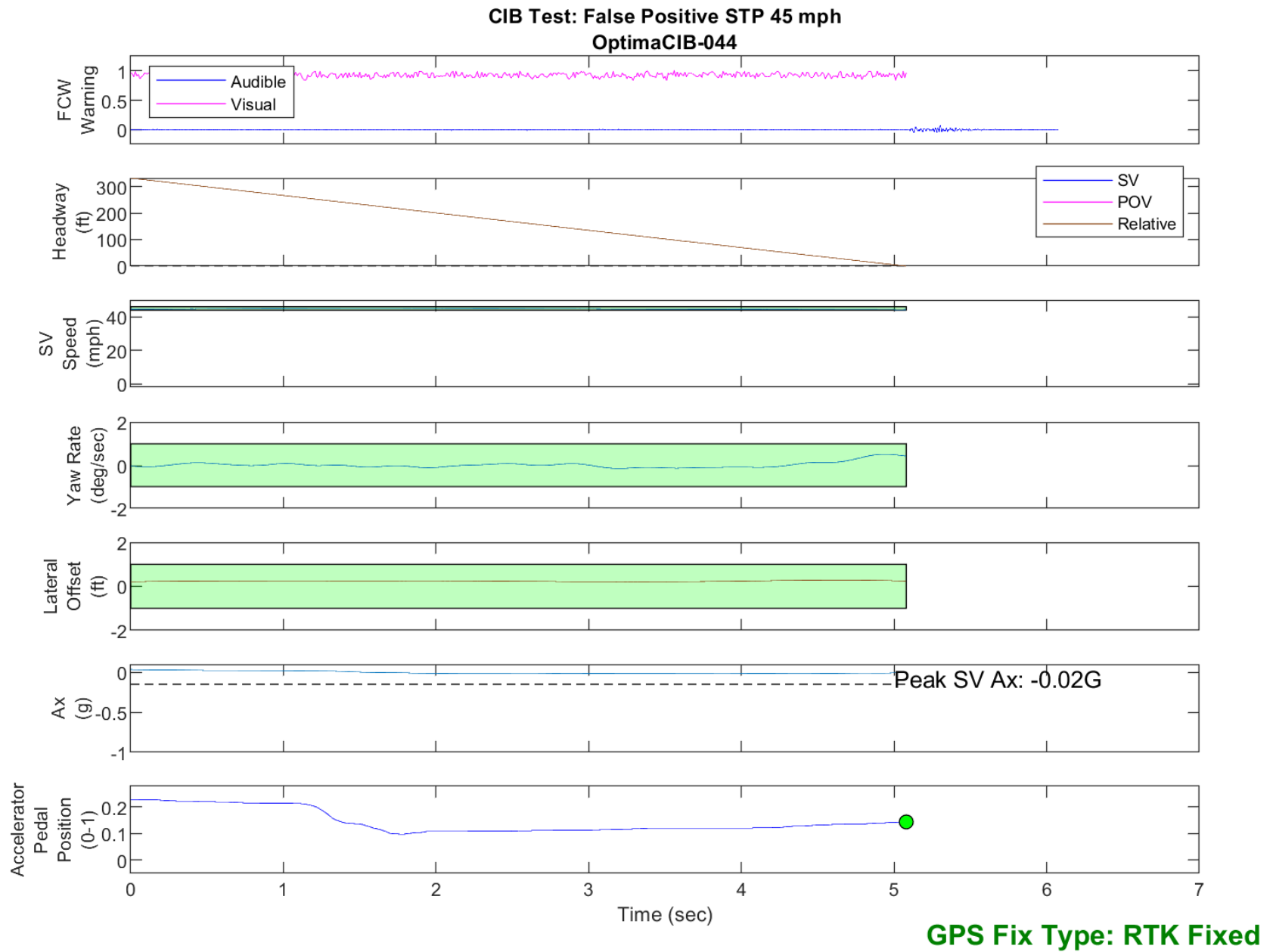


Figure D45. Time History for CIB Run 44, SV Encounters Steel Trench Plate, SV 45 mph

