NEW CAR ASSESSMENT PROGRAM
CRASH IMMINENT BRAKING SYSTEM CONFIRMATION TEST
NCAP-DRI-CIB-21-18

2021 Volkswagen ID.4 Pro S (Statement)

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

22 July 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: 22 July 2021

1. Report No. NCAP-DRI-CIB-21-18	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 Volkswagen ID.4 Pro S (Statement).		5. Report Date 22 July 2021	
		6. Performing Organization Code DRI	
7. Author(s) J. Lenkeit, Program Manager K. Nagao, Test Engineer		8. Performing Organization Report No. DRI-TM-20-204	
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 June - July 2021	
		14. Sponsoring Agency Code NRM-110	
15. Supplementary Notes			
16. Abstract These tests were conducted on the subject 2021 Volkswagen ID.4 Pro S (Statement) 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 118	22. Price

TABLE OF CONTENTS

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 Volkswagen ID.4 Pro S (Statement). This test is part of the New Car Assessment Program to assess Crash Imminent Braking Systems sponsored by the National Highway Traffic Safety Administration under Contract No. DTNH22-14-D-00333.

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

Section II

DATA SHEETS

CRASH IMMINENT BRAKING

DATA SHEET 1: TEST RESULTS SUMMARY

(Page 1 of 1)

2021 Volkswagen ID.4 Pro S (Statement)

VIN: *WVGTMPE21MP03xxxx*

Test Date: *6/28/2021, 7/8/2021*

Crash Imminent Braking System settings: *Front Assist (Auto. Emerg. Braking): On*

Advance warning: Early

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

SV 25 mph: *Pass*

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

SV 25 mph POV 10 mph: *Pass*

SV 45 mph POV 20 mph: *Pass*

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

SV 35 mph POV 35 mph: *Pass*

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

SV 25 mph: *Pass*

SV 45 mph: *Pass*

Overall: *Pass*

Notes:

CRASH IMMINENT BRAKING

DATA SHEET 2: VEHICLE DATA

(Page 1 of 1)

2021 Volkswagen ID.4 Pro S (Statement)

TEST VEHICLE INFORMATION

VIN: *WVGTMPE21MP03xxxx*

Body Style: *SUV* Color: *Dusk Blue Metallic*

Date Received: *5/31/2021* Odometer Reading: *17 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *VOLKSWAGEN AG*

Date of manufacture: *03/21*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *235/55 R19 105T XL*

Rear: *255/50 R19 107T XL*

Recommended cold tire pressure: Front: *290 kPa (42 psi)*

Rear: *290 kPa (42 psi)*

TIRES

Tire manufacturer and model: *Hankook Kinergy AS x ev*

Front tire designation: *235/55R19 105T*

Rear tire designation: *255/50R19 107T*

Front tire DOT prefix: *15M98 9U HO*

Rear tire DOT prefix: *15M7F 9U HO*

CRASH IMMINENT BRAKING

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2021 Volkswagen ID.4 Pro S (Statement)

GENERAL INFORMATION

Test date: *6/28/2021, 7/8/2021*

AMBIENT CONDITIONS

Air temperature: *31.7 C (89 F)*

Wind speed: *4.6 m/s (10.4 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: *290 kPa (42 psi)*

Rear: *290 kPa (42 psi)*

CRASH IMMINENT BRAKING

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2021 Volkswagen ID.4 Pro S (Statement)

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*543.4 kg (1198 lb)*	Right Front:	*527.1 kg (1162 lb)*
Left Rear:	*601.5 kg (1326 lb)*	Right Rear:	*586.9 kg (1294 lb)*
		Total:	*2258.9 kg (4980 lb)*

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

(Page 1 of 3)

2021 Volkswagen ID.4 Pro S (Statement)

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

Front Assist (Forward Collision Warning & Autonomous Emergency Braking w/ Pedestrian Monitoring)

Front Assist is a part of the IQ.Drive package and is standard equipment.

Type and location of sensors the system uses:

Mono camera mounted behind the windshield above the rearview mirror and radar located behind the front bumper.

System setting used for test (if applicable):

Front Assist (Auto. Emerg. Braking): On

Advance warning: Early

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

5 km/h (3 mph) (Per manufacturer supplied information)

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

85 km/h (53 mph) for stationary POV

250 km/h (155 mph) for moving POV (Per manufacturer supplied information)

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

____ No

If yes, please provide a full description.

To ensure the full AEB-performance, please take the following steps:

- *Drive above 10 km/h*
- *Drive in a straight line*
- *Drive past or alongside metallic objects (e.g. parked vehicles, guardrails, lampposts)*

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

____ Yes

X No

If yes, please provide a full description.

Under regular testing conditions and if the sensors are not damaged the system will not deactivate. A deactivation would be indicated to the driver via warning icons and a corresponding text message on the gauge cluster behind the steering wheel. Cycling the ignition can reactivate the system if the cause for the deactivation is not permanent.

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

(Check all that apply)

X Warning light

X Buzzer or auditory alarm

____ Vibration

X Other *Initial brake jerk*

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

Advance warning (FCW)

The system detects a possible collision and prepares the vehicle for possible emergency braking. An auditory warning sounds and the red warning lamp lights up. See Appendix A, Figure A16.

Urgent warning

If the driver does not react to the advance warning, the system may initiate a short braking jolt in order to draw attention to the increasing collision risk. .

Automatic braking (CIB)

If the driver also does not react to the urgent warning, the vehicle can brake automatically with braking force that increases in several stages. The reduced speed means that it is possible to minimize the consequences of an accident.

Is there a way to deactivate the system? **X** Yes

____ No

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

System menus are accessed by pressing the "Assist" button in the center console. An image appears in the center touchscreen showing a vehicle, two adjacent blue vehicles and blue lane lines. To disable the system:

Navigate to the Front Assist menu by either:

- *Touching the picture of a vehicle with another vehicle ahead or*
- *Touching the button in the upper right of the screen, which will bring up the Assistance system settings menu*
  - *Select Front Assist (Autonomous Emergency Braking)*
  - *Select Advance Warning*
  - *Select or deselect "Off" from the dropdown.*

Note that selecting or deselecting "Active" enables or disables the AEB portion of the system.

See Appendix A, Figures A14 and A15.

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

____ No

If yes, please provide a full description.

System menus are accessed by pressing the "Assist" button in the center console. An image appears in the center touchscreen showing a vehicle, two adjacent blue vehicles and blue lane lines. To disable the system:

Navigate to the Front Assist menu by either:

- *Touching the picture of a vehicle with another vehicle ahead, or*
- *Touching the button in the upper right of the screen, which will bring up the Assistance system settings menu*
  - *Select Front Assist*
  - *Select Advance Warning*
  - *Select "Early", "Medium", or "Late" to set the alert timing.*

This affects the FCW warning timing only.

See Appendix A, Figures A14 and A15.

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

X Yes

____ No

If yes, please provide a full description.

System limitations are described on page 162 of the Owner's Manual, shown in Appendix B, page B-6.

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Four test scenarios were used, as follows:

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

Test 2. Subject Vehicle Encounters Slower Principal Other Vehicle

Test 3. Subject Vehicle Encounters Decelerating Principal Other Vehicle

Test 4. Subject Vehicle Encounters Steel Trench Plate

An overview of each of the test procedures follows.

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

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

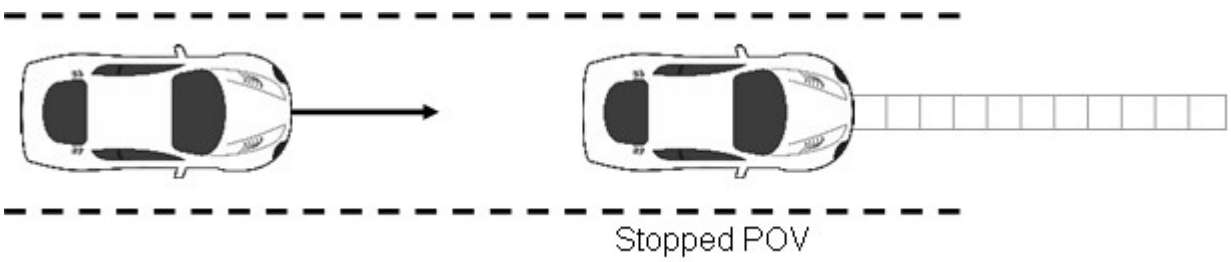

Figure 1. Depiction of Test 1

a. Procedure

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

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

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

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

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

b. Criteria

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

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

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

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

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

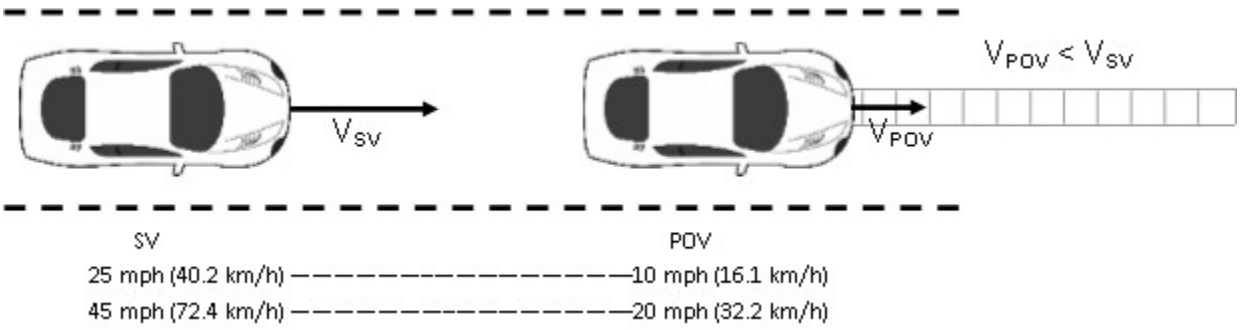

Figure 2. Depiction of Test 2

a. Procedure

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

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

The SV driver then braked to a stop.

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

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

b. Criteria

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

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

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

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

3. 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.

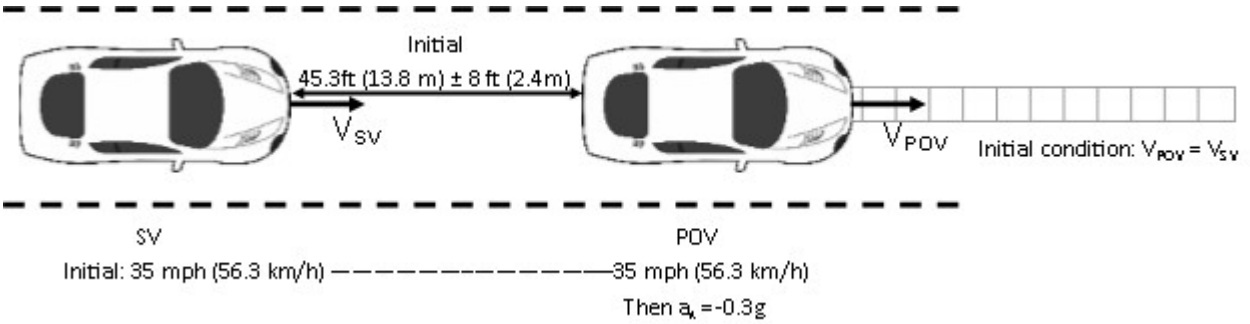

Figure 3. Depiction of Test 3

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 auditory, and the onset of the alert was determined by post-processing the test data.

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

Table 1. Auditory and Tactile Warning Filter Parameters

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

2. GENERAL VALIDITY CRITERIA

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

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

3. VALIDITY PERIOD

The valid test interval began:

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

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

Test 3: 3 seconds before the onset of POV braking

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

The valid test interval ended:

Test 1: When either of the following occurred:

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

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

- The SV came into contact with the POV; or
- 1 second after 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 0-690 kPa	< 1% error between 20 and 100 psi	Omega DPG8001	17042707002	By: DRI Date: 8/18/2020 Due: 8/18/2021
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 2/10/2021 Due: 2/10/2022
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	45050091	By: DRI Date: 4/15/2021 Due: 4/15/2022
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	N/A
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rate ±100 deg/s, Angle >45 deg, Velocity >200 km/h	Accels .01g, Angular Rate 0.05 deg/s, Angle 0.05 deg, Velocity 0.1 km/h	Oxford Inertial +		By: Oxford Technical Solutions
					2182	Date: 9/16/2019 Due: 9/16/2021
					2176	Date: 6/26/2020 Due: 6/26/2022

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

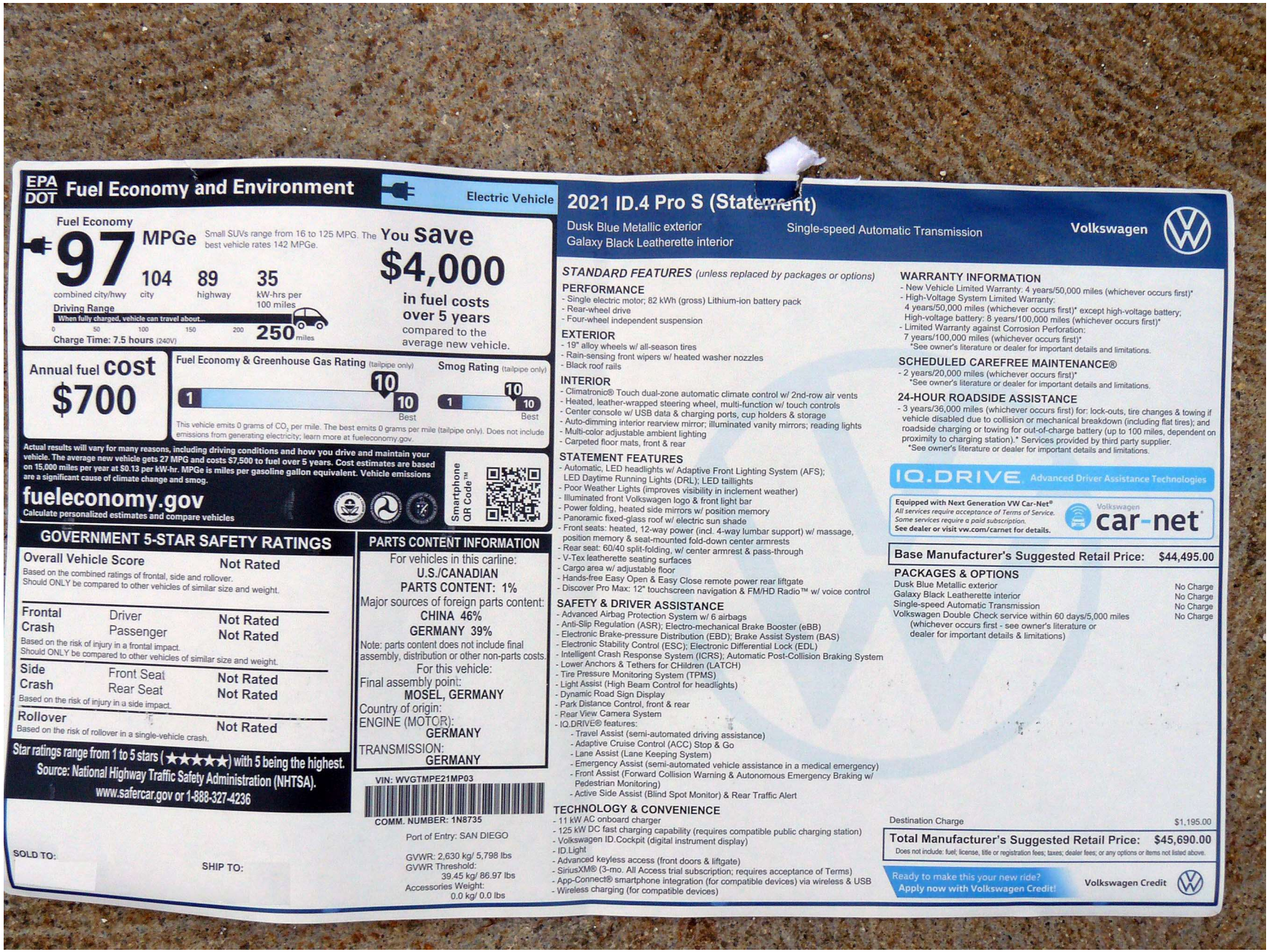

Figure A3. Window Sticker (Monroney Label)

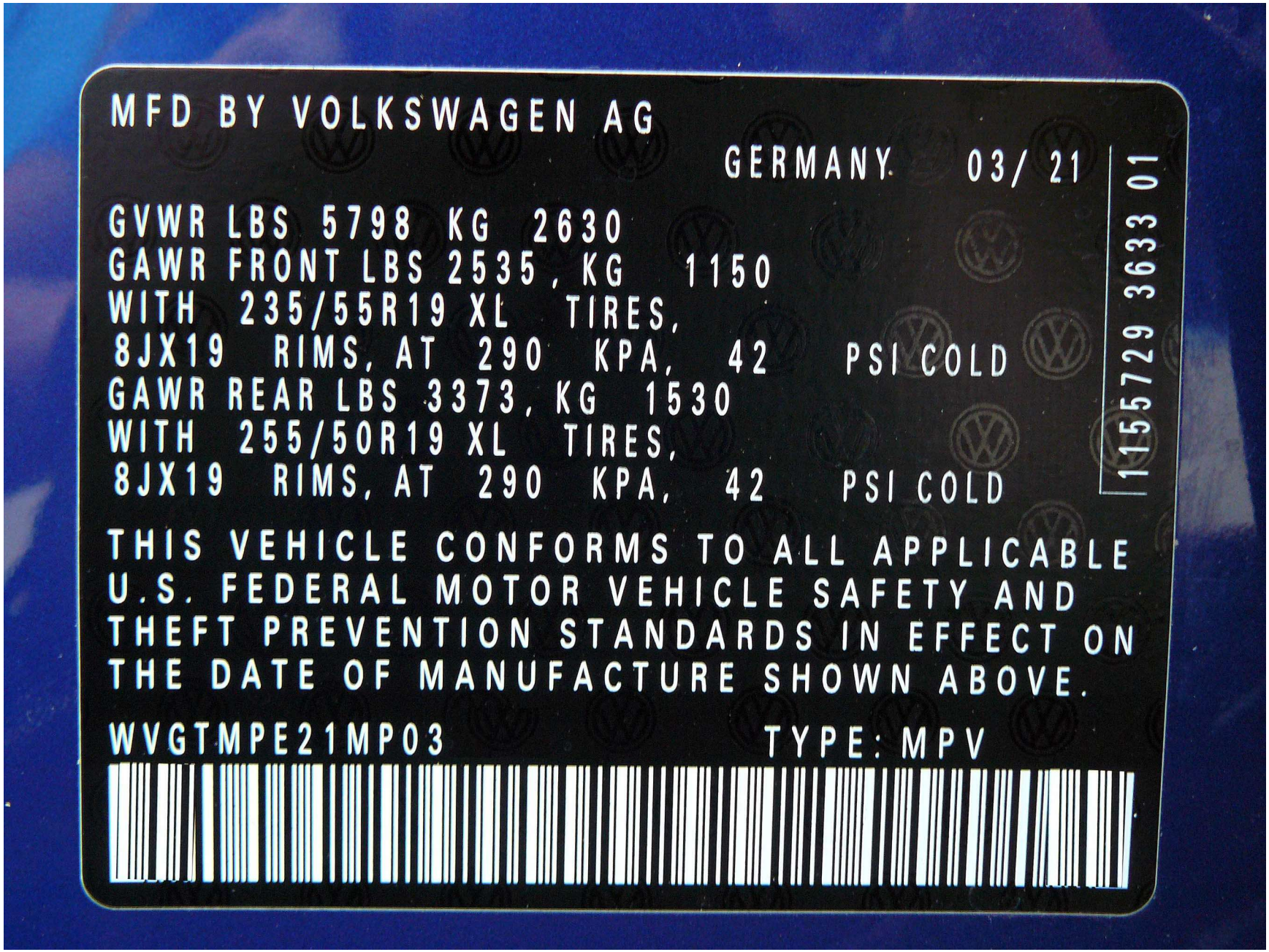

Figure A4. Vehicle Certification Label

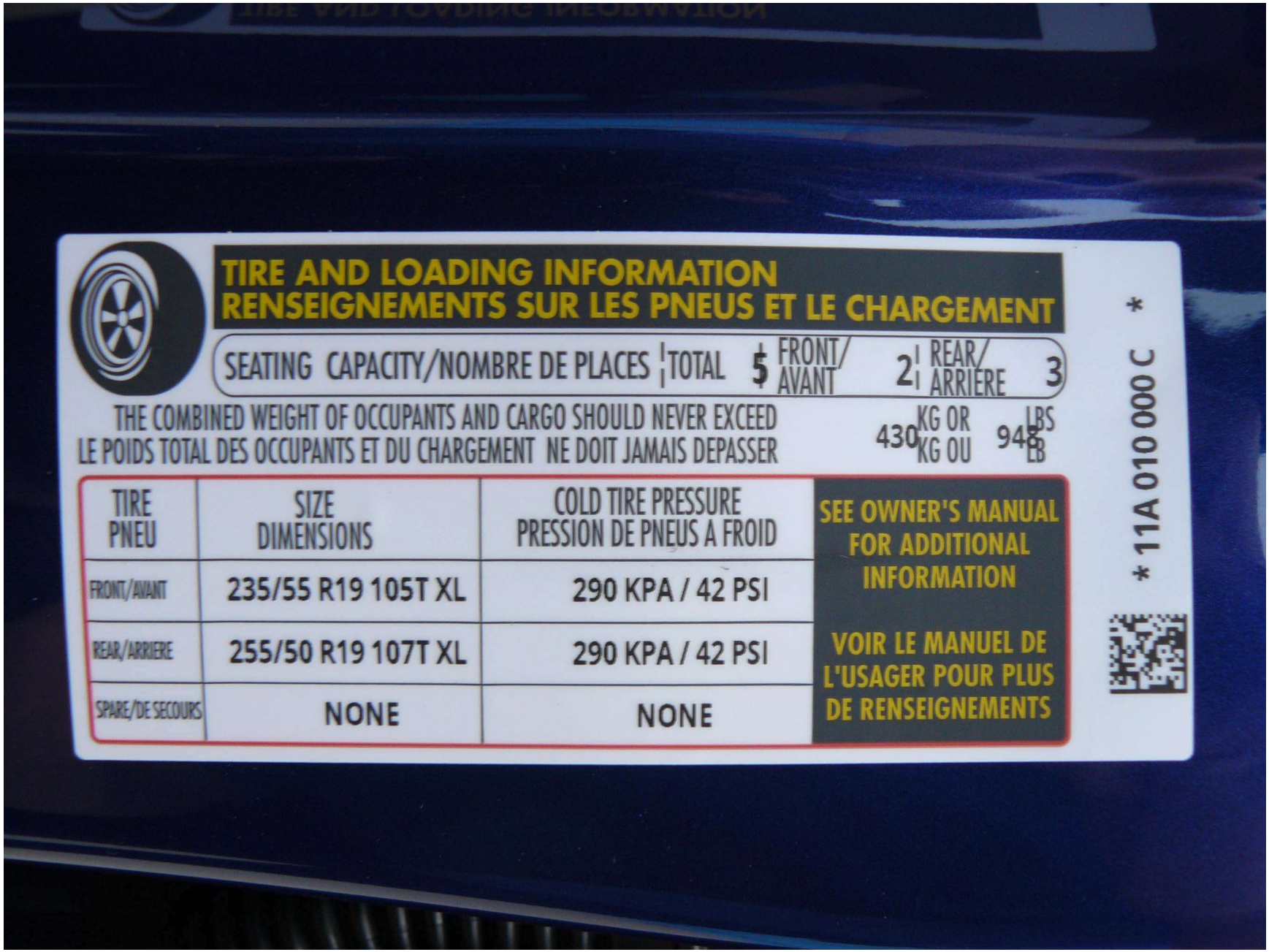

Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

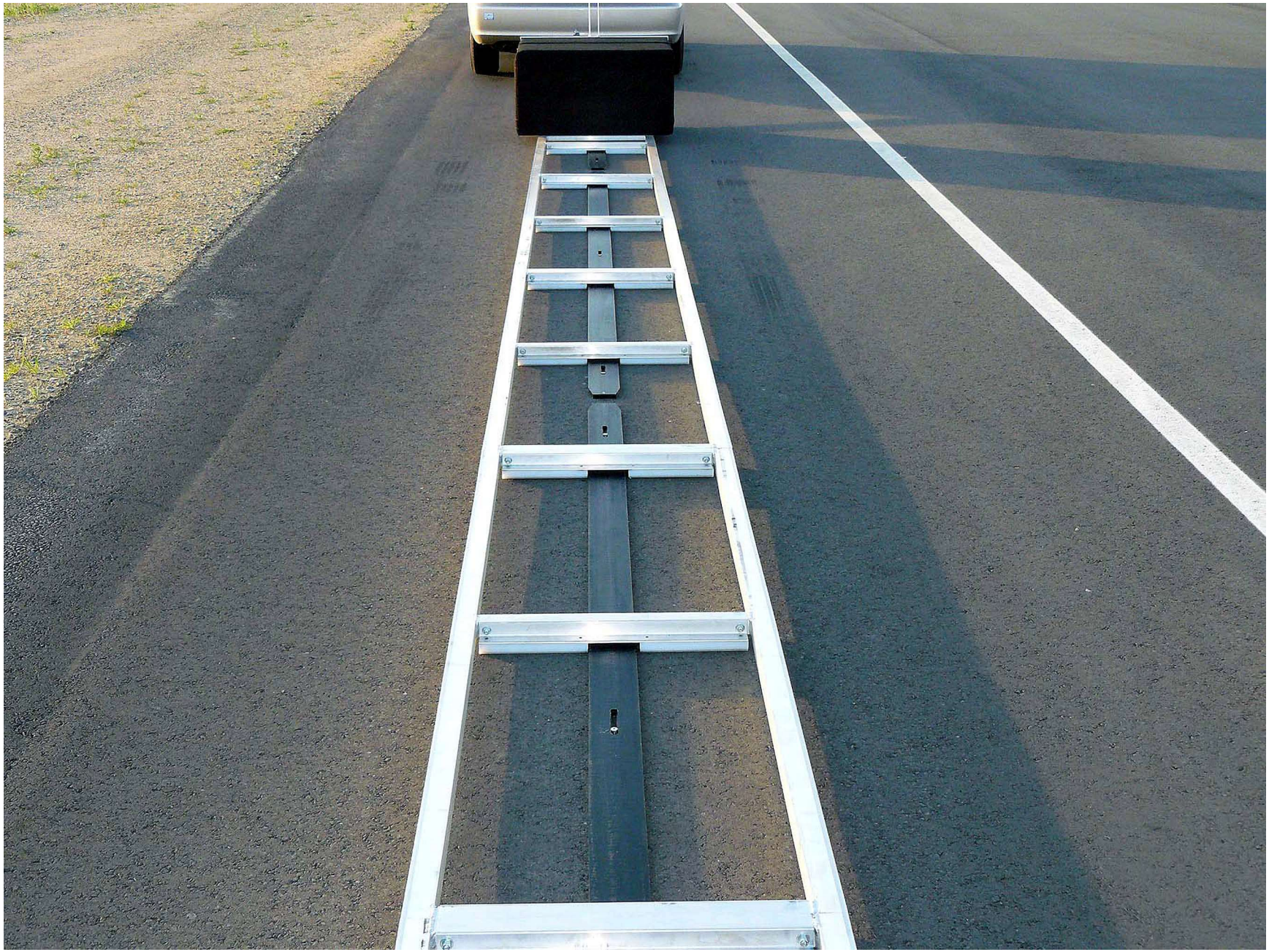

Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

Figure A9. Steel Trench Plate

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

Figure A11. Sensor for Detecting Auditory Alert

Figure A12. Computer Installed in Subject Vehicle

Figure A13. Brake Actuator Installed in POV System

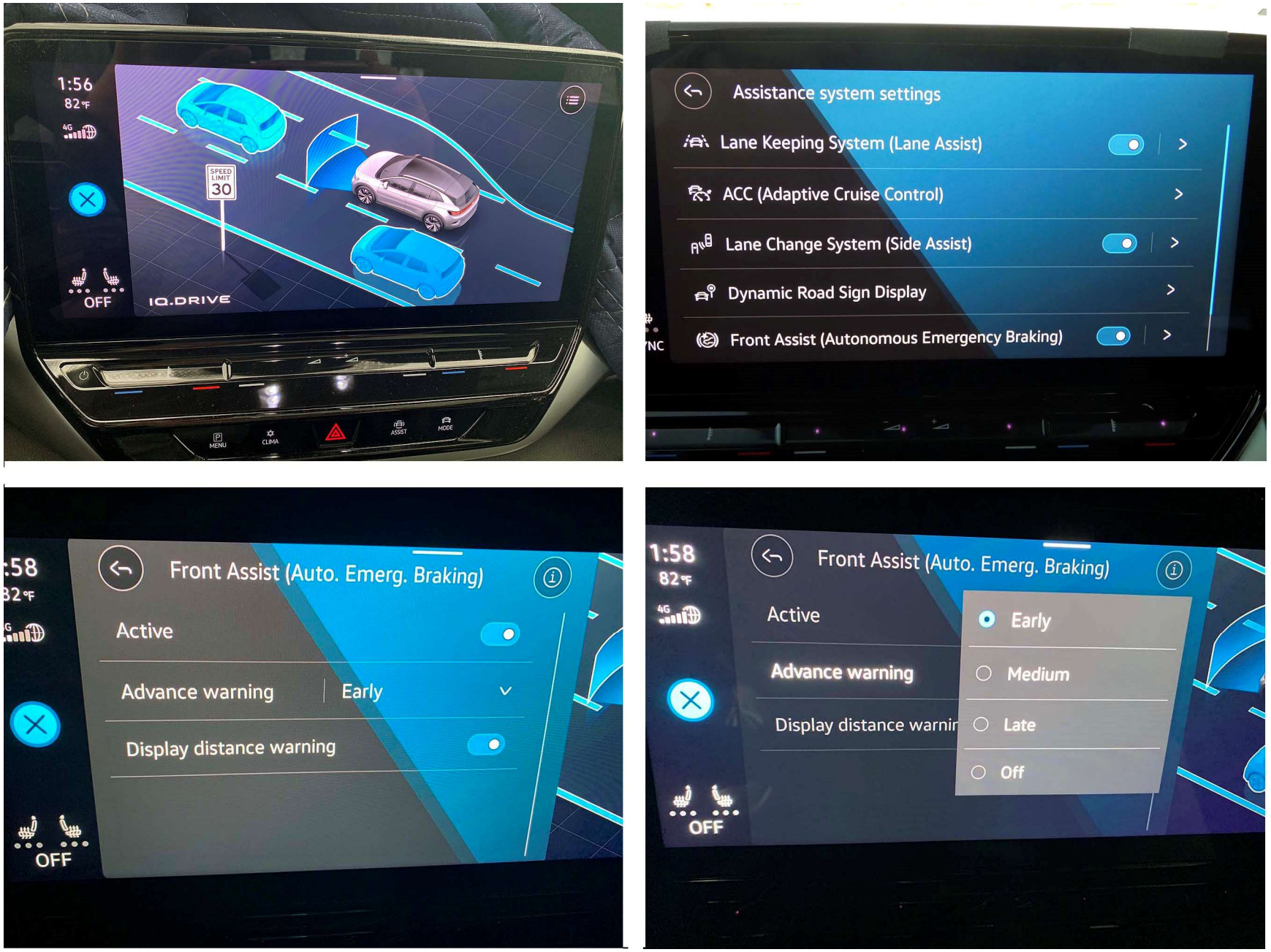

Figure A14. AEB Setup Menus

Figure A15. Button for Accessing Menus

Figure A16. Visual Alert

APPENDIX B

Excerpts from Owner’s Manual

Symbol	Meaning
	 Do not drive on! Low tyre pressure → page 327
	 Do not drive on! Fault in the Tyre Pressure Monitoring System → page 327
	Fault in electric drive system → page 139, → page 142
	Reduced power → page 137
	Electronic engine sound fault → page 140
	Front Assist not available → page 165
	Front Assist switched off → page 164
	Speed limiter not available → page 148
	Fault in the Cruise Control System → page 147
	Adaptive Cruise Control (ACC) is not available → page 156
	Emergency Assist not available → page 172
	Lane keeping system (Lane Assist) not available → page 167
	Lane keeping system (Lane Assist) is regulating → page 167
	Emergency Assist intervention → page 171
	Fault in the lane change system (Side Assist) → page 174
	Rear Traffic Alert braking intervention → page 189
	Rear Traffic Alert fault → page 189

Symbol	Meaning
	12-volt vehicle battery → page 323
	Low charge level of the high-voltage battery → page 285
	High-voltage battery empty → page 285
	Adaptive chassis control fault → page 144
	Ball head of the towing bracket is not locked → page 273
	The vehicle is held stationary → page 179
	Turn signals → page 110
	Trailer turn signal → page 111
	Cruise control system switched on, control active. → page 145
	Speed limiter active → page 147
	Lane Assist active → page 167
	Travel Assist active → page 169
	The ACC is regulating, no vehicle detected in front → page 154
	The ACC is regulating, vehicle in front detected → page 154
	Speed regulation due to the road layout → page 158
	Speed regulation due to a roundabout → page 158
	Speed regulation due to a junction → page 158
	Speed regulation due to cancellation of the speed limit → page 158
	Speed regulation due to the end of a traffic jam → page 158

11A0127210AB

If you adjust the announced speed excessively, predictive cruise control will be terminated.

