NEW CAR ASSESSMENT PROGRAM
CRASH IMMINENT BRAKING SYSTEM CONFIRMATION TEST
NCAP-DRI-CIB-21-13

2021 Mercedes-Benz E350 Sedan

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11 February 2021

Final Report

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

U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
New Car Assessment Program
1200 New Jersey Avenue, SE
West Building, 4th Floor (NRM-110)
Washington, DC 20590

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16. Abstract

These tests were conducted on the subject 2021 Mercedes-Benz E350 Sedan 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.

17. Key Words	18. Distribution Statement
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Section I

INTRODUCTION

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

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

The purpose of the testing reported herein was to objectively quantify the performance of a Crash Imminent Braking system installed on a 2021 Mercedes-Benz E350 Sedan. 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

<u>CRASH IMMINENT BRAKING</u>

<u>DATA SHEET 1: TEST RESULTS SUMMARY</u>

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2021 Mercedes-Benz E350 Sedan

VIN: *W1KZF8DB5MA91xxxx*

Test Date: *1/26/2021*

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

(Page 1 of 1)

2021 Mercedes-Benz E350 Sedan

TEST VEHICLE INFORMATION

VIN: *W1KZF8DB5MA91xxxx*

Body Style: *Sedan* Color: *Graphite Grey Metallic*

Date Received: *1/18/2021* Odometer Reading: *162 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *MERCEDES-BENZ AG STUTTGART*

Date of manufacture: *11/20*

Vehicle Type: *PASSENGER CAR*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *245/40 R19*

Rear: *245/40 R19*

Recommended cold tire pressure: Front: *270 kPa (39 psi)*

Rear: *320 kPa (46 psi)*

TIRES

Tire manufacturer and model: *Goodyear Eagle Sport RSC Extended All-Season*

Front tire designation: *245/40 R19 98H*

Rear tire designation: *245/40 R19 98H*

Front tire DOT prefix: *DM66 JAJR*

Rear tire DOT prefix: *DM66 JAJR*

CRASH IMMINENT BRAKING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2021 Mercedes-Benz E350 Sedan

GENERAL INFORMATION

Test date: *1/26/2021*

AMBIENT CONDITIONS

Air temperature: *10.0 C (50 F)*

Wind speed: *1.3 m/s (3.0 mph)*

X Windspeed ≤ 10 m/s (22 mph)

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

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

VEHICLE PREPARATION

Verify the following:

All non-consumable fluids at 100% capacity: **X**

Fuel tank is full: **X**

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

Front: *270 kPa (39 psi)*

Rear: *320 kPa (46 psi)*

CRASH IMMINENT BRAKING

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2021 Mercedes-Benz E350 Sedan

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*509.4 kg (1123 lb)*	Right Front:	*494.9 kg (1091 lb)*
Left Rear:	*460.8 kg (1016 lb)*	Right Rear:	*453.1 kg (999 lb)*
		Total:	*1918.2 kg (4229 lb)*

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

(Page 1 of 3)

2021 Mercedes-Benz E350 Sedan

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

> *Active Brake Assist w/ Cross-Traffic Function is an optional upgrade; it is a part of the "Driver Assistance Package"*

Type and location of sensors the system uses:

> *Radar is located under the star emblem on grille; camera is located on the top center of windshield*

System setting used for test (if applicable): *Early*

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

> *4 mph (7 km/h) (Per manufacturer supplied information)*

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

> *Maximum speeds for which the systems function are situation and equipment dependent. These are fully described on page 196 of the Owner's Manual, shown in Appendix B, page B-4 (Per manufacturer supplied information).*

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

_____ No

If yes, please provide a full description.

> *Accumulate 100 km-150 km of highway driving with obstacles in the surrounding prior to any testing. After significant change of vehicle loading (i.e. after installation of measurement system), drive at least 5 min on marked lanes with a minimum speed of 50 km/h.*
>
> *After an ignition cycle, a calibration run is required.*

- *After ignition cycle, wait 15 s before driving on the route provided by Mercedes-Benz.*
- *Perform smooth acceleration from the starting point.*
- *At least 2 runs required while passing lane/vehicles with the least amount of steering input at a constant speed approx. 20 mph (approx. 30 km/h).*
- *Return to starting point: Drive in fully marked lane with about 30-40 mph or 50-60 km/h; min. driving distance: at least 300 m*

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

____ Yes

X No

If yes, please provide a full description.

How is the Forward Collision Warning system alert presented to the driver?

(Check all that apply)

X Warning light

X Buzzer or audible alarm

____ Vibration

____ Other __________

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

> *The driver is alerted with a series of beeps at approximately 1875 Hz. The driver is also alerted by a red warning triangle-shaped symbol that flashes on, located on the bottom of the instrument panel. See Appendix A, Figure A16.*

Is there a way to deactivate the system?

X Yes

____ No

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

> *System menus can be accessed via the multimedia touch screen, buttons on the right side of the steering wheel, and a track pad located in the center console. The menu hierarchy for disabling the system is:*
>
> *Settings*
>
> *Assistance*
>
> *Active Brake Assist; select "Off"*
>
> *See Appendix A, Figures A14 and A15.*

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

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2021 Mercedes-Benz E350 Sedan

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

If yes, please provide a full description.

System menus can be accessed via the multimedia touch screen, buttons on the right side of the steering wheel, and a track pad located in the center console. The menu hierarchy for setting the system sensitivity is:

Settings

Assistance

Active Brake Assist; select "Early, "Medium", or "Late".

See Appendix A, Figures A14 and A15.

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

If yes, please provide a full description.

System limitations are described on pages 197 and 198 of the Owner's Manual, shown in Appendix B, pages B-5 and B-6.

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Four test scenarios were used, as follows:

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

Test 2. Subject Vehicle Encounters Slower Principal Other Vehicle

Test 3. Subject Vehicle Encounters Decelerating Principal Other Vehicle

Test 4. Subject Vehicle Encounters Steel Trench Plate

An overview of each of the test procedures follows.

1. TEST 1 – SUBJECT VEHICLE ENCOUNTERS STOPPED PRINCIPAL OTHER VEHICLE ON A STRAIGHT ROAD

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

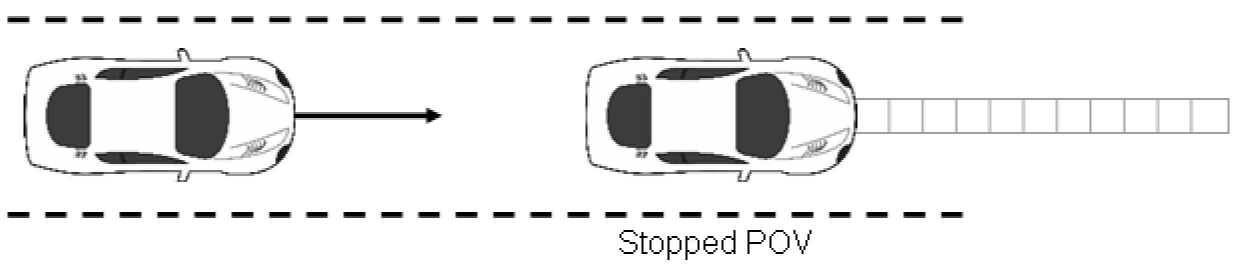


Figure 1. Depiction of Test 1

a. Procedure

The POV was parked in the center of a travel lane, with its longitudinal axis oriented parallel to the roadway edge and facing the same direction as the SV so that the SV approached the rear of the POV.

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

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

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

- The 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. <u>TEST 2 – SUBJECT VEHICLE ENCOUNTERS SLOWER PRINCIPAL OTHER VEHICLE</u>

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

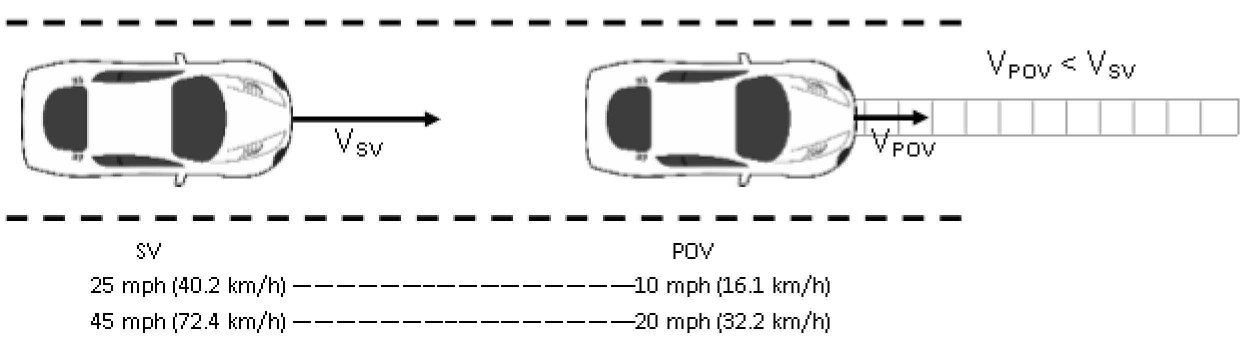


Figure 2. Depiction of Test 2

a. Procedure

The SV ignition was cycled prior to each test run. The tests were conducted two ways. In the first, the POV was driven at a constant 10.0 mph (16.1 km/h) in the center of the lane of travel while the SV was driven at 25.0 mph (40.2 km/h), in the center lane of travel, toward the slower-moving POV. In the second, the POV was driven at a constant 20.0 mph (32.2 km/h) in the center of the lane of travel while the SV was driven at 45.0 mph (72.4 km/h), in the center lane of travel, toward the slower-moving POV. In both cases, the SV throttle pedal was released within 500 ms after t_{FCW}, i.e. within 500 ms of the FCW alert. The test concluded when either:

- The SV came into contact with the POV or
- 1 second after the speed of the SV becomes less than or equal to that of the POV.

The SV driver then braked to a stop.

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

- The lateral distance between the centerline of the 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-to-POV impact for at least five of the seven valid test trials.

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

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

prevented the crash), the CIB speed reduction was calculated by subtracting the SV speed at the minimum longitudinal SV-to-POV range during the validity period from the SV speed at t_{FCW}.

3. <u>TEST 3 – SUBJECT VEHICLE ENCOUNTERS DECELERATING PRINCIPAL OTHER VEHICLE</u>

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

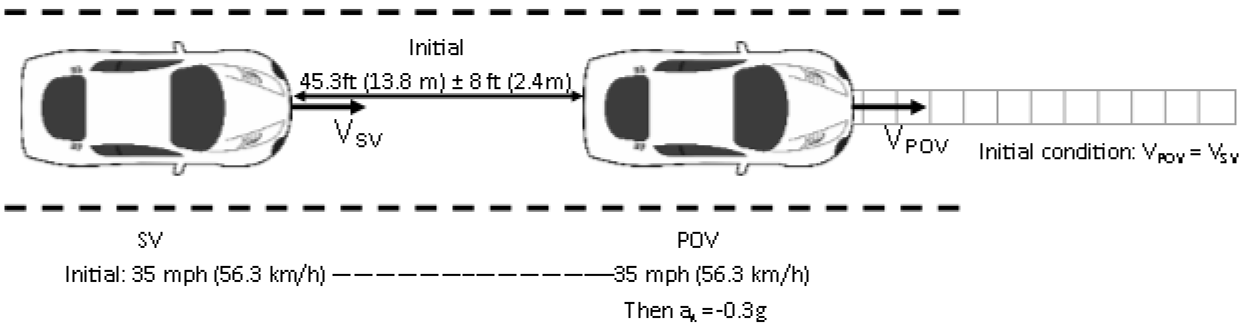


Figure 3. Depiction of Test 3

a. Procedure

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

- The SV came into contact with the POV or
- For the decelerating POV, 1 second after minimal longitudinal SV-to-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 ±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 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 ±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 ±8 ft (2.4 m) during an interval defined by the onset of the validity period to the onset of POV braking.
- The average POV deceleration could not deviate by more than ±0.03 g from the nominal 0.3 g deceleration during the interval beginning at 1.5 seconds after the onset of POV braking and ending either 250 ms prior to the POV coming to a stop or the SV coming into contact with the POV.

b. Criteria

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

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

4. <u>TEST 4 – FALSE POSITIVE SUPPRESSION</u>

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. <u>T_{FCW}</u>

The time at which the Forward Collision Warning (FCW) activation flag indicates that the system has issued an alert to the SV driver is designated as t_{FCW}. FCW alerts are typically either visual, haptic or 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	5th	3 dB	60 dB	Identified Center Frequency ± 5%
Tactile	5th	3 dB	60 dB	Identified Center Frequency ± 20%

2. GENERAL VALIDITY CRITERIA

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

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

3. VALIDITY PERIOD

The valid test interval began:

Test 1: When the SV-to-POV TTC = 5.1 seconds

Test 2: When the SV-to-POV TTC = 5.0 seconds

Test 3: 3 seconds before the onset of POV braking

Test 4: When the SV-to-STP TTC = 5.1 seconds

The valid test interval ended:

Test 1: When either of the following occurred:

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

Tests 2 and 3: When either of the following occurred:

- The SV came into contact with the POV; or
- 1 second after the velocity of the SV became less than or equal to that of the POV.
- 1 second after minimal longitudinal SV-to-POV distance occurred.

Test 4: At the instant the front-most part of SV reached a vertical plane defined by the leading edge of the STP first encountered by the SV (i.e., just before it was driven onto the STP).

4. STATIC INSTRUMENTATION CALIBRATION

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

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

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

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

The key requirements of the POV delivery system are to:

- Accurately control the nominal POV speed up to 35 mph (56 km/h).
- Accurately control the lateral position of the POV within the travel lane.
- Allow the POV to move away from the SV after an impact occurs.

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

D. Automatic Braking System

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

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

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

E. Instrumentation

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

Table 2. Test Instrumentation and Equipment

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi	< 1% error between 20 and 100 psi	Omega DPG8001	18111410000	By: DRI Date: 5/4/2020 Due: 5/4/2021
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 4/20/2020 Due: 4/20/2021
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	45040532	By: DRI Date: 7/2/2020 Due: 7/2/2021
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	N/A
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rate ±100 deg/s, Angle >45 deg, Velocity >200 km/h	Accels .01g, Angular Rate 0.05 deg/s, Angle 0.05 deg, Velocity 0.1 km/h	Oxford Inertial +		By: Oxford Technical Solutions
					2258	Date: 5/3/2019 Due: 5/3/2021
					2182	Date: 9/16/2019 Due: 9/16/2021

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	N/A
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	N/A	N/A
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	N/A	N/A
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	N/A	N/A
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2021 Due: 1/6/2022

Type	Description	Mfr, Model	Serial Number
Data Acquisition System	Data acquisition is achieved using a dSPACE MicroAutoBox II. Data from the Oxford IMU, including Longitudinal, Lateral, and Vertical Acceleration, Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle are sent over Ethernet to the MicroAutoBox. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (listed above).	dSPACE Micro-Autobox II 1401/1513	
		Base Board	549068
		I/O Board	588523

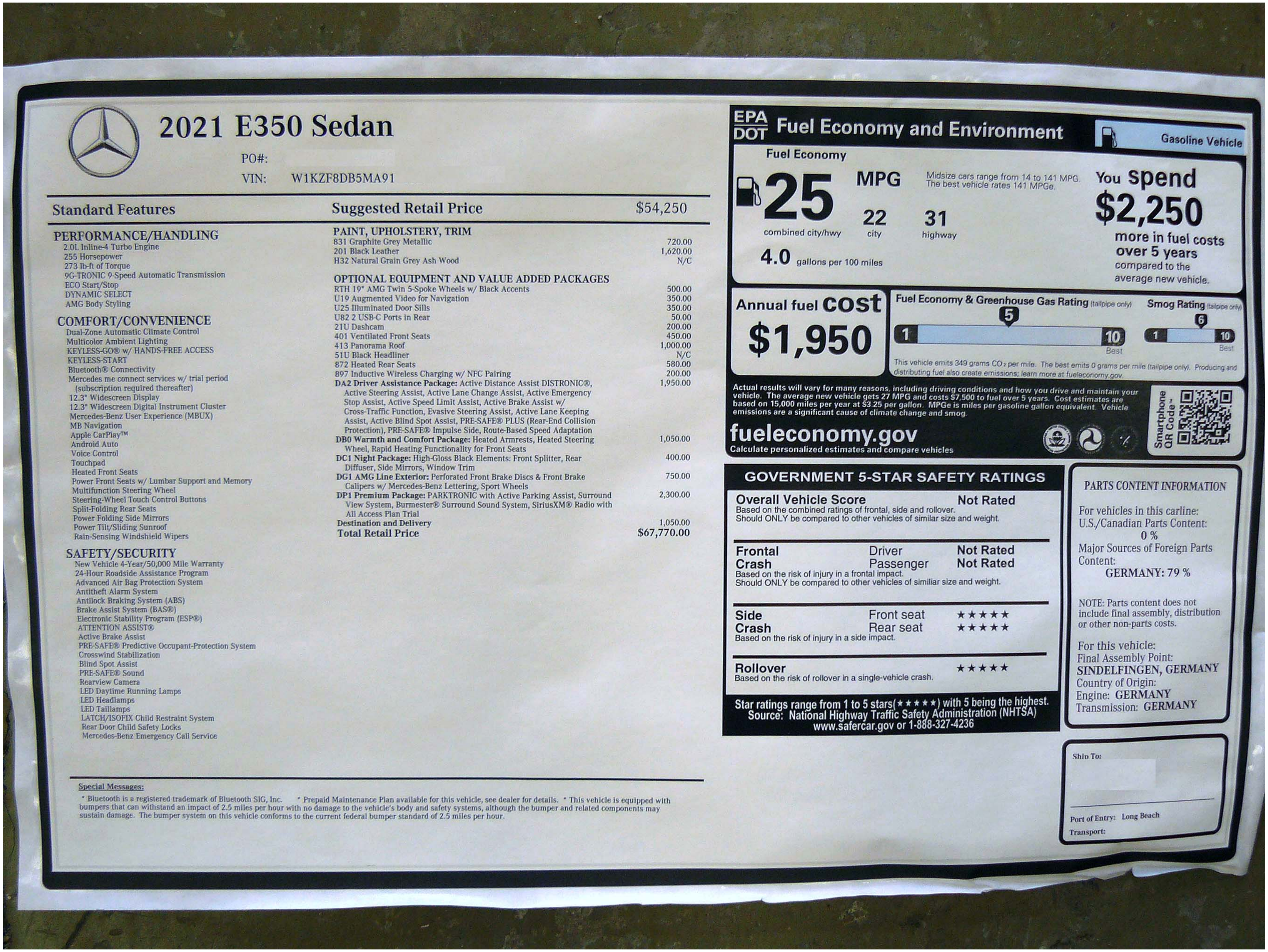
APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle



2021 E350 Sedan

PO#:

VIN: W1KZF8DB5MA91

Standard Features	Suggested Retail Price	$54,250

PERFORMANCE/HANDLING
2.0L Inline-4 Turbo Engine
255 Horsepower
273 lb-ft of Torque
9G-TRONIC 9-Speed Automatic Transmission
ECO Start/Stop
DYNAMIC SELECT
AMG Body Styling

COMFORT/CONVENIENCE
Dual-Zone Automatic Climate Control
Multicolor Ambient Lighting
KEYLESS-GO® w/ HANDS-FREE ACCESS
KEYLESS-START
Bluetooth® Connectivity
Mercedes me connect services w/ trial period (subscription required thereafter)
12.3" Widescreen Display
12.3" Widescreen Digital Instrument Cluster
Mercedes-Benz User Experience (MBUX)
MB Navigation
Apple CarPlay™
Android Auto
Voice Control
Touchpad
Heated Front Seats
Power Front Seats w/ Lumbar Support and Memory
Multifunction Steering Wheel
Steering-Wheel Touch Control Buttons
Split-Folding Rear Seats
Power Folding Side Mirrors
Power Tilt/Sliding Sunroof
Rain-Sensing Windshield Wipers

SAFETY/SECURITY
New Vehicle 4-Year/50,000 Mile Warranty
24-Hour Roadside Assistance Program
Advanced Air Bag Protection System
Antitheft Alarm System
Antilock Braking System (ABS)
Brake Assist System (BAS®)
Electronic Stability Program (ESP®)
ATTENTION ASSIST®
Active Brake Assist
PRE-SAFE® Predictive Occupant-Protection System
Crosswind Stabilization
Blind Spot Assist
PRE-SAFE® Sound
Rearview Camera
LED Daytime Running Lamps
LED Headlamps
LED Taillamps
LATCH/ISOFIX Child Restraint System
Rear Door Child Safety Locks
Mercedes-Benz Emergency Call Service

PAINT, UPHOLSTERY, TRIM	
831 Graphite Grey Metallic	720.00
201 Black Leather	1,620.00
H32 Natural Grain Grey Ash Wood	N/C
OPTIONAL EQUIPMENT AND VALUE ADDED PACKAGES	
RTH 19" AMG Twin 5-Spoke Wheels w/ Black Accents	500.00
U19 Augmented Video for Navigation	350.00
U25 Illuminated Door Sills	350.00
U82 2 USB-C Ports in Rear	50.00
21U Dashcam	200.00
401 Ventilated Front Seats	450.00
413 Panorama Roof	1,000.00
51U Black Headliner	N/C
872 Heated Rear Seats	580.00
897 Inductive Wireless Charging w/ NFC Pairing	200.00
DA2 Driver Assistance Package: Active Distance Assist DISTRONIC®, Active Steering Assist, Active Lane Change Assist, Active Emergency Stop Assist, Active Speed Limit Assist, Active Brake Assist w/ Cross-Traffic Function, Evasive Steering Assist, Active Lane Keeping Assist, Active Blind Spot Assist, PRE-SAFE® PLUS (Rear-End Collision Protection), PRE-SAFE® Impulse Side, Route-Based Speed Adaptation	1,950.00
DB0 Warmth and Comfort Package: Heated Armrests, Heated Steering Wheel, Rapid Heating Functionality for Front Seats	1,050.00
DC1 Night Package: High-Gloss Black Elements: Front Splitter, Rear Diffuser, Side Mirrors, Window Trim	400.00
DG1 AMG Line Exterior: Perforated Front Brake Discs & Front Brake Calipers w/ Mercedes-Benz Lettering, Sport Wheels	750.00
DP1 Premium Package: PARKTRONIC with Active Parking Assist, Surround View System, Burmester® Surround Sound System, SiriusXM® Radio with All Access Plan Trial	2,300.00
Destination and Delivery	1,050.00
Total Retail Price	**$67,770.00**

Special Messages:
* Bluetooth is a registered trademark of Bluetooth SIG, Inc. * Prepaid Maintenance Plan available for this vehicle, see dealer for details. * This vehicle is equipped with bumpers that can withstand an impact of 2.5 miles per hour with no damage to the vehicle's body and safety systems, although the bumper and related components may sustain damage. The bumper system on this vehicle conforms to the current federal bumper standard of 2.5 miles per hour.

EPA DOT **Fuel Economy and Environment** — Gasoline Vehicle

Fuel Economy
25 MPG combined city/hwy
22 city
31 highway
4.0 gallons per 100 miles
Midsize cars range from 14 to 141 MPG. The best vehicle rates 141 MPGe.

You spend $2,250 more in fuel costs over 5 years compared to the average new vehicle.

Annual fuel cost $1,950

Fuel Economy & Greenhouse Gas Rating (tailpipe only): 5 (1 – 10 Best)
Smog Rating (tailpipe only): 6 (1 – 10 Best)

This vehicle emits 349 grams CO_2 per mile. The best emits 0 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 $3.25 per gallon. MPGe is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

fueleconomy.gov
Calculate personalized estimates and compare vehicles

Smartphone QR Code™

GOVERNMENT 5-STAR SAFETY RATINGS

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

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

PARTS CONTENT INFORMATION

For vehicles in this carline:
U.S./Canadian Parts Content: 0 %
Major Sources of Foreign Parts Content: GERMANY: 79 %

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

For this vehicle:
Final Assembly Point: SINDELFINGEN, GERMANY
Country of Origin:
Engine: GERMANY
Transmission: GERMANY

Ship To:

Port of Entry: Long Beach
Transport:

Figure A3. Window Sticker (Monroney Label)

Figure A4. Vehicle Certification Label

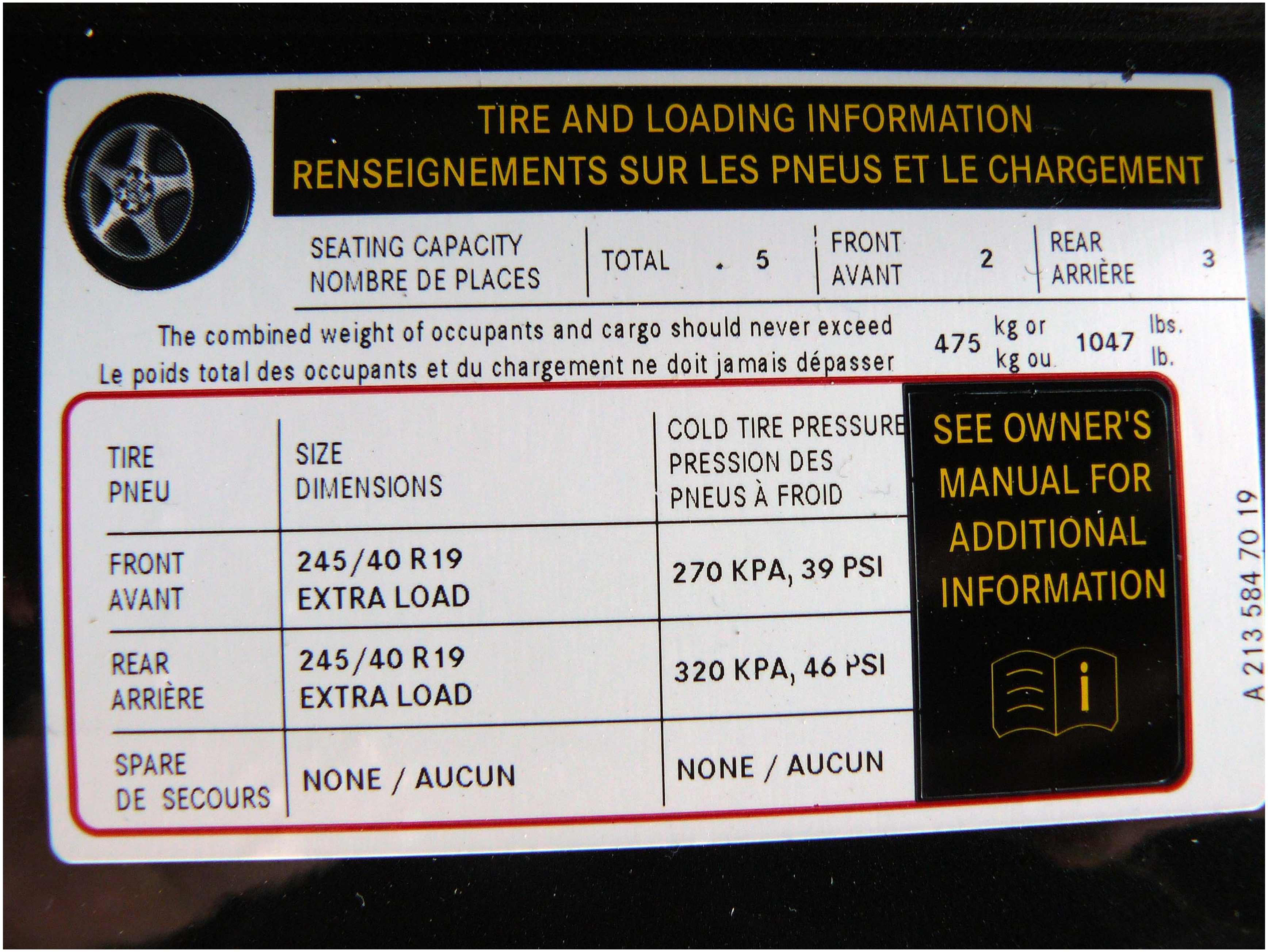


Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

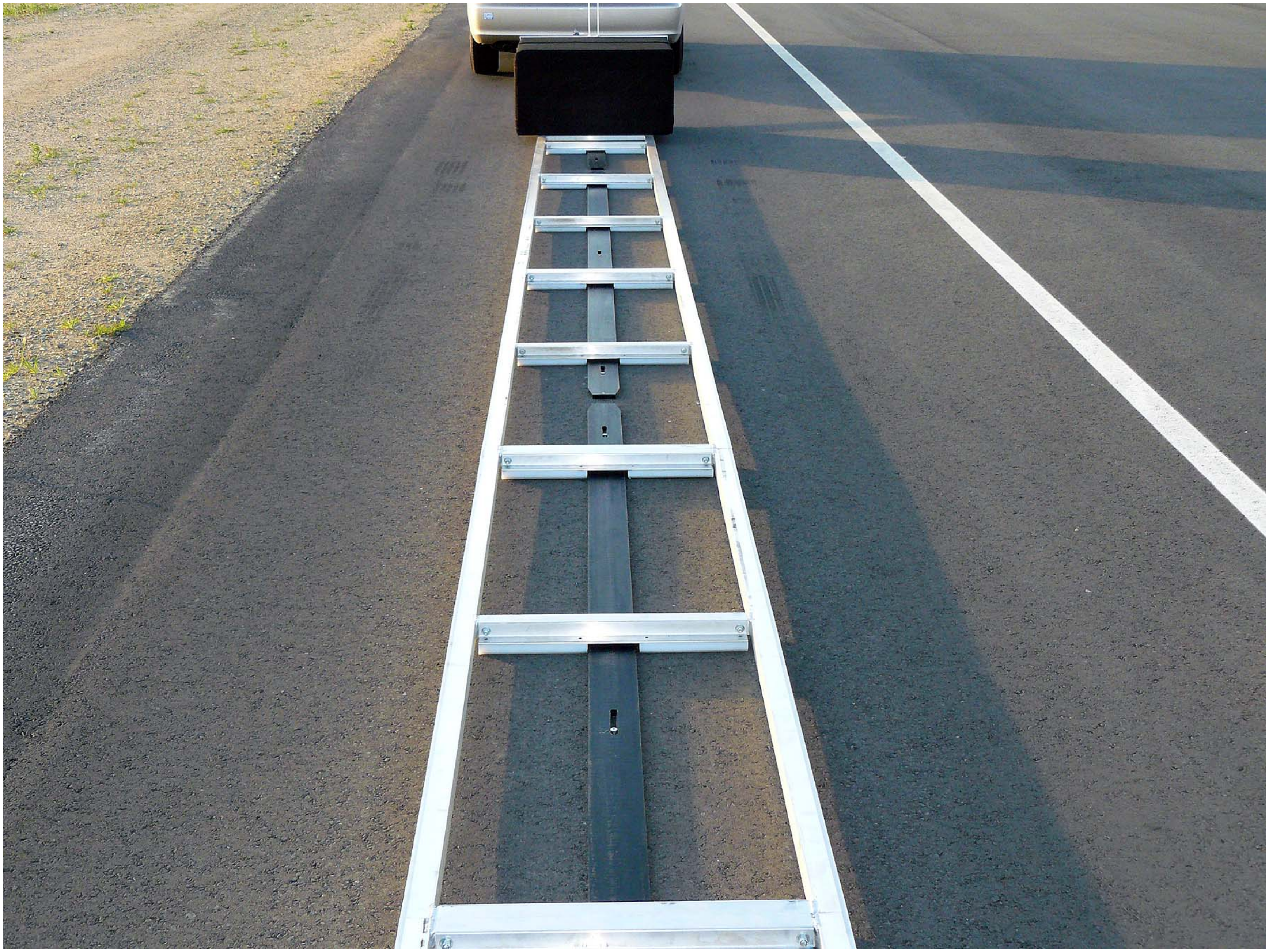


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

Figure A9. Steel Trench Plate

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

Figure A11. Sensors for Detecting Auditory and Visual Alerts

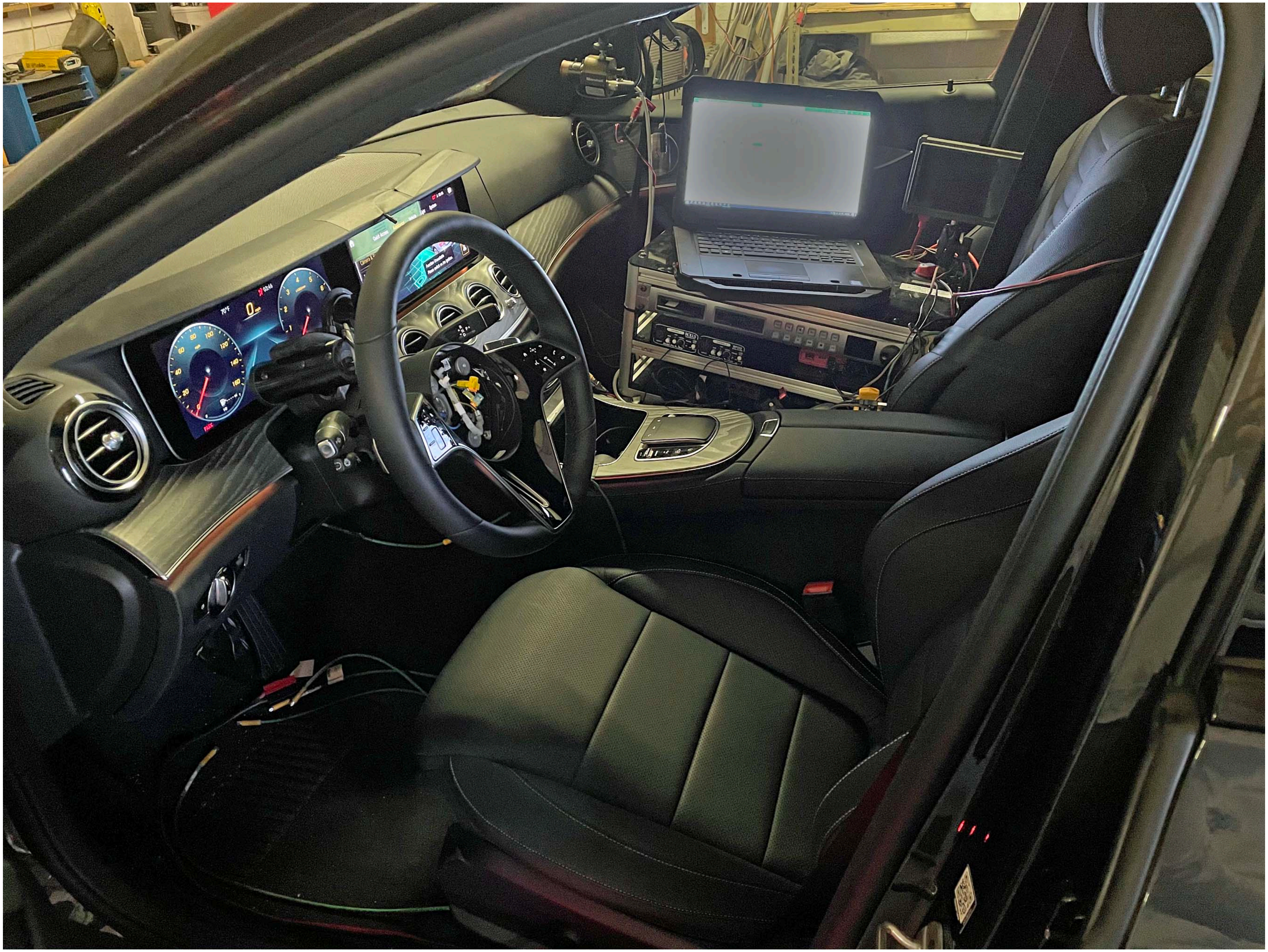


Figure A12. Computer Installed in Subject Vehicle

Figure A13. Brake Actuator Installed in POV System

Figure A14. System Setup Menus

Figure A15. Controls for Interacting with System Menus

Figure A16. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

ⓘ The Active Lane Change Assist sensors adjust automatically while a certain distance is being driven after the vehicle has been delivered. Active Lane Change Assist is unavailable or only partially available during this teach-in process; no arrow appears next to the Active Steering Assist symbol when the turn signal indicator is activated.

