OCAS-DRI-CIB-20-06
NEW CAR ASSESSMENT PROGRAM
CRASH IMMINENT BRAKE SYSTEM CONFIRMATION TEST

2020 Hyundai Palisade

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Final Report

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National Highway Traffic Safety Administration
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16. Abstract These tests were conducted on the subject in accordance with the specifications of the New Car Assessment Program's (NCAP) most current Test Procedure in docket NHTSA-2015-0006-0025; CRASH IMMINENT BRAKE SYSTEM PERFORMANCE EVALUATION FOR THE NEW CAR ASSESSMENT PROGRAM, October 2015. The vehicle passed the requirements of the test for all four CIB test scenarios and all speeds.			
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Section I
OVERVIEW AND TEST SUMMARY

Crash Imminent Brake (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 Brake system installed on a 2020 Hyundai Palisade. This test is part of the New Car Assessment Program to assess Crash Imminent Brake 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 BRAKE SYSTEM

DATA SHEET 1: TEST RESULTS SUMMARY

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2020 Hyundai Palisade

SUMMARY RESULTS

VIN: *KM8R44HE0LU0xxxx*

Test Date: *12/17/2019*

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 BRAKE SYSTEM

DATA SHEET 2: VEHICLE DATA

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TEST VEHICLE INFORMATION

VIN: *KM8R44HE0LU0xxxx*

Body Style: *SUV* Color: *Becketts Black*

Date Received: *12/9/2019* Odometer Reading: *22 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Hyundai Motor Company*

Date of manufacture: *5/27/19*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD:

Tires size as stated on Tire Placard: Front: *245/50R20*

Rear: *245/50R20*

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

Rear: *240 kPa (35 psi)*

TIRES

Tire manufacturer and model: *Bridgestone Dueler H/P Sport AS*

Front tire size: *245/50R20*

Rear tire size: *245/50R20*

Front tire DOT prefix: *EJ KH*

Rear tire DOT prefix: *EJ KH*

CRASH IMMINENT BRAKE SYSTEM

DATA SHEET 3: TEST CONDITIONS

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GENERAL INFORMATION

Test date: *12/17/2019*

AMBIENT CONDITIONS

Air temperature: *15.6 C (60 F)*

Wind speed: *7.7 m/s (17.3 mph)*

X Windspeed ≤ 10 m/s (22 mph)

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

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

VEHICLE PREPARATION

Verify the following:

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

Fuel tank is full: **X**

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

Front: *240 kPa (35 psi)*

Rear: *240 kPa (35 psi)*

CRASH IMMINENT BRAKE SYSTEM

DATA SHEET 3: TEST CONDITIONS

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WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*597.4 kg (1317 lb)*	Right Front	*563.8 kg (1243 lb)*
Left Rear	*473.1 kg (1043 lb)*	Right Rear	*460.4 kg (1015 lb)*
		Total:	*2094.7 kg (4618 lb)*

CRASH IMMINENT BRAKE SYSTEM

DATA SHEET 4: CRASH IMMINENT BRAKE SYSTEM OPERATION

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Name of the CIB option, option package, etc.

Forward Collision Avoidance Assist (FCA)

Type of sensors the system uses:

The system uses a fusion type which includes radar and mono camera.

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

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

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

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

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

Does the vehicle system require an initialization sequence/procedure?

The vehicle does not require an initialization sequence.

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

In general, the FCA does not deactivate due to repeated FCA activations or impacts. However, if the brake actuator or radar/camera sensors are damaged or have problems due to repeated activations or impacts, the FCA can deactivate. In this case, the system provides a diagnostic light to the driver.

CRASH IMMINENT BRAKE

DATA SHEET 4: CRASH IMMINENT BRAKE SYSTEM OPERATION

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

- **X** Warning light
- **X** Buzzer or audible alarm
- **X** Vibration
- ____ Other

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

The driver is alerted by a visual display (Figure A18), a repeated beep with a dominant frequency of 1506 Hz, and steering wheel vibration.

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 driver can deactivate the FCA via User Select Menu (USM) interface:
User Settings
Driver Assistance
Forward Safety
Off
The FCA is reactivated on each ignition cycle.

CRASH IMMINENT BRAKE

DATA SHEET 4: CRASH IMMINENT BRAKE SYSTEM OPERATION

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

X Yes

____ No

If yes, please provide a full description.

The driver can adjust the FCA via User Select Menu (USM) interface:
User Settings
Driver Assistance
Warning Timing
Normal
Later
Warning Volume
High
Medium
Low
Off
Forward Safety
Active Assist
Warning Only
Off

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.

See pages 5-72 through 5-77 of the Owner's manual shown in Appendix B pages B-13 through B-18.

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.

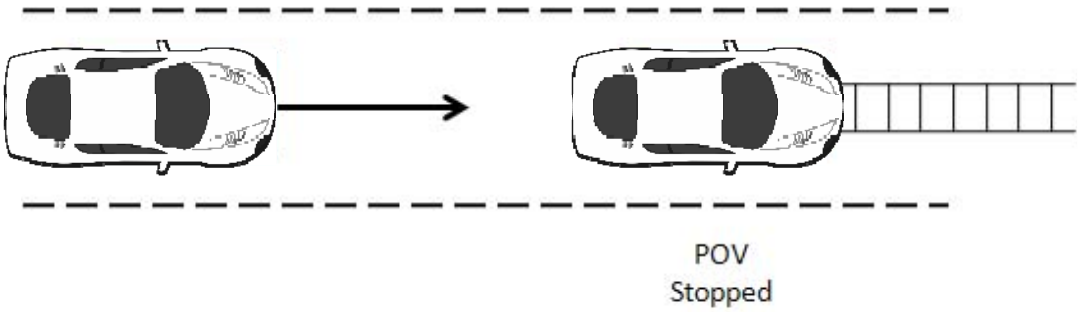

Figure 1. Depiction of Test 1

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.

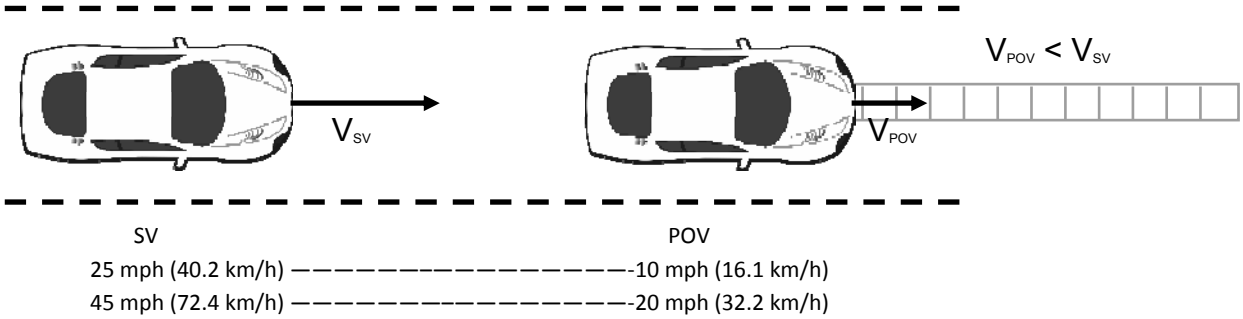

Figure 2. Depiction of Test 2

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-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-POV range during the validity period from the SV speed at t_{FCW}.

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

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

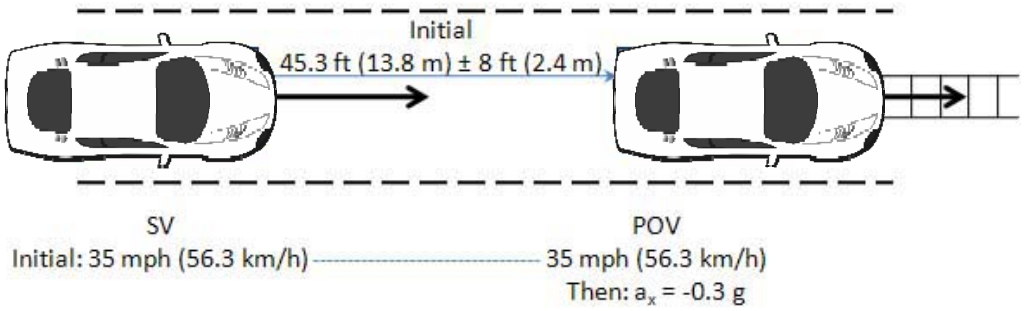

Figure 3. Depiction of Test 3 with POV Decelerating

a. Procedure

The SV ignition was cycled prior to each test run. For this test scenario, both the POV and SV were driven at a constant 35.0 mph (56.3 km/h) in the center of the lane, with a headway of 45.3 ft (13.8 m) ± 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-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 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 bandpass 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	Pass-Band 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 0.25g.
- The SV driver did not apply any force to the brake pedal during the applicable validity period.
- The lateral distance between the centerline of the SV and the centerline of the POV or STP did not deviate more than ±1 ft (0.3 m) during the applicable validity period.

3. VALIDITY PERIOD

The valid test interval began:

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

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

Test 3: 3 seconds before the onset of POV braking

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

The valid test interval ended:

Test 1: When either of the following occurred:

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

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

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

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

4. STATIC INSTRUMENTATION CALIBRATION

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

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

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

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

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

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

5. NUMBER OF TRIALS

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

6. TRANSMISSION

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

C. Principal Other Vehicle

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

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

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

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

Operationally, the POV shell is attached to the slider and load frame which includes rollers that allows the entire assembly to move longitudinally along the guide rail. The guide rail is coupled to a tow vehicle and guided by the lateral restraint track secured to the test track surface. The rail includes a provision for restraining the shell and roller assembly in the ward direction. In operation, the shell and roller assembly engage the rail assembly through detents to prevent relative motion during run-up to test speeds and deceleration of the tow vehicle. The combination of rearward stops and forward motion detents allows the test conditions, such as relative POV-SV headway distance, speed, etc., to be achieved and adjusted as needed in the preliminary part of a test. If during the test, the SV strikes the rear of the POV shell, the detents are overcome and the entire shell/roller assembly moves forward in a two-stage manner along the rail and away from the SV. The forward end of the rail has a cushioned stop to restrain forward

motion of the shell/roller assembly. After impacting the SSV, the SV driver uses the steering wheel to maintain SV position in the center of the travel lane, thereby straddling the two-rail track. The SV driver must manually apply the SV brakes after impact. The SSV system is shown in Figures A6 through A8 and a detailed description can be found in the NHTSA report: NHTSA'S STRIKEABLE SURROGATE VEHICLE PRELIMINARY DESIGN+OVERVIEW, May 2013.

D. Automatic Braking System

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

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

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

E. Instrumentation

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

TABLE 2. TEST INSTRUMENTATION AND EQUIPMENT

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	< 1% error between 20 and	Omega DPG8001	17042707002	By: DRI Date: 7/3/2019 Due: 7/3/2020
Platform Scales	Vehicle Total, Wheel, and Axle Load	1200 lb/platform 5338 N/	0.5% of applied load	Intercomp SWI	1110M206352	By: DRI Date: 1/3/2019 Due: 1/3/2020
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	45040532	By: DRI Date: 5/10/2019 Due: 5/10/2020
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	NA
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rat	Accels .01g, Angular Rate	Oxford Inertial +		By: Oxford Technical Solutions
					2258	Date: 5/3/2019 Due: 5/3/2021
					2176	Date: 4/11/2018 Due: 4/11/2020

TABLE 2. TEST INSTRUMENTATION AND EQUIPMENT

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Real-Time Calculation of Position and Velocity Relative to Lane Markings (LDW) and POV (FCW)	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec Longitudinal Range to POV: ±200 m Longitudinal Range Rate: ±50 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec Longitudinal Range: ±3 cm Longitudinal Range Rate: ±0.02 m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	NA
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	NA	NA
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	NA	NA
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	NA	NA
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/2/2019 Due: 1/2/2020

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

APPENDIX A

Photographs

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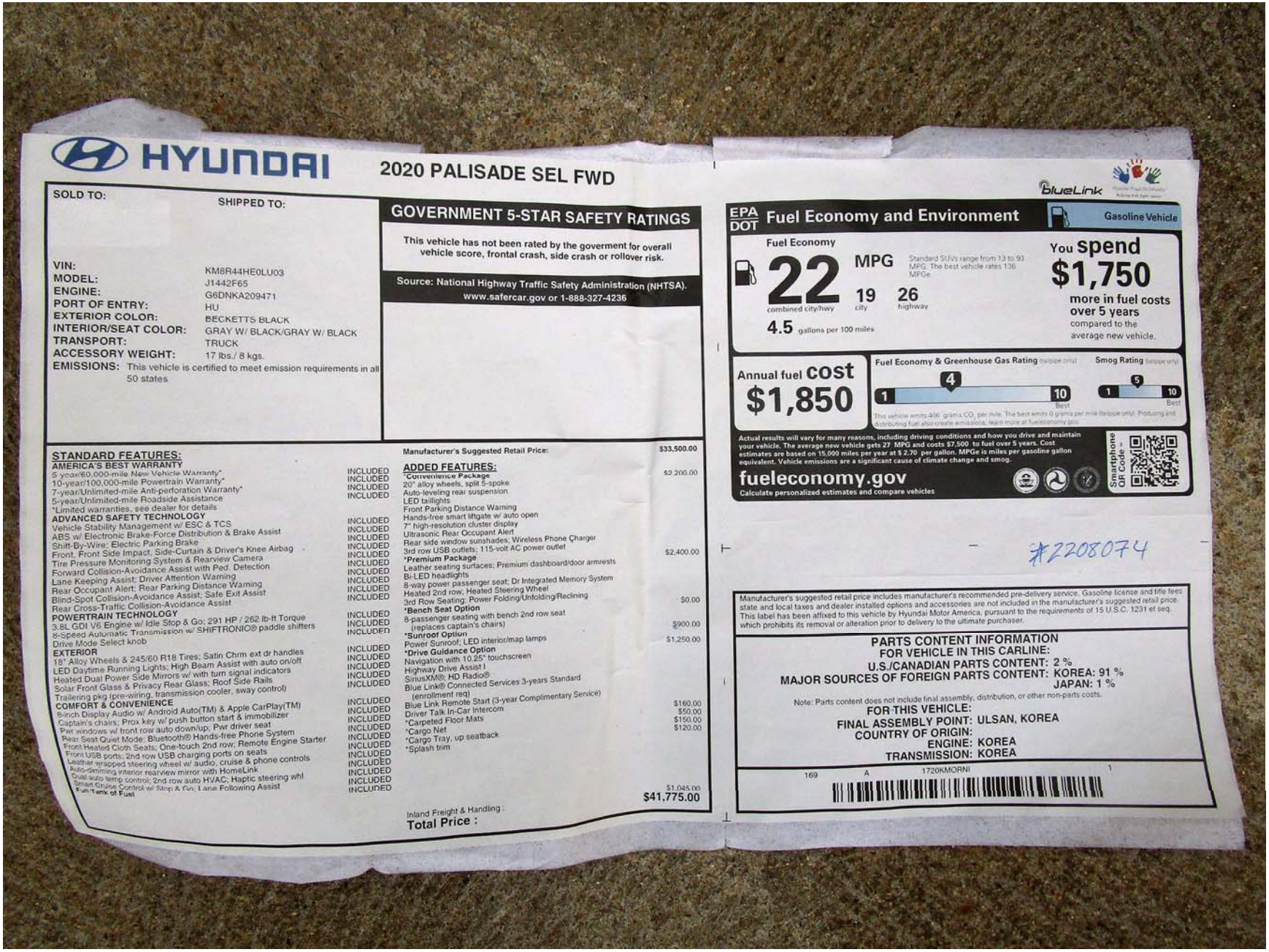
Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle



HYUNDAI

2020 PALISADE SEL FWD

SOLD TO: SHIPPED TO:

VIN: KM8R44HE0LU03
MODEL: J1442F65
ENGINE: G6DNKA209471
PORT OF ENTRY: HU
EXTERIOR COLOR: BECKETTS BLACK
INTERIOR/SEAT COLOR: GRAY W/ BLACK/GRAY W/ BLACK
TRANSPORT: TRUCK
ACCESSORY WEIGHT: 17 lbs./ 8 kgs.
EMISSIONS: This vehicle is certified to meet emission requirements in all 50 states

GOVERNMENT 5-STAR SAFETY RATINGS

This vehicle has not been rated by the goverment for overall vehicle score, frontal crash, side crash or rollover risk.

Source: National Highway Traffic Safety Administration (NHTSA). www.safercar.gov or 1-888-327-4236

BlueLink

EPA DOT Fuel Economy and Environment — Gasoline Vehicle

Fuel Economy
22 MPG combined city/hwy (19 city, 26 highway)
4.5 gallons per 100 miles

Standard SUVs range from 13 to 93 MPG. The best vehicle rates 136 MPGe.

You spend $1,750 more in fuel costs over 5 years compared to the average new vehicle.

Annual fuel cost $1,850

Fuel Economy & Greenhouse Gas Rating (tailpipe only): 4 (1 – 10, Best)
Smog Rating (tailpipe only): 5 (1 – 10, Best)

This vehicle emits 406 grams CO_2 per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel also create emissions; learn more at fueleconomy.gov

Actual results will vary for many reasons, including driving conditions and how you drive and maintain your vehicle. The average new vehicle gets 27 MPG and costs $7,500 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at $ 2.70 per gallon. MPGe is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

fueleconomy.gov
Calculate personalized estimates and compare vehicles

Smartphone QR Code

#2208074

STANDARD FEATURES:

AMERICA'S BEST WARRANTY	
5-year/60,000-mile New Vehicle Warranty*	INCLUDED
10-year/100,000-mile Powertrain Warranty*	INCLUDED
7-year/Unlimited-mile Anti-perforation Warranty*	INCLUDED
5-year/Unlimited-mile Roadside Assistance	INCLUDED
*Limited warranties, see dealer for details	
ADVANCED SAFETY TECHNOLOGY	
Vehicle Stability Management w/ ESC & TCS	INCLUDED
ABS w/ Electronic Brake-Force Distribution & Brake Assist	INCLUDED
Shift-By-Wire: Electric Parking Brake	INCLUDED
Front, Front Side Impact, Side-Curtain & Driver's Knee Airbag	INCLUDED
Tire Pressure Monitoring System & Rearview Camera	INCLUDED
Forward Collision-Avoidance Assist with Ped. Detection	INCLUDED
Lane Keeping Assist; Driver Attention Warning	INCLUDED
Rear Occupant Alert; Rear Parking Distance Warning	INCLUDED
Blind-Spot Collision-Avoidance Assist; Safe Exit Assist	INCLUDED
Rear Cross-Traffic Collision-Avoidance Assist	INCLUDED
POWERTRAIN TECHNOLOGY	
3.8L GDI V6 Engine w/ Idle Stop & Go; 291 HP / 262 lb-ft Torque	INCLUDED
8-Speed Automatic Transmission w/ SHIFTRONIC® paddle shifters	INCLUDED
Drive Mode Select knob	INCLUDED
EXTERIOR	
18" Alloy Wheels & 245/60 R18 Tires; Satin Chrm ext dr handles	INCLUDED
LED Daytime Running Lights; High Beam Assist with auto on/off	INCLUDED
Heated Dual Power Side Mirrors w/ with turn signal indicators	INCLUDED
Solar Front Glass & Privacy Rear Glass; Roof Side Rails	INCLUDED
Trailering pkg (pre-wiring, transmission cooler, sway control)	INCLUDED
COMFORT & CONVENIENCE	
8-inch Display Audio w/ Android Auto(TM) & Apple CarPlay(TM)	INCLUDED
Captain's chairs; Prox key w/ push button start & immobilizer	INCLUDED
Pwr windows w/ front row auto down/up; Pwr driver seat	INCLUDED
Rear Seat Quiet Mode; Bluetooth® Hands-free Phone System	INCLUDED
Front Heated Cloth Seats; One-touch 2nd row; Remote Engine Starter	INCLUDED
Front USB ports; 2nd row USB charging ports on seats	INCLUDED
Leather wrapped steering wheel w/ audio, cruise & phone controls	INCLUDED
Auto-dimming interior rearview mirror with HomeLink	INCLUDED
Dual auto temp control; 2nd row auto HVAC; Haptic steering whl	INCLUDED
Smart Cruise Control w/ Stop & Go; Lane Following Assist	INCLUDED
Full Tank of Fuel	INCLUDED

Manufacturer's Suggested Retail Price:	$33,500.00
ADDED FEATURES:	
*Convenience Package	$2,200.00
20" alloy wheels, split 5-spoke	
Auto-leveling rear suspension	
LED taillights	
Front Parking Distance Warning	
Hands-free smart liftgate w/ auto open	
7" high-resolution cluster display	
Ultrasonic Rear Occupant Alert	
Rear side window sunshades; Wireless Phone Charger	
3rd row USB outlets; 115-volt AC power outlet	$2,400.00
*Premium Package	
Leather seating surfaces; Premium dashboard/door armrests	
Bi-LED headlights	
8-way power passenger seat; Dr Integrated Memory System	
Heated 2nd row; Heated Steering Wheel	
3rd Row Seating; Power Folding/Unfolding/Reclining	$0.00
*Bench Seat Option	
8-passenger seating with bench 2nd row seat (replaces captain's chairs)	$900.00
*Sunroof Option	
Power Sunroof; LED interior/map lamps	$1,250.00
*Drive Guidance Option	
Navigation with 10.25" touchscreen	
Highway Drive Assist I	
SiriusXM®; HD Radio®	
Blue Link® Connected Services 3-years Standard	
(enrollment req)	
Blue Link Remote Start (3-year Complimentary Service)	$160.00
Driver Talk In-Car Intercom	$50.00
*Carpeted Floor Mats	$150.00
*Cargo Net	$120.00
*Cargo Tray, up seatback	
*Splash trim	
	$1,045.00
Inland Freight & Handling :	$41,775.00
Total Price :	

Manufacturer's suggested retail price includes manufacturer's recommended pre-delivery service. Gasoline license and title fees, state and local taxes and dealer installed options and accessories are not included in the manufacturer's suggested retail price. This label has been affixed to this vehicle by Hyundai Motor America, pursuant to the requirements of 15 U.S.C. 1231 et seq. which prohibits its removal or alteration prior to delivery to the ultimate purchaser.

PARTS CONTENT INFORMATION
FOR VEHICLE IN THIS CARLINE:
U.S./CANADIAN PARTS CONTENT: 2 %
MAJOR SOURCES OF FOREIGN PARTS CONTENT: KOREA: 91 %
JAPAN: 1 %

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

FOR THIS VEHICLE:
FINAL ASSEMBLY POINT: ULSAN, KOREA
COUNTRY OF ORIGIN:
ENGINE: KOREA
TRANSMISSION: KOREA

169 A 1720KMORNI 1

Figure A3. Window Sticker (Monroney Label)

