NEW CAR ASSESSMENT PROGRAM
DYNAMIC BRAKE SUPPORT SYSTEM CONFIRMATION TEST
NCAP-DRI-DBS-20-05

2020 Audi Q5 45 TFSI quattro

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7 August 2020

Final Report

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

U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
New Car Assessment Program
1200 New Jersey Avenue, SE
West Building, 4th Floor (NRM-110)
Washington, DC 20590

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

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Date: 7 August 2020

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NCAP-DRI-DBS-20-05		

4. Title and Subtitle	5. Report Date
Final Report of Dynamic Brake Support System Confirmation Test of a 2020 Audi Q5 45 TFSI quattro.	7 August 2020
	6. Performing Organization Code DRI
7. Author(s) J. Lenkeit, Technical Director S. Judy, Test Engineer	8. Performing Organization Report No. DRI-TM-19-158
9. Performing Organization Name and Address Dynamic Research, Inc. 355 Van Ness Ave, STE 200 Torrance, CA 90501	10. Work Unit No. 11. Contract or Grant No. DTNH22-14-D-00333
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration New Car Assessment Program 1200 New Jersey Avenue, SE, West Building, 4th Floor (NRM-110) Washington, DC 20590	13. Type of Report and Period Covered Final Test Report June - July 2020 14. Sponsoring Agency Code NRM-110

15. Supplementary Notes

16. Abstract

These tests were conducted on the subject 2020 Audi Q5 45 TFSI quattro in accordance with the specifications of the New Car Assessment Program's (NCAP) 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.

17. Key Words	18. Distribution Statement
Dynamic Brake Support, DBS, AEB, New Car Assessment Program, NCAP	Copies of this report are available from the following: NHTSA Technical Reference Division National Highway Traffic Safety Administration 1200 New Jersey Avenue, SE Washington, DC 20590

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	156	

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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 when the system determines that the braking applied by the driver is insufficient to avoid a collision.

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

The method prescribed by the National Highway Traffic Safety Administration (NHTSA) to evaluate DBS performance on the test track involves three longitudinal, rear-end type crash configurations and a false positive test. In the rear-end scenarios, a subject vehicle (SV) approaches a stopped, slower-moving, or decelerating principal other vehicle (POV) in the same lane of travel. For these tests, the POV is a strikeable object with the characteristics of a compact passenger car. The fourth scenario is used to evaluate the propensity of a DBS system to inappropriately activate in a non-critical driving scenario that does not present a safety risk to the SV occupant(s).

The purpose of the testing reported herein was to objectively quantify the performance of a Dynamic Brake Support system installed on a 2020 Audi Q5 45 TFSI quattro. This test to assess Dynamic Brake Support systems is sponsored by the National Highway Traffic Safety Administration under Contract No. DTNH22-14-D-00333 with the New Car Assessment Program (NCAP).

Section II

DATA SHEETS

DYNAMIC BRAKE SUPPORT

DATA SHEET 1: TEST RESULTS SUMMARY

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2020 Audi Q5 45 TFSI quattro

VIN: *WA1BNAFY0L200xxxx*

Test Date: *6/23/2020*

Dynamic Brake Support System setting: *Early*

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)

2020 Audi Q5 45 TFSI quattro

TEST VEHICLE INFORMATION

VIN: *WA1BNAFY0L200xxxx*

Body Style: *SUV* Color: *Monsoon Gray Metallic*

Date Received: *5/18/2020* Odometer Reading: *55 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Audi AG*

Date of manufacture: *08/19*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *255/45R20*

Rear: *255/45R20*

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

Rear: *250 kPa (36 psi)*

TIRES

Tire manufacturer and model: *Continental Cross Contact LX Sport*

Front tire specification: *255/45R20 101H*

Rear tire specification: *255/45R20 101H*

Front tire DOT prefix: *P512WC1L*

Rear tire DOT prefix: *P512WC1L*

DYNAMIC BRAKE SUPPORT

DATA SHEET 3: TEST CONDITIONS

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2020 Audi Q5 45 TFSI quattro

GENERAL INFORMATION

Test date: *6/23/2020*

AMBIENT CONDITIONS

Air temperature: *28.9 C (84 F)*

Wind speed: *1.8 m/s (4.0 mph)*

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.

VEHICLE PREPARATION

Verify the following:

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

Fuel tank is full: **X**

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

Front: *230 kPa (33 psi)*

Rear: *250 kPa (36 psi)*

DYNAMIC BRAKE SUPPORT

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2020 Audi Q5 45 TFSI quattro

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*533.0 kg (1175 lb)*	Right Front:	*527.1 kg (1162 lb)*
Left Rear:	*477.2 kg (1052 lb)*	Right Rear:	*477.2 kg (1052 lb)*
		Total:	*2014.5 kg (4441 lb)*

DYNAMIC BRAKE SUPPORT

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

(Page 1 of 3)

2020 Audi Q5 45 TFSI quattro

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

Pre Sense City

Type and location of sensors the system uses:

Single camera located behind the windshield near the rearview mirror.

System setting used for test (if applicable):

Early

Brake application mode used for test: *Hybrid control*

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

9.6 km/h (6 mph) (Per manufacturer supplied information)

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

80 km/h (50 mph) (Per manufacturer supplied information)

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

X No

If yes, please provide a full description.

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

X No

If yes, please provide a full description.

How is the Forward Collision Warning system alert presented to the driver?

(Check all that apply)

X Warning light

X Buzzer or audible alarm

___ Vibration

X Other: Brake Jerk

The visual warning is presented in the center of the instrument cluster. See Appendix A, Figure A17.

The auditory warning is a constant tone centered at 1800 Hz.

In addition to these, there is a brake jerk as part of the warning cascade.

** For these tests, the visual alert could not reliably be detected.*

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.

Select in the Infotainment system: button left control button >

Vehicle

Audi drive select

Driver assistance

Audi pre sense

Turn on/off Audi pre sense - select or deselect

If the system is switched off, it switches on again automatically once the ignition is switched on again.

See Appendix A, Figures A14 and A15

DYNAMIC BRAKE SUPPORT

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

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2020 Audi Q5 45 TFSI quattro

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

If yes, please provide a full description.

Select in the Infotainment system (left control button):

Vehicle

Audi drive select

Driver assistance

Audi pre sense

Prewarning select Off, Early, Medium or Late

See Appendix A, Figures A14 and A15

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.

The system has a self-test algorithm, which will reduce the system performance or deactivate completely if the following conditions are observed:

- *Mud/dirt/snow accumulation on the sensor*
- *If the ESC is turned off or in sport mode*

If the system detects sensor blockage, FCW, DBS, CIB will not be available and the system will show a notification in the vehicle cluster.

Additional system limitations are described in the Owner's Manual, pages 134 and 135, shown in Appendix B, pages B-7 and B-8.

Notes:

For these tests, the visual alert could not reliably be detected.

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.

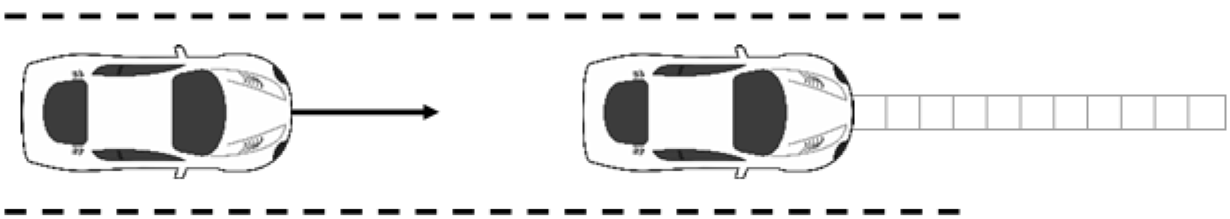

Figure 1. Depiction of Test 1

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. The SV brakes were applied at TTC = 1.1 seconds (SV-to-POV distance of 40 ft (12 m)). The test concluded when either:

- The SV came into contact with the POV or

- The SV came to a stop before making contact with the POV.

In addition to the general test validity criteria described below, for an individual test trial to be valid, the following was required throughout the test:

- The SV speed could not deviate from the nominal speed by more than 1.0 mph (1.6 km/h) during an interval defined by a Time to Collision (TTC) = 5.1 seconds to t_{FCW}. For this test, TTC = 5.1 seconds is taken to occur at an SV-to-POV distance of 187 ft (57 m).

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.

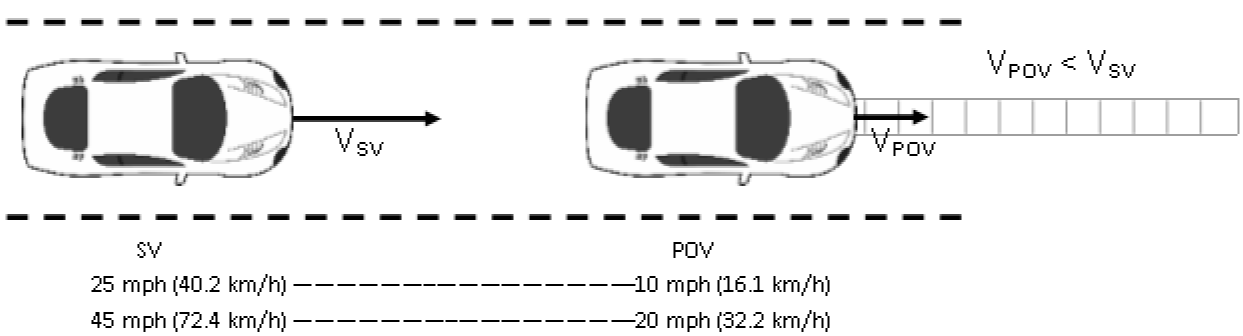

Figure 2. Depiction of Test 2

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

The test concluded when either:

- The SV came into contact with the POV or
- 1 second after the speed of the SV became less than or equal to that of the POV.

The SV driver then braked to a stop.

In addition to the general test validity criteria described below, for an individual test trial to be valid, the following was required throughout the test:

- The lateral distance between the centerline of the POV and the center of the travel lane could not deviate more than ±1 ft (0.3 m) during the validity period.
- The SV speed could not deviate more than ±1.0 mph (±1.6 km/h) during an interval defined by TTC = 5.0 seconds to t_{FCW}.
- The POV speed could not deviate more than ±1.0 mph (±1.6 km/h) during the validity period.

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.

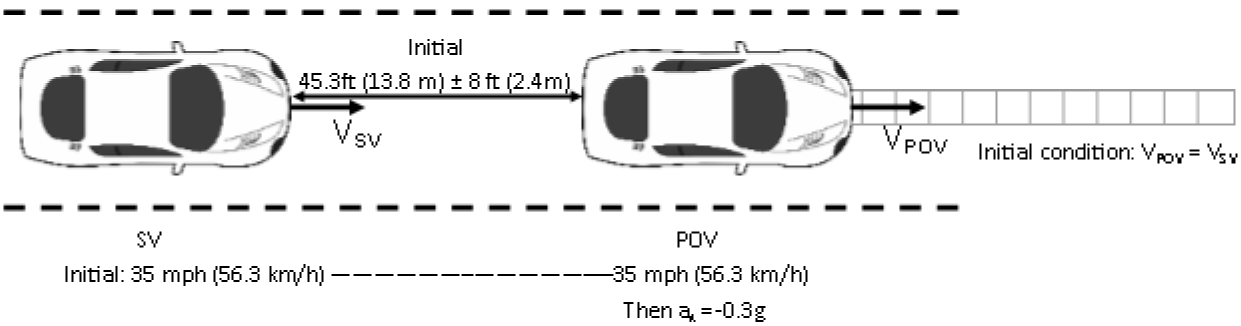

Figure 3. Depiction of Test 3

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. The SV throttle pedal was released within 500 ms of $t_{FCW,}$ and the SV brakes were applied when TTC was 1.4 seconds (31.5 ft (9.6 m)).

The test concluded when either:

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

The SV driver then braked to a stop.

In addition to the general test validity criteria described below, for an individual test trial to be valid, the following was required throughout the test:

- The lateral distance between the centerline of the POV and the center of the travel lane could not deviate more than ±1 ft (0.3 m) during the validity period.
- The headway between the SV and POV must have been constant from the onset

of the applicable validity period to the onset of POV braking.

- The SV and POV speed could not deviate more than ±1.0 mph (1.6 km/h) 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. <u>TEST 4 – FALSE POSITIVE SUPPRESSION</u>

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 1.25 times the average of the deceleration experienced by the baseline command from the braking actuator for at least five of seven valid test trials.

B. General Information

1. T_{FCW}

The time at which the Forward Collision Warning (FCW) activation flag indicates that the system has issued an alert to the SV driver is designated as t_{FCW}. FCW alerts are typically haptic, visual, or audible, and the onset of the alert is determined by post-processing the test data.

For systems that implement audible or haptic alerts, part of the pre-test instrumentation verification process is to determine the tonal frequency of the audible warning or the vibration frequency of the tactile warning through use of the PSD (Power Spectral Density) function in Matlab. This is accomplished in order to identify the center frequency around which a band-pass filter is applied to subsequent audible or tactile warning data so that the beginning of such warnings can be programmatically determined. The 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. Audible and Tactile Warning Filter Parameters

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

2. GENERAL VALIDITY CRITERIA

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

- The SV driver seatbelt was latched.
- If any load had been placed on the SV front passenger seat (e.g., for instrumentation), the vehicle's front passenger seatbelt was latched.
- The SV was driven at the nominal speed in the center of the travel lane, toward the POV or STP.
- The driver used the least amount of steering input necessary to maintain SV position in the center of the travel lane during the validity period; use of abrupt steering inputs or corrections was avoided.
- The yaw rate of the SV did not exceed ±1.0 deg/s from the onset of the validity period to the instant SV deceleration exceeded 0.25 g.
- The SV driver did not apply any force to the brake pedal during the during the applicable validity period. All braking shall be performed by the programmable brake controller.
- The lateral distance between the centerline of the SV and the centerline of the POV or STP did not deviate more than ±1 ft (0.3 m) during the applicable validity period.

3. <u>VALIDITY PERIOD</u>

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. <u>STATIC INSTRUMENTATION CALIBRATION</u>

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

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

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

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

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

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

5. <u>NUMBER OF TRIALS</u>

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. <u>TRANSMISSION</u>

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	Omega DPG8001	17042707002	By: DRI Date: 7/3/2019 Due: 7/3/2020
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 4/20/2020 Due: 4/20/2021
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	49041189	By: DRI Date: 5/22/2020 Due: 5/22/2021
Load Cell	Force applied to brake pedal					By: DRI
		0 - 250 lb 0 -1112 N	0.1% FS	Honeywell 41A	1464391	Date: 8/30/2019 Due: 8/30/2020
		0-250 lb 1112 N	0.05% FS	Stellar Technology PNC700	1607338	Date: 8/30/2019 Due: 8/30/2020
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	NA

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
					2258	Date: 5/3/2019 Due: 5/3/2021
					2182	Date: 9/16/2019 Due: 9/16/2021
Real-Time Calculation of Position and Velocity Relative to Lane Markings (LDW) and POV (FCW)	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec Longitudinal Range to POV: ±200 m Longitudinal Range Rate: ±50 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec Longitudinal Range: ±3 cm Longitudinal Range Rate: ±0.02 m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	NA
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	NA	NA
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	NA	NA
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	NA	NA

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2020 Due: 1/6/2021

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

APPENDIX A

Photographs

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Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

2020 Audi Q5 45 TFSI quattro

STANDARD EQUIPMENT (unless replaced by options)

TECHNICAL
- 2.0 TFSI® I4 engine
- quattro® all-wheel drive system
- 7-speed S tronic® transmission
- 18" 5-arm-turbine design wheels with all-season tires
- Energy recuperation system with start-stop
- Space-saving spare tire

COMFORT/TECHNOLOGY
- Audi connect® CARE (limited time subscription)
- Audi drive select
- Audi sound system
- Audi xenon plus headlights
- Aluminum high-gloss window surrounds
- Aluminum roof rails with crossbars
- Auto-dimming interior mirror w/ compass
- Garage door opener (HomeLink®)
- Driver information system w/ 7" color display
- Heated front seats
- Heated, power exterior mirrors
- High beam assist
- High-gloss Burl Walnut Wood inlays
- Hill descent control
- Leather seating surfaces
- Power tailgate
- Preparation for mobile phone (Bluetooth®) with audio streaming
- Rear privacy glass
- Sliding 40/20/40 split-folding 2nd row with adjustable recline
- Three-zone automatic climate control with digital rear display
- USB Audi music interface w/ Audi smartphone interface
- 3-spoke multi-function steering wheel w/ shift paddles
- 8-way power front seats, 4-way power lumbar for driver

SAFETY/CONVENIENCE
- Advanced Airbag Protection System with 6 airbags
- Anti-lock Braking System (ABS) w/ Brake Assist
- Audi pre sense basic (preventative occupant protection)
- Audi pre sense city (low speed collision assist)
- Child safety locks in rear doors, power
- Electronic Stabilization Control (ESC) w/ Offroad mode
- Electronic vehicle immobilization w/ anti-theft alarm & interior motion sensor
- LED Daytime Running Lights (DRLs) and taillights
- Lower Anchors and Tethers for CHildren (LATCH)
- Rearview camera
- Tire Pressure Monitoring System (TPMS)

WARRANTY/MAINTENANCE
- 4 Year/50,000 mile (whichever occurs first) New Vehicle Limited Warranty*
- 12 Year Limited Warranty Against Corrosion Perforation
- 4 Years Roadside Assistance coverage provided by a third party supplier

*Please refer to the 2020 Audi Warranty and Maintenance Booklet for complete coverage information.

MANUFACTURER'S SUGGESTED RETAIL PRICE

2020 Audi Q5 45 TFSI quattro	**$43,300.00**
PACKAGES / OPTIONS	
Monsoon Gray metallic	$595.00
Black interior	Included
Premium Plus package 19" 5-spoke-dynamic design wheels with all-season tires Auto-dimming, power-folding exterior mirrors with memory SiriusXM® All Access service w/3-month trial subscription Audi advanced key & memory for driver's seat LED headlights Panoramic sunroof Parking system plus Leatherette covered center console and door armrests Aluminum front door sill inlays Audi side assist with pre sense rear MMI® Navigation plus with MMI® all-in-touch Audi virtual cockpit Audi connect PRIME and PLUS (6 month trial subscription) Audi phone box & rear USB charge ports	$6,650.00
Driver assistance package Adaptive cruise control with Traffic Jam assist Audi active lane assist	$1,500.00
Black optic package Titanium black exterior package w/ matte black roof rails 20" 5-arm-offroad design wheels with all-season tires	$1,300.00
Bang & Olufsen® sound system with 3D sound	$950.00
Apple® Lightning® and USB Type-C cables	$110.00
Destination Charge	$995.00
Subtotal:	**$55,400.00**
Convenience package plus credit	-$750.00
Convenience package credit	-$1,500.00
Total Price:	**$53,150.00**

Fuel, license, title fees, taxes and dealer-installed accessories are not included.

MODEL: FYB5NY
VIN: WA1BNAFY0L200

GOVERNMENT 5-STAR SAFETY RATINGS

Overall Vehicle Score		★★★★★
Based on the combined ratings of frontal, side and rollover. Should ONLY be compared to other vehicles of similar size and weight.		
Frontal Crash	Driver	★★★★★
	Passenger	★★★★★
Based on the risk of injury in a frontal impact. Should ONLY be compared to other vehicles of similar size and weight.		
Side Crash	Front Seat	★★★★★
	Rear Seat	★★★★★
Based on the risk of injury in a side impact.		
Rollover		★★★★
Based on the risk of rollover in a single-vehicle crash.		

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

EPA DOT Fuel Economy and Environment — Gasoline Vehicle

Fuel Economy
24 MPG combined city/hwy — **22** city — **28** highway
4.2 gallons per 100 miles

Small Sport Utility Vehicles range from 18 to 120 MPG. The best vehicle rates 136 MPGe.

You **spend $2,750** more in fuel costs over 5 years compared to the average new vehicle.

Annual fuel **cost $2,050**

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

This vehicle emits 364 grams of CO_2 per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel also create emissions; learn more at fueleconomy.gov.

Actual results will vary for many reasons, including driving conditions and how you drive and maintain your vehicle. The average new vehicle gets 27 MPG and costs $7,500 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at $3.25 per gallon. MPGe is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

fueleconomy.gov
Calculate personalized estimates and compare vehicles

Smartphone QR Code™

PARTS CONTENT INFORMATION

For Vehicles In This Carline
U.S./Canadian Parts Content: 3%
Major Sources Of Foreign Parts Content: MEXICO: 77%

For This Vehicle:
Final Assembly Point: SAN JOSE CHIAPA, MEXICO
Country Of Origin:
ENGINE: MEXICO
TRANSMISSION: GERMANY

NOTE: PARTS CONTENT DOES NOT INCLUDE FINAL ASSEMBLY, DISTRIBUTION OR OTHER NON-PARTS COSTS.

Figure A3. Window Sticker (Monroney Label)

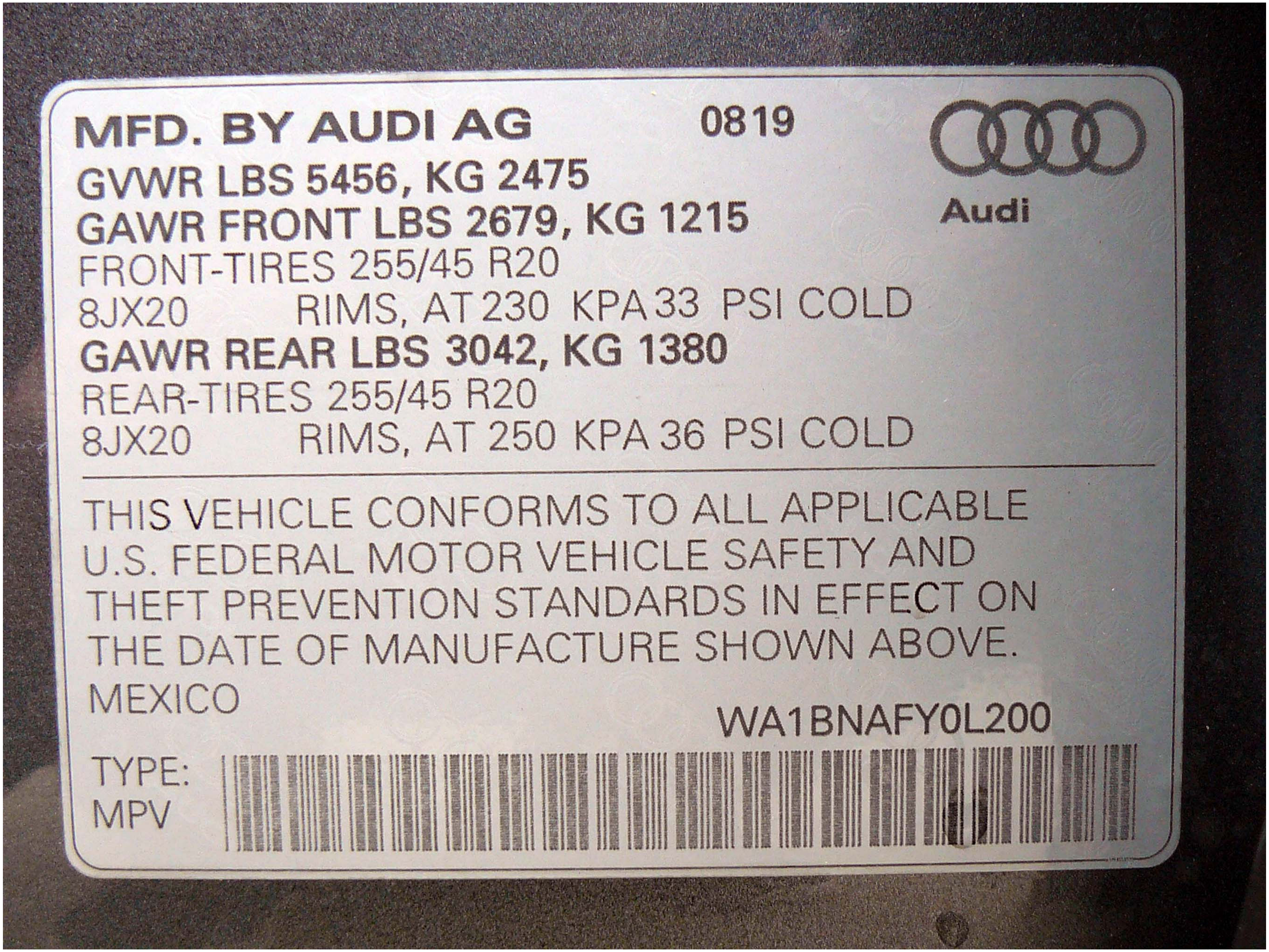

Figure A4. Vehicle Certification Label

Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

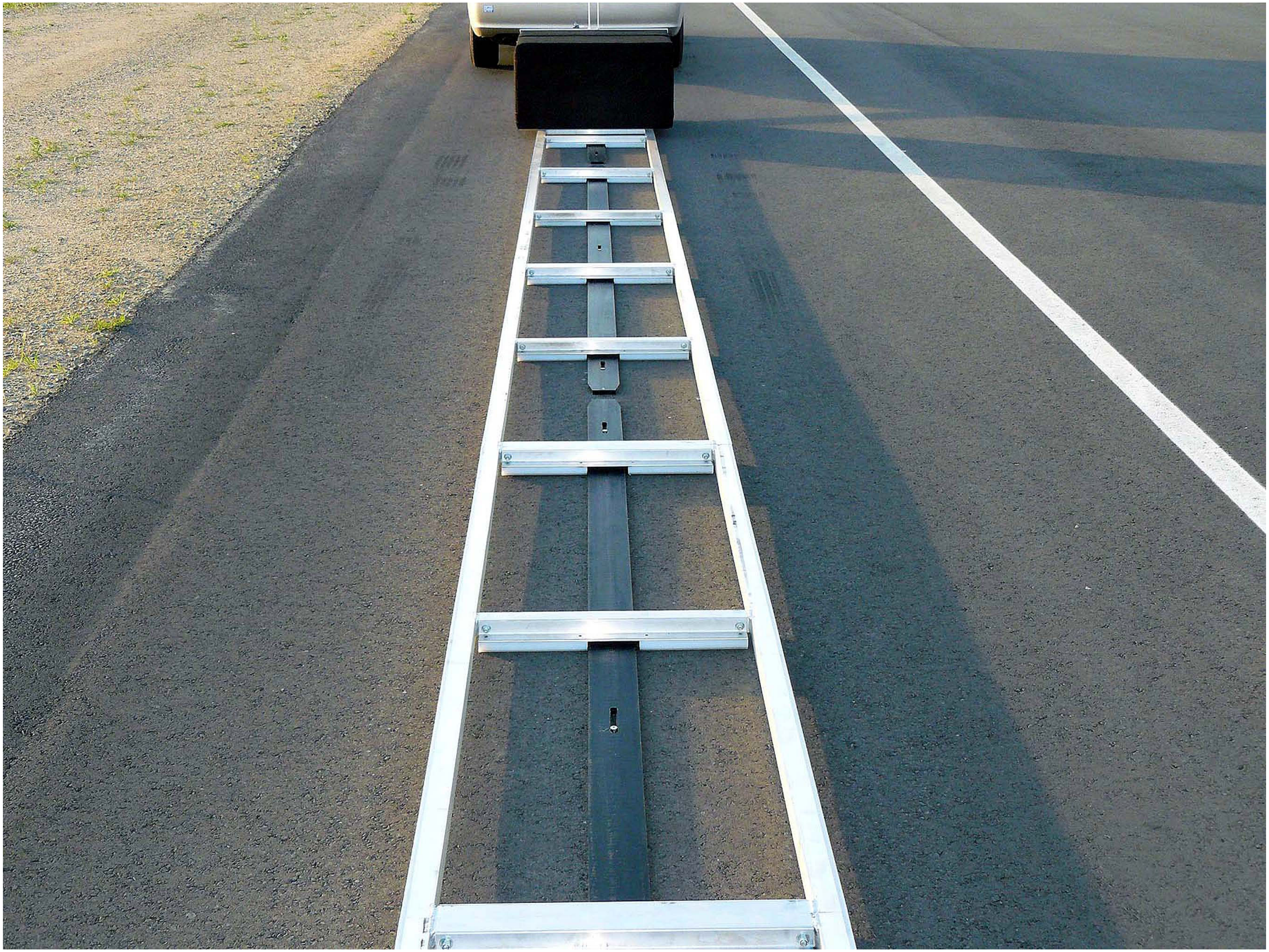

Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

Figure A9. Steel Trench Plate

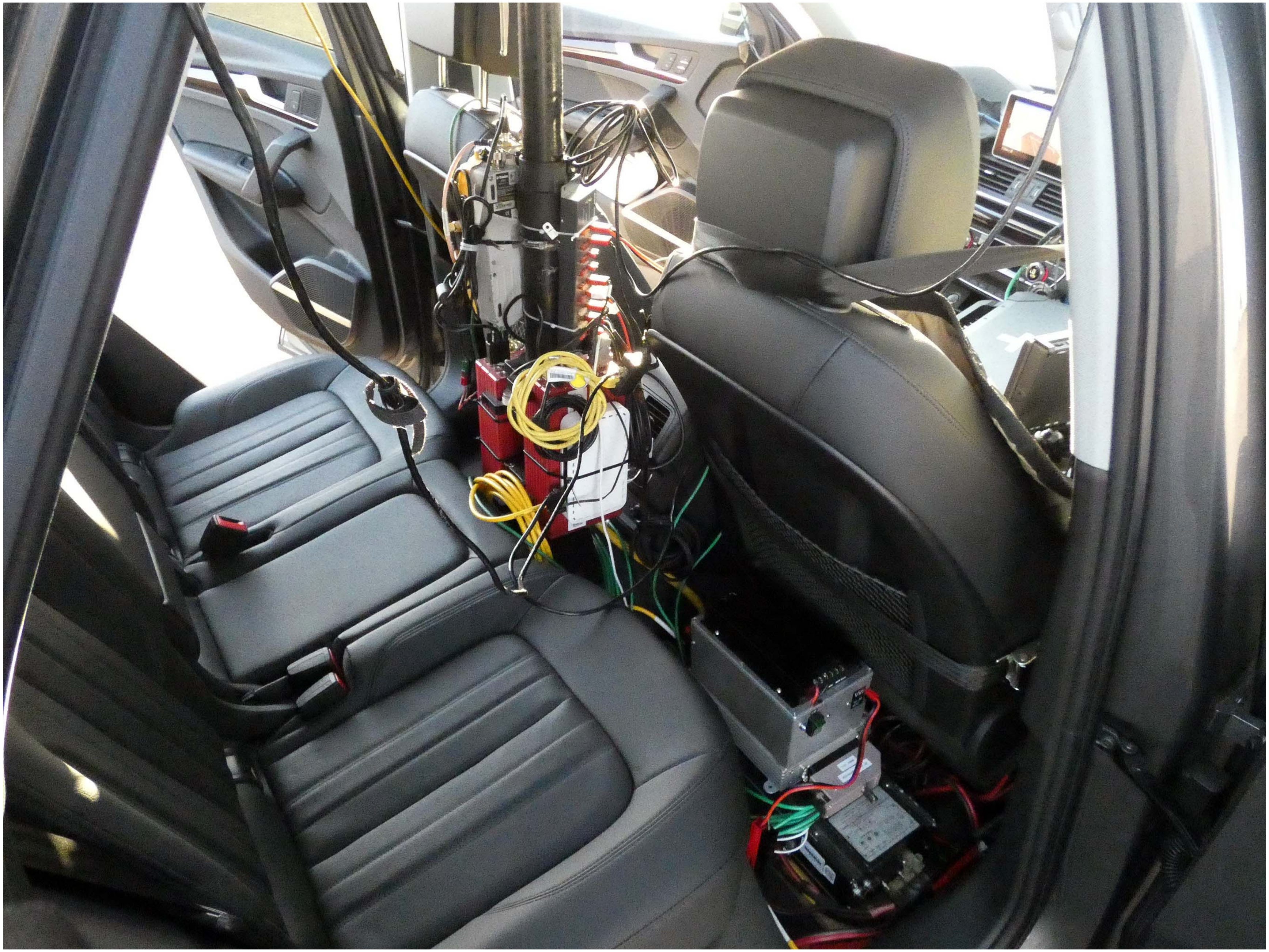

Figure A10. DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle

Figure A11. Sensor for Detecting Auditory Alerts

Figure A12. Computer and Brake Actuator Installed in Subject Vehicle

Figure A13. Brake Actuator Installed in POV System

Figure A14. Menu Page for AEB Settings (page 1 of 2)

Figure A15. Menu Page for AEB Settings (page 2 of 2)

Figure A16. Controls for Changing Parameters

Figure A17. AEB Visual Alert

APPENDIX B

Excerpts from Owner’s Manual

Indicator lights overview

Description

The indicator lights in the instrument cluster blink or turn on. They indicate functions or malfunctions.

Messages may appear with some indicator lights. A warning signal will sound at the same time. The indicator lights and messages may be covered by other displays. To show them again, select the second tab for messages with the multifunction steering wheel ⇨ *page 17* or ⇨ *page 20*.

Some indicator lights in the display can display in several colors.

⚠ Central indicator light

If the or indicator light turns on, check the message in the instrument cluster.

Overview

Some indicator lights turn on briefly as a function check when you switch the ignition on. These systems are marked with a ✓ in the following tables. If one of these indicator lights does not turn on, there is a malfunction in that system.

Your vehicle has either a monochrome display or a multicolored display, depending on vehicle equipment. Some indicator lights appear white on a monochrome display. The or central indicator light turns on at the same time to indicate the priority of these indicator lights.

The following indicator lights may be available, depending on the vehicle equipment:

Red indicator lights
Central indicator light ⇨ *page 10*, Audi pre sense ⇨ *page 131*, instrument cluster ⇨ *page 14*
Safety belt ⇨ *page 273*
Engine start system ⇨ *page 76*
Transmission ⇨ *page 82*
Drive system ⇨ *page 86*
Electromechanical parking brake ⇨ *page 89*
Electromechanical parking brake ⇨ *page 89*
Brake system ✓ ⇨ *page 90*, ⇨ *page 89*, ⇨ *page 335*
Brake system ✓ ⇨ *page 90*, ⇨ *page 89*, ⇨ *page 335*
Steering ✓ ⇨ *page 166*
Air suspension ⇨ *page 23*
Electrical system ⇨ *page 336*
Engine oil pressure ⇨ *page 330*
Engine oil level (MIN) ⇨ *page 330*
Cooling system ⇨ *page 333*
Hood ⇨ *page 328*
Adaptive cruise control ✓ ⇨ *page 123*
Traffic jam assist ⇨ *page 128*

Yellow indicator lights
Central indicator light ⇨ *page 10*
Safety systems ✓ ⇨ *page 269*
Transmission ⇨ *page 82*

	Drive system ⇨ page 86, ⇨ page 333
	Vehicle sound ⇨ page 86
	Engine start system ⇨ page 76
	Keys ⇨ page 76
	Electromechanical parking brake ⇨ page 90
	Brake system ⇨ page 89
	Electronic Stabilization Control (ESC) ⇨ page 22
OFF	Electronic Stabilization Control (ESC) ✓ ⇨ page 22
ESC OFF	Electronic Stabilization Control (ESC) ⇨ page 165
ABS	Anti-lock braking system (ABS) ✓ ⇨ page 22
ABS	Anti-lock braking system (ABS) ✓ ⇨ page 22
	Steering ⇨ page 166

	All wheel drive/sport differential ⇨ page 23
	Suspension control ⇨ page 23
	Air suspension ⇨ page 23
	Engine speed limitation ⇨ page 16
	Tank system ⇨ page 324
	Electrical system ⇨ page 336
MIN	Engine oil level (MIN) ⇨ page 330
MAX	Engine oil level (MAX) ⇨ page 330
SENSOR	Engine oil sensor ⇨ page 330
	Malfunction Indicator Lamp (MIL) ✓ ⇨ page 326
	Engine warm-up request ⇨ page 330
	Washer fluid level ⇨ page 339
	Windshield wipers ⇨ page 50
AC	Charging system ⇨ page 100
P	Parking aid ⇨ page 163
	Tire pressure ⇨ page 359
TPMS	Tire pressure ⇨ page 359
	Bulb failure indicator ⇨ page 44
	Headlight range control system ⇨ page 44
	Adaptive light ⇨ page 44
	Light/rain sensor ⇨ page 44, ⇨ page 50
	Driver's door ⇨ page 30
	Battery in vehicle key ⇨ page 27
	Audi side assist ⇨ page 145
	Active lane assist ⇨ page 137
	Audi pre sense ⇨ page 135
SOS	Emergency call function ⇨ page 217

80A012721BJ

General information

Applies to: vehicles with Audi adaptive cruise control

Fig. 110 Front of the vehicle: sensors and video camera

The areas with the radar and ultrasonic sensors and the video camera ⇨ *fig. 110* must not be covered by stickers, deposits or any other objects, because this can interfere with the adaptive cruise control function. For information on cleaning, see ⇨ *page 361*. The same applies for any modifications made in the front area.

In some driving situations, the adaptive cruise control function is restricted:

– Vehicles can only be detected when they are within the sensor detection zones ⇨ *page 121, fig. 109*.
– The system has a limited ability to detect vehicles that are a short distance ahead, off to the side of your vehicle or moving into your lane.
– Objects that are difficult to detect such as motorcycles, vehicles with high ground clearance or an overhanging load are detected late or not detected at all.
– When driving through curves ⇨ *page 123*.
– When the vehicle is stationary ⇨ *page 123*.

⚠ WARNING

Always pay attention to the traffic around you when adaptive cruise control is switched on. As the driver, you are still responsible for your own speed and the distance to other vehicles. The adaptive cruise control is used to assist you. The driver must always take action to avoid a collision. The driver is always responsible for braking at the correct time.

– For safety reasons, do not use adaptive cruise control when the road surface is in poor condition and/or in bad weather conditions (such as ice, fog, gravel, heavy rain and hydroplaning). Using the system under these conditions increases the risk of an accident.
– Switch adaptive cruise control off temporarily when driving in turning lanes, on expressway exits (except if predictive control is switched on) or in construction zones. This prevents the vehicle from accelerating to the stored speed when in these situations.
– The adaptive cruise control system will not brake by itself if you put your foot on the accelerator pedal. Doing so can override the speed and distance regulation.
– When approaching stationary obstacles such as stopped traffic, adaptive cruise control will respond with limited function.
– Adaptive cruise control does not respond to people, animals, or crossing or oncoming objects.
– The function of the radar sensors can be affected by reflective objects such as guard rails, the entrance to a tunnel, heavy rain or ice.

(!) Note

The sensors can be displaced by impacts or damage to the bumper, wheel housing and underbody. This can impair the adaptive cruise control. Have an authorized Audi dealer or authorized Audi Service Facility check their function.

(i) Tips

For an explanation on conformity with the FCC regulations in the United States and the Industry Canada regulations, see ⇨ *page 390*.

Distance warning: currently unavailable. See owner's manual

This message appears if the system has a temporary failure. If this occurs multiple times, drive to an authorized Audi dealer or authorized Audi Service Facility immediately to have the malfunction corrected.

ACC: Please fasten seat belt

The system is not completely available if the driver's seat belt is unfastened.

Stationary object ahead

This message appears if you would like to switch the system on and there is a stationary object directly in front of your vehicle.

Door open

The system is not available when the door is open.

Audi pre sense

Introduction

Applies to: vehicles with Audi pre sense

Within the limits of the system, the pre sense functions can initiate measures in particularly dangerous situations to protect the vehicle passengers and other road users.

- Due to the interlinking of various vehicle systems, critical driving situations can be detected by **pre sense basic** and measures for preventative occupant protection are can be initiated.
- The **pre sense front** system uses the data from the adaptive cruise control* radar sensors and the camera to calculate the probability of a collision. Within the limits of the system, an impending collision with vehicles can be detected in both urban and rural speed ranges. In this case, the system warns the driver visually, acoustically and with a jerk on the brakes if necessary. If needed, it can initiate a partial or full deceleration to reduce the collision speed or to avoid the collision under certain circumstances. In conjunction with pre sense basic/rear, the front safety belts are also reversibly tensioned when needed. The pre sense front is also active when adaptive cruise control* is switched off.
- **Pre sense rear** contains pre sense basic functions. It uses the data from the side assist* radar sensors and calculates within the limits of the system the probability of a rear end collision with the vehicle behind you. Pre sense rear is also active when side assist* is switched off.
- Within the limits of the system, **pre sense city** uses the camera data and can detect an impending collision with vehicles and pedestrians. In this case, the system warns the driver visually, acoustically and with a jerk on the brakes if necessary. If needed, it can initiate a full deceleration to reduce the collision speed or to avoid the collision under certain circumstances. In conjunction with pre sense basic/rear, the front safety belts are also reversibly tensioned when needed.

⚠ WARNING

Read the general information in ⇨ ⚠ *in General information on page 122*, ⇨ ⚠ *in General information on page 141*.

ⓘ Tips

- Certain pre sense functions switch off when driving in reverse.
- The pre sense functions may not be available if there is a malfunction in the ESC system or the airbag control module.
- Note that the reversible belt tensioner on the front passenger's side deactivates when the front passenger's airbag is deactivated.
- Switch the pre sense off when you are not using public streets or when loading the vehicle onto a vehicle carrier, train, ship, or other type of transportation. This can prevent an undesired intervention from the pre sense system.

Audi pre sense basic

Applies to: vehicles with Audi pre sense basic

The pre sense basic functions are activated at a speed of approximately 20 mph (30 km/h) or higher. ▶

The following functions can be triggered under certain conditions within the limits of the system:

– Tensioning of the safety belts (for example, during heavy braking): the front safety belts have reversible belt tensioners. If a collision does not occur, the safety belts loosen slightly and are ready to trigger again.
– Closing the windows and sunroof*
– Activation of the emergency flashers[1]

The message **Audi pre sense** ⇨ *page 132, fig. 123* will warn you about the danger.

Audi drive select*: the trigger times are adjusted depending on the mode selected.

Audi pre sense front

Applies to: vehicles with Audi pre sense front

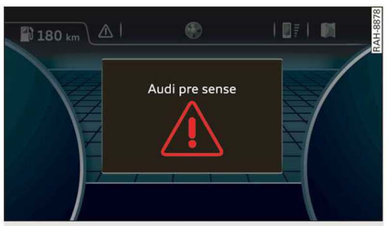

Fig. 123 Instrument cluster: approach warning

Description

Within the limits of the system, pre sense front can warn you of impending collisions and initiate the corresponding braking maneuvers or the supporting measures when avoiding a collision.

If detected in time, the system can rank the dangerous situation as critical if a vehicle driving ahead brakes suddenly, if your own vehicle is approaching a significantly slower vehicle at high speed or when there is an oncoming vehicle during a turning maneuver.

If detection is not possible, then pre sense front does not react.

Warnings

The system recognizes various dangerous situations. The **early warning** occurs if:

– A vehicle driving ahead brakes suddenly
– Your own vehicle approaches a significantly slower vehicle or stationary vehicle in the direction of travel

When this warning occurs, it may only be possible to avoid a collision by swerving or braking strongly. The message **Audi pre sense** ⇨ *fig. 123* and a warning tone will warn you about the danger.

If you do not react enough or not at all to a dangerous situation that was detected by the system, pre sense front provides assistance by applying the brakes.

If a collision is imminent, the system will first provide an **acute warning** by braking sharply. You will also warned by an indicator in the instrument cluster display ⇨ *fig. 123*. If you do not react to the acute warning, pre sense front can brake with increasing force within the limits of the system [1]. This reduces the vehicle speed in the event of a collision. At low vehicle speeds, pre sense front can initiate a complete deceleration shortly before a collision with a vehicle driving ahead [1]. If pre sense front determines that you are not braking strongly enough when a collision is imminent, it can increase the braking force.

The following functions trigger in conjunction with pre sense basic/rear at corresponding vehicle speeds:

– Reversible tensioning of the front safety belts
– Closing the windows and sunroof*

Audi drive select*: depending on the selected mode, the reversible belt tensioner and the closing of the windows and sunroof* are not active.

Swerve assist

Swerve assist helps you to steer the vehicle around an obstacle in a critical situation. If you avoid an obstacle after the acute warning, then the swerve assist assists you by applying slight ▶

[1] This is not available in some countries.

underbody. Pre sense rear can be impaired by this. Have an authorized Audi dealer or authorized Audi Service Facility check their function.

Tips

- The pre sense rear functions switch off when towing a trailer.
- The pre sense rear functions may also switch off if there is a malfunction in the side assist* system.

Audi pre sense city

Applies to: vehicles with Audi pre sense city

Description

Within the limits of the system, pre sense city can warn you of impending collisions with vehicles and pedestrians and initiate the applicable braking maneuver if needed. Pre sense city is active at speeds of approximately 6 mph (10 km/h) and higher.

A pedestrian warning can occur at speeds up to 50 mph (85 km/h), and vehicle warnings can occur at speeds up to 155 mph (250 km/h). A pre sense city braking maneuver is possible at speeds up to 50 mph (85 km/h).

Warnings

The system recognizes various dangerous situations. The **early warning** occurs if:

- A vehicle driving ahead brakes suddenly
- Your own vehicle approaches a vehicle in front of you that is traveling at a significantly slower speed or that is stationary
- A pedestrian is standing in the lane or is moving into the lane

When this warning occurs, it may only be possible to avoid a collision by swerving or braking strongly. The message **Audi pre sense** ⚠ ⇨ *page 132, fig. 123* and a warning tone will warn you about the danger.

The brakes may also be applied as an **acute warning** when there is an impending collision. If you do not react to the acute warning, pre sense city can brake to the point of complete deceleration within the limits of the system. This reduces the vehicle speed in the event of a collision. The message **Audi pre sense** ⚠ also appears.