If a speed limit is detected, the predictive cruise control function will adjust the stored speed even if ACC is deactivated. However, speed regulation will not take place.

If the current speed significantly exceeds a speed limit detected by the Dynamic Road Sign Display function, a warning will appear on the instrument cluster display.

When you join a motorway without a speed limit, the recommended speed will automatically be stored as the desired speed. If a higher speed has previously been stored on a motorway without a speed limit, this will be adopted instead of the recommended speed. ◁

Troubleshooting

🕮 Please refer to ⚠ at the start of the chapter on page 156.

A message is displayed that predictive cruise control is currently not available or is not available in your country.

— If this message is displayed for an extended period and predictive cruise control is available in your country, go to a qualified workshop.

Depending on the malfunction, additional information may be displayed in the vehicle status → page 30. ◁

11A012720AB

Area monitoring system (Front Assist)

🕮 Introduction to the topic

The Autonomous Emergency Braking (Front Assist) can detect imminent frontal collisions and issue corresponding warnings. The system can also provide assistance for braking and taking avoiding action and can also automatically brake the vehicle.

Front Assist can help to avoid accidents, but is not a substitute for the full concentration of the driver. Front Assist functions only within the system limits. The warning times vary depending on the traffic situation and driver behaviour.

Driving with Front Assist

You can cancel the automatic braking and steering interventions of Front Assist pressing the accelerator or steering.

Automatic braking

Front Assist can decelerate the vehicle to a standstill. The vehicle will then not be held permanently. Depress the brake pedal!

The brake pedal will feel harder during an automatic braking operation.

Detection of the traffic situation

Front Assist detects driving situations by means of a camera located in the upper area of the windscreen and a radar sensor in the front of the vehicle.

Functions included in the system

Front Assist includes the following functions depending on vehicle equipment and country:

— Pedestrian Monitoring.

— Cyclist Monitoring.

— Swerve support.

— Oncoming vehicle braking when turning.

The listed functions are automatically active when Front Assist is switched on.

⚠ WARNING

The intelligent technology used in Front Assist cannot overcome the physical limits specified, and functions only within the limits of the system. Never let the extra convenience afforded by Front Assist tempt you into taking risks when driving. The driver is always responsible for braking and steering in time.

- If Front Assist issues a warning, brake your vehicle immediately depending on the traffic situation or avoid the obstacle.
- Adapt your speed and distance from the vehicles ahead to suit visibility, weather, road and traffic conditions.
- Be prepared to take over control of the vehicle yourself at all times and to override automatic braking and steering interventions. Front Assist cannot prevent accidents and serious injuries on its own.
- Front Assist can issue unnecessary warnings and carry out unwanted braking or steering interventions in certain complex driving situations, e.g. at traffic islands.
- Front Assist can issue unnecessary warnings and carry out unwanted braking or steering interventions when its function is impaired, e.g. if the radar sensor is dirty or its position has been changed.
- Front Assist does not react to pedestrians without Pedestrian Monitoring or cyclists without Cyclist Monitoring. In addition, the system does not react to animals or to vehicles that are crossing or approaching in the same lane.
- If you are unsure about what systems your vehicle has, please enquire at a qualified workshop before starting your journey.
- Be prepared to take over control of the vehicle yourself at all times. ◁

Warning levels and braking intervention

🕮 Please refer to ⚠ at the start of the chapter on page 159.

Front Assist can detect the following objects within the system limits and depending on the vehicle equipment:

— Pedestrians, cyclists and vehicles also moving relative to your vehicle.

— Crossing pedestrians and cyclists.

— Stationary vehicles.

Front Assist can provide assistance and intervene if the vehicle is approaching a detected object in such a way that a collision with the object will occur if the vehicle speed is maintained and there is no driver intervention. The assistance may include an advance warning, an urgent warning and automatic braking.

Under ideal conditions, this can prevent a collision or help to reduce the consequences of the collision.
Front Assist operates in the following speed ranges:

	Advance warning	Urgent warning	Automatic braking	Braking intervention
Vehicle stationary	30 to 85 km/h (20 to 53 mph)	30 to 85 km/h (20 to 53 mph)	5 to 85 km/h (3 to 53 mph)	5 to 85 km/h (3 to 53 mph)

	Advance warning	Urgent warning	Automatic braking	Braking intervention
Vehicle also moving	30 to 250 km/h (20 to 155 mph)	30 to 250 km/h (20 to 155 mph)	5 to 250 km/h (3 to 155 mph)	5 to 250 km/h (3 to 155 mph)
Pedestrian also moving	30 to 85 km/h (20 to 53 mph)	30 to 85 km/h (20 to 53 mph)	5 to 85 km/h (3 to 53 mph)	5 to 85 km/h (3 to 53 mph)
Crossing pedestrian	30 to 85 km/h (20 to 53 mph)	-	5 to 65 km/h (3 to 40 mph)	5 to 65 km/h (3 to 40 mph)
Cyclist also moving	30 to 250 km/h (20 to 155 mph)	30 to 250 km/h (20 to 155 mph)	5 to 250 km/h (3 to 155 mph)	5 to 250 km/h (3 to 155 mph)
Crossing cyclist	30 to 85 km/h (20 to 53 mph)	-	5 to 65 km/h (3 to 40 mph)	5 to 65 km/h (3 to 40 mph)

The values apply only under ideal conditions and are approximate values which depend on the market and vehicle equipment. Please contact a qualified workshop if you have any queries about the equipment installed in your vehicle.

Advance warning

The system detects a possible collision and prepares the vehicle for possible emergency braking.

An acoustic warning sounds and the red warning lamp lights up. Brake or take avoiding action.

Urgent warning

If the driver does not react to the advance warning, the system may initiate a short braking jolt in order to draw attention to the increasing collision risk. Brake or take avoiding action.

Automatic braking

If the driver also does not react to the urgent warning, the vehicle can be braked automatically with braking force that increases in several stages. The reduced speed means that it is possible to minimise the consequences of an accident.

Braking intervention

If the system detects that the driver is braking insufficiently when there is a risk of collision, the system can increase the braking force and help prevent a collision. The braking intervention takes place only for as long as the brake pedal is pressed hard.

Distance warning

The system detects when safety is endangered by driving too close to the vehicle in front. The indicator lamp lights up. Increase the distance.

Speed range: around 65 km/h (around 40 mph) to around 250 km/h (around 155 mph). ◁

11A012720AB

Limits of Front Assist

Please refer to ⚠ at the start of the chapter on page 159.

Front Assist is not available or its functions are restricted immediately after the vehicle is started. The indicator lamp lights up in the instrument cluster display during this time.

Front Assist has physical and system-related limitations. You should therefore always be prepared to take full control of the vehicle if necessary.

Delayed response

If the camera or radar sensor is exposed to environmental conditions that impair functioning, the system may detect this only after a certain delay. For this reason, any restrictions to functions may be displayed only after a delay at the start of the journey and when driving → page 159.

Objects that cannot be detected

Front Assist may not react or may react with a delay or provide with an unwanted response in the following situations:

- Vehicles that are driving outside the sensor range in close proximity to your vehicle, e.g. vehicles that are driving offset to your vehicle or motorbikes.
- Vehicles that change into your lane directly in front of your vehicle.
- Vehicles with bodies or attachments that project beyond the vehicle.
- Oncoming vehicles or vehicles crossing your path.
- Oncoming pedestrians.
- Oncoming cyclists.
- When pedestrians and cyclists are not detected, for example because they are partially or fully hidden.
- Objects or narrow objects such as walls, rails, fences, posts, trees or garage doors.

Function limitations

Front Assist may not react or may react with a delay or provide with an unwanted response in the following situations:

- In tight bends.
- Driving in heavy rain, snow, fog or heavy spray.
- Driving in multi-storey car parks and tunnels.
- Driving on roads with embedded metal objects, e.g. railway tracks.
- Reversing.
- If ESC is regulating or faulty.
- If the radar sensor or camera window is dirty, covered or damaged.
- If several brake lights on the vehicle are faulty.
- If there is a fault in several brake lights on a trailer or bicycle carrier with an electrical connection to the vehicle.
- If the vehicle accelerates hard or the accelerator is fully depressed.
- In complex driving situations, e.g. at traffic islands.
- In unclear traffic situations, e.g. vehicles ahead are braking heavily or turning off.
- When the sun is low in the sky, in darkness or with glare from oncoming vehicles.
- When driving into and out of tunnels.
- If there is a fault in Front Assist.

Switching off Front Assist

Front Assist is not suitable for use in the following situations due to the limitations of the system and must be switched off → ⚠:

- If the vehicle is utilised in a capacity beyond usage on public roads, e.g. off-road or on a race track.
- If the vehicle is being towed or is loaded onto another vehicle.
- If add-on parts cover the radar sensor or camera.
- If the camera or the radar sensor is faulty.

– After external force on the radar sensor, e.g. after a rear-end collision.
– If the windscreen is damaged in the area of the camera window.
– In the event of multiple unwanted interventions.

⚠ WARNING

Failure to switch off Front Assist in the situations mentioned can result in accidents and serious injuries. ◁

Pedestrian Monitoring

🕮 Please refer to ⚠ at the start of the chapter on page 159.

Pedestrian Monitoring and Cyclist Monitoring can help to avoid accidents with pedestrians and cyclists or to mitigate the consequences of an accident.

The system may give a warning when there is a risk of collision, prepare the vehicle for emergency braking, help to brake the vehicle or perform an automatic brake intervention. In the event of an advance warning, the red warning lamp 🚶 lights up in the instrument cluster display.

When Front Assist is switched on and active, Pedestrian Monitoring is also active as an element of Front Assist.

⚠ WARNING

The intelligent technology of Pedestrian Monitoring cannot overcome the laws of physics, and functions only within the limits of the system. Never let the extra convenience afforded by Pedestrian Monitoring tempt you into taking any risks when driving. The driver is always responsible for braking in time.

- If Pedestrian Monitoring issues a warning, brake your vehicle immediately depending on the traffic situation or avoid the object.
- Pedestrian Monitoring cannot prevent accidents and serious injuries by itself.
- Pedestrian Monitoring can issue unnecessary warnings and carry out unwanted braking interventions in complex driving situations, e.g. in a sharply turning main road with an intersection.
- Pedestrian Monitoring can issue unnecessary warnings and carry out unwanted braking interventions when its function is impaired, e.g. if the radar sensor is covered or if the camera window is dirty.
- Be prepared to take over control of the vehicle yourself at all times. ◁

Swerve support

🕮 Please refer to ⚠ at the start of the chapter on page 159.

The swerve support function can help to steer the vehicle around an obstacle in critical driving situations.

If you steer to avoid an obstacle after an urgent warning, swerve support can help you. Swerve support brakes individual wheels and supports you with a corrective steering intervention as long as you steer.

Speed range

Swerve support is available in a speed range from around 30 km/h (20 mph) up to around 150 km/h (90 mph).

Limits

Swerve support does not react to crossing objects and animals. Always also observe the fundamental limits of Front Assist → page 162. ◁

11A012720AB

Oncoming vehicle braking when turning

Please refer to ⚠ at the start of the chapter on page 159.

The oncoming vehicle braking when turning function can prevent the vehicle from colliding with an oncoming vehicle during a turn.

If there is a risk of the vehicle colliding with an oncoming vehicle in the adjacent lane when turning, the oncoming vehicle braking when turning function can brake your vehicle. The vehicle can then remain in its own lane as a result.

Speed range

The oncoming vehicle braking when turning function is available up to around 15 km/h (around 9 mph).

Limits

The oncoming vehicle braking when turning function is available only if you indicate, have turned the steering wheel and have therefore started the turning manoeuvre. After changing from right-hand traffic to left-hand traffic or vice versa, the oncoming vehicle braking when turning function is available only after a certain time (30 minutes or more).

The oncoming vehicle braking when turning function does not react to persons, animals, crossing vehicles or objects that are not detected as a vehicle. Always also observe the fundamental limits of Front Assist → page 162. ◁

Operating Front Assist

Please refer to ⚠ at the start of the chapter on page 159.

Front Assist and all the included functions (country-dependent) are automatically switched on when you switch on the ignition.

However, Front Assist is not available or only partially available as long as the indicator lamp is on.

Volkswagen recommends that Front Assist and all the included functions (country-dependent) are switched on at all times. Exceptions → page 162.

Switching on and off

— Switch Front Assist on and off in the Assist systems menu of the Infotainment system → page 31.

If you switch off Front Assist, all the included functions (country-dependent) are also switched off. The yellow indicator lamp lights up in the instrument cluster display.

Making settings for the included functions (country-dependent)

You can make further settings when Front Assist is switched on:

— Switch the desired function on and off in the Assist systems menu of the Infotainment system → page 31.

You can also set the warning time for the advance warning. ◁

Troubleshooting

Please refer to ⚠ at the start of the chapter on page 159.

Front Assist is starting up.

The indicator lamp lights up.

— Front Assist is temporarily unavailable or limited. Front Assist is available after driving straight ahead for a short time, and the indicator light goes out. When the vehicle is not in motion, the indicator lamp lights up continuously.

Front Assist not available or functions restricted.

The indicator lamp lights up yellow and a text message is also displayed.

— The radar sensor or camera window is dirty. Clean the radar sensor and windscreen → page 355.

— The view of the radar sensor or camera is impaired due to the weather conditions, e.g. snow, or due to detergent deposits or coatings. Clean the radar sensor and windscreen → page 355.

— The view of the radar sensor is impaired by add-on parts, the trim frames of number plate holders or stickers. Keep the area around the radar sensor free.

— The view of the camera is impaired by add-on parts or stickers. Keep the area around the camera window free.

— The radar sensor or camera has been displaced or damaged, e.g. due to damage to the front of the vehicle or the windscreen. Check whether damage is visible → page 362.

— Paint work or structural modifications were carried out on the front of the vehicle.

— If the problem persists, switch off Front Assist and go to a qualified workshop.

Front Assist does not function as expected or is triggered unnecessarily several times.

— The radar sensor or camera window is dirty. Clean the radar sensor and windscreen → page 355.

— The system limits have been exceeded → page 162.

— Low sun or darkness.

— If the problem persists, switch off Front Assist and go to a qualified workshop.

Touch panels react differently than expected.

Moisture, dirt and grease can impede the functioning of the touch panels.

— Make sure the touch panels are always clean and dry. ◁

Lane keeping system (Lane Assist)

Introduction to the topic

Within the system limits, the lane keeping system (Lane Assist) helps the driver to stay in lane. The function is not designed to keep the vehicle in lane automatically, nor is it suited to this purpose.

Using a camera in the windscreen, the lane keeping system detects road lane markings on the road. If your vehicle moves too close to a recognised road lane marking, the system will warn the driver with a corrective steering intervention. The corrective steering intervention can be overridden by the driver at any time.

System limits

Use the lane keeping system only on motorways and well-developed country roads.

11A012720AB

APPENDIX C

Run Log

Test Date: **6/28/2021**

7/8/2021

Subject Vehicle: **2021 Volkswagen ID.4 Pro S (Statement)**

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**	N							Throttle
3		N							IP camera
4		N							Throttle
5		N							IP camera
6		N							IP camera
7		N							IP camera
8		Y	2.48	2.29	25.1	0.80	0.93	Pass	
9		Y	2.62	2.15	25.2	0.85	0.90	Pass	
10		Y	2.62	2.03	25.3	0.88	0.89	Pass	
11		Y	2.59	2.38	25.3	0.79	0.93	Pass	Rear cross traffic unavailable message
12		Y	2.58	0.00	4.5	1.06	0.22	Fail	
13		N							Driver brake
14		Y	2.57	2.23	25.3	0.94	0.80	Pass	
15		Y	0.21	0.00	1.1	0.59	0.10	Fail	
16	Static Run								

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
17	**Slower POV, 25 vs 10**	Y	2.15	1.24	15.4	0.56	1.15	Pass	
18		Y	2.07	1.80	14.7	0.53	0.86	Pass	
19		Y	2.16	1.38	15.4	0.93	0.70	Pass	
20		N							Throttle
21		Y	2.17	1.64	14.5	0.49	0.71	Pass	
22		N							POV speed
23		Y	2.21	1.58	15.6	0.43	1.14	Pass	
24		Y	2.18	1.35	15.1	0.84	0.94	Pass	
25		Y	2.04	1.49	14.7	0.60	0.70	Pass	
26	Static Run								Check zero data is within ± 0.167 ft (±0.05m)
27	**Slower POV, 45 vs 20**	N							POV speed
28		Y	2.52	1.35	25.3	0.87	1.44	Pass	
29		N							POV speed
30		N							POV speed, broke SSV frame
31		Static: Resume testing 7/8/21							
32		Y	2.54	0.87	25.7	0.94	1.33	Pass	
33		Y	2.50	1.80	25.1	0.82	1.29	Pass	
34		Y	2.41	1.34	24.7	0.87	1.27	Pass	
35		Y	2.41	1.30	25.0	0.80	1.33	Pass	
36		Y	2.49	1.77	24.8	0.56	1.28	Pass	
37		Y	2.25	1.58	26.1	0.92	1.16	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
38	Static run								Check zero data is within ± 0.167 ft (±0.05m)
39	**Decelerating POV**	N							POV brakes
40		Y	1.62	0.00	32.1	0.96	1.20	Pass	
41		Y	1.52	0.00	30.4	0.81	1.08	Pass	
42		N							POV speed
43		Y	1.57	0.00	27.5	0.69	1.19	Pass	
44		Y	1.52	1.54	31.1	0.94	1.19	Pass	
45		Y	1.60	0.00	32.5	0.93	1.21	Pass	
46		Y	1.65	0.00	26.8	0.75	0.91	Pass	
47		Y	1.69	0.00	27.4	0.86	0.96	Pass	
48	Static Run								Check zero data is within ± 0.167 ft (±0.05m)
49	STP - Static Run								Zero SV front bumper to rear edge of steel plate and collect data
50	**STP False Positive, 25**	Y				0.01		Pass	
51		Y				0.01		Pass	
52		Y				0.01		Pass	
53		Y				0.02		Pass	
54		Y				0.01		Pass	
55		Y				0.01		Pass	
56		Y				0.01		Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
57	STP - Static Run								Check zero data is within ± 0.167 ft (±0.05m)
58	**STP False Positive, 45**	Y				0.02		Pass	
59		Y				0.02		Pass	
60		Y				0.02		Pass	
61		Y				0.02		Pass	
62		Y				0.02		Pass	
63		Y				0.02		Pass	
64		Y				0.02		Pass	
65	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 auditory, visual, or haptic). Depending on the type of FCW alert or instrumentation used to measure the alert, this can be any combination of the following:
    - Filtered, rectified, and normalized sound signal. The vertical scale is 0 to 1.
    - Filtered, rectified, and normalized acceleration (i.e., haptic alert, such as steering wheel vibration). The vertical scale is 0 to 1.
    - Normalized light sensor signal. The vertical scale is 0 to 1.

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

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

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

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

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

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

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

Envelopes and Thresholds

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

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

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

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

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

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

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

Color Codes

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

Color codes can be broken into four categories:

