NEW CAR ASSESSMENT PROGRAM
CRASH IMMINENT BRAKING SYSTEM CONFIRMATION TEST
NCAP-DRI-CIB-21-11

2021 Kia Seltos SX Turbo AWD

DYNAMIC RESEARCH, INC.
355 Van Ness Avenue, STE 200
Torrance, California 90501

18 March 2021

Final Report

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

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

Prepared for the Department of Transportation, National Highway Traffic Safety Administration, under Contract No. DTNH22-14-D-00333.

Prepared By: J. Lenkeit — Program Manager
K. Nagao — Test Engineer

Date: 18 March 2021

1. Report No. NCAP-DRI-CIB-21-11	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Final Report of Crash Imminent Braking System Confirmation Test of a 2021 Kia Seltos SX Turbo AWD.		5. Report Date 18 March 2021	
		6. Performing Organization Code DRI	
7. Author(s) J. Lenkeit, Program Manager K. Nagao, Test Engineer		8. Performing Organization Report No. DRI-TM-20-197	
9. Performing Organization Name and Address Dynamic Research, Inc. 355 Van Ness Ave, STE 200 Torrance, CA 90501		10. Work Unit No.	
		11. Contract or Grant No. DTNH22-14-D-00333	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration New Car Assessment Program 1200 New Jersey Avenue, SE, West Building, 4th Floor (NRM-110) Washington, DC 20590		13. Type of Report and Period Covered Final Test Report February - March 2021	
		14. Sponsoring Agency Code NRM-110	
15. Supplementary Notes			
16. Abstract These tests were conducted on the subject 2021 Kia Seltos SX Turbo AWD in accordance with the specifications of the New Car Assessment program's most current Test Procedure in docket NHTSA-2015-0006-0025; CRASH IMMINENT BRAKE SYSTEM PERFORMANCE EVALUATION FOR THE NEW CAR ASSESSMENT PROGRAM, October 2015. The vehicle passed the requirements of the test for all four CIB test scenarios and all speeds.			
17. Key Words Crash Imminent Braking, CIB, AEB, New Car Assessment Program, NCAP		18. Distribution Statement Copies of this report are available from the following: NHTSA Technical Reference Division National Highway Traffic Safety Administration 1200 New Jersey Avenue, SE Washington, DC 20590	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 141	22. Price

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Section I

INTRODUCTION

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

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

The purpose of the testing reported herein was to objectively quantify the performance of a Crash Imminent Braking system installed on a 2021 Kia Seltos SX Turbo AWD. This test is part of the New Car Assessment Program to assess Crash Imminent Braking Systems sponsored by the National Highway Traffic Safety Administration under Contract No. DTNH22-14-D-00333.

The 2021 Kia Seltos is available with two types of AEB systems. One of these uses a camera-only system, and the other system uses a fusion of a camera and forward-facing radar. The vehicle covered in this report was equipped with the fusion system.

[1] NHTSA-2015-0006-0025; Crash Imminent Brake System Performance Evaluation for the New Car Assessment Program, October 2015.

Section II

DATA SHEETS

CRASH IMMINENT BRAKING

DATA SHEET 1: TEST RESULTS SUMMARY

(Page 1 of 1)

2021 Kia Seltos SX Turbo AWD

VIN: *KNDETCA29M718xxxx*

Test Date: *2/18/2021*

Crash Imminent Braking System setting: *Active Assist - On*

Warning Timing - Normal

Test 1 – **Subject Vehicle Encounters Stopped Principal Other Vehicle**

SV 25 mph: *Pass*

Test 2 – **Subject Vehicle Encounters Slower Principal Other Vehicle**

SV 25 mph POV 10 mph: *Pass*

SV 45 mph POV 20 mph: *Pass*

Test 3 – **Subject Vehicle Encounters Decelerating Principal Other Vehicle**

SV 35 mph POV 35 mph: *Pass*

Test 4 – **Subject Vehicle Encounters Steel Trench Plate**

SV 25 mph: *Pass*

SV 45 mph: *Pass*

Overall: *Pass*

Notes:

CRASH IMMINENT BRAKING

DATA SHEET 2: VEHICLE DATA

(Page 1 of 1)

2021 Kia Seltos SX Turbo AWD

TEST VEHICLE INFORMATION

VIN: *KNDETCA29M718xxxx*

Body Style: *SUV* Color: *Cherry Black*

Date Received: *2/8/2021* Odometer Reading: *11 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *KIA MOTORS CORPORATION*

Date of manufacture: *12/20*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *235/45R18*

Rear: *235/45R18*

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

Rear: *230 kPa (33 psi)*

TIRES

Tire manufacturer and model: *Kumho Majesty 9 Solus TA91*

Front tire designation: *235/45R18 94V*

Rear tire designation: *235/45R18 94V*

Front tire DOT prefix: *1Y0 KRYAJ9*

Rear tire DOT prefix: *1Y0 KRYAJ9*

CRASH IMMINENT BRAKING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2021 Kia Seltos SX Turbo AWD

GENERAL INFORMATION

Test date: *2/18/2021*

AMBIENT CONDITIONS

Air temperature: *18.9 C (66 F)*

Wind speed: *0.0 m/s (0.0 mph)*

X Windspeed ≤ 10 m/s (22 mph)

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

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

VEHICLE PREPARATION

Verify the following:

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

Fuel tank is full: **X**

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

Front: *230 kPa (33 psi)*

Rear: *230 kPa (33 psi)*

CRASH IMMINENT BRAKING

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2021 Kia Seltos SX Turbo AWD

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*481.3 kg (1061 lb)*	Right Front:	*460.8 kg (1016 lb)*
Left Rear:	*347.5 kg (766 lb)*	Right Rear:	*324.3 kg (715 lb)*
		Total:	*1613.9 kg (3558 lb)*

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

(Page 1 of 3)

2021 Kia Seltos SX Turbo AWD

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

FCA (Forward Collision-Avoidance Assist-Pedestrian). This is available as standard equipment on the SX Turbo trim. In order to have the sensor fusion, the vehicle must also be equipped with 'Smart Cruise Control w/ Stop & Go', which is included on this trim.

Type and location of sensors the system uses:

Sensor fusion (Front camera, front radar). The front camera is located in the top center of the windshield and the front radar is located in the center of the front bumper.

System setting used for test (if applicable):

Active Assist - On

Warning Timing - Normal

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

10 km/h (6 mph) (Per manufacturer supplied information)

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

Forward vehicle: 76 km/h (47 mph)

Pedestrians and cyclists: 64 km/h (40 mph) (Per manufacturer supplied information)

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

X No

If yes, please provide a full description.

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

X No

If yes, please provide a full description.

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

(Page 2 of 3)

2021 Kia Seltos SX Turbo AWD

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 is presented in the instrument panel. It shows a picture of the rear end of a leading vehicle, the words "Collision Warning", and a picture of an exclamation point within a triangle. See Appendix A, Figure A17.

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.

The system can be disabled using the system menus, accessed by a setup button located at the bottom of the center display. See Appendix A, Figure A16. The menu hierarchy is:

Setup

Vehicle Settings

Driver Assistance

Forward Safety

Select from: Active Assist, Warning Only, or Off

See Appendix A, Figures A14 and A15.

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

(Page 3 of 3)

2021 Kia Seltos SX Turbo AWD

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

X Yes

____ No

If yes, please provide a full description.

The timing can be adjusted using the system menus, accessed by a setup button located at the bottom of the center display. See Appendix A, Figure A16. The menu hierarchy is:

Setup

Vehicle Settings

Driver Assistance

Warning Timing

Select Normal or Late

See Appendix A, Figures A14 and A15.

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

X Yes

____ No

If yes, please provide a full description.

System limitations are described in the Owner's Manual on pages 5-94 through 5-101, shown in Appendix B, pages B-26 through B-33

Notes:

The 2021 Kia Seltos is available with two types of AEB systems. One of these uses a camera-only system, and the other system uses a fusion of a camera and forward-facing radar. The vehicle covered in this report was equipped with the fusion system.

Section III

TEST PROCEDURES

A. Test Procedure Overview

Four test scenarios were used, as follows:

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

Test 2. Subject Vehicle Encounters Slower Principal Other Vehicle

Test 3. Subject Vehicle Encounters Decelerating Principal Other Vehicle

Test 4. Subject Vehicle Encounters Steel Trench Plate

An overview of each of the test procedures follows.

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

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

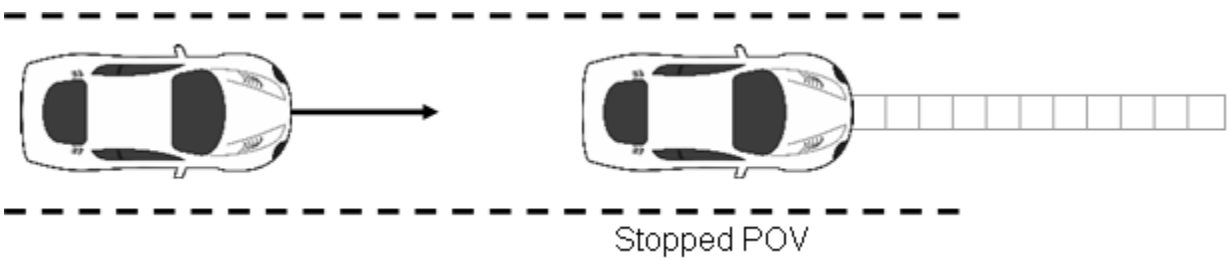


Figure 1. Depiction of Test 1

a. Procedure

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

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

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

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

- The SV speed could not deviate from the nominal speed by more than 1.0 mph (1.6 km/h) during an interval defined by a Time to Collision (TTC) = 5.1 seconds to t_{FCW}. For this test, TTC = 5.1 seconds is taken to occur at an SV-to-POV distance of 187 ft (57 m).

b. Criteria

In order to pass the test, the magnitude of the SV speed reduction attributable to CIB intervention must have been ≥ 9.8 mph (15.8 km/h) for at least five of seven valid test trials.

The magnitude of the SV speed reduction attributable to CIB intervention was calculated in one of two ways, depending on whether a test trial concluded with the SV colliding with the POV.

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

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

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

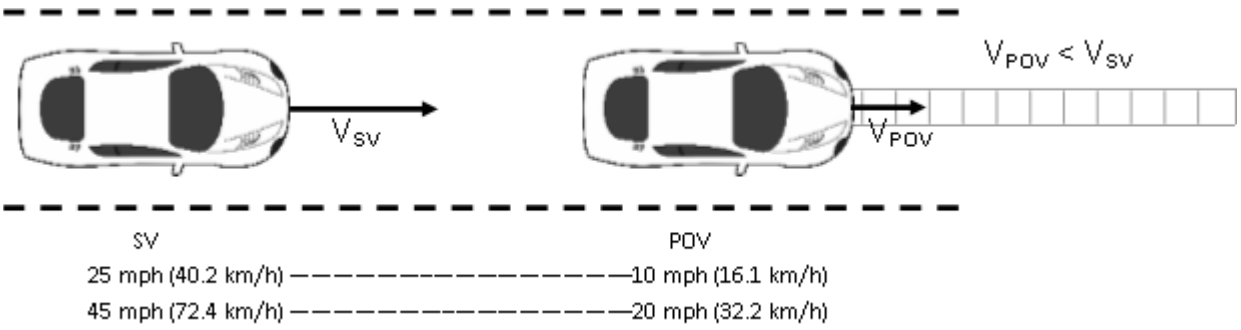


Figure 2. Depiction of Test 2

a. Procedure

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

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

The SV driver then braked to a stop.

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

- The lateral distance between the centerline of the POV and the center of the travel lane could not deviate more than ±1 ft (0.3 m) during the validity period.
- The lateral distance between the centerline of the SV and the center of the travel lane could not deviate more than ±1 ft (0.3 m) during the validity period.
- The SV speed could not deviate more than ±1.0 mph (±1.6 km/h) during an interval defined by TTC = 5.0 seconds to t_{FCW}.
- The POV speed could not deviate more than ±1.0 mph (±1.6 km/h) during the validity period.

b. Criteria

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

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

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

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

3. TEST 3 – SUBJECT VEHICLE ENCOUNTERS DECELERATING PRINCIPAL OTHER VEHICLE

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

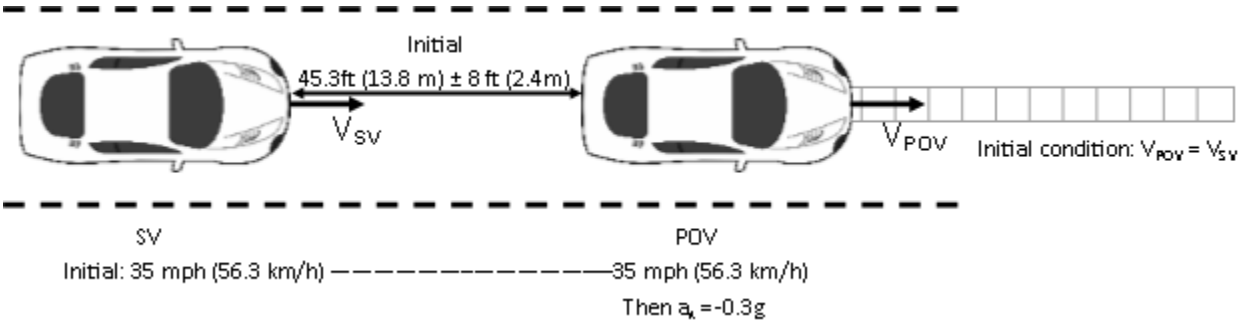


Figure 3. Depiction of Test 3

a. Procedure

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

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

The SV driver then braked to a stop.

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

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

- The headway between the SV and POV must have been constant from the onset of the applicable validity period to the onset of POV braking.
- The SV and POV speed could not deviate more than ±1.0 mph (1.6 km/h) during an interval defined by the onset of the validity period to the onset of POV braking.
- The SV- POV headway distance could not deviate more than ±8 ft (2.4 m) during an interval defined by the onset of the validity period to the onset of POV braking.
- The average POV deceleration could not deviate by more than ±0.03 g from the nominal 0.3 g deceleration during the interval beginning at 1.5 seconds after the onset of POV braking and ending either 250 ms prior to the POV coming to a stop or the SV coming into contact with the POV.

b. Criteria

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

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

4. TEST 4 – FALSE POSITIVE SUPPRESSION

The false positive suppression test series evaluates the ability of a CIB system to differentiate a steel trench plate (STP) from an object presenting a genuine safety risk to the SV. Although the STP is large and metallic, it is designed to be driven over without risk of injury to the driver or damage to the SV. Therefore, in this scenario, the automatic braking available from CIB is not necessary and should be suppressed. The test condition is nearly equivalent to that previously defined for Test 1, the stopped POV condition, but with an STP in the SV forward path in lieu of a POV.

a. Procedure

This test was conducted at two speeds, 25 mph (40.2 km/h) and 45 mph (72.4 km/h). The SV was driven directly towards, and over, the STP, which was positioned in the center of a travel lane, with its longest sides parallel to the road edge.

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

- The SV speed could not deviate from the nominal speed by more than 1.0 mph (1.6 km/h) during an interval defined by a Time to Collision (TTC) = 5.1 seconds to t_{FCW} where:
    - For SV test speed of 25 mph, TTC = 5.1 seconds is taken to occur at an SV-to-STP distance of 187 ft (57 m).
    - For SV test speed of 45 mph, TTC = 5.1 seconds is taken to occur at an SV-to-STP distance of 337 ft (106 m).
- If the SV did not present an FCW alert before the end of the validity period, SV speed could not deviate more than ±1.0 mph (±1.6 km/h) from TTC = 5.1 s to the end of the validity period.

If an FCW alert was presented, the driver released the throttle pedal within 500 ms of the alert. If no alert was presented, the driver did not release the throttle pedal until the end of the validity period. The SV driver then braked to a stop.

b. Criteria

In order to pass the False Positive test series, the magnitude of the SV deceleration reduction attributable to CIB intervention must have been ≤ 0.50 g for at least five of seven valid test trials.

B. General Information

1. T_{FCW}

The time at which the Forward Collision Warning (FCW) activation flag indicates that the system has issued an alert to the SV driver is designated as t_{FCW}. FCW alerts are typically either visual, haptic or audible, and the onset of the alert was determined by post-processing the test data.

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

Table 1. Audible and Tactile Warning Filter Parameters

Warning Type	Filter Order	Peak-to-Peak Ripple	Minimum Stop Band Attenuation	Passband Frequency Range
Audible	5th	3 dB	60 dB	Identified Center Frequency ± 5%
Tactile	5th	3 dB	60 dB	Identified Center Frequency ± 20%

2. GENERAL VALIDITY CRITERIA

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

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

3. VALIDITY PERIOD

The valid test interval began:

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

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

Test 3: 3 seconds before the onset of POV braking

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

The valid test interval ended:

Test 1: When either of the following occurred:

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

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

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

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

4. STATIC INSTRUMENTATION CALIBRATION

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

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

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

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

If the zero position reported by the data acquisition system was found to differ by more than ±2 in (±5 cm) from that measured during collection of the pre-test static calibration data file, the pre-test longitudinal offset was adjusted to output zero and another pre-test static calibration data file was collected. If the zero position reported by the data acquisition system was found to differ by more than ±2 in (±5 cm) from that measured during collection of the post-test static calibration data file, the test trials performed between collection of that post-test static calibration data file and the last valid pre-test static calibration data file were repeated.

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

5. NUMBER OF TRIALS

A target total of seven (7) valid trials were performed for each scenario. In cases where the test driver performed more than seven trials, the first seven trials satisfying all test tolerances were used to assess the SV performance.

6. TRANSMISSION

All trials were performed with SV automatic transmissions in ‘‘Drive’’ or with manual transmissions in the highest gear capable of sustaining the desired test speed. Manual transmission clutches remained engaged during all maneuvers. The brake lights of the POV were not illuminated.

C. Principal Other Vehicle

CIB testing requires a POV that realistically represents typical vehicles, does not suffer damage or cause damage to a test vehicle in the event of collision, and can be accurately positioned and moved during the tests. The tests reported herein made use of the NHTSA developed Strikeable Surrogate Vehicle (SSV).

This SSV system was designed specifically for common rear-end crash scenarios which AEB systems address. The key components of the SSV system are:

- A POV shell which is a visually and dimensionally accurate representation of a passenger car.
- A slider and load frame assembly to which the shell is attached.
- A two-rail track on which the slider operates.
- A road-based lateral restraint track.
- A tow vehicle.

The key requirements of the POV element are to:

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

The key requirements of the POV delivery system are to:

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

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

D. Automatic Braking System

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

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

In some cases, the SV is also equipped with an automatic braking system (E-brake) for the purpose of slowing the SV before impact with the SSV in cases where the SV is

likely to fail a test. The system fires when TTC is below 0.7 sec. It is typically enabled when an SV has already impacted the SSV one or two times.

E. Instrumentation

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

Table 2. Test Instrumentation and Equipment

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi	< 1% error between 20 and 100 psi	Omega DPG8001	18111410000	By: DRI Date: 5/4/2020 Due: 5/4/2021
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 4/20/2020 Due: 4/20/2021
Linear (string) encoder	Throttle pedal travel	10 in	0.1 in	UniMeasure LX-EP	50060726	By: DRI Date: 6/19/2020 Due: 6/19/2021
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	N/A
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rate ±100 deg/s, Angle >45 deg, Velocity >200 km/h	Accels .01g, Angular Rate 0.05 deg/s, Angle 0.05 deg, Velocity 0.1 km/h	Oxford Inertial +		By: Oxford Technical Solutions
					2258	Date: 5/3/2019 Due: 5/3/2021
					2182	Date: 9/16/2019 Due: 9/16/2021

Table 2. Test Instrumentation and Equipment (continued)

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Real-Time Calculation of Position and Velocity Relative to Lane Markings (LDW) and POV (FCW)	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec Longitudinal Range to POV: ±200 m Longitudinal Range Rate: ±50 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec Longitudinal Range: ±3 cm Longitudinal Range Rate: ±0.02 m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	N/A
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	N/A	N/A
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	N/A	N/A
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	N/A	N/A
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2021 Due: 1/6/2022

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

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

Figure A3. Window Sticker (Monroney Label)

Figure A4. Vehicle Certification Label

Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

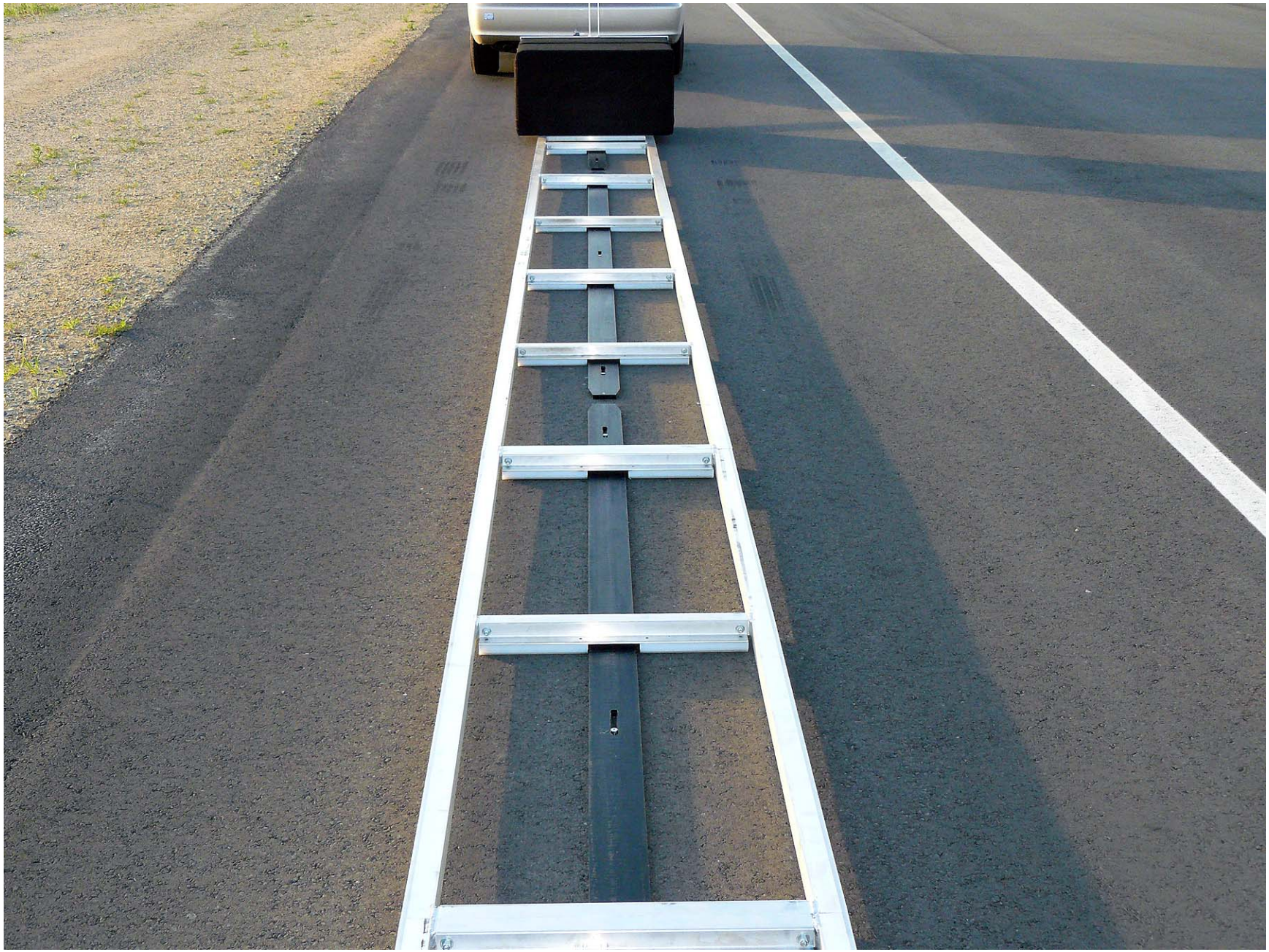


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

Figure A9. Steel Trench Plate

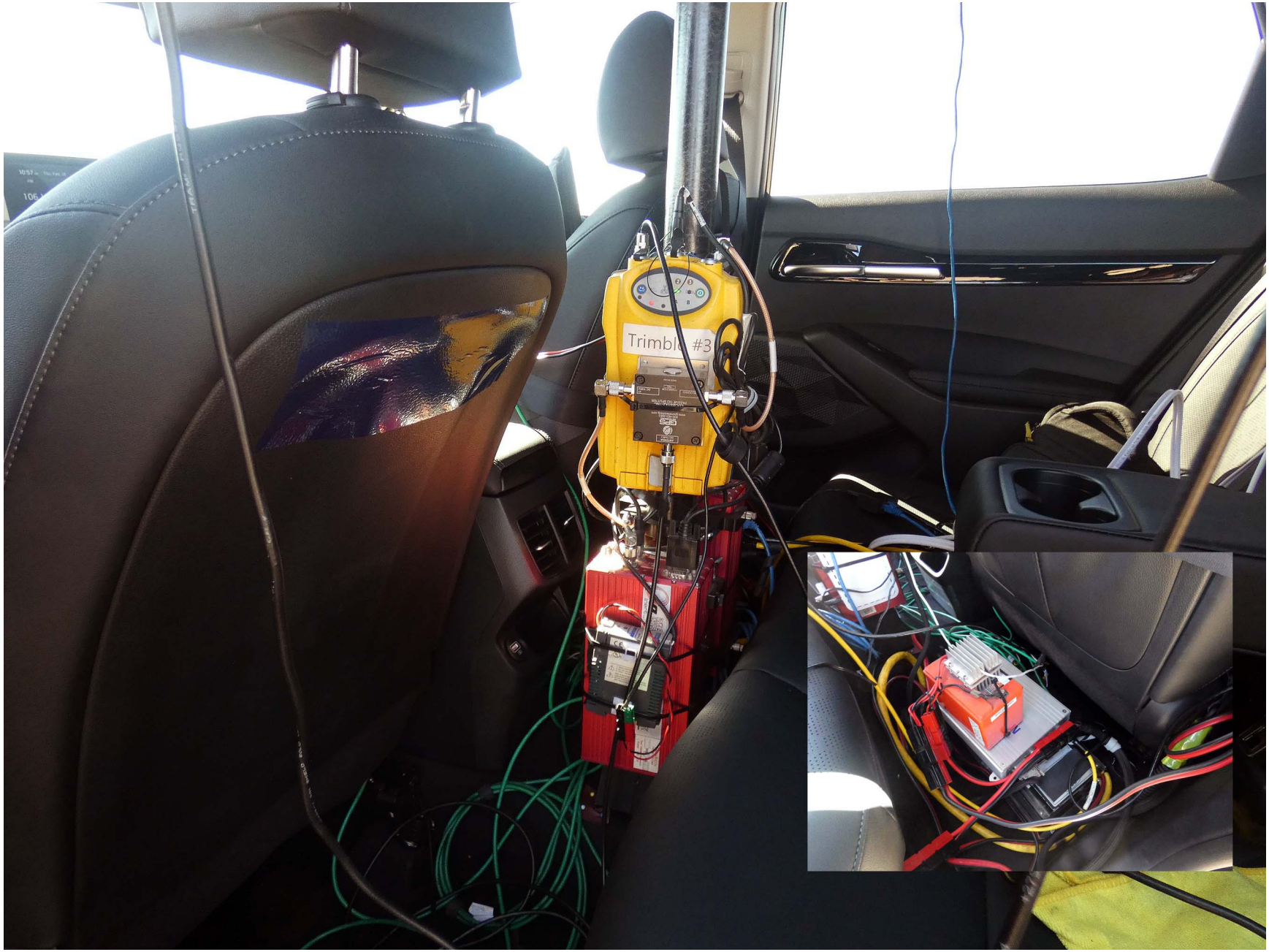


Figure A10. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

Figure A11. Sensors for Detecting Auditory and Visual Alerts

Figure A12. Computer Installed in Subject Vehicle

Figure A13. Brake Actuator Installed in POV System

Figure A14. AEB Setup Menus (page 1 of 2)

Figure A15. AEB Setup Menus (page 2 of 2)

Figure A16. Button for Accessing System Setup Menus

Figure A17. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

1. Head-Up Display (if equipped)

Items	Explanation
Display Height	Adjust the height (1~20) of the HUD image on the HUD screen.
Rotation	Adjust the degree (-5~+5) of the HUD rotation.
Brightness	Adjust the intensity (1~20) of the HUD brightness.
Speed Size	Small/Medium/Large
Speed Color	White/Orange/Green

2. Driver Assistance (if equipped)

Items	Explanation
Driving Assist	• Highway Driving Assist • Highway Auto Curve Zone Slowdown To select the functions.
Warning Timing	• Normal/Later To select the Warning time
Warning Volume	• High/Medium/Low To select the Warning volume
Driver Attention Warning	• Leading vehicle departure alert • Inattentive Driving Warning To select the function. * For more details, refer to the "Driver Attention Warning (DAW)" on page 5-145.
Forward Safety	To adjust Forward Collision-Avoidance Assist system. • Active Assist / Warning Only / Off To select the functions.
Lane Safety	To adjust Lane Keeping Assist system. • Lane Keeping Assist / Lane Departure Warning / Off To select the functions.
Blind-Spot Safety	To select the functions. • Safe Exit Assist To adjust Blind-Spot Collision-Avoidance Assist system. • Active Assist / Warning Only / Off

This warning light blinks:

- When there is a malfunction with a LED headlamp related part.

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

⚠ CAUTION

LED Headlamp Warning Light

Continuous driving with the LED Headlamp Warning Light on or blinking can reduce LED headlamp (low beam) life.

Forward Collision-Avoidance Assist Warning Light (if equipped)

This indicator light illuminates:

- Once you set the ignition switch or ENGINE START/STOP button to the ON position.
  - It illuminates for approximately 3 seconds and then goes off.
- When FCA system is turned off.
- When the radar sensor or cover is blocked with dirt or snow. Check the sensor and cover and clean them by using a soft cloth.
- When there is a malfunction with FCA. If this occurs, have your vehicle inspected by an authorized Kia dealer.

* For more details, refer to "Forward Collision-Avoidance Assist (FCA) - front view camera only (if equipped)" on page 5-72.

Electronic Parking Brake (EPB) warning light EPB (if equipped)

This warning light illuminates:

- Once you set the ignition switch or ENGINE START/STOP button to the ON position.
  - It illuminates for approximately 3 seconds and then goes off.
- When there is a malfunction with the EPB.
  In this case, you should have the vehicle inspected by an authorized Kia dealer.

✻ NOTICE

Electronic Parking Brake (EPB) Warning Light

The Electronic Parking Brake (EPB) Warning Light may illuminate when the Electronic Stability Control (ESC) Indicator Light comes on to indicate that the ESC is not working properly (This does not indicate malfunction of the EPB).

Exhaust system (GPF) warning light

This warning light illuminates:

- When there is a malfunction with Gasoline Particulate Filter (GPF) system.

SPORT mode

SPORT SPORT mode manages the driving dynamics by automatically adjusting the steering effort, and the engine and transmission control logic for enhanced driver performance.

- When SPORT mode is selected by turning the knob, the SPORT indicator (red color) will illuminate.
- Whenever the engine is restarted, the Drive Mode will revert back to NORMAL mode. If SPORT mode is desired, re-select SPORT mode from the knob.
- When SPORT mode is activated:
  - The engine rpm will tend to remain raised over a certain length of time even after releasing the accelerator.
  - Upshifts are delayed when accelerating.

✻ NOTICE

In SPORT mode, the fuel efficiency may decrease.

Forward Collision-Avoidance Assist (FCA) - front view camera only (if equipped)

Forward Collision-Avoidance Assist system is designed to detect and monitor the vehicle ahead or a pedestrian in the roadway through front view camera recognition to warn the driver that a collision is imminent, and if necessary, apply emergency braking.

⚠ WARNING

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

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

System setting and activation

System setting

The driver can activate FCA by placing the ignition switch to the ON position and by selecting on the LCD display:

'User Settings → Driver Assistance → Forward Safety'

- If you select "Active Assist", FCA system activates. FCA produces warning messages and warning alarms in accordance with the collision risk levels. Braking assist will be applied in accordance with the collision risk.
- If you select 'Warning Only', FCA system activates and produces only warning alarms in accordance with the collision risk levels. Braking assist will not be applied in this setting.
- If you select 'Off', FCA system deactivates.

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

Setting Warning Timing

The driver can select the initial warning activation time on the LCD display. If your vehicle is equipped with an infotainment system, you can learn how to setup on the website via QR code in the infotainment quick reference guide.

Go to the 'User Settings → Driver Assistance → Warning Timing → Normal/Later'.

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

- Normal: When this option is selected, the initial Forward Collision Warning is activated sensitively. If you feel the warning activates too early, set Forward Collision Warning to 'Later'.
  Even though, 'Normal' is selected if the front vehicle suddenly stops the initial warning activation time may not seem fast.
- Later: When this option is selected, the initial Forward Collision Warning is activated later than normal. This setting reduces the amount of distance between the vehicle ahead before the initial warning occurs.
  Select 'Later' when traffic is light and when driving speed is slow.

✻ NOTICE

If you change the warning timing, the warning time of other systems may change. Always be aware before changing the warning timing.

Prerequisite for activation

FCA gets ready to be activated, when 'Active Assist' or 'Warning Only' under Forward Safety is selected in on the LCD display, and when the following prerequisites are satisfied.

- The ESC (Electronic Stability Control) is on.
- Vehicle speed is over 6 mph (10 km/h). (FCA is only activated within a certain speed range.)
- The system detects a vehicle in front, which may collide with your vehicle. (FCA may not be activated or may sound a warning alarm in accordance with the driving situation or vehicle condition.)

⚠ WARNING

- FCA automatically activates upon placing the ignition switch or START/STOP button to the ON position. The driver can deactivate FCA by canceling the system setting on the LCD display. To avoid driver distractions, do not attempt to set or cancel FCA while driving the vehicle.
- FCA automatically deactivates upon canceling the ESC. When the ESC is canceled, FCA cannot be activated on the LCD display. In this situation, FCA warning light will illuminate, but it does not indicate a malfunction of the system.
- Set or cancel FCA with controlling switches on steering wheel after stopping the vehicle in a safe place for your safety.

FCA warning message and brake control

FCA produces warning messages, and warning alarms in accordance with the collision risk levels, such as abrupt stopping of the vehicle in front, insufficient braking distance, pedestrian detection. Also, it controls the brakes in accordance with the collision risk levels.