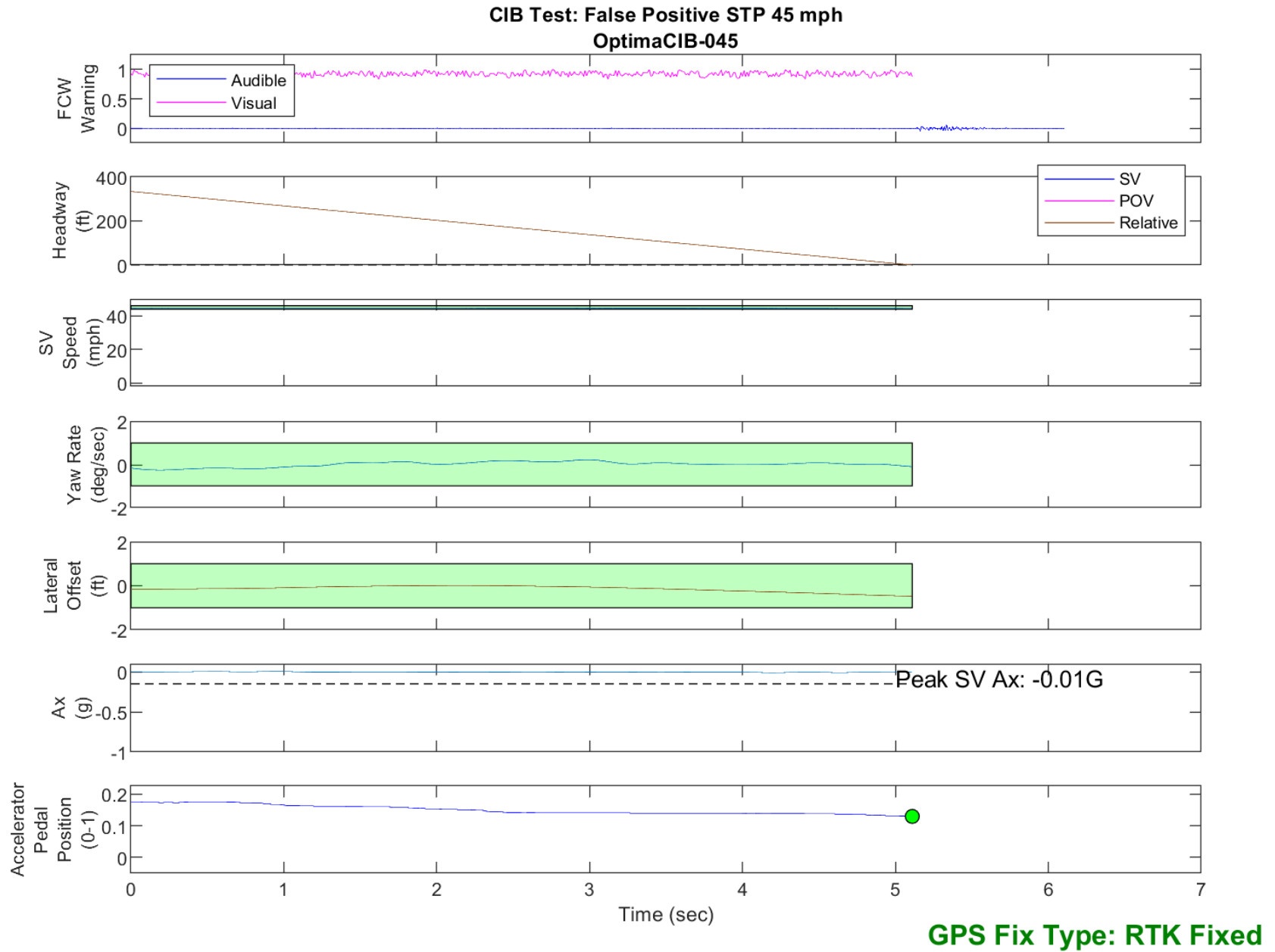


Figure D46. Time History for CIB Run 45, SV Encounters Steel Trench Plate, SV 45 mph