Activating/deactivating Active Lane Change Assist

Multimedia system:

» Settings » Assistance » Active Lane Change Assist

▶ Activate or deactivate the function.

Active Brake Assist

Function of Active Brake Assist

Active Brake Assist consists of the following functions:

- Distance warning function
- Autonomous braking function
- Situation-dependent braking assistance
- **Vehicles with Driving Assistance Package:** Evasive Steering Assist and cornering function

Active Brake Assist can help you to minimize the risk of a collision with vehicles, cyclists or pedestrians or to reduce the effects of such a collision.

If Active Brake Assist has detected a risk of collision, a warning tone sounds and the distance warning lamp lights up in the instrument cluster.

If you do not react to the warning, autonomous braking can be initiated in critical situations.

In especially critical situations, Active Brake Assist can initiate autonomous braking directly. In this case, the warning lamp and warning tone occur simultaneously with the braking application.

If you apply the brake yourself in a critical situation or apply the brake during autonomous braking, situation-dependent braking assistance occurs. The brake pressure increases up to maximum full-stop braking if necessary.

Observe the notes on driving systems and your responsibility; you may otherwise fail to recognize dangers (→ page 172).

If autonomous braking or situation-dependent braking assistance has occurred, display 1 appears in the multifunction display and then automatically goes out after a short time.

⚠ **WARNING** Risk of an accident caused by limited detection performance of Active Brake Assist

Active Brake Assist cannot always clearly identify objects and complex traffic situations.

- Always pay careful attention to the traffic situation; do not rely on Active Brake Assist alone. Active Brake Assist is only an aid. The driver is responsible for maintaining a sufficiently safe distance to the vehicle in front, vehicle speed and for braking in good time.
- Be prepared to brake or swerve if necessary.

Also observe the system limits of Active Brake Assist.

The individual subfunctions are available in various speed ranges:

The distance warning function can issue a warning in the following situations:

- From approximately 4 mph (7 km/h), if your vehicle is critically close to a vehicle, cyclist or pedestrian, you will hear an intermittent warning tone and the [distance warning symbol] distance warning lamp lights up in the instrument cluster.

Brake immediately or take evasive action, provided it is safe to do so and the traffic situation allows this.

Distance warning function (vehicles without Driving Assistance Package)

The distance warning function can aid you in the following situations with an intermittent warning tone and a warning lamp:

- At speeds up to approximately 155 mph (250 km/h) when approaching vehicles ahead
- At speeds up to approximately 50 mph (80 km/h) when approaching stationary vehicles, pedestrians walking in the direction of travel and cyclists ahead
- At speeds up to approximately 37 mph (60 km/h) when approaching crossing pedestrians

Distance warning function (vehicles with Driving Assistance Package)

The distance warning function can aid you in the following situations with an intermittent warning tone and a warning lamp:

- At speeds up to approximately 155 mph (250 km/h) when approaching vehicles ahead
- At speeds up to approximately 62 mph (100 km/h) when approaching stationary vehicles
- At speeds up to approximately 50 mph (80 km/h) when approaching moving pedestrians and cyclists ahead
- At speeds up to approximately 43 mph (70 km/h) when approaching stationary pedestrians, crossing vehicles and stationary and crossing cyclists

Autonomous braking function (vehicles without Driving Assistance Package)

If the vehicle is traveling at speeds above approximately 4 mph (7 km/h), the autonomous braking function may intervene in the following situations:

- At speeds up to approximately 124 mph (200 km/h) when approaching vehicles ahead
- At speeds up to approximately 50 mph (80 km/h) when approaching cyclists ahead
- At speeds up to approximately 37 mph (60 km/h) when approaching stationary vehicles or moving pedestrians

Autonomous braking function (vehicles with Driving Assistance Package)

If the vehicle is traveling at speeds above approximately 4 mph (7 km/h), the autonomous braking function may intervene in the following situations:

- At speeds up to approximately 155 mph (250 km/h) when approaching vehicles ahead
- At speeds up to approximately 62 mph (100 km/h) when approaching stationary vehicles
- At speeds up to approximately 50 mph (80 km/h) when approaching cyclists ahead
- At speeds up to approximately 43 mph (70 km/h) when approaching stationary and moving pedestrians, crossing vehicles and stationary and crossing cyclists

Situation-dependent braking assistance (vehicles without Driving Assistance Package)

The situation-dependent braking assistance can intervene from a speed of approximately 4 mph (7 km/h) in the following situations:

- At speeds up to approximately 155 mph (250 km/h) when approaching vehicles ahead
- At speeds up to approximately 50 mph (80 km/h) when approaching stationary vehicles and vehicles ahead
- At speeds up to approximately 37 mph (60 km/h) when approaching moving pedestrians

Situation-dependent braking assistance (vehicles with Driving Assistance Package)

The situation-dependent braking assistance can intervene from a speed of approximately 4 mph (7 km/h) in the following situations:

- At speeds up to approximately 155 mph (250 km/h) when approaching vehicles ahead
- At speeds up to approximately 62 mph (100 km/h) when approaching stationary vehicles
- At speeds up to approximately 50 mph (80 km/h) when approaching cyclists ahead
- At speeds up to approximately 37 mph (60 km/h) when approaching stationary and moving pedestrians, crossing vehicles and stationary and crossing cyclists

Canceling a brake application of Active Brake Assist

You can cancel a brake application of Active Brake Assist at any time by:

- Sharply depressing the accelerator pedal or with kickdown
- Releasing the brake pedal

Active Brake Assist may cancel the brake application when one of the following conditions is fulfilled:

- You maneuver to avoid the obstacle.
- There is no longer a risk of collision.
- An obstacle is no longer detected in front of your vehicle.

Evasive Steering Assist (only vehicles with Driving Assistance Package)

Evasive Steering Assist has the following characteristics:

- The ability to detect stationary or moving pedestrians.
- Assistance through power-assisted steering if it detects a swerving maneuver.
- Activation by an abrupt steering movement during a swerving maneuver.
- Assistance during swerving and straightening of the vehicle.
- Reaction from a speed of approximately 12 mph (20 km/h) up to a speed of approximately 43 mph (70 km/h).

You can prevent the assistance at any time by actively steering.

Cornering function (only vehicles with Driving Assistance Package)

If a danger of collision from an oncoming vehicle is detected when turning across an oncoming lane, autonomous braking can be initiated at speeds below 9 mph (15 km/h) before you have left the lane in which you are driving.

⚠ **WARNING** Risk of accident despite Evasive Steering Assist

Evasive Steering Assist cannot always recognize objects or complex traffic situations clearly.

Moreover, the steering support provided by Evasive Steering Assist is not sufficient to avoid a collision.

▶ Always pay careful attention to the traffic situation; do not rely on Evasive Steering Assist alone.

▶ Be prepared to brake or swerve if necessary.

▶ End the support by actively steering in non-critical situations.

▶ Drive at an appropriate speed if there are pedestrians close to the path of your vehicle.

System limits

Full system performance is not available for a few seconds after switching on the ignition or after driving off.

If Active Brake Assist is impaired or inoperative due to a malfunction, the warning lamp appears in the multifunction display.

The system may be impaired or may not function, particularly in the following situations:

- In snow, rain, fog, heavy spray, if there is glare, in direct sunlight or in greatly varying ambient light.
- If the sensors are dirty, fogged up, damaged or covered.
- If the sensors are impaired due to interference from other radar sources, e.g. strong radar reflections in parking garages.
- If a loss of tire pressure or a faulty tire has been detected and displayed.
- In complex traffic situations where objects cannot always be clearly identified.
- If pedestrians or vehicles move quickly into the sensor detection range.
- If pedestrians are hidden by other objects.
- If the typical outline of a pedestrian cannot be distinguished from the background.
- If a pedestrian is not detected as such, e.g. due to special clothing or other objects.
- If the driver's seat belt is not fastened.
- On bends with a tight radius.

ⓘ The Active Brake Assist sensors adjust automatically while a certain distance is being driven after the vehicle has been delivered. Active Brake Assist is unavailable or only partially available during the teach-in process.

Setting Active Brake Assist

Requirements:
- The ignition is switched on.

Multimedia system:

⮑ ⌂ ▸▸ Settings ▸▸ Assistance ▸▸ Active Brake Assist

▶ Select the desired setting.
The setting is retained when the drive system is next started.

Deactivating Active Brake Assist

ⓘ It is recommended that you always leave Active Brake Assist activated.

▶ Select Off.
The distance warning function, the autonomous braking function and the Evasive Steering Assist are deactivated.
When the vehicle is next started, the middle setting is automatically selected.

ⓘ If Active Brake Assist is deactivated, the OFF symbol appears in the status bar of the multifunction display.

Traffic Sign Assist

Function of Traffic Sign Assist

Traffic Sign Assist detects traffic signs with the multifunction camera (→ page 172). It assists you by displaying detected speed limits and overtaking restrictions in the instrument cluster.

Observe the notes on driving systems and your responsibility; you may otherwise fail to recognize dangers (→ page 172).

Since Traffic Sign Assist also uses the data stored in the navigation system, it can update the display in the following situations without detecting traffic signs.

Full-screen menus

You can display the following menus full-screen on the Instrument Display:

- Assistance
- Trip
- Navigation

▶ On the corresponding menu, use the left-hand Touch Control to scroll to the end of the list.

▶ Press the left-hand Touch Control.
The selected menu will be displayed full-screen.

Overview of displays on the multifunction display

Displays on the multifunction display

Active Parking Assist activated (→ page 221)

Parking Assist PARKTRONIC deactivated (→ page 218)

Cruise control (→ page 180)

Active Distance Assist DISTRONIC (→ page 182)

Active Brake Assist (→ page 198)

Active Steering Assist (→ page 190)

Active Traffic Jam Assist (→ page 189)

Active Lane Keeping Assist (→ page 205)

Active Lane Change Assist (→ page 192)

ECO start/stop function (→ page 152)

HOLD HOLD function (→ page 177)

Adaptive Highbeam Assist (→ page 126)

Adaptive Highbeam Assist Plus (→ page 127)

Vehicles with Traffic Sign Assist: Detected instructions and traffic signs (→ page 198).

For an overview of the indicator and warning lamps, see (→ page 399).

Head-up Display

Function of the Head-up Display

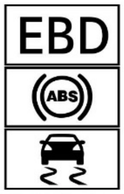
! **NOTE** Mercedes-AMG vehicles

▶ Observe the notes in the Supplement. You could otherwise fail to recognize dangers.

The Head-up Display projects the following information into the driver's field of vision above the cockpit, for example:

- The vehicle speed
- Information from the navigation system
- Information from the driving systems and driving safety systems
- Some warning messages

Depending on the vehicle's equipment, different content can be shown in the three areas of the Head-up Display (→ page 231).

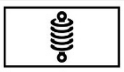
Display messages	Possible causes/consequences and ▶ Solutions
	▶ Have ESP® checked at a qualified specialist workshop.
 Inoperative See Operator's Manual	* EBD, ABS and ESP® are malfunctioning. Other driving systems and driving safety systems (e.g. BAS) may also be malfunctioning. ⚠ **WARNING** Risk of skidding if EBD, ABS and ESP® are malfunctioning The wheels may block during braking and ESP® does not perform any vehicle stabilization. The steerability and braking characteristics are heavily impaired and the braking distance may increase. In addition, other driving safety systems are switched off. ▶ Drive on carefully. ▶ Have the brake system checked immediately at a qualified specialist workshop.
Active Brake Assist Functions Currently Limited See Operator's Manual	* **Vehicles with the Driving Assistance Package:** Active Brake Assist with cross-traffic function, Evasive Steering Assist or PRE-SAFE® PLUS are temporarily unavailable or only partially available. **Vehicles without the Driving Assistance Package:** Active Brake Assist is temporarily unavailable. ▶ Drive on. As soon as the ambient conditions are within the system limits, the system will become available again. ▶ If the display message does not disappear, stop the vehicle in accordance with the traffic conditions and restart the engine.

Display messages	Possible causes/consequences and ▶ Solutions
Active Brake Assist Functions Limited See Operator's Manual	* **Vehicles with the Driving Assistance Package:** Active Brake Assist with cross-traffic function, Evasive Steering Assist or PRE-SAFE® PLUS are temporarily unavailable or only partially available. **Vehicles without the Driving Assistance Package:** Active Brake Assist is temporarily unavailable or only partially available. ▶ Consult a qualified specialist workshop.

Mercedes me connect

Display messages	Possible causes/consequences and ▶ Solutions
Mercedes me connect Services Limited See Operator's Manual	* The vehicle functions for fault detection are restricted. At least one of the main functions of the Mercedes me connect system is malfunctioning. ▶ Observe the notes on the diagnostics connection (→ page 26). ▶ Consult a qualified specialist workshop.
 Inoperative	* At least one of the main functions of the Mercedes me connect system or of the SOS emergency call system is malfunctioning. ▶ Consult a qualified specialist workshop.

Driving systems

Warning/indicator lamp	Possible causes/consequences and ▶ Solutions
 Active Brake Assist warning lamp	* The white Active Brake Assist warning lamp is lit. The system is switched off or unavailable.
 Warning lamp for distance warning function	* The red distance warning lamp lights up while the vehicle is in motion. The distance to the vehicle in front is too small for the speed selected. If there is an additional warning tone, you are approaching an obstacle at too high a speed. ▶ Be prepared to brake immediately. ▶ Increase the distance. Function of Active Brake Assist (→ page 194).
 Suspension warning lamp (yellow)	* The yellow AIR BODY CONTROL warning lamp is lit. The yellow DYNAMIC BODY CONTROL warning lamp is lit. A malfunction has occurred in the AIR BODY CONTROL. A malfunction has occurred in the DYNAMIC BODY CONTROL. ▶ Note the messages on the multifunction display.

APPENDIX C

Run Log

Subject Vehicle: **2021 Mercedes-Benz E350 Sedan** Test Date: **1/26/2021**

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								Zero SV front bumper to SSV rear bumper and collect data
2	**Stopped POV**	Y	2.30	0.00	22.9	1.05	0.91	Pass	
3		Y	2.27	0.00	19.7	0.86	0.93	Pass	
4		Y	2.28	0.00	20.8	0.91	0.89	Pass	
5		Y	2.32	0.00	22.9	1.01	0.91	Pass	
6		Y	2.32	0.00	20.2	0.91	0.93	Pass	
7		Y	2.30	0.00	19.6	0.90	0.91	Pass	
8		Y	2.30	0.05	24.9	1.01	0.88	Pass	
9	Static Run								
10	**Slower POV, 25 vs 10**	Y	2.09	3.87	15.6	0.99	0.75	Pass	
11		Y	2.12	2.44	15.0	0.90	0.67	Pass	
12		Y	2.08	0.78	15.5	0.85	0.75	Pass	
13		Y	2.09	3.46	15.4	0.91	0.72	Pass	
14		Y	1.26	3.50	15.1	0.99	0.69	Pass	
15		Y	2.11	3.27	15.5	0.95	0.70	Pass	
16		Y	2.12	1.03	15.3	1.02	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
17	Static Run								Check zero data is within ± 0.167 ft (±0.05m)
18	**Slower POV, 45 vs 20**	Y	2.85	2.88	24.7	0.98	1.06	Pass	
19		Y	2.87	2.56	25.1	0.98	1.11	Pass	
20		Y	2.92	2.58	25.1	0.99	1.05	Pass	
21		Y	2.89	2.06	25.1	0.99	1.03	Pass	
22		Y	2.89	1.74	24.6	0.63	1.14	Pass	
23		Y	2.89	1.19	24.2	1.04	1.10	Pass	
24		Y	2.88	2.21	25.5	0.98	1.07	Pass	
25	Static run								Check zero data is within ± 0.167 ft (±0.05m)
26	**Decelerating POV, 35**	Y	2.16	2.63	26.4	1.02	1.11	Pass	
27		Y	1.90	4.95	24.7	1.02	1.10	Pass	
28		Y	2.24	1.80	26.9	1.02	1.09	Pass	
29		Y	2.24	7.46	25.0	0.99	1.04	Pass	
30		Y	1.78	3.53	24.7	1.02	1.06	Pass	
31		Y	2.02	3.37	23.8	1.02	1.11	Pass	
32		Y	2.13	3.10	25.3	1.00	1.10	Pass	
33	Static Run								Check zero data is within ± 0.167 ft (±0.05m)
34	STP - Static Run								Zero SV front bumper to rear edge of steel plate and collect data

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
35	**STP False Positive, 25**	Y				0.01		Pass	
36		Y				0.01		Pass	
37		Y				0.01		Pass	
38		Y				0.01		Pass	
39		Y				0.01		Pass	
40		Y				0.01		Pass	
41		Y				0.01		Pass	
42	STP - Static Run								Check zero data is within ± 0.167 ft (±0.05m)
43	**STP False Positive, 45**	Y				0.03		Pass	
44		Y				0.03		Pass	
45		Y				0.02		Pass	
46		Y				0.02		Pass	
47		Y				0.02		Pass	
48		Y				0.03		Pass	
49		Y				0.02		Pass	
50	STP - Static Run								Check zero data is within ± 0.167 ft (±0.05m)

APPENDIX D

Time History Plots

LIST OF FIGURES

Description of Time History Plots

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

Time History Plot Description

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

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

Time history figures include the following sub-plots:

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

Envelopes and Thresholds

Some of the time history plot figures contain either green or yellow envelopes and/or black threshold lines. These envelopes and thresholds are used to programmatically and visually determine the validity of a given test run. Envelope and threshold exceedances are indicated with either red shading or red asterisks, and red text is placed to the right side of the plot indicating the type of exceedance. Such exceedances indicate either that the test was invalid or that the requirements of the test were not met (i.e., failure of the AEB system).

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

For plots with yellow envelopes, in order for the test to be valid, the time-varying data must not exceed the envelope at the beginning (left edge of the boundary) and/or end (right edge), but may exceed the boundary during the time between the left and right edges. Exceedances at the left or right extent of a yellow envelope are indicated by red asterisks.

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

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

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

Color Codes

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

Color codes can be broken into four categories:

1. Time-varying data
2. Validation envelopes and thresholds
3. Individual data points
4. Text

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

2. Validation envelope and threshold color codes:
   - Green envelope = time varying data must be within the envelope at all times in order to be valid
   - Yellow envelope = time varying data must be within limits at left and/or right ends
   - Black threshold (Solid) = time varying data must cross this threshold in the time period shown in order to be valid
   - Black threshold (Dashed) = for reference only – this can include warning level thresholds, TTC thresholds, and acceleration thresholds

3. Individual data point color codes:
   - Green circle = passing or valid value at a given moment in time
   - Red asterisk = failing or invalid value at a given moment in time

4. Text color codes:
   - Green = passing or valid value
   - Red = failing or invalid value

Other Notations

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

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

Examples of time history plots for each test type (including passing, failing and invalid runs) are shown in Figure D1 through Figure D9. Figures D1 through D6 show passing runs for each of the 6 test types. Figures D7 and D8 show examples of invalid runs. Figure D9 shows an example of a valid test that failed the CIB requirements.