The following functions are triggered in conjunction with pre sense basic/rear:

- Reversible tensioning of the front safety belts
- Closing the windows and sunroof*

Audi drive select*: the function is not active depending on the mode selected.

⚠ WARNING

- Pre sense city cannot overcome the laws of physics. It is a system designed to assist and it cannot prevent a collision in every circumstance. The driver must always intervene. The driver is always responsible for braking at the correct time. Do not let the increased safety provided tempt you into taking risks. This could increase your risk of a collision.
- The system can deploy incorrectly due to system-specific limits.
- To reduce the risk of an accident, please note that the camera does not always detect every object.
- Pre sense city does not react to animals, crossing or oncoming vehicles, objects such as bars, railings or railcars, and objects that are difficult to detect ⇨ ⚠ *in General information on page 122*.
- In trailer mode, the braking behavior of the trailer can be different than usual during automatic braking.

⚠ WARNING

Pre sense city may be restricted or unavailable in the following types of situations:

- In heavy fog, rain, spray, or snow
- When there are visual obstructions, such as glare, reflections or variations in light
- When it is dark
- If the camera window or the windshield is dirty, iced over, damaged or covered
- When driving on snow, ice or loose ground
- In curves
- If the ESC was restricted or switched off
- When towing a trailer

– When the driver's seat belt is unfastened
– For several seconds after the ignition is switched on

Note

Impacts or damage to the camera mount on the windshield can displace the sensor. Pre sense city can be impaired by this. Have an authorized Audi dealer or authorized Audi Service Facility check their function.

Tips

– You can cancel the system braking intervention if you accelerate considerably or swerve away.
– Keep in mind that pre sense city can brake unexpectedly. Always secure any cargo or objects that you are transporting to reduce the risk of damage or injury.
– Specific pre sense city functions switch off when the ESC is limited or switched off ⇨ *page 165* or the hill descent assist is switched on ⇨ *page 92*.
– When there is a malfunction in the camera, the pre sense city functions also switch off.

Settings in the Infotainment system

Applies to: vehicles with Audi pre sense

▸ Select in the Infotainment system: MENU button > **Vehicle** > left control button > **Driver assistance** > **Audi pre sense**.

Turn on/off Audi pre sense - The pre sense functions can be turned on and off.

If the system is switched off, it switches on again automatically once the ignition is switched on again.

Prewarning - The early warning can be switched **off** or the pre sense city/front warning point can be set (**Early**/**Medium**/**Late**).

Set the warning time for the early warning to **Early** at first. If this causes undesired early warnings to appear, then set the warning time to **Medium**. The **Late** warning time should only be set in special circumstances.

Tips

Your settings are automatically stored and assigned to the vehicle key being used.

Messages

Applies to: vehicles with Audi pre sense

Audi pre sense: malfunction! Please contact Service

This message appears when the pre sense function is affected. For example, this could be caused by a faulty sensor. Drive immediately to an authorized Audi dealer or authorized Audi Service Facility to have the malfunction repaired.

Audi pre sense: currently limited. Sensor view limited due to surroundings. See owner's manual

This message appears if the radar sensor and camera view is obstructed, for example by leaves, snow, heavy spray or dirt. If necessary, clean the sensors and the area around the camera ⇨ *page 122, fig. 110* or ⇨ *page 141, fig. 131*.

Audi pre sense: currently limited. Trailer towing mode

For vehicles with a trailer hitch installed at the factory, the pre sense rear functions switch off when the electrical connector at the socket is plugged in. There is no guarantee the functions will switch off when using a retrofitted trailer hitch.

Audi pre sense: currently limited

This message appears if the ESC is restricted or switched off, for example.

Audi pre sense: currently limited. See owner's manual

This message appears when there is a temporary failure in a subsystem, such as the ESC. If this message appears repeatedly, drive to an authorized Audi dealer or authorized Audi Service Facility to have the malfunction corrected.

Audi pre sense: emergency braking system off ▸

This message appears if the pre sense functions are switched off through the Infotainment system or if the system is not ready.

Audi active lane assist

Description

Applies to: vehicles with Audi active lane assist

Active lane assist (lane departure warning) detects lane marker lines within the limits of the system using a camera in the windshield. If you are approaching a detected lane marker line and it appears likely that you will leave the lane, the system will warn you with corrective steering. You can override this steering at any time. If you pass over a line, the steering wheel will vibrate lightly. In order for this warning vibration to occur, it must first be switched on in the Infotainment system. Active lane assist is ready for operation when the lane marker line is detected on at least one side of the vehicle.

The system is designed for driving on expressways and highways and therefore only activates at speeds above approximately 40 mph (65 km/h).

Applies to: vehicles with side assist: If you activate a turn signal when active lane assist is ready and it classifies a lane change as critical because of vehicles traveling alongside you or approaching you, there will be noticeable corrective steering shortly before you leave the lane. This will attempt to keep your vehicle in the lane.

Applies to: vehicles without side assist: When the system is ready, it will not warn you if you activate a turn signal before crossing the lane marker line. In this case, it assumes that you are changing lanes intentionally.

Applies to: vehicles with adaptive cruise control: There is no corrective steering or warnings if the system recognizes a distinct passing maneuver. If the conditions are met, traffic jam assist switches on at speeds under approximately 40 mph (65 km/h) ⇨ *page 128*.

⚠ WARNING

- The system warns the driver that the vehicle is leaving the lane using corrective steering. The driver is always responsible for keeping the vehicle within the lane.
- The system can help you keep the vehicle in the lane, but it does not drive by itself. Always keep your hands on the steering wheel.
- Corrective steering may not occur in certain situations, such as during heavy braking.
- There may be cases where the camera does not recognize all lane marker lines. Corrective steering can only take place on the side of the vehicle where lane marker lines are detected.
- Other road structures or objects could possibly be identified unintentionally as lane marker lines. As a result, corrective steering may be unexpected or may not occur.
- The camera view can be restricted, for example by vehicles driving ahead or by rain, snow, heavy spray or light shining into the camera. This can result in active lane assist not detecting the lane marker lines or detecting them incorrectly.
- In certain situations where visibility is low, the vehicle may switch from an “early” to “late” steering correction.
- Under certain conditions such as ruts in the road, an inclined roadway or crosswinds, the corrective steering alone may not be enough to keep the vehicle in the middle of the lane.
- For safety reasons, active lane assist must not be used when there are poor road and/or weather conditions such as slippery roads, fog, gravel, heavy rain, snow and the potential for hydroplaning. Using active lane assist under these conditions may increase the risk of a crash.

APPENDIX C

Run Log

Subject Vehicle: **2020 Audi Q5 45 TFSI quattro** Test Date: **6/23/2020**

Principal Other Vehicle: **SSV**

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
1-22	Brake characterization and determination						See Appendix D
23	Static Run						
24	**Stopped POV**	Y	2.08	11.83	1.09	Pass	
25		Y	2.04	13.95	1.08	Pass	
26		Y	1.96	4.56	0.74	Pass	Brake onset threshold set to 3.5 lbf
27		Y	2.07	6.27	0.89	Pass	
28		Y	2.07	4.43	0.83	Pass	
29		Y	2.10	5.77	0.84	Pass	Brake onset threshold set to 3.5 lbf
30		Y	2.06	12.22	0.93	Pass	Brake onset threshold set to 3 lbf
31	Static Run						
32	**Slower POV, 25 vs 10**	N					
33		N					
34		N					
35		N					POV Speed
36		N					Brake force not zeroed
37		Y	2.36	6.60	0.72	Pass	
38		Y	2.39	7.99	0.75	Pass	
39		Y	2.47	8.10	0.77	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
40		Y	2.50	8.02	0.77	Pass	
41	Static run						
42	**Slower POV, 45 vs 20**	Y	2.71	4.43	0.76	Pass	
43		Y	2.68	4.43	0.76	Pass	
44		Y	2.72	4.30	0.82	Pass	
45		Y	2.78	5.33	0.88	Pass	
46		Y	2.79	4.31	0.81	Pass	
47		Y	2.81	3.70	0.83	Pass	
48		N					Lateral offset
49		Y	2.67	3.99	0.78	Pass	
50	Static run						
51	**Decelerating POV, 35**	Y	1.64	10.70	0.76	Pass	
52		N					SV brake application in window
53		N					SV brake application in window
54		N					SV brake application in window
55		N					SV brake application in window
56		Y	1.63	7.08	0.73	Pass	
57		N					SV speed
58		N					SV speed, yaw rate, lateral offset
59		N					POV brake
60		N					Actuator fired early
61		Y	1.54	3.10	0.67	Pass	
62		N					SV brake application in window

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
63		N					
64		Y	1.60	0.00	0.73	Fail	
65		Y	1.86	13.51	0.92	Pass	
66	Static run						
67	STP - Static run						
68	**Baseline, 25**	N					SV speed
69		Y			0.51		
70		Y			0.51		
71		N					Brake application early
72		N					Brake application early
73		N					Brake application early
74		N					Brake application early
75		Y			0.44		
76		N					Brake application widow error
77		N					SV speed
78		N					SV speed
79		N					SV speed
80		Y			0.50		
81		N					SV speed
82		Y			0.49		
83		Y			0.50		
84		Y			0.54		

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
85	STP - Static run						
86	**Baseline, 45**	Y			0.49		
87		Y			0.49		
88		Y			0.48		
89		Y			0.50		
90		Y			0.53		
91		Y			0.52		
92		Y			0.51		
93	STP - Static run						
94	**STP False Positive, 25 mph**	Y			0.53	Pass	
95		Y			0.52	Pass	
96		Y			0.53	Pass	
97		Y			0.51	Pass	
98		N					Throttle release late
99		Y			0.48	Pass	
100		Y			0.47	Pass	
101		Y			0.48	Pass	
102	STP - Static run						
103	**STP False Positive, 45 mph**	Y			0.47	Pass	
104		Y			0.52	Pass	
105		Y			0.49	Pass	
106		Y			0.50	Pass	
107		N					Lateral offset

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
108		Y			0.53	Pass	
109		Y			0.56	Pass	
110		Y			0.55	Pass	
112	STP - Static run						

APPENDIX D

Brake Characterization

Subject Vehicle: **2020 Audi Q5 45 TFSI quattro** Test Date: **6/23/2020**

DBS Initial Brake Characterization				
Run Number	**Stroke at 0.4 g (in)**	**Force at 0.4 g (lb)**	**Slope**	**Intercept**
1	2.047318	21.60221	0.810615	0.862158
2	2.008781	21.57329	0.811936	0.859698
3	2.112569	22.19486	0.808893	0.865694

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	Y	0.424	2.06	21.79	1.94	
5			Y	0.374	2.00	21.79	2.14	
6			Y	0.372	2.03	21.79	2.18	
7			N					SV Speed
8			N					SV Speed
9			N					SV Speed
10			Y	0.394	2.04	21.79	2.07	
11		25	Y	0.391	2.04	21.79	2.09	
12		45	Y	0.428	2.04	21.79	1.91	

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**
13			Y	0.451	2.04	21.79	1.81	Tried a lower temp
14			Y	0.449	2.02	21.79	1.80	
15			Y	0.430	1.99	21.79	1.85	
16			Y	0.392	1.93	21.79	1.97	
17	**Hybrid**	35	Y	0.519	2.04	21.79	16.79	
18			N					SV speed
19			Y	0.387	2.04	16.00	16.54	
20		25	Y	0.388	2.04	16.00	16.49	
21		45	Y	0.422	2.04	16.00	15.17	
22			Y	0.417	2.04	16.00	15.35	Confirmation run

Appendix E

TIME HISTORY PLOTS

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Description of Time History Plots

A set of time history plots is provided for each valid run in the test series. Each set of plots comprises time varying data from both the Subject Vehicle (SV) and the Principal Other Vehicle (POV), as well as pass/fail envelopes and thresholds. 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 audible, visual, or haptic). Depending on the type of FCW alert or instrumentation used to measure the alert, this can be any combination of the following:
    - Filtered, rectified, and normalized sound signal. The vertical scale is 0 to 1.
    - Filtered, rectified, and normalized acceleration (i.e., haptic alert, such as steering wheel vibration). The vertical scale is 0 to 1.
    - Normalized light sensor signal. The vertical scale is 0 to 1.

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

- Headway (ft) – Longitudinal separation between the 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.

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

Envelopes and Thresholds

Some of the time history plot figures contain either green or yellow envelopes and/or black 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 0.27g (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 0.27g. A green circle indicates that the test was valid (the threshold was crossed during the appropriate interval) and a red asterisk indicates that the test was invalid (the threshold was crossed out of the appropriate interval).

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

For the brake force 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 fore 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.