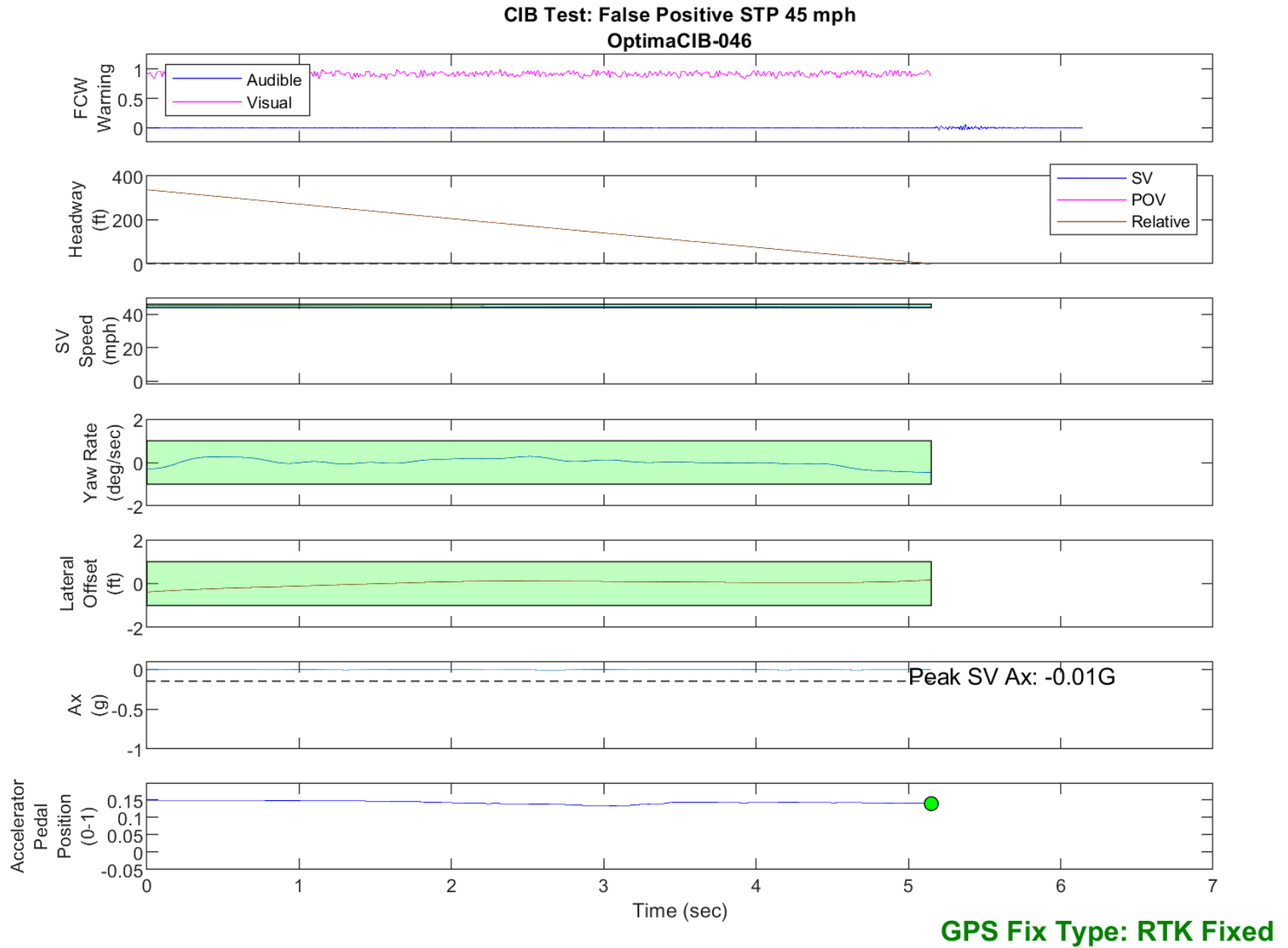


Figure D47. Time History for CIB Run 46, SV Encounters Steel Trench Plate, SV 45 mph