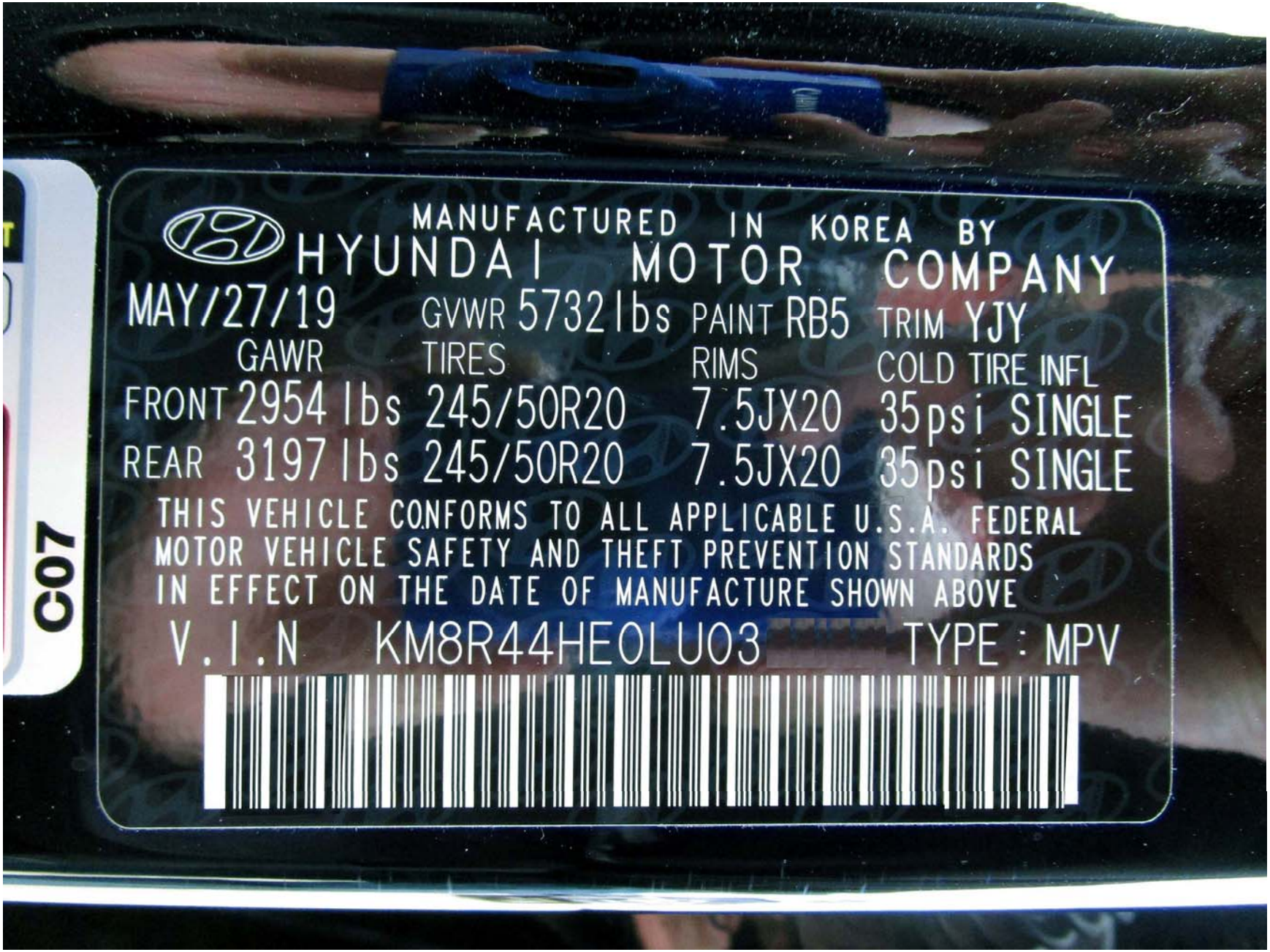


Figure A4. Vehicle Certification Label

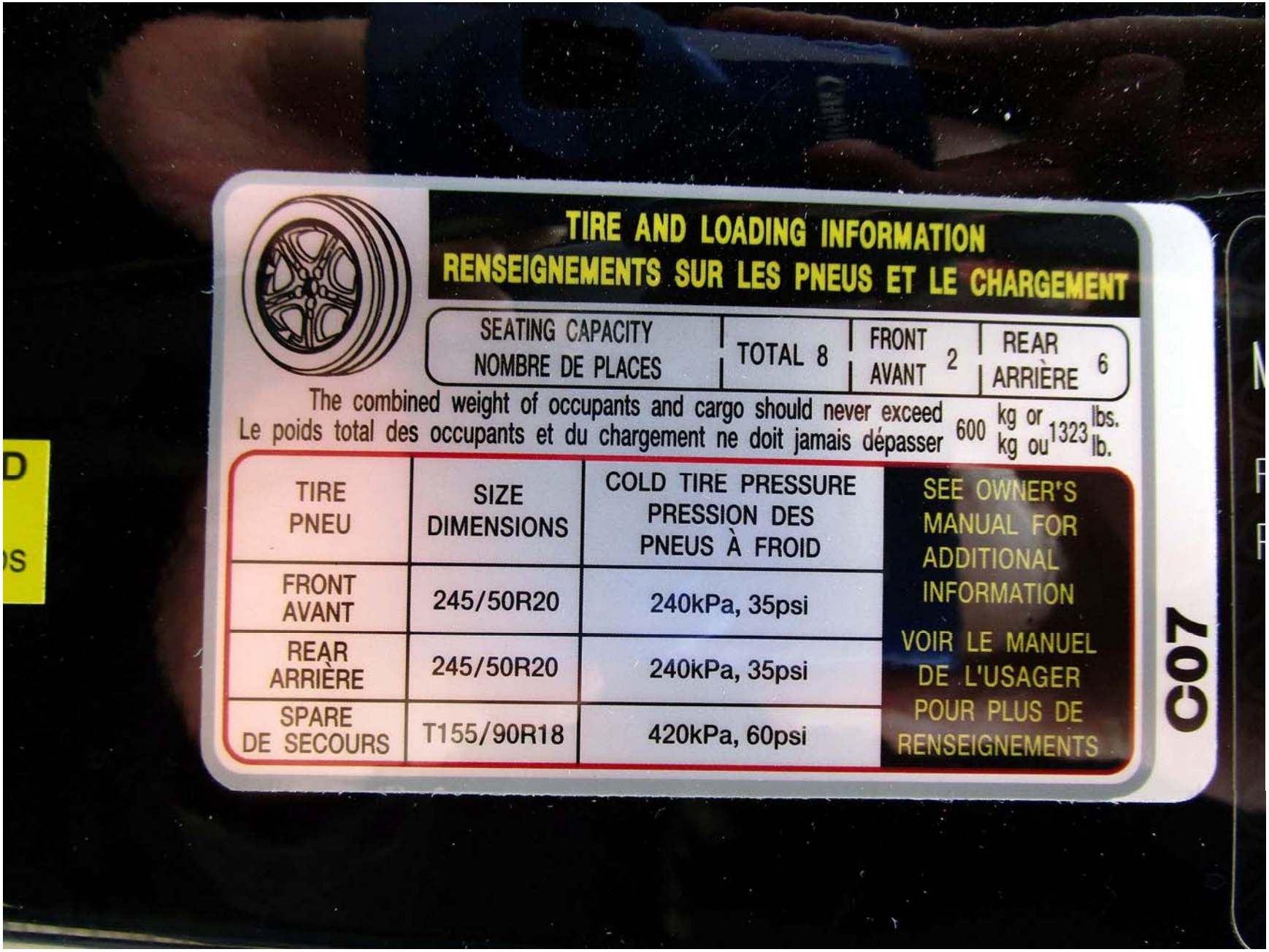


Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

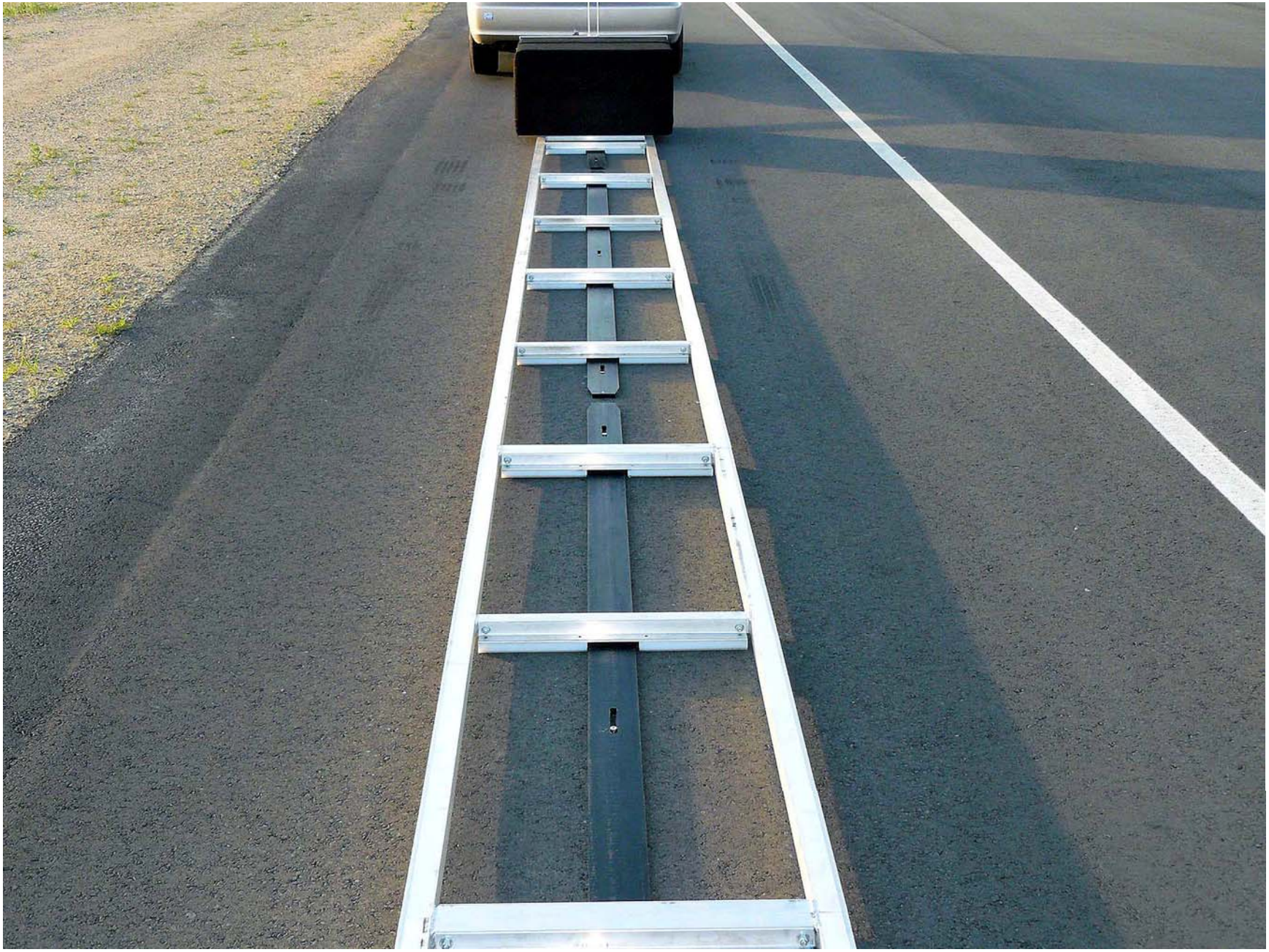


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

Figure A9. Steel Trench Plate

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

Figure A11. Sensor for Detecting Auditory Alerts

Figure A12. Sensor for Detecting Visual Alerts

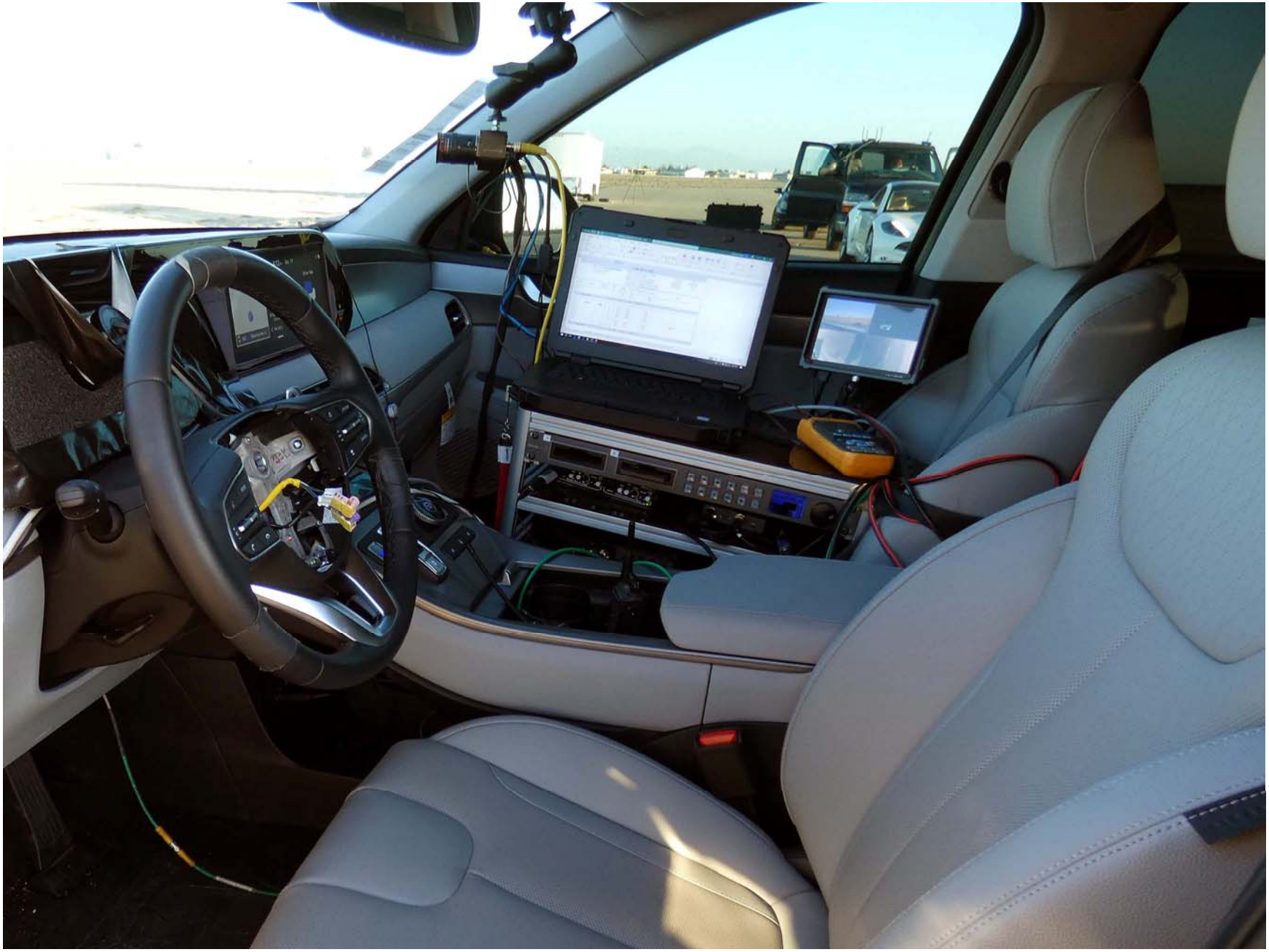


Figure A13. Computer Installed in Subject Vehicle

Figure A14. Brake Actuator Installed in POV System

Figure A15. AEB Setup Menus (1 of 2)

Figure A16. AEB Setup Menus (2 of 2)

Figure A17. Steering Wheel Mounted Controls for Changing Parameters

Figure A18. AEB Visual Alert

APPENDIX B

Excerpts from Owner's Manual

Forward Collision-Avoidance Assist (FCA) System Warning Light

This warning light illuminates:

- When you set the ignition switch or the 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 FCA.

If this occurs, have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Forward Collision-Avoidance Assist (FCA) system" in chapter 5.

Lane Keeping Assist (LKA) System Indicator Light

This indicator light illuminates:

- [Green] When the system operating conditions are satisfied.
- [White] The system operating conditions are not satisfied.
- [Yellow] When there is a malfunction with the lane keeping assist system.

  If this occurs, have your vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Lane Keeping Assist (LKA) system" in chapter 5.

LED Headlight Warning Light (if equipped)

This warning light illuminates:

- When you set the ignition switch or the Engine Start/Stop button to the ON position.
- When there is a malfunction with the LED headlight.

  If this occurs, have the vehicle inspected by an authorized HYUNDAI dealer.

This warning light blinks:

When there is a malfunction with a LED headlight related part.

If this occurs, have the vehicle inspected by an authorized HYUNDAI dealer.

NOTICE

Continuous driving with the LED Headlight Warning Light on or blinking can reduce LED headlight life.

Check headlight (if equipped)

This warning message is displayed if the headlights are not operating properly. A headlight bulb may need to be replaced.

Information

Make sure to replace the burned out bulb with a new one of the same wattage rating.

Check turn signal (if equipped)

This warning message is displayed if the turn signal lamps are not operating properly. A lamp may need to be replaced.

Information

Make sure to replace the burned out bulb with a new one of the same wattage rating.

Check High Beam Assist (HBA) system (if equipped)

This warning message is displayed if there is a problem with the High Beam Assist (HBA) system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "High Beam Assist (HBA) system" in chapter 3.

Check headlight LED (if equipped)

This warning message is displayed if there is a problem with the LED headlight. Have the vehicle inspected by an authorized HYUNDAI dealer.

Check Forward Collision-Avoidance Assist system (if equipped)

This warning message is displayed if there is a problem with the Forward Collision-Avoidance Assist (FCA) system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Forward Collision-Avoidance Assist (FCA) system" in chapter 5.

Check Blind-Spot Collision Warning (BCW) system (if equipped)

This warning message is displayed if there is a problem with the Blind-Spot Collision Warning system. Have the vehicle inspected by an authorized HYUNDAI dealer.

For more details, refer to "Blind-Spot Collision Warning (BCW)/ Blind-Spot Collision-Avoidance Assist (BCA)" or "Rear Cross-Traffic Collision Warning (RCCW)/ Rear Cross-Traffic Collision-Avoidance Assist (RCCA)" System in chapter 5.

FORWARD COLLISION-AVOIDANCE ASSIST (FCA) SYSTEM

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

⚠ WARNING

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

- **This system is only a supplemental system and it is not intended to, nor does it replace the need for extreme care and attention of the driver. The sensing range and objects detectable by the sensors are limited. Pay attention to the road conditions at all times.**
- **Drive at posted speed limits and accordance to road conditions.**
- **Always drive cautiously to prevent unexpected and sudden situations from occurring. The Forward Collision-Avoidance system may not always stop the vehicle completely and is only intended to help mitigate a collision that is imminent.**

System Setting and Operation

System setting

OTMA058186

- Setting Forward Safety function

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

  'User Settings → Driver Assistance → Forward Safety'

  - If you select "Active Assist", the FCA system activates. The 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', the 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', the FCA system deactivates.

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

OTMA058089

• Setting Warning Timing

The driver can select the initial warning activation time on the LCD 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 option is selected, the initial Forward Collision Warning is activated sensitively. If you feel the warning activates too early, set the 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, pedestrian ahead before the initial warning occurs.

  Select 'Later' when traffic is light and when driving speed is slow.

Information

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

The FCA system is on and ready when 'Active Assist' or 'Warning Only' under Forward Safety is selected in the LCD display and when the following prerequisites are satisfied:

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

⚠ WARNING

- **To avoid driver distractions, do not attempt to set or cancel the FCA while driving the vehicle. Always completely stop the vehicle at a safe place before setting or canceling the system.**
- **FCA automatically activates upon placing the ignition switch to the ON position. The driver can deactivate FCA by canceling the system setting in the cluster LCD display.**
- **FCA automatically deactivates upon canceling ESC. When ESC is canceled, FCA cannot be activated in the cluster LCD display. In this situation, the FCA warning light will illuminate which is normal.**

FCA Warning Message and Brake Control

FCA produces warning messages, warning alarms, and emergency braking based on the level of risk of a frontal collision, such as when a vehicle ahead suddenly brakes, or when the system detects that a collision with a pedestrian is imminent.

Collision Warning (First and second warning)

OLX2059026N

- The warning message appears on the cluster LCD display with a warning chime.
- Your vehicle speed may decelerate moderately.
- If FCA detects a vehicle in front, the system operates when your vehicle speed is between 5 mph (8 km/h) and 100 mph (160km/h). Maximum vehicle speed may decrease depending on the condition of the vehicle ahead and surroundings.
- If FCA detects a pedestrian in front, the system operates when your vehicle speed is between 5 mph (8 km/h) and 55 mph (90 km/h). Maximum vehicle speed may decrease depending on the condition of the vehicle ahead and surroundings.
- If you select 'Warning only' for the system setting, the FCA system activates and produces only warning alarms in accordance with the collision risk levels. You should control the brake directly because the FCA system will not control the brake.

Emergency Braking (Third warning)

OLX2059027N

- The warning message appears on the cluster 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.
- If FCA detects a vehicle in front, the system operates when your vehicle speed is above 5 mph (8 km/h) and 50 mph (80 km/h) or under. Maximum vehicle speed may decrease depending on the condition of the vehicle ahead and surroundings.
- If FCA detects a pedestrian in front, the system operates when your vehicle speed is 5 mph (8 km/h) or above and under 45 mph (70 km/h). Maximum vehicle speed may decrease depending on the condition of the vehicle ahead and surroundings.
- If you select 'Warning only' for the system setting, the FCA system activates and produces only warning alarms in accordance with the collision risk levels. You should control the brake directly because the 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 FCA provides additional braking power for optimum braking performance, when the driver depresses the brake pedal.
- The braking control is automatically deactivated, when the driver sharply depresses the accelerator pedal, or when the driver abruptly operates the steering wheel.
- The FCA braking 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 the FCA system.
- After the brake control is activated, the driver must immediately depress the brake pedal and check the surroundings. The brake activation by the system lasts for about 2 seconds.
- If any other warning sound such as seat belt warning chime is already generated, the Forward Collision-Avoidance Assist (FCA) system warning may not sound.
- Playing the vehicle audio system at high volume may prevent occupants from hearing the system warning sounds.

⚠ WARNING

The FCA 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

The FCA system logic operates within certain parameters, such as the distance from the vehicle, 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 the FCA system.

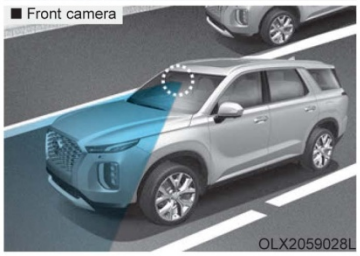
⚠ WARNING

Never deliberately drive dangerously to activate the system.

FCA Sensor (Front Radar/Front Camera)

■ Front radar

■ Front camera



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

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 frame or foreign objects such as a bumper sticker or a bumper guard near the sensor. Doing so may adversely affect the sensing performance of the radar.**
- **Always keep the 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 sensor or sensor cover. If the sensor is forcibly moved out of proper alignment, the FCA system may not operate correctly. In this case, a warning message may not be displayed. Have the vehicle inspected by an authorized HYUNDAI dealer.**
- **If the front bumper becomes damaged in the area around the sensor, the FCA system may not operate properly. Have the vehicle inspected by an authorized HYUNDAI dealer.**
- **Use only genuine HYUNDAI 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, or tint the front windshield.**
- **NEVER place any reflective objects (i.e. white paper, mirror) over the crash pad. Any light reflection may prevent the system from functioning properly.**
- **Pay extreme caution to keep the camera dry.**
- **NEVER disassemble the camera assembly, or apply any impact on the camera assembly.**
- **If the sensor is forcibly moved out of proper alignment, the FCA system may not operate correctly. In this case, a warning message may not be displayed. Have the vehicle inspected by an authorized HYUNDAI dealer.**

Information

Have the system checked by an authorized HYUNDAI dealer when:

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

Warning message and warning light

OIK057090L

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

When the sensor cover is covered with dirt, snow, or debris, the 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.

⚠ WARNING

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

System Malfunction

OIK057091L

Check Forward Collision-Avoidance Assist system

- When FCA is not working properly, the FCA warning light (⛐) will illuminate and the warning message will appear for a few seconds. After the message disappears, the master warning light (⚠) will illuminate. In this case, have the vehicle inspected by an authorized HYUNDAI dealer.
- The 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 the 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, the FCA system may activate prematurely. This initial warning message appears on the LCD display with a warning chime.**

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

- **If there is a malfunction with the FCA system, the Forward Collision avoidance assist system is not applied even though the braking system is operating normally.**
- **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.**
- **The FCA system may activate during braking and the vehicle may stop suddenly shifting loose objects toward the passengers. Always keep loose objects secured.**
- **The FCA system may not activate if the driver applies the brake pedal to avoid collision.**
- **The brake control may be insufficient, possibly causing a collision, if a vehicle in front abruptly stops. Always pay extreme caution.**
- **The FCA system may not activate according to the road conditions, inclement weather, driving conditions or traffic conditions.**
- **Occupants may get injured, if the vehicle abruptly stops by the activated FCA system. Pay extreme caution.**
- **The FCA system operates only to detect vehicles, pedestrian in front of the vehicle.**

⚠ WARNING

- **The FCA system operates only to help detect vehicles or pedestrians in front of the vehicle.**
- **The FCA system does not operate when the vehicle is in reverse.**
- **The FCA system is not designed to detect other objects on the road such as animals.**
- **The FCA system does not detect vehicles in the opposite lane.**
- **The FCA system does not detect cross traffic vehicles that are approaching.**
- **The FCA system cannot detect the cross traffic cyclist that are approaching.**
- **The FCA system cannot detect vehicles that are stopped vertically to your vehicle at a intersection or 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 the System

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

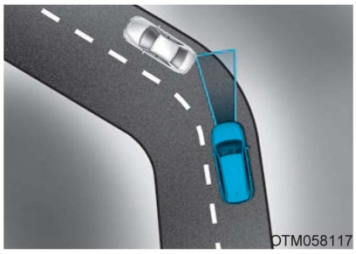
In certain situations, the radar sensor or the camera may not be able to detect the vehicle, pedestrian ahead. In these cases, the FCA system may not operate normally. The driver must pay careful attention in the following situations where the FCA operation may be limited.

Detecting vehicles

The sensor may be limited when:

- The system may not operate for 15 seconds after the engine is started or the camera is initialized
- The radar sensor or camera is covered 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 radar sensor or camera
- There is interference by electromagnetic waves
- There is severe irregular reflection from the radar sensor
- The radar/camera sensor recognition is limited
- The vehicle in front is too small to be detected (for example a motorcycle or a bicycle, etc.)
- The vehicle in front is an oversize vehicle or trailer that is too big to be detected by the camera recognition system (for example a tractor trailer, etc.)
- The camera's field of view is not well illuminated (either too dark or too much reflection or too much backlight that obscures the field of view)
- The vehicle in front does not have their rear lights properly turned ON or their rear lights are located unusually
- The outside brightness changes suddenly, for example when entering or exiting a tunnel
- 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 on unpaved or uneven rough surfaces, or road with sudden gradient changes
- 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 camera does not recognize the entire vehicle in front
- The camera is damaged
- The brightness outside is too low such as when the headlamps are not on at night or the vehicle is going through a tunnel
- 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



- Driving on a curve

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

  In certain instances on a curved road, the FCA system may activate prematurely.

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

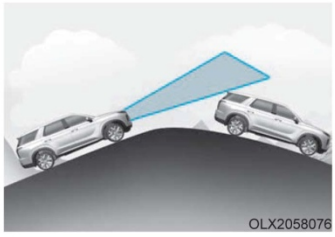
  In these cases, the driver must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.

The 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.

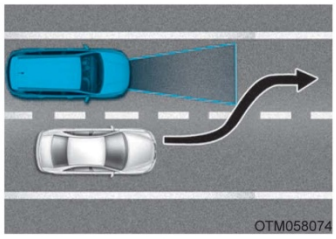


- Driving on a slope

  The performance of the 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.

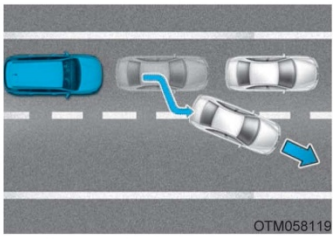
  When the FCA suddenly recognizes the vehicle in front while passing over a slope, you may experience sharp deceleration.

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

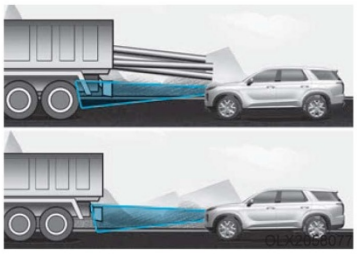


- Changing lanes

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



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



- Detecting the vehicle in front of you

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

Detecting pedestrians

The sensor may be limited when:

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

⚠ WARNING

- **Do not use the Forward Collision Avoidance Assist (FCA) system when towing a vehicle. Application of the FCA system while towing may adversely affect the safety of your vehicle or the towing vehicle.**
- **Use extreme caution when the vehicle in front of you has cargo that extends rearward from the cab, or when the vehicle in front of you has higher ground clearance.**
- **The FCA system is designed to help detect and monitor the vehicle ahead to help detect a pedestrian 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 the FCA system. Doing so may cause severe injury or death.**

Information

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

Information

This device complies with Part 15 of the FCC rules.

Operation is subject to the following two conditions:

1. **This device may not cause harmful interference.**
2. **This device must accept any interference received, including interference that may cause undesired operation.**

APPENDIX C

Run Log

Subject Vehicle: **2020 Hyundai Palisade** Test Date: **12/17/2019**

Principal Other Vehicle: **SSV**

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
1	Static Run								
2	**Stopped POV**	Y	2.09	11.77	25.1	1.24	1.07	Pass	
3		Y	2.10	10.46	25.3	1.12	1.11	Pass	
4		Y	2.05	10.49	25.5	1.25	1.10	Pass	
5		Y	2.04	10.69	25.1	1.21	1.11	Pass	
6		Y	2.04	10.49	24.5	1.20	1.10	Pass	
7		Y	1.81	9.42	24.0	1.22	1.02	Pass	
8		Y	2.07	9.83	25.7	1.23	1.14	Pass	
9	Static Run								
10	**Slower POV, 25 vs 10**	Y	1.76	11.58	14.7	1.04	0.98	Pass	
11		Y	1.74	10.18	15.0	1.05	0.93	Pass	
12		Y	1.80	9.48	15.5	1.04	0.90	Pass	
13		Y	1.82	10.72	15.0	1.07	0.95	Pass	
14		Y	1.66	11.31	14.9	1.05	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
15		Y	1.81	10.37	15.4	1.06	0.92	Pass	
16		Y	1.75	9.36	14.8	1.08	0.86	Pass	
17	Static Run								
18	**Slower POV, 45 vs 20**	Y	2.27	14.95	25.3	1.04	1.42	Pass	
19		Y	2.41	13.81	25.1	1.11	1.21	Pass	
20		Y	2.35	15.06	25.7	1.12	1.25	Pass	
21		Y	2.38	14.67	25.5	1.13	1.24	Pass	
22		N							SV yaw
23		Y	2.32	16.16	25.2	1.12	1.30	Pass	
24		Y	2.38	15.90	25.2	1.15	1.28	Pass	
25		Y	2.38	14.82	26.2	1.16	1.29	Pass	
26	Static run								
27	**Decelerating POV, 35**	N							SV speed
28		N							SV speed
29		N							GPS drop
30	Static run								
31		Y	1.74	6.95	24.8	1.12	1.00	Pass	
32		N							POC speed

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
33		Y	1.63	7.58	23.7	1.14	1.06	Pass	
34		Y	1.58	8.76	22.5	1.11	1.01	Pass	
35		Y	1.51	7.95	22.1	1.09	0.95	Pass	
36		Y	1.48	7.36	21.5	1.13	0.97	Pass	
37		N							PP error
38		Y	1.57	8.82	22.2	1.11	1.01	Pass	
39		Y	1.40	8.71	21.0	1.13	0.94	Pass	
40	Static Run								
41	STP - Static Run								
42	**STP False Positive, 25**	Y				0.01		Pass	
43		Y				0.01		Pass	
44		Y				0.00		Pass	
45		Y				0.01		Pass	
46		Y				0.01		Pass	
47		Y				0.01		Pass	
48		Y				0.01		Pass	
49	STP - Static Run								

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
50	**STP False Positive, 45**	Y				0.01		Pass	
51		Y				0.01		Pass	
52		Y				0.02		Pass	
53		Y				0.01		Pass	
54		Y				0.01		Pass	
55		N							SV speed
56		Y				0.01		Pass	
57		Y				0.01		Pass	
58	STP - Static Run								

APPENDIX D

Time History Plots

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Description of Time History Plots

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

Time History Plot Description

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

- Stopped POV (SV at 25 mph)
- Slower POV, 25/10 (SV at 25 mph, POV at 10 mph)
- Slower POV, 45/20 (SV at 45 mph, POV at 20 mph)
- Braking 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. A green dot is displayed if the accelerator pedal was released within 0.5 seconds of the onset of the FCW warning.

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

Envelopes and Thresholds

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

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

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

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

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

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

Examples of time history plots for each test type (including passing, failing and invalid runs) are shown in Figure 1 through Figure 9. Figures 1 through 6 show passing runs for each of the 6 test types. Figures 7 and 8 show examples of invalid runs. Figure 9 shows an example of a valid test that failed the CIB requirements.

Time history data plots for the tests of the vehicle under consideration herein are provided beginning with Figure 10.

