NEW CAR ASSESSMENT PROGRAM
DYNAMIC BRAKE SUPPORT SYSTEM CONFIRMATION TEST
NCAP-DRI-DBS-21-18

2021 Volkswagen ID.4 Pro S (Statement)

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5 August 2021

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
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16. Abstract

These tests were conducted on the subject 2021 Volkswagen ID.4 Pro S (Statement) 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 test requirements for the stopped POV, decelerating POV, false positive, and 25/10 mph slower-moving POV scenarios, but failed the requirements for the 45/20 mph slower-moving POV scenario, resulting in an overall test failure.

17. Key Words Dynamic Brake Support, DBS, AEB, New Car Assessment Program, NCAP		18. Distribution Statement 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	
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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 (SV) when the system determines that the braking applied by the driver is insufficient to avoid a collision.

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

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

The purpose of the testing reported herein was to objectively quantify the performance of a Dynamic Brake Support system installed on a 2021 Volkswagen ID.4 Pro S (Statement). This test to assess Dynamic Brake Support systems is sponsored by the National Highway Traffic Safety Administration under Contract No. DTNH22-14-D-00333 with the New Car Assessment Program (NCAP).

Section II

DATA SHEETS

DYNAMIC BRAKE SUPPORT

DATA SHEET 1: TEST RESULTS SUMMARY

(Page 1 of 1)

2021 Volkswagen ID.4 Pro S (Statement)

VIN: *WVGTMPE21MP03xxxx*

Test Date: *7/9/2021*

Dynamic Brake Support System settings:

Front Assist (Auto. Emerg. Braking): On

Advance warning: 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: *Fail*

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: ***Fail***

Notes:

DYNAMIC BRAKE SUPPORT

DATA SHEET 2: VEHICLE DATA

2021 Volkswagen ID.4 Pro S (Statement)

TEST VEHICLE INFORMATION

VIN: *WVGTMPE21MP03xxxx*

Body Style: *SUV* Color: *Dusk Blue Metallic*

Date Received: *5/31/2021* Odometer Reading: *17 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *VOLKSWAGEN AG*

Date of manufacture: *03/21*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *235/55 R19 105T XL*

Rear: *255/50 R19 107T XL*

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

Rear: *290 kPa (42 psi)*

TIRES

Tire manufacturer and model: *Hankook Kinergy AS x ev*

Front tire specification: *235/55R19 105T*

Rear tire specification: *255/50R19 107T*

Front tire DOT prefix: *15M98 9U HO*

Rear tire DOT prefix: *15M7F 9U HO*

DYNAMIC BRAKE SUPPORT

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2021 Volkswagen ID.4 Pro S (Statement)

GENERAL INFORMATION

Test date: *7/9/2021*

AMBIENT CONDITIONS

Air temperature: *43.3 C (110 F)*

Wind speed: *2.1 m/s (4.6 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: *290 kPa (42 psi)*

Rear: *290 kPa (42 psi)*

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*543.4 kg (1198 lb)*	Right Front:	*527.1 kg (1162 lb)*
Left Rear:	*601.5 kg (1326 lb)*	Right Rear:	*586.9 kg (1294 lb)*
		Total:	*2258.9 kg (4980 lb)*

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

2021 Volkswagen ID.4 Pro S (Statement)

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

Front Assist (Forward Collision Warning & Autonomous Emergency Braking w/ Pedestrian Monitoring)

Front Assist is a part of the IQ Drive package and is standard equipment.

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

Mono camera mounted behind the windshield above the rearview mirror and radar located behind the front bumper.

System settings used for test (if applicable):

Front Assist (Auto. Emerg. Braking): On
Advance warning: Early

Brake application mode used for test: *Hybrid control*

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

5 km/h (3 mph) (Per manufacturer supplied information)

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

85 km/h (53 mph) for stationary POV

250 km/h (155 mph) for moving POV (Per manufacturer supplied information)

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

___ No

If yes, please provide a full description.

To ensure the full AEB-performance, please take the following steps:

- *Drive above 10 km/h*
- *Drive in a straight line*
- *Drive past or alongside metallic objects (e.g. parked vehicles, guardrails, lampposts)*

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

___ Yes

X No

If yes, please provide a full description.

Under regular testing conditions and if the sensors are not damaged the system will not deactivate. A deactivation would be indicated to the driver via warning icons and a corresponding text message on the gauge cluster behind the steering wheel. Cycling the ignition can reactivate the system if the cause for the deactivation is not permanent.

How is the Forward Collision Warning presented to the driver?

(Check all that apply)

X Warning light

X Buzzer or auditory alarm

___ Vibration

X Other *Initial brake pulse*

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

Advance warning (FCW):

The system detects a possible collision and prepares the vehicle for possible emergency braking. An auditory warning sounds and the red warning lamp lights up. See Appendix A, Figure A16.

Urgent warning:

If the driver does not react to the advance warning, the system may initiate a short braking jolt in order to draw attention to the increasing collision risk.

(Continued)

Braking intervention (DBS)

If the system detects that the driver is braking insufficiently when there is a risk of collision, the system can increase the braking force and help prevent a collision. The braking intervention takes place only for as long as the brake pedal is pressed hard.

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.

System menus are accessed by pressing the "Assist" button in the center console. An image appears in the center touchscreen showing a vehicle, two adjacent blue vehicles and blue lane lines. To disable the system:

Navigate to the Front Assist menu by either:

- *Touching the picture of a vehicle with another vehicle ahead or*
- *Touching the button in the upper right of the screen, which will bring up the Assistance system settings menu*
    - *Select Front Assist (Autonomous Emergency Braking)*
    - *Select Advance Warning*
    - *Select or deselect "Off" from the dropdown.*

Note that selecting or deselecting "Active" enables or disables the AEB portion of the system.

See Appendix A, Figures A14 and A15.

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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.

System menus are accessed by pressing the "Assist" button in the center console. An image appears in the center touchscreen showing a vehicle, two adjacent blue vehicles and blue lane lines. To disable the system:

Navigate to the Front Assist menu by either:

- *Touching the picture of a vehicle with another vehicle ahead or*
- *Touching the button in the upper right of the screen, which will bring up the Assistance system settings menu*
  - *Select Front Assist (Autonomous Emergency Braking)*
  - *Select Advance Warning*
  - *Select "Early", "Medium", or "Late" to set the alert timing.*

This affects the FCW warning timing only.

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.

System limitations are described on page 162 of the Owner's Manual, shown in Appendix B, page B-6.

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Four test scenarios were used, as follows:

Test 1. Subject Vehicle (SV) Encounters Stopped Principal Other Vehicle (POV)

Test 2. Subject Vehicle Encounters Slower Principal Other Vehicle

Test 3. Subject Vehicle Encounters Decelerating Principal Other Vehicle

Test 4. Subject Vehicle Encounters Steel Trench Plate

An overview of each of the test procedures follows.

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

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

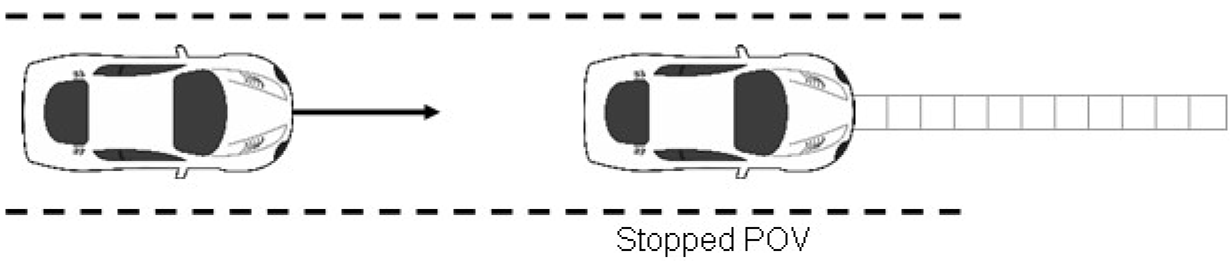


Figure 1. Depiction of Test 1

a. Procedure

The POV was parked in the center of a travel lane, with its longitudinal axis oriented parallel to the roadway edge and facing the same direction as the SV so that the SV approaches the rear of the POV.

The SV ignition was cycled prior to each test run. The SV was driven at a nominal speed of 25 mph (40.2 km/h) in the center of the lane of travel, toward the parked POV. The SV throttle pedal was released within 500 ms after t_{FCW}, i.e., within 500 ms of the FCW alert. 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.

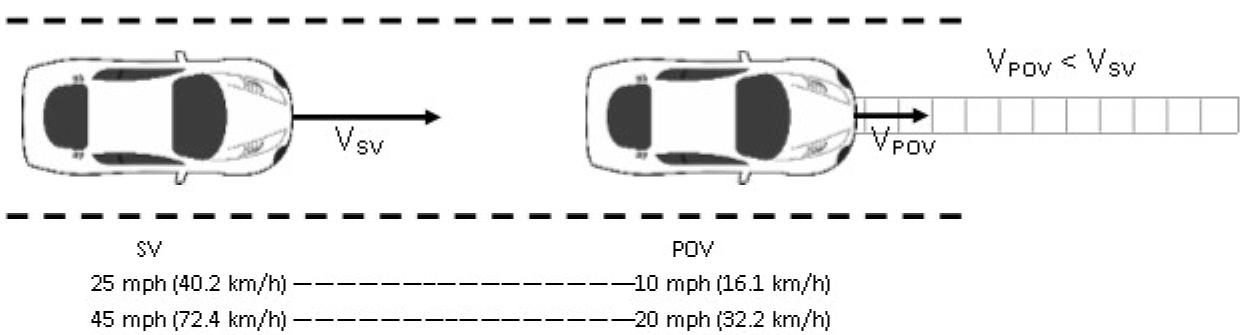


Figure 2. Depiction of Test 2

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.

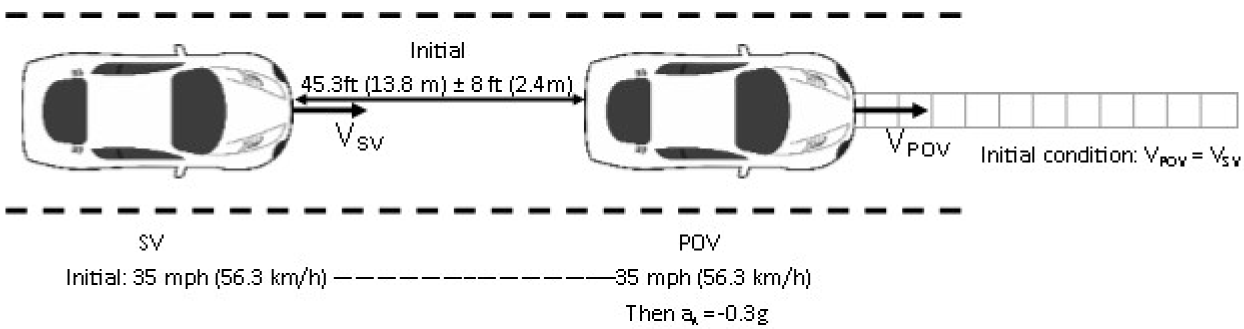


Figure 3. Depiction of Test 3

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

B. General Information

1. T_{FCW}

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

For systems that implement auditory or haptic alerts, part of the pre-test instrumentation verification process is to determine the tonal frequency of the auditory warning or the vibration frequency of the tactile warning through use of the PSD (Power Spectral Density) function in Matlab. This is accomplished in order to identify the center frequency around which a band-pass filter is applied to subsequent auditory or tactile warning data so that the beginning of such warnings can be programmatically determined. The band-pass filter used for these warning signal types is a phaseless, forward-reverse pass, elliptical (Cauer) digital filter, with filter parameters as listed in Table 4.

Table 4. Auditory and Tactile Warning Filter Parameters

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

2. GENERAL VALIDITY CRITERIA

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

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

3. VALIDITY PERIOD

The valid test interval began:

Test 1: When the SV-to-POV TTC = 5.1 seconds

Test 2: When the SV-to-POV TTC = 5.0 seconds

Test 3: 3 seconds before the onset of POV braking

Test 4: 2 seconds prior to the SV throttle pedal being released

The valid test interval ended:

Test 1: When either of the following occurred:

- The SV came in contact with the POV (SV-to-POV contact was assessed by using GPS-based range data or by measurement of direct contact sensor output); or
- The SV came to a stop before making contact with the POV.

Test 2: When either of the following occurred:

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

Test 3: When either of the following occurred:

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

Test 4: When the SV stopped.

4. STATIC INSTRUMENTATION CALIBRATION

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

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

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

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

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

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

5. <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. <u>POV AUTOMATIC BRAKING SYSTEM</u>

The POV was equipped with an automatic braking system, which was used in Test Type 3. The braking system consisted of the following components:

- Electronically controlled linear actuator, mounted on the seat rail and attached to the brake pedal. The actuator can be programmed for control of stroke and rate.
- PC module programmed for control of the stroke and rate of the linear actuator.
- Switch to activate actuator.

F. Instrumentation

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

Table 5. Test Instrumentation and Equipment

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	< 1% error between 20 and 100 psi	Omega DPG8001	17042707002	By: DRI Date: 8/18/2020 Due: 8/18/2021
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 2/10/2021 Due: 2/10/2022
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	45050091	By: DRI Date: 4/15/2021 Due: 4/15/2022
Load Cell	Force applied to brake pedal					By: DRI
		0-250 lb 1112 N	0.05% FS	Stellar Technology PNC700	1607338	Date: 4/9/2021 Due: 4/9/2022
		0 - 250 lb 0 -1112 N	0.1% FS	Honeywell 41A	1464391	Date: 2/4/2021 Due: 2/4/2022
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	N/A

Table 5. Test Instrumentation and Equipment (continued)

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rate ±100 deg/s, Angle >45 deg, Velocity >200 km/h	Accels .01g, Angular Rate 0.05 deg/s, Angle 0.05 deg, Velocity 0.1 km/h	Oxford Inertial +		By: Oxford Technical Solutions
					2182	Date: 9/16/2019 Due: 9/16/2021
					2176	Date: 6/26/2020 Due: 6/26/2022
Real-Time Calculation of Position and Velocity Relative to Lane Markings (LDW) and POV (FCW)	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec Longitudinal Range to POV: ±200 m Longitudinal Range Rate: ±50 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec Longitudinal Range: ±3 cm Longitudinal Range Rate: ±0.02 m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	N/A
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	N/A	N/A
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	N/A	N/A
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	N/A	N/A

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2021 Due: 1/6/2022

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

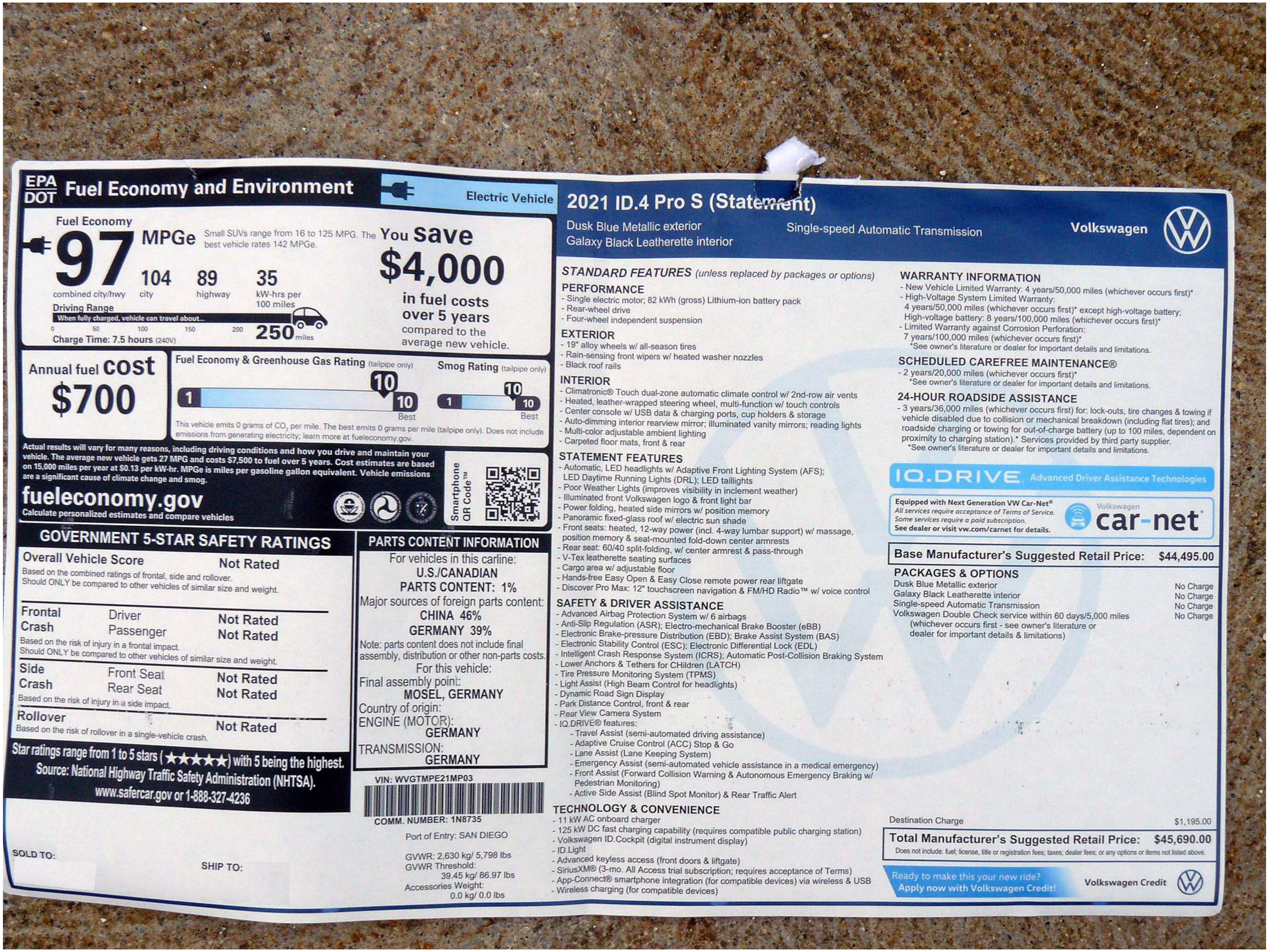
APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle



EPA DOT **Fuel Economy and Environment** — Electric Vehicle

Fuel Economy

97 MPGe — combined city/hwy

Small SUVs range from 16 to 125 MPG. The best vehicle rates 142 MPGe.

104	89	35
city	highway	kW-hrs per 100 miles

Driving Range
When fully charged, vehicle can travel about... 250 miles
0 50 100 150 200

Charge Time: 7.5 hours (240V)

You save **$4,000** in fuel costs over 5 years compared to the average new vehicle.

Annual fuel cost **$700**

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

Smog Rating (tailpipe only): 10 (1 – 10 Best)

This vehicle emits 0 grams of CO_2 per mile. The best emits 0 grams per mile (tailpipe only). Does not include emissions from generating electricity; 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 $0.13 per kW-hr. 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™

GOVERNMENT 5-STAR SAFETY RATINGS

Overall Vehicle Score		Not Rated
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	Not Rated
	Passenger	Not Rated
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	Not Rated
	Rear Seat	Not Rated
Based on the risk of injury in a side impact.		
Rollover		Not Rated
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

PARTS CONTENT INFORMATION

For vehicles in this carline:
U.S./CANADIAN PARTS CONTENT: 1%
Major sources of foreign parts content:
CHINA 46%
GERMANY 39%
Note: parts content does not include final assembly, distribution or other non-parts costs.
For this vehicle:
Final assembly point: MOSEL, GERMANY
Country of origin:
ENGINE (MOTOR): GERMANY
TRANSMISSION: GERMANY

VIN: WVGTMPE21MP03
COMM. NUMBER: 1N8735

Port of Entry: SAN DIEGO

GVWR: 2,630 kg/ 5,798 lbs
GVWR Threshold: 39.45 kg/ 86.97 lbs
Accessories Weight: 0.0 kg/ 0.0 lbs

SOLD TO:

SHIP TO:

2021 ID.4 Pro S (Statement)

Dusk Blue Metallic exterior
Galaxy Black Leatherette interior
Single-speed Automatic Transmission
Volkswagen

STANDARD FEATURES (unless replaced by packages or options)

PERFORMANCE
- Single electric motor; 82 kWh (gross) Lithium-ion battery pack
- Rear-wheel drive
- Four-wheel independent suspension

EXTERIOR
- 19" alloy wheels w/ all-season tires
- Rain-sensing front wipers w/ heated washer nozzles
- Black roof rails

INTERIOR
- Climatronic® Touch dual-zone automatic climate control w/ 2nd-row air vents
- Heated, leather-wrapped steering wheel, multi-function w/ touch controls
- Center console w/ USB data & charging ports, cup holders & storage
- Auto-dimming interior rearview mirror; illuminated vanity mirrors; reading lights
- Multi-color adjustable ambient lighting
- Carpeted floor mats, front & rear

STATEMENT FEATURES
- Automatic, LED headlights w/ Adaptive Front Lighting System (AFS); LED Daytime Running Lights (DRL); LED taillights
- Poor Weather Lights (improves visibility in inclement weather)
- Illuminated front Volkswagen logo & front light bar
- Power folding, heated side mirrors w/ position memory
- Panoramic fixed-glass roof w/ electric sun shade
- Front seats: heated, 12-way power (incl. 4-way lumbar support) w/ massage, position memory & seat-mounted fold-down center armrests
- Rear seat: 60/40 split-folding, w/ center armrest & pass-through
- V-Tex leatherette seating surfaces
- Cargo area w/ adjustable floor
- Hands-free Easy Open & Easy Close remote power rear liftgate
- Discover Pro Max: 12" touchscreen navigation & FM/HD Radio™ w/ voice control

SAFETY & DRIVER ASSISTANCE
- Advanced Airbag Protection System w/ 6 airbags
- Anti-Slip Regulation (ASR); Electro-mechanical Brake Booster (eBB)
- Electronic Brake-pressure Distribution (EBD); Brake Assist System (BAS)
- Electronic Stability Control (ESC); Electronic Differential Lock (EDL)
- Intelligent Crash Response System (ICRS); Automatic Post-Collision Braking System
- Lower Anchors & Tethers for CHildren (LATCH)
- Tire Pressure Monitoring System (TPMS)
- Light Assist (High Beam Control for headlights)
- Dynamic Road Sign Display
- Park Distance Control, front & rear
- Rear View Camera System
- IQ.DRIVE® features:
  - Travel Assist (semi-automated driving assistance)
  - Adaptive Cruise Control (ACC) Stop & Go
  - Lane Assist (Lane Keeping System)
  - Emergency Assist (semi-automated vehicle assistance in a medical emergency)
  - Front Assist (Forward Collision Warning & Autonomous Emergency Braking w/ Pedestrian Monitoring)
  - Active Side Assist (Blind Spot Monitor) & Rear Traffic Alert

TECHNOLOGY & CONVENIENCE
- 11 kW AC onboard charger
- 125 kW DC fast charging capability (requires compatible public charging station)
- Volkswagen ID.Cockpit (digital instrument display)
- ID.Light
- Advanced keyless access (front doors & liftgate)
- SiriusXM® (3-mo. All Access trial subscription; requires acceptance of Terms)
- App-Connect® smartphone integration (for compatible devices) via wireless & USB
- Wireless charging (for compatible devices)

WARRANTY INFORMATION
- New Vehicle Limited Warranty: 4 years/50,000 miles (whichever occurs first)*
- High-Voltage System Limited Warranty: 4 years/50,000 miles (whichever occurs first)* except high-voltage battery; High-voltage battery: 8 years/100,000 miles (whichever occurs first)*
- Limited Warranty against Corrosion Perforation: 7 years/100,000 miles (whichever occurs first)*

*See owner's literature or dealer for important details and limitations.

SCHEDULED CAREFREE MAINTENANCE®
- 2 years/20,000 miles (whichever occurs first)*

*See owner's literature or dealer for important details and limitations.

24-HOUR ROADSIDE ASSISTANCE
- 3 years/36,000 miles (whichever occurs first) for: lock-outs, tire changes & towing if vehicle disabled due to collision or mechanical breakdown (including flat tires); and roadside charging or towing for out-of-charge battery (up to 100 miles, dependent on proximity to charging station).* Services provided by third party supplier.

*See owner's literature or dealer for important details and limitations.

IQ.DRIVE Advanced Driver Assistance Technologies

Equipped with Next Generation VW Car-Net®
All services require acceptance of Terms of Service. Some services require a paid subscription.
See dealer or visit vw.com/carnet for details.
Volkswagen car-net

Base Manufacturer's Suggested Retail Price:	$44,495.00

PACKAGES & OPTIONS

Dusk Blue Metallic exterior	No Charge
Galaxy Black Leatherette interior	No Charge
Single-speed Automatic Transmission	No Charge
Volkswagen Double Check service within 60 days/5,000 miles (whichever occurs first - see owner's literature or dealer for important details & limitations)	No Charge
Destination Charge	$1,195.00
Total Manufacturer's Suggested Retail Price:	**$45,690.00**

Does not include: fuel; license, title or registration fees; taxes; dealer fees; or any options or items not listed above.

Ready to make this your new ride? Apply now with Volkswagen Credit!
Volkswagen Credit

Figure A3. Window Sticker (Monroney Label)

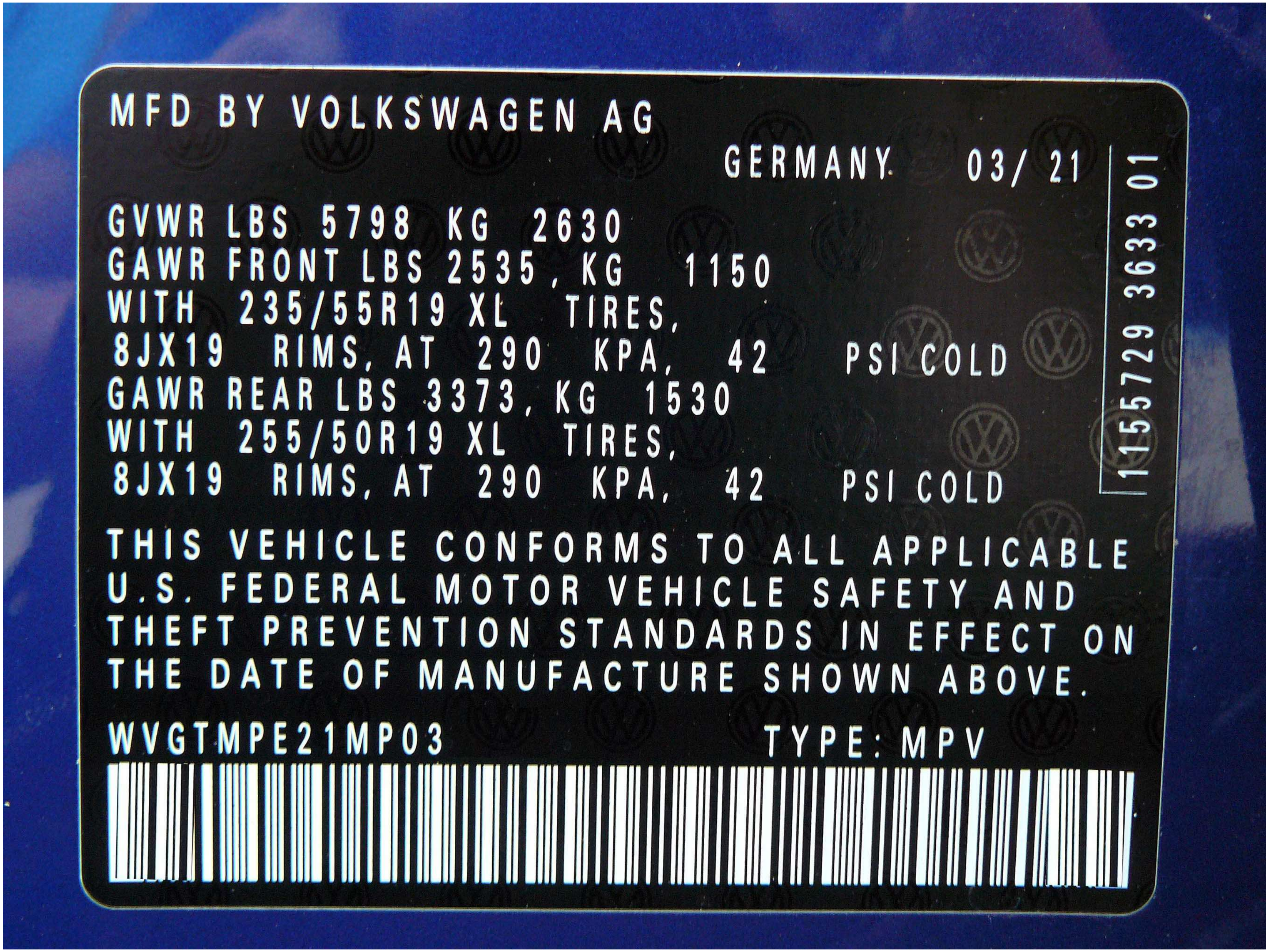


Figure A4. Vehicle Certification Label

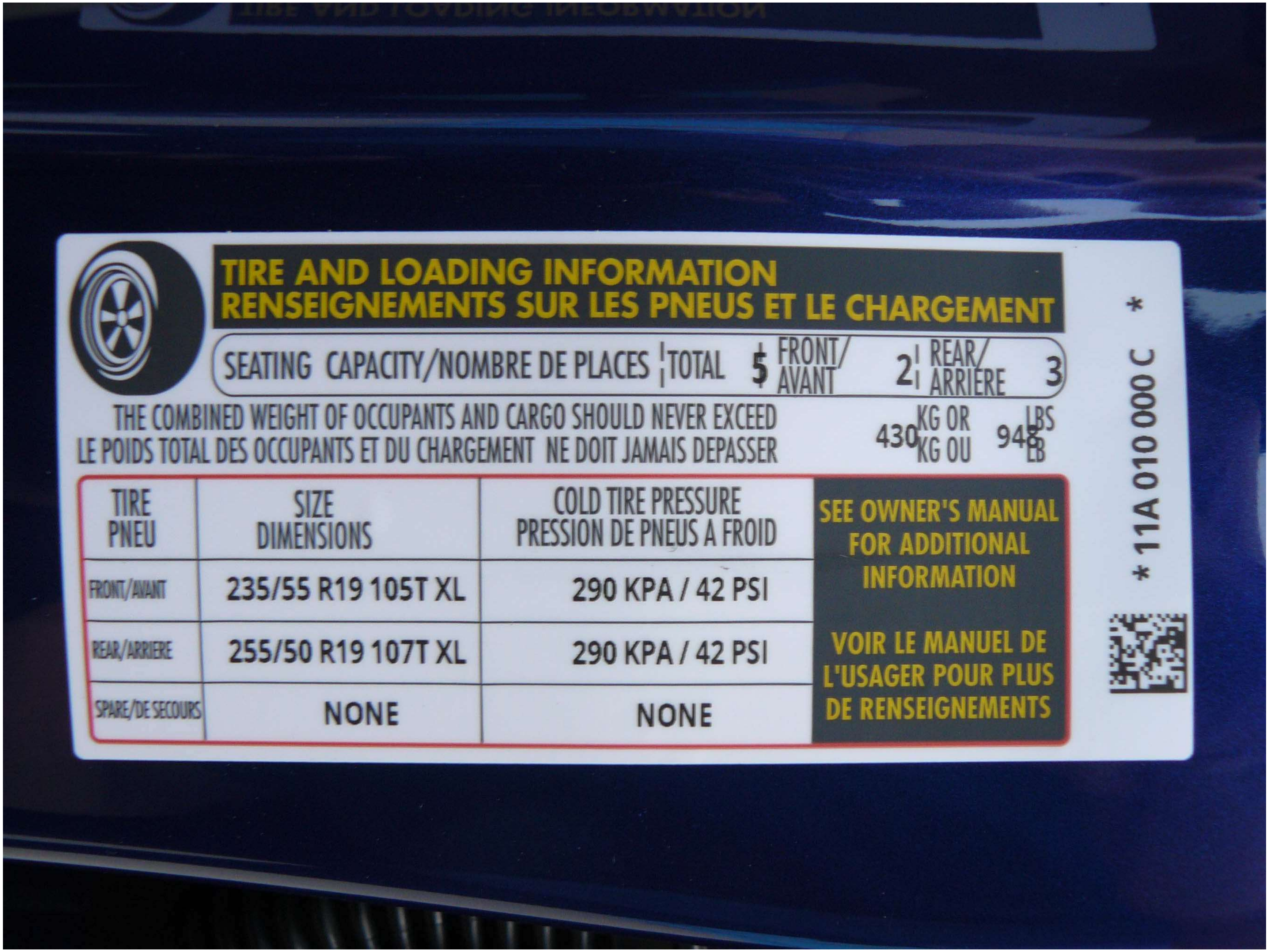


Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

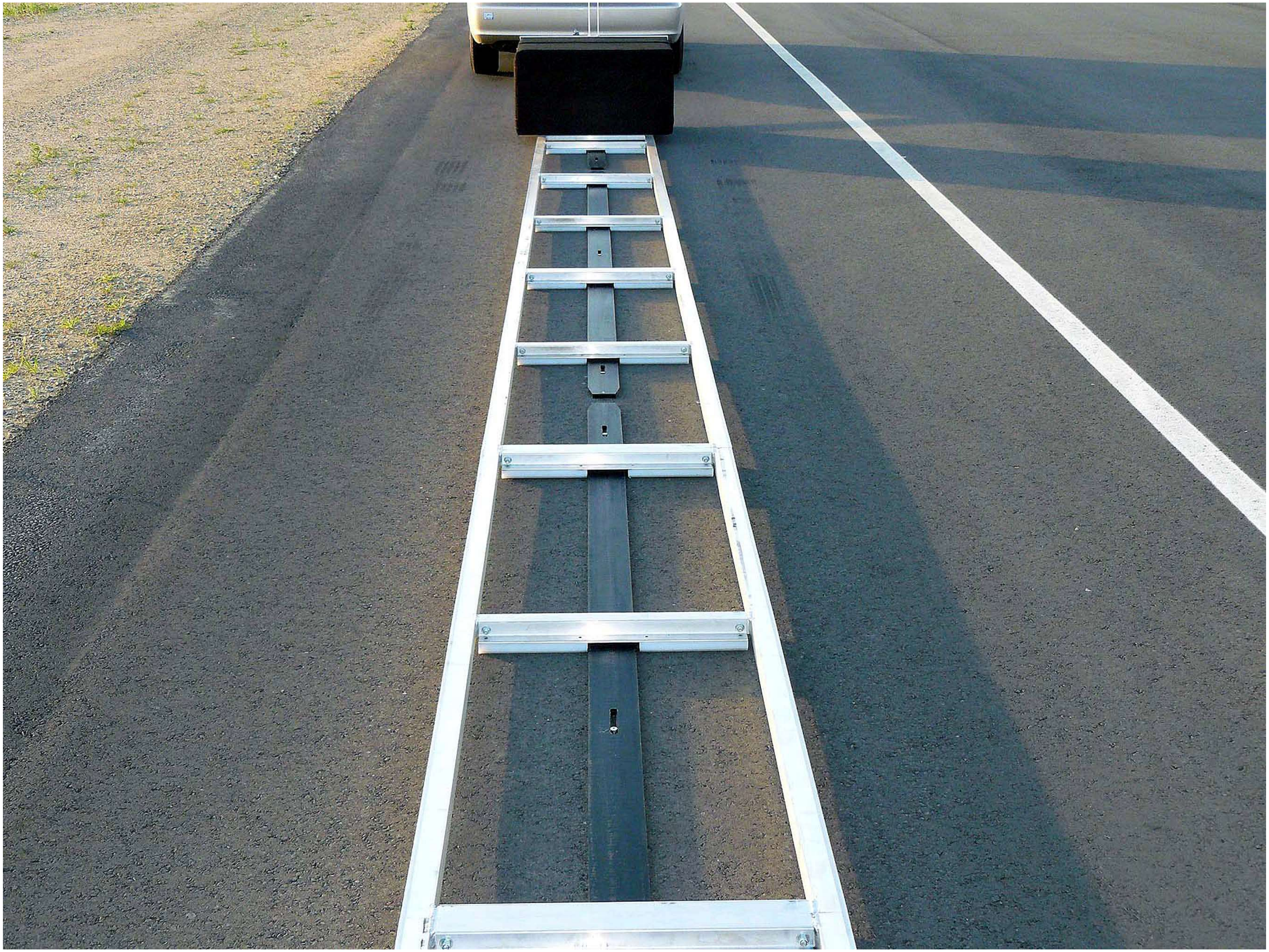


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

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

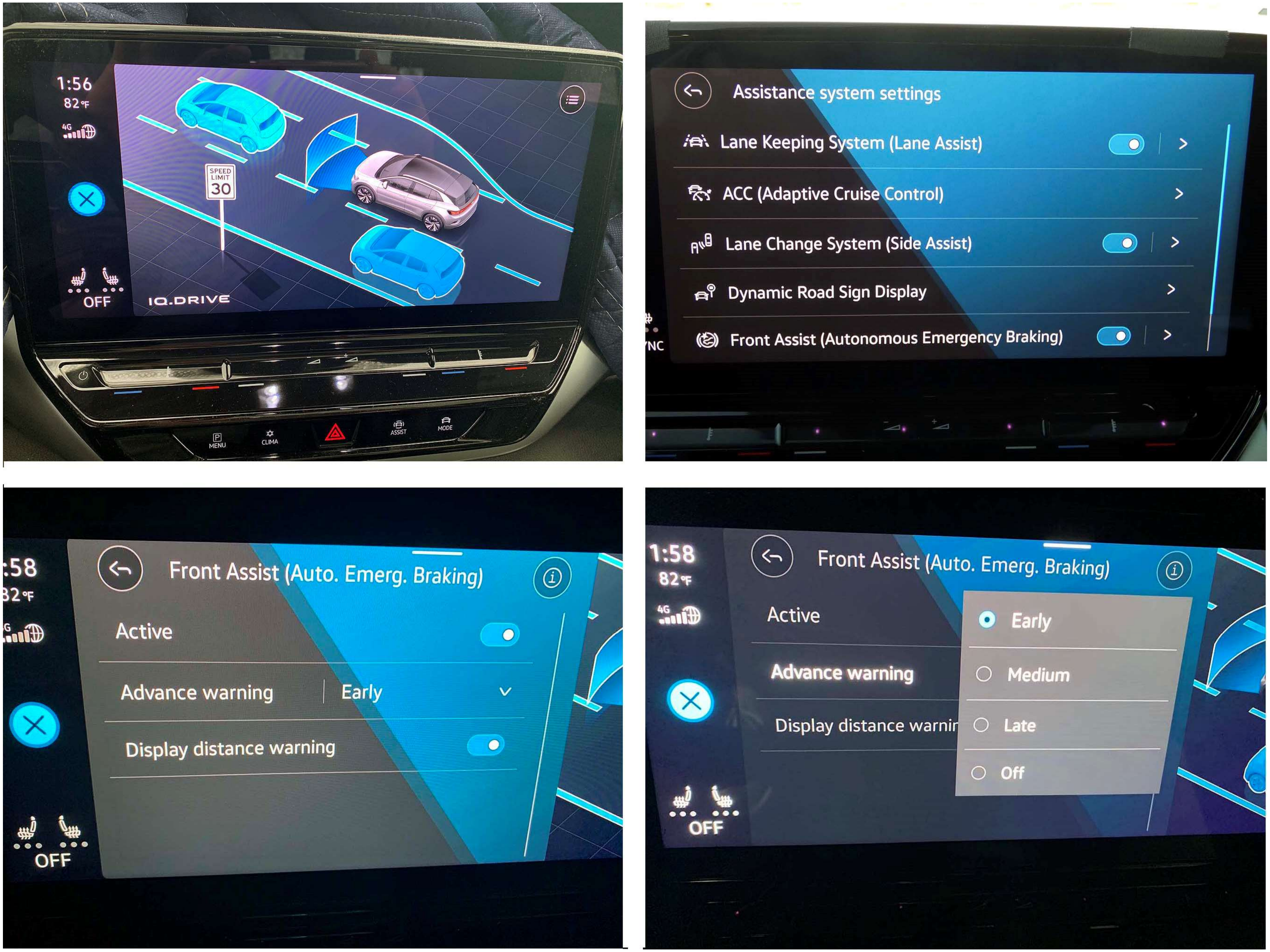


Figure A14. AEB Setup Menus

Figure A15. Button for Accessing Setup Menus

Figure A16. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

Symbol	Meaning
	 Do not drive on! Low tyre pressure → page 327
	 Do not drive on! Fault in the Tyre Pressure Monitoring System → page 327
	Fault in electric drive system → page 139, → page 142
	Reduced power → page 137
	Electronic engine sound fault → page 140
	Front Assist not available → page 165
	Front Assist switched off → page 164
! LIM	Speed limiter not available → page 148
	Fault in the Cruise Control System → page 147
	Adaptive Cruise Control (ACC) is not available → page 156
	Emergency Assist not available → page 172
	Lane keeping system (Lane Assist) not available → page 167
	Lane keeping system (Lane Assist) is regulating → page 167
	Emergency Assist intervention → page 171
	Fault in the lane change system (Side Assist) → page 174
	Rear Traffic Alert braking intervention → page 189
	Rear Traffic Alert fault → page 189
	12-volt vehicle battery → page 323
	Low charge level of the high-voltage battery → page 285
	High-voltage battery empty → page 285
	Adaptive chassis control fault → page 144
	Ball head of the towing bracket is not locked → page 273
AUTO HOLD	The vehicle is held stationary → page 179
	Turn signals → page 110
	Trailer turn signal → page 111
	Cruise control system switched on, control active. → page 145
	Speed limiter active → page 147
	Lane Assist active → page 167
	Travel Assist active → page 169
	The ACC is regulating, no vehicle detected in front → page 154
	The ACC is regulating, vehicle in front detected → page 154
	Speed regulation due to the road layout → page 158
	Speed regulation due to a roundabout → page 158
	Speed regulation due to a junction → page 158
	Speed regulation due to cancellation of the speed limit → page 158
	Speed regulation due to the end of a traffic jam → page 158

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If you adjust the announced speed excessively, predictive cruise control will be terminated.

If a speed limit is detected, the predictive cruise control function will adjust the stored speed even if ACC is deactivated. However, speed regulation will not take place.

If the current speed significantly exceeds a speed limit detected by the Dynamic Road Sign Display function, a warning will appear on the instrument cluster display.

When you join a motorway without a speed limit, the recommended speed will automatically be stored as the desired speed. If a higher speed has previously been stored on a motorway without a speed limit, this will be adopted instead of the recommended speed. ◁

Troubleshooting

Please refer to ⚠ at the start of the chapter on page 156.

A message is displayed that predictive cruise control is currently not available or is not available in your country.

— If this message is displayed for an extended period and predictive cruise control is available in your country, go to a qualified workshop.

Depending on the malfunction, additional information may be displayed in the vehicle status → page 30. ◁

Area monitoring system (Front Assist)

Introduction to the topic

The Autonomous Emergency Braking (Front Assist) can detect imminent frontal collisions and issue corresponding warnings. The system can also provide assistance for braking and taking avoiding action and can also automatically brake the vehicle.

Front Assist can help to avoid accidents, but is not a substitute for the full concentration of the driver. Front Assist functions only within the system limits. The warning times vary depending on the traffic situation and driver behaviour.

Driving with Front Assist

You can cancel the automatic braking and steering interventions of Front Assist pressing the accelerator or steering.

Automatic braking

Front Assist can decelerate the vehicle to a standstill. The vehicle will then not be held permanently. Depress the brake pedal!

The brake pedal will feel harder during an automatic braking operation.

Detection of the traffic situation

Front Assist detects driving situations by means of a camera located in the upper area of the windscreen and a radar sensor in the front of the vehicle.

Functions included in the system

Front Assist includes the following functions depending on vehicle equipment and country:

— Pedestrian Monitoring.
— Cyclist Monitoring.
— Swerve support.

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— Oncoming vehicle braking when turning.

The listed functions are automatically active when Front Assist is switched on.

⚠ WARNING

The intelligent technology used in Front Assist cannot overcome the physical limits specified, and functions only within the limits of the system. Never let the extra convenience afforded by Front Assist tempt you into taking risks when driving. The driver is always responsible for braking and steering in time.

- If Front Assist issues a warning, brake your vehicle immediately depending on the traffic situation or avoid the obstacle.
- Adapt your speed and distance from the vehicles ahead to suit visibility, weather, road and traffic conditions.
- Be prepared to take over control of the vehicle yourself at all times and to override automatic braking and steering interventions. Front Assist cannot prevent accidents and serious injuries on its own.
- Front Assist can issue unnecessary warnings and carry out unwanted braking or steering interventions in certain complex driving situations, e.g. at traffic islands.
- Front Assist can issue unnecessary warnings and carry out unwanted braking or steering interventions when its function is impaired, e.g. if the radar sensor is dirty or its position has been changed.
- Front Assist does not react to pedestrians without Pedestrian Monitoring or cyclists without Cyclist Monitoring. In addition, the system does not react to animals or to vehicles that are crossing or approaching in the same lane.
- If you are unsure about what systems your vehicle has, please enquire at a qualified workshop before starting your journey.
- Be prepared to take over control of the vehicle yourself at all times. ◁

Warning levels and braking intervention

Please refer to ⚠ at the start of the chapter on page 159.

Front Assist can detect the following objects within the system limits and depending on the vehicle equipment:

— Pedestrians, cyclists and vehicles also moving relative to your vehicle.

— Crossing pedestrians and cyclists.

— Stationary vehicles.

Front Assist can provide assistance and intervene if the vehicle is approaching a detected object in such a way that a collision with the object will occur if the vehicle speed is maintained and there is no driver intervention. The assistance may include an advance warning, an urgent warning and automatic braking.

Under ideal conditions, this can prevent a collision or help to reduce the consequences of the collision.
Front Assist operates in the following speed ranges:

	Advance warning	Urgent warning	Automatic braking	Braking intervention
Vehicle stationary	30 to 85 km/h (20 to 53 mph)	30 to 85 km/h (20 to 53 mph)	5 to 85 km/h (3 to 53 mph)	5 to 85 km/h (3 to 53 mph)

	Advance warning	Urgent warning	Automatic braking	Braking intervention
Vehicle also moving	30 to 250 km/h (20 to 155 mph)	30 to 250 km/h (20 to 155 mph)	5 to 250 km/h (3 to 155 mph)	5 to 250 km/h (3 to 155 mph)
Pedestrian also moving	30 to 85 km/h (20 to 53 mph)	30 to 85 km/h (20 to 53 mph)	5 to 85 km/h (3 to 53 mph)	5 to 85 km/h (3 to 53 mph)
Crossing pedestrian	30 to 85 km/h (20 to 53 mph)	-	5 to 65 km/h (3 to 40 mph)	5 to 65 km/h (3 to 40 mph)
Cyclist also moving	30 to 250 km/h (20 to 155 mph)	30 to 250 km/h (20 to 155 mph)	5 to 250 km/h (3 to 155 mph)	5 to 250 km/h (3 to 155 mph)
Crossing cyclist	30 to 85 km/h (20 to 53 mph)	-	5 to 65 km/h (3 to 40 mph)	5 to 65 km/h (3 to 40 mph)

The values apply only under ideal conditions and are approximate values which depend on the market and vehicle equipment. Please contact a qualified workshop if you have any queries about the equipment installed in your vehicle.

Advance warning

The system detects a possible collision and prepares the vehicle for possible emergency braking.

An acoustic warning sounds and the red warning lamp lights up. Brake or take avoiding action.

Urgent warning

If the driver does not react to the advance warning, the system may initiate a short braking jolt in order to draw attention to the increasing collision risk. Brake or take avoiding action.

Automatic braking

If the driver also does not react to the urgent warning, the vehicle can be braked automatically with braking force that increases in several stages. The reduced speed means that it is possible to minimise the consequences of an accident.

Braking intervention

If the system detects that the driver is braking insufficiently when there is a risk of collision, the system can increase the braking force and help prevent a collision. The braking intervention takes place only for as long as the brake pedal is pressed hard.

Distance warning

The system detects when safety is endangered by driving too close to the vehicle in front. The indicator lamp lights up. Increase the distance.

Speed range: around 65 km/h (around 40 mph) to around 250 km/h (around 155 mph). ◁

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Limits of Front Assist

Please refer to ⚠ at the start of the chapter on page 159.

Front Assist is not available or its functions are restricted immediately after the vehicle is started. The indicator lamp lights up in the instrument cluster display during this time.

Front Assist has physical and system-related limitations. You should therefore always be prepared to take full control of the vehicle if necessary.

Delayed response

If the camera or radar sensor is exposed to environmental conditions that impair functioning, the system may detect this only after a certain delay. For this reason, any restrictions to functions may be displayed only after a delay at the start of the journey and when driving → page 159.

Objects that cannot be detected

Front Assist may not react or may react with a delay or provide with an unwanted response in the following situations:

- Vehicles that are driving outside the sensor range in close proximity to your vehicle, e.g. vehicles that are driving offset to your vehicle or motorbikes.
- Vehicles that change into your lane directly in front of your vehicle.
- Vehicles with bodies or attachments that project beyond the vehicle.
- Oncoming vehicles or vehicles crossing your path.
- Oncoming pedestrians.
- Oncoming cyclists.
- When pedestrians and cyclists are not detected, for example because they are partially or fully hidden.
- Objects or narrow objects such as walls, rails, fences, posts, trees or garage doors.

Function limitations

Front Assist may not react or may react with a delay or provide with an unwanted response in the following situations:

- In tight bends.
- Driving in heavy rain, snow, fog or heavy spray.
- Driving in multi-storey car parks and tunnels.
- Driving on roads with embedded metal objects, e.g. railway tracks.
- Reversing.
- If ESC is regulating or faulty.
- If the radar sensor or camera window is dirty, covered or damaged.
- If several brake lights on the vehicle are faulty.
- If there is a fault in several brake lights on a trailer or bicycle carrier with an electrical connection to the vehicle.
- If the vehicle accelerates hard or the accelerator is fully depressed.
- In complex driving situations, e.g. at traffic islands.
- In unclear traffic situations, e.g. vehicles ahead are braking heavily or turning off.
- When the sun is low in the sky, in darkness or with glare from oncoming vehicles.
- When driving into and out of tunnels.
- If there is a fault in Front Assist.

Switching off Front Assist

Front Assist is not suitable for use in the following situations due to the limitations of the system and must be switched off → ⚠:

- If the vehicle is utilised in a capacity beyond usage on public roads, e.g. off-road or on a race track.
- If the vehicle is being towed or is loaded onto another vehicle.
- If add-on parts cover the radar sensor or camera.
- If the camera or the radar sensor is faulty.

— After external force on the radar sensor, e.g. after a rear-end collision.
— If the windscreen is damaged in the area of the camera window.
— In the event of multiple unwanted interventions.

⚠ WARNING

Failure to switch off Front Assist in the situations mentioned can result in accidents and serious injuries. ◁

Pedestrian Monitoring

Please refer to ⚠ at the start of the chapter on page 159.

Pedestrian Monitoring and Cyclist Monitoring can help to avoid accidents with pedestrians and cyclists or to mitigate the consequences of an accident.

The system may give a warning when there is a risk of collision, prepare the vehicle for emergency braking, help to brake the vehicle or perform an automatic brake intervention. In the event of an advance warning, the red warning lamp lights up in the instrument cluster display.

When Front Assist is switched on and active, Pedestrian Monitoring is also active as an element of Front Assist.

⚠ WARNING

The intelligent technology of Pedestrian Monitoring cannot overcome the laws of physics, and functions only within the limits of the system. Never let the extra convenience afforded by Pedestrian Monitoring tempt you into taking any risks when driving. The driver is always responsible for braking in time.

- If Pedestrian Monitoring issues a warning, brake your vehicle immediately depending on the traffic situation or avoid the object.
- Pedestrian Monitoring cannot prevent accidents and serious injuries by itself.
- Pedestrian Monitoring can issue unnecessary warnings and carry out unwanted braking interventions in complex driving situations, e.g. in a sharply turning main road with an intersection.
- Pedestrian Monitoring can issue unnecessary warnings and carry out unwanted braking interventions when its function is impaired, e.g. if the radar sensor is covered or if the camera window is dirty.
- Be prepared to take over control of the vehicle yourself at all times. ◁

Swerve support

Please refer to ⚠ at the start of the chapter on page 159.

The swerve support function can help to steer the vehicle around an obstacle in critical driving situations.

If you steer to avoid an obstacle after an urgent warning, swerve support can help you. Swerve support brakes individual wheels and supports you with a corrective steering intervention as long as you steer.

Speed range

Swerve support is available in a speed range from around 30 km/h (20 mph) up to around 150 km/h (90 mph).

Limits

Swerve support does not react to crossing objects and animals. Always also observe the fundamental limits of Front Assist → page 162. ◁

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Oncoming vehicle braking when turning

📖 **Please refer to ⚠ at the start of the chapter on page 159.**

The oncoming vehicle braking when turning function can prevent the vehicle from colliding with an oncoming vehicle during a turn.

If there is a risk of the vehicle colliding with an oncoming vehicle in the adjacent lane when turning, the oncoming vehicle braking when turning function can brake your vehicle. The vehicle can then remain in its own lane as a result.

Speed range

The oncoming vehicle braking when turning function is available up to around 15 km/h (around 9 mph).

Limits

The oncoming vehicle braking when turning function is available only if you indicate, have turned the steering wheel and have therefore started the turning manoeuvre. After changing from right-hand traffic to left-hand traffic or vice versa, the oncoming vehicle braking when turning function is available only after a certain time (30 minutes or more).

The oncoming vehicle braking when turning function does not react to persons, animals, crossing vehicles or objects that are not detected as a vehicle. Always also observe the fundamental limits of Front Assist → page 162. ◁

Operating Front Assist

📖 **Please refer to ⚠ at the start of the chapter on page 159.**

Front Assist and all the included functions (country-dependent) are automatically switched on when you switch on the ignition.

However, Front Assist is not available or only partially available as long as the indicator lamp is on.

Volkswagen recommends that Front Assist and all the included functions (country-dependent) are switched on at all times. Exceptions → page 162.

Switching on and off

— Switch Front Assist on and off in the Assist systems menu of the Infotainment system → page 31.

If you switch off Front Assist, all the included functions (country-dependent) are also switched off. The yellow indicator lamp lights up in the instrument cluster display.

Making settings for the included functions (country-dependent)

You can make further settings when Front Assist is switched on:

— Switch the desired function on and off in the Assist systems menu of the Infotainment system → page 31.

You can also set the warning time for the advance warning. ◁

Troubleshooting

Please refer to ⚠ at the start of the chapter on page 159.

Front Assist is starting up.

The indicator lamp lights up.

— Front Assist is temporarily unavailable or limited. Front Assist is available after driving straight ahead for a short time, and the indicator light goes out. When the vehicle is not in motion, the indicator lamp lights up continuously.

Front Assist not available or functions restricted.

The indicator lamp lights up yellow and a text message is also displayed.

— The radar sensor or camera window is dirty. Clean the radar sensor and windscreen → page 355.

— The view of the radar sensor or camera is impaired due to the weather conditions, e.g. snow, or due to detergent deposits or coatings. Clean the radar sensor and windscreen → page 355.

— The view of the radar sensor is impaired by add-on parts, the trim frames of number plate holders or stickers. Keep the area around the radar sensor free.

— The view of the camera is impaired by add-on parts or stickers. Keep the area around the camera window free.

— The radar sensor or camera has been displaced or damaged, e.g. due to damage to the front of the vehicle or the windscreen. Check whether damage is visible → page 362.

— Paint work or structural modifications were carried out on the front of the vehicle.

— If the problem persists, switch off Front Assist and go to a qualified workshop.

Front Assist does not function as expected or is triggered unnecessarily several times.

— The radar sensor or camera window is dirty. Clean the radar sensor and windscreen → page 355.

— The system limits have been exceeded → page 162.

— Low sun or darkness.

— If the problem persists, switch off Front Assist and go to a qualified workshop.

Touch panels react differently than expected.

Moisture, dirt and grease can impede the functioning of the touch panels.

— Make sure the touch panels are always clean and dry. ◁

Lane keeping system (Lane Assist)

Introduction to the topic

Within the system limits, the lane keeping system (Lane Assist) helps the driver to stay in lane. The function is not designed to keep the vehicle in lane automatically, nor is it suited to this purpose.

Using a camera in the windscreen, the lane keeping system detects road lane markings on the road. If your vehicle moves too close to a recognised road lane marking, the system will warn the driver with a corrective steering intervention. The corrective steering intervention can be overridden by the driver at any time.

System limits

Use the lane keeping system only on motorways and well-developed country roads.

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APPENDIX C

Run Log

Subject Vehicle: **2021 Volkswagen ID.4 Pro S (Statement)** Test Date: **7/9/2021**

Principal Other Vehicle: **SSV**

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
1-16	Brake characterization and determination						See Appendix D
17	Static Run						Zero SV front bumper to SSV rear bumper and collect data
18	**Stopped POV**	N					Brake application rate
19		Y	2.53	3.21	0.71	Pass	
53							Static Run: Zero SV front bumper to SSV rear bumper and collect data
54		N					Brake application rate
55		Y	2.62	2.30	0.68	Pass	
56		Y	2.56	2.64	0.63	Pass	
57		Y	2.61	2.55	0.71	Pass	
58		Y	2.63	1.99	0.74	Pass	
59		Y	2.60	2.55	0.72	Pass	
60		Y	2.63	2.97	0.69	Pass	
61	Static Run						
62	**Slower POV, 25 vs 10**	Y	2.13	1.69	0.91	Pass	
63		N					Brake application rate
64		Y	2.17	1.05	0.80	Pass	
65		Y	2.14	1.74	0.45	Pass	
66		Y	2.07	2.07	0.50	Pass	
67		Y	2.14	1.74	0.49	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
68	**Slower POV, 25 vs 10**	Y	2.19	2.62	0.57	Pass	
69		Y	2.23	2.02	0.54	Pass	
70	Static run						Check zero data is within ± 0.167 ft (±0.05m)
71	**Slower POV, 45 vs 20**	N					Brake application rate, brake force timing
72		N					Brake application rate, brake force timing
73		Y	2.48	0.00	0.41	Fail	
74		N					Lat offset, brake application rate, brake force
75		N					Brake force timing
76		N					Brake application rate, brake force timing
89		N					GPS, brake application rate
90		N					Brake application rate, brake force timing
91		Y	2.53	0.00	0.43	Fail	
92		N					Brake force timing
93		Y	2.50	0.00	0.49	Fail	
94		Y	2.54	0.00	0.43	Fail	
95		N					Brake application rate
96		N					Brake force timing
97		N					Brake application rate
98		Y	2.52	0.00	0.53	Fail	
99	Static Run						

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
77	**Decelerating POV**	N					Brake force TTC
78		N					POV brakes
79		N					Throttle
80		N					Throttle
81		Y	1.48	0.89	0.93	Pass	
82		Y	1.43	1.54	0.95	Pass	
83		N					Brake force
84		Y	1.42	0.34	0.71	Pass	
85		Y	1.39	1.72	0.85	Pass	
86		N					Brake force
87		Y	1.55	1.54	0.95	Pass	
88	Static run						Check zero data is within ± 0.167 ft (±0.05m)
20	STP - Static run						Zero SV front bumper to rear edge of steel plate and collect data
21	**Baseline, 25**	Y			0.46		
22		Y			0.47		
23		Y			0.47		
24		Y			0.46		
25		Y			0.48		
26		Y			0.48		
27		Y			0.48		
28	STP - Static run						Check zero data is within ± 0.167 ft (±0.05m)

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
29	**Baseline, 45**	Y			0.48		
30		Y			0.41		
31		Y			0.44		
32		Y			0.47		
33		Y			0.49		
34		Y			0.47		
35		Y			0.42		
36	STP - Static run						Check zero data is within ± 0.167 ft (±0.05m)
37	**STP False Positive, 25**	Y			0.39	Pass	
38		Y			0.40	Pass	
39		Y			0.39	Pass	
40		Y			0.37	Pass	
41		Y			0.38	Pass	
42		Y			0.37	Pass	
43		Y			0.39	Pass	
44	STP - Static run						Check zero data is within ± 0.167 ft (±0.05m)
45	**STP False Positive, 45**	Y			0.34	Pass	
46		Y			0.35	Pass	
47		Y			0.34	Pass	
48		Y			0.35	Pass	
49		Y			0.34	Pass	
50		Y			0.35	Pass	
51		Y			0.35	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
52	STP - Static run						Check zero data is within ± 0.167 ft (±0.05m)

APPENDIX D

Brake Characterization

Subject Vehicle: **2021 Volkswagen ID.4 Pro S (Statement)** Test Date: **7/9/2021**

DBS Initial Brake Characterization				
Run Number	**Stroke at 0.4 g (in)**	**Force at 0.4 g (lb)**	**Slope**	**Intercept**
1	1.31	18.64	1.36	0.28
2	1.31	18.56	1.16	0.47
3	1.30	18.28	1.32	0.34

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	0.431	1.30		1.21	
5		35	Y	0.366	1.21		1.32	
6		35	Y	0.447	1.30		1.16	
7		35	Y	0.389	1.25		1.29	
8		25	N					Brake rate
9		25	Y	0.382	1.25		1.31	
10		45	Y	0.378	1.25		1.32	

DBS Brake Characterization Determination								
Run	DBS Mode	Speed	Valid Run	Average Decel. (g)	0.4 g Stroke Value (in)	0.4 g Force Value (lb)	Stroke/Force Calculator (in)	Notes
11	Hybrid	35	Y	0.487		18.50	15.20	
12		35	Y	0.374		15.50	16.58	
13		35	Y	0.421		16.50	15.68	
14		35	Y	0.403		16.00	15.88	
15		25	Y	0.390		16.00	16.41	
16		45	Y	0.387		16.00	16.54	

Appendix E

TIME HISTORY PLOTS

LIST OF FIGURES

Description of Time History Plots

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

Time History Plot Description

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

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

Time history figures include the following sub-plots:

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

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

- Headway (ft) – Longitudinal separation between the front-most point of the Subject Vehicle and the rearmost point of the Strikeable Surrogate Vehicle (SSV) towed by the Principal Other Vehicle. The minimum headway during the run is displayed to the right of the subplot.
- SV/POV Speed (mph) – Speed of the Subject Vehicle and the Principal Other Vehicle (if any). For DBS tests, in the case of an impact, the speed reduction experienced by the Subject Vehicle up until the moment of impact is displayed to the right of the subplot.
- Yaw Rate (deg/sec) – Yaw rate of the Subject Vehicle and Principal Other Vehicle (if any).
- Lateral Offset (ft) – Lateral offset within the lane of the Subject Vehicle to the center of the lane of travel. Note that for tests involving the Strikeable Surrogate Vehicle (SSV), the associated lateral restraint track is defined to be the center of the lane of travel. If testing is done with a different POV which does not have a lateral restraint track, lateral offset is defined to be the lateral offset between the SV and POV.
- Ax (g) – Longitudinal acceleration of the Subject Vehicle and Principal Other Vehicle (if any). The peak value of Ax for the SV is shown on the subplot.
- Pedal Position – Position of the accelerator pedal and brake pedal. The units for the brake pedal are inches and the units for the accelerator pedal are percent of full scale divided by 10.
- Brake Force (lb) – Force on the brake pedal as applied by the DBS controller. The TTC at the onset of the brake by the DBS controller is shown on the subplot. Additionally, the average force at the brake pedal while the DBS controller is active is displayed.

Envelopes and Thresholds

Some of the time history plot figures contain either green or yellow envelopes and/or black or red threshold lines. These envelopes and thresholds are used to programmatically and visually determine the validity of a given test run. Envelope and threshold exceedances are indicated with either red shading or red asterisks, and red text is placed to the right side of the plot indicating the type of exceedance. Such exceedances indicate either that the test was invalid or that the requirements of the test were not met (i.e., failure of the AEB system).

For plots with green envelopes, in order for the test to be valid, the time-varying data must not exceed the envelope boundaries at any time within the envelope. Exceedances of a green envelope are indicated by red shading in the area between the measured time-varying data and the envelope boundaries.

With the exception of the brake force plots (see description below), for plots with yellow envelopes, in order for the test to be valid, the time-varying data must not exceed the envelope at the beginning (left edge of the boundary) and/or end (right edge), but may exceed the boundary during the time between the left and right edges. Exceedances at the left or right extent of a yellow envelope are indicated by red asterisks.

For the headway plot, a dashed black threshold line indicating a relative headway of zero is given. If no impact occurs, a green circle is displayed at the moment of minimum distance. If impact occurs, a red asterisk is displayed at the moment of impact.

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

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

For the brake force plots:

- If the tests are done in Hybrid mode, the brake force plot shows a dashed black threshold line indicating a brake force of 2.5 lbs. For the time period where the DBS controller is active, the brake force at the pedal must not fall below this 2.5 lb threshold. Exceedances of this threshold are indicated by red shading in the area between the measured time-varying data and the dashed threshold line. A blue envelope represents the target average brake force necessary to be valid
- If the tests are done in Displacement mode, there are no relevant brake force level thresholds or average brake force calculations.

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

Color Codes

Color codes have been adopted to easily identify which data correspond to which vehicle, as well as to indicate the types of envelopes and thresholds used in the plots.

Color codes can be broken into four categories:

1. Time-varying data
2. Validation envelopes and thresholds
3. Individual data points
4. Text

1. Time-varying data color codes:
   - Blue = Subject Vehicle data
   - Magenta = Principal Other Vehicle data
   - Brown = Relative data between SV and POV (i.e., TTC, lateral offset and headway distance)

2. Validation envelope and threshold color codes:
   - Green envelope = time varying data must be within the envelope at all times in order to be valid
   - Yellow envelope = time varying data must be within limits at left and/or right ends
   - Blue envelope = visualized target range for the time varying data averaged over a period equal to the length of the envelope
   - Black threshold (Solid) = time varying data must cross this threshold in the time period shown in order to be valid
   - Black threshold (Dashed) = for reference only – this can include warning level thresholds, TTC thresholds, and acceleration thresholds.
   - Red threshold (Solid) = for reference only – indicates the activation of last-minute braking by the brake robot. Data after the solid red line is not used to determine test validity.

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

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

Other Notations

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

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

Examples of valid or passing time history plots for each test type (including passing, failing, and invalid runs) are shown in Figure E1 through E12. Figures E1 through E8 show passing runs for each of the 8 test types. Figure E9 shows an example of a passing brake characterization run. Figures E10 and E11 show examples of invalid runs. Figure E12 shows an example of a valid test that failed the DBS requirements. Time history data plots for the tests of the vehicle under consideration herein are provided beginning with Figure E13.

Notes

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

One of the methods this vehicle system uses to alert the driver is a haptic “brake jerk”. The momentary effect of this can be seen in the brake pedal position and brake force traces in many of the plots e.g., Figure E13 for run 19 on page E-23. For these tests, rather than using TTC to trigger the initial brake application, the corresponding distances listed in the test procedure was used. This method ensures more repeatability between runs as the TTC is often adversely affected by the brake jerk given by the vehicle’s AEB system. When the brake controller is run in displacement mode, there is no TTC written out as the TTC may vary from the nominal. However, the green dot still indicates that the brake application was within a required distance tolerance for the initial brake application.

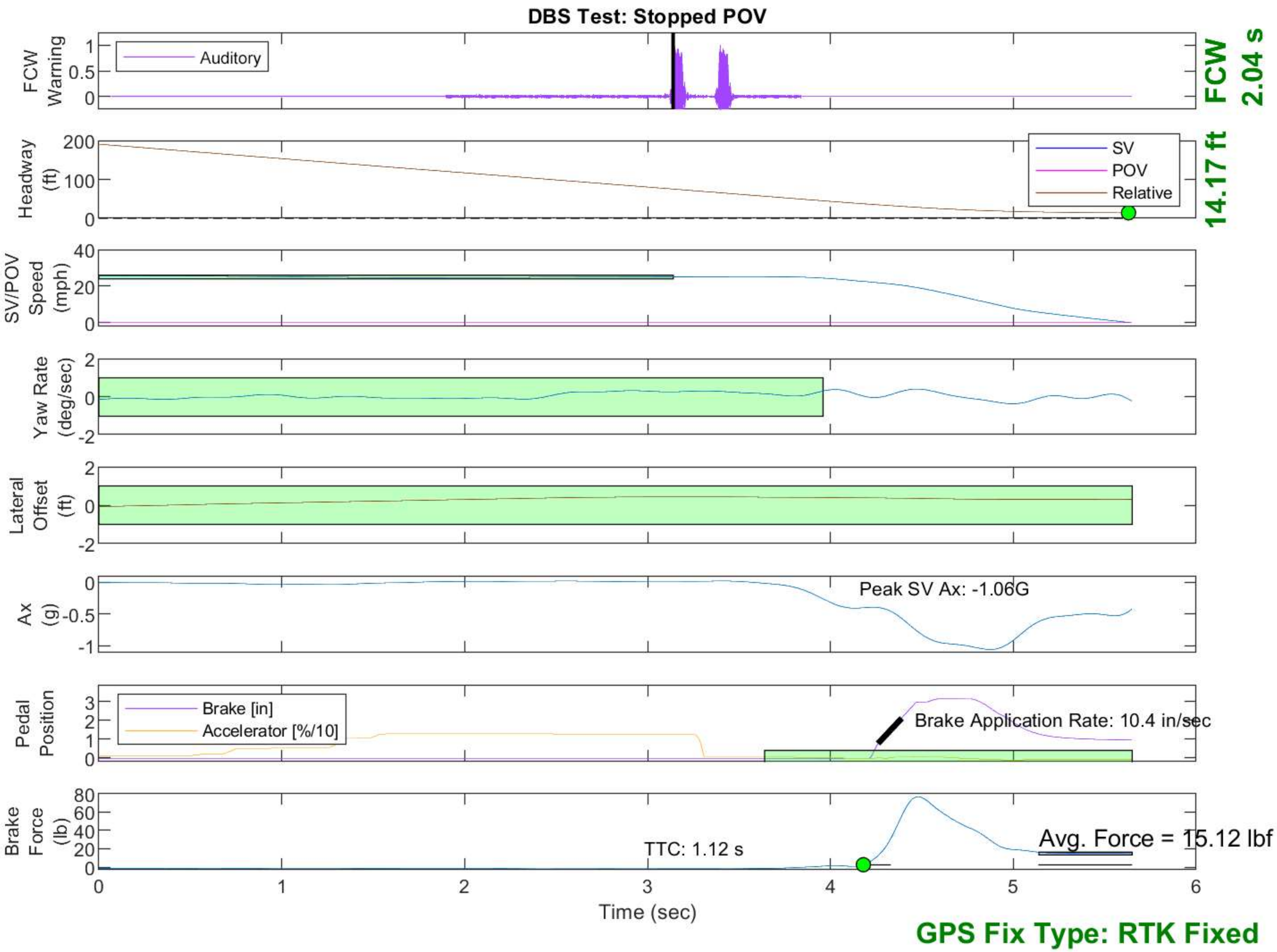

Figure E1. Example Time History for Stopped POV, Passing

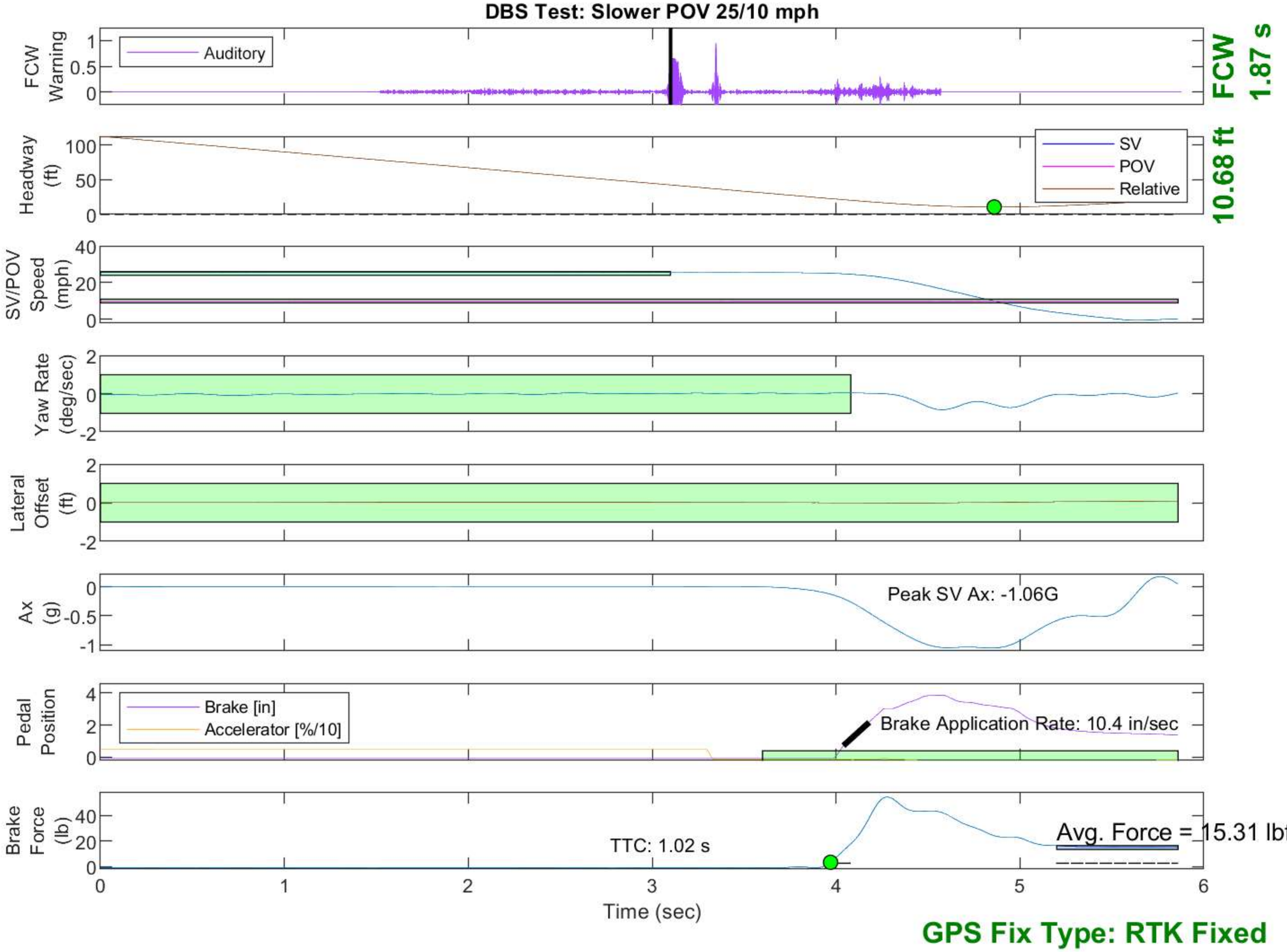

Figure E2. Example Time History for Slower POV 25 vs. 10, Passing

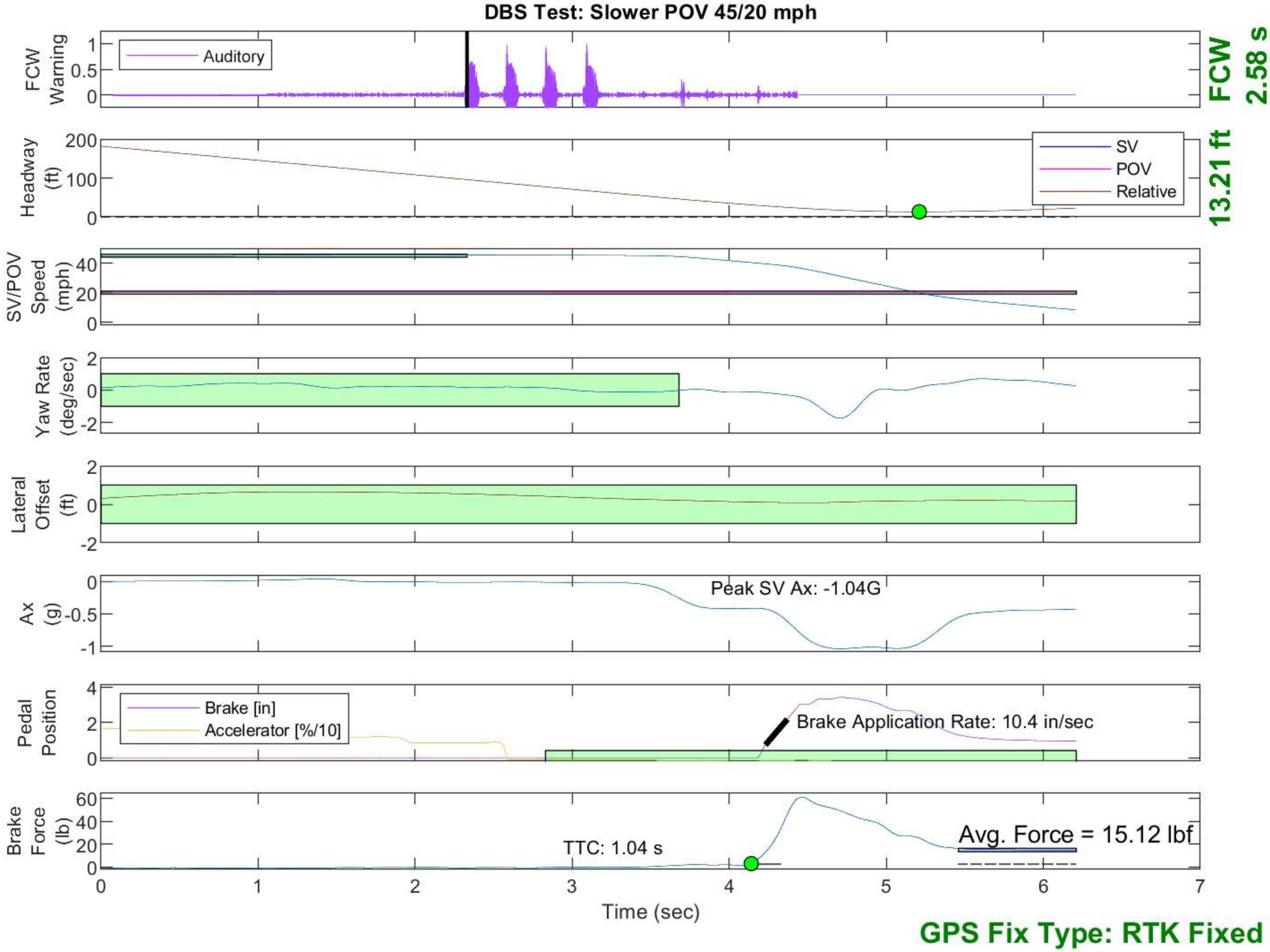

Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

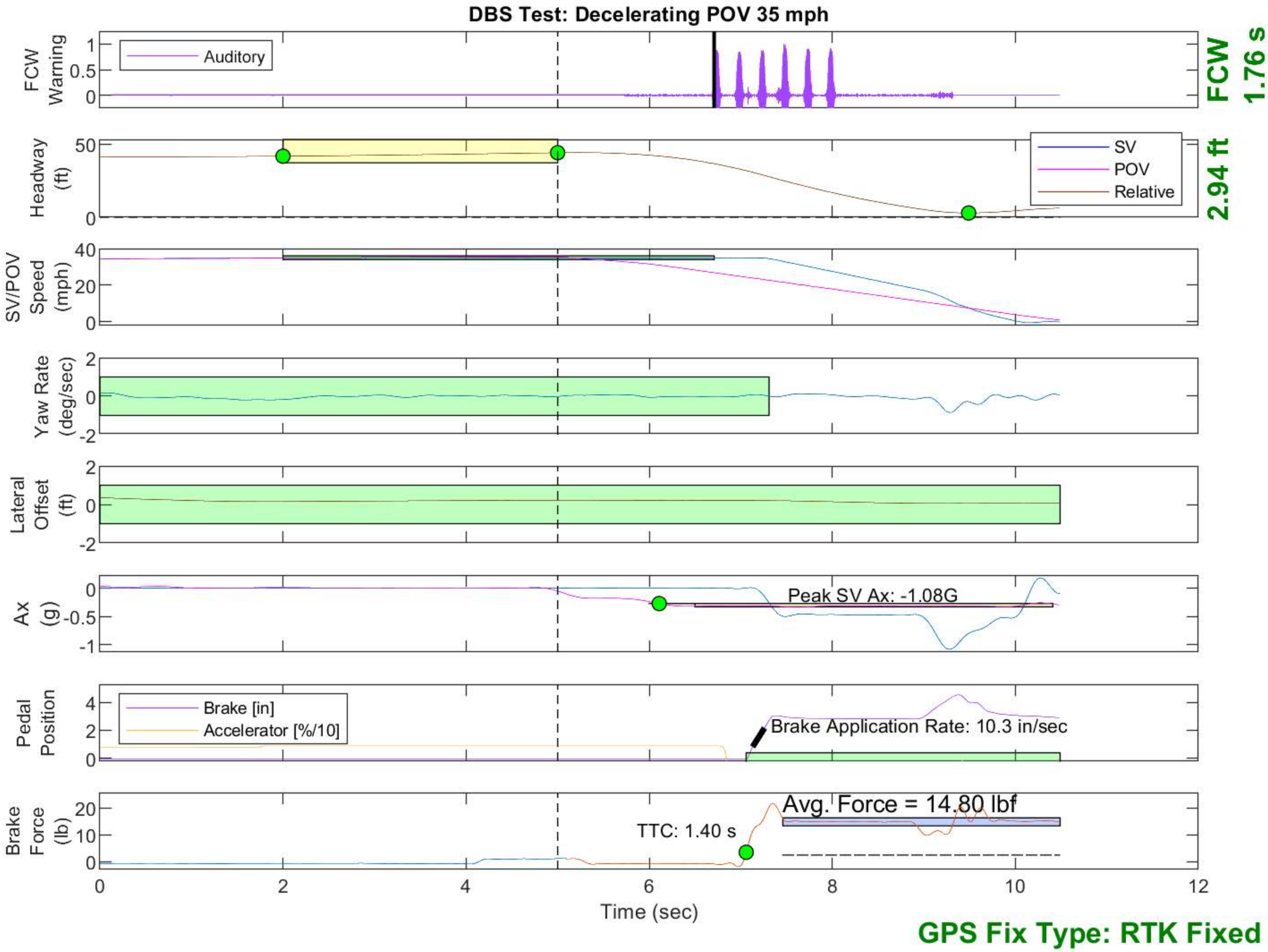

Figure E4. Example Time History for Decelerating POV 35, Passing

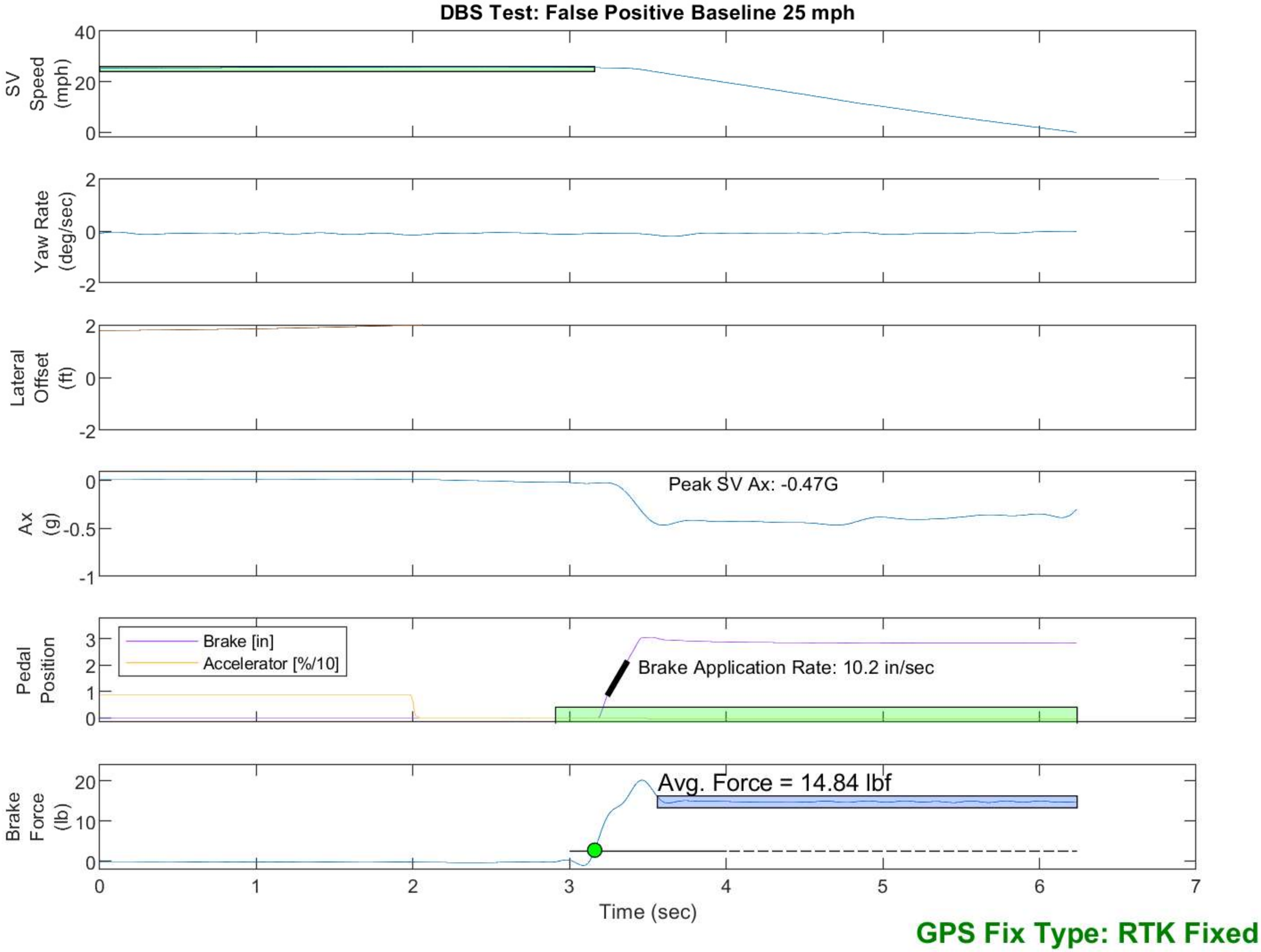

Figure E5. Example Time History for False Positive Baseline 25

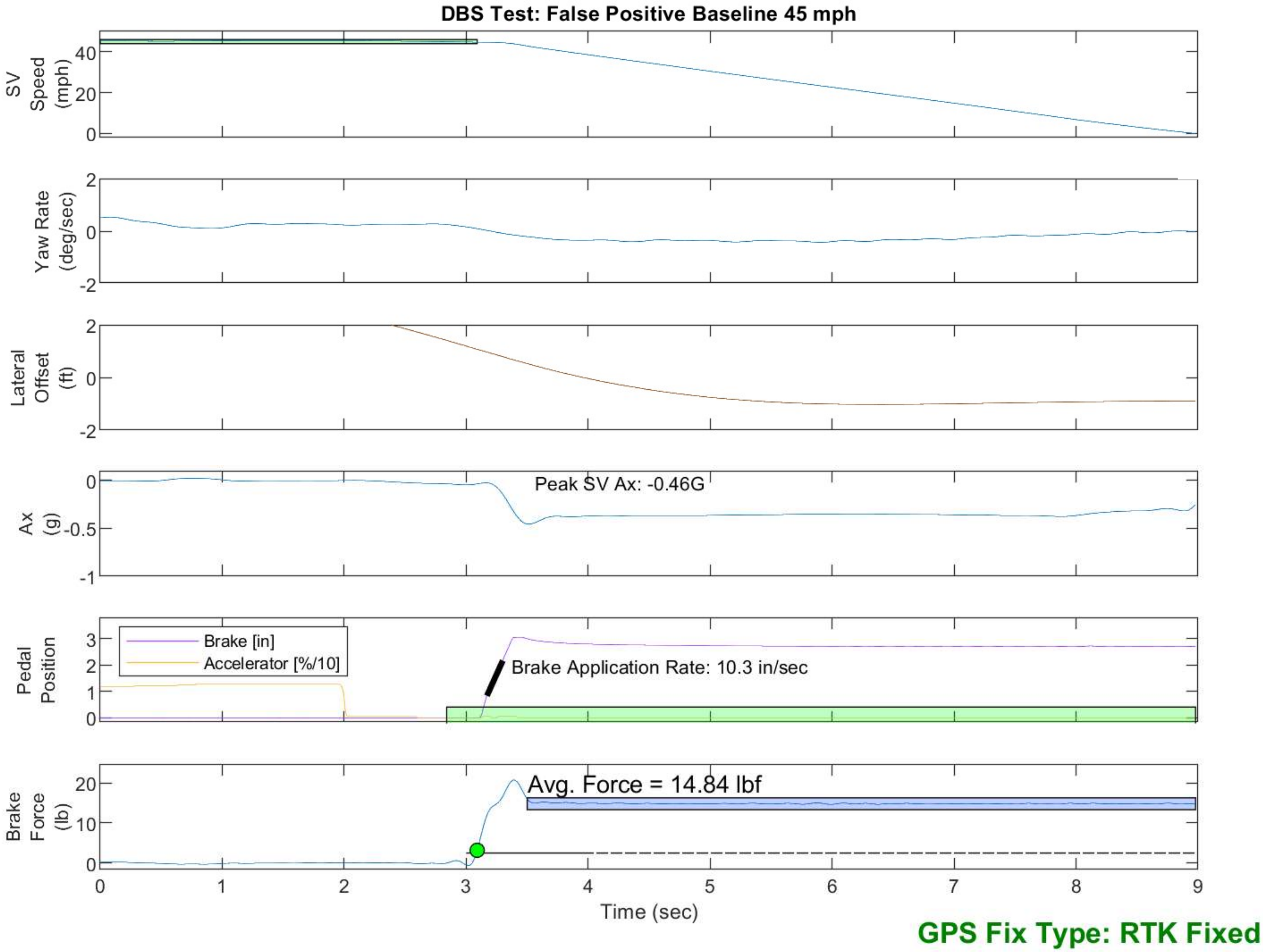

Figure E6. Example Time History for False Positive Baseline 45

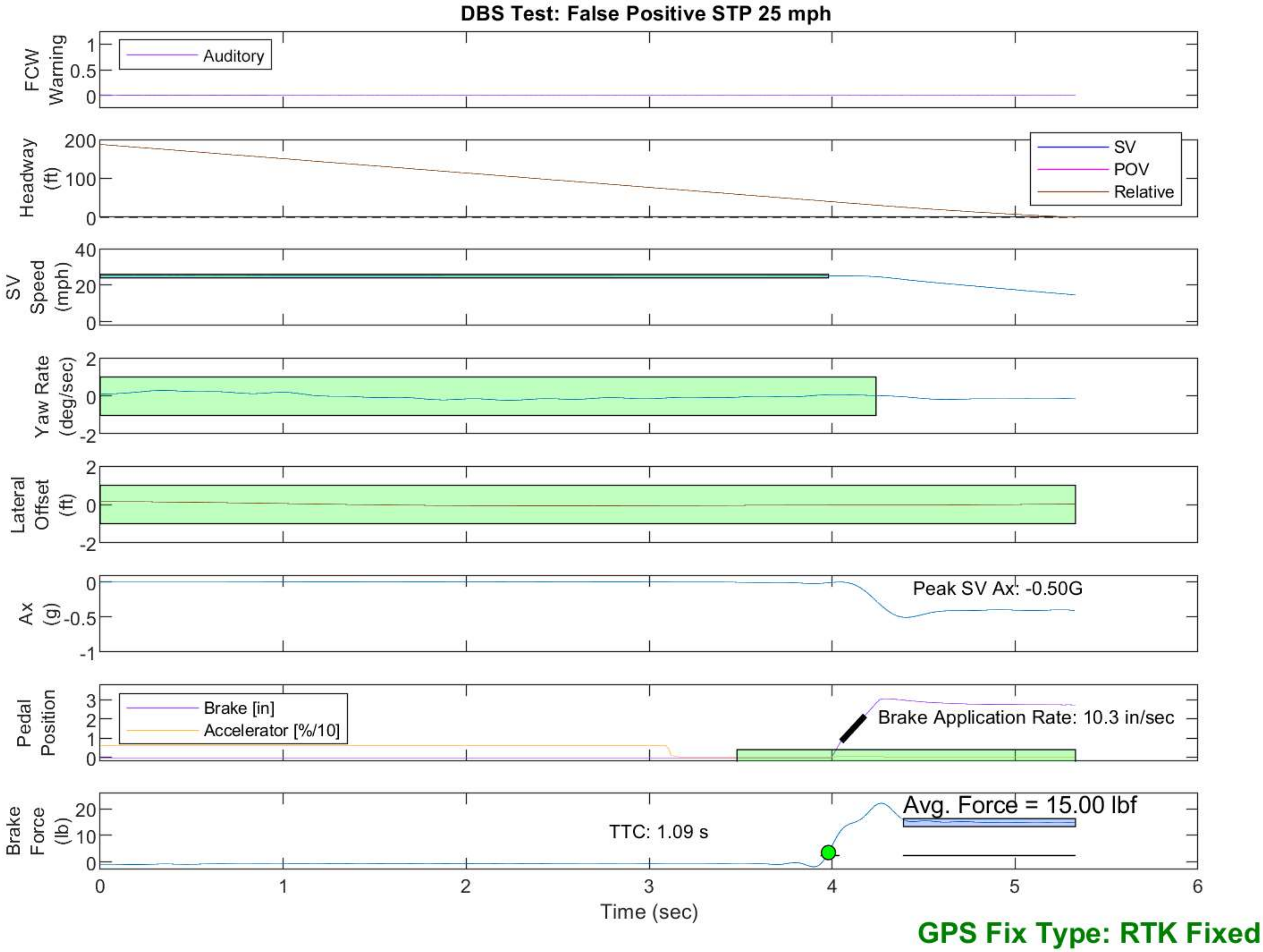

Figure E7. Example Time History for False Positive Steel Plate 25, Passing

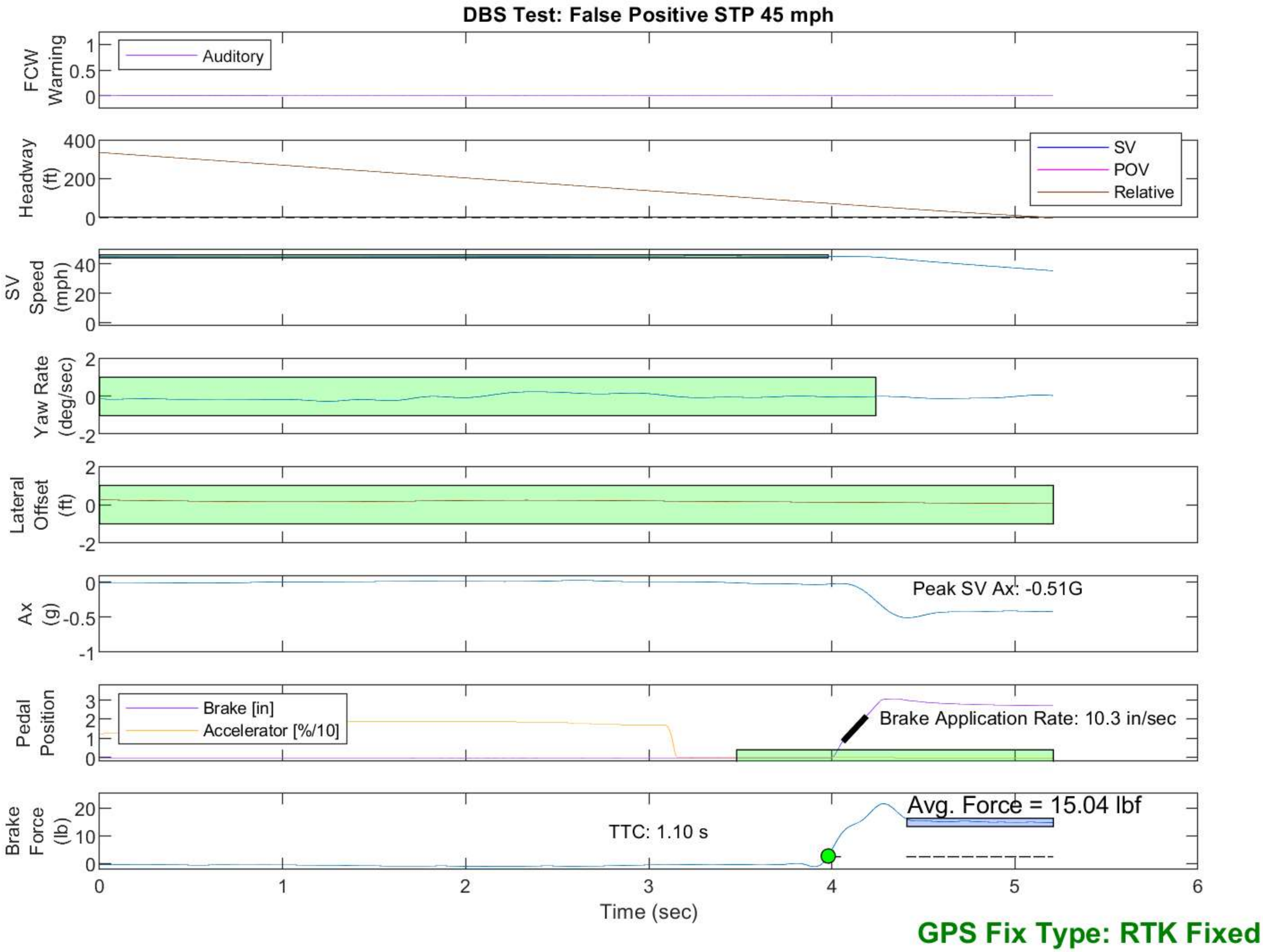

Figure E8. Example Time History for False Positive Steel Plate 45, Passing

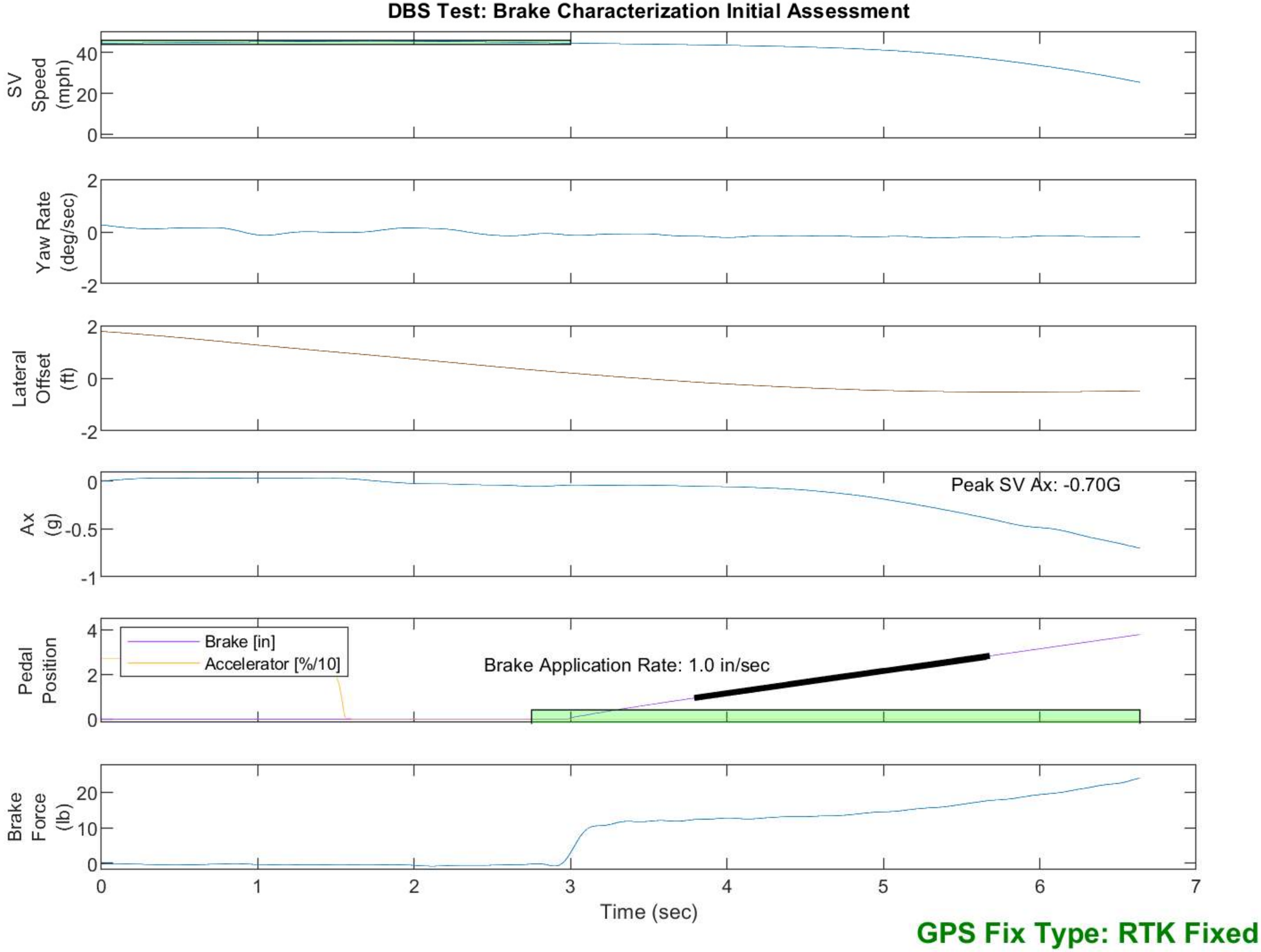

Figure E9. Example Time History for DBS Brake Characterization, Passing

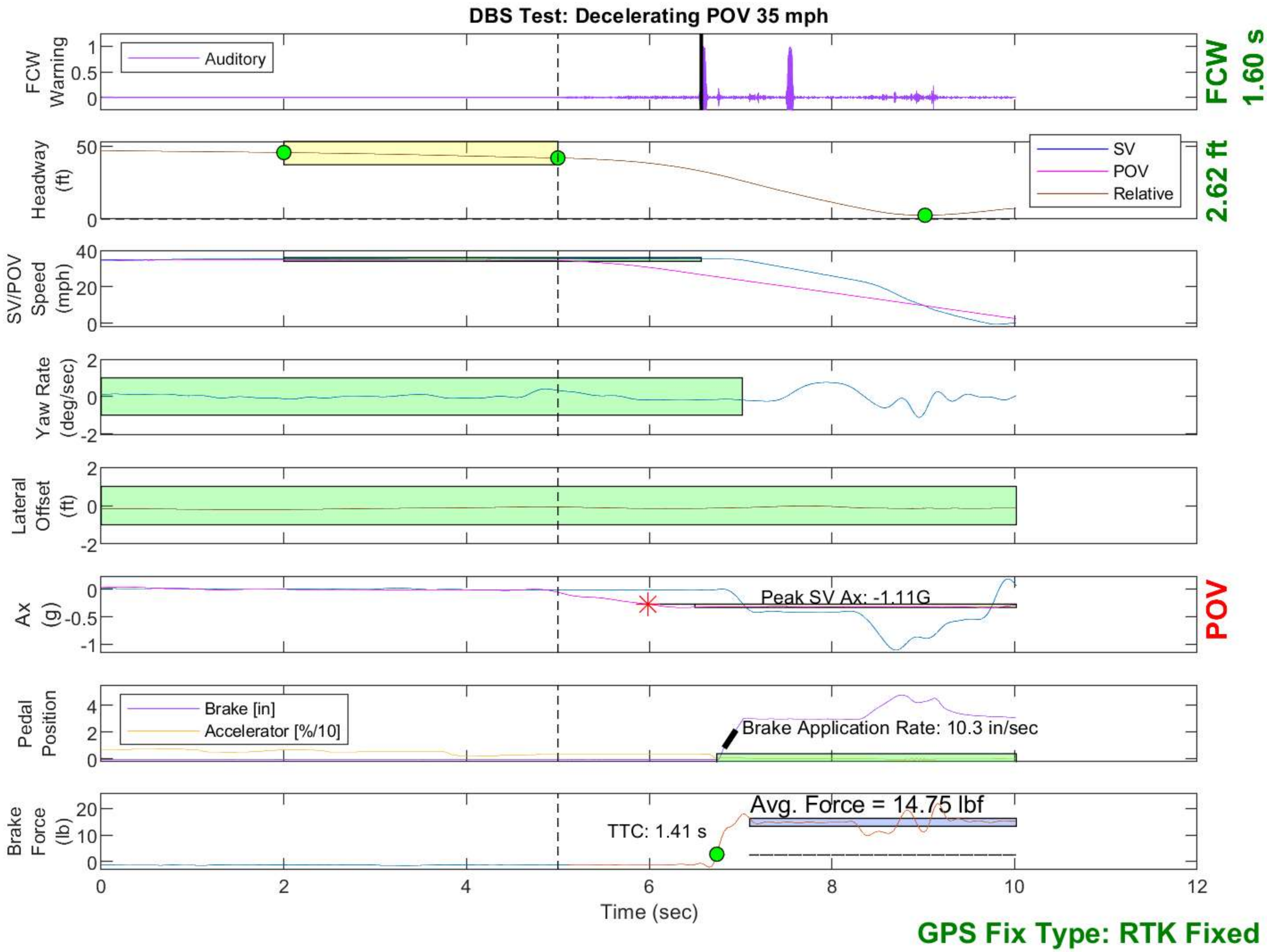

Figure E10. Example Time History Displaying Invalid POV Acceleration Criteria

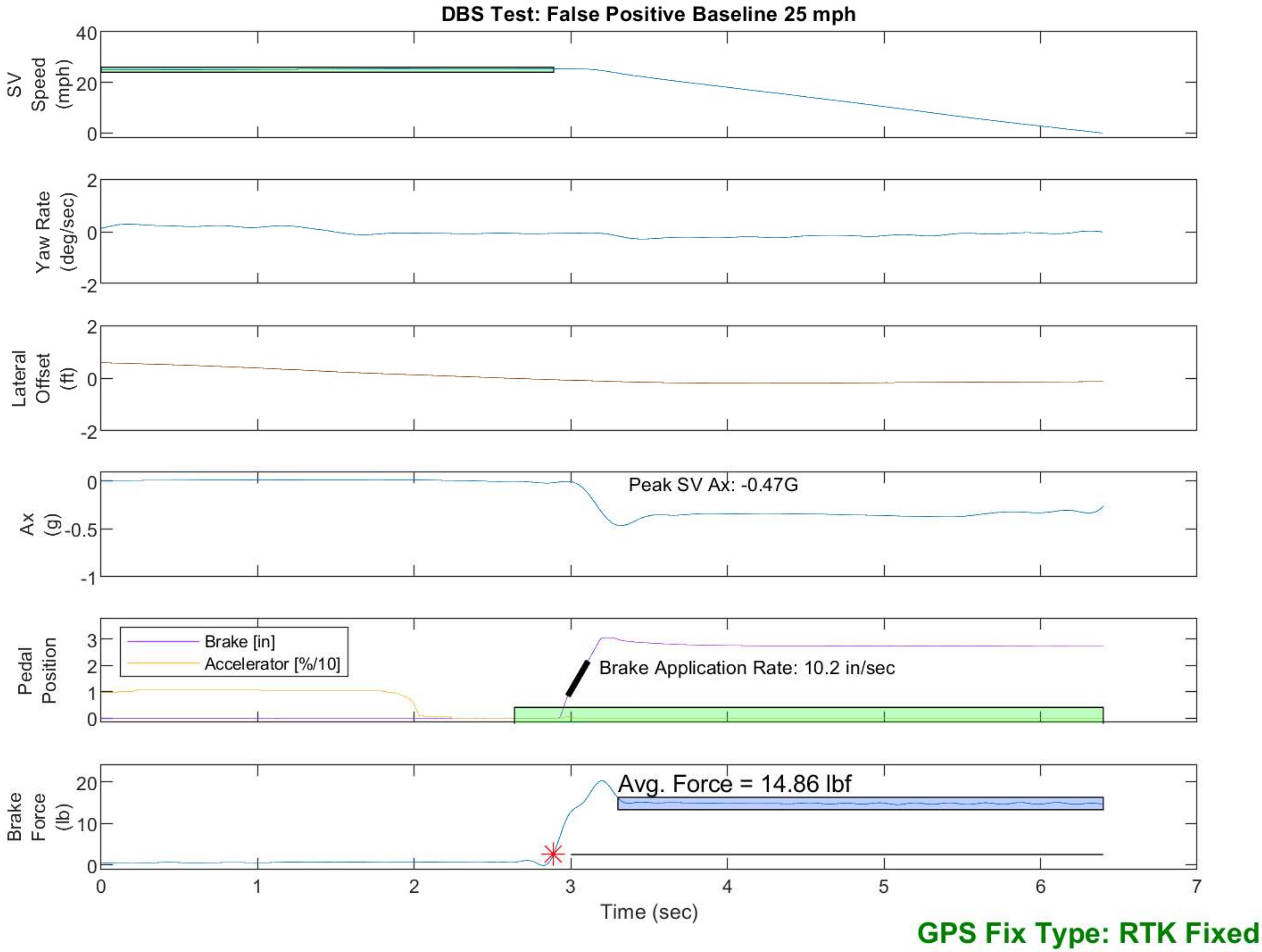

Figure E11. Example Time History Displaying Invalid Brake Force Criteria

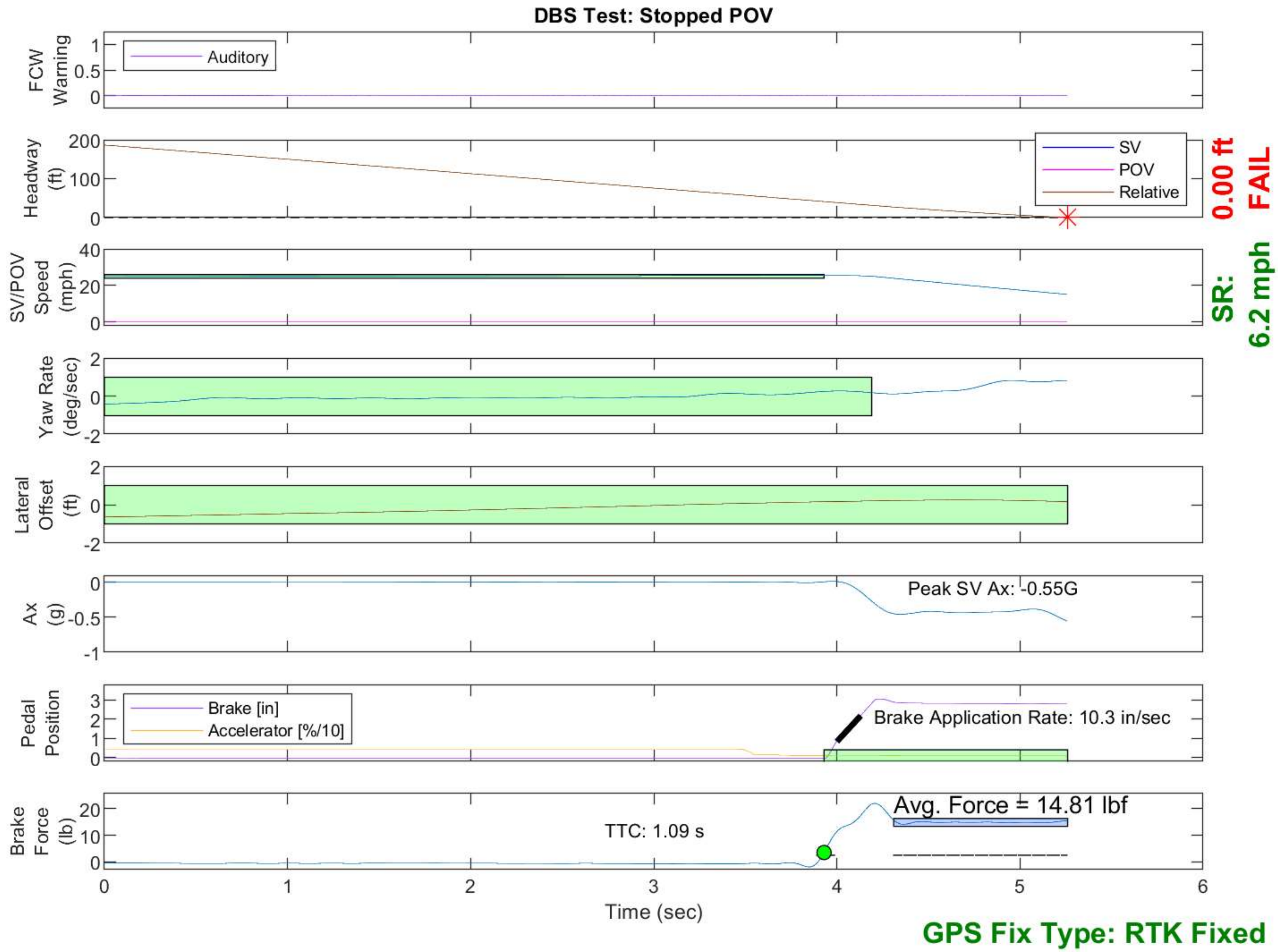

Figure E12. Example Time History for a Failed Run

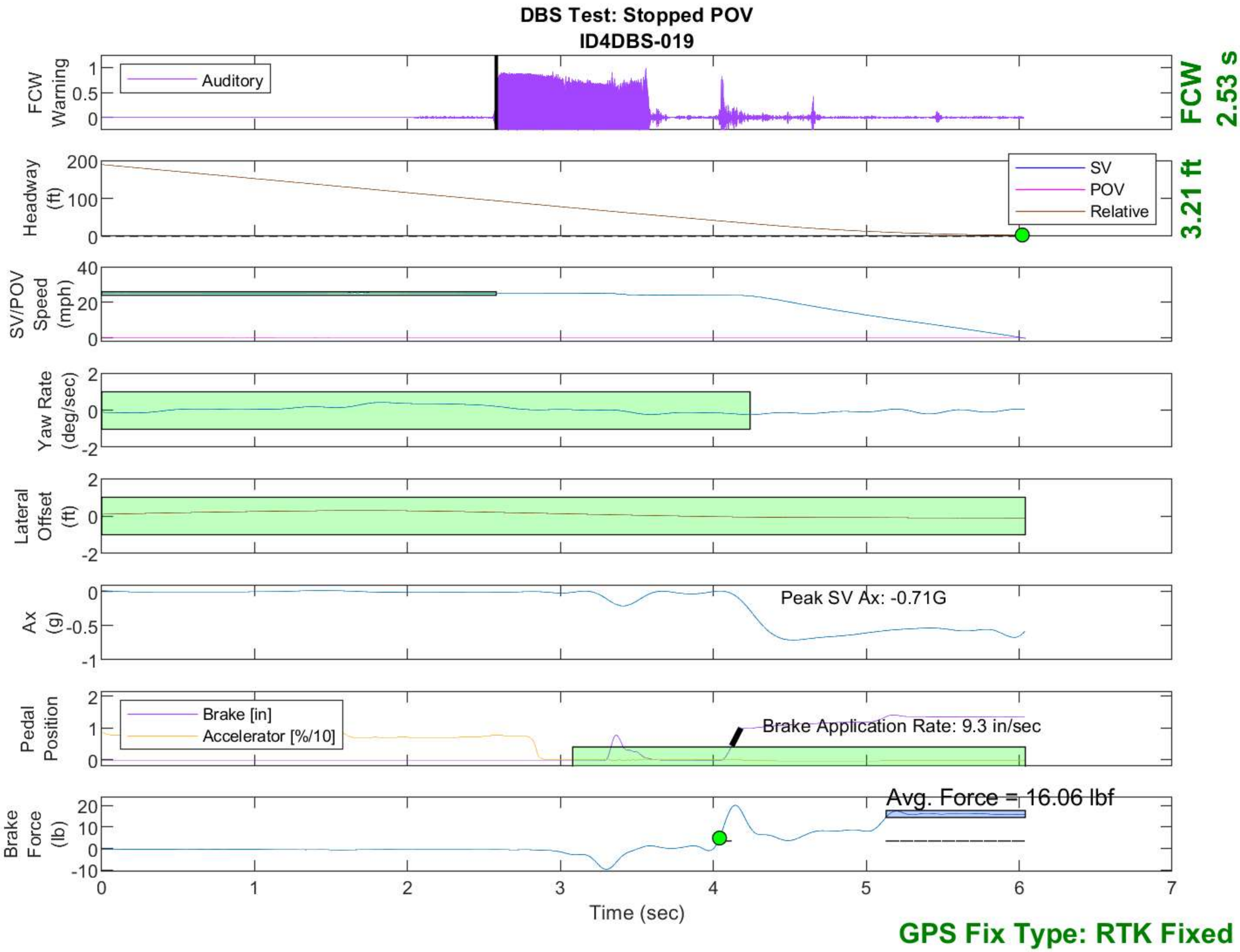

Figure E13. Time History for DBS Run 19, SV Encounters Stopped POV

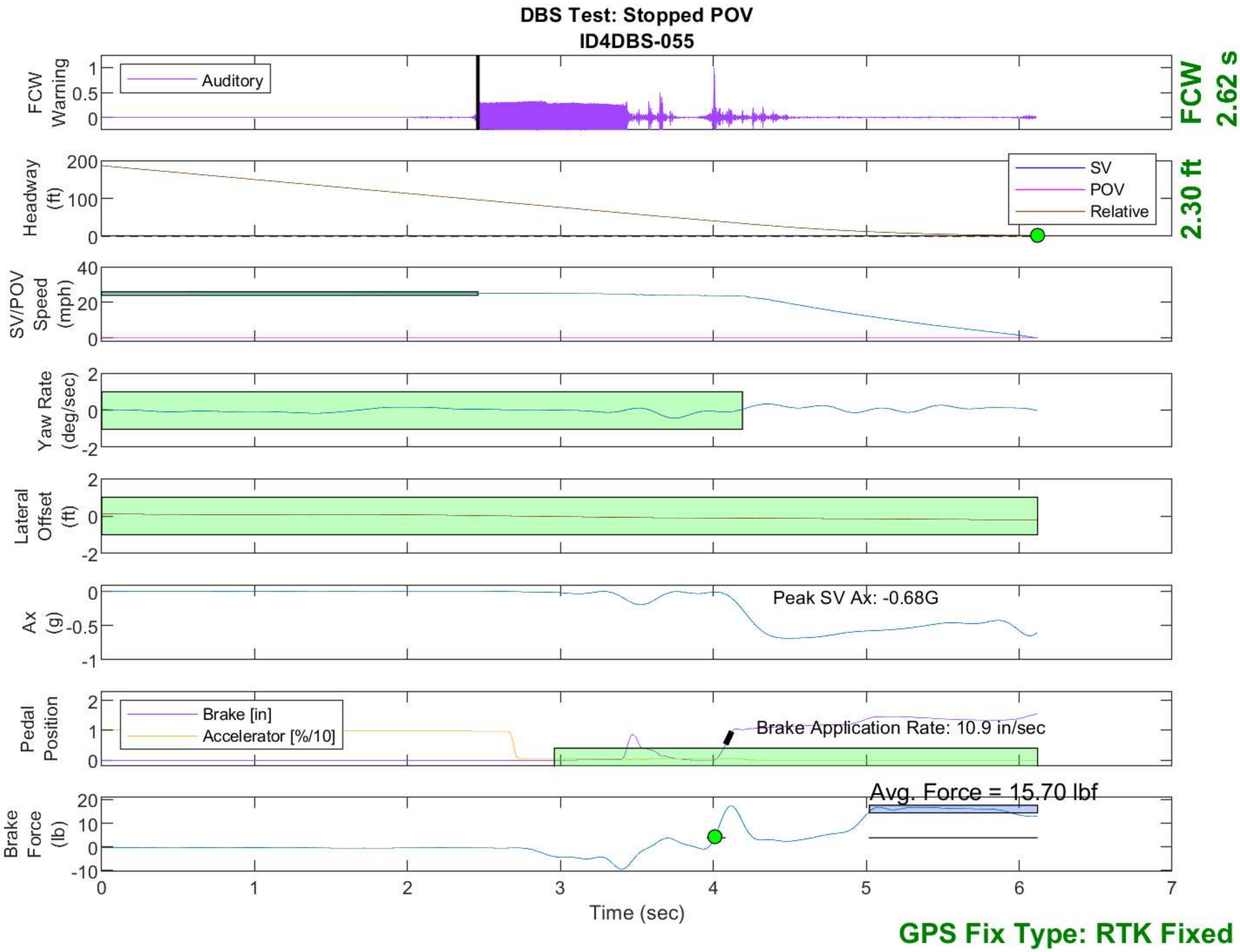

Figure E14. Time History for DBS Run 55, SV Encounters Stopped POV

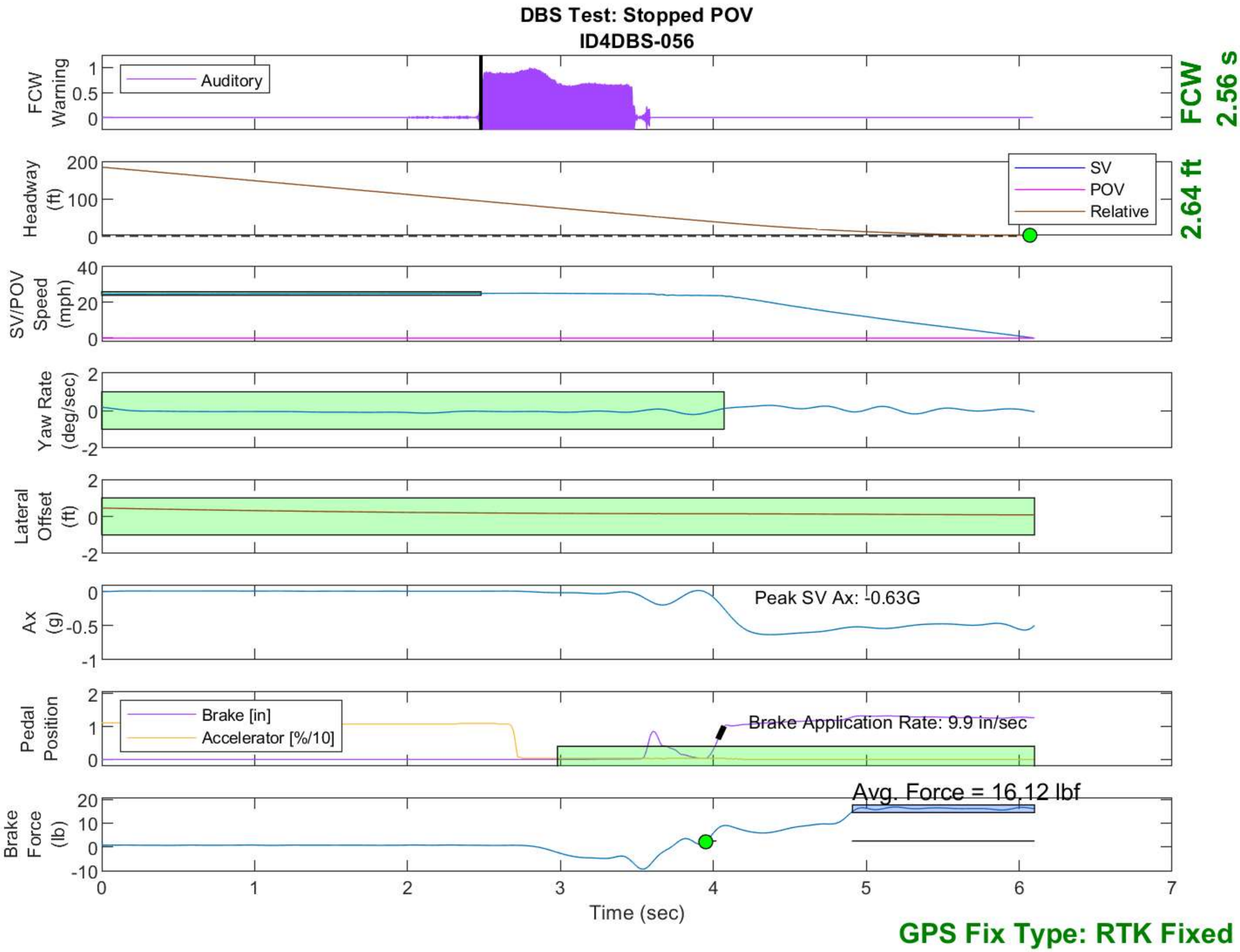

Figure E15. Time History for DBS Run 56, SV Encounters Stopped POV

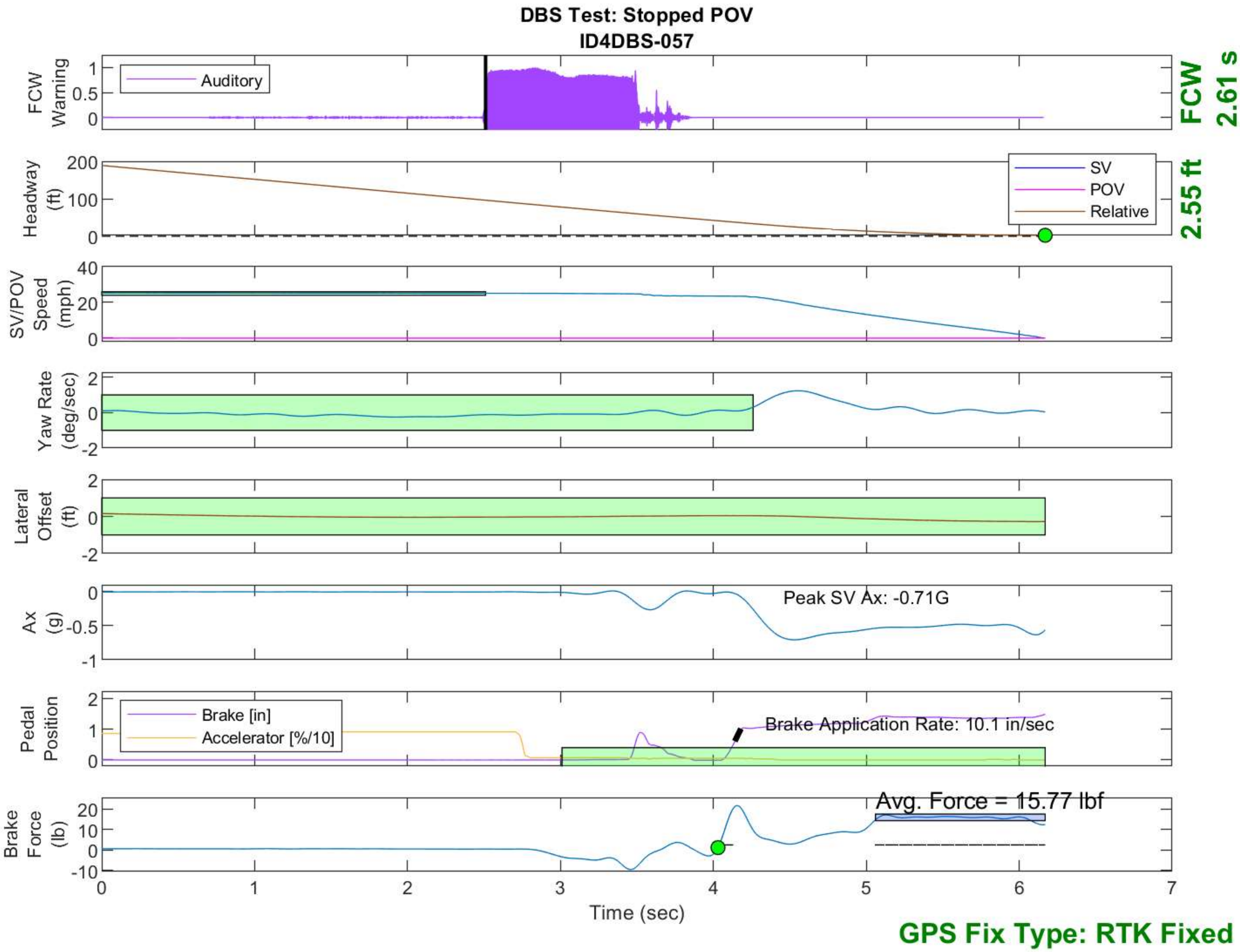

Figure E16. Time History for DBS Run 57, SV Encounters Stopped POV

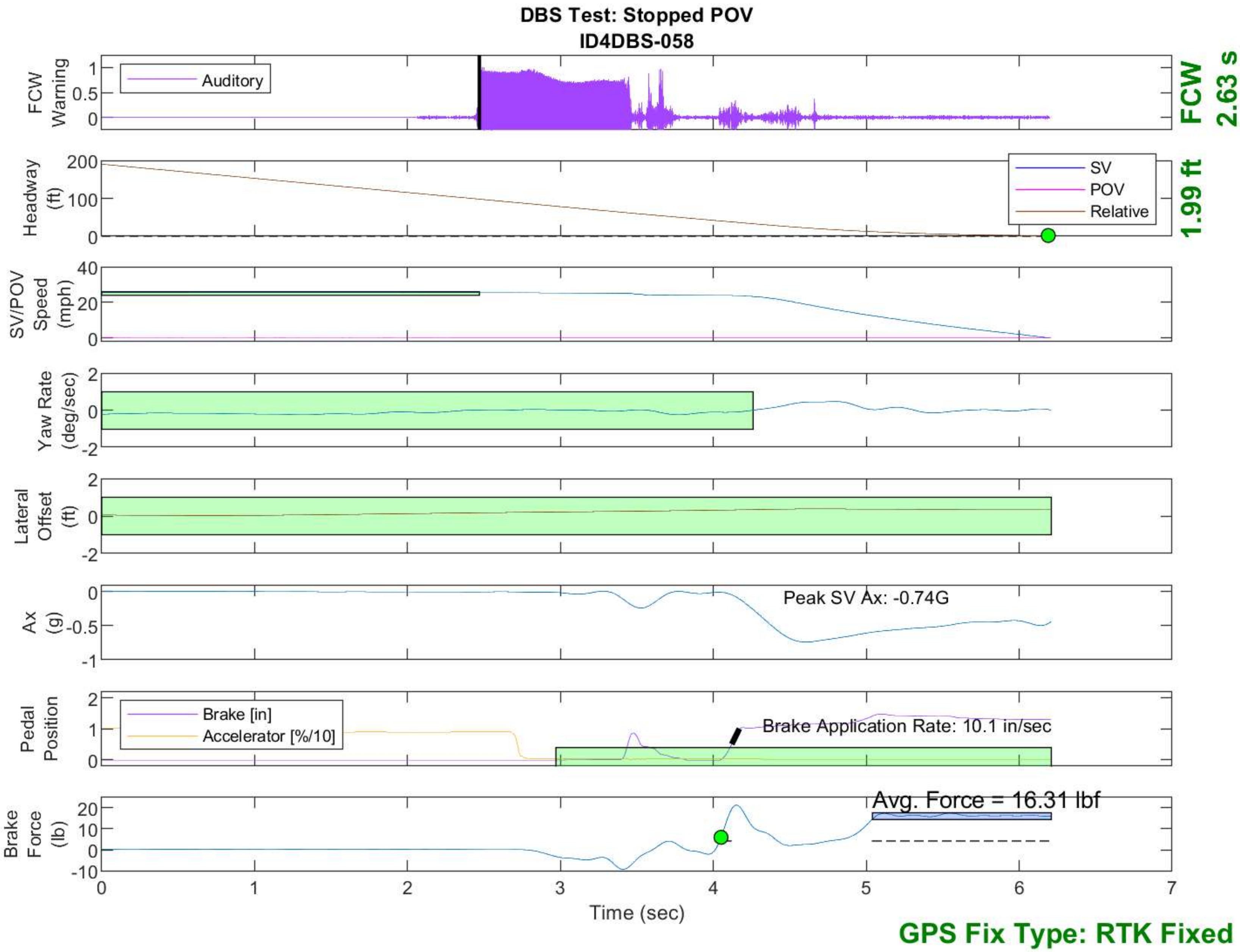

Figure E17. Time History for DBS Run 58, SV Encounters Stopped POV

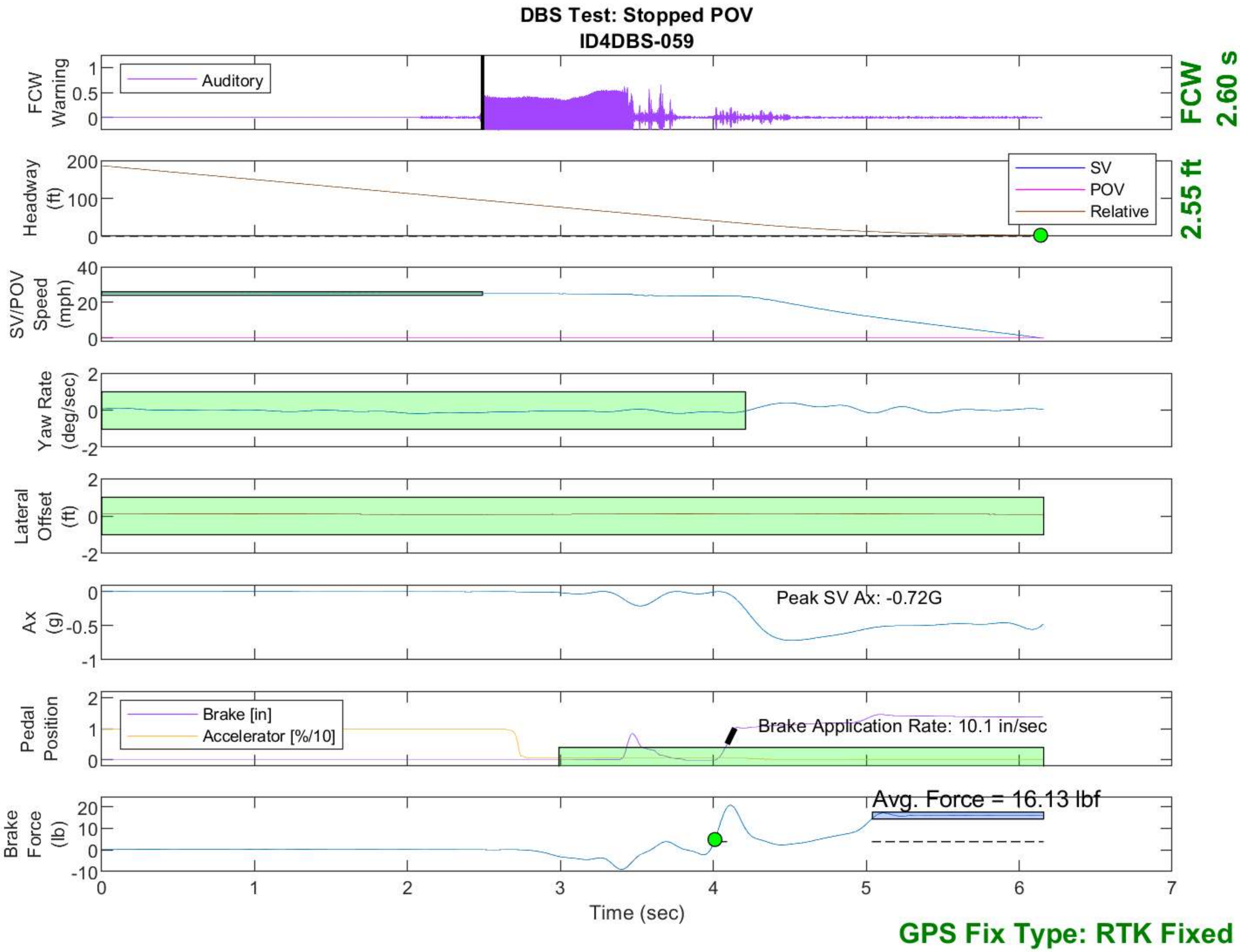

Figure E18. Time History for DBS Run 59, SV Encounters Stopped POV

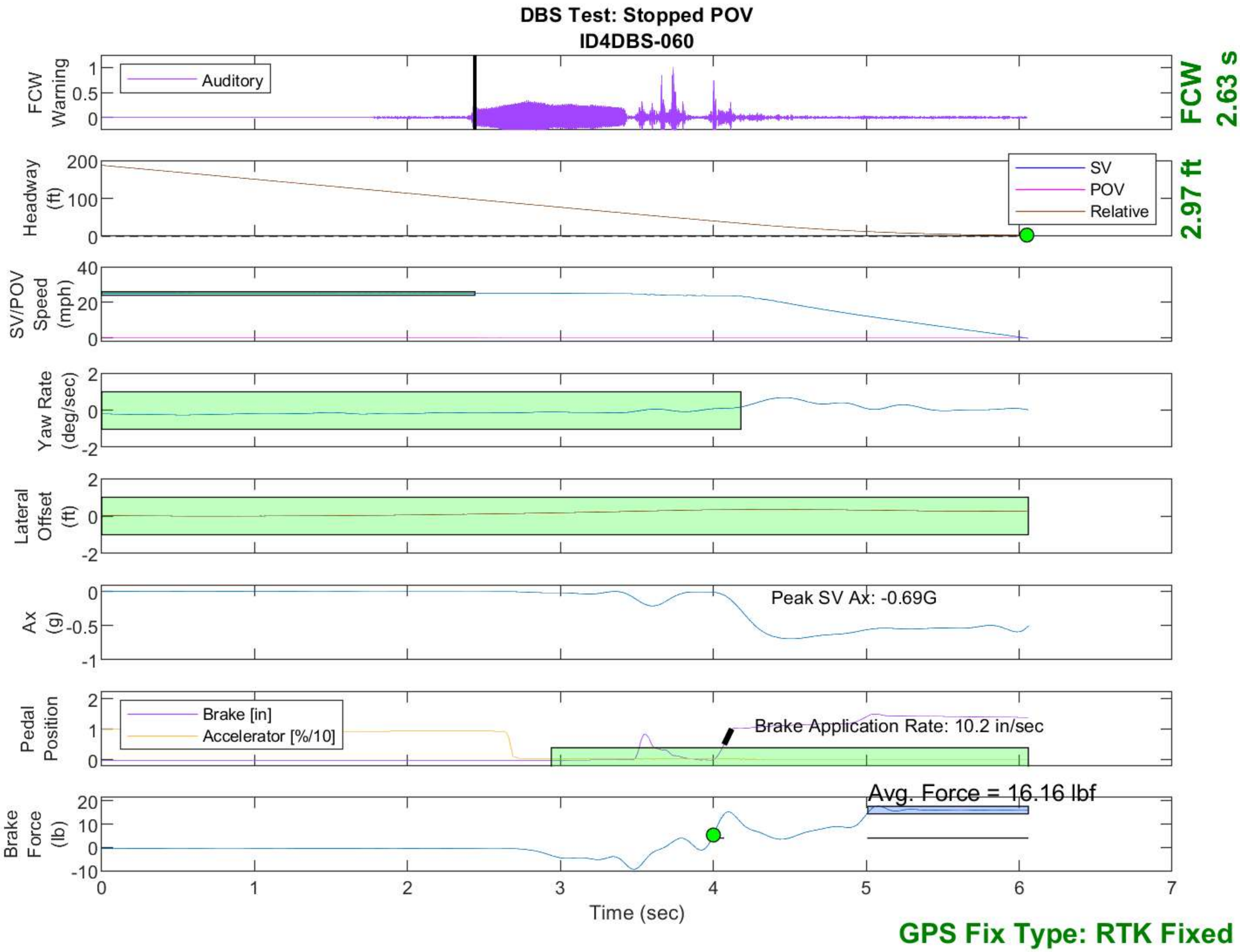

Figure E19. Time History for DBS Run 60, SV Encounters Stopped POV

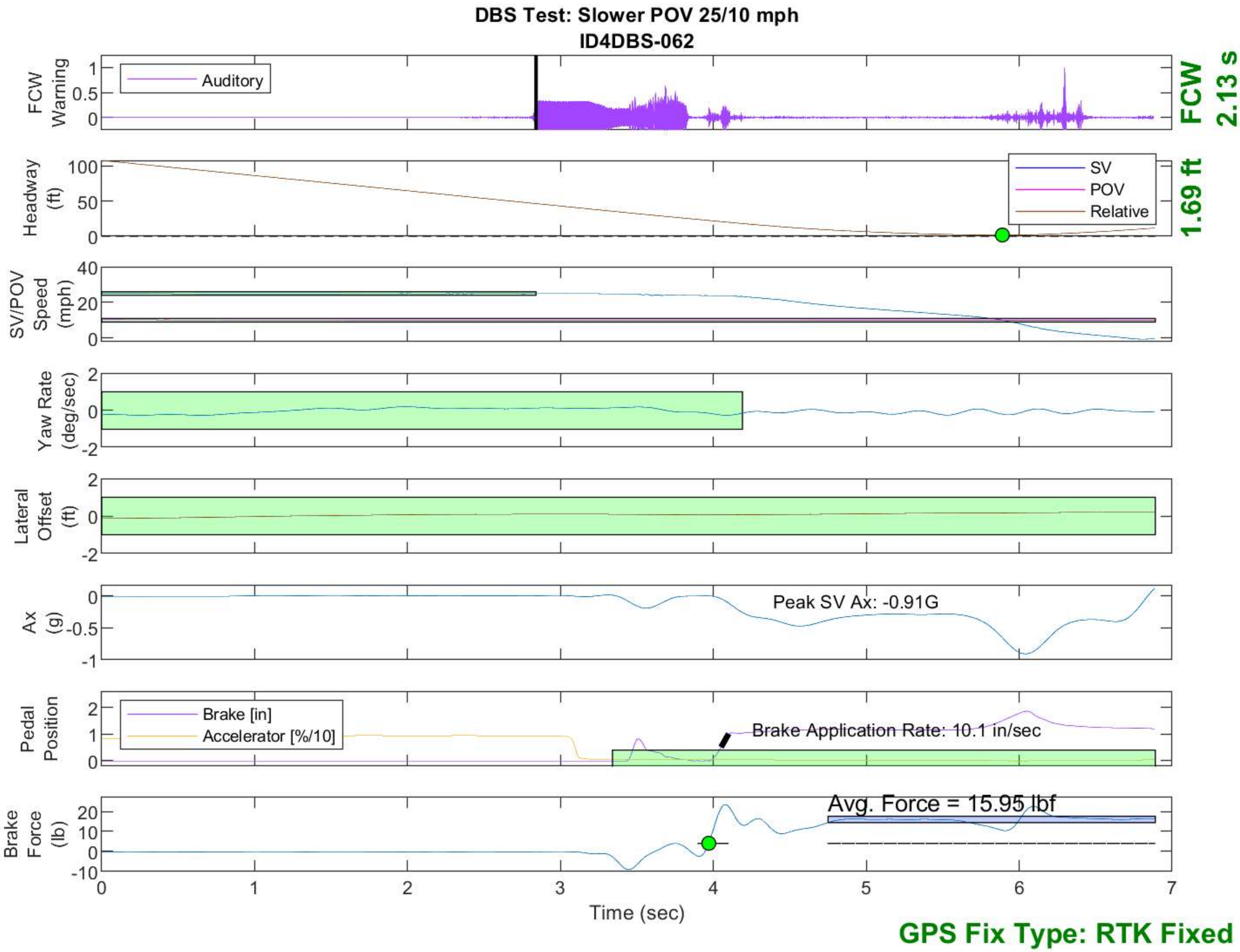

Figure E20. Time History for DBS Run 62, SV Encounters Slower POV, SV 25 mph, POV 10 mph

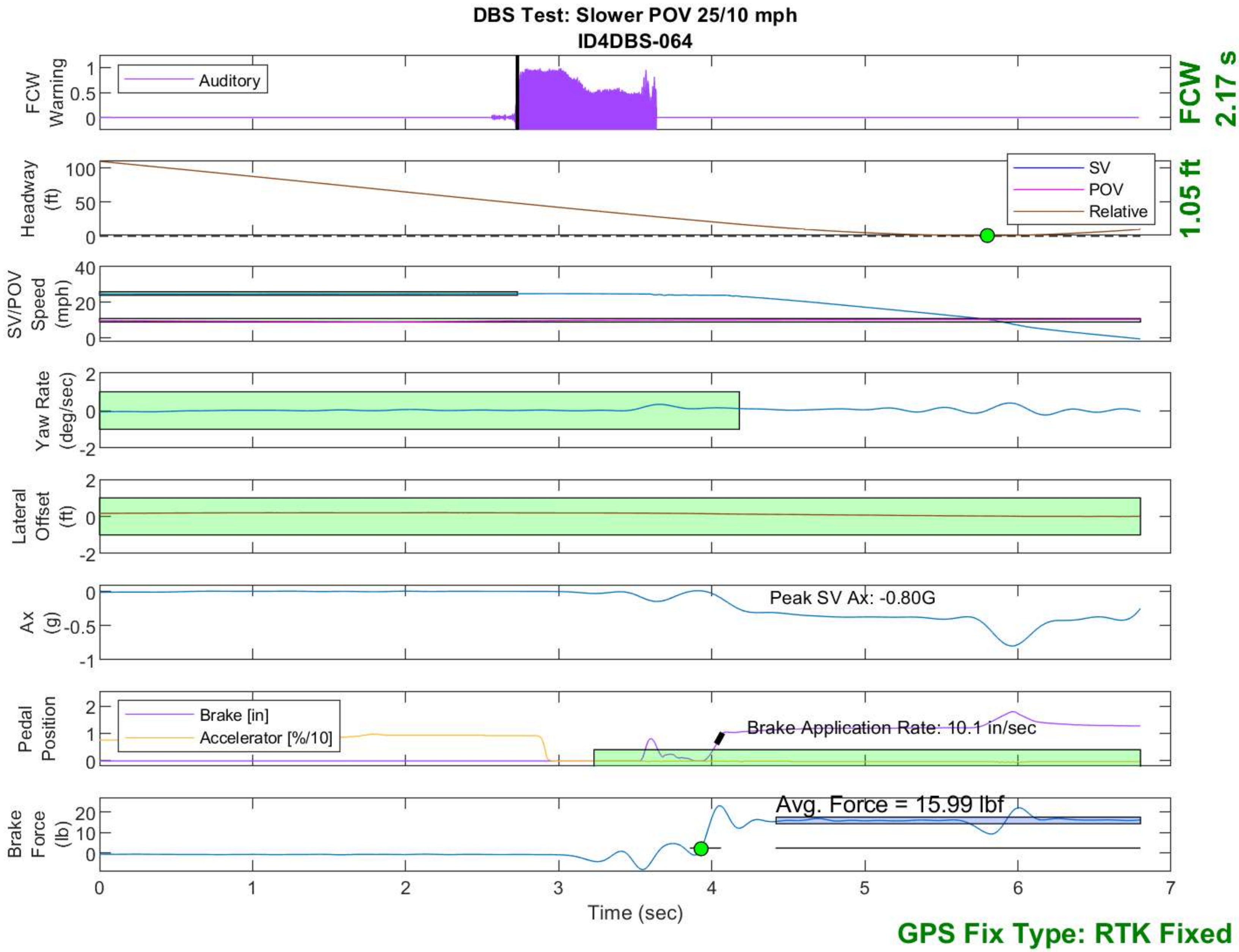

Figure E21. Time History for DBS Run 64, SV Encounters Slower POV, SV 25 mph, POV 10 mph

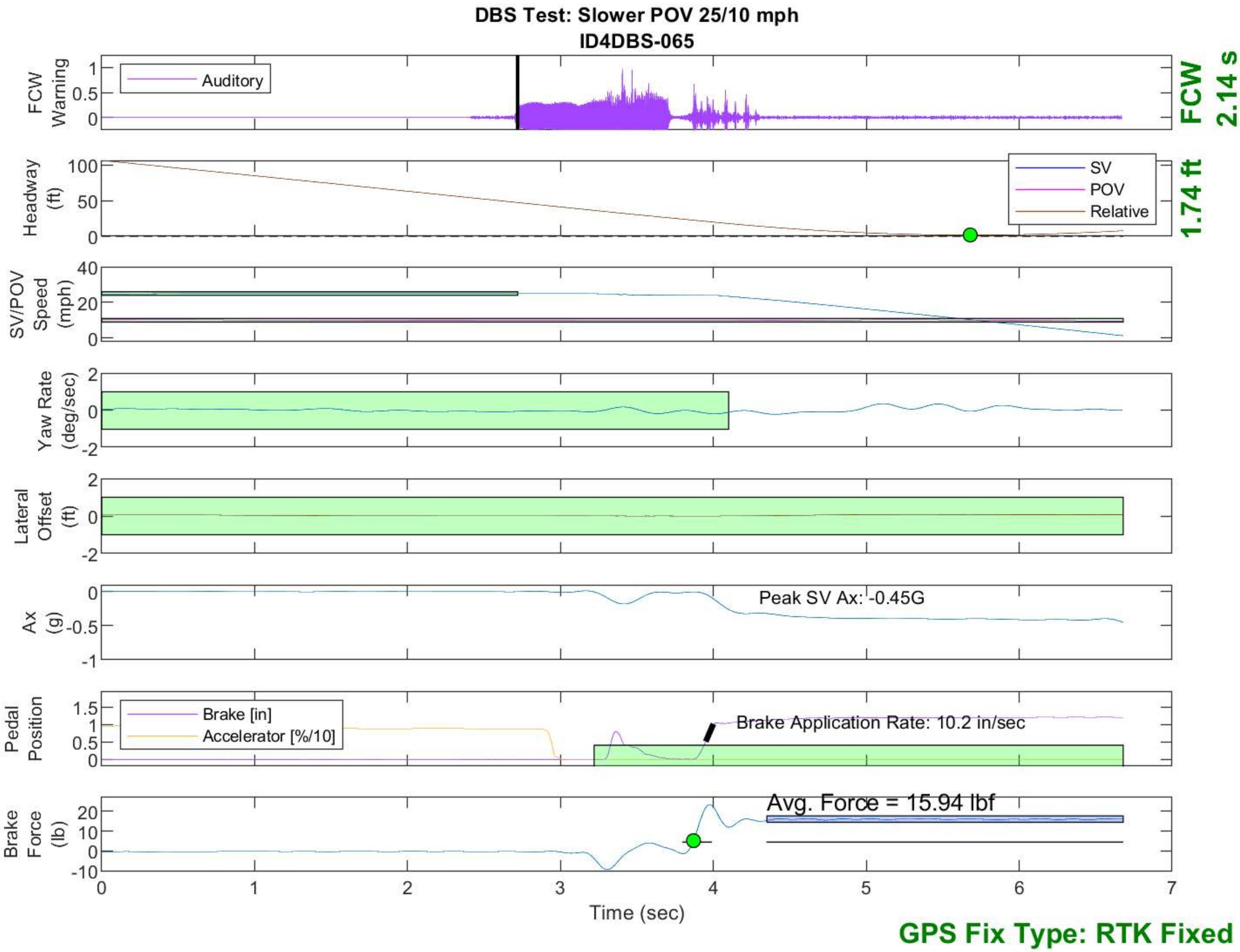

Figure E22. Time History for DBS Run 65, SV Encounters Slower POV, SV 25 mph, POV 10 mph

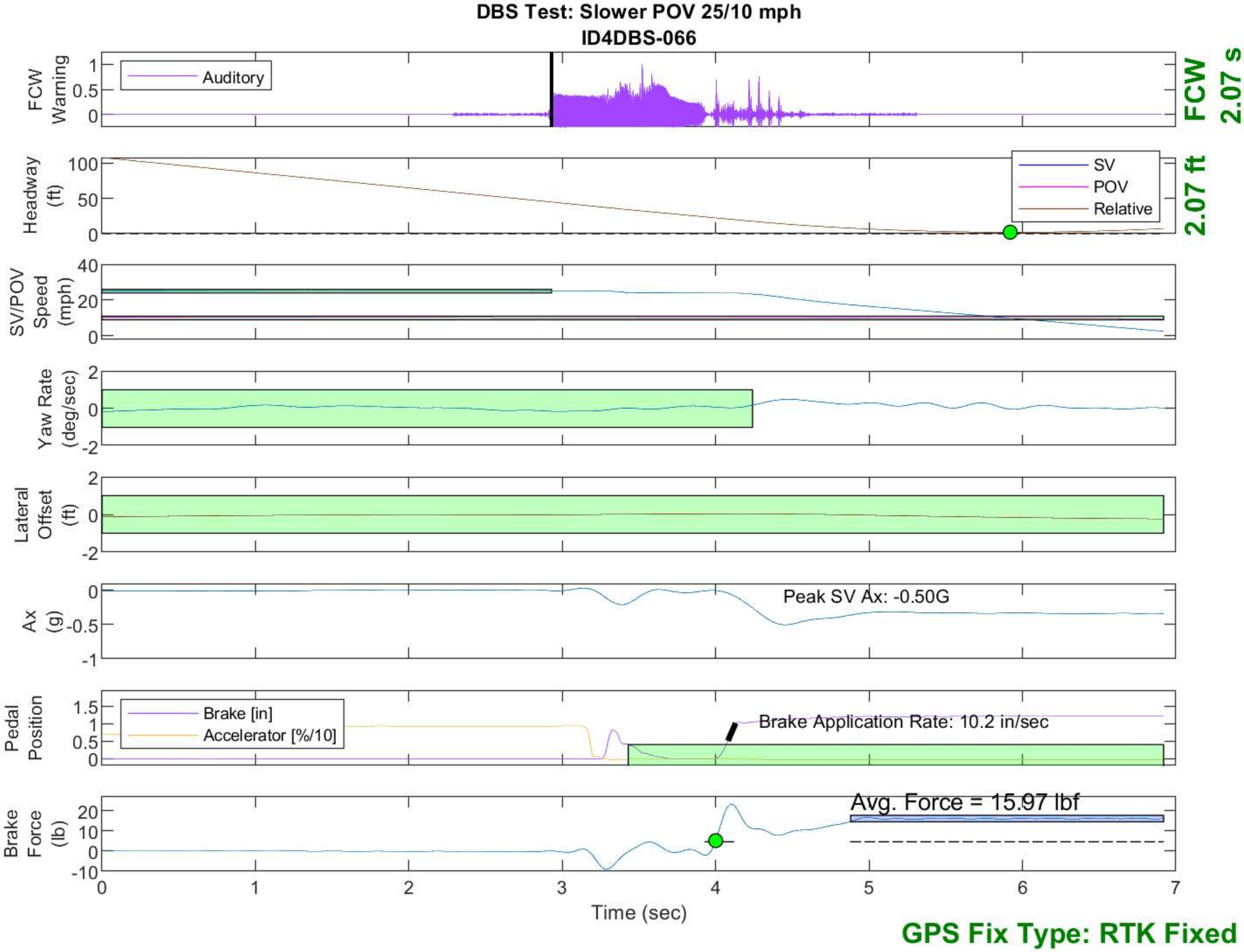

Figure E23. Time History for DBS Run 66, SV Encounters Slower POV, SV 25 mph, POV 10 mph

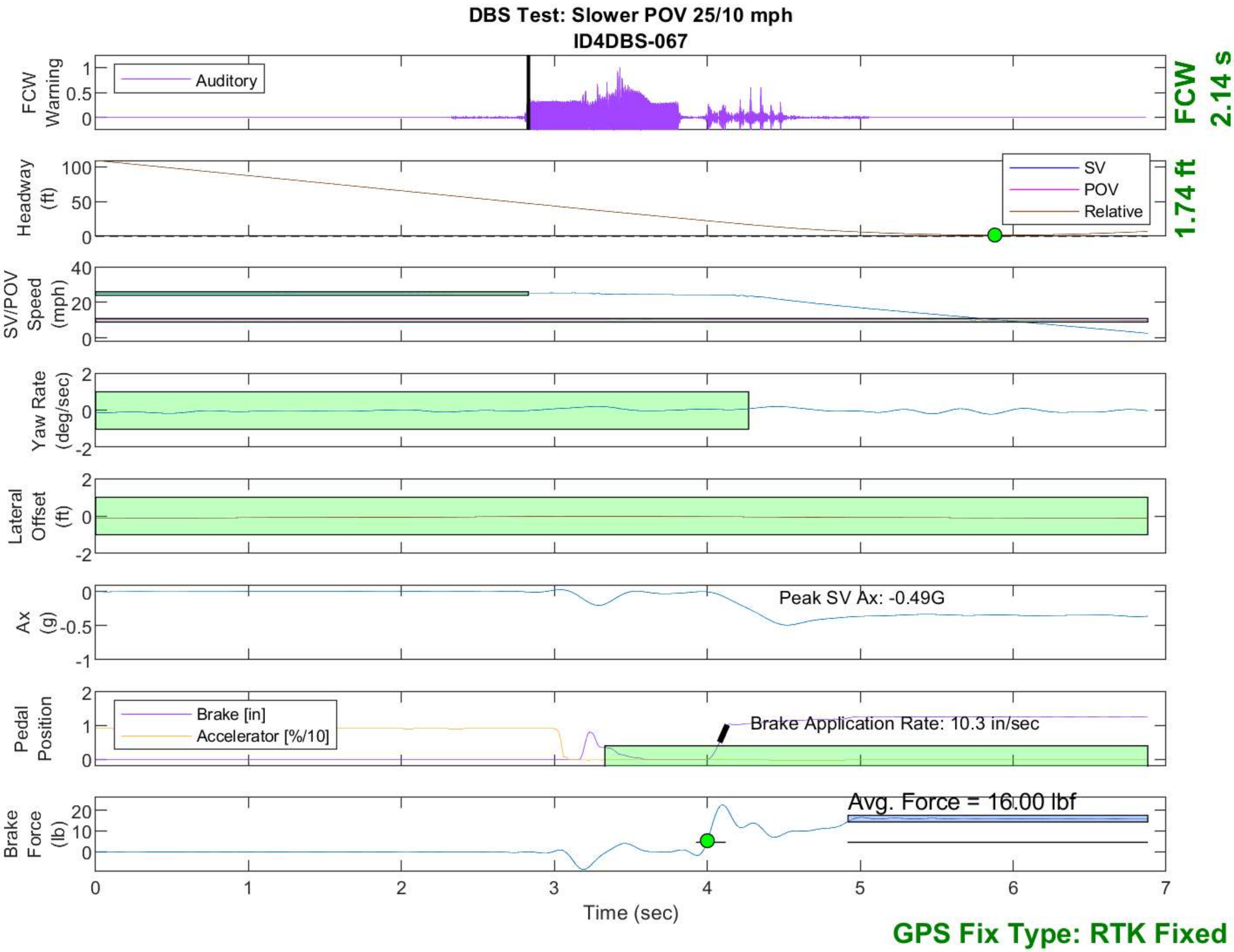

Figure E24. Time History for DBS Run 67, SV Encounters Slower POV, SV 25 mph, POV 10 mph

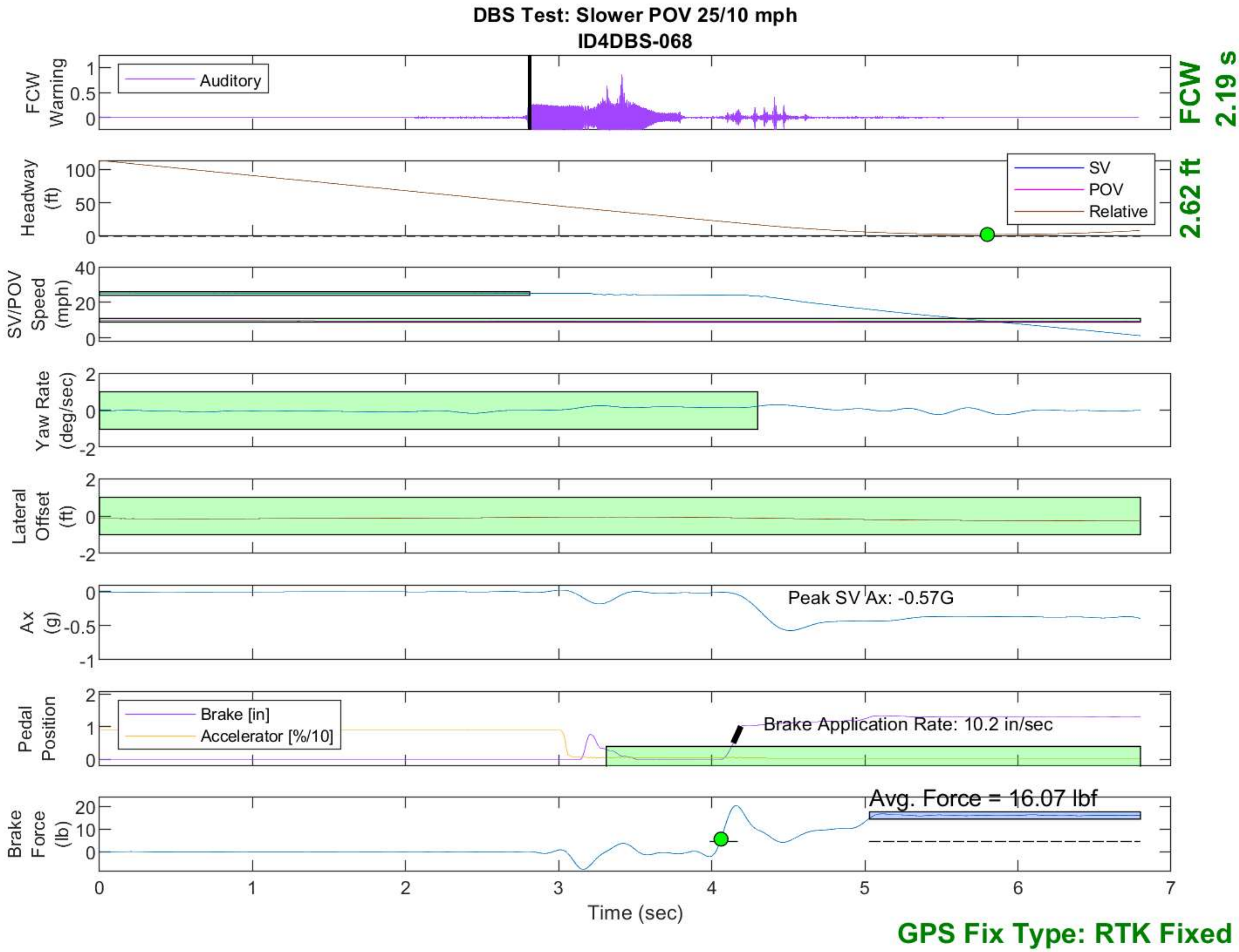

Figure E25. Time History for DBS Run 68, SV Encounters Slower POV, SV 25 mph, POV 10 mph

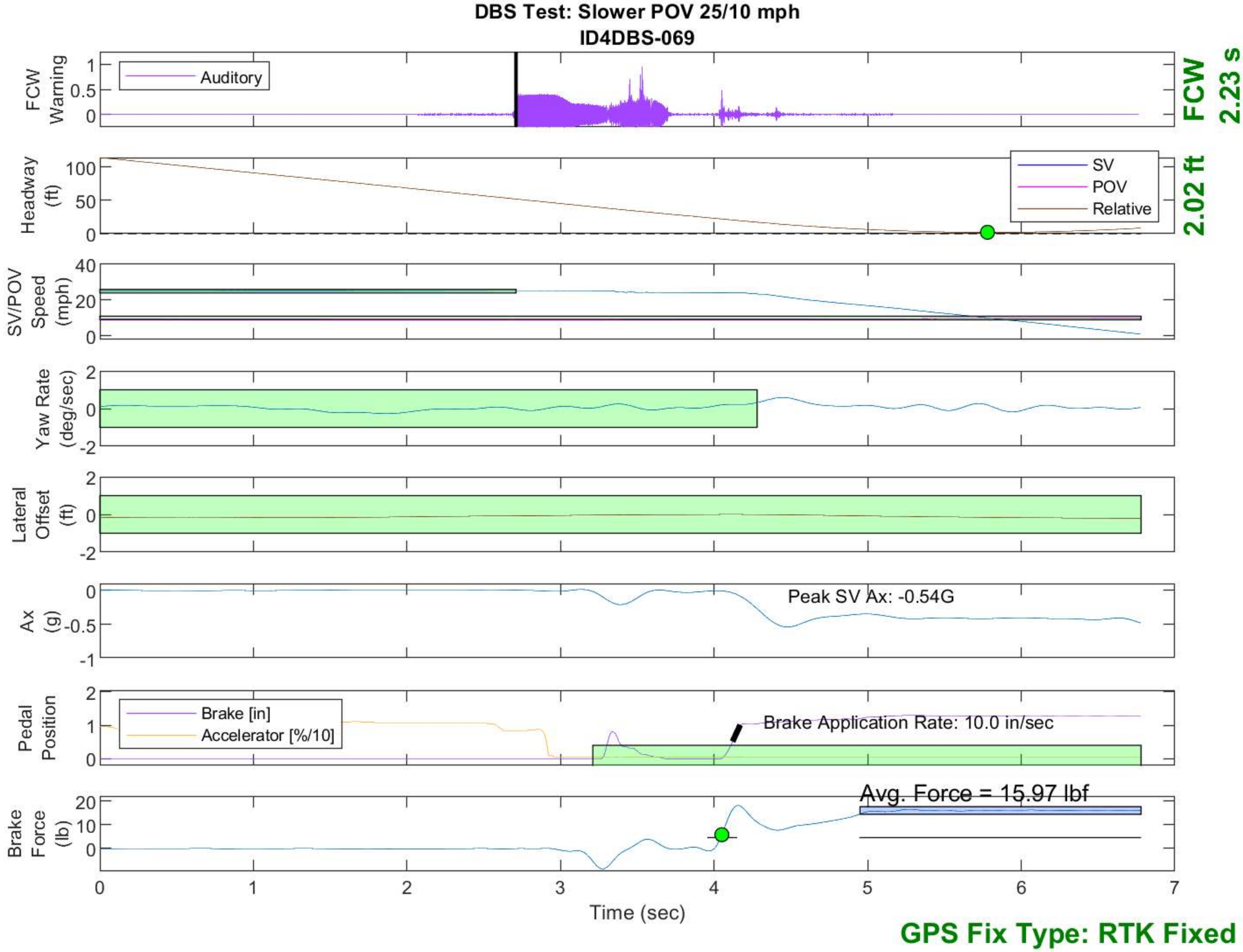

Figure E26. Time History for DBS Run 69, SV Encounters Slower POV, SV 25 mph, POV 10 mph

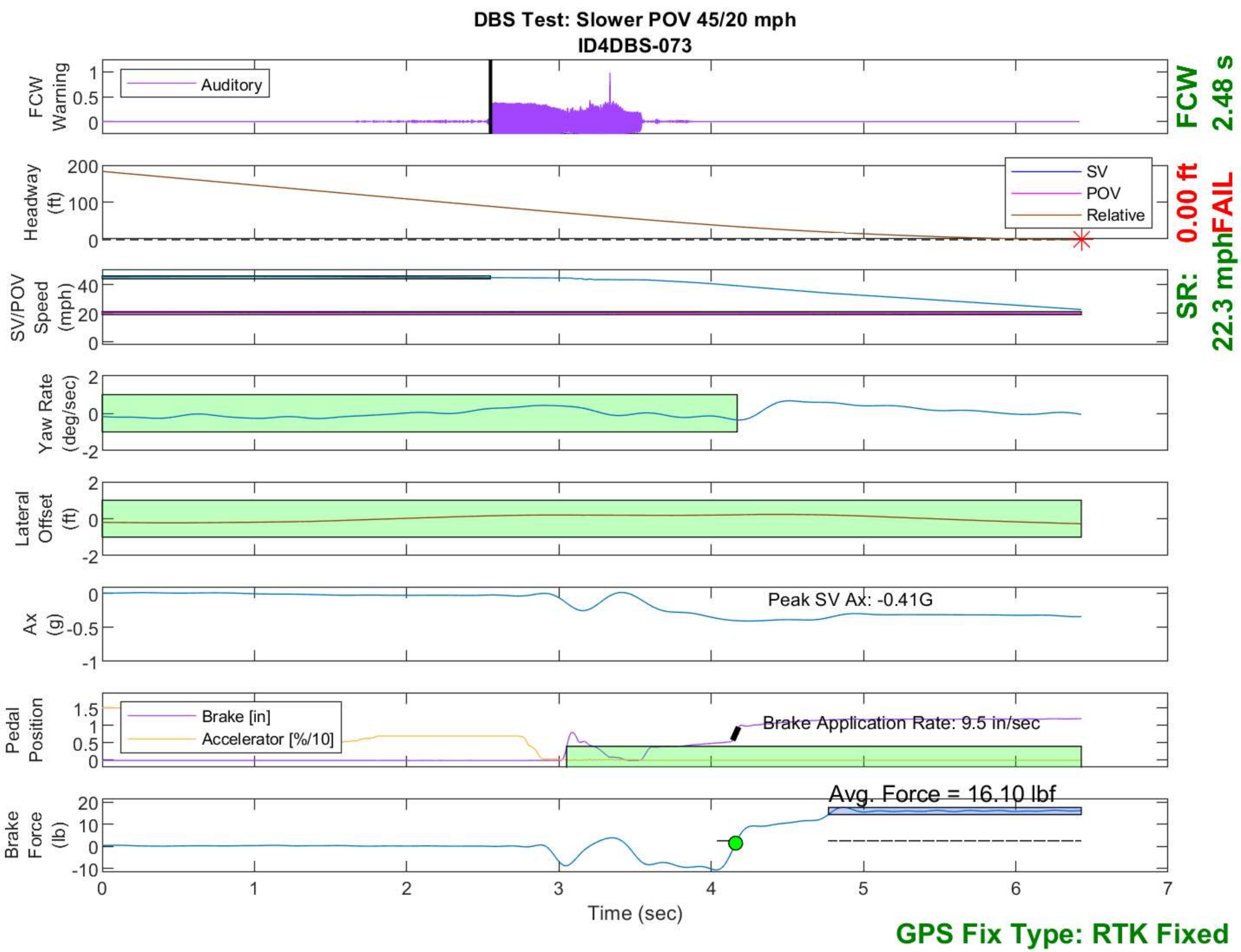

Figure E27. Time History for DBS Run 73, SV Encounters Slower POV, SV 45 mph, POV 20 mph

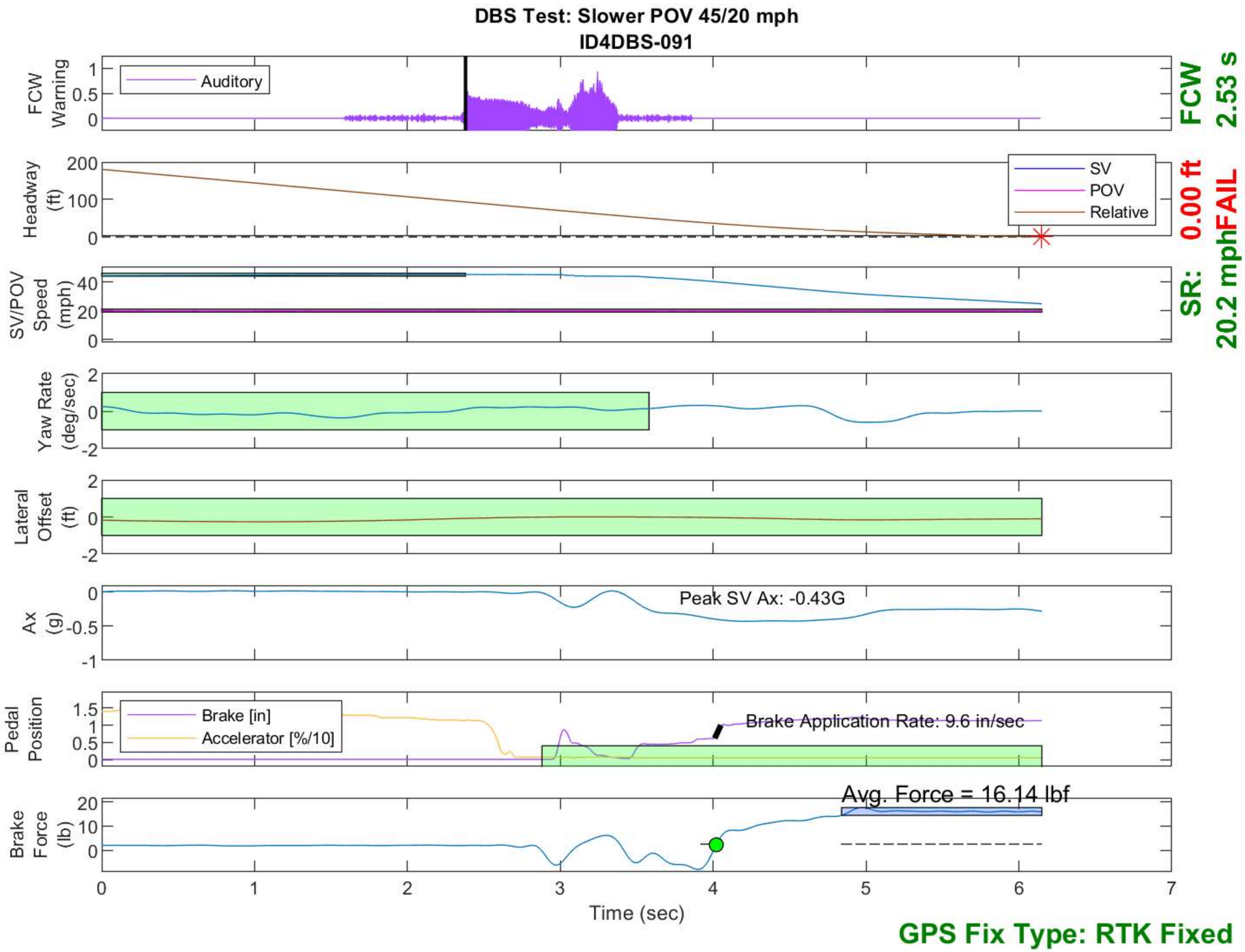

Figure E28. Time History for DBS Run 91, SV Encounters Slower POV, SV 45 mph, POV 20 mph

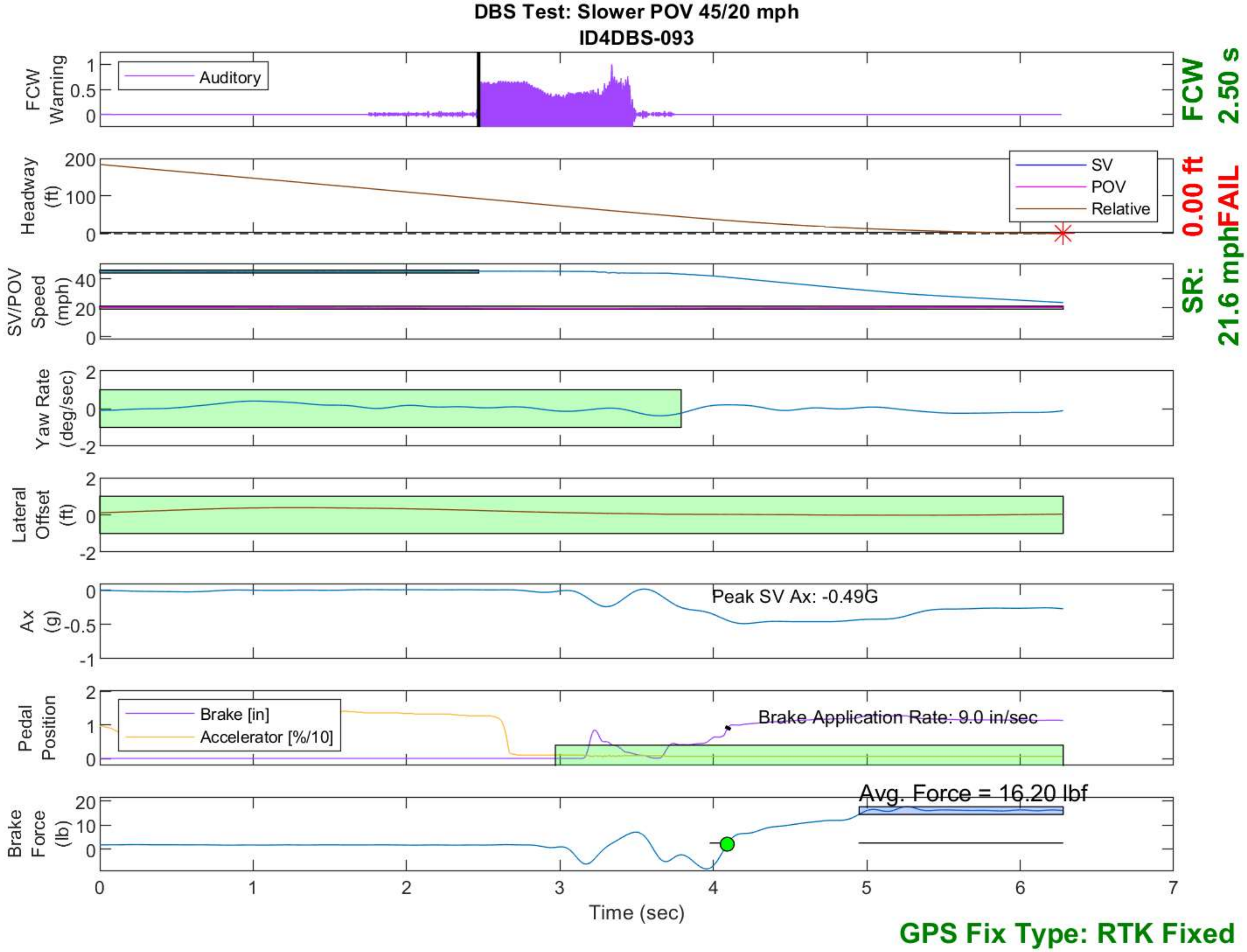

Figure E29. Time History for DBS Run 93, SV Encounters Slower POV, SV 45 mph, POV 20 mph

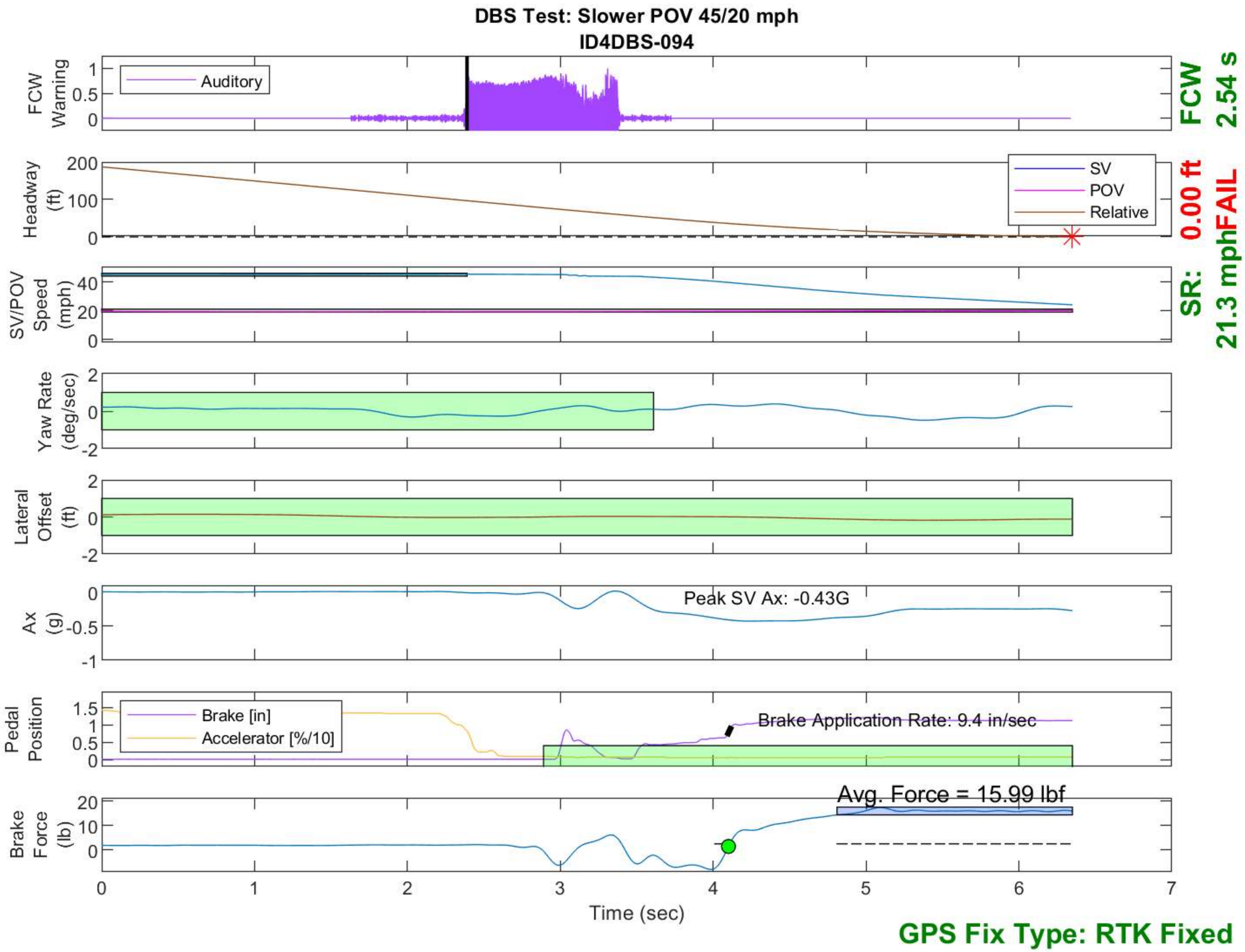

Figure E30. Time History for DBS Run 94, SV Encounters Slower POV, SV 45 mph, POV 20 mph

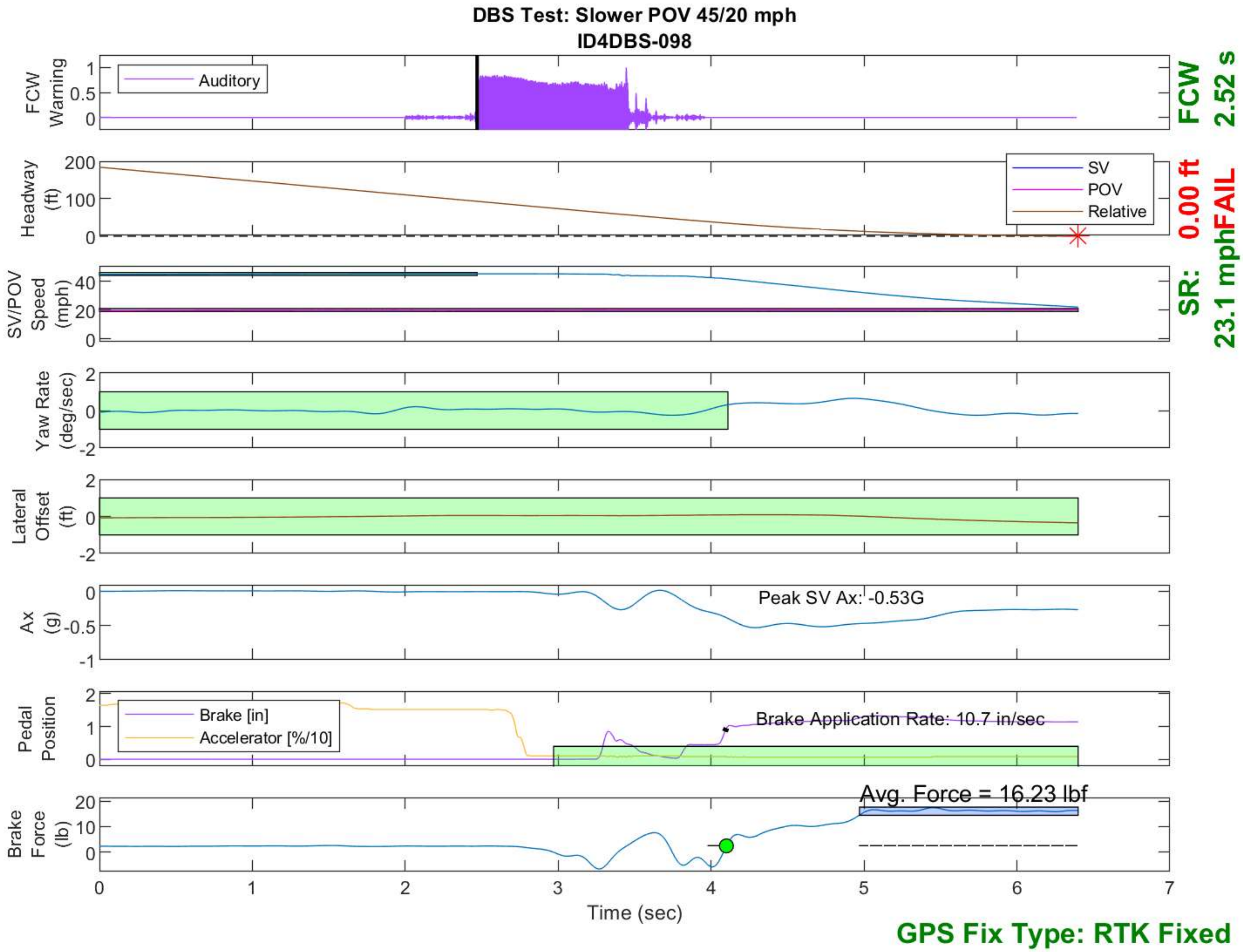

Figure E31. Time History for DBS Run 98, SV Encounters Slower POV, SV 45 mph, POV 20 mph

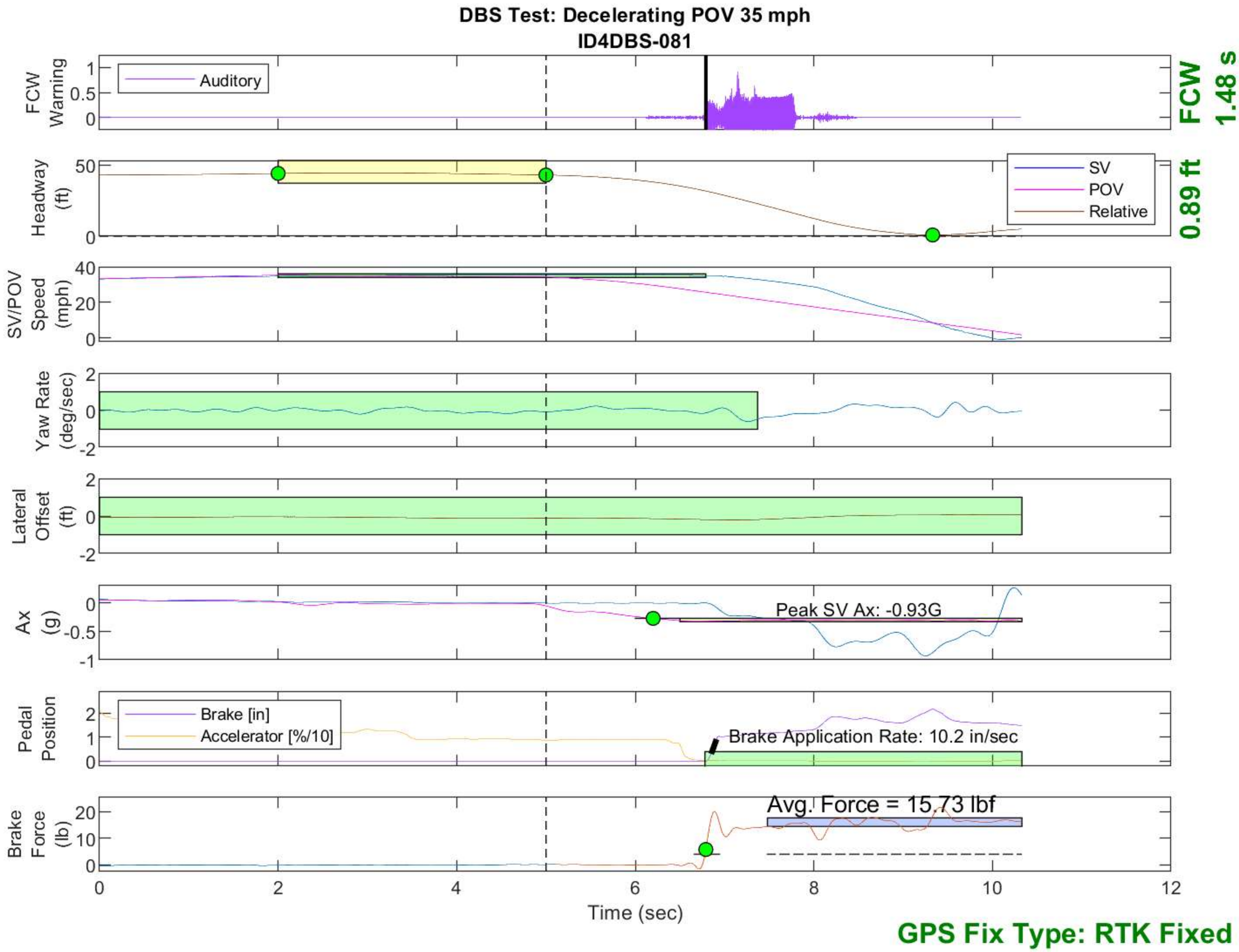

Figure E32. Time History for DBS Run 81, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

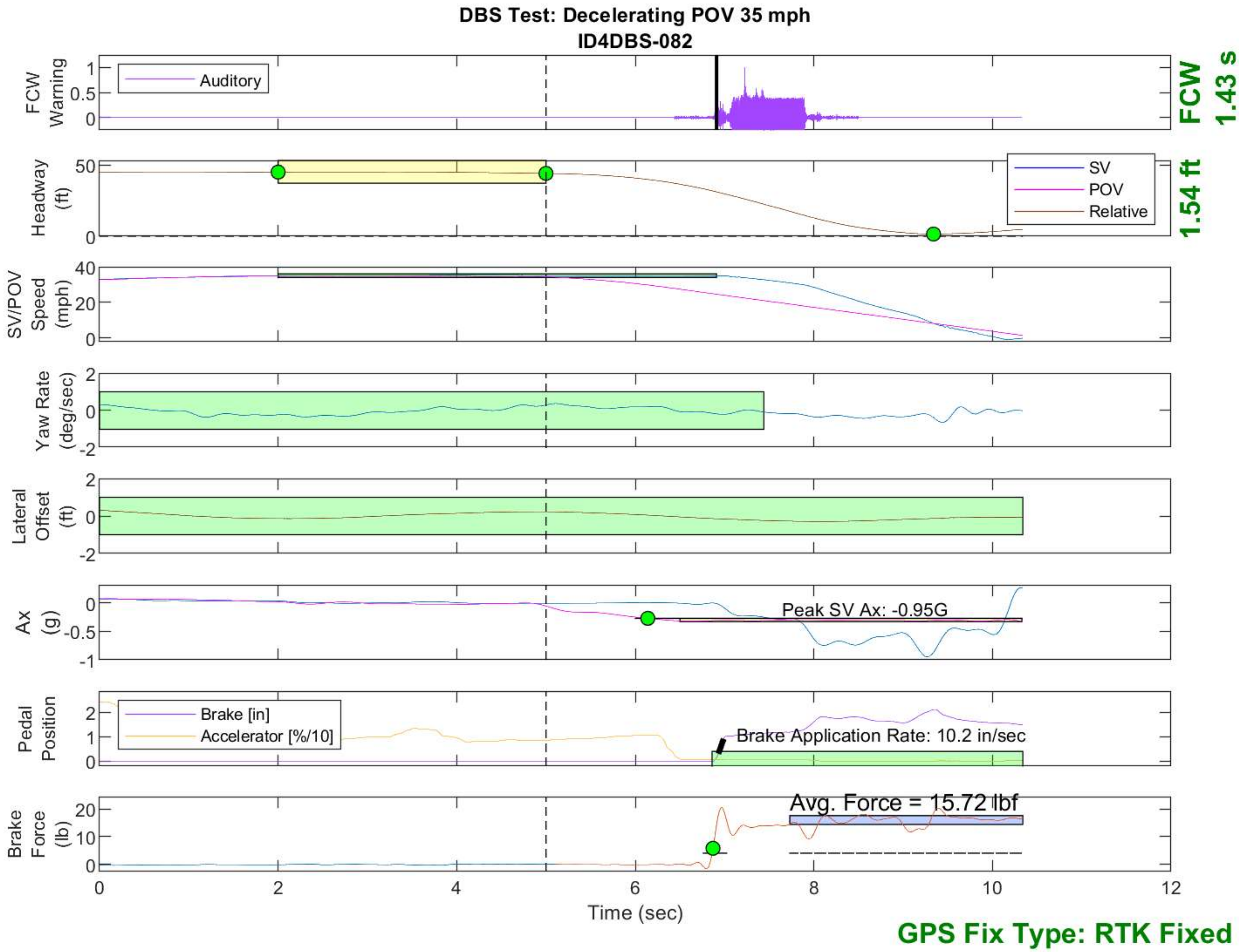

Figure E33. Time History for DBS Run 82, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

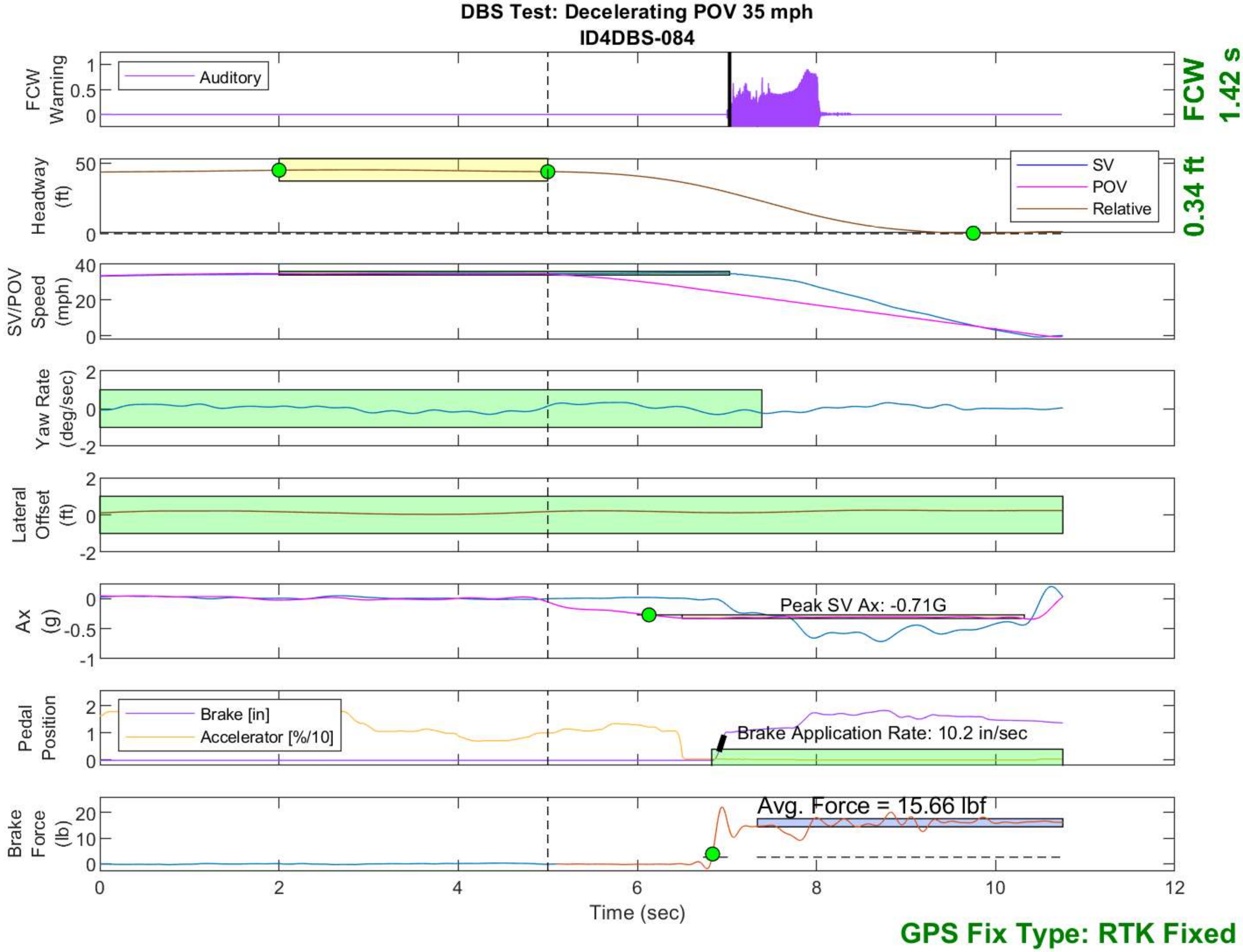

Figure E34. Time History for DBS Run 84, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

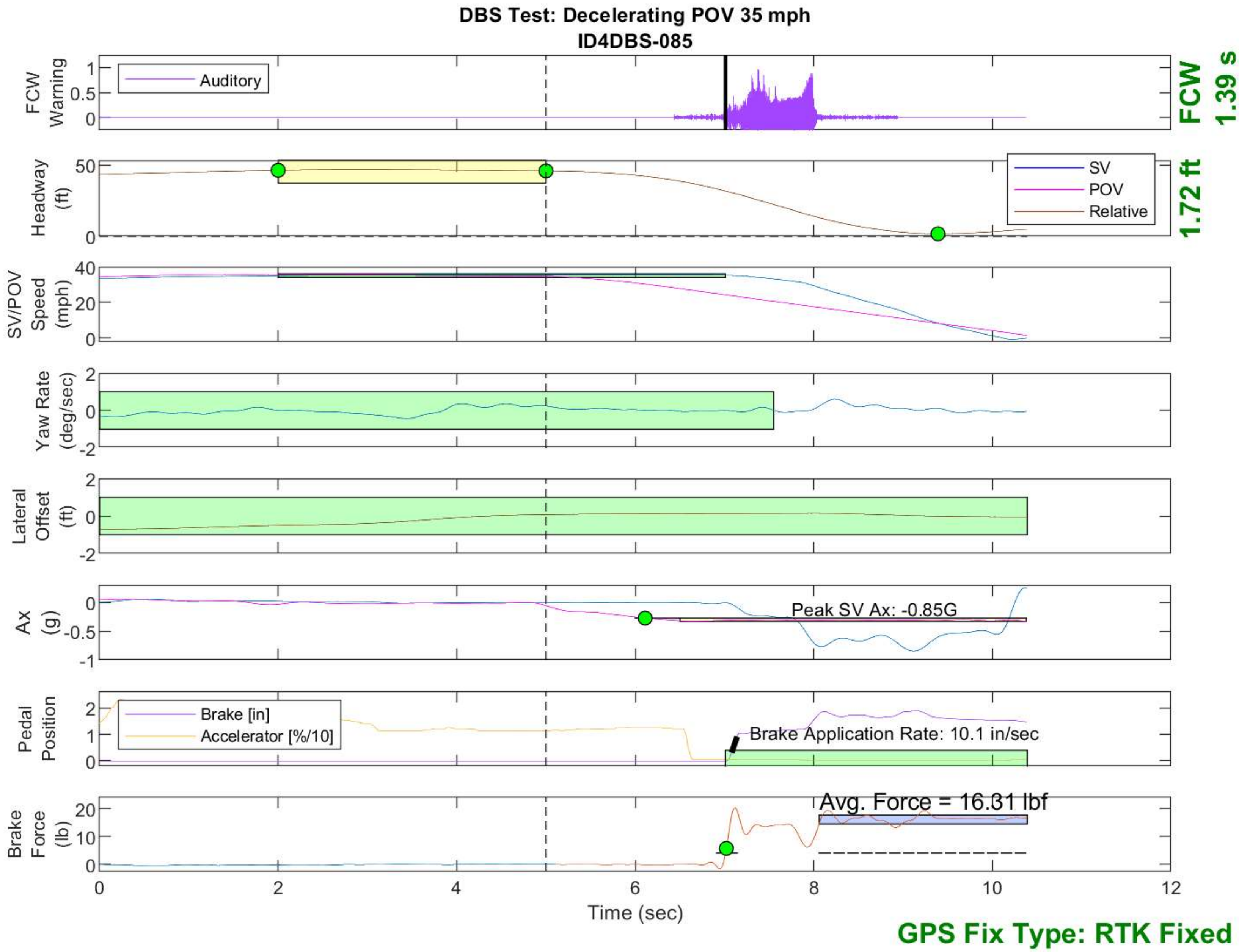

Figure E35. Time History for DBS Run 85, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

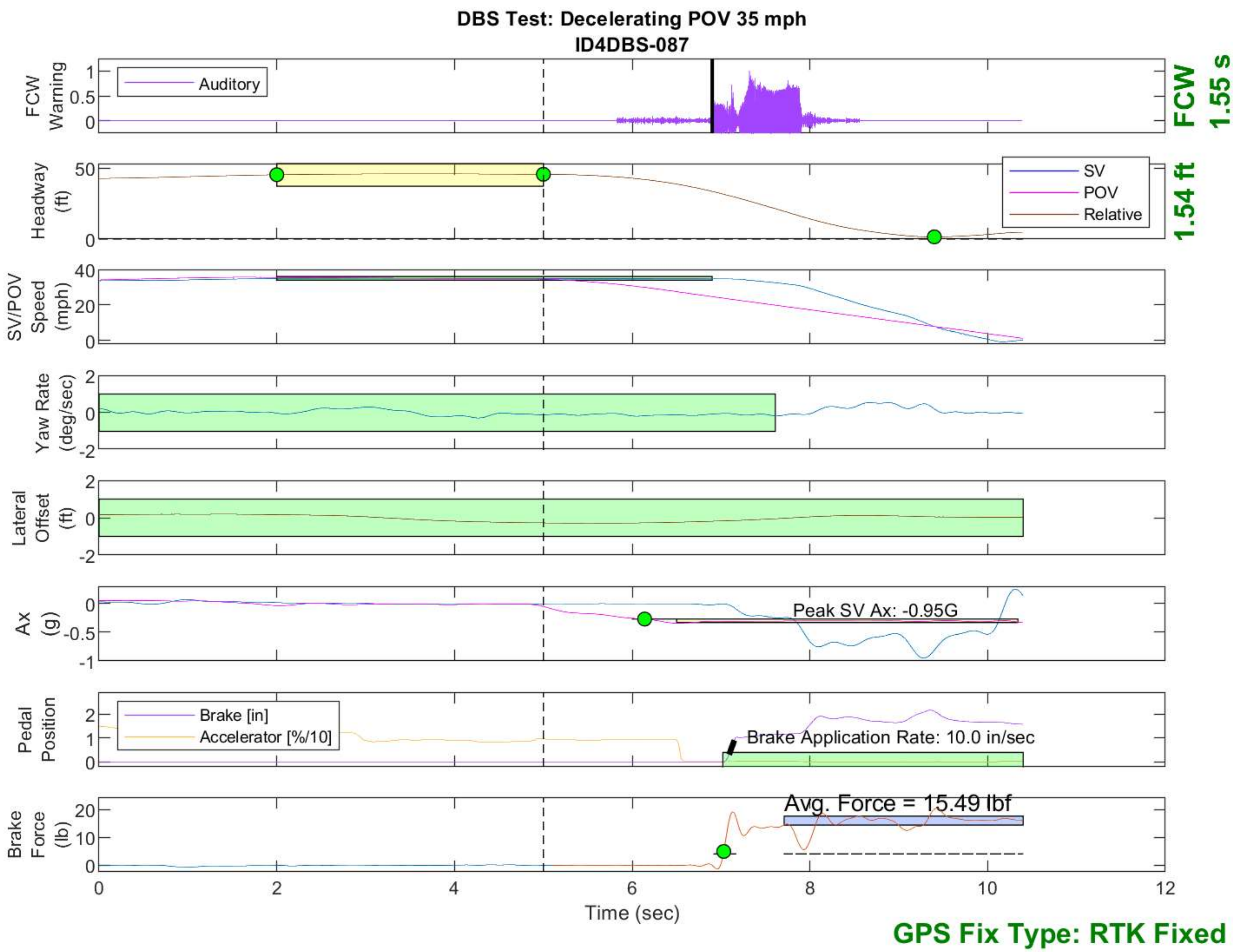

Figure E36. Time History for DBS Run 87, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

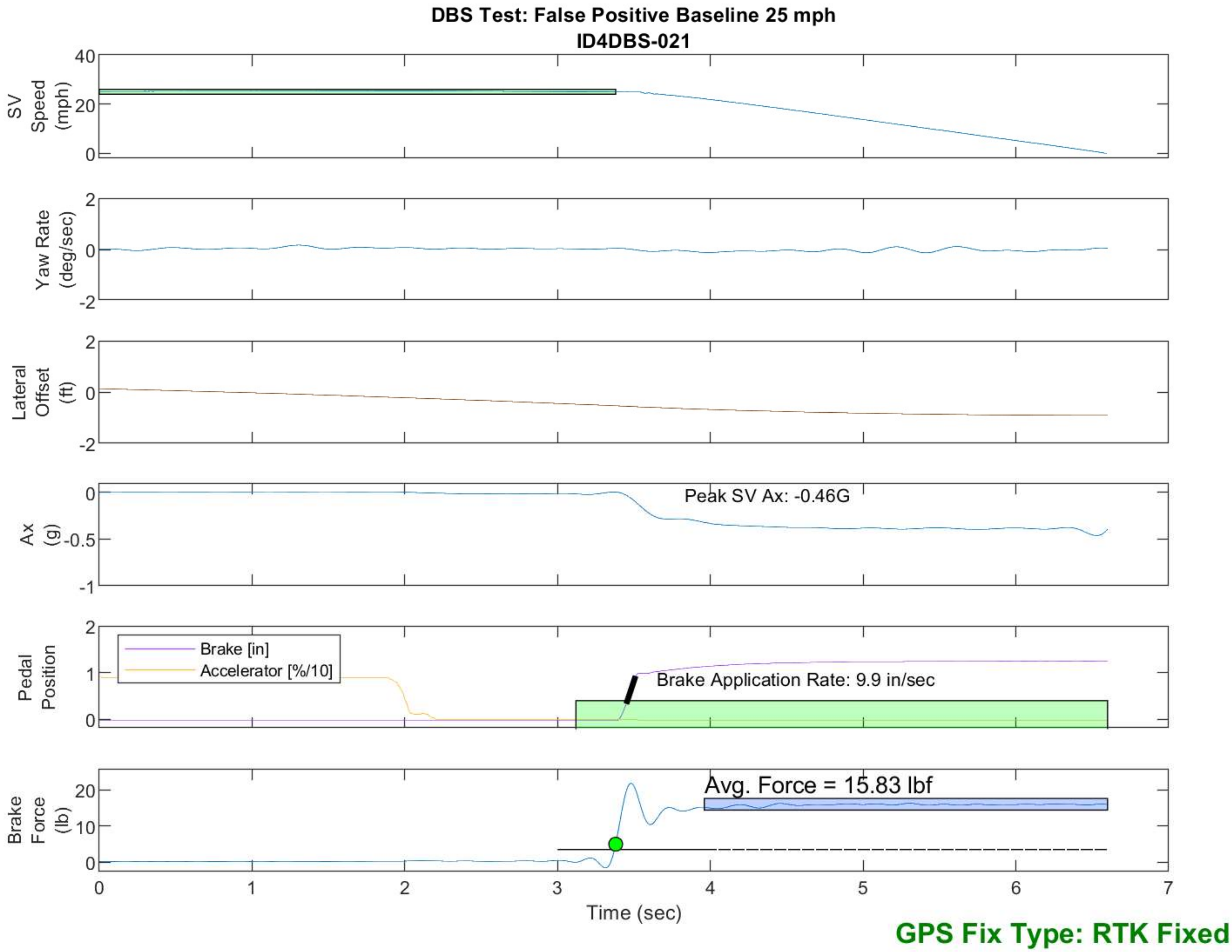

Figure E37. Time History for DBS Run 21, False Positive Baseline, SV 25 mph

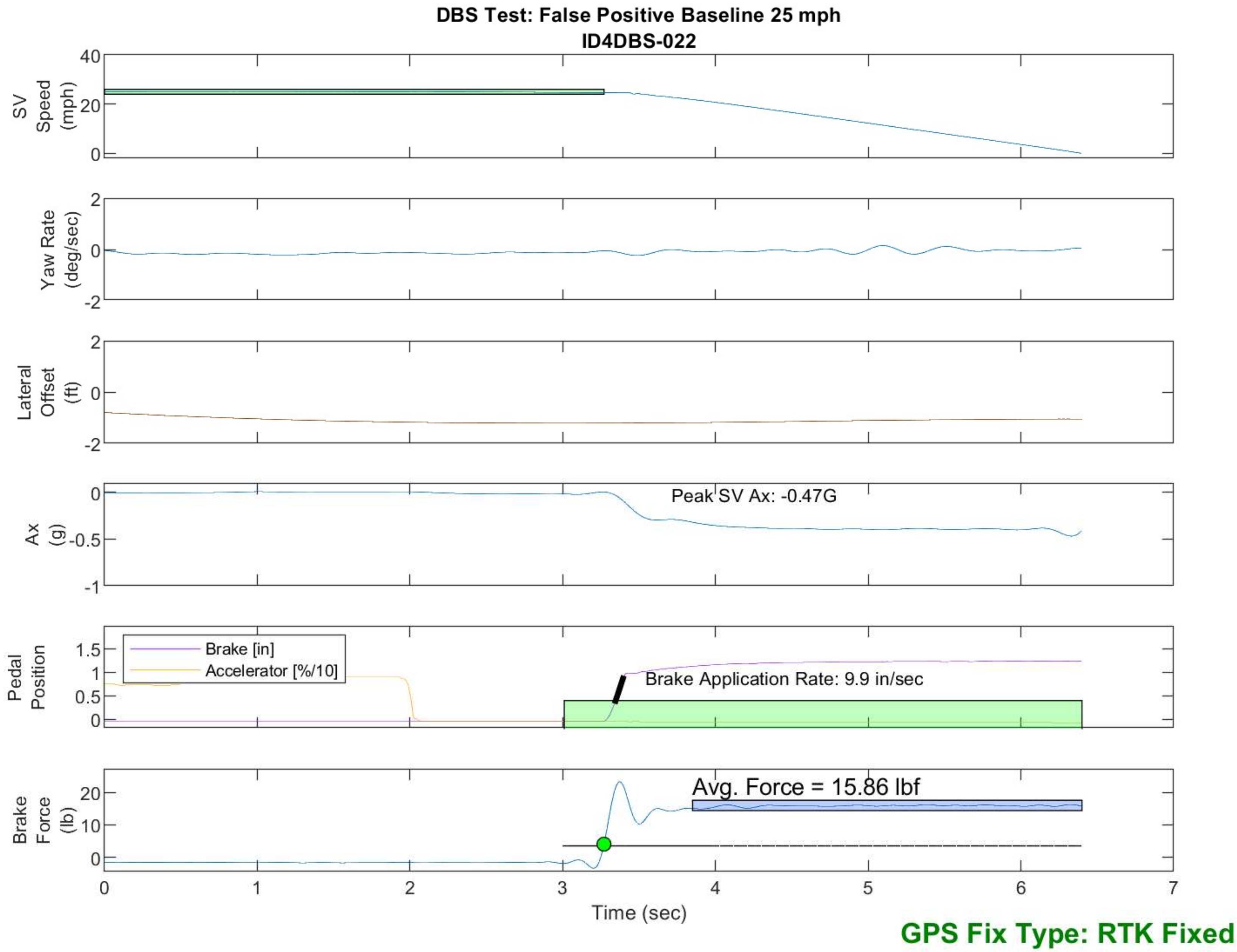

Figure E38. Time History for DBS Run 22, False Positive Baseline, SV 25 mph

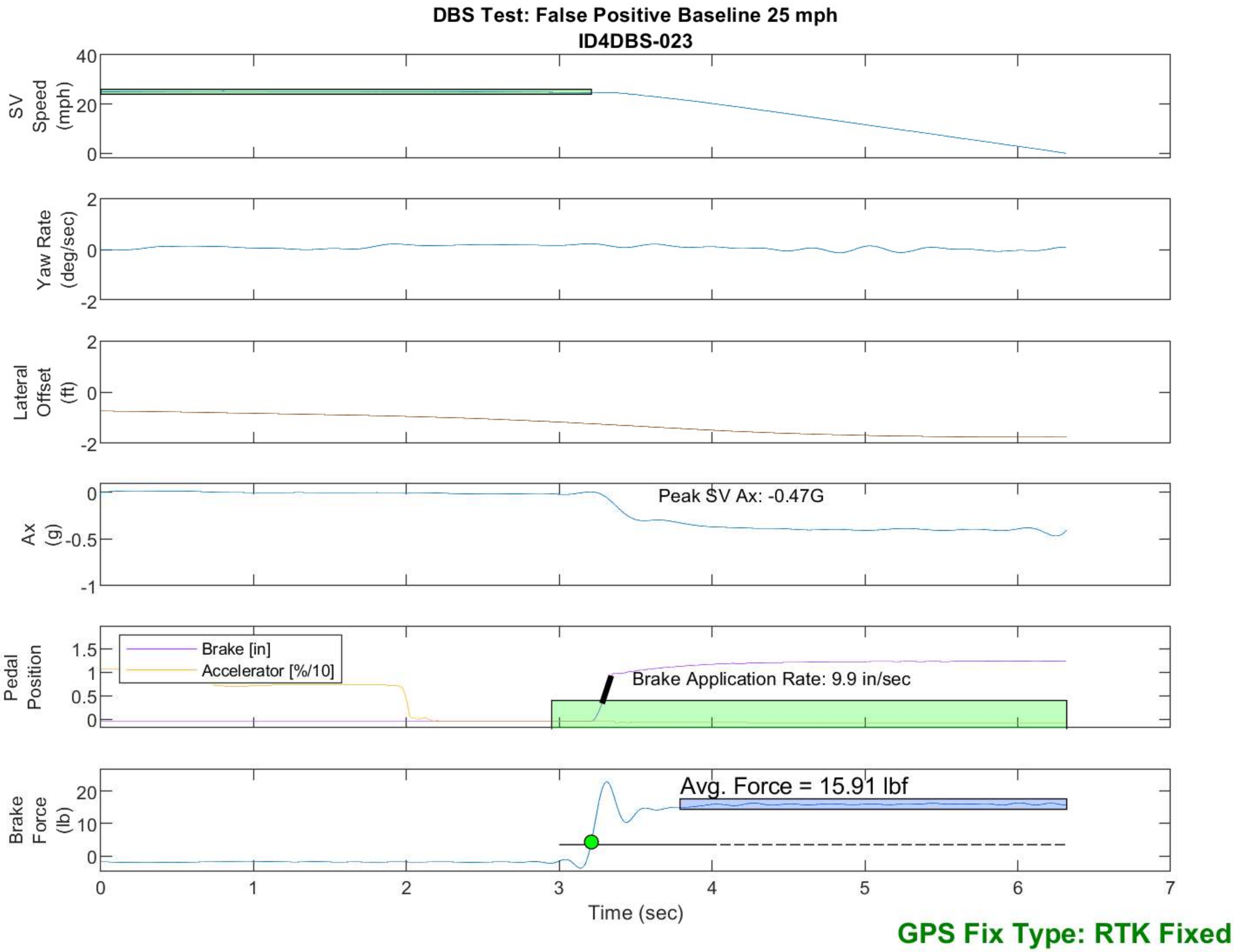

Figure E39. Time History for DBS Run 23, False Positive Baseline, SV 25 mph

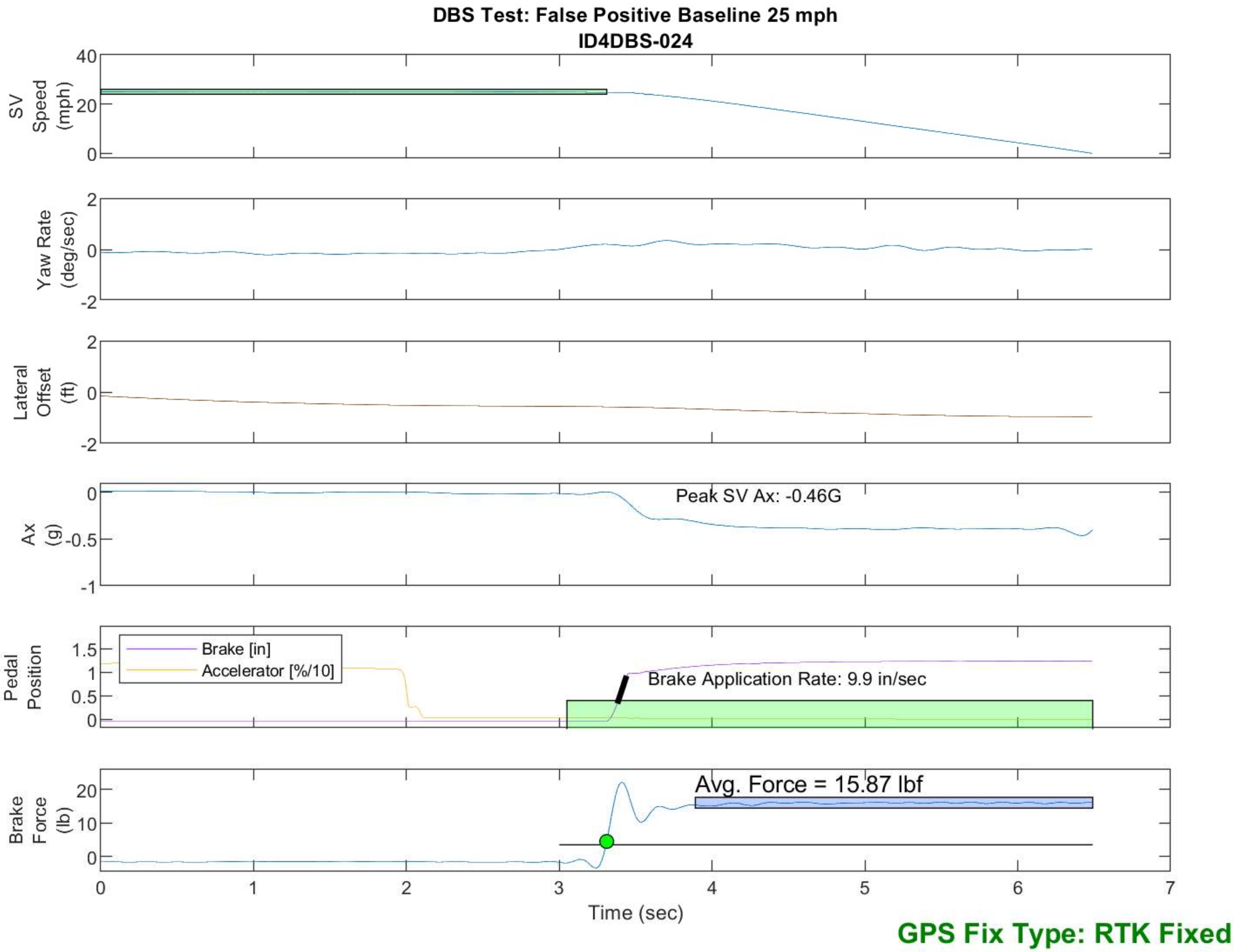

Figure E40. Time History for DBS Run 24, False Positive Baseline, SV 25 mph

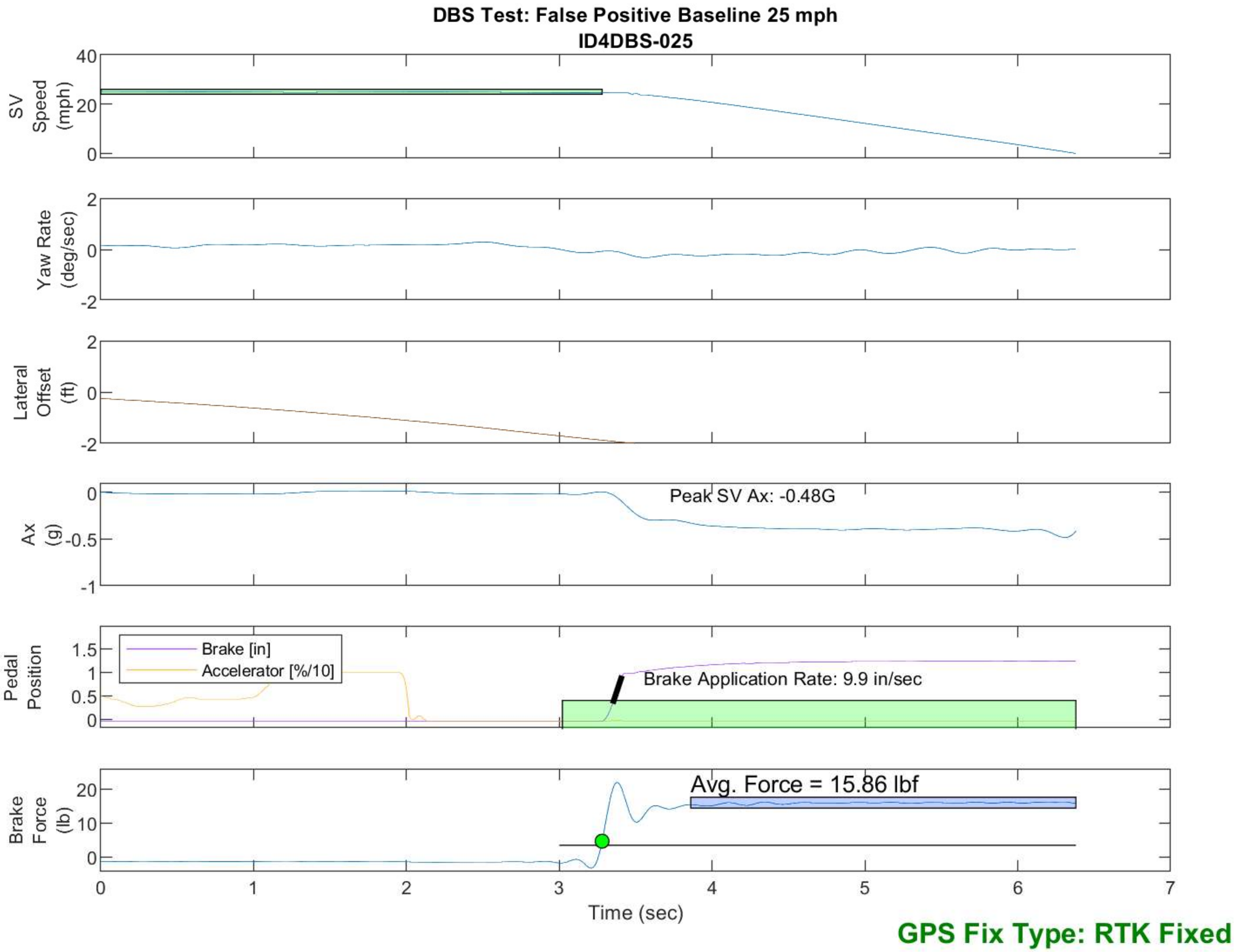

Figure E41. Time History for DBS Run 25, False Positive Baseline, SV 25 mph

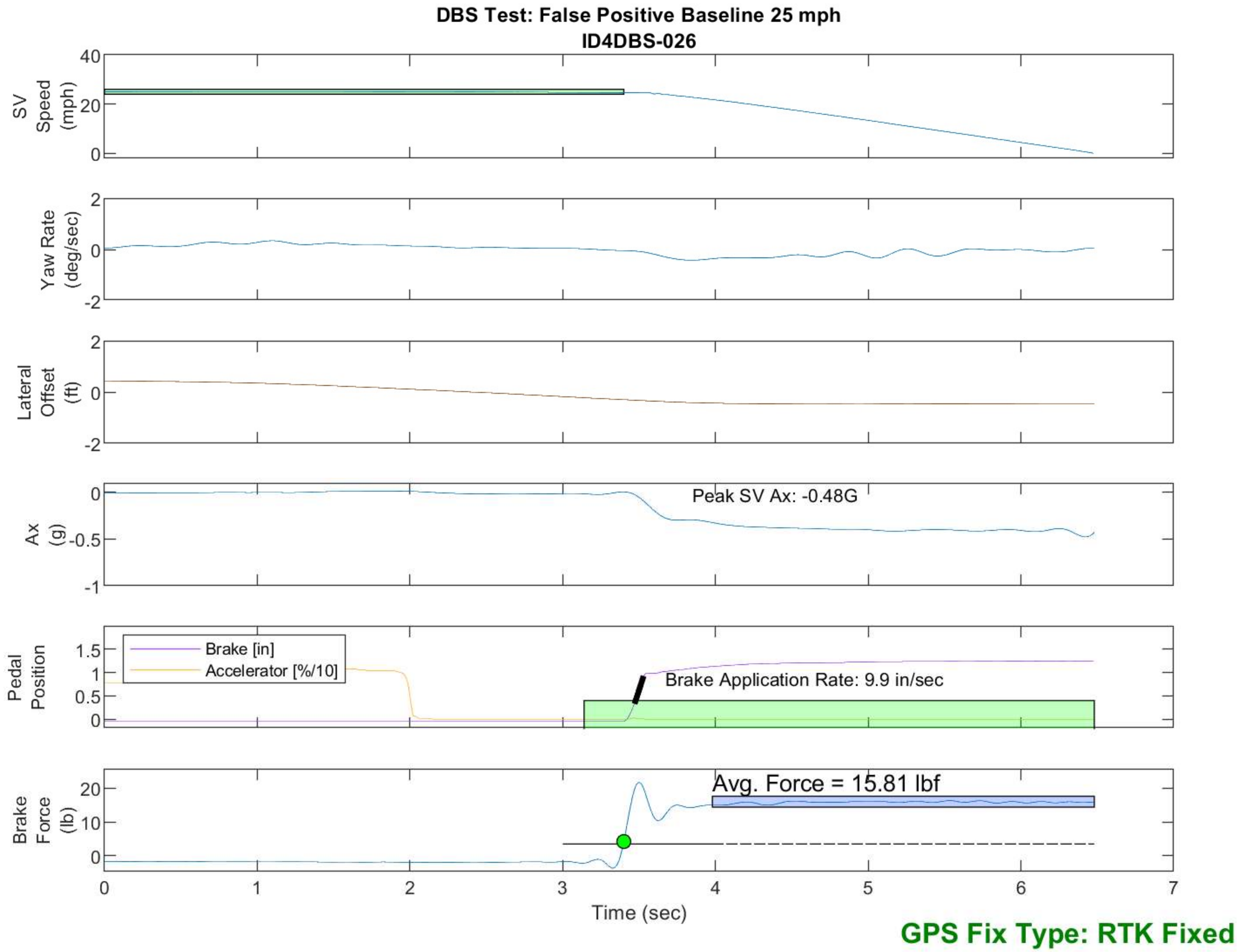

Figure E42. Time History for DBS Run 26, False Positive Baseline, SV 25 mph

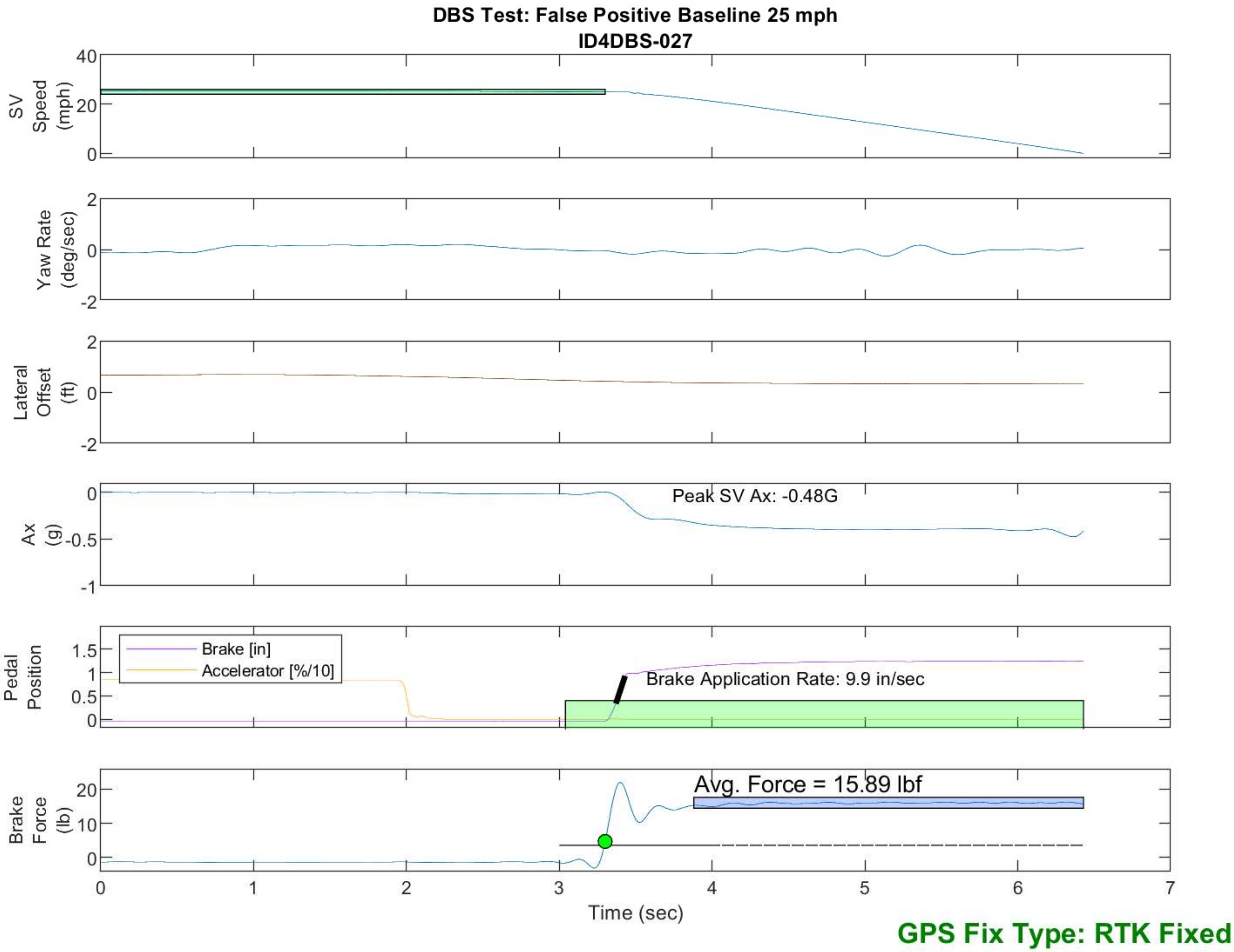

Figure E43. Time History for DBS Run 27, False Positive Baseline, SV 25 mph

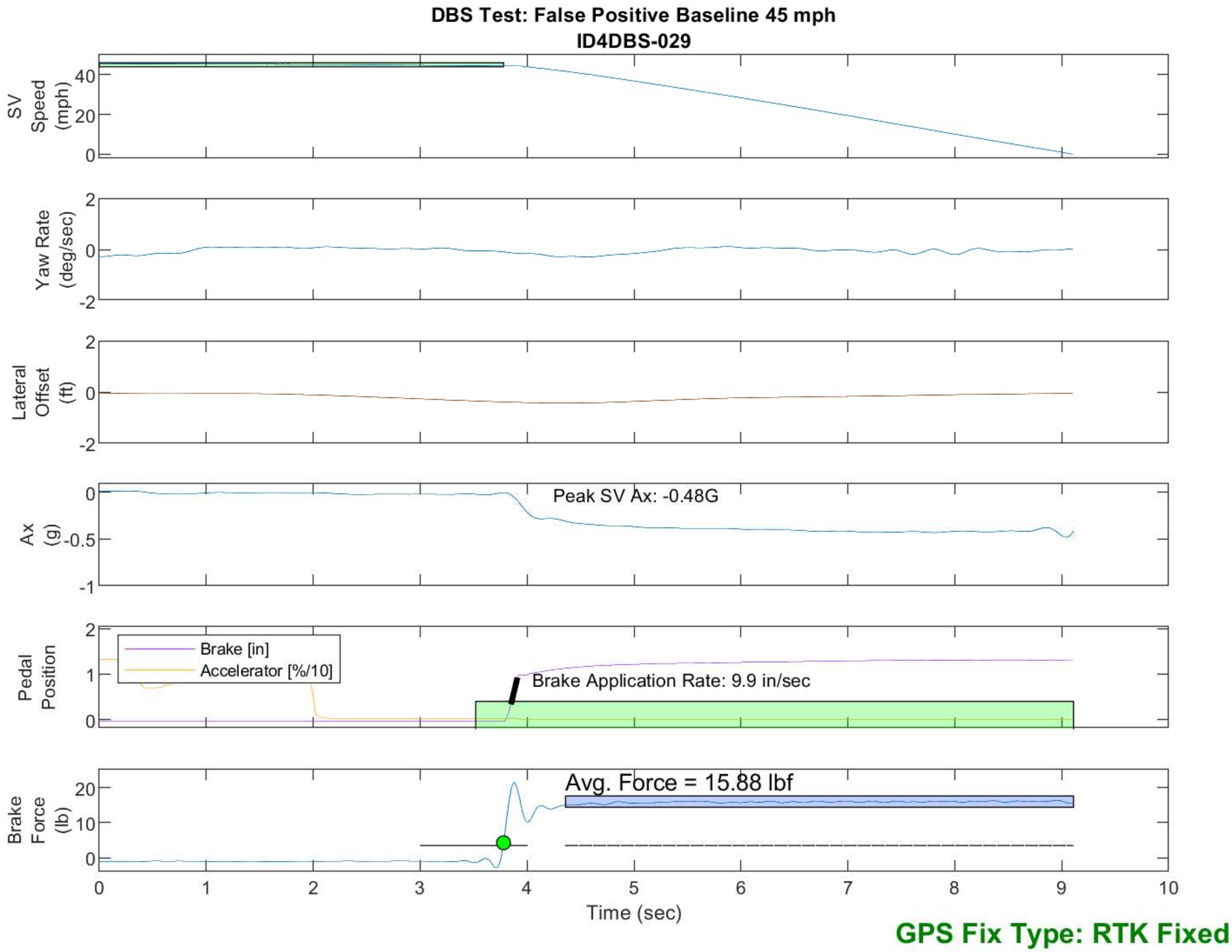

Figure E44. Time History for DBS Run 29, False Positive Baseline, SV 45 mph

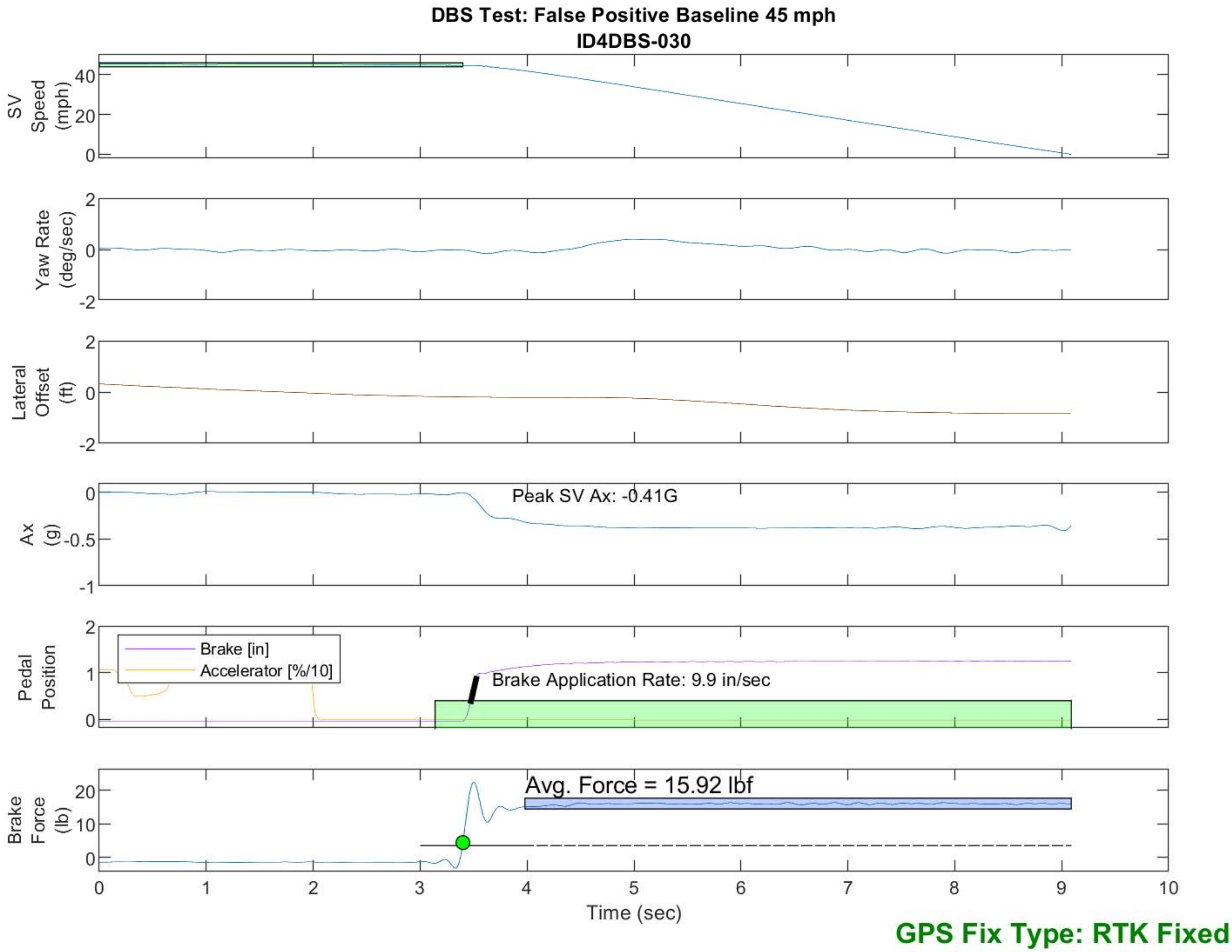

Figure E45. Time History for DBS Run 30, False Positive Baseline, SV 45 mph

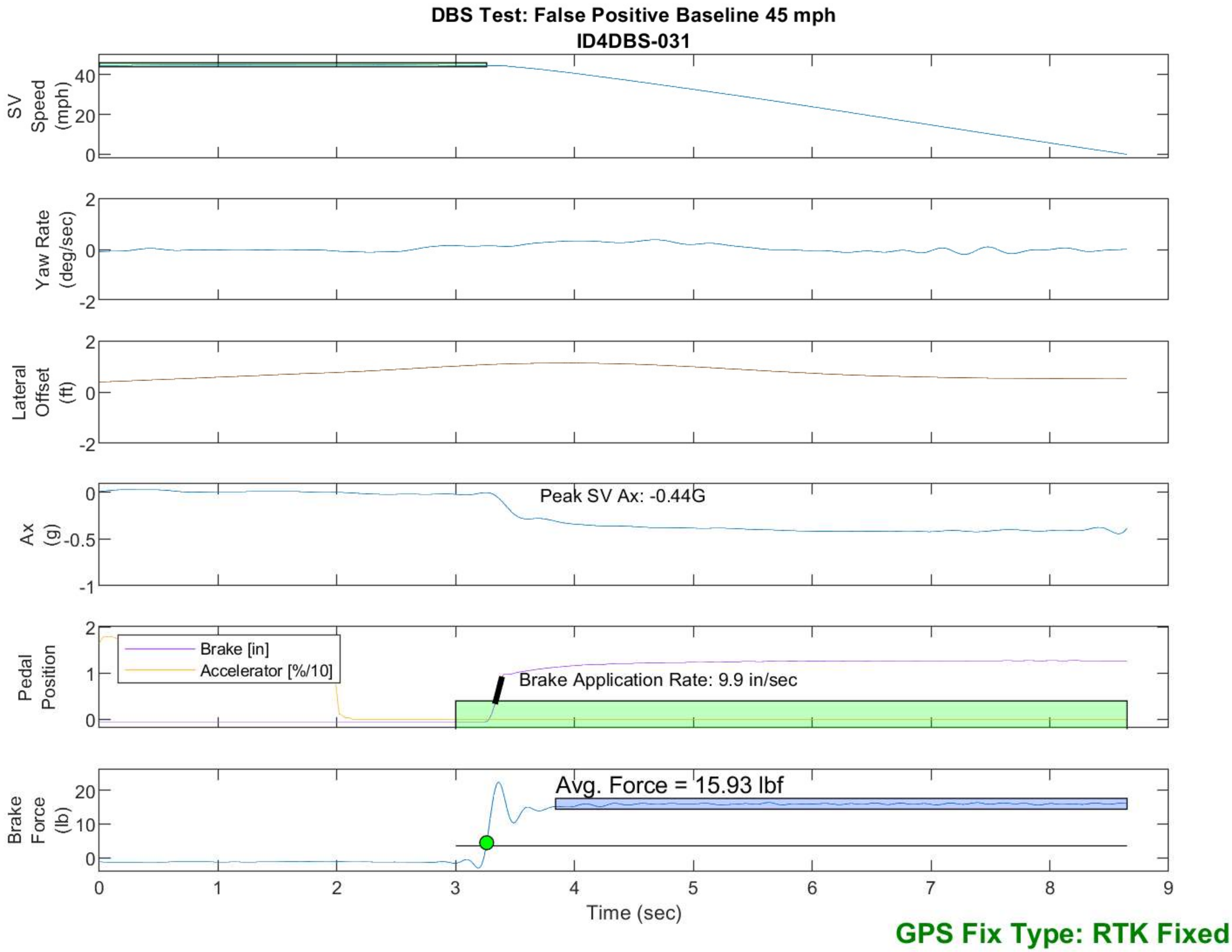

Figure E46. Time History for DBS Run 31, False Positive Baseline, SV 45 mph

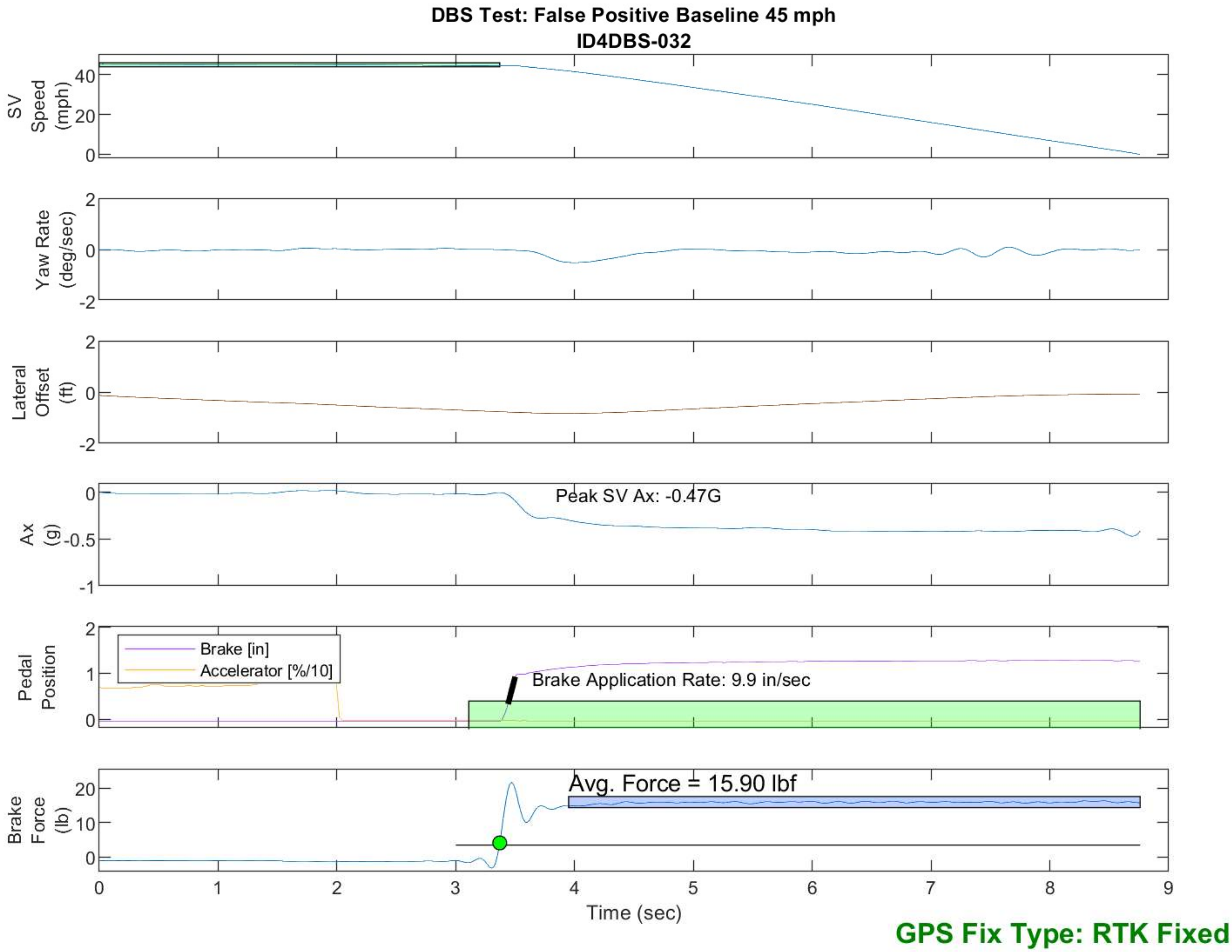

Figure E47. Time History for DBS Run 32, False Positive Baseline, SV 45 mph

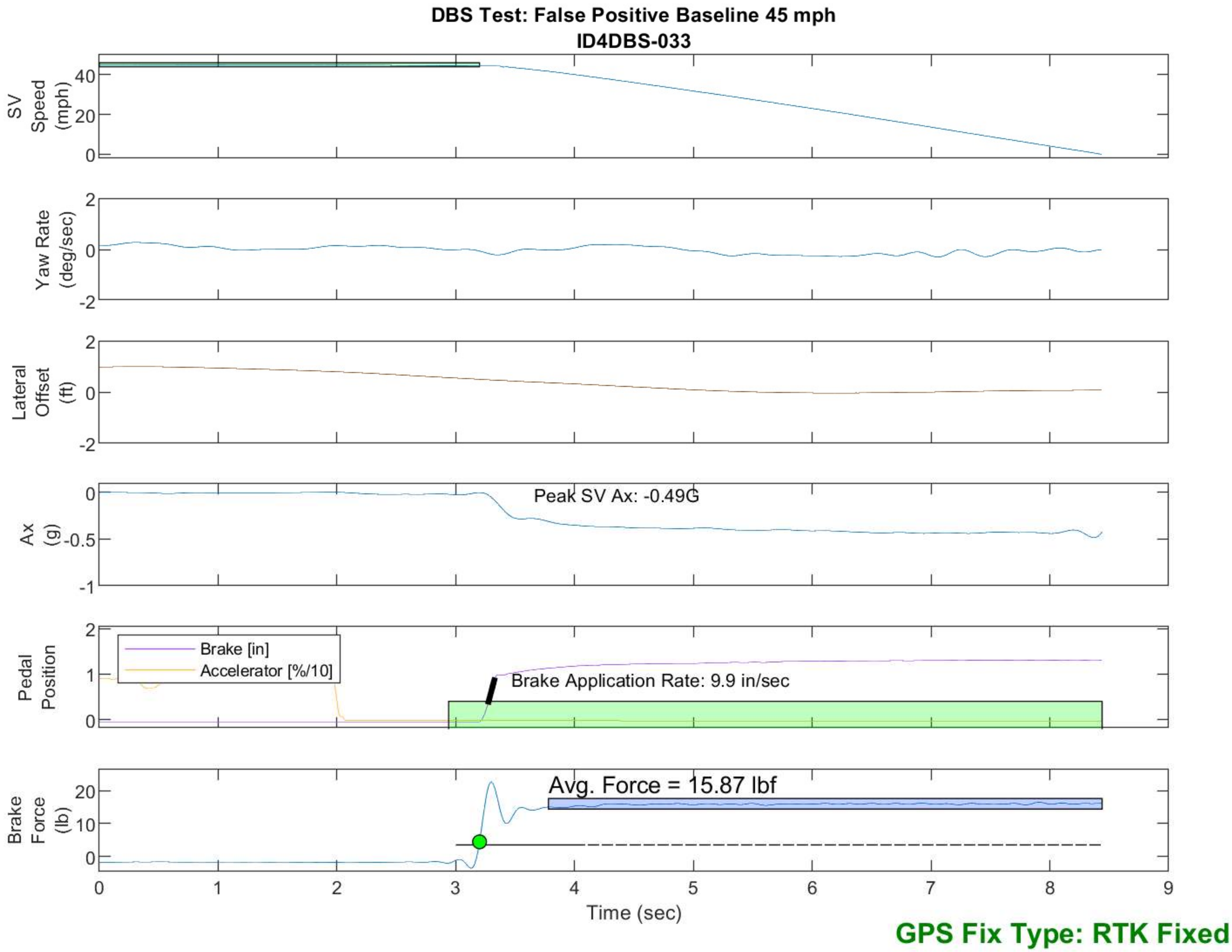

Figure E48. Time History for DBS Run 33, False Positive Baseline, SV 45 mph

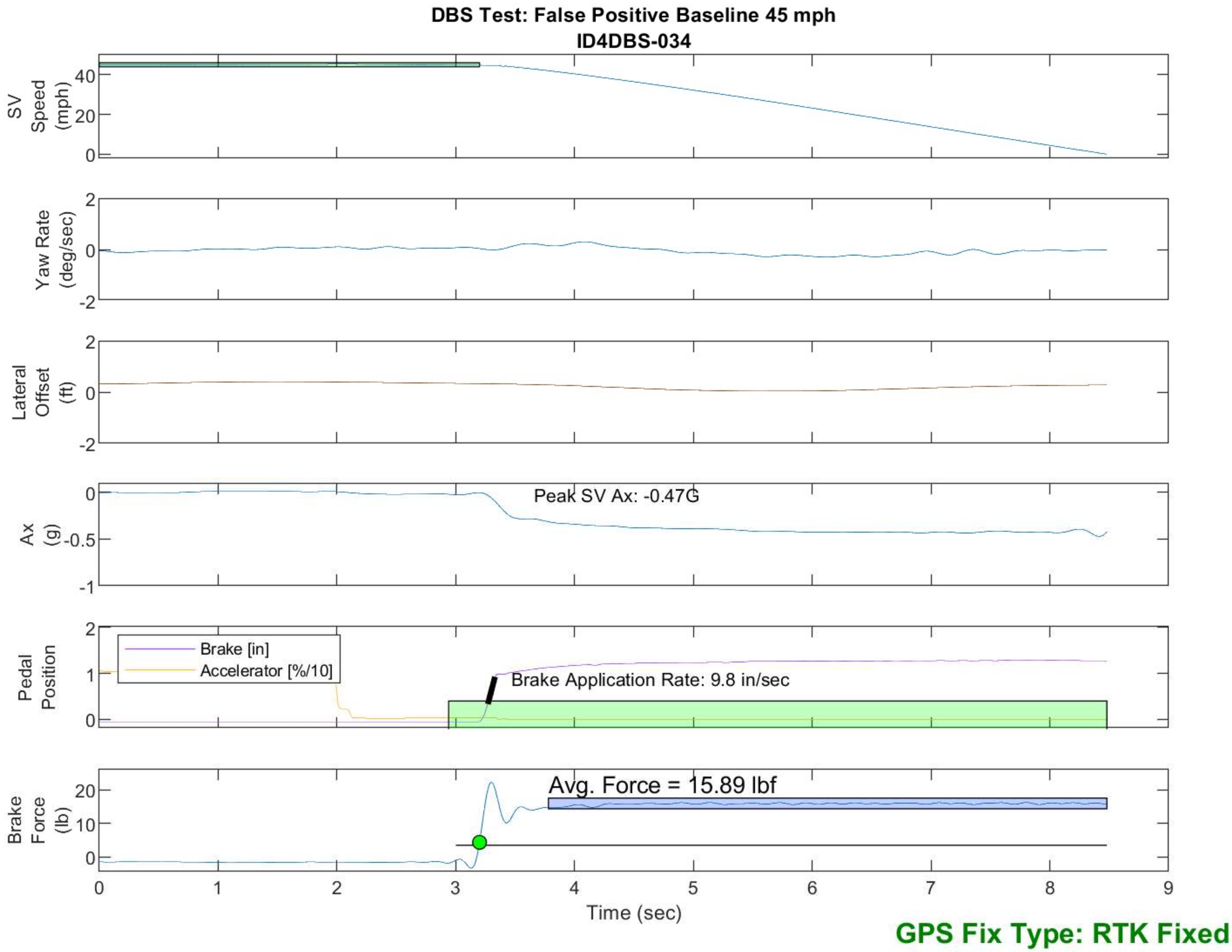

Figure E49. Time History for DBS Run 34, False Positive Baseline, SV 45 mph

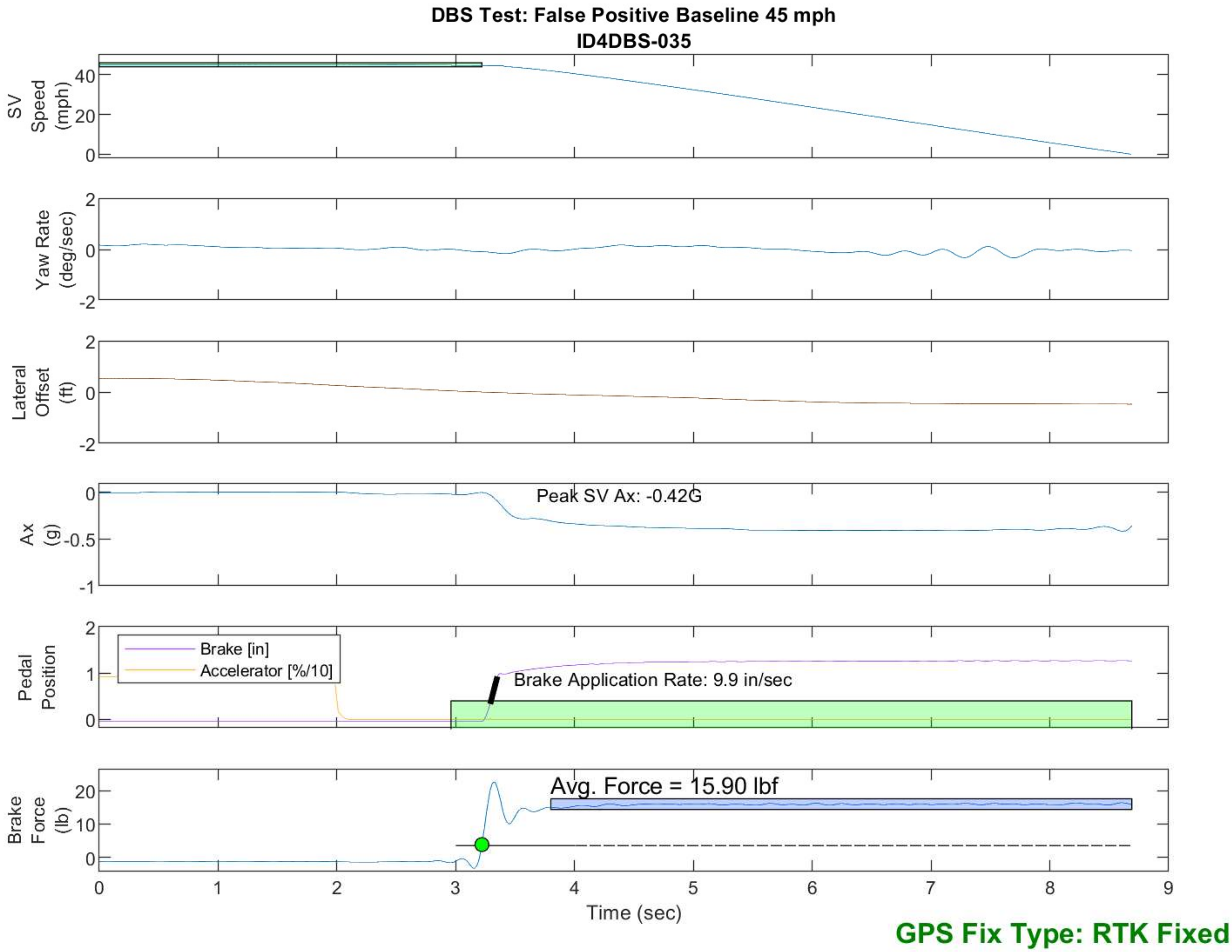

Figure E50. Time History for DBS Run 35, False Positive Baseline, SV 45 mph

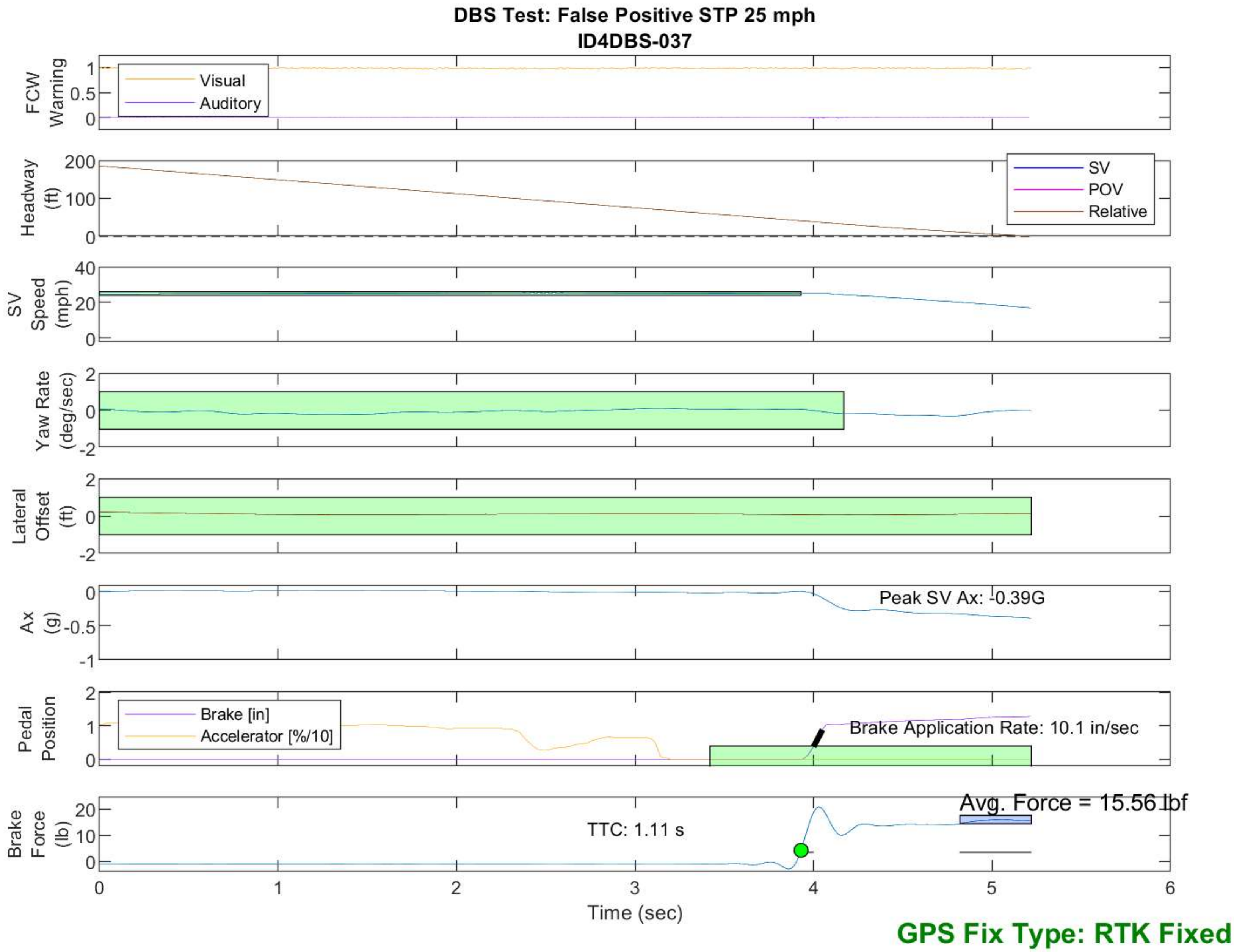

Figure E51. Time History for DBS Run 37, SV Encounters Steel Trench Plate, SV 25 mph

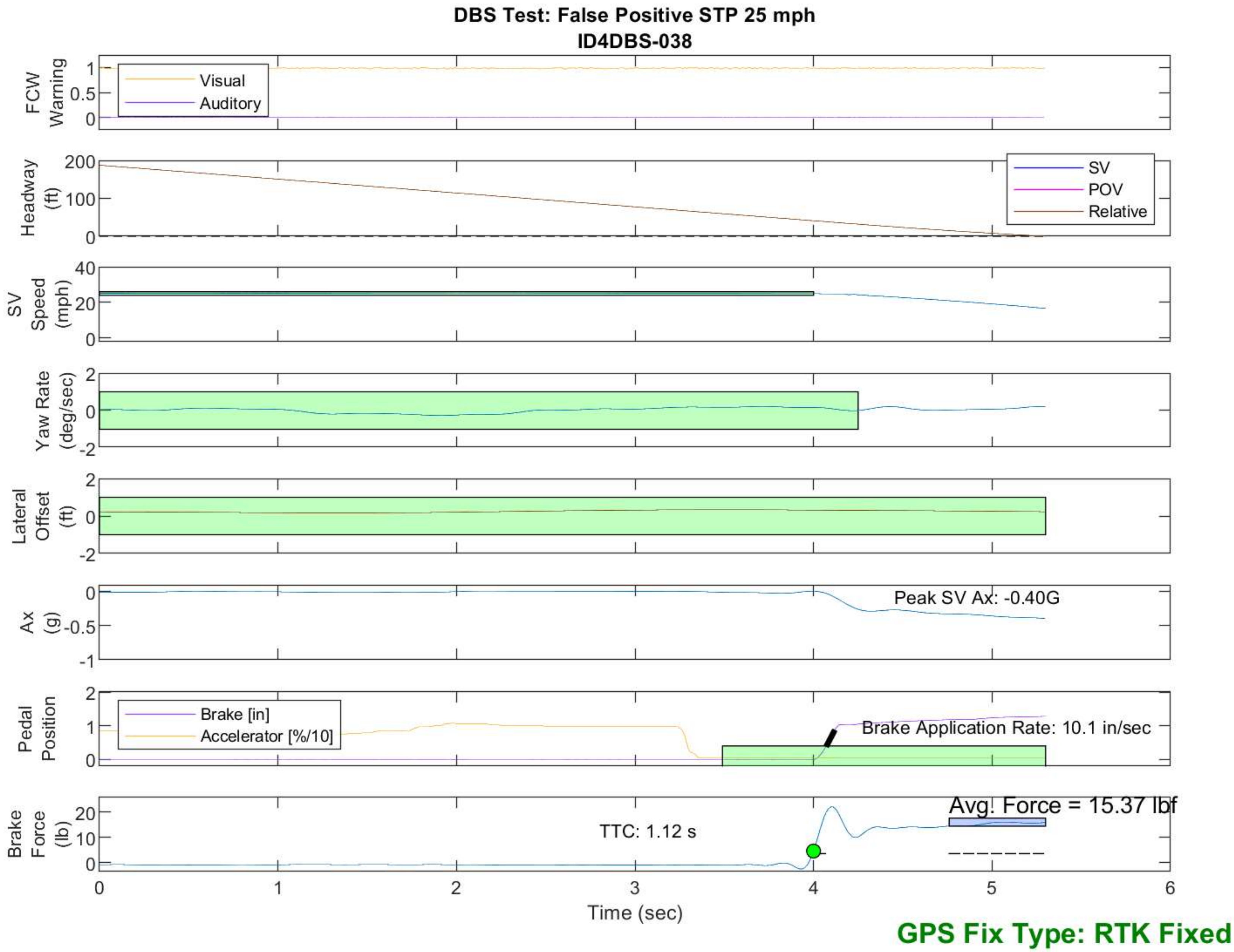

Figure E52. Time History for DBS Run 38, SV Encounters Steel Trench Plate, SV 25 mph

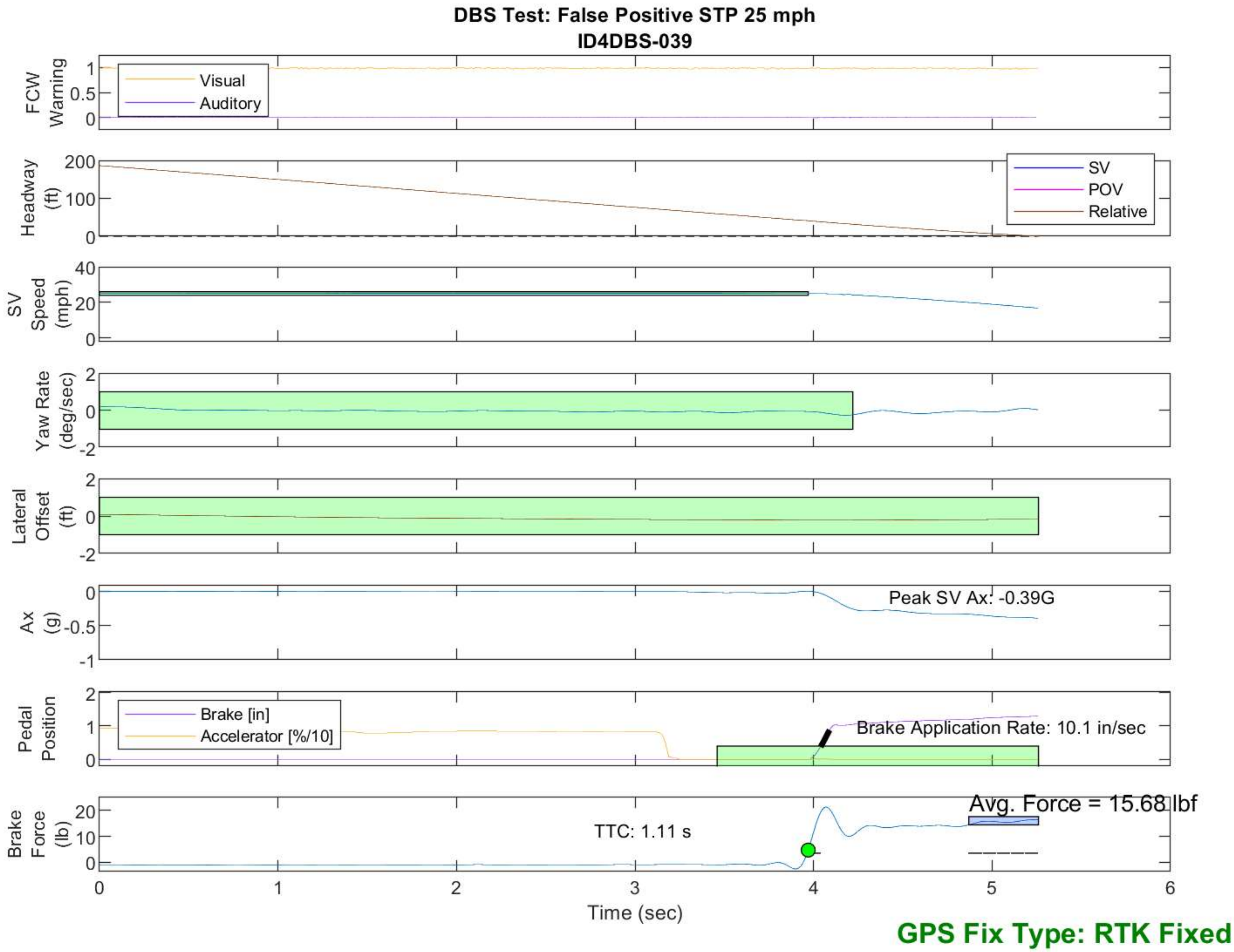

Figure E53. Time History for DBS Run 39, SV Encounters Steel Trench Plate, SV 25 mph

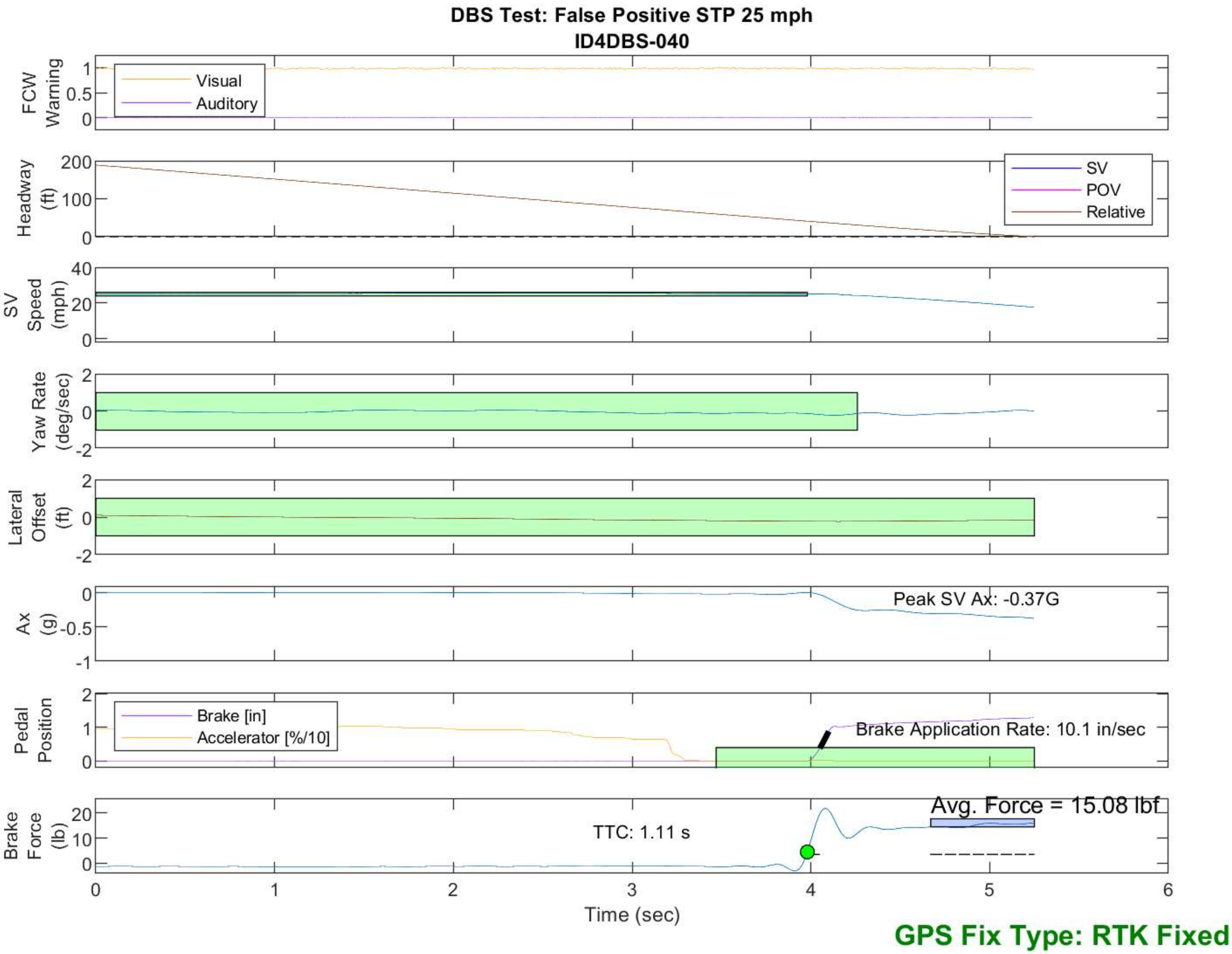

Figure E54. Time History for DBS Run 40, SV Encounters Steel Trench Plate, SV 25 mph

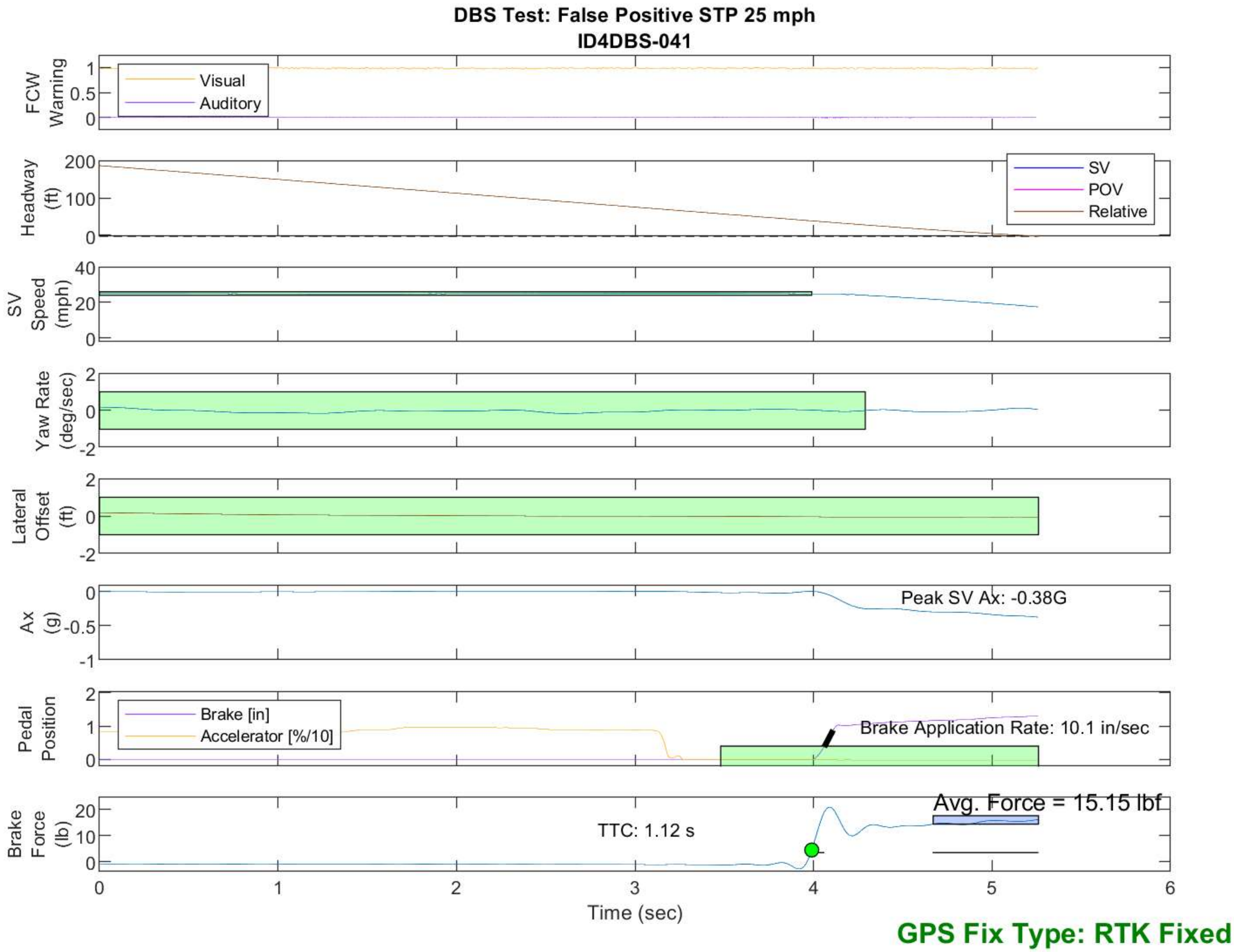

Figure E55. Time History for DBS Run 41, SV Encounters Steel Trench Plate, SV 25 mph

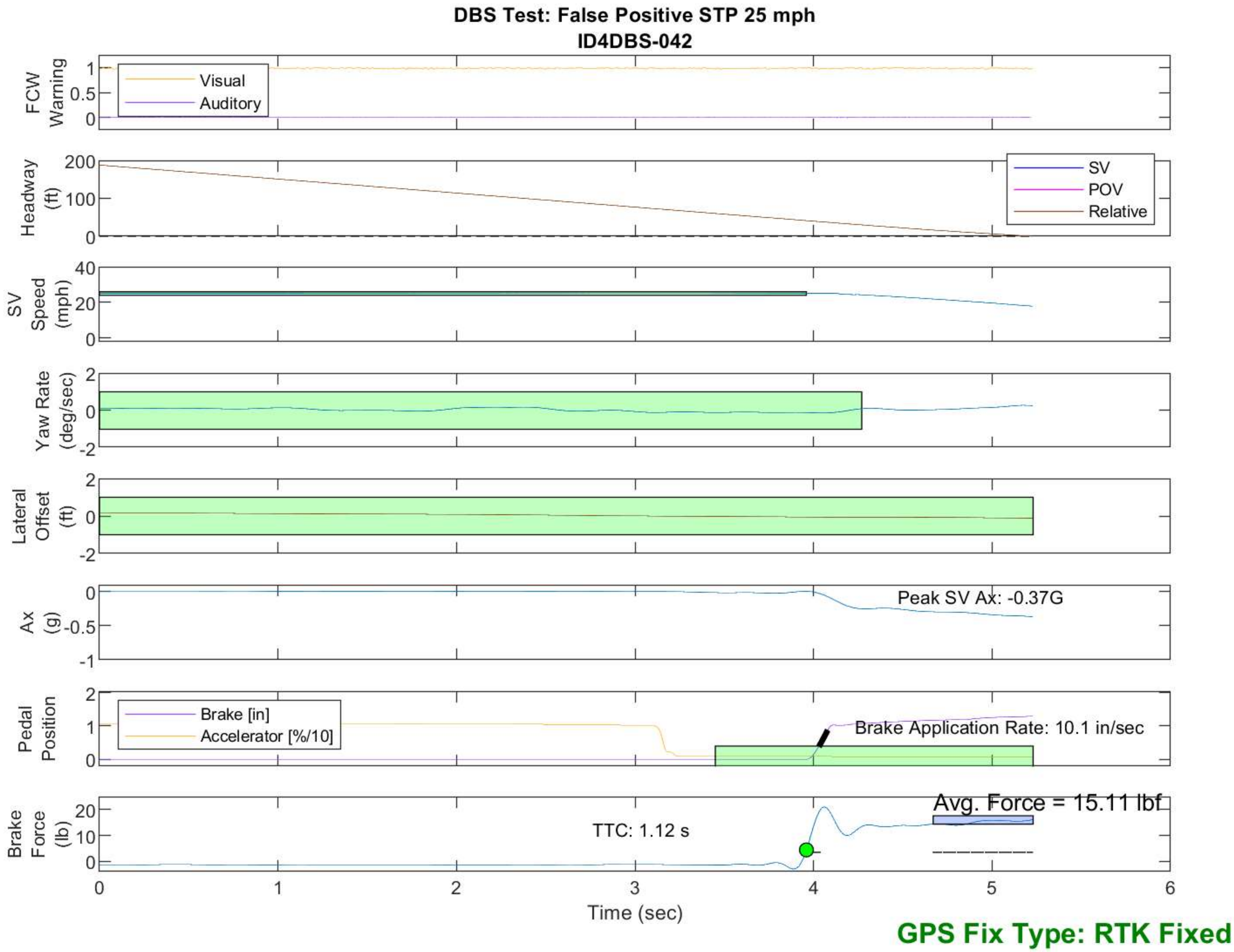

Figure E56. Time History for DBS Run 42, SV Encounters Steel Trench Plate, SV 25 mph

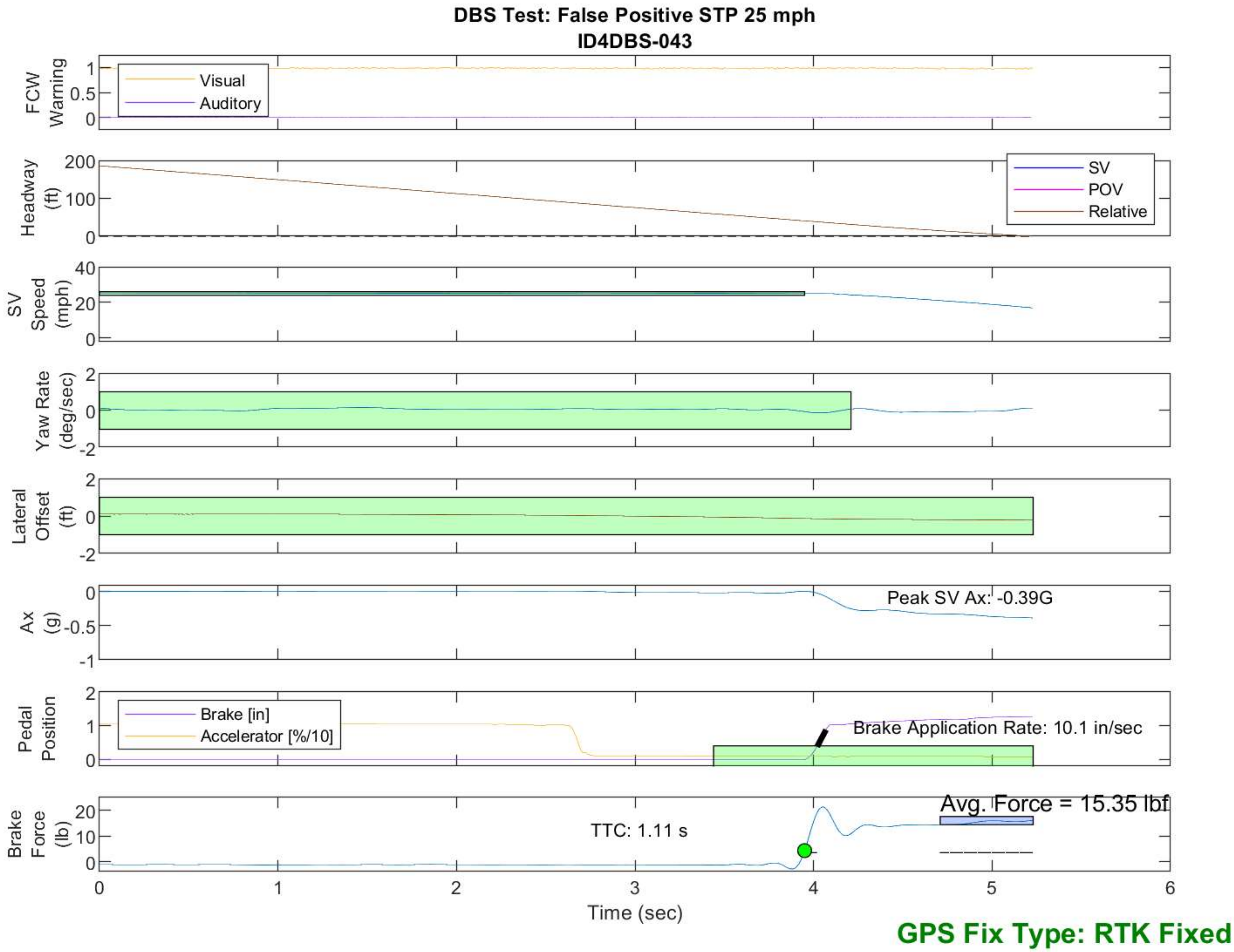

Figure E57. Time History for DBS Run 43, SV Encounters Steel Trench Plate, SV 25 mph

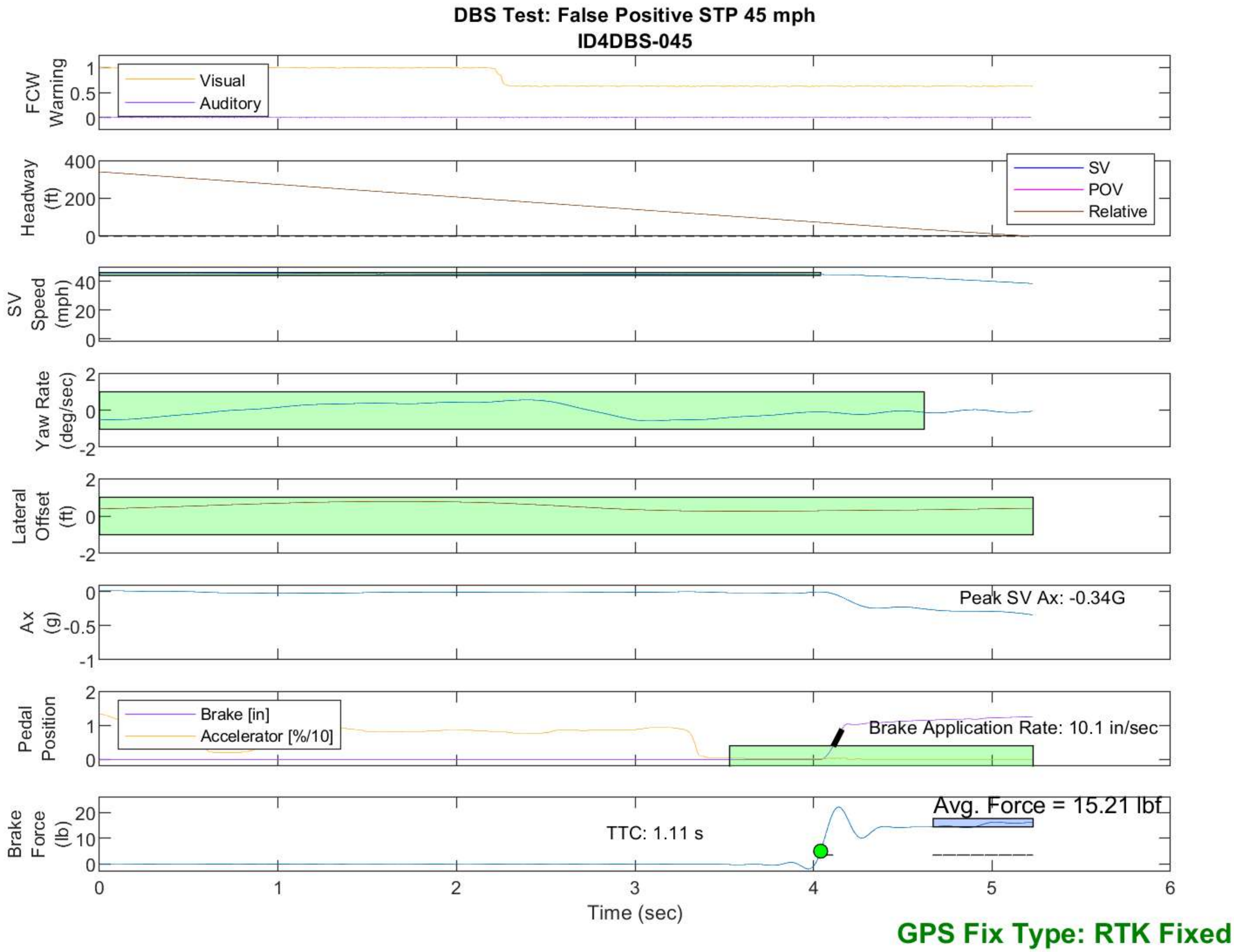

Figure E58. Time History for DBS Run 45, SV Encounters Steel Trench Plate, SV 45 mph

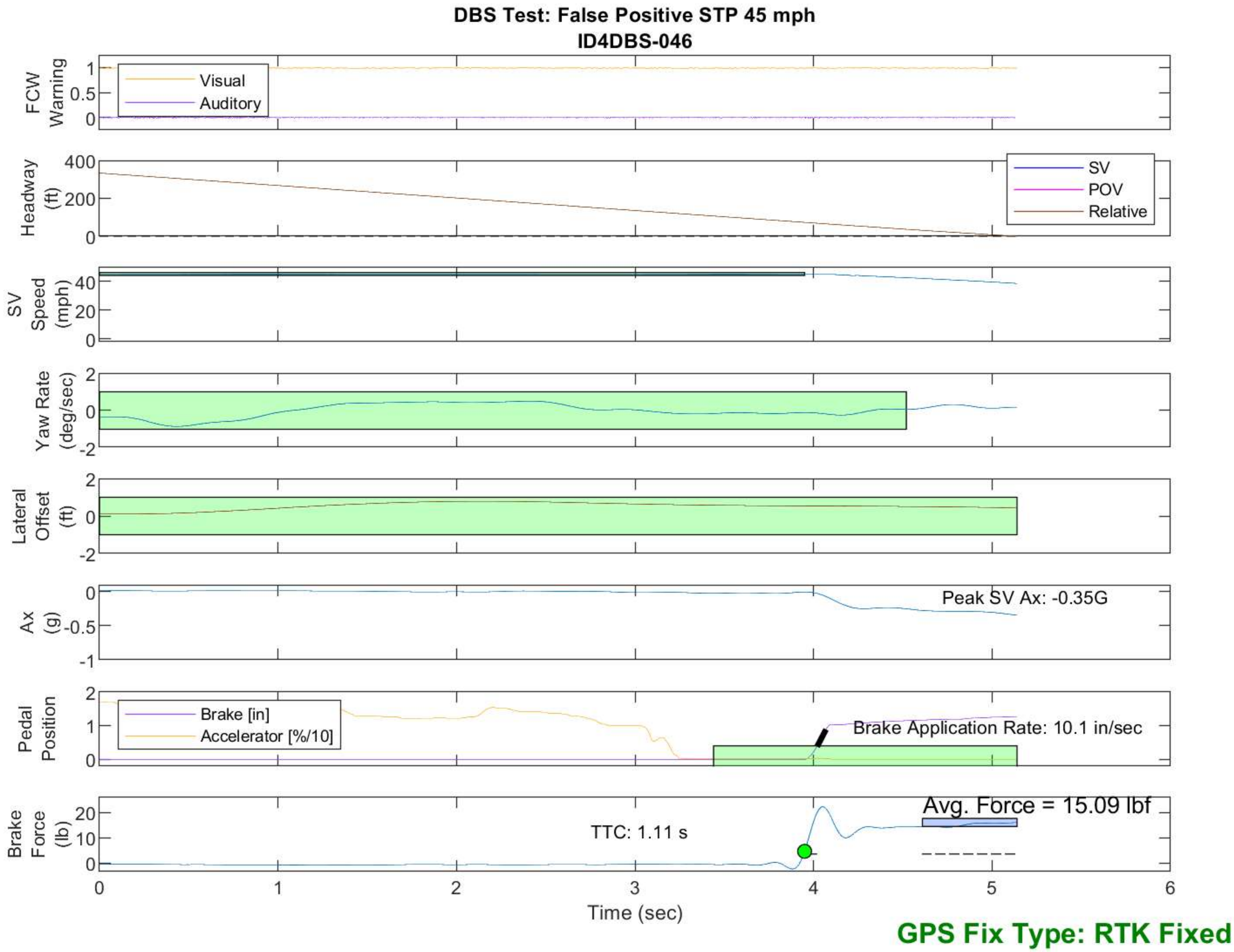

Figure E59. Time History for DBS Run 46, SV Encounters Steel Trench Plate, SV 45 mph

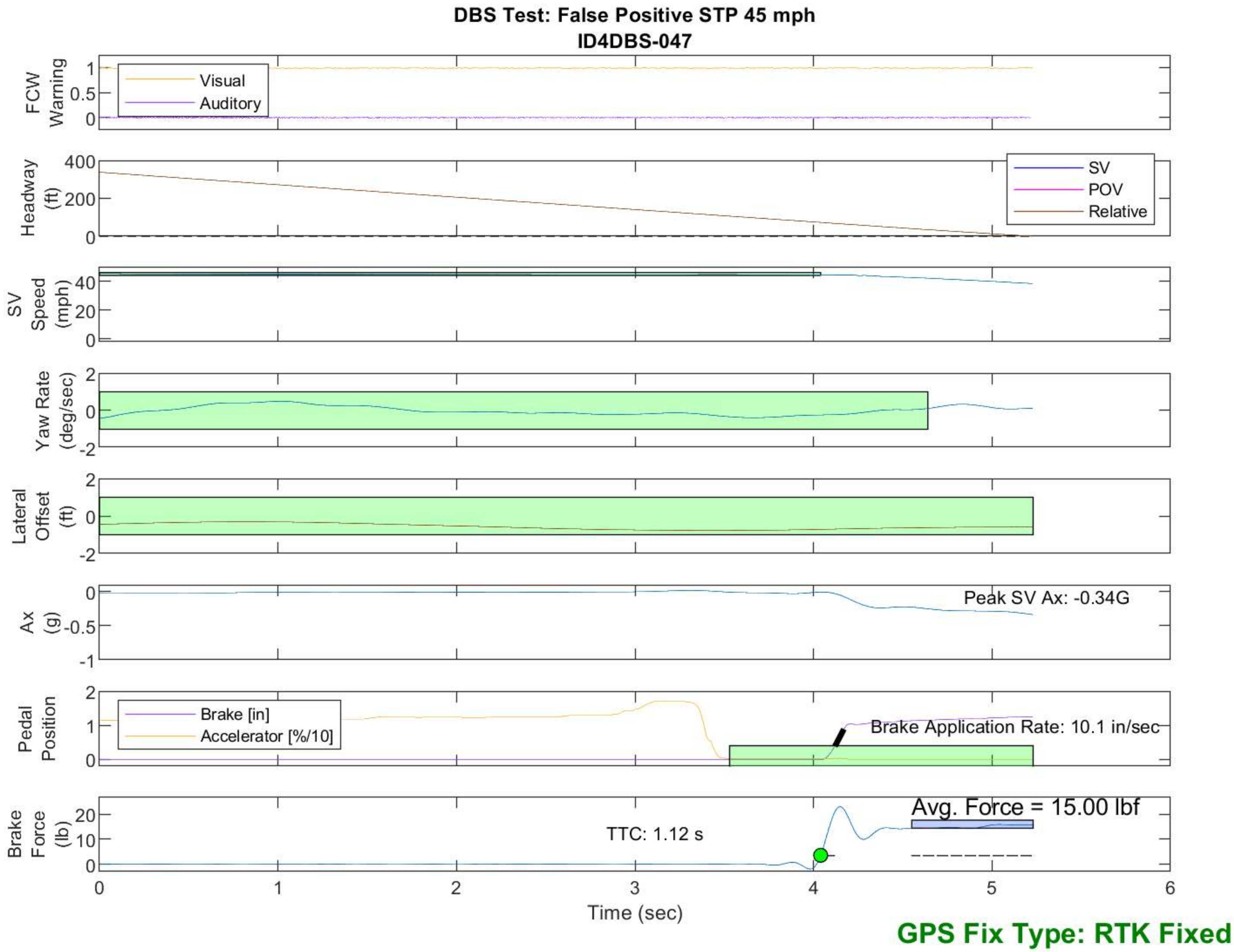

Figure E60. Time History for DBS Run 47, SV Encounters Steel Trench Plate, SV 45 mph

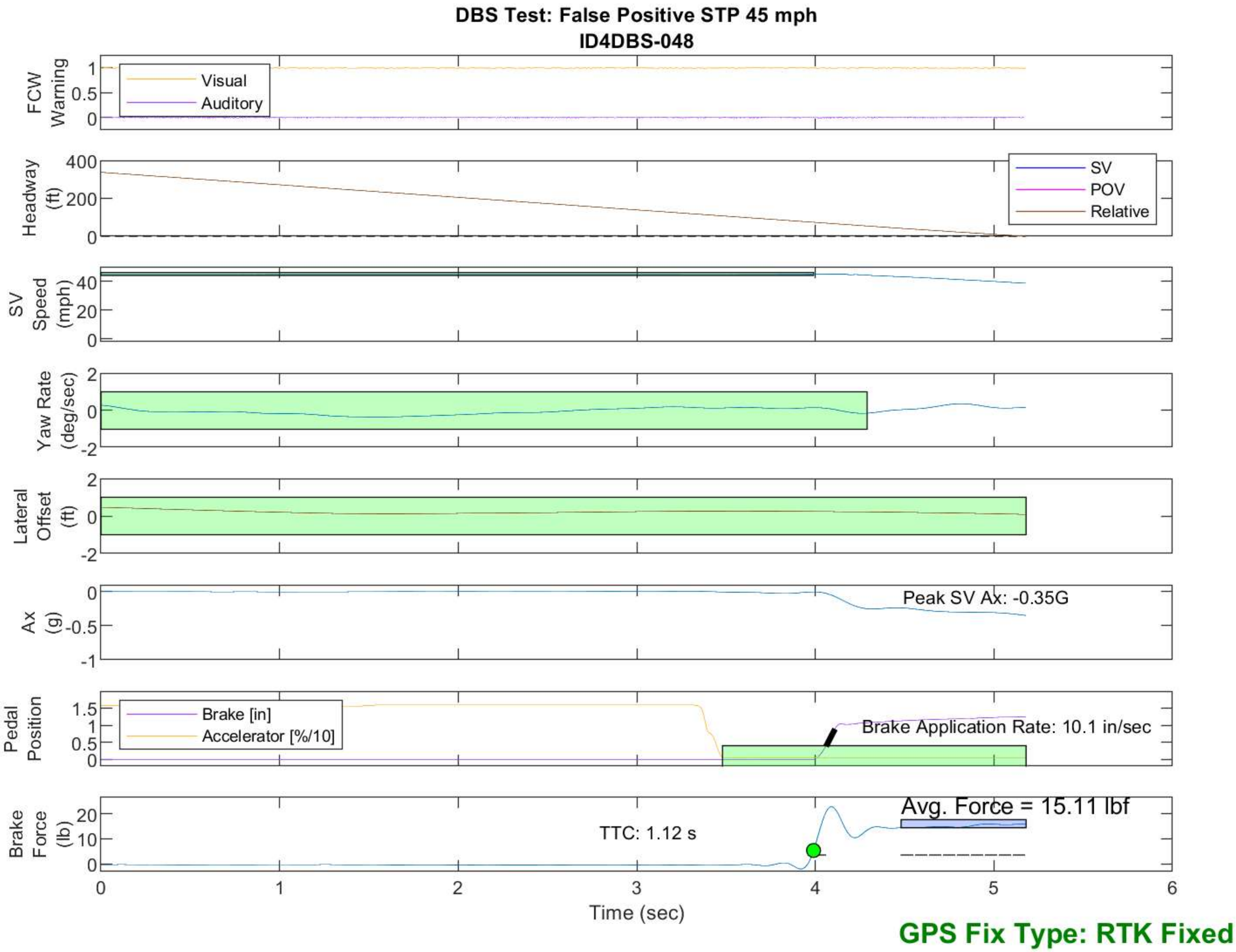

Figure E61. Time History for DBS Run 48, SV Encounters Steel Trench Plate, SV 45 mph

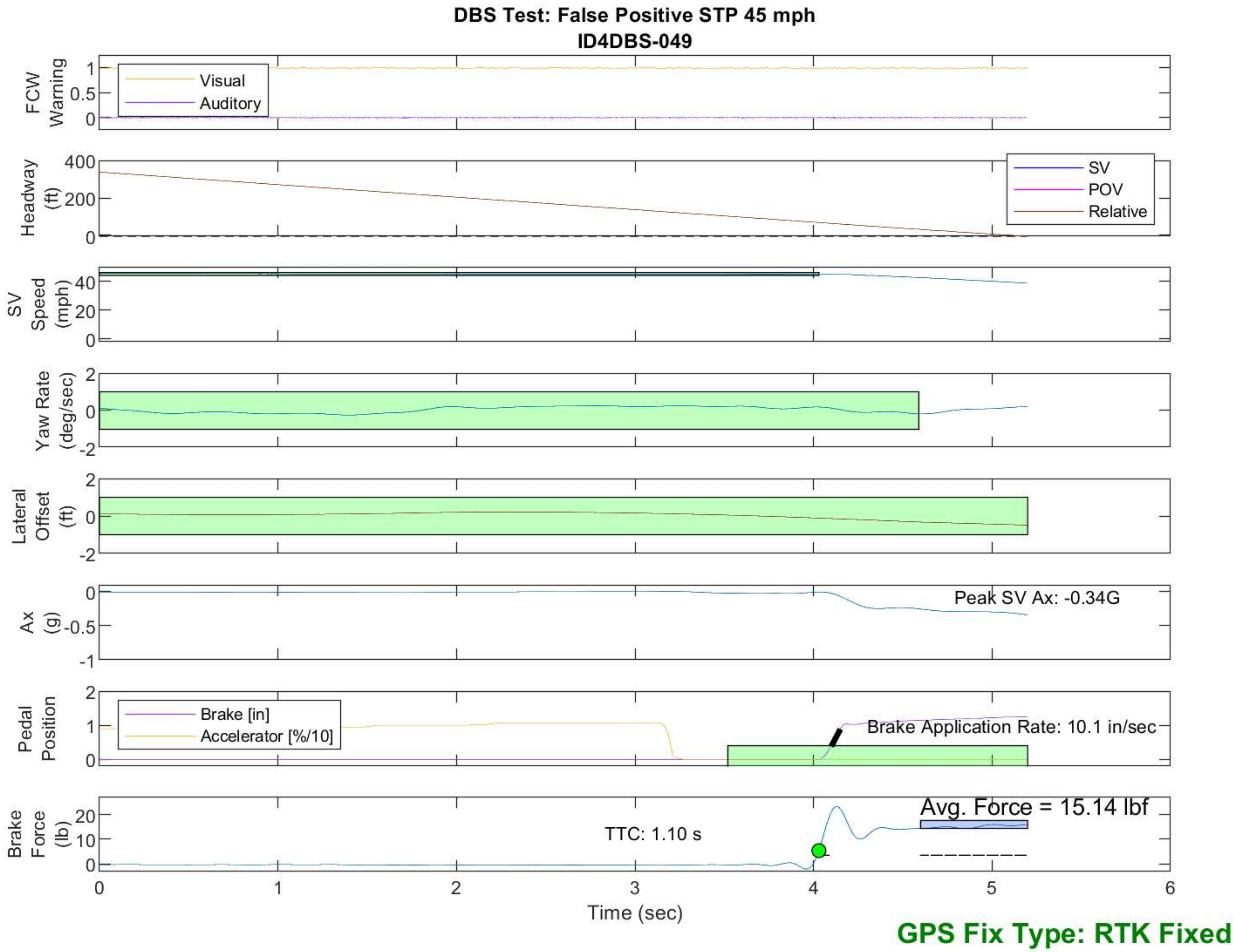

Figure E62. Time History for DBS Run 49, SV Encounters Steel Trench Plate, SV 45 mph

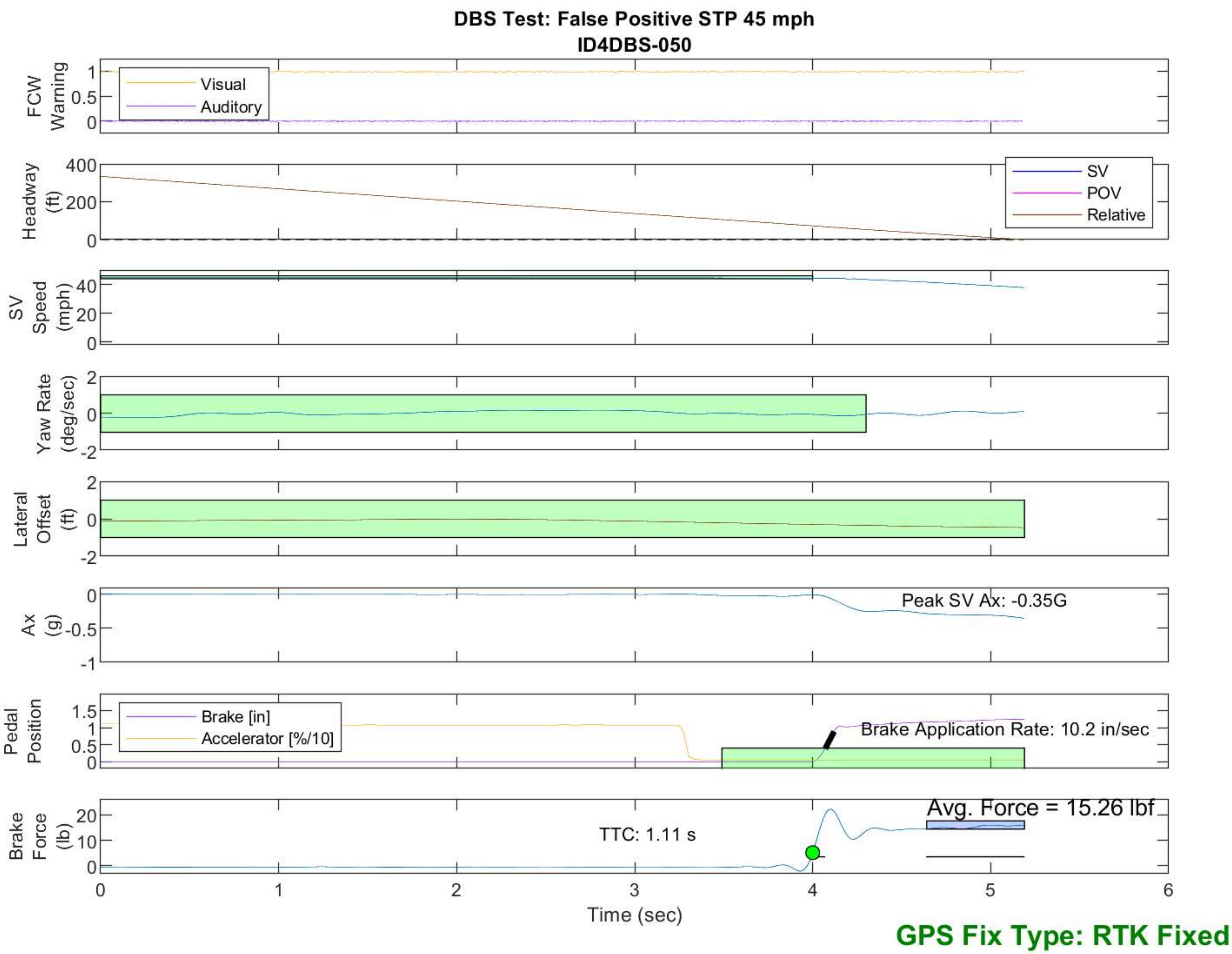

Figure E63. Time History for DBS Run 50, SV Encounters Steel Trench Plate, SV 45 mph

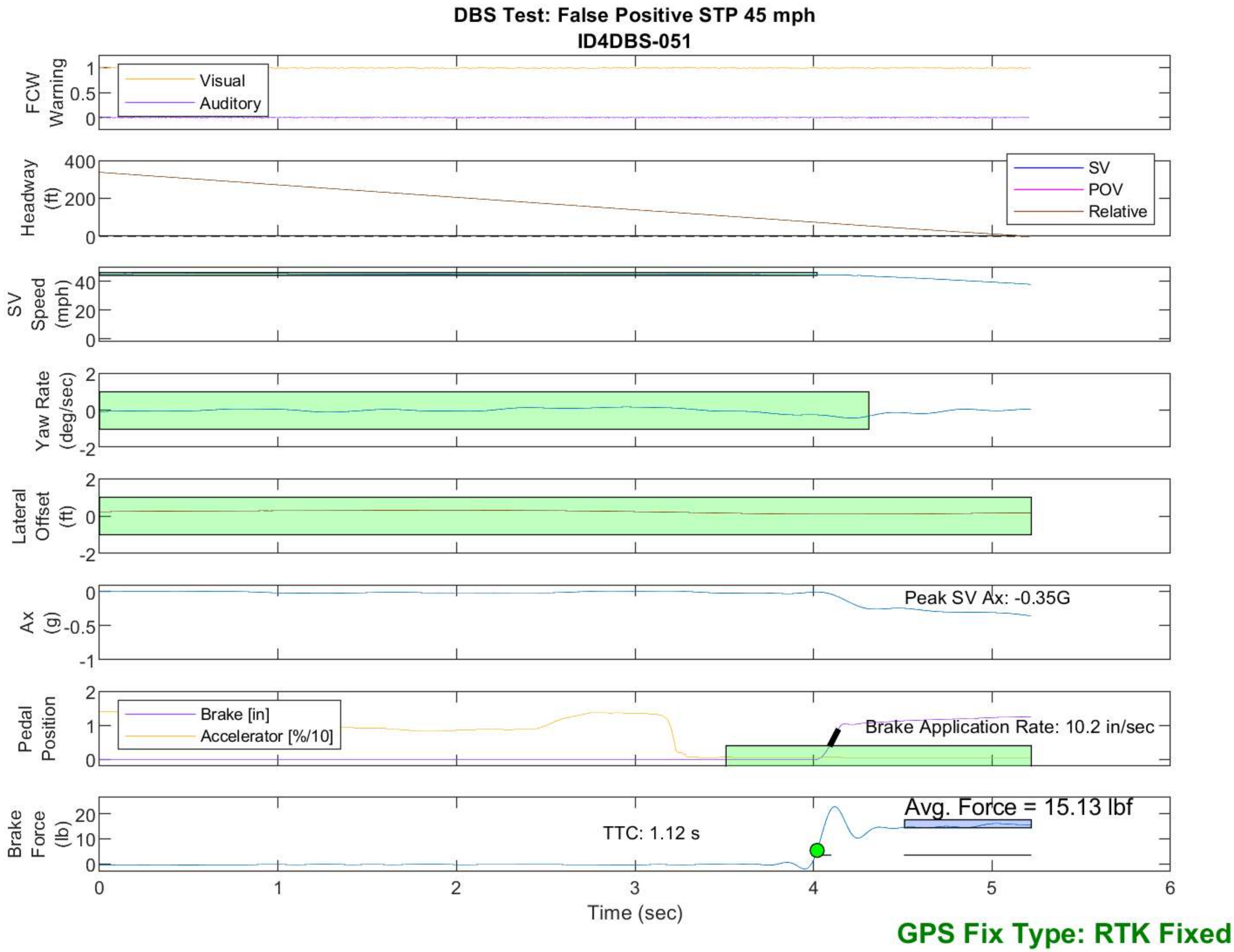

Figure E64. Time History for DBS Run 51, SV Encounters Steel Trench Plate, SV 45 mph

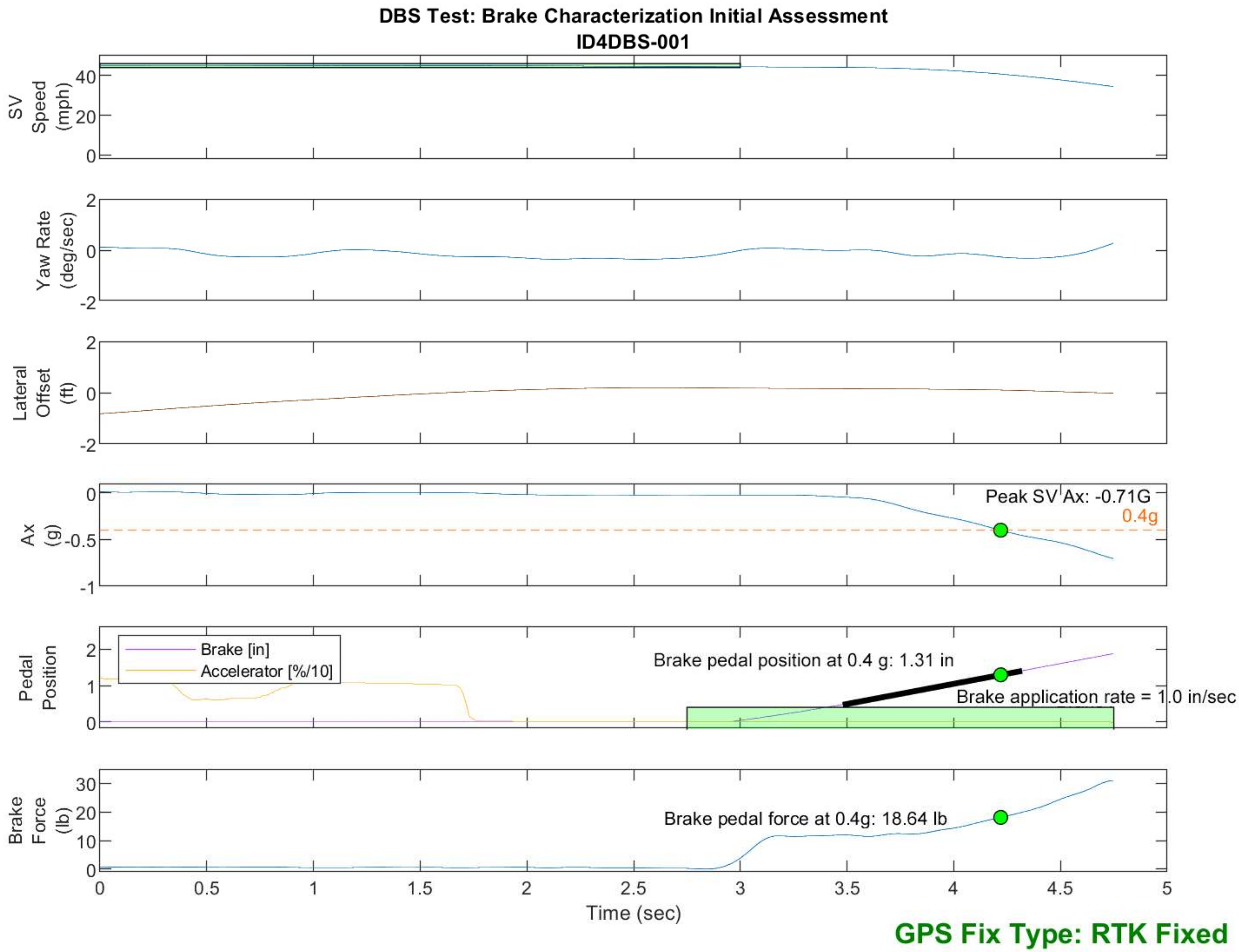

Figure E65. Time History for DBS Run 1, Brake Characterization Initial

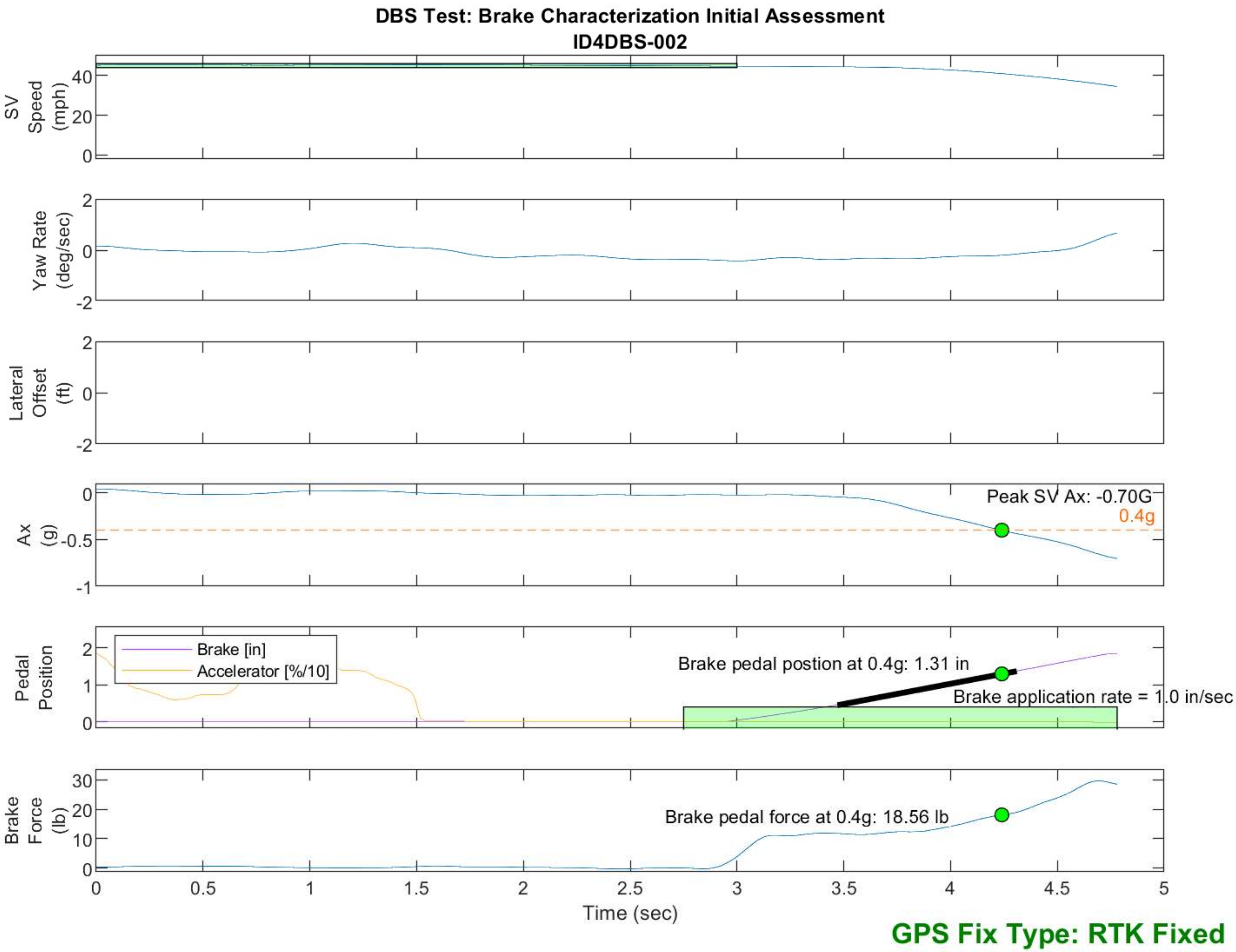

Figure E66. Time History for DBS Run 2, Brake Characterization Initial

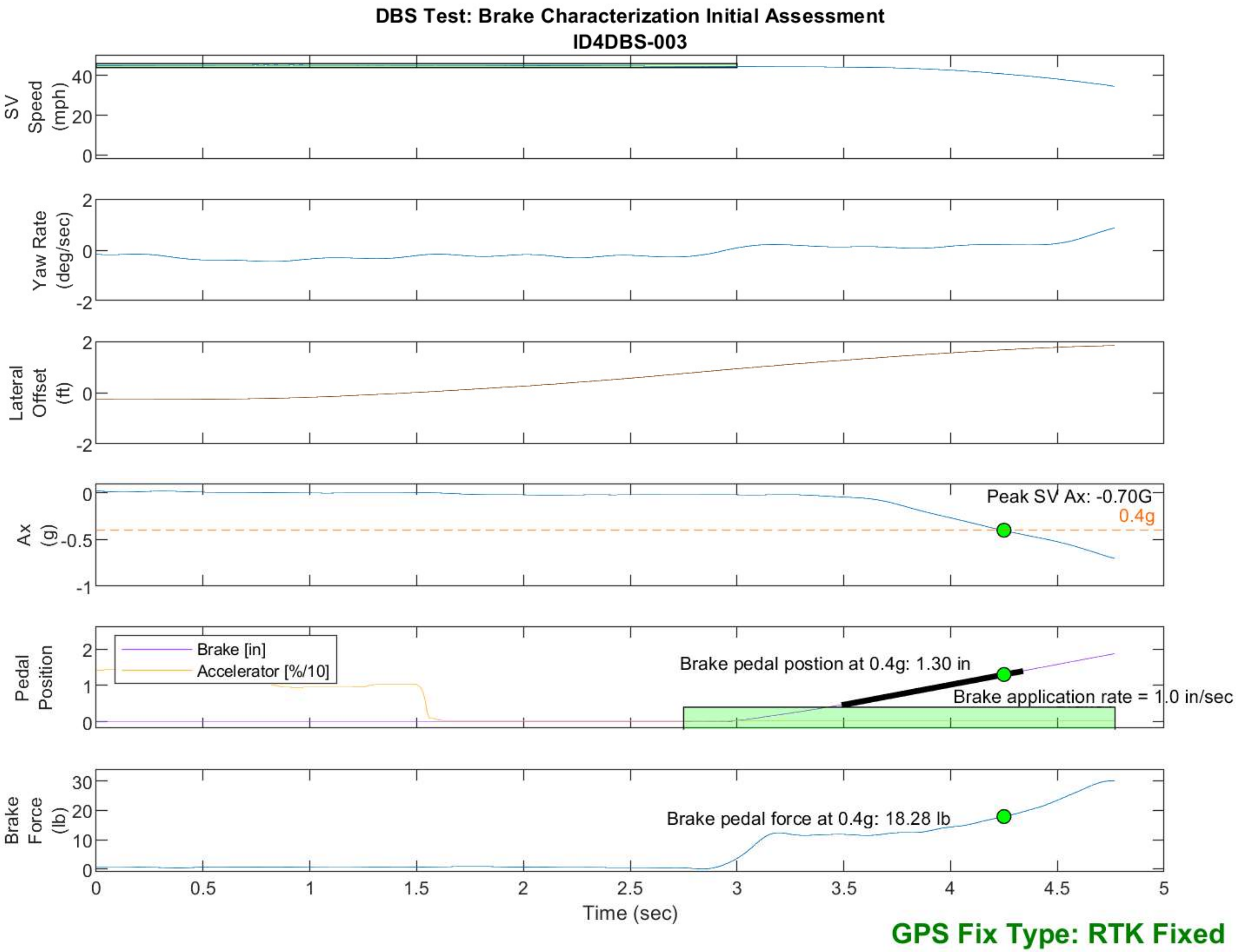

Figure E67. Time History for DBS Run 3, Brake Characterization Initial