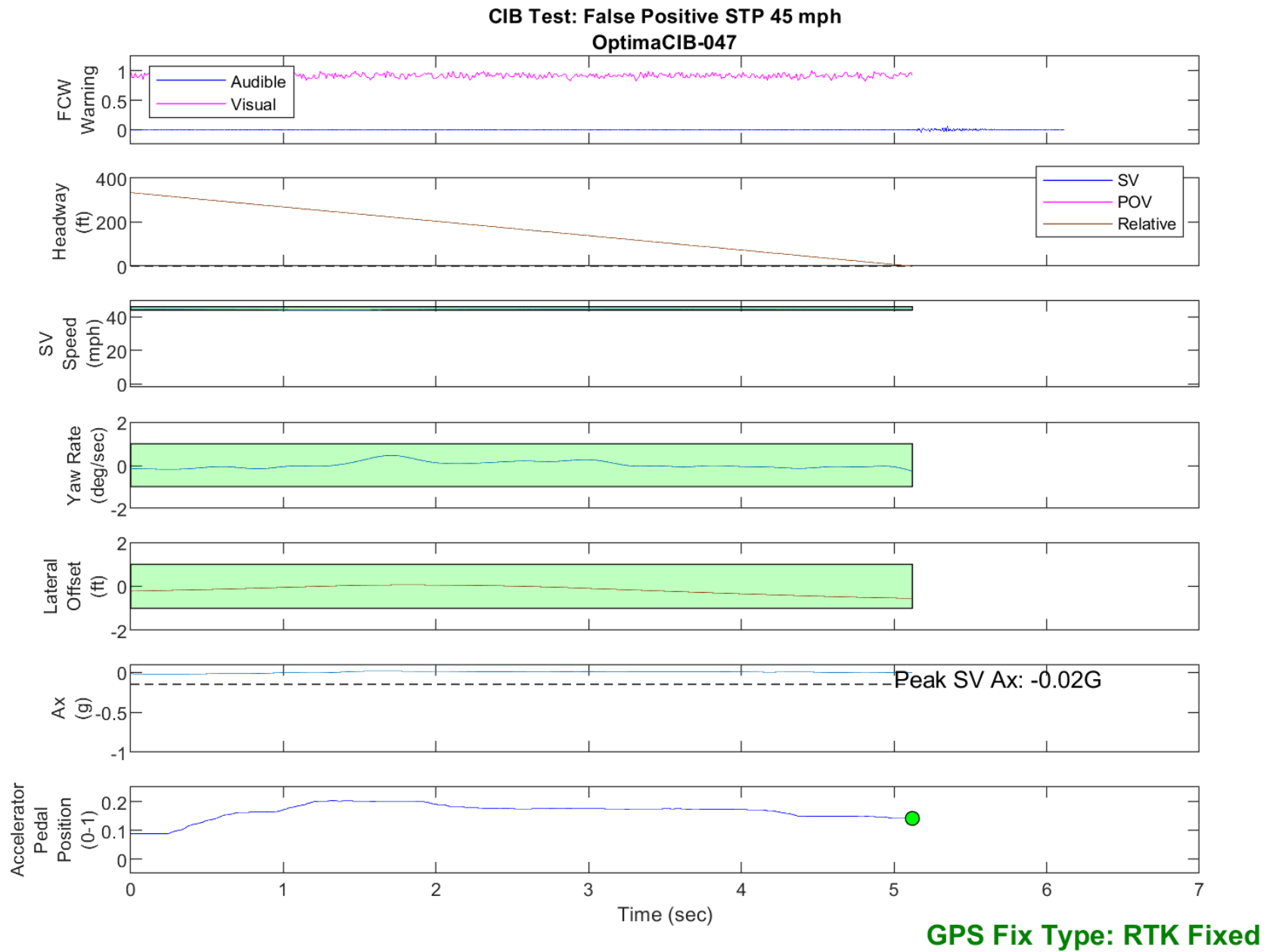


Figure D48. Time History for CIB Run 47, SV Encounters Steel Trench Plate, SV 45 mph

