CRASH IMMINENT BRAKING SYSTEM RESEARCH TEST
NCAP-DRI-CIBHS-20-06

2020 Subaru Outback Premium/LDD

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10 July 2020

Final Report

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National Highway Traffic Safety Administration
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16. Abstract These research tests were conducted on the subject 2020 Subaru Outback Premium/LDD 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, with modifications to include use of Global Vehicle Target (GVT) and additional test speeds or deceleration rates to assess system performance and point of failure. The system met the acceptability criteria for 58 out of 58 valid test runs.			
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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) in the New Car Assessment Program's (NCAP's) Crash Imminent Brake System Test Procedure (dated October 2015)[1] to evaluate CIB performance on the test track 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).

This report describes the results of research tests conducted in accordance with the NHTSA test procedure, but several modifications were made to the specified test matrix and an alternative POV was used.

The modified test matrix replaces the "false positive" test condition in the standard CIB confirmation test with additional test speeds or deceleration rates, as indicated in Table 1.

The NHTSA test procedure does not specify a particular strikeable POV, but the New Car Assessment Program (NCAP) has been using the Strikeable Surrogate Vehicle (SSV) for the CIB confirmation tests.[2] However, the Global Vehicle Target (GVT) system, which is in general use worldwide, was used in these research tests instead of the SSV. A detailed description of the GVT system is given in Section III C.

[1] NHTSA-2015-0006-0025; Crash Imminent Brake System Performance Evaluation for the New Car Assessment Program, October 2015.
[2] A detailed description of the SSV system can be found in the NHTSA report: NHTSA'S STRIKEABLE SURROGATE VEHICLE PRELIMINARY DESIGN+OVERVIEW, May 2013.

Table 1. Comparison of NCAP CIB Confirmation Test and Research Test Conditions

Test Scenario		Initial SV Speed mph (km/h)	Initial POV Speed mph (km/h)	POV Deceleration g	Standard NCAP CIB Confirmation Test Condition	Research Test Condition (Evaluated Herein)
1	**Stopped POV**	25 (40.2)	0	0	Yes	Yes
		30 (48.3)	0	0	Not Applicable	Yes
		35 (56.3)	0	0	Not Applicable	Yes
		40 (64.4)	0	0	Not Applicable	Yes
		45 (72.4)	0	0	Not Applicable	Yes
2	**Slower Moving POV**	25 (40.2)	10 (16.1)	0	Yes	Yes
		45 (72.4)	20 (32.2)	0	Yes	Yes
3	**Decelerating POV**	35 (56.3)	35 (56.3)	0.3	Yes	Yes
		35 (56.3)	35 (56.3)	0.5	Not Applicable	Yes
		45 (72.4)	45 (72.4)	0.3	Not Applicable	Yes
4	**Steel Trench Plate**	25 (40.2)	Not Applicable	Not Applicable	Yes	No
		45 (72.4)	Not Applicable	Not Applicable	Yes	No

Section II

DATA SHEETS

CRASH IMMINENT BRAKING

DATA SHEET 1: TEST RESULTS SUMMARY

(Page 1 of 1)

2020 Subaru Outback Premium/LDD

VIN: *4S4BTACC3L319xxxx* Test Date: *6/1/2020*

Crash Imminent Braking System setting: *Pre-Collision Braking On*

		Number of valid test runs for which acceptability[3] criteria were:		
Test 1 –	**Subject Vehicle Encounters Stopped Principal Other Vehicle**	**Met**	**Not met**	**Valid Runs**
	SV 25 mph:	*7*	*0*	*7*
	SV 30 mph:	*5*	*0*	*5*
	SV 35 mph:	*5*	*0*	*5*
	SV 40 mph:	*5*	*0*	*5*
	SV 45 mph:	*5*	*0*	*5*
Test 2 –	**Subject Vehicle Encounters Slower Principal Other Vehicle**			
	SV 25 mph POV 10 mph:	*7*	*0*	*7*
	SV 45 mph POV 20 mph:	*7*	*0*	*7*
Test 3 –	**Subject Vehicle Encounters Decelerating Principal Other Vehicle**			
	SV 35 mph POV 35 mph, 0.3 g decel:	*7*	*0*	*7*
	SV 35 mph POV 35 mph, 0.5 g decel:	*5*	*0*	*5*
	SV 45 mph POV 45 mph, 0.3 g decel:	*5*	*0*	*5*
	Overall:	***58***	***0***	***58***

Notes:
The system met the acceptability criteria for 58 out of 58 valid test runs.

[3] The acceptability criteria listed herein are used only as a guide to gauge vehicle performance and are identical to the Pass/Fail criteria given in 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.

CRASH IMMINENT BRAKING

DATA SHEET 2: VEHICLE DATA

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2020 Subaru Outback Premium/LDD

TEST VEHICLE INFORMATION

VIN: *4S4BTACC3L319xxxx*

Body Style: *SUV* Color: *Magnetite Gray Metallic*

Date Received: *5/14/2020* Odometer Reading: *114 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Subaru Corporation*

Date of manufacture: *2/20*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *225/65R17*

Rear: *225/65R17*

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

Rear: *230 kPa (33 psi)*

TIRES

Tire manufacturer and model: *Yokohama Avid GT*

Front tire designation: *225/65R17 102H*

Rear tire designation: *225/65R17 102H*

Front tire DOT prefix: *4UF5 6JK*

Rear tire DOT prefix: *4UF5 6JK*

CRASH IMMINENT BRAKING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2020 Subaru Outback Premium/LDD

GENERAL INFORMATION

Test date: *6/1/2020*

AMBIENT CONDITIONS

Air temperature: *29.4 C (85 F)*

Wind speed: *3.6 m/s (8.1 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: *240 kPa (35 psi)*

Rear: *230 kPa (33 psi)*

CRASH IMMINENT BRAKING

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2020 Subaru Outback Premium/LDD

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*518.9 kg (1144 lb)*	Right Front:	*474.9 kg (1047 lb)*
Left Rear:	*400.1 kg (882 lb)*	Right Rear:	*378.3 kg (834 lb)*
		Total:	*1772.2 kg (3907 lb)*

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

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2020 Subaru Outback Premium/LDD

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

Pre-Collision Braking System, as a sub-function of Eyesight. It is specified on the Monroney label as Eyesight Driver-Assist System w/ Automatic Emergency Braking

Type and location of sensors the system uses:

Stereo cameras located behind the windshield near the rearview mirror.

System setting used for test (if applicable): *Pre-Collision Braking On*

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

1.6 km/h (1 mph) (Per manufacturer supplied information)

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

160 km/h (100 mph) (Per manufacturer supplied information)

Does the vehicle system require an initialization sequence/procedure? **X** Yes ___ No

If yes, please provide a full description.

Initialization is accomplished by operation on a public road for about 1 hour. The initialization should be performed under the following conditions and should not be performed in inclement weather:

1. Dry road surfaces

2. Daylight hours

3. Public road with both left and right lane markings

4. If traffic exists, keep a comfortable distance from a lead vehicle

5. Maintain the posted speed limit

If the vehicle ignition is turned off and the engine is restarted following each test run, it's NOT necessary to reinitialize the system.

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

X Yes

____ No

If yes, please provide a full description.

If the Pre-Collision Braking System OFF indicator light illuminates, AEB is NOT operational. For example, if AEB has operated 3 times in one driving cycle, AEB will NO longer operate. To reactivate, restart the engine. After the engine is restarted, it takes approximately 7 seconds for the pre-collision braking system to activate.

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 visual alert alternates between two graphics, shown in Appendix A, Figure A13. The auditory alert is a tone centered at 2200 HZ and pulsed approximately 8 times per second.

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 settings are accessed by means of a touch screen center screen. The hierarchy is:

Settings

Driver Assistance

Pre-Collision Braking

Select: 'Setting ON' or 'Setting OFF'

The system is automatically reactivated after cycling the ignition.

Please see EyeSight Owner's Manual, Pages 126 and 127. These are shown in Appendix B, Pages B-33 and B-34. See also Appendix A, Figure A12.

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

____ Yes

X No

If yes, please provide a full description.

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.

Limitations of the system are addressed at length in the EyeSight Owner's Manual, Pages 5 through 9 and Pages 27 through 35. These are shown in Appendix B, Pages B-2 through B-6 and Pages B-17 through B-25.

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Three 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

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. Test conditions for Test 1 are shown in Table 2.

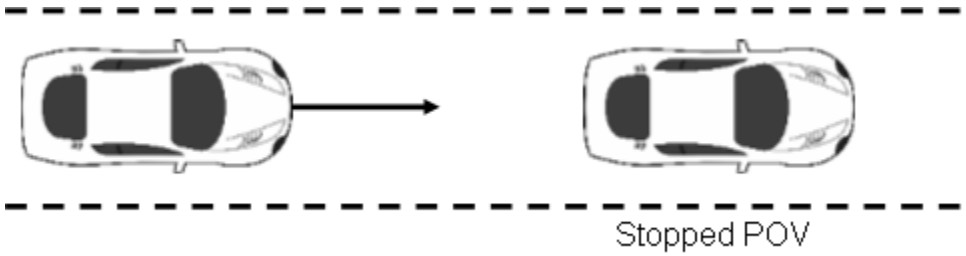


Figure 1. Depiction of Test 1

Table 2. Test Conditions for Stopped POV

Initial SV Speed mph (km/h)	**Initial POV Speed** mph (km/h)	**POV Deceleration** g
25 (40.2)	0	0
30 (48.3)	0	0
35 (56.3)	0	0
40 (64.4)	0	0
45 (72.4)	0	0

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 tests were conducted at five different SV nominal speeds. The nominal speeds were 25 mph (40.2 km/h), 30 mph (48.3 km/h), 35 mph (56.3 km/h), 40 mph (64.4 km/h), and 45 mph (72.4 km/h). The guideline for test speed was to start at the lowest speed and increase the test speed incrementally until a speed was reached at which the system performance was no longer acceptable. If the system performance became unacceptable before all the nominal speeds were completed, an additional series of tests was then conducted at a speed 2.5 mph less than the speed at which unacceptable performance was observed. The SV was driven at the nominal speed 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}.

b. Criteria

If, at each nominal speed, the magnitude of the SV speed reduction attributable to CIB intervention was ≥ 9.8 mph (15.8 km/h) for at least three of five valid test trials the system performance was considered acceptable.

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. Test conditions for Test 2 are shown in Table 3.

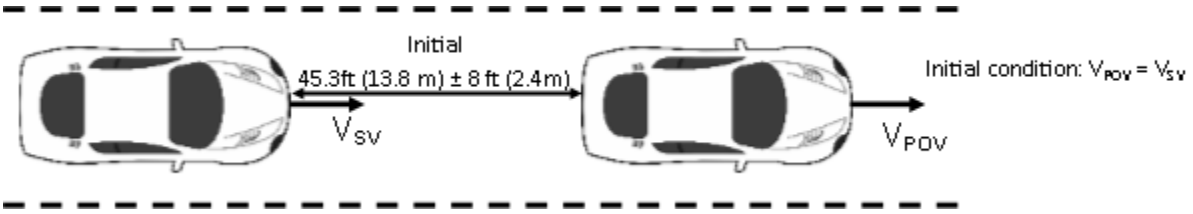


Figure 2. Depiction of Test 2

Table 3. Test Conditions for Slower POV

Initial SV Speed mph (km/h)	**Initial POV Speed** mph (km/h)	**POV Deceleration** g
25 (40.2)	10 (16.1)	0
45 (72.4)	20 (32.2)	0

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 acceptability was that there be no SV-to-POV impact for at least three of five valid test trials.

To be considered acceptable for 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 three of five 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. 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 by the example in Figure 3. Test conditions for Test 3 are shown in Table 4.

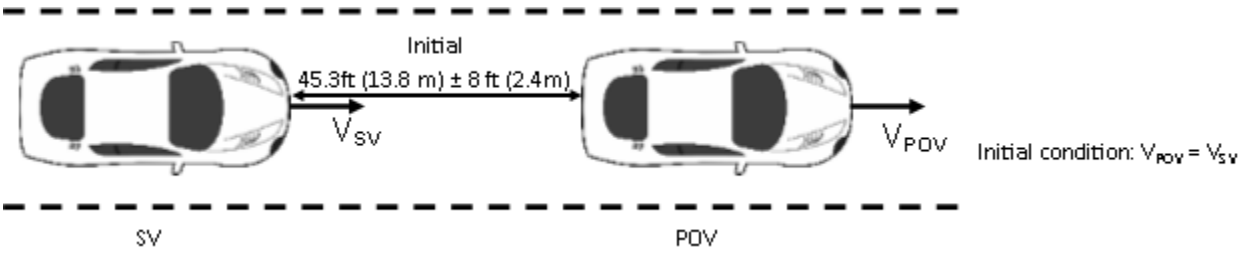


Figure 3. Depiction of Test 3 with POV Decelerating with V_0 =35 mph (56.3 km/h)

Table 4. Test Conditions for Decelerating POV

Initial SV Speed mph (km/h)	Initial POV Speed mph (km/h)	POV Deceleration g
35 (56.3)	35 (56.3)	-0.3
35 (56.3)	35 (56.3)	-0.5
45 (72.4)	45 (72.4)	-0.3

a. Procedure

The SV ignition was cycled prior to each test run. This test scenario was conducted at three different combinations of nominal initial speeds (V_0) and deceleration levels ($-a_x$). The first two combinations comprised V_0 = 35.0 mph (56.3 km/h) with a_x = -0.3 ± 0.03 g and -0.5 ± 0.03 g respectively. The third combination comprised V_0 = 45 mph (72.4 km/h) and a_x = 0.3 ± 0.03 g. Both the POV and SV were driven at a constant V_0 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 for at least three seconds, the POV (GVT) brakes were applied to achieve the nominal level of deceleration ($-a_x$). 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 or 0.5 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

For the decelerating POV test series, in order to be considered acceptable, the magnitude of the SV speed reduction attributable to CIB intervention must have been ≥ 10.5 mph (16.9 km/h) for at least three of five valid test trials, for each combination of initial speeds and deceleration levels. 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}.

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 audible, visual, or haptic 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 5.

Table 5. 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.
- 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 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

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.

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 and POV (i.e., GVT and LPRV) were centered in the same travel lane with the same orientation (i.e., facing the same direction).

For these tests, the SV was also positioned such that it just contacted a vertical plane that defines the rearmost location of the POV. 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 five (5) valid trials were performed for each scenario. In cases where the test driver performed more than five trials, the first five 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 Global Vehicle Target (GVT) secured to a low profile robotic vehicle (LPRV).

This GVT system was designed for a wide range of crash scenarios including scenarios that AEB systems address. The key components of the GVT system are:

- A soft GVT, which is visually and dimensionally similar to a 2013 Ford Fiesta hatchback. It is designed to appear realistic to the sensors used by automotive safety systems and automated vehicles: radar, camera, and lidar. Appropriate radar characteristics are achieved by using a combination of radar-reflective and radar-absorbing material enclosed within the GVT’s vinyl covers. Internally, the GVT consists of a vinyl-covered foam structure. If a test vehicle impacts the GVT at low speeds, it is designed to separate, and is typically pushed off and away from the supporting LPRV platform. At higher impact speeds, the GVT breaks apart as the SV essentially drives through it. The GVT can be repeatedly struck from any approach angle without harm to those performing the tests or the vehicles being evaluated. Reassembly of the GVT occurs on top of the robotic platform and takes a team of 3 to 5 people approximately 7 to 10 minutes to complete.
- An LPRV platform that supports the GVT and provides for precisely controlled GVT motion. The LPRV contains the batteries, drive motors, GPS receiver, and the control electronics for the system. It has a top speed of 50 mph (80 km/h); a maximum longitudinal acceleration and deceleration of 0.12 g (1.18 m/s^2) and 0.8

g (7.8 m/s^2), respectively; and a maximum lateral acceleration of 0.5 g (4.9 m/s^2). The LPRV is preprogrammed and allows the GVT's movement to be accurately and repeatedly choreographed with the test vehicle and/or other test equipment required by a pre-crash scenario using closed-loop control. The LPRV is designed to be safely driven over by the SV without damage if the GVT is struck by the SV.

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 45 mph (72.4 km/h).
- Accurately control the lateral position of the POV within the travel lane.

Operationally, the GVT body is attached to LPRV using Velcro hook and loop fasteners. The GVT and LPRV are designed to separate if the GVT is struck by the SV. The GVT/LPRV system is shown in Figures A6 and A7 in Appendix A and a detailed description can be found in the NHTSA report: "A Test Track Comparison of the Global Vehicle Target (GVT) and NHTSA's Strikeable Surrogate Vehicle (SSV)".[4]

D. Automatic Braking System

The LPRV includes an automatic braking system, which was used in Test 3. The braking system can provide for pre-programmed controlled deceleration up to 0.5 g (4.9 m/s^2).

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 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 in prior runs of the same test.

E. Instrumentation

Table 6 lists the sensors, signal conditioning, and data acquisition equipment used for these tests.

[4] Snyder, A.C., Forkenbrock, G.J., Davis, I.J., O'Harra, B.C., and Schnelle, S.C., A Test Track Comparison of the Global Vehicle Target (GVT) and NHTSA's Strikeable Surrogate Vehicle (SSV), DOT HS 812 698, Vehicle Research and Test Center, National Highway Traffic Safety Administration, Washington, DC, July 2019.

Table 6. 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	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	49041189	By: DRI Date: 5/22/2020 Due: 5/22/2021
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	NA
SV 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 +	2258	By: Oxford Technical Solutions Date: 5/3/2019 Due: 5/3/2021
POV Multi-Axis Inertial Sensing System		Latitude: ±90º Longitude	Position: ±2 cm Velocity	Oxford PinPoint 2G	24504	By: Oxford Technical Solutions Date: 7/18/2019 Due: 7/18/2021

Table 6. Test Instrumentation and Equipment (continued)

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
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
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

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

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

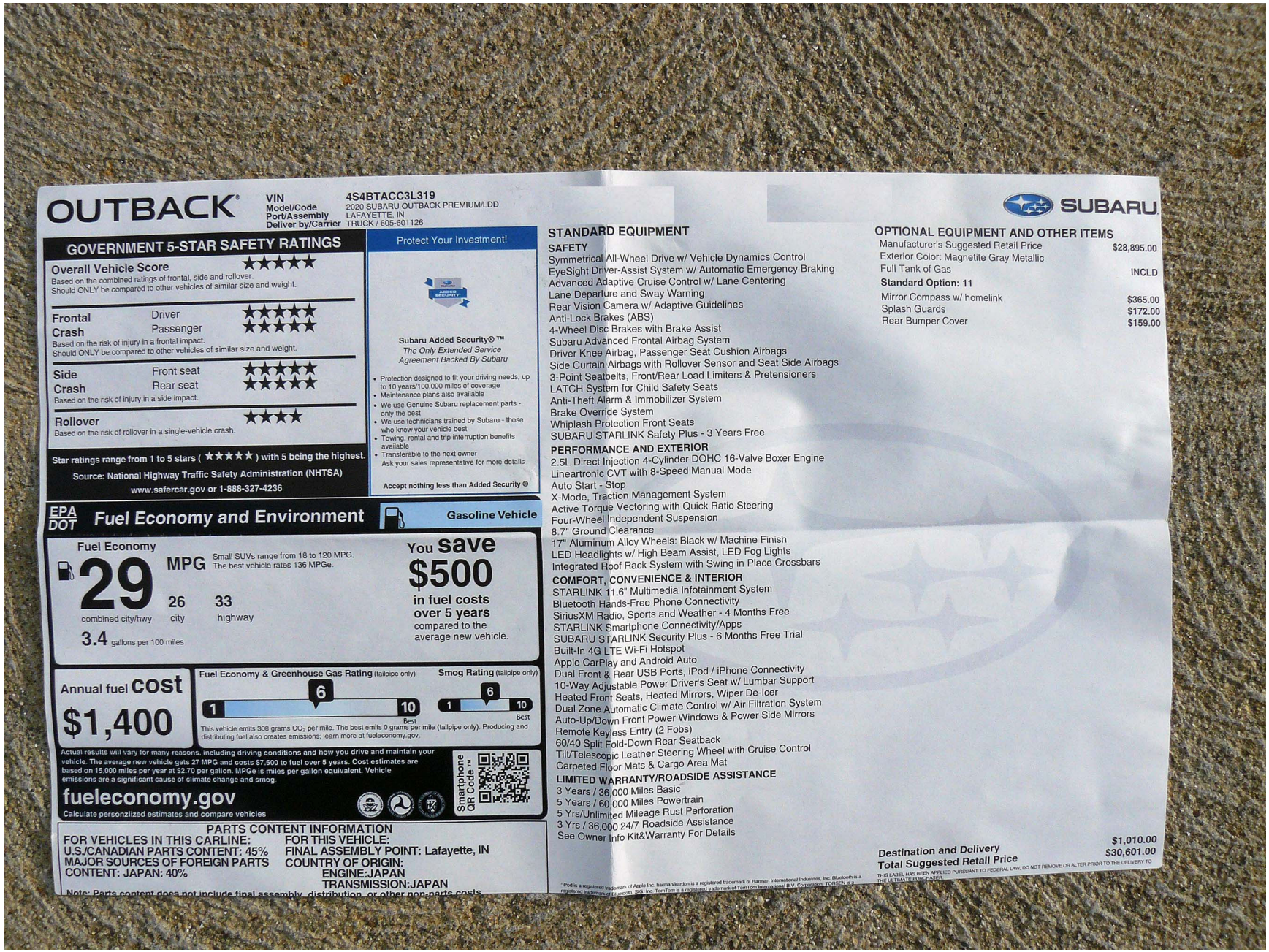


Figure A3. Window Sticker (Monroney Label)

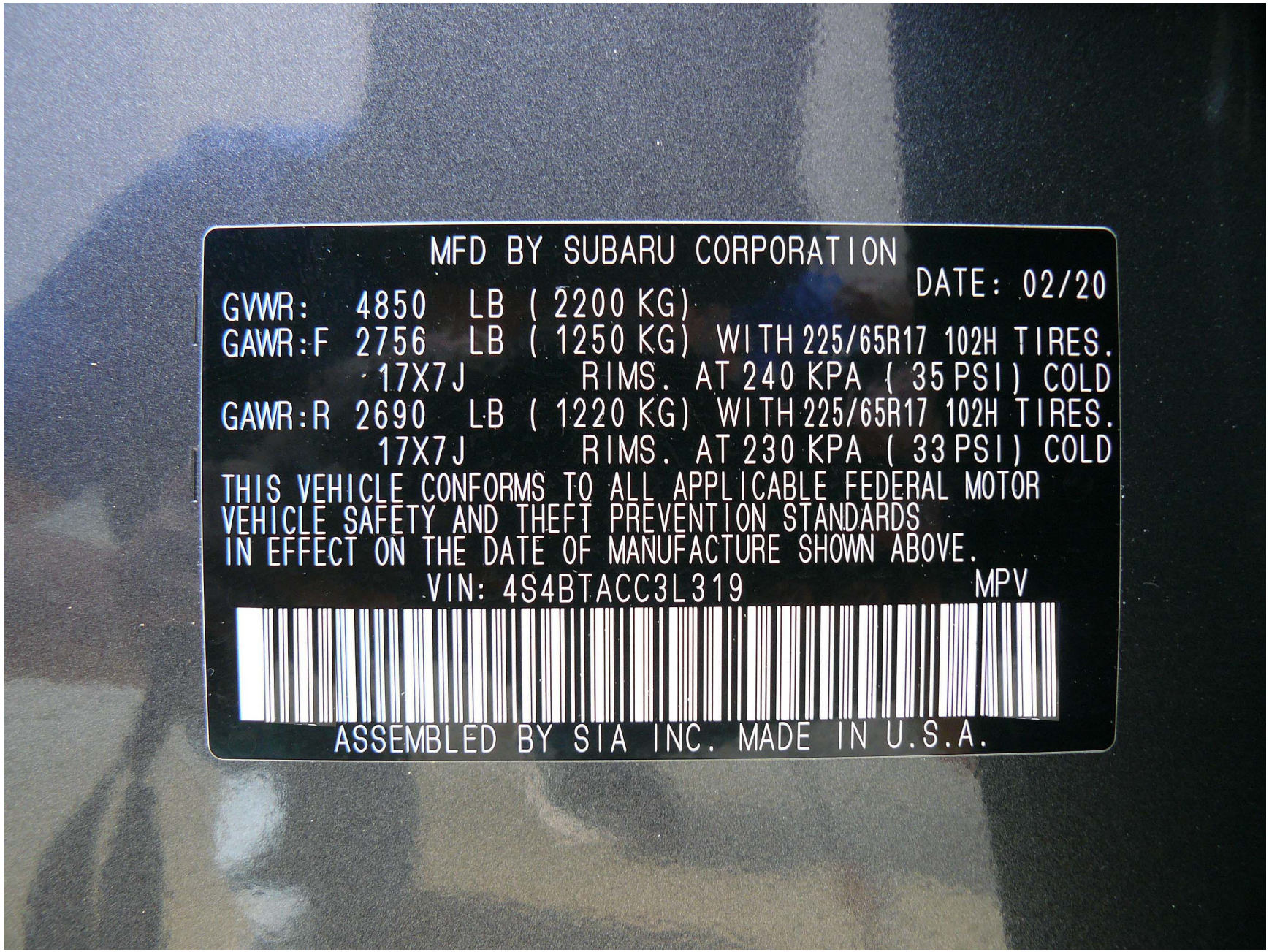


Figure A4. Vehicle Certification Label

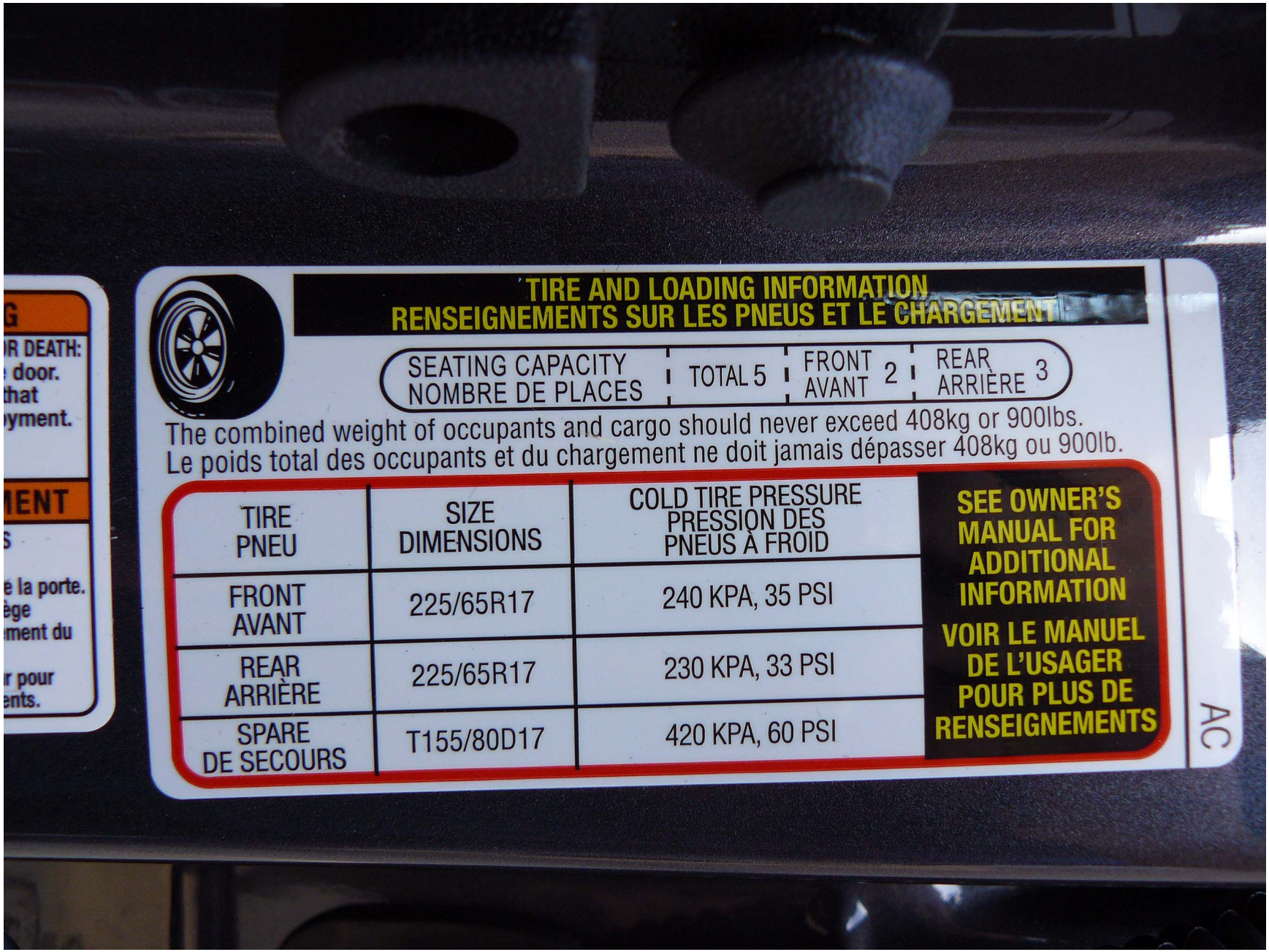


Figure A5. Tire Placard

Figure A6. Front View of Principal Other Vehicle: Global Vehicle Target

Figure A7. Rear View of Principal Other Vehicle: Global Vehicle Target

Figure A8. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

Figure A9. Sensor for Detecting Auditory Alerts

Figure A10. Sensor for Detecting Visual Alerts

Figure A11. Computer Installed in Subject Vehicle

Figure A12. System Setup Menus

Figure A13. Visual Alerts

APPENDIX B

Excerpts from Owner’s Manual

In LHD vehicles, EyeSight is configured for driving on the right-hand side of the road. However, it can be reconfigured by changing the Driving Lane Customize setting for driving on the left-hand side.*
⇒ **Page 126**
If the setting for the traffic lane (driving side of the road) does not match the traffic lane, full EyeSight performance may not be available.
***: Characteristics and settings that are affected by specific differences between RHD and LHD vehicles cannot be changed.**

- The system may not operate correctly under the conditions listed below. When these conditions occur, turn off the Pre-Collision Braking System. Also, do not use Adaptive Cruise Control, Lane Centering Function, Lane Departure Prevention Function or Conventional Cruise Control.
  - The tire pressure is not correct.[*1]
  - The temporary spare tire is installed.[*1]
  - Tires that are unevenly worn or tires with uneven wear patterns are installed.[*1]
  - Tires that are the wrong size are installed.[*1]
  - A flat tire has been fixed temporarily with a tire repair kit.
  - The suspension has been modified (including a genuine SUBARU suspension that has been modified).
  - An object that obstructs the stereo camera's view is installed on the vehicle.
  - The headlights are dirty or they have snow and ice or dirt on them. (Objects are not correctly illuminated and are difficult to detect.)
  - The optical axes are not aligned correctly. (Objects are not correctly illuminated and are difficult to detect.)
  - The lights including headlights and fog lights have been modified.
  - Vehicle operation has become unstable due to an accident or malfunction.
  - The brake system warning light is illuminated in red.[*2]
  - A heavy cargo is loaded onto or inside the vehicle.
  - The maximum number of occupants is exceeded.
  - The combination meter is not operating properly; such as when the lights do not illuminate, the beeps do not sound, the display is different from when it is normal, etc.[*3]

Continued on next page ⇒

⇒ Continued from previous page

- The system will not operate correctly in the following conditions. Do not use Adaptive Cruise Control, Lane Centering Function, Lane Departure Prevention Function or Conventional Cruise Control.
  - The wheels are out of balance (e.g., the balance weight is removed or misaligned).*1
  - The wheels are out of alignment.*1
  - A trailer or another vehicle, etc. is being towed.
- The system may not operate properly under the following conditions. Do not use Lane Centering Function.
  - There is an abnormal vibration in the steering wheel or the steering wheel is heavier than usual.
  - The steering wheel has been replaced with parts other than genuine SUBARU parts.

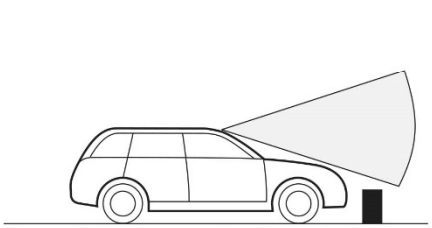
*1: The wheels and tires have functions that are critically important. Be sure to use the correct ones. For details, refer to the Owner's Manual for your vehicle.

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

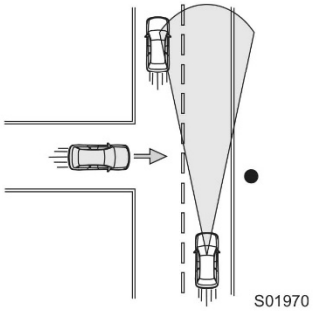
*3: For details about the combination meter, refer to the Owner's Manual for your vehicle.

CAUTION

- The characteristics of the stereo camera are similar to those of human eyes. For this reason, conditions that make it difficult for the driver to see in the forward direction have the same effect on the stereo camera. They also make it difficult for the system to detect vehicles, obstacles, and traffic lanes.
- Detection by the EyeSight system is limited to objects that are within the range of the stereo camera's field of view. Also, after an object enters the range of the camera's field of view, it may take some time for the system to detect it as a controllable target and to warn the driver.



Low objects surrounding the vehicle cannot be detected.



S01970

- Under the conditions listed below, it will become more difficult for the system to detect the vehicle in front, motorcycles, bicycles, pedestrians and obstacles on the road, and lane markers. Also, EyeSight may temporarily stop operating. However, the temporary stop will be canceled once these conditions have improved and the vehicle is driven for a short period of time.
  - Bad weather (for example heavy rain, a blizzard or thick fog). In particular, the system is more likely to temporarily stop operating when there is an oil film adhering to the windshield, a glass coating has been applied, or poorly performing wipers are used.
  - Strong light is coming from the front (sunlight or headlight beams of oncoming traffic, etc.).
  - The windshield washer is in use.
  - Raindrops, water drops, or dirt on the windshield are not wiped off sufficiently.
  - The windshield has become fogged, scratched, or snow, dirt, dust or frost has adhered to it, or it is otherwise affected. These will reduce the stereo camera's field of view.
  - The vehicle is tilted at an extreme angle due to loaded cargo or other factors.

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- Visibility is poor due to sand, smoke or water vapor blowing in the wind, or the front vision is obscured due to water splashes, snow, dirt or dust stir up generated by the vehicle in front or oncoming traffic.
- The stereo camera's field of view is obstructed (for example by a canoe on the roof of the vehicle).
- Through the entrance or exit of a tunnel
- The rear aspect of the vehicle in front is low, small or irregular (for example a low bed trailer, etc.).
- The obstacle is a fence, a wall or a shutter, etc. with a uniform pattern (a striped pattern, brick, etc.) or with no pattern in front.
- The obstacle is a wall or door made of glass or a mirror in front.
- Driving at night or in a tunnel when there is a vehicle in front that does not have its taillights on
- Driving through a banner or flag, low branches on a tree or thick/tall vegetation
- On steep uphill or downhill grades
- The stereo camera is obstructed by a hand, etc. (If even one of the lenses is obstructed, the system does not operate properly.)
- It is completely dark and no objects are detected.
- The area around the vehicle has a uniform color (such as when completely covered in snow, etc.).
- Accurate detection is not possible due to reflections in the windshield.

• Under the conditions listed below, EyeSight may temporarily stop operating. If this occurs, EyeSight will resume operating when the conditions improve.
- The temperature inside the vehicle is high, such as after the vehicle was left in bright sunshine, or the temperature inside the vehicle is low, such as after the vehicle was left in an extremely cold environment.
- Immediately after the engine starts

• Under the conditions listed below, it is difficult to recognize vehicles in front, motorcycles, pedestrians, obstacles on the road, traffic lanes, etc. Also, the EyeSight system may temporarily stop operating. If the EyeSight system repeatedly stops operating several times, contact a SUBARU dealer and have the system inspected.
- The stereo camera lenses are smeared such as from fingerprints.
- The stereo camera has become misaligned due to a strong impact.

- When there is a malfunction in the EyeSight system, turn off the Pre-Collision Braking System (⇒ page 41) and the Lane Departure Warning (⇒ page 102), and stop using the Adaptive Cruise Control, Lane Centering Function, Lane Departure Prevention Function and Conventional Cruise Control. Contact a SUBARU dealer and have the system inspected.
- When the Vehicle Dynamics Control warning light is illuminated, the Pre-Collision Braking System may not operate properly. If the indicator light is illuminated, turn off the Pre-Collision Braking System. Also, do not use the Adaptive Cruise Control or Conventional Cruise Control.

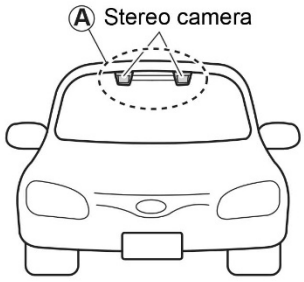
NOTE

EyeSight records and stores the following data when the Pre-Collision Braking System is operated. It does not record conversations or other audio data.

- Stereo camera image data
- Distance from the vehicle in front
- Vehicle speed
- Steering wheel turning angle
- Lateral movement with regards to the direction of travel
- Accelerator pedal operation status
- Brake pedal operation status
- Select lever position
- Odometer reading
- Data related to ABS, Vehicle Dynamics Control and Traction Control Function SUBARU and third parties contracted by SUBARU may acquire and use the recorded data for the purpose of vehicle research and development. SUBARU and third parties contracted by SUBARU will not disclose or provide the acquired data to any other third party except under the following conditions.
  - The vehicle owner has given his/her consent.
  - The disclosure/provision is based on a court order or other legally enforceable request.
  - Data that has been modified so that the user and vehicle cannot be identified is provided to a research institution for statistical processing or similar purposes.

Handling of the Stereo Camera

The stereo camera is located on the front map lights unit.

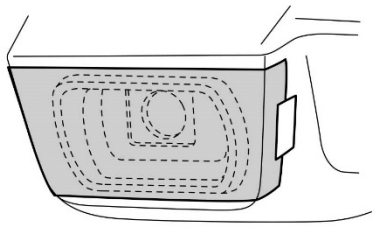


S01107

⚠ CAUTION

- The stereo camera monitors and detects smears or blurs on the front of the camera. However, detection is not 100% accurate.
  Under certain conditions, the function may fail to detect smears or blurs on the front of the stereo camera accurately. In addition, this function may not detect that there is snow or ice on the windshield close to the stereo camera. In such conditions, be sure to keep the windshield clean at all times (indicated by Ⓐ). Otherwise the system may not operate correctly. When this function detects that the front of the stereo camera is smeared or blurred, no EyeSight functions can be activated except for Conventional Cruise Control.
- The stereo camera lenses are precision components. Always observe the following precautions especially when handling them.
  - Never touch the stereo camera lenses, and do not attempt to wipe or clean the lenses. Doing so could damage or soil the lens, and lead to improper system performance.
    If you ever touch a lens for any reason, be sure to contact a SUBARU dealer.

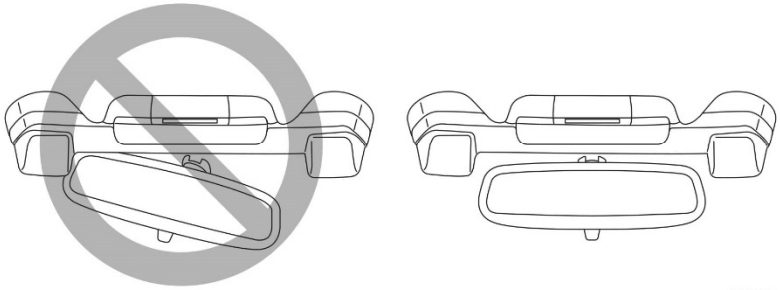
- When cleaning the windshield, cover the front of the camera casing with paper that does not collect dust, such as copy paper. Affix the paper to prevent glass cleaner from getting on the camera lenses. At this point, make sure that the tape's adhesive surface does not come in contact with the windshield or the lens. Be sure to remove the paper after cleaning.



S03066

- When having the inside of windshield cleaned at a service station, etc., be sure to request that the attendant covers the camera covers before washing the vehicle.
- Do not subject the stereo camera to a strong impact.
- Do not remove or disassemble the stereo camera.
- Do not change the positions where the stereo camera is installed or modify any of the surrounding structures.

• Do not install an interior rearview mirror other than a genuine SUBARU rearview mirror (such as a wide-type mirror) and the sun visor. Also, use the rearview mirror so that it does not obstruct the stereo camera. Failure to do so may affect the stereo camera's field of view and could prevent the EyeSight system from functioning properly.



S00509

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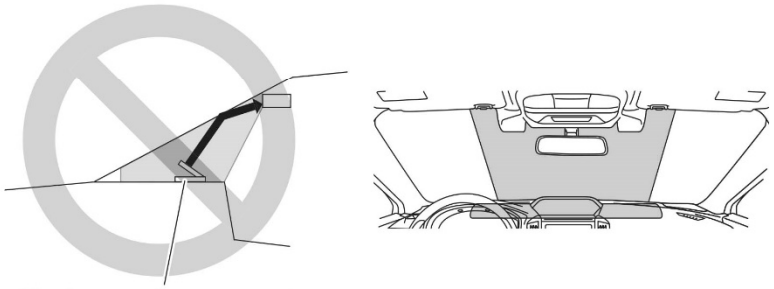
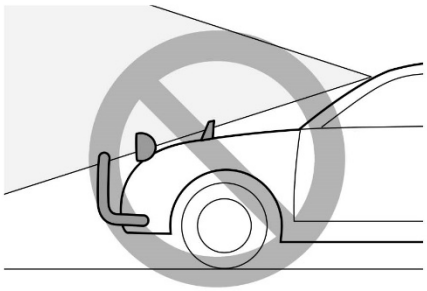
- Do not install any accessories other than the ones designated by SUBARU on the prohibited areas shown in the illustrations (gray zones).
  Even if some accessories are installed on the outside of the prohibited areas, abnormal operation of EyeSight may occur due to the reflection of the light or any objects. In this situation, move the accessories. For details, contact a SUBARU dealer.

