NEW CAR ASSESSMENT PROGRAM
DYNAMIC BRAKE SUPPORT SYSTEM CONFIRMATION TEST
NCAP-DRI-DBS-22-13

2022 Nissan Sentra CVT

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29 April 2022

Final Report

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

U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
New Car Assessment Program
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16. Abstract

These tests were conducted on the subject 2022 Nissan Sentra CVT in accordance with the specifications of the New Car Assessment Program's (NCAP's) 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 all four DBS test scenarios.

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TABLE OF CONTENTS

Section I

INTRODUCTION

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 (SV) 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 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 2022 Nissan Sentra CVT. 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

(Page 1 of 1)

2022 Nissan Sentra CVT

VIN: *3N1AB8CV5NY25xxxx*

Test start date: *4/12/2022* Test end date: *4/12/2022*

Dynamic Brake Support System settings: *N/A*

Test 1 - Subject Vehicle Encounters Stopped Principal Other Vehicle

SV 25 mph: *Pass*

Test 2 - Subject Vehicle Encounters Slower Principal Other Vehicle

SV 25 mph POV 10 mph: *Pass*

SV 45 mph POV 20 mph: *Pass*

Test 3 - Subject Vehicle Encounters Decelerating Principal Other Vehicle

SV 35 mph POV 35 mph: *Pass*

Test 4 - Subject Vehicle Encounters Steel Trench Plate

SV 25 mph: *Pass*

SV 45 mph: *Pass*

Overall: ***Pass***

Notes:

DYNAMIC BRAKE SUPPORT

DATA SHEET 2: VEHICLE DATA

(Page 1 of 1)

2022 Nissan Sentra CVT

TEST VEHICLE INFORMATION

VIN: *3N1AB8CV5NY25xxxx*

Body Style: *Sedan* Color: *Brilliant Silver*

Date Received: *3/25/2022* Odometer Reading: *6 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *NISSAN MOTOR CO., LTD.*

Date of manufacture: *02/22*

Vehicle Type: *Passenger Car*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *205/60R16*

Rear: *205/60R16*

Recommended cold tire pressure: Front: *230 kPa (33 psi)*

Rear: *230 kPa (33 psi)*

TIRES

Tire manufacturer and model: *Hankook Kinergy GT*

Front tire specification: *205/60R16 92H*

Rear tire specification: *205/60R16 92H*

Front tire DOT prefix: *1BC9X 1B H0*

Rear tire DOT prefix: *1BC9X 1B H0*

<u>DYNAMIC BRAKE SUPPORT</u>
<u>DATA SHEET 3: TEST CONDITIONS</u>
(Page 1 of 2)

2022 Nissan Sentra CVT

<u>GENERAL INFORMATION</u>

Test start date: *<u>4/12/2022</u>* Test start date: *<u>4/12/2022</u>*

<u>AMBIENT CONDITIONS</u>

Air temperature: *<u>8.9 C (48 F)</u>*

Wind speed: *<u>6.7 m/s (15.0 mph)</u>*

X Wind speed ≤ 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.

<u>VEHICLE PREPARATION</u>

Verify the following:

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

Fuel tank is full: **X**

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

Front: *<u>230 kPa (33 psi)</u>*

Rear: *<u>230 kPa (33 psi)</u>*

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*469.9 kg (1036 lb)*	Right Front:	*437.7 kg (965 lb)*
Left Rear:	*297.1 kg (655 lb)*	Right Rear:	*298.0 kg (657 lb)*
		Total:	*1502.7 kg (3313 lb)*

DYNAMIC BRAKE SUPPORT

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

(Page 1 of 3)

2022 Nissan Sentra CVT

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

Automatic Emergency Braking with Pedestrian Detection

Type and location of sensor(s) the system uses:

The front radar is located in the grille and the front view camera is located in the upper center windshield.

System settings used for test (if applicable):

N/A

Brake application mode used for test: *Hybrid control*

Over what speed range is the system operational?

The AEB system is operational between 5-80 km/h (3-50 mph) against a stationary vehicle and 5-200 km/h (3-124 mph) against a moving vehicle per manufacturer supplied information.

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

____ No

If yes, please provide a full description.

The AEB system must be initialized by driving the vehicle at approximately 40 km/h between 2 stationary vehicles spaced 7 m apart and offset 20 m longitudinally with minimal yaw rate and acceleration changes 5 times.

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

X Yes

____ No

If yes, please provide a full description.

The AEB system will deactivate after 3 activations and a warning will be displayed in the instrument panel. To re-enable the system, cycle the ignition and perform the initialization procedure.

How is the Forward Collision Warning presented to the driver?

(Check all that apply)

X Warning light

X Buzzer or auditory alarm

____ Vibration

____ Other ________________

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

The AEB system alerts the driver with a two-stage visual and auditory alert. The first stage of the alert consists of a yellow flashing vehicle icon in the top left corner of the vehicle information display and an auditory alert consisting of repeated beeps with a primary frequency of 1800 Hz. The second stage of the alert consists of a red and white flashing band and vehicle icon across the top of the vehicle information display and an auditory alert consisting of repeated beeps with a primary frequency of 2500 Hz.

Is there a way to deactivate the system? — **X** Yes; ___ No

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

The AEB system can be turned on/off using the buttons on the left side of the steering wheel. The procedure is as follows:

1. Select the Left or Right button to reach the "Settings" menu in the vehicle information display.

2. Select the Up or Down button to reach the "Driver Assistance" menu and press "OK".

3. Select "Emergency Brake" and press "OK"

4. Select "Front" and press "OK" to turn the AEB system on/off.

When the AEB system is turned off, a warning light illuminates. The system is automatically enabled each time the engine switch is turned on.

Is the vehicle equipped with a control whose purpose is to adjust the range setting or otherwise influence the operation of DBS? — ___ Yes; **X** No

If yes, please provide a full description.

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.

Refer to the owner's manual pages 5-95 to 5-101 shown in Appendix B pages B-7 to B-13.

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. <u>TEST 1 – SUBJECT VEHICLE ENCOUNTERS STOPPED PRINCIPAL OTHER VEHICLE ON A STRAIGHT ROAD</u>

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.

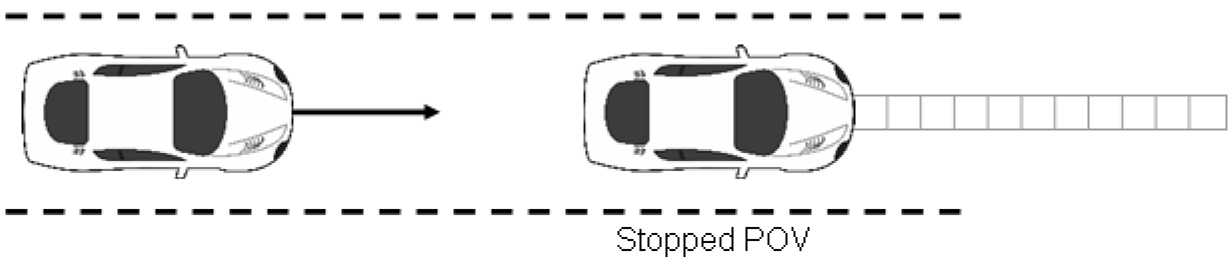


Figure 1. Depiction of Test 1

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 km/h) in the center of the lane of travel, toward the parked POV. The SV throttle pedal was released within 500 ms after t_{FCW}, i.e., within 500 ms of the FCW alert or SV brake application if no FCW alert was given. 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 lateral distance between the centerline of the SV to the center of the travel lane could not deviate more than ±1 ft (0.3 m) during the validity period.
- The yaw rate of the SV could not deviate more than ±1 deg/sec during the validity period.
- The SV speed could not deviate from the nominal speed by more than ±1.0 mph (±1.6 km/h) during an interval defined by a Time to Collision (TTC) = 5.1 seconds to t_{FCW} or impact if no FCW alert was given.

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 km/h)	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-to-POV impact for at least five of the seven valid test trials.

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

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.

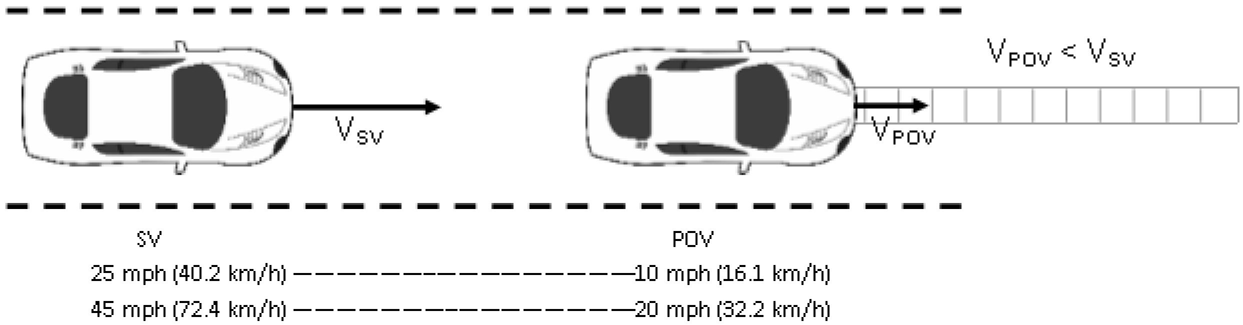


Figure 2. Depiction of Test 2

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 km/h) in the center of the lane of travel while the SV was driven at 25.0 mph (40.2 km/h), in the center lane of travel, toward the slower-moving POV. In the second, the POV was driven at a constant 20.0 mph (32.2 km/h) in the center of the lane of travel while the SV was driven at 45.0 mph (72.4 km/h), in the center lane of travel, toward the slower-moving POV. In both cases, the SV throttle pedal was released within 500 ms after t_{FCW}, i.e., within 500 ms of the FCW alert or SV brake application if no FCW alert was given. 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 SV and POV to the center of the travel lane could not deviate more than ±1 ft (0.3 m) during the validity period.
- The yaw rate of the SV and POV could not deviate more than ±1 deg/sec during the validity period.
- The SV speed could not deviate more than ±1.0 mph (±1.6 km/h) during an interval defined by TTC = 5.0 seconds to t_{FCW} or impact if no FCW alert was given.
- The POV speed could not deviate more than ±1.0 mph (±1.6 km/h) 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 km/h)	10 mph (16 km/h)	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 km/h)	20 mph (32 km/h)	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-to-POV impact for at least five of the seven valid test trials.

3. <u>TEST 3 – SUBJECT VEHICLE ENCOUNTERS DECELERATING PRINCIPAL OTHER VEHICLE</u>

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.

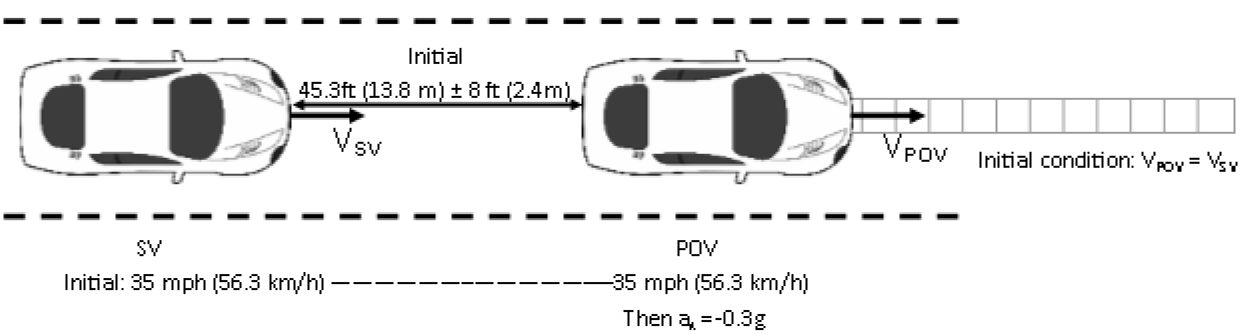


Figure 3. Depiction of Test 3

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 km/h) in the center of the lane, with headway of 45.3 ft (13.8 m) ± 8 ft (2.4 m). Once these conditions were met, the POV tow vehicle brakes were applied to achieve 0.3 ± 0.03 g of deceleration within 1.5 ± 0.1 sec. The SV throttle pedal was released within 500 ms of t_{FCW} or SV brake application if no FCW alert was given. 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 SV and POV to the center of the travel lane could not deviate more than ±1 ft (0.3 m) during the validity period.
- The yaw rate of the SV and POV could not deviate more than ±1 deg/sec during the validity period.
- The SV speed could not deviate more than ±1.0 mph (1.6 km/h) during an interval defined by 3.0 seconds before the onset of POV braking to t_{FCW} or impact if no FCW alert was given.
- The POV speed could not deviate more than ±1.0 mph (1.6 km/h) during an interval of 3.0 seconds before the onset of POV braking.
- The SV- POV headway distance could not deviate more than ±8 ft (2.4 m) during an interval defined by the onset of the validity period to the onset of POV braking.
- The average POV deceleration could not deviate by more than ±0.03 g from the nominal 0.3 g deceleration during the interval beginning at 1.5 seconds after the onset of POV braking and ending either 250 ms prior to the POV coming to a stop or the SV coming into contact with the POV.

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 km/h)	35 mph (56 km/h)	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-to-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 km/h) and 45 mph (72.4 km/h). The SV was driven directly towards, and over, the STP, which was positioned in the center of a travel lane, with its longest sides parallel to the road edge. 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 1.5 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 auditory, and the onset of the alert is determined by post-processing the test data.

For systems that implement auditory or haptic alerts, part of the pre-test instrumentation verification process is to determine the tonal frequency of the auditory warning or the vibration frequency of the tactile warning through use of the PSD (Power Spectral

Density) function in Matlab. This is accomplished in order to identify the center frequency around which a band-pass filter is applied to subsequent auditory or tactile warning data so that the beginning of such warnings can be programmatically determined. The band-pass filter used for these warning signal types is a phaseless, forward-reverse pass, elliptical (Cauer) digital filter, with filter parameters as listed in Table 4.

Table 4. Auditory and Tactile Warning Filter Parameters

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

2. GENERAL VALIDITY CRITERIA

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

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

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 offset was adjusted to output zero, another pre-test static calibration data file was collected, and the test series was repeated.

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 components of the SSV system are:

- A POV shell which is a visually and dimensionally accurate representation of a passenger car.
- A slider and load frame assembly to which the shell is attached.
- A two-rail track on which the slider operates.
- A road-based lateral restraint track.
- A tow vehicle.

The key requirements of the POV element are to:

- Provide an accurate representation of a real vehicle to 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.

The key requirements of the POV delivery system are to:

- Accurately control the nominal POV speed up to 35 mph (56 km/h).
- Accurately control the lateral position of the POV within the travel lane.
- Allow the POV to move away from the SV after an impact occurs.

Operationally, the POV shell is attached to the slider and load frame, which includes rollers that allow 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 SV-to-POV 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 and 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 100 psi	Omega DPG8001	17042707002	By: DRI Date: 10/5/2021 Due: 10/5/2022
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 2/11/2022 Due: 2/11/2023
Linear (string) encoder	Throttle pedal travel	50 in	0.05 in	TE Connectivity SE1-50	K3161850	By: DRI Date: 1/18/2022 Due: 1/18/2023
Load Cell	Force applied to brake pedal					By: DRI
		0-250 lb 1112 N	0.05% FS	Stellar Technology PNC700	1607338	Date: 3/30/2022 Due: 3/30/2023
		0-250 lb	0.05% FS	Stellar Technology PNC700	2002506	Date: 2/25/2022 Due: 2/25/2023
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	N/A

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 Rate ±100 deg/s, Angle >45 deg, Velocity >200 km/h	Accels .01g, Angular Rate 0.05 deg/s, Angle 0.05 deg, Velocity 0.1 km/h	Oxford Inertial +		By: Oxford Technical Solutions
					2176	Date: 6/26/2020 Due: 6/26/2022
					2258	Date: 4/28/2021 Due: 4/28/2023
Real-Time Calculation of Position and Velocity Relative to Lane Markings (LDW) and POV (FCW)	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec Longitudinal Range to POV: ±200 m Longitudinal Range Rate: ±50 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec Longitudinal Range: ±3 cm Longitudinal Range Rate: ±0.02 m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	N/A
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	N/A	N/A
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	N/A	N/A
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	N/A	N/A

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: 1/6/2022 Due: 1/6/2023

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

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

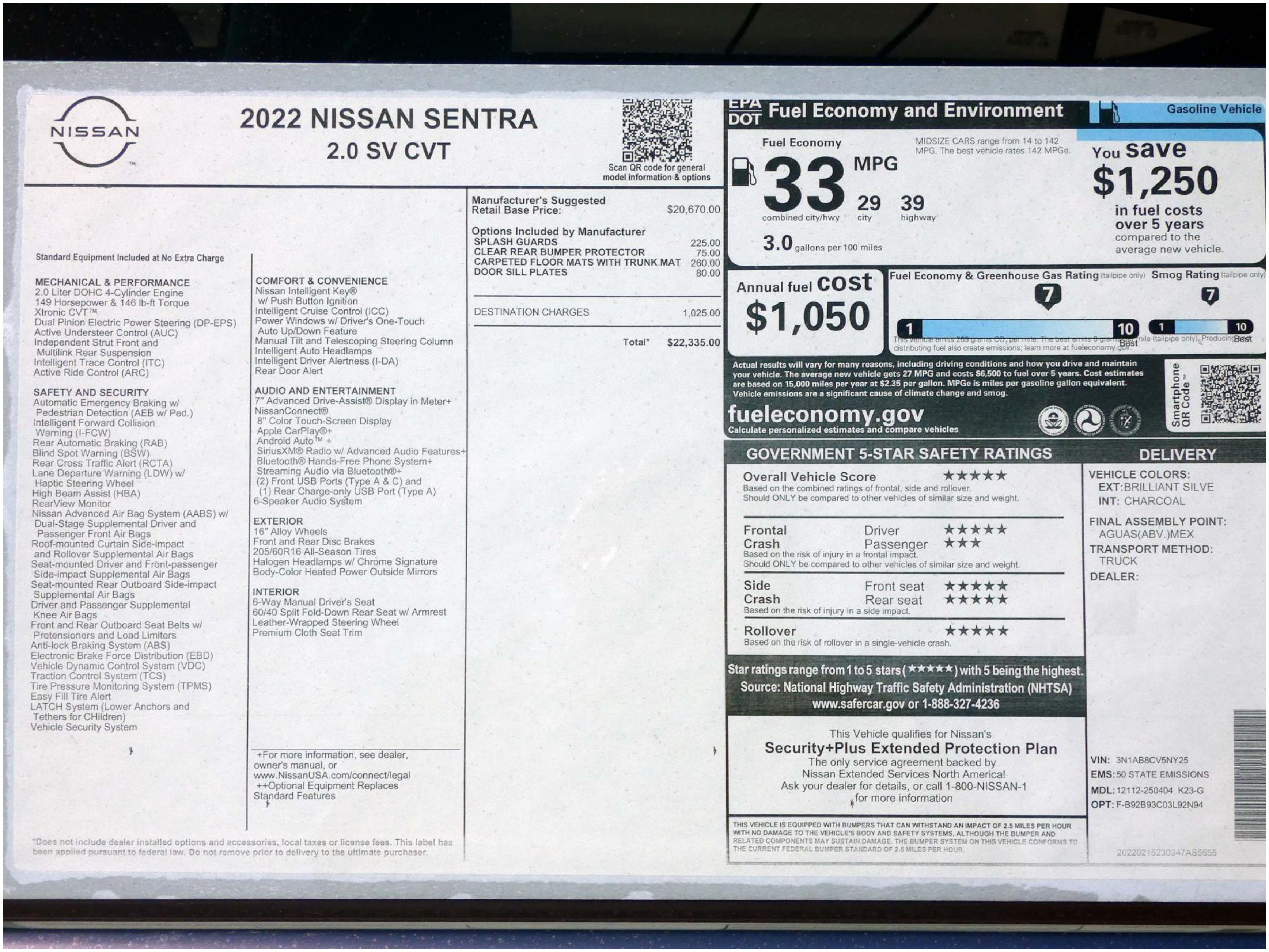


Figure A3. Window Sticker (Monroney Label)

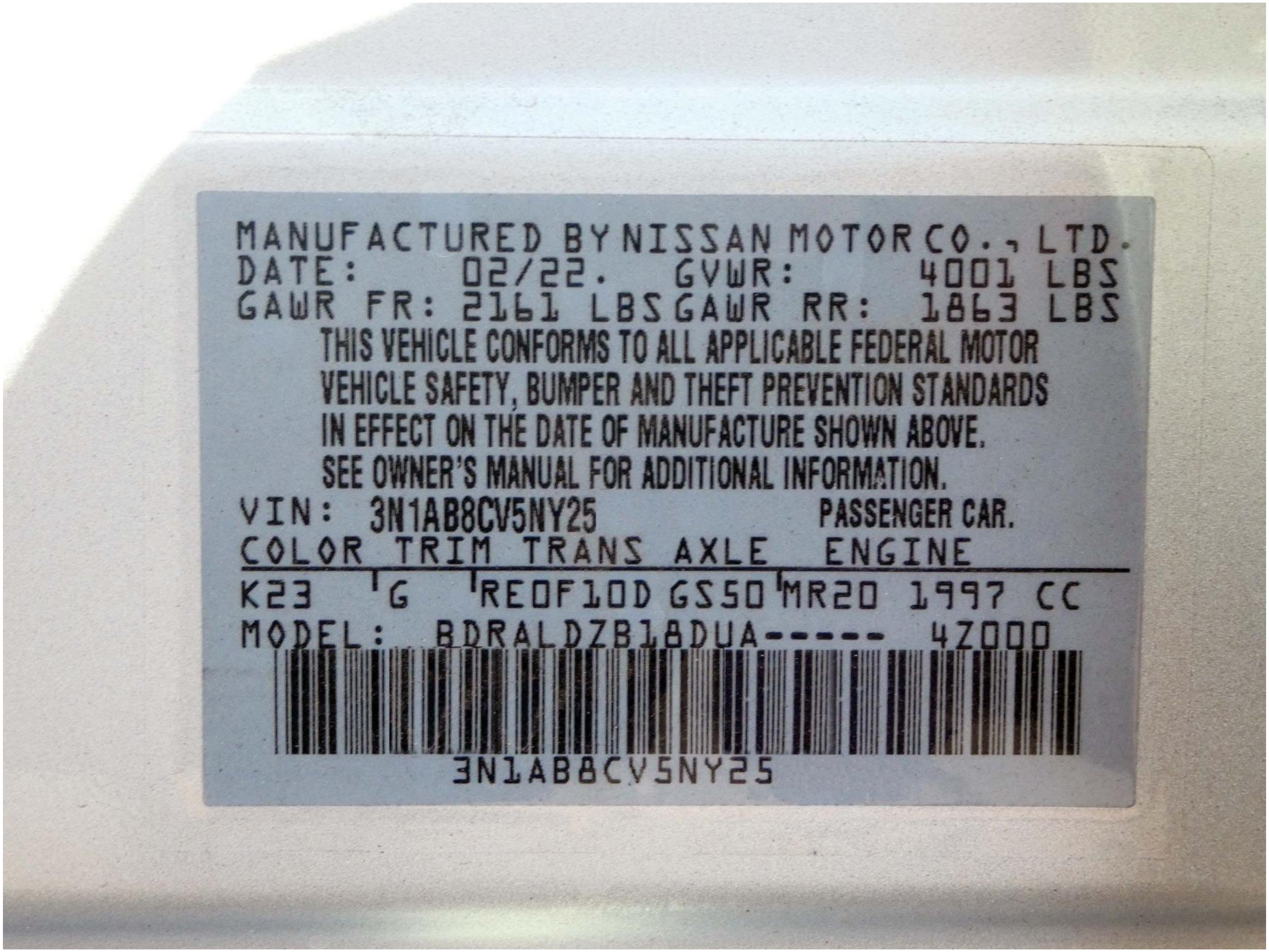


Figure A4. Vehicle Certification Label

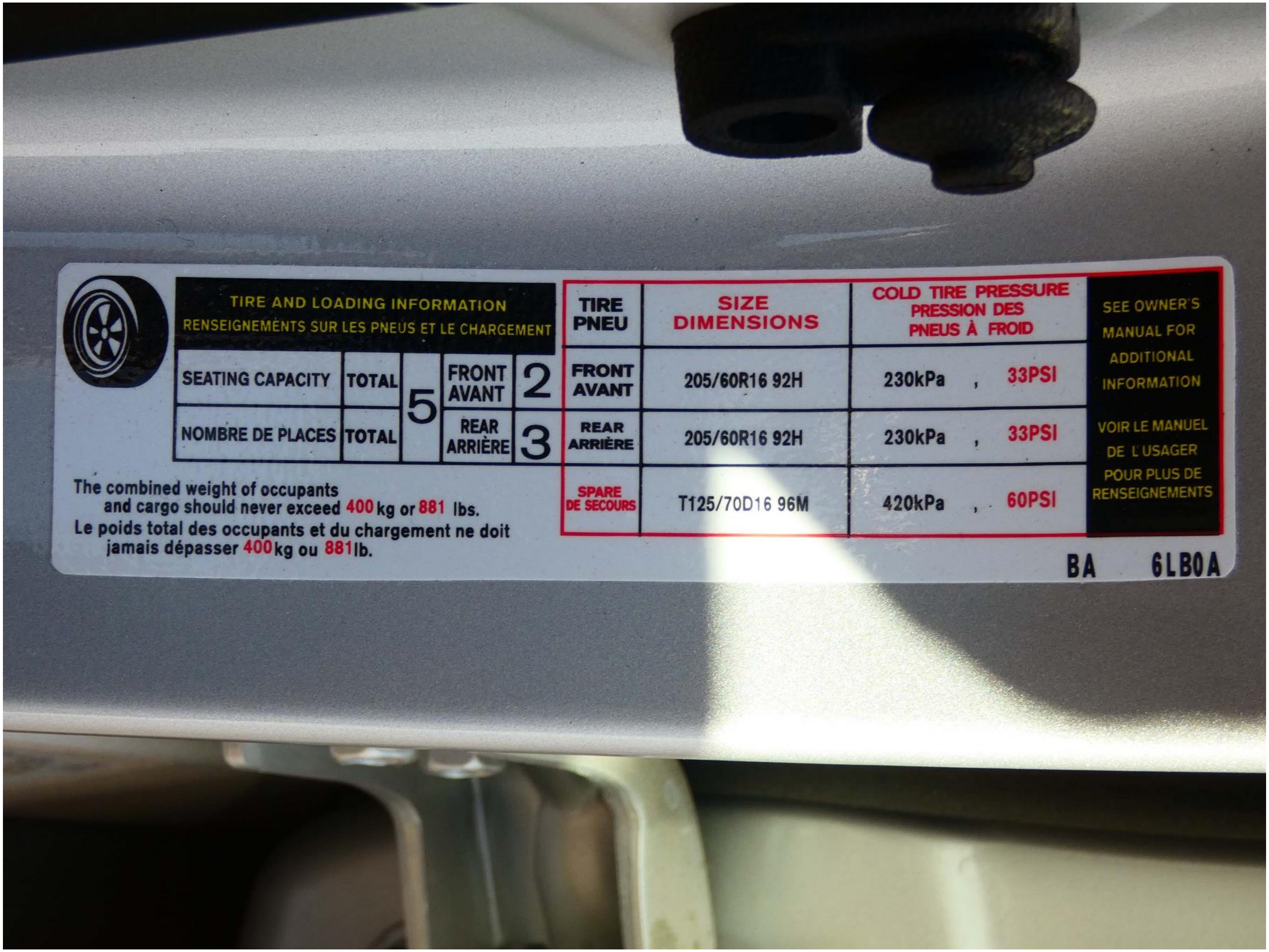


Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

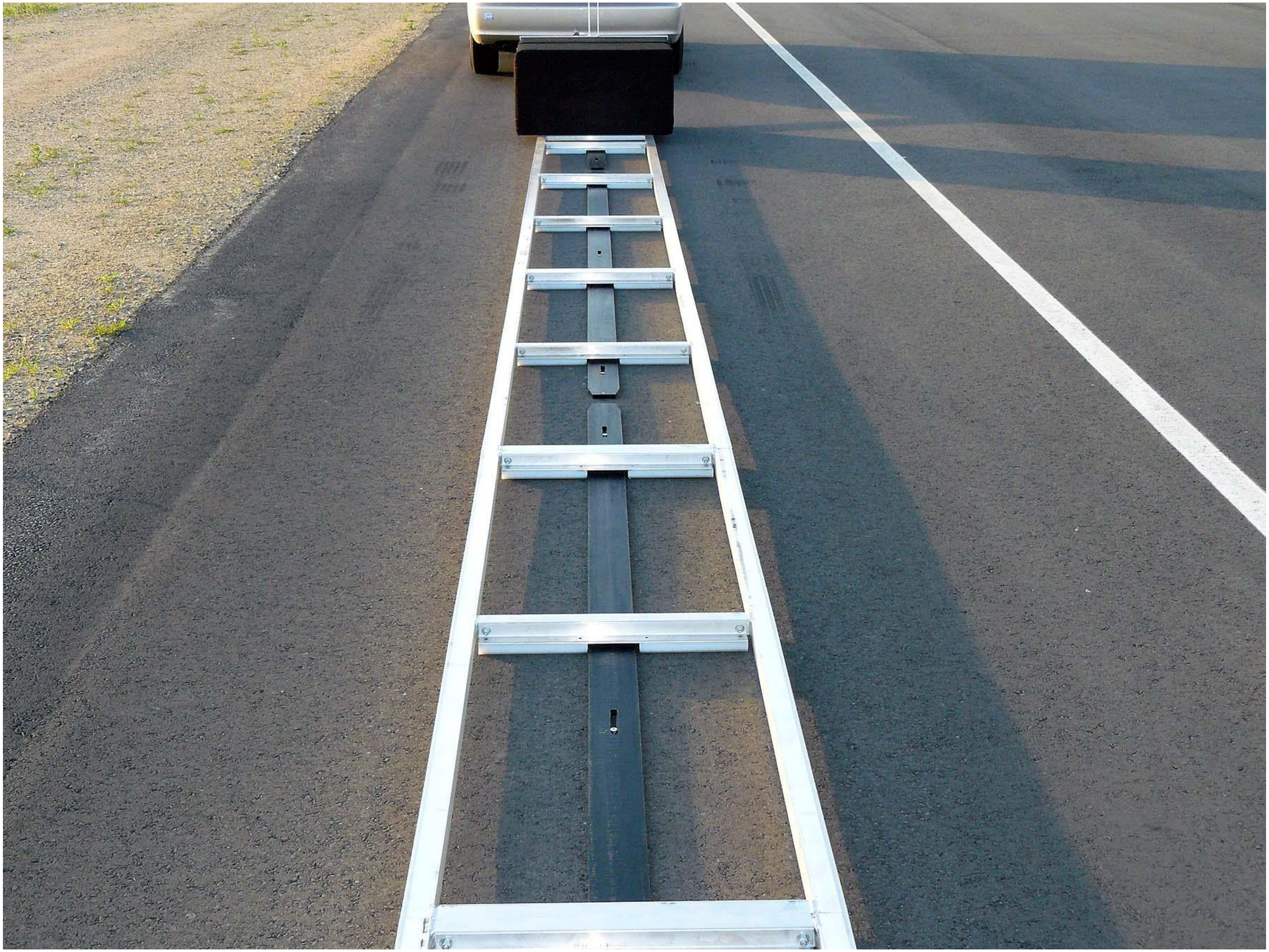


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

Figure A9. Steel Trench Plate

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

Figure A11. Sensor for Detecting Auditory and Visual Alerts

Figure A12. Computer Installed in Subject Vehicle

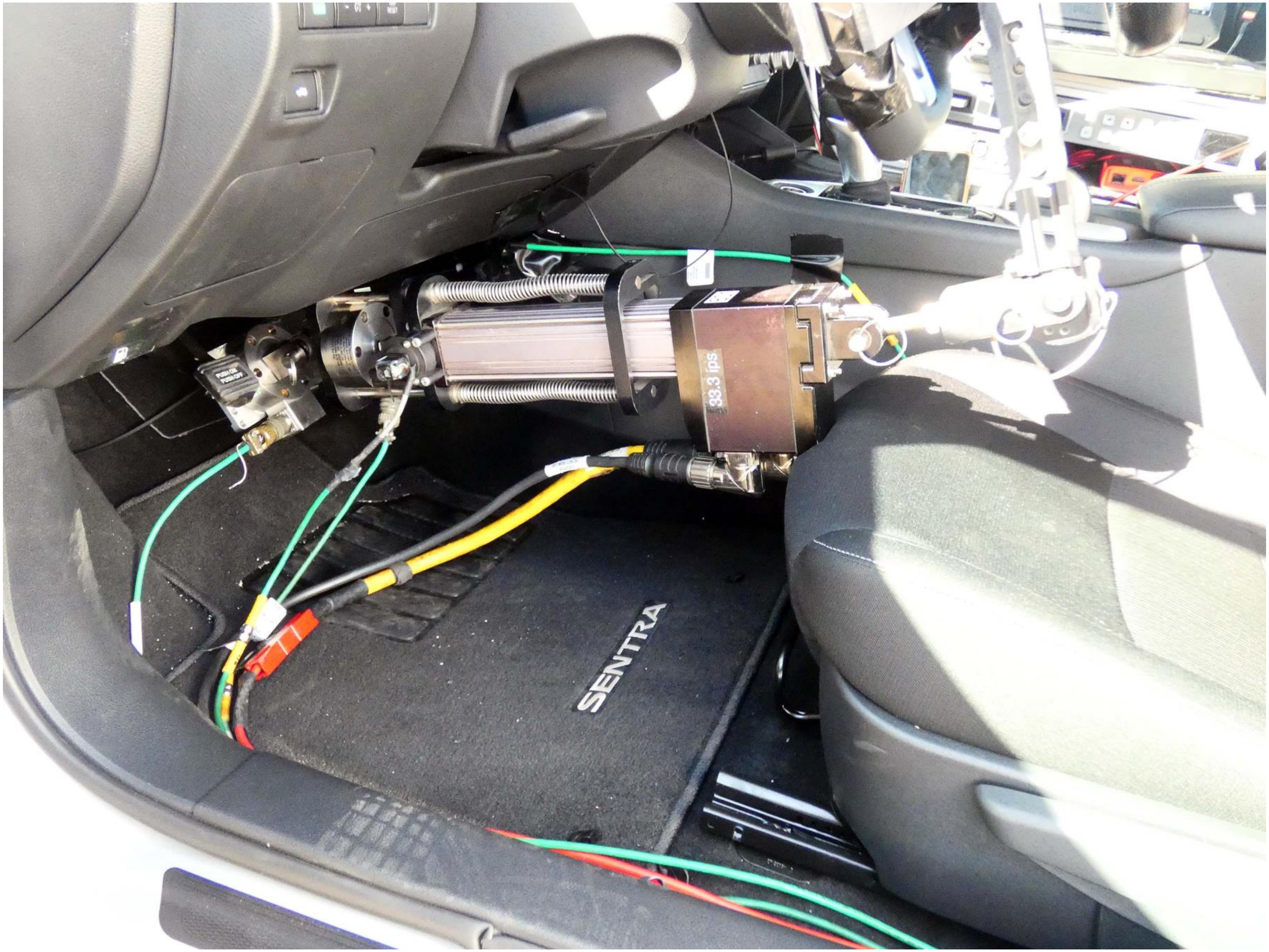


Figure A13. Brake Actuator Installed in Subject Vehicle

Figure A14. Brake Actuator Installed in POV System

Figure A15. AEB System Control Buttons

Figure A16. AEB System Setup Menu

Figure A17. First Stage Visual Alert

Figure A18. Second Stage Visual Alert

APPENDIX B

Excerpts from Owner's Manual

- Do not subject the area around the parking sensors ① to strong impact. Also, do not remove or disassemble the parking sensors. If the parking sensors and peripheral areas are deformed in an accident, etc., have the sensors checked. It is recommended that you visit a NISSAN dealer for this service.
- Do not install any stickers (including transparent stickers) or accessories on the parking sensors ① and their surrounding areas. This may cause a malfunction or improper operation.

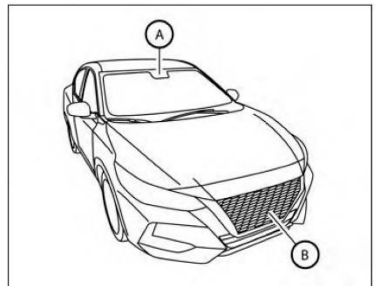
AUTOMATIC EMERGENCY BRAKING (AEB) WITH PEDESTRIAN DETECTION

⚠WARNING

Failure to follow the warnings and instructions for proper use of the AEB with Pedestrian Detection system could result in serious injury or death.

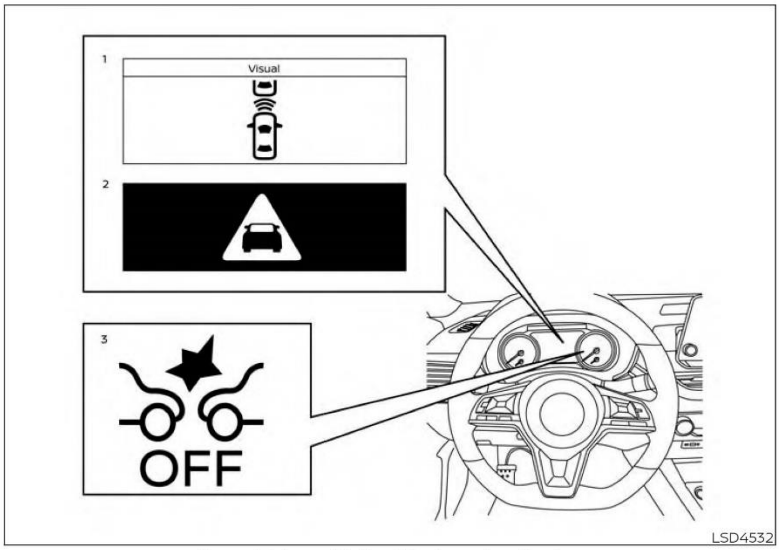
- **The AEB with Pedestrian Detection system is a supplemental aid to the driver. It is not a replacement for the driver's attention to traffic conditions or responsibility to drive safely. It cannot prevent accidents due to carelessness or dangerous driving techniques.**
- **The AEB with Pedestrian Detection system does not function in all driving, traffic, weather and road conditions.**

The AEB with Pedestrian Detection system can assist the driver when there is a risk of a forward collision with the vehicle ahead in the traveling lane or with a pedestrian ahead in the traveling lane.



LSD3756

The AEB with Pedestrian Detection system uses a radar sensor located on the front of the vehicle Ⓑ to measure the distance to the vehicle ahead in the same lane. For pedestrians, the AEB with Pedestrian Detection system uses a camera installed behind the windshield Ⓐ in addition to the radar sensor.



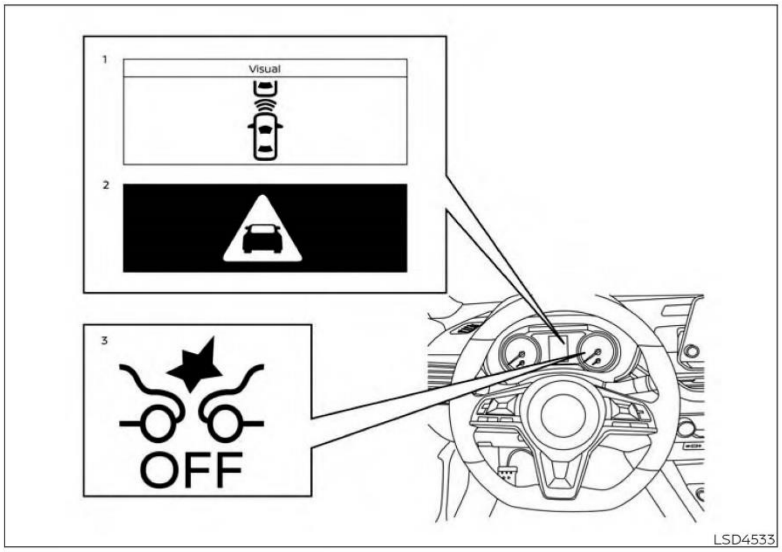
For vehicles with the 7 inch meter display

AEB WITH PEDESTRIAN DETECTION SYSTEM OPERATION

1. Vehicle ahead detection indicator
2. AEB with Pedestrian Detection emergency warning indicator
3. AEB with Pedestrian Detection system warning light

The AEB system operates at speeds above approximately 3 mph (5 km/h). For the pedestrian detection function, the system operates at speeds between 6 – 37 mph (10 – 60 km/h).

If a risk of a forward collision is detected, the AEB with Pedestrian Detection system will firstly provide the warning to the driver by flashing the vehicle ahead detection indicator (yellow) in the vehicle information display and providing an audible alert. If the driver applies the brakes quickly and forcefully after the warning, and the AEB with Pedestrian Detection system detects that there is still the possibility of a forward collision, the system will automatically increase the braking force.



For the vehicle with 4.2 inch meter display

If the driver does not take action, the AEB with Pedestrian Detection system issues the second visual (flashing) (red and white) and audible warning. If the driver releases the accelerator pedal, then the system applies partial braking. If the risk of a collision becomes imminent, the AEB with Pedestrian Detection system applies harder braking automatically.

While the AEB with Pedestrian Detection system is operating, you may hear the sound of brake operation. This is normal and indicates that the AEB with Pedestrian Detection system is operating properly.

NOTE:

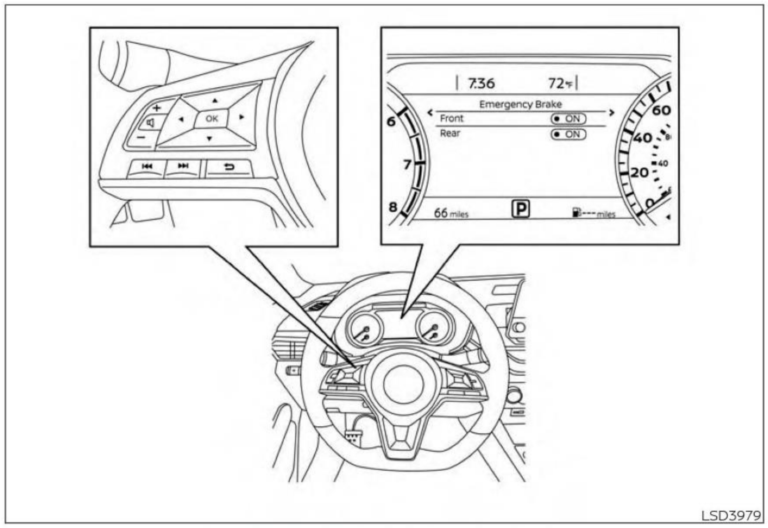
The vehicle's brake lights come on when any braking is performed by the AEB with Pedestrian Detection system.

Depending on vehicle speed and distance to the vehicle or pedestrian ahead, as well as driving and roadway conditions, the system may help the driver avoid a forward collision or may help mitigate the consequences if a collision should be unavoidable. If the driver is handling the steering wheel, accelerating or braking, the AEB with Pedestrian Detection system will function later or will not function.

The automatic braking will cease under the following conditions:

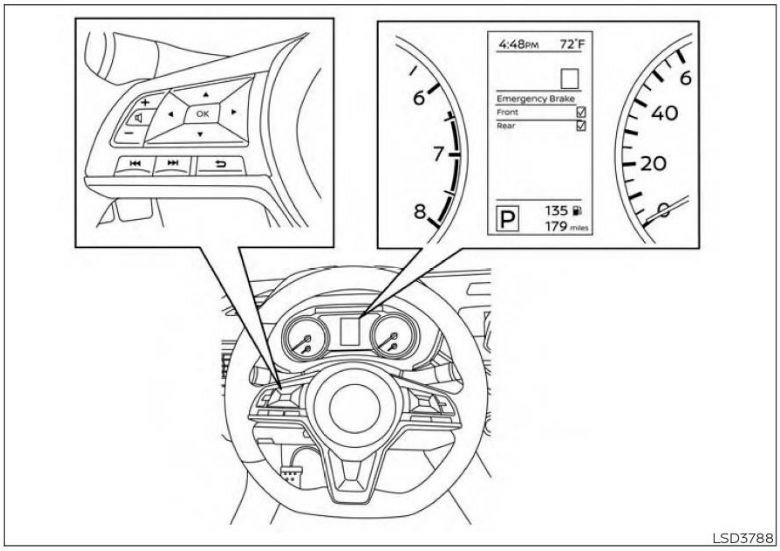
- When the steering wheel is turned to avoid a collision.
- When the accelerator pedal is depressed.
- When there is no longer a vehicle or a pedestrian detected ahead.

If the AEB with Pedestrian Detection system has stopped the vehicle, the vehicle will remain at a standstill for approximately 2 seconds before the brakes are released.



For vehicles with the 7 inch meter display

TURNING THE AEB WITH PEDESTRIAN DETECTION SYSTEM ON/OFF



For vehicles with the 4.2 inch meter display

Perform the following steps to enable or disable the AEB with Pedestrian Detection system.

1. Press the ◀▶ button until "Settings" displays in the vehicle information display. Use the ▲▼ button to select "Driver Assistance." Then press the OK button.
2. Select "Emergency Brake" and press the OK button.
3. Select "Front" and press the OK button to turn the system on or off.

When the AEB with Pedestrian Detection system is turned off, the AEB with Pedestrian Detection system warning light illuminates.

NOTE:

- **The AEB with Pedestrian Detection system will be automatically turned on when the engine is restarted.**
- **The I-FCW system is integrated into the AEB with Pedestrian Detection system. There is not a separate selection in the vehicle information display for the I-FCW system. When the AEB system is turned off, the I-FCW system is also turned off.**

AEB WITH PEDESTRIAN DETECTION SYSTEM LIMITATIONS

⚠WARNING

Listed below are the system limitations for the AEB with Pedestrian Detection system. Failure to operate the vehicle in accordance with these system limitations could result in serious injury or death.

- **The AEB with Pedestrian Detection system cannot detect all vehicles or pedestrians under all conditions.**
- **The AEB with Pedestrian Detection system does not detect the following:**
  - **Pedestrians that are small (for example, children), in a sitting position, operating toys/skateboards, on scooters or in wheelchairs, or not in an upright standing or walking position.**
  - **Animals of any size.**
  - **Obstacles (for example, cargo or debris) on the roadway or roadside.**
  - **Oncoming or crossing vehicles.**
  - **Vehicles where the tires are difficult to see or the shape of the rear of the vehicle is unclear or obstructed.**
  - **Parked vehicles.**
- **The AEB with Pedestrian Detection system has some performance limitations.**
  - **If a stationary vehicle is in the vehicle's path, the system will not function when the vehicle approaches the stationary vehicle at speeds over approximately 50 mph (80 km/h).**
  - **Pedestrian detection will not function when the vehicle is driven at speeds over approximately 37 mph (60 km/h) or below approximately 6 mph (10km/h).**
- **For pedestrians, the AEB with Pedestrian Detection system will not issue the first warning.**
- **The AEB with Pedestrian Detection system may not function properly or detect a vehicle or pedestrians ahead in the following conditions:**
  - **In poor visibility conditions (such as rain, snow, fog, dust storms, sand storms, smoke, and road spray from other vehicles).**
  - **If dirt, ice, snow, fog or other material is covering the radar sensor area or camera area of windshield.**
  - **If a strong light (for example, sunlight or high beams) enters the front camera or a sudden change in brightness occurs (for example, entering a tunnel or driving in lightning).**
  - **In dark or dimly lit conditions, such as at night or in tunnels, including cases where your vehicle's headlights are off or dim, or the tail lights of the vehicle ahead are off.**
  - **When the direction of the camera is misaligned.**
  - **When driving on a steep downhill slope, on roads with sharp curves, and/or bumpy or dirt roads.**
  - **If there is interference by other radar sources.**
  - **When your vehicle's position or movement is changed quickly or significantly (for example, lane change, turning vehicle, abrupt steering, sudden acceleration or deceleration).**

- When your vehicle or the vehicle or pedestrian ahead moves quickly or significantly such that the system cannot detect and react in time (for example, pedestrian moving quickly toward the vehicle at close range, vehicle cutting in, changing lanes, making a turn, steering abruptly, sudden acceleration or deceleration).
- When the vehicle or pedestrian is offset from the vehicle's forward path.
- If the speed difference between the two vehicles is small.
- The pedestrian's profile is partially obscured or unidentifiable; for example, due to transporting luggage, pushing a stroller, wearing bulky or very loose-fitting clothing or accessories, or being in a unique posture (such as raising hands).
- There is poor contrast of a person to the background, such as having clothing color or pattern which is similar to the background.
- For approximately 15 seconds after starting the engine.
- If the vehicle ahead has a unique or unusual shape, extremely low or high clearance heights, or unusual cargo loading or is narrow (for example, a motorcycle).
- When the vehicle or pedestrian is located near a traffic sign, a reflective area (for example, water on road), or is in a shadow.
- When multiple pedestrians are grouped together.
- When the view of the pedestrian is obscured by a vehicle or other object.

· The system performance may be degraded in the following conditions:
  - The vehicle is driven on a slippery road.
  - The vehicle is driven on a slope.
  - Excessively heavy baggage is loaded in the rear seat or the cargo area of your vehicle.

· The system is designed to automatically check the sensor's (radar and camera) functionality, within certain limitations. The system may not detect some forms of obstruction of the sensor area such as ice, snow or stickers, for example. In these cases, the system may not be able to warn the driver properly. Be sure that you check, clean and clear sensor areas regularly.

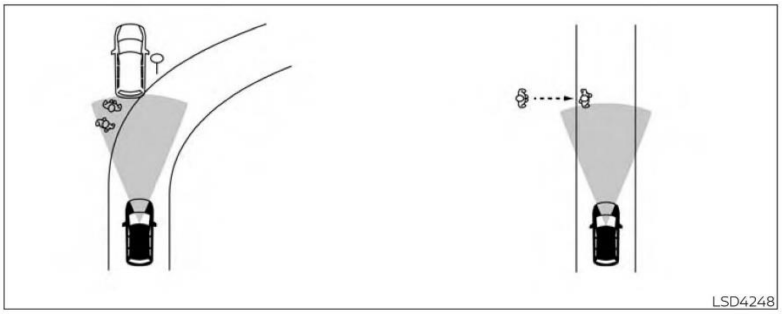
· In some road and traffic conditions, the AEB with Pedestrian Detection system may unexpectedly apply partial braking. When acceleration is necessary, depress the accelerator pedal to override the system.