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

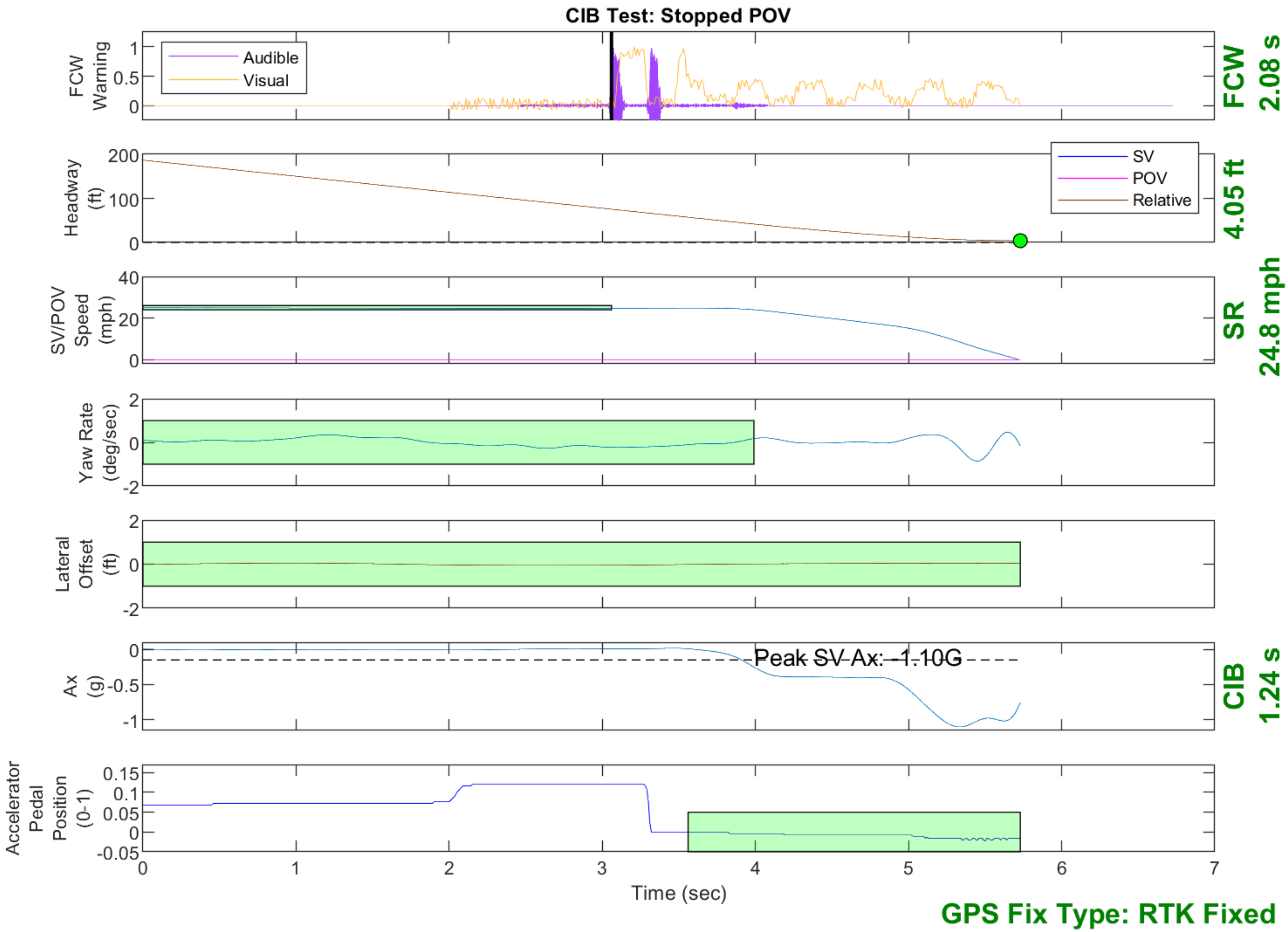


Figure D1. Example Time History for Stopped POV, Passing

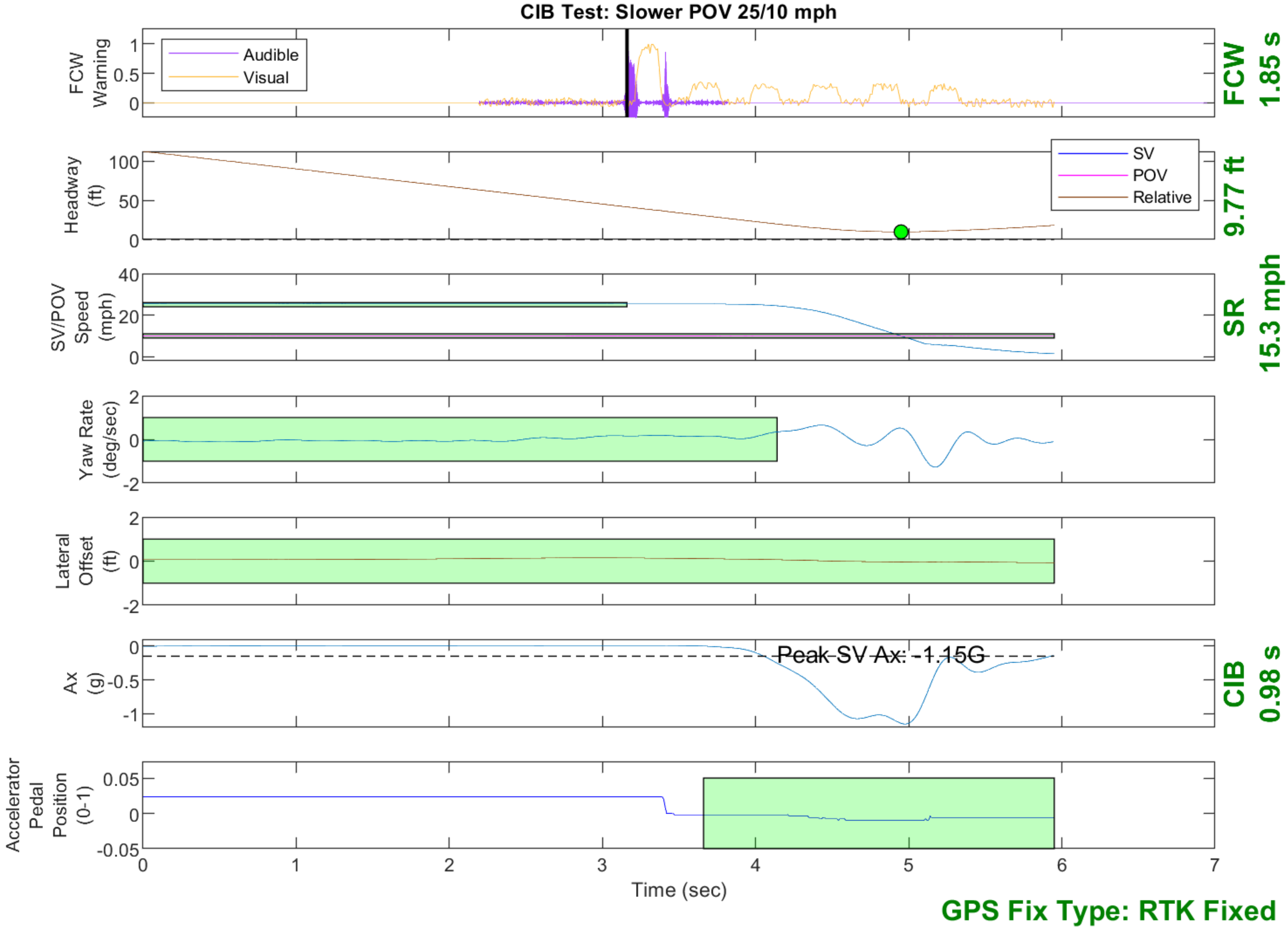


Figure D2. Example Time History for Slower POV 25 vs. 10, Passing

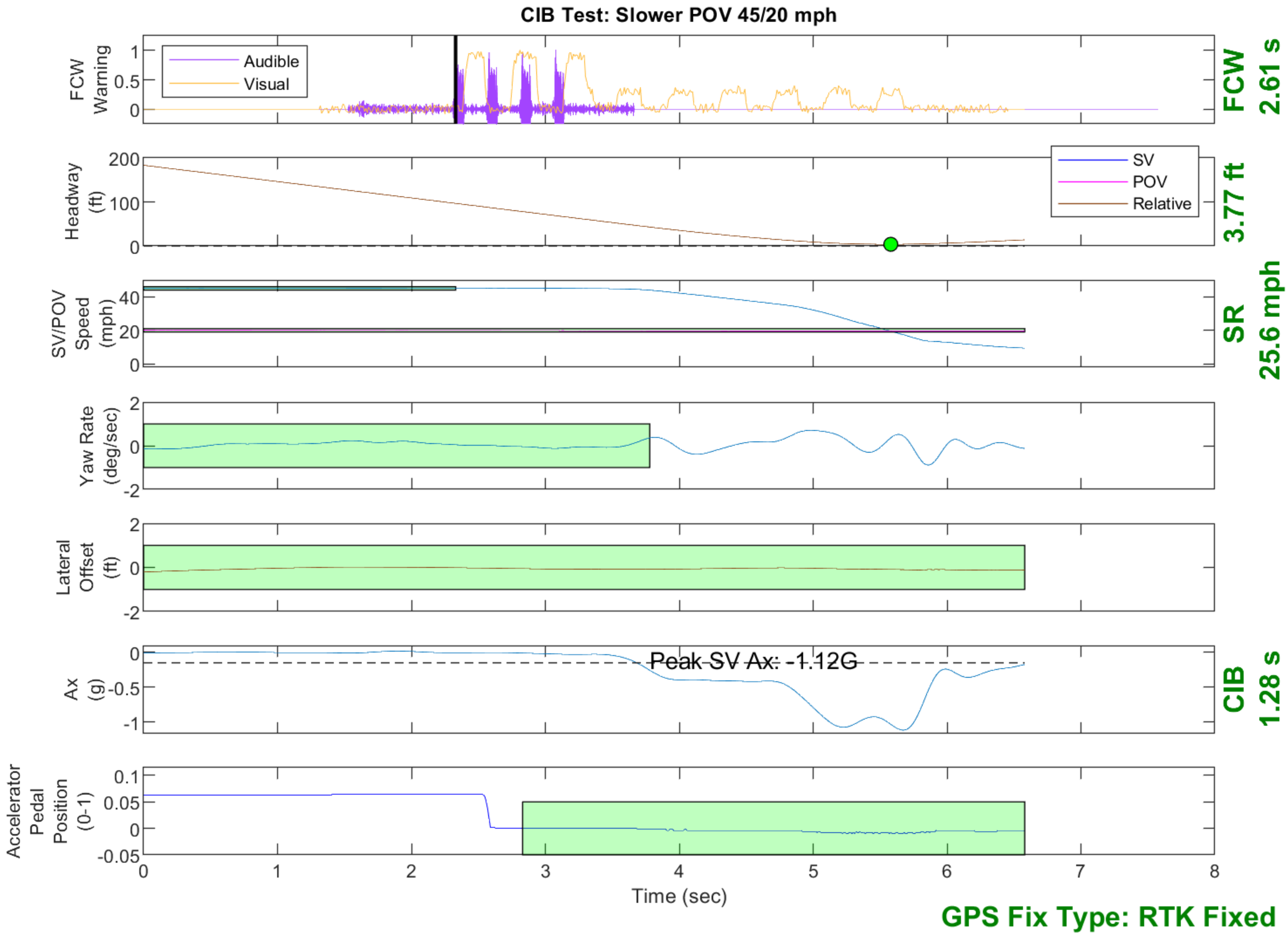


Figure D3. Example Time History for Slower POV 45 vs. 20, Passing

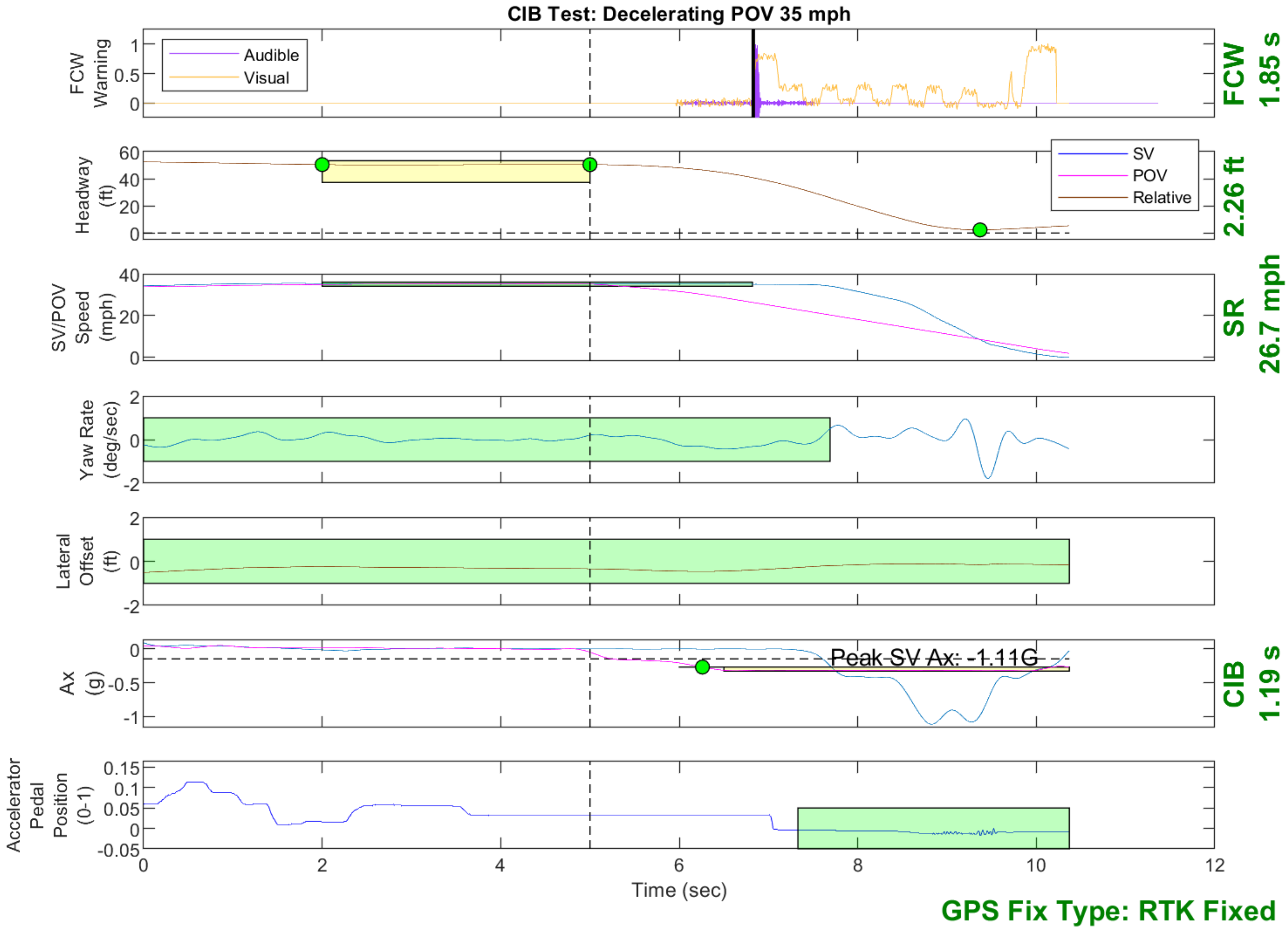


Figure D4. Example Time History for Decelerating POV 35, Passing

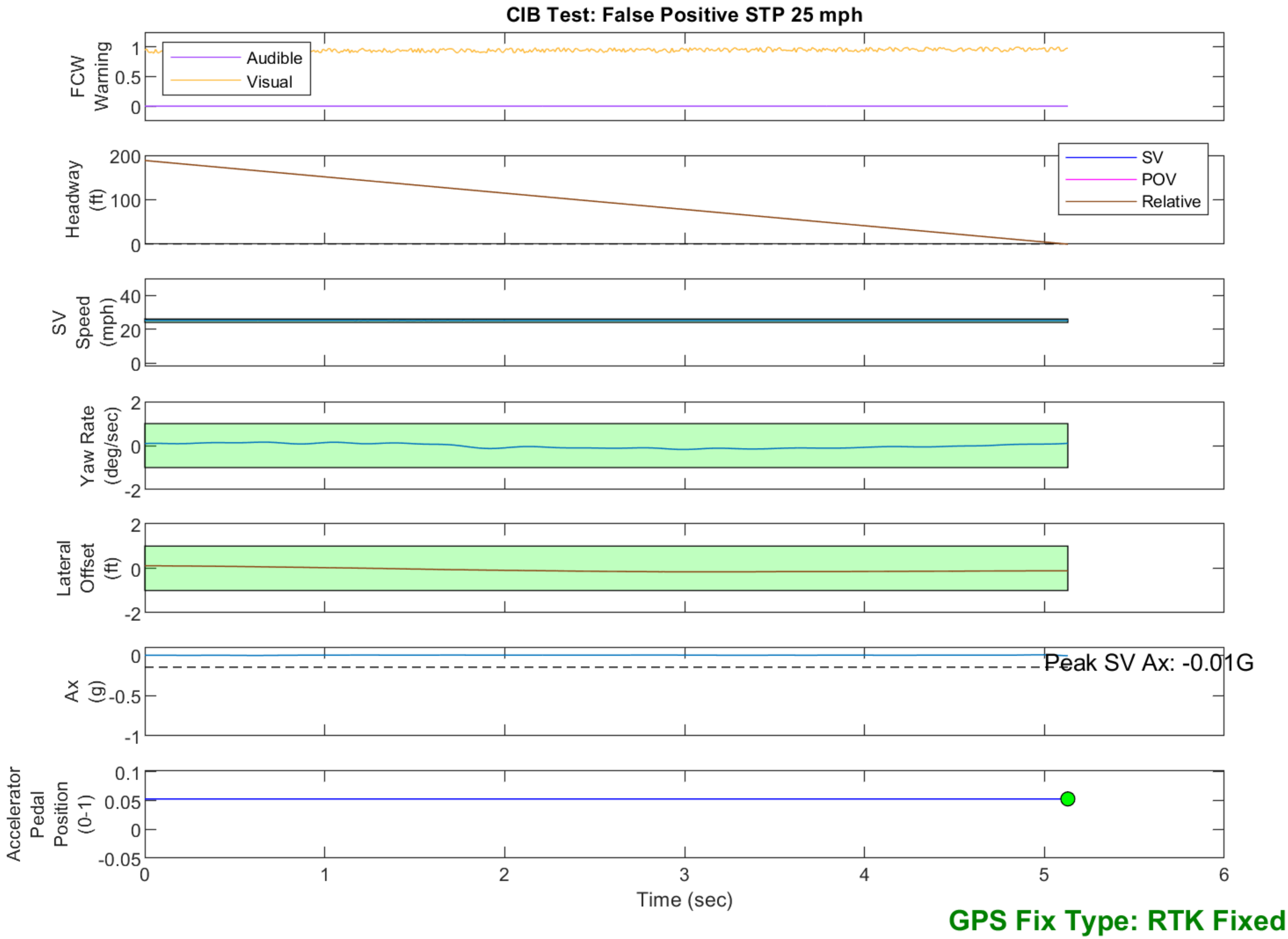


Figure D5. Example Time History for False Positive STP 25, Passing

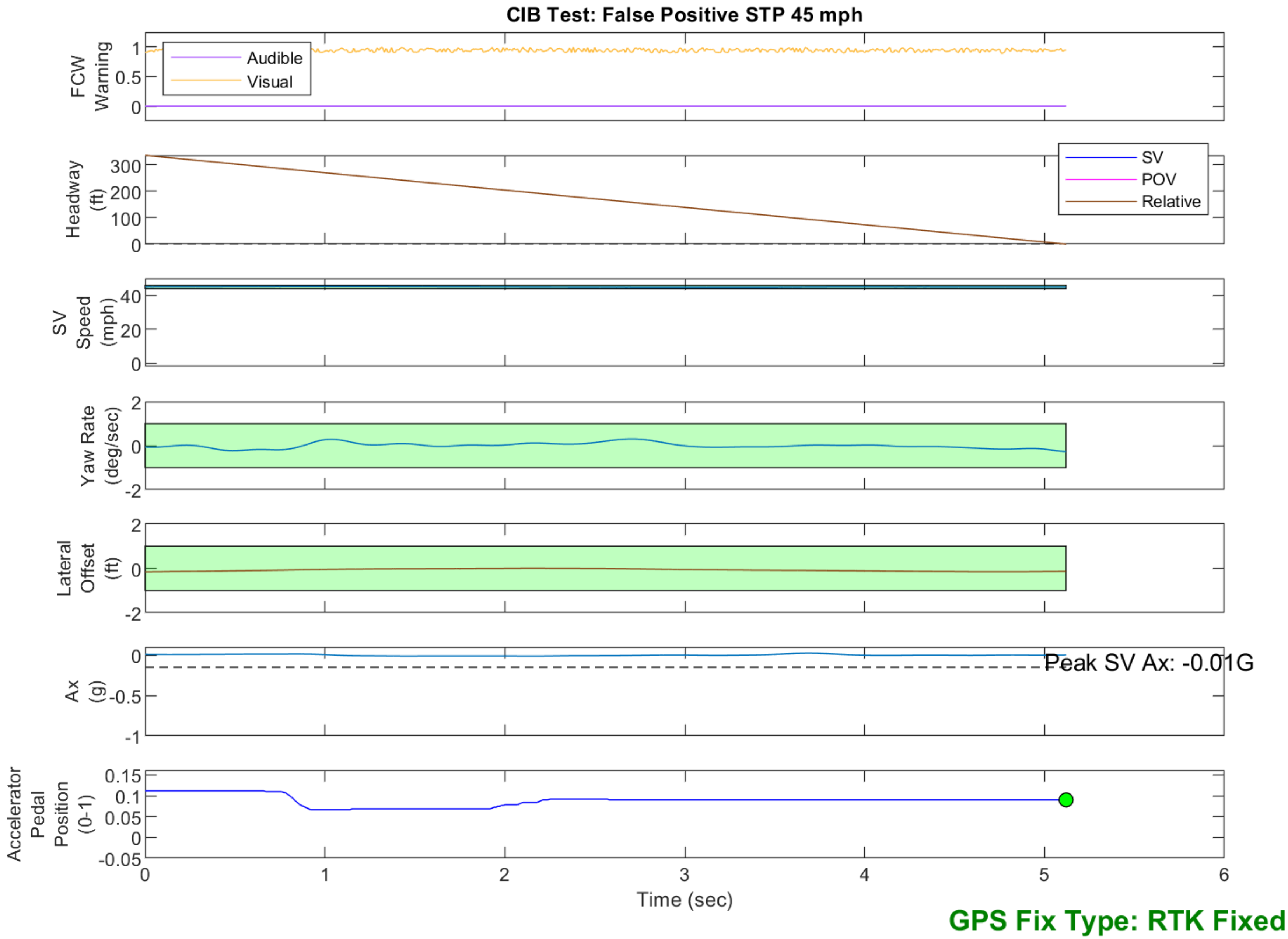


Figure D6. Example Time History for False Positive STP 45, Passing

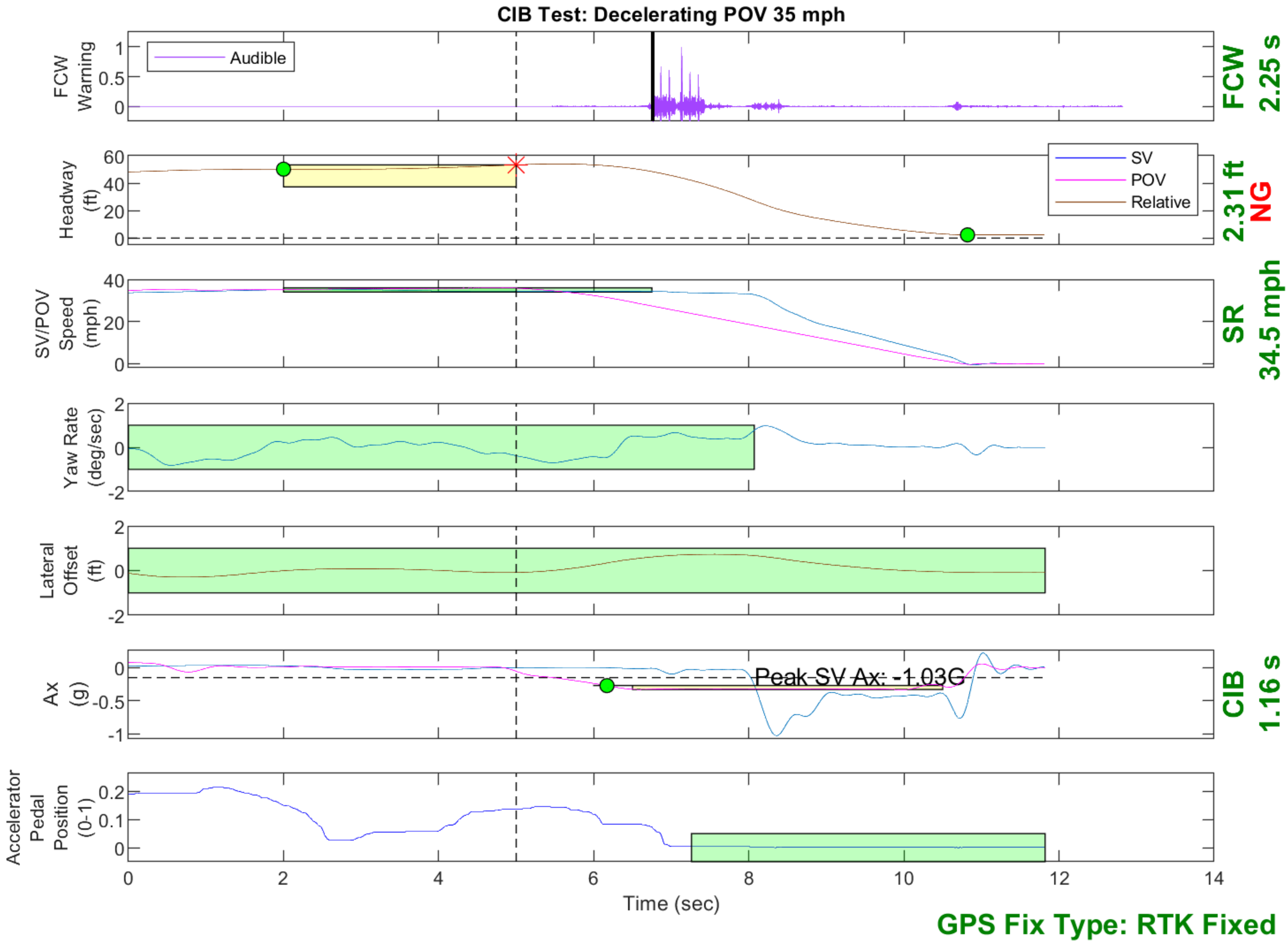


Figure D7. Example Time History Displaying Invalid Headway Criteria

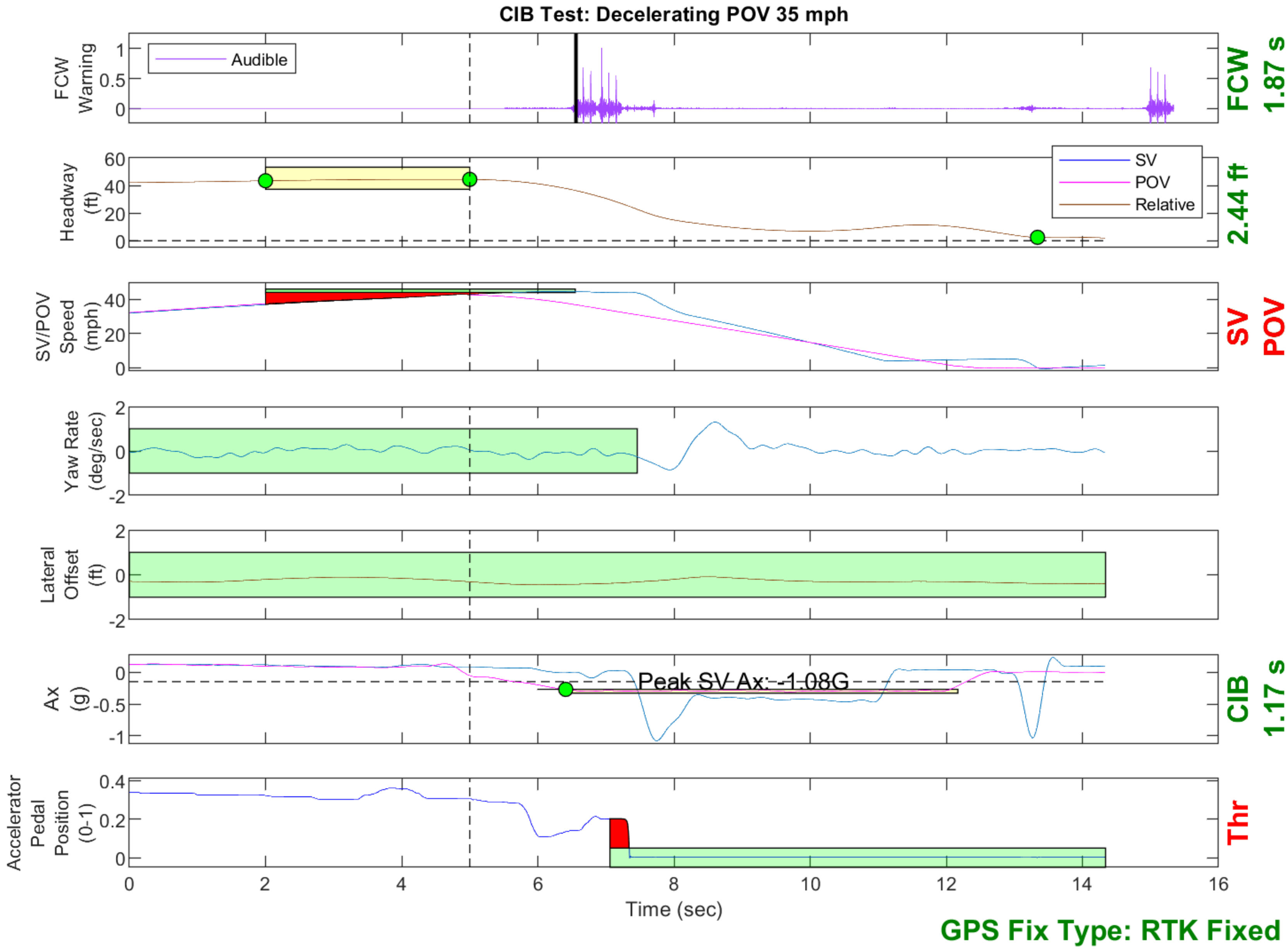


Figure D8. Example Time History Displaying Various Invalid Criteria

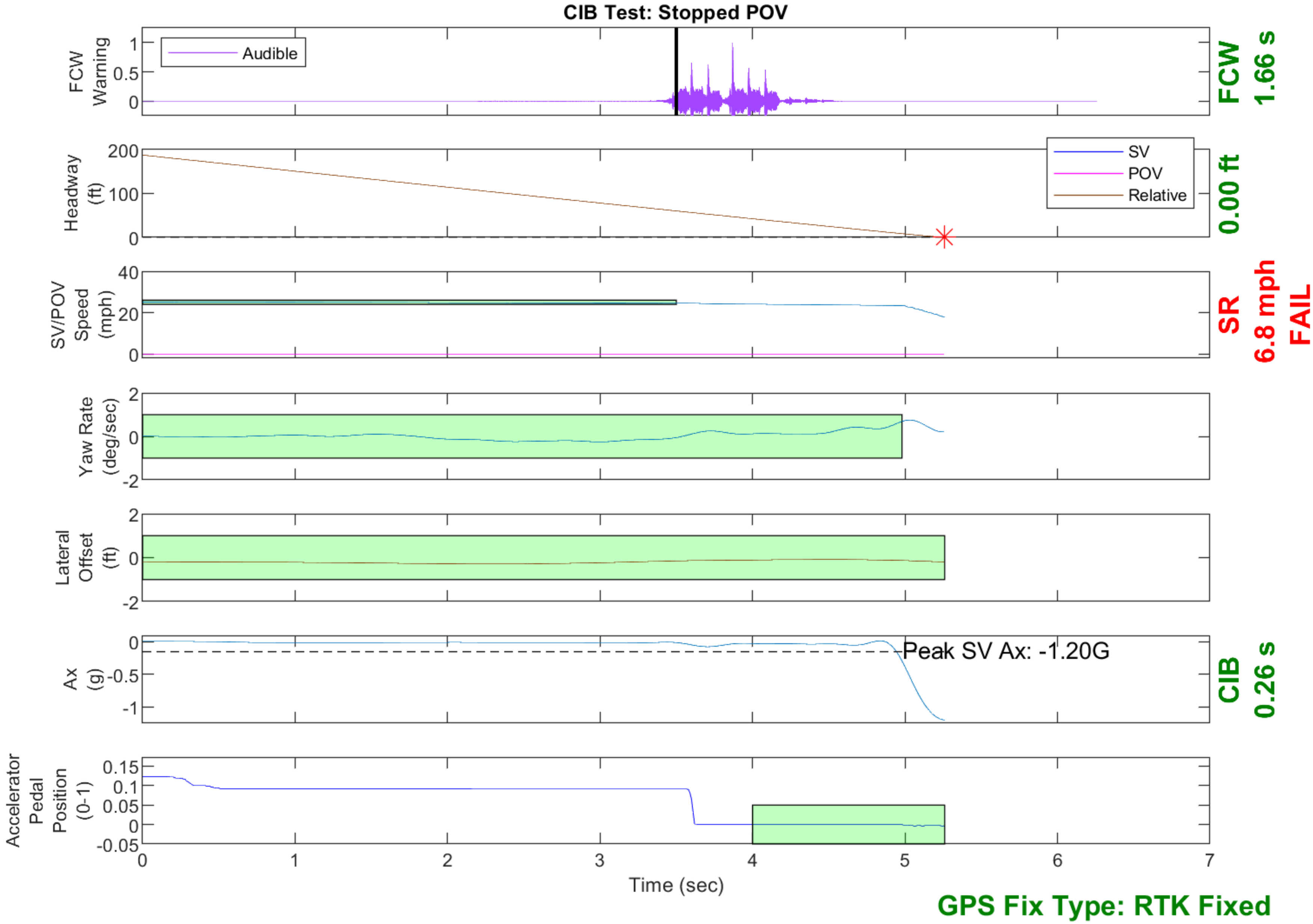


Figure D9. Example Time History for a Failed Run