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

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

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

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

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

Other Notations

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

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

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

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

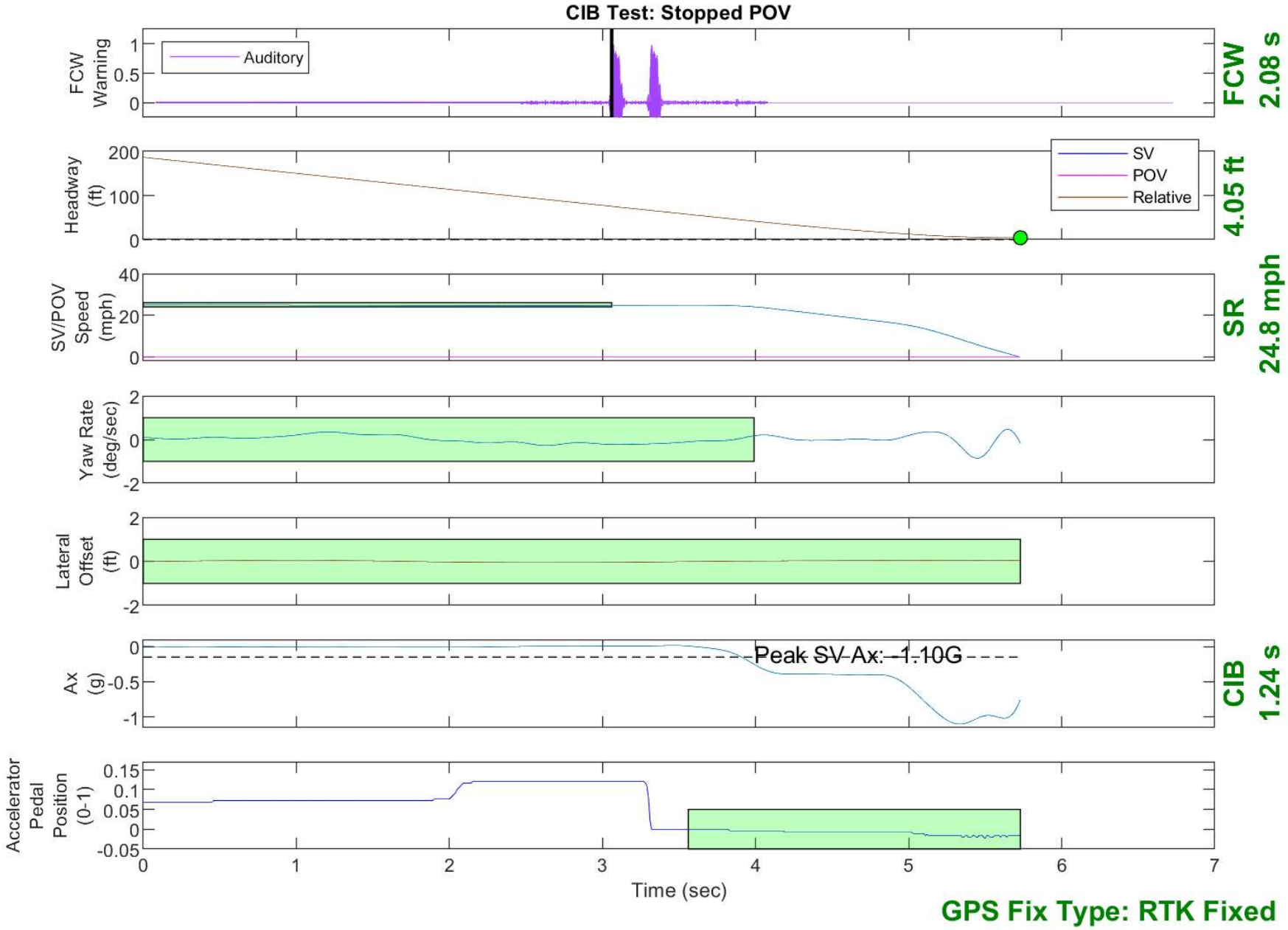

Figure D1. Example Time History for Stopped POV, Passing

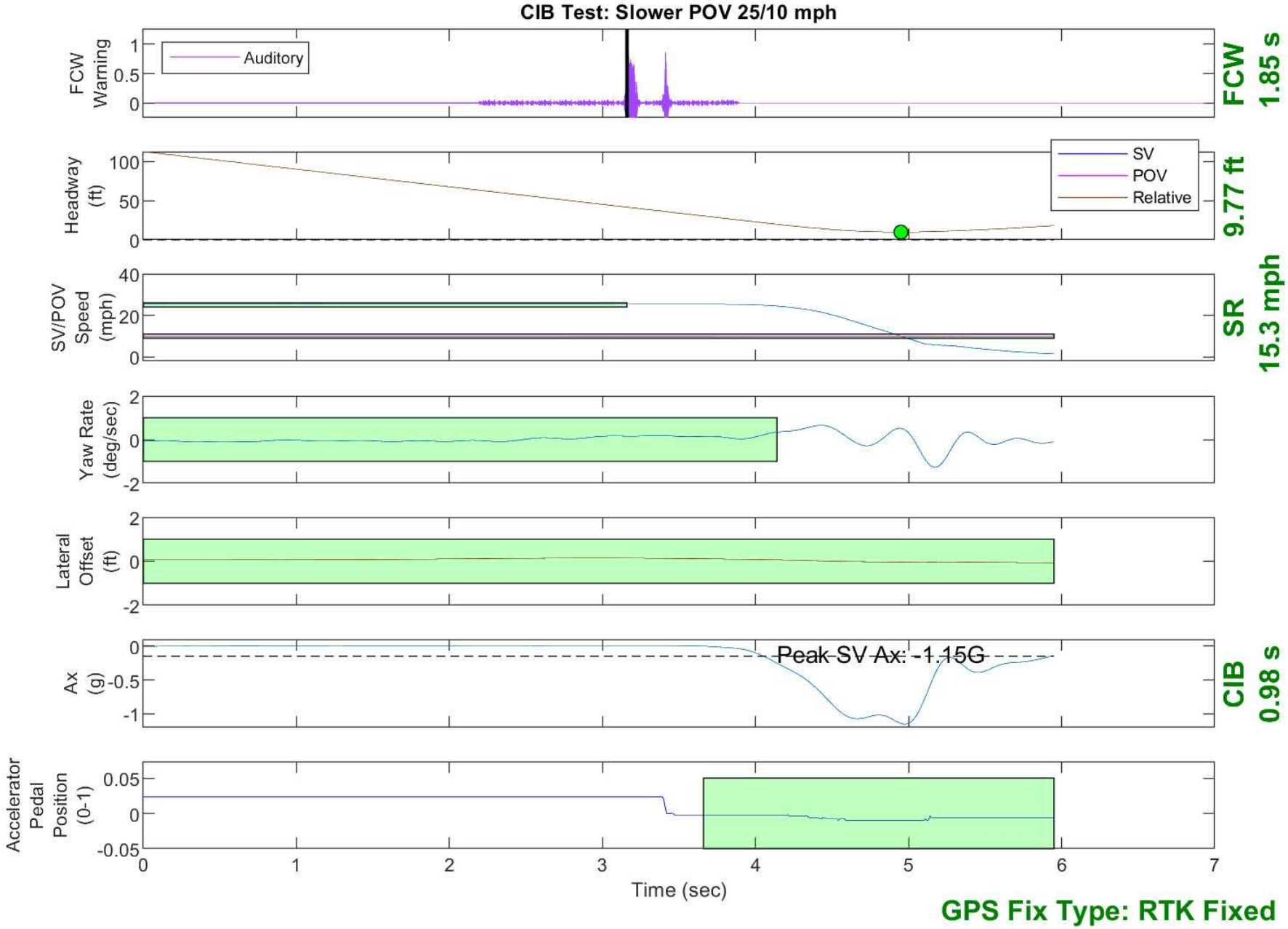

Figure D2. Example Time History for Slower POV 25 vs. 10, Passing

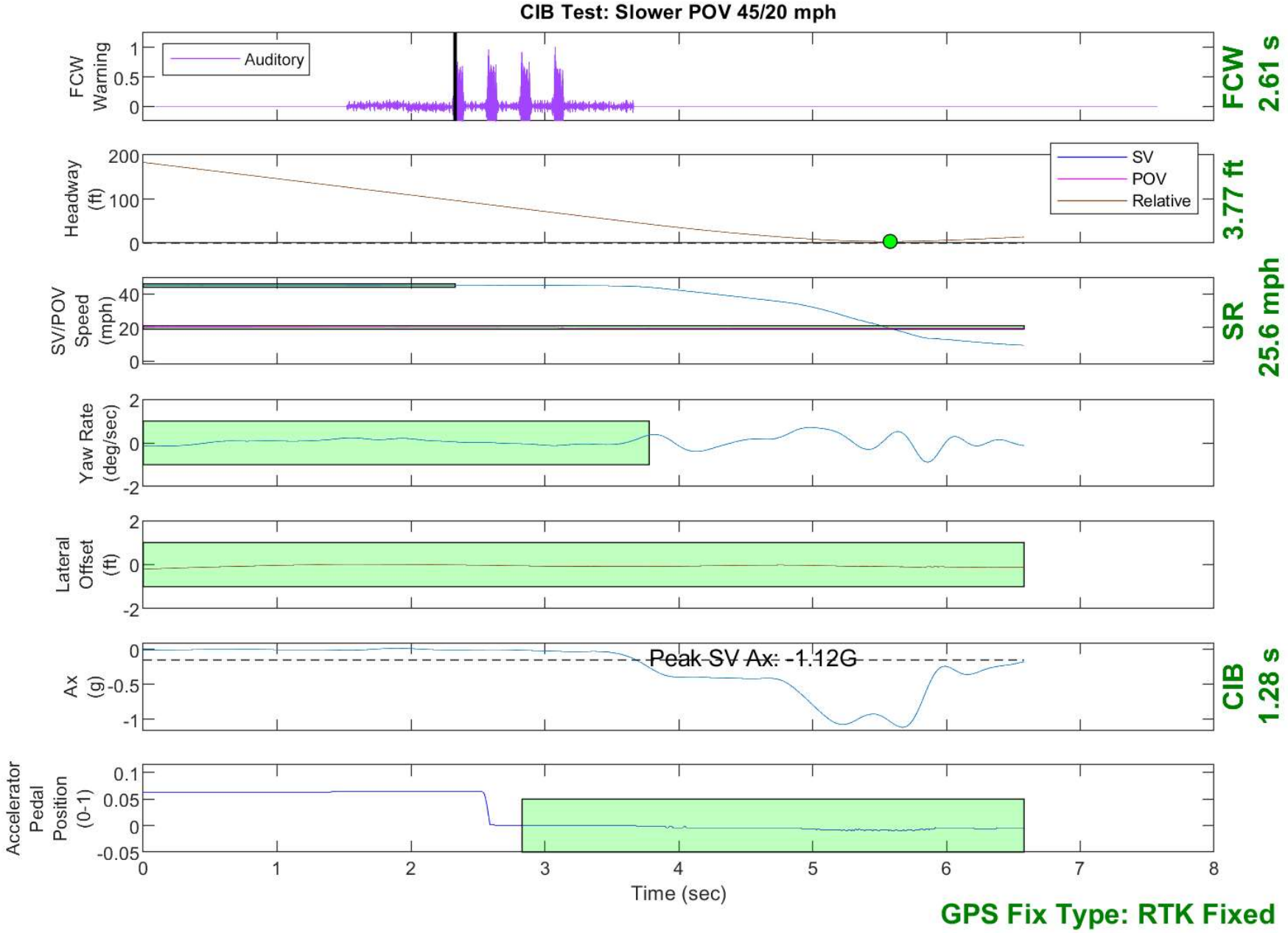

Figure D3. Example Time History for Slower POV 45 vs. 20, Passing

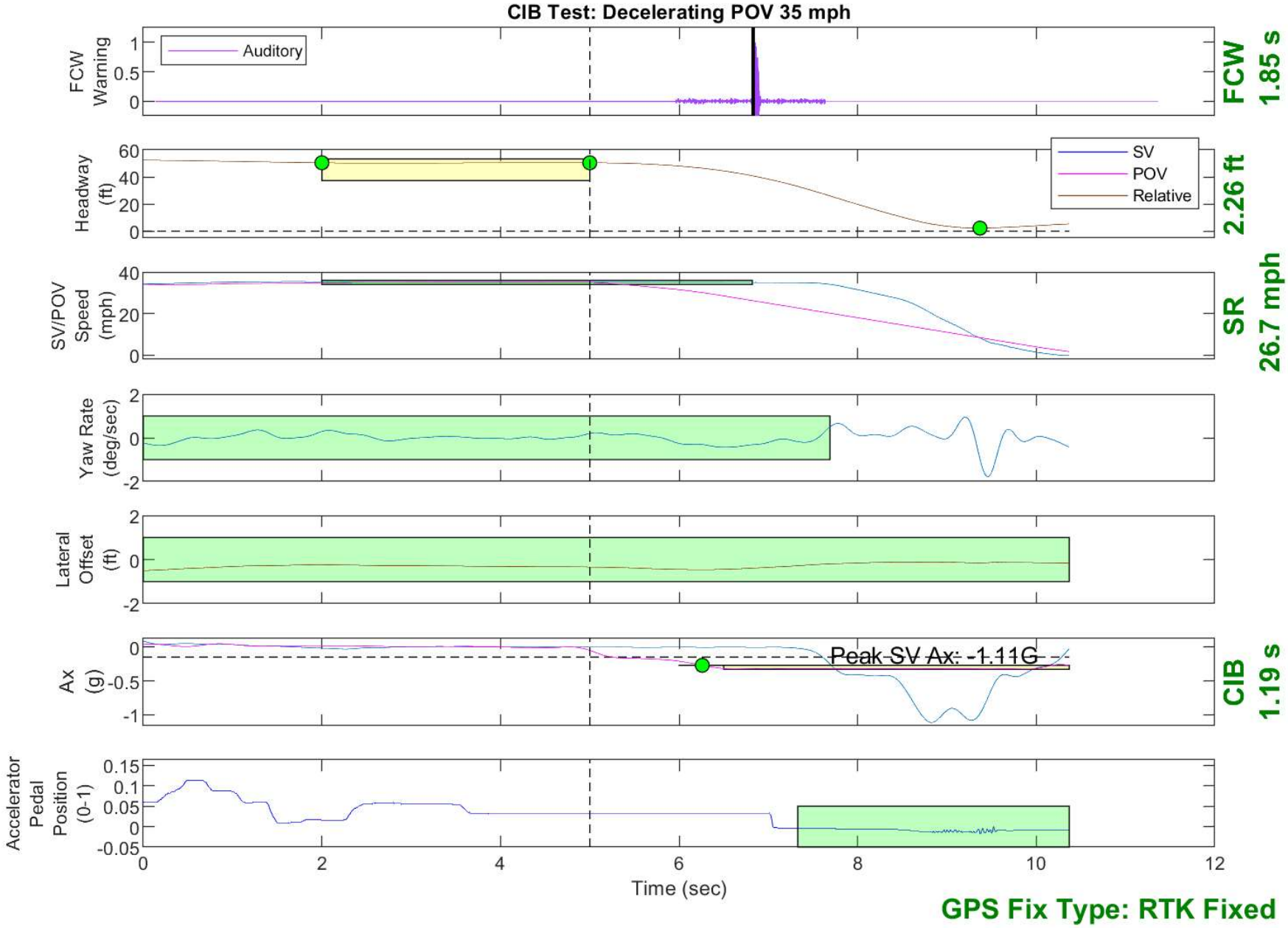

Figure D4. Example Time History for Decelerating POV 35, Passing

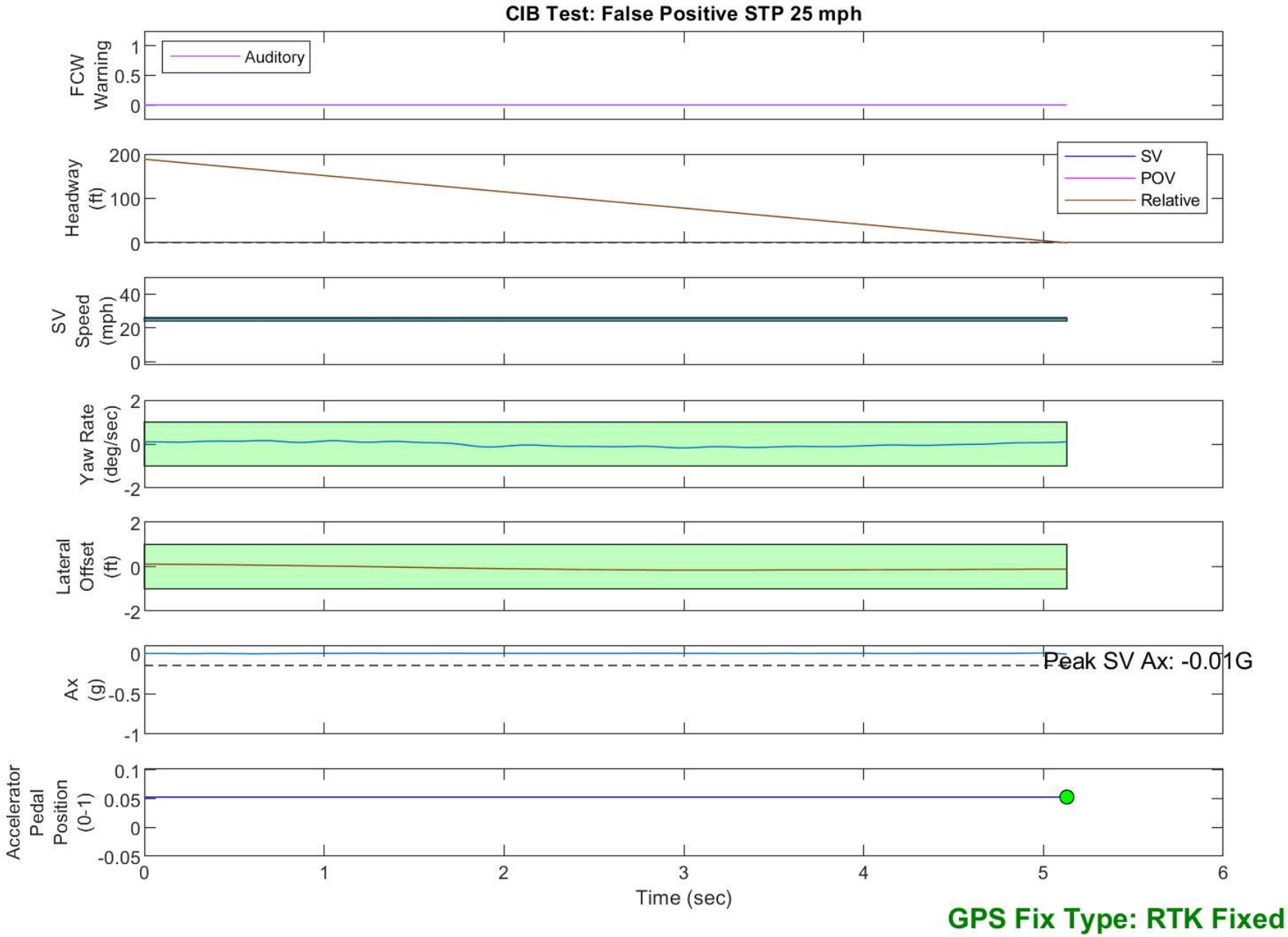

Figure D5. Example Time History for False Positive STP 25, Passing

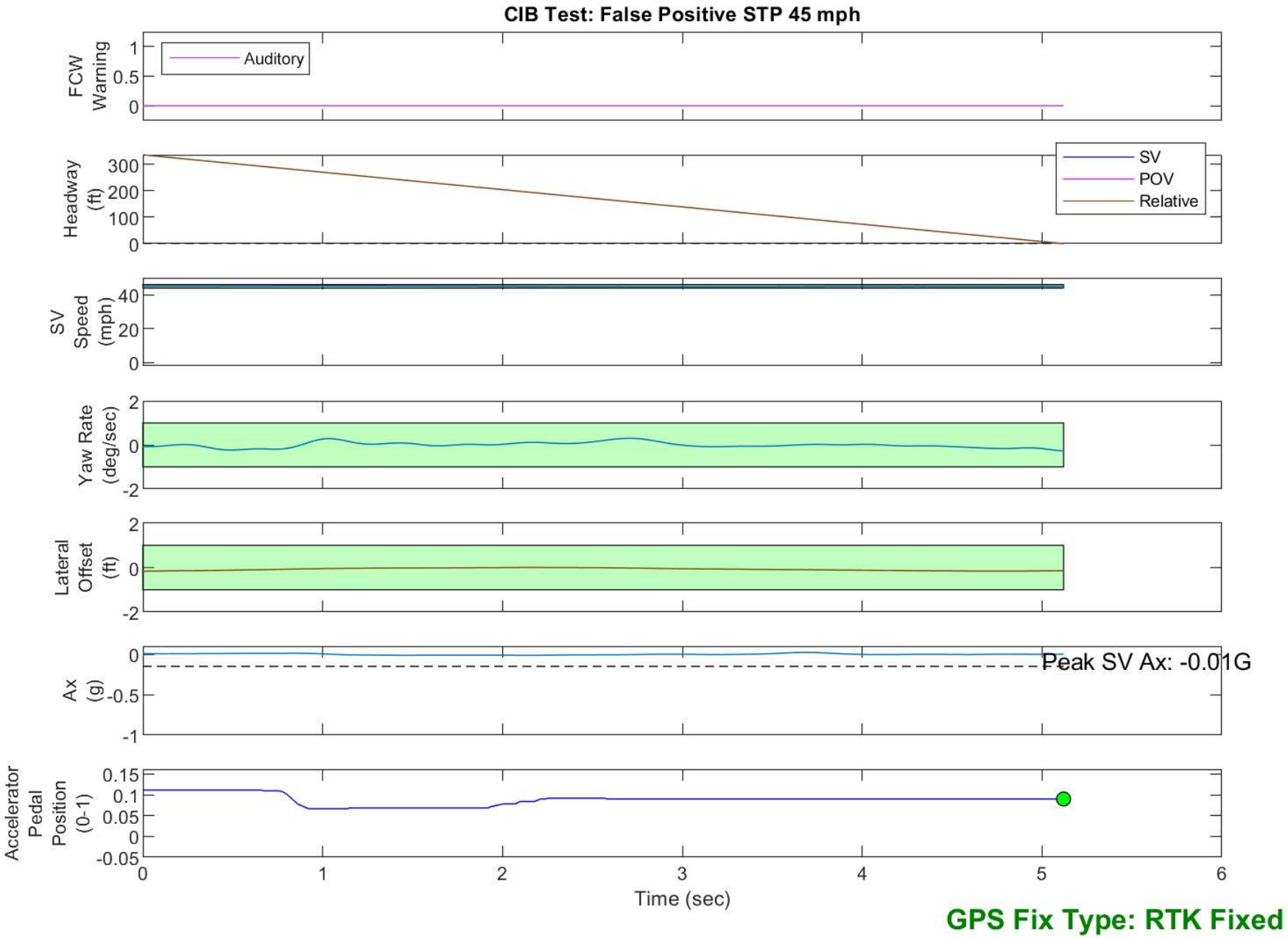

Figure D6. Example Time History for False Positive STP 45, Passing

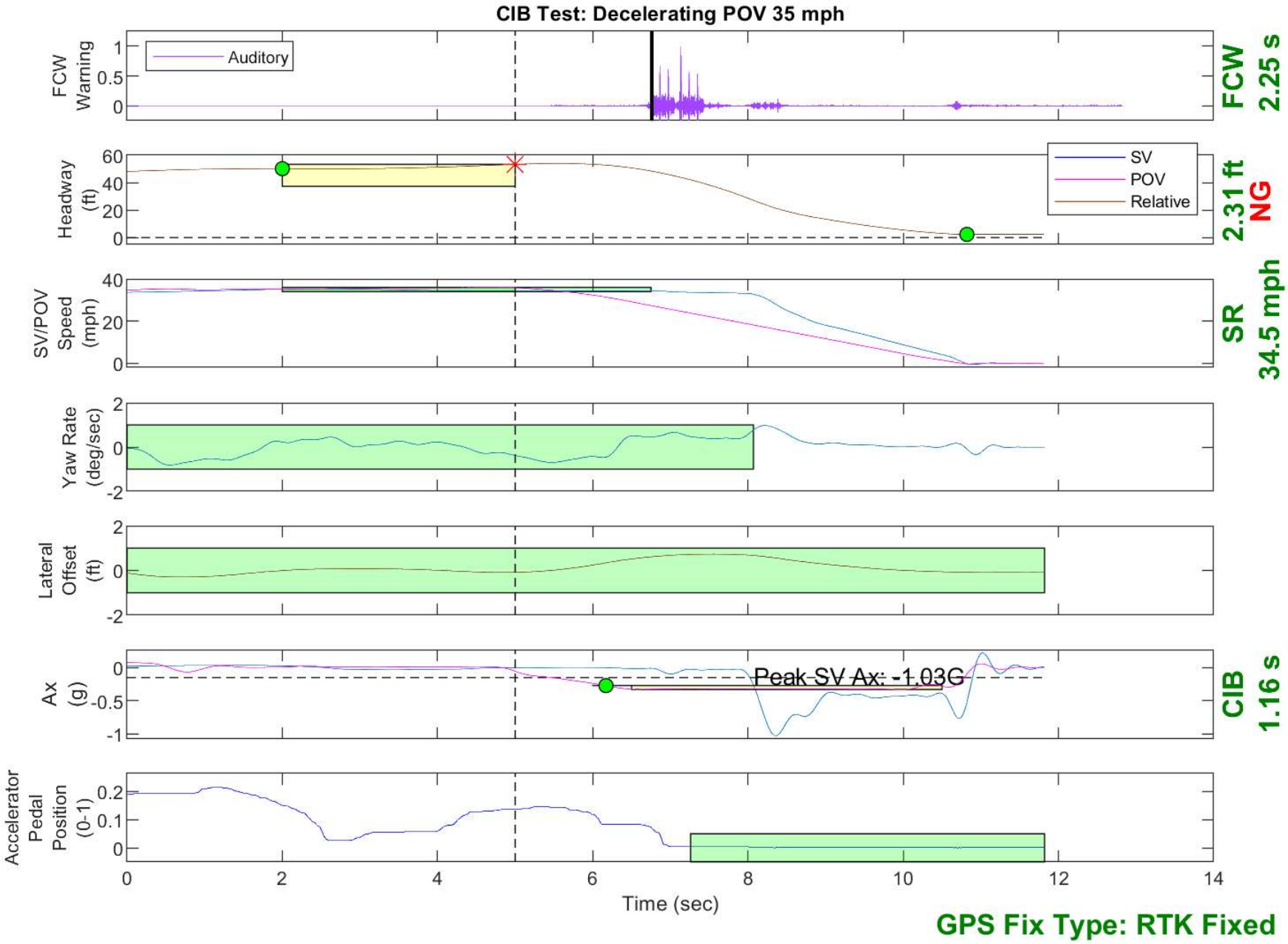

Figure D7. Example Time History Displaying Invalid Headway Criteria

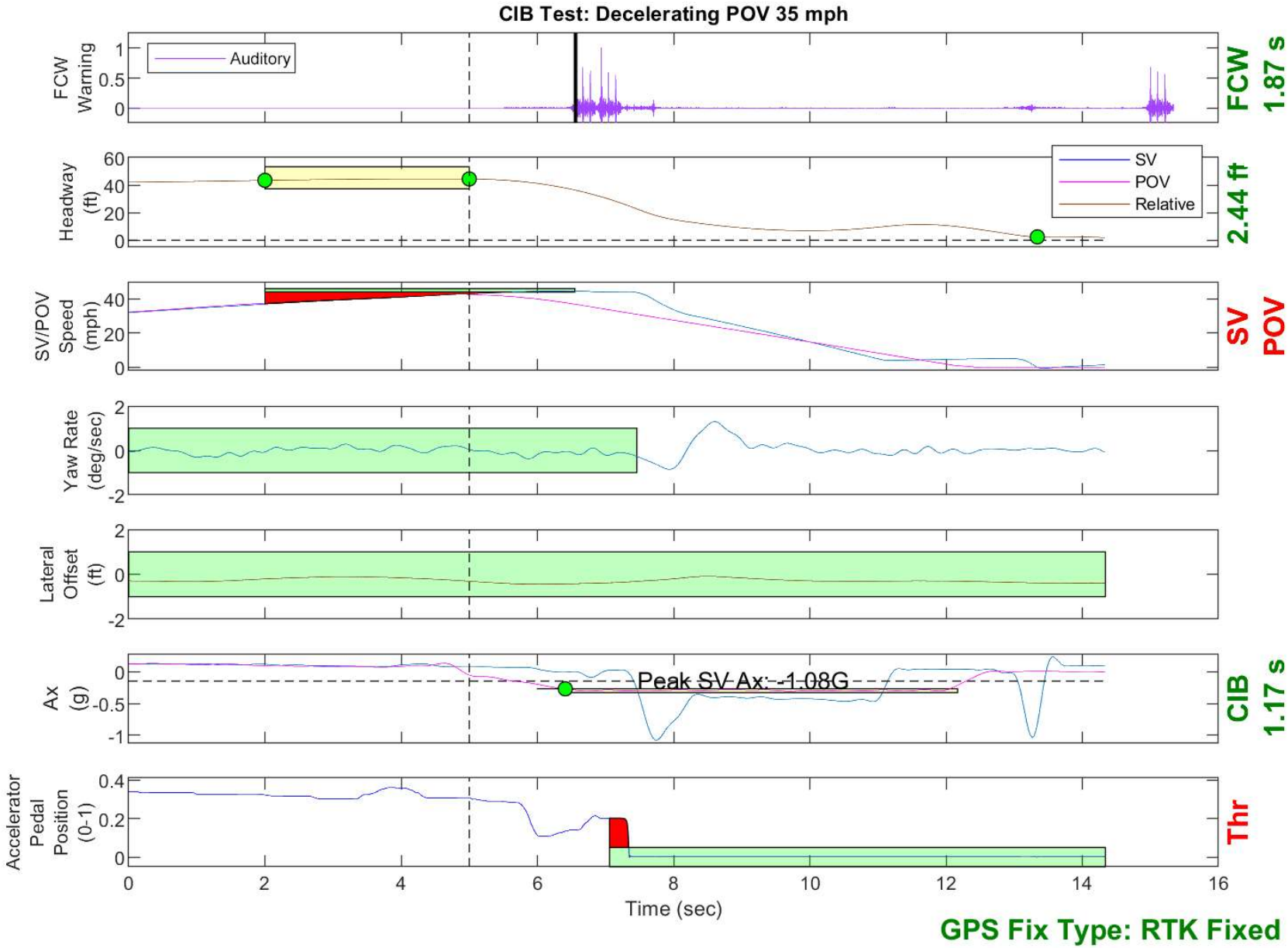