· The AEB with Pedestrian Detection system may operate when a pattern, object, shadow or lights are detected that are similar to the outline of vehicles or pedestrians, or if they are the same size and position as a vehicle or motorcycle's tail lights.

· The system may keep operating when the vehicle ahead is turning right or left.

· The system may operate when your vehicle is approaching and passing a vehicle ahead.

· Depending on the road shape (curved road, entrance and exit of the curve, winding road, lane regulation, under construction, etc.), the system may operate temporarily for the oncoming vehicle in front of your vehicle.



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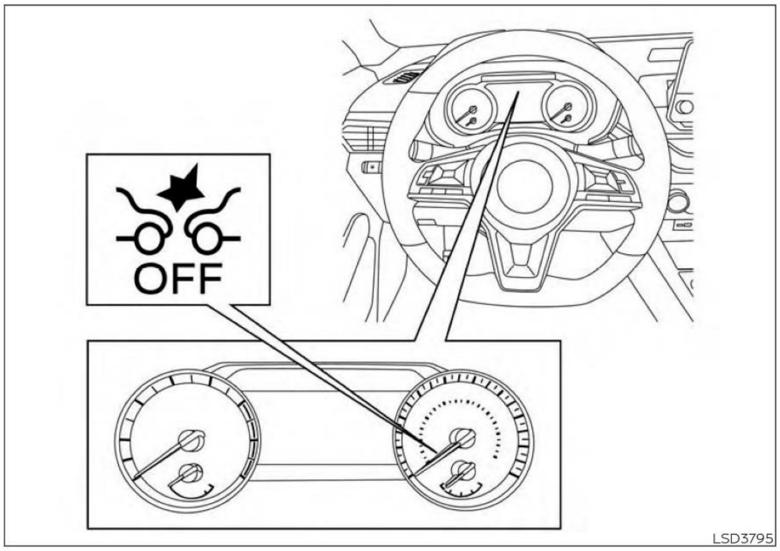
⚠WARNING

Listed below are the system limitations for the AEB with Pedestrian Detection system. Failure to operate the vehicle in accordance with these system limitations could result in serious injury or death.

- **The AEB with Pedestrian Detection system may react to:**
  - **objects on the roadside (traffic sign, guardrail, pedestrian, motorcycle, vehicle, etc.)**
  - **pedestrians when driving on the narrow alleys, etc.**
  - **pedestrians who temporarily protrude into or approaching the driving lane to avoid the obstacles on the road shoulder**
  - **objects above road (low bridge, traffic sign, etc.)**
  - **objects on the road surface (railroad track, grate, steel plate, etc.)**
  - **objects in the e parking garage (beam, pillar, etc.)**
  - **pedestrians or motorcycles approaching the travelling lane**
  - **vehicles, pedestrians, motorcycles or objects in adjacent lanes or close to the vehicle**
  - **oncoming pedestrians**
  - **objects on the road (such as trees)**
- **Braking distances increase on slippery surfaces.**
- **Excessive noise will interfere with the warning chime sound, and the chime may not be heard.**



For vehicles with the 7 inch meter display

SYSTEM TEMPORARILY UNAVAILABLE

Condition A:

In the following conditions, the AEB with Pedestrian Detection system warning light blinks and the system will be turned off automatically:

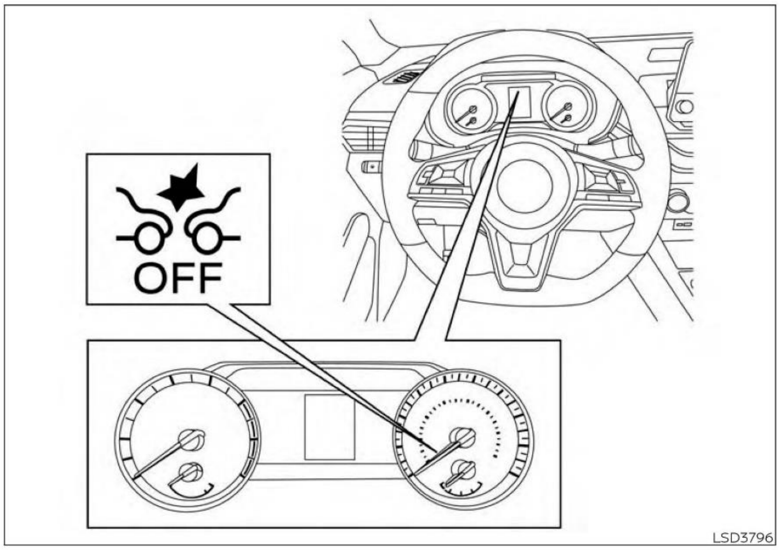
- The radar sensor picks up interference from another radar source.
- The camera area of the windshield is misted or frozen.
- Strong light is shining from the front.
- The cabin temperature is over approximately 104°F (40°C) in direct sunlight.
- The camera area of the windshield glass is continuously covered with dirt, etc.

Action to take

When the above conditions no longer exist, the AEB with Pedestrian Detection system will resume automatically.

NOTE:

When the inside of the windshield on the camera area is misted or frozen, it will take a period of time to remove it after the A/C turns on. If dirt appears on this area, it is recommended that you visit a NISSAN dealer.



For vehicles with the 4.2 inch meter display

Condition B:

When there is inclement weather (rain, fog, snow, etc.) blocking the front radar sensor, the AEB with Pedestrian Detection system will automatically be canceled, the chime will sound and the "Forward Driving Aids Temporarily Disabled Front Sensor Blocked: See Owner's Manual" or "Driving Aids Temporarily Disabled Front Sensor Blocked: See Manual" warning message will appear in the vehicle information display.

Action to take:

When the conditions listed above are no longer present, the warning message will no longer be available in the vehicle information display. If the "Forward Driving Aids Temporarily Disabled Front Sensor Blocked: See Owner's Manual" or "Driving Aids Temporarily Disabled Front Sensor Blocked: See Manual" warning message continues to be displayed, have the system checked. It is recommended that you visit a NISSAN dealer for this service.

Condition C:

When the radar sensor of the front bumper is covered with mud, dirt, snow ice, etc., or is obstructed, the AEB with Pedestrian Detection system will automatically be canceled. The chime will sound and the "Forward Driving Aids Temporarily Disabled Front Sensor Blocked: See Owner's Manual" or "Driving Aids Temporarily Disabled Front Sensor Blocked: See Manual" warning message will appear in the vehicle information display.

Action to take:

If the warning message appears, stop the vehicle in a safe place, place the shift lever in the P (Park) position, and turn the engine off. When the radar signal is temporarily interrupted, clean the sensor area of the front bumper and restart the engine. If the "Forward Driving Aids Temporarily Disabled Front Sensor Blocked: See Owner's Manual" or "Driving Aids Temporarily Disabled Front Sensor Blocked: See Manual" warning message continues to be displayed, have the system checked. It is recommended that you visit a NISSAN dealer for this service.

Condition D:

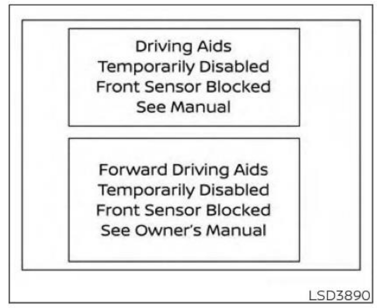
When driving on roads with limited road structures or buildings (for example, long bridges, deserts, snowfields, driving next to long walls), the system may illuminate the system warning light and display the "Forward Driving Aids Temporarily Disabled Front Sensor Blocked: See Owner's Manual" or "Driving Aids Temporarily Disabled Front Sensor Blocked: See Manual" message.

Action to take:

When the above driving conditions no longer exist, turn the system back on.

NOTE:

If the AEB with Pedestrian Detection system stops working, the I-FCW system will also stop working.

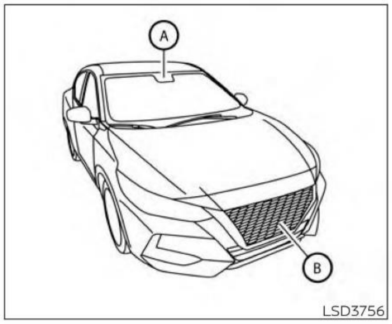


SYSTEM MALFUNCTION

If the AEB with Pedestrian Detection system malfunctions, it will be turned off automatically, a chime will sound, the AEB with Pedestrian Detection system warning light (orange) will illuminate and the warning message [Malfunction] will appear in the vehicle information display.

Action to take

If the warning light (orange) comes on, stop the vehicle in a safe location, turn the engine off and restart the engine. If the warning light continues to illuminate, have the AEB with Pedestrian Detection system checked. It is recommended that you visit a NISSAN dealer for this service.



LSD3756

SYSTEM MAINTENANCE

The radar sensor is located on the front of the vehicle Ⓑ. The camera is located on the upper side of the windshield Ⓐ.

To keep the AEB with Pedestrian Detection system operating properly, be sure to observe the following:

- Always keep the sensor areas of the front bumper/emblem and windshield clean.
- Do not strike or damage the areas around the sensors (e.g., bumper, windshield).
- Do not cover or attach stickers, or install any accessory near the sensors. This could block sensor signals and/or cause failure or malfunction.
- Do not attach metallic objects near the radar sensor (brush guard, etc.). This could cause failure or malfunction.
- Do not place reflective materials, such as white paper or a mirror, on the instrument panel. The reflection of sunlight may adversely affect the camera unit's detection capability.
- Do not alter, remove or paint the front bumper. Before customizing or restoring the front bumper, it is recommended that you visit a NISSAN dealer.

Radio frequency statement

For USA

FCC ID OAYARS4B

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

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

APPENDIX C

Run Log

Subject Vehicle: **2022 Nissan Sentra CVT** Test start date: **4/12/2022**

Principal Other Vehicle: **SSV** Test end date: **4/12/2022**

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
1-14	Brake characterization and determination						See Appendix D
15-20	Run numbers skipped						
21	Static Run						
22	**Stopped POV**	Y	2.18	17.41	1.13	Pass	
23		Y	2.13	17.42	1.06	Pass	
24		Y	2.16	17.59	1.08	Pass	
25		N					Avg Brk Force
26		N					Throttle drop
27		Y	2.17	13.71	1.06	Pass	
28		Y	2.11	16.73	1.05	Pass	
29		Y	2.17	16.47	1.07	Pass	
30	Static Run						
31	**Slower POV, 25 vs 10**	Y	1.96	12.89	1.20	Pass	
32		Y	1.89	12.53	1.19	Pass	
33		Y	1.82	11.33	1.13	Pass	
34		N					Brk Force Onset

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
35		Y	1.93	10.84	1.04	Pass	
36		N					Avg Brk Force
37		Y	1.80	12.16	1.10	Pass	
38		Y	1.89	12.43	1.11	Pass	
39		Y	1.91	11.74	1.10	Pass	
40	Static run						
41	**Slower POV, 45 vs 20**	Y	2.58	14.43	1.10	Pass	
42		Y	2.66	12.64	1.14	Pass	
43		Y	2.63	13.85	1.12	Pass	
44		Y	2.62	13.59	1.07	Pass	
45		N					Low Deceleration
46		N					Low Deceleration
47		N					Low Deceleration
48	Static Run						
49-50	Brake Confirmation						Target Force set to 14.00 lbs
51		Y	2.60	12.66	1.15	Pass	
52		Y	2.64	13.08	1.11	Pass	
53		N					Lat Offset
54		Y	2.68	12.71	1.04	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
55	Static run						
56-58	Brake Confirmation						Target Force set to 13.0 lbs
59	**Decelerating POV**	N					POV brakes
60		N					Brake Actuator Released
61		N					Brake Actuator did not activate
62		N					Lateral offset
63		N					Low Deceleration
64-66	Brake Confirmation						Target Force set to 14.0 lbs
67		Y	1.60	0.90	1.16	Pass	
68		Y	1.83	0.15	1.14	Pass	
69		N					POV brakes
70		Y	1.94	0.00	1.16	Fail	
71		Y	2.02	0.35	1.14	Pass	
72		Y	1.70	0.00	1.11	Fail	
73		Y	1.75	0.46	1.08	Pass	
74		N					POV brakes, speed
75		Y	1.68	0.51	1.10	Pass	
76	Static run						
77	STP - Static run						

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
78	**Baseline, 25**	N					Low Deceleration
79		N					Low Deceleration
80	Brake Confirmation						
81		Y			0.56		
82		Y			0.50		
83		Y			0.52		
84		Y			0.52		
85		Y			0.47		
86		Y			0.51		
87		Y			0.51		
88	STP - Static run						
89	**Baseline, 45**	Y			0.54		
90		Y			0.56		
91		Y			0.58		
92		Y			0.52		
93		Y			0.51		
94		Y			0.51		
95		Y			0.52		
96	STP - Static run						

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
97	**STP False Positive, 25**	Y			0.49	Pass	
98		N					Throttle drop
99		Y			0.53	Pass	
100		Y			0.48	Pass	
101		Y			0.51	Pass	
102		Y			0.50	Pass	
103		Y			0.52	Pass	
104		Y			0.52	Pass	
105	STP - Static run						
106	**STP False Positive, 45**	Y			0.51	Pass	
107		Y			0.54	Pass	
108		Y			0.57	Pass	
109		Y			0.58	Pass	
110		Y			0.56	Pass	
111		N					Lat Offset
112		Y			0.57	Pass	
113		Y			0.55	Pass	
114	STP - Static run						

APPENDIX D

Brake Characterization

Subject Vehicle: **2022 Nissan Sentra CVT**

Test start date: **4/12/2022**

Test end date: **4/12/2022**

DBS Initial Brake Characterization				
Run Number	**Stroke at 0.4 g (in)**	**Force at 0.4 g (lb)**	**Slope**	**Intercept**
1	1.61	13.79	0.83	-0.41
2	1.61	14.15	0.77	-0.35
3	1.61	13.90	0.71	-0.30

DBS Brake Characterization Determination								
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					Brake Rate
5		35	N					Brake Rate
6		35	Y	0.415	1.67		1.61	
7		25	Y	0.391	1.67		1.71	
8		45	Y	0.410	1.67		1.63	
9	**Hybrid**	35	Y	0.504		15.13	12.01	
10		35	Y	0.454		13.50	11.89	

DBS Brake Characterization Determination								
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**
11		35	Y	0.484		12.20	10.08	
12		35	Y	0.401		10.80	10.77	
13		25	Y	0.393		10.80	10.99	
14		45	Y	0.389		10.80	11.11	
49	Hybrid	45	Y	0.285		10.80		
50		45	Y	0.416		14.00		
56		35	Y	0.279		10.80		
57		35	Y	0.453		14.00		
58		35	Y	0.420		13.00		
64		35	Y	0.362		13.00		
65		35	Y	0.369		14.00		
66		35	Y	0.417		14.00		
80		20	Y	0.400		14.00		

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. Plots shown herein are grouped by test type and are presented sequentially within a given test type. 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)
- Decelerating 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 auditory, visual, or haptic). Depending on the type of FCW alert or instrumentation used to measure the alert, this can be any combination of the following:
    - Filtered, rectified, and normalized sound signal. The vertical scale is 0 to 1.
    - Filtered, rectified, and normalized acceleration (i.e., haptic alert, such as steering wheel vibration). The vertical scale is 0 to 1.
    - Normalized light sensor signal. The vertical scale is 0 to 1.

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

- Headway (ft) – Longitudinal separation between the front-most 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 – Position of the accelerator pedal and brake pedal. The units for the brake pedal are inches and the units for the accelerator pedal are percent of full scale divided by 10.

- 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.

Envelopes and Thresholds

Some of the time history plot figures contain either green or yellow envelopes and/or black or red 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.

With the exception of the brake force plots (see description below), 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 Ax plot, if the scenario is an AEB brake to stop scenario, a vertical dashed black line is displayed for all plots indicating the moment of first POV braking. The yellow envelope in this case is relevant to the POV braking only. The left edge of the envelope is at 1.5 seconds after the first POV braking. A solid black threshold line extends horizontally 0.5 seconds to the left of the envelope. This threshold line represents the time during which the Ax of the Principal Other Vehicle must first achieve 0.27 g (the upper edge of the envelope, i.e., 0.30 g ± 0.03 g). A green circle or red asterisk is displayed at the moment the POV brake level achieves 0.27 g. A green circle indicates that the test was valid (the threshold was crossed during the appropriate interval) and a red asterisk indicates that the test was invalid (the threshold was crossed 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 plots:

- If the tests are done in Hybrid mode, the brake force plot shows a dashed black threshold line indicating a brake force of 2.5 lbs. 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. A blue envelope represents the target average brake force necessary to be valid
- If the tests are done in Displacement mode, there are no relevant brake force level thresholds or average brake force calculations.

In the instance of the “last second” braking applied by the brake robot, a thick vertical red line will appear on the plots at the moment the brake robot activates. Note that last second braking is only done when it has been determined by the onboard computer that test failure cannot be avoided. It is done simply to reduce the collision speed in order to minimize the likelihood of damage to the SSV and to the Subject Vehicle. Therefore, data validity checks are not performed after the red line, and certain values, such as minimum distance or peak deceleration, may not be accurate.

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
   - Blue envelope = visualized target range for the time varying data averaged over a period equal to the length of the envelope
   - 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.
   - Red threshold (Solid) = for reference only – indicates the activation of last-minute braking by the brake robot. Data after the solid red line is not used to determine test validity.

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

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

Other Notations

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

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

Examples of valid or passing time history plots for each test type (including passing, failing, and invalid runs) are shown in Figure 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.

Notes

For valid runs, plots are shown for all warning types. In some cases, one of the plots may indicate that a run was invalid, but if the run was valid for either warning type it is considered valid. The companion plots are shown for the sake of completeness.