Side view **Front view**



- Do not place any objects on top of the instrument panel. The stereo camera may not be able to detect objects accurately and the EyeSight system may not function properly due to reflections in the windshield. For details, contact a SUBARU dealer.
- If the top of the instrument panel is polished with chemicals or other substances, the stereo camera may not be able to detect objects accurately and the EyeSight system may not operate properly due to reflections in the windshield.
- Do not install any wiper blades other than genuine SUBARU wiper blades. Doing so may affect the stereo camera's field of view and could prevent the EyeSight system from functioning properly.
- Replace damaged wiper blades or worn wiper blade rubbers as soon as possible. Using damaged wiper blades or worn wiper blade rubbers may cause streaking on the windshield. The stereo camera may not be able to detect objects accurately and the EyeSight system may not function properly due to streaks or droplets remaining on the windshield.

- Do not install any accessories on the front side such as on the hood or the grille. It may affect the camera view and the system may not operate correctly.
- Make sure that the cargo loaded on the roof does not interfere in the stereo camera's field of view. Obstructing the stereo camera's view may impair the system operation. For details, contact a SUBARU dealer.



S01098

- Keep the windshield (outside and inside) clean at all times. When the windshield has become fogged, or it has a dirt or an oil film on it, the stereo camera may not detect objects accurately and the EyeSight system may not operate correctly. Never mount any device to the center air vent, as any airflow change may impact performance of the EyeSight system.
- Do not place any stickers or accessories on the windshield (outside or inside). If you have to do so (for example, legally required or electronic toll tag), avoid the area directly in front of the camera. Otherwise, it may adversely affect the field of view of the stereo camera and can cause improper operation of the system. For details, contact a SUBARU dealer.
- Do not use any glass coating agents or similar substances on the windshield. Doing so may interfere with the proper operation of the system.
- Do not install any film or an additional layer of glass on the windshield. The system may not operate correctly.
- If there are scratches or cracks on the windshield, contact a SUBARU dealer.
- To have the windshield replaced or repaired, contact a SUBARU dealer. Do not install a windshield other than a genuine SUBARU windshield. The stereo camera may not be able to detect objects accurately and the EyeSight system may not operate properly.

EyeSight Functions

EyeSight includes the following functions.

■ Pre-Collision Braking System

This function uses a following distance warning feature to warn the driver to take evasive action when there is the possibility of a collision with a vehicle or obstacle in front of you. If the driver does not take evasive action, the brakes are applied automatically to help reduce vehicle collision damage or, if possible, help prevent a collision.
⇒ Page 27

■ Advanced Adaptive Cruise Control

Adaptive Cruise Control

This function maintains the set vehicle speed and when there is a vehicle in front in the same traffic lane, it follows the speed of the vehicle in front up to the maximum of the set vehicle speed.
⇒ Page 43

Lane Centering Function

This function helps suppress lane drifting by detecting lane markings (e.g., white lines) and the lead vehicle on expressways, freeways and interstate highways, and by assisting steering operation. Lane Centering Function will work only when the Adaptive Cruise Control is activated.
⇒ Page 71

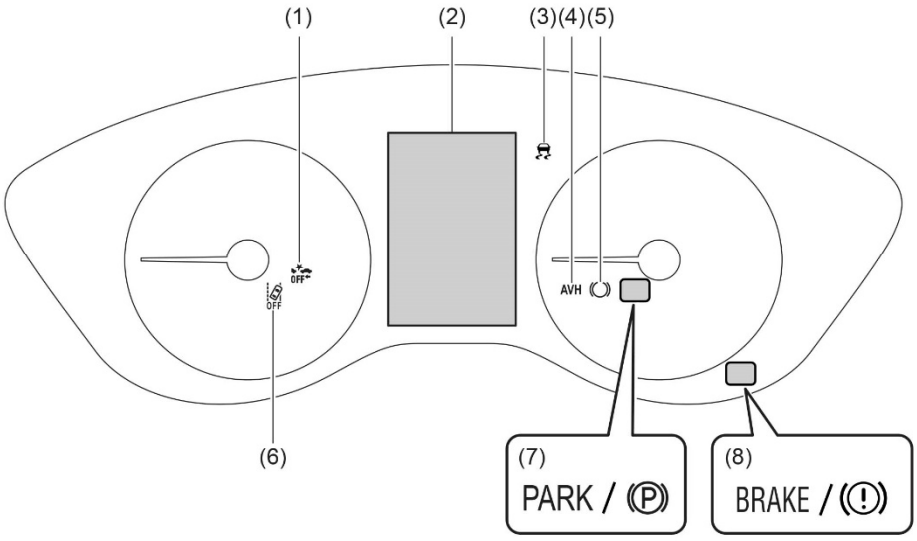
■ Lane Departure Prevention Function

When driving on expressways, freeways, or interstate highways, the system recognizes the lane markings on both sides of the vehicle. If the vehicle appears likely to depart from the lane, the system assists with steering operation in the direction that prevents the lane departure, preventing the vehicle from leaving the lane.
⇒ Page 84

■ Pre-Collision Throttle Management

This function reduces accidental forward movement caused by the select lever being placed in the wrong position or the accelerator pedal being accidentally depressed, or depressed too strongly.
⇒ Page 93

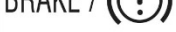
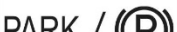
Instrument panel display layout



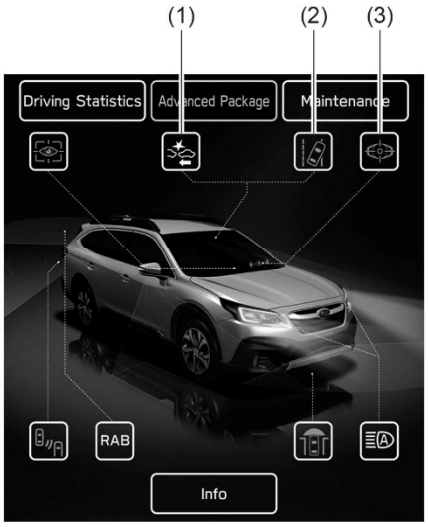
S03537

(1) Pre-Collision Braking System OFF indicator light
(2) Combination meter display
(3) Vehicle Dynamics Control warning light
(4) Auto Vehicle Hold ON indicator light
(5) Auto Vehicle Hold operation indicator light
(6) Lane Departure Warning OFF indicator light
(7) Electronic parking brake indicator light
(8) Brake system warning light

	**Select lever/gear position indicator** This indicator illuminates and shows which position the select lever or the gear is in.
	**EyeSight warning indicator (yellow)** • This indicator illuminates or flashes when a malfunction occurs in the EyeSight system. • When it is illuminated or flashing, none of the EyeSight functions can be used (including Adaptive Cruise Control and the Pre-Collision Braking System, etc.). ⇒ Page 122
	**EyeSight temporary stop indicator (white)** • This indicator illuminates when the EyeSight system is temporarily stopped. • When the ignition switch is placed in the ON position, it will illuminate if the (CRUISE) switch or (Lane Centering) switch is set to ON within approximately 7 seconds of the engine starting. It turns off when approximately 7 seconds have elapsed since the engine started. • When it is illuminated, none of the EyeSight functions can be used except for Conventional Cruise Control. ⇒ Page 124
	**Auto Start Stop indicator (green) (also used as Auto Start Stop warning indicator (yellow))** • This indicator illuminates in yellow when the ignition switch is turned to the ON position, and then it turns off after the engine starts. • It illuminates in green while the Auto Start Stop system operates. It turns off after the engine restarts. • It illuminates in yellow if a malfunction occurs in the Auto Start Stop system.
	**Auto Start Stop OFF indicator** This indicator illuminates when the Auto Start Stop system is turned off. It turns off when the Auto Start Stop system is turned on. ⇒ Refer to the vehicle Owner's Manual for details.
	**Auto Start Stop No Activity Detected indicator light** When a vehicle is stopped, the indicator light illuminates when the operating conditions of the Auto Start Stop system are not met. The light will turn off when the vehicle starts driving.
	**X-MODE indicator (if equipped)** The X-MODE indicator illuminates when the X-MODE is on. ⇒ Refer to the vehicle Owner's Manual for details.

	**Lane Departure Warning OFF indicator light** • This indicator light illuminates when the Lane Departure Warning and Lane Sway Warning are off. • It also illuminates when the ignition switch is turned to the ON position. Approximately 7 seconds after the engine starts, the Lane Departure Warning OFF indicator light will turn off or remain illuminated depending on the current status (ON or OFF). ⇒ Pages 102 and 105
	**Pre-Collision Braking System OFF indicator light** • This indicator light illuminates when the Pre-Collision Braking System and Pre-Collision Throttle Management are off. • It also illuminates when the ignition switch is turned to the ON position, and then turns off approximately 7 seconds after the engine starts. ⇒ Pages 42 and 99
	**Lane indicator** • This indicator illuminates in gray when the Lane Departure Prevention Function is turned on. • It illuminates in white under the following conditions. - The Lane Departure Prevention Function goes into the standby status. - Lane Centering Function is operating by detecting the lane markings. • It illuminates in yellow when the Lane Departure Prevention Function is operating. ⇒ Pages 80 and 89
	**Brake system warning light** If the brake system warning light illuminates when the electronic parking brake is released while driving, turn the Pre-Collision Braking System off. At this time, do not use the Conventional Cruise Control mode or Adaptive Cruise Control mode. If the brake system warning light does not turn off, immediately pull the vehicle over to a safe location. Contact a SUBARU dealer to have the system inspected. ⇒ Refer to the vehicle Owner's Manual for details.
	**Electronic parking brake indicator light** This indicator light illuminates when the electronic parking brake is applied. ⇒ Refer to the vehicle Owner's Manual for details.
	**Your vehicle indicator** When the brake pedal is depressed or the brake control function is activated, the brake indicator light illuminates in red.

Center information display



S03520

(1) Pre-Collision Braking System indicator
(2) Lane Departure/Sway Warning indicator
(3) EyeSight Assist Monitor

The settings of the on-board systems can be changed by operating the center information display.
Warning screens will be displayed on the center information display as needed.

●Pre-Collision Braking System indicator

This indicator illuminates when the Pre-Collision Braking System is on.

●Lane Departure/Sway Warning indicator

This indicator illuminates when the Lane Departure Warning and Lane Sway Warning are on.

●EyeSight Assist Monitor

This indicator illuminates when the EyeSight Assist Monitor is on.

■ Changing settings

The EyeSight settings can be changed by operating the center information display.
⇒ Page 126

The following systems can also be turned ON/OFF by operating the center information display.

- Vehicle Dynamics Control
- X-MODE (if equipped)
- Auto Vehicle Hold (AVH)

⇒ Refer to the vehicle Owner's Manual for details.

■ Warning screens

The following warning screens will be displayed on the center information display.

Item	Displayed screen
Pre-Collision Braking System warning (first braking and secondary braking)	 S03539
"Obstacle Detected" warning	
Lane Centering Function warning (no-operation of the steering wheel)	 S03540
Lane Centering Function cancellation (no-operation of the steering wheel)	 S03541

Pre-Collision Braking System

When there is the risk of a rear-end collision with an obstacle in front, the EyeSight system helps to prevent or minimize a collision by warning the driver. If the driver still does not take evasive action to avoid a collision, the brakes can be automatically applied just before the collision in order to reduce impact damage, or if possible, prevent the collision. If the driver takes evasive action to avoid a collision, Pre-Collision Braking Assist will operate in order to help the driver to prevent or minimize the collision.
This system can be effective not only with direct rear-end collisions, but also with offset rear-end collisions. This function can be activated when the select lever is in the D, M or N positions.

⚠ WARNING

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

Continued on next page ⇒

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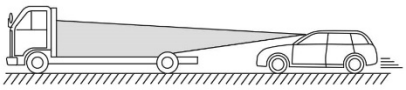
- When the difference in speed with the obstacle in front is the following figure*1 or more, it may not be possible to avoid a collision. Even if the speed difference is the following figure*1 or less, in cases such as when another vehicle cuts in front of you, or in other cases depending on visibility, the condition of road surface and other factors*2, the function may be unable to stop the vehicle or may not activate. Pre-Collision Braking Assist also may not activate depending on the conditions*2 listed below.

*1: For vehicles: approximately 30 mph (50 km/h),
For pedestrians: approximately 21 mph (35 km/h)

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

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

- Recognition conditions of the stereo camera
  In particular, the function may be unable to stop the vehicle or may not activate in the following cases.
  - Bad weather (for example heavy rain, a blizzard or thick fog)
  - Visibility is poor due to sand, smoke or water vapor blowing in the wind, or the front vision is obscured due to water splashes, snow, dirt or dust stir up generated by the vehicle in front or oncoming traffic.
  - At night or in a tunnel without the headlights on
  - At night or in a tunnel when there is a vehicle in front that does not have its taillights on
  - Approaching a motorcycle, bicycle or pedestrian at night
  - Ambient light is poor in the evening or early morning.
  - A vehicle, motorcycle, bicycle or pedestrian is outside the area illuminated by the headlights.
  - Strong light is coming from the front (for example, sunlight at dawn, sunset or headlight beams, etc.).
  - The windshield has become fogged, scratched, or snow, dirt, dust or frost has adhered to it, or it is otherwise affected.
  - Fluid has not been fully wiped off the windshield during or after washer use.
  - The target cannot be correctly recognized because the stereo camera's view is obstructed by water droplets from rain or the window washer, or by the wiper blades.
  - The stereo camera's field of view is obstructed (for example by a canoe on the roof of the vehicle).
  - The rear aspect of the vehicle in front is low, small or irregular (the system may recognize another part of the vehicle as its rear and will determine operation from that).
    - There is an empty truck or trailer with no rear and/or side panels on the cargo bed.
    - With vehicles that have cargo protruding from their back ends
    - With non-standard shaped vehicles (vehicle transporters or vehicles with a sidecar fitted, etc.)
    - The height of the vehicle is low, etc.



S02133

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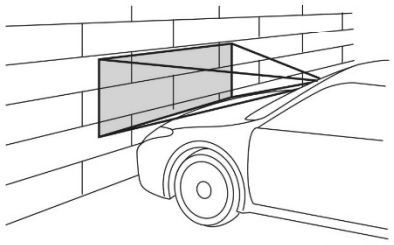
- There is a wall, etc. in front of a stopped vehicle.
- There is another object near the vehicle.
- A vehicle, etc. has its side facing you.
- With vehicles that are backing up or with oncoming vehicles, etc.
- The size and height of an obstacle is smaller than the limitations of the stereo camera's recognition capability.
  - With small animals or children, etc.
  - With pedestrians who are sitting or lying down
- The detected object is a fence or wall, etc. with a uniform pattern (a striped pattern or brick pattern, etc.).
- There is a wall or door made of glass or a mirror in front.
- The vehicle in front suddenly swerves, accelerates, or decelerates.
- A vehicle, motorcycle, bicycle or pedestrian suddenly cuts in from the side or suddenly runs in front of you.


S00653

- Your vehicle is immediately behind an obstacle after changing lanes.
- There is a vehicle, motorcycle, bicycle or pedestrian in a location close to your vehicle's bumper.
- The speed difference between your vehicle and an obstacle is 4 mph (5 km/h) or less (As braking is performed once the obstacle is in close proximity to your vehicle, depending on the shape and size of the obstacle, there may be some cases when the obstacle is outside the range of the camera's field of view.).
- On sharp curves, steep uphill grades or steep downhill grades
- On a bumpy or unpaved road
- There are changes in brightness, such as at a tunnel entrance or exit.

- Do not test Pre-Collision Braking System on its own. It may operate improperly and cause an accident.
- The system may not operate correctly under the conditions listed below. When these conditions occur, turn off the Pre-Collision Braking System.
  - The tire pressure is not correct.*1
  - The temporary spare tire is installed.*1
  - Tires that are unevenly worn or tires with uneven wear patterns are installed.*1

- Tires that are the wrong size are installed.*1
- A flat tire has been fixed temporarily with a tire repair kit.
- The suspension has been modified (including a genuine SUBARU suspension that has been modified).
- An object that obstructs the stereo camera's view is installed on the vehicle.
- The headlights are dirty or they have snow and ice or dirt on them. (Objects are not correctly illuminated and are difficult to detect.)
- The optical axes are not aligned correctly. (Objects are not correctly illuminated and are difficult to detect.)
- The lights including headlights and fog lights have been modified.
- Vehicle operation has become unstable due to an accident or malfunction.
- The brake system warning light is illuminated in red.*2
- A heavy cargo is loaded onto or inside the vehicle.
- The maximum number of occupants is exceeded.
- The combination meter is not operating properly; such as when the lights do not illuminate, the beeps do not sound, the display is different from when it is normal, etc.*3

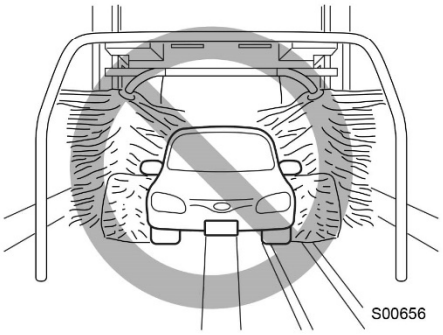
*1: The wheels and tires have functions that are critically important. Be sure to use the correct ones. For details, refer to the Owner's Manual for your vehicle.

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

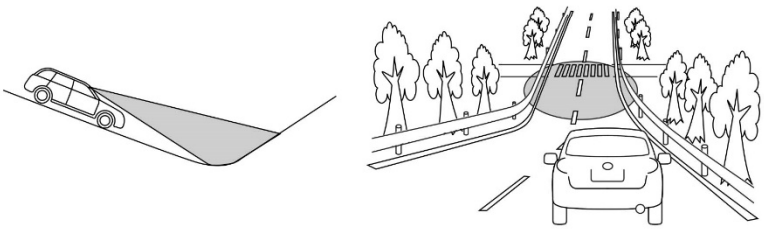
*3: For details about the combination meter, refer to the Owner's Manual for your vehicle.

CAUTION

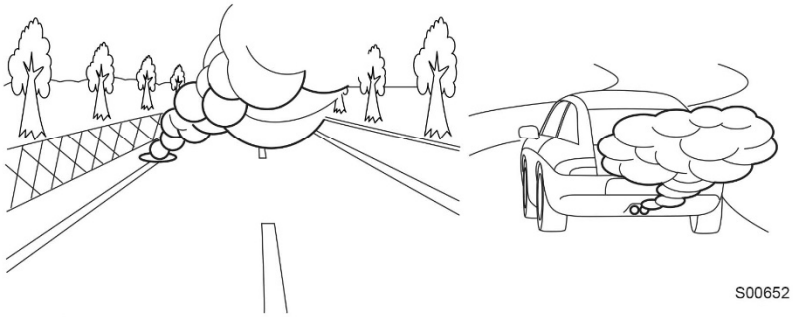
- In the following situations, turn off the Pre-Collision Braking System. Otherwise the Pre-Collision Braking System may activate unexpectedly.
  - The vehicle is being towed.
  - The vehicle is being loaded onto a carrier.
  - A chassis dynamometer, free-rollers or similar equipment is being used.
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



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

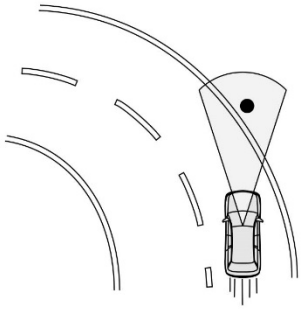


- Visibility is poor due to sand, smoke or water vapor blowing in the wind, or the front vision is obscured due to water splashes, snow, dirt or dust stir up generated by the vehicle in front or oncoming traffic.
- Passing through clouds of steam or smoke, etc.
- In adverse weather, such as heavy snow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

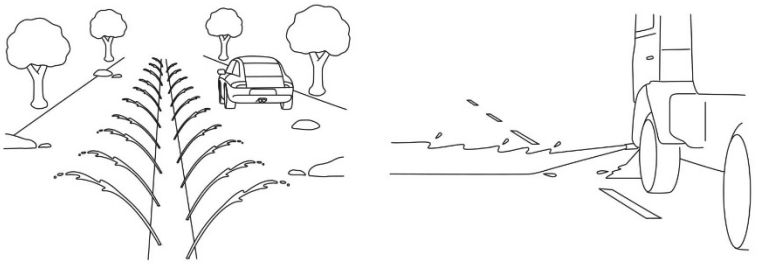


S00652

- There is an obstacle on a curve or intersection.
- A vehicle or an object is being narrowly passed.
- Stopping very close to a wall or a vehicle in front
- Passing through water spray from road sprinklers or snow clearing sprinklers on the road



S02669



S02636

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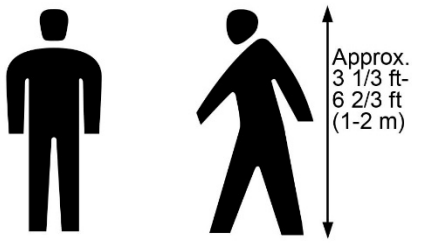
- If there is cargo or installed accessories, etc. that are protruding beyond the edge of the front bumper, the vehicle's length will increase and the system may not be able to prevent a collision.
- If the driver operates the brake pedal during automatic braking, the pedal may feel stiff; however, this is normal. By depressing the brake pedal further you can apply more braking force.

NOTE

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

■ Detection of pedestrians

The EyeSight system can also detect pedestrians. The EyeSight system detects pedestrians from their size, shape and movement. The system detects a pedestrian when the contour of the head and shoulders are clear.



S02846

WARNING

The EyeSight system's Pre-Collision Braking function also identifies pedestrians as obstacles. However, depending on the conditions, there may be cases when the system cannot detect a pedestrian. In the following conditions, the possibility that the system may not be able to detect a pedestrian as an object is particularly high.

- Pedestrians are walking in a group.
- A pedestrian is next to a wall or other obstacle.
- A pedestrian is using an umbrella.
- A pedestrian is wearing clothes that are a similar color to the surrounding environment.
- A pedestrian is carrying bulky luggage.
- A pedestrian is bent over, crouching down or lying down.
- A pedestrian is in a dark location.
- A pedestrian suddenly crosses in front of you from the side or suddenly runs in front of you.

Pre-Collision Braking System operation

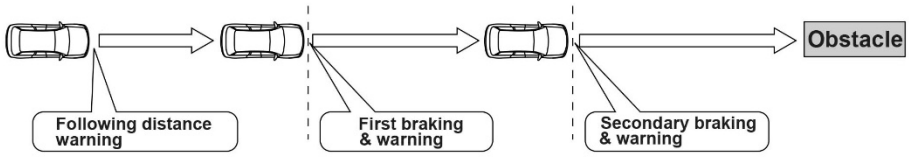
When there is an obstacle in front of you during driving, the system activates in the following sequence in order to warn the driver and to activate braking control and the brake lights.

Following Distance Warning:
When the system determines that there is a risk of collision, an alert sounds repeated short beeps and the indicators on the combination meter display illuminate to warn the driver.
The Following Distance Warning operates when Adaptive Cruise Control is not activated.
When the driver depresses the brake pedal to decelerate and achieves a suitable following distance, the warning is canceled.

First Braking and Warning:
When the system determines that there is a high risk of collision with an obstacle in front, an alert sounds repeated short beeps and the indicators on the combination meter display and the center information display illuminate to warn the driver. Braking control may be activated and in some situations, engine output may also be controlled. If the system determines that the amount of evasive action (braking, steering, etc.) taken by the driver has reduced the risk of collision, braking activation is canceled.

Secondary Braking and Warning:
If the system then determines that the risk of collision is extremely high, the alert changes to a continuous beeping sound and stronger braking control is activated. Despite any evasive action taken by the driver, if the system subsequently determines that a collision is unavoidable, braking and engine output are controlled by the system.

When the vehicle is stopped by secondary braking, the driver should depress the brake pedal in order to ensure that the vehicle stays stopped.



Operating system	Strength of Automatic Braking	Indication on the combination meter display	Alert type
Following distance warning	No brake control		Repeated short beeps
First braking	Moderate		Repeated short beeps
Secondary braking	Strong		Continuous beep

S03559

NOTE

- To release the brake control after the vehicle has come to a stop through Pre-Collision Braking System, perform the following.
  - Depress the brake pedal.
  - Depress the accelerator pedal (except when the select lever is in the N position).
  - Shift the select lever into the P position.
- After stopping with secondary braking, in the following cases, brake control will be released and the electronic parking brake will be applied.
  (For details about how to release the electronic parking brake, refer to the Owner's Manual for your vehicle.)
  - Approximately 2 minutes have elapsed since stopping and the brake pedal is not depressed.
  - Any door (except the rear gate/trunk) is opened.
  - The driver's seatbelt is unfastened.
  - The EyeSight system has a malfunction.
  - The EyeSight system has stopped temporarily.

Continued on next page ⇒

⇒ Continued from previous page

- Neither first braking nor secondary braking will operate in the following cases.
  - The vehicle speed is approximately 1 mph (1 km/h) or less (When the select lever is in the [N] position and your vehicle speed is approximately 2 mph (4 km/h) or less) or 100 mph (160 km/h) or more.
  - Vehicle Dynamics Control is active.
- If the system detects the brake lights of the vehicle in front, your vehicle will start decelerating earlier than if it does not.
- There are some cases where the first braking is applied for a longer period of time. One of the reasons for this is due to a large speed difference with an obstacle in front. In those cases, stronger or weaker braking control may be activated.

■ Pre-Collision Braking System operation indicator

After the Pre-Collision Braking System operation, a message appears and stays in the warning screen area of the combination meter display for a certain period of time.

▼If the Pre-Collision Braking System stopped operating before the vehicle came to a stop

The message appears and stays in the warning screen area of the combination meter display to indicate that the Pre-Collision Braking System has activated. This screen will be displayed for 10 seconds.

S03129

▼If the Pre-Collision Braking System continued operating until the vehicle came to a stop

The screen displays the message “Apply Brake To Hold Position” to urge the driver to depress the brake pedal. At this time the alert sounds. This screen will be displayed for approximately 2 minutes until the driver depresses the brake pedal.

S02962

If the brake pedal is depressed or 2 minutes have elapsed, a message changes and stays in the warning screen area of the combination meter display to indicate that the Pre-Collision Braking System has activated. This screen will be displayed for 10 seconds.

S03130

Pre-Collision Braking Assist operation

When the Pre-Collision Braking System is activated (when the system determines that there is a high risk of collision with an obstacle in front), if the driver depresses the brake pedal, the system determines that this is emergency braking and activates braking assist automatically.

CAUTION

If the driver depresses the brake pedal while following distance warning is activated, the Pre-Collision Braking Assist will not work. The vehicle decelerates with the normal braking force operated by the driver.

NOTE

- Pre-Collision Braking Assist function does not operate when the vehicle speed is approximately 7 mph (10 km/h) or less or 100 mph (160 km/h) or more.
- For information about the brake assist function, refer to the Owner's Manual for your vehicle.

Turning on/off the Pre-Collision Braking System

Operate the center information display to turn on/off the Pre-Collision Braking System (including Pre-Collision Braking Assist).
This function is turned on by selecting “Setting ON” on the “Pre-Collision Braking” screen of the EyeSight settings.
This function is turned off by selecting “Setting OFF” on the “Pre-Collision Braking” screen of the EyeSight settings.
⇒ Page 126

The Pre-Collision Braking System on/off setting interlocks with the Pre-Collision Throttle Management setting.

- When this system is turned off, the Pre-Collision Braking System OFF indicator light illuminates.
- When this system is turned on, the Pre-Collision Braking System OFF indicator light turns off.

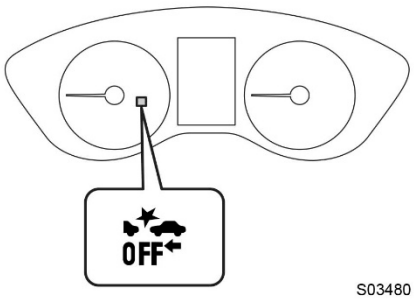
NOTE

Even when the Pre-Collision Braking System is turned off, if the engine is turned off and then restarted, the Pre-Collision Braking System will be turned on. The system default setting when the vehicle is restarted is on.

■ Pre-Collision Braking System OFF indicator light

This indicator light illuminates when the ignition switch is turned to the ON position, and remains illuminated for approximately 7 seconds after the engine starts. It turns on when the Pre-Collision Braking System and Pre-Collision Throttle Management are turned off. It also illuminates under the following conditions.

- The EyeSight system has a malfunction.
  ⇒ Page 122
- The EyeSight system has stopped temporarily.
  ⇒ Page 124



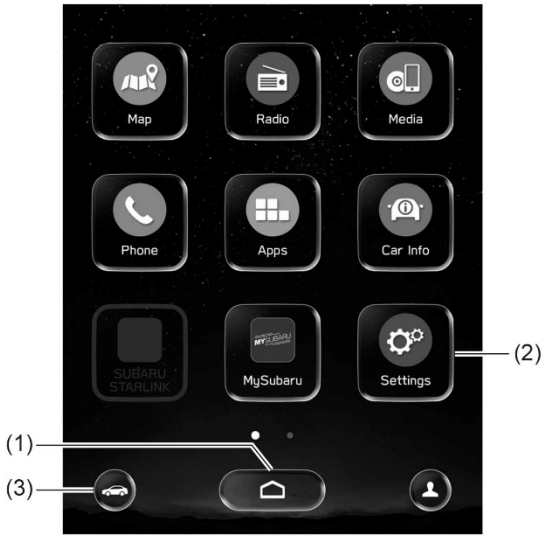
S03480

NOTE

When the Pre-Collision Braking System OFF indicator light is turned on, the Pre-Collision Braking System (including the Pre-Collision Braking Assist function) and Pre-Collision Throttle Management do not operate.

Changing settings

■ 11.6-inch display models (if equipped)



S03581

(1) HOME icon
(2) Settings icon
(3) Car settings icon

Change the EyeSight system setting as follows:
1. Touch (HOME).
2. → (Settings)
3. → “Car”
4. Select the preferred menu.

The setting adjustments to the following items can be manually changed to meet your personal requirements.

Item		Setting
EyeSight	Pre-Collision Braking	Setting ON/Setting OFF
	Lane Departure Prevention Function	All Functions/ Lane Departure Prevention Function Only/ Warning Buzzer Only/ OFF
	Cruise Control Acceleration Characteristics	Lv. 1 (Eco)/ Lv. 2 (Comfort)/ Lv. 3 (Standard)/ Lv. 4 (Dynamic)
	Select Drive on Left/Drive on Right	Right Lane/ Left Lane
	Lead Vehicle Acquisition Sound	ON/OFF
	Lead Vehicle Moving Monitor	ON/OFF
EyeSight Assist Monitor	Red Indicator	ON/OFF
	Yellow Indicator	ON/OFF
	Green Indicator	ON/OFF
Warning Volume	—	Min/Mid/Max

Touch  (Car settings icon) to display the items that are changeable while driving.
Change the EyeSight system setting as follows:
1. Touch  (Car settings icon).
2. Select the preferred menu.

Item		Setting
Driving Assistance	Pre-Collision Braking	Setting ON/Setting OFF
	Lane Departure Prevention Function	All Functions/ Lane Departure Prevention Function Only/ Warning Buzzer Only/ OFF
Others	Cruise Control Acceleration Characteristics	Lv. 1 (Eco)/ Lv. 2 (Comfort)/ Lv. 3 (Standard)/ Lv. 4 (Dynamic)
	Warning Volume	Min/Mid/Max

APPENDIX C

Run Log

Subject Vehicle: **2020 Subaru Outback Premium/LDD** Test Date: **6/1/2020**

Principal Other Vehicle: **GVT**

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Acceptability Criteria met [5]	Notes
1	Static Run								
2	**Stopped POV, SV 25 mph**	Y	2.77	2.03	25.0	0.97	1.33	Yes	
3		Y	2.93	2.14	25.1	0.98	1.33	Yes	
4		Y	2.88	1.79	24.6	0.96	1.25	Yes	
5		Y	2.84	2.06	24.5	0.96	1.35	Yes	
6		Y	2.83	1.83	24.6	0.96	1.27	Yes	
7		Y	2.80	2.11	25.1	0.97	1.33	Yes	
8		Y	2.78	2.02	24.8	0.98	1.29	Yes	
9	Static Run								
10	**Stopped POV, SV 30 mph**	Y	2.97	1.60	30.0	0.88	1.39	Yes	
11		Y	3.06	2.08	30.1	0.97	1.38	Yes	
12		Y	3.07	2.01	29.9	0.98	1.48	Yes	
13		Y	3.18	2.22	30.0	0.96	1.42	Yes	
14		Y	3.13	1.94	30.2	0.99	1.40	Yes	
15	Static Run								

[5] The acceptability criteria listed herein are used only a guide to gauge vehicle performance, and are identical to the Pass/Fail criteria given in 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.

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Acceptability Criteria met [5]	Notes
16	**Stopped POV, SV 35 mph**	Y	3.32	2.66	35.1	0.91	1.63	Yes	
17		Y	3.38	2.30	34.8	0.93	1.62	Yes	
18		Y	3.31	1.62	35.2	0.91	1.62	Yes	
19		Y	3.30	2.35	35.0	0.88	1.65	Yes	
20		Y	3.50	2.47	34.8	0.89	1.62	Yes	
21	Static Run								
22	**Stopped POV, SV 40 mph**	Y	3.37	2.04	40.1	0.95	1.76	Yes	
23		Y	3.26	0.59	40.6	0.98	1.77	Yes	
24		Y	3.36	2.16	39.9	0.90	1.86	Yes	
25		Y	3.27	0.58	40.4	0.98	1.85	Yes	
26		Y	3.31	1.56	39.8	0.88	1.78	Yes	
27	Static Run								
28	**Stopped POV, SV 45 mph**	Y	2.88	0.00	38.3	0.96	1.86	Yes	
29		N							GST Comms Dropout
30		Y	2.92	0.00	36.1	0.91	1.79	Yes	
31		Y	2.96	0.87	45.2	0.95	1.85	Yes	
32		Y	2.91	0.00	40.0	0.91	1.90	Yes	
33		Y	2.96	0.00	40.4	0.94	1.87	Yes	
34	Static Run								
35	**Slower POV 25/10**	Y	2.46	4.34	14.9	0.84	0.91	Yes	
36		Y	2.38	3.75	15.0	0.87	0.95	Yes	
37		Y	2.41	4.65	14.8	0.83	0.91	Yes	
38		Y	2.45	3.95	15.4	0.85	1.04	Yes	
39		Y	2.38	3.82	15.5	0.84	0.99	Yes	
40		Y	2.42	3.88	14.9	0.89	0.97	Yes	
41		Y	2.30	3.39	14.5	0.92	1.00	Yes	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Acceptability Criteria met [5]	Notes
42	Static Run								
43	Static Run								
44	**Slower POV 45/20**	N							Throttle
45		Y	3.08	7.14	24.9	0.70	1.20	Yes	
46		Y	2.97	4.50	25.4	0.81	1.33	Yes	
47		Y	3.02	3.36	24.9	0.84	1.28	Yes	
48		Y	3.04	3.86	25.0	0.80	1.37	Yes	
49		Y	3.09	2.89	24.9	0.92	1.35	Yes	
50		Y	2.95	3.07	24.8	0.88	1.42	Yes	
51		Y	2.95	5.87	25.2	0.72	1.20	Yes	
52	Static Run								
53	**Decelerating POV, 0.3g, SV 35 mph**	Y	1.99	7.15	23.4	0.79	1.33	Yes	
54		Y	1.84	5.16	24.3	0.91	1.35	Yes	
55		N							SV, POV Speed
56		Y	1.86	6.99	23.9	0.79	1.11	Yes	
57		Y	1.96	6.56	24.1	0.82	1.18	Yes	
58		Y	1.90	6.70	23.9	0.79	1.25	Yes	
59		N							POV Speed
60		N							SV, POV Speed
61		Y	1.76	5.51	23.8	0.93	1.31	Yes	
62		Y	1.89	7.87	23.7	0.79	1.12	Yes	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Acceptability Criteria met [5]	Notes
63	**Decelerating POV, 0.5g, SV 35 mph**	N							POV Braking
64		N							POV Braking
65		Y	1.65	5.44	35.9	0.97	1.34	Yes	
66		Y	1.62	5.06	35.1	0.89	1.34	Yes	
67		Y	1.64	4.44	34.9	0.92	1.39	Yes	
68		Y	1.69	5.70	35.2	0.89	1.39	Yes	
69		N							Throttle drop
70		Y	1.70	6.29	35.3	0.89	1.34	Yes	
71	**Decelerating POV, 0.3g, SV 45 mph**	N							POV Braking
72		N							POV Braking
73		N							POV Braking
74		Y	1.99	7.58	23.2	0.82	1.25	Yes	
75		Y	1.85	6.54	22.9	0.94	1.37	Yes	
76		N							POV Braking
77		N							POV Braking
78		Y	1.86	6.76	23.4	0.86	1.61	Yes	
79		N							SV Yaw Rate
80		N							SV Speed
81		Y	1.91	7.70	23.2	0.81	1.32	Yes	
82		Y	2.00	8.22	22.8	0.81	1.22	Yes	
83	Static Run								

APPENDIX D

Time History Plots

LIST OF FIGURES

Description of Time History Plots

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

Time History Plot Description

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

Stopped POV (SV at 25 mph)
Stopped POV (SV at 30 mph)
Stopped POV (SV at 35 mph)
Stopped POV (SV at 40 mph)
Stopped POV (SV at 45 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)
Decelerating POV 35 mph (Both vehicles at 35 mph with 13.8 m gap, POV brakes at 0.5 g)
Decelerating POV 45 mph (Both vehicles at 45 mph with 13.8 m gap, POV brakes at 0.3 g)

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.

- Headway (ft) – Longitudinal separation (gap) between the front-most point of the Subject Vehicle and the rearmost point of the Global Vehicle Target (GVT). 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. The lateral offset is defined to be the lateral distance between the centerline of the SV and the centerline of the 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.

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 Figures D1 through Figure D7. Figures D1 through D4 show passing runs for each of the 4 test types. Figures D5 and D6 show examples of invalid runs. Figure D7 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 D8.