Collision Warning (1st warning)

OSP2059111L

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

Your vehicle may slow down slightly.

- It will operate if the vehicle speed is greater than 6 mph (10 km/h) and less than or equal to 112 mph (180 km/h) on a forward vehicle. (Depending on the condition of the vehicle ahead and the environment surrounding it, the possible maximum operating speed may be reduced.)
- For pedestrians the vehicle speed is greater than or equal to 6 mph (10 km/h) and less than 37 mph (60 km/h). (Depending on the condition of pedestrians and the surrounding environment the possible maximum operating speed may be reduced.)
- If you select 'Warning Only', FCA system activates and produces only warning alarms in accordance with the collision risk levels. You should control the brake directly because FCA system do not control the brake.

Emergency Braking (2nd warning)

OSP2059112L

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

The brake control is maximized just before a collision, reducing impact when it strikes a forward vehicle.

- It will operate if the vehicle speed is greater than 6 mph (10 km/h) and less than or equal to 37 mph (60 km/h) on a forward vehicle. (Depending on the condition of the vehicle ahead and the environment surrounding it, the possible maximum operating speed may be reduced.)

- For pedestrians, the vehicle speed is greater than or equal to 6 mph (10 km/h) and less than 37 mph (60 km/h). (Depending on the condition of pedestrians and the surrounding environment the possible maximum operating speed may be reduced.)
- If you select 'Warning Only', FCA system activates and produces only warning alarms in accordance with the collision risk levels. You should control the brake directly because FCA system do not control the brake.

Brake operation

In an urgent situation, the braking system enters into the ready status for prompt reaction against the driver's depressing the brake pedal.

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

⚠ CAUTION

The driver should always use extreme caution when operating the vehicle, even though there is no warning message or warning alarm.

⚠ WARNING

FCA system cannot avoid all collisions nor completely stop the vehicle before collision. The driver is responsible to safely drive and control the vehicle.

⚠ WARNING

FCA system logic operates within certain parameters, such as the distance from the vehicle ahead, the speed of the vehicle ahead, and the driver's vehicle speed. Certain conditions such as inclement weather and road conditions may affect the operation of FCA system.

Never deliberately drive dangerously to activate the system.

FCA sensor (front view camera)

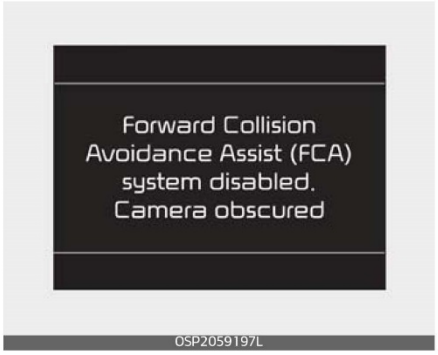
The sensor detects vehicle or pedestrian ahead. In order for FCA system to operate properly, always make sure the sensor cover or sensor is clean and free of dirt, snow, and debris.

OSP2N059011

Dirt, snow, or foreign substances may adversely affect the sensing performance of the sensor.

Warning message and warning light

Forward Collision-Avoidance Assist (FCA) system disabled. Camera obscured



OSP2059197L

When the camera is blocked with dirt, snow, or debris, FCA system operation may not be able to detect other vehicles.

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

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

FCA may not properly operate in an area (e.g. open terrain) where any objects or vehicles are not detected after turning on the engine.

Also, even though a warning message does not appear on the LCD display, FCA may not properly operate.

⚠ WARNING

FCA system may not activate without any warning messages depending on driving and road conditions.

✻ NOTICE

- Doing so may adversely affect the sensing performance of the sensor.
- Always keep the sensor clean and free of dirt and debris.
- Be careful not to apply unnecessary force on the sensor. If the sensor is forcibly moved out of proper alignment, FCA system may not operate correctly. In this case, a warning message may not be displayed. In this case, take your vehicle to an authorized Kia dealer and have the system inspected.
- Use only genuine parts to repair or replace a damaged part.
- Do not tint the window or install stickers and/or accessories around the inside mirror where the camera is installed.
- Make sure the front camera installation point does not get wet.
- Do not impact or arbitrarily remove any camera components.
- Do not place reflective objects (white paper or mirror etc.) on the dashboard.

The system may activate unnecessarily due to reflect of the sunlight.

- Excessive audio volume may disturb the sound of the system warning alarm.
- For more precautions related to the camera sensor, refer to the "Lane Keeping Assist (LKA)" on page 5-125.

FCA malfunction

Check Forward Collision-Avoidance Assist system

OSK3058067NR

- When FCA is not working properly, FCA warning light () will illuminate and the warning message will appear for a few seconds. After the message disappears, the master warning light () will illuminate. In this case, you should have the vehicle inspected by an authorized Kia dealer.

- FCA warning message may appear along with the illumination of the ESC (Electronic Stability Control) warning light.
  Both FCA warning light and warning message will disappear once the ESC warning light issue is resolved.

⚠ WARNING

- FCA is only a supplemental system for the driver's convenience. It is the driver's responsibility to control the vehicle operation. Do not solely depend on FCA system. Rather, maintain a safe braking distance, and, if necessary, depress the brake pedal to reduce the driving speed or to stop the vehicle.
- In certain instances and under certain driving conditions, FCA system may activate unintentionally. This initial warning message appears on the LCD display with a warning chime.
  Also, due to sensing limitations, in certain situations, the camera recognition system may not detect the vehicle ahead. FCA system may not activate and the warning message may not be displayed.
- FCA system may not activate if the driver applies the brake pedal before warning to avoid the risk of a collision.
- FCA system does not operate when the vehicle is in reverse.
- FCA system is not designed to detect other objects on the road such as animals.
- FCA system does not detect vehicles in the opposite lane.
- FCA system does not detect cross traffic vehicles that are approaching.
- FCA system cannot detect the driver approaching the side view of a parked vehicle (for example on a dead end street).
  In these cases, you must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce the driving speed in order to maintain a safe distance or to stop the vehicle.

Limitations of FCA

Forward Collision-Avoidance Assist system is designed to assist driver in highly dangerous driving situation and has not responsibility to all kind of situations.

FCA System detects driving situations through radar signals and camera recognition and FCA system may not operate normally in driving situation beyond radar signals and camera recognition performance. The driver must pay careful attention in the following situations

where the FCA operation may not be operated properly.

Detecting vehicles

The sensor may be limited when:

- Starting engine or rebooting front camera system wouldn't operate for 15 seconds.
- The camera is blocked with a foreign object or debris
- The camera lens is contaminated due to tinted, filmed or coated windshield, damaged glass, or stuck of foreign matter (sticker, bug, etc.) on the glass
- Inclement weather such as heavy rain or snow obscures the field of view of the camera
- There is interference by electromagnetic waves
- The camera sensor recognition is limited
- The vehicle in front is too small to be detected (for example a motor cycle or bicycle etc.)
- The camera does not recognize the entire vehicle in front.
- The vehicle in front is an oversize vehicle or trailer that is too big to be detected by the camera recognition system (for example a tractor trailer, etc.)
- The camera's field of view is not well illuminated (either too dark or too much reflection or too much backlight that obscures the field of view)
- The vehicle in front does not have their rear lights properly turned ON
- The outside brightness changes suddenly (for example when entering or exiting a tunnel)
- Light coming from a street light or an oncoming vehicle is reflected on a wet road surface such as a puddle in the road
- Backlight is projected in the direction of the vehicle (including oposite vehicle headlights)
- The field of view in front is obstructed by sun glare or head light of oncoming vehicle.
- The windshield glass is fogged up; a clear view of the road is obstructed
- The vehicle in front is driving erratically The vehicle is on unpaved or uneven rough surfaces, or road with sudden gradient changes.
- In case of a vehicle in front is special vehicle, truck and trailer, etc. that contains a irregular form of luggage.
- The vehicle is severely shaken.
- In case of camera sensor recognition is in a marginal state.
- In case of be towed by a trailer or other vehicle.
- In case of interference caused by other electromagnetic waves.
- In case of a vehicle in front is driving erratically.

- In case of a vehicle in front has extremely high ground clearance.
- The vehicle drives inside a building, such as a basement parking lot
- The camera is damaged.
- The brightness outside is too low such as when the headlamps are not on at night or the vehicle is going through a tunnel.
- The shadow is on the road by a median strip, trees, etc.
- The vehicle drives through a tollgate.
- The rear part of the vehicle in front is not normally visible. (the vehicle turns in other direction or the vehicle is overturned.)
- The adverse road conditions cause excessive vehicle vibrations while driving
- The sensor recognition changes suddenly when passing over a speed bump
- The vehicle in front is moving vertically to the driving direction
- The vehicle in front is stopped vertically
- The vehicle in front is driving towards your vehicle or reversing
- You are on a roundabout and the vehicle in front circles

Detecting pedestrians

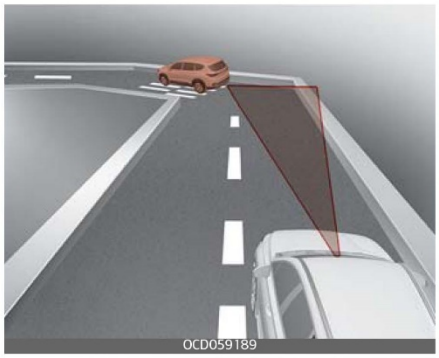
The sensor may be limited when:

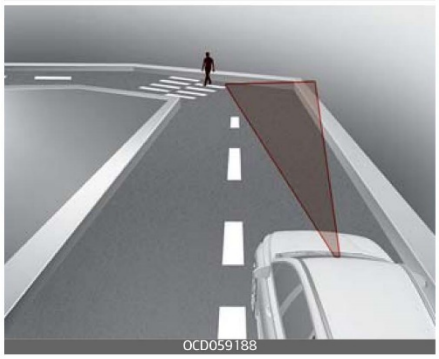
- The pedestrian is not fully detected by the camera recognition system, for example, if the pedestrian is leaning over or is not fully walking upright.
- The pedestrian is moving very quickly or appears abruptly in the camera detection area
- The pedestrian is wearing clothing that easily blends into the background, making it difficult to be detected by the camera.

Recognition system

- The outside lighting is too bright (e.g. when driving in bright sunlight or in sun glare) or too dark (e.g. when driving on a dark rural road at night)
- It is difficult to detect and distinguish the pedestrian from other objects in the surroundings, for example, when there is a group of pedestrians or a large crowd.
- There is an item similar to a person's body structure.
- The pedestrian is small.
- The pedestrian has impaired mobility. Never try to test the operation
- When the pedestrian suddenly interrupts in front of the vehicle

Driving on a curve





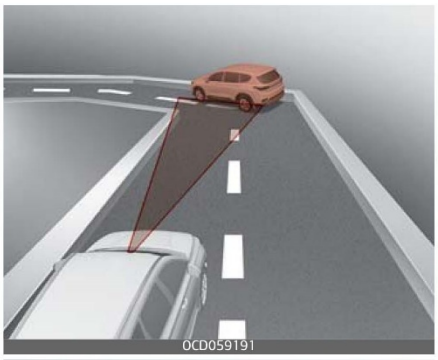
The performance of FCA system may be limited when driving on a curved road.

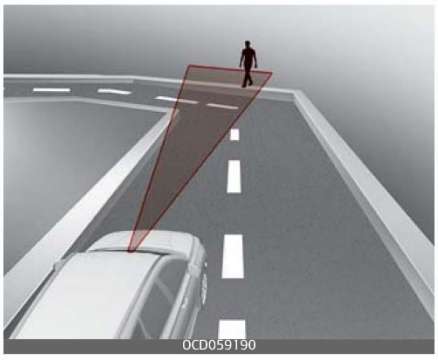
On curved roads, the other vehicle on the same lane is not recognized and FCA system's performance may be degraded. This may result in unnecessary alarm or braking or no alarm or braking when necessary.

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

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

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





In this case, the system may unnecessarily alarm the driver and apply the brake.

Always pay attention to road and driving conditions, while driving. If necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.

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

Check to be sure that the road conditions permit safe operation of FCA.

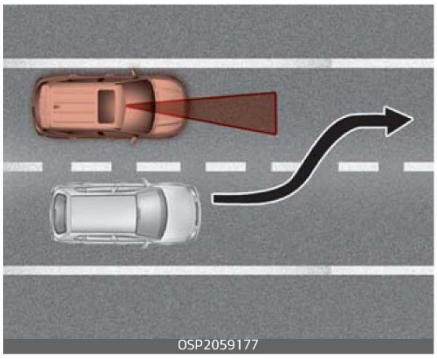
Driving on a slope

The performance of FCA decreases while driving upward or downward on a slope, not recognizing the vehicle in front in the same lane. It may unnecessarily produce the warning message and the warning alarm, or it may not produce the warning message and the warning alarm at all.

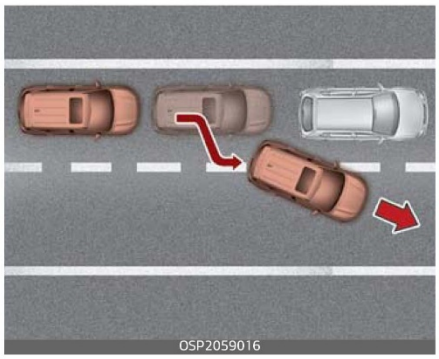
When FCA suddenly recognizes the vehicle in front while passing over a slope, you may experience sharp deceleration.

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

Changing lanes

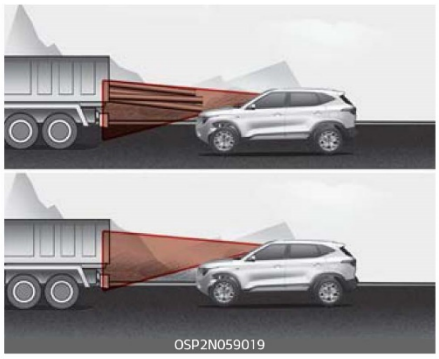


When a vehicle changes lanes in front of you, FCA system may not immediately detect the vehicle, especially if the vehicle changes lanes abruptly. In this case, you must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe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



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

Recognizing the vehicle



If the vehicle in front of you has cargo that extends rearward from the cab, or when the vehicle in front of you has higher ground clearance, additional special attention is required. FCA system may not be able to detect the cargo extending from the vehicle. In these instances, you must maintain a safe braking distance from the rearmost object, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain distance.

⚠ WARNING

- Do not use Forward Collision-Avoidance Assist system when towing a vehicle. Application of FCA system while towing may adversely affect the safety of your vehicle or the towing vehicle.
- Use extreme caution when the vehicle in front of you has cargo that extends rearward from the cab, or when the vehicle in front of you has higher ground clearance.
- Forward Collision-Avoidance Assist may operate when an object, which has similar shape or characteristic to a vehicle or pedestrian, is detected.
- FCA system is designed to detect and monitor the vehicle ahead in the roadway through camera recognition. It is not designed to detect pedestrians, bicycles, motorcycles, or smaller wheeled objects such as luggage bags, shopping carts, or strollers.

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

*** NOTICE**

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

This device complies with Part 15 of the FCC rules.

Operation is subject to the following three conditions:

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

Radio frequency radiation exposure information:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 8 in (20 cm) between the radiator (antenna) and your body.

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

Forward Collision-Avoidance Assist (FCA) - sensor fusion (if equipped)

Forward Collision-Avoidance Assist system is designed to detect and monitor the vehicle, a pedestrian or a cyclist ahead in the roadway through and front view camera recognition and front radar signals to warn the driver that a collision is imminent, and if necessary, apply emergency braking.

⚠ WARNING

Forward Collision-Avoidance Assist system Limitations

FCA system is a supplemental system and is not a substitute for safe driving practices.

It is the responsibility of the driver to always check the speed and distance to the vehicle ahead and to be prepared to apply the brakes.

⚠ WARNING

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

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

System setting and activation

System setting

The driver can activate FCA by placing the ignition switch to the ON position and by selecting on the LCD display 'User Settings → Driver Assistance → Forward Safety'. If your vehicle is equipped with an infotainment system, you can learn how to setup on the website via QR code in the infotainment quick reference guide.:

- If you select "Active Assist", FCA system activates. FCA produces warning messages and warning alarms in accordance with the collision risk levels. Also, it controls the brakes in accordance with the collision risk levels.
- If you select "Warning Only", FCA system activates and produces only warning alarms in accordance with the collision risk levels.

You should control the brake directly because FCA system do not control the brake.
- If you select "Off", FCA system deactivates.

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

- The driver can select the initial warning activation time on the LCD display or infotainment system display.
  Go to the 'User Settings → Driver Assistance → Warning Timing → Normal/Later'.

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

- Normal: When this condition is selected, the initial Forward Collision Warning is activated sensitively. If you feel the warning activates too early, set Forward Collision Warning to 'Later'.
  Even though, 'Normal' is selected if the front vehicle suddenly stops the initial warning activation time may not seem fast.
- Later: When this condition is selected, the initial Forward Collision Warning is activated later than normal. This setting reduces the amount of distance between the vehicle or pedestrian ahead before the initial warning occurs. Select 'Later' when traffic is light and when driving speed is slow.
- The driver can select the warning volume of Forward Collision Warning in the User Settings in the LCD display by selecting 'User Settings → Driver Assistance → Warning Volume → High/Medium/Low'.

Prerequisite for activation

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

- The ESC (Electronic Stability Control) is on.
- Vehicle speed is over 6 mph (10 km/h). (FCA is only activated within a certain speed range.)
- The system detects a vehicle or pedestrian in front, which may collide with your vehicle. (FCA may not be activated or may sound a warning alarm in accordance with the driving situation or vehicle condition.)

⚠ WARNING

- Completely stop the vehicle on a safe location before operating the switch on the steering wheel to activate/deactivate FCA system.
- FCA automatically activates upon placing the ignition switch to the ON position. The driver can deactivate FCA by canceling the system setting on the LCD display or infotainment system display.
- FCA automatically deactivates upon canceling the ESC (Electronic Stability Control). When the ESC is canceled, FCA cannot be activated on the LCD display or infotainment system display. FCA warning light will illuminate which is normal. At this time, FCA cannot be set even in instrument cluster or infotainment system user setting mode.

FCA warning message and system control

FCA produces warning messages and warning alarms in accordance with the collision risk levels, such as abrupt stopping of the vehicle in front, insufficient braking distance, pedestrian or cyclist (if equipped) detection. Also, it controls the brakes in accordance with the collision risk levels.

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

Collision Warning (1st warning)

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

The Vehicle may slow down slightly.

- It will operate if the vehicle speed is greater than 6 mph (10 km/h) and less than or equal to 112 mph (180 km/h) on a forward vehicle. (Depending on the condition of the vehicle ahead and the environment surrounding it, the possible maximum operating speed may be reduced.)

- For pedestrians and cyclists, the vehicle speed is greater than or equal to 6 mph (10 km/h) and less than 53 mph (85 km/h). (Depending on the condition of pedestrians and bike riders and the surrounding environment the possible maximum operating speed may be reduced.)
- If you select "Warning Only", FCA system activates and produces only warning alarms in accordance with the collision risk levels. You should control the brake directly because FCA system do not control the brake.

Emergency Braking (2nd warning)

OSP2059112L

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

The brake control is maximized just before a collision, reducing impact when it strikes a forward vehicle.

- It will operate if the vehicle speed is greater than 6 mph (10 km/h) and less than or equal to 47 mph (75 km/h) on a forward vehicle. (Depending on the condition of the vehicle ahead and the environment surrounding it, the possible maximum operating speed may be reduced.)
- For pedestrians and cyclists, the vehicle speed is greater than or equal to 6 mph (10 km/h) and less than 40 mph (65 km/h). (Depending on the condition of pedestrians and bike riders and the surrounding environment the possible maximum operating speed may be reduced.)
- If you select "Warning Only", FCA system activates and produces only warning alarms in accordance with the collision risk levels. You should control the brake directly because FCA system do not control the brake.

Brake operation

In an urgent situation, the braking system enters into the ready status for prompt reaction against the driver's depressing the brake pedal.

- The braking control is automatically deactivated, when the driver sharply depresses the accelerator pedal, or when the driver abruptly operates the steering wheel.
- FCA brake control is automatically canceled, when risk factors disappear.

⚠ CAUTION

- The driver should always use extreme caution while operating the vehicle, whether or not there is a warning message or alarm from FCA system.
- If any other warning sound such as seat belt warning chime is already generated, Forward Collision-Avoidance Assist system warning may not sound.

⚠ WARNING

The braking control cannot completely stop the vehicle nor avoid all collisions. The driver should hold the responsibility to safely drive and control the vehicle.

⚠ WARNING

FCA system logic operates within certain parameters, such as the distance from the vehicle or pedestrian ahead, the speed of the vehicle ahead, and the driver's vehicle speed. Certain conditions such as inclement weather and road conditions may affect the operation of FCA system.

⚠ WARNING

Never deliberately drive dangerously to activate the system.

FCA sensor (front view camera/ front radar) (if equipped)

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

front view camera

front radar

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

✻ NOTICE

- Do not apply license plate molding or foreign objects such as a bumper sticker or a bumper guard near the radar sensor. Doing so may adversely affect the sensing performance of the radar.
- Always keep the radar sensor and cover clean and free of dirt and debris.
- Use only a soft cloth to wash the vehicle. Do not spray pressurized water directly on the sensor or sensor cover.
- Be careful not to apply unnecessary force on the radar sensor or sensor cover. If the sensor is forcibly moved out of proper alignment, FCA system may not operate correctly. In this case, a warning message may not be displayed. You should have the vehicle inspected by an authorized Kia dealer.
- If the front bumper becomes damaged in the area around the radar sensor, FCA system may not operate properly. You should have the vehicle inspected by an authorized Kia dealer.
- Use only genuine parts to repair or replace a damaged sensor or sensor cover. Do not apply paint to the sensor cover.

✻ NOTICE

- NEVER install any accessories or stickers on the front windshield, nor tint the front windshield.
- NEVER locate any reflective objects (i.e. white paper, mirror) over the dashboard. Any light reflection may cause a malfunction of the system.
- Pay extreme caution to keep the camera out of water.
- NEVER disassemble the camera assembly, nor apply any impact on the camera assembly.
  If the sensor is forcibly moved out of proper alignment, FCA system may not operate correctly. In this case, a warning message may not be displayed. You should have the vehicle inspected by an authorized Kia dealer.

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

✻ NOTICE

Have the vehicle inspected by an authorized Kia dealer when:

- The windshield glass is replaced.
- The radar sensor or cover gets damaged or replaced.

Warning message and warning light

Forward Collision-Avoidance Assist (FCA) system disabled. Radar blocked

OSK3058069NR

When the sensor cover is blocked with dirt, snow, or debris, FCA system operation may stop temporarily. If this occurs, a warning message will appear on the LCD display.

Remove any dirt, snow, or debris and clean the radar sensor cover before operating FCA system.

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

However FCA may not properly operate in an area (e.g. open terrain), where any substances are not detected after turning ON the engine. Also, even though a warning message does not appear on the LCD display, FCA may not properly operate.

⚠ WARNING

FCA system may not activate according to road conditions, inclement weather, driving conditions or traffic conditions.

System malfunction

Check Forward Collision Avoidance Assist system

OSK3058067NR

- When FCA is not working properly, FCA warning light () will illuminate and the warning message

will appear for a few seconds. After the message disappears, the master warning light (⚠) will illuminate. In this case, you should have the vehicle inspected by an authorized Kia dealer.

- FCA warning message may appear along with the illumination of the ESC (Electronic Stability Control) warning light.

⚠ WARNING

- FCA is only a supplemental system for the driver's convenience. The driver should hold the responsibility to control the vehicle operation. Do not solely depend on FCA system. Rather, maintain a safe braking distance, and, if necessary, depress the brake pedal to reduce the driving speed.
- In certain instances and under certain driving conditions, FCA system may activate unintentionally. This initial warning message appears on the LCD display with a warning chime. Also, in certain instances the camera recognition system or front radar sensor may not detect the vehicle, pedestrian or cyclist (if equipped) ahead. FCA system may not activate and the warning message will not be displayed.
- If the vehicle in front stops suddenly, you may have less control of the brake system. Therefore, always keep a safe distance between your vehicle and the vehicle in front of you.
- FCA system may activate during braking and the vehicle may stop suddenly, shifting loose objects toward the passengers. Always keep loose objects secured.
- FCA system may not activate if the driver applies the brake pedal to avoid a collision.
- The brake control may be insufficient, possibly causing a collision, if a vehicle in front abruptly stops. Always use extreme caution.
- Occupants may get injured, if the vehicle abruptly stops by the activated FCA system. Use extreme caution.
- FCA system operates only to detect vehicles, pedestrians or cyclists in front of the vehicle.

⚠ WARNING

- FCA system does not operate when the vehicle is in reverse.
- FCA system is not designed to detect other objects on the road, such as animals.
- FCA system does not detect vehicles in the opposite lane.
- FCA system does not detect cross traffic vehicles that are approaching.
- FCA system cannot detect the driver approaching the side view

of a parked vehicle (for example on a dead end street.)
- FCA system cannot detect the cross traffic cyclist that are approaching.

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

Limitations of FCA

Forward Collision-Avoidance Assist system is designed to monitor assist driver in highly dangerous driving situation but does not have responsibility to all kinds of situations. FCA System detects driving situations through camera recognitions and radar signals, and thus, FCA system may not operate normally in driving situation beyond camera recognition performance and radar signals. The driver must pay careful attention in the following situations where FCA operation may not be operated properly.

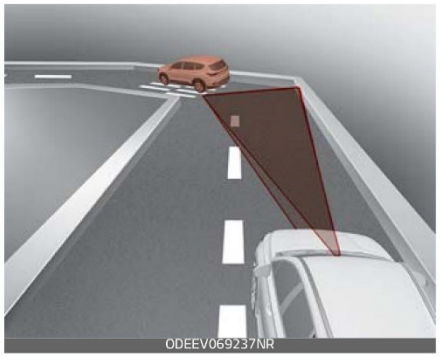
Detecting vehicles

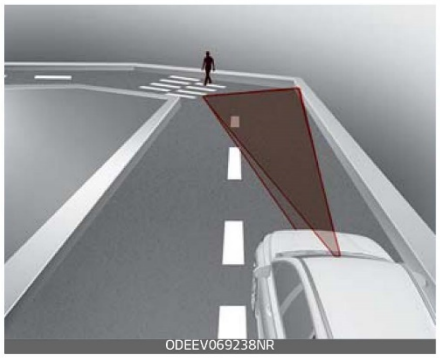
The sensor may be limited when:
- Starting engine or rebooting front camera system wouldn't operate for 15 seconds.
- Front view camera and front radar contaminated or blocked.
- The system may not work around 15 seconds after starting the vehicle or the initialization or rebooting of the front view camera.
- The front view camera or front radar is blocked with a foreign object or debris
- The camera lens is contaminated due to tinted, filmed or coated windshield, damaged glass, or stuck of foreign matter (sticker, bug, etc.) on the glass
- Inclement weather such as heavy rain or snow obscures the field of view of the front view camera or front radar
- In case of interference caused by other electromagnetic waves.
- The vehicle in front is too small to be detected (for example a motorcycle etc.)
- In case of a vehicle in front is an oversized vehicle or trailer that is too big to be detected by the camera recognition system (for example a tractor, trailer, etc.)
- The camera does not recognize the entire vehicle in front.

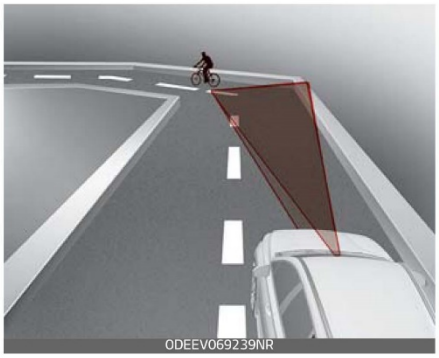
- In case of a vehicle in front is driving erratically.
- In case of camera or radar sensor recognition is in a marginal state.
- The camera is damaged.
- The vehicle is severely shaken.
- When backlight is projected in the direction of the vehicle (including opposite vehicle headlights)
- In case of a vehicle in front has extremely high ground clearance.
- In case of being towed by a trailer or other vehicle.
- There is interference by electromagnetic waves.
- There is severe irregular reflection from the radar sensor (for example guardrail or oncoming vehicle, etc.)
- The front view camera or front radar recognition is limited.
- The front view camera does not recognize the entire vehicle in front.
- The front view camera is damaged.
- The brightness outside is too low such as when the headlamps are not on at night or the vehicle is going through a tunnel.
- The shadow is on the road by a median strip, trees, etc.
- The vehicle drives through a tollgate.
- The rear part of the vehicle in front is not normally visible. (the vehicle turns in other direction or the vehicle is overturned.)
- The vehicle in front is too small to be detected (for example a motorcycle or a bicycle, etc.)
- The vehicle in front is an oversize vehicle or trailer that is too big to be detected by the camera recognition system (for example a tractor trailer, etc.)
- The camera's field of view is not well illuminated (either too dark or too much reflection or too much backlight that obscures the field of view)
- The vehicle in front does not have their rear lights or their rear lights does not turned ON or their rear lights are located unusually.
- The outside brightness changes suddenly, for example when entering or exiting a tunnel
- When light coming from a street light or an oncoming vehicle is reflected on a wet road surface such as a puddle in the road
- The field of view in front is obstructed by sun glare
- The windshield glass is fogged up; a clear view of the road is obstructed
- The vehicle in front is driving erratically
- The vehicle is driven near areas containing metal substances as a construction zone, railroad, etc.
- The vehicle drives inside a building, such as a basement parking lot

- The adverse road conditions cause excessive vehicle vibrations while driving
- The sensor recognition changes suddenly when passing over a speed bump
- The vehicle in front is moving vertically to the driving direction
- The vehicle in front is stopped vertically
- The vehicle in front is driving towards your vehicle or reversing
- You are on a roundabout and the vehicle in front circles

Driving on a curve





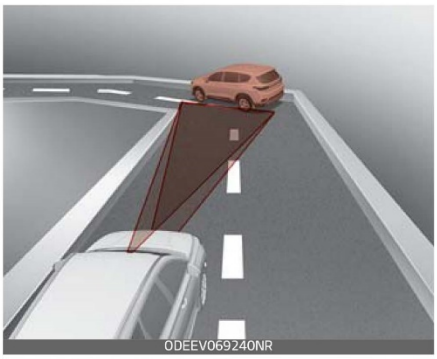


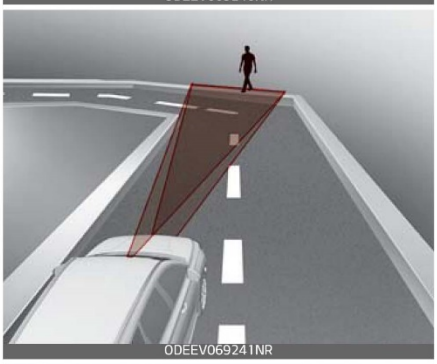
The performance of FCA system may be limited when driving on a curved road.

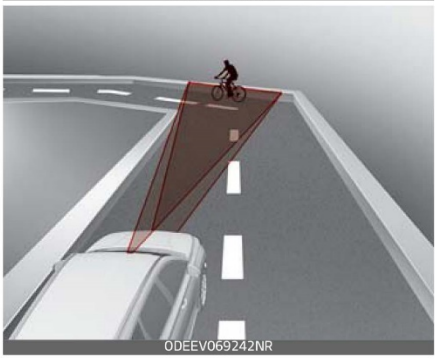
Also, in certain instances the front radar sensor or front view camera recognition system may not detect the vehicle traveling on a curved road.

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

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







In this case, the system may unnecessarily alarm the driver and apply the brake.

Always pay attention to the road and driving conditions, while driving. If necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.

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

Check to be sure that the road conditions permit safe operation of FCA.

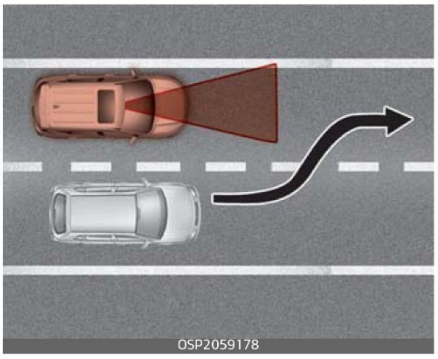
Driving on a slope

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

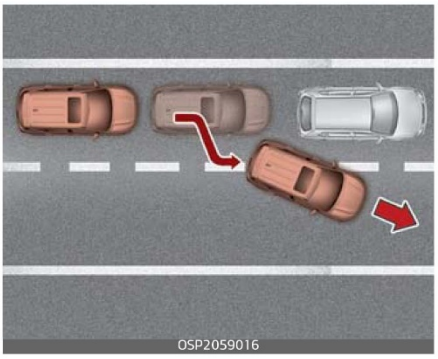
When FCA suddenly recognizes the vehicle in front while passing over a slope, you may experience sharp deceleration.

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

Changing lanes



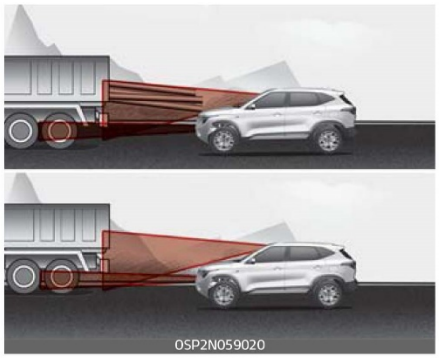
When a vehicle changes lanes in front of you, FCA system may not immediately detect the vehicle, especially if the vehicle changes lanes abruptly. In this case, you must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe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



When driving in stop-and-go traffic, and a stopped vehicle in front of you merges out of the lane, FCA system may not immediately detect the new vehicle that is now in front of

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

Recognizing the vehicle



If the vehicle in front of you has cargo that extends rearward from the cab, or when the vehicle in front of you has higher ground clearance, additional special attention is required. FCA system may not be able to detect the cargo extending from the vehicle. In these instances, you must maintain a safe braking distance from the rearmost object, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain distance.

Situation in which the system may not detect pedestrian and cyclist properly.