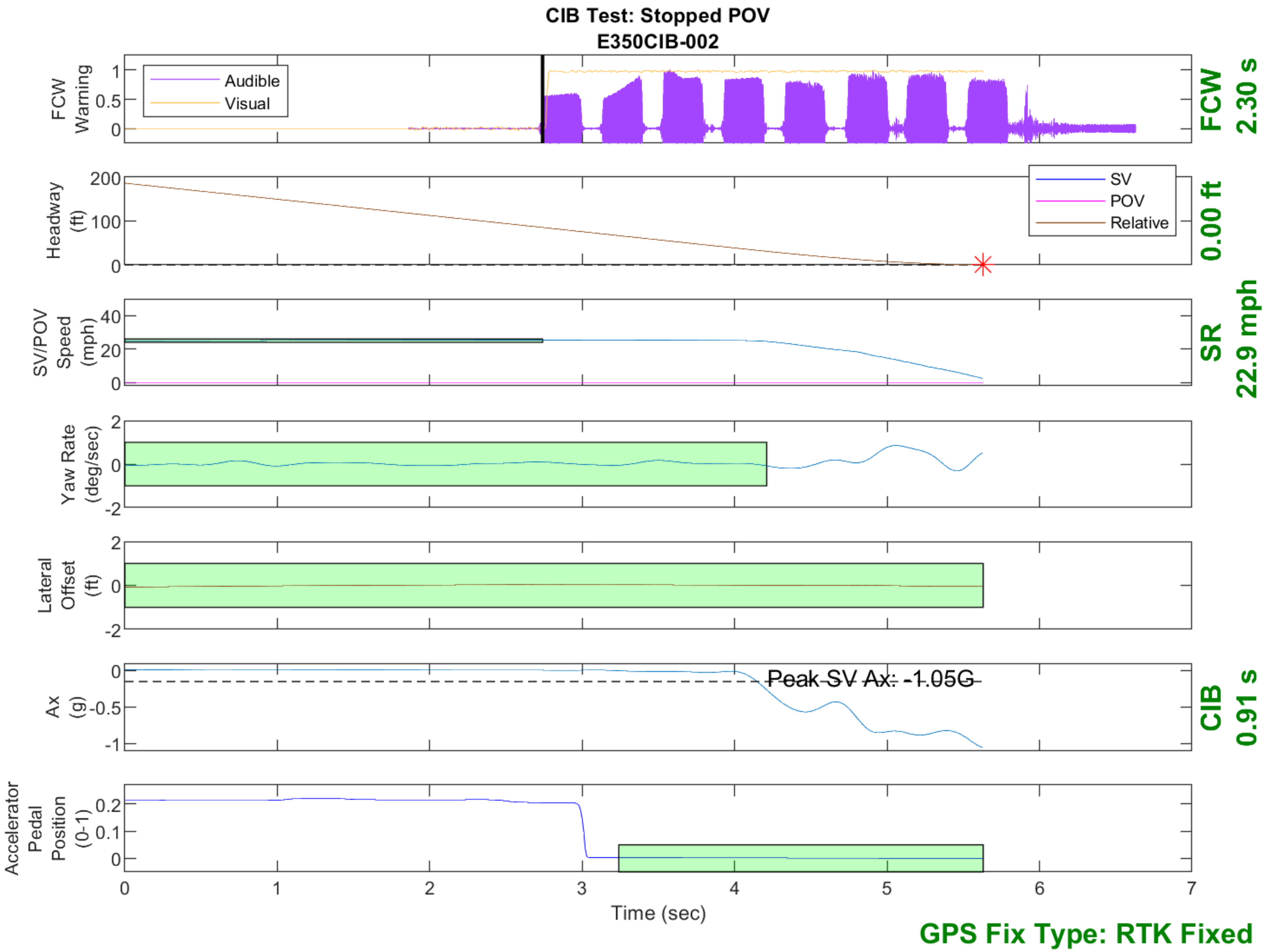


Figure D10. Time History for CIB Run 2, SV Encounters Stopped POV

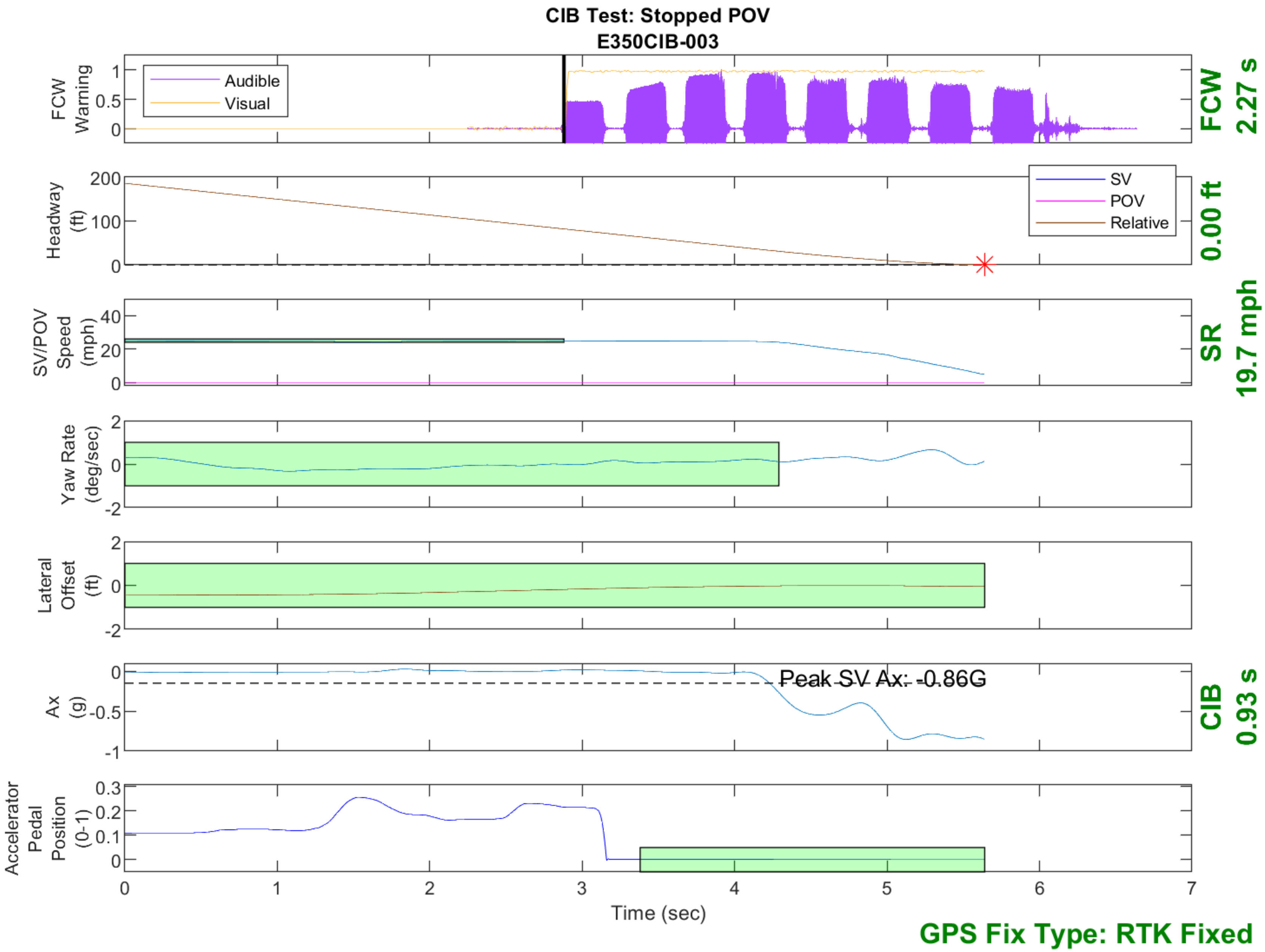


Figure D11. Time History for CIB Run 3, SV Encounters Stopped POV

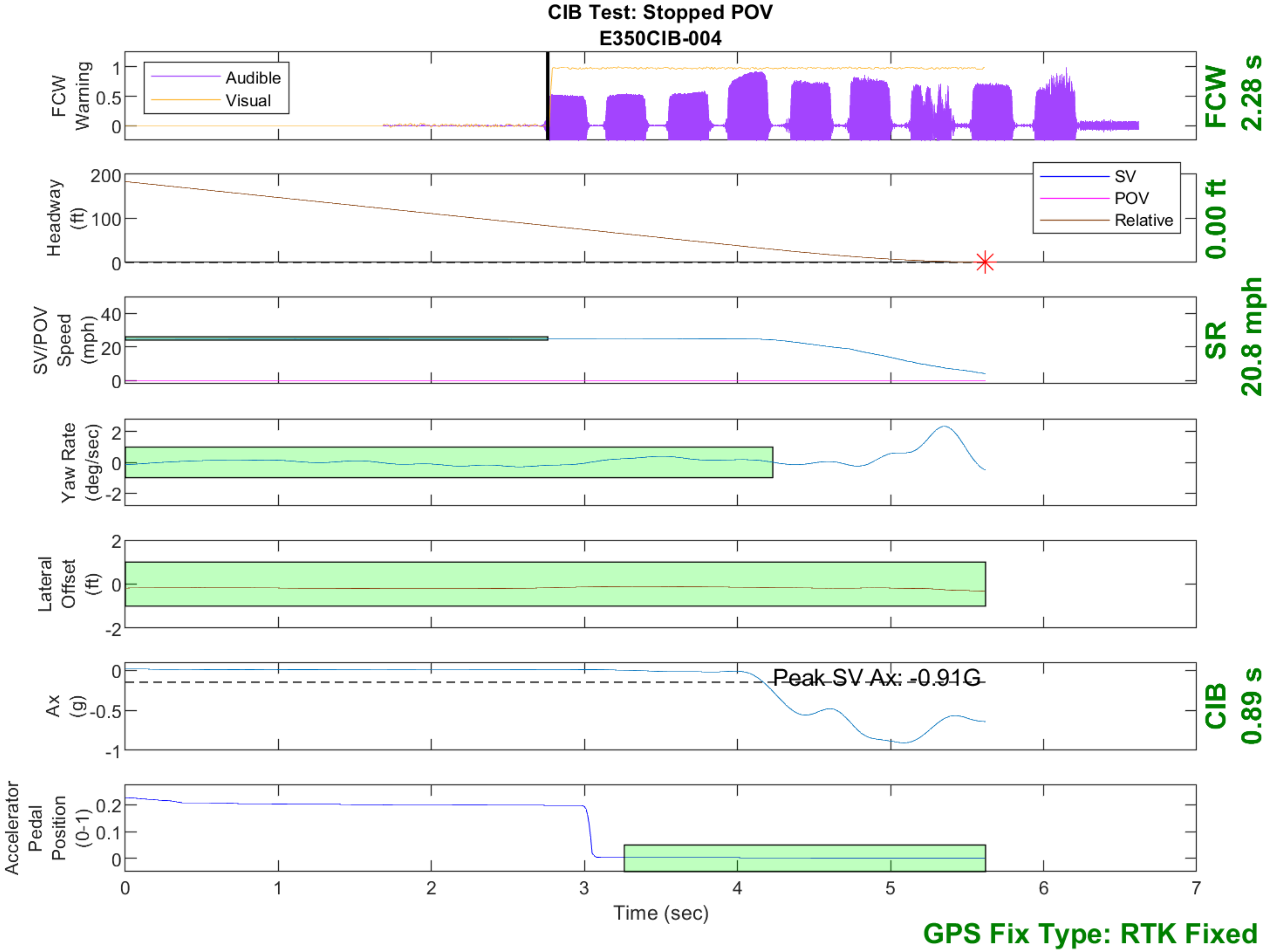


Figure D12. Time History for CIB Run 4, SV Encounters Stopped POV

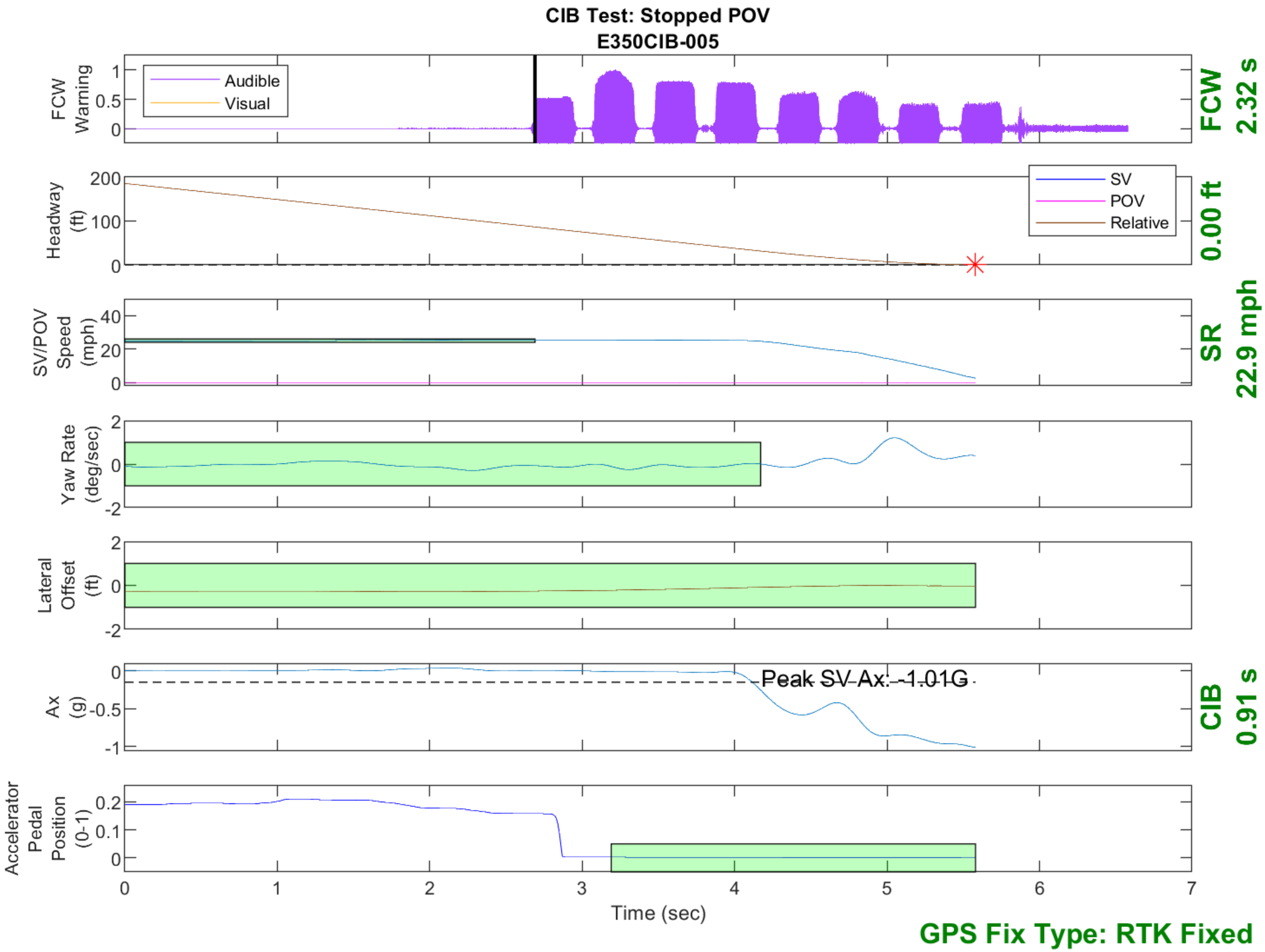


Figure D13. Time History for CIB Run 5, SV Encounters Stopped POV

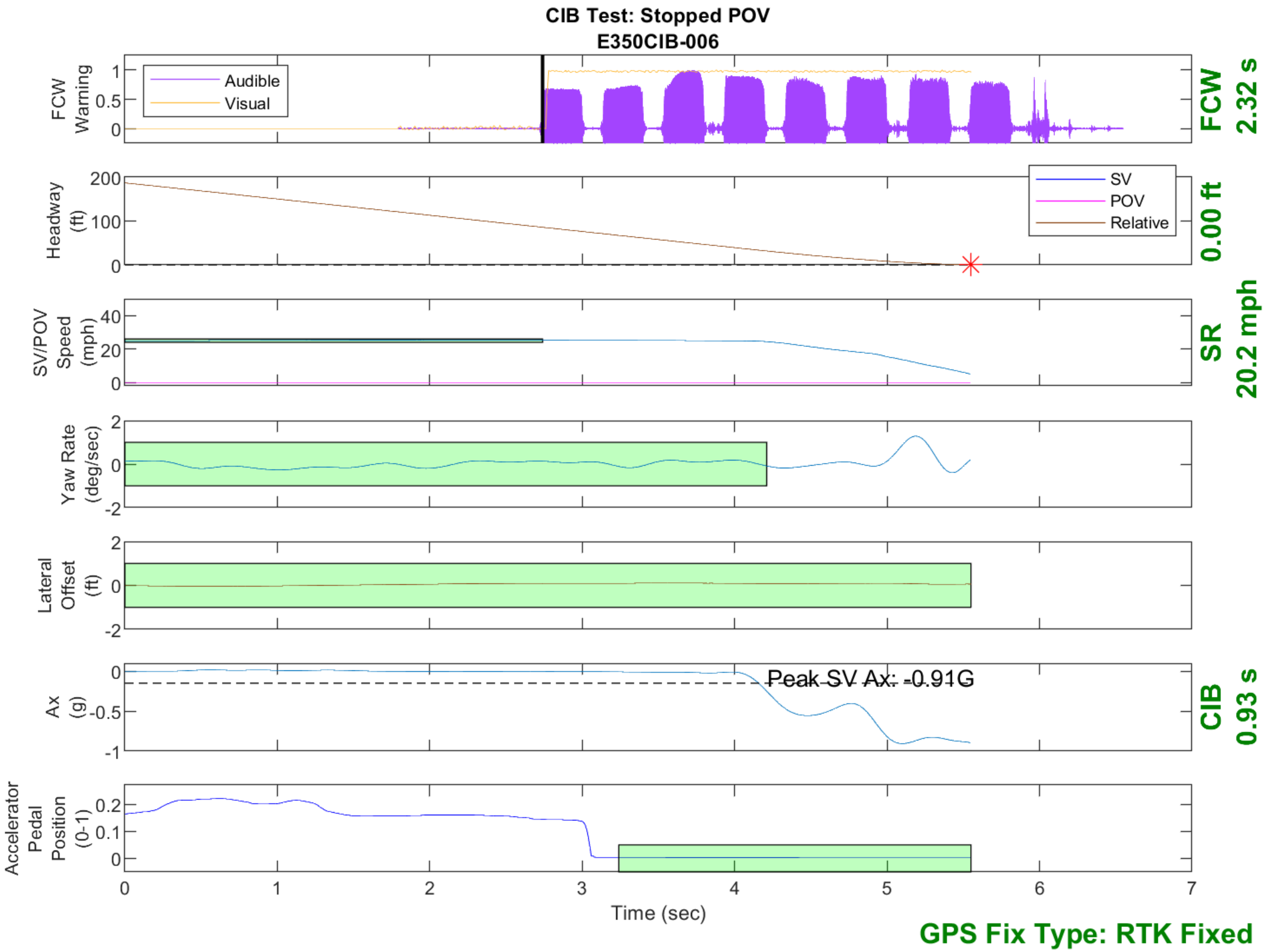


Figure D14. Time History for CIB Run 6, SV Encounters Stopped POV

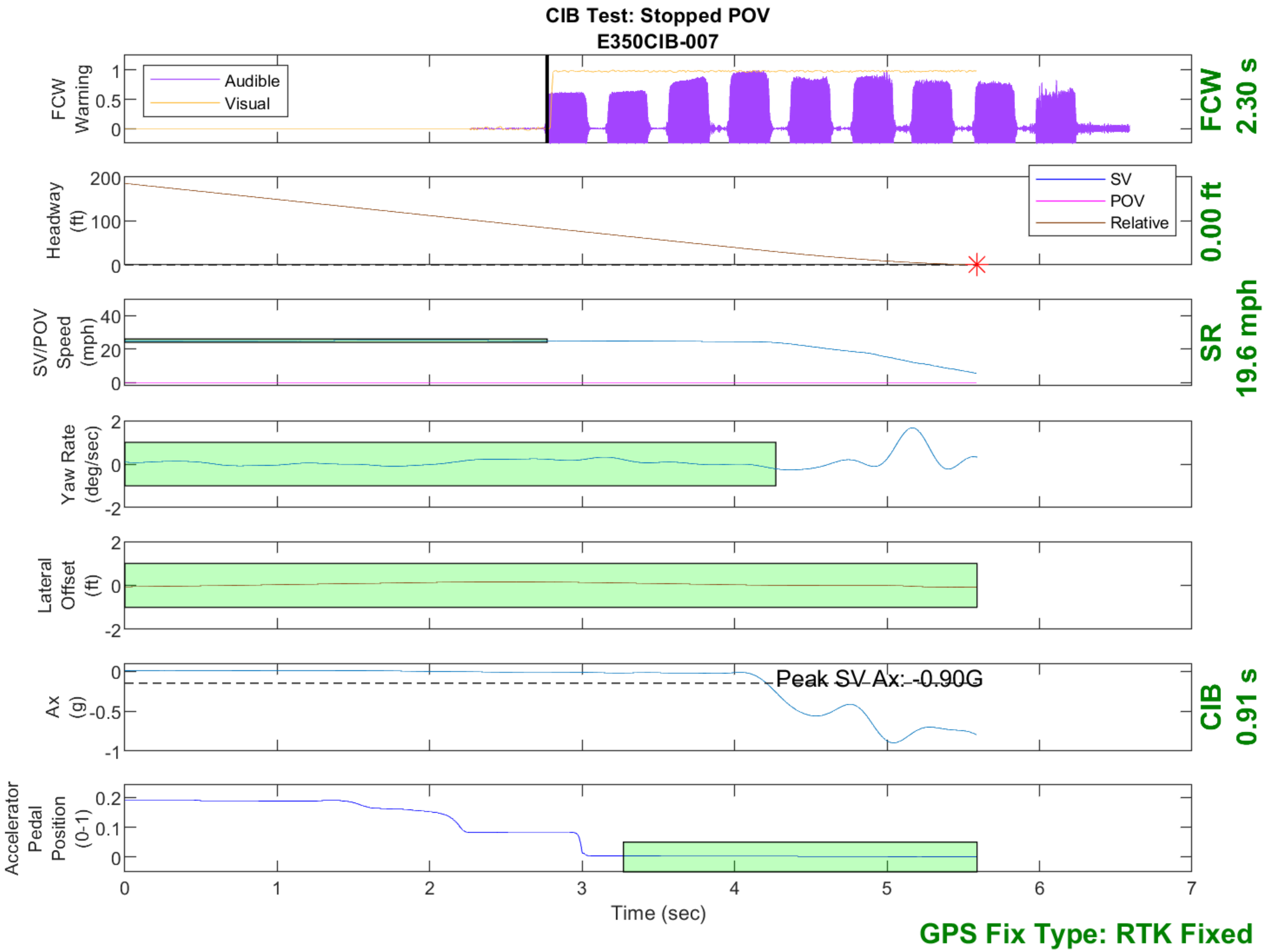


Figure D15. Time History for CIB Run 7, SV Encounters Stopped POV

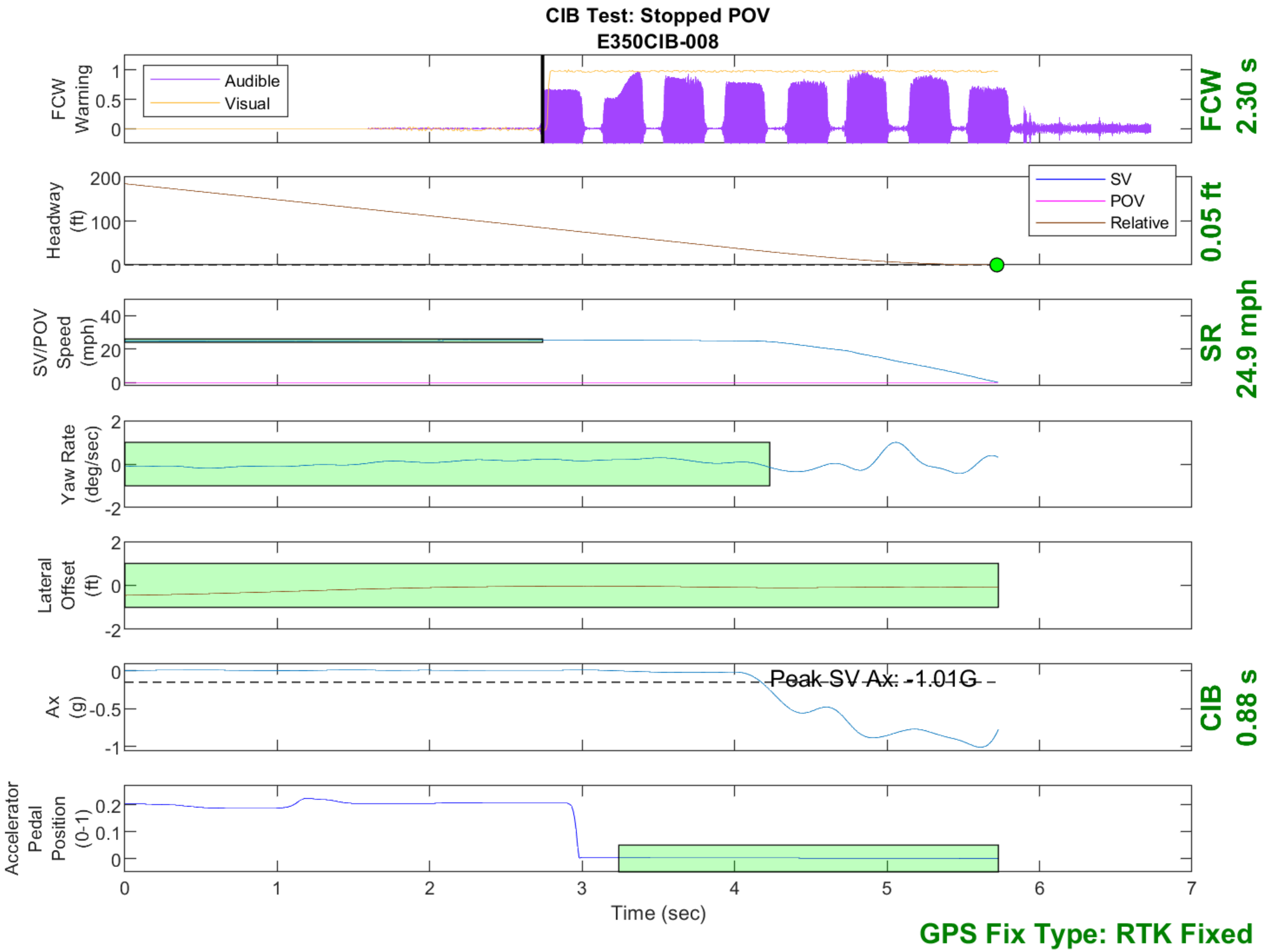


Figure D16. Time History for CIB Run 8, SV Encounters Stopped POV

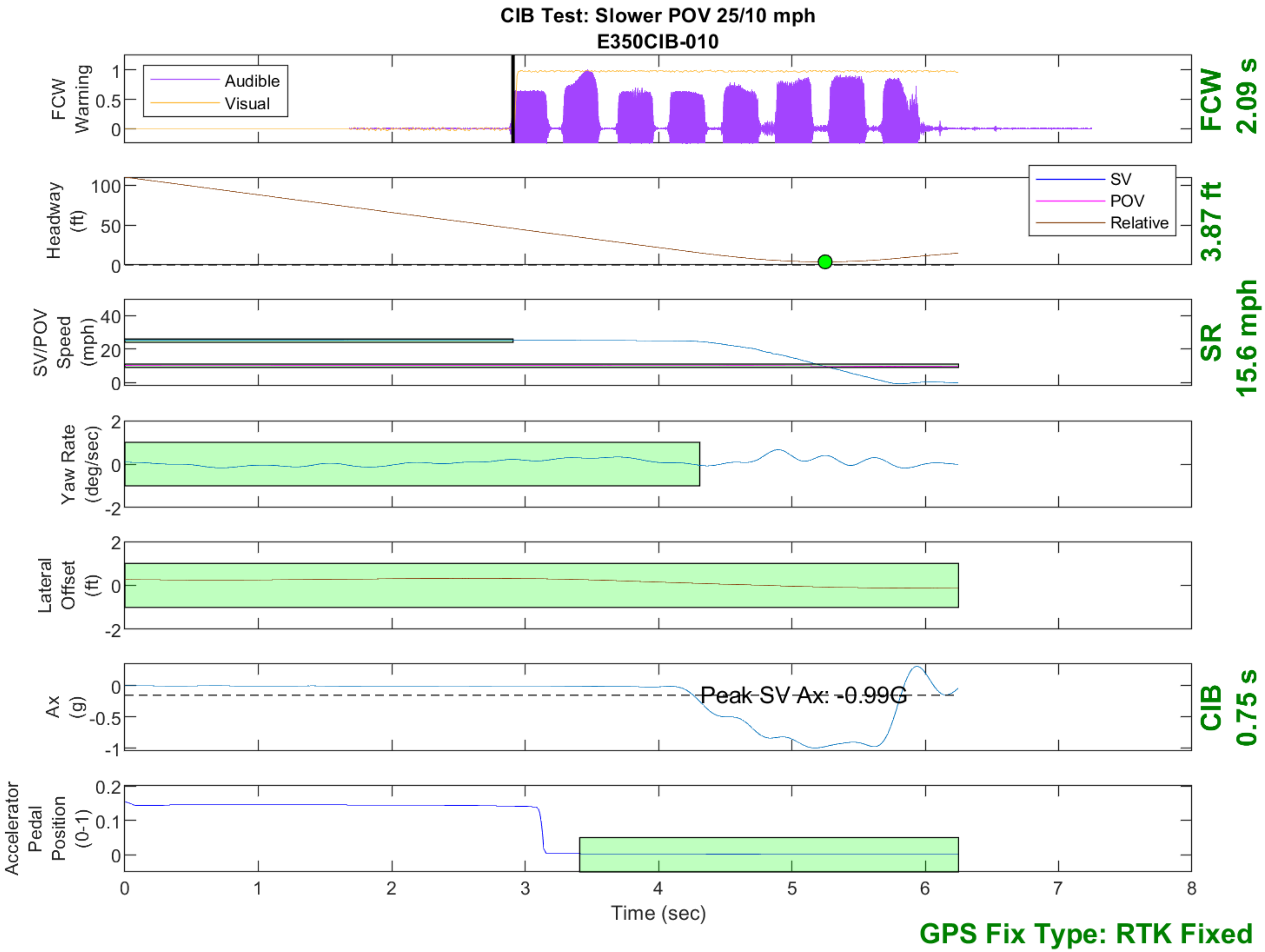


Figure D17. Time History for CIB Run 10, SV Encounters Slower POV, SV 25 mph, POV 10 mph

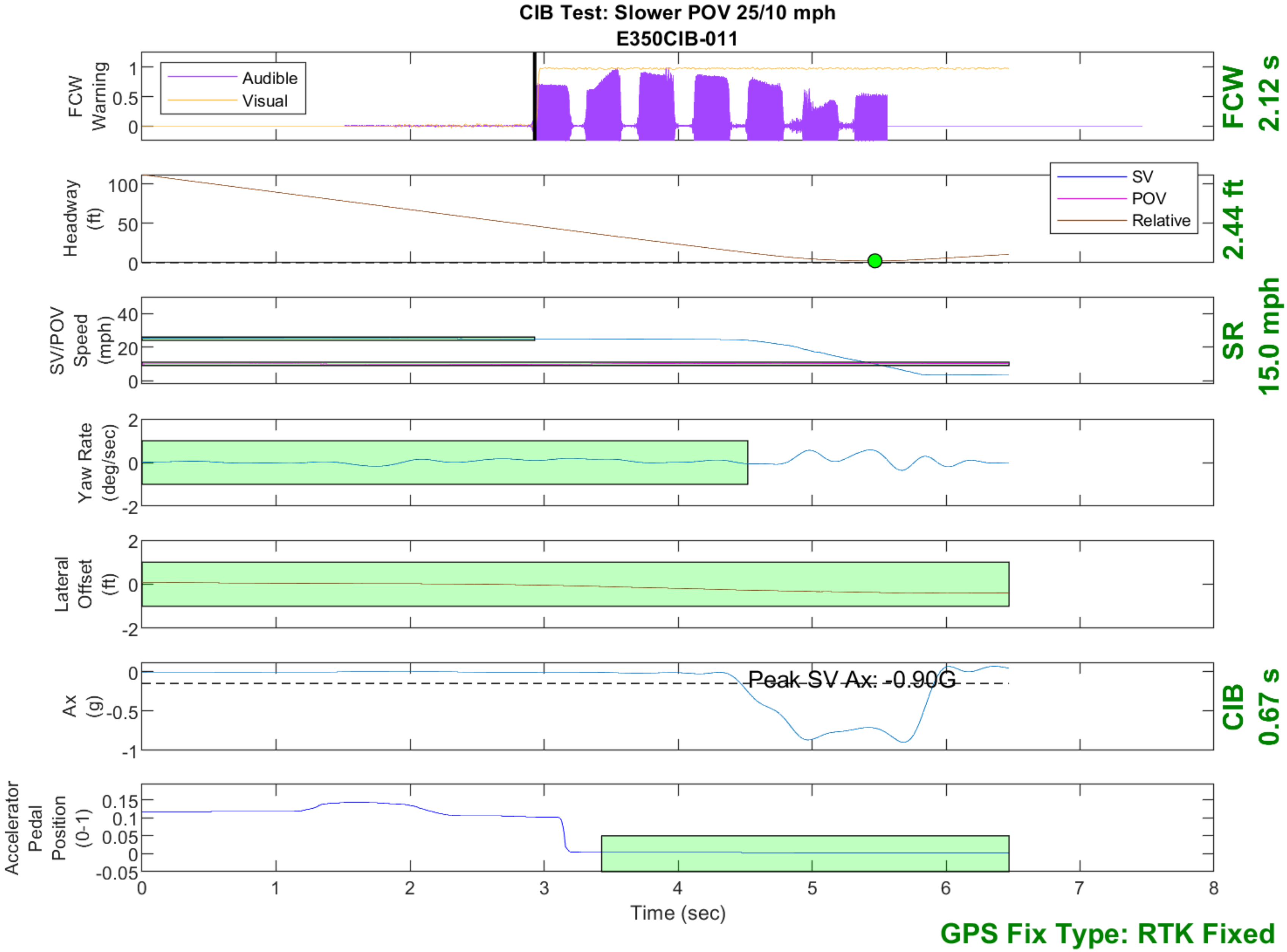


Figure D18. Time History for CIB Run 11, SV Encounters Slower POV, SV 25 mph, POV 10 mph