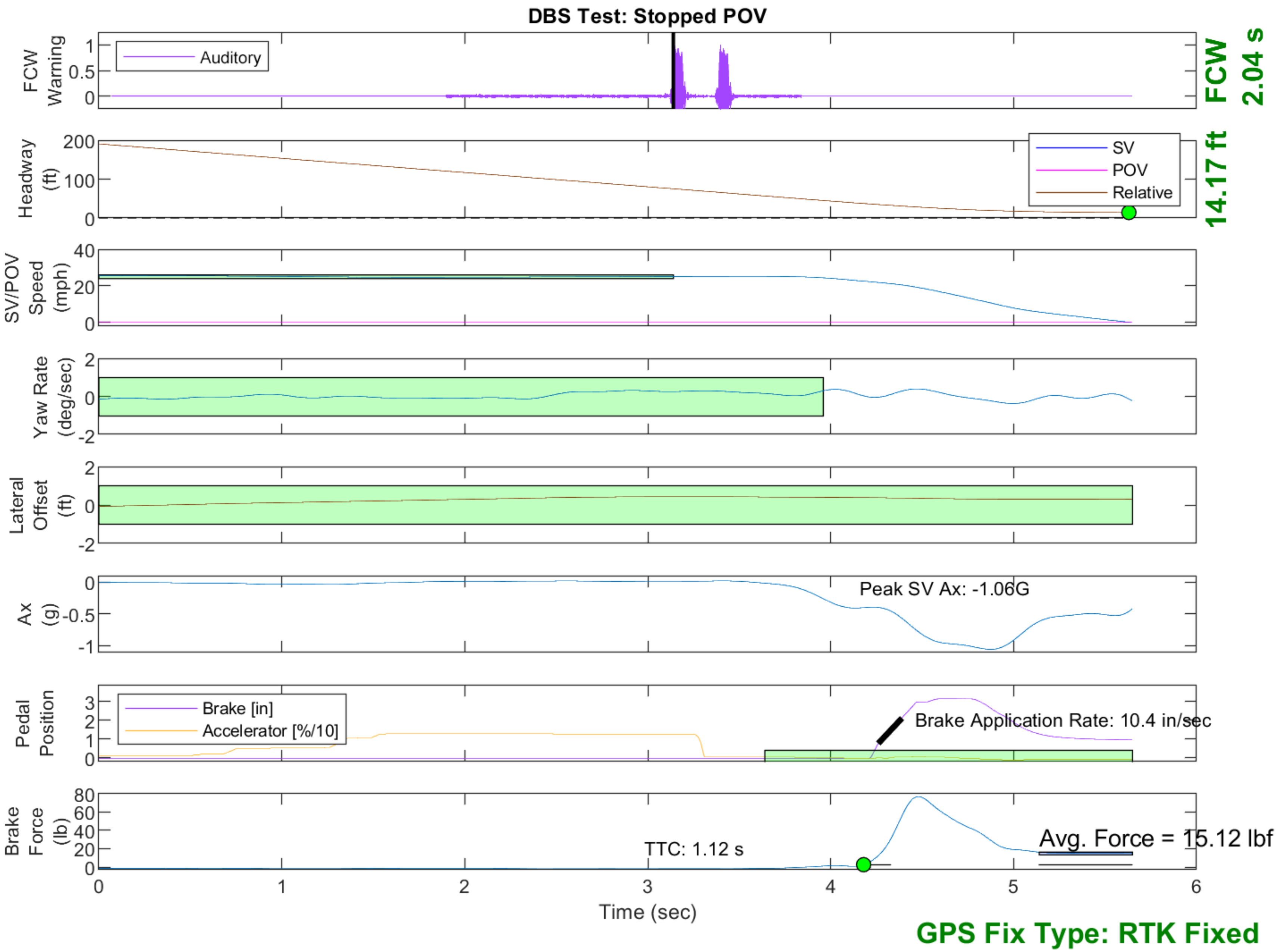


Figure E1. Example Time History for Stopped POV, Passing

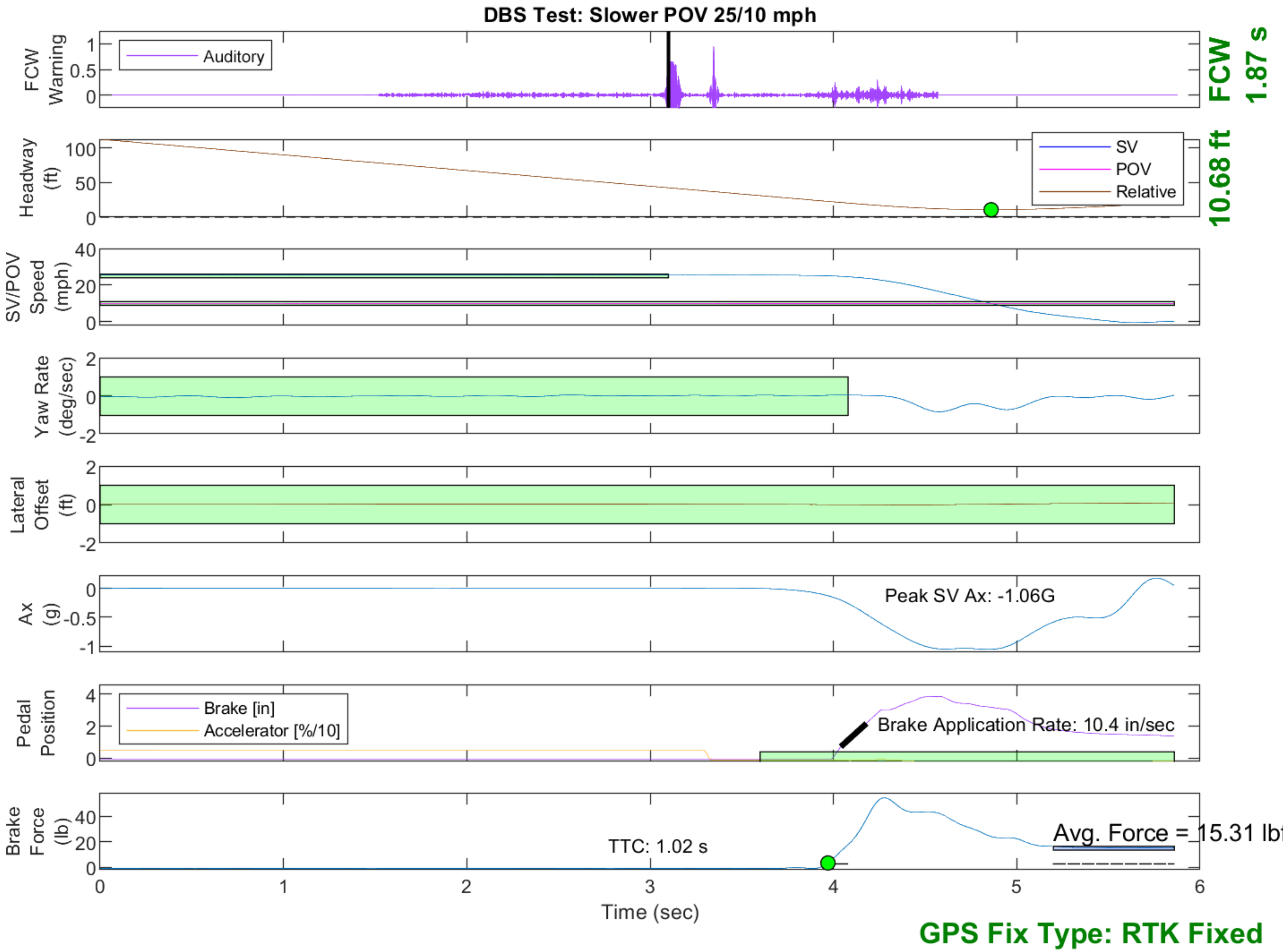


Figure E2. Example Time History for Slower POV 25 vs. 10, Passing

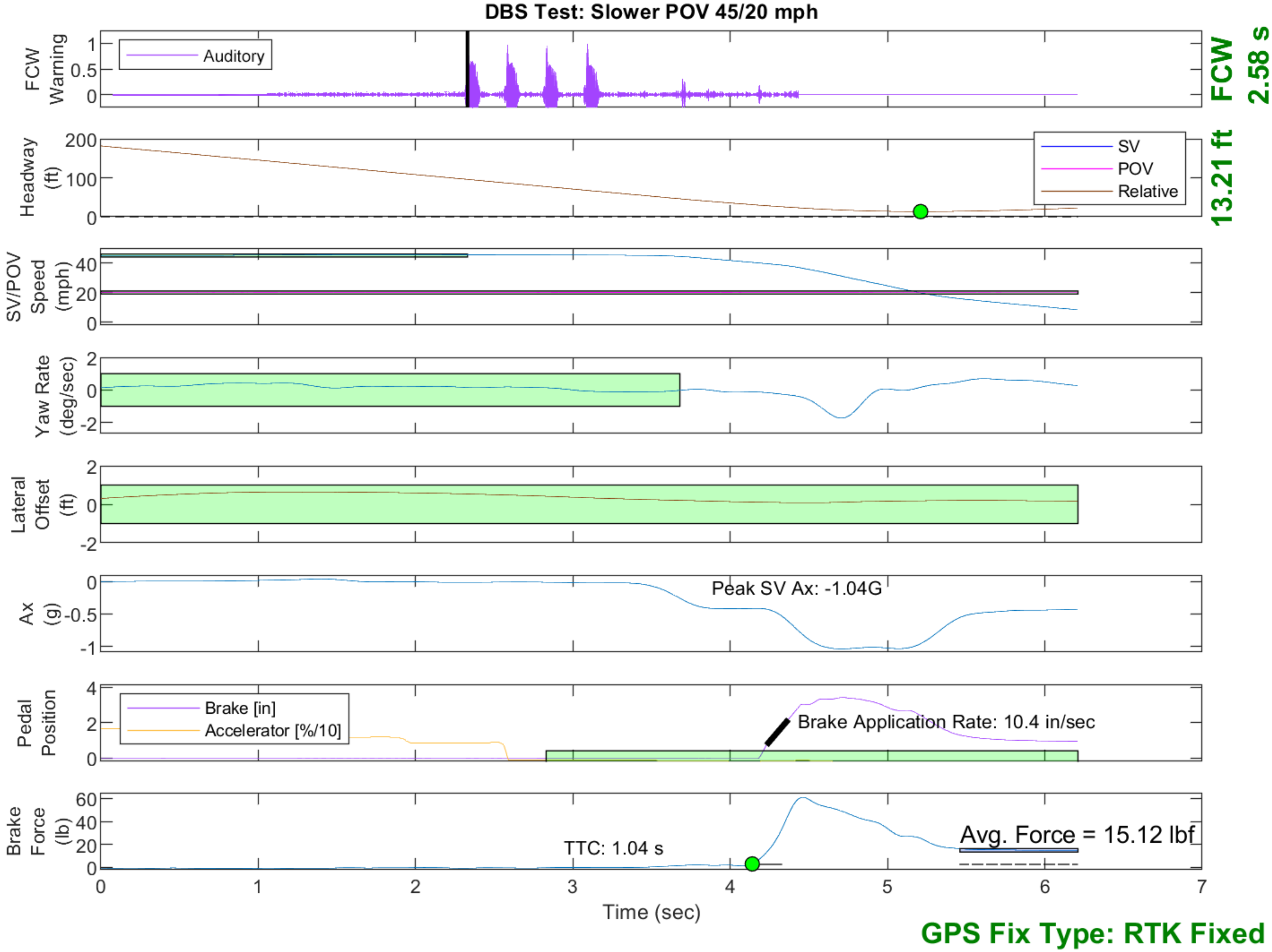


Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

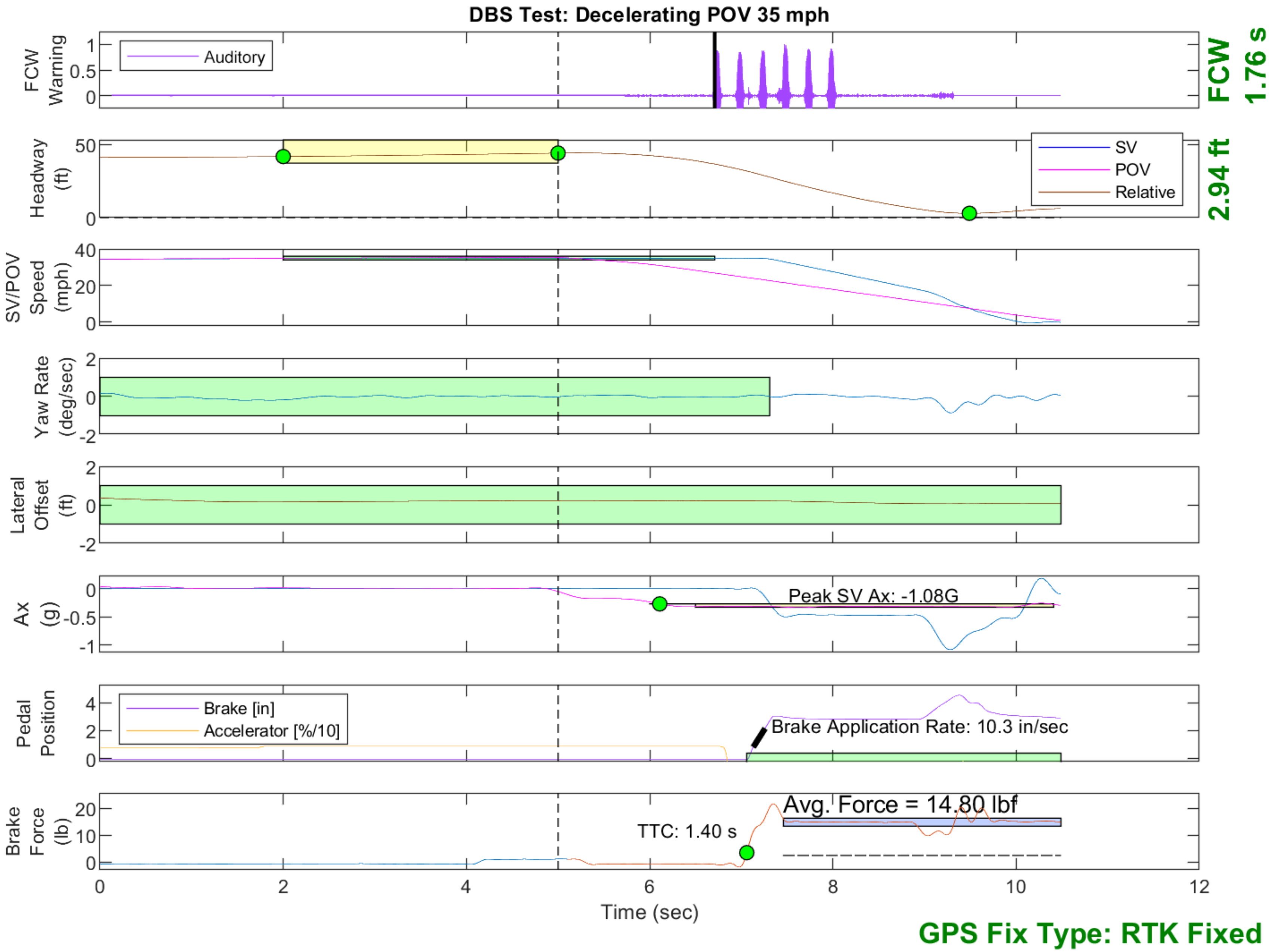


Figure E4. Example Time History for Decelerating POV 35, Passing

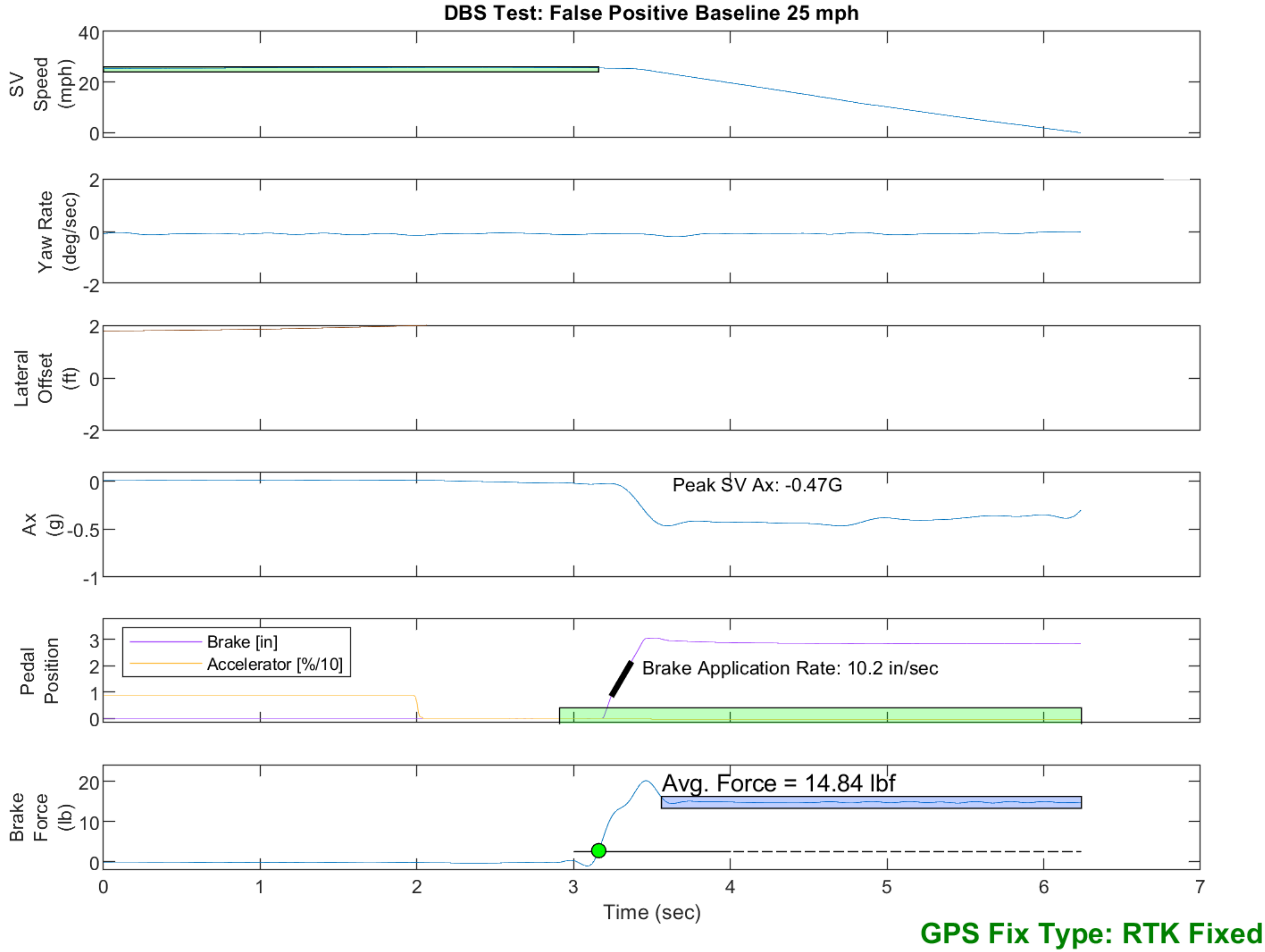


Figure E5. Example Time History for False Positive Baseline 25

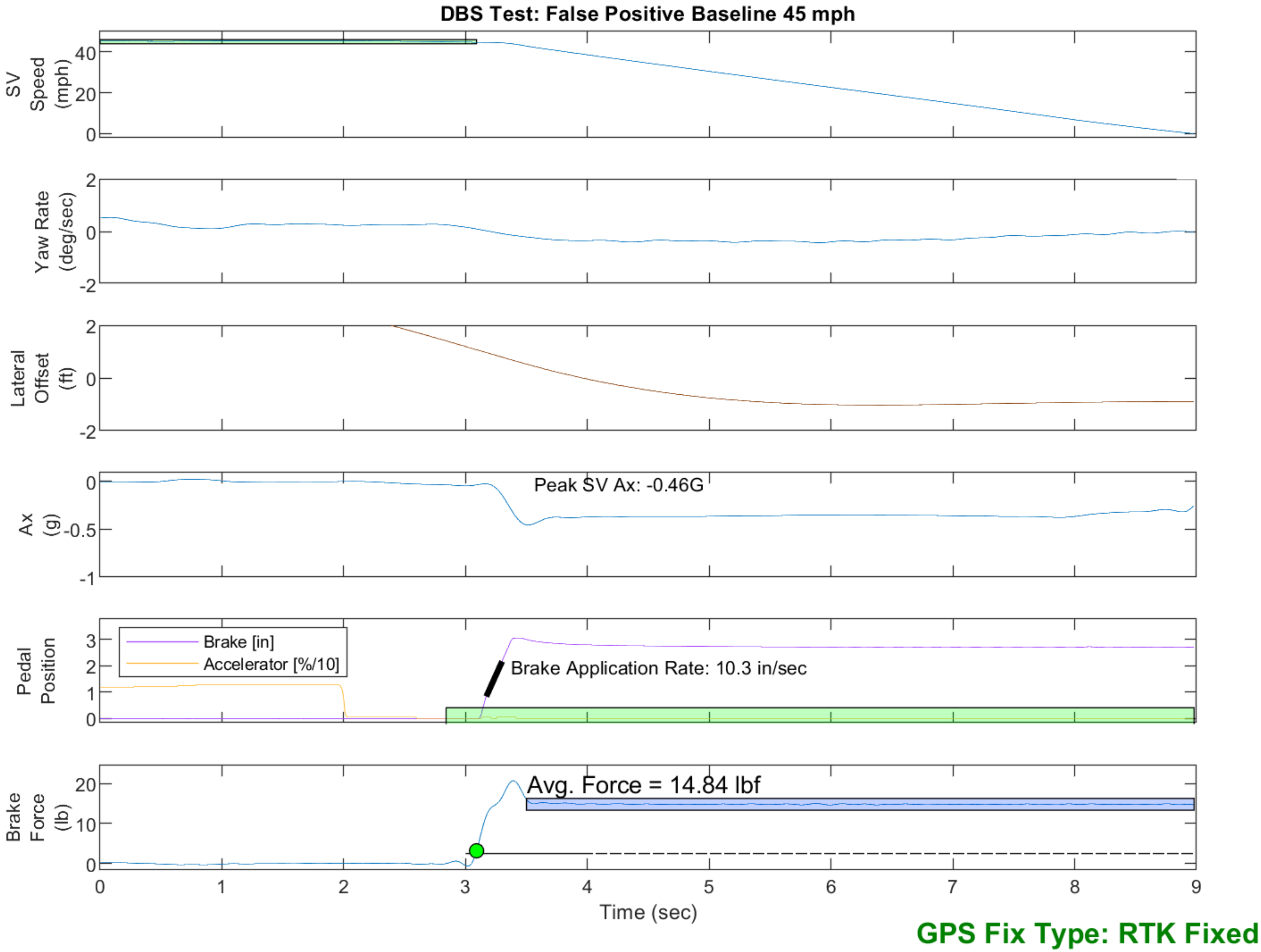


Figure E6. Example Time History for False Positive Baseline 45

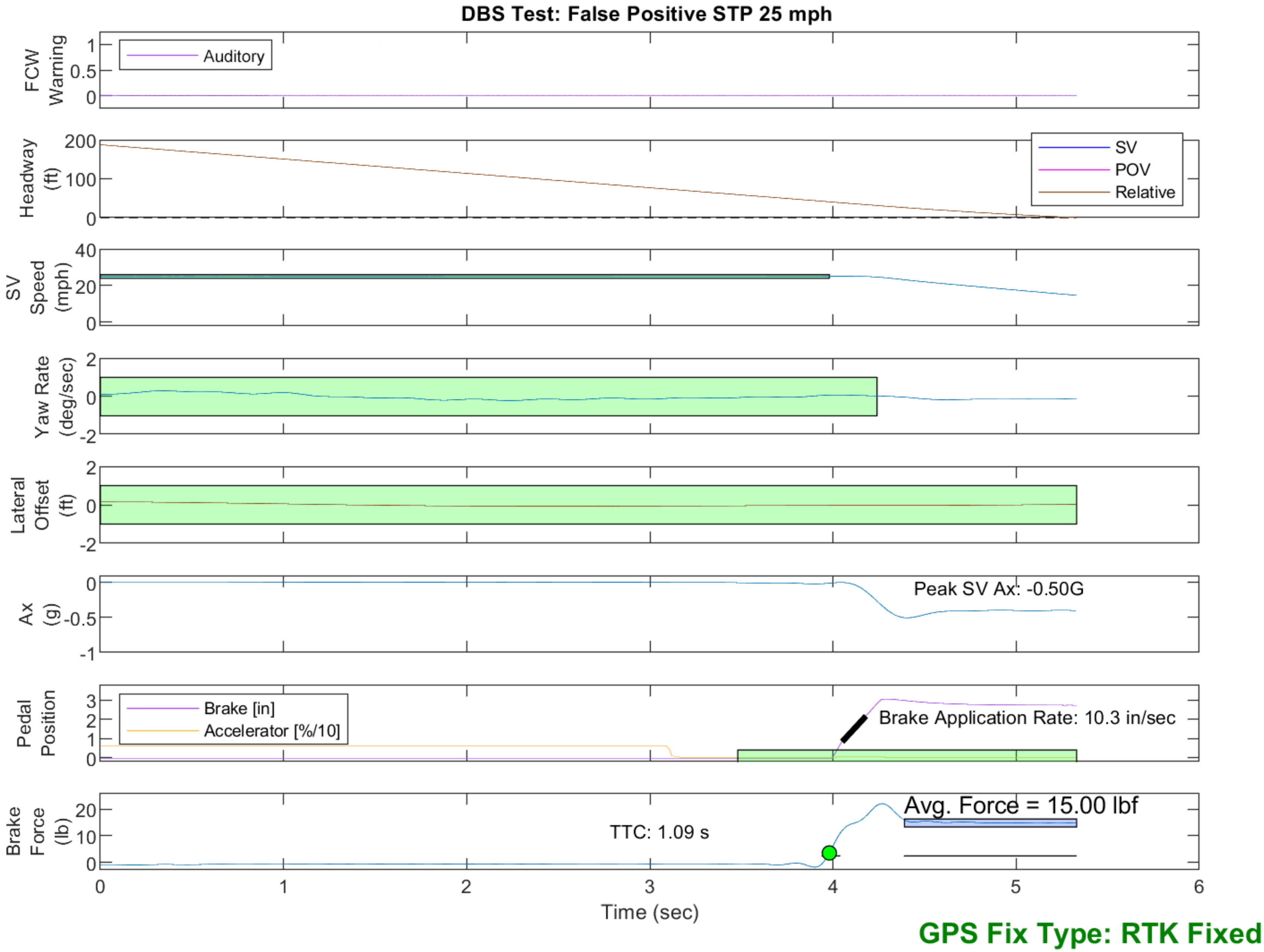


Figure E7. Example Time History for False Positive Steel Plate 25, Passing

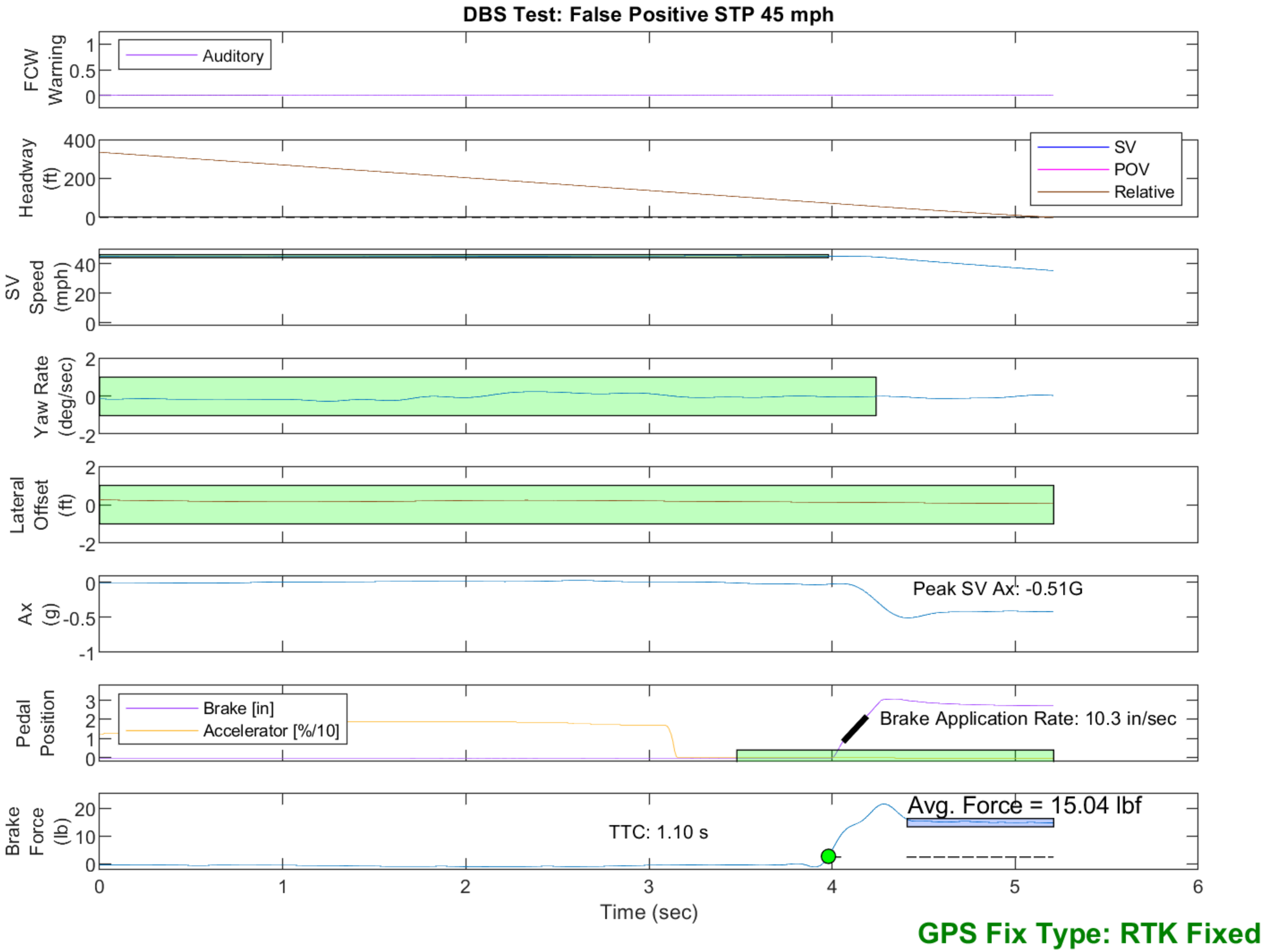


Figure E8. Example Time History for False Positive Steel Plate 45, Passing

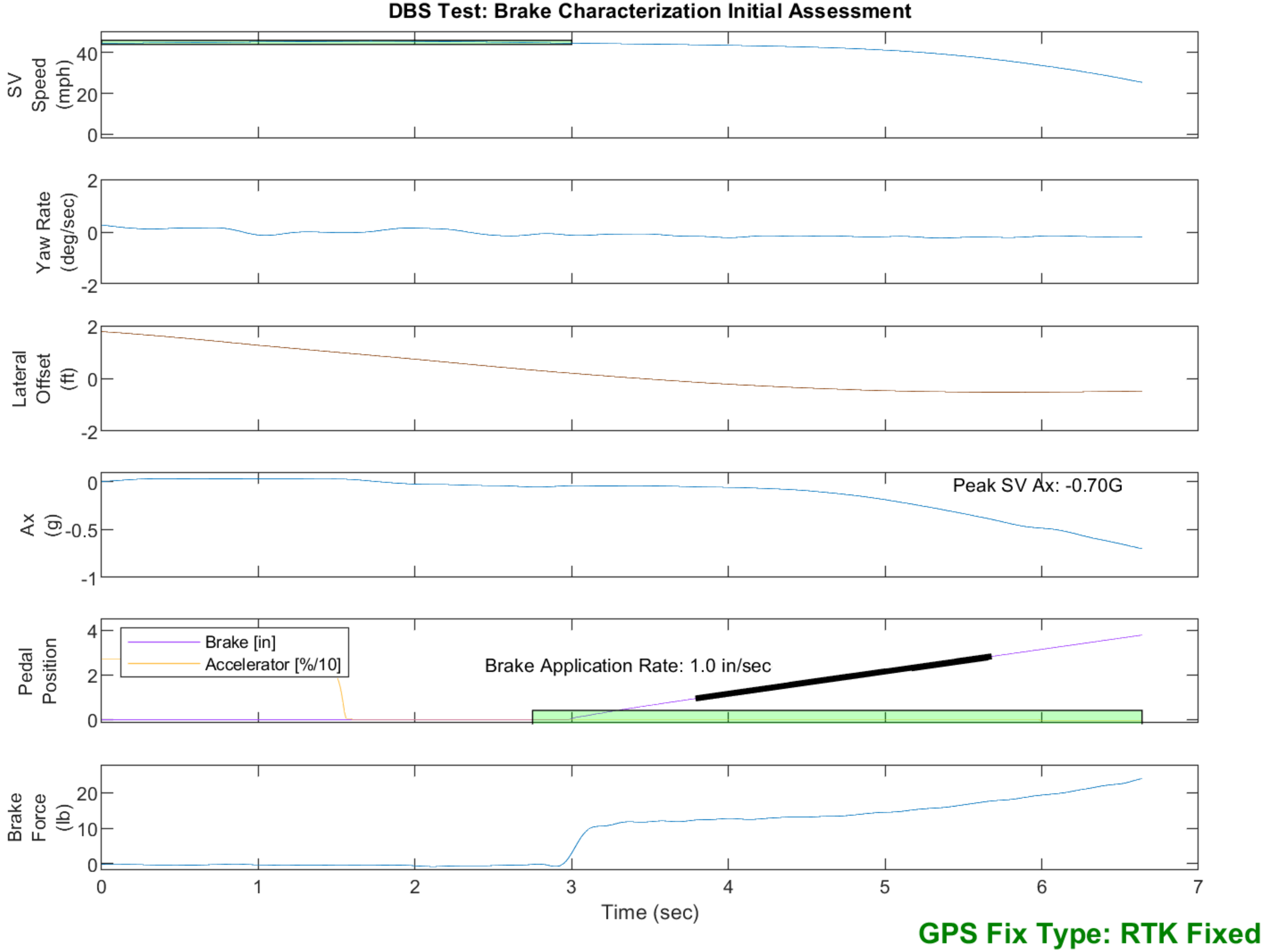


Figure E9. Example Time History for DBS Brake Characterization, Passing

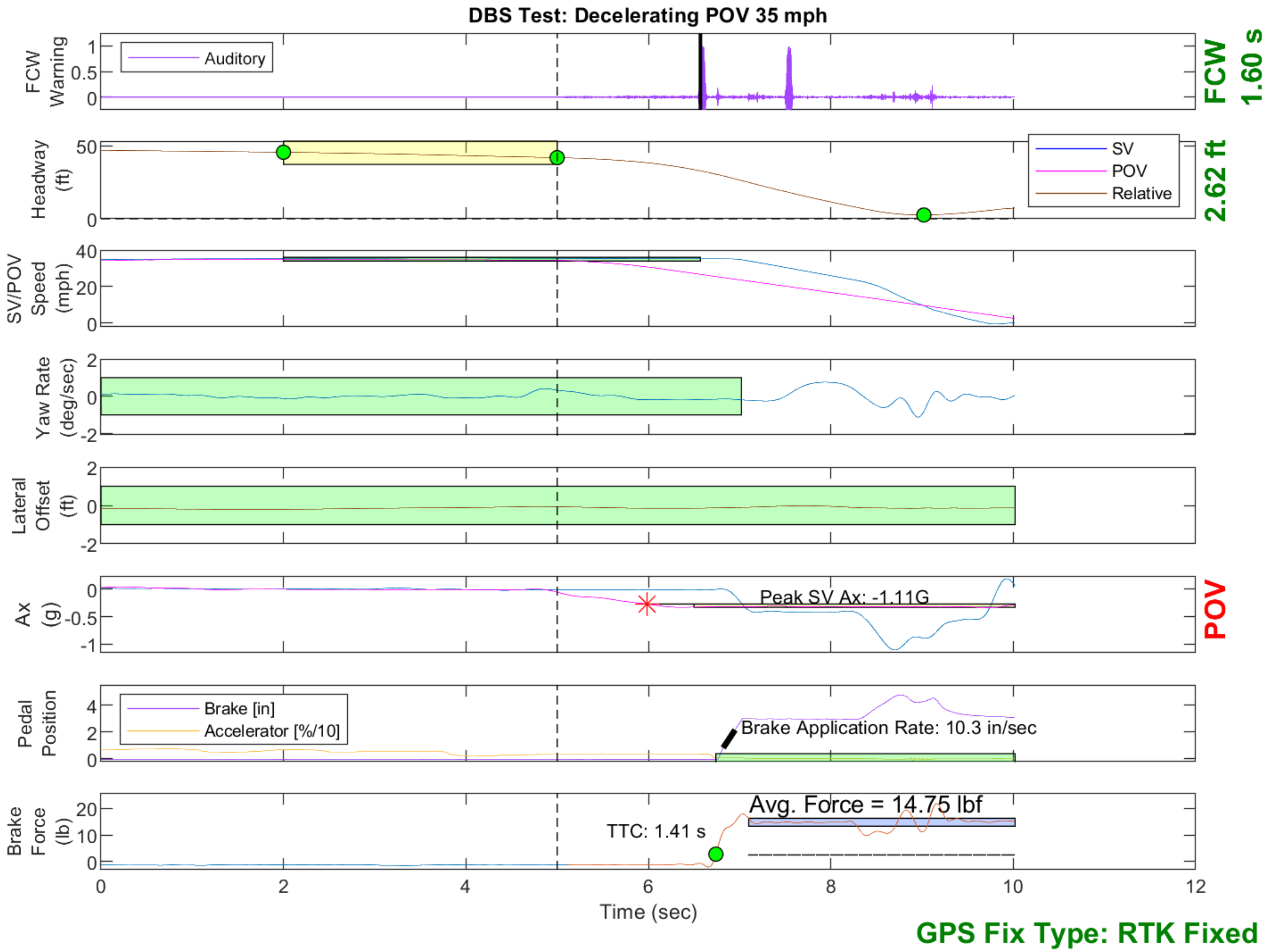


Figure E10. Example Time History Displaying Invalid POV Acceleration Criteria

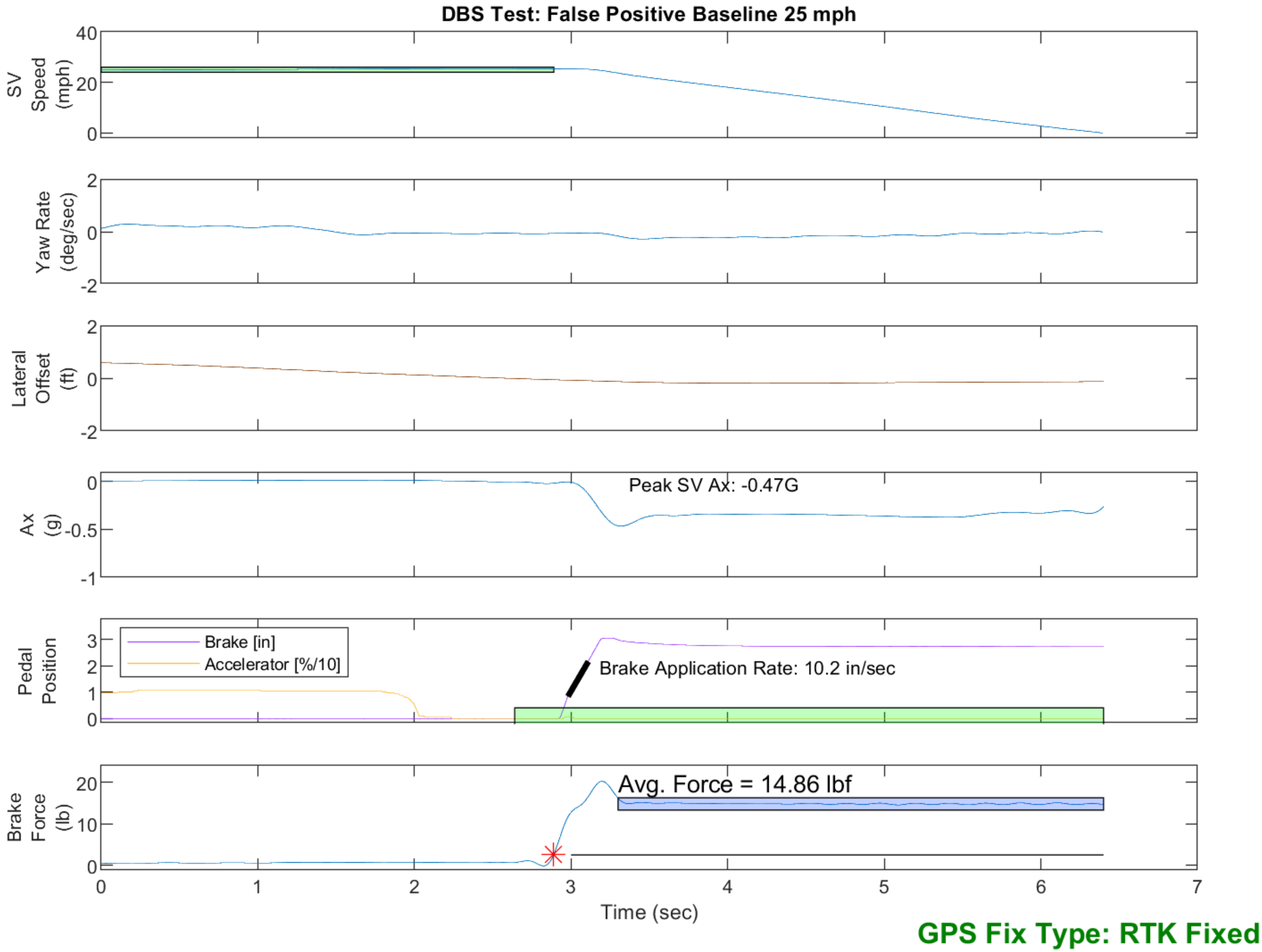


Figure E11. Example Time History Displaying Invalid Brake Force Criteria

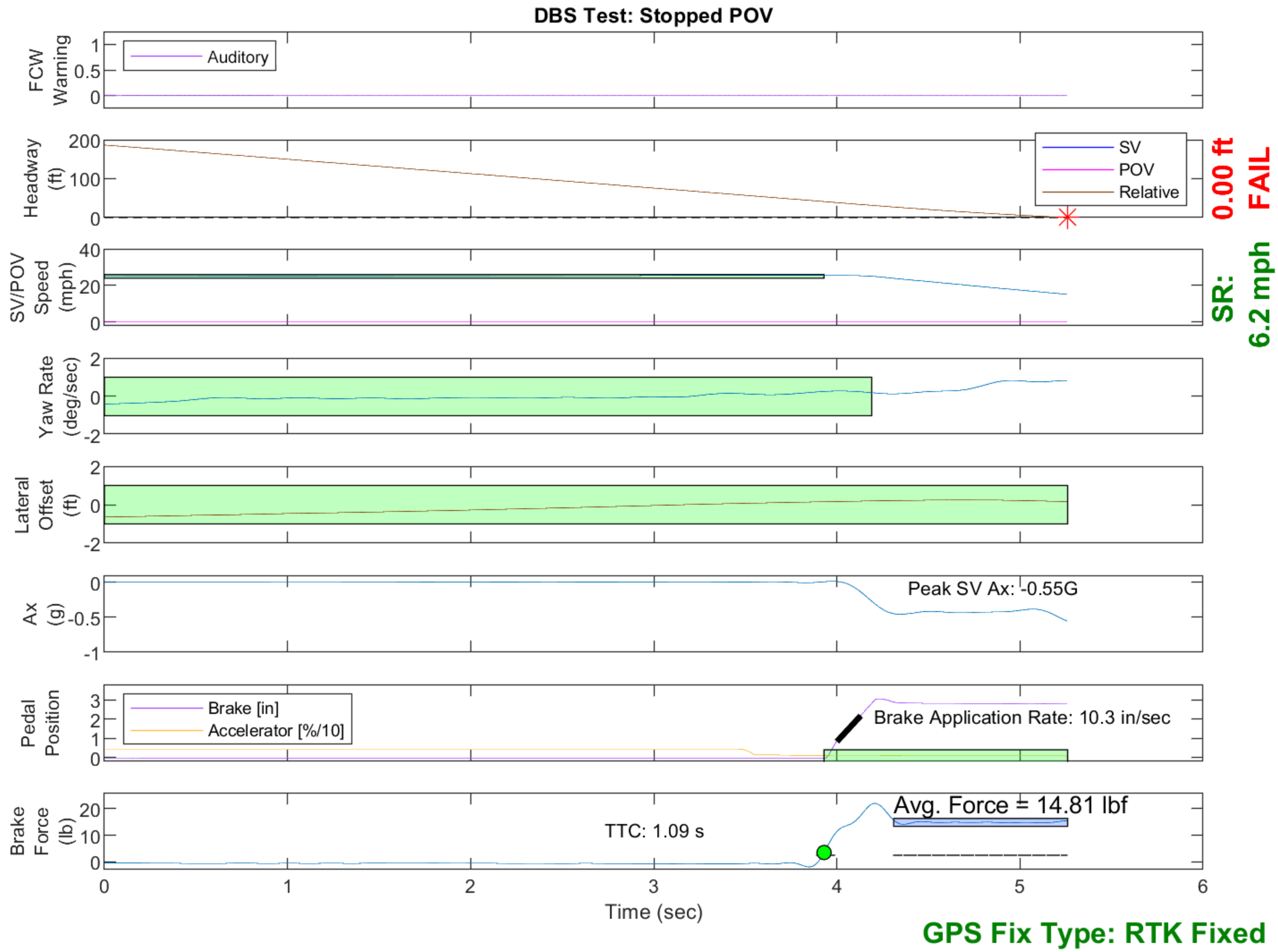


Figure E12. Example Time History for a Failed Run

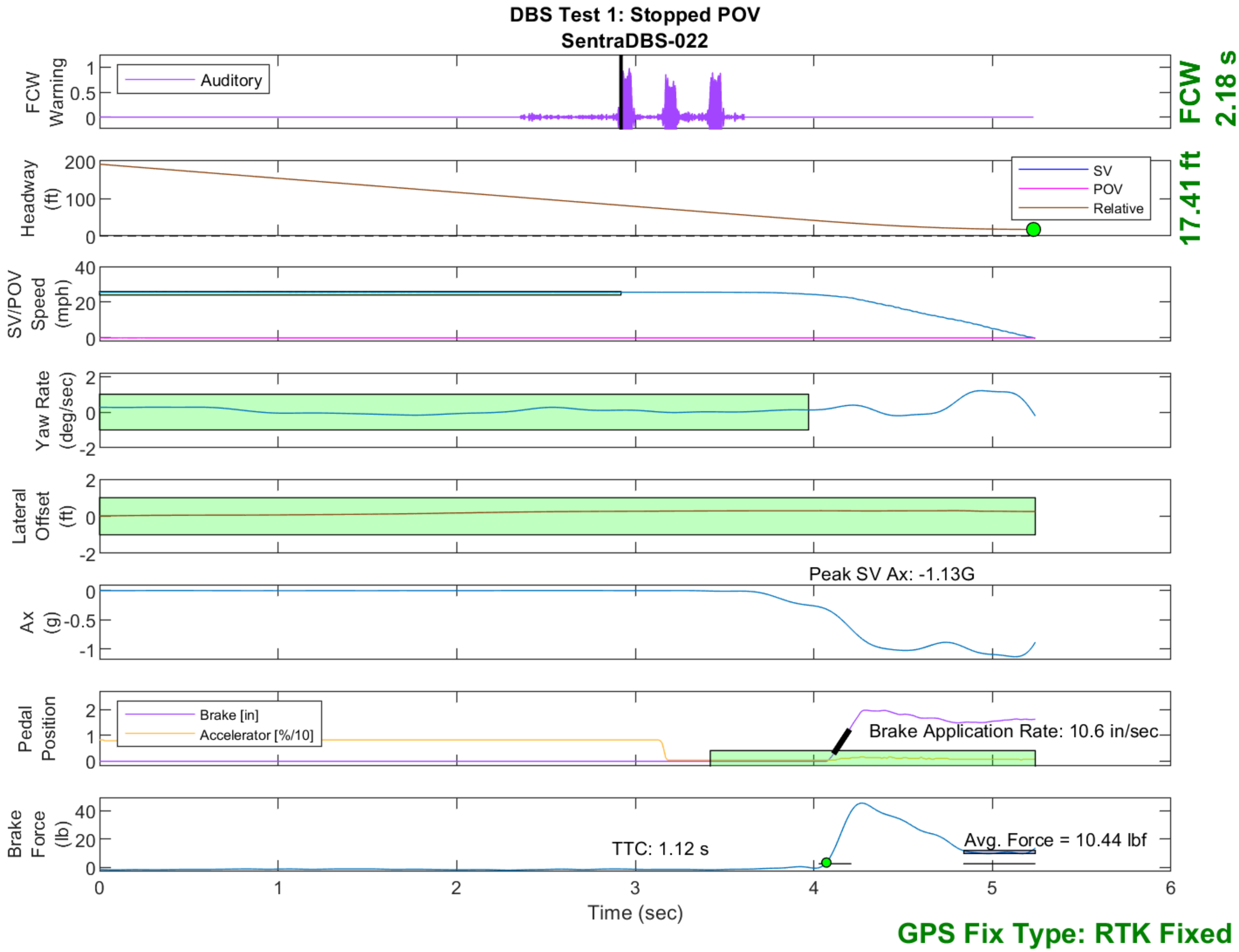


Figure E13. Time History for DBS Run 22, Test 1 - Stopped POV

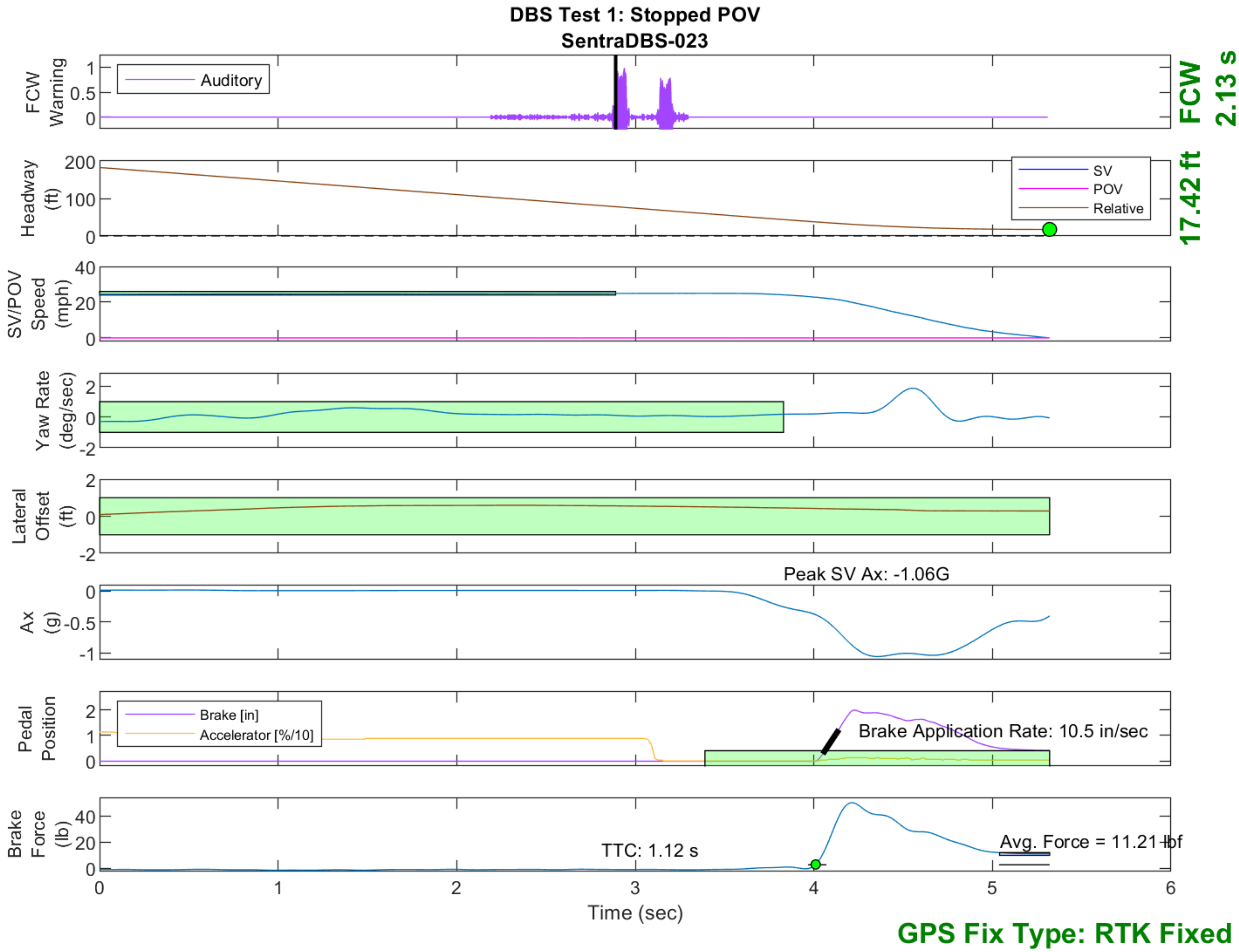


Figure E14. Time History for DBS Run 23, Test 1 - Stopped POV

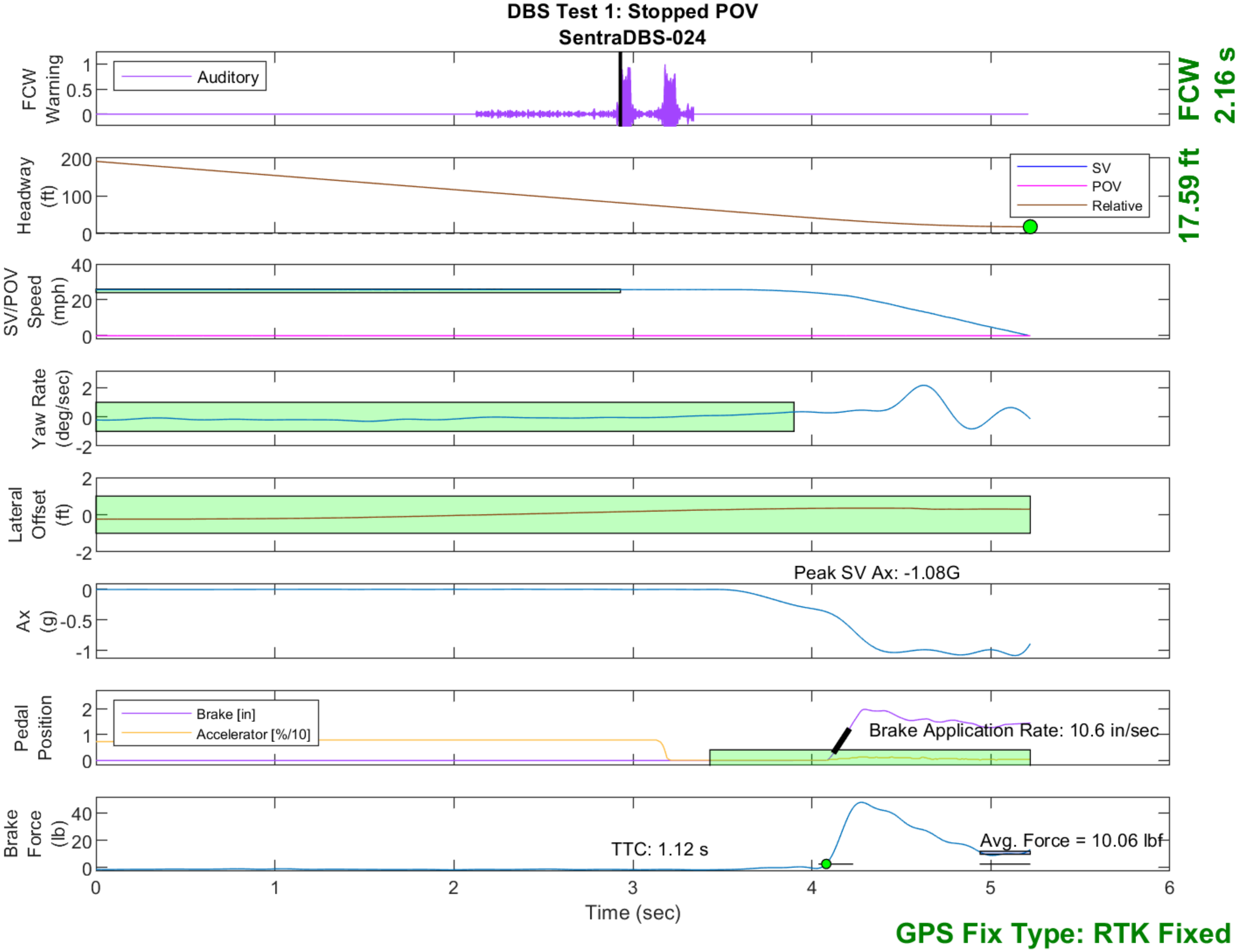


Figure E15. Time History for DBS Run 24, Test 1 - Stopped POV

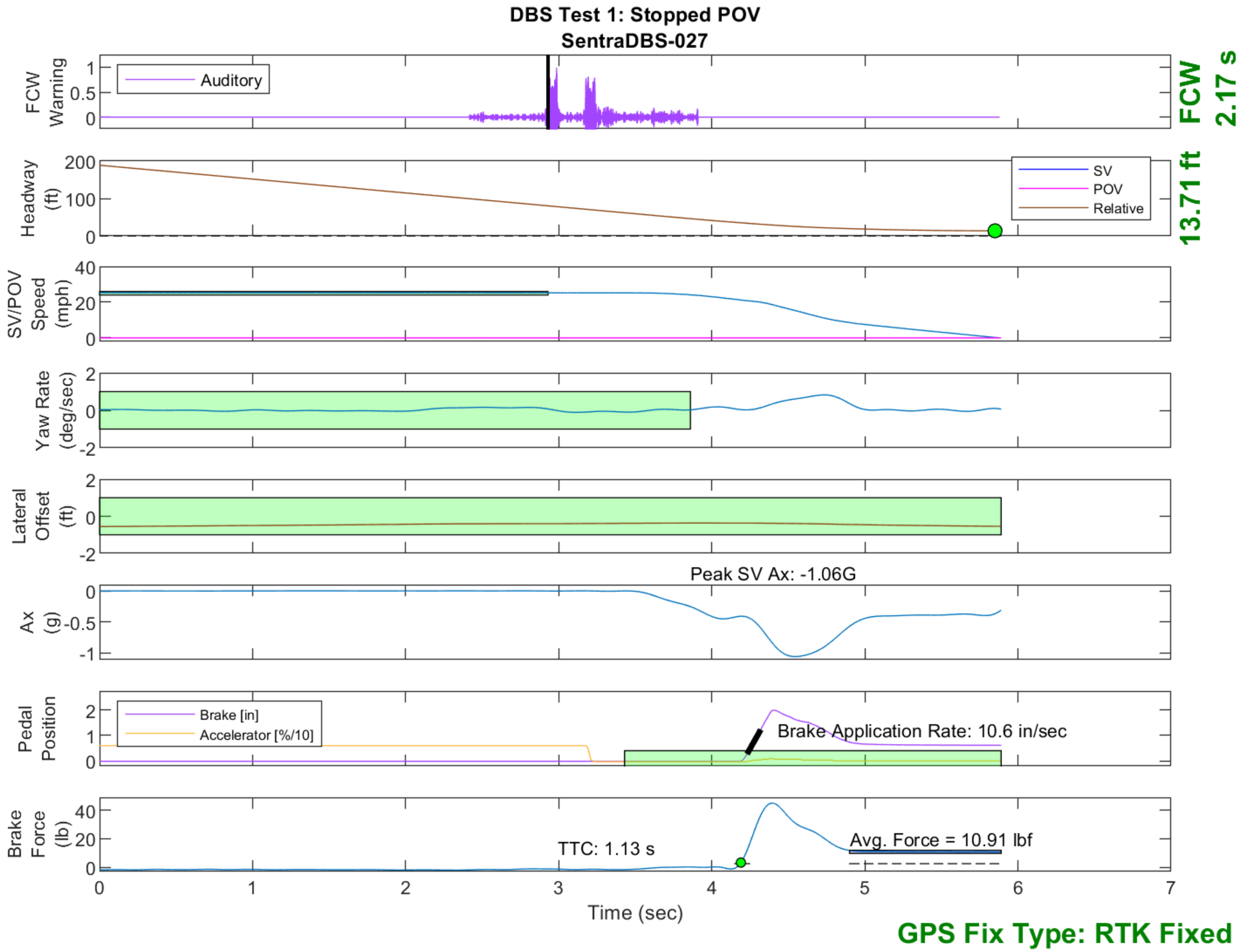


Figure E16. Time History for DBS Run 27, Test 1 - Stopped POV

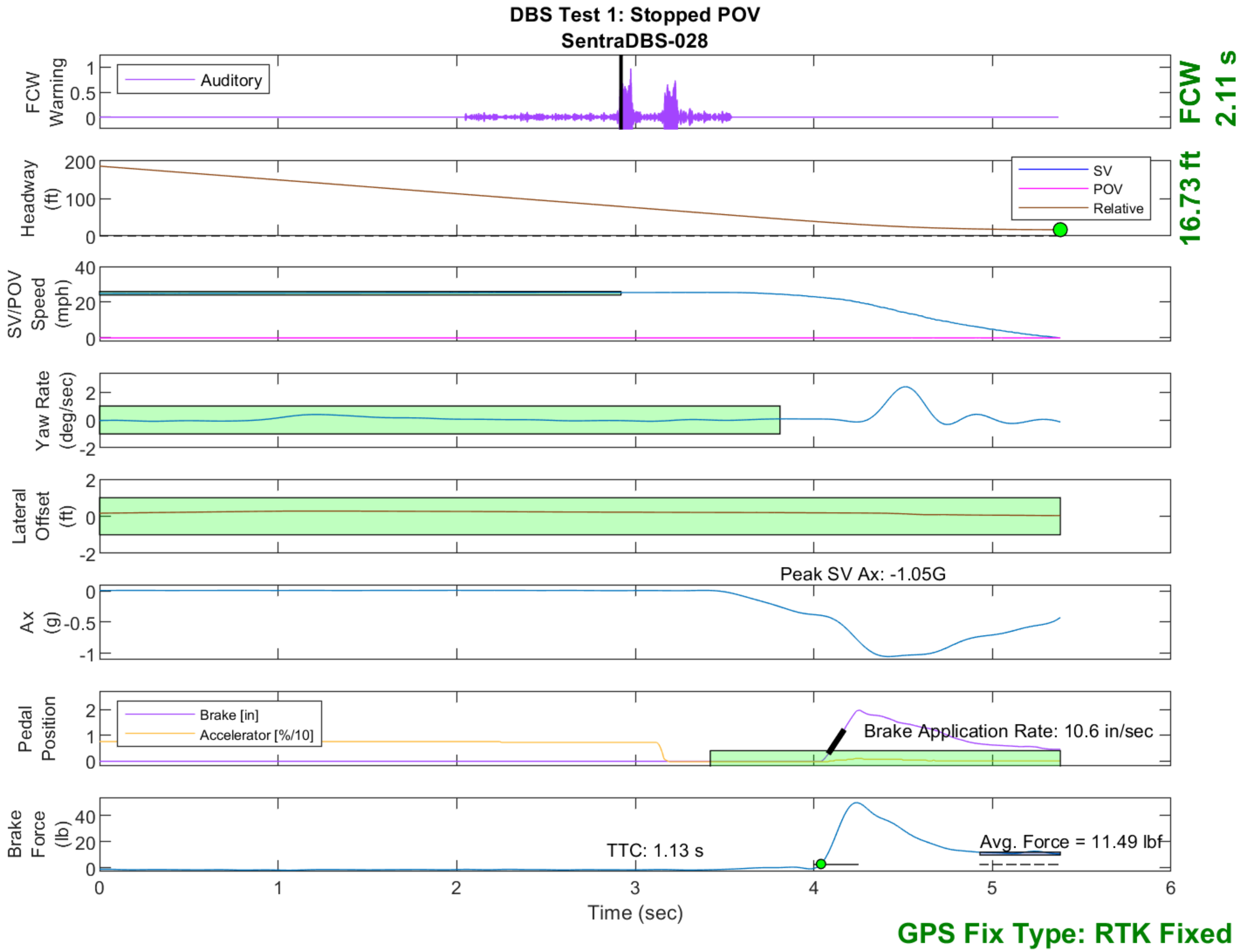