The sensor may be limited when:

- The pedestrians or cyclists are not fully detected by the front view camera recognition system, for example, if the pedestrian is leaning over or is not fully walking upright.
- The pedestrians or cyclists are moving very quickly or appears abruptly in the front view camera detection area.
- The pedestrians or cyclists are wearing clothing that easily blends into the background, making it difficult to be detected by the front view camera recognition system.
- The outside lighting is too bright (e.g. when driving in bright sunlight or in sun glare) or too dark (e.g. when driving on a dark rural road at night).
- It is difficult to detect and distinguish the pedestrians or cyclists from other objects in the surroundings, for example, when there is a group of pedestrians or cyclists or a large crowd.
- There is an item similar to a person's body structure.
- The pedestrians or cyclists are small.
- The pedestrian has impaired mobility.

- The sensor recognition is limited
- In case of radar or camera sensor recognition is in a marginal state.
- In case of a large number of pastries or cyclists are gathered.
- The radar sensor or front view camera is blocked with a foreign object or debris.
- The camera lens is contaminated due to tinted, filmed or coated windshield, damaged glass, or stuck of foreign matter (sticker, bug, etc.) on the glass.
- The brightness outside is too low such as when the headlamps are not on at night or the vehicle is going through a tunnel.
- Inclement weather such as heavy rain or snow obscures the field of view of the radar sensor or front view camera.
- When light coming from a street light or an oncoming vehicle is reflected on a wet road surface such as a puddle in the road.
- The field of view in front is obstructed by sun glare.
- The windshield glass is fogged up; a clear view of the road is obstructed.
- The adverse road conditions cause excessive vehicle vibrations while driving.
- The sensor recognition changes suddenly when passing over a speed bump.
- You are on a roundabout.
- When the pedestrian or cyclist suddenly interrupts in front of the vehicle.
- When the cyclist in front is riding intersected with the driving direction.
- When there is any other electromagnetic interference.
- When the construction area, rail or other metal object is near the cyclist.
- If the bicycle material is not reflected well on the radar.

⚠ WARNING

- Do not use Forward Collision-Avoidance Assist system when towing a vehicle. Application of FCA system while towing may adversely affect the safety of your vehicle or the towing vehicle.
- Use extreme caution when the vehicle in front of you has cargo that extends rearward from the cab, or when the vehicle in front of you has higher ground clearance.
- FCA system is designed to detect and monitor the vehicle ahead or detect a pedestrian or cyclist (if equipped) in the roadway through radar signals and camera recognition. It is not designed to detect bicycles, motorcycles, or smaller wheeled objects, such as luggage bags, shopping carts, or strollers.

- Never try to test the operation of FCA system. Doing so may cause severe injury or death.
- If the front bumper, front glass, front radar or front view camera have been replaced or repaired, you should have the vehicle inspected by an authorized Kia dealer.

*** NOTICE**

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

This device complies with Part 15 of the FCC rules.

Operation is subject to the following three conditions:

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

Radio frequency radiation exposure information:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 8 in (20 cm) between the radiator (antenna) and your body.

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

APPENDIX C

Run Log

Subject Vehicle: **2021 Kia Seltos SX Turbo AWD** Test Date: **2/18/2021**

Principal Other Vehicle: **SSV**

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
1	Static Run								Zero SV front bumper to SSV rear bumper and collect data
2	**Stopped POV**	Y	2.10	10.78	25.2	0.99	1.09	Pass	
3		Y	2.10	11.07	25.1	0.97	1.10	Pass	
4		Y	2.08	11.92	25.1	0.99	1.10	Pass	
5		Y	2.09	11.55	24.8	0.99	1.09	Pass	
6		Y	2.04	11.80	24.9	0.99	1.08	Pass	
7		Y	2.09	11.81	25.0	0.99	1.11	Pass	
8		Y	2.11	11.57	25.2	0.99	1.10	Pass	
9	Static Run								Check zero data is within ± 0.167 ft (±0.05m)
10	**Slower POV, 25 vs 10**	N							Throttle
11		Y	1.83	11.58	15.5	0.98	0.98	Pass	
12		N							GPS
13		Y	1.80	11.05	14.4	1.00	0.95	Pass	
14		Y	1.84	11.00	15.3	1.00	0.96	Pass	
15		Y	1.91	11.76	14.9	1.02	0.99	Pass	
16		Y	1.84	11.03	15.1	0.99	0.96	Pass	
17		Y	1.87	11.09	15.3	1.00	0.97	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
18	**Slower POV, 25 vs 10**	Y	1.87	11.25	15.3	1.00	0.95	Pass	
19	Static Run								Check zero data is within ± 0.167 ft (±0.05m)
20	**Slower POV, 45 vs 20**	Y	2.34	11.60	25.1	0.93	1.29	Pass	
21		Y	2.32	11.49	25.1	0.94	1.24	Pass	
22		Y	2.36	12.66	24.9	0.96	1.28	Pass	
23		Y	2.32	12.50	25.3	0.96	1.29	Pass	
24		Y	2.40	12.32	25.3	0.99	1.35	Pass	
25		N							Can't run in post processor
26		Y	2.28	12.95	24.6	0.90	1.27	Pass	
27		Y	2.38	12.97	24.9	0.99	1.32	Pass	
28	Static run								Check zero data is within ± 0.167 ft (±0.05m)
29	**Decelerating POV**	Y	1.71	8.04	22.3	1.04	0.92	Pass	
30		Y	1.67	8.01	23.0	0.99	0.96	Pass	
31		Y	1.64	8.58	22.5	0.93	0.97	Pass	
32		Y	1.64	7.04	23.8	0.97	1.00	Pass	
33		Y	1.78	7.42	23.8	1.04	0.91	Pass	
34		Y	1.70	8.85	22.7	0.97	0.97	Pass	
35		Y	1.67	8.11	22.9	0.91	0.98	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
36	Static Run								Check zero data is within ± 0.167 ft (±0.05m)
37	STP - Static Run								Zero SV front bumper to rear edge of steel plate and collect data
38	**STP False Positive, 25**	Y				0.01		Pass	
39		Y				0.01		Pass	
40		Y				0.01		Pass	
41		Y				0.01		Pass	
42		Y				0.02		Pass	
43		Y				0.01		Pass	
44		Y				0.01		Pass	
45	STP - Static Run								Check zero data is within ± 0.167 ft (±0.05m)
46	**STP False Positive, 45**	Y				0.02		Pass	
47		Y				0.03		Pass	
48		Y				0.02		Pass	
49		Y				0.02		Pass	
50		Y				0.02		Pass	
51		N							Throttle
52		Y				0.01		Pass	
53		Y				0.01		Pass	
54	STP - Static Run								Check zero data is within ± 0.167 ft (±0.05m)

APPENDIX D

Time History Plots

LIST OF FIGURES

Description of Time History Plots

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

Time History Plot Description

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

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

Time history figures include the following sub-plots:

- FCW Warning – Displays the Forward Collision Warning alert (which can be audible, visual, or haptic). Depending on the type of FCW alert or instrumentation used to measure the alert, this can be any combination of the following:
    - Filtered, rectified, and normalized sound signal. The vertical scale is 0 to 1.
    - Filtered, rectified, and normalized acceleration (i.e., haptic alert, such as steering wheel vibration). The vertical scale is 0 to 1.
    - Normalized light sensor signal. The vertical scale is 0 to 1.

    As only the audible or haptic alert is perceptible by the driver during a test run, the earliest of either of these alerts is used to define the onset of the FCW alert. A vertical black bar on the plot indicates the TTC (sec) at the first moment of the warning issued by the FCW system. The FCW TTC is displayed to the right of the subplot in green. For False Positive tests, when the FCW presents a warning “FCW” is shown in red at the right edge of the FCW plot.

- Headway (ft) – Longitudinal separation (gap) between the frontmost point of the Subject Vehicle and the rearmost point of the Strikeable Surrogate Vehicle (SSV) towed by the Principal Other Vehicle. The minimum headway during the run is displayed to the right of the subplot.

- SV/POV Speed (mph) – Speed of the Subject Vehicle and Principal Other Vehicle (if any). For CIB tests, the speed reduction experienced by the Subject Vehicle is displayed to the right of the subplot.

- Yaw Rate (deg/sec) – Yaw rate of the Subject Vehicle and Principal Other Vehicle (if any).

- Lateral Offset (ft) – Lateral offset within the lane of the Subject Vehicle to the center of the lane of travel. Note that for tests involving the Strikeable Surrogate Vehicle (SSV), the associated lateral restraint track is defined to be the center of the lane of travel. If testing is done with a different POV which does not have a lateral restraint track, lateral offset is defined to be the lateral offset between the SV and POV.

- Ax (g) – Longitudinal acceleration of the Subject Vehicle and Principal Other Vehicle (if any). For CIB tests, the TTC (sec) at the moment of first CIB activation is displayed to the right of the subplot in green. Also, the peak value of Ax for the SV is shown on the subplot.

- Accelerator Pedal Position (0-1) – Normalized position of the accelerator pedal.

Envelopes and Thresholds

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

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

For plots with yellow envelopes, in order for the test to be valid, the time-varying data must not exceed the envelope at the beginning (left edge of the boundary) and/or end (right edge), but may exceed the boundary during the time

between the left and right edges. Exceedances at the left or right extent of a yellow envelope are indicated by red asterisks.

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

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

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

Color Codes

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

Color codes can be broken into four categories:

