

**OCAS-DRI-CIB-19-02
NEW CAR ASSESSMENT PROGRAM
CRASH IMMINENT BRAKE SYSTEM CONFIRMATION TEST**

2019 Ford Mustang GT Coupe

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Final Report

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National Highway Traffic Safety Administration
Office of Crash Avoidance Standards
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16. Abstract These tests were conducted on the subject 2019 Ford Mustang GT Coupe 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 track¹ 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 Ford Mustang GT Coupe. 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

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2019 Ford Mustang GT Coupe

SUMMARY RESULTS

VIN: 1FA6P8CF7K51xxxx

Test Date: 3/27/2019

**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

(Page 1 of 2)

2019 Ford Mustang GT Coupe

TEST VEHICLE INFORMATION

VIN: 1FA6P8CF7K51xxxx

Body Style: Coupe

Color: Magnetic Metallic

Date Received: 3/25/2019

Odometer Reading: 20 mi

Engine: 5 L V-8

Transmission: Automatic

Final Drive: RWD

Is the vehicle equipped with:

ABS	<u>X</u>	Yes	<u> </u>	No
Adaptive Cruise Control	<u>X</u>	Yes	<u> </u>	No
Collision Mitigating Brake System	<u>X</u>	Yes	<u> </u>	No

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: Ford Motor Co.

Date of manufacture: 09/18

DATA FROM TIRE PLACARD:

Tires size as stated on Tire Placard: Front: 255/40ZR19

Rear: 275/40ZR19

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

Rear: 220 kPa (32 psi)

CRASH IMMINENT BRAKE
DATA SHEET 2: VEHICLE DATA

(Page 2 of 2)

2019 Ford Mustang GT Coupe

TIRES

Tire manufacturer and model: Michelin Pilot Sport 4 S

Front tire size: 255/40ZR19

Rear tire size: 275/40ZR19

VEHICLE ACCEPTANCE

Verify the following before accepting the vehicle:

- All options listed on the "window sticker" are present on the test vehicle
- Tires and wheel rims are the same as listed.
- There are no dents or other interior or exterior flaws.
- The vehicle has been properly prepared and is in running condition.
- 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

(Page 1 of 2)

2019 Ford Mustang GT Coupe

GENERAL INFORMATION

Test date: 3/27/2019

AMBIENT CONDITIONS

Air temperature: 19.4 C (67 F)

Wind speed: 3.1 m/s (6.9 mph)

- X Windspeed \leq 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 X
recommended cold tire pressure:

Front: 220 kPa (32 psi)

Rear: 220 kPa (32 psi)

CRASH IMMINENT BRAKE
DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2019 Ford Mustang GT Coupe

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front: 509.4 kg (1123 lb)

Right Front 508.0 kg (1120 lb)

Left Rear 442.3 kg (975 lb)

Right Rear 427.3 kg (942 lb)

Total: 1887.0 kg (4160 lb)

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

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2019 Ford Mustang GT Coupe

Name of the CIB option, option package, etc.

Pre-Collision Assist

System setting used for test (if applicable): *High Sensitivity*

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

The CIB system is available from 5 kph (Per manufacturer supplied information)

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

The CIB system is available to the maximum speed of the vehicle for vehicle targets. (Per manufacturer supplied information)

Does the vehicle system require an initialization sequence/procedure?

If Active Braking is enabled, the vehicle should require no other initialization.

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

It is recommended to wait a minimum of 90 seconds between test runs and to turn around when restaging as opposed to simply reversing in order to completely remove the target from the sensors field of view. The system effectiveness may reduce if too many AEB activations occur in quick succession. The message "Pre-Collision Assist Not Available" may also appear under repeated AEB activations/impacts. In this case, cycle the ignition to re-enable the Pre-Collision Assist feature.

If there has been a sufficiently hard impact to the target, the radar mounting may become damaged. It is recommended to visually inspect after a hard impact to verify this is not the case. If the radar mounting or sensing zone is affected, after a sufficient amount of time has passed the driver may be notified via a cluster message referencing the Front Sensor. If the radar, sensing zone, or mounting is damaged, the parts should be replaced and a service alignment procedure should be performed.

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

(Page 2 of 3)

2019 Ford Mustang GT Coupe

How is the Forward Collision Warning presented to the driver? Warning light
(Check all that apply) 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 driver is provided with an audible and visual alert. The audible sound is a four-tone chime repeated three times. The visual alert is through a red flashing LED light bar that is reflected in the lower part of the windshield in front of the driver.

Is there a way to deactivate the system? Yes
 No

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

A set of buttons on the right side of the steering wheel are used to interact with the system menus displayed in the center of the instrument panel. The CIB and DBS functionality can be turned off through a single checkbox in the cluster menu:

-Driver Assist

-Pre-Collision

-Active Braking (checkbox)

CIB and DBS are on by default after every ignition cycle.

CRASH IMMINENT BRAKING

DATA SHEET 4: CRASH IMMINENT BRAKING SYSTEM OPERATION

(Page 3 of 3)

2019 Ford Mustang GT Coupe

Is the vehicle equipped with a control whose purpose is to adjust the range setting or otherwise influence the operation of CIB? Yes
 No

If yes, please provide a full description.

A set of buttons on the right side of the steering wheel are used to interact with the system menus displayed in the center of the instrument panel:

-Driver Assist

-Pre-Collision

-Alert sensitivity: High, Normal, Low

Are there other driving modes or conditions that render CIB inoperable or reduce its effectiveness? Yes
 No

If yes, please provide a full description.

- *The system does not operate during hard acceleration or steering.*
- *The system may fail or operate with reduced function during cold and severe weather conditions.*
- *Snow, ice, rain, spray and fog can adversely affect the system.*

In situations where the vehicle camera has limited detection capability, this may reduce system performance. These situations include but are not limited to:

- *direct or low sunlight,*
- *vehicles at night without tail lights,*
- *unconventional vehicle types,*
- *pedestrians with complex backgrounds,*
- *running pedestrians,*
- *partly obscured pedestrians, or pedestrians that the system cannot distinguish from a group.*

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.

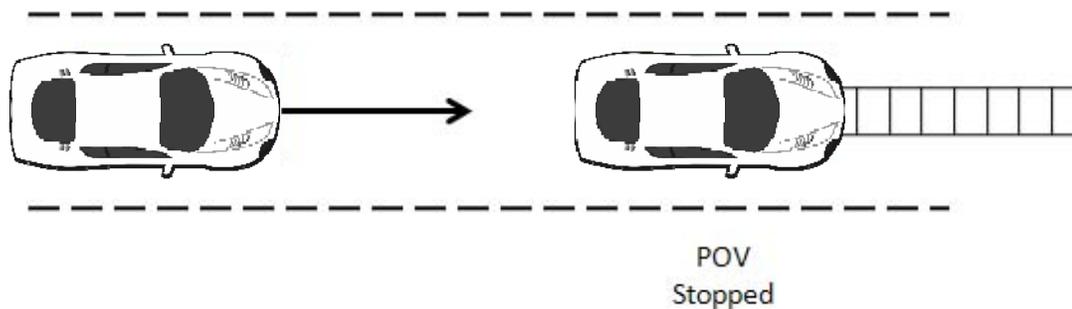


Figure 1. Depiction of Test 1

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.

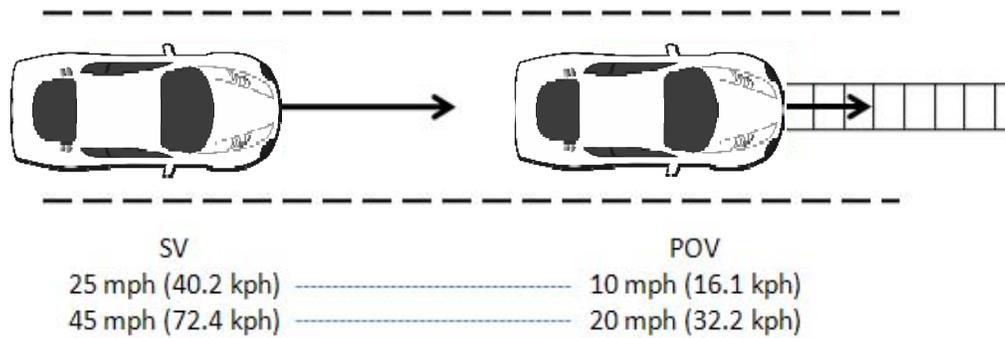


Figure 2. Depiction of Test 2

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 (74.4 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.

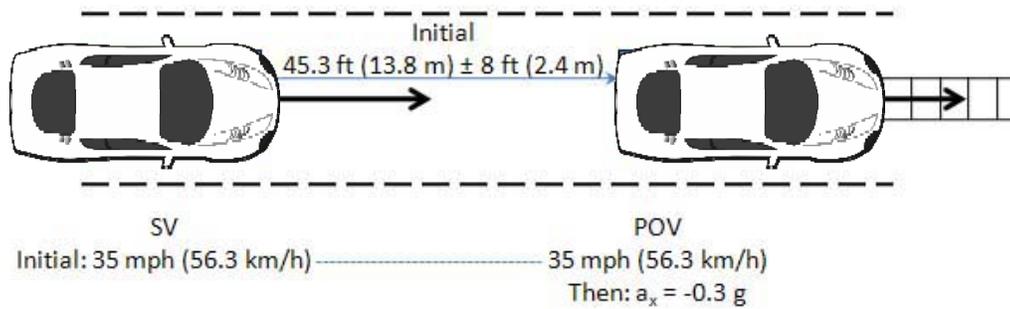


Figure 3. Depiction of Test 3 with POV Decelerating

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	5 th	3 dB	60 dB	Identified Center Frequency \pm 5%
Tactile	5 th	3 dB	60 dB	Identified Center Frequency \pm 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, conduct 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	1200 lb/platform 5338 N/	0.5% of applied load	Intercomp SWI	1110M206352	By: DRI Date: 1/3/2019 Due: 1/3/2020
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	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: ± 0.02 m/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)	$\pm 5g$	$\leq 3\%$ 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	U08-05-08-06636	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).			D-Space Micro-Autobox II 1401/1513		
				Base Board	549068	
				I/O Board	588523	

APPENDIX A

Photographs

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Figure A1. Front View of Subject Vehicle



Figure A2. Rear View of Subject Vehicle



VEHICLE DESCRIPTION

MUSTANG

2019 GT COUPE
4-PASSENGER SPORTS CAR
5.0L I4 VCT V8
10-SPEED AUTOMATIC TRANS

K5 12

EXTERIOR
MAGNETIC METALLIC
INTERIOR:
EBONY CLOTH BUCKET SEATS

STANDARD EQUIPMENT INCLUDED AT NO EXTRA CHARGE

EXTERIOR

- EASY FUEL® CAPLESS FILLER
- FOG LAMPS-LED
- GRILLE-PAINTED BLACK
- HEADLAMPS - AUTOLAMP (ON/OFF)
- HEADLAMPS- LED WITH SIGNATURE LIGHTING
- HOOD VENTS
- MIRRORS - MAN-FOLD POWER W/ INTEGRATED BLIND SPOT
- QUAD TIP DUAL EXHAUST
- TAILLAMPS-LED W/SEQUENTIAL TURN SIGNAL
- WIPERS- INTERMITTENT

INTERIOR

- 1TOUCH UP/DOWN DR/PASS WIN
- AUTODIM REARVIEW MIRROR
- CENTER CONSOLE W/ARMREST
- DUAL ILLUM VANITY MIRRORS
- FLOOR MATS - FRONT
- LEATHER WRAPPED STR WHEEL W/CRUISE AND AUDIO CONTRO
- POWER DRIV AND PASS SEATS
- 6-WAY
- POWERPOINTS (2)
- SMART CHARGING USB PORT(2)
- SPLIT FOLD REAR SEAT
- TILT/TELESCOPE STR COLUMN
- WINDOWS - GLOBAL OPEN

FUNCTIONAL

- AM/FM WITH MP3
- ELECTRONIC PWR ASST STEER
- INDEPENDENT REAR SUSPEN
- INTELLIGENT ACCESS W/PUSH BUTTON START
- LIMITED SLIP REAR AXLE
- MYKEY®
- REAR VIEW CAMERA
- REVERSE SENSING SYSTEM
- SELECTABLE DRIVE MODES
- SIRIUSXM® - SVC N/A AK&H
- SYNCG3® 8" SCRIN W/APPLINK®
- TRACK APPS™

SAFETY/SECURITY

- ADVANCETRAC ESC
- AIRBAG-DRIVER/PASS KNEE
- AIRBAGS - DUAL STAGE FRONT
- AIRBAGS - FRONT SEAT MOUNTED SIDE IMPACT
- AIRBAGS - SIDE AIR CURTAIN
- INDIV TIRE PRESS MONIT SYS
- LATCH CHILD SAFETY SYSTEM
- PERIMETER ALARM
- SECURILOCK PASS ANTI THEFT
- SOS POST CRASH ALERT SYS

WARRANTY

- 3YR/36000 BUMPER TO BUMPER
- 5YR/60,000 POWERTRAIN
- 5YR/60,000 ROADSIDE ASSIST

INCLUDED ON THIS VEHICLE

- EQUIPMENT GROUP 301A**
-DUAL-ZONE ELEC AUTO TEMP CTRL
-SIRIUSXM RADIO N/A AK&H

(MSRP)

2,000.00

OPTIONAL EQUIPMENT/OTHER

- 10-SPEED AUTOMATIC TRANS
- GT PERFORMANCE PACKAGE
- 19 EBONY BLACK PNTD ALUM WHL
- P255S/P275R/40R19 SUMMER TIRE
- PERFORMANCE REAR WING
- 3.55 RATIO LIMITED SLIP AXLE
- FORD SAFE & SMART PACKAGE
- ADAPTIVE CRUISE CONTROL
- FRONT LICENSE PLATE BRACKET
- 50 STATE EMISSIONS
- VOICE-ACT TOUCHSCREEN NAV SYS

1,595.00

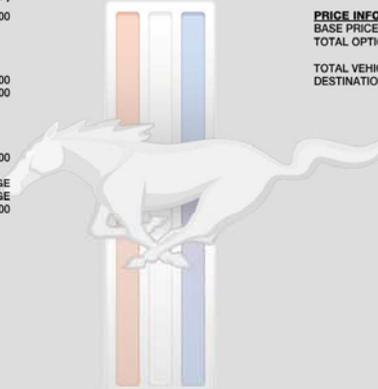
3,995.00

1,000.00

NO CHARGE

NO CHARGE

795.00



PRICE INFORMATION

BASE PRICE	\$35,355.00
TOTAL OPTIONS/OTHER	9,385.00
TOTAL VEHICLE & OPTIONS/OTHER DESTINATION & DELIVERY	44,740.00
	995.00

(MSRP)

RAMP ONE	RH27	RAIL	Whether you decide to lease or finance your vehicle, you'll find the choices that are right for you. See your dealer for details or visit www.ford.com/finance .	TOTAL MSRP \$45,735.00
RAMP TWO	ITEM #: 71-G200 O/T 2			
This label is affixed pursuant to the Federal Automobile Information Disclosure Act. Gasoline, License, and Title Fees, State and Local taxes are not included. Dealer installed options or accessories are not included unless listed above.			JJ101 N RA 2X 925 000671 09 10 18	

EPA DOT Fuel Economy and Environment

Gasoline Vehicle

Fuel Economy

19 MPG
combined city/hwy
5.3 gallons per 100 miles

16 city
25 highway

Subcompact Cars range from 14 to 124 MPG. The best vehicle rates 136 MPG.

You spend **\$3,000** more in fuel costs over 5 years compared to the average new vehicle.

Annual fuel cost **\$2,000**

Fuel Economy & Greenhouse Gas Rating (tailpipe only)



Smog Rating (tailpipe only)



This vehicle emits 471 grams CO₂ per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel also create emissions; learn more at fuelconomy.gov.

Actual results will vary for many reasons, including driving conditions and how you drive and maintain your vehicle. The average new vehicle gets 27 MPG and costs \$7,000 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at \$2.55 per gallon. MPG is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

fuelconomy.gov

Calculate personalized estimates and compare vehicles

GOVERNMENT 5-STAR SAFETY RATINGS

Overall Vehicle Score ★★★★★
Based on the combined ratings of frontal, side and rollover. Should ONLY be compared to other vehicles of similar size and weight.

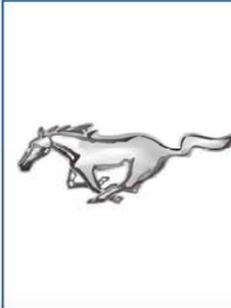
Frontal Crash	Driver	★★★★★
	Passenger	★★★★★
Side Crash	Front seat	★★★★★
	Rear seat	★★★★★
Rollover		★★★★★

Based on the risk of injury in a frontal impact. Should ONLY be compared to other vehicles of similar size and weight.

Based on the risk of injury in a side impact.

Based on the risk of rollover in a single-vehicle crash.

Star ratings range from 1 to 5 stars (★★★★★), with 5 being the highest. Source: National Highway Traffic Safety Administration (NHTSA). www.safercar.gov or 1-888-327-4236



1FA6P8CF7K512

WARNING: Operating, servicing and maintaining a passenger vehicle, pickup truck, van, or off-road vehicle can expose you to chemicals including engine exhaust, carbon monoxide, phthalates, and lead, which are known to the State of California to cause cancer and birth defects or other reproductive harm. To minimize exposure, avoid breathing exhaust, do not idle the engine except as necessary, service your vehicle in a well-ventilated area and wear gloves or wash your hands frequently when servicing your vehicle. For more information go to www.P65Warnings.ca.gov/passenger-vehicle.

FORD PROTECT™

Insist on Ford Protect! The only extended service plan fully backed by Ford and honored at every Ford dealership in the U.S., Canada and Mexico. See your Ford dealer or visit www.FordOwner.com.

SCAN OR TEXT 1FJK512 0 48028

Mag 6 Data codes may apply. Text HELP for help.

www.ford.com/help/privacy-terms/

0 1 1 5 2 0 1 1 8

1201809170925

Figure A3. Window Sticker (Monroney Label)

MFD. BY FORD MOTOR CO.

DATE: 09/18
FRONT GAWR: 1089 KG (2400 LB) GVWR: 2141 KG (4720 LB)
REAR GAWR: 1057 KG (2330 LB)

THIS VEHICLE CONFORMS TO ALL APPLICABLE FEDERAL MOTOR
VEHICLE SAFETY, BUMPER, AND THEFT PREVENTION STANDARDS
IN EFFECT ON THE DATE OF MANUFACTURE SHOWN ABOVE.

VIN: 1FA6P8CF7K512 TYPE: Passenger Car
MAXIMUM LOAD = OCCUPANTS + LUGGAGE = 303KG/ 668LB
OCCUPANTS = 4 TOTAL; 2 FRONT, 2 REAR

TIRE (FR): 255/40ZR19 100Y RIMS (FR): 19x9.0J
(RR): 275/40ZR19 105Y (RR): 19x9.5J
PRESSURE (FR): 220 kPa/ 32 PSI COLD (RR): 220 kPa/ 32 PSI COLD



1FA6P8CF7K512

TRAILER TOWING - SEE OWNER GUIDE

EXT PNT: J7

IRC: 71 IDSO:

INT TR	TP/PS	R	AXLE	TR	SPR
21		E	DD	U	JJHH

F0093
R0069

1201809170925

CMC

▽5U5A-5420472-AA

Figure A4. Vehicle Certification Label



TIRE AND LOADING INFORMATION

SEATING CAPACITY TOTAL : 4 FRONT: 2 REAR: 2

The combined weight of occupants and cargo should never exceed : **303 kg or 668 lbs.**

▽5U5A-1532-AA (TLU)

TIRE	SIZE	COLD TIRE PRESSURE
FRONT	255/40ZR19 100Y	220 KPA, 32 PSI
REAR	275/40ZR19 105Y	220 KPA, 32 PSI
SPARE	NONE	NONE

**SEE OWNERS
MANUAL FOR
ADDITIONAL
INFORMATION**

1FA6P8CF7K512



Figure A5. Tire Placard



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



Figure A7. Load Frame/Slider of SSV

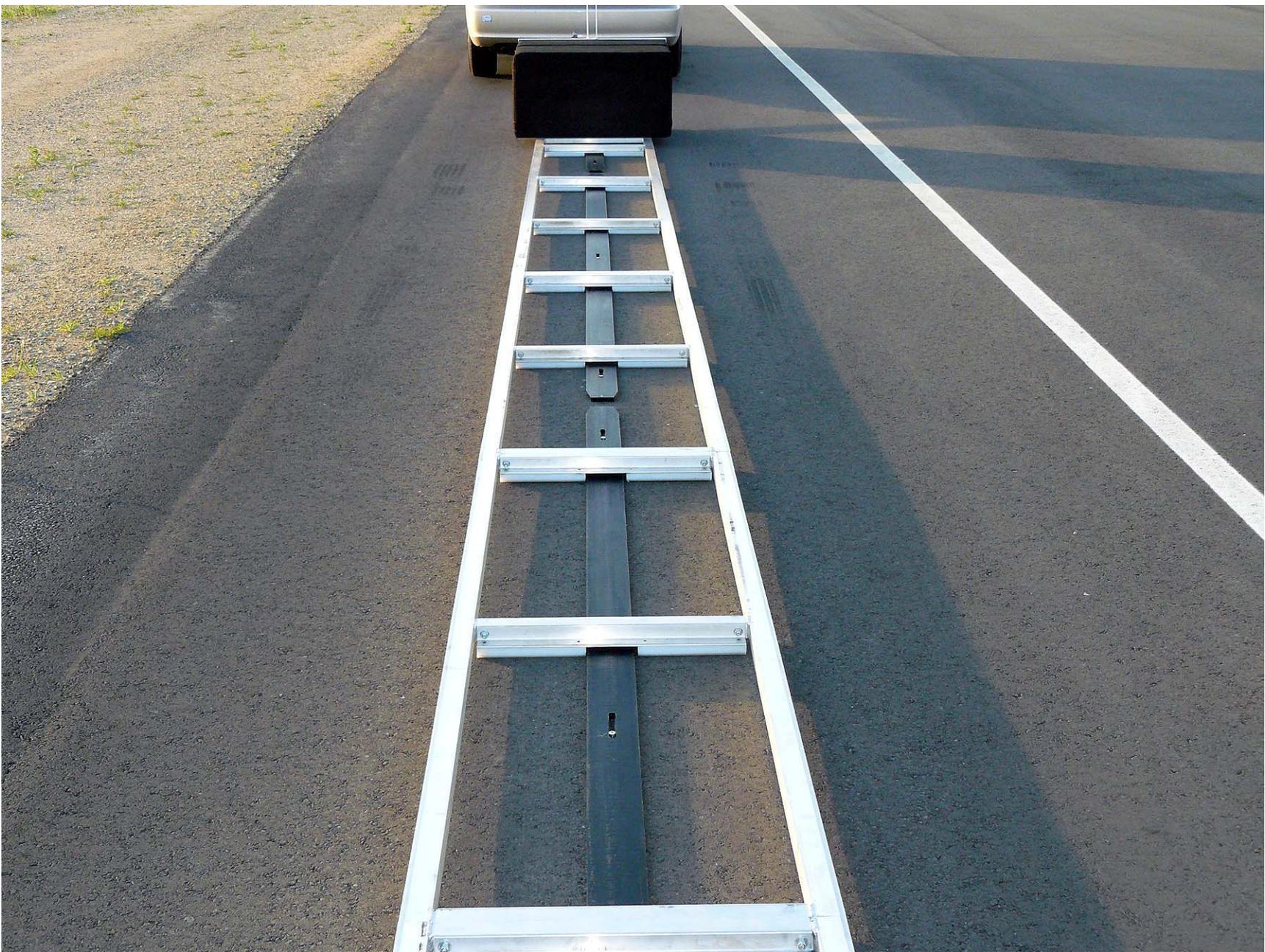


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track



Figure A9. Steel Trench Plate

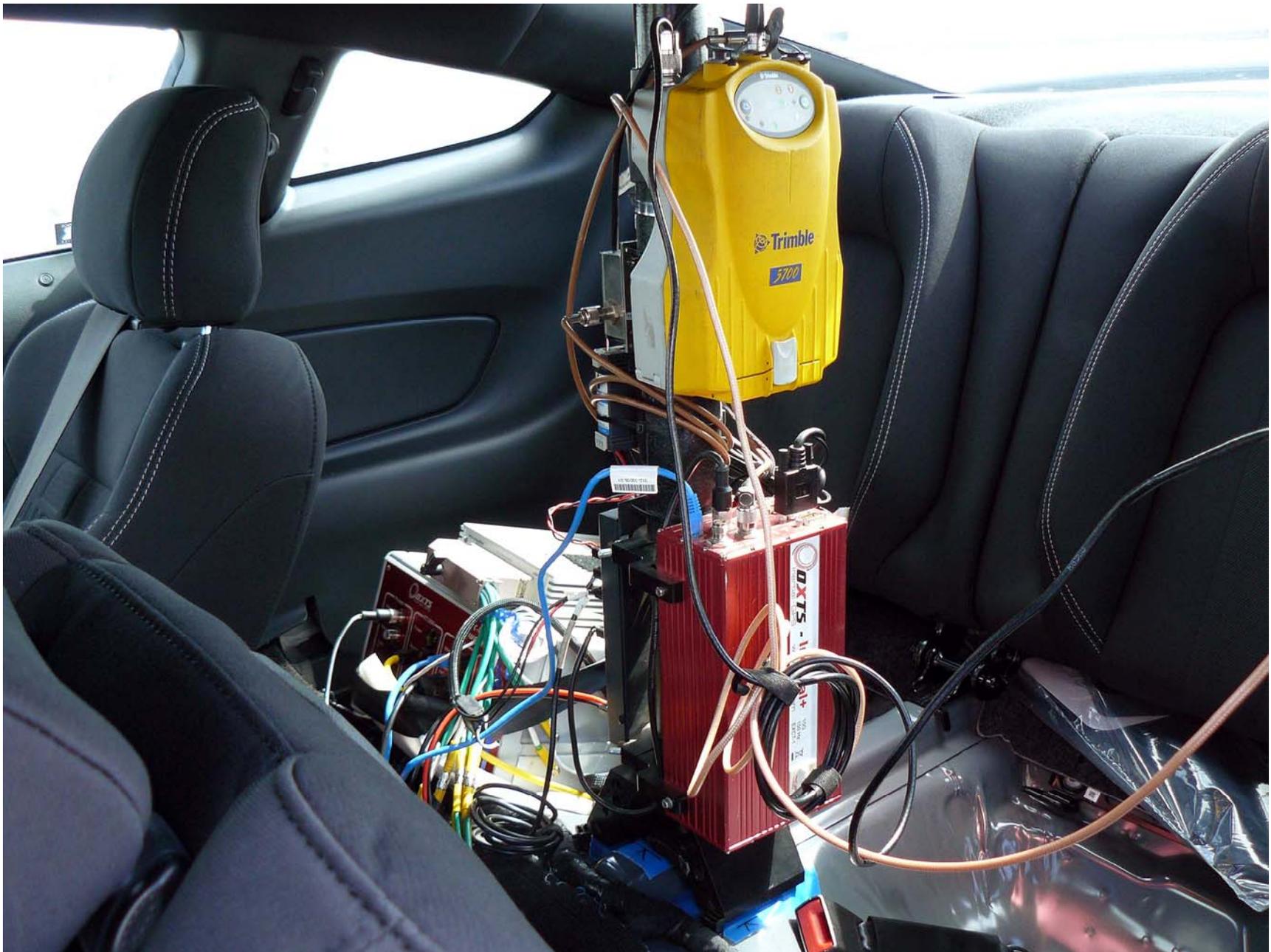


Figure A10. DGPS, Inertial Measurement Unit and MicroAutoBox Installed in Subject Vehicle



Figure A11. Sensor for Detecting Visual heads Up Alert

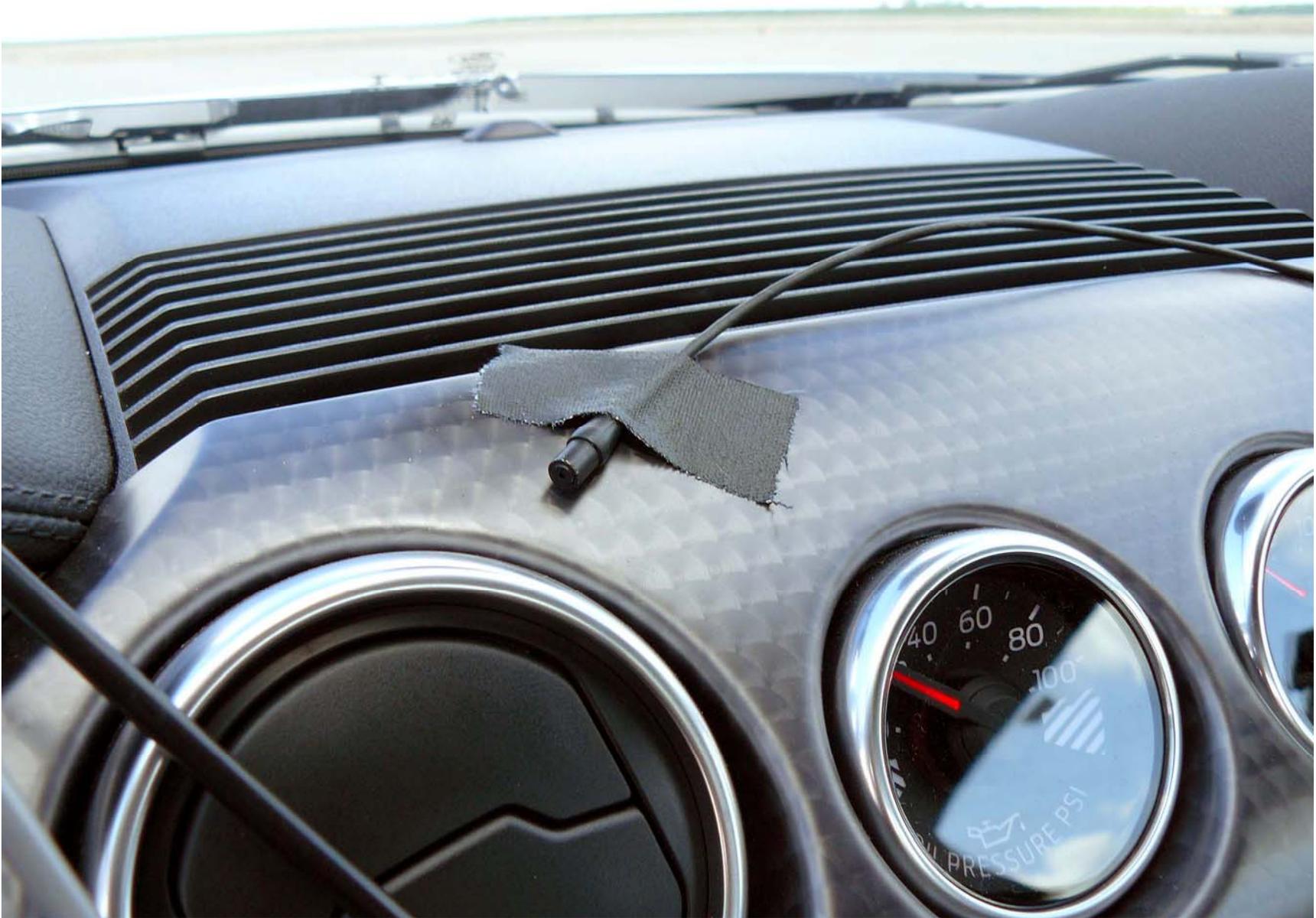


Figure A12. Sensor for Detecting Auditory Alerts



Figure A13. Computer Installed in Subject Vehicle



Figure A14. Brake Actuator Installed in POV System



Figure A15. Heads Up AEB Visual Alert



Figure A16. Instrument Panel AEB Visual Alert



Figure A17. AEB Setup Menus



Figure A18. Steering Wheel Mounted Controls for Changing Parameters.