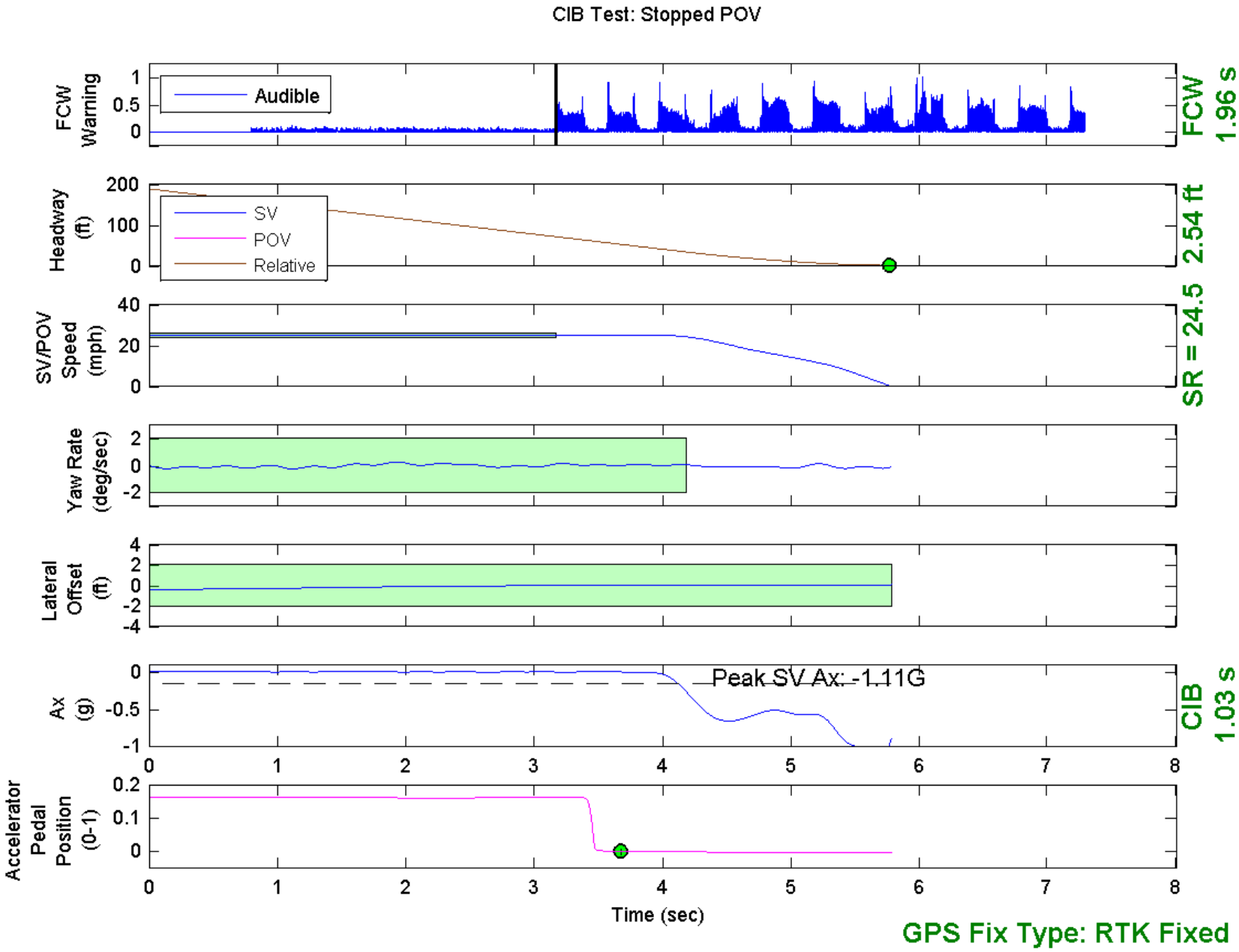

Figure D1. Example Time History for Stopped POV, Passing

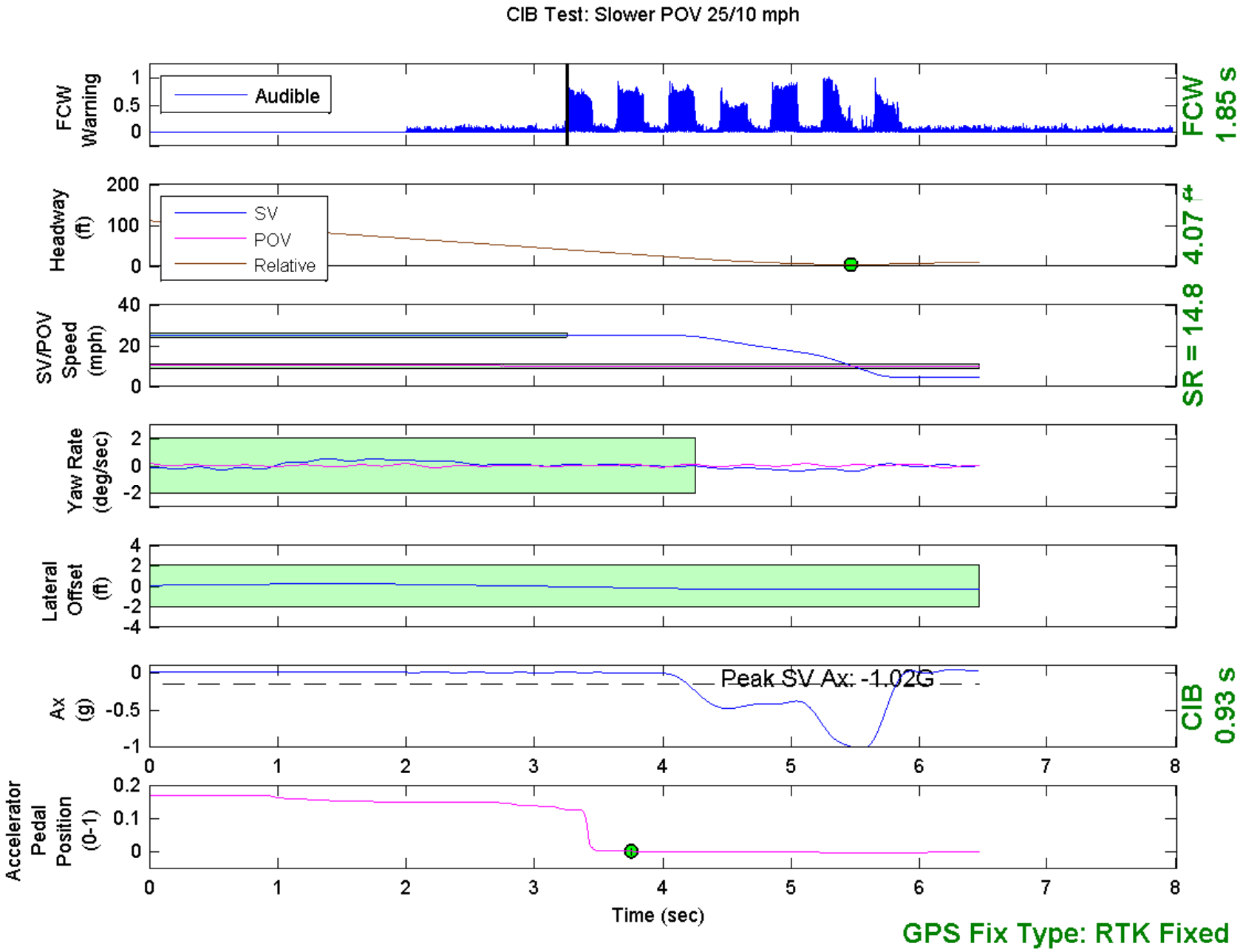

Figure D2. Example Time History for Slower POV 25 vs. 10, Passing

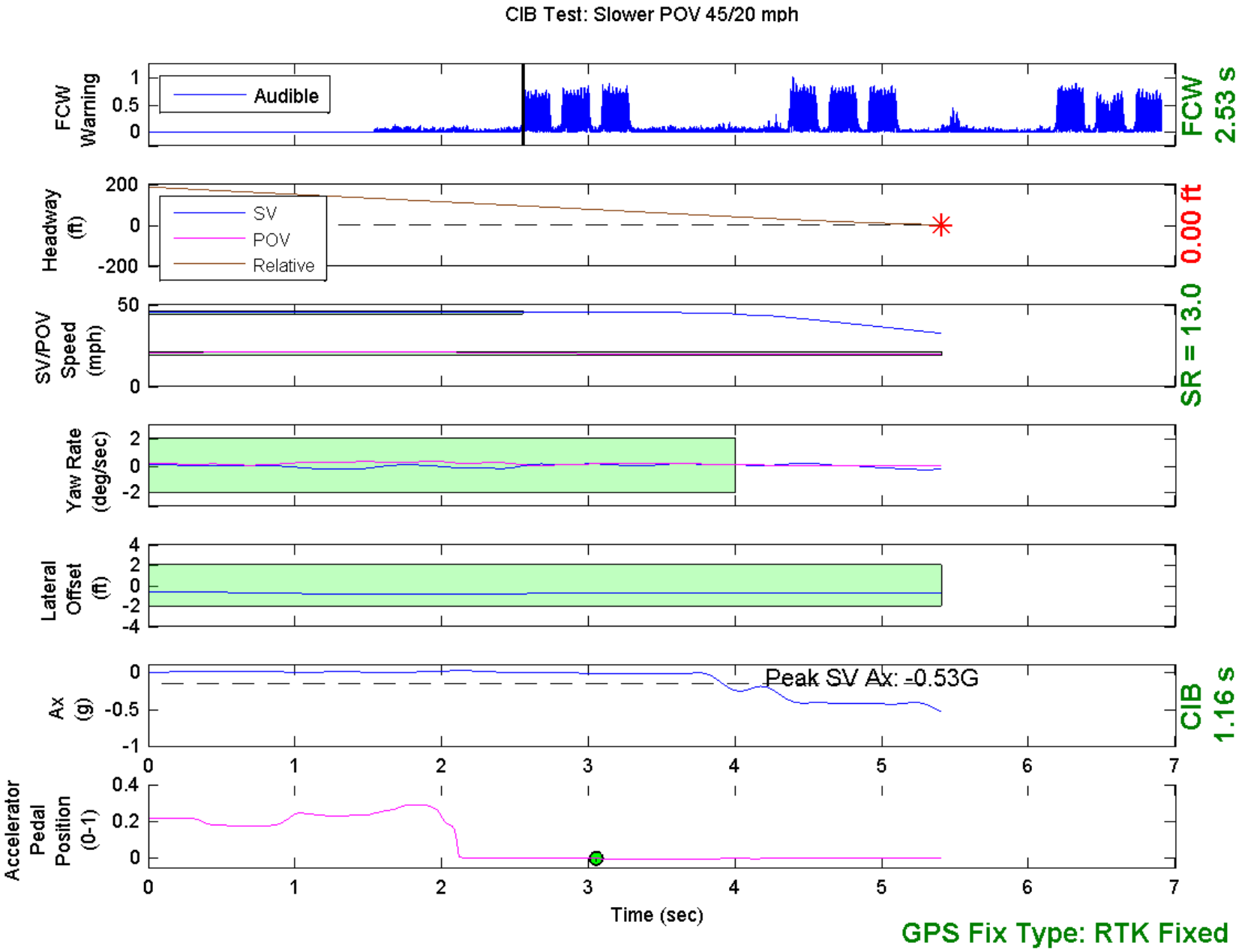

Figure D3. Example Time History for Slower POV 45 vs. 20, Passing

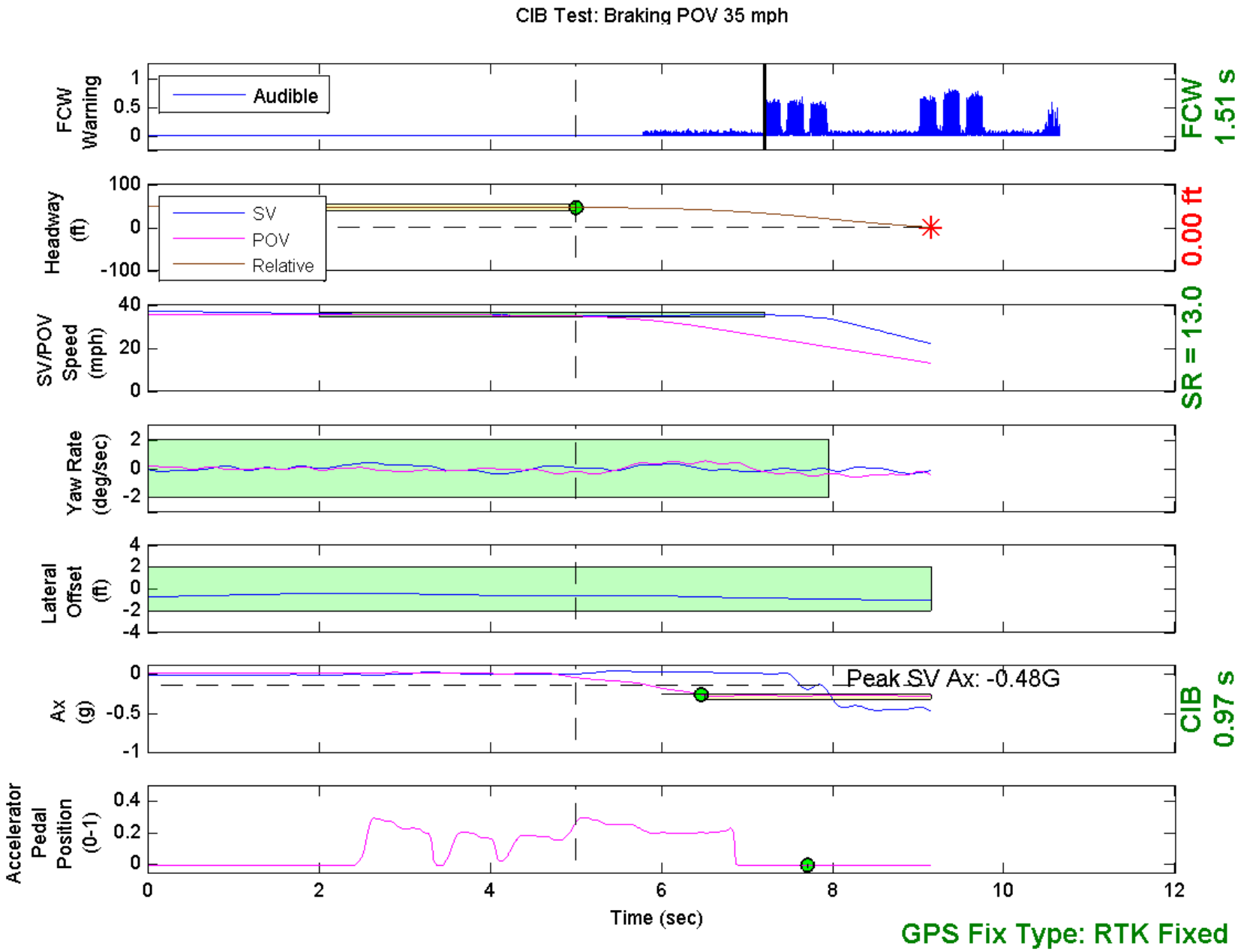

Figure D4. Example Time History for Braking POV 35, Passing

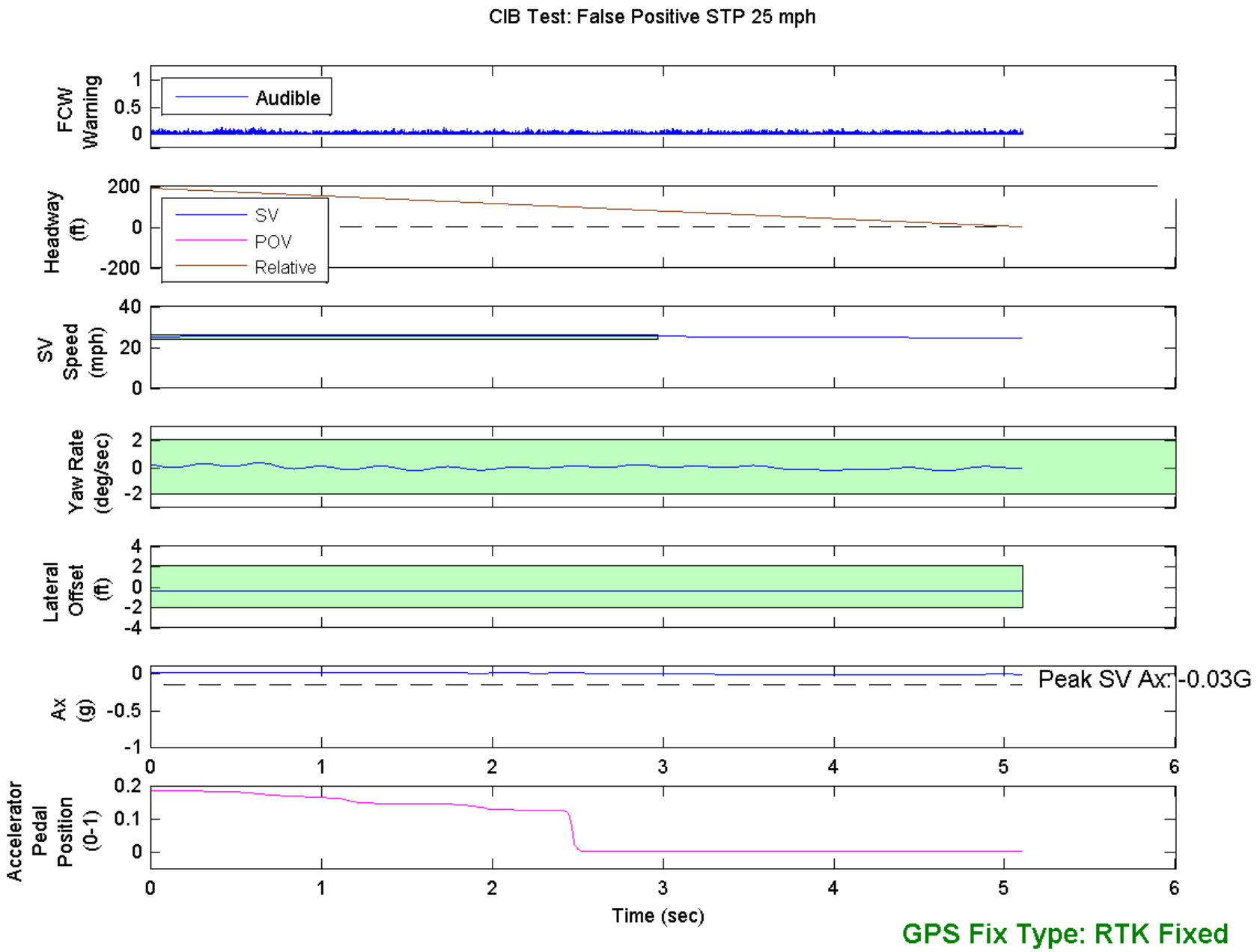

Figure D5. Example Time History for False Positive STP 25, Passing

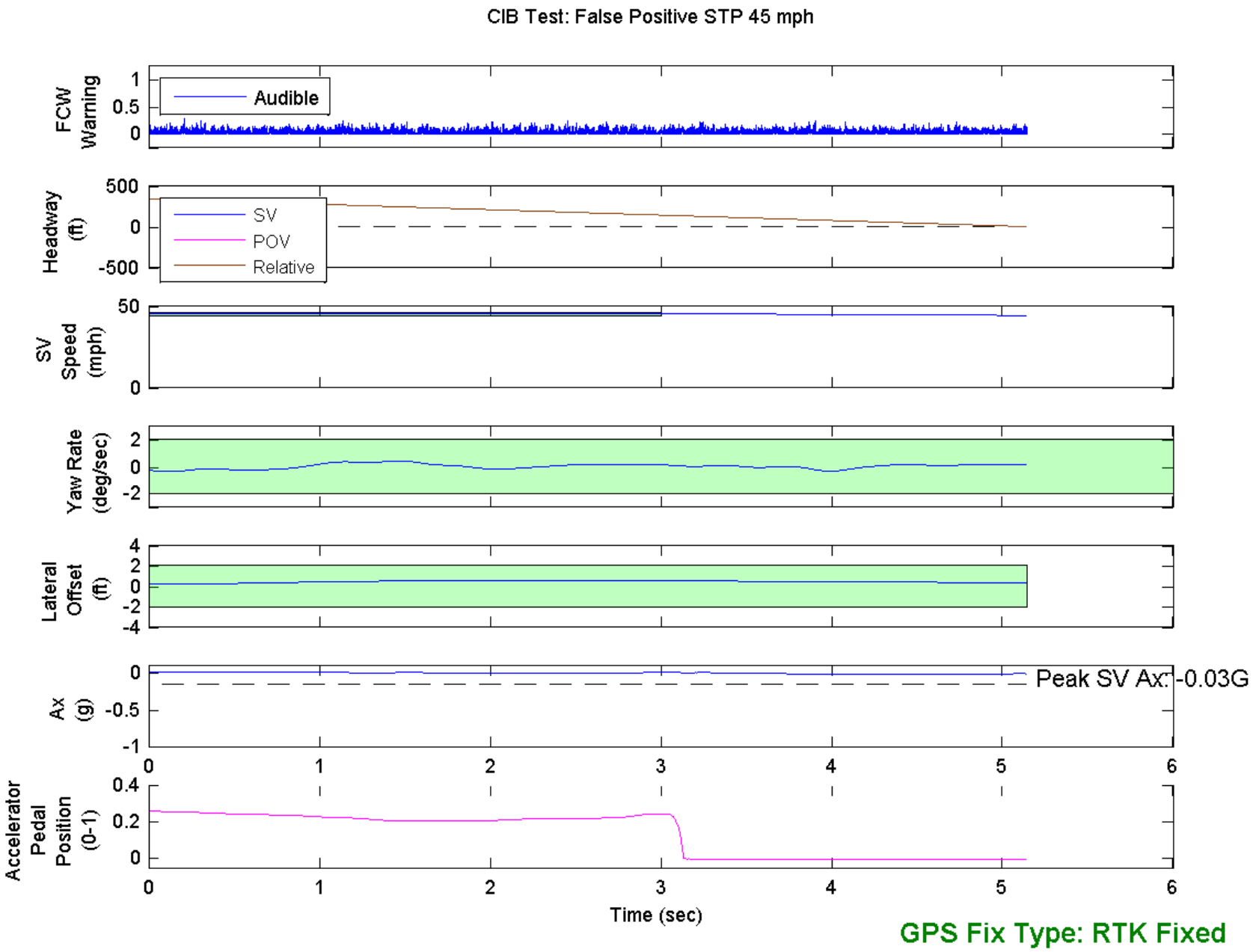

Figure D6. Example Time History for False Positive STP 45, Passing

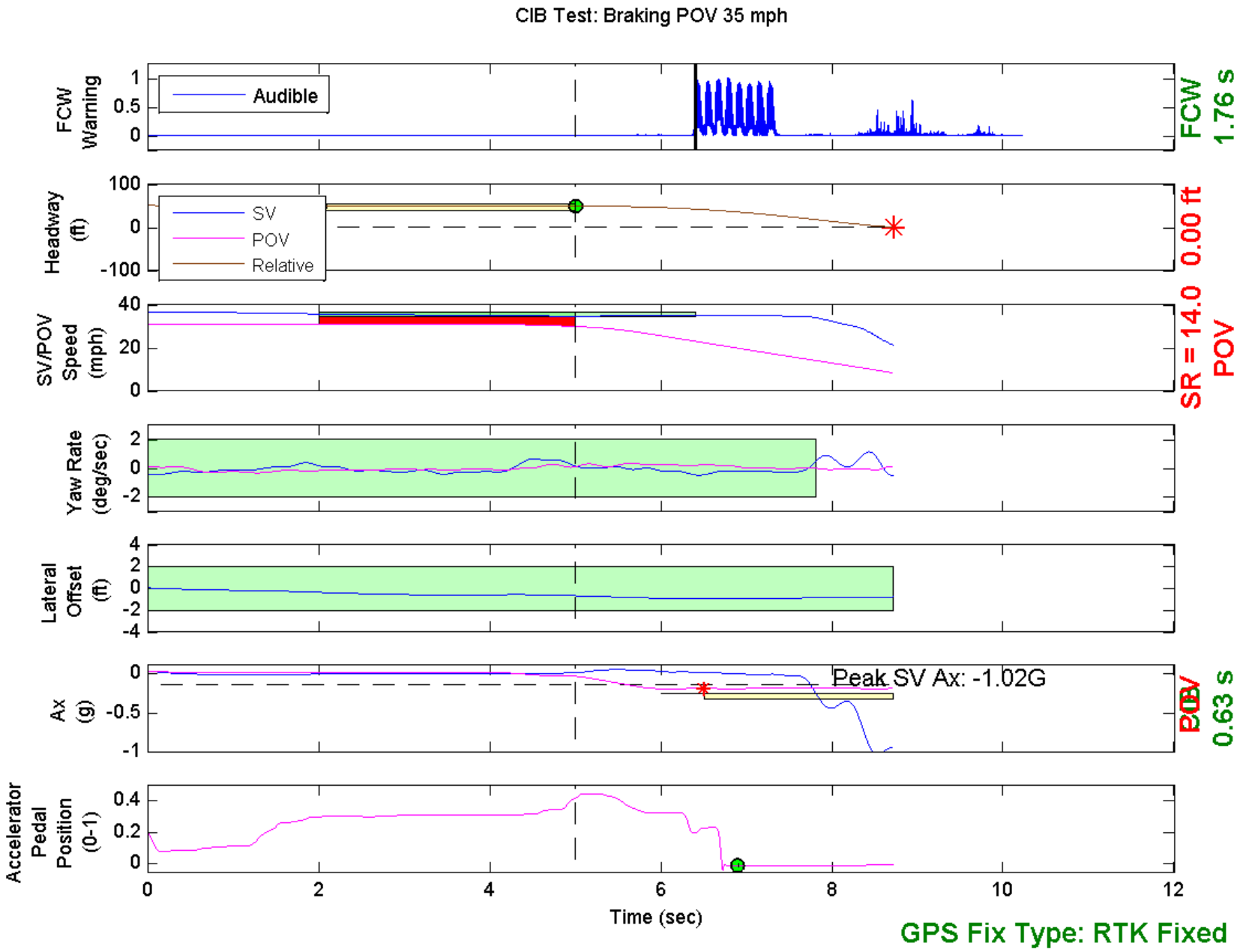

Figure D7. Example Time History Displaying Various Invalid Criteria

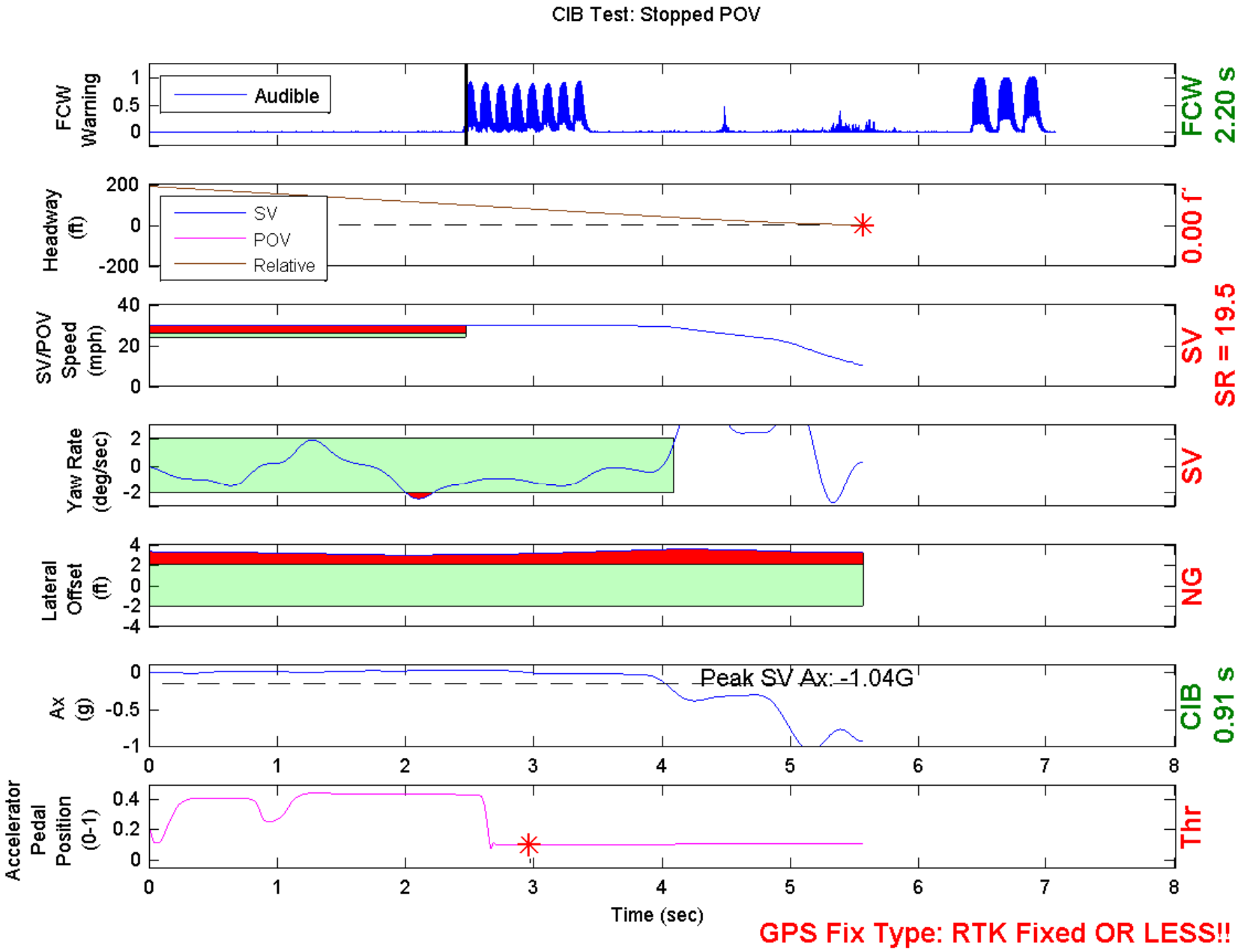

Figure D8. Example Time History Displaying Various Invalid Criteria

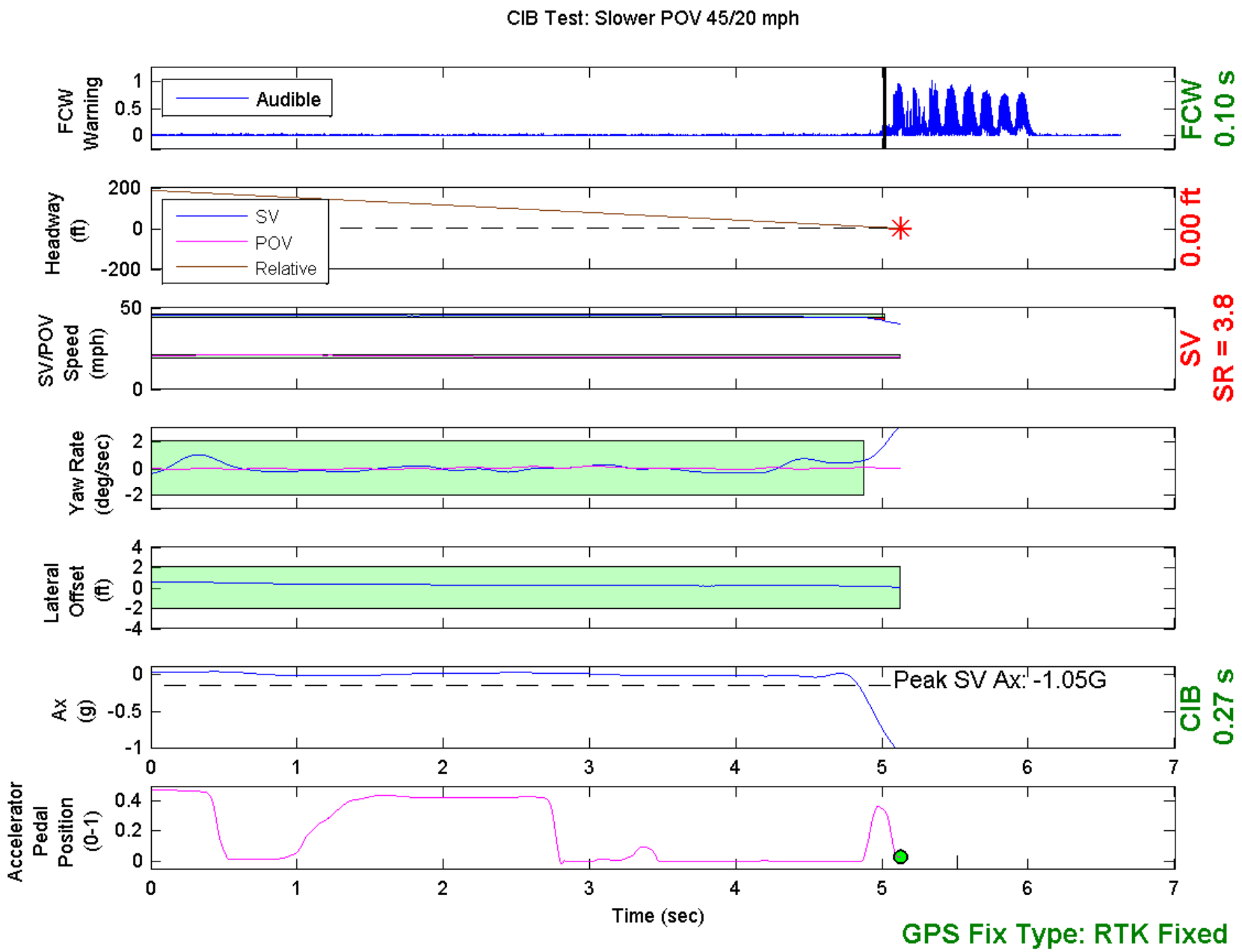

Figure D9. Example Time History for a Failed Run

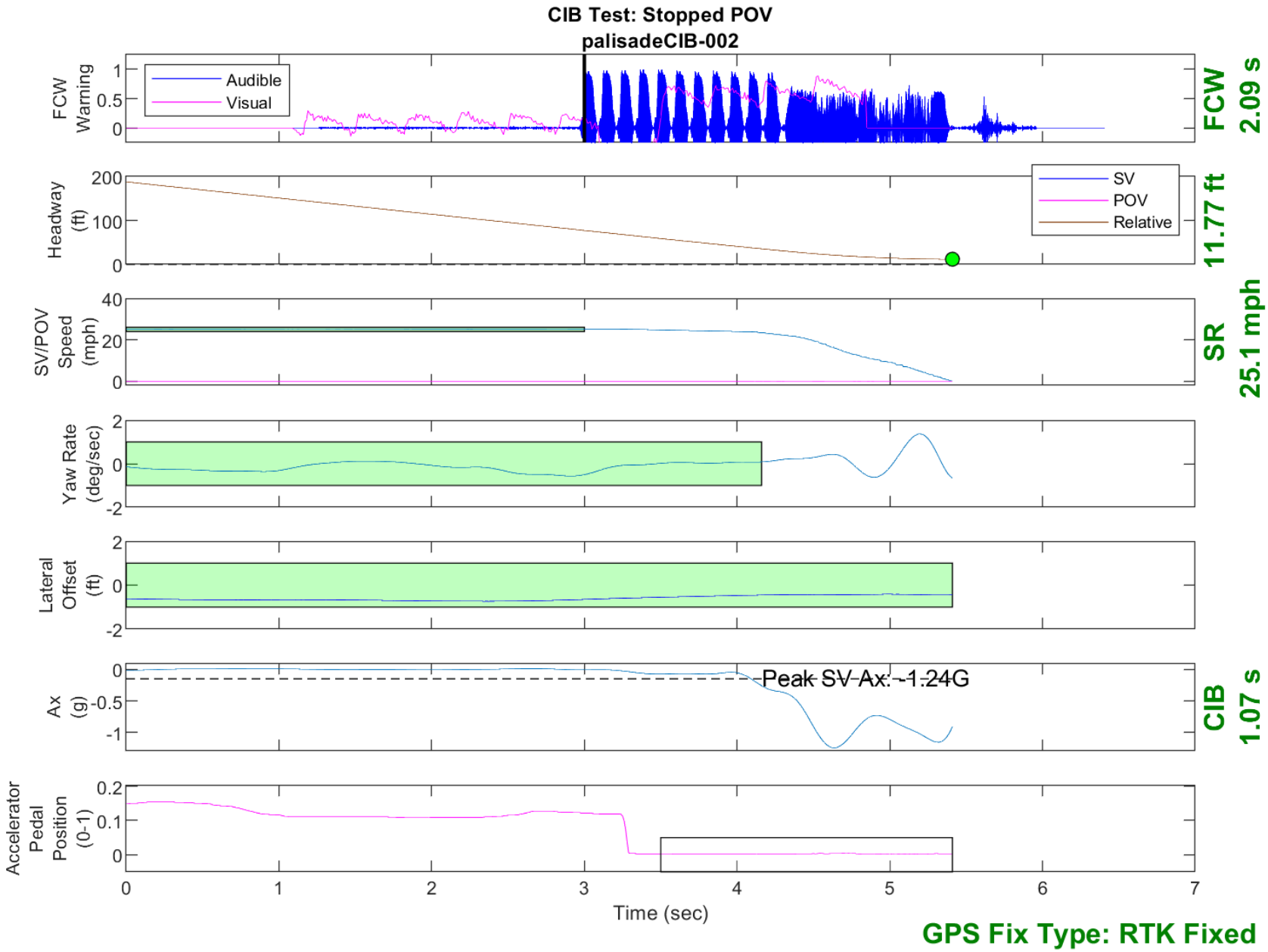