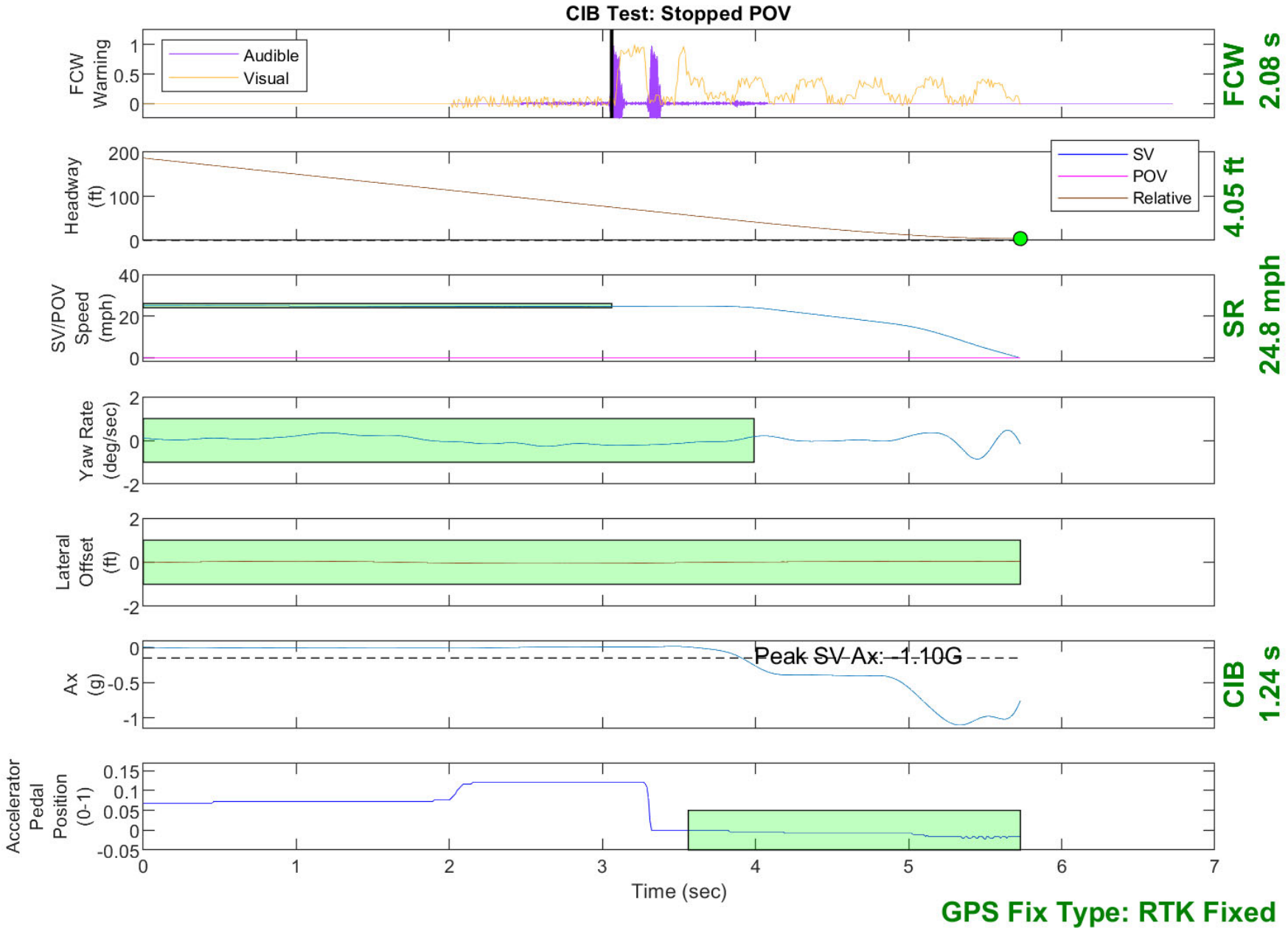


Figure D1. Example Time History for Stopped POV, Passing

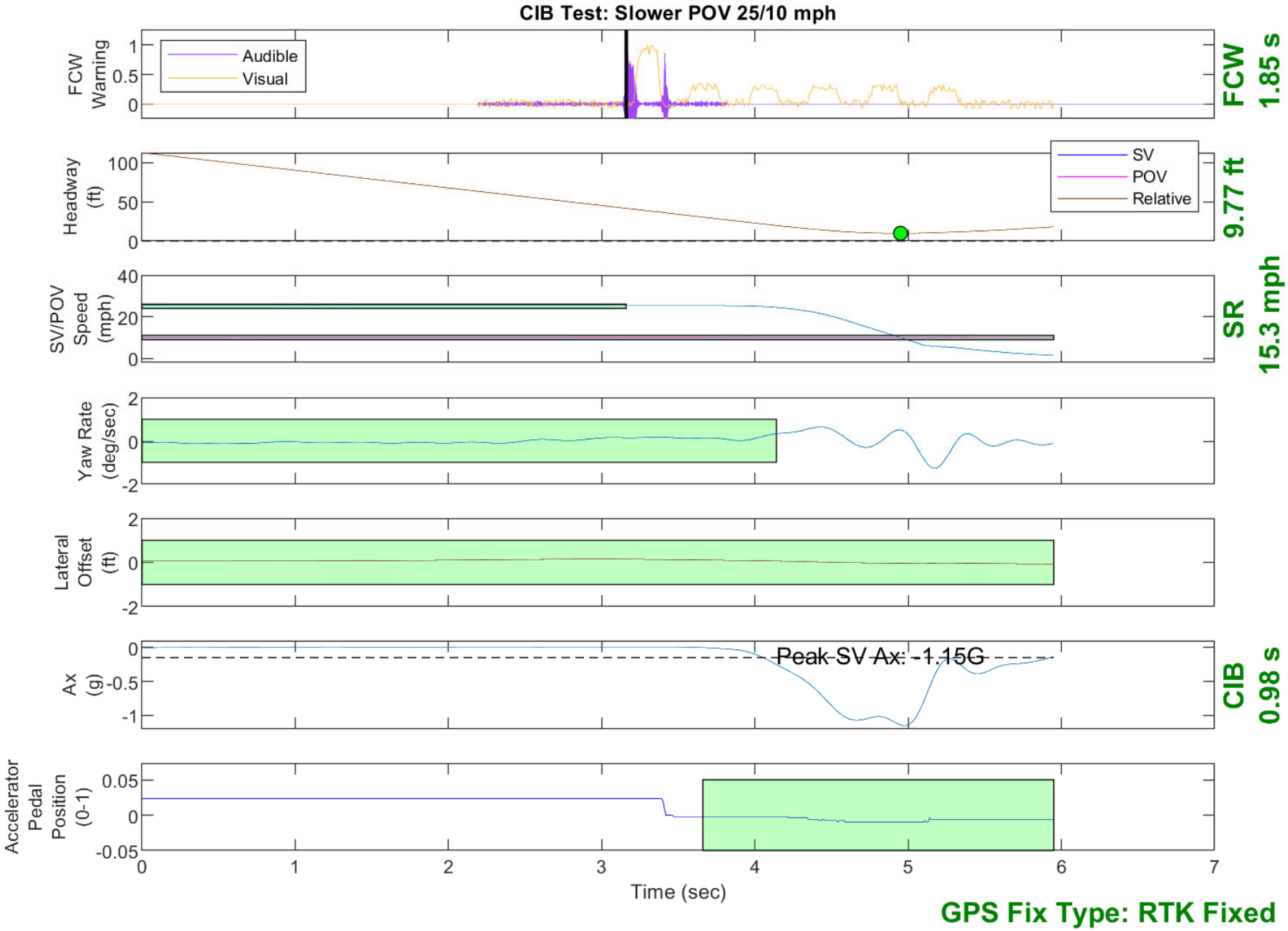


Figure D2. Example Time History for Slower POV 25 vs. 10, Passing

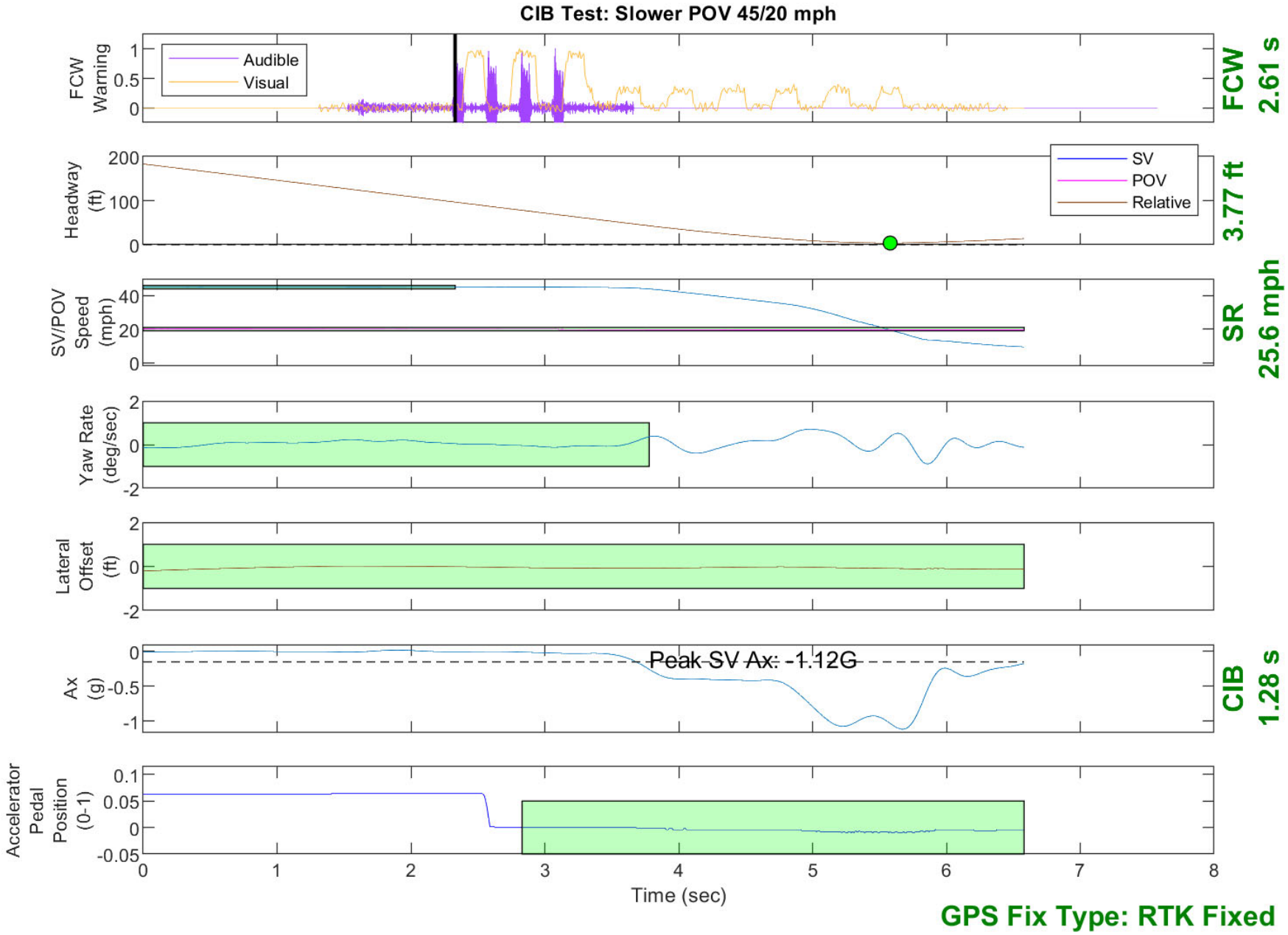


Figure D3. Example Time History for Slower POV 45 vs. 20, Passing

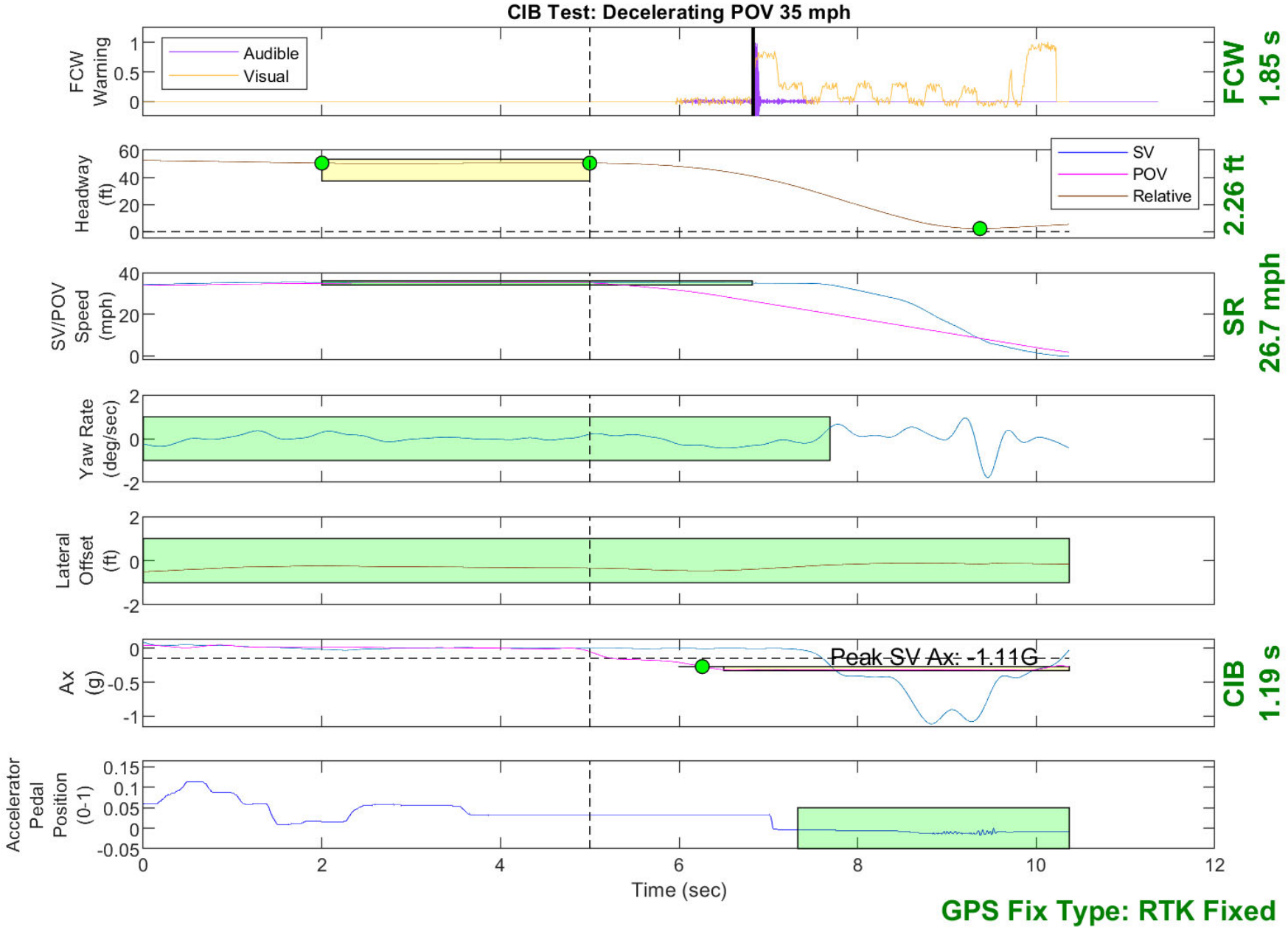


Figure D4. Example Time History for Decelerating POV 35, Passing

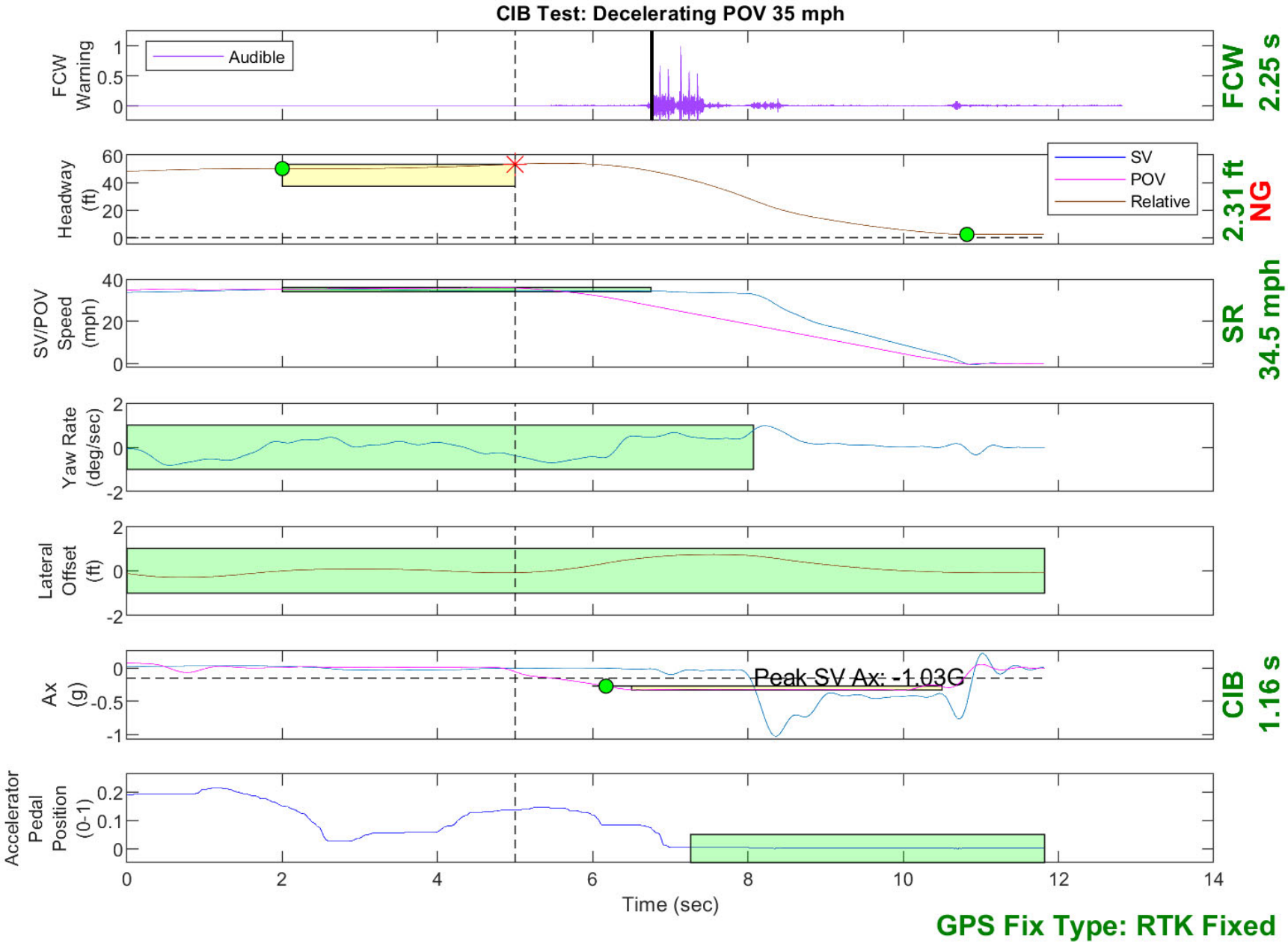


Figure D5. Example Time History Displaying Various Invalid Criteria

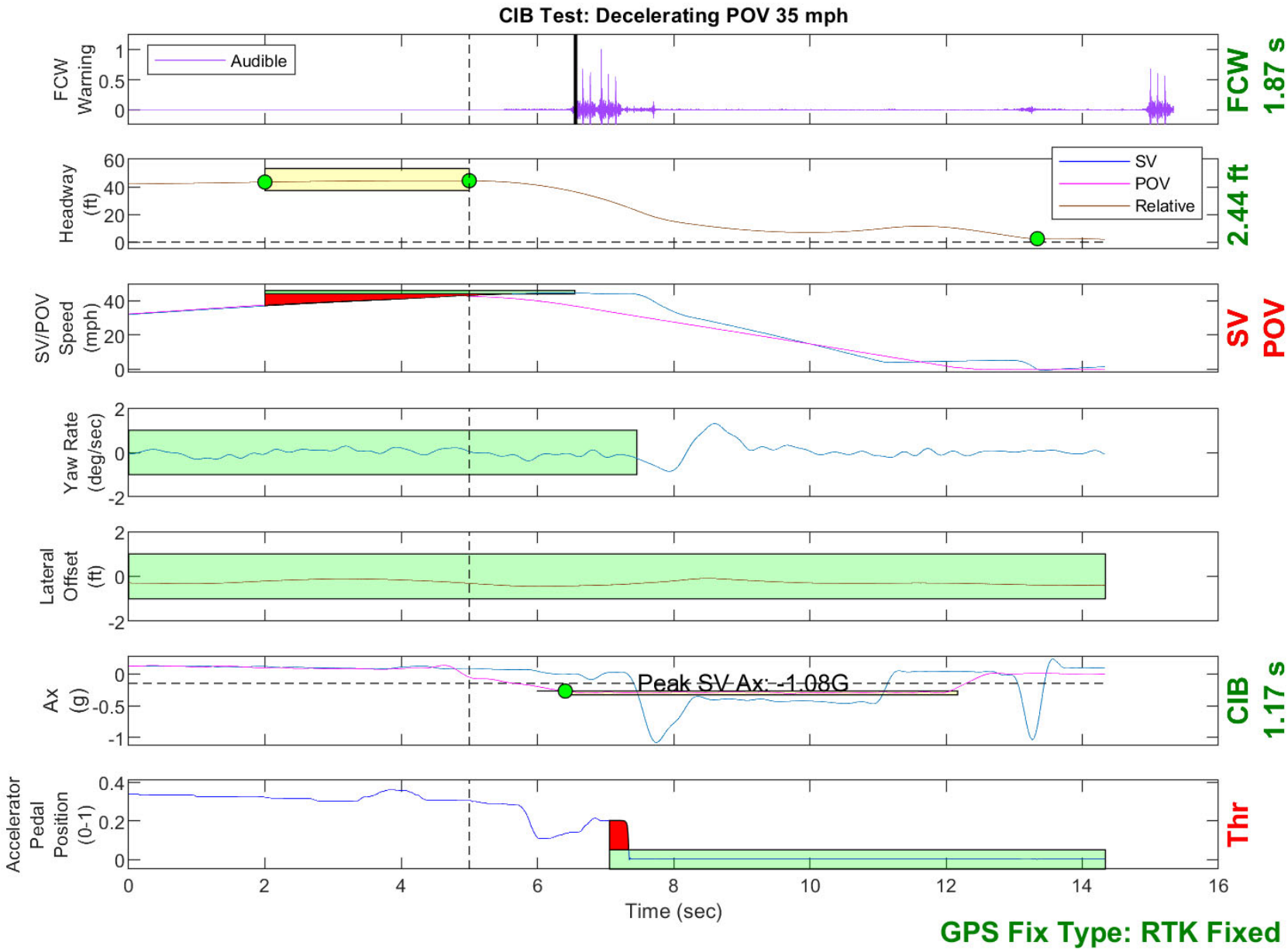


Figure D6. Example Time History Displaying Various Invalid Criteria

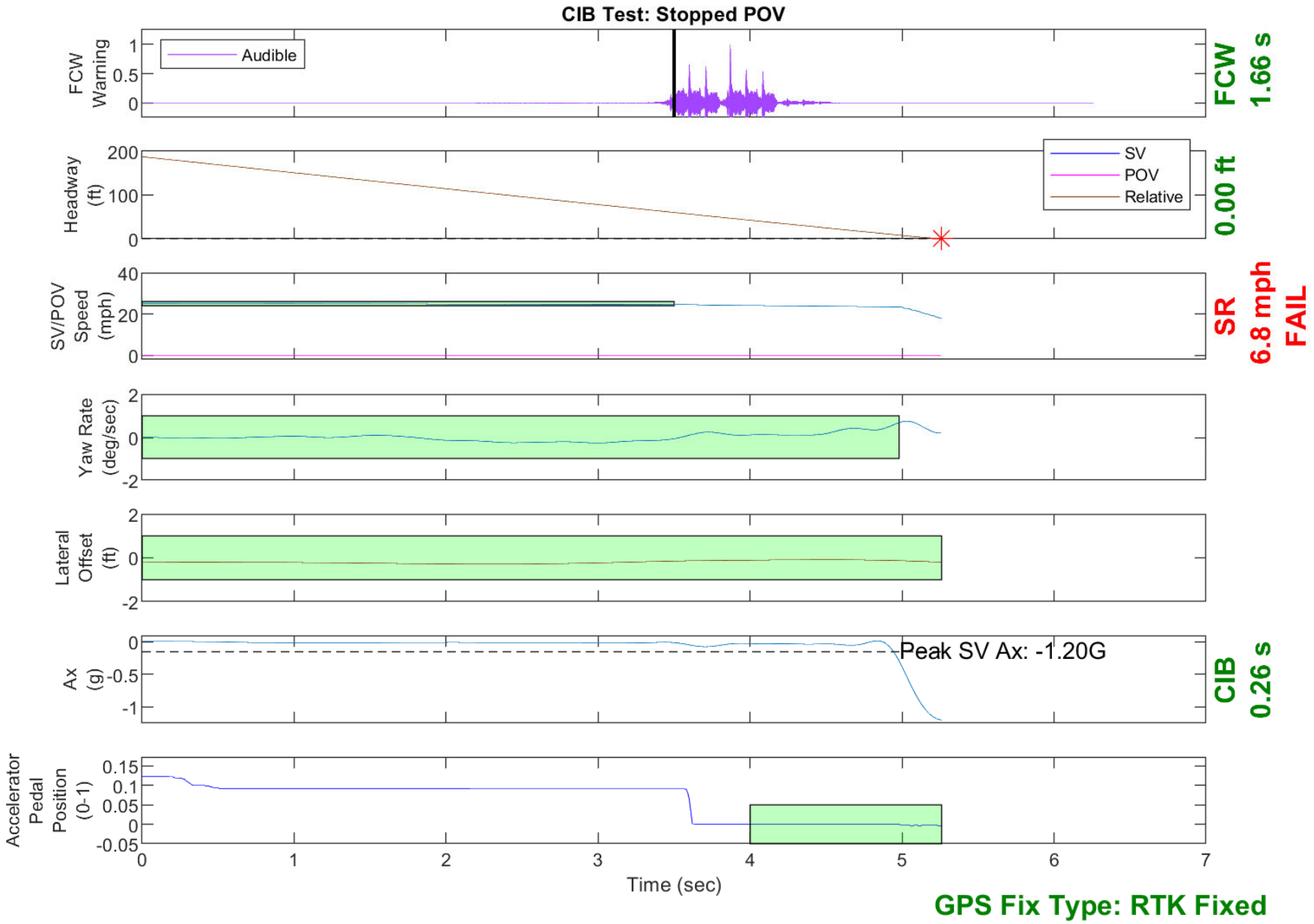


Figure D7. Example Time History for a Failed Run

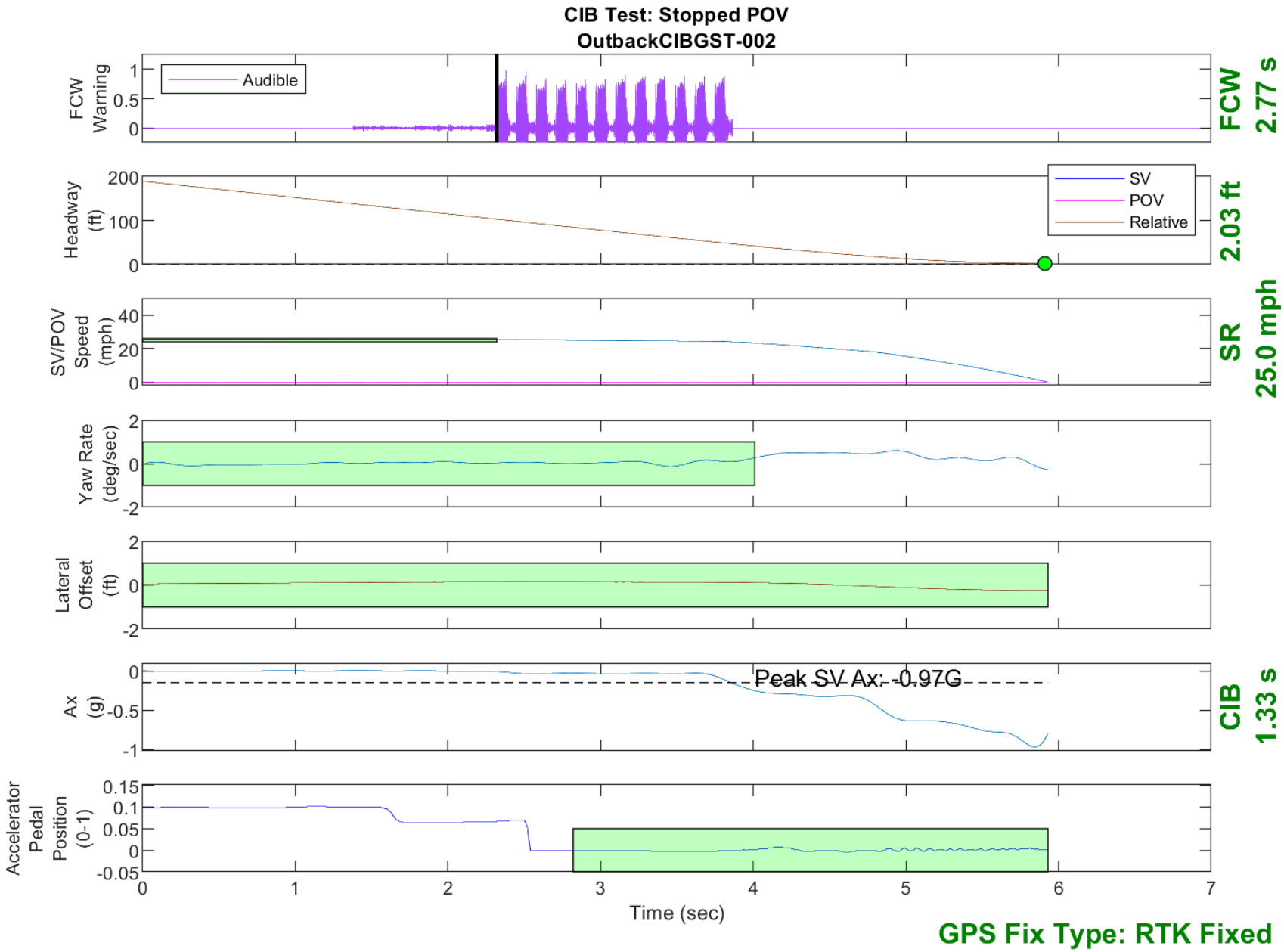


Figure D8. Time History for CIB Run 2, Stopped POV, 25 mph

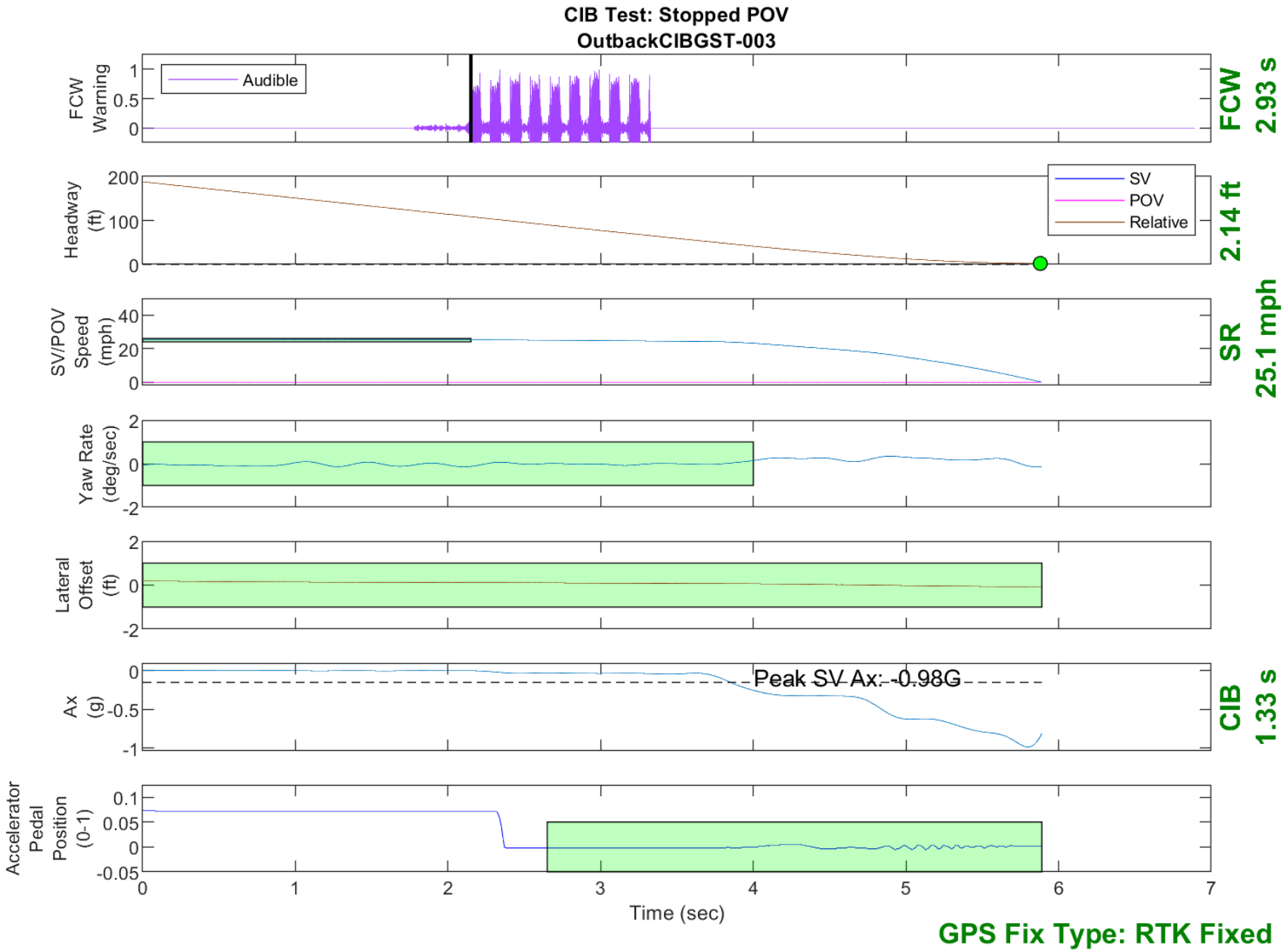


Figure D9. Time History for CIB Run 3, Stopped POV, 25 mph

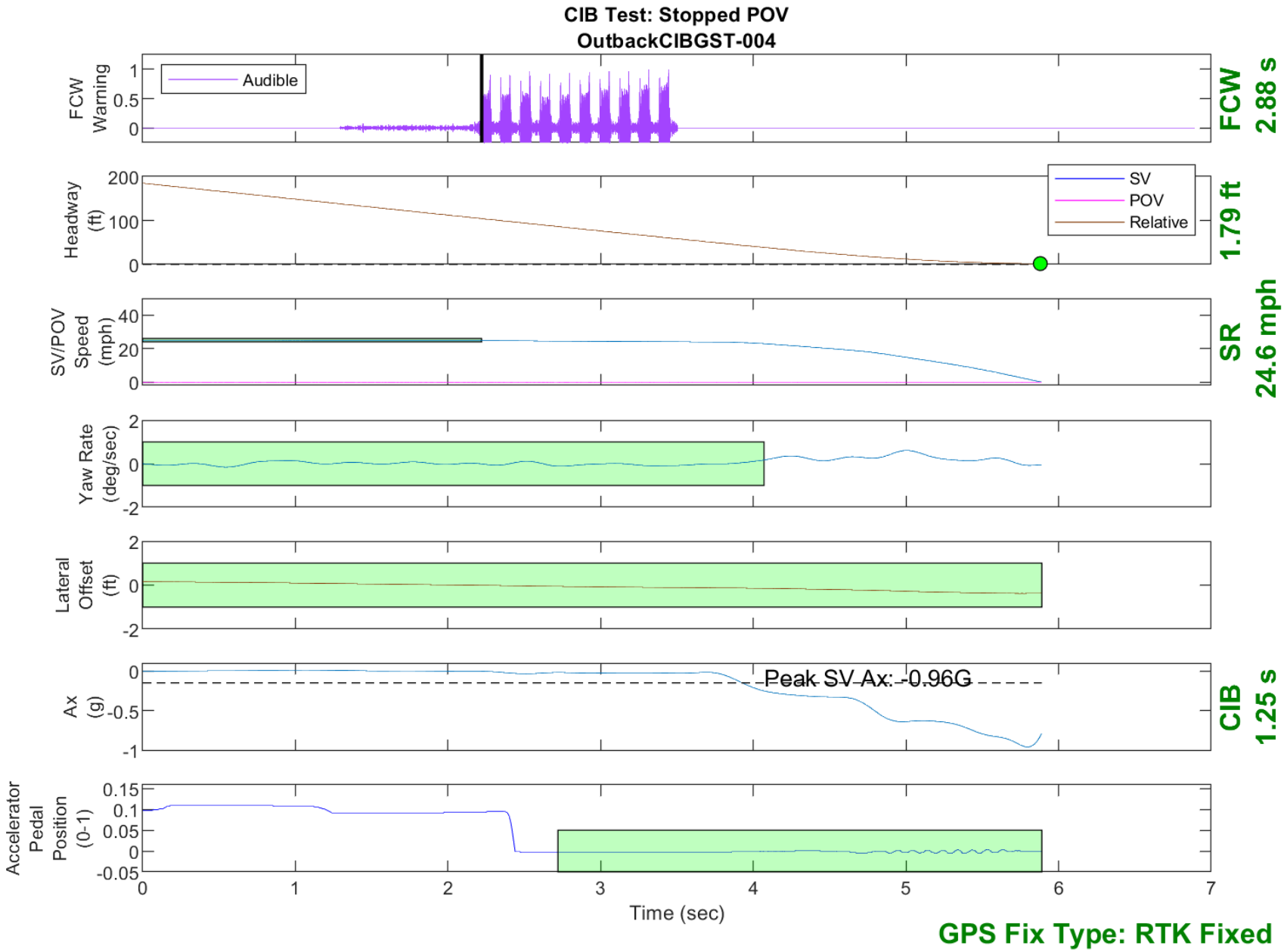


Figure D10. Time History for CIB Run 4, Stopped POV, 25 mph

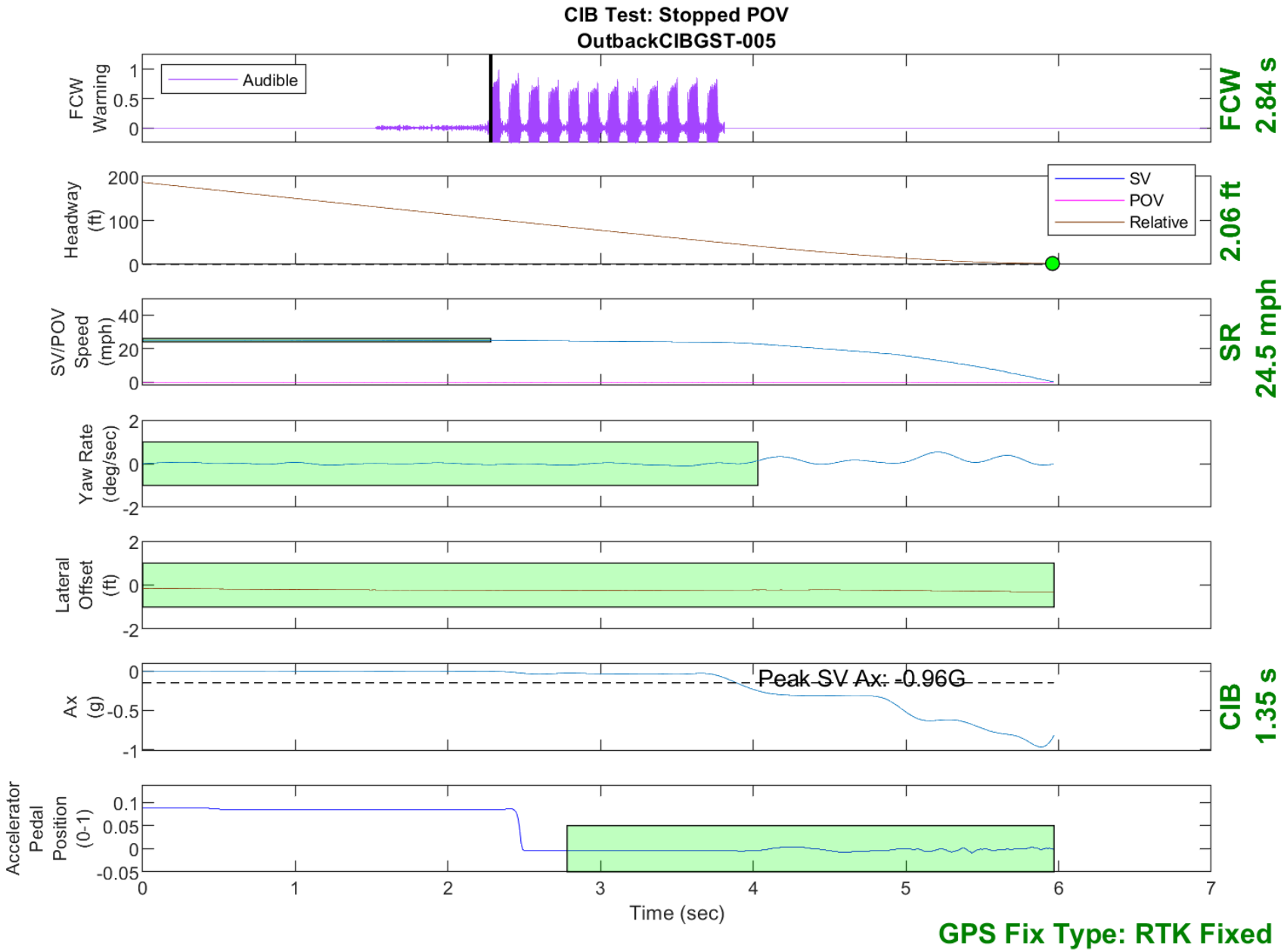


Figure D11. Time History for CIB Run 5, Stopped POV, 25 mph