APPENDIX B

Excerpts from Owner's Manual

Information Displays

Track Apps™	
	RPM
Rev Match	
View/Clear Results	Acceleration Timer
	Brake Performance
	Lap Timer
	All Time Best
	Clear Saved Data
	Clear All Time Best
	Clear Accel.

Note: Some items are optional and may not appear.

Driver Assist	
AdvanceTrac	
Auto Engine Off	
Blindspot	
Driver Alert	
Pre-Collision Assist	Sensitivity
	Active Braking
	Distance Indication
Cross Traffic Alert	
Rear Park Aid	
Cruise Control	Choose your applicable setting.
Hill Start Assist	
Lane Keeping Assist	Mode
	Intensity
Tire Monitor	Hold OK to Reset

Information Displays

- | | |
|--|--|
| <ul style="list-style-type: none"> F Audio Button. G Phone Buttons. H Settings Button. I Navigation Button. <ul style="list-style-type: none"> • Press one of the quick action menu (QAM) buttons to enter a menu. • Toggle (B) and (D) to scroll through and highlight the options within a menu. | <ul style="list-style-type: none"> • Press the OK button to enter a sub-menu. • Press (A) to exit a menu. • Press the open menu's QAM button at any time to close the menu (escape button). • Press the OK button to choose and confirm settings or messages. |
|--|--|

Settings

Settings	
Trip/Fuel Info	
Driver Assist	Auto Engine Off
	Blindspot
	Pre-Collision Assist
	Cross Traffic Assist
	Cruise Control
	Driver Alert
	Hill Start Assist
	Rear Park Aid
	Lane Keeping System
	Tire Monitor
	Wipers
Speedometer km/h or Speedometer MPH	
Advanced Settings	Vehicle
	MyKey
	Display Setup

Driving Aids

PRE-COLLISION ASSIST (if

Equipped)

 **WARNING:** At all times, you are responsible for controlling your vehicle, supervising the system and intervening, if required. Failure to take care may result in the loss of control of your vehicle, serious personal injury or death.

 **WARNING:** The system does not detect vehicles that are driving in a different direction, cyclists or animals. Failure to take care may result in the loss of control of your vehicle, serious personal injury or death.

 **WARNING:** The system does not operate during hard acceleration or steering. Failure to take care may lead to a crash or personal injury.

 **WARNING:** The system may fail or operate with reduced function during cold and severe weather conditions. Snow, ice, rain, spray and fog can adversely affect the system. Keep the front camera and radar free of snow and ice. Failure to take care may result in the loss of control of your vehicle, serious personal injury or death.

 **WARNING:** In situations where the vehicle camera has limited detection capability, this may reduce system performance. These situations include but are not limited to direct or low sunlight, vehicles at night without tail lights, unconventional vehicle types, pedestrians with complex backgrounds, running

pedestrians, partly obscured pedestrians, or pedestrians that the system cannot distinguish from a group. Failure to take care may result in the loss of control of your vehicle, serious personal injury or death.

 **WARNING:** The system cannot help prevent all crashes. Do not rely on this system to replace driver judgment and the need to maintain a safe distance and speed.

Using the Pre-Collision Assist System

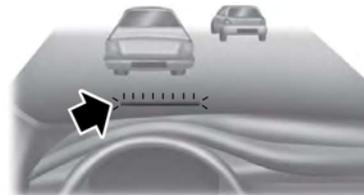
The system is active at speeds above approximately 3 mph (5 km/h) and pedestrian detection is active at speeds up to 50 mph (80 km/h).



E156130

If your vehicle is rapidly approaching another stationary vehicle, a vehicle traveling in the same direction as yours, or a pedestrian within your driving path, the system is designed to provide three levels of functionality:

1. Alert
2. Brake Support
3. Active Braking



E156131

Driving Aids

Alert: When activated, a flashing visual warning and an audible warning tone sounds.

Brake Support: Assists the driver in reducing collision speed by preparing the brake system for rapid braking. Brake support does not automatically activate the brakes, but if the driver presses the brake pedal even lightly, brake support could add additional braking up to full force.

Active Braking: Active braking may activate if the system determines that a collision is imminent. The system may help the driver reduce impact damage or avoid the crash completely.

Note: If you perceive Pre-Collision Assist alerts as being too frequent or disturbing, then you can reduce the alert sensitivity, though the manufacturer recommends using the highest sensitivity setting where possible. Setting lower sensitivity would lead to fewer and later system warnings.

Note: The system turns off when you manually disable AdvanceTrac™, or when you select **Track** mode.

Distance Indication and Alert

Distance Indication and Alert is a function that provides a graphical indication of the time gap to other preceding vehicles traveling in the same direction. The Distance Indication and Alert screen in the information display shows a graphic similar to the one that follows.



E190004

If the time gap to a preceding vehicle is small, a red visual indication displays.

Note: Distance Indication and Alert deactivates and the graphics do not display when adaptive cruise control is active.

Speed	Sensitivity	Graphics	Distance Gap	Time Gap
62 mph (100 km/h)	Normal	Grey	>82 ft (25 m)	>0.9sec
62 mph (100 km/h)	Normal	Yellow	56–82 ft (17–25 m)	0.6sec - 0.9sec
62 mph (100 km/h)	Normal	Red	<56 ft (17 m)	<0.6sec

Adjusting Pre-Collision Assist Settings

You can adjust the Alert and Distance Alert sensitivity to one of three possible settings by using the information display control. See **General Information** (page 88).

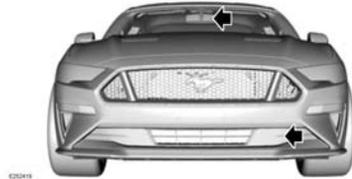
You can switch the distance alert and indication function off using the information display controls. See **General Information** (page 88).

If required, you can switch active braking off using the information display controls. See **General Information** (page 88).

Driving Aids

Note: Active braking automatically turns on every time you switch your vehicle on.

Blocked Sensors



If a message regarding a blocked sensor or camera appears in the information display, the radar signals or camera images are obstructed. The radar sensor is located behind a fascia cover near the driver side of the lower grille. With an obstructed radar, the Pre-Collision Assist system does not function and cannot detect a vehicle ahead. With the front camera obstructed, the Pre-Collision Assist system does not respond to pedestrians or stationary vehicles and the system performance on moving vehicles reduces. The following table lists possible causes and actions for when this message displays.

Cause	Action
The surface of the radar in the grille is dirty or obstructed in some way.	Clean the grille surface in front of the radar or remove the object causing the obstruction.
The surface of the radar in the grille is clean but the message remains in the display.	Wait a short time. It may take several minutes for the radar to detect that there is no obstruction.
Heavy rain, spray, snow, or fog is interfering with the radar signals.	The Pre-Collision Assist system is temporarily disabled. Pre-Collision Assist should automatically reactivate a short time after the weather conditions improve.
Swirling water, or snow or ice on the surface of the road may interfere with the radar signals.	The Pre-Collision Assist system is temporarily disabled. Pre-Collision Assist should automatically reactivate a short time after the weather conditions improve.
Radar is out of alignment due to a front end impact.	Contact an authorized dealer to have the radar checked for proper coverage and operation.
The windshield in front of the camera is dirty or obstructed in some way.	Clean the outside of the windshield in front of the camera.
The windshield in front of the camera is clean but the message remains in the display.	Wait a short time. It may take several minutes for the camera to detect that there is no obstruction.

Driving Aids

Note: Proper system operation requires a clear view of the road by the camera. Have any windshield damage in the area of the camera's field of view repaired.

Note: If something hits the front end of your vehicle or damage occurs, the radar sensing zone may change. This could cause missed or false vehicle detections. Contact an authorized dealer to have the radar checked for proper coverage and operation.

Note: If your vehicle detects excessive heat at the camera or a potential misalignment condition, a message may display in the information display indicating temporary sensor unavailability. When operational conditions are correct, the message deactivates. For example, when the ambient temperature around the sensor decreases or the sensor automatically recalibrates successfully.

DRIVE CONTROL (If Equipped)

Selectable Drive Modes

Selectable drive modes deliver a customized driving experience using a variety of electronic vehicle systems. The systems optimize vehicle dynamics and powertrain response based on your selected mode. Systems associated with selectable drive modes are:

- Electronically power assisted steering. See **Steering** (page 182).
- Electronic stability control and traction control maintain your vehicle control in adverse conditions or high performance driving. See **Stability Control** (page 157).
- Electronic throttle control enhances the powertrain response to your driving input.

- Adaptive dampers (if equipped).
- Active exhaust adjusts the sound characteristics of your vehicle (if equipped).

Using Selectable Drive Modes

Note: Your vehicle may have some of the drive modes that follow.

MODE To change the drive mode setting, press the mode button on the instrument panel under the display. The first press illuminates the selected mode, subsequent presses change the selected mode.

Note: Mode changes are not available when the ignition is off or when the transmission is in reverse (R). Some modes may be unavailable when the transmission is in drive (D) or sport (S).

Modes:

- **Normal** – Best suited for everyday driving. If your vehicle is equipped with adaptive dampers, the suspension delivers a balanced combination of comfort and handling. Selectable steering defaults to **Normal** but can be changed using the steering button.
- **Sport** – Engages when you shift your automatic transmission into sport (S). Sport mode increases throttle response and helps your vehicle accelerate faster, but does not change the vehicle dynamics or stability system.
- **Sport +** – Best suited for spirited driving. This mode increases throttle response, and if your vehicle is equipped with active exhaust, it takes on a more powerful tone. If your vehicle is equipped with adaptive dampers, the suspension becomes stiffer. This mode has less body motion and more precise steering. Selectable steering defaults to **Sport** but can be changed using the steering button.

Track Use



WARNING: *Track Apps™* is for track use only. Remember that even advanced technology cannot defy the laws of physics. It is always possible to lose control of a vehicle due to inappropriate driver input for the conditions. Aggressive driving on any road condition can cause you to lose control of your vehicle increasing the risk of personal injury or property damage.

Appropriately change the engine oil for racing and other track events:

- 2.3L: Prior to the track event, drain the engine oil, replace the oil filter and change the engine oil to 5W-50. After the track event, drain the engine oil, replace the oil filter and refill the engine oil with 5W-30. See **Capacities and Specifications** (page 298).
- 5.0L: Prior to the track event, drain the engine oil, replace the oil filter and change the engine oil to 5W-30. After the track event, drain the engine oil, replace the oil filter and refill the engine oil with 5W-20. See **Capacities and Specifications** (page 298).

Regularly check the engine oil level during the event. Maintain the engine oil level at or near the max mark on the engine oil dipstick. See **Engine Oil Check** (page 233).

Track Apps™

This information display driven feature provides a suite of menu options to record and optimize your track performances. See **General Information** (page 88).

Note: *Track Apps™* are for track use only. Do not use them under any other driving conditions.

Note: You cannot view or clear your results unless your vehicle is at a complete stop with the right arrow on the display menu inactive. If your vehicle does not reach 100 mph (160 km/h) during the track run, your display may not show your selected interval's results.

Note: The pre-collision assist system turns off when using *Track Apps™* or when you switch off your stability control system.

Acceleration Timer

Displays your vehicle's rate of acceleration for a given speed or distance range.

Accelerometer

Displays your vehicle's rate of acceleration or deceleration. A dot moves toward the area of acceleration or deceleration.

LEFT Acceleration or Deceleration

When accelerating or decelerating left, the dot moves to the right on the accelerometer.

RIGHT Acceleration or Deceleration

When accelerating or decelerating right, the dot moves to the left on the accelerometer.

Brake Performance

Displays your vehicle's rate of deceleration for a given speed range.

Exhaust Mode

Gives the driver the ability to choose the vehicle's exhaust mode.

APPENDIX C

Run Log

Subject Vehicle: 2019 Ford Mustang GT Coupe

Test Date: 3/27/2019

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	2.00	0.89	25.5	0.70	1.35	Pass	
3		Y	1.99	1.37	24.8	0.56	1.35	Pass	
4		Y	2.07	1.33	25.3	0.71	1.36	Pass	
5		Y	1.95	2.44	25.4	0.76	1.30	Pass	
6		Y	1.95	0.10	24.9	0.59	1.34	Pass	
7		Y	1.98	1.73	24.6	0.58	1.36	Pass	
8		Y	1.94	0.77	24.9	0.64	1.34	Pass	
9	Static Run								
10	Slower POV, 25 vs 10	Y	1.77	7.42	14.7	0.82	0.92	Pass	
11		Y	1.92	6.46	15.1	0.75	0.92	Pass	
12		Y	1.84	6.90	15.3	0.72	0.95	Pass	
13		Y	1.83	6.62	15.2	0.77	0.92	Pass	
14		Y	1.84	6.88	15.1	0.85	0.88	Pass	
15		Y	1.80	6.10	15.5	0.68	0.94	Pass	
16		Y	1.88	1.52	15.6	0.56	1.02	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
17	Static Run								
18	Static Run								
19	Slower POV, 45 vs 20	Y	2.19	0.63	24.9	0.99	1.15	Pass	
20		Y	2.25	1.36	25.4	1.04	1.08	Pass	
21		Y	2.22	1.66	25.3	1.06	1.06	Pass	
22		Y	2.17	1.86	24.9	1.00	1.18	Pass	
23		Y	2.20	2.02	25.4	0.99	1.12	Pass	
24		Y	2.22	2.13	24.9	0.92	1.16	Pass	
25		Y	2.21	1.31	24.7	0.99	1.12	Pass	
26	Static run								
27	Braking POV, 35	Y	1.65	0.00	32.2	1.02	1.15	Pass	
28		Y	1.77	0.00	32.6	1.02	1.22	Pass	
29		Y	1.64	0.00	32.3	0.89	1.17	Pass	
30		Y	1.53	0.00	32.4	0.94	1.10	Pass	
31		Y	1.60	0.00	32.3	0.99	1.13	Pass	
32		Y	1.55	0.00	30.7	0.87	1.04	Pass	
33		N							Throttle
34		Y	1.71	0.00	31.9	0.95	1.14	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	Static Run								
36	STP - Static Run								
37	STP False Positive, 25	Y				0.01		Pass	
38		Y				0.01		Pass	
39		Y				0.04		Pass	
40		Y				0.01		Pass	
41		Y				0.01		Pass	
42		Y				0.00		Pass	
43		Y				0.00		Pass	
44	STP - Static Run								
45	STP False Positive, 45	Y				0.03		Pass	
46		Y				0.02		Pass	
47		Y				0.02		Pass	
48		Y				0.02		Pass	
49		Y				0.03		Pass	
50		Y				0.01		Pass	
51		Y				0.03		Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Min. Distance (ft)	Speed Reduction (mph)	Peak Decel. (g)	CIB TTC (s)	Pass/Fail	Notes
52	STP - Static Run								

APPENDIX D

Time History Plots

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Description of Time History Plots

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

Time History Plot Description

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

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

Time history figures include the following sub-plots:

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

As only the audible or haptic alert is perceptible by the driver during a test run, the earliest of either of these alerts is used to define the onset of the FCW alert. A vertical black bar on the plot indicates the

TTC (sec) at the first moment of the warning issued by the FCW system. The FCW TTC is displayed to the right of the subplot in green.

- 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.