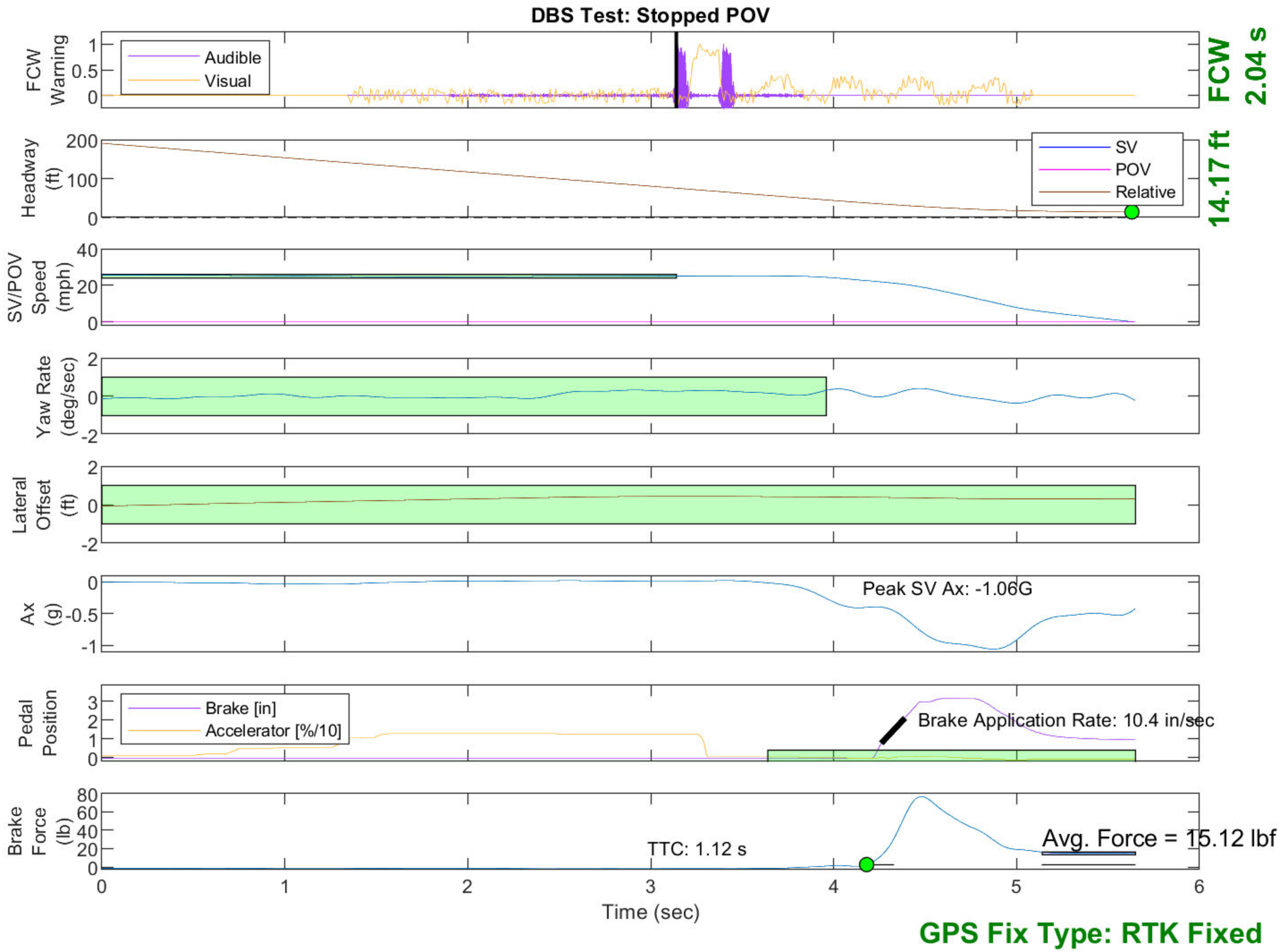

Figure E1. Example Time History for Stopped POV, Passing

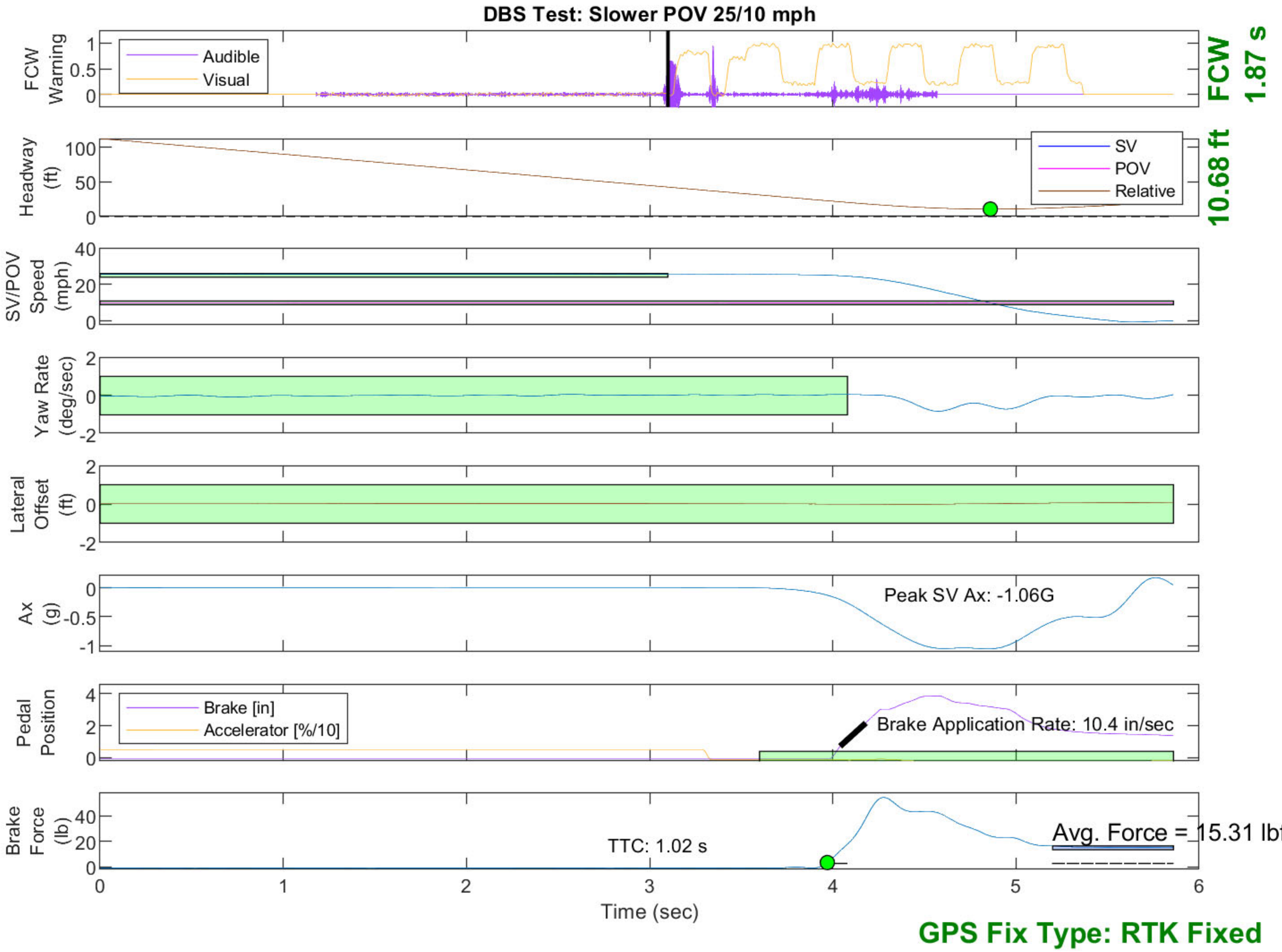

Figure E2. Example Time History for Slower POV 25 vs. 10, Passing

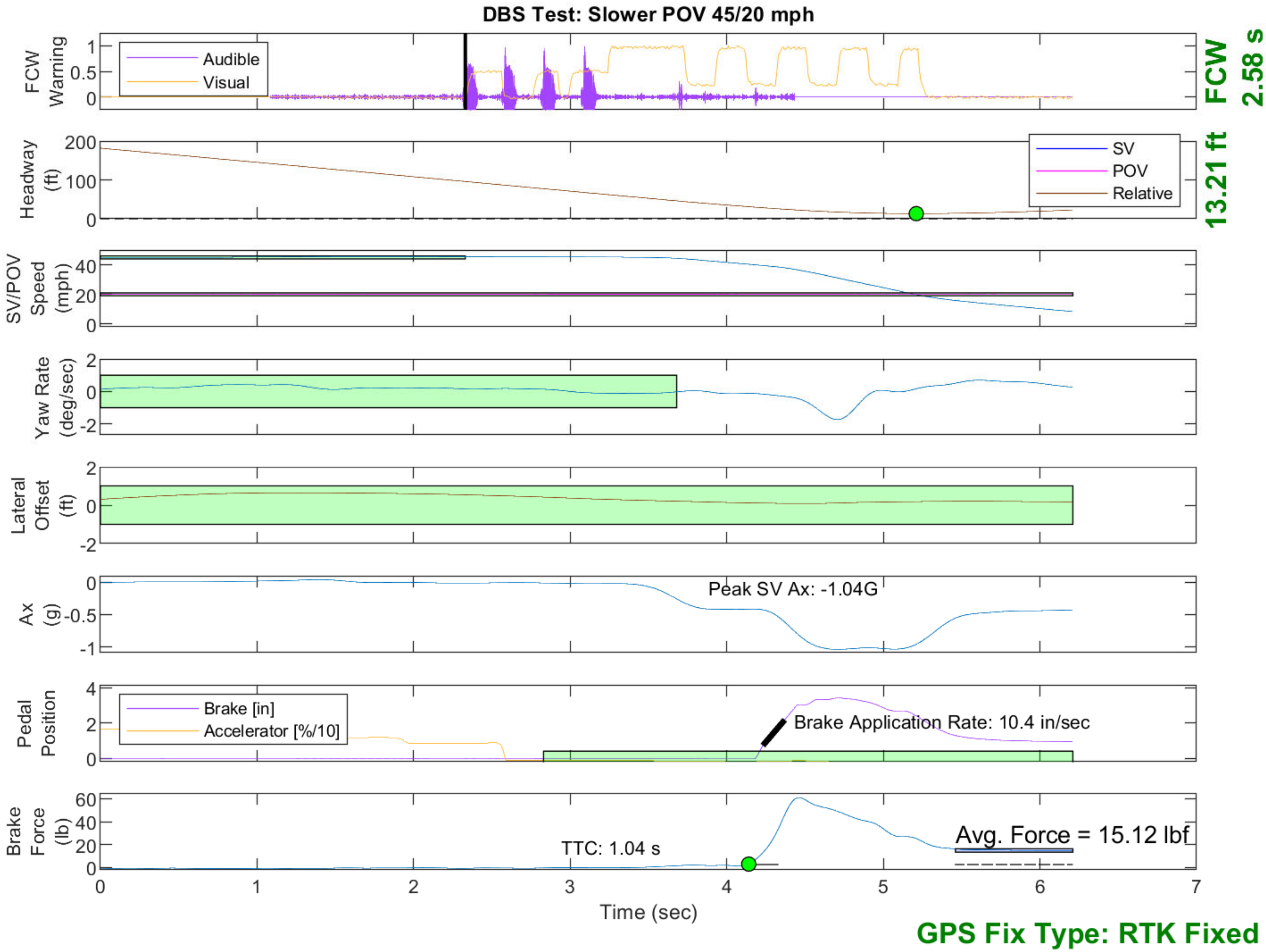

Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

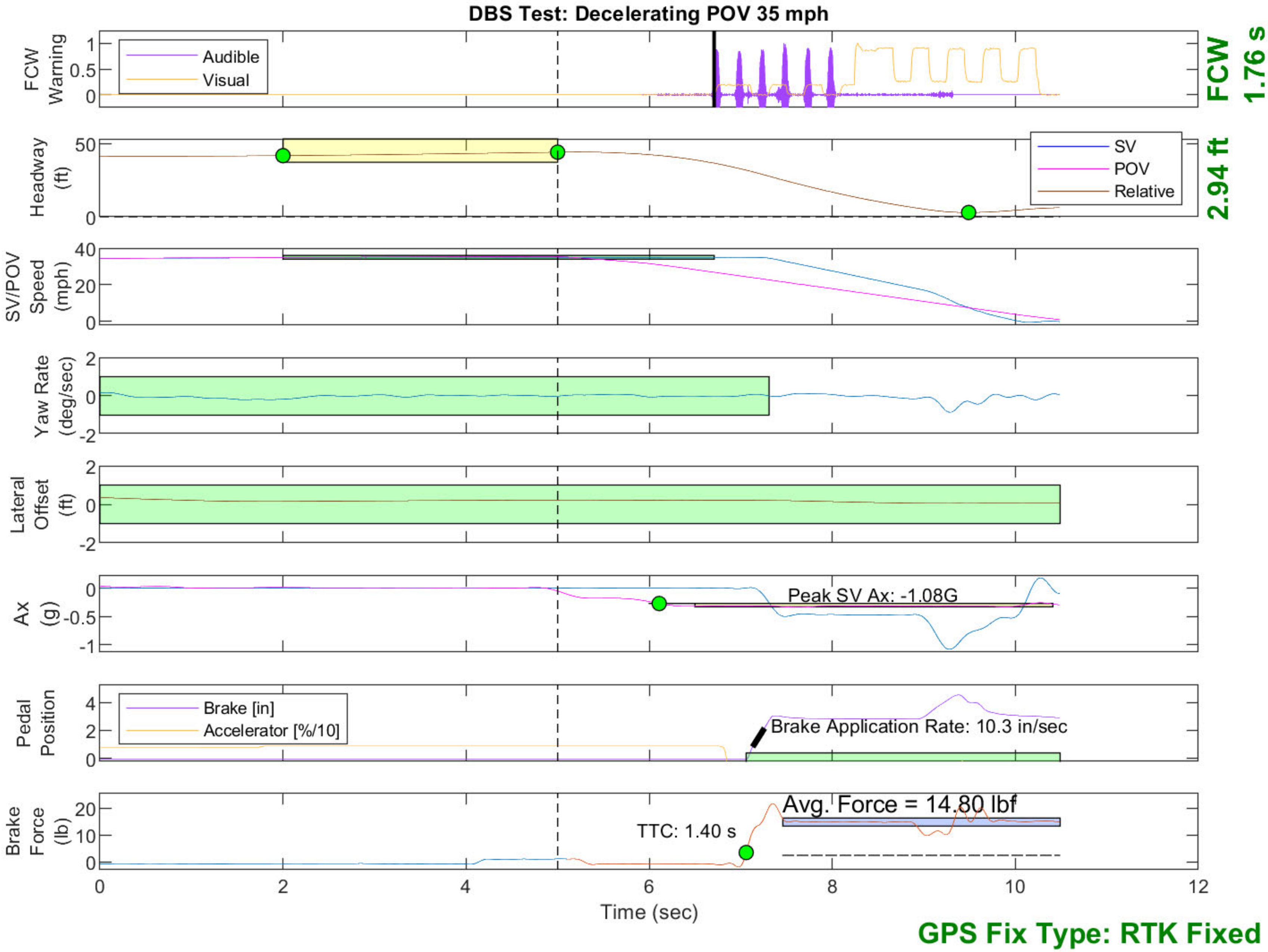

Figure E4. Example Time History for Decelerating POV 35, Passing

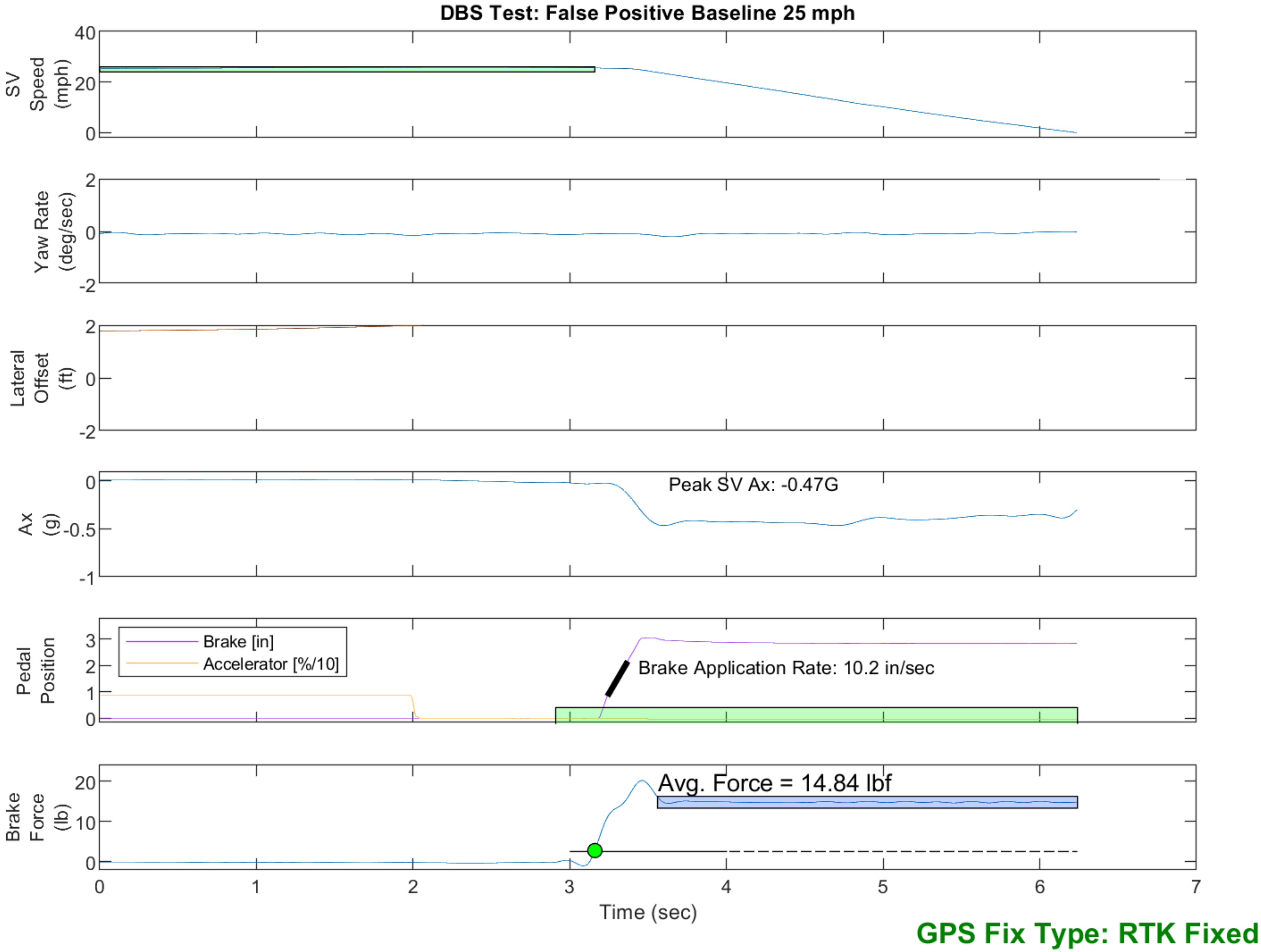

Figure E5. Example Time History for False Positive Baseline 25

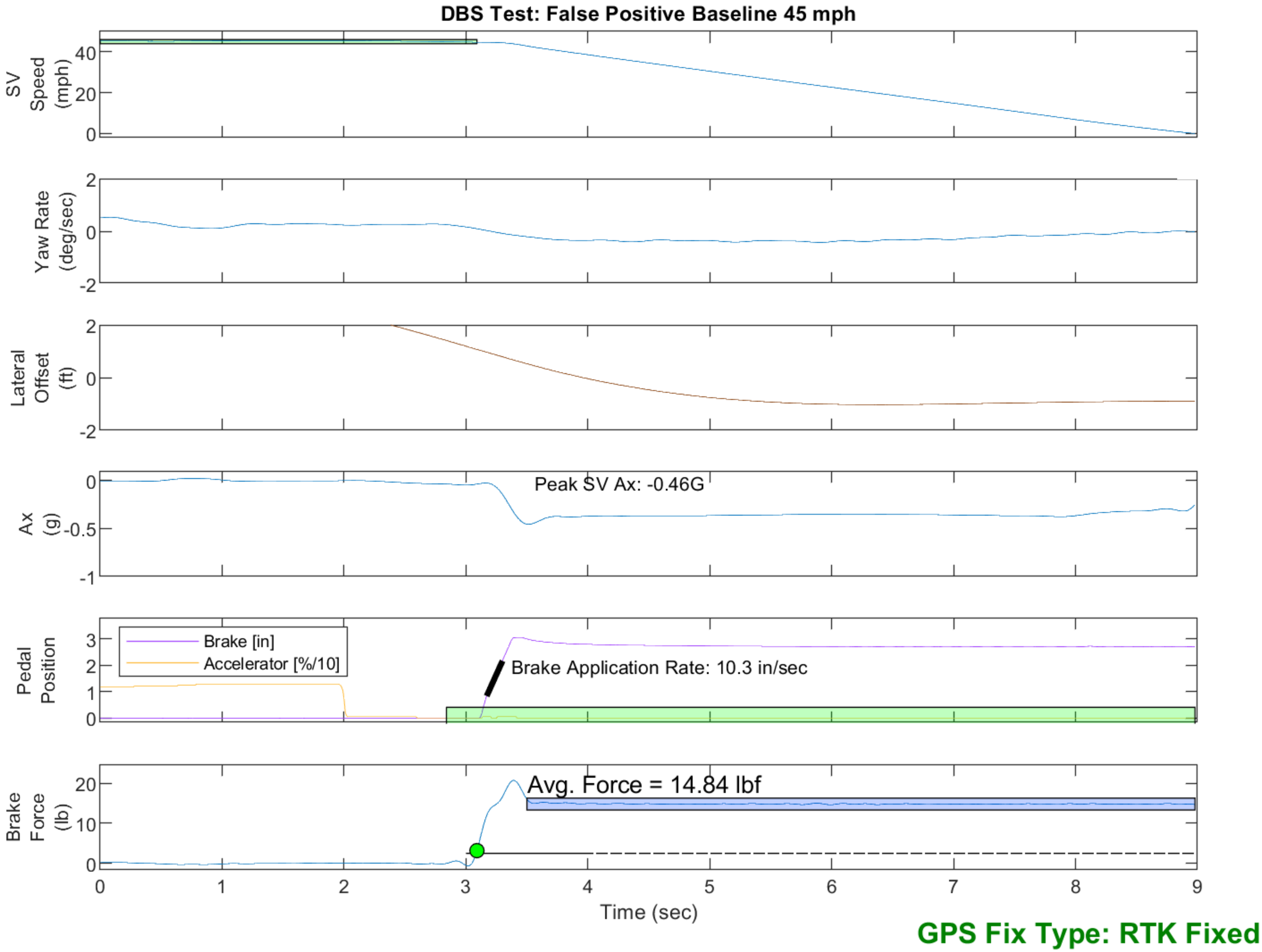

Figure E6. Example Time History for False Positive Baseline 45

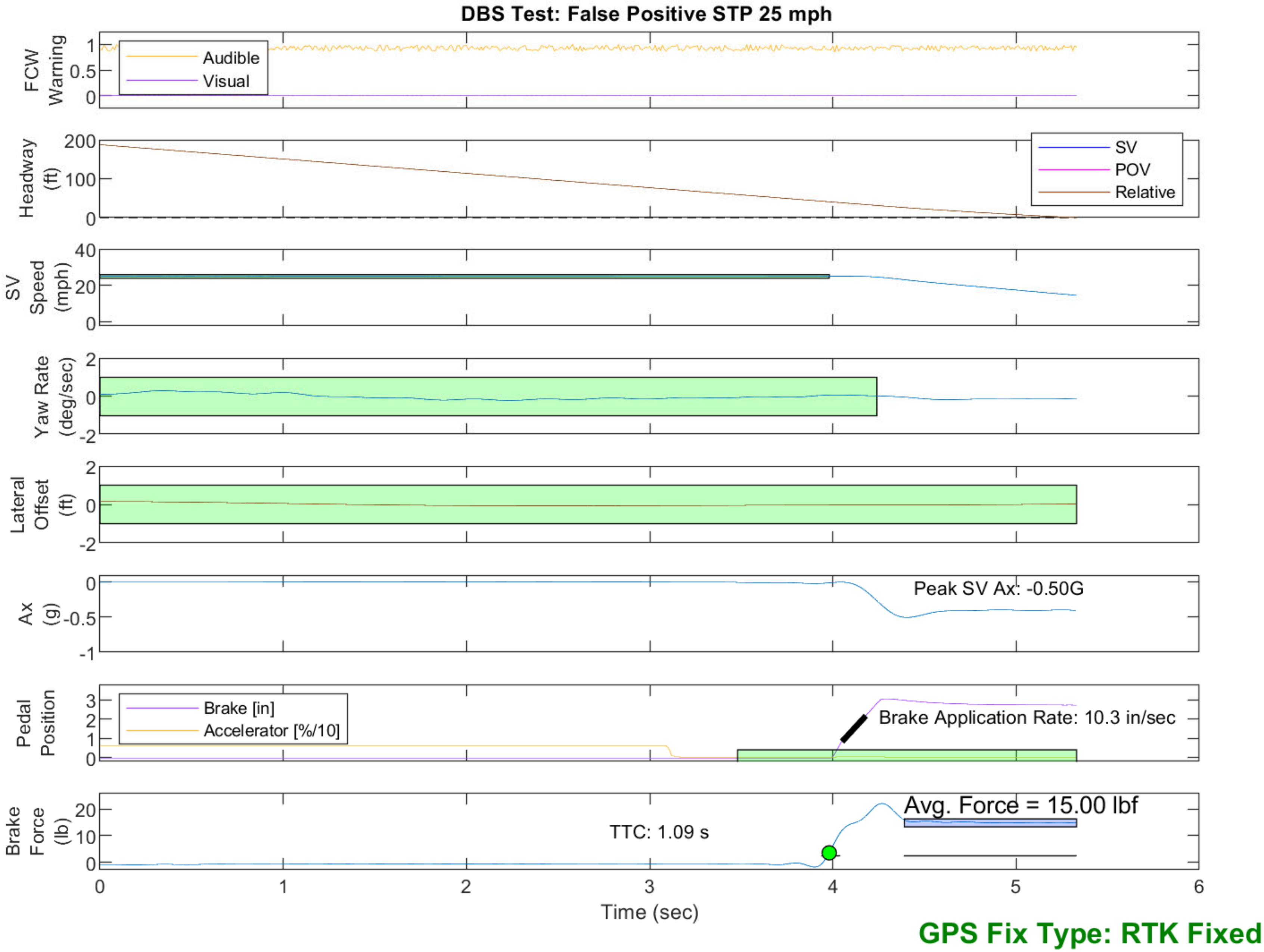

Figure E7. Example Time History for False Positive Steel Plate 25, Passing

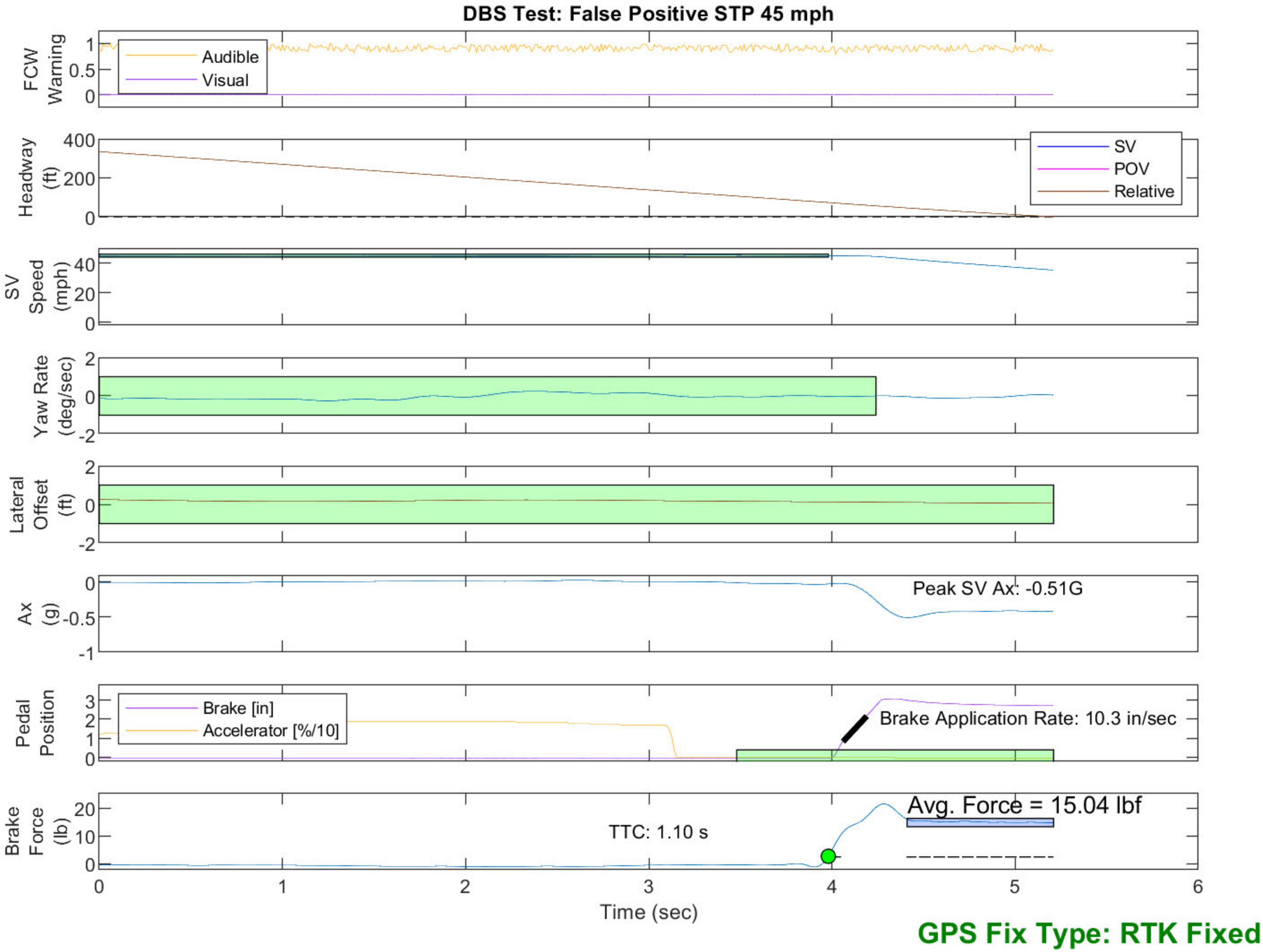

Figure E8. Example Time History for False Positive Steel Plate 45, Passing

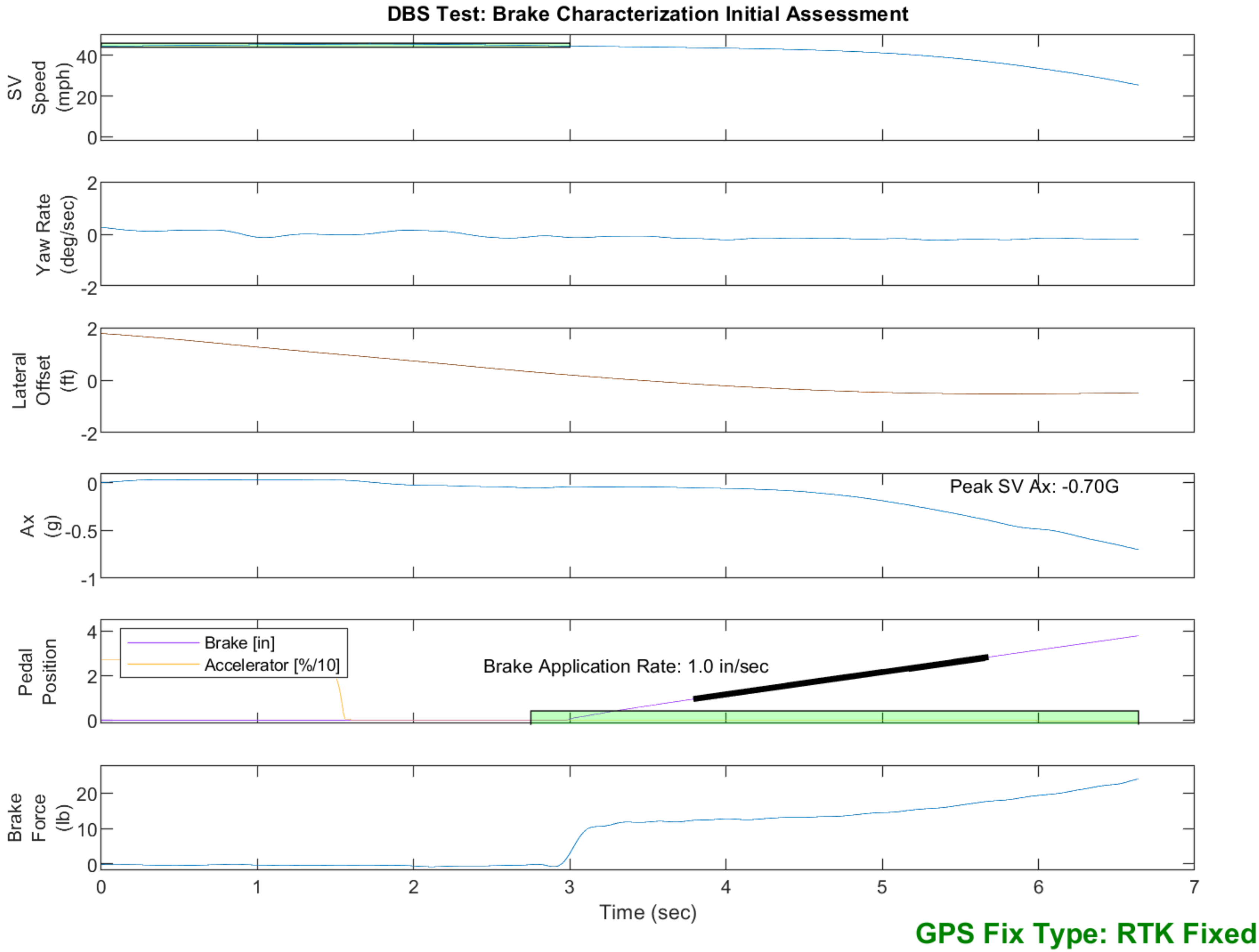

Figure E9. Example Time History for DBS Brake Characterization, Passing

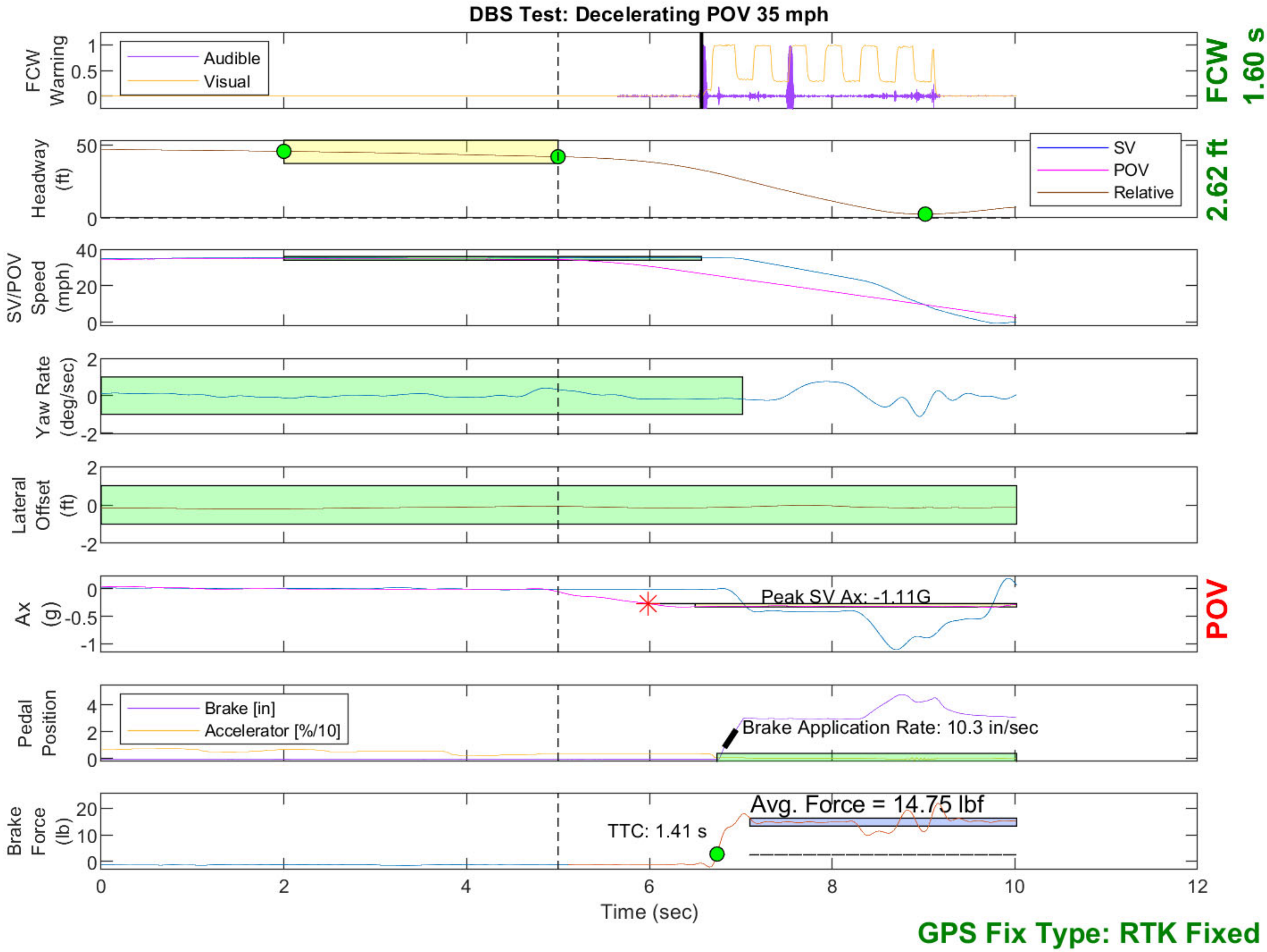

Figure E10. Example Time History Displaying Invalid POV Acceleration Criteria

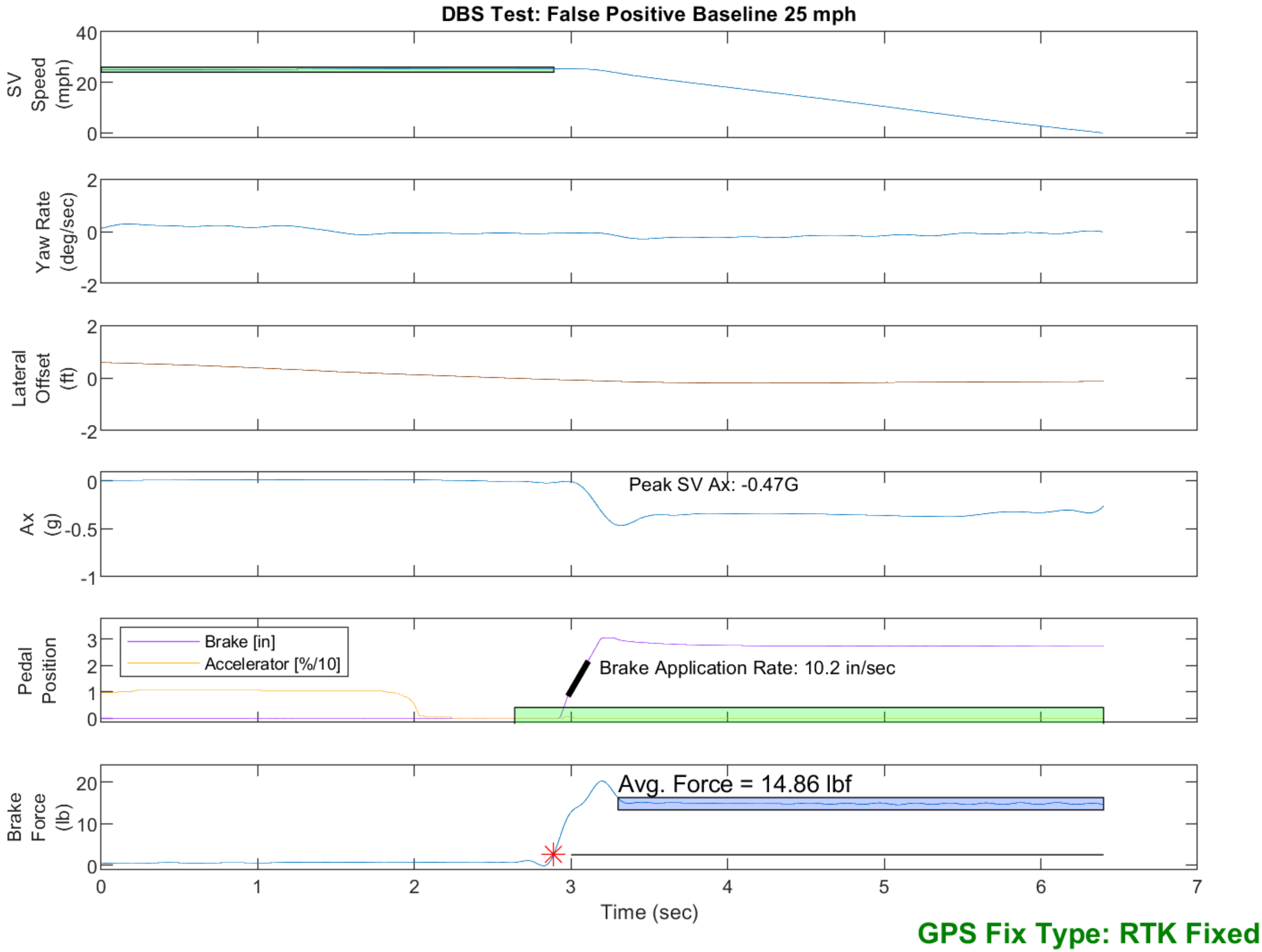

Figure E11. Example Time History Displaying Invalid Brake Force Criteria

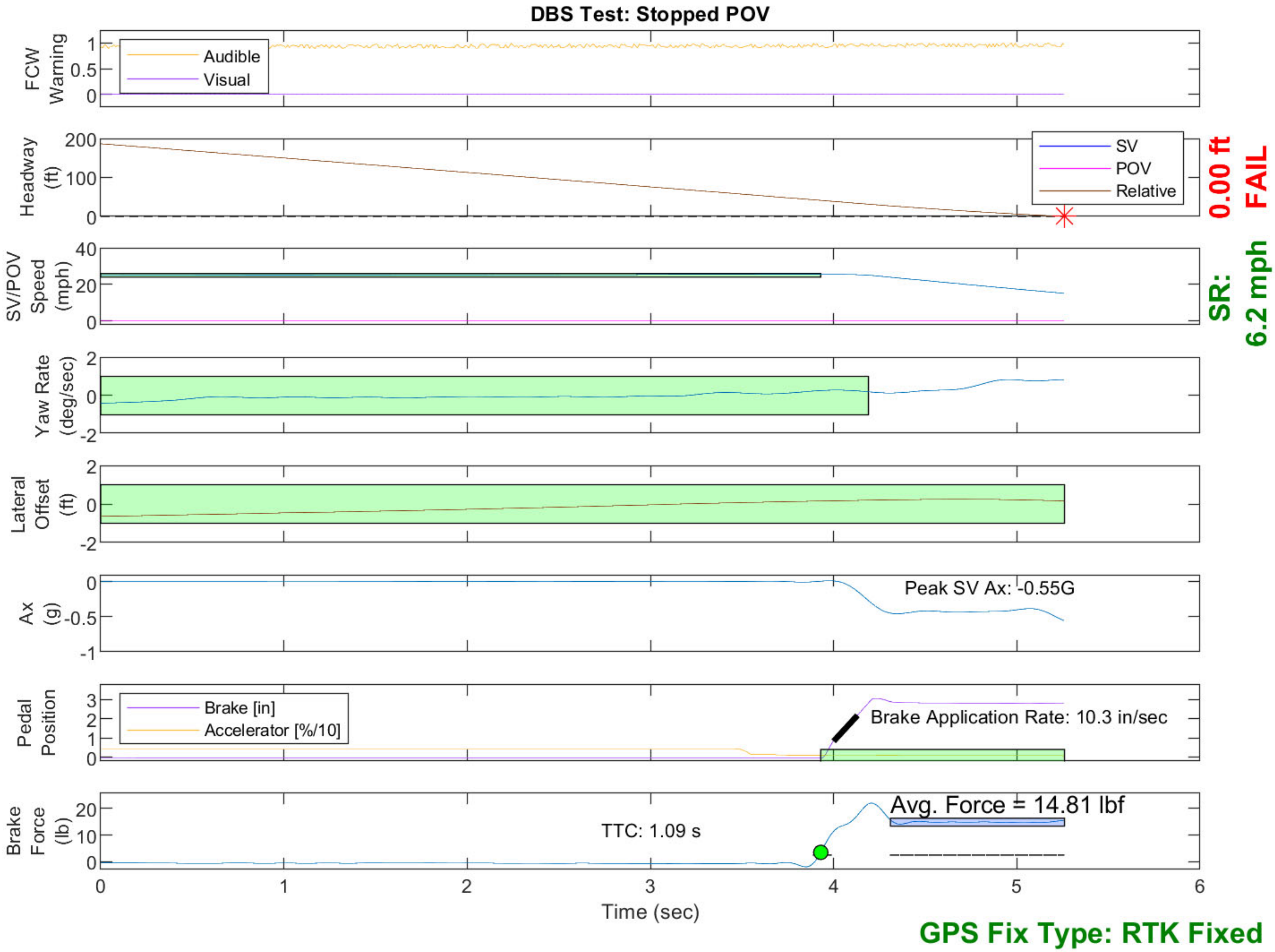

Figure E12. Example Time History for a Failed Run

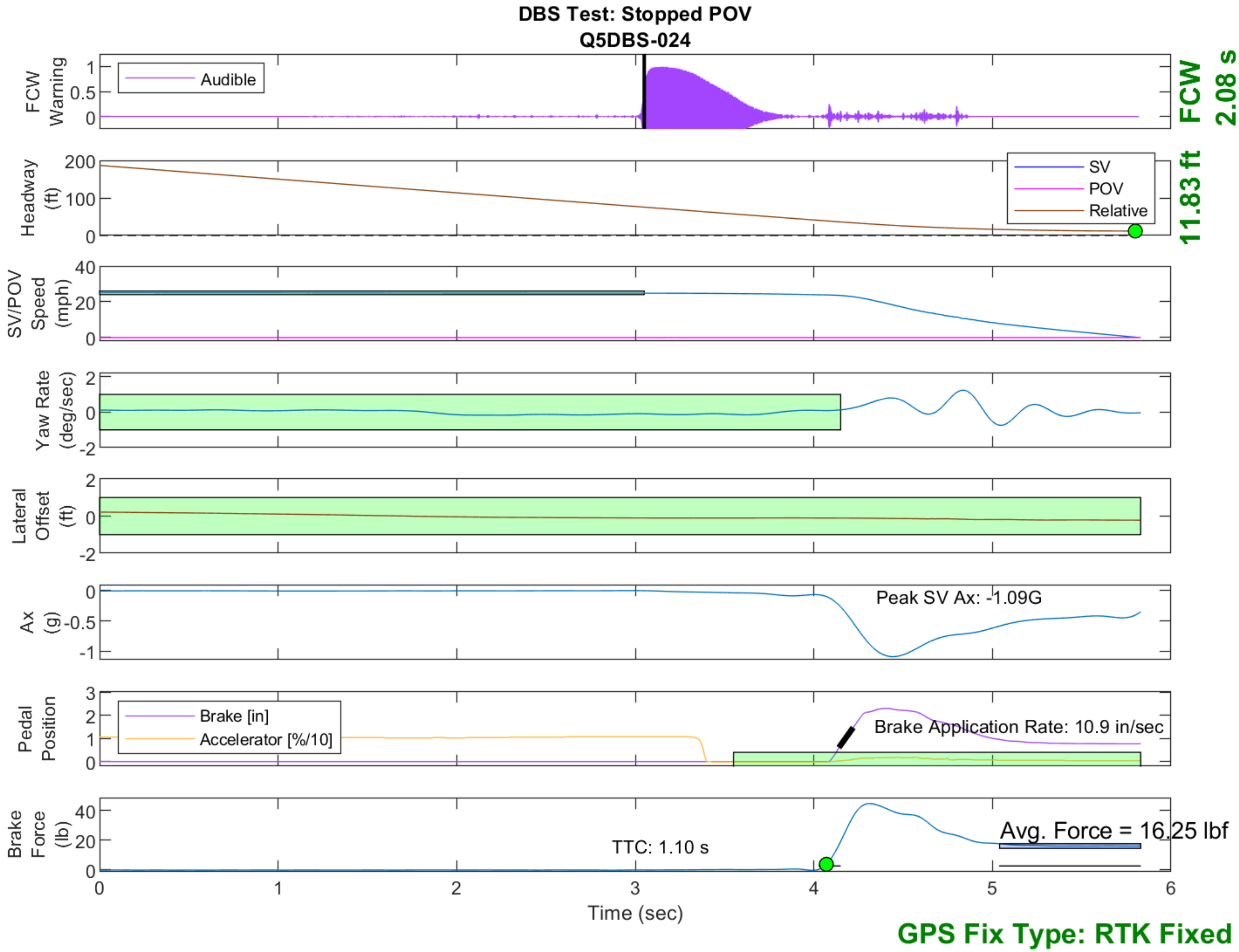

Figure E13. Time History for DBS Run 24, SV Encounters Stopped POV

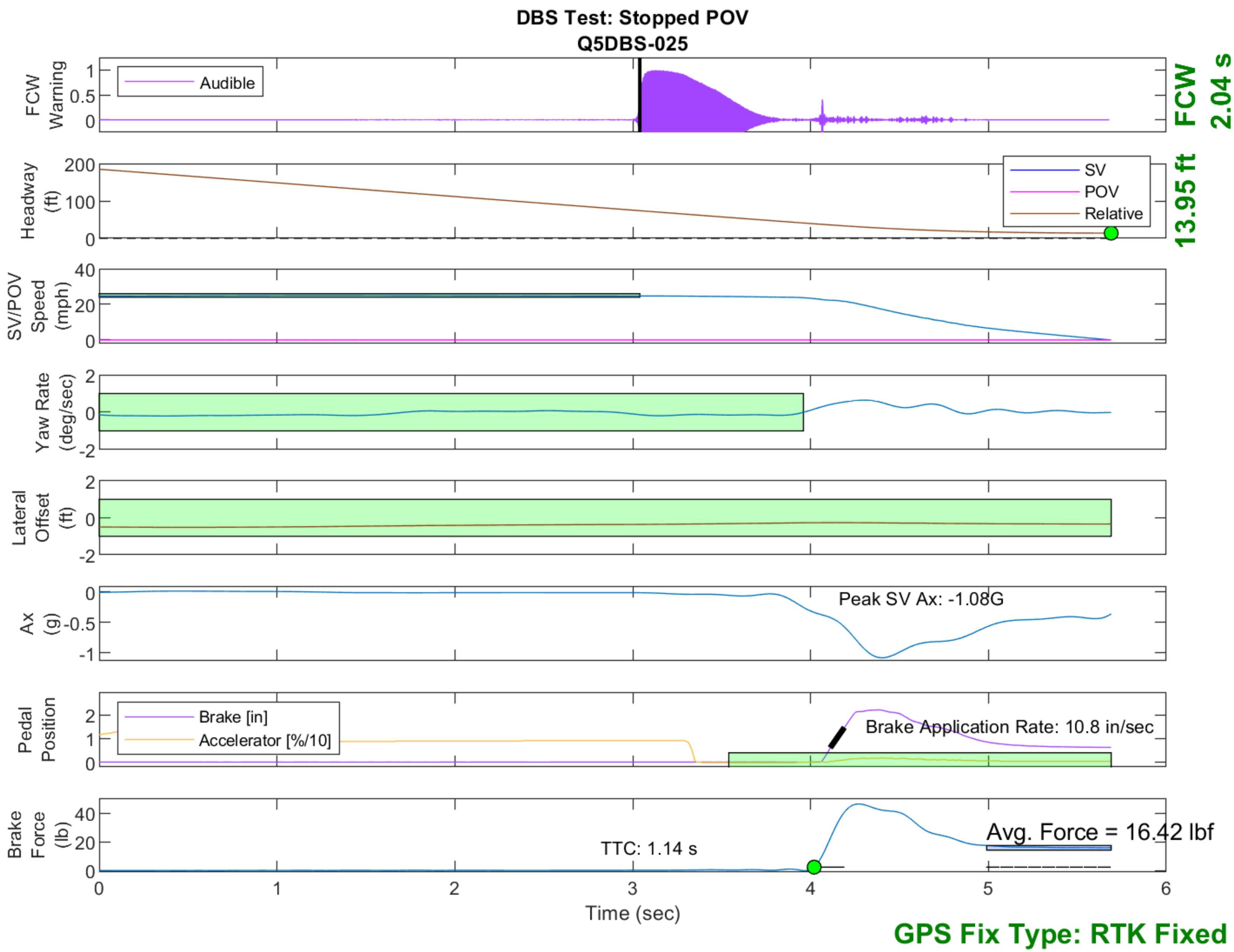

Figure E14. Time History for DBS Run 25, SV Encounters Stopped POV

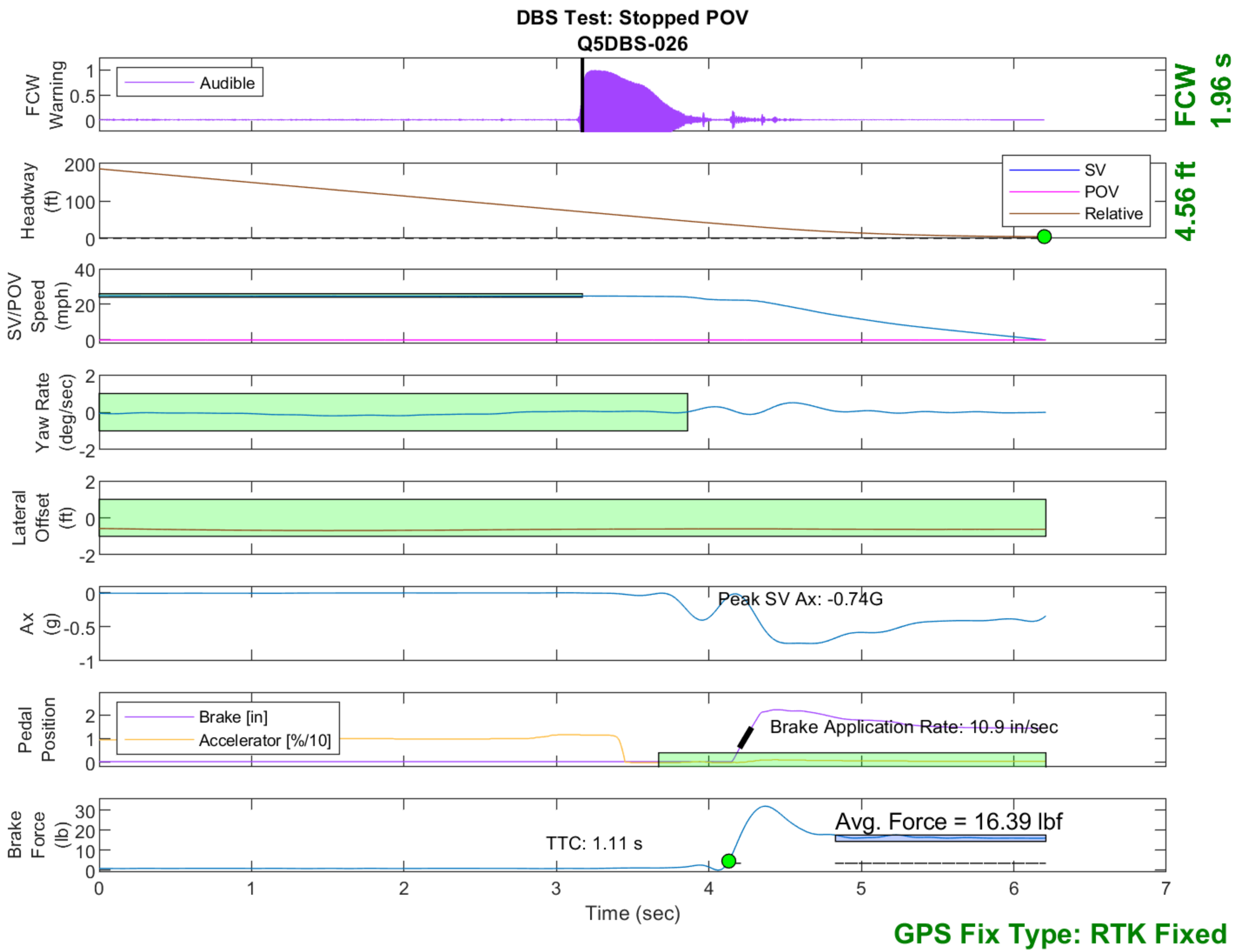

Figure E15. Time History for DBS Run 26, SV Encounters Stopped POV

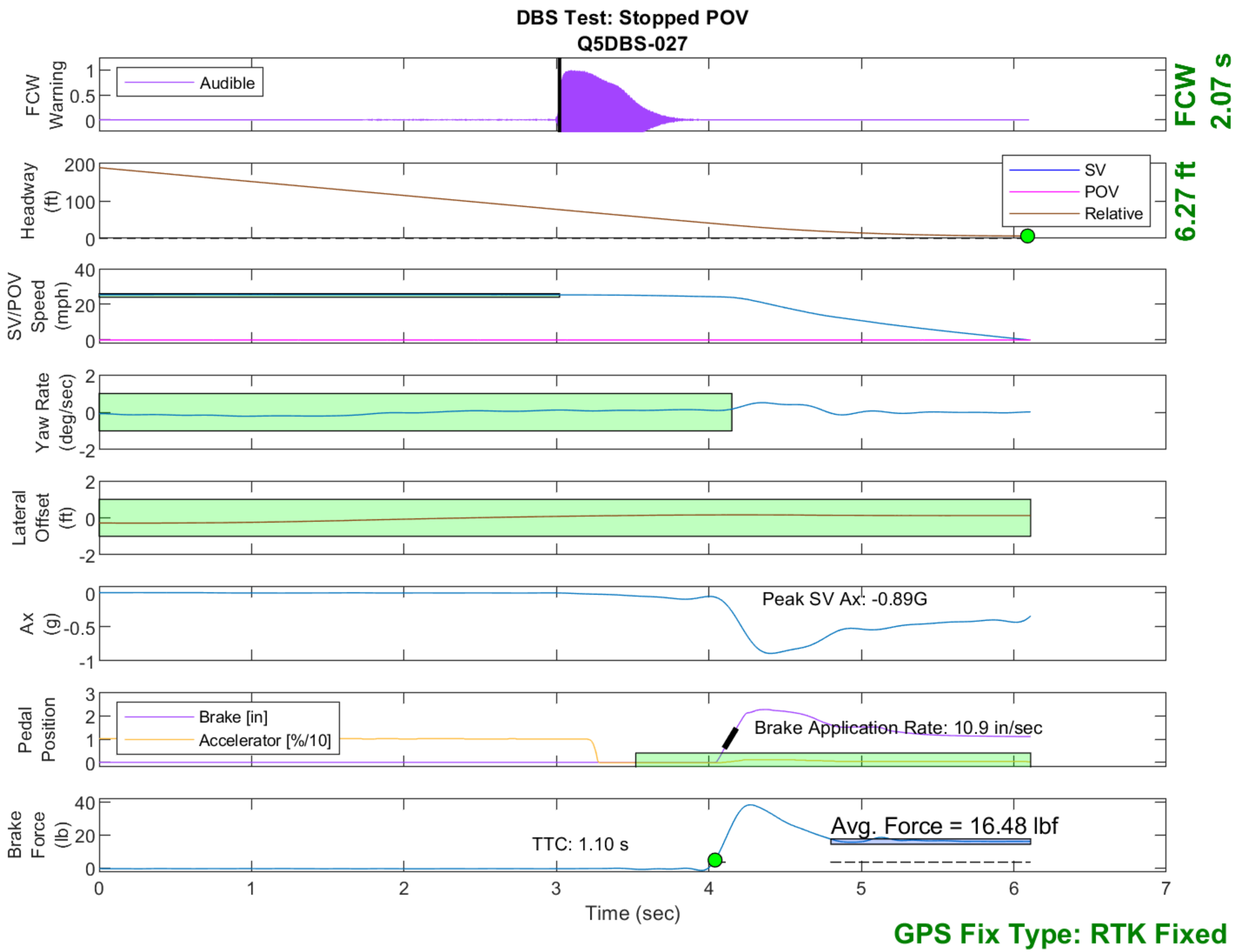

Figure E16. Time History for DBS Run 27, SV Encounters Stopped POV

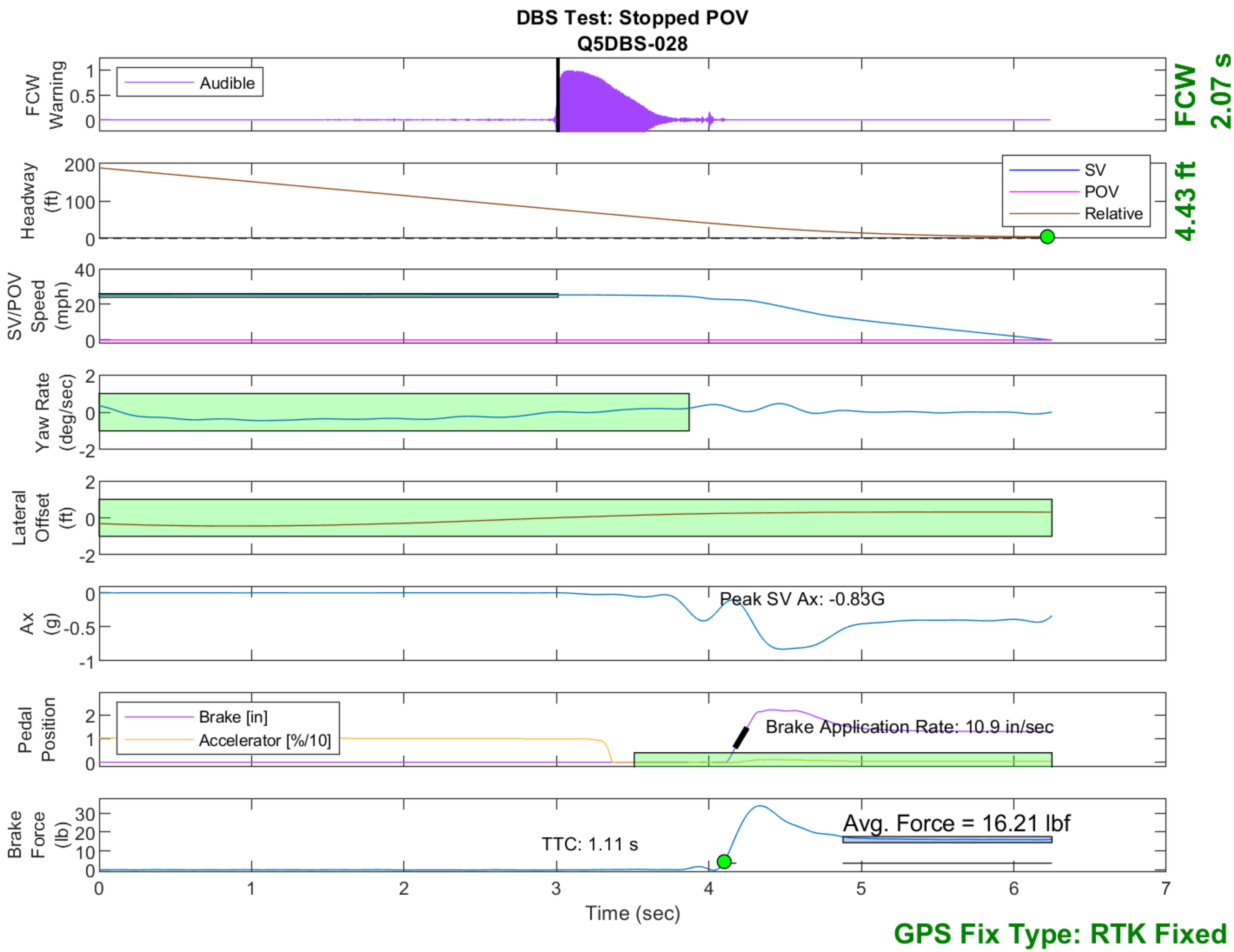

Figure E17. Time History for DBS Run 28, SV Encounters Stopped POV

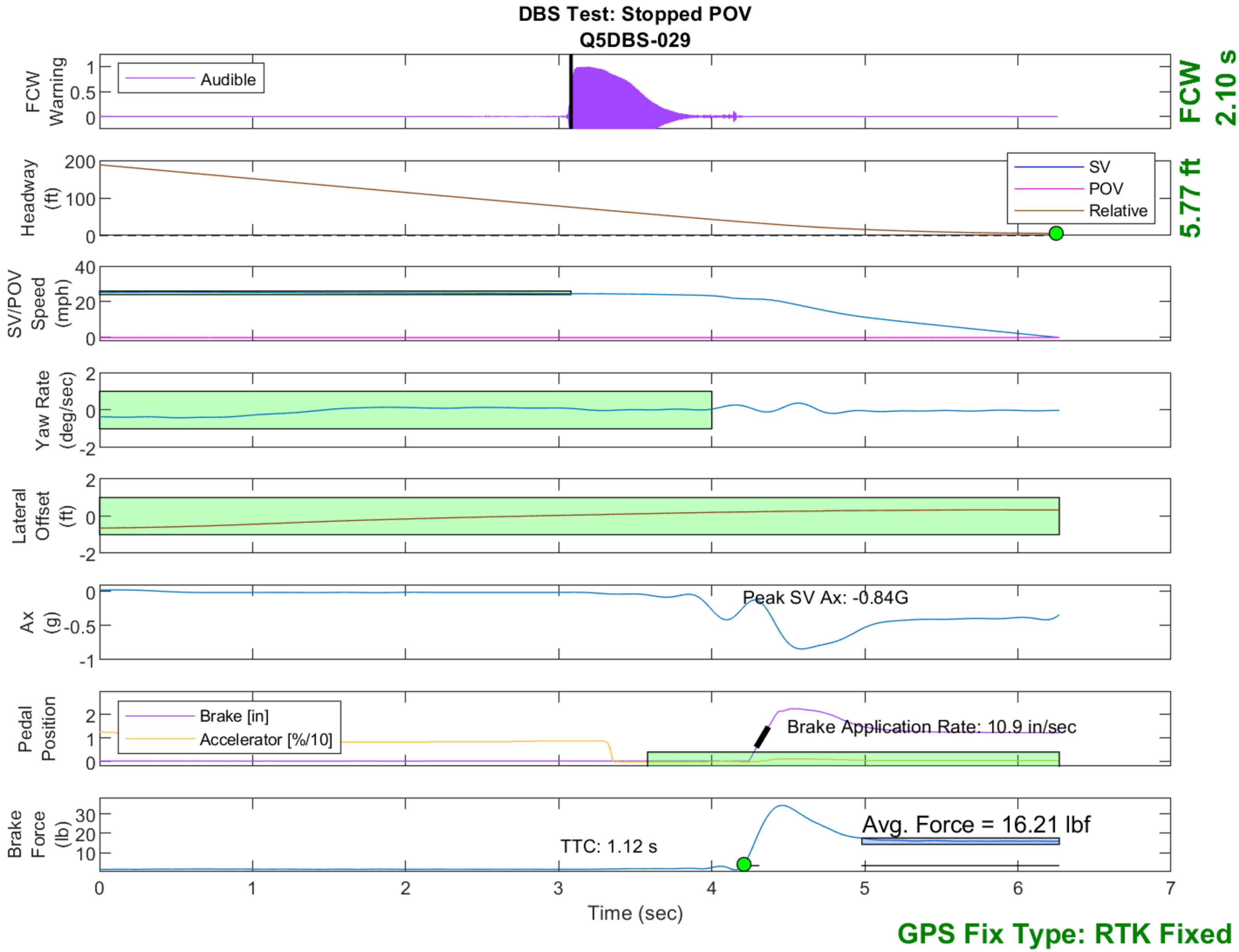

Figure E18. Time History for DBS Run 29, SV Encounters Stopped POV

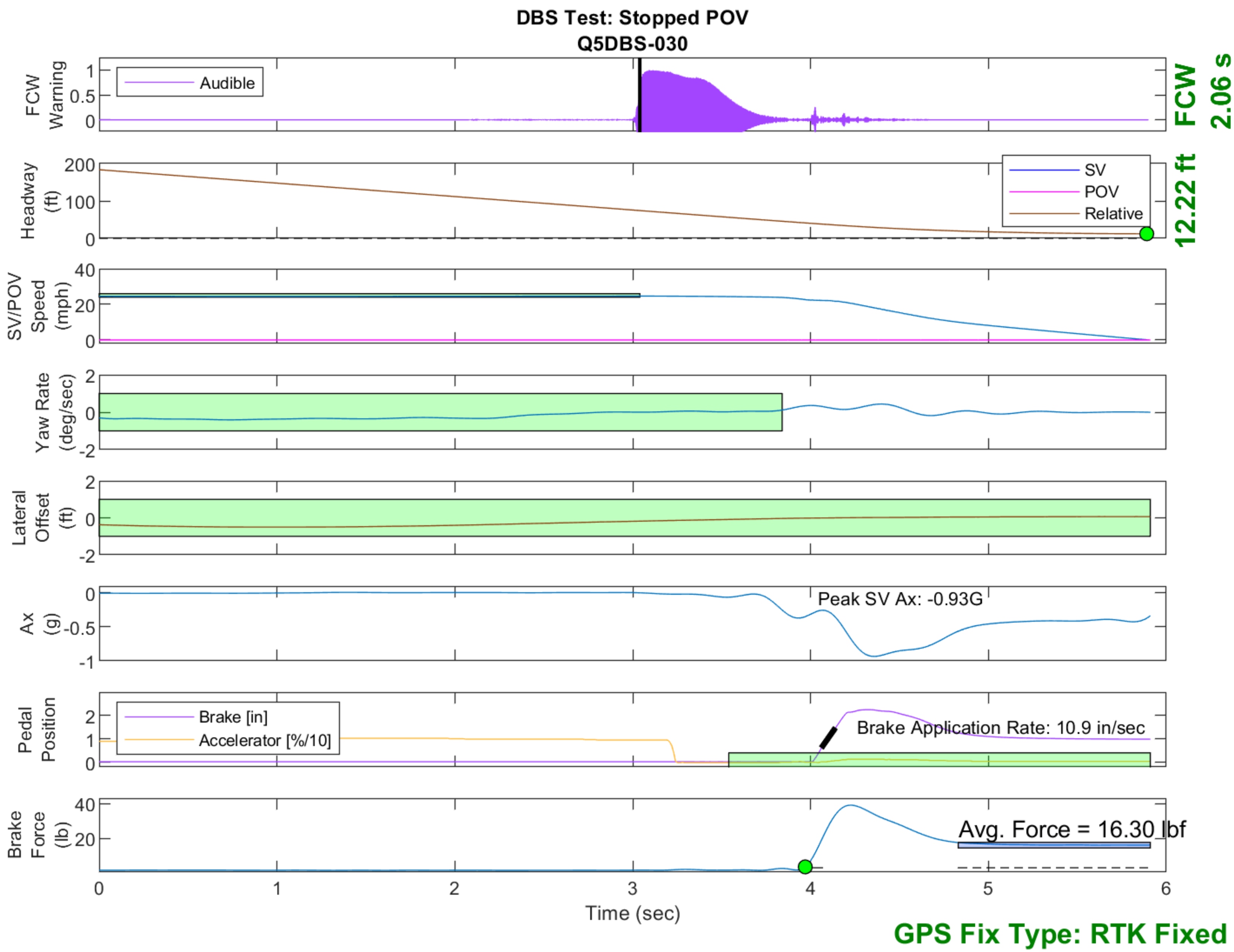

Figure E19. Time History for DBS Run 30, SV Encounters Stopped POV

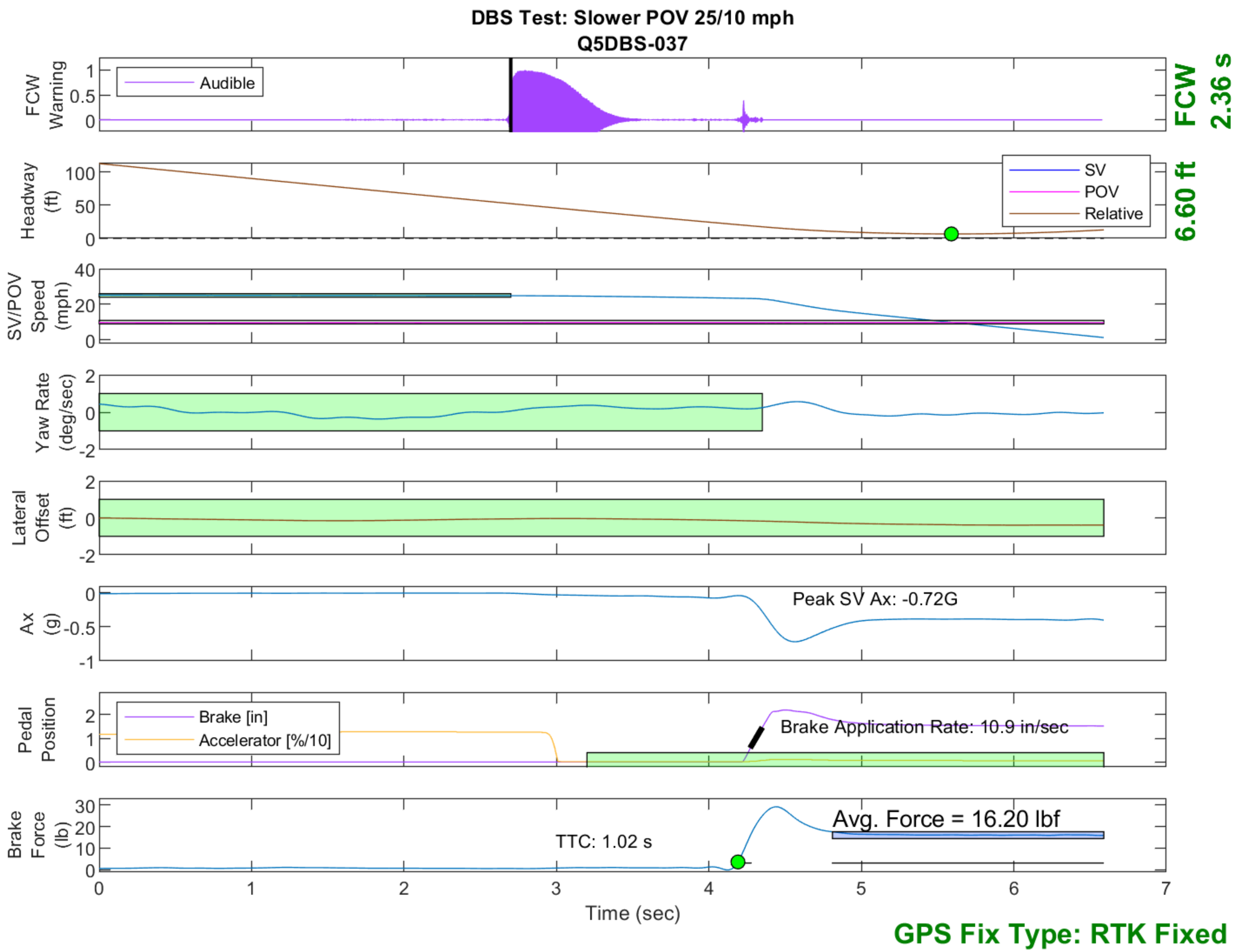

Figure E20. Time History for DBS Run 37, SV Encounters Slower POV, SV 25 mph, POV 10 mph

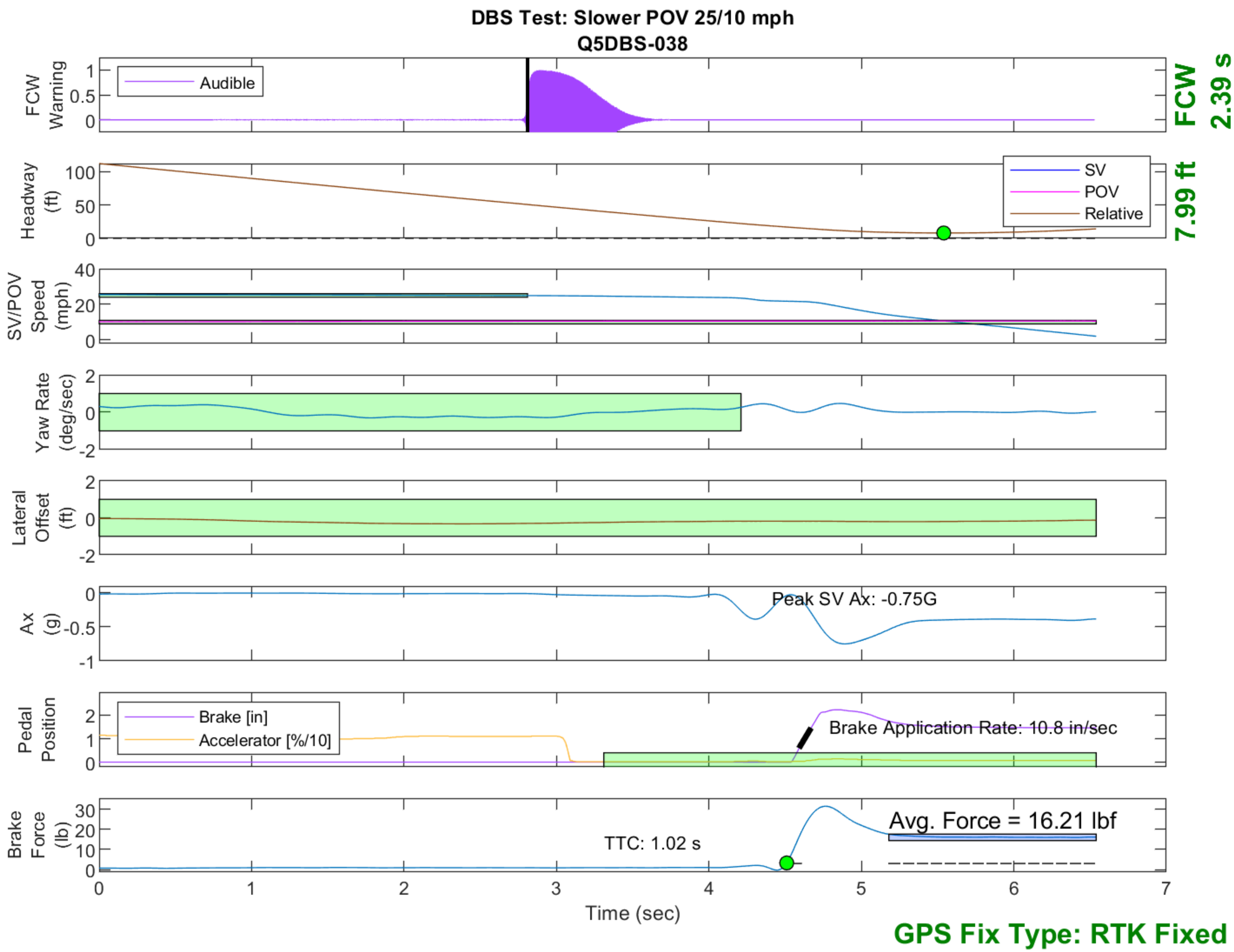

Figure E21. Time History for DBS Run 38, SV Encounters Slower POV, SV 25 mph, POV 10 mph