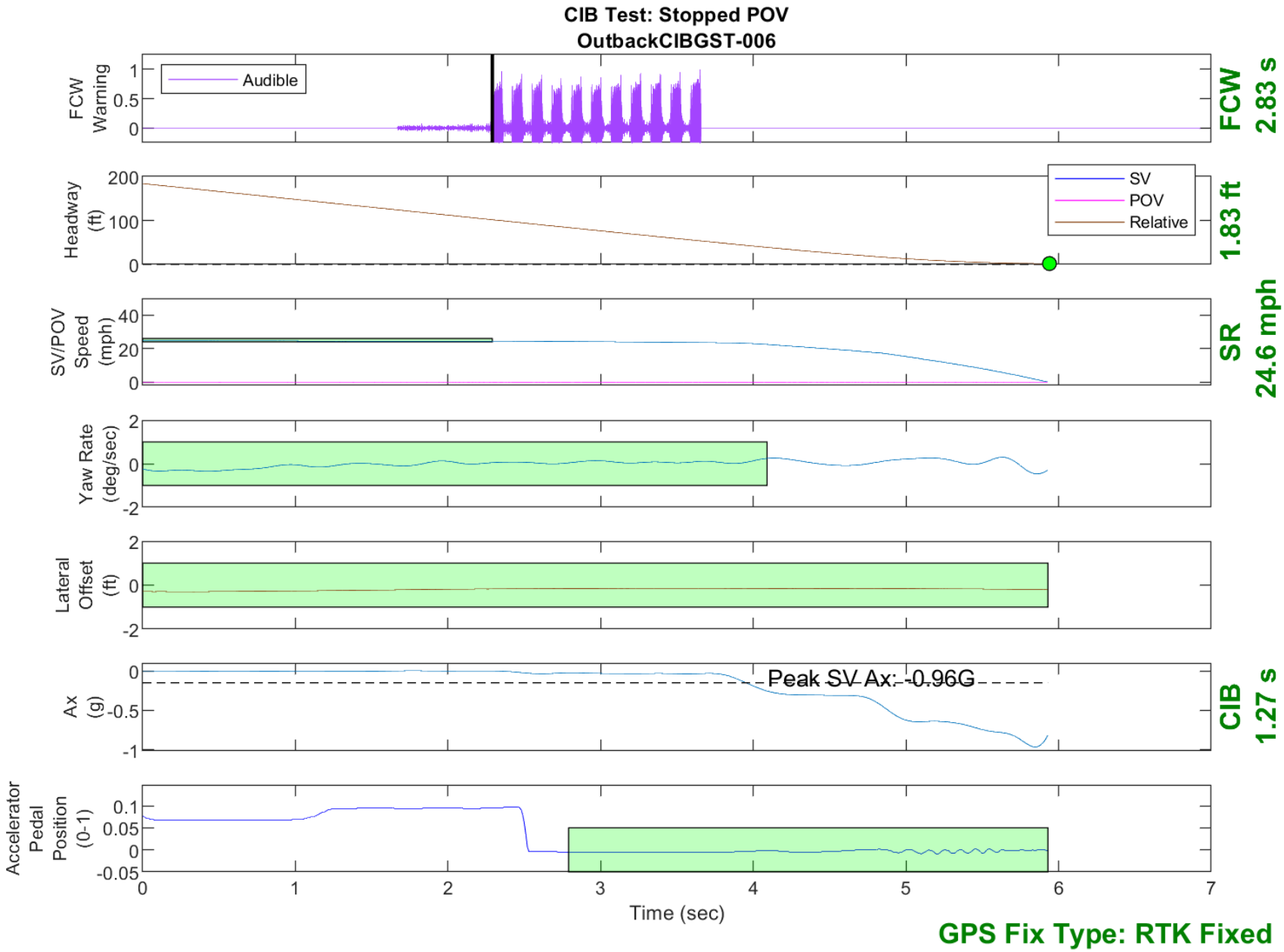


Figure D12. Time History for CIB Run 6, Stopped POV, 25 mph

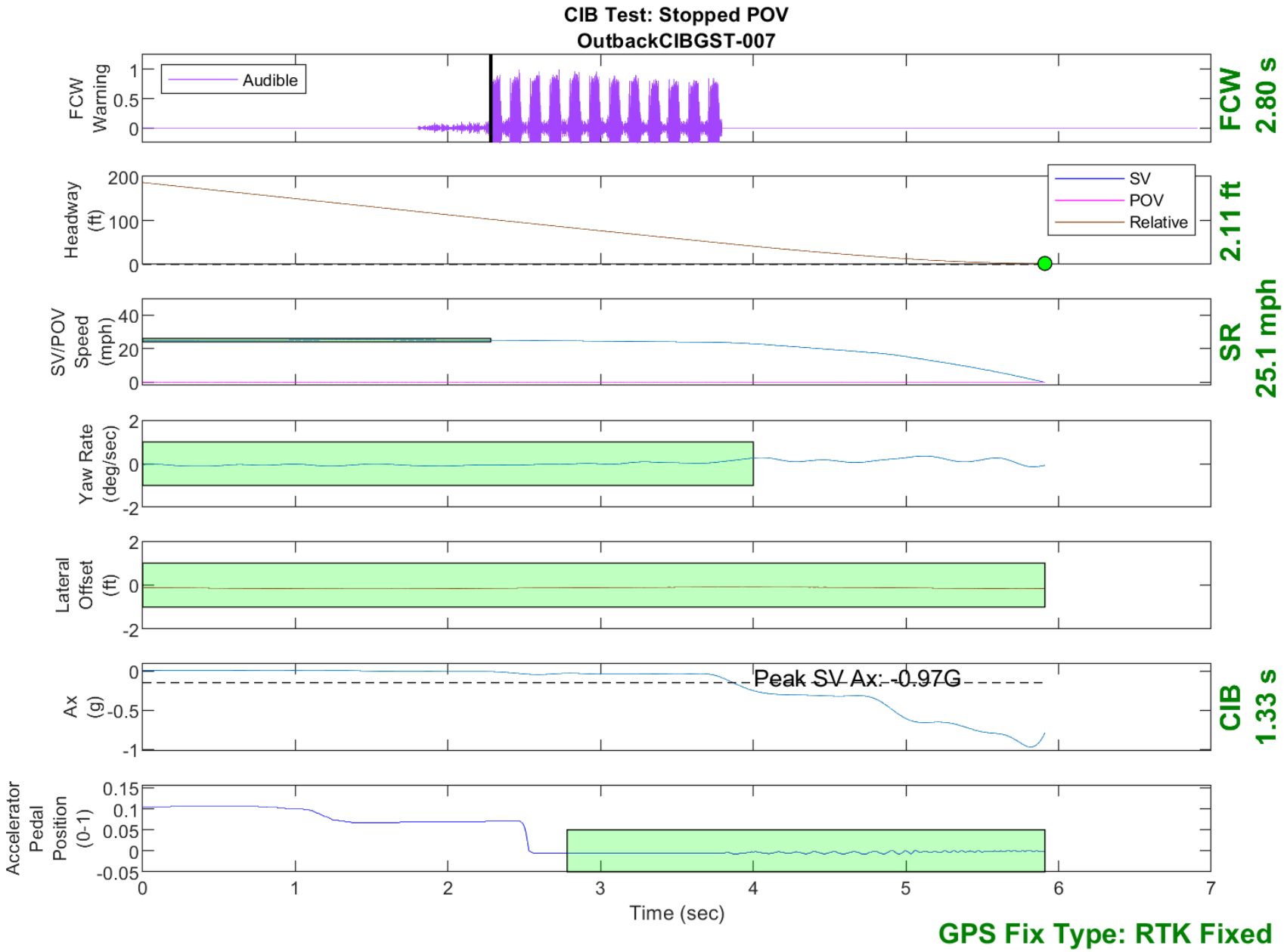


Figure D13. Time History for CIB Run 7, Stopped POV, 25 mph

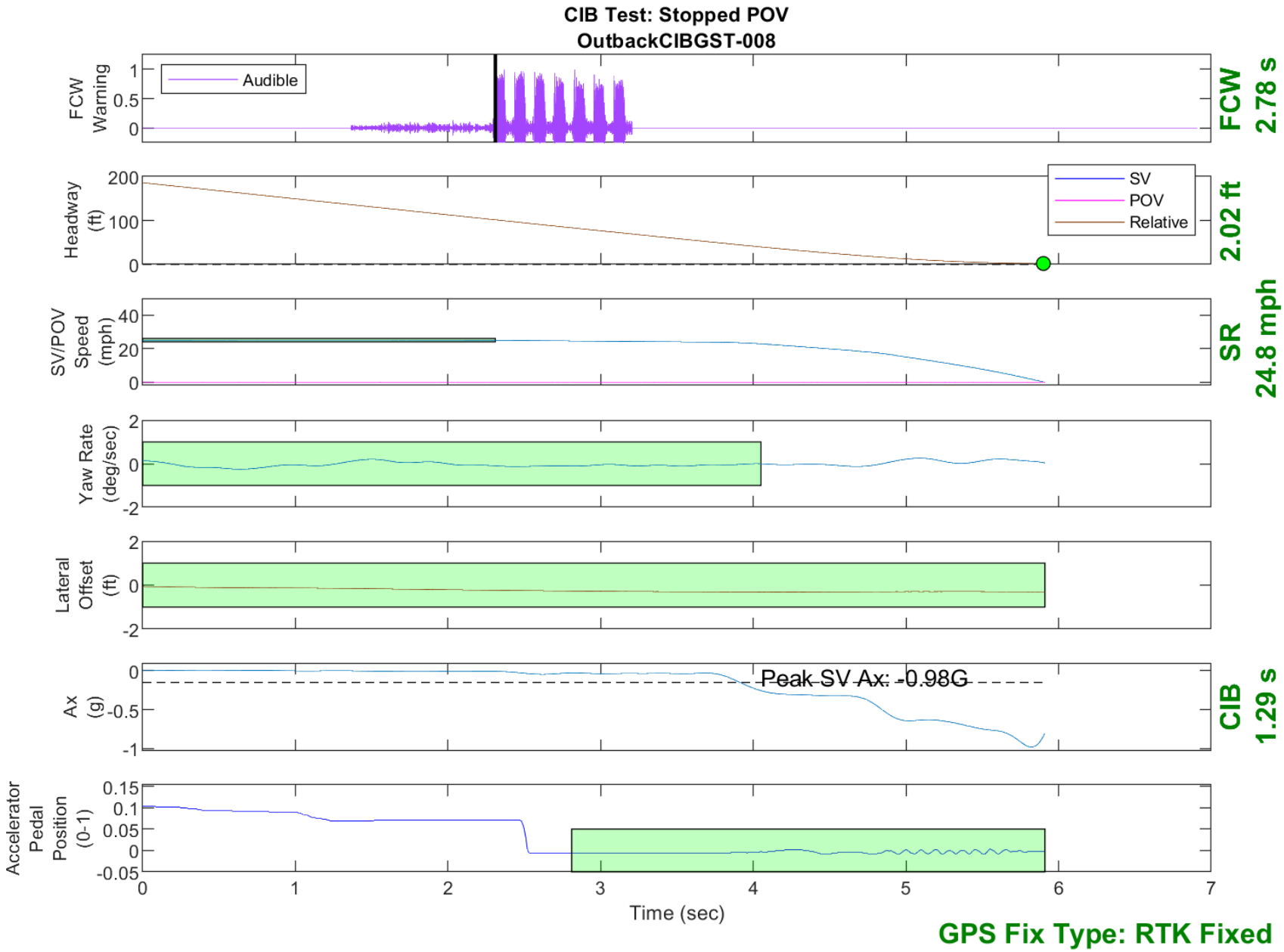


Figure D14. Time History for CIB Run 8, Stopped POV, 25 mph

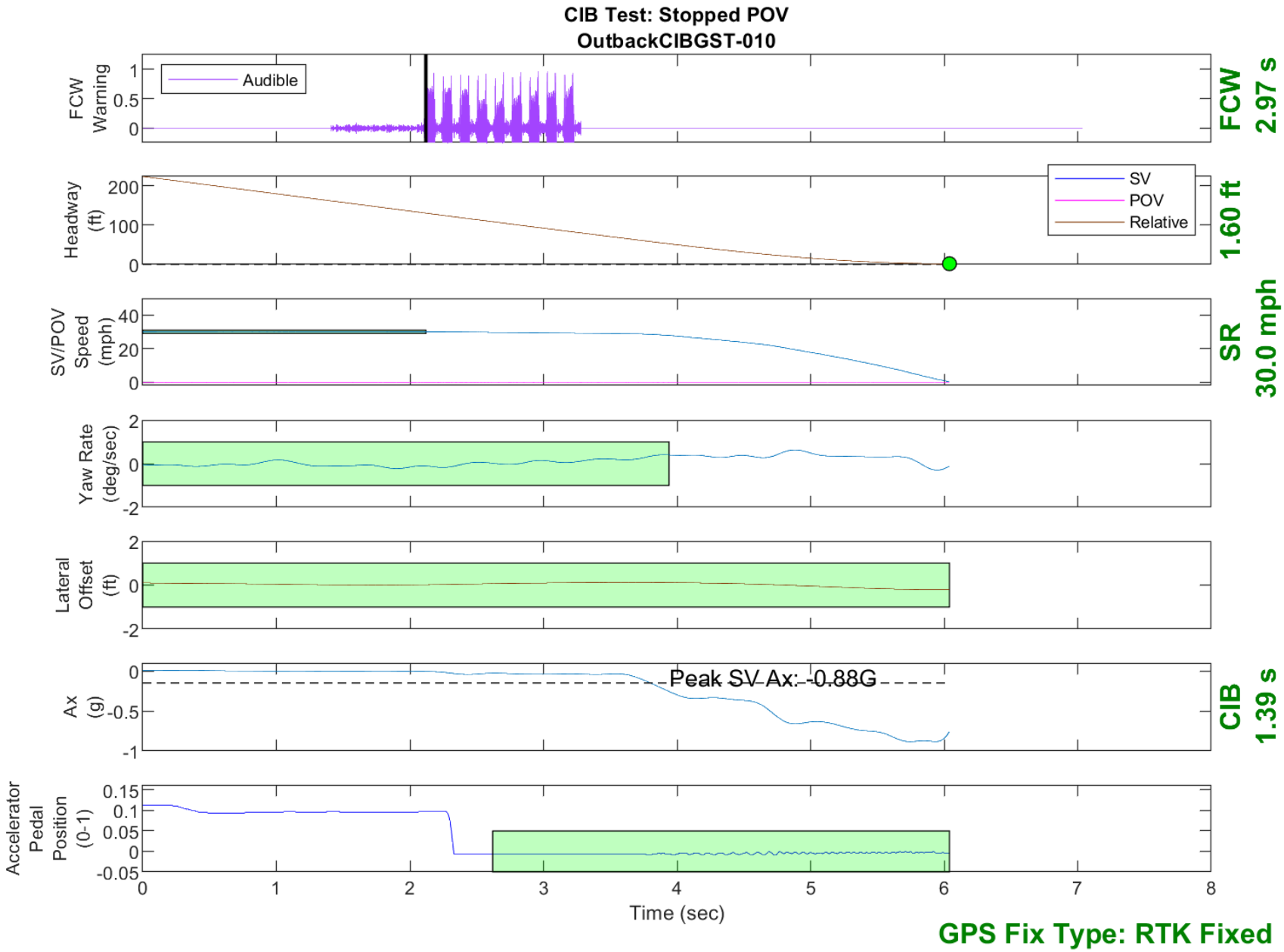


Figure D15. Time History for CIB Run 10, Stopped POV, 30 mph

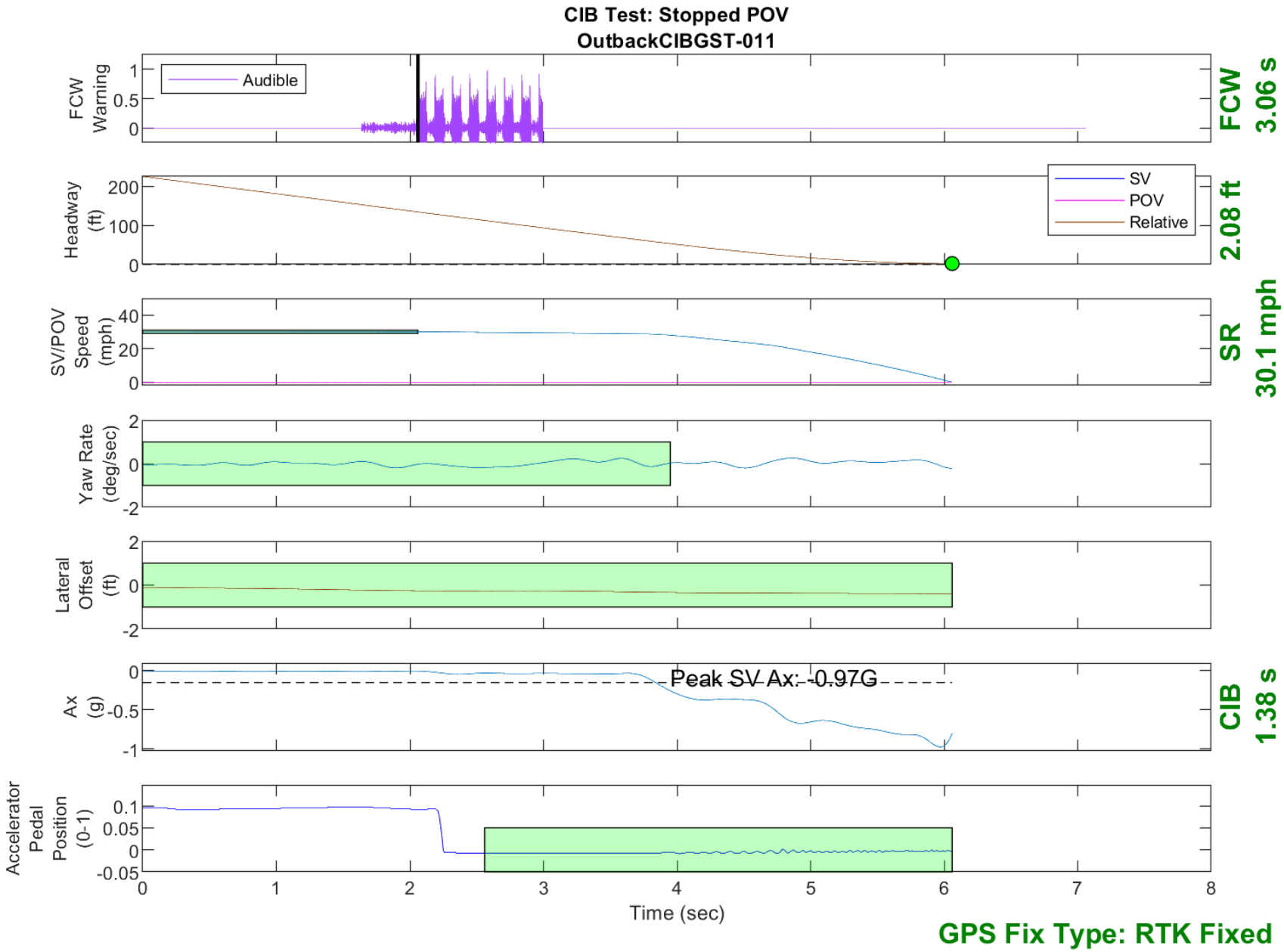


Figure D16. Time History for CIB Run 11, Stopped POV, 30 mph

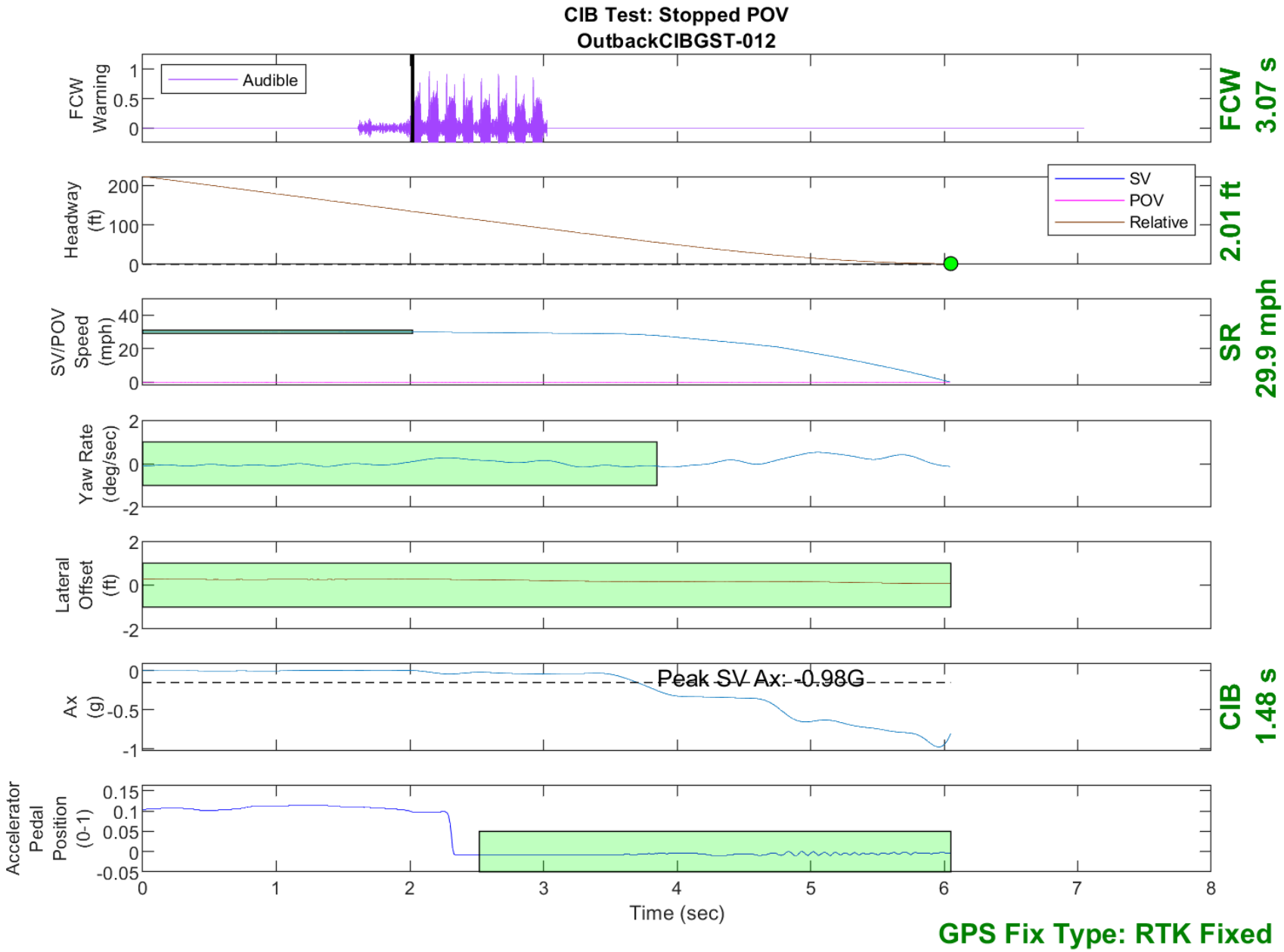


Figure D17. Time History for CIB Run 12, Stopped POV, 30 mph

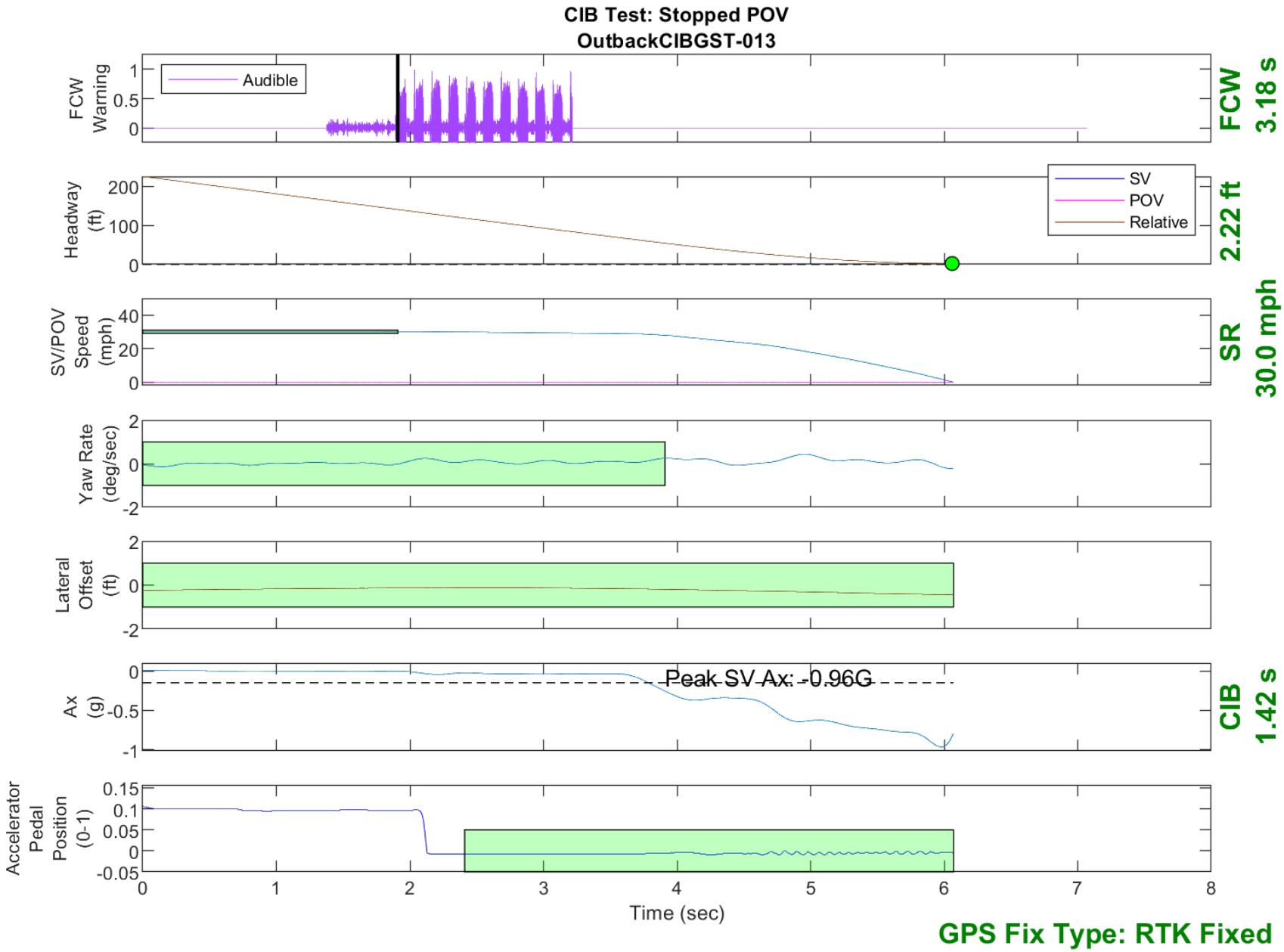


Figure D18. Time History for CIB Run 13, Stopped POV, 30 mph

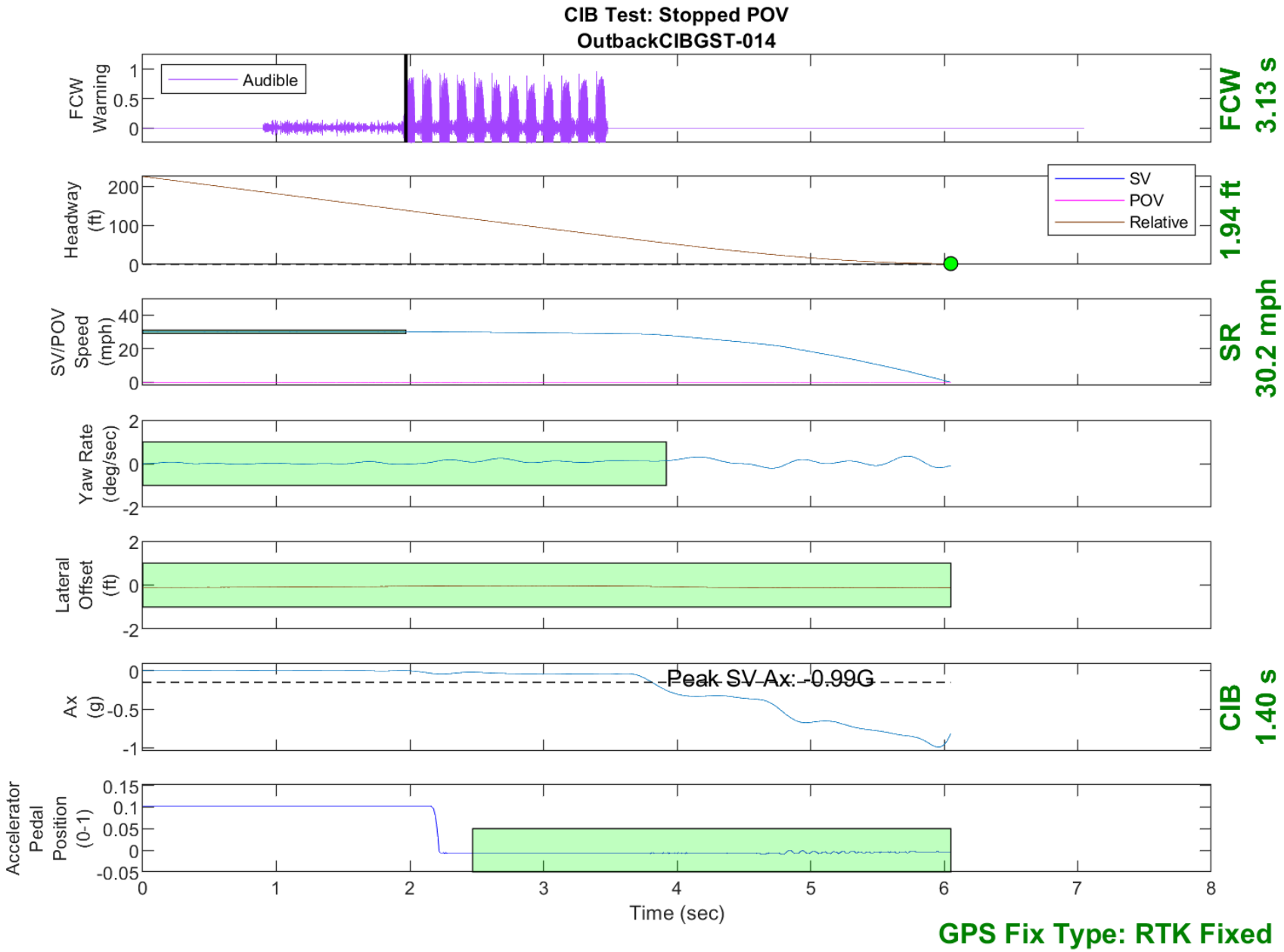


Figure D19. Time History for CIB Run 14, Stopped POV, 30 mph

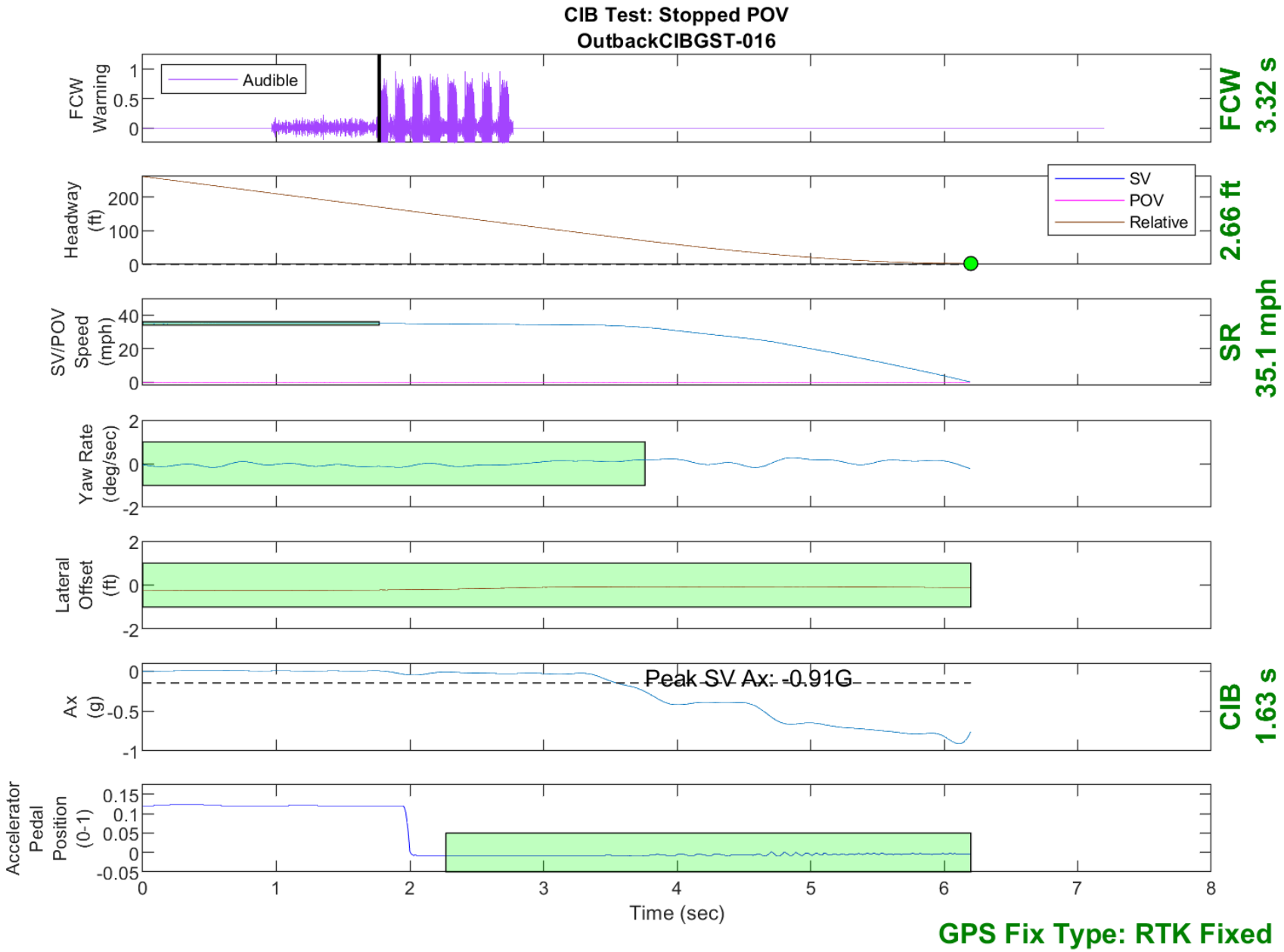


Figure D20. Time History for CIB Run 16, Stopped POV, 35 mph

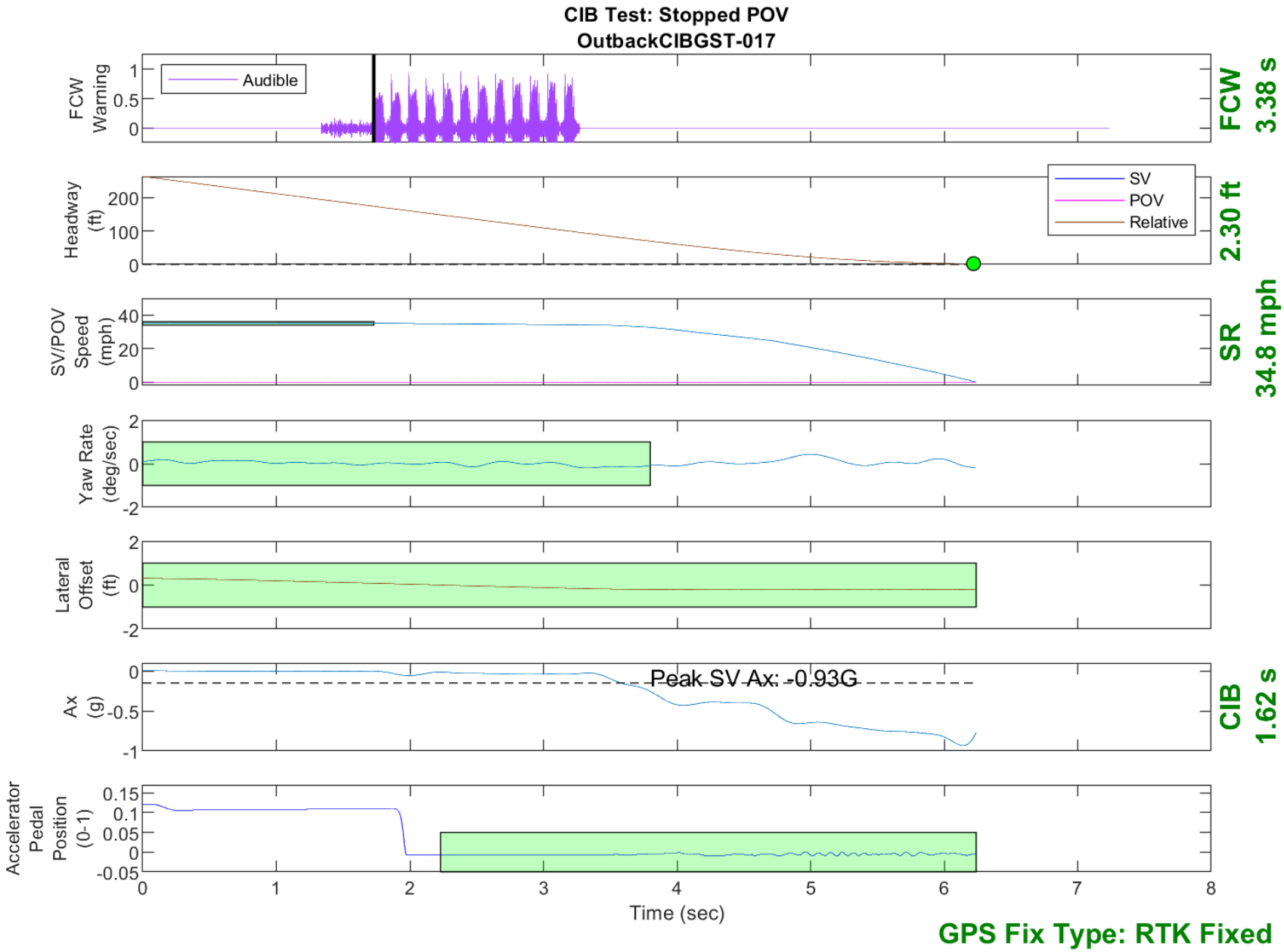


Figure D21. Time History for CIB Run 17, Stopped POV, 35 mph

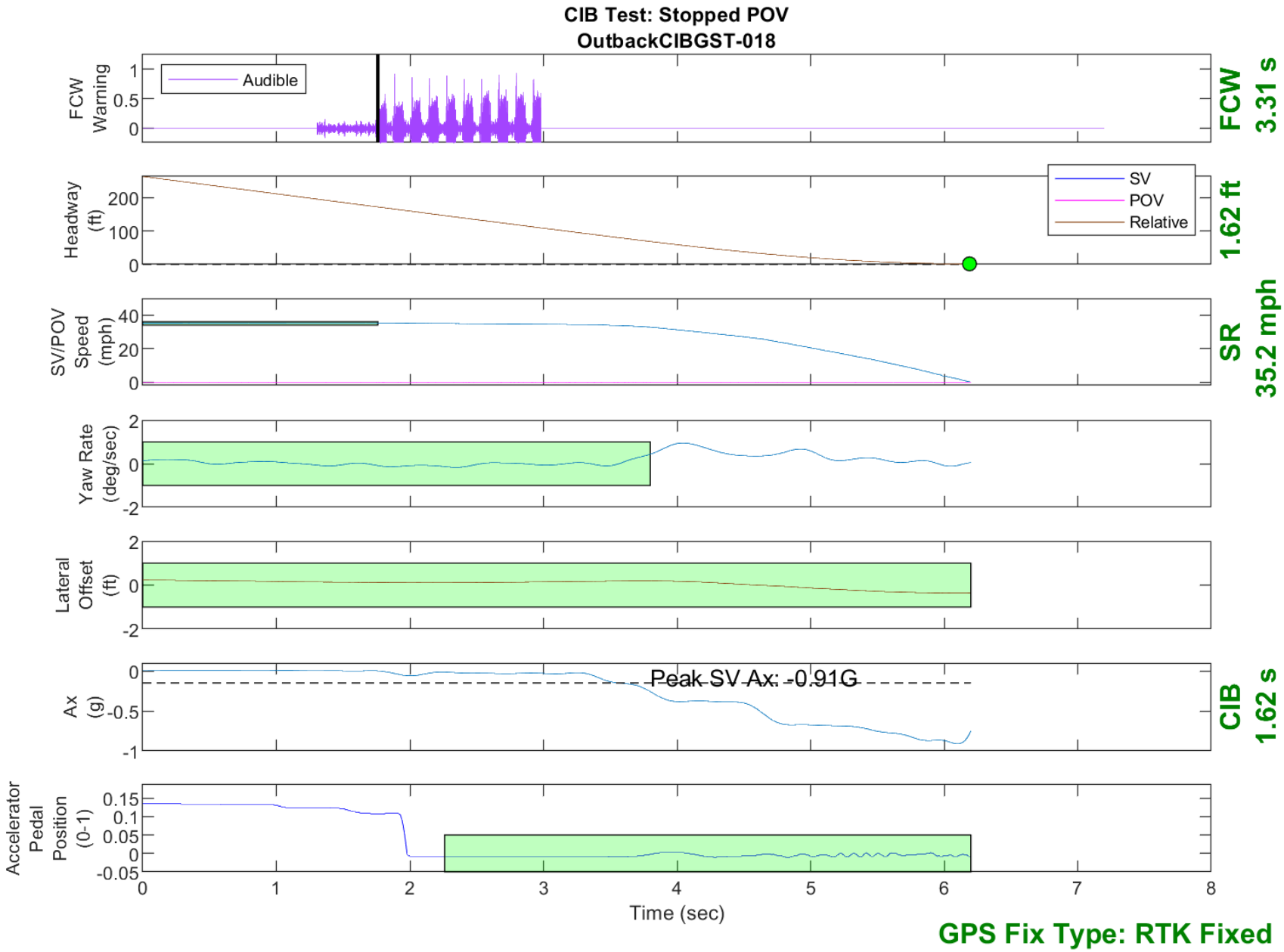


Figure D22. Time History for CIB Run 18, Stopped POV, 35 mph

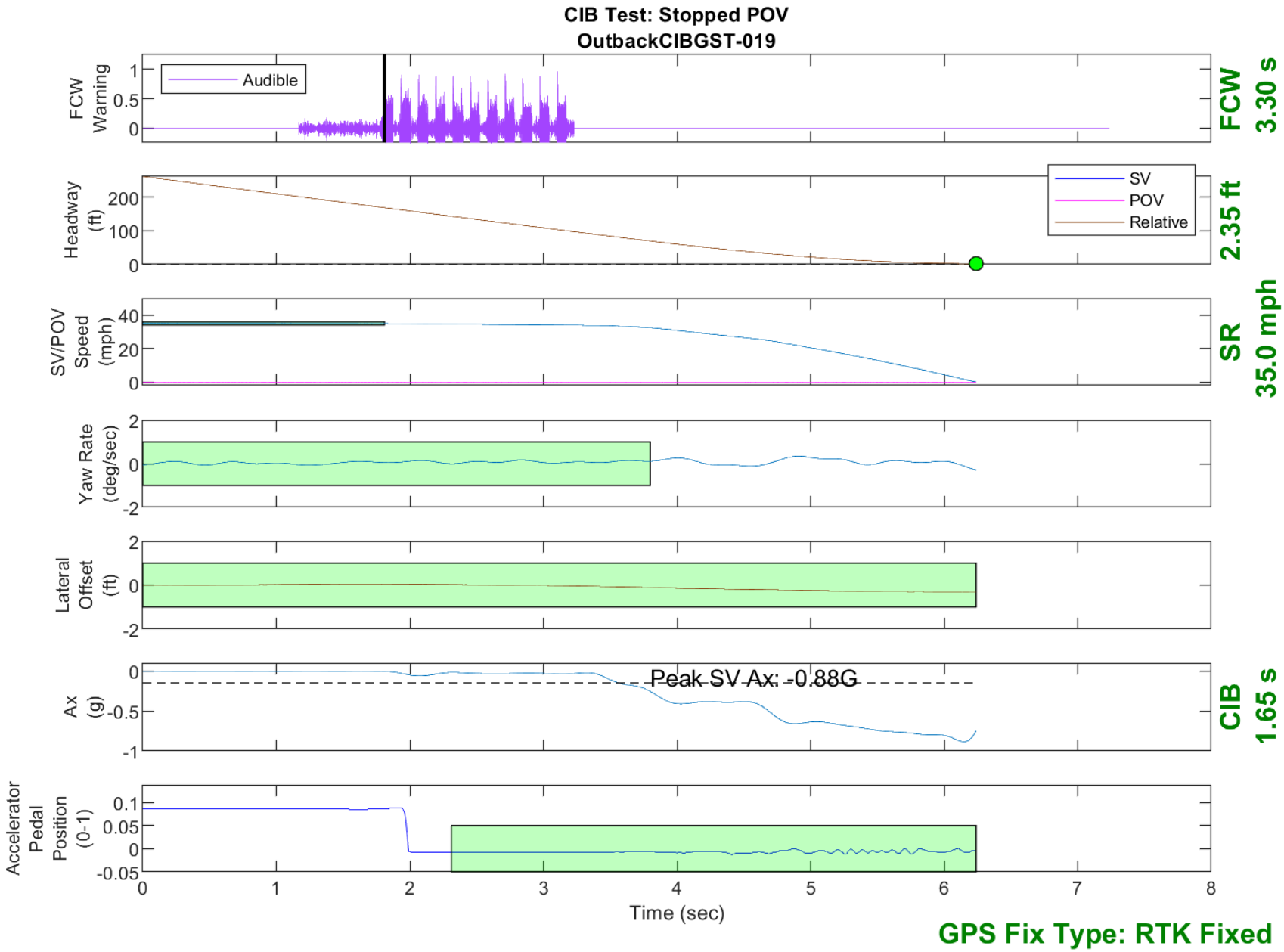