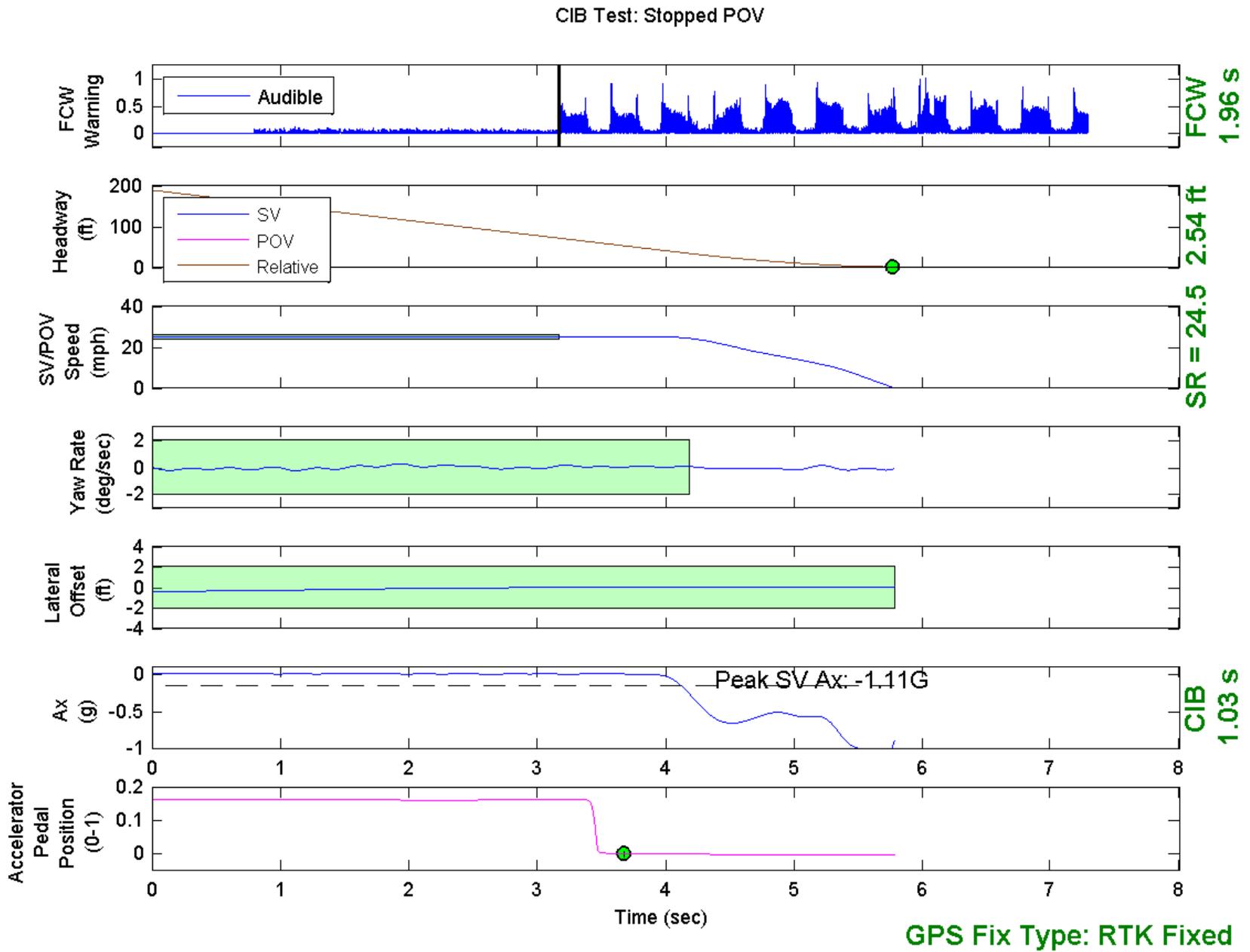


Figure D1. Example Time History for Stopped POV, Passing

CIB Test: Slower POV 25/10 mph

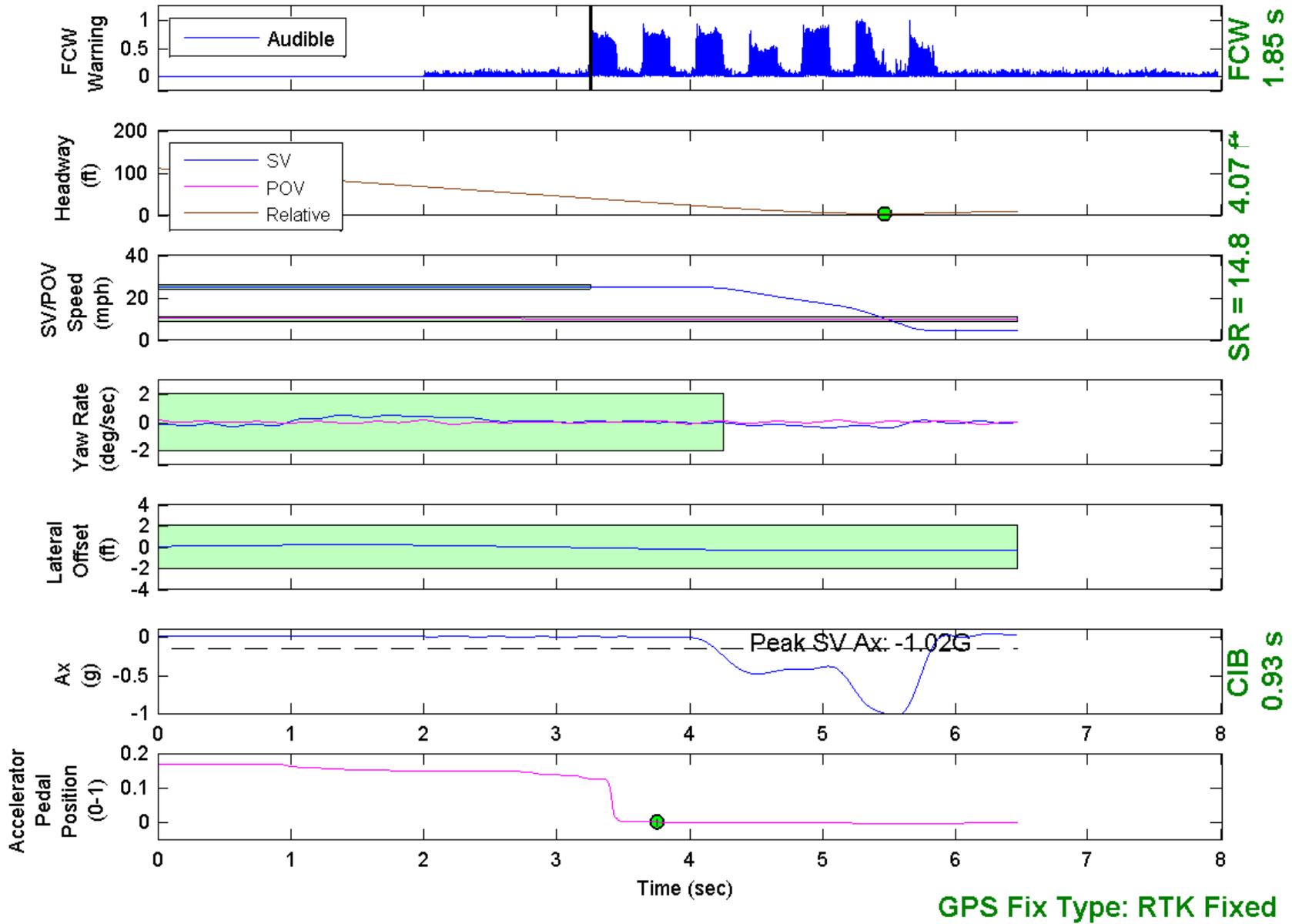


Figure D2. Example Time History for Slower POV 25 vs. 10, Passing

CIB Test: Slower POV 45/20 mph

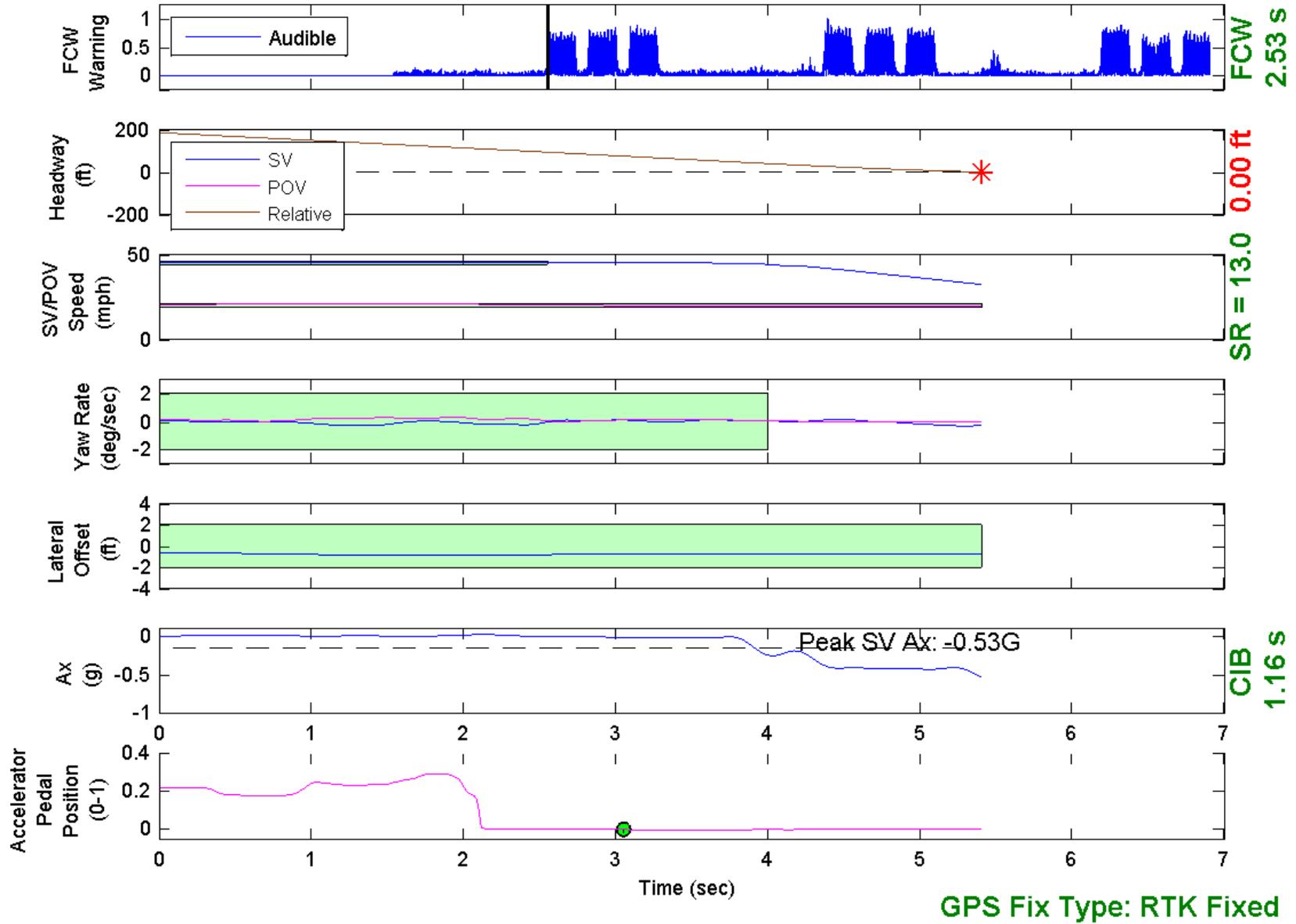


Figure D3. Example Time History for Slower POV 45 vs. 20, Passing

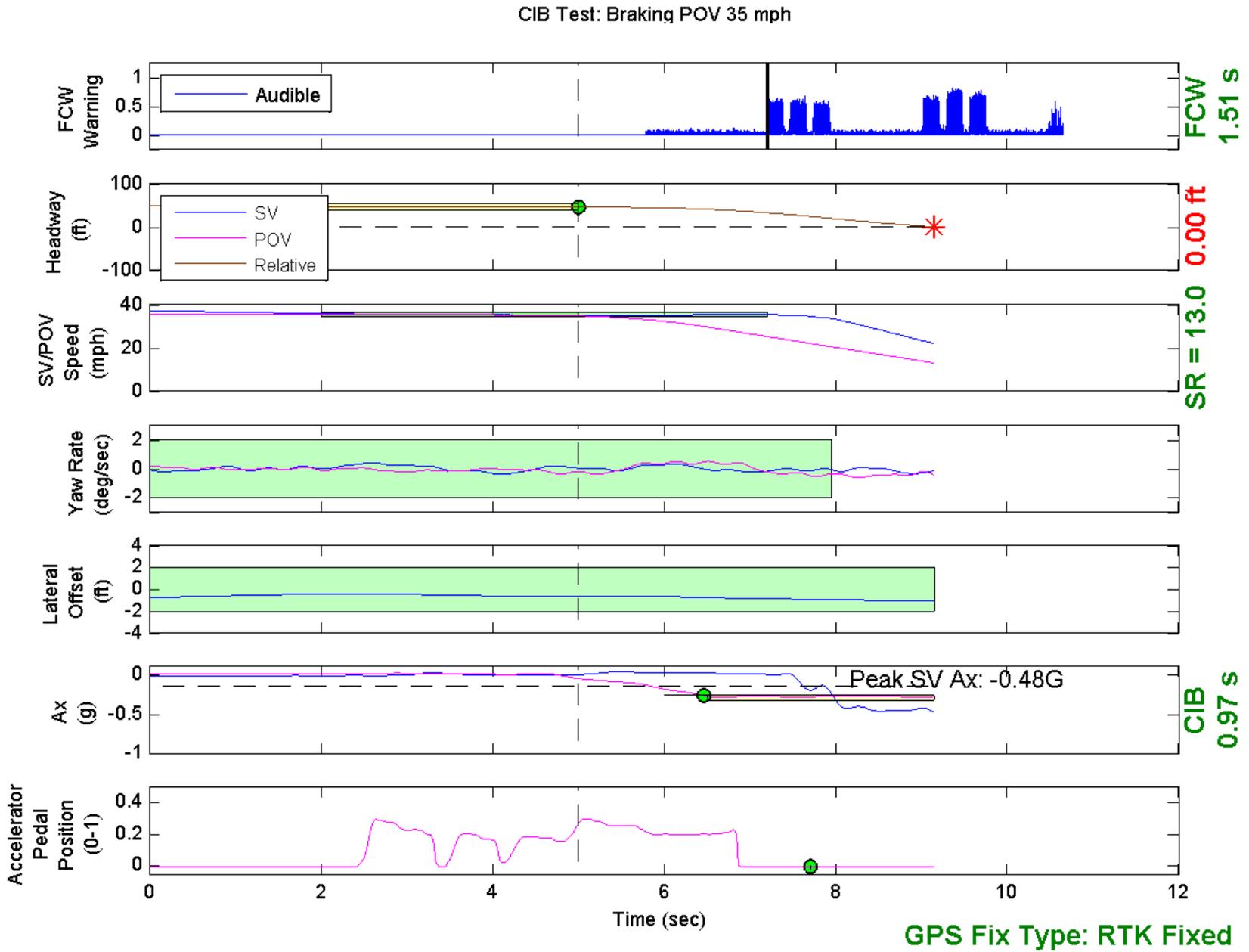


Figure D4. Example Time History for Braking POV 35, Passing

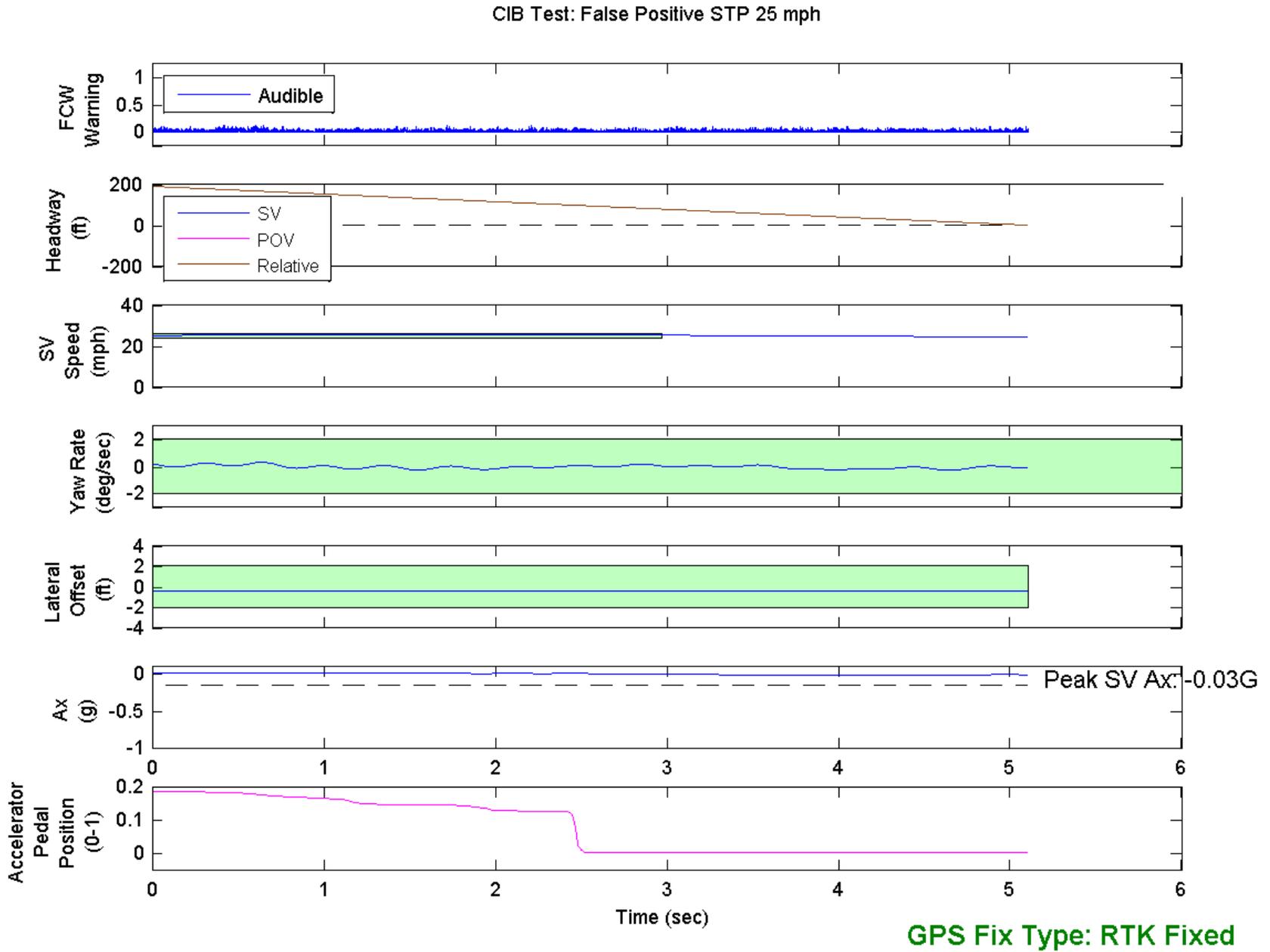


Figure D5. Example Time History for False Positive STP 25, Passing

CIB Test: False Positive STP 45 mph

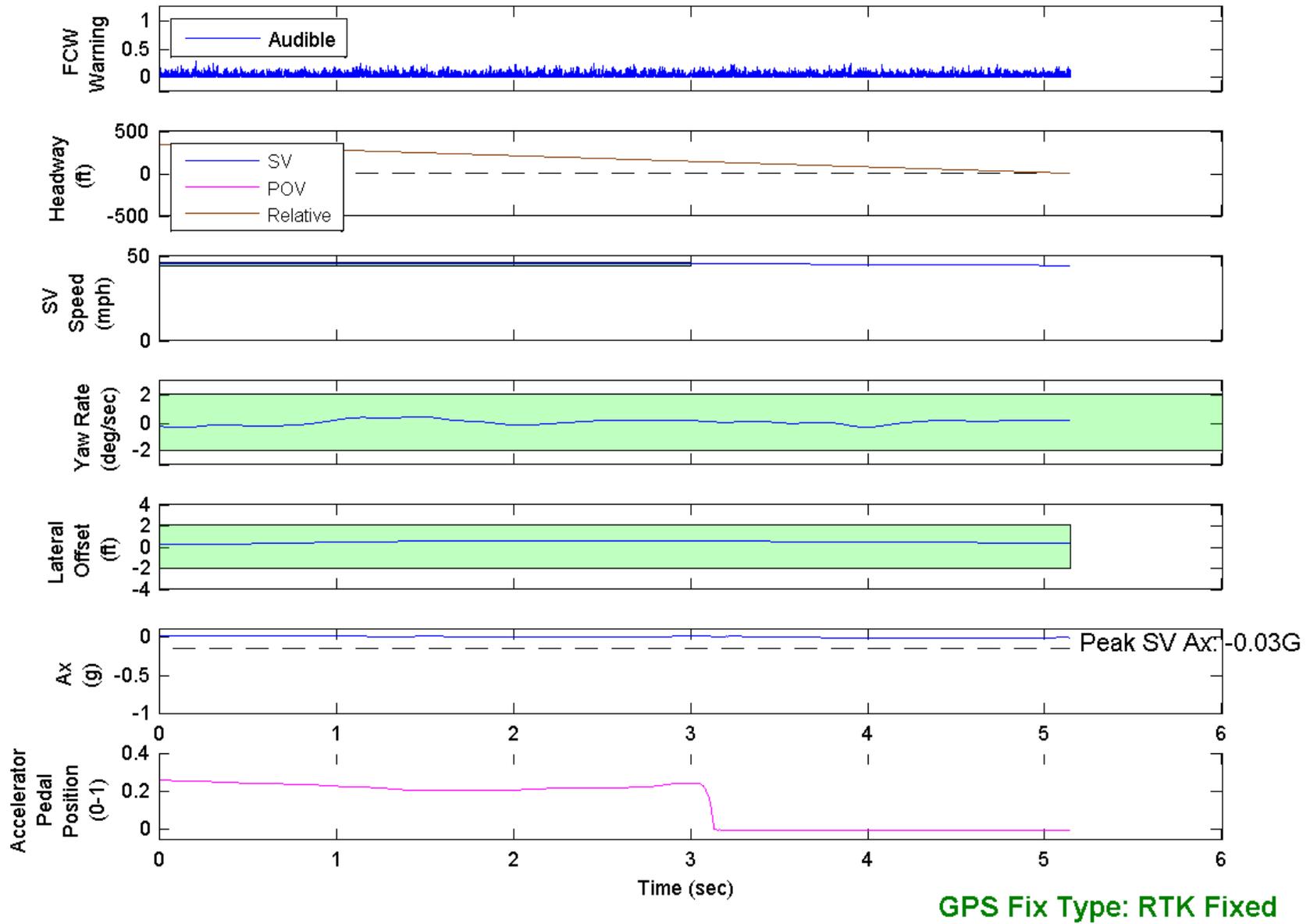


Figure D6. Example Time History for False Positive STP 45, Passing

CIB Test: Braking POV 35 mph

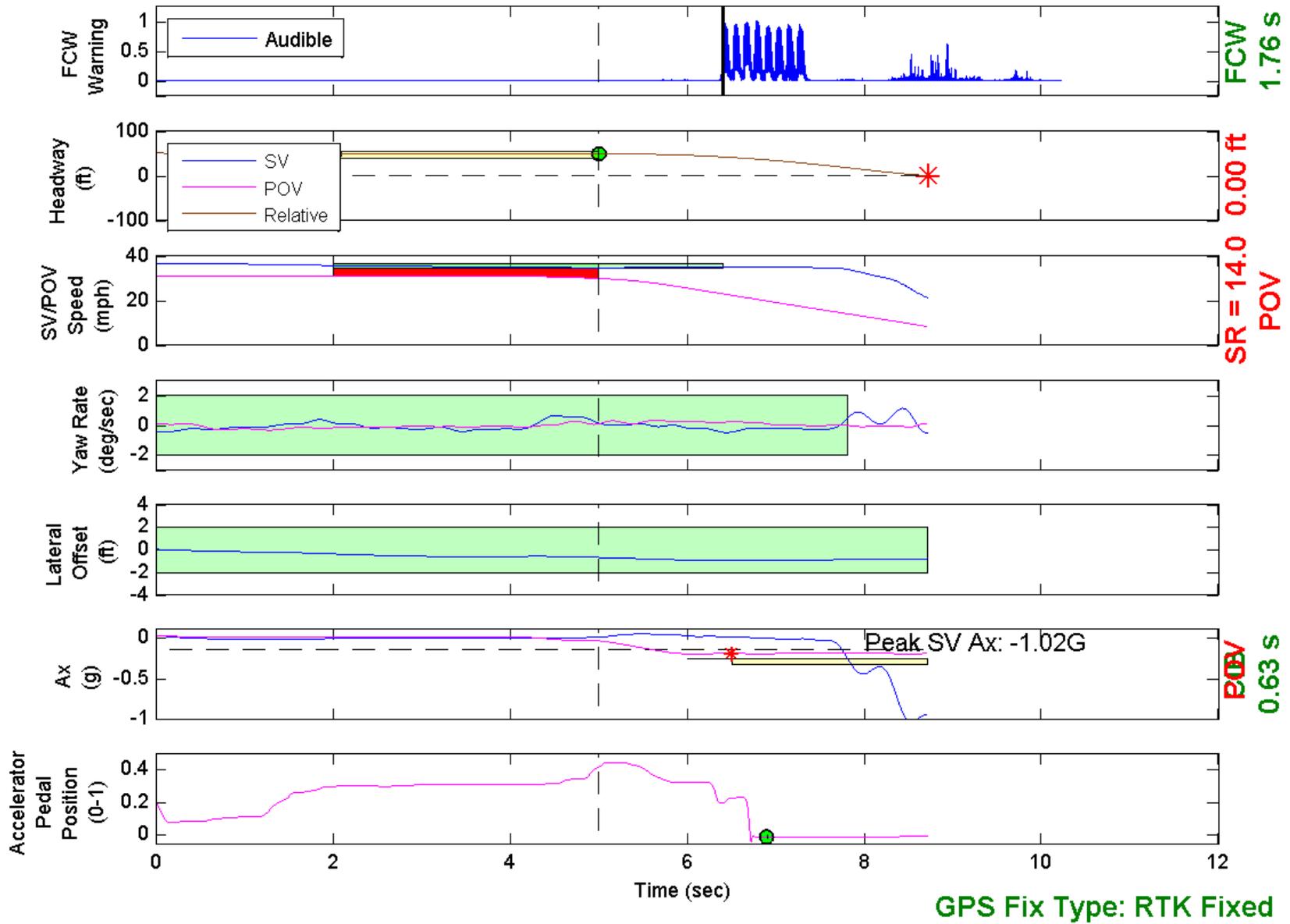


Figure D7. Example Time History Displaying Various Invalid Criteria

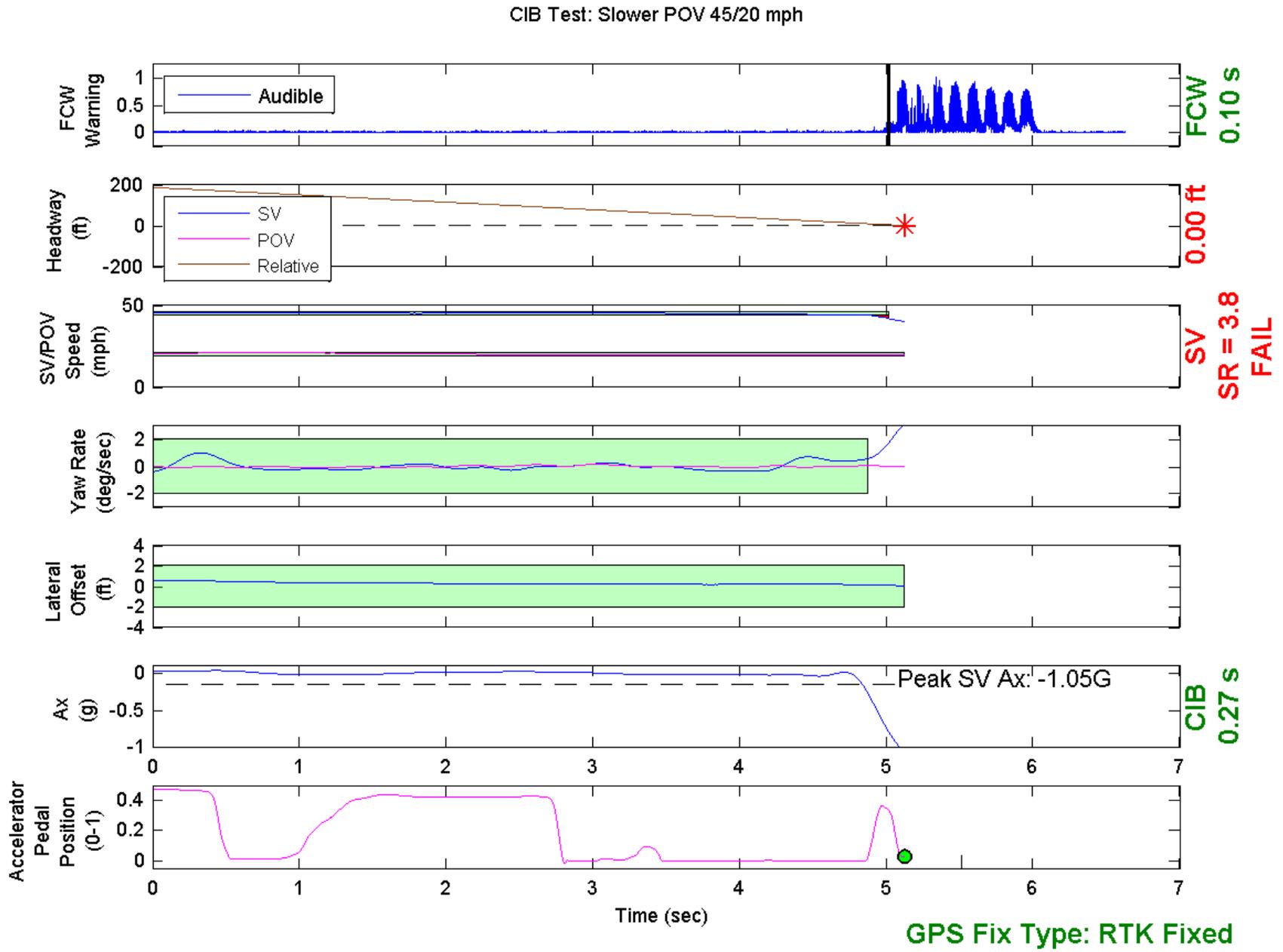


Figure D9. Example Time History for a Failed Run

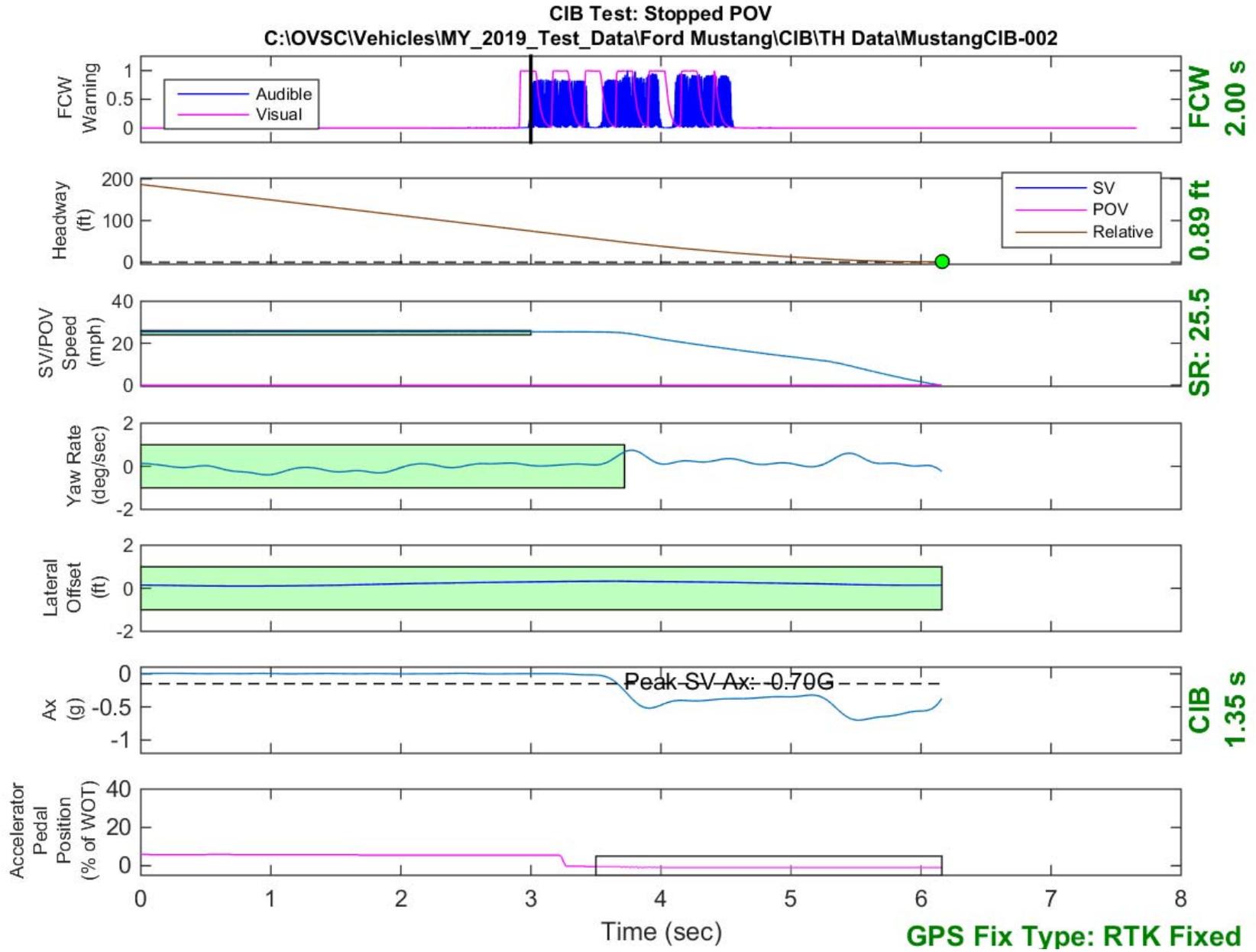


Figure D10. Time History for CIB Run 2, SV Encounters Stopped POV

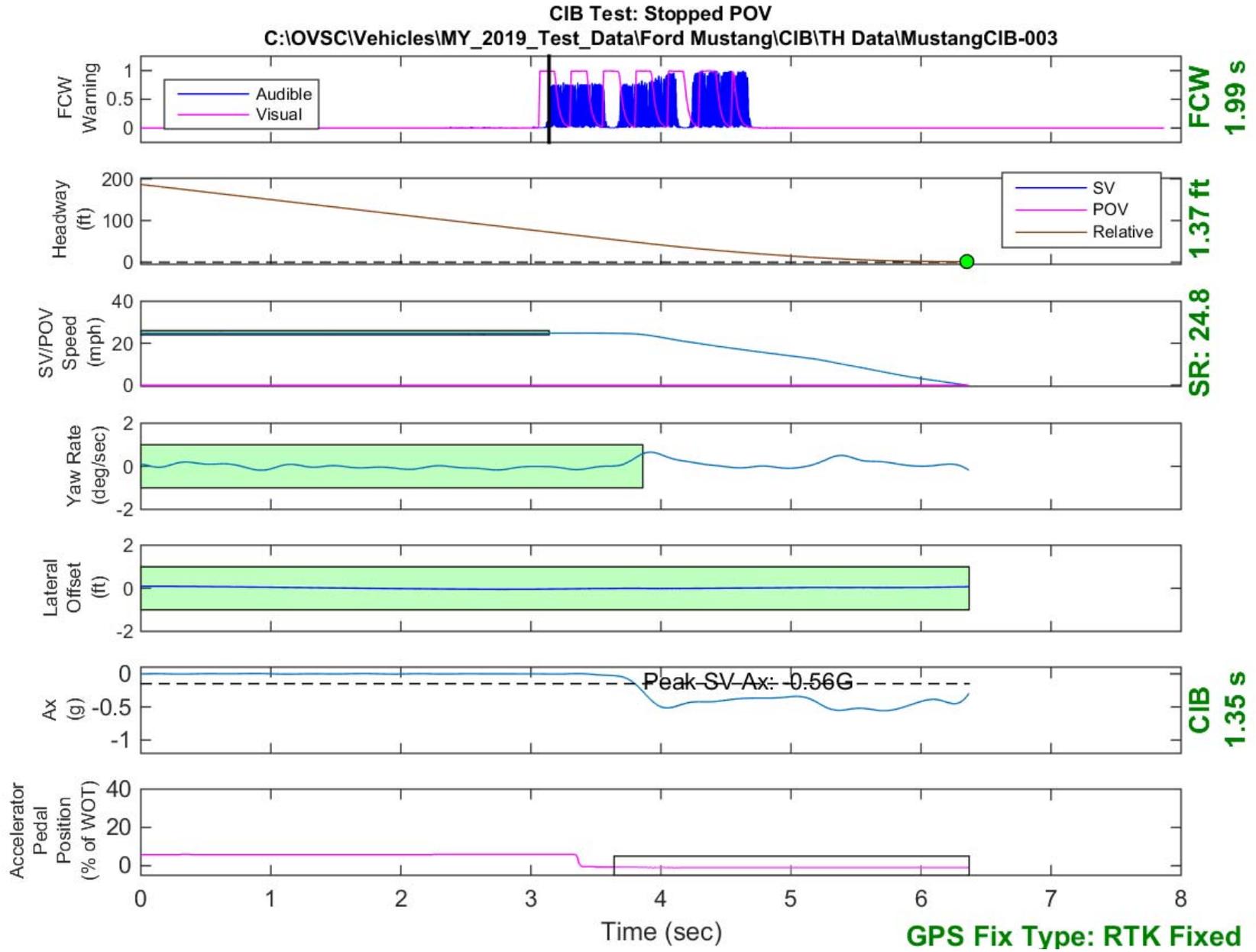