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

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

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

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

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

Other Notations

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

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

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

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

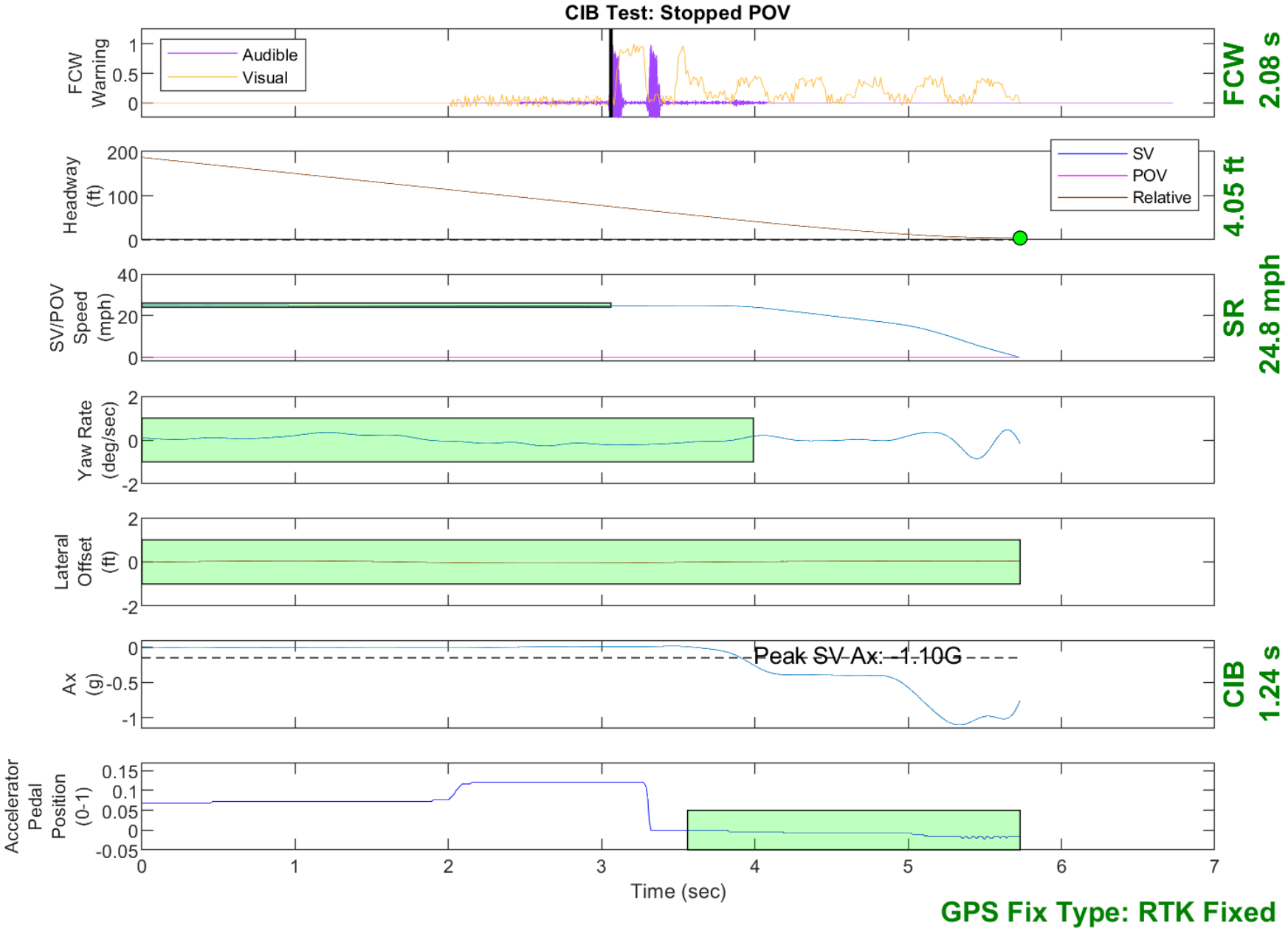


Figure D1. Example Time History for Stopped POV, Passing

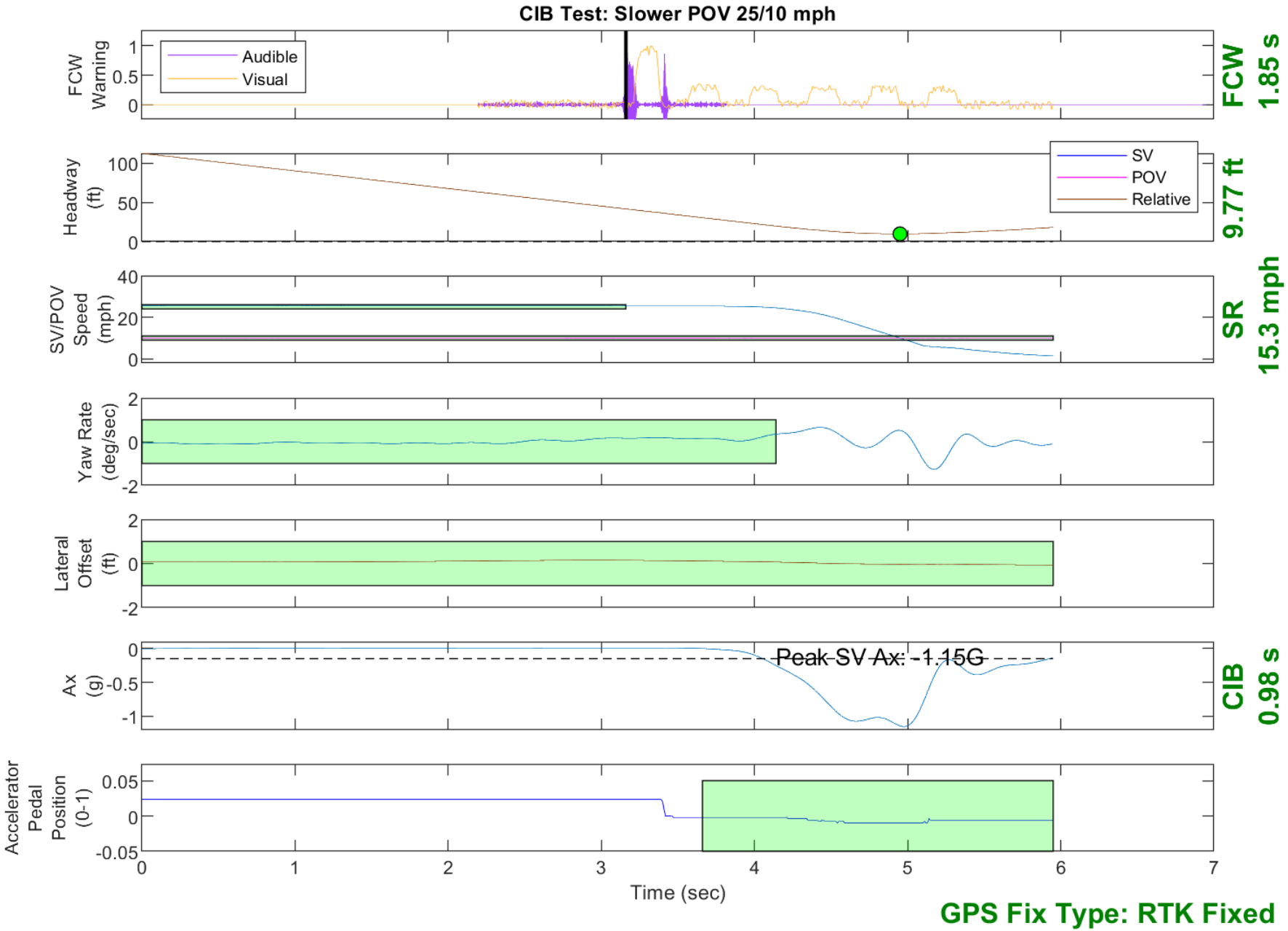


Figure D2. Example Time History for Slower POV 25 vs. 10, Passing

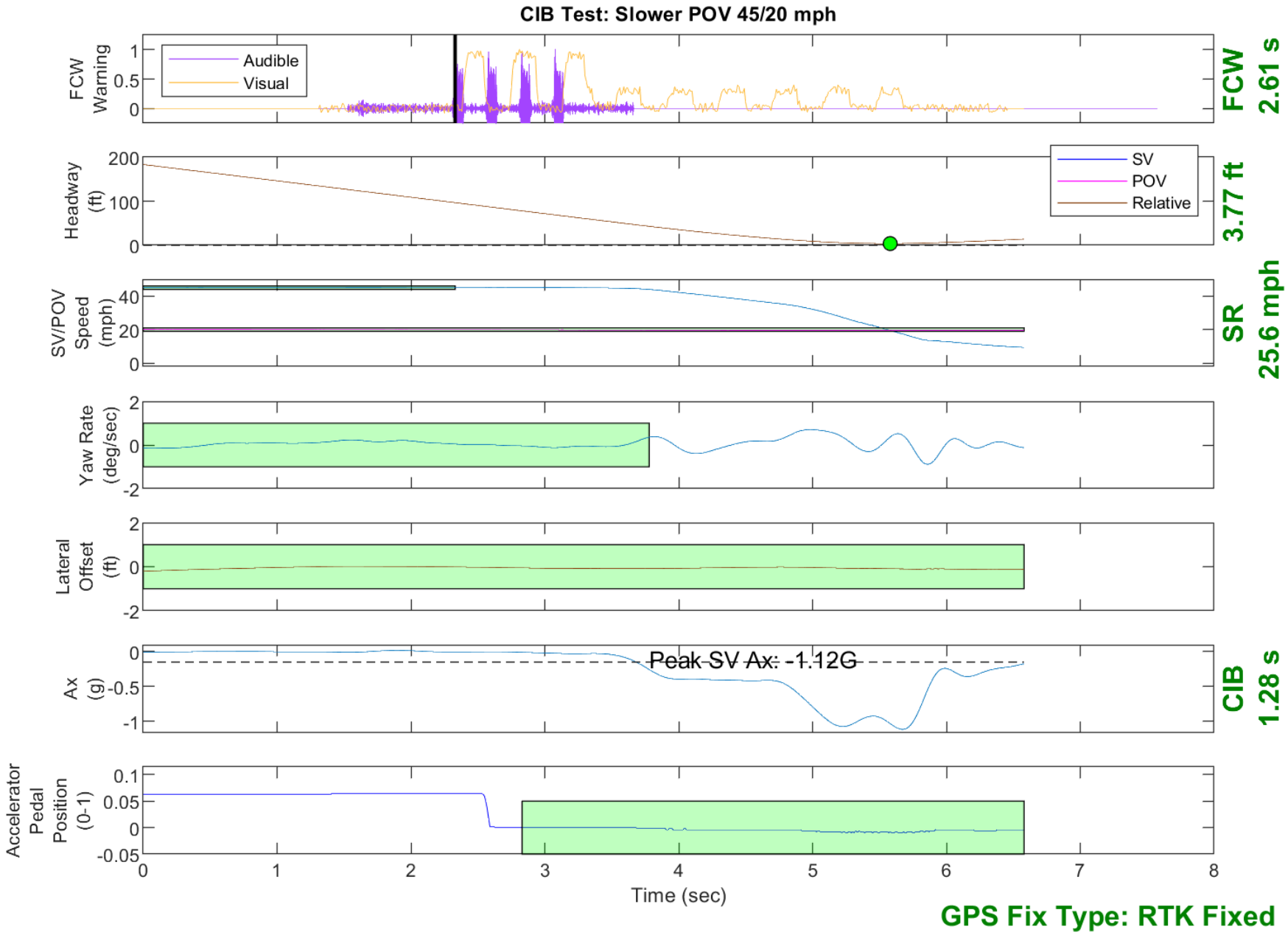


Figure D3. Example Time History for Slower POV 45 vs. 20, Passing

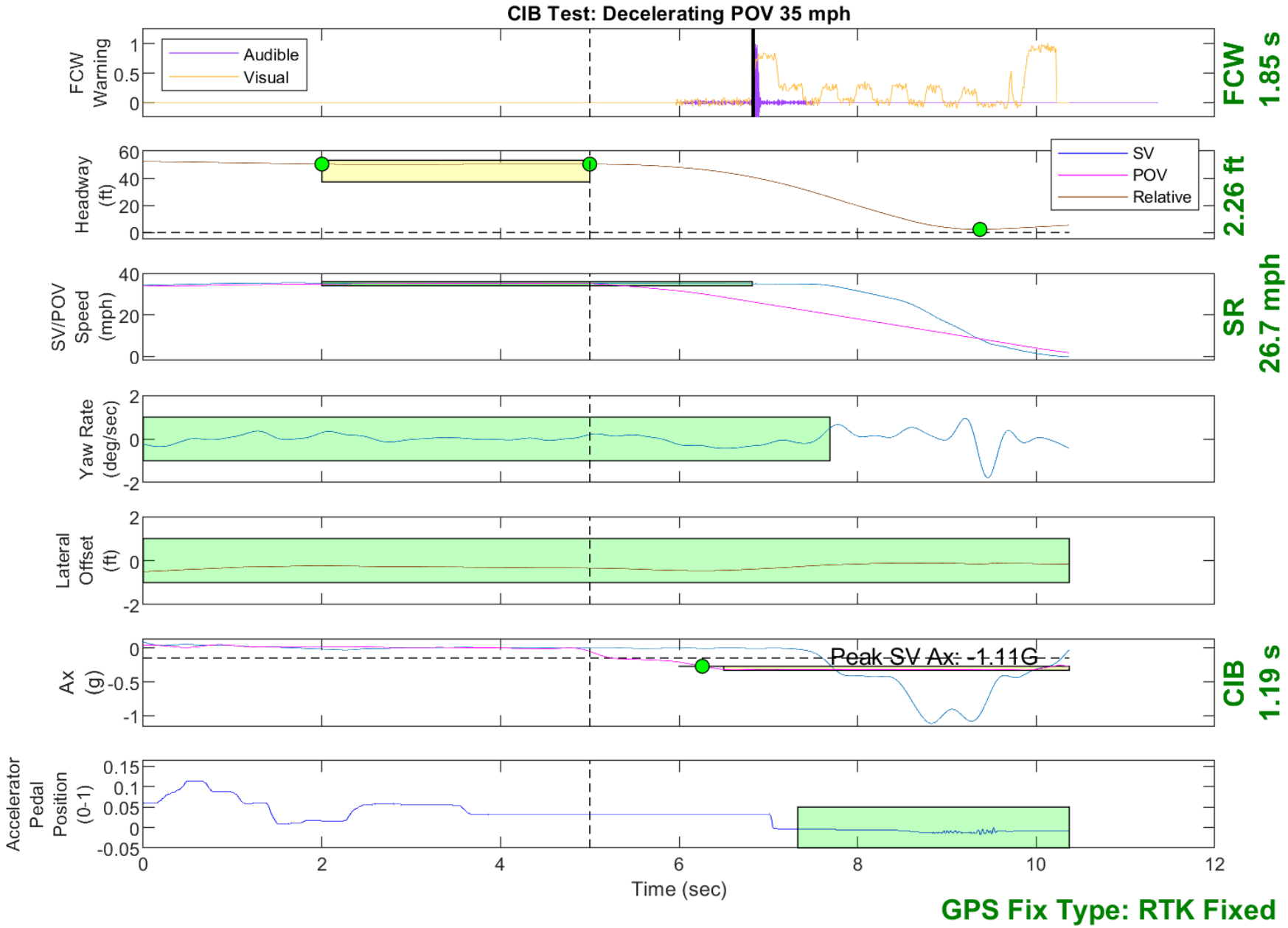


Figure D4. Example Time History for Decelerating POV 35, Passing

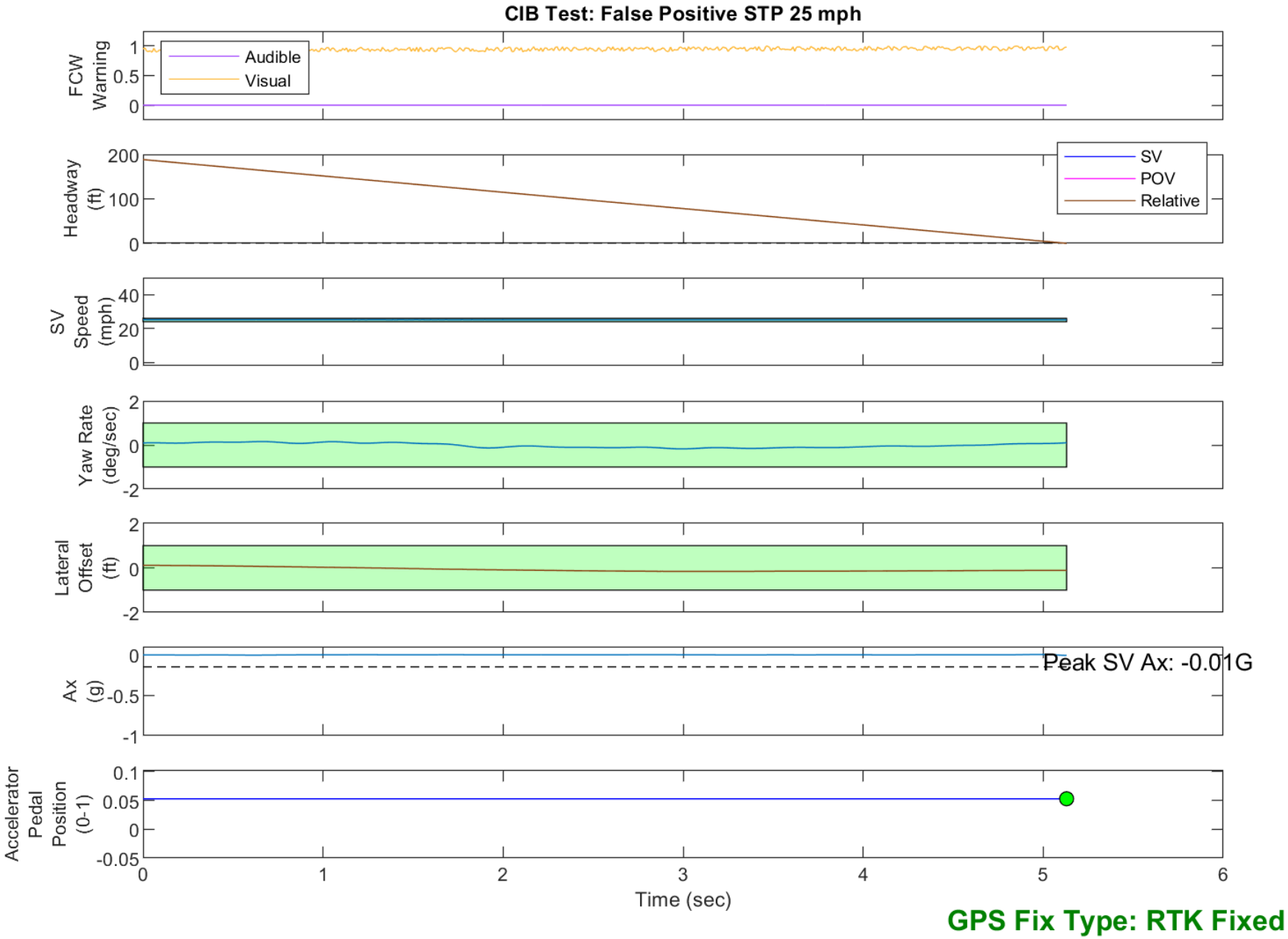


Figure D5. Example Time History for False Positive STP 25, Passing

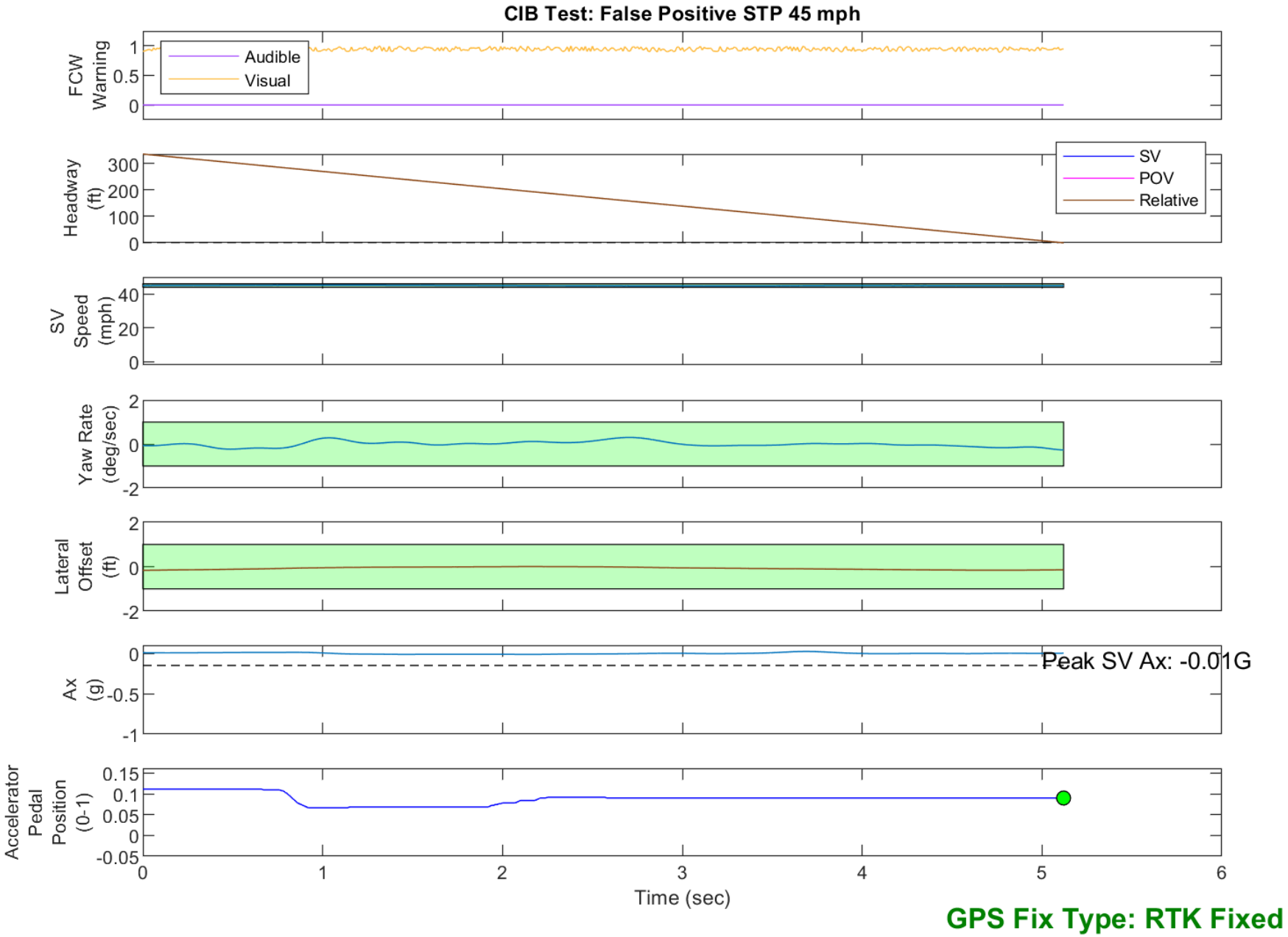


Figure D6. Example Time History for False Positive STP 45, Passing

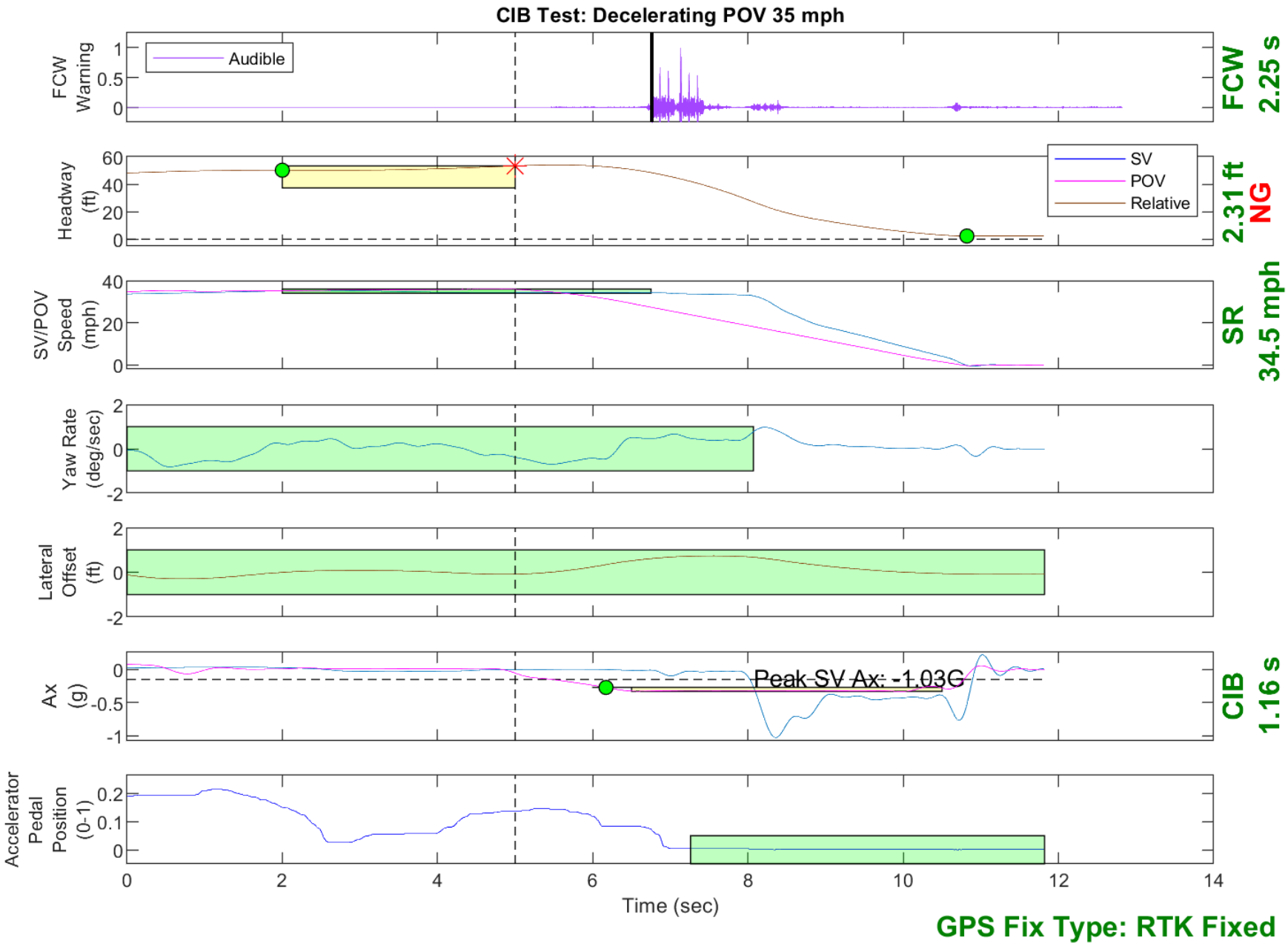


Figure D7. Example Time History Displaying Invalid Headway Criteria

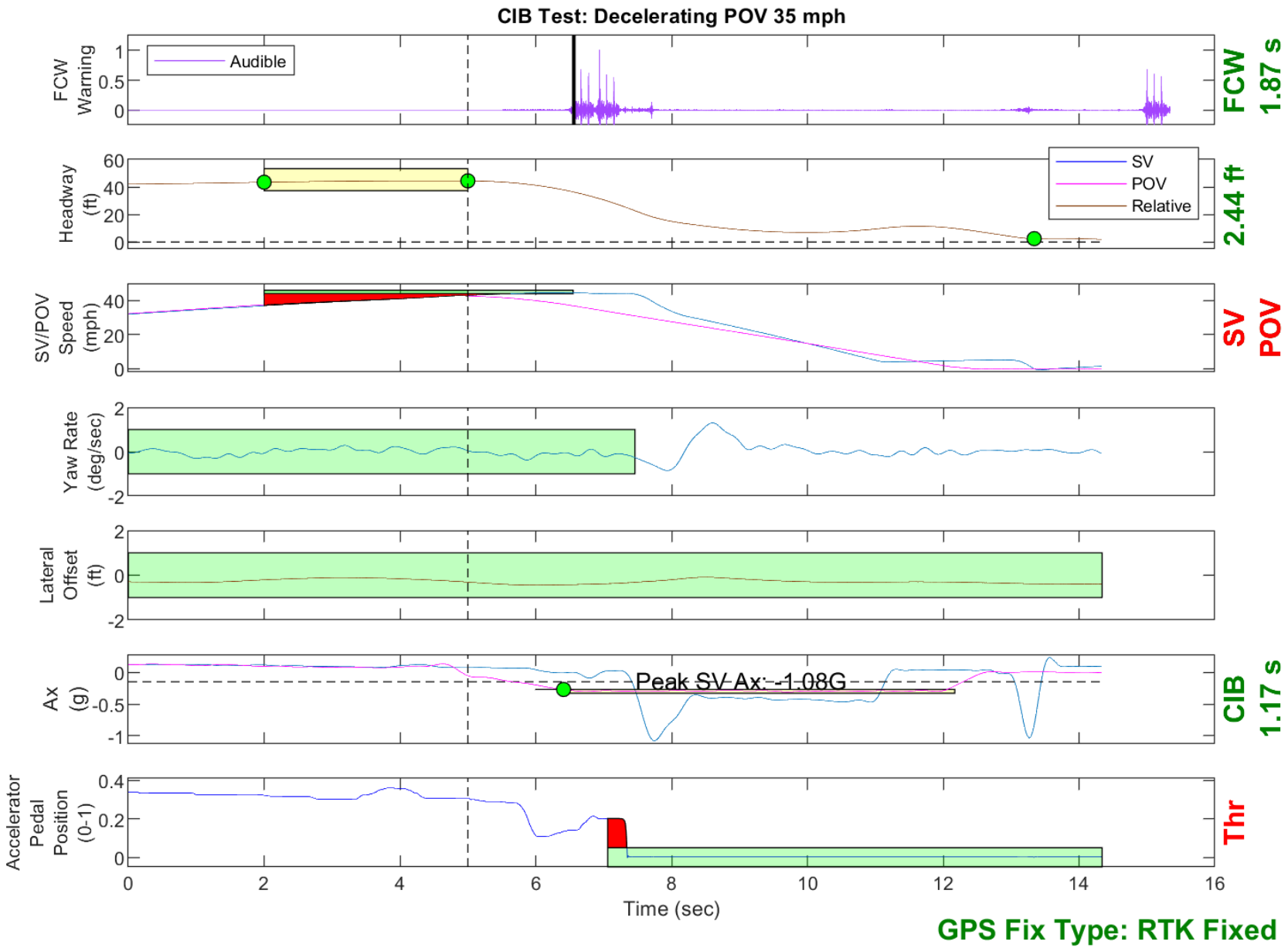


Figure D8. Example Time History Displaying Various Invalid Criteria

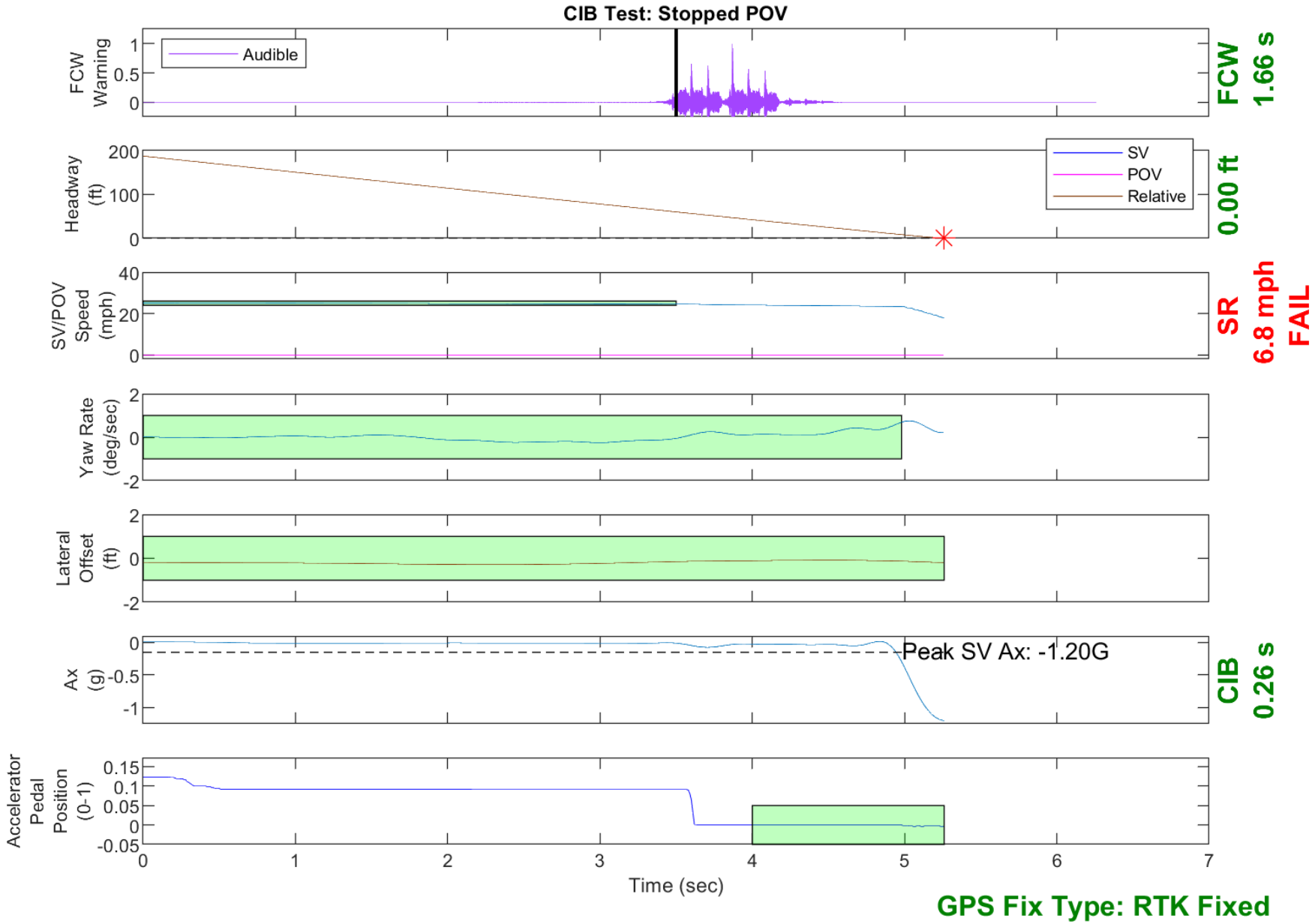


Figure D9. Example Time History for a Failed Run

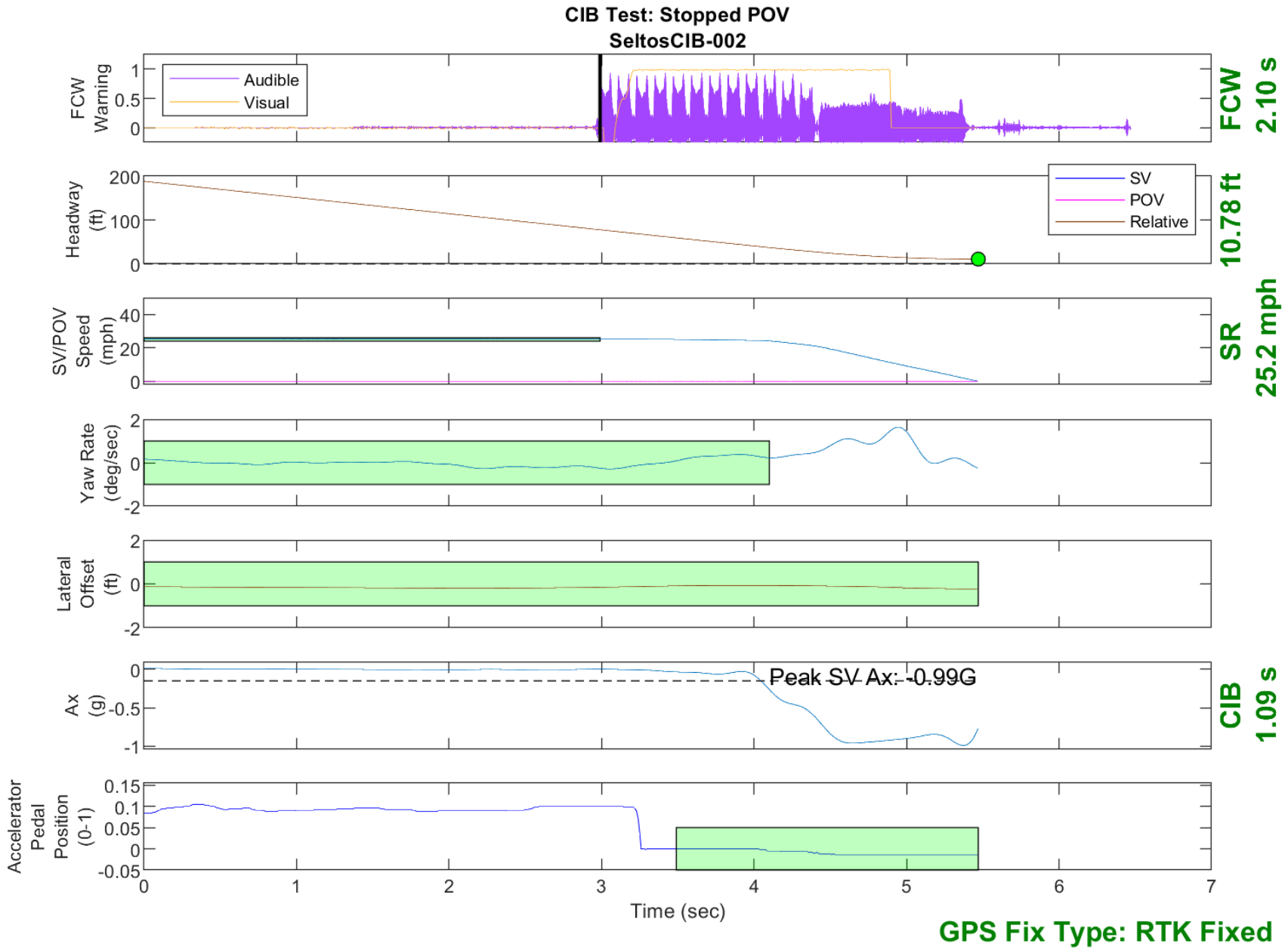


Figure D10. Time History for CIB Run 2, SV Encounters Stopped POV

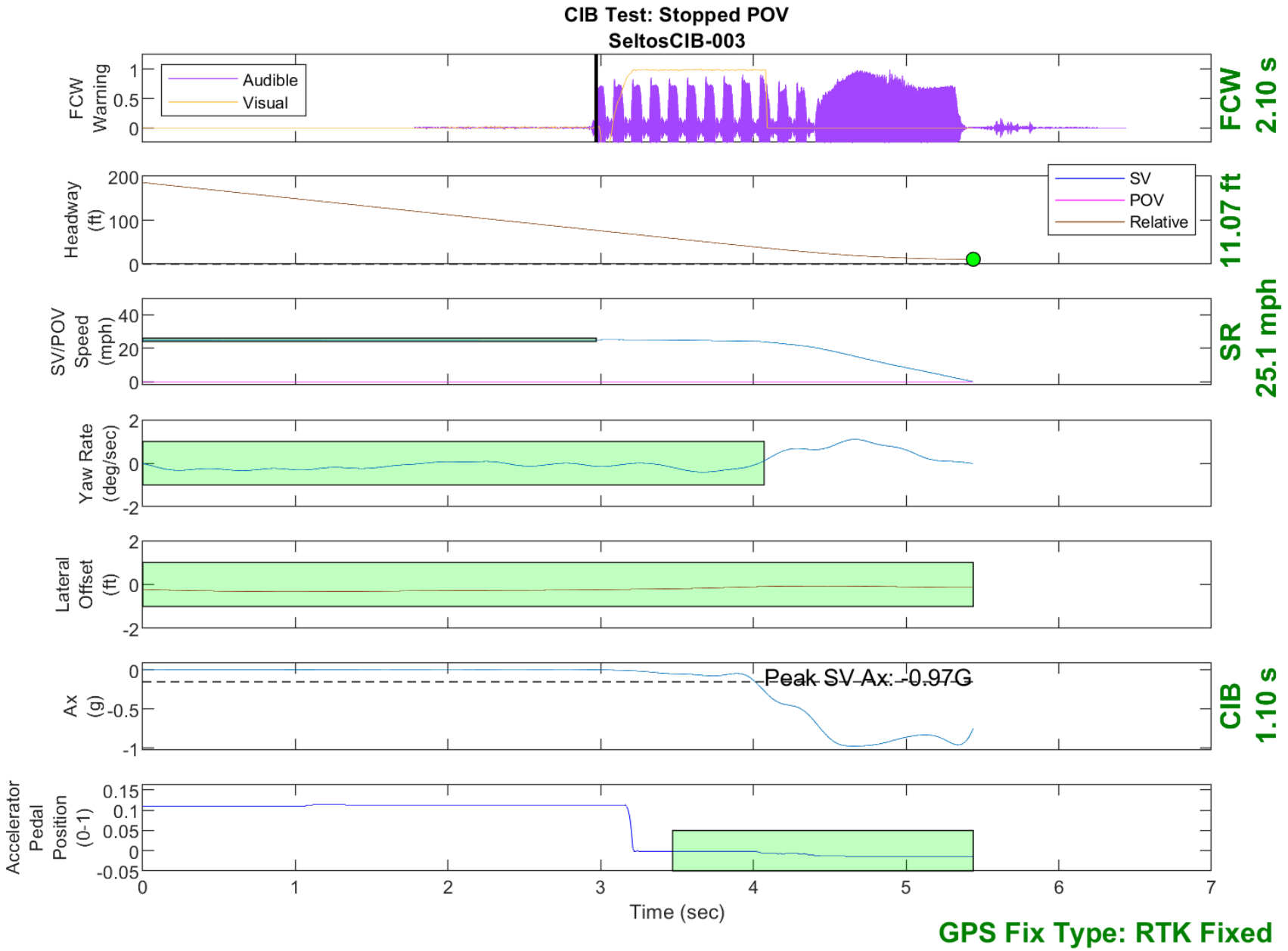