Figure D23. Time History for CIB Run 19, Stopped POV, 35 mph

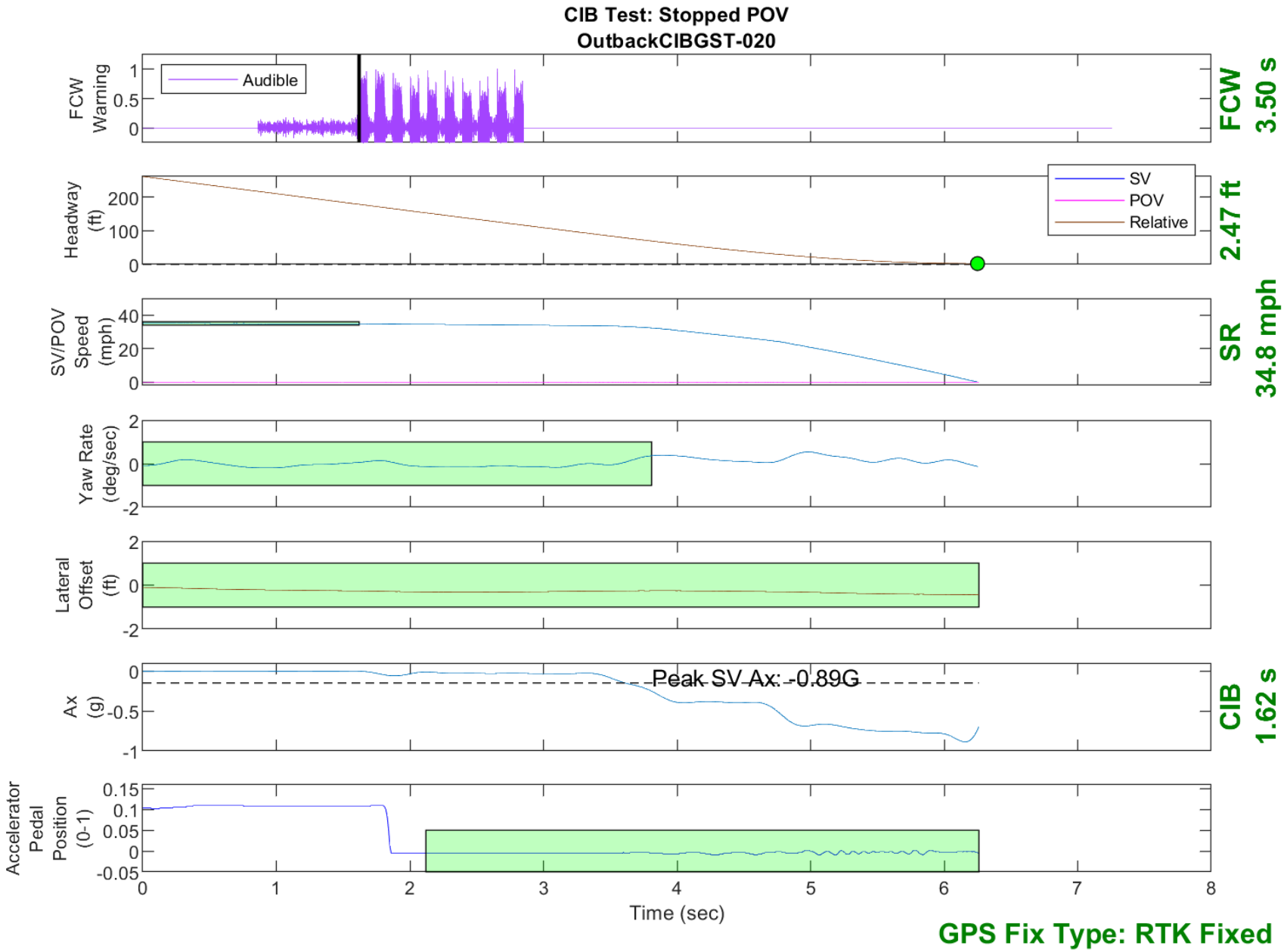


Figure D24. Time History for CIB Run 20, Stopped POV, 35 mph

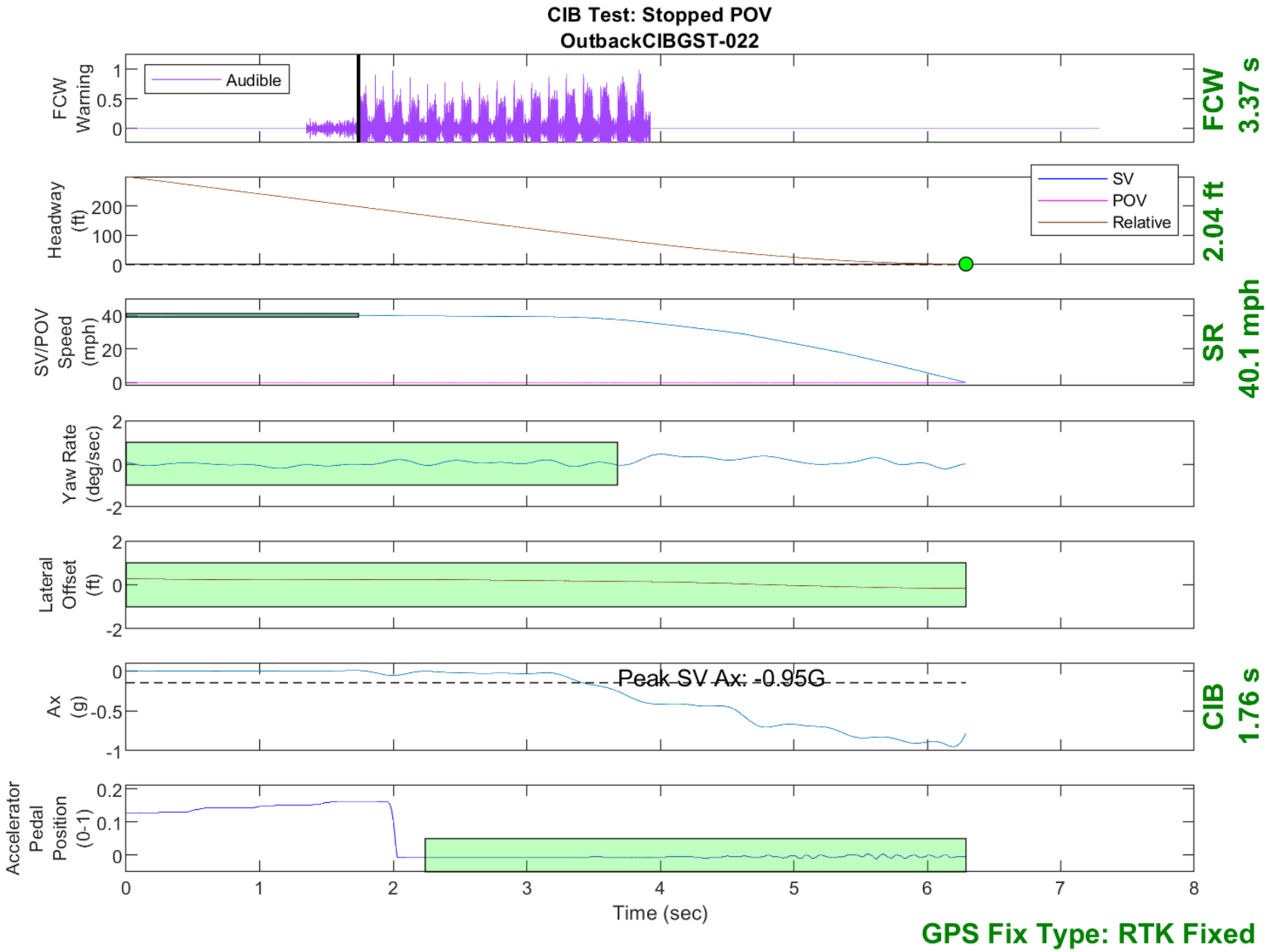


Figure D25. Time History for CIB Run 22, Stopped POV, 40 mph

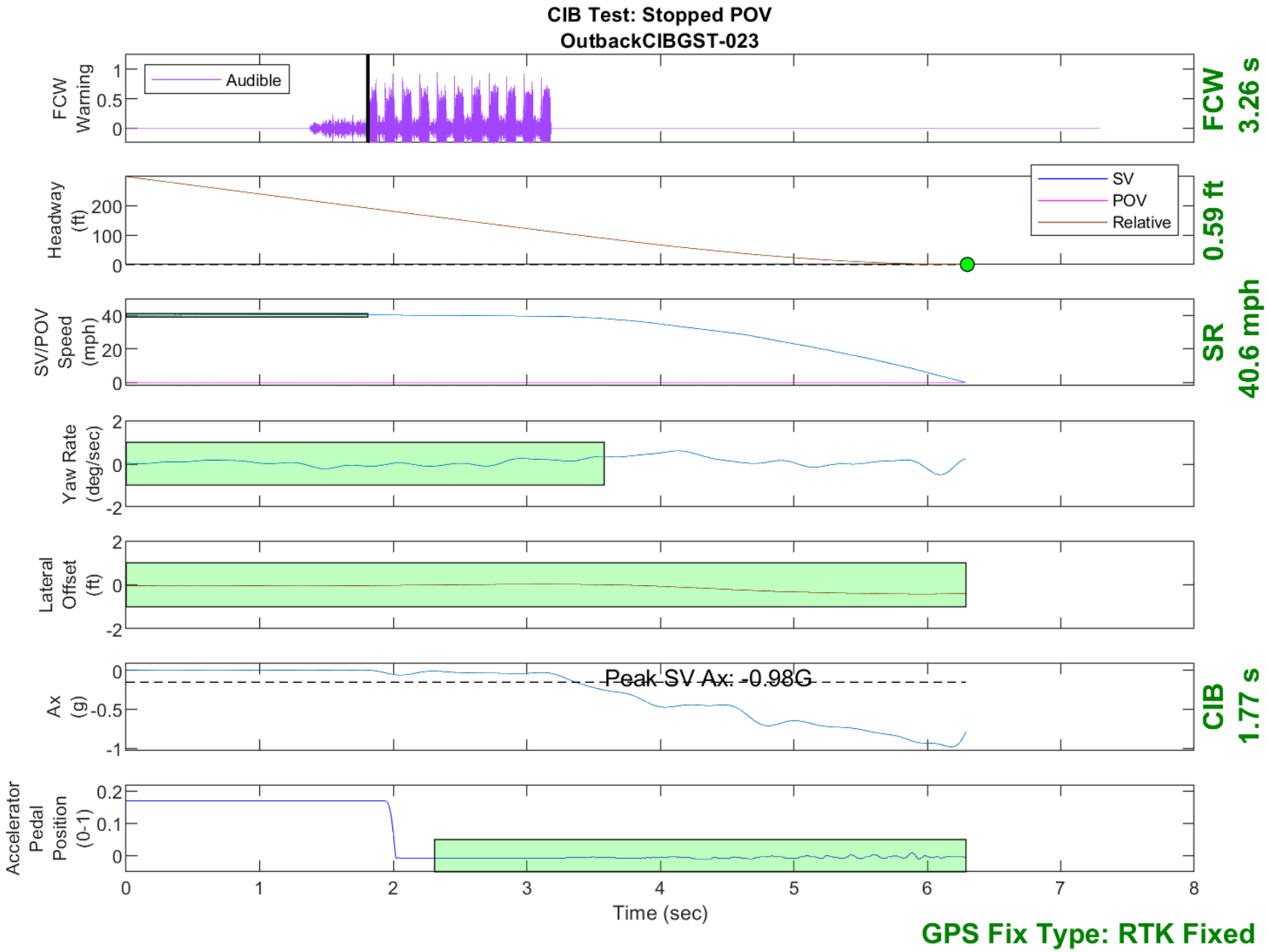


Figure D26. Time History for CIB Run 23, Stopped POV, 40 mph

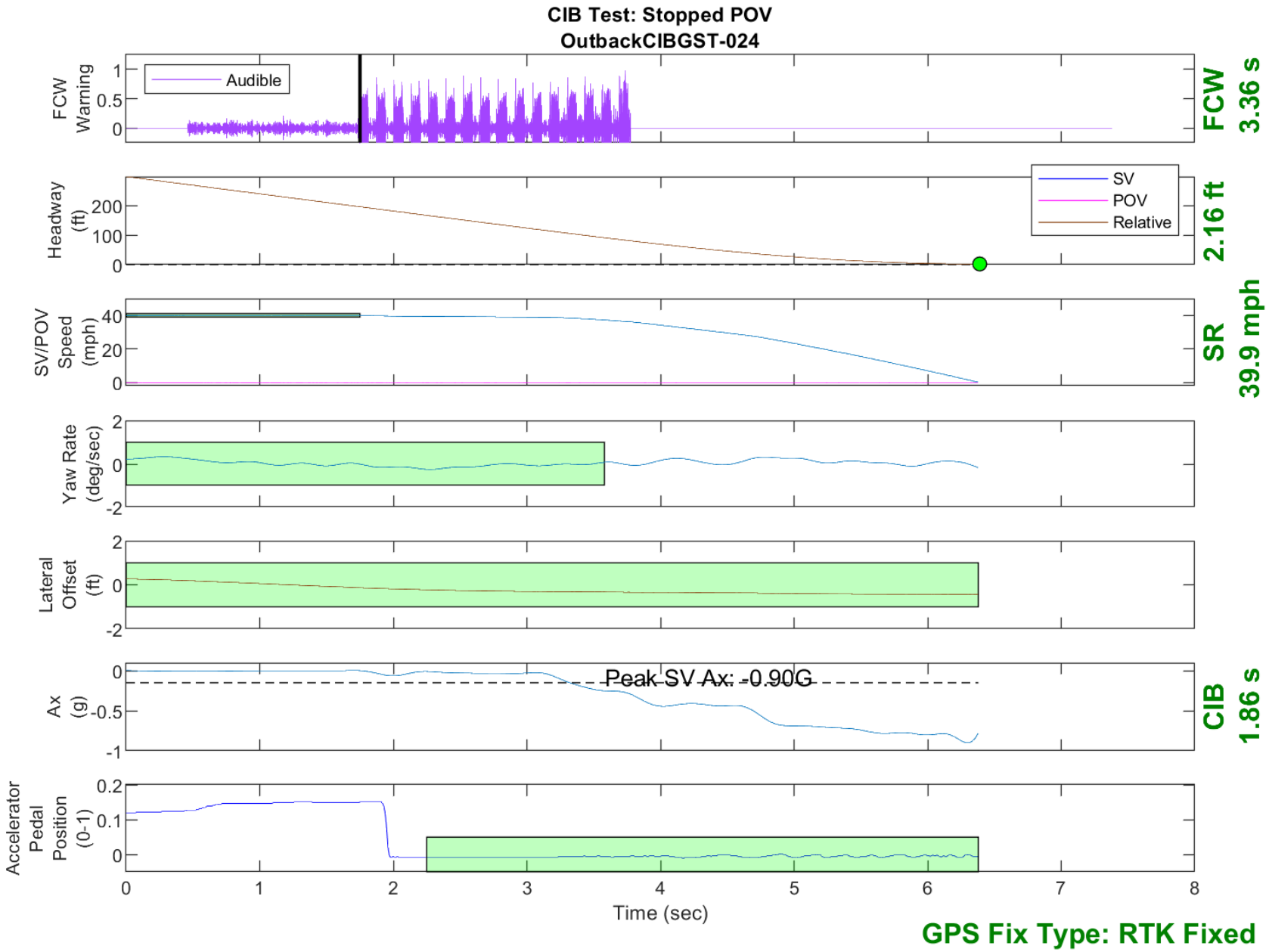


Figure D27. Time History for CIB Run 24, Stopped POV, 40 mph

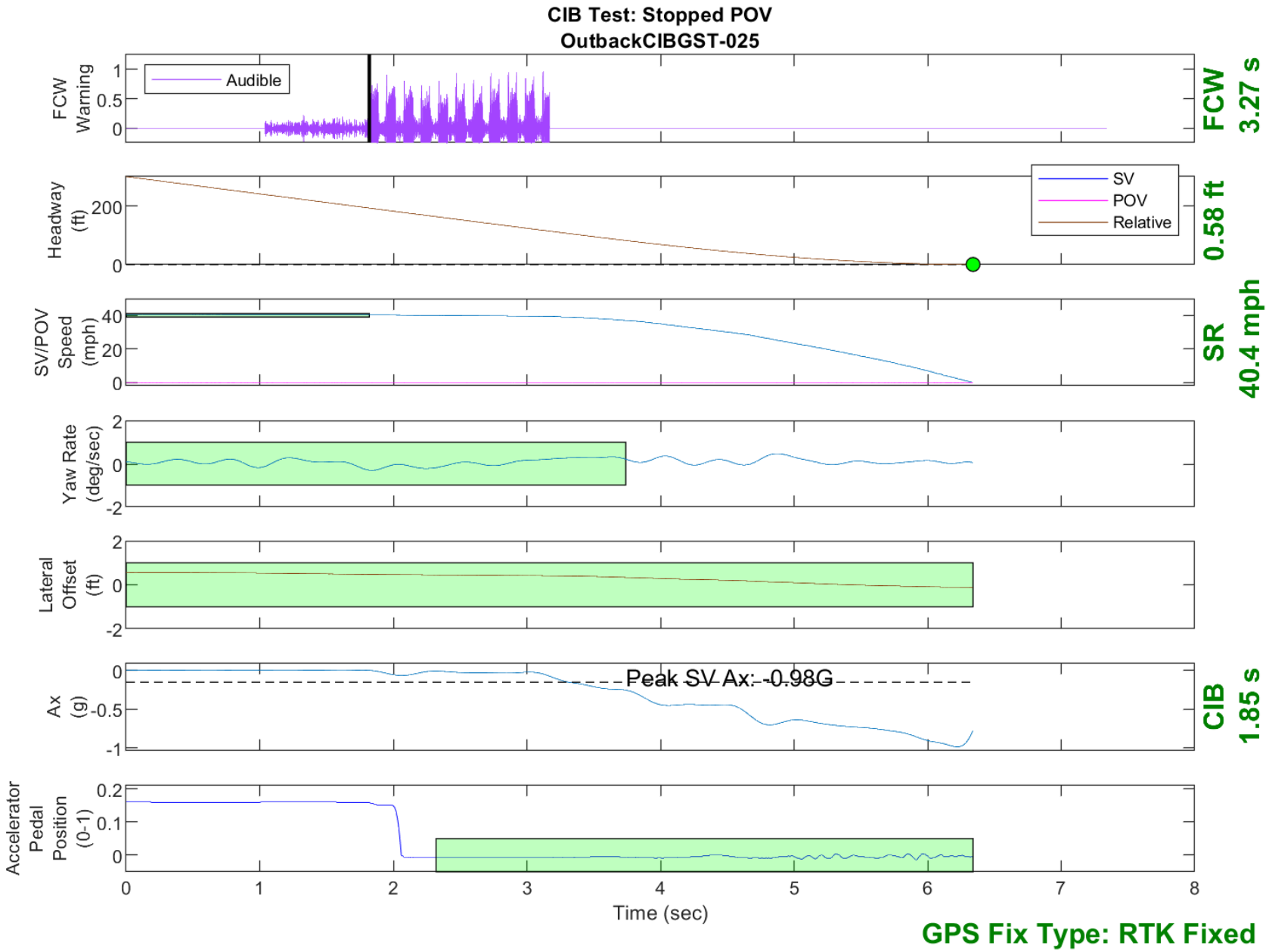


Figure D28. Time History for CIB Run 25, Stopped POV, 40 mph

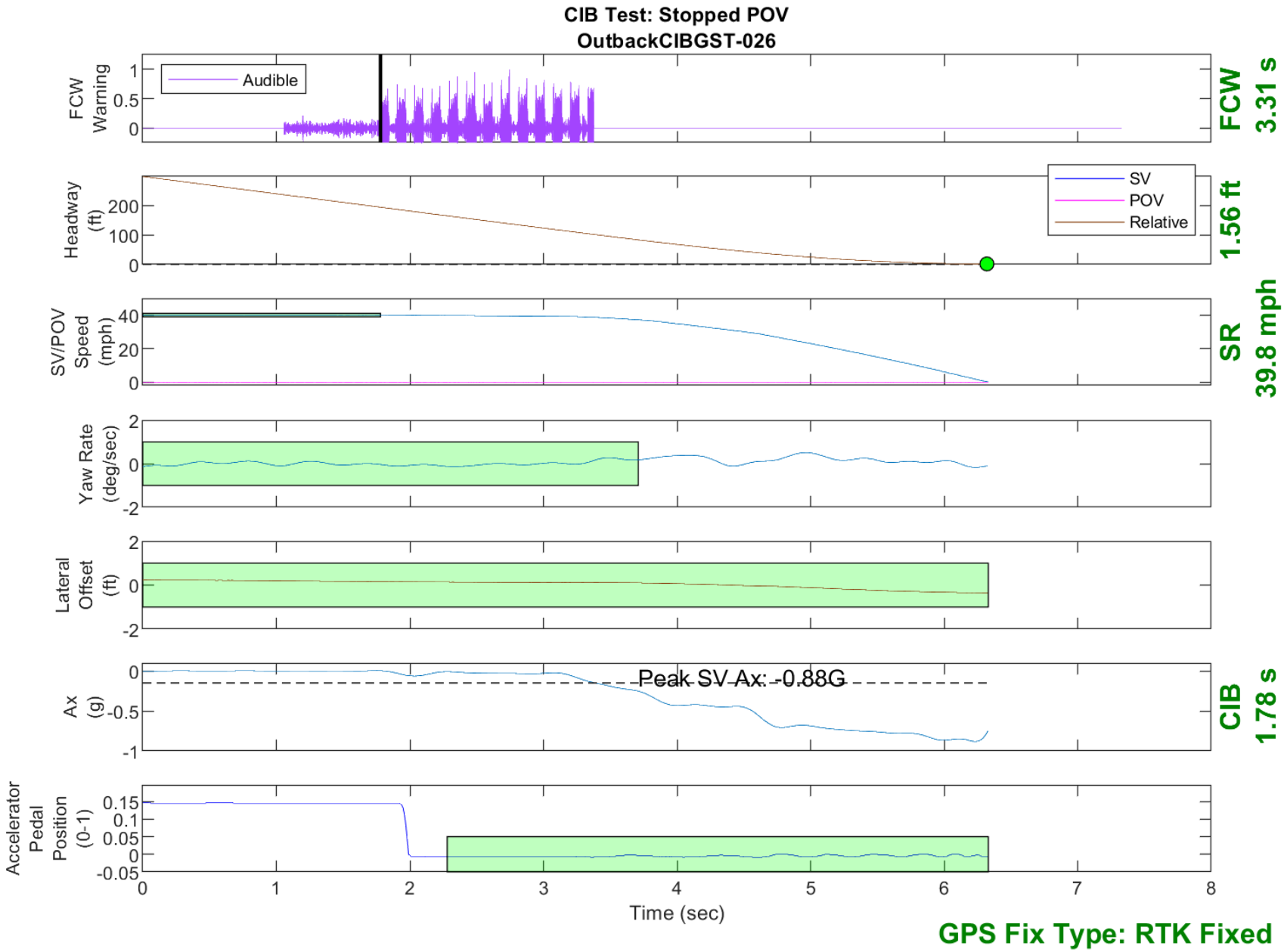


Figure D29. Time History for CIB Run 26, Stopped POV, 40 mph

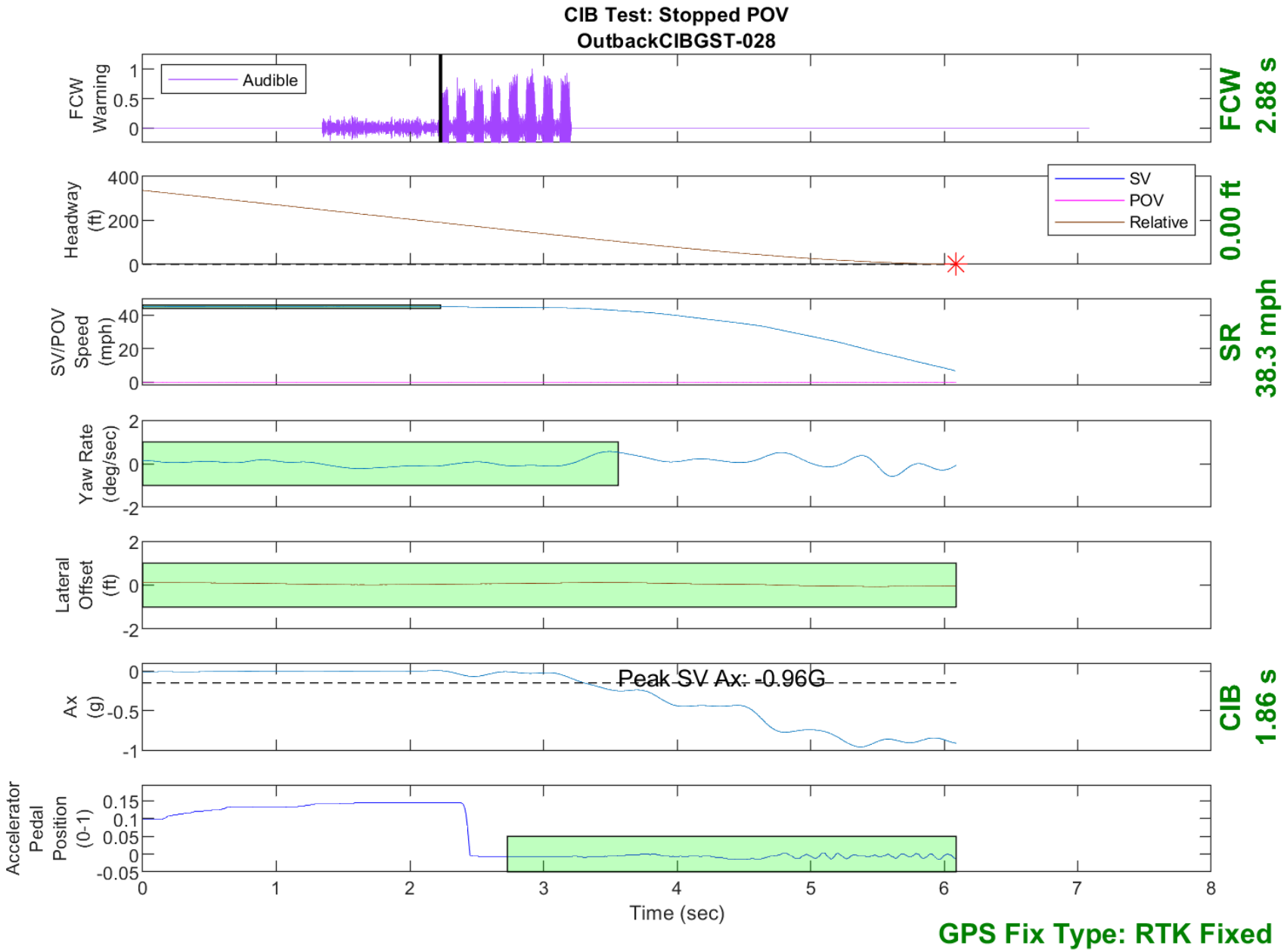


Figure D30. Time History for CIB Run 28, Stopped POV, 45 mph

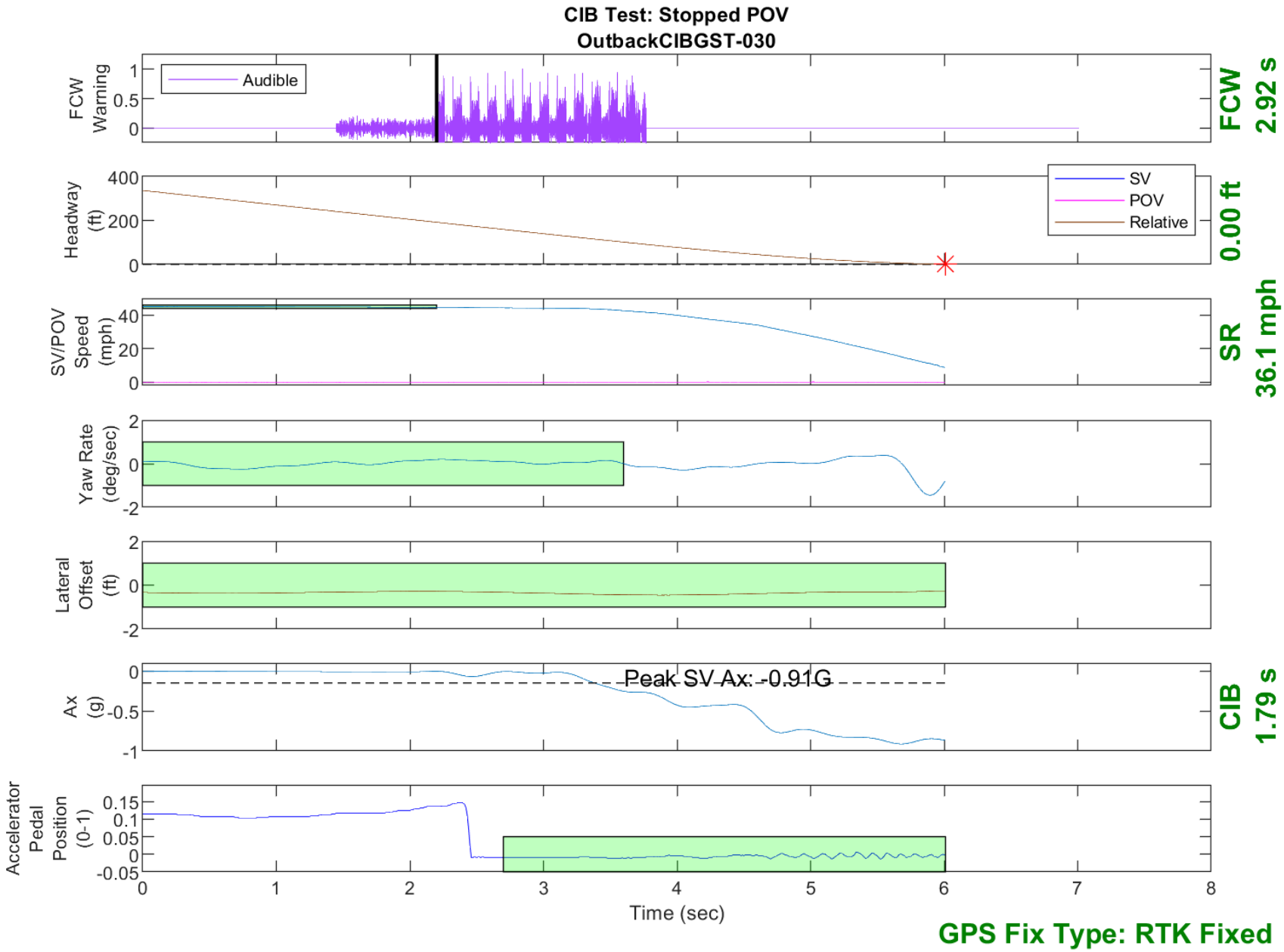


Figure D31. Time History for CIB Run 30, Stopped POV, 45 mph

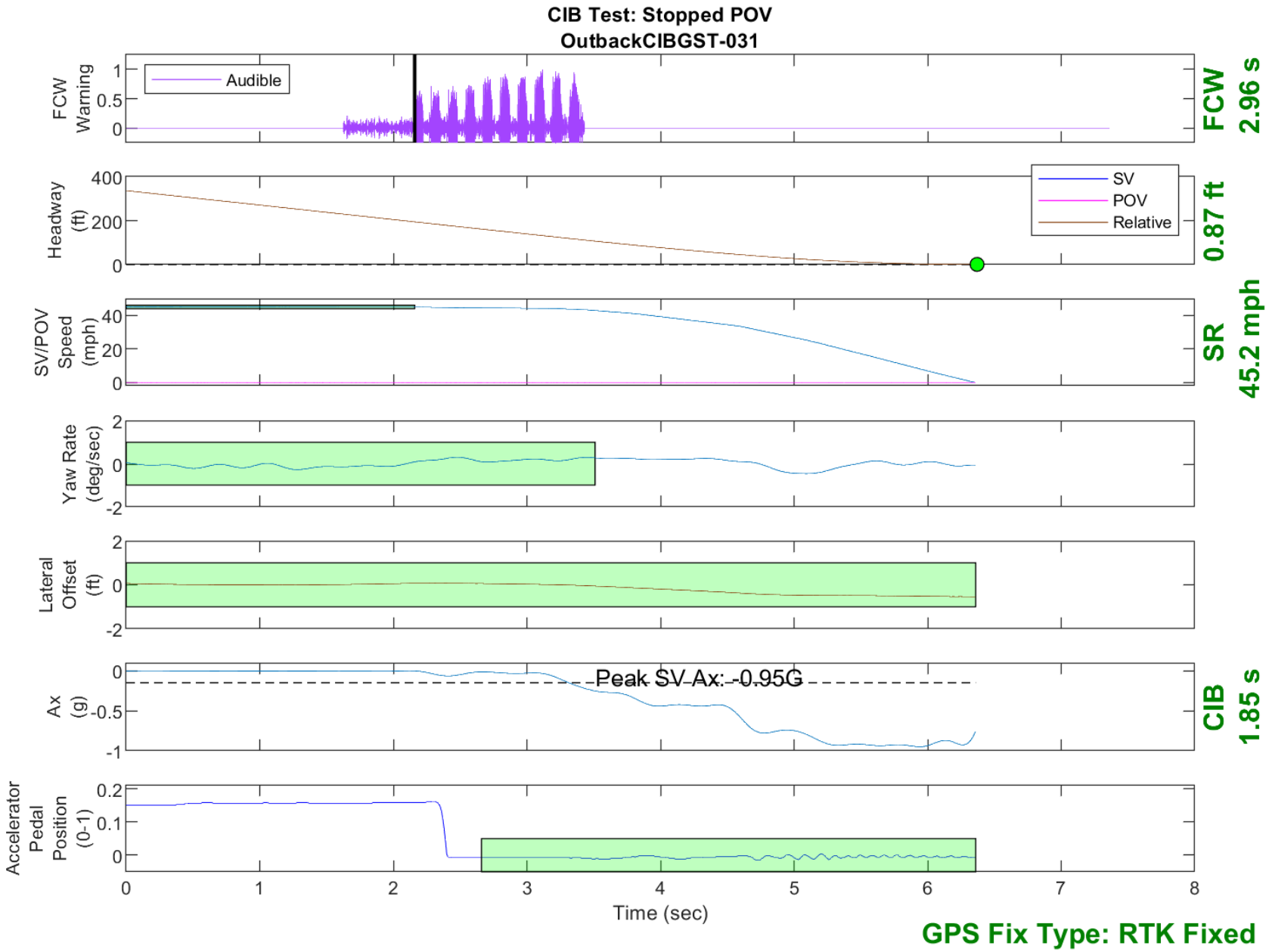


Figure D32. Time History for CIB Run 31, Stopped POV, 45 mph

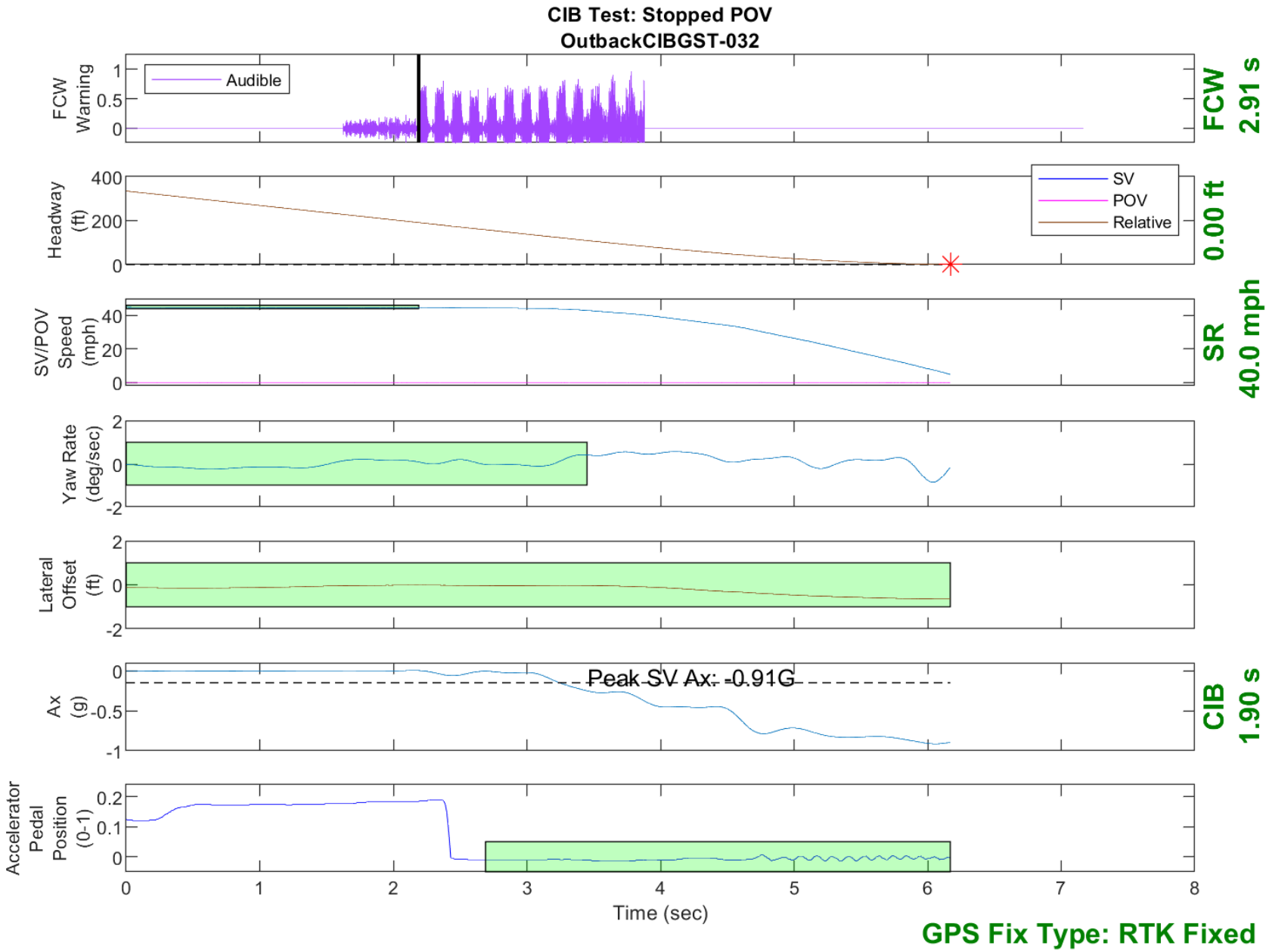


Figure D33. Time History for CIB Run 32, Stopped POV, 45 mph

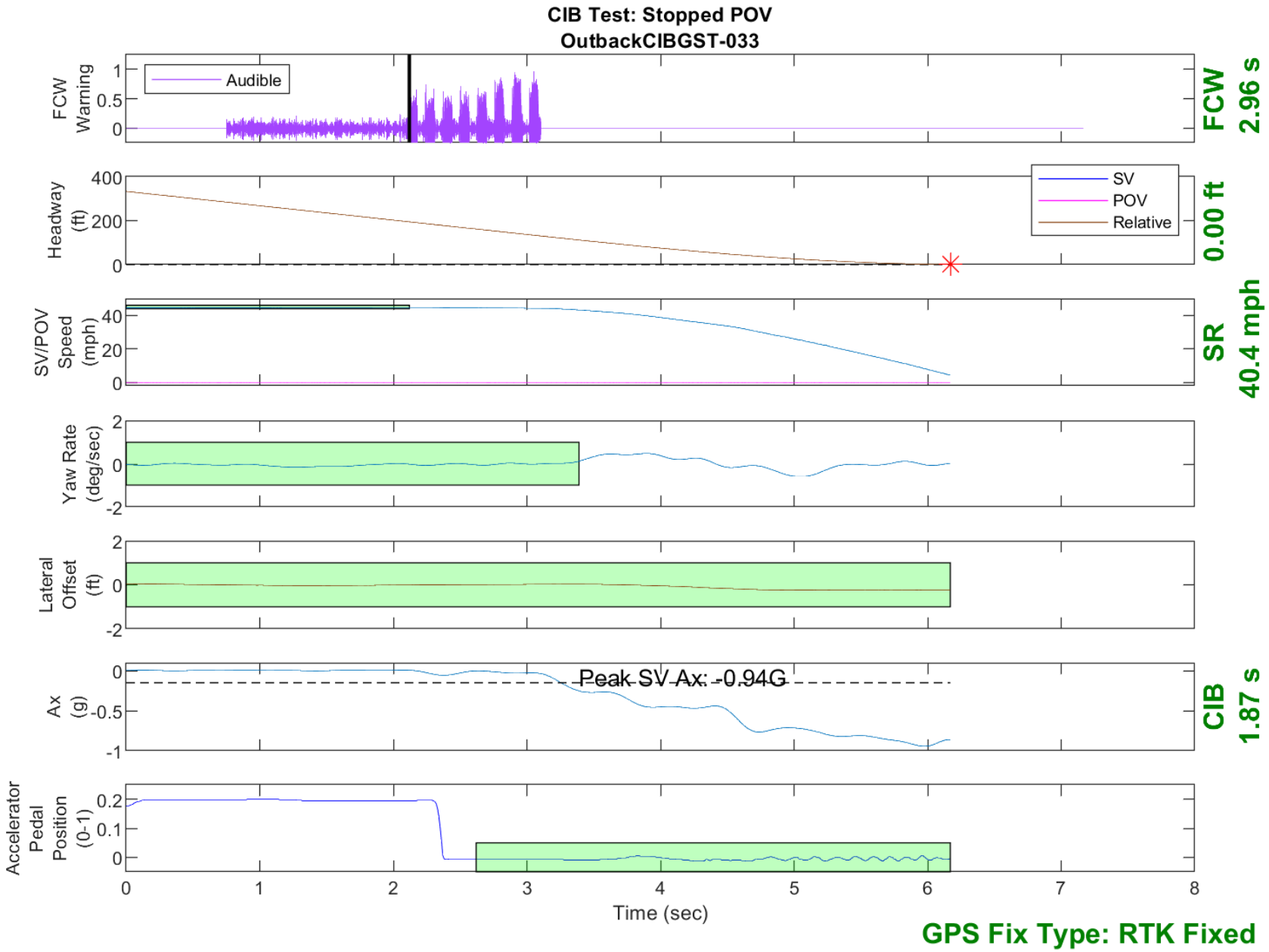