Figure D11. Time History for CIB Run 3, SV Encounters Stopped POV

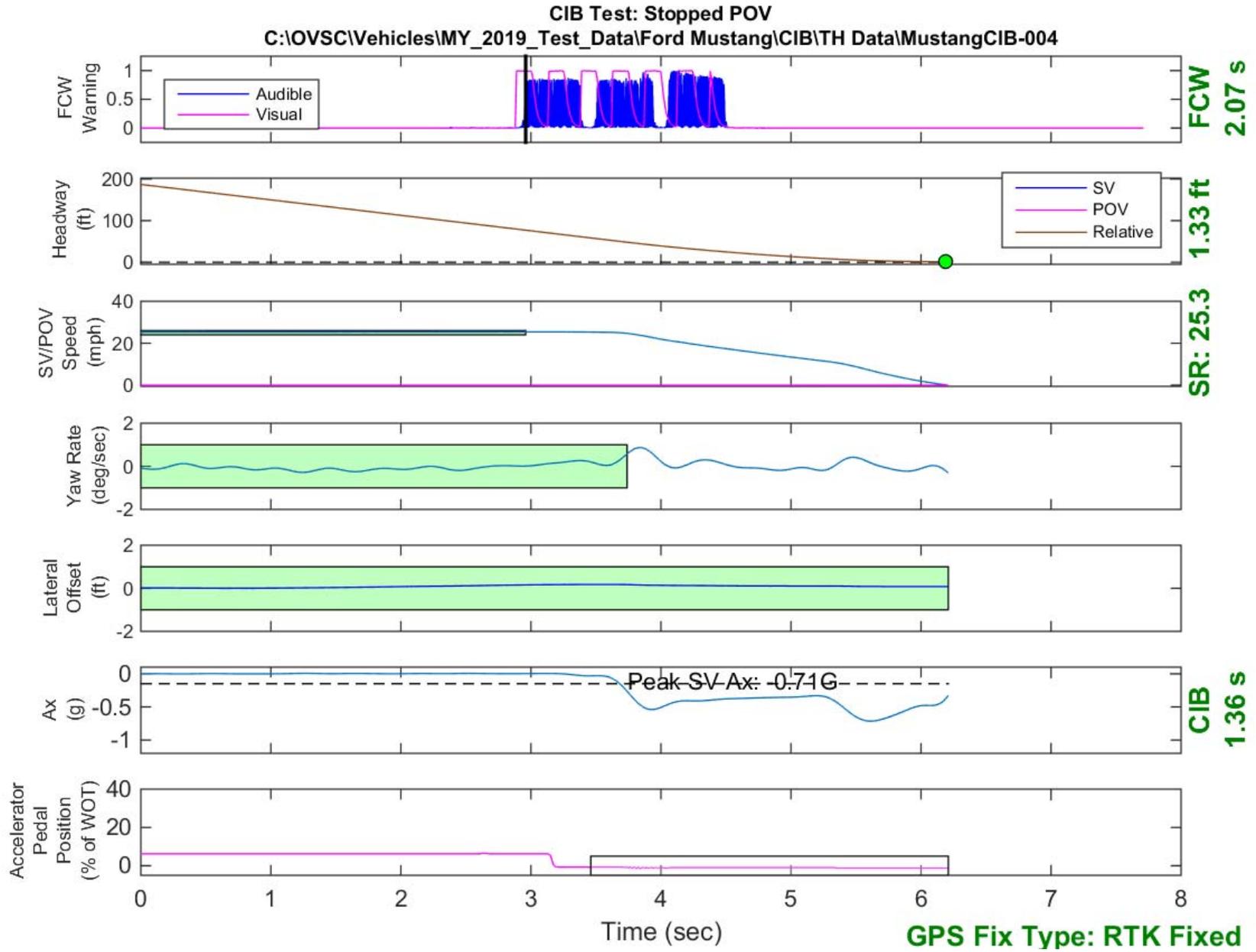


Figure D12. Time History for CIB Run 4, SV Encounters Stopped POV

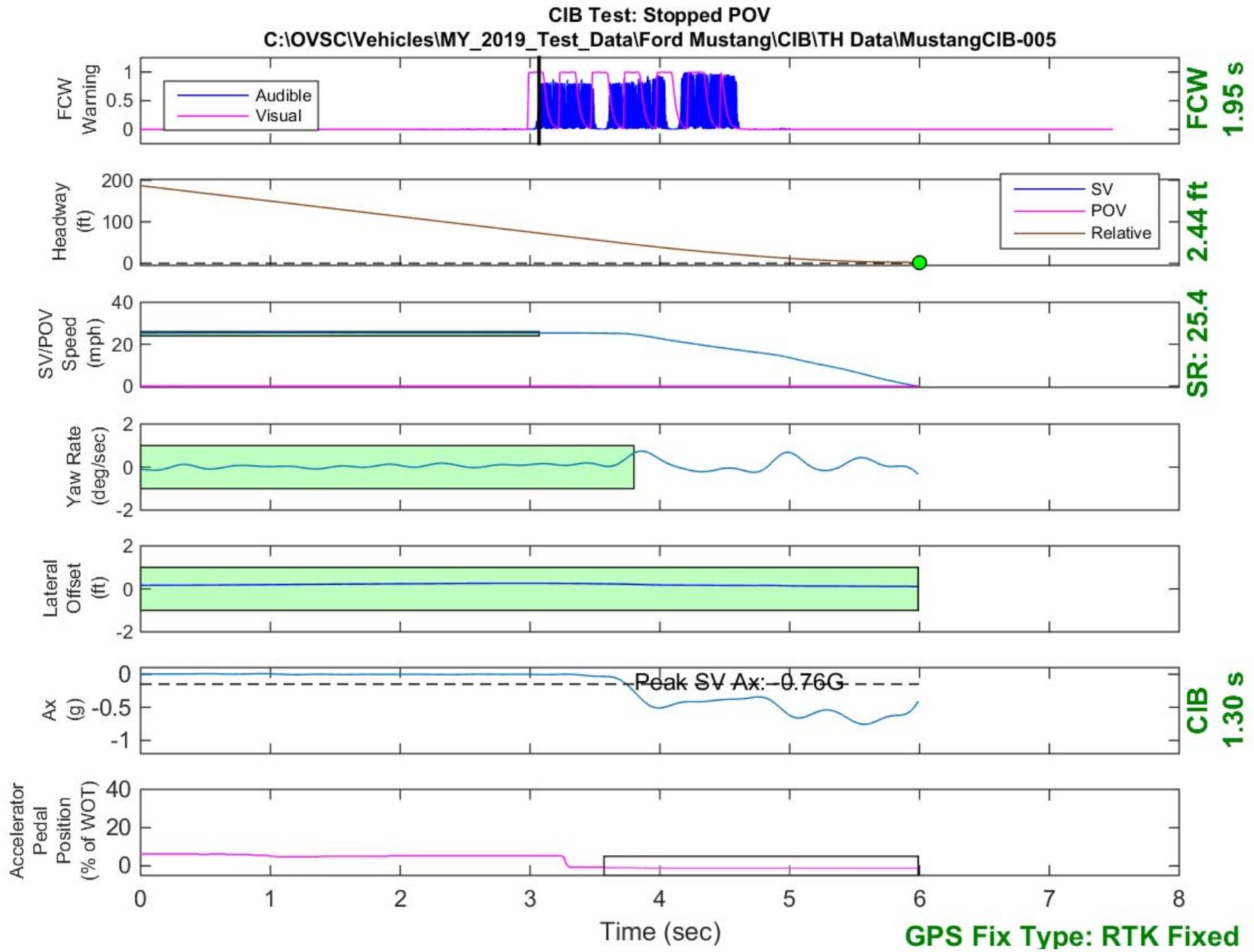


Figure D13. Time History for CIB Run 5, SV Encounters Stopped POV

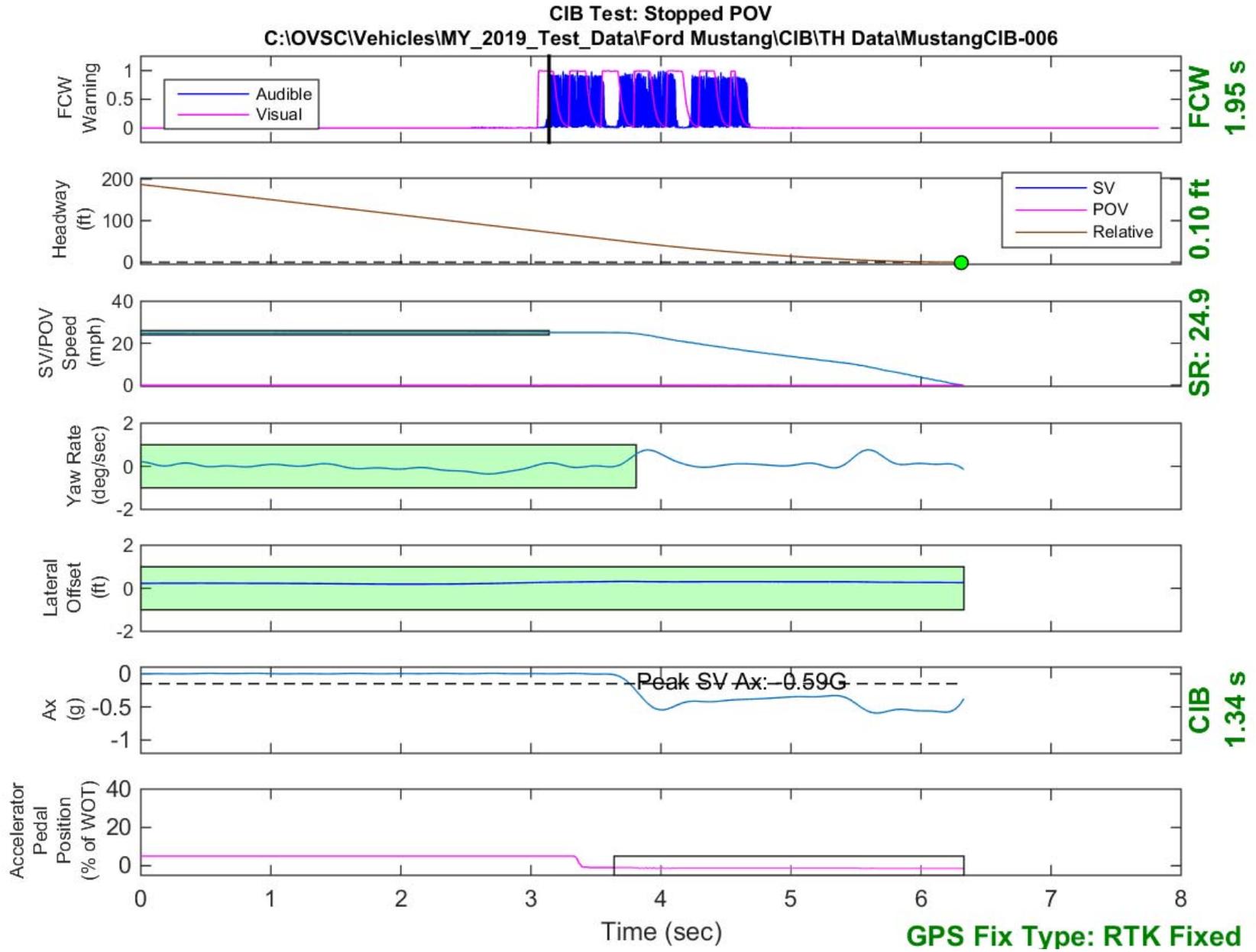


Figure D14. Time History for CIB Run 6, SV Encounters Stopped POV

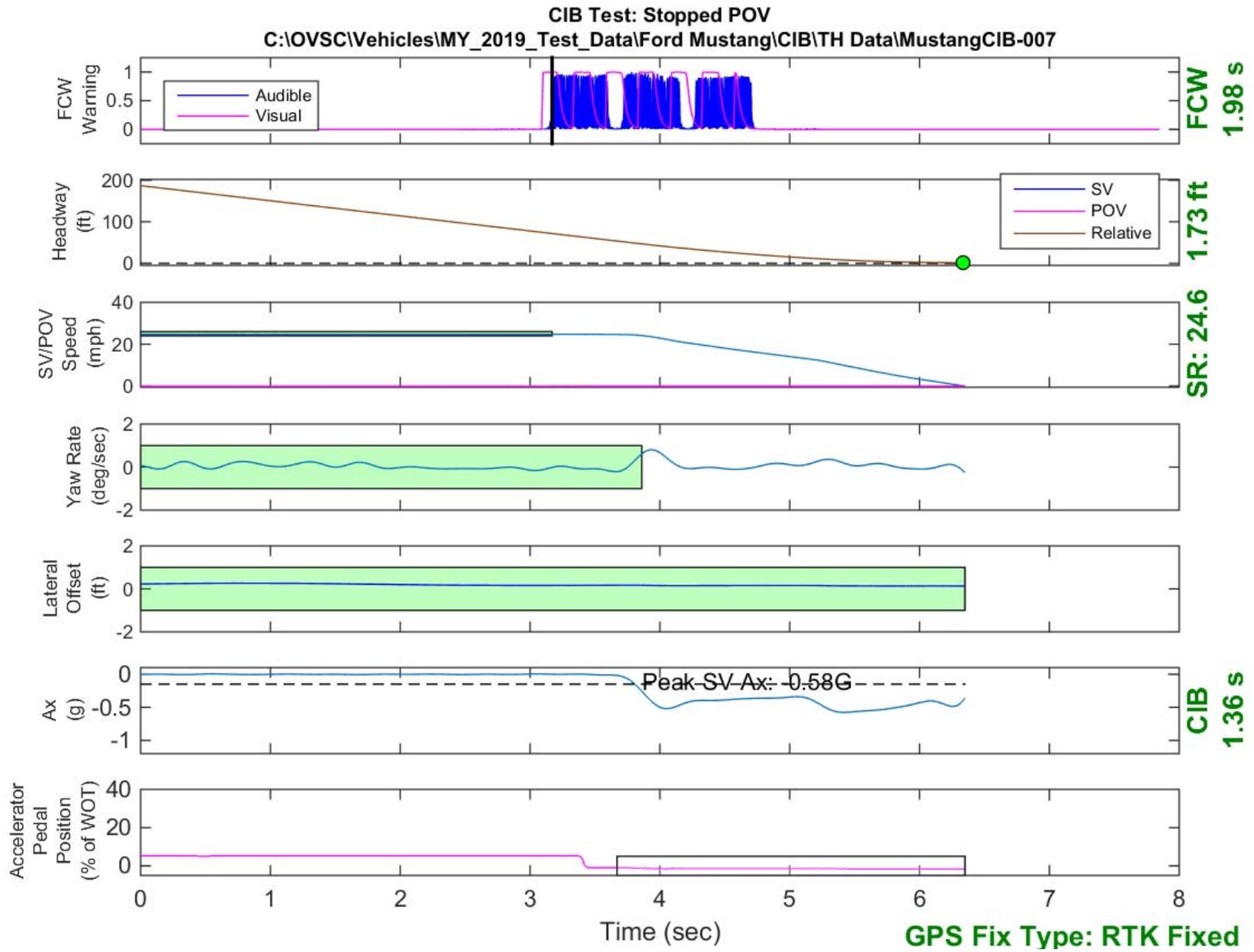


Figure D15. Time History for CIB Run 7, SV Encounters Stopped POV

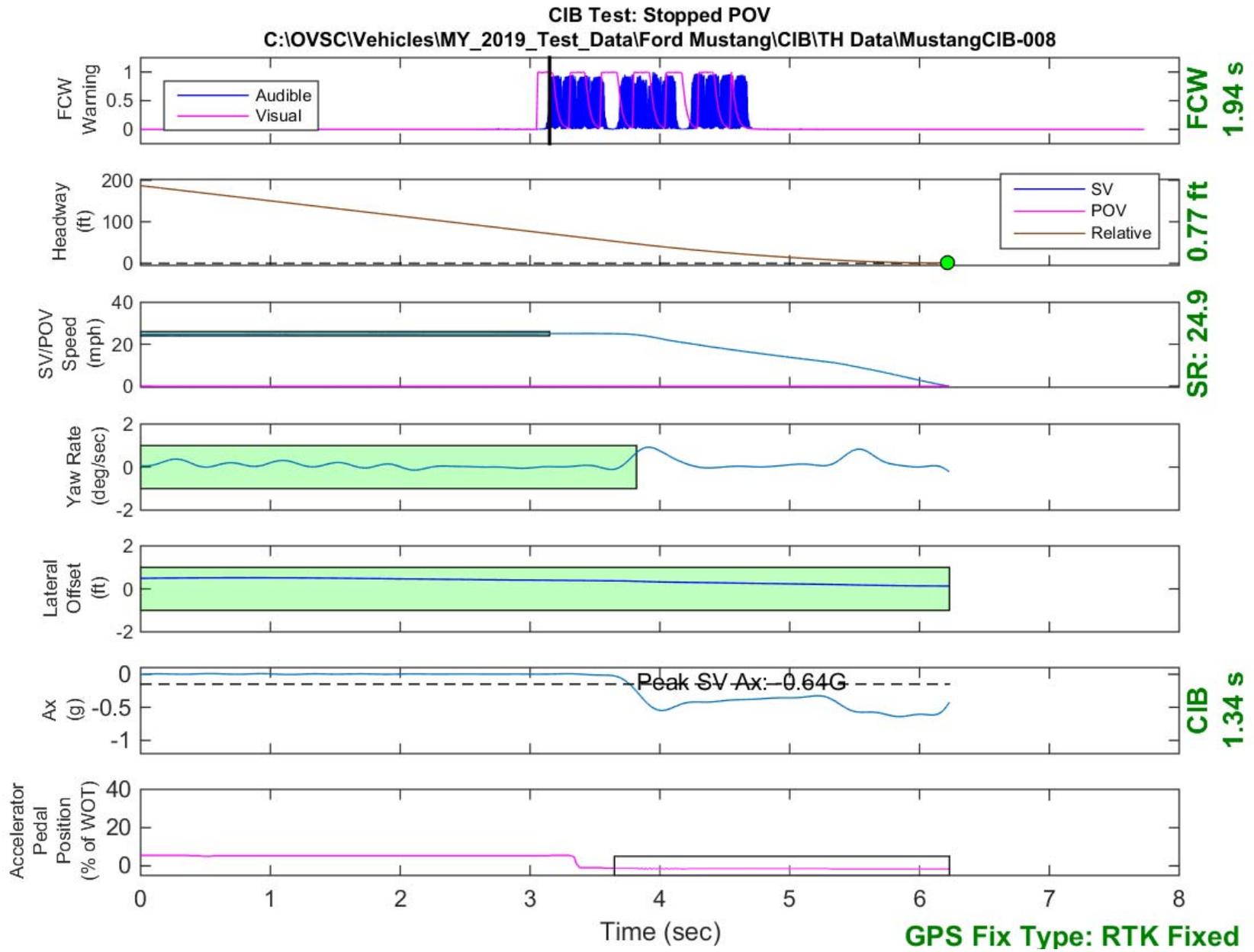


Figure D16. Time History for CIB Run 8, SV Encounters Stopped POV

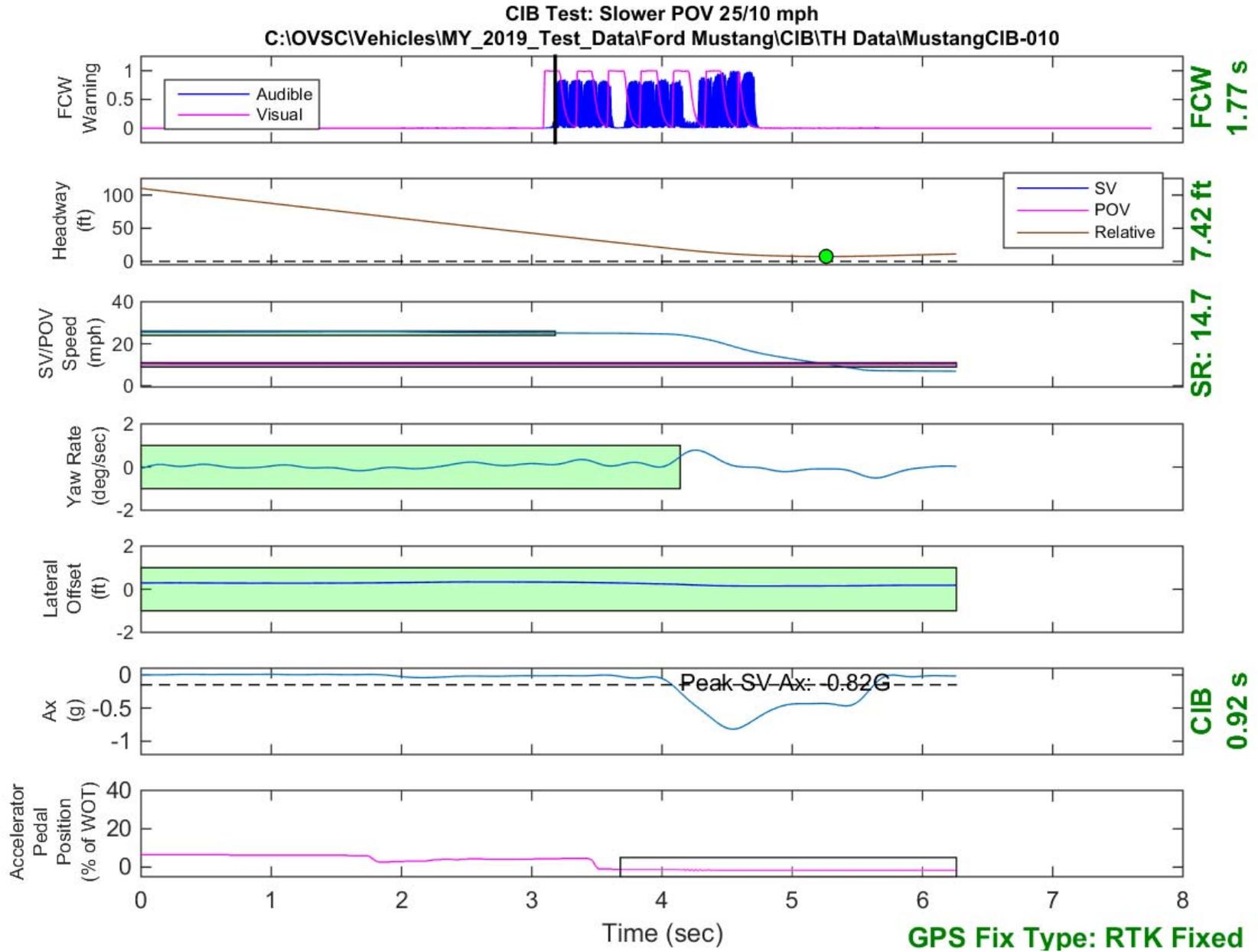


Figure D17. Time History for CIB Run 10, SV Encounters Slower POV, SV 25 mph, POV 10 mph

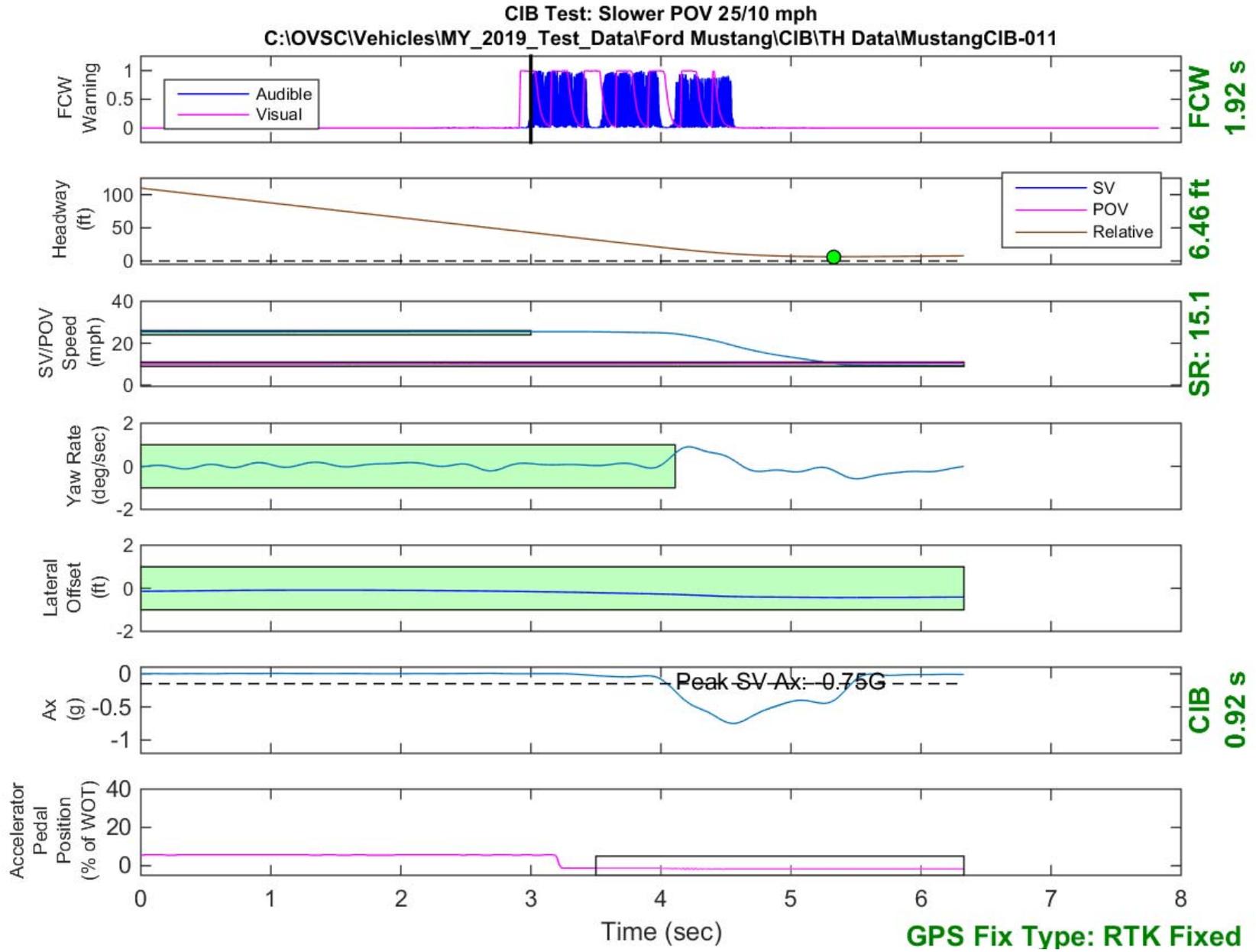


Figure D18. Time History for CIB Run 11, SV Encounters Slower POV, SV 25 mph, POV 10 mph

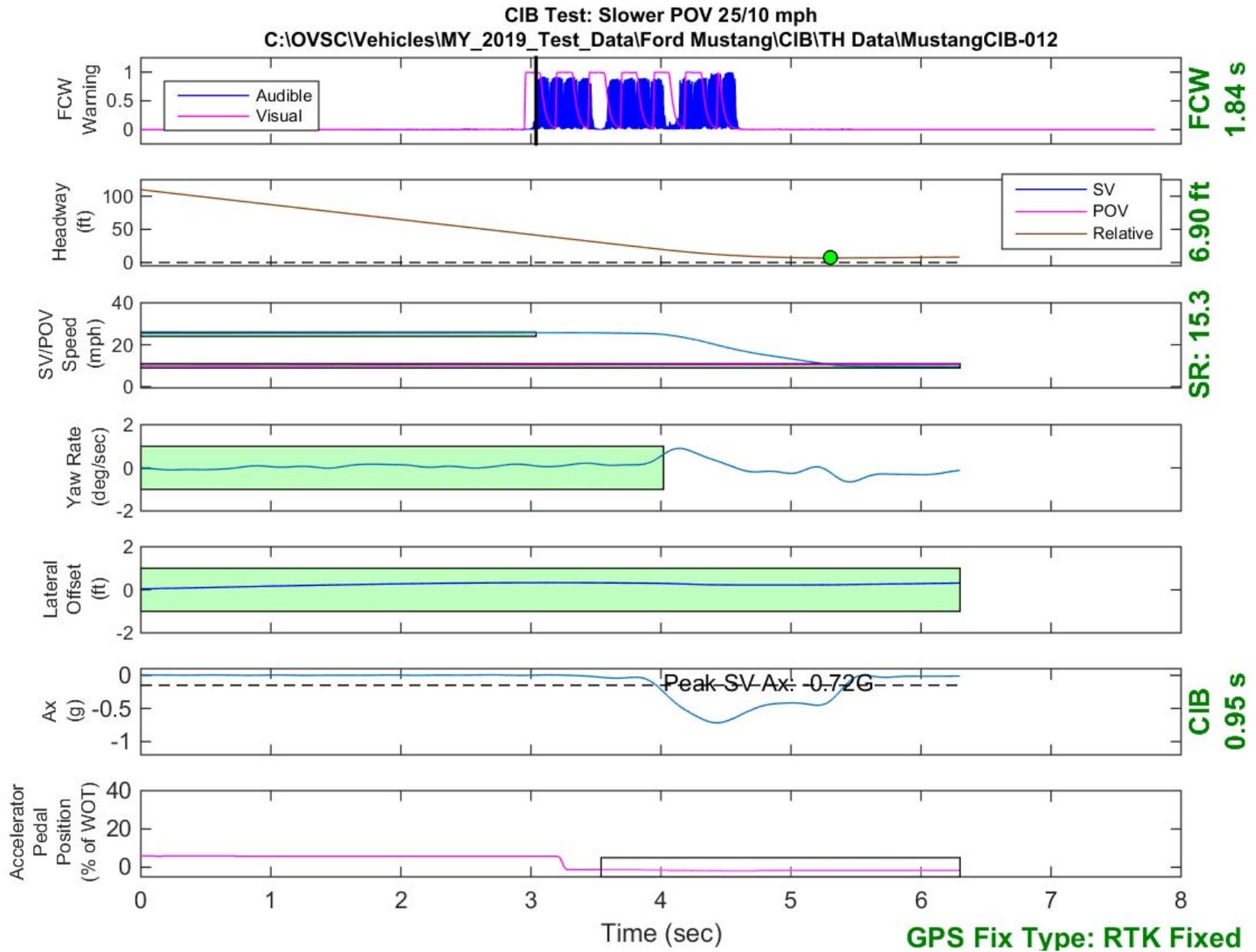


Figure D19. Time History for CIB Run 12, SV Encounters Slower POV, SV 25 mph, POV 10 mph

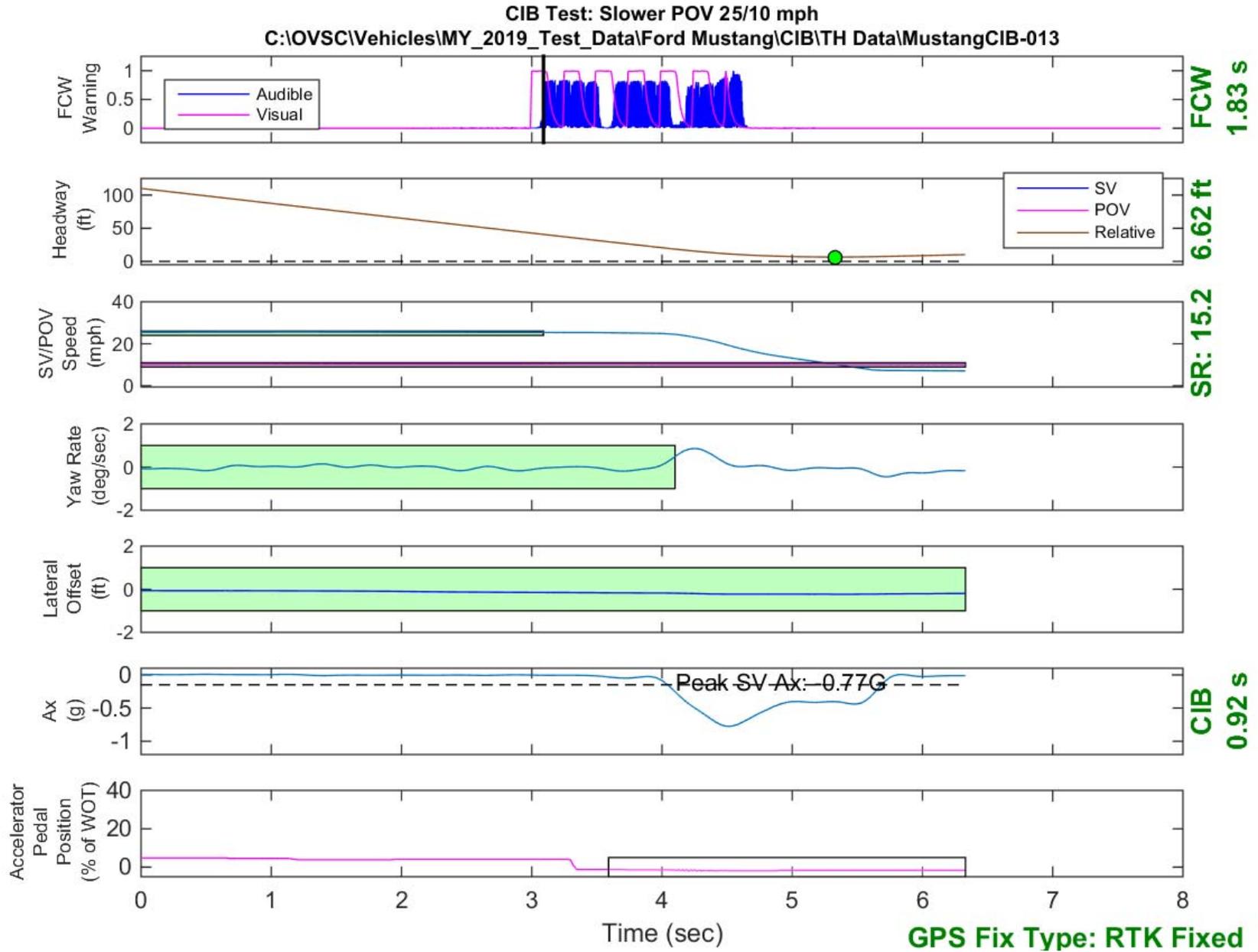


Figure D20. Time History for CIB Run 13, SV Encounters Slower POV, SV 25 mph, POV 10 mph