Figure D11. Time History for CIB Run 3, SV Encounters Stopped POV

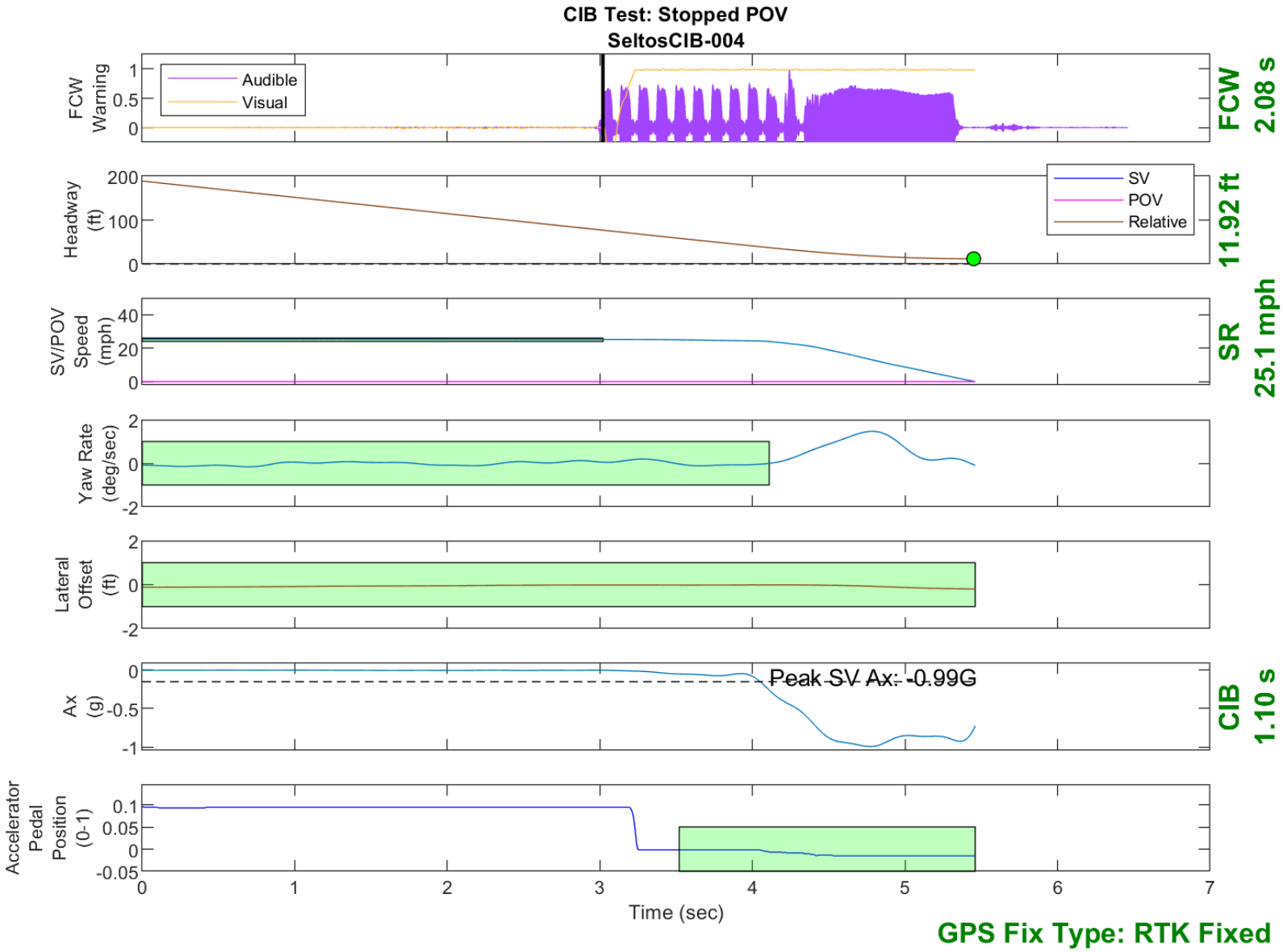


Figure D12. Time History for CIB Run 4, SV Encounters Stopped POV

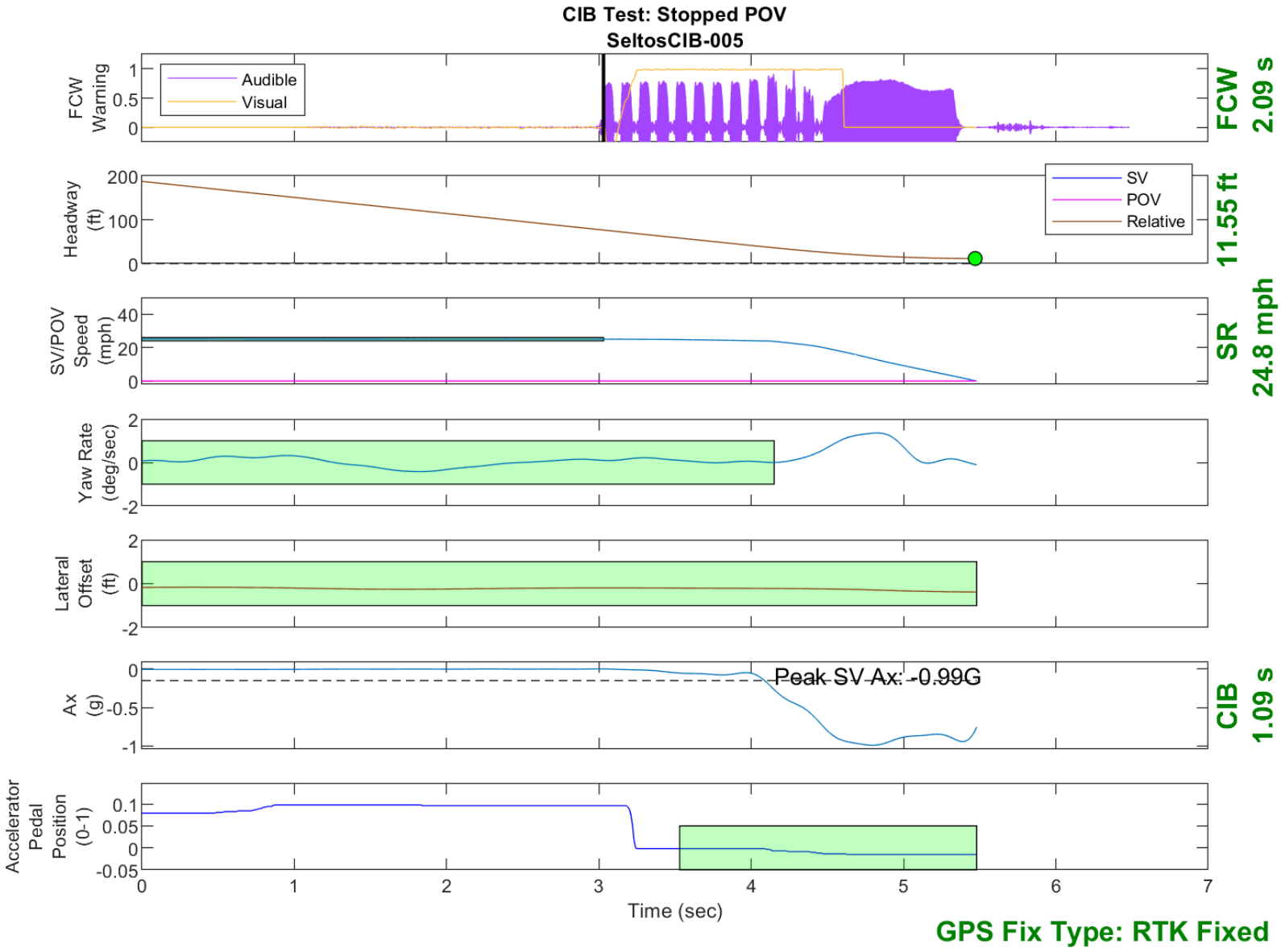


Figure D13. Time History for CIB Run 5, SV Encounters Stopped POV

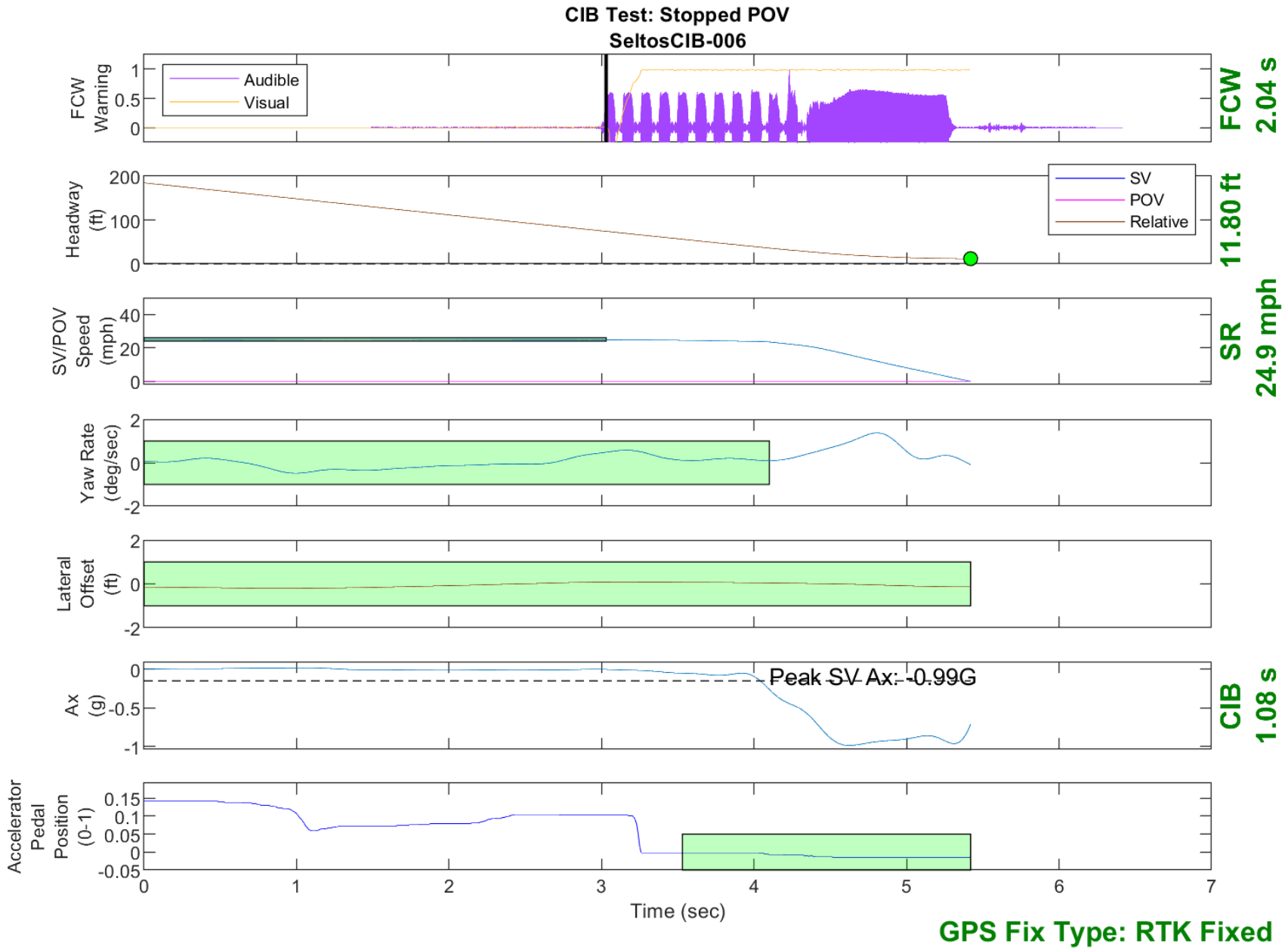


Figure D14. Time History for CIB Run 6, SV Encounters Stopped POV

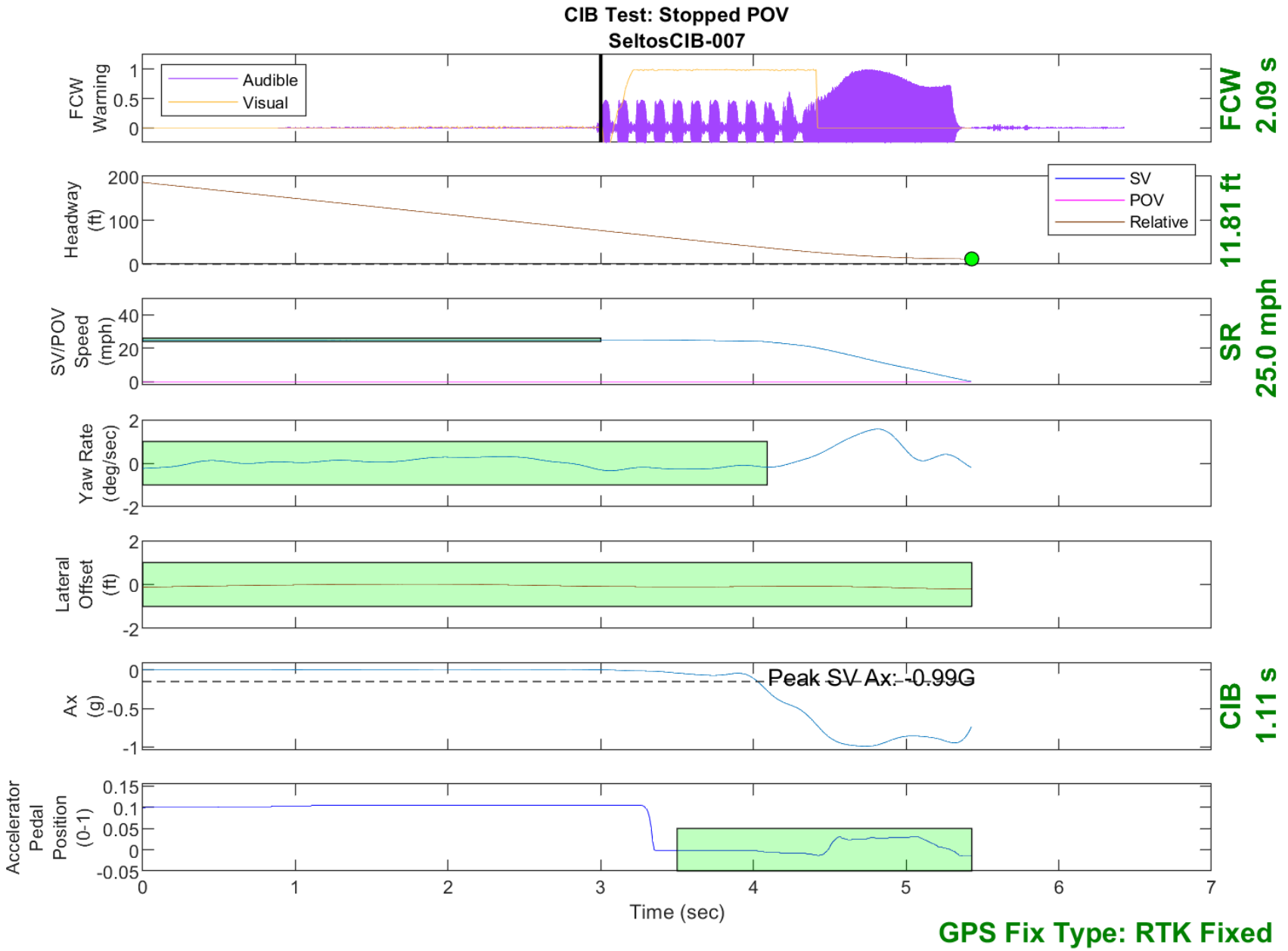


Figure D15. Time History for CIB Run 7, SV Encounters Stopped POV

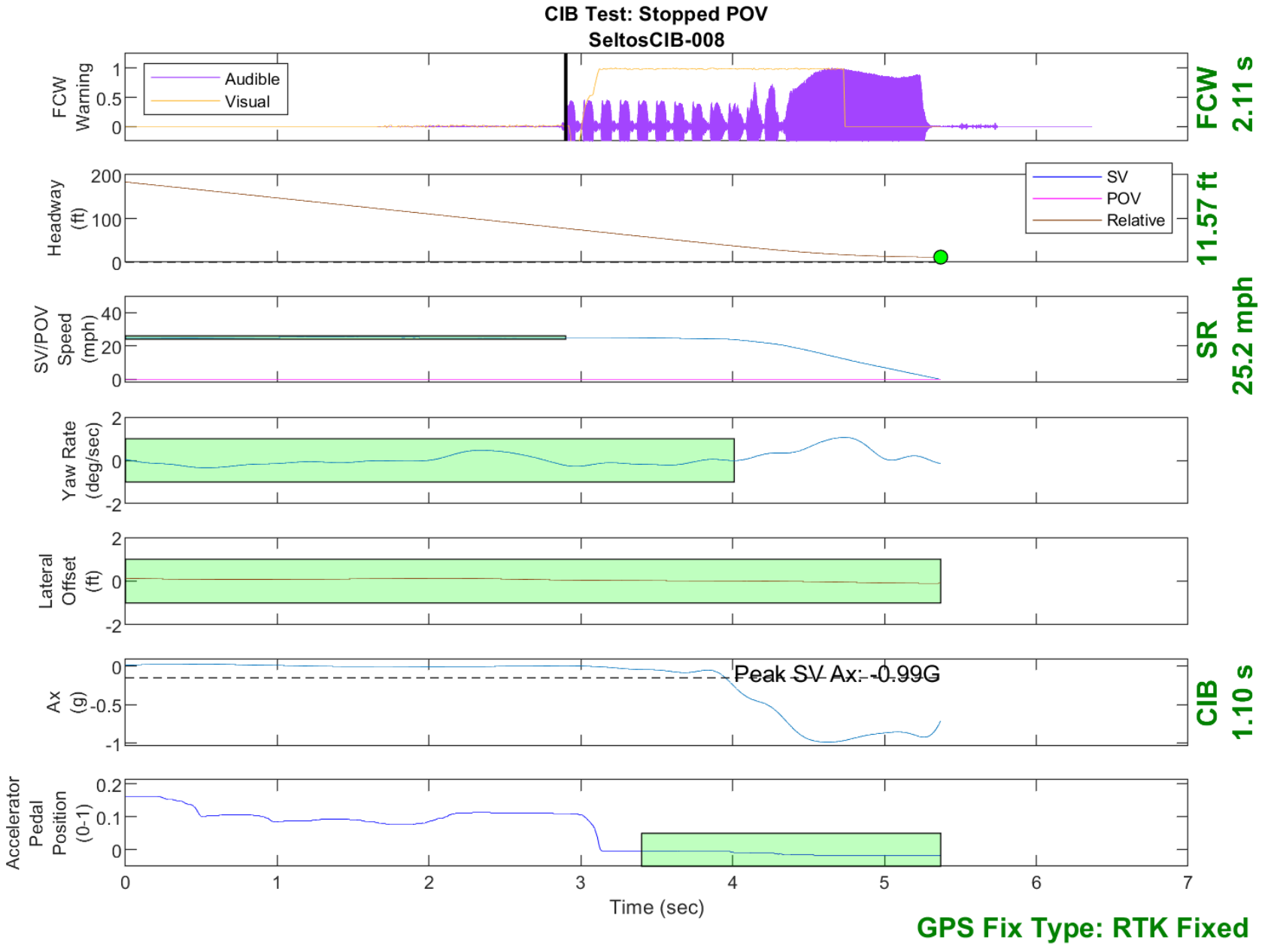


Figure D16. Time History for CIB Run 8, SV Encounters Stopped POV

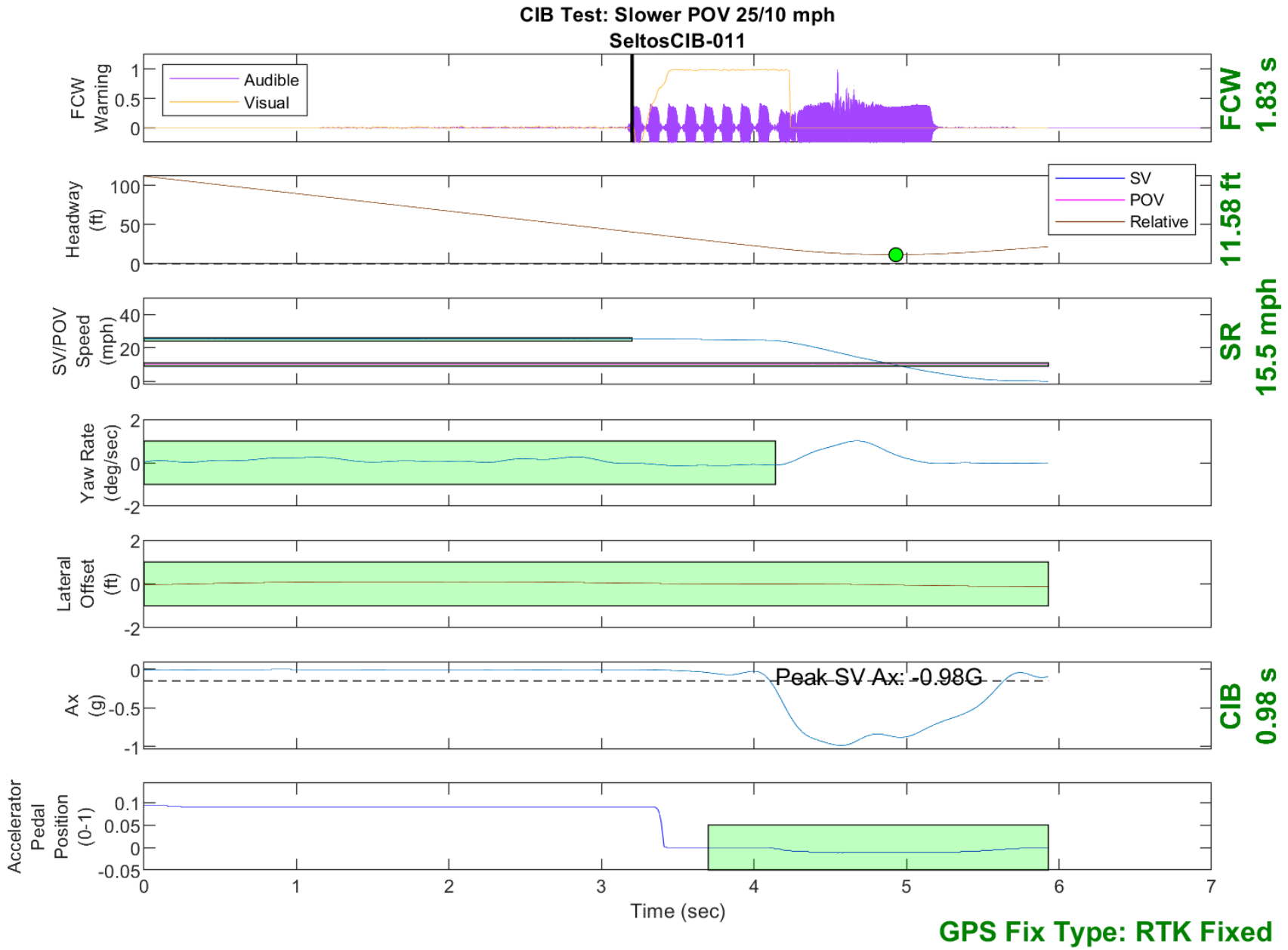


Figure D17. Time History for CIB Run 11, SV Encounters Slower POV, SV 25 mph, POV 10 mph

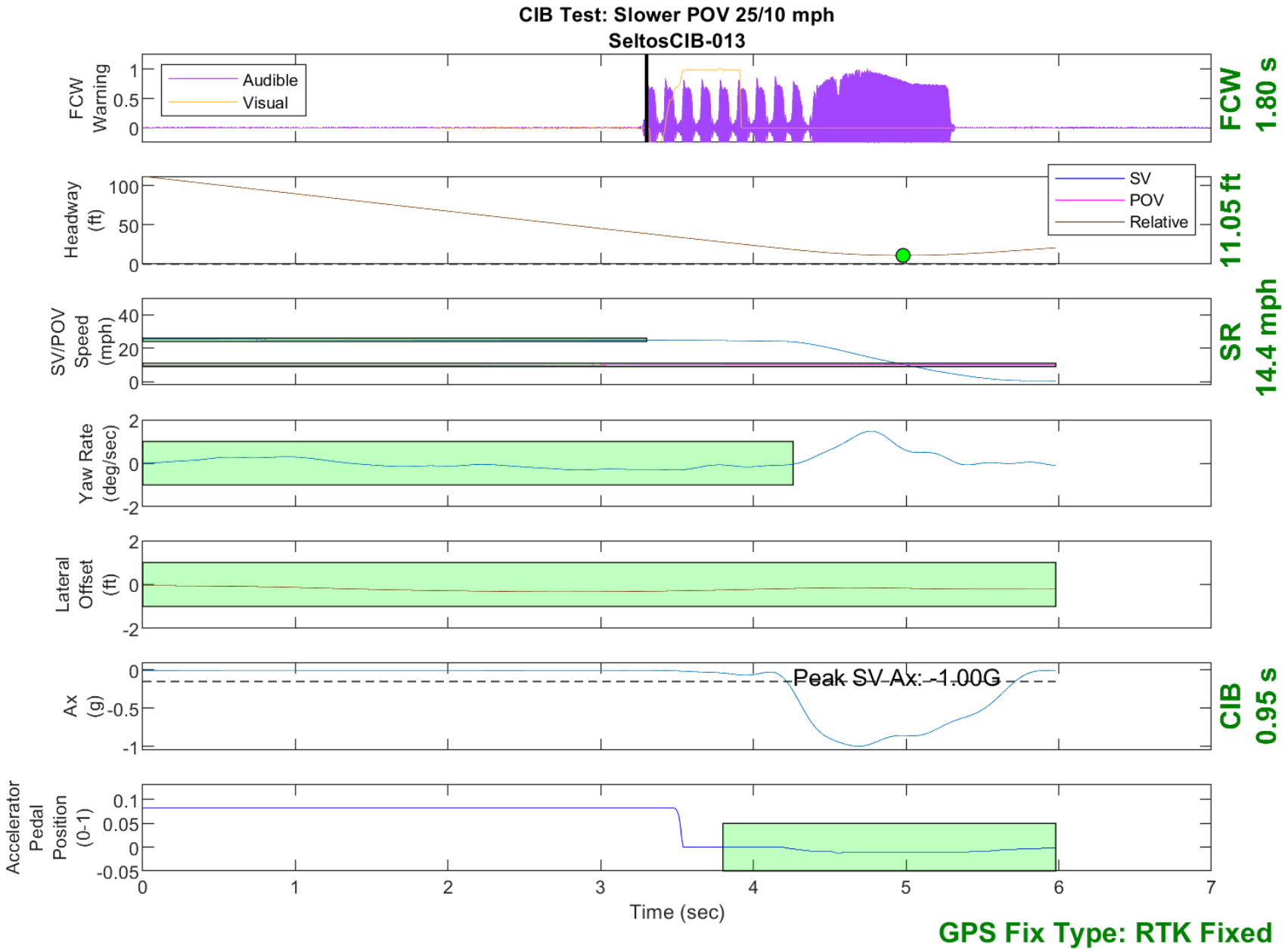


Figure D18. Time History for CIB Run 13, SV Encounters Slower POV, SV 25 mph, POV 10 mph

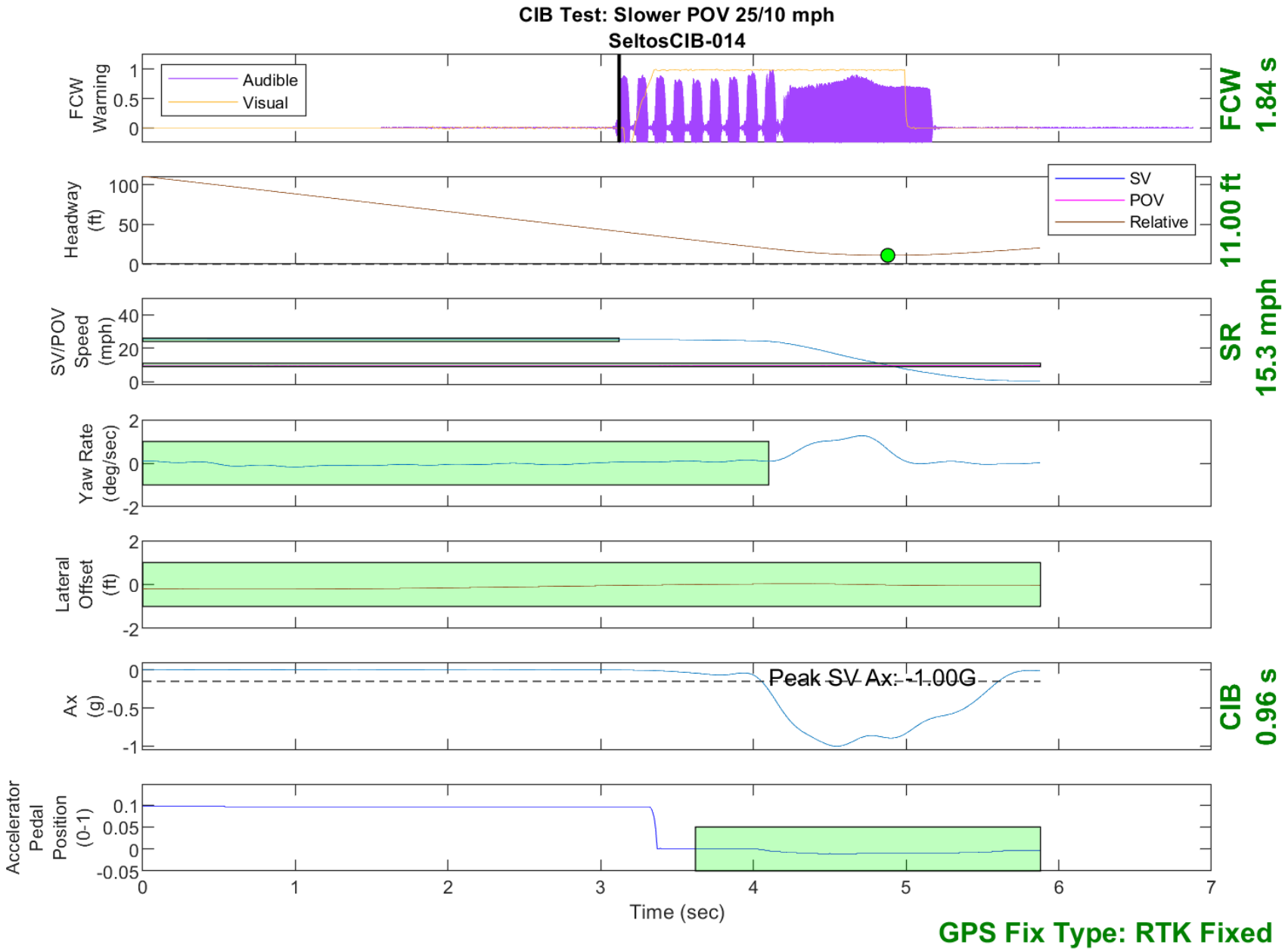


Figure D19. Time History for CIB Run 14, SV Encounters Slower POV, SV 25 mph, POV 10 mph

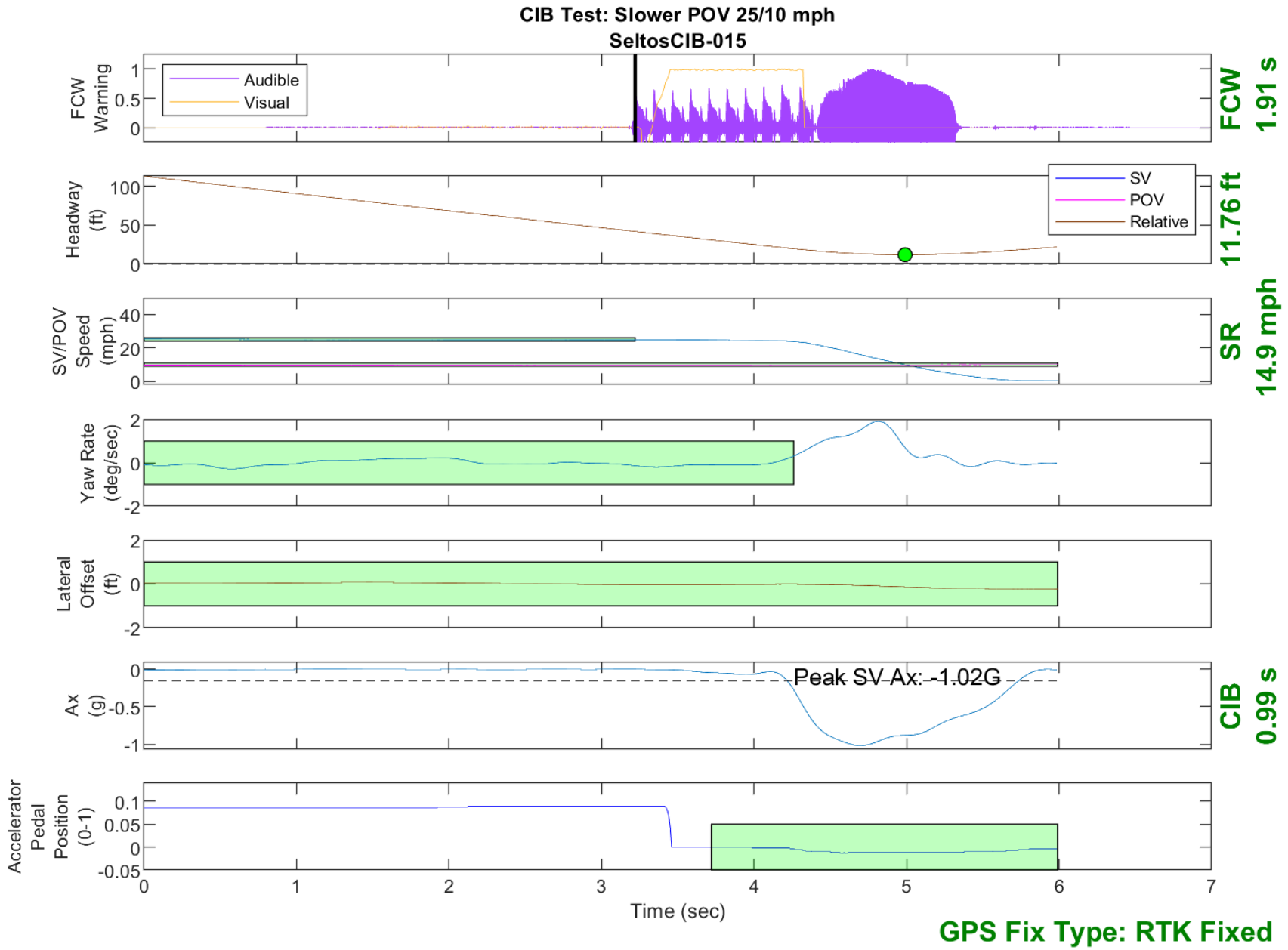


Figure D20. Time History for CIB Run 15, SV Encounters Slower POV, SV 25 mph, POV 10 mph

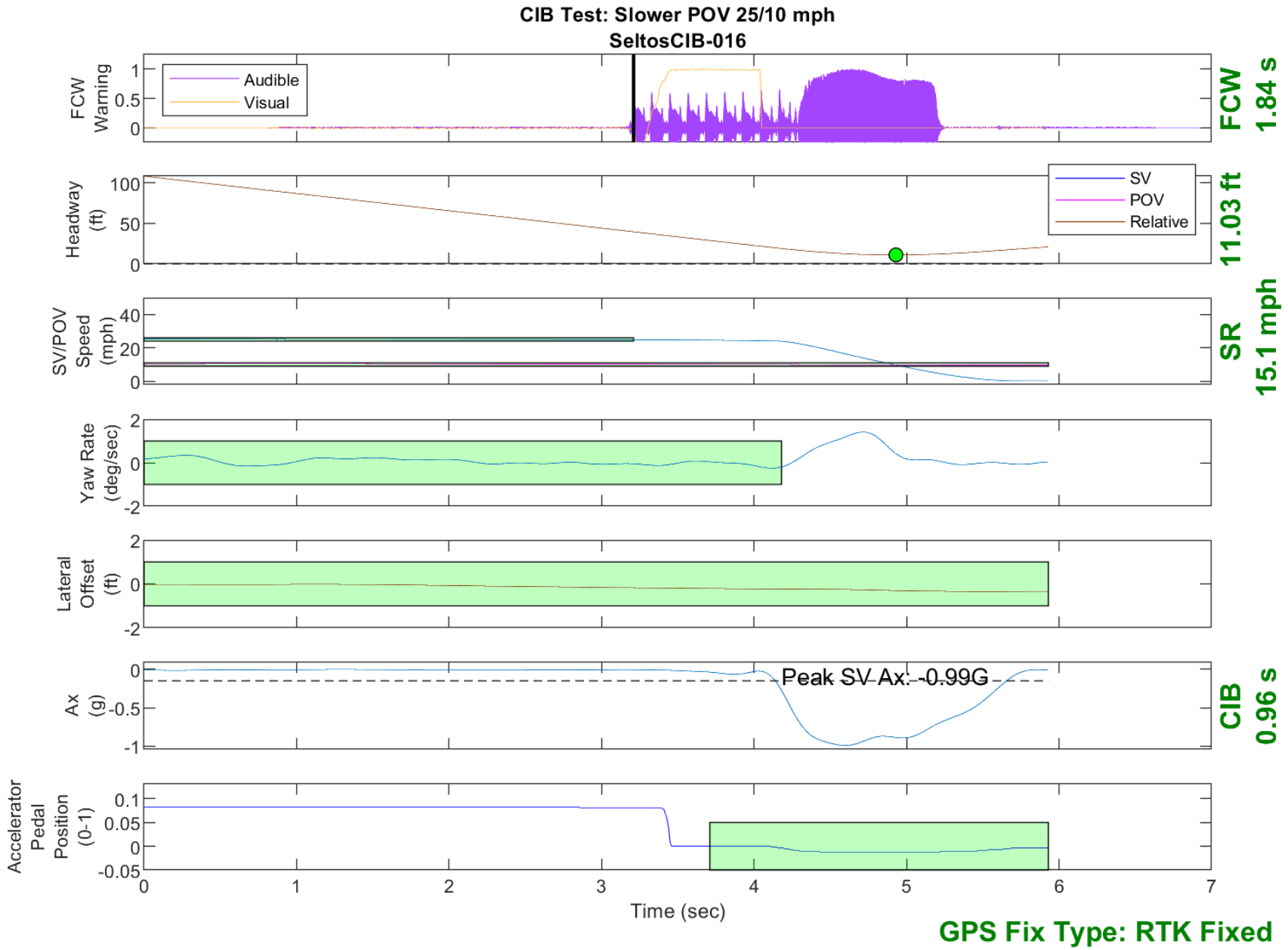


Figure D21. Time History for CIB Run 16, SV Encounters Slower POV, SV 25 mph, POV 10 mph

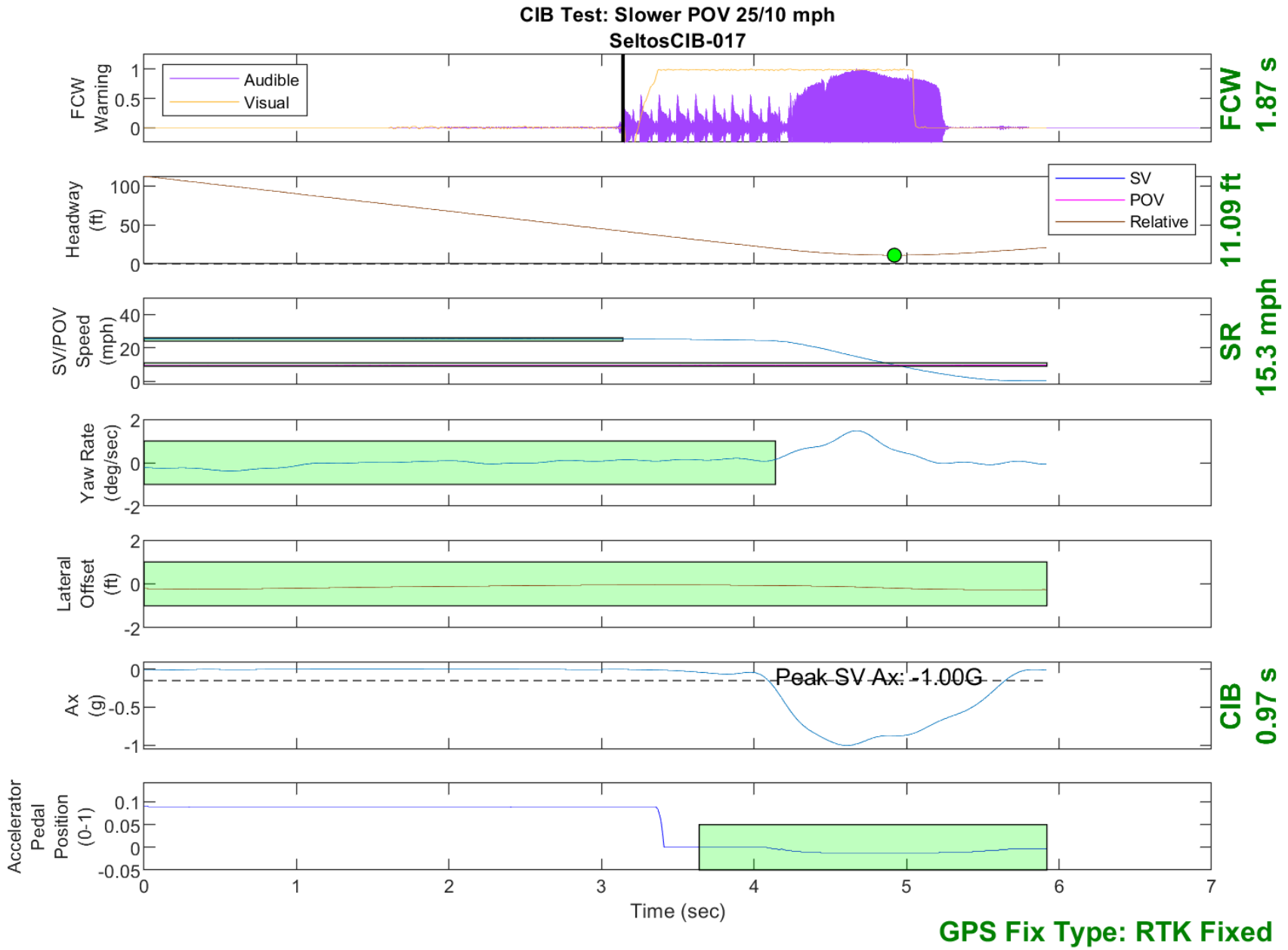


Figure D22. Time History for CIB Run 17, SV Encounters Slower POV, SV 25 mph, POV 10 mph

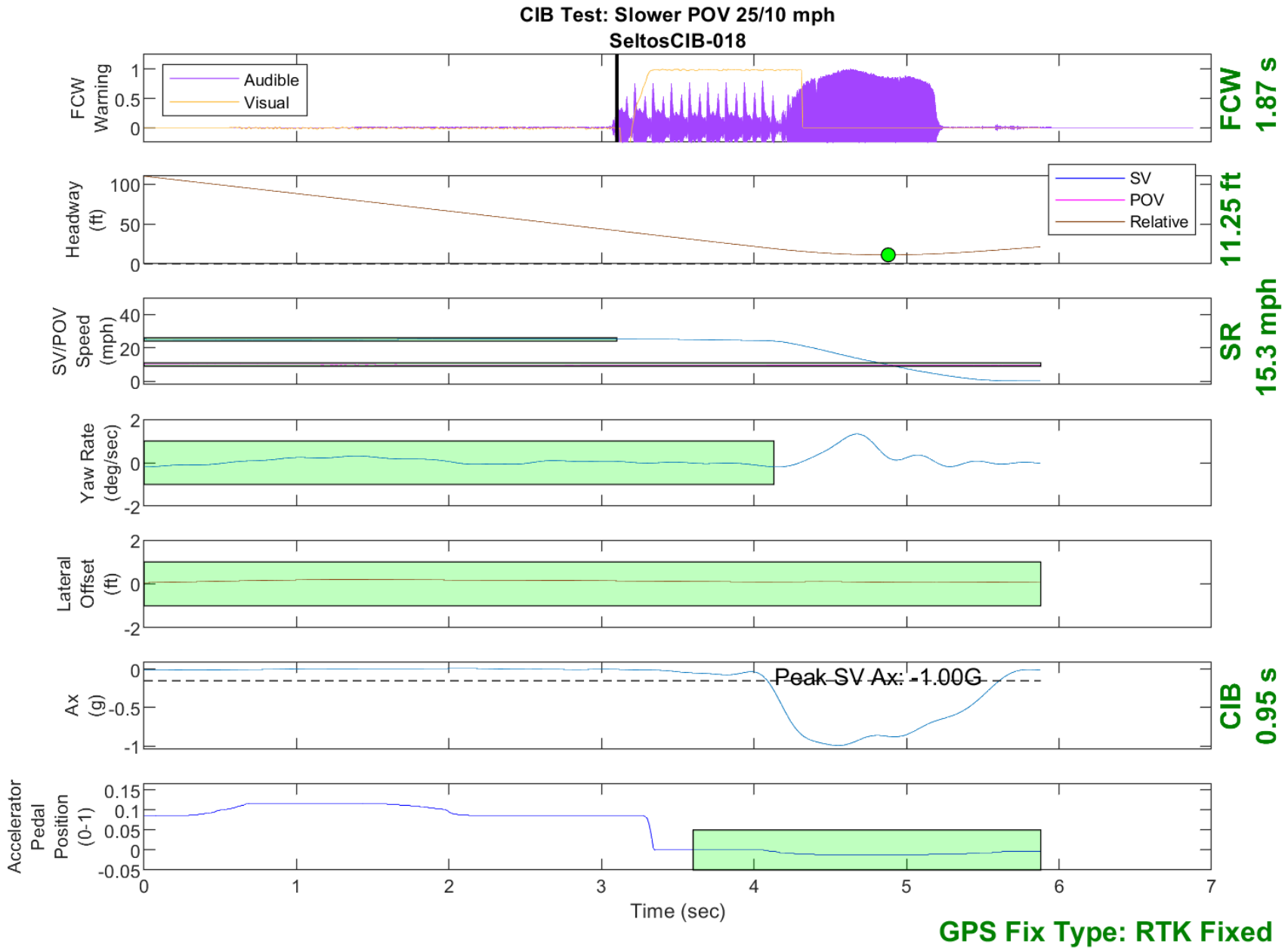


Figure D23. Time History for CIB Run 18, SV Encounters Slower POV, SV 25 mph, POV 10 mph

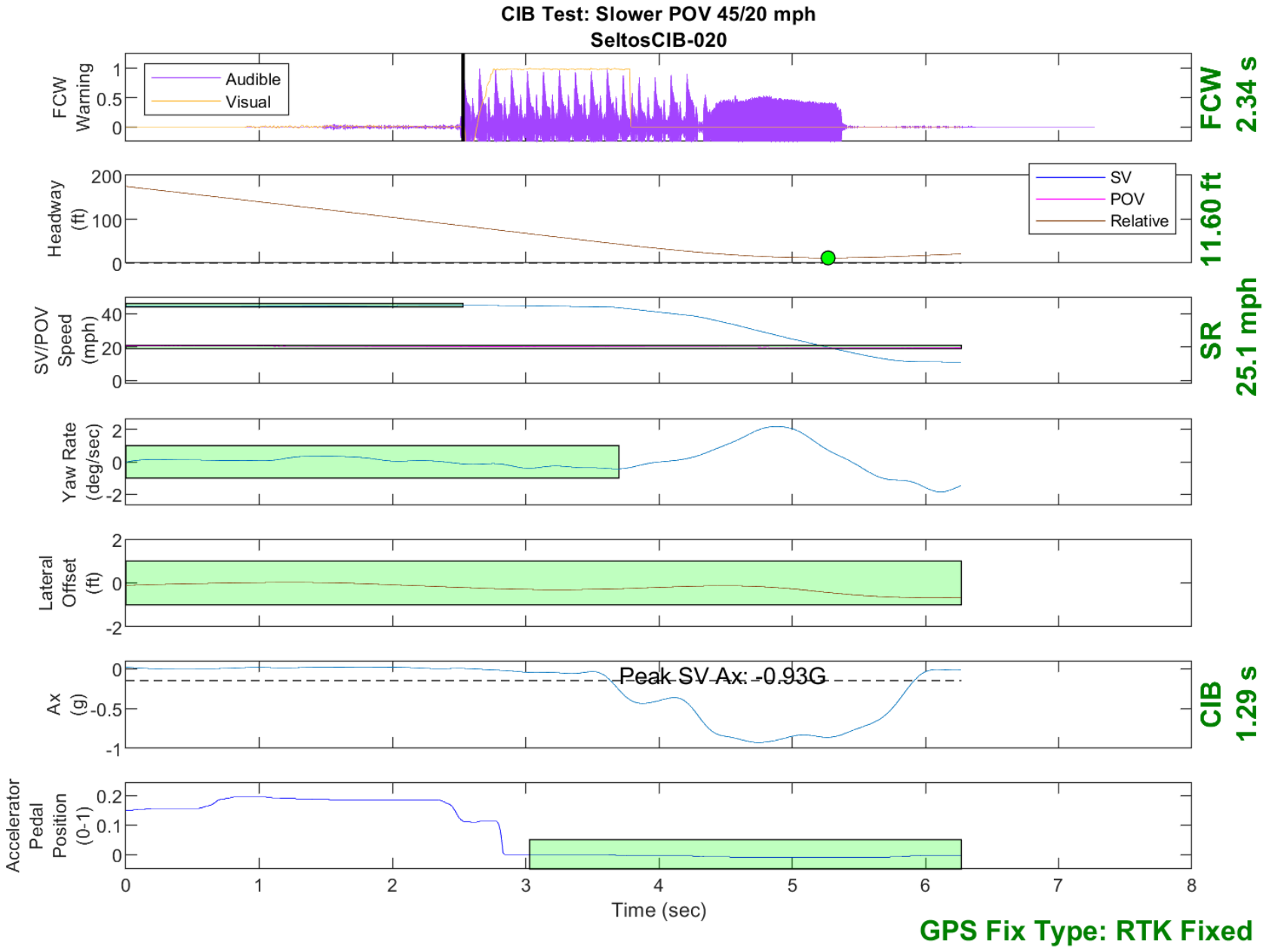


Figure D24. Time History for CIB Run 20, SV Encounters Slower POV, SV 45 mph, POV 20 mph