Figure D34. Time History for CIB Run 33, Stopped POV, 45 mph

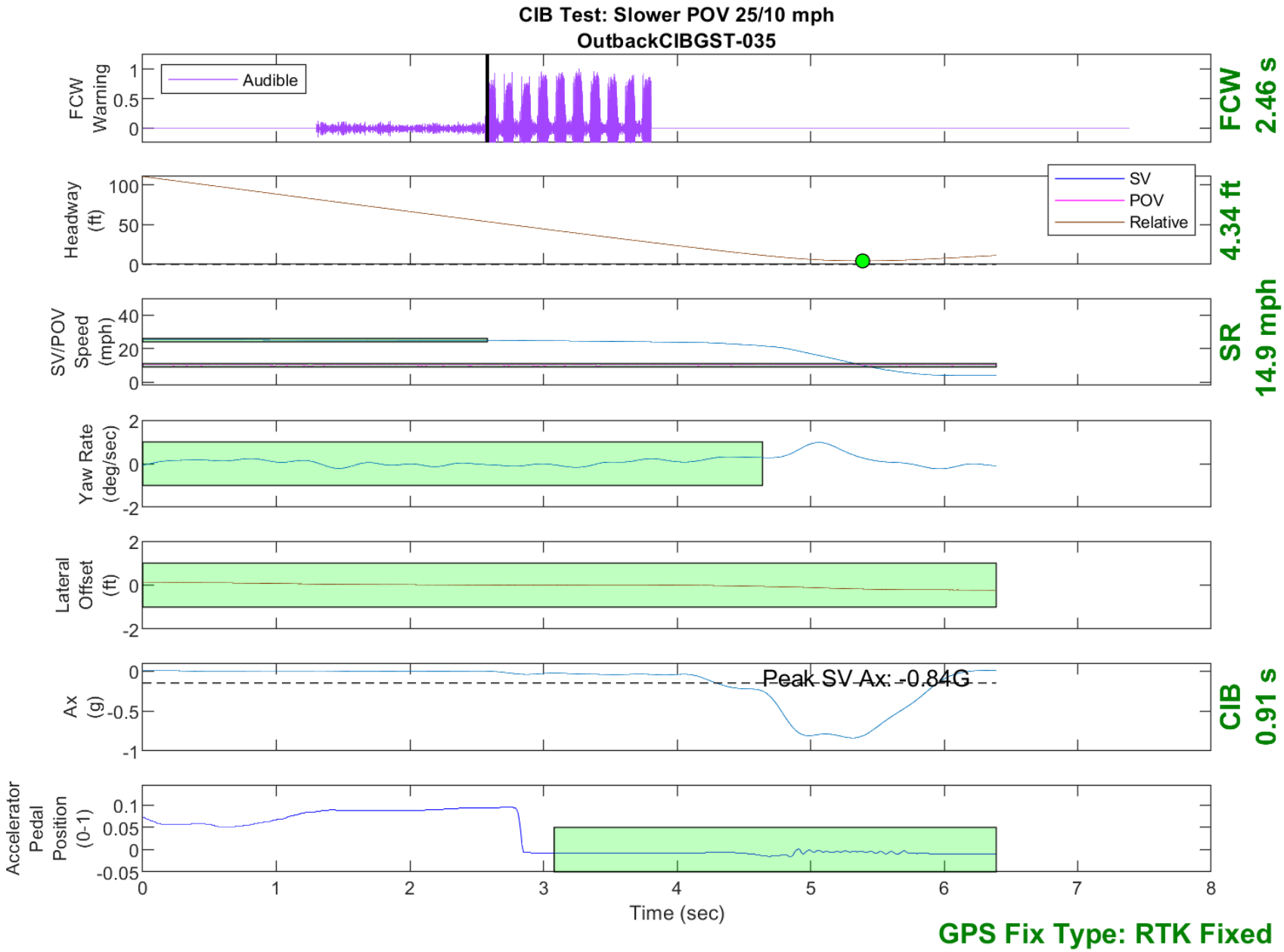


Figure D35. Time History for CIB Run 35, Slower POV, 25/10 mph

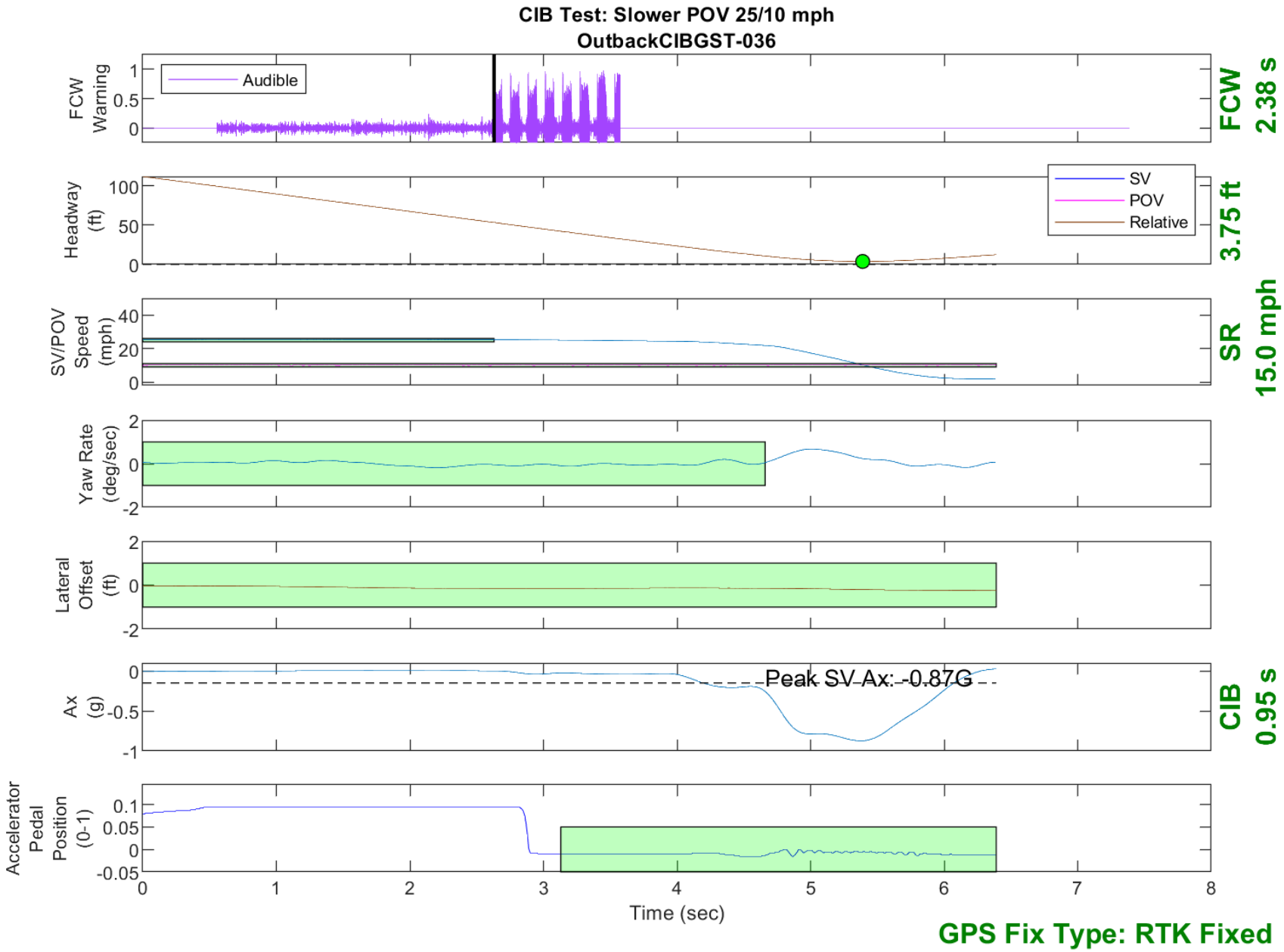


Figure D36. Time History for CIB Run 36, Slower POV, 25/10 mph

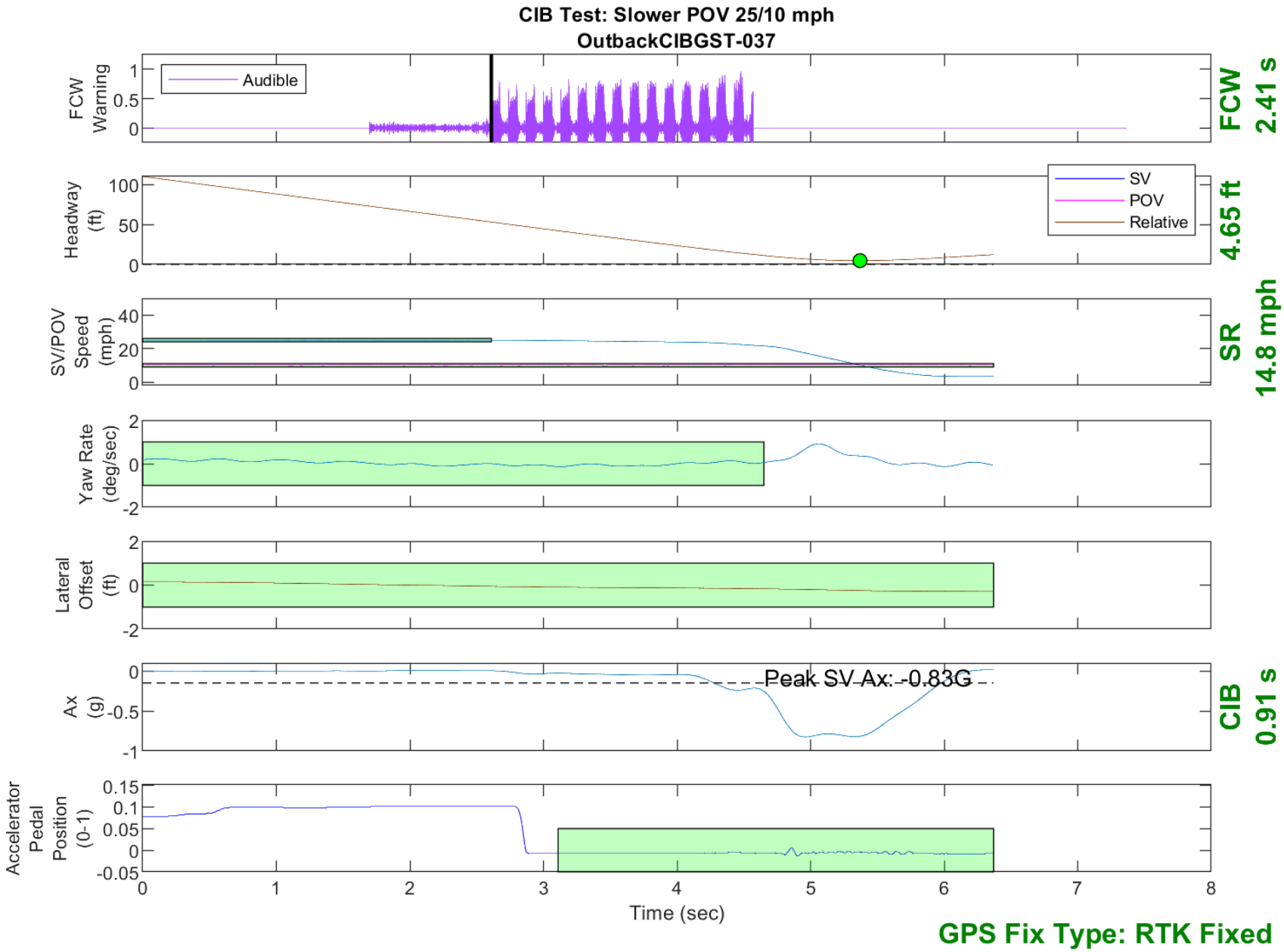


Figure D37. Time History for CIB Run 37, Slower POV, 25/10 mph

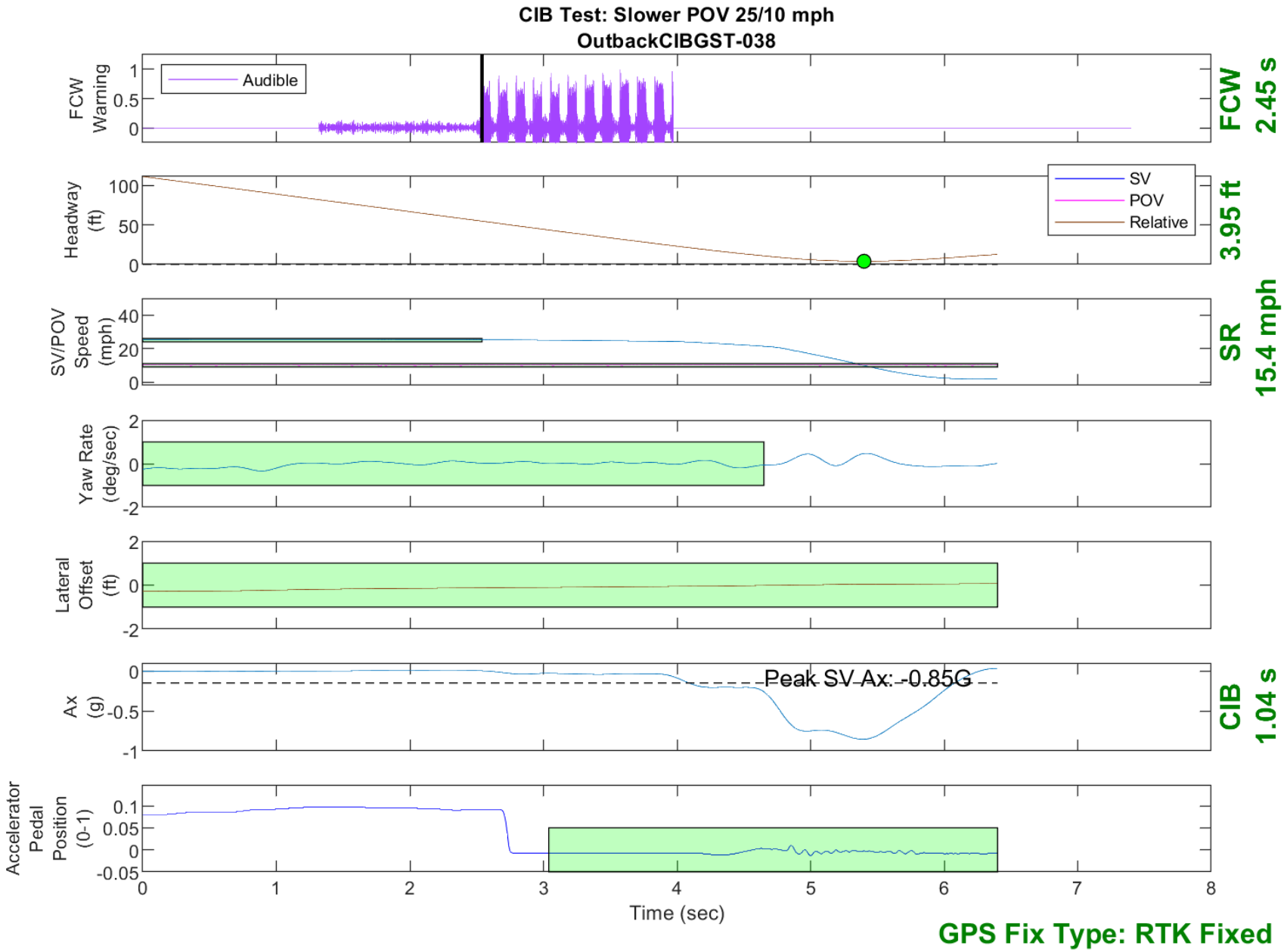


Figure D38. Time History for CIB Run 38, Slower POV, 25/10 mph

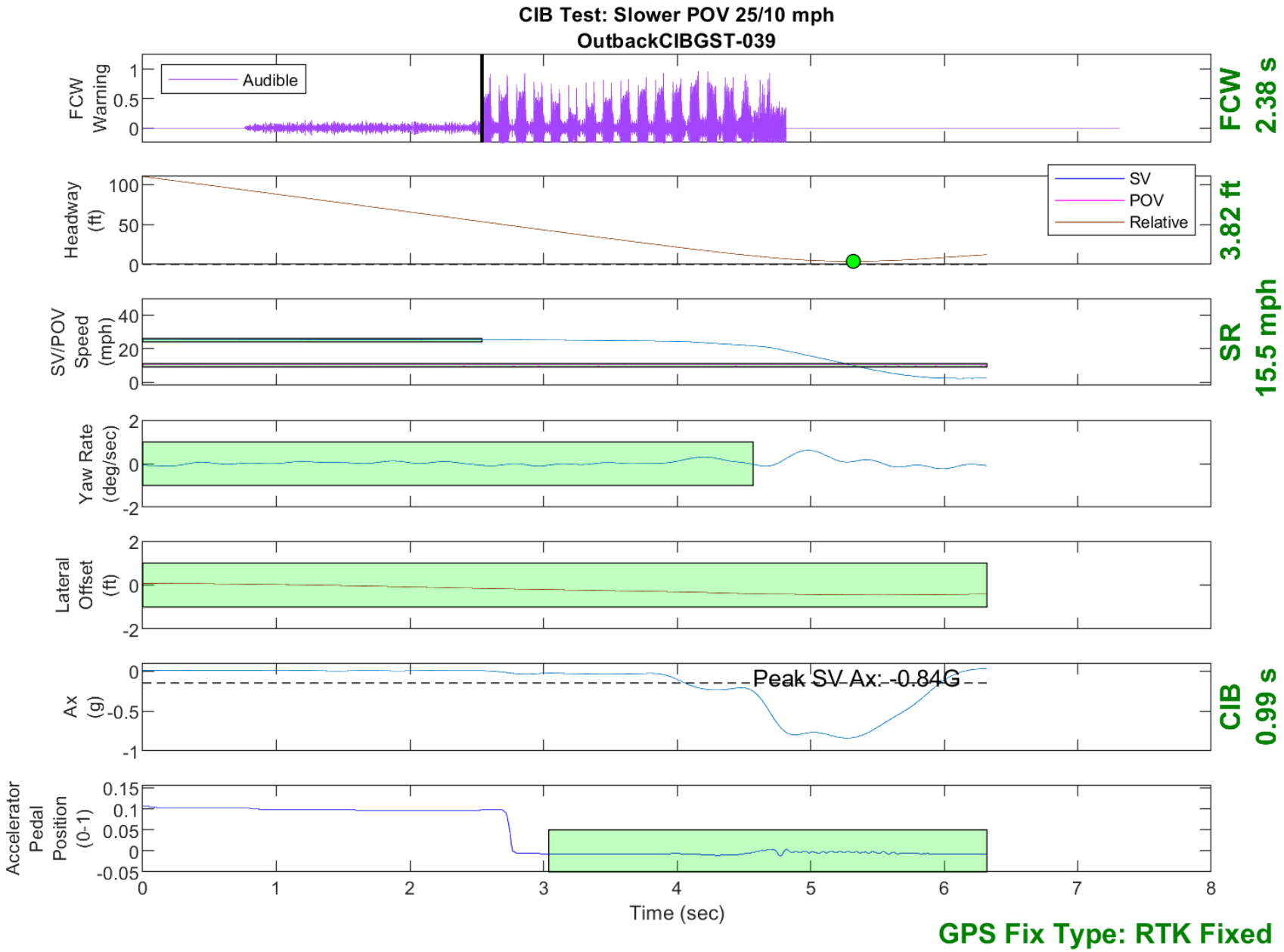


Figure D39. Time History for CIB Run 39, Slower POV, 25/10 mph

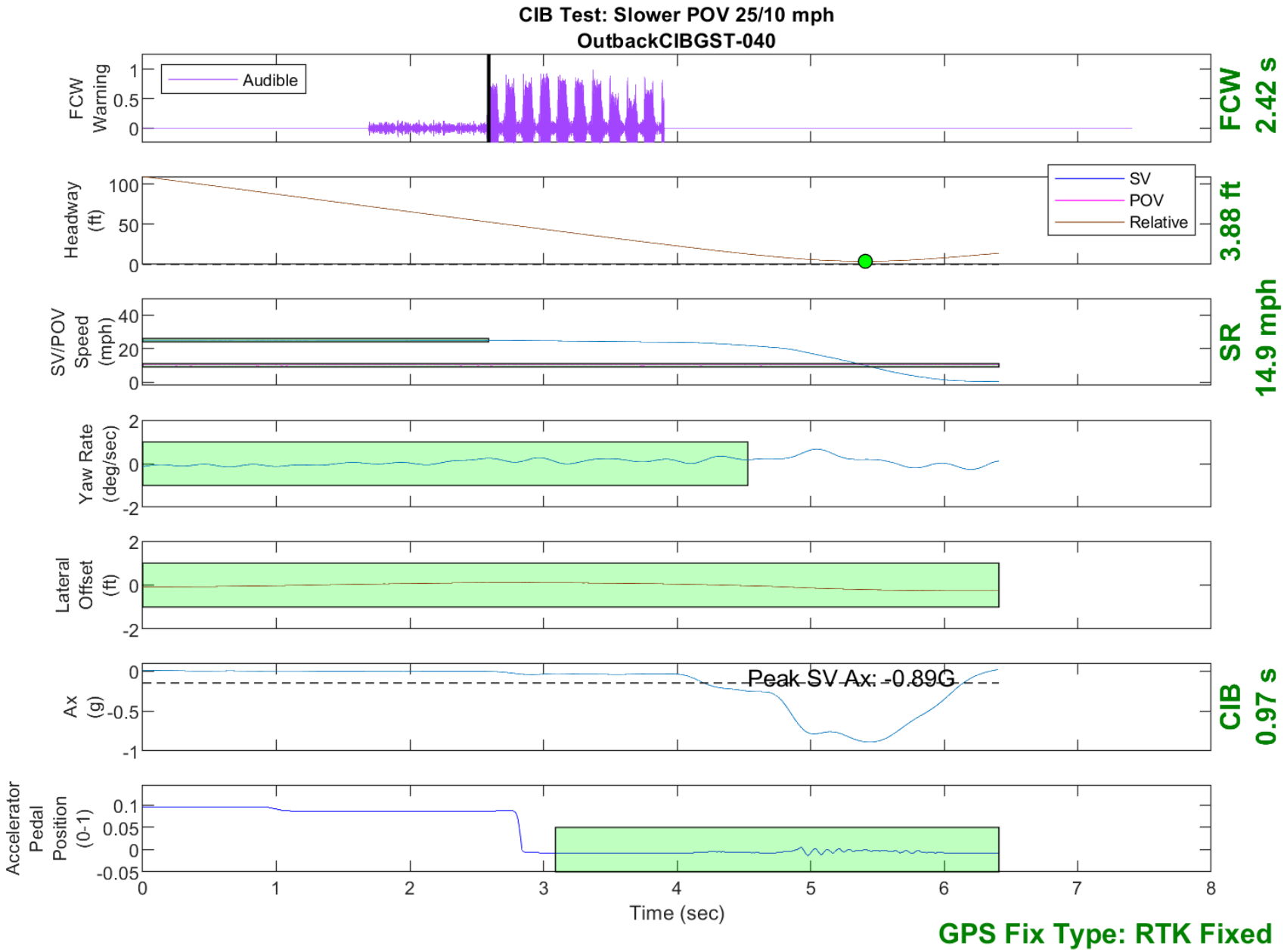


Figure D40. Time History for CIB Run 40, Slower POV, 25/10 mph

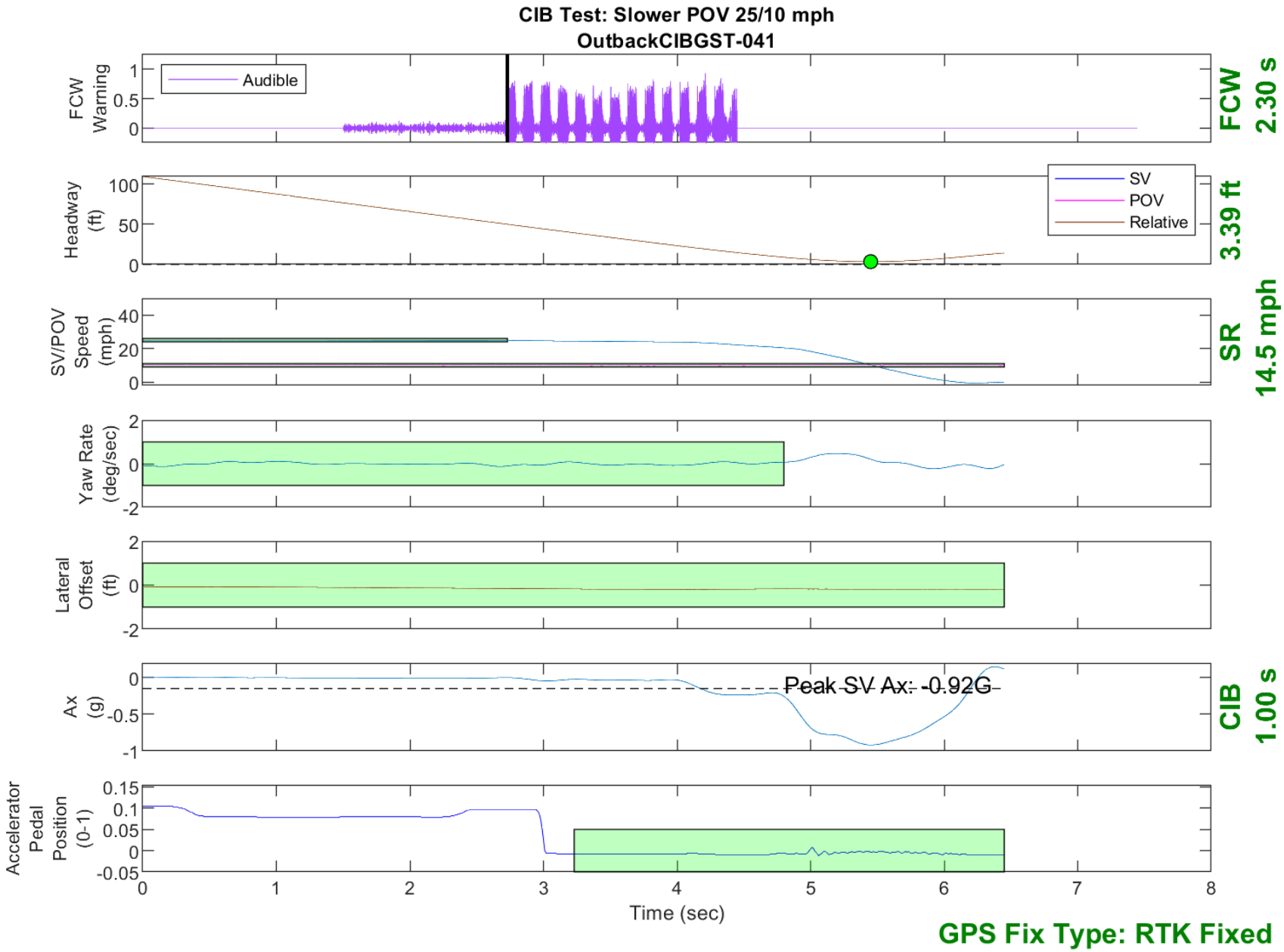


Figure D41. Time History for CIB Run 41, Slower POV, 25/10 mph

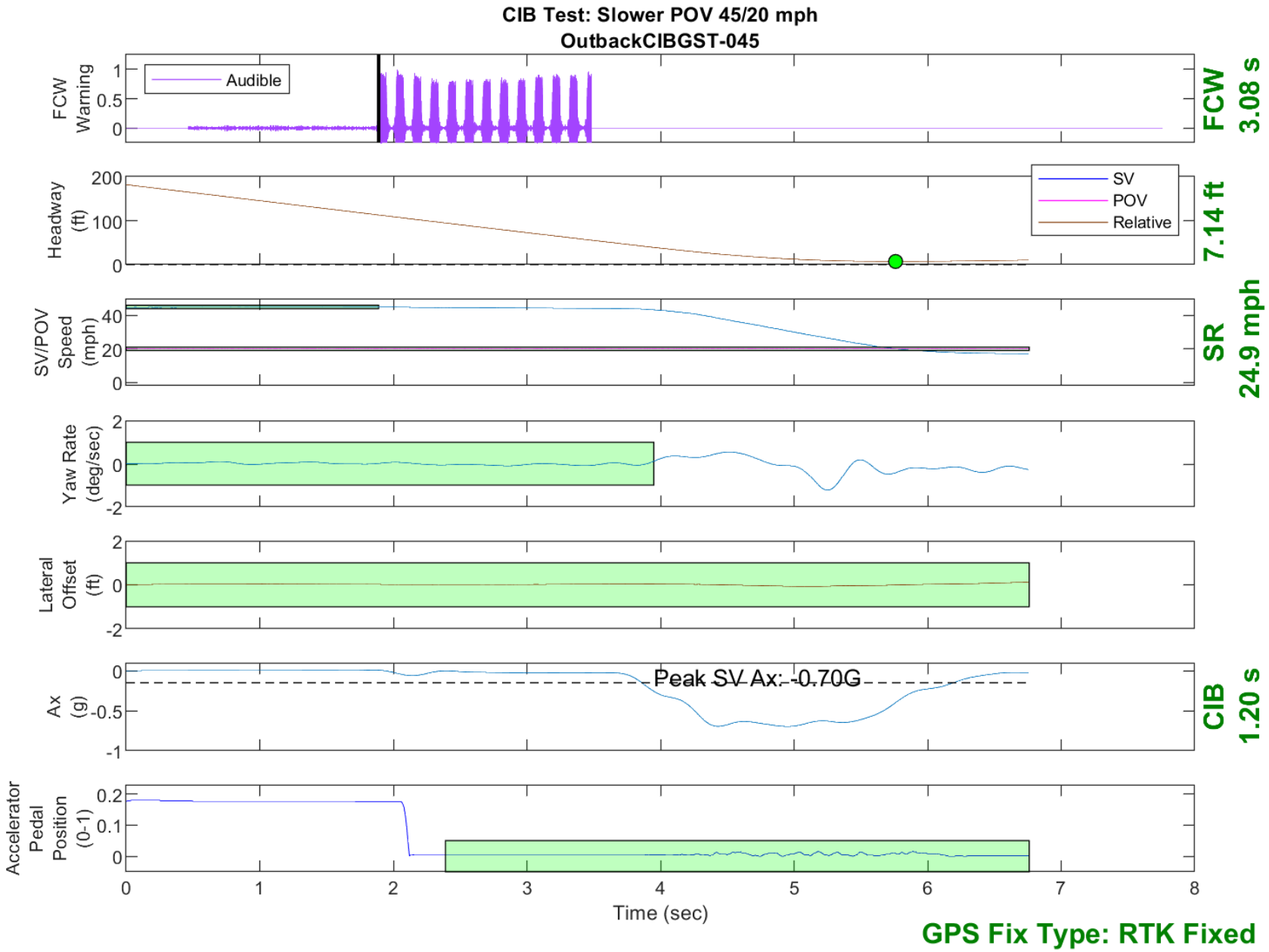


Figure D42. Time History for CIB Run 45, Slower POV, 45/20 mph

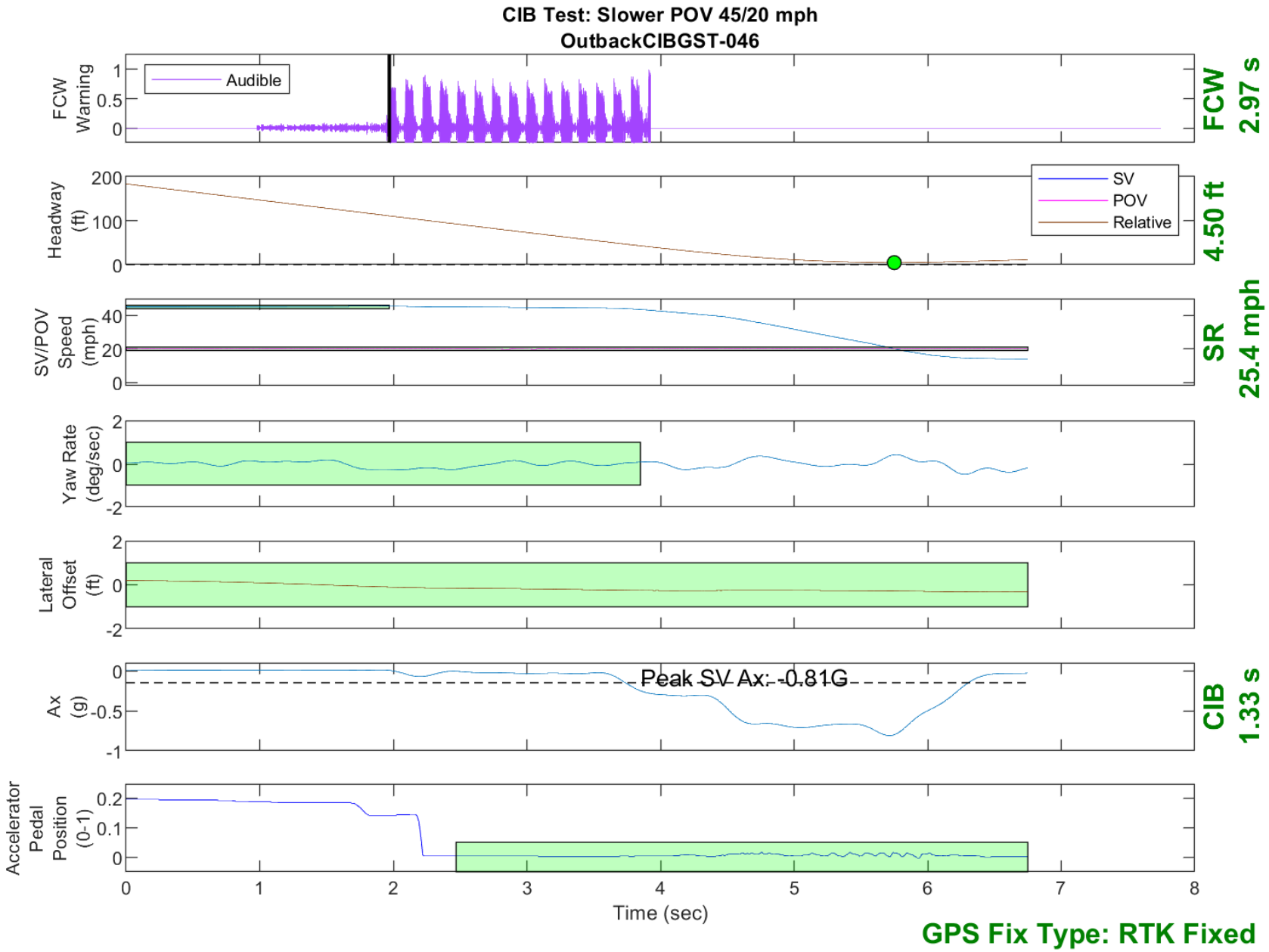


Figure D43. Time History for CIB Run 46, Slower POV, 45/20 mph

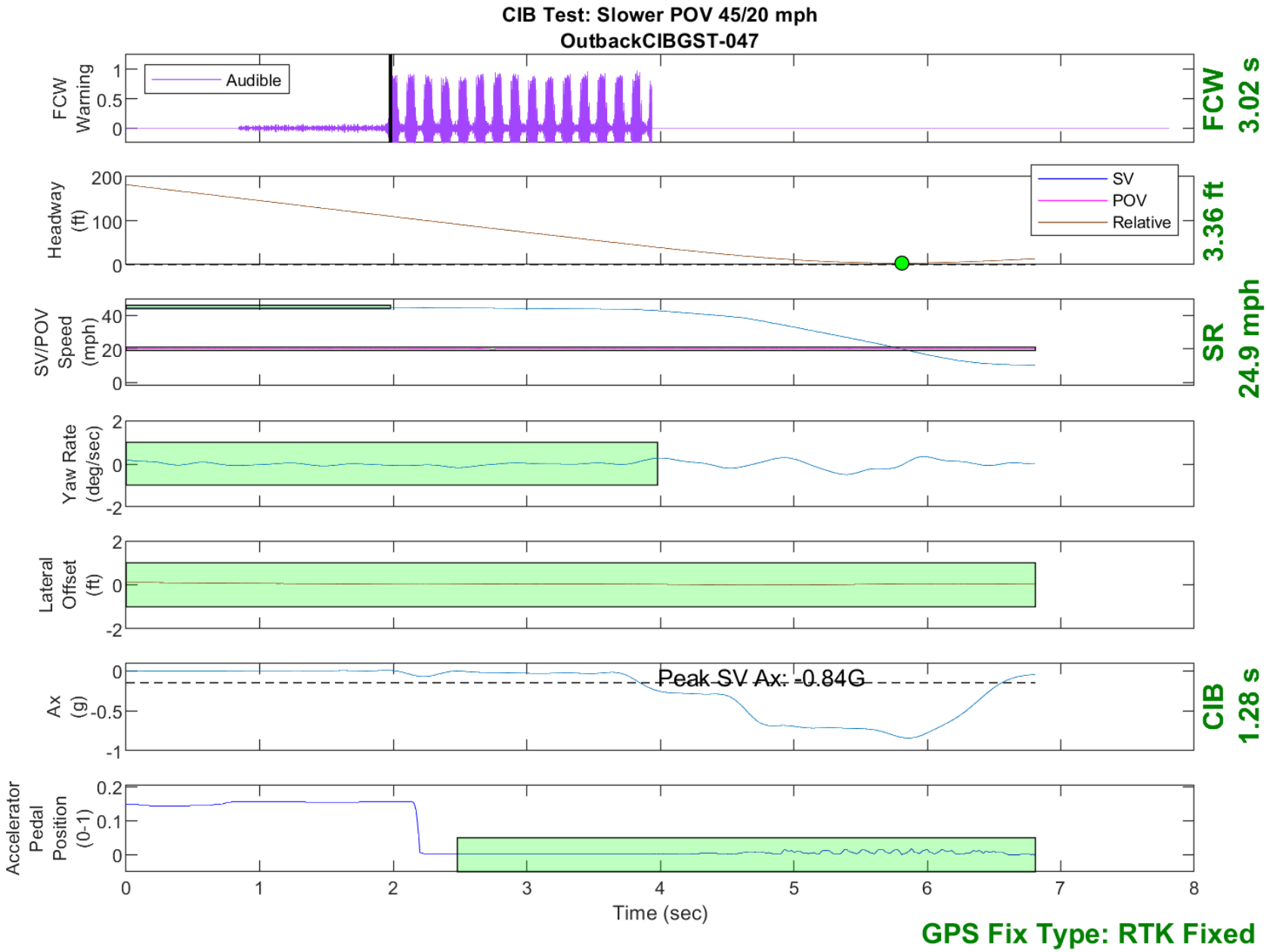


Figure D44. Time History for CIB Run 47, Slower POV, 45/20 mph

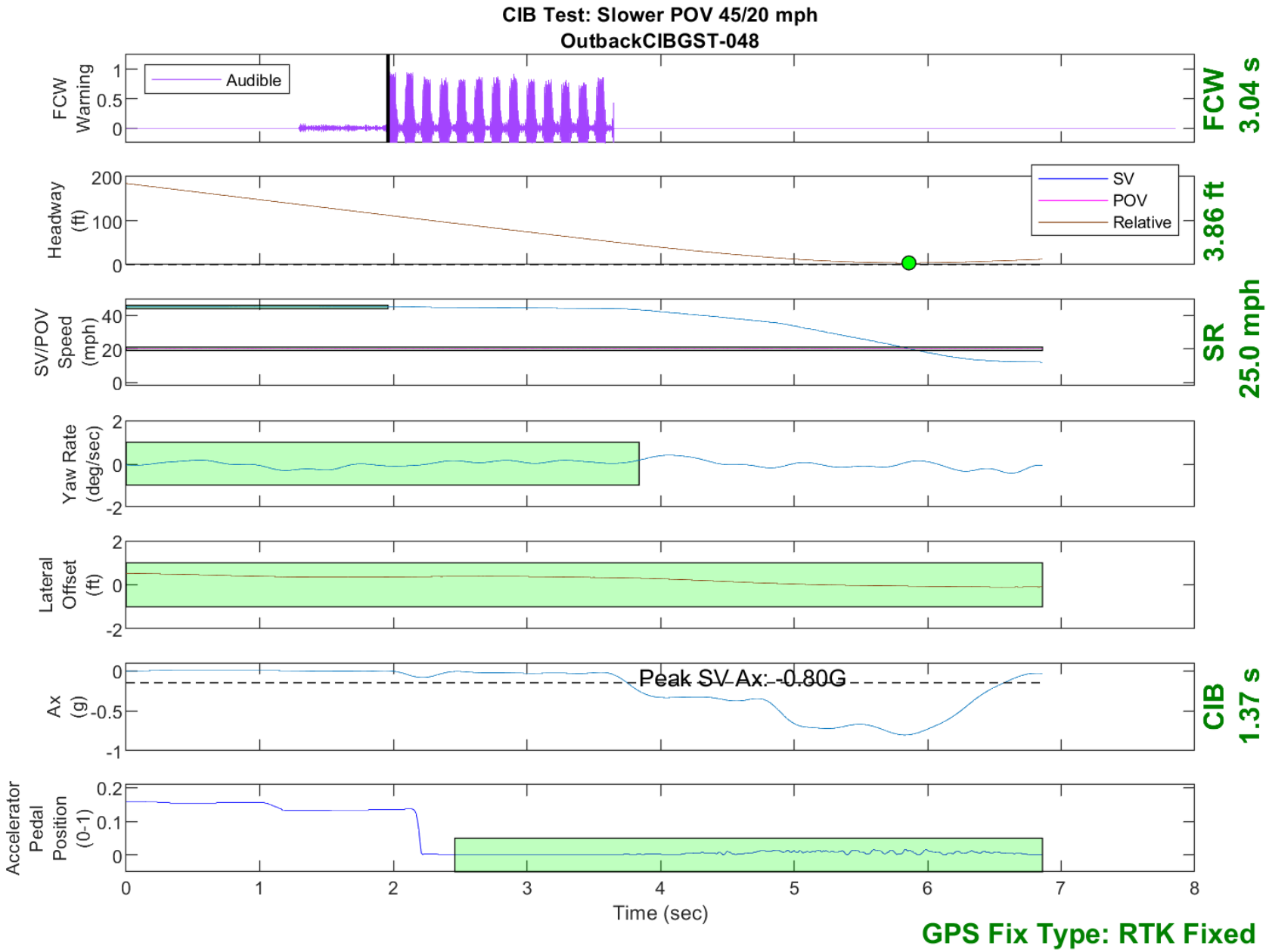