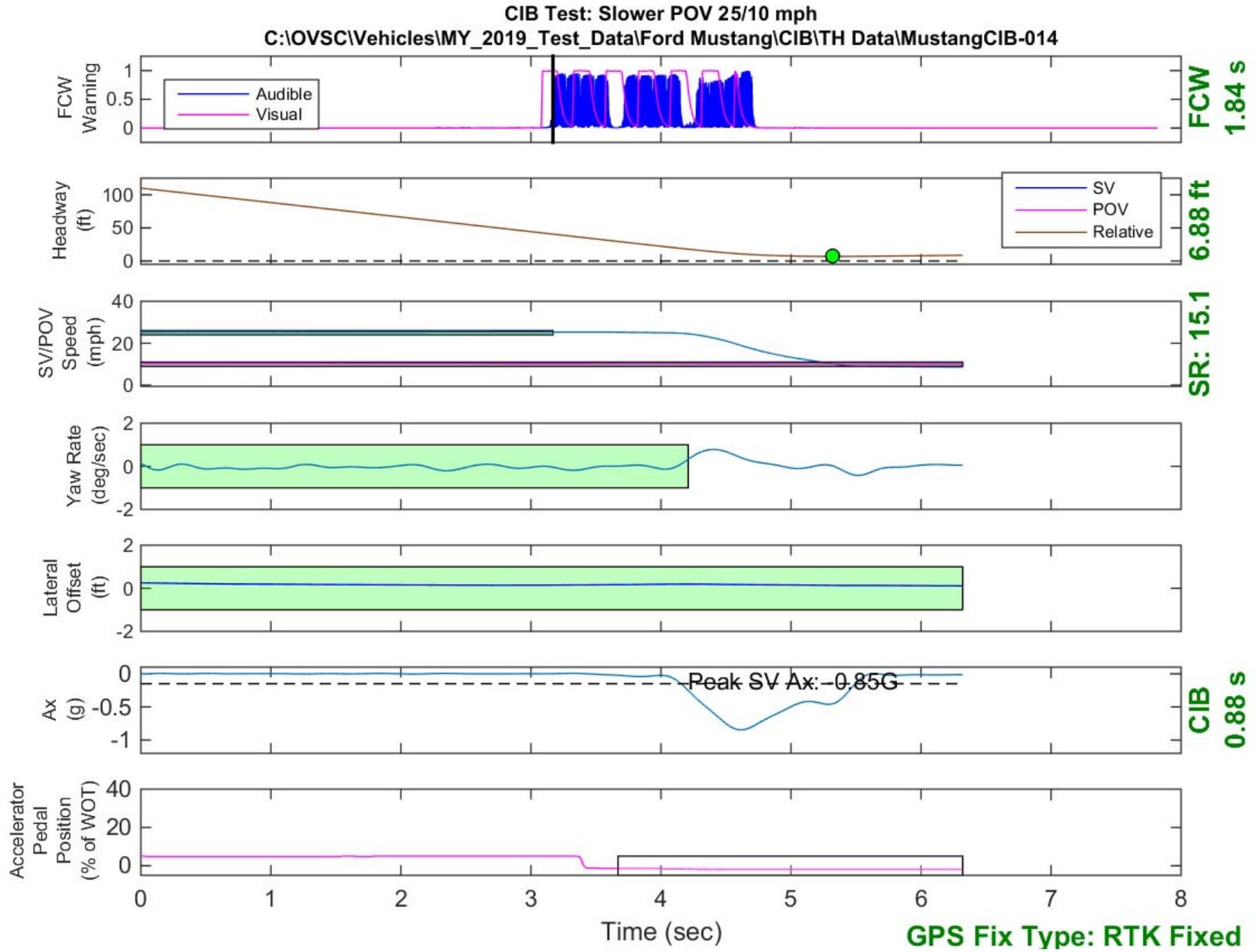


Figure D21. Time History for CIB Run 14, SV Encounters Slower POV, SV 25 mph, POV 10 mph

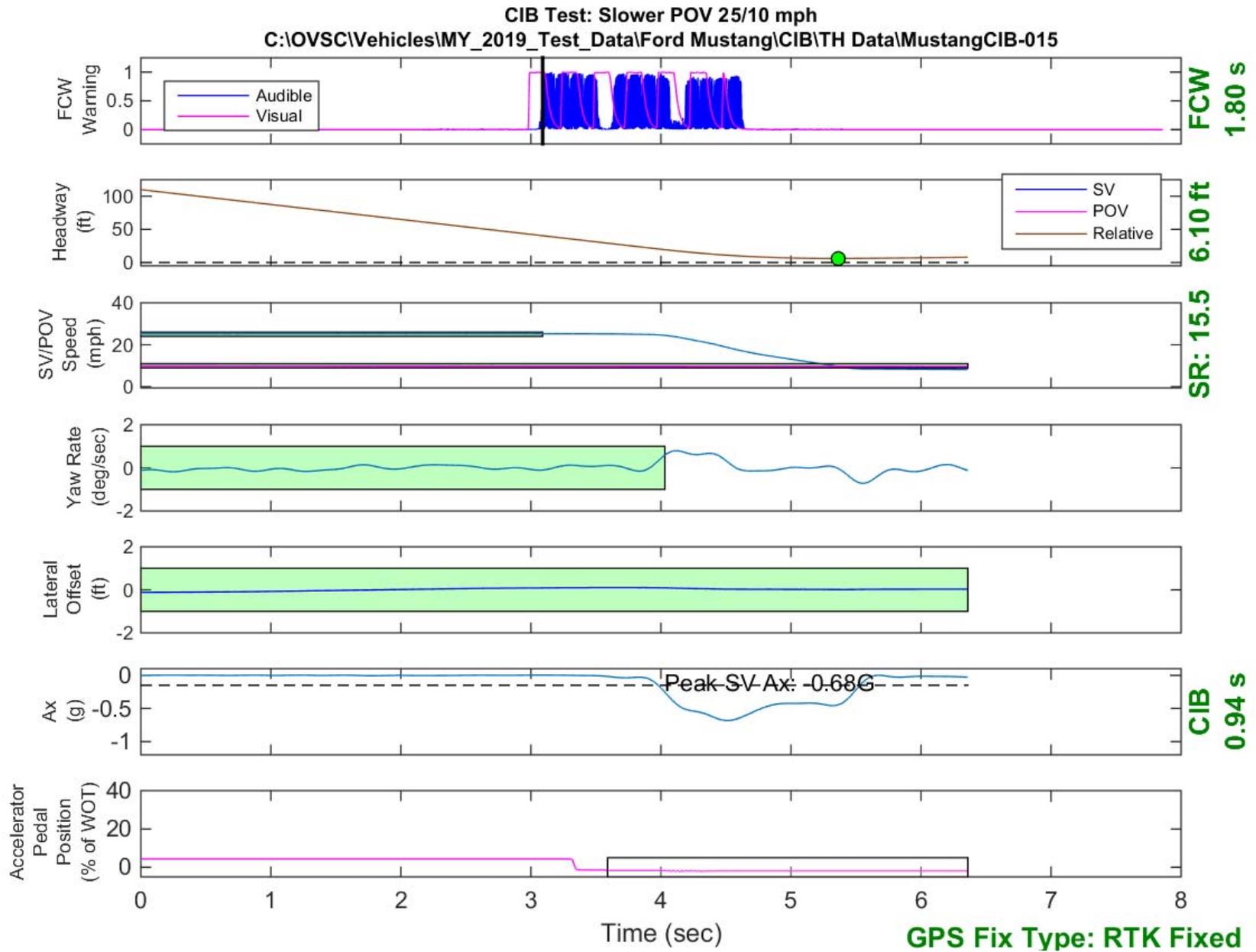


Figure D22. Time History for CIB Run 15, SV Encounters Slower POV, SV 25 mph, POV 10 mph

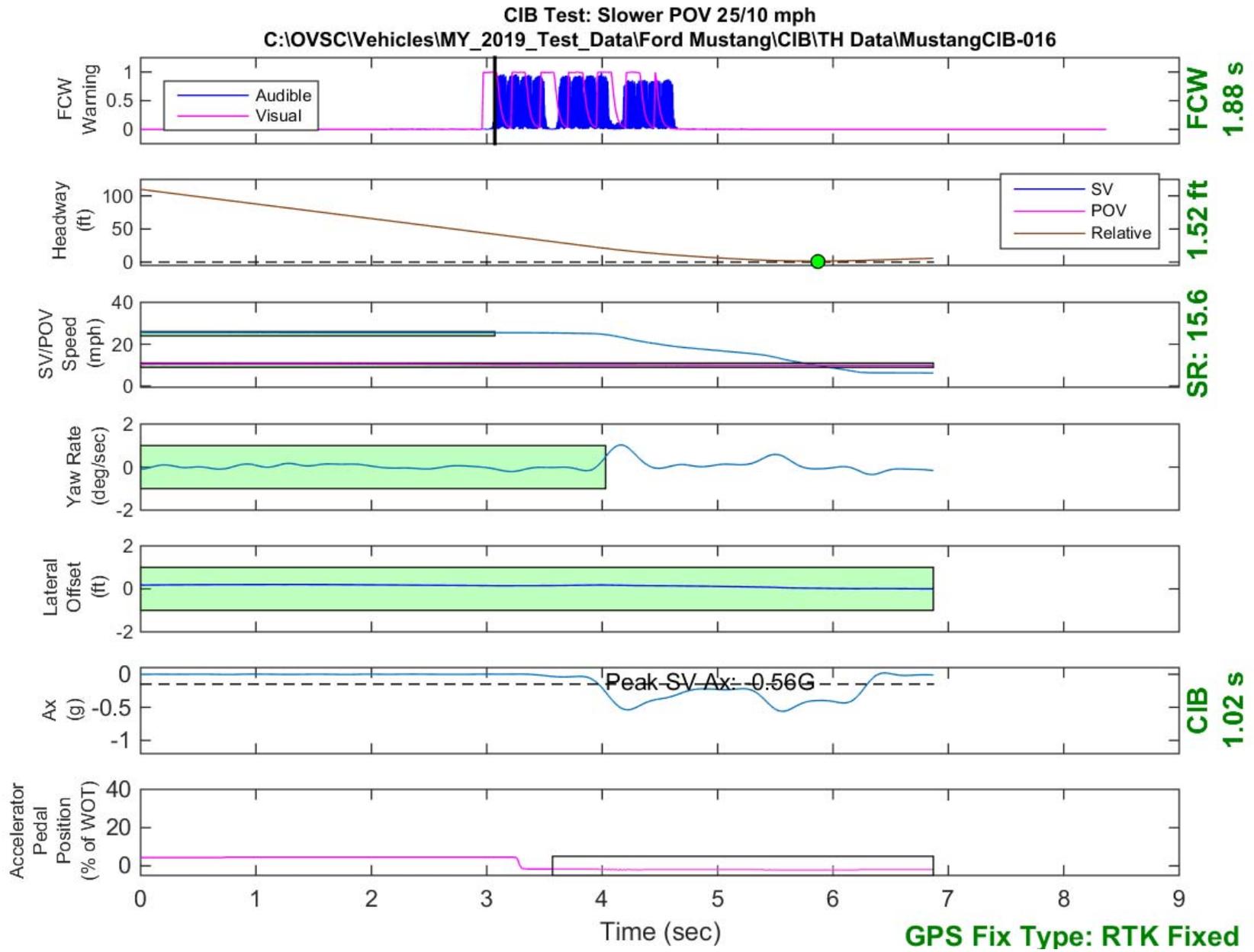


Figure D23. Time History for CIB Run 16, SV Encounters Slower POV, SV 25 mph, POV 10 mph

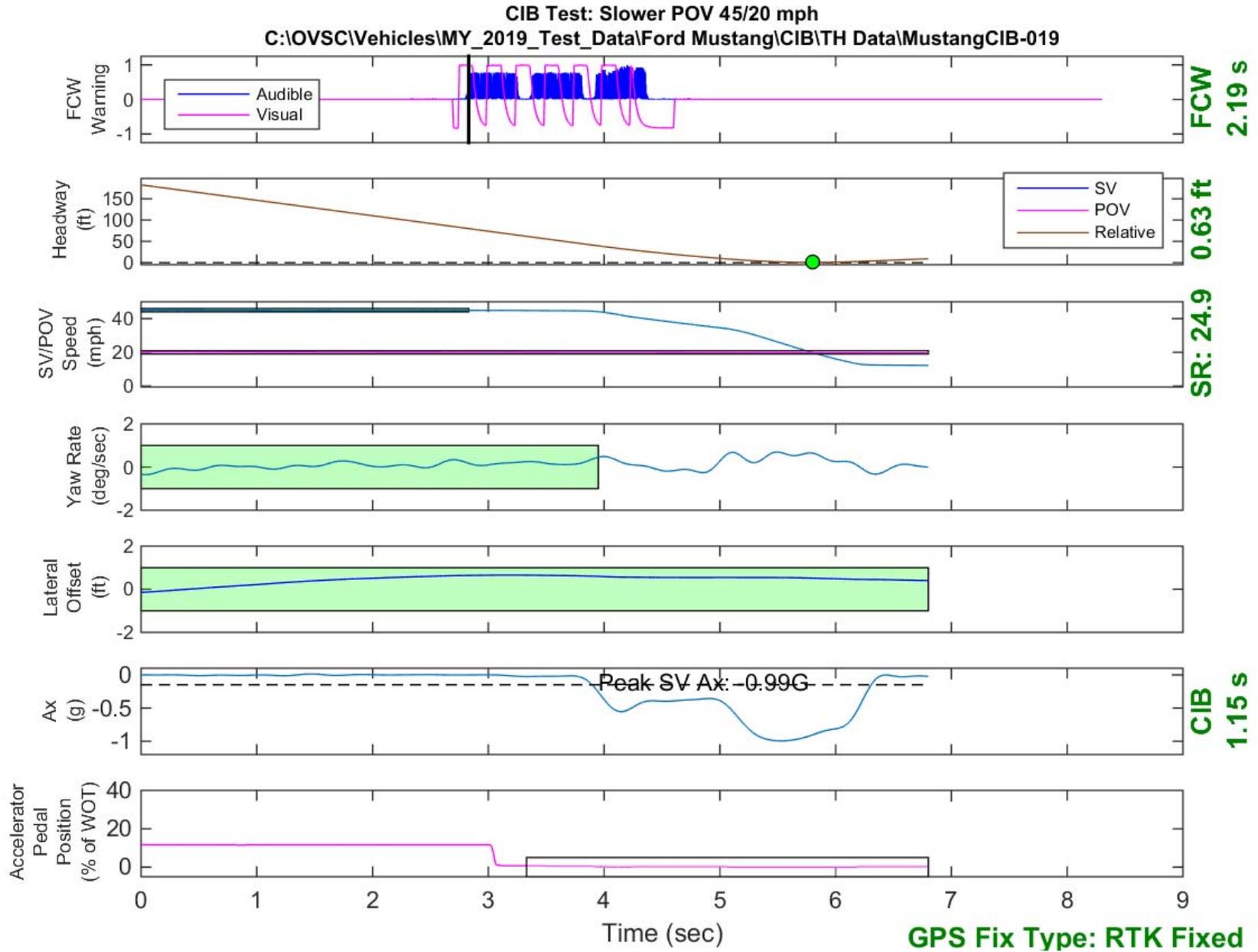


Figure D24. Time History for CIB Run 19, SV Encounters Slower POV, SV 45 mph, POV 20 mph

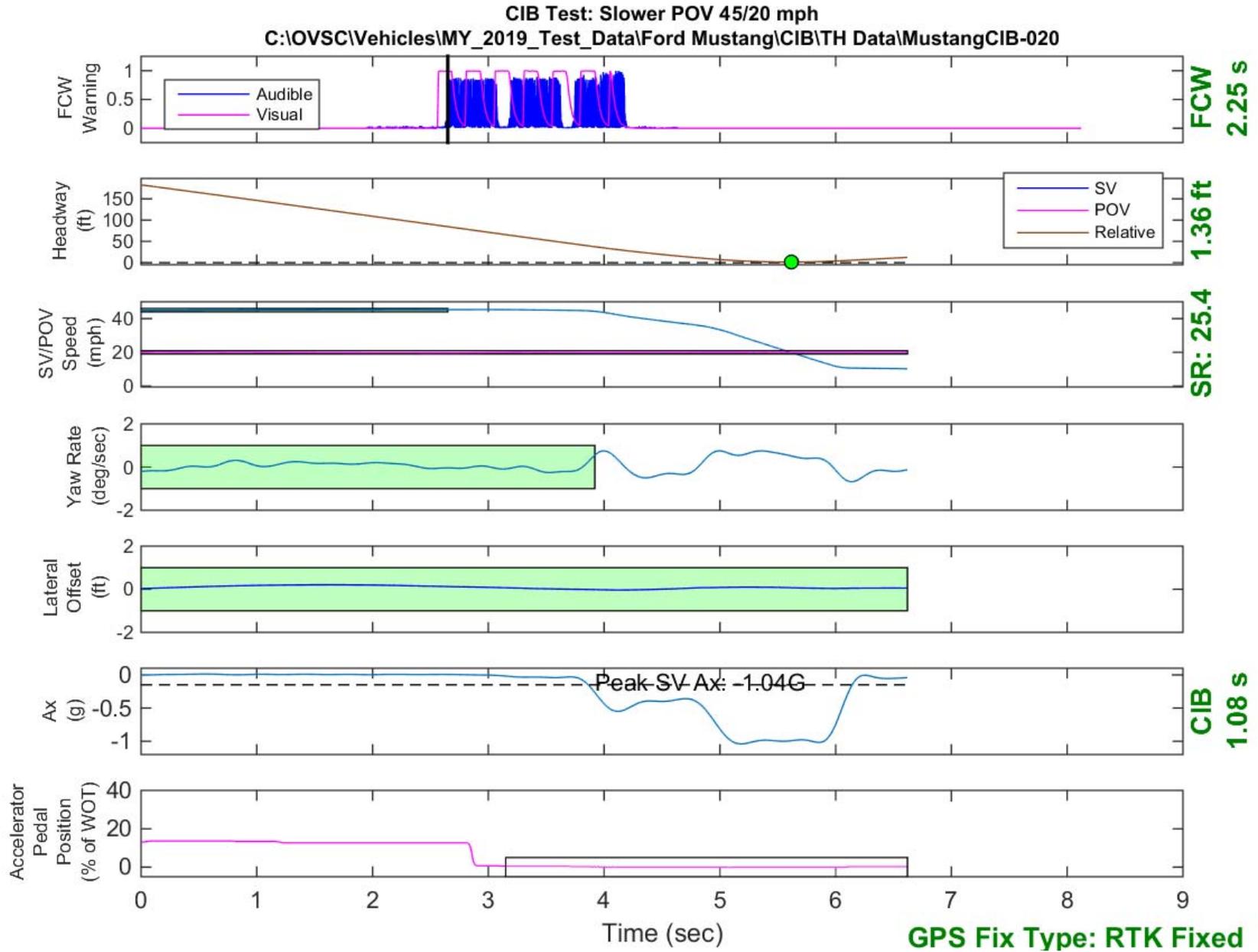


Figure D25. Time History for CIB Run 20, SV Encounters Slower POV, SV 45 mph, POV 20 mph

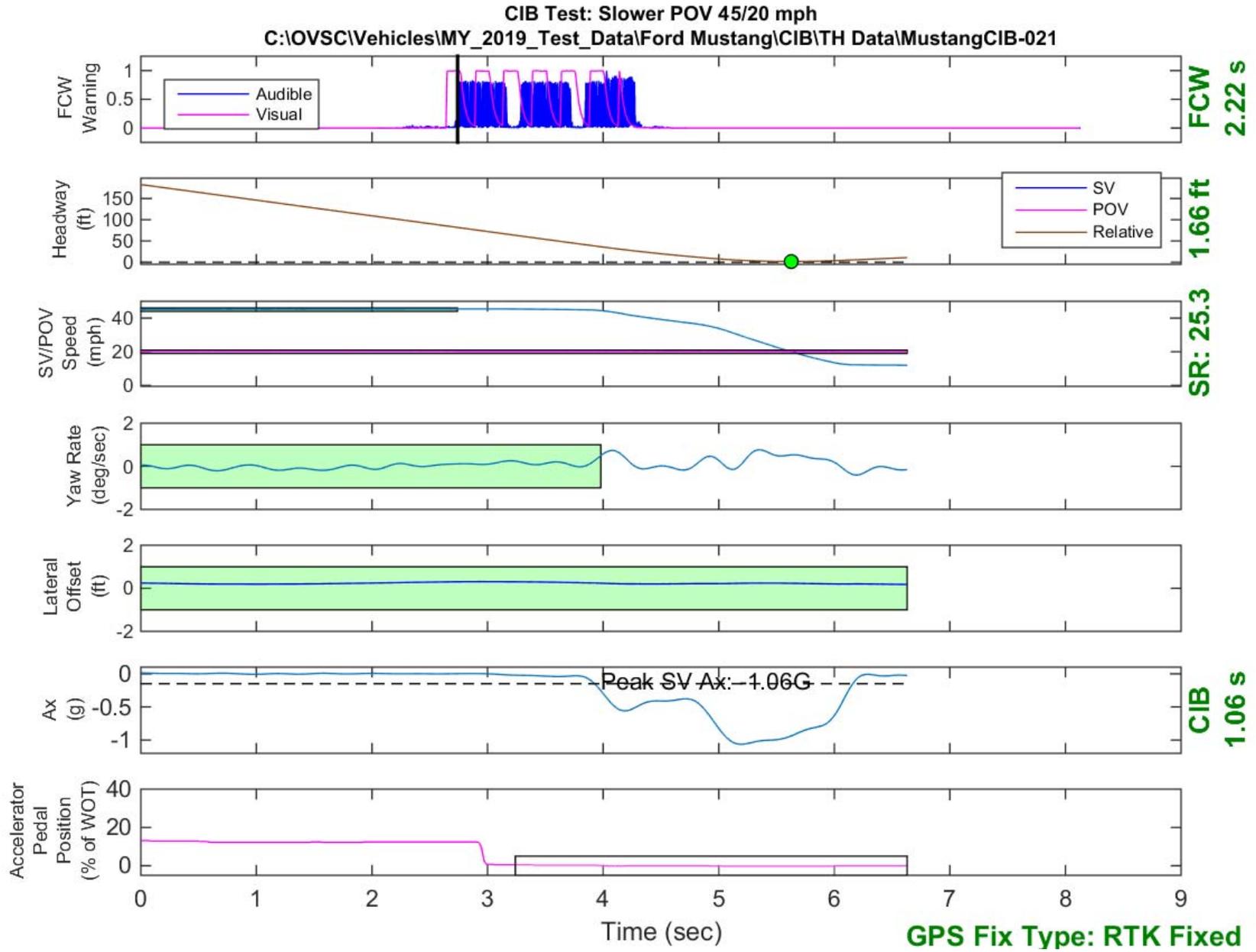


Figure D26. Time History for CIB Run 21, SV Encounters Slower POV, SV 45 mph, POV 20 mph

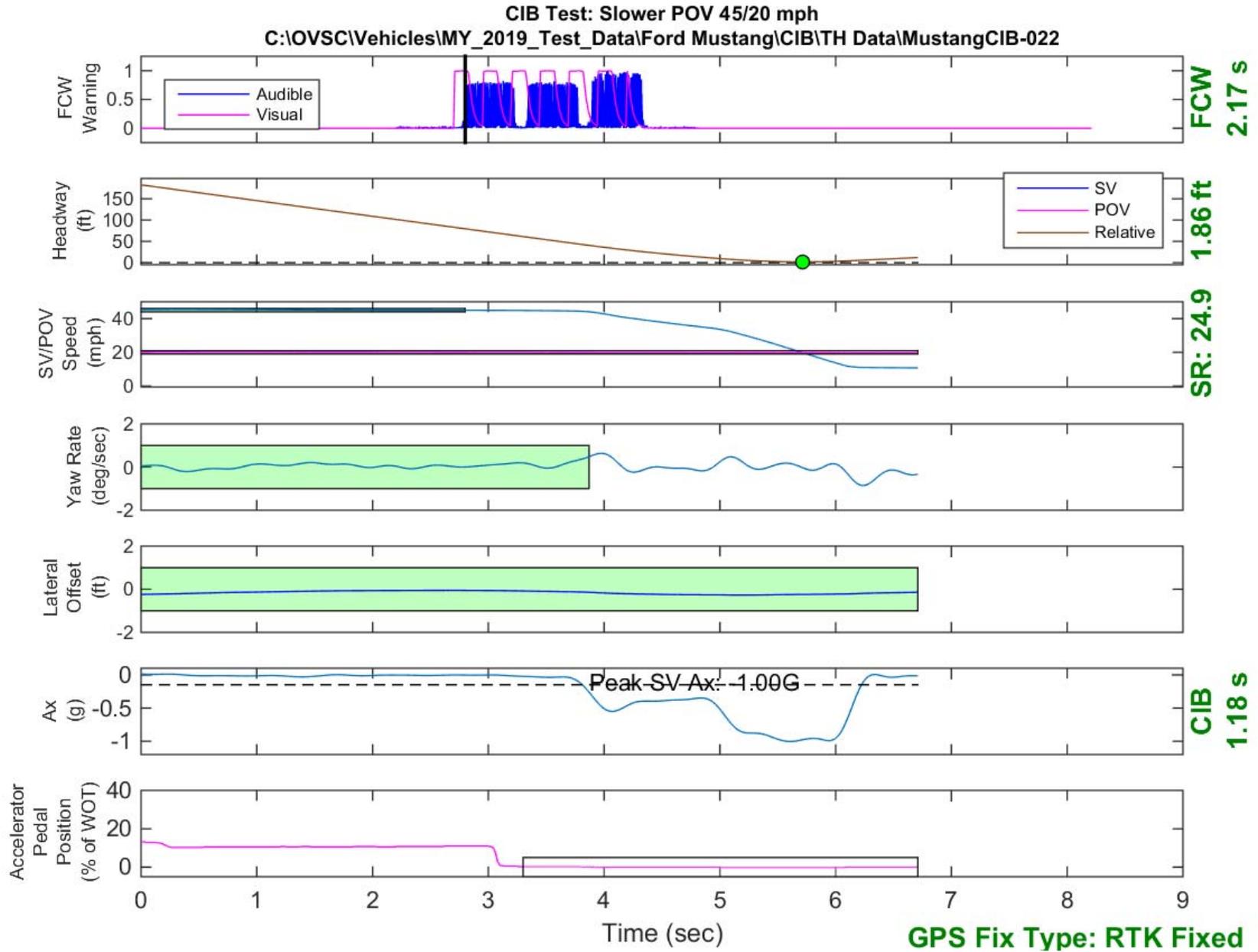


Figure D27. Time History for CIB Run 22, SV Encounters Slower POV, SV 45 mph, POV 20 mph

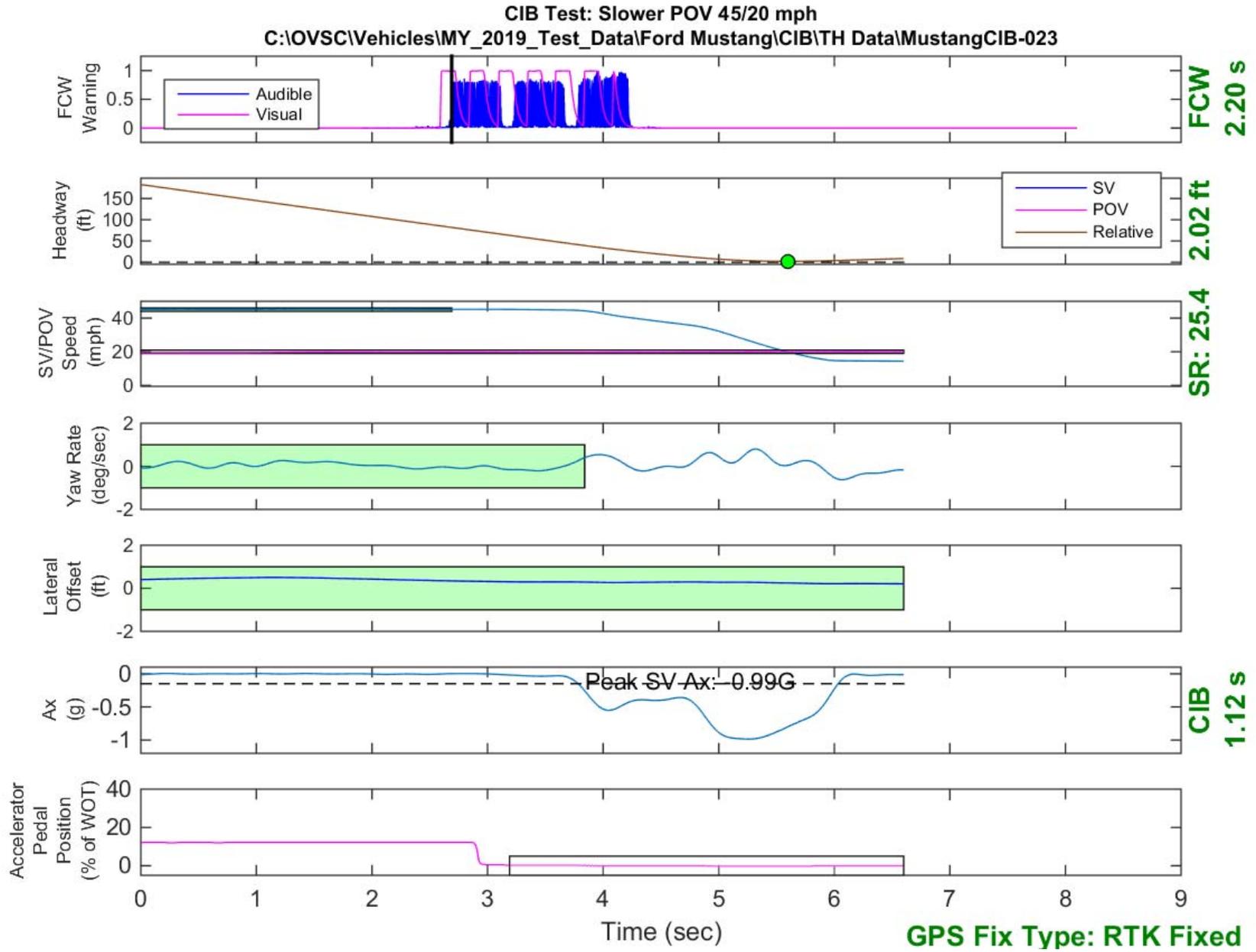


Figure D28. Time History for CIB Run 23, SV Encounters Slower POV, SV 45 mph, POV 20 mph