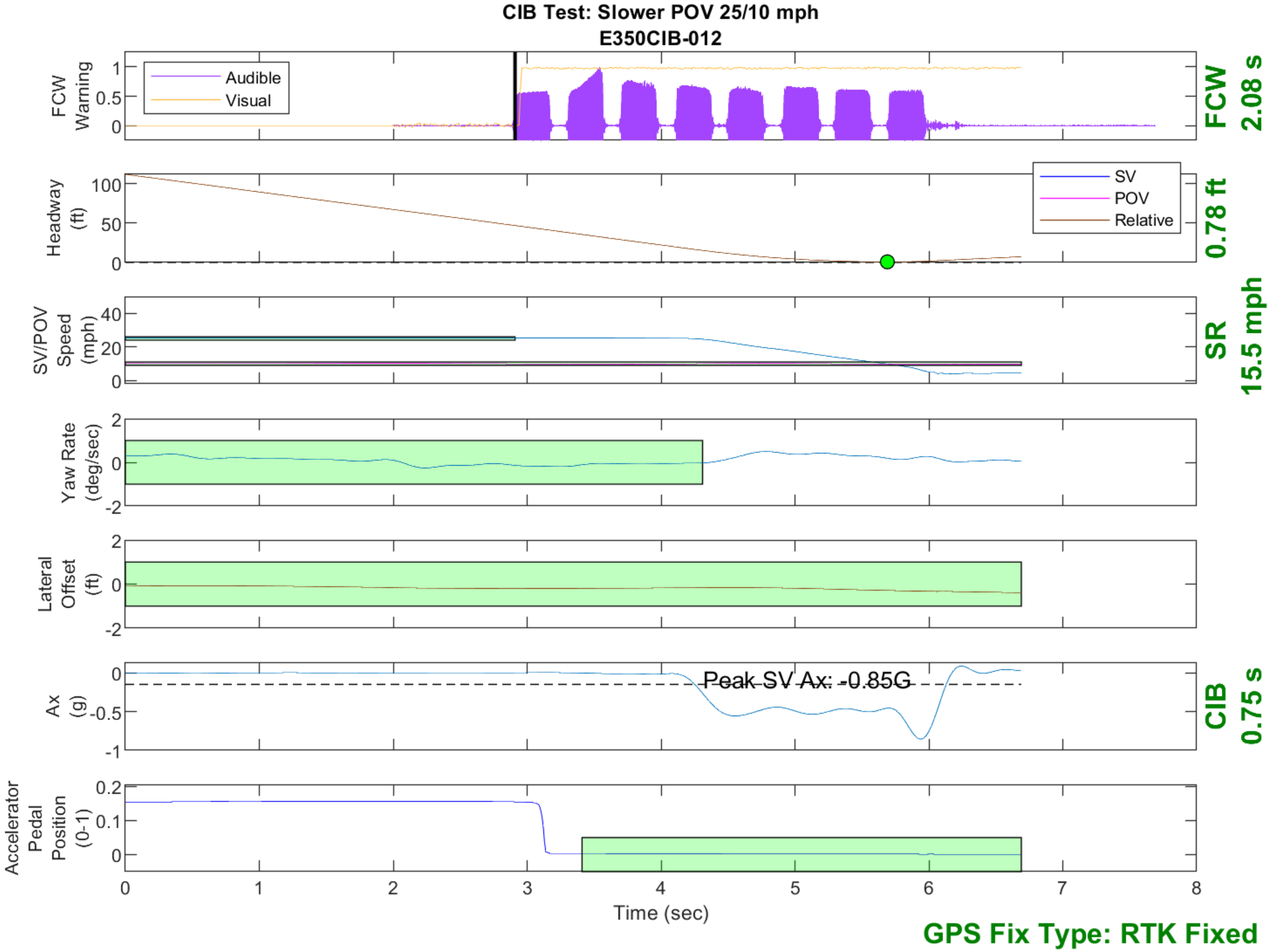


Figure D19. Time History for CIB Run 12, SV Encounters Slower POV, SV 25 mph, POV 10 mph

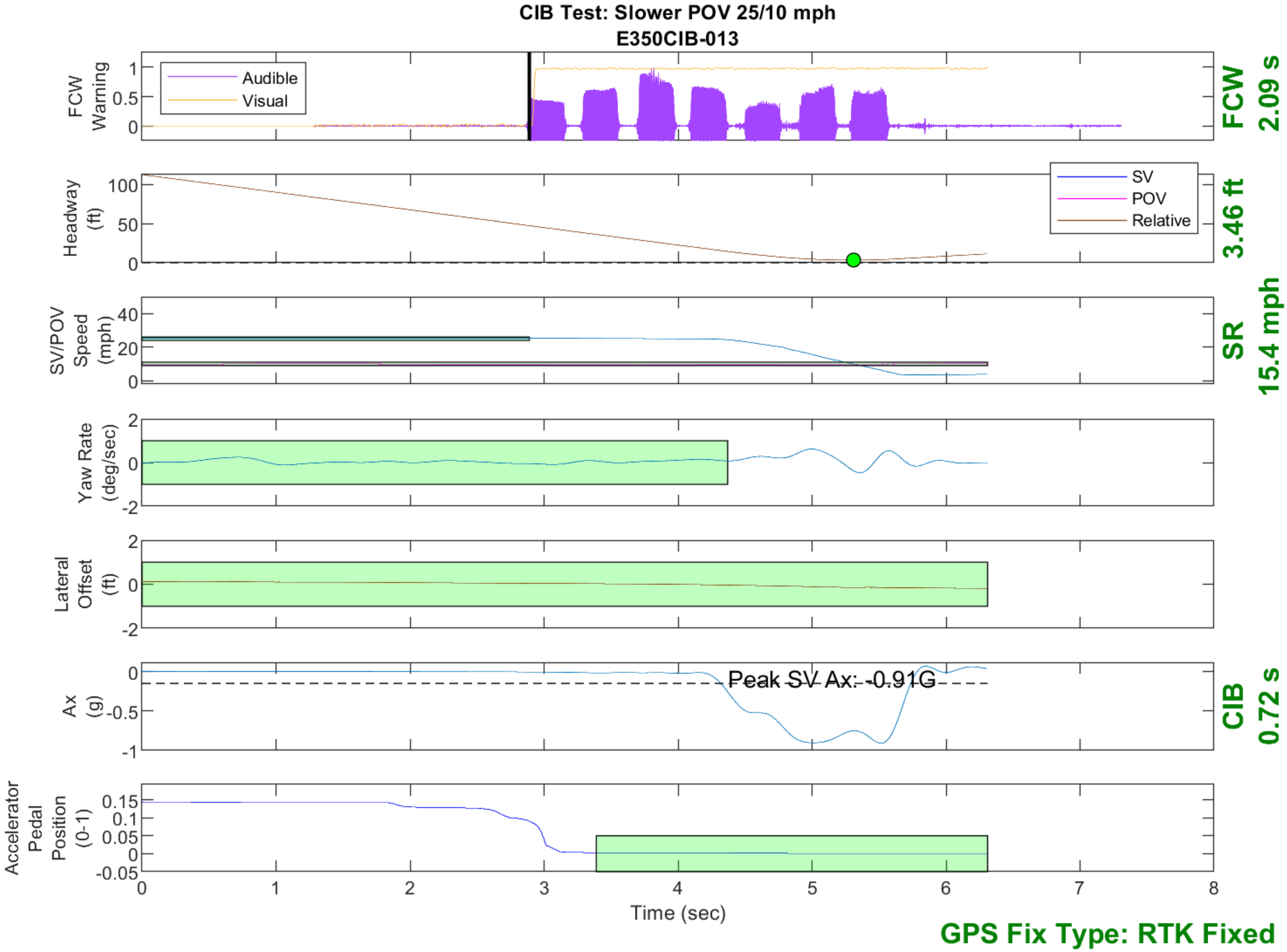


Figure D20. Time History for CIB Run 13, SV Encounters Slower POV, SV 25 mph, POV 10 mph

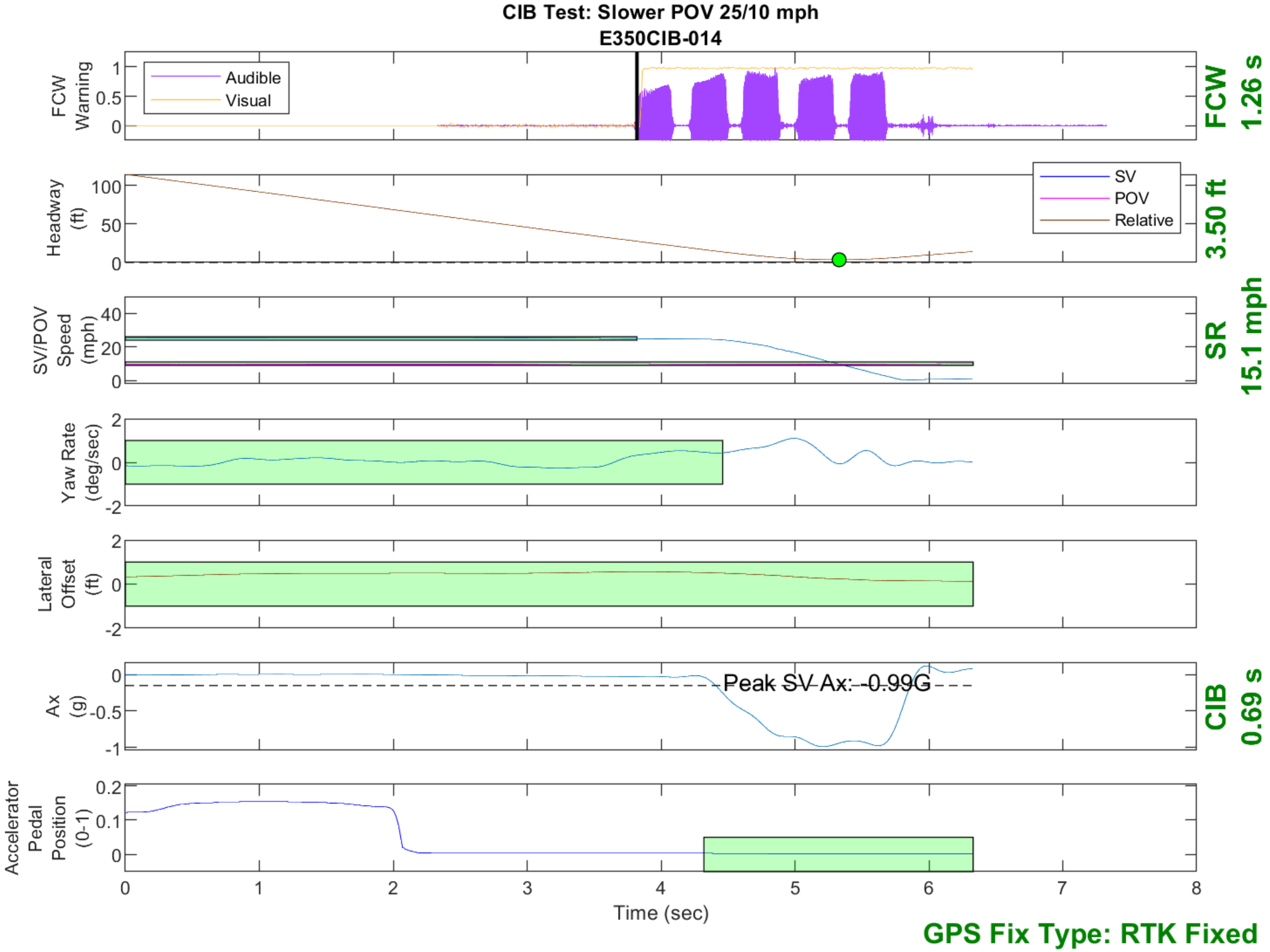


Figure D21. Time History for CIB Run 14, SV Encounters Slower POV, SV 25 mph, POV 10 mph

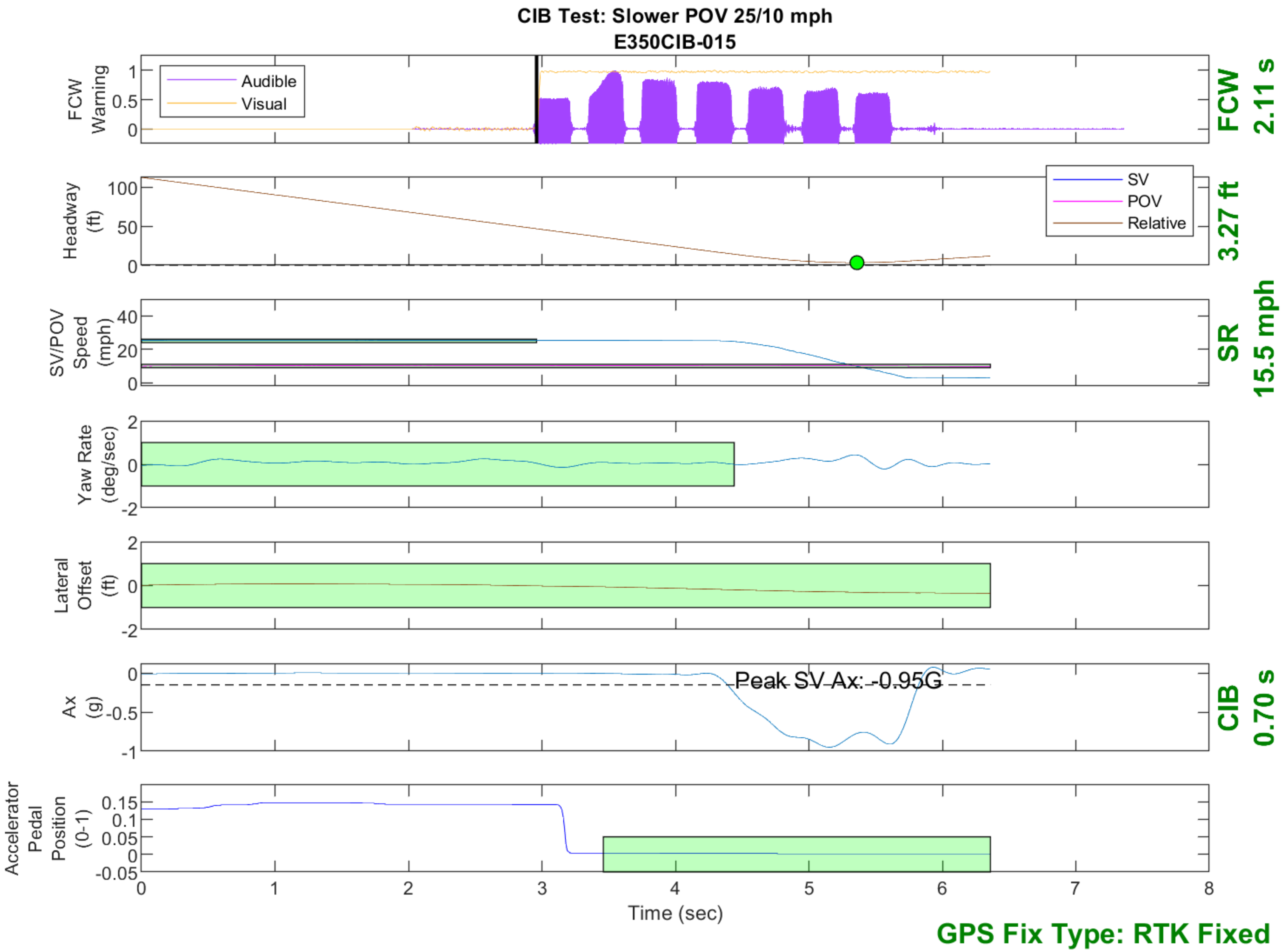


Figure D22. Time History for CIB Run 15, SV Encounters Slower POV, SV 25 mph, POV 10 mph

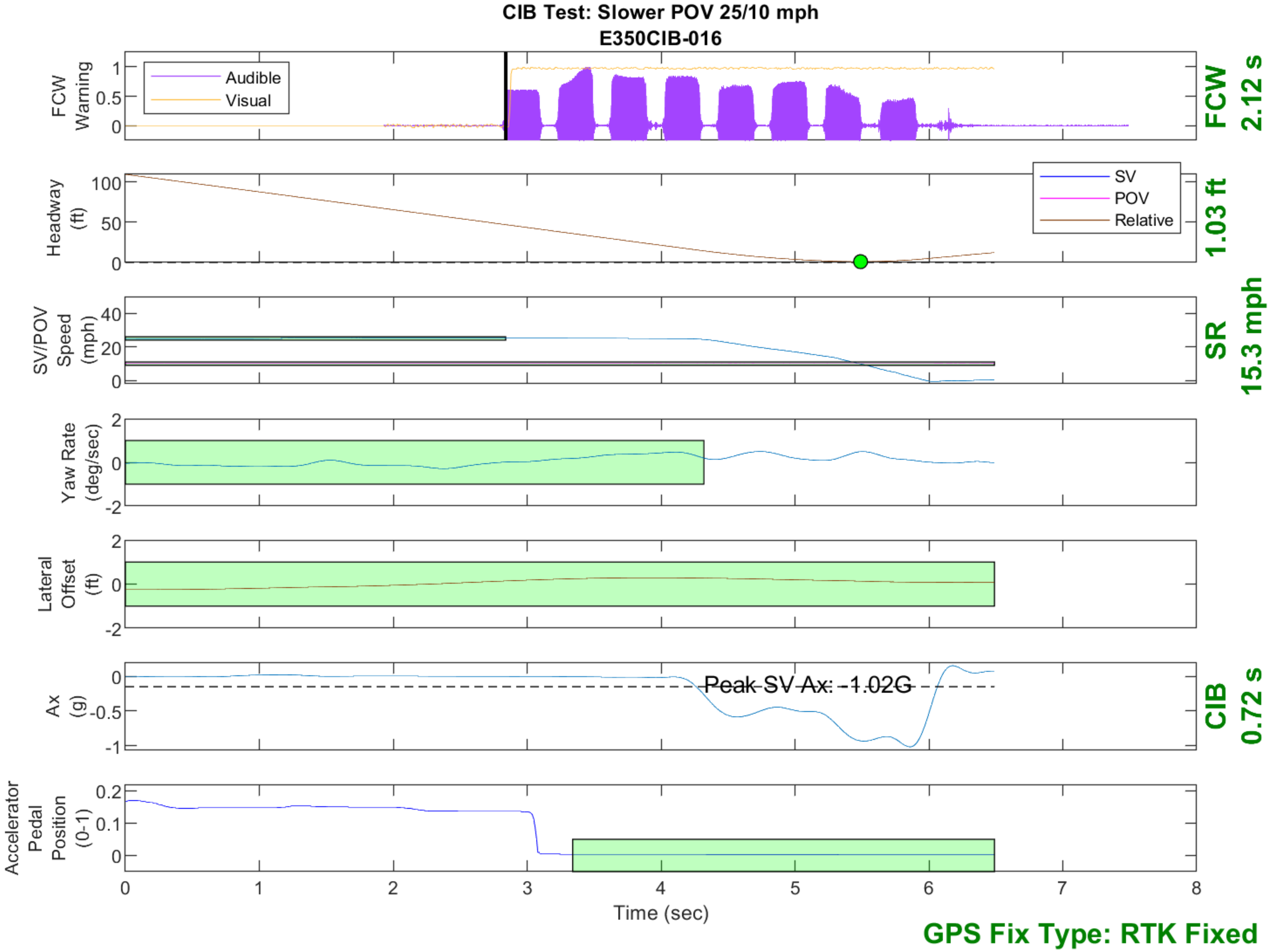


Figure D23. Time History for CIB Run 16, SV Encounters Slower POV, SV 25 mph, POV 10 mph

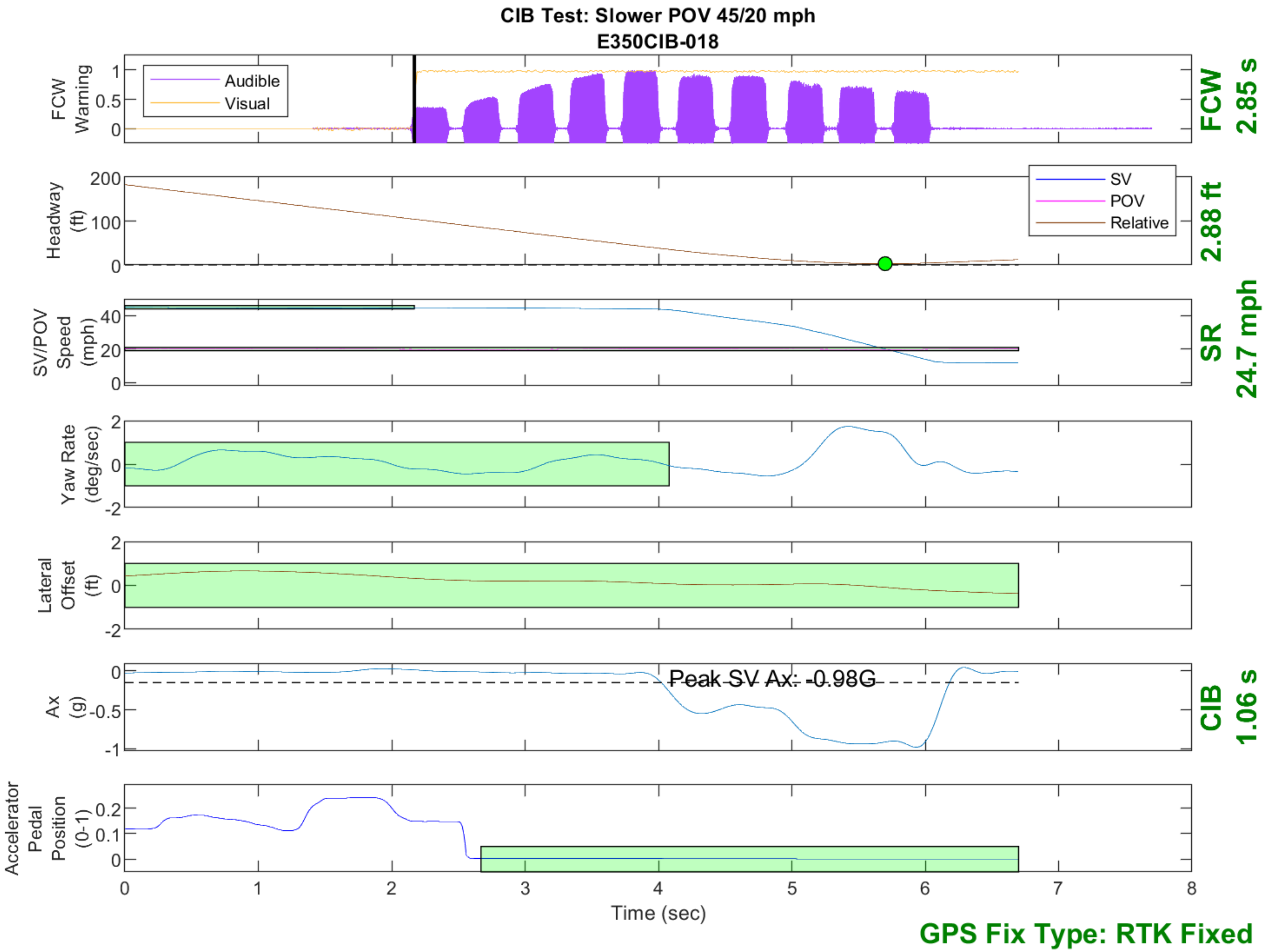


Figure D24. Time History for CIB Run 18, SV Encounters Slower POV, SV 45 mph, POV 20 mph

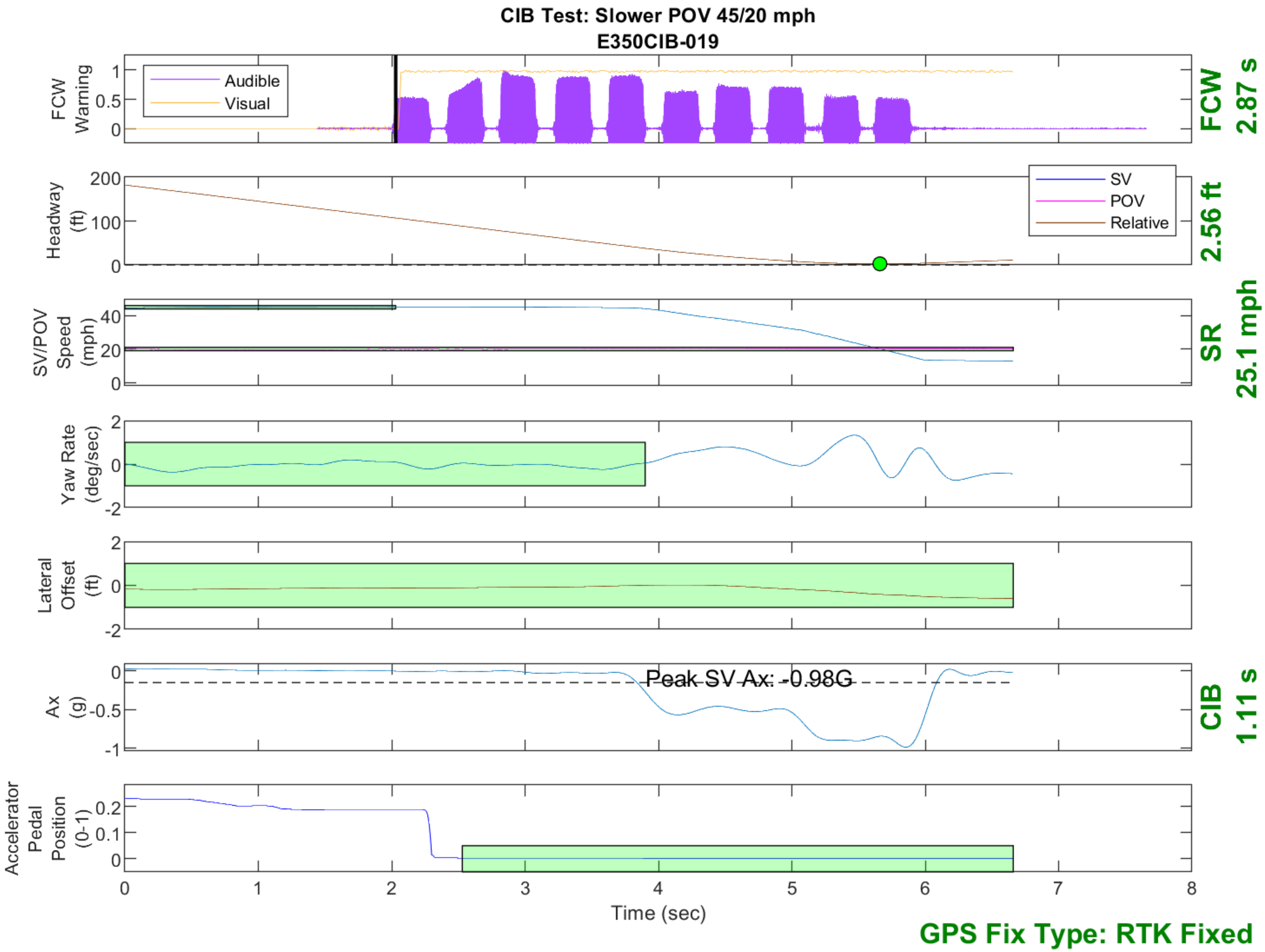


Figure D25. Time History for CIB Run 19, SV Encounters Slower POV, SV 45 mph, POV 20 mph

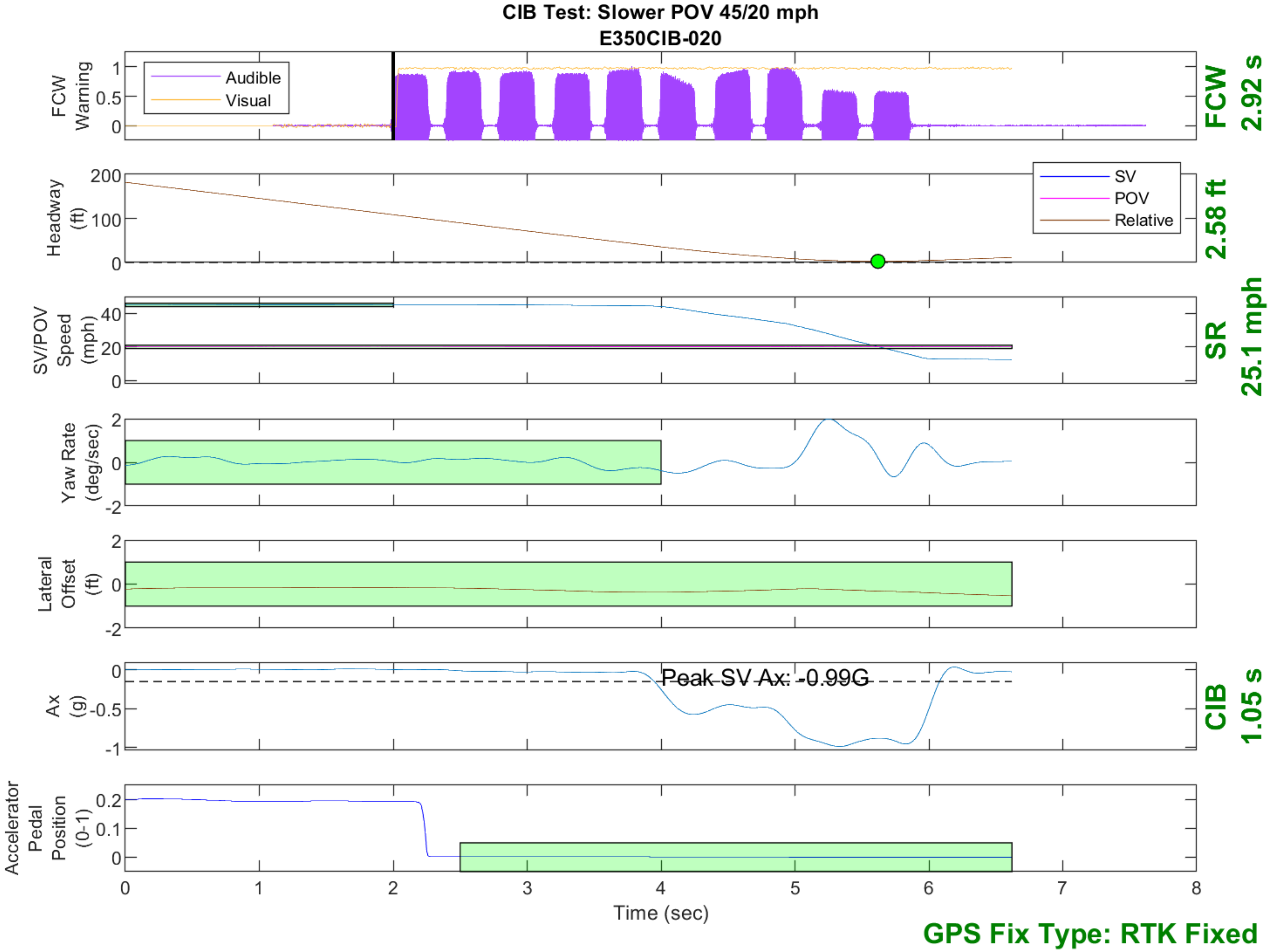


Figure D26. Time History for CIB Run 20, SV Encounters Slower POV, SV 45 mph, POV 20 mph