Figure E17. Time History for DBS Run 28, Test 1 - Stopped POV

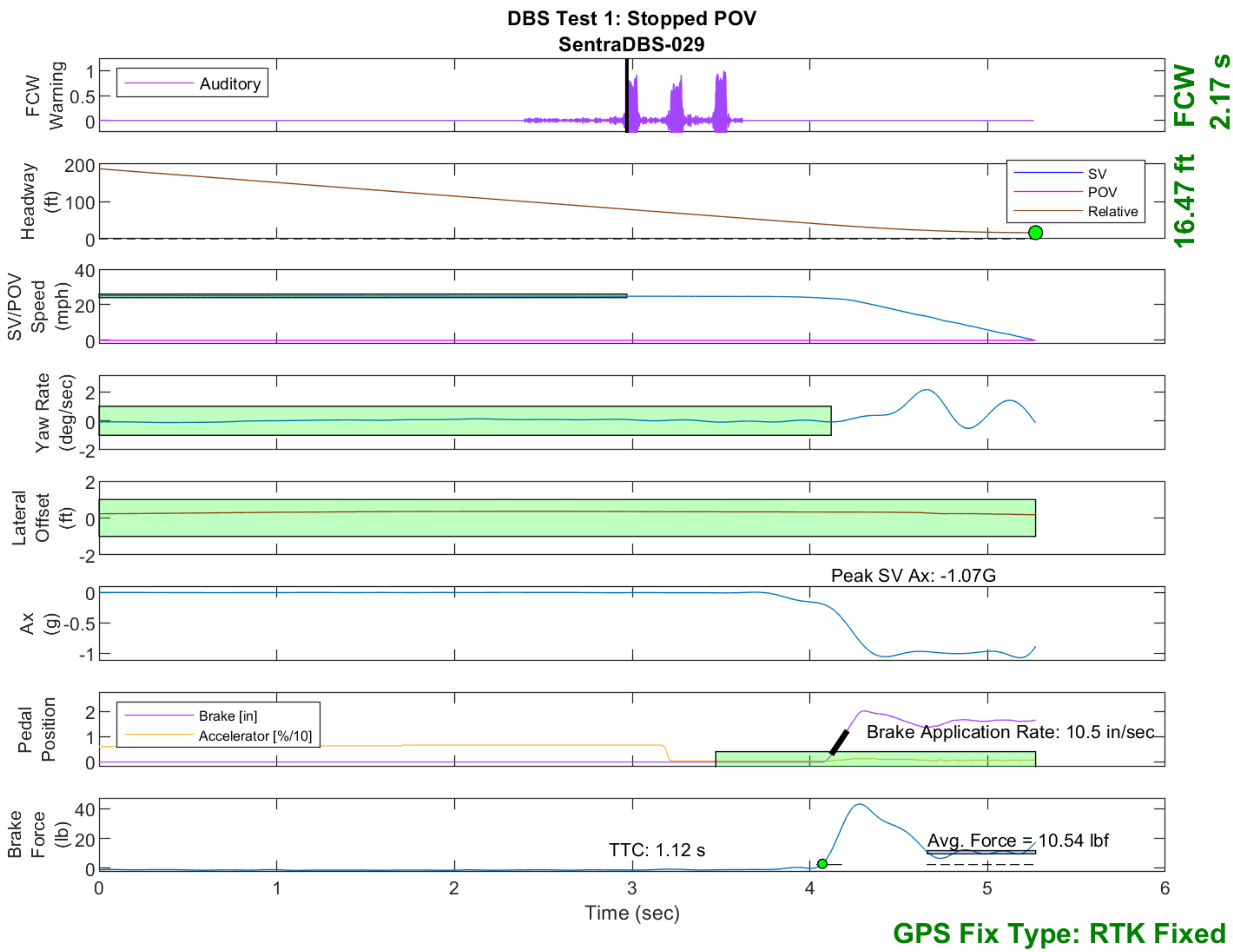


Figure E18. Time History for DBS Run 29, Test 1 - Stopped POV

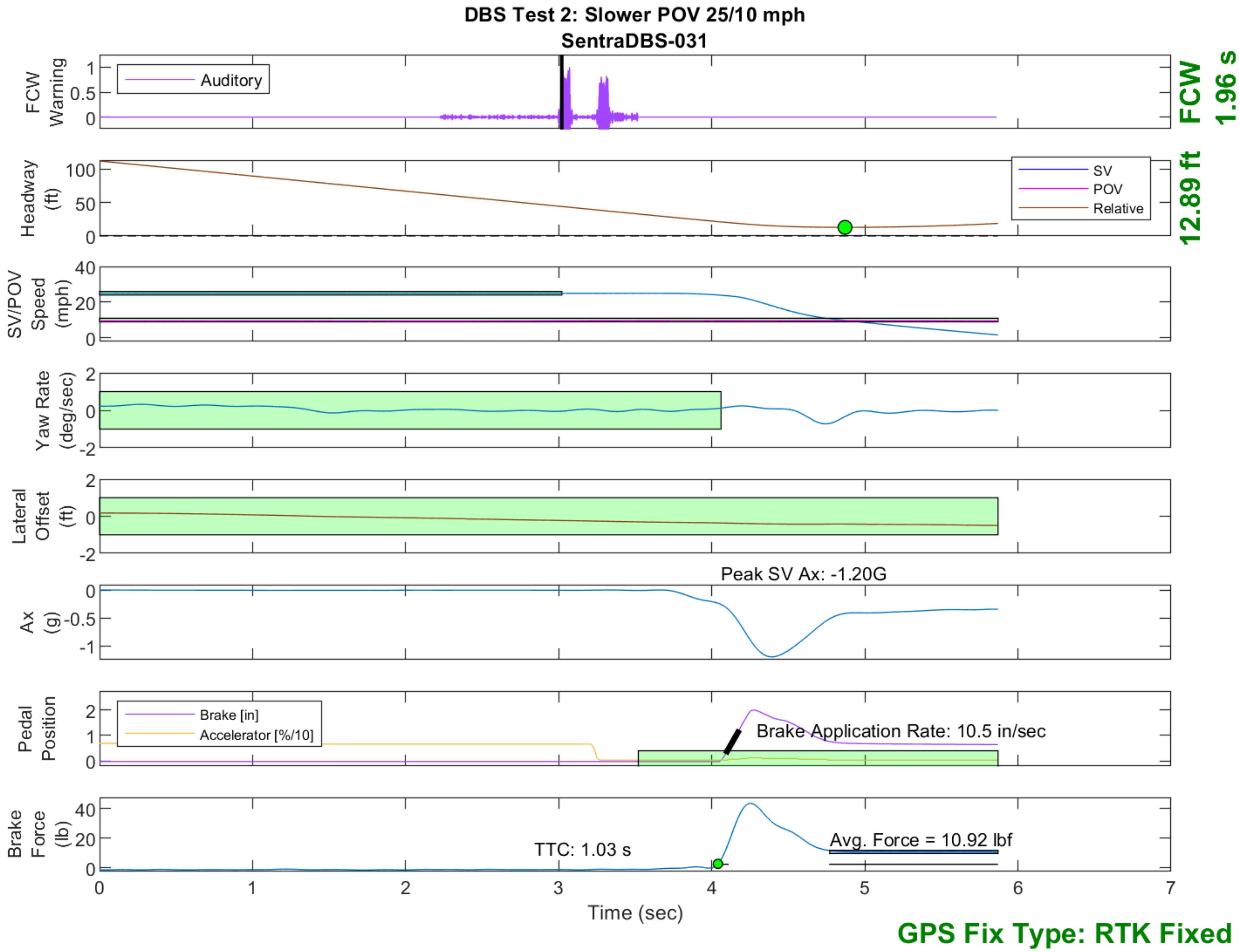


Figure E19. Time History for DBS Run 31, Test 2 - Slower Moving POV 25/10 mph

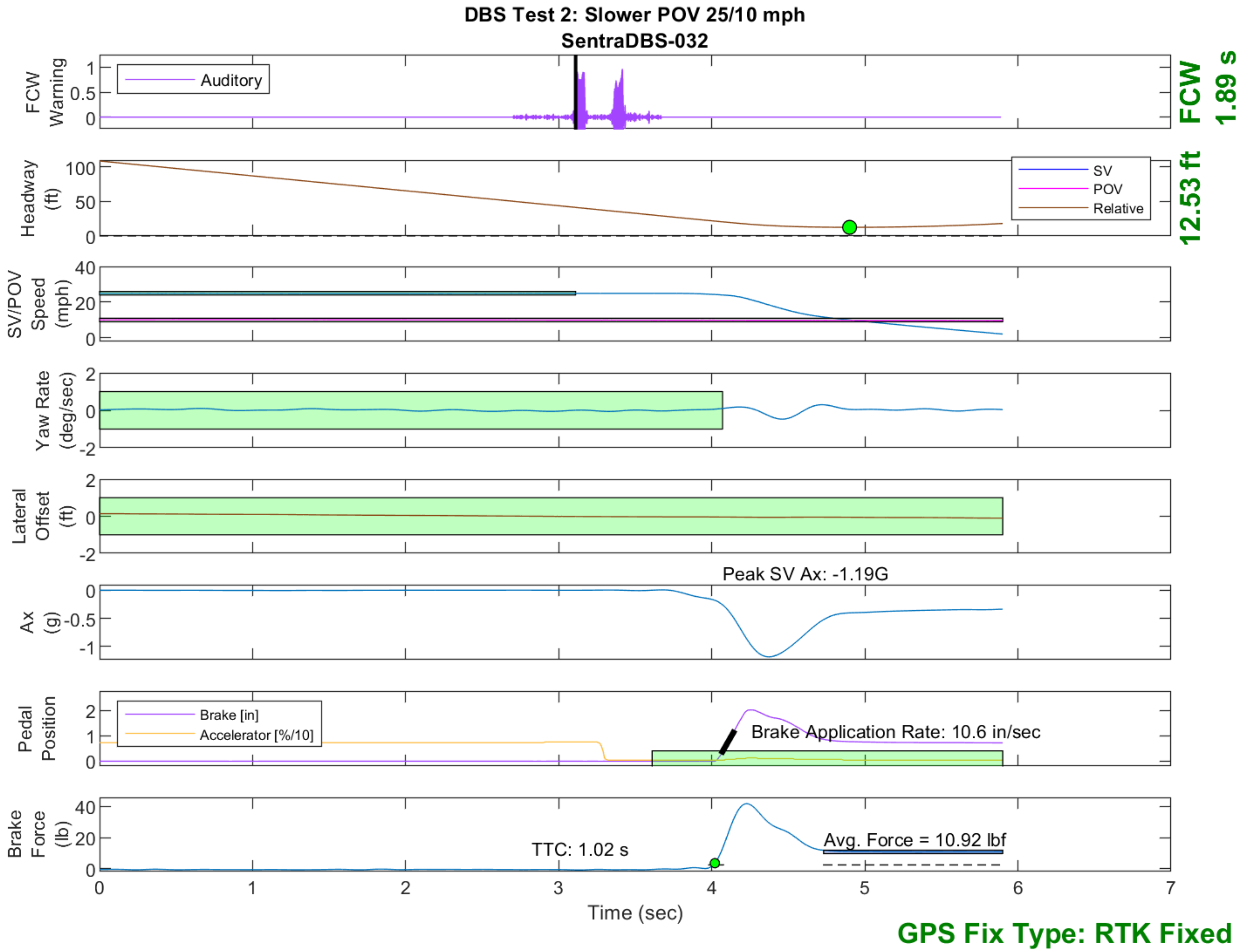


Figure E20. Time History for DBS Run 32, Test 2 - Slower Moving POV 25/10 mph

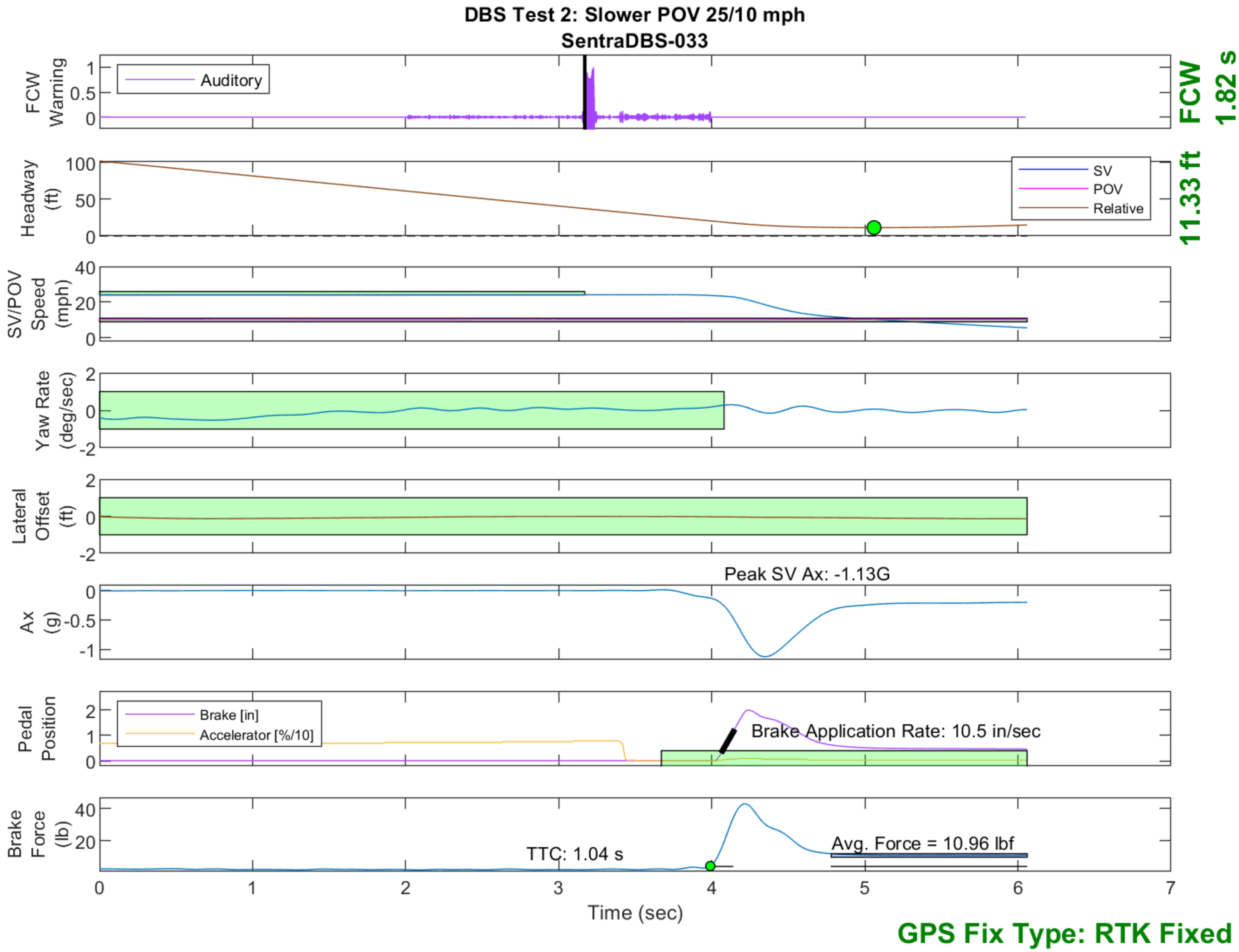


Figure E21. Time History for DBS Run 33, Test 2 - Slower Moving POV 25/10 mph

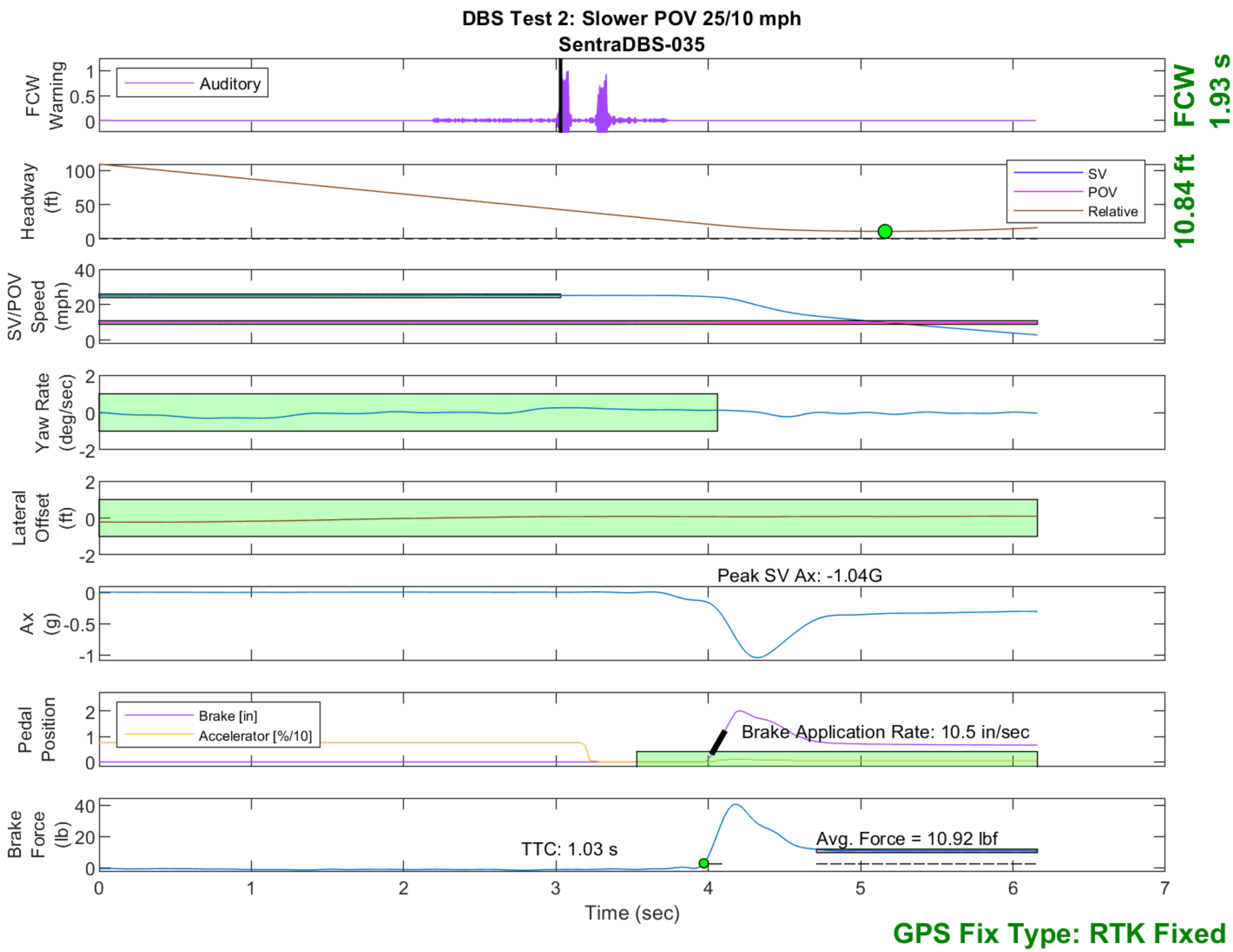


Figure E22. Time History for DBS Run 35, Test 2 - Slower Moving POV 25/10 mph

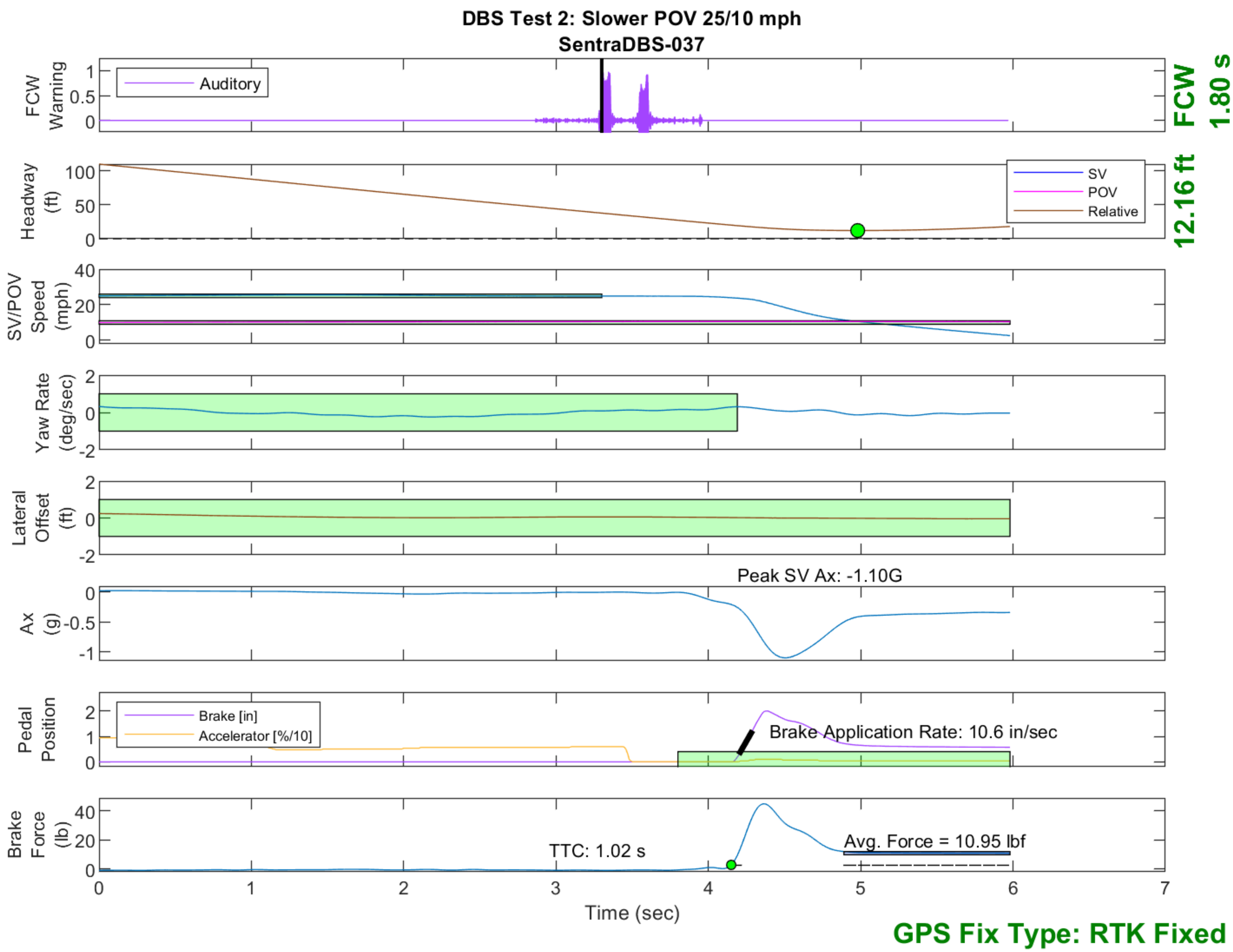


Figure E23. Time History for DBS Run 37, Test 2 - Slower Moving POV 25/10 mph

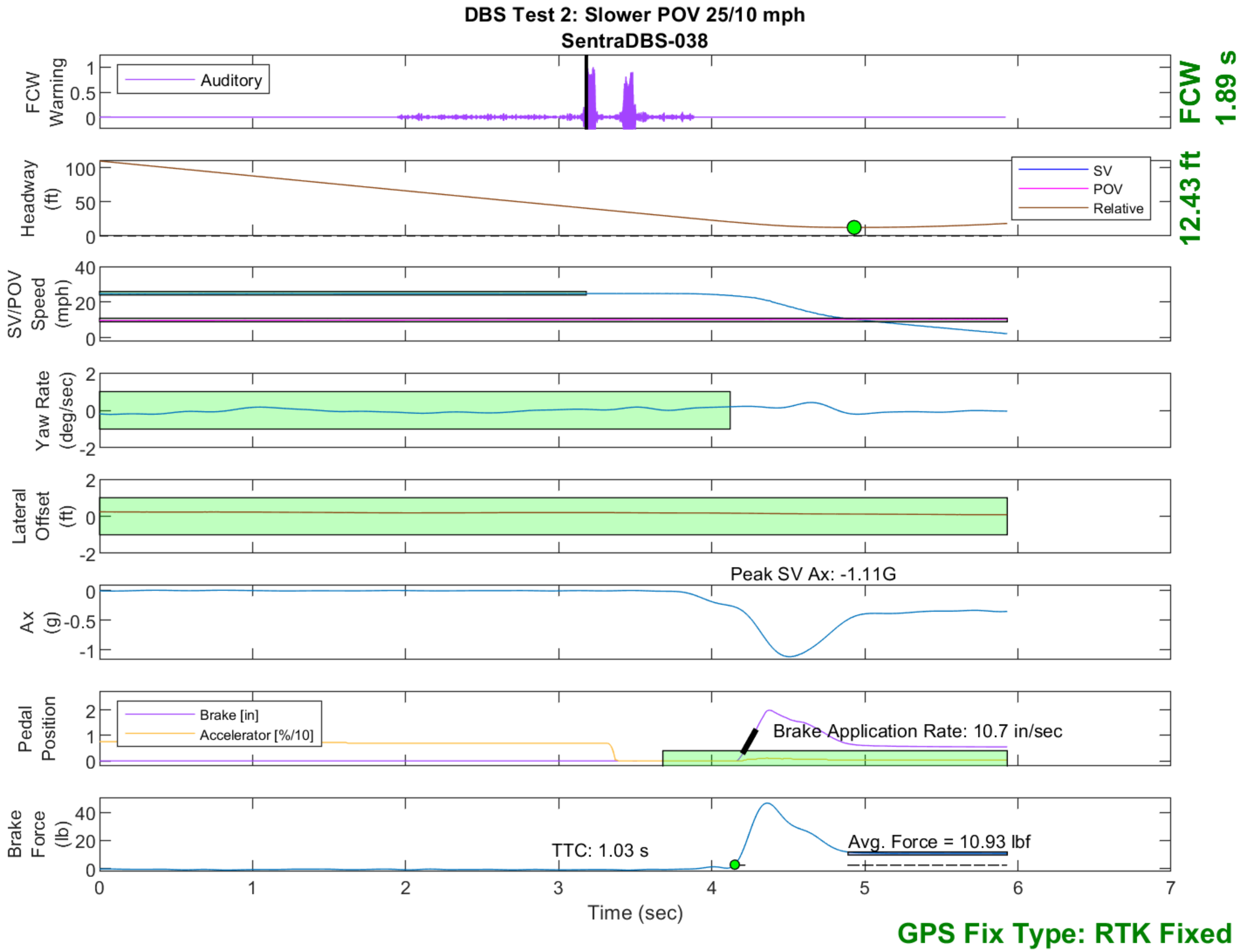


Figure E24. Time History for DBS Run 38, Test 2 - Slower Moving POV 25/10 mph

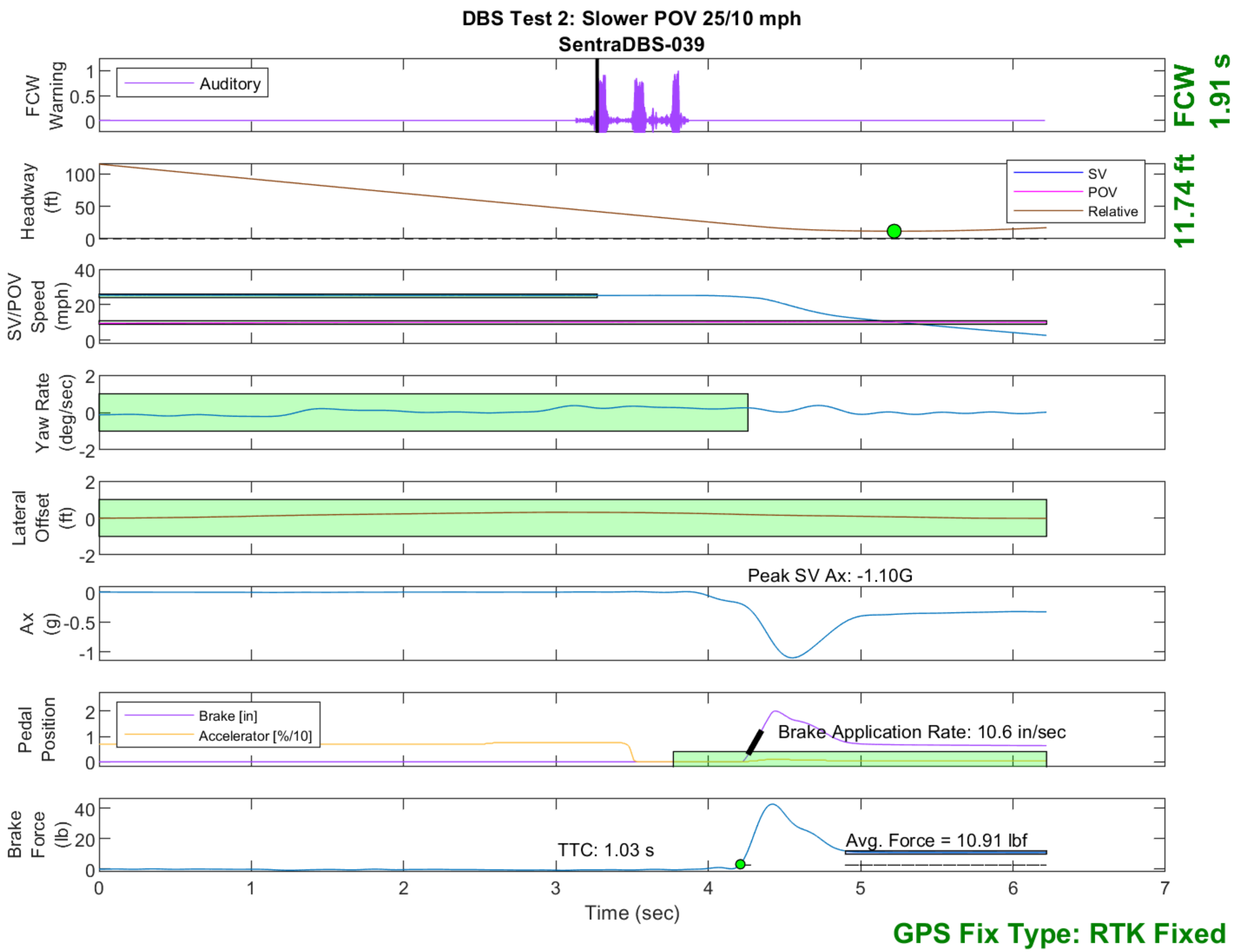


Figure E25. Time History for DBS Run 39, Test 2 - Slower Moving POV 25/10 mph

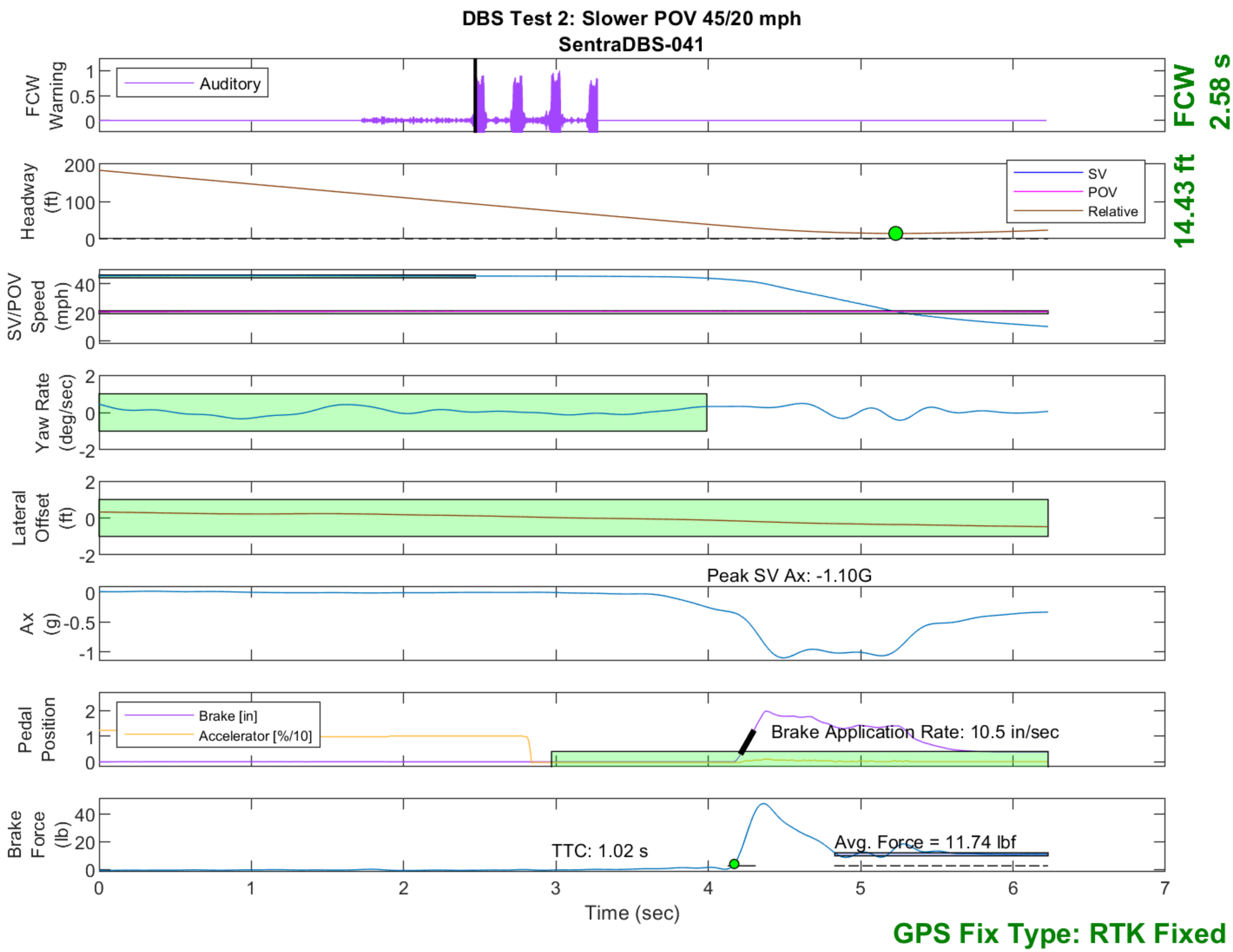


Figure E26. Time History for DBS Run 41, Test 2 - Slower Moving POV 45/20 mph

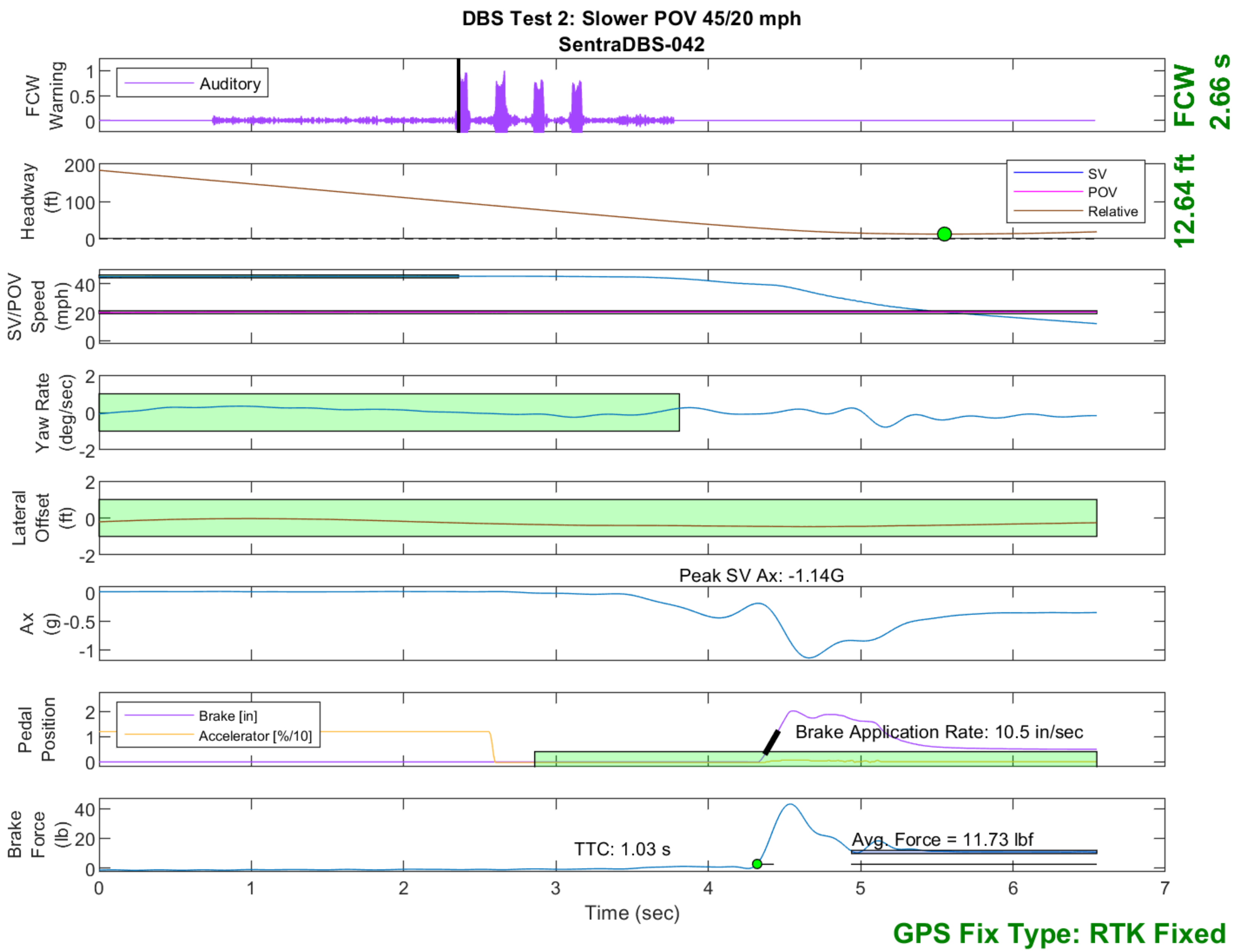


Figure E27. Time History for DBS Run 42, Test 2 - Slower Moving POV 45/20 mph

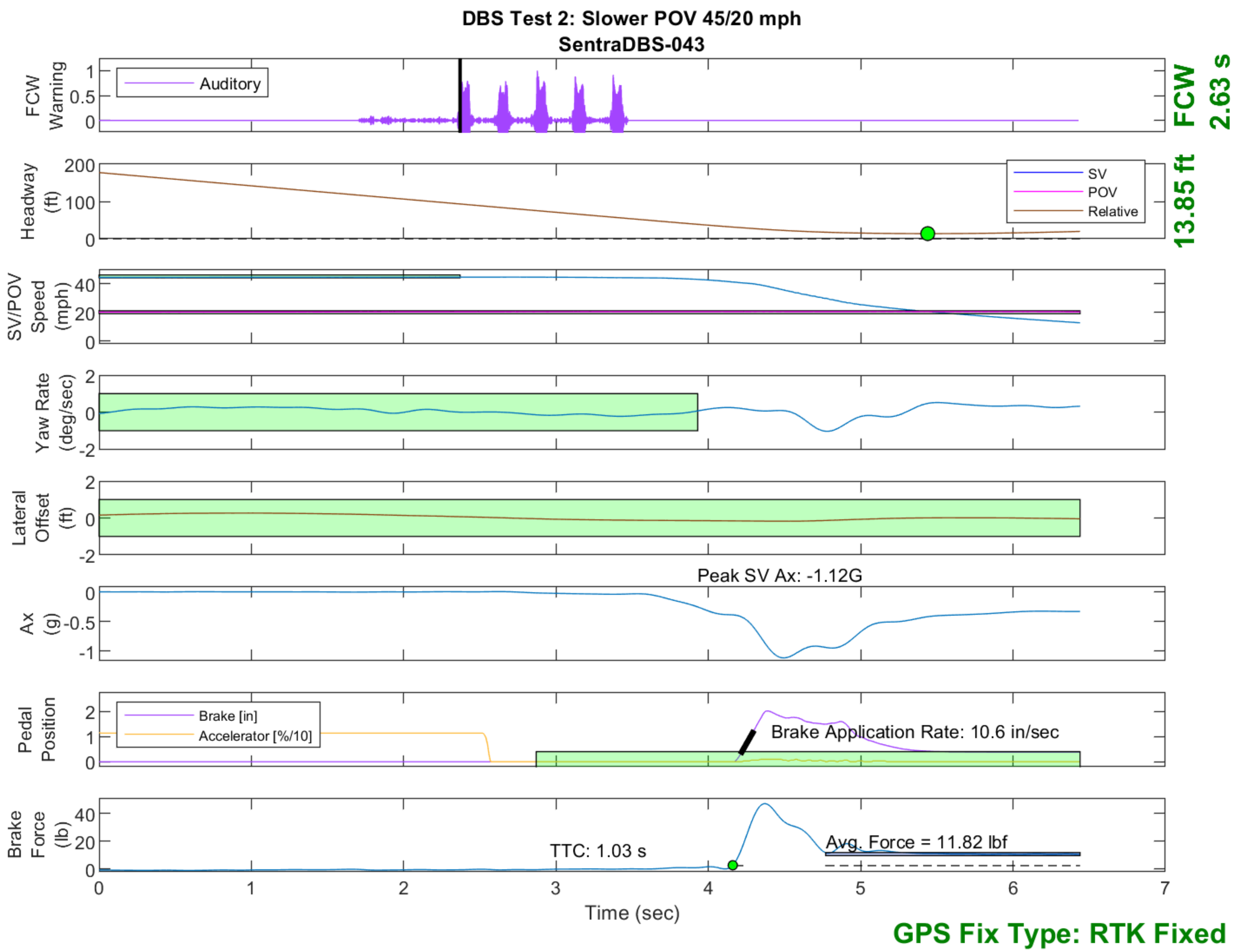


Figure E28. Time History for DBS Run 43, Test 2 - Slower Moving POV 45/20 mph

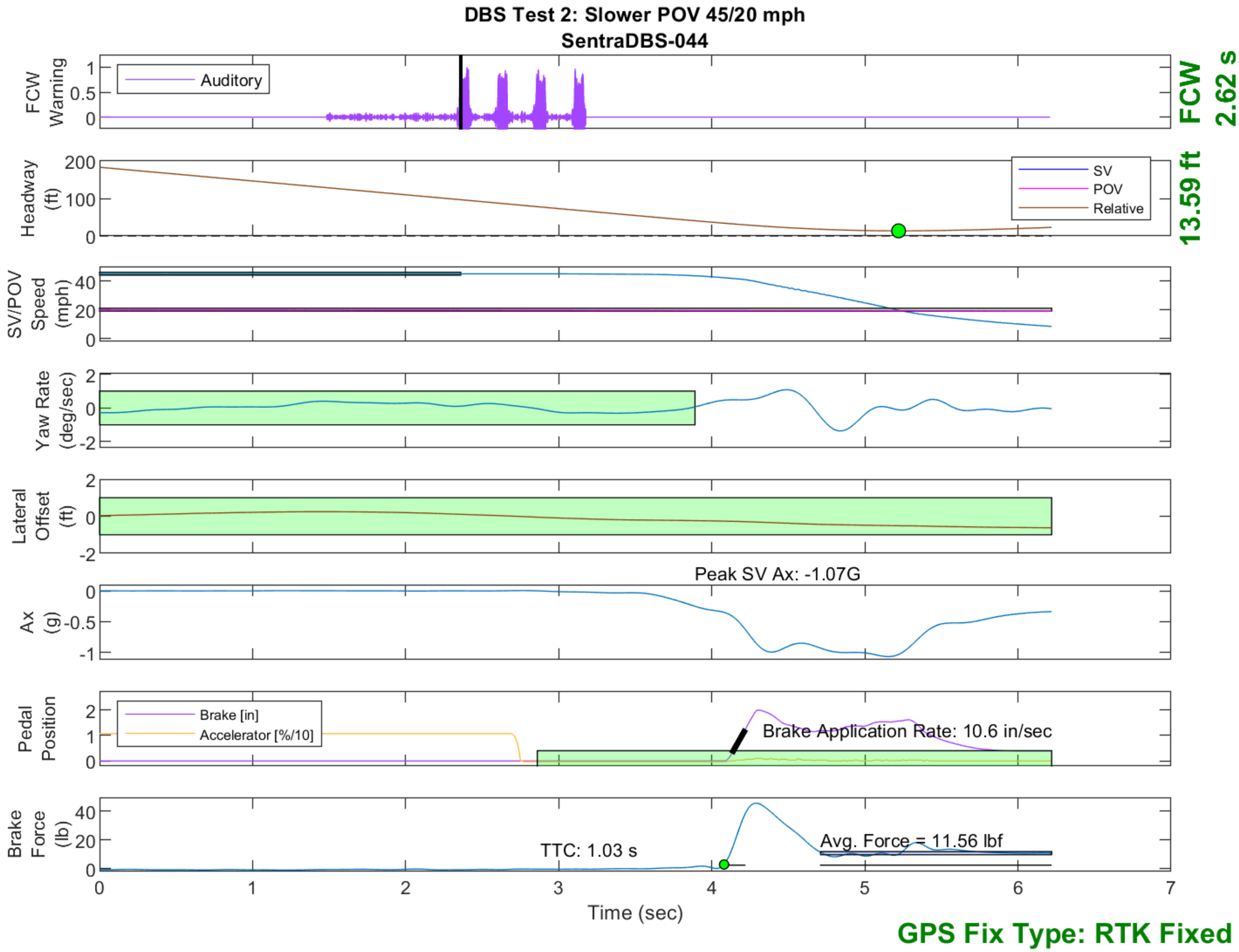


Figure E29. Time History for DBS Run 44, Test 2 - Slower Moving POV 45/20 mph

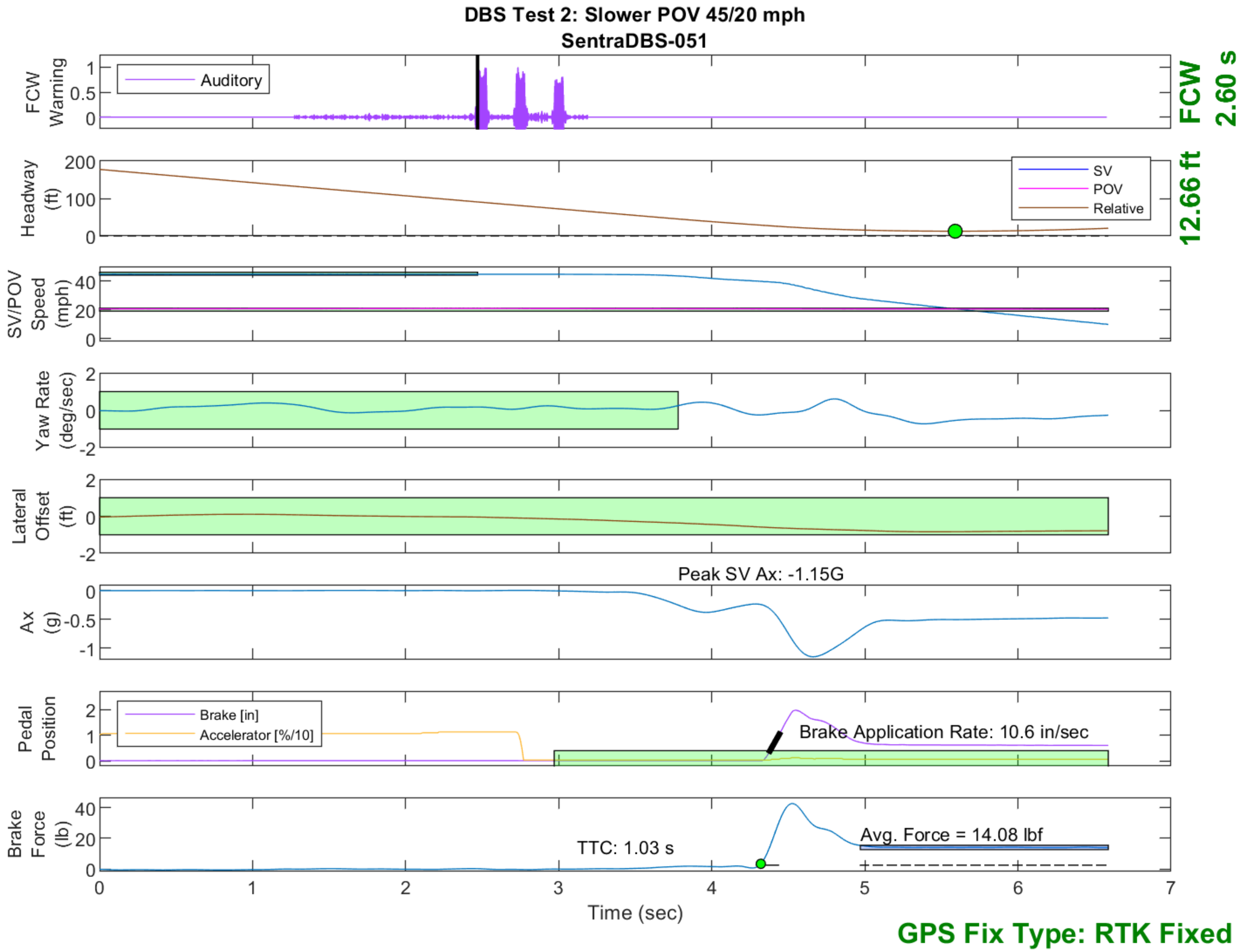


Figure E30. Time History for DBS Run 51, Test 2 - Slower Moving POV 45/20 mph

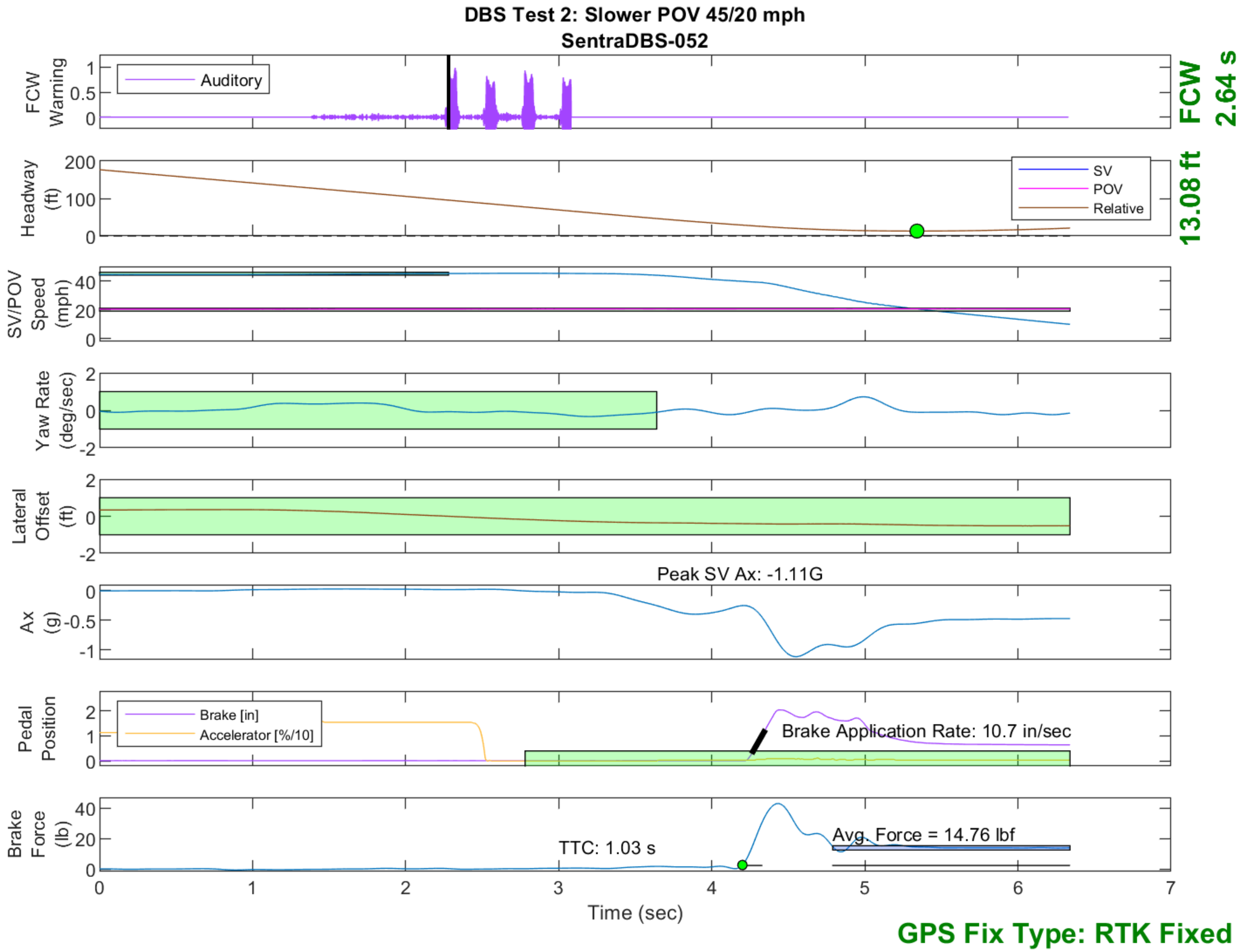


Figure E31. Time History for DBS Run 52, Test 2 - Slower Moving POV 45/20 mph

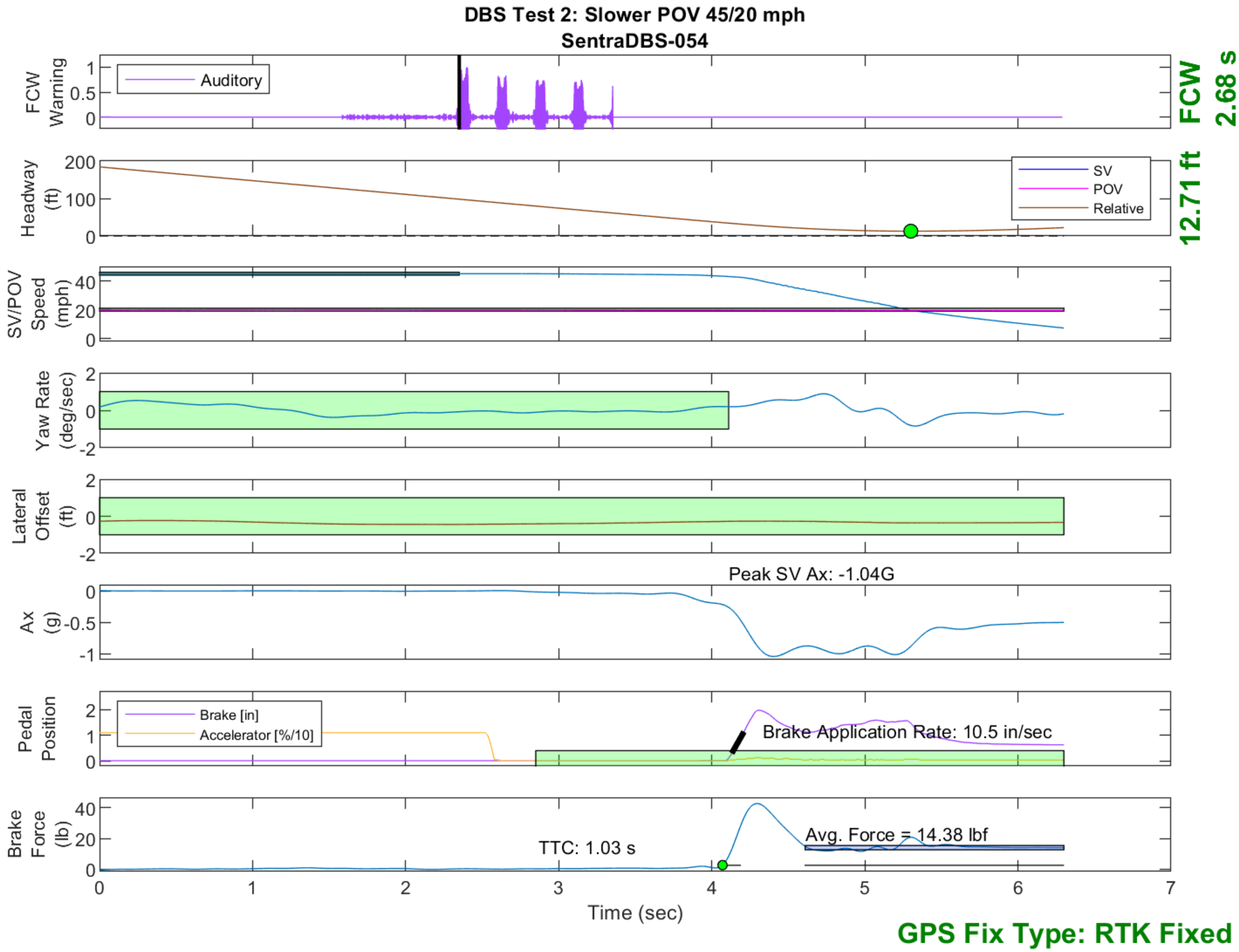