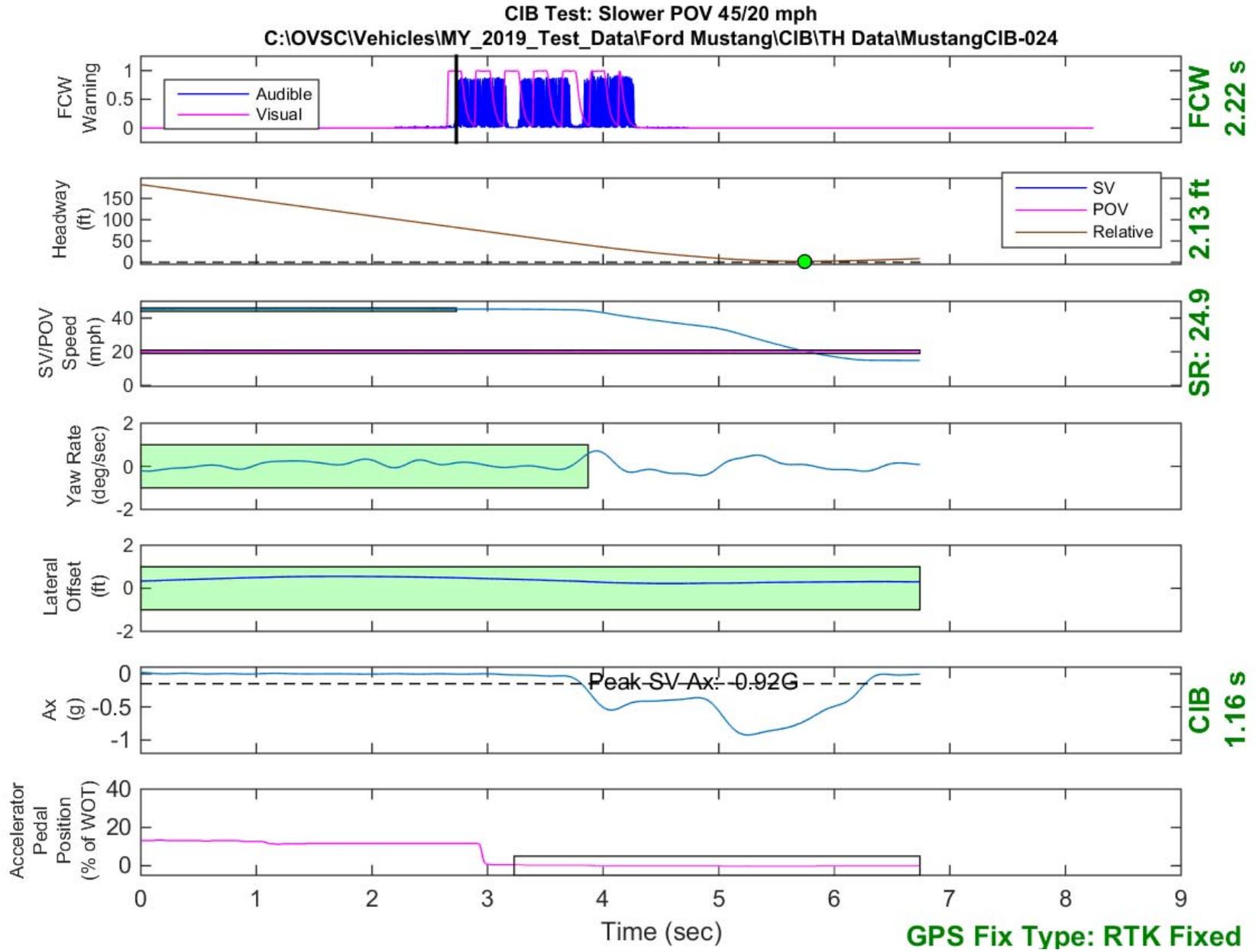


Figure D29. Time History for CIB Run 24, SV Encounters Slower POV, SV 45 mph, POV 20 mph

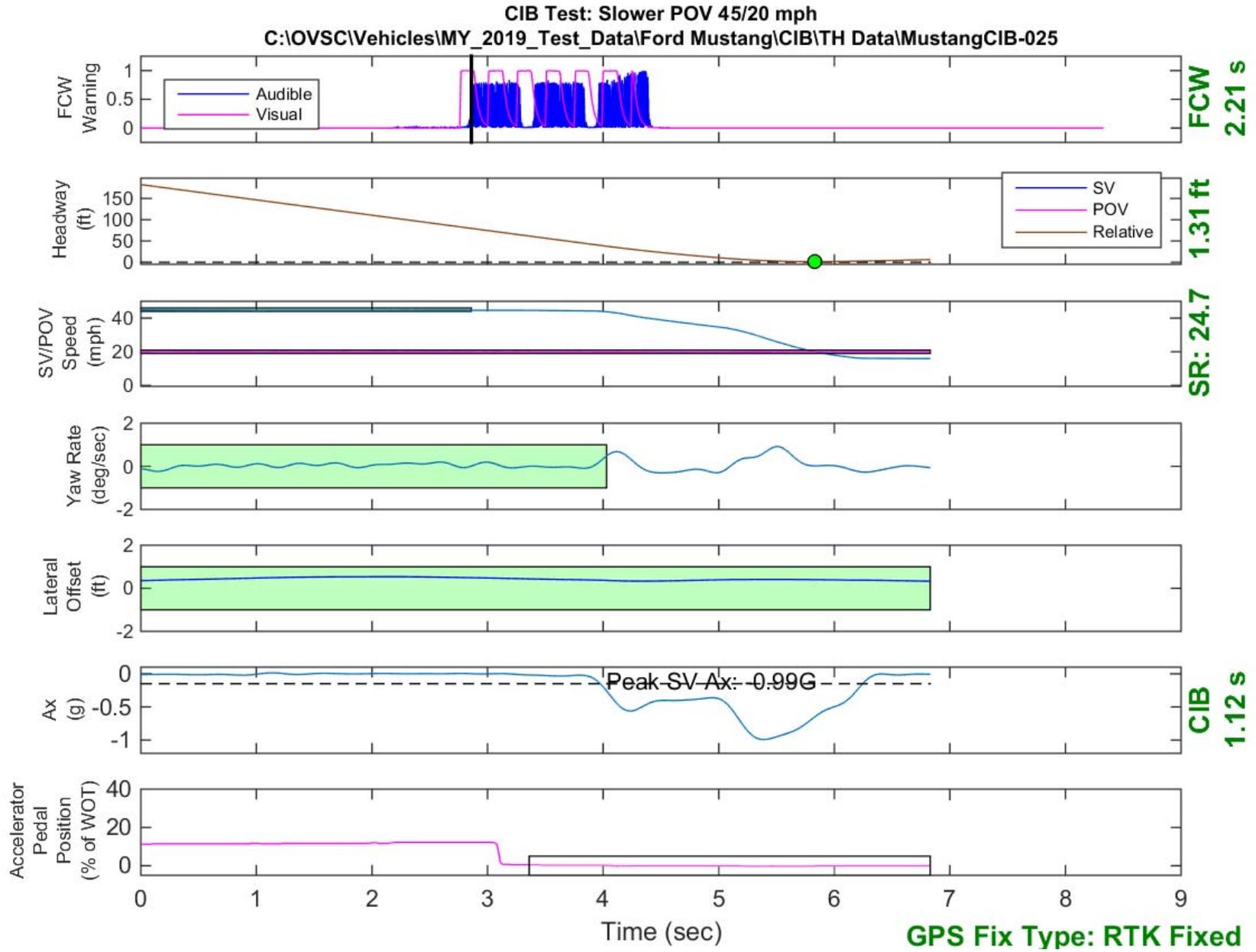


Figure D30. Time History for CIB Run 25, SV Encounters Slower POV, SV 45 mph, POV 20 mph

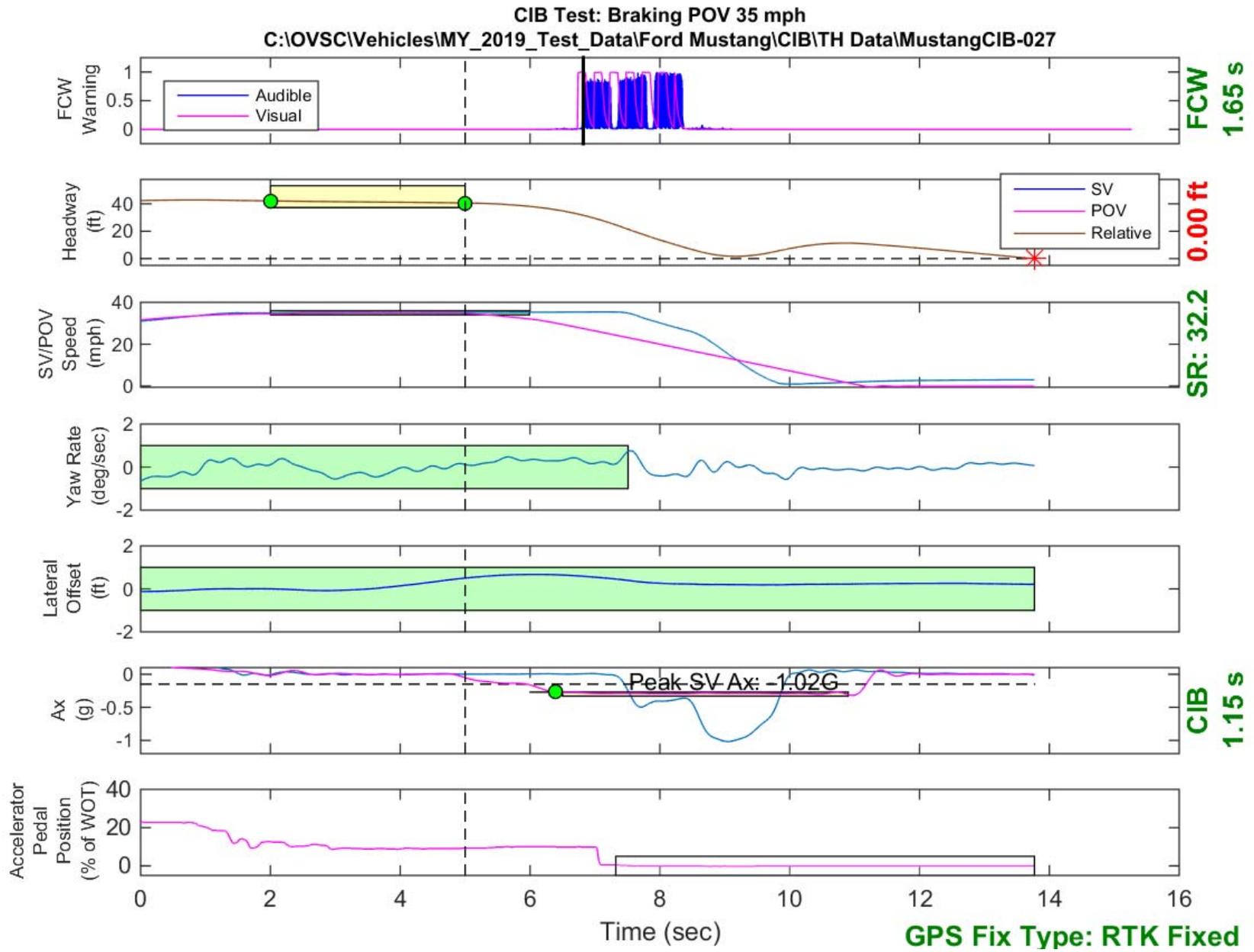


Figure D31. Time History for CIB Run 27, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

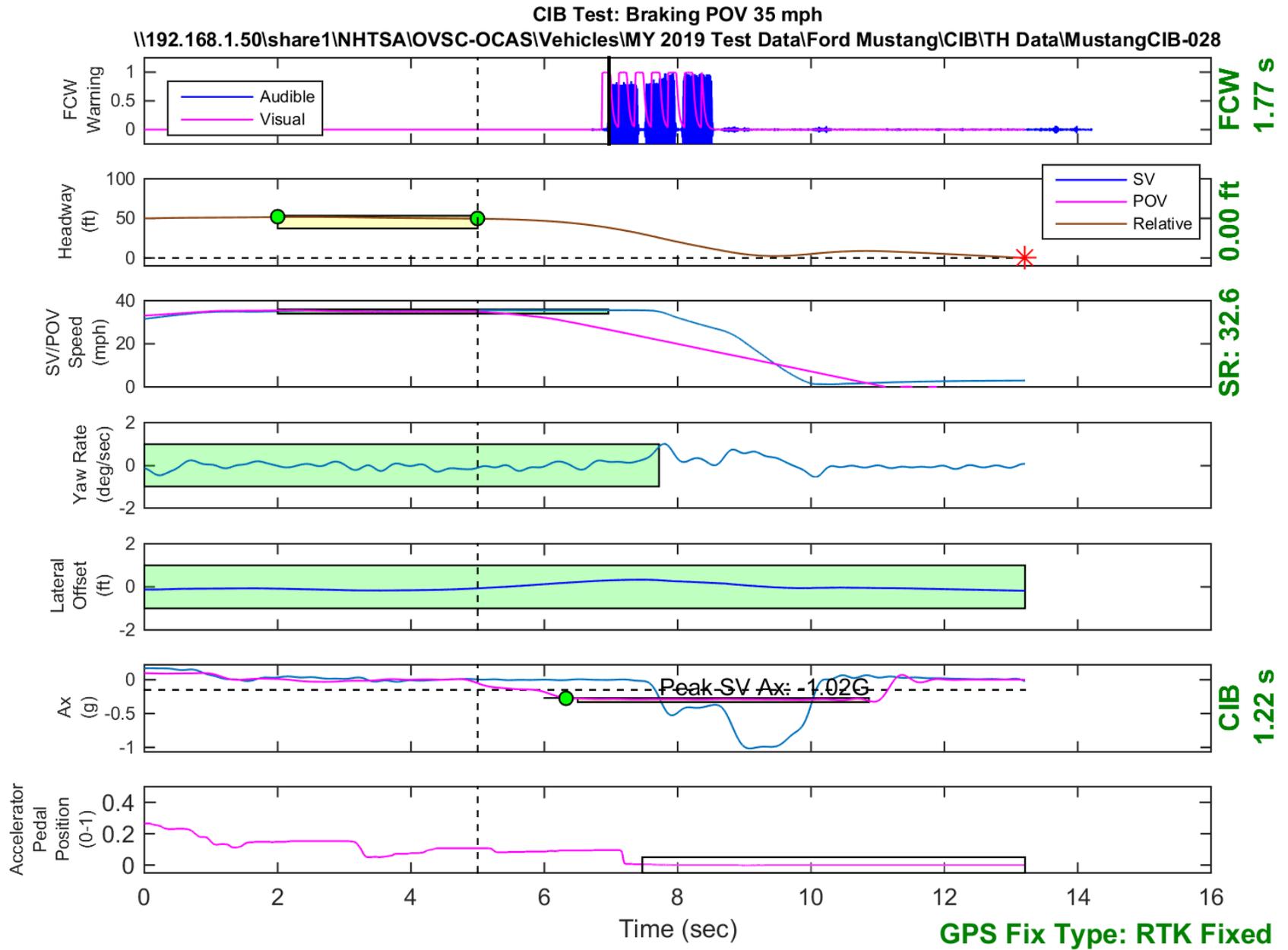


Figure D32. Time History for CIB Run 28, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

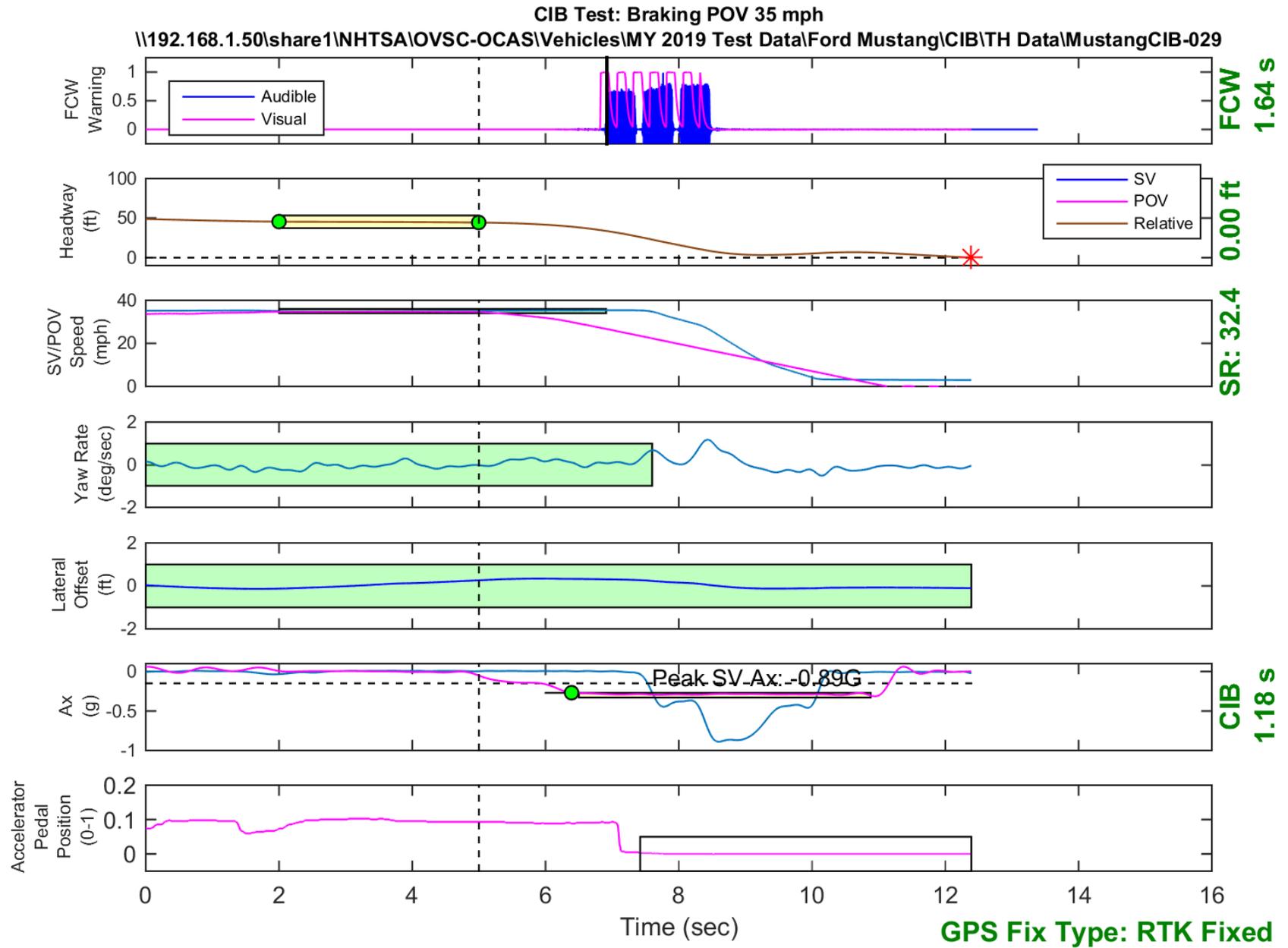


Figure D33. Time History for CIB Run 29, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

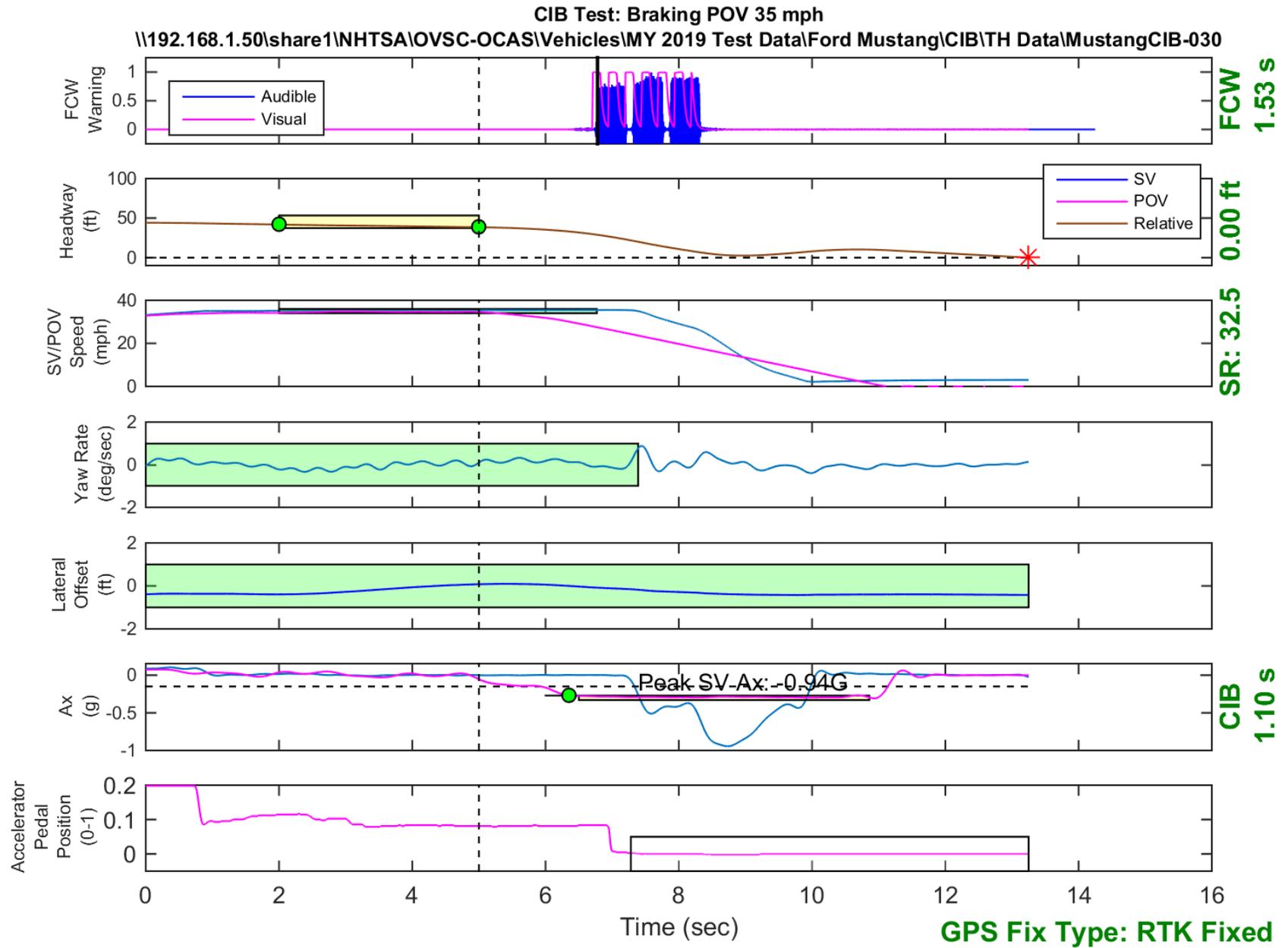


Figure D34. Time History for CIB Run 30, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

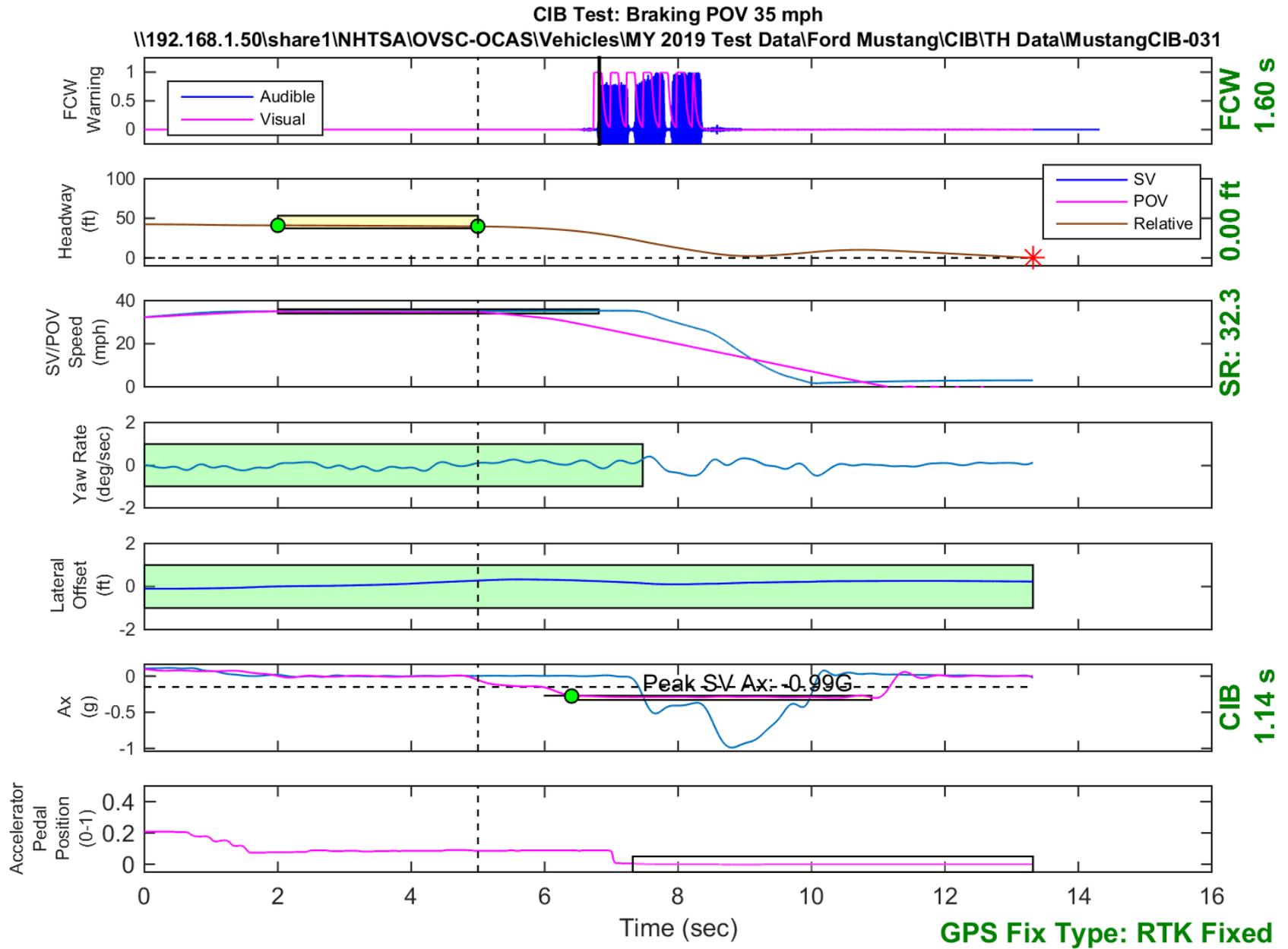


Figure D35. Time History for CIB Run 31, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