Figure D45. Time History for CIB Run 48, Slower POV, 45/20 mph

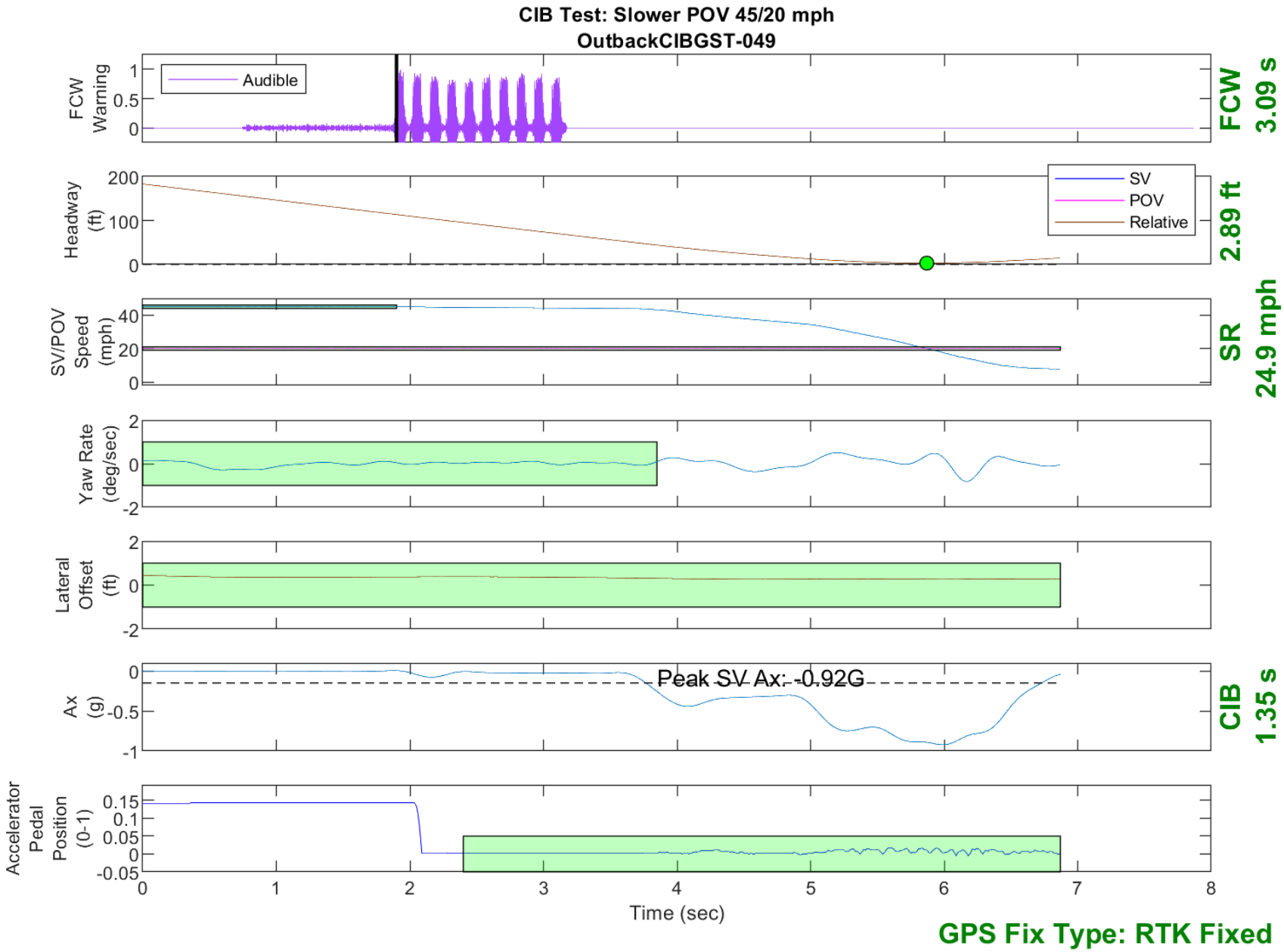


Figure D46. Time History for CIB Run 49, Slower POV, 45/20 mph

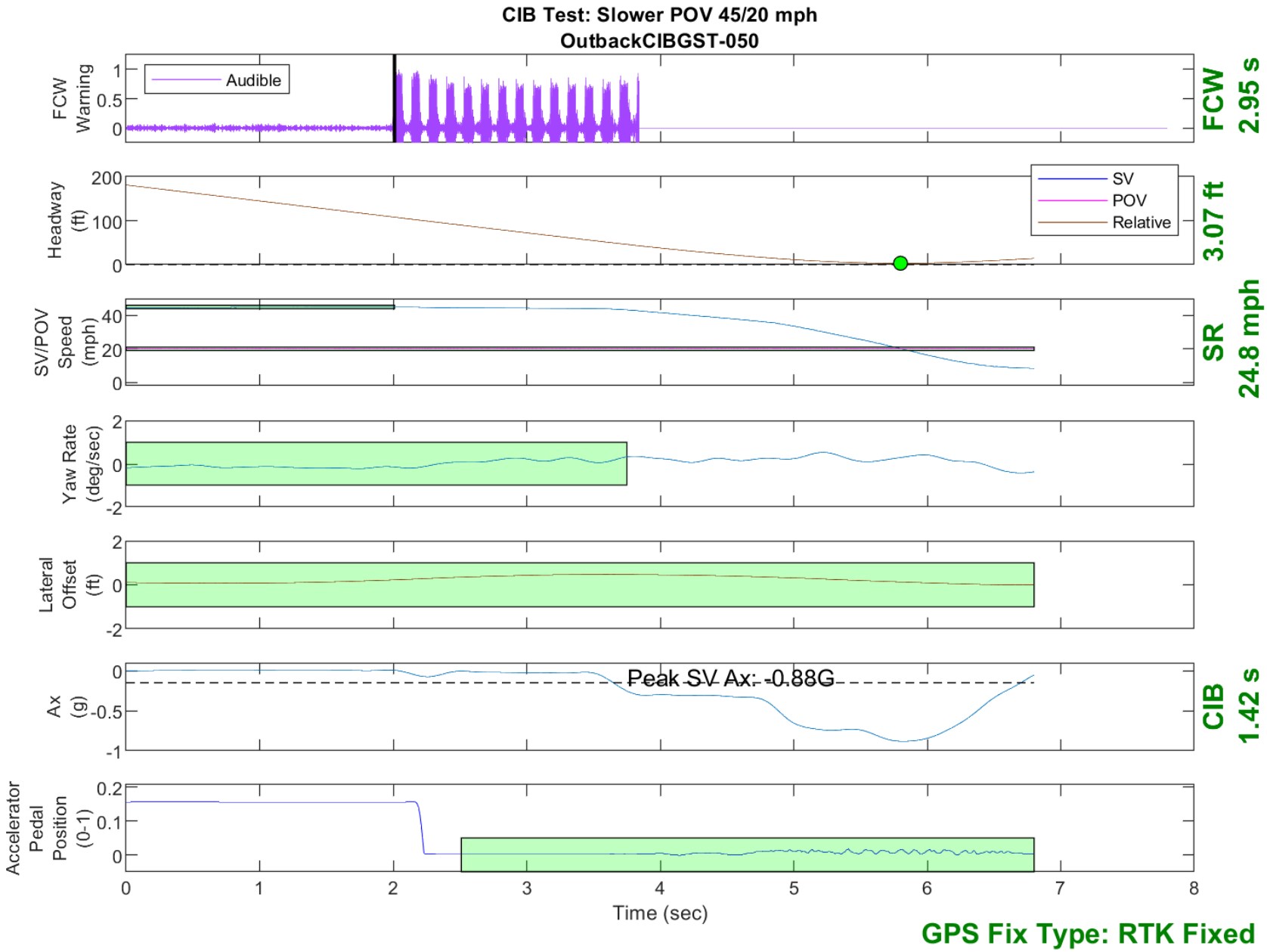


Figure D47. Time History for CIB Run 50, Slower POV, 45/20 mph

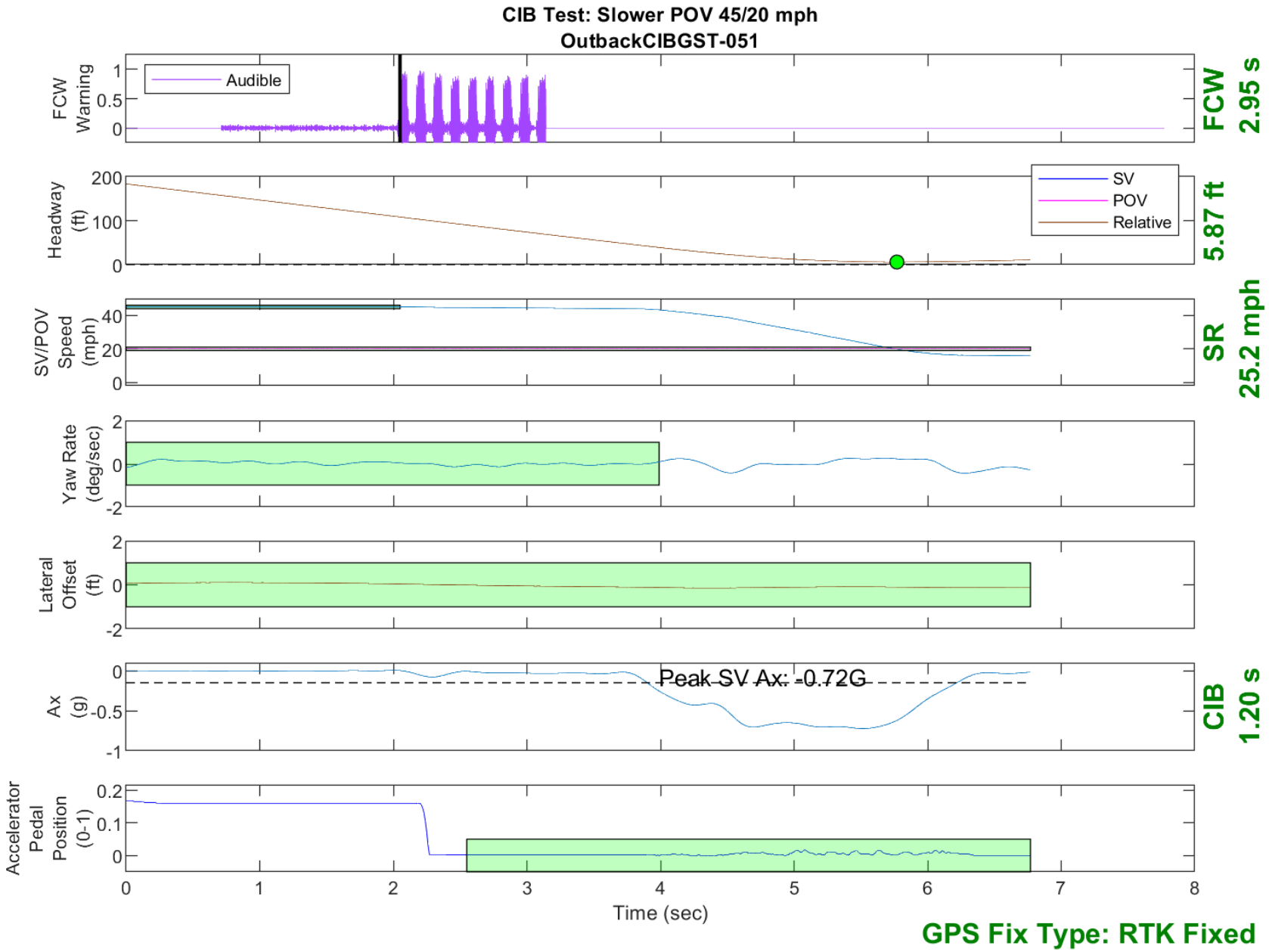


Figure D48. Time History for CIB Run 51, Slower POV, 45/20 mph

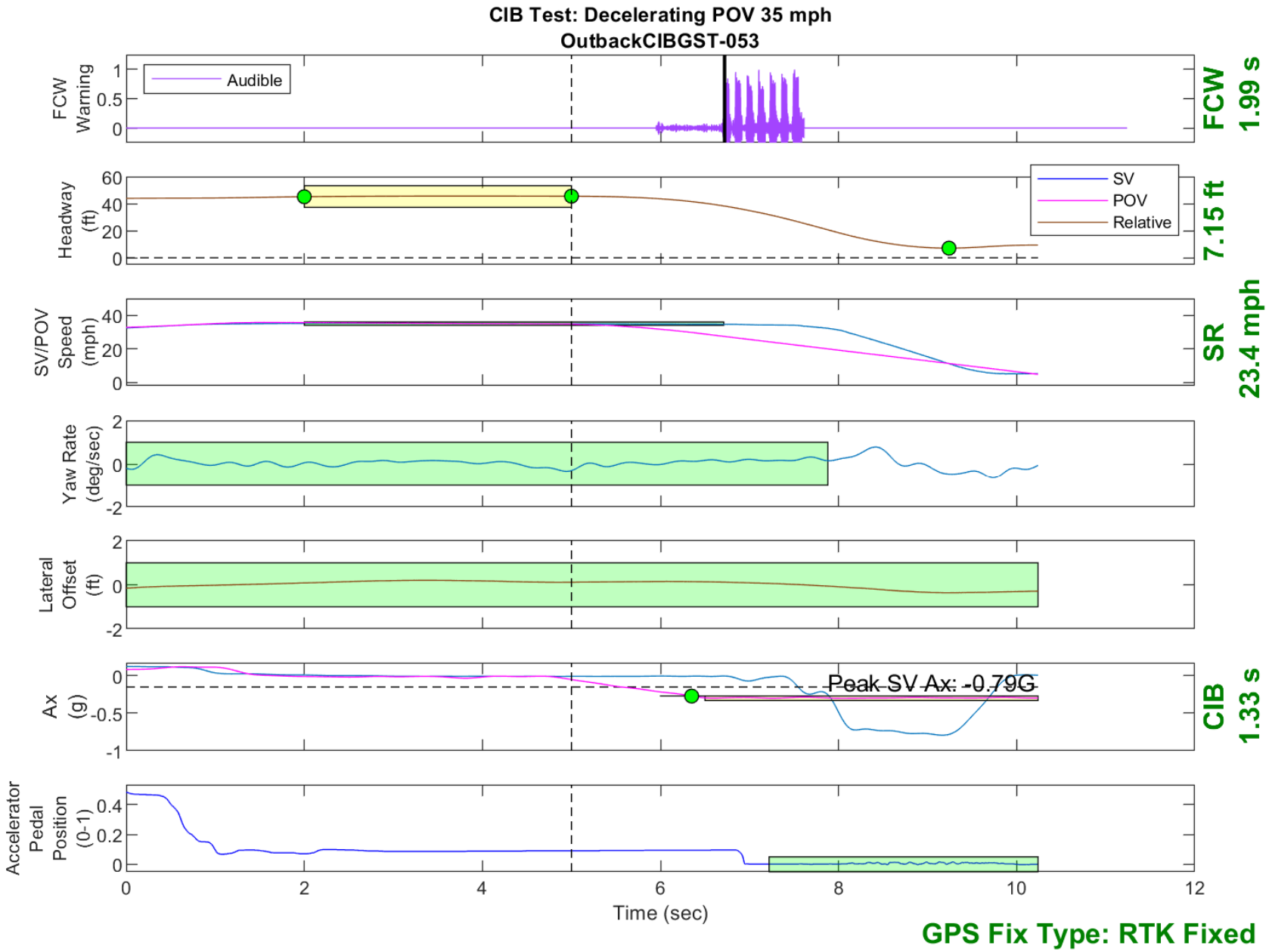


Figure D49. Time History for CIB Run 53, Decelerating POV, 35 mph 0.3g

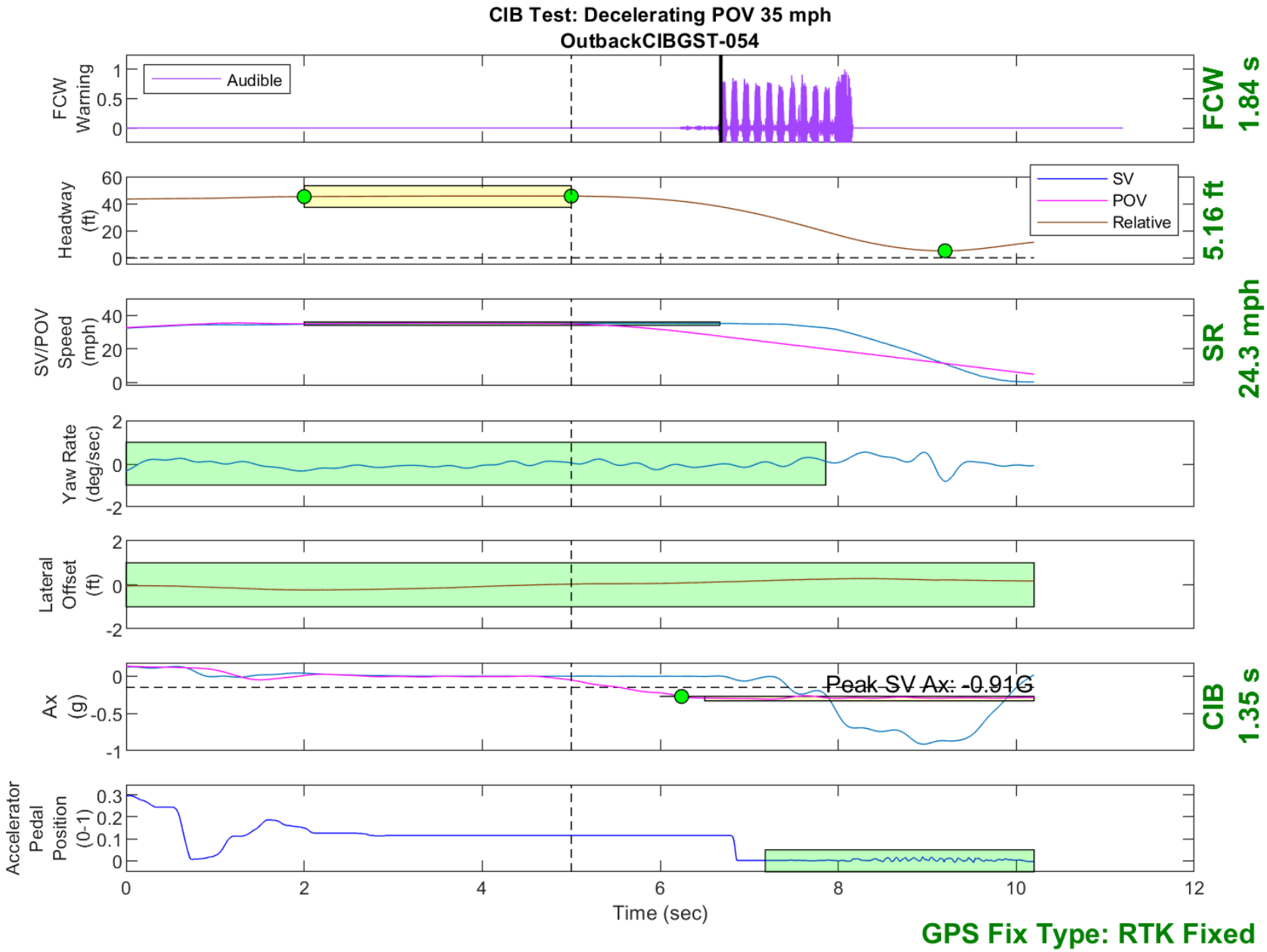


Figure D50. Time History for CIB Run 54, Decelerating POV, 35 mph 0.3g

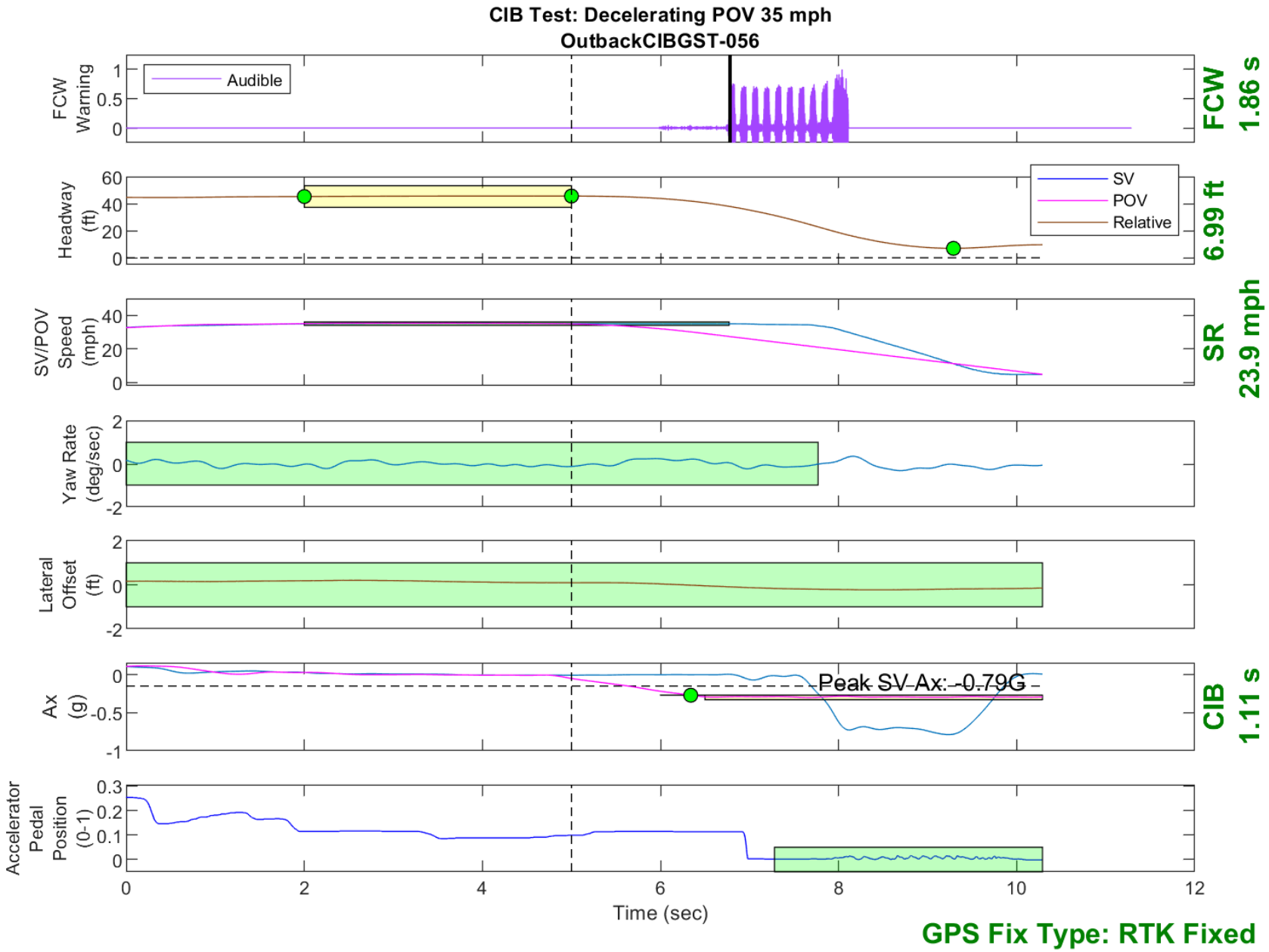


Figure D51. Time History for CIB Run 56, Decelerating POV, 35 mph 0.3g

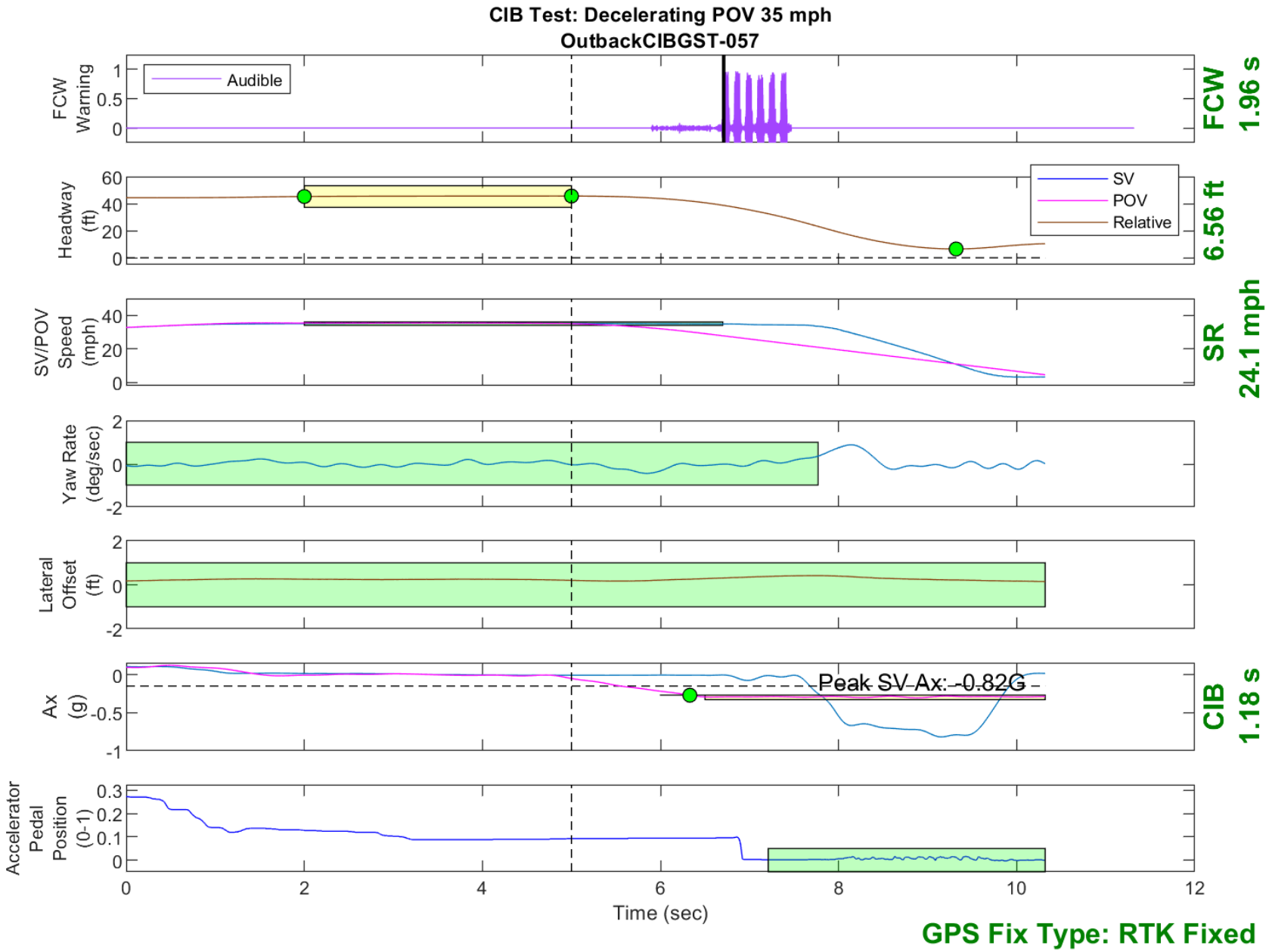


Figure D52. Time History for CIB Run 57, Decelerating POV, 35 mph 0.3g

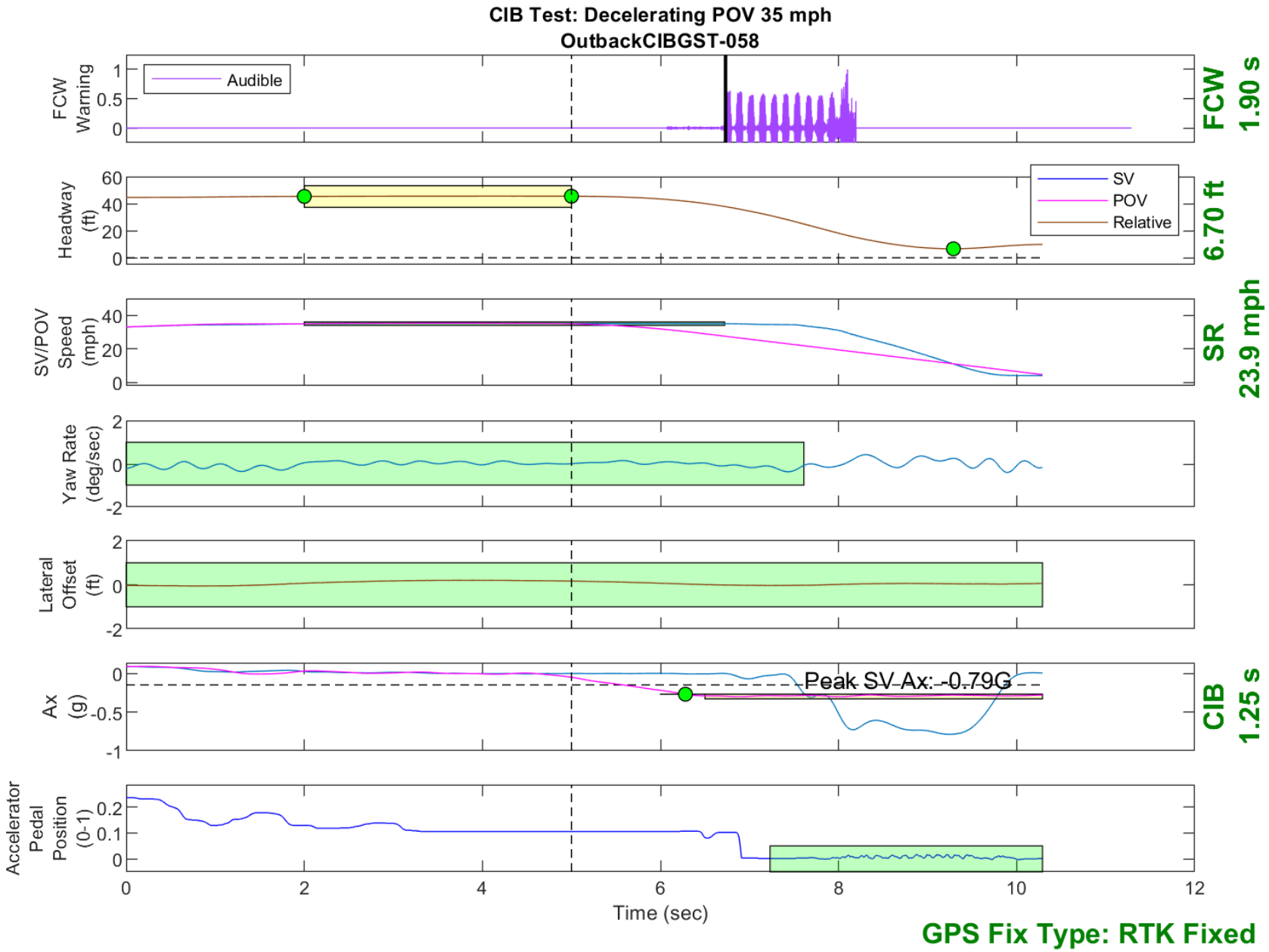


Figure D53. Time History for CIB Run 58, Decelerating POV, 35 mph 0.3g

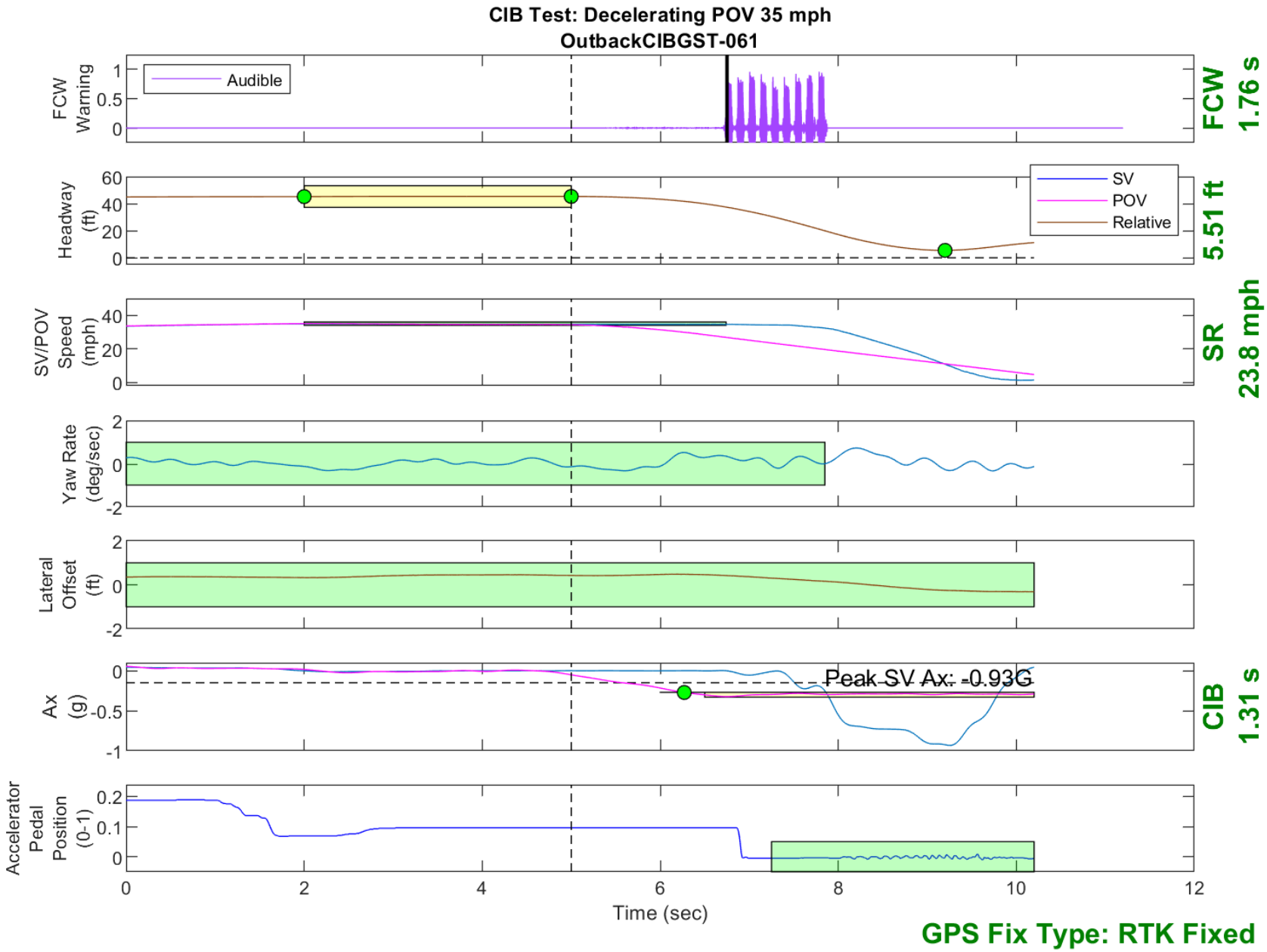


Figure D54. Time History for CIB Run 61, Decelerating POV, 35 mph 0.3g

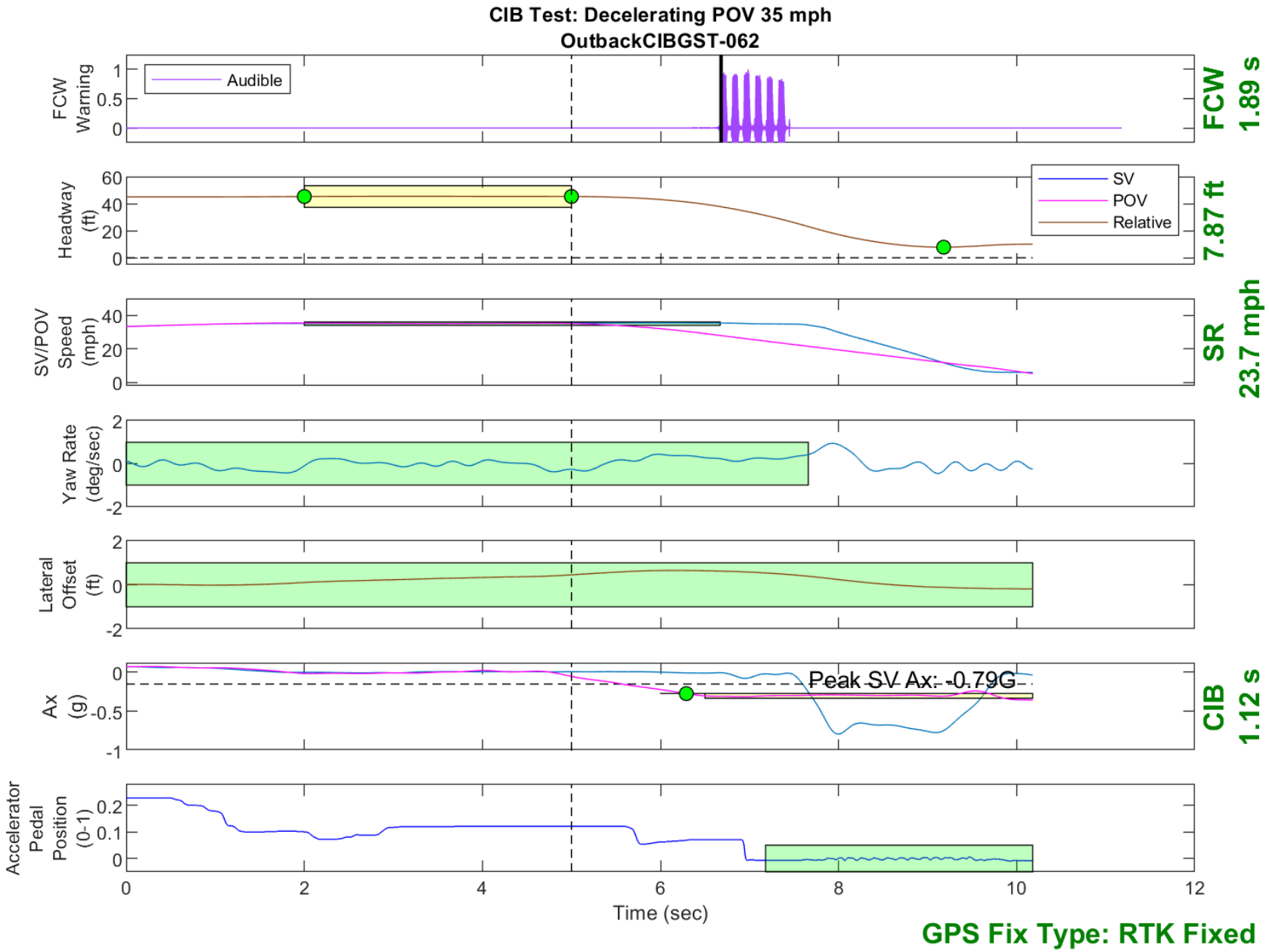


Figure D55. Time History for CIB Run 62, Decelerating POV, 35 mph 0.3g