Figure E32. Time History for DBS Run 54, Test 2 - Slower Moving POV 45/20 mph

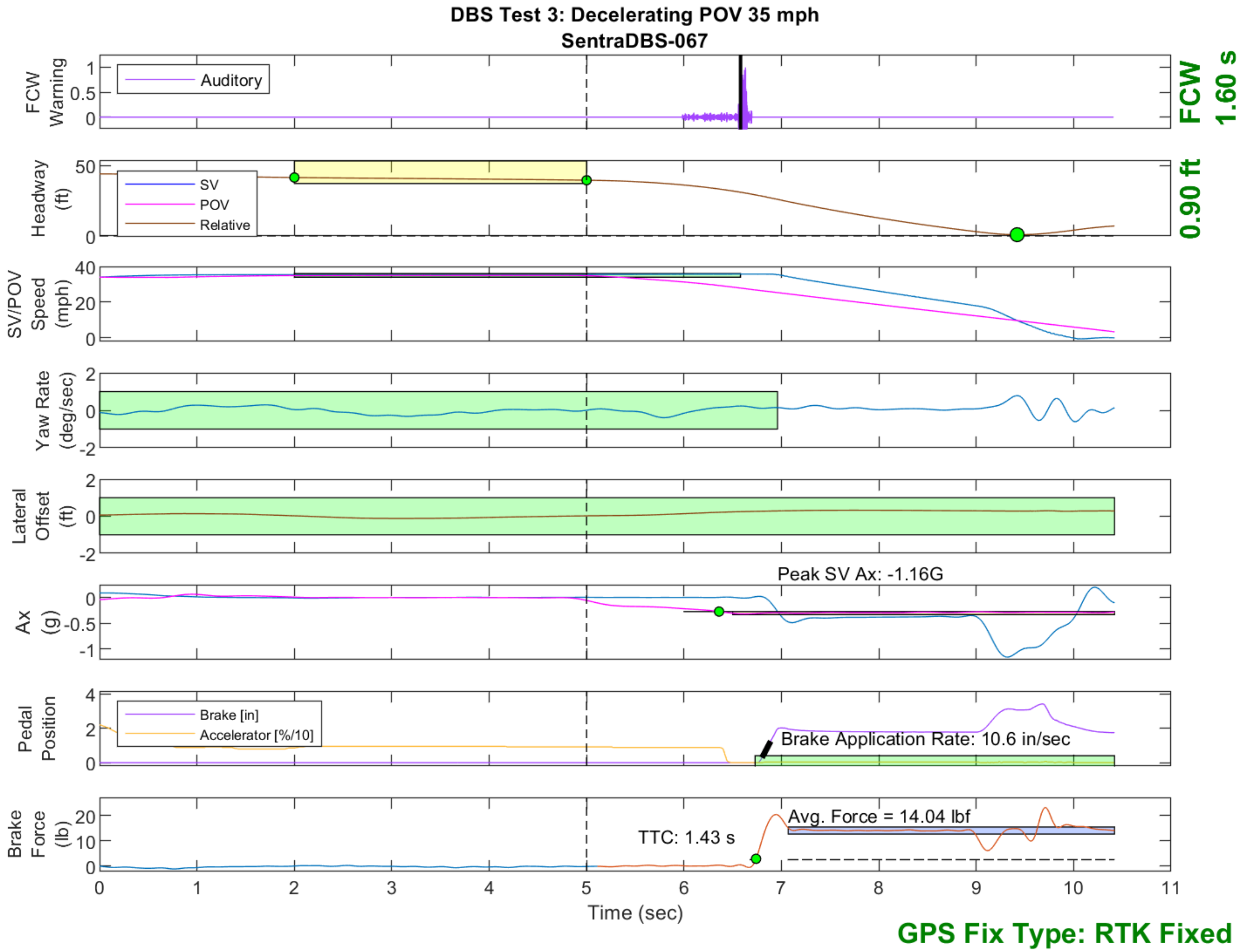


Figure E33. Time History for DBS Run 67, Test 3 - Decelerating POV 35 mph

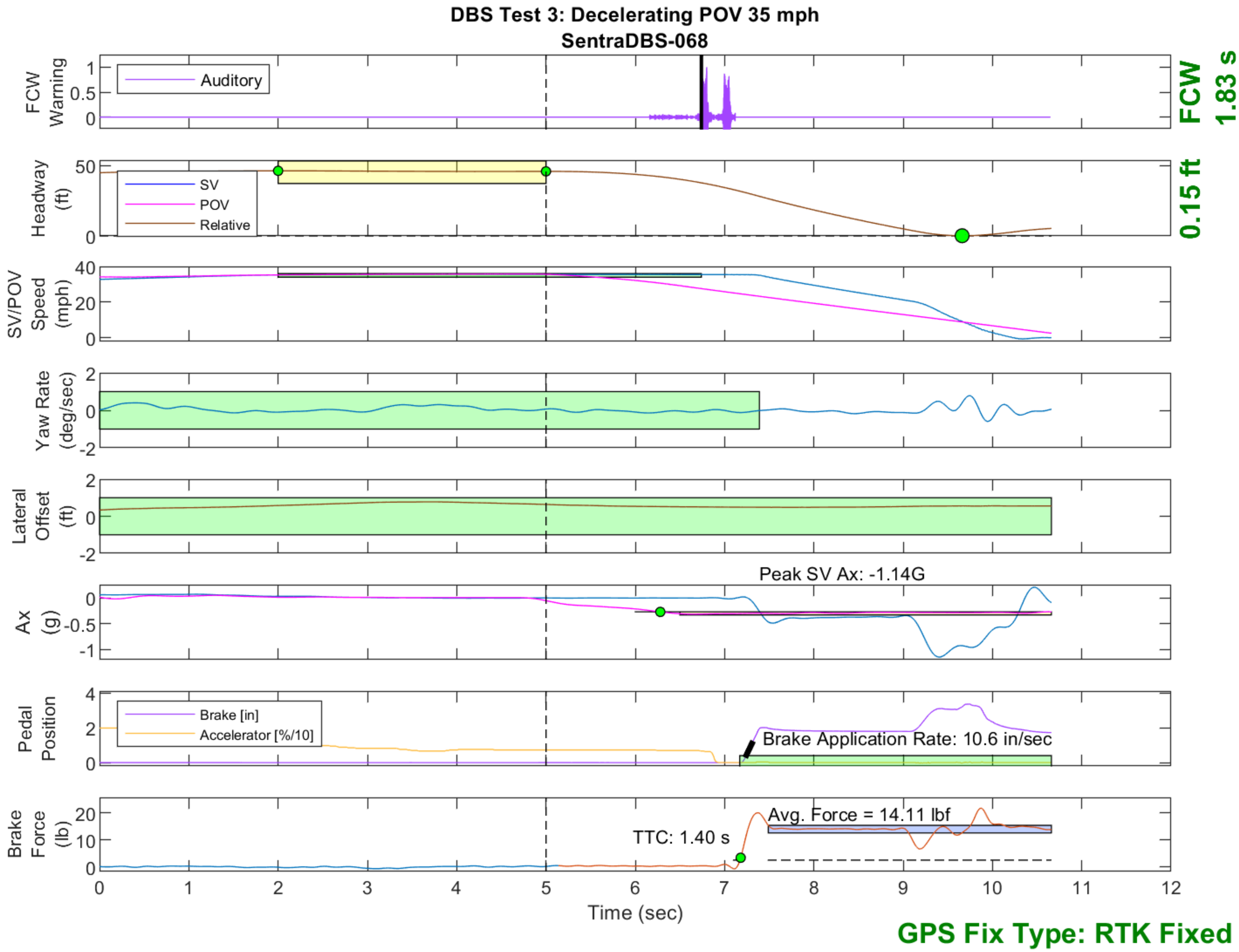


Figure E34. Time History for DBS Run 68, Test 3 - Decelerating POV 35 mph

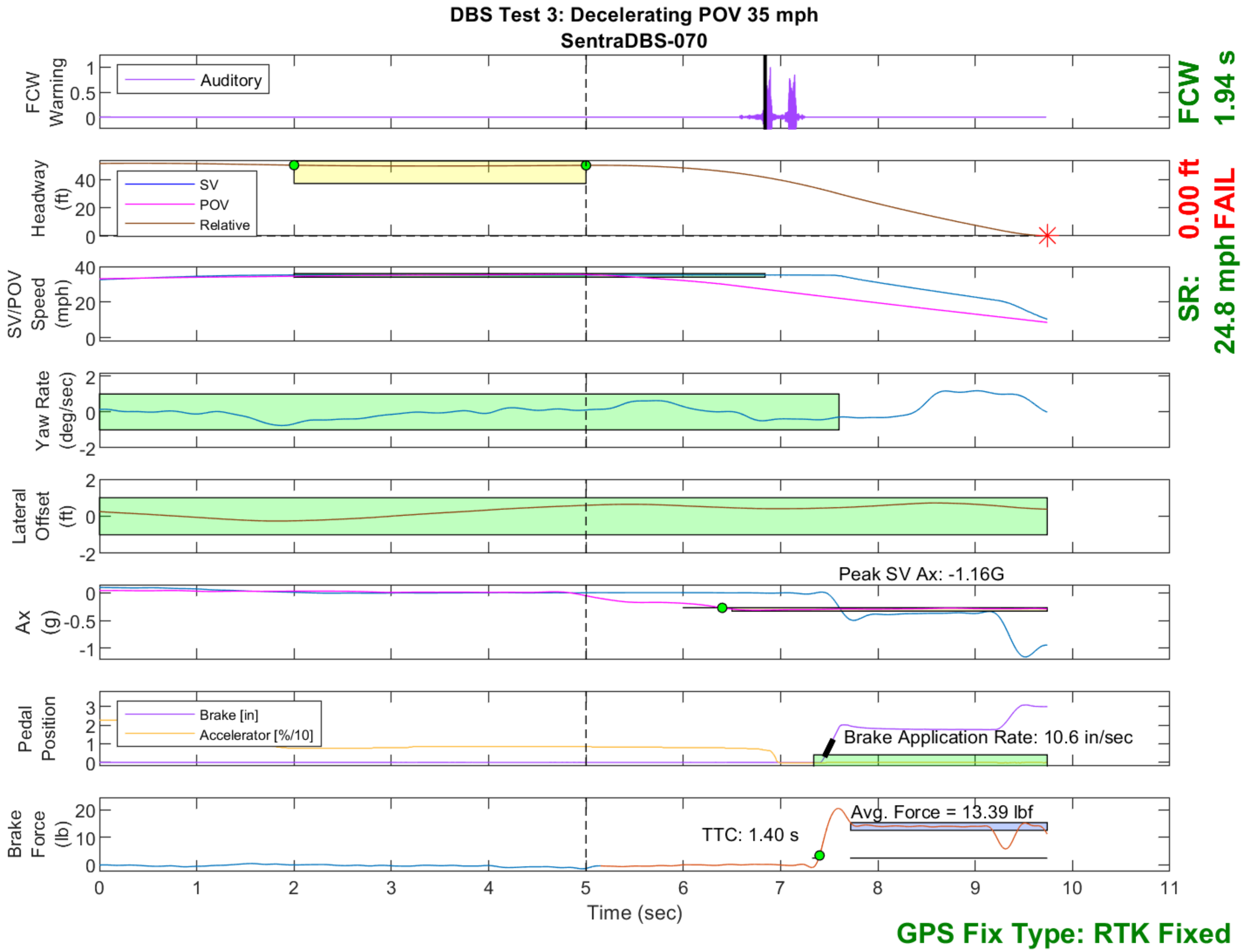


Figure E35. Time History for DBS Run 70, Test 3 - Decelerating POV 35 mph

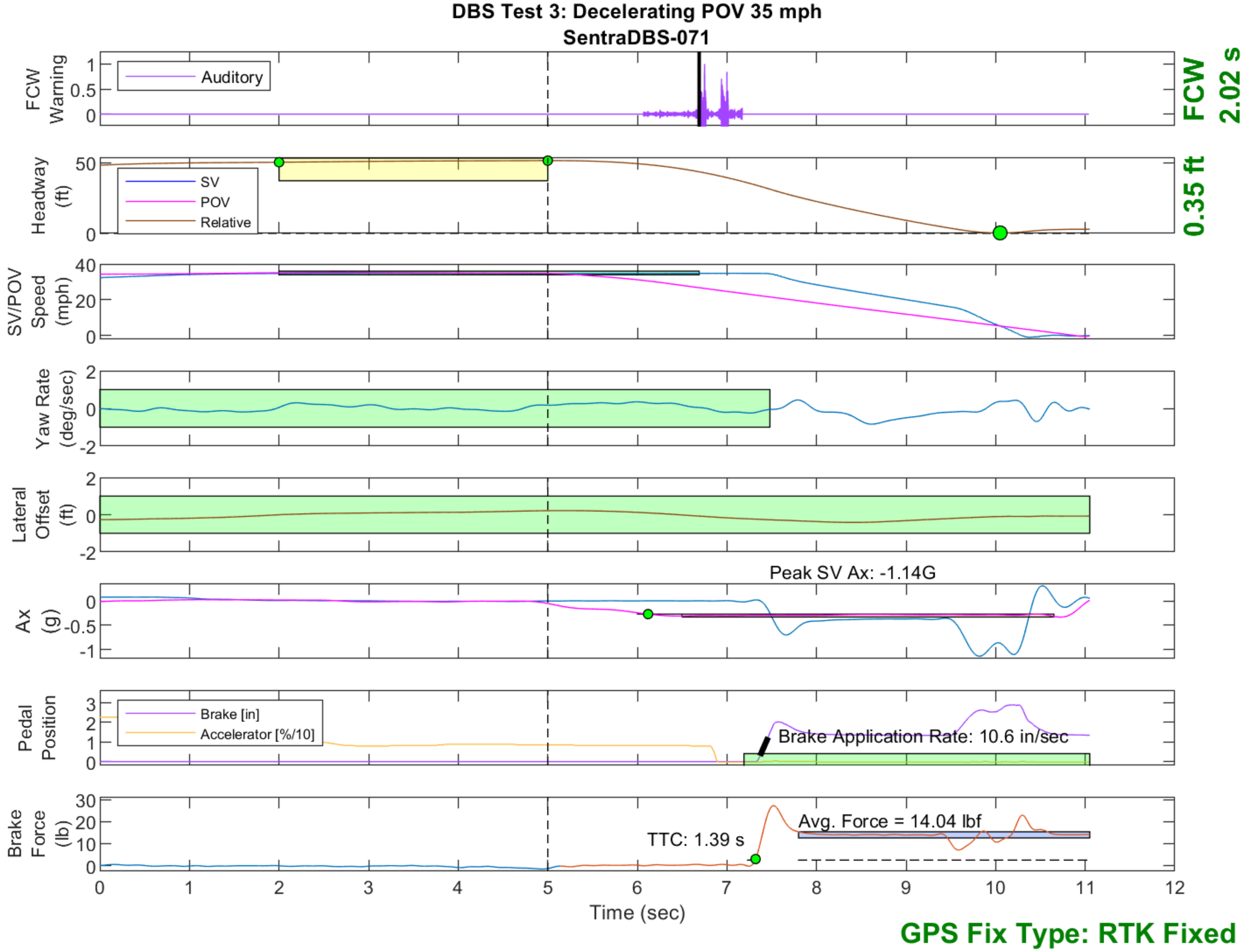


Figure E36. Time History for DBS Run 71, Test 3 - Decelerating POV 35 mph

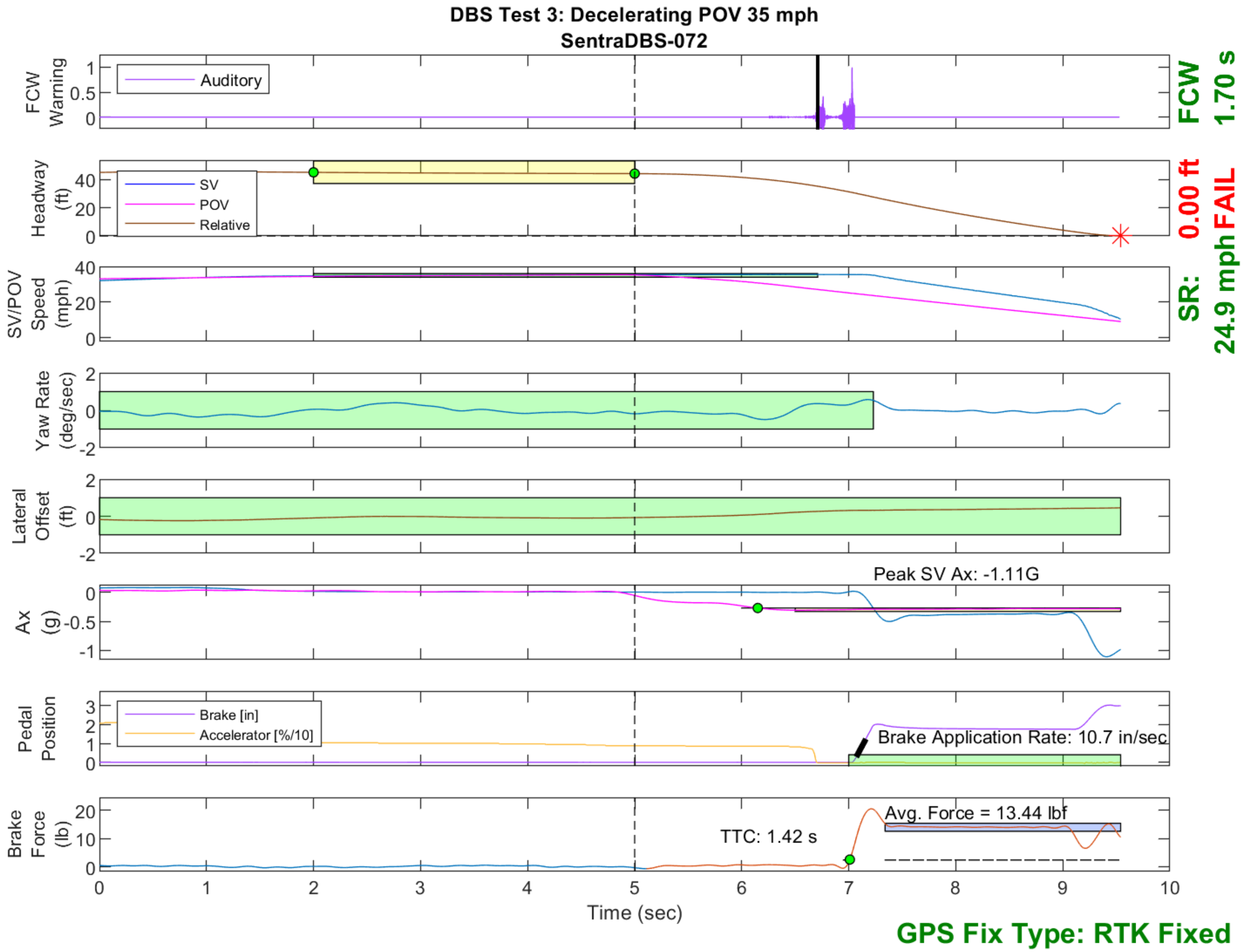


Figure E37. Time History for DBS Run 72, Test 3 - Decelerating POV 35 mph

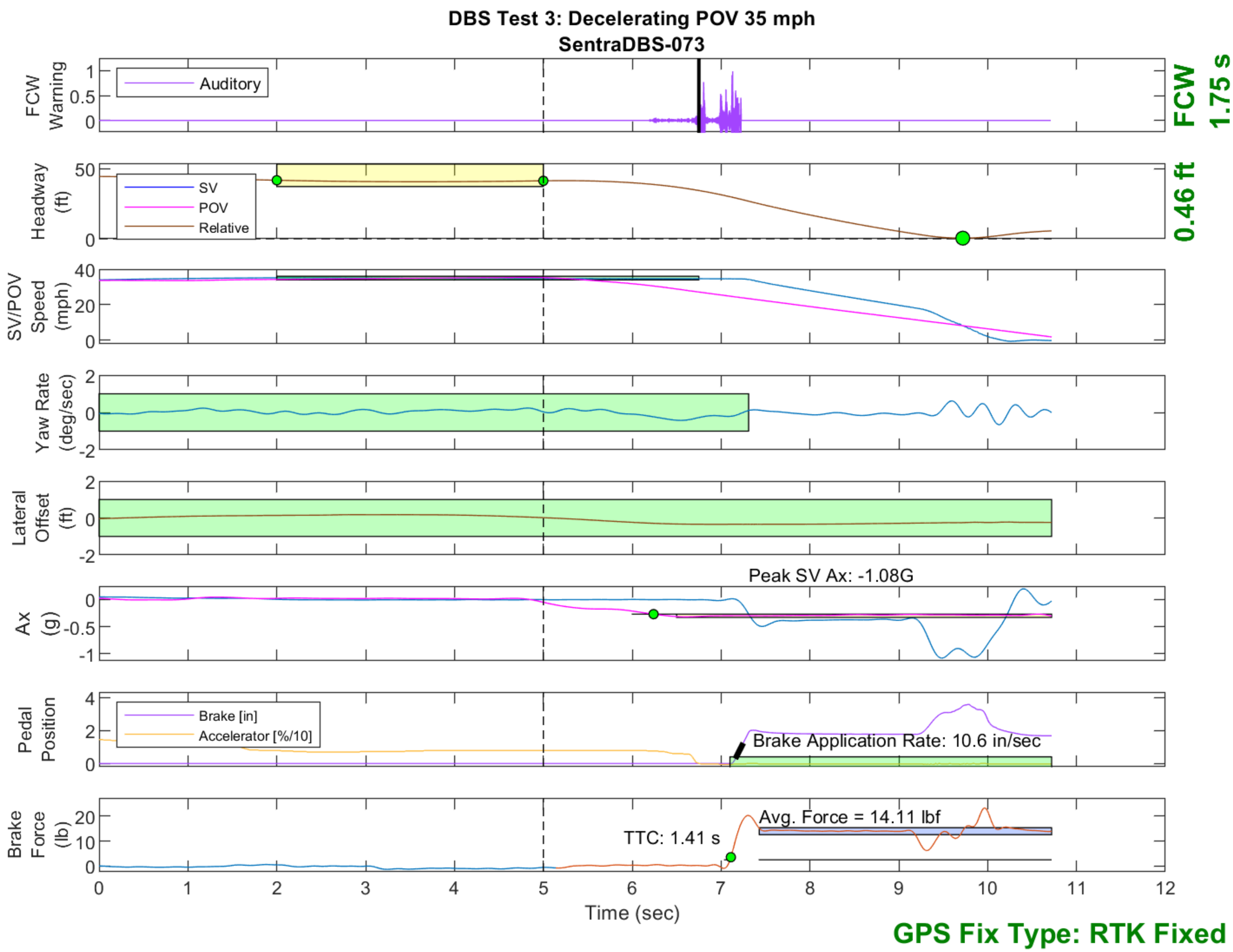


Figure E38. Time History for DBS Run 73, Test 3 - Decelerating POV 35 mph

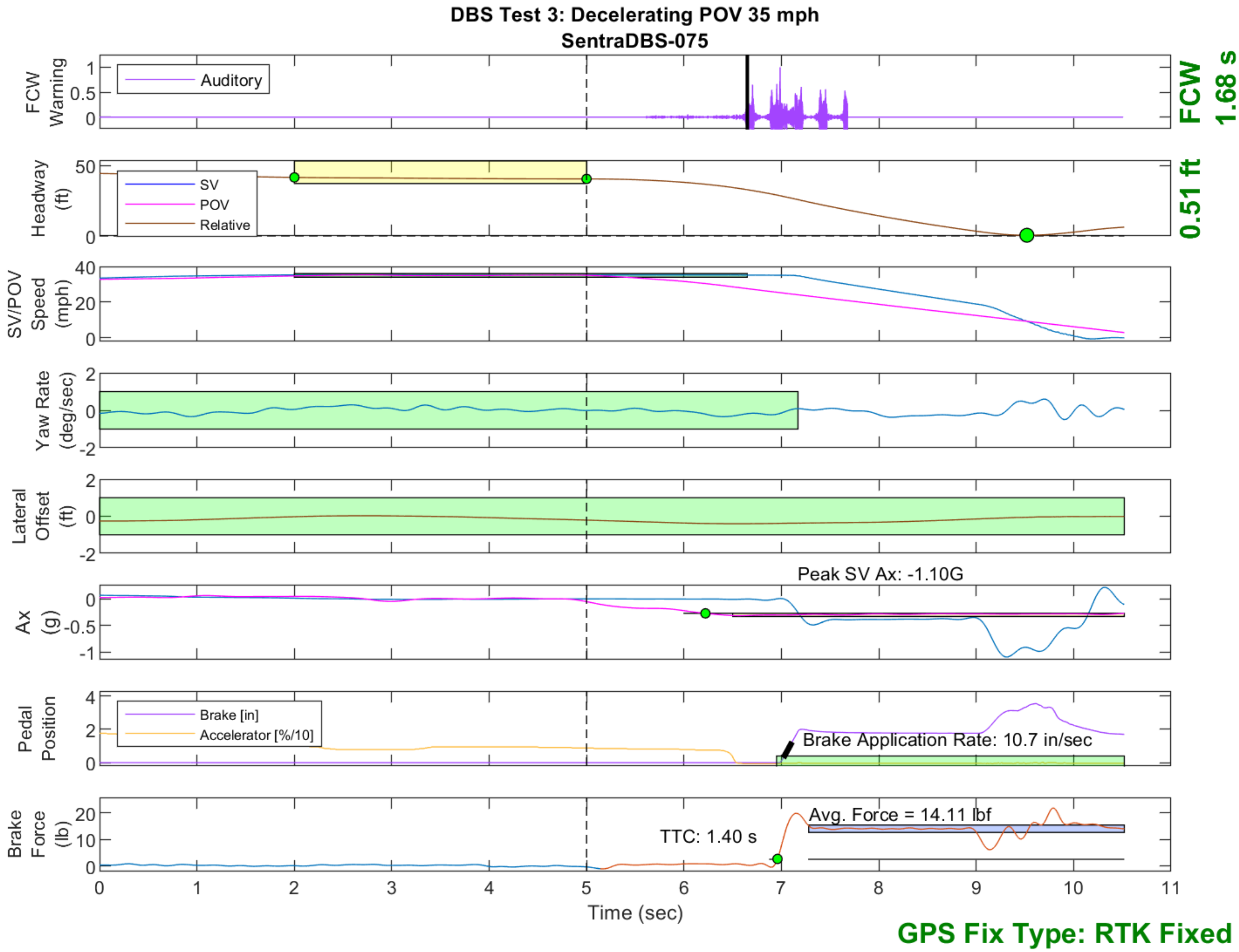


Figure E39. Time History for DBS Run 75, Test 3 - Decelerating POV 35 mph

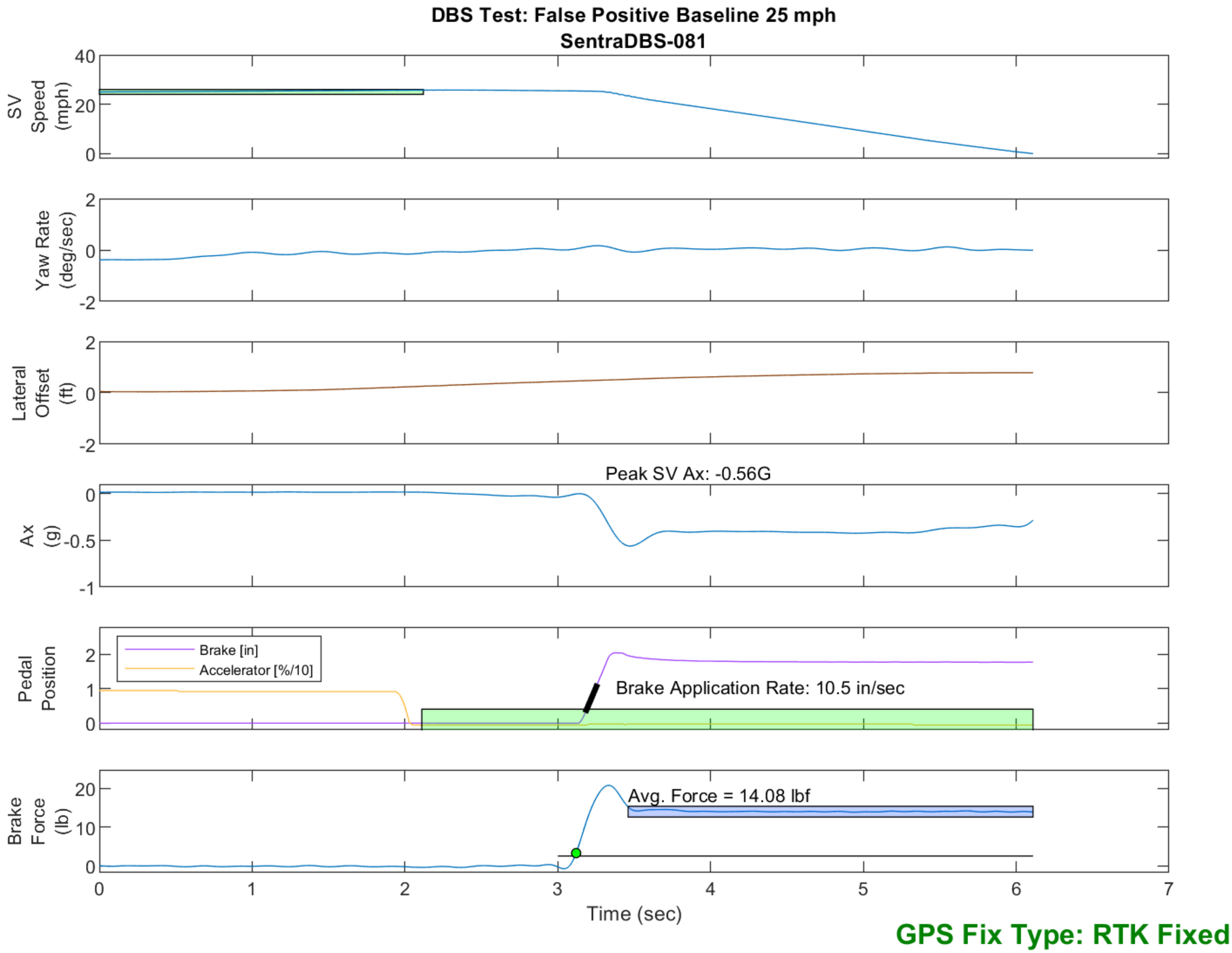


Figure E40. Time History for DBS Run 81, False Positive Baseline, SV 25 mph

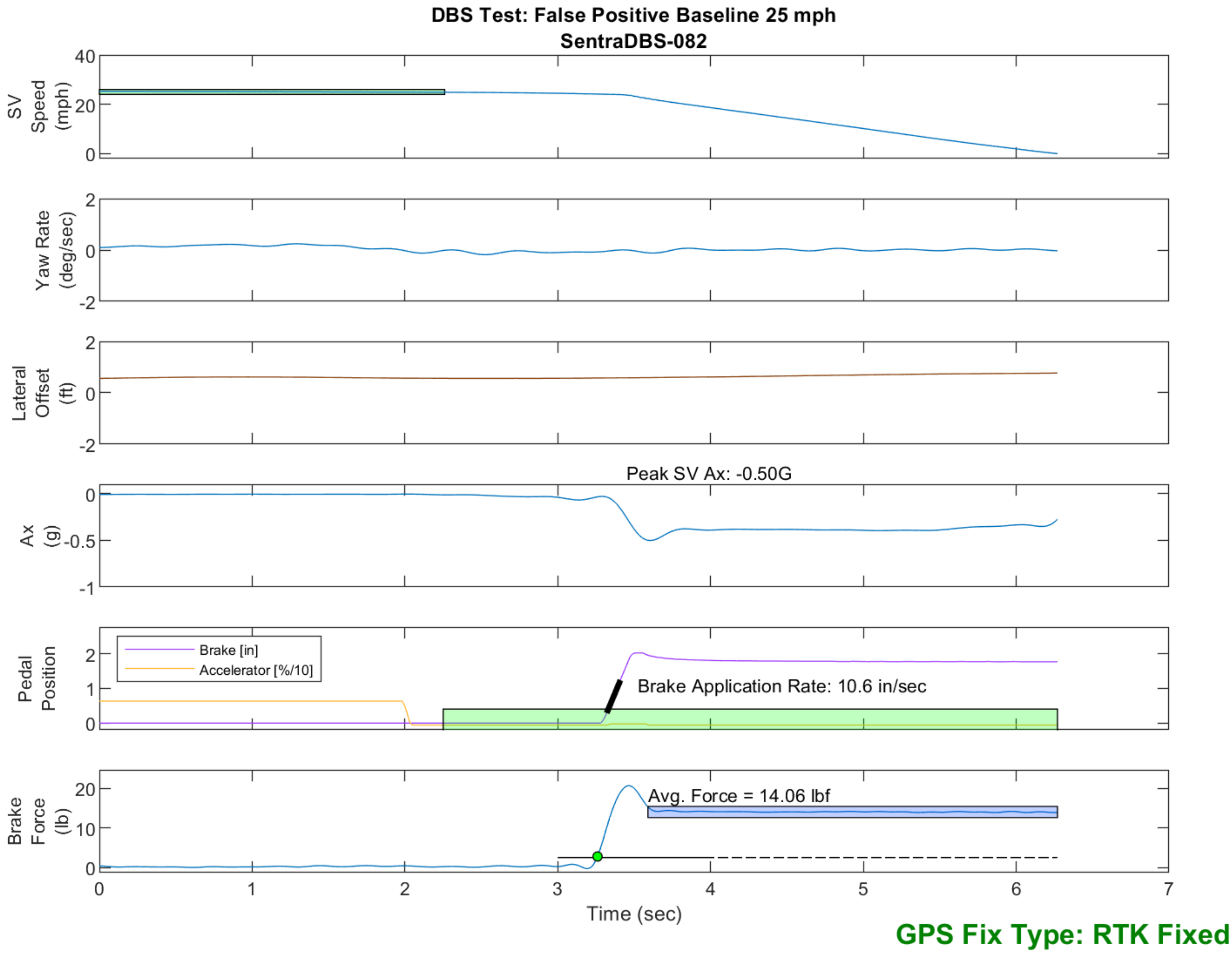


Figure E41. Time History for DBS Run 82, False Positive Baseline, SV 25 mph

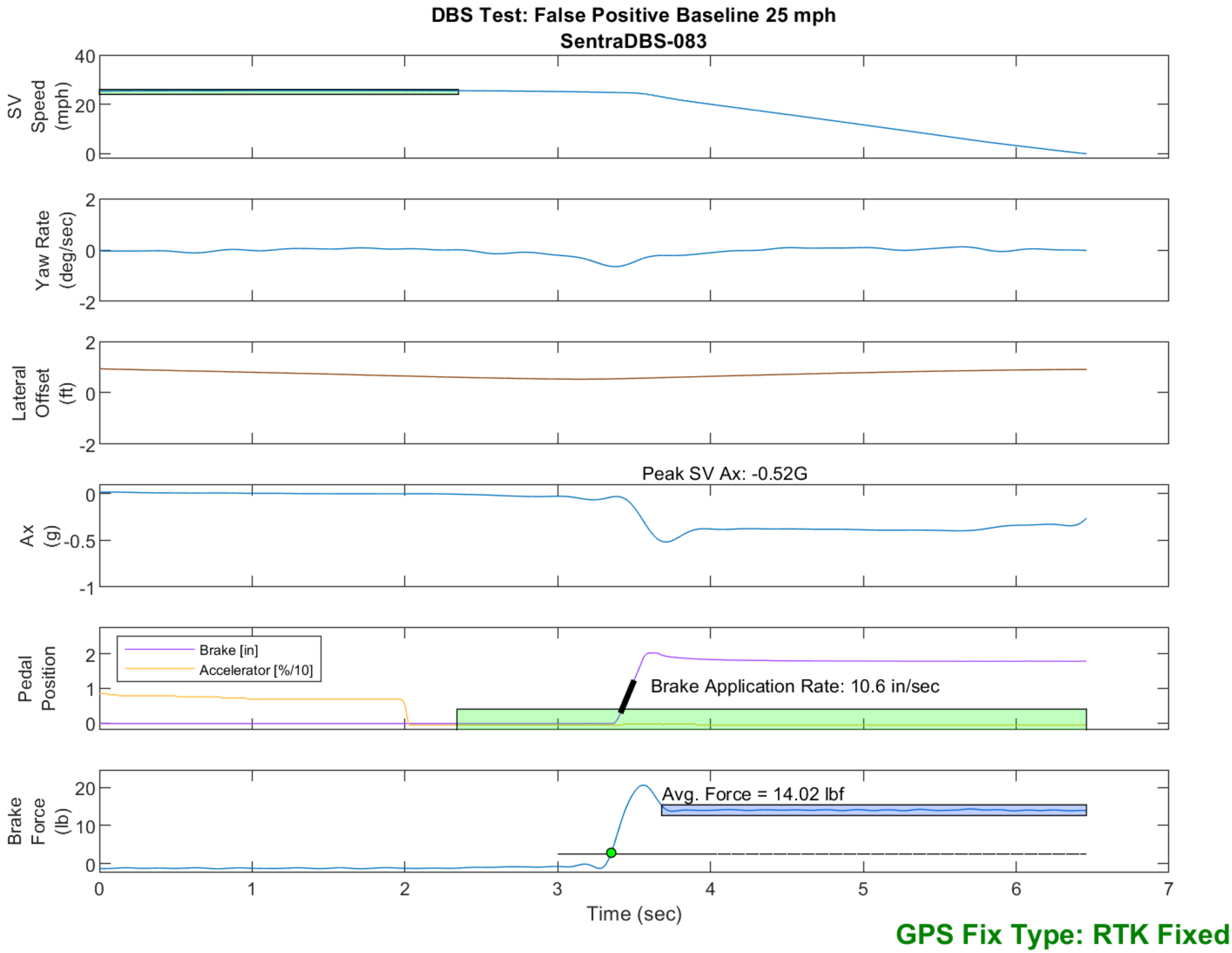


Figure E42. Time History for DBS Run 83, False Positive Baseline, SV 25 mph

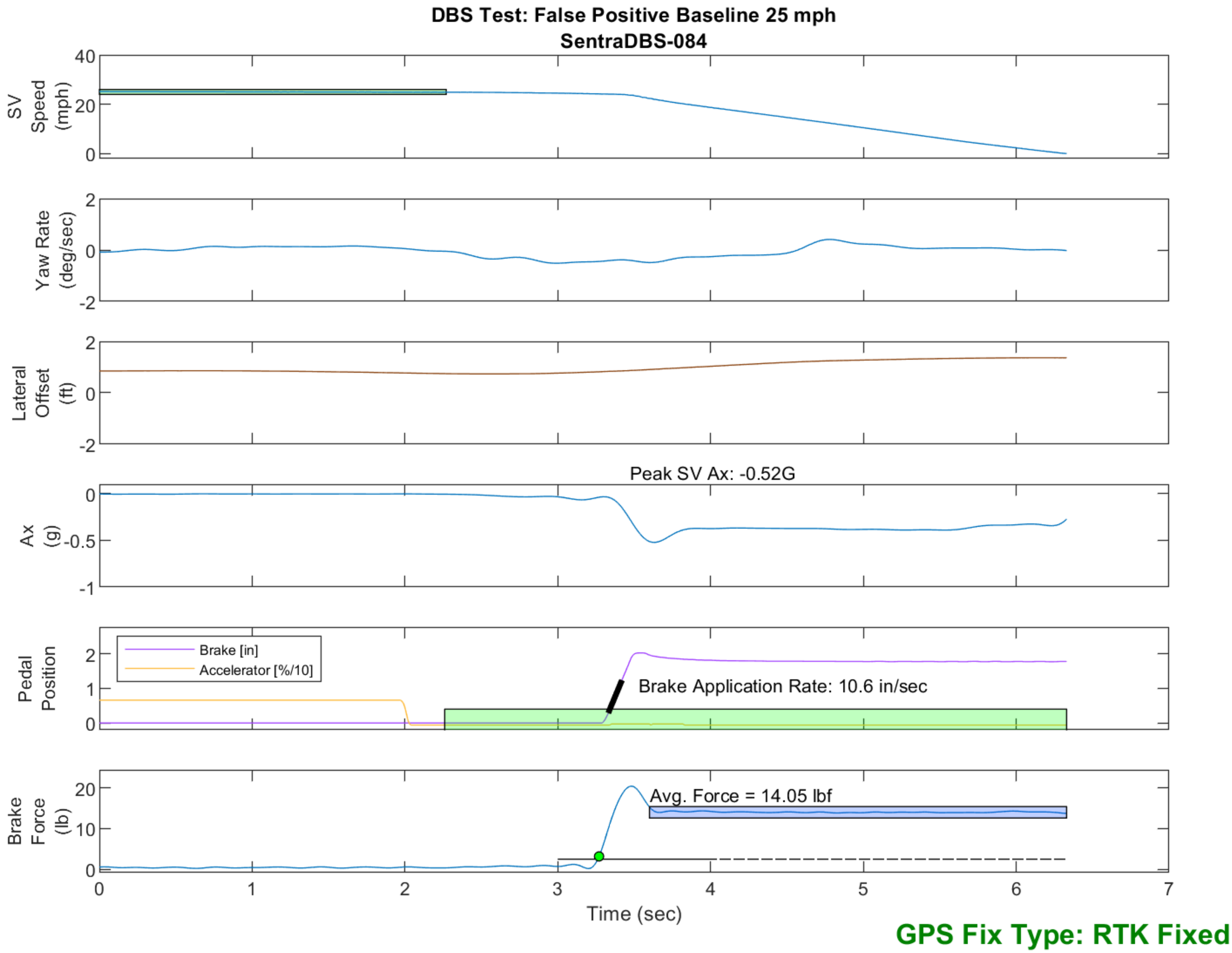


Figure E43. Time History for DBS Run 84, False Positive Baseline, SV 25 mph

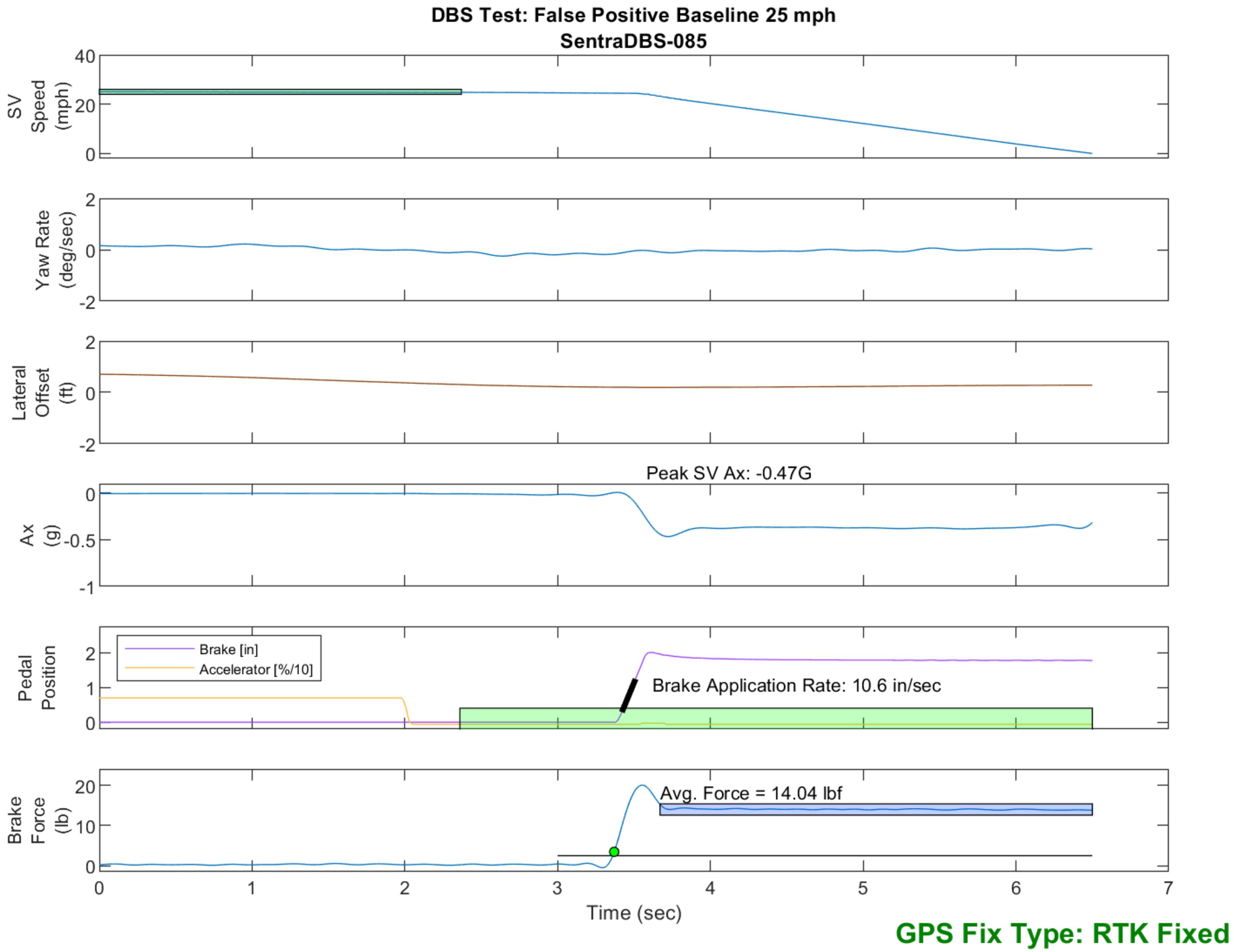


Figure E44. Time History for DBS Run 85, False Positive Baseline, SV 25 mph

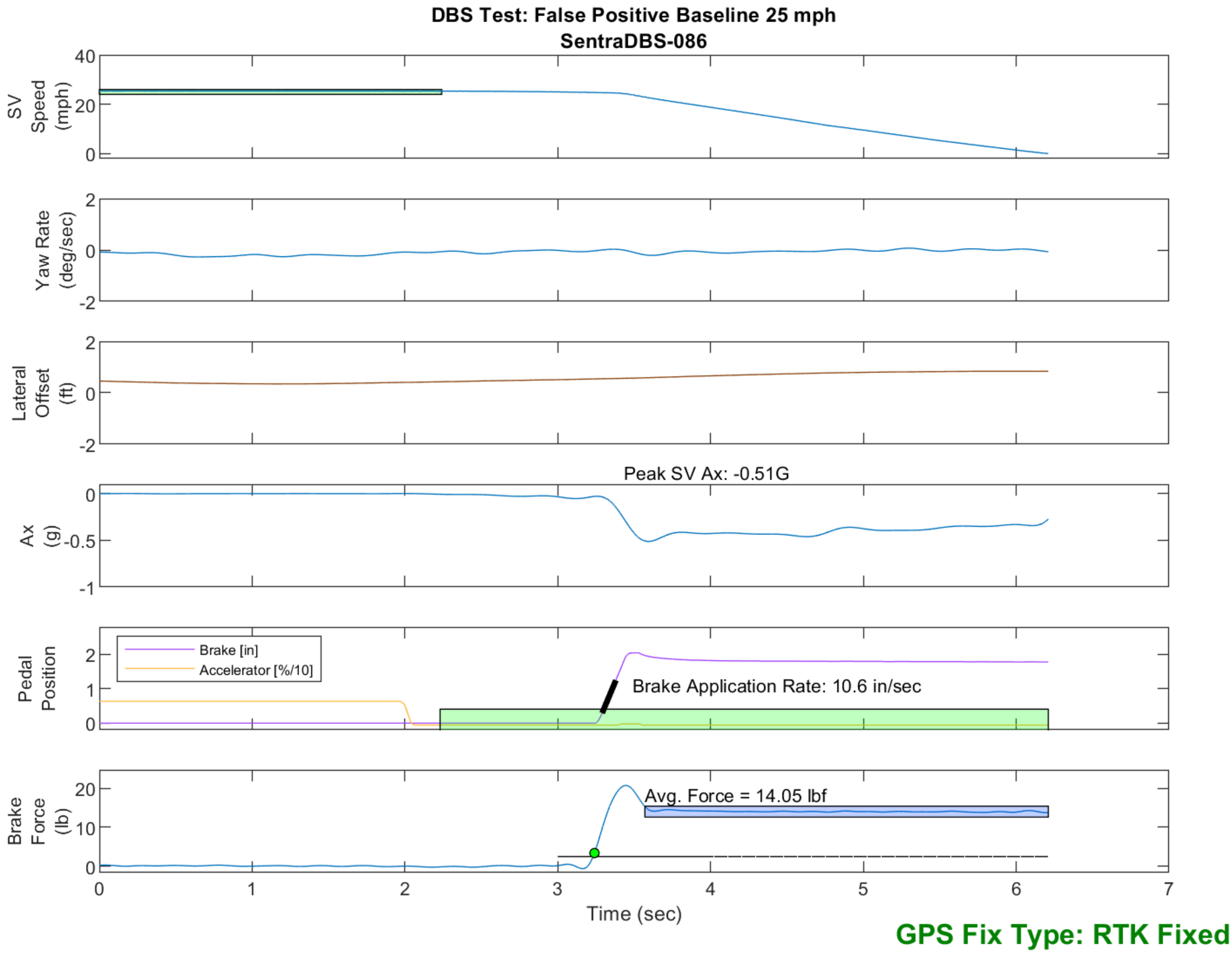


Figure E45. Time History for DBS Run 86, False Positive Baseline, SV 25 mph

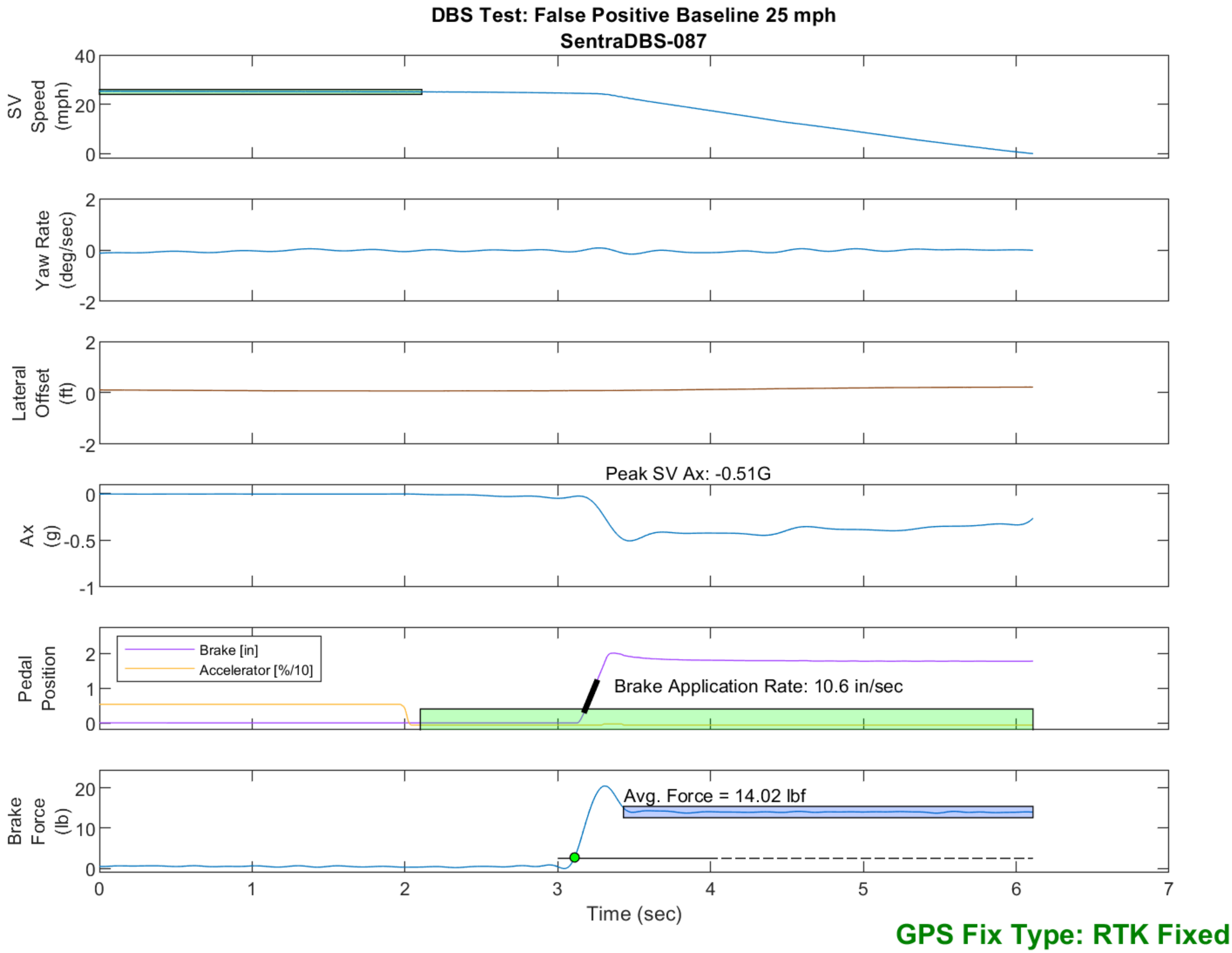


Figure E46. Time History for DBS Run 87, False Positive Baseline, SV 25 mph

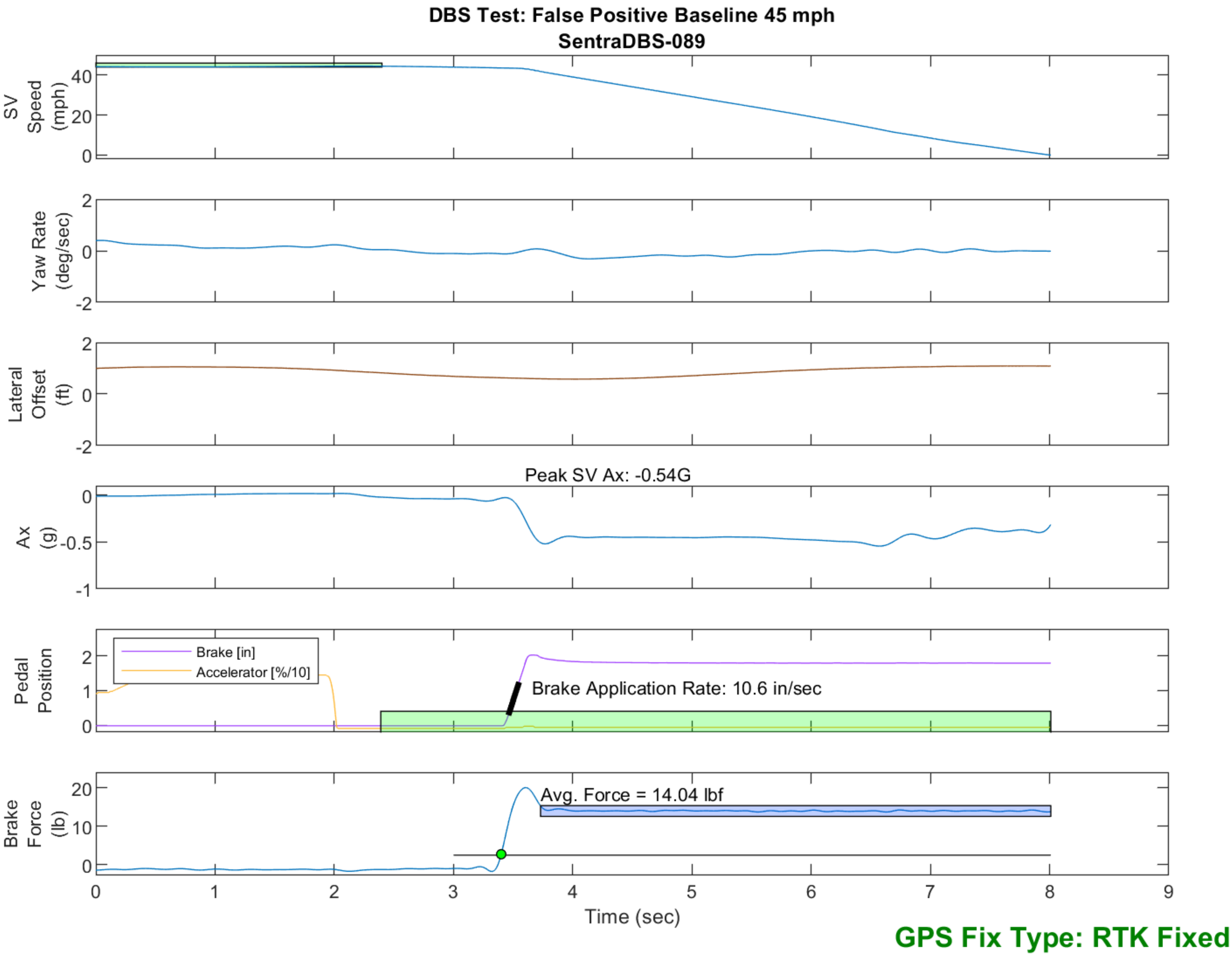