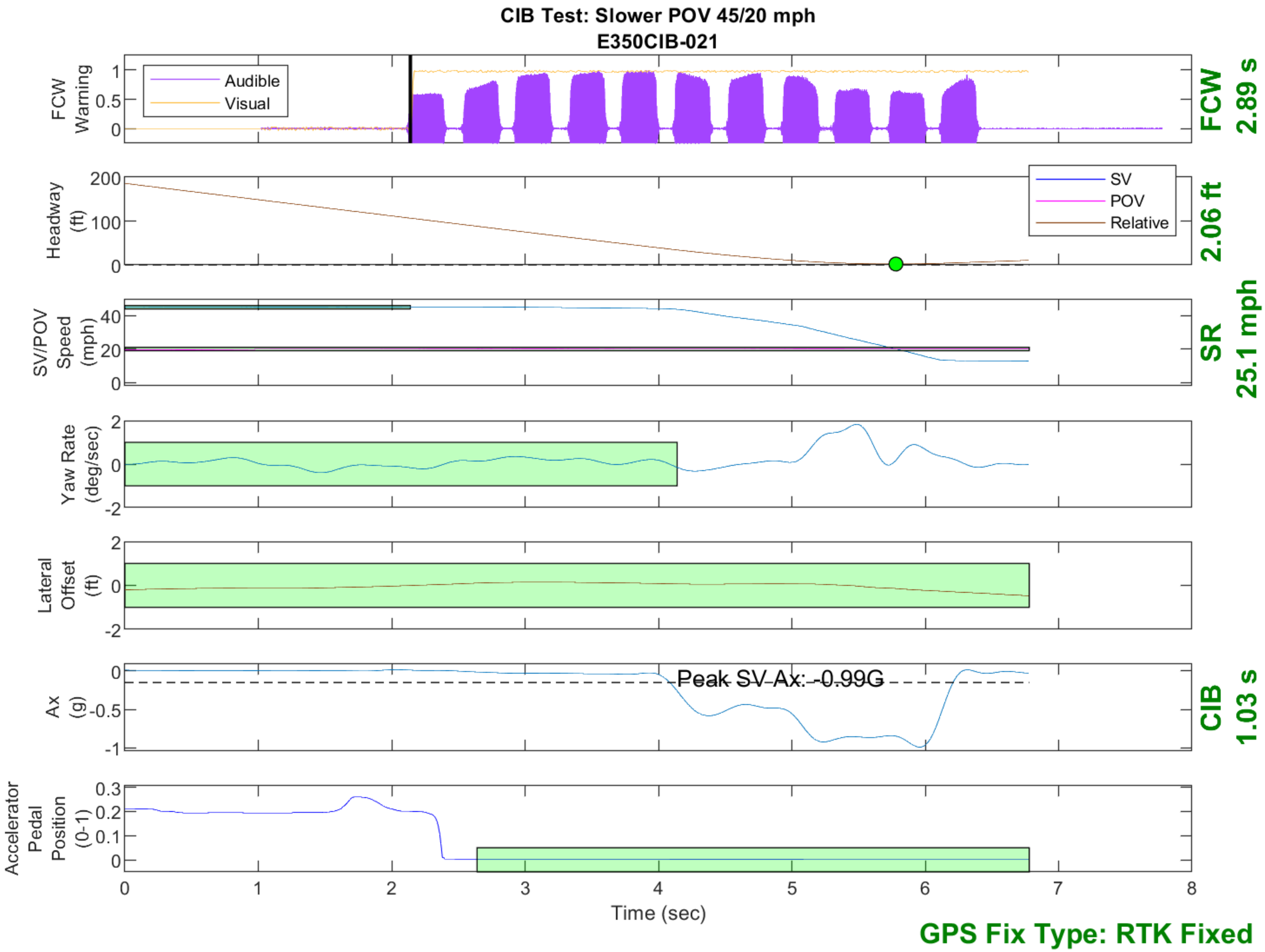


Figure D27. Time History for CIB Run 21, SV Encounters Slower POV, SV 45 mph, POV 20 mph

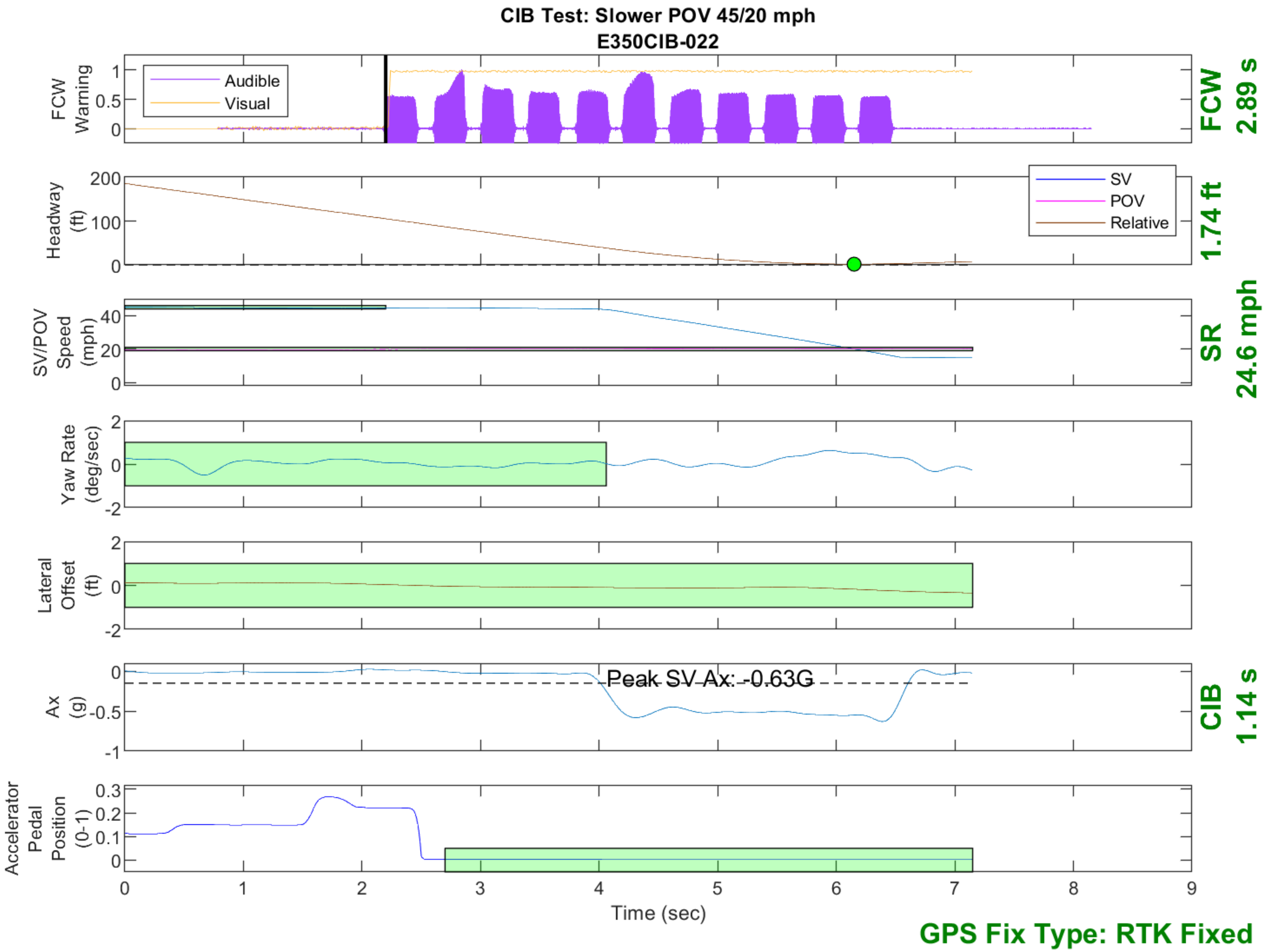


Figure D28. Time History for CIB Run 22, SV Encounters Slower POV, SV 45 mph, POV 20 mph

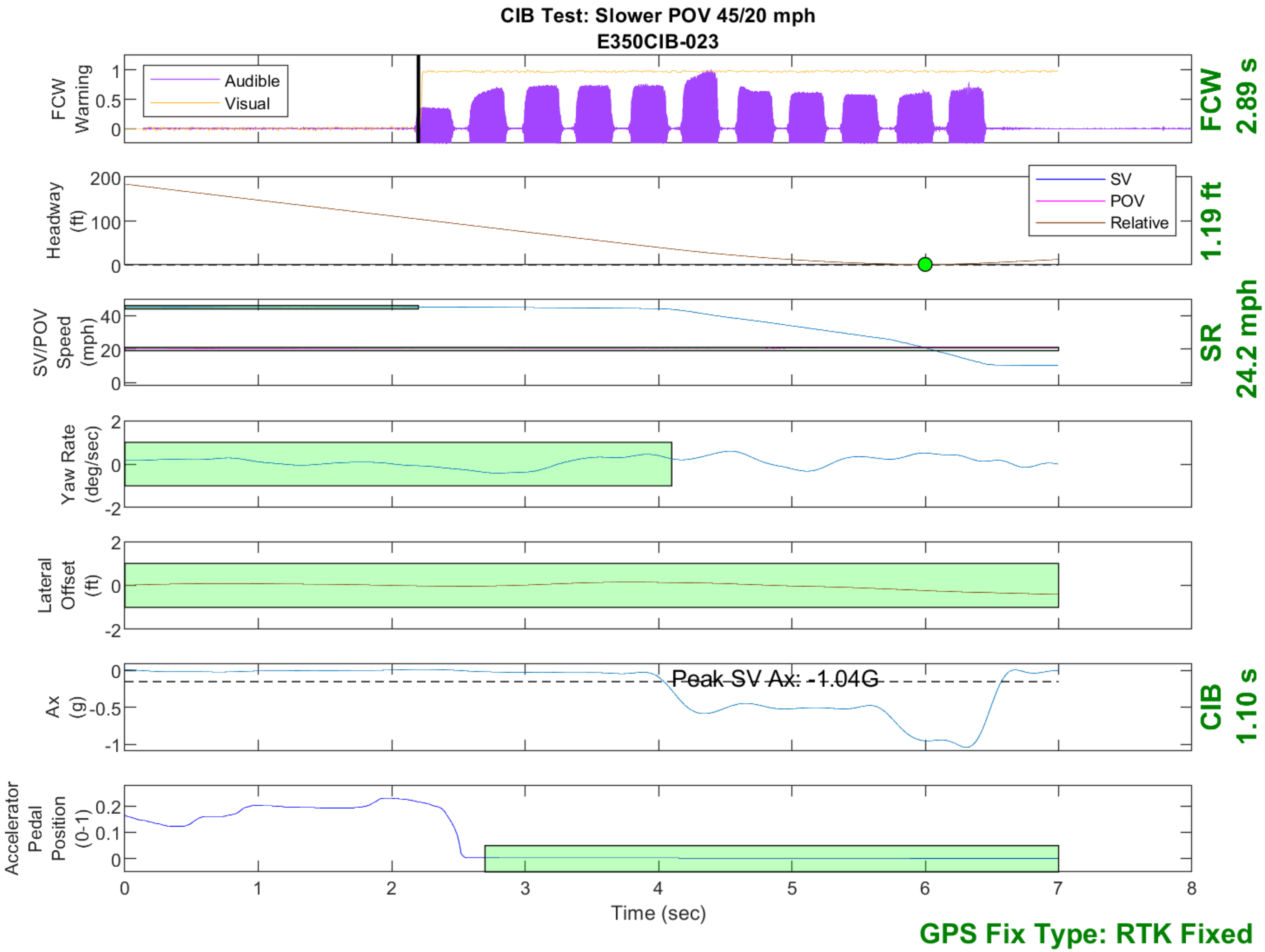


Figure D29. Time History for CIB Run 23, SV Encounters Slower POV, SV 45 mph, POV 20 mph

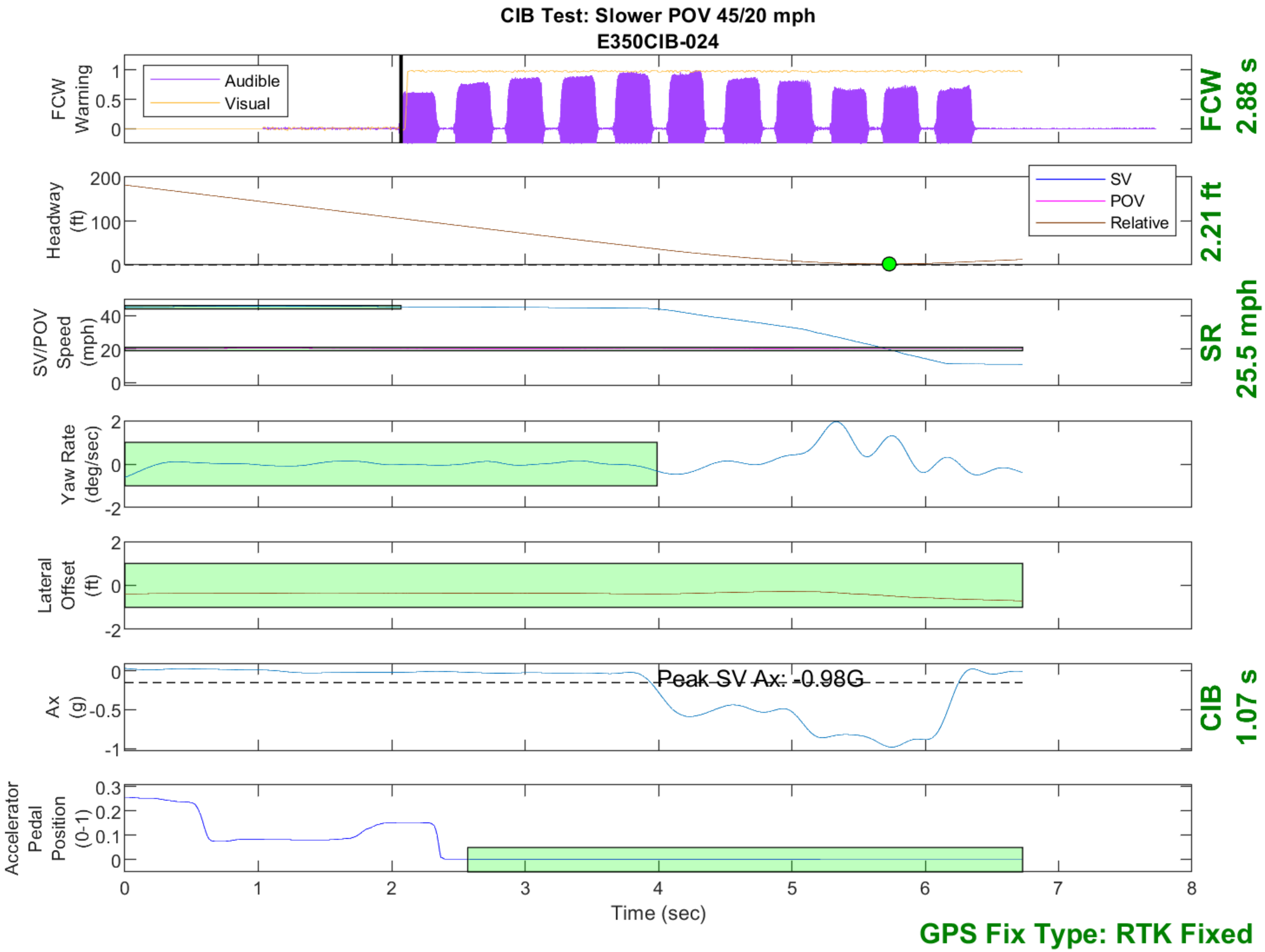


Figure D30. Time History for CIB Run 24, SV Encounters Slower POV, SV 45 mph, POV 20 mph

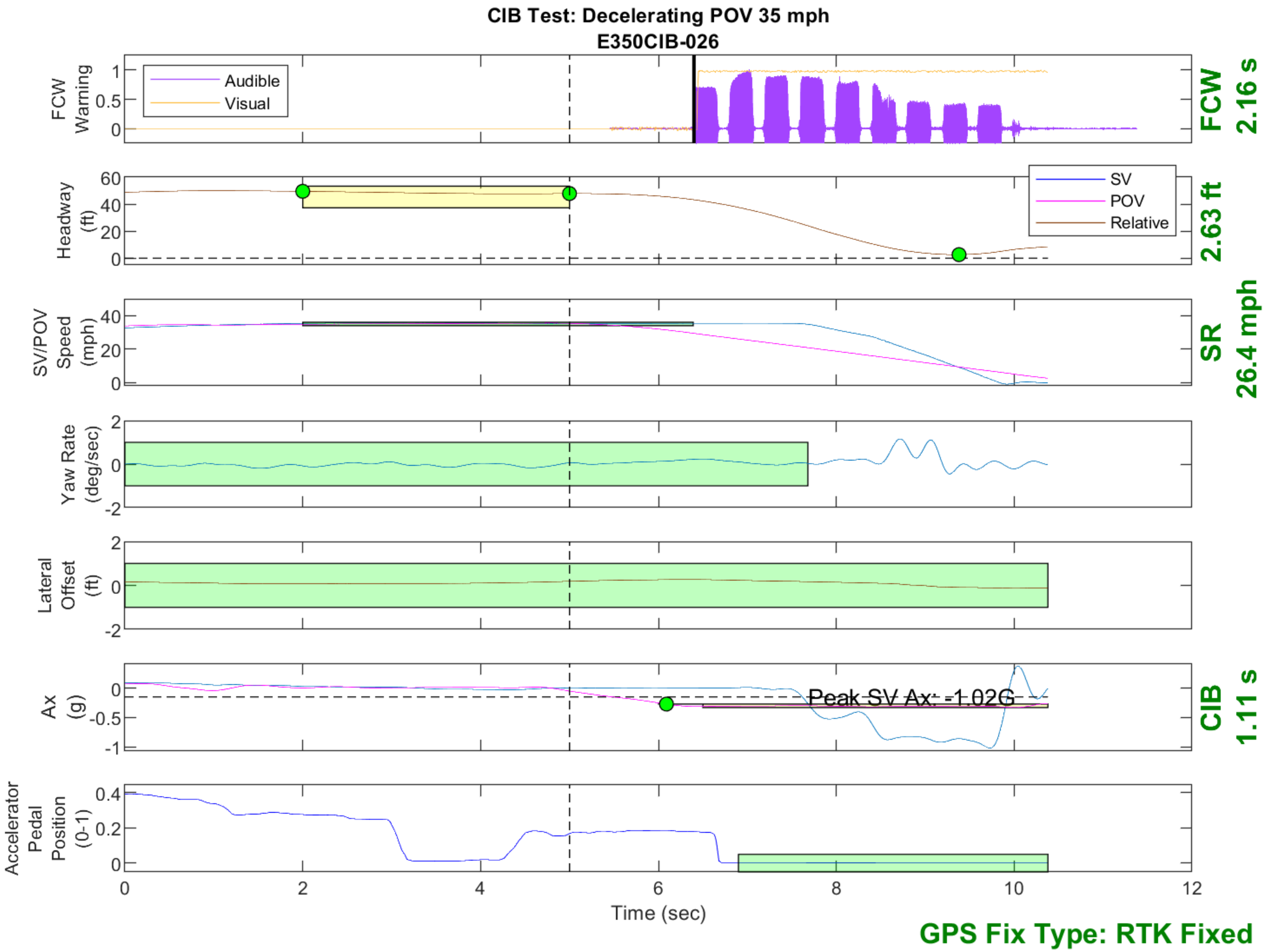


Figure D31. Time History for CIB Run 26, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

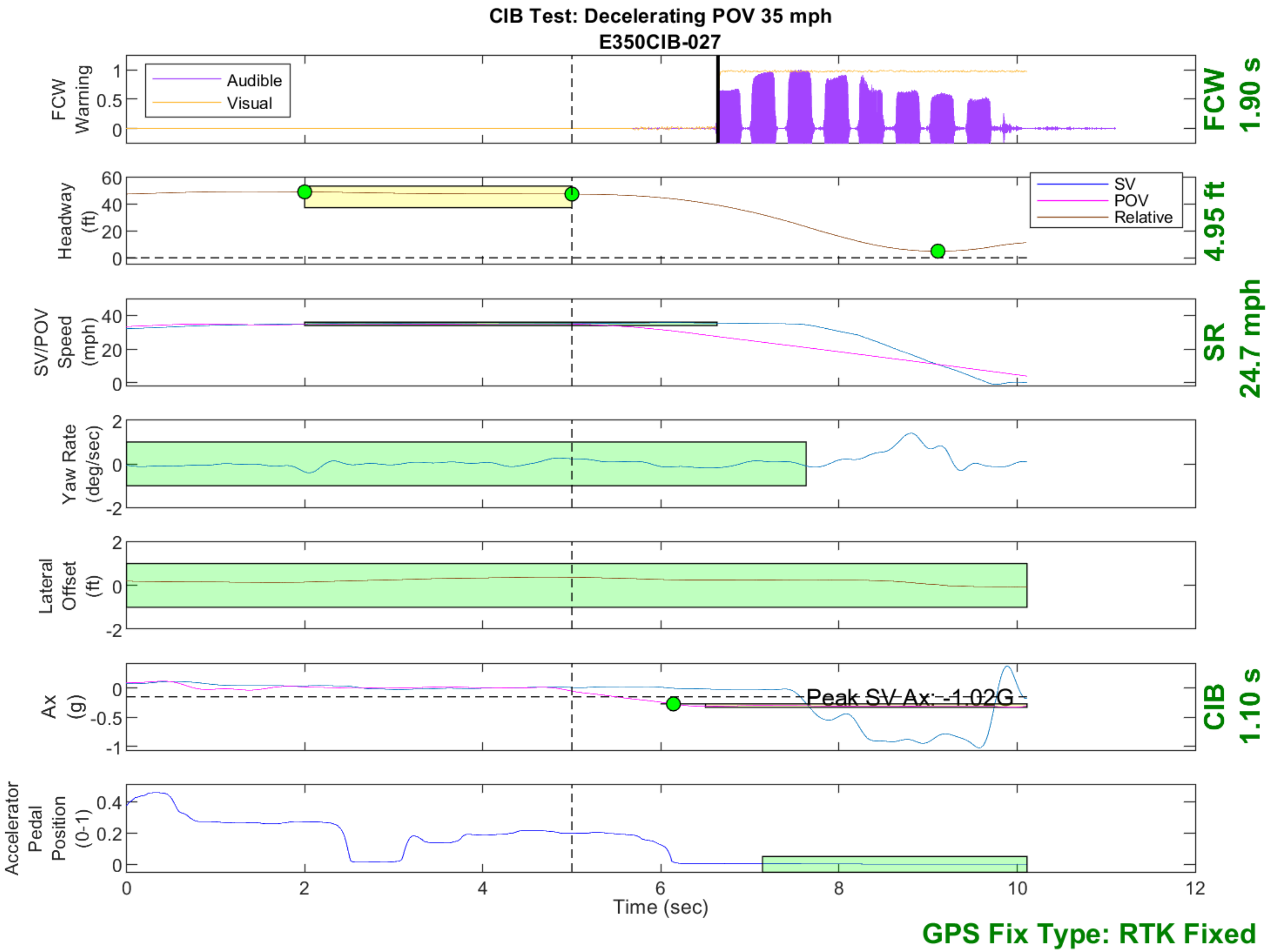


Figure D32. Time History for CIB Run 27, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

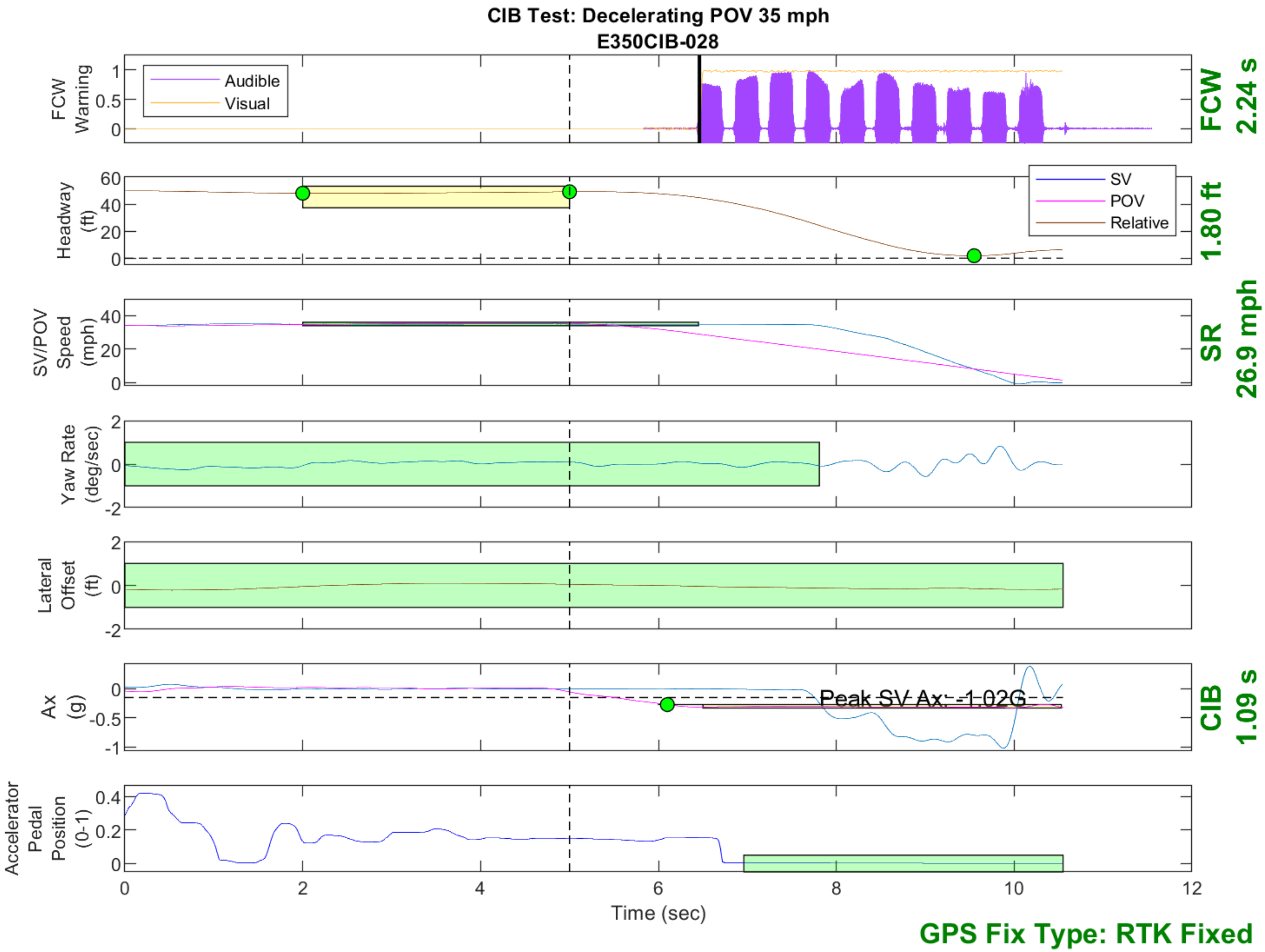


Figure D33. Time History for CIB Run 28, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

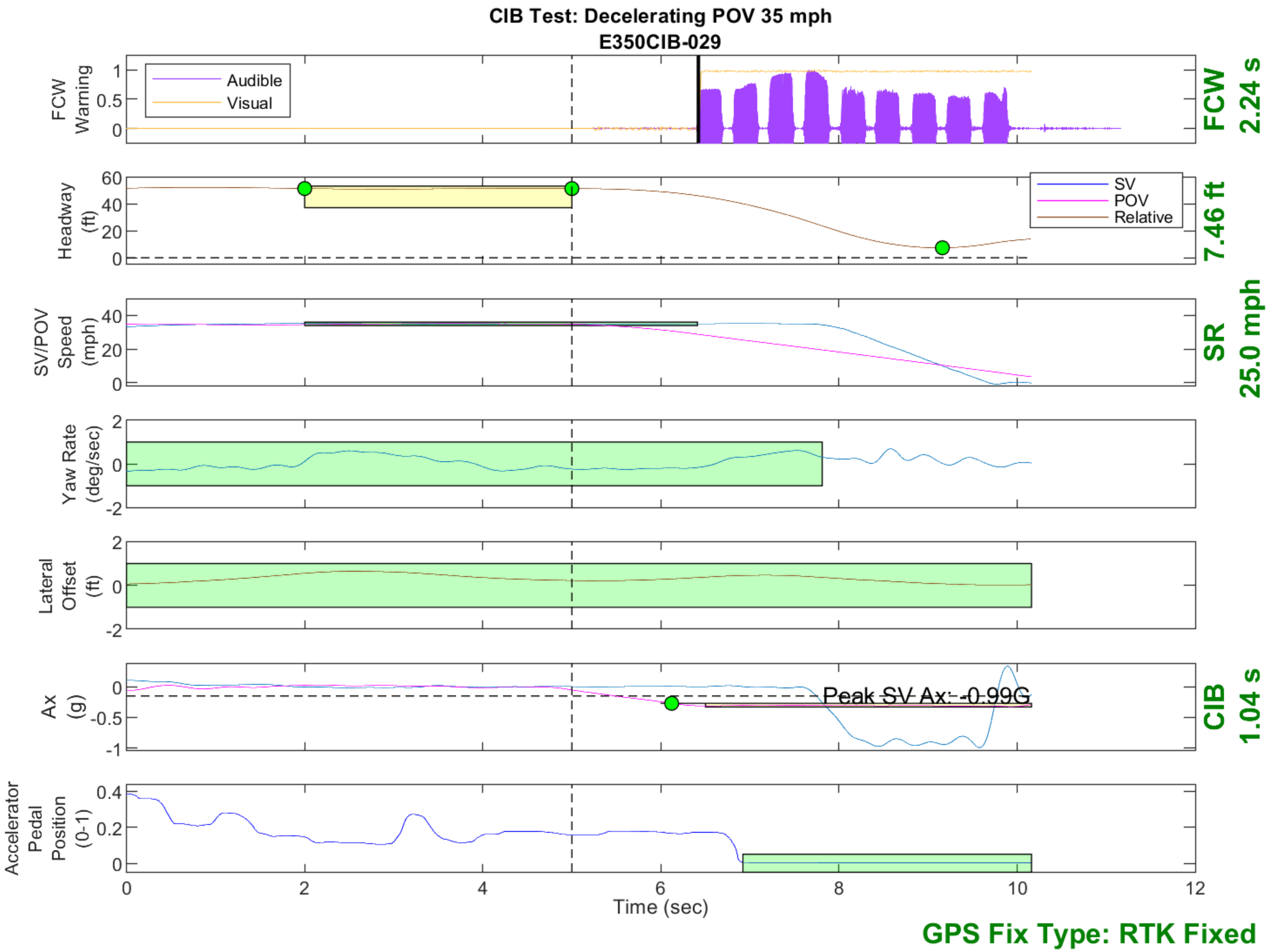


Figure D34. Time History for CIB Run 29, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

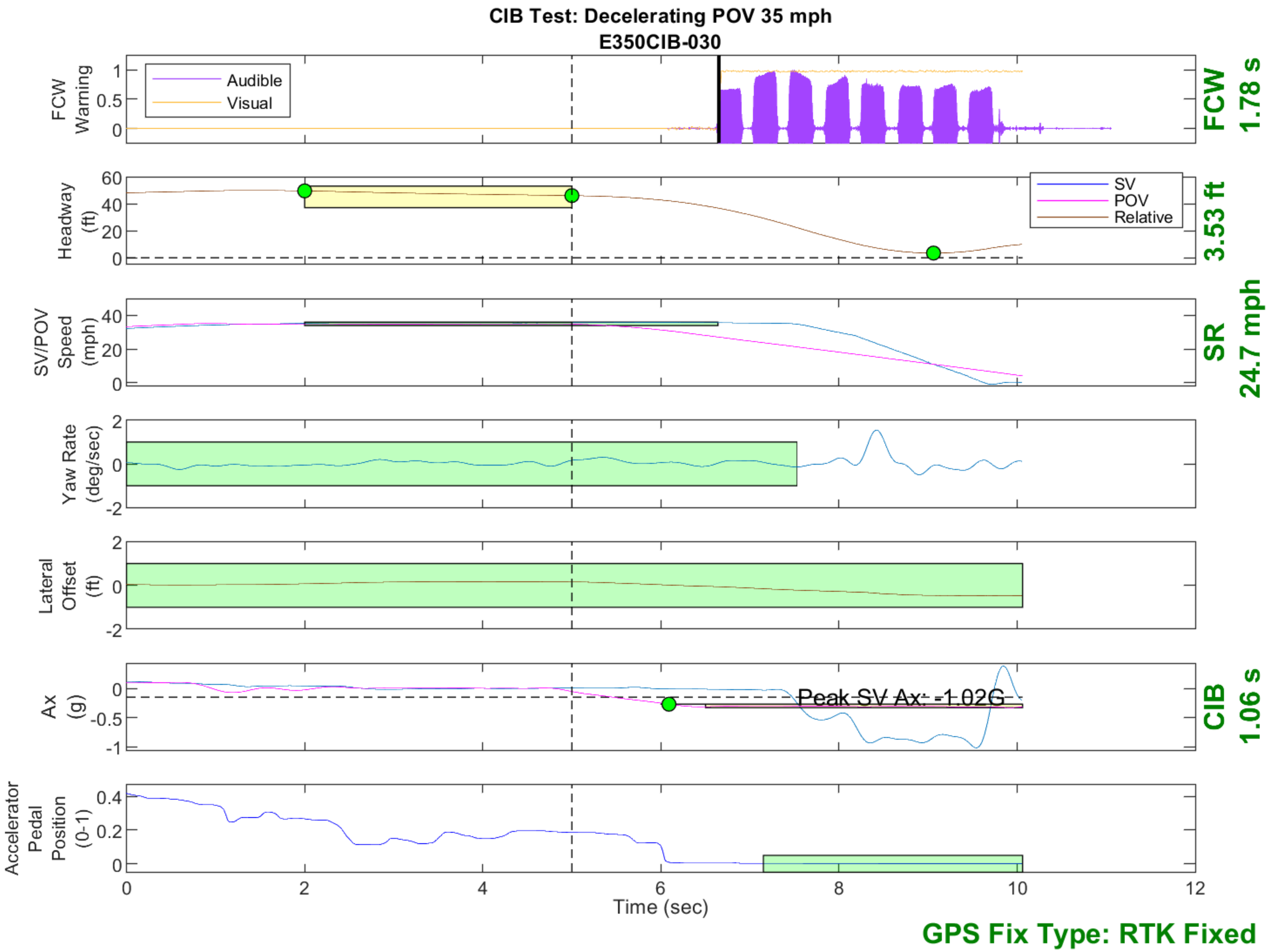


Figure D35. Time History for CIB Run 30, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