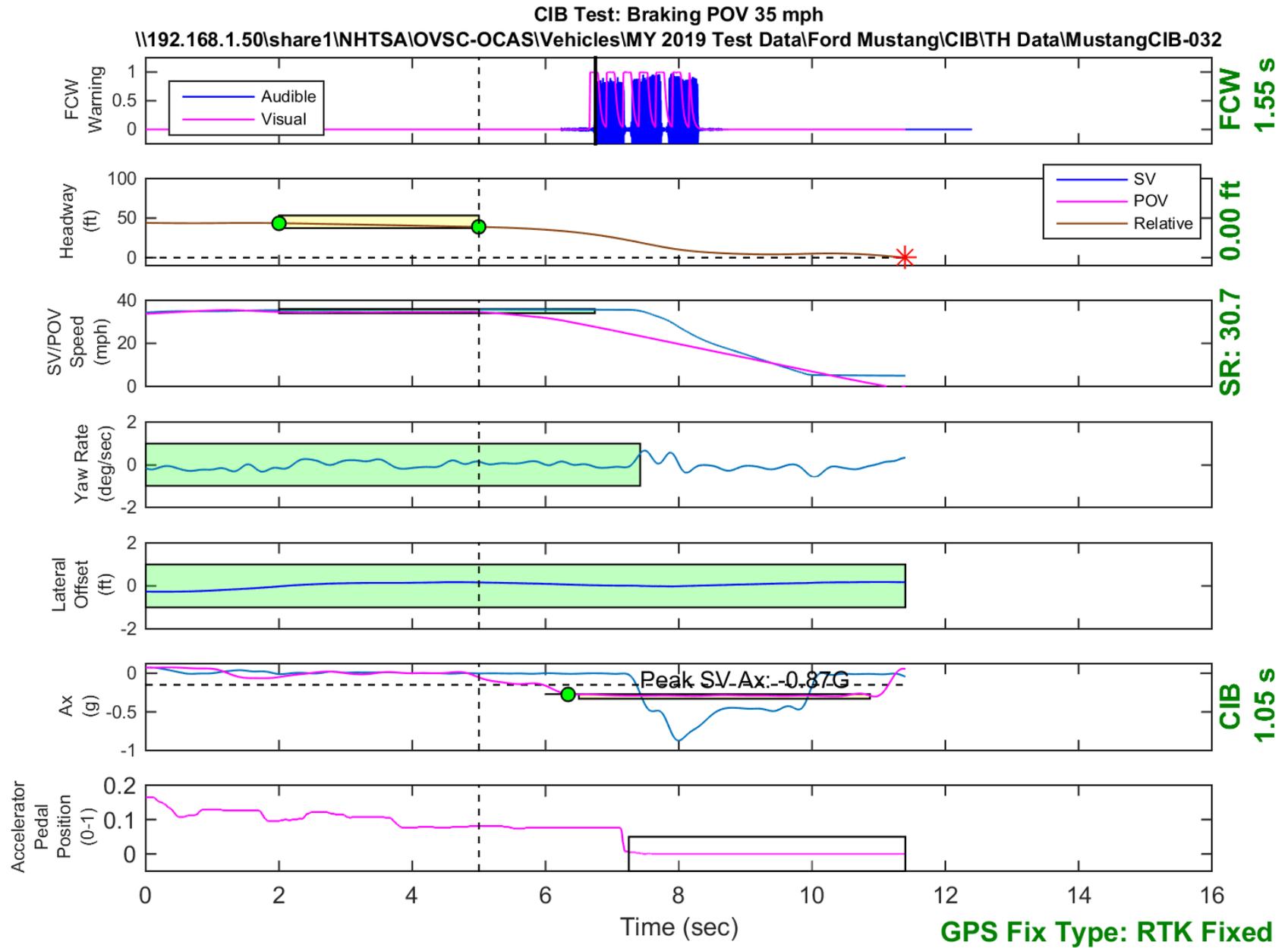


Figure D36. Time History for CIB Run 32, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

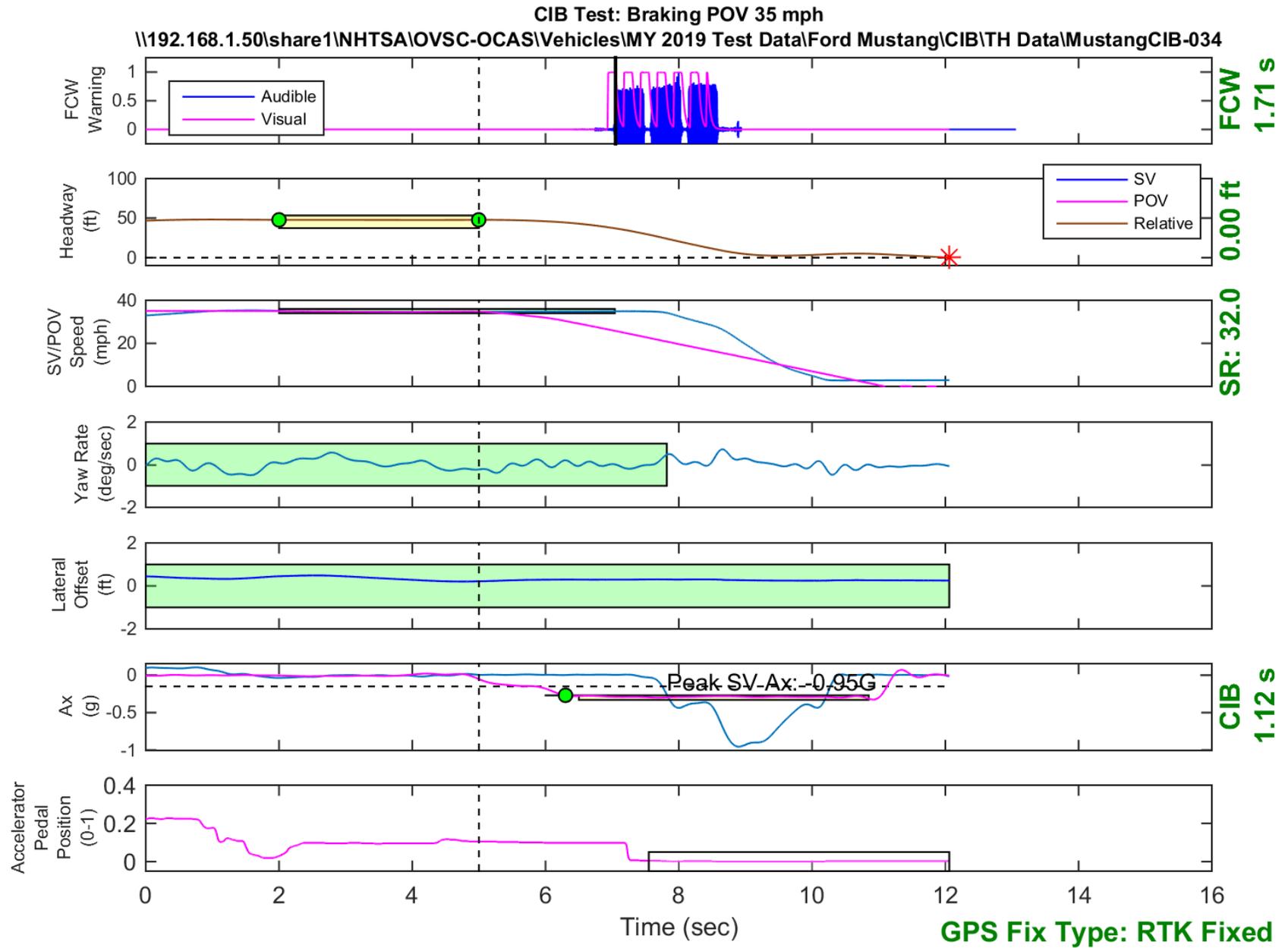


Figure D37. Time History for CIB Run 34, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

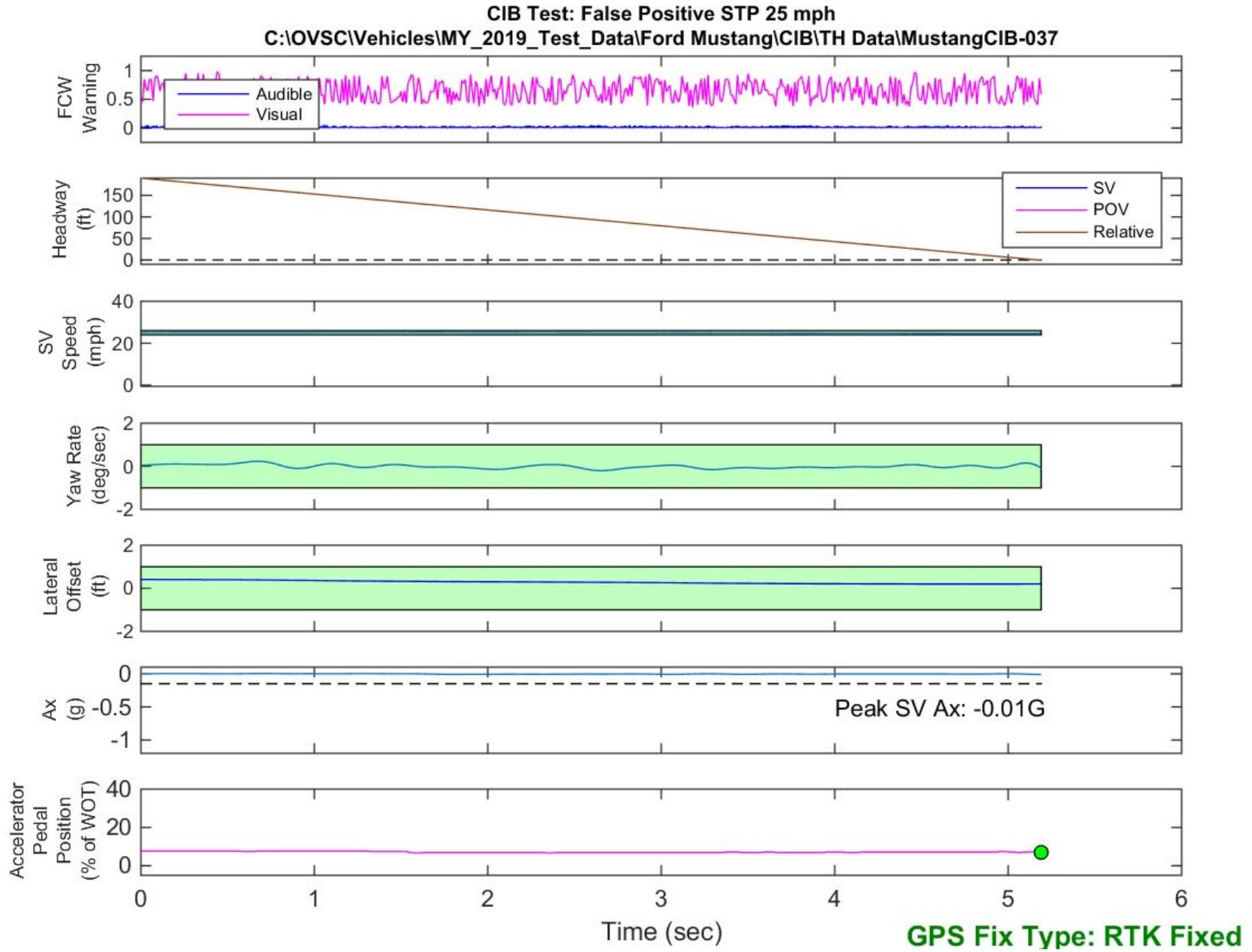


Figure D38. Time History for CIB Run 37, SV Encounters Steel Trench Plate, SV 25 mph

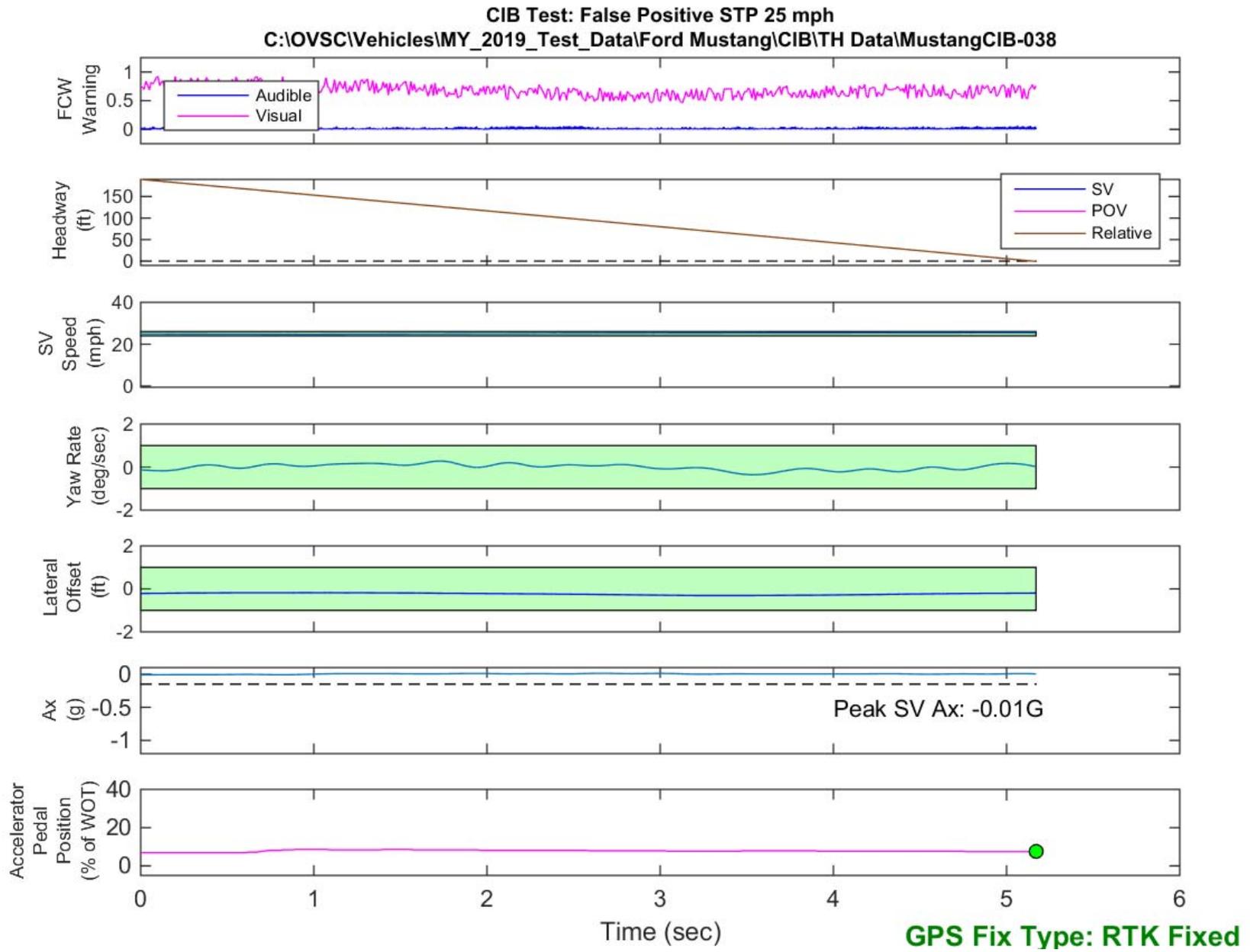


Figure D39. Time History for CIB Run 38, SV Encounters Steel Trench Plate, SV 25 mph

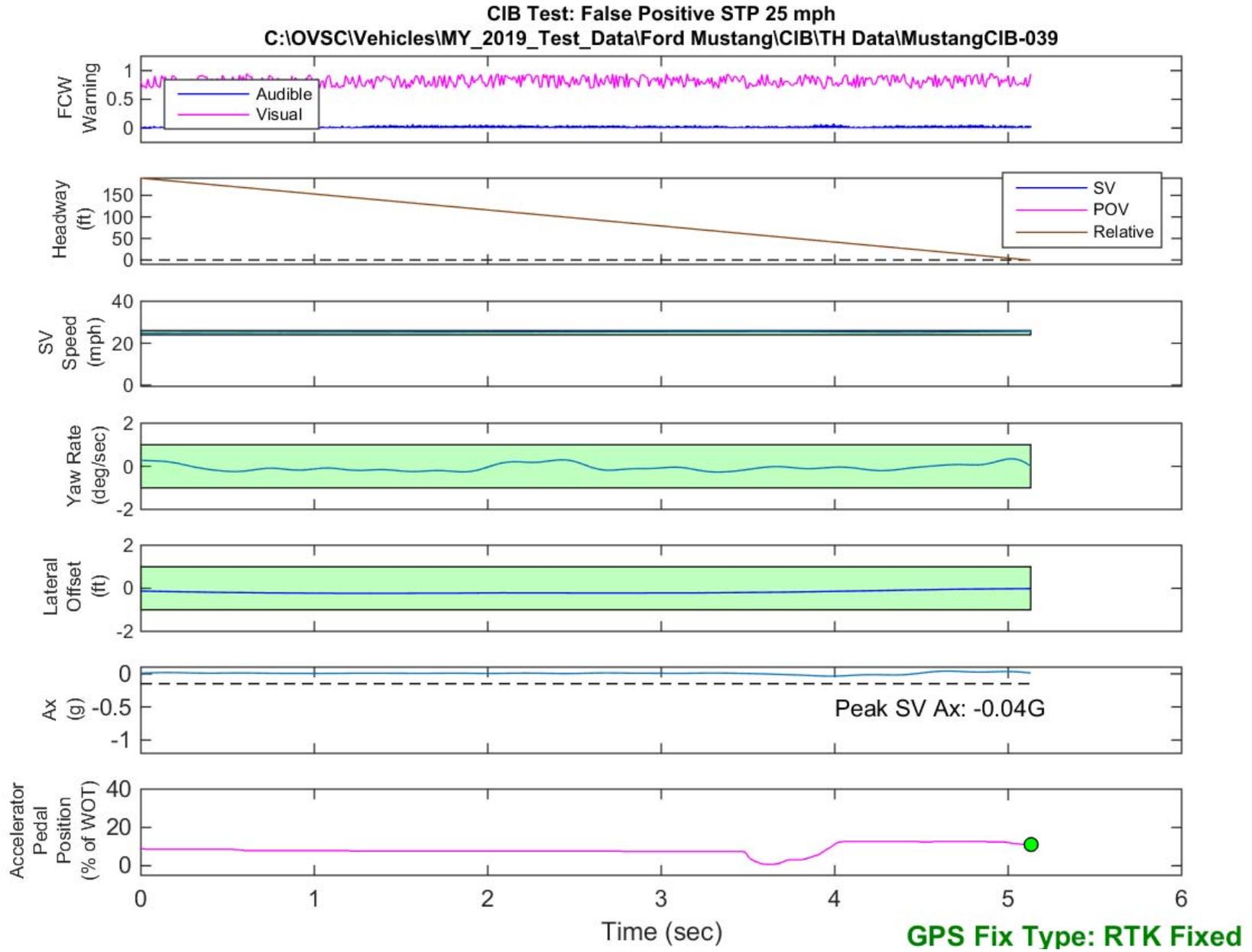


Figure D40. Time History for CIB Run 39, SV Encounters Steel Trench Plate, SV 25 mph

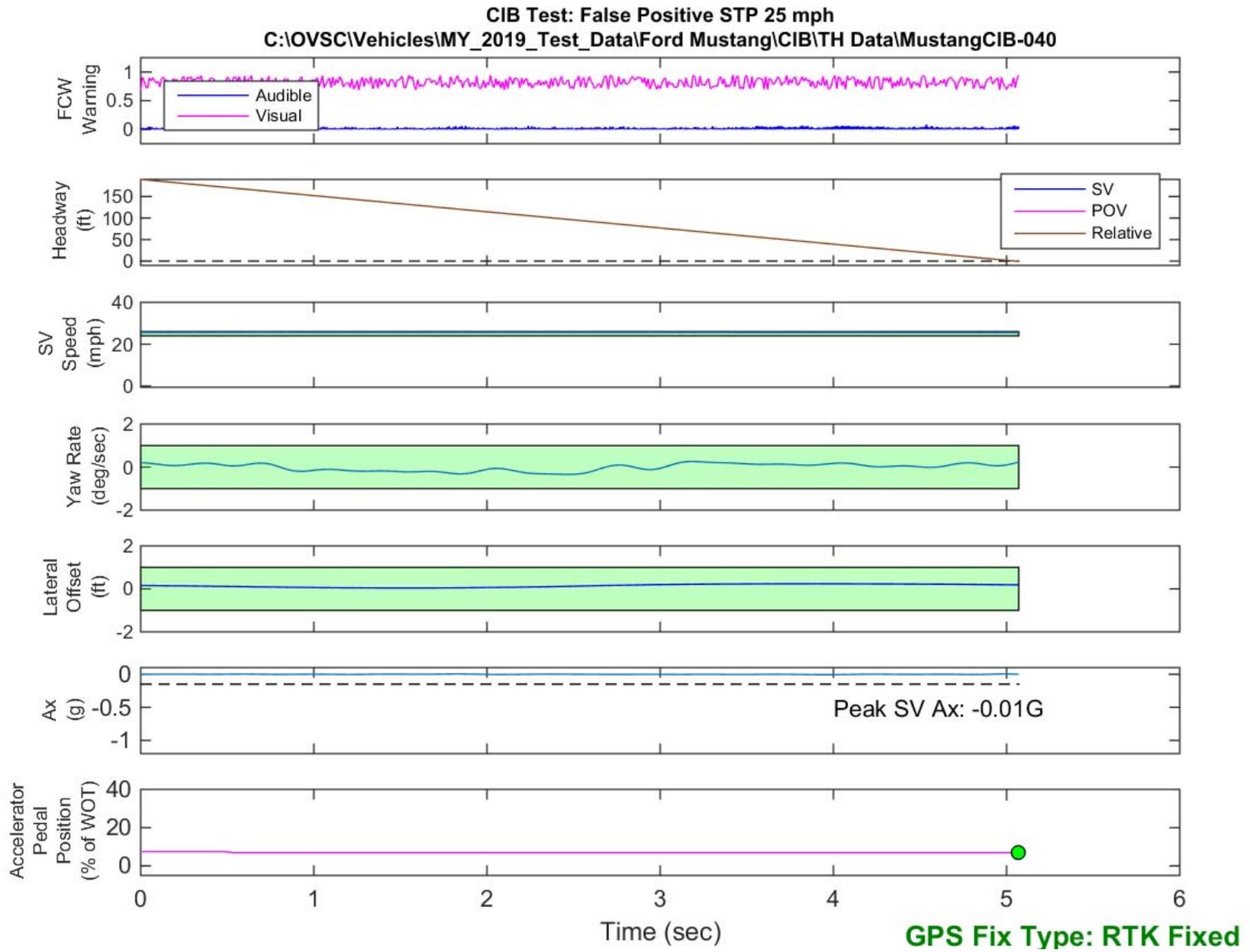


Figure D41. Time History for CIB Run 40, SV Encounters Steel Trench Plate, SV 25 mph

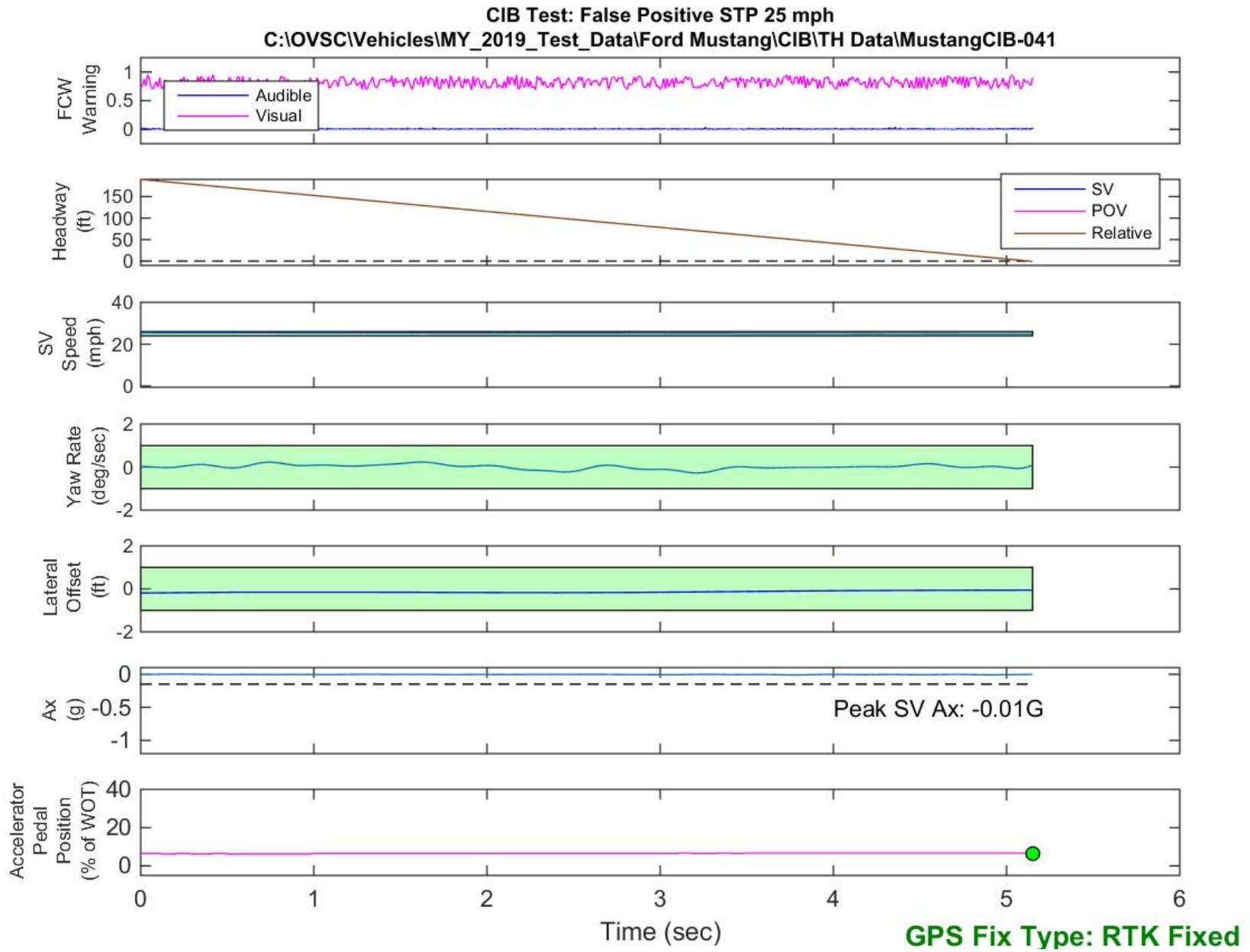


Figure D42. Time History for CIB Run 41, SV Encounters Steel Trench Plate, SV 25 mph

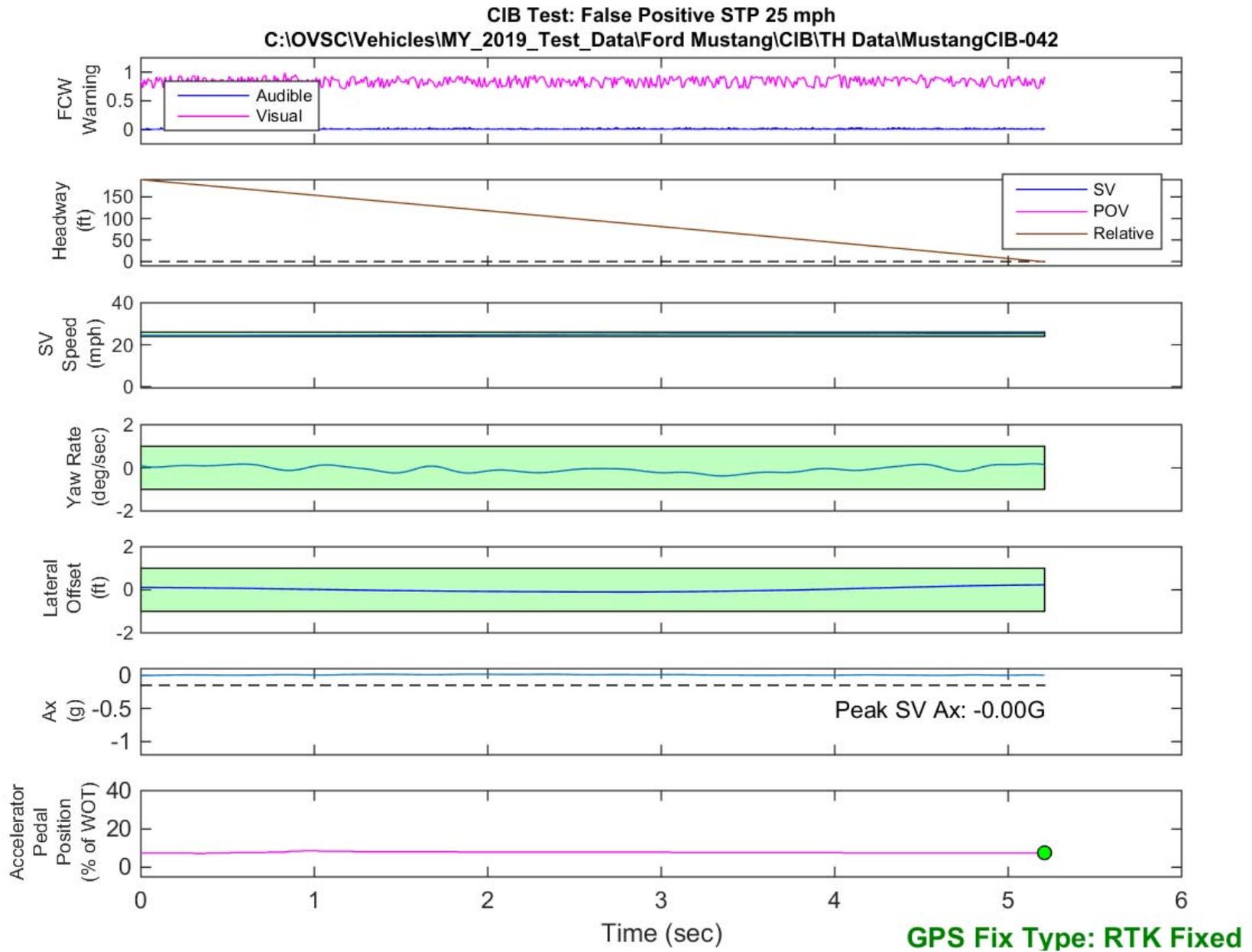


Figure D43. Time History for CIB Run 42, SV Encounters Steel Trench Plate, SV 25 mph