Figure D8. Example Time History Displaying Various Invalid Criteria

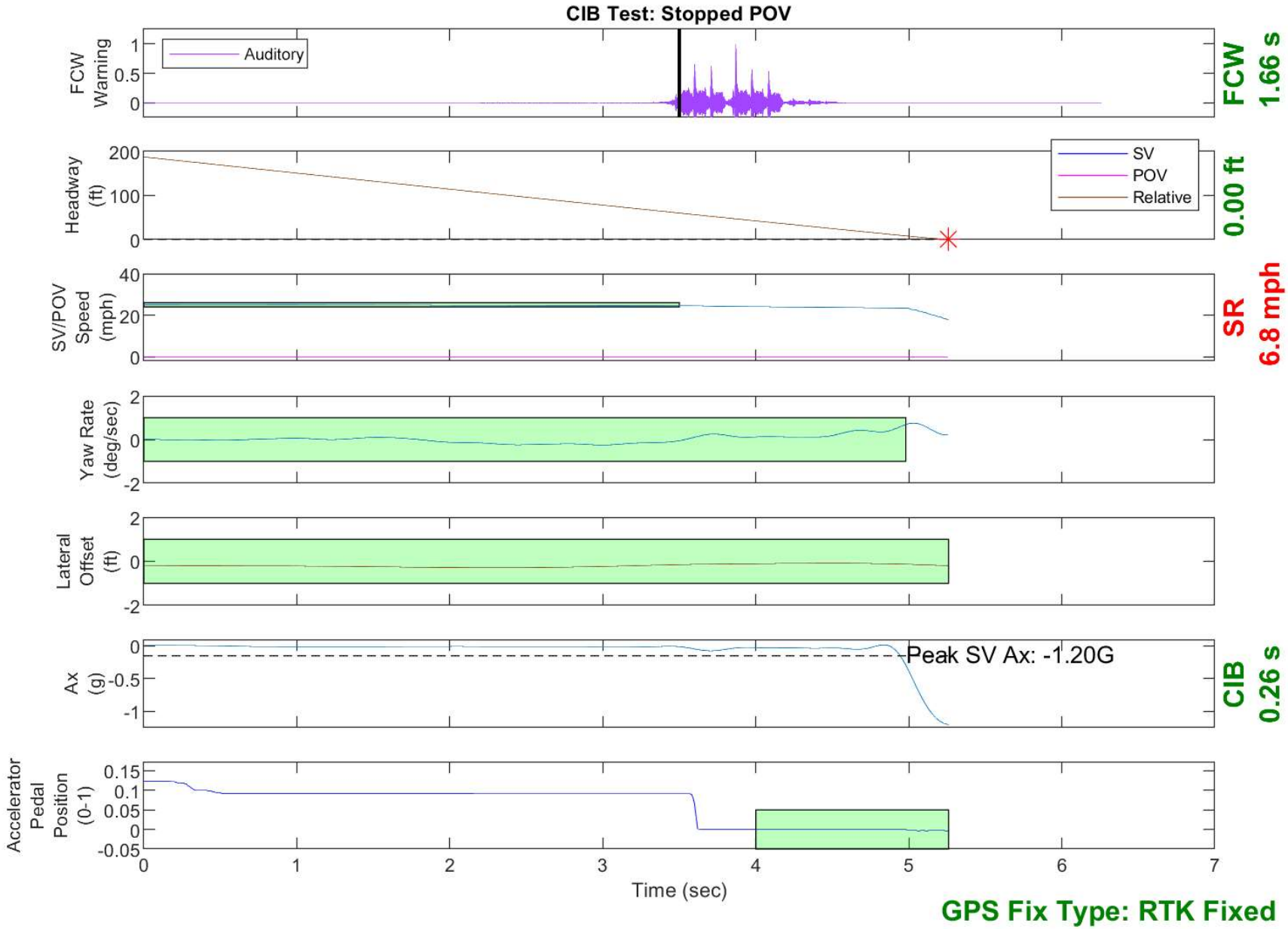

Figure D9. Example Time History for a Failed Run

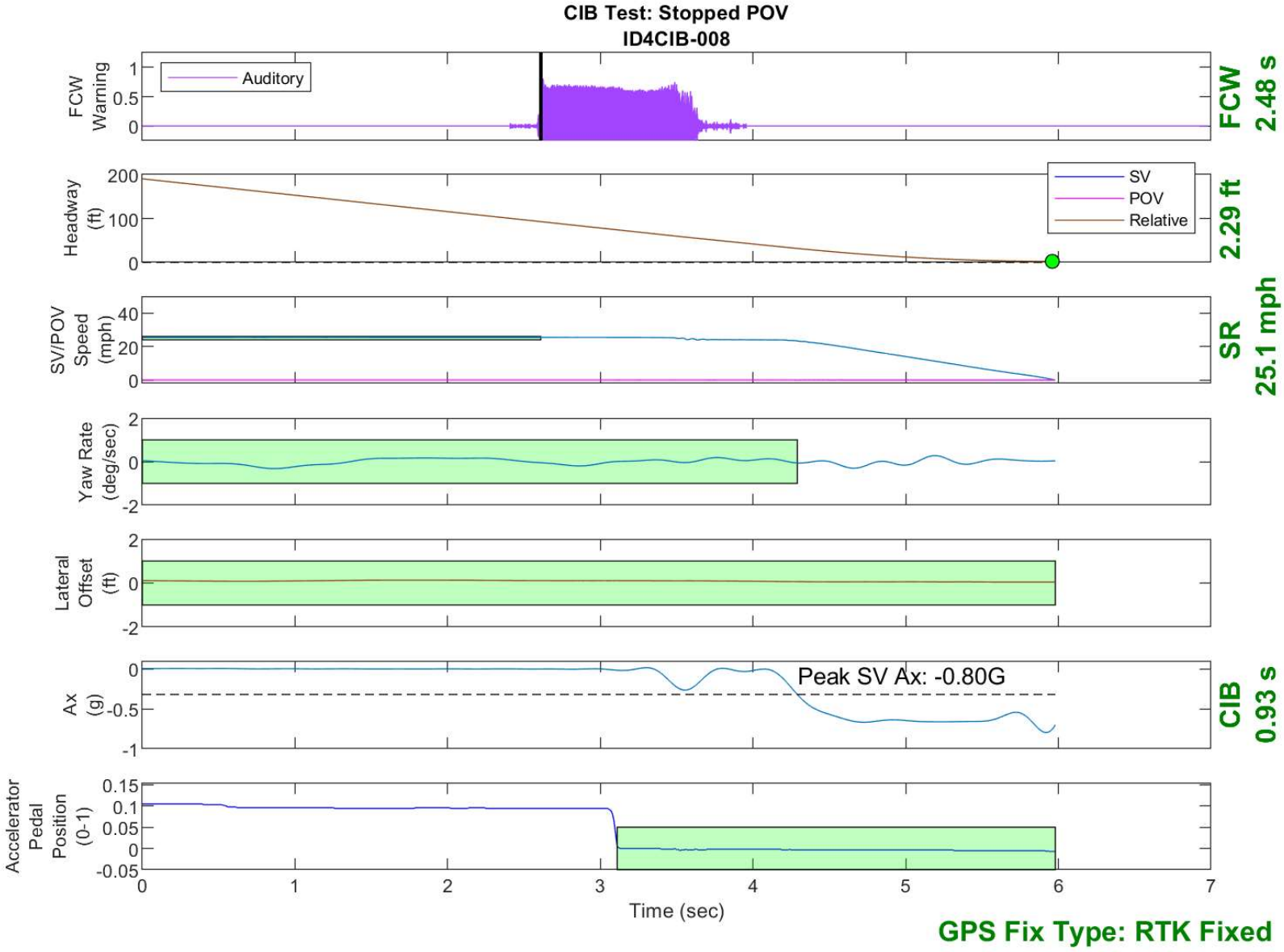

Figure D10. Time History for CIB Run 8, SV Encounters Stopped POV

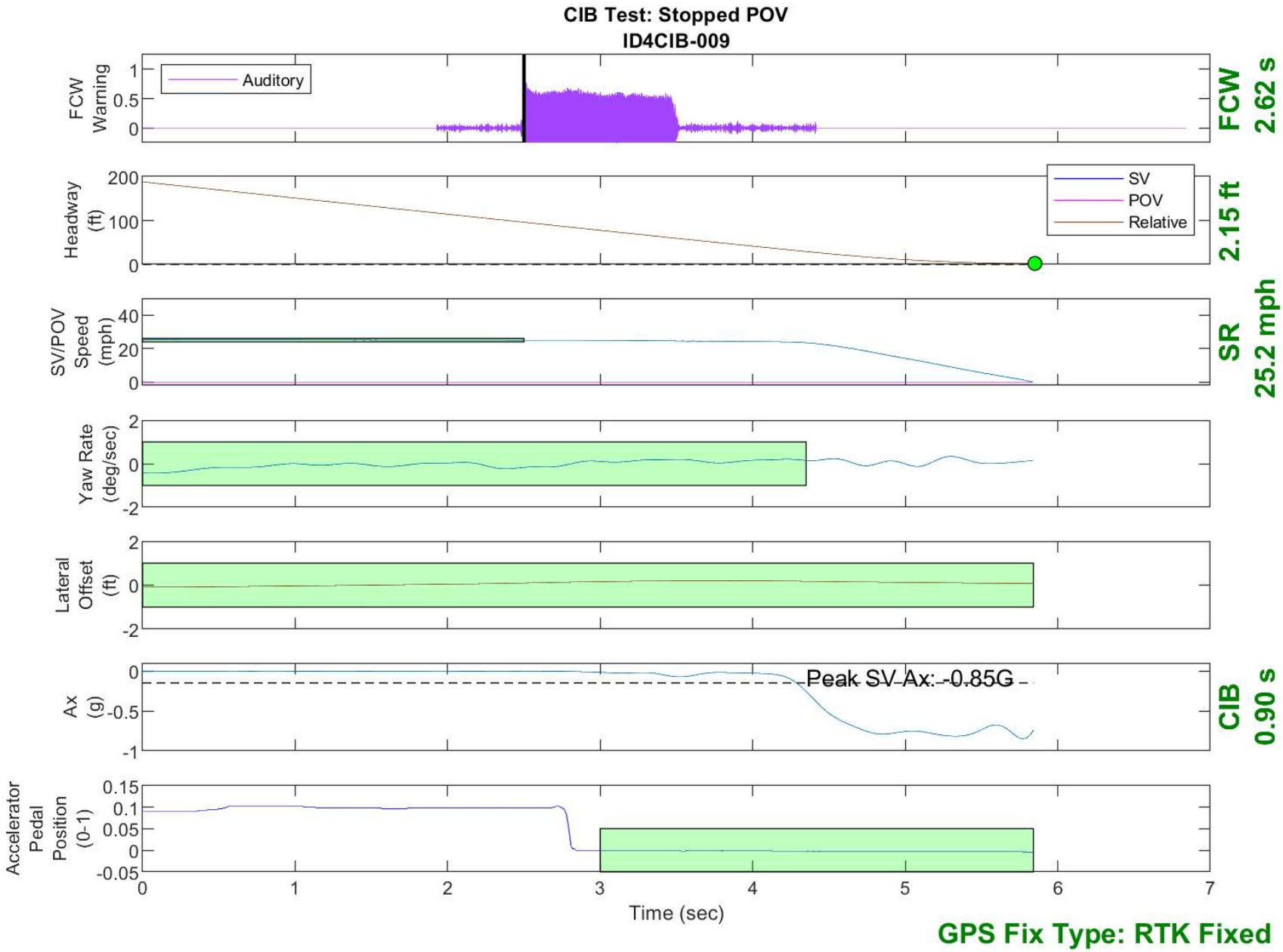

Figure D11. Time History for CIB Run 9, SV Encounters Stopped POV

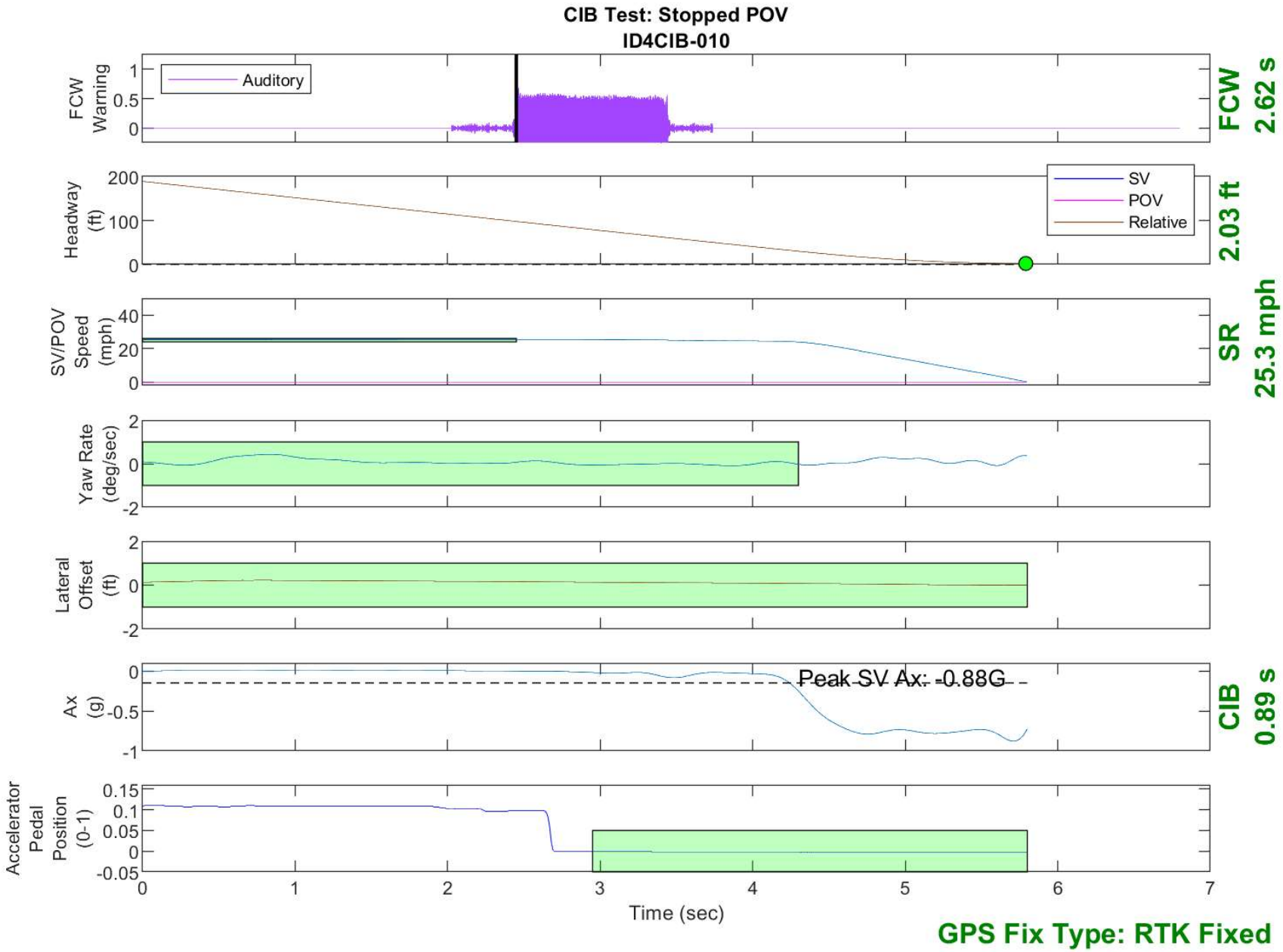

Figure D12. Time History for CIB Run 10, SV Encounters Stopped POV

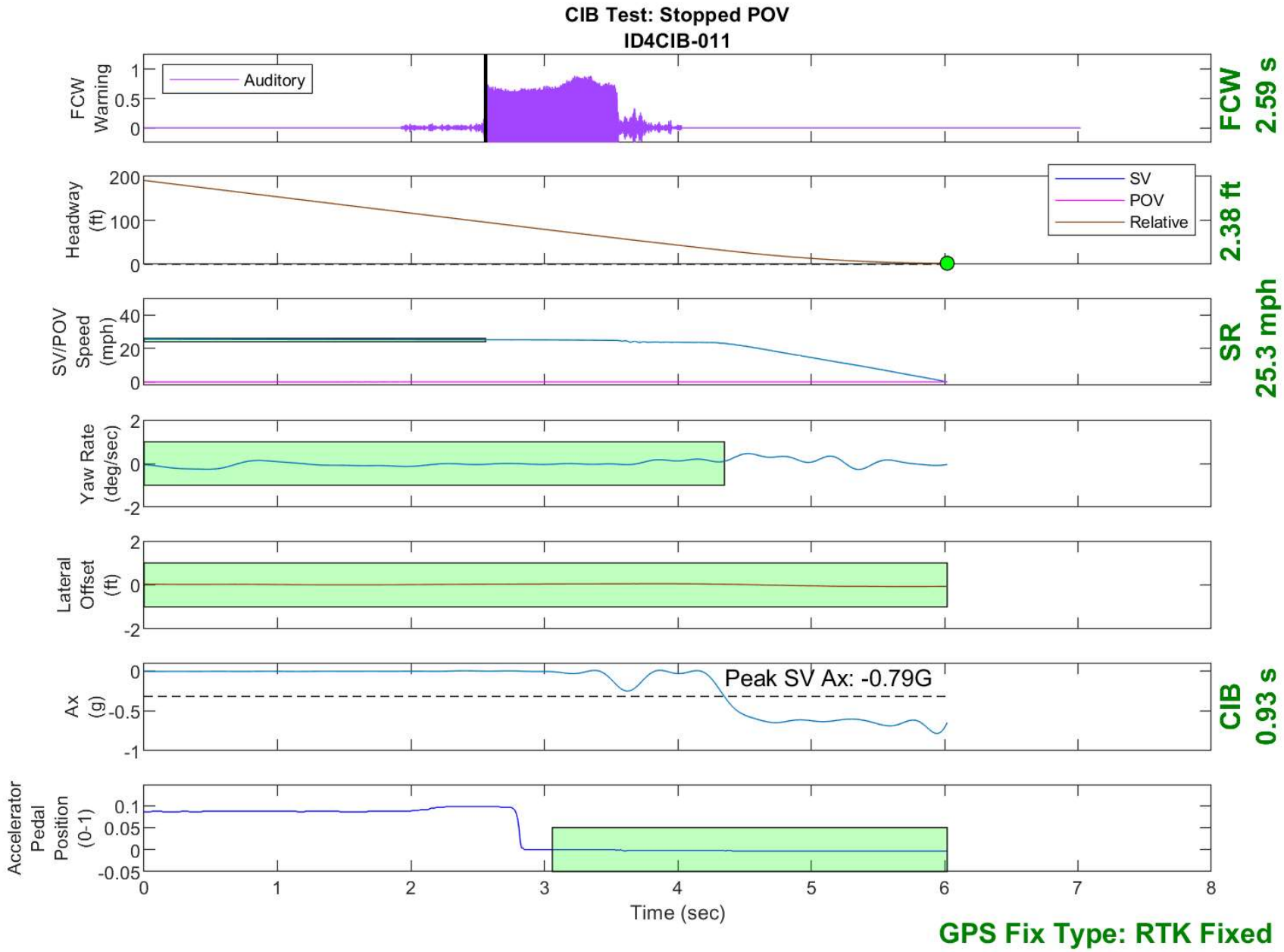

Figure D13. Time History for CIB Run 11, SV Encounters Stopped POV

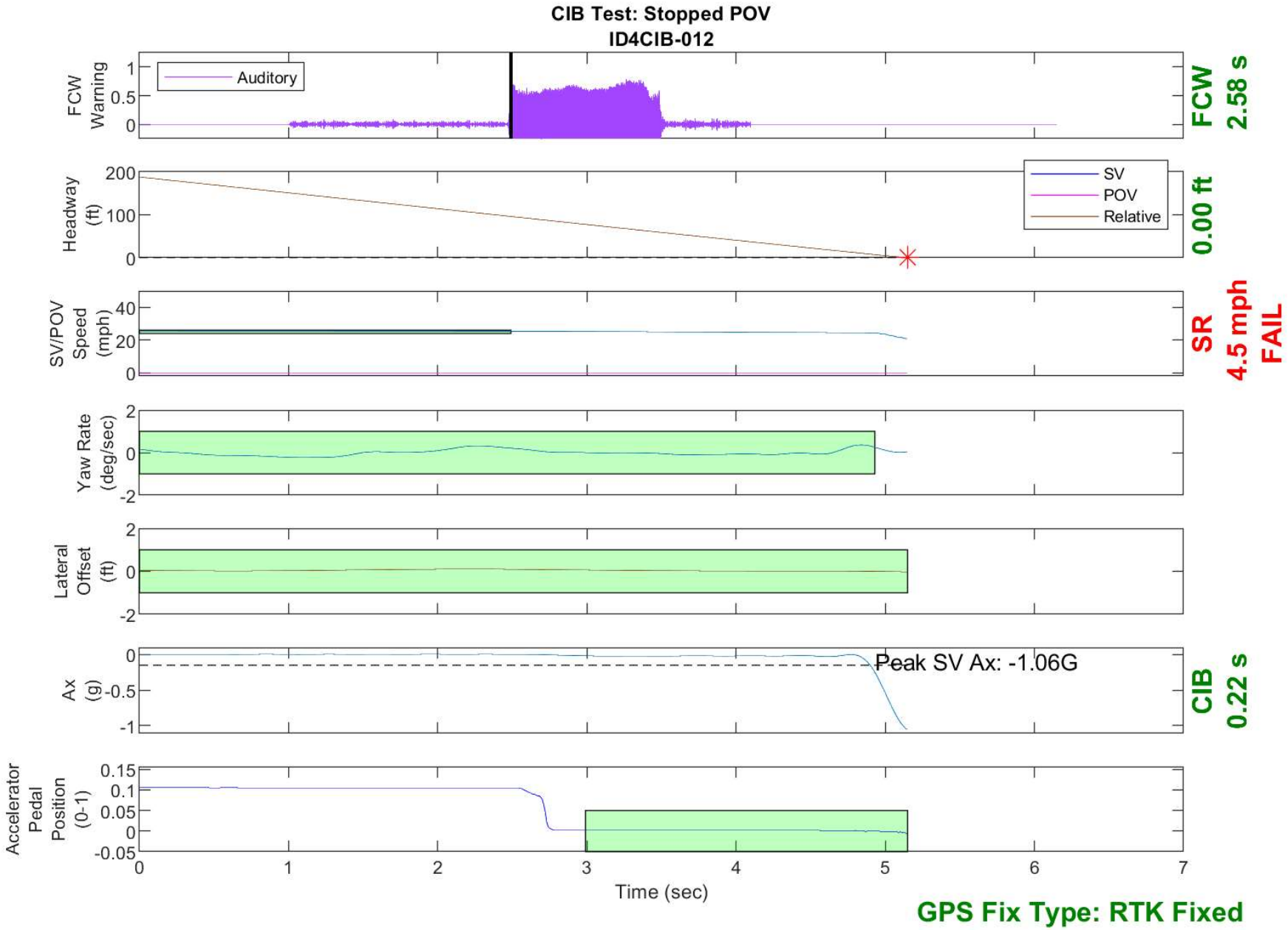

Figure D14. Time History for CIB Run 12, SV Encounters Stopped POV

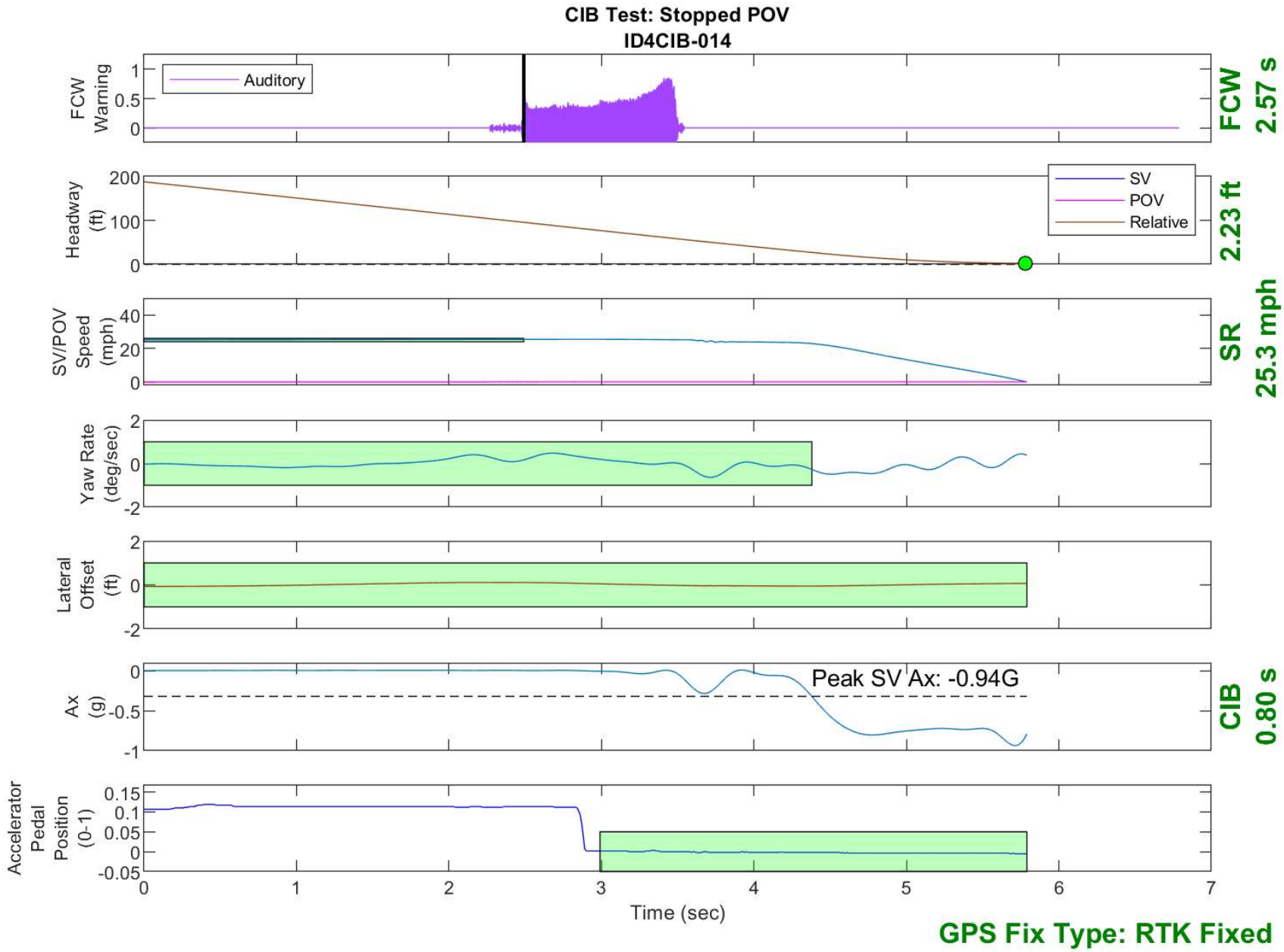

Figure D15. Time History for CIB Run 14, SV Encounters Stopped POV

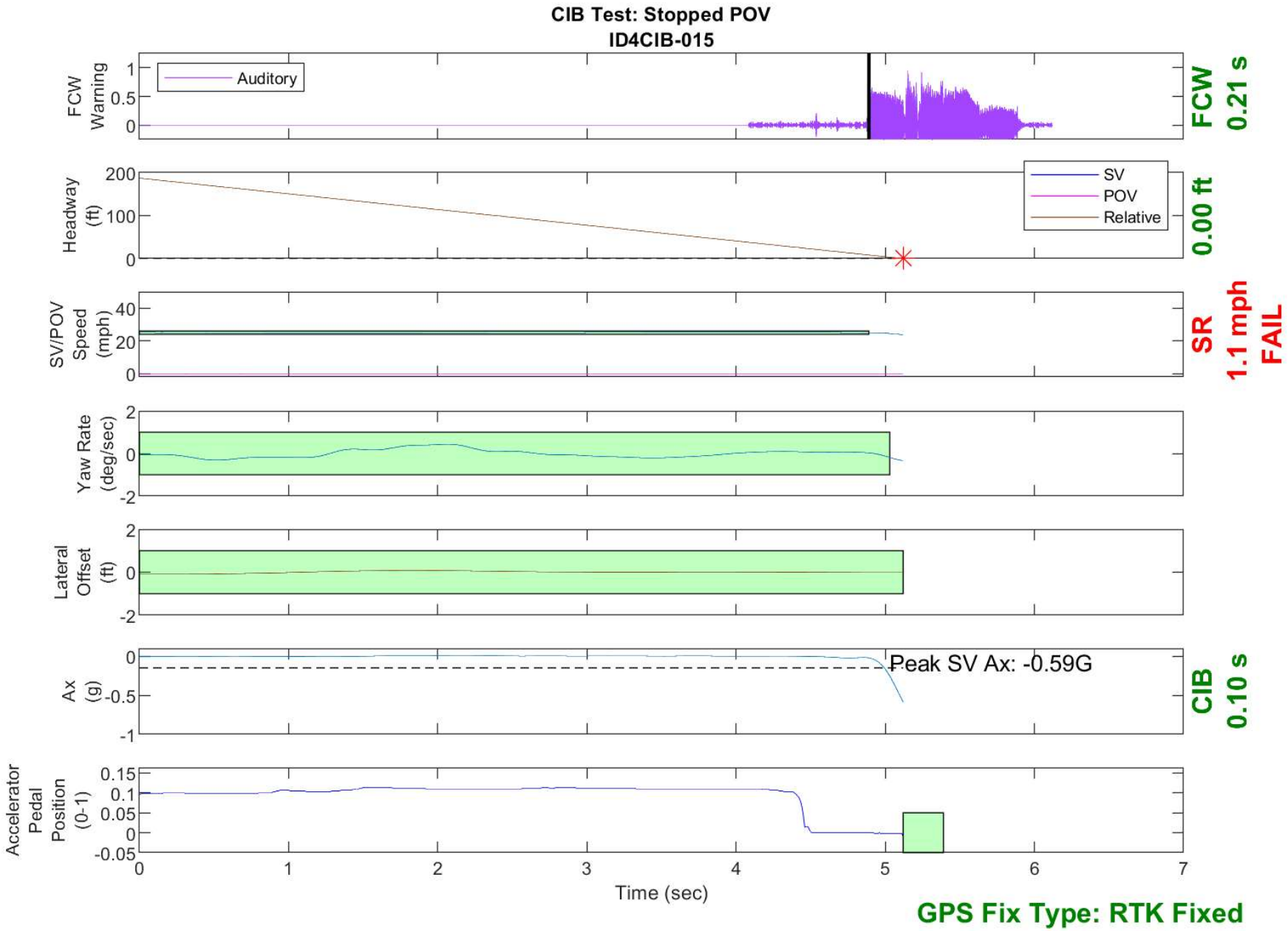

Figure D16. Time History for CIB Run 15, SV Encounters Stopped POV

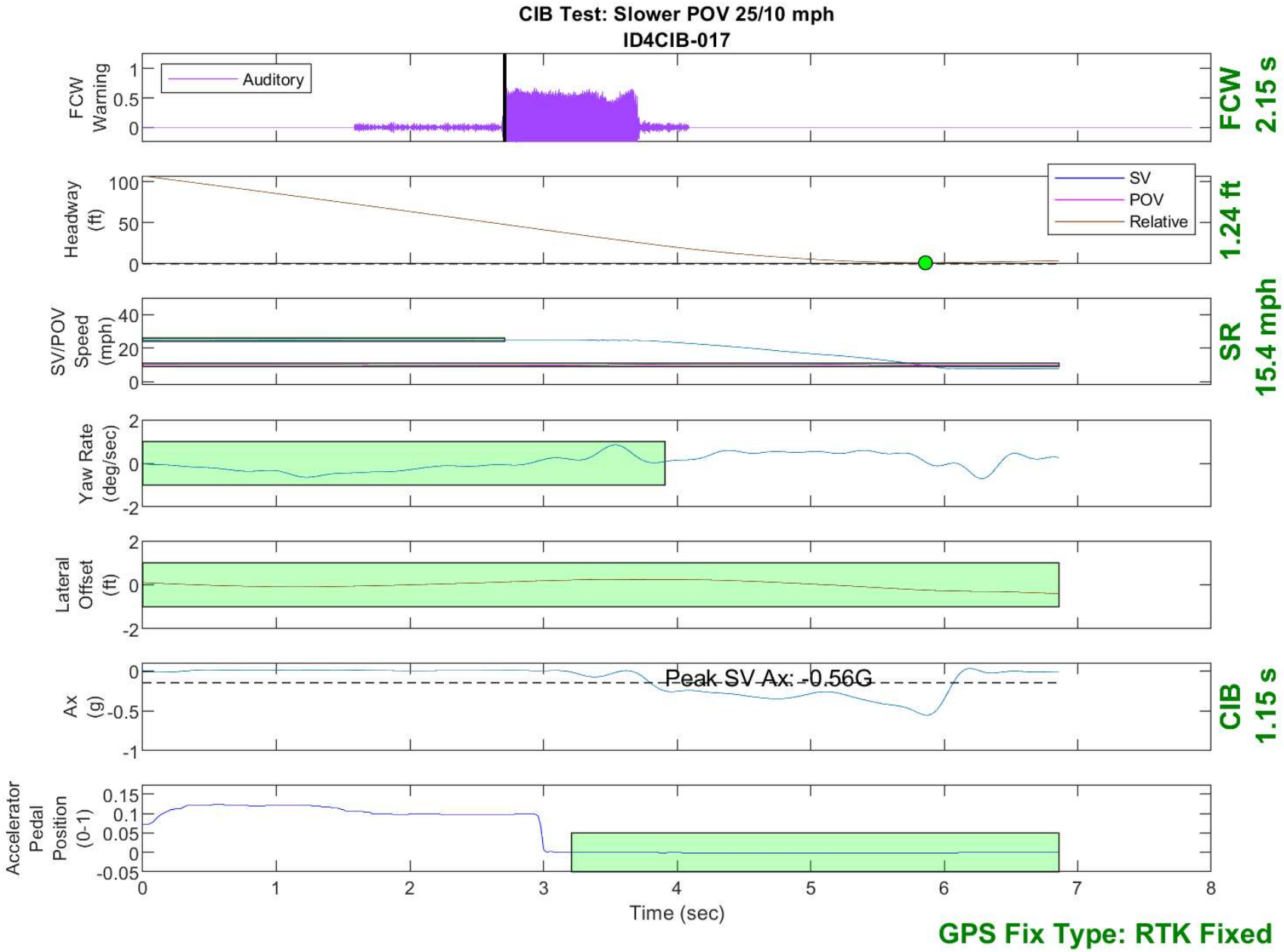

Figure D17. Time History for CIB Run 17, SV Encounters Slower POV, SV 25 mph, POV 10 mph

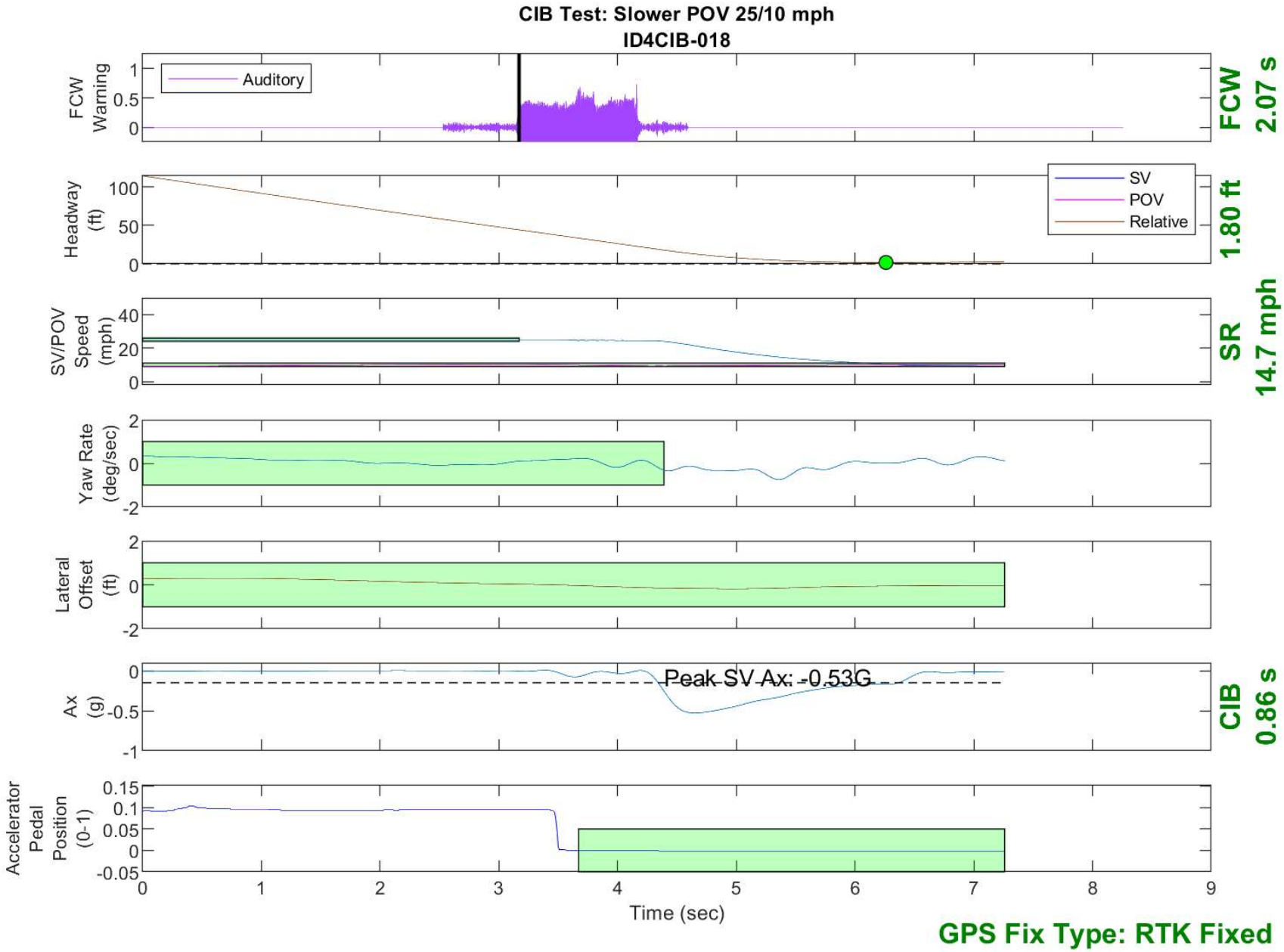

Figure D18. Time History for CIB Run 18, SV Encounters Slower POV, SV 25 mph, POV 10 mph

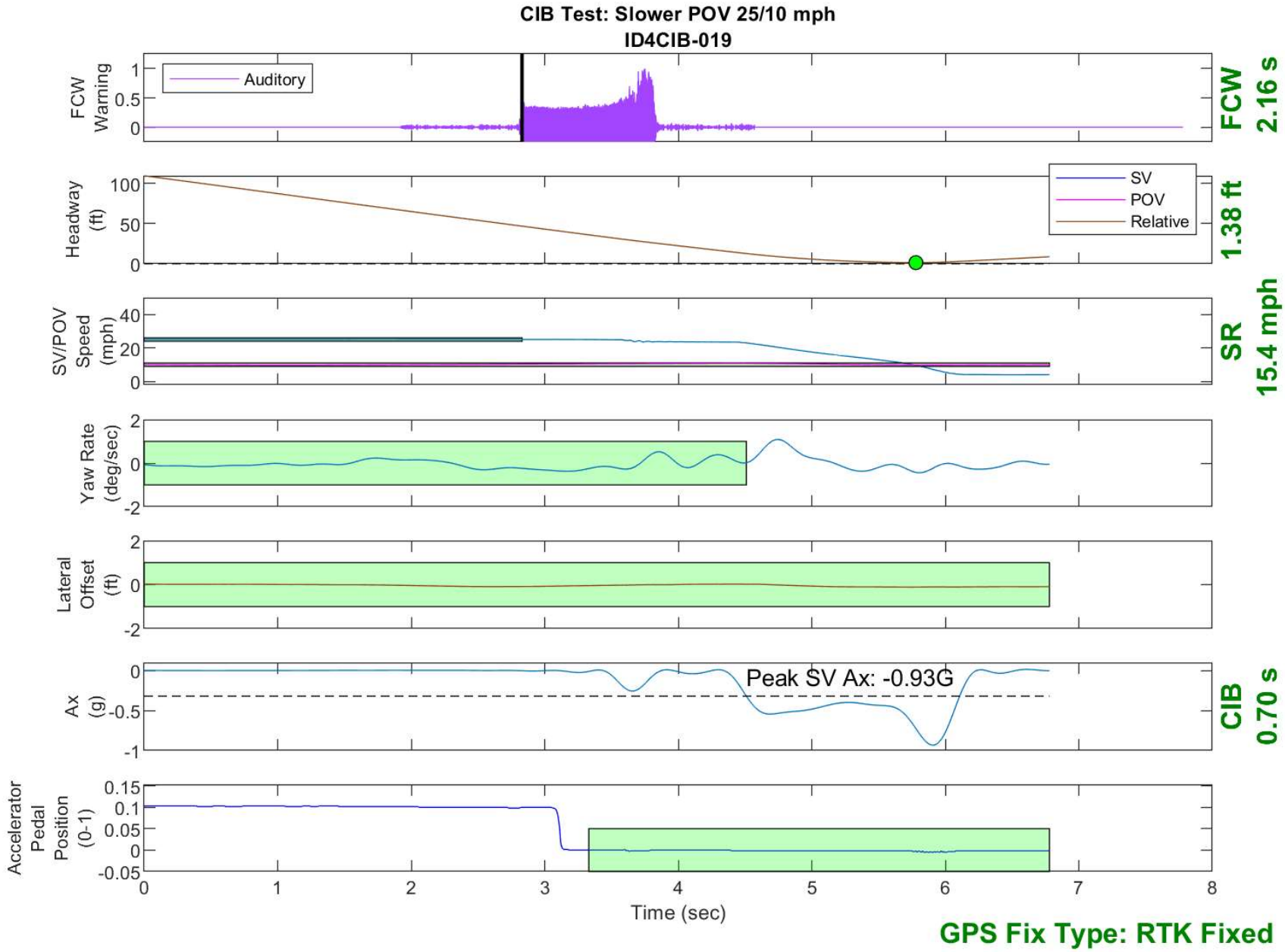

Figure D19. Time History for CIB Run 19, SV Encounters Slower POV, SV 25 mph, POV 10 mph