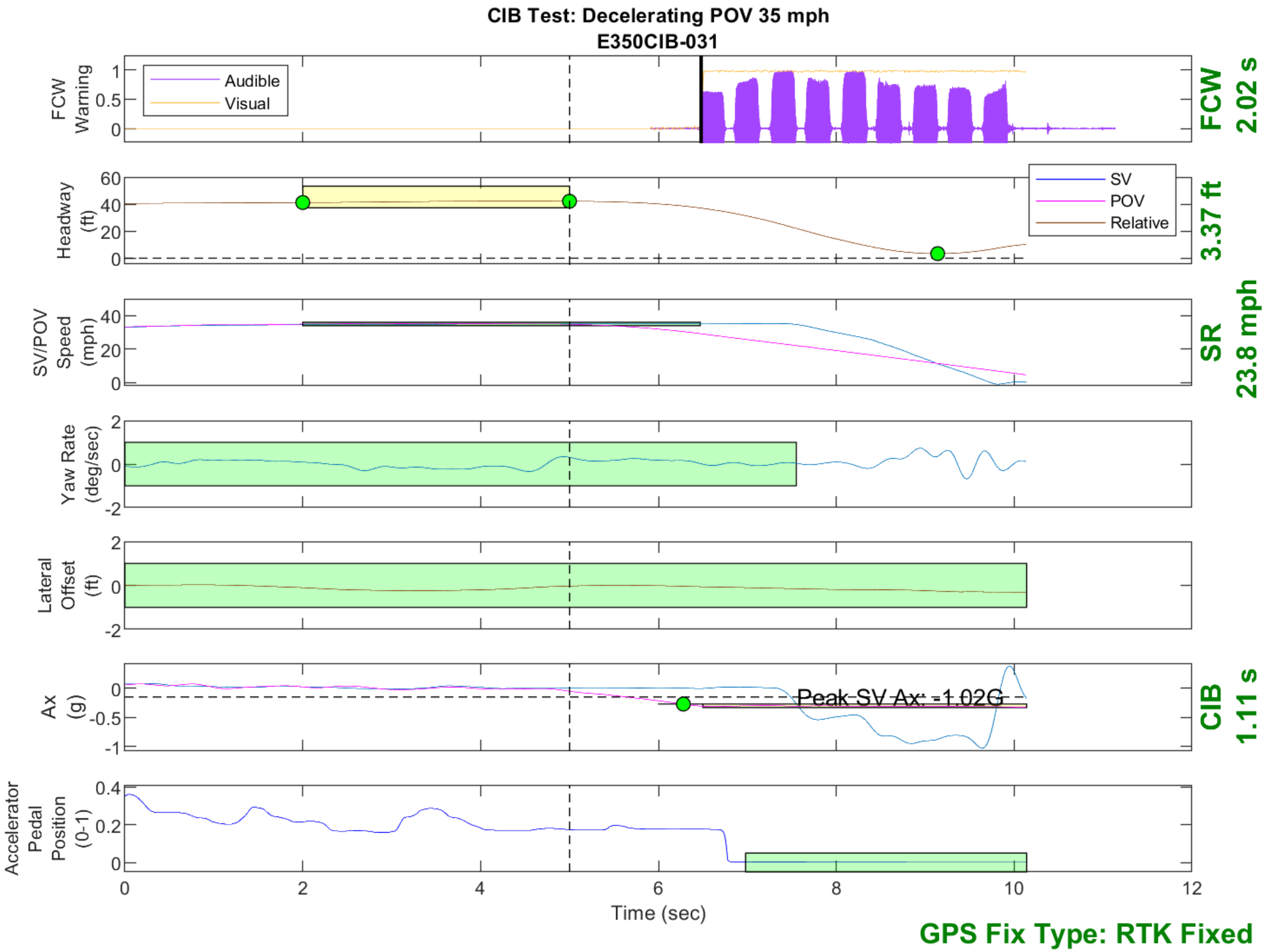


Figure D36. Time History for CIB Run 31, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

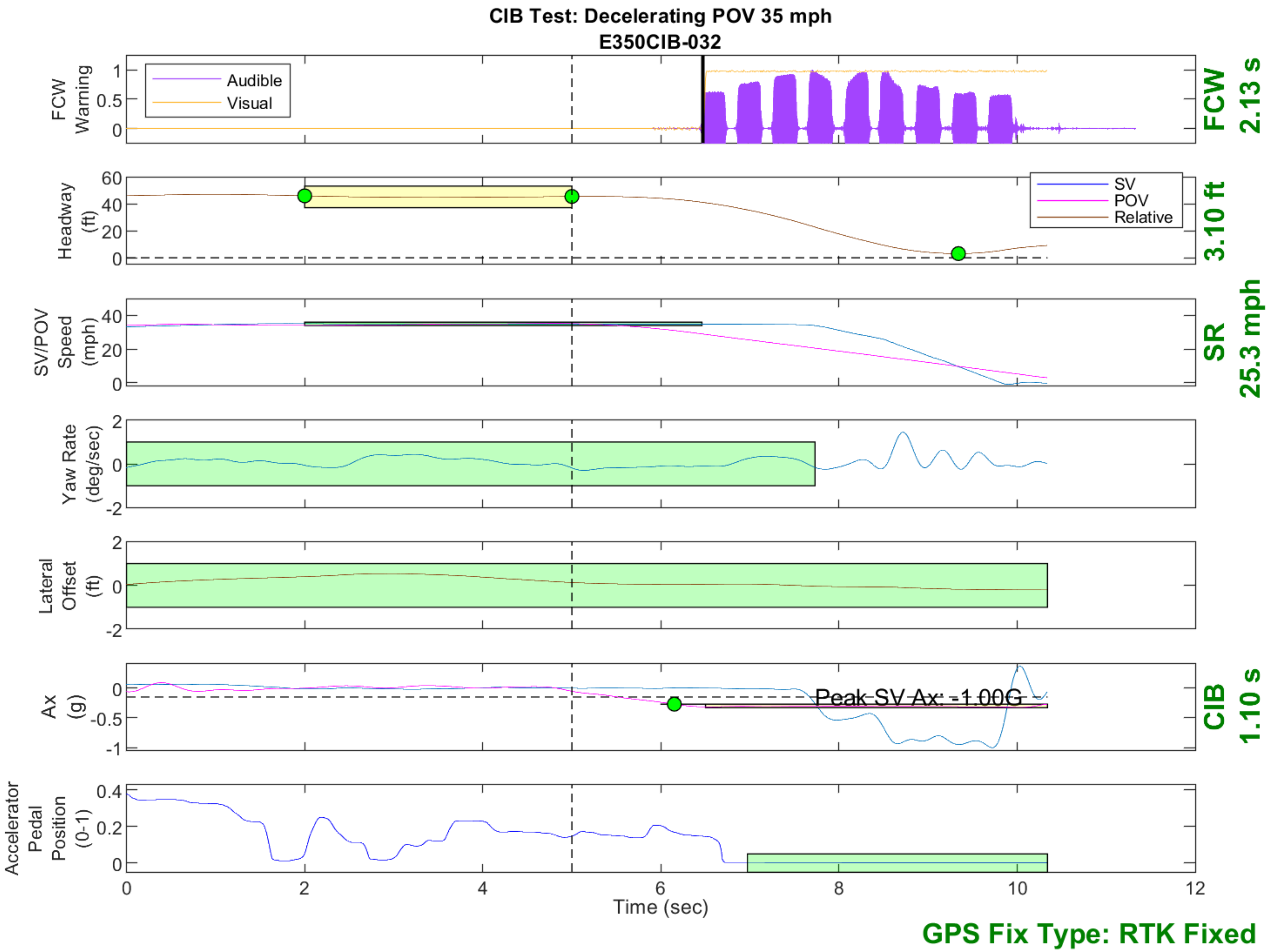


Figure D37. Time History for CIB Run 32, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

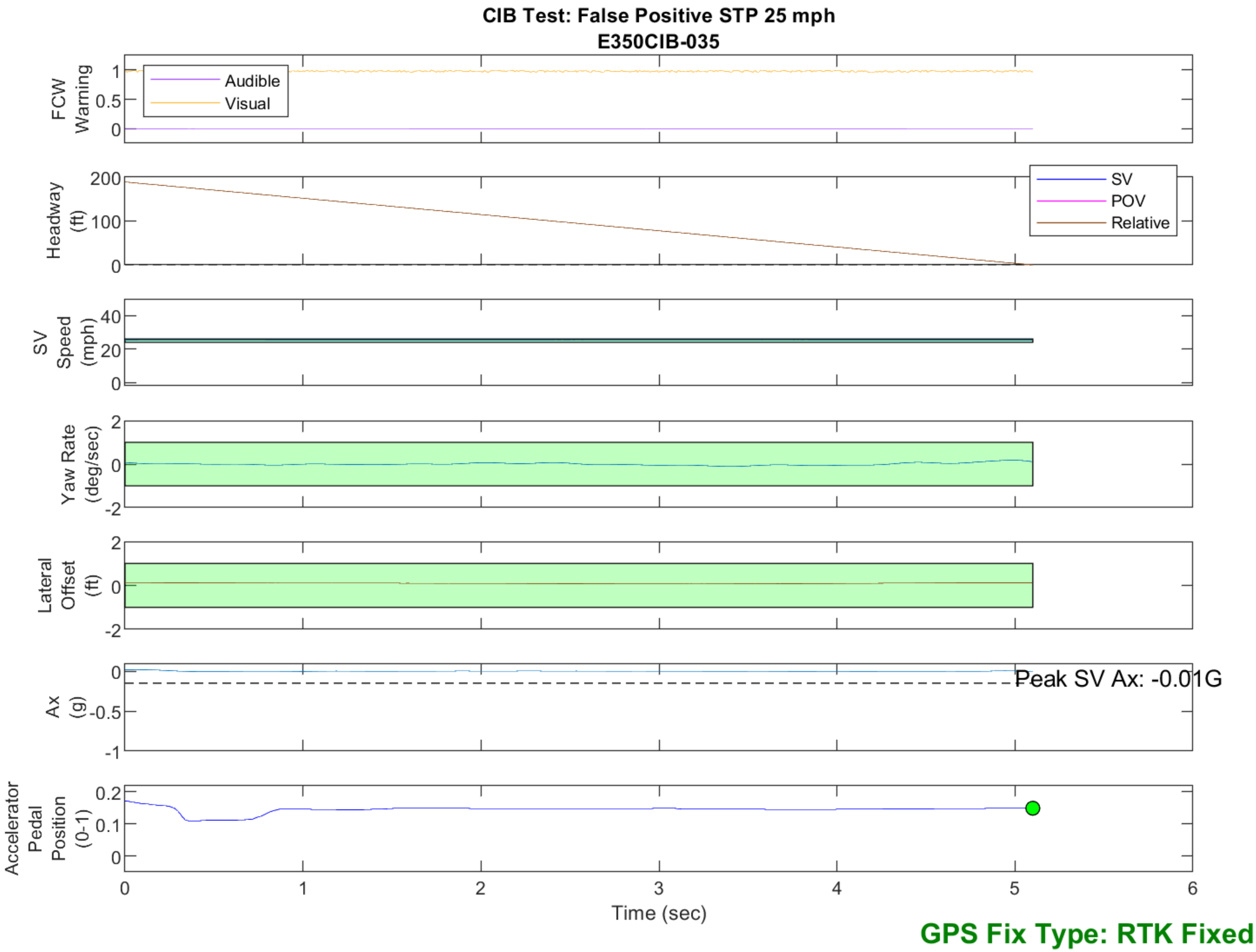


Figure D38. Time History for CIB Run 35, SV Encounters Steel Trench Plate, SV 25 mph

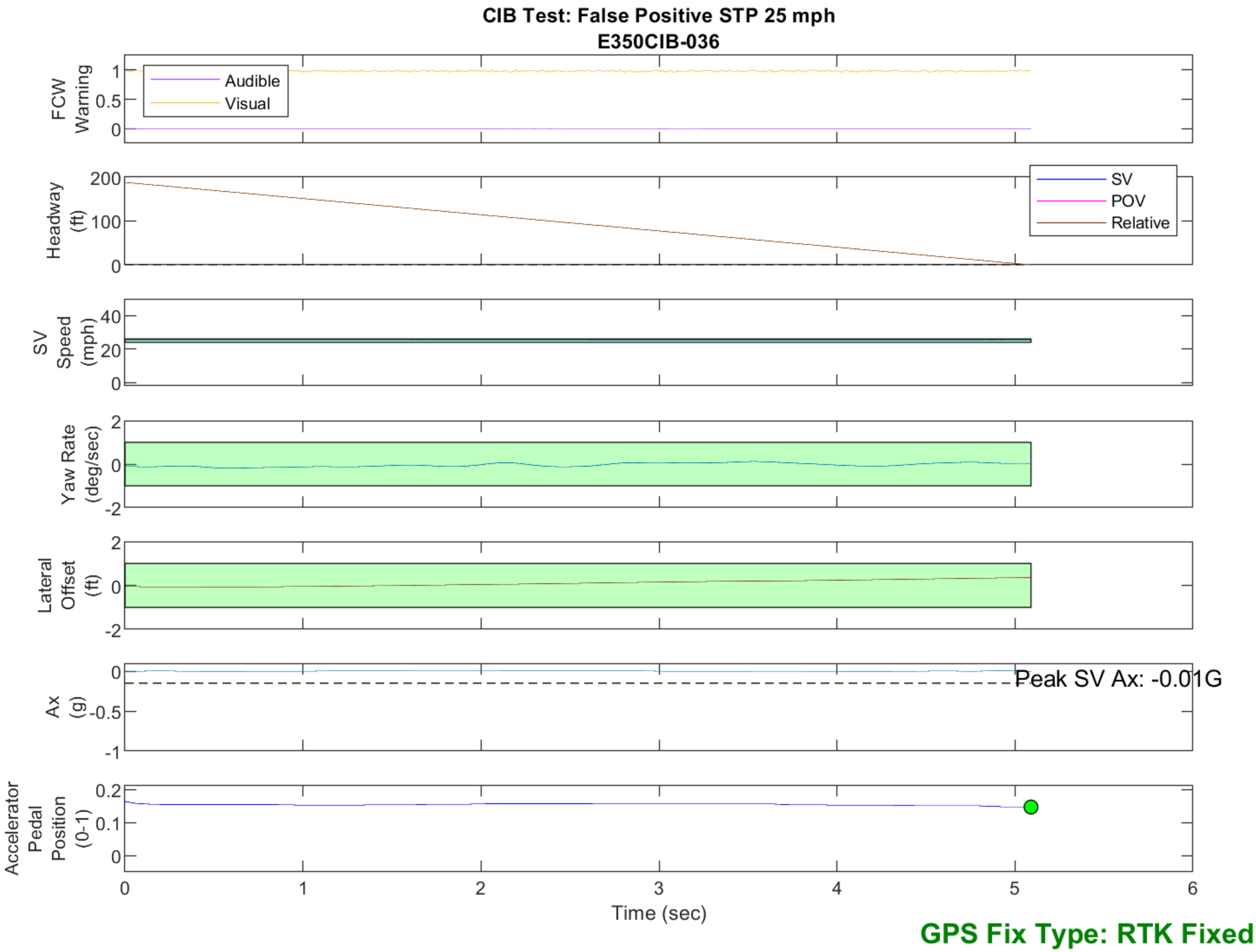


Figure D39. Time History for CIB Run 36, SV Encounters Steel Trench Plate, SV 25 mph

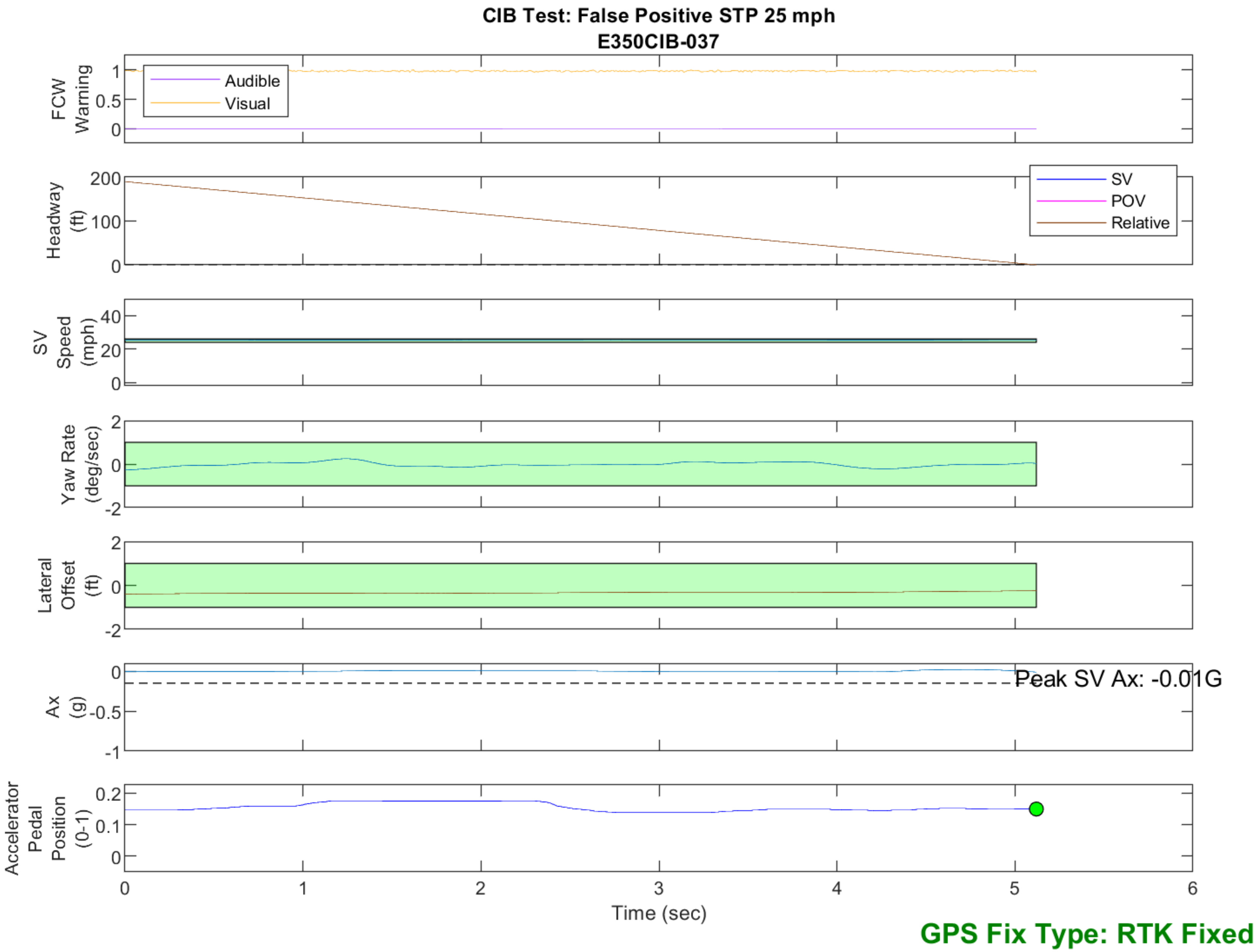


Figure D40. Time History for CIB Run 37, SV Encounters Steel Trench Plate, SV 25 mph

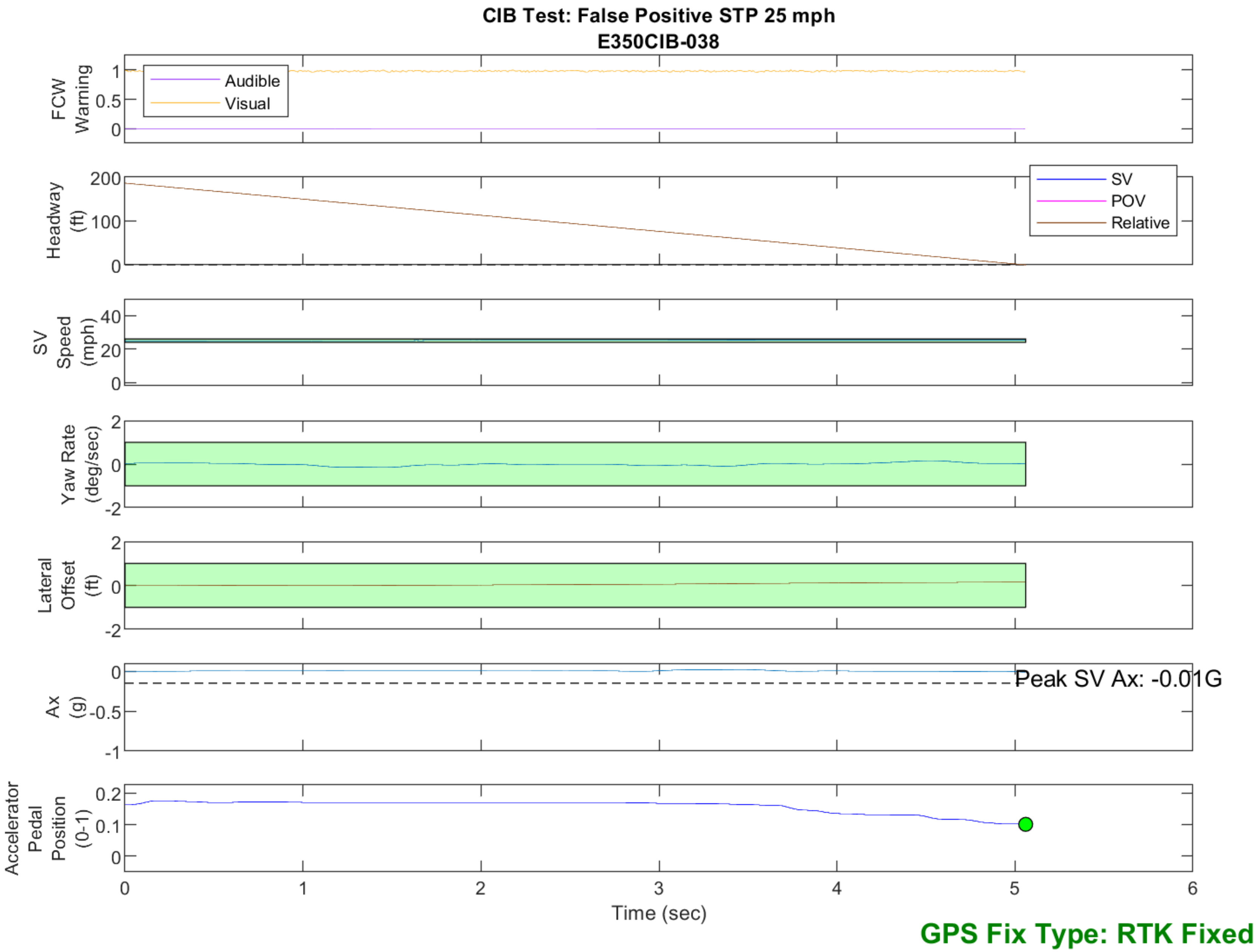


Figure D41. Time History for CIB Run 38, SV Encounters Steel Trench Plate, SV 25 mph

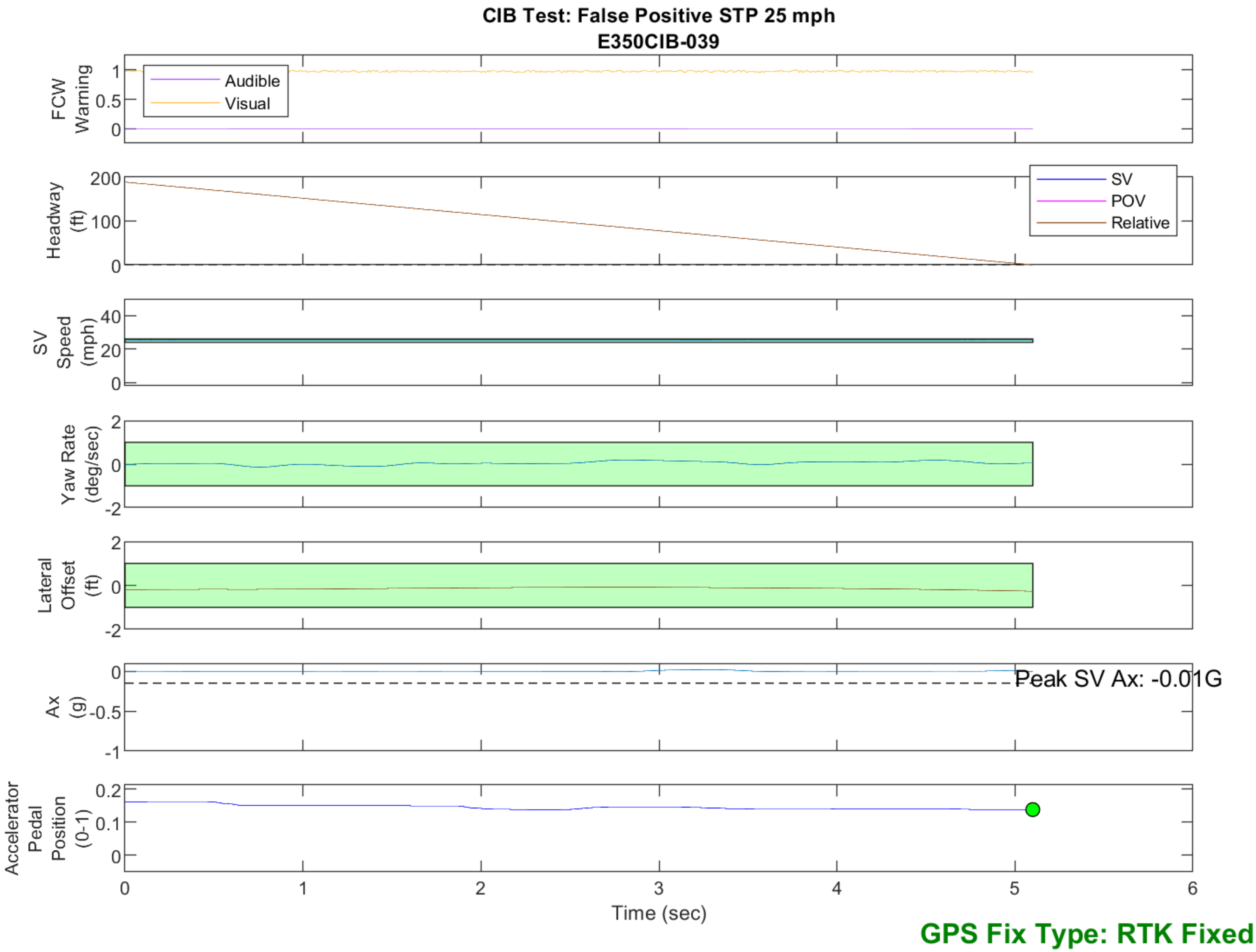


Figure D42. Time History for CIB Run 39, SV Encounters Steel Trench Plate, SV 25 mph

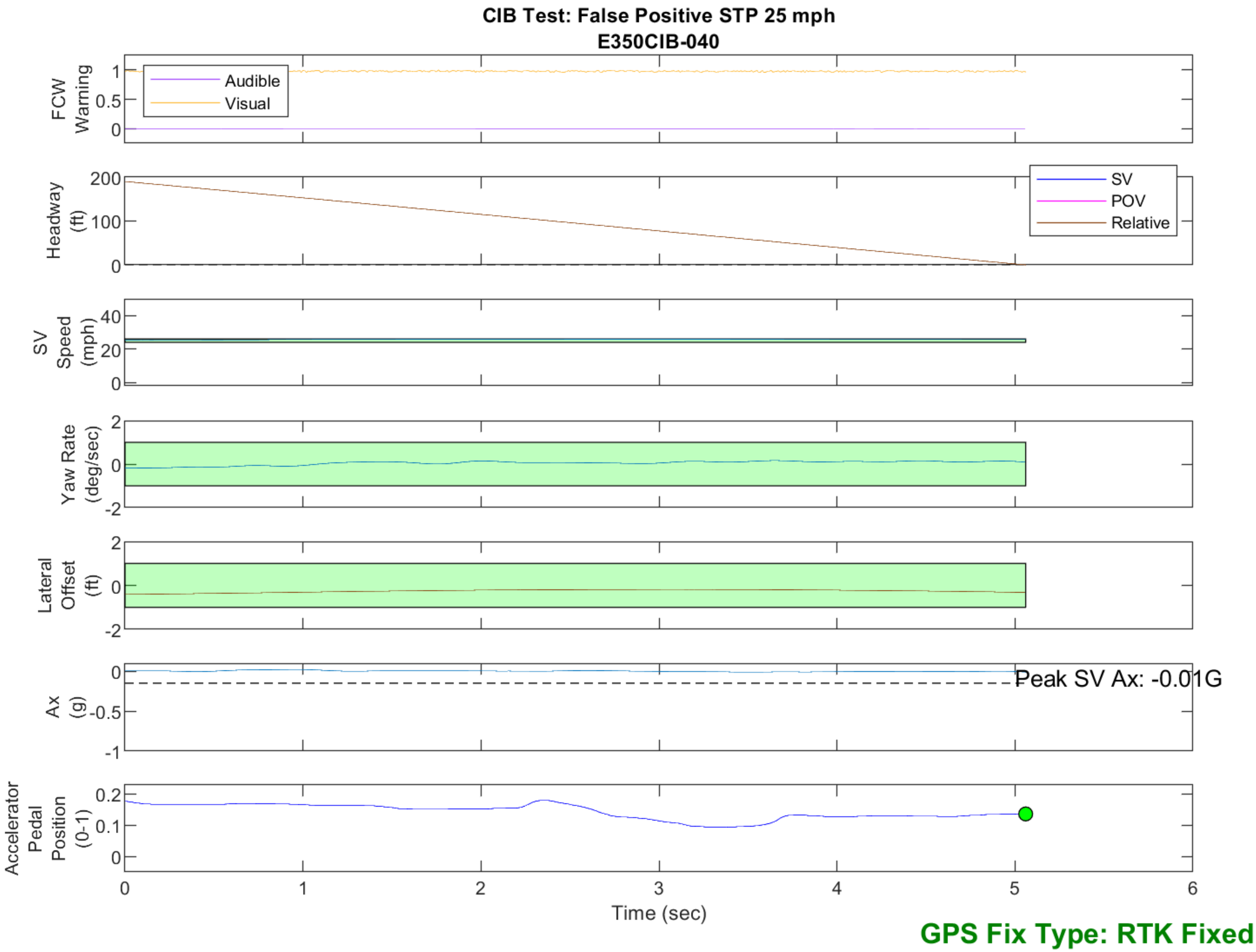


Figure D43. Time History for CIB Run 40, SV Encounters Steel Trench Plate, SV 25 mph