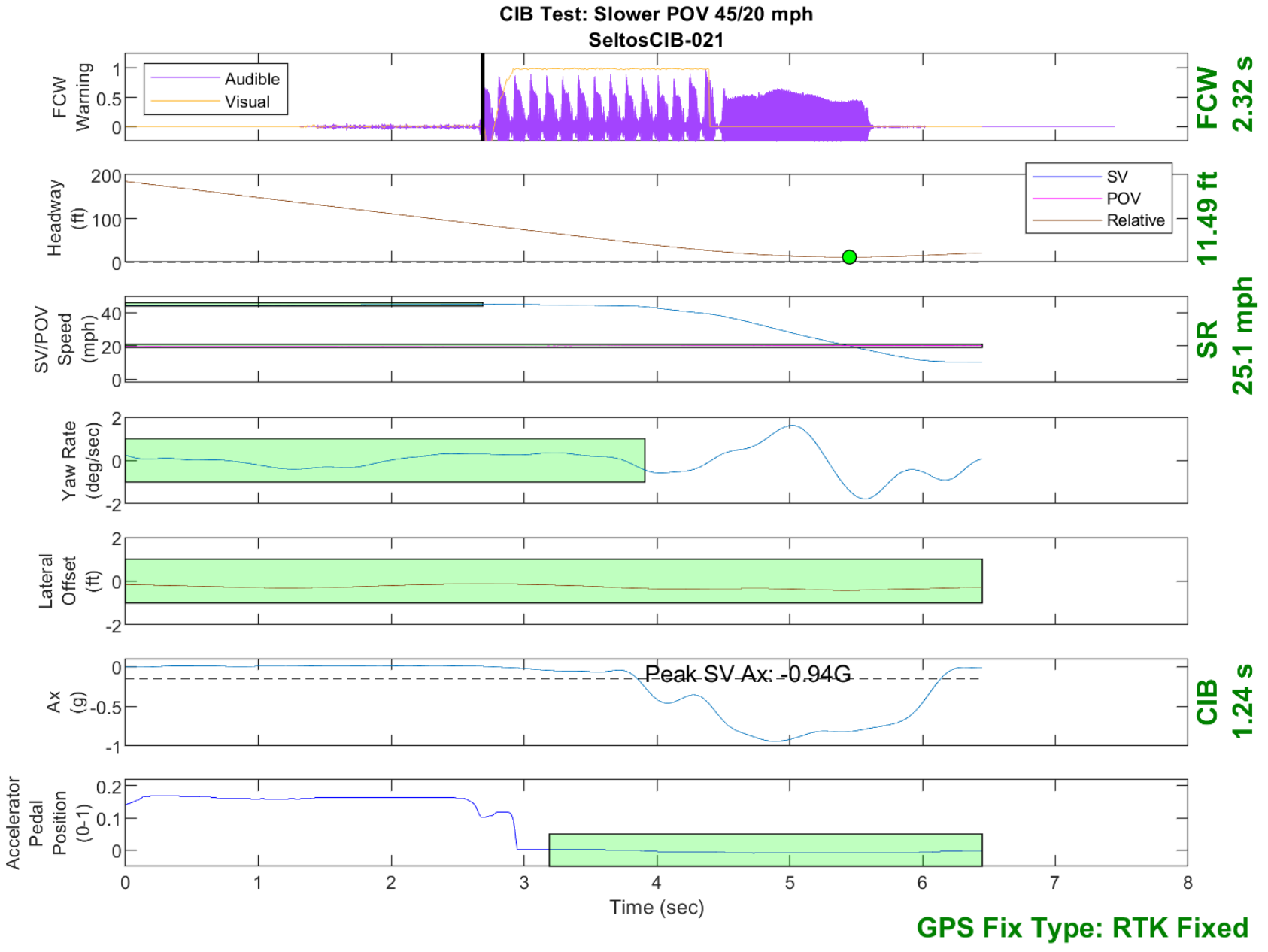


Figure D25. Time History for CIB Run 21, SV Encounters Slower POV, SV 45 mph, POV 20 mph

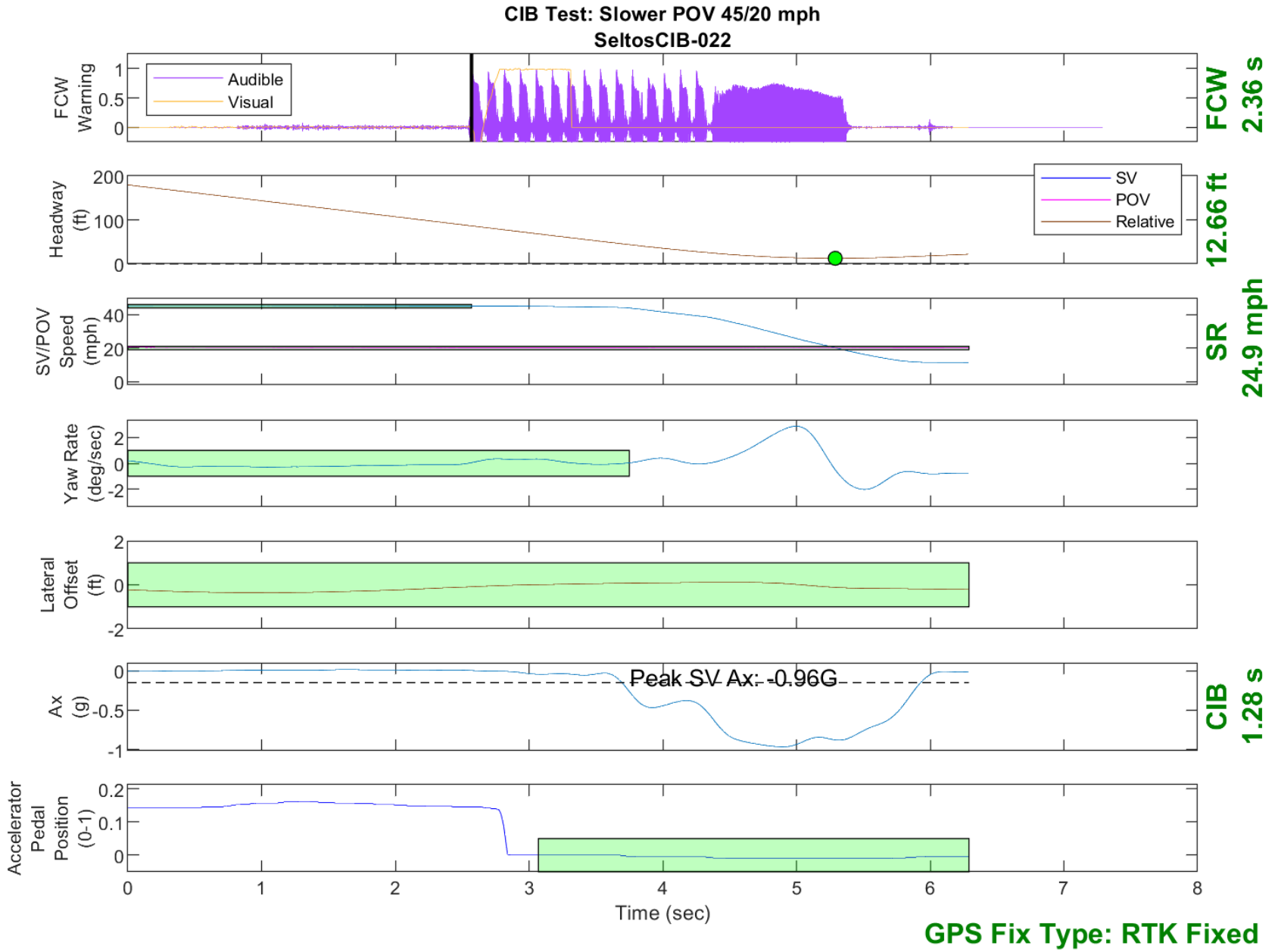


Figure D26. Time History for CIB Run 22, SV Encounters Slower POV, SV 45 mph, POV 20 mph

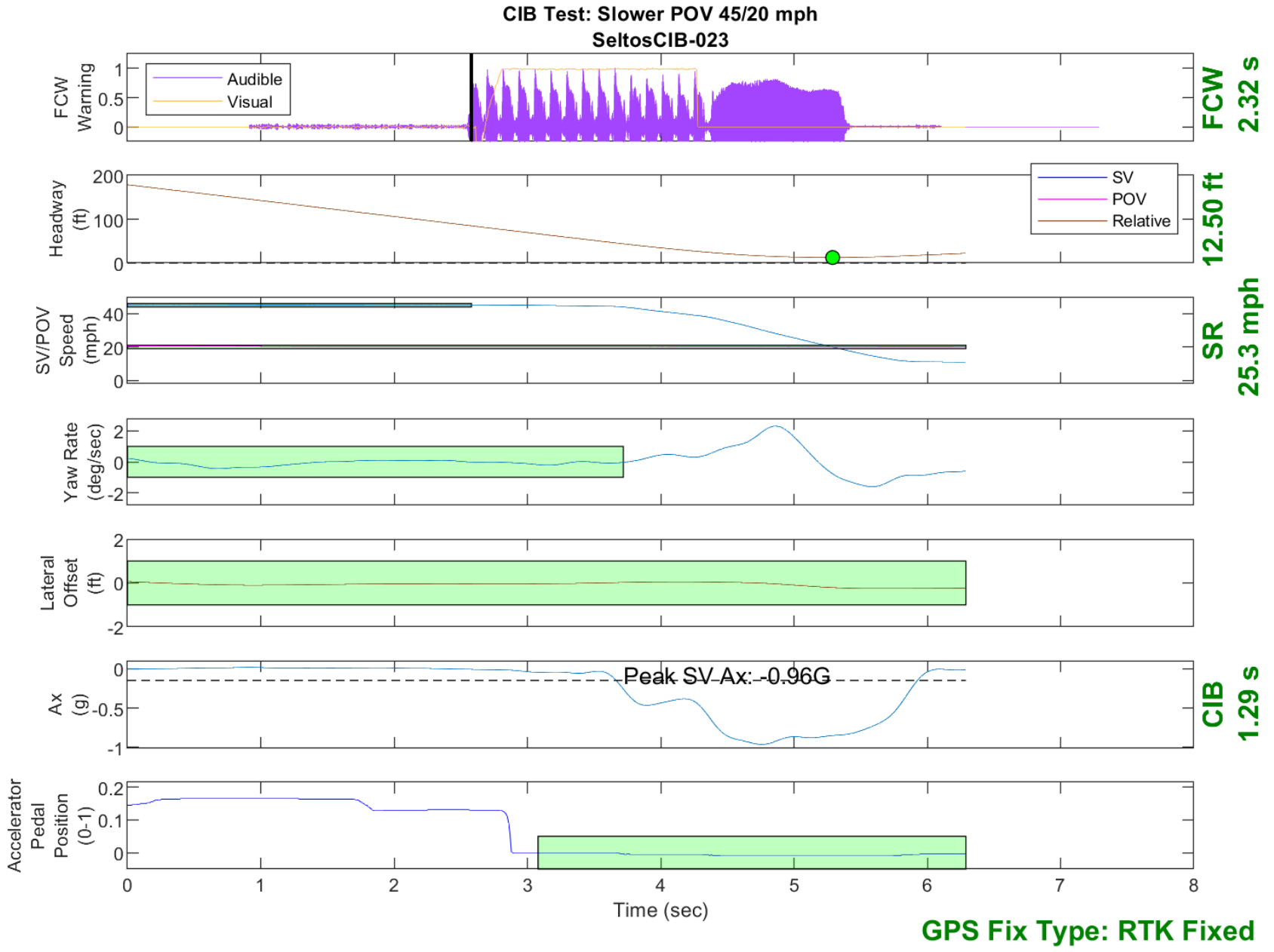


Figure D27. Time History for CIB Run 23, SV Encounters Slower POV, SV 45 mph, POV 20 mph

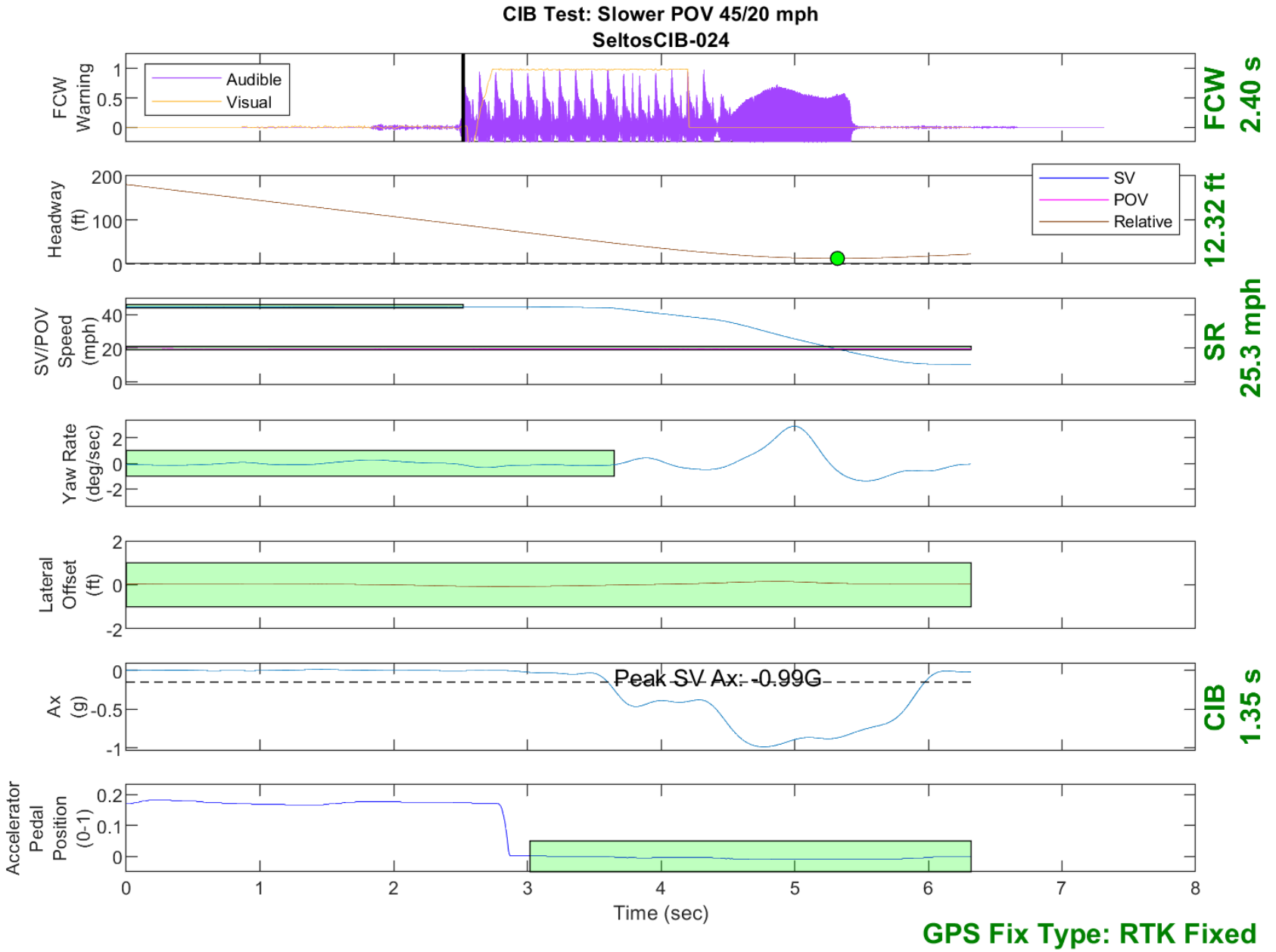


Figure D28. Time History for CIB Run 24, SV Encounters Slower POV, SV 45 mph, POV 20 mph

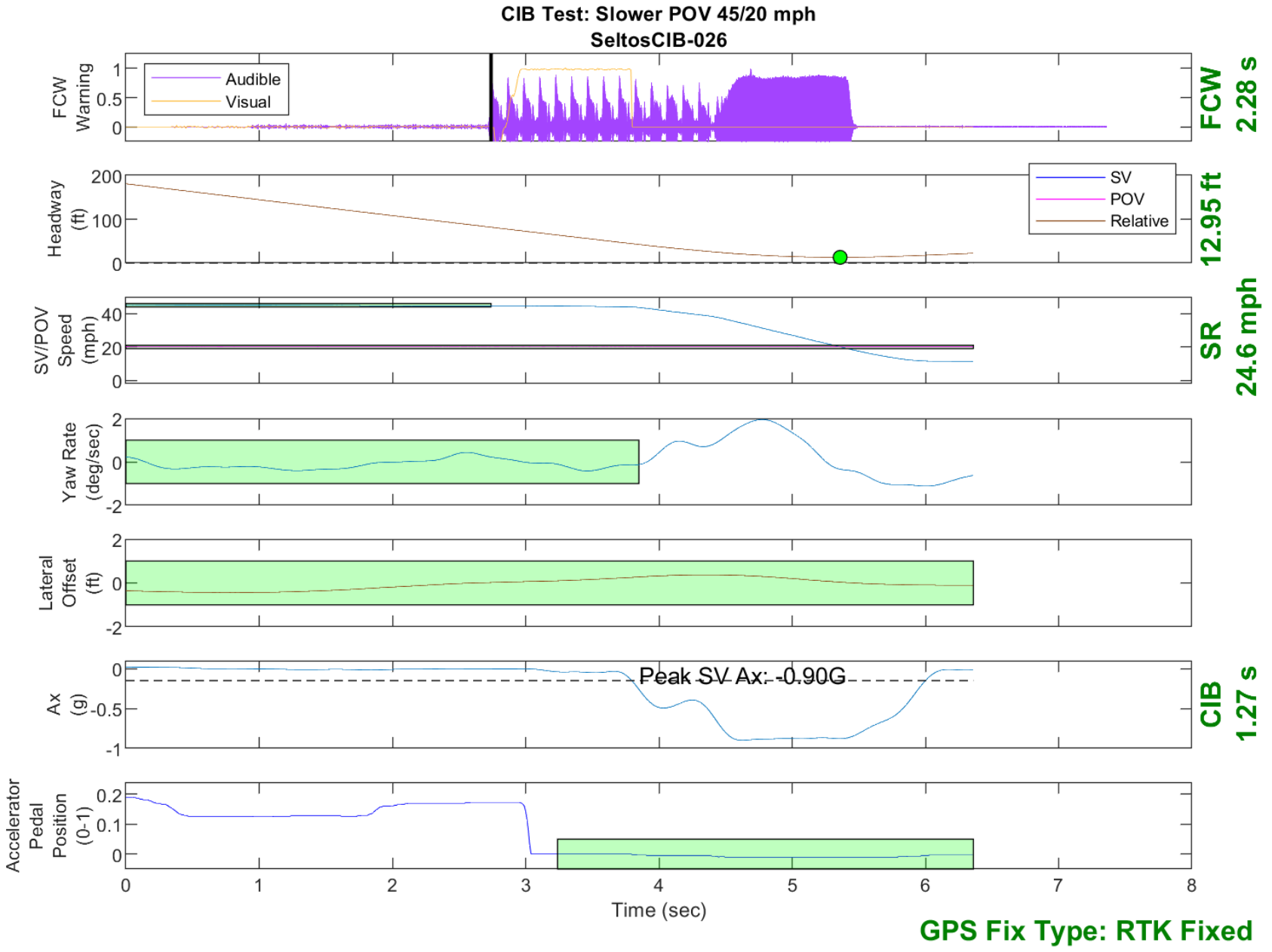


Figure D29. Time History for CIB Run 26, SV Encounters Slower POV, SV 45 mph, POV 20 mph

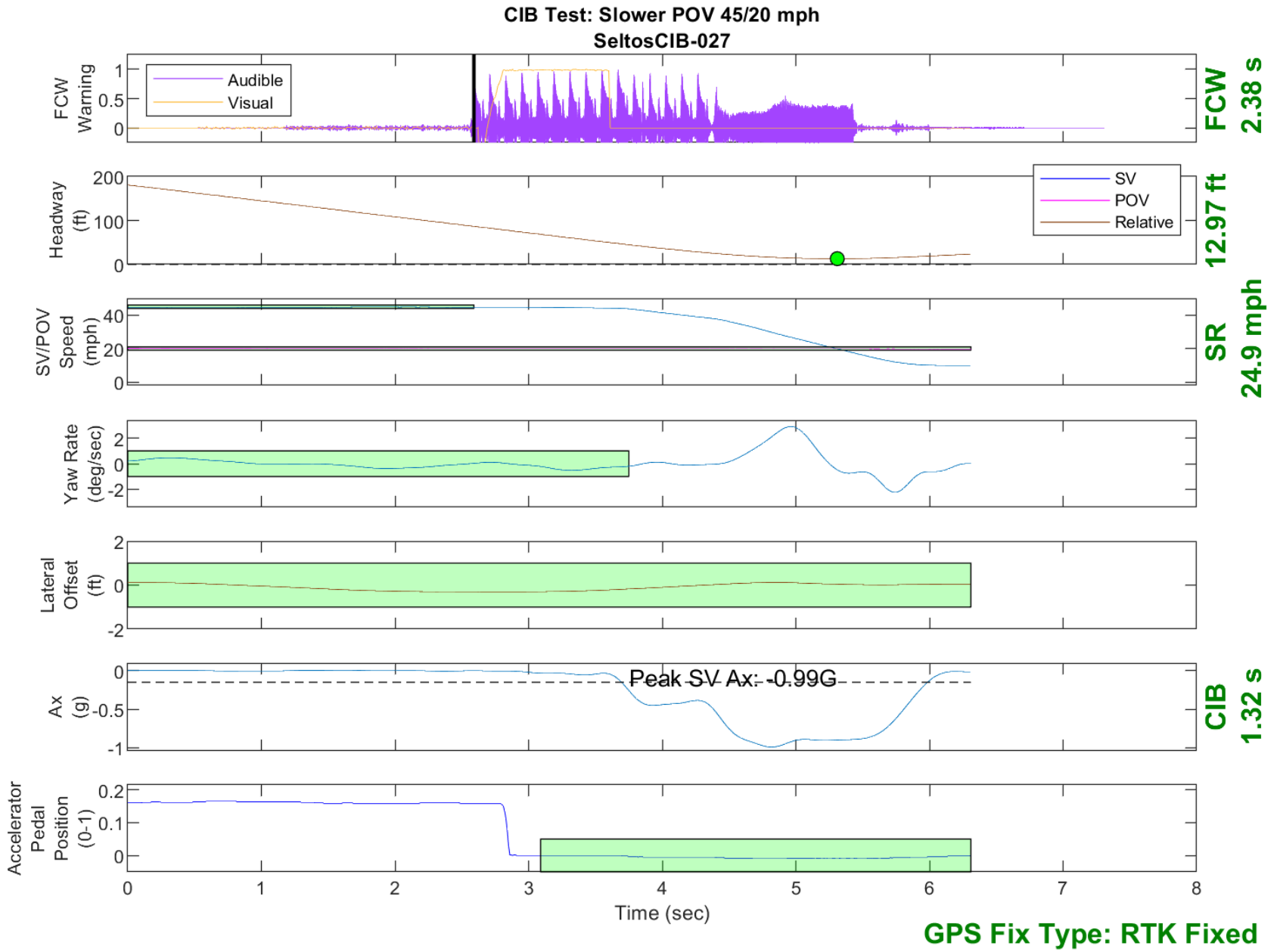


Figure D30. Time History for CIB Run 27, SV Encounters Slower POV, SV 45 mph, POV 20 mph

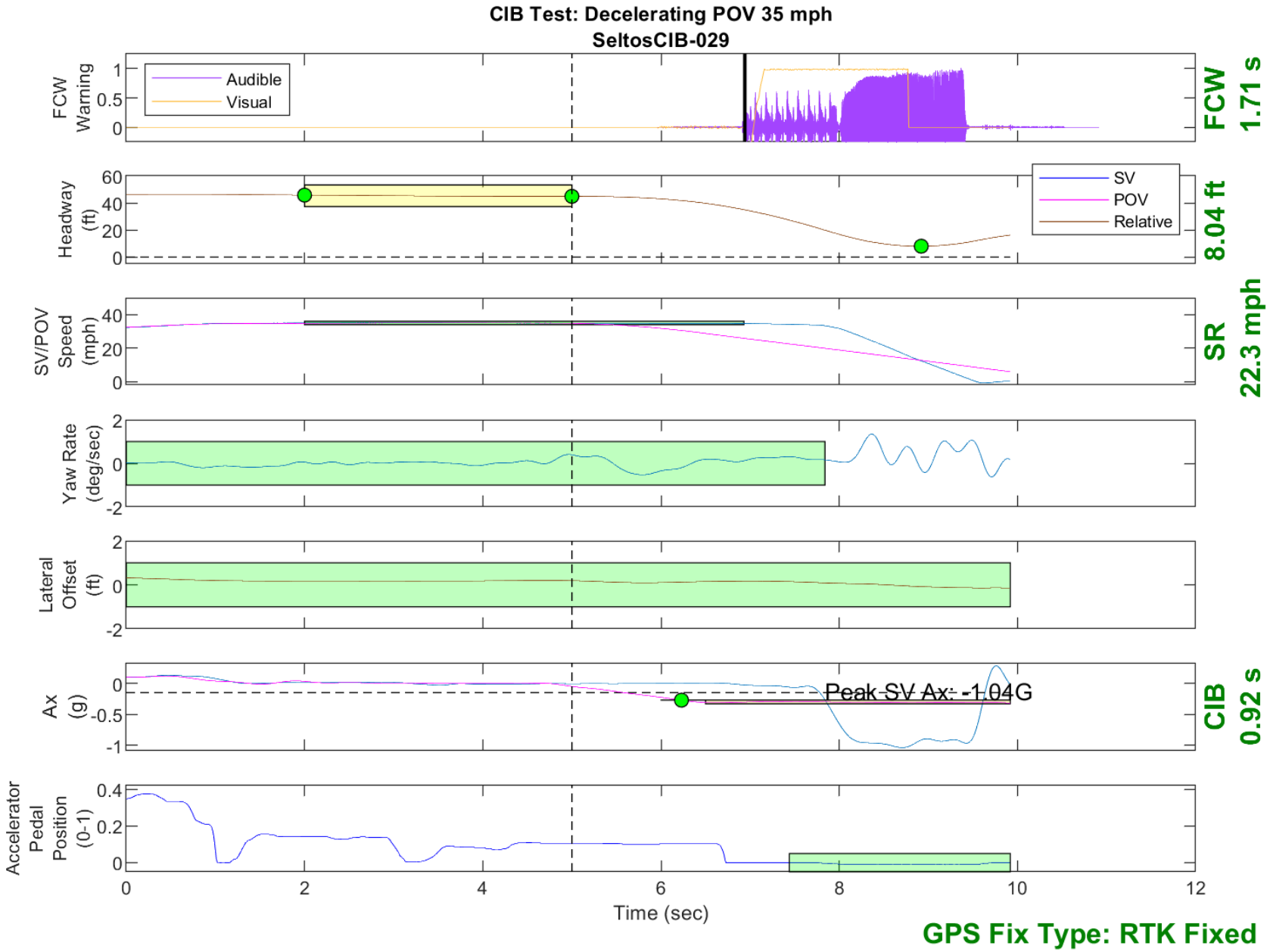


Figure D31. Time History for CIB Run 29, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

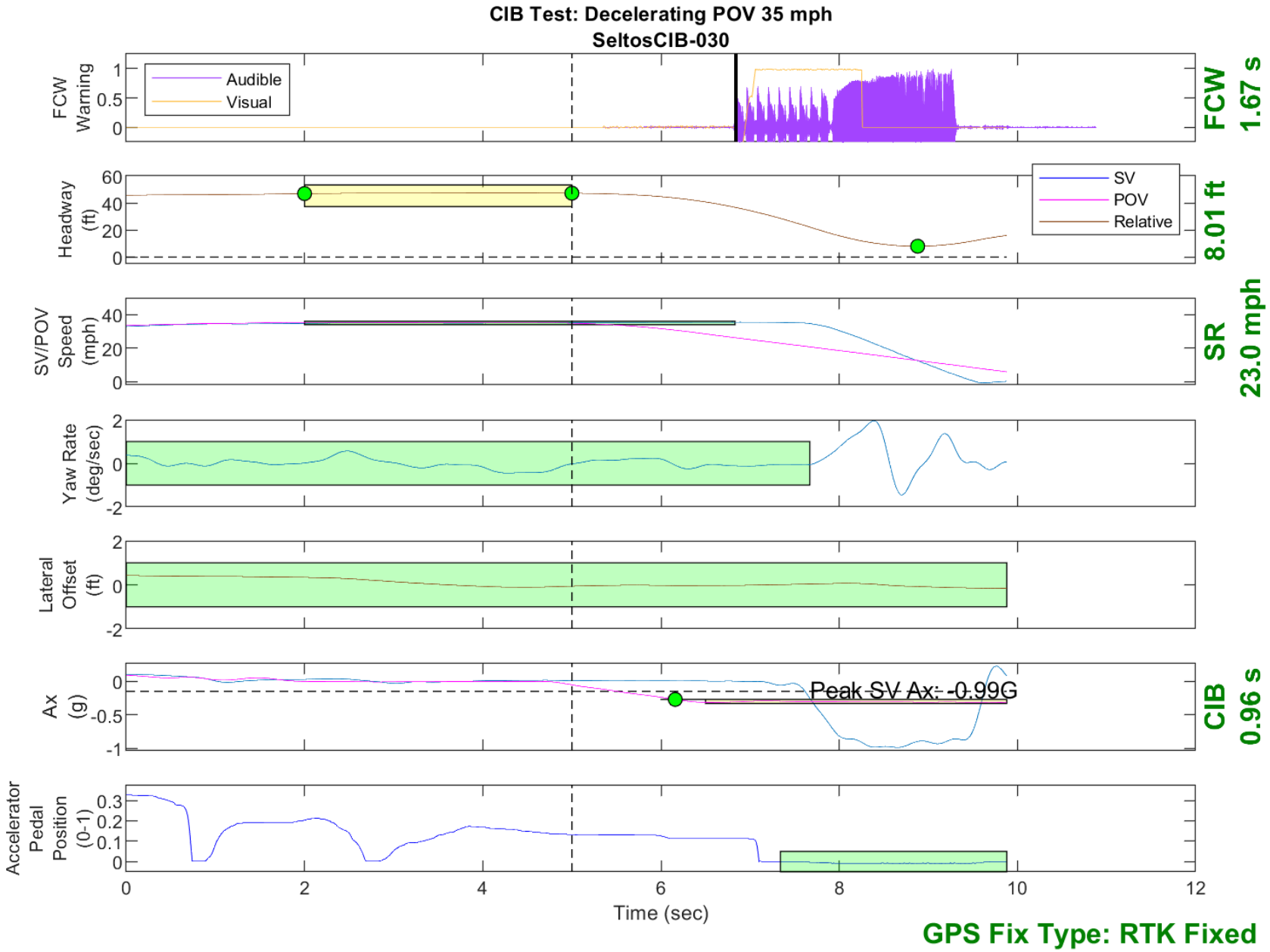


Figure D32. Time History for CIB Run 30, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

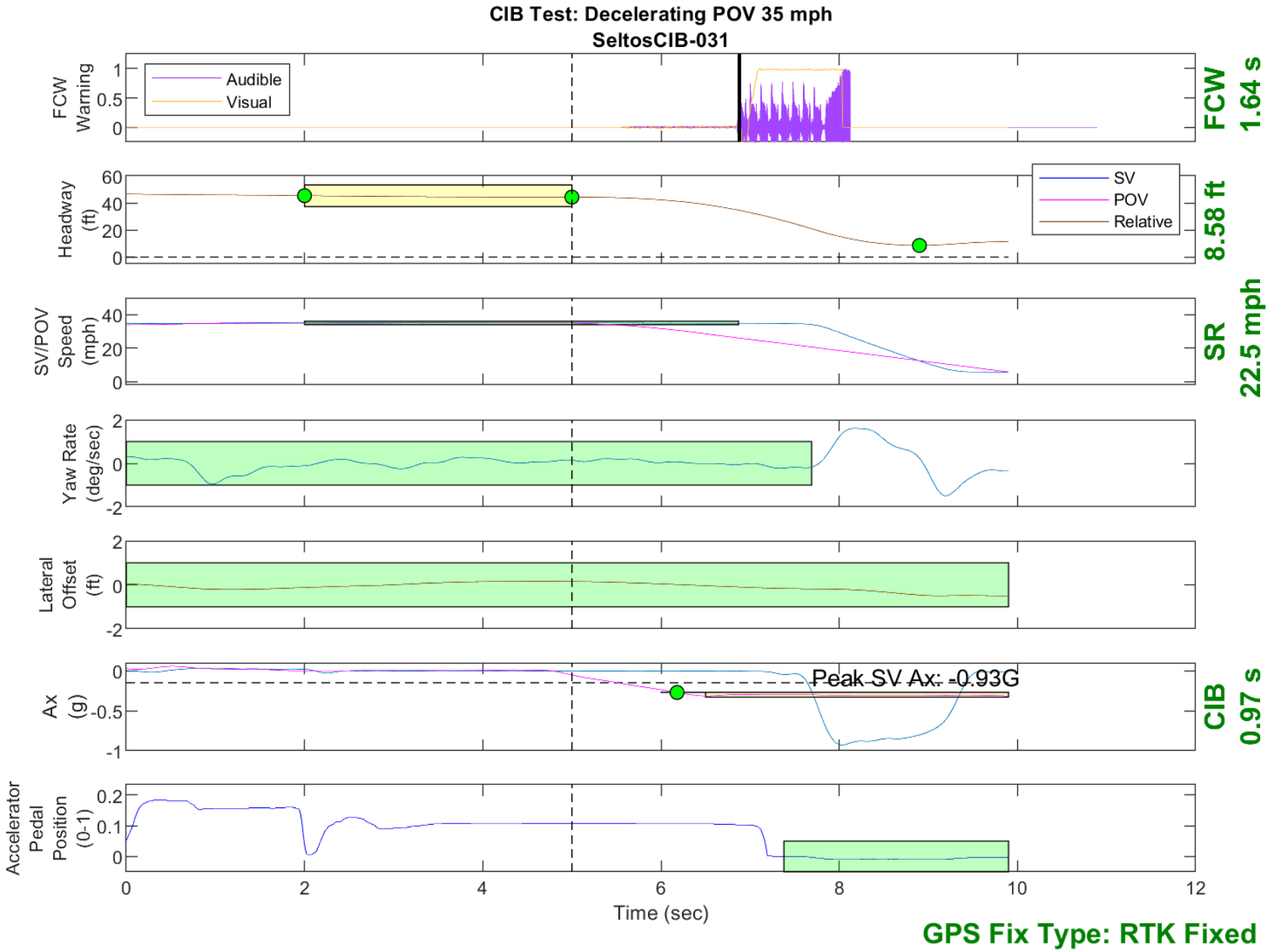


Figure D33. Time History for CIB Run 31, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