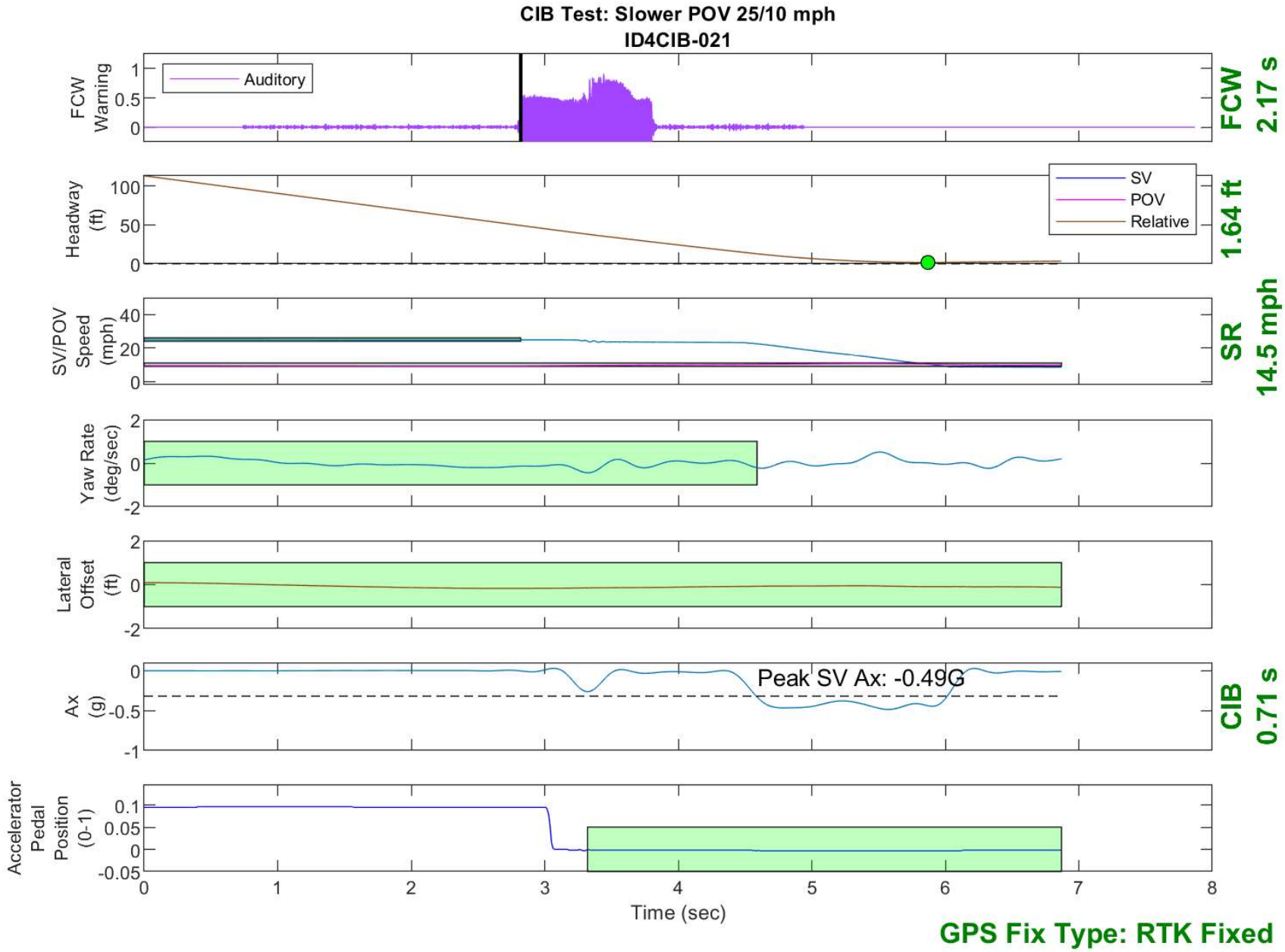

Figure D20. Time History for CIB Run 21, SV Encounters Slower POV, SV 25 mph, POV 10 mph

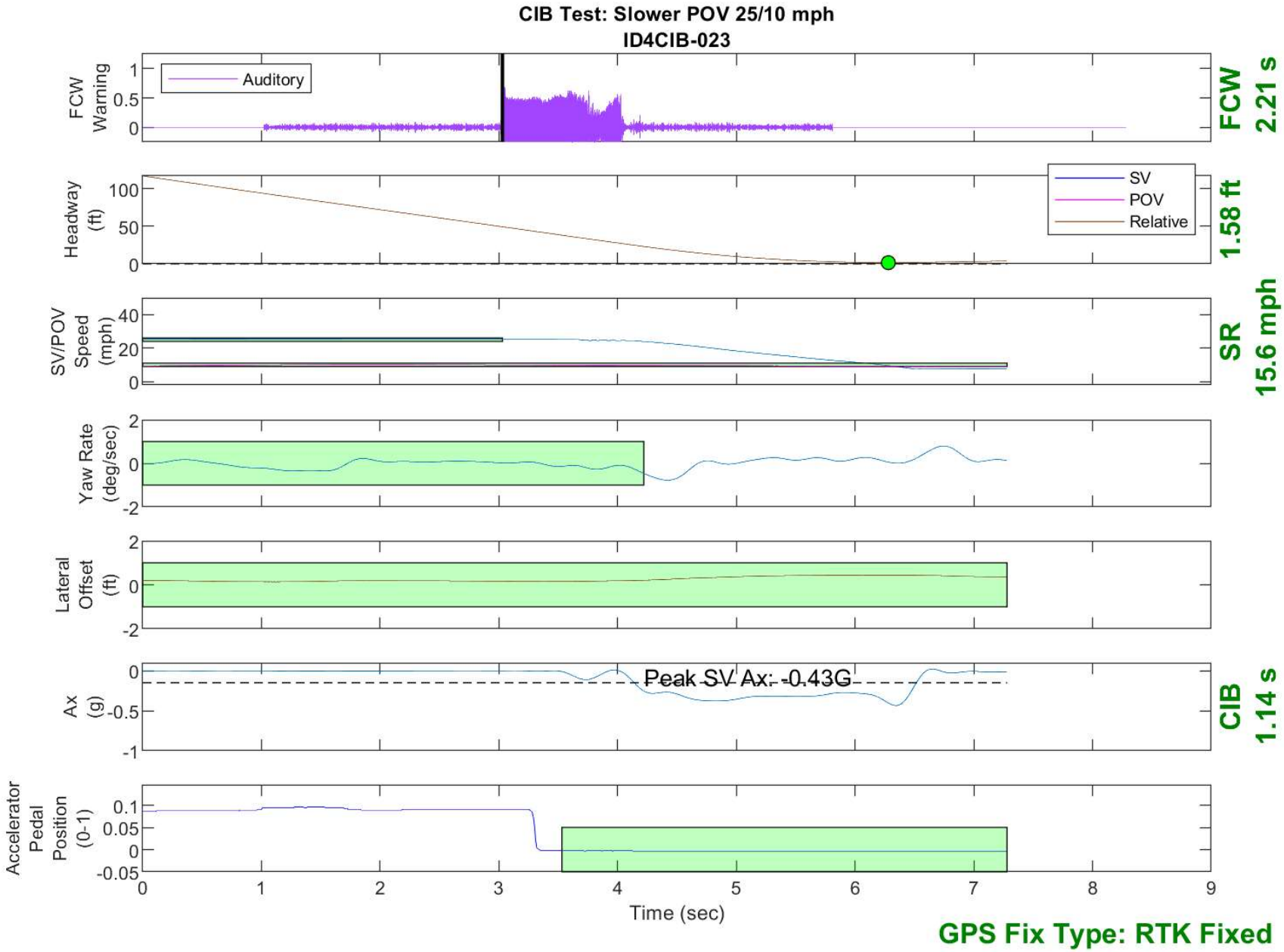

Figure D21. Time History for CIB Run 23, SV Encounters Slower POV, SV 25 mph, POV 10 mph

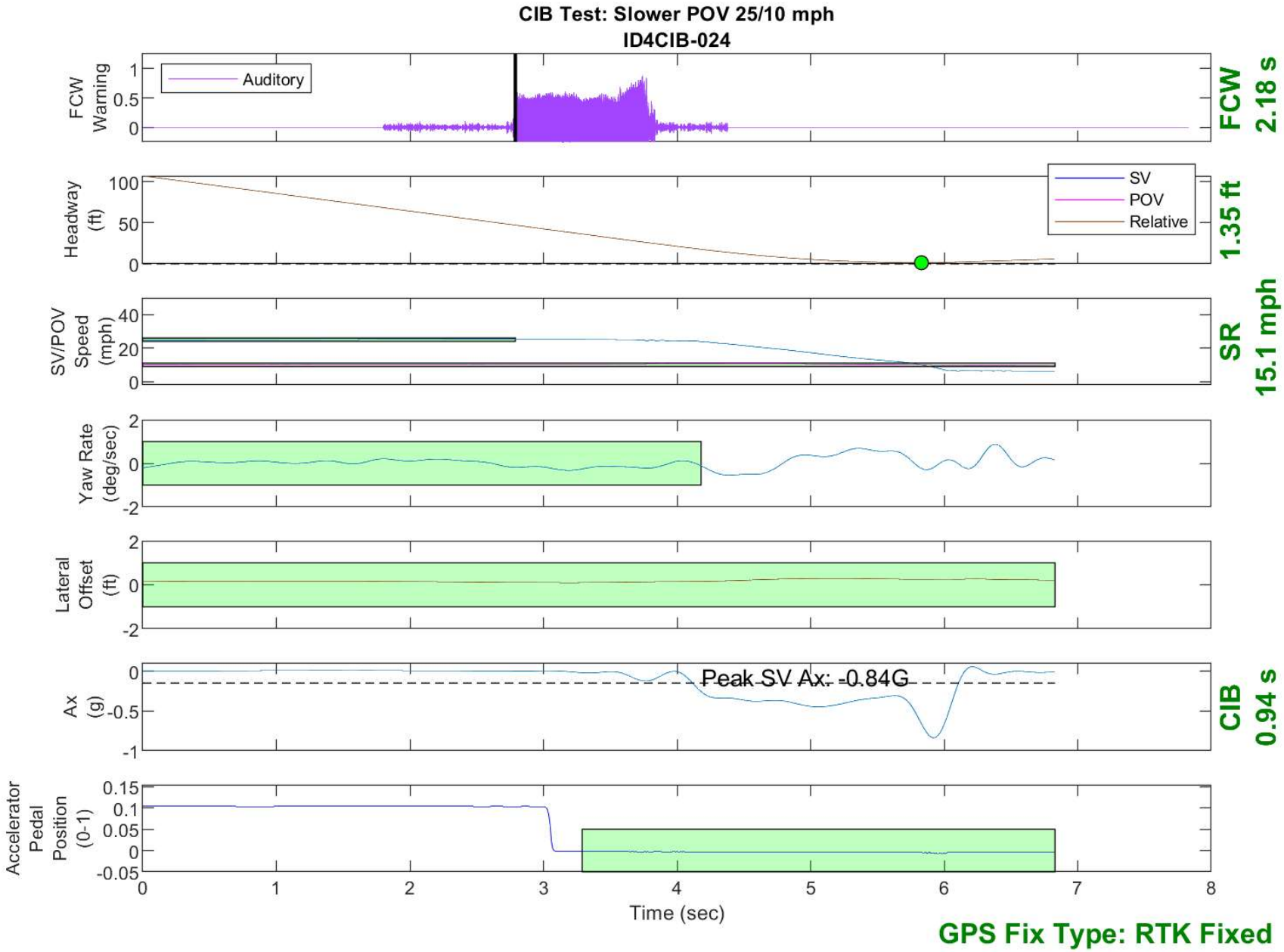

Figure D22. Time History for CIB Run 24, SV Encounters Slower POV, SV 25 mph, POV 10 mph

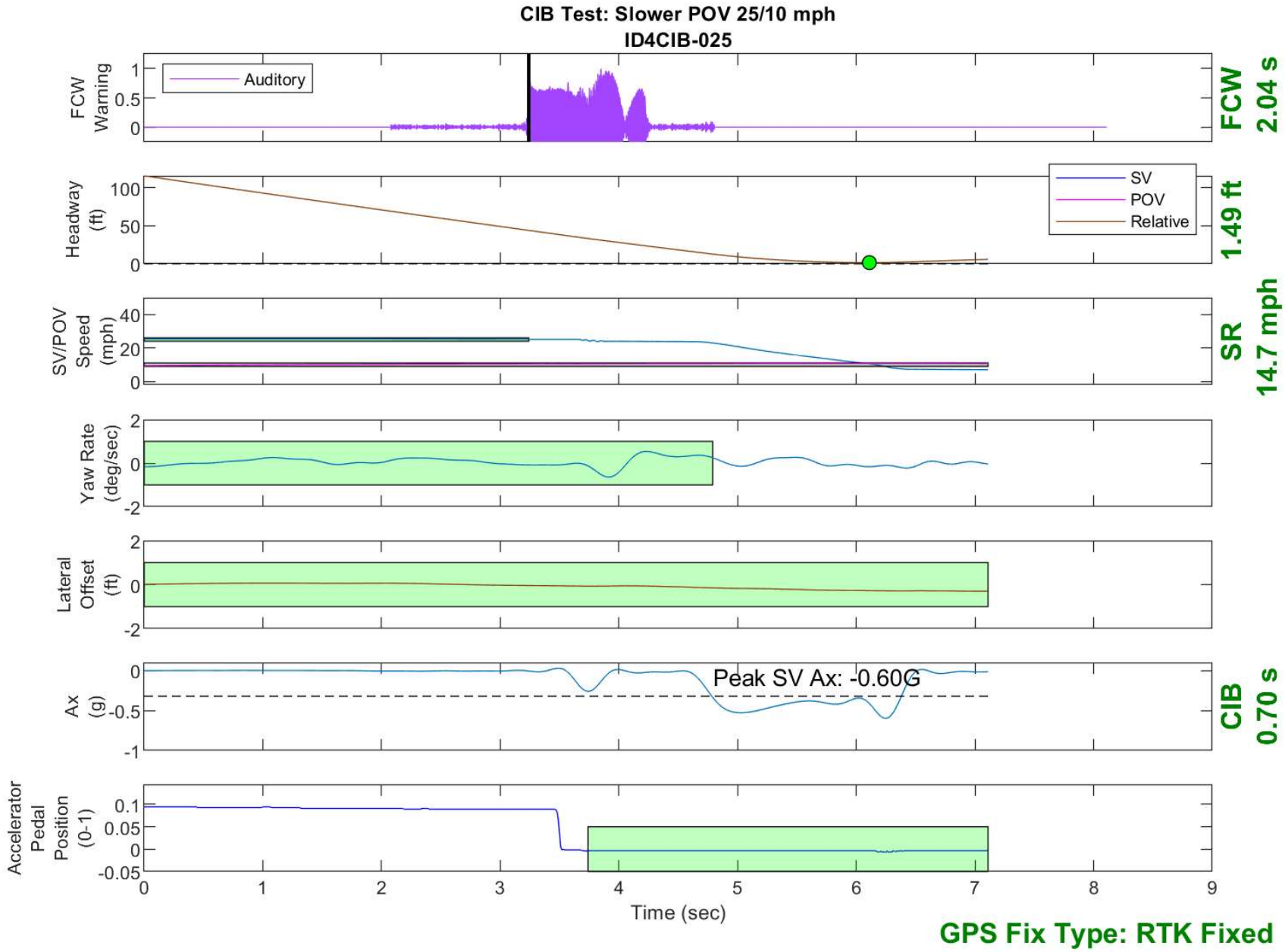

Figure D23. Time History for CIB Run 25, SV Encounters Slower POV, SV 25 mph, POV 10 mph

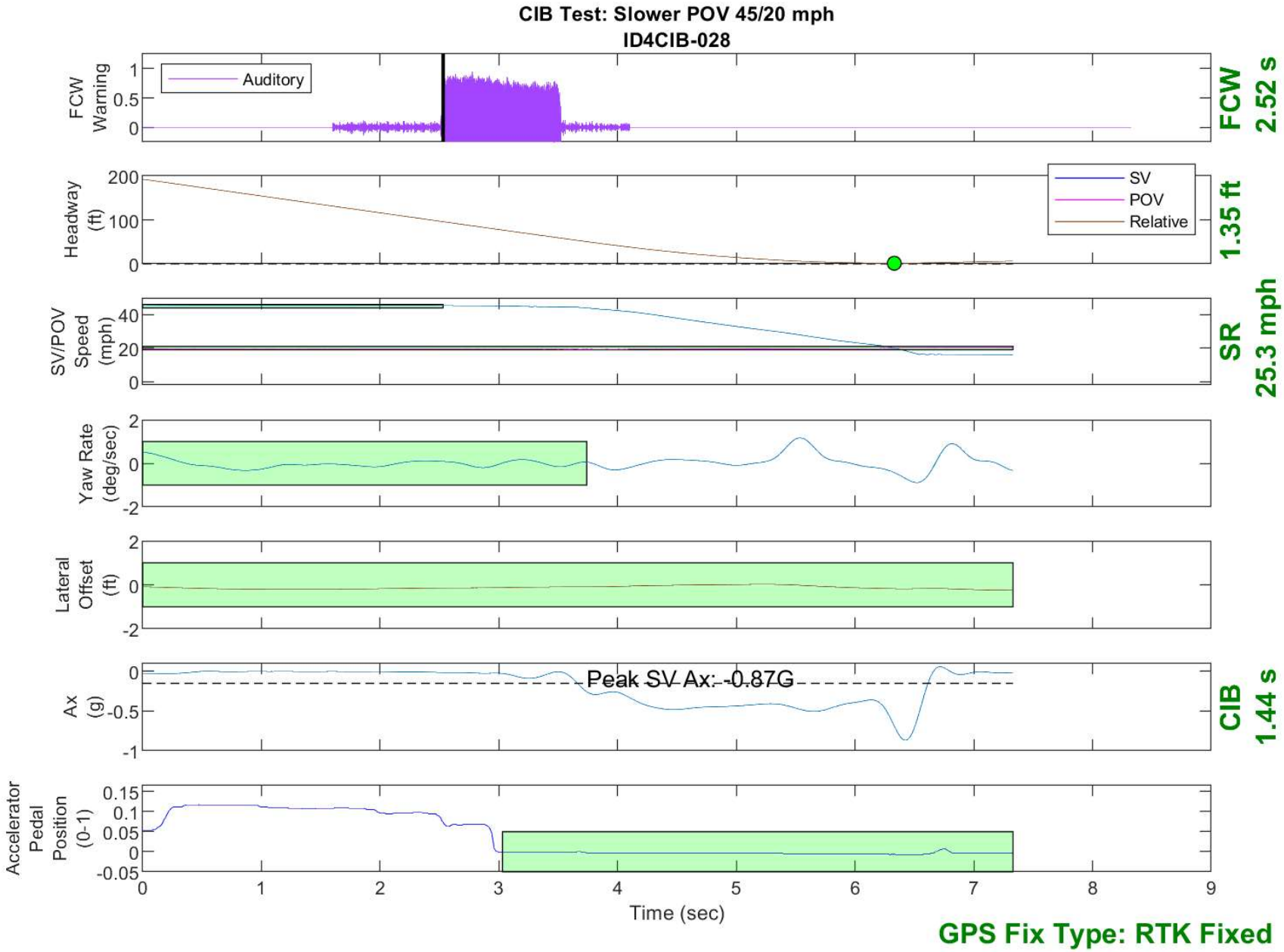

Figure D24. Time History for CIB Run 28, SV Encounters Slower POV, SV 45 mph, POV 20 mph

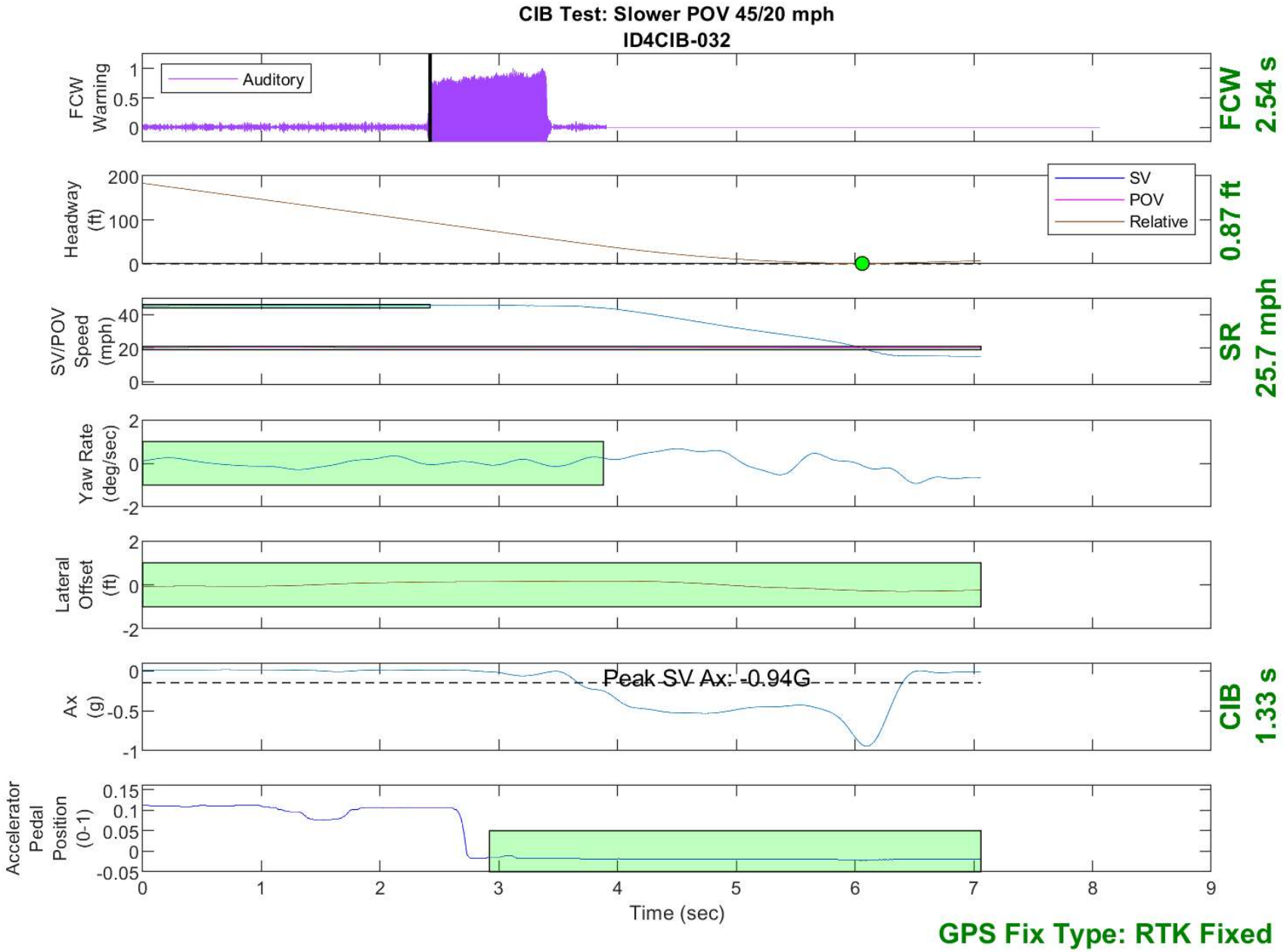

Figure D25. Time History for CIB Run 32, SV Encounters Slower POV, SV 45 mph, POV 20 mph

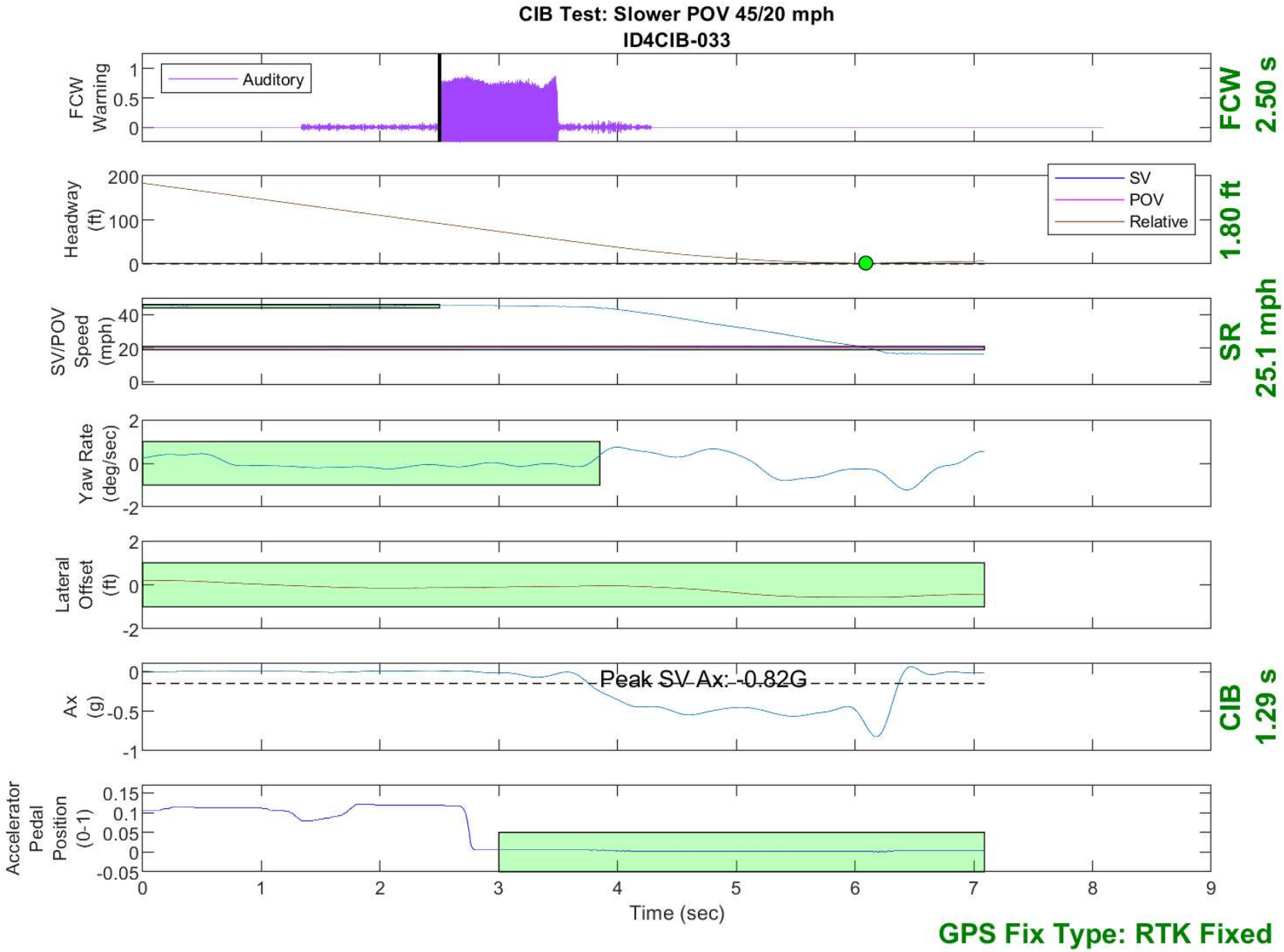

Figure D26. Time History for CIB Run 33, SV Encounters Slower POV, SV 45 mph, POV 20 mph

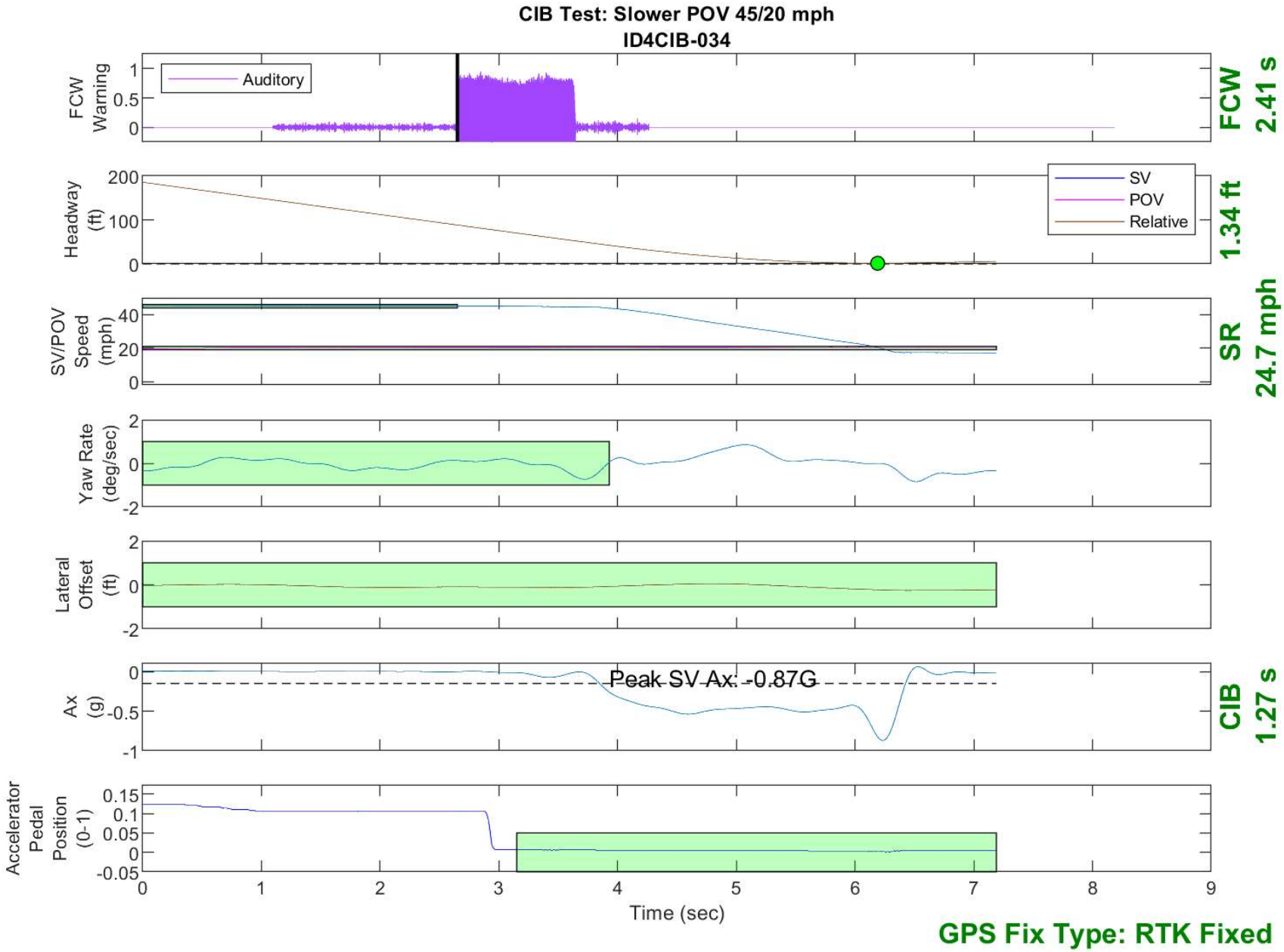

Figure D27. Time History for CIB Run 34, SV Encounters Slower POV, SV 45 mph, POV 20 mph