Figure E47. Time History for DBS Run 89, False Positive Baseline, SV 45 mph

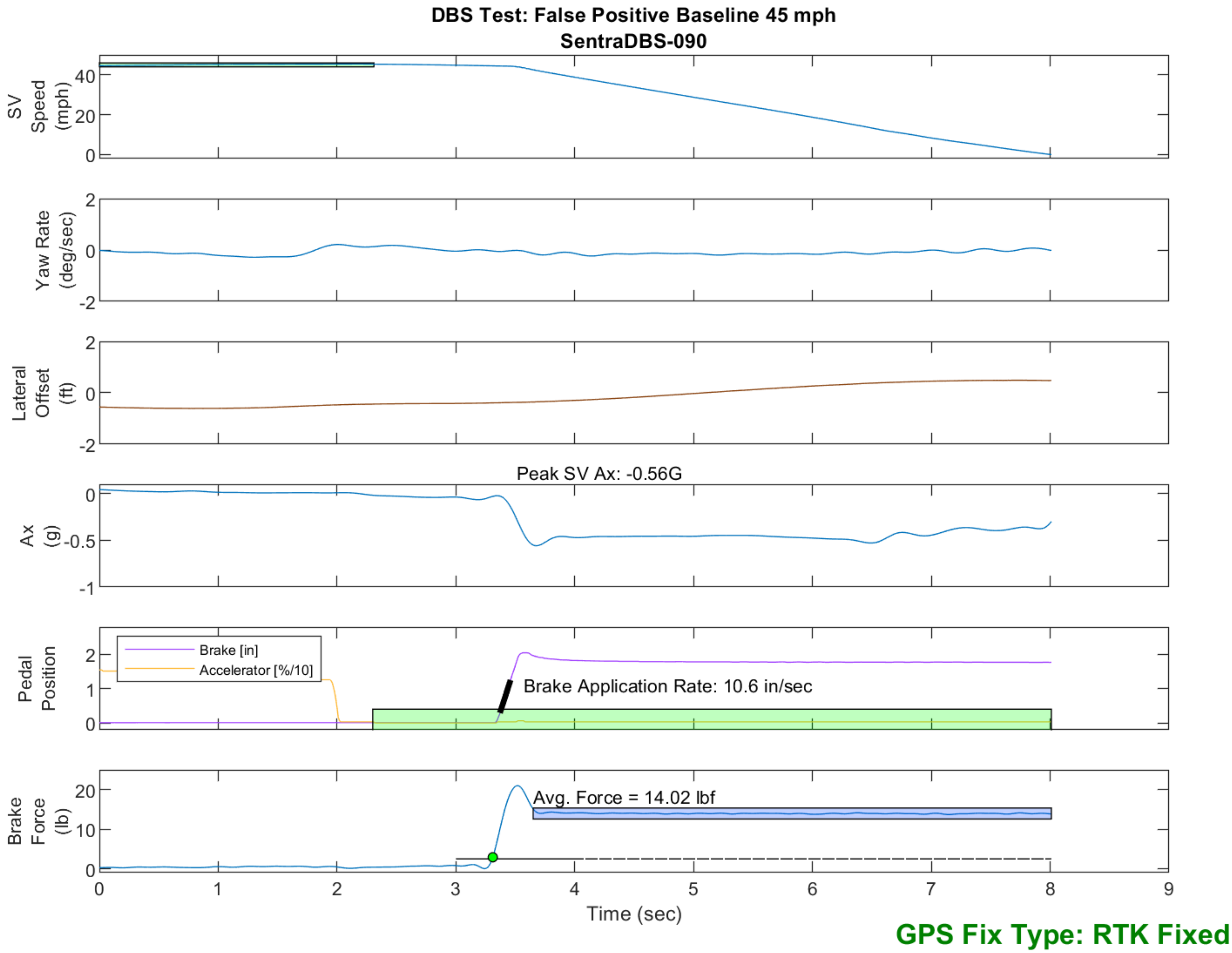


Figure E48. Time History for DBS Run 90, False Positive Baseline, SV 45 mph

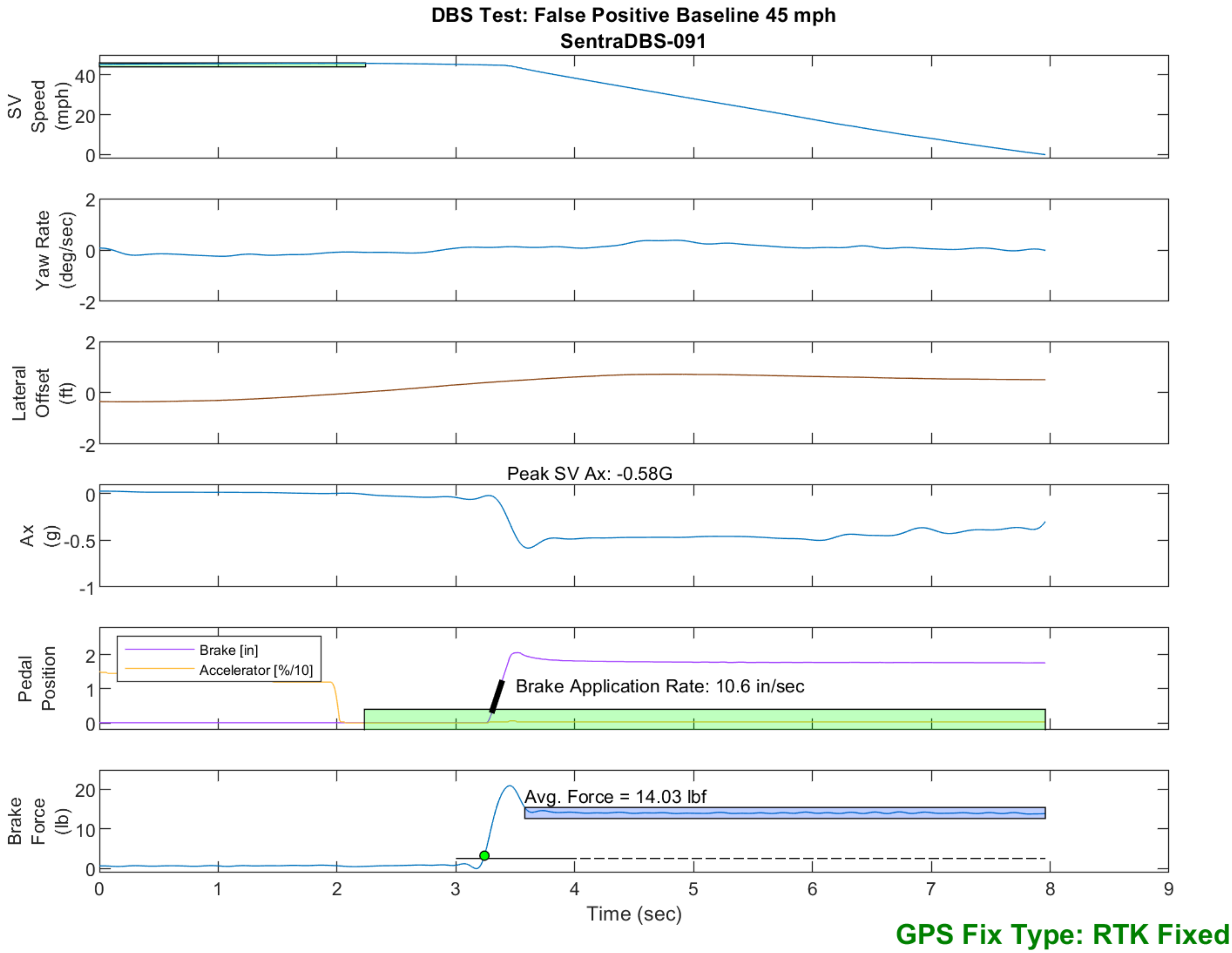


Figure E49. Time History for DBS Run 91, False Positive Baseline, SV 45 mph

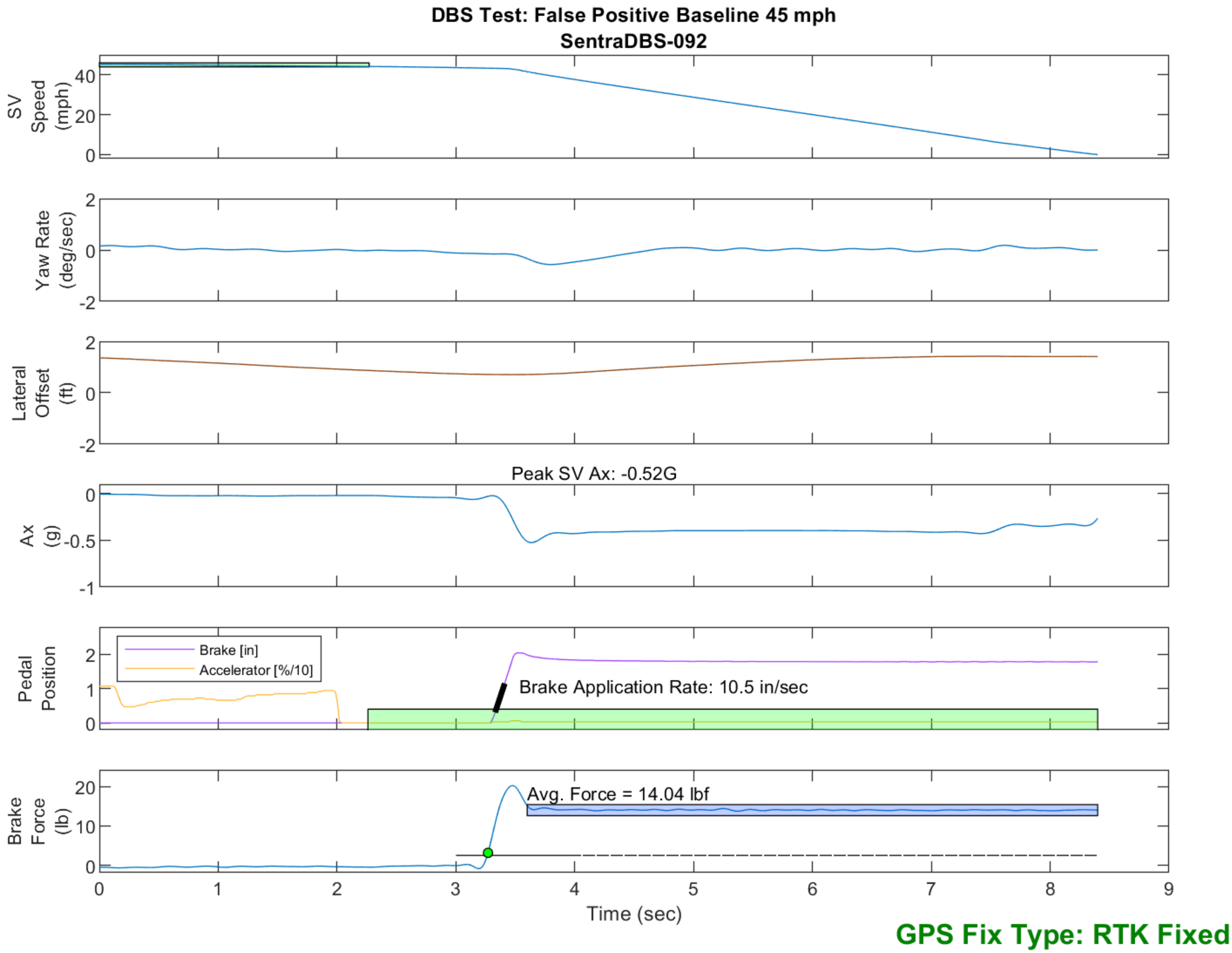


Figure E50. Time History for DBS Run 92, False Positive Baseline, SV 45 mph

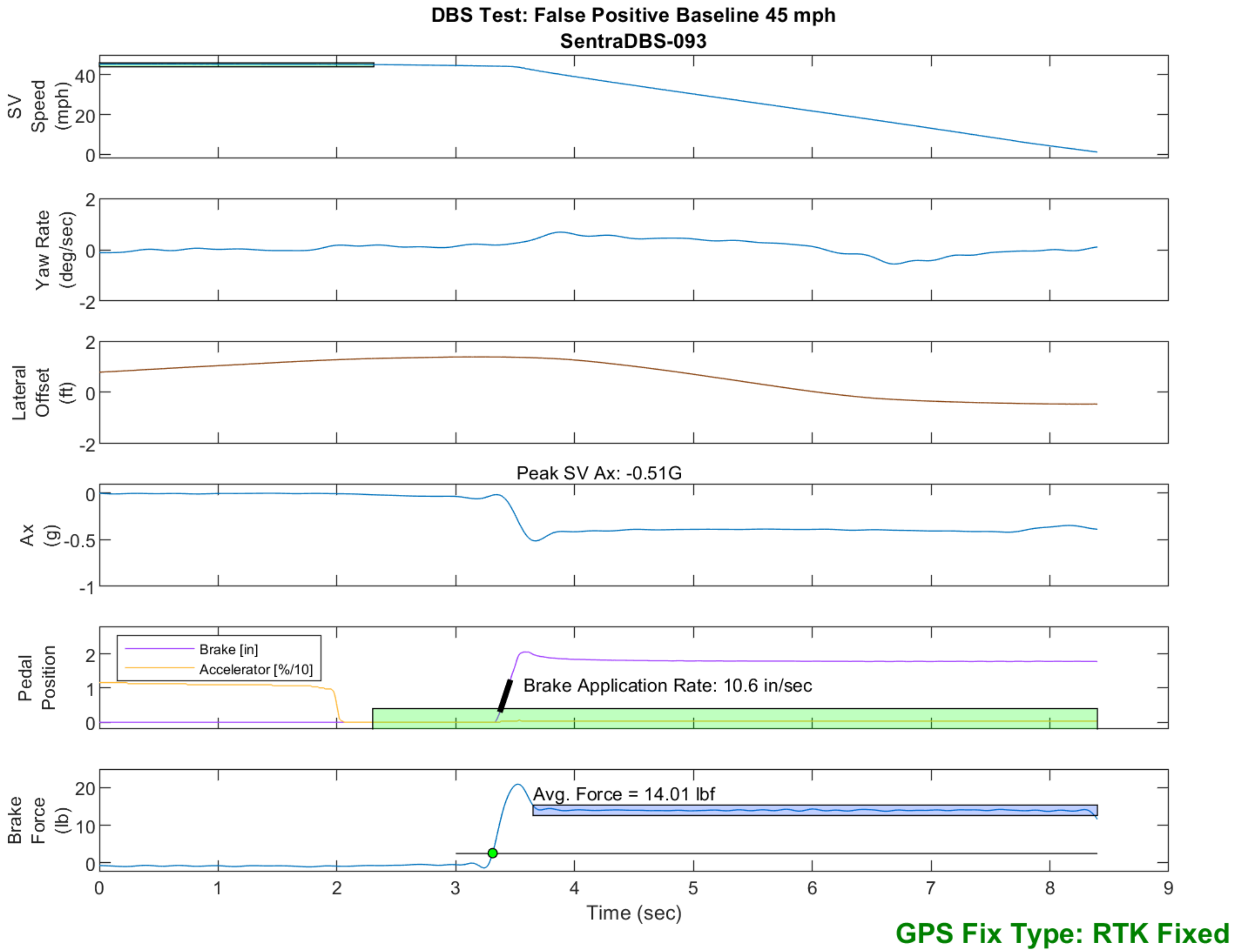


Figure E51. Time History for DBS Run 93, False Positive Baseline, SV 45 mph

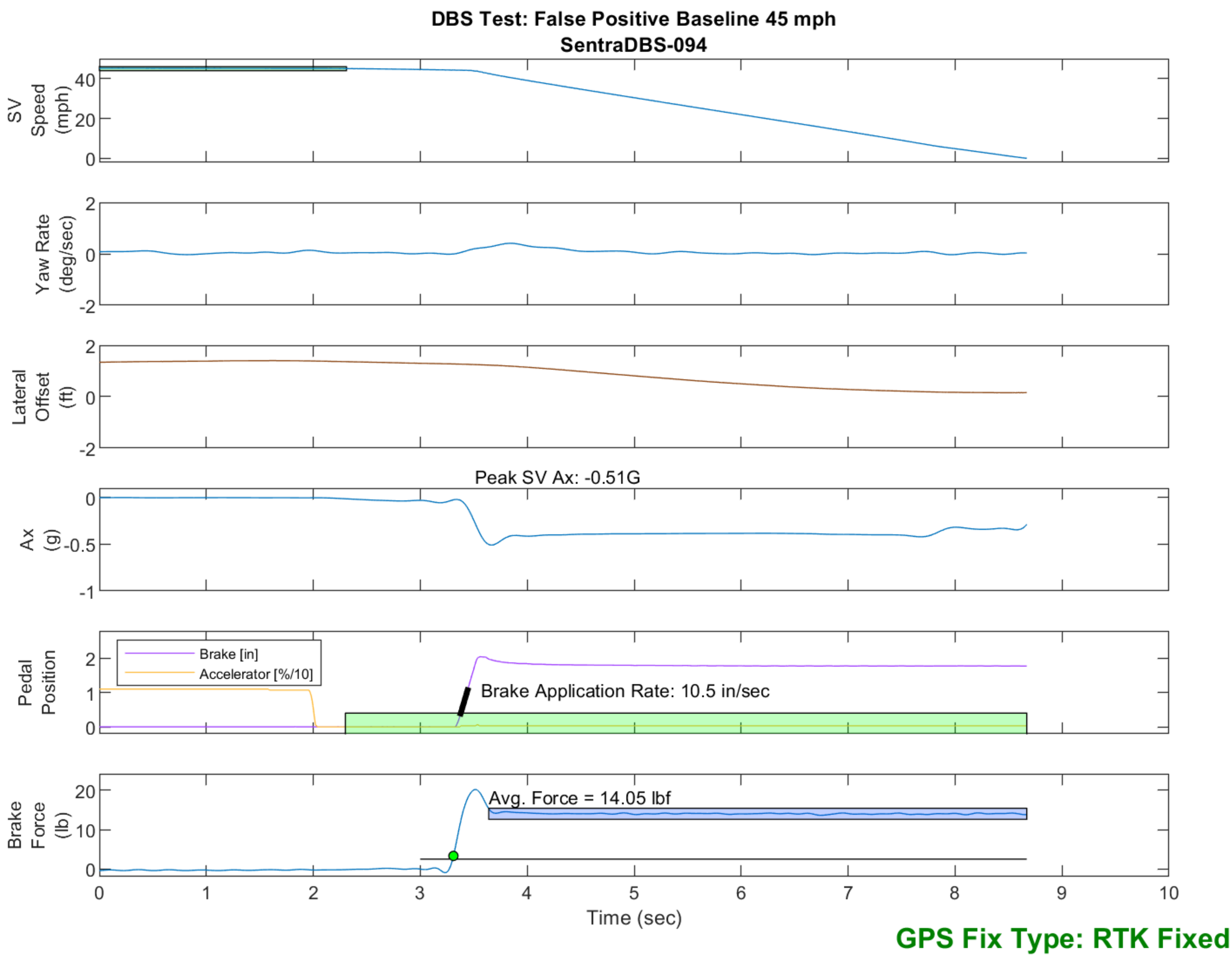


Figure E52. Time History for DBS Run 94, False Positive Baseline, SV 45 mph

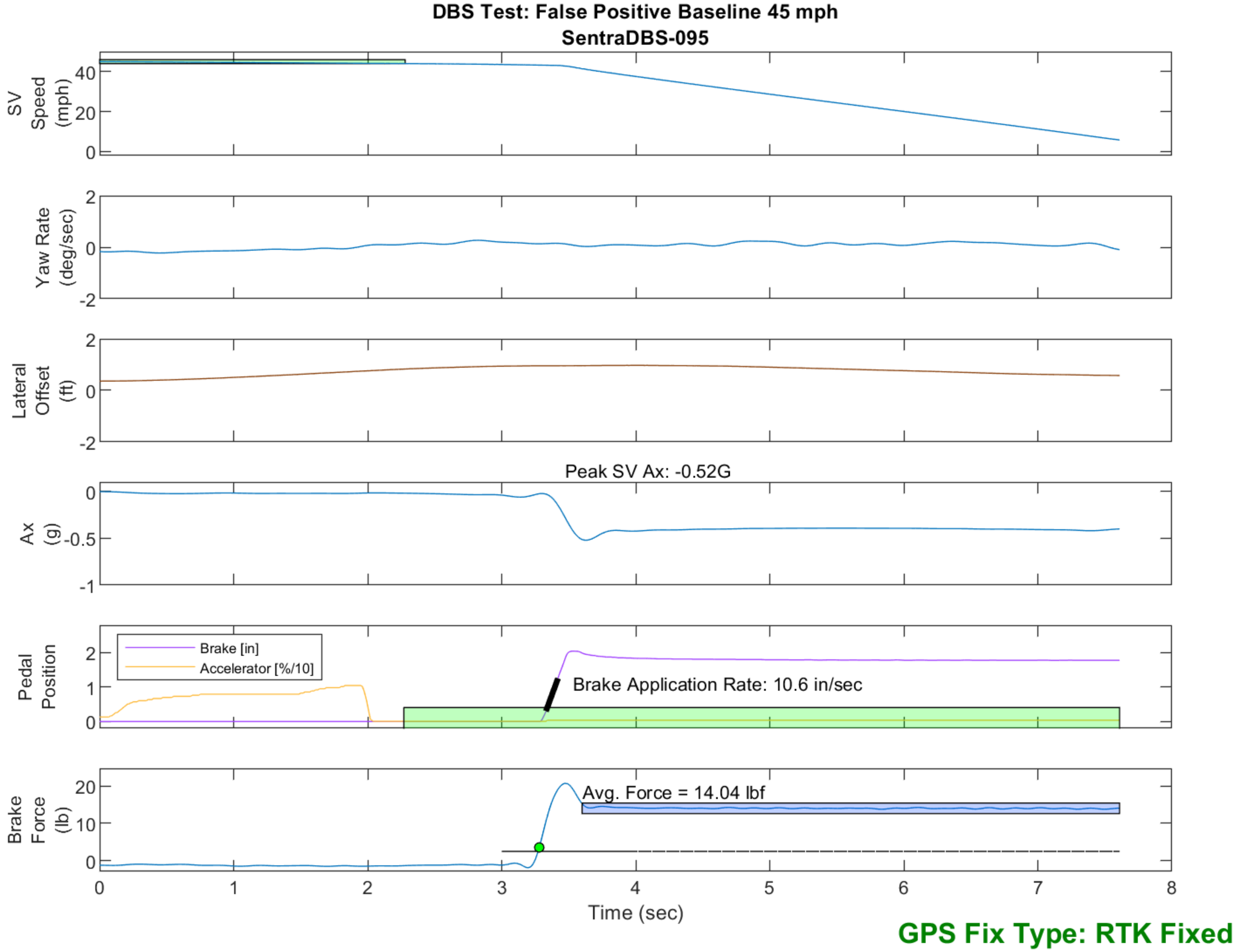


Figure E53. Time History for DBS Run 95, False Positive Baseline, SV 45 mph

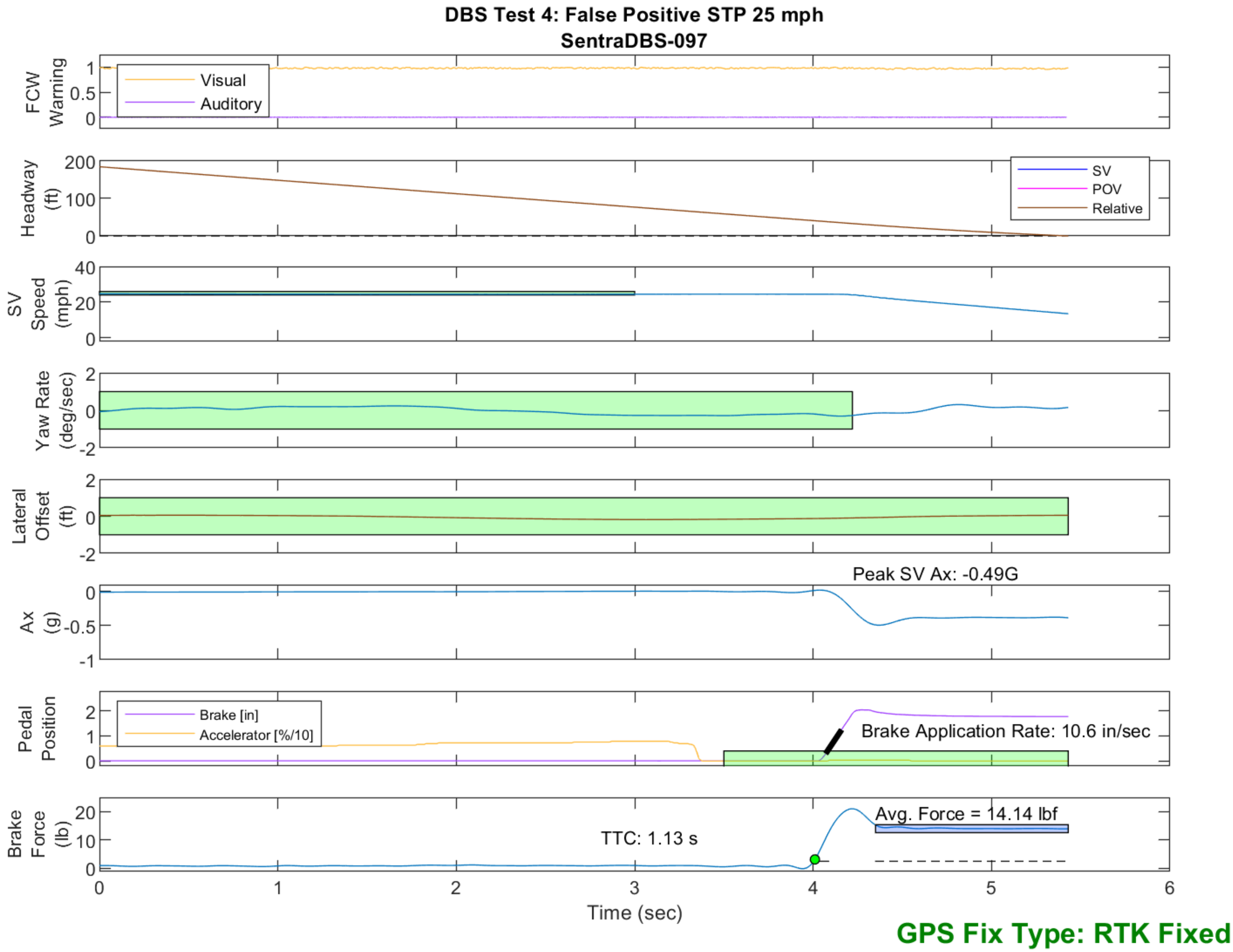


Figure E54. Time History for DBS Run 97, Test 4 - False Positive STP 25 mph

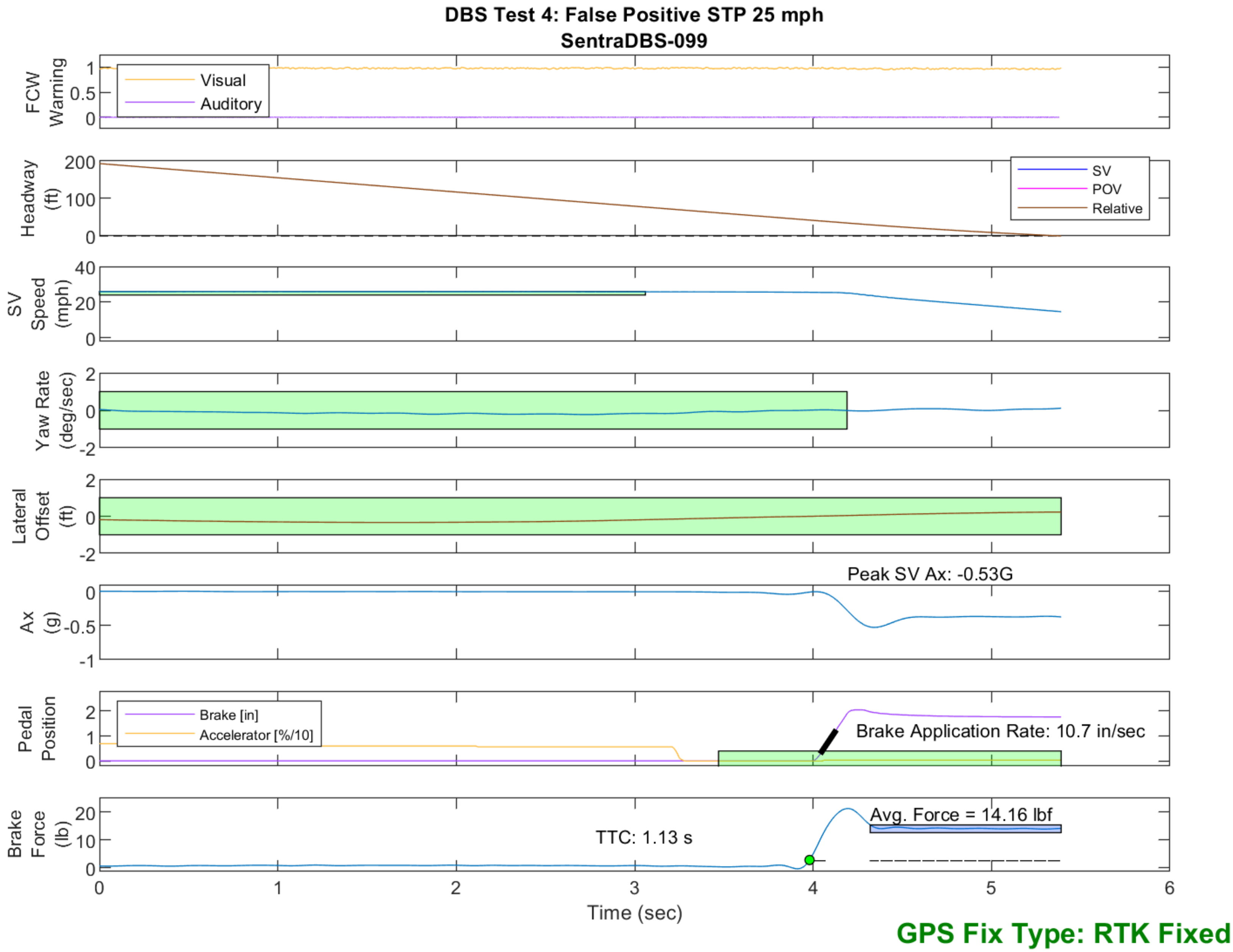


Figure E55. Time History for DBS Run 99, Test 4 - False Positive STP 25 mph

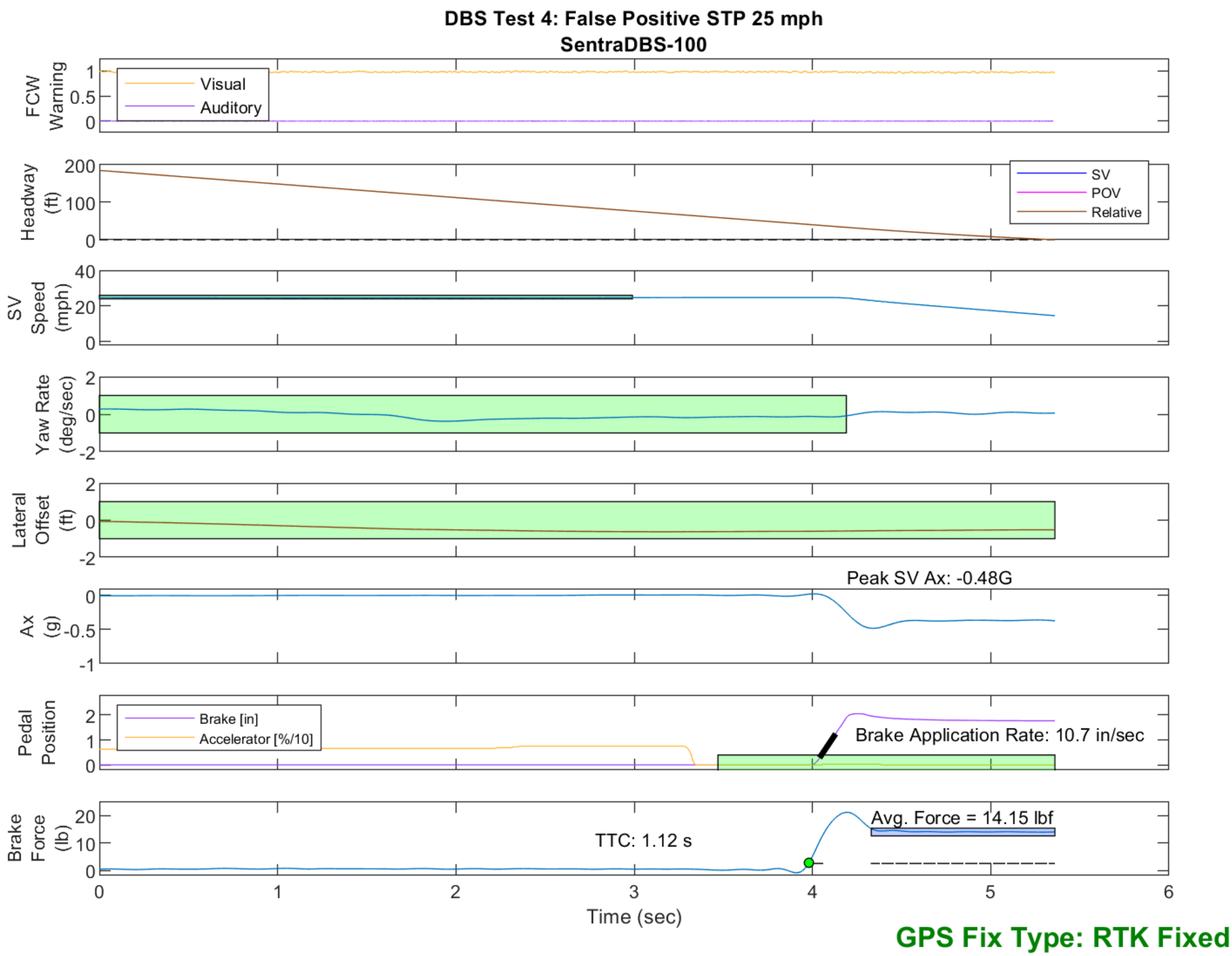


Figure E56. Time History for DBS Run 100, Test 4 - False Positive STP 25 mph

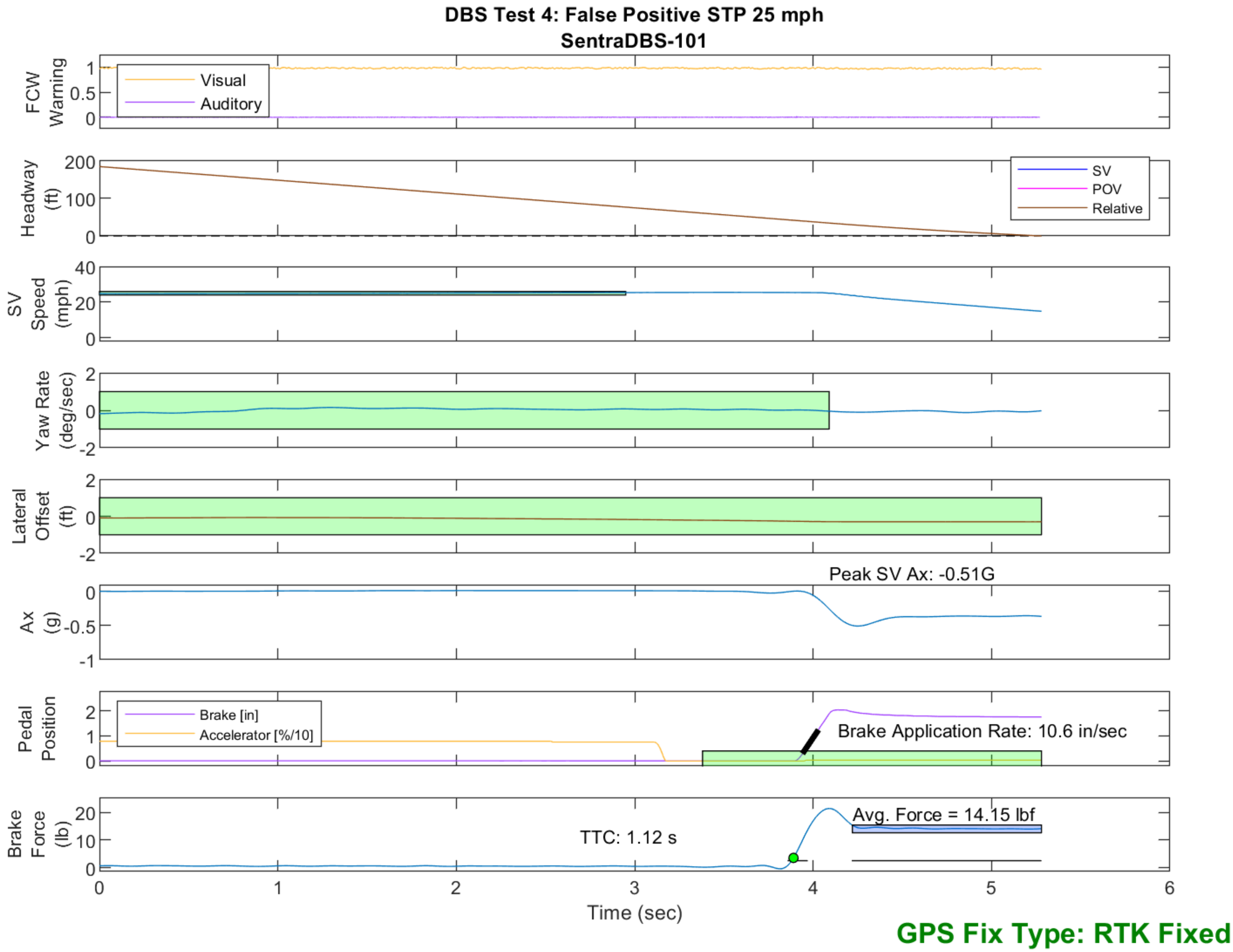


Figure E57. Time History for DBS Run 101, Test 4 - False Positive STP 25 mph

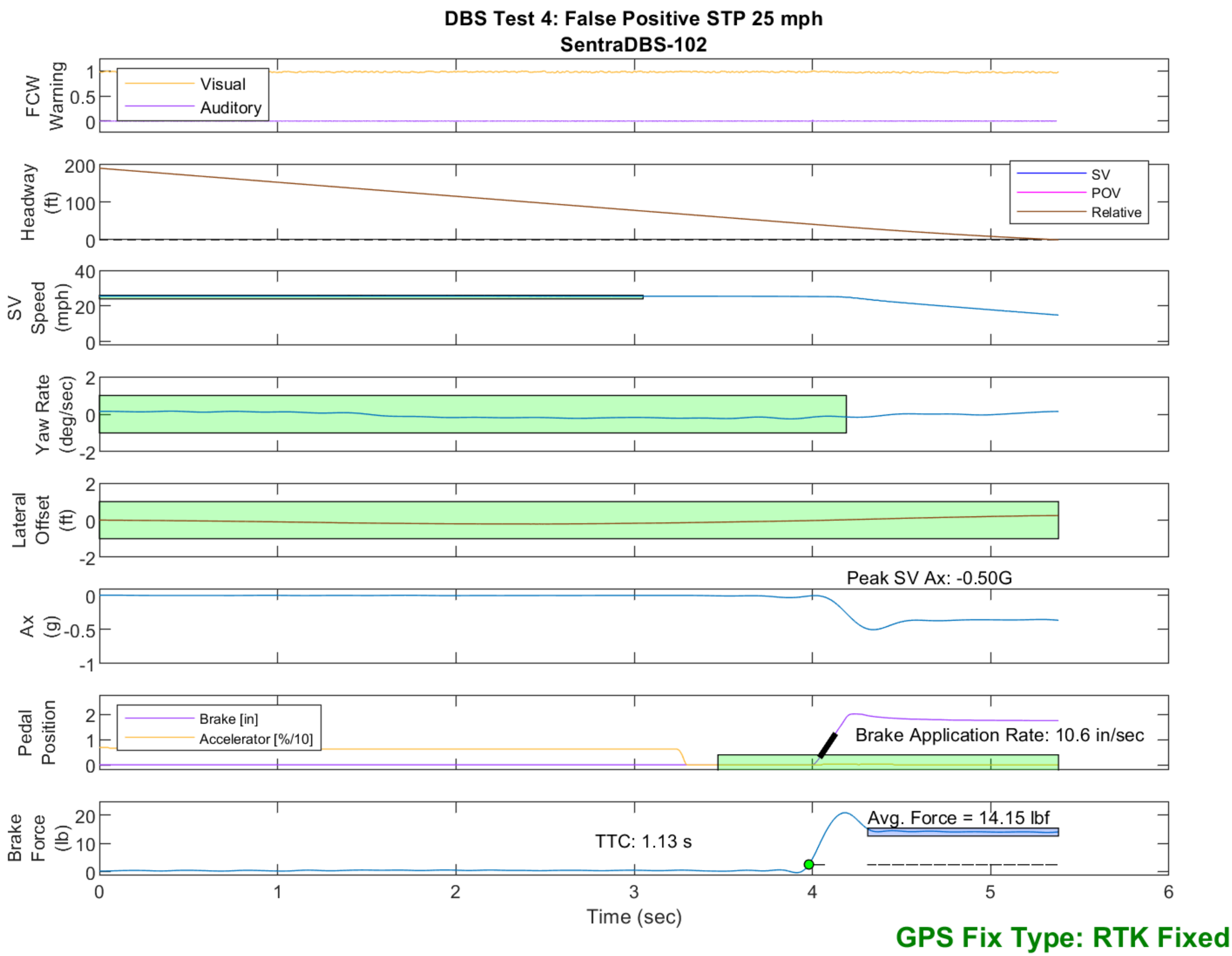


Figure E58. Time History for DBS Run 102, Test 4 - False Positive STP 25 mph

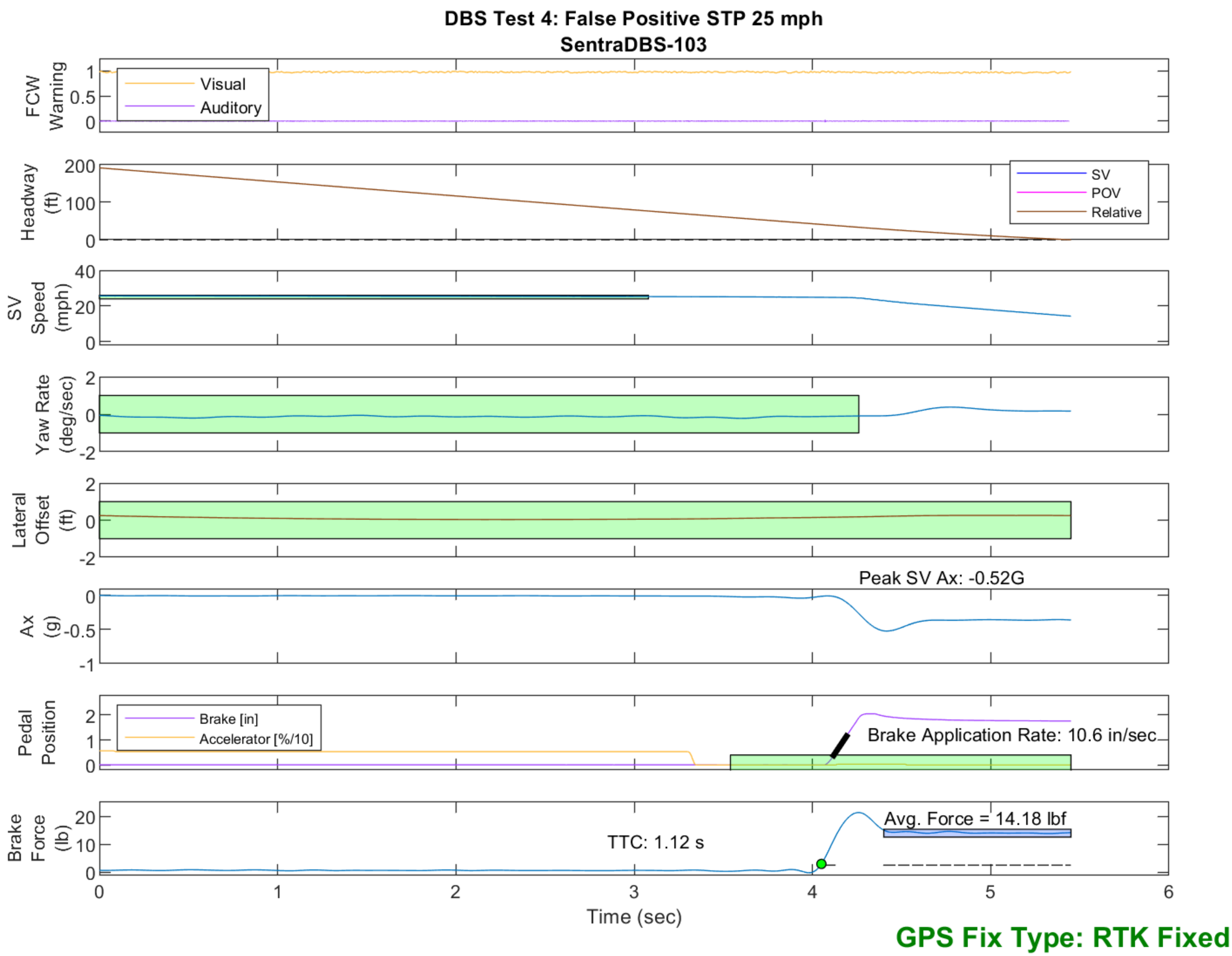


Figure E59. Time History for DBS Run 103, Test 4 - False Positive STP 25 mph

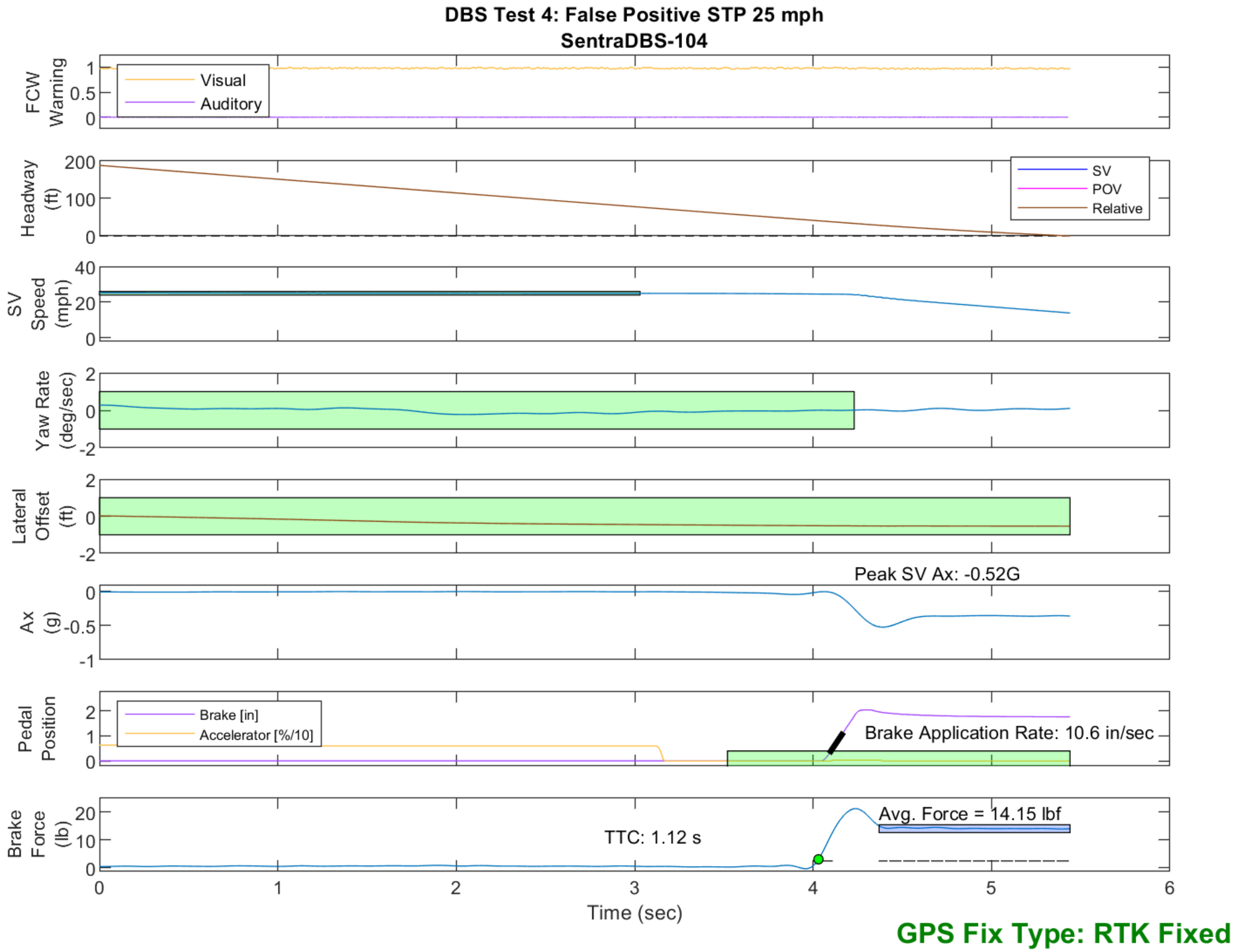


Figure E60. Time History for DBS Run 104, Test 4 - False Positive STP 25 mph

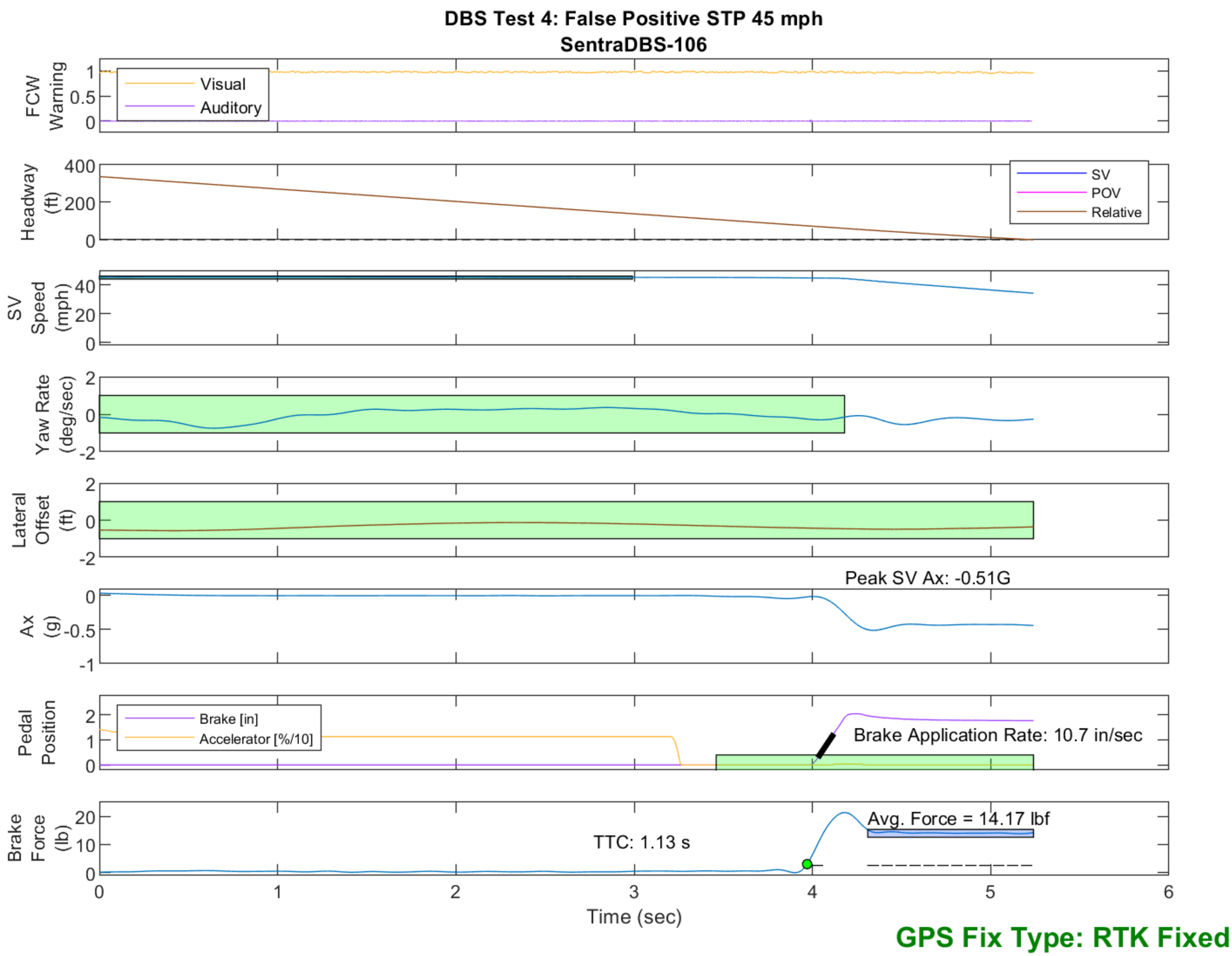


Figure E61. Time History for DBS Run 106, Test 4 - False Positive STP 45 mph