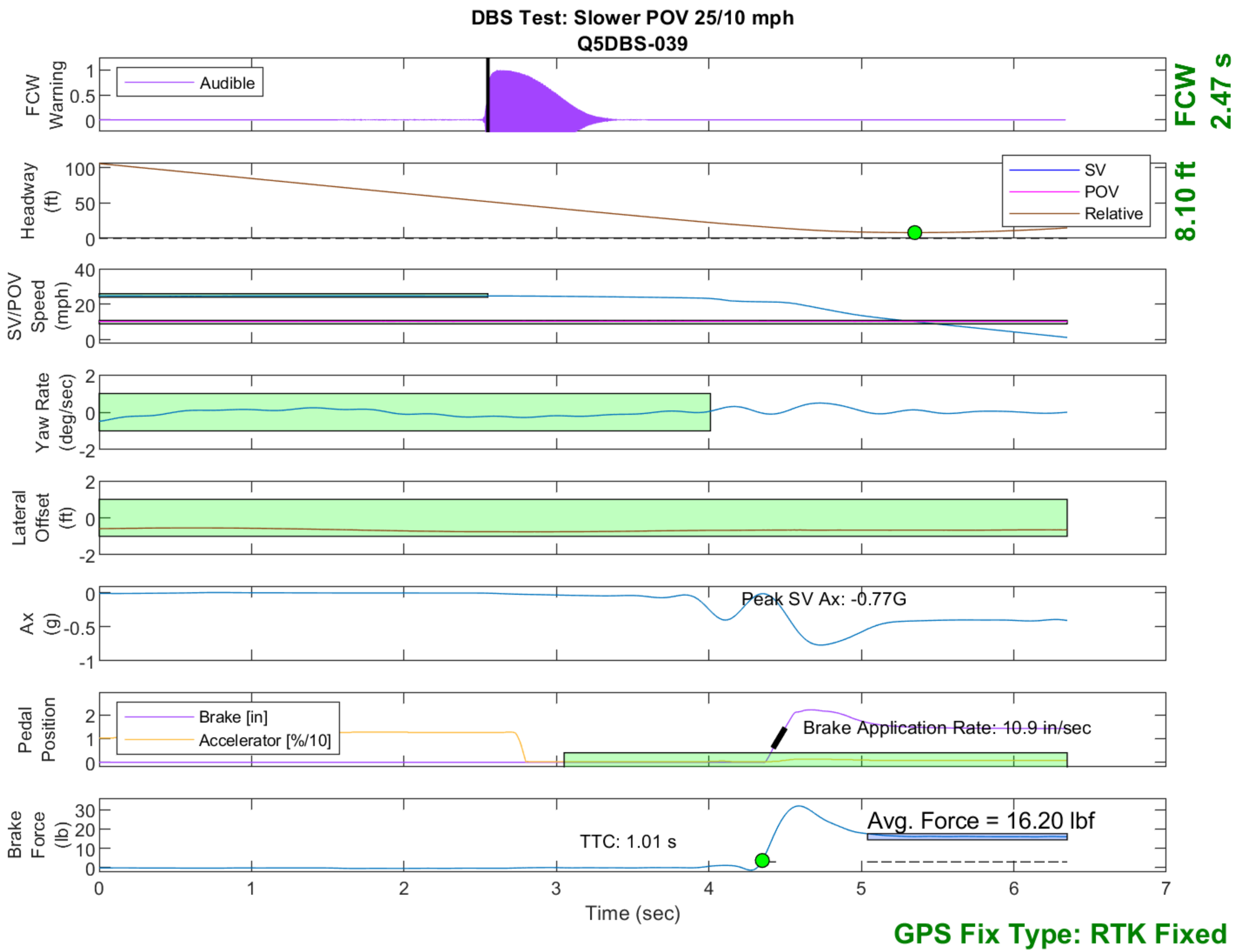

Figure E22. Time History for DBS Run 39, SV Encounters Slower POV, SV 25 mph, POV 10 mph

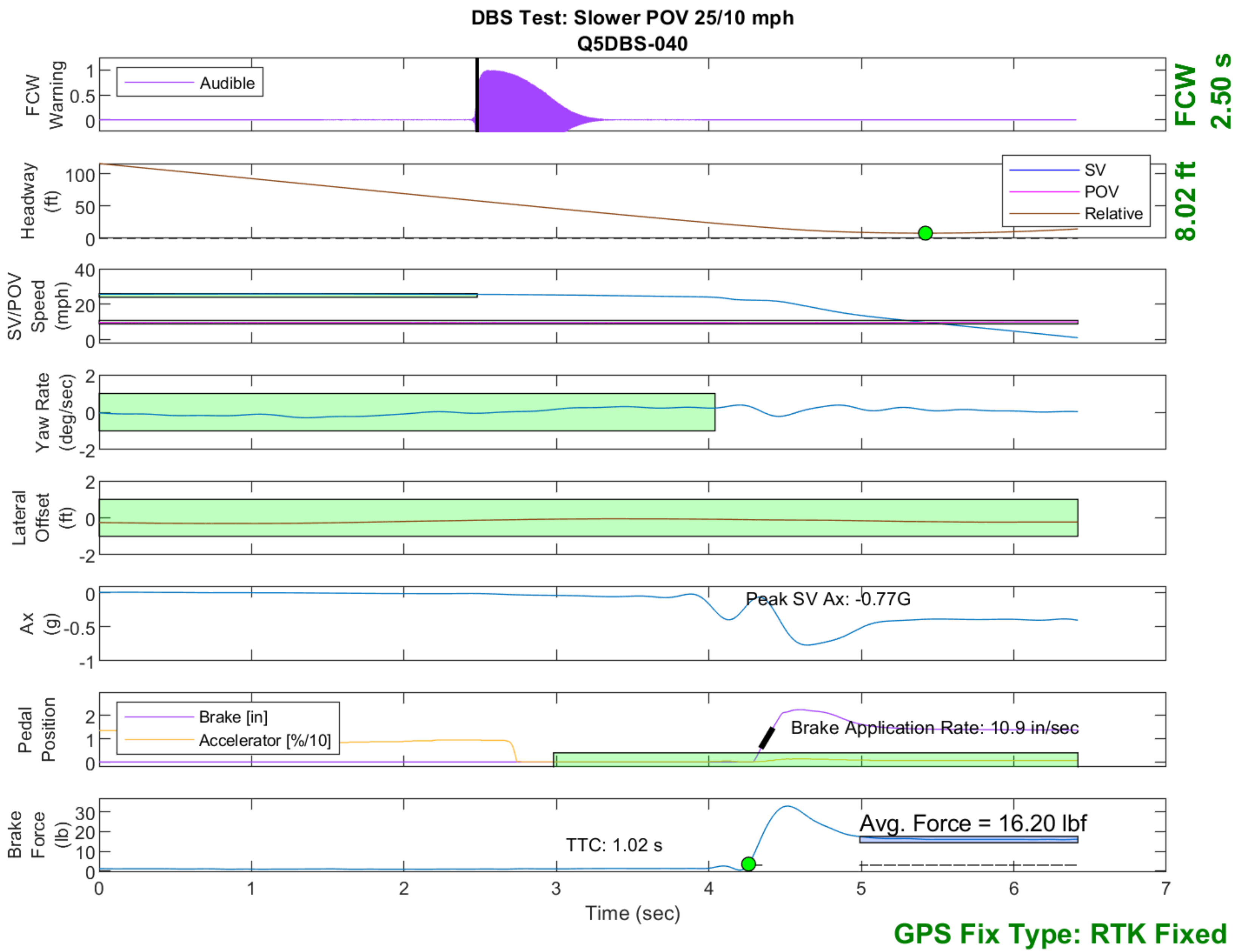

Figure E23. Time History for DBS Run 40, SV Encounters Slower POV, SV 25 mph, POV 10 mph

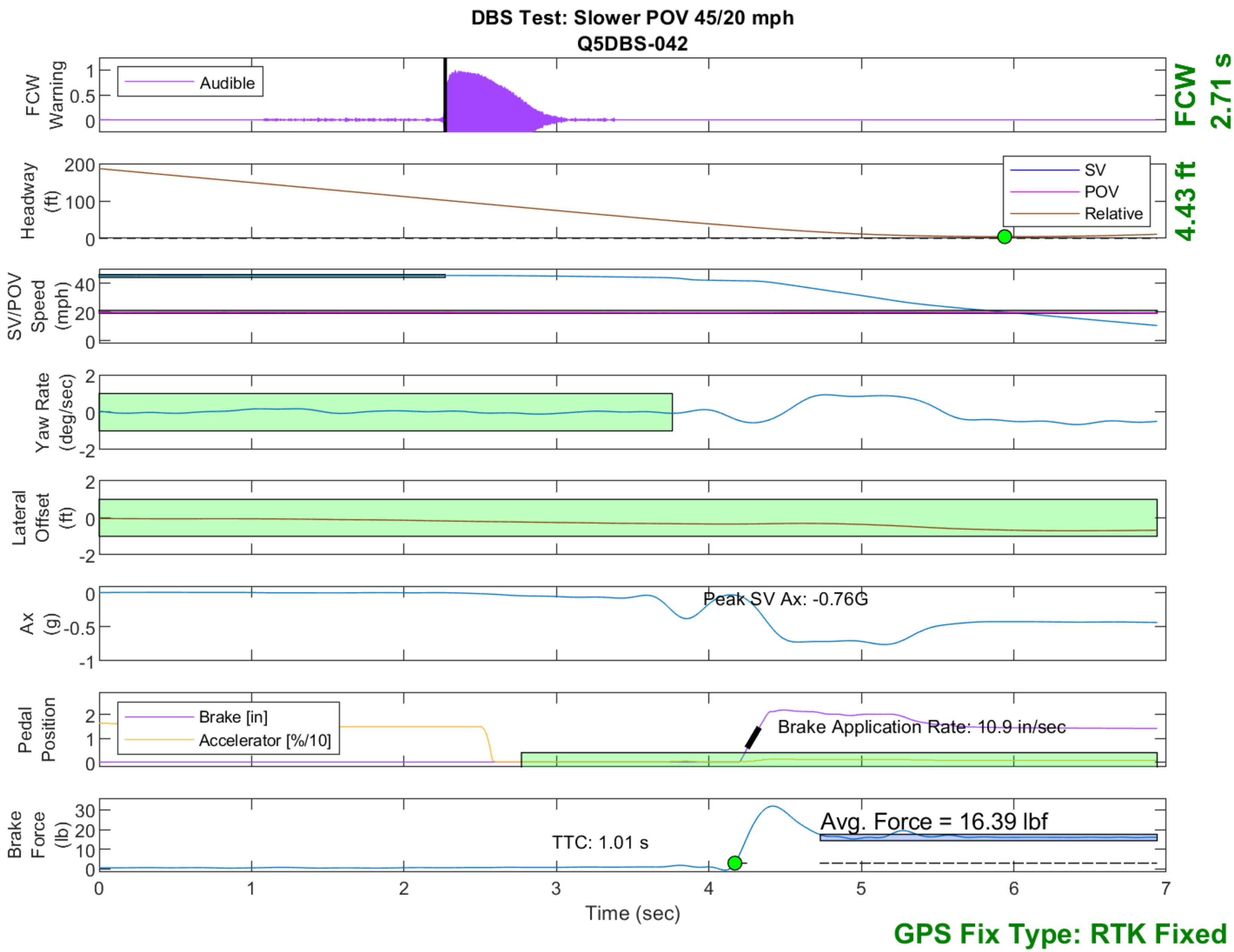

Figure E24. Time History for DBS Run 42, SV Encounters Slower POV, SV 45 mph, POV 20 mph

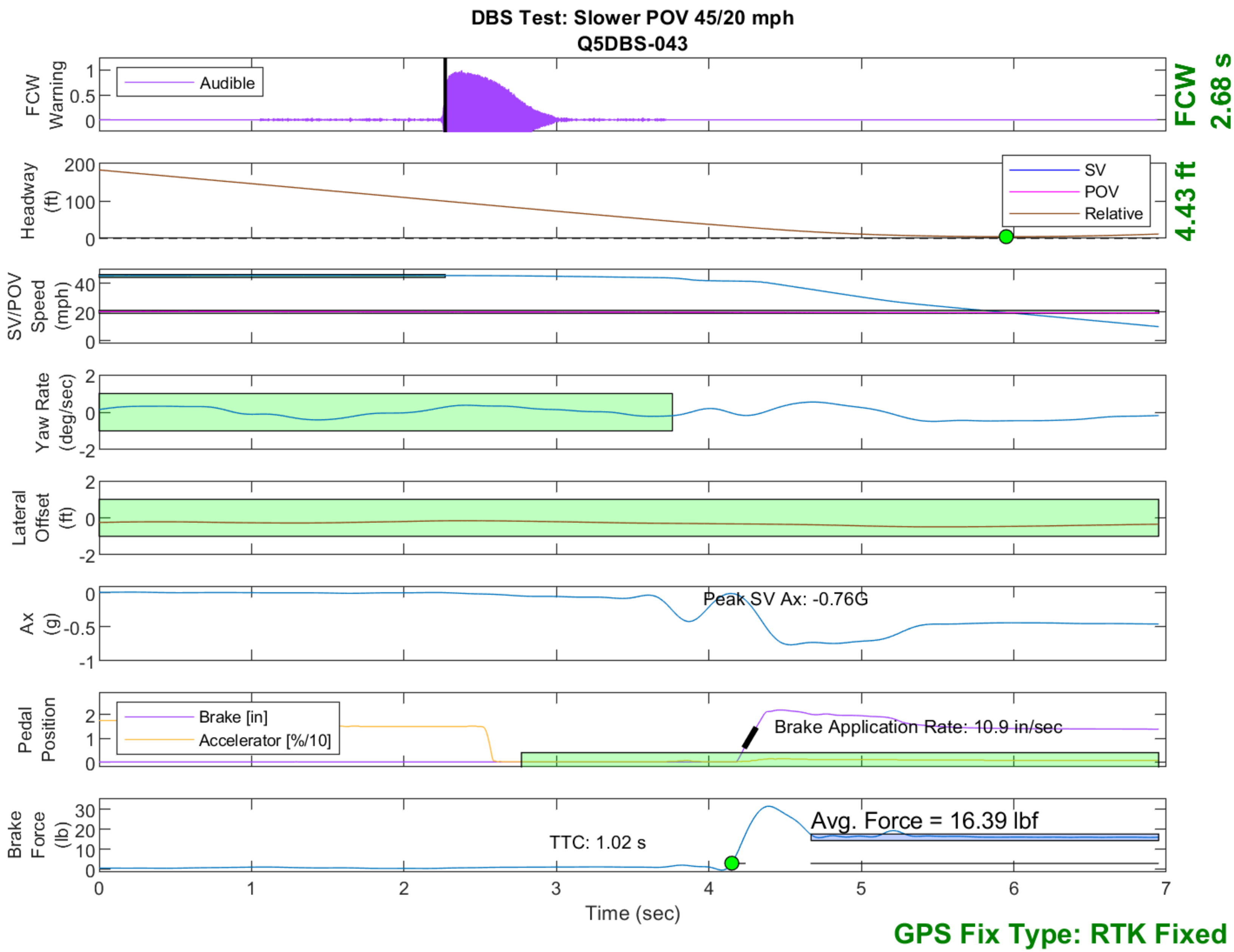

Figure E25. Time History for DBS Run 43, SV Encounters Slower POV, SV 45 mph, POV 20 mph

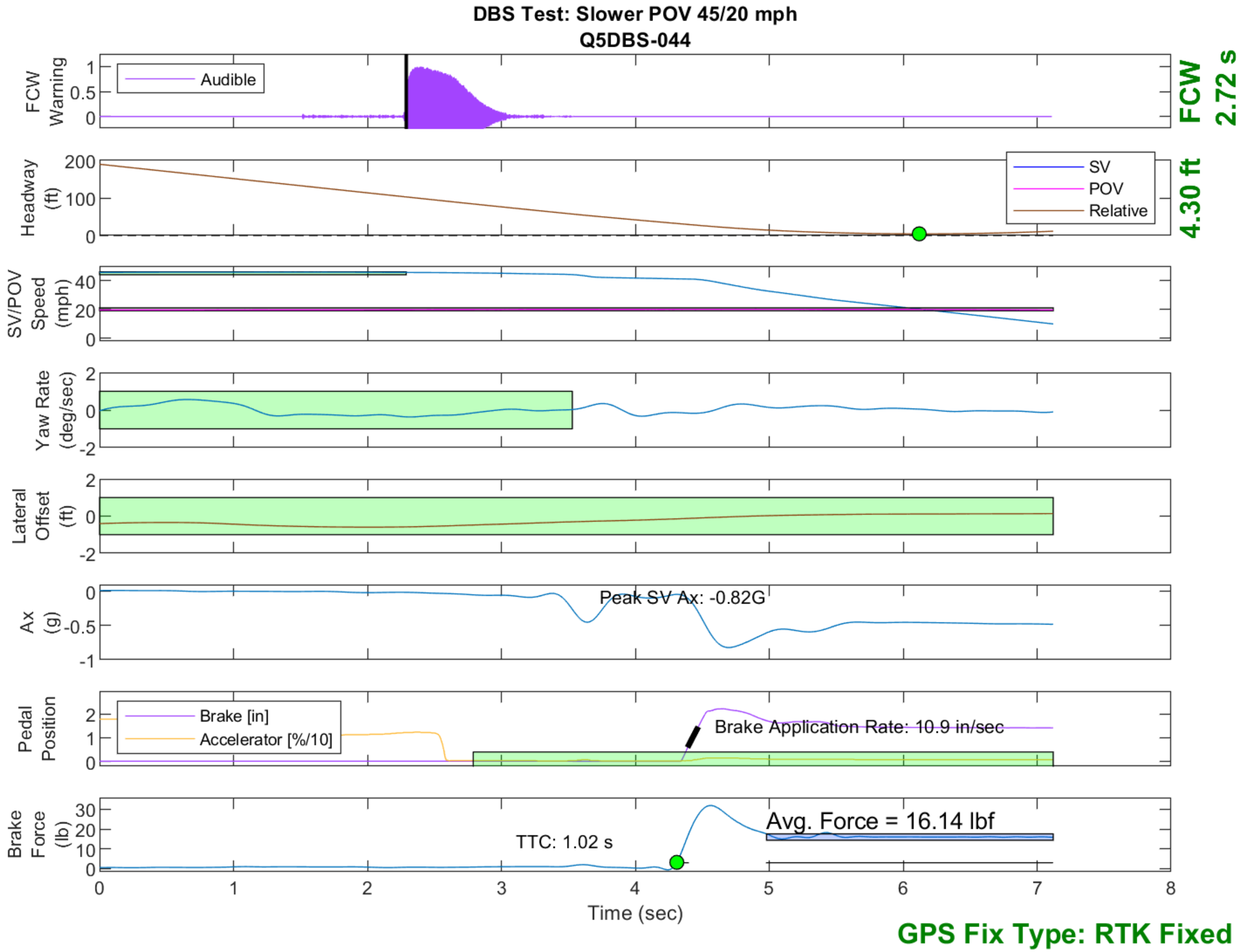

Figure E26. Time History for DBS Run 44, SV Encounters Slower POV, SV 45 mph, POV 20 mph

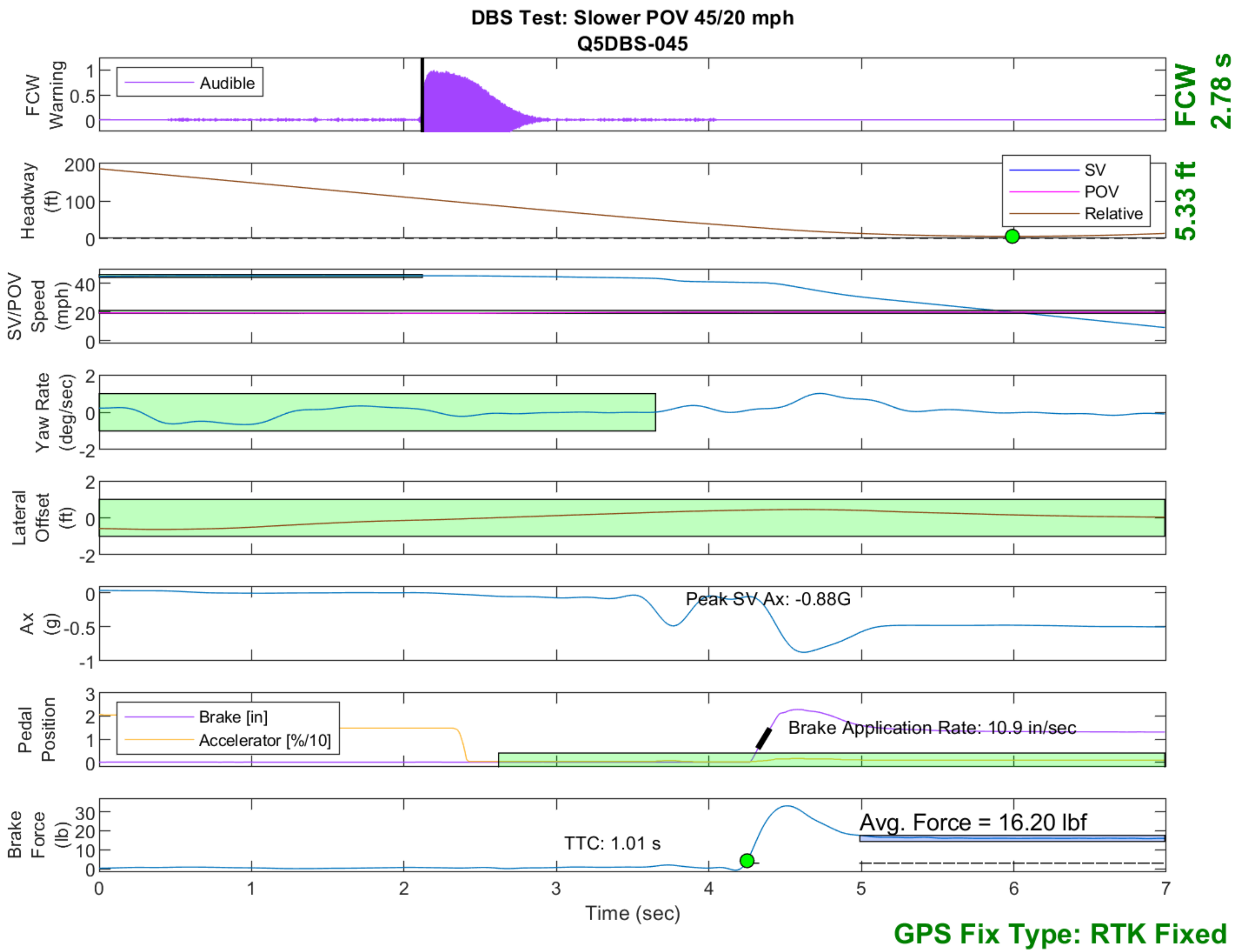

Figure E27. Time History for DBS Run 45, SV Encounters Slower POV, SV 45 mph, POV 20 mph

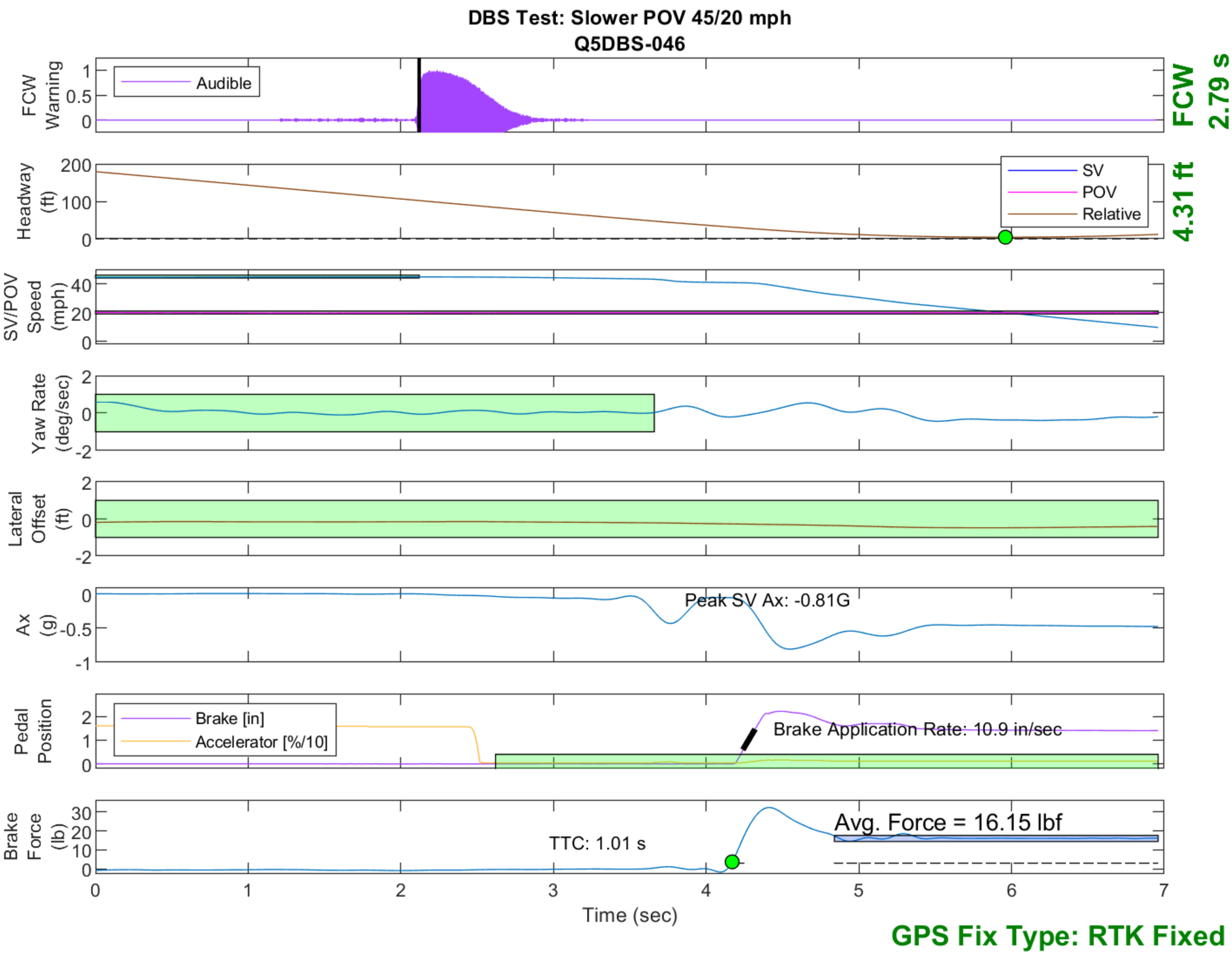

Figure E28. Time History for DBS Run 46, SV Encounters Slower POV, SV 45 mph, POV 20 mph

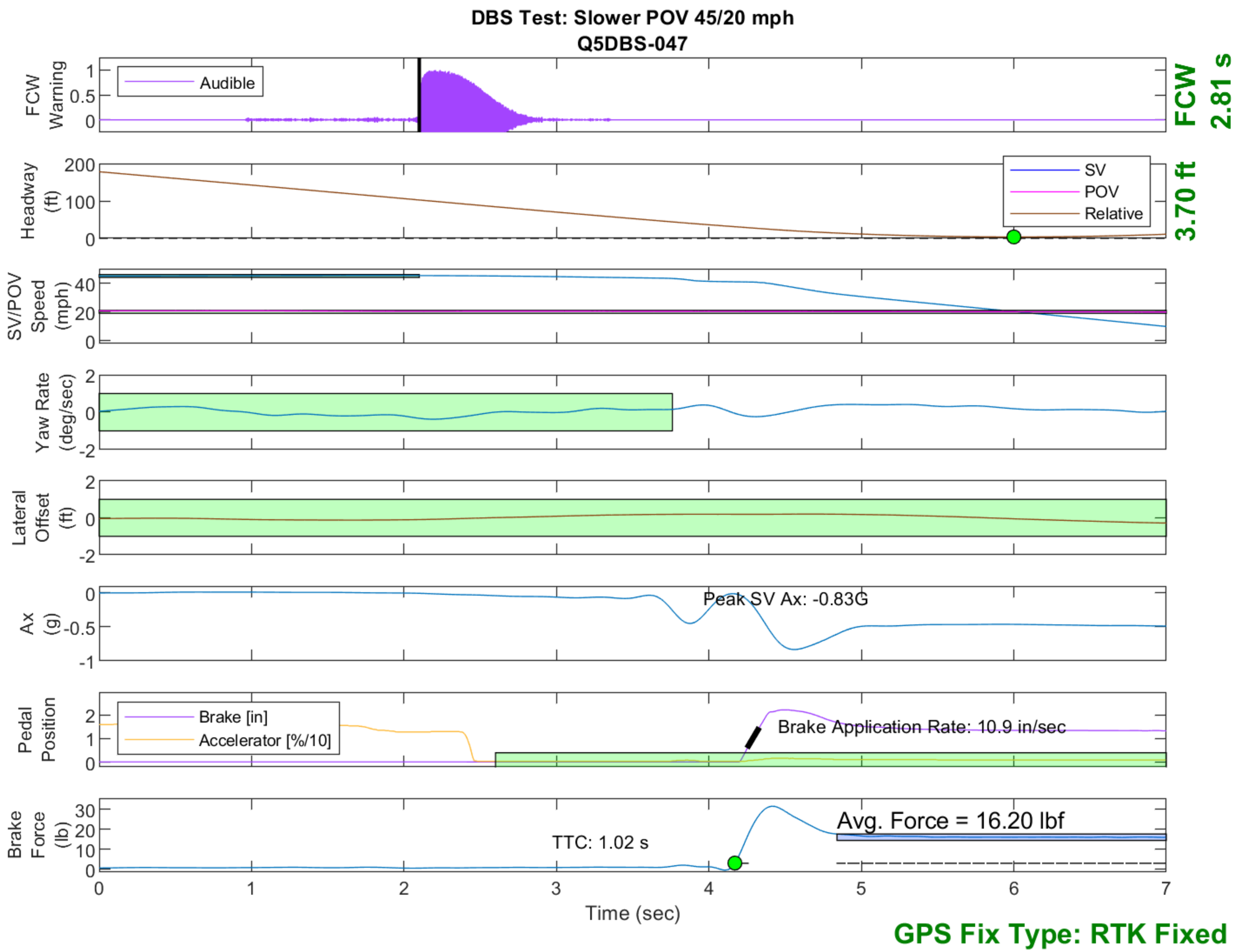

Figure E29. Time History for DBS Run 47, SV Encounters Slower POV, SV 45 mph, POV 20 mph

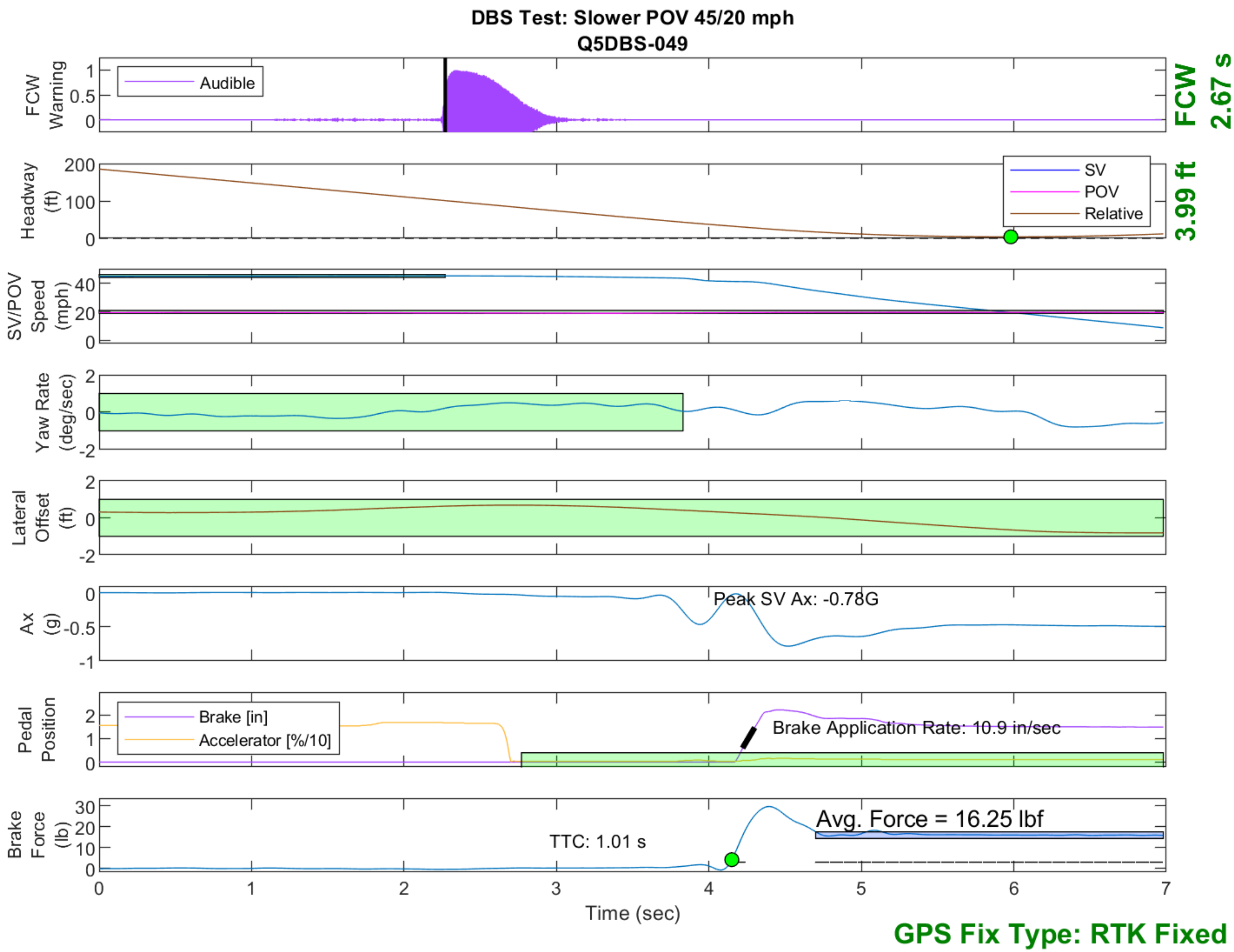

Figure E30. Time History for DBS Run 49, SV Encounters Slower POV, SV 45 mph, POV 20 mph

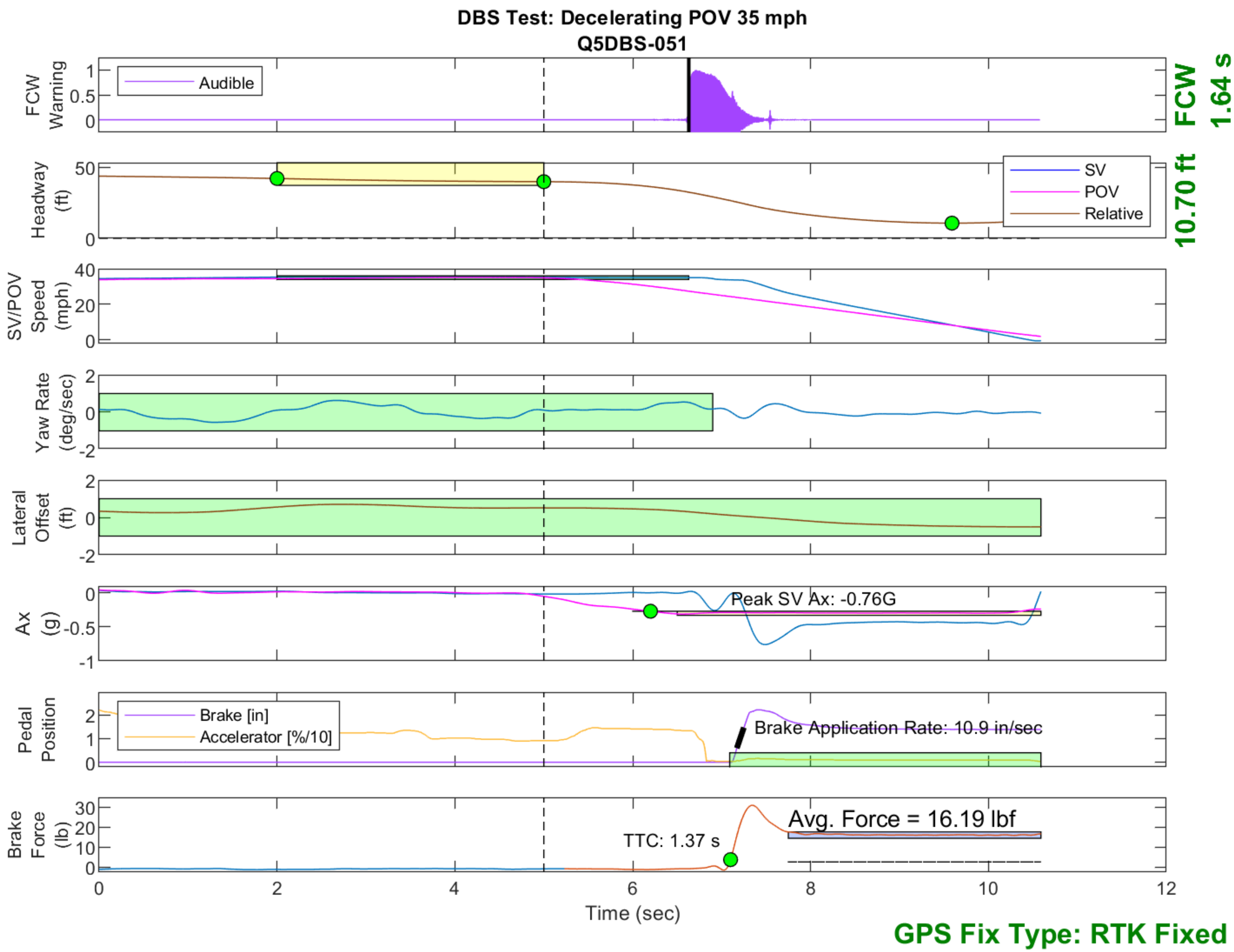

Figure E31. Time History for DBS Run 51, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

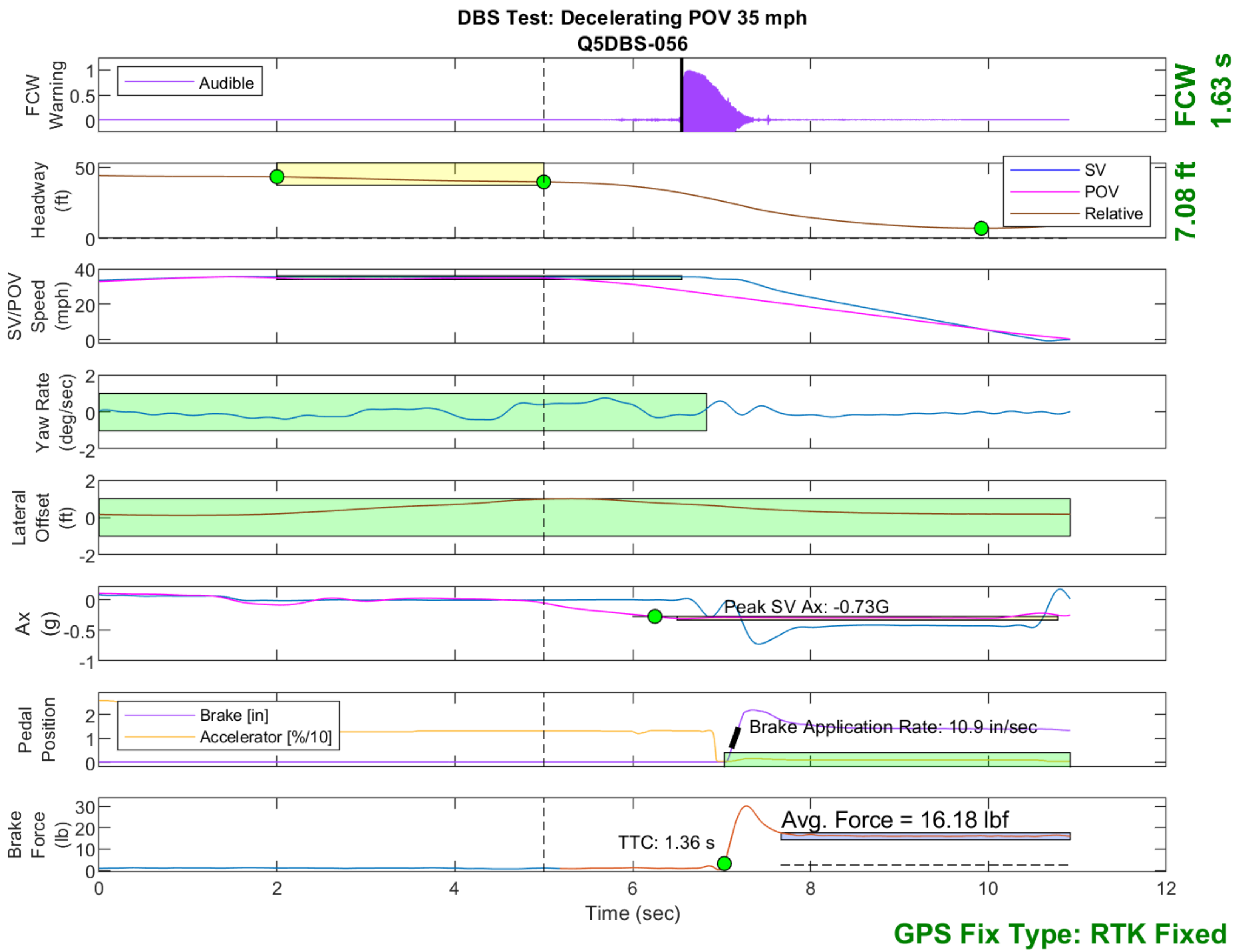

Figure E32. Time History for DBS Run 56, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

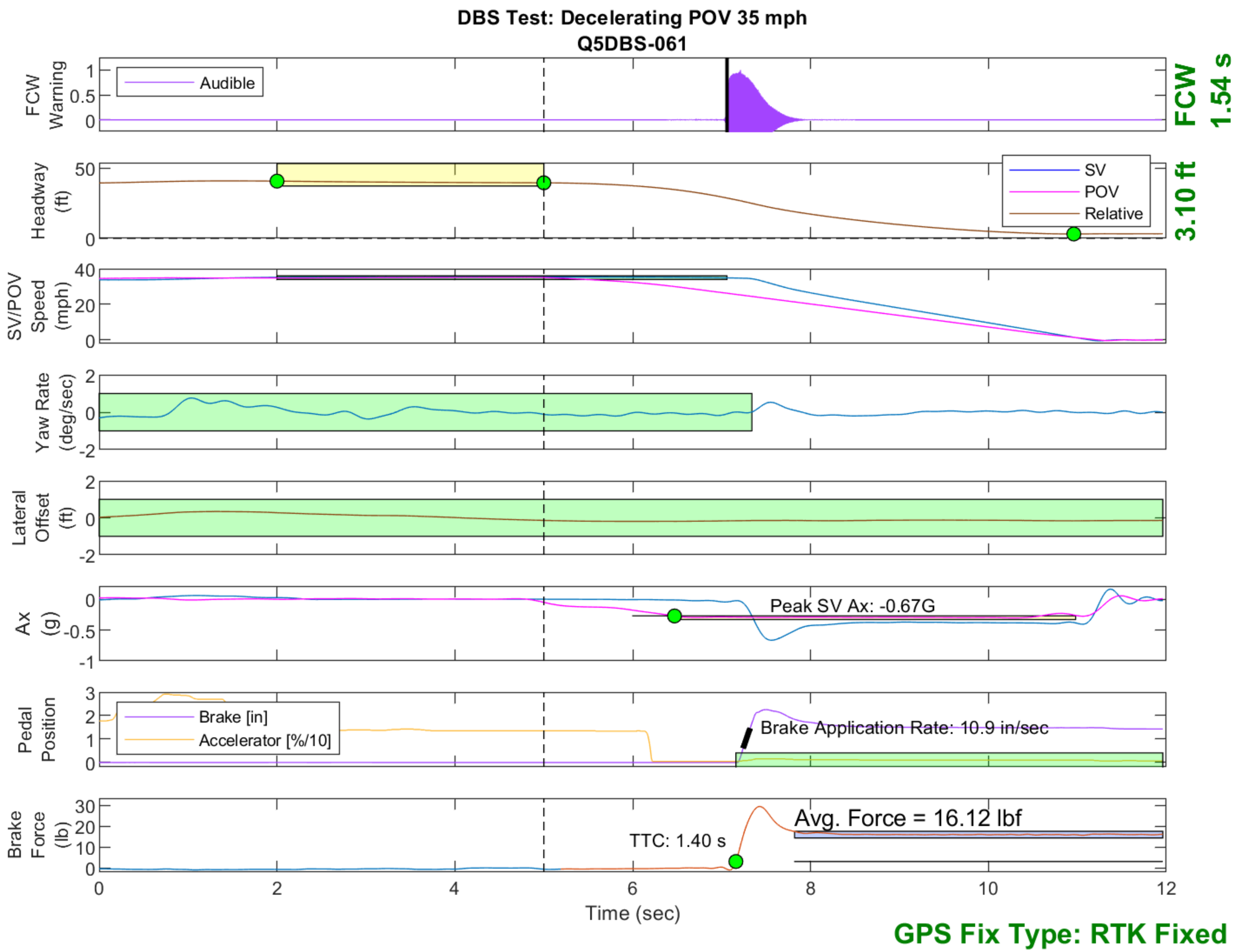

Figure E33. Time History for DBS Run 61, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