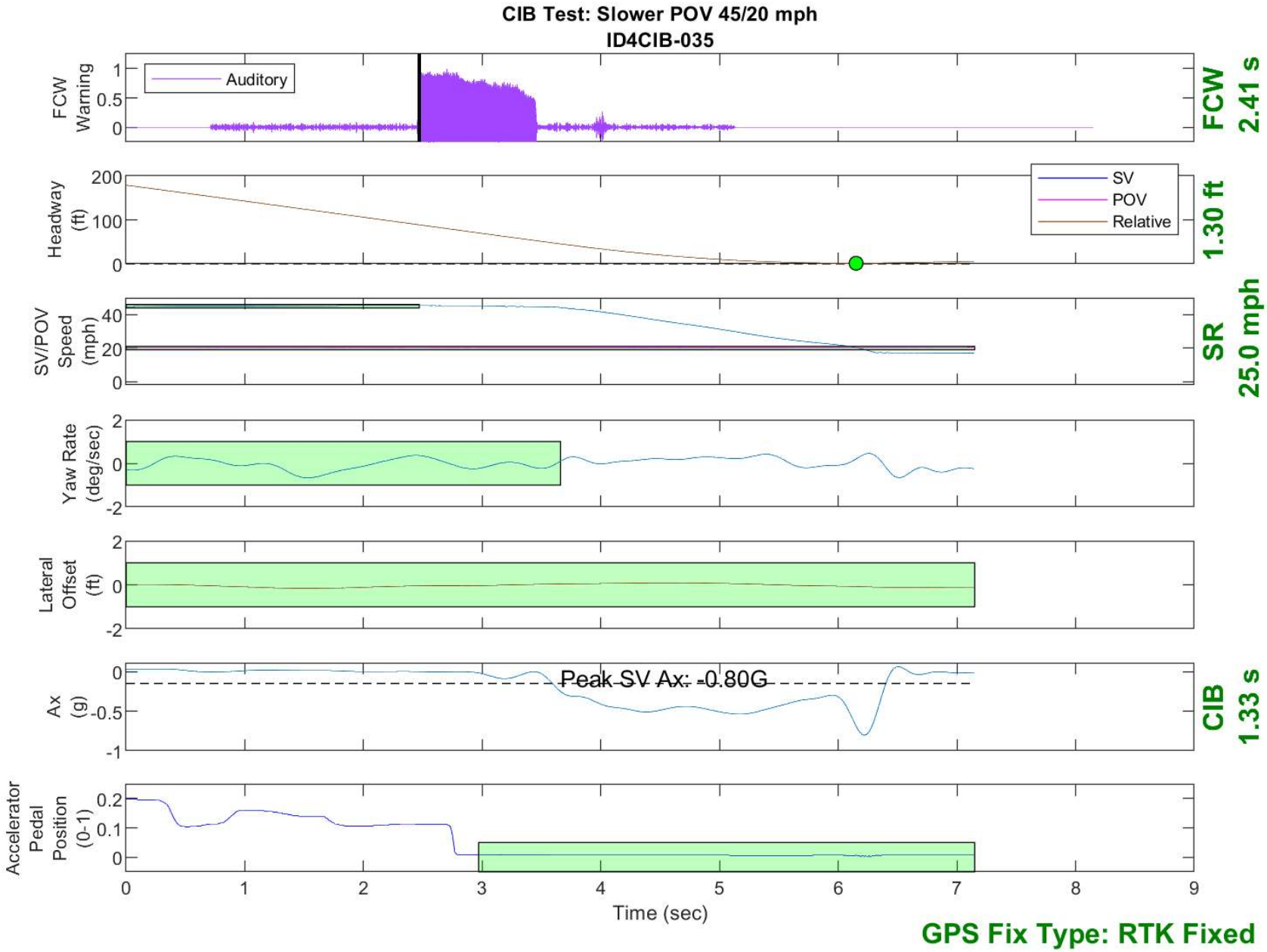

Figure D28. Time History for CIB Run 35, SV Encounters Slower POV, SV 45 mph, POV 20 mph

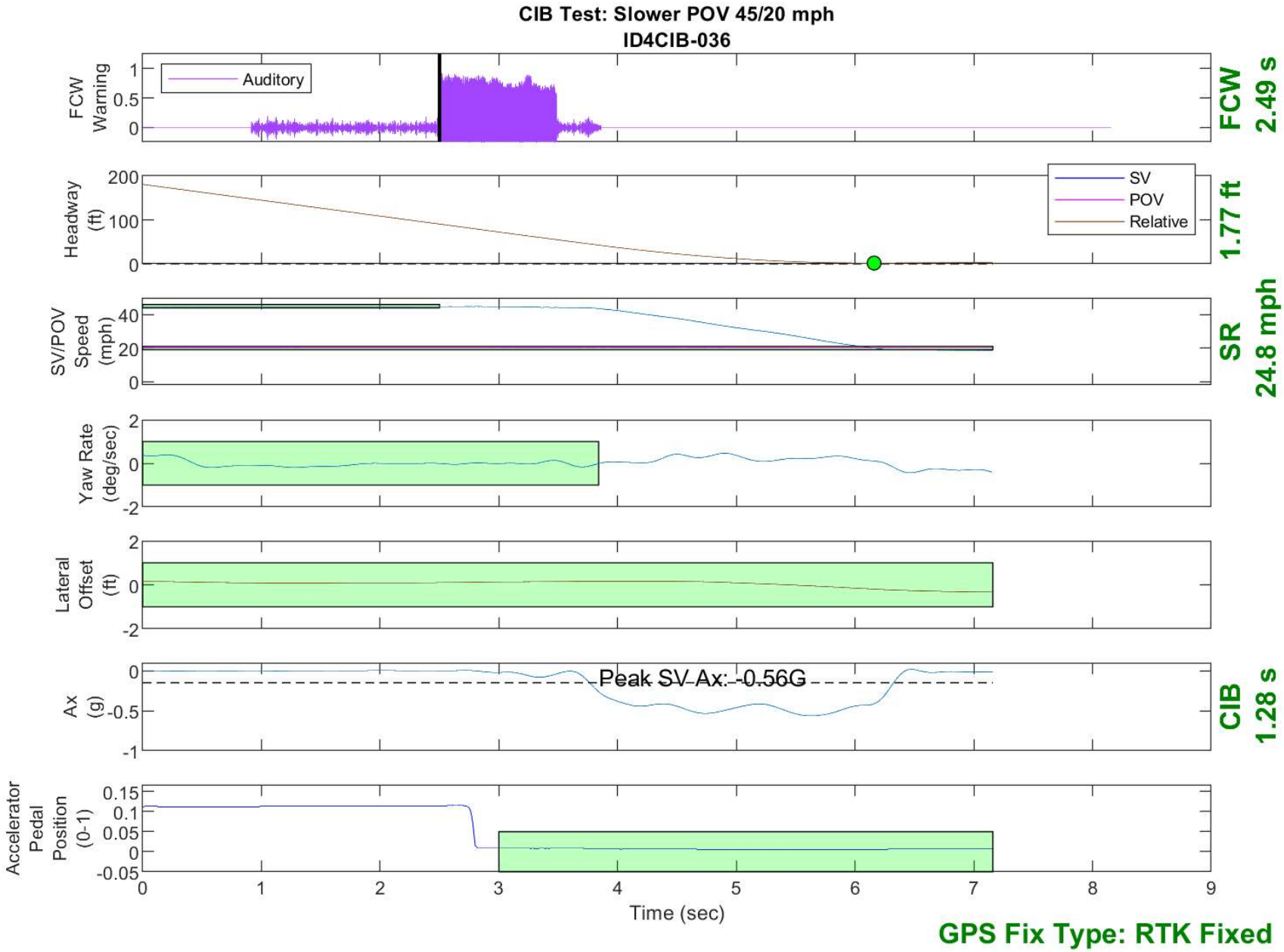

Figure D29. Time History for CIB Run 36, SV Encounters Slower POV, SV 45 mph, POV 20 mph

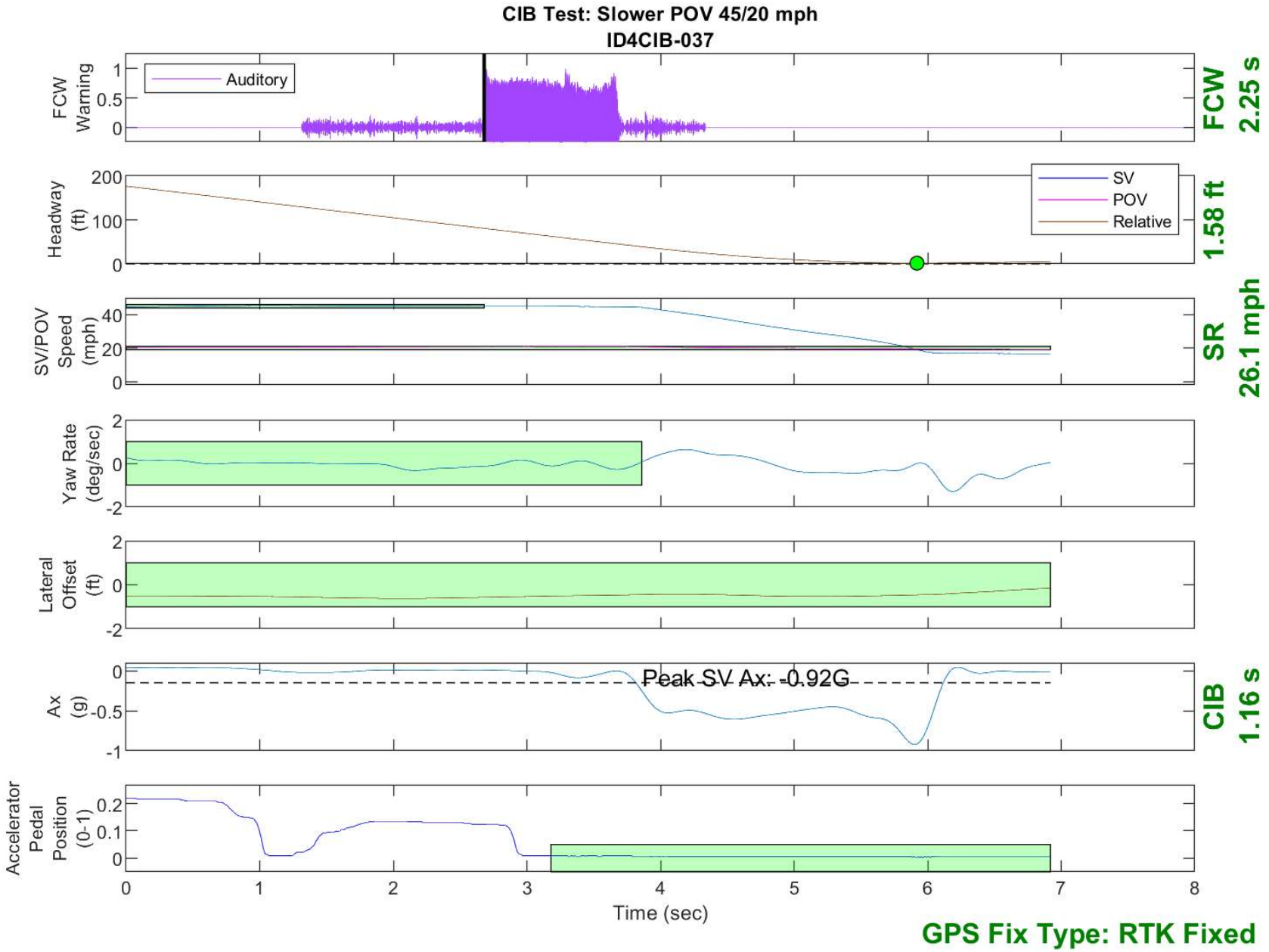

Figure D30. Time History for CIB Run 37, SV Encounters Slower POV, SV 45 mph, POV 20 mph

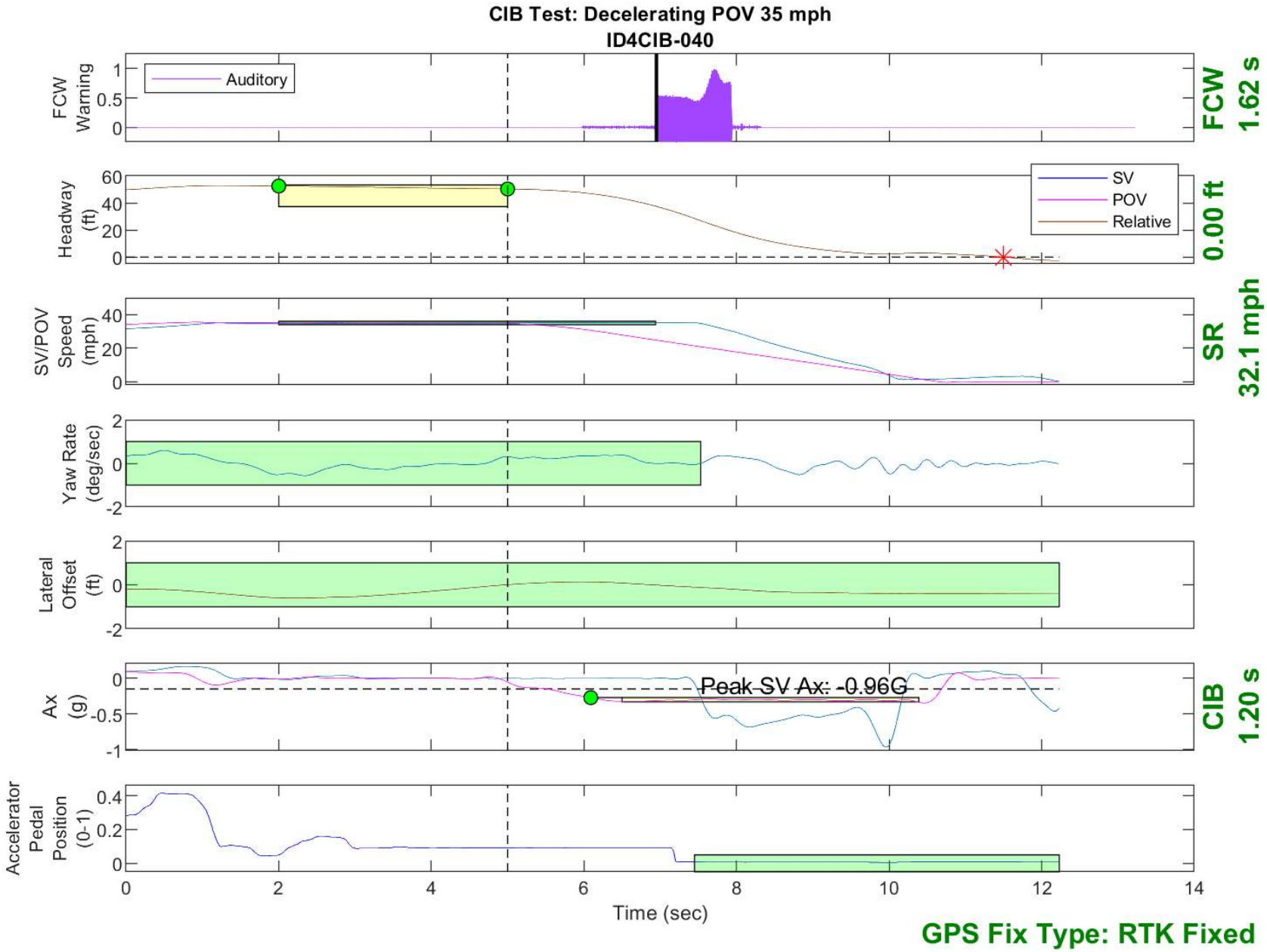

Figure D31. Time History for CIB Run 40, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

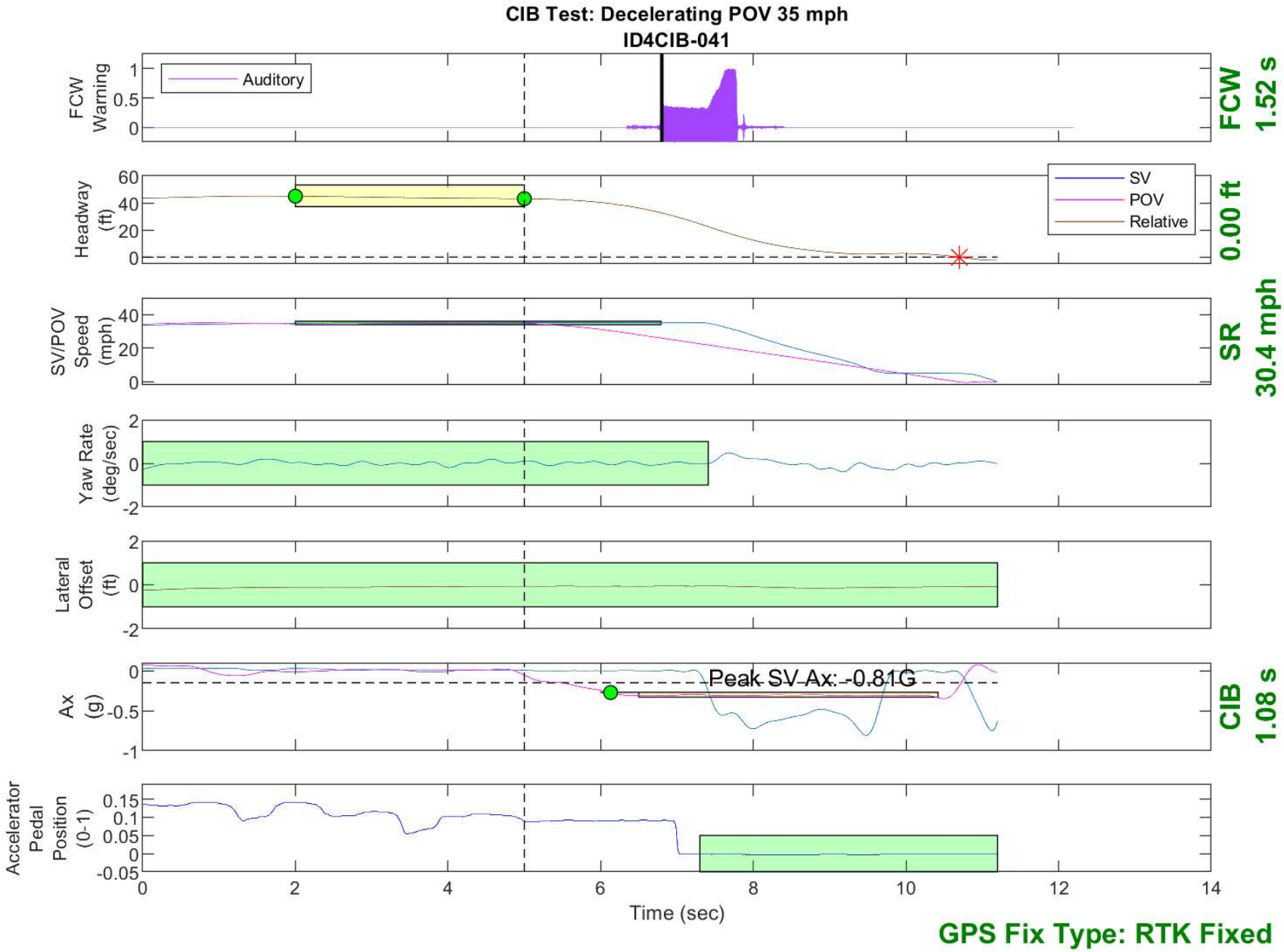

Figure D32. Time History for CIB Run 41, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

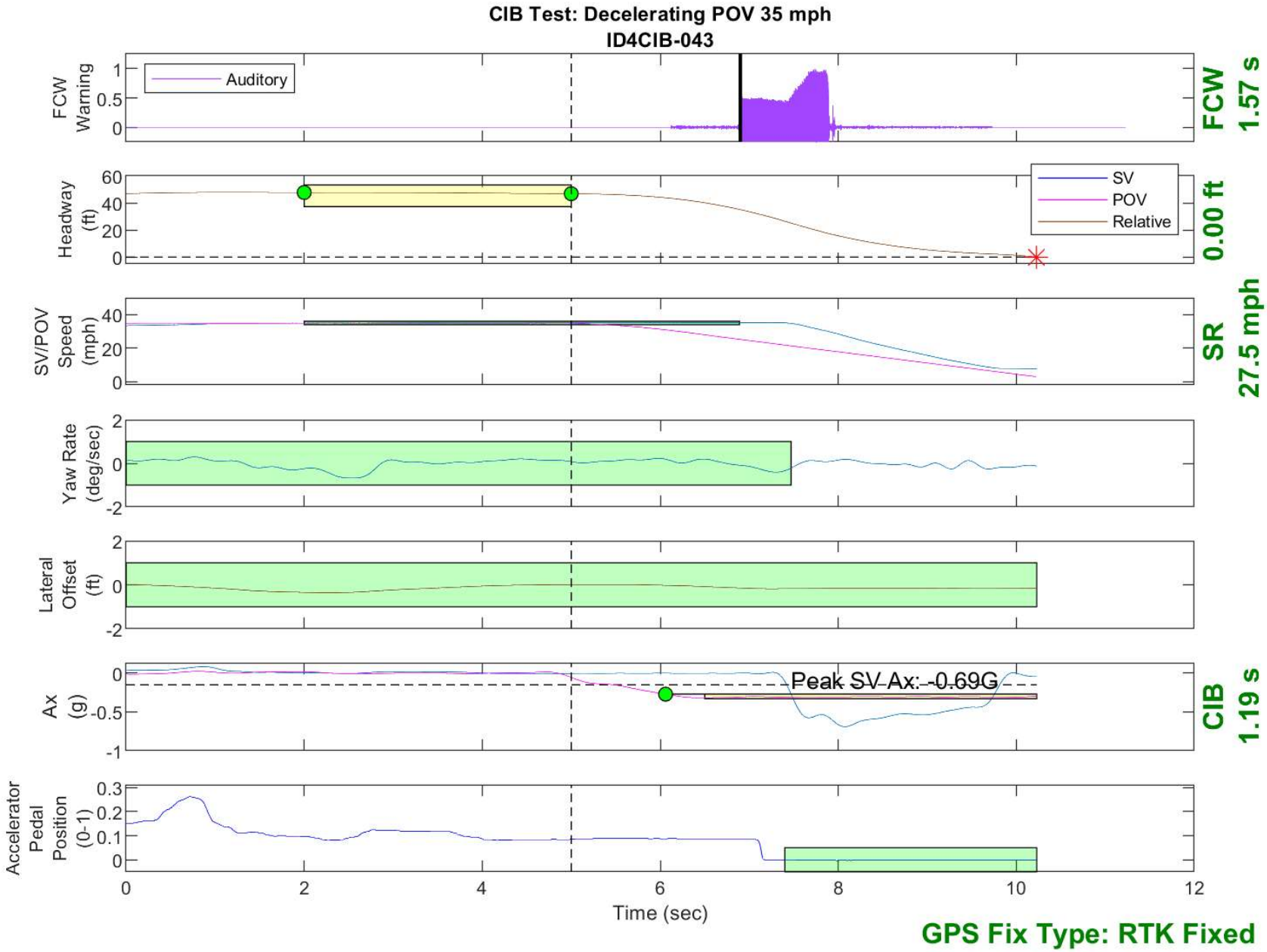

Figure D33. Time History for CIB Run 43, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

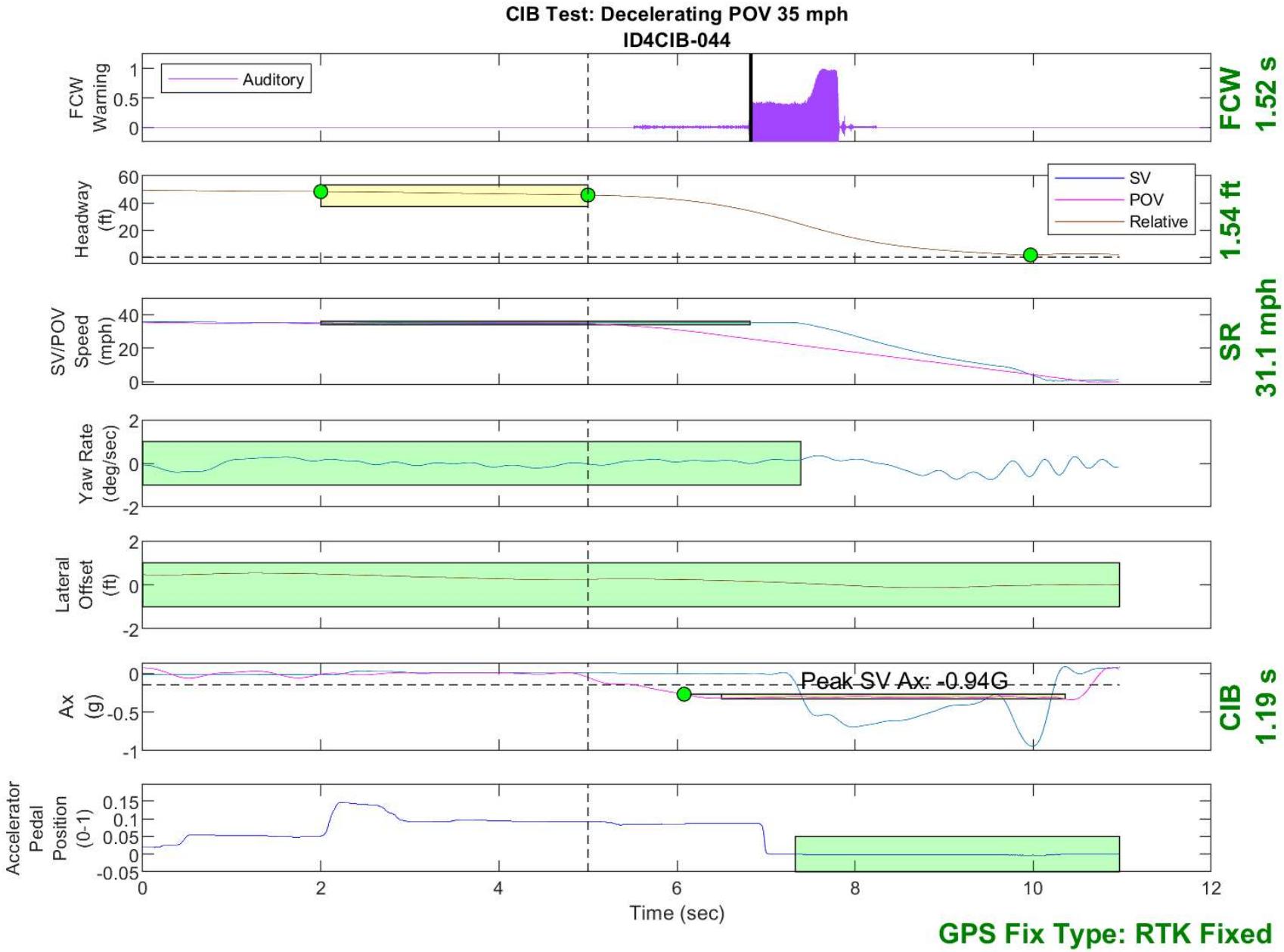

Figure D34. Time History for CIB Run 44, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

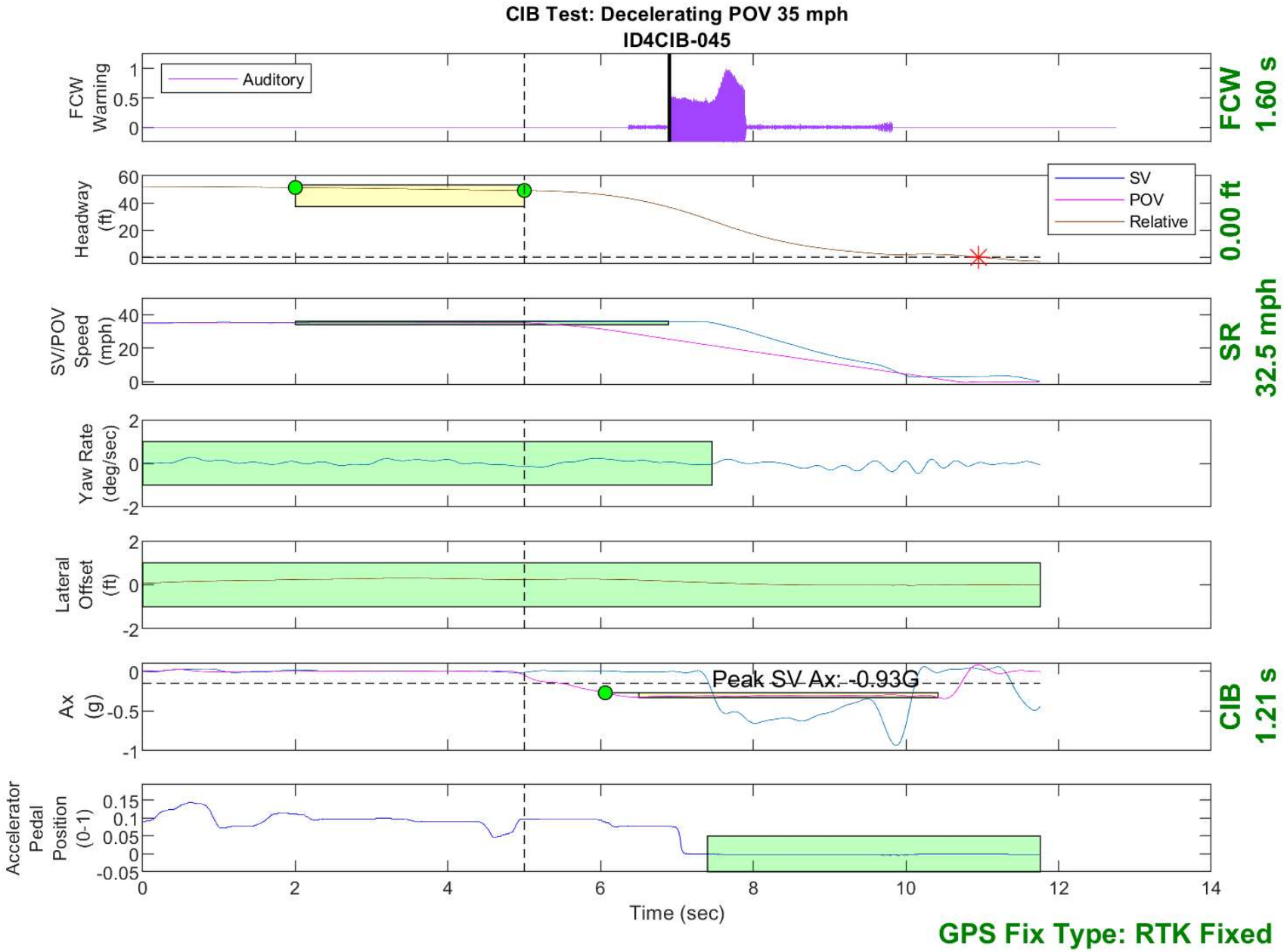

Figure D35. Time History for CIB Run 45, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