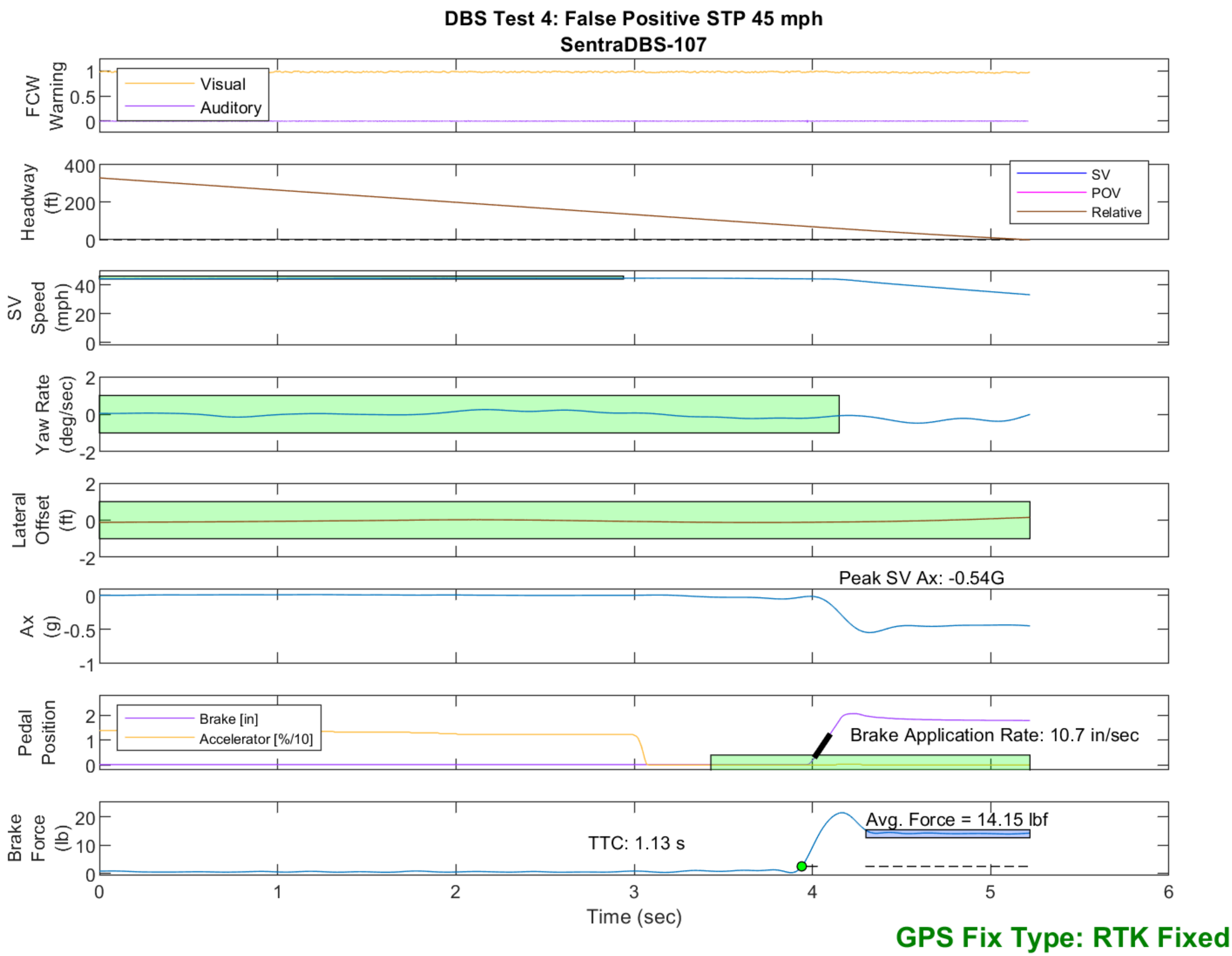


Figure E62. Time History for DBS Run 107, Test 4 - False Positive STP 45 mph

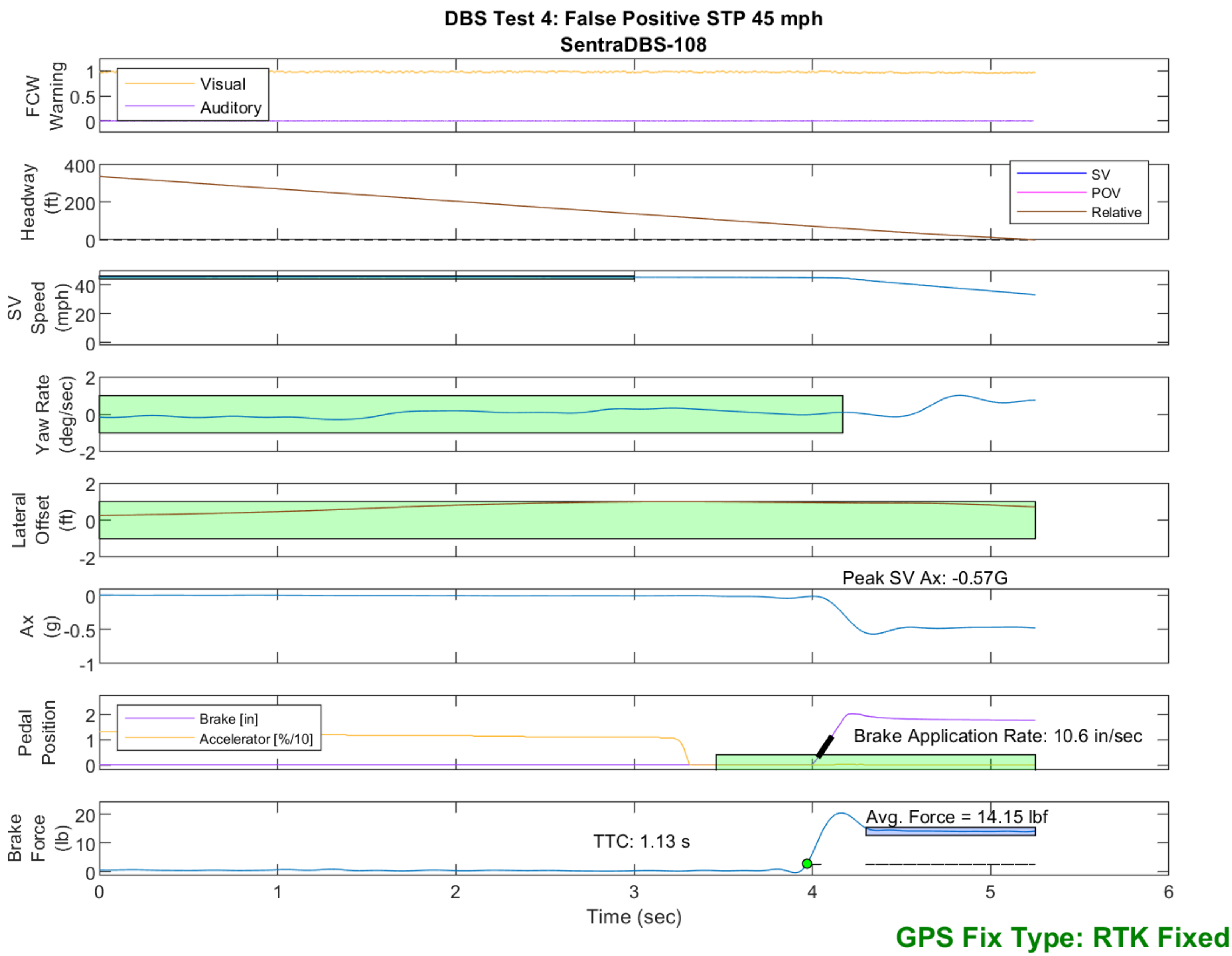


Figure E63. Time History for DBS Run 108, Test 4 - False Positive STP 45 mph

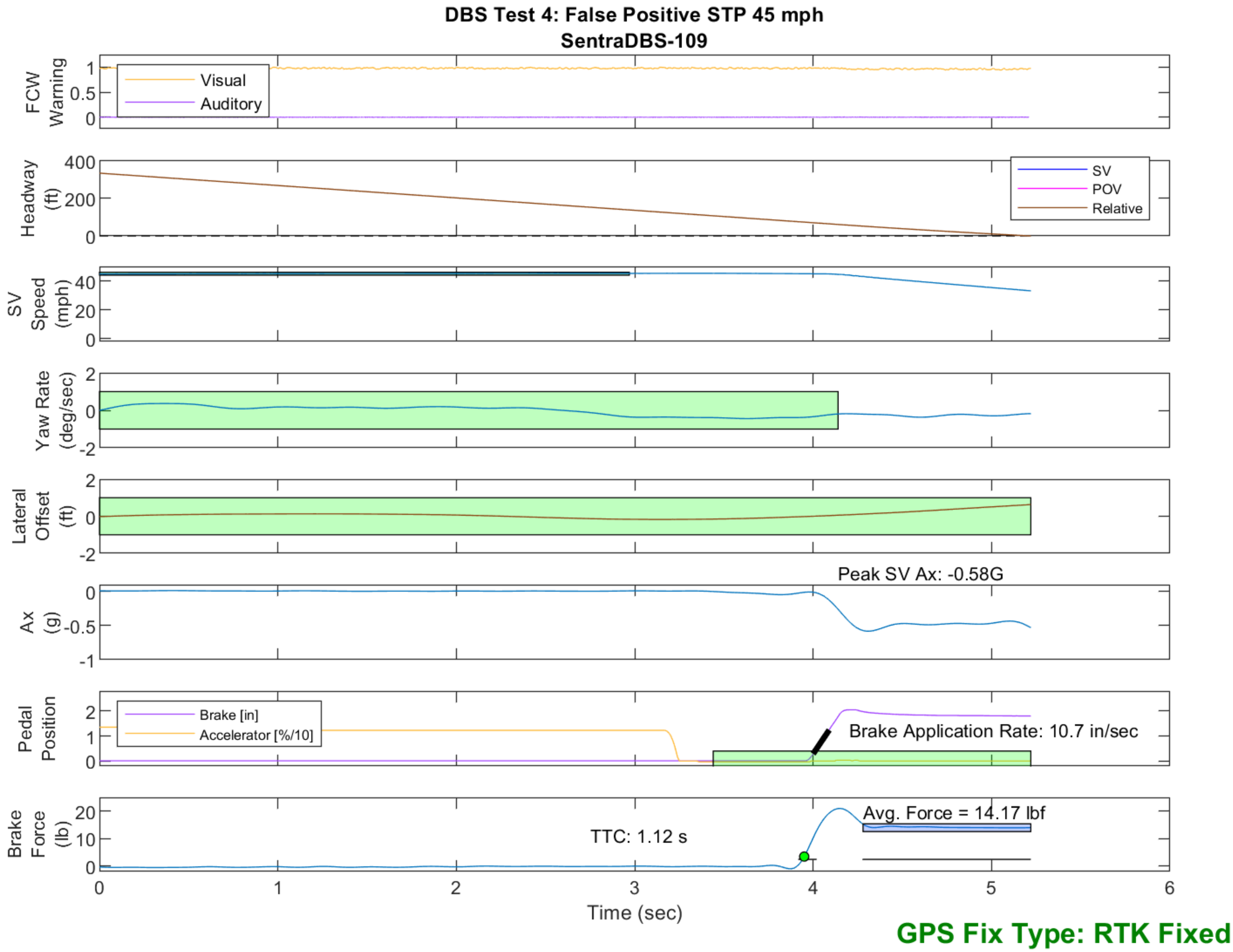


Figure E64. Time History for DBS Run 109, Test 4 - False Positive STP 45 mph

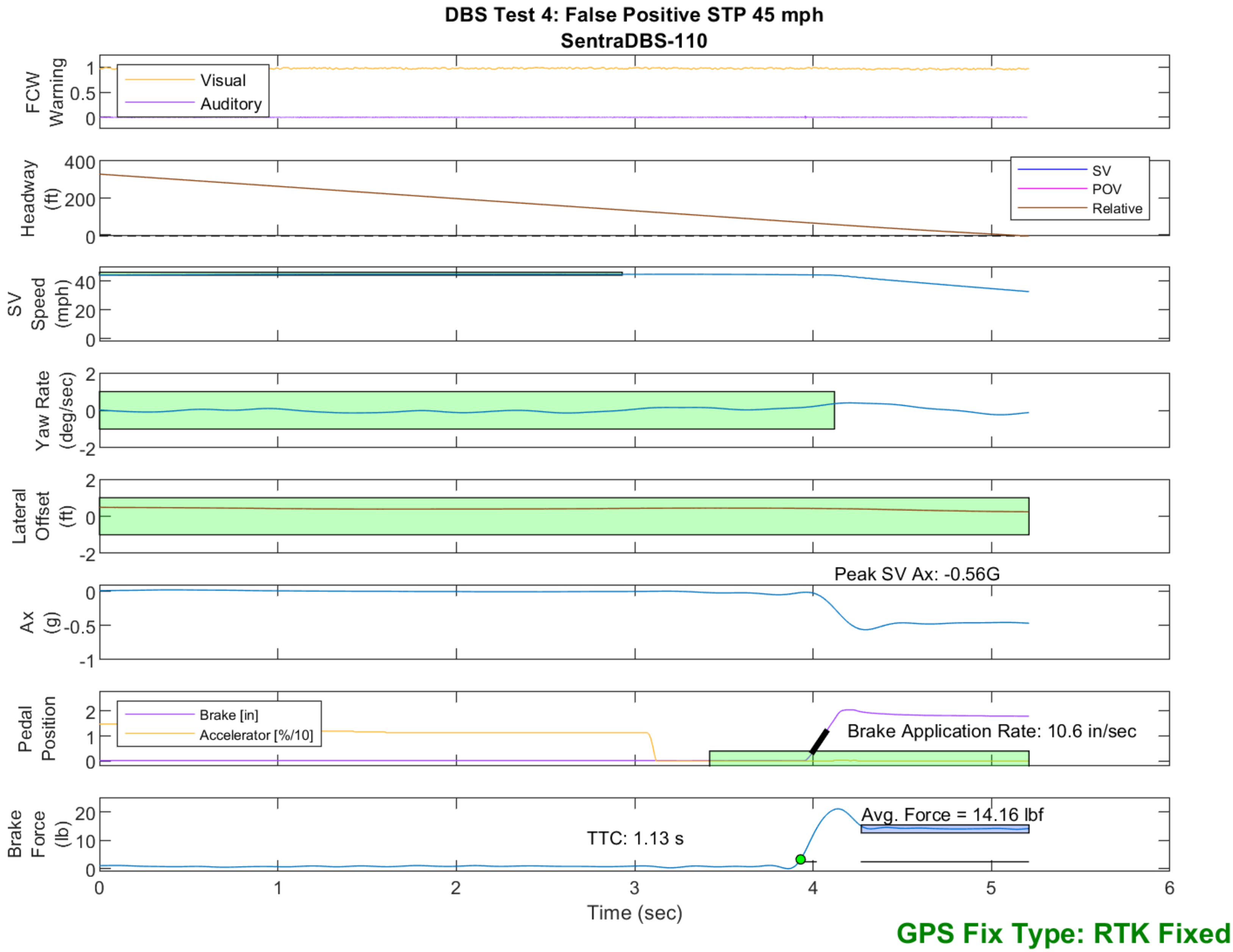


Figure E65. Time History for DBS Run 110, Test 4 - False Positive STP 45 mph

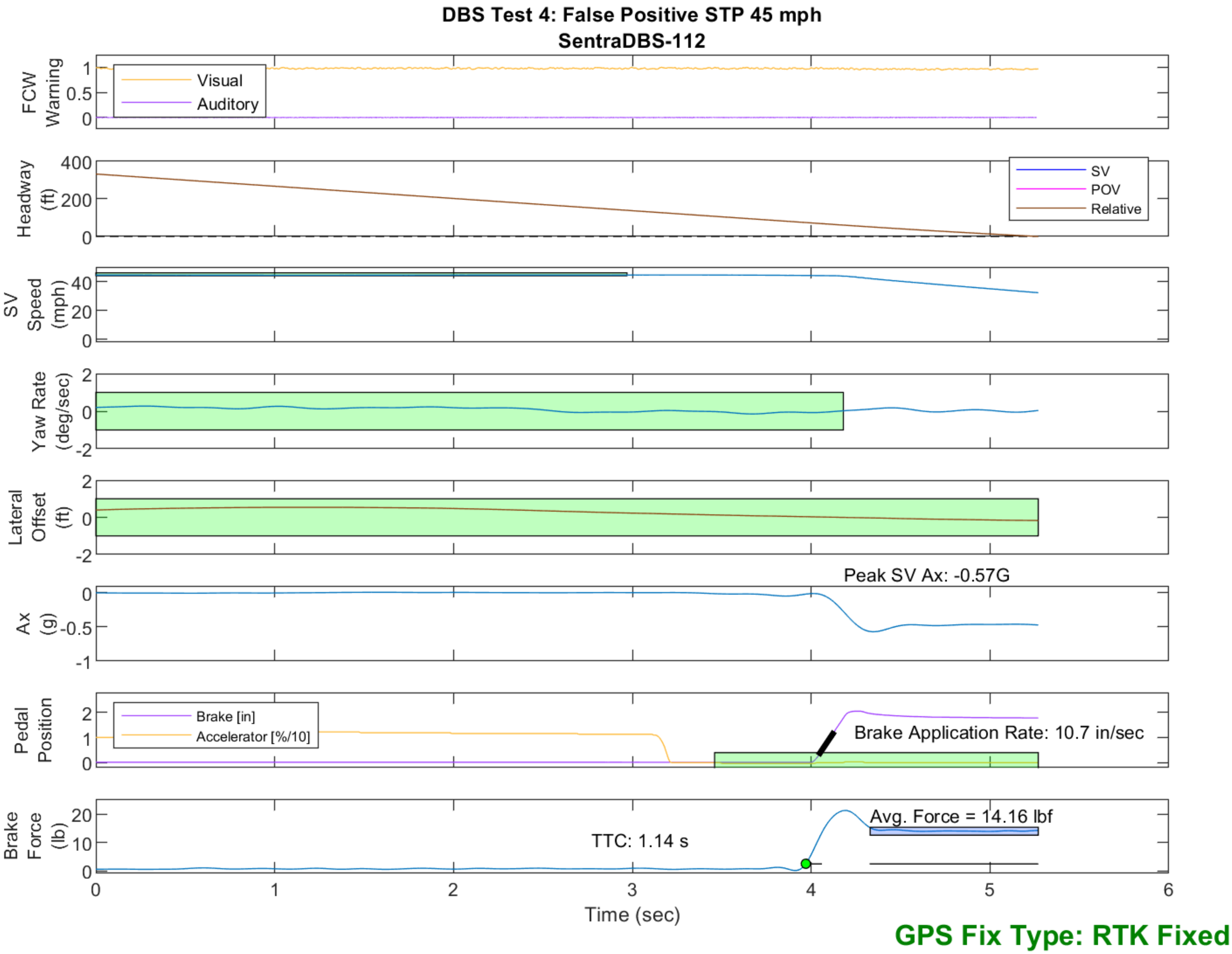


Figure E66. Time History for DBS Run 112, Test 4 - False Positive STP 45 mph

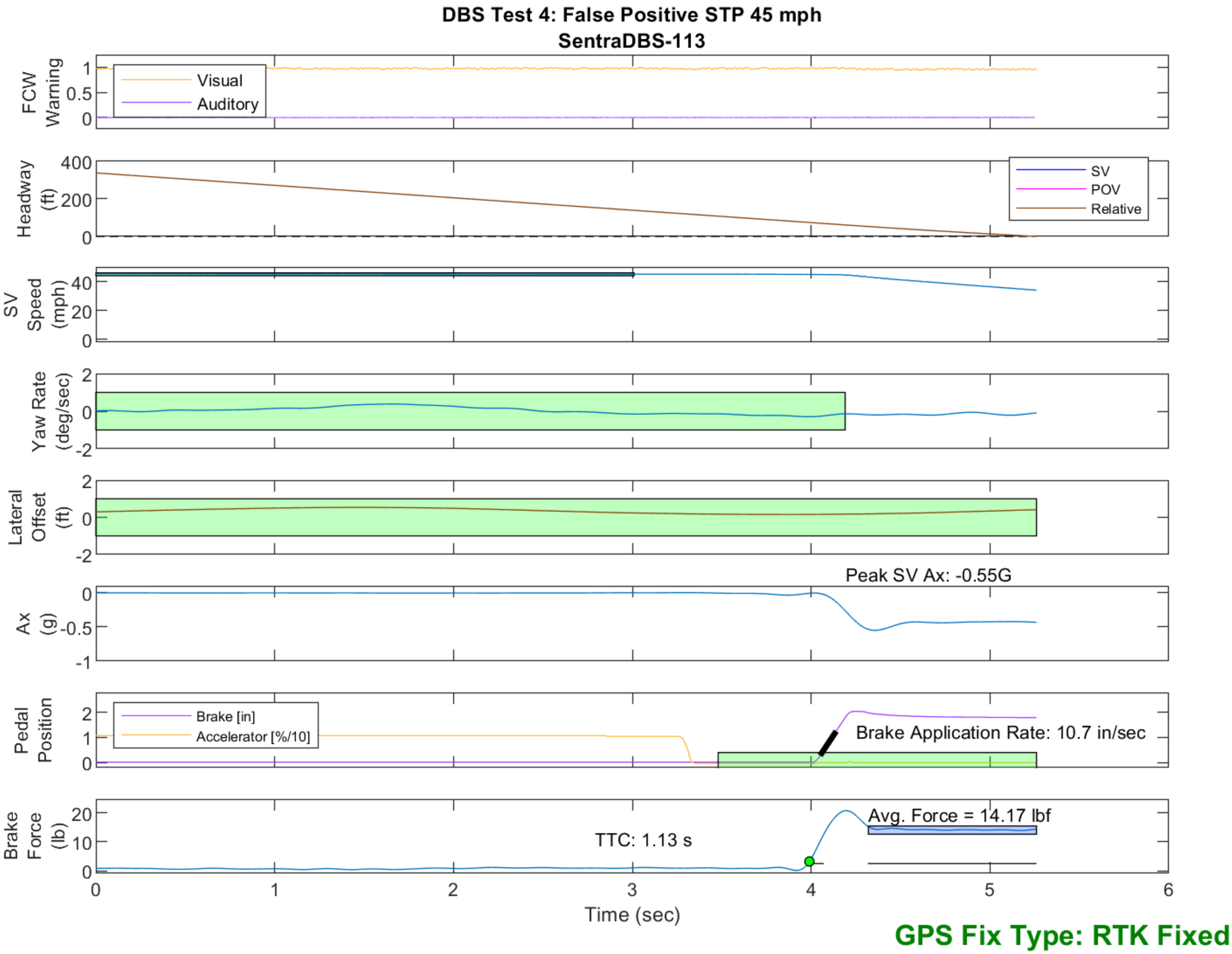


Figure E67. Time History for DBS Run 113, Test 4 - False Positive STP 45 mph

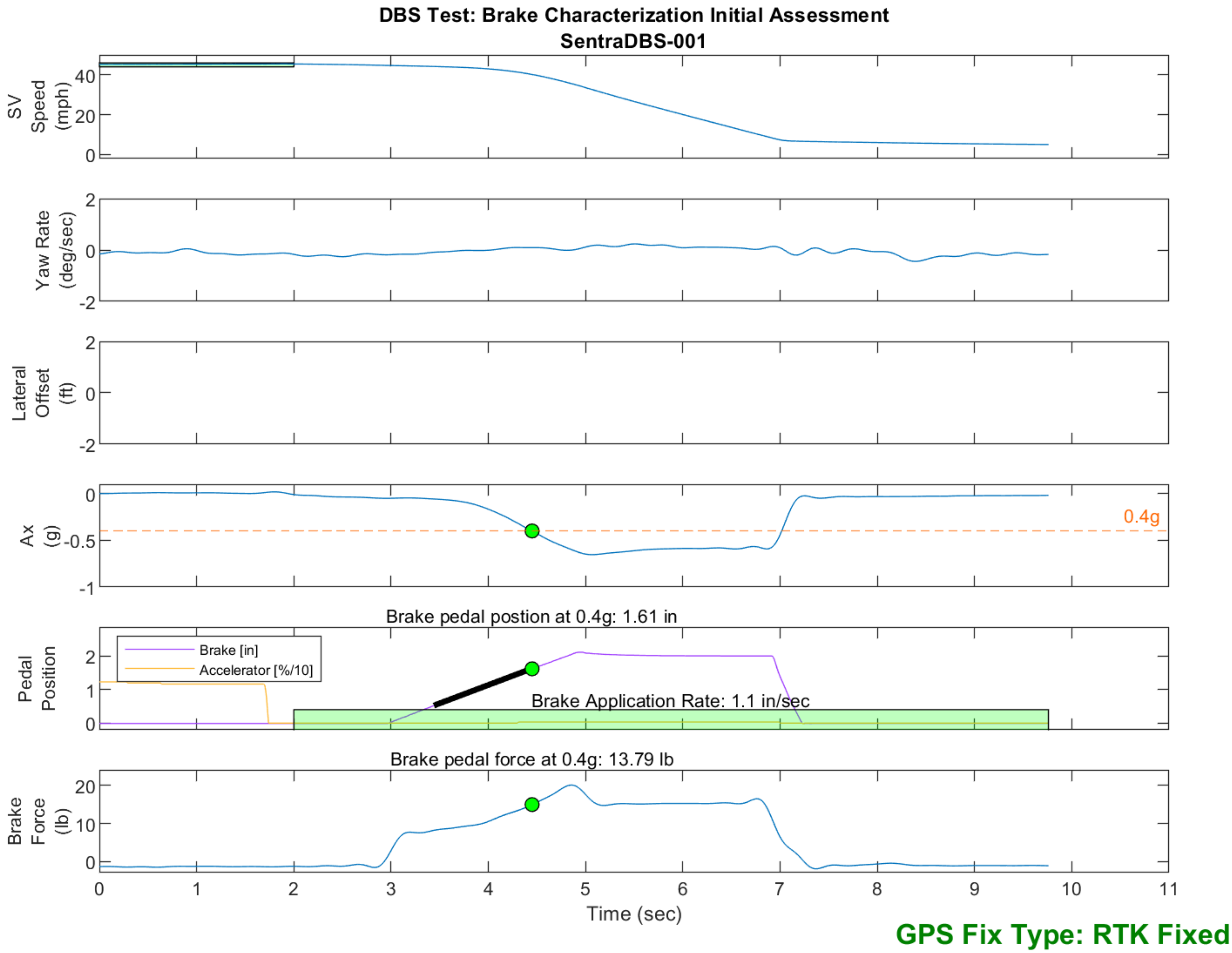


Figure E68. Time History for DBS Run 1, Brake Characterization Initial

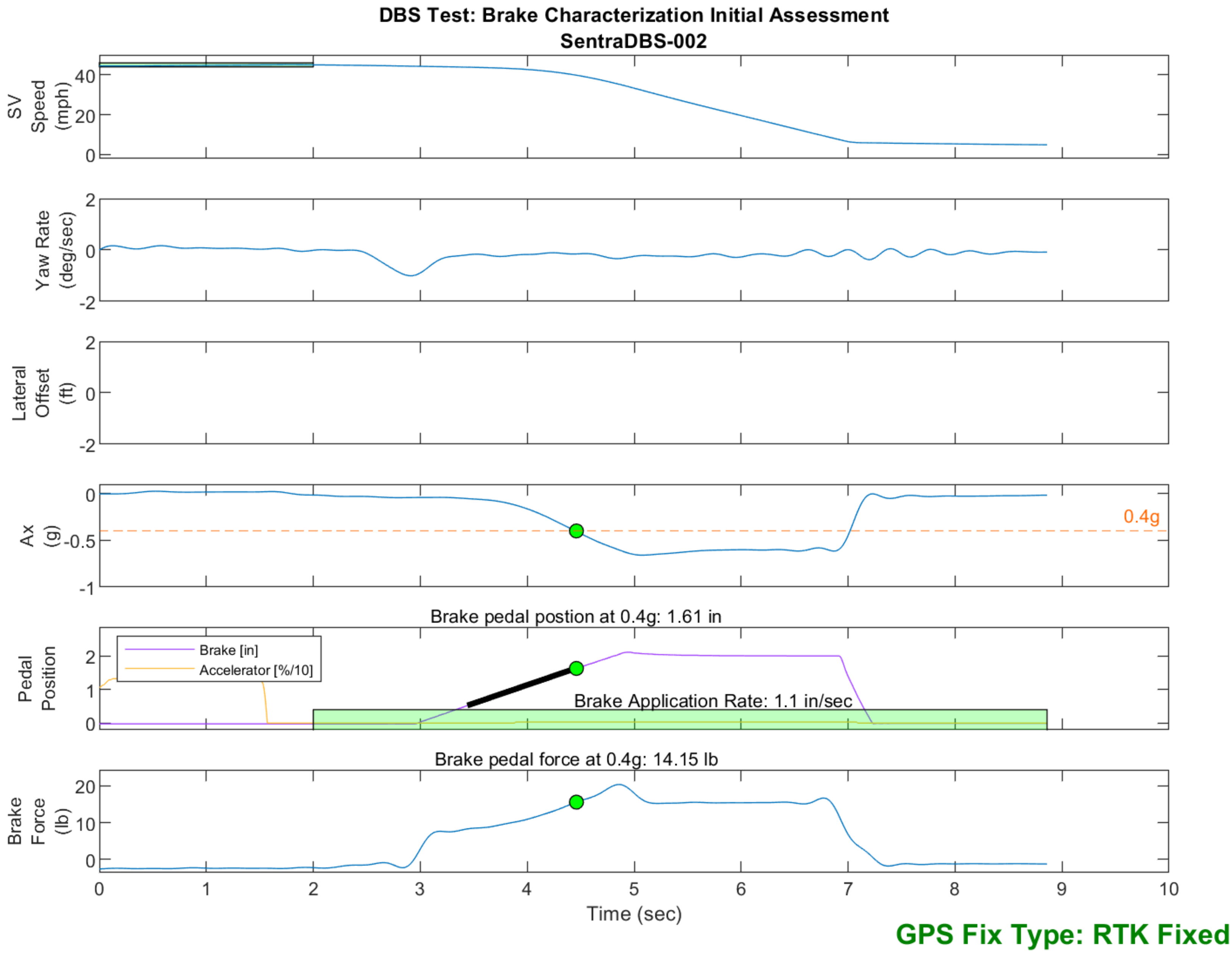


Figure E69. Time History for DBS Run 2, Brake Characterization Initial

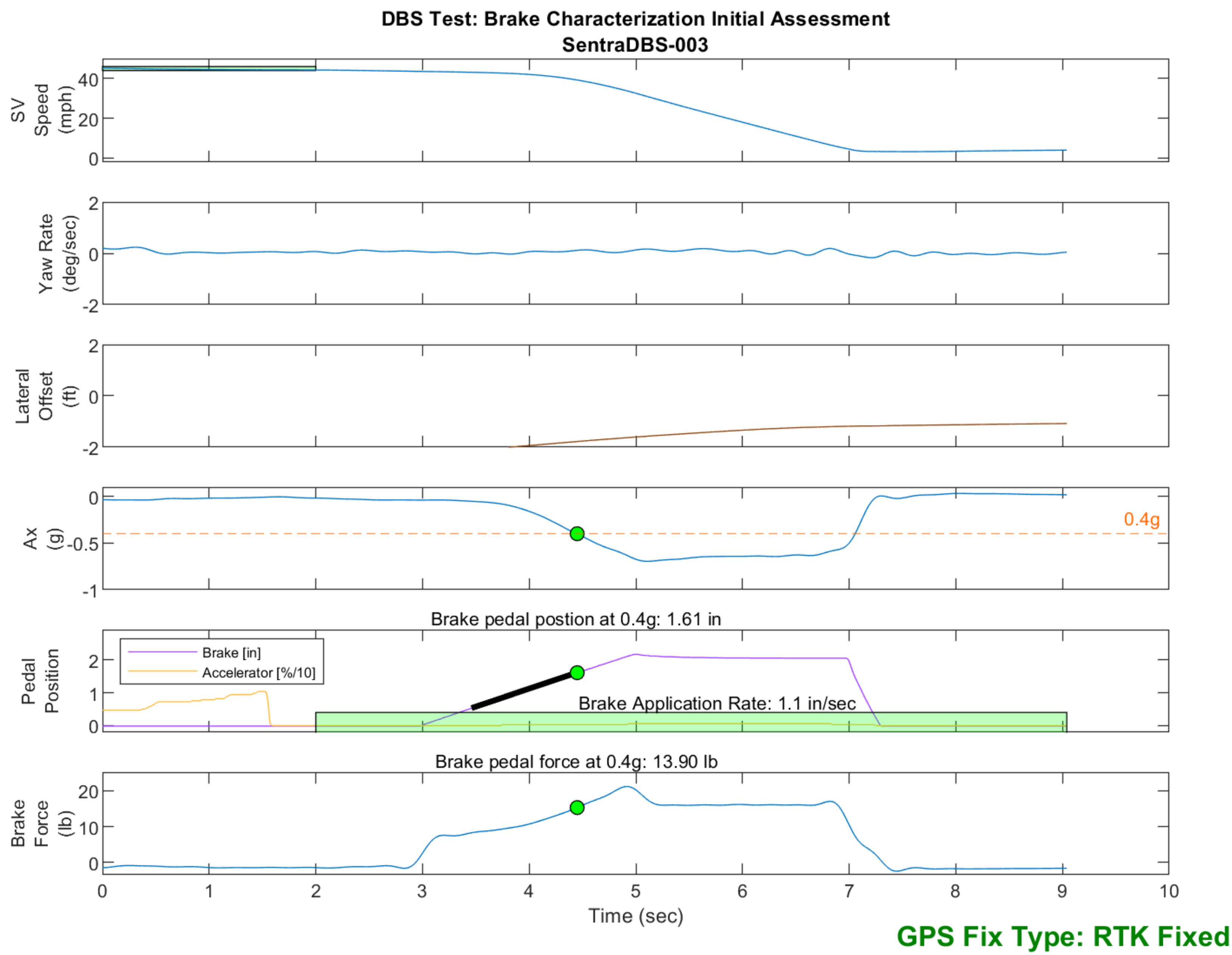


Figure E70. Time History for DBS Run 3, Brake Characterization Initial

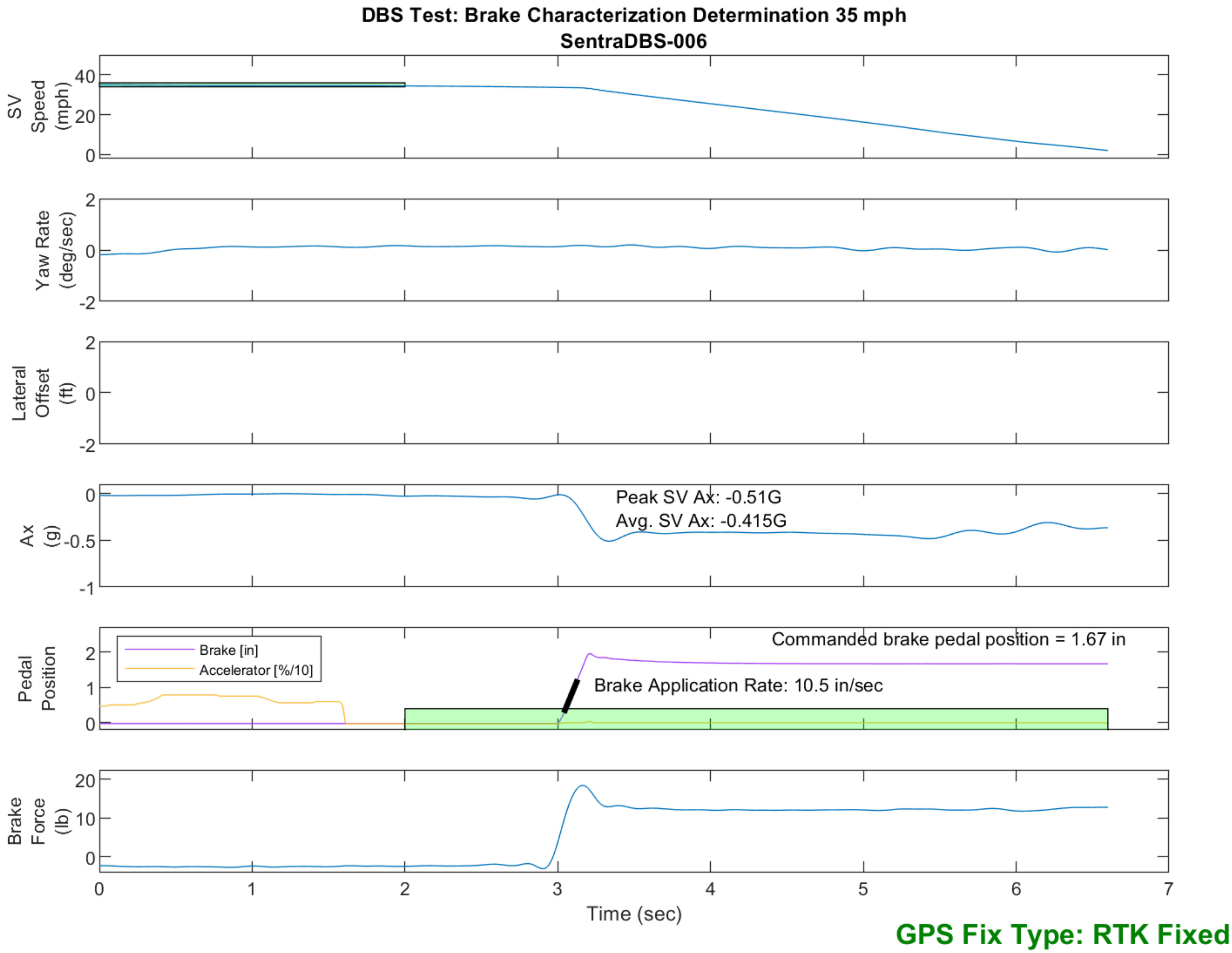


Figure E71. Time History for DBS Run 6, Brake Characterization Determination, Displacement Mode, 35 mph

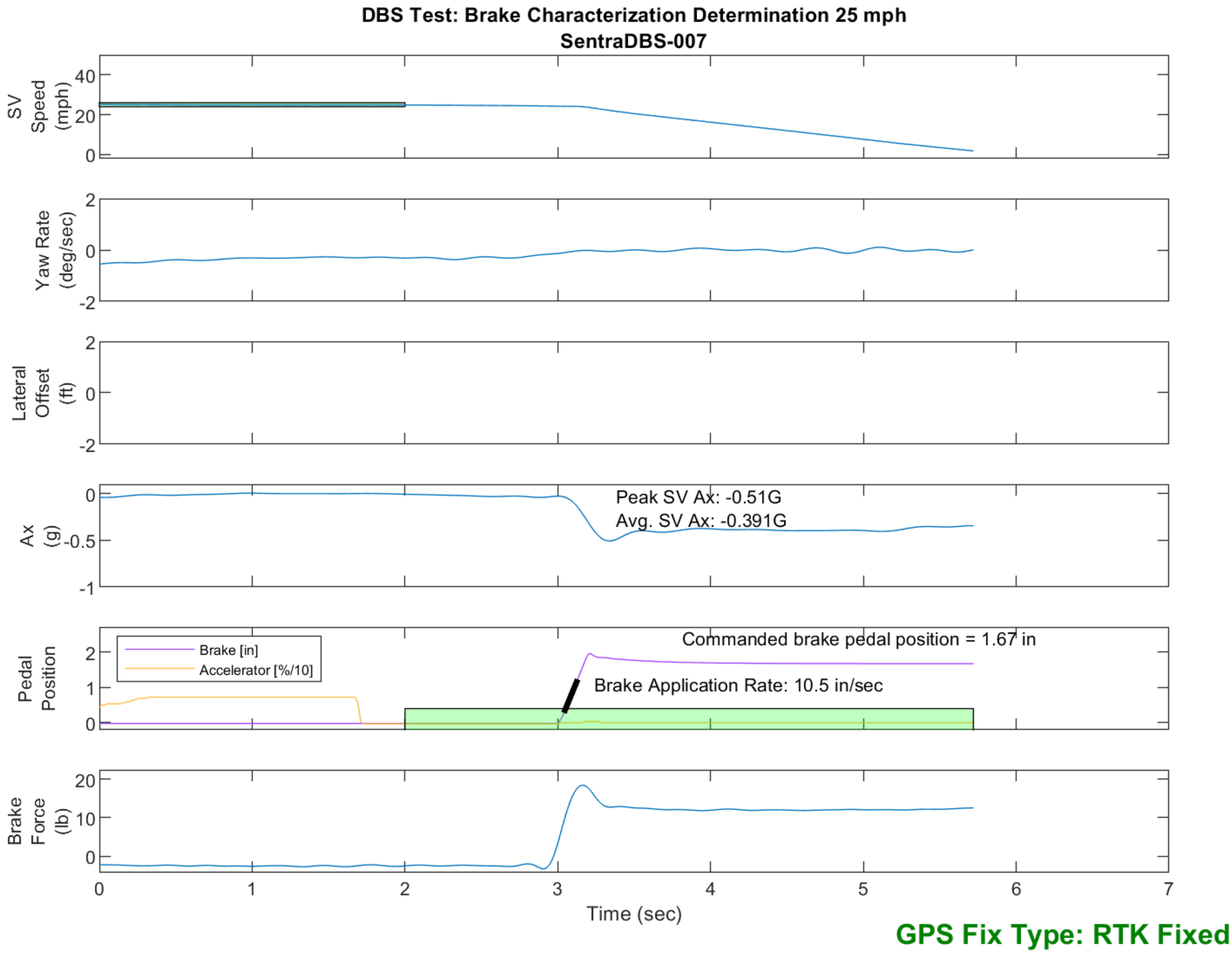


Figure E72. Time History for DBS Run 7, Brake Characterization Determination, Displacement Mode, 25 mph

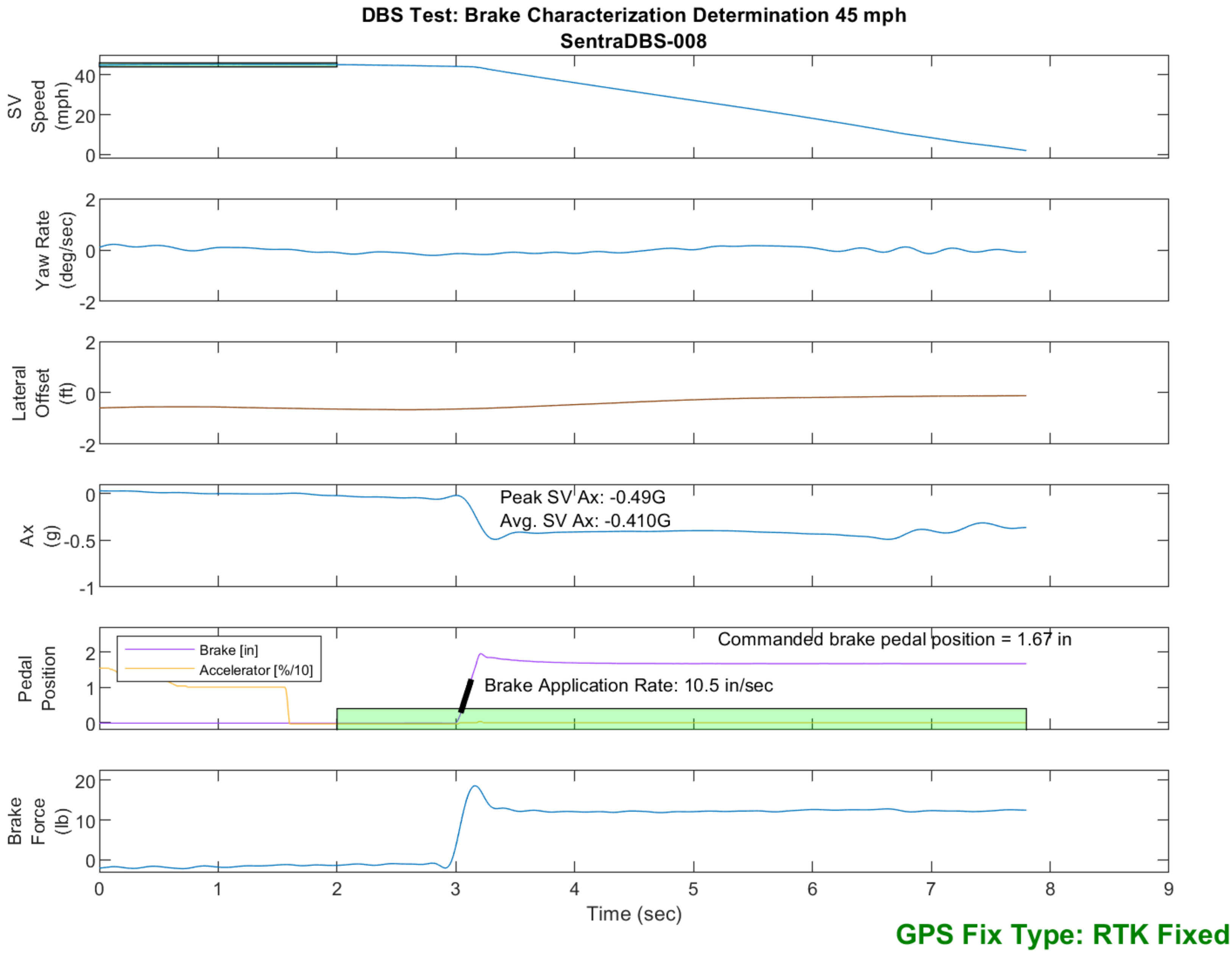


Figure E73. Time History for DBS Run 8, Brake Characterization Determination, Displacement Mode, 45 mph

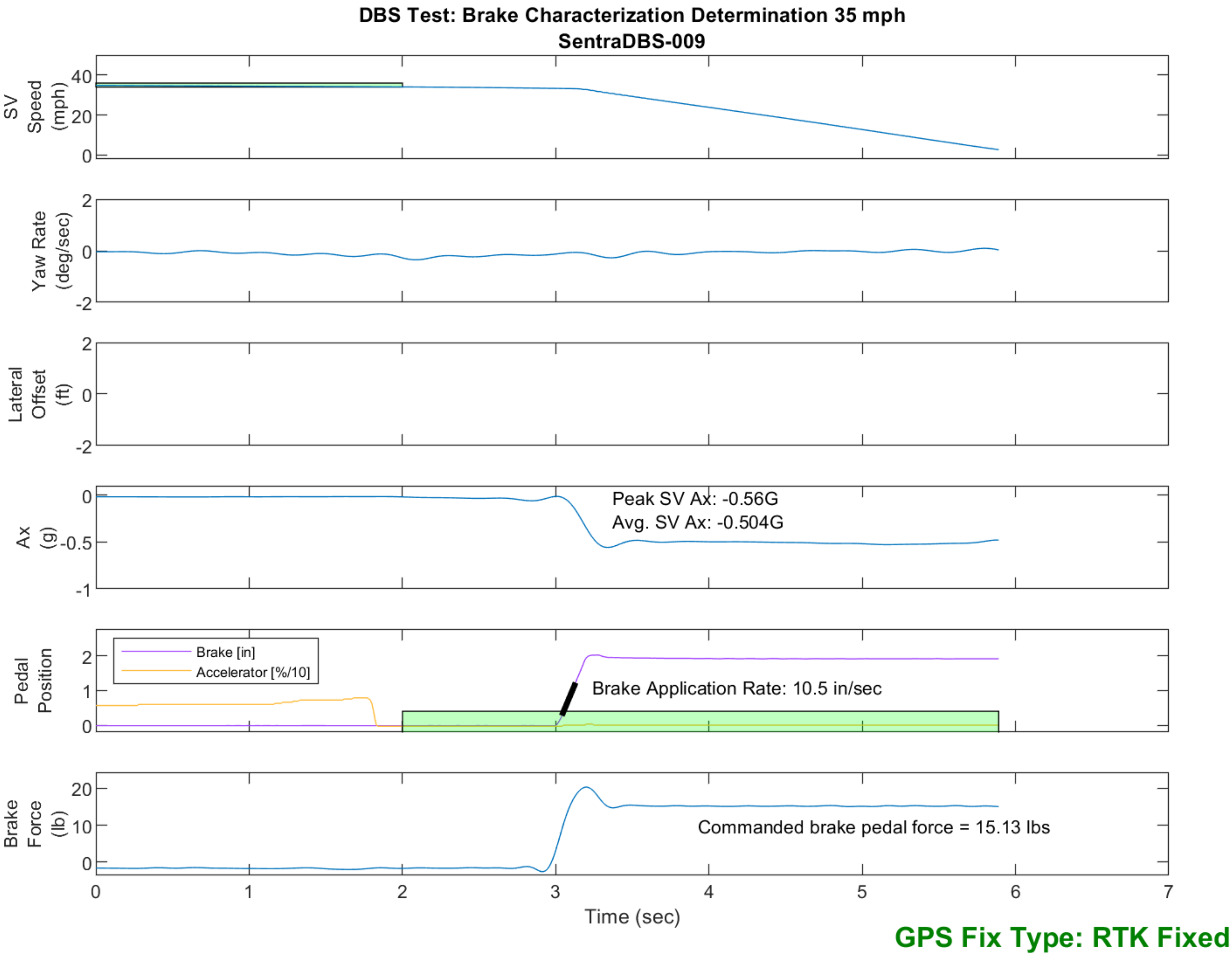


Figure E74. Time History for DBS Run 9, Brake Characterization Determination, Hybrid Mode, 35 mph

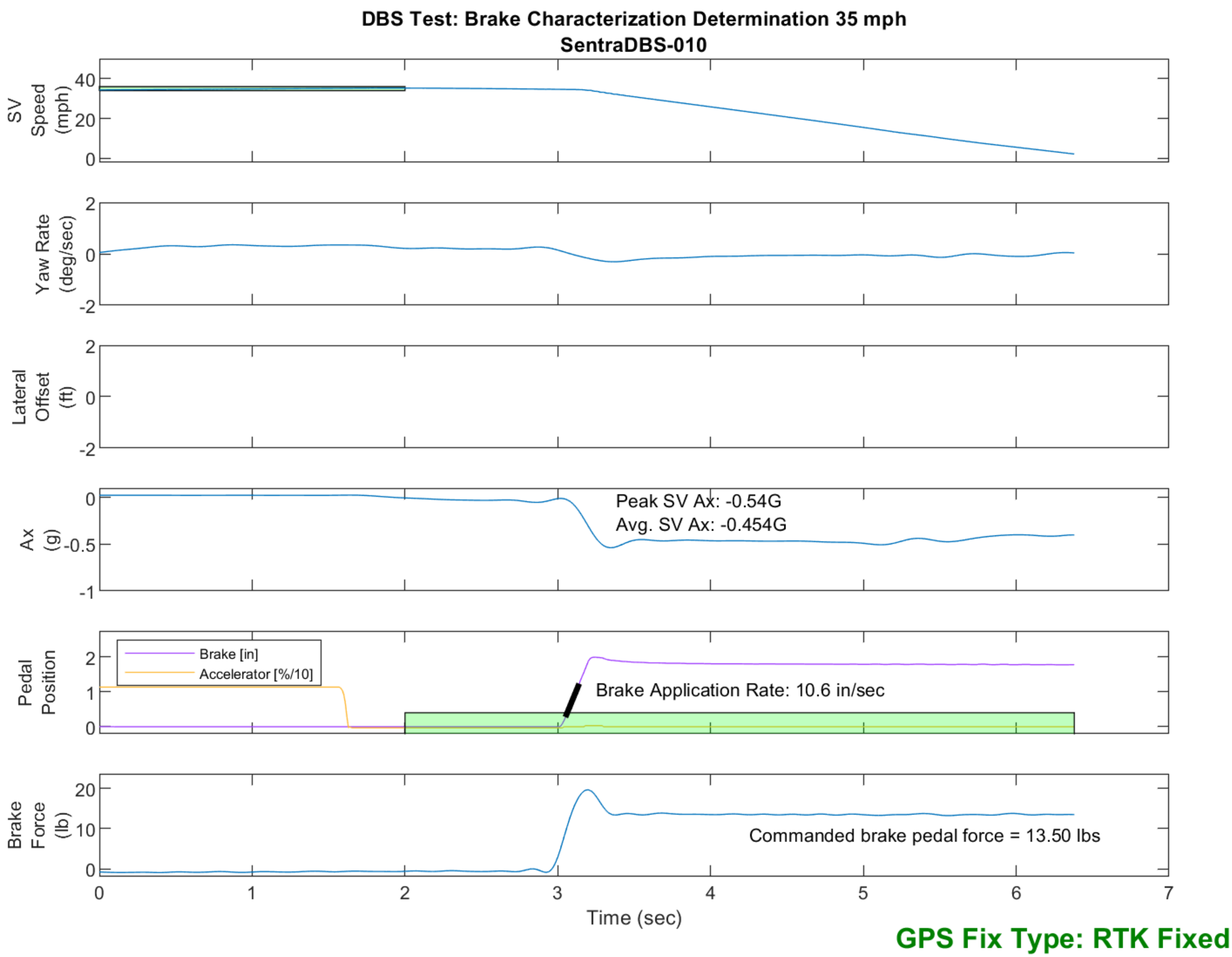


Figure E75. Time History for DBS Run 10, Brake Characterization Determination, Hybrid Mode, 35 mph