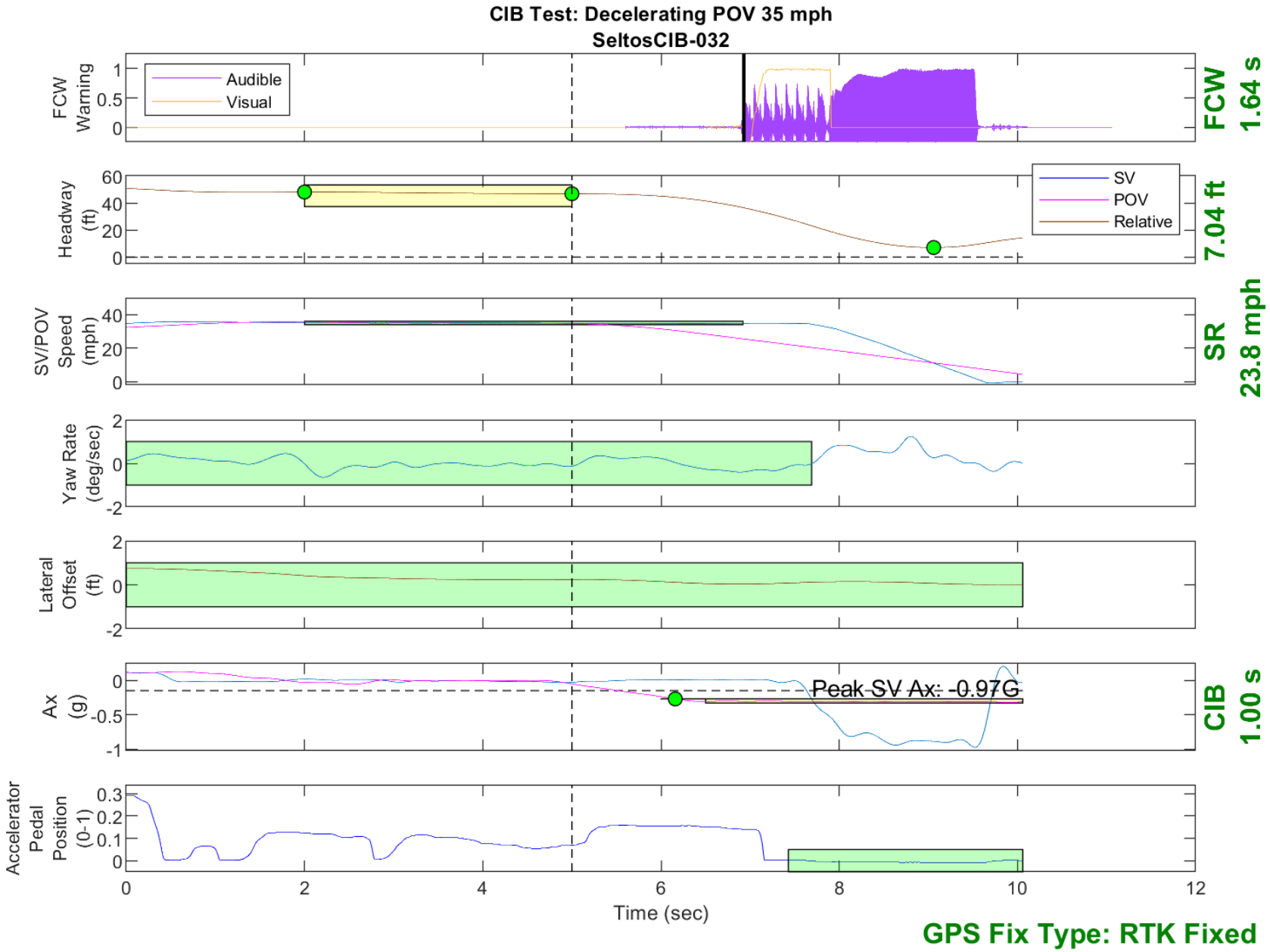


Figure D34. Time History for CIB Run 32, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

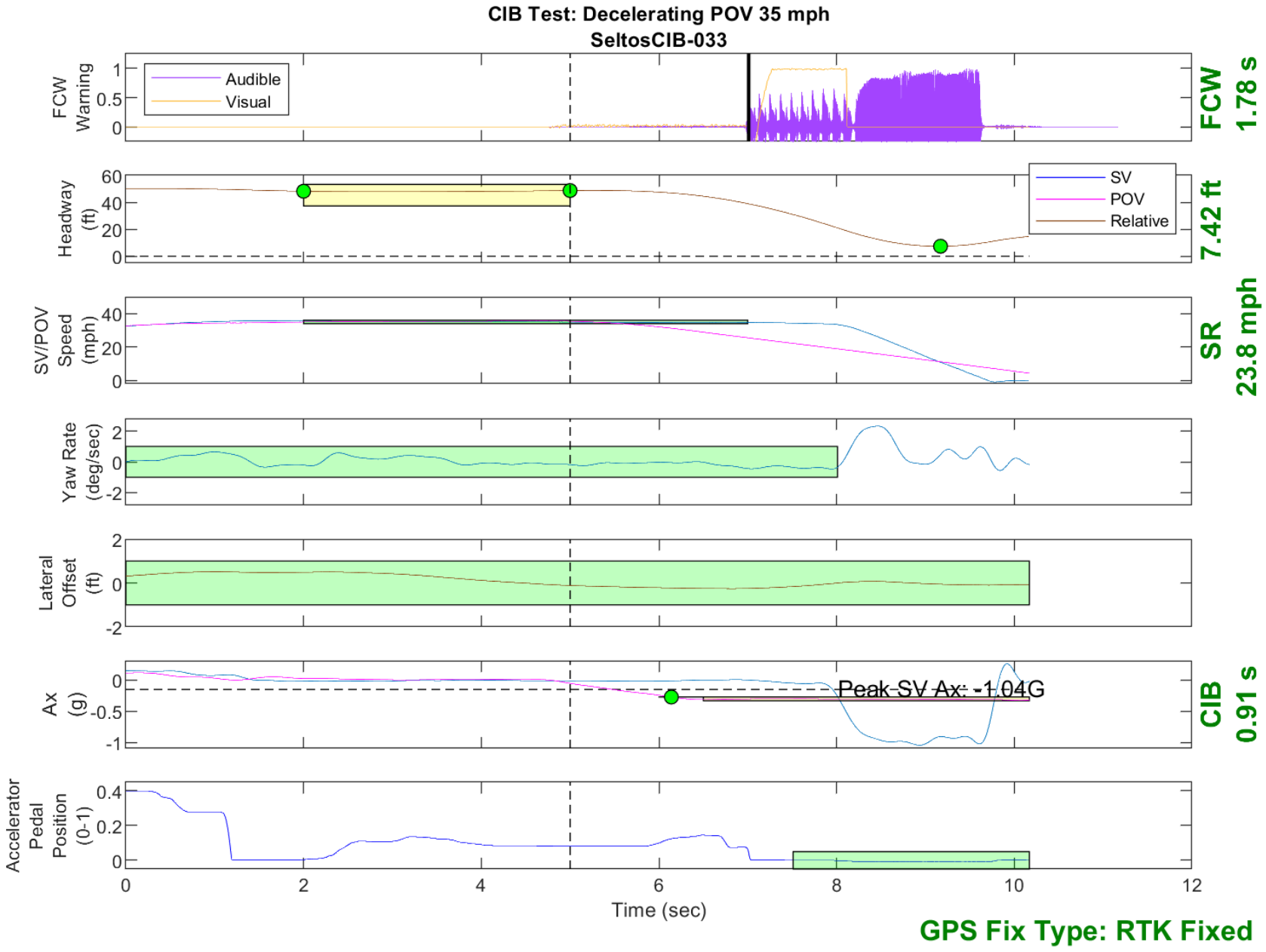


Figure D35. Time History for CIB Run 33, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

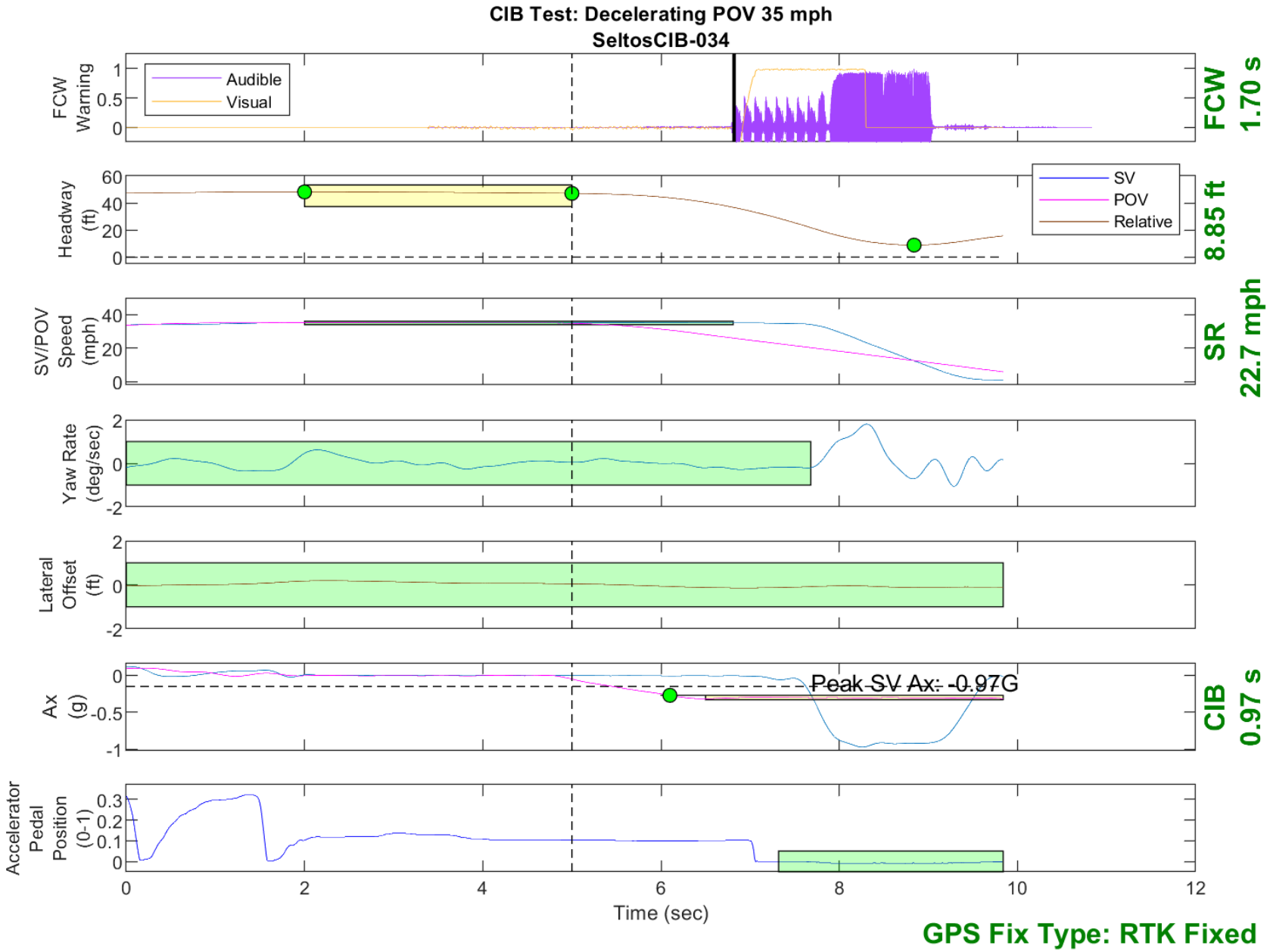


Figure D36. Time History for CIB Run 34, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

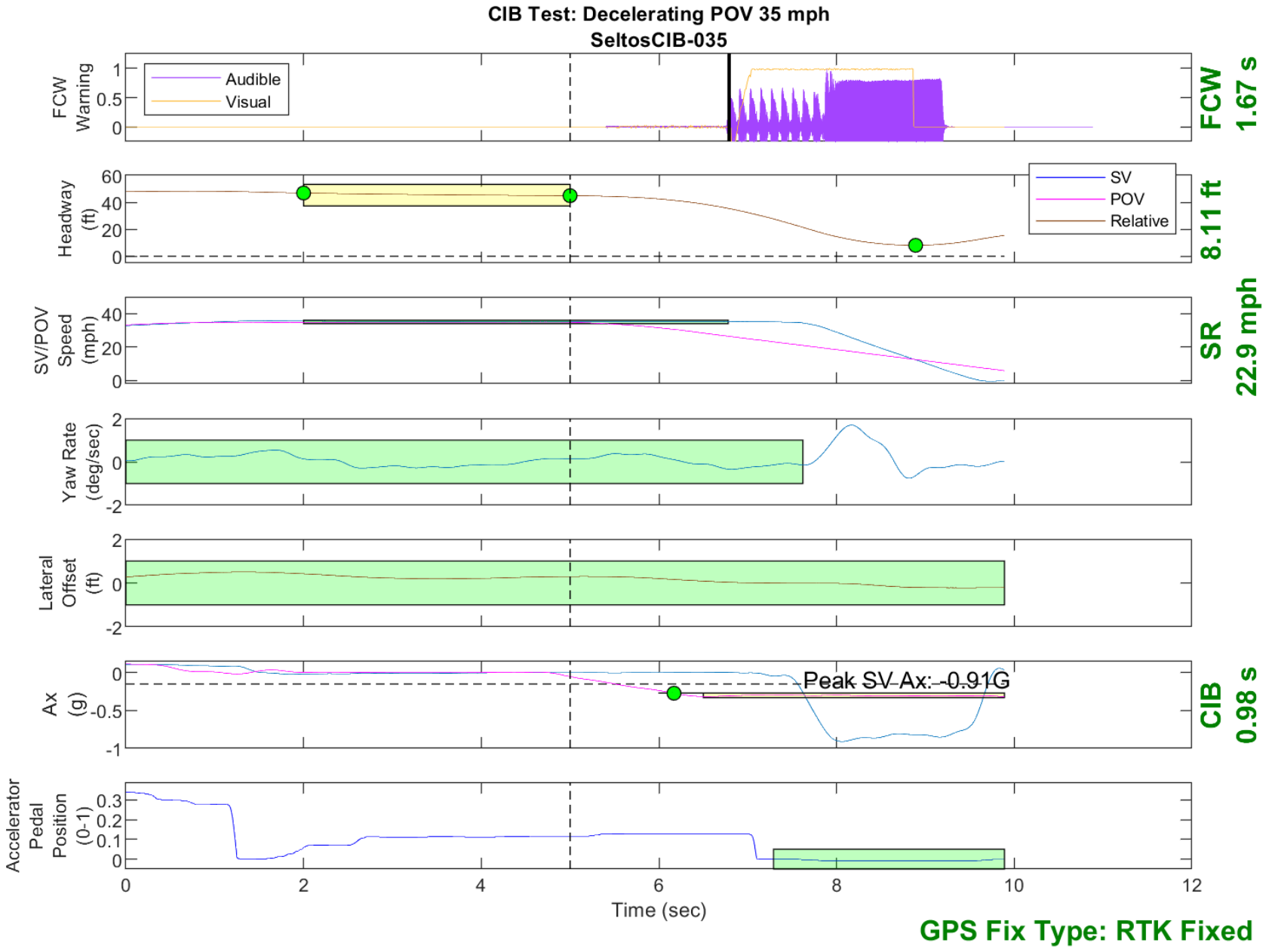


Figure D37. Time History for CIB Run 35, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

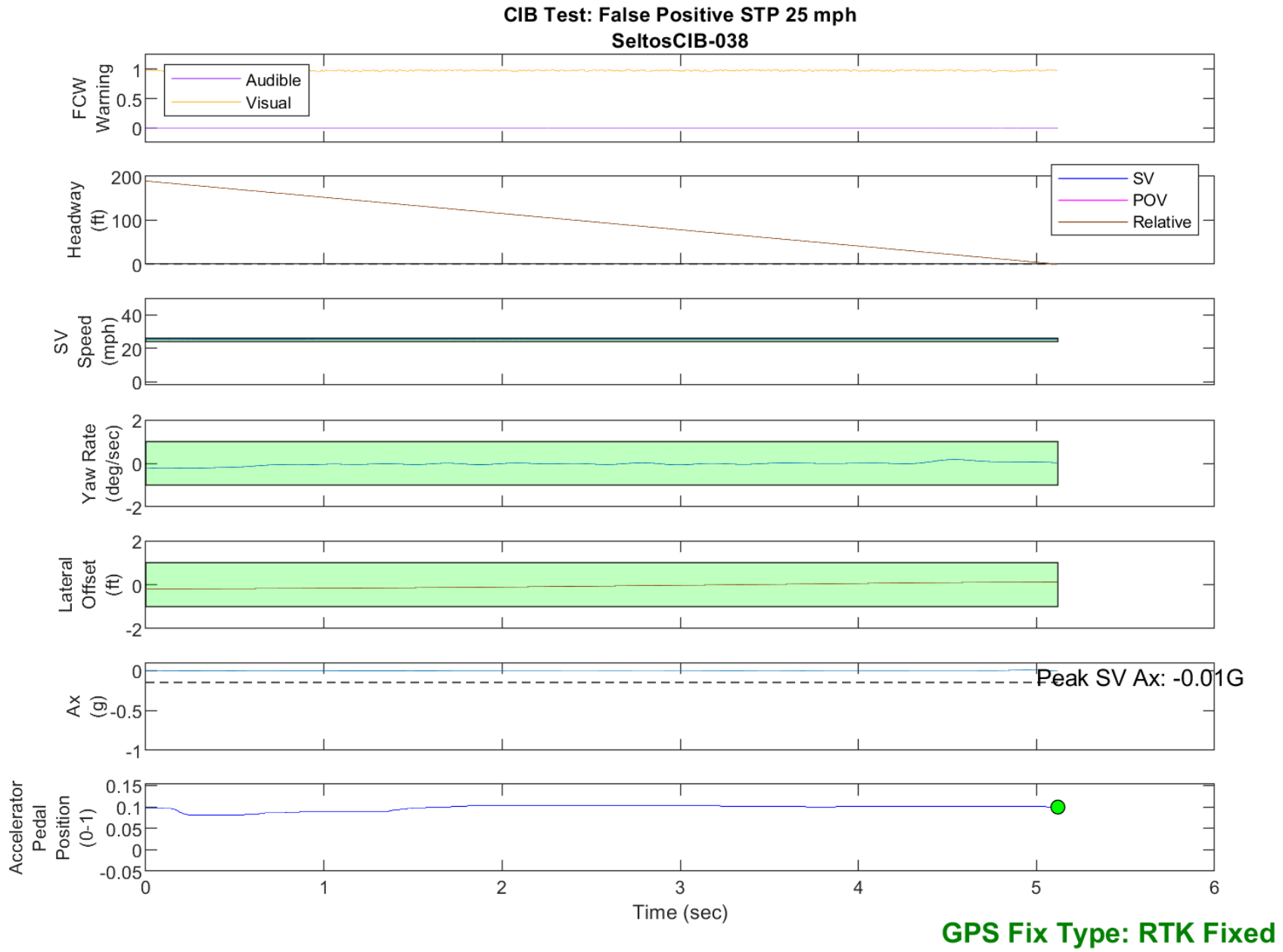


Figure D38. Time History for CIB Run 38, SV Encounters Steel Trench Plate, SV 25 mph

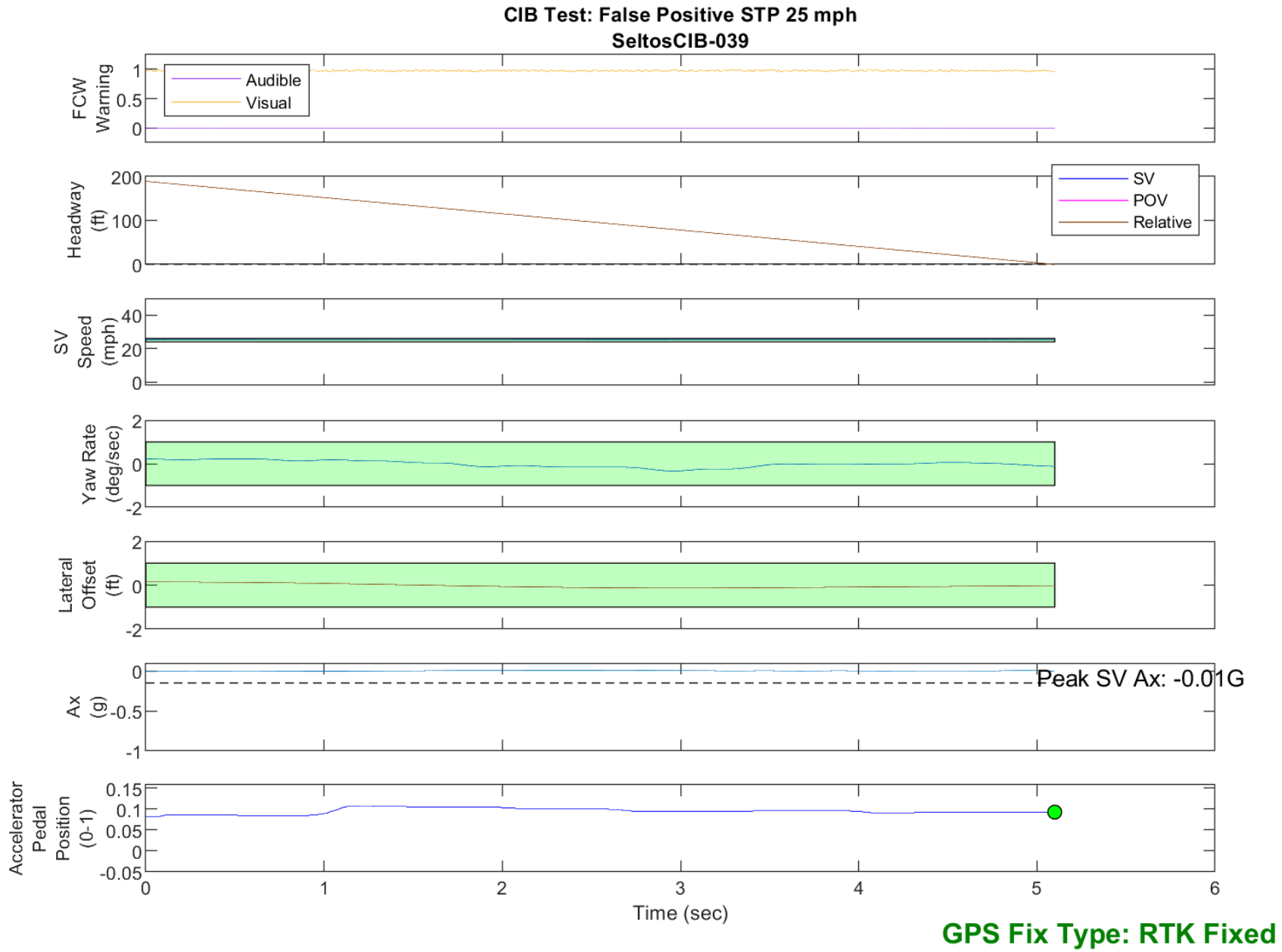


Figure D39. Time History for CIB Run 39, SV Encounters Steel Trench Plate, SV 25 mph

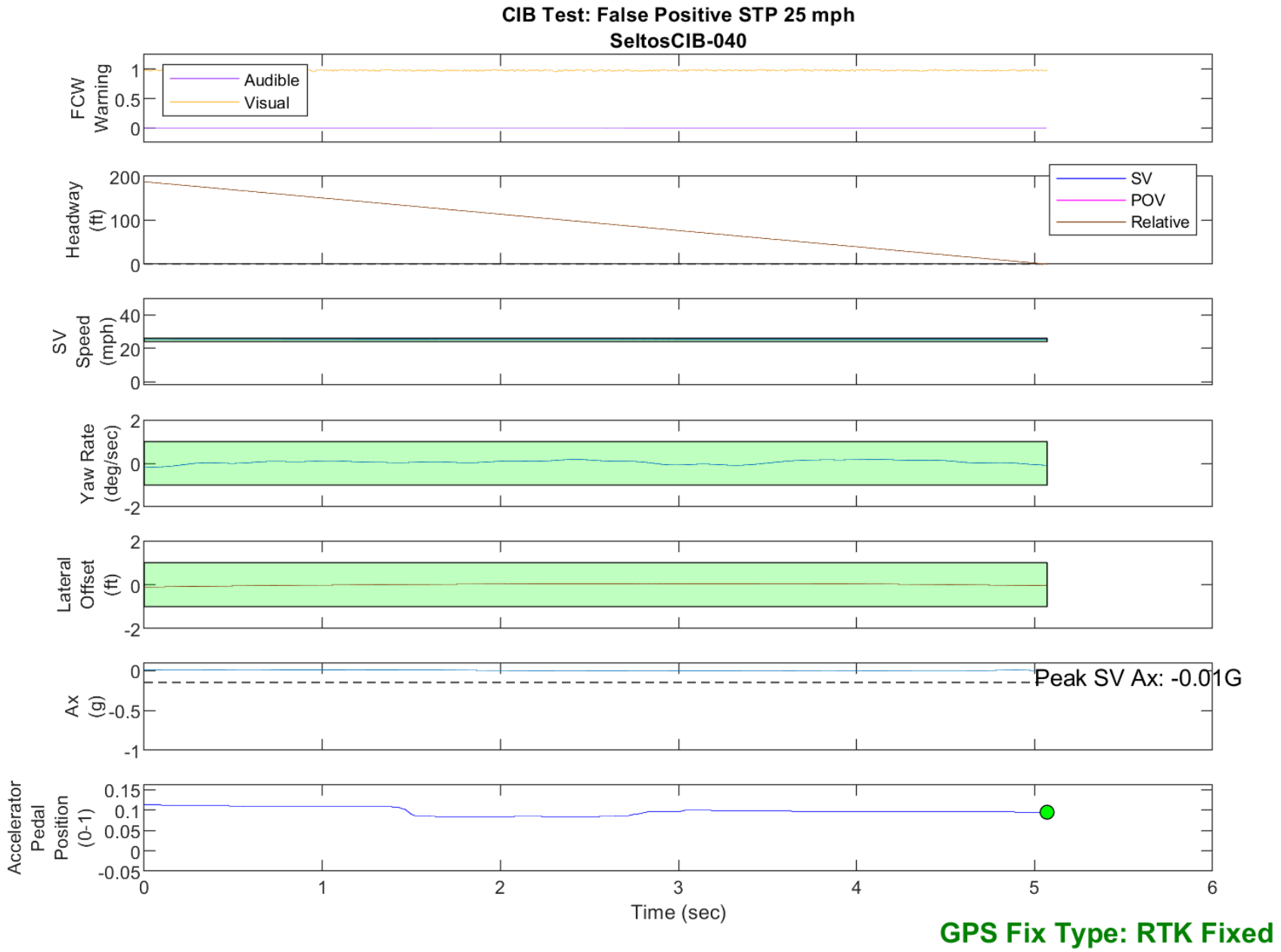


Figure D40. Time History for CIB Run 40, SV Encounters Steel Trench Plate, SV 25 mph

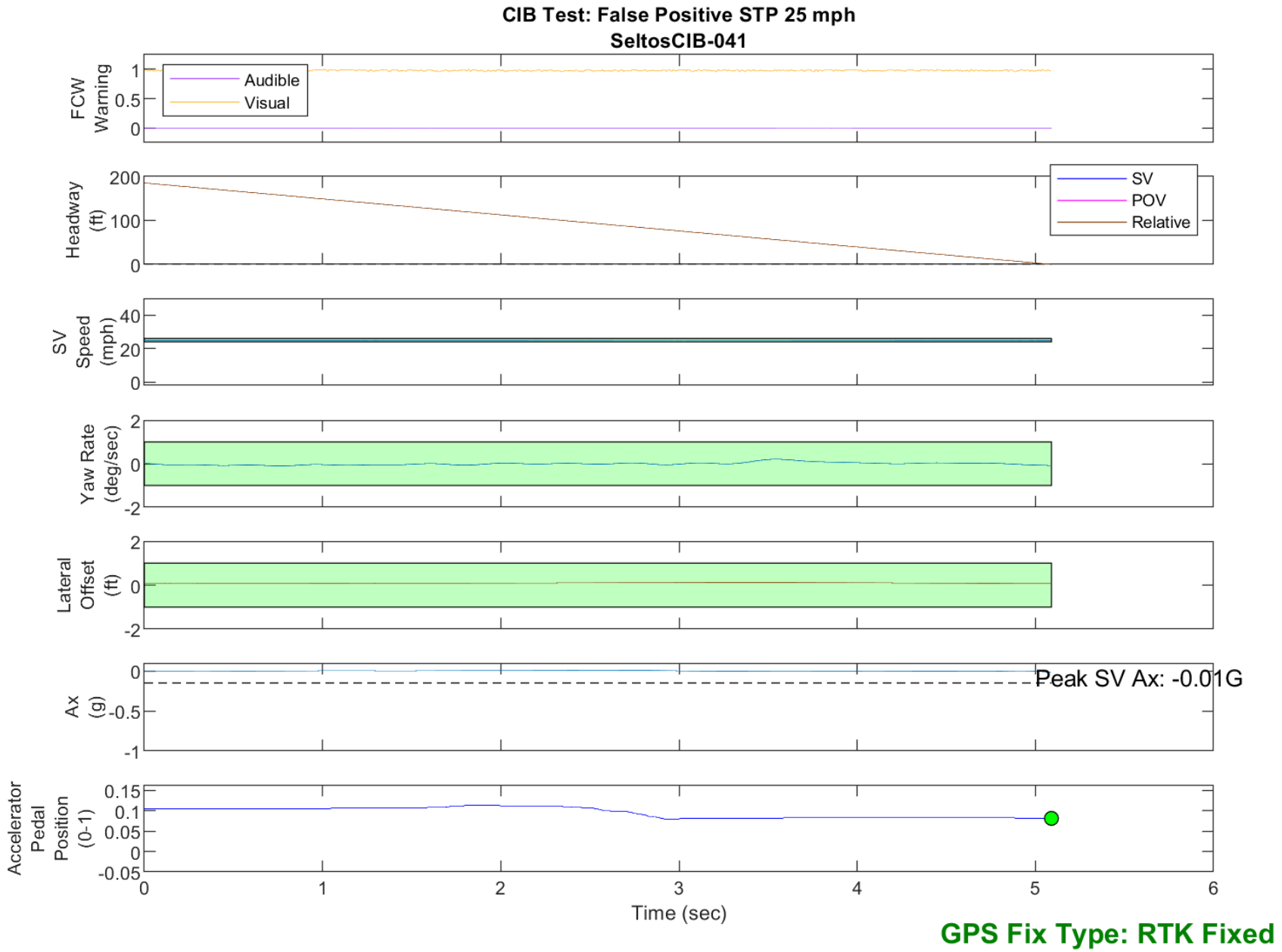


Figure D41. Time History for CIB Run 41, SV Encounters Steel Trench Plate, SV 25 mph

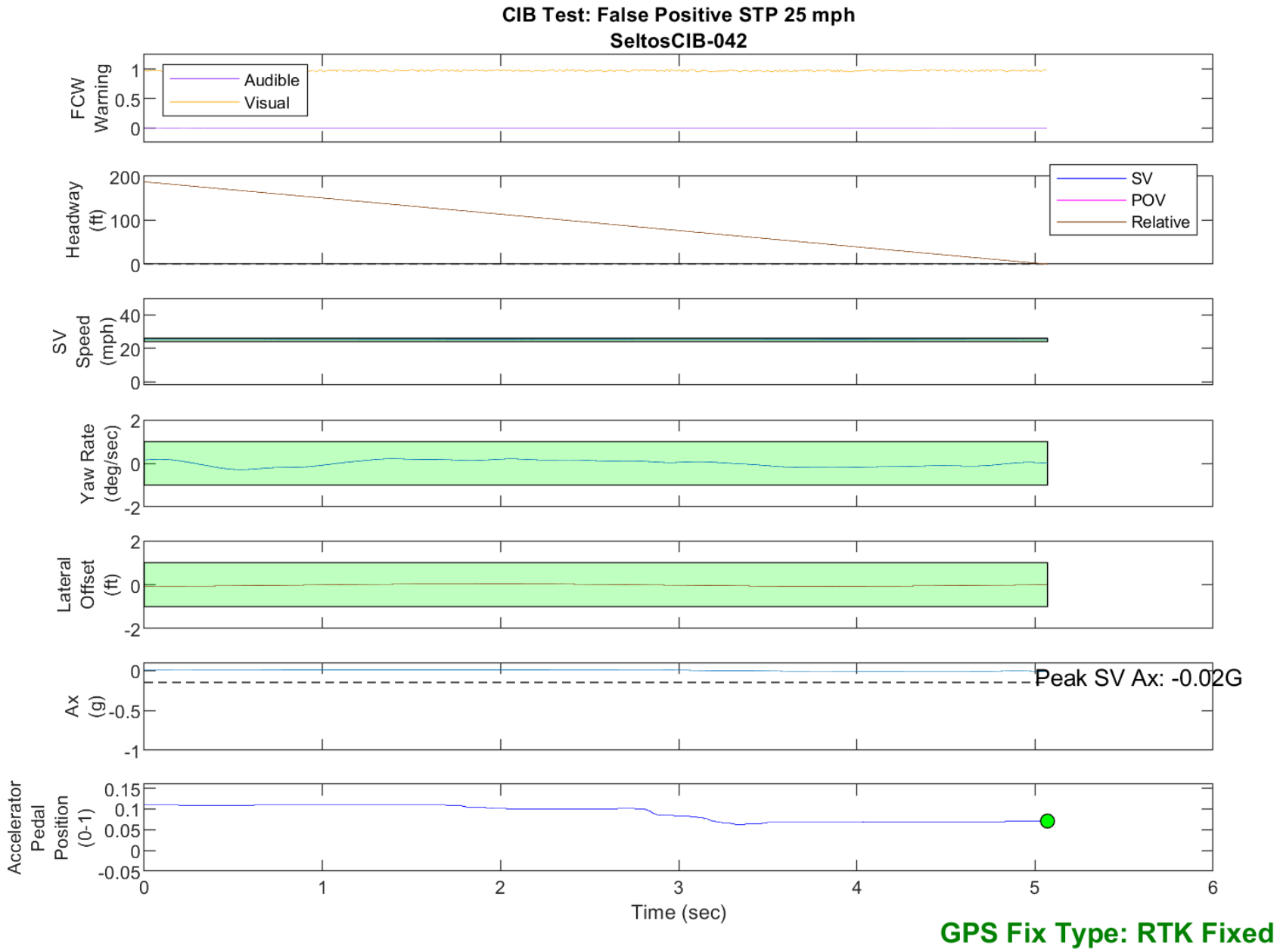


Figure D42. Time History for CIB Run 42, SV Encounters Steel Trench Plate, SV 25 mph