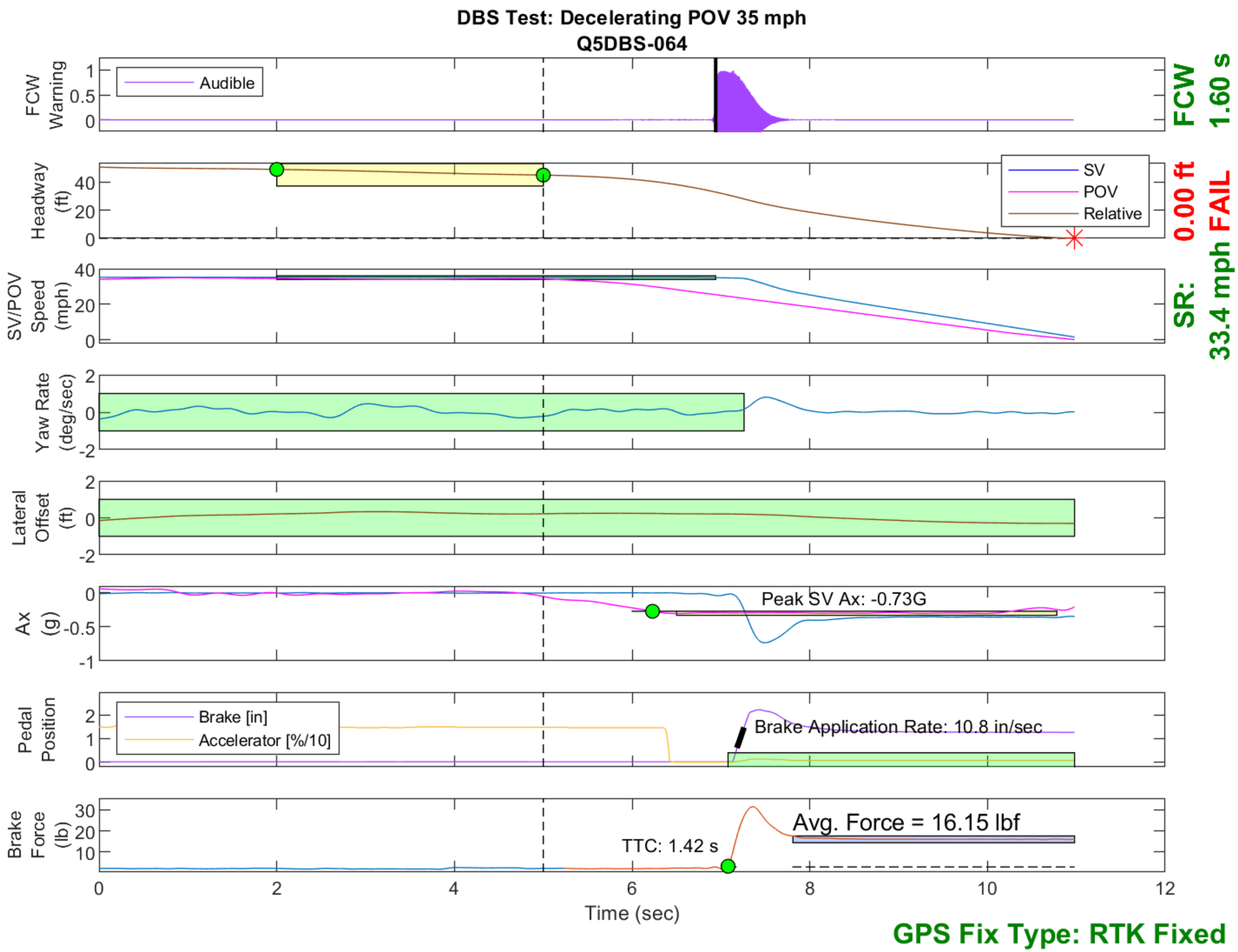

Figure E34. Time History for DBS Run 64, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

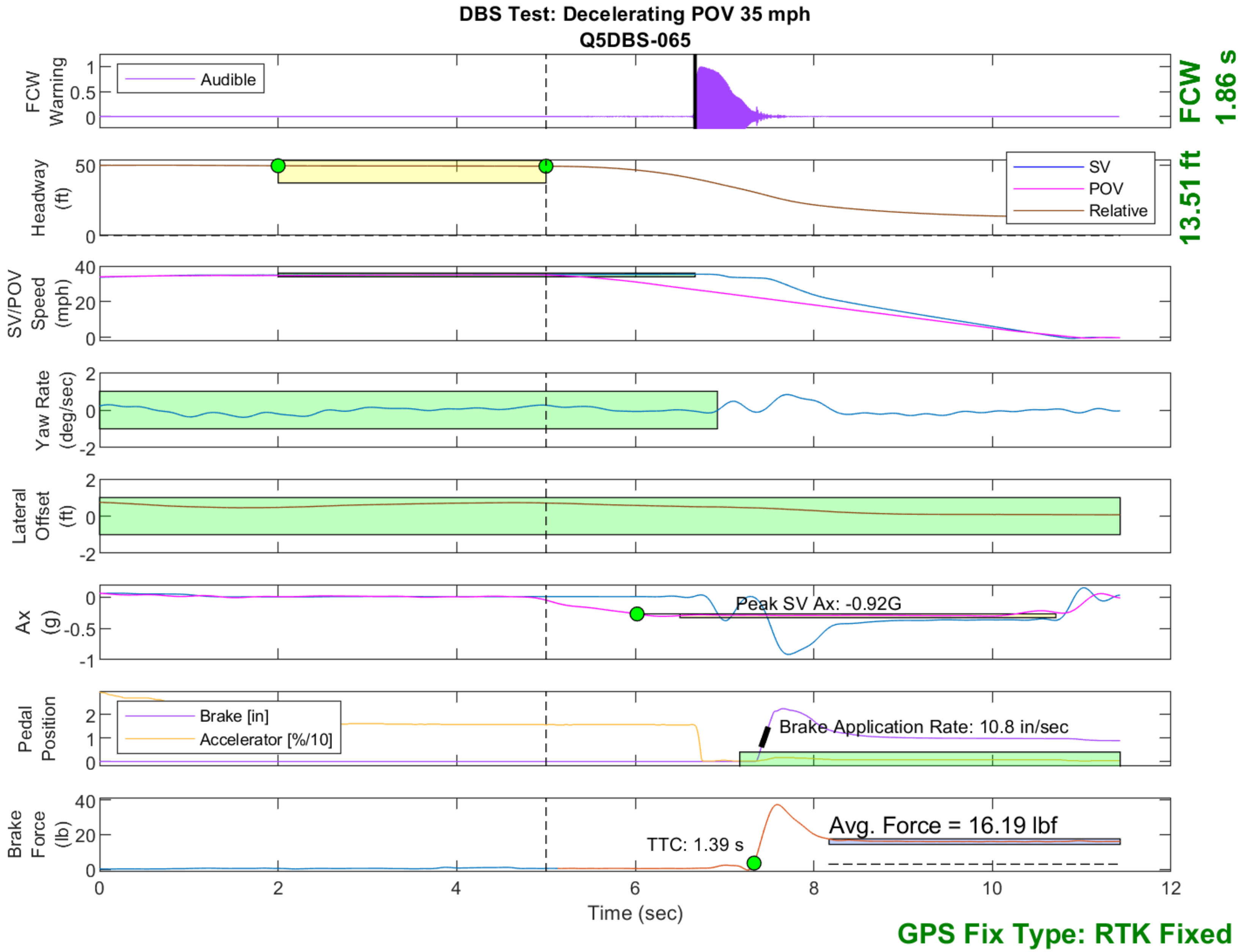

Figure E35. Time History for DBS Run 65, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

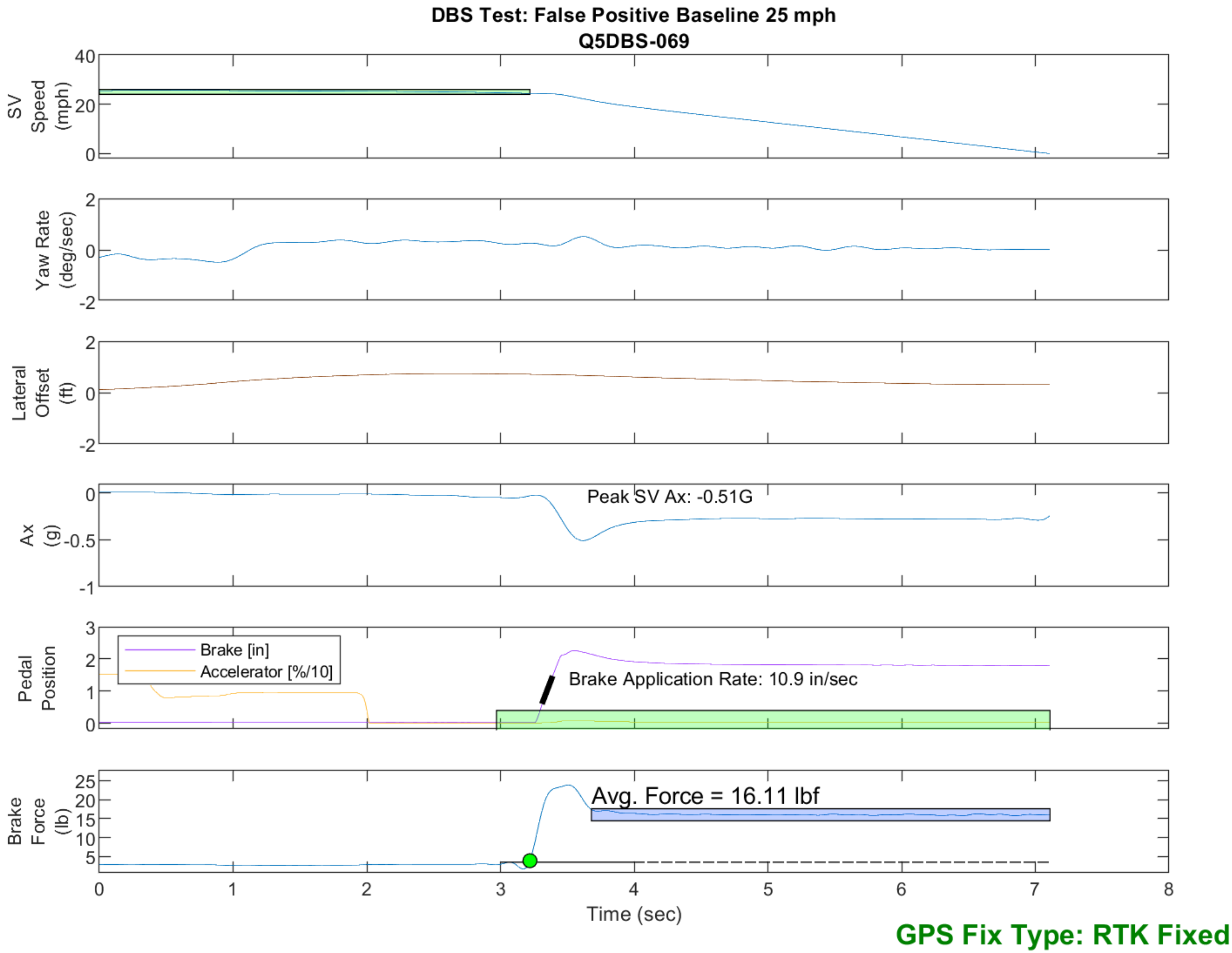

Figure E36. Time History for DBS Run 69, False Positive Baseline, SV 25 mph

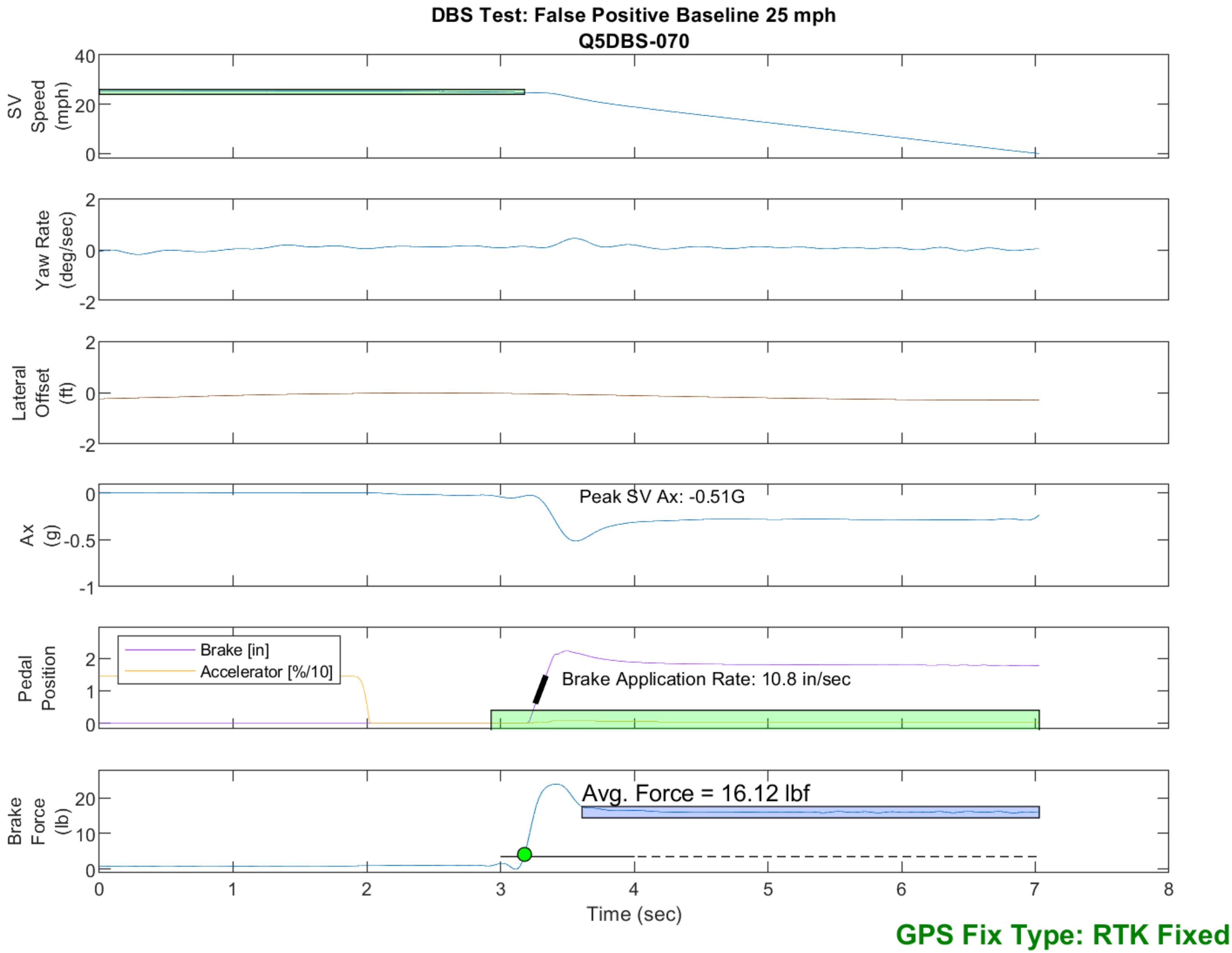

Figure E37. Time History for DBS Run 70, False Positive Baseline, SV 25 mph

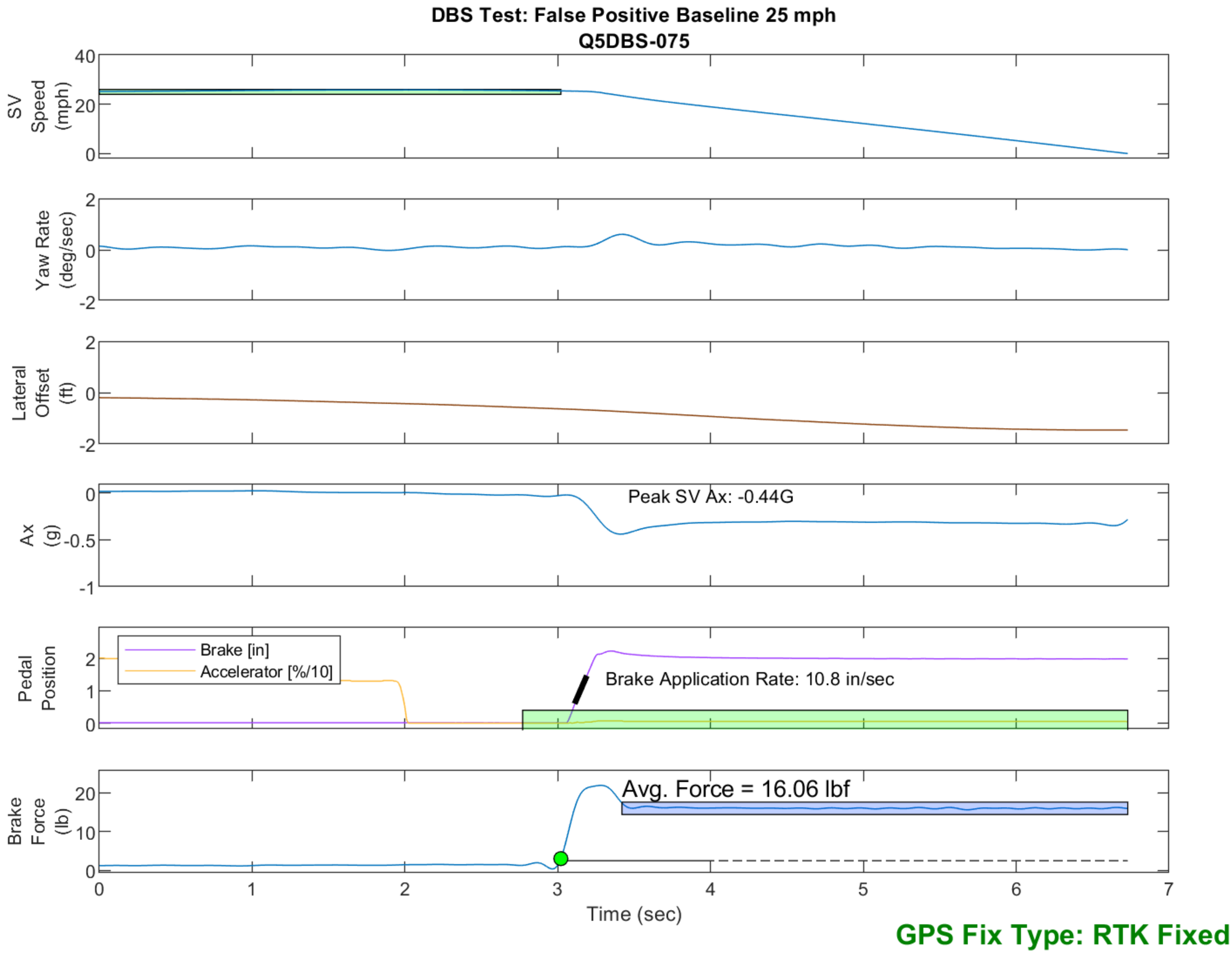

Figure E38. Time History for DBS Run 75, False Positive Baseline, SV 25 mph

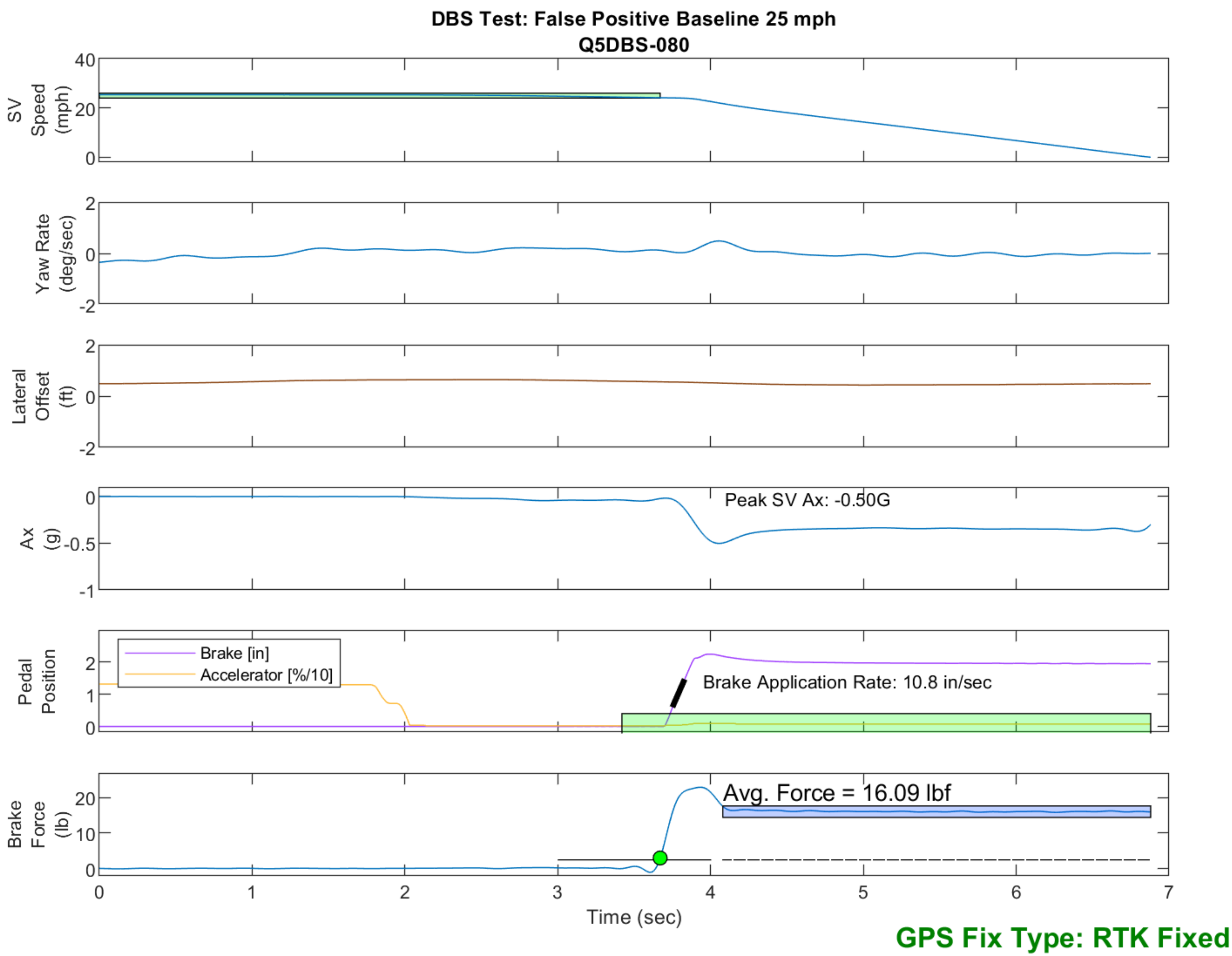

Figure E39. Time History for DBS Run 80, False Positive Baseline, SV 25 mph

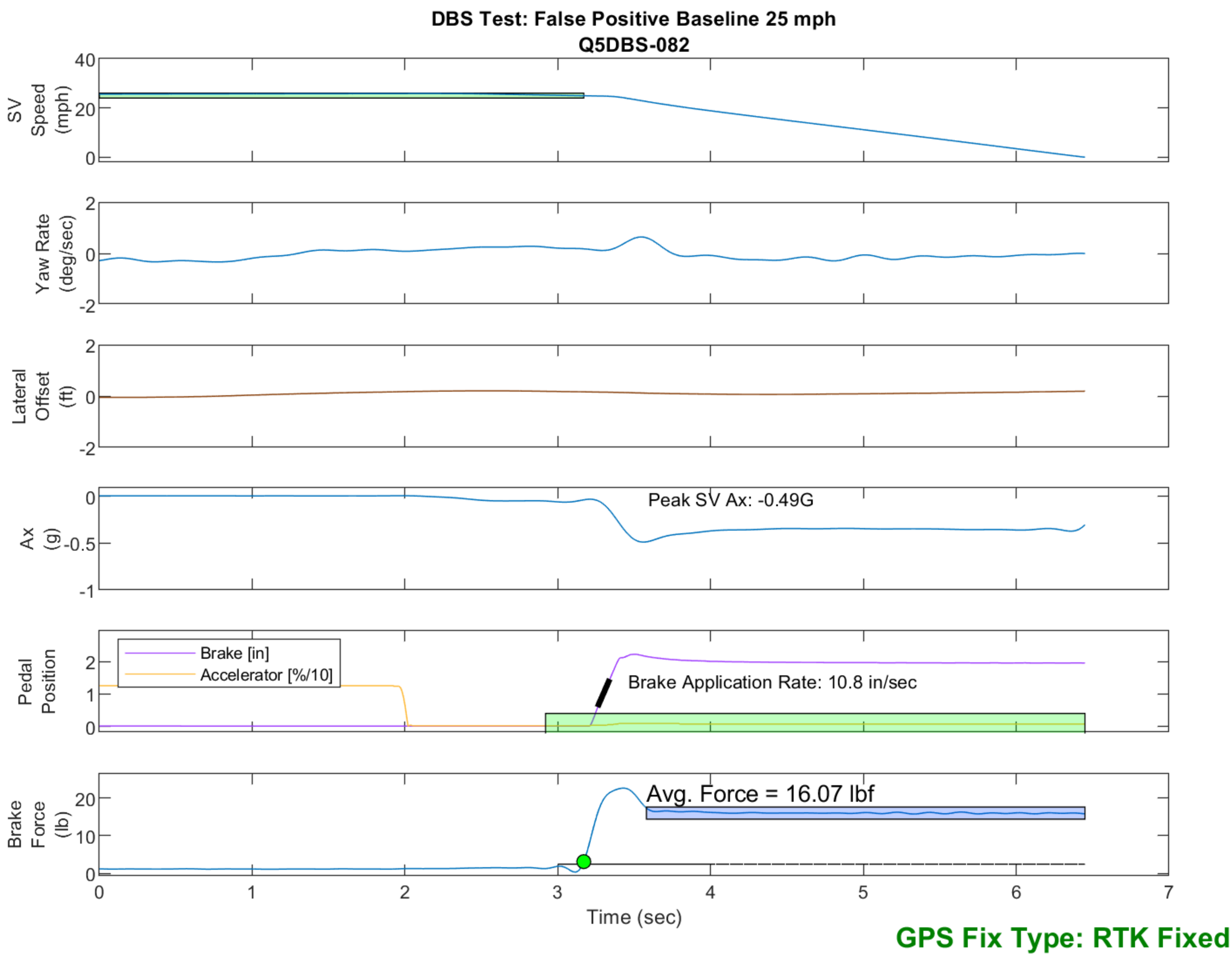

Figure E40. Time History for DBS Run 82, False Positive Baseline, SV 25 mph

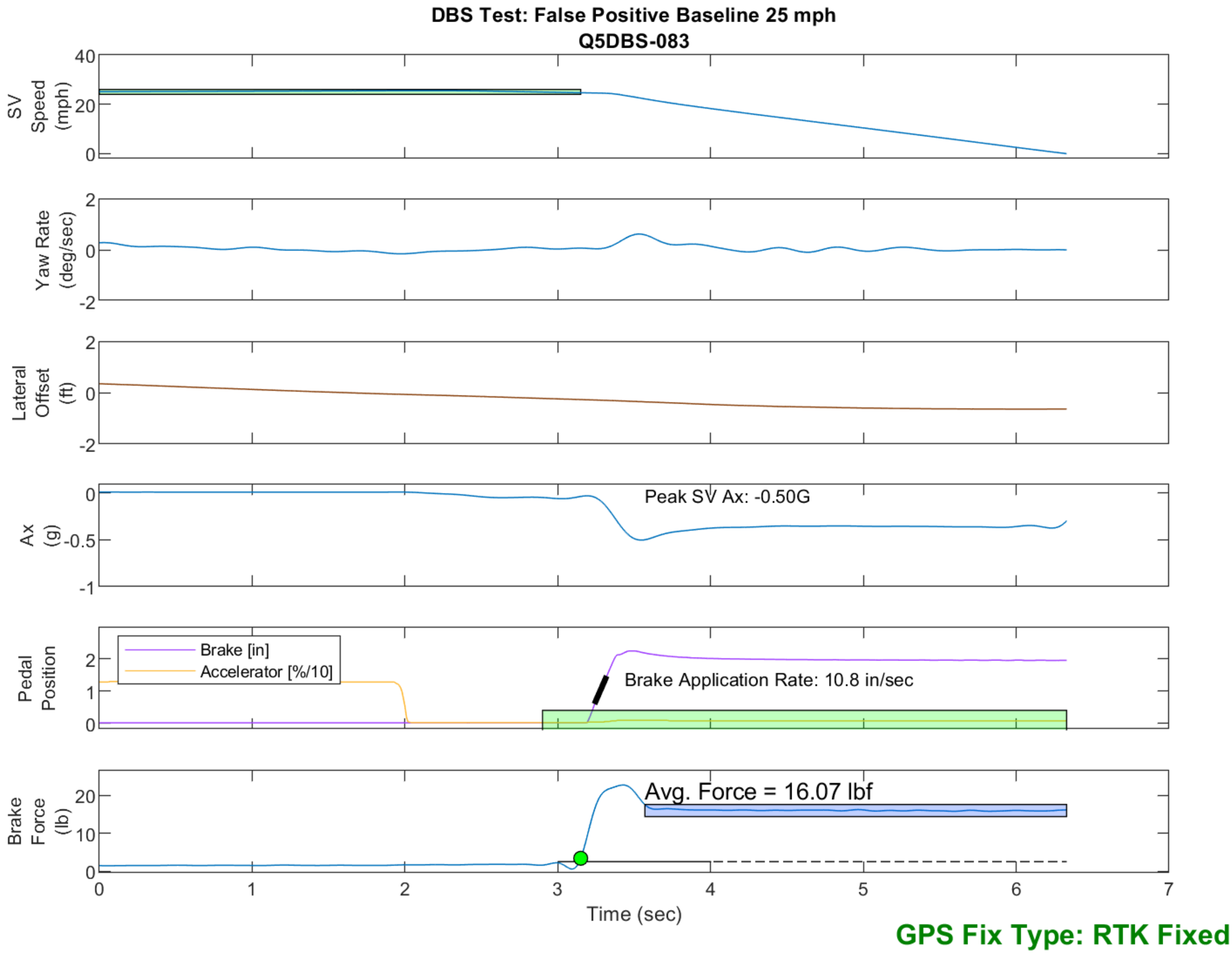

Figure E41. Time History for DBS Run 83, False Positive Baseline, SV 25 mph

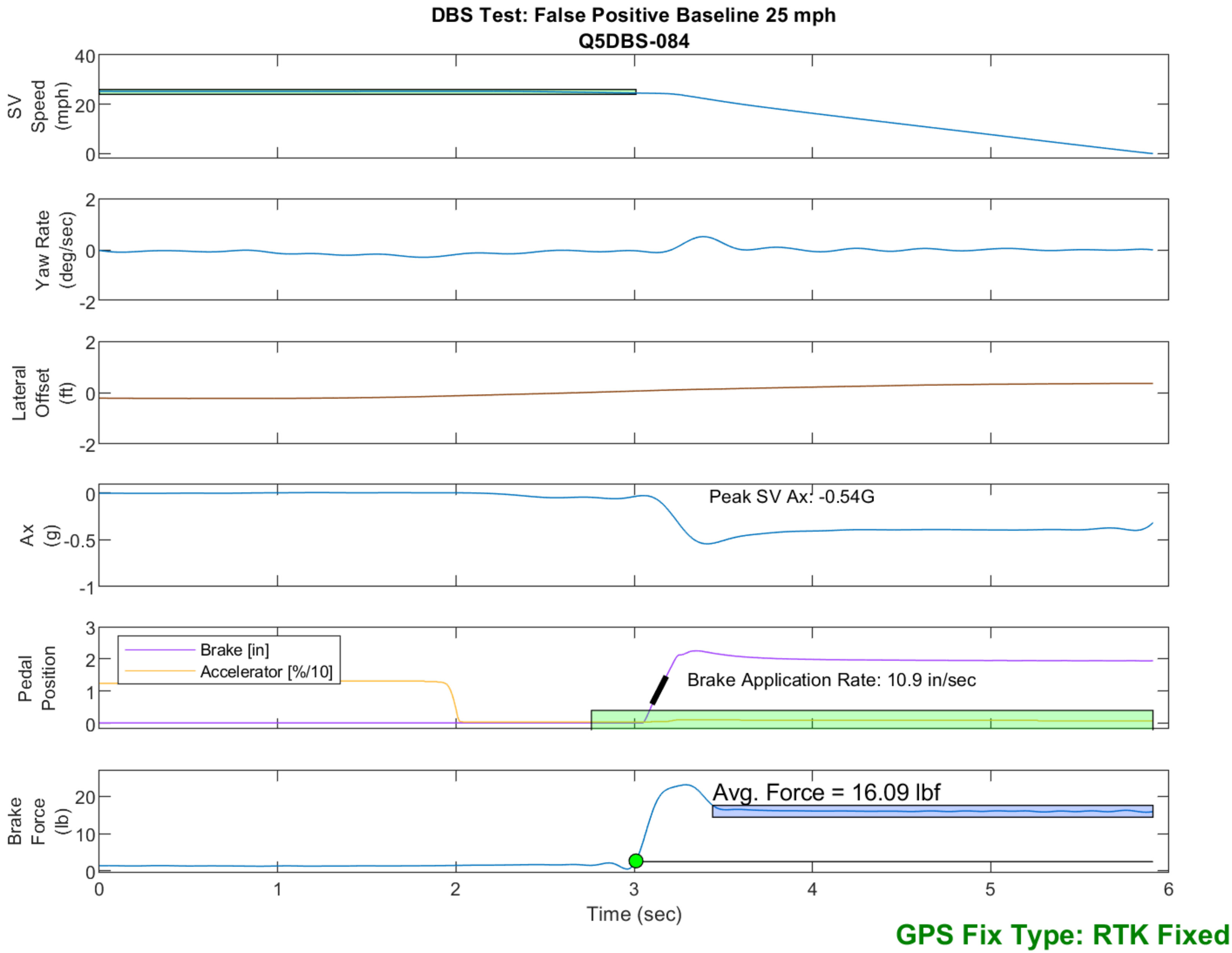

Figure E42. Time History for DBS Run 84, False Positive Baseline, SV 25 mph

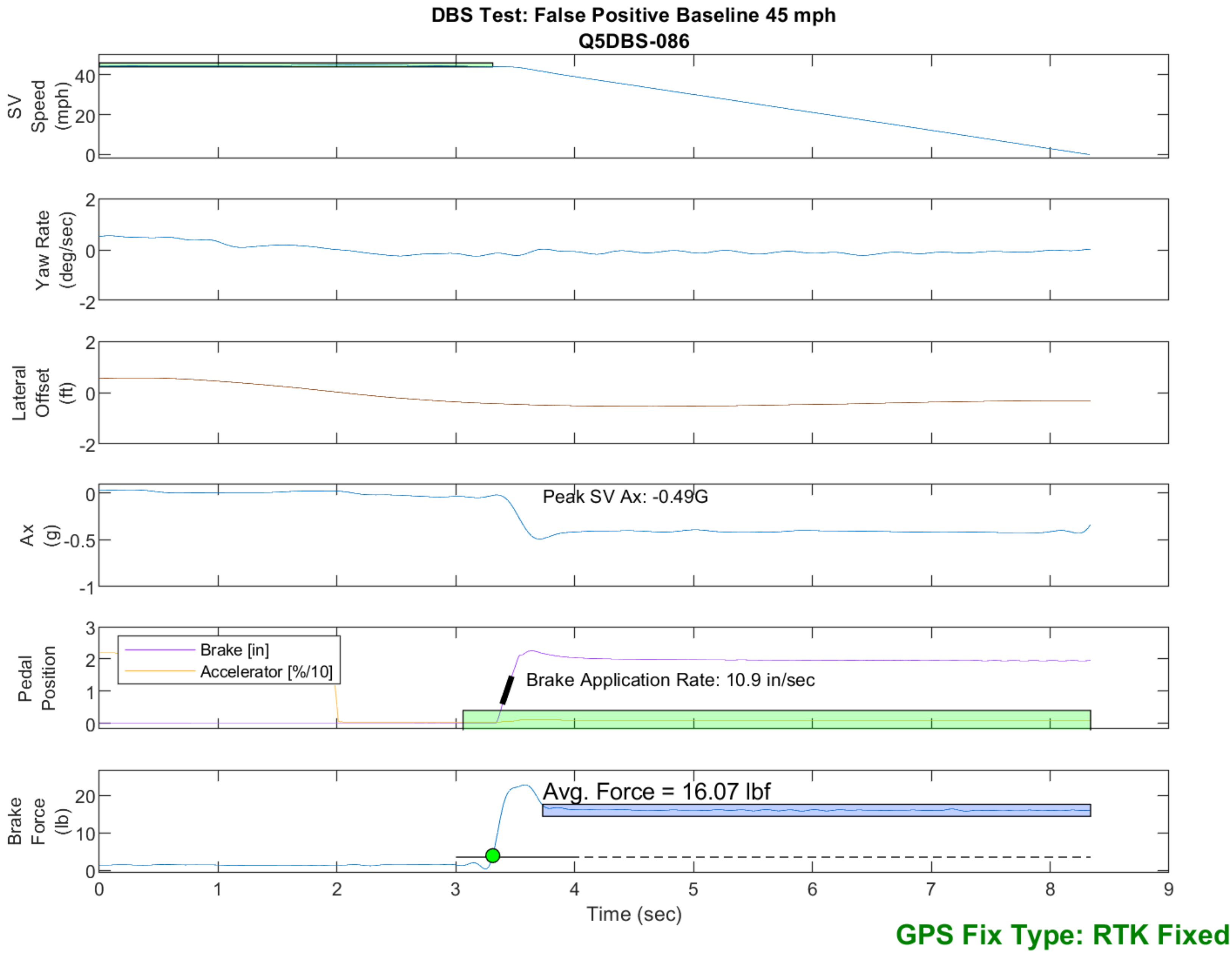

Figure E43. Time History for DBS Run 86, False Positive Baseline, SV 45 mph

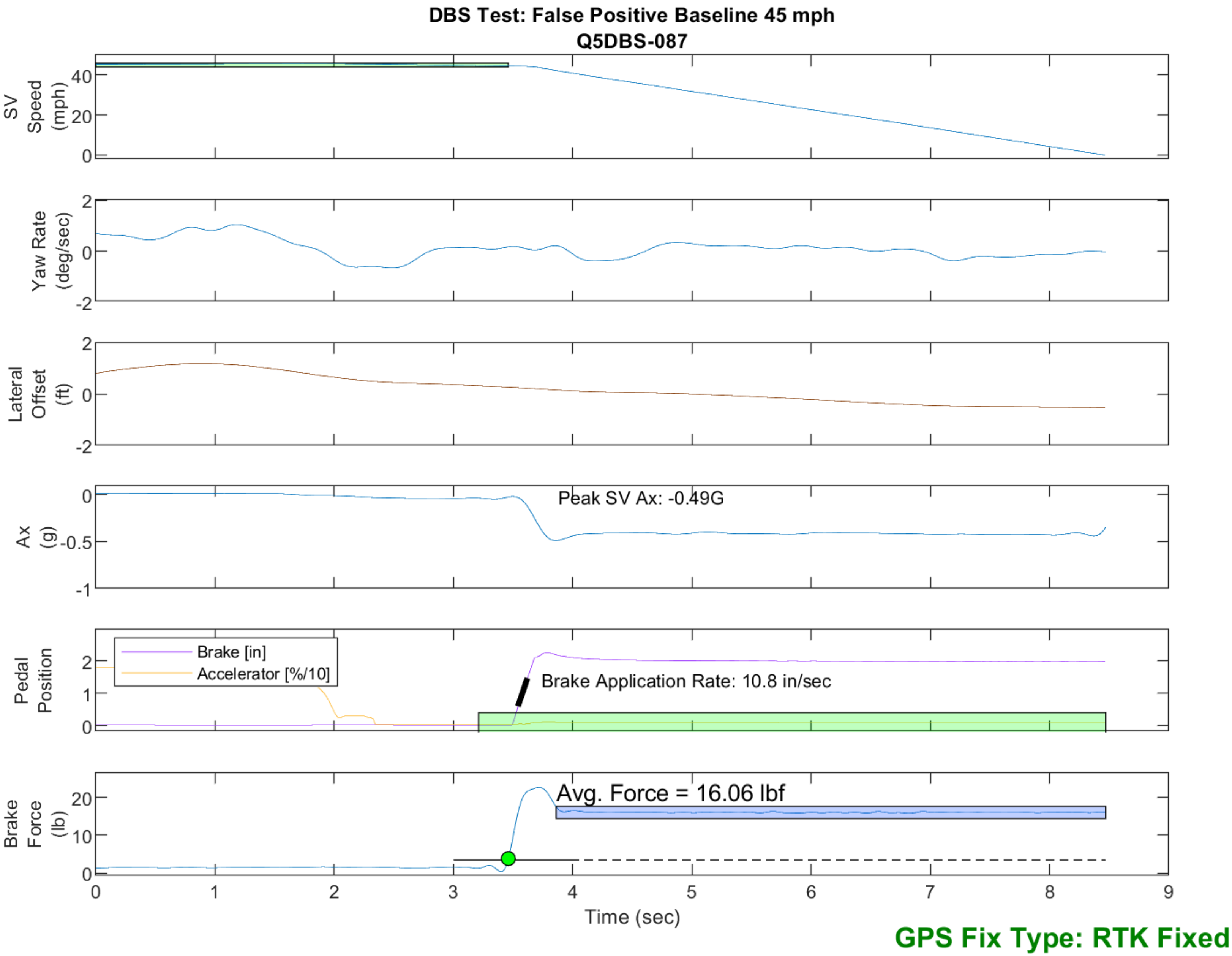

Figure E44. Time History for DBS Run 87, False Positive Baseline, SV 45 mph

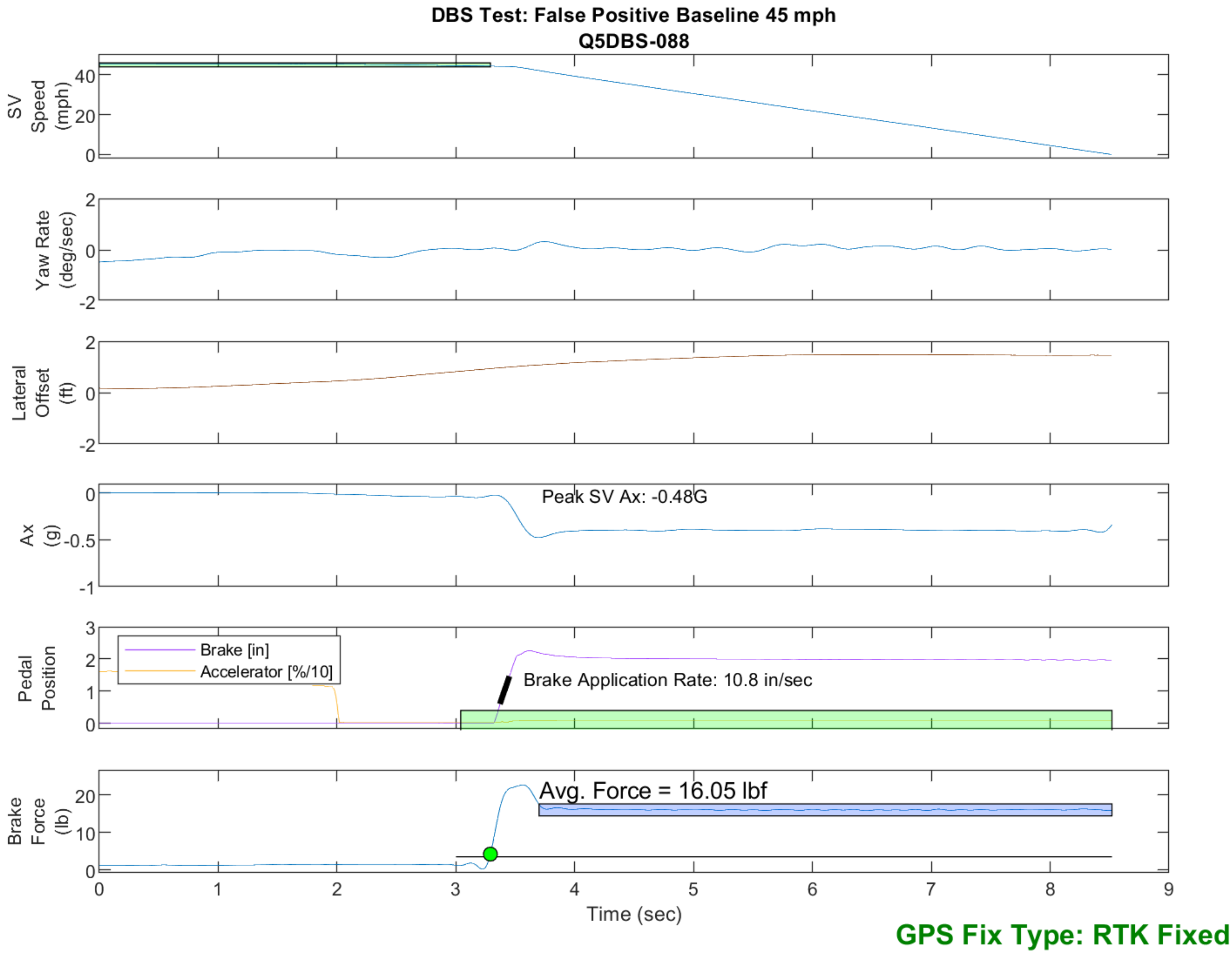

Figure E45. Time History for DBS Run 88, False Positive Baseline, SV 45 mph

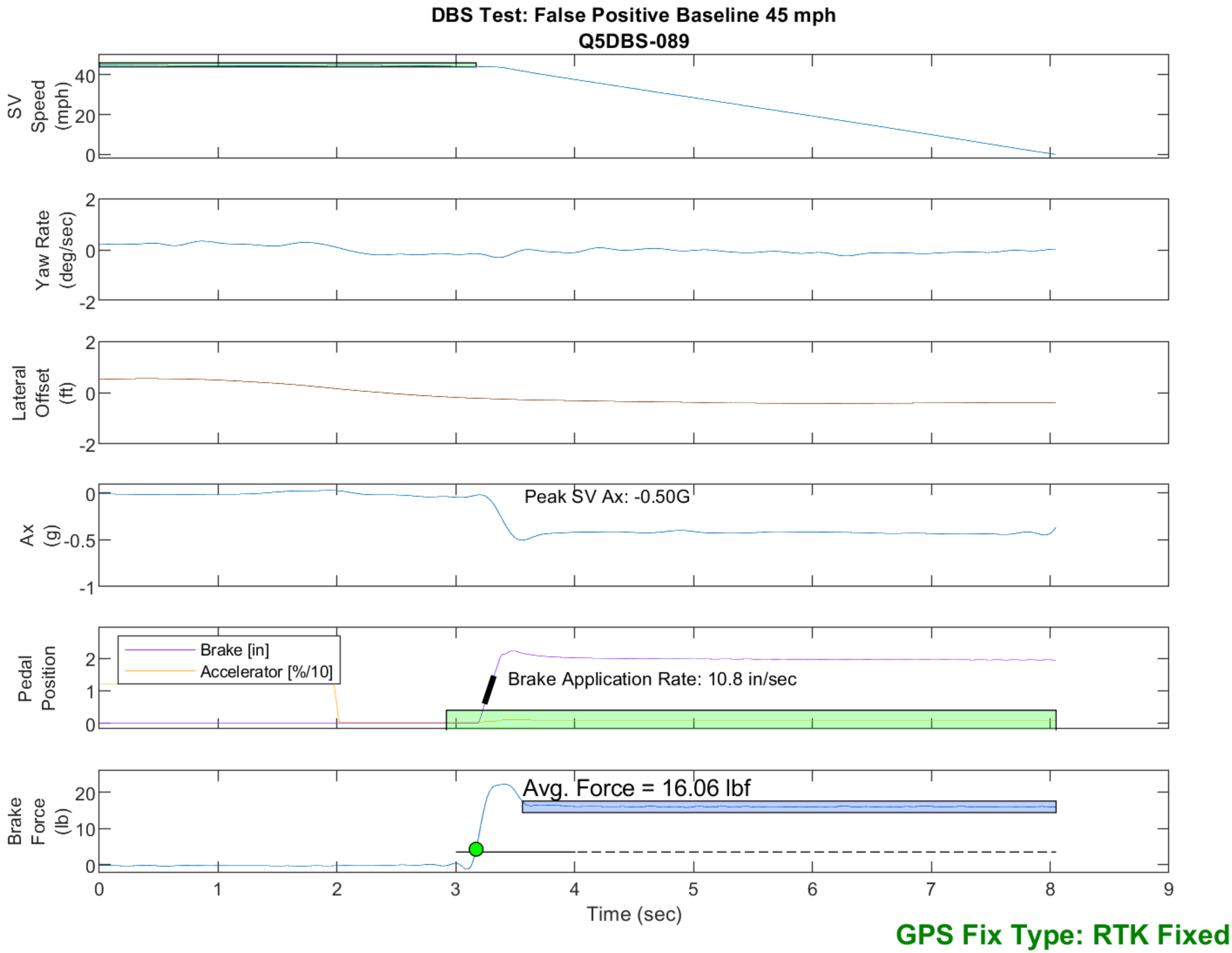

Figure E46. Time History for DBS Run 89, False Positive Baseline, SV 45 mph

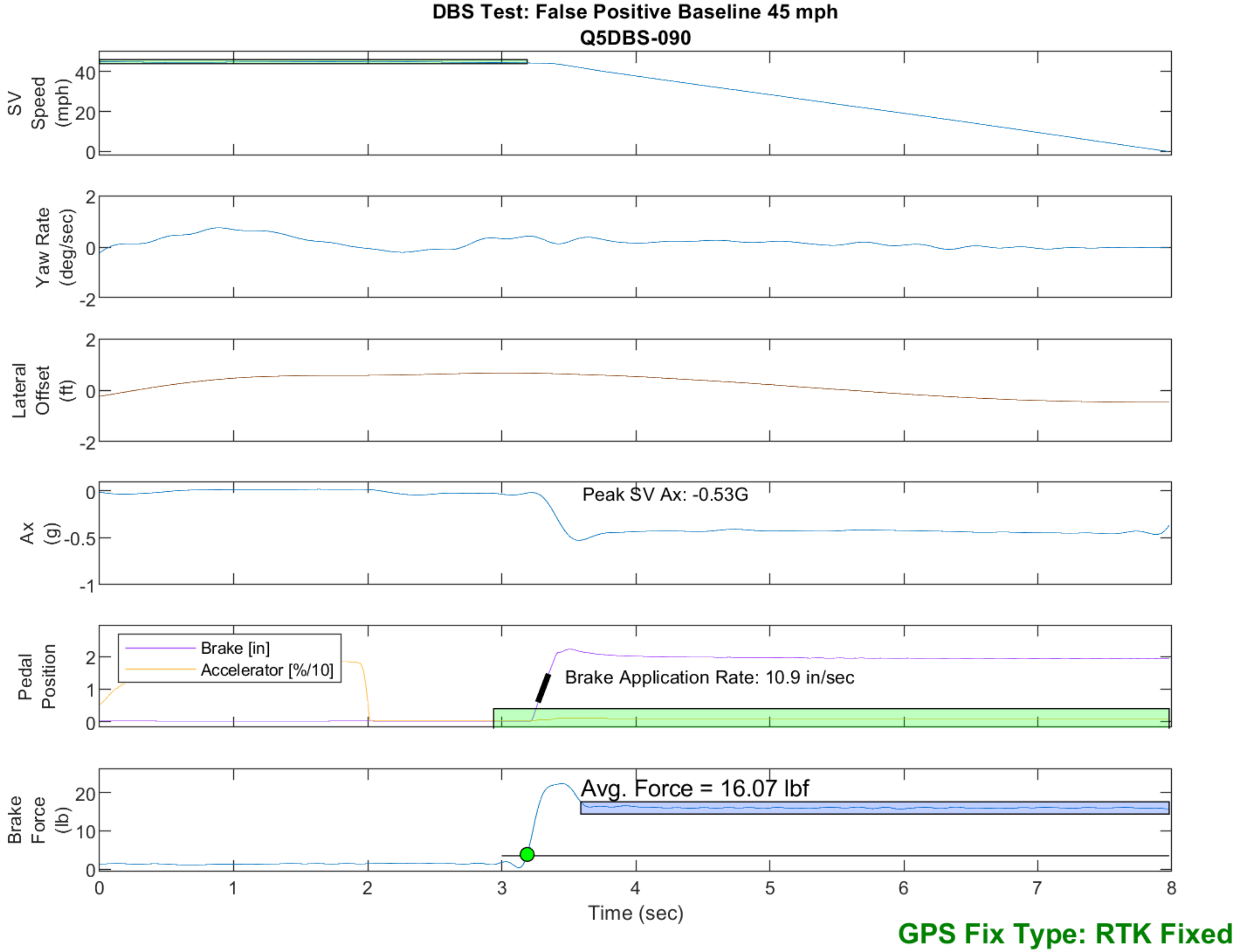

Figure E47. Time History for DBS Run 90, False Positive Baseline, SV 45 mph

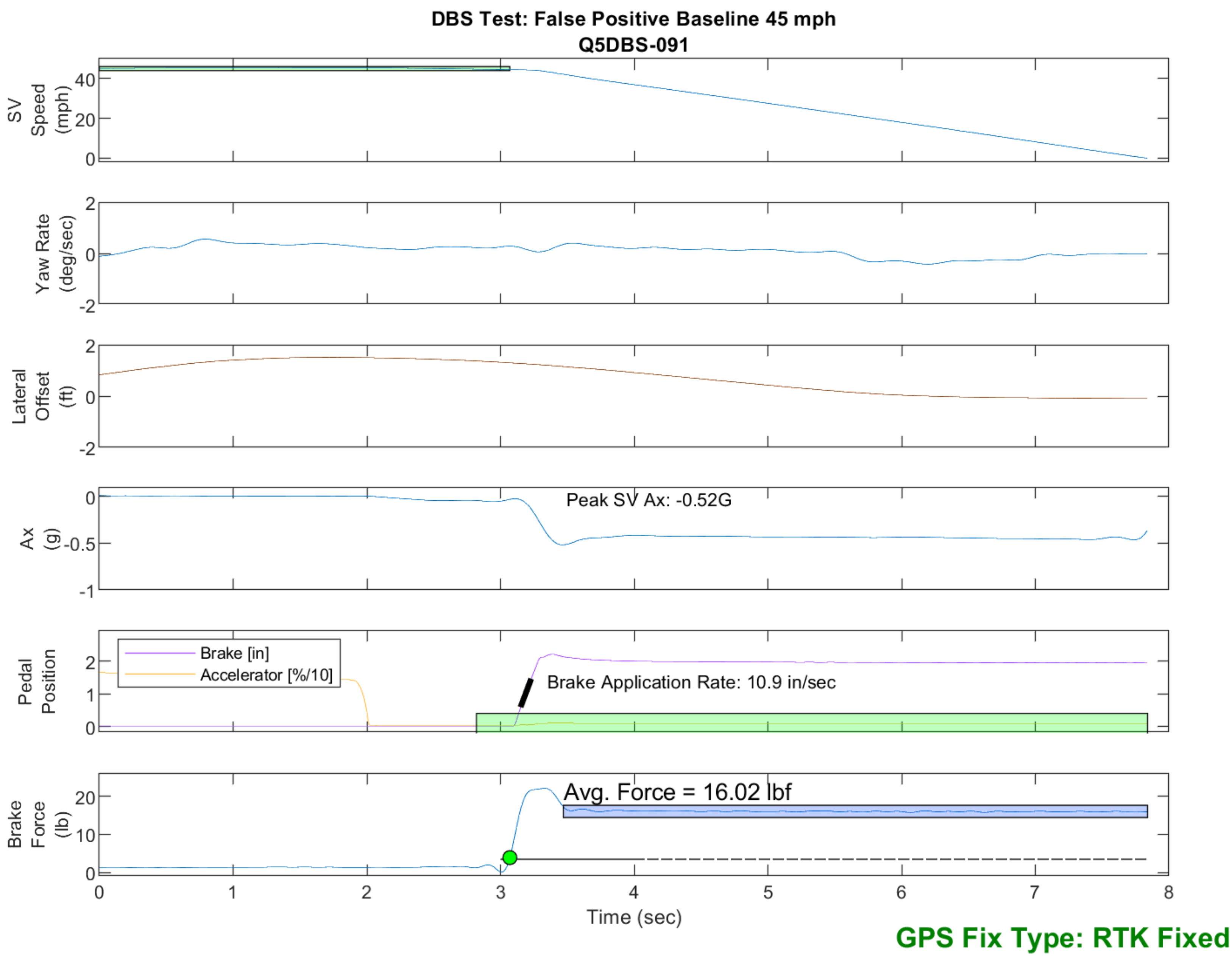

Figure E48. Time History for DBS Run 91, False Positive Baseline, SV 45 mph

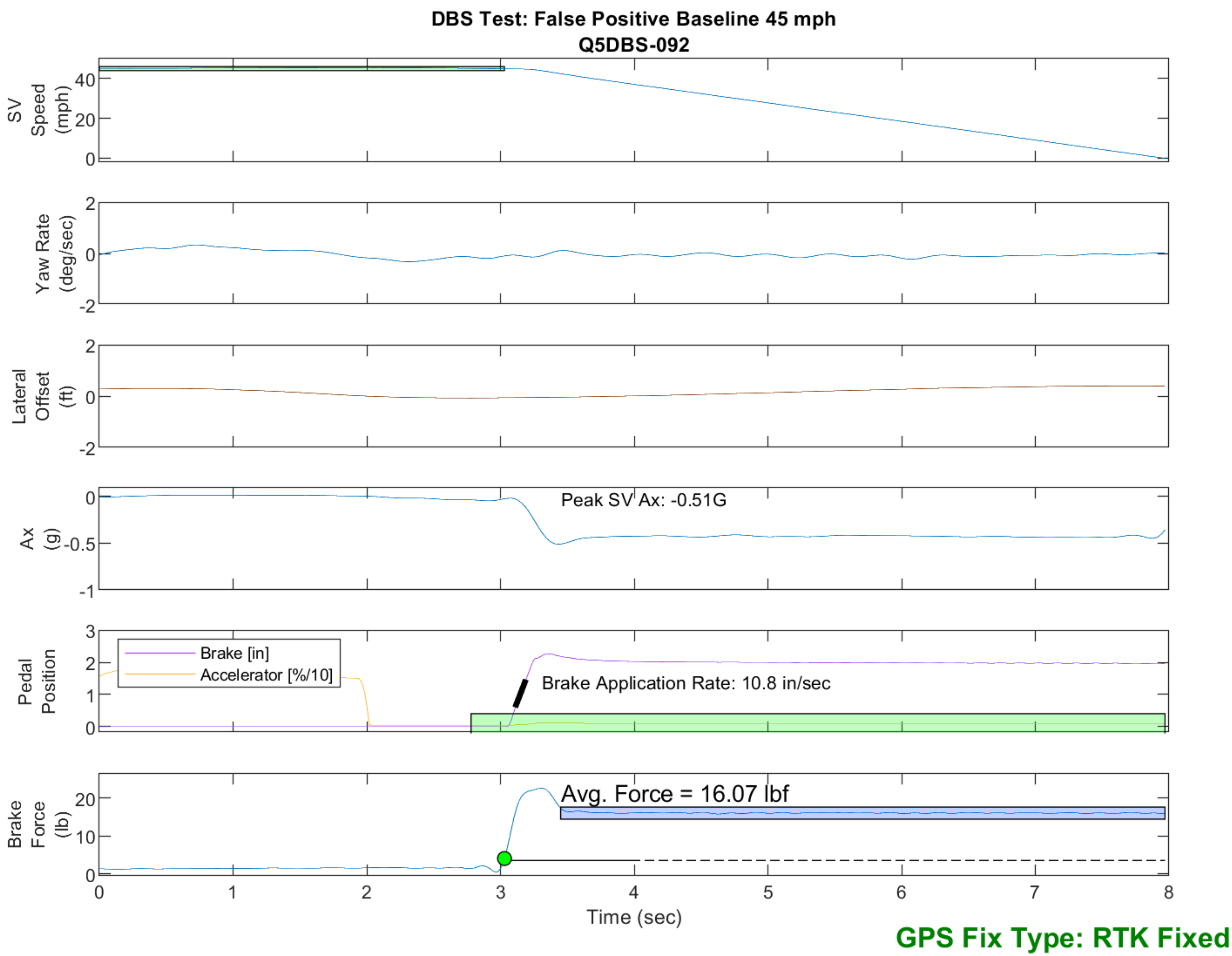

Figure E49. Time History for DBS Run 92, False Positive Baseline, SV 45 mph

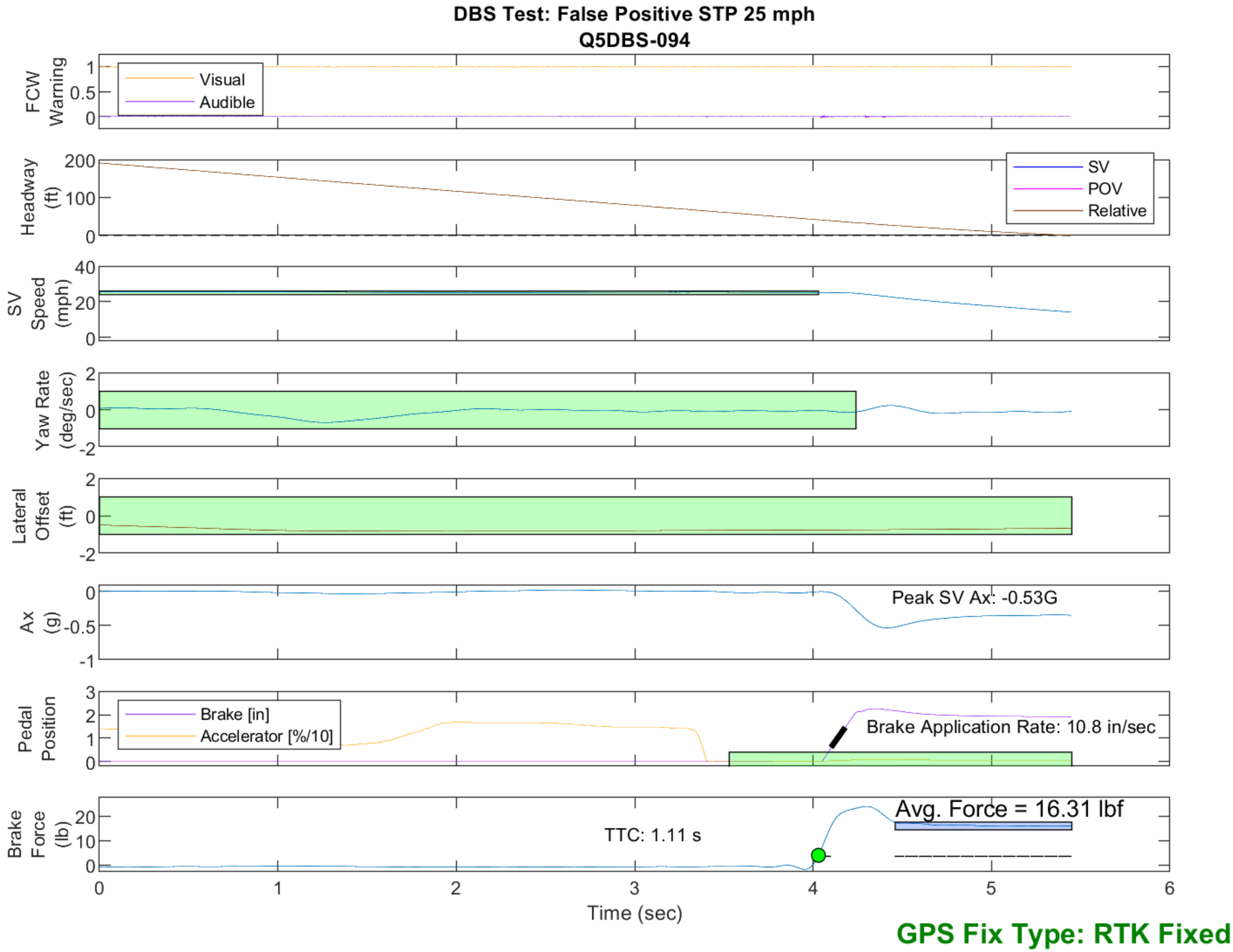

Figure E50. Time History for DBS Run 94, SV Encounters Steel Trench Plate, SV 25 mph

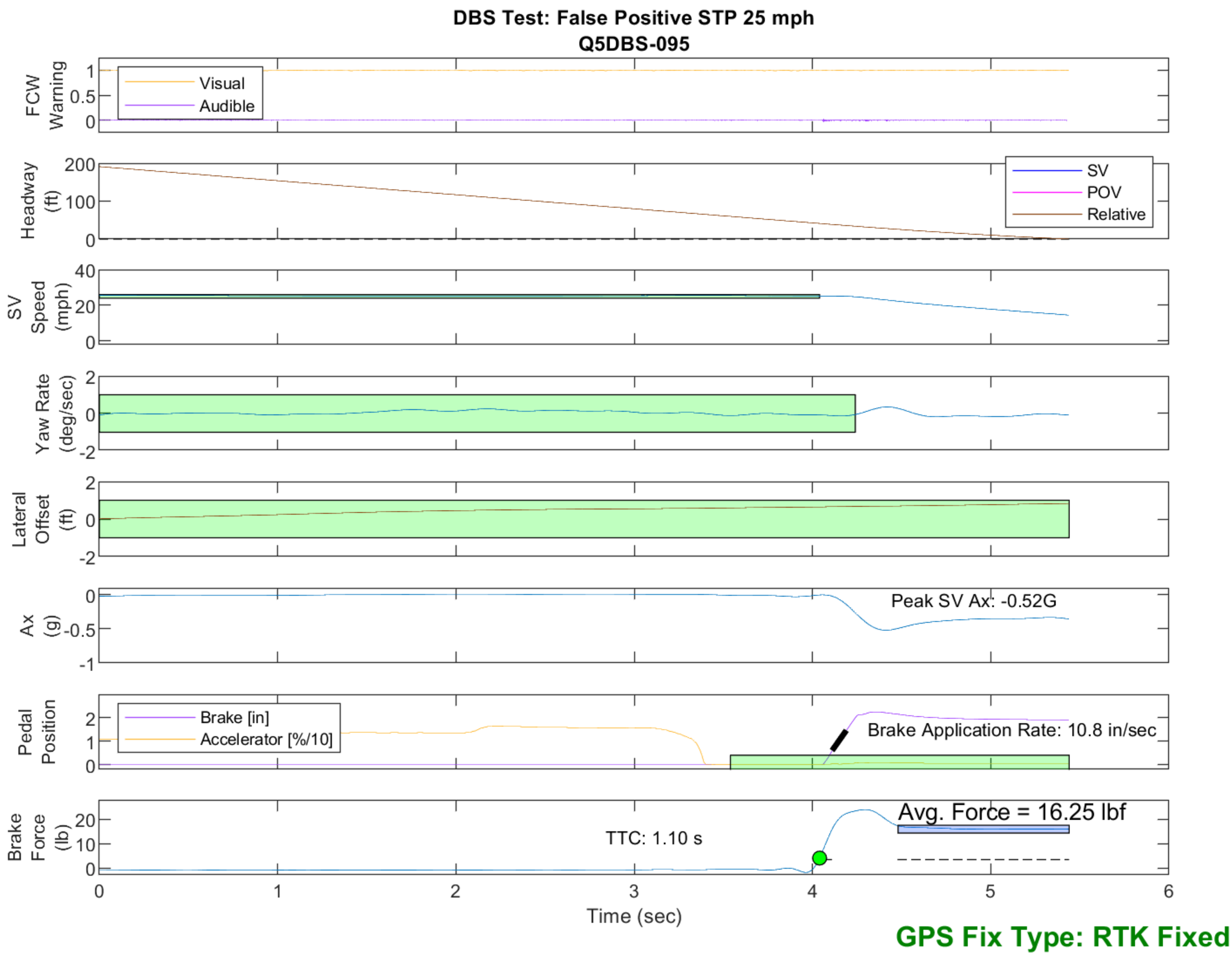

Figure E51. Time History for DBS Run 95, SV Encounters Steel Trench Plate, SV 25 mph

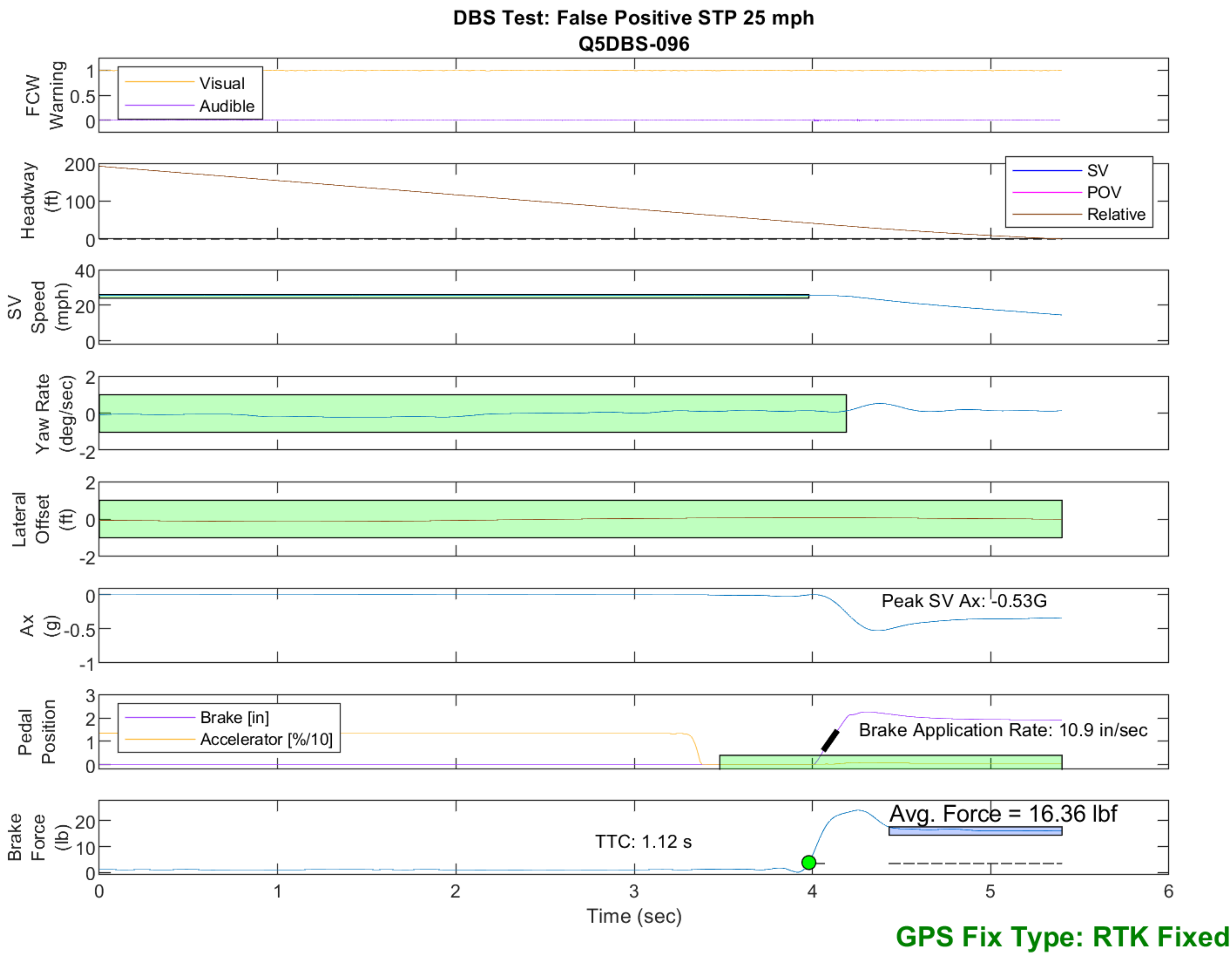

Figure E52. Time History for DBS Run 96, SV Encounters Steel Trench Plate, SV 25 mph

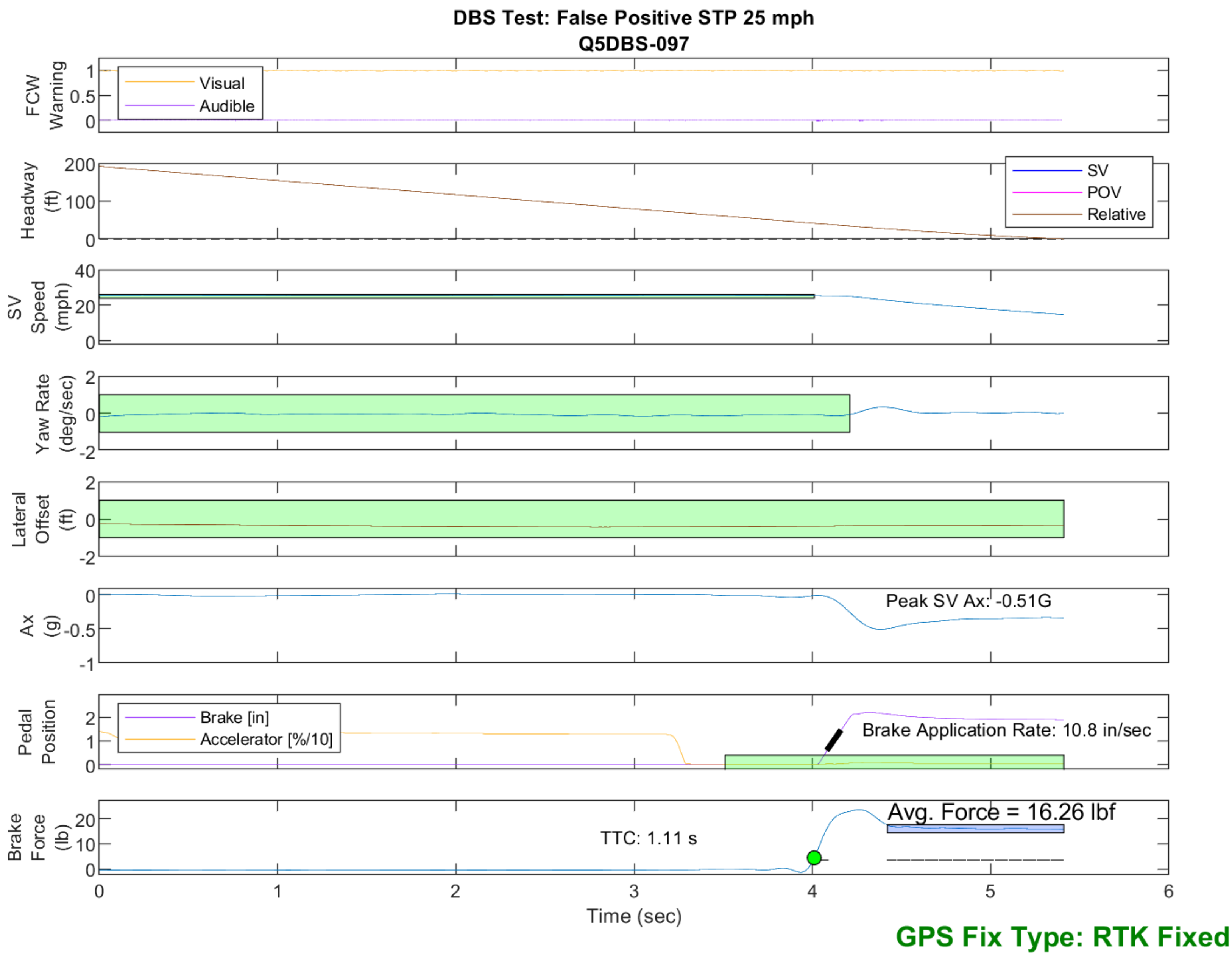

Figure E53. Time History for DBS Run 97, SV Encounters Steel Trench Plate, SV 25 mph

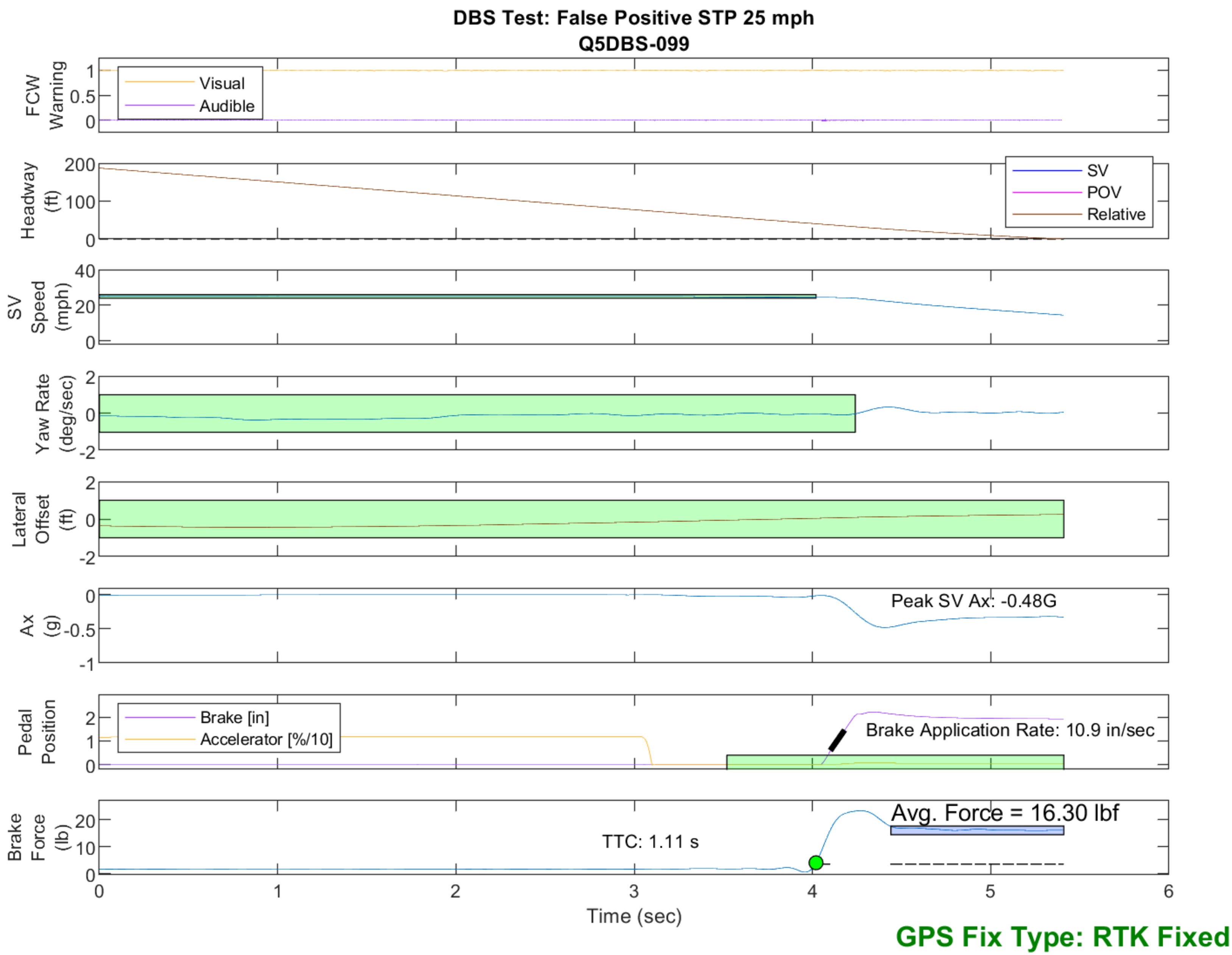

Figure E54. Time History for DBS Run 99, SV Encounters Steel Trench Plate, SV 25 mph

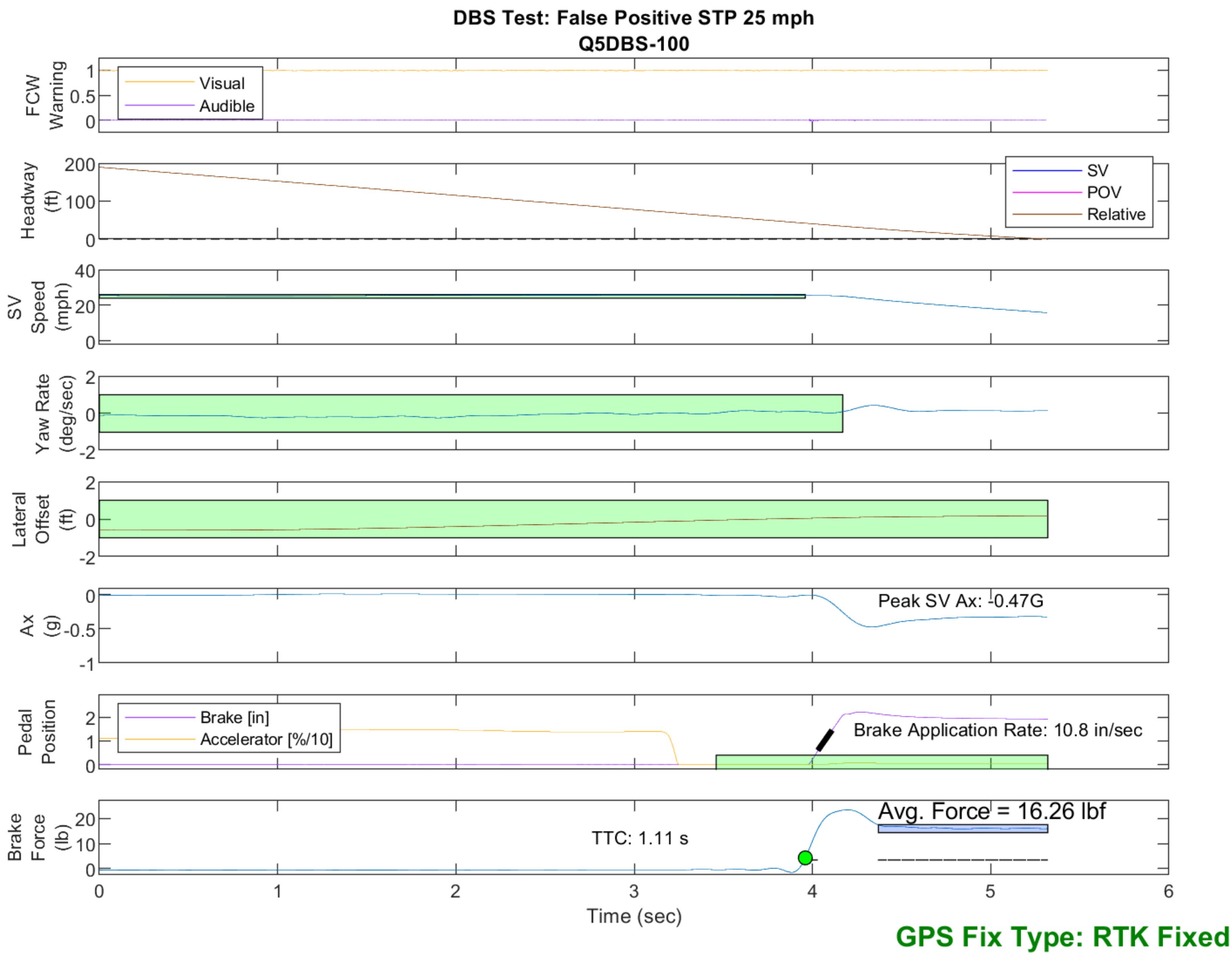

Figure E55. Time History for DBS Run 100, SV Encounters Steel Trench Plate, SV 25 mph

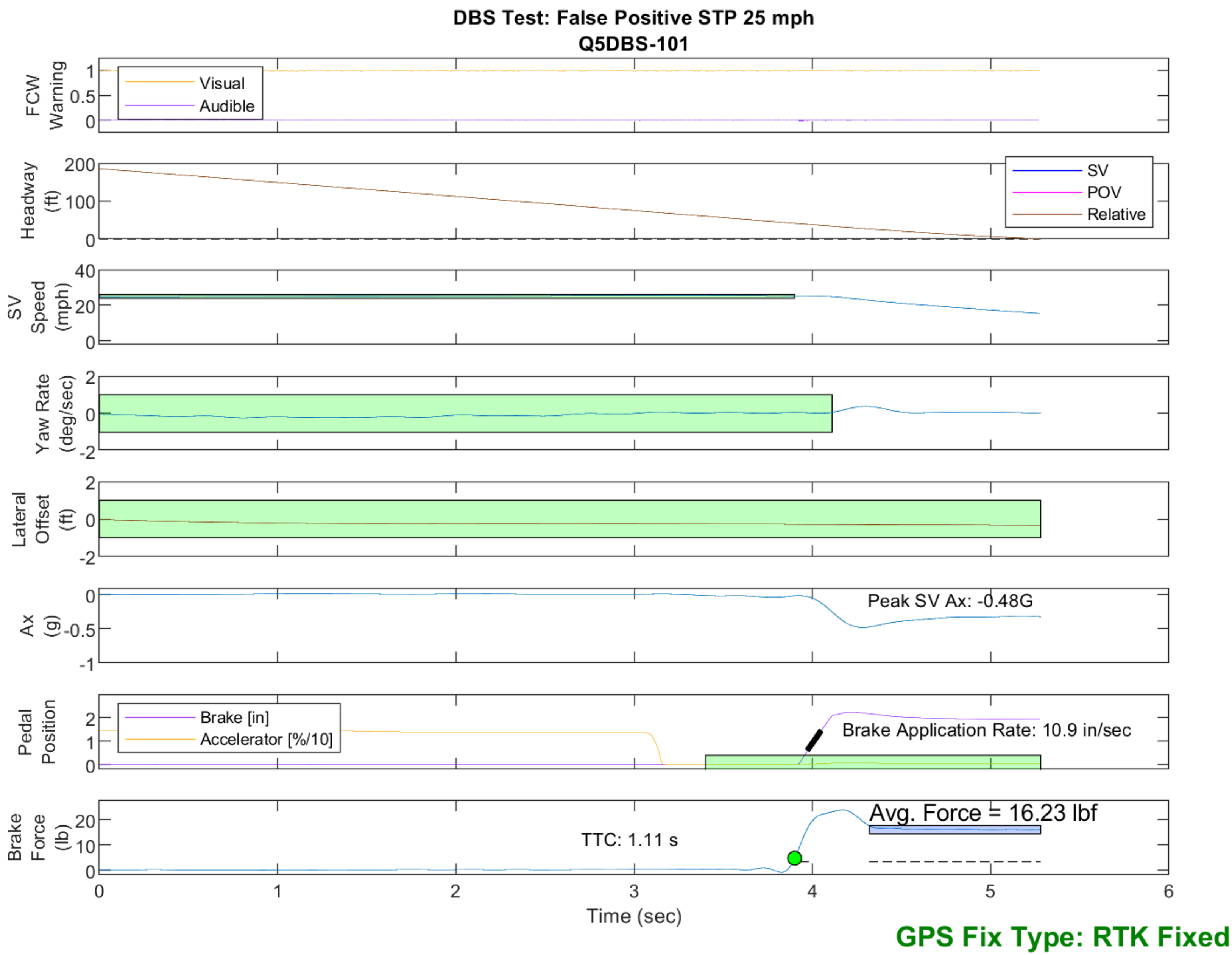

Figure E56. Time History for DBS Run 101, SV Encounters Steel Trench Plate, SV 25 mph

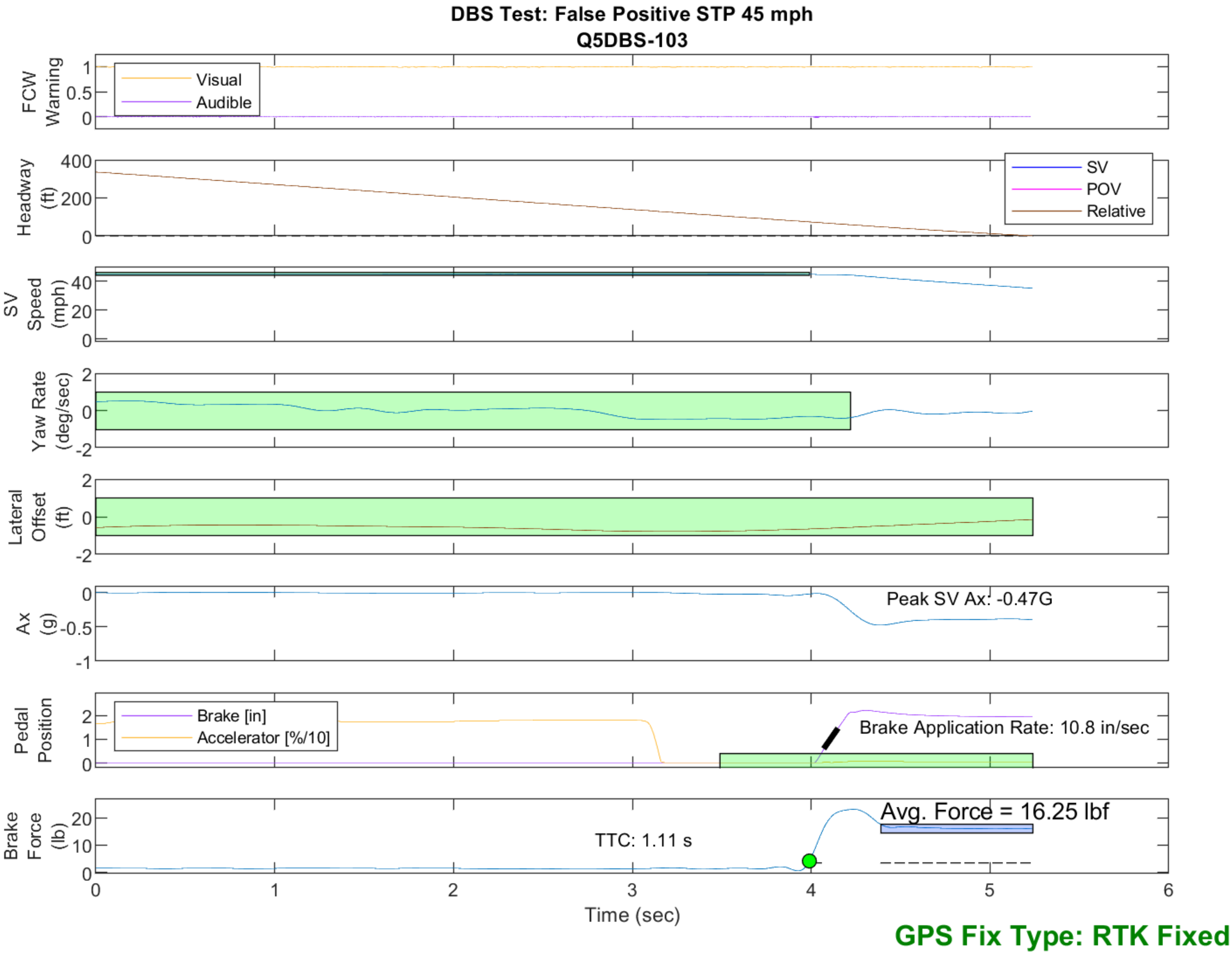

Figure E57. Time History for DBS Run 103, SV Encounters Steel Trench Plate, SV 45 mph

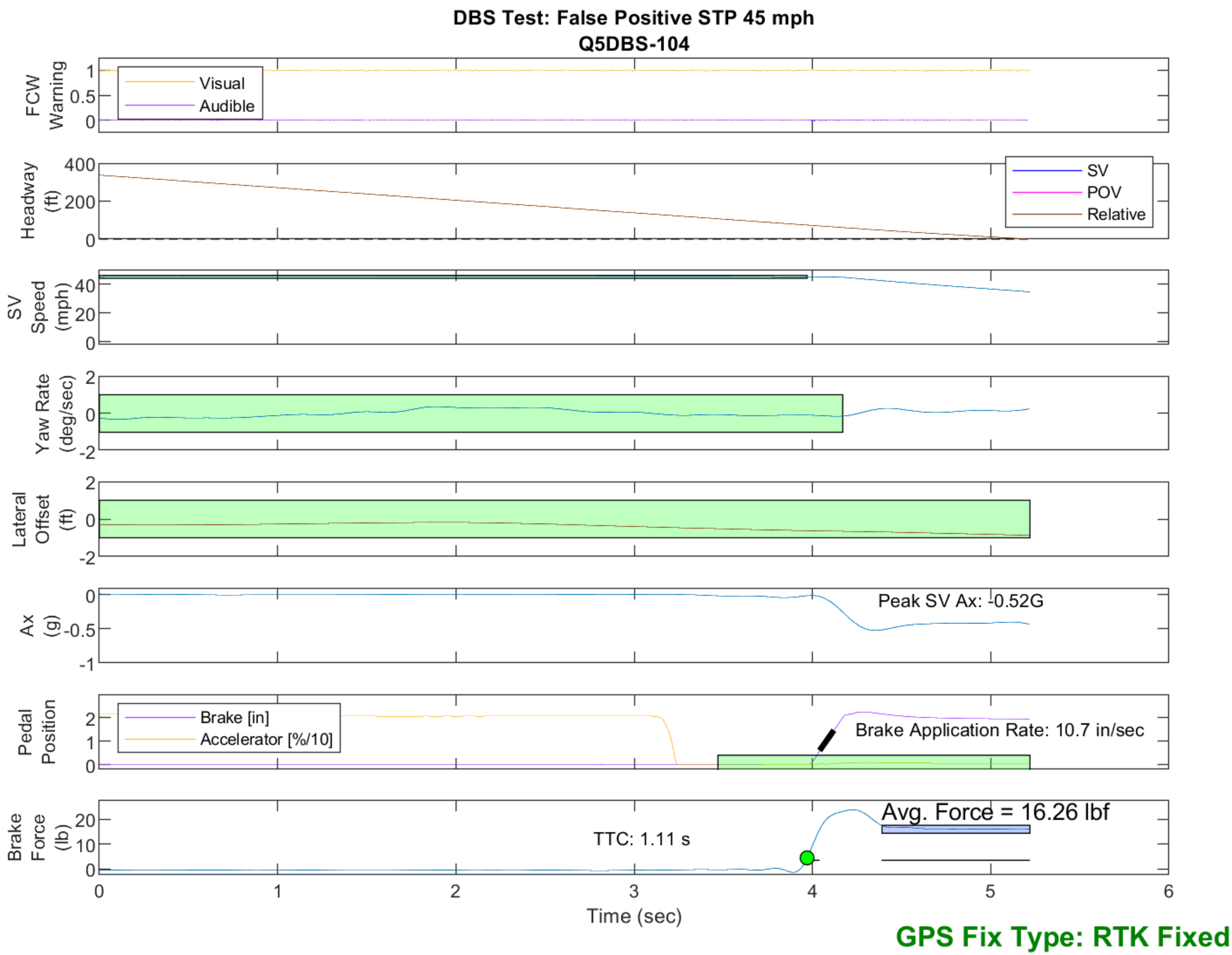

Figure E58. Time History for DBS Run 104, SV Encounters Steel Trench Plate, SV 45 mph

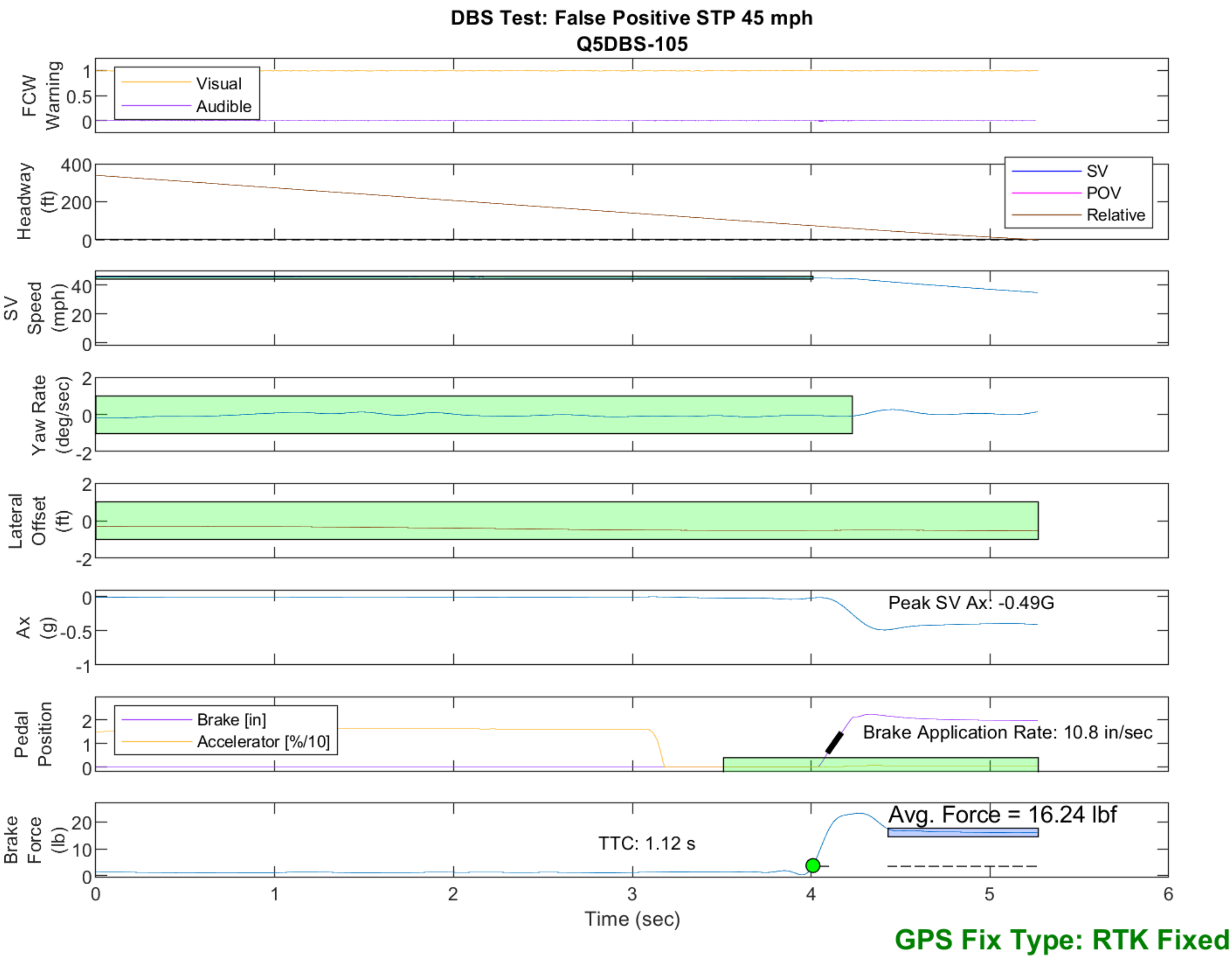

Figure E59. Time History for DBS Run 105, SV Encounters Steel Trench Plate, SV 45 mph

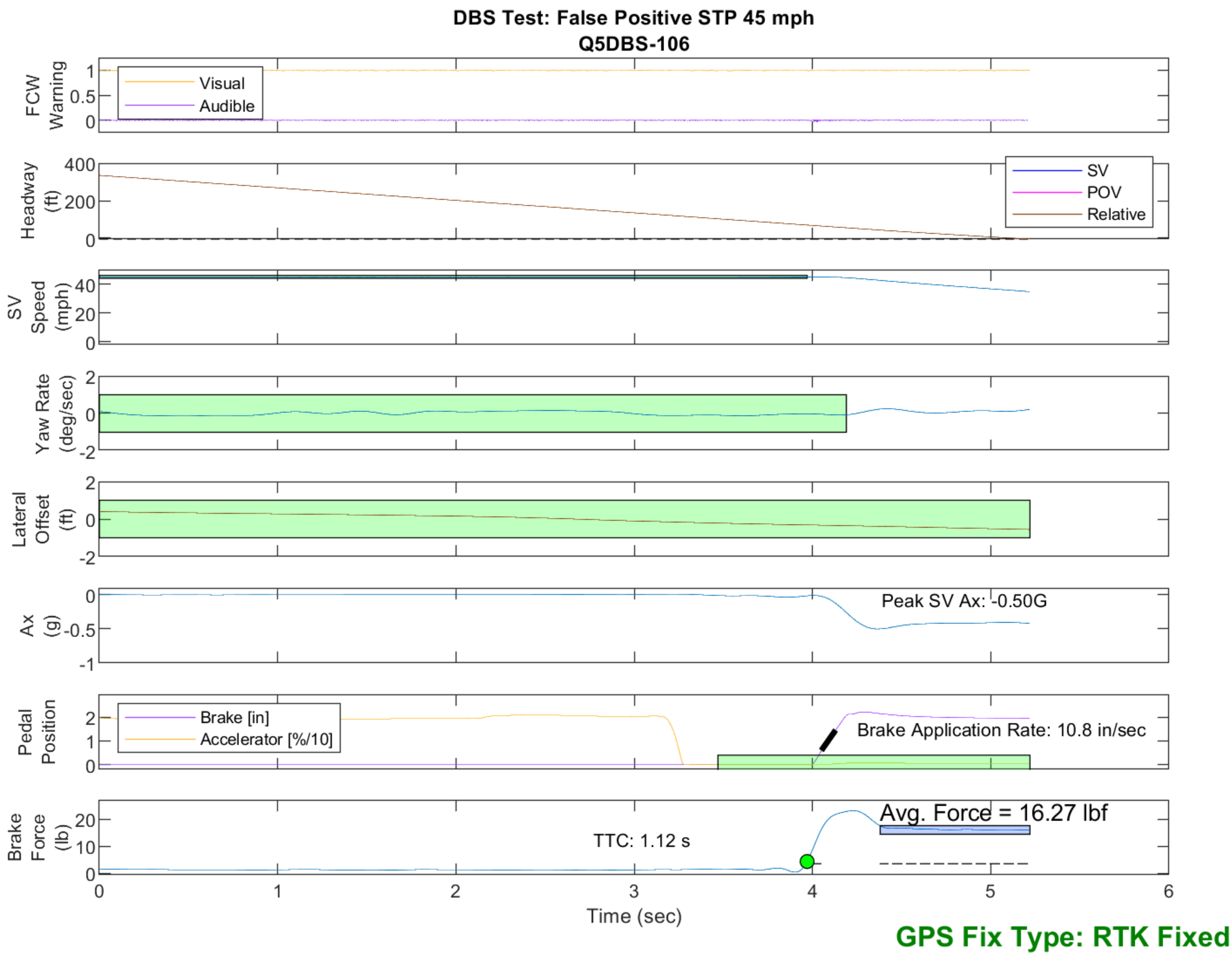

Figure E60. Time History for DBS Run 106, SV Encounters Steel Trench Plate, SV 45 mph

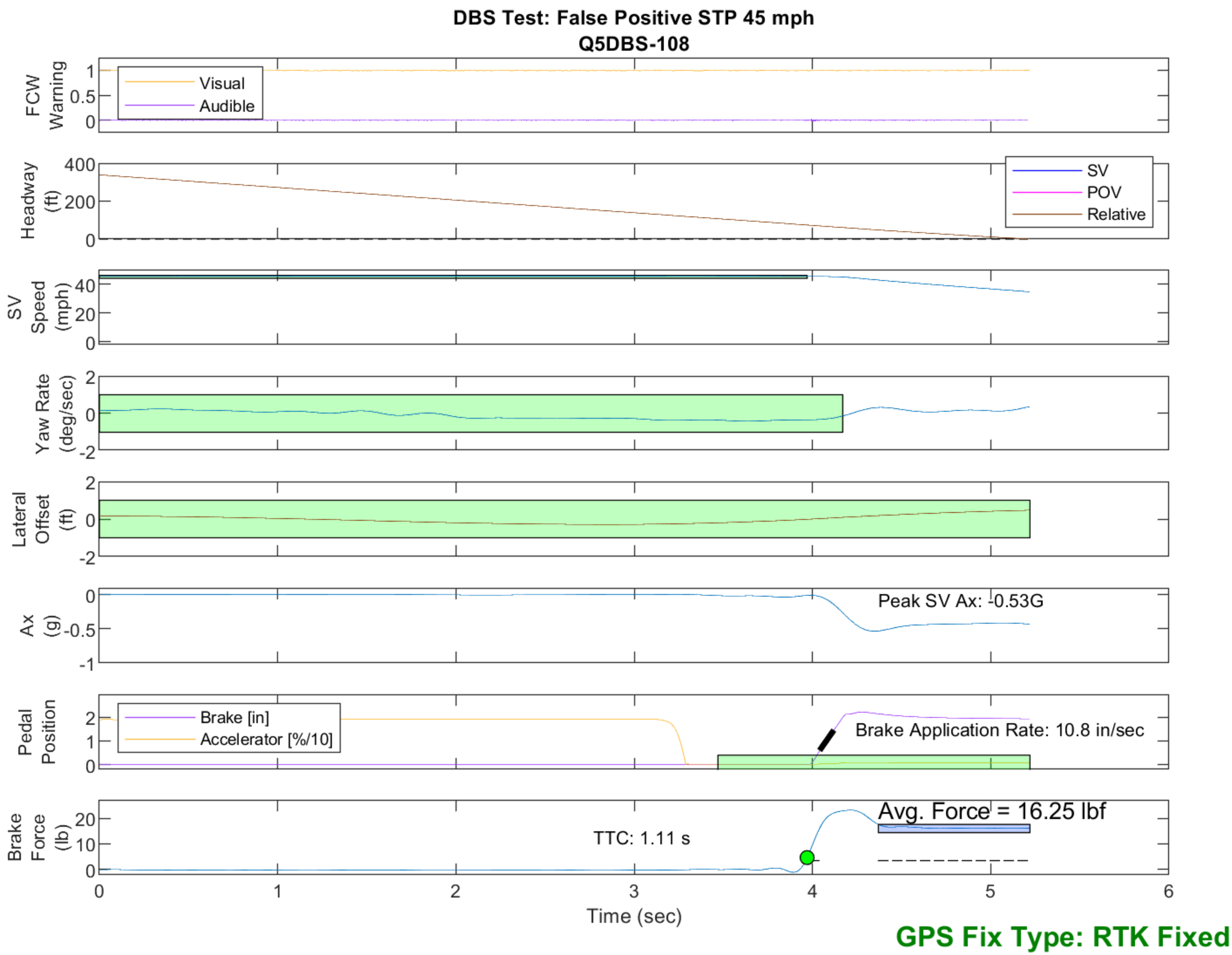

Figure E61. Time History for DBS Run 108, SV Encounters Steel Trench Plate, SV 45 mph

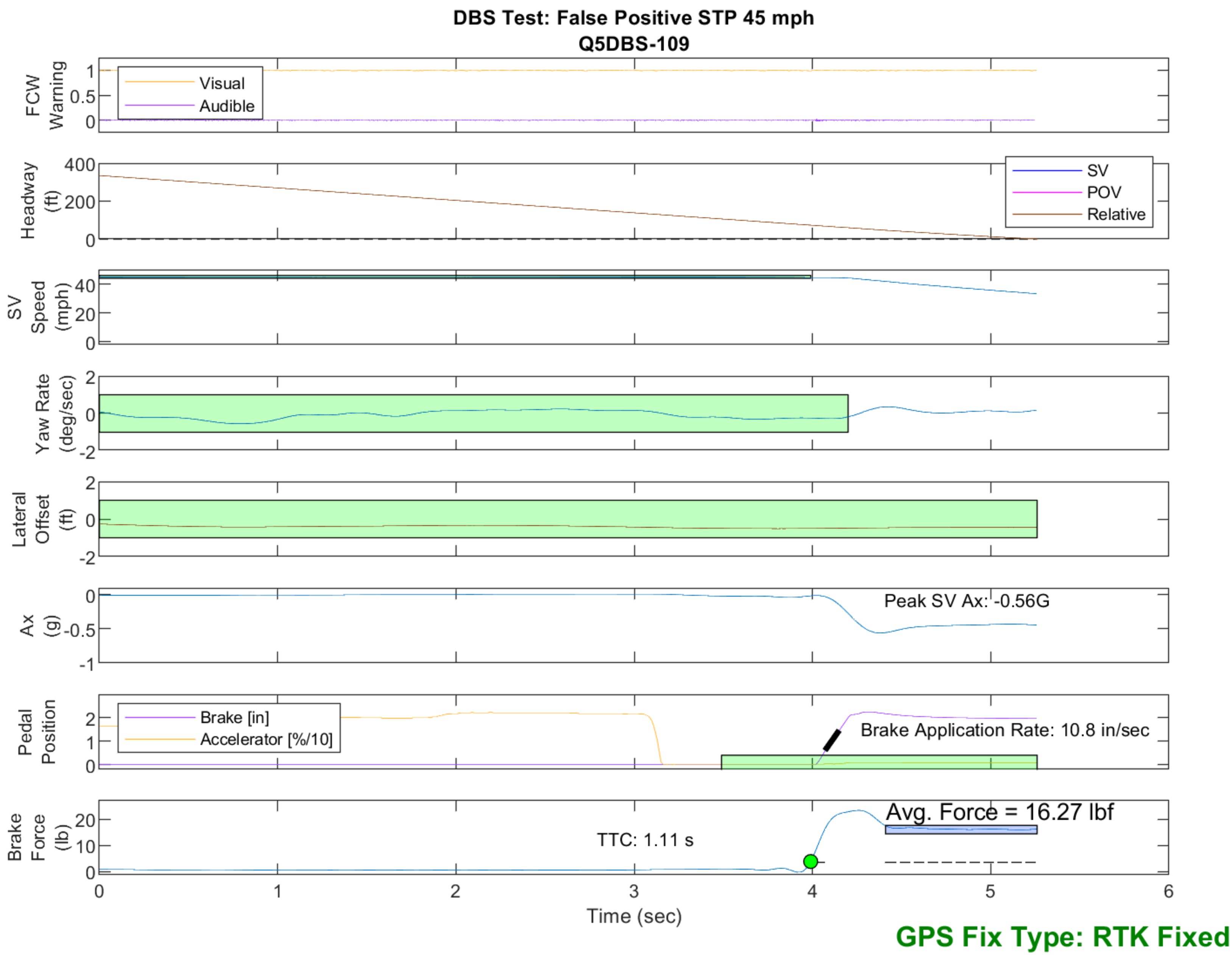

Figure E62. Time History for DBS Run 109, SV Encounters Steel Trench Plate, SV 45 mph

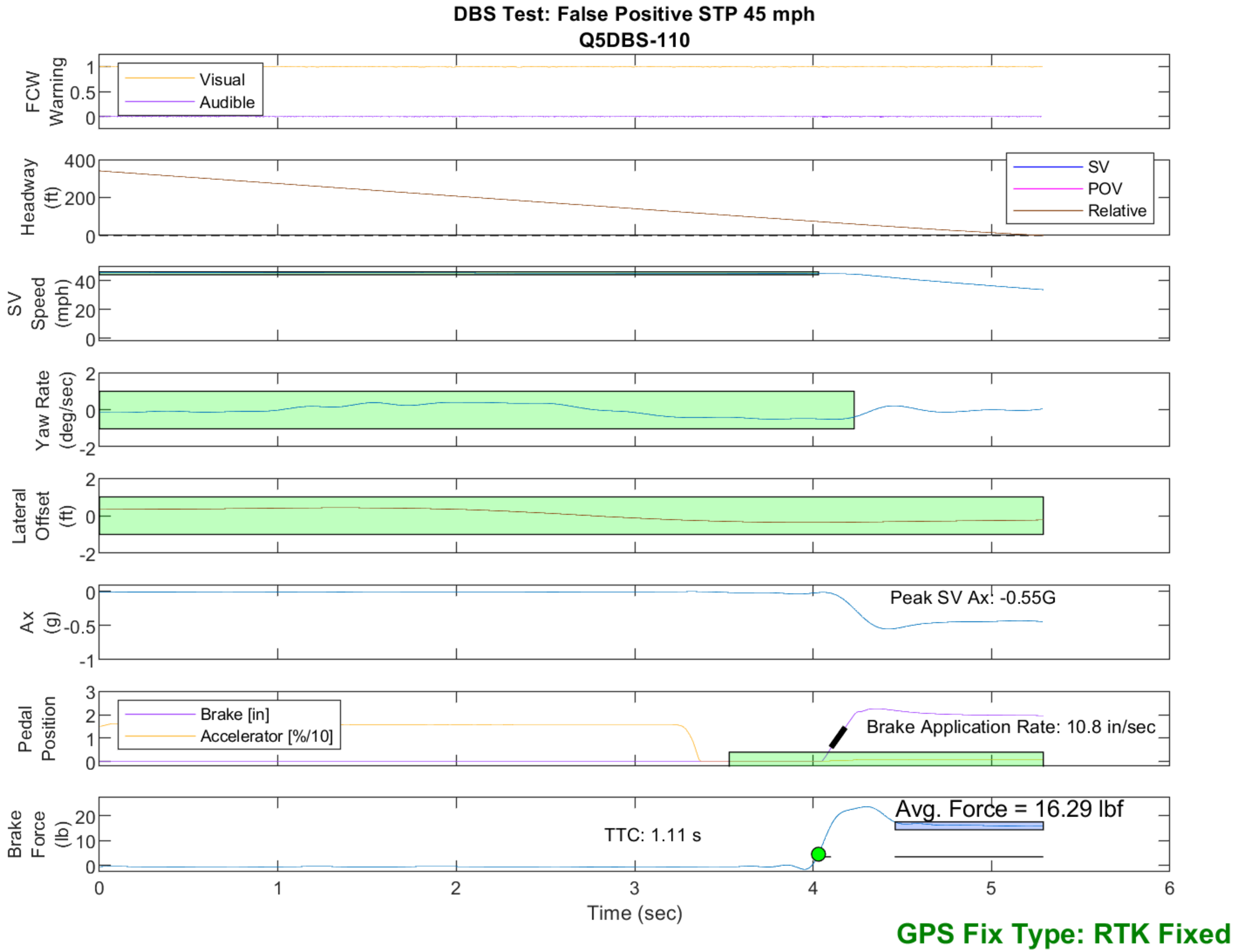

Figure E63. Time History for DBS Run 110, SV Encounters Steel Trench Plate, SV 45 mph

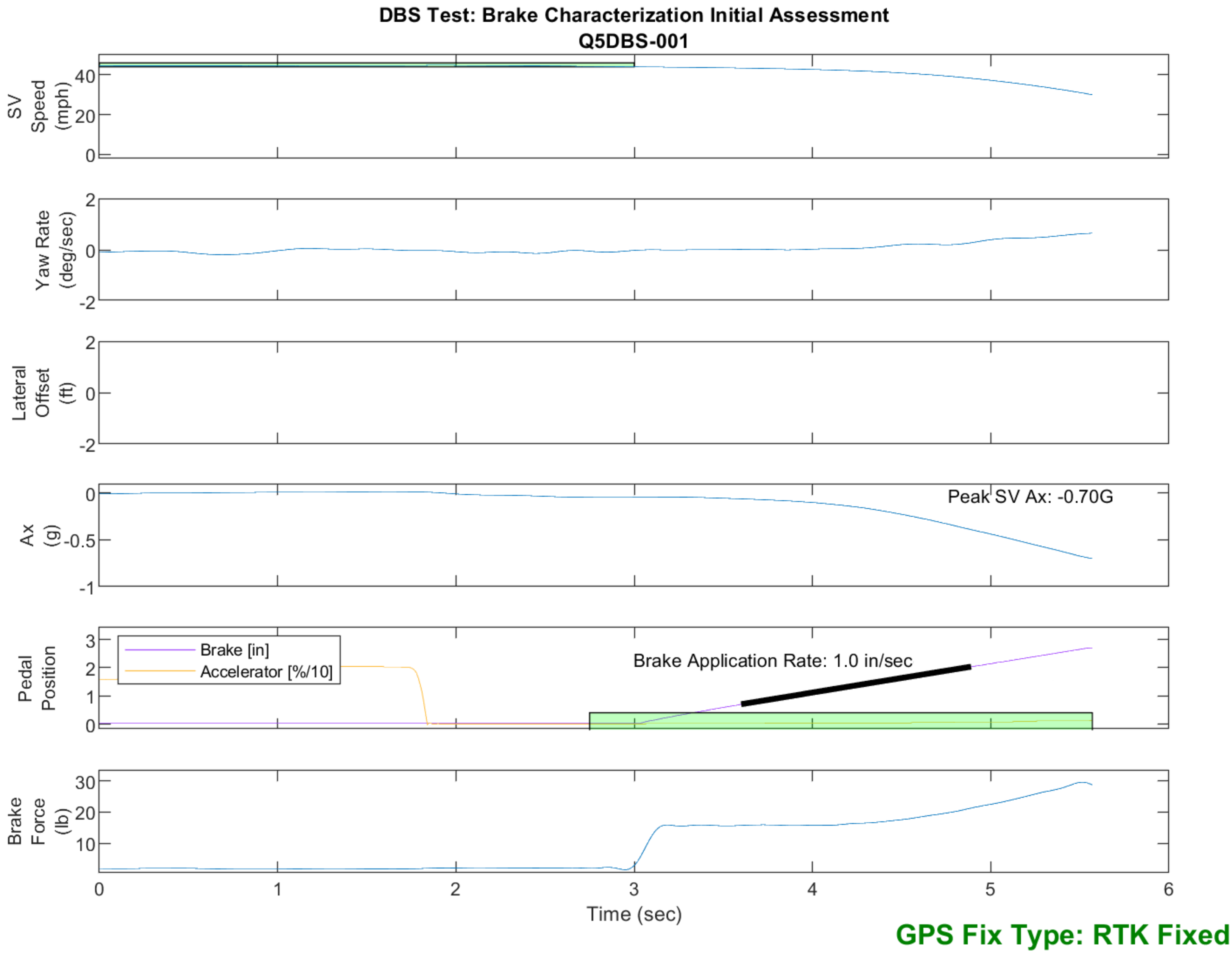

Figure E64. Time History for DBS Run 1, Brake Characterization Initial

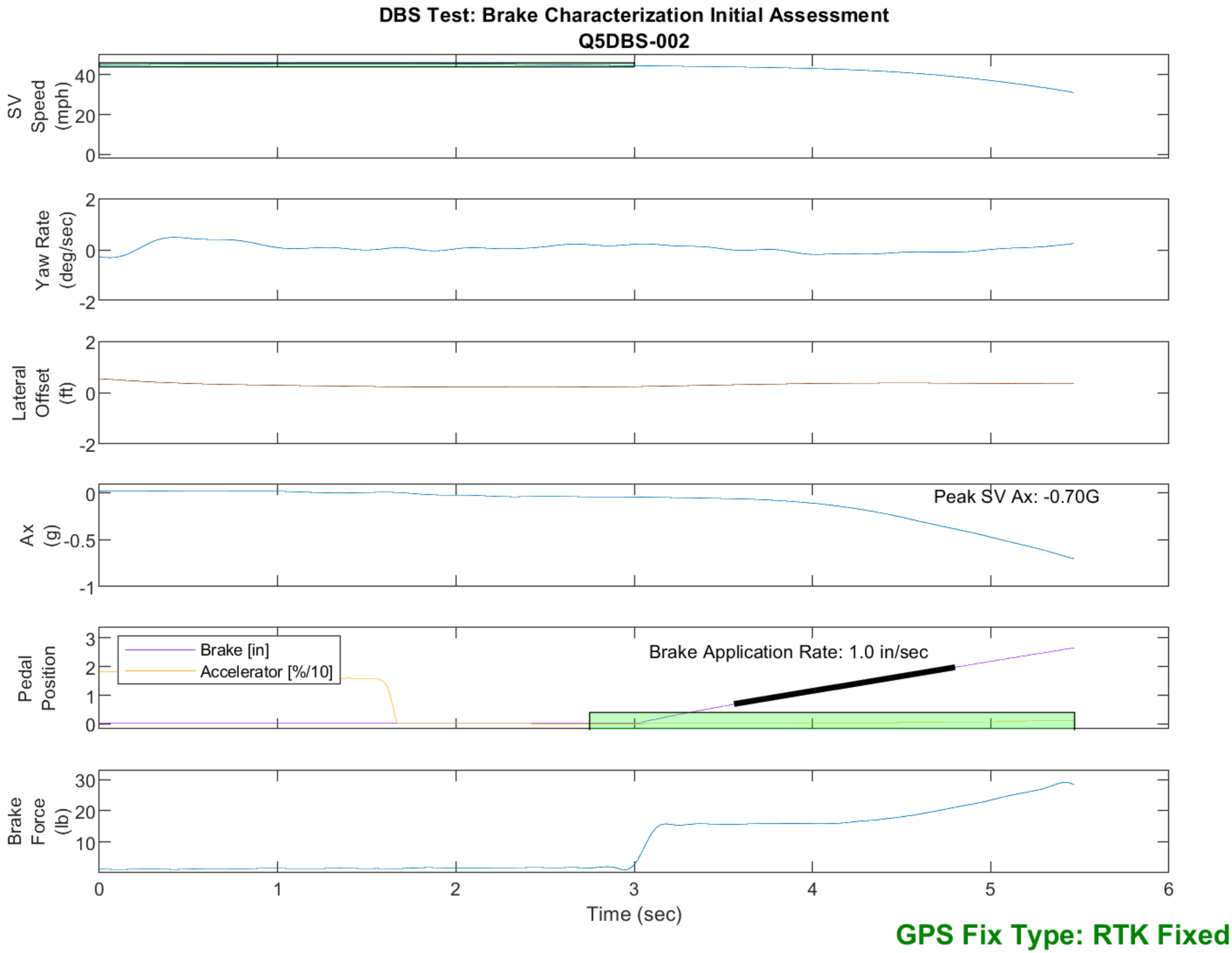

Figure E65. Time History for DBS Run 2, Brake Characterization Initial

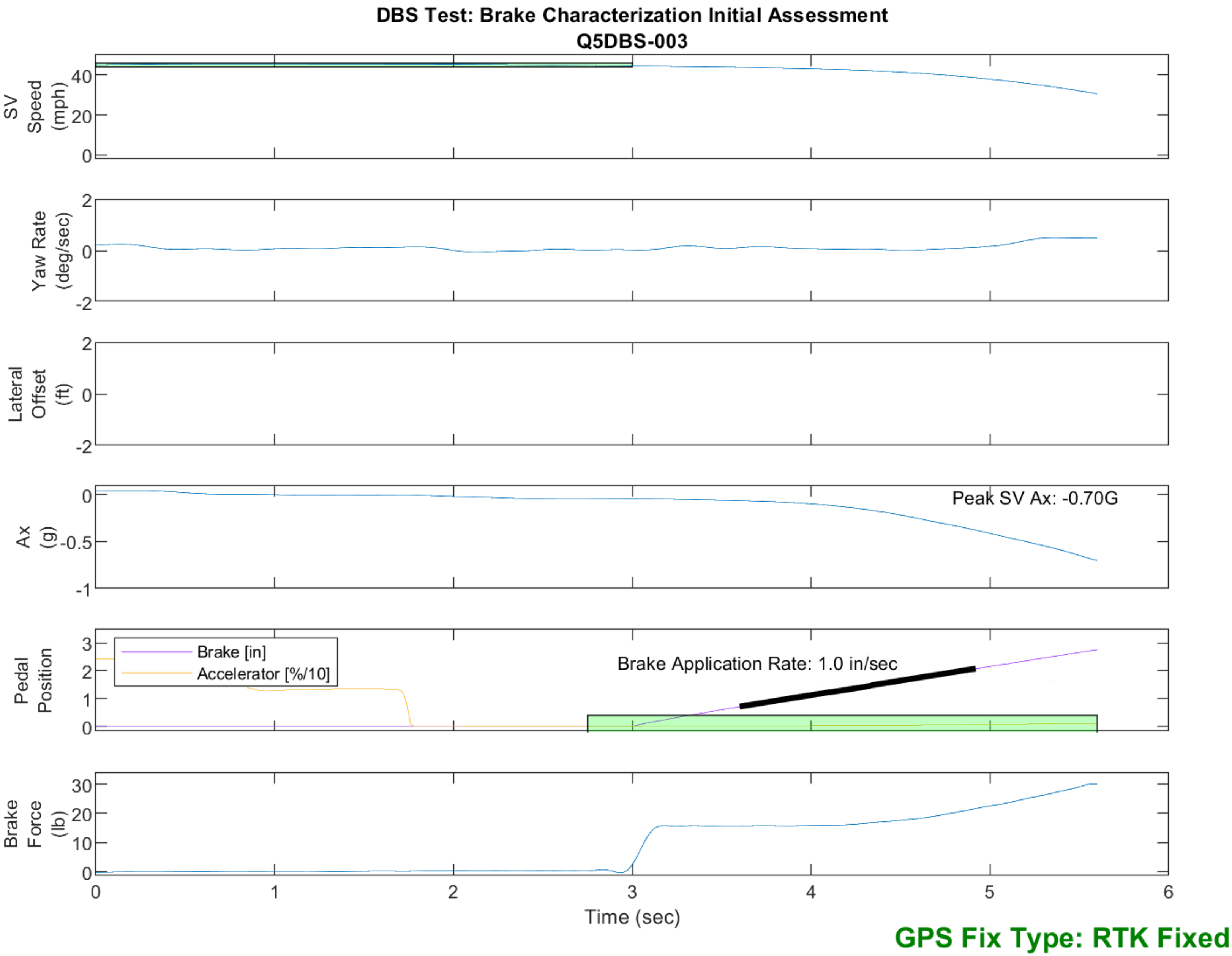

Figure E66. Time History for DBS Run 3, Brake Characterization Initial

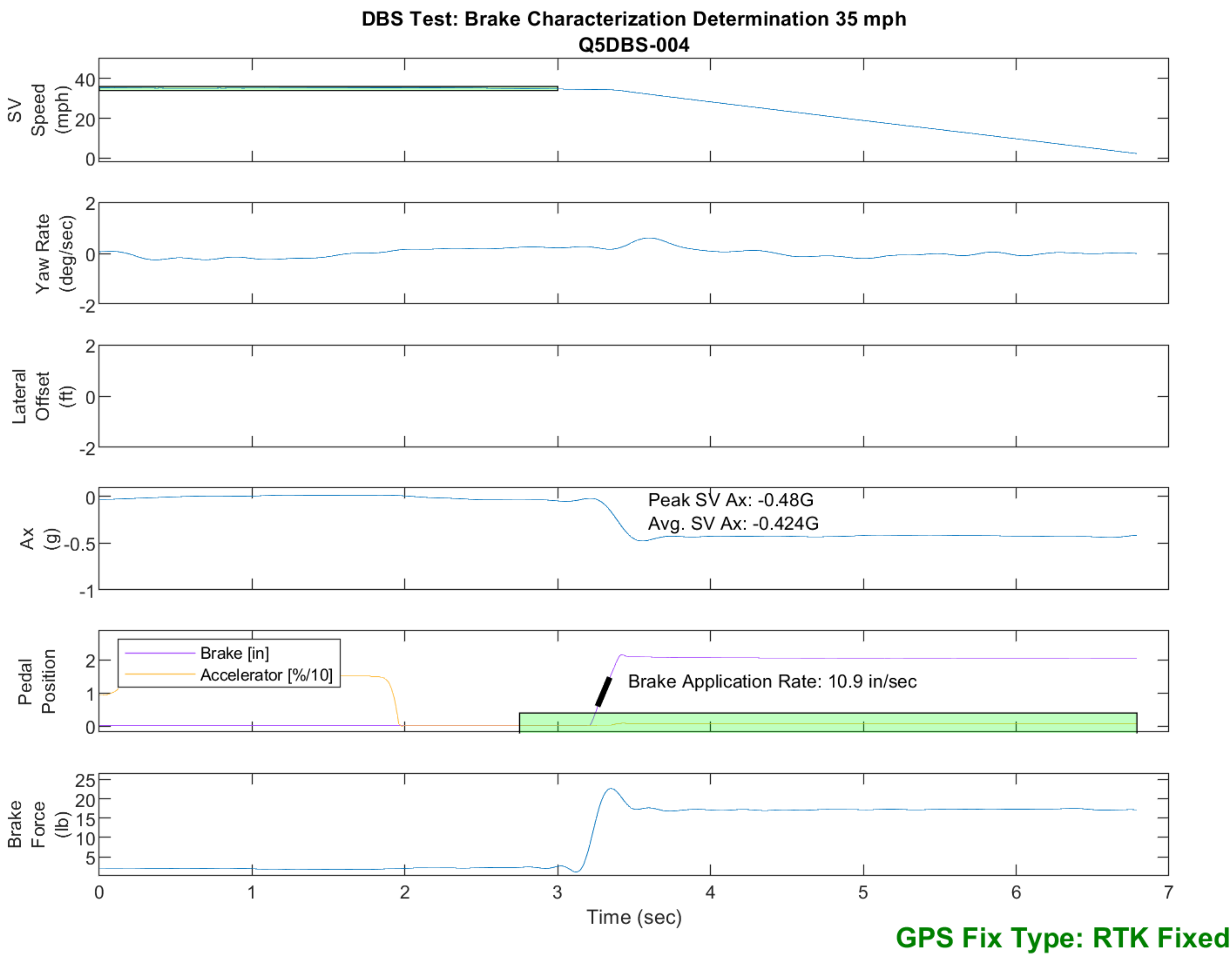

Figure E67. Time History for DBS Run 4, Brake Characterization Determination 35 mph

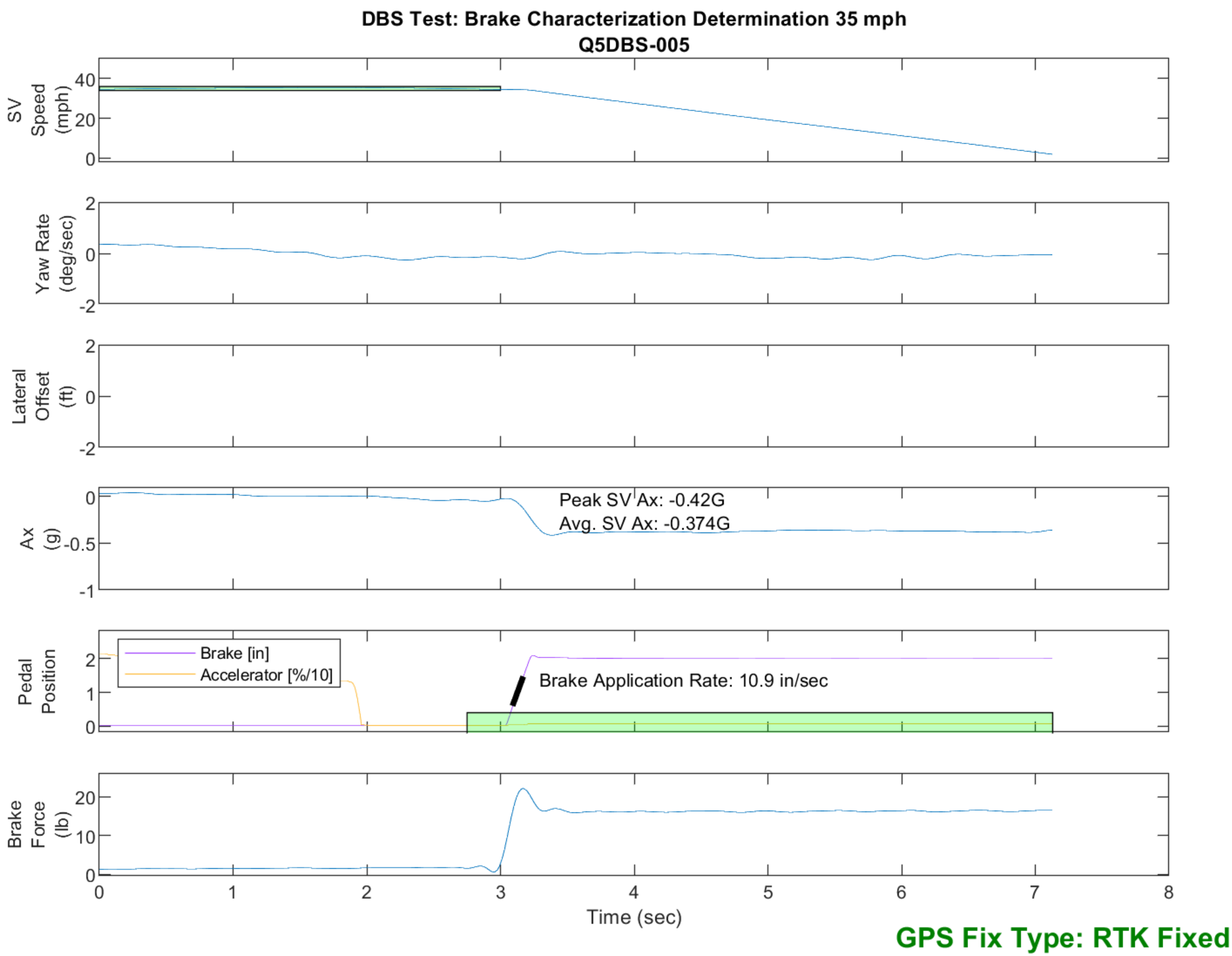

Figure E68. Time History for DBS Run 5, Brake Characterization Determination 35 mph

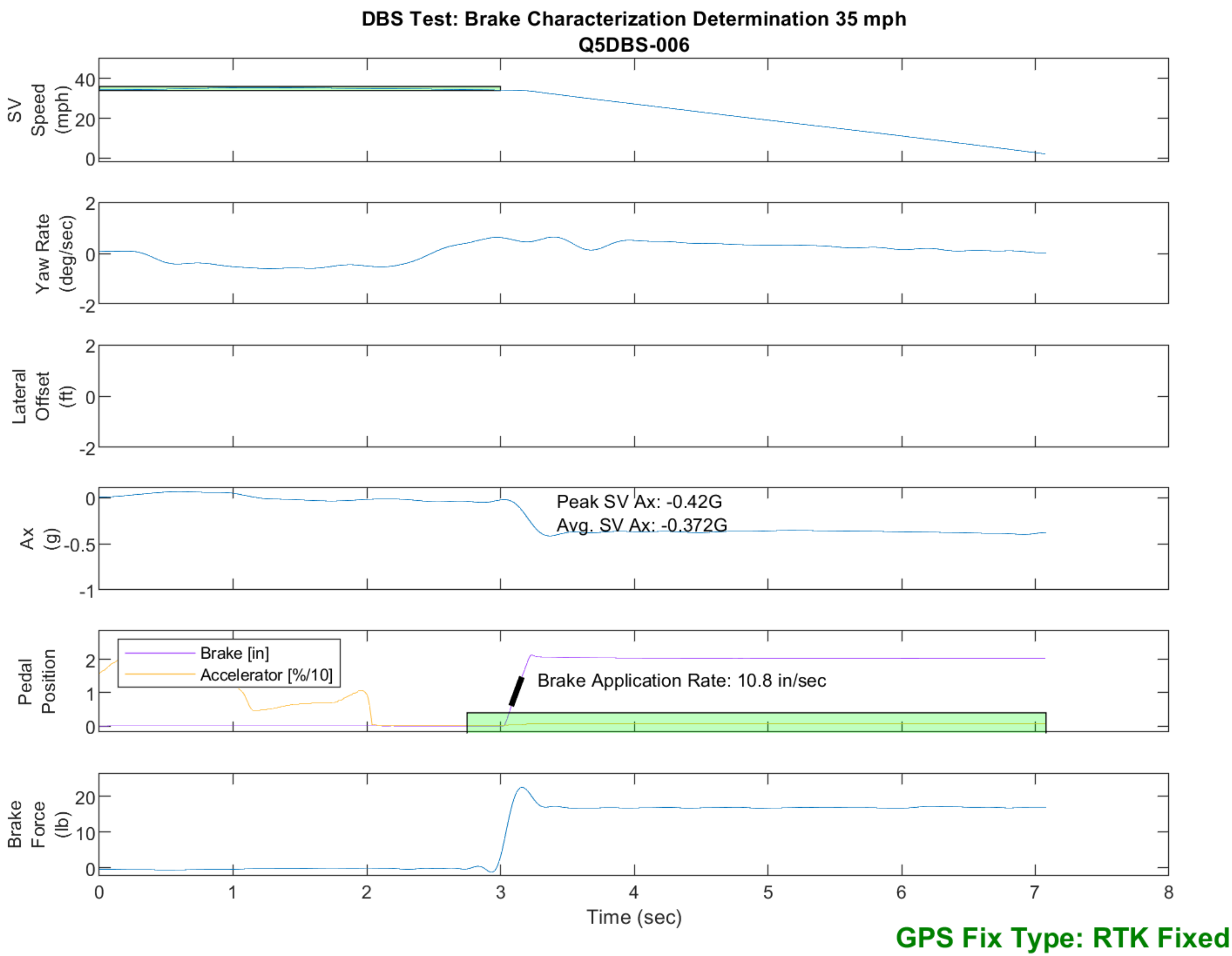

Figure E69. Time History for DBS Run 6, Brake Characterization Determination 35 mph

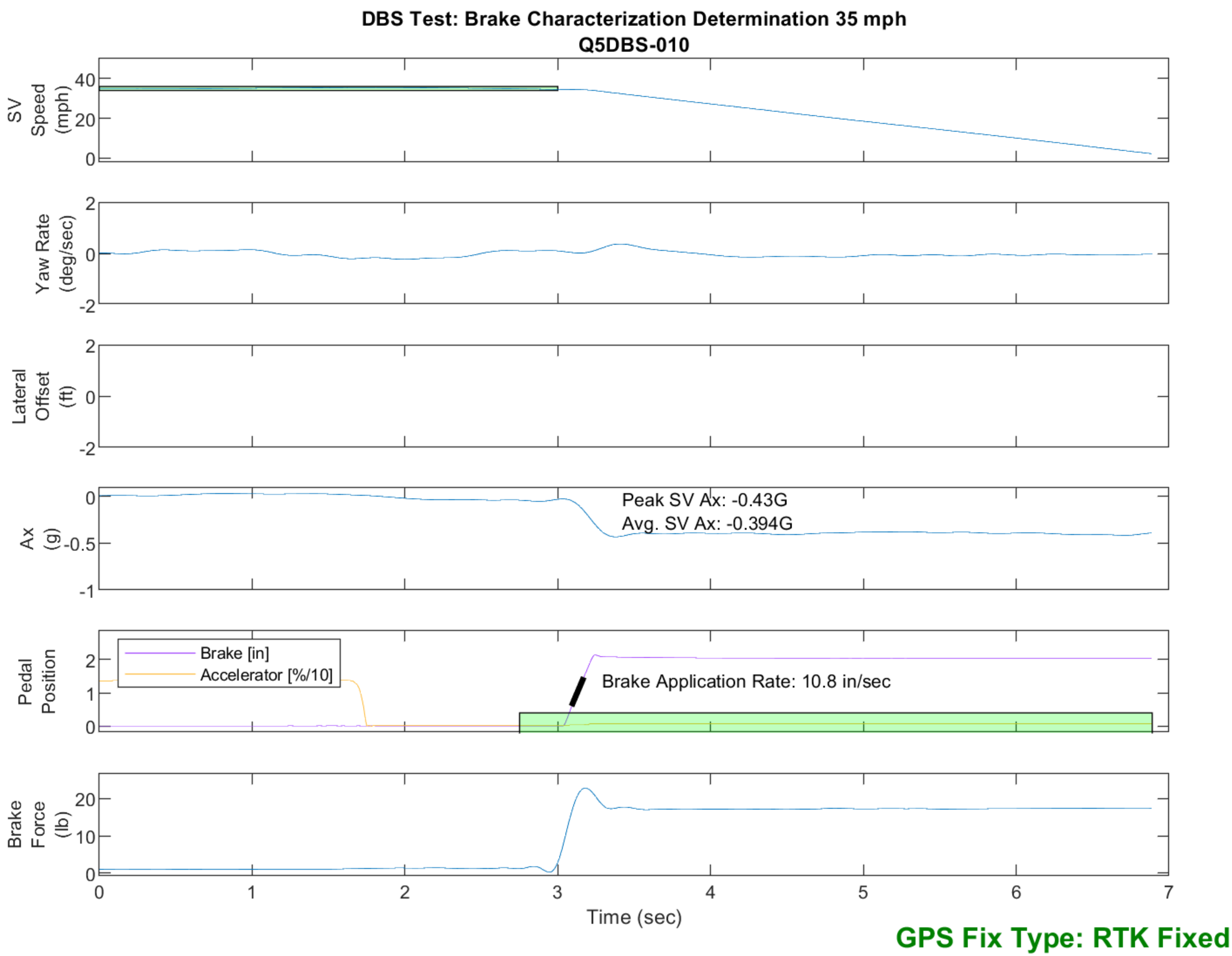

Figure E70. Time History for DBS Run 10, Brake Characterization Determination 35 mph

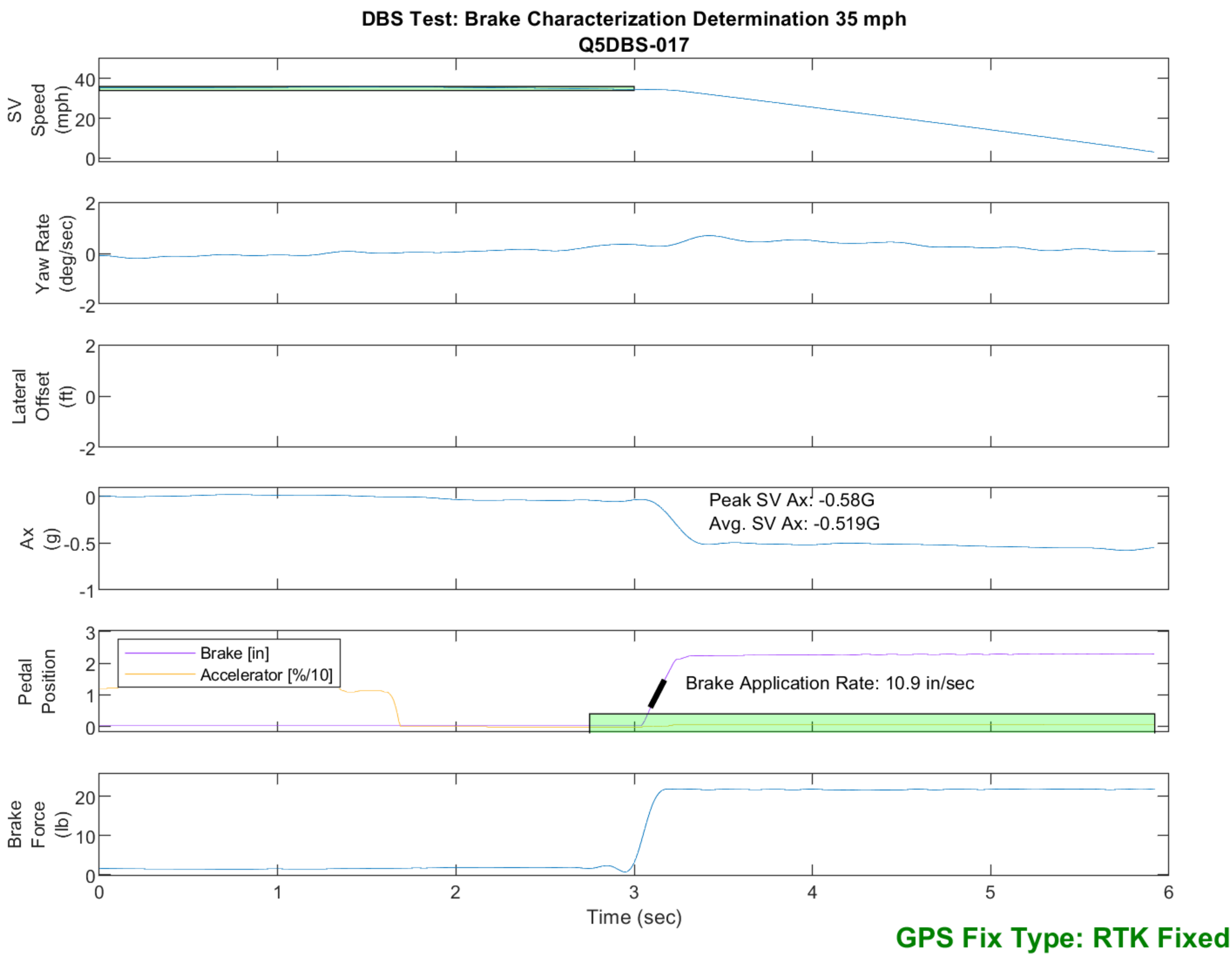

Figure E71. Time History for DBS Run 17, Brake Characterization Determination 35 mph

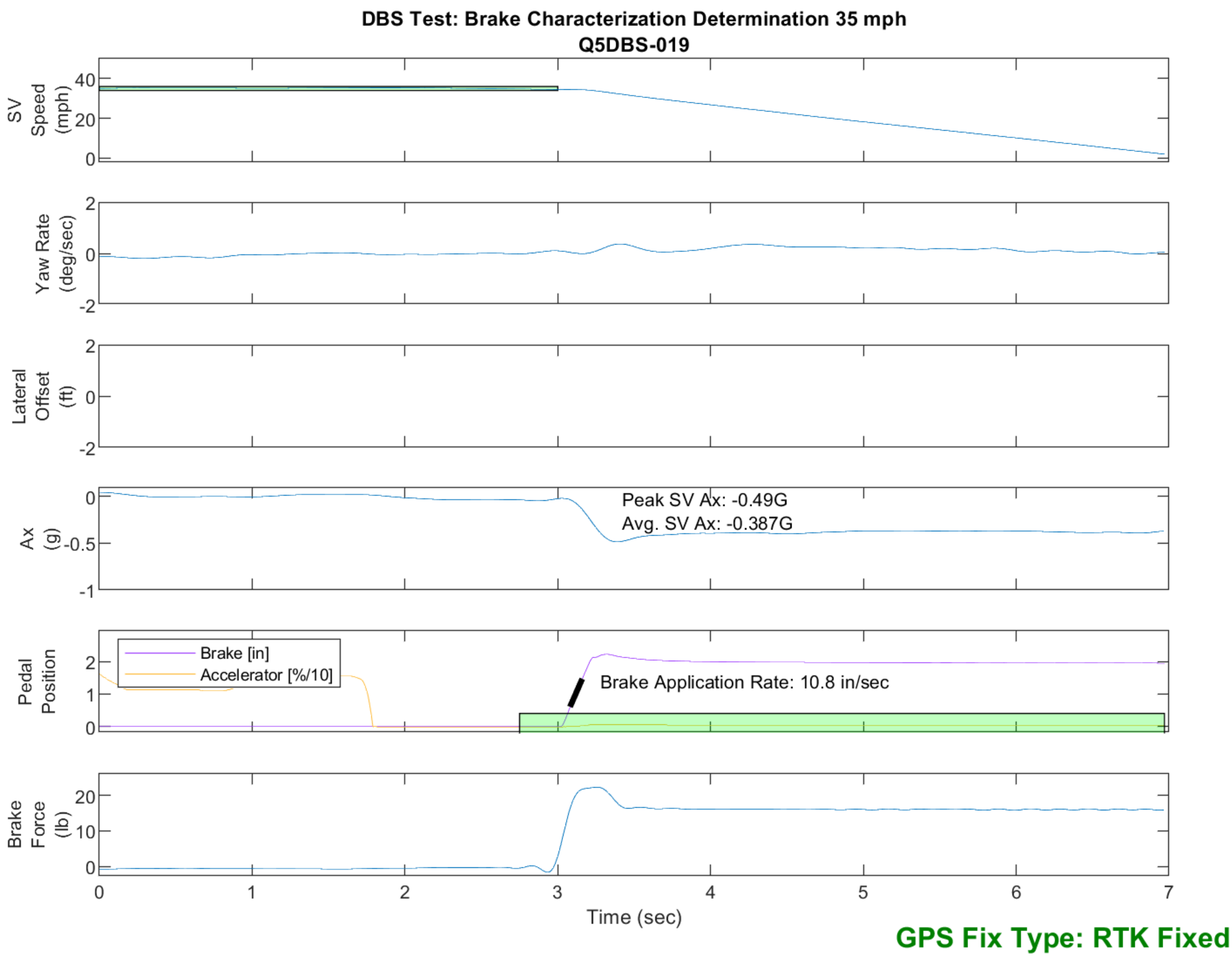

Figure E72. Time History for DBS Run 19, Brake Characterization Determination 35 mph

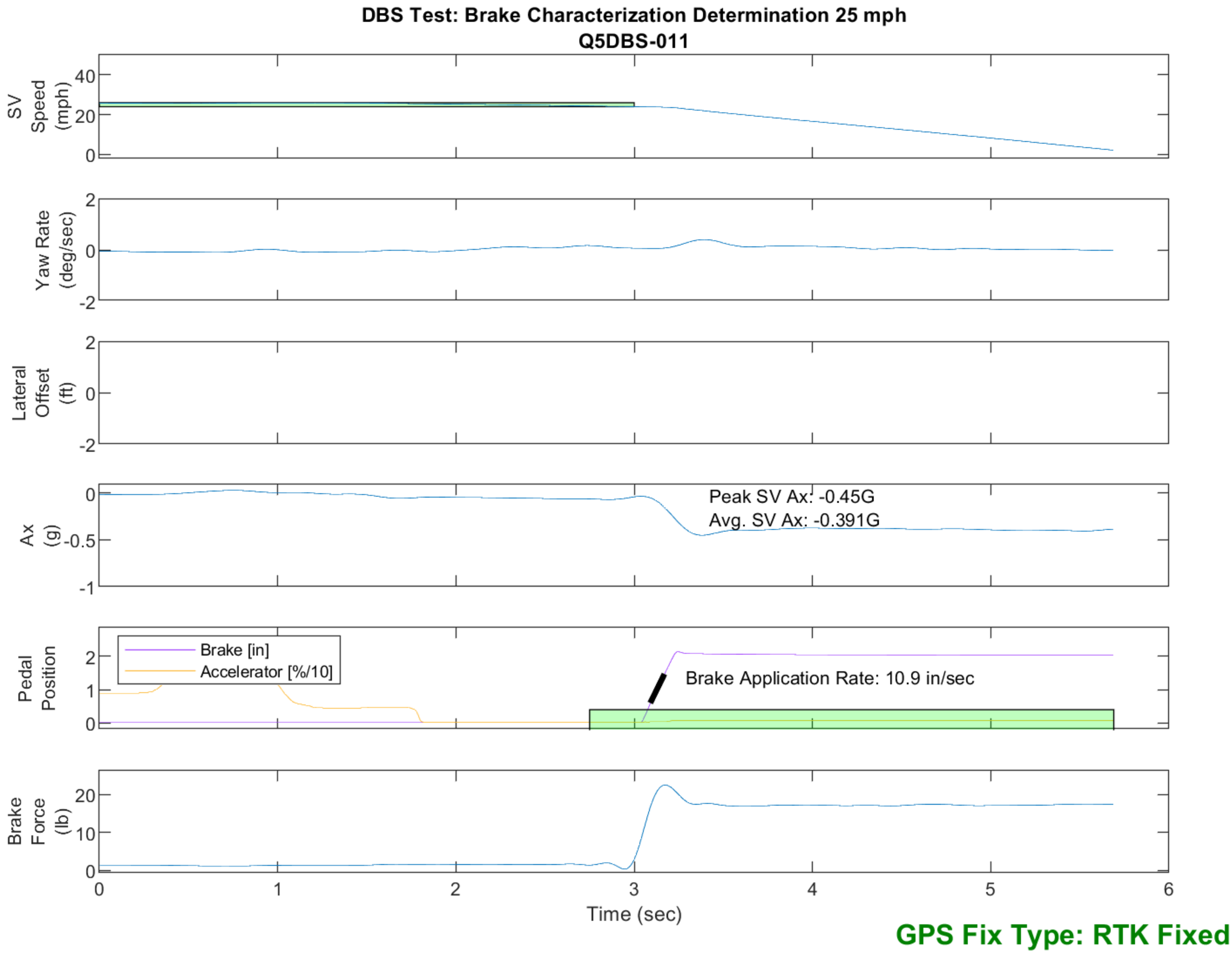

Figure E73. Time History for DBS Run 11, Brake Characterization Determination 25 mph

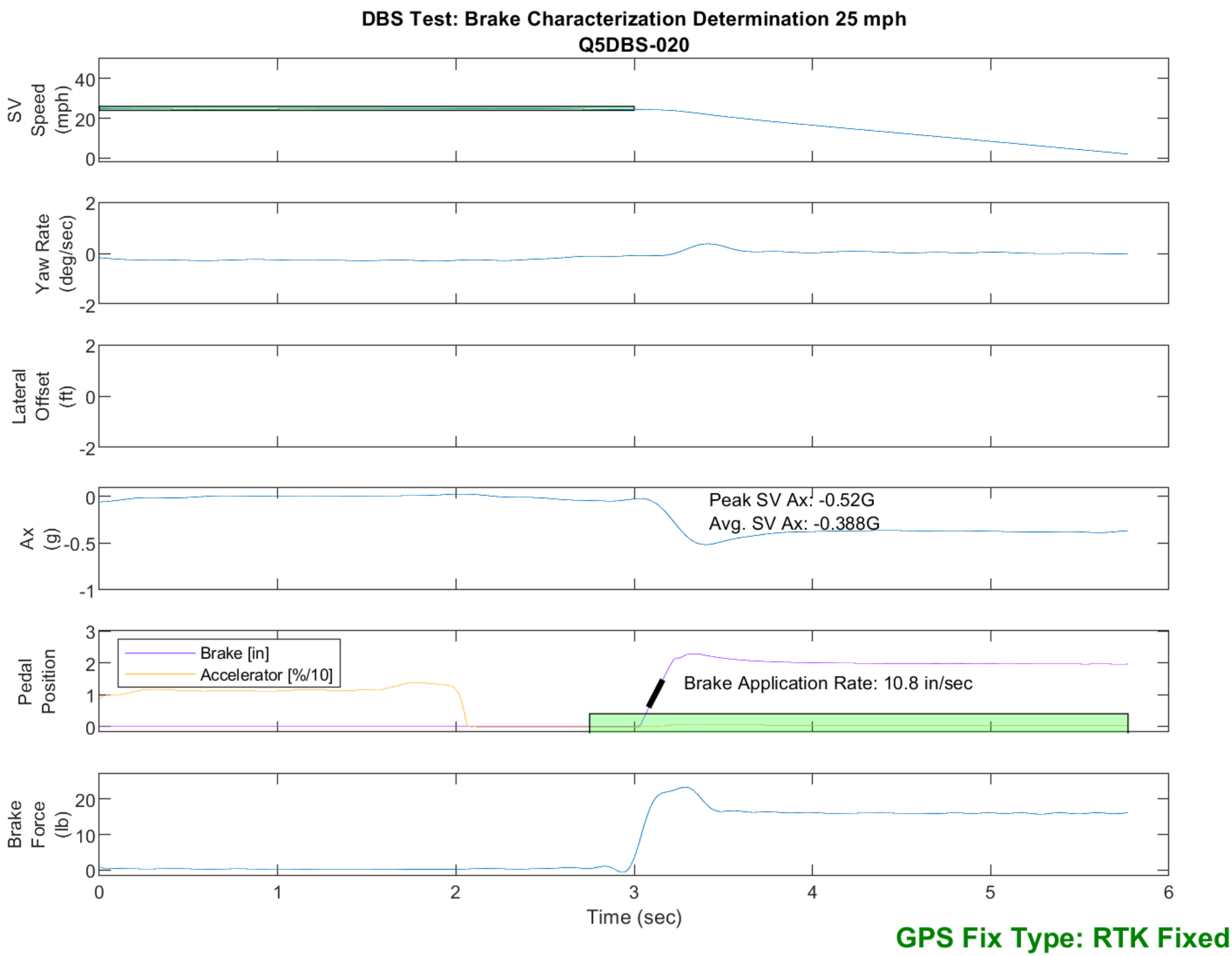

Figure E74. Time History for DBS Run 20, Brake Characterization Determination 25 mph

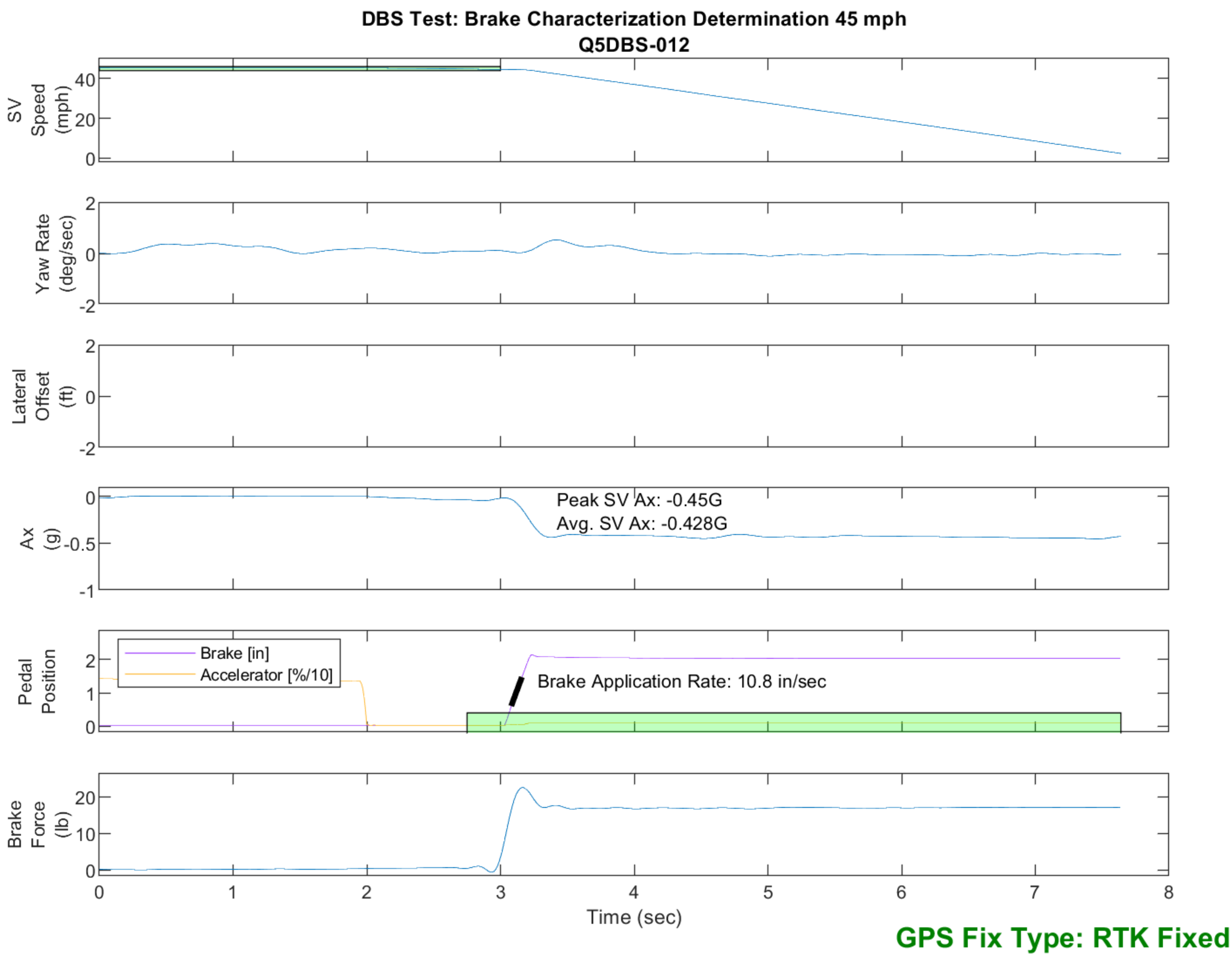

Figure E75. Time History for DBS Run 12, Brake Characterization Determination 45 mph

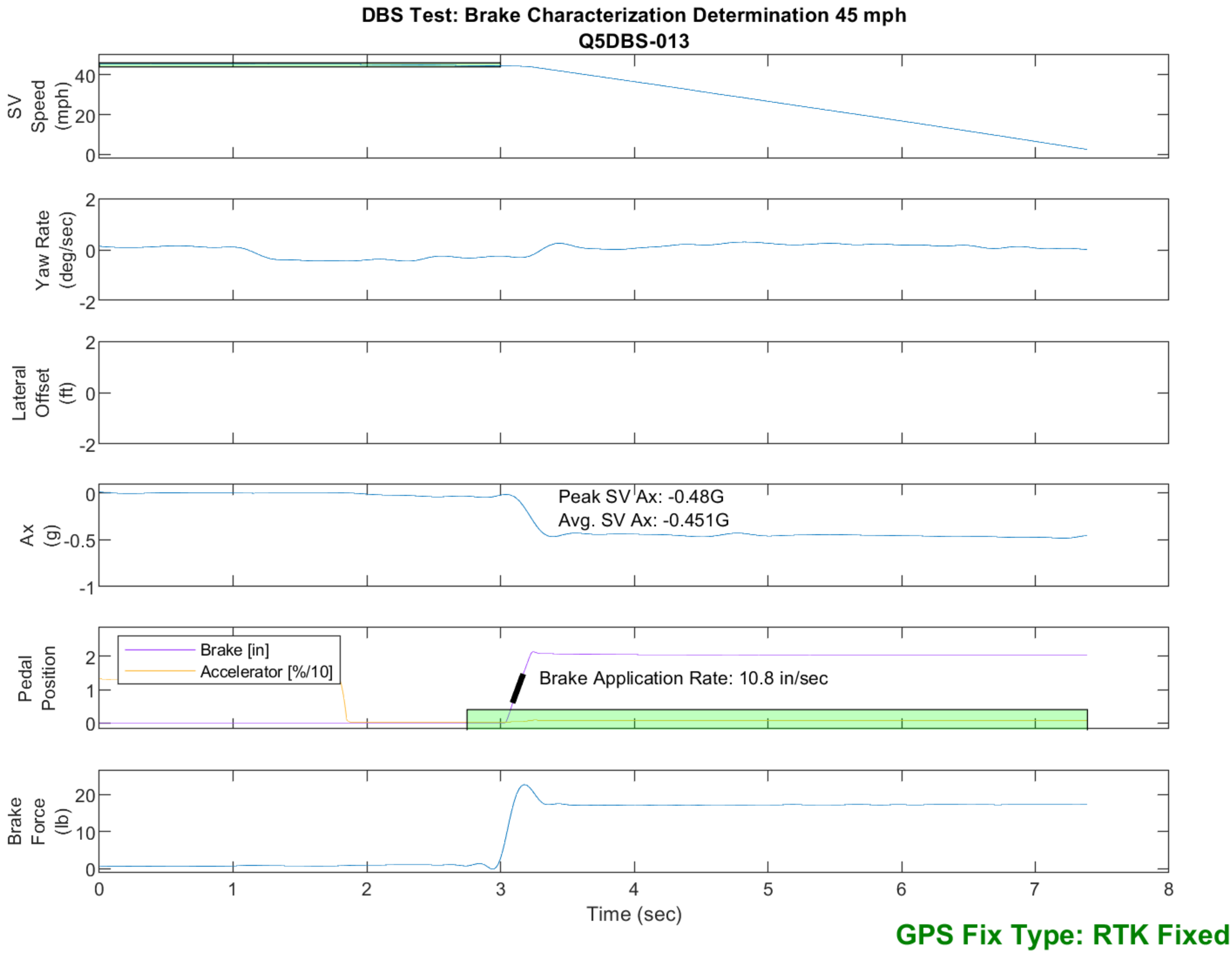

Figure E76. Time History for DBS Run 13, Brake Characterization Determination 45 mph

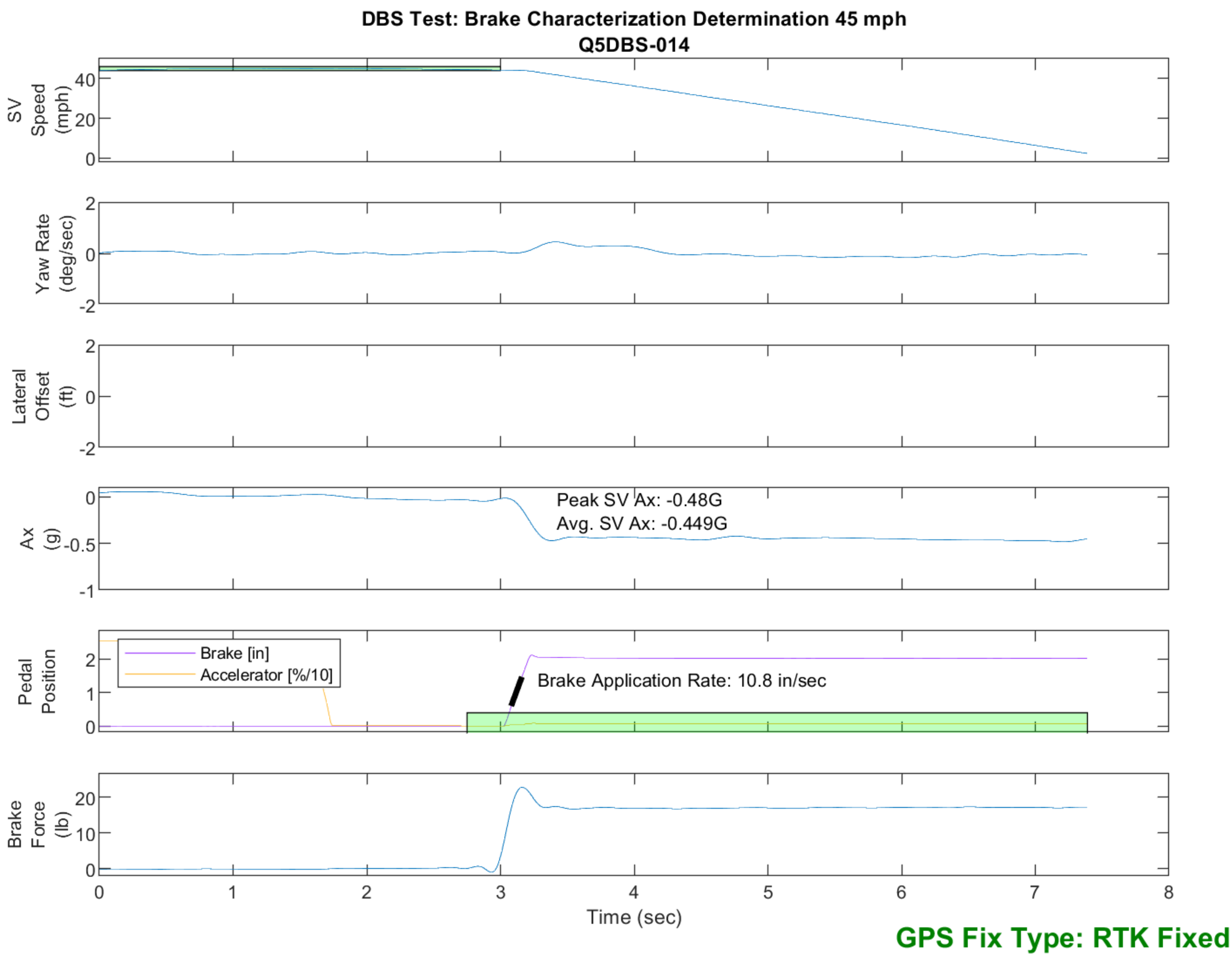

Figure E77. Time History for DBS Run 14, Brake Characterization Determination 45 mph

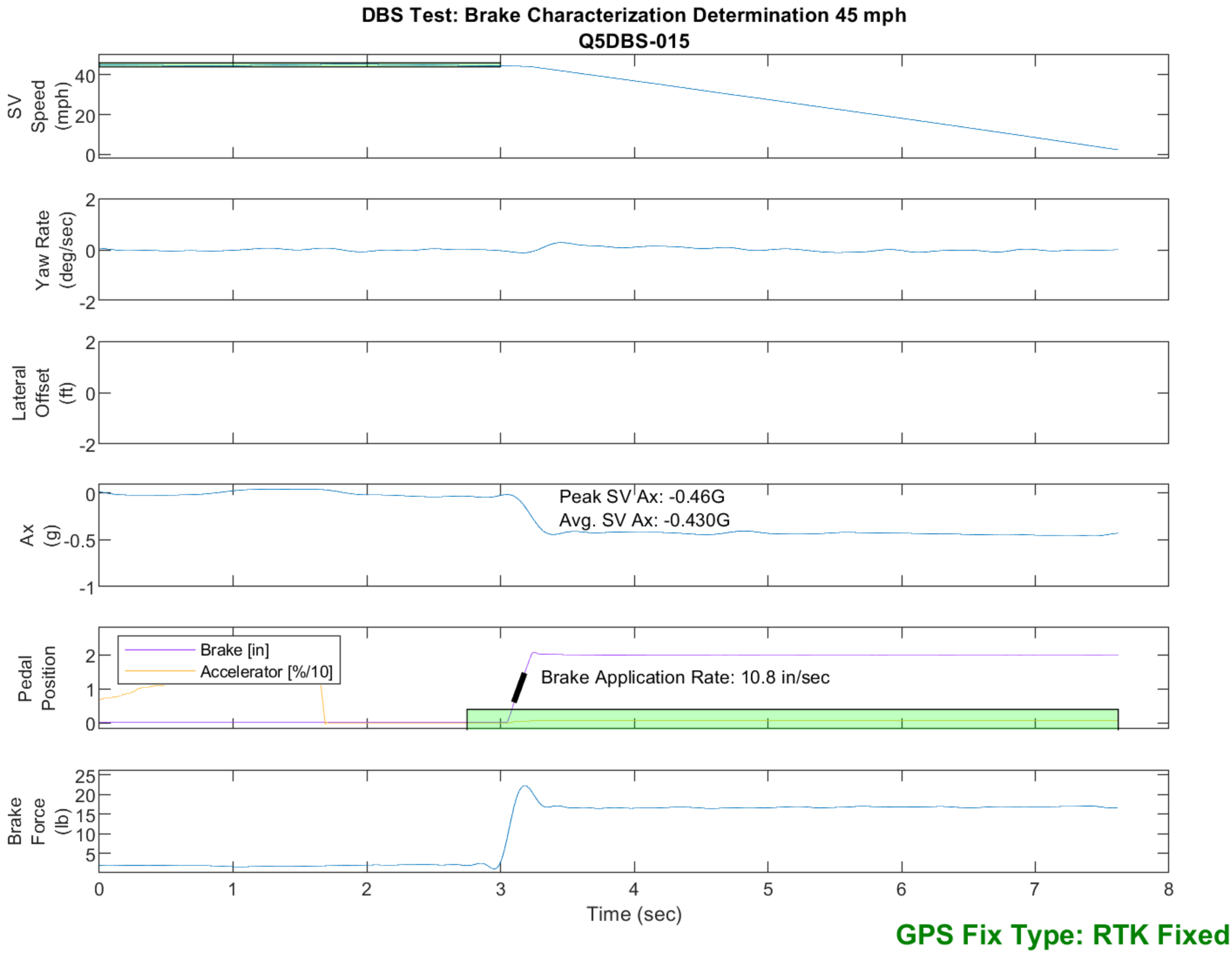

Figure E78. Time History for DBS Run 15, Brake Characterization Determination 45 mph

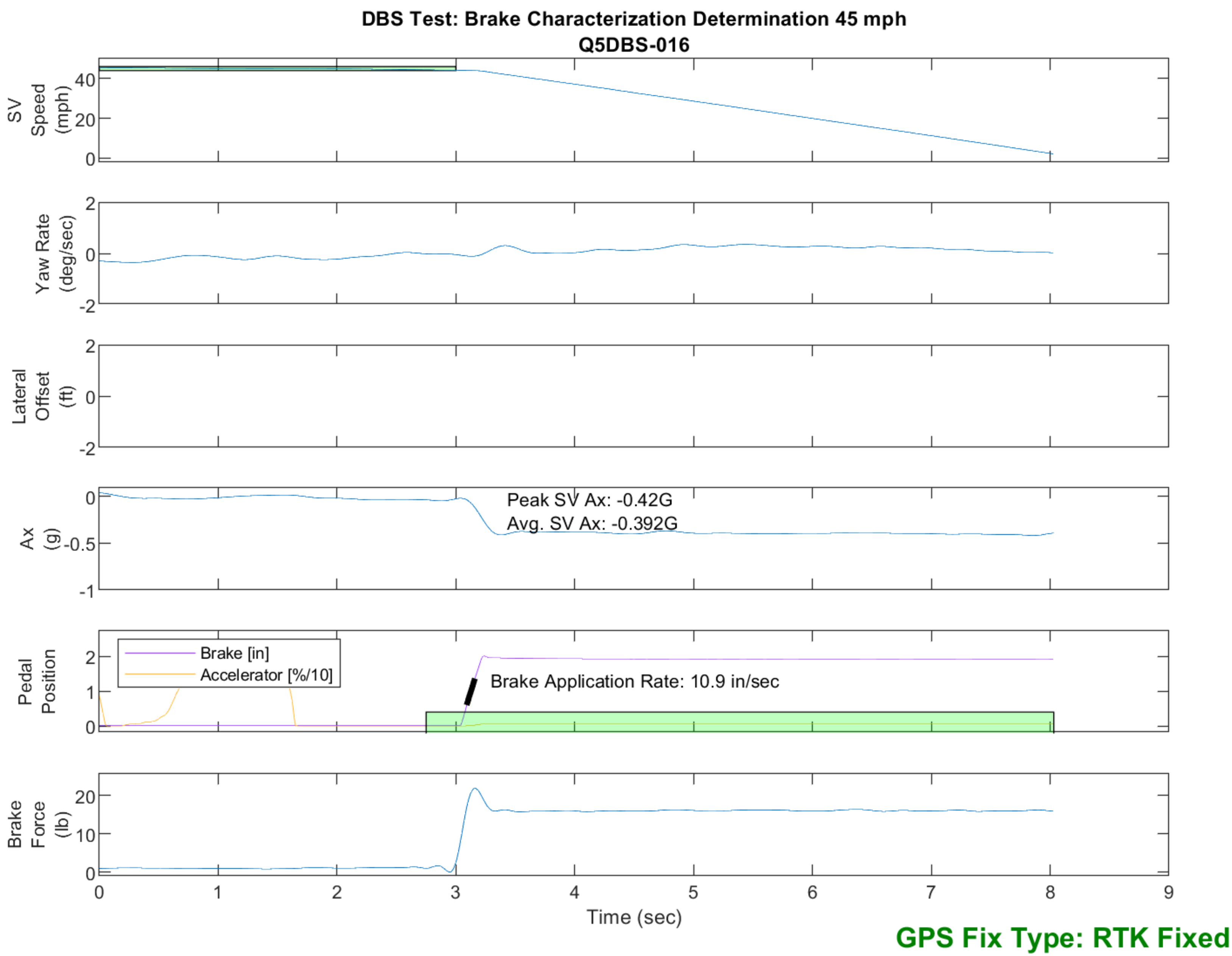

Figure E79. Time History for DBS Run 16, Brake Characterization Determination 45 mph

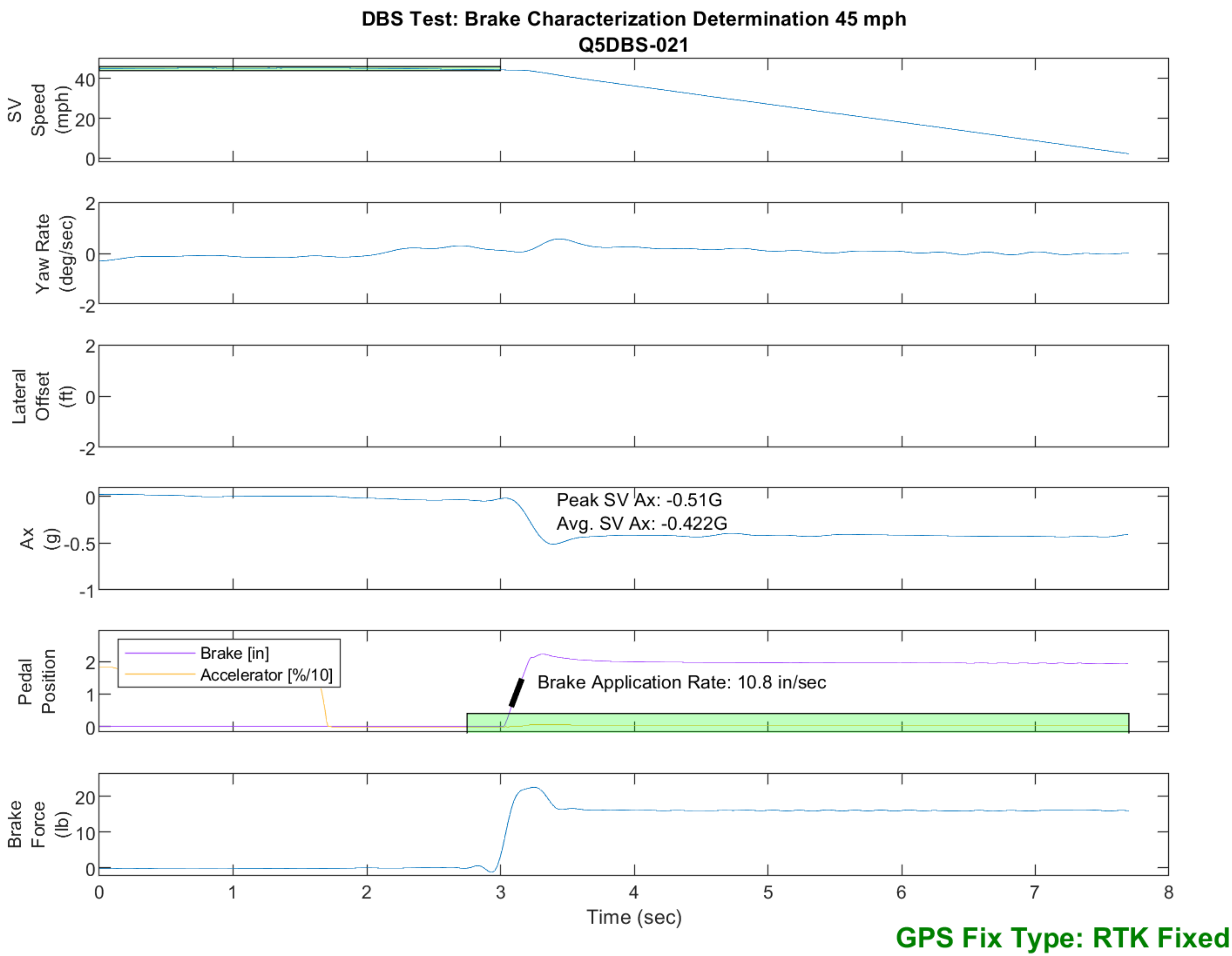

Figure E80. Time History for DBS Run 21, Brake Characterization Determination 45 mph

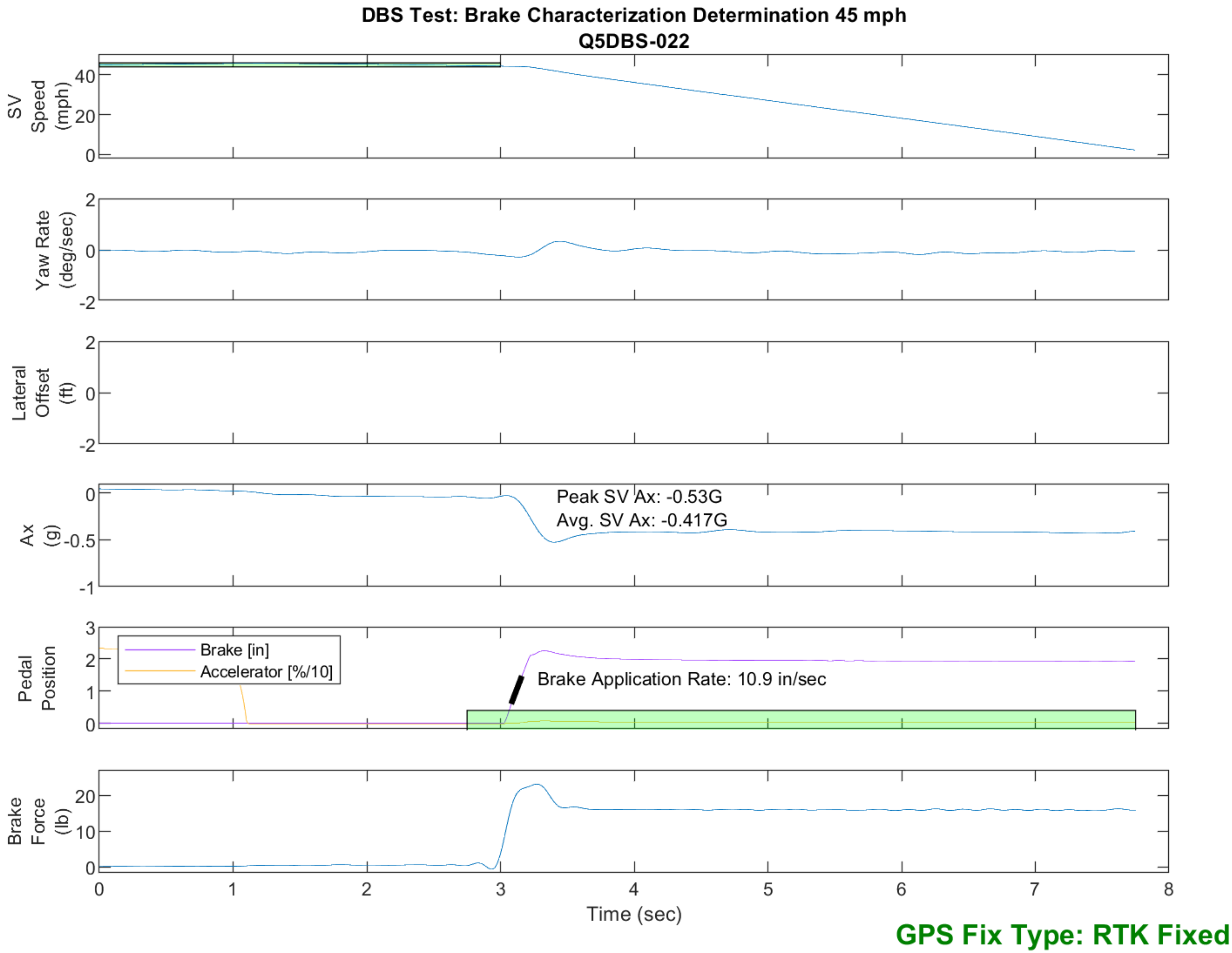

Figure E81. Time History for DBS Run 22, Brake Characterization Determination 45 mph