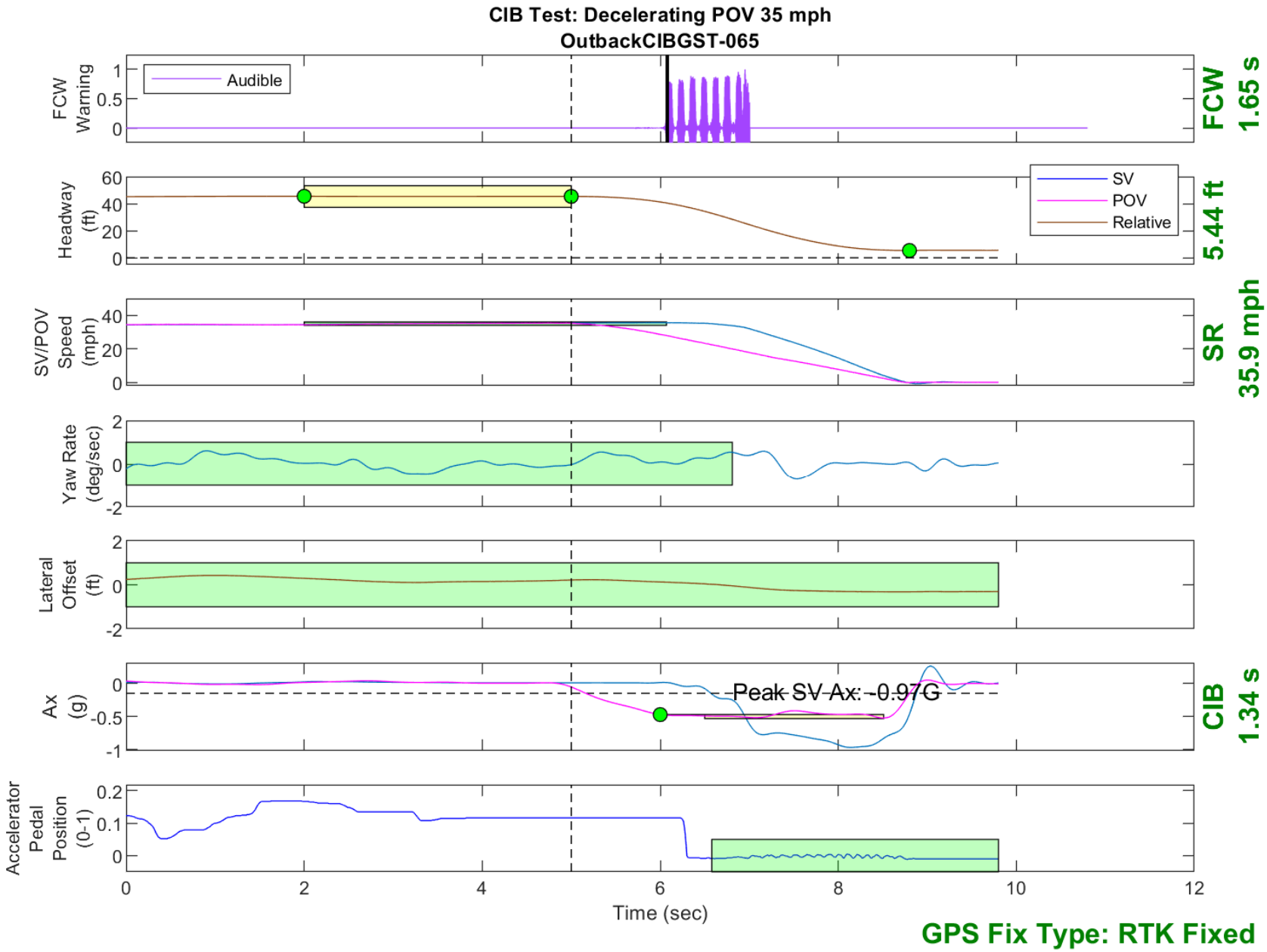


Figure D56. Time History for CIB Run 65, Decelerating POV, 35 mph 0.5g

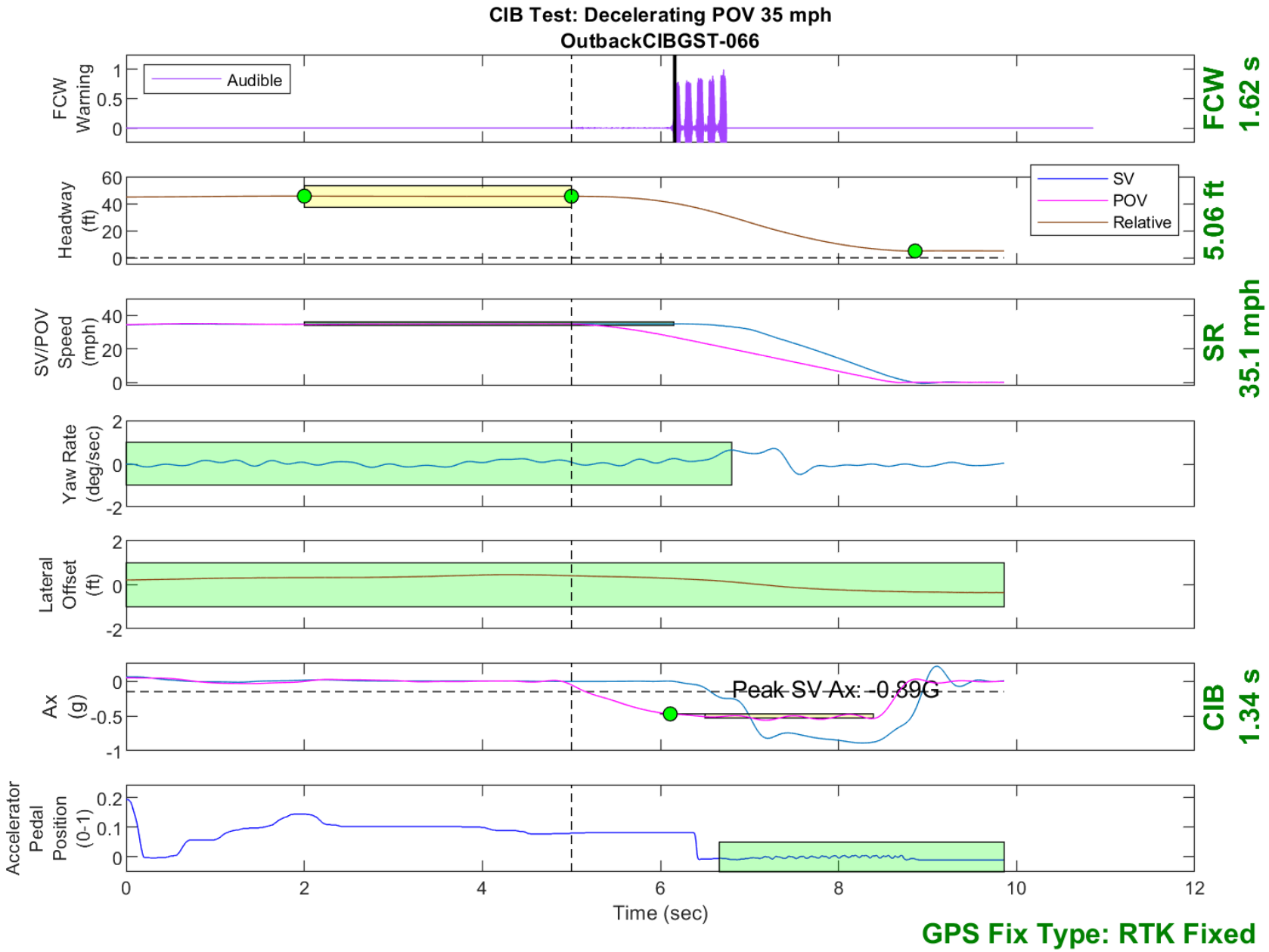


Figure D57. Time History for CIB Run 66, Decelerating POV, 35 mph 0.5g

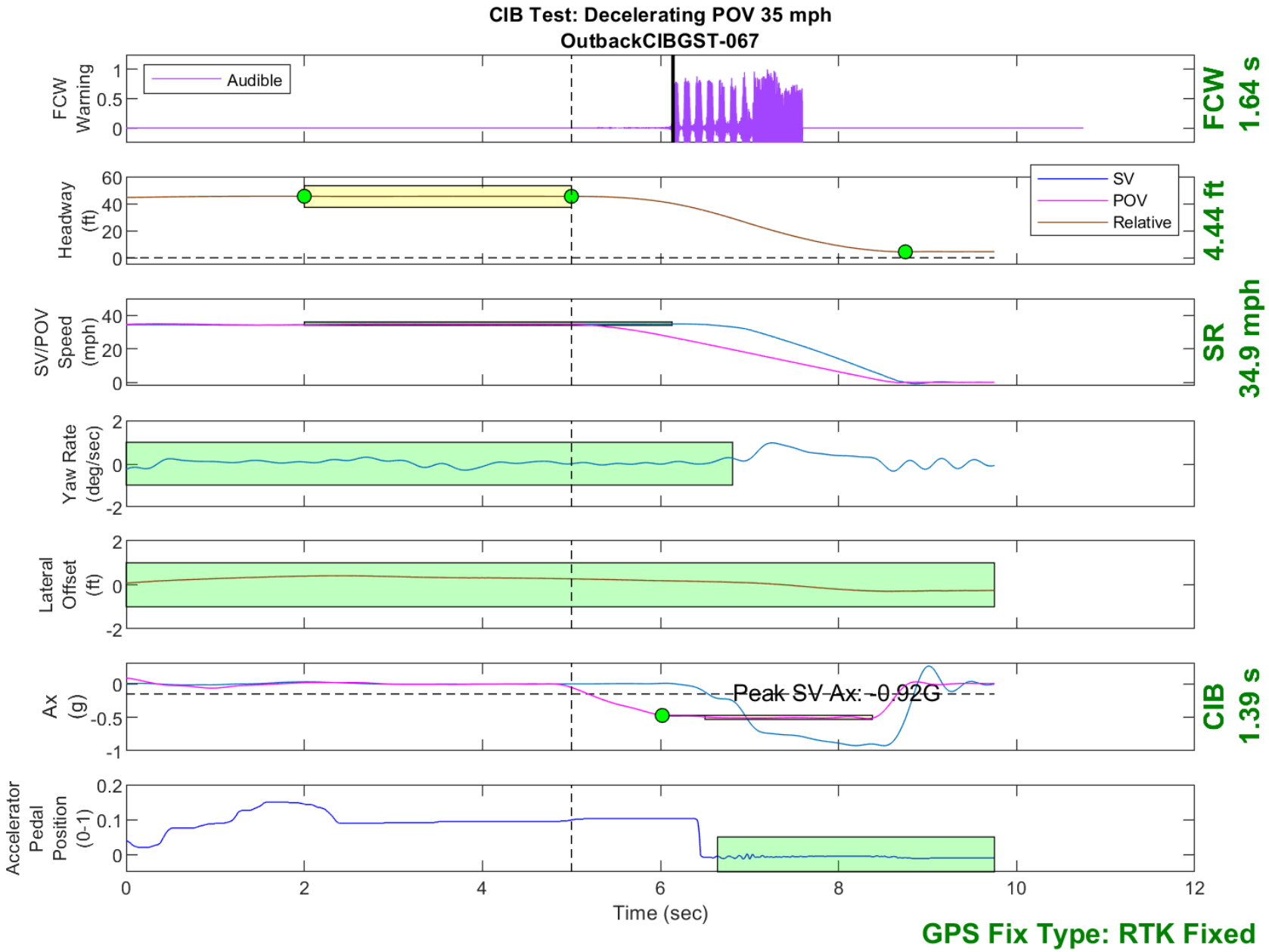


Figure D58. Time History for CIB Run 67, Decelerating POV, 35 mph 0.5g

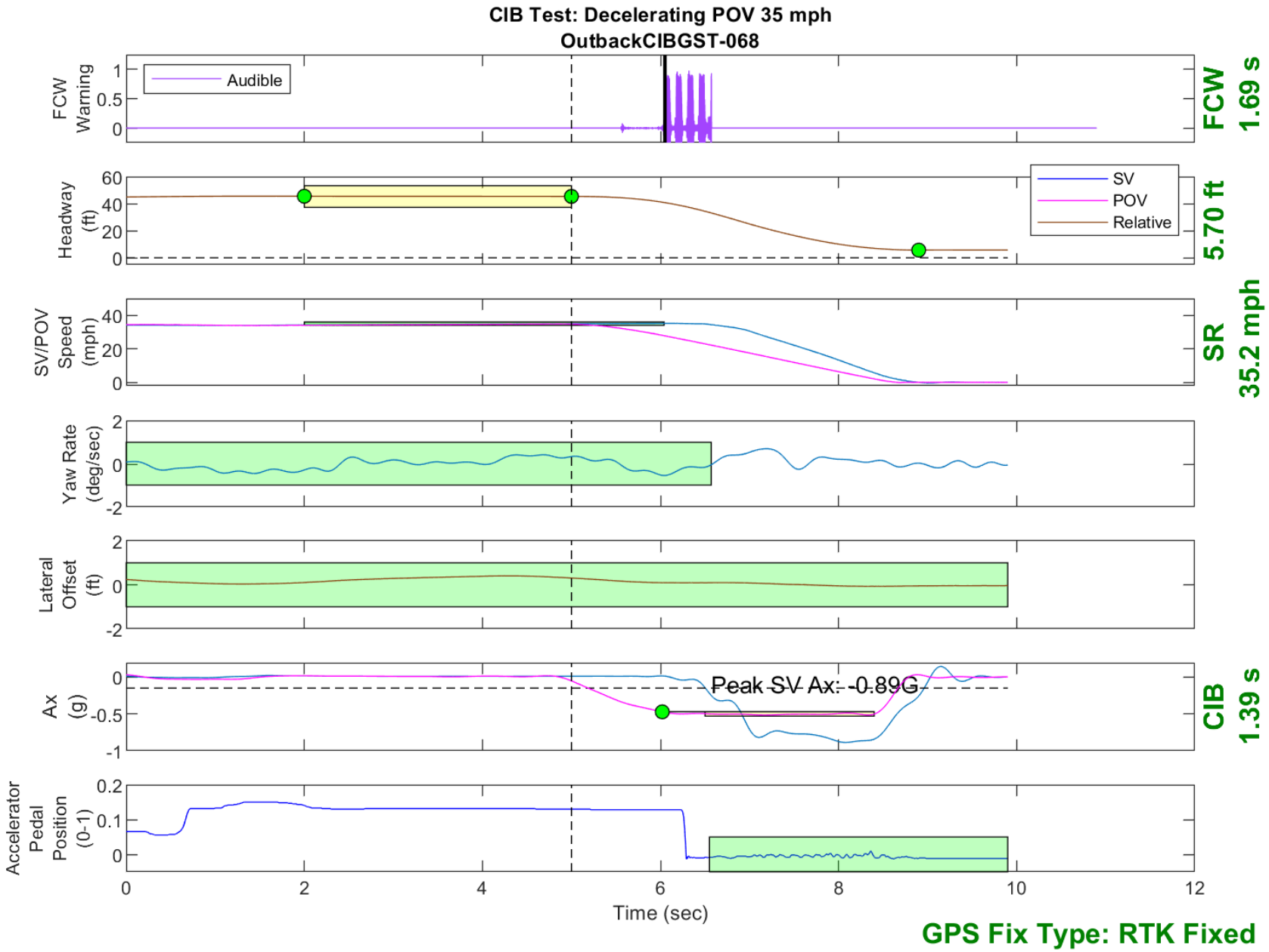


Figure D59. Time History for CIB Run 68, Decelerating POV, 35 mph 0.5g

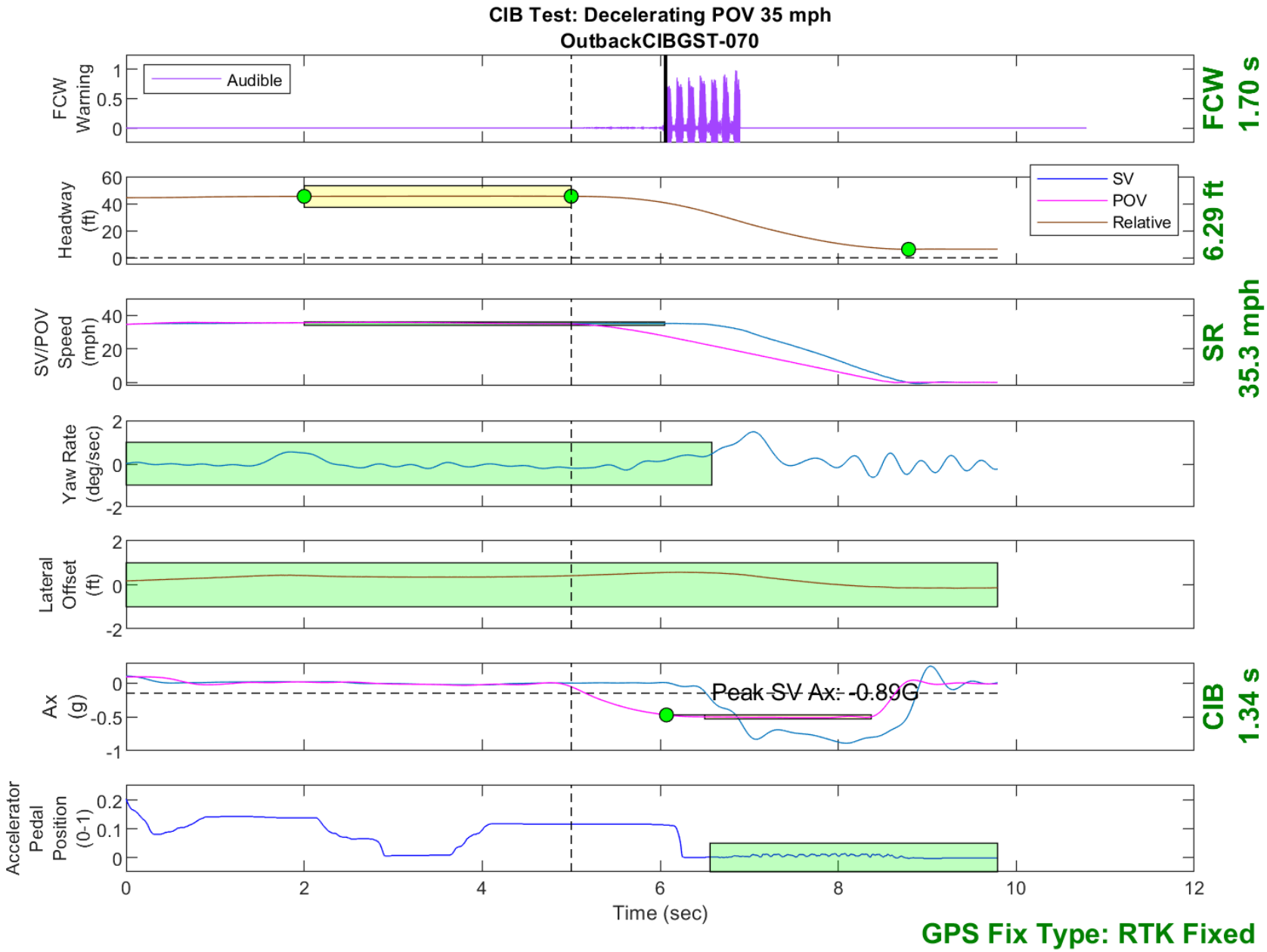


Figure D60. Time History for CIB Run 70, Decelerating POV, 35 mph 0.5g

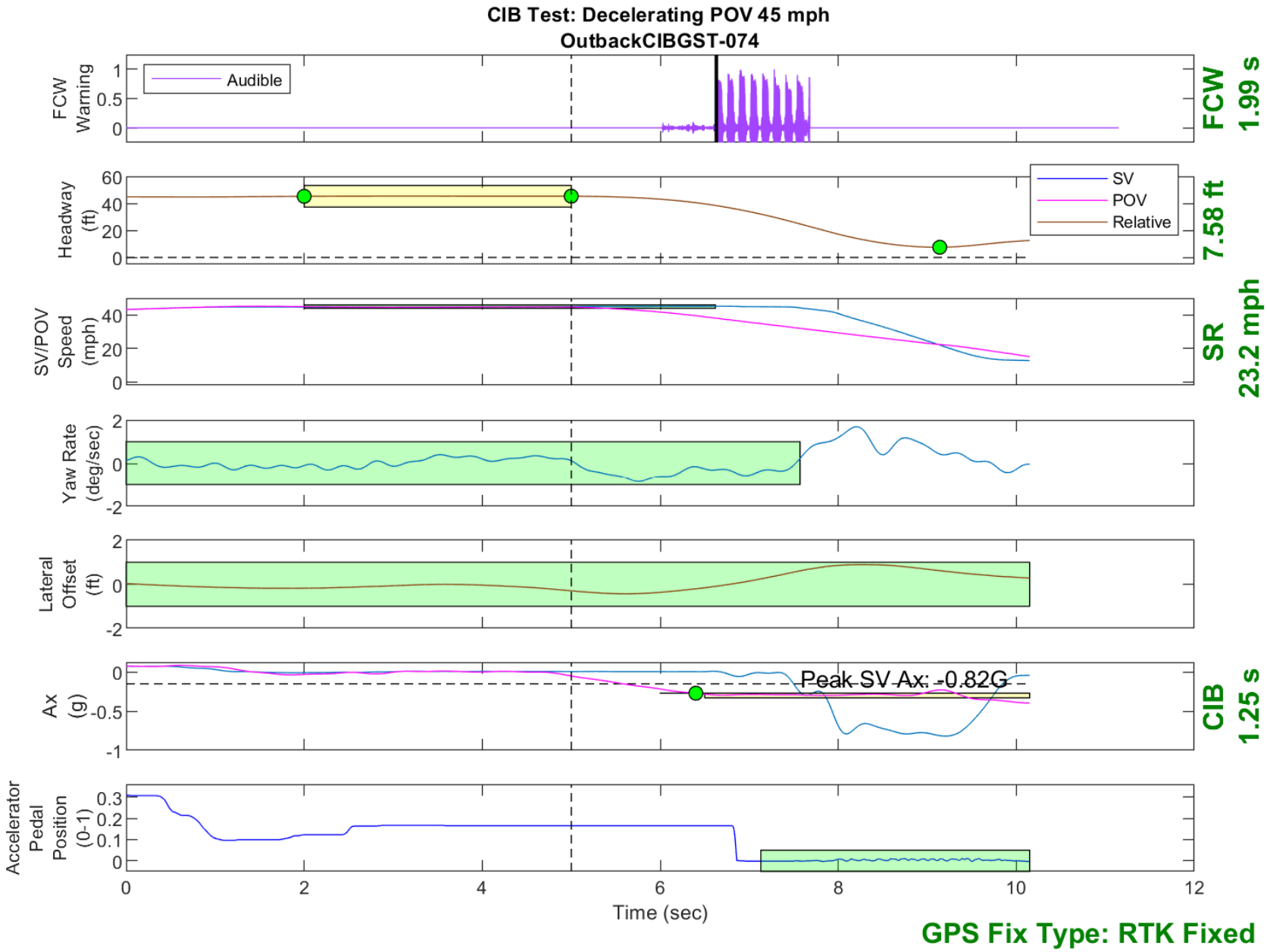


Figure D61. Time History for CIB Run 74, Decelerating POV, 45 mph 0.3g

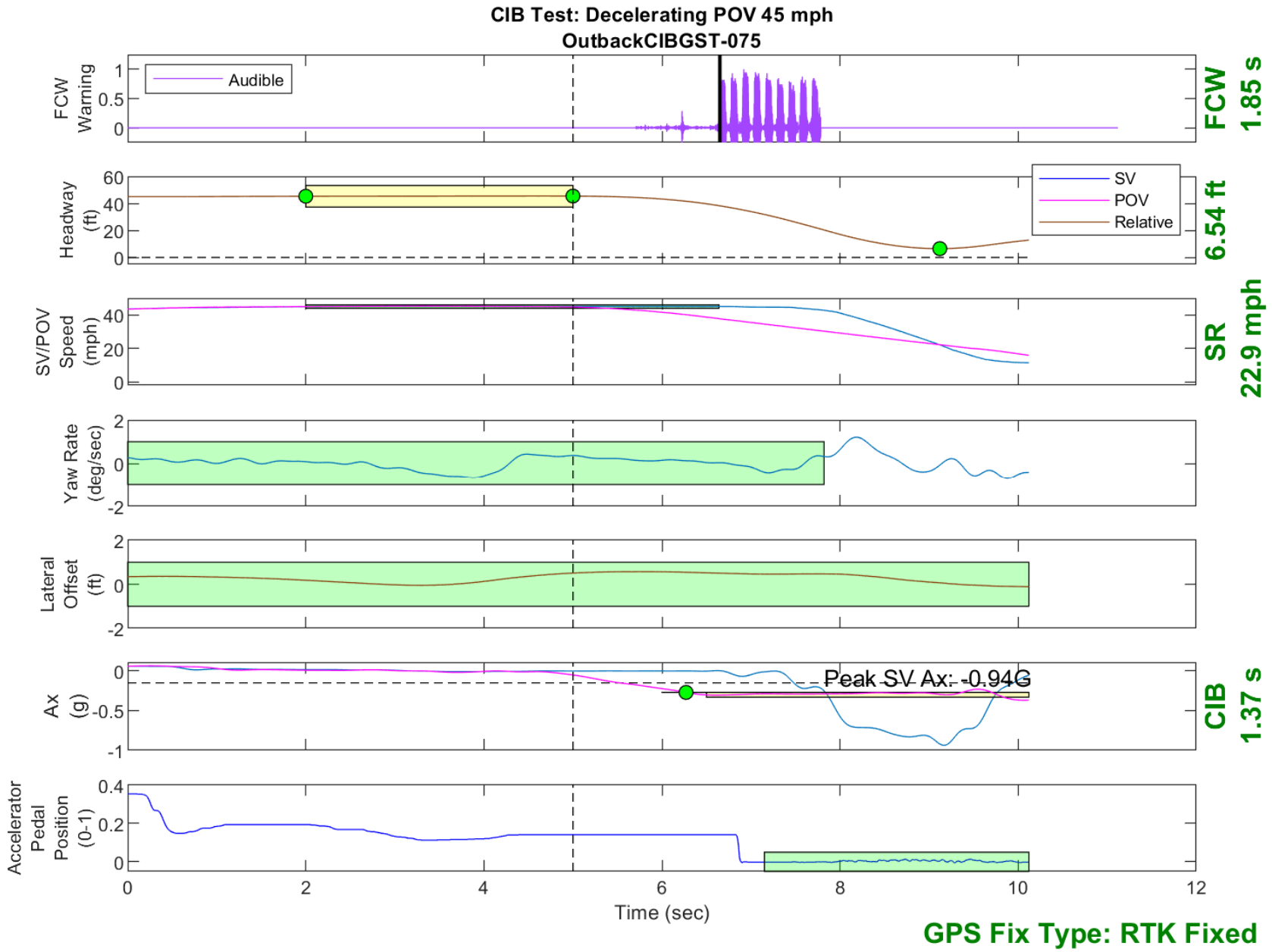


Figure D62. Time History for CIB Run 75, Decelerating POV, 45 mph 0.3g

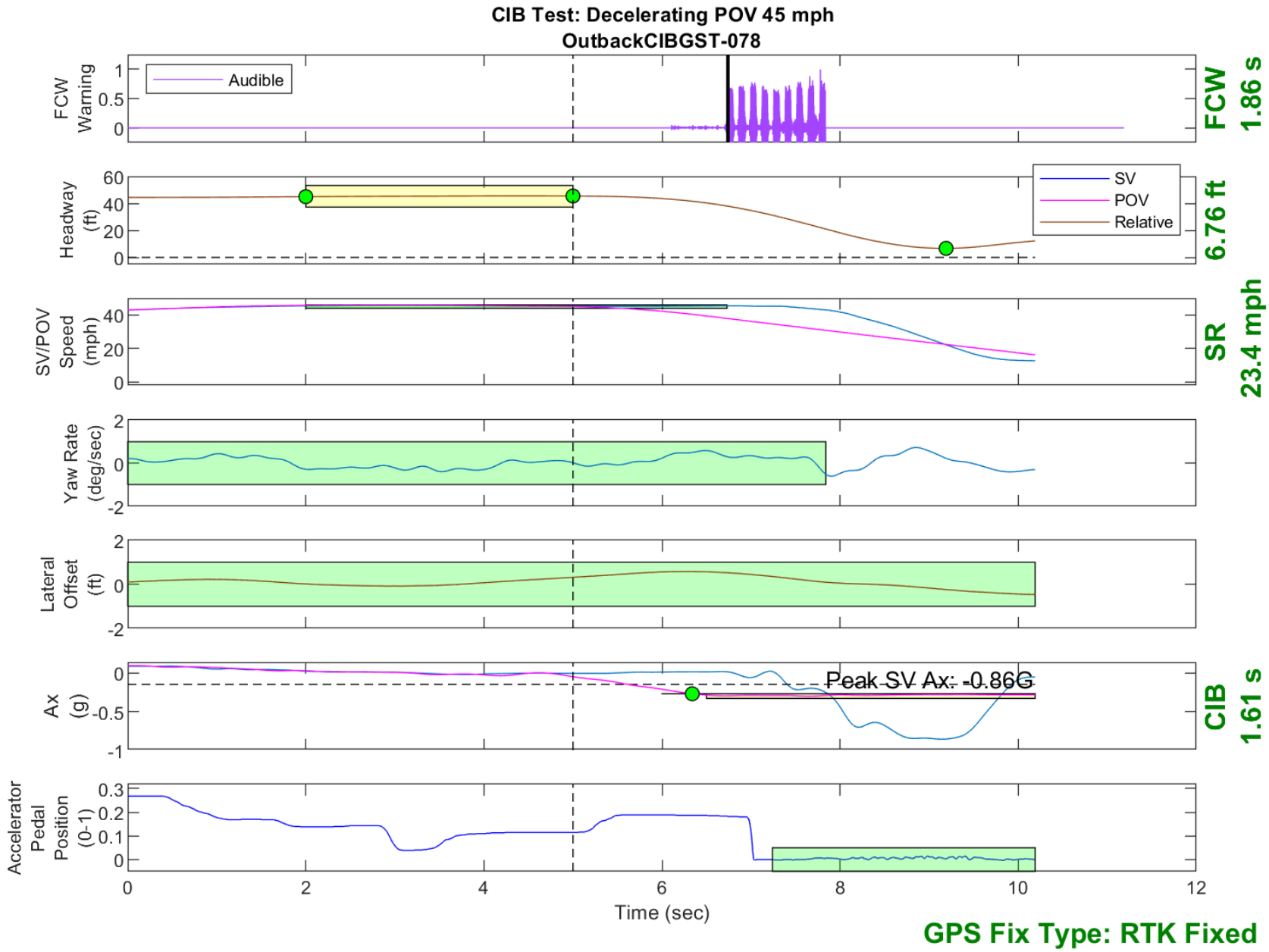


Figure D63. Time History for CIB Run 78, Decelerating POV, 45 mph 0.3g

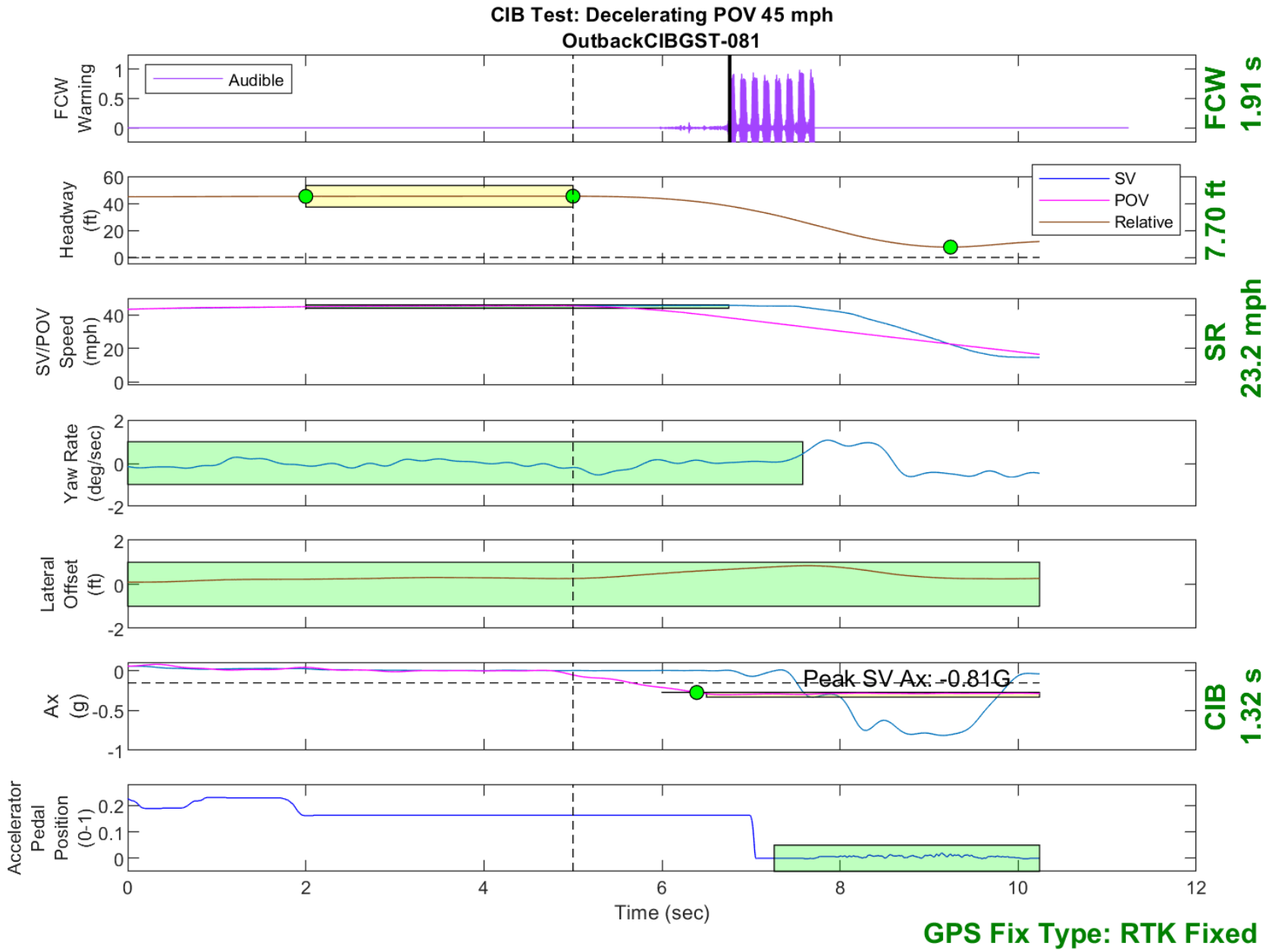


Figure D64. Time History for CIB Run 81, Decelerating POV, 45 mph 0.3g

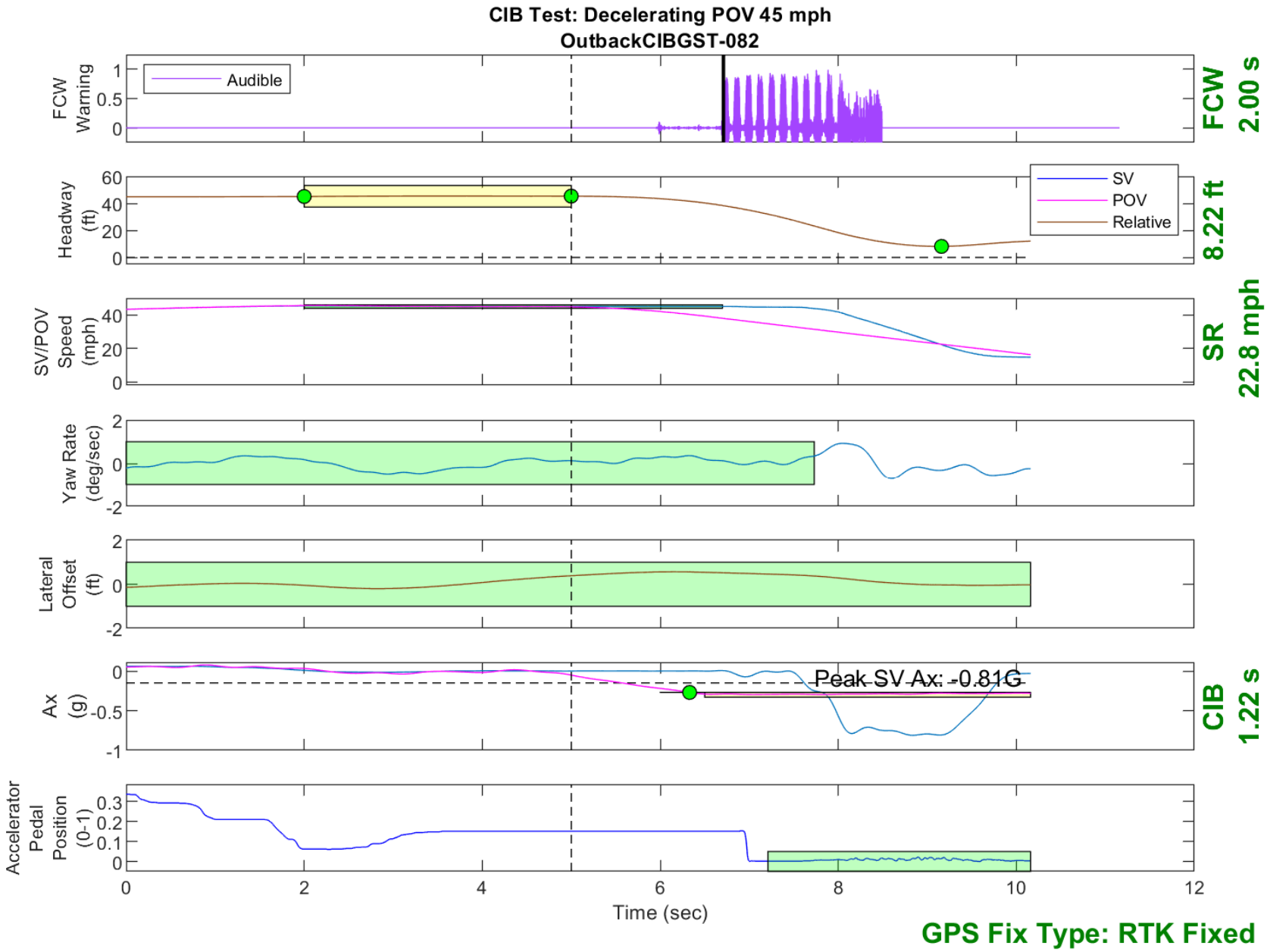


Figure D65. Time History for CIB Run 82, Decelerating POV, 45 mph 0.3g