Figure D10. Time History for CIB Run 2, SV Encounters Stopped POV

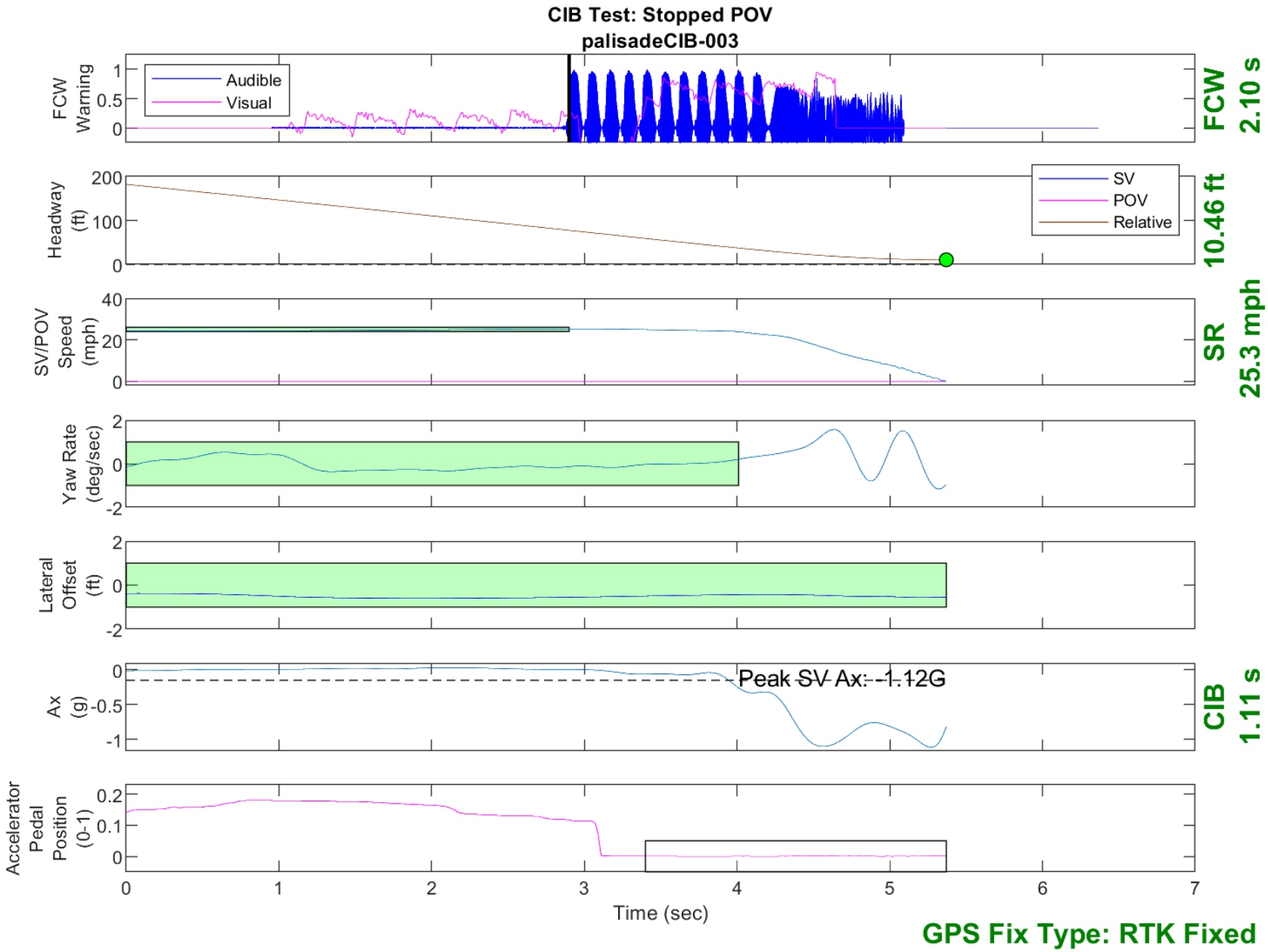

Figure D11. Time History for CIB Run 3, SV Encounters Stopped POV

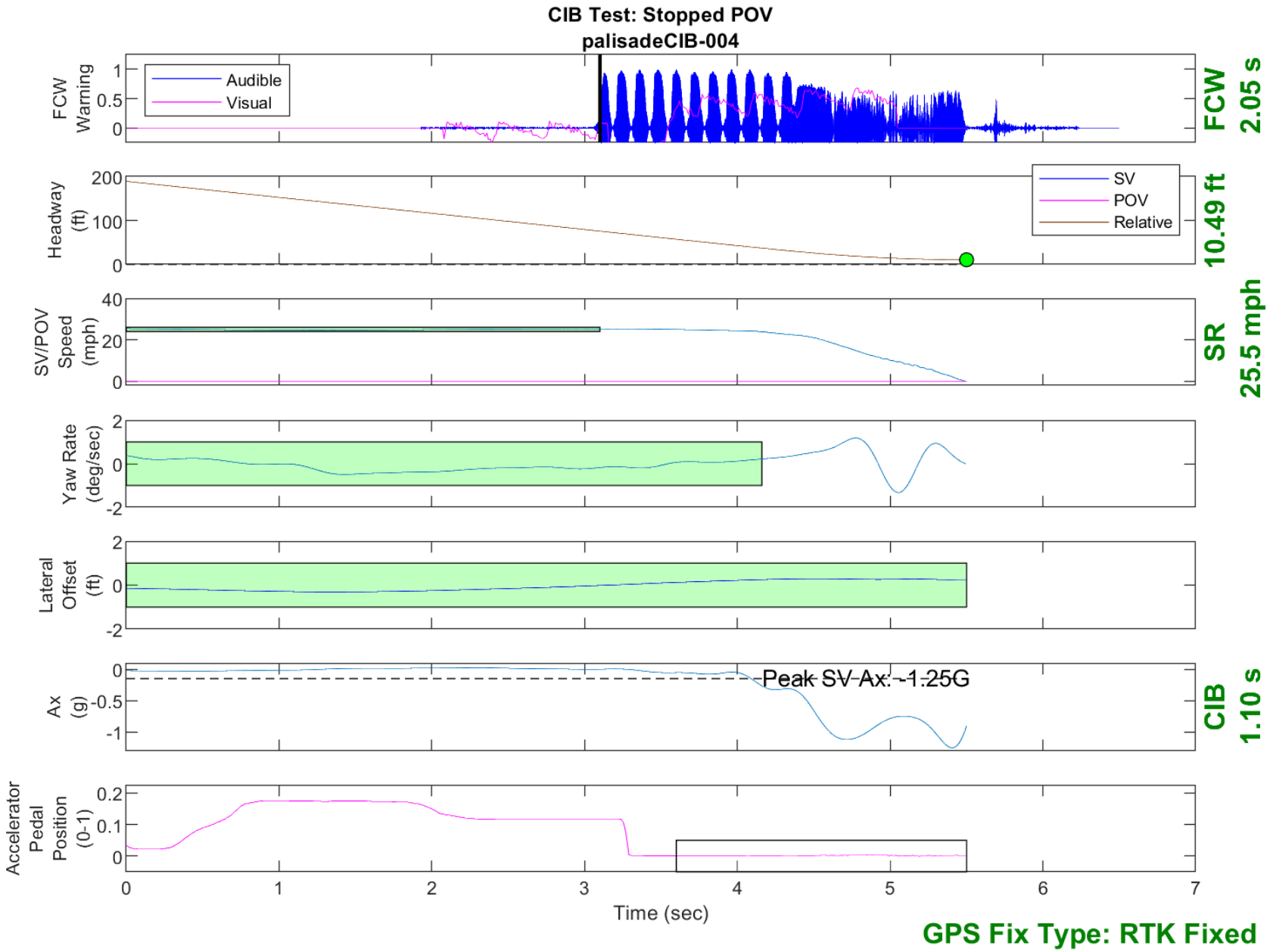

Figure D12. Time History for CIB Run 4, SV Encounters Stopped POV

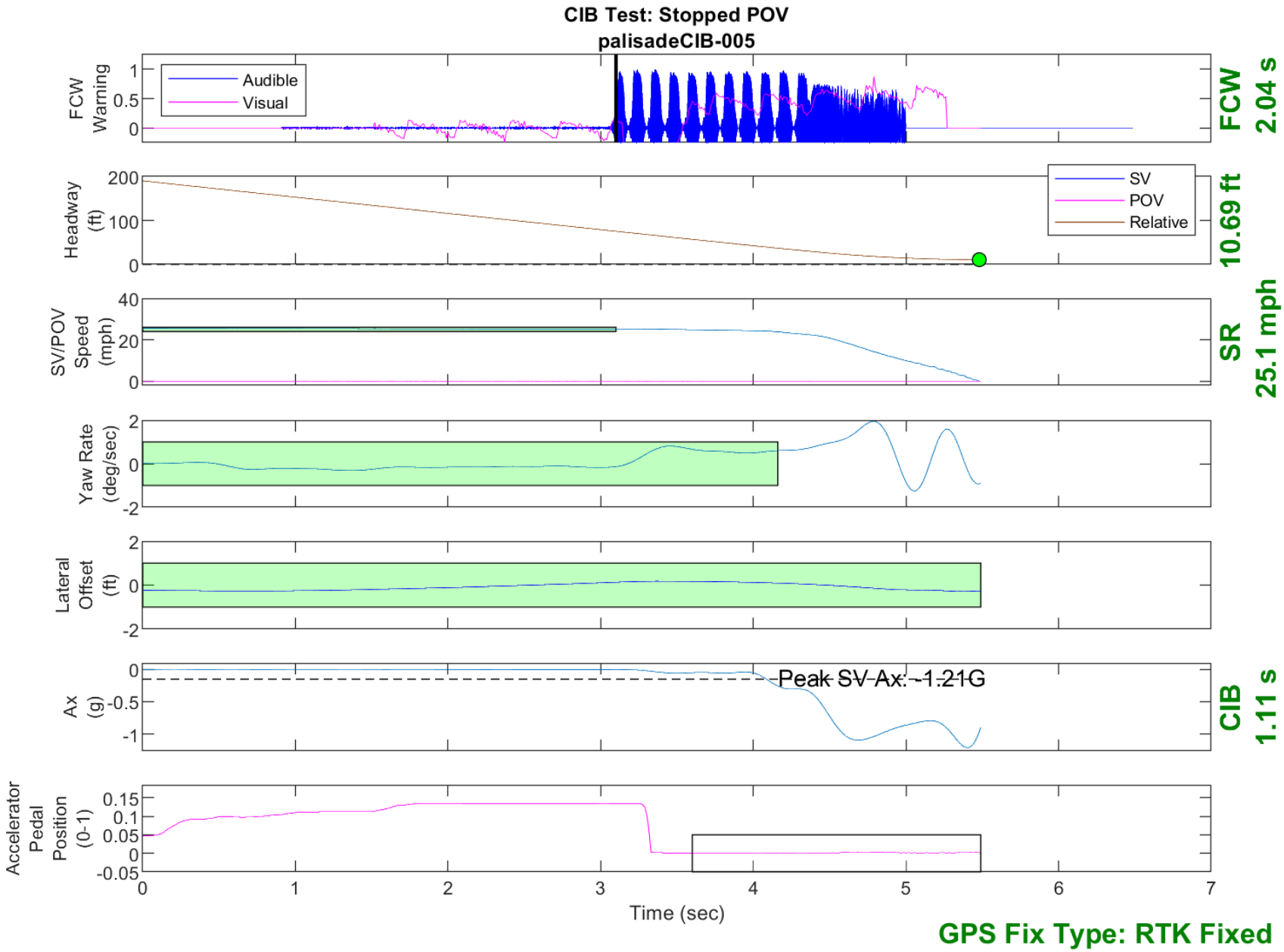

Figure D13. Time History for CIB Run 5, SV Encounters Stopped POV

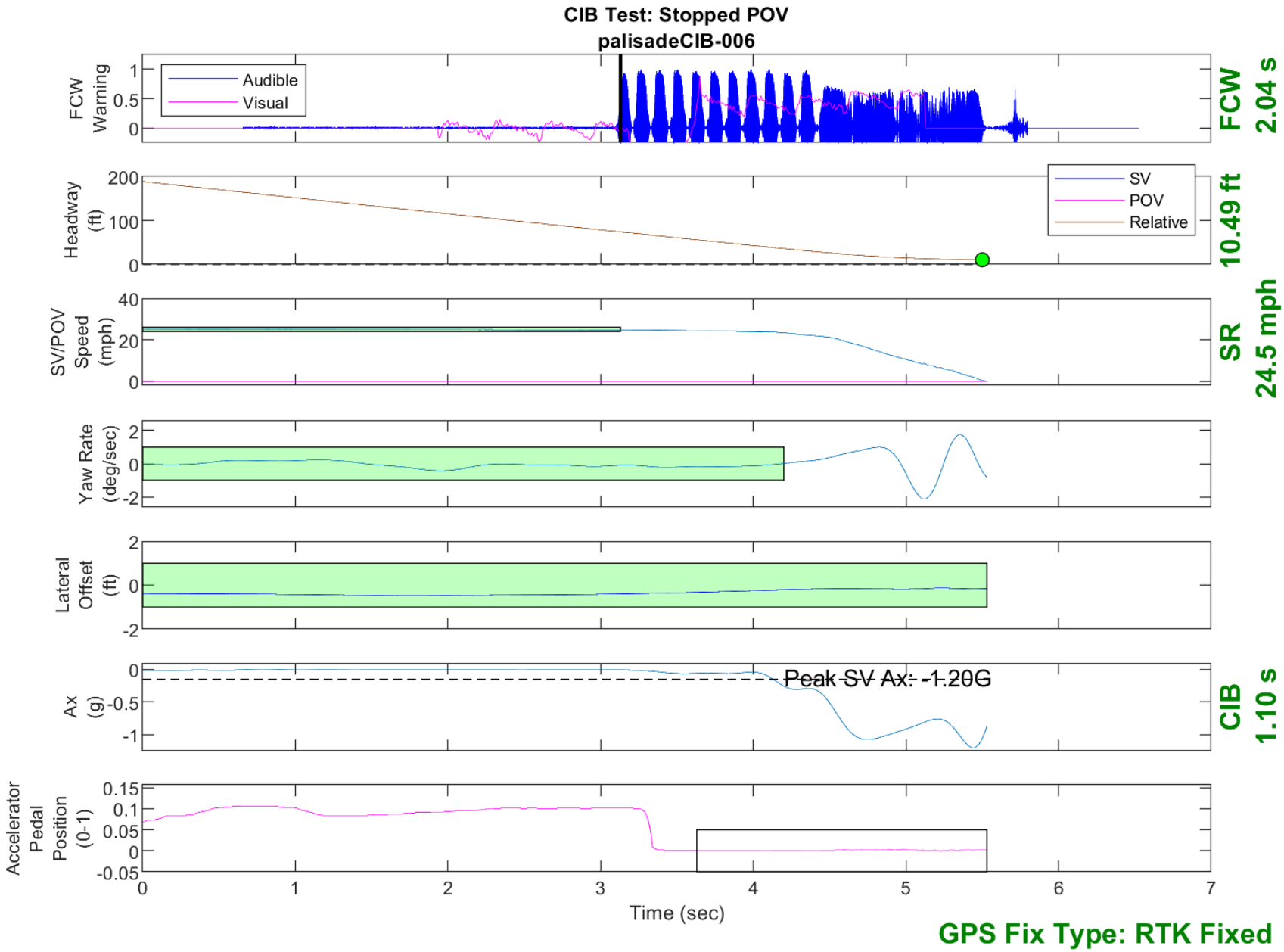

Figure D14. Time History for CIB Run 6, SV Encounters Stopped POV

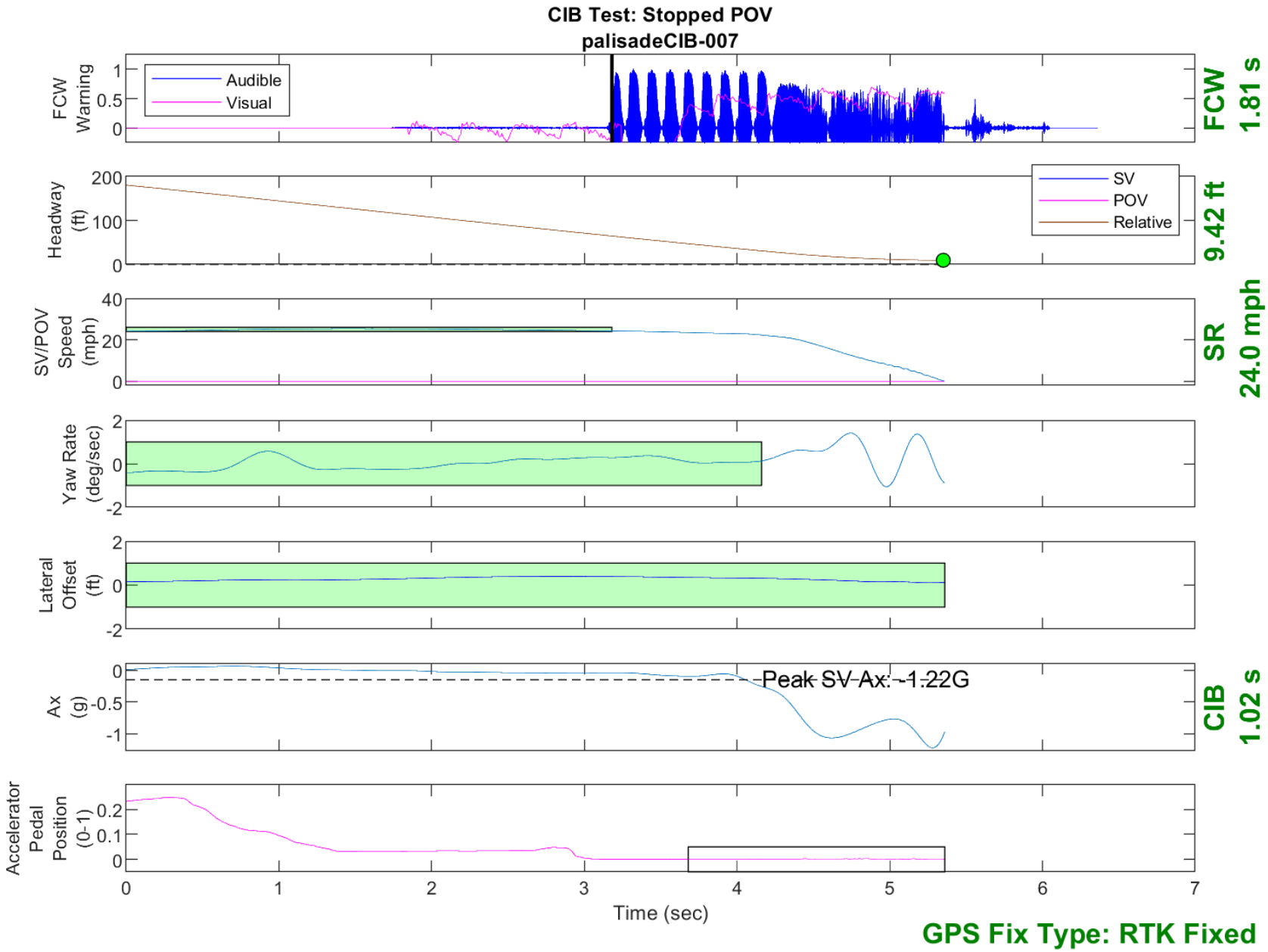

Figure D15. Time History for CIB Run 7, SV Encounters Stopped POV

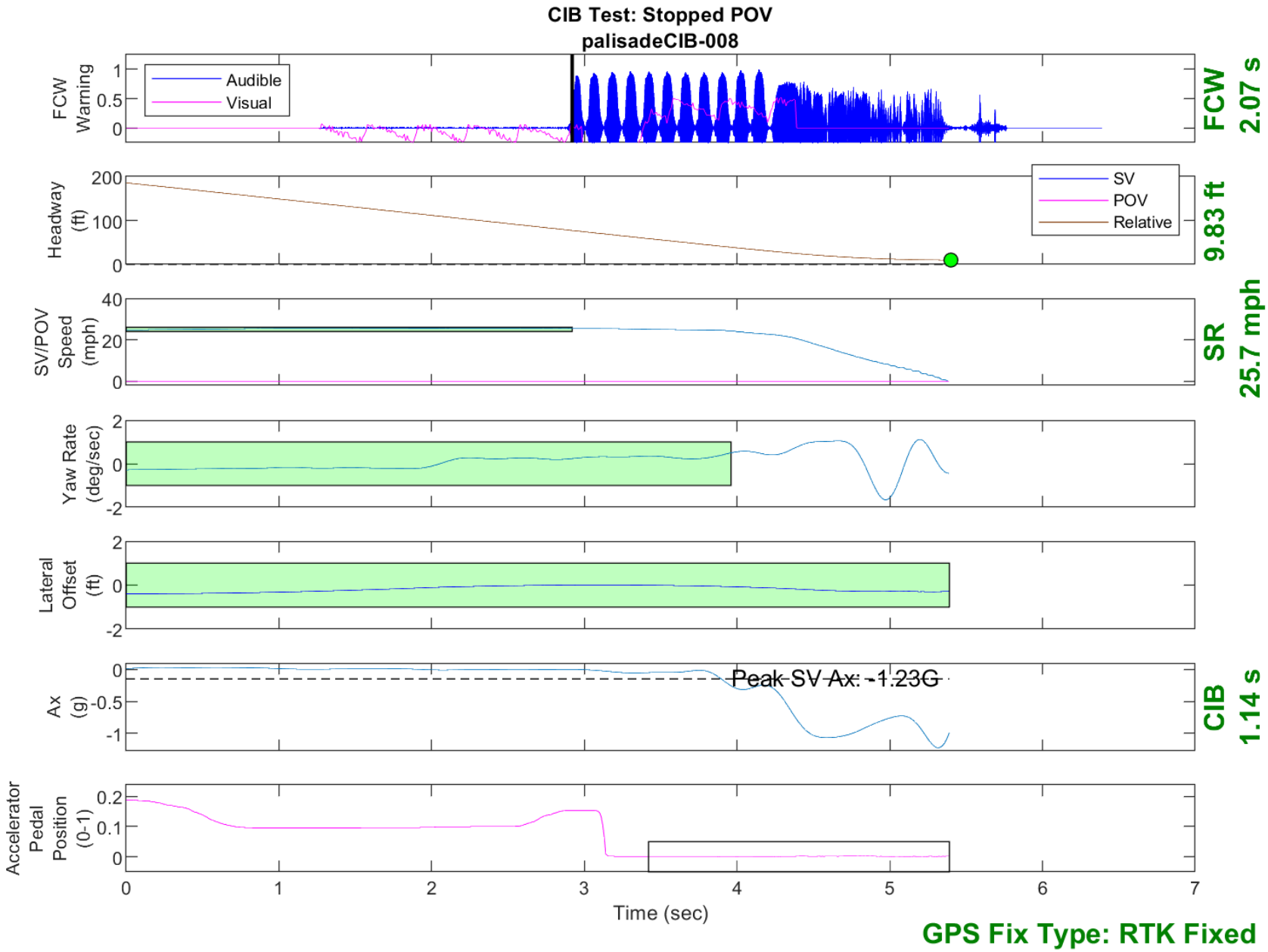

Figure D16. Time History for CIB Run 8, SV Encounters Stopped POV

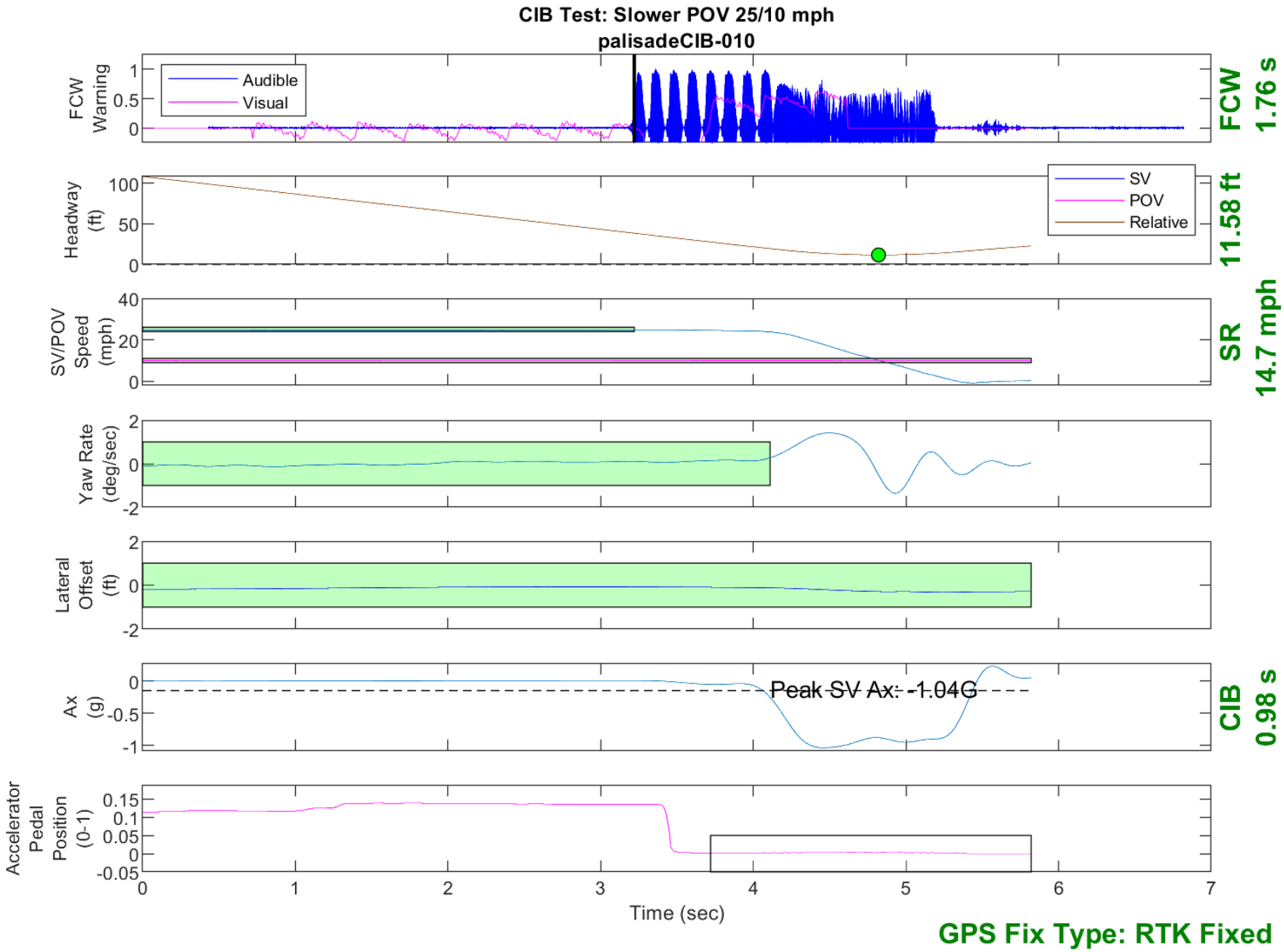

Figure D17. Time History for CIB Run 10, SV Encounters Slower POV, SV 25 mph, POV 10 mph

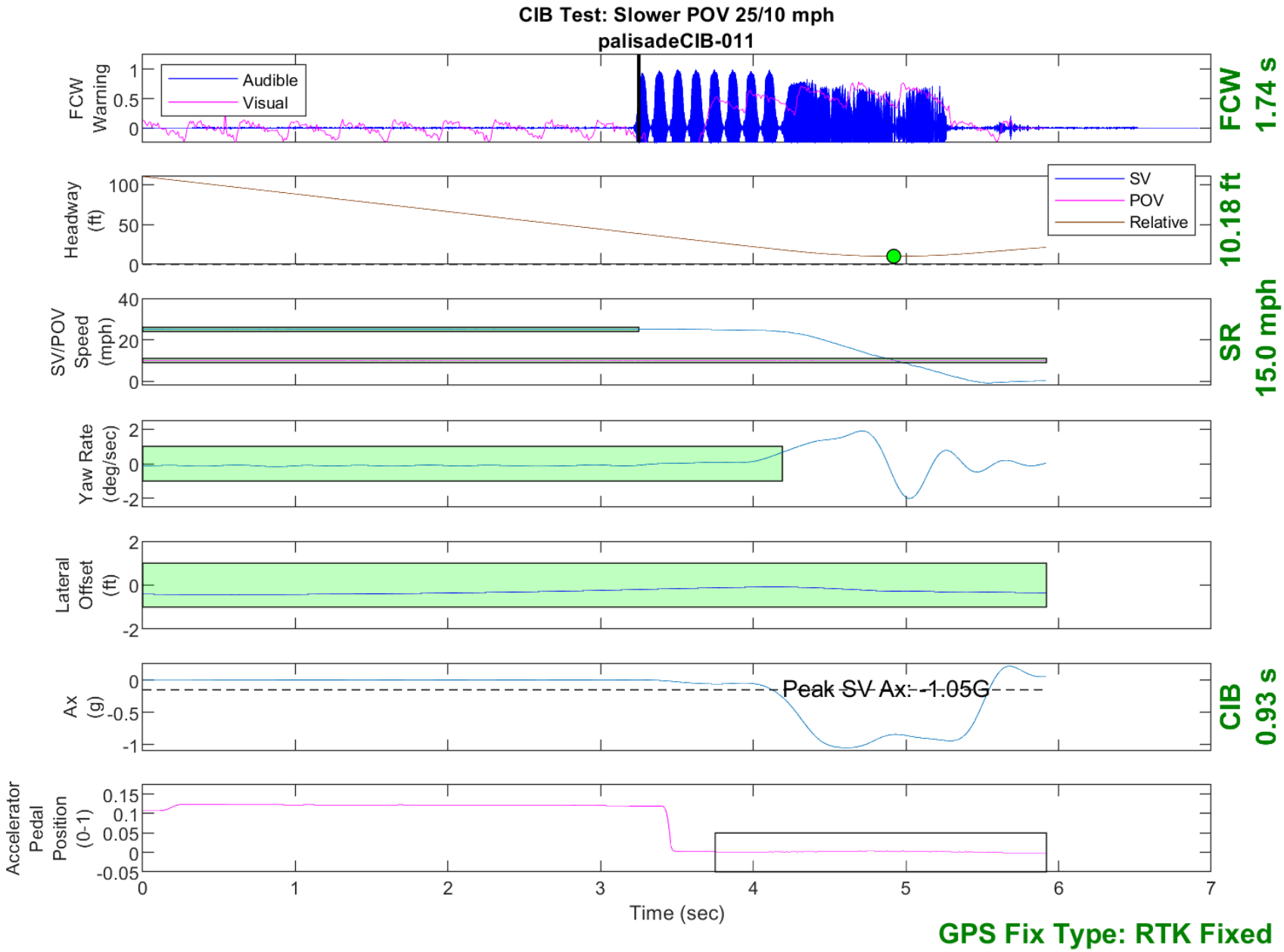

Figure D18. Time History for CIB Run 11, SV Encounters Slower POV, SV 25 mph, POV 10 mph

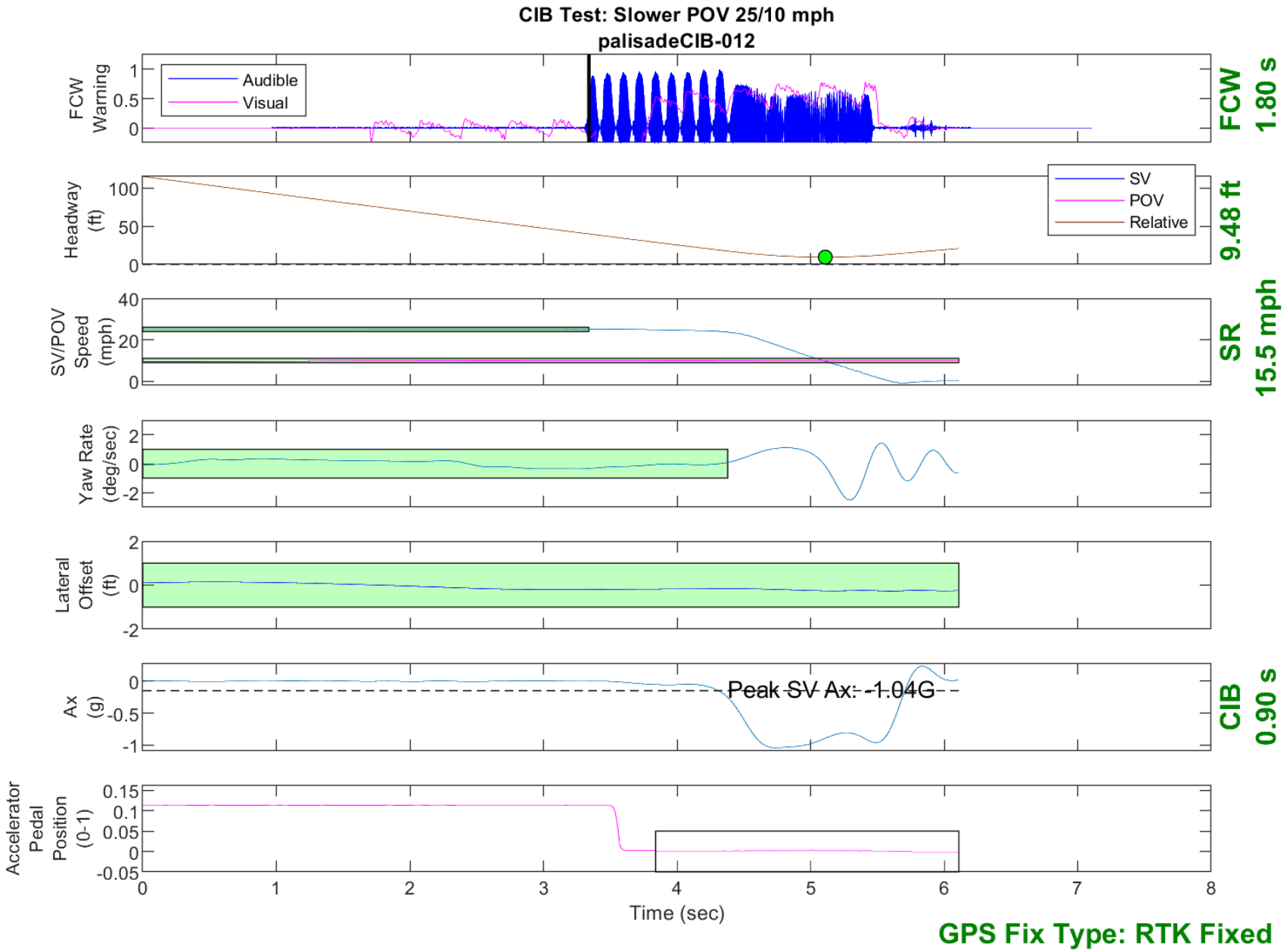

Figure D19. Time History for CIB Run 12, SV Encounters Slower POV, SV 25 mph, POV 10 mph

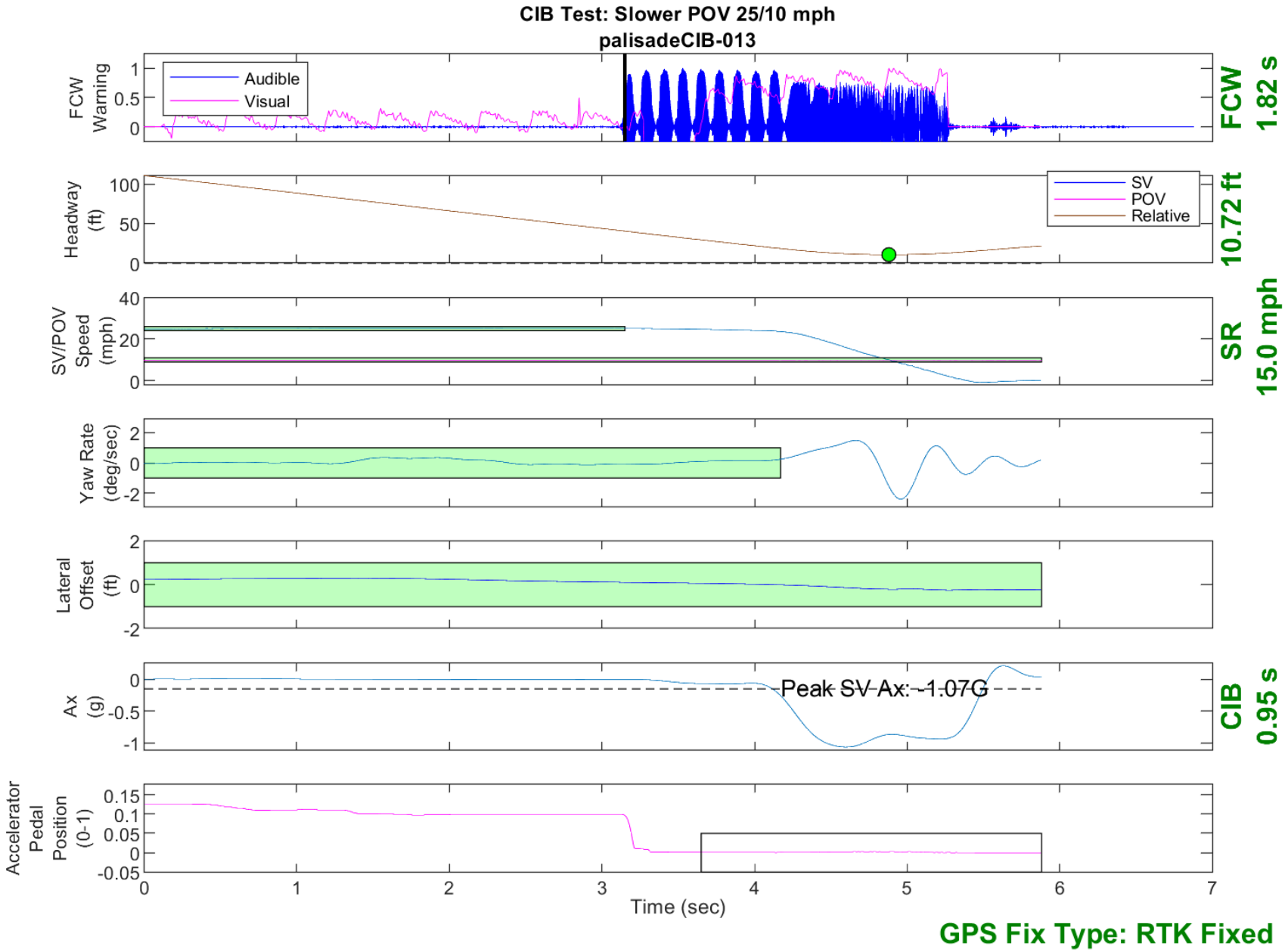

Figure D20. Time History for CIB Run 13, SV Encounters Slower POV, SV 25 mph, POV 10 mph

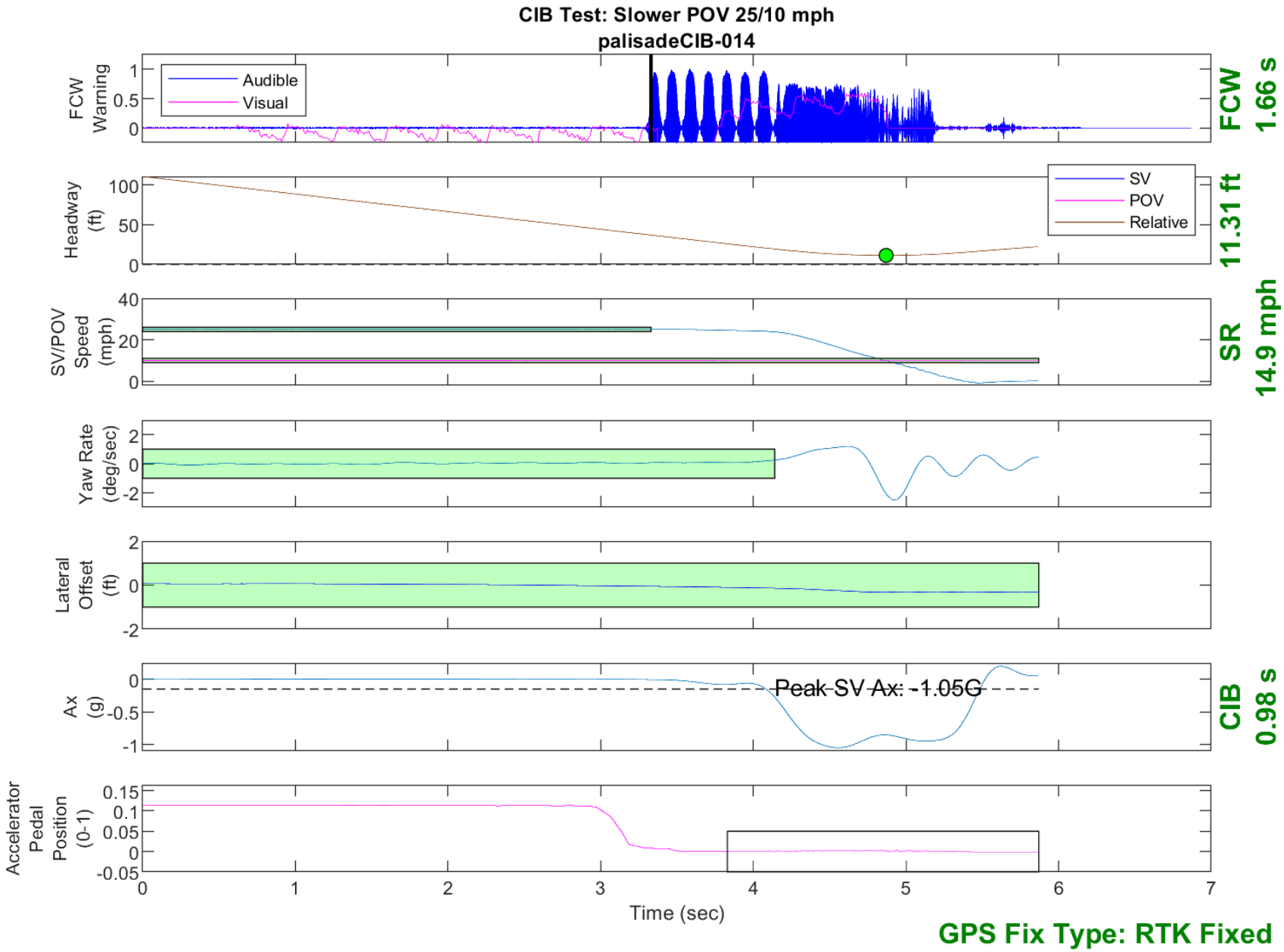

Figure D21. Time History for CIB Run 14, SV Encounters Slower POV, SV 25 mph, POV 10 mph

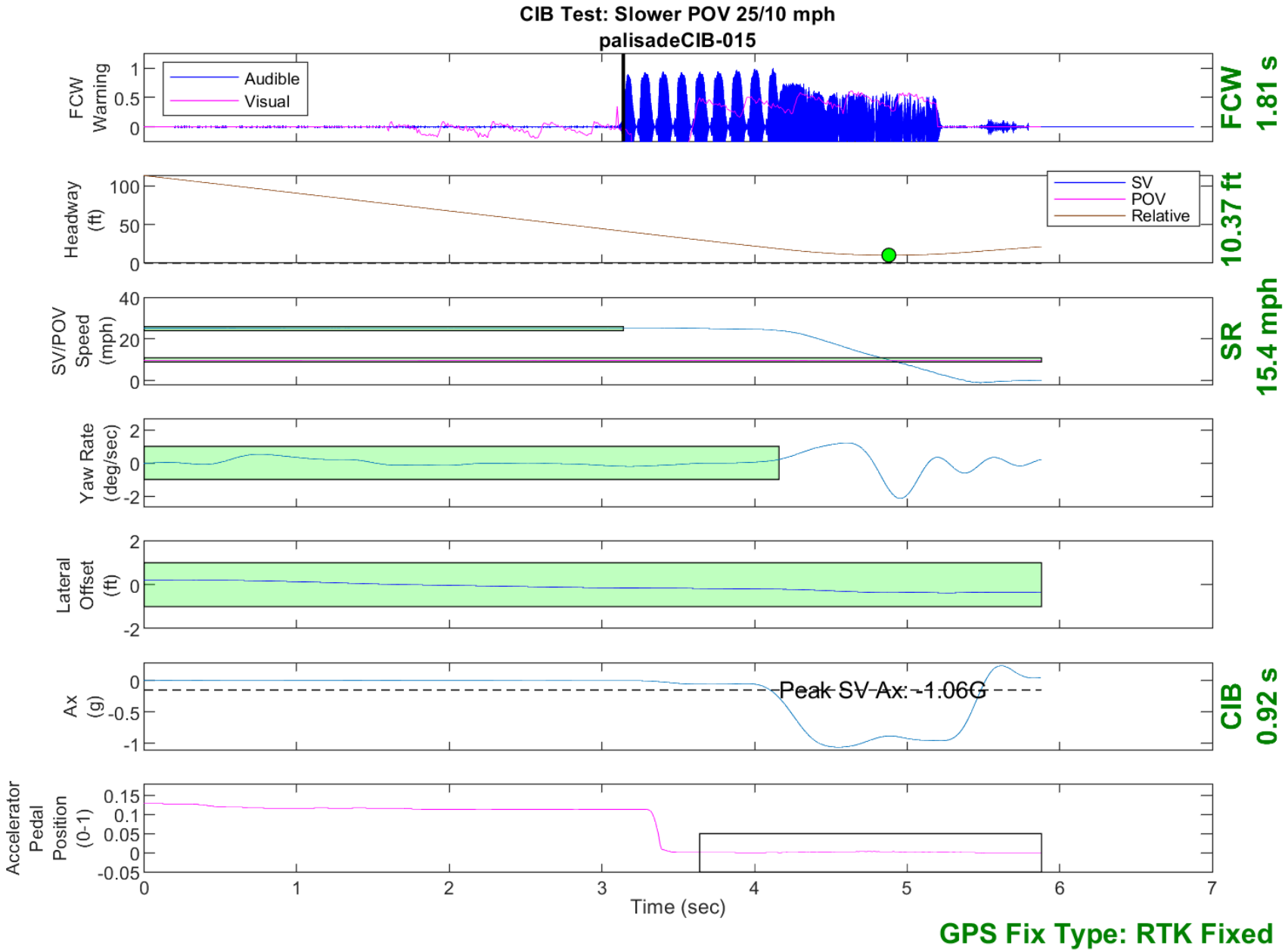

Figure D22. Time History for CIB Run 15, SV Encounters Slower POV, SV 25 mph, POV 10 mph

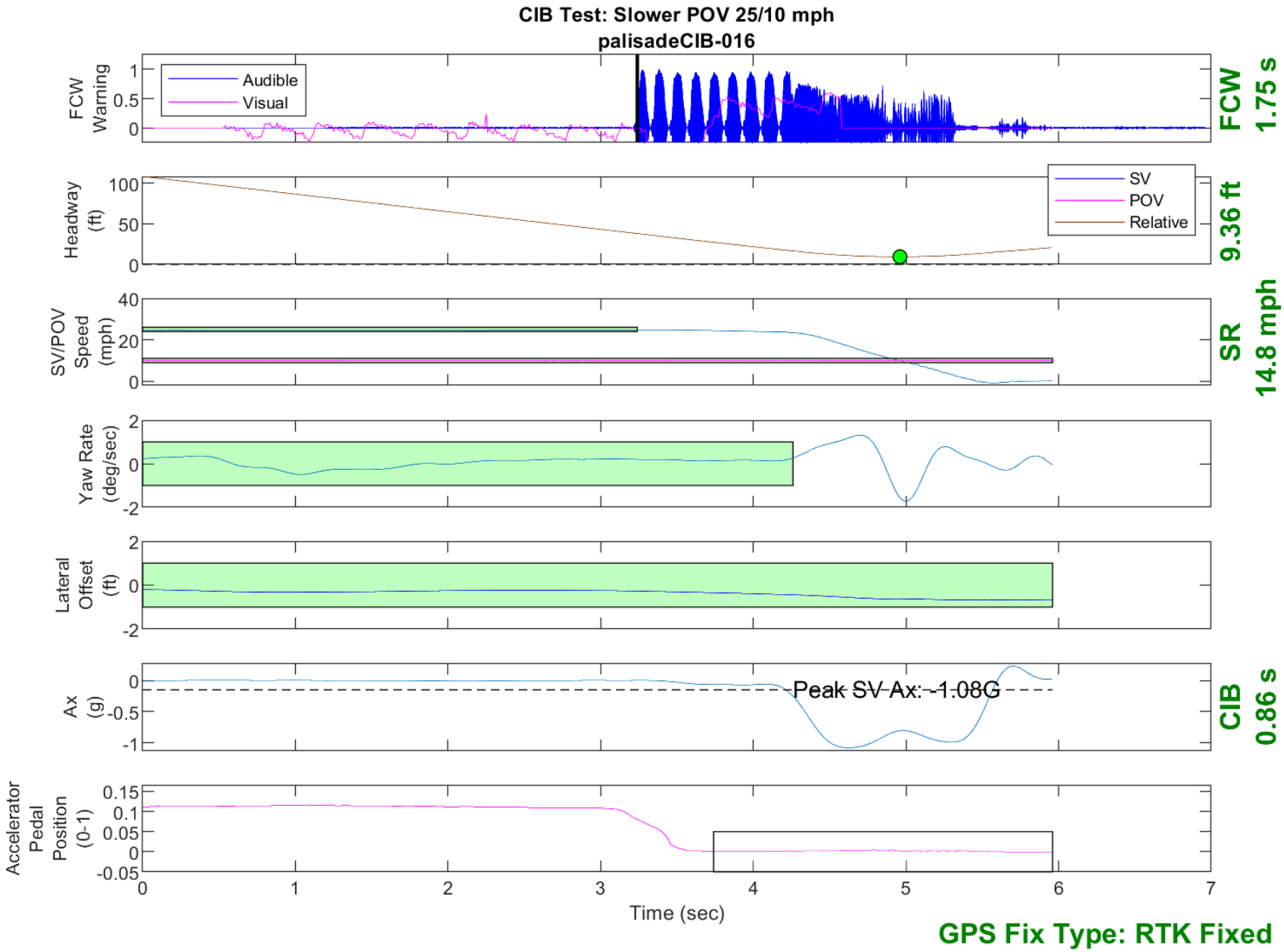

Figure D23. Time History for CIB Run 16, SV Encounters Slower POV, SV 25 mph, POV 10 mph

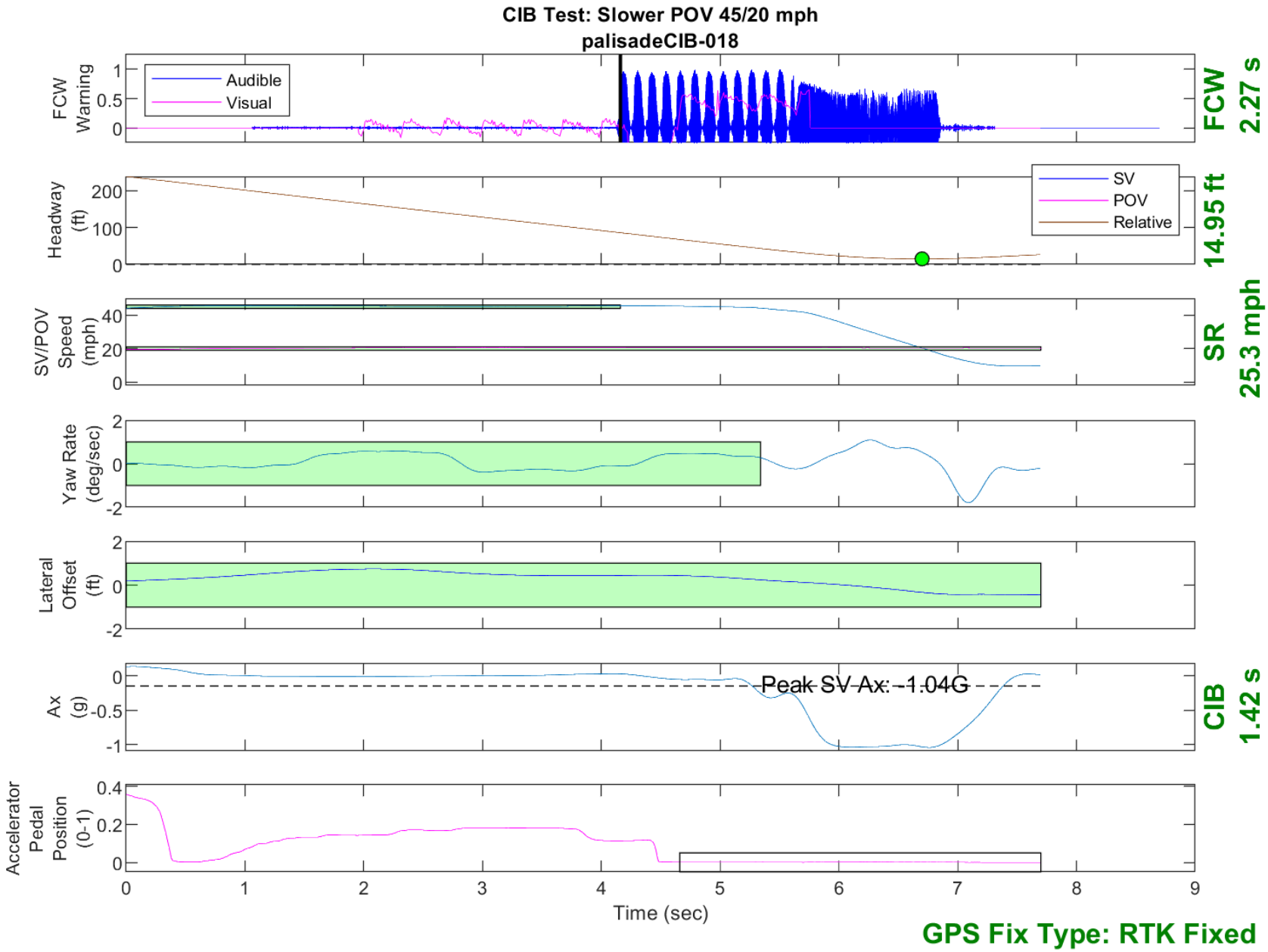

Figure D24. Time History for CIB Run 18, SV Encounters Slower POV, SV 45 mph, POV 20 mph

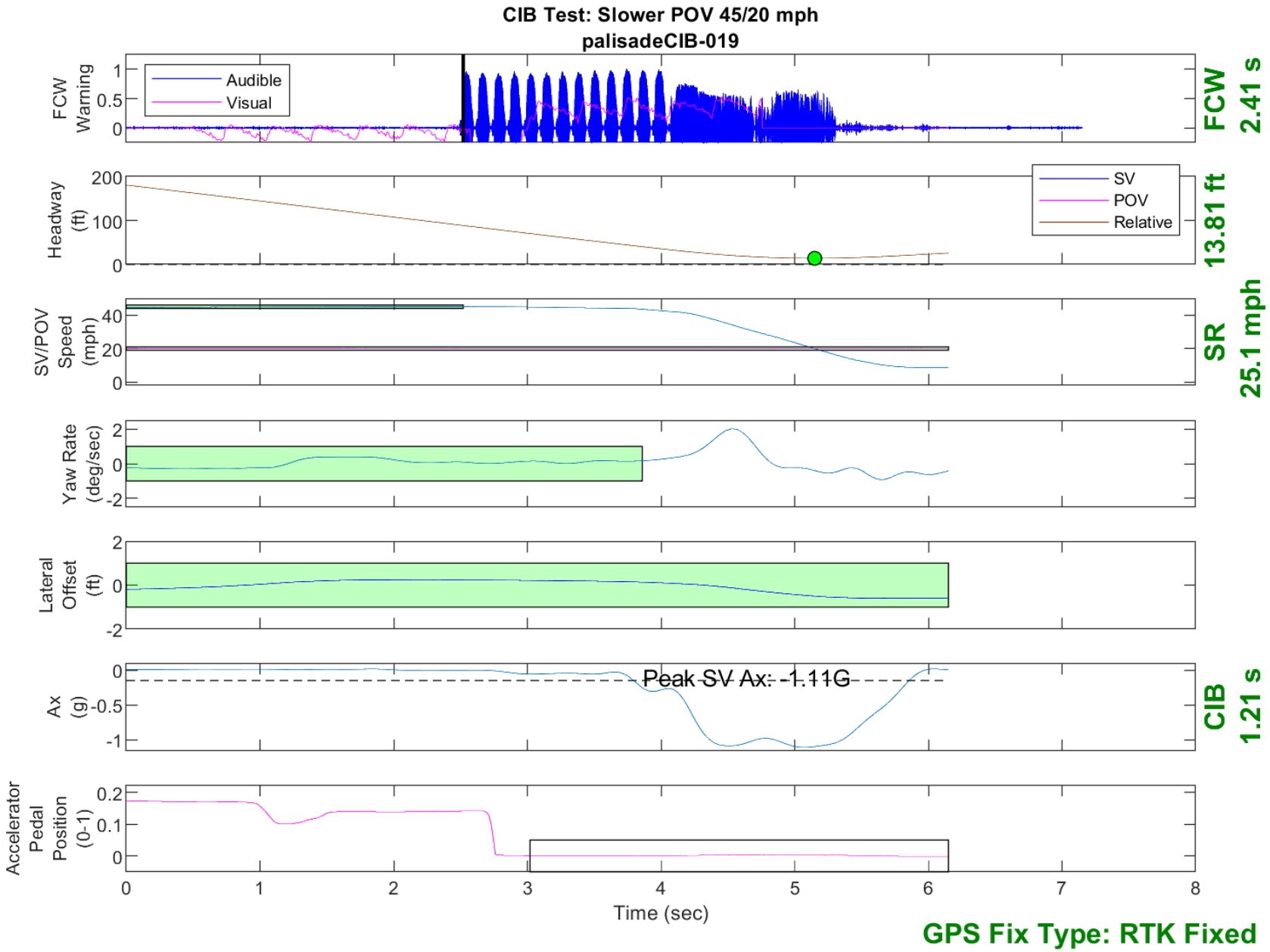

Figure D25. Time History for CIB Run 19, SV Encounters Slower POV, SV 45 mph, POV 20 mph

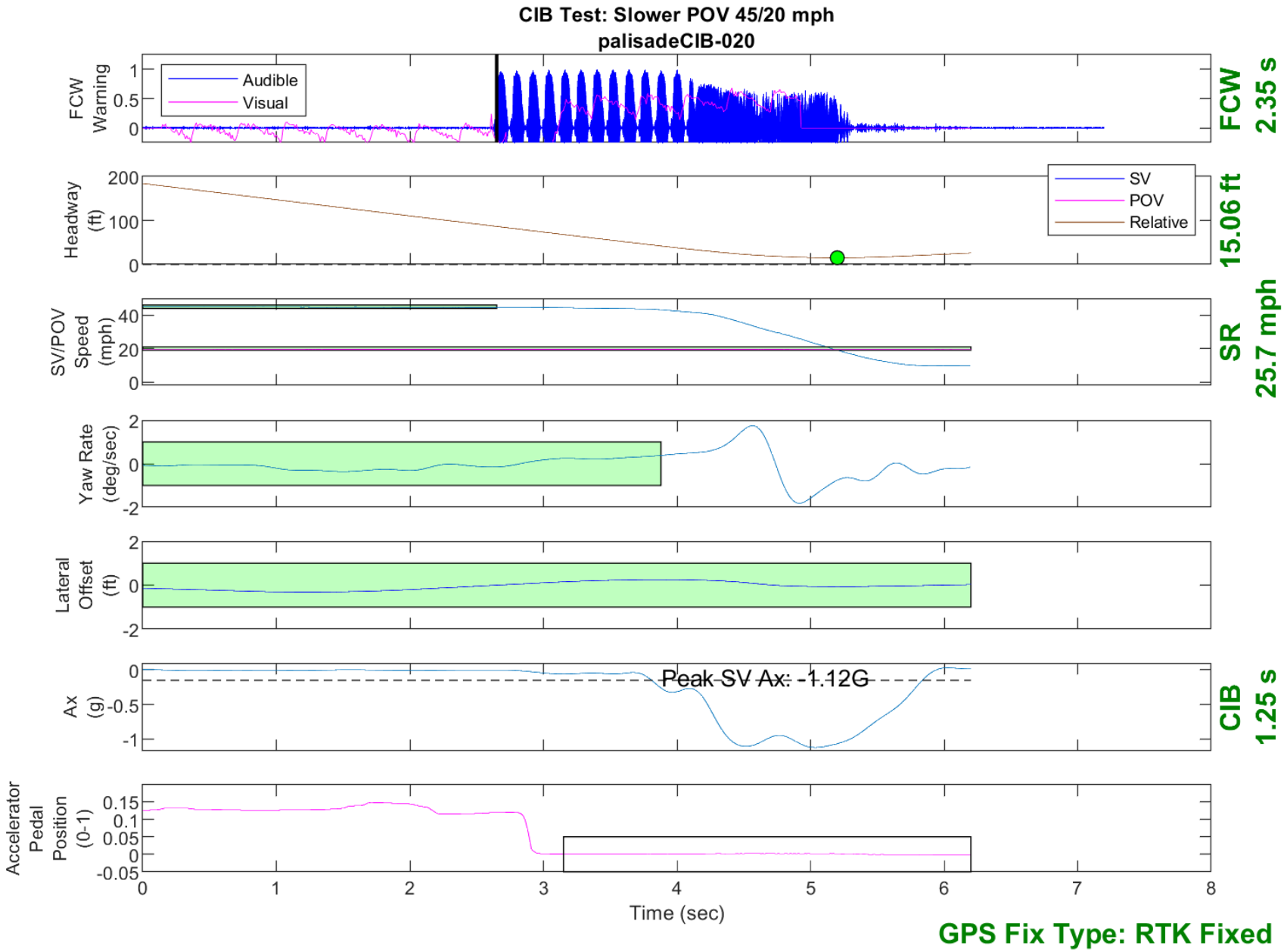

Figure D26. Time History for CIB Run 20, SV Encounters Slower POV, SV 45 mph, POV 20 mph

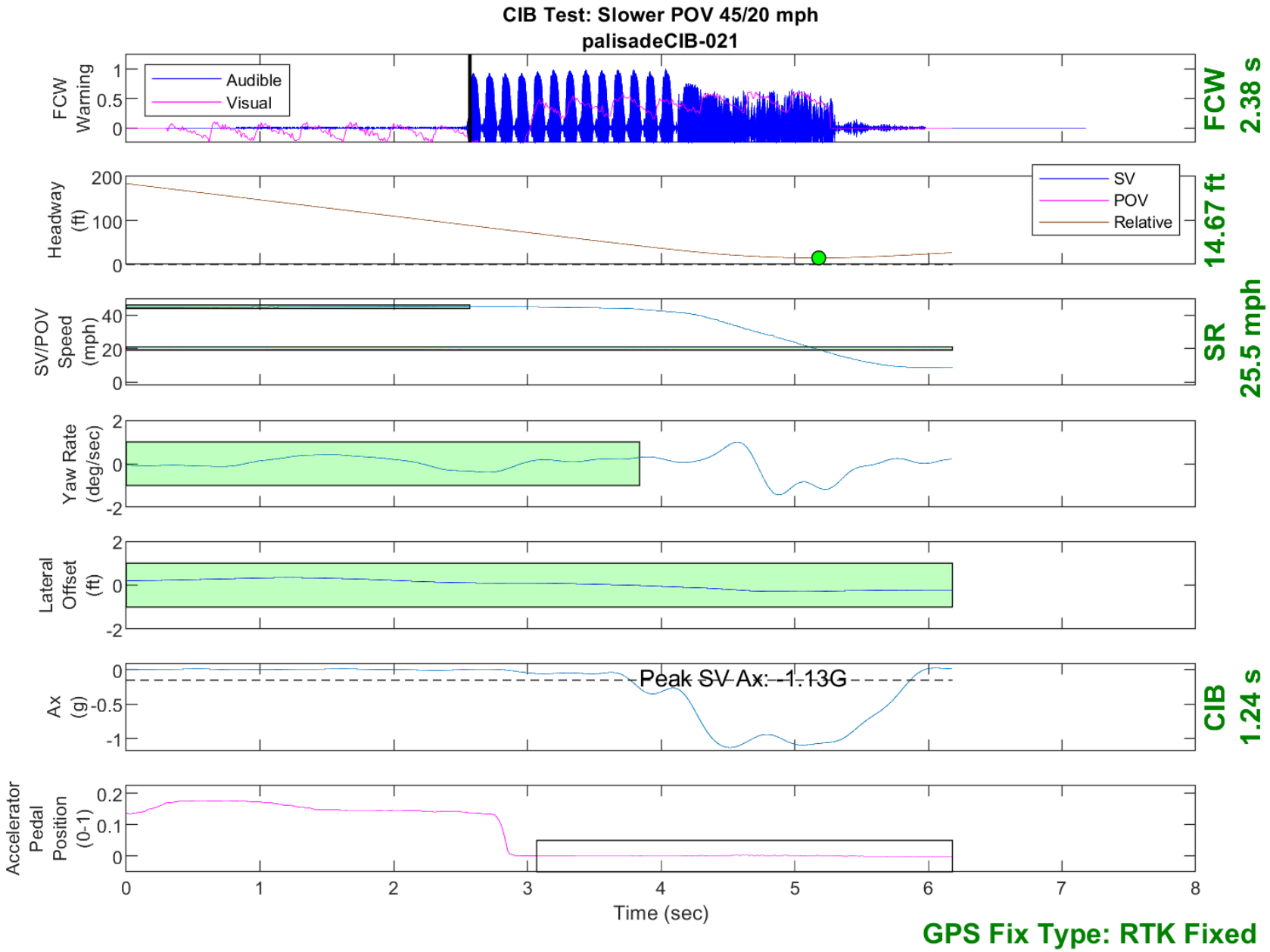

Figure D27. Time History for CIB Run 21, SV Encounters Slower POV, SV 45 mph, POV 20 mph

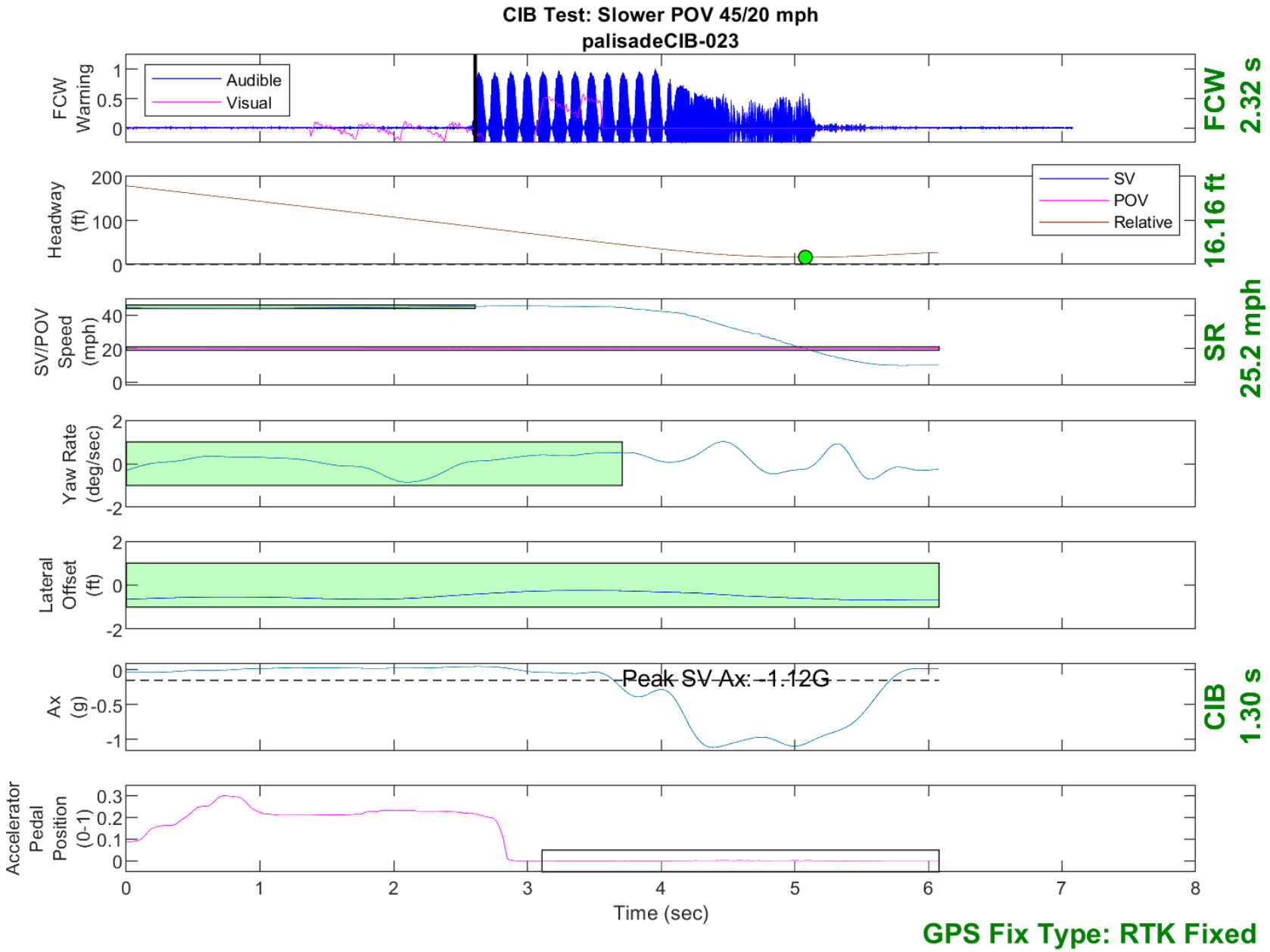

Figure D28. Time History for CIB Run 23, SV Encounters Slower POV, SV 45 mph, POV 20 mph

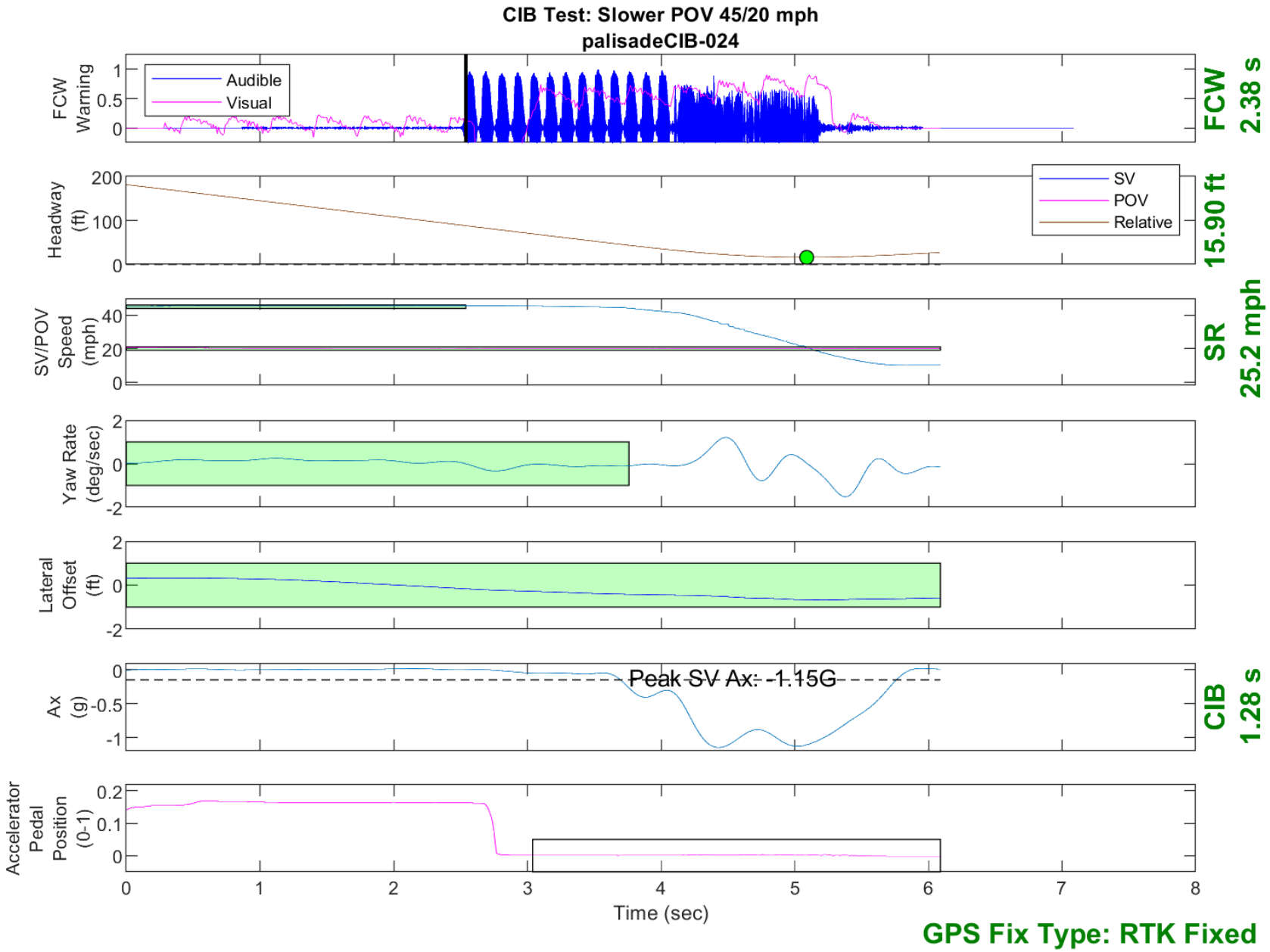

Figure D29. Time History for CIB Run 24, SV Encounters Slower POV, SV 45 mph, POV 20 mph

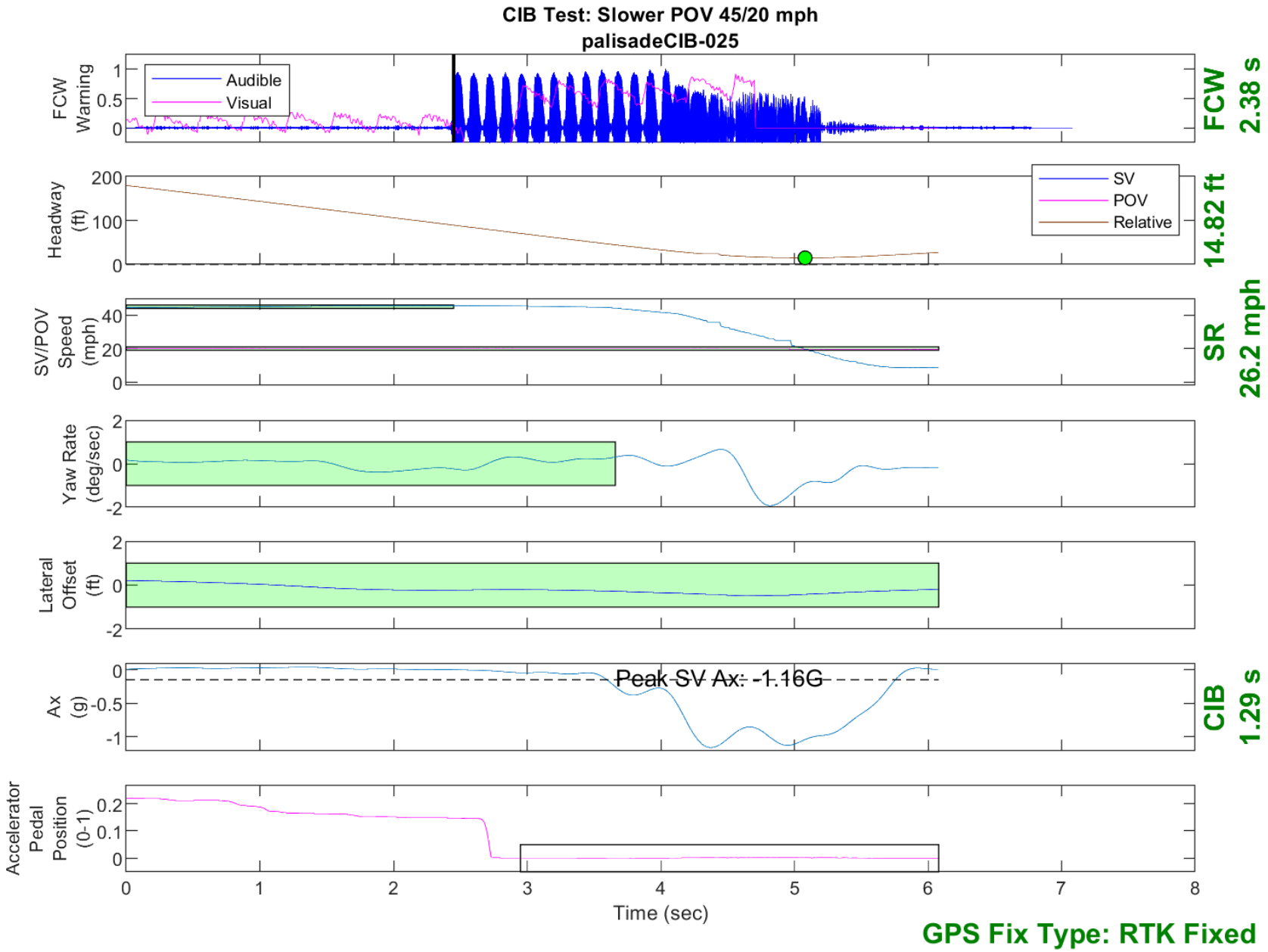

Figure D30. Time History for CIB Run 25, SV Encounters Slower POV, SV 45 mph, POV 20 mph

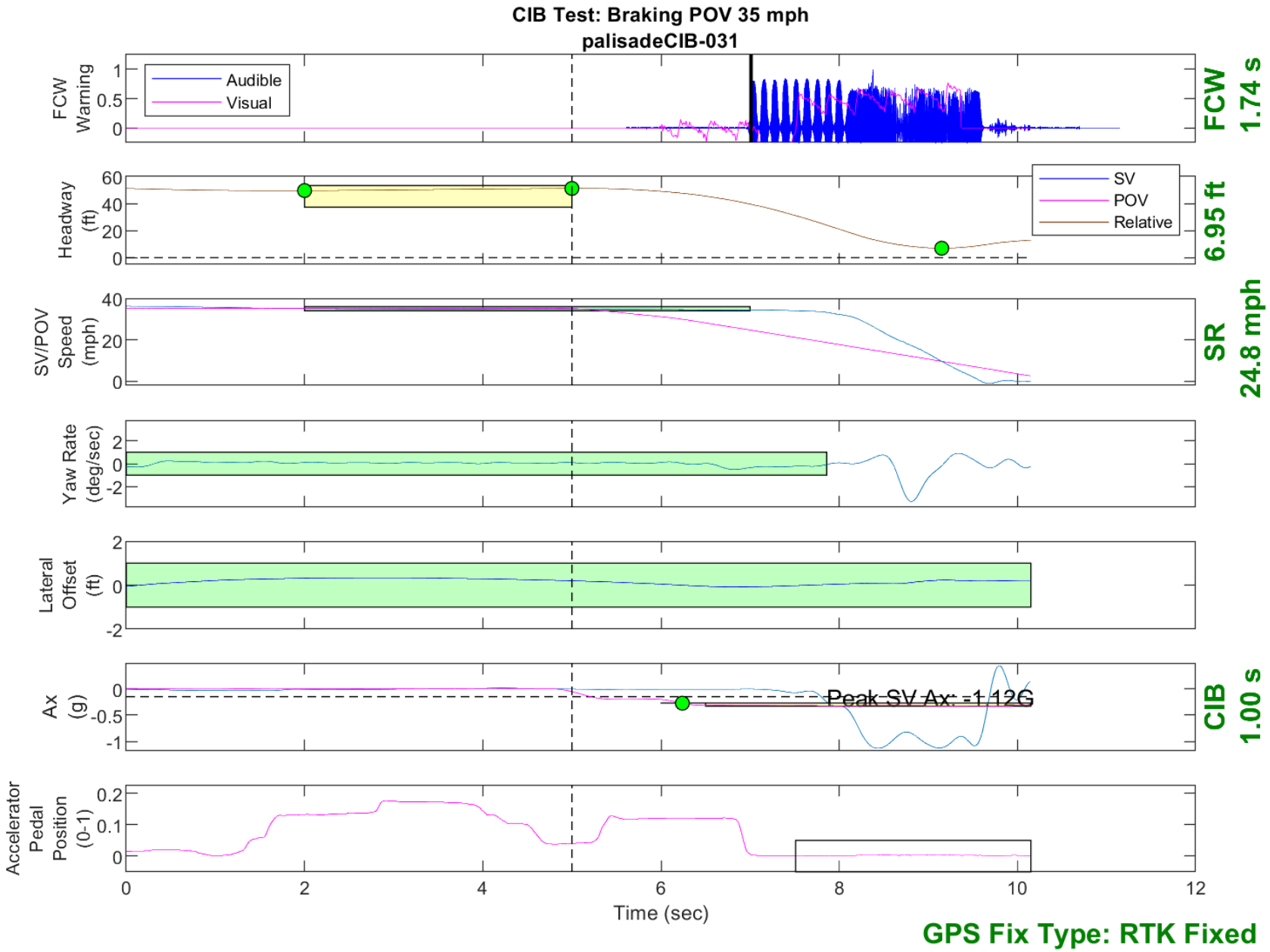

Figure D31. Time History for CIB Run 31, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

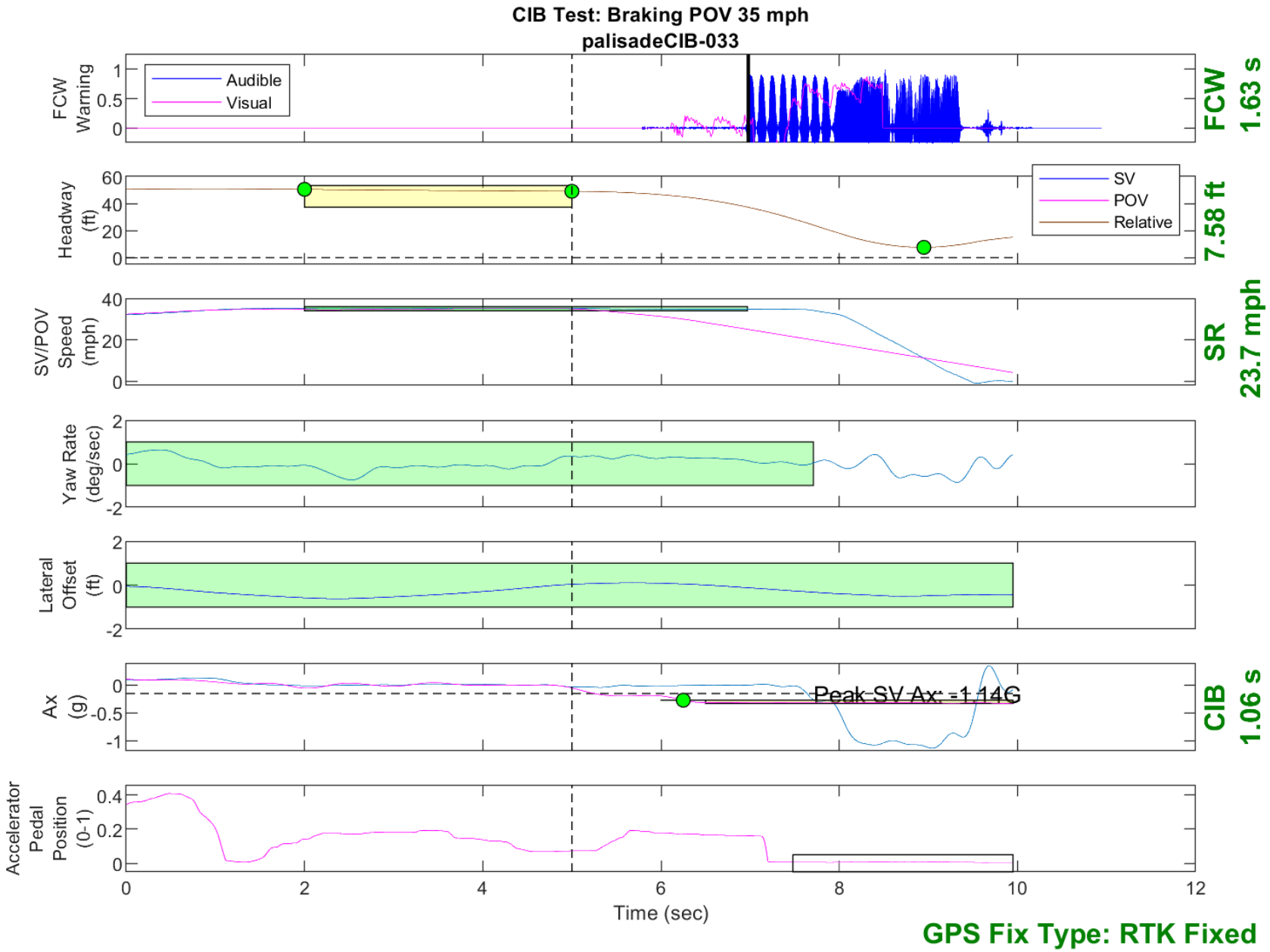

Figure D32. Time History for CIB Run 33, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

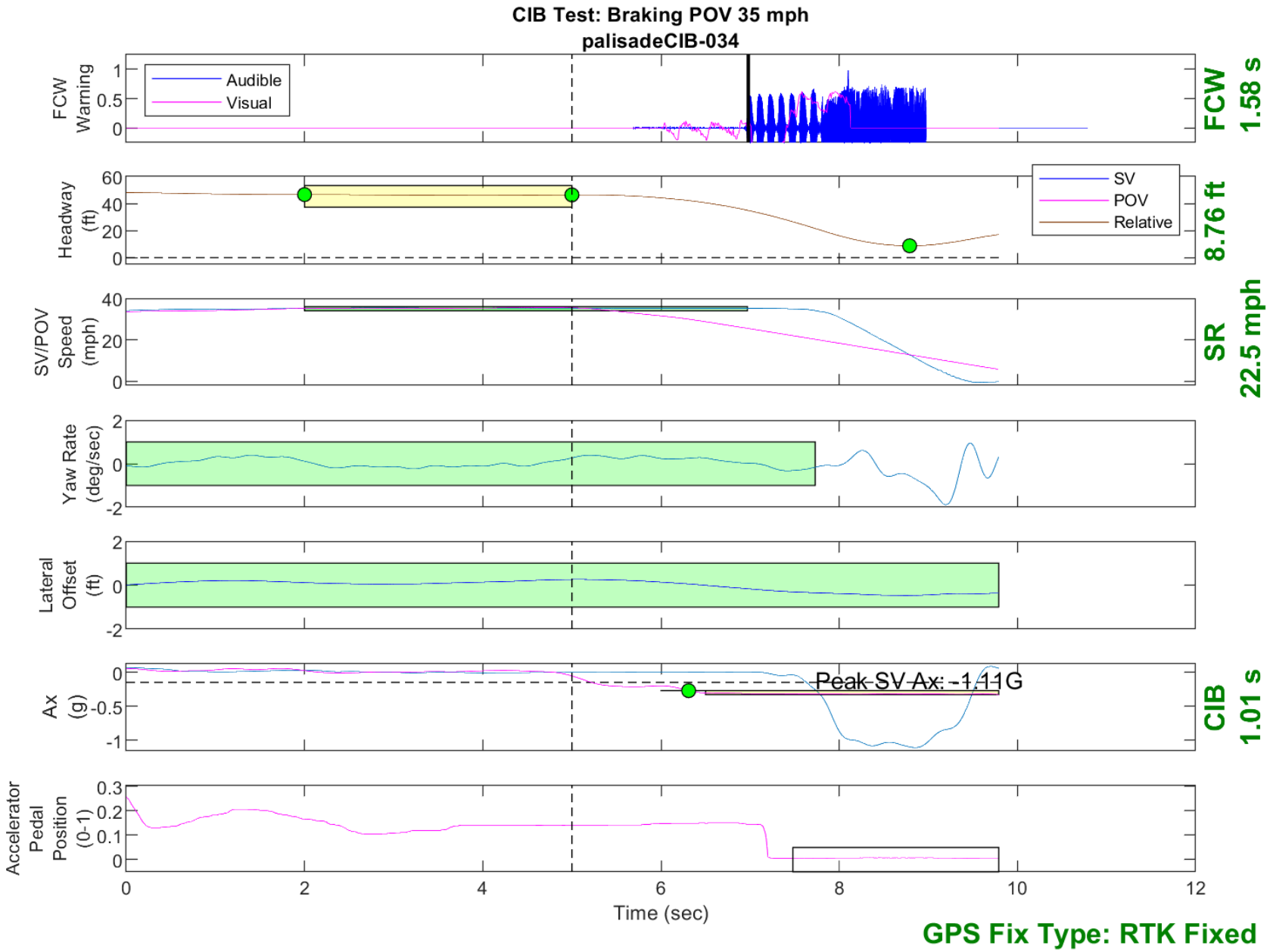

Figure D33. Time History for CIB Run 34, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

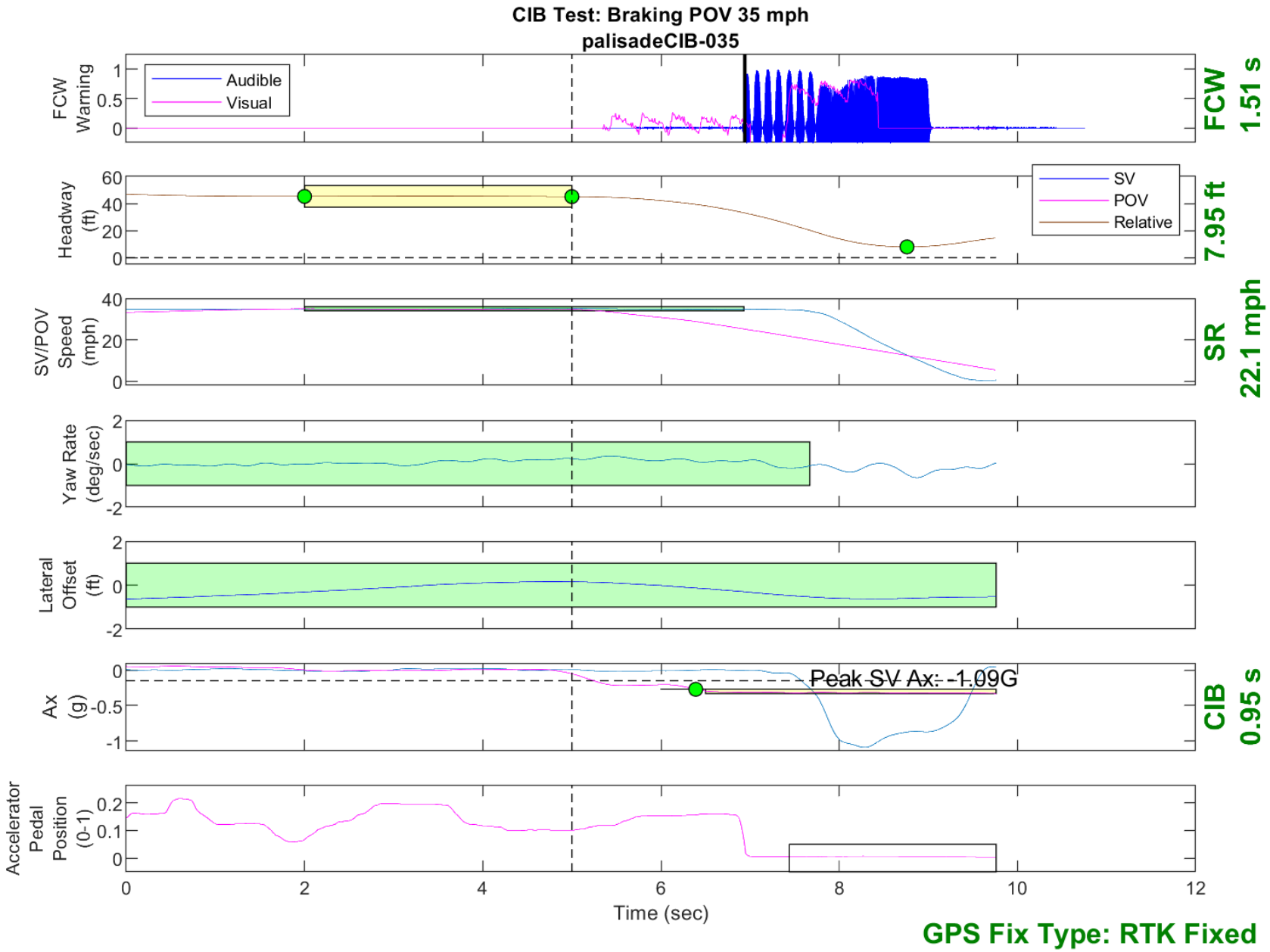

Figure D34. Time History for CIB Run 35, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

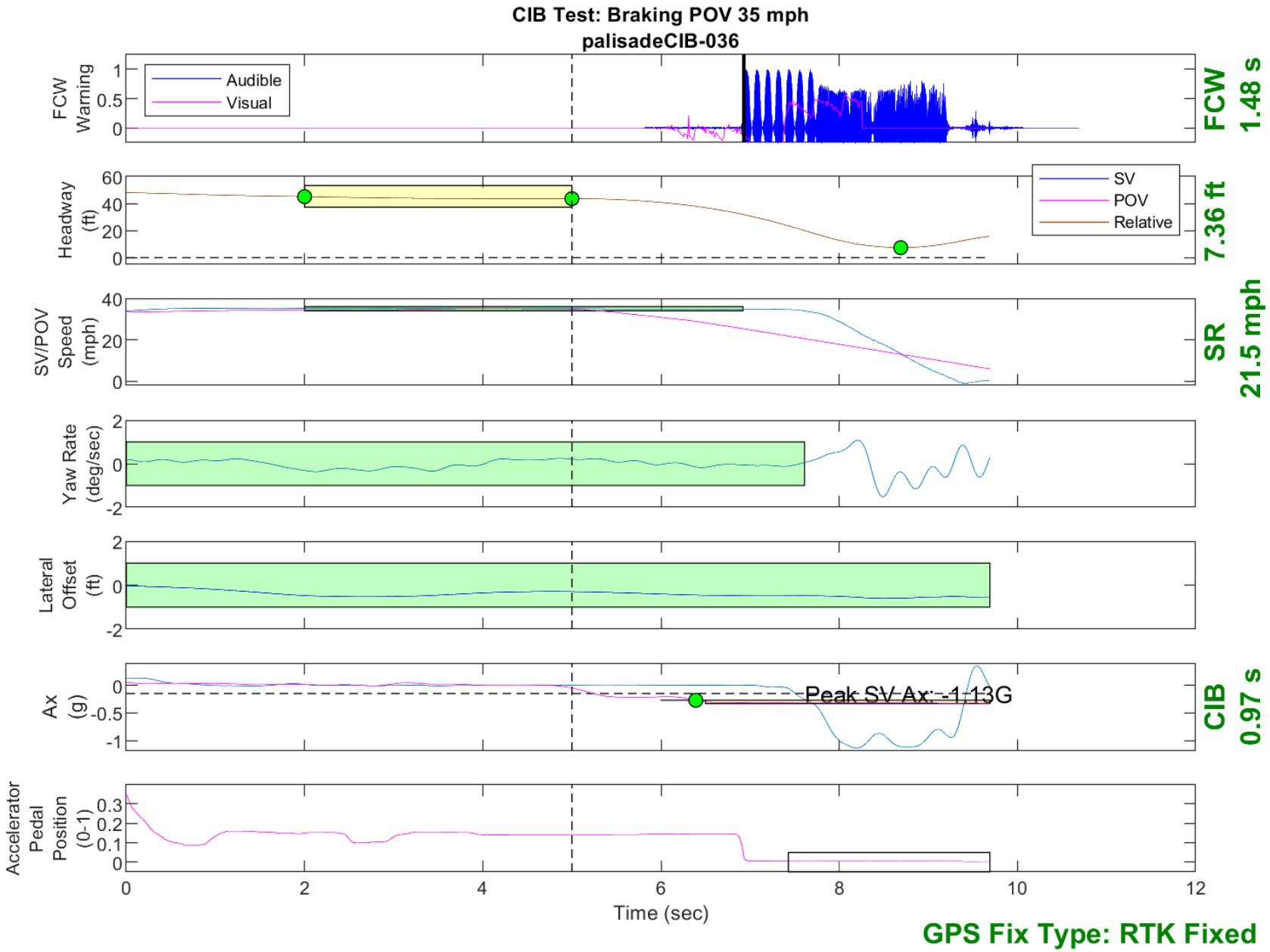

Figure D35. Time History for CIB Run 36, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

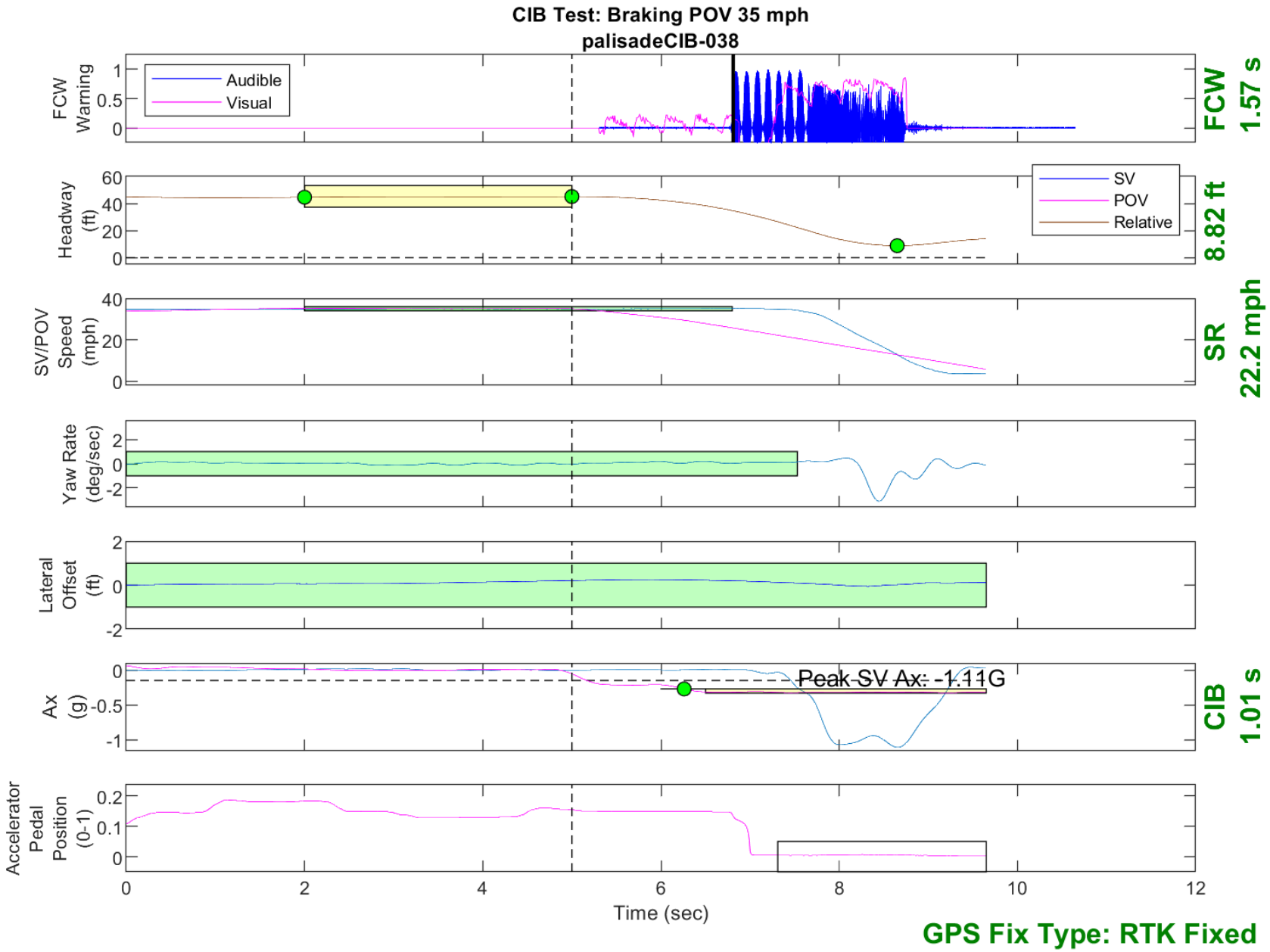

Figure D36. Time History for CIB Run 38, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

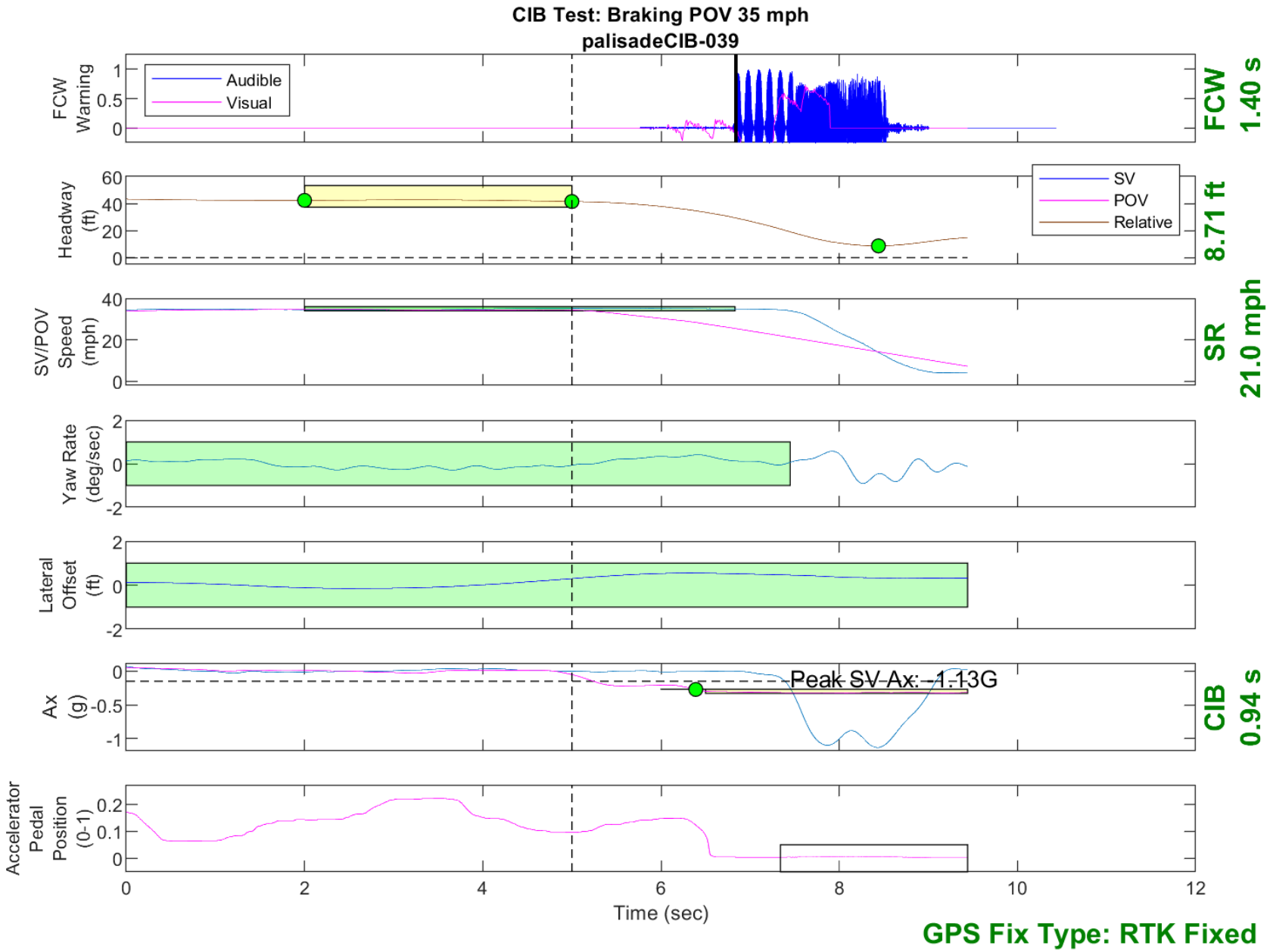

Figure D37. Time History for CIB Run 39, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

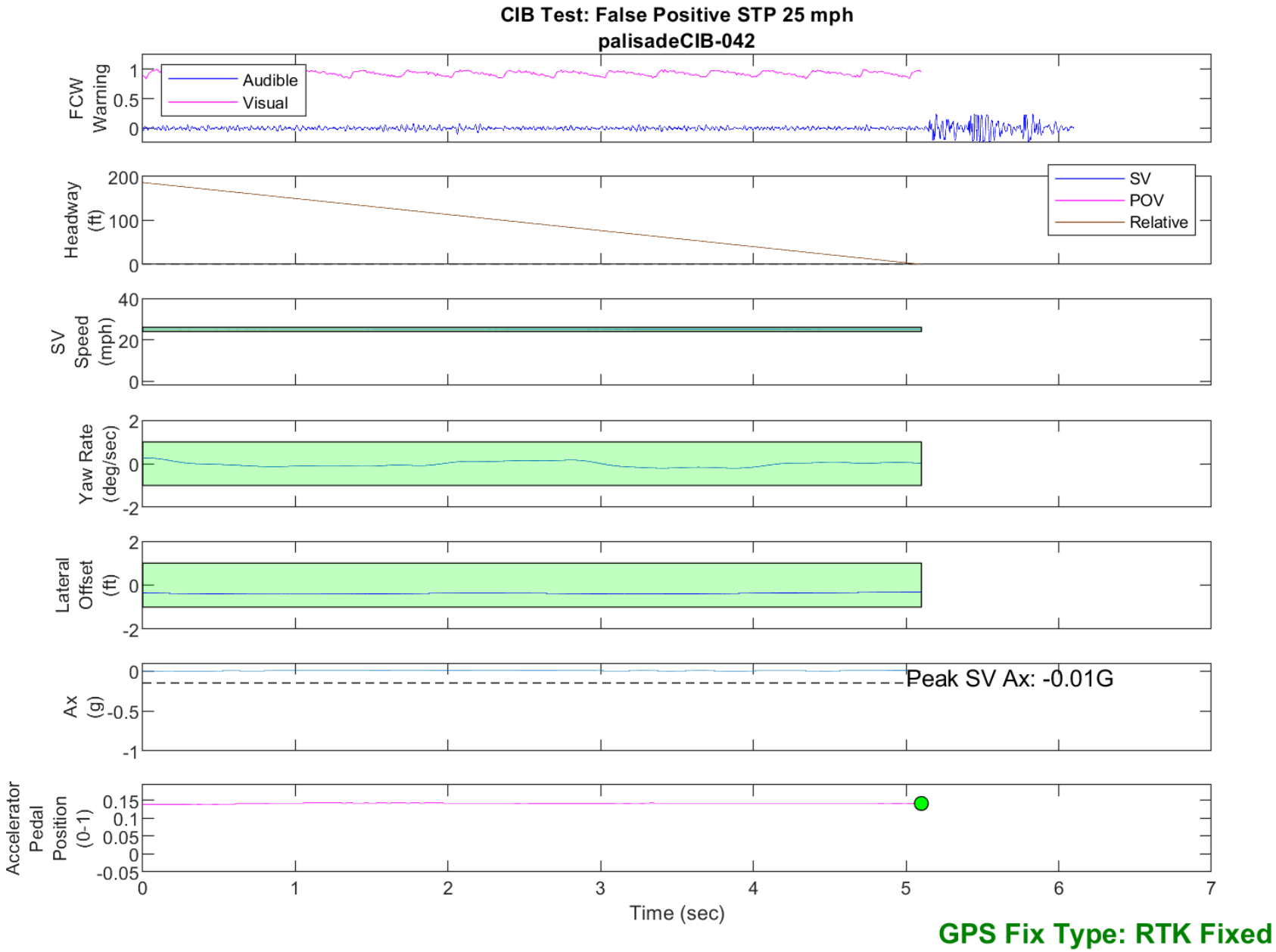

Figure D38. Time History for CIB Run 42, SV Encounters Steel Trench Plate, SV 25 mph

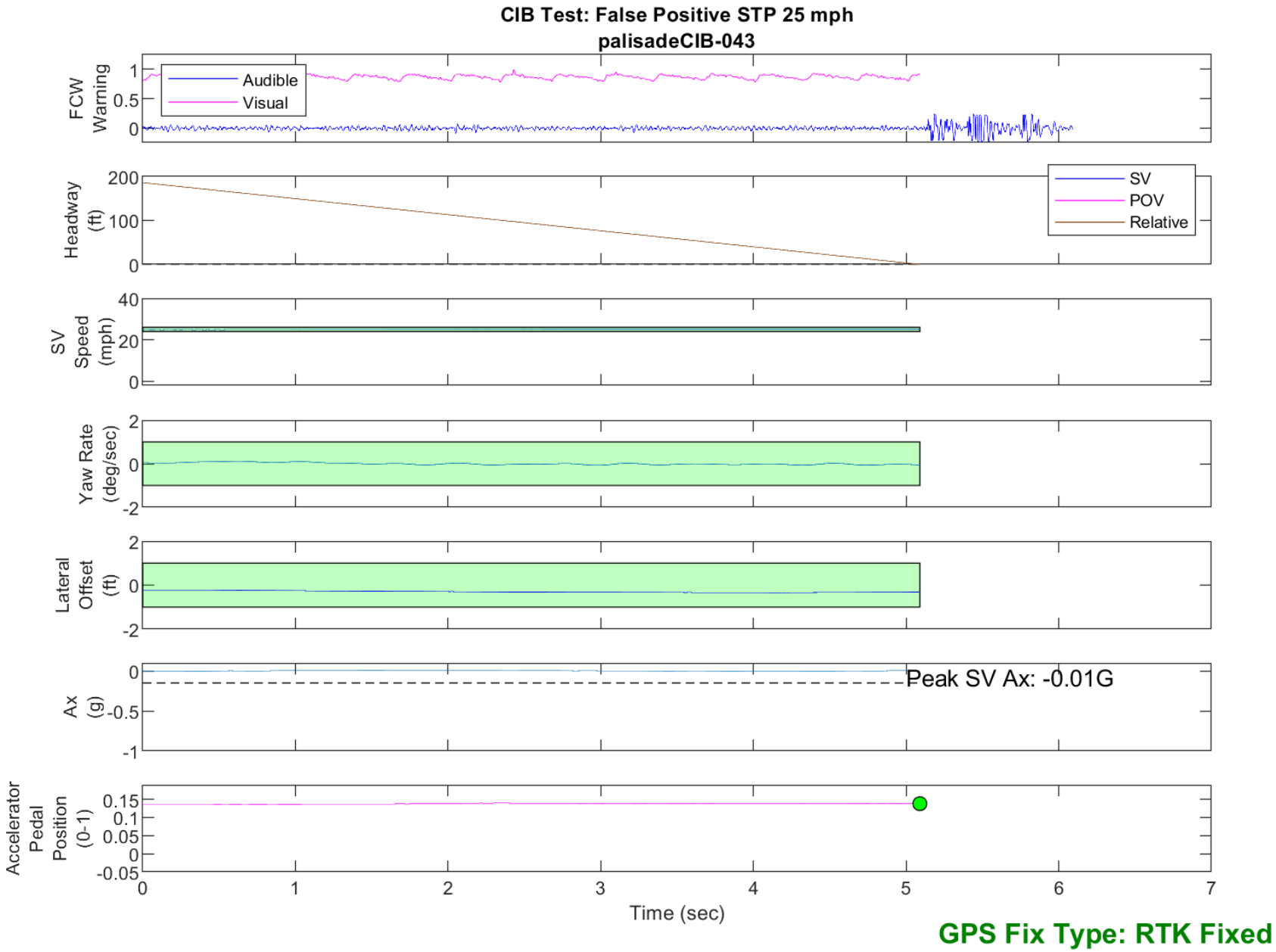

Figure D39. Time History for CIB Run 43, SV Encounters Steel Trench Plate, SV 25 mph

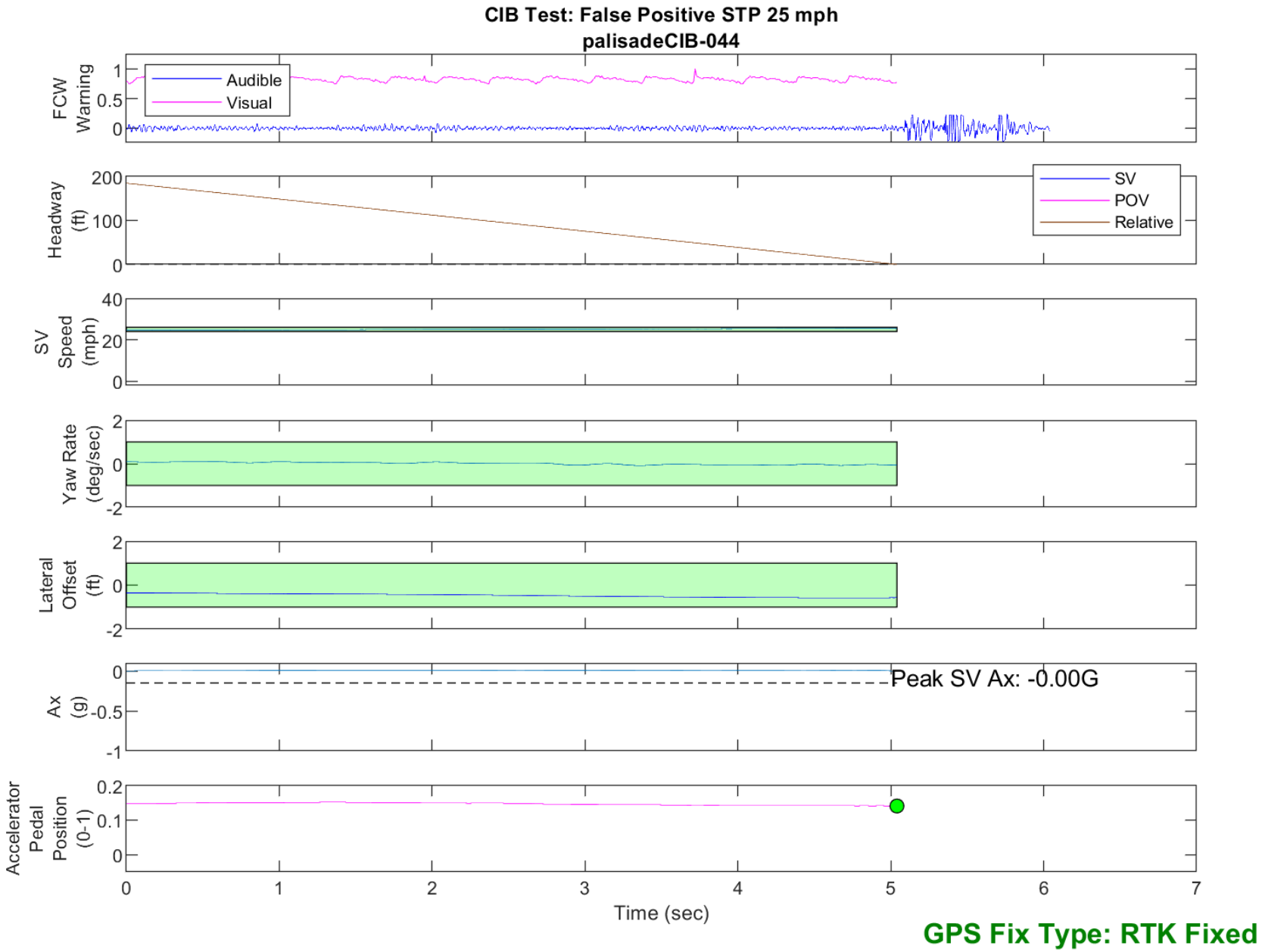

Figure D40. Time History for CIB Run 44, SV Encounters Steel Trench Plate, SV 25 mph

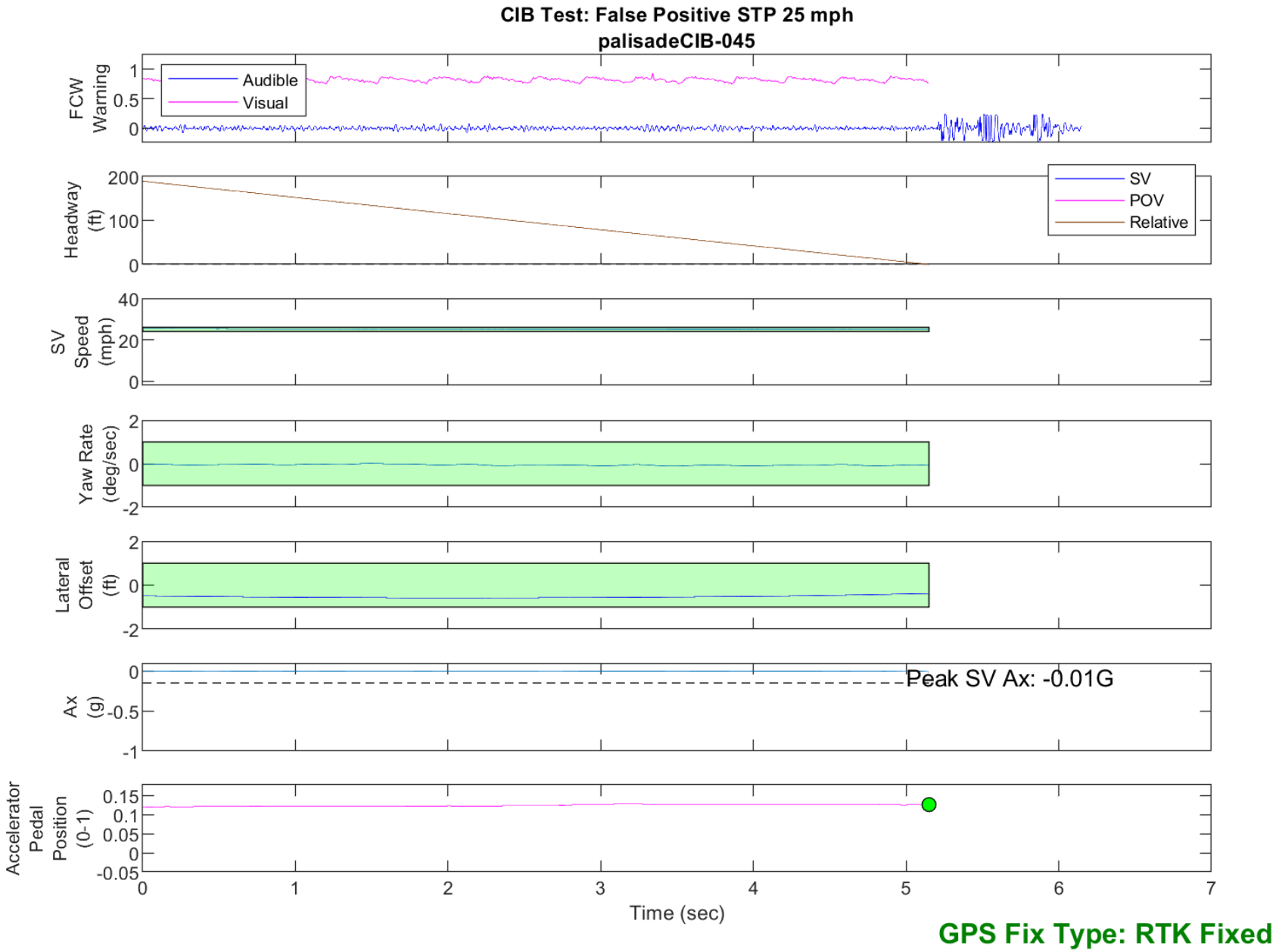

Figure D41. Time History for CIB Run 45, SV Encounters Steel Trench Plate, SV 25 mph

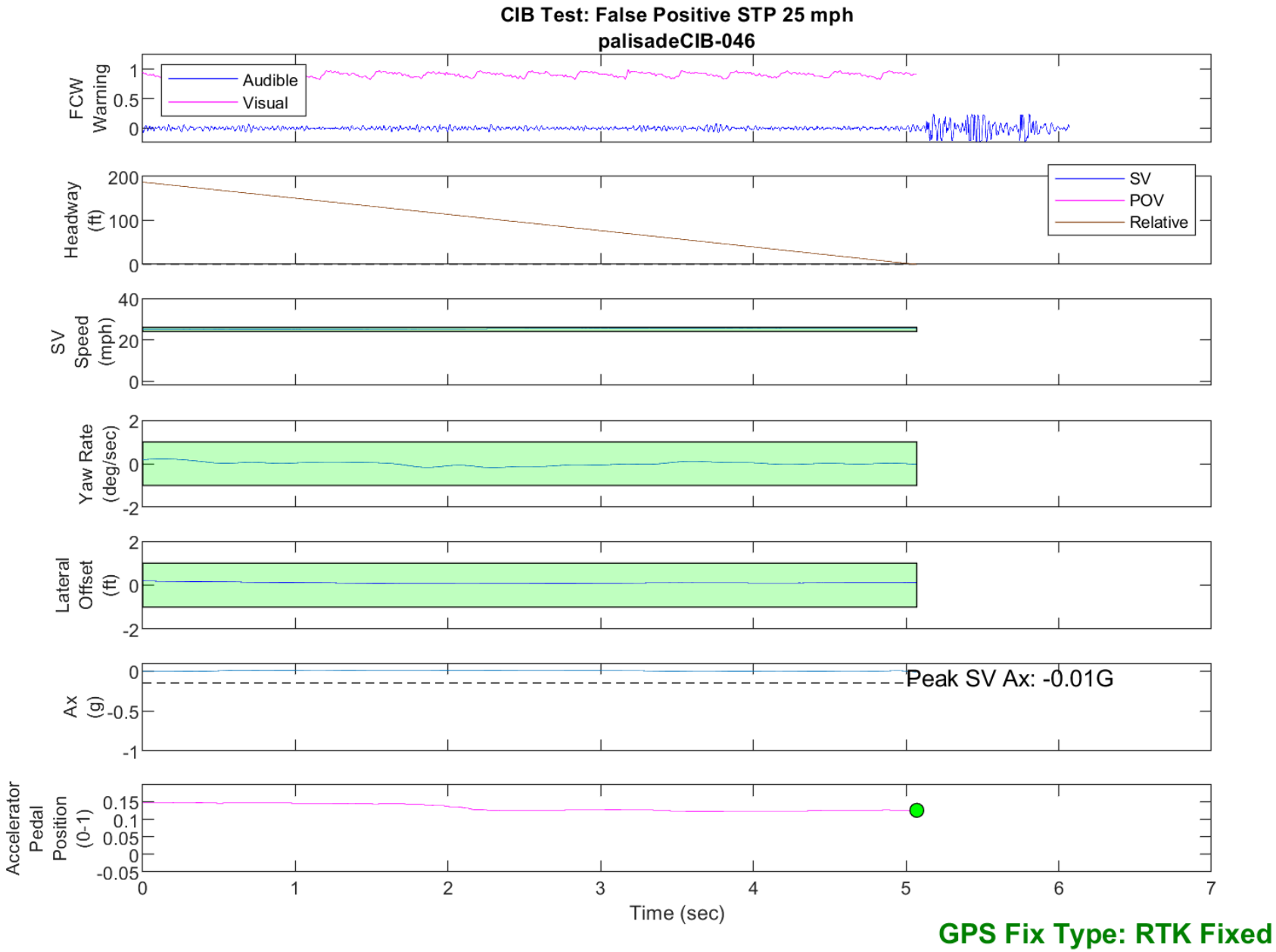

Figure D42. Time History for CIB Run 46, SV Encounters Steel Trench Plate, SV 25 mph

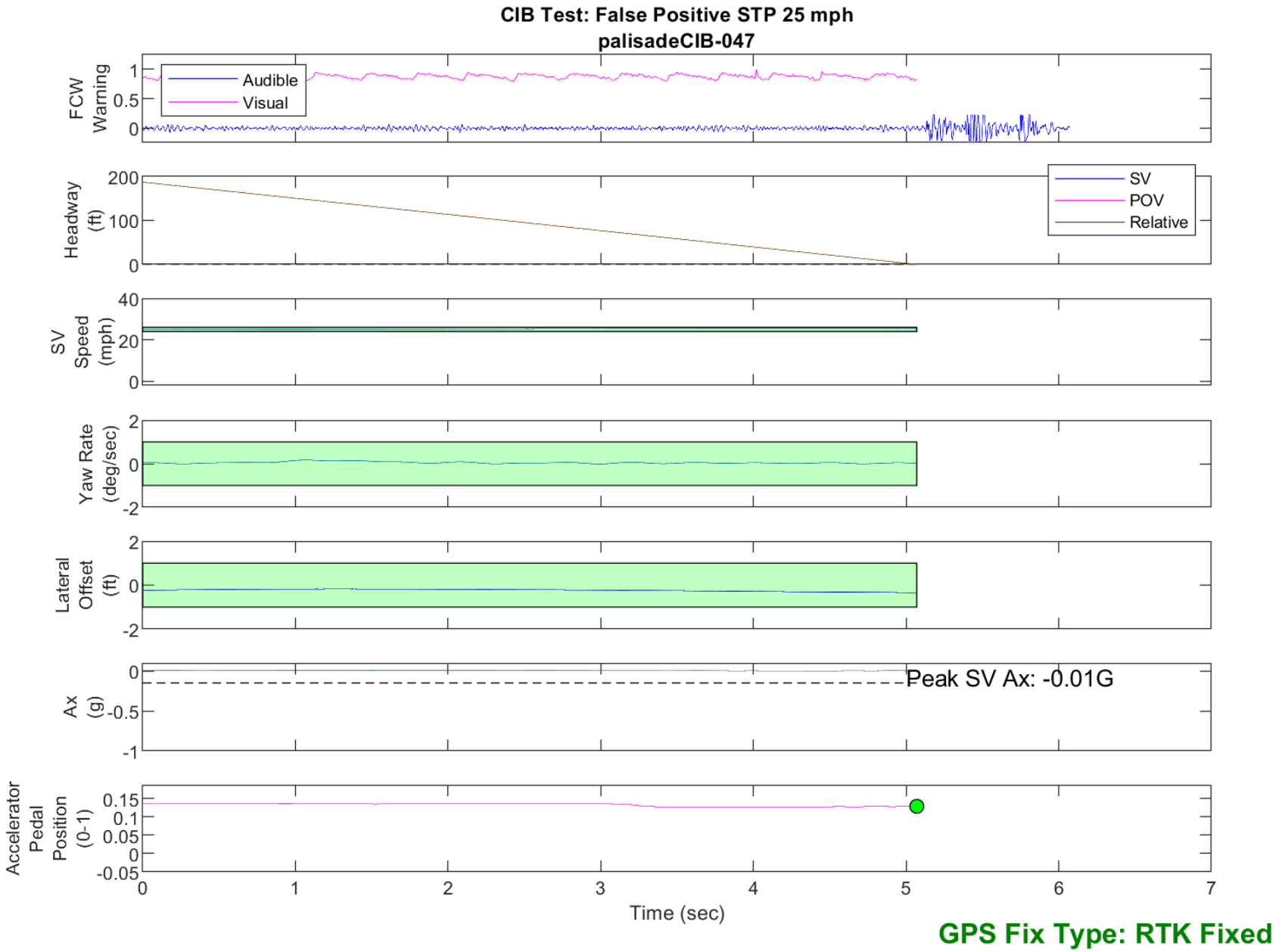

Figure D43. Time History for CIB Run 47, SV Encounters Steel Trench Plate, SV 25 mph

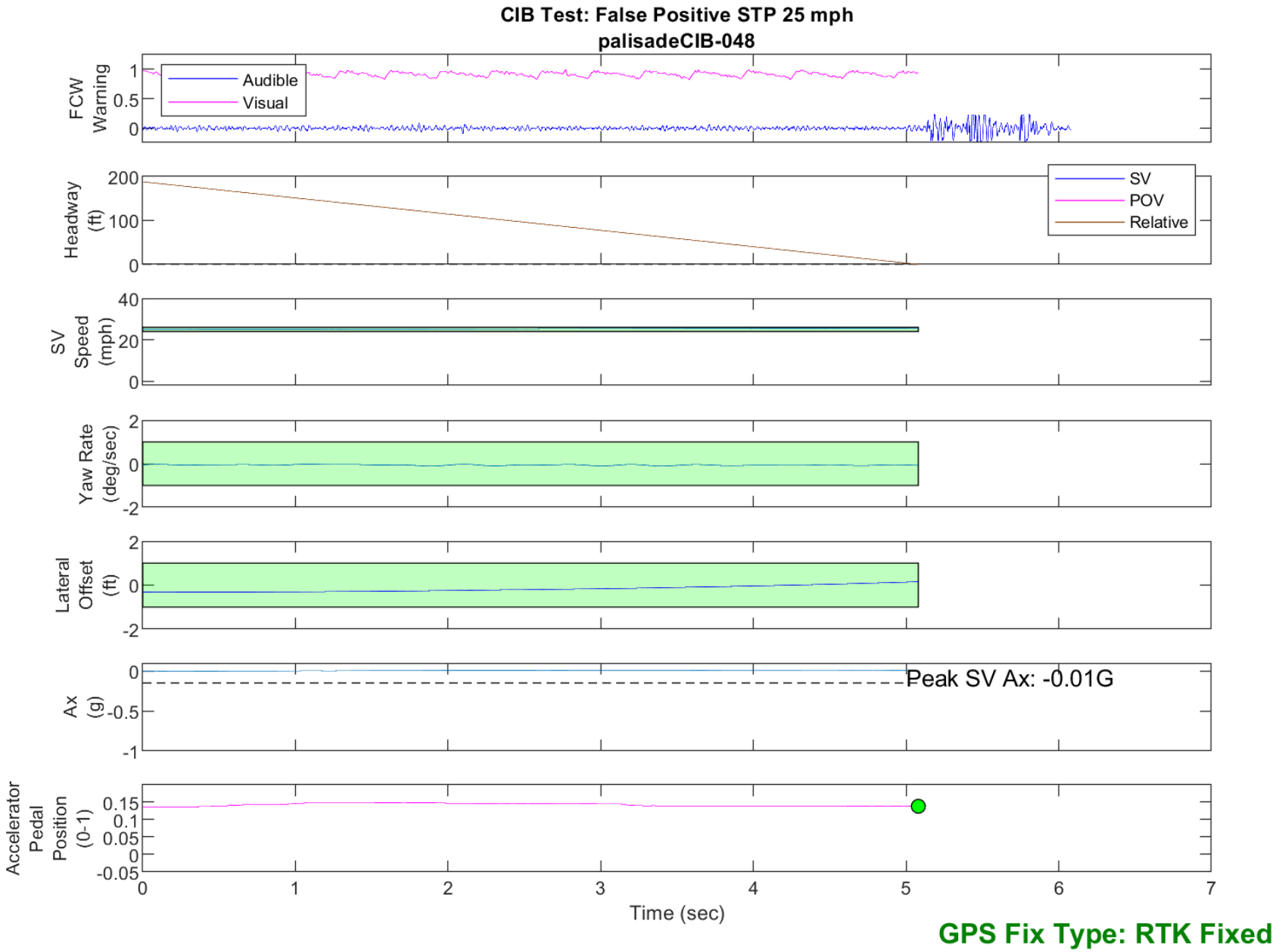

Figure D44. Time History for CIB Run 48, SV Encounters Steel Trench Plate, SV 25 mph

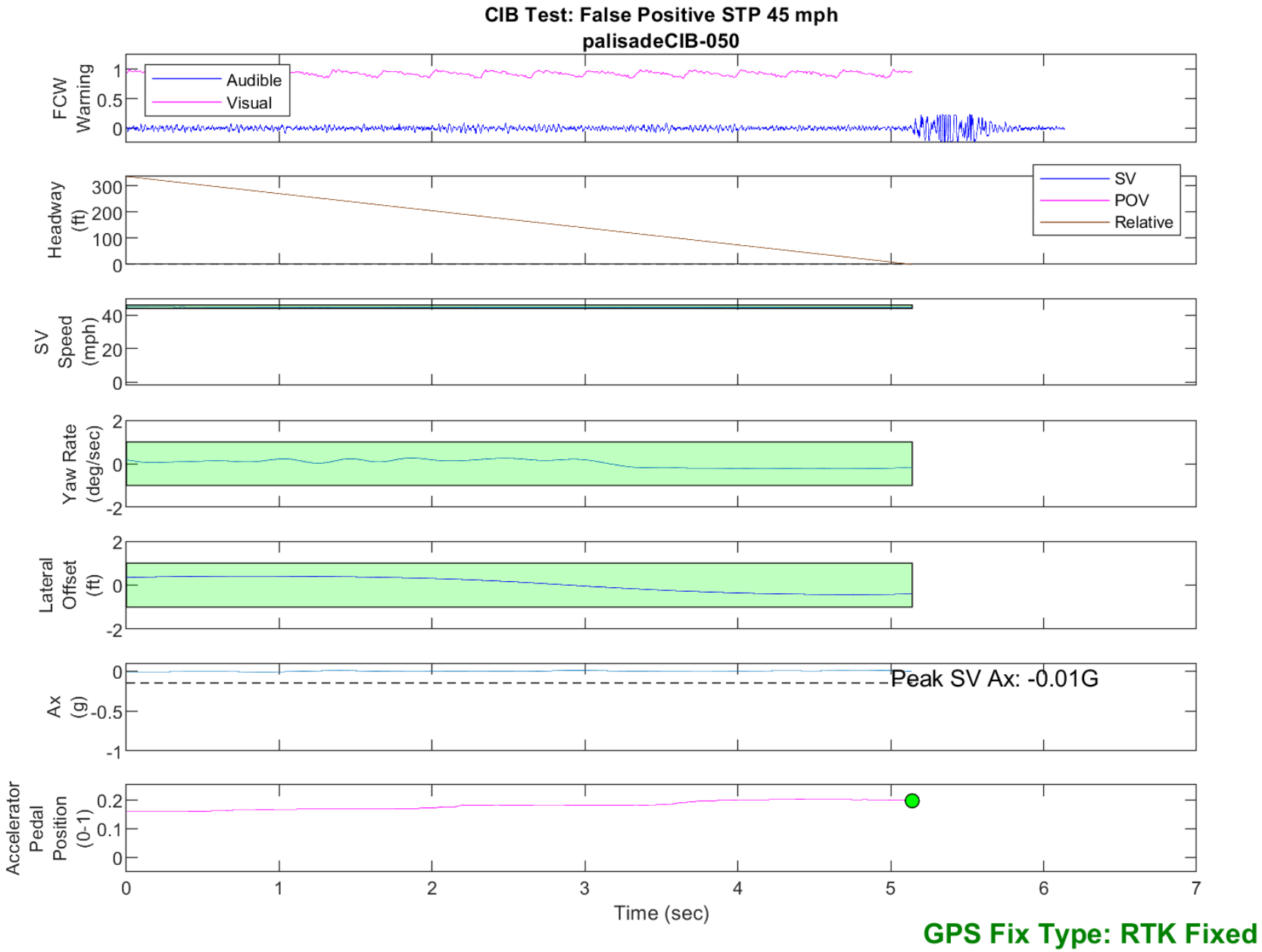

Figure D45. Time History for CIB Run 50, SV Encounters Steel Trench Plate, SV 45 mph

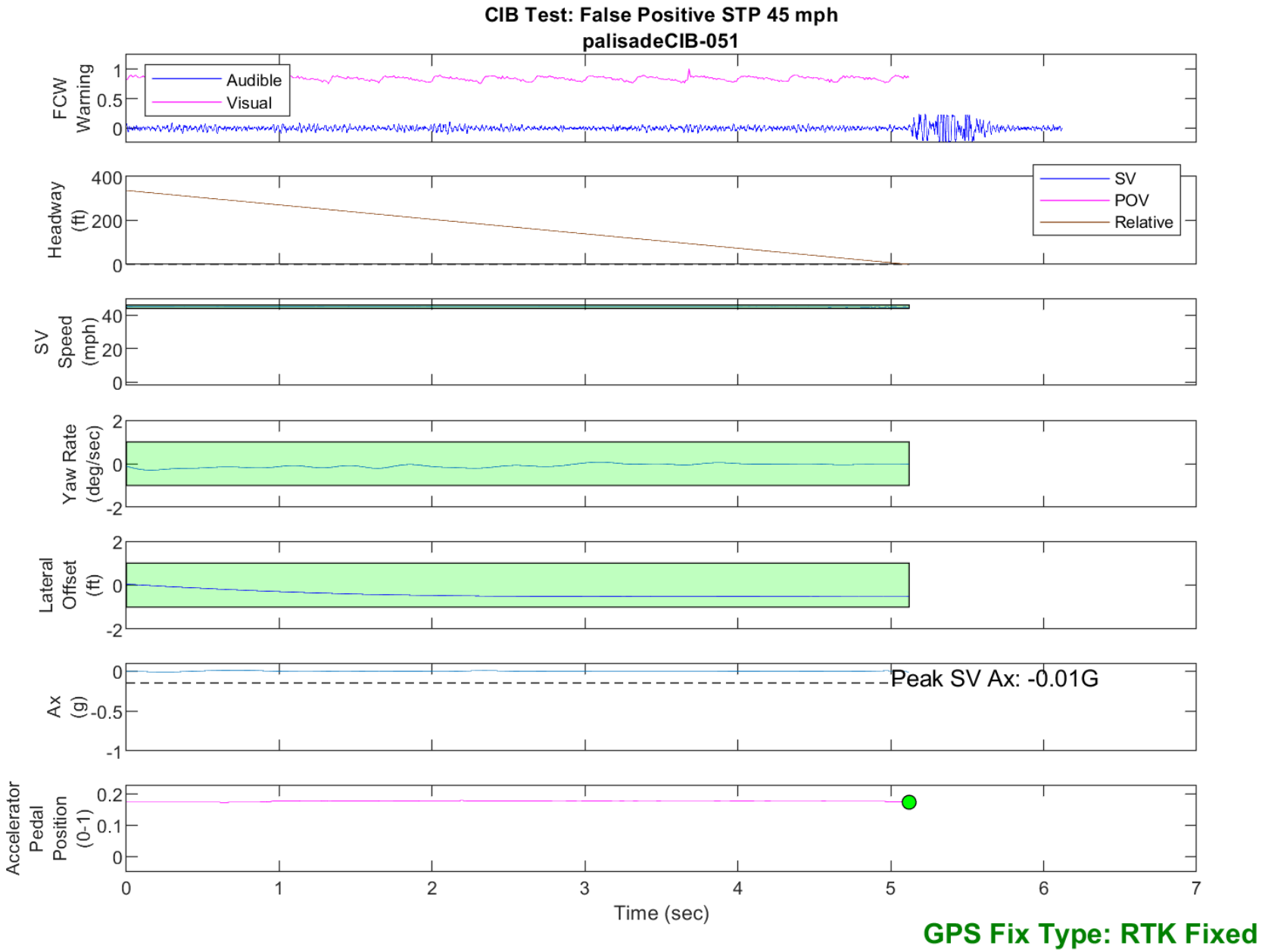

Figure D46. Time History for CIB Run 51, SV Encounters Steel Trench Plate, SV 45 mph

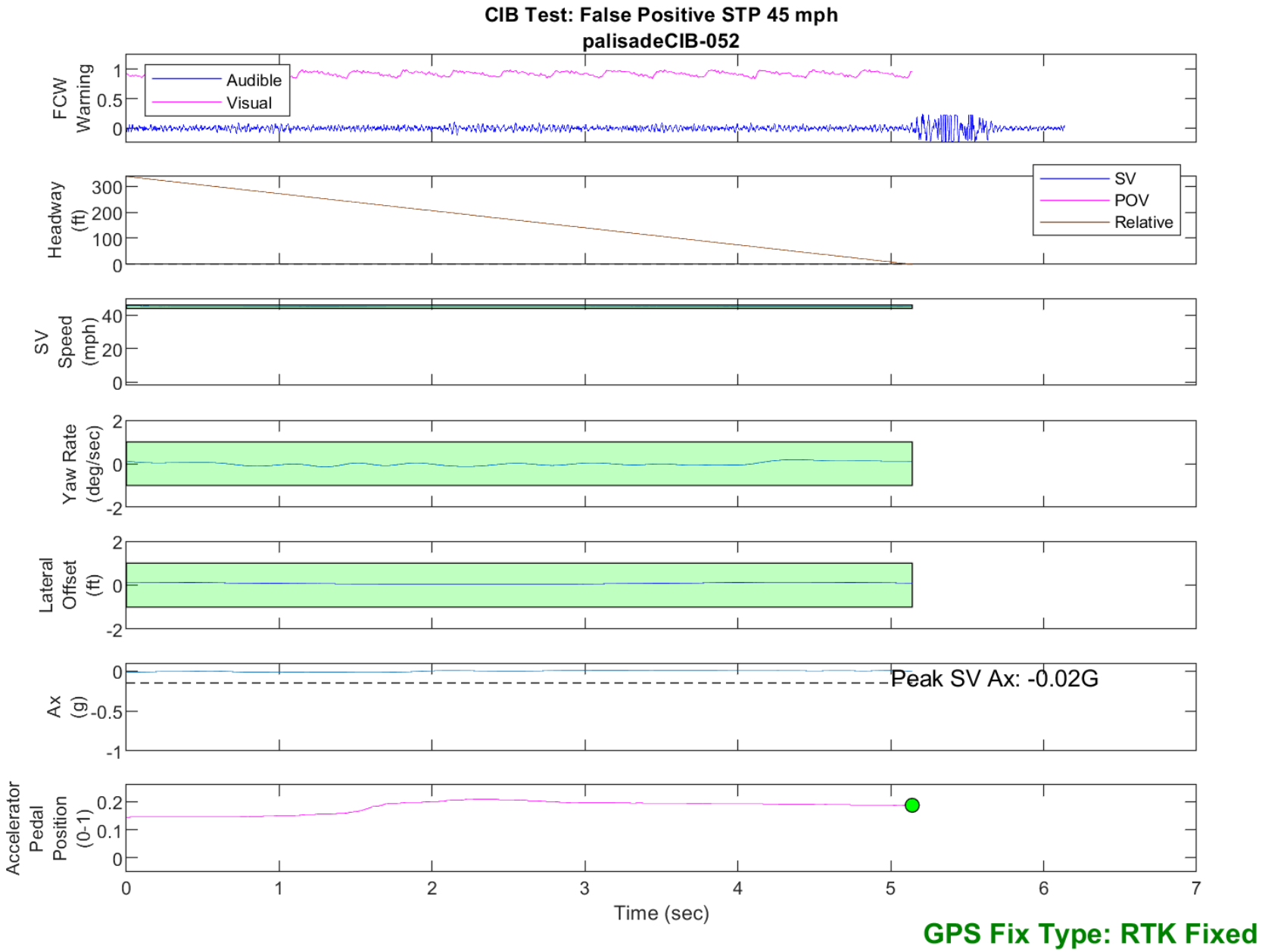

Figure D47. Time History for CIB Run 52, SV Encounters Steel Trench Plate, SV 45 mph

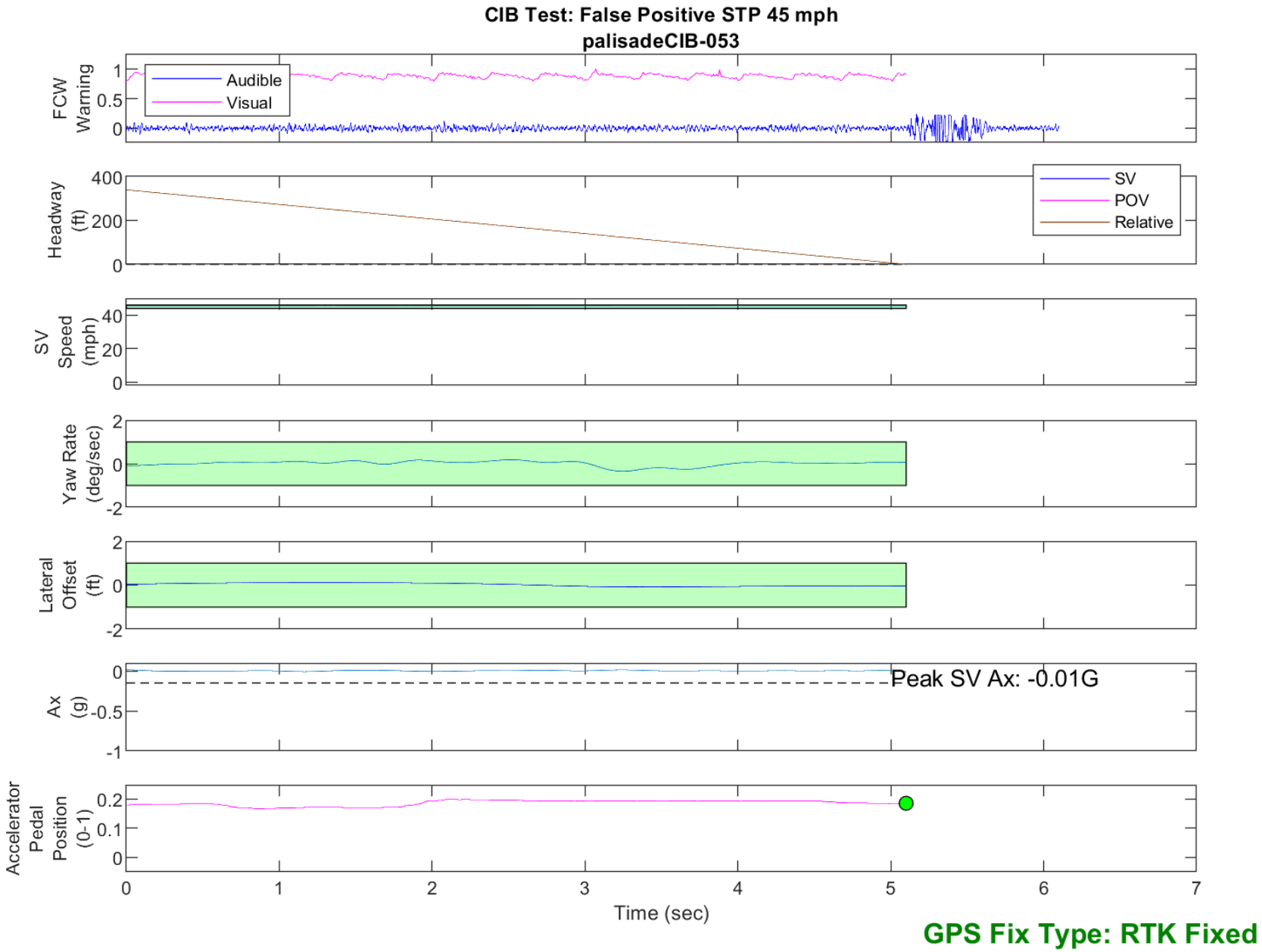

Figure D48. Time History for CIB Run 53, SV Encounters Steel Trench Plate, SV 45 mph

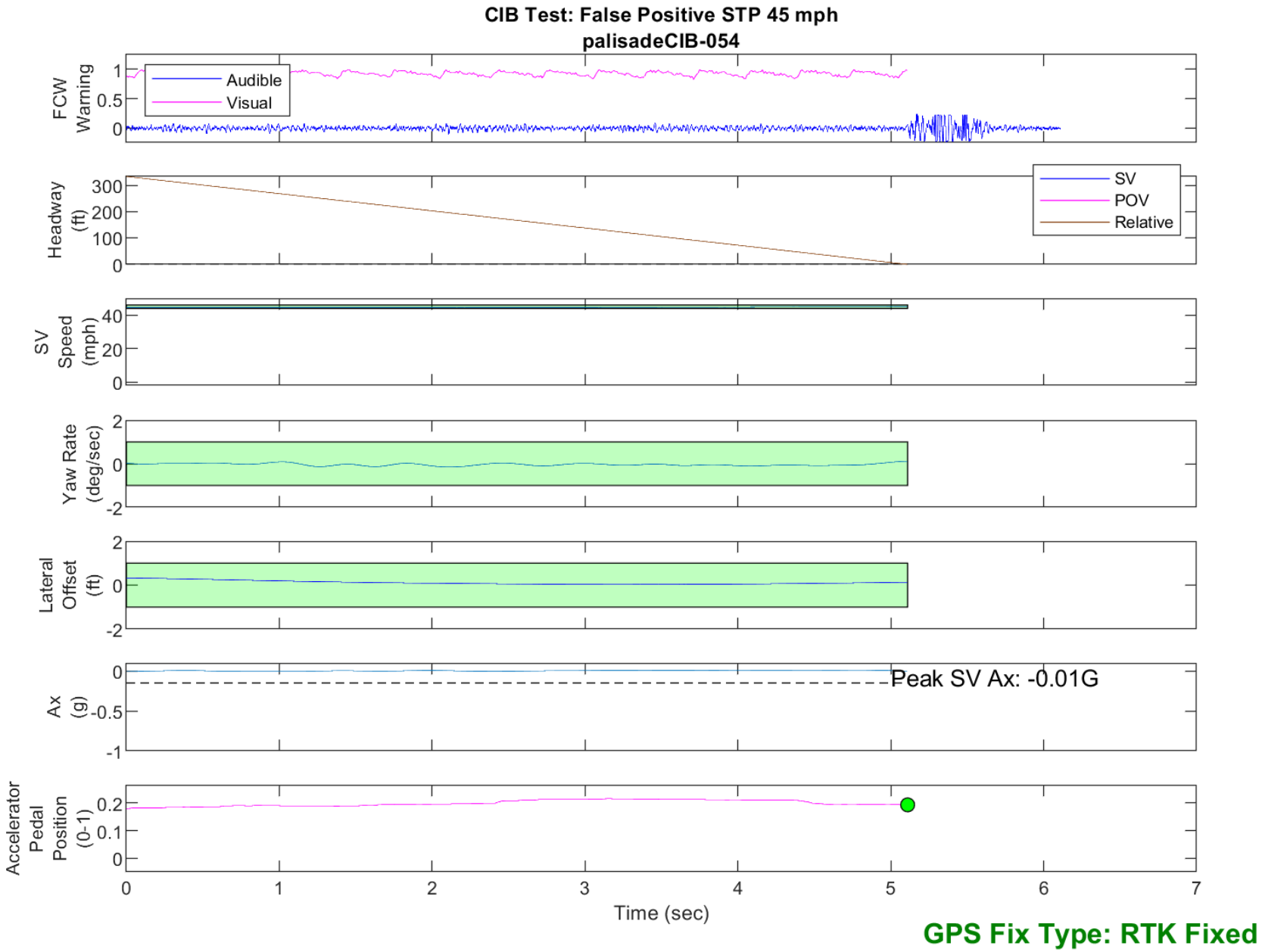

Figure D49. Time History for CIB Run 54, SV Encounters Steel Trench Plate, SV 45 mph

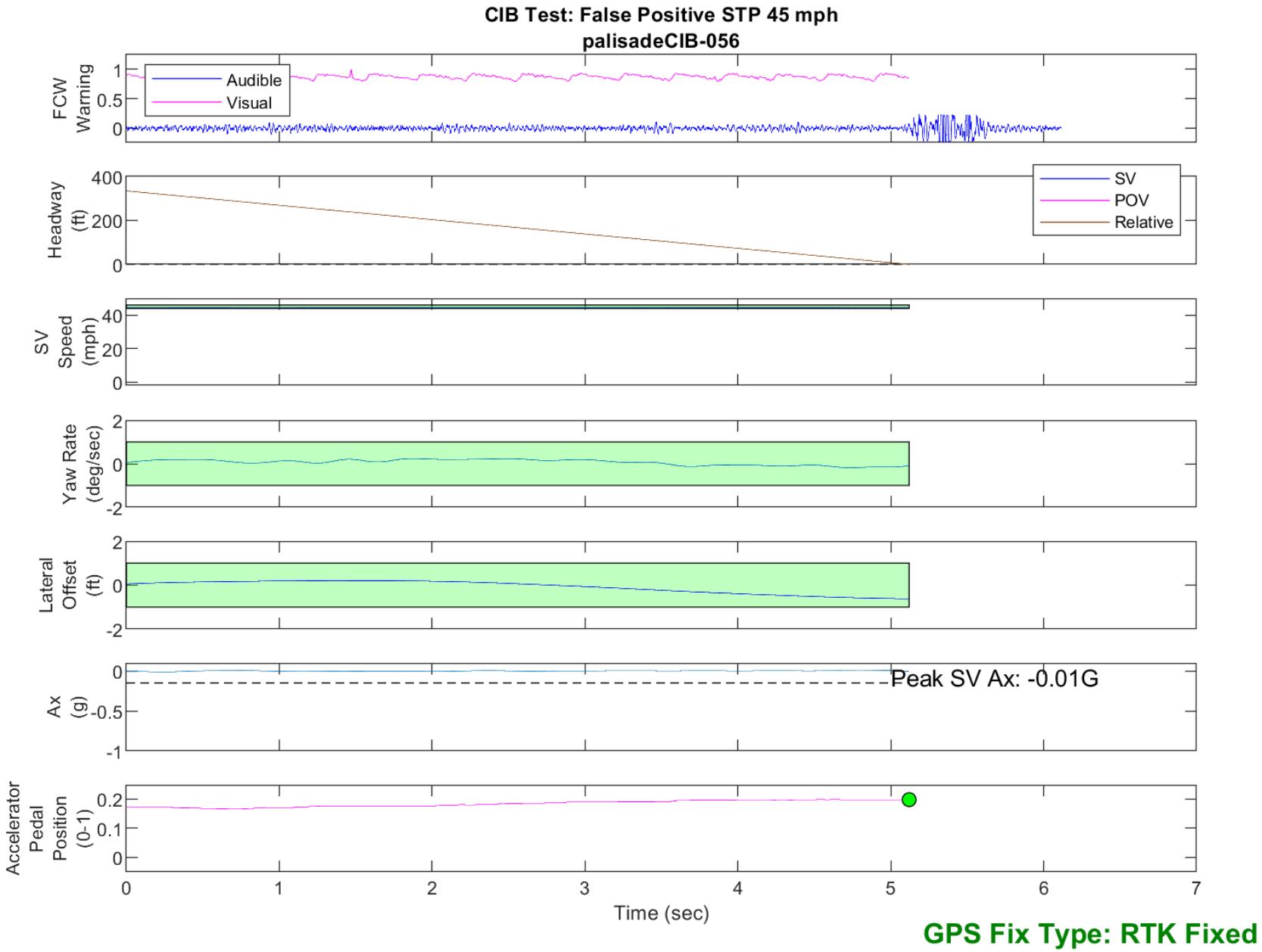

Figure D50. Time History for CIB Run 56, SV Encounters Steel Trench Plate, SV 45 mph

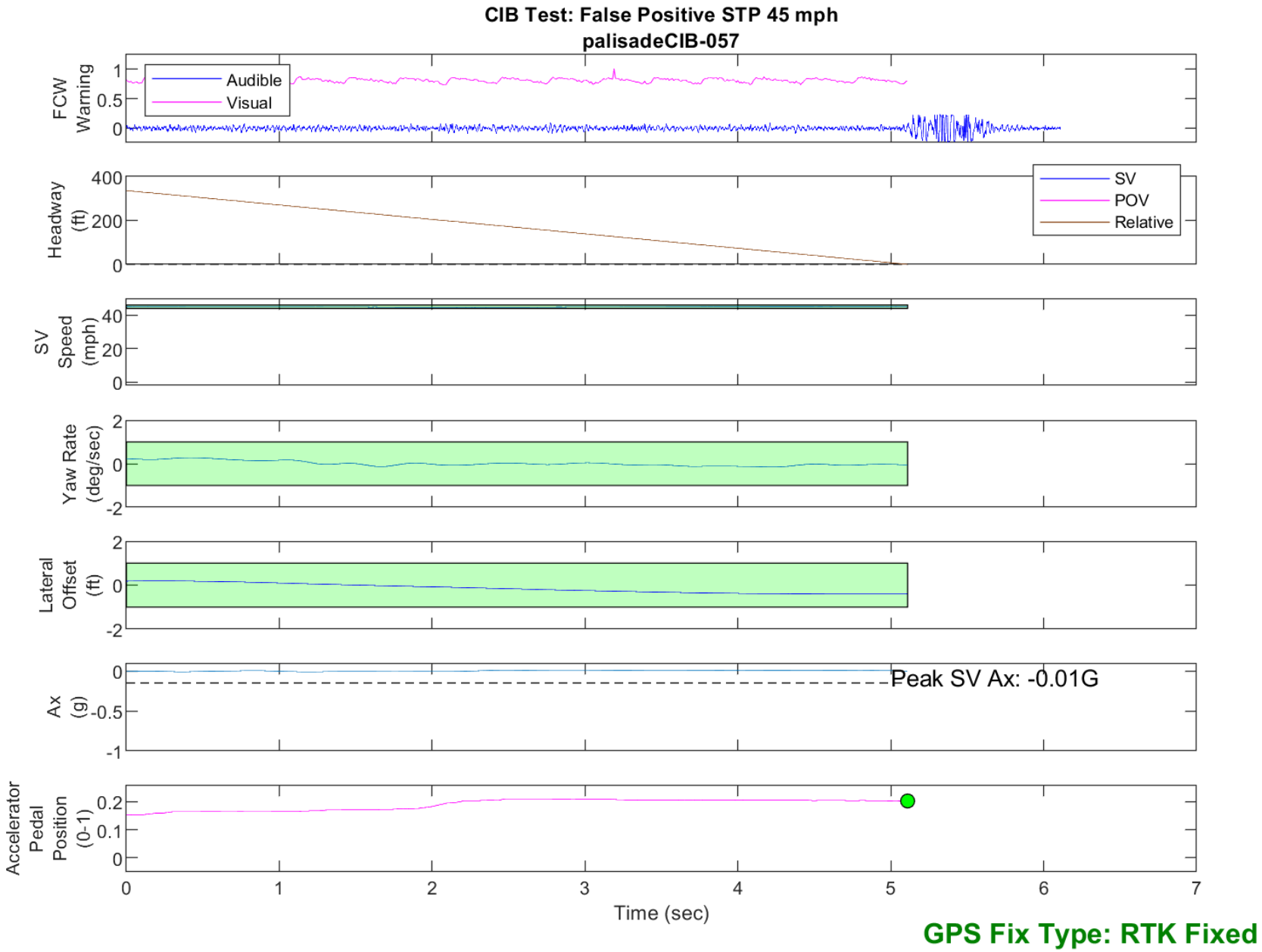

Figure D51. Time History for CIB Run 57, SV Encounters Steel Trench Plate, SV 45 mph