OCAS-DRI-DBS-18-12
NEW CAR ASSESSMENT PROGRAM
DYNAMIC BRAKE SUPPORT SYSTEM CONFIRMATION TEST

2018 Tesla Model 3

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

6 December 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
West Building, 4th Floor (NRM-200)
Washington, DC 20590

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

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These tests were conducted on the subject 2018 Tesla Model 3 in accordance with the specifications of the Office of Crash Avoidance Standards most current Test Procedure in docket NHTSA-2015-0006-0026; DYNAMIC BRAKE SUPPORT PERFORMANCE EVALUATION CONFIRMATION TEST FOR THE NEW CAR ASSESSMENT PROGRAM, October 2015. The vehicle passed the requirements of the test for the stopped Principal Other Vehicle (POV), slower moving POV and Steel Trench Plate, but failed the requirements for the decelerating POV, thus failing the overall test.</td></tr>
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Section I
OVERVIEW AND TEST SUMMARY

Dynamic Brake Support (DBS) systems are a subset of Automatic Emergency Braking (AEB) systems. DBS systems are designed to avoid or mitigate consequences of rear-end crashes by automatically applying supplemental braking on the subject vehicle when the system determines that the braking applied by the driver is insufficient to avoid a collision.

DBS systems intervene in driving situations where a rear-end collision is expected to be unavoidable unless additional braking is realized. Since DBS interventions are designed to occur late in the pre-crash timeline, and the driver has already initiated crash-avoidance braking, DBS systems are not required to alert the driver that a DBS intervention has occurred. In addition to sensors monitoring vehicle operating conditions, such as speed, brake application, etc., DBS systems employ RADAR, LIDAR, and/or vision-based sensors capable of detecting surrounding vehicles in traffic. Algorithms in the system's Central Processing Unit (CPU) use this information to continuously monitor the likelihood of a rear-end crash, and command additional braking as needed to avoid or mitigate such a crash.

The method prescribed by the National Highway Traffic Safety Administration (NHTSA) to evaluate DBS performance on the test track involves three longitudinal, 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 fourth scenario is used to evaluate the propensity of a DBS system to inappropriately activate in a non-critical driving scenario that does not present a safety risk to the SV occupant(s).

The purpose of the testing reported herein was to objectively quantify the performance of a Dynamic Brake Support system installed on a 2018 Tesla Model 3. This test to assess Dynamic Brake Support systems is sponsored by the National Highway Traffic Safety Administration under Contract No. DTNH22-14-D-00333 with the New Car Assessment Program (NCAP).

Section II
DATA SHEETS

DYNAMIC BRAKE SUPPORT

DATA SHEET 1: TEST RESULTS SUMMARY

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2018 Tesla Model 3

SUMMARY RESULTS

VIN: *5YJ3E1EB9JF0xxxx*

Test Date: *5/15/2019*

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: *Fail*

Test 4 - Subject Vehicle Encounters Steel Trench Plate

SV 25 mph: *Pass*

SV 45 mph: *Pass*

Overall: ***Fail***

Notes:

DYNAMIC BRAKE SUPPORT

DATA SHEET 2: VEHICLE DATA

(Page 1 of 2)

2018 Tesla Model 3

TEST VEHICLE INFORMATION

VIN: *5YJ3E1EB9JF0xxxx*

Body Style: *Sedan* Color: *Pearl White Multi Coat*

Date Received: *5/1/2019* Odometer Reading: *1396 mi*

Engine: *L Electric*

Transmission: *Automatic*

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: *Tesla, inc.*

Date of manufacture: *08/18*

DATA FROM TIRE PLACARD:

Tires size as stated on Tire Placard: Front: *235/40R19*

Rear: *235/40R19*

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

Rear: *290 kPa (42 psi)*

DYNAMIC BRAKE SUPPORT

DATA SHEET 2: VEHICLE DATA

(Page 2 of 2)

2018 Tesla Model 3

TIRES

Tire manufacturer and model: *Continental Procontact RX*

Front tire size: *235/40R19*

Rear tire size: *235/40R19*

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.

DYNAMIC BRAKE SUPPORT

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2018 Tesla Model 3

GENERAL INFORMATION

Test date: *5/15/2019*

AMBIENT CONDITIONS

Air temperature: *25.6 C (78 F)*

Wind speed: *5.1 m/s (11.5 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 : **NA**

Fuel tank is full: **NA**

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

Front: *290 kPa (42 psi)*

Rear: *290 kPa (42 psi)*

DYNAMIC BRAKE SUPPORT

DATA SHEET 3: TEST CONDITIONS

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2018 Tesla Model 3

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*508.5 kg (1121 lb)*	Right Front	*499.9 kg (1102 lb)*
Left Rear	*501.2 kg (1105 lb)*	Right Rear	*486.3 kg (1072 lb)*
		Total:	*1995.9 kg (4400 lb)*

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

(Page 1 of 3)

2018 Tesla Model 3

Name of the DBS option, option package, etc.: *Automatic Emergency Brake (AEB)*

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

Brake application mode used for test: *Hybrid control*

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

10 kph (7 mph) (Per manufacturer supplied information)

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

150 kph (90 mph) (Per manufacturer supplied information)

Does the vehicle system require an initialization sequence/procedure?

Before some features can be used for the first time, some cameras must complete a self-calibration process. Calibration typically completes after driving 20-25 miles (32-40 km), but the distance varies depending on road and environmental conditions. Driving on a straight road with highly-visible lane lines allows Model 3 to calibrate quicker. When calibration is complete, the features are available for use.

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

The system should not deactivate or reduce effectiveness due to repeated AEB activations. However, radar blindness can sometimes occur due to periods of inactivity. When that happens, user will not be able to engage Adaptive Cruise Control. System can be restored by power cycling the vehicle.

How is the Forward Collision Warning presented to the driver?

(Check all that apply)

X Warning light*

X Buzzer or audible alarm

___ Vibration

___ Other

* The sensor used to detect the visual alerts was saturated by the brightness of the screen and therefore unable to reliably detect the onset of the visual alert.

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.

Alerts are shown on the left side of center screen.

Forward Collision Warning is designed to sound a chime and highlight the vehicle in front of you in red on the touchscreen"

When Automatic Emergency Braking applies the brakes, the touchscreen displays a visual warning and sounds a chime. The brake pedal may also have an abrupt downward movement. The brake lights turn on to alert other road users that the vehicle is slowing down.

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.

Automatic Emergency Braking enabled by default. To disable it use touch controls:

> Autopilot

> Settings

> Automatic Emergency Braking > Off

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

_____ No

If yes, please provide a full description.

By default, Forward Collision Warning is turned on. To turn it off or adjust its sensitivity, touch Controls and select:

> Autopilot

> Settings

> Forward Collision Warning: Off, Late, Medium, or Early

>Automatic Emergency Braking: On/Off

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

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2018 Tesla Model 3

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

If yes, please provide a full description.

Collision Avoidance features cannot always detect all objects, vehicles, bikes, or pedestrians, and you may experience unnecessary, inaccurate, invalid, or missed warnings for many reasons, particularly if:

- *The road has sharp curves.*
- *Visibility is poor (due to heavy rain, snow, fog, etc.).*
- *Bright light (such as from oncoming headlights or direct sunlight) is interfering with the view of the camera(s).*
- *The radar sensor is obstructed (dirty, covered, etc.).*
- *The windshield is obstructing the view of the camera(s) (fogged over, dirty, covered by a sticker, etc.).*
- *The limitations previously described do not represent an exhaustive list of situations that may interfere with proper operation of Collision Avoidance Assist features. These features may fail to provide their intended function for many other reasons. It is the driver's responsibility to avoid collisions by staying alert, paying attention, and taking corrective action as early as possible*

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 DBS system to detect and respond to a stopped lead vehicle in the immediate forward path of the SV, as depicted in Figure 1.

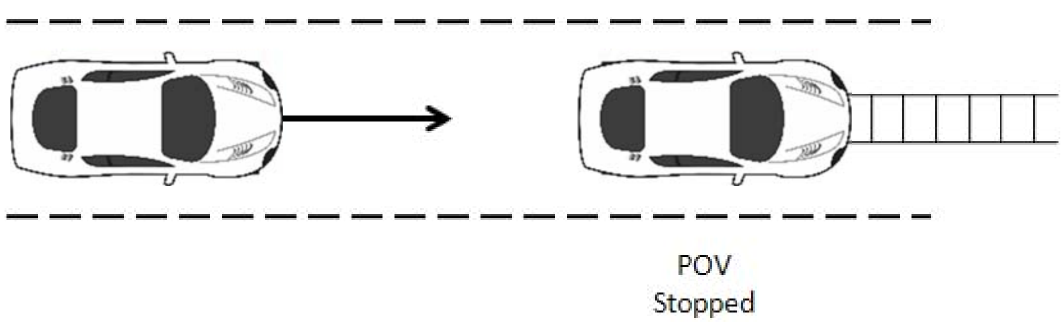


Figure 1. Depiction of Test 1

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 approaches 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 SV brakes were applied at TTC = 1.1 seconds (SV-to-POV distance of 40 ft (12 m)).

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).

Table 1. Nominal Stopped POV DBS Test Choreography

Test Speeds		SV Speed Held Constant		SV Throttle Fully Released By		SV Brake Application Onset (for each application magnitude)	
SV	POV	TTC (seconds)	SV-to-POV Headway	TTC (seconds)	SV-to-POV Headway	TTC (seconds)	SV-to-POV Headway
25 mph (40.2 kph)	0	5.1 → t_{FCW}	187 ft (57 m) → t_{FCW}	Within 500 ms of FCW1 onset	Varies	1.1	40 ft (12 m)

b. Criteria

The performance requirement for this series of tests is that there be no SV-POV impact for at least five of the seven valid test trials.

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

This test evaluates the ability of the DBS 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.

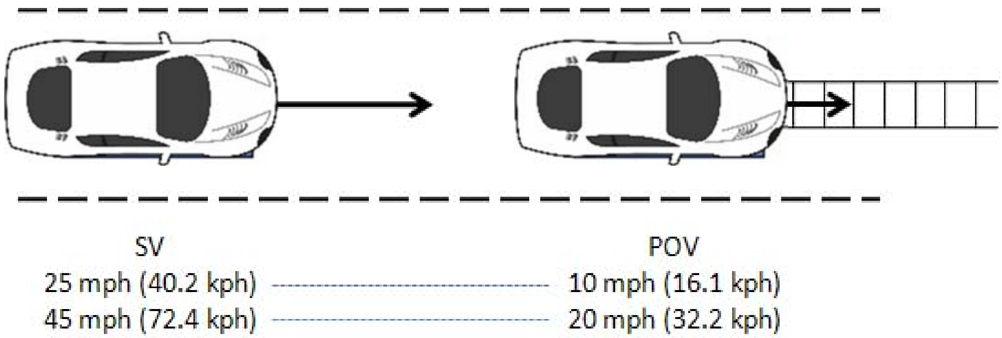


Figure 2. Depiction of Test 2

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 (40.2 kph), 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 SV brakes were applied at TTC = 1.0 seconds, assumed to be SV-to-POV distance of 22 ft (7 m) for an SV speed of 25 mph and 37 ft (11 m) for an SV speed of 45 mph.

The test concluded when either:

- The SV came into contact with the POV or
- 1 second after the speed 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 SV speed could not deviate more than ±1.0 mph (±1.6 kph) 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 kph) during the validity period.

Table 2. Nominal Slower Moving POV DBS Test Choreography

Test Speeds		SV Speed Held Constant		SV Throttle Fully Released By		SV Brake Application Onset (for each application magnitude)	
SV	POV	TTC (seconds)	SV-to-POV Headway	TTC (seconds)	SV-to-POV Headway	TTC (seconds)	SV-to-POV Headway
25 mph (40 kph)	10 mph (16 kph)	5.0 → t_{FCW}	110 ft (34 m) → t_{FCW}	Within 500 ms of FCW1 onset	Varies	1.0	22 ft (7 m)
45 mph (72 kph)	20 mph (32 kph)	5.0 → t_{FCW}	183 ft (56 m) → t_{FCW}	Within 500 ms of FCW1 onset	Varies	1.0	37 ft (11 m)

b. Criteria

The performance requirement for this series of tests is that there be no SV-POV impact for at least five of the seven valid test trials.

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

This test evaluates the ability of the DBS 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. Should the SV foundation brake system be unable to prevent an SV-to-POV impact for a given test condition, the DBS system should automatically provide supplementary braking capable of preventing an SV-to-POV collision.

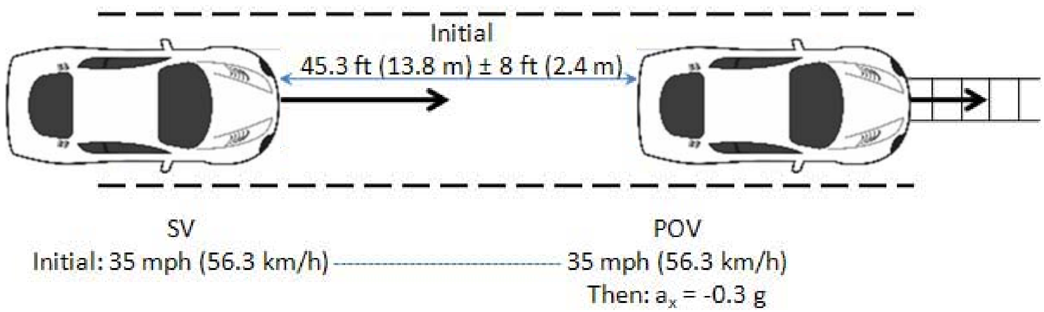


Figure 3. Depiction of Test 3 with POV Decelerating

a. Procedure

The SV ignition was cycled prior to each test run. For this scenario both the POV and SV were driven at a constant 35.0 mph (56.3 kph) in the center of the lane, with headway of 45 ft (14 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. The SV throttle pedal was released within 500 ms of t_{FCW}, and the SV brakes were applied when TTC was 1.4 seconds (31.5 ft (9.6 m)).

The test concluded when either:

- 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.

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 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 kph) 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.

Table 3. Nominal Decelerating POV DBS Test Choreography

Test Speeds		SV Speed Held Constant		SV Throttle Fully Released By		SV Brake Application Onset (for each application magnitude)	
SV	POV	TTC (seconds)	SV-to-POV Headway	TTC (seconds)	SV-to-POV Headway	TTC (seconds)	SV-to-POV Headway
35 mph (56 kph)	35 mph (56 kph)	3.0 seconds prior to POV braking → t_{FCW}	45 ft (14 m) → t_{FCW}	Within 500 ms of FCW1 onset	Varies	1.4	32 ft (10 m)

b. Criteria

The performance requirement for this series of tests is that no SV-POV contact occurs for at least five of the seven valid test trials.

4. TEST 4 – FALSE POSITIVE SUPPRESSION

The false positive suppression test series evaluates the ability of a DBS 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 DBS 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 kph) and 45 mph (72.4 kph). 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. The SV was driven at constant speed in the center of the lane toward the STP. If the SV did not present an FCW alert during the approach to the STP by TTC = 2.1 s, the SV driver initiated release of the throttle pedal at TTC = 2.1 s and the throttle pedal was fully released within 500 ms of TTC = 2.1 s. The SV brakes were applied at TTC of 1.1 seconds, assumed to be 40 ft (12.3 m) from the edge of the STP at 25 mph or 73 ft (22.1 m) at 45 mph. The test concluded when the front most part of the SV reached a vertical plane defined by the edge of the STP first encountered by the SV.

b. Criteria

In order to pass the False Positive test series, the magnitude of the SV deceleration reduction attributable to DBS intervention must have been less than or equal to 1.25 times the average of the deceleration experienced by the baseline command from the braking actuator 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 haptic, visual, or audible, and the onset of the alert is determined by post-processing the test data.

For systems that implement audible or haptic alerts, part of the pre-test instrumentation verification process is 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 is accomplished in order to identify the center frequency around which a band-pass filter is 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 is a phaseless, forward-reverse pass, elliptical (Cauer) digital filter, with filter parameters as listed in Table 4.

Table 4. 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 ± 5%
Tactile	5^{th}	3 dB	60 dB	Identified Center Frequency ± 20%

2. General Validity Criteria

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

- The SV driver seatbelt was latched.
- If any load had been placed on the SV front passenger seat (e.g., for instrumentation), the vehicle's front passenger seatbelt was latched.
- The SV was driven at the nominal speed in the center of the travel lane, toward the POV or STP.
- The driver used the least amount of steering input necessary to maintain SV position in the center of the travel lane during the validity period; use of abrupt steering inputs or corrections was avoided.
- The yaw rate of the SV did not exceed ±1.0 deg/s from the onset of the validity period to the instant SV deceleration exceeded 0.25 g.
- The SV driver did not apply any force to the brake pedal during the during the applicable validity period. All braking shall be performed by the programmable brake controller.
- 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: 2 seconds prior to the SV throttle pedal being released

The valid test interval ended:

Test 1: When either of the following occurred:

- The SV came in 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.

Test 2: 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.

Test 3: When either of the following occurred:

- The SV came in contact with the POV; or
- 1 second after minimum SV-to-POV range occurred.

Test 4: When the SV stopped.

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 defining 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

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

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

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

- POV delivery system, whose requirements are to:
  - Accurately control the nominal POV speed up to 35 mph (56 kph).
  - 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 rearward direction. In operation, the shell and roller assembly engages the rail assembly through detents to prevent relative motion during run-up to test speeds and minor 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 and 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 away from the SV. The forward end of the rail has a soft 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. FOUNDATION BRAKE SYSTEM CHARACTERIZATION

Data collected and analyzed from a series of pre-test braking runs were used to objectively quantify the response of the vehicle’s foundation brake system without the contribution of DBS. The results of these analyses were used to determine the brake pedal input magnitudes needed for the main tests.

This characterization was accomplished by recording longitudinal acceleration and brake pedal force and travel data for a variety of braking runs. For three initial brake characterization runs, the vehicle was driven at 45 mph, and the brakes were applied at a rate of 1 inch/sec up to the brake input level needed for at least 0.7 g. Linear regressions were performed on the data from each run to determine the linear vehicle deceleration response as a function of both applied brake pedal force and brake pedal travel. The brake input force or displacement level needed to achieve a vehicle deceleration of 0.4 g was determined from the average of the three runs. Using the 0.4 g brake input force or displacement level found from the three initial runs, subsequent runs were performed at 25 mph, 35 mph, and 45 mph, with the brakes applied at a rate of 10 inch/sec to the determined 0.4 g brake input force or displacement level. For each of the three test speeds, if the average calculated deceleration level was found to be within 0.4 ± 0.025 g, the resulting force or displacement was recorded and used. If the average calculated deceleration level exceeded this tolerance, the brake input force or displacement levels were adjusted and retested until the desired magnitude was realized. Prior to each braking event, the brake pad temperatures were required to be in the range of 149° - 212°F.

E. BRAKE CONTROL

1. Subject Vehicle programmable brake controller

To achieve accurate, repeatable, and reproducible SV brake pedal inputs, a programmable brake controller was used for all brake applications. The controller has the capability to operate in one of two user-selectable, closed-loop, control modes:

- Constant pedal displacement. By maintaining constant actuator stroke, the position of the vehicle's brake pedal remains fixed for the duration of the input. To achieve this, the brake controller modulates application force.

- Hybrid control. Hybrid control uses position-based control to command the initial brake application rate and actuator position, then changes to force-based control to command a reduction of applied force to a predetermined force. This force is maintained until the end of the braking maneuver by allowing the brake controller to modulate actuator displacement.

2. Subject Vehicle brake parameters

- Each test run began with the brake pedal in its natural resting position, with no preload or position offset.

- The onset of the brake application was considered to occur when the brake actuator had applied 2.5 lbf (11 N) of force to the brake pedal.

- The magnitude of the brake application was that needed to produce 0.4 g deceleration, as determined in the foundation brake characterization.

- The SV brake application rate was between 9 to 11 in/s (229 to 279 mm/s), where the application rate is defined as the slope of a linear regression line applied to brake pedal position data over a range from 25% to 75% of the commanded input magnitude.

3. POV Automatic Braking System

The POV was equipped with an automatic braking system, which was used in Test Type 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.

F. INSTRUMENTATION

Table 5 lists the sensors, signal conditioning, and data acquisition equipment used for these tests.

TABLE 5. 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	45040532	By: DRI Date: 5/10/2019 Due: 5/10/2020
Load Cell	Force applied to brake pedal					By: DRI
		0 - 250 lb 0 -1112 N	0.1% FS	Honeywell 41A	1464391	Date: 8/28/2018 Due: 8/28/2019
		0-250 lb 1112 N	0.05% FS	Stellar Technology PNC700	1607338	Date: 8/28/2018 Due: 8/28/2019
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 kph	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	NA

TABLE 5. TEST INSTRUMENTATION AND EQUIPMENT (continued)

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rat	Accels .01g, Angular Rate	Oxford Inertial +		By: Oxford Technical Solutions
					2182	Date: 10/16/2017 Due: 10/16/2019
					2176	Date: 4/11/2018 Due: 4/11/2020
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).	D-Space 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

Year: 2018
Make: Tesla
Model: Model 3 AWD
VIN: 5YJ3E1EB9JF06

Engine: Electric Motor
Transmission: 1-Speed A/T
Exterior: Pearl White Multi-Coat
Interior: Black

MECHANICAL

· Dual Motor: Fr AC Induction/ Rr AC Permanent Magnet
· Automatic Full-Time All-Wheel Drive
· 9.00 Axle Ratio
· 33-Amp/Hr Maintenance-Free Battery
· 3 Skid Plates
· Gas-Pressurized Shock Absorbers
· Front Anti-Roll Bar
· Electric Power-Assist Speed-Sensing Steering
· Double Wishbone Front Suspension w/Coil Springs
· Multi-Link Rear Suspension w/Coil Springs
· Regenerative 4-Wheel Disc Brakes w/4-Wheel ABS, Front And Rear Vented Discs, Brake Assist, Hill Hold Control and Electric Parking Brake
· Lithium Ion Traction Battery w/12 Hrs Charge Time @ 220/240V

EXTERIOR

· Clearcoat Paint
· Body-Colored Front Bumper
· Body-Colored Rear Bumper
· Chrome Side Windows Trim
· Chrome Door Handles
· Fixed Rear Window w/Defroster
· Light Tinted Glass
· Variable Intermittent Wipers
· Galvanized Steel/Aluminum Panels
· Trunk Rear Cargo Access
· Fully Automatic Aero-Composite Led Low/High Beam Daytime Running Auto-Leveling Auto High-Beam Headlamps w/Delay-Off
· Perimeter/Approach Lights
· LED Brakelights

ENTERTAINMENT

· Radio: FM w/Premium Audio System -inc: 15" touchscreen, Bluetooth connectivity, on-demand and internet radio capability, 4 USB ports, docking for 2 smartphones and 1 year Premium Connectivity
· Regular Amplifier
· Window Grid Antenna
· 1 LCD Monitor In The Front

INTERIOR

· Heated Front Bucket Seats -inc: 12-way power adjustable front seats and custom driver profiles
· 8-Way Passenger Seat -inc: Power 4-Way Lumbar Support
· 60-40 Folding Bench Front Facing Heated Fold Forward Seatback Rear Seat
· Power Tilt/Telescoping Steering Column
· Leatherette Steering Wheel
· Front Cupholder
· Rear Cupholder
· Compass
· Valet Function
· Remote Releases -Inc: Power Cargo Access and Power Charge Port Door
· Homelink Garage Door Transmitter
· Cruise Control w/Steering Wheel Controls
· Dual Zone Front Automatic Air Conditioning w/Steering Wheel Controls
· HVAC -inc: Console Ducts
· Illuminated Locking Glove Box
· Driver Foot Rest
· Interior Trim -inc: Aluminum/Genuine Wood Instrument Panel Insert, Metal-Look Door Panel Insert, Piano Black/Aluminum Console Insert and Metal-Look Interior Accents
· Full Cloth Headliner
· Simulated Suede Door Trim Insert
· Day-Night Auto-Dimming Rearview Mirror
· Driver And Passenger Visor Vanity Mirrors w/Driver And Passenger Illumination, Driver And Passenger Auxiliary Mirror
· Full Floor Console w/Covered Storage and 1 12V DC Power Outlet
· Front And Rear Map Lights
· Fade-To-Off Interior Lighting
· Full Carpet Floor Covering -inc: Carpet Front And Rear Floor Mats
· Carpet Floor Trim
· Cargo Area Concealed Storage
· Cargo Space Lights
· Tracker System
· Smart Device Integration
· Instrument Panel Covered Bin, Driver / Passenger And Rear Door Bins
· Delayed Accessory Power
· Systems Monitor
· Outside Temp Gauge
· Digital Display
· Fixed Front Head Restraints and Fixed Rear Head Restraints
· Front Center Armrest and Rear Center Armrest
· 2 Seatback Storage Pockets
· 1 12V DC Power Outlet
· Air Filtration

SAFETY

· Side Impact Beams
· Dual Stage Driver And Passenger Seat-Mounted Side Airbags
· Front And Rear Parking Sensors
· Blind Spot Sensor
· Forward Collision Mitigation and Rear Collision Warning
· Tire Specific Low Tire Pressure Warning
· Dual Stage Driver And Passenger Front Airbags
· Curtain 1st And 2nd Row Airbags
· Airbag Occupancy Sensor
· Driver And Passenger Knee Airbag
· Power Rear Child Safety Locks
· Outboard Front Lap And Shoulder Safety Belts -inc: Rear Center 3 Point, Height Adjusters and Pretensioners
· Back-Up Camera
· Front Camera
· Left Side Camera
· Right Side Camera

CITY MPG 136

Fuel Economy Information

HIGHWAY MPG 123

Actual mileage will vary with options, driving conditions, driving habits and vehicle's condition

New

MSRP	**$53,000.00**
INSTALLED OPTIONS	
Pearl White Multi Coat	$2,000
Black, Synthetic Leather Seat Trim	$0
White & Black Premium Interior	$1,000
Enhanced Autopilot	$5,000
Wheels: 19" Sport	$1,500
Tires: 19"	included
Enhanced Autopilot	$7,000
Original Shipping Charge	$1,200
RETAIL PRICE (ORIGINALLY NEW)	$70,700.00

Get more information on your smartphone:

Figure A3. Window Sticker (Monroney Label)

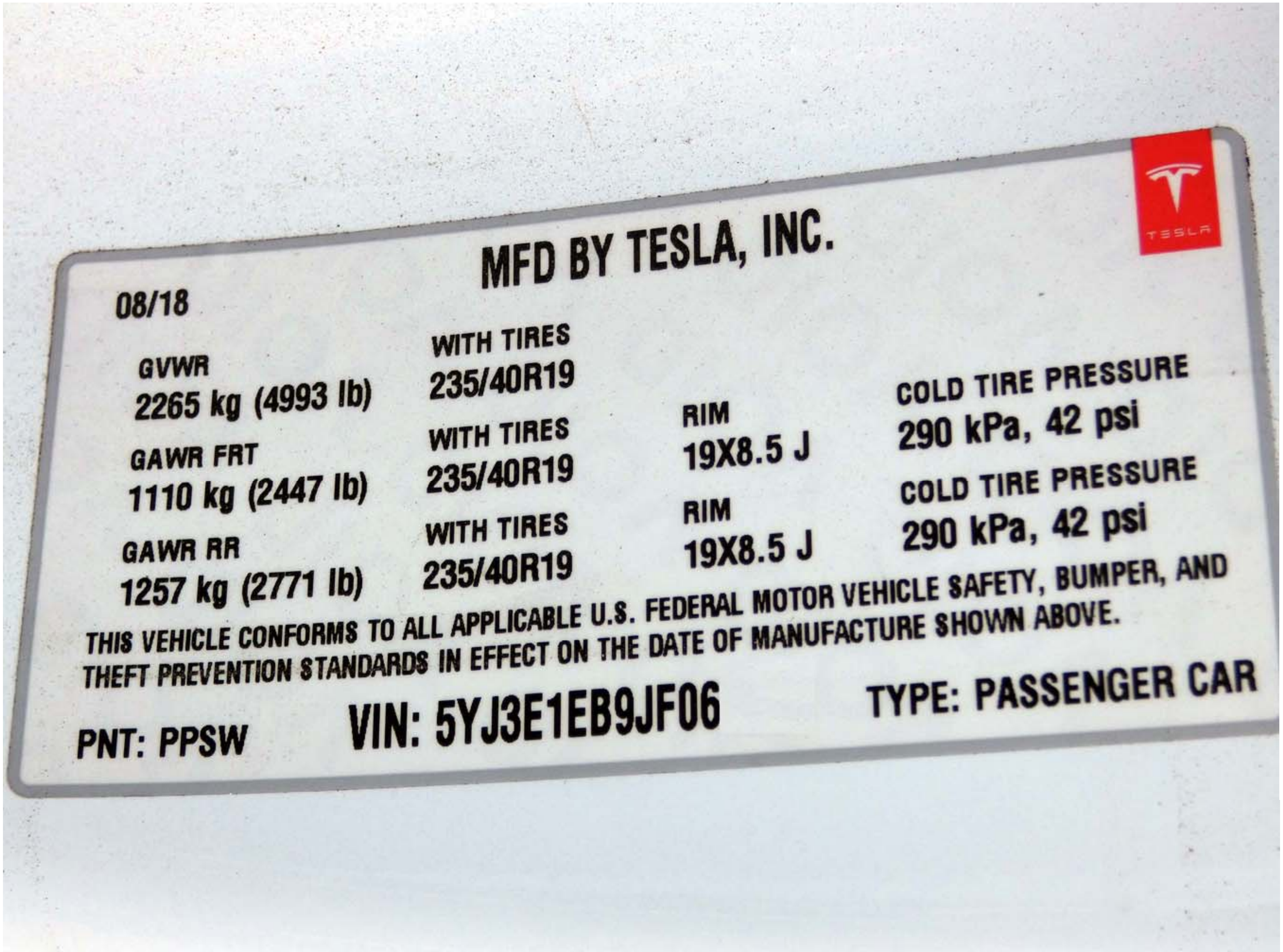


Figure A4. Vehicle Certification Label

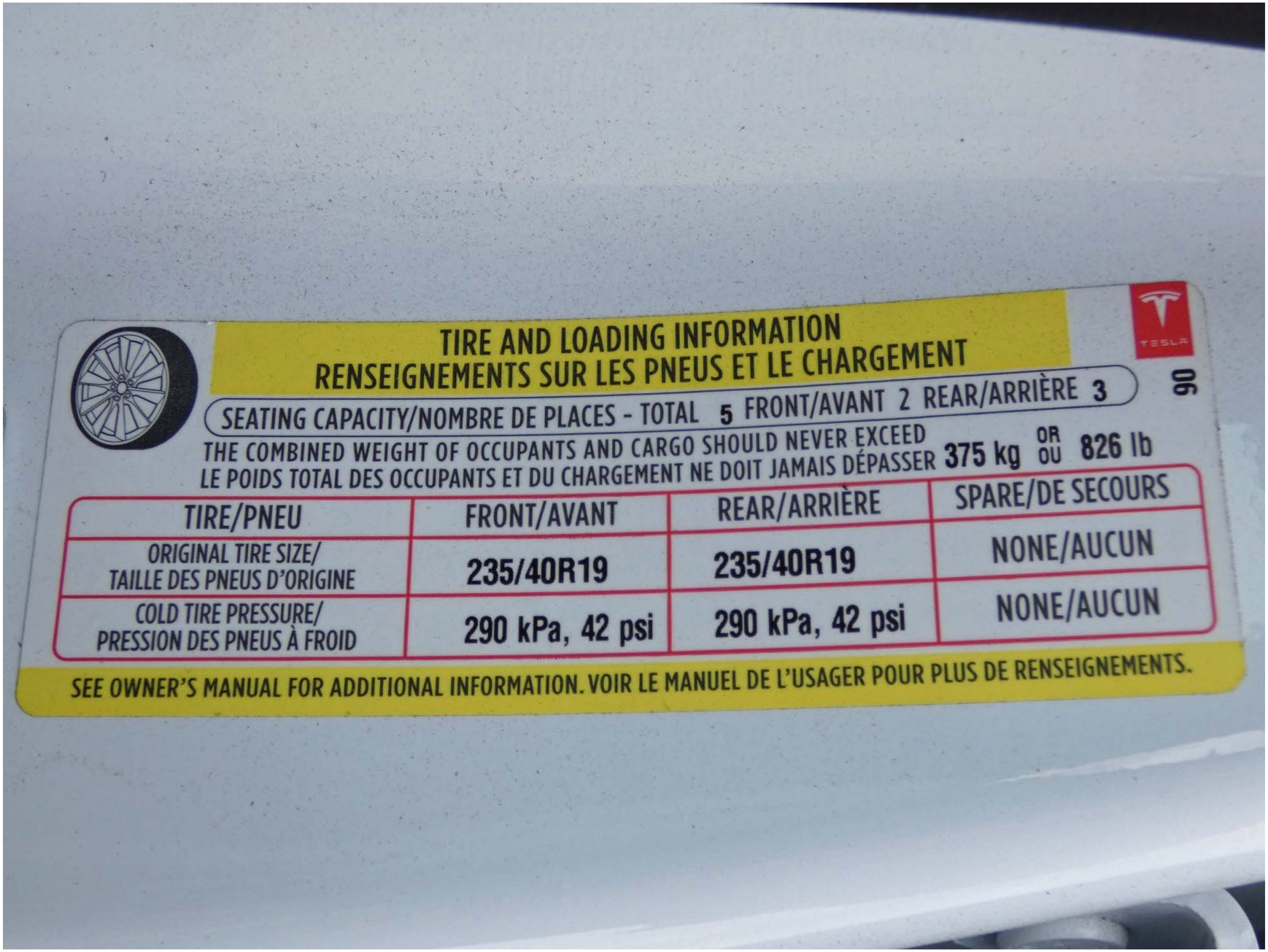


Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

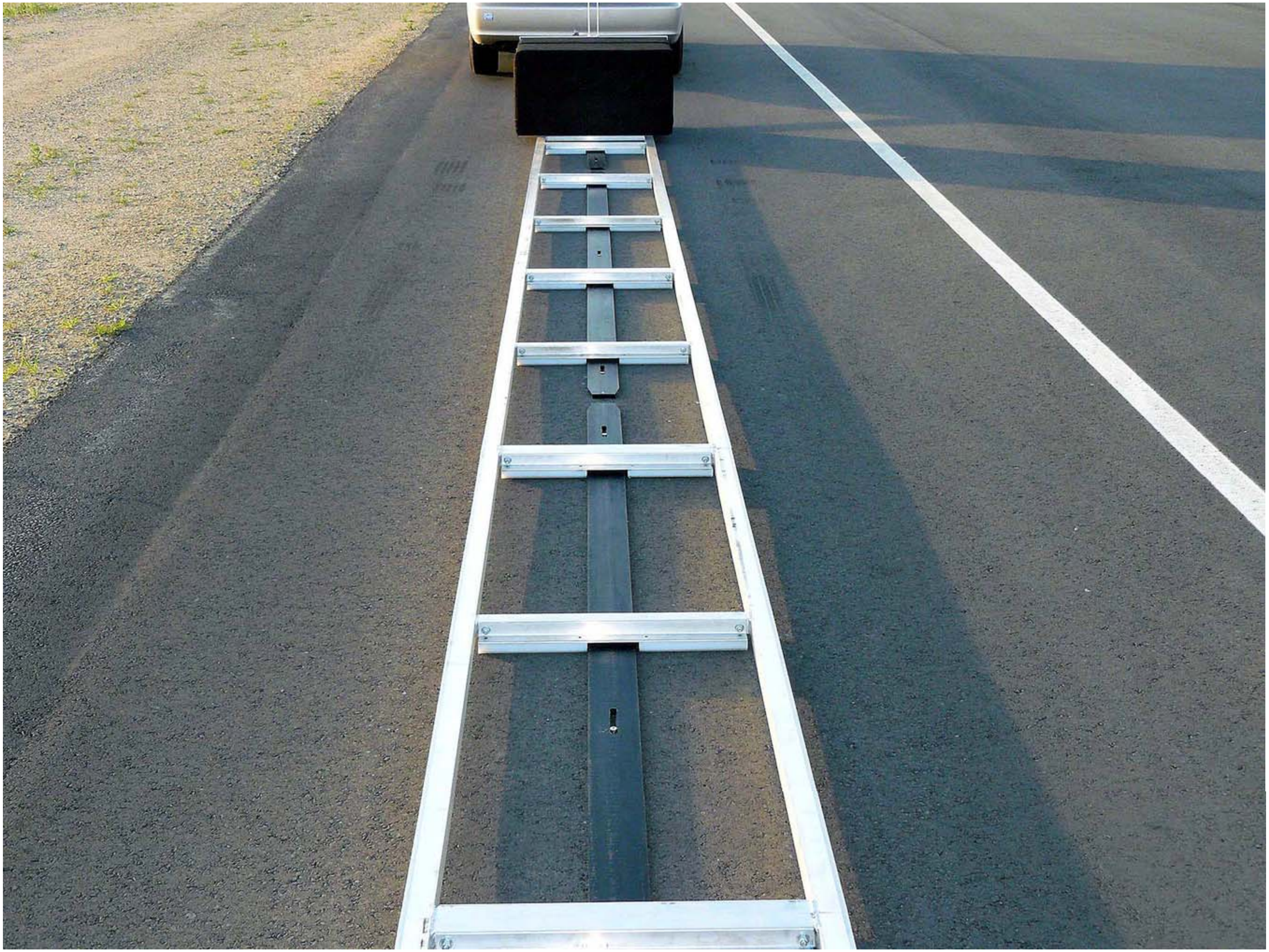


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

Figure A9. Steel Trench Plate

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

Figure A11. Sensor for Detecting Auditory Alerts

Figure A12. Sensor for Detecting Visual Alerts

Figure A13. Computer and Brake Actuator Installed in Subject Vehicle

Figure A14. Brake Actuator Installed in POV System

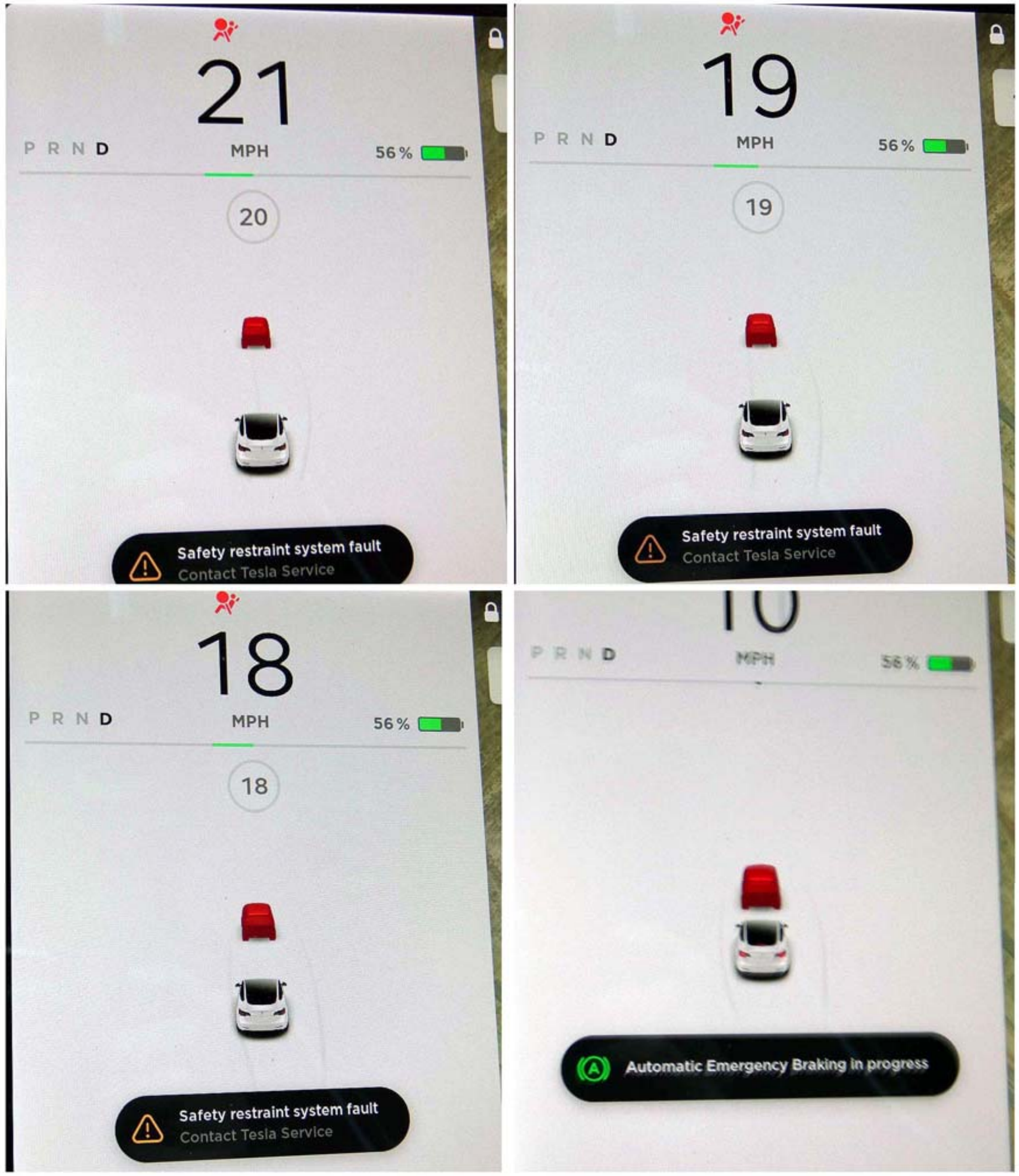


Figure A15. Collision Warning Visual Alert

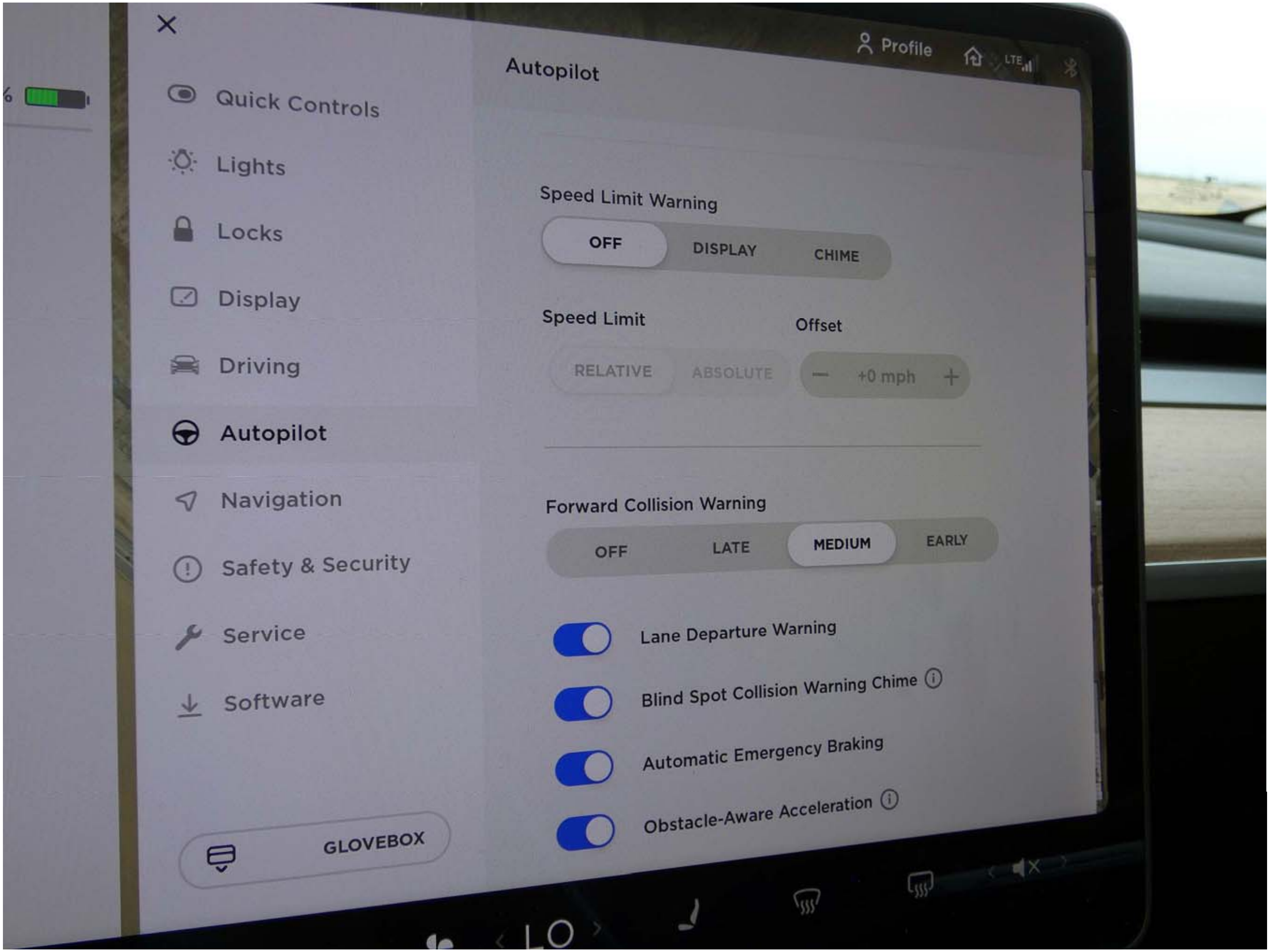


Figure A16. AEB Setup Menus

APPENDIX B

Excerpts from Owner's Manual

The following collision avoidance features are designed to increase the safety of you and your passengers:

- **Forward Collision Warning** - provides visual and audible warnings in situations when Model 3 detects that there is a high risk of a frontal collision (see Forward Collision Warning on page 86).
- **Automatic Emergency Braking** - automatically applies braking to reduce the impact of a frontal collision (see Automatic Emergency Braking on page 87).
- **Obstacle-Aware Acceleration** - reduces acceleration if Model 3 detects an object in its immediate driving path (see Obstacle-Aware Acceleration on page 88).

Warning: Forward Collision Warning is for guidance purposes only and is not a substitute for attentive driving and sound judgment. Keep your eyes on the road when driving and never depend on Forward Collision Warning to warn you of a potential collision. Several factors can reduce or impair performance, causing either unnecessary, invalid, inaccurate, or missed warnings. Depending on Forward Collision Warning to warn you of a potential collision can result in serious injury or death.

Warning: Automatic Emergency Braking is not designed to prevent all collisions. In certain situations, it can minimize the impact of a frontal collision by attempting to reduce your driving speed. Depending on Automatic Emergency Braking to avoid a collision can result in serious injury or death.

Warning: Obstacle-Aware Acceleration is not designed to prevent a collision. In certain situations, it can minimize the impact of a collision. Depending on Obstacle-Aware Acceleration to avoid a collision can result in serious injury or death.

Forward Collision Warning

The forward looking camera(s) and the radar sensor monitor the area in front of Model 3 for the presence of an object such as a vehicle, motorcycle, bicycle, or pedestrian. If a collision is considered likely unless you take immediate corrective action, Forward Collision Warning is designed to sound a chime and highlight the vehicle in front of you in red on the touchscreen. If this happens, **TAKE IMMEDIATE CORRECTIVE ACTION!**

Warnings cancel automatically when the risk of a collision has been reduced (for example, you have decelerated or stopped Model 3, or the object in front of your vehicle has moved out of your driving path).

If immediate action is not taken when Model 3 issues a Forward Collision Warning, Automatic Emergency Braking (if enabled) may automatically apply the brakes if a collision is considered imminent (see Automatic Emergency Braking on page 87).

By default, Forward Collision Warning is turned on. To turn it off or adjust its sensitivity, touch **Controls** > **Autopilot** > **Forward Collision Warning**. Instead of the default warning level of **Medium**, you can turn the warning **Off**, or you can choose to be warned **Late** or **Early**.

Note: Your chosen setting for Forward Collision Warning is retained until you manually change it.

Warning: The camera(s) and sensors associated with Forward Collision Warning are designed to monitor an approximate area of up to 525 feet (160 meters) in your driving path. The area being monitored by Forward Collision Warning can be adversely affected by road and weather conditions. Use appropriate caution when driving.

Warning: Forward Collision Warning is designed only to provide visual and audible alerts. It does not attempt to apply the brakes or decelerate Model 3. When seeing and/or hearing a warning, it is the driver's responsibility to take corrective action immediately.

Warning: Forward Collision Warning may provide a warning in situations where the likelihood of collision may not exist. Stay alert and always pay attention to the area in front of Model 3 so you can anticipate whether any action is required.

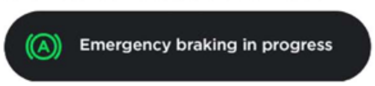
Warning: Forward Collision Warning operates only when driving between approximately 7 mph (10 km/h) and 90 mph (150 km/h).

Warning: Forward Collision Warning does not provide a warning when the driver is already applying the brake.

Automatic Emergency Braking

The forward looking camera(s) and the radar sensor are designed to determine the distance from a detected object traveling in front of Model 3. When a frontal collision is considered unavoidable, Automatic Emergency Braking is designed to apply the brakes to reduce the severity of the impact.

When Automatic Emergency Braking applies the brakes, the touchscreen displays a visual warning and sounds a chime. You may also notice abrupt downward movement of the brake pedal. The brake lights turn on to alert other road users that you are slowing down.



If driving 35 mph (56 km/h) or faster, the brakes are released after Automatic Emergency Braking has reduced your driving speed by 30 mph (50 km/h). For example, if Automatic Emergency Braking applies braking when driving 56 mph (90 km/h), it releases the brakes when your speed has been reduced to 26 mph (40 km/h).

Automatic Emergency Braking operates only when driving between approximately 7 mph (10 km/h) and 90 mph (150 km/h).

Automatic Emergency Braking does not apply the brakes, or stops applying the brakes, when:

- You turn the steering wheel sharply.
- You press and release the brake pedal while Automatic Emergency Braking is applying the brakes.
- You accelerate hard while Automatic Emergency Braking is applying the brakes.
- The vehicle, motorcycle, bicycle, or pedestrian is no longer detected ahead.

Automatic Emergency Braking is always enabled when you start Model 3. To disable it for your current drive, touch **Controls** > **Autopilot** > **Automatic Emergency Braking**.

Warning: It is strongly recommended that you do not disable Automatic Emergency Braking. If you disable it, Model 3 does not automatically apply the brakes in situations where a collision is considered likely.

Warning: Automatic Emergency Braking is designed to reduce the severity of an impact. It is not designed to avoid a collision.

Warning: Several factors can affect the performance of Automatic Emergency Braking, causing either no braking or inappropriate or untimely braking, such as when a vehicle is partially in the path of travel or there is road debris. It is the driver's responsibility to drive safely and remain in control of the vehicle at all times. Never depend on Automatic Emergency Braking to avoid or reduce the impact of a collision.

Warning: Automatic Emergency Braking is designed to reduce the impact of frontal collisions only and does not function when Model 3 is in Reverse.

Warning: Automatic Emergency Braking is not a substitute for maintaining a safe traveling distance between you and the vehicle in front of you.

Warning: The brake pedal moves downward abruptly during automatic braking events. Always ensure that the brake pedal can move freely. Do not place material under or on top of the Tesla-supplied driver's floor mat (including an additional mat) and always ensure that the driver's floor mat is properly secured. Failure to do so can impede the ability of the brake pedal to move freely.

Obstacle-Aware Acceleration

Obstacle-Aware Acceleration is designed to reduce the impact of a collision by reducing motor torque if Model 3 detects an object in its driving path. For example, Model 3, while parked in front of a closed garage door with the Drive gear engaged, detects that you have pressed hard on the accelerator pedal. Although Model 3 still accelerates and hits the garage door, the reduced torque may result in less damage.

Obstacle-Aware Acceleration is designed to operate only when all of these conditions are simultaneously met:

- A driving gear is engaged (Drive or Reverse).
- Model 3 is stopped or traveling less than 10 mph (16 km/h).
- Model 3 detects an object in its immediate driving path.

To disable Obstacle-Aware Acceleration, touch **Controls** > **Autopilot** > **Obstacle-Aware Acceleration**.

Warning: Obstacle-Aware Acceleration is designed to reduce the severity of an impact. It is not designed to avoid a collision.

Warning: Obstacle-Aware Acceleration may not limit torque in all situations. Several factors, including environmental conditions, distance from an obstacle, and a driver's actions, can limit, delay, or inhibit Obstacle-Aware Acceleration.

Warning: Obstacle-Aware Acceleration may not limit torque when performing a sharp turn, such as into a parking space.

Warning: Do not rely on Obstacle-Aware Acceleration to control acceleration or to avoid, or limit, the severity of a collision, and do not attempt to test Obstacle-Aware Acceleration. Doing so can result in serious property damage, injury, or death.

Warning: Several factors can affect the performance of Obstacle-Aware Acceleration, causing an inappropriate or untimely reduction in motor torque. It is the driver's responsibility to drive safely and remain in control of Model 3 at all times.

Limitations and Inaccuracies

Collision Avoidance features cannot always detect all objects, vehicles, bikes, or pedestrians, and you may experience unnecessary, inaccurate, invalid, or missed warnings for many reasons, particularly if:

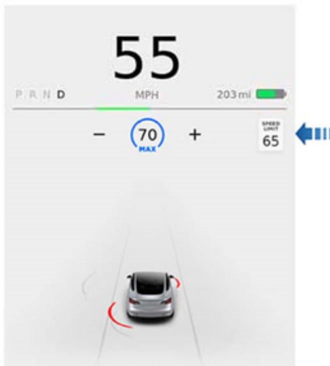
- The road has sharp curves.
- Visibility is poor (due to heavy rain, snow, fog, etc.).
- Bright light (such as from oncoming headlights or direct sunlight) is interfering with the view of the camera(s).
- The radar sensor is obstructed (dirty, covered, etc.).
- The windshield is obstructing the view of the camera(s) (fogged over, dirty, covered by a sticker, etc.).

Warning: The limitations previously described do not represent an exhaustive list of situations that may interfere with proper operation of Collision Avoidance Assist features. These features may fail to provide their intended function for many other reasons. It is the driver's responsibility to avoid collisions by staying alert, paying attention, and taking corrective action as early as possible.

Caution: If a fault occurs with a Collision Avoidance Assist feature, Model 3 displays an alert. Contact Tesla Service.

How Speed Assist Works

When the Speed Limit Warning is turned on, the touchscreen displays a speed limit as determined by GPS data. You can touch this speed limit sign to automatically change the set speed to the detected speed limit (including any offsets that you have set). Warnings (described later) take effect when you exceed this limit.



In situations where Speed Assist is unable to determine a speed limit (for example, speed limit signs and GPS data are not available at the current location), or if Speed Assist is uncertain that an acquired speed limit is accurate (for example, although a speed limit sign was initially detected, some time has passed before a subsequent sign has been detected), the touchscreen may not display a speed limit sign and warnings do not take effect.

If you set the speed limit warning to **Display** (see Controlling Speed Assist on page 89) and exceed the determined speed limit, the speed limit sign on the touchscreen increases in size.

If you set the speed limit warning to **Chime** (see Controlling Speed Assist on page 89) and exceed the determined speed limit, the speed limit sign on the touchscreen increases in size and Model 3 also sounds a warning chime.

Note: Speed limit warnings go away after ten seconds, or when Model 3 slows down below the specified limit.

Warning: Do not rely on Speed Assist to determine the appropriate speed limit or driving speed. Always drive at a safe speed based on traffic and road conditions.

Controlling Speed Assist

To adjust the Speed Limit Warning setting, touch **Controls** > **Autopilot** > **Speed Limit Warning**, then choose one of these options:

- **Off** - Speed limit warnings do not display and chimes are not sounded.
- **Display** - Speed limit signs display on the touchscreen and the sign increases in size when you exceed the determined limit.
- **Chime** - In addition to the visual display, a chime is sounded whenever you exceed the determined speed limit.

You can also specify how the speed limit is determined:

- **Relative** - The speed limit is determined automatically based on detected traffic signs and GPS data. If desired, you can set a speed limit offset (+ or -) if you want to be alerted only when you exceed the offset speed limit by a specified amount. For example, you can increase the offset to +10 mph (10 km/h) if you only want to be warned when you exceed the speed limit by 10 mph (10 km/h).
- **Absolute** - Manually specify any speed limit between 20 and 140 mph (30 and 240 km/h).

Note: GPS data is not always accurate. The GPS can miscalculate a road's location and provide the speed limit for a directly adjacent road that may have a different speed limit. For example, the GPS can assume Model 3 is on a freeway or highway when it is actually on a nearby surface street, and vice versa.

Note: Your chosen setting is retained until you manually change it.

Limitations and Inaccuracies

Speed Assist may not be fully functional or may provide inaccurate information in these situations:

- The speed limits stored in the GPS database are incorrect or outdated.
- Model 3 is being driven in an area where GPS data is not available.
- A road or a speed limit has recently changed.

Warning: The list above does not represent an exhaustive list of situations

APPENDIX C

Run Log

Subject Vehicle: **2018 Tesla Model 3** Test Date: 5/15/2019

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
	Brake characterization and confirmation						See Appendix D
11	Static Run						
12	Stopped POV	N					Displacement Mode
13		N					Displacement Mode
20	Static Run						Hybrid mode runs
21		N					Brake force threshold
22		N					Brake force threshold
23		N					Low braking before AEB
24		N					Low braking before AEB
25	Static Run						
26	**Stopped POV**	N					Brake force threshold Brake Force = 13.75 lbs after check run
27		N					Brake force threshold
28		Y	2.59	2.24	1.14	Pass	
29		Y	2.66	1.44	1.16	Pass	
30		Y	2.69	2.17	1.15	Pass	

Subject Vehicle: **2018 Tesla Model 3** Test Date: 5/15/2019

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
31		Y	2.63	1.90	1.12	Pass	
32		Y	2.61	1.74	1.20	Pass	
33		Y	2.56	2.98	1.10	Pass	
34		Y	2.58	2.21	1.14	Pass	
35	Static Run						
36	**Slower POV, 25 vs 10**	Y	2.62	4.70	0.59	Pass	
37		Y	2.64	4.00	0.60	Pass	
38		Y	2.62	4.74	0.57	Pass	
39		Y	2.68	4.85	0.59	Pass	
40		Y	2.58	5.37	0.57	Pass	
41		Y	2.62	5.33	0.68	Pass	
42		Y	2.68	4.98	0.62	Pass	
43	Static run						
44	Static run						
45	**Slower POV, 45 vs 20**	Y	2.95	7.12	1.02	Pass	Brake force = 14 lbs after check run

Subject Vehicle: **2018 Tesla Model 3** Test Date: 5/15/2019

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
46		Y	2.92	8.10	1.06	Pass	
47		Y	3.03	8.15	1.09	Pass	
48		Y	3.00	8.52	1.06	Pass	
49		N					Brake force threshold
50		N					Brake force threshold
51		Y	3.10	8.29	0.98	Pass	
52		Y	3.01	8.34	0.98	Pass	
53		Y	3.06	8.69	1.02	Pass	
54	Static run						
55	**Braking POV, 35**	N					Brake Force
56		N					Brake Force
57		Y	2.05	0.48	1.08	Pass	
58		Y	1.96	0.13	1.07	Pass	
59		Y	2.07	0.00	0.98	Fail	Speed reduction = 25.3 mph
60		Y	2.00	0.00	0.99	Fail	Speed reduction = 24.8 mph
61		N					Check PP
62		Y	2.03	0.00	0.94	Fail	Speed reduction = 24.5 mph
63		Y	2.12	0.94	1.16	Pass	
64		Y	2.16	0.00	0.85	Fail	Speed reduction = 26.3 mph

Subject Vehicle: **2018 Tesla Model 3** Test Date: 5/15/2019

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
65	Static run						
66	STP - Static run						
67	**Baseline, 25**	Y			0.61		Brake stroke = 1.35 in and Brake Force = 16 lbs after check runs
68		Y			0.63		
69		N					Brake level high
70		Y			0.68		
71		Y			0.64		
72		Y			0.62		
73		Y			0.63		
74		Y			0.72		
75	STP - Static run						
76	**Baseline, 45**	N					Brake level high
77		Y			0.71		
78		N					Brake level high
79		Y			0.71		
80		Y			0.73		

Subject Vehicle: **2018 Tesla Model 3** Test Date: 5/15/2019

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
81		N					Brake level high
82		N					Brake force
83		Y			0.72		
84		Y			0.76		
85		N					Brake level high
86		Y			0.69		
87		Y			0.75		
88	STP - Static run						
89	**STP False Positive, 25**	Y			0.72	Pass	
90		Y			0.67	Pass	
91		Y			0.67	Pass	
92		Y			0.65	Pass	
93		Y			0.65	Pass	
94		Y			0.66	Pass	
95		Y			0.67	Pass	
96	STP - Static run						

Subject Vehicle: **2018 Tesla Model 3** Test Date: 5/15/2019

Principal Other Vehicle: SSV

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
97	**STP False Positive, 45**	N					Incorrect brake robot settings
98		Y			0.74	Pass	
99		Y			0.69	Pass	
100		N					Brake level high
101		Y			0.73	Pass	
102		Y			0.74	Pass	
103		N					Throttle drop
104		Y			0.72	Pass	
105		Y			0.72	Pass	
106		Y			0.72	Pass	
107	STP - Static run						

APPENDIX D

Brake Characterization

Subject Vehicle: **2018 Tesla Model 3** Test Date: 5/15/2019

DBS Initial Brake Characterization				
Run Number	**Stroke at 0.4 g (in)**	**Force at 0.4 g (lb)**	**Slope**	**Intercept**
1	1.39983	18.83264	0.85459	0.042135
2	1.432497	18.63984	0.894677	0.033476
3	1.415108	18.41757	0.725388	0.173294

DBS Brake Characterization Confirmation								
Run	**DBS Mode**	**Speed**	**Valid Run**	**Average Decel. (g)**	**0.4 g Stroke Value (in)**	**0.4 g Force Value (lb)**	**Stroke/Force Calculator (in)**	**Notes**
4	**Displacement**	35	N	0.408	1.42		1.39	Brake Rate
5			Y	0.383	1.42		1.48	
6		25	N	0.365	1.42		1.56	Low Braking
7			N	0.430	1.50		1.40	High Braking
8			Y	0.383	1.45		1.51	
9		45	N	0.428	1.45		1.36	High Braking
10			Y	0.414	1.42		1.37	
14	**Hybrid**	35	N	0.552	1.42	18.63	13.50	High Braking
15			N	0.400	1.42	14.00	14.00	SV Speed
16			Y	0.403	1.42	14.00	13.90	
17		25	Y	0.405	1.45	14.00	13.83	

DBS Brake Characterization Confirmation								
Run	DBS Mode	Speed	Valid Run	Average Decel. (g)	0.4 g Stroke Value (in)	0.4 g Force Value (lb)	Stroke/Force Calculator (in)	Notes
18		45	N	0.425	1.42	14.00	13.18	High Braking
19			Y	0.408	1.42	13.50	13.24	

Appendix E

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 code 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 Baseline 25 mph (Baseline run at 25 mph)
- False Positive Baseline 45 mph (Baseline run at 45 mph)
- 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)
- DBS Brake Characterization, Initial
- DBS Brake Characterization Determination

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 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 the Principal Other Vehicle (if any). For DBS tests, in the case of an impact, the speed reduction experienced by the Subject Vehicle up until the moment of impact 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). The peak value of Ax for the SV is shown on the subplot.

- Pedal Position (in) – position of the accelerator pedal and brake pedal.

- Brake Force (lb) – force on the brake pedal as applied by the DBS controller. The TTC at the onset of the brake by the DBS controller is shown on the subplot. Additionally, the average force at the brake pedal while the DBS controller is active is displayed.

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 within the envelope. 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 given. 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 plot indicating the Ax, 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 0.27g (the upper edge of the envelope). A green circle or red asterisk is displayed at the moment the POV brake level achieves 0.27g. 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 out of the appropriate interval).

For the pedal position plot, a thick black bar appears on the brake pedal position data over the DBS controller brake onset period to signify the time over which the brake application rate is determined. The calculated brake application rate is also displayed on the figure.

For the brake force plot, a dashed black threshold line indicating a brake force of 2.5 lbs is given. For the time period where the DBS controller is active, the brake force at the pedal must not fall below this 2.5 lb threshold. Exceedances of this threshold are indicated by red shading in the area between the measured time-varying data and the dashed threshold line. The yellow envelope in this case is used only to visualize the target average brake force necessary for the test to be valid.

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 valid or passing time history plots for each test type (including passing, failing, and invalid runs) are shown in Figures E1 through E12. Figures E1 through E8 show passing runs for each of the 8 test types. Figure E9 shows an example of a passing brake characterization run. Figures E10 and E11 show examples of invalid runs. Figure E12 shows an example of a valid test that failed the DBS requirements.

Time history data plots for the tests of the vehicle under consideration herein are provided beginning with Figure E13.

Note that for this vehicle the sensor used to detect the visual alerts was saturated by the brightness of the screen and therefore unable to reliably detect the onset of the visual alert. The plots for visual alerts are therefore not shown.

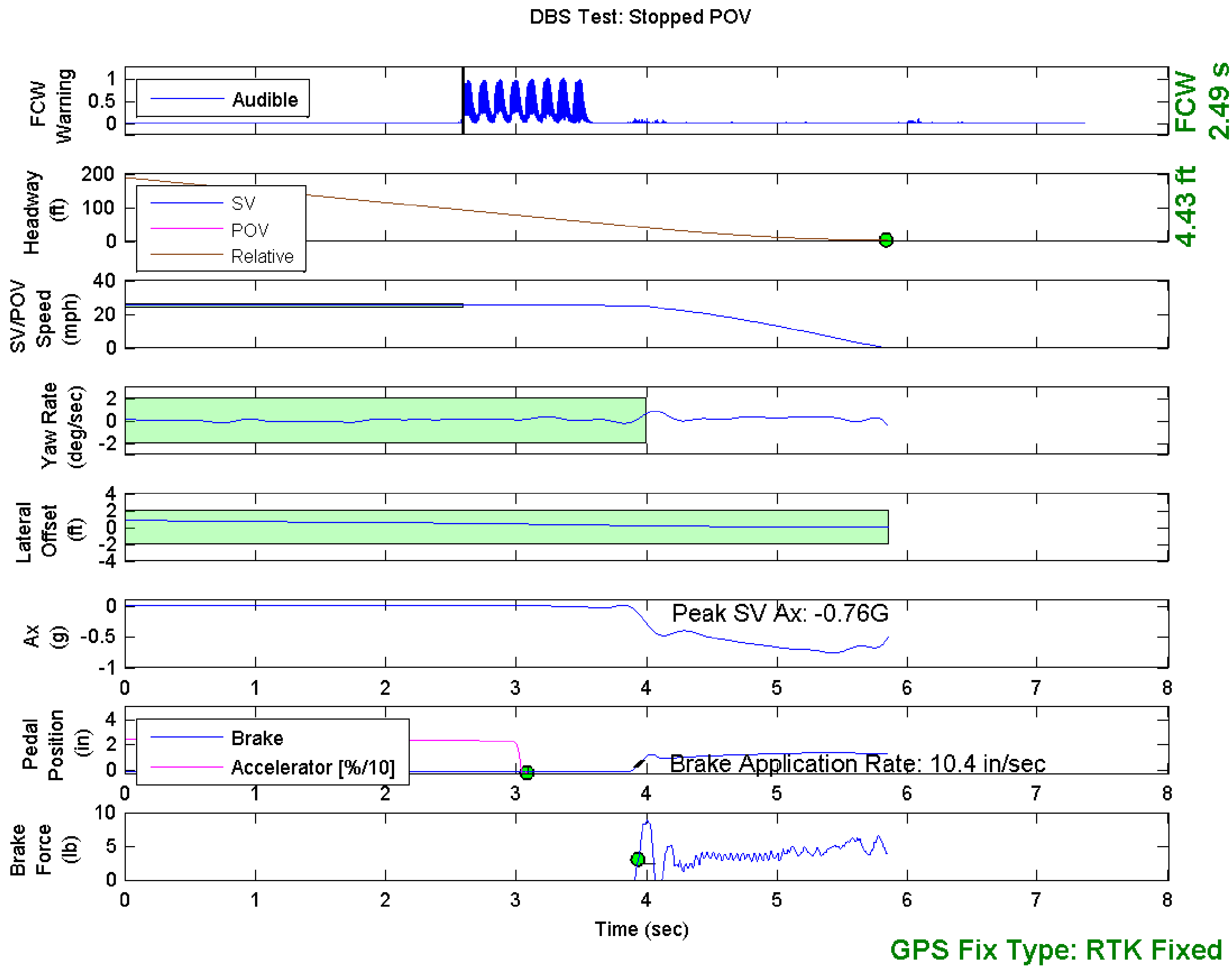


Figure E1. Example Time History for Stopped POV, Passing

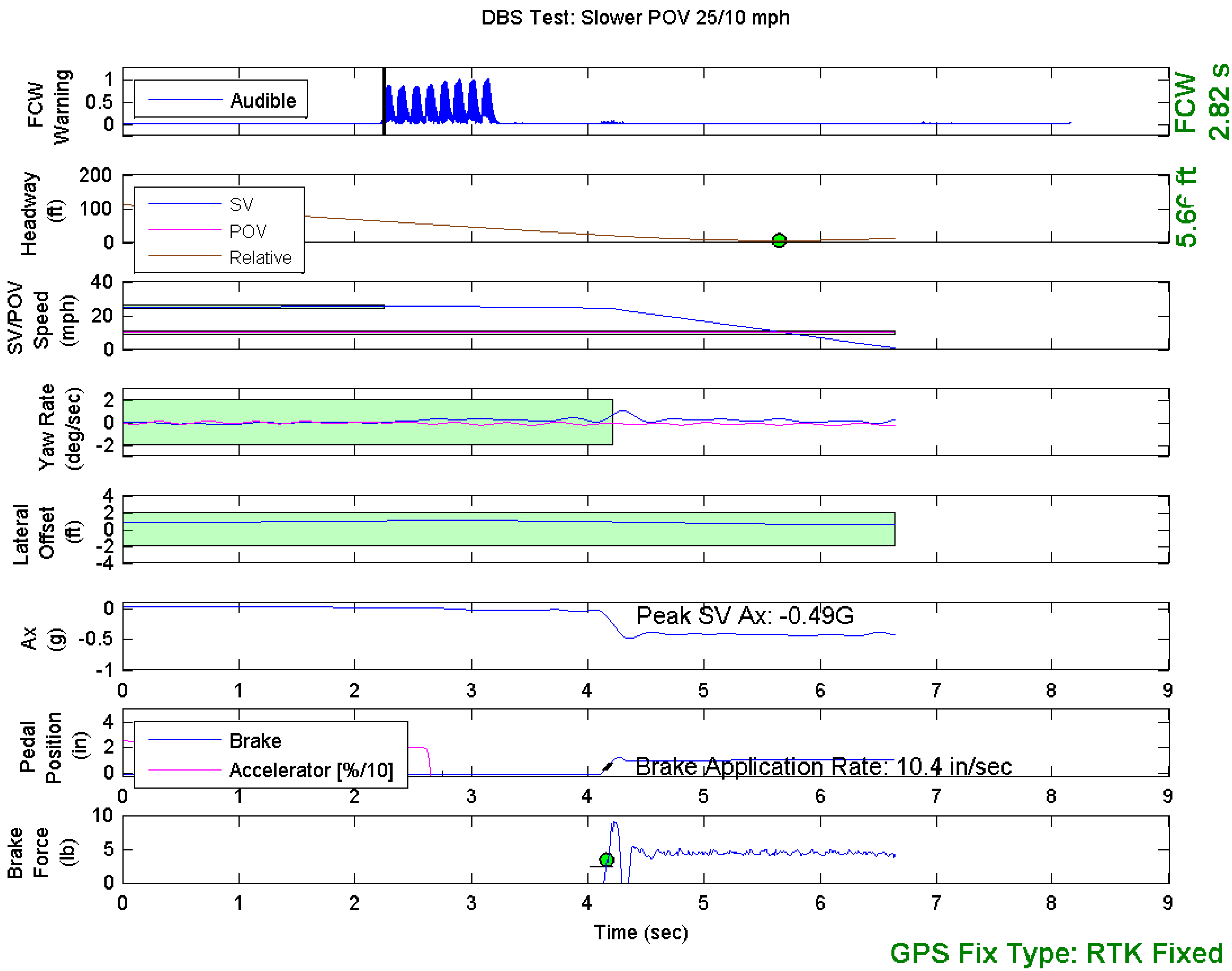


Figure E2. Example Time History for Slower POV 25 vs. 10, Passing

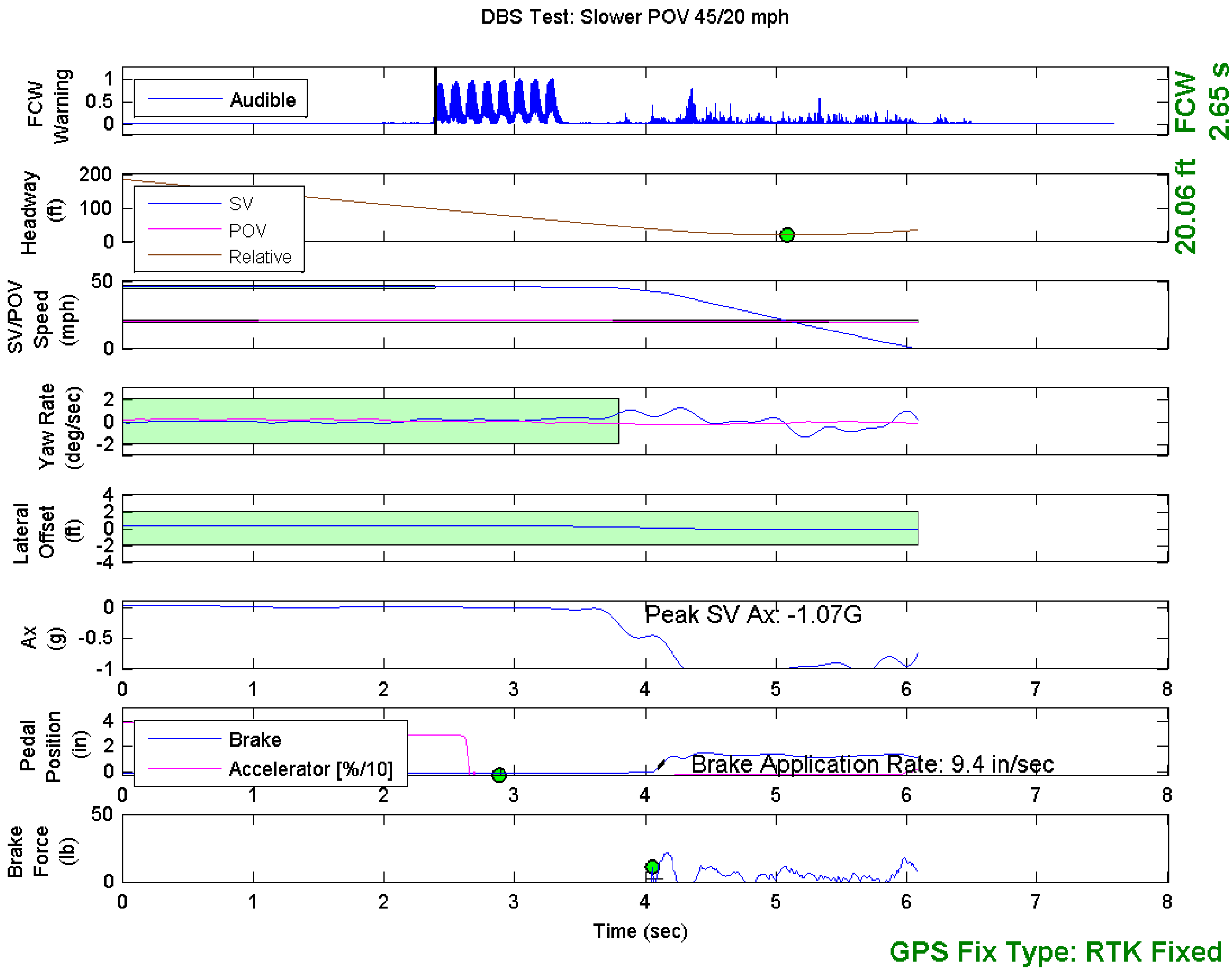


Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

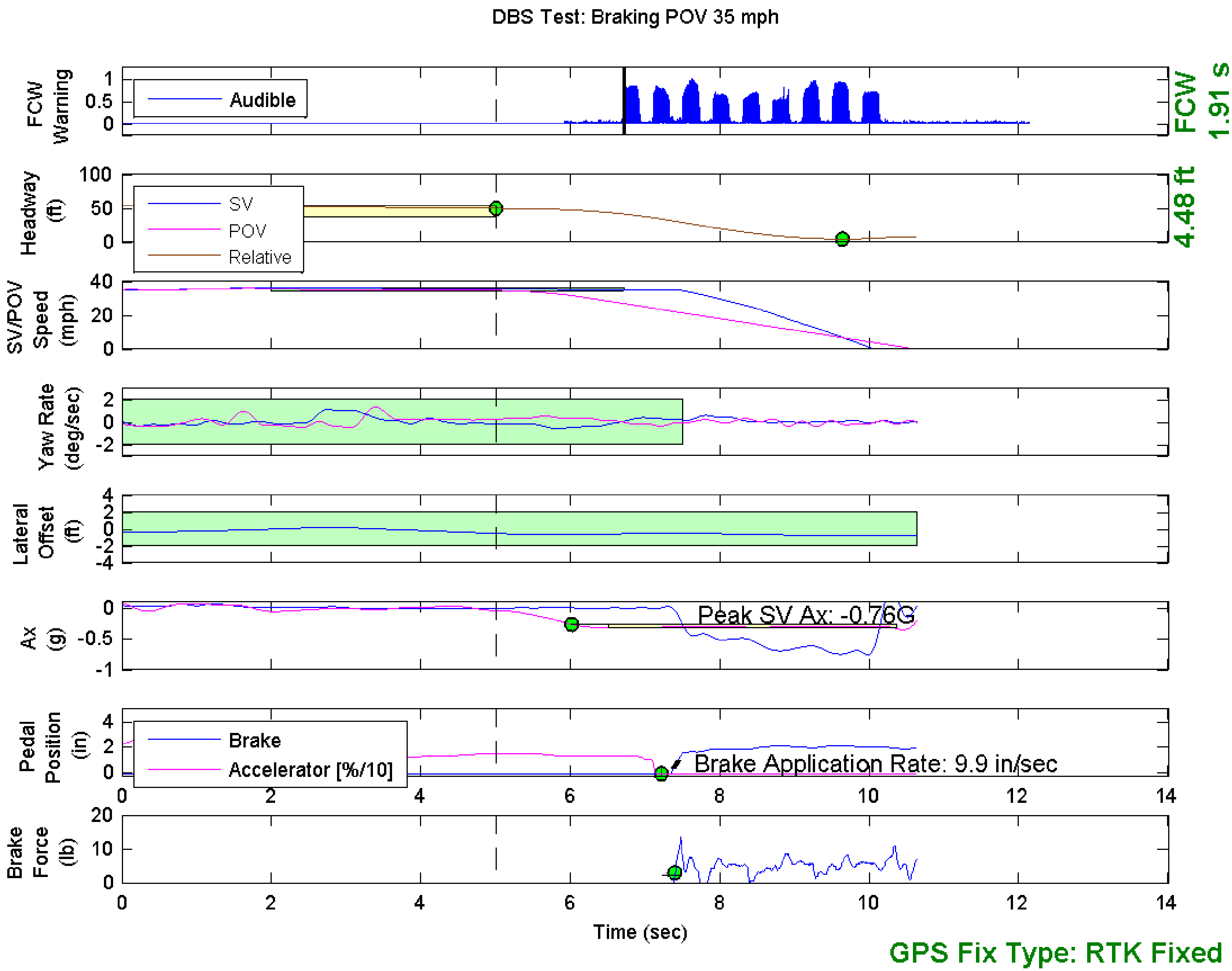


Figure E4. Example Time History for Braking POV 35, Passing

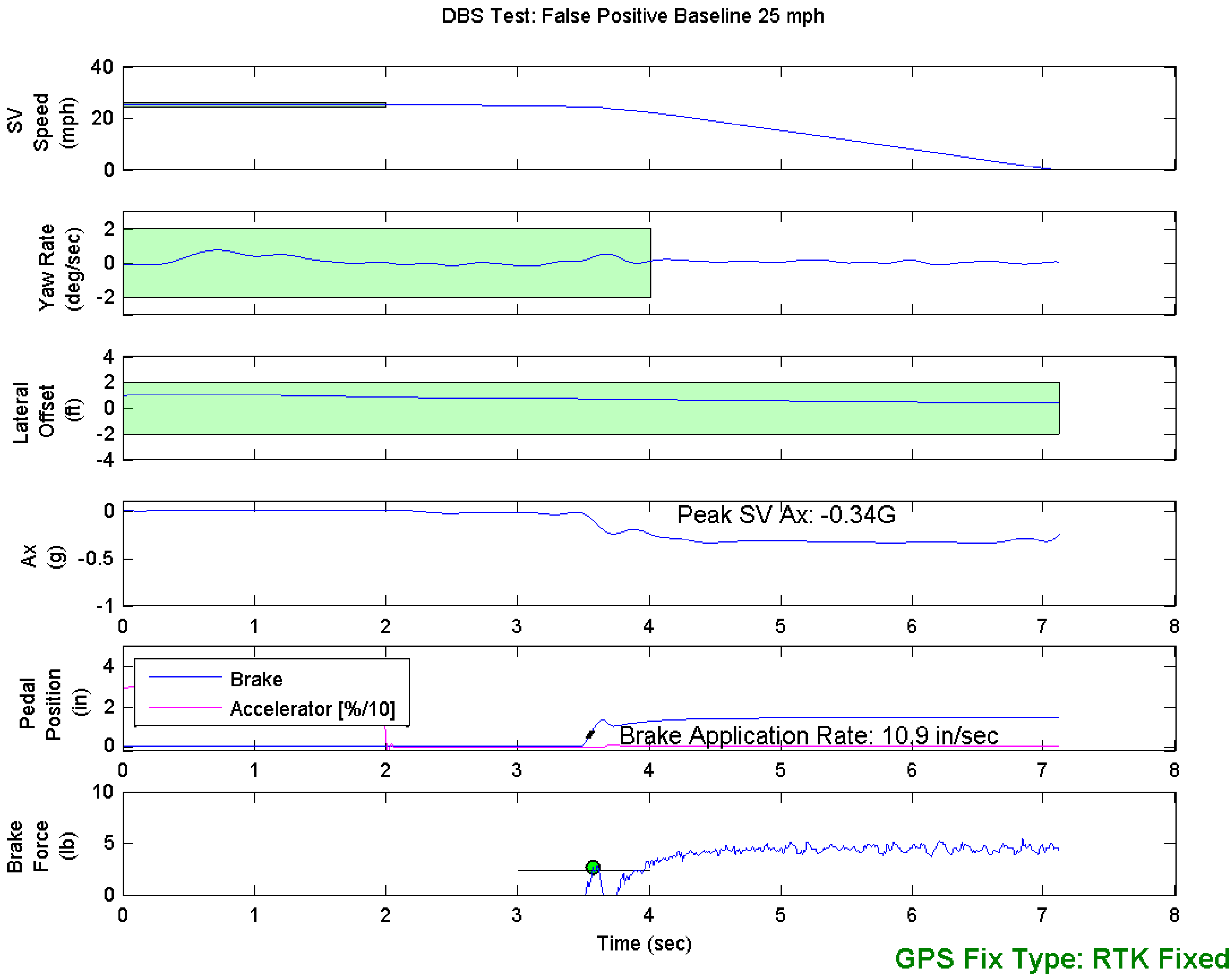


Figure E5. Example Time History for False Positive Baseline 25, Passing

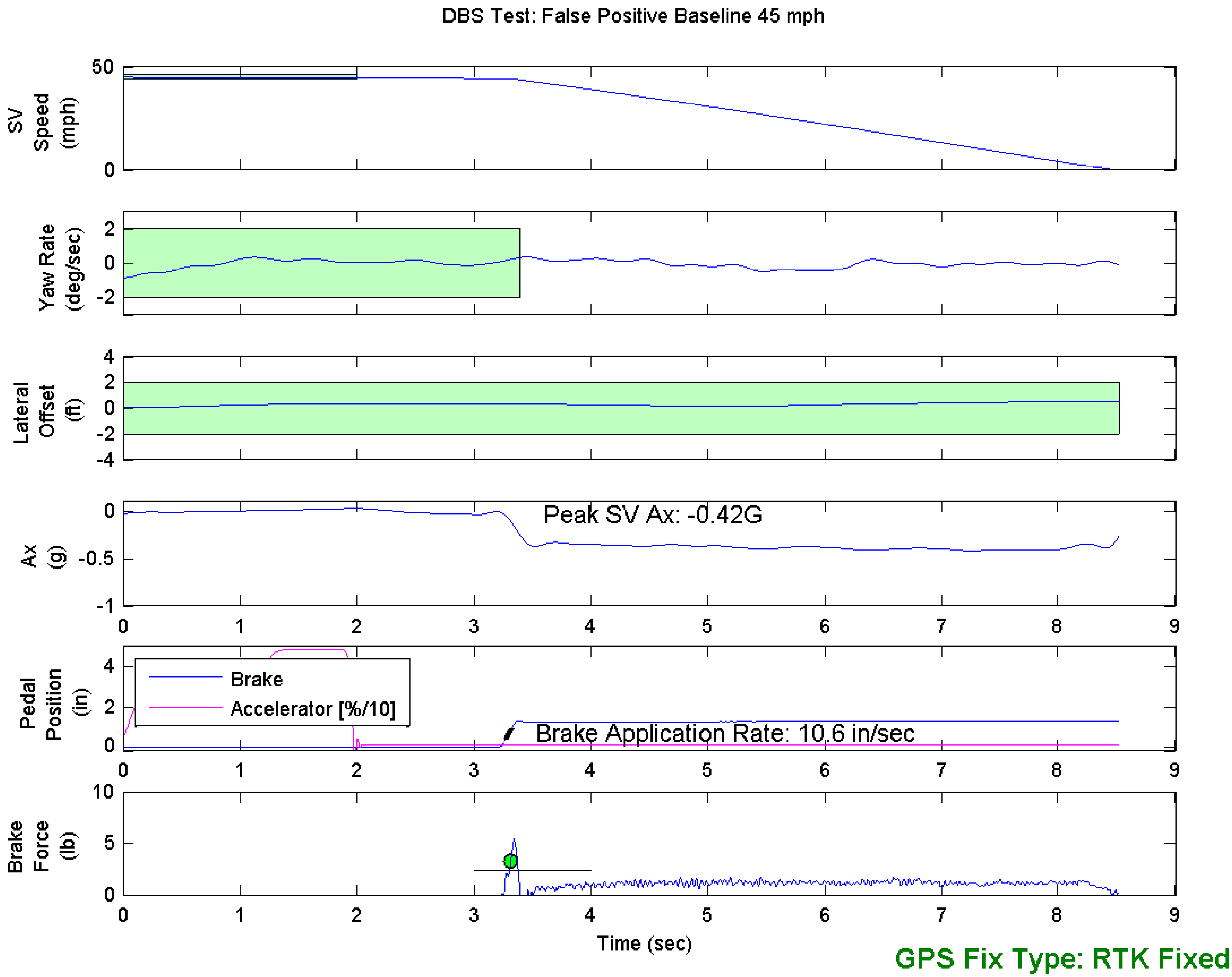


Figure E6. Example Time History for False Positive Baseline 45, Passing

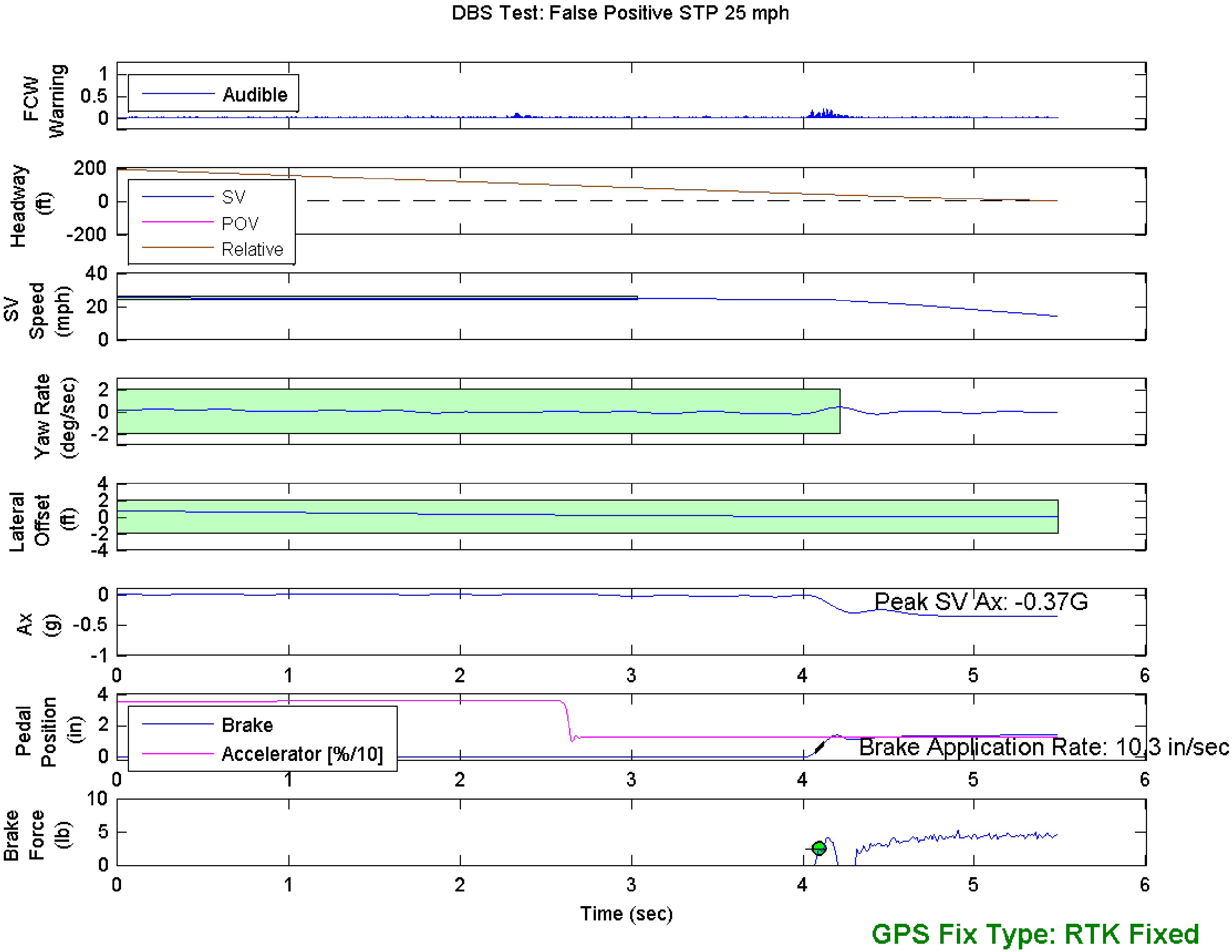


Figure E7. Example Time History for False Positive Steel Plate 25, Passing

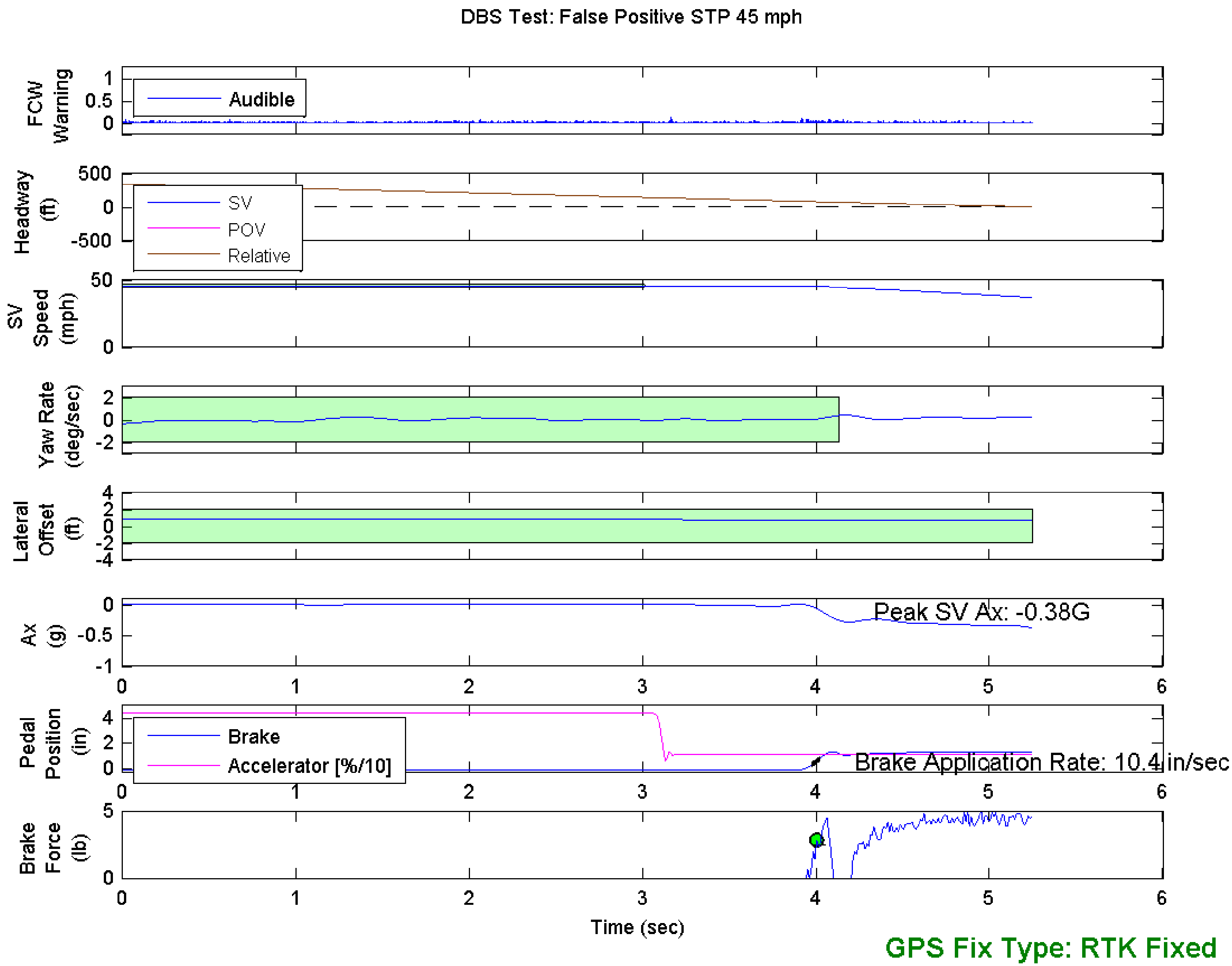


Figure E8. Example Time History for False Positive Steel Plate 45, Passing

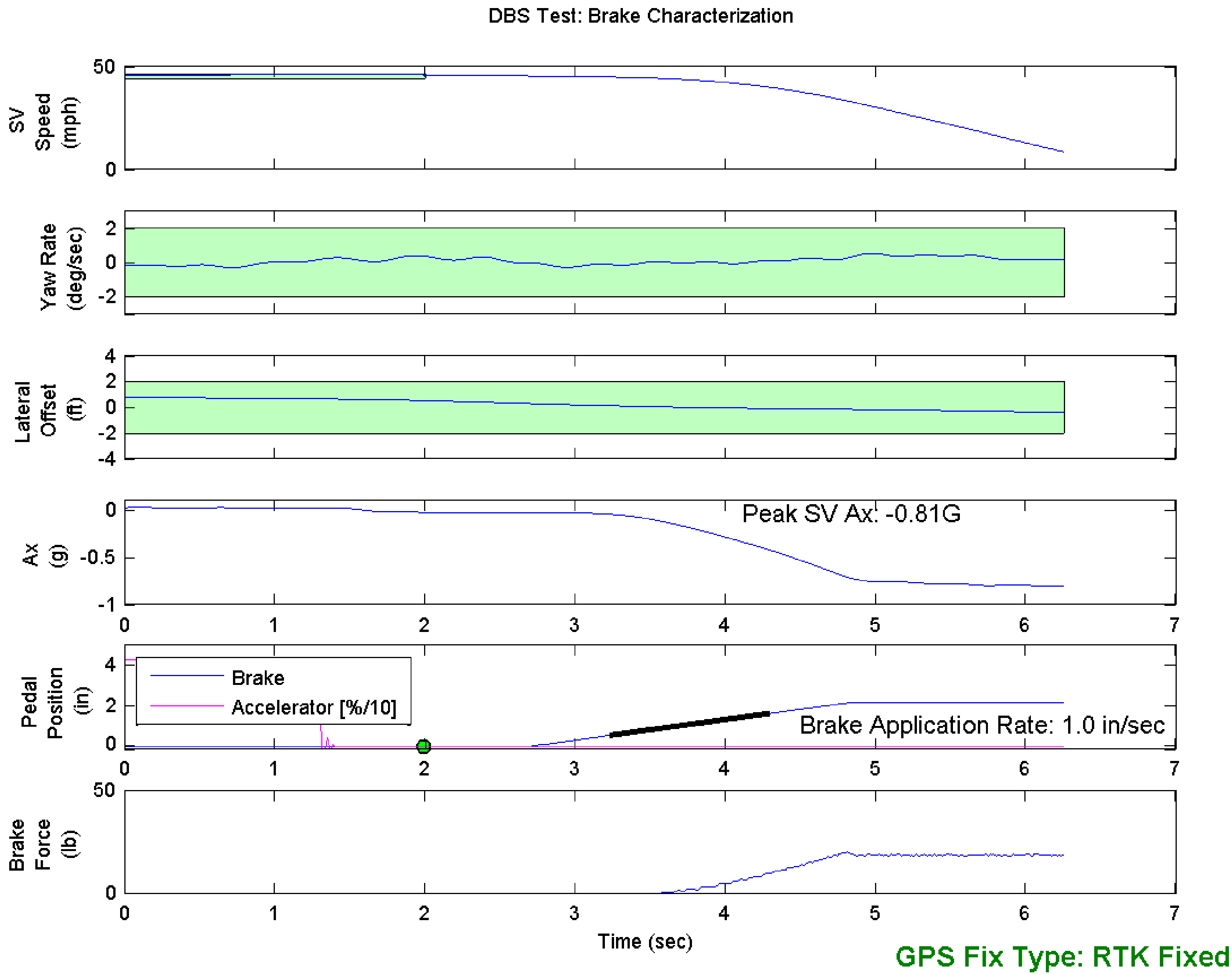


Figure E9. Example Time History for DBS Brake Characterization, Passing

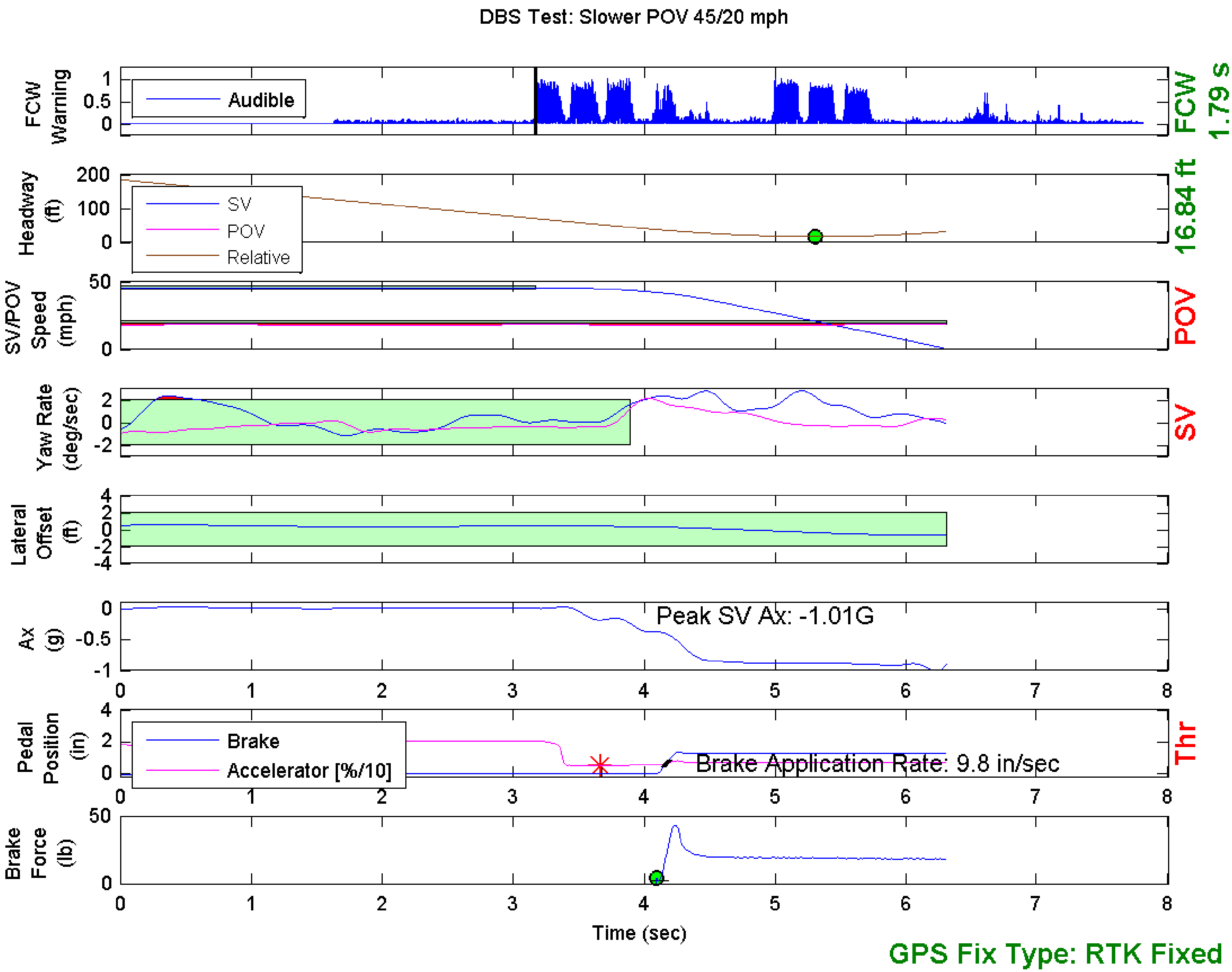


Figure E10. Example Time History Displaying Various Invalid Criteria

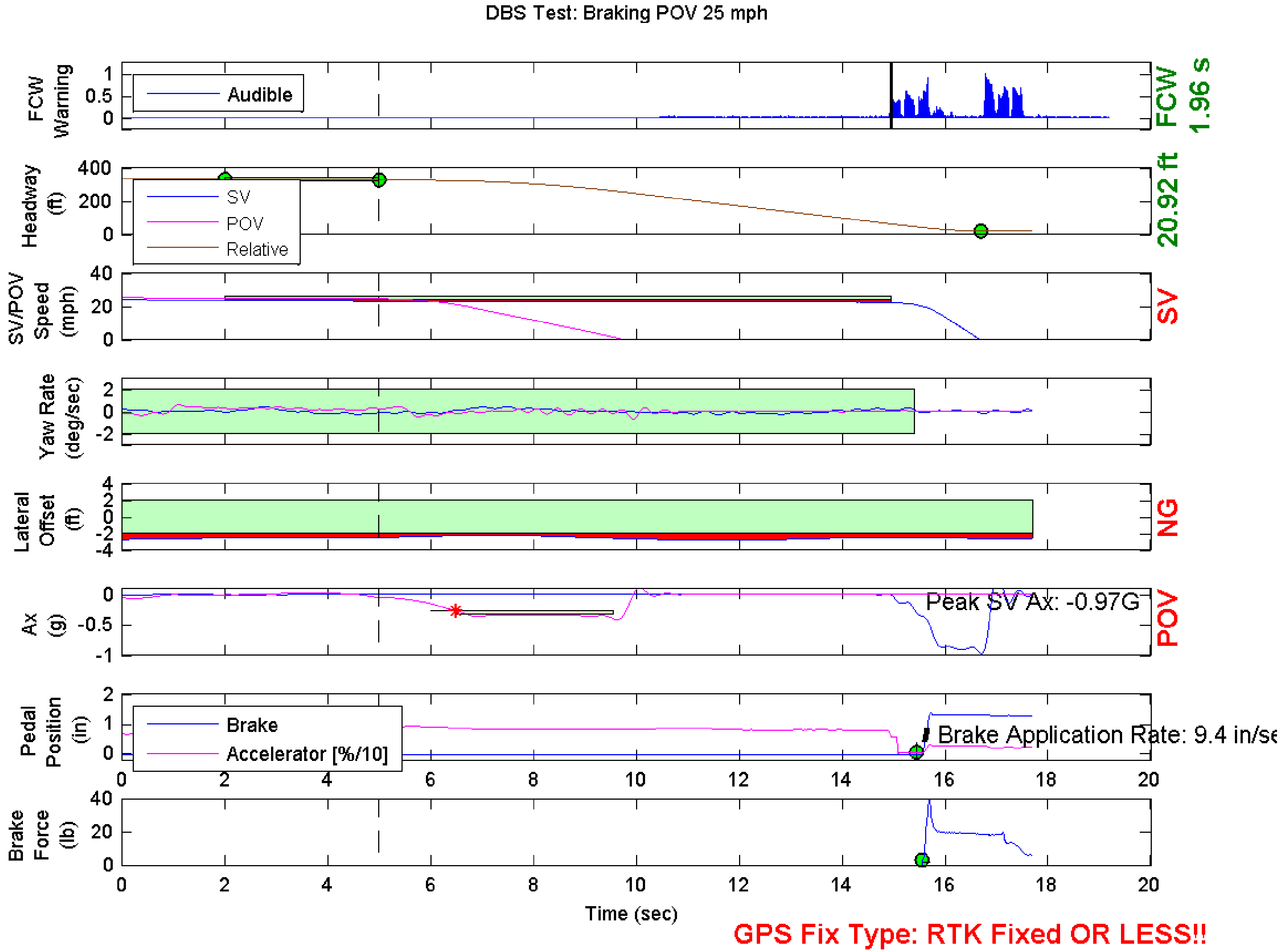


Figure E11. Example Time History Displaying Various Invalid Criteria

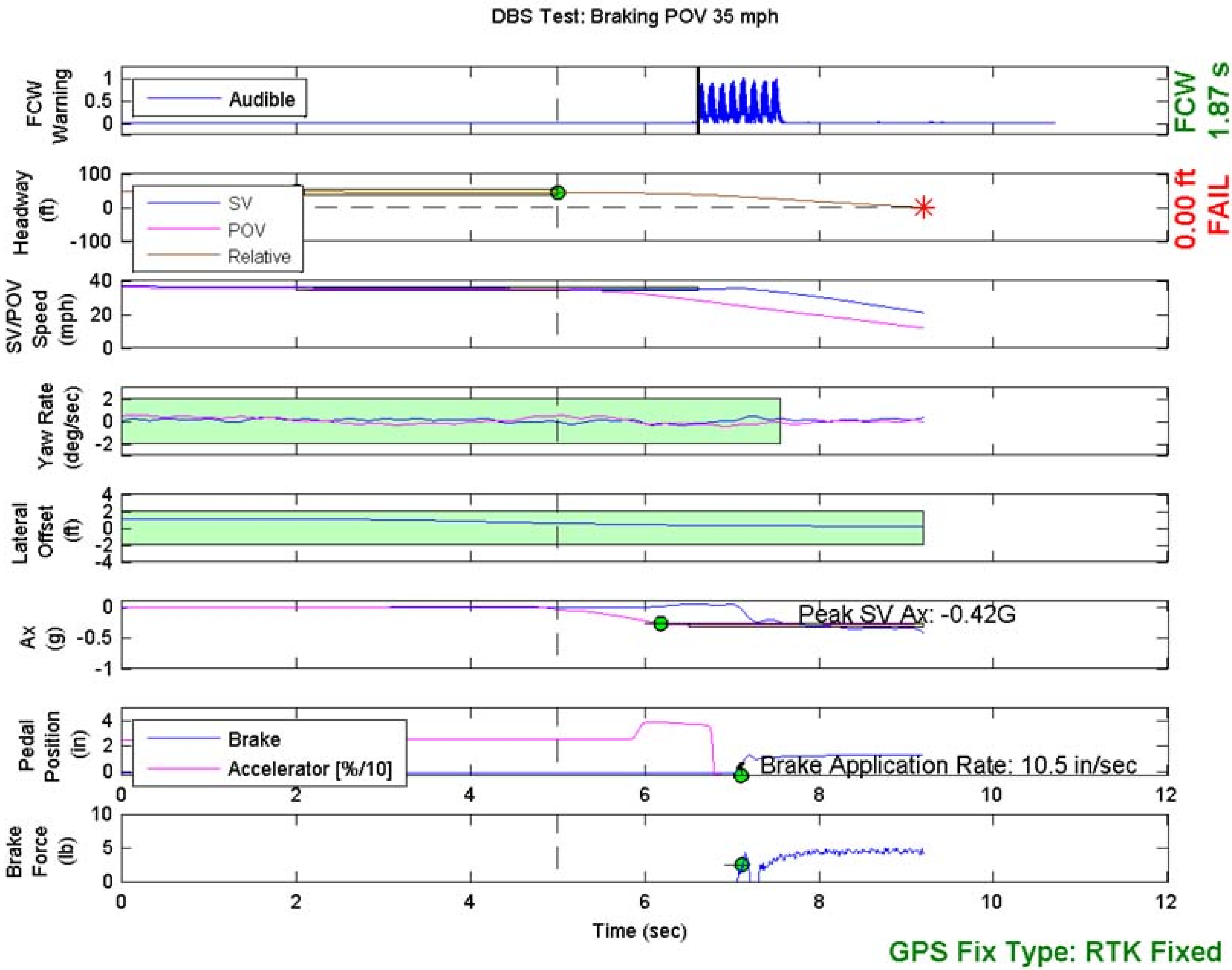


Figure E12. Example Time History for a Failed Run

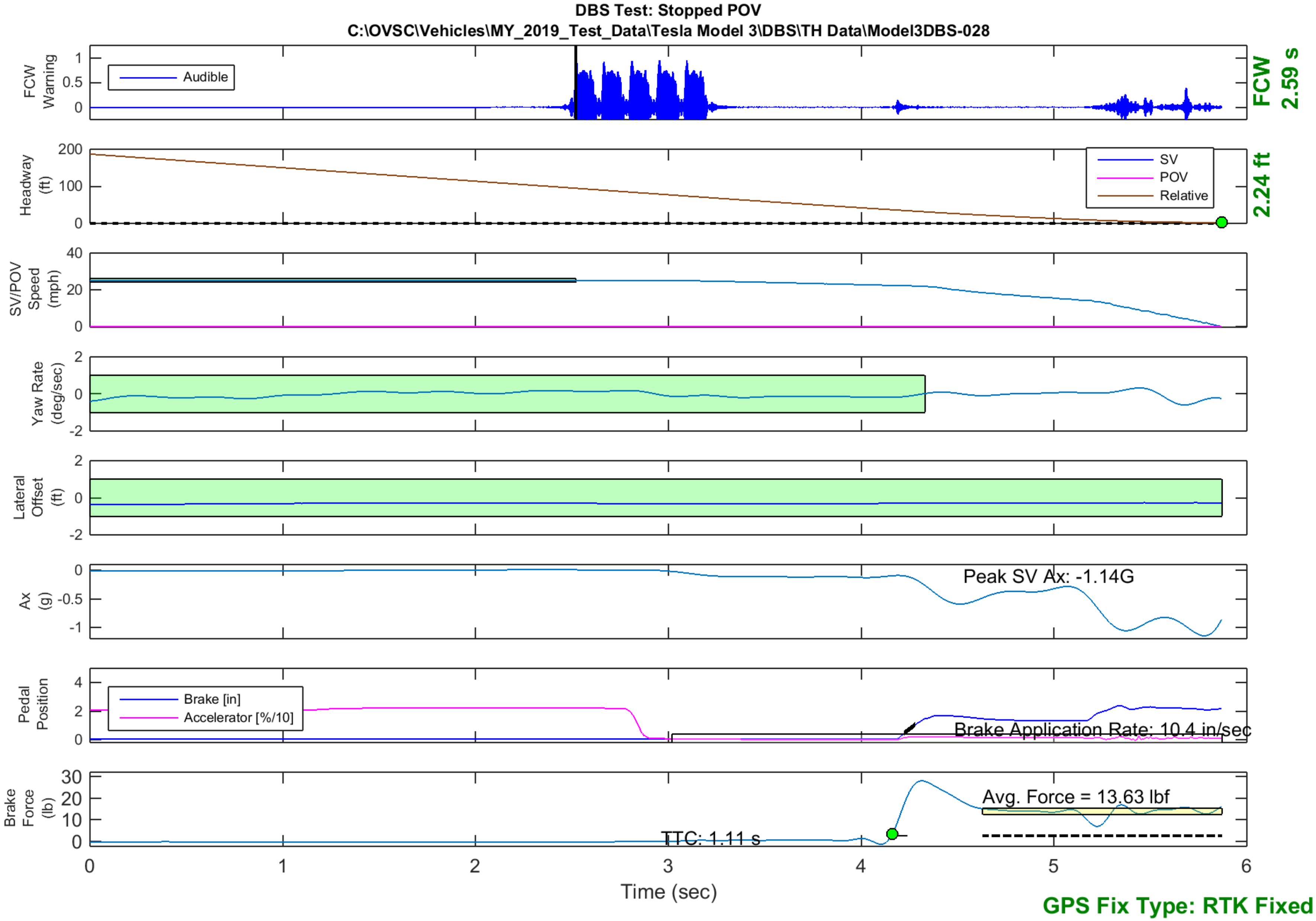


Figure E13. Time History for DBS Run 28, SV Encounters Stopped POV

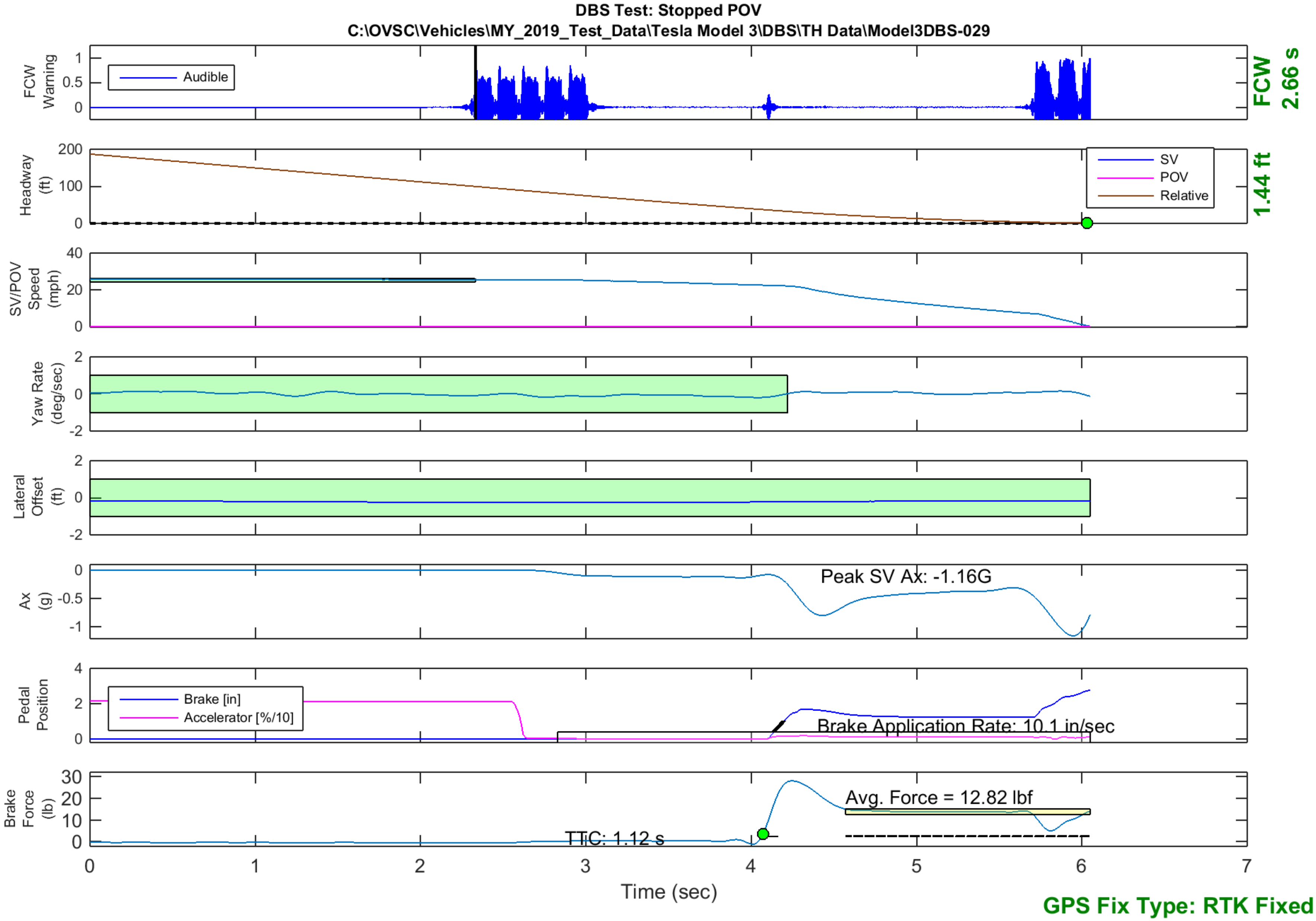


Figure E14. Time History for DBS Run 29, SV Encounters Stopped POV

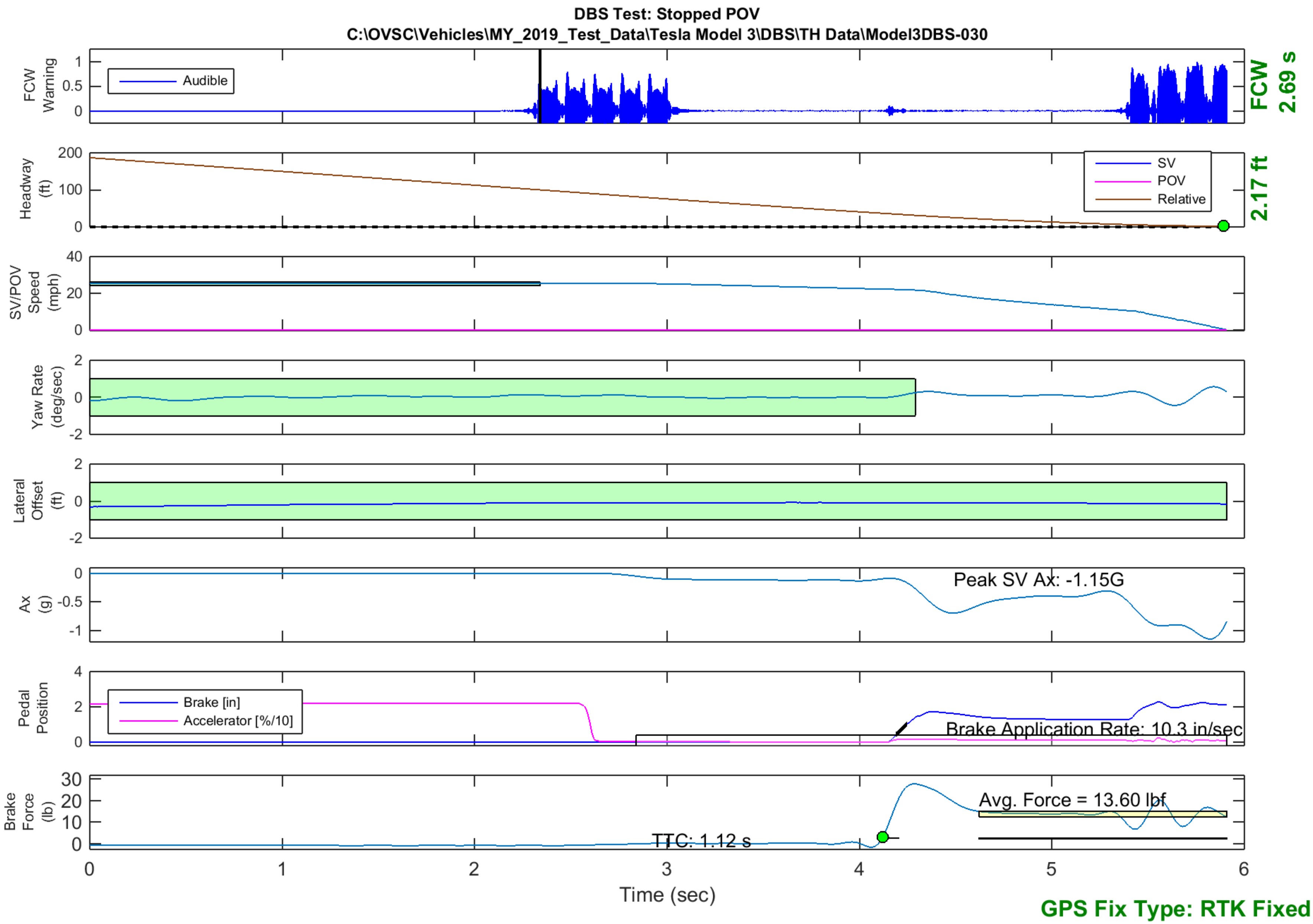


Figure E15. Time History for DBS Run 30, SV Encounters Stopped POV

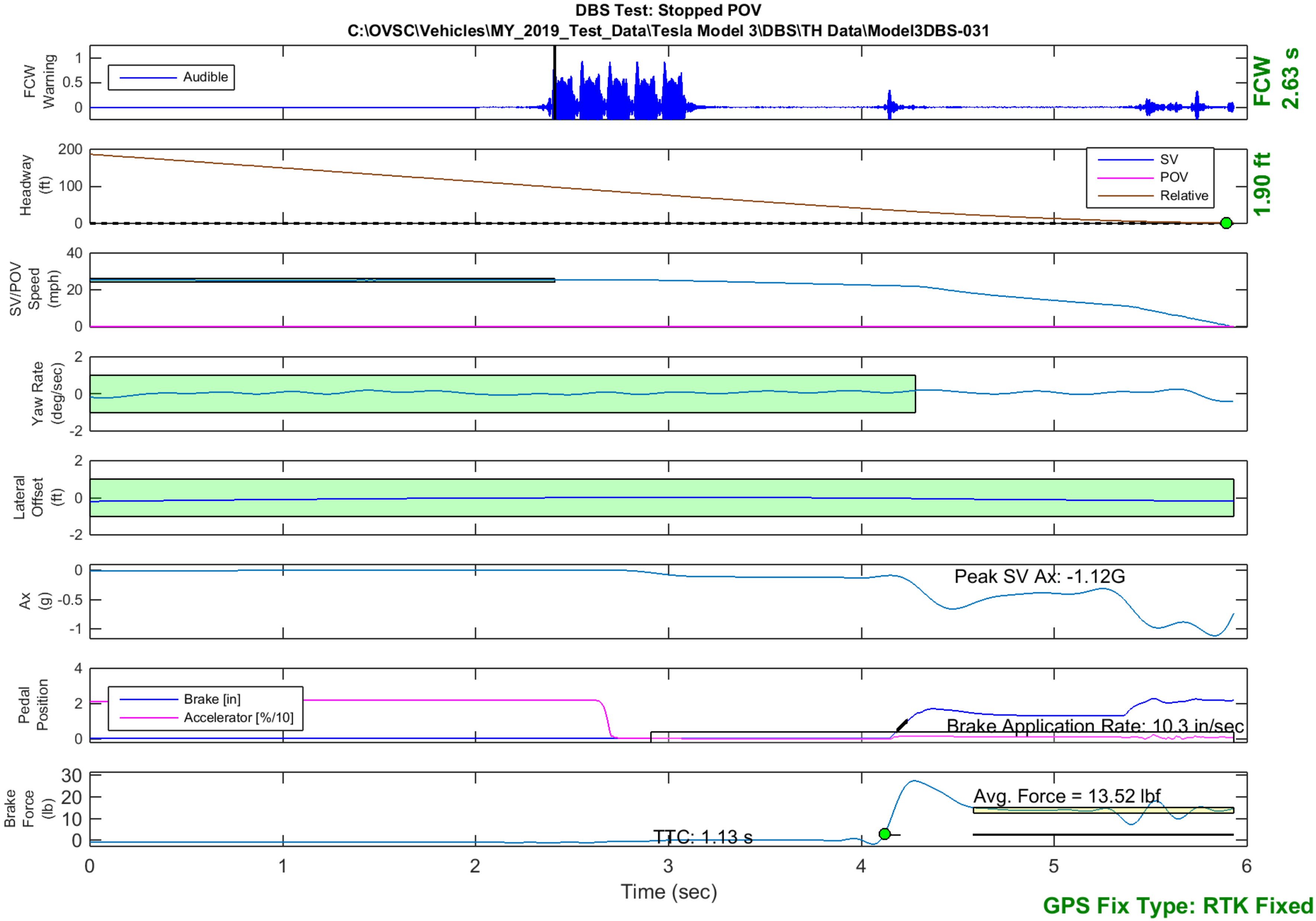


Figure E16. Time History for DBS Run 31, SV Encounters Stopped POV

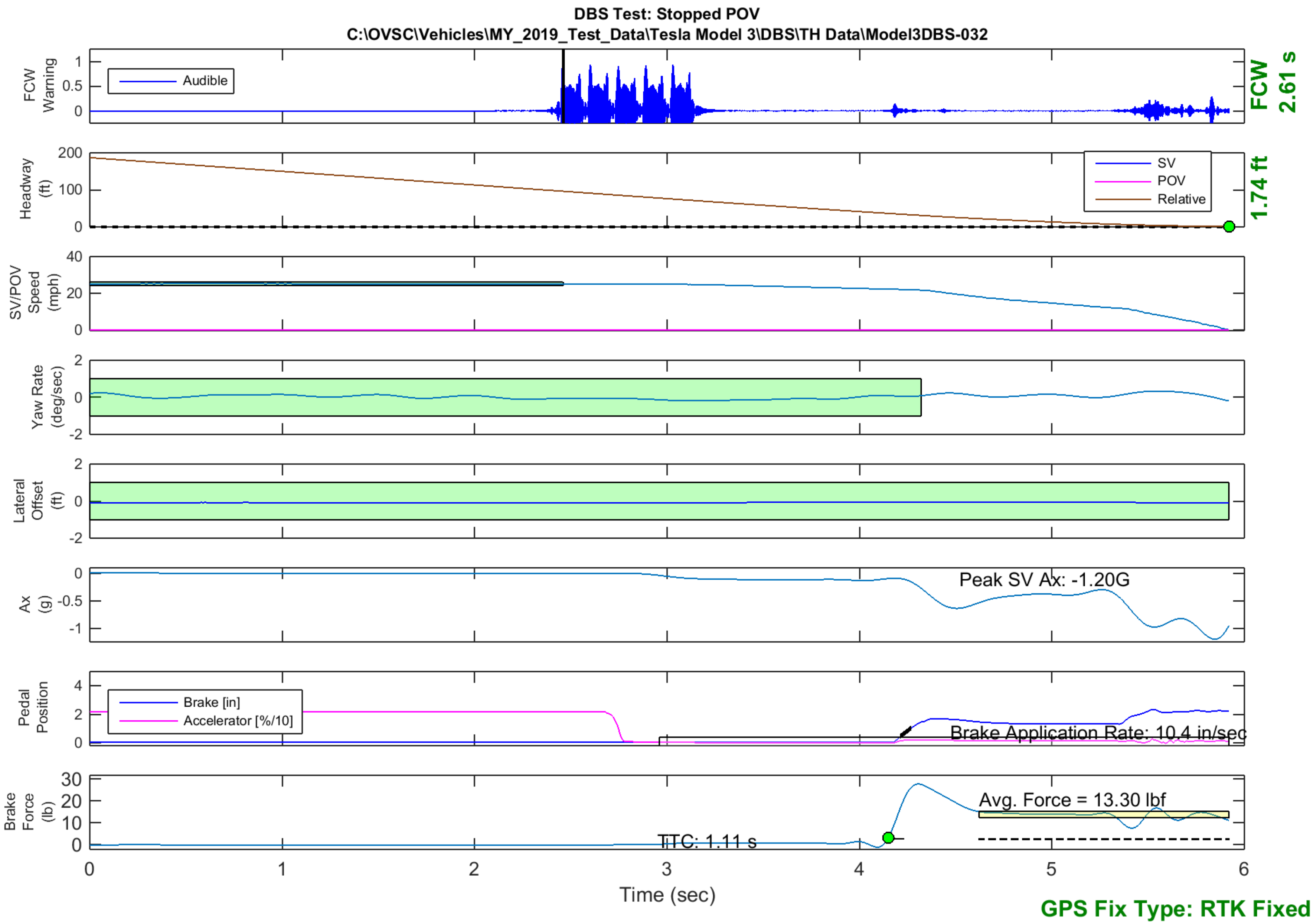


Figure E17. Time History for DBS Run 32, SV Encounters Stopped POV

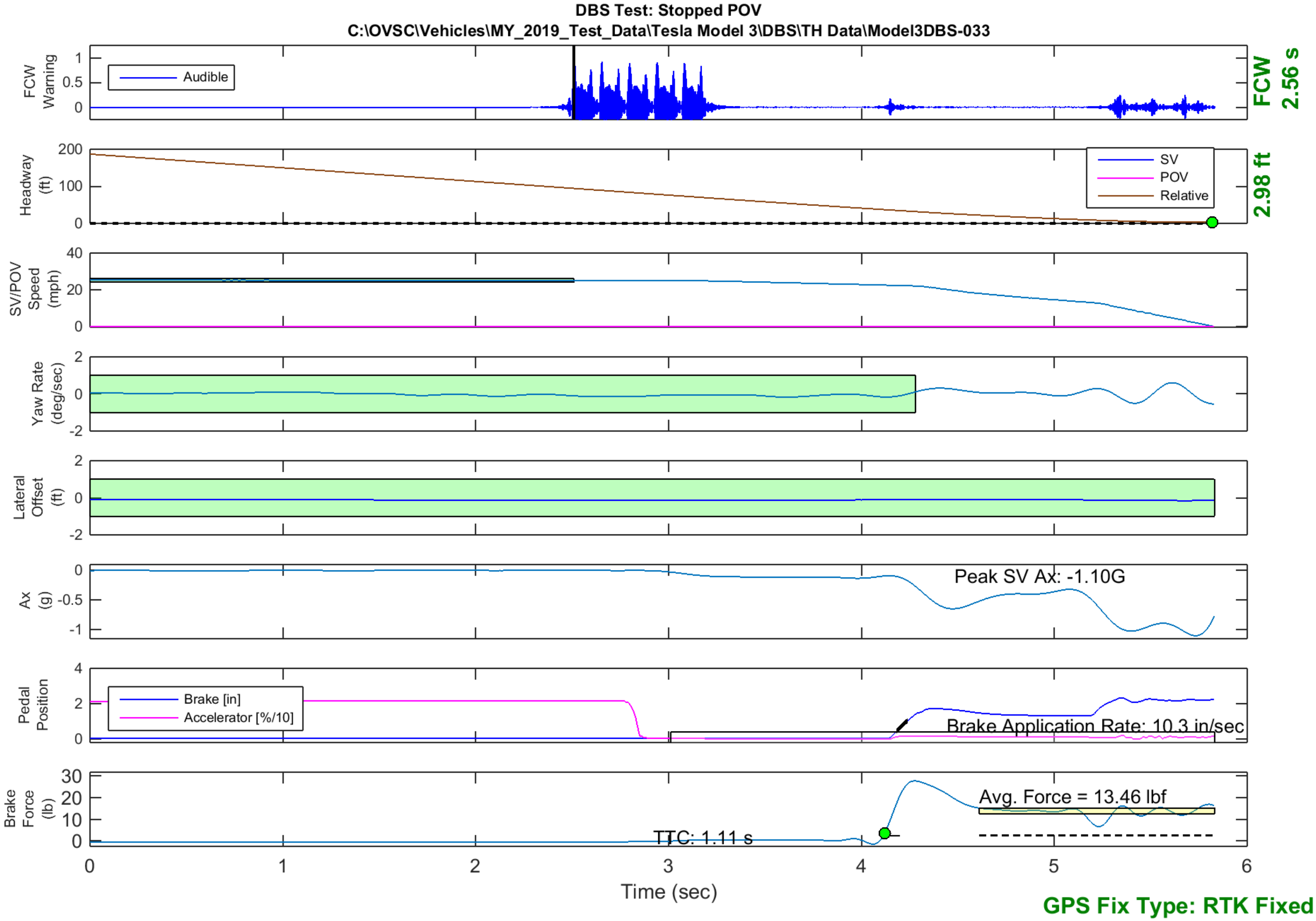


Figure E18. Time History for DBS Run 33, SV Encounters Stopped POV

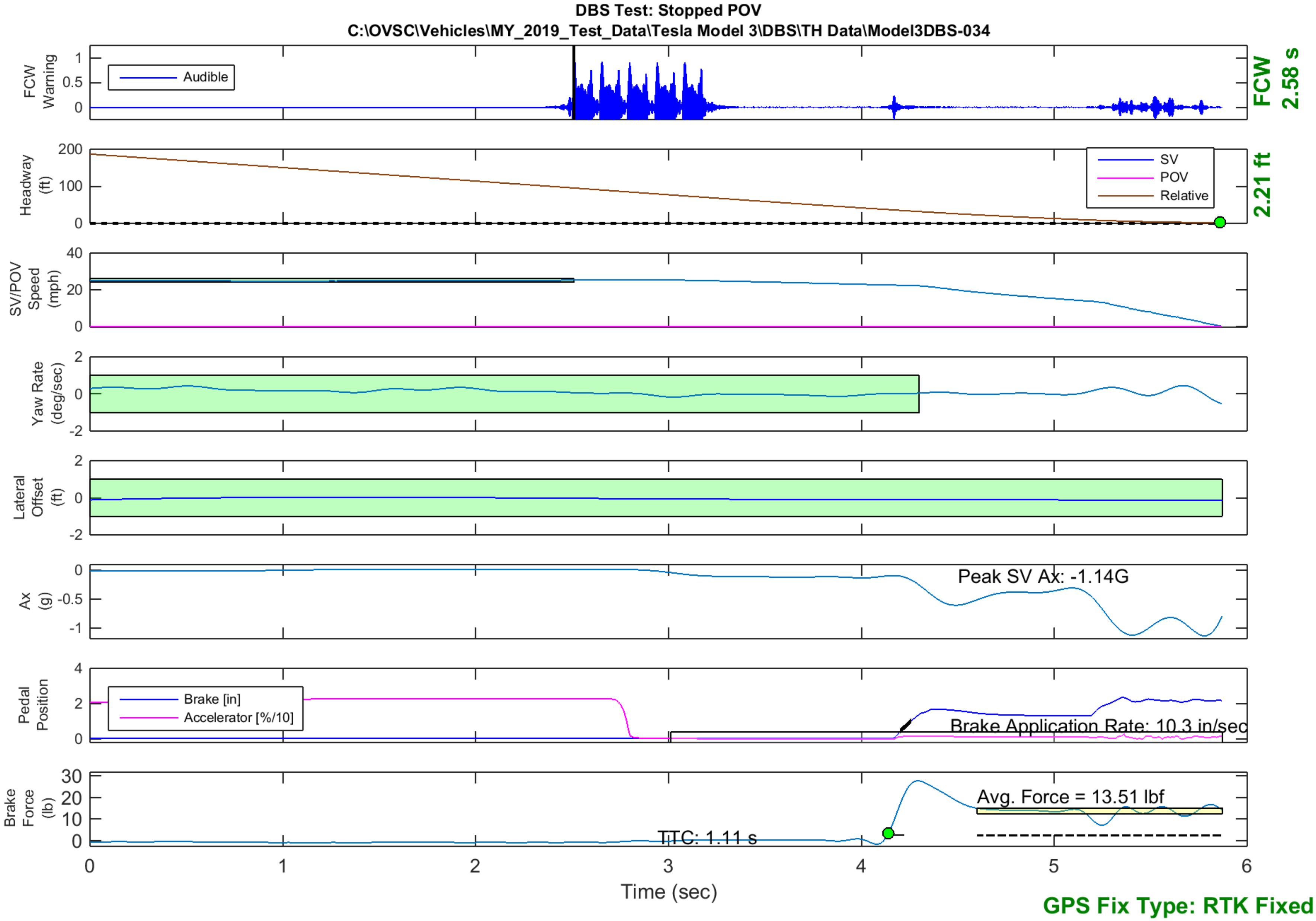


Figure E19. Time History for DBS Run 34, SV Encounters Stopped POV

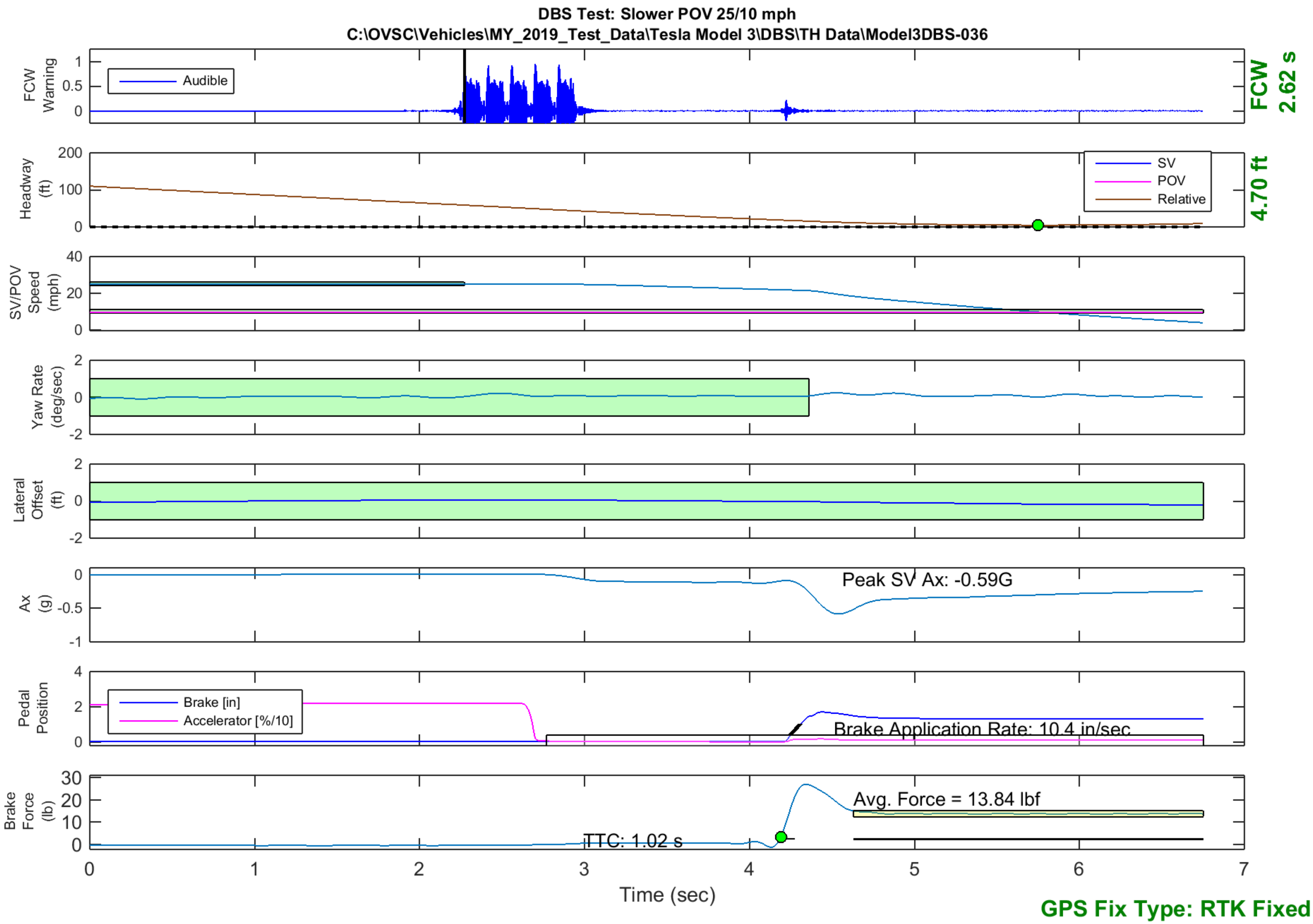


Figure E20. Time History for DBS Run 36, SV Encounters Slower POV, SV 25 mph, POV 10 mph

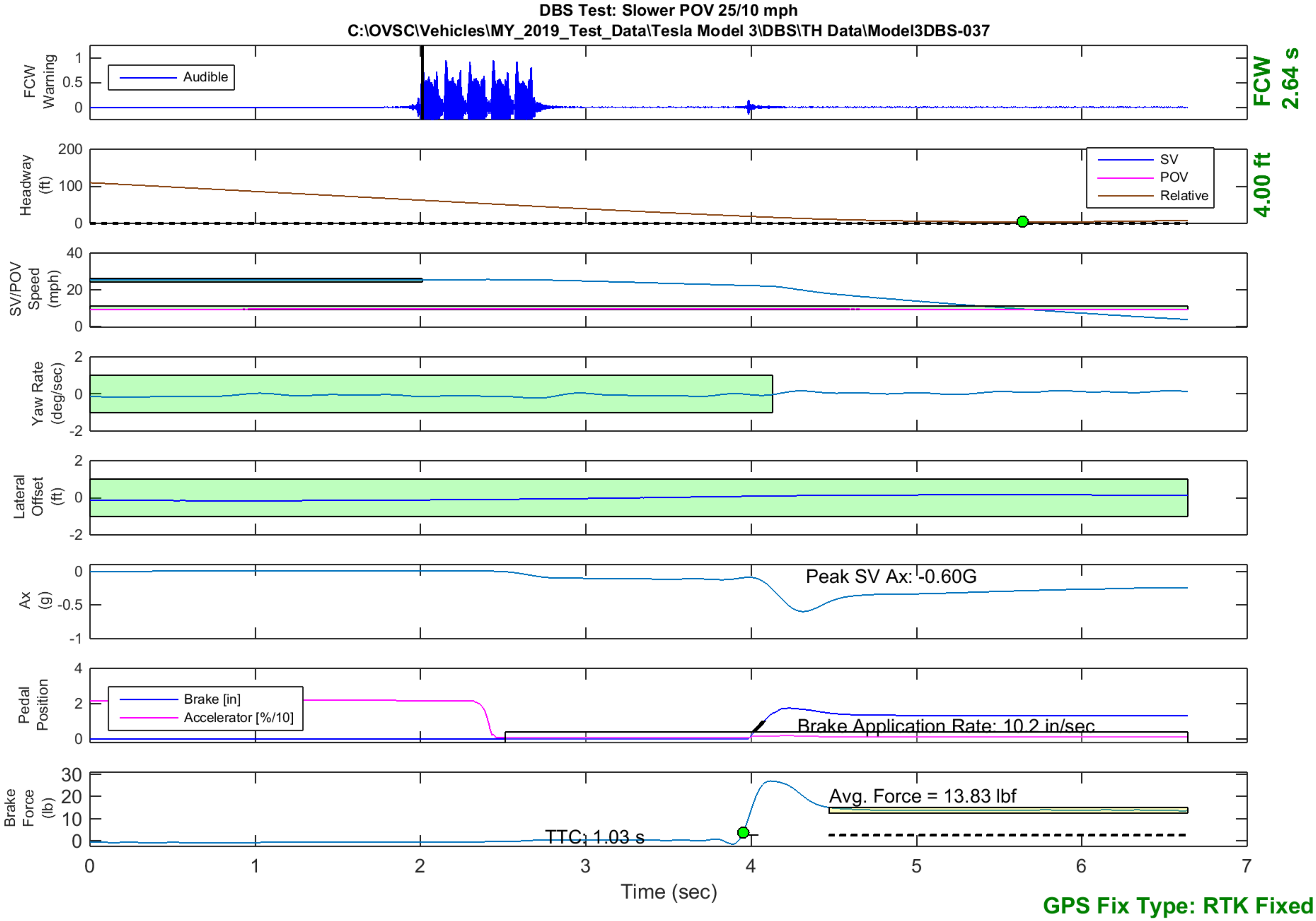


Figure E21. Time History for DBS Run 37, SV Encounters Slower POV, SV 25 mph, POV 10 mph

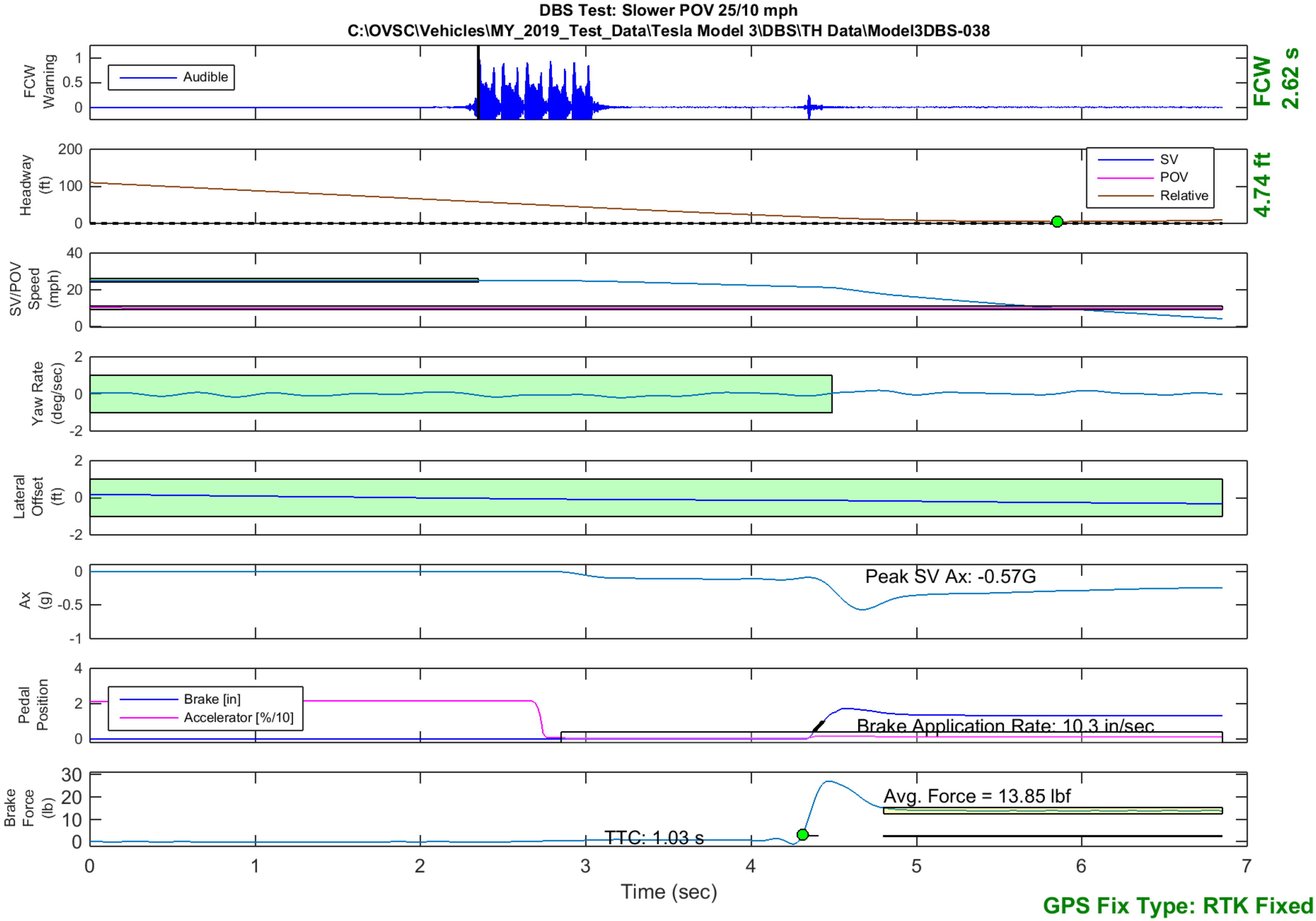


Figure E22. Time History for DBS Run 38, SV Encounters Slower POV, SV 25 mph, POV 10 mph

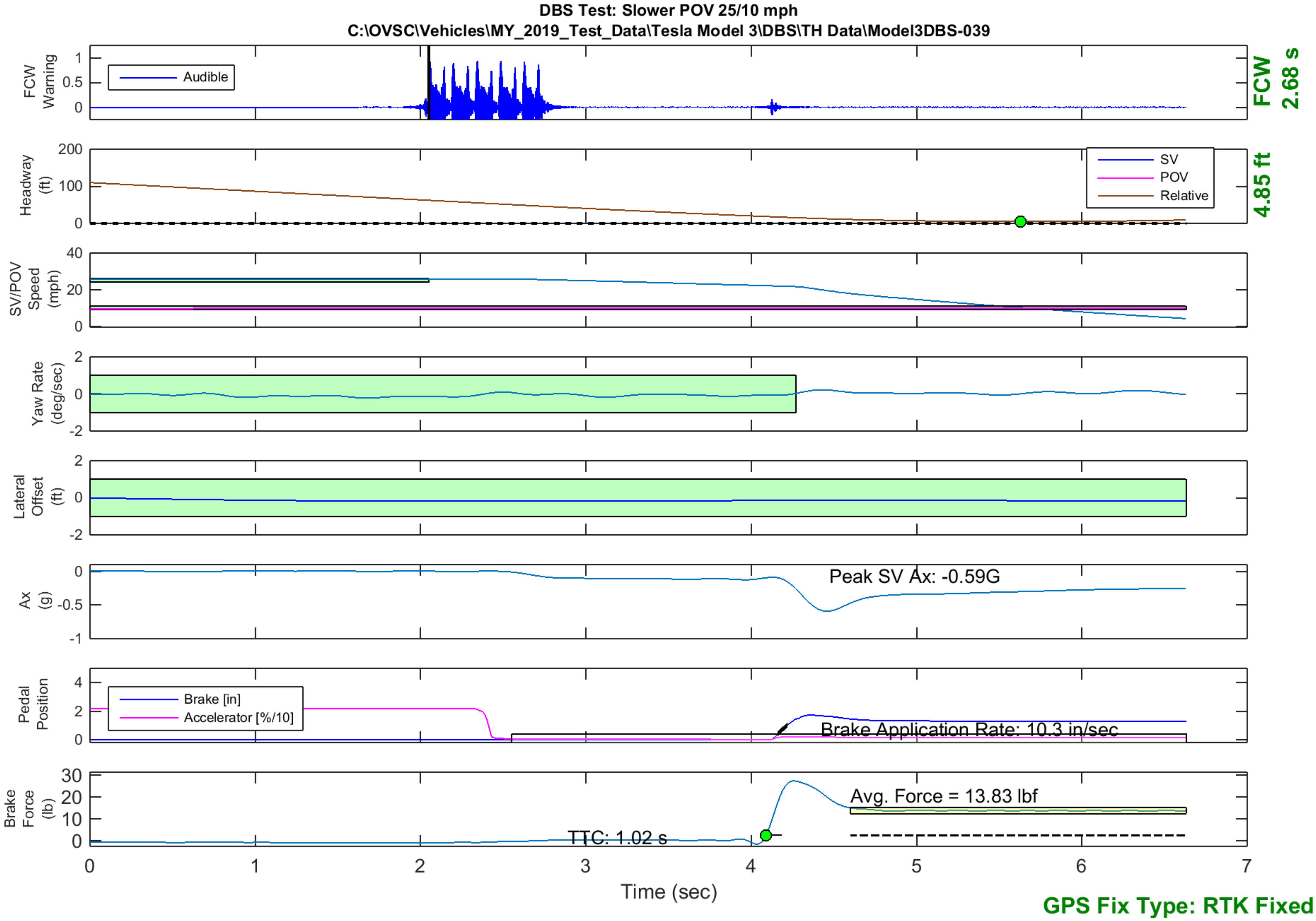


Figure E23. Time History for DBS Run 39, SV Encounters Slower POV, SV 25 mph, POV 10 mph

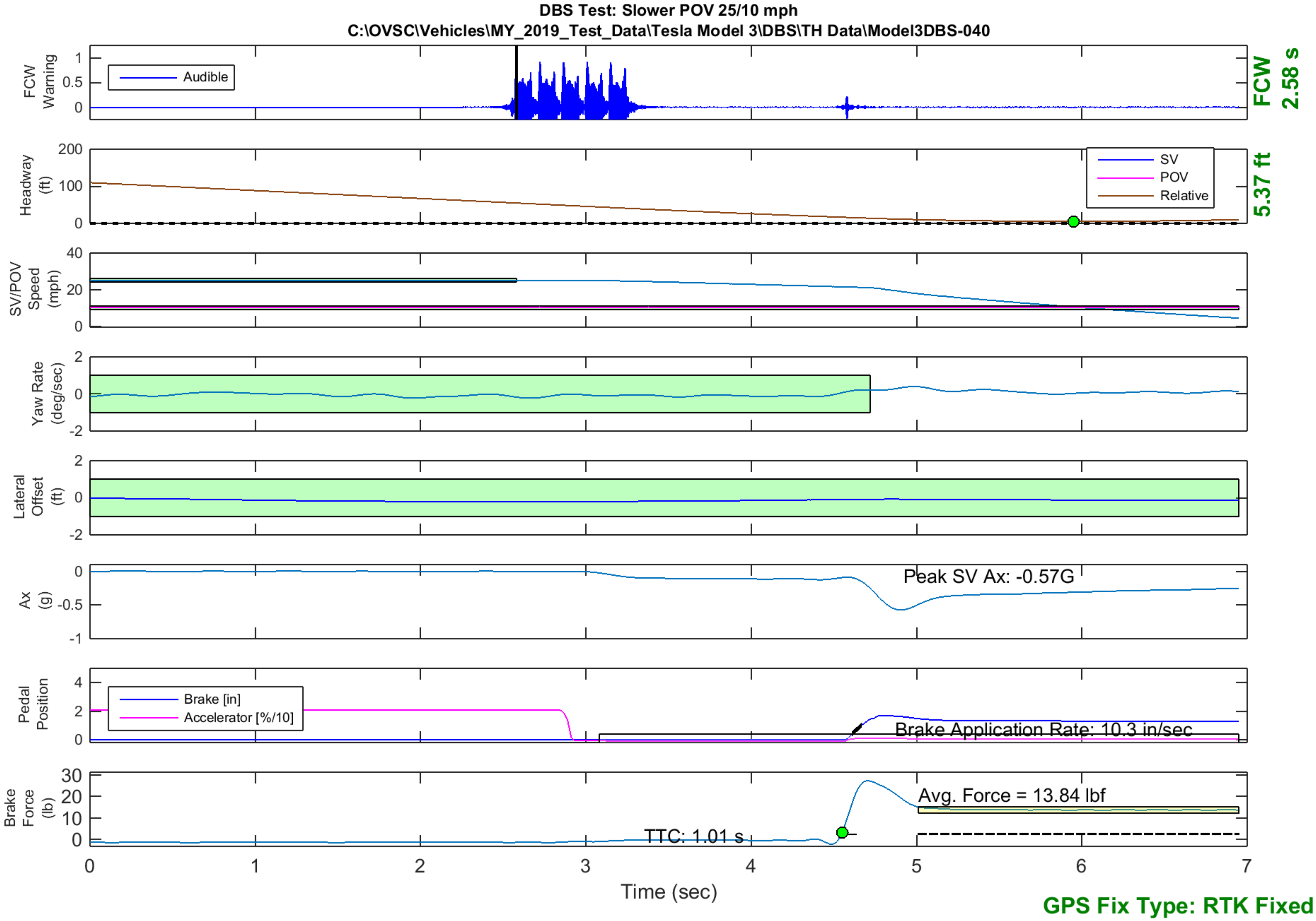


Figure E24. Time History for DBS Run 40, SV Encounters Slower POV, SV 25 mph, POV 10 mph

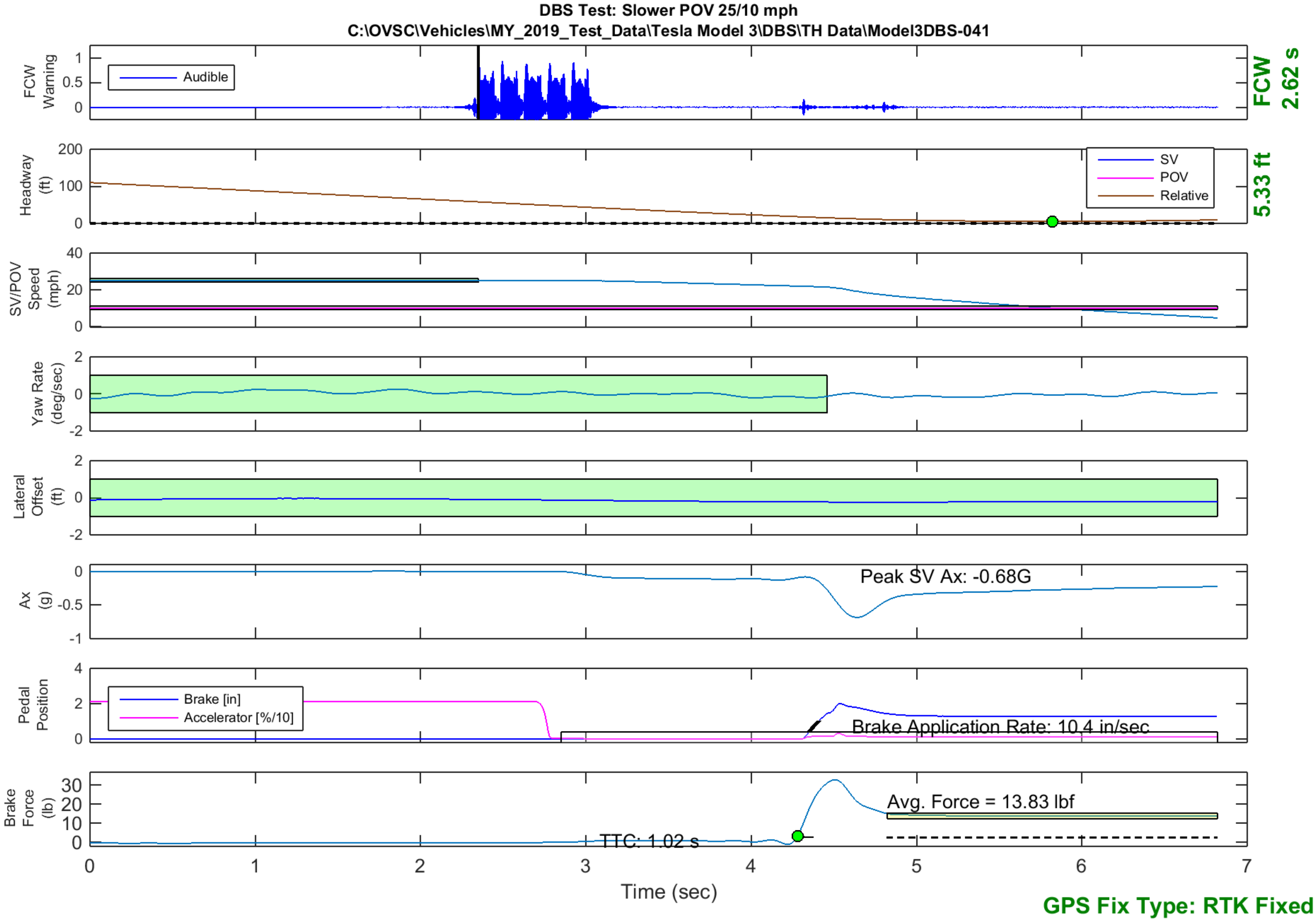


Figure E25. Time History for DBS Run 41, SV Encounters Slower POV, SV 25 mph, POV 10 mph

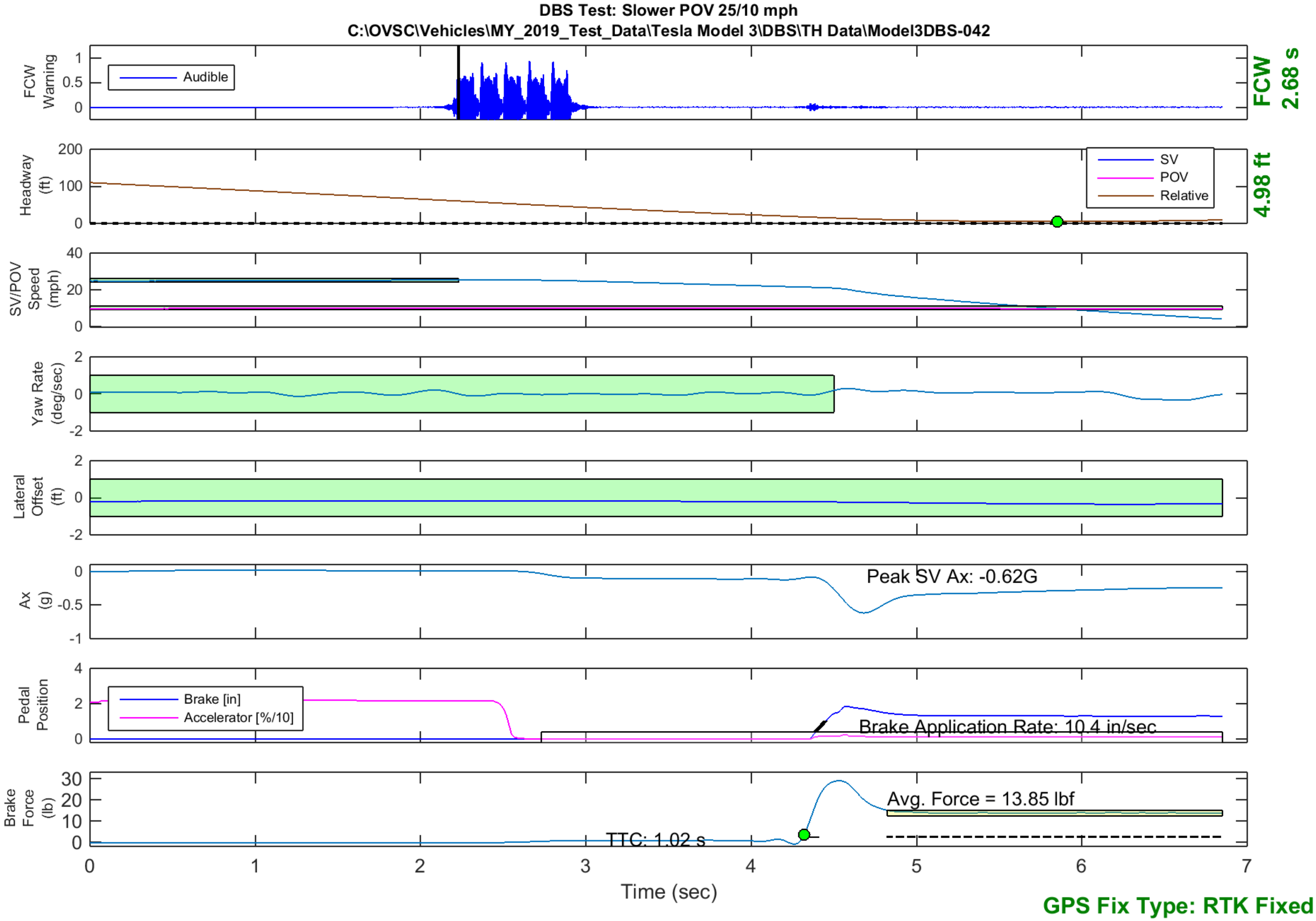


Figure E26. Time History for DBS Run 42, SV Encounters Slower POV, SV 25 mph, POV 10 mph

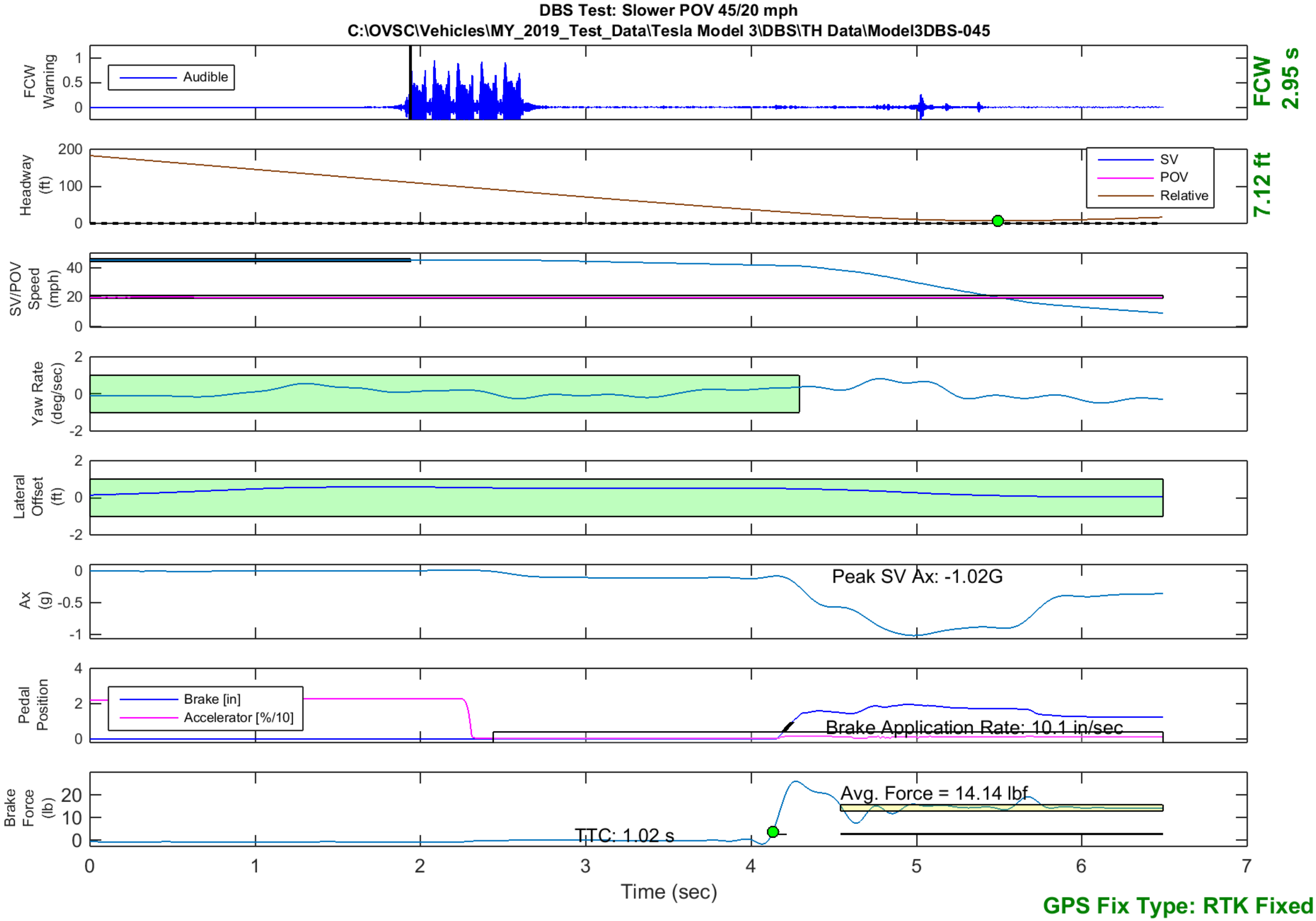


Figure E27. Time History for DBS Run 45, SV Encounters Slower POV, SV 45 mph, POV 20 mph

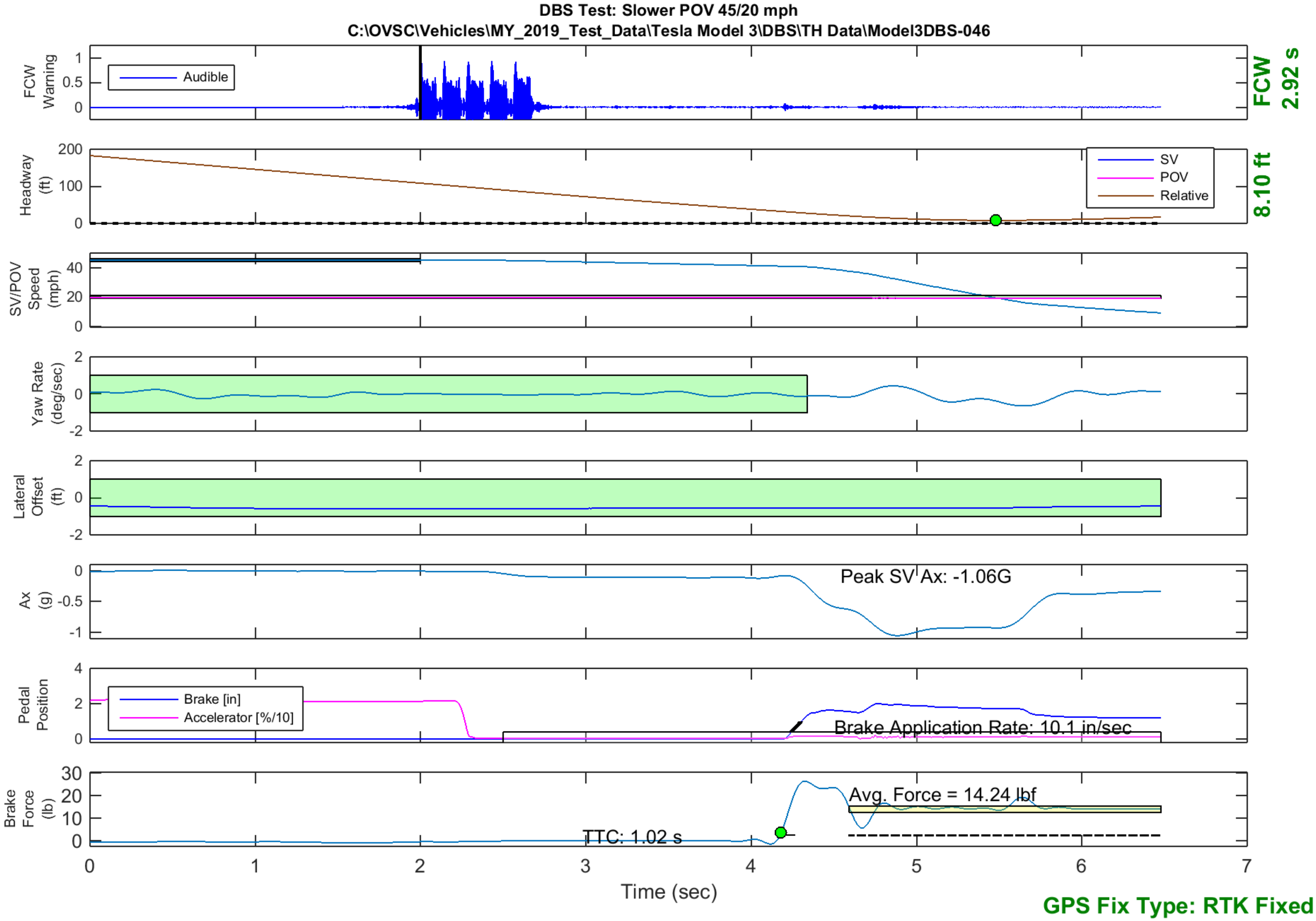


Figure E28. Time History for DBS Run 46, SV Encounters Slower POV, SV 45 mph, POV 20 mph

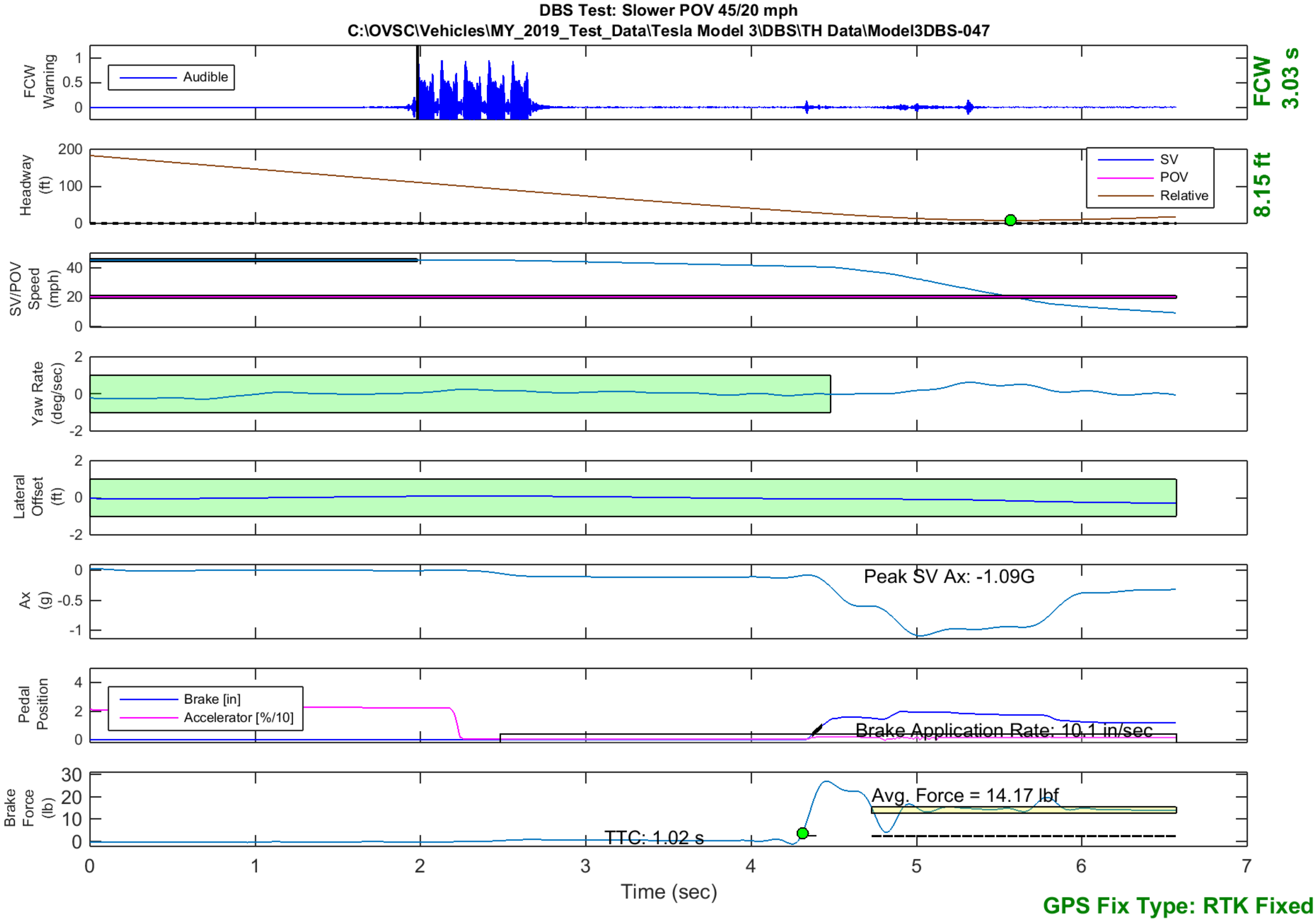


Figure E29. Time History for DBS Run 47, SV Encounters Slower POV, SV 45 mph, POV 20 mph

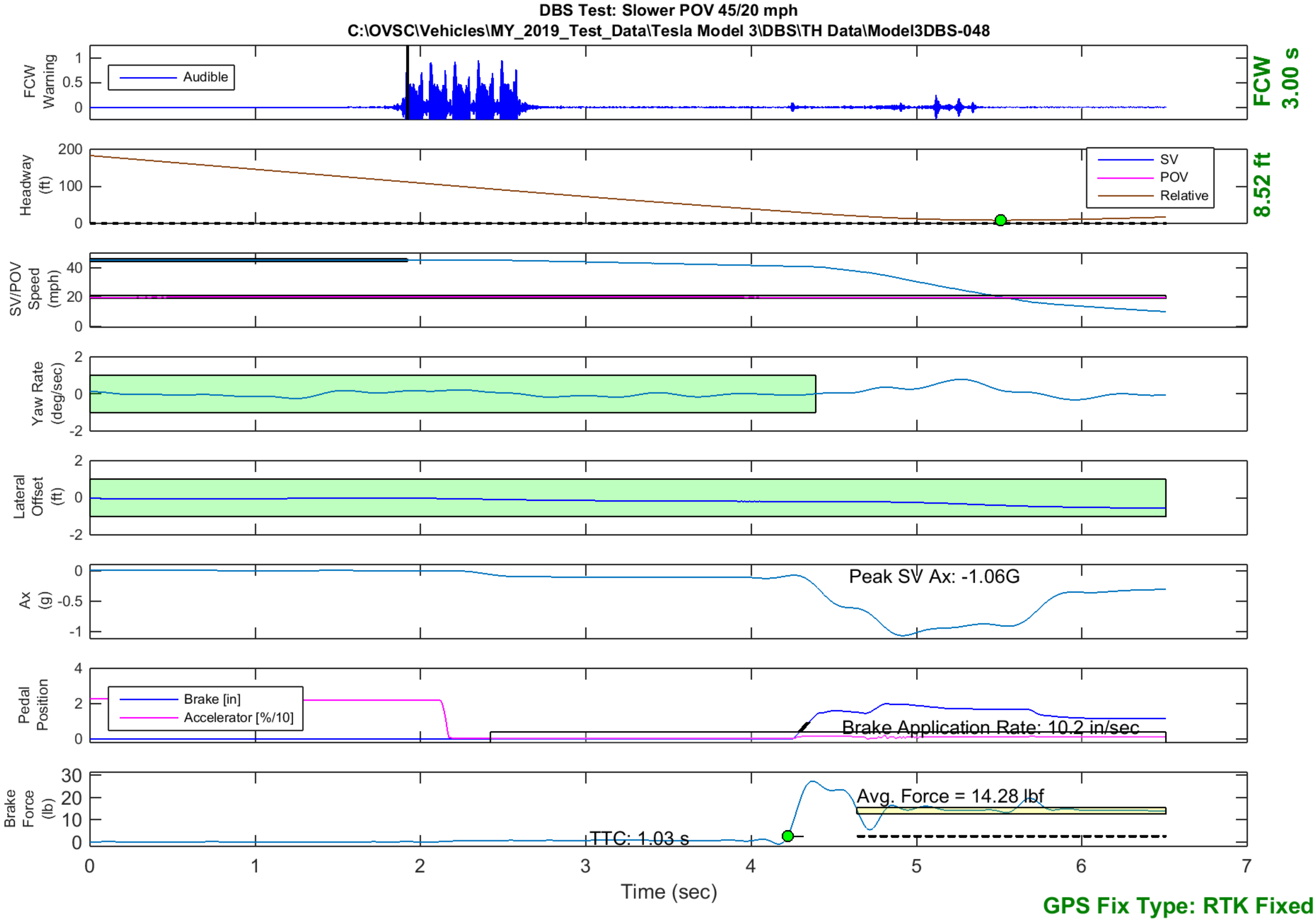


Figure E30. Time History for DBS Run 48, SV Encounters Slower POV, SV 45 mph, POV 20 mph

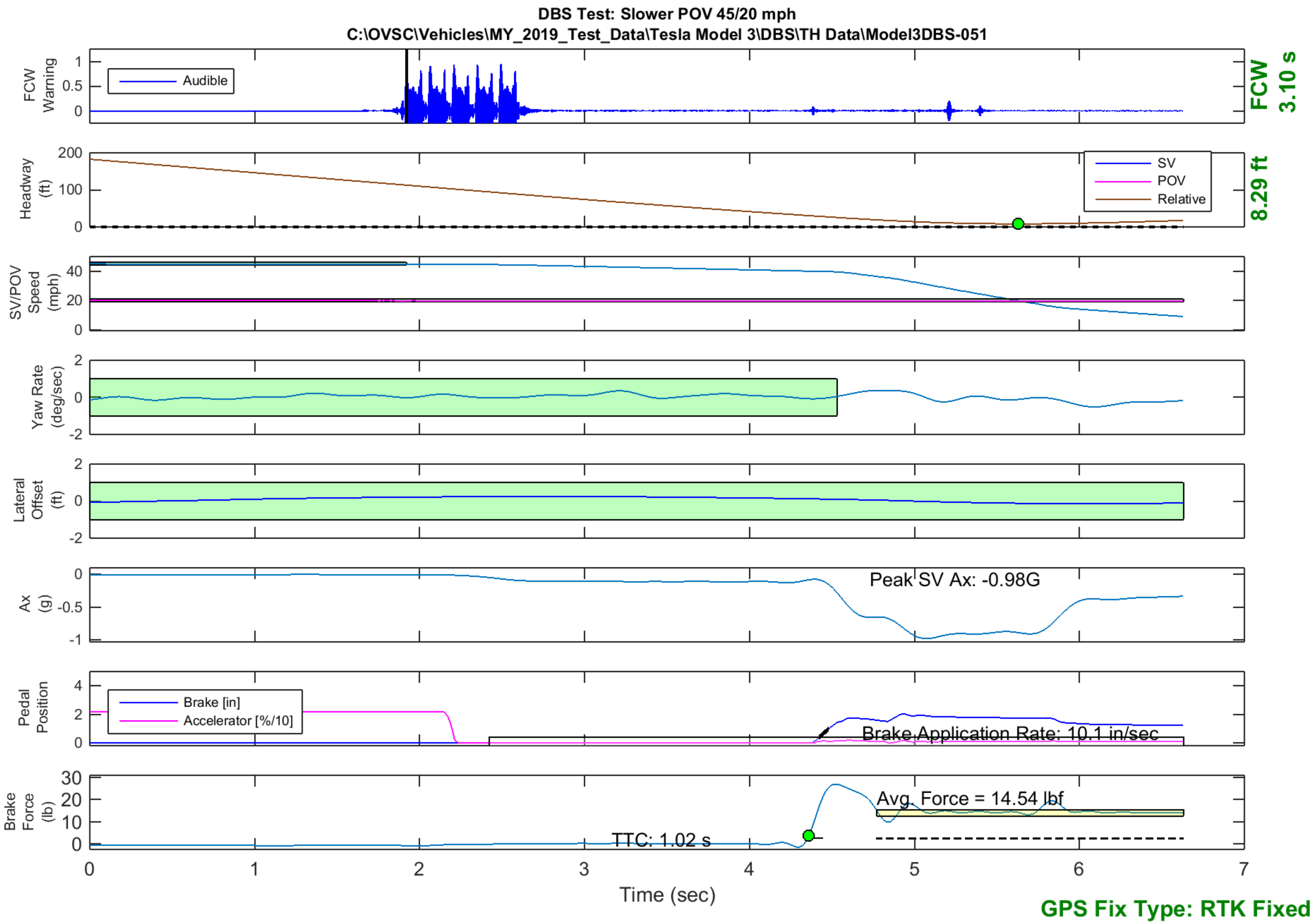


Figure E31. Time History for DBS Run 51, SV Encounters Slower POV, SV 45 mph, POV 20 mph

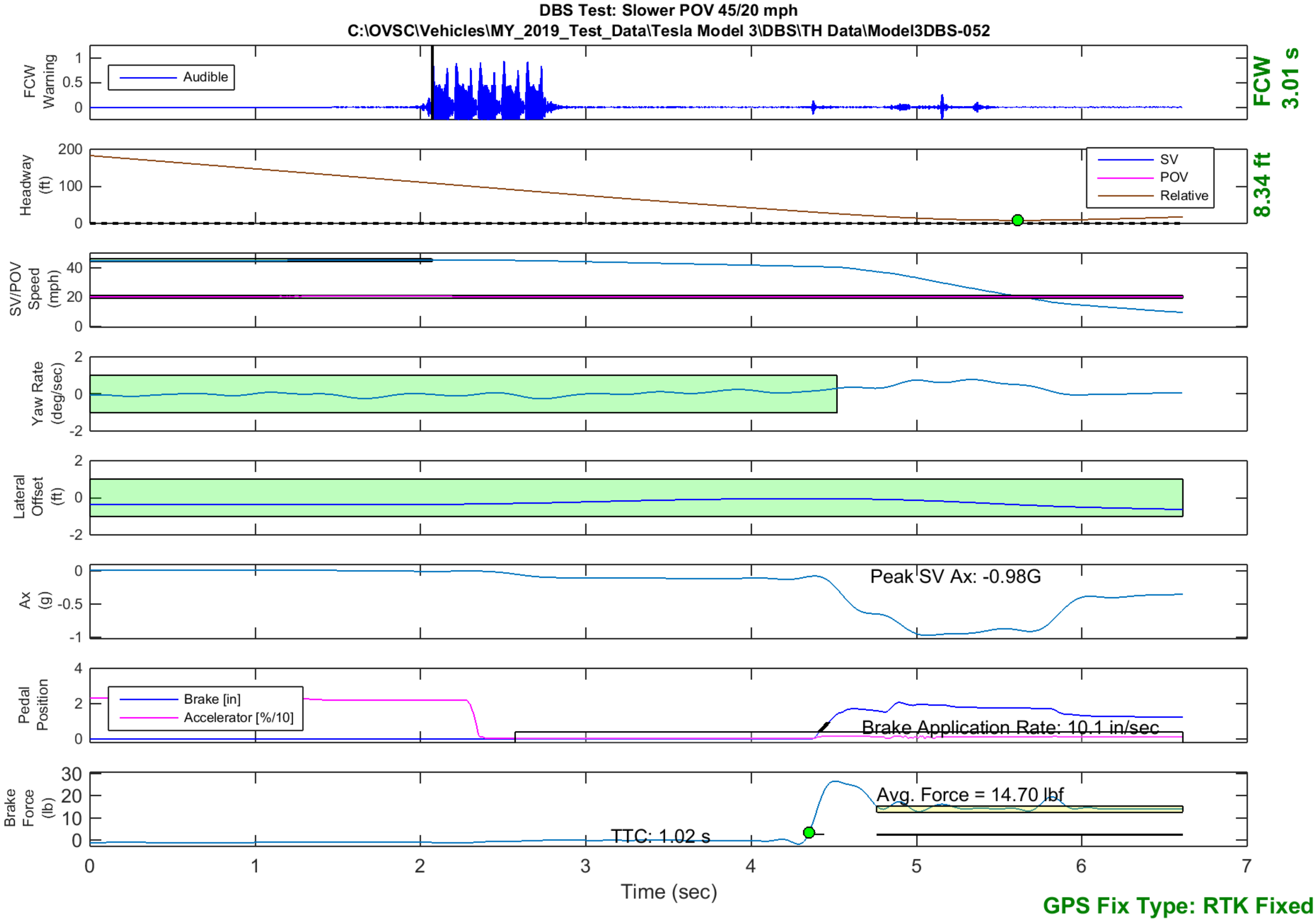


Figure E32. Time History for DBS Run 52, SV Encounters Slower POV, SV 45 mph, POV 20 mph

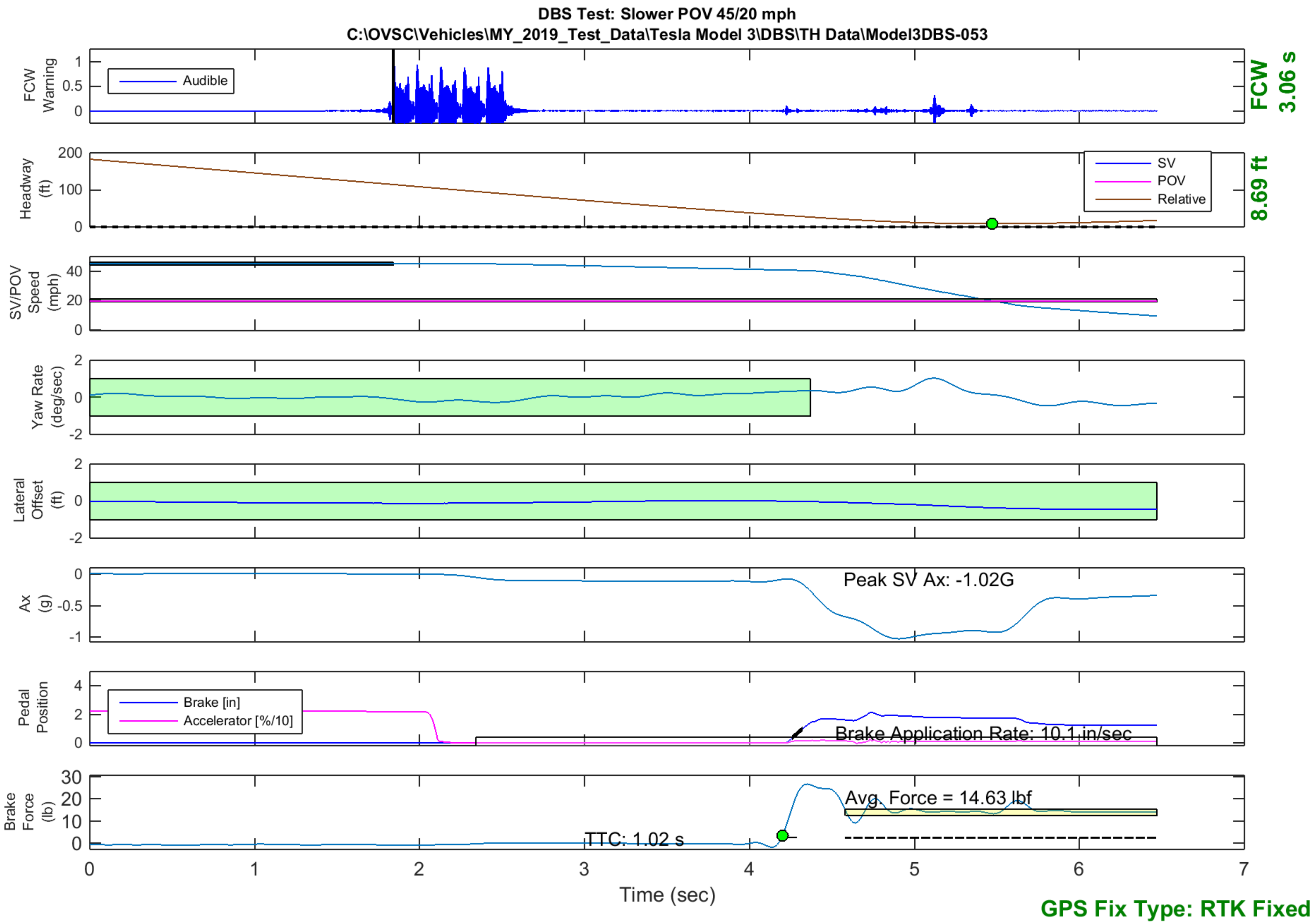


Figure E33. Time History for DBS Run 53, SV Encounters Slower POV, SV 45 mph, POV 20 mph

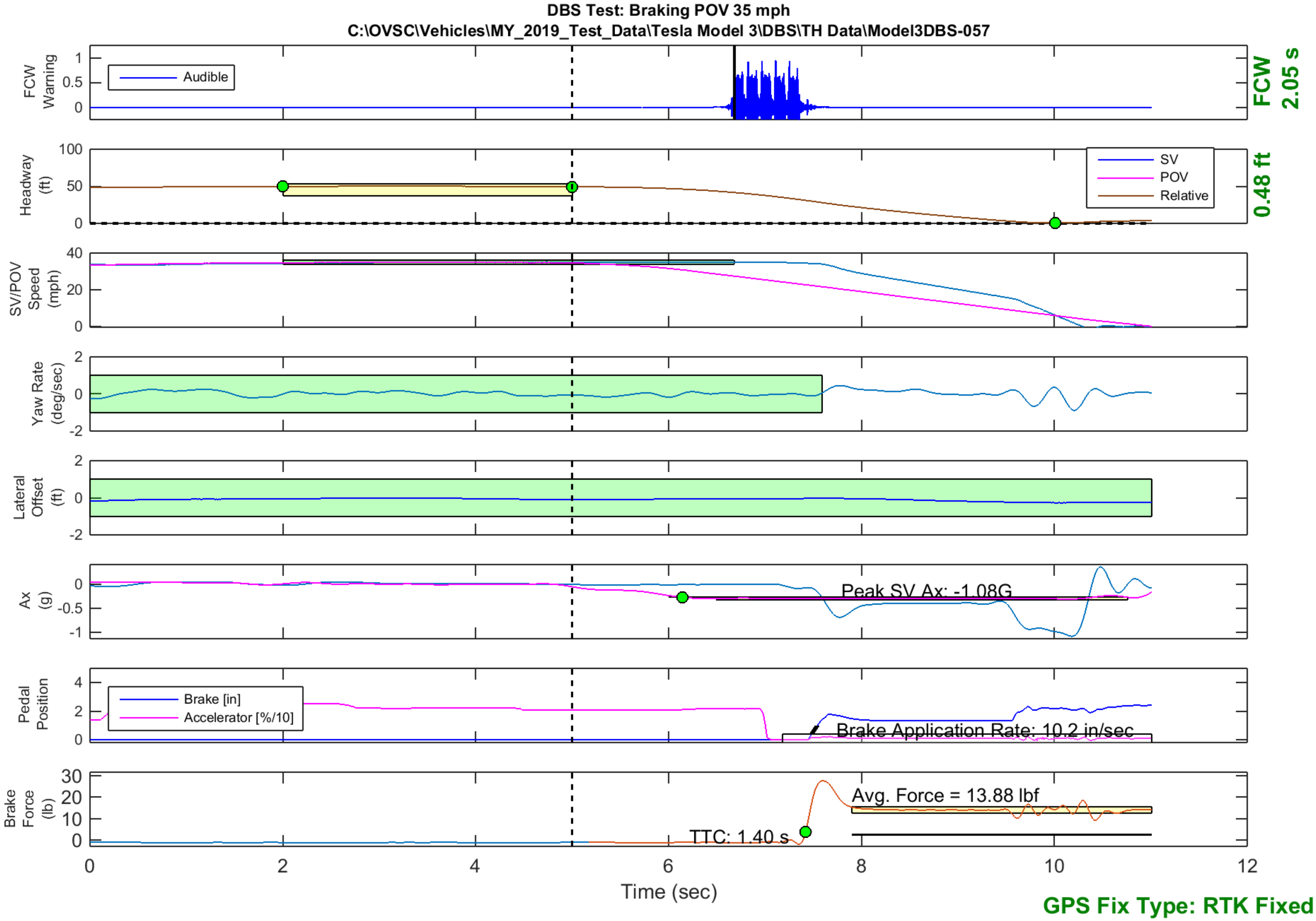


Figure E34. Time History for DBS Run 57, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

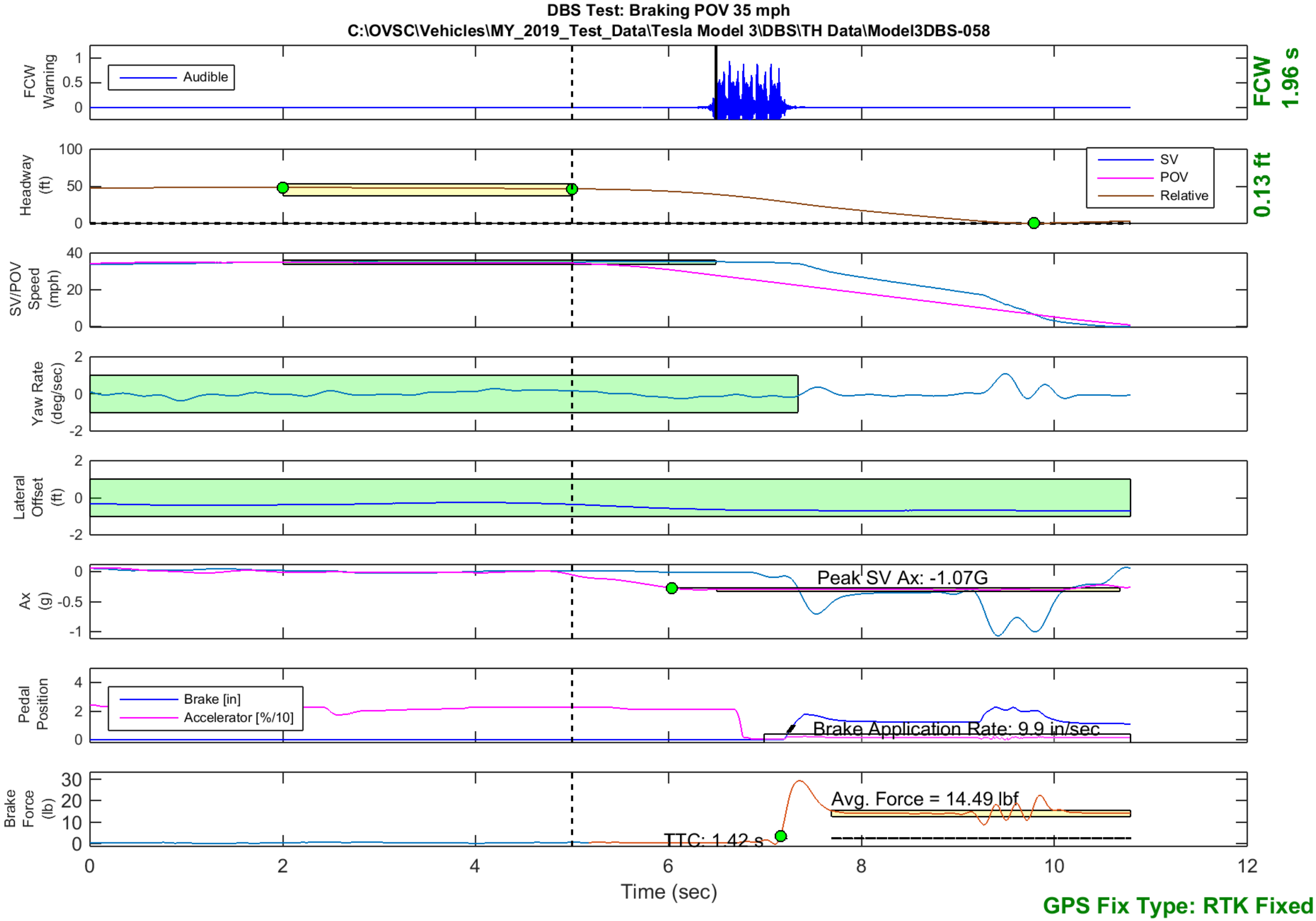


Figure E35. Time History for DBS Run 58, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

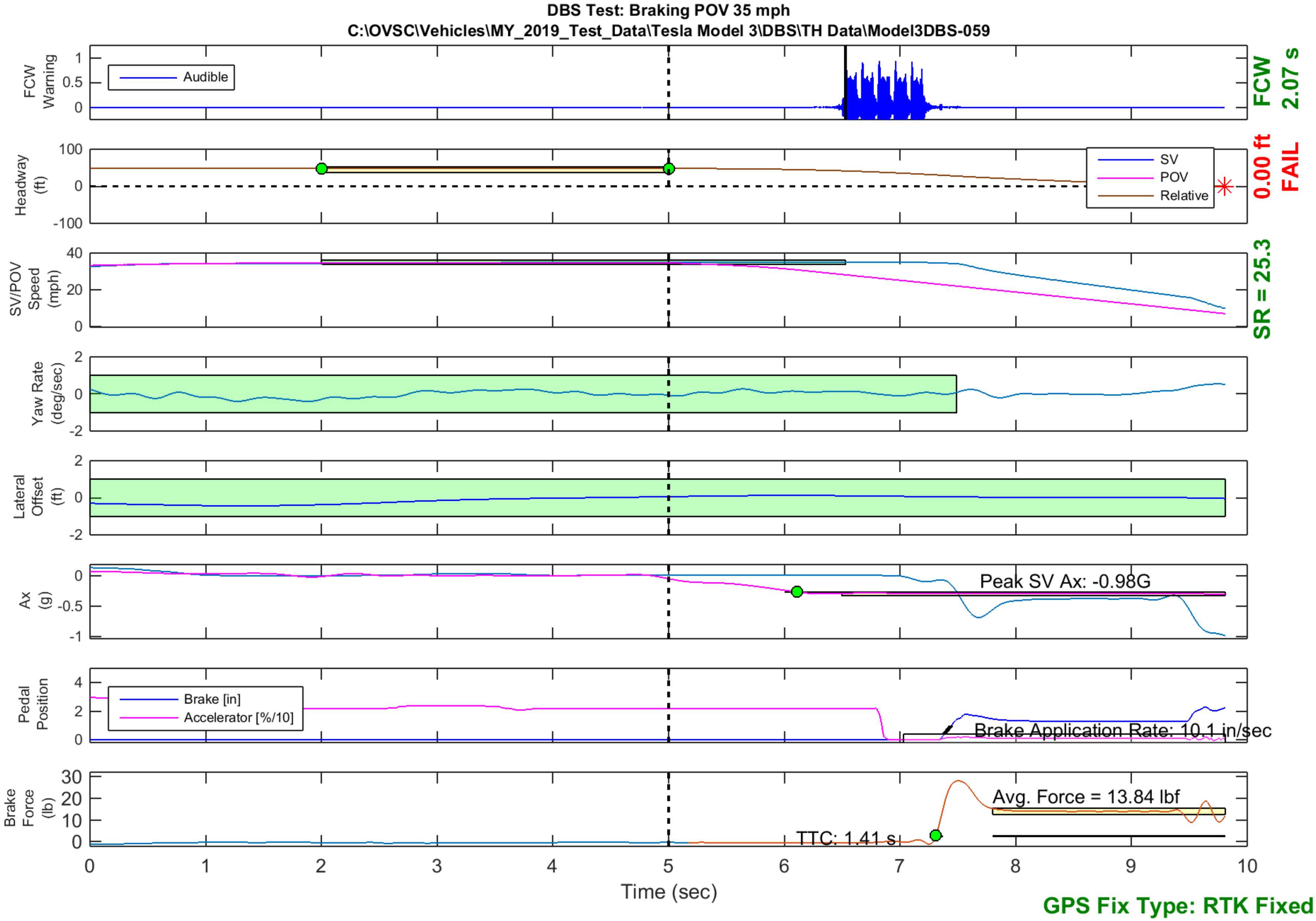


Figure E36. Time History for DBS Run 59, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

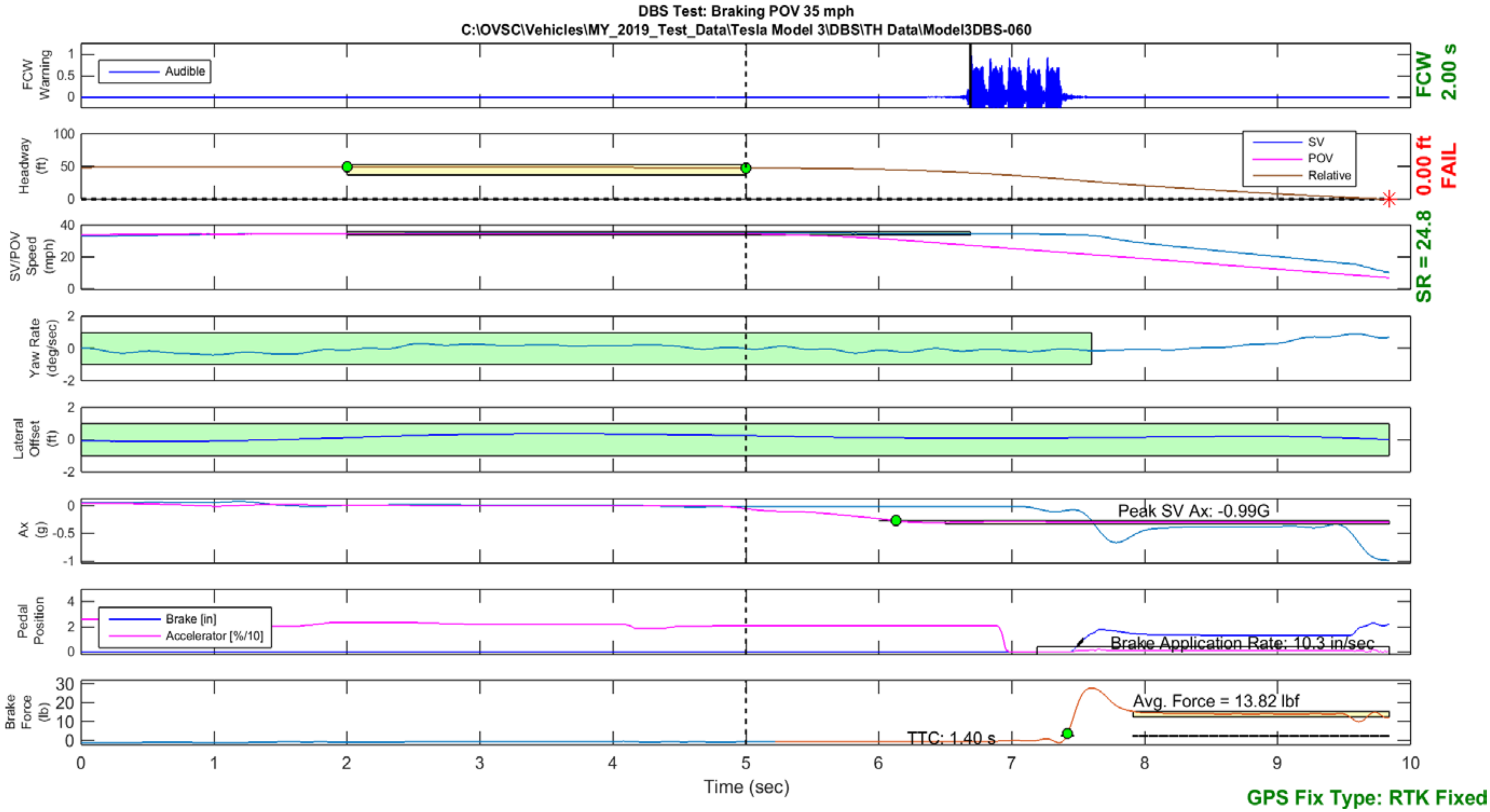


Figure E37. Time History for DBS Run 60, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

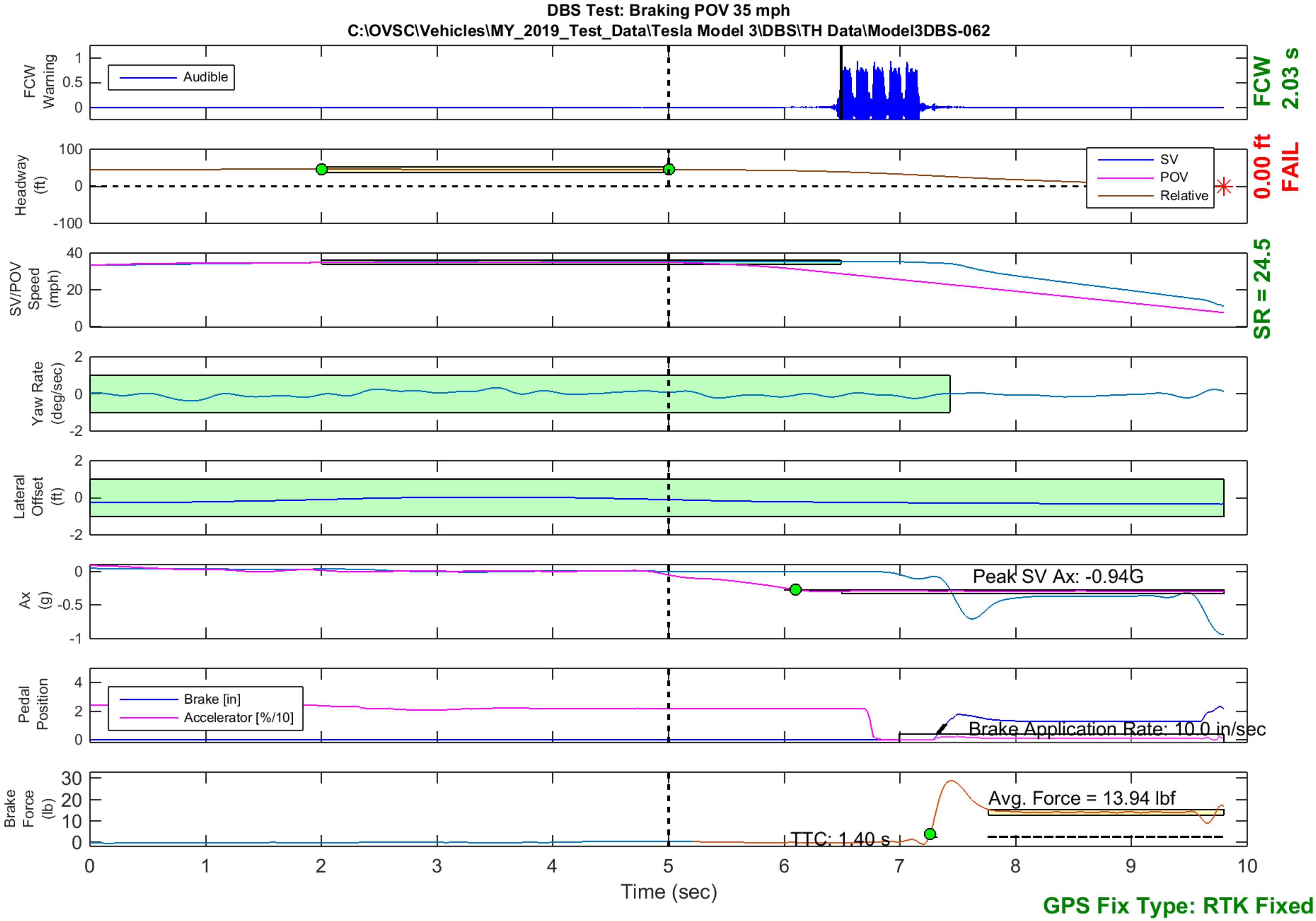


Figure E38. Time History for DBS Run 62, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

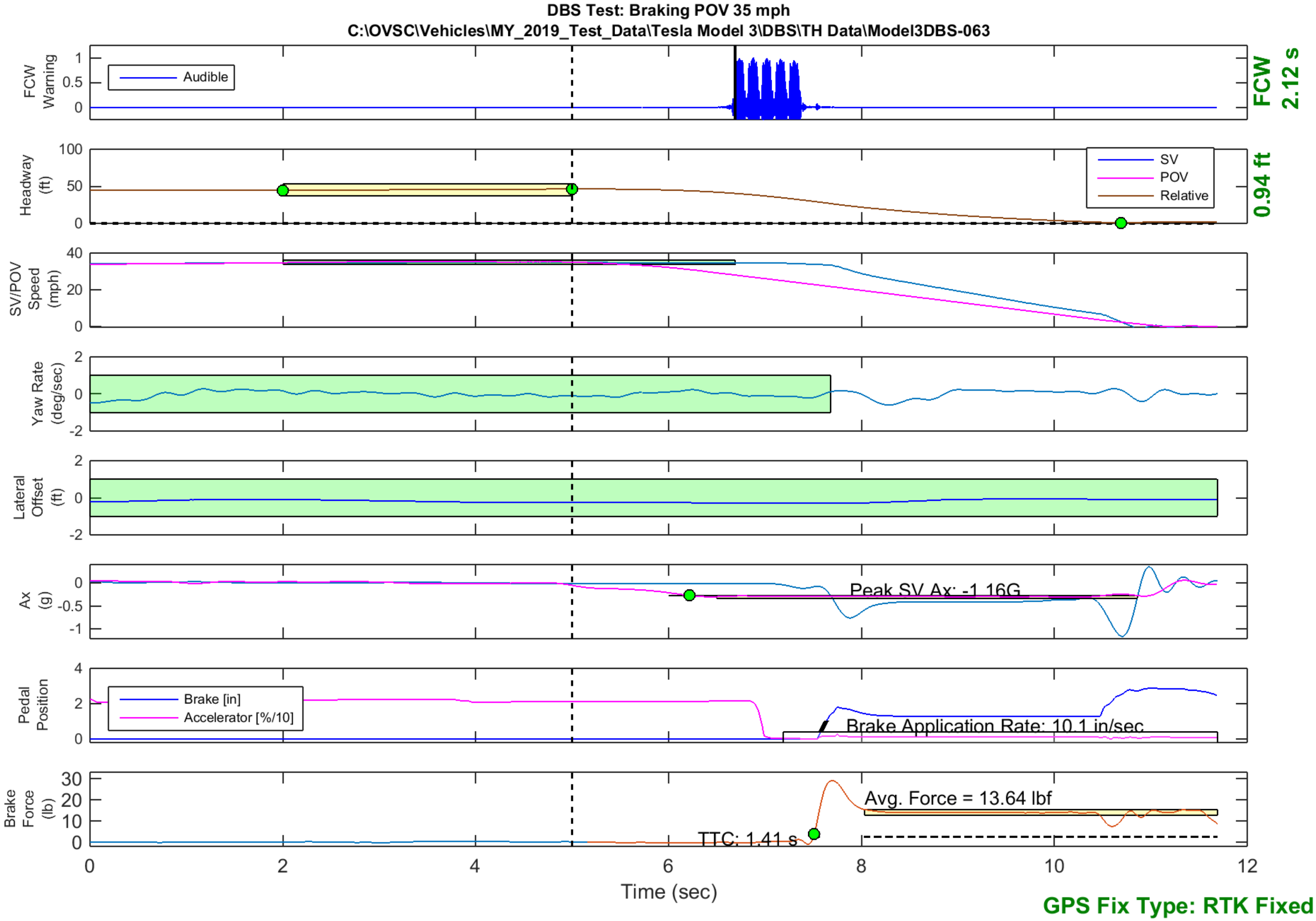


Figure E39. Time History for DBS Run 63, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

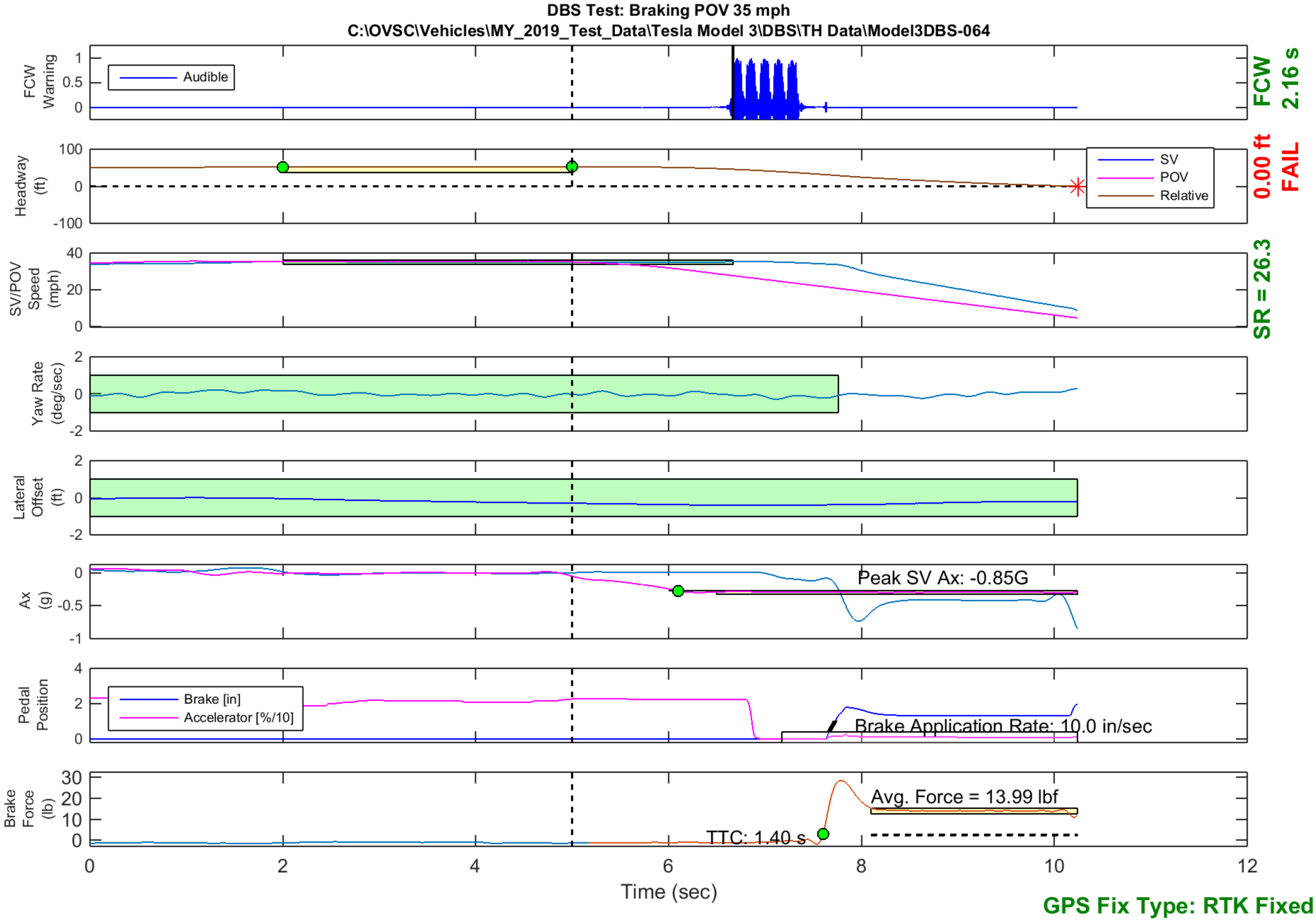


Figure E40. Time History for DBS Run 64, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

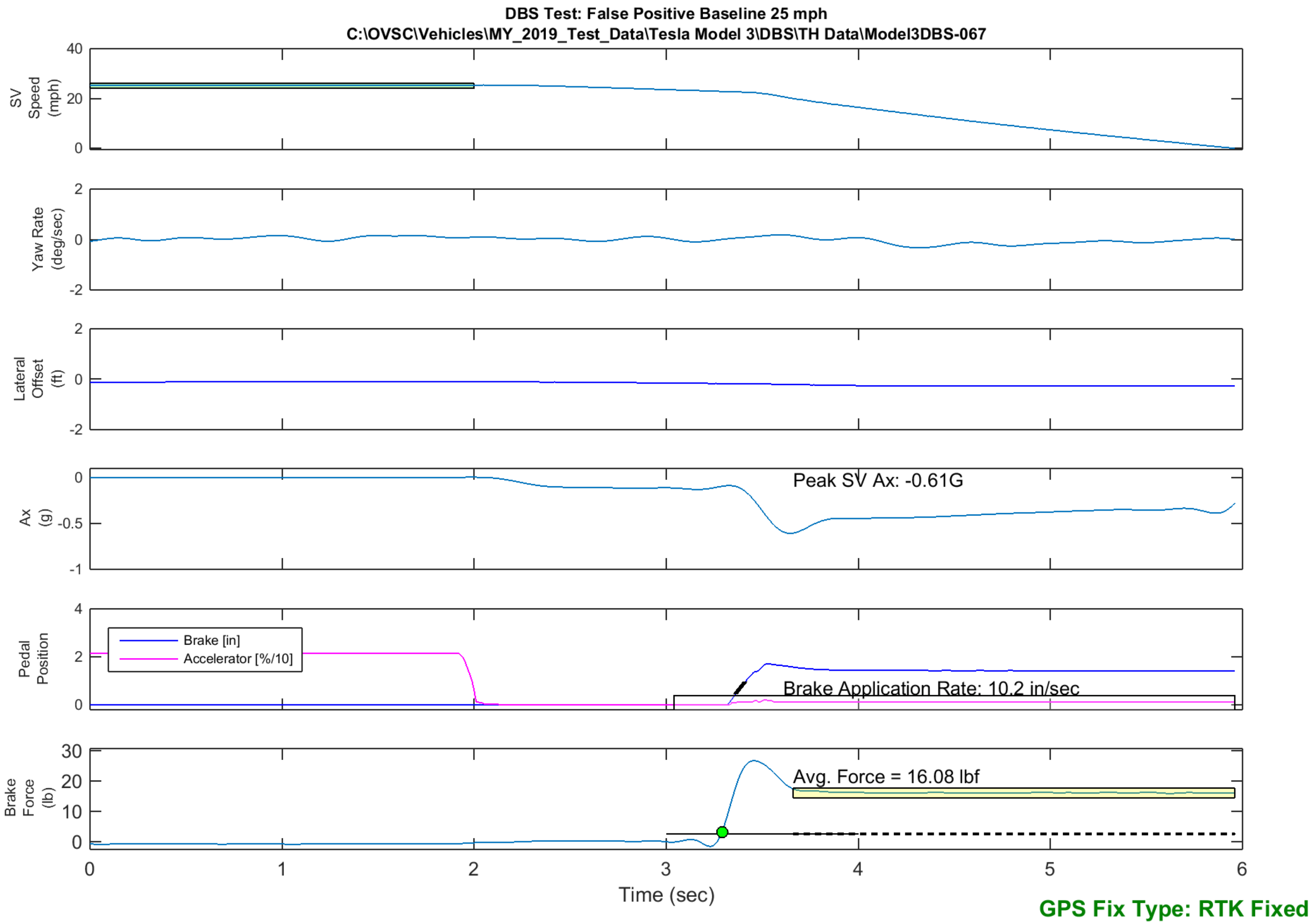


Figure E41. Time History for DBS Run 67, False Positive Baseline, SV 25 mph

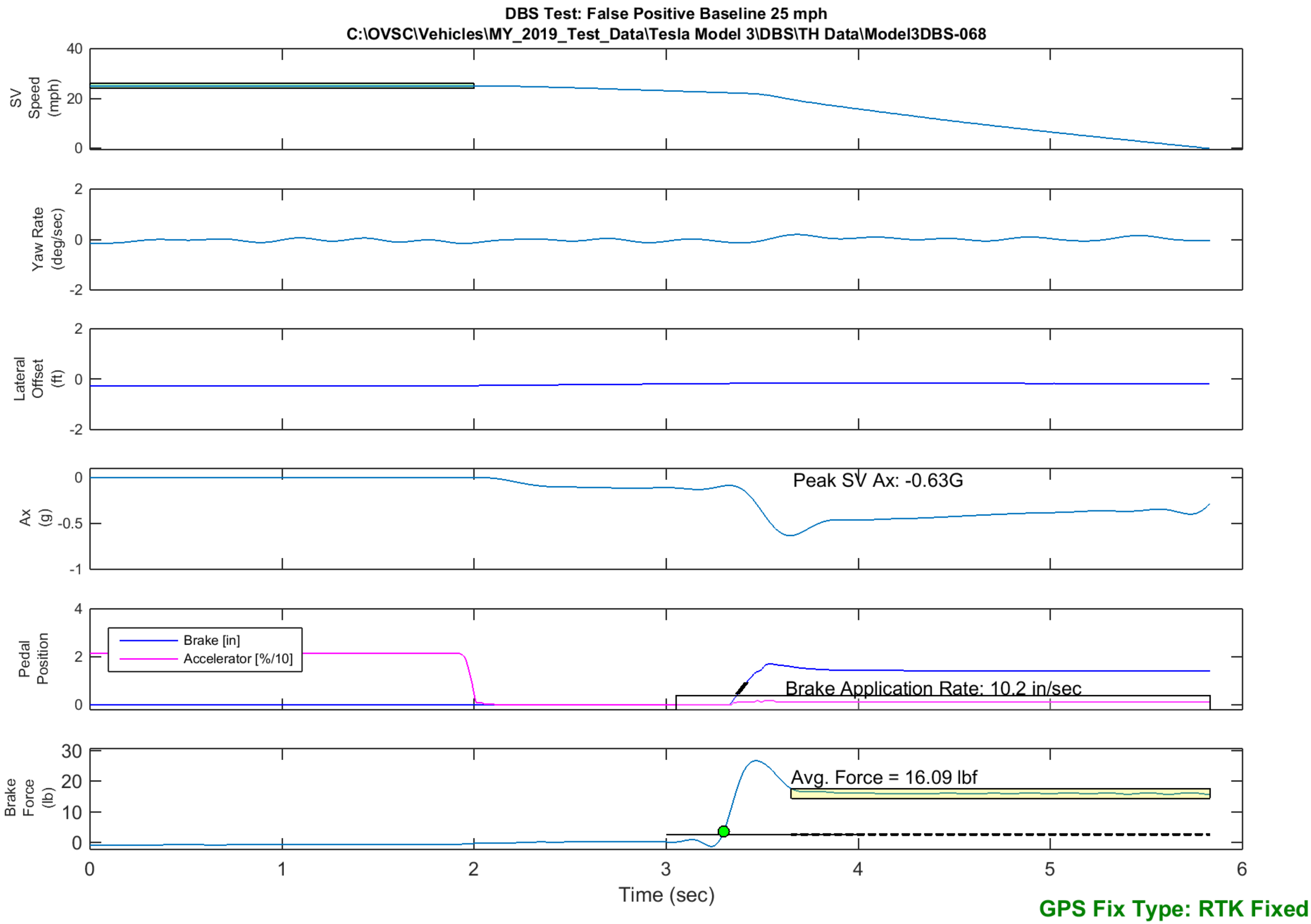


Figure E42. Time History for DBS Run 68, False Positive Baseline, SV 25 mph

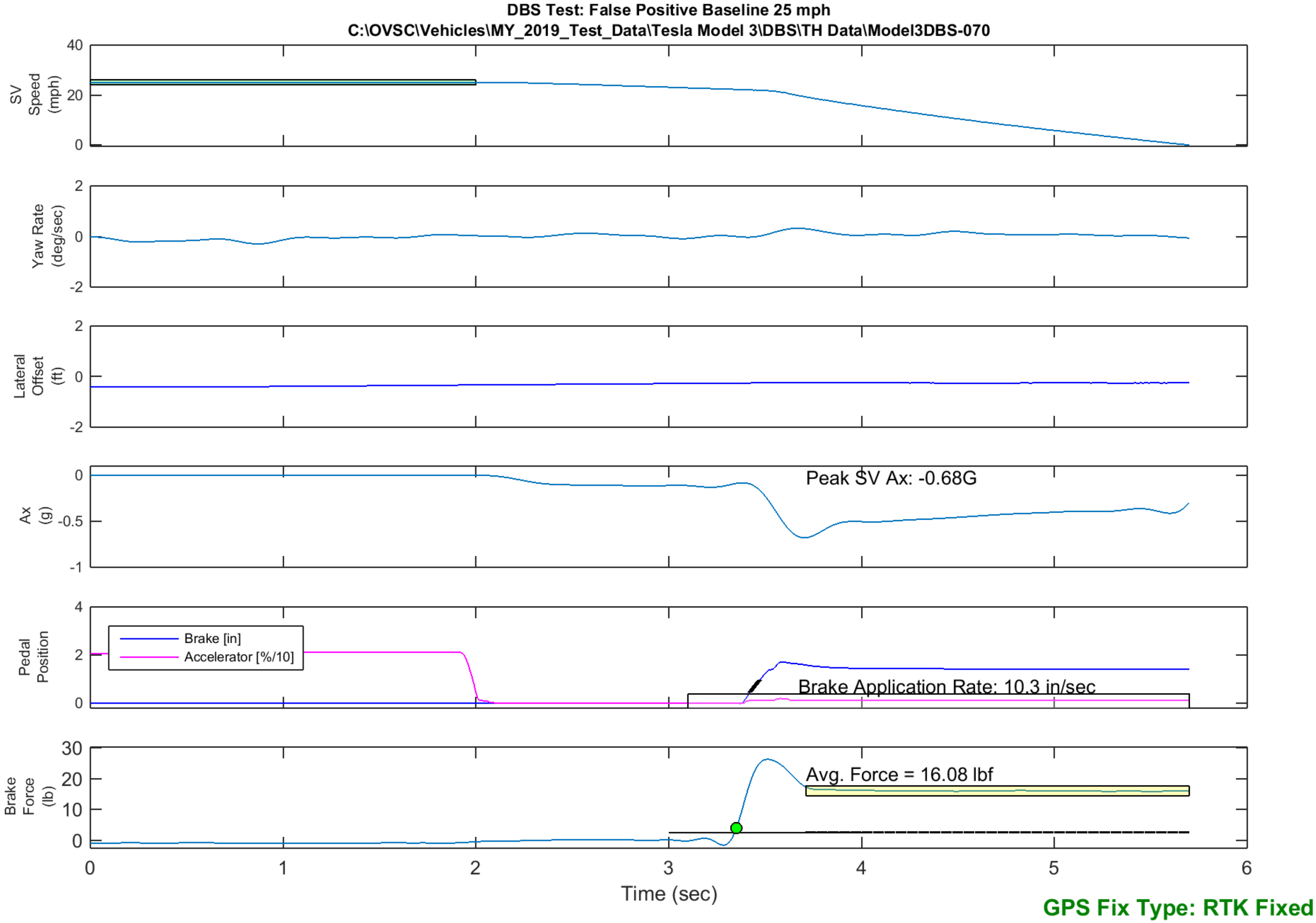


Figure E43. Time History for DBS Run 70, False Positive Baseline, SV 25 mph

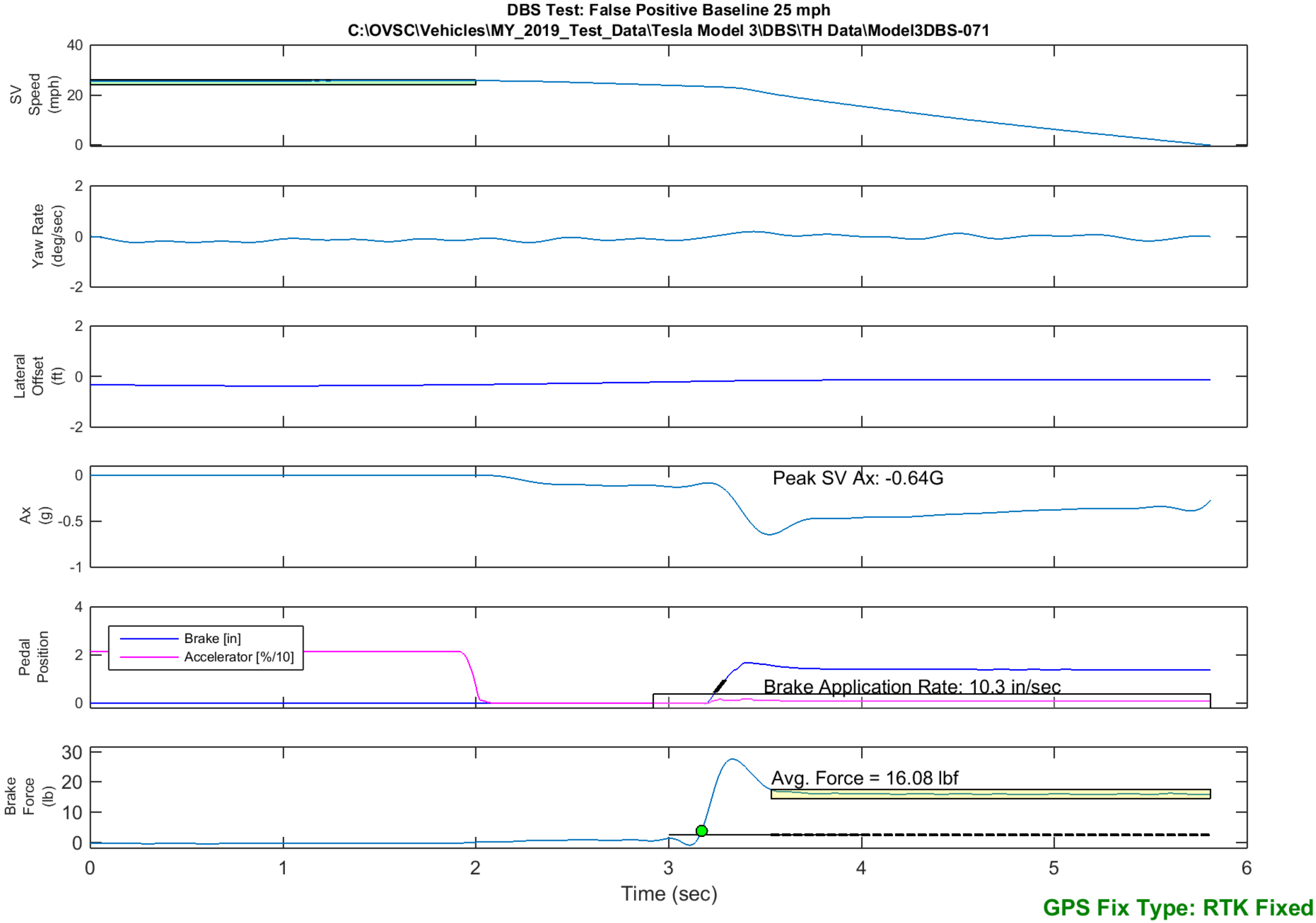


Figure E44. Time History for DBS Run 71, False Positive Baseline, SV 25 mph

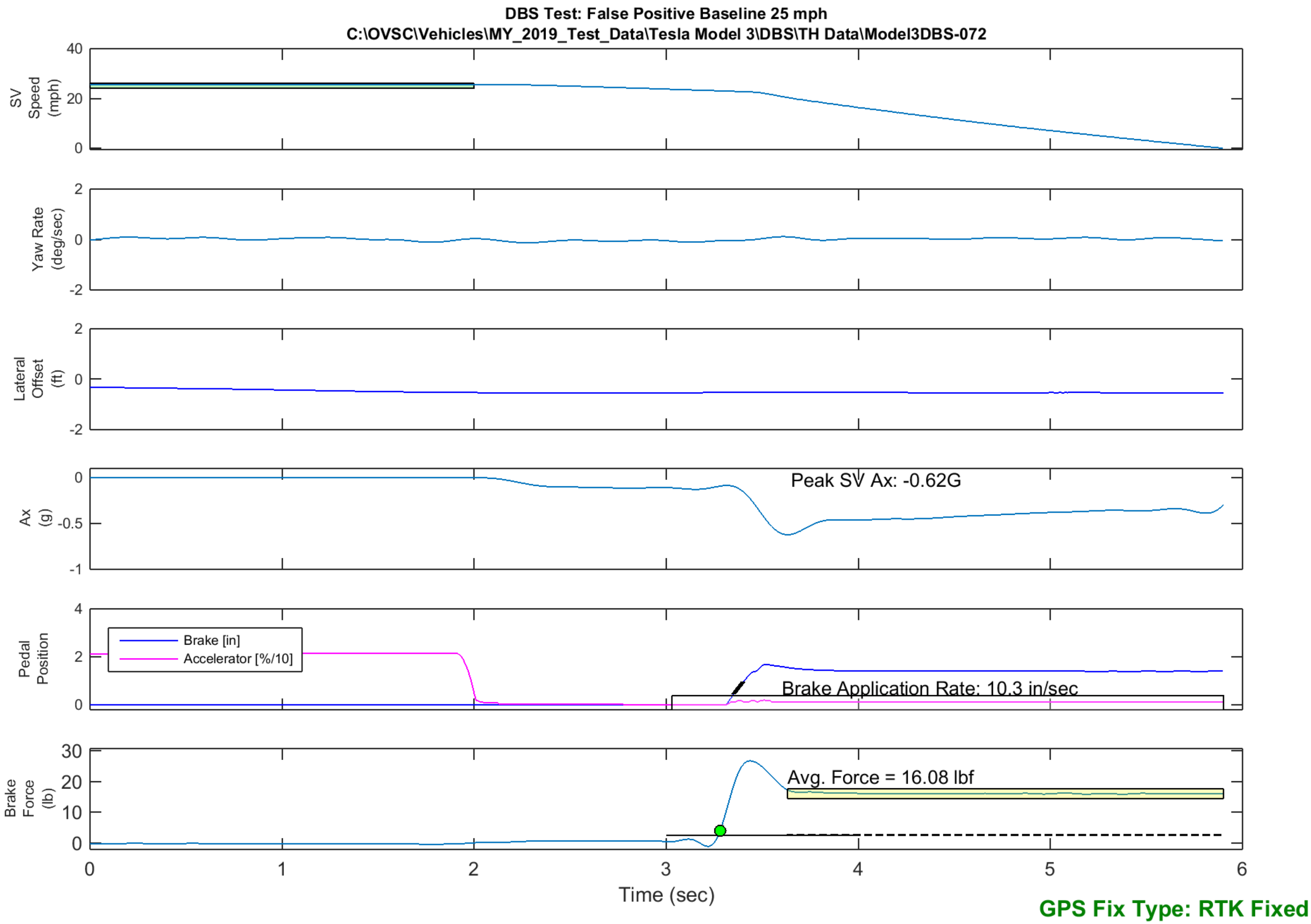


Figure E45. Time History for DBS Run 72, False Positive Baseline, SV 25 mph

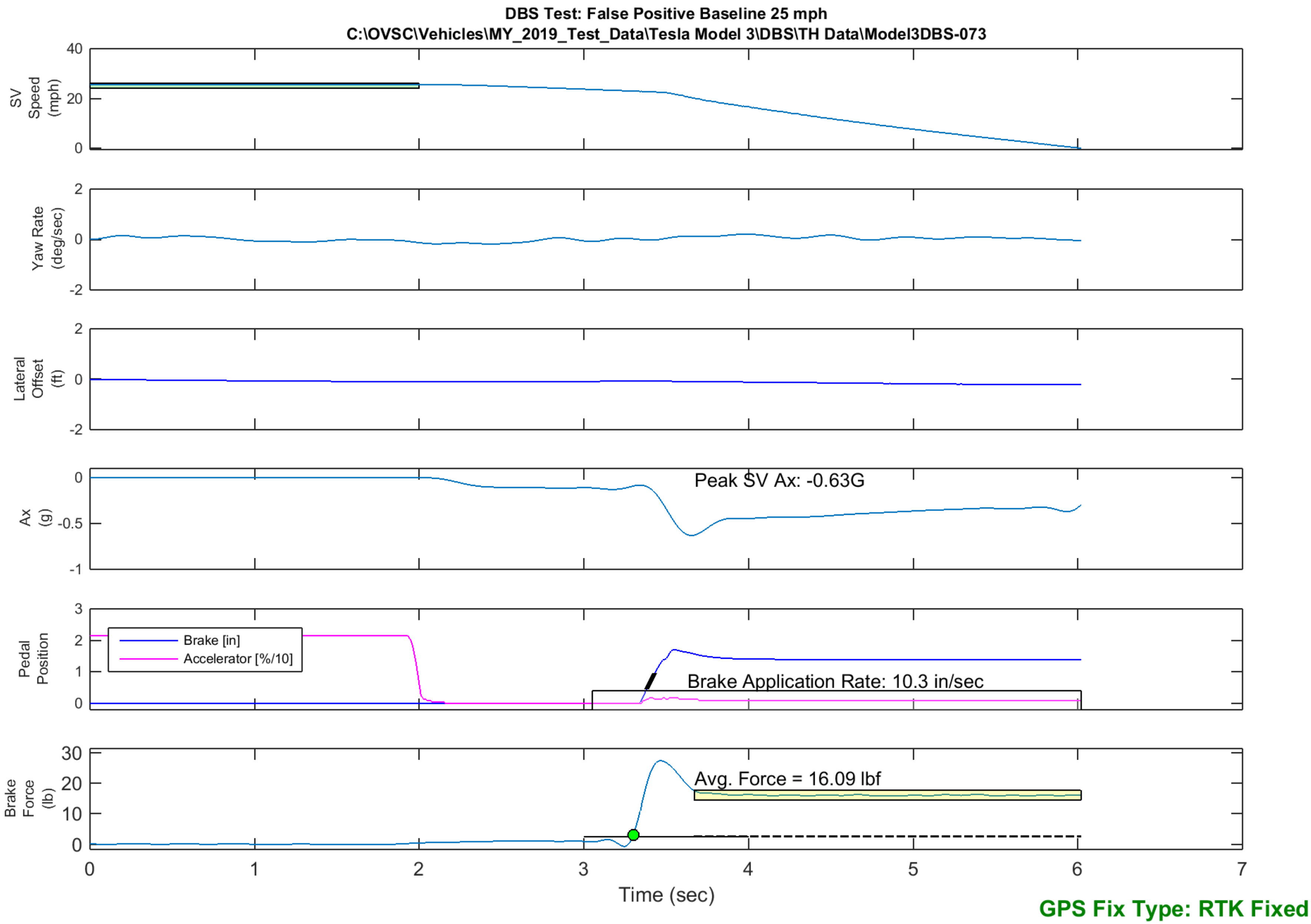


Figure E46. Time History for DBS Run 73, False Positive Baseline, SV 25 mph

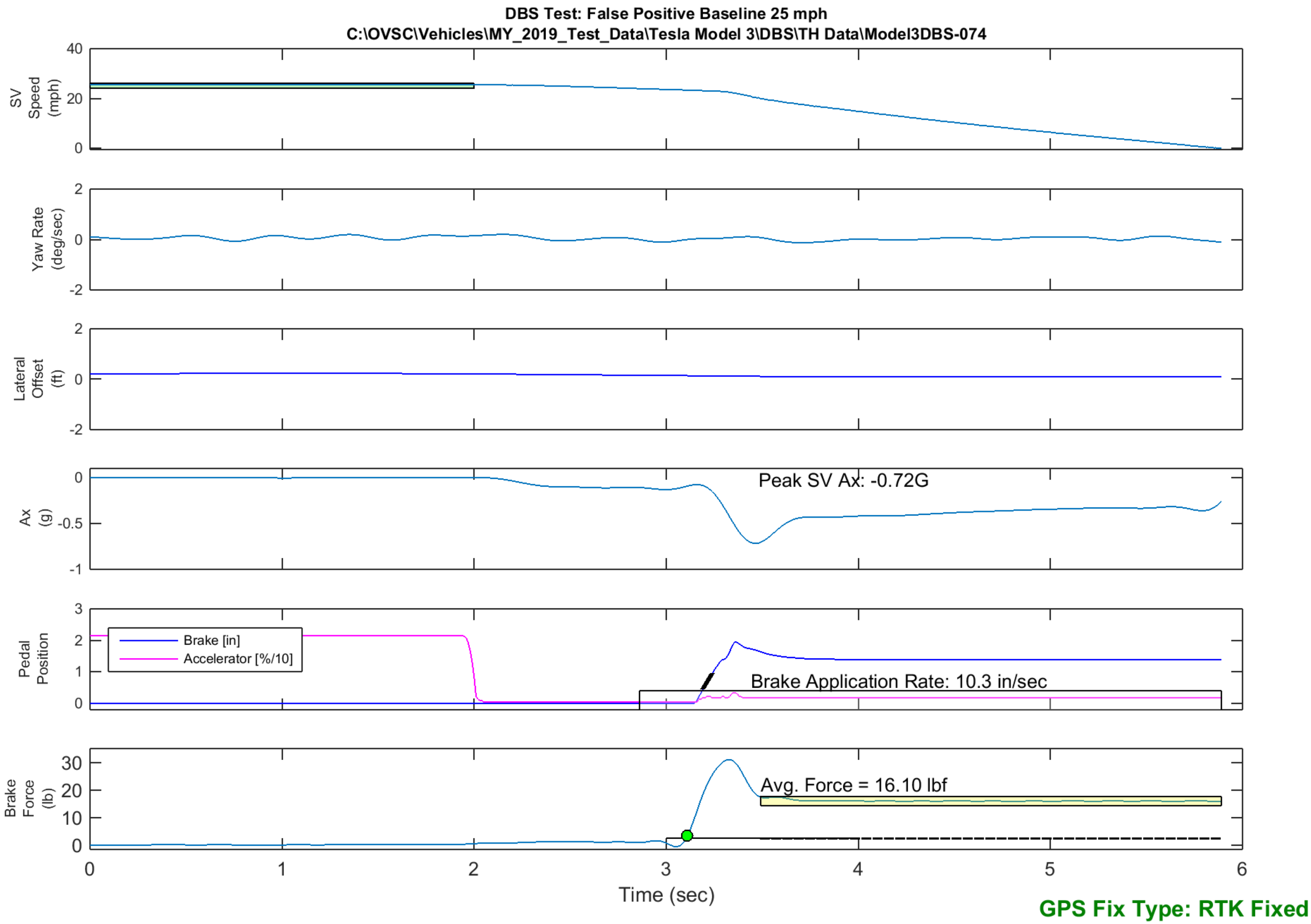


Figure E47. Time History for DBS Run 74, False Positive Baseline, SV 25 mph

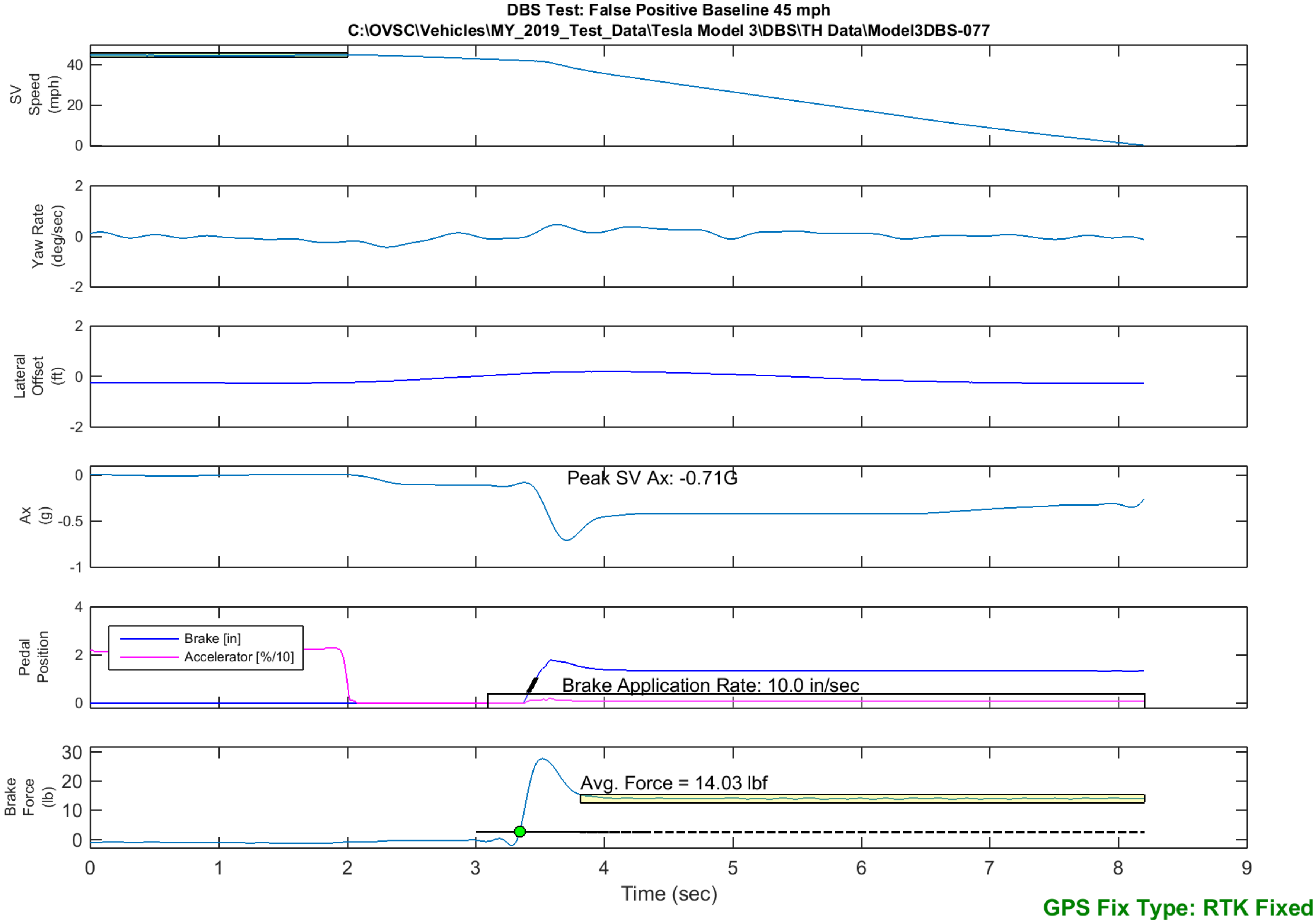


Figure E48. Time History for DBS Run 77, False Positive Baseline, SV 45 mph

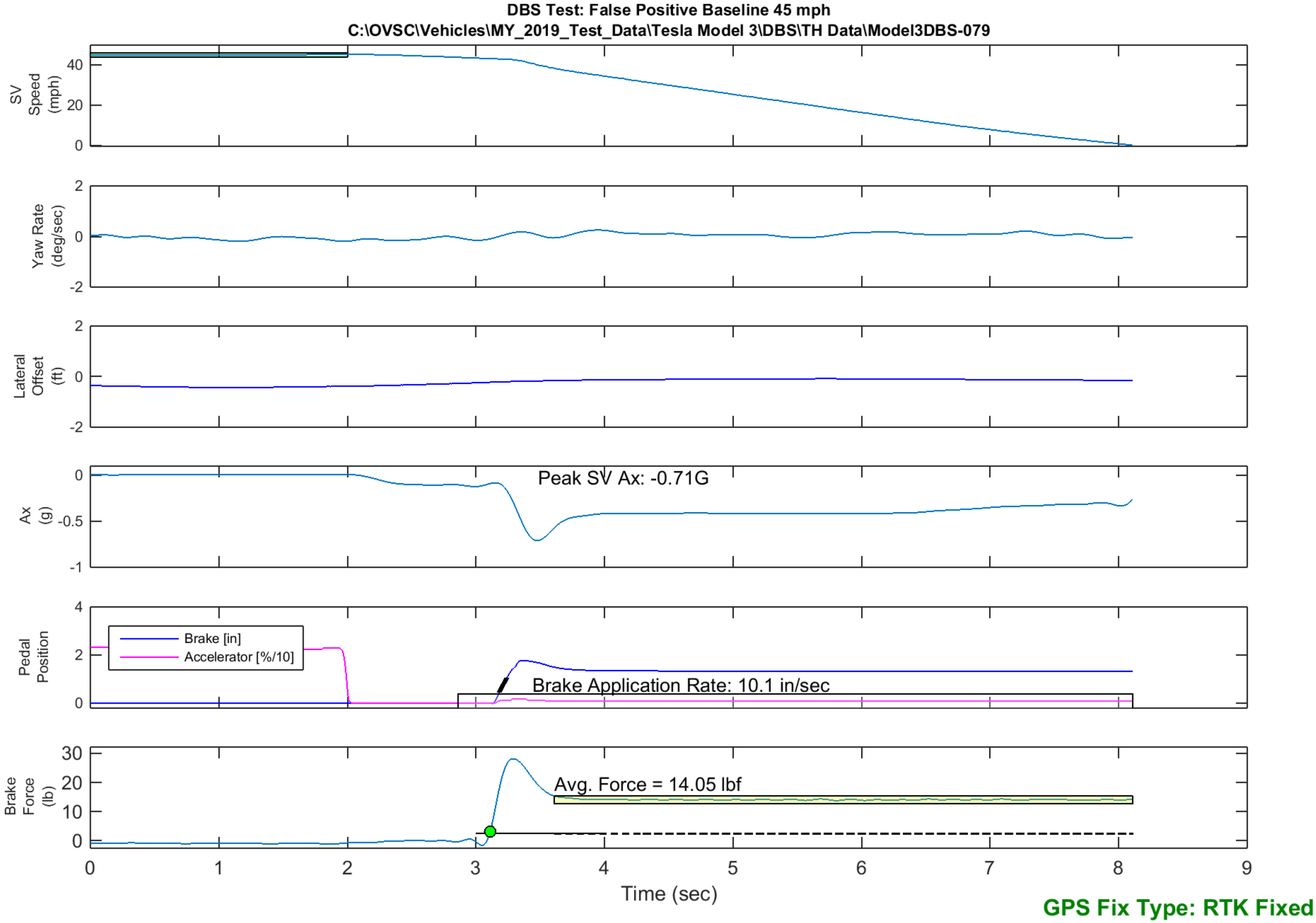


Figure E49. Time History for DBS Run 79, False Positive Baseline, SV 45 mph

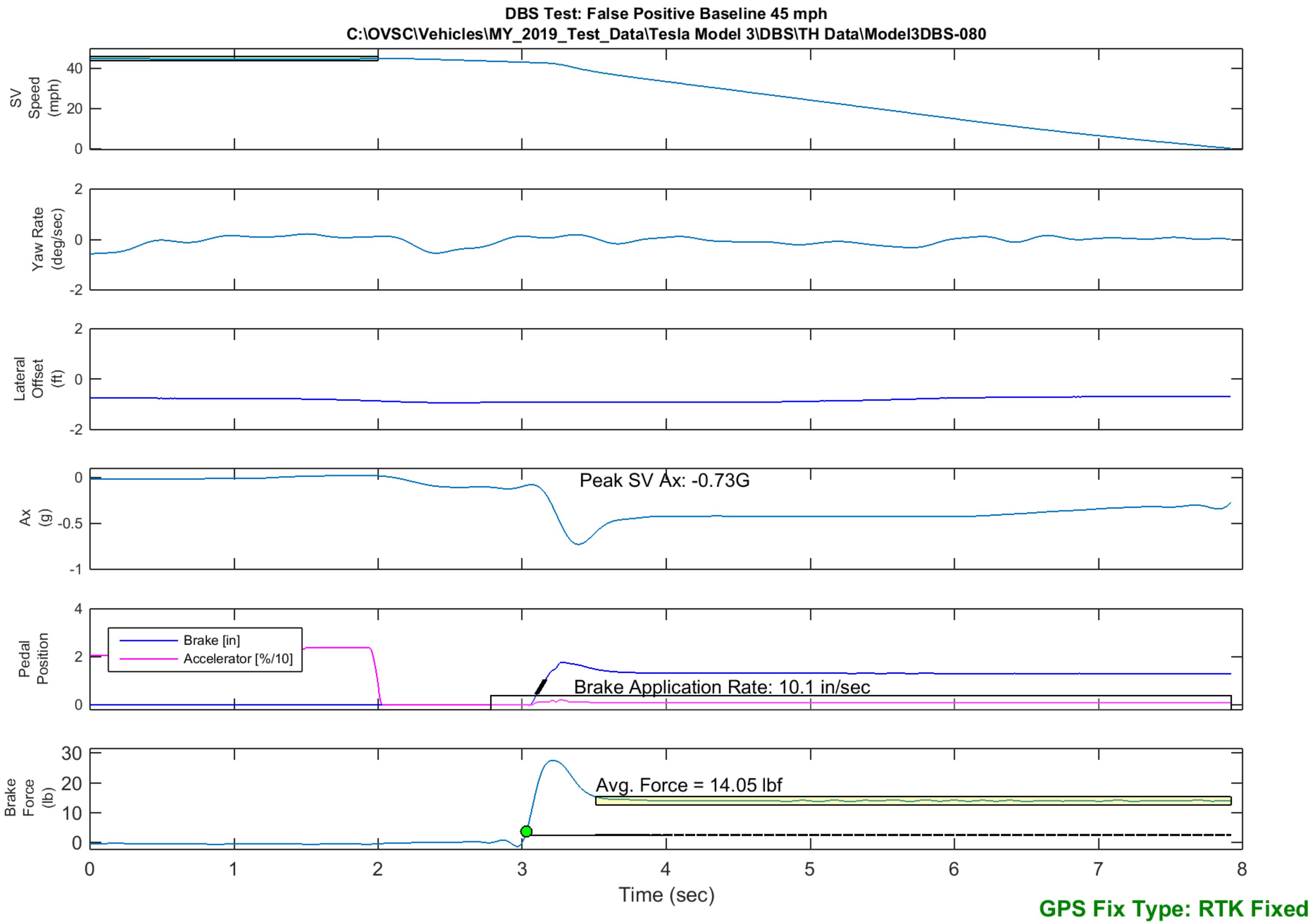


Figure E50. Time History for DBS Run 80, False Positive Baseline, SV 45 mph

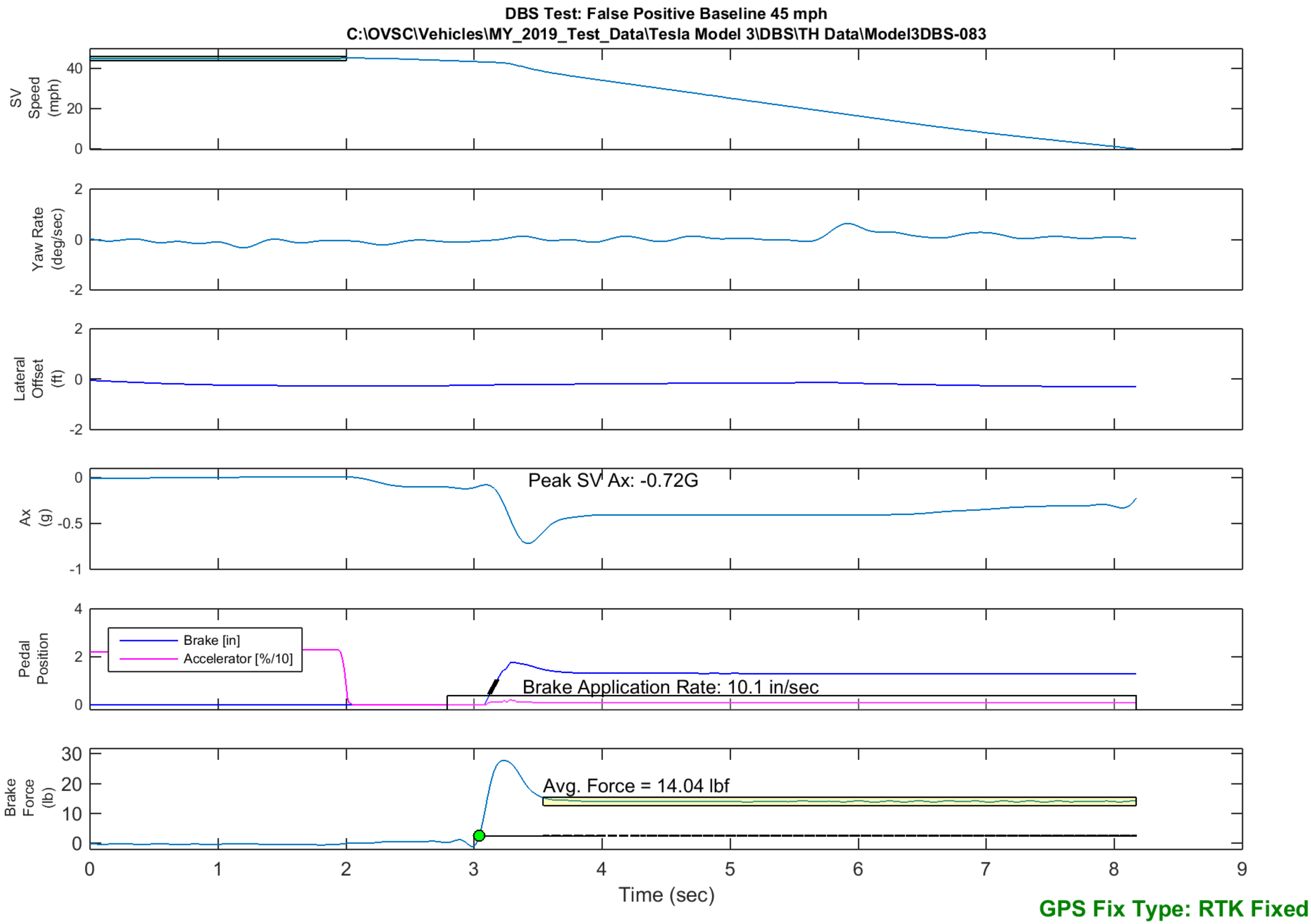


Figure E51. Time History for DBS Run 83, False Positive Baseline, SV 45 mph

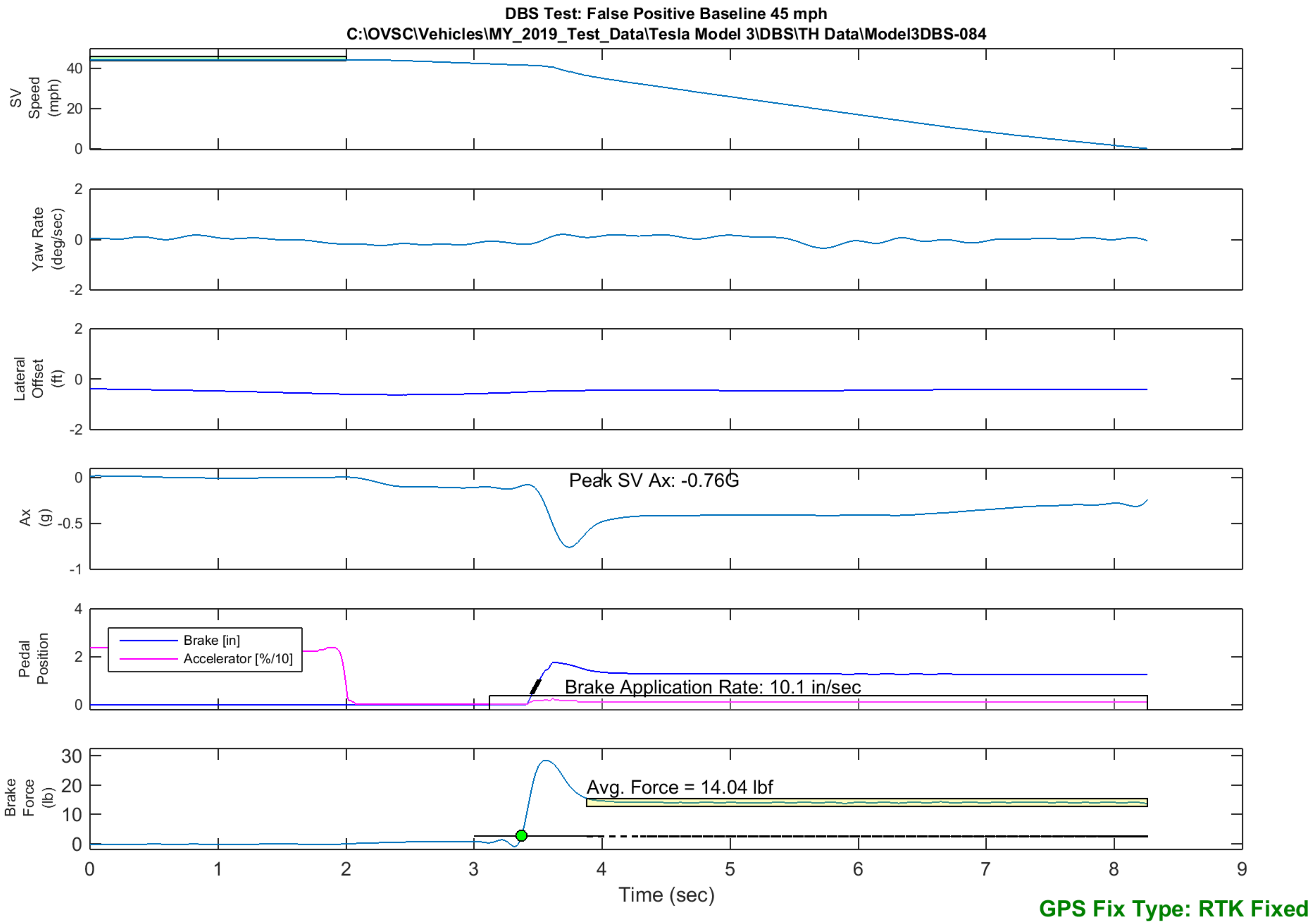


Figure E52. Time History for DBS Run 84, False Positive Baseline, SV 45 mph

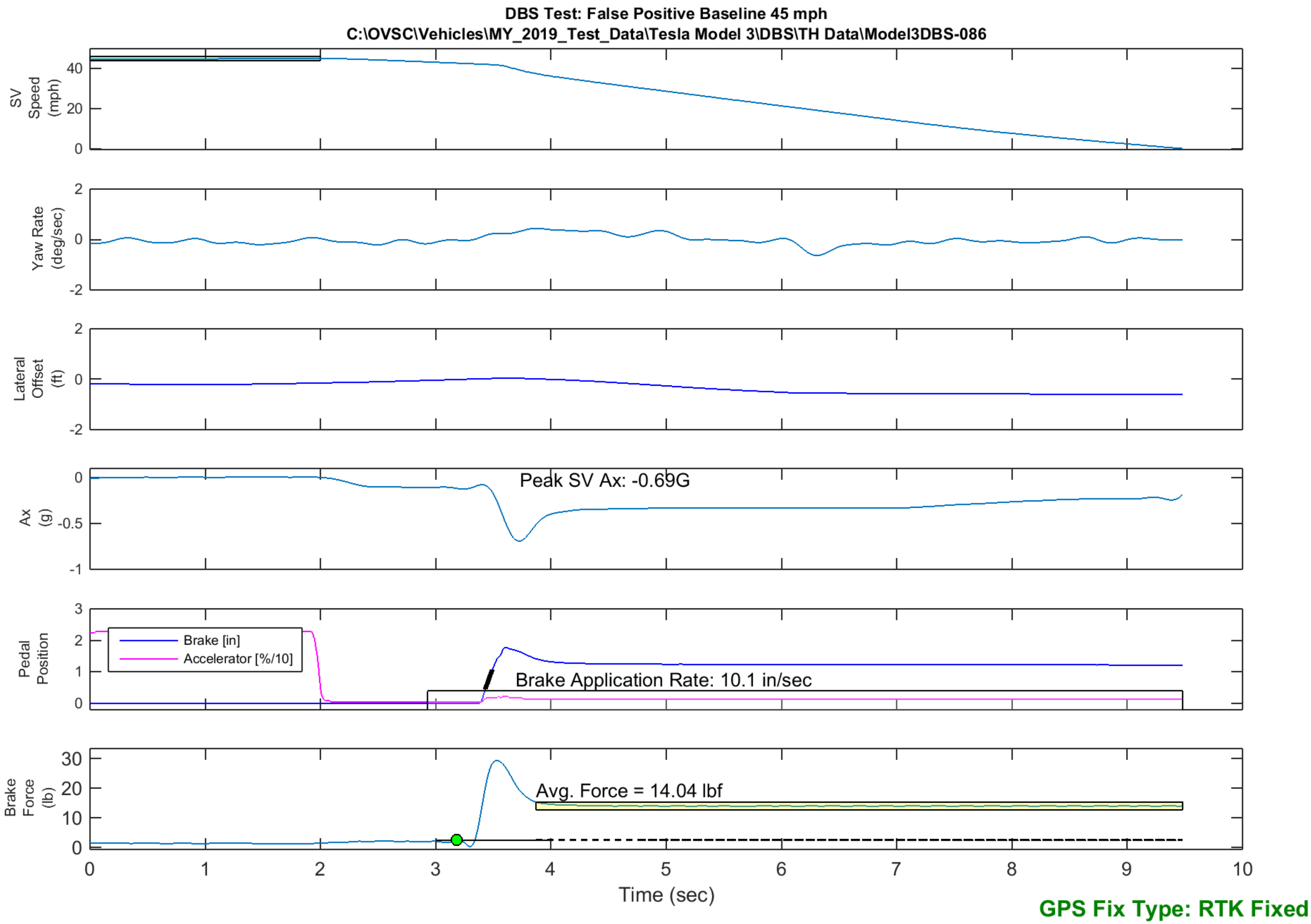


Figure E53. Time History for DBS Run 86, False Positive Baseline, SV 45 mph

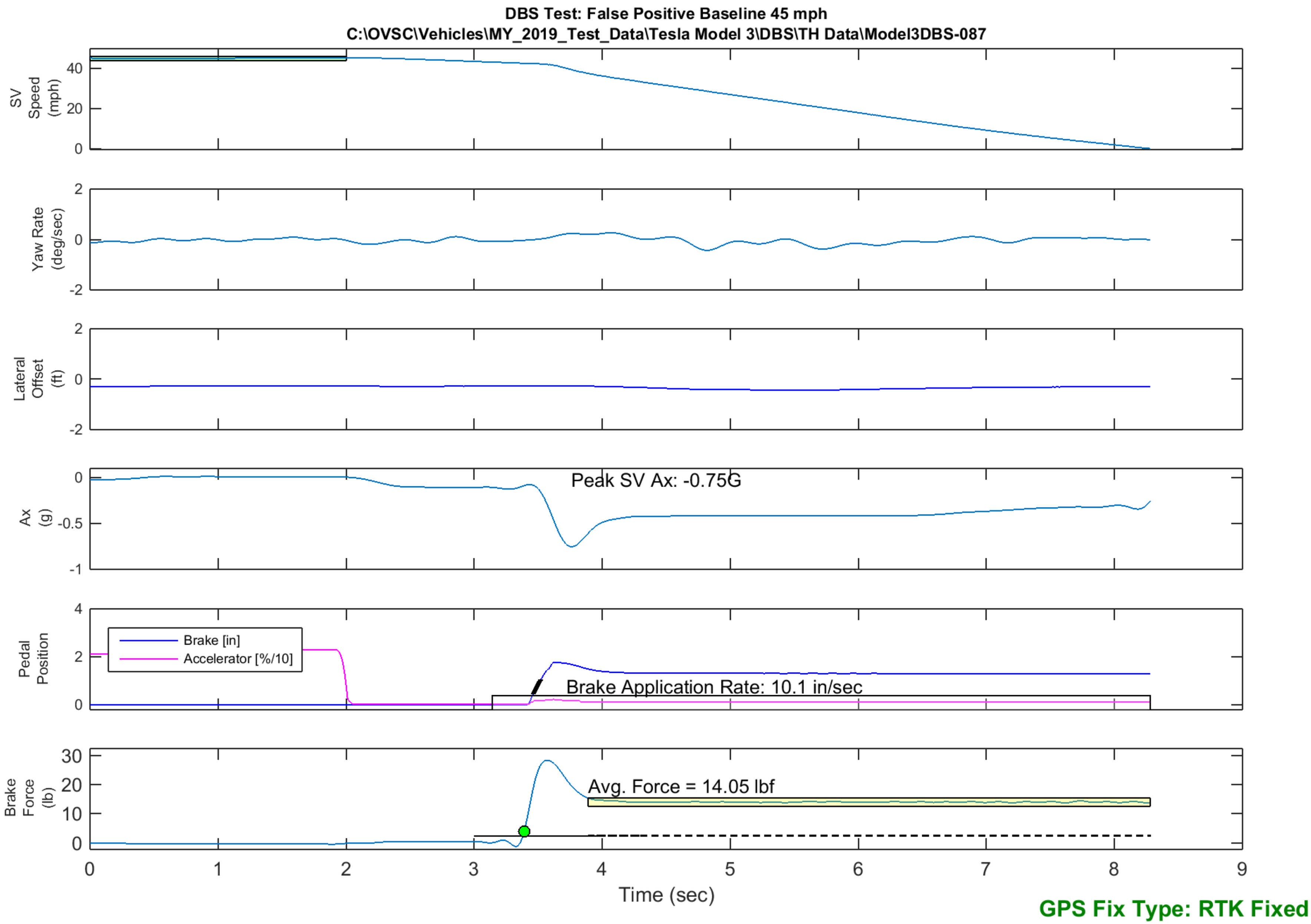


Figure E54. Time History for DBS Run 87, False Positive Baseline, SV 45 mph

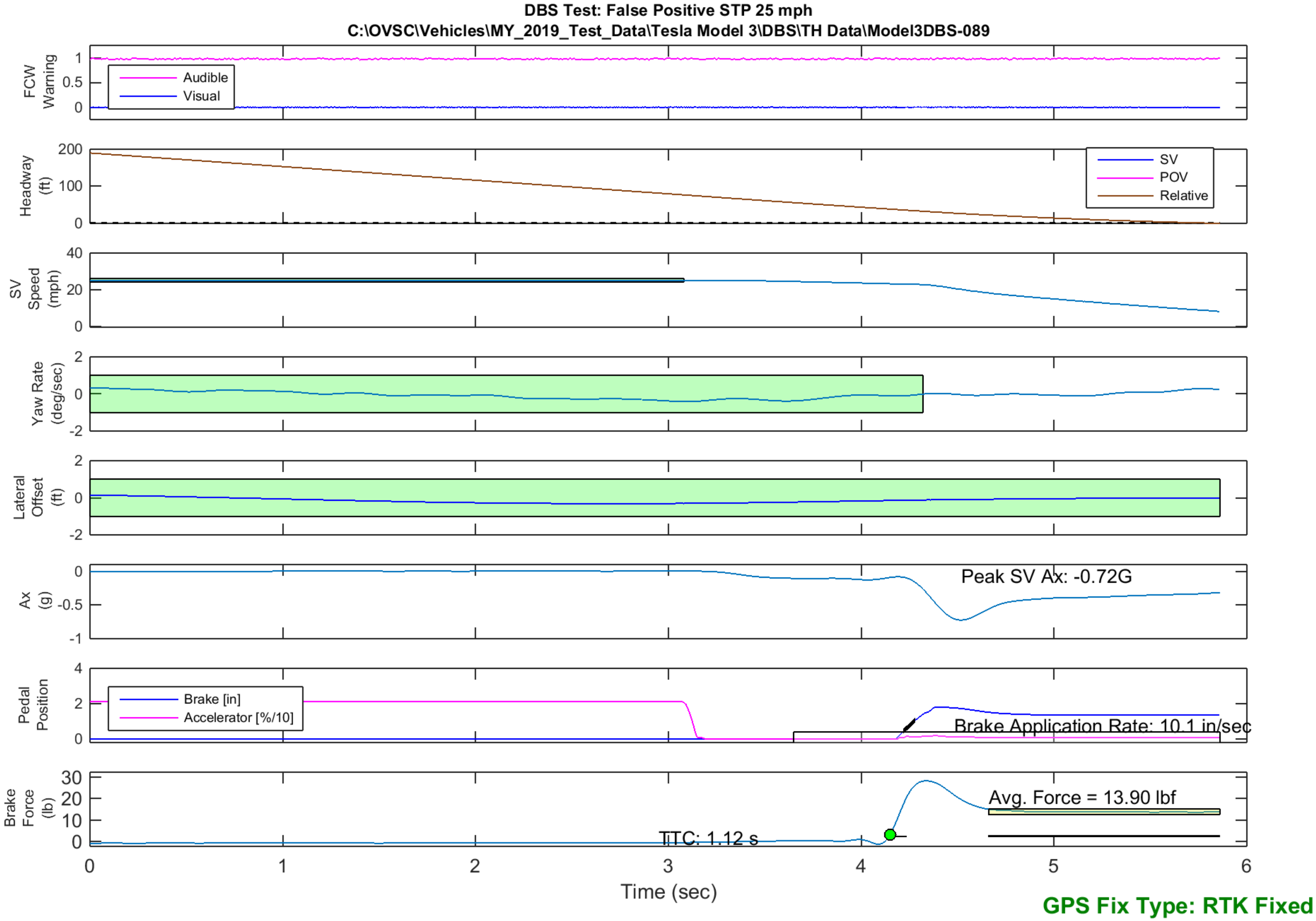


Figure E55. Time History for DBS Run 89, SV Encounters Steel Trench Plate, SV 25 mph

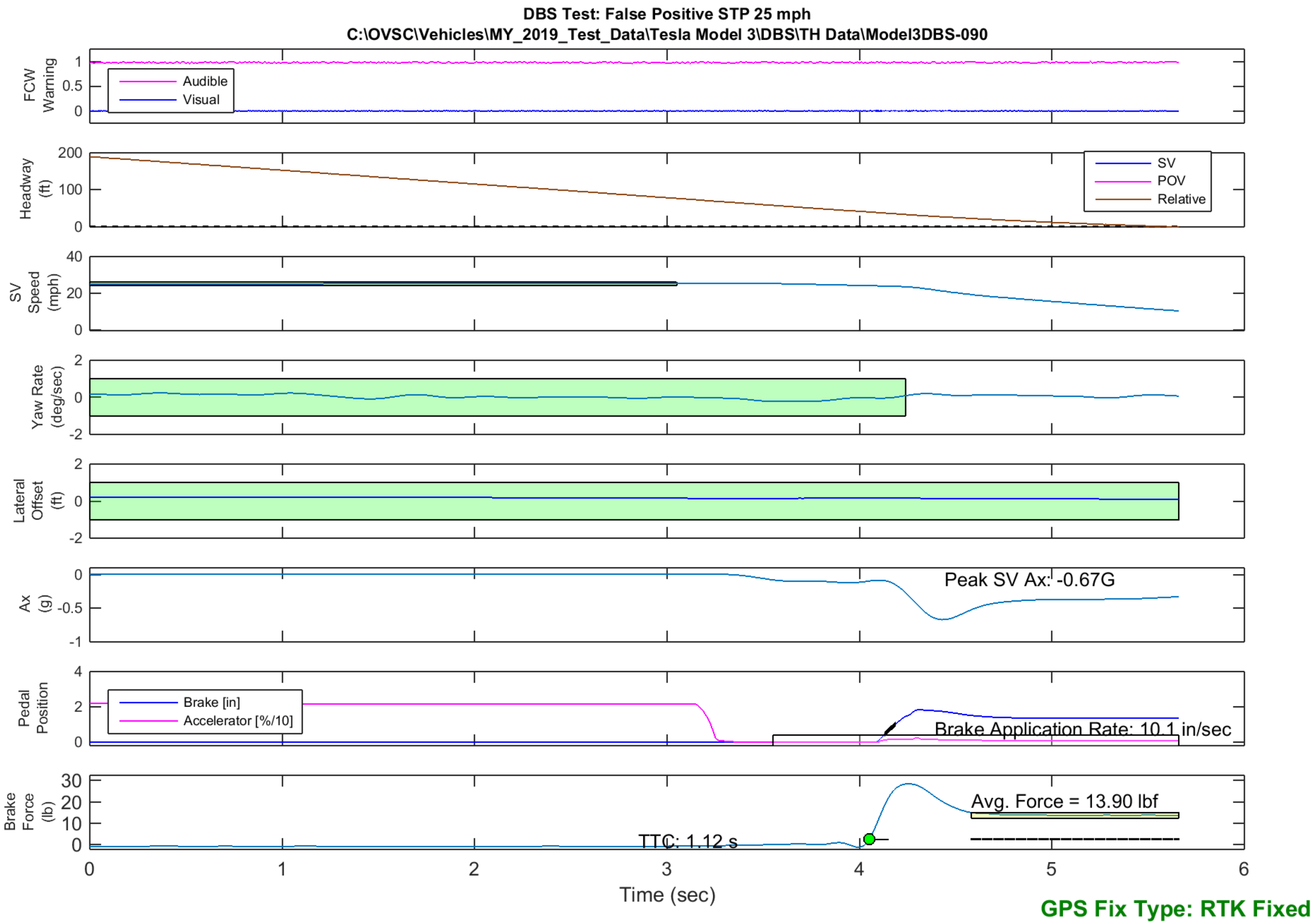


Figure E56. Time History for DBS Run 90, SV Encounters Steel Trench Plate, SV 25 mph

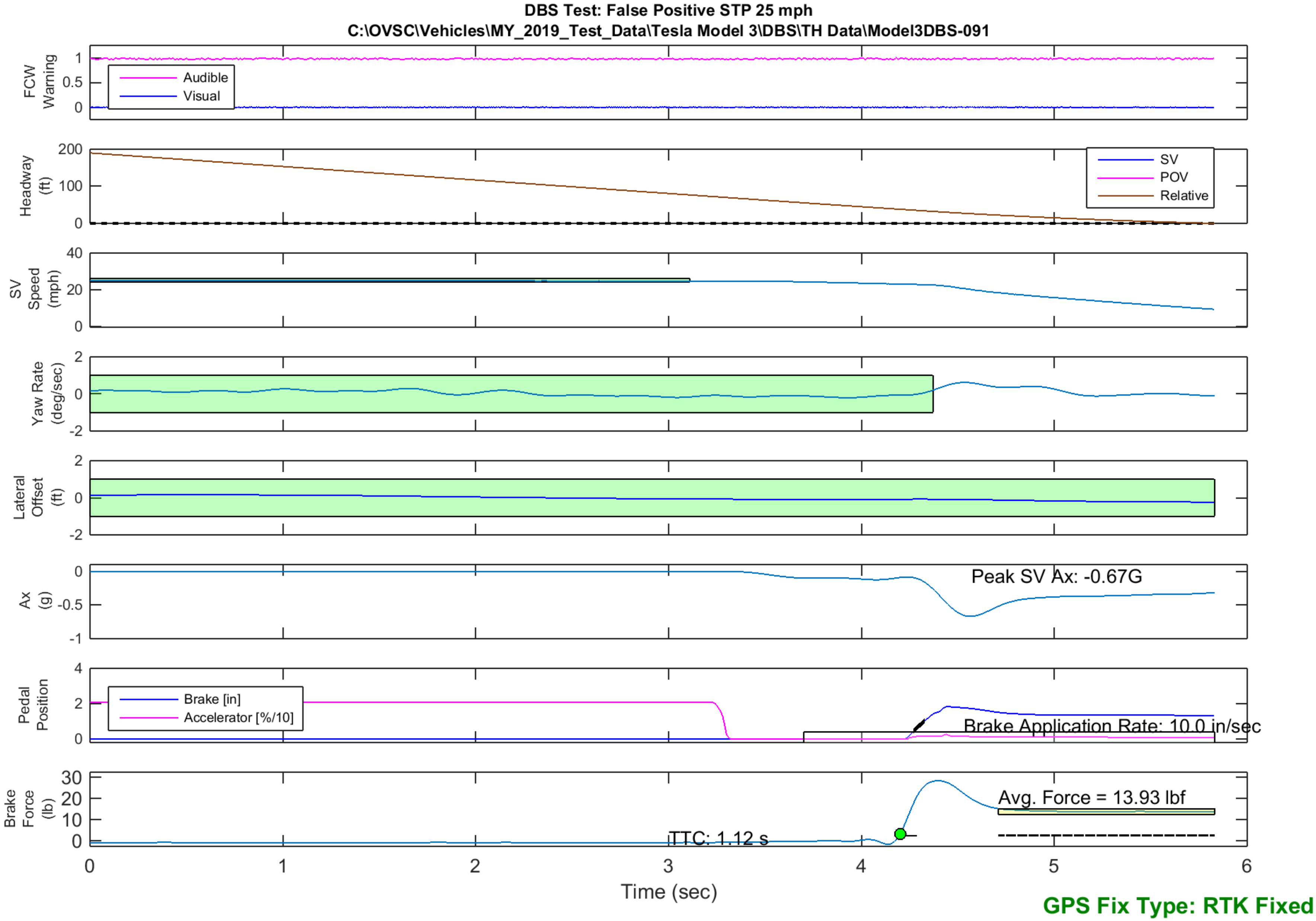


Figure E57. Time History for DBS Run 91, SV Encounters Steel Trench Plate, SV 25 mph

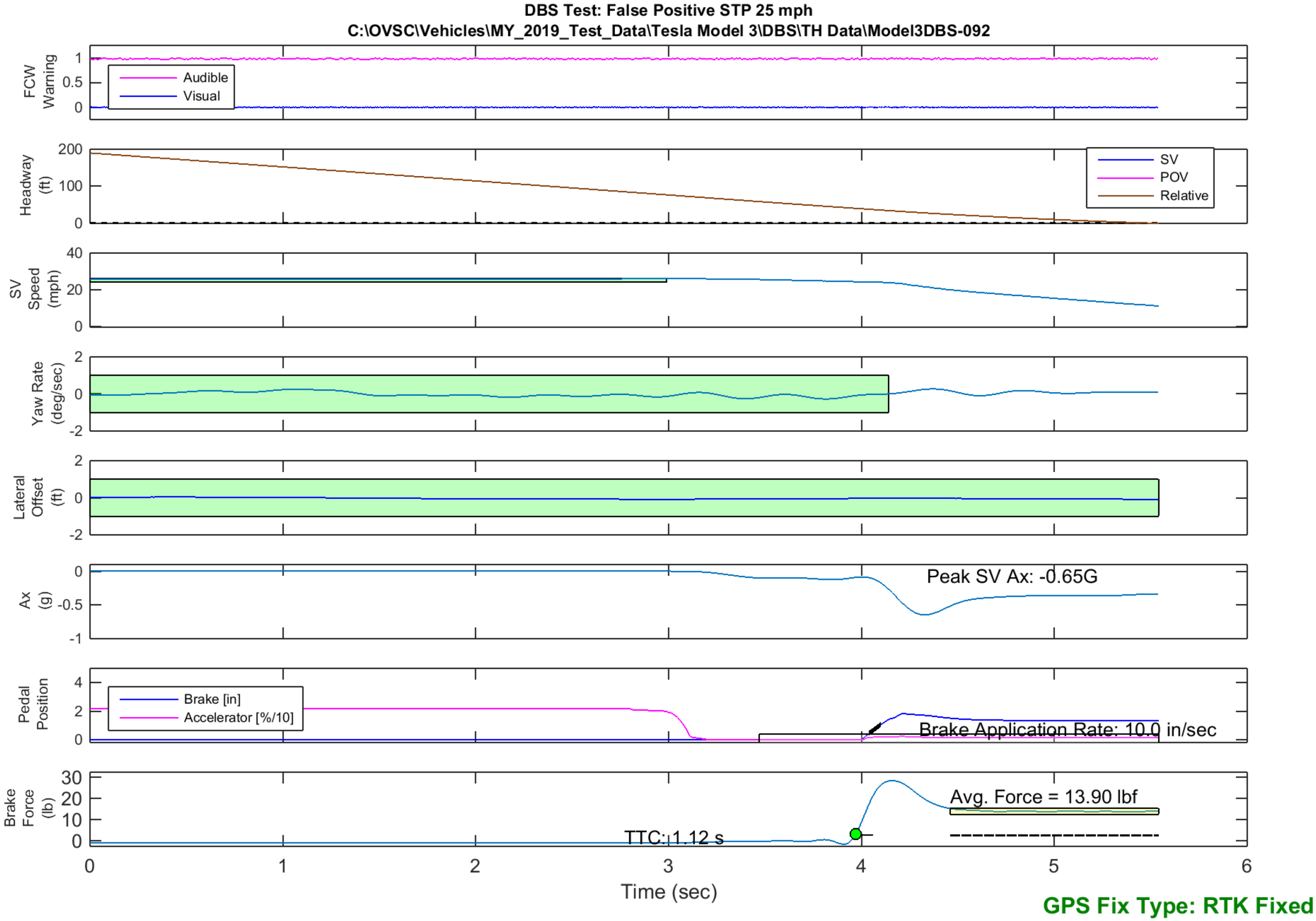


Figure E58. Time History for DBS Run 92, SV Encounters Steel Trench Plate, SV 25 mph

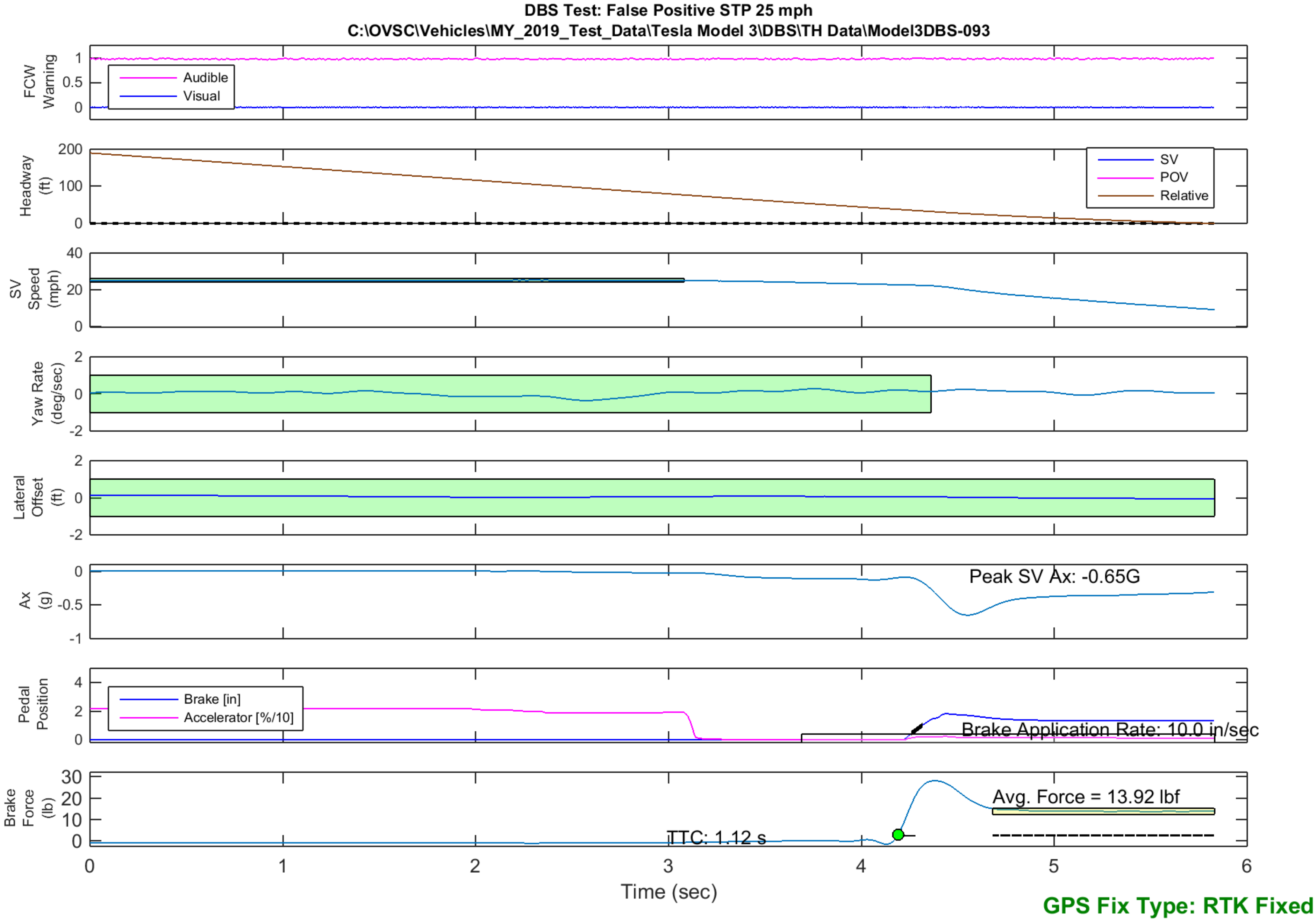


Figure E59. Time History for DBS Run 93, SV Encounters Steel Trench Plate, SV 25 mph

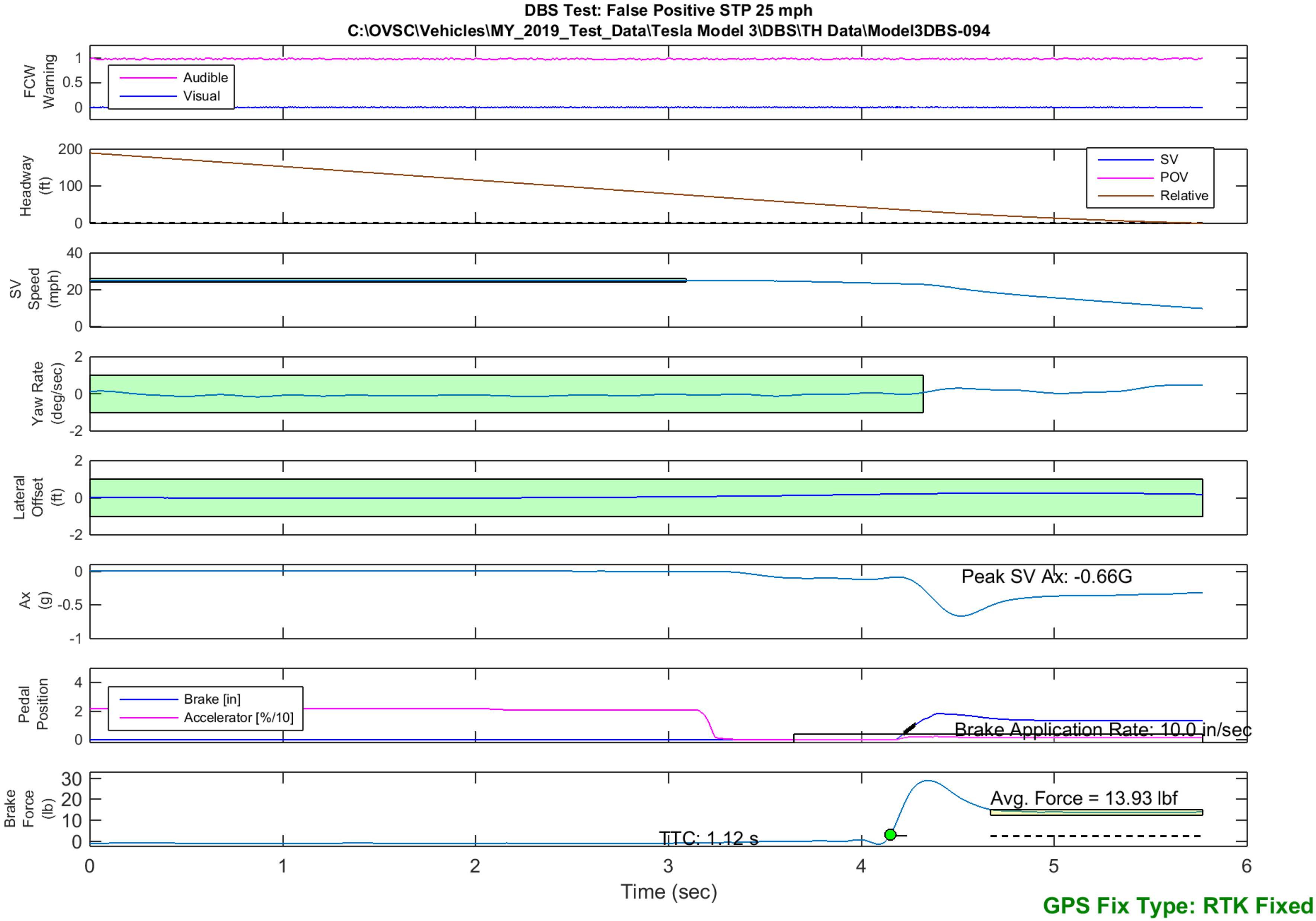


Figure E60. Time History for DBS Run 94, SV Encounters Steel Trench Plate, SV 25 mph

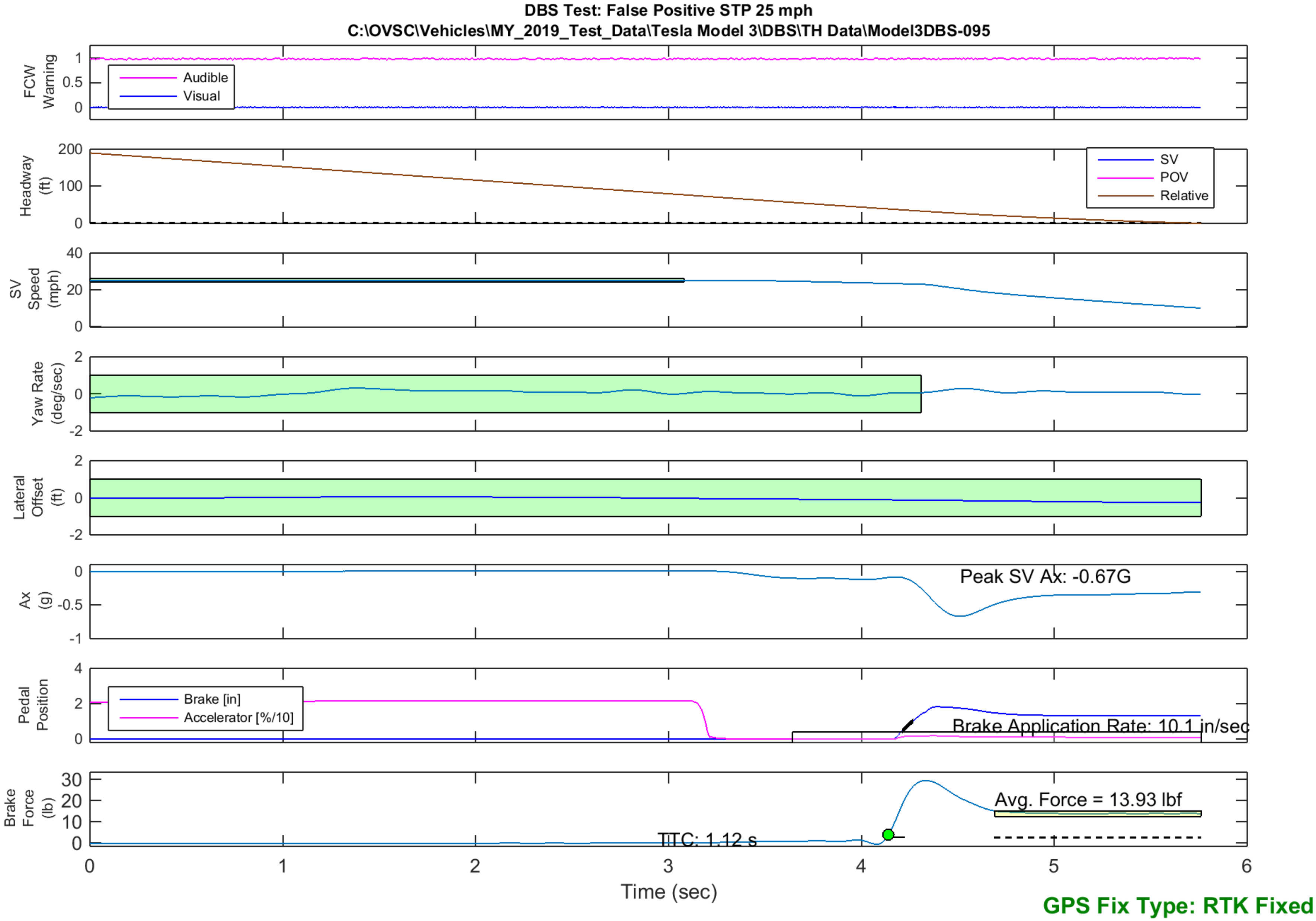


Figure E61. Time History for DBS Run 95, SV Encounters Steel Trench Plate, SV 25 mph

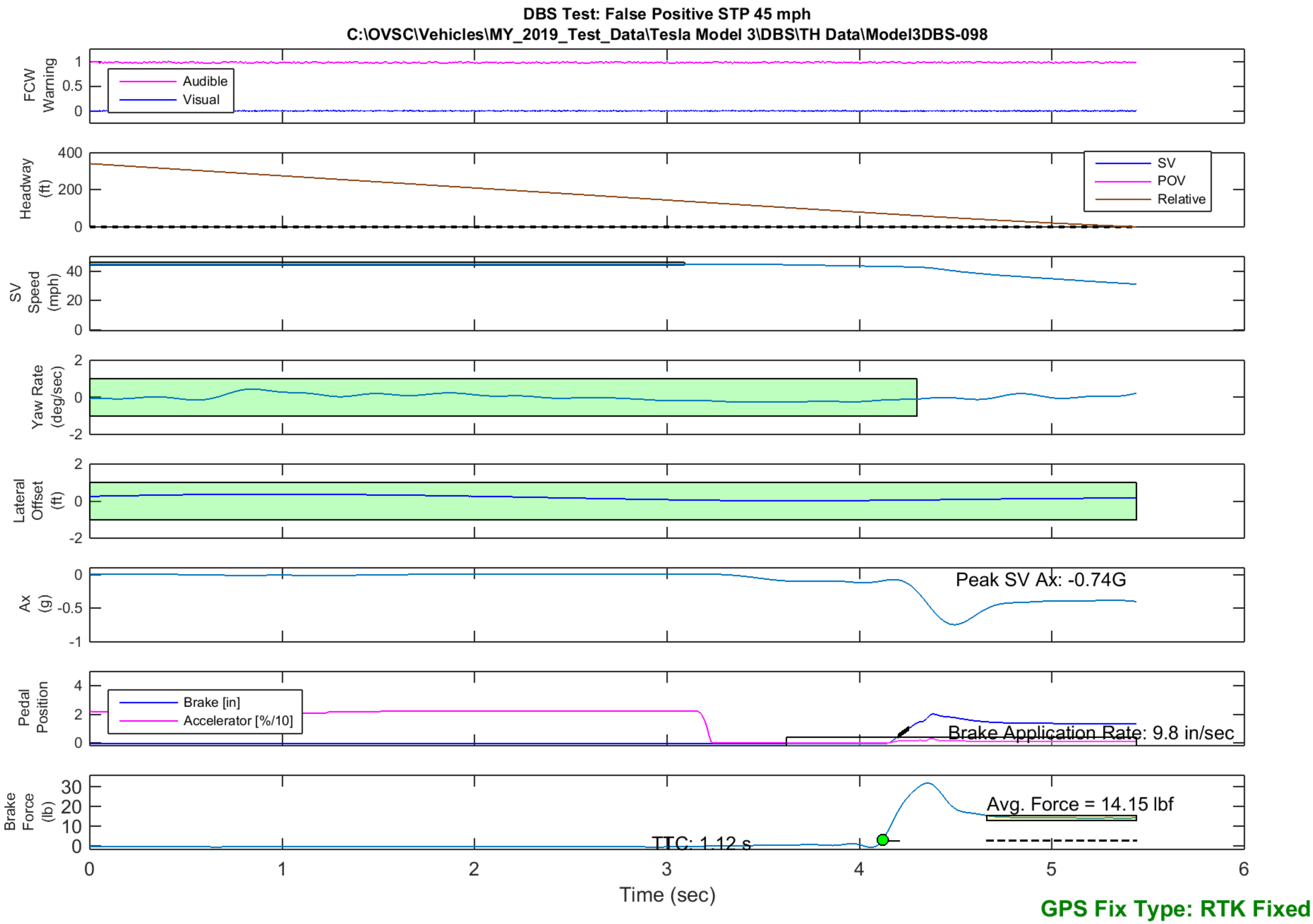


Figure E62. Time History for DBS Run 98, SV Encounters Steel Trench Plate, SV 45 mph

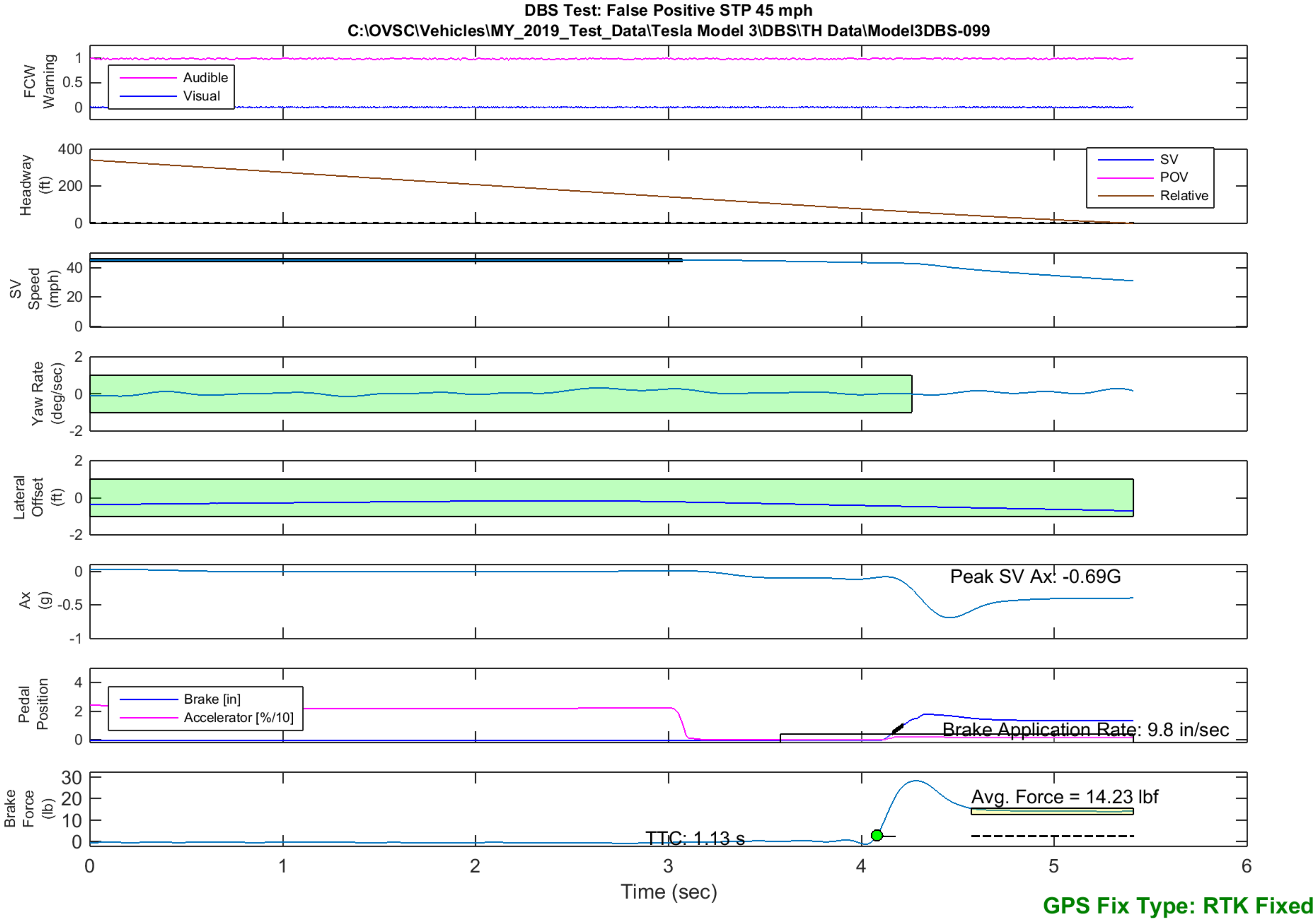


Figure E63. Time History for DBS Run 99, SV Encounters Steel Trench Plate, SV 45 mph

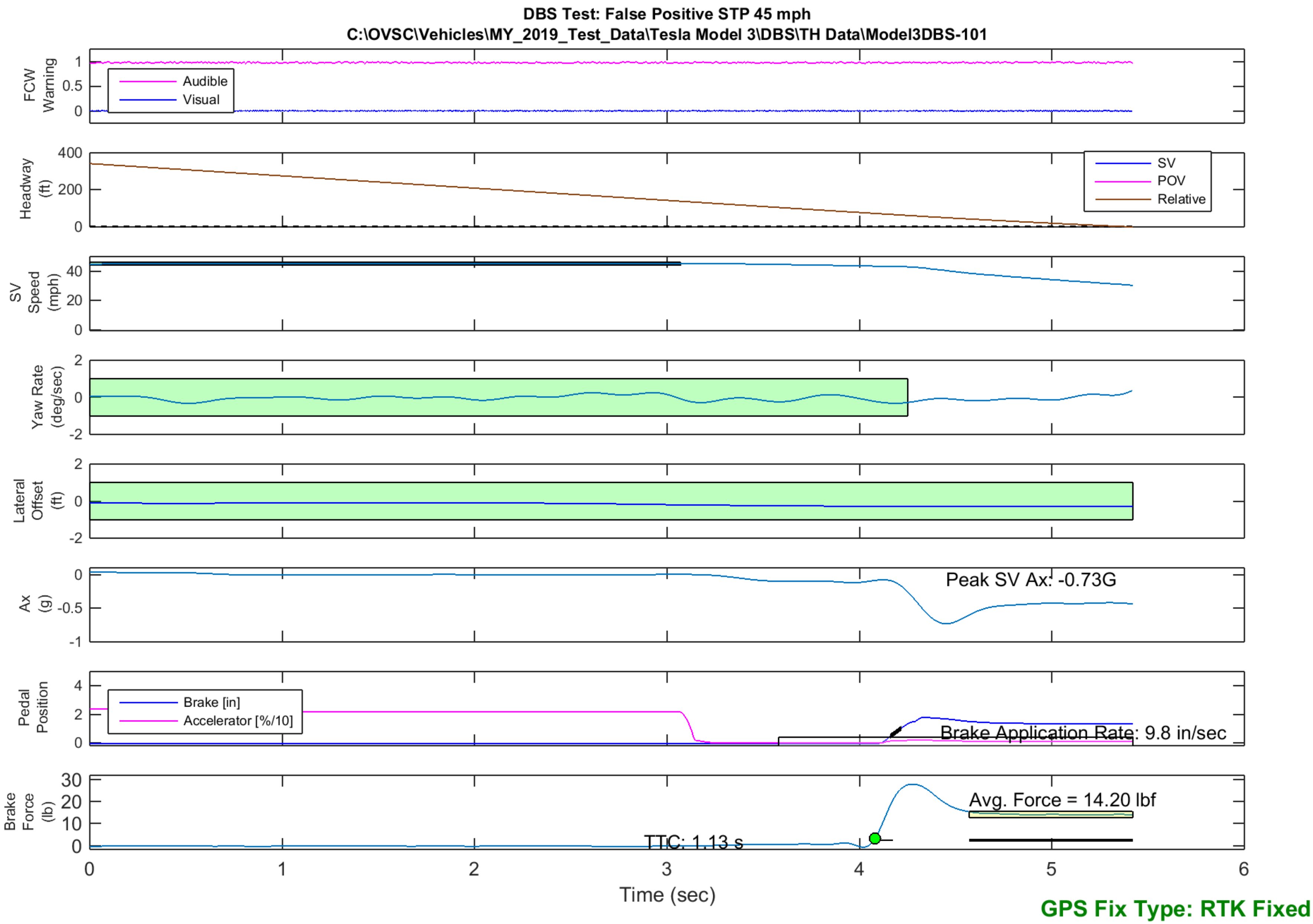


Figure E64. Time History for DBS Run 101, SV Encounters Steel Trench Plate, SV 45 mph

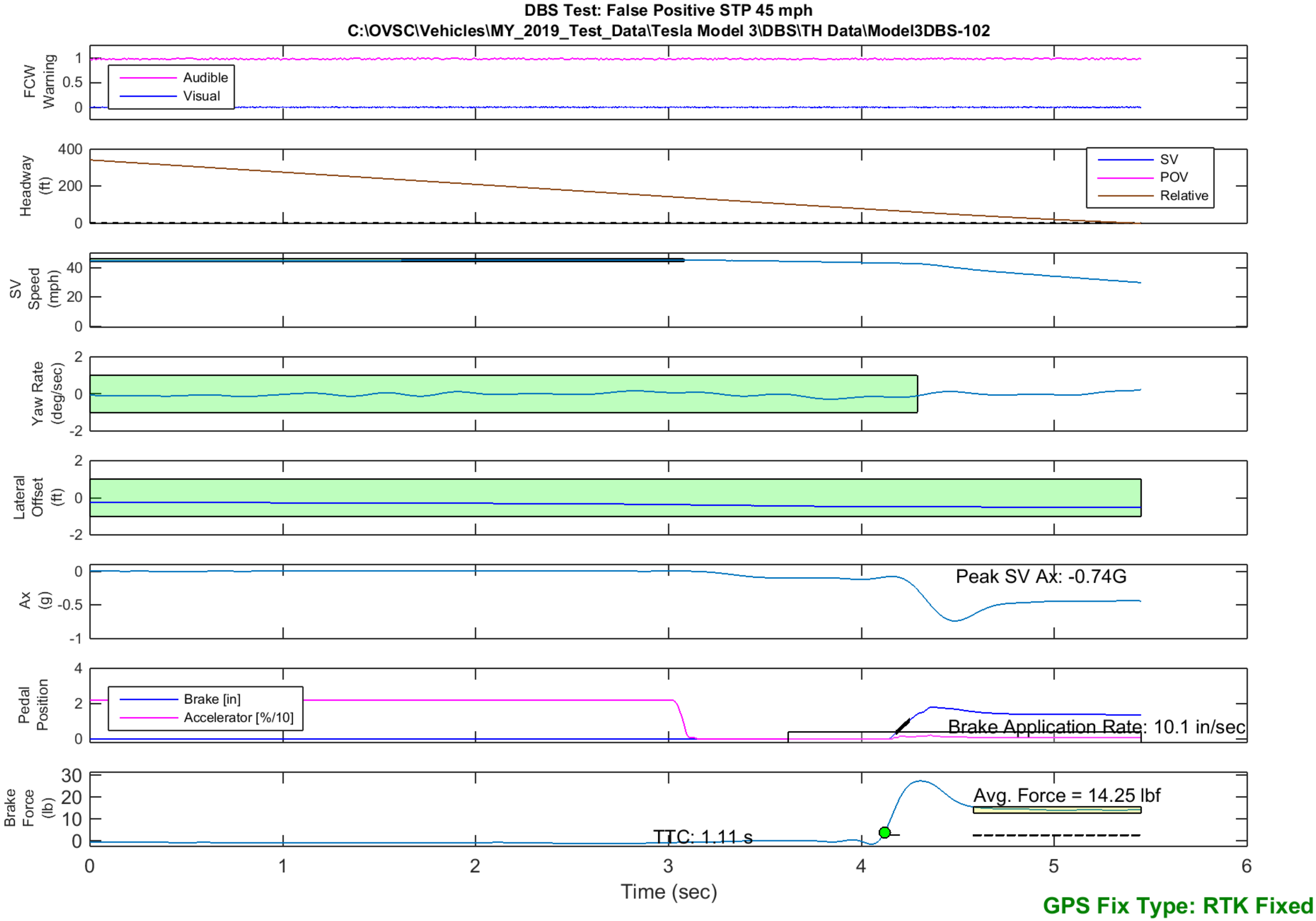


Figure E65. Time History for DBS Run 102, SV Encounters Steel Trench Plate, SV 45 mph

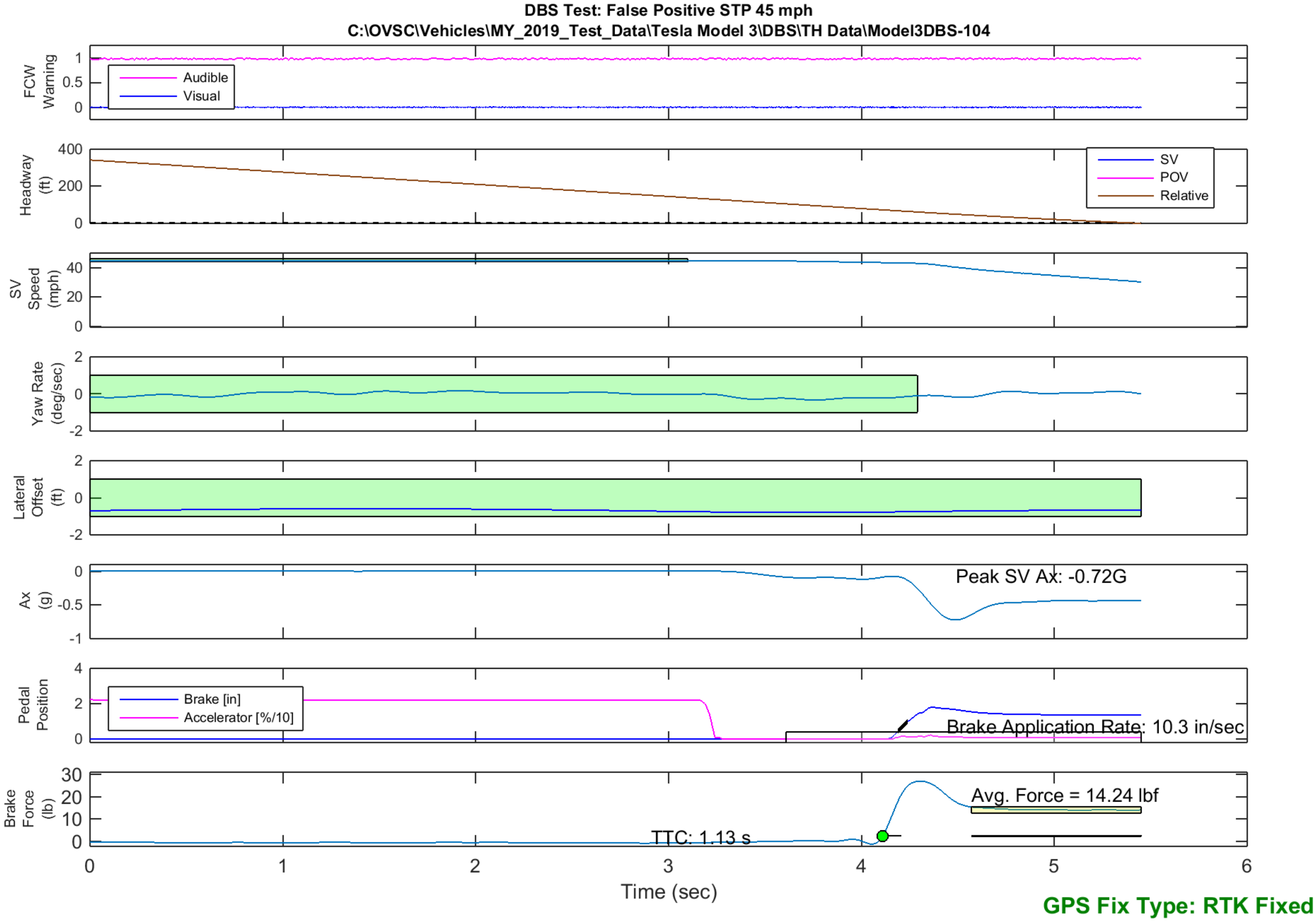


Figure E66. Time History for DBS Run 104, SV Encounters Steel Trench Plate, SV 45 mph

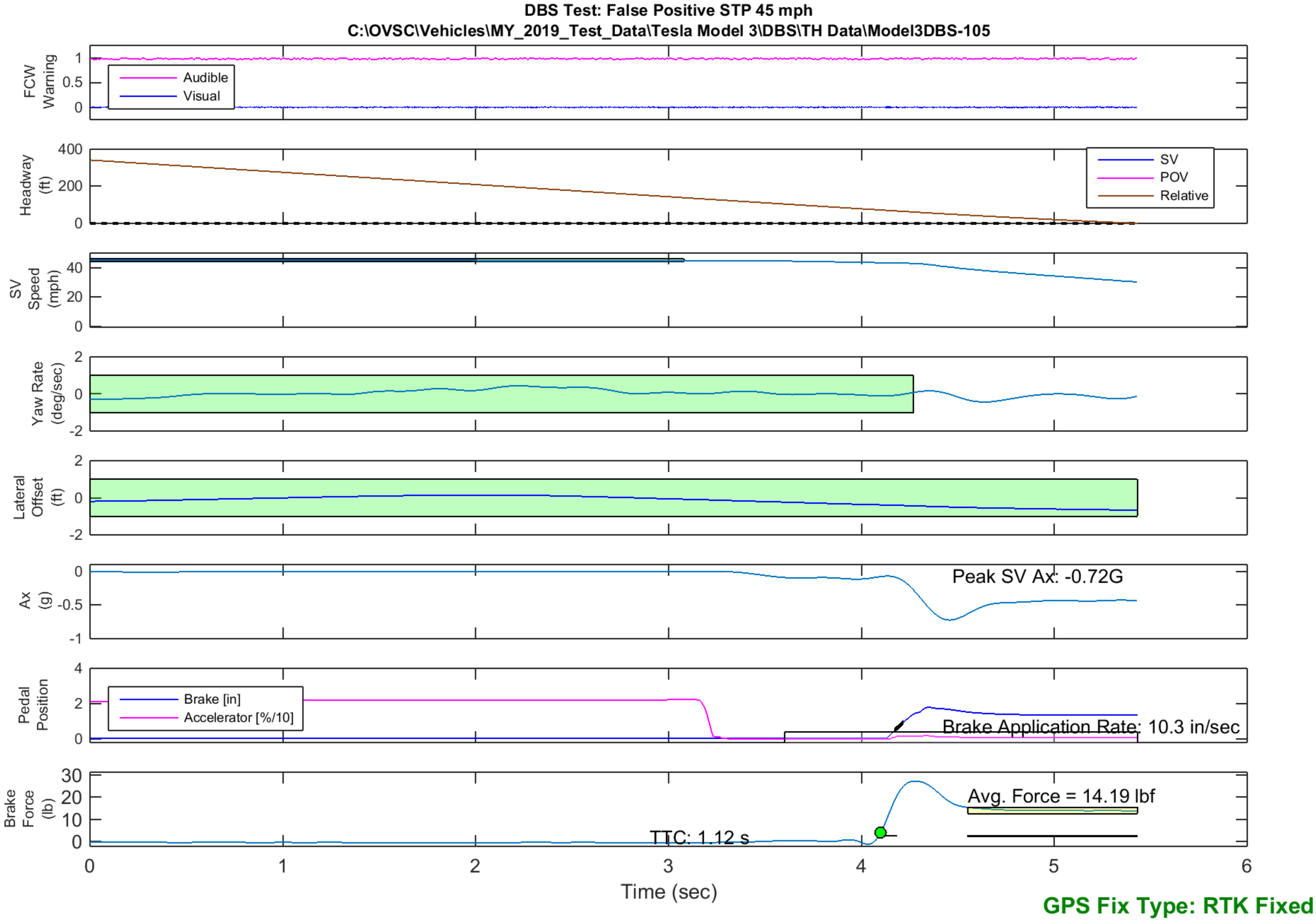


Figure E67. Time History for DBS Run 105, SV Encounters Steel Trench Plate, SV 45 mph

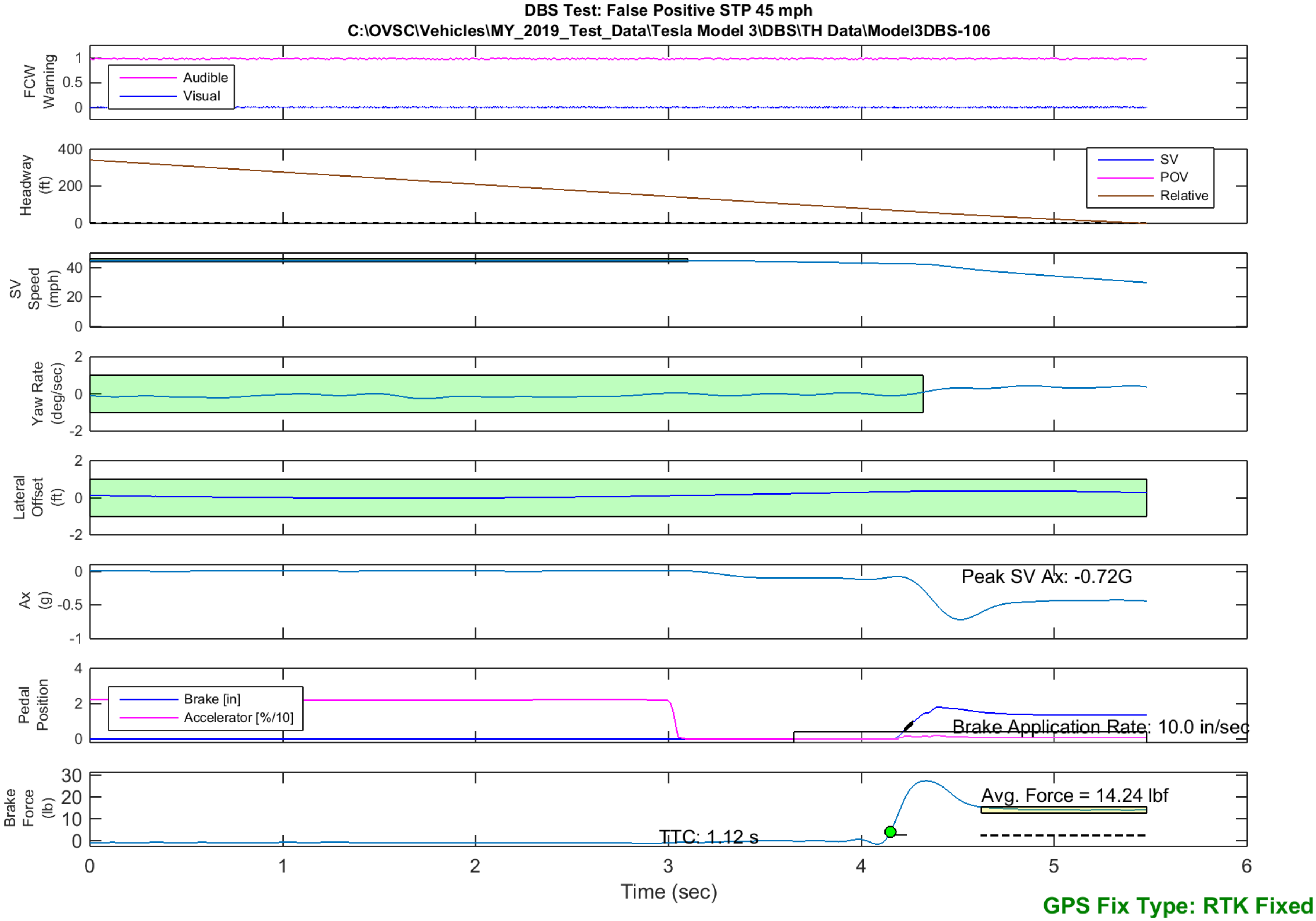


Figure E68. Time History for DBS Run 106, SV Encounters Steel Trench Plate, SV 45 mph

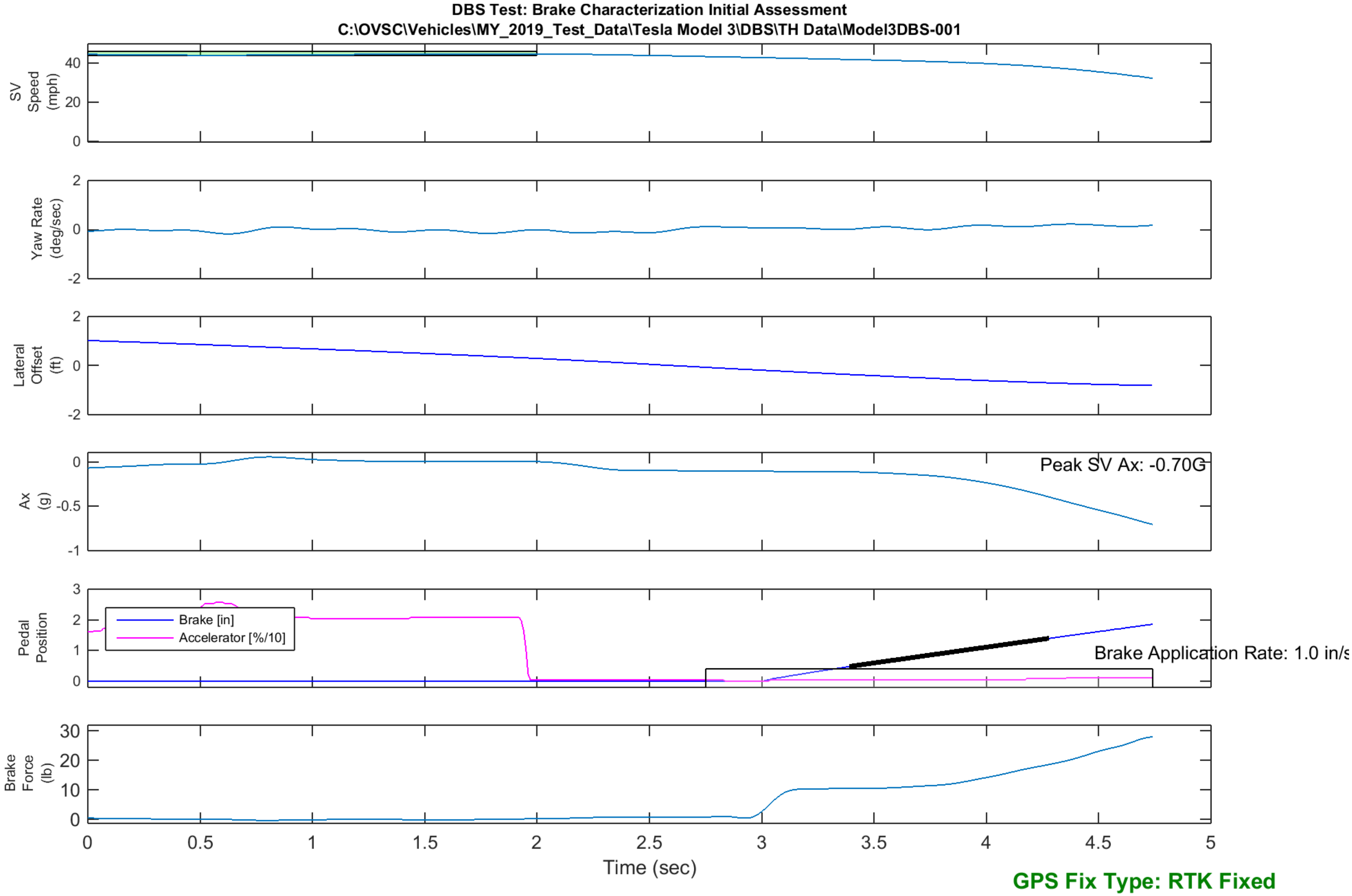


Figure E69. Time History for DBS Run 1, Brake Characterization Initial

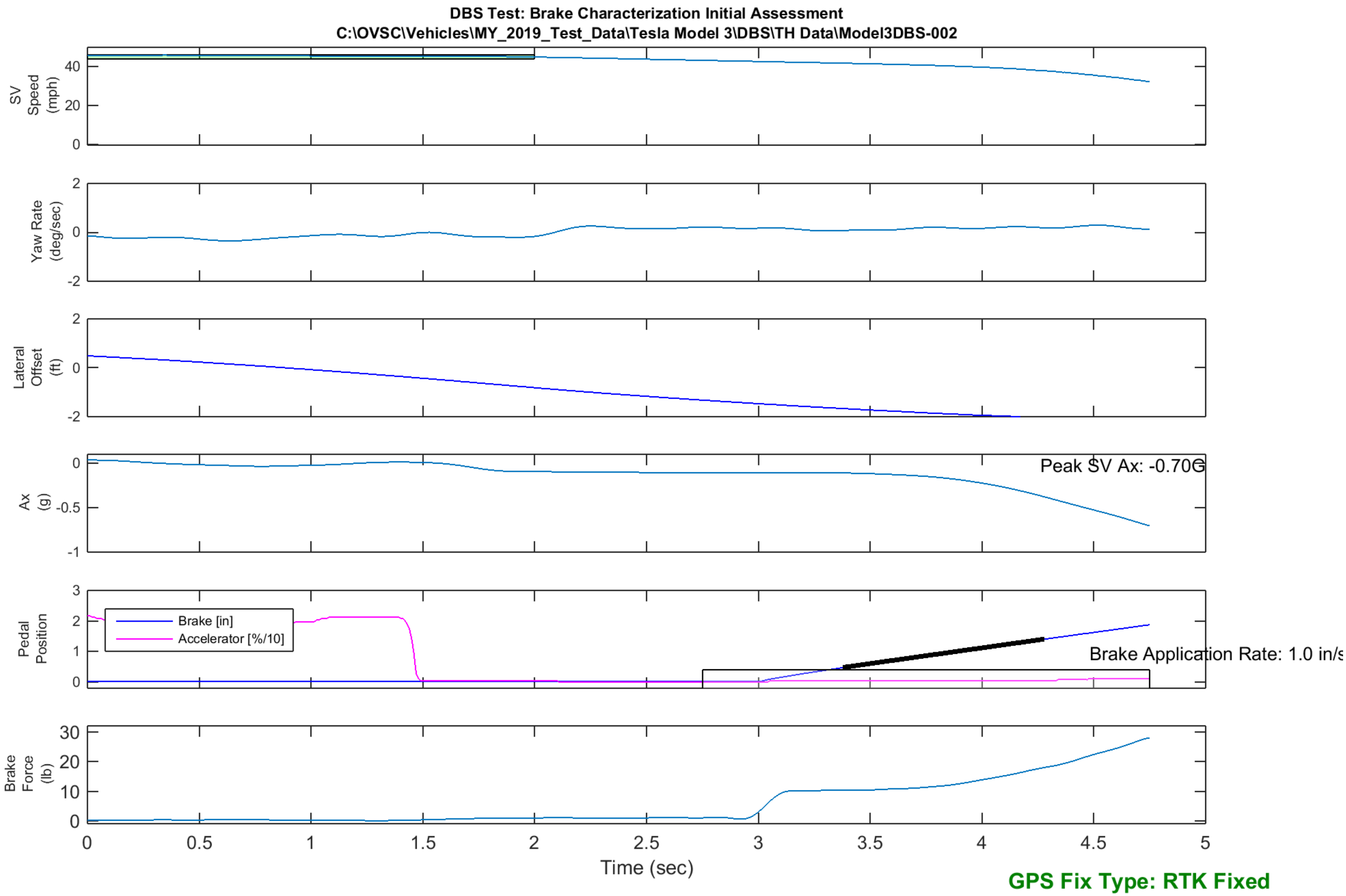


Figure E70. Time History for DBS Run 2, Brake Characterization Initial

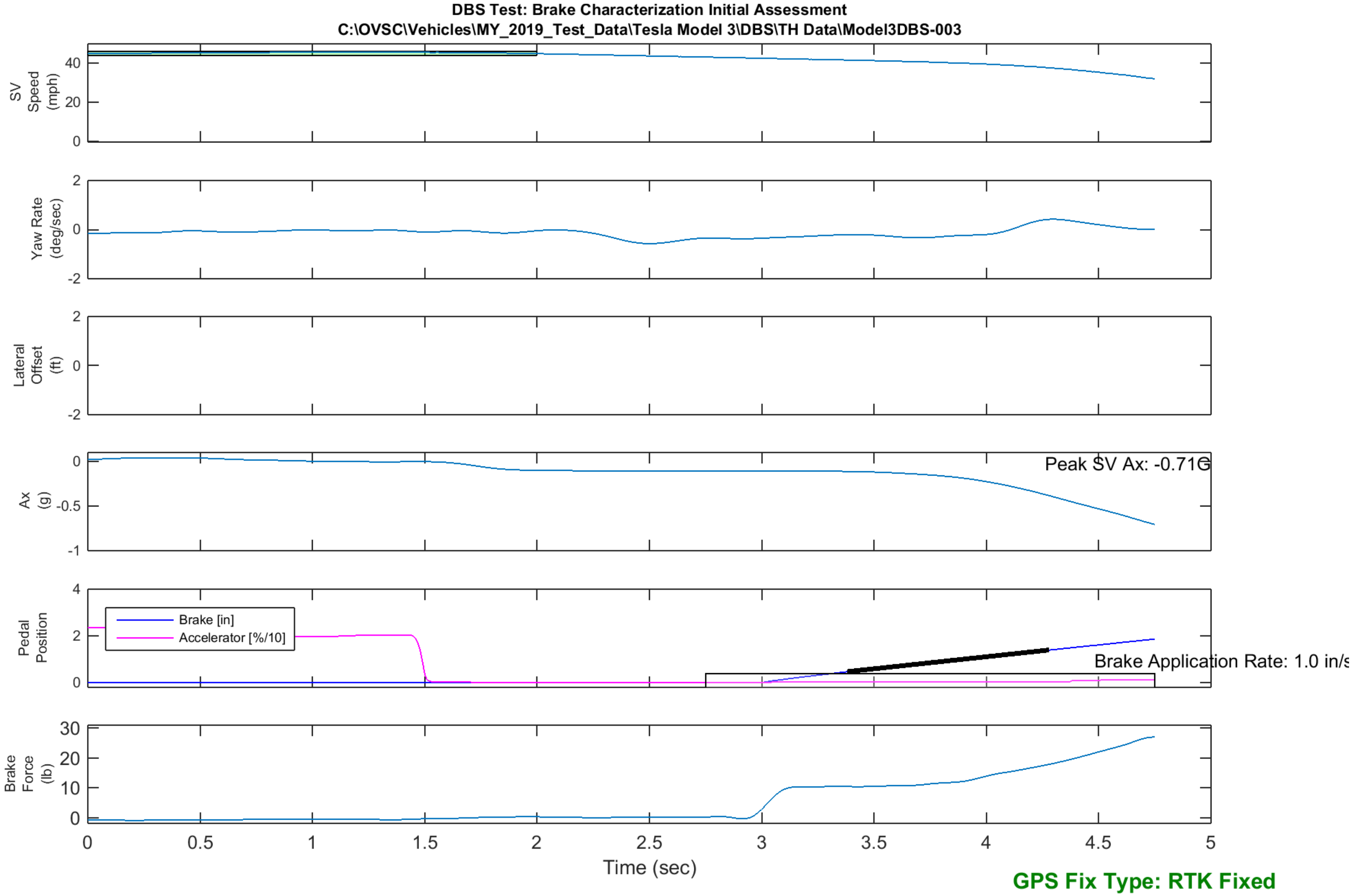


Figure E71. Time History for DBS Run 3, Brake Characterization Initial

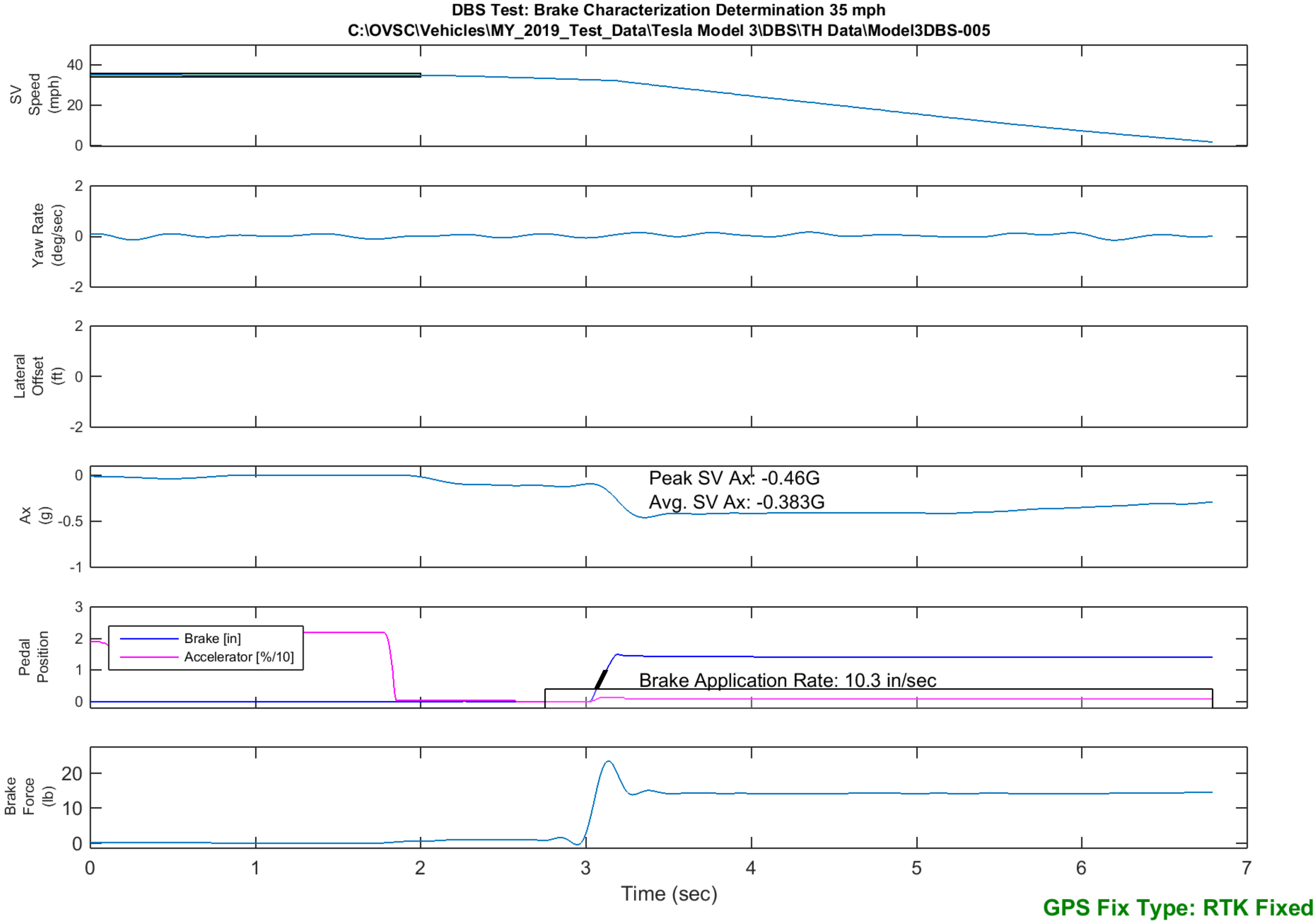


Figure E72. Time History for DBS Run 5, Brake Characterization Determination 35 mph

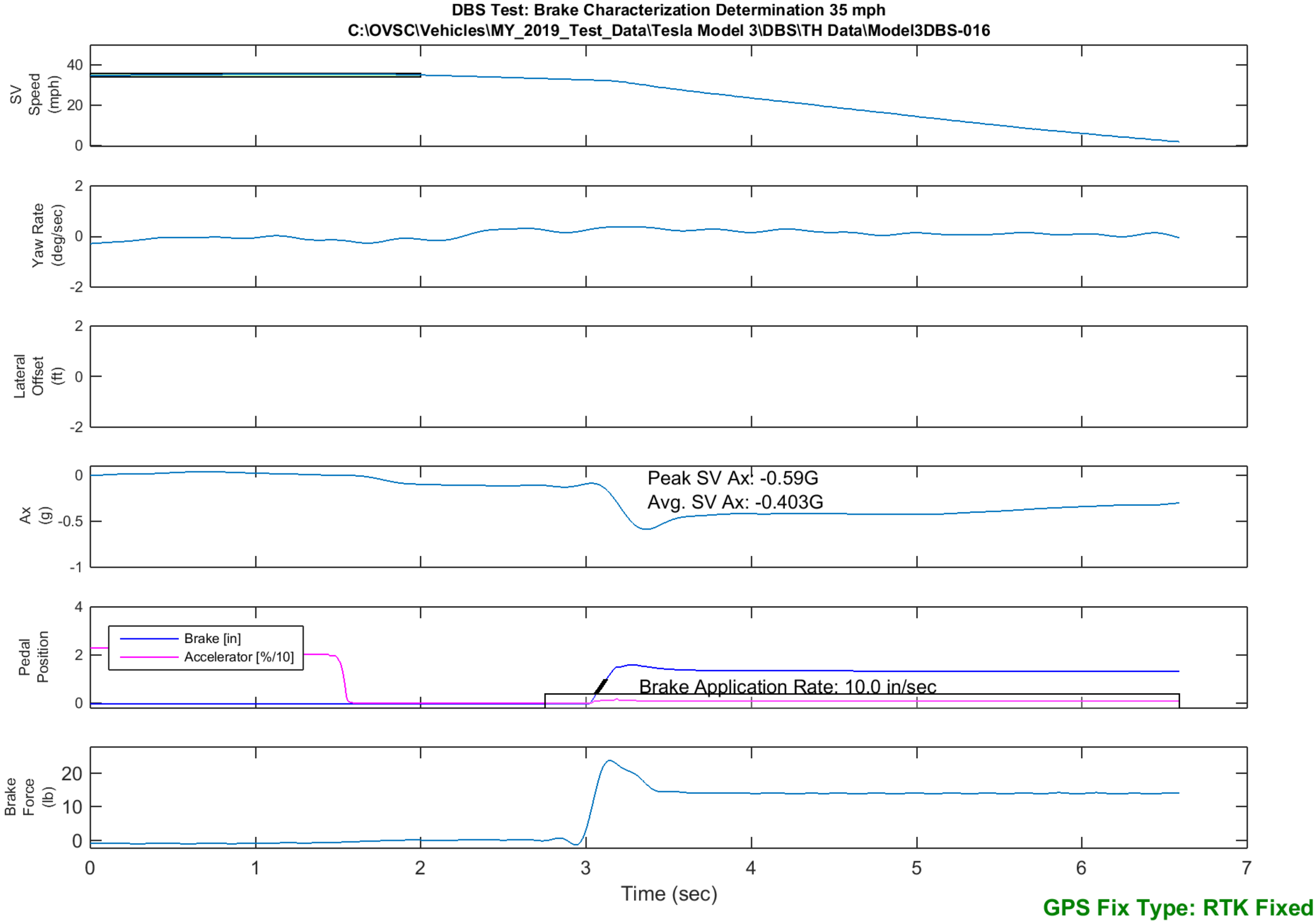


Figure E73. Time History for DBS Run 16, Brake Characterization Determination 35 mph

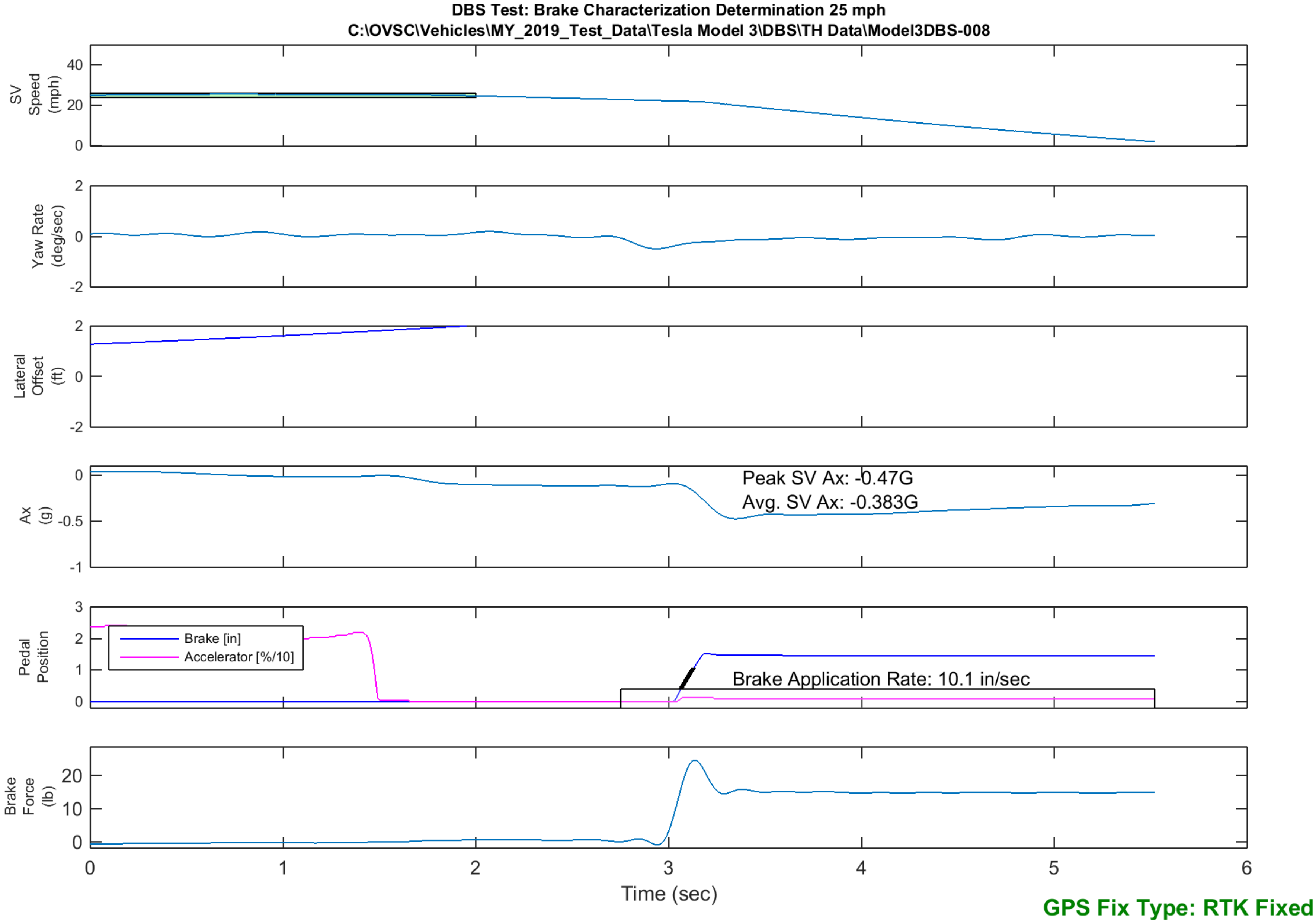


Figure E74. Time History for DBS Run 8, Brake Characterization Determination 25 mph

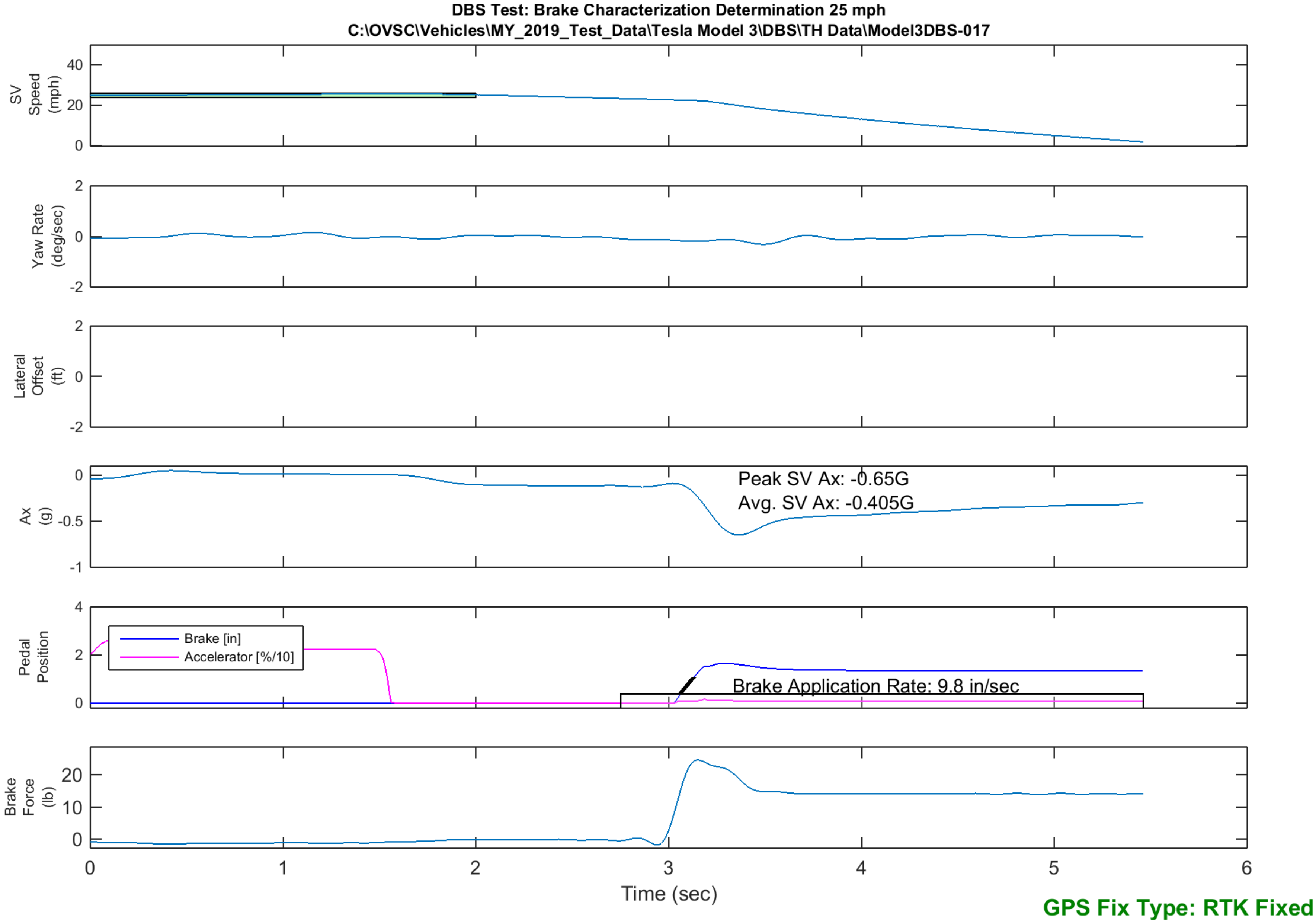


Figure E75. Time History for DBS Run 17, Brake Characterization Determination 25 mph

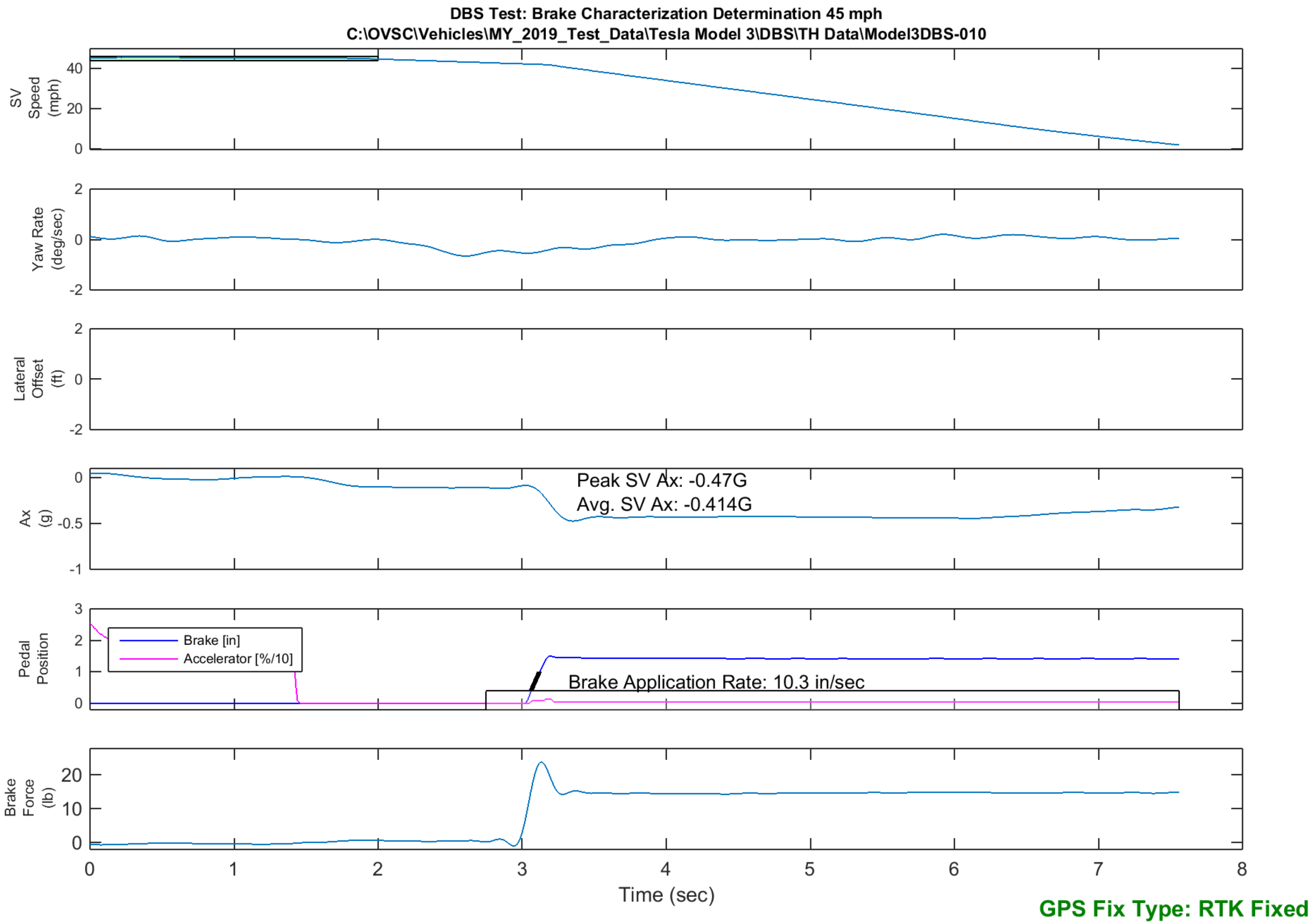


Figure E76. Time History for DBS Run 10, Brake Characterization Determination 45 mph

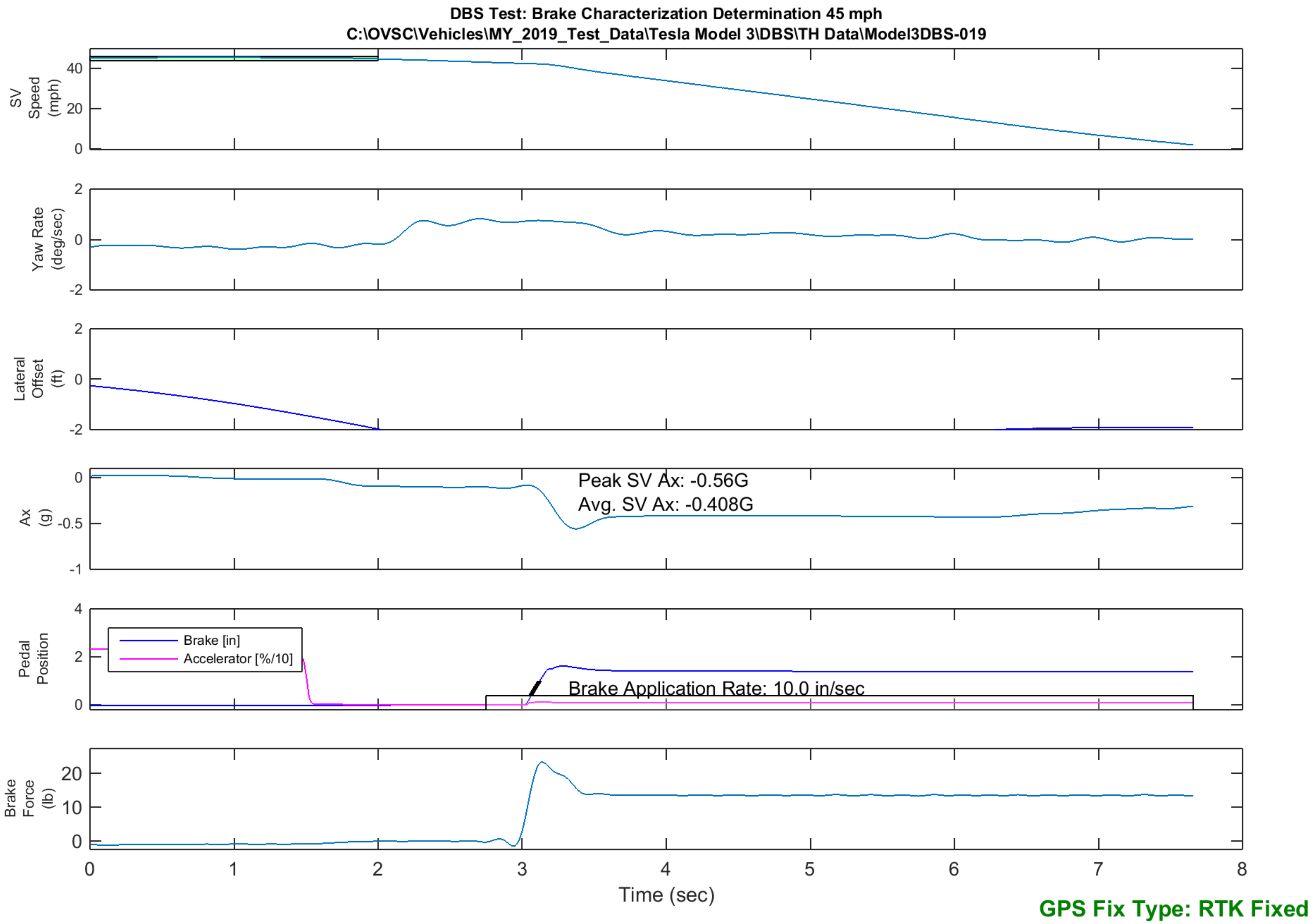


Figure E77. Time History for DBS Run 19, Brake Characterization Determination 45 mph