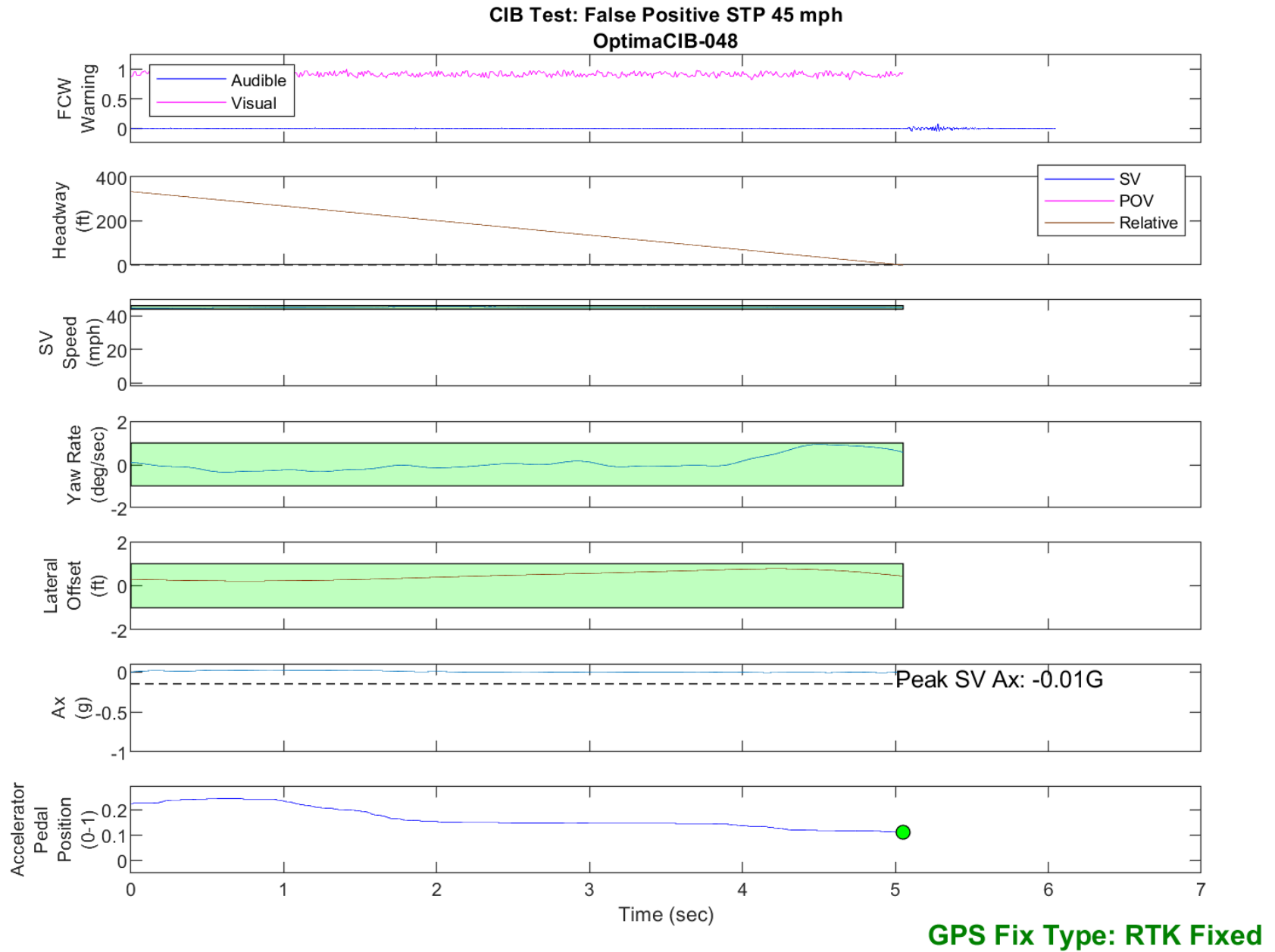


Figure D49. Time History for CIB Run 48, SV Encounters Steel Trench Plate, SV 45 mph