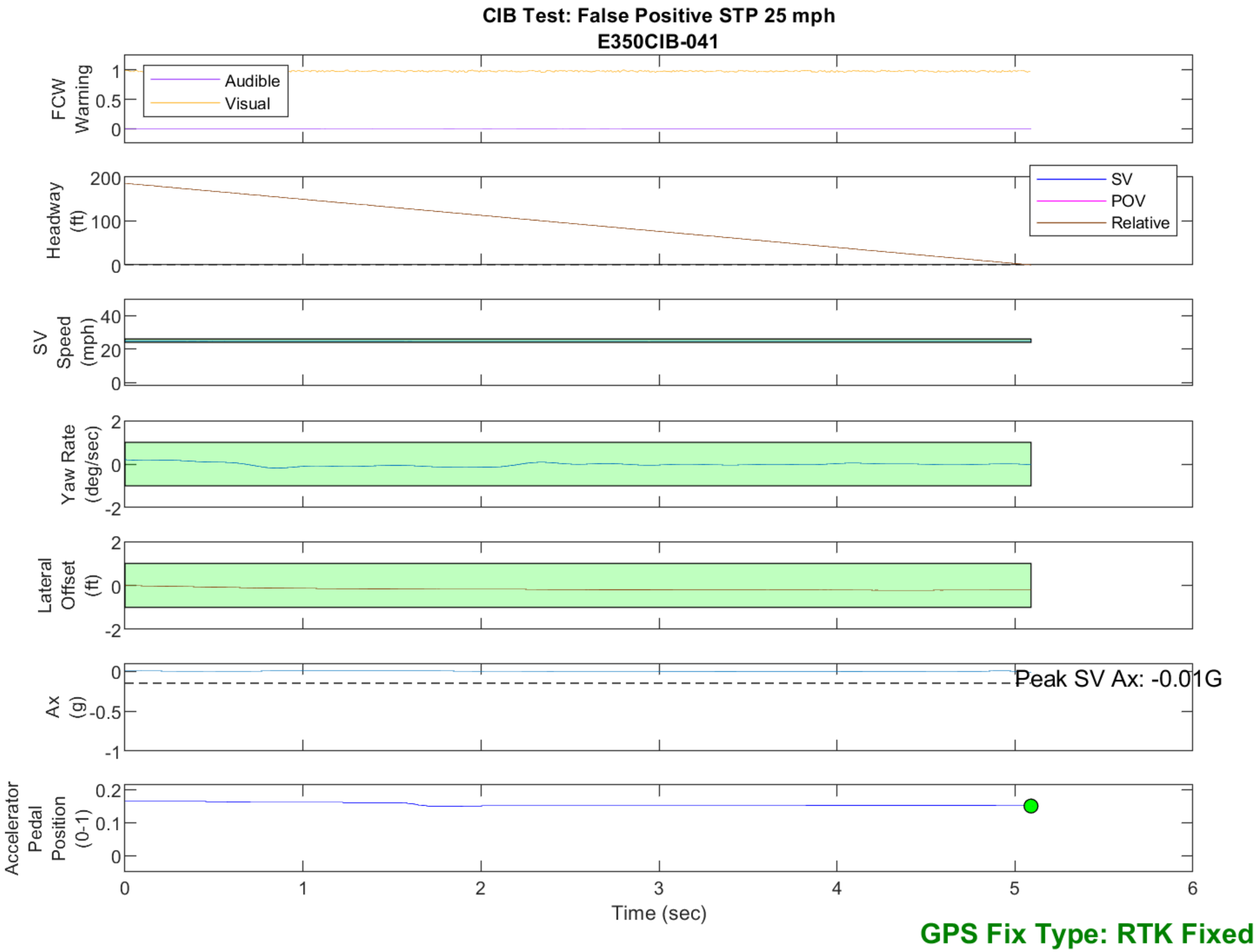


Figure D44. Time History for CIB Run 41, SV Encounters Steel Trench Plate, SV 25 mph

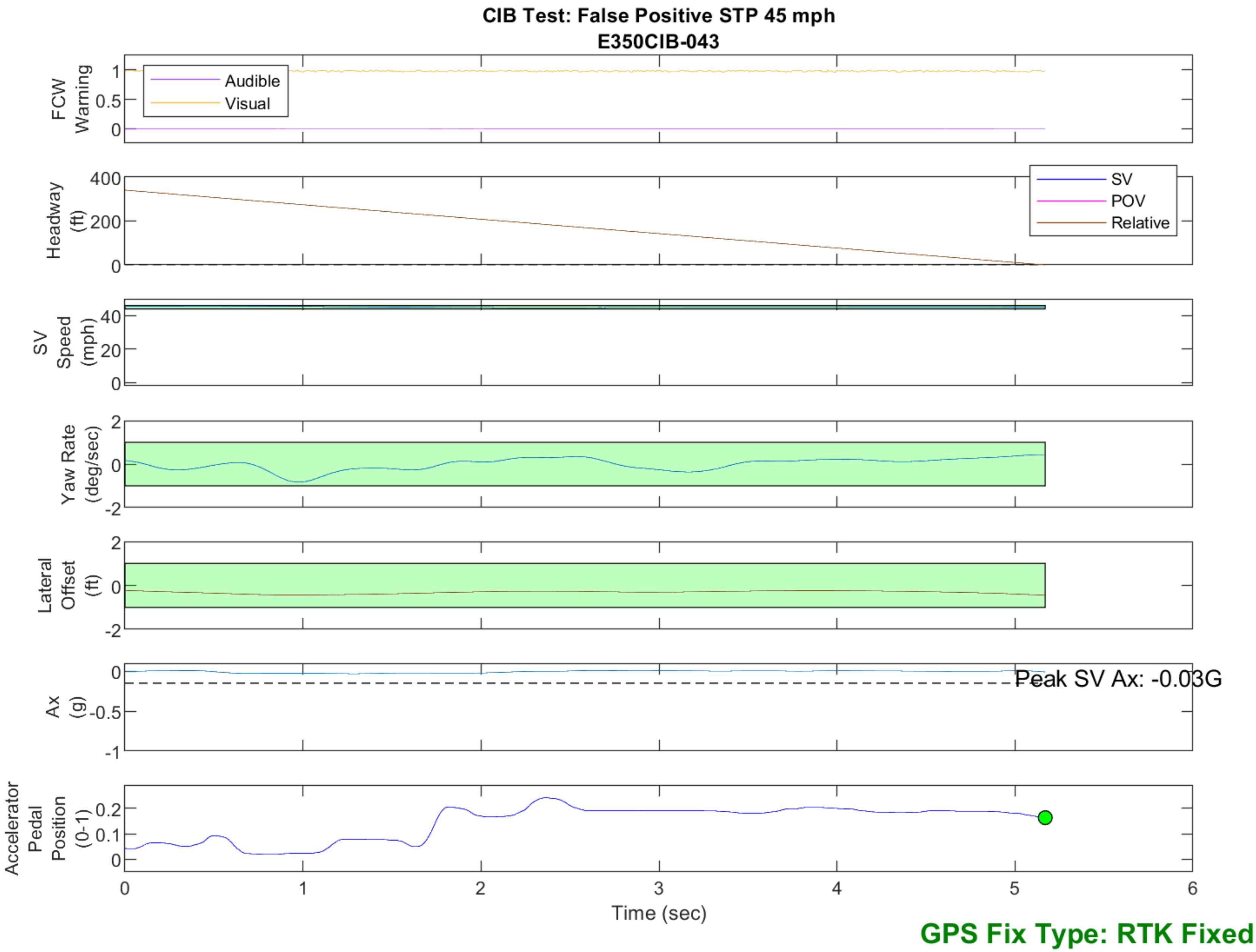


Figure D45. Time History for CIB Run 43, SV Encounters Steel Trench Plate, SV 45 mph

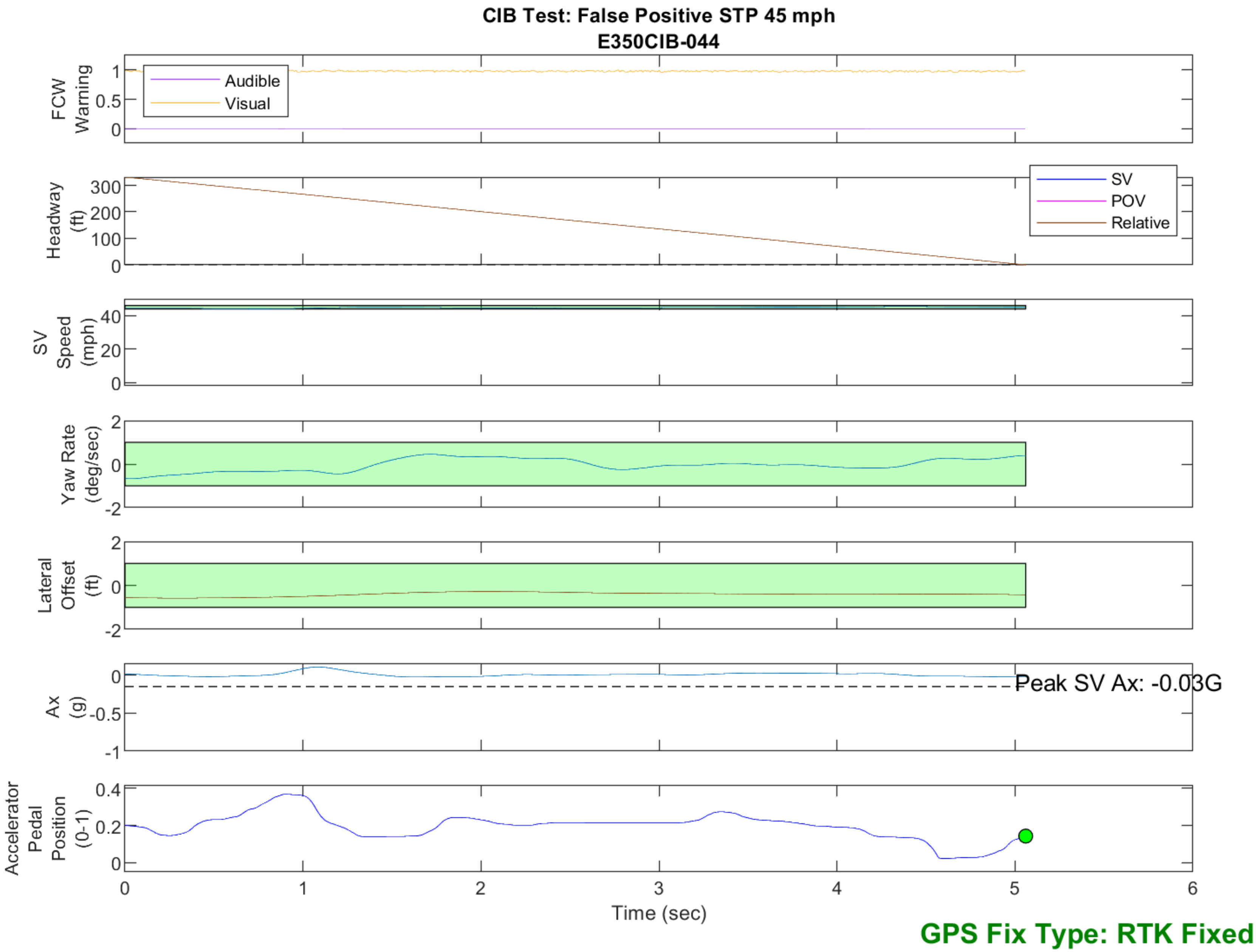


Figure D46. Time History for CIB Run 44, SV Encounters Steel Trench Plate, SV 45 mph

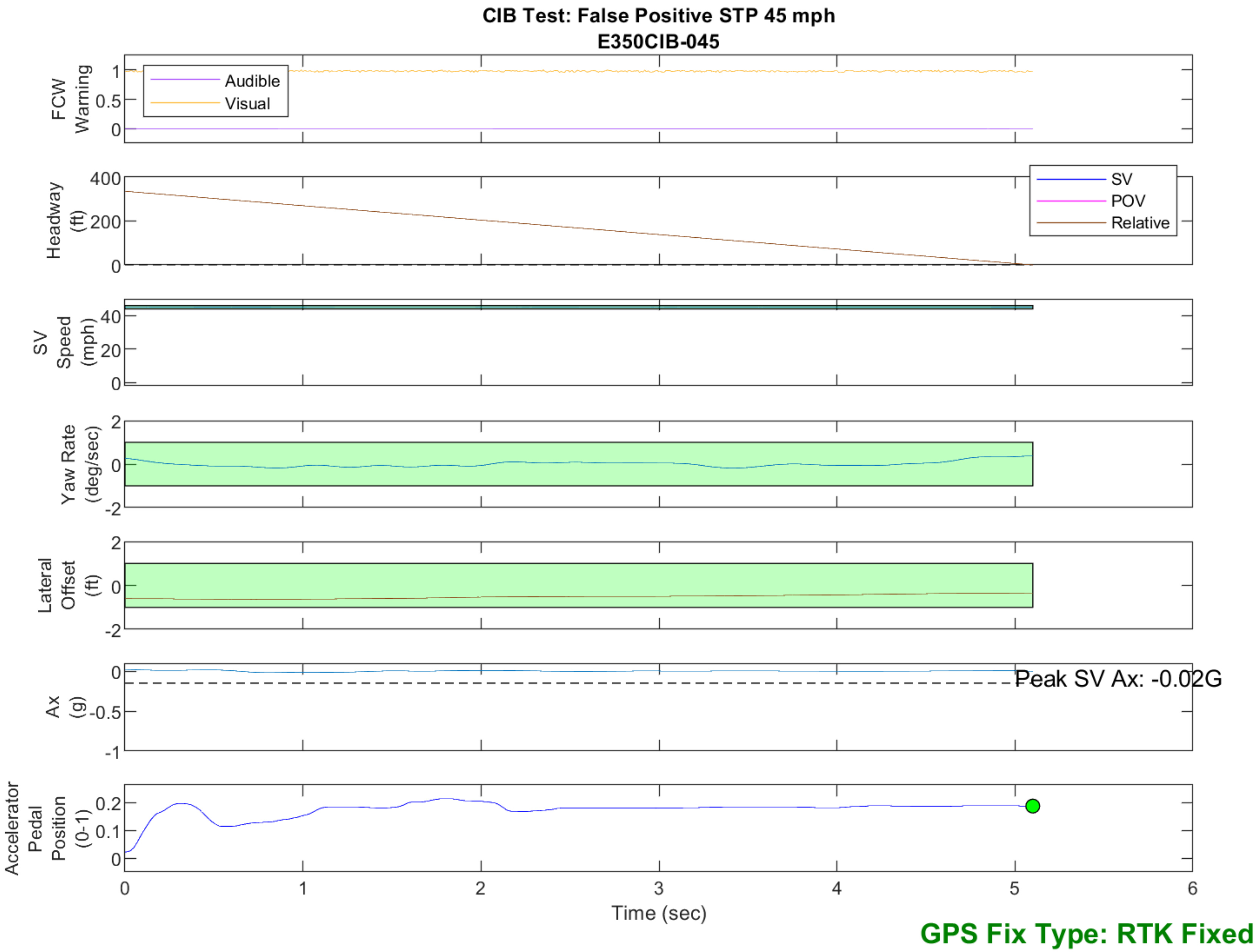


Figure D47. Time History for CIB Run 45, SV Encounters Steel Trench Plate, SV 45 mph

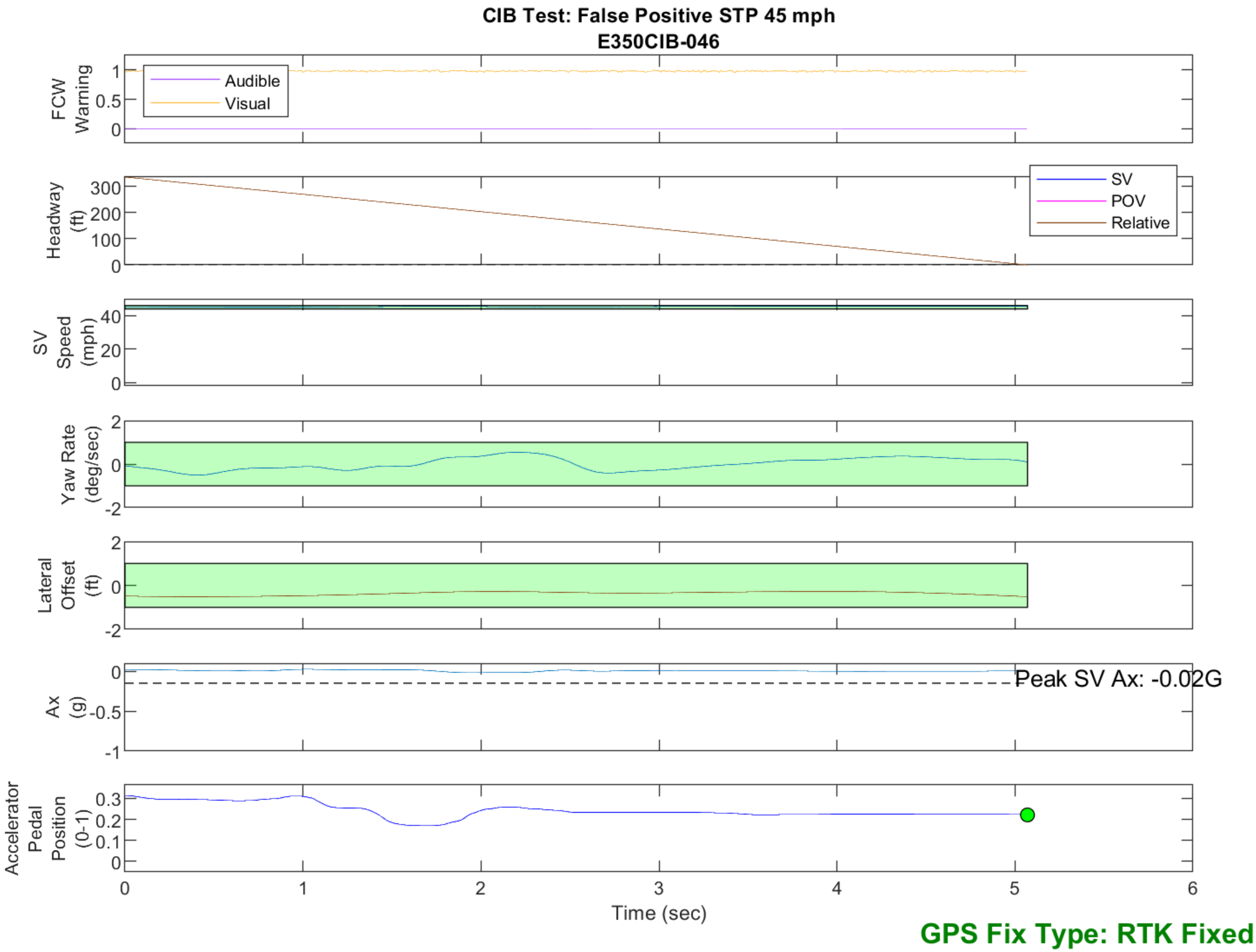


Figure D48. Time History for CIB Run 46, SV Encounters Steel Trench Plate, SV 45 mph

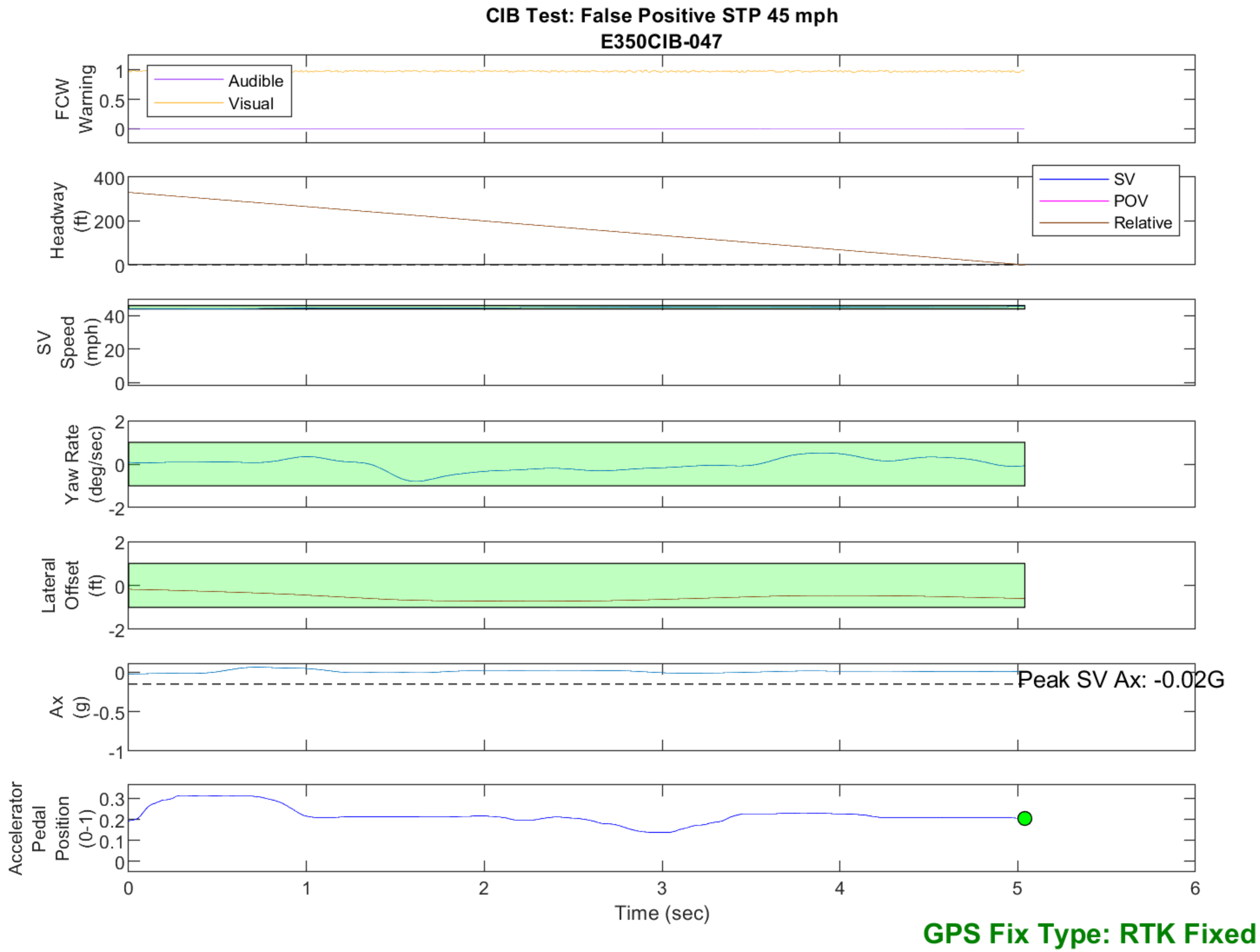


Figure D49. Time History for CIB Run 47, SV Encounters Steel Trench Plate, SV 45 mph

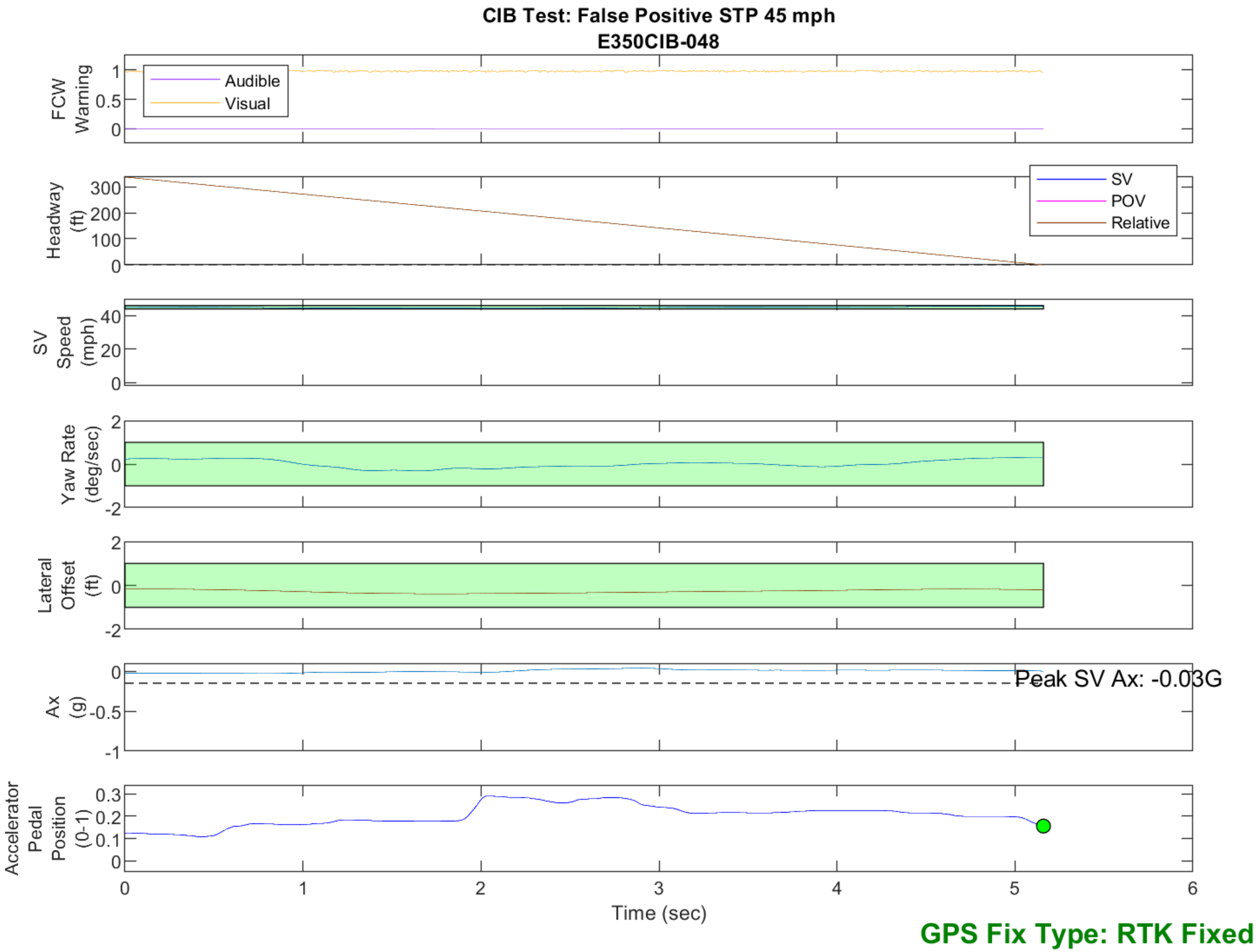


Figure D50. Time History for CIB Run 48, SV Encounters Steel Trench Plate, SV 45 mph

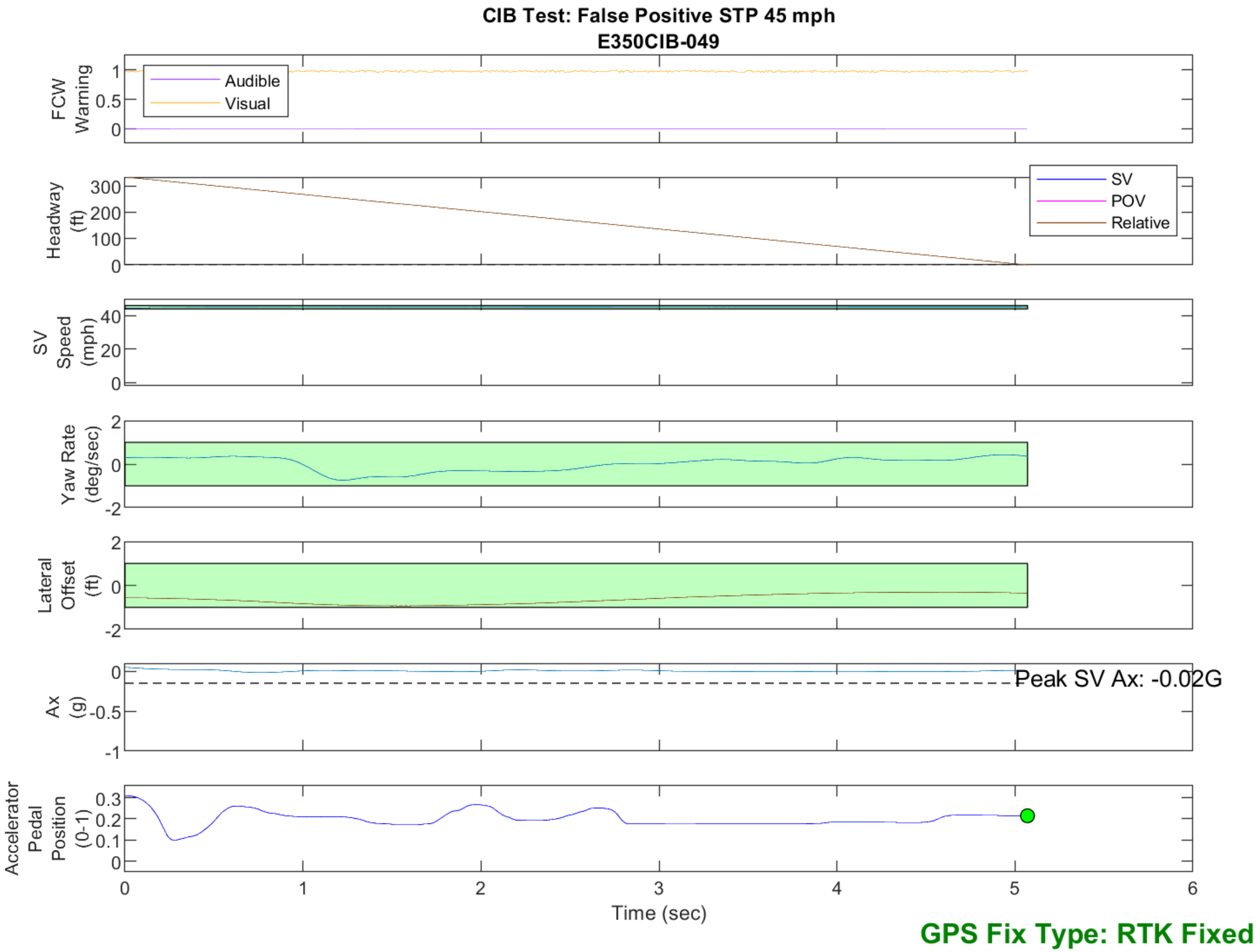


Figure D51. Time History for CIB Run 49, SV Encounters Steel Trench Plate, SV 45 mph