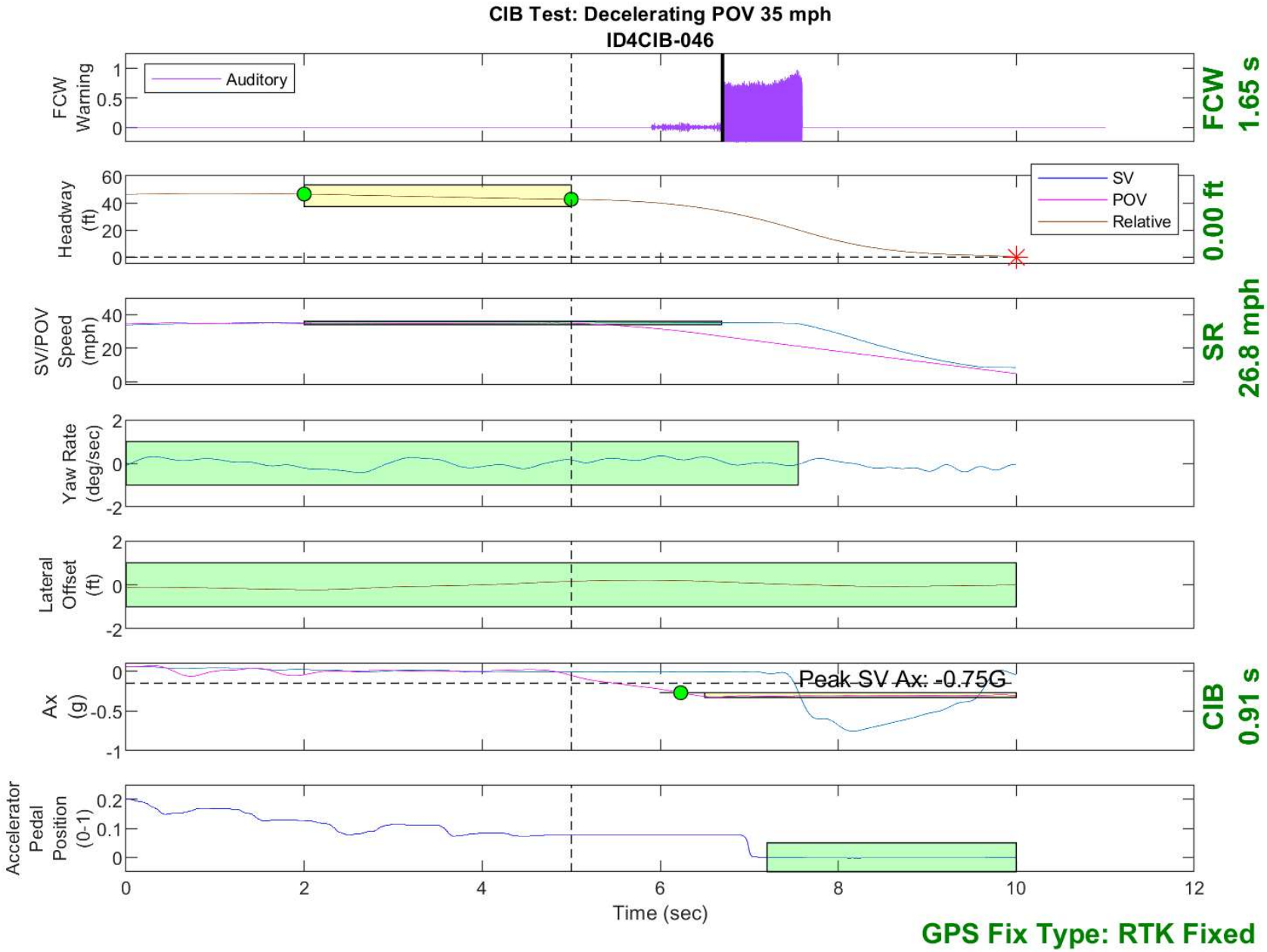

Figure D36. Time History for CIB Run 46, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

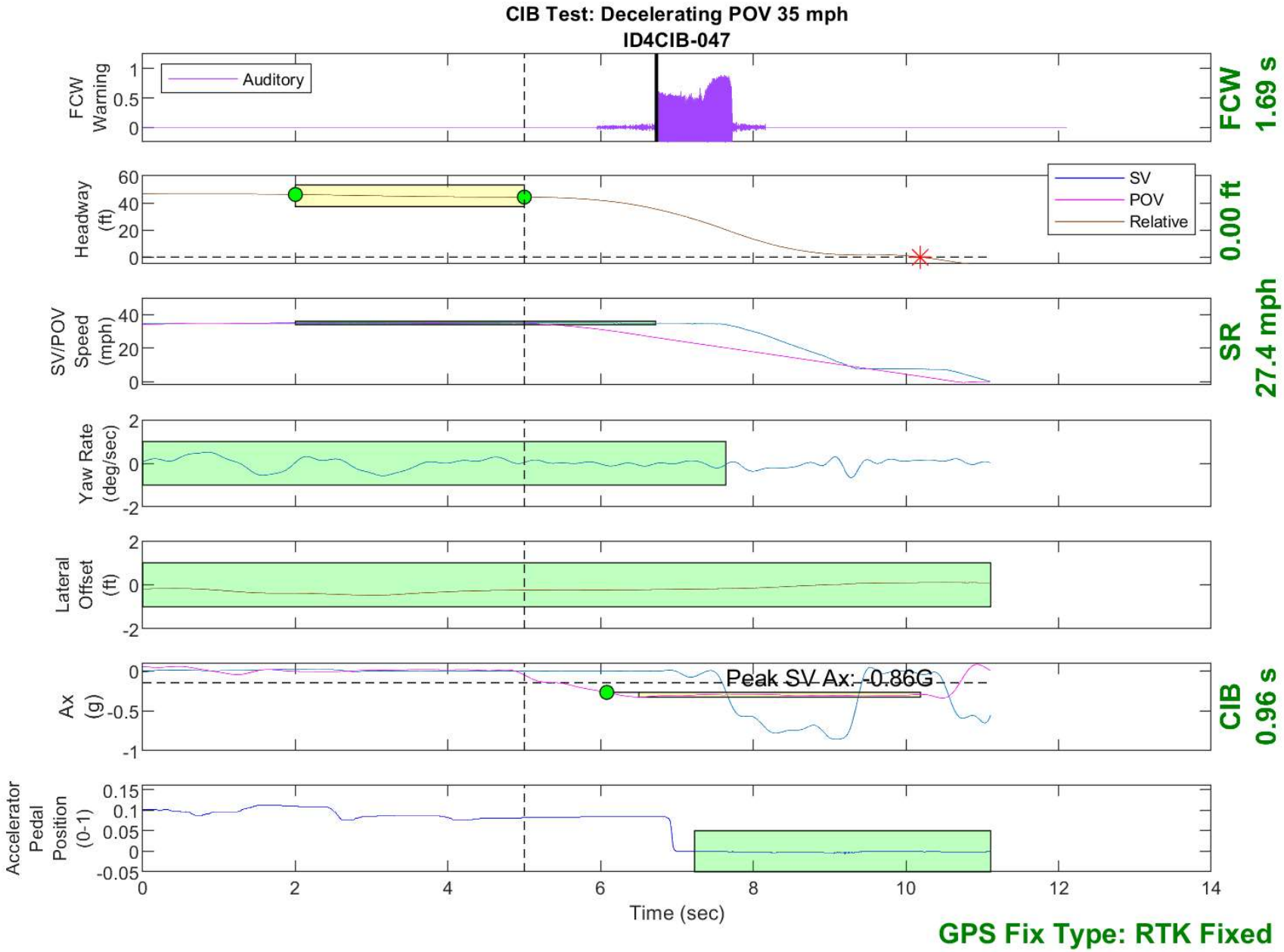

Figure D37. Time History for CIB Run 47, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

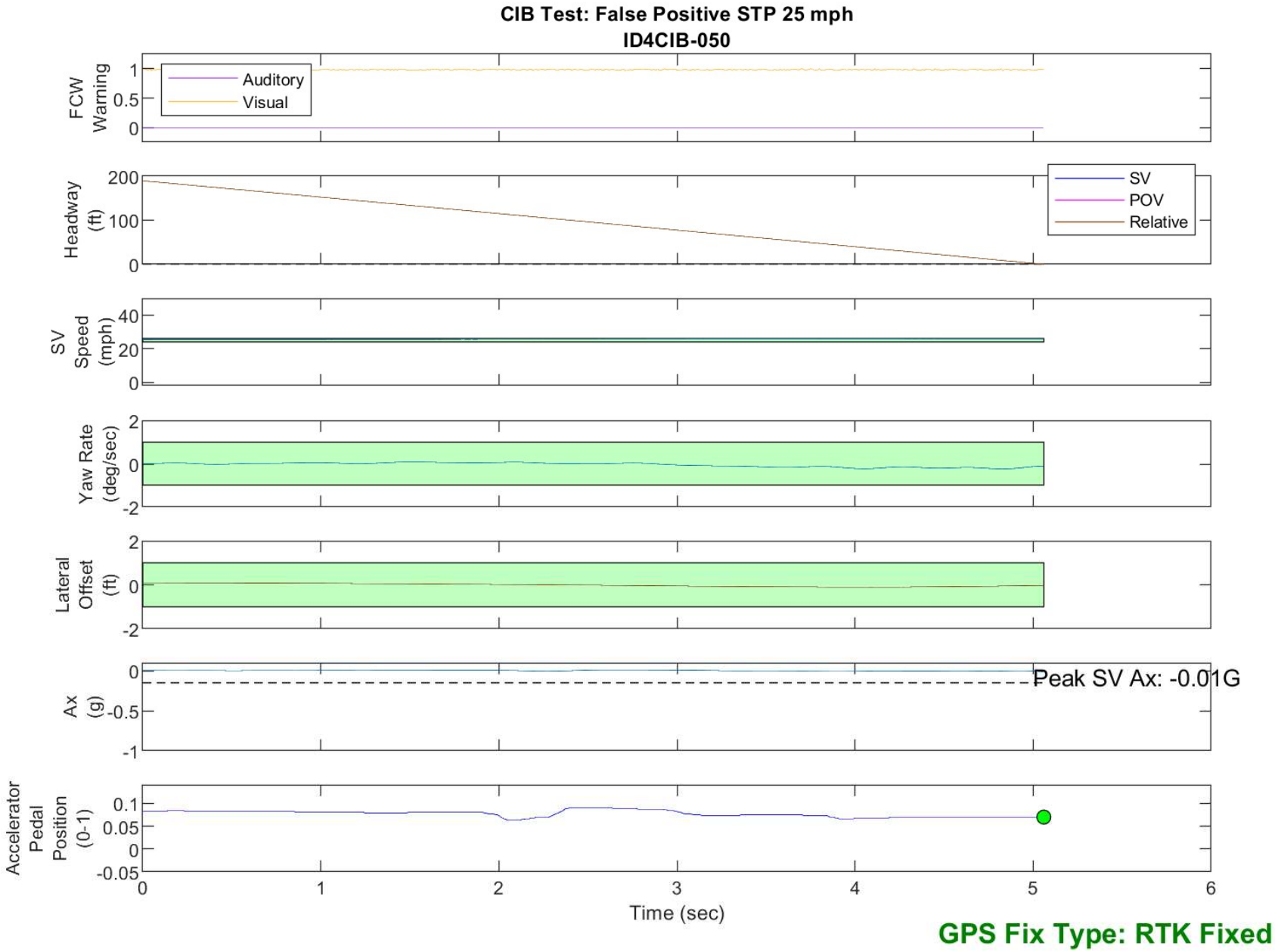

Figure D38. Time History for CIB Run 50, SV Encounters Steel Trench Plate, SV 25 mph

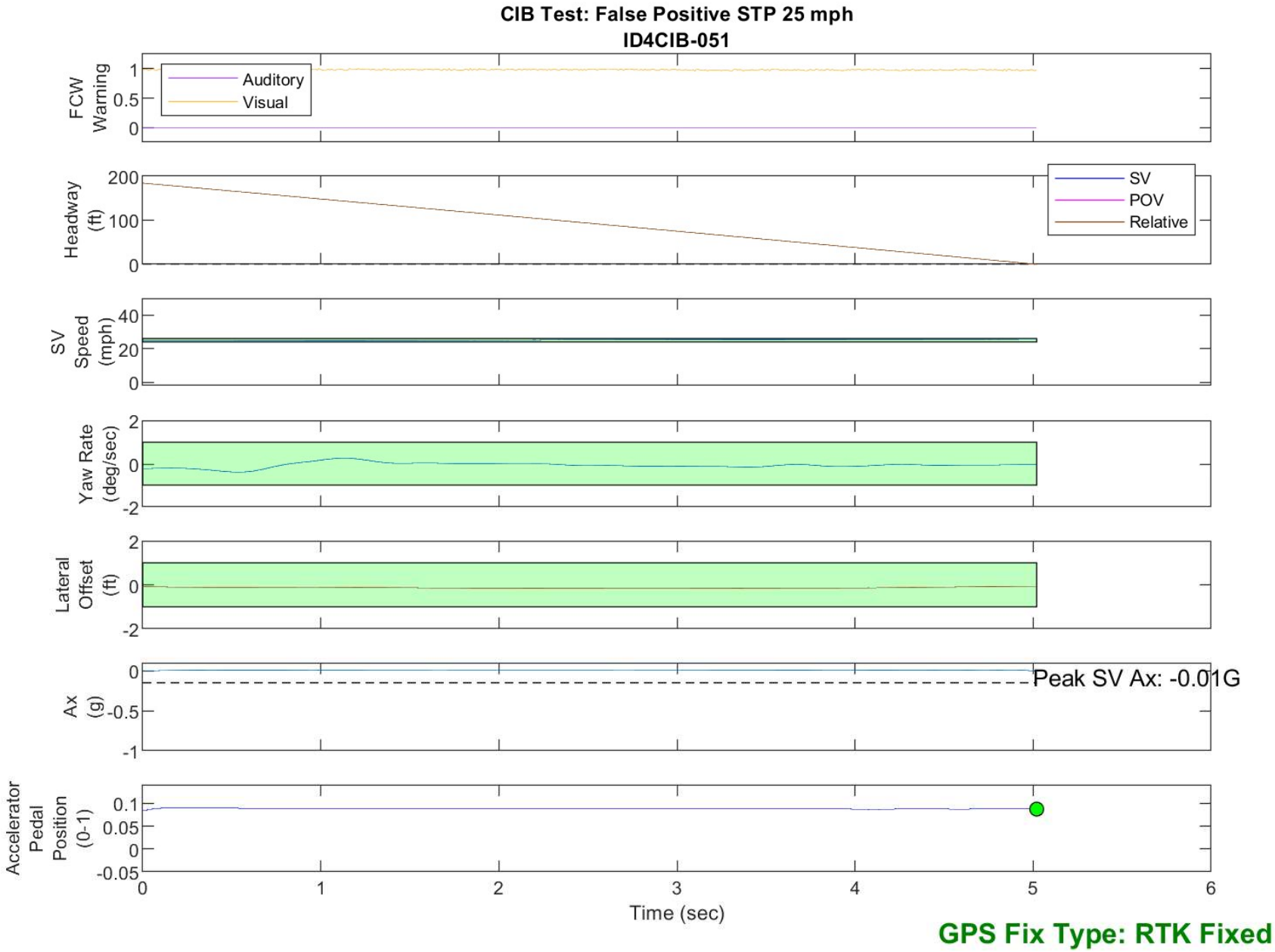

Figure D39. Time History for CIB Run 51, SV Encounters Steel Trench Plate, SV 25 mph

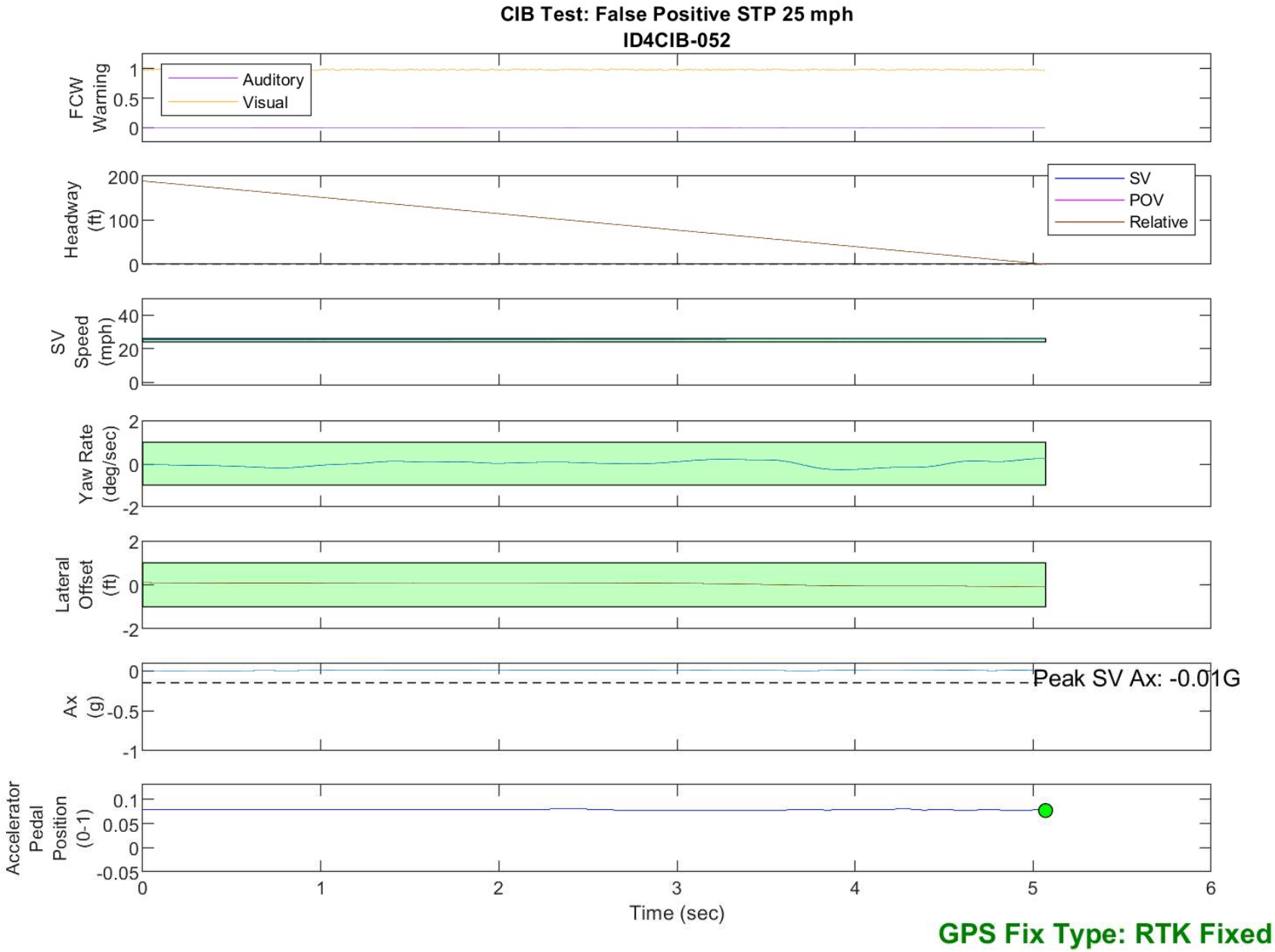

Figure D40. Time History for CIB Run 52, SV Encounters Steel Trench Plate, SV 25 mph

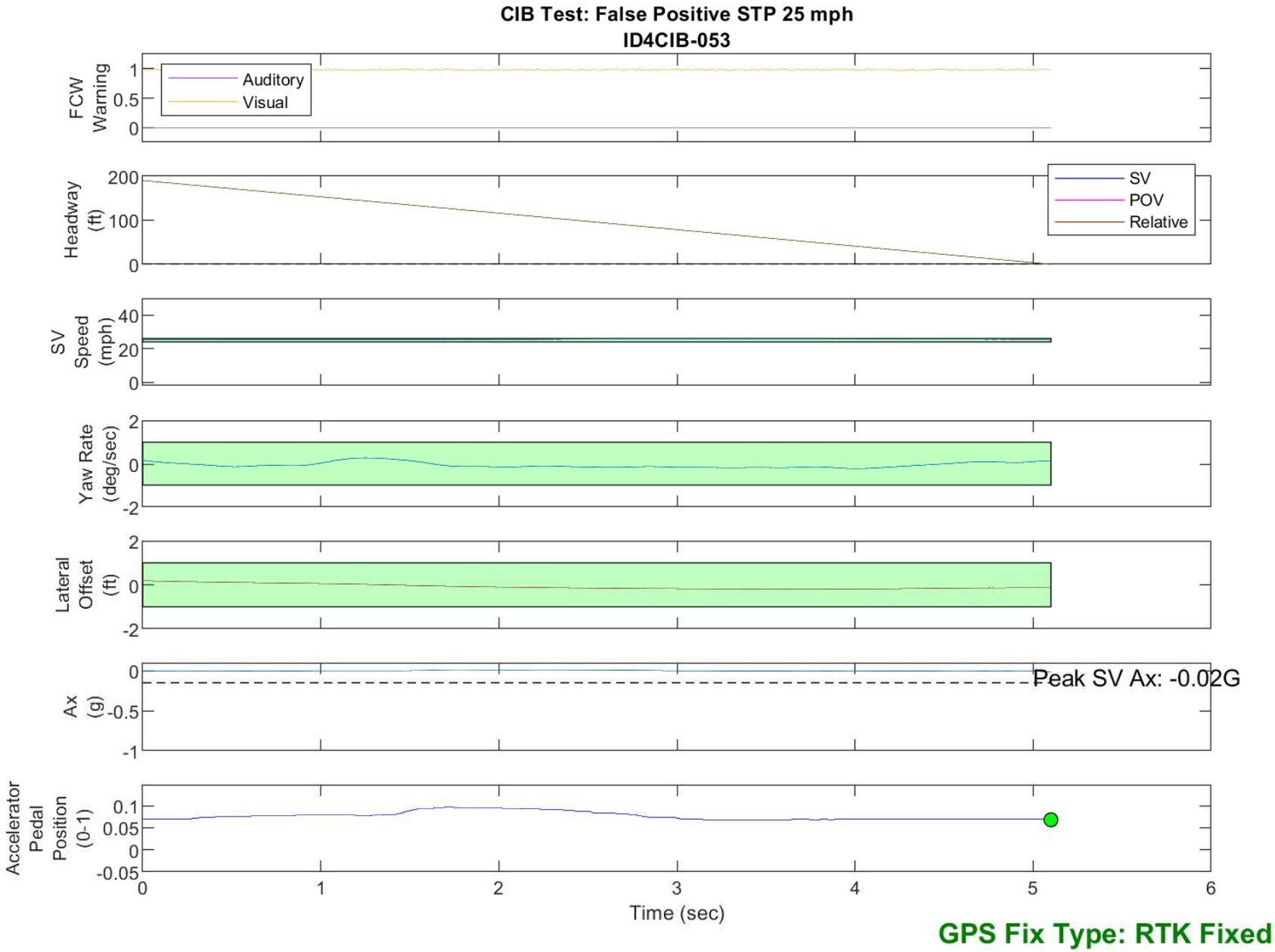

Figure D41. Time History for CIB Run 53, SV Encounters Steel Trench Plate, SV 25 mph

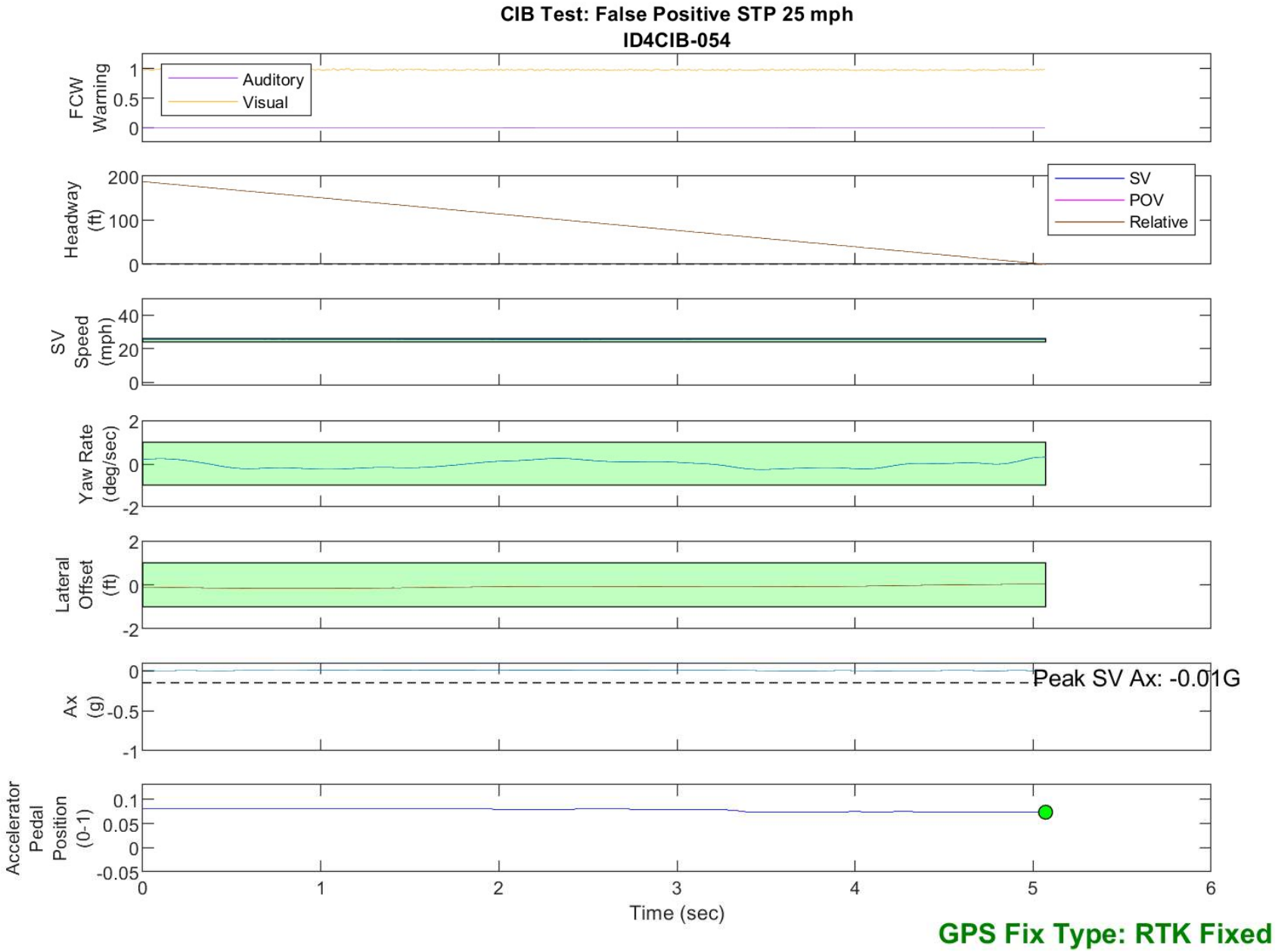

Figure D42. Time History for CIB Run 54, SV Encounters Steel Trench Plate, SV 25 mph

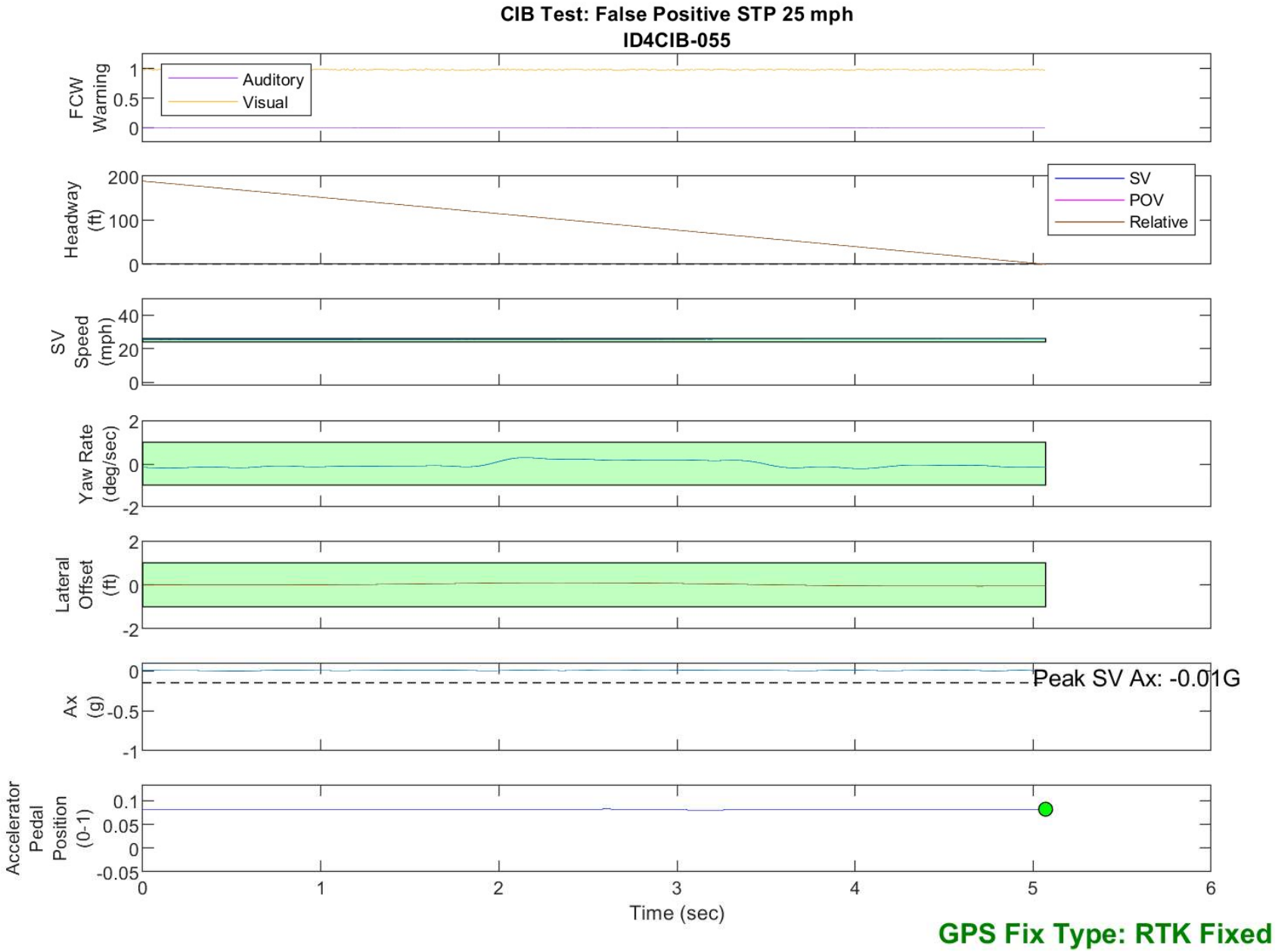

Figure D43. Time History for CIB Run 55, SV Encounters Steel Trench Plate, SV 25 mph