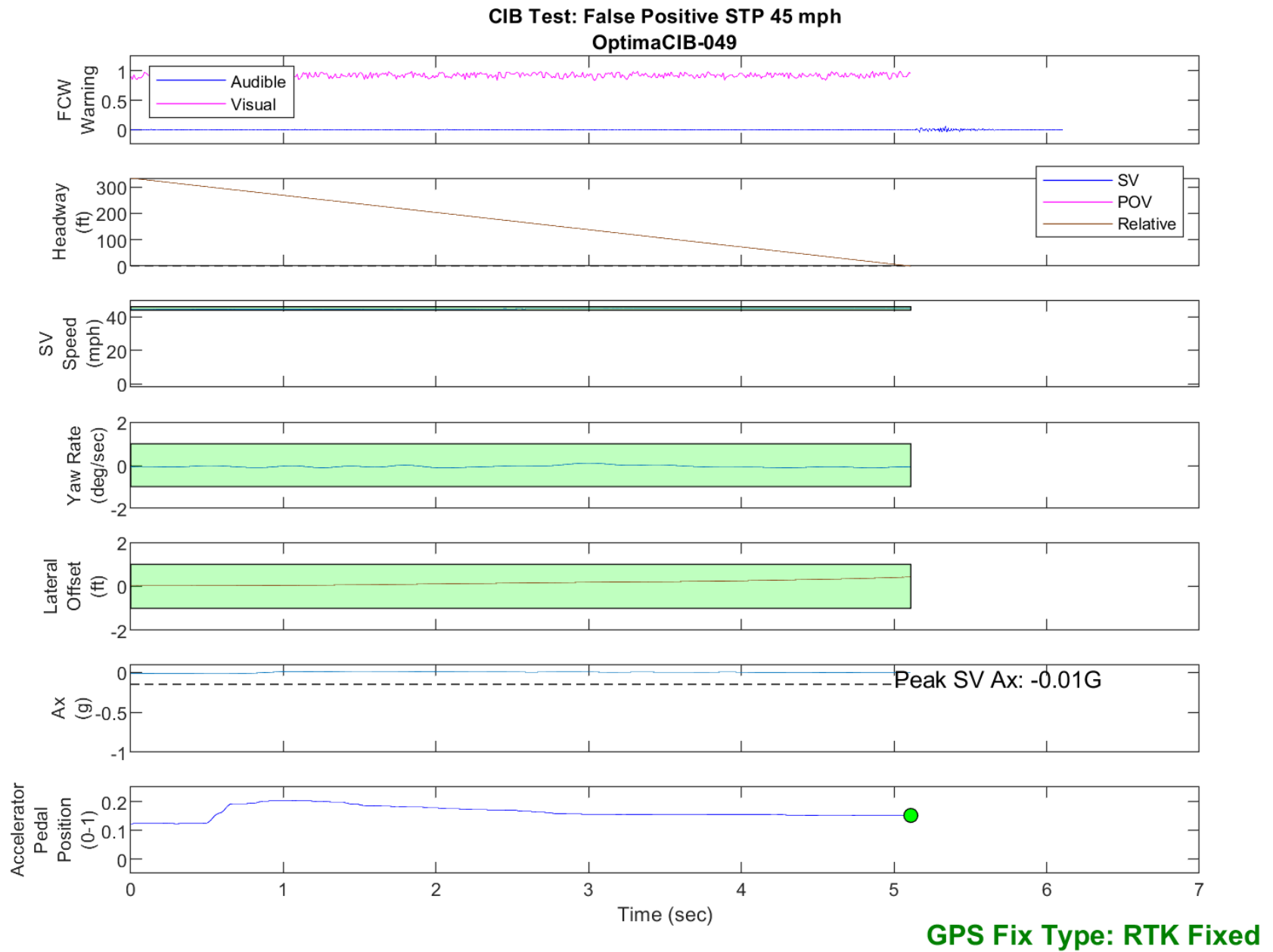


Figure D50. Time History for CIB Run 49, SV Encounters Steel Trench Plate, SV 45 mph