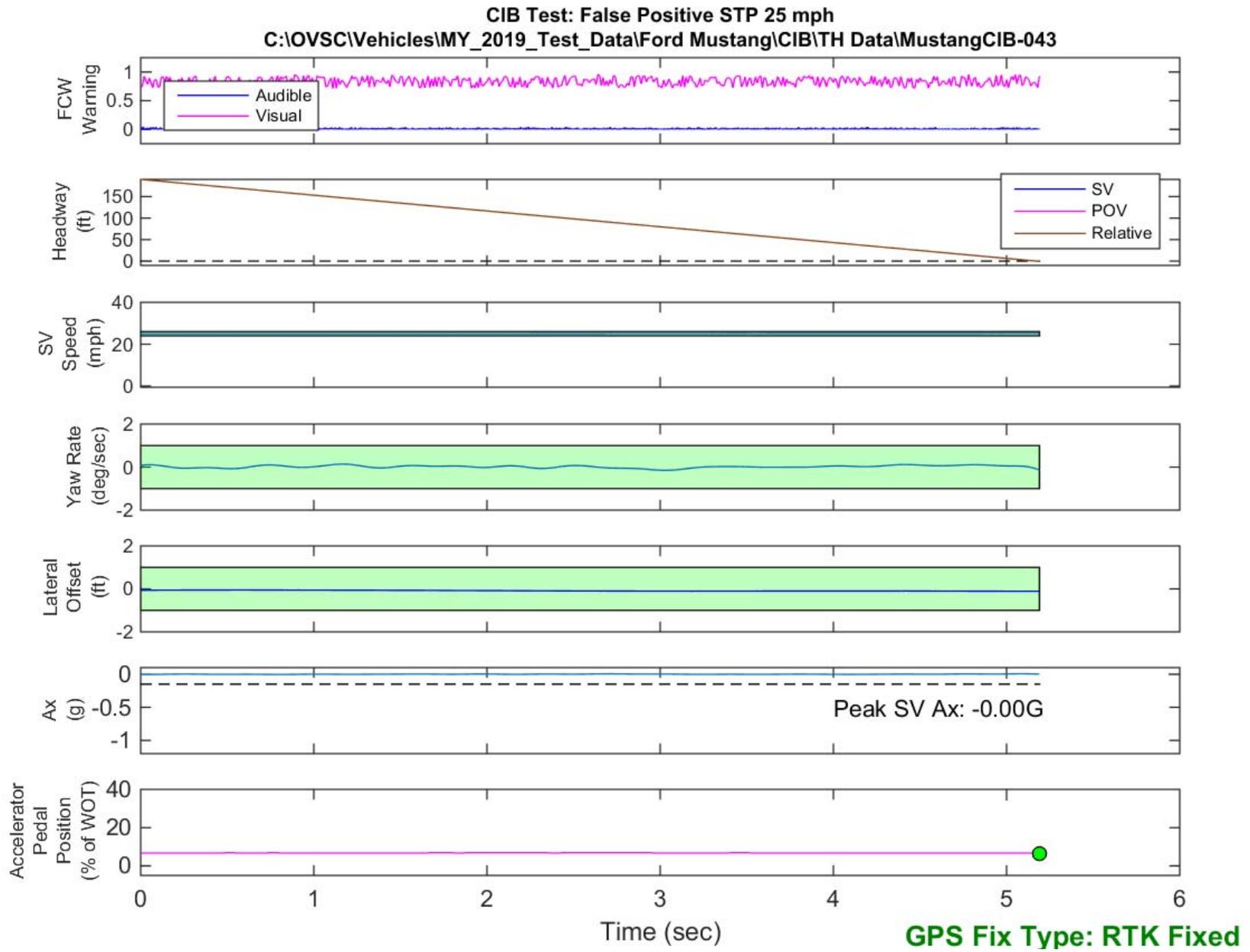


Figure D44. Time History for CIB Run 43, SV Encounters Steel Trench Plate, SV 25 mph

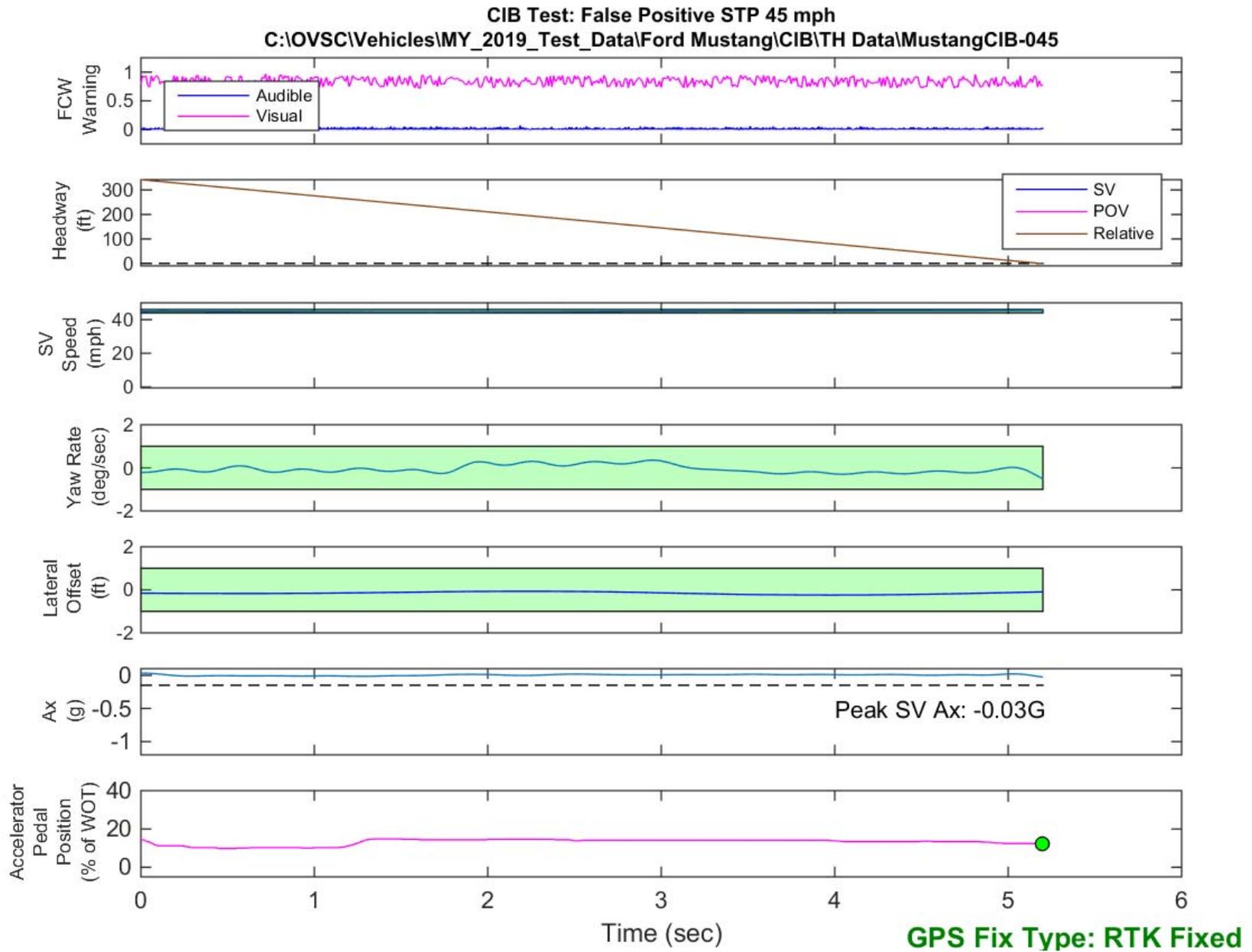


Figure D45. Time History for CIB Run 45, SV Encounters Steel Trench Plate, SV 45 mph

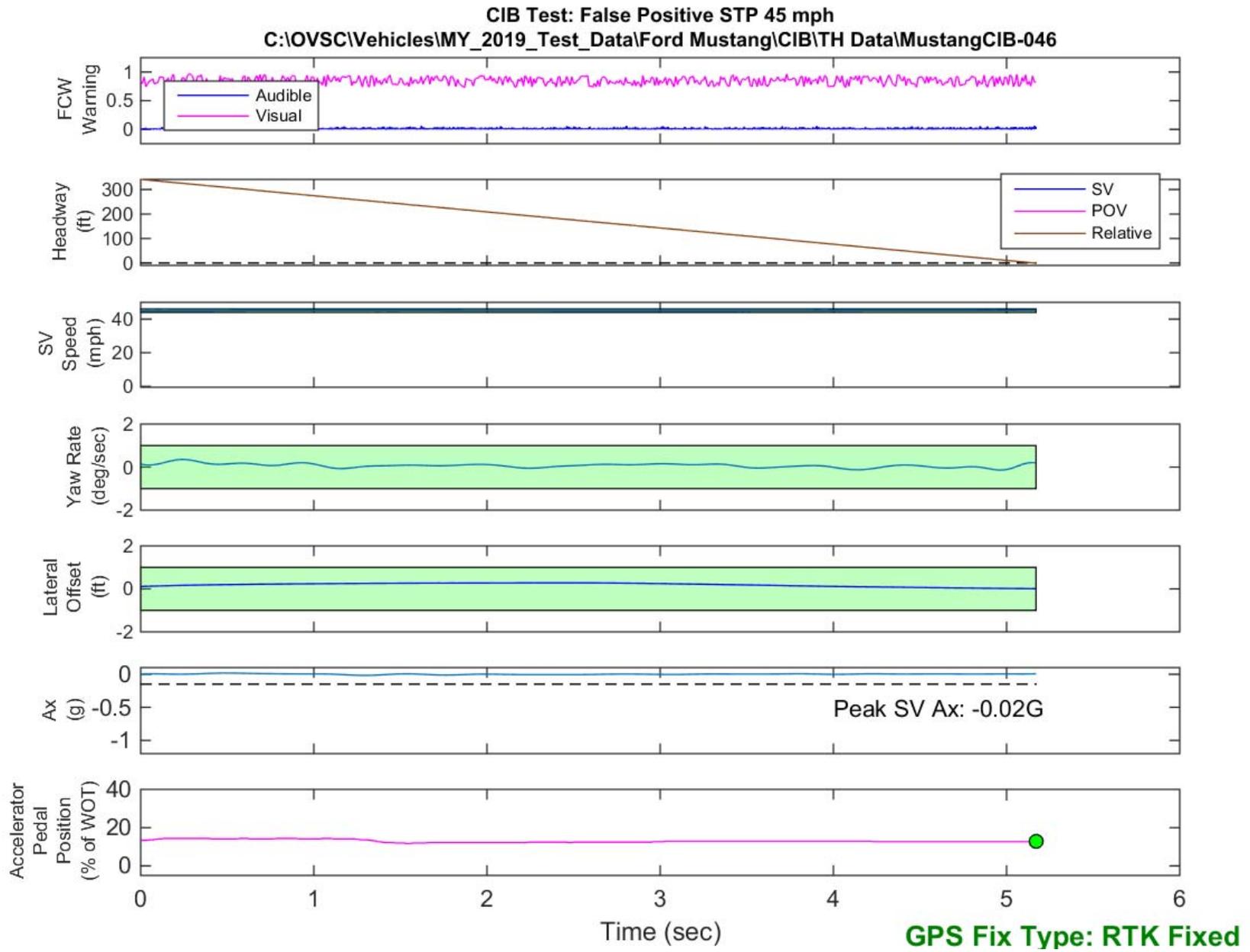


Figure D46. Time History for CIB Run 46, SV Encounters Steel Trench Plate, SV 45 mph

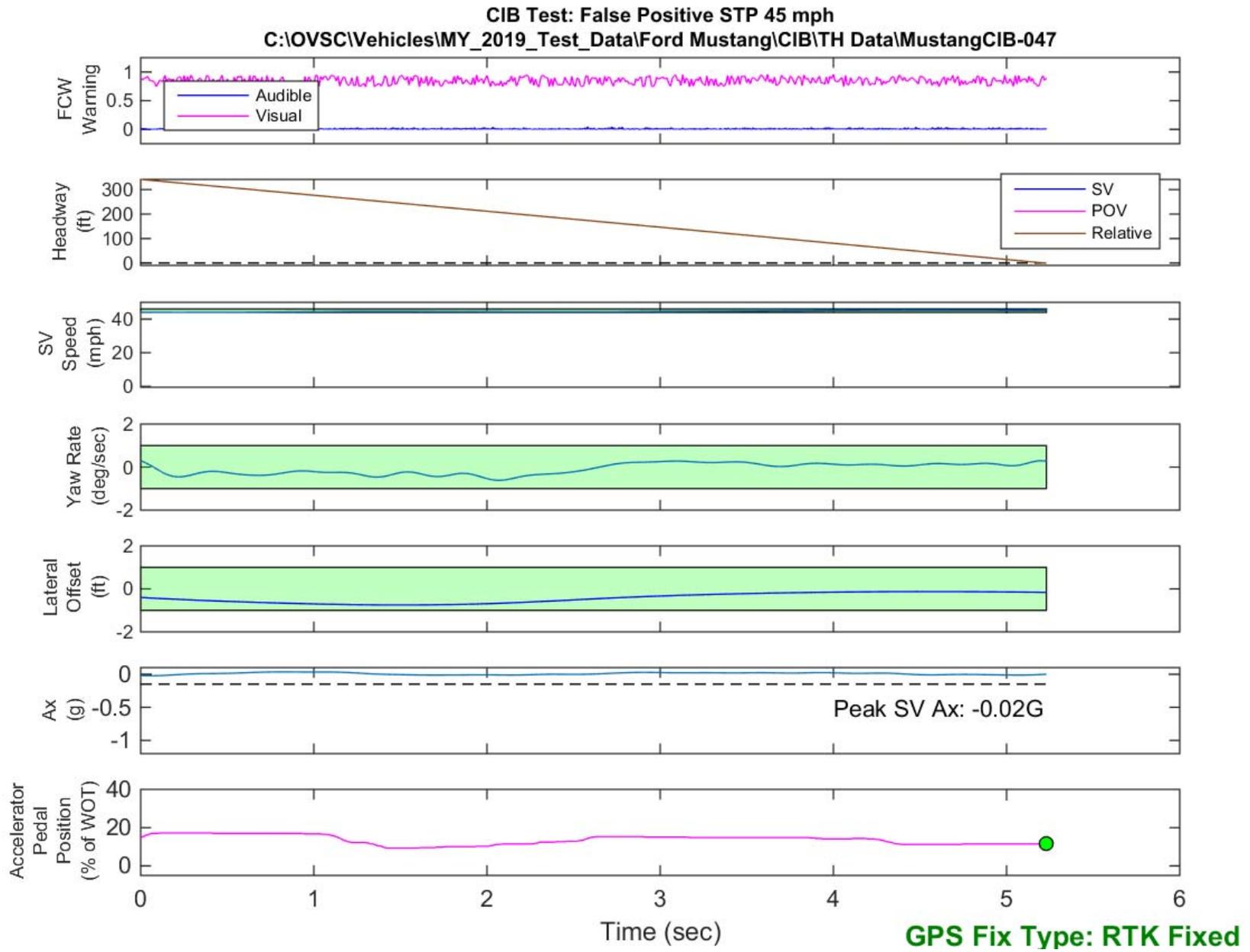


Figure D47. Time History for CIB Run 47, SV Encounters Steel Trench Plate, SV 45 mph

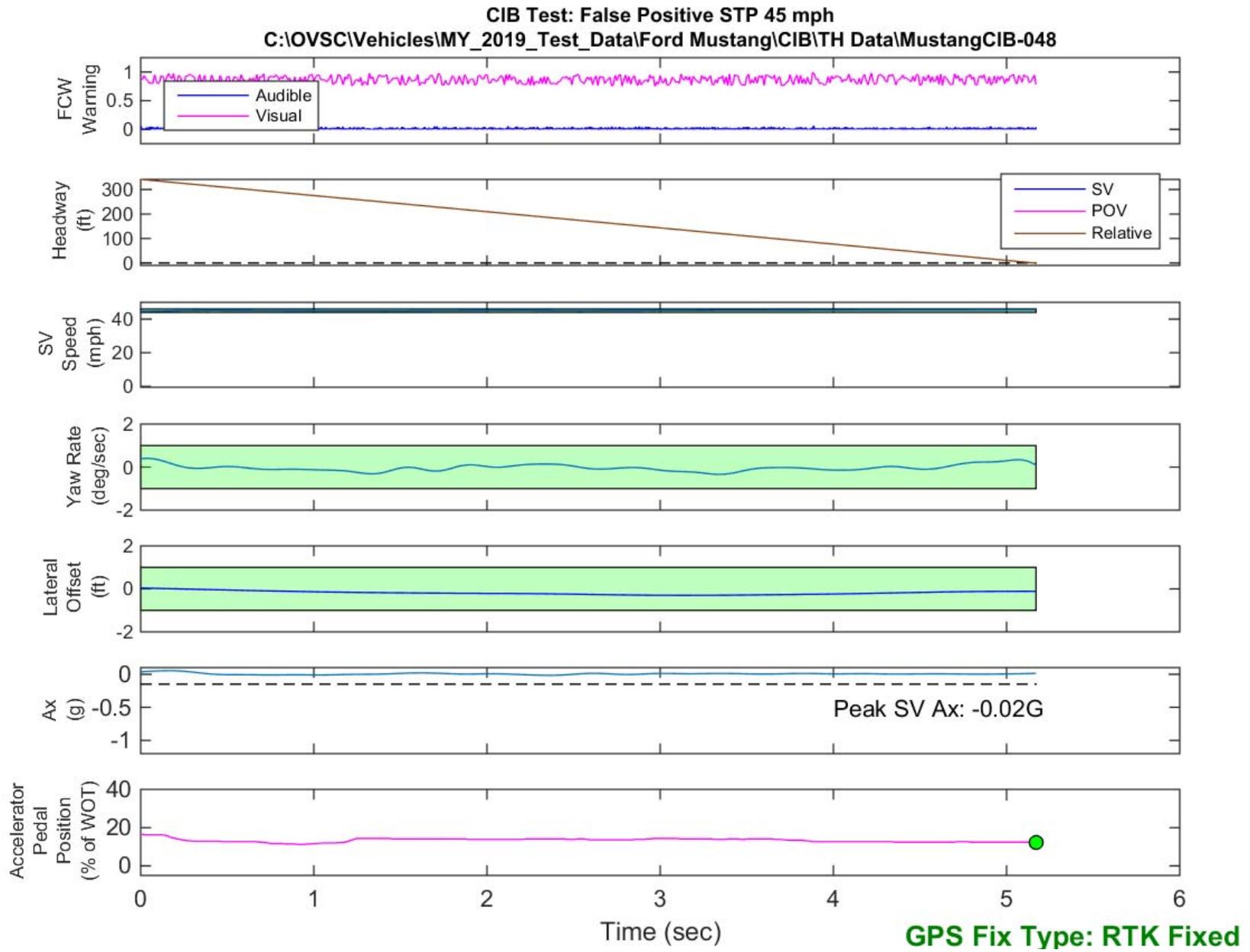


Figure D48. Time History for CIB Run 48, SV Encounters Steel Trench Plate, SV 45 mph

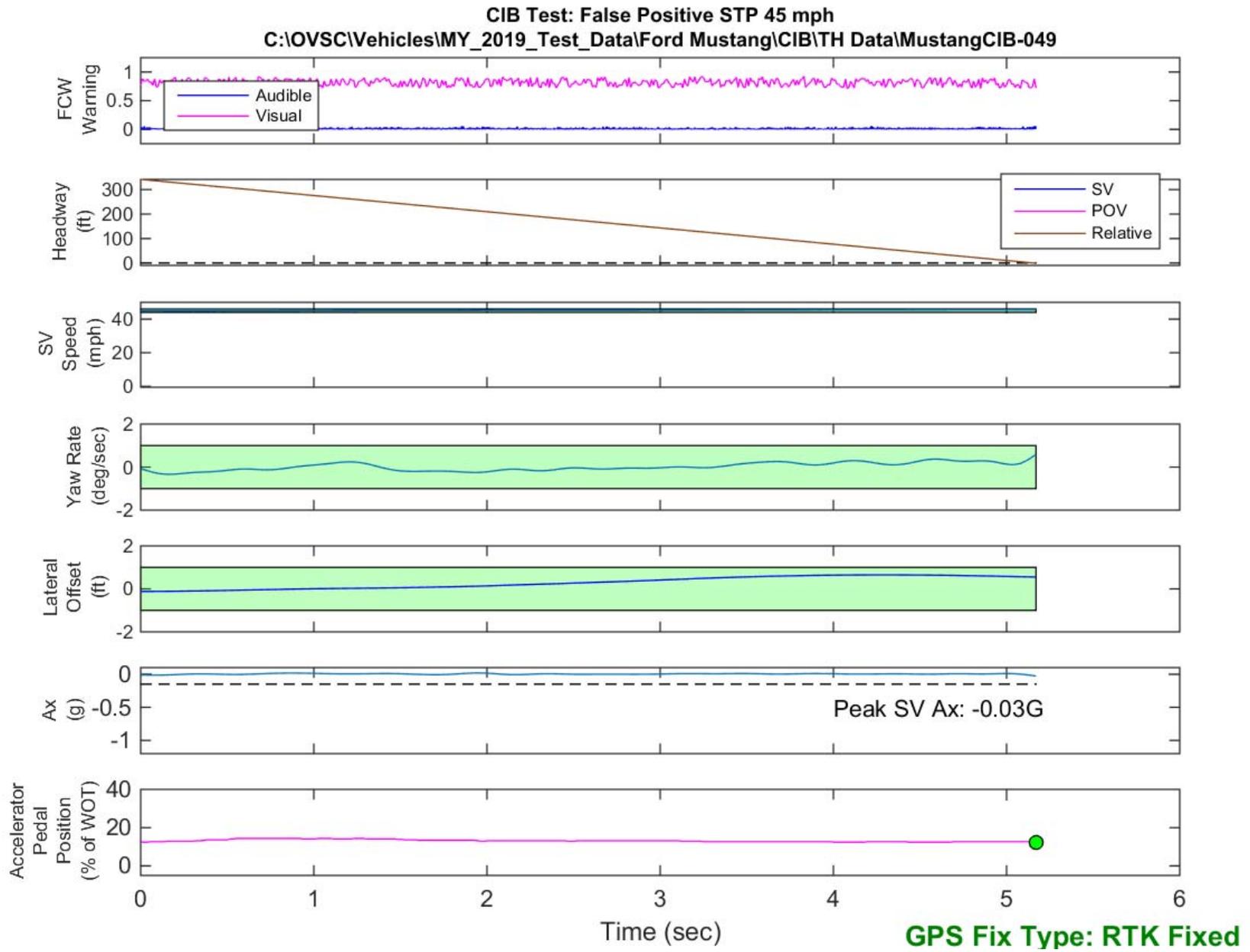


Figure D49. Time History for CIB Run 49, SV Encounters Steel Trench Plate, SV 45 mph

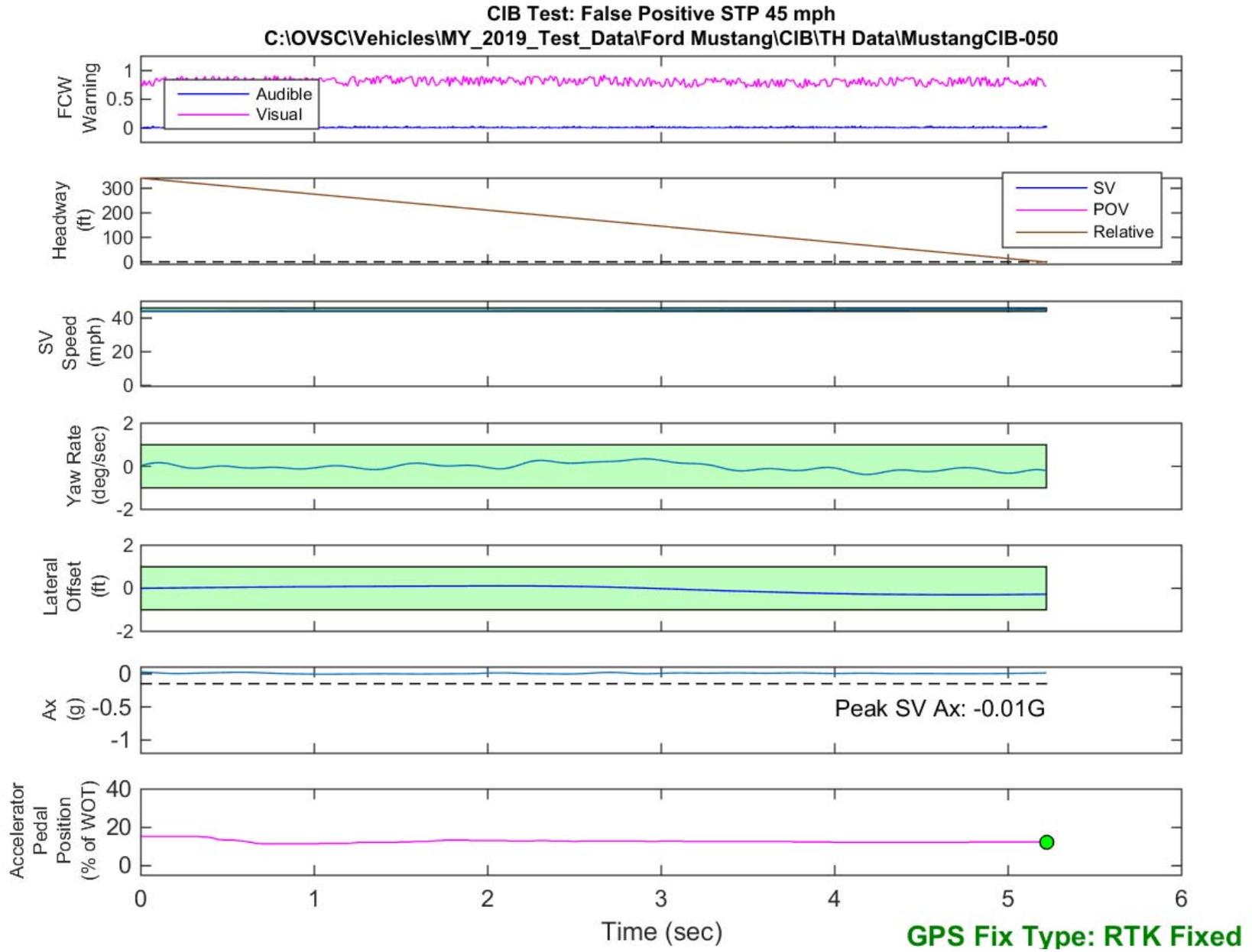


Figure D50. Time History for CIB Run 50, SV Encounters Steel Trench Plate, SV 45 mph

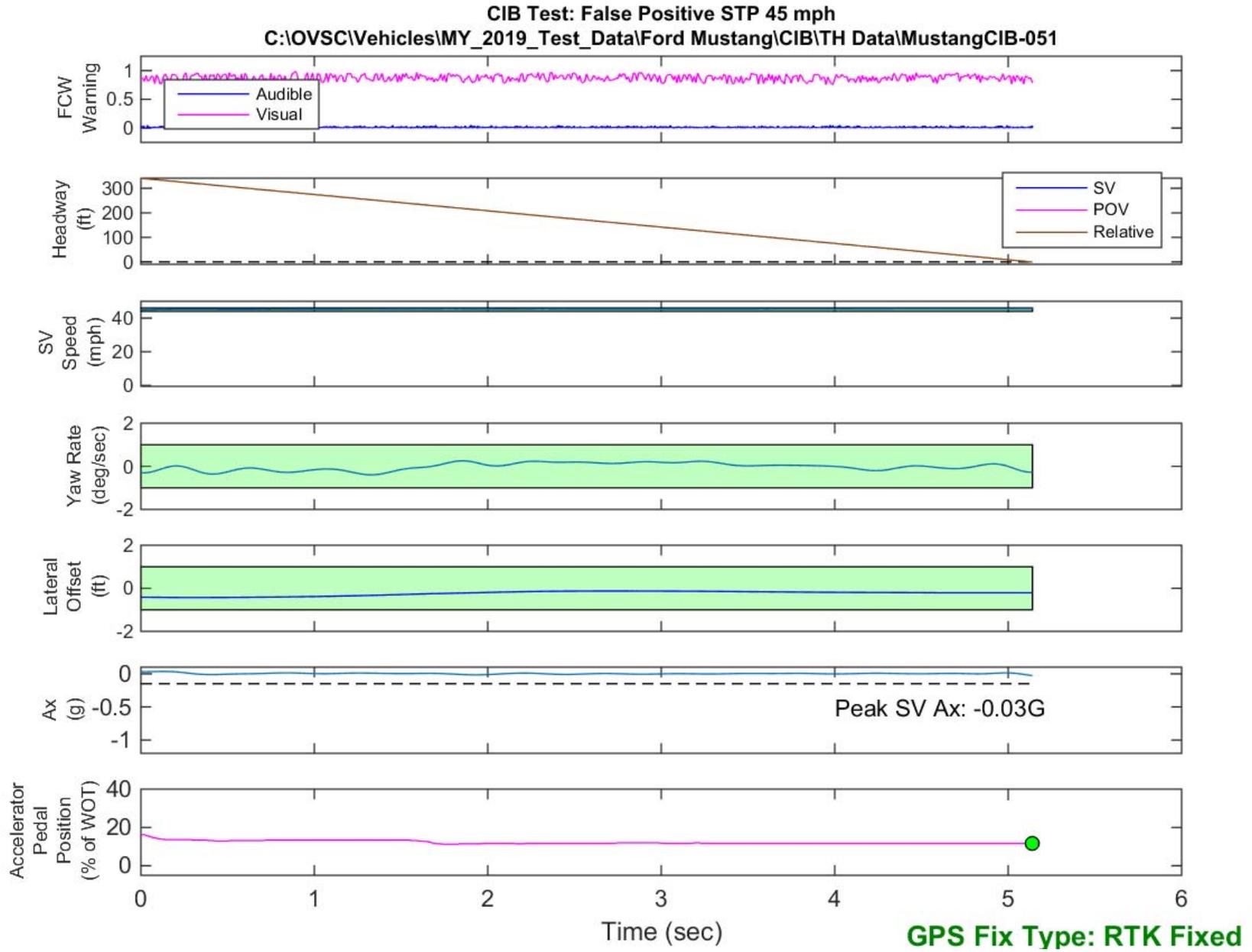


Figure D51. Time History for CIB Run 51, SV Encounters Steel Trench Plate, SV 45 mph