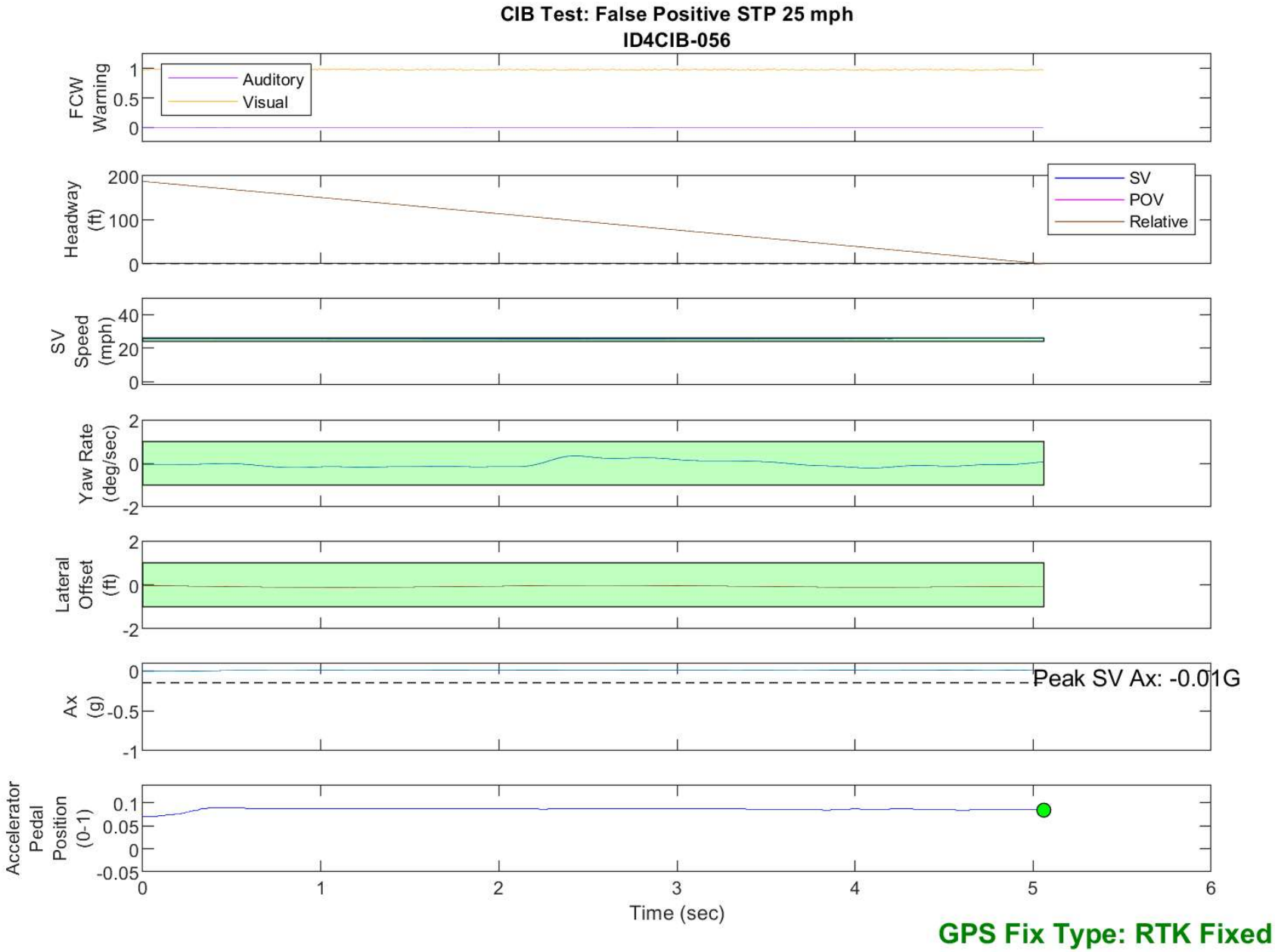

Figure D44. Time History for CIB Run 56, SV Encounters Steel Trench Plate, SV 25 mph

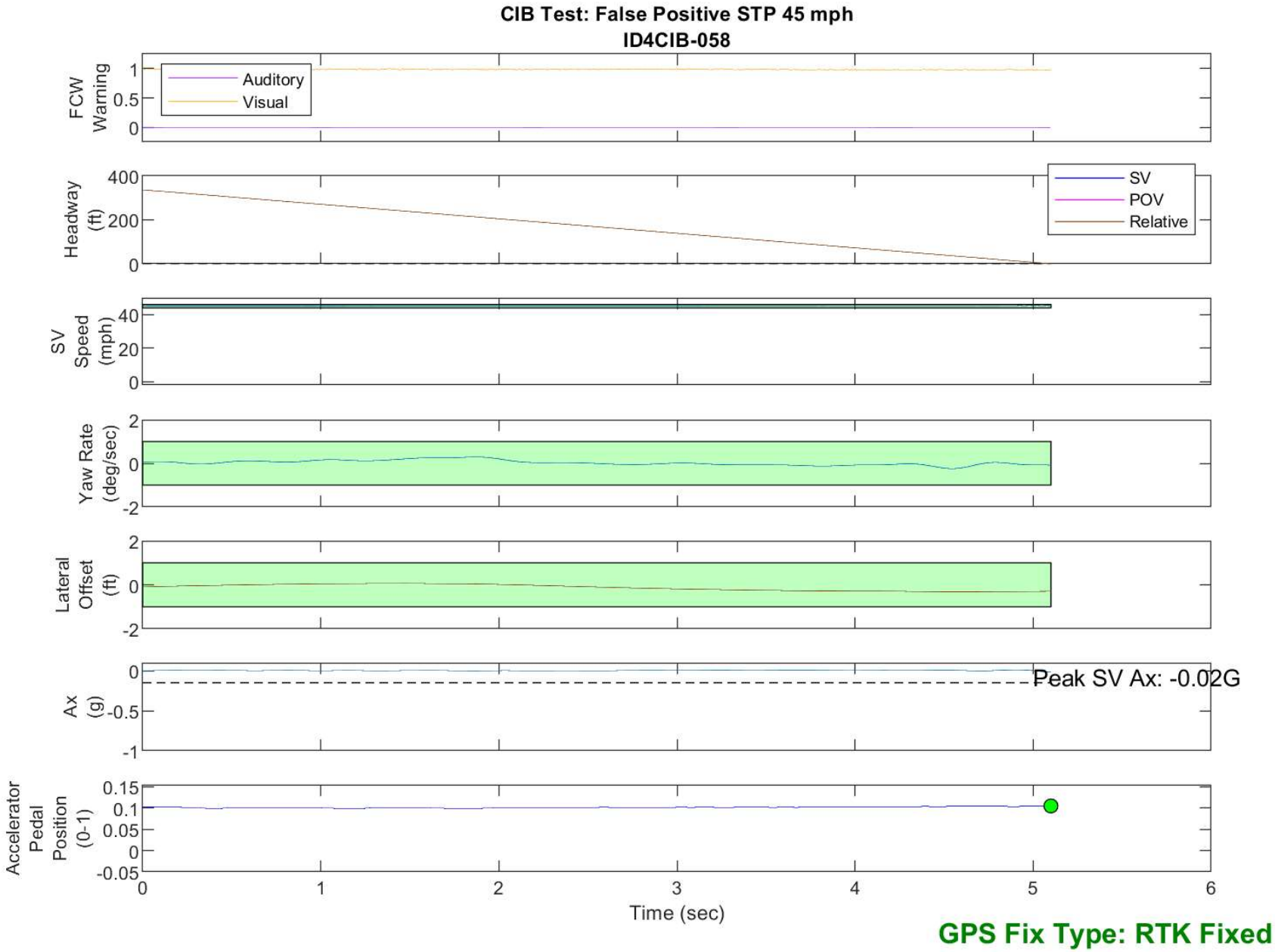

Figure D45. Time History for CIB Run 58, SV Encounters Steel Trench Plate, SV 45 mph

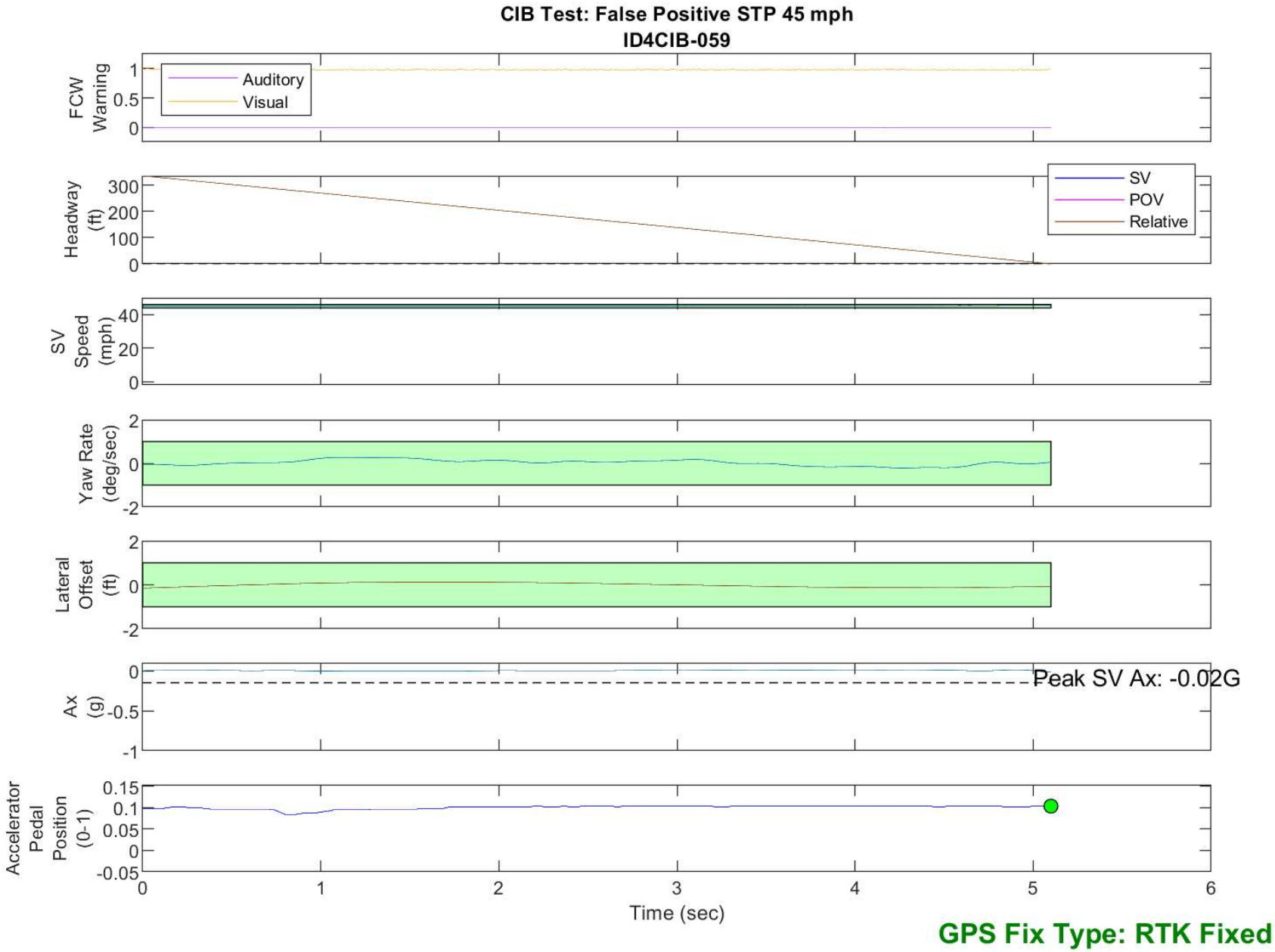

Figure D46. Time History for CIB Run 59, SV Encounters Steel Trench Plate, SV 45 mph

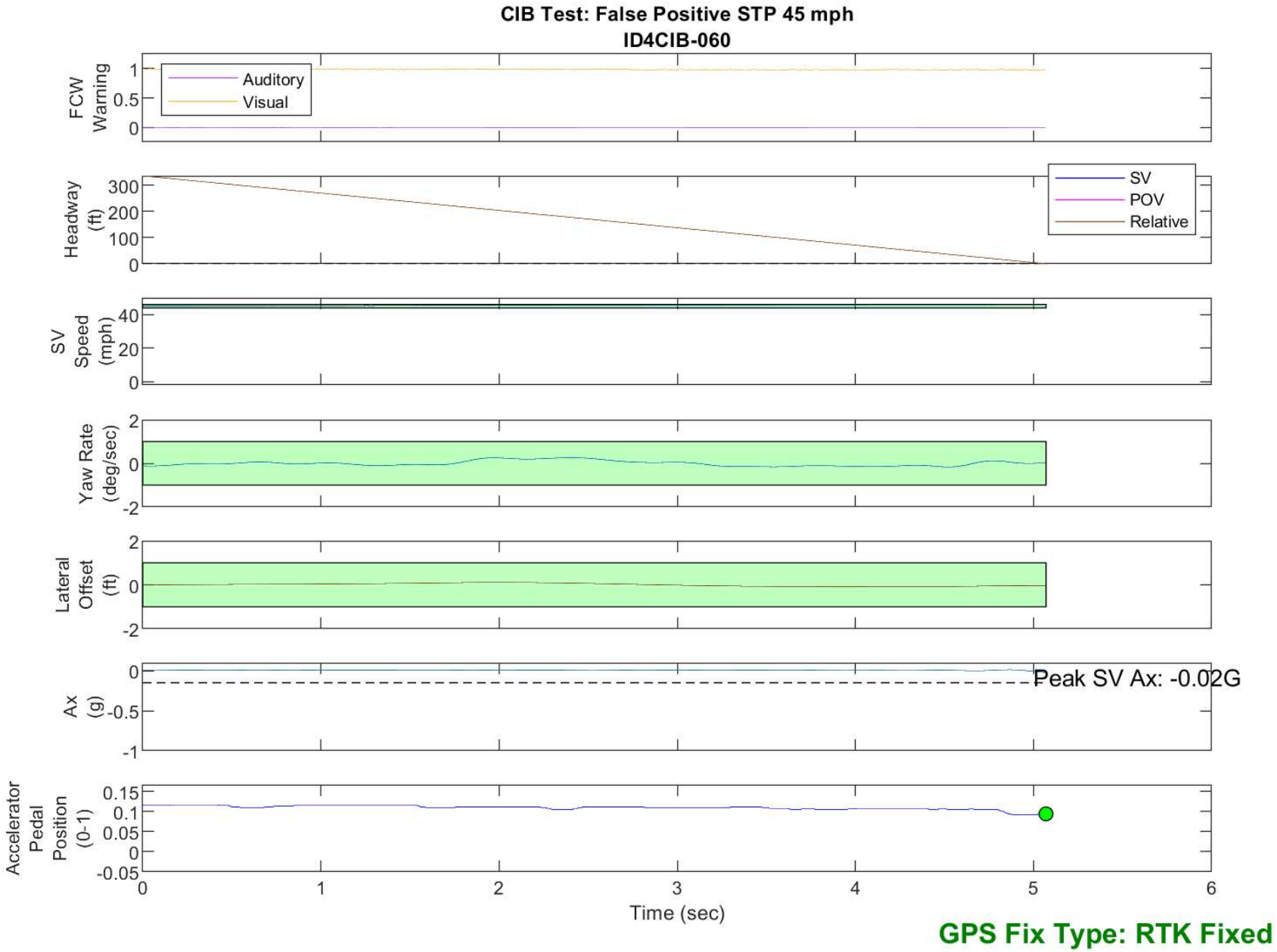

Figure D47. Time History for CIB Run 60, SV Encounters Steel Trench Plate, SV 45 mph

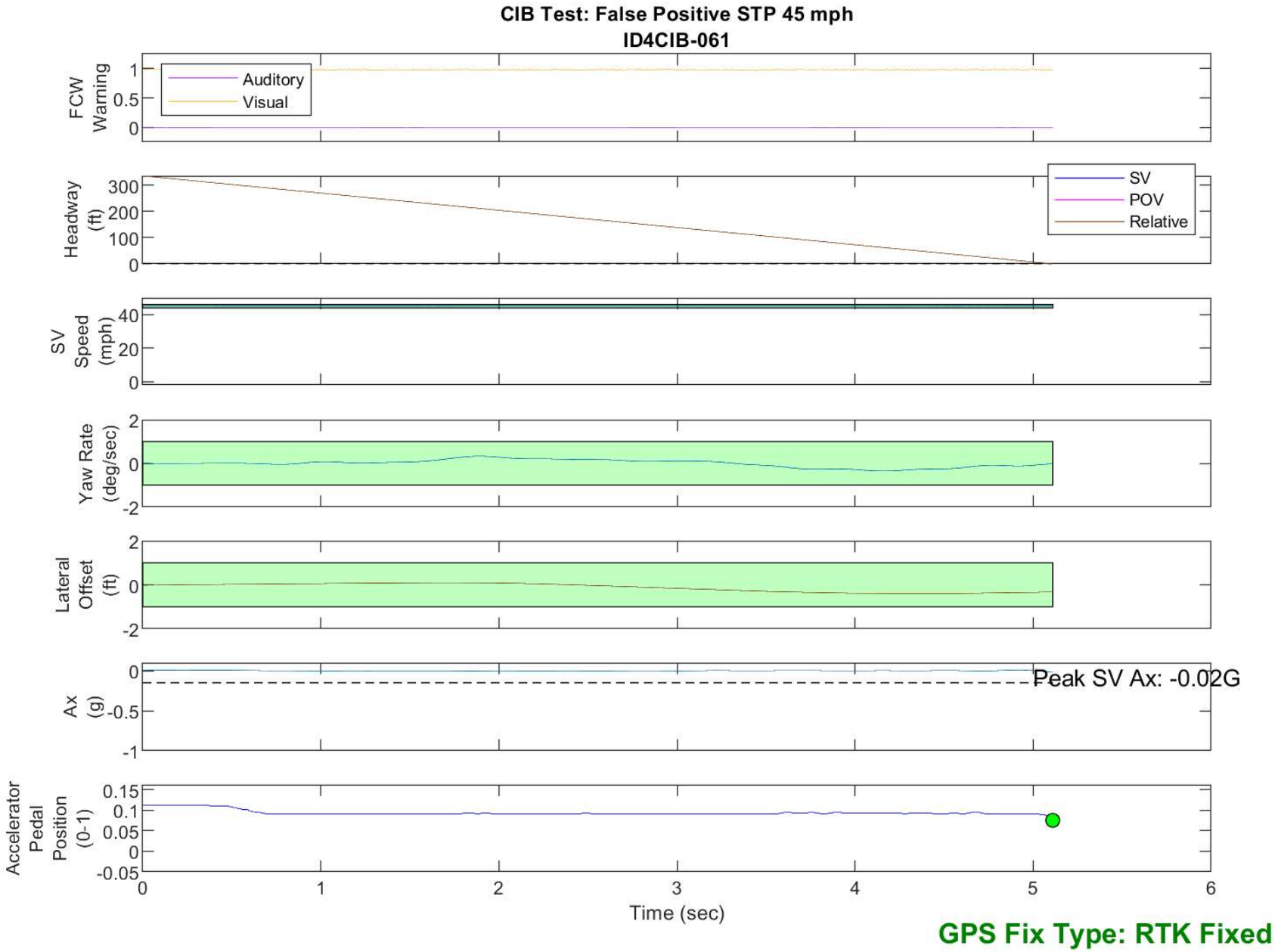

Figure D48. Time History for CIB Run 61, SV Encounters Steel Trench Plate, SV 45 mph

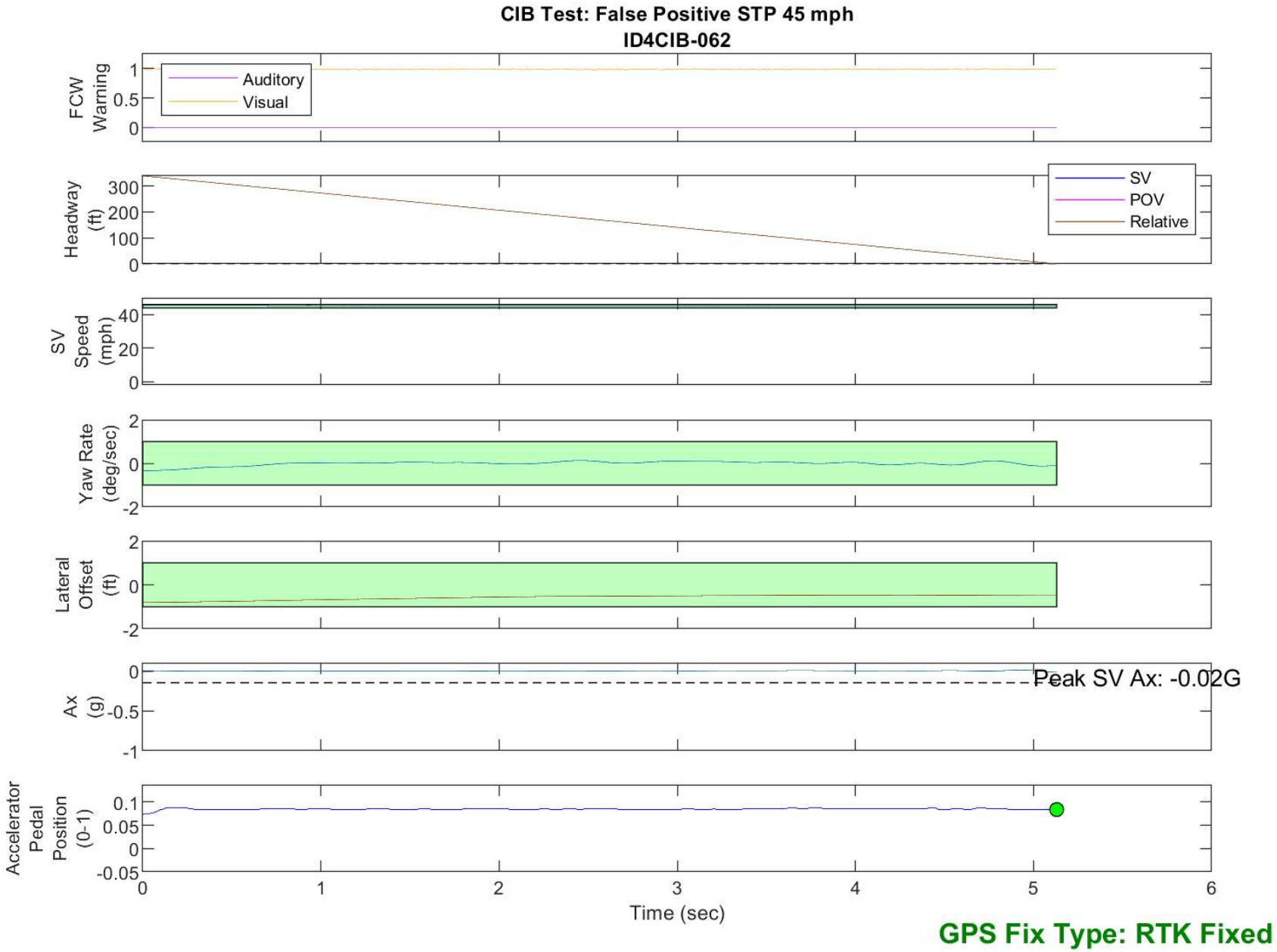

Figure D49. Time History for CIB Run 62, SV Encounters Steel Trench Plate, SV 45 mph

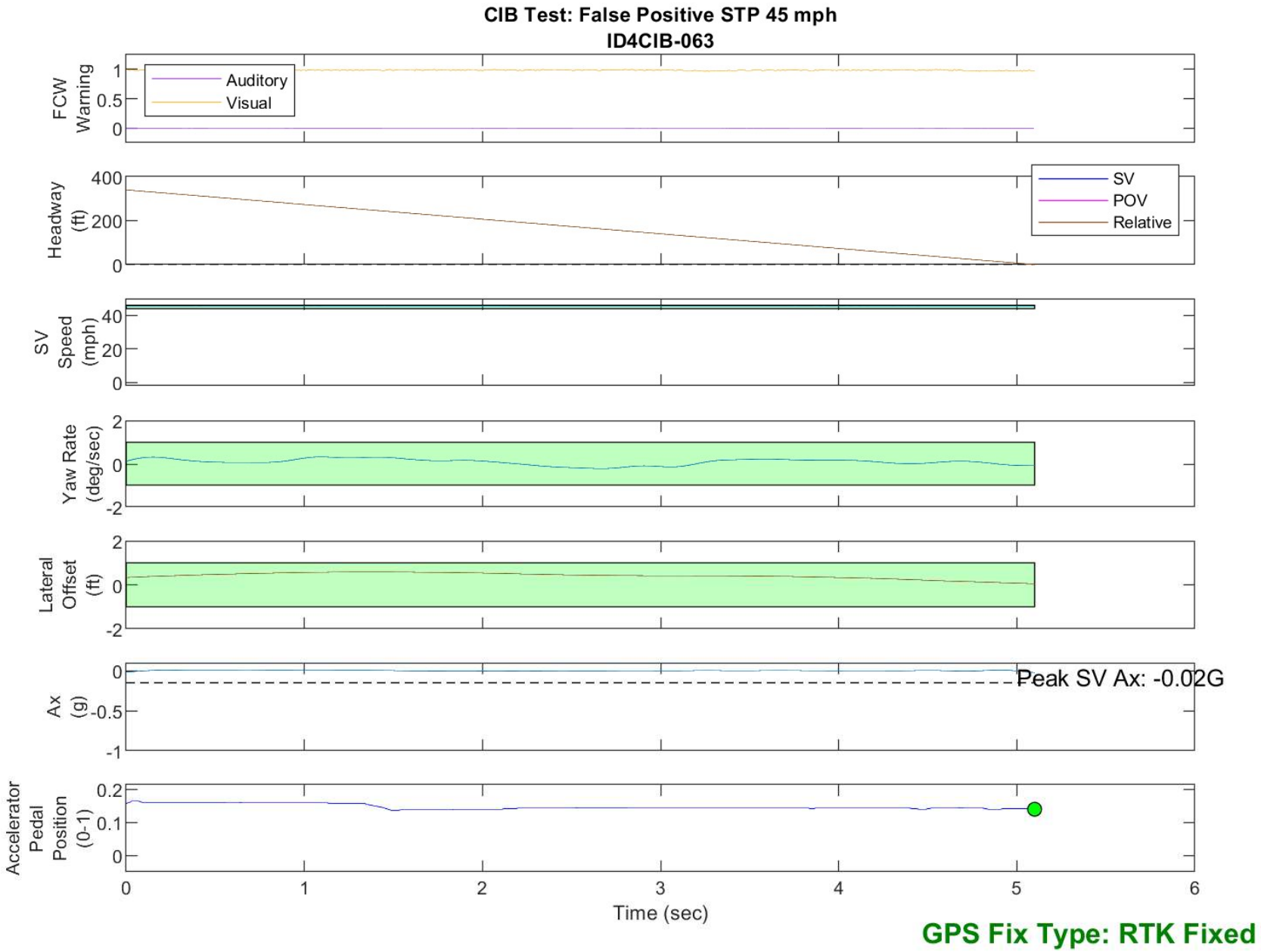

Figure D50. Time History for CIB Run 63, SV Encounters Steel Trench Plate, SV 45 mph

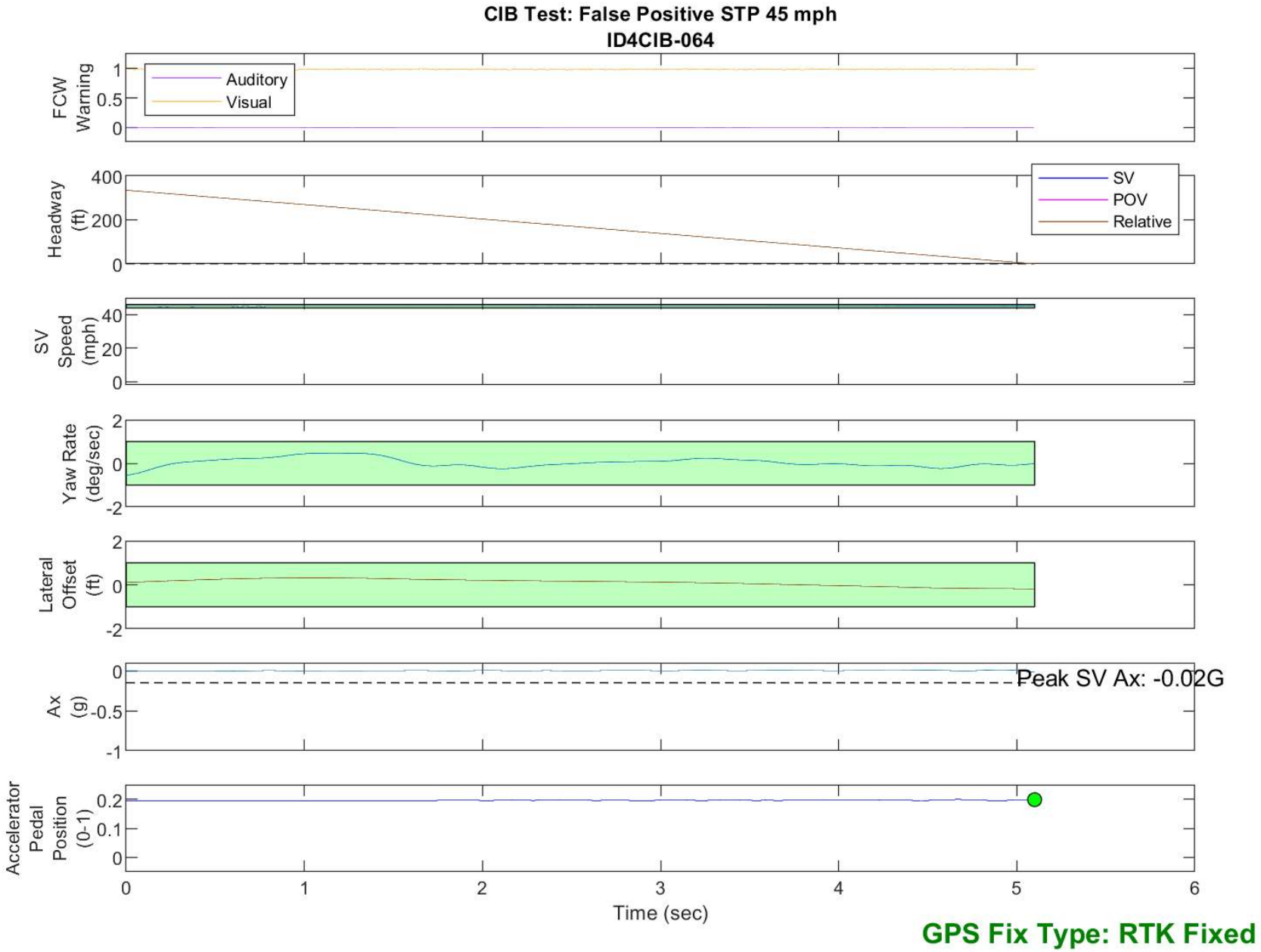

Figure D51. Time History for CIB Run 64, SV Encounters Steel Trench Plate, SV 45 mph