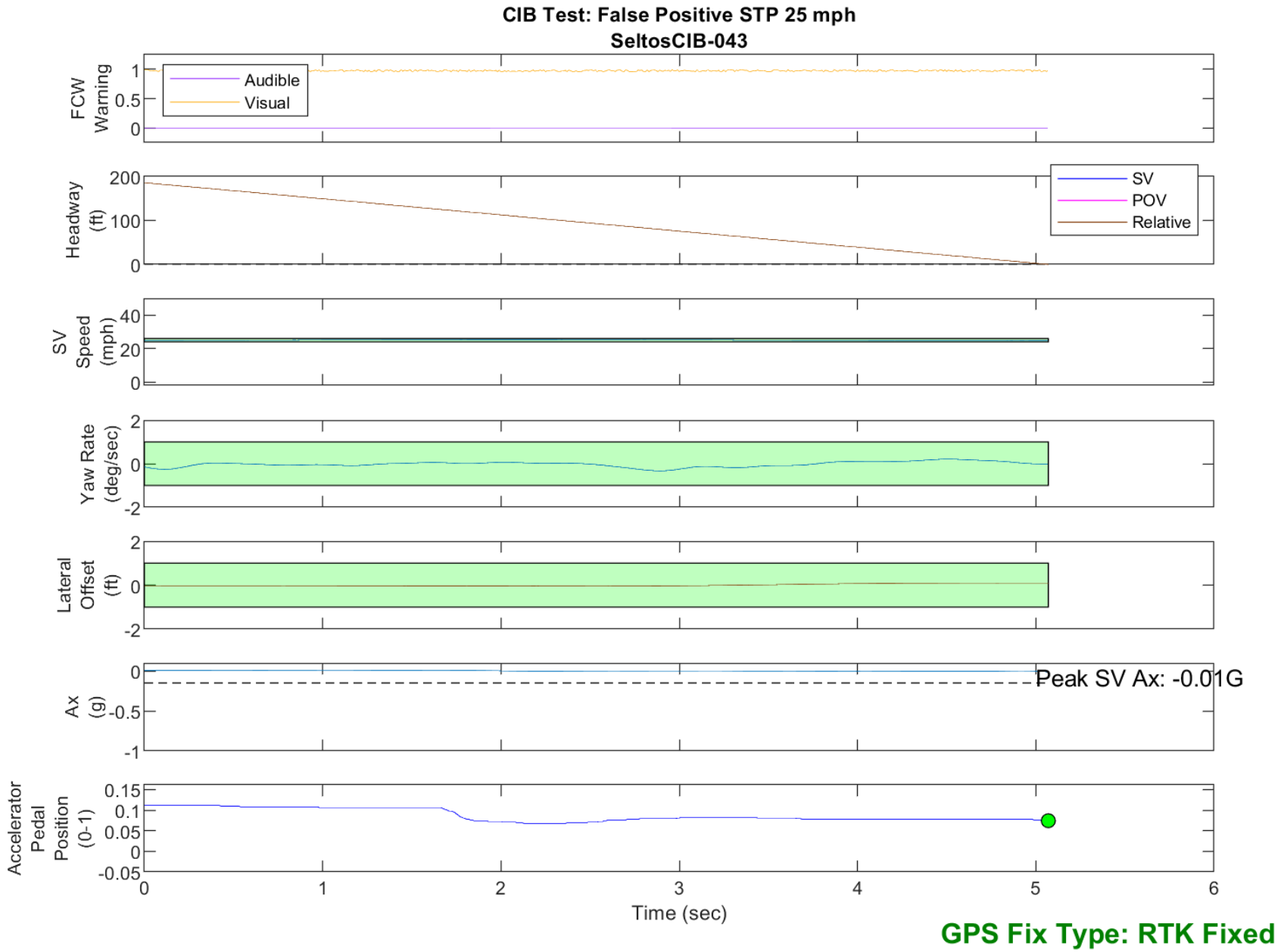


Figure D43. Time History for CIB Run 43, SV Encounters Steel Trench Plate, SV 25 mph

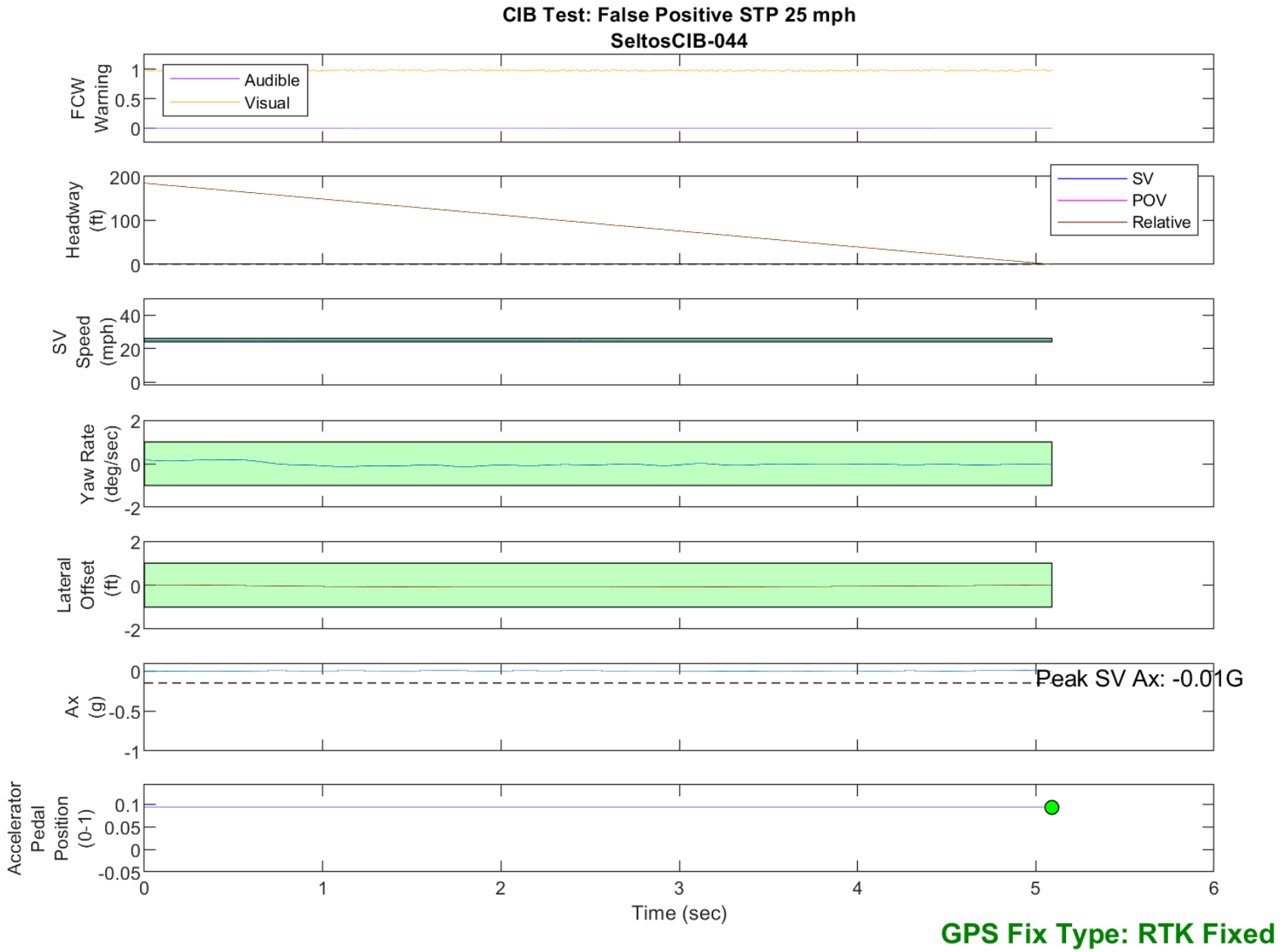


Figure D44. Time History for CIB Run 44, SV Encounters Steel Trench Plate, SV 25 mph

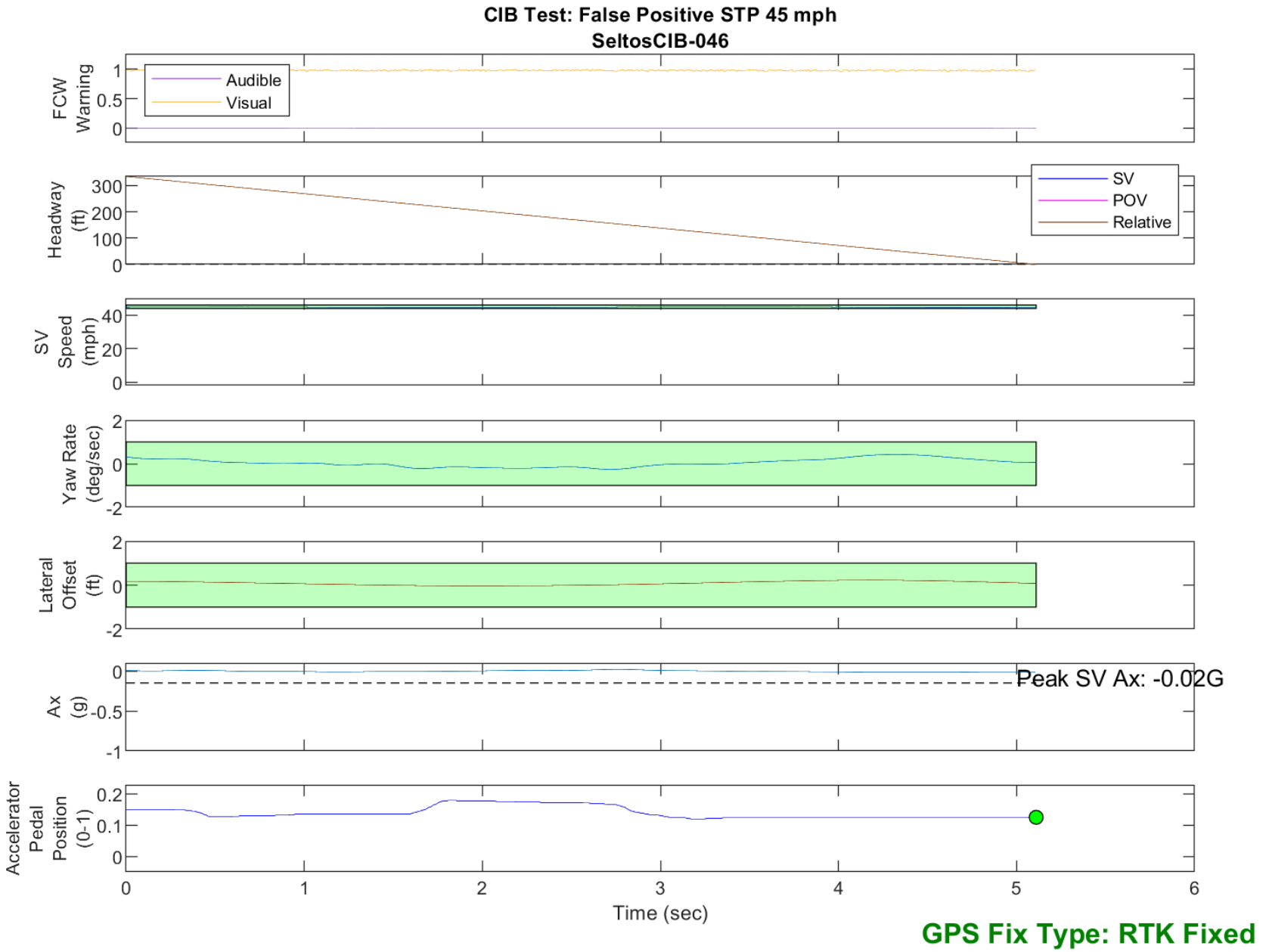


Figure D45. Time History for CIB Run 46, SV Encounters Steel Trench Plate, SV 45 mph

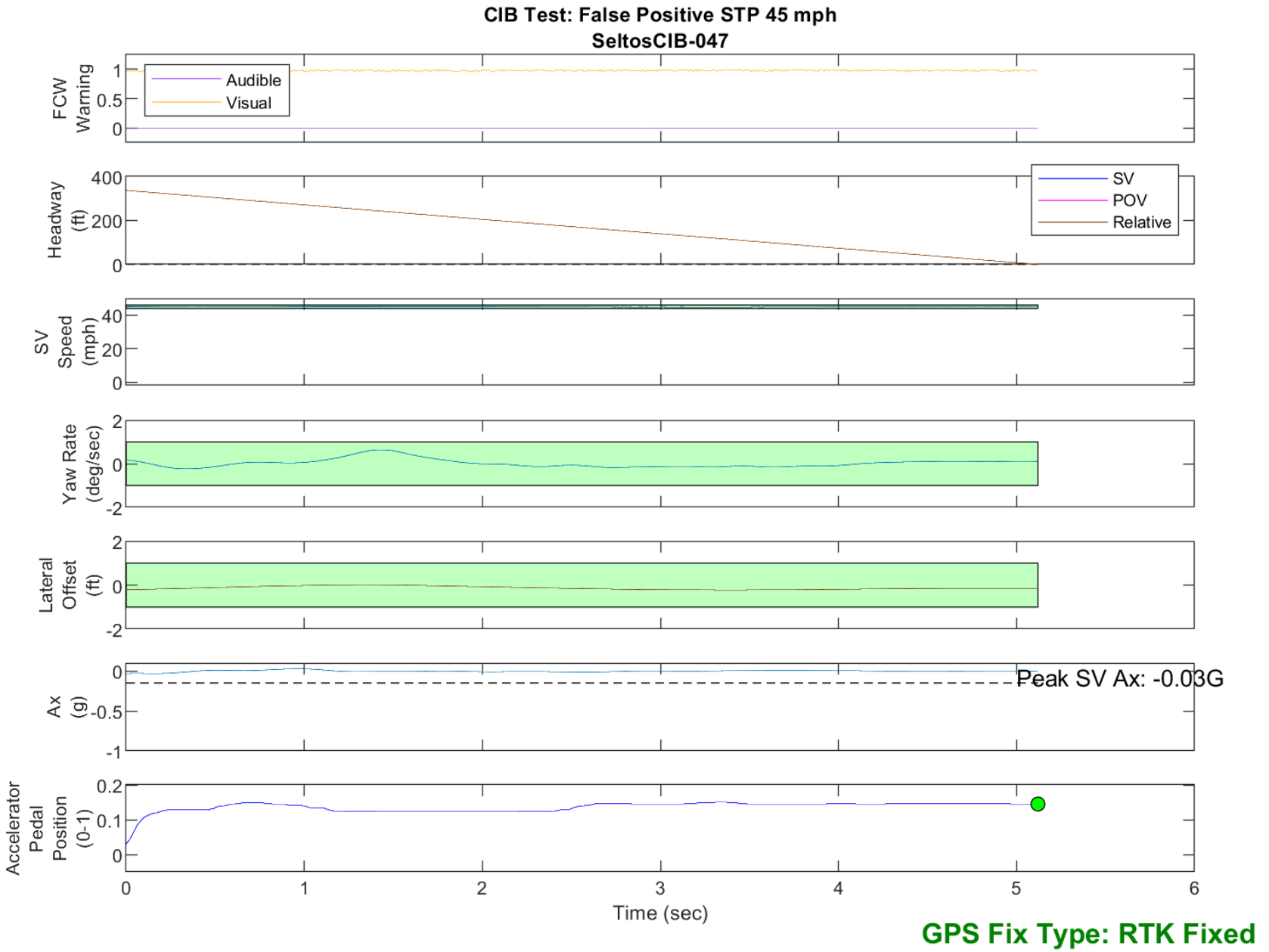


Figure D46. Time History for CIB Run 47, SV Encounters Steel Trench Plate, SV 45 mph

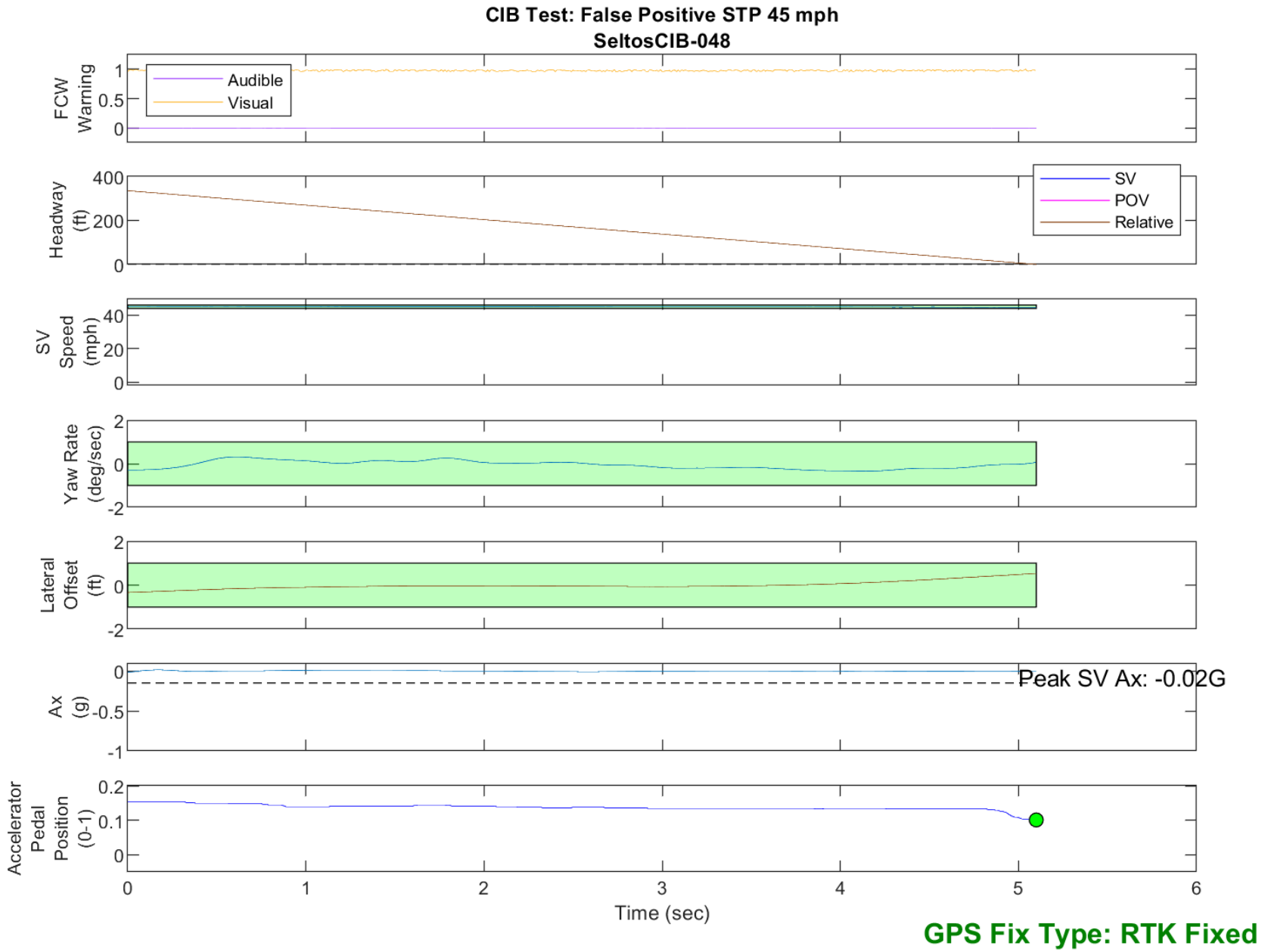


Figure D47. Time History for CIB Run 48, SV Encounters Steel Trench Plate, SV 45 mph

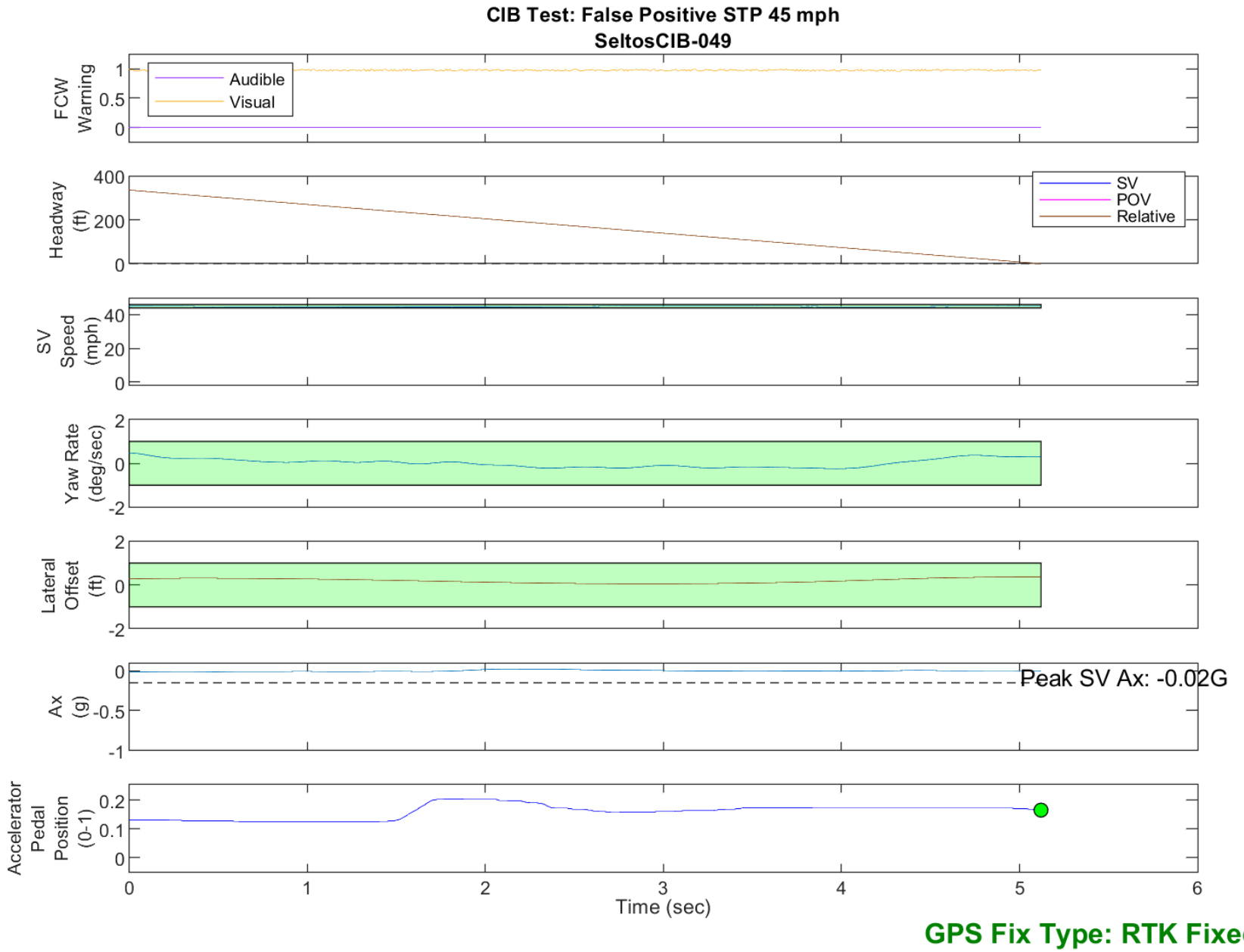


Figure D48. Time History for CIB Run 49, SV Encounters Steel Trench Plate, SV 45 mph

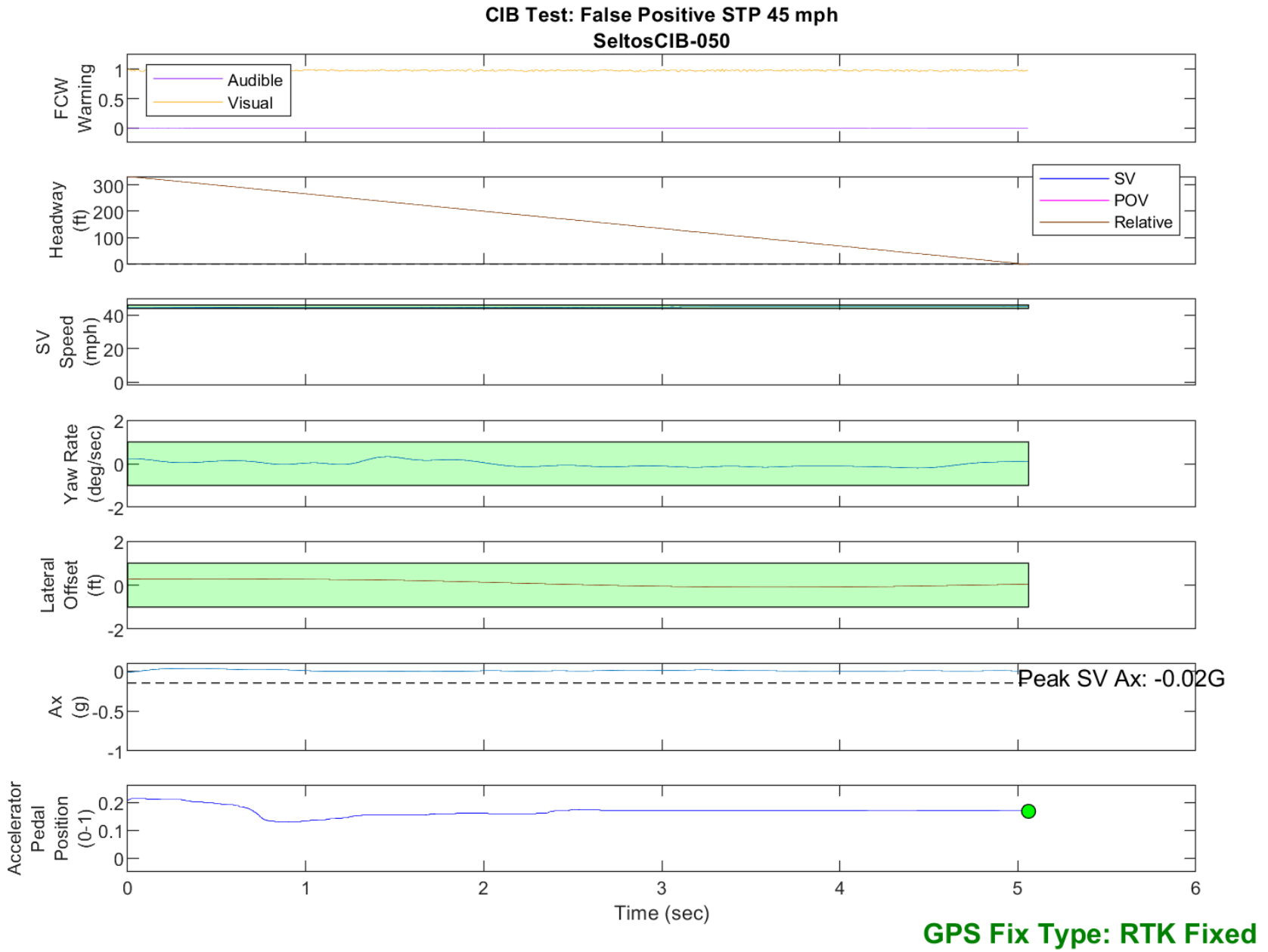


Figure D49. Time History for CIB Run 50, SV Encounters Steel Trench Plate, SV 45 mph

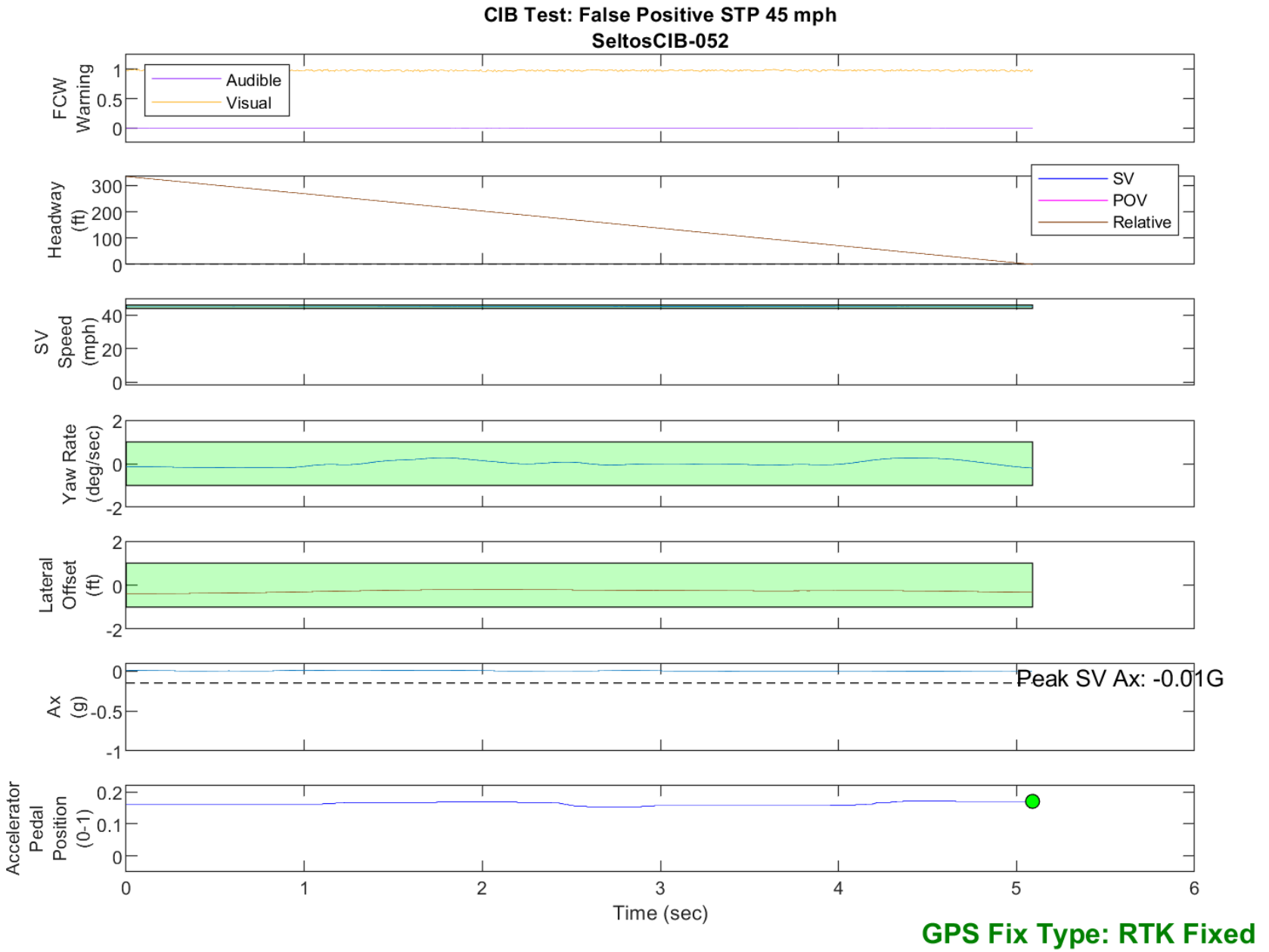


Figure D50. Time History for CIB Run 52, SV Encounters Steel Trench Plate, SV 45 mph

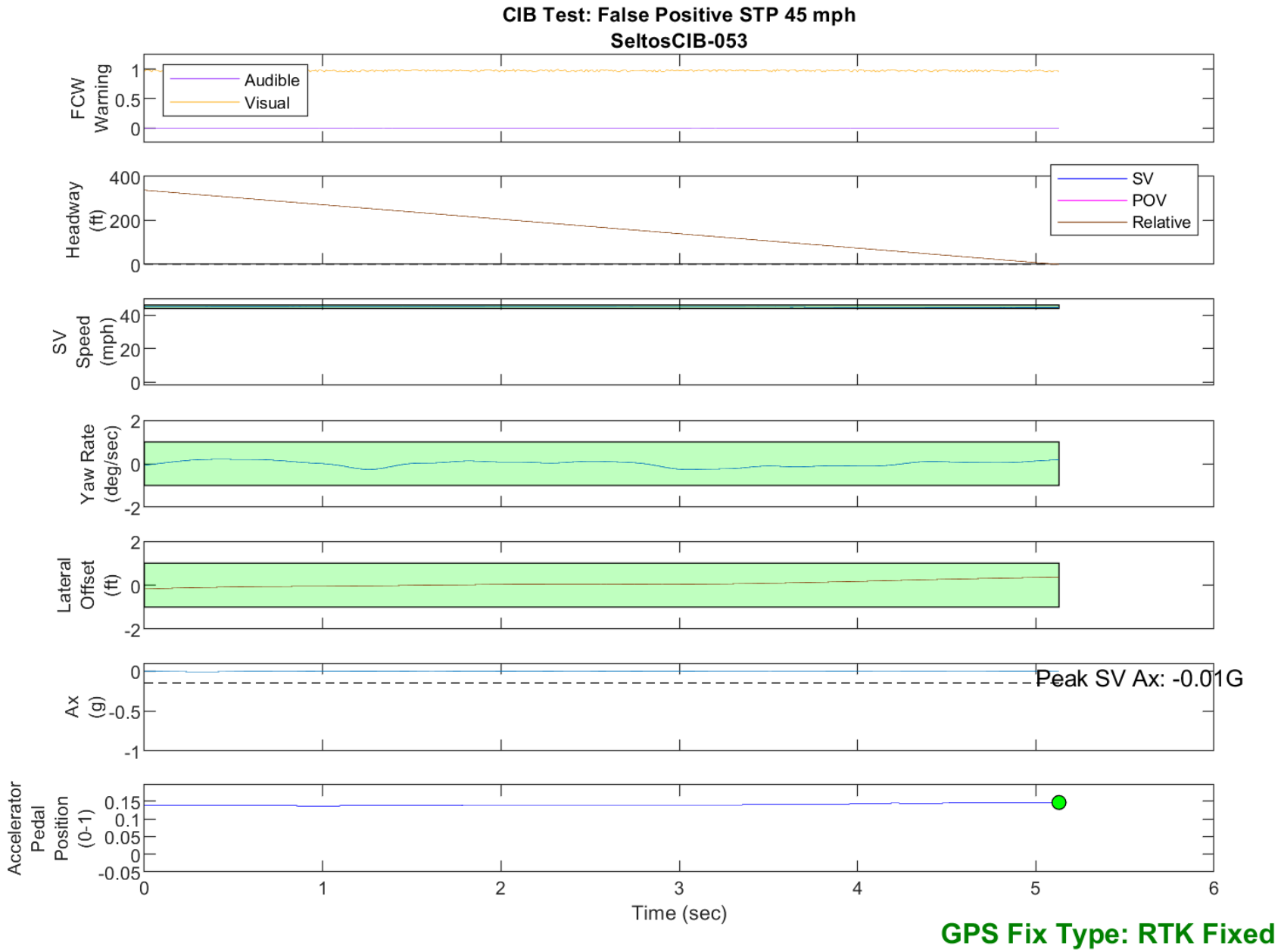


Figure D51. Time History for CIB Run 53, SV Encounters Steel Trench Plate, SV 45 mph