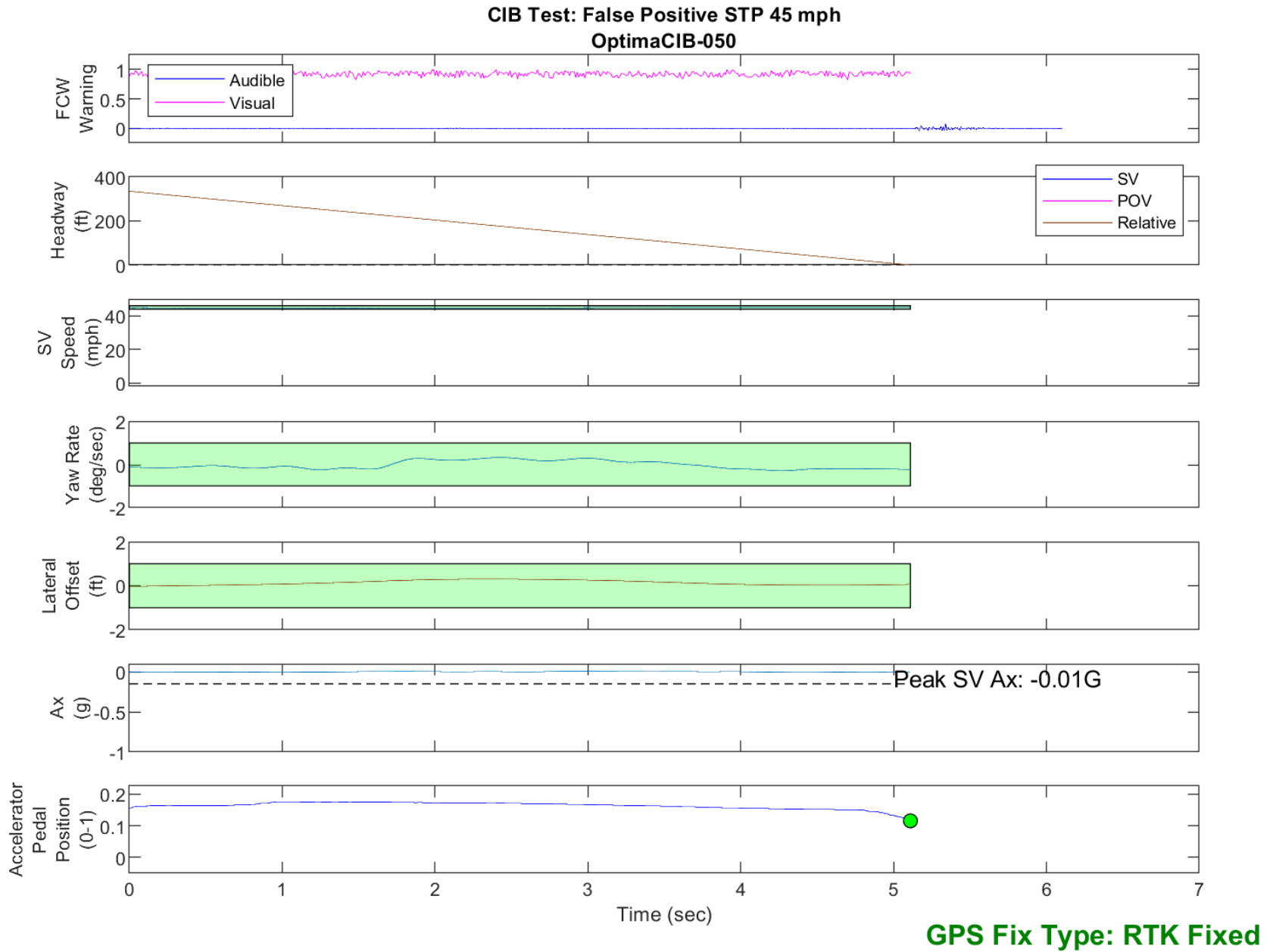


Figure D51. Time History for CIB Run 50, SV Encounters Steel Trench Plate, SV 45 mph