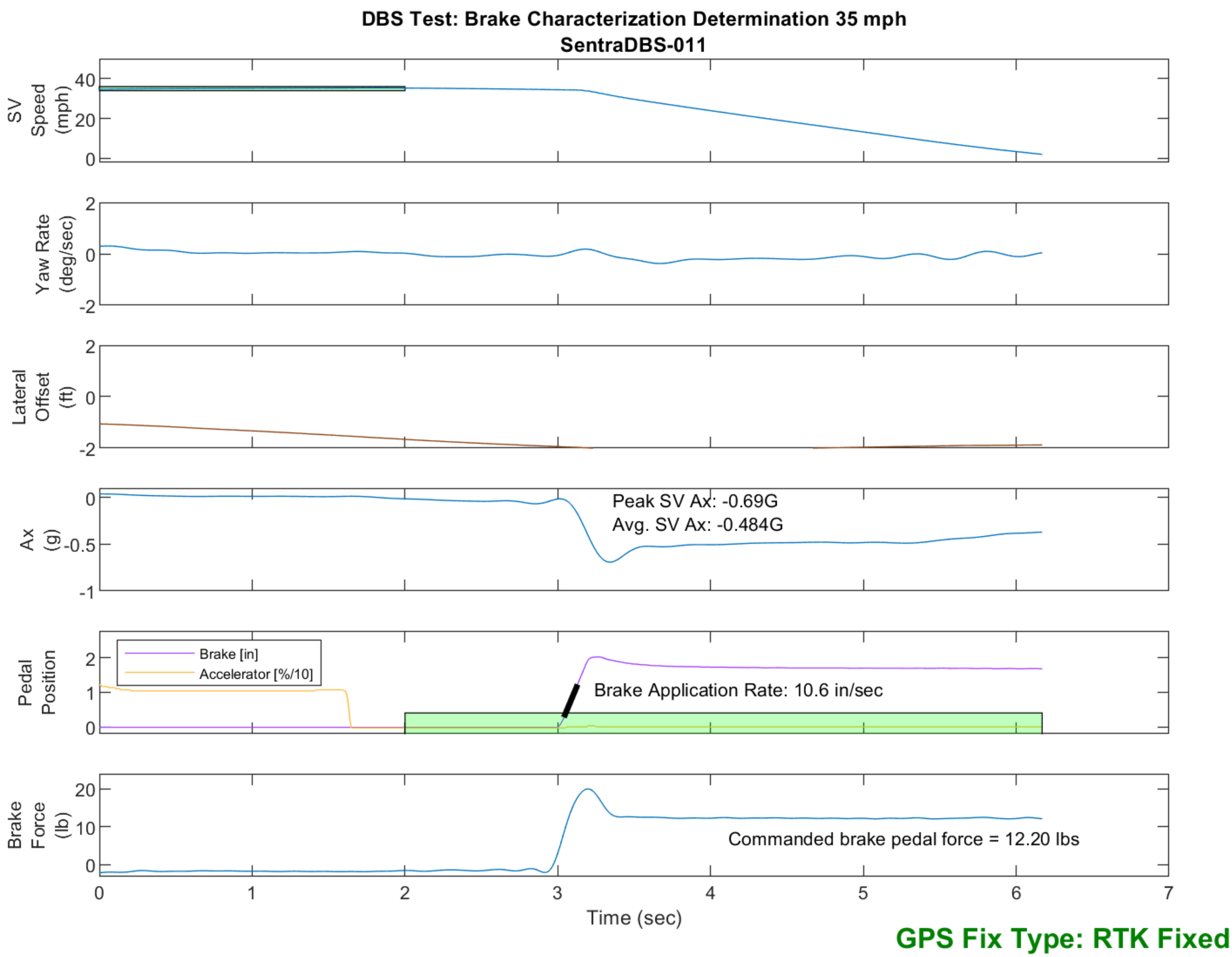


Figure E76. Time History for DBS Run 11, Brake Characterization Determination, Hybrid Mode, 35 mph

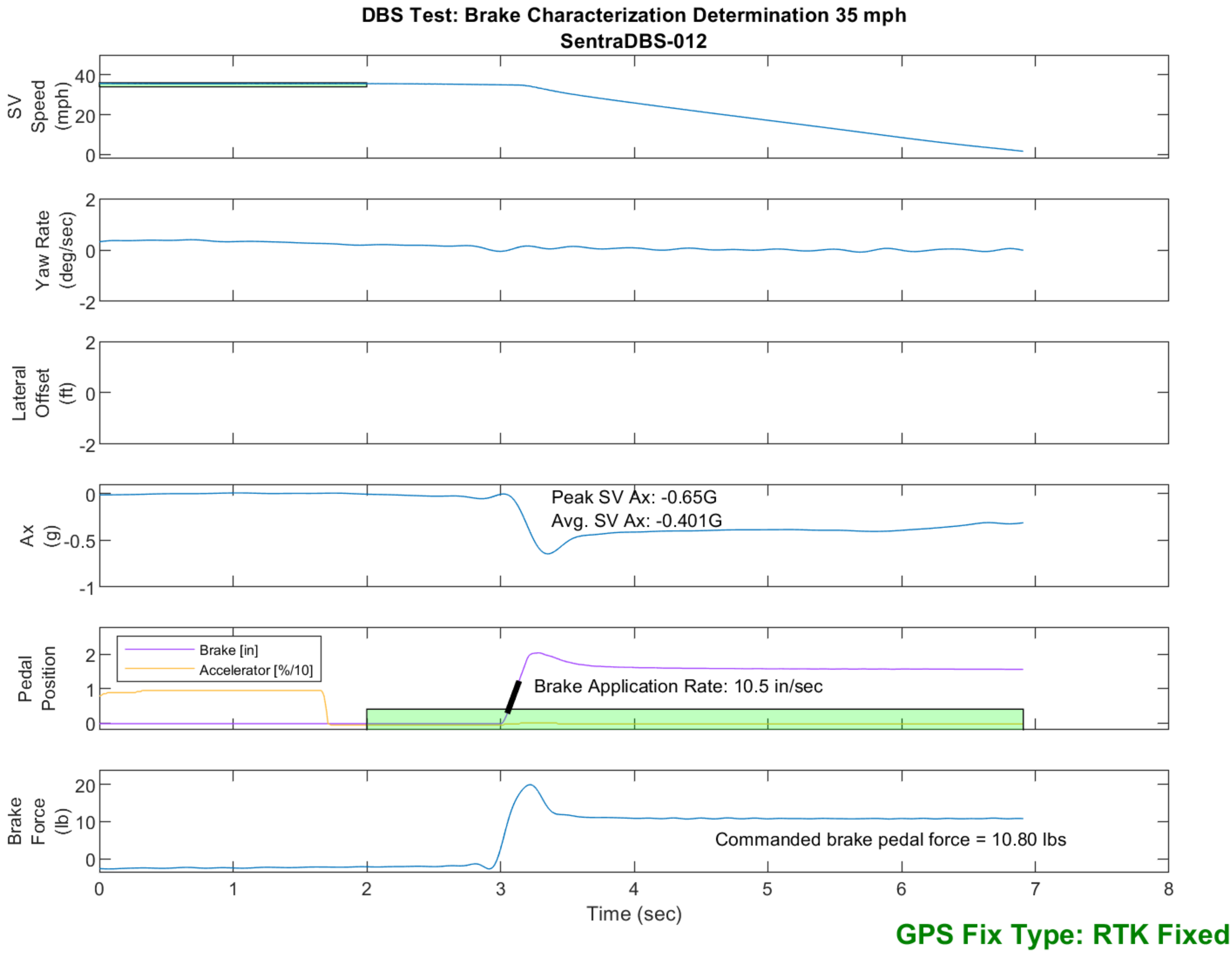


Figure E77. Time History for DBS Run 12, Brake Characterization Determination, Hybrid Mode, 35 mph

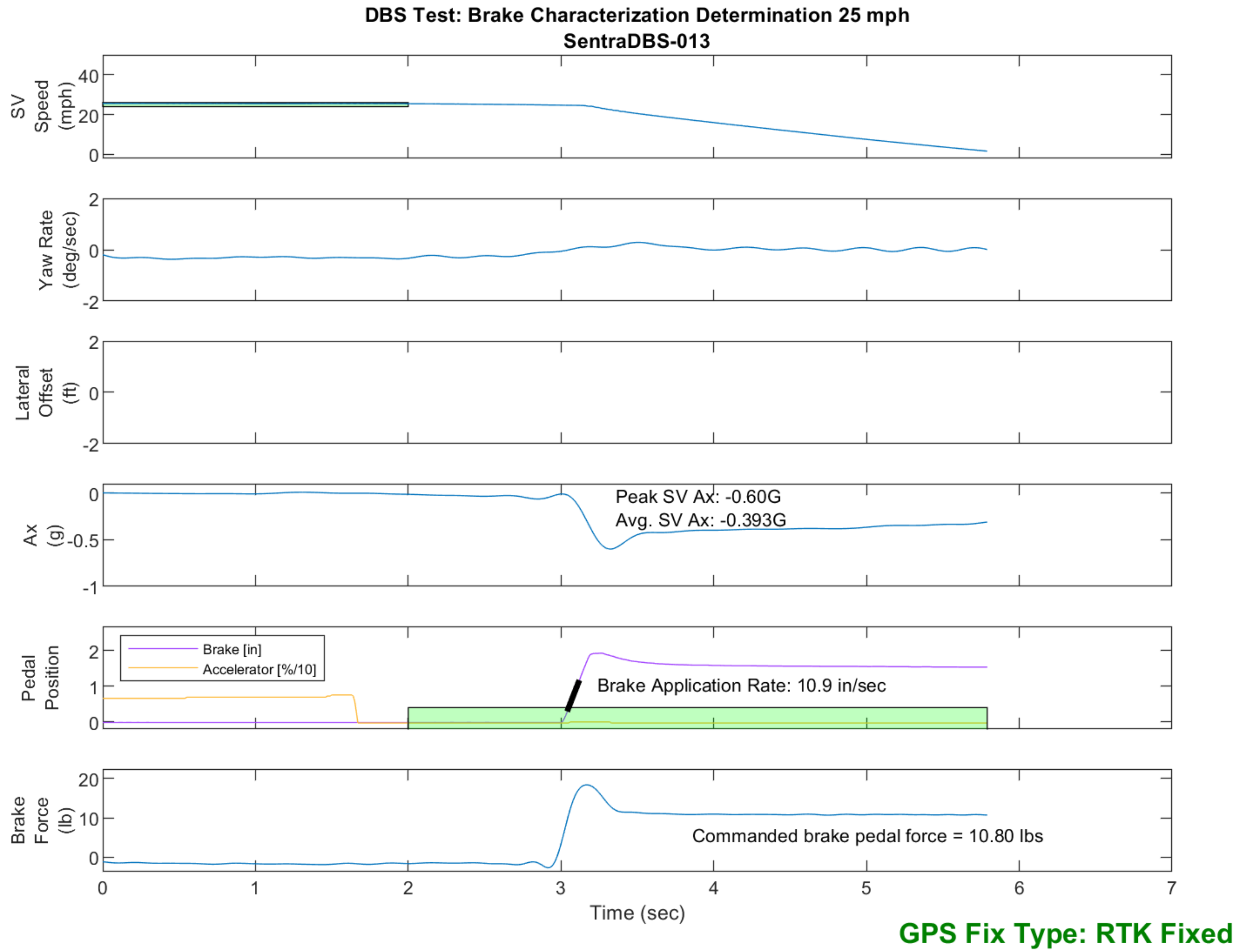


Figure E78. Time History for DBS Run 13, Brake Characterization Determination, Hybrid Mode, 25 mph

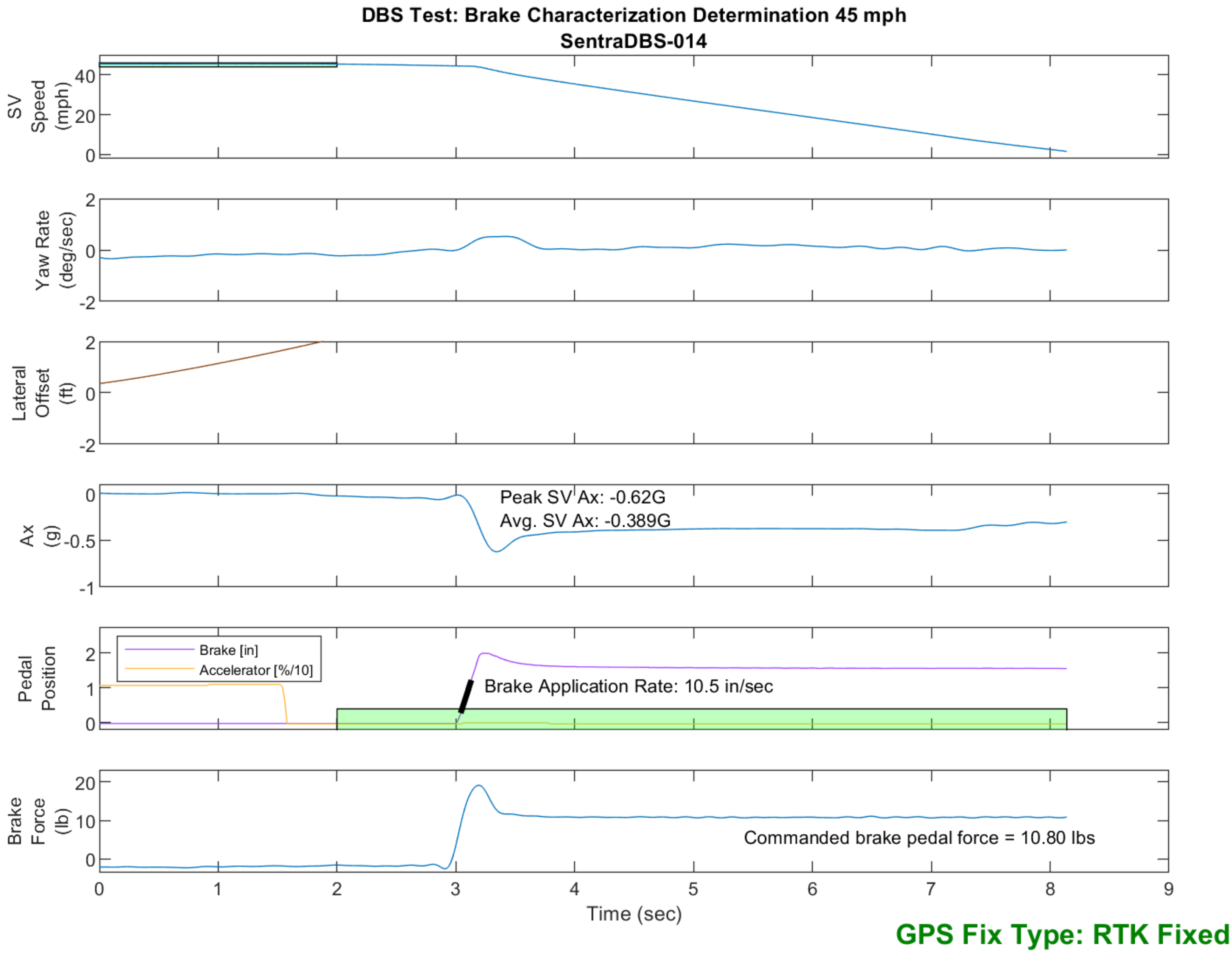


Figure E79. Time History for DBS Run 14, Brake Characterization Determination, Hybrid Mode, 45 mph

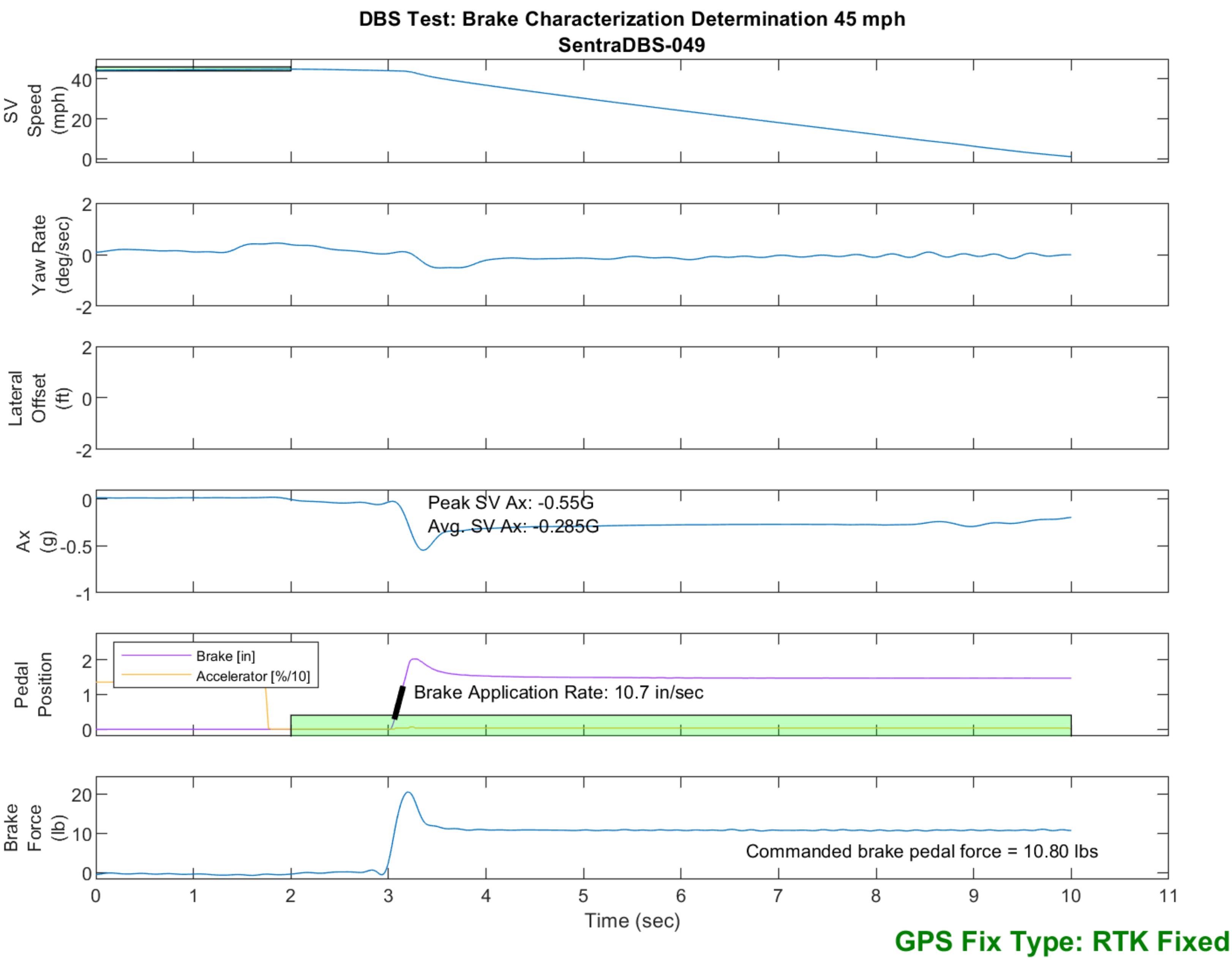


Figure E80. Time History for DBS Run 49, Brake Characterization Determination, Hybrid Mode, 45 mph

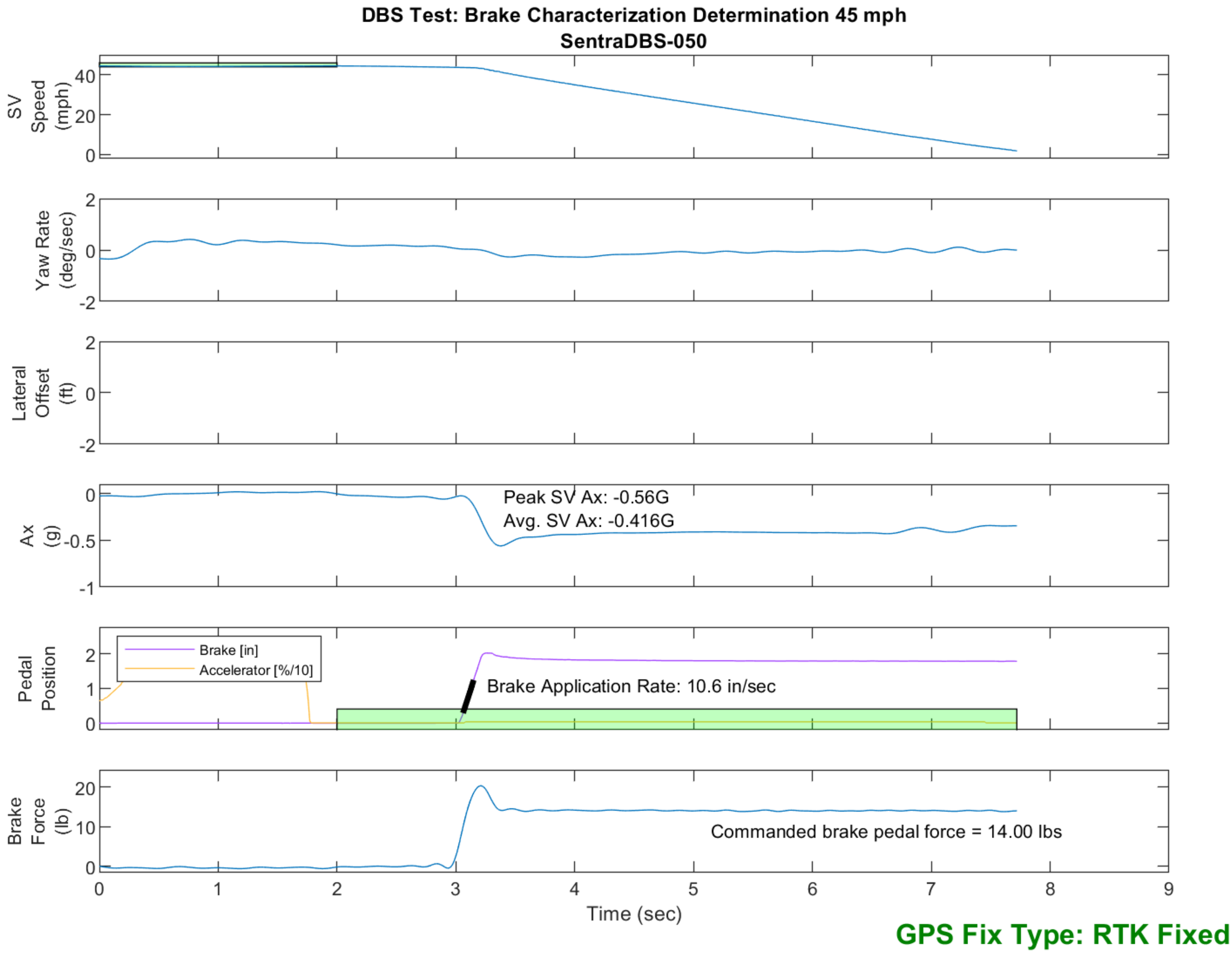


Figure E81. Time History for DBS Run 50, Brake Characterization Determination, Hybrid Mode, 45 mph

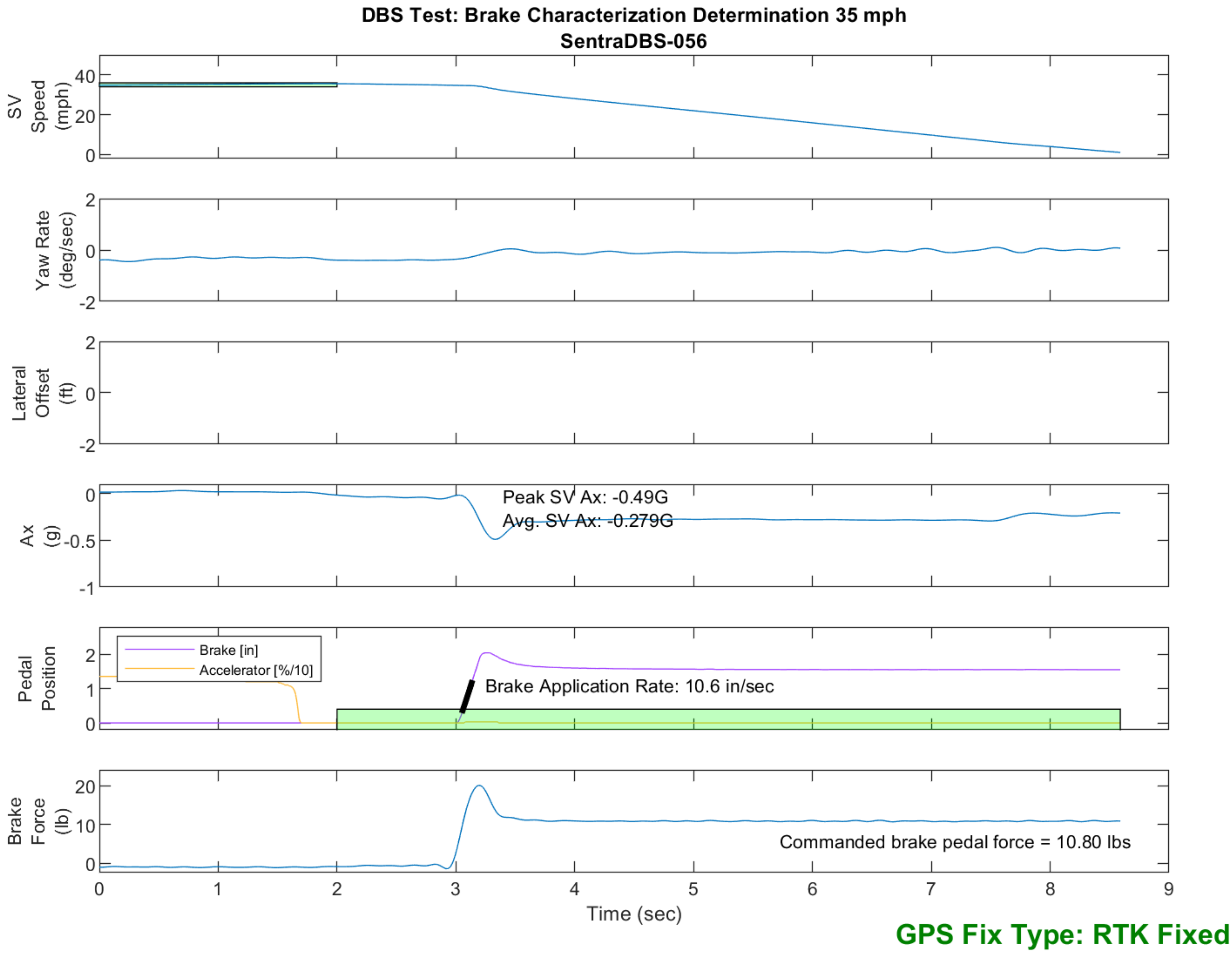


Figure E82. Time History for DBS Run 56, Brake Characterization Determination, Hybrid Mode, 35 mph

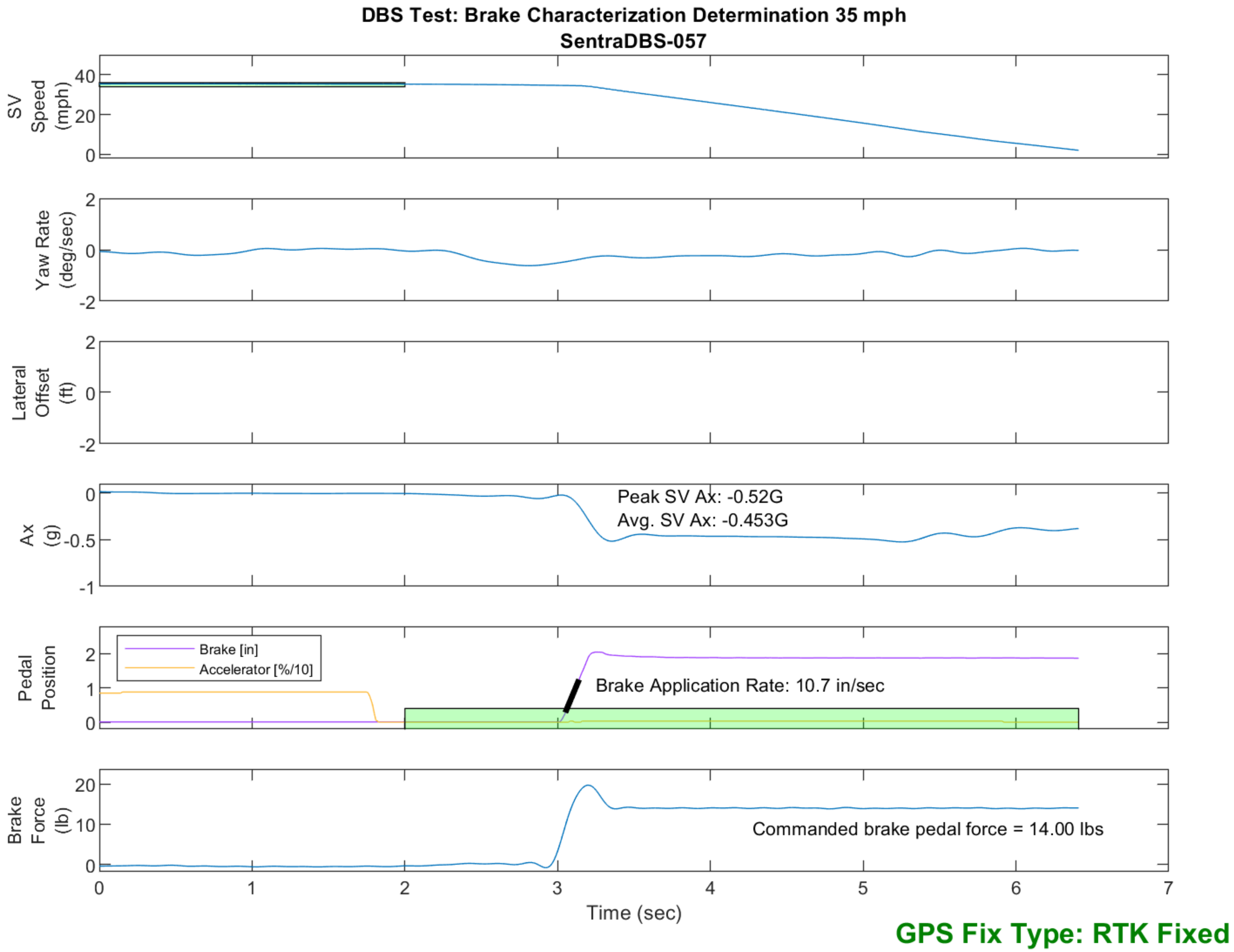


Figure E83. Time History for DBS Run 57, Brake Characterization Determination, Hybrid Mode, 35 mph

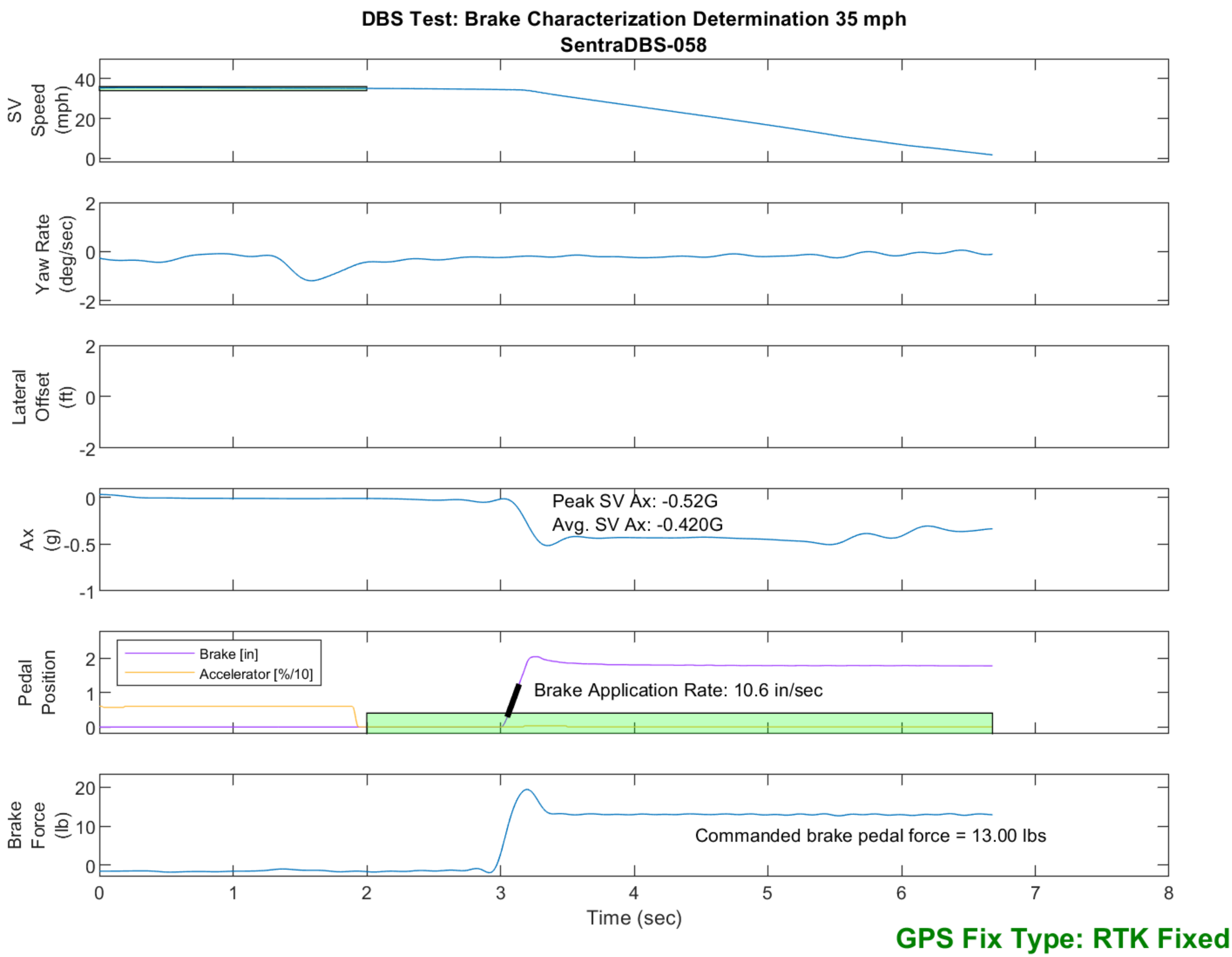


Figure E84. Time History for DBS Run 58, Brake Characterization Determination, Hybrid Mode, 35 mph

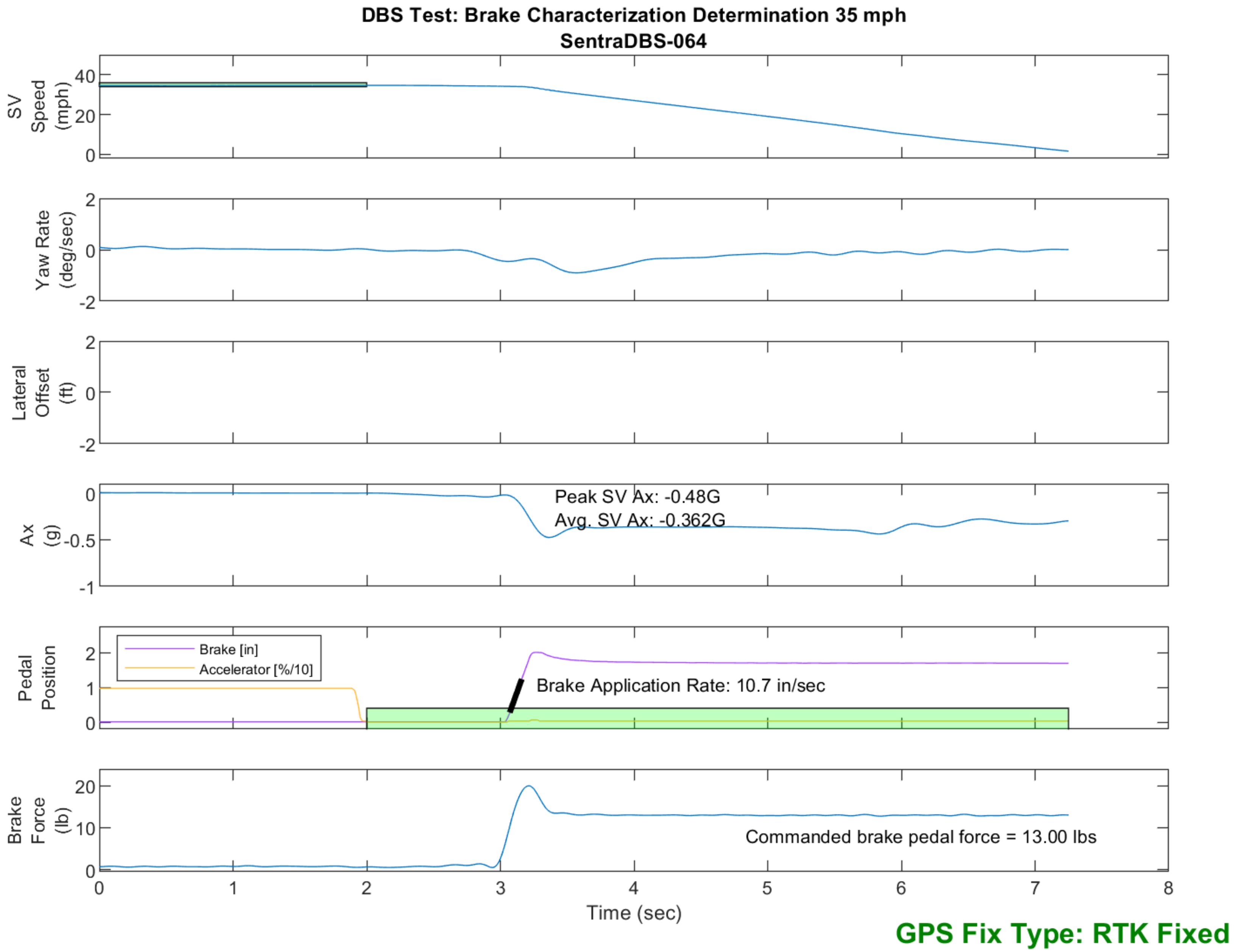


Figure E85. Time History for DBS Run 64, Brake Characterization Determination, Hybrid Mode, 35 mph

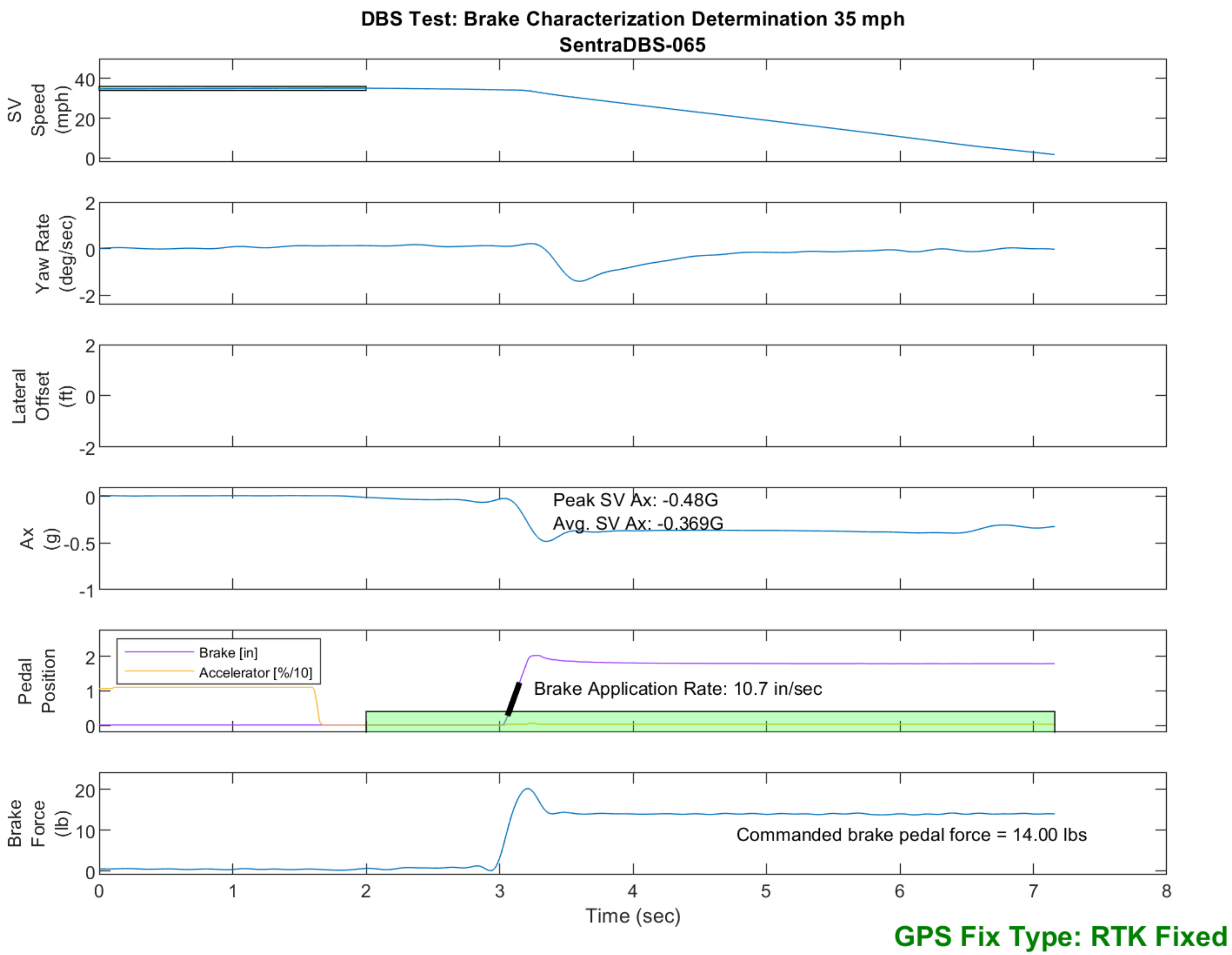


Figure E86. Time History for DBS Run 65, Brake Characterization Determination, Hybrid Mode, 35 mph

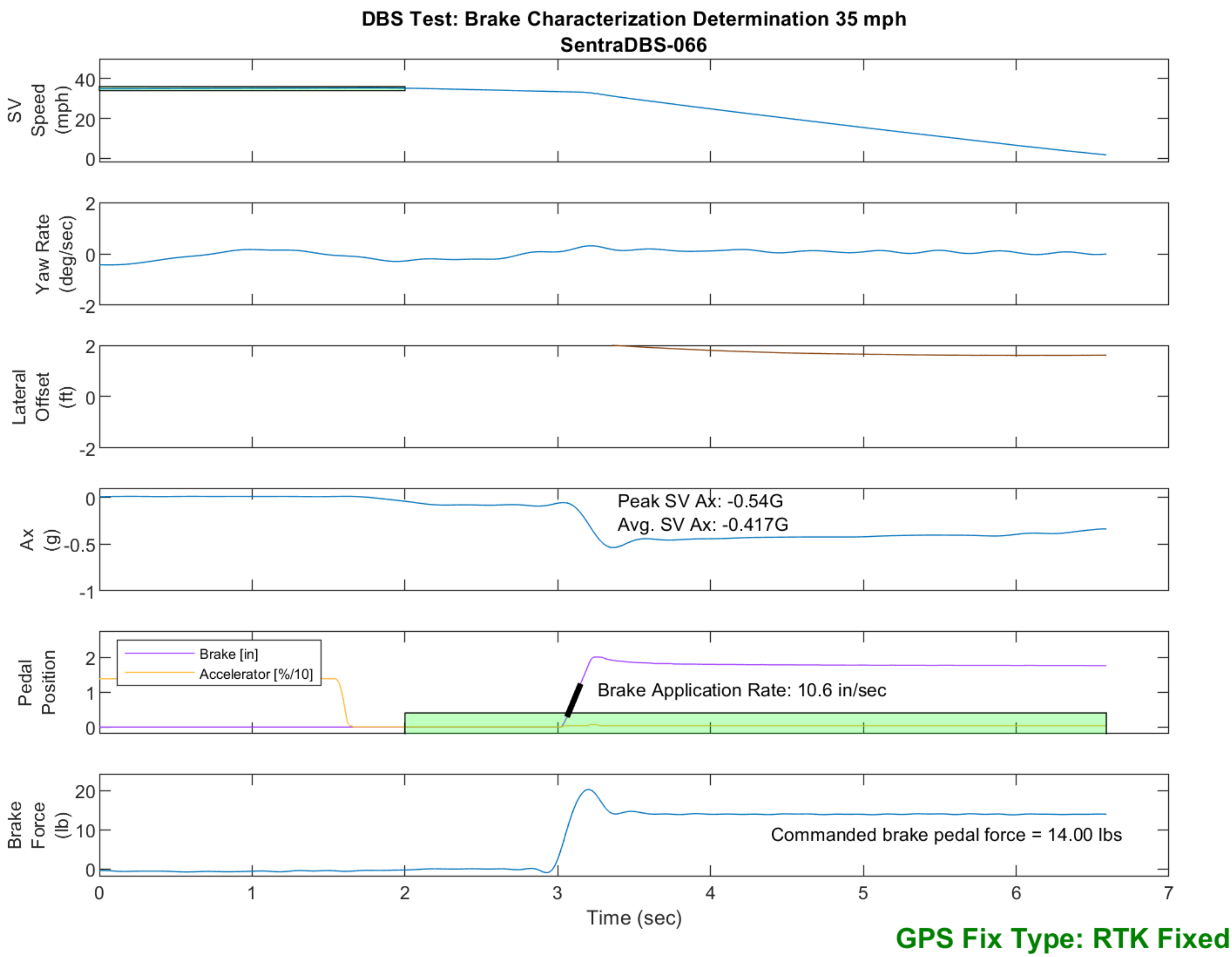


Figure E87. Time History for DBS Run 66, Brake Characterization Determination, Hybrid Mode, 35 mph

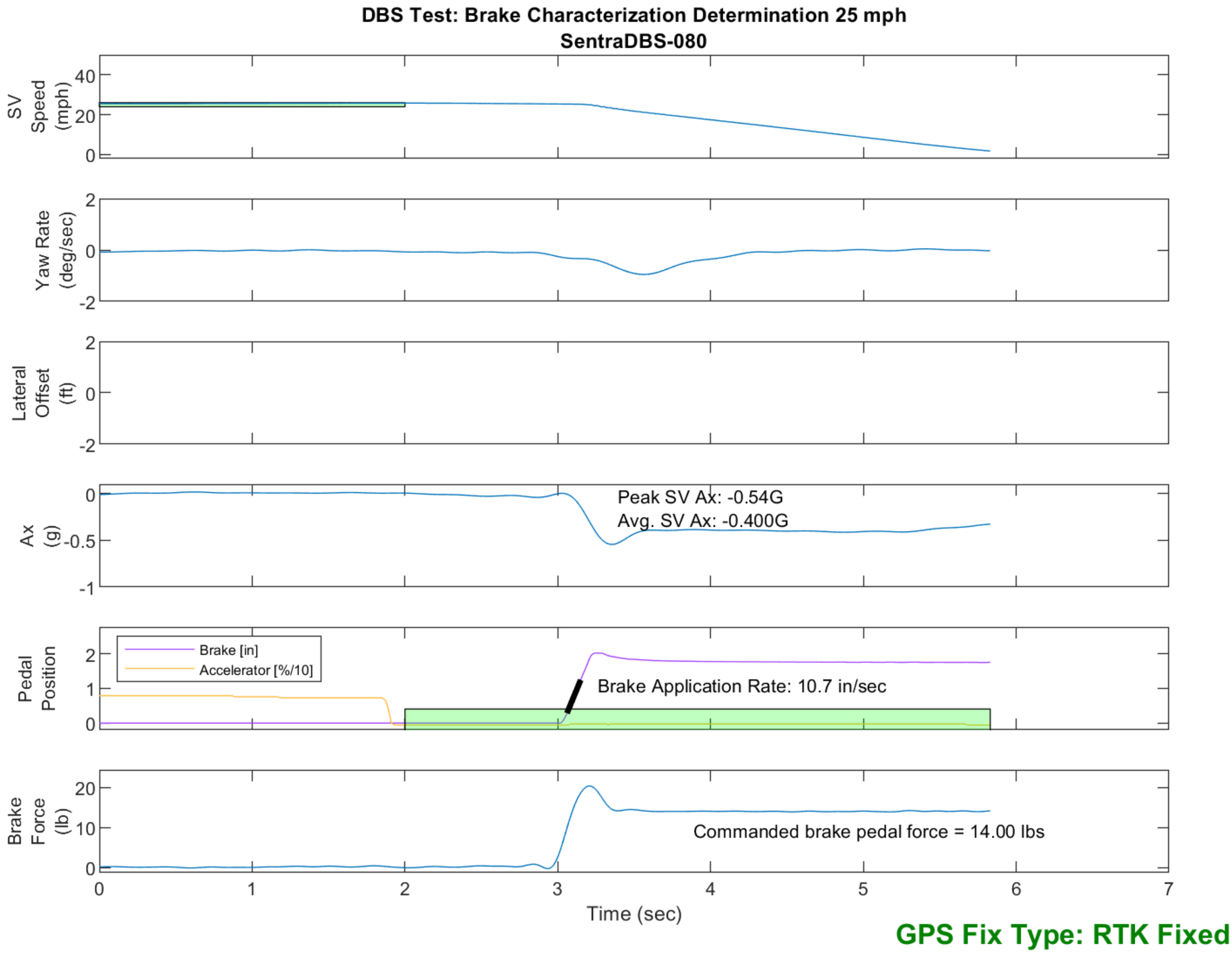


Figure E88. Time History for DBS Run 80, Brake Characterization Determination, Hybrid Mode, 25 mph