OCAS-DRI-CIB-19-22
NEW CAR ASSESSMENT PROGRAM
CRASH IMMINENT BRAKE SYSTEM CONFIRMATION TEST

2019 Subaru Forester

DYNAMIC RESEARCH, INC.
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18 November 2019

Final Report

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

U. S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crash Avoidance Standards
1200 New Jersey Avenue, SE
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16. Abstract

These tests were conducted on the subject in accordance with the specifications of the Office of Crash Avoidance Standards 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 2019 Subaru Forester. 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

DATA SHEET 1: TEST RESULTS SUMMARY

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SUMMARY RESULTS

VIN: *JF2SKACC2KH5xxxx*

Test Date: *4/25/2019*

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

DATA SHEET 2: VEHICLE DATA

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2019 Subaru Forester

TEST VEHICLE INFORMATION

VIN: *JF2SKACC2KH5xxxx*

Body Style: *SUV* Color: *Horizon Blue Pearl*

Date Received: *4/11/2019* Odometer Reading: *19 mi*

Engine: *2.5 L Inline 4*

Transmission: *CVT*

Final Drive: *AWD*

Is the vehicle equipped with:

ABS	**X**	Yes	____	No
Adaptive Cruise Control	**X**	Yes	____	No
Collision Mitigating Brake System	**X**	Yes	____	No

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Subaru Corporation*

Date of manufacture: *2/19*

DATA FROM TIRE PLACARD:

Tires size as stated on Tire Placard: Front: *225/60R17*

Rear: *225/60R17*

Recommended cold tire pressure: Front: *220 kPa (32 psi)*

Rear: *220 kPa (32 psi)*

CRASH IMMINENT BRAKE

DATA SHEET 2: VEHICLE DATA

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TIRES

Tire manufacturer and model: *Bridgestone Ecopia H/L 422 Plus*

Front tire size: *225/60R17*

Rear tire size: *225/60R17*

VEHICLE ACCEPTANCE

Verify the following before accepting the vehicle:

X All options listed on the "window sticker" are present on the test vehicle.

X Tires and wheel rims are the same as listed.

X There are no dents or other interior or exterior flaws.

X The vehicle has been properly prepared and is in running condition.

X Verify that spare tire, jack, lug wrench, and tool kit (if applicable) is located in the vehicle cargo area.

CRASH IMMINENT BRAKE

DATA SHEET 3: TEST CONDITIONS

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2019 Subaru Forester

GENERAL INFORMATION

Test date: *4/25/2019*

AMBIENT CONDITIONS

Air temperature: *24.4 C (76 F)*

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

X Windspeed ≤ 10 m/s (22 mph)

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

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

VEHICLE PREPARATION

Verify the following:

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

Fuel tank is full: **X**

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

Front: *220 kPa (32 psi)*

Rear: *220 kPa (32 psi)*

CRASH IMMINENT BRAKE

DATA SHEET 3: TEST CONDITIONS

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WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*501.7 kg (1106 lb)*	Right Front	*473.1 kg (1043 lb)*
Left Rear	*379.2 kg (836 lb)*	Right Rear	*356.1 kg (785 lb)*
		Total:	*1710.0 kg (3770 lb)*

CRASH IMMINENT BRAKE

DATA SHEET 4: CRASH IMMINENT BRAKE SYSTEM OPERATION

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Name of the CIB option, option package, etc.

Pre-Collision Braking System

System setting used for test (if applicable): *Default - System On*

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

1 mph (Per manufacturer supplied information)

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

100 mph (Per manufacturer supplied information)

Does the vehicle system require an initialization sequence/procedure?

Yes. Approximately 1 hour of driving on normal roadways under the following conditions:

1. *Dry road surfaces*
2. *Daylight hours*
3. *Public road with both left and right lane markings*
4. *If traffic exists, keep a comfortable distance from lead vehicles*
5. *Maintain posted speed limit*

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

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

The system may switch off if AEB has operated 3 times in one driving cycle, in which case the Pre-Collision Braking System OFF indicator light illuminates and AEB is NOT operational. The system is reactivated by cycling the ignition, after which it takes approximately 7 seconds for the pre-collision braking system to become functional.

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

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

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

The alerts are staged depending on the urgency of the situation.

Following Distance Warning:

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

First Braking and Warning:

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

Secondary Braking and Warning:

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

CRASH IMMINENT BRAKE

DATA SHEET 4: CRASH IMMINENT BRAKE SYSTEM OPERATION

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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.

A button is provided in the upper console, above the windscreen. It is necessary to press and hold the Pre-Collision Braking System OFF switch for approximately 2 seconds. The system is automatically reactivated after cycling the ignition.

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

X No

If yes, please provide a full description.

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

____ No

If yes, please provide a full description.

There may be cases when detection of an object is not possible depending on a variety of conditions. For example, when a vehicle is viewed from the side, oncoming vehicle, vehicles approaching in reverse, small animals or children, or walls or doors are not likely to be detected.

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Conditions in which the Pre-Collision Braking system cannot detect obstacles:

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

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

(continued next page)

- *When there is a wall, etc. in front of a stopped vehicle*
- *When there is another object near the vehicle*
- *When a vehicle, etc. has its side facing you.*
- *With vehicles that are backing up or with oncoming vehicles, etc.*
- *When the size and height of an obstacle is smaller than the limitations of the stereo camera's recognition capability*
  - *With small animals or children, etc.*
  - *With pedestrians who are sitting or lying down*
- *When the detected object is a fence or wall, etc. with a uniform pattern (a striped pattern or brick pattern, etc.)*
- *When there is a wall or door made of glass or a mirror in front*
- *When the vehicle in front suddenly swerves, accelerates, or decelerates.*
- *When a vehicle, motorcycle, bicycle or pedestrian suddenly cuts in from the side or suddenly runs in front of you.*
- *When you suddenly change lanes and your vehicle is immediately behind an obstacle*
- *When there is a vehicle, motorcycle, bicycle or pedestrian in a location close to your vehicle's bumper*
- *When the speed difference between your vehicle and an obstacle is 4 MPH (5 km/h) or less (As braking is performed once the obstacle is in close proximity to your vehicle, depending on the shape and size of the obstacle, there may be some cases when the obstacle is outside the range of the camera's field of view.)*
- *When driving on sharp curves, steep uphill grades or steep downhill grades*
- *When driving on a bumpy or unpaved road*
- *When there are changes in brightness, such as at a tunnel entrance or exit*

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The system may not operate correctly under the conditions listed below. When these conditions occur, turn off the Pre-Collision Braking System.

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

In the following situations, turn off the Pre-Collision Braking System. Otherwise the Pre-Collision Braking System may activate unexpectedly.

- *When the vehicle is being towed*
- *When loading the vehicle onto a carrier*
- *When a chassis dynamometer, free-rollers or similar equipment is used*

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- *When a mechanic lifts up the vehicle, starts the engine and spins the wheels freely*
- *When passing hanging banners, flags or branches, or when thick/tall vegetation is contacting the vehicle*
- *When driving in sport mode such as on a circuit*
- *When using a drive-through car wash*

- *The Pre-Collision Braking System may activate in the following situations.*
  - *When passing through an automatic gate (opening and shutting)*
  - *When driving close to the vehicle in front*
  - *When driving in a location where the grade of the road changes rapidly*
  - *When visibility is poor due to sand, smoke or water vapor blowing in the wind, or when the front vision is obscured due to water splashes, snow, dirt or dust stir up generated by the vehicle in front or oncoming traffic*
  - *When passing through clouds of steam or smoke, etc.*
  - *When driving in adverse weather, such as heavy snow or snowstorms*
  - *When the exhaust gas emitted by the vehicle in front is clearly visible in cold weather, etc.*
  - *When there is an obstacle on a curve or intersection*
  - *When narrowly passing a vehicle or an object*
  - *When stopping very close to a wall or a vehicle in front*
  - *When passing through water spray from road sprinklers or snow clearing sprinklers on the road.*
  - *If there is cargo or installed accessories, etc. that are protruding beyond the edge of the front bumper, the vehicle's length will increase and the system may not be able to prevent a collision.*
  - *If the driver operates the brake pedal during automatic braking, the pedal may feel stiff; however, this is normal. By depressing the brake pedal further you can apply more braking force*

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In the following conditions, the possibility that system may not be able to detect a pedestrian as an object is particularly high.

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

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.

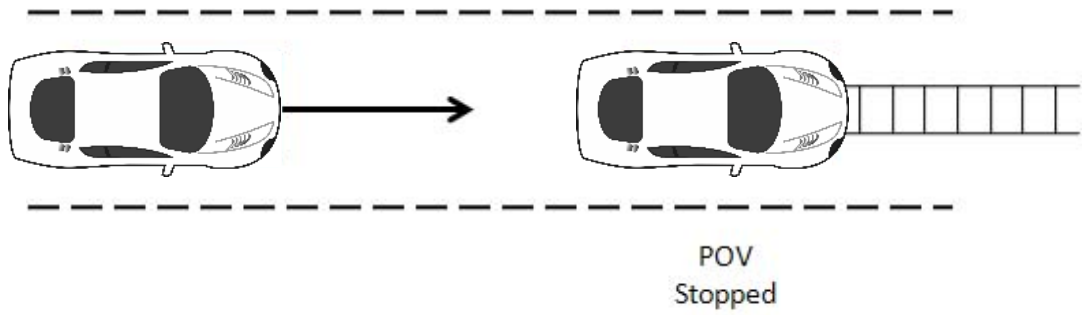


Figure 1. Depiction of Test 1

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 kph) 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 kph) 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. TEST 2 – SUBJECT VEHICLE ENCOUNTERS SLOWER PRINCIPAL OTHER VEHICLE

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

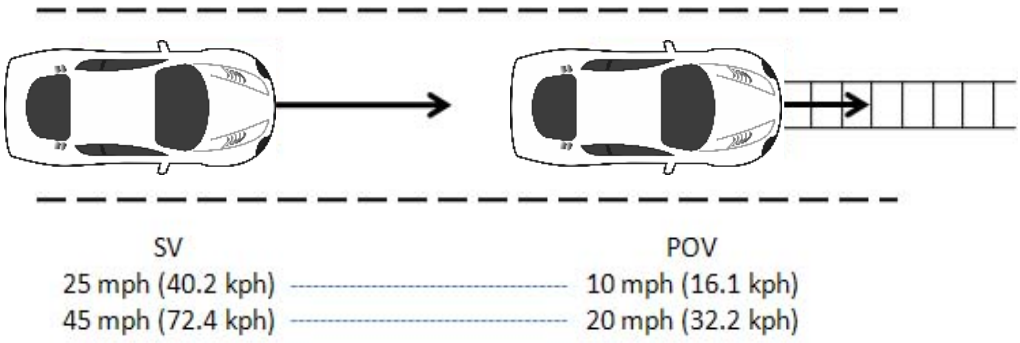


Figure 2. Depiction of Test 2

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 kph) in the center of the lane of travel while the SV was driven at 25.0 mph (40.2kph), 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 kph) in the center of the lane of travel while the SV was driven at 45.0 mph (72.4 kph), 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.

1. 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}.

2. 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.

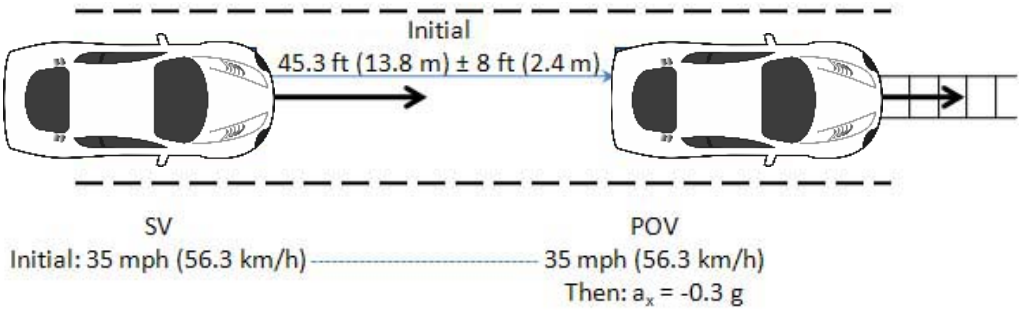


Figure 3. Depiction of Test 3 with POV Decelerating

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 kph) 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 kph) 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.

1. 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}.

2. 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 kph) 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: 6/21/2018 Due: 6/21/2019
Platform Scales	Vehicle Total, Wheel, and Axle Load	1500 lb/platform 6672 N/	0.5% of applied load	Intercomp SW I	24032361	By: DRI Date: 12/11/2018 Due: 12/11/2019
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	43020490	By: DRI Date: 5/1/2018 Due: 5/1/2019
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;	Accels ± 10g, Angular Rat	Accels .01g, Angular Rate	Oxford Inertial +		By: Oxford Technical Solutions
					2182	Date: 10/16/2017 Due: 10/16/2019

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
	Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles				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

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/2/2019 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

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

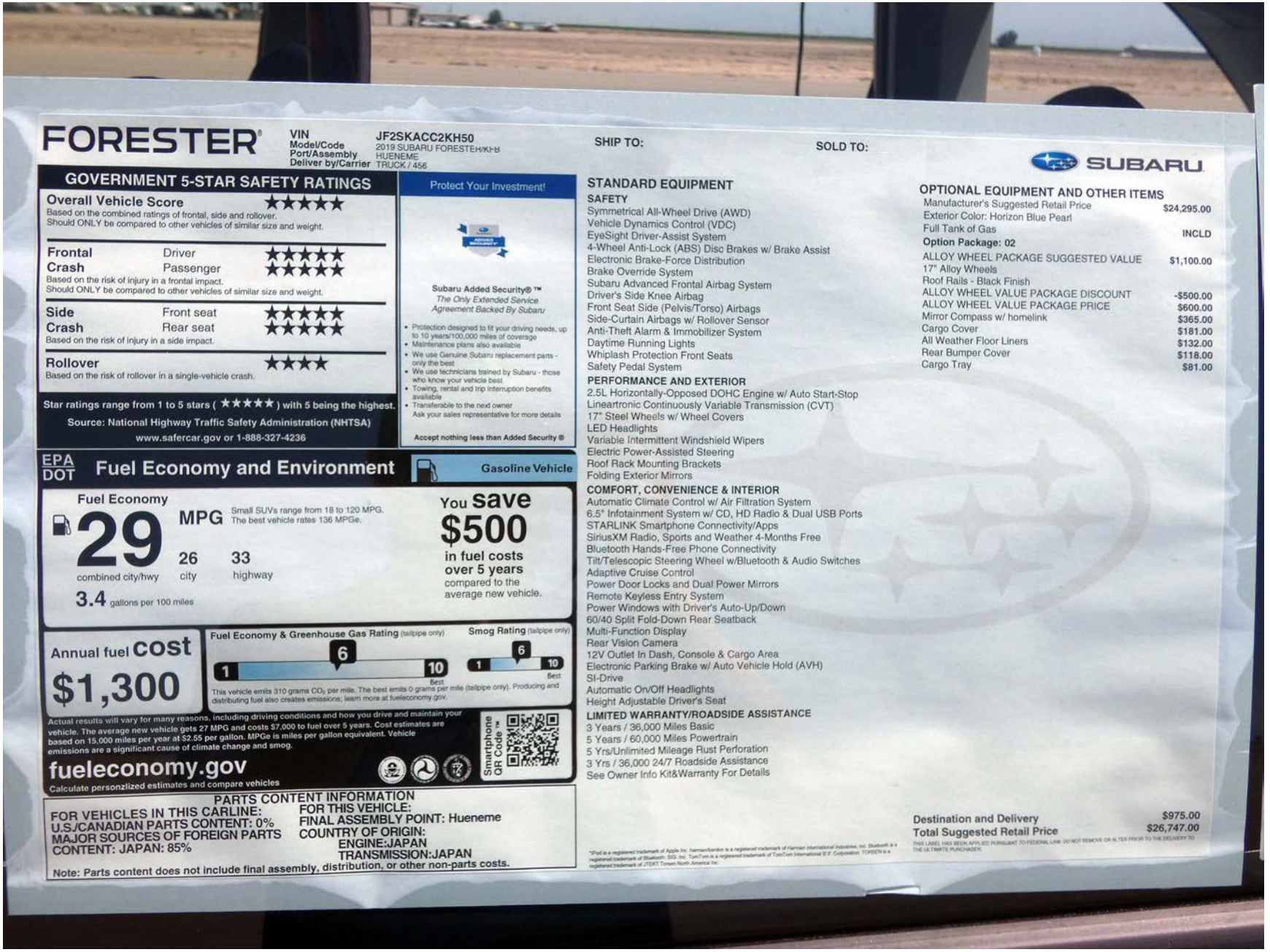


Figure A3. Window Sticker (Monroney Label)

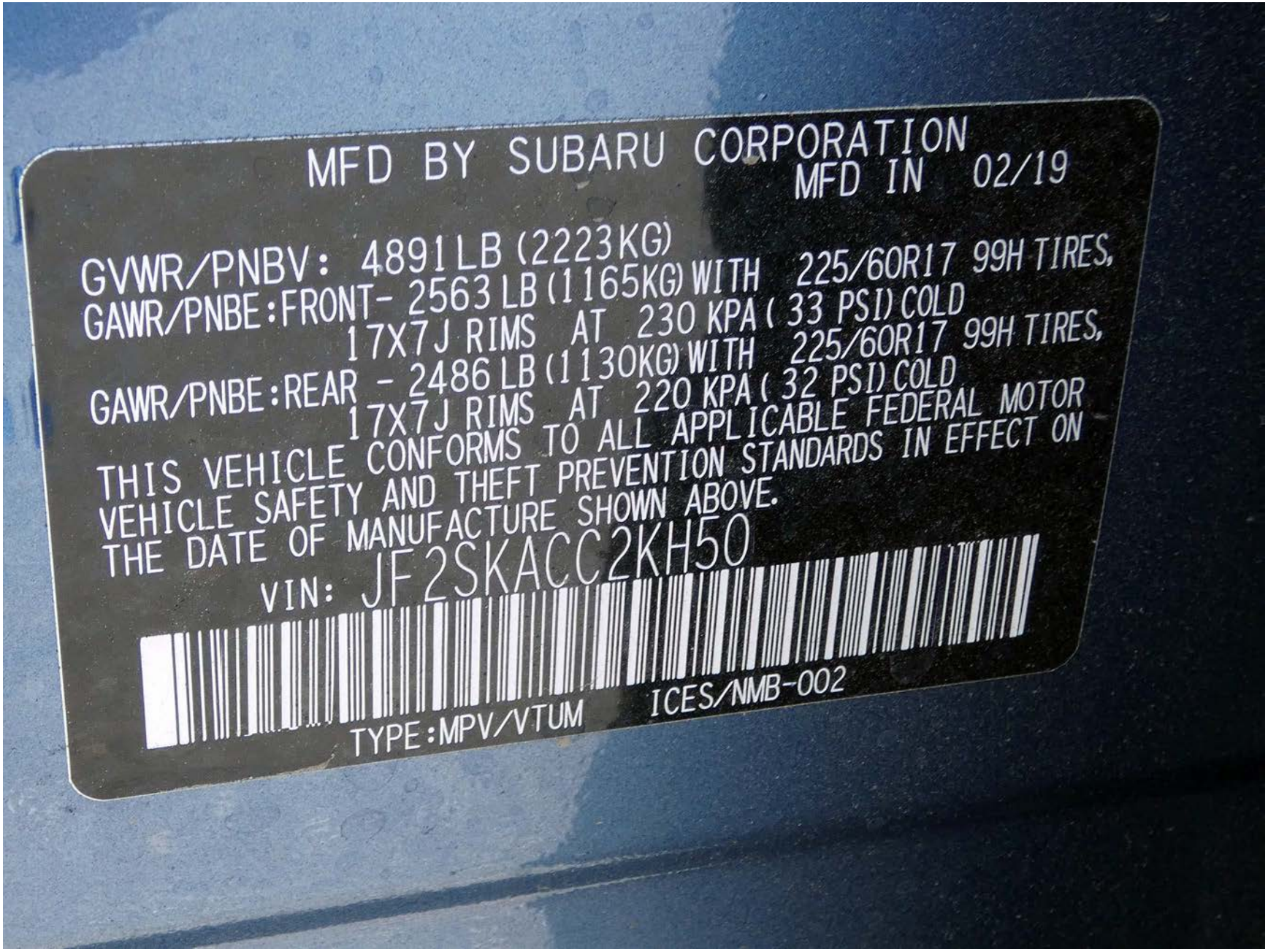


Figure A4. Vehicle Certification Label

Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

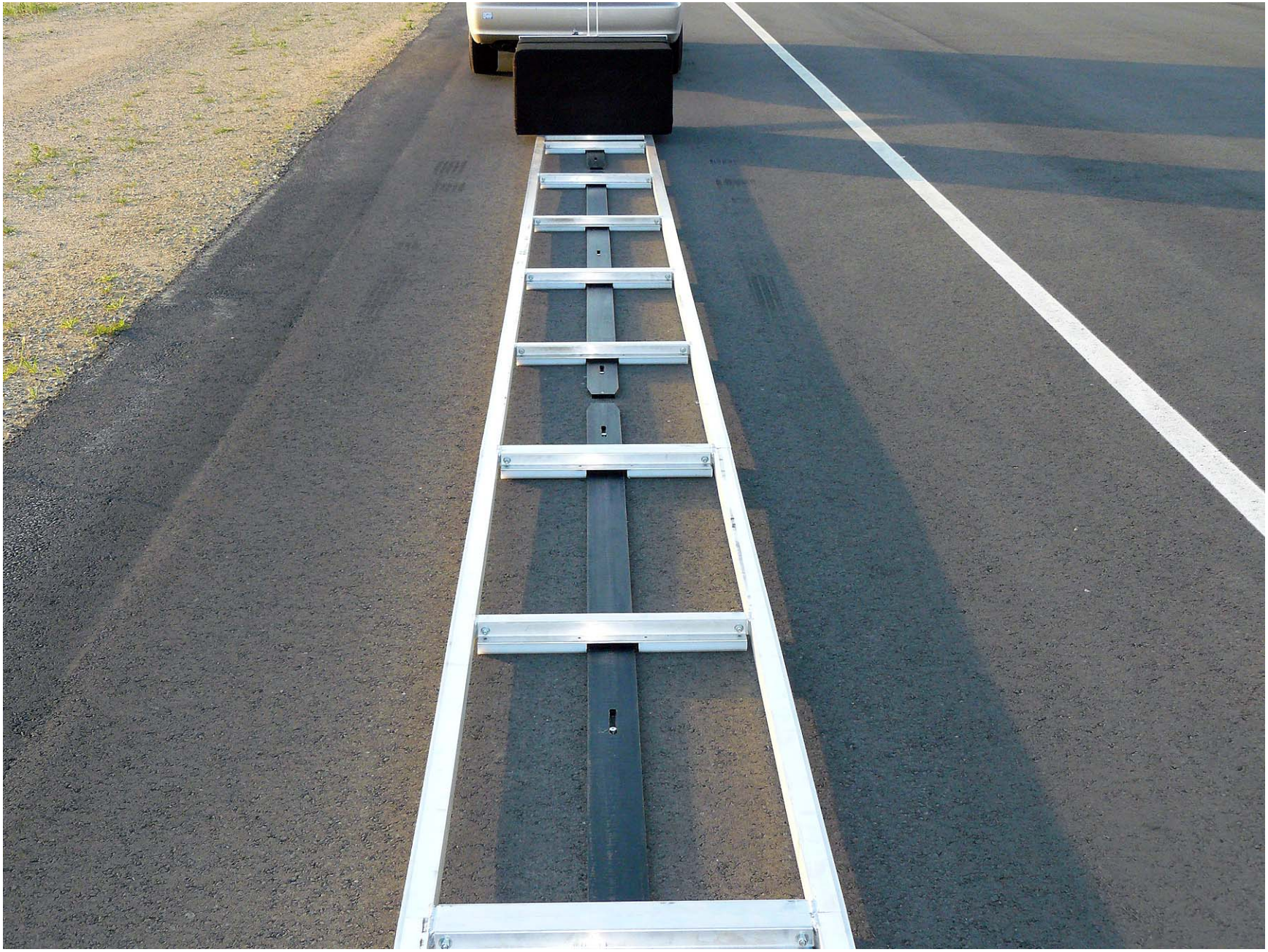


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

Figure A9. Steel Trench Plate

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

Figure A11. Sensor for Detecting Auditory Alerts

Figure A12. Sensor for Detecting Visual Alert

Figure A13. Computer Installed in Subject Vehicle

Figure A14. Brake Actuator Installed in POV System

Figure A15. AEB Instrument Panel Visual Alert

Figure A16. AEB Off Indicator

Figure A17. AEB On/Off Switch

APPENDIX B

Excerpts from Owner's Manual

EyeSight Functions

EyeSight includes the following functions.

■Pre-Collision Braking System

This function uses a following distance warning feature to warn the driver to take evasive action when there is the possibility of a collision with a vehicle or obstacle in front of you. If the driver does not take evasive action, the brakes are applied automatically to help reduce vehicle collision damage or, if possible, help prevent a collision.
⇒ Refer to page 25.

■Adaptive Cruise Control

This function maintains the set vehicle speed and when there is a vehicle in front in the same traffic lane, it follows the speed of the vehicle in front up to the maximum of the set vehicle speed.
⇒ Refer to page 40.

■Lane Keep Assist

This function helps suppress lane drifting by detecting lane markings (e.g., white lines) on highways and roads, and by assisting steering operation.
⇒ Refer to page 66.

■Pre-Collision Throttle Management

This function reduces accidental forward movement caused by the select lever being placed in the wrong position or the accelerator pedal being accidentally depressed, or depressed too strongly.
⇒ Refer to page 75.

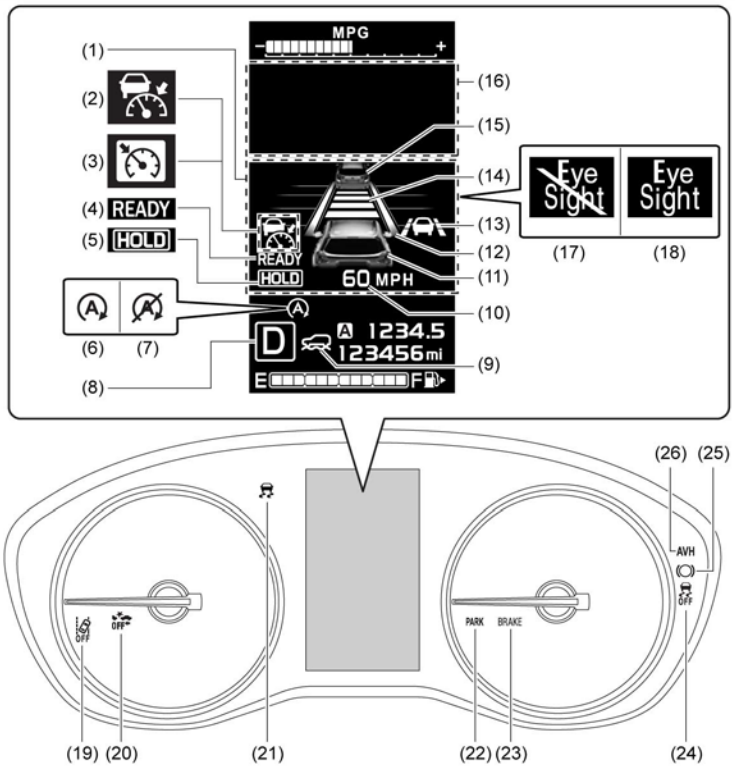
■Lane Departure Warning

This function warns the driver when the vehicle is about to drift off the road.
⇒ Refer to page 81.

■Lane Sway Warning

This function warns the driver when it detects vehicle drifting caused by driver fatigue, failure to concentrate on the road, inattention, strong crosswinds or other factors.
⇒ Refer to page 84.

Instrument panel display layout



* Display units can be changed in the Screen Settings. For details, refer to the Owner's Manual for your vehicle. S03298

(1) EyeSight display area
(2) Adaptive Cruise Control indicator
(3) Conventional Cruise Control indicator
(4) READY indicator
(5) HOLD indicator
(6) Auto Start Stop indicator (green)/Auto Start Stop OFF indicator (yellow)/Auto Start Stop warning indicator (yellow)
(7) Auto Start Stop No Activity Detected indicator light (white)
(8) Select lever/gear position indicator
(9) X-MODE indicator light
(10) Set vehicle speed display
(11) Your vehicle indicator
(12) Lane Indicator
(13) Lane Keep Assist indicator
(14) Following distance setting indicator
(15) Lead vehicle indicator
(16) Warning screen area
(17) EyeSight temporary stop indicator (White)
(18) EyeSight warning indicator (Yellow)
(19) Lane Departure Warning OFF indicator light
(20) Pre-Collision Braking System OFF indicator light
(21) Vehicle Dynamics Control warning light
(22) Electronic parking brake indicator light
(23) Brake system warning light
(24) Vehicle Dynamics Control OFF indicator light
(25) Auto Vehicle Hold operation indicator light
(26) Auto Vehicle Hold ON indicator light

■EyeSight warning indicator (yellow)

- This indicator illuminates or flashes when a malfunction occurs in the EyeSight system.
- When it is illuminated or flashing, none of the EyeSight functions can be used (including Adaptive Cruise Control and the Pre-Collision Braking System, etc.).

⇒ Refer to page 99.

■EyeSight temporary stop indicator (white)

- This indicator illuminates when the EyeSight system is temporarily stopped.
- When the ignition switch is placed in the ON position, it will illuminate if the (CRUISE) switch or (Lane Keep Assist) switch is set to ON within approximately 7 seconds of the engine starting. It turns off when approximately 7 seconds have elapsed since the engine started.
- When it is illuminated, none of the EyeSight functions can be used except for Conventional Cruise Control.

⇒ Refer to page 101.

■Auto Start Stop indicator (green) (also used both as Auto Start Stop warning indicator (yellow) and Auto Start Stop OFF indicator (yellow))

- This indicator illuminates in yellow when the ignition switch is turned to the ON position, and then it turns off after the engine starts.
- It illuminates in green while the Auto Start Stop system operates. It turns off after the engine restarts.
- It flashes in yellow if a malfunction occurs in the Auto Start Stop system.

■Auto Start Stop No Activity Detected indicator light

It illuminates in white when the Auto Start Stop system stops temporarily.

■X-MODE indicator light (if equipped)

The X-MODE indicator light illuminates when the X-MODE is ON.

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

■Lane Departure Warning OFF indicator light

- This indicator illuminates when the Lane Departure Warning and Lane Sway Warning are off.
- It also illuminates when the ignition switch is turned to the ON position. Approximately 7 seconds after the engine starts, the Lane Departure Warning OFF indicator light will turn off or remain illuminated depending on the current status (ON or OFF).

⇒ Refer to page 83.

■Pre-Collision Braking System OFF indicator light

- Illuminates when the Pre-Collision Braking System and Pre-Collision Throttle Management are off.
- It also illuminates when the ignition switch is turned to the ON position, and then turns off approximately 7 seconds after the engine starts.

⇒ Refer to page 39.

■Lane Indicator

This indicator illuminates in gray when the (Lane Keep Assist) switch is pressed. When the Lane Keep Assist is operational or operating, this indicator illuminates in white.

⇒ Refer to page 71.

■Brake System warning light

If the brake warning light illuminates when the electronic parking brake is released while driving, turn the Pre-Collision Braking System off. At this time, do not use the Conventional Cruise Control mode or Adaptive Cruise Control mode.
If the brake warning light does not turn off, immediately pull the vehicle over to a safe location. Contact a SUBARU dealer to have the system inspected.

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

■Electronic parking brake indicator light

This indicator light illuminates when the electronic parking brake is applied.

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

■Your vehicle indicator

When the brake pedal is depressed or the brake control function is activated, the brake indicator light illuminates in red.

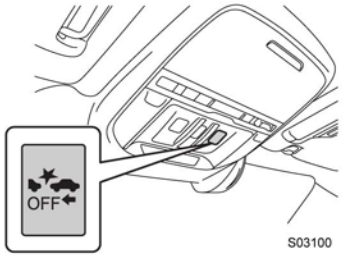
■Vehicle Dynamics Control OFF indicator light

- This indicator light illuminates when the ignition switch is turned to the "ON" position, and it turns off after approximately 2 seconds.
- This indicator light illuminates when the Vehicle Dynamics Control OFF switch is pressed and Vehicle Dynamics Control is off.

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

■ (Pre-Collision Braking System OFF) switch

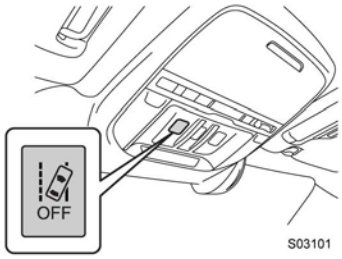
Press and hold this switch for approximately 2 seconds or longer to turn off the Pre-Collision Braking System and Pre-Collision Throttle Management.
When these functions are off, the Pre-Collision Braking System OFF indicator light on the instrument panel illuminates.
Press and hold the switch again to turn on the Pre-Collision Braking System and Pre-Collision Throttle Management. This turns off the Pre-Collision Braking System OFF indicator light.
⇒ Refer to page 38.



S03100

■ (Lane Departure Warning OFF) switch

Press and hold this switch for approximately 2 seconds or longer to turn off the Lane Departure Warning and Lane Sway Warning functions.
When these functions are off, the Lane Departure Warning OFF indicator light on the instrument panel illuminates.
Press and hold the switch again to turn on the Lane Departure Warning and Lane Sway Warning functions. This turns off the Lane Departure Warning OFF indicator light.
⇒ Refer to page 83.



S03101

Pre-Collision Braking System

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

⚠ WARNING

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

Continued on next page ⇒

⇒ Continued from previous page

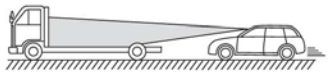
- When the difference in speed with the obstacle in front is the following figure*1 or more, it may not be possible to avoid a collision. Even if the speed difference is the following figure*1 or less, in cases such as when another vehicle cuts in front of you, or in other cases depending on visibility,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

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

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

- Distance to obstacle in front of you, speed difference, proximity conditions, lateral displacement (the amount of offset)
- Vehicle conditions (amount of load, number of occupants, etc.)
- Road conditions (grade, slipperiness, shape, bumps, etc.)
- When visibility ahead is poor (rain, snow, fog or smoke, etc.)
- When the detected object is something other than a vehicle, motorcycle, bicycle or pedestrian
  - A domestic animal or other animal (a dog or deer, etc.)
  - A guardrail, telephone pole, tree, fence or wall, etc.
- Even if the obstacle is a motorcycle, bicycle or pedestrian, depending on the brightness of the surroundings as well as the relative movement, and aspect or angle of the object, there may be cases when the system cannot detect it.
- When the system determines that operation by the driver (based on accelerator pedal operation, braking, steering wheel angle, etc.) is intended as evasive action
- Vehicle maintenance status (brake systems, tire wear, tire pressure, whether a temporary spare tire is being used, etc.)
- When towing a trailer or another vehicle, etc.
- When the brakes are cold due to outside temperature being low or just after starting the engine.
- When the brakes are overheated on downhill grades (braking performance is reduced)
- When driving in rain or after washing the vehicle (the brakes are wet and braking performance is reduced)
- Recognition conditions of the stereo camera
  In particular, the function may be unable to stop the vehicle or may not activate in the following cases.
  - Bad weather (for example heavy rain, a blizzard or thick fog)
  - When visibility is poor due to sand, smoke or water vapor blowing in the wind, or when the front vision is obscured due to water splashes, snow, dirt or dust stir up generated by the vehicle in front or oncoming traffic
  - When driving at night or in a tunnel without the headlights on

- When driving at night or in a tunnel when there is a vehicle in front that does not have its taillights on
- When approaching a motorcycle, bicycle or pedestrian at night
- When ambient light is poor in the evening or early morning
- When a vehicle, motorcycle, bicycle or pedestrian is outside the area illuminated by the headlights
- When affected by strong light from the front (for example, sunlight at dawn, sunset or headlight beams, etc.)
- When the windshield has become fogged, scratched, or snow, dirt, dust or frost has adhered to it, or it is otherwise affected.
- When fluid has not been fully wiped off the windshield during or after washer use
- When the target cannot be correctly recognized because the stereo camera's view is obstructed by water droplets from rain or the window washer, or by the wiper blades.
- When the stereo camera's field of view is obstructed (for example by a canoe on the roof of the vehicle)
- When the rear aspect of the vehicle in front is low, small or irregular (the system may recognize another part of the vehicle as its rear and will determine operation from that)
  - When there is an empty truck or trailer with no rear and/or side panels on the cargo bed
  - With vehicles that have cargo protruding from their back ends



S02133

  - With non-standard shaped vehicles (vehicle transporters or vehicles with a sidecar fitted, etc.)
  - When the height of the vehicle is low, etc.
- When there is a wall, etc. in front of a stopped vehicle
- When there is another object near the vehicle
- When a vehicle, etc. has its side facing you.
- With vehicles that are backing up or with oncoming vehicles, etc.
- When the size and height of an obstacle is smaller than the limitations of the stereo camera's recognition capability
  - With small animals or children, etc.
  - With pedestrians who are sitting or lying down

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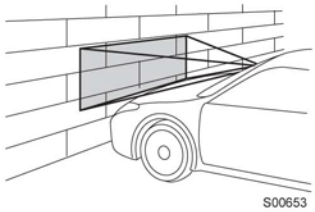
- When the detected object is a fence or wall, etc. with a uniform pattern (a striped pattern or brick pattern, etc.)
- When there is a wall or door made of glass or a mirror in front
- When the vehicle in front suddenly swerves, accelerates, or decelerates.
- When a vehicle, motorcycle, bicycle or pedestrian suddenly cuts in from the side or suddenly runs in front of you.


S00653

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

- Do not test Pre-Collision Braking System on its own. It may operate improperly and cause an accident.
- The system may not operate correctly under the conditions listed below. When these conditions occur, turn off the Pre-Collision Braking System.
  - The tire pressure is not correct.*1
  - The temporary spare tire is installed.*1
  - Tires that are unevenly worn or tires with uneven wear patterns are installed.*1
  - Tires that are the wrong size are installed.*1
  - A flat tire has been fixed temporarily with a tire repair kit.
  - The suspension has been modified (including a genuine SUBARU suspension that has been modified).
  - An object that obstructs the stereo camera's view is installed on the vehicle.
  - The headlights are dirty or they have snow and ice or dirt on them. (Objects are not correctly illuminated and are difficult to detect.)

- The optical axes are not aligned correctly. (Objects are not correctly illuminated and are difficult to detect.)
- The lights including headlights and fog lights have been modified.
- Vehicle operation has become unstable due to an accident or malfunction.
- The brake system warning light is illuminated in red.*2
- A heavy cargo is loaded onto or inside the vehicle.
- The maximum number of occupants is exceeded.
- The combination meter is not operating properly; such as when the lights do not illuminate, the beeps do not sound, the display is different from when it is normal, etc.*3

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

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

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

⚠ CAUTION

- In the following situations, turn off the Pre-Collision Braking System. Otherwise the Pre-Collision Braking System may activate unexpectedly.
  - When the vehicle is being towed
  - When loading the vehicle onto a carrier
  - When a chassis dynamometer, free-rollers or similar equipment is used
  - When a mechanic lifts up the vehicle, starts the engine and spins the wheels freely
  - When passing hanging banners, flags or branches, or when thick/tall vegetation is contacting the vehicle
  - When driving in sport mode such as on a circuit

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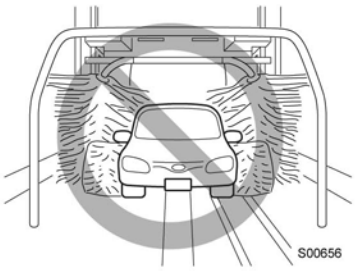
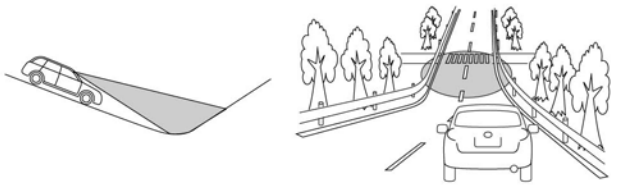
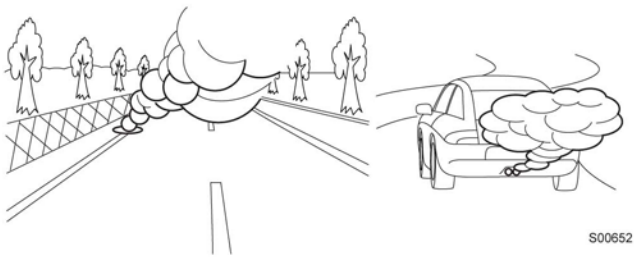
- When using a drive-through car wash



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

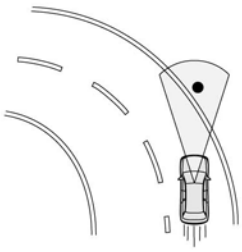


  - When visibility is poor due to sand, smoke or water vapor blowing in the wind, or when the front vision is obscured due to water splashes, snow, dirt or dust stir up generated by the vehicle in front or oncoming traffic
  - When passing through clouds of steam or smoke, etc.
  - When driving in adverse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

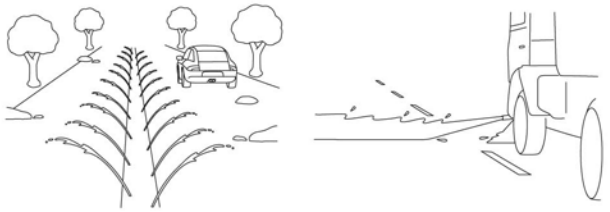


S00652

- When there is an obstacle on a curve or intersection
- When narrowly passing a vehicle or an object
- When stopping very close to a wall or a vehicle in front
- When passing through water spray from road sprinklers or snow clearing sprinklers on the road.



S02669



S02636

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

NOTE

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

■Detection of pedestrians

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

S00693

WARNING

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

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

Pre-Collision Braking System operation

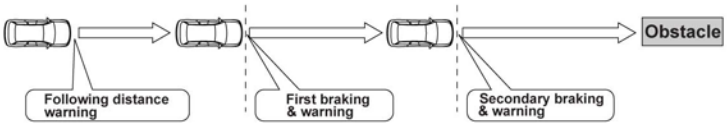
When there is an obstacle in front of you during driving, the system activates in the following sequence in order to warn the driver, activate braking control, and active the brake lights.

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

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

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

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



Possible collision area **Highly possible collision area** **Extremely highly possible collision area**

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

S03104

NOTE

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

- Neither first braking nor secondary braking will operate in the following cases.
  - When the vehicle speed is approximately 1 MPH (1 km/h) or less (When the select lever is in the [N] position and your vehicle speed is approximately 2 MPH (4 km/h) or less) or 100 MPH (160 km/h)* or more
    *: For Mexico models, 200 km/h.
  - When Vehicle Dynamics Control is active
- If the system detects the brake lights of the vehicle in front, your vehicle will start decelerating earlier than if it does not.
- There are some cases where the first braking is applied for a longer period of time. One of the reasons for this is due to a large speed difference with an obstacle in front. In those cases, stronger or weaker braking control may be activated.

■Pre-Collision Braking System operation indicator

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

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

The message appears and stays in the warning screen area of the combination meter display to indicate that the Pre-Collision Braking System has activated.

S03130

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

A message appears and stays in the warning screen area of the combination meter display to indicate that the Pre-Collision Braking System has activated. At this time the buzzer (beep) sounds. It will continue to sound for approximately 2 minutes until the driver depresses the brake pedal.

S03129

If the brake pedal is not depressed after a certain amount of time has passed, the screen changes to the message “Apply Brake To Hold Position” to urge the driver to depress the brake pedal. This screen will be displayed for approximately 2 minutes until the driver depresses the brake pedal.

S02962

List of buzzer sounds

Buzzer sound	Status	Reference page
Single continuous beep	Pre-Collision Braking System: Secondary Braking is active.	⇒ Refer to page 33.
1 short beep and 1 long beep	Adaptive Cruise Control or Conventional Cruise Control is canceled automatically.	⇒ Refer to pages 61 and 95.
	The electronic parking brake was automatically applied during the stay-stopped condition by Adaptive Cruise Control.	⇒ Refer to page 61.
	Lane Keep Assist is canceled automatically.	⇒ Refer to page 73.
Repeated short beeps	Pre-Collision Braking System: First Braking is active.	⇒ Refer to page 33.
	Pre-Collision Braking System: The following distance warning is active.	
	The "Obstacle Detected" warning from Adaptive Cruise Control is active.	⇒ Refer to page 64.
	Pre-Collision Throttle Management is active.	⇒ Refer to page 75.
3 short beeps	The Lane Departure Warning is active.	⇒ Refer to page 81.
	The Lane Sway Warning is active.	⇒ Refer to page 84.
5 intermittent beeps, 1 short beep and 1 long beep	The stay-stopped function of Adaptive Cruise Control continued for 2 minutes and the electronic parking brake is automatically applied.	⇒ Refer to page 58.
1 short beep	Either of the following occurred while Adaptive Cruise Control was set. - A vehicle in front is detected*. - A vehicle in front is no longer detected*.	⇒ Refer to page 49.
	The cruise control mode (Adaptive Cruise Control ⟷ Conventional Cruise Control) is changed.	⇒ Refer to pages 89 and 91.
	EyeSight is malfunctioning.	⇒ Refer to pages 99 and 101.
	EyeSight operation is temporarily stopped.	
	Pre-Collision Braking System and Pre-Collision Throttle Management are turned on/off.	⇒ Refer to pages 38 and 80.
	The Lane Departure Warning and the Lane Sway Warning are turned on/off.	⇒ Refer to pages 83 and 86.
Two-tone beep	Lead Vehicle Start Alert is active*.	⇒ Refer to page 87.

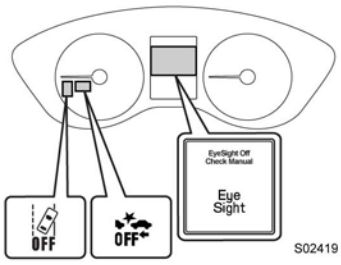
*: The buzzer that indicates when a lead vehicle is detected or when it is no longer detected (Lead Vehicle Acquisition Sound), as well as the Lead Vehicle Start Alert can be turned on or off.
⇒ Refer to page 103.

EyeSight malfunction and temporary stop

If a malfunction is detected in the EyeSight system, the indicators in the instrument panel and the combination meter display inform the driver of the malfunction. Check the displayed contents and take the appropriate action.

■Malfunction (including position/angle misalignment of stereo camera)

The buzzer sounds 1 short beep and the EyeSight warning indicator (yellow) flashes or illuminates. At the same time, the Pre-Collision Braking System OFF indicator light and the Lane Departure Warning OFF indicator light will illuminate. A message will also be displayed on the combination meter display.



S02419

Displayed screen	Cause	Action
EyeSight Off Check Manual S03005	An EyeSight malfunction or position/angle misalignment of stereo camera has occurred.	Inspection and adjustment is necessary. Contact your SUBARU dealer.

CAUTION

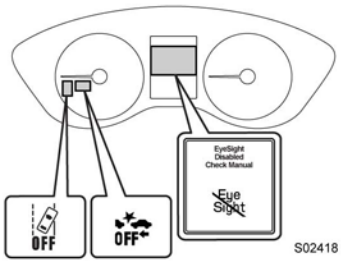
If both the EyeSight warning indicator and the CHECK ENGINE warning light/malfunction indicator light illuminate at the same time while driving, have your vehicle checked/repaired by a SUBARU dealer as soon as possible. EyeSight cannot be used if there is an abnormality with the engine, etc.

■Temporary stop

The buzzer will sound one short beep, and the EyeSight temporary stop indicator (white), Pre-Collision Braking System OFF indicator light and Lane Departure Warning OFF indicator light will illuminate at the same time.

A message will also be displayed on the combination meter display.

When the cause has been resolved, temporary stop will be canceled and the EyeSight system will automatically restart.



S02418

Displayed screen	Cause	Action
EyeSight Disabled No Camera View S02996	It is difficult for the stereo camera to detect objects in front • The windshield is dirty or fogged up • Poor weather conditions • Strong light from the front	• Clean the windshield. • In poor weather conditions or if there is strong light from the front, the EyeSight system will restart once you have driven your vehicle for a period of time and the conditions affecting the system have improved. If the system does not restart, even after the conditions have improved and a period of time has elapsed, contact your SUBARU dealer for an inspection.
EyeSight Disabled Temp Range S02997	In low or high temperatures	The system will restart once the temperature is within the operational range of the EyeSight system. If the system does not restart, even when the temperature inside the vehicle is within the operational range, contact your SUBARU dealer for an inspection.

■Message screen list (precautions and notices)

Item	Displayed screen	ℹ mark	Reference page
Pre-Collision Braking System	Obstacle Detected S02999	None	⇒ Refer to page 33.
The “Obstacle Detected” warning		None	⇒ Refer to page 64.
Pre-Collision Throttle Management		None	⇒ Refer to page 75.
Apply Brake	Apply Brake To Hold Position S03000	None	⇒ Refer to page 36.
Lane Departure Warning	Lane Departure S03002	None	⇒ Refer to page 81.
Lane Sway Warning	Stay Alert S03003	None	⇒ Refer to page 84.
Lead vehicle Start alert	Vehicle Ahead Has Moved S03004	None	⇒ Refer to page 87.
Steering operation is not detected by Lane Keep Assist	Keep Hands On Steering Wheel S03001	None	⇒ Refer to page 74.
Adaptive Cruise Control/Conventional Cruise Control automatic cancellation (when the grade of the road is very steep)	Steep Slope S02425	None	⇒ Refer to pages 61 and 95.

APPENDIX C

Run Log

Subject Vehicle: **2019 Subaru Forester** Test Date: **4/25/2019**

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	2.87	1.78	25.4	0.91	1.30	Pass	
3		Y	2.83	1.93	25.2	0.94	1.27	Pass	
4		Y	2.81	1.89	25.0	0.96	1.31	Pass	
5		Y	2.76	2.05	25.1	0.81	1.30	Pass	
6		Y	2.84	2.08	25.1	0.88	1.29	Pass	
7		Y	2.79	1.74	24.7	0.97	1.27	Pass	
8		Y	2.83	1.93	25.1	0.92	1.34	Pass	
9	Static Run								
10	**Slower POV, 25 vs 10**	Y	2.53	2.63	15.0	0.82	0.95	Pass	
11		Y	2.63	2.69	15.4	0.84	0.94	Pass	
12		Y	2.52	0.57	15.1	0.91	0.97	Pass	
13		Y	2.49	2.26	15.2	0.91	0.89	Pass	
14		N							Video Cut During Braking
15		Y	2.45	1.05	14.6	0.92	0.92	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
16		Y	2.50	3.29	14.7	0.81	0.89	Pass	
17		Y	2.45	1.17	14.7	0.92	0.95	Pass	
18	Static Run								
19	**Slower POV, 45 vs 20**	N							Throttle
20		Y	3.45	2.03	25.2	0.92	1.18	Pass	
21		Y	3.24	4.52	24.9	0.70	1.19	Pass	
22		Y	3.30	0.79	24.8	0.95	1.23	Pass	
23		Y	3.09	1.54	25.1	0.95	1.30	Pass	
24		N							POV Speed
25		Y	3.25	4.63	24.4	0.71	1.19	Pass	
26		Y	3.22	2.34	24.7	0.87	1.19	Pass	
27		Y	3.15	1.39	24.8	0.99	1.26	Pass	
28	Static run								
29	**Braking POV, 35**	Y	1.98	0.00	30.0	0.82	1.12	Pass	
30		Y	1.94	0.00	28.5	0.81	1.21	Pass	
31		Y	1.83	0.00	29.9	0.87	1.20	Pass	
32		Y	1.82	0.00	30.3	0.79	1.22	Pass	
33		Y	1.83	0.00	30.2	0.78	1.22	Pass	
34		Y	1.73	0.00	31.4	0.84	1.37	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
35		Y	1.92	0.00	29.3	0.76	1.13	Pass	
36	Static Run								
37	STP - Static Run								
38	**STP False Positive, 25**	Y				0.02		Pass	
39		Y				0.01		Pass	
40		Y				0.01		Pass	
41		Y				0.02		Pass	
42		Y	.			0.03		Pass	
43		N							Throttle
44		Y				0.01		Pass	
45		Y				0.00		Pass	
46	STP - Static Run								
47	**STP False Positive, 45**	Y				0.05		Pass	
48		Y				0.04		Pass	
49		Y				0.01		Pass	
50		Y				0.01		Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
51		N							SV Speed
52		Y				0.01		Pass	
53		Y				0.03		Pass	
54		Y				0.04		Pass	
55	STP - Static Run								

APPENDIX D

Time History Plots

LIST OF FIGURES

Description of Time History Plots

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

Time History Plot Description

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

- Stopped POV (SV at 25 mph)
- 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.

- 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.

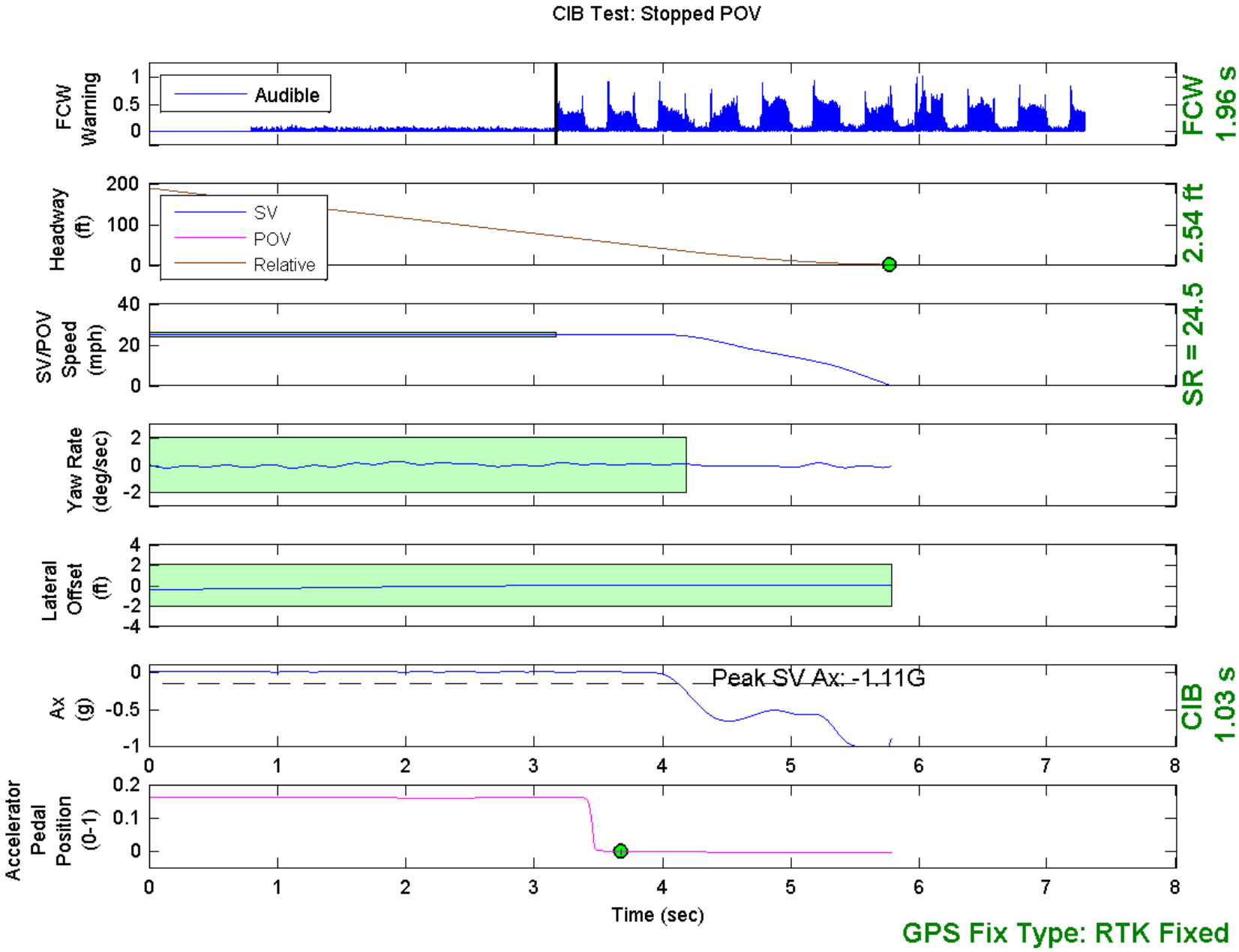


Figure D1. Example Time History for Stopped POV, Passing

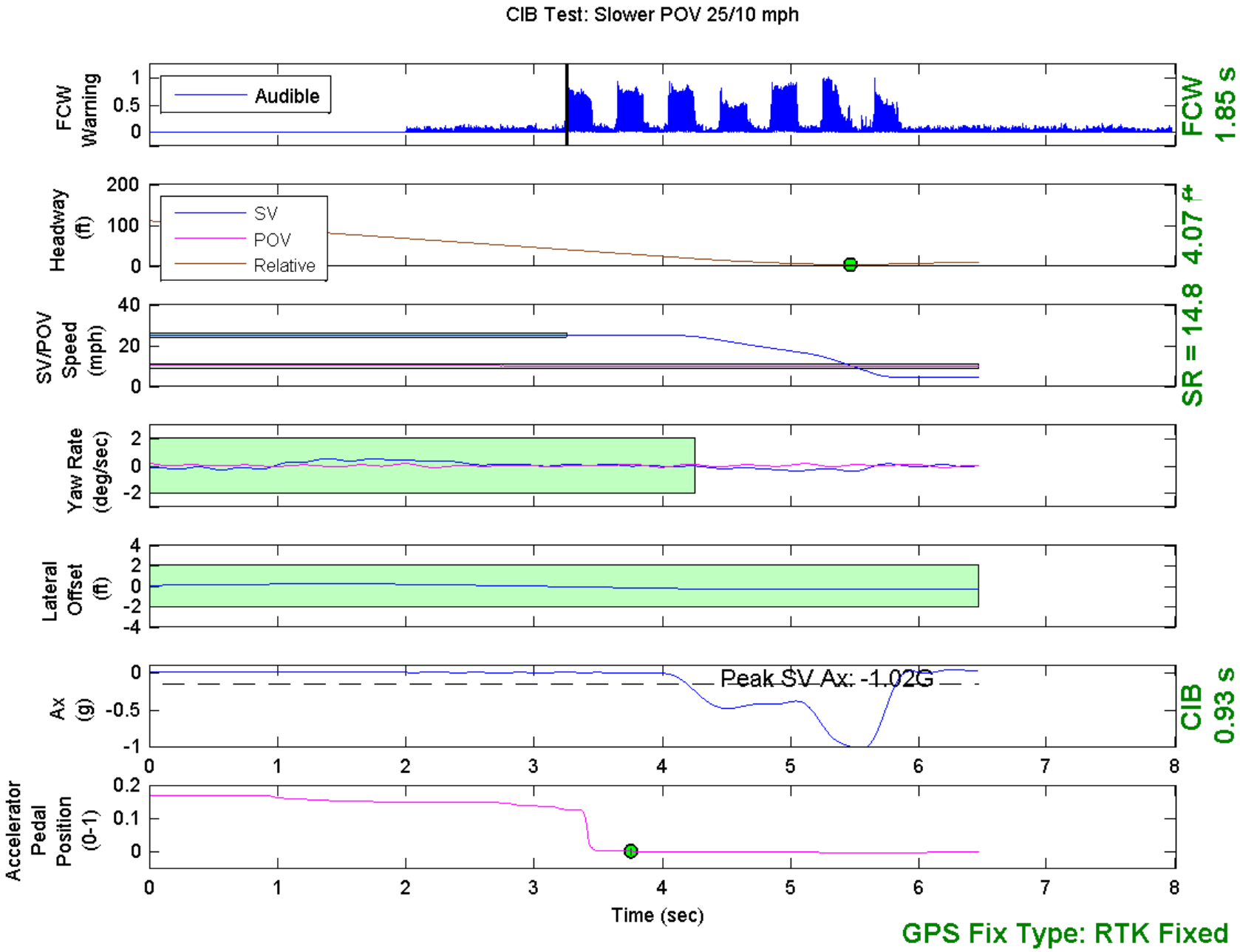


Figure D2. Example Time History for Slower POV 25 vs. 10, Passing

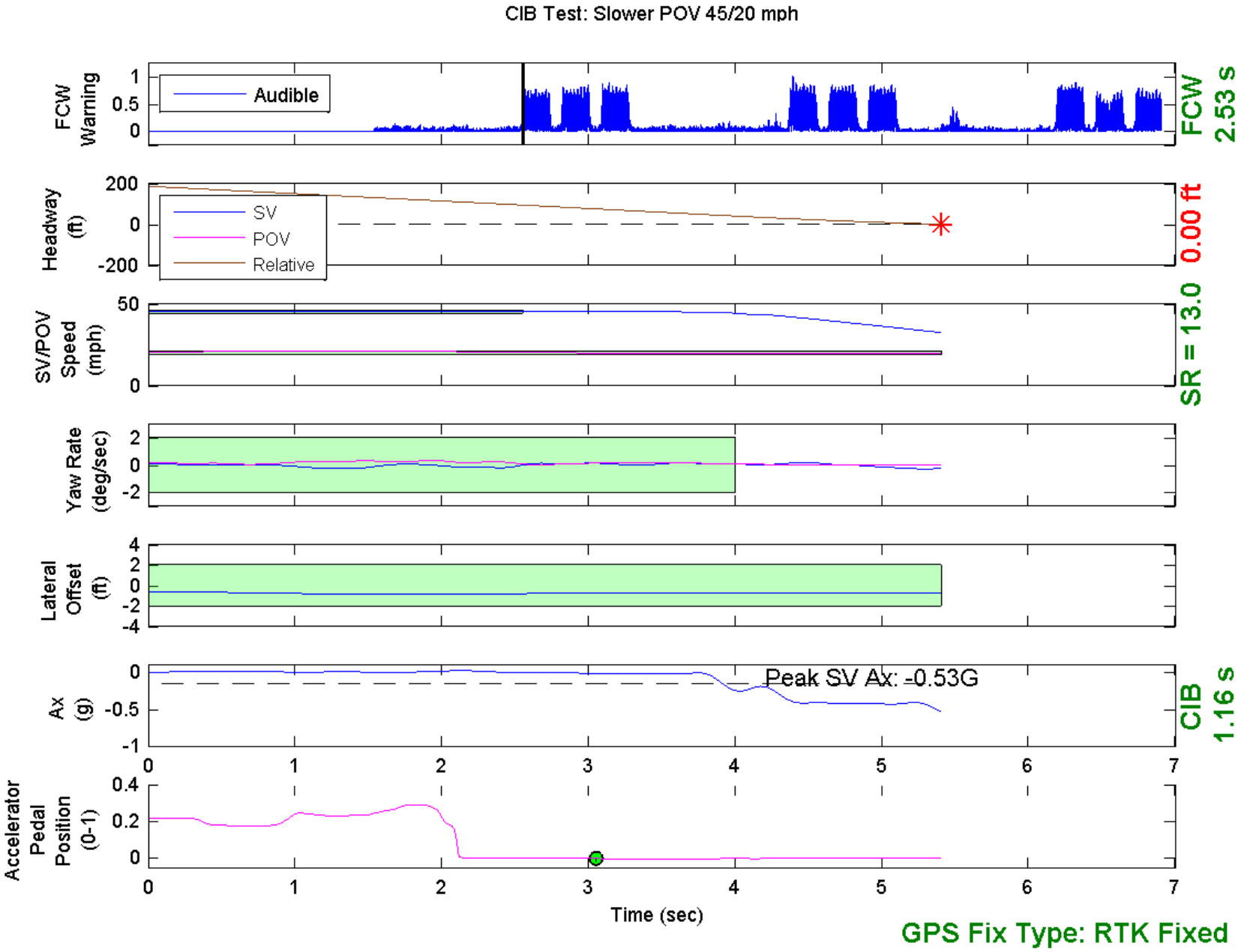


Figure D3. Example Time History for Slower POV 45 vs. 20, Passing

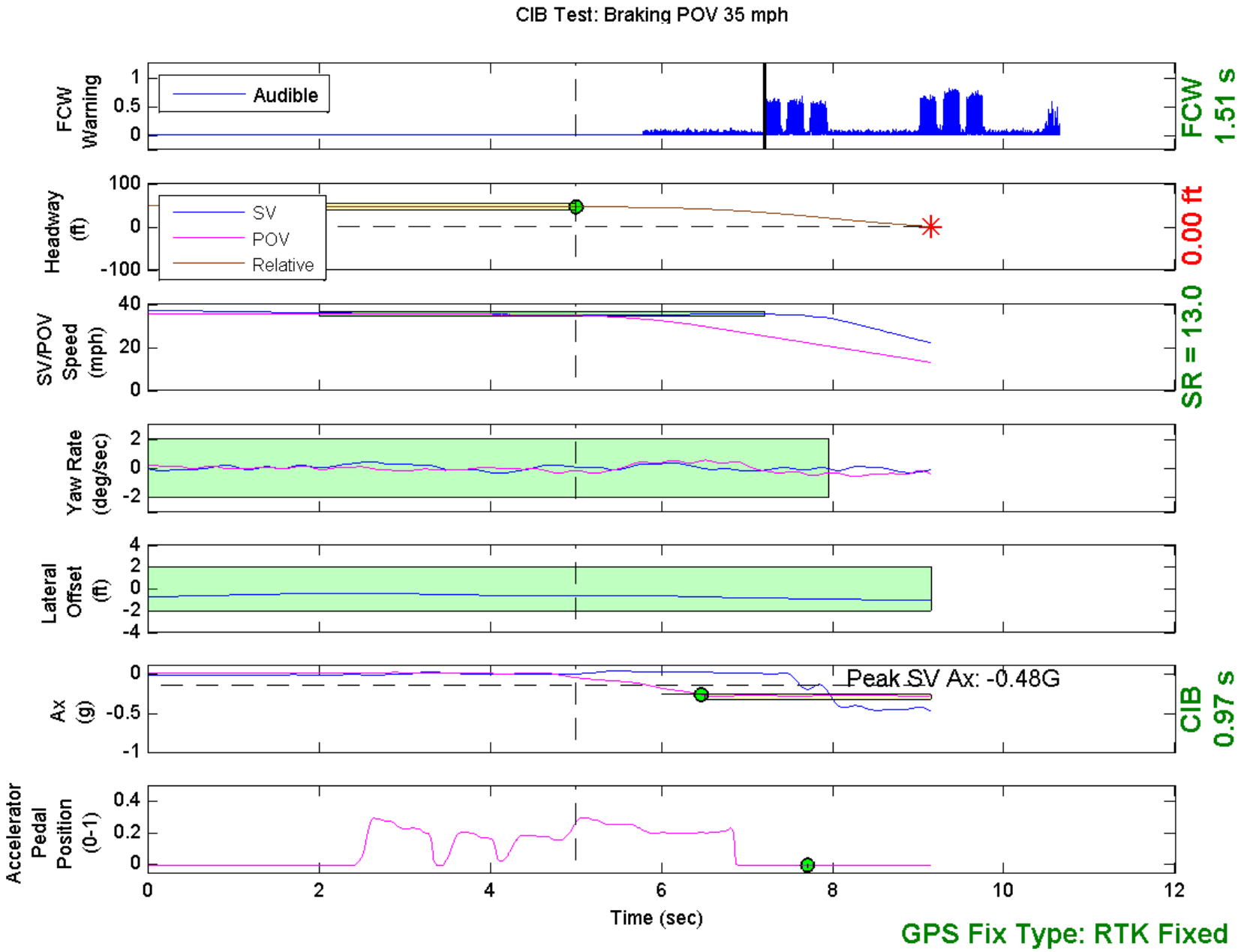


Figure D4. Example Time History for Braking POV 35, Passing

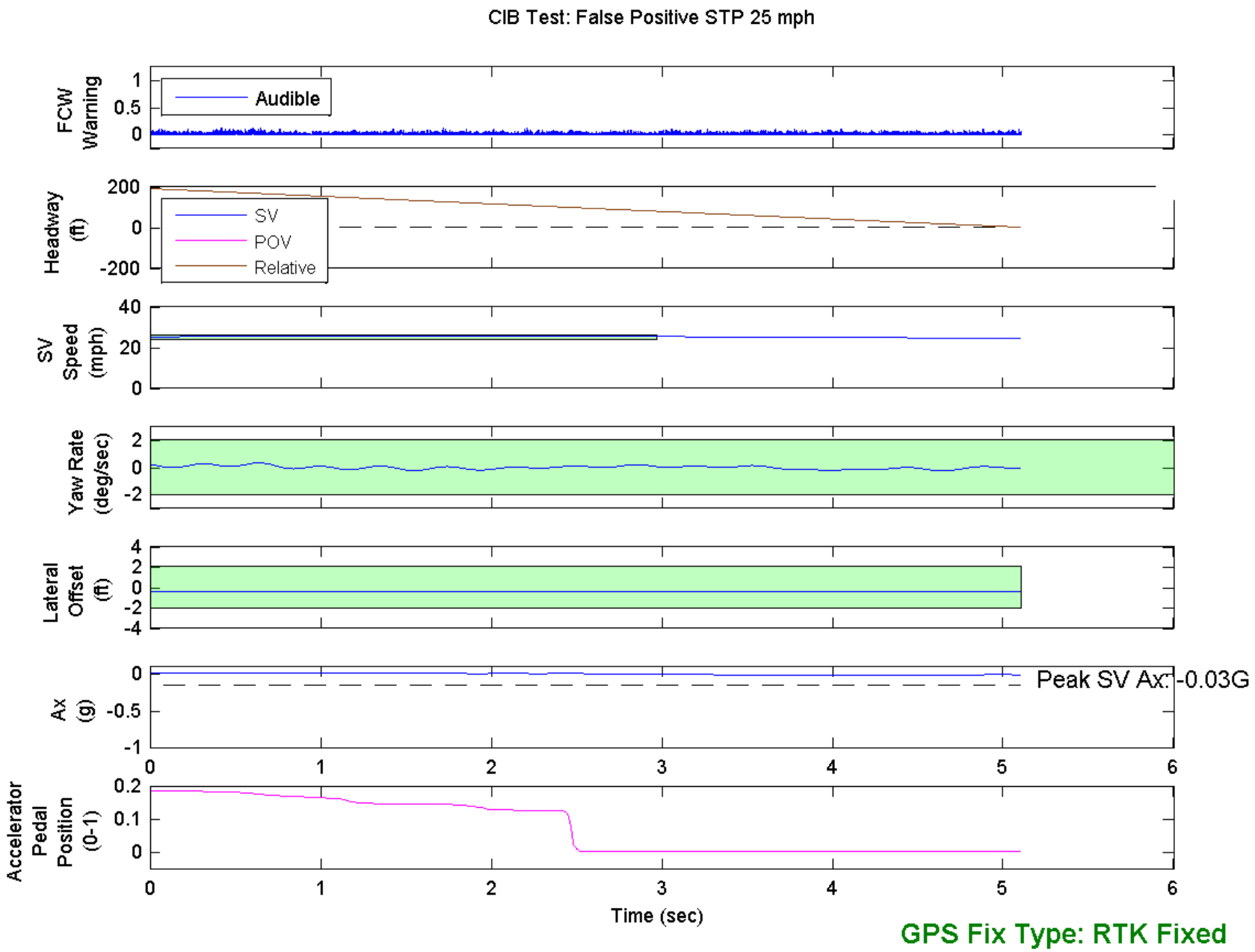


Figure D5. Example Time History for False Positive STP 25, Passing

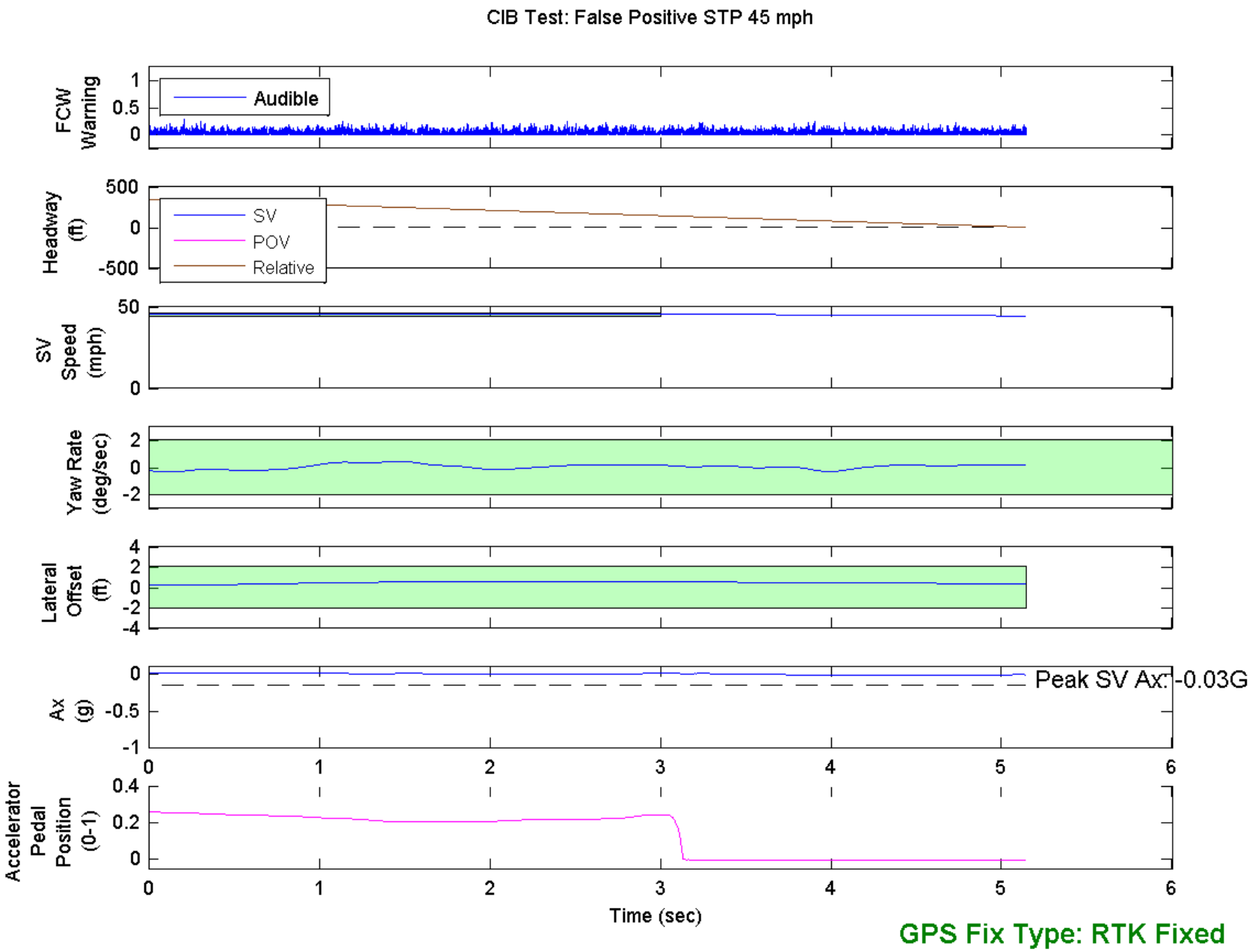


Figure D6. Example Time History for False Positive STP 45, Passing

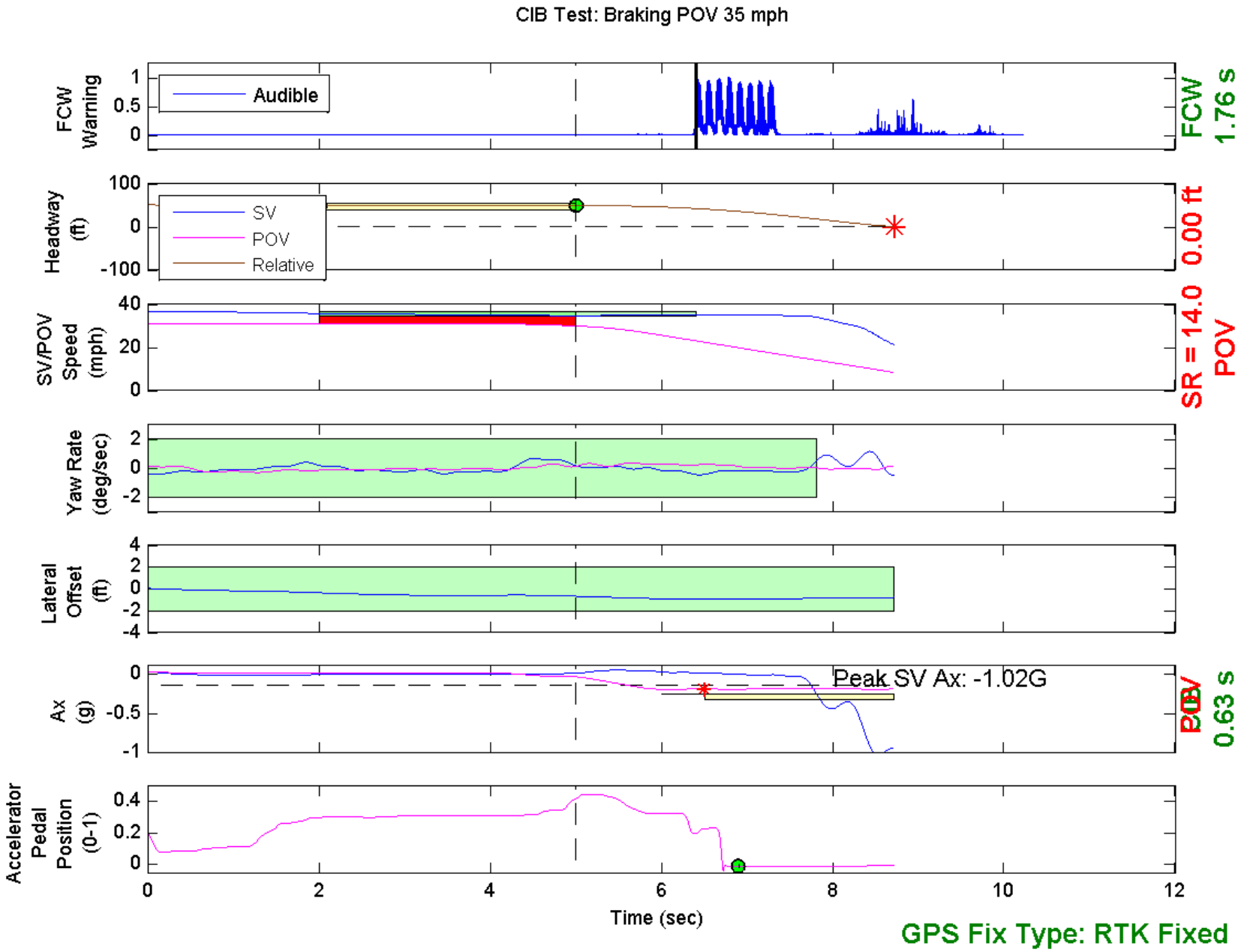


Figure D7. Example Time History Displaying Various Invalid Criteria

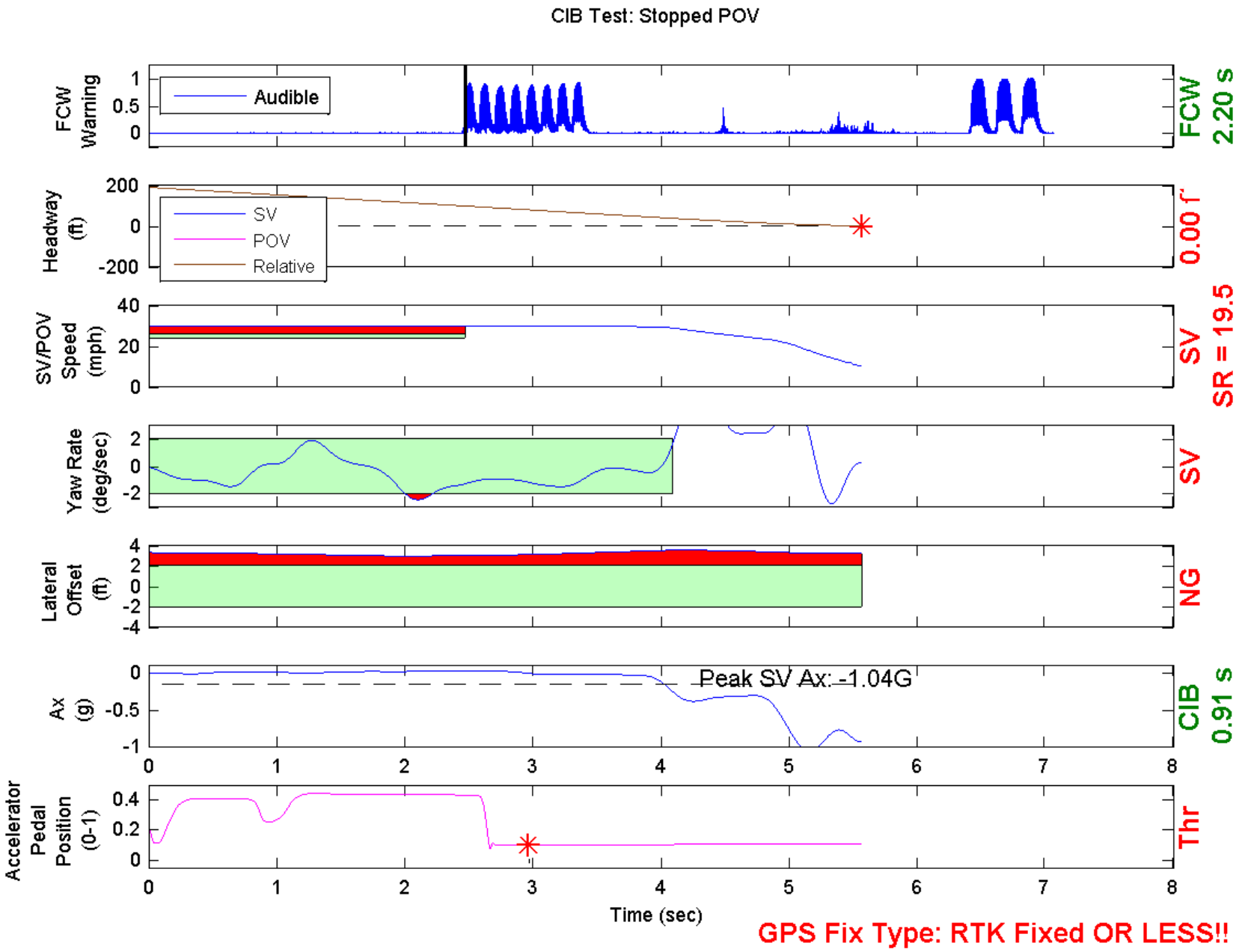


Figure D8. Example Time History Displaying Various Invalid Criteria

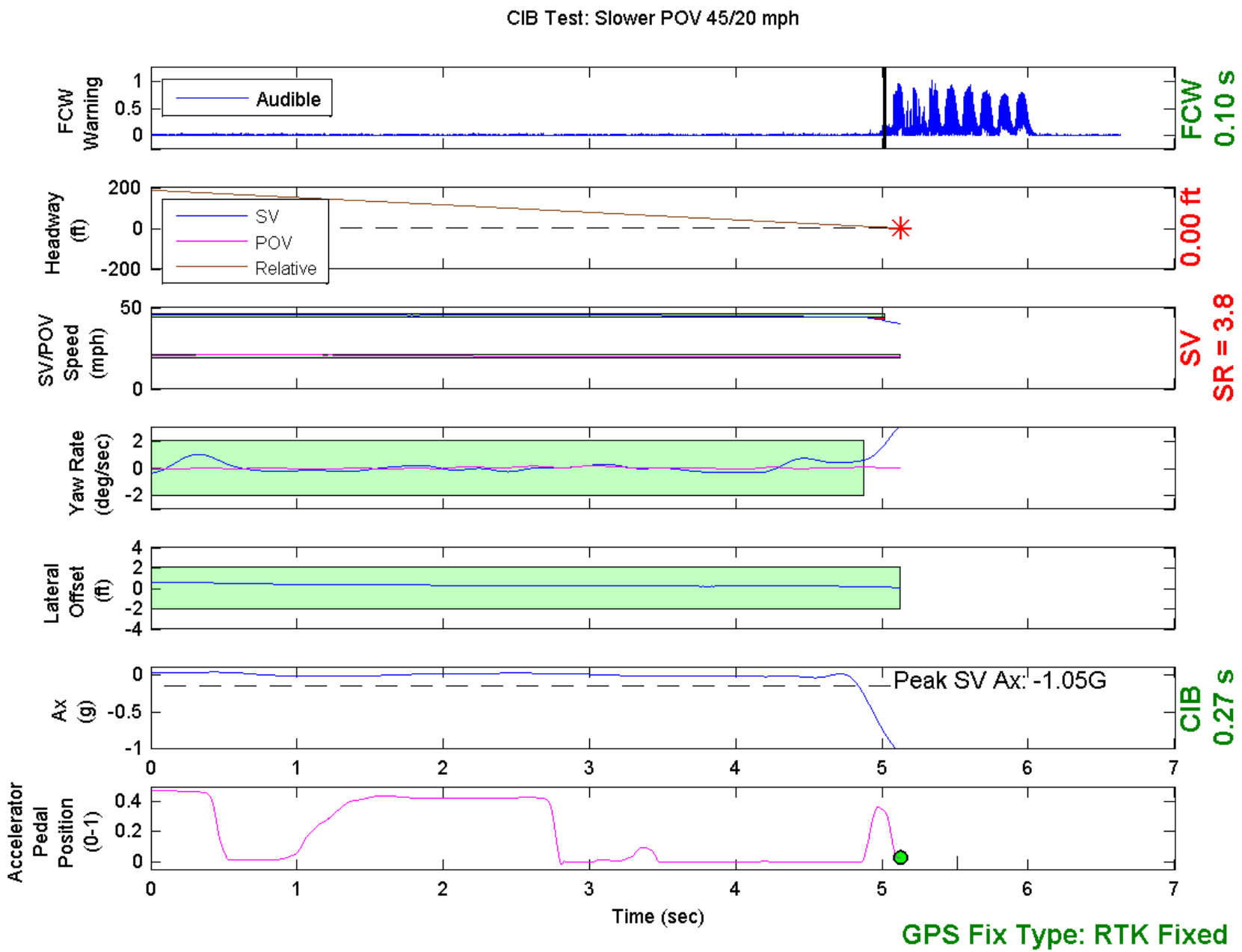


Figure D9. Example Time History for a Failed Run

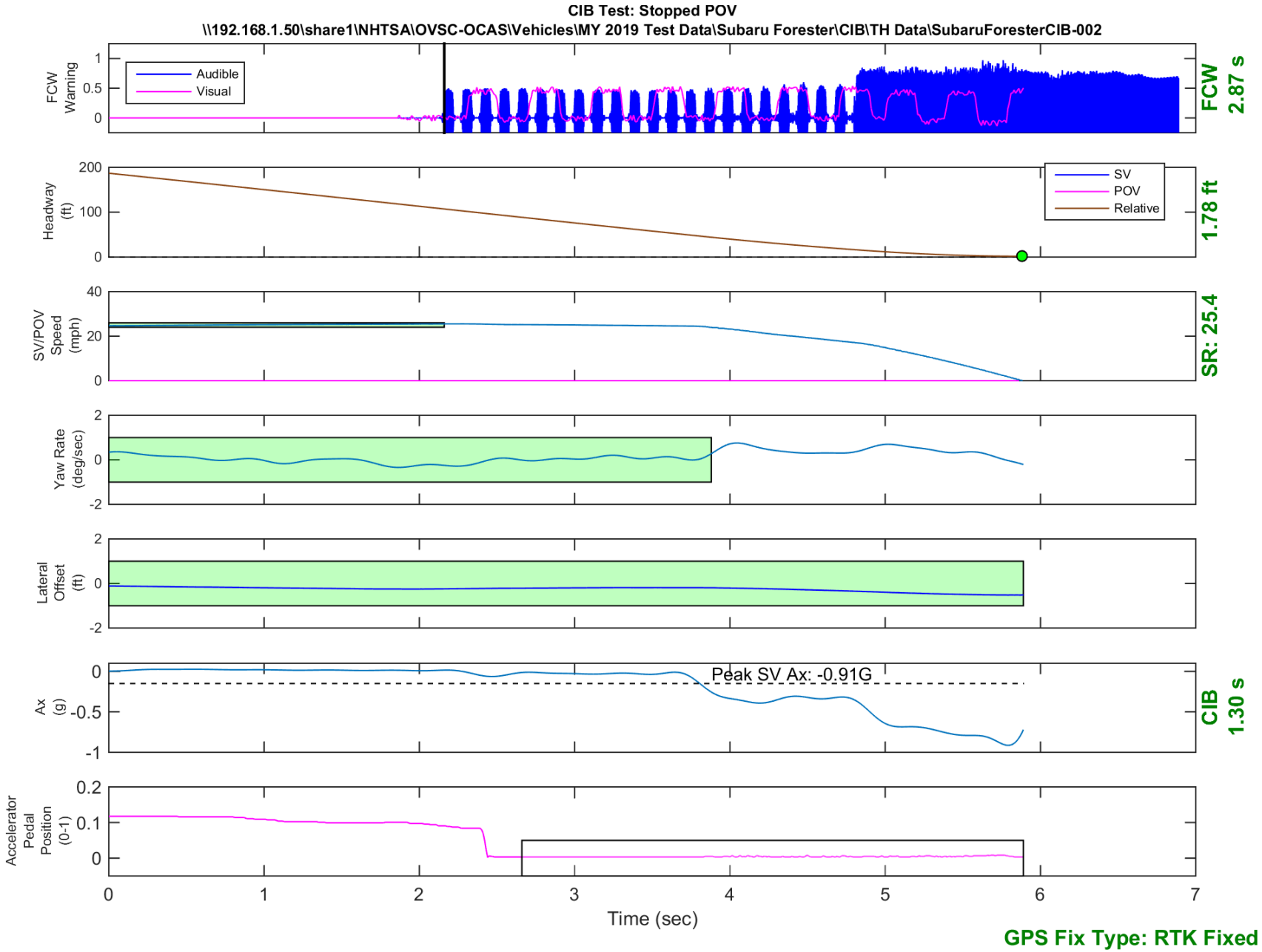


Figure D10. Time History for CIB Run 2, SV Encounters Stopped POV

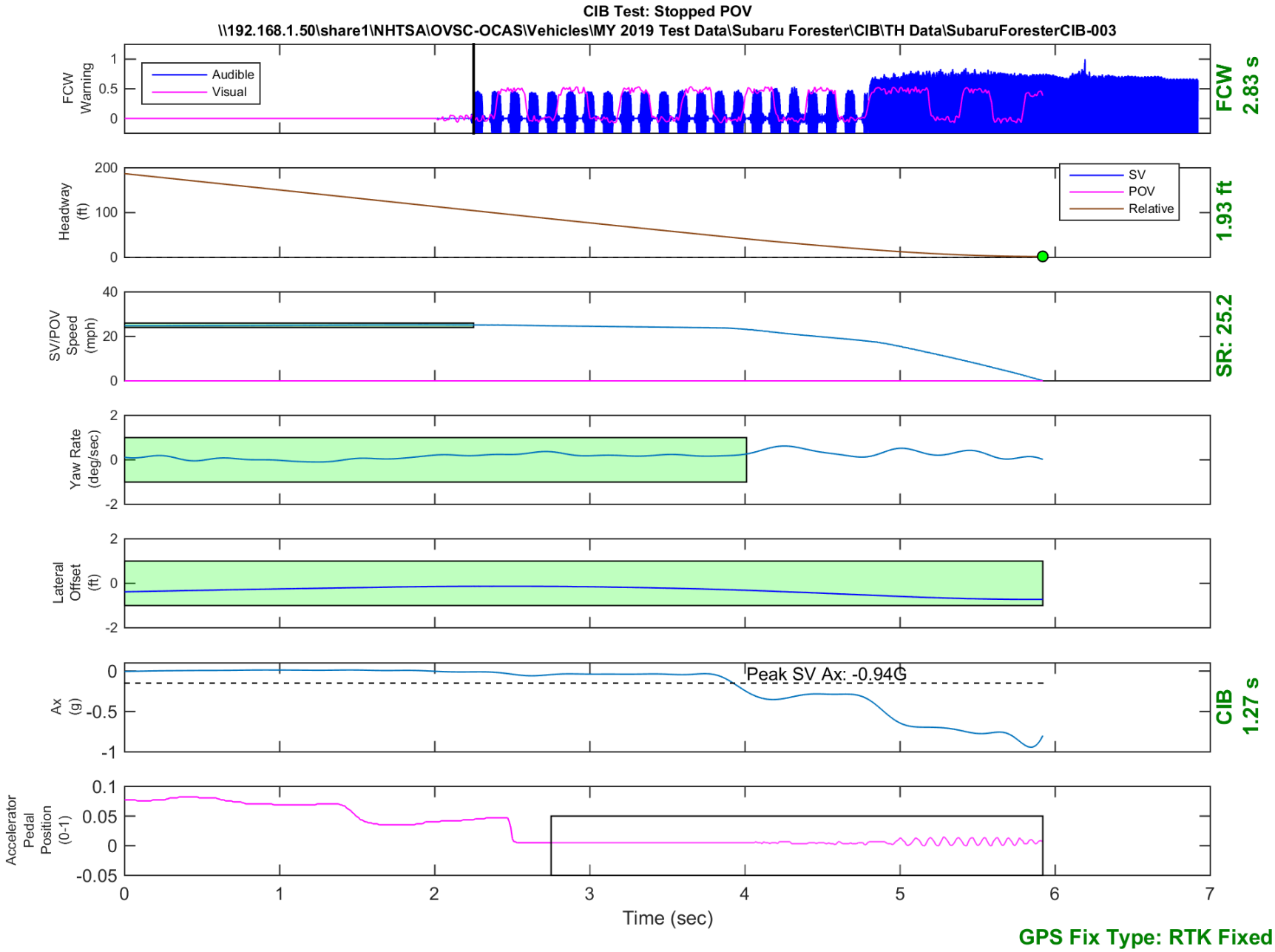


Figure D11. Time History for CIB Run 3, SV Encounters Stopped POV

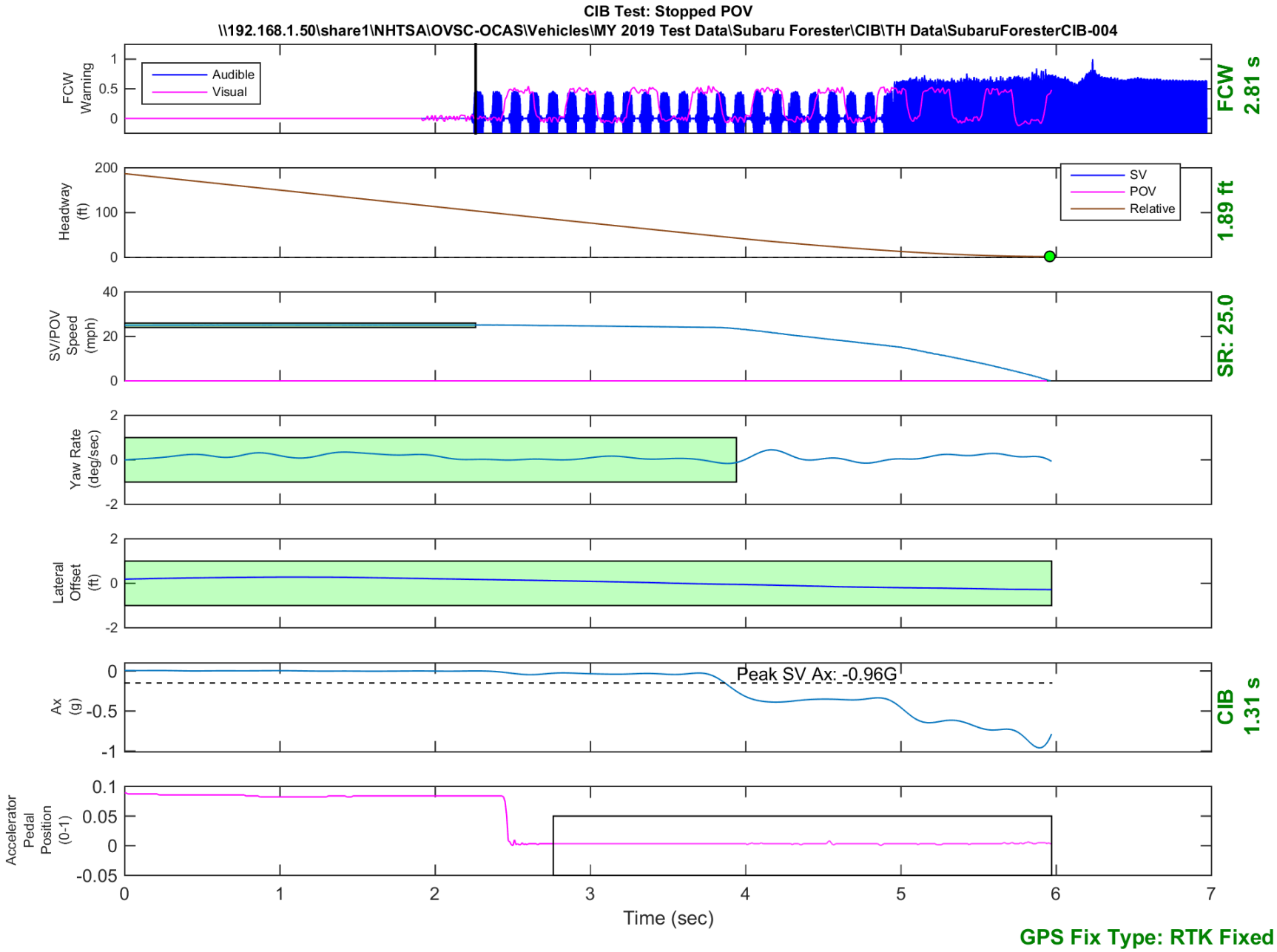


Figure D12. Time History for CIB Run 4, SV Encounters Stopped POV

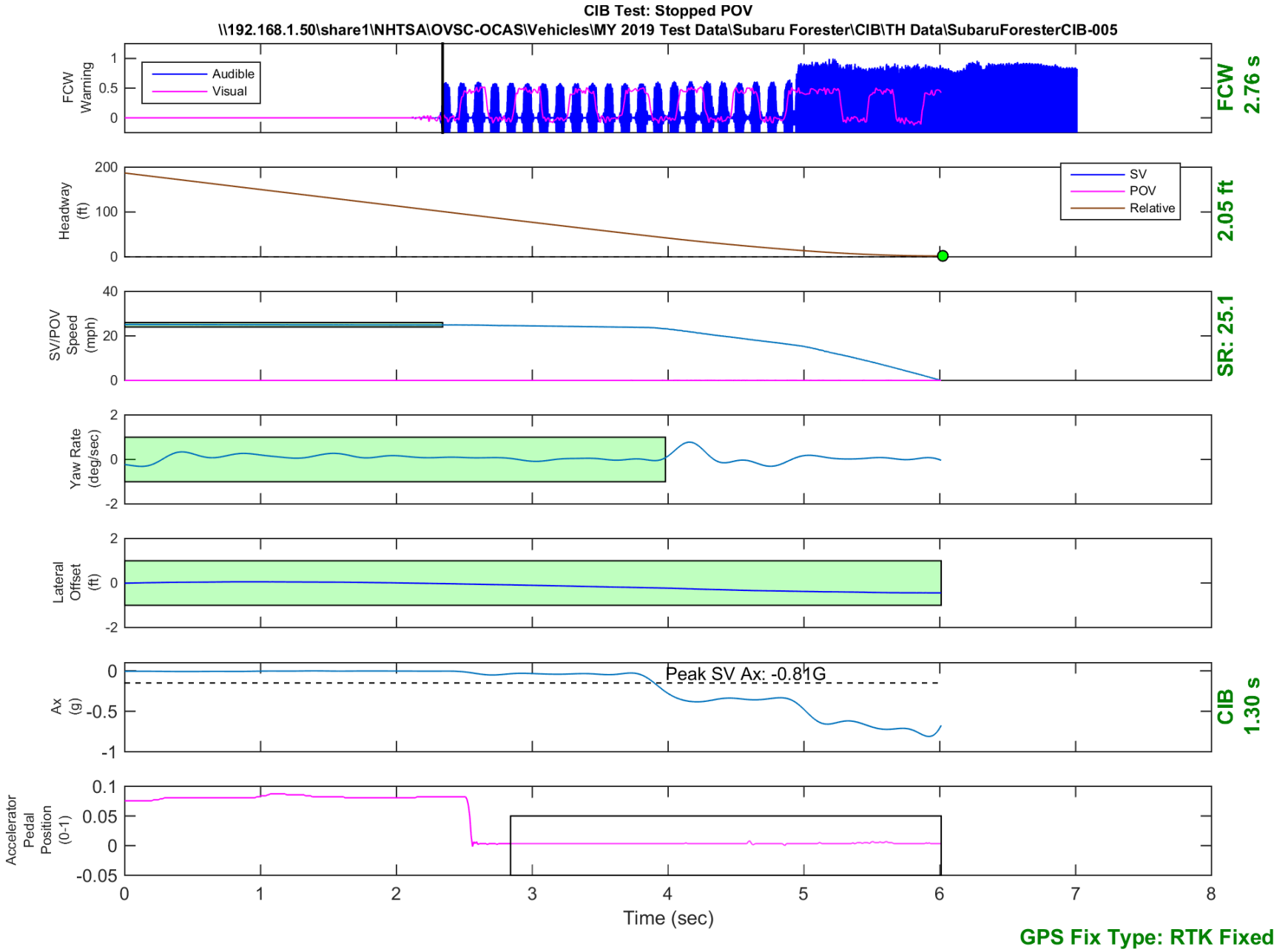


Figure D13. Time History for CIB Run 5, SV Encounters Stopped POV

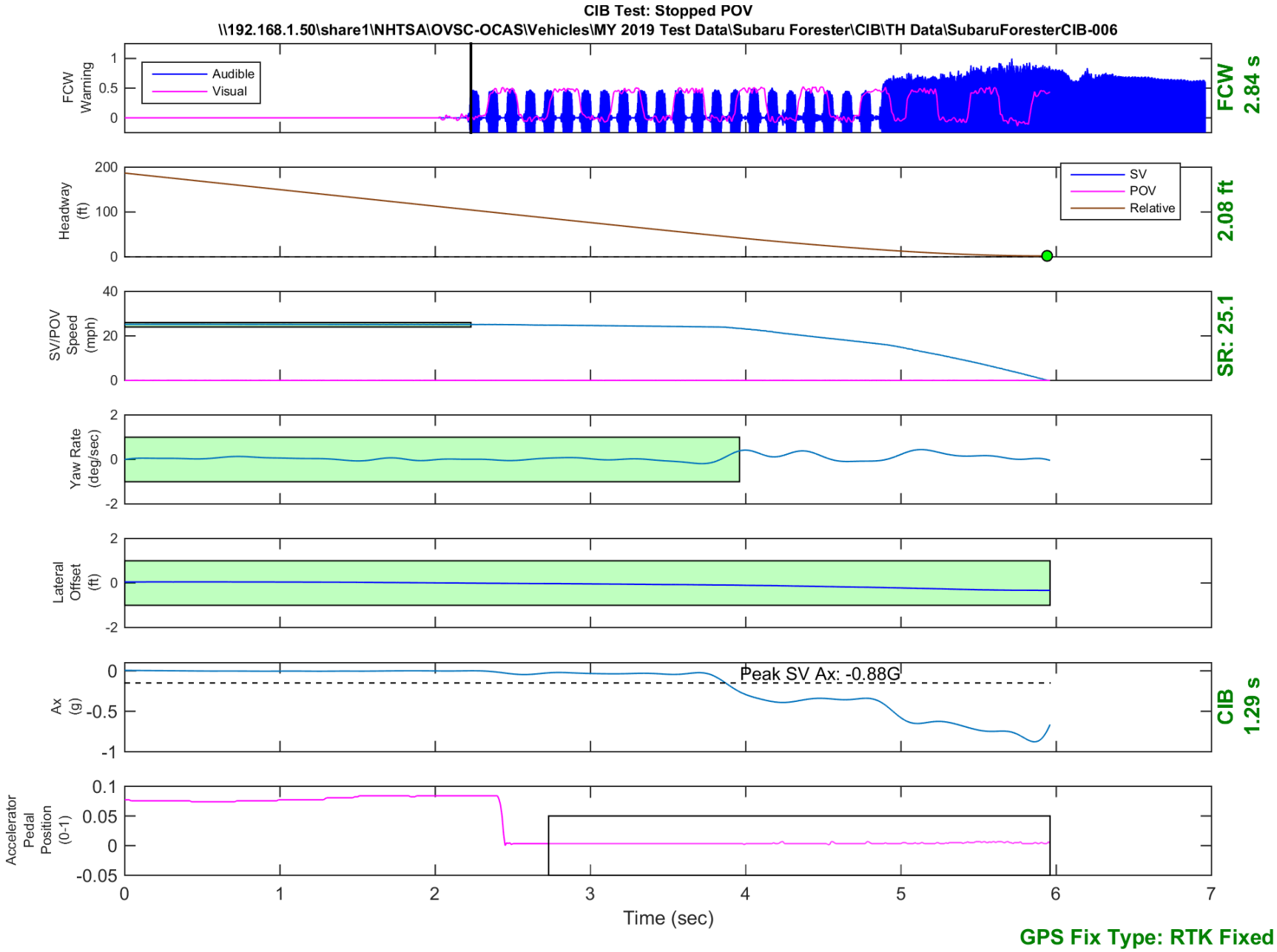


Figure D14. Time History for CIB Run 6, SV Encounters Stopped POV

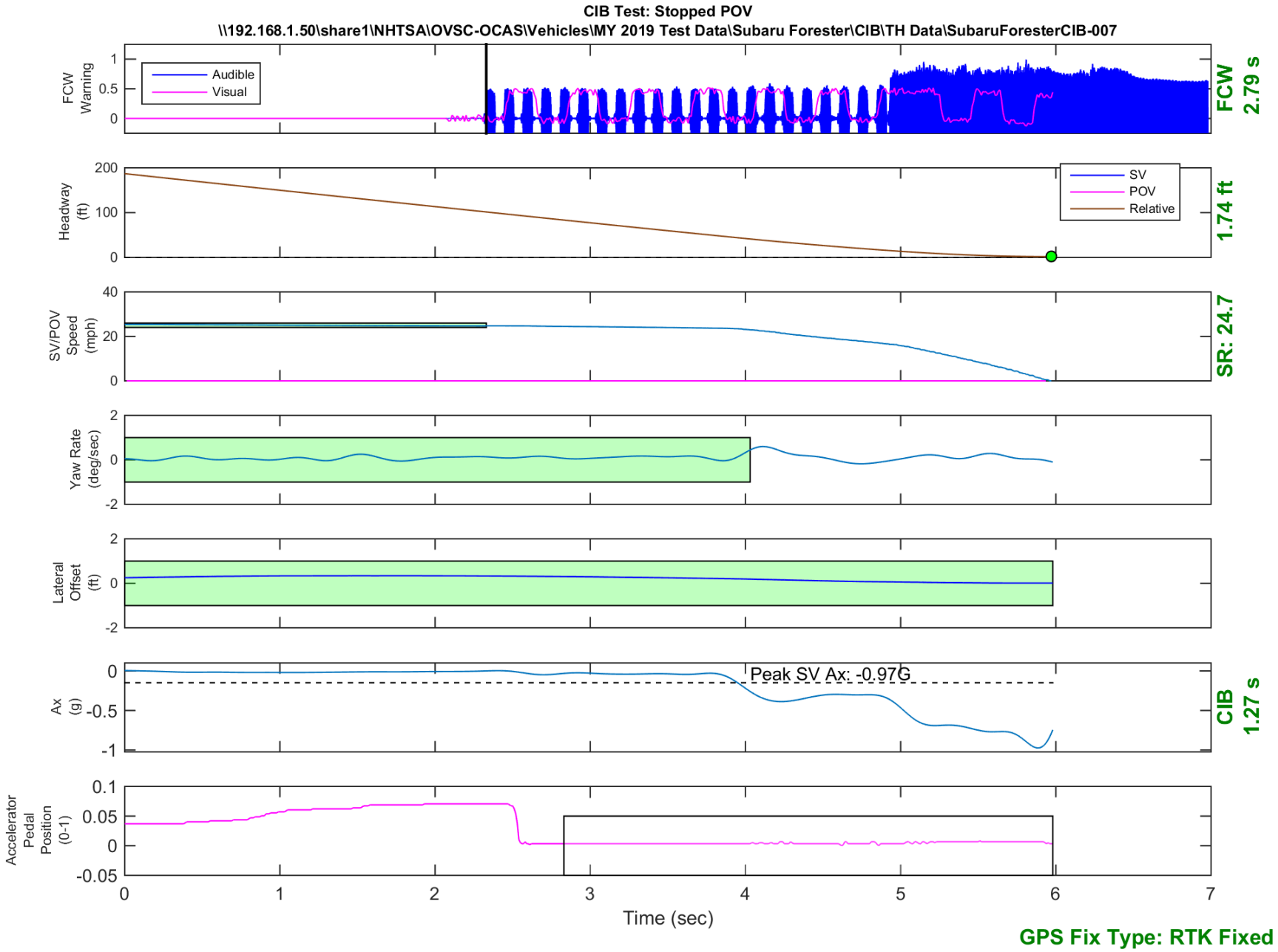


Figure D15. Time History for CIB Run 7, SV Encounters Stopped POV

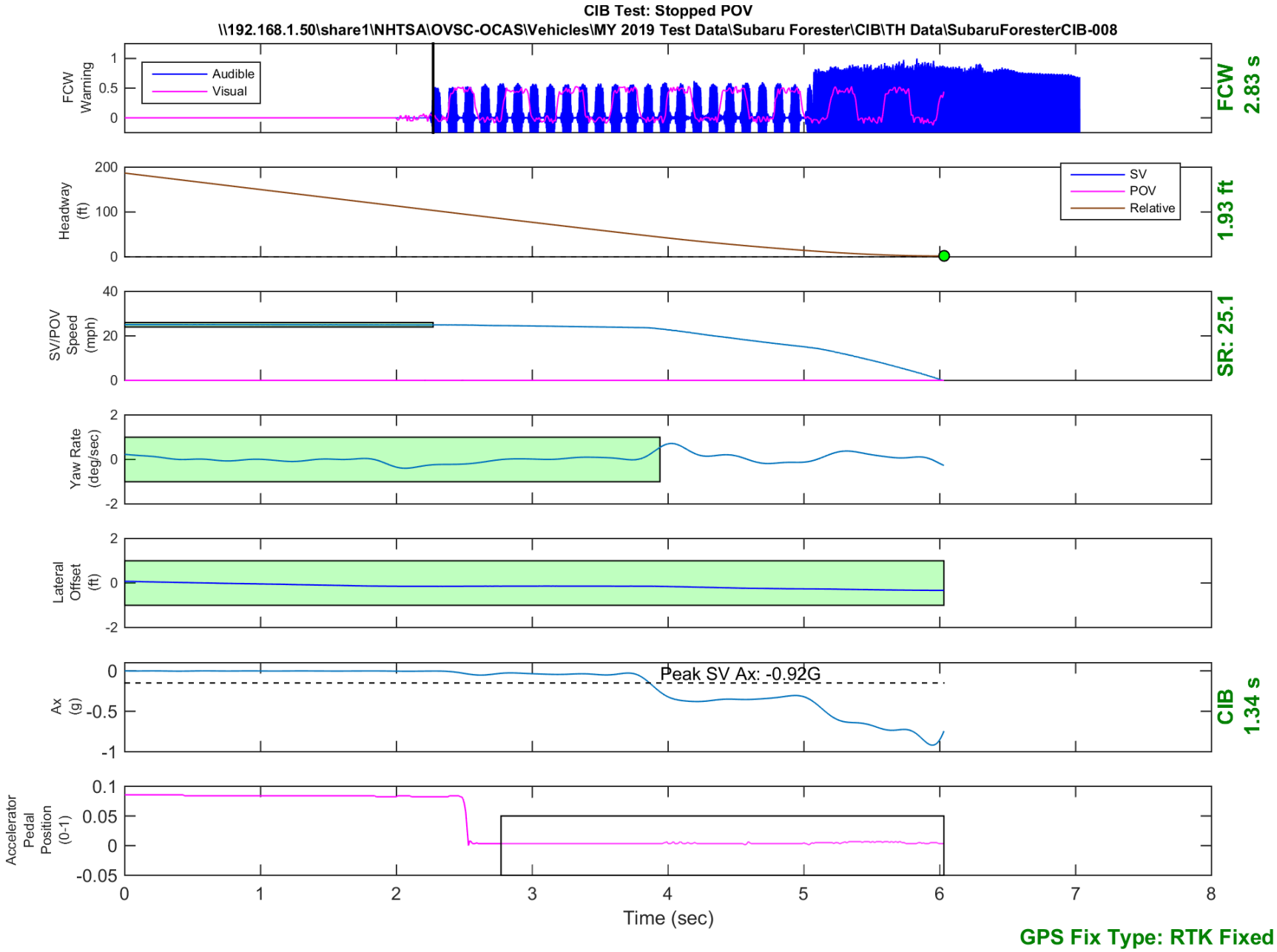


Figure D16. Time History for CIB Run 8, SV Encounters Stopped POV

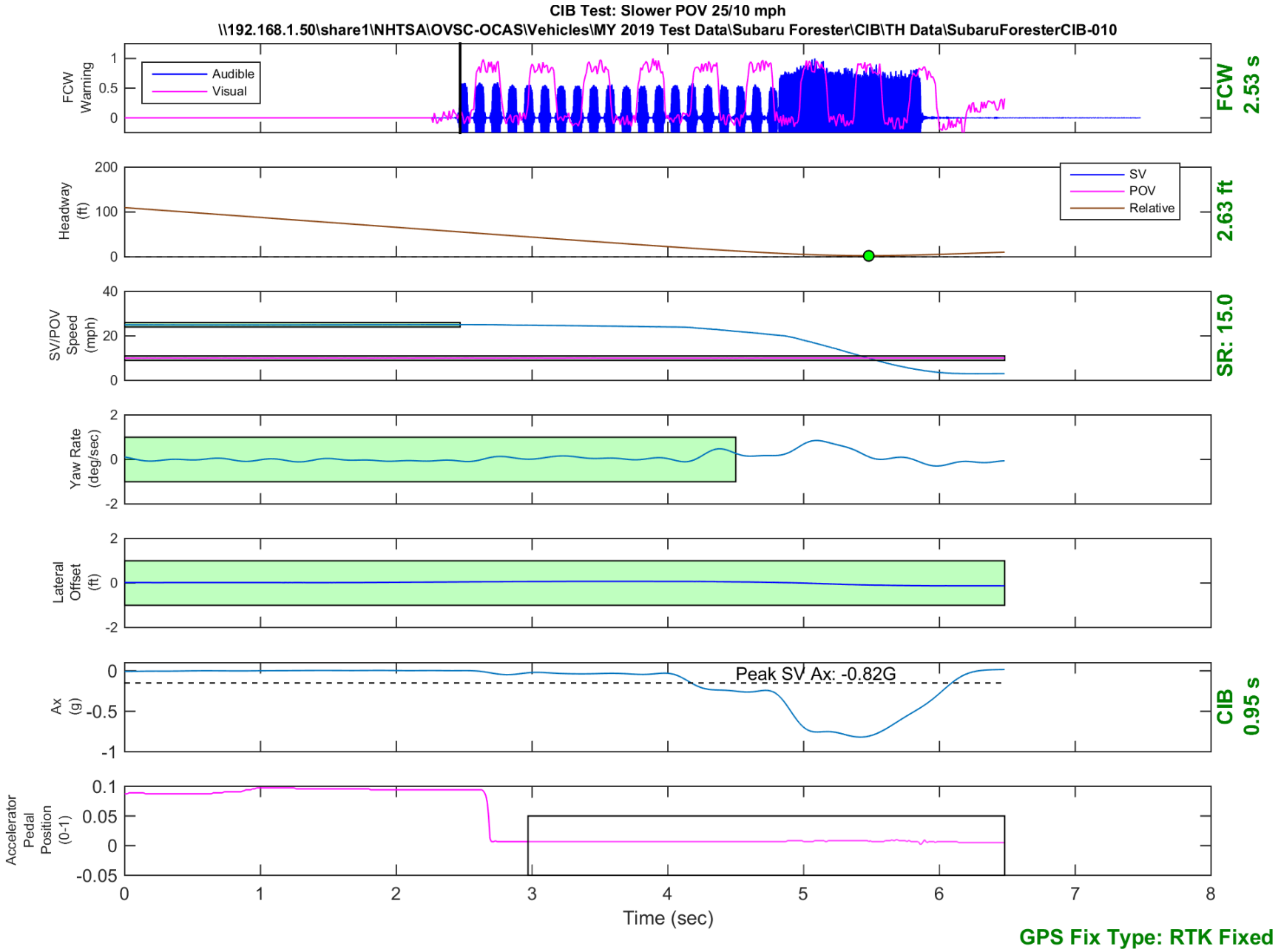


Figure D17. Time History for CIB Run 10, SV Encounters Slower POV, SV 25 mph, POV 10 mph

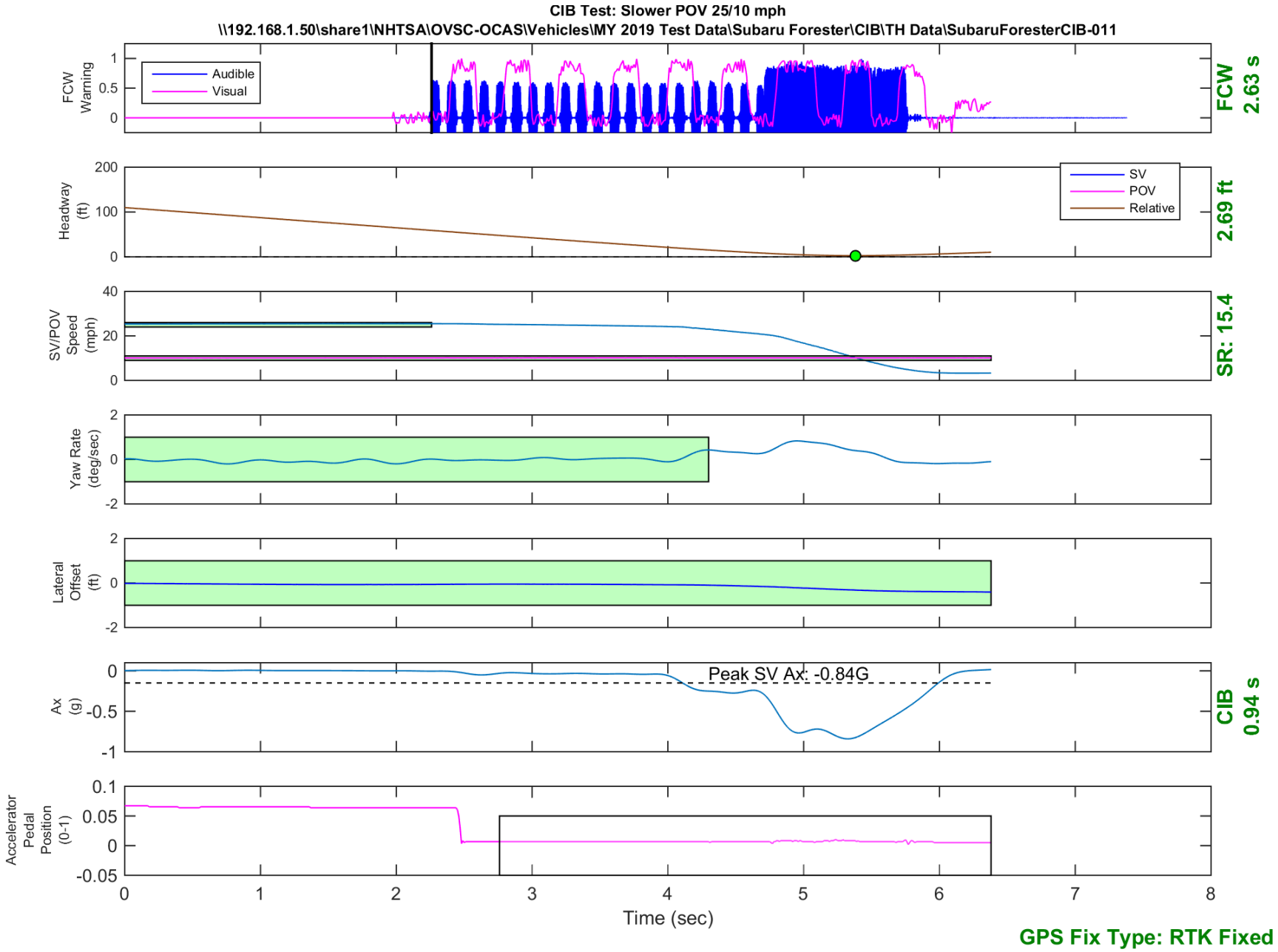


Figure D18. Time History for CIB Run 11, SV Encounters Slower POV, SV 25 mph, POV 10 mph

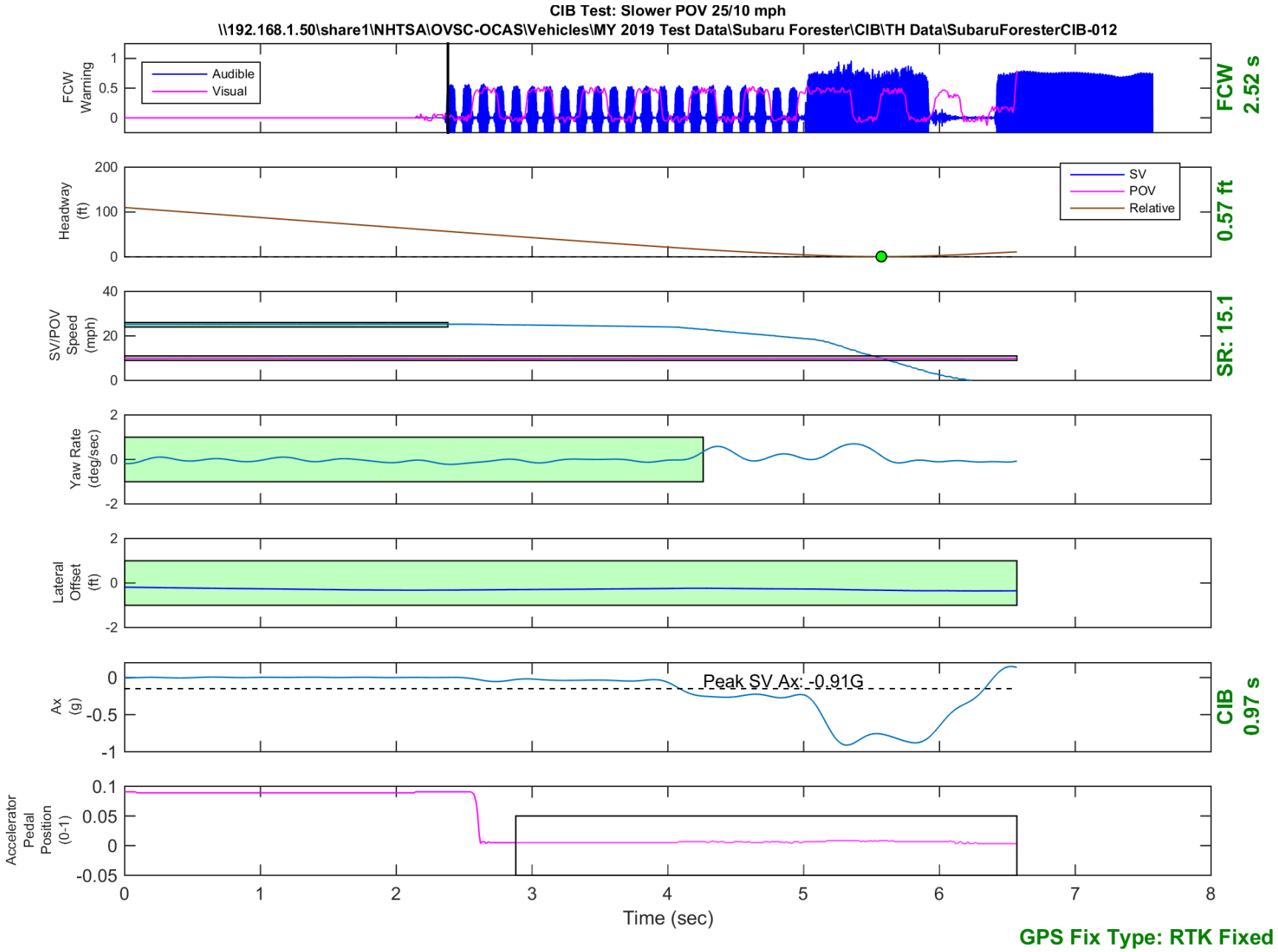


Figure D19. Time History for CIB Run 12, SV Encounters Slower POV, SV 25 mph, POV 10 mph

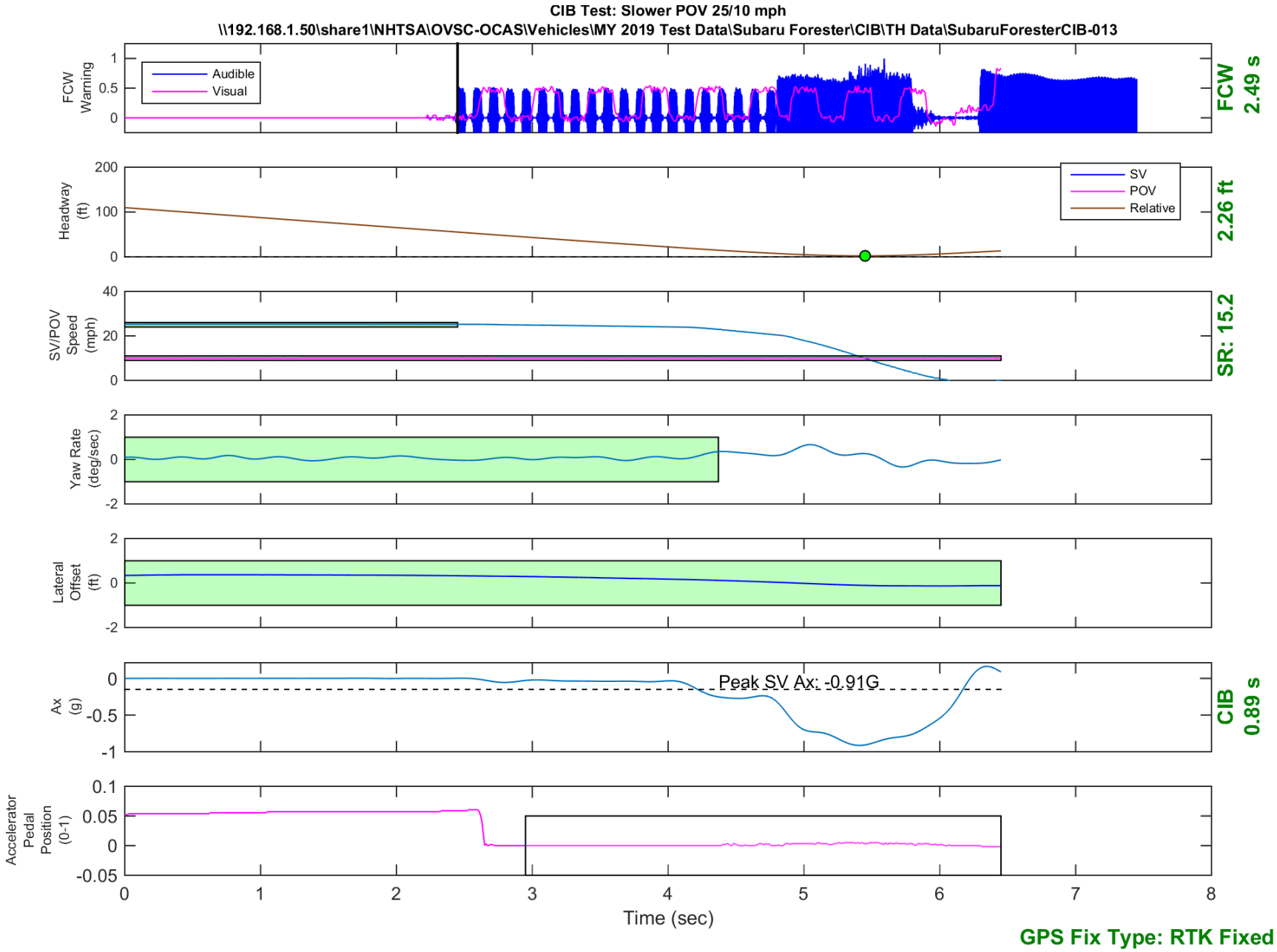


Figure D20. Time History for CIB Run 13, SV Encounters Slower POV, SV 25 mph, POV 10 mph

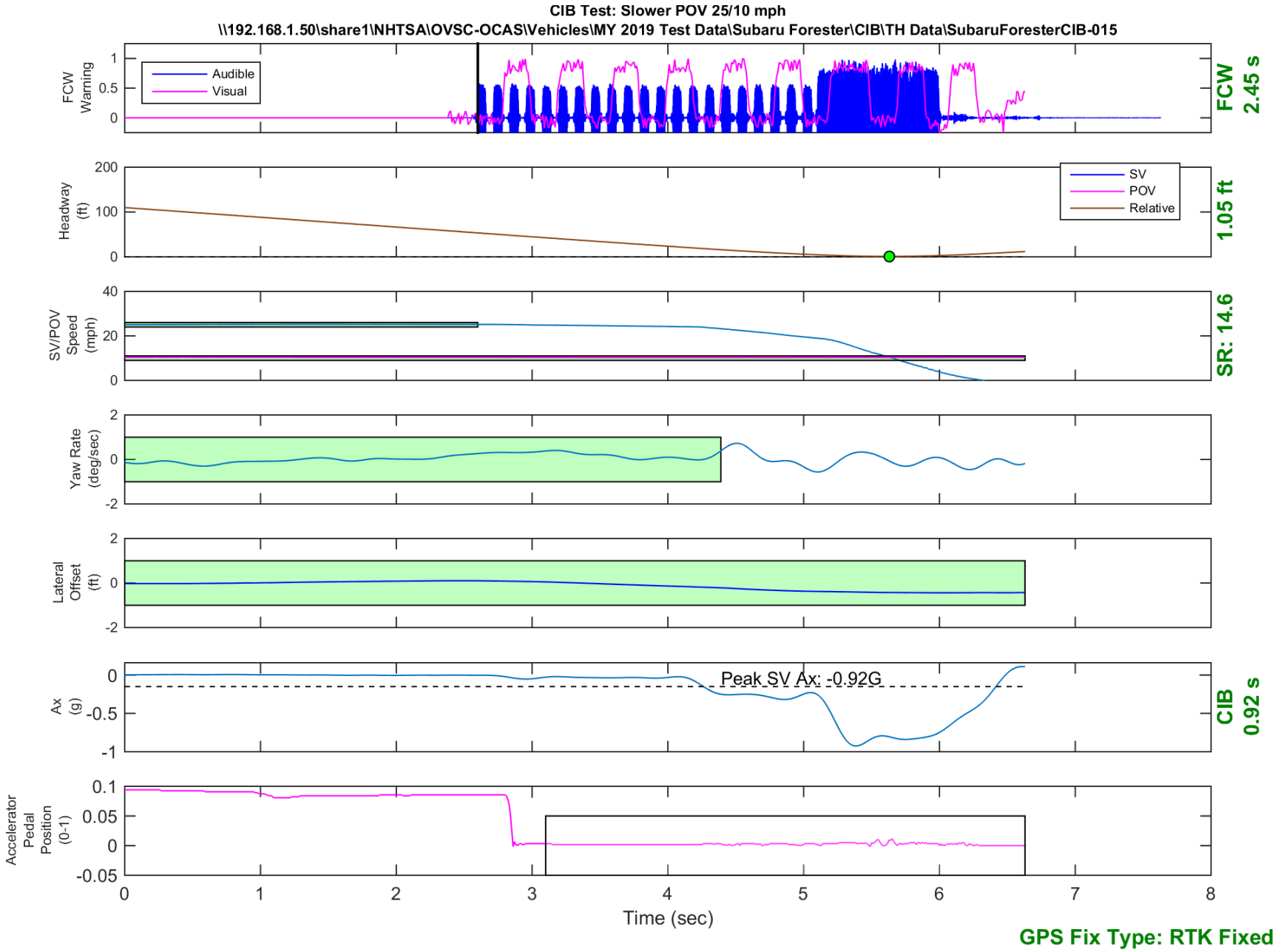


Figure D21. Time History for CIB Run 15, SV Encounters Slower POV, SV 25 mph, POV 10 mph

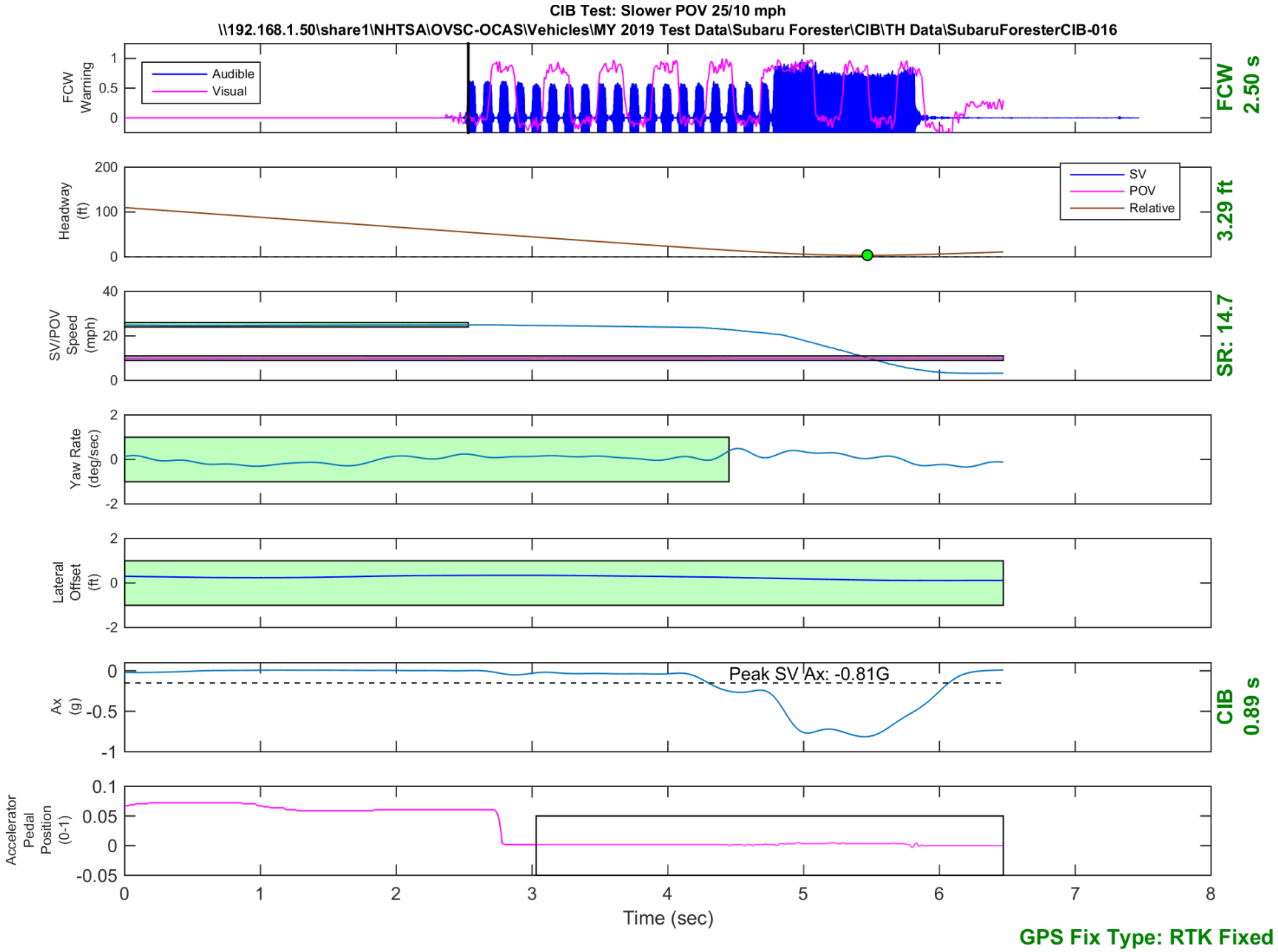


Figure D22. Time History for CIB Run 16, SV Encounters Slower POV, SV 25 mph, POV 10 mph

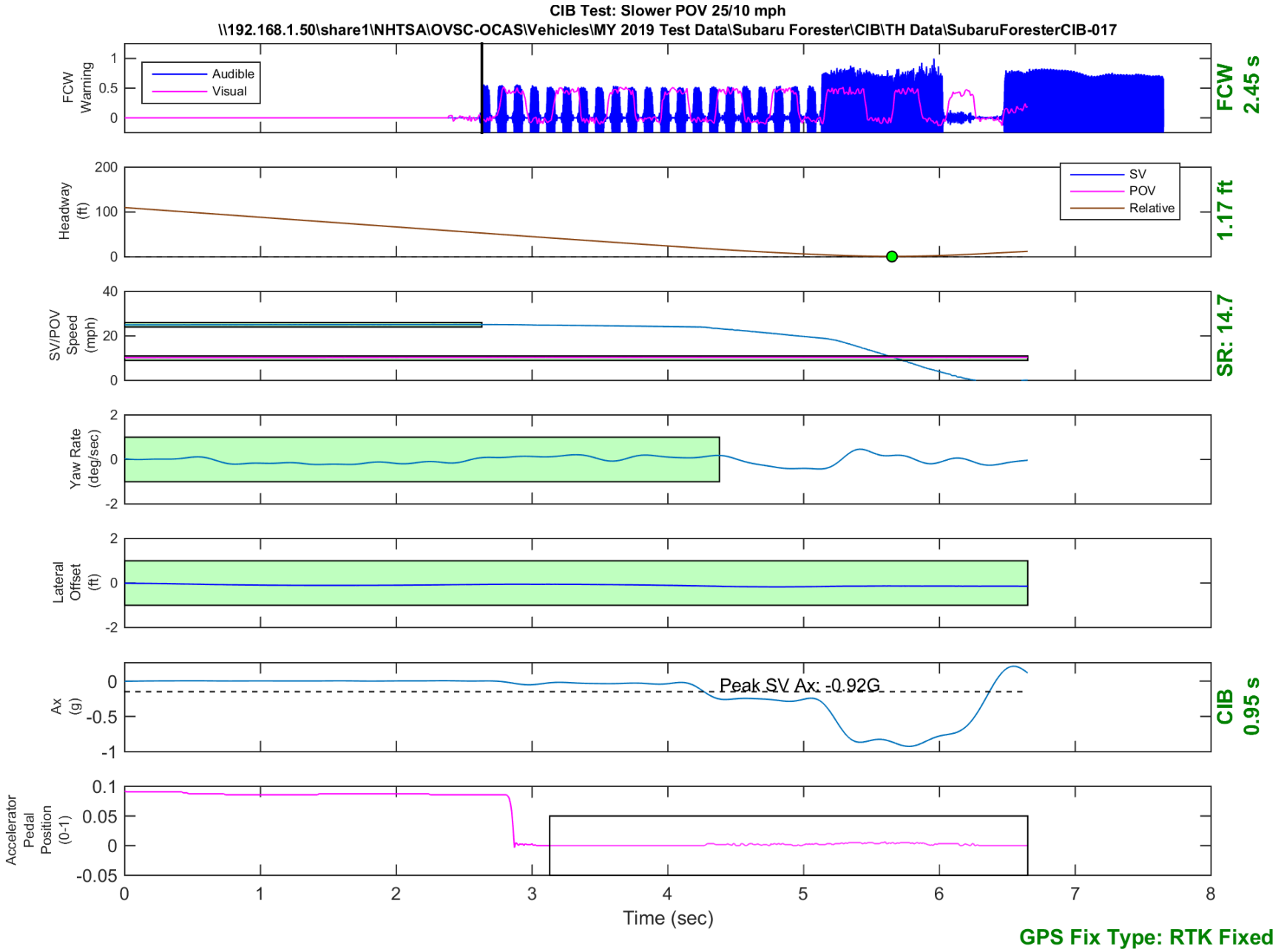


Figure D23. Time History for CIB Run 17, SV Encounters Slower POV, SV 25 mph, POV 10 mph

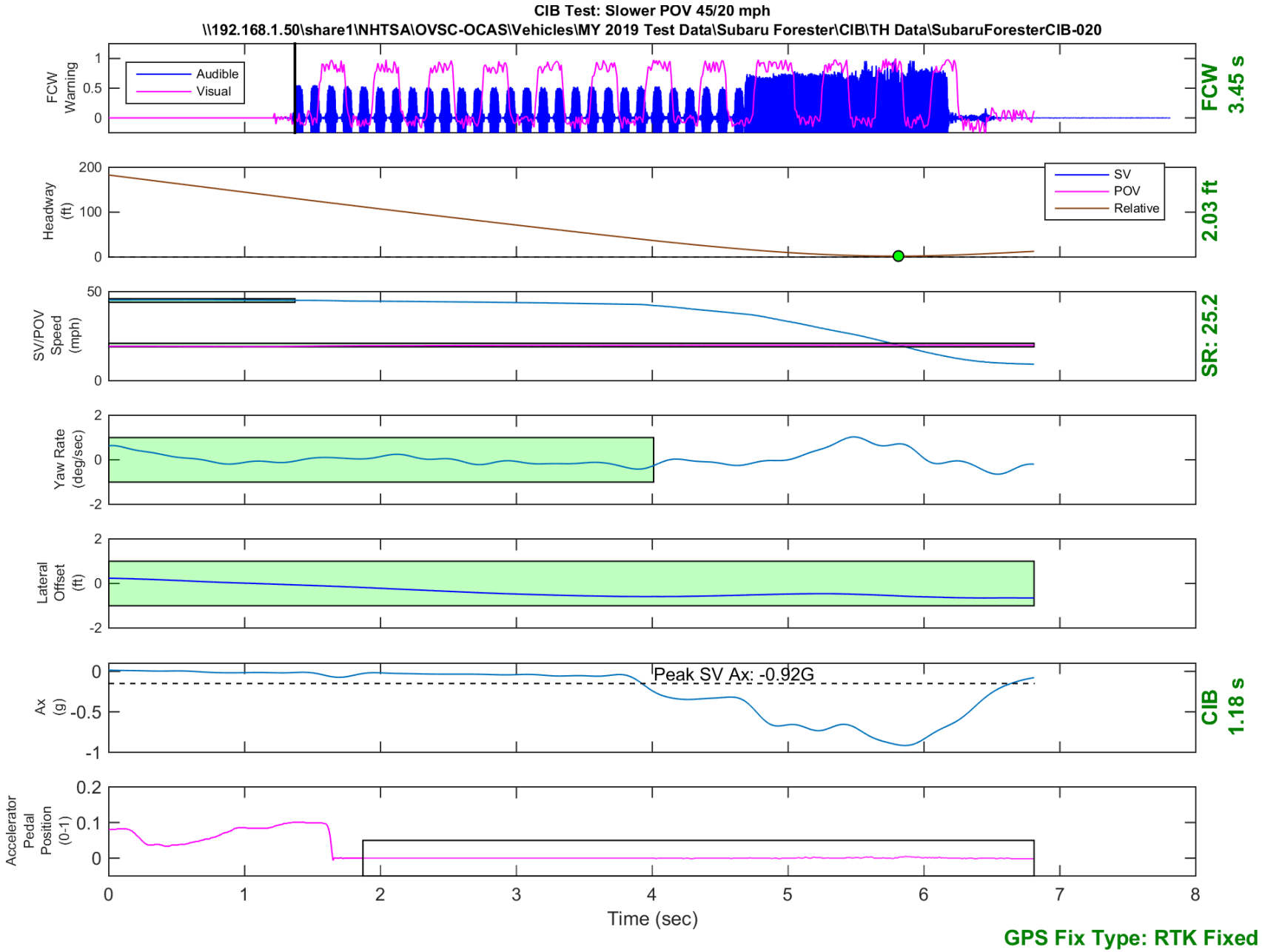


Figure D24. Time History for CIB Run 20, SV Encounters Slower POV, SV 45 mph, POV 20 mph

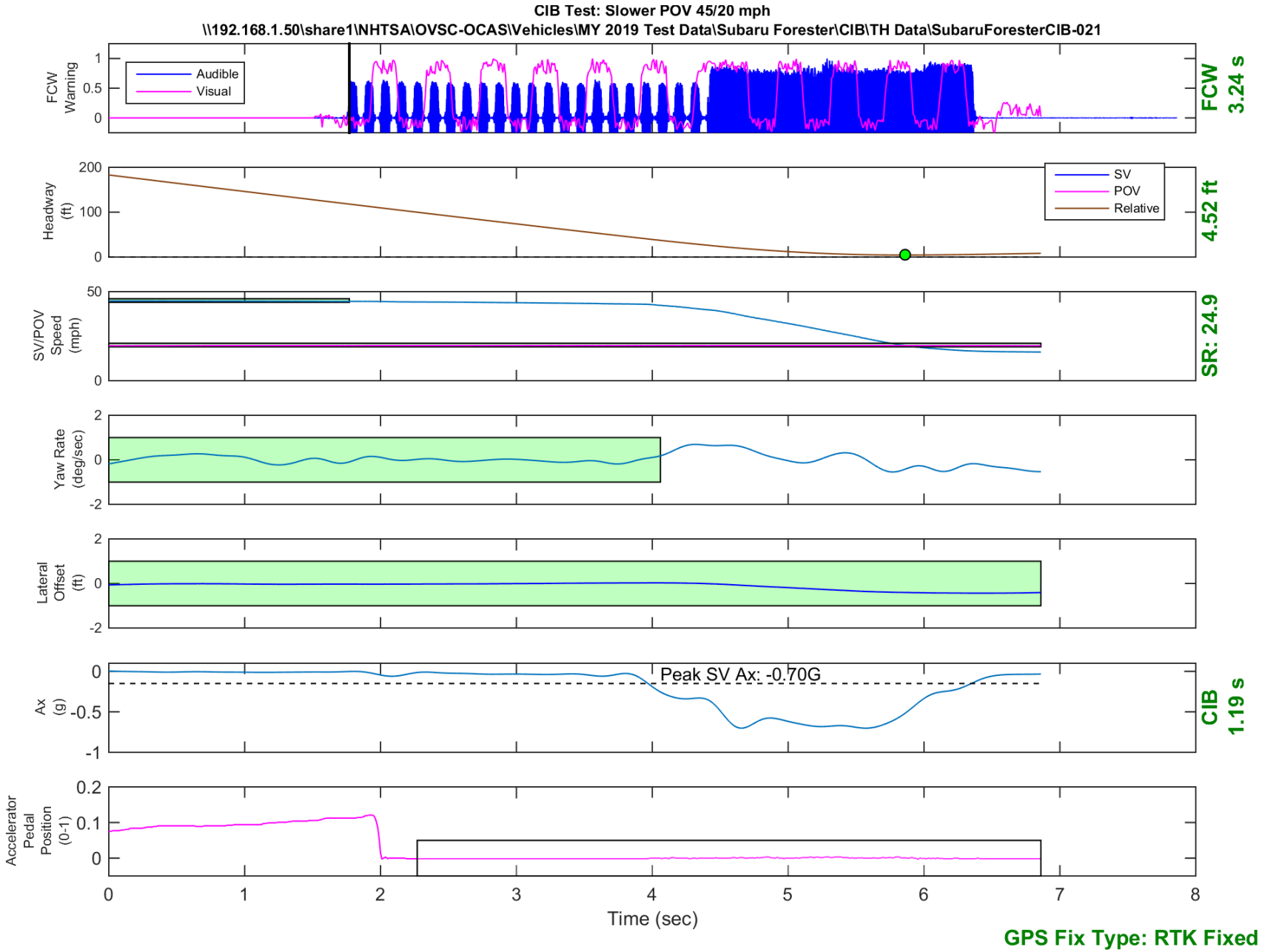


Figure D25. Time History for CIB Run 21, SV Encounters Slower POV, SV 45 mph, POV 20 mph

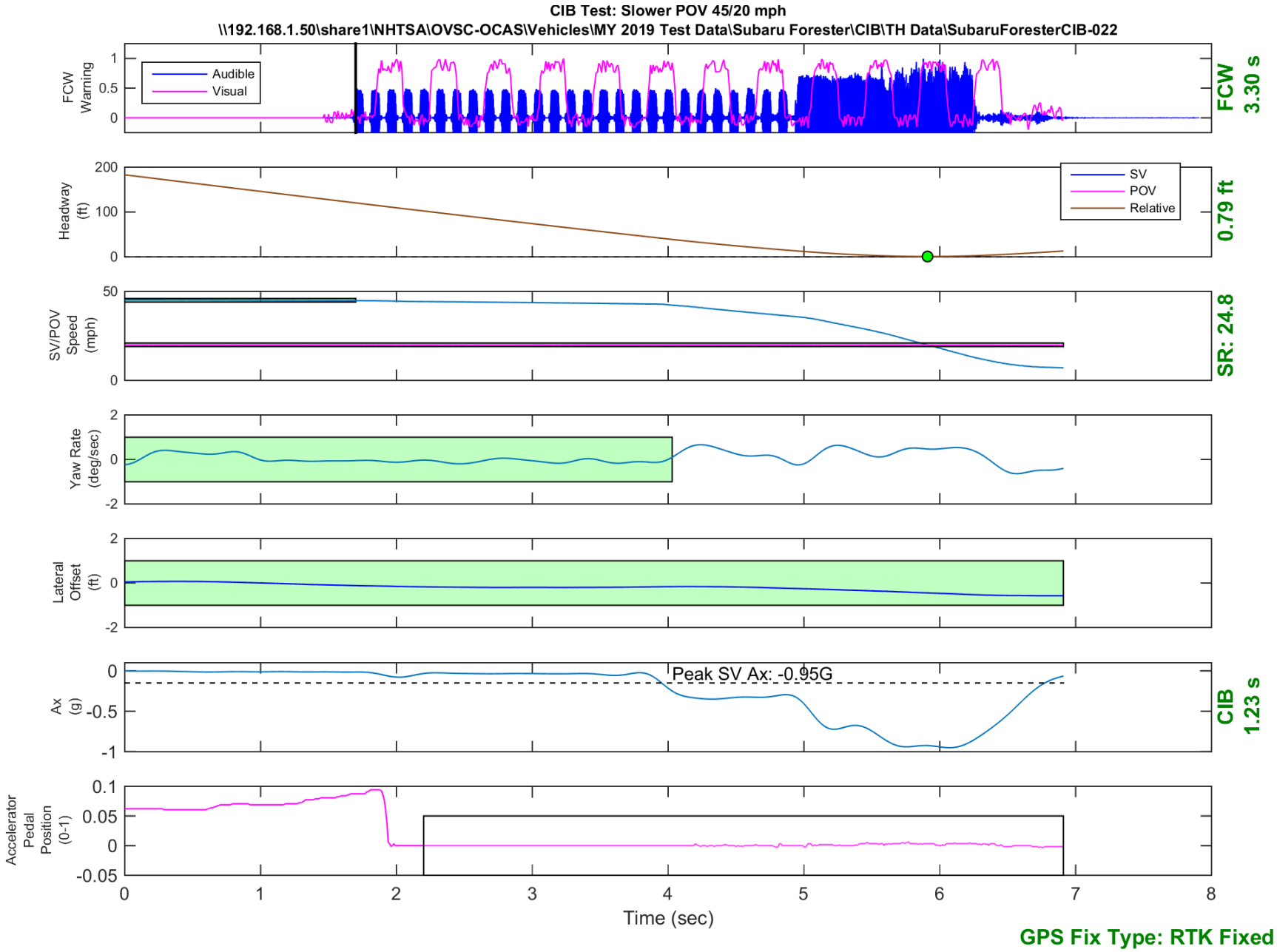


Figure D26. Time History for CIB Run 22, SV Encounters Slower POV, SV 45 mph, POV 20 mph

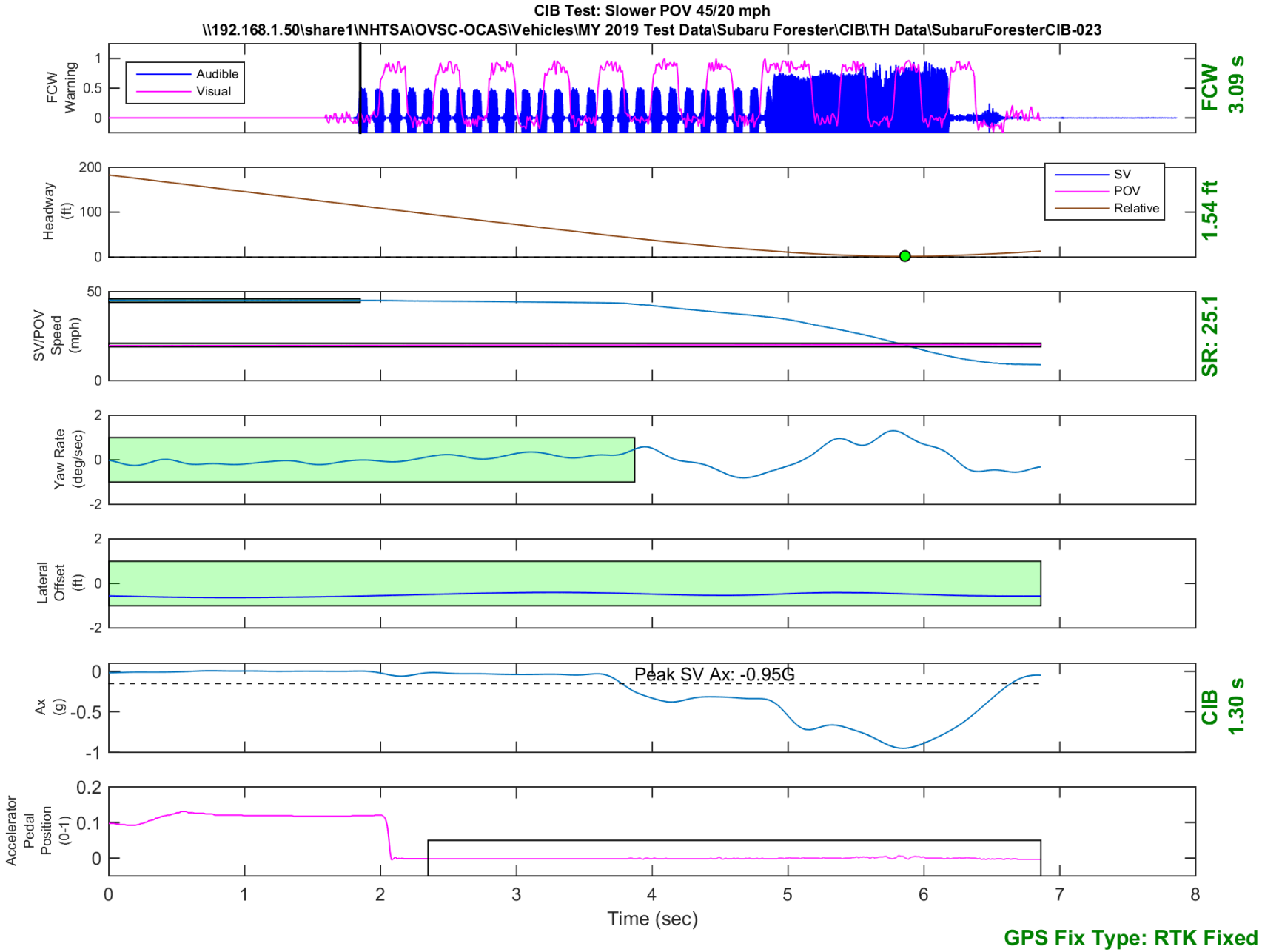


Figure D27. Time History for CIB Run 23, SV Encounters Slower POV, SV 45 mph, POV 20 mph

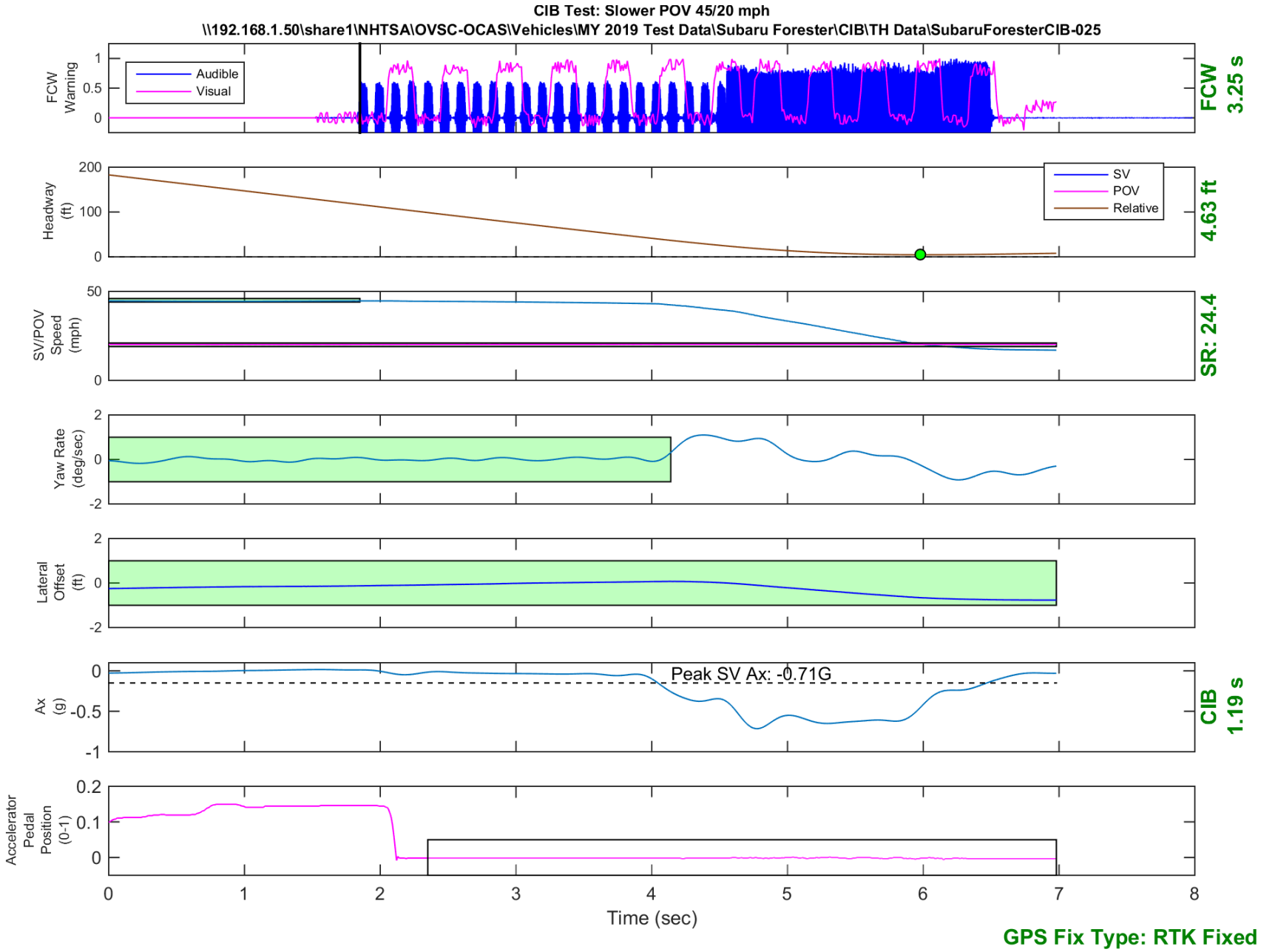


Figure D28. Time History for CIB Run 25, SV Encounters Slower POV, SV 45 mph, POV 20 mph

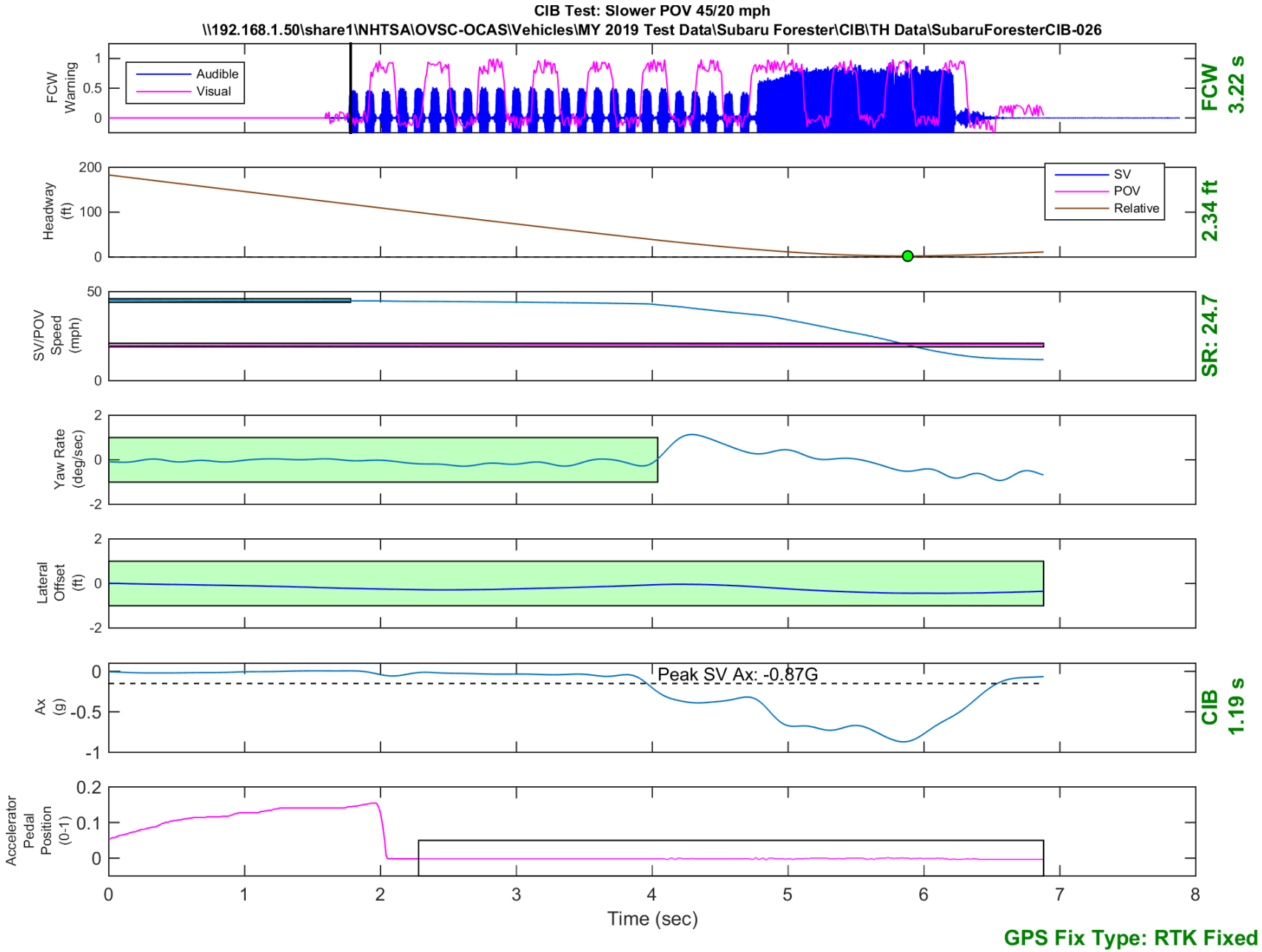


Figure D29. Time History for CIB Run 26, SV Encounters Slower POV, SV 45 mph, POV 20 mph

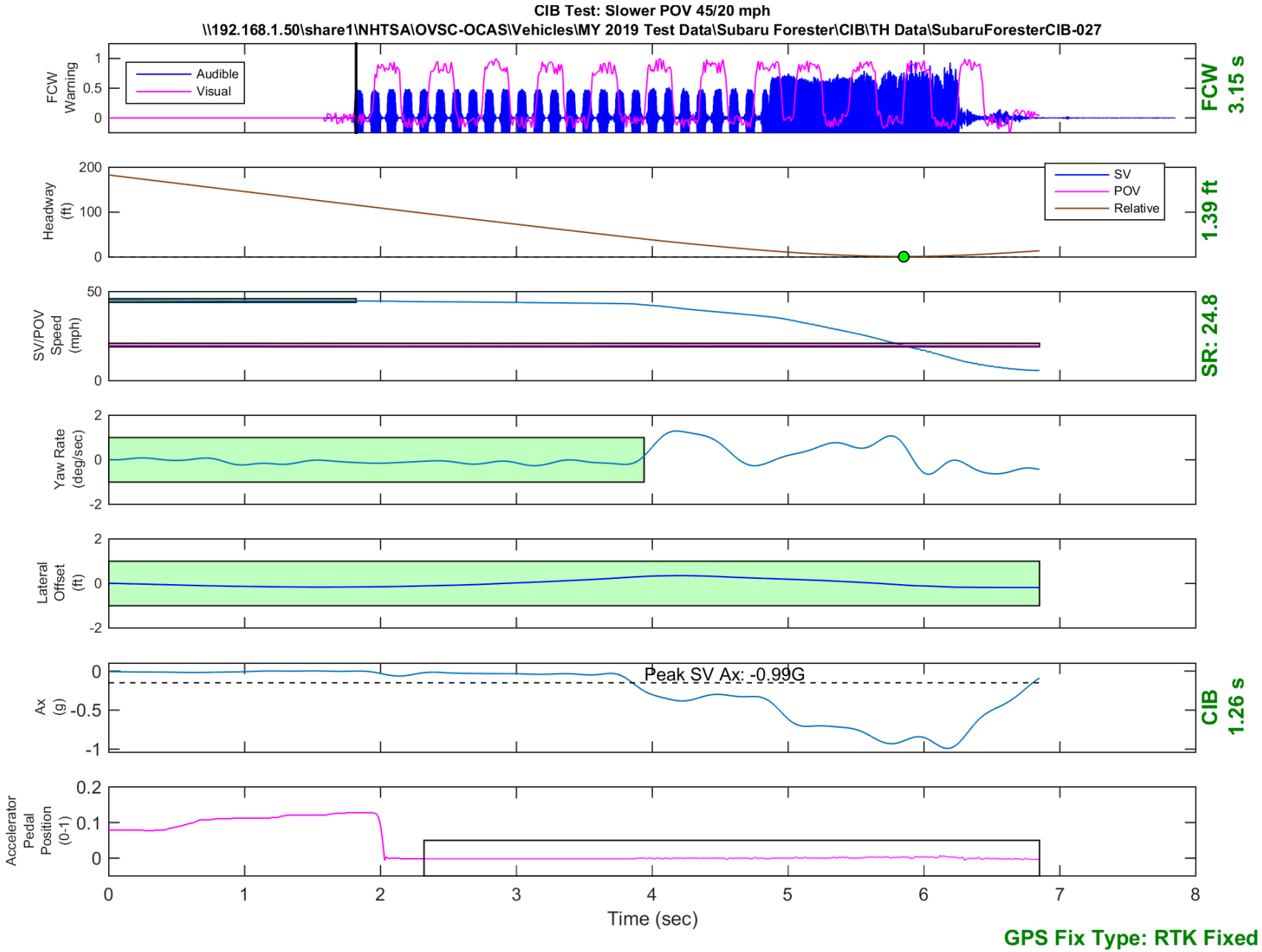


Figure D30. Time History for CIB Run 27, SV Encounters Slower POV, SV 45 mph, POV 20 mph

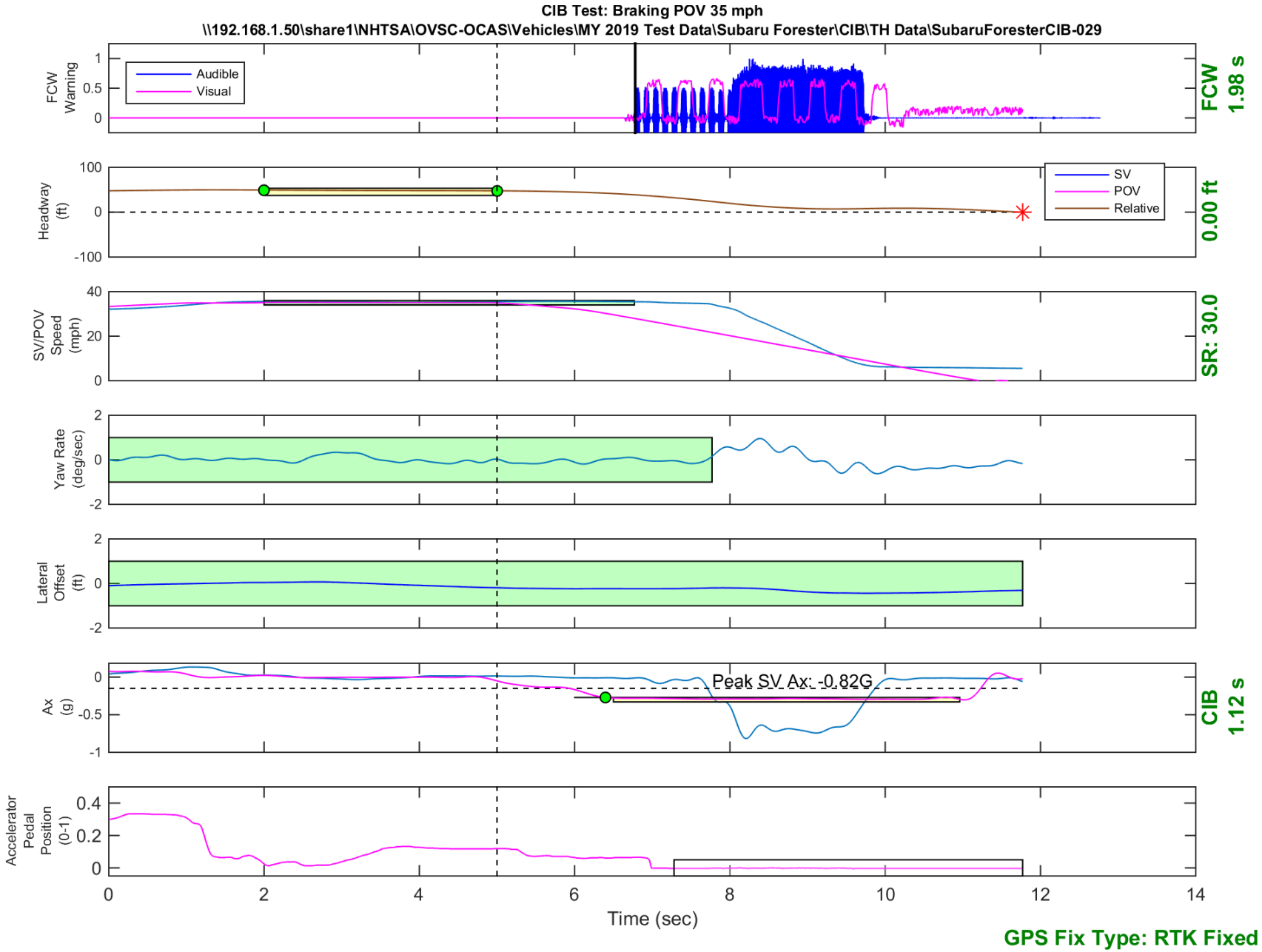


Figure D31. Time History for CIB Run 29, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

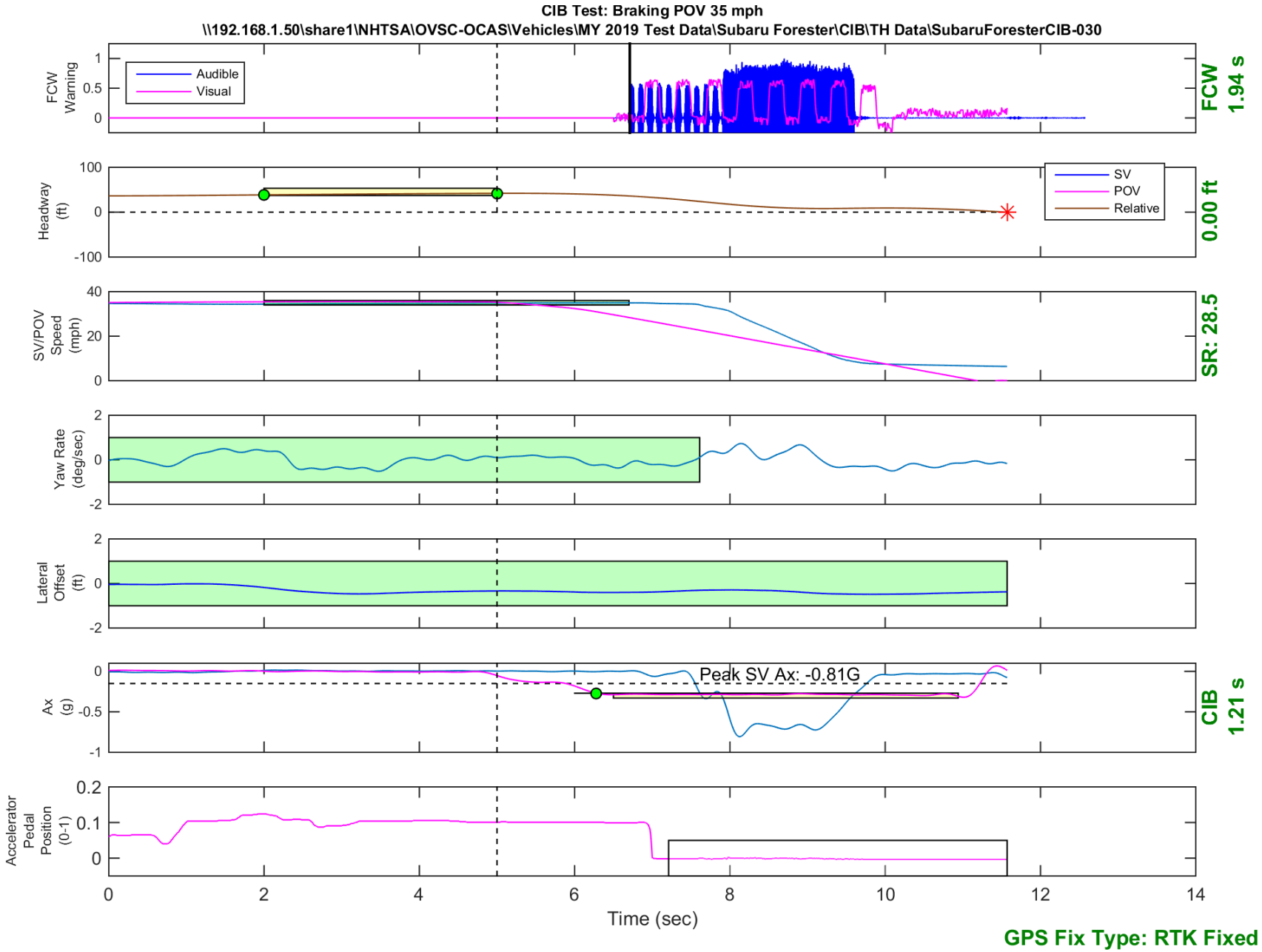


Figure D32. Time History for CIB Run 30, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

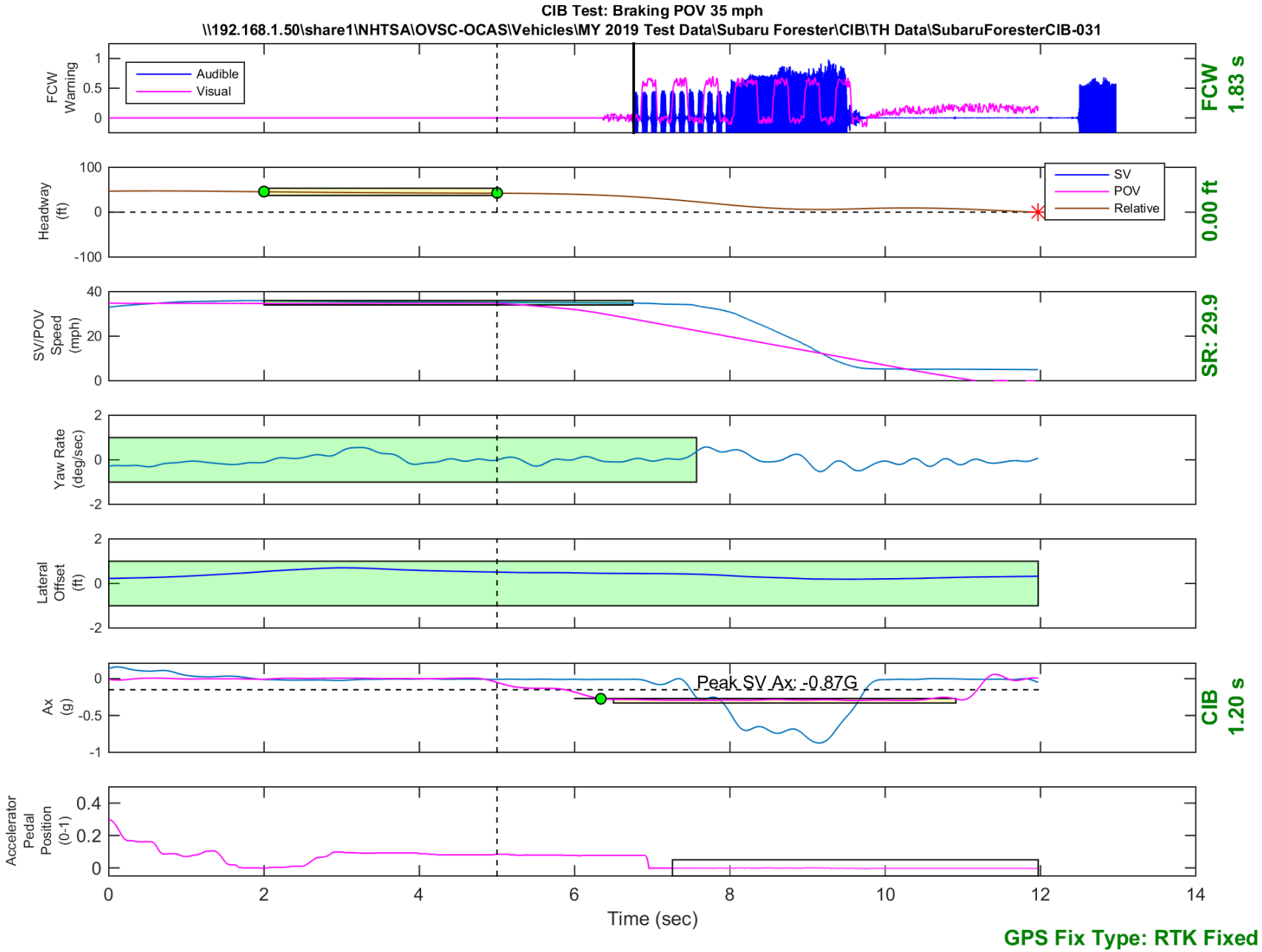


Figure D33. Time History for CIB Run 31, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

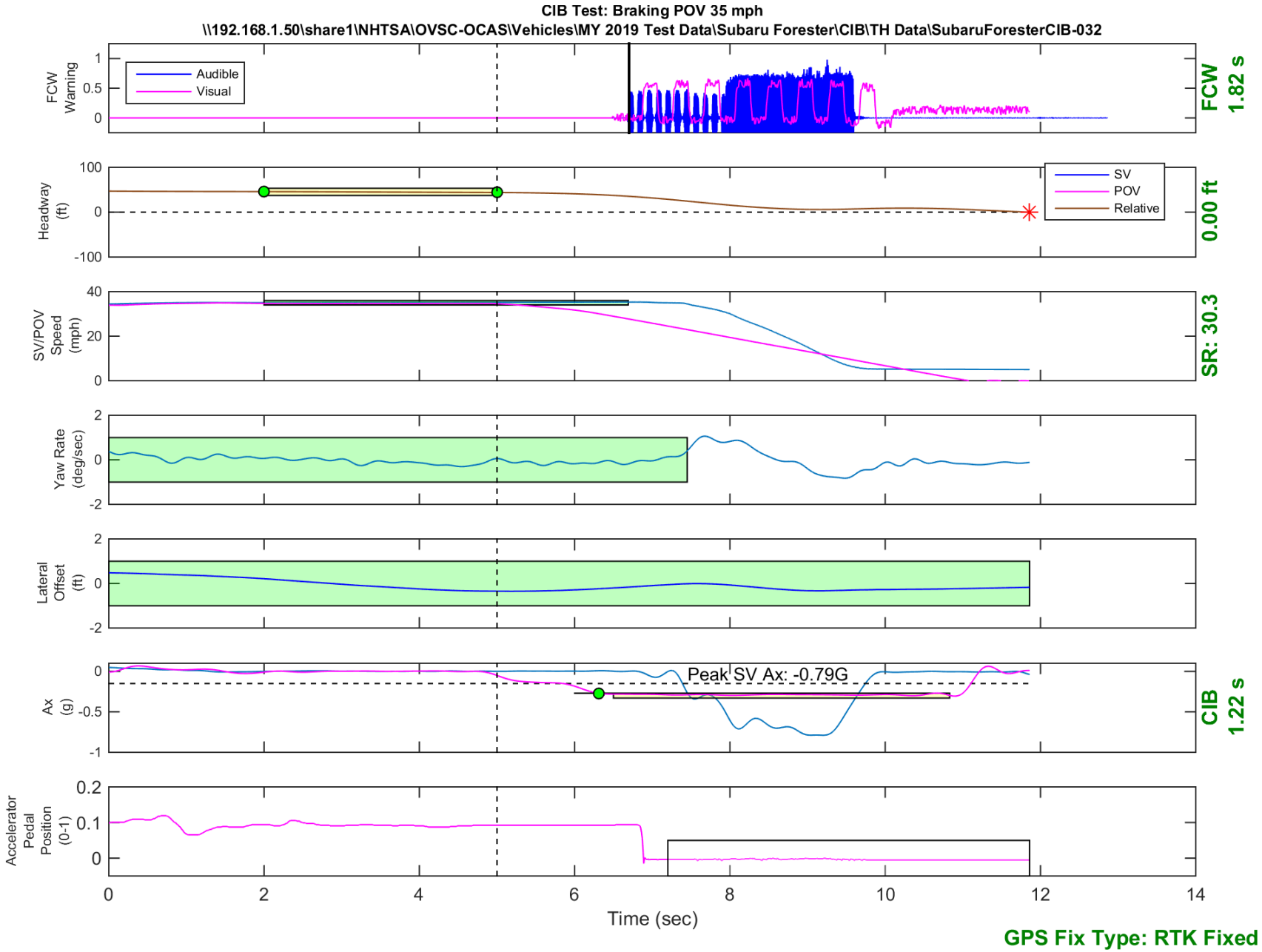


Figure D34. Time History for CIB Run 32, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

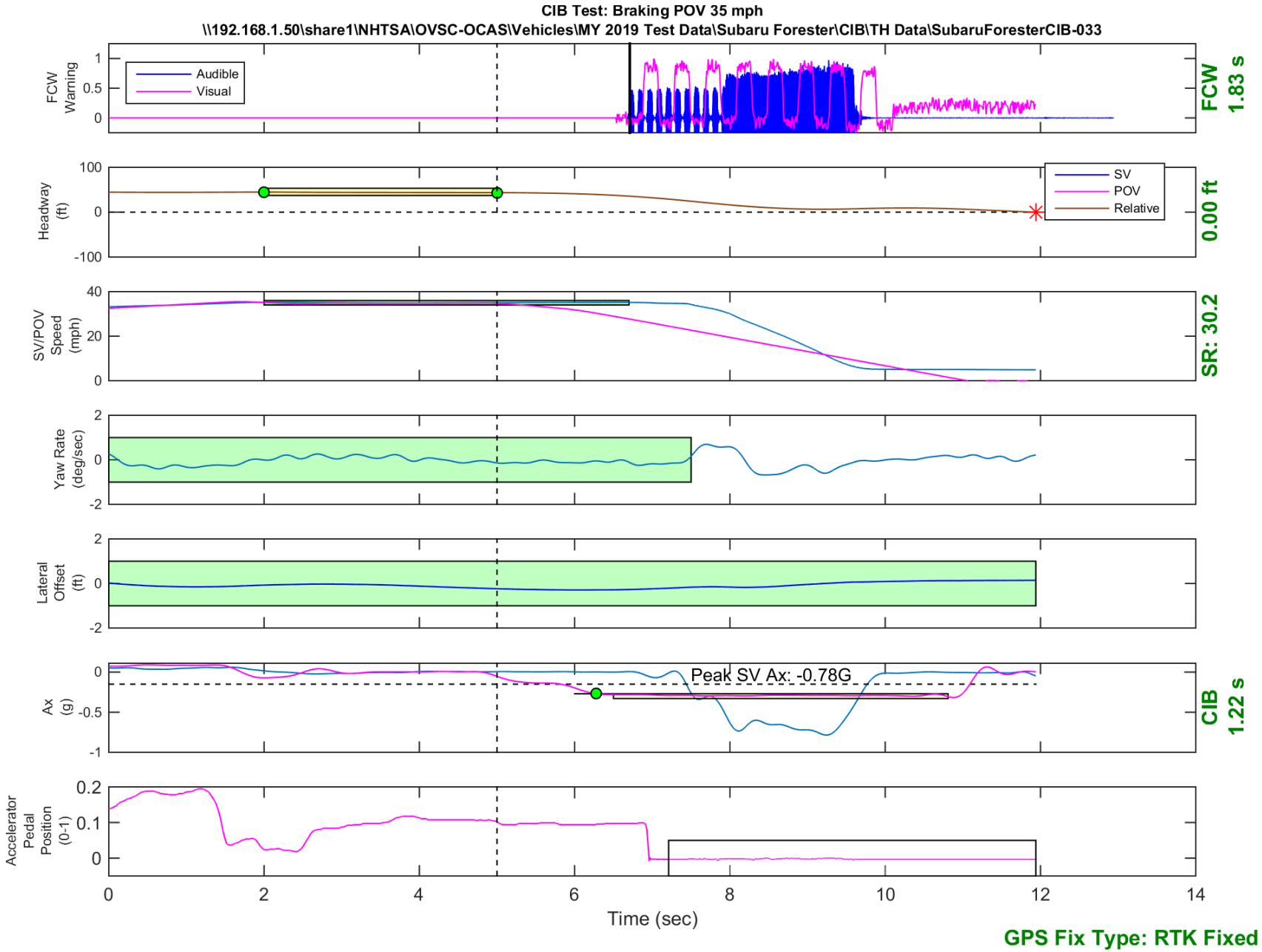


Figure D35. Time History for CIB Run 33, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

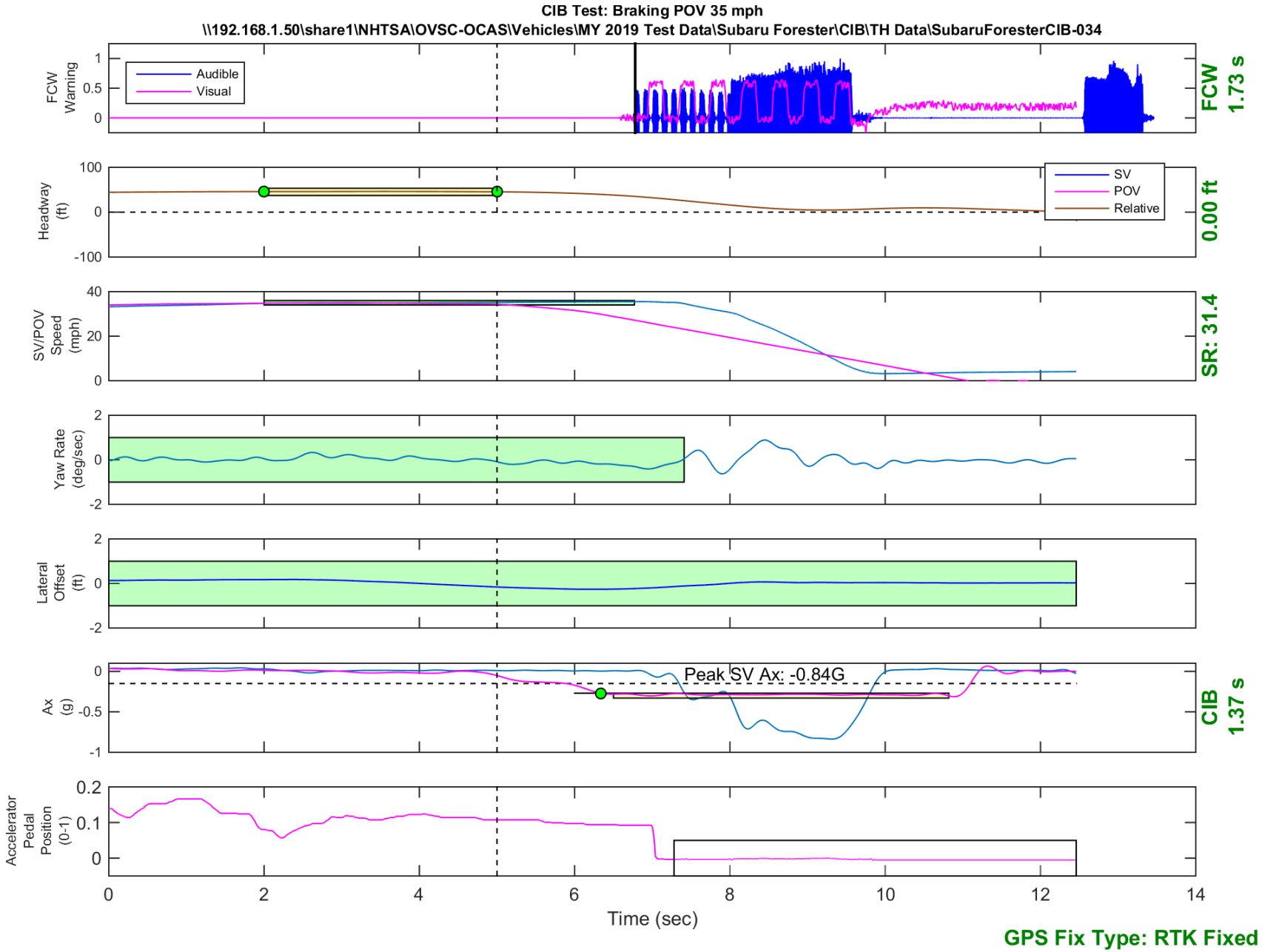


Figure D36. Time History for CIB Run 34, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

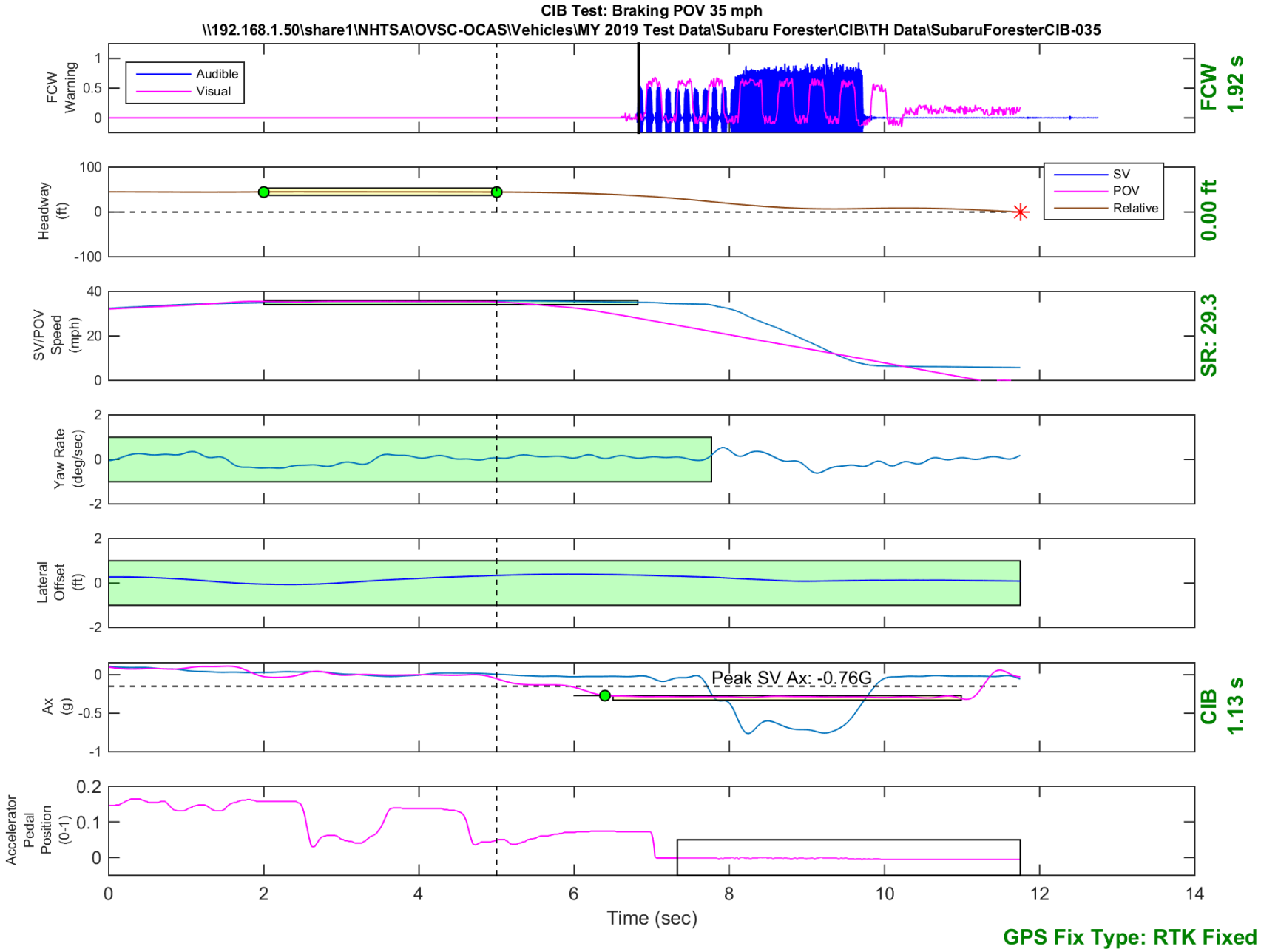


Figure D37. Time History for CIB Run 35, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

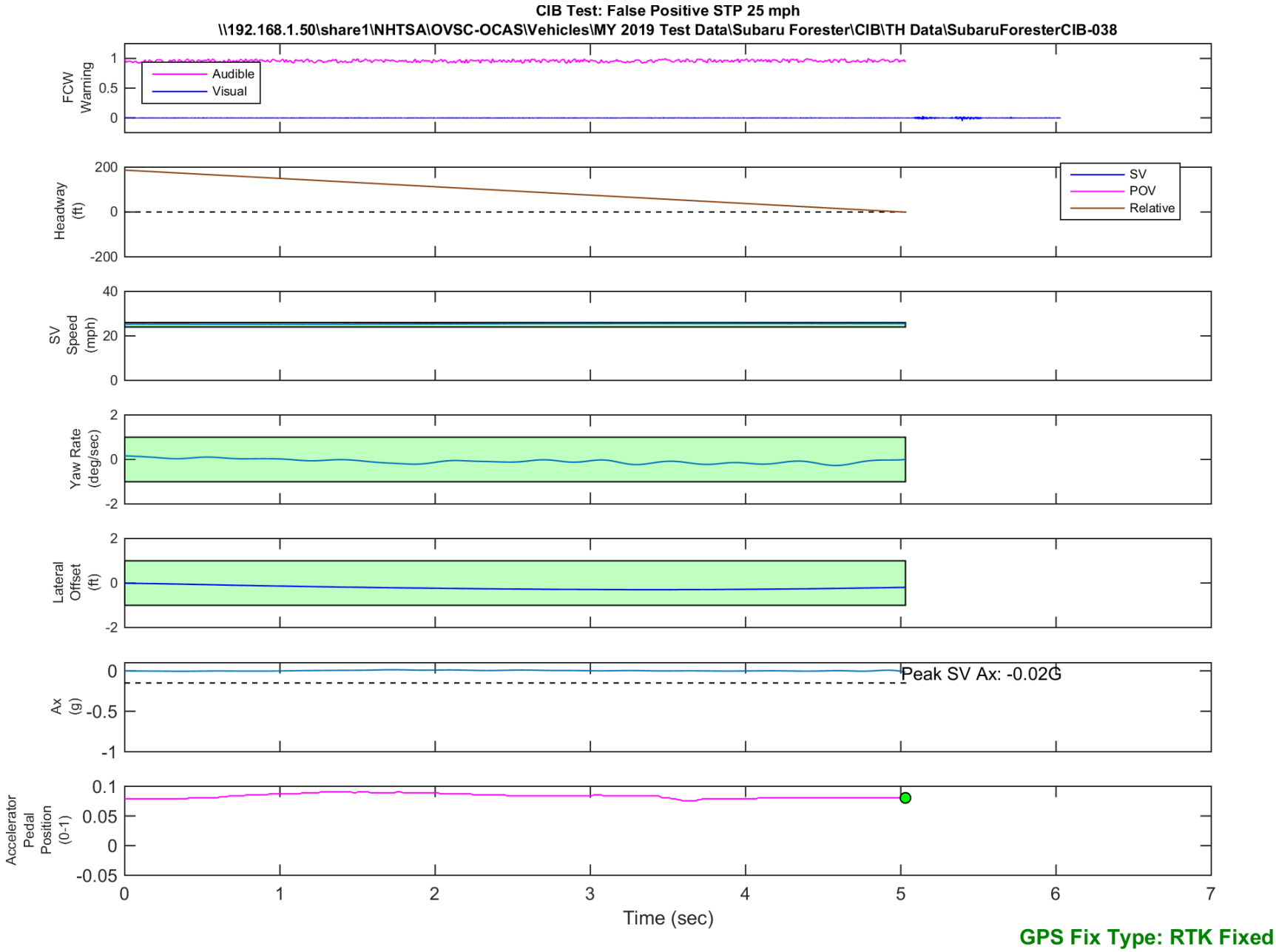


Figure D38. Time History for CIB Run 38, SV Encounters Steel Trench Plate, SV 25 mph

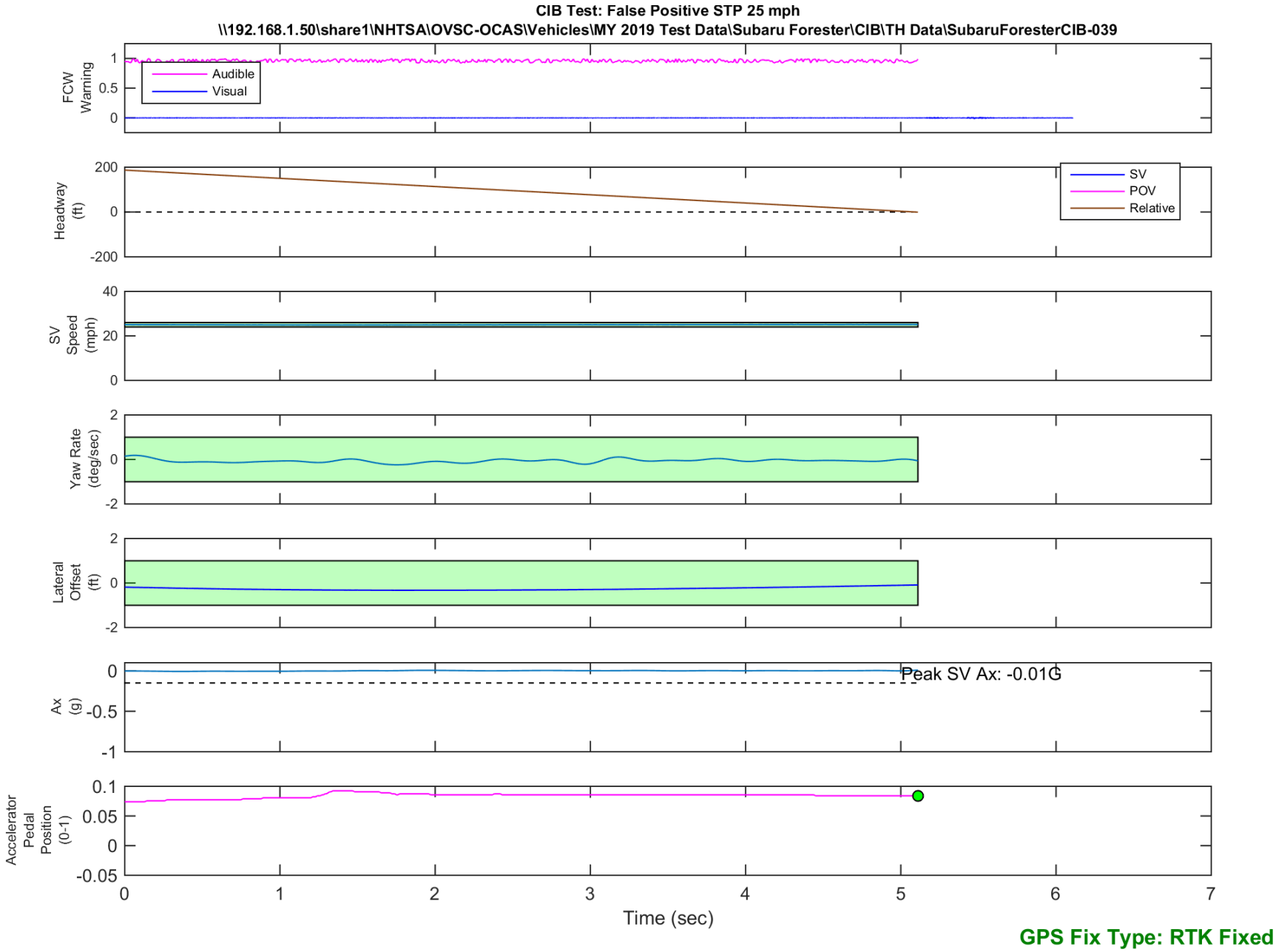


Figure D39. Time History for CIB Run 39, SV Encounters Steel Trench Plate, SV 25 mph

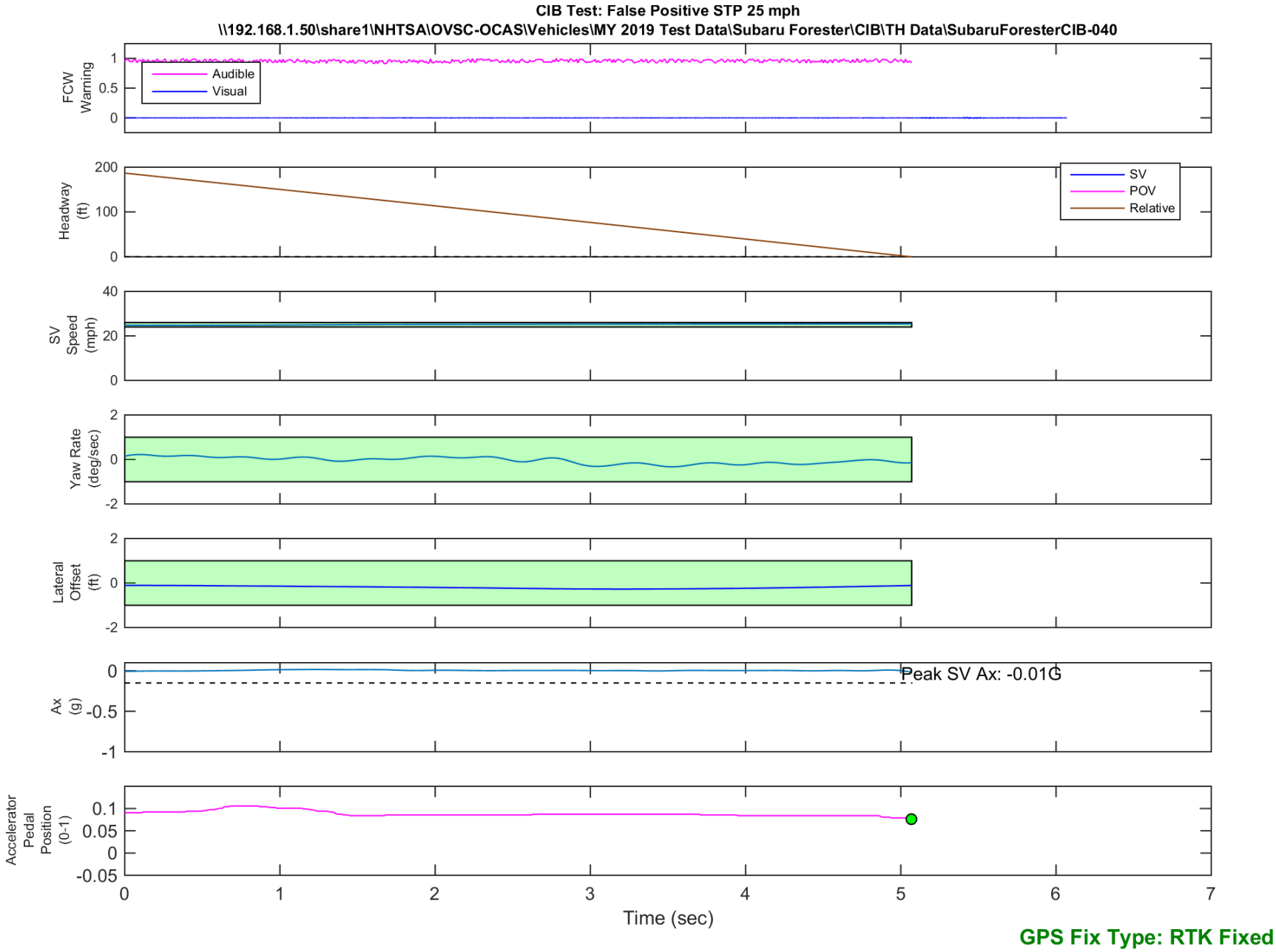


Figure D40. Time History for CIB Run 40, SV Encounters Steel Trench Plate, SV 25 mph

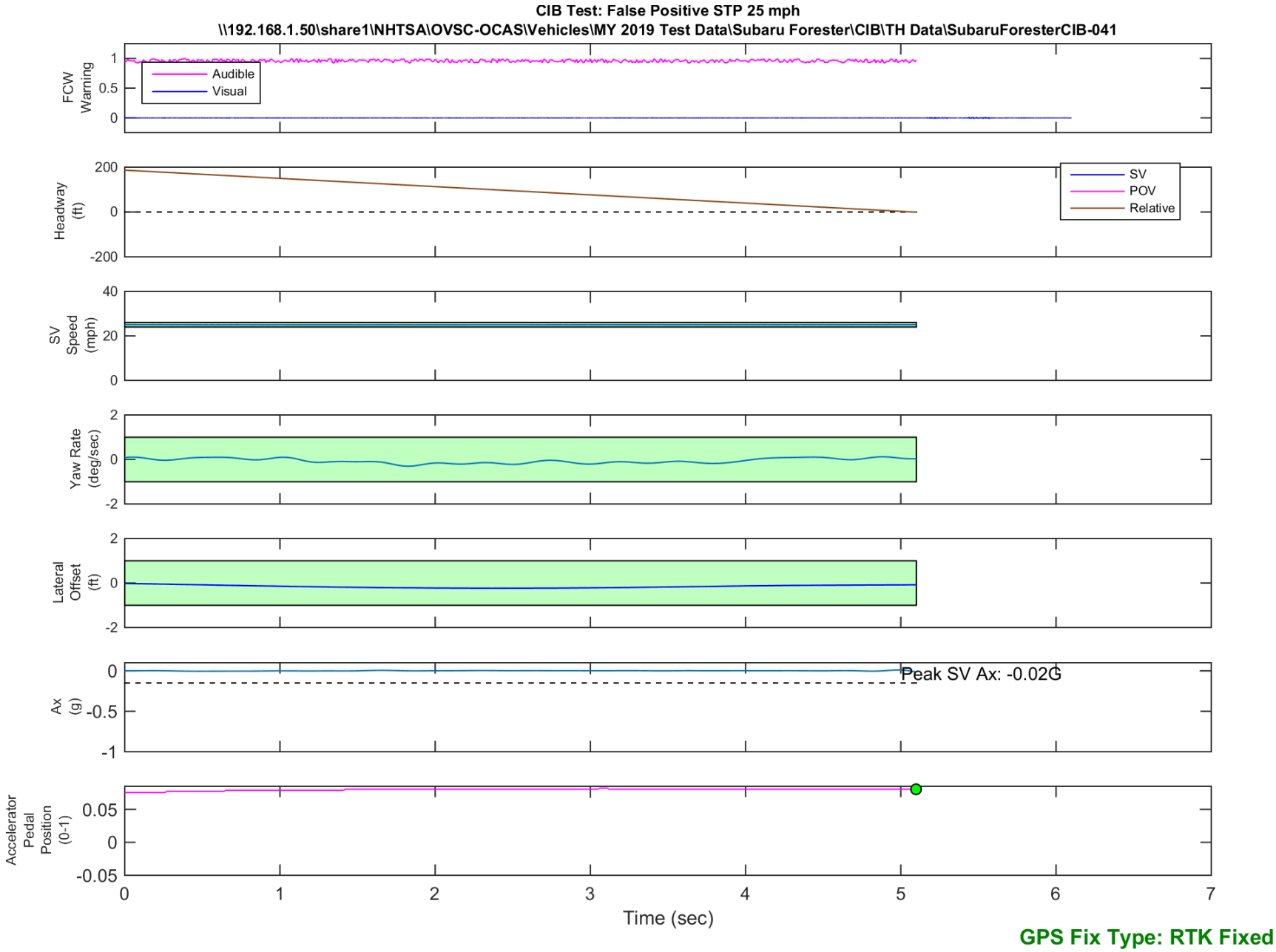


Figure D41. Time History for CIB Run 41, SV Encounters Steel Trench Plate, SV 25 mph

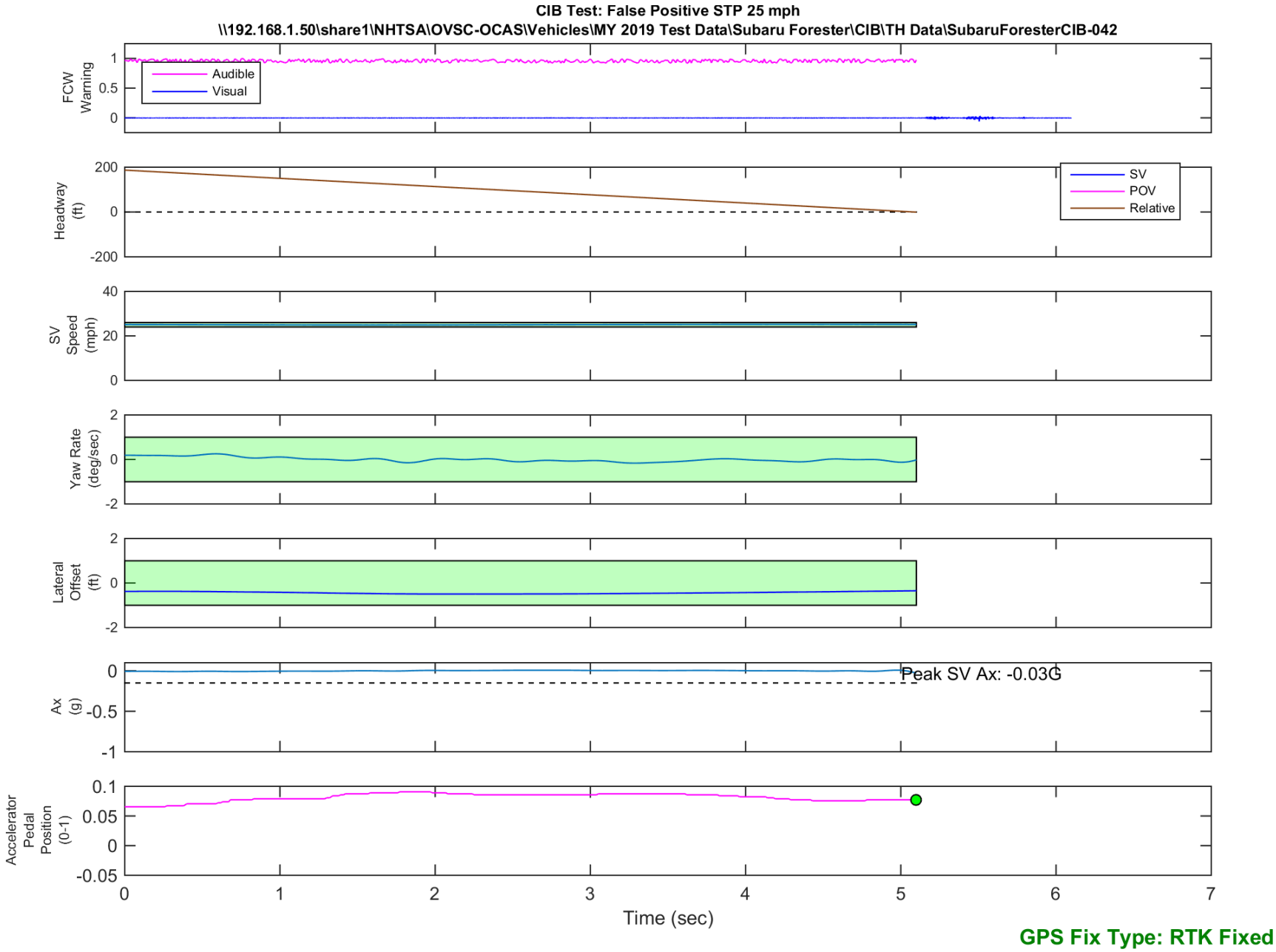


Figure D42. Time History for CIB Run 42, SV Encounters Steel Trench Plate, SV 25 mph

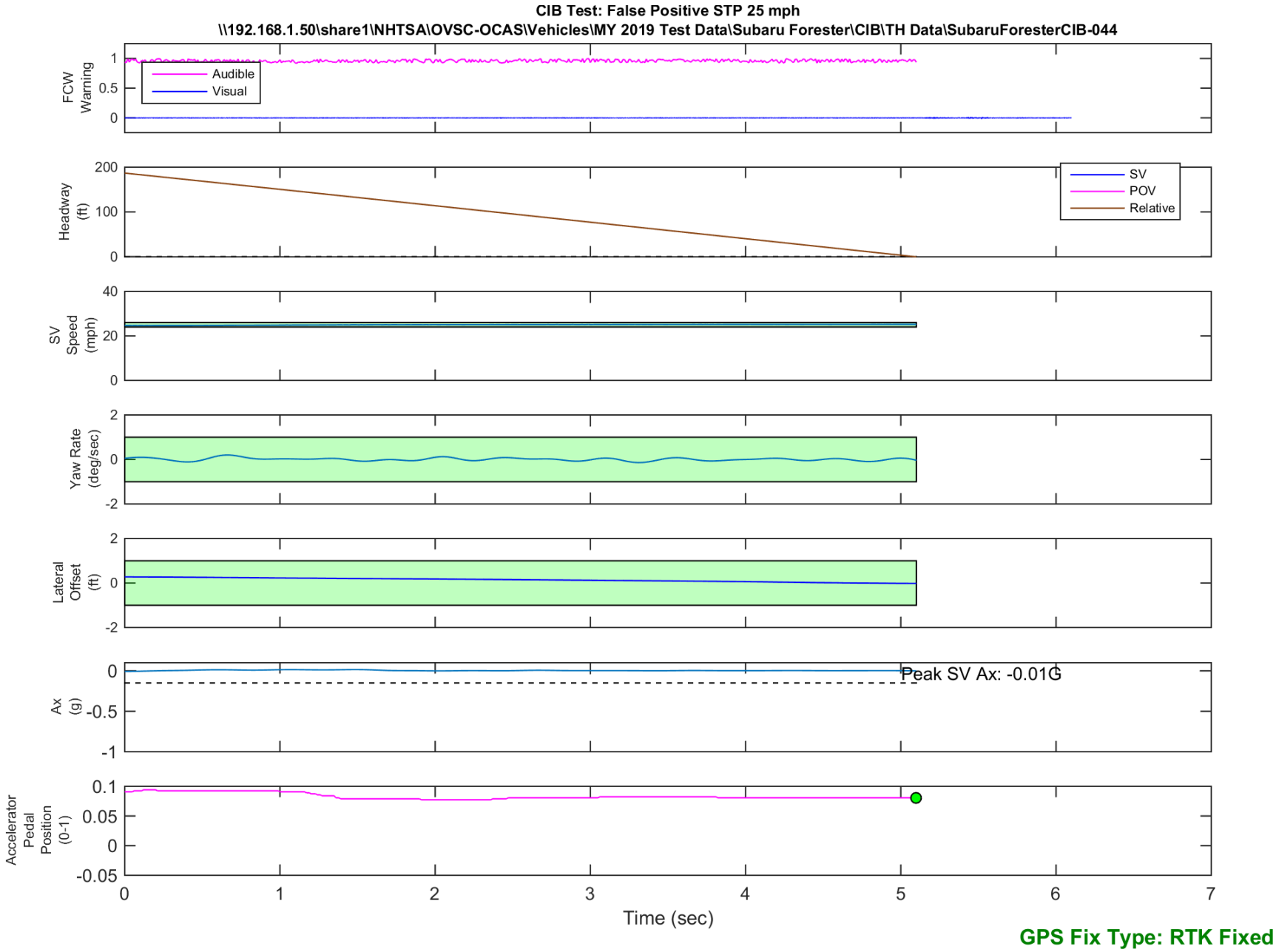


Figure D43. Time History for CIB Run 44, SV Encounters Steel Trench Plate, SV 25 mph

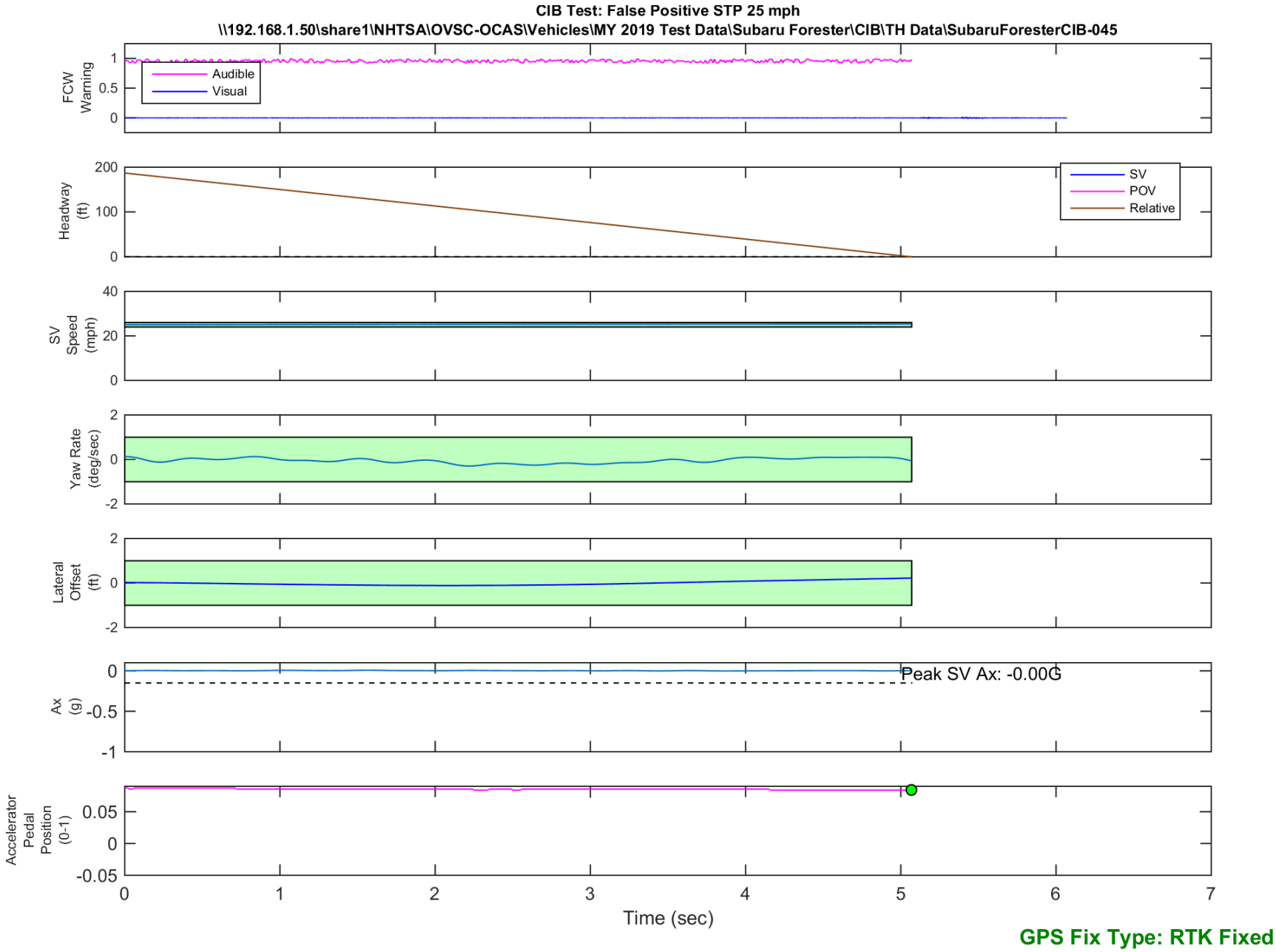


Figure D44. Time History for CIB Run 45, SV Encounters Steel Trench Plate, SV 25 mph

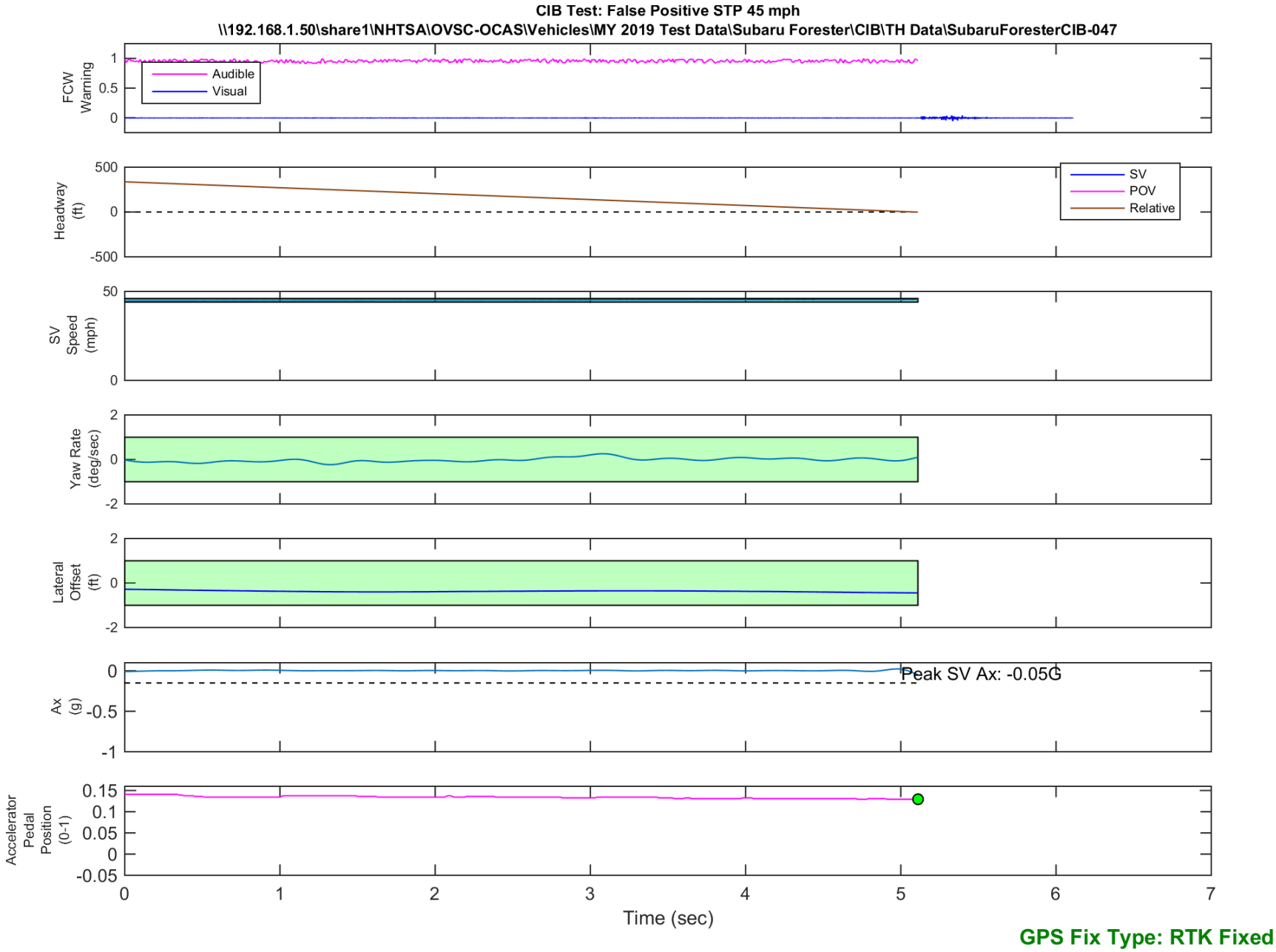


Figure D45. Time History for CIB Run 47, SV Encounters Steel Trench Plate, SV 45 mph

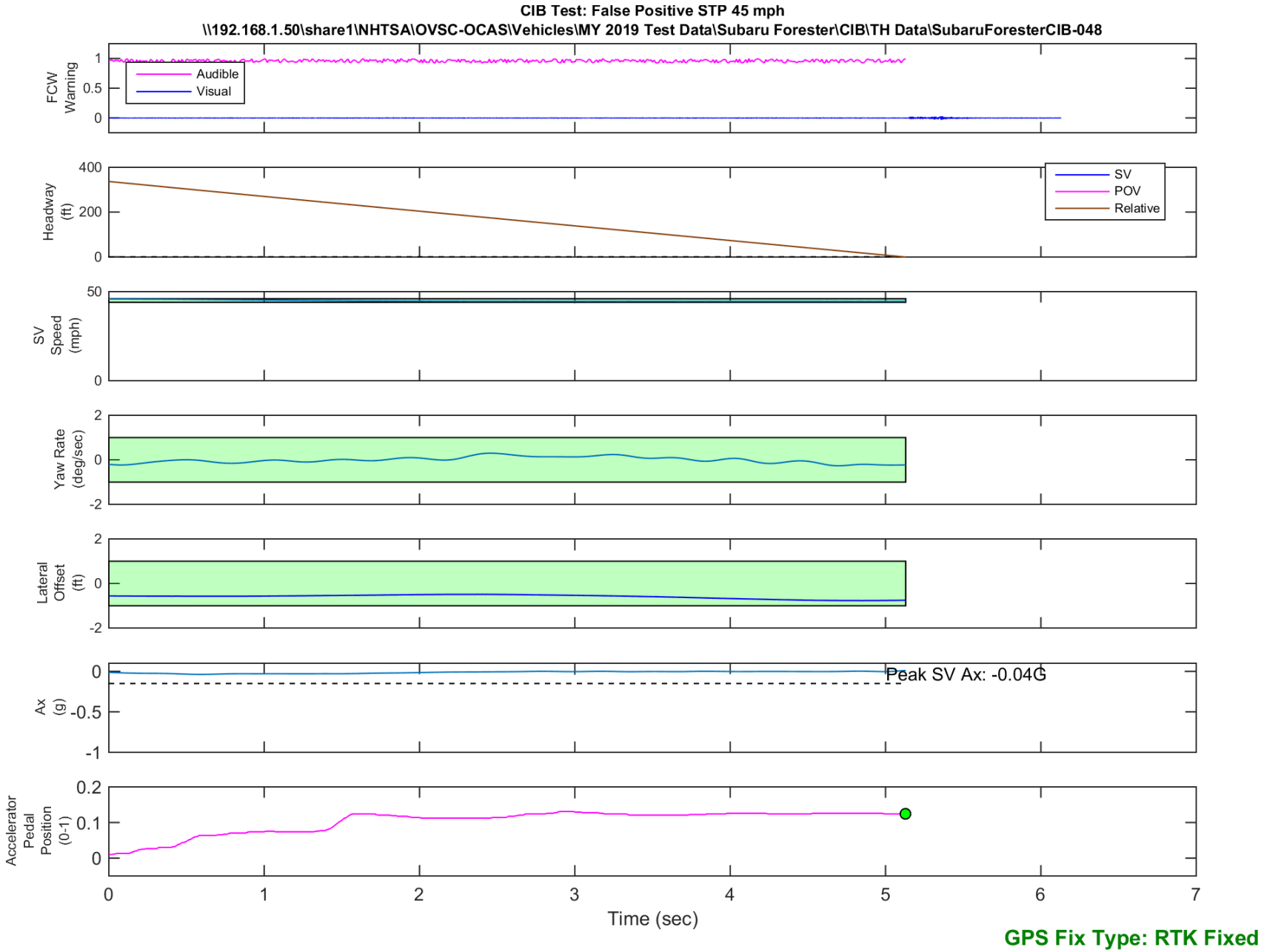


Figure D46. Time History for CIB Run 48, SV Encounters Steel Trench Plate, SV 45 mph

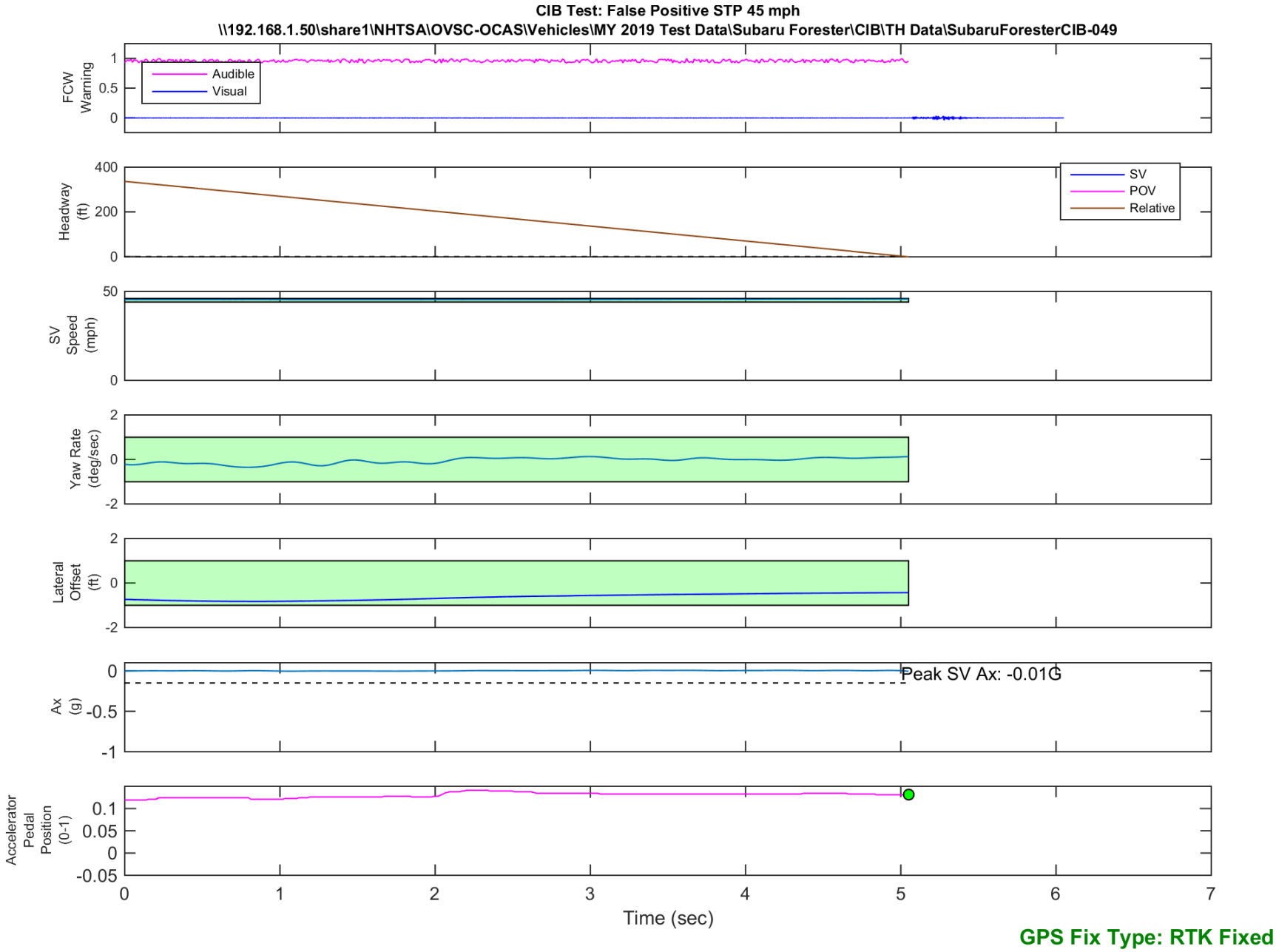


Figure D47. Time History for CIB Run 49, SV Encounters Steel Trench Plate, SV 45 mph

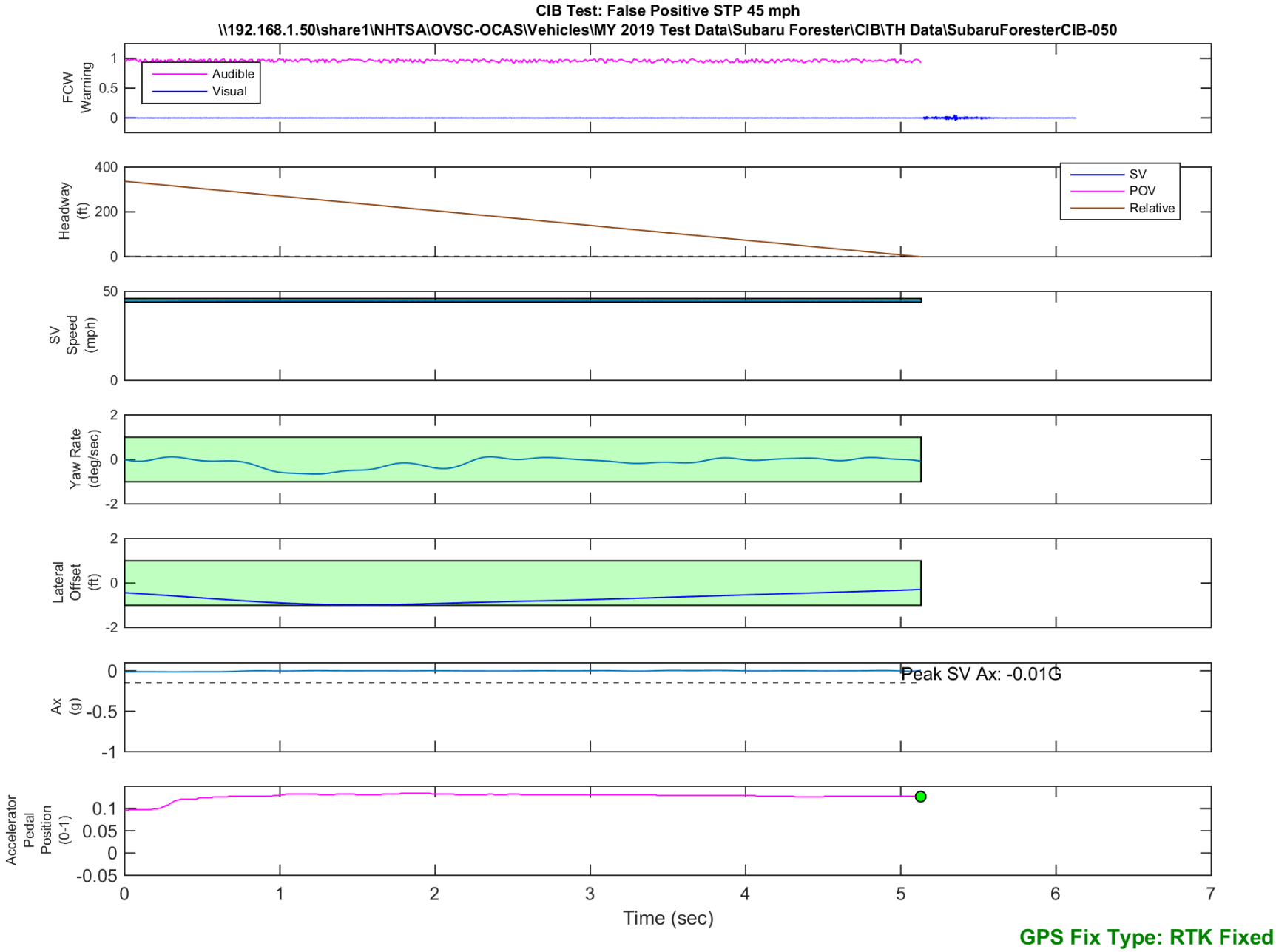


Figure D48. Time History for CIB Run 50, SV Encounters Steel Trench Plate, SV 45 mph

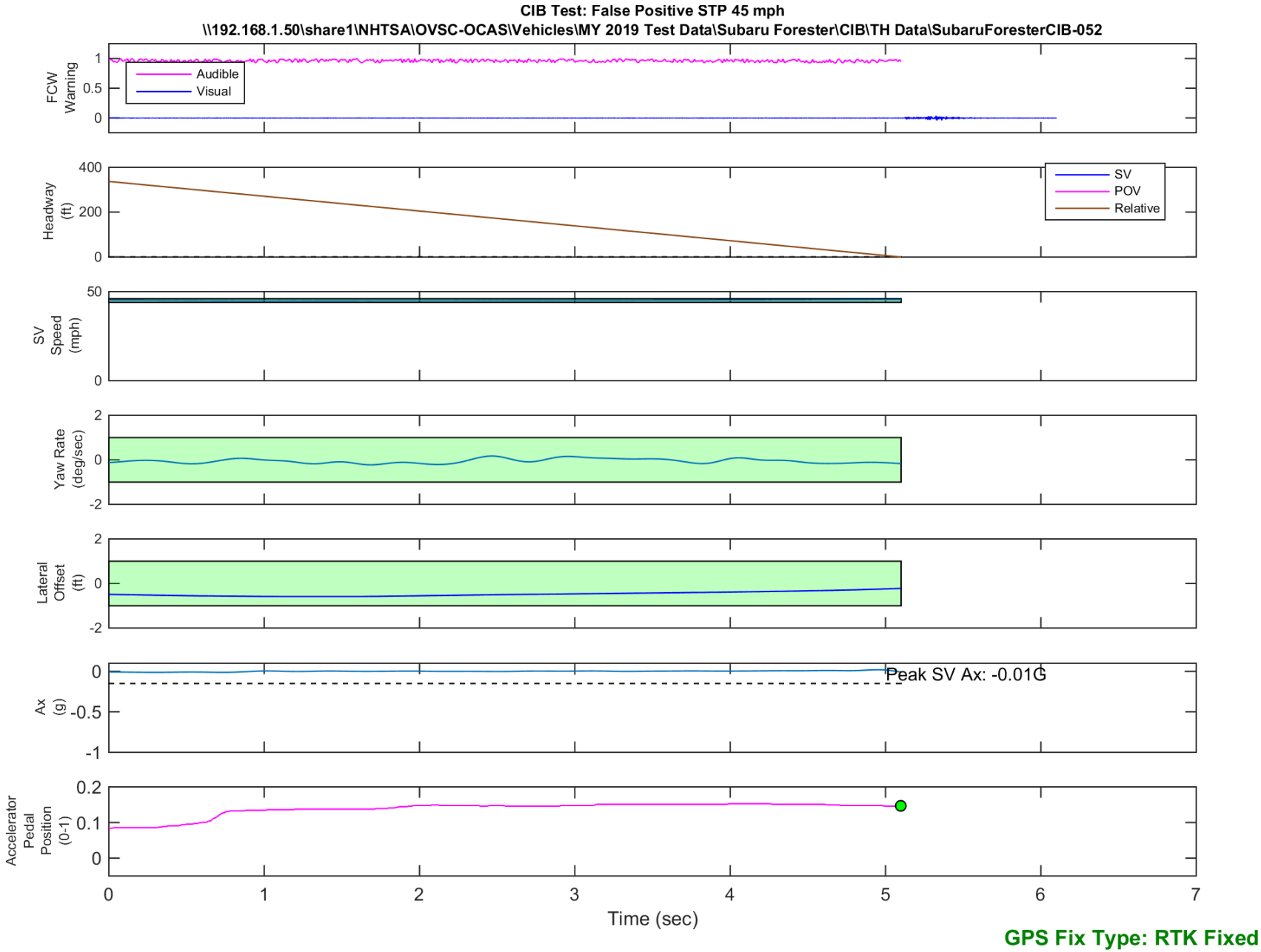


Figure D49. Time History for CIB Run 52, SV Encounters Steel Trench Plate, SV 45 mph

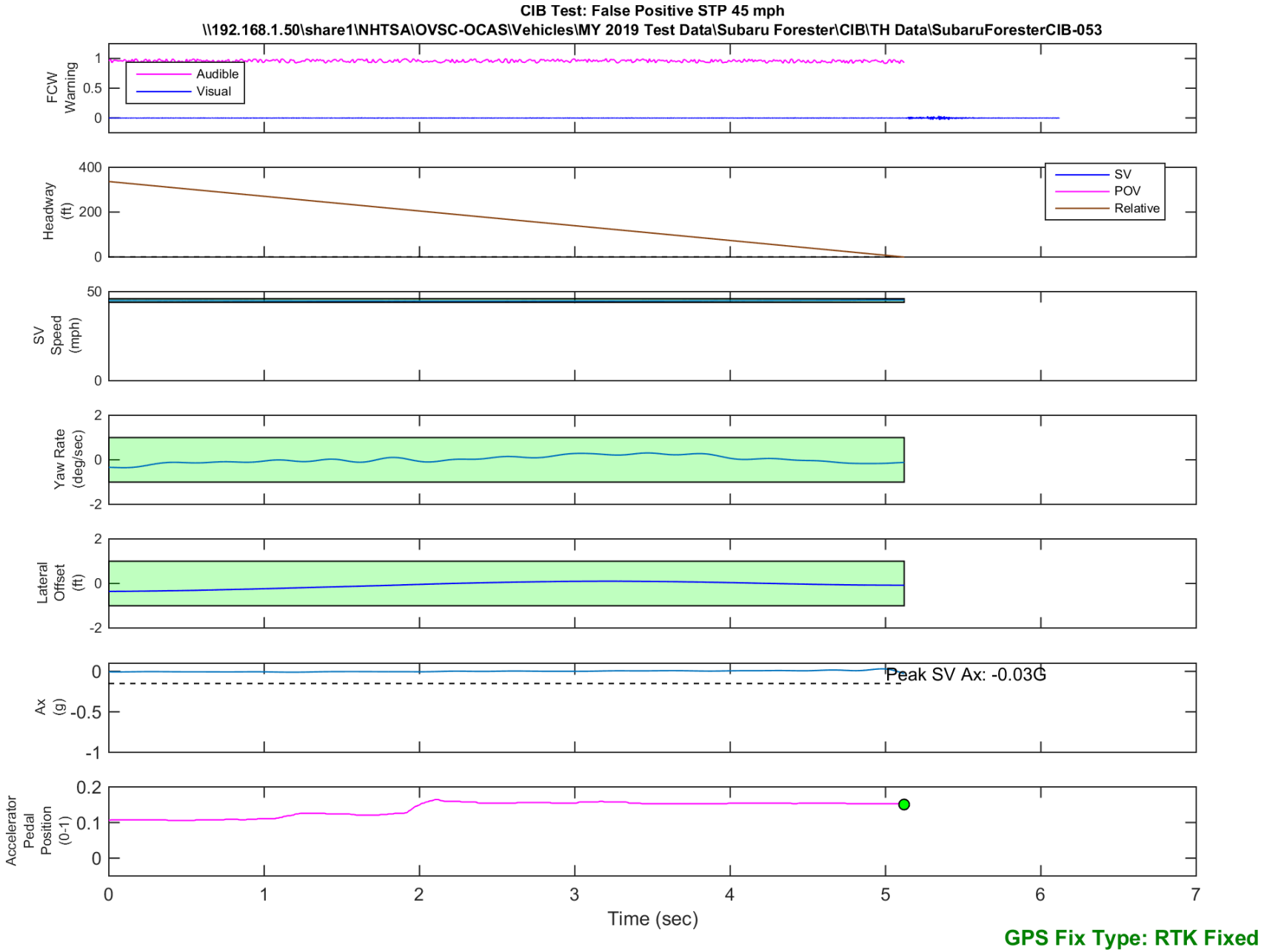


Figure D50. Time History for CIB Run 53, SV Encounters Steel Trench Plate, SV 45 mph

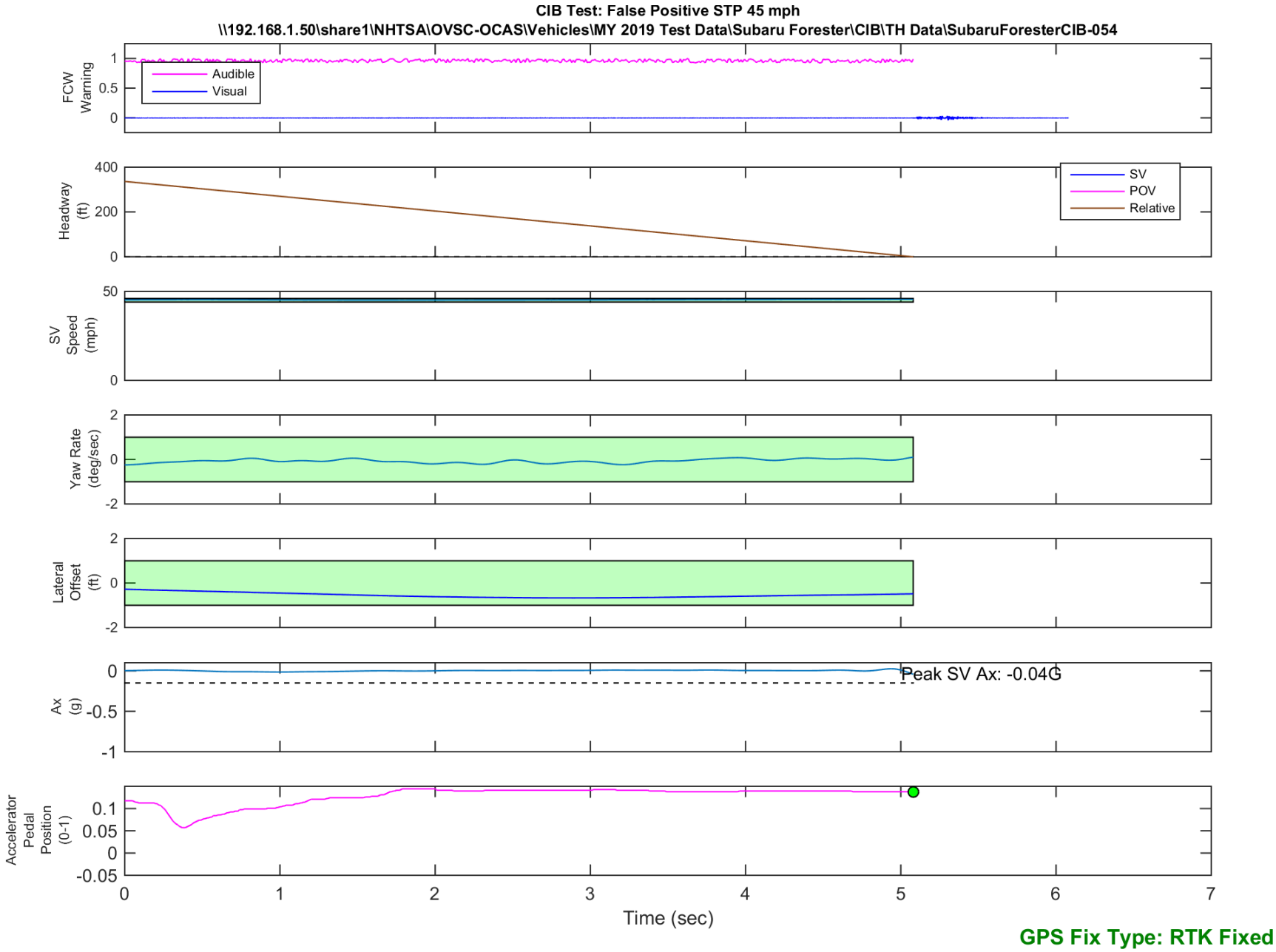


Figure D51. Time History for CIB Run 54, SV Encounters Steel Trench Plate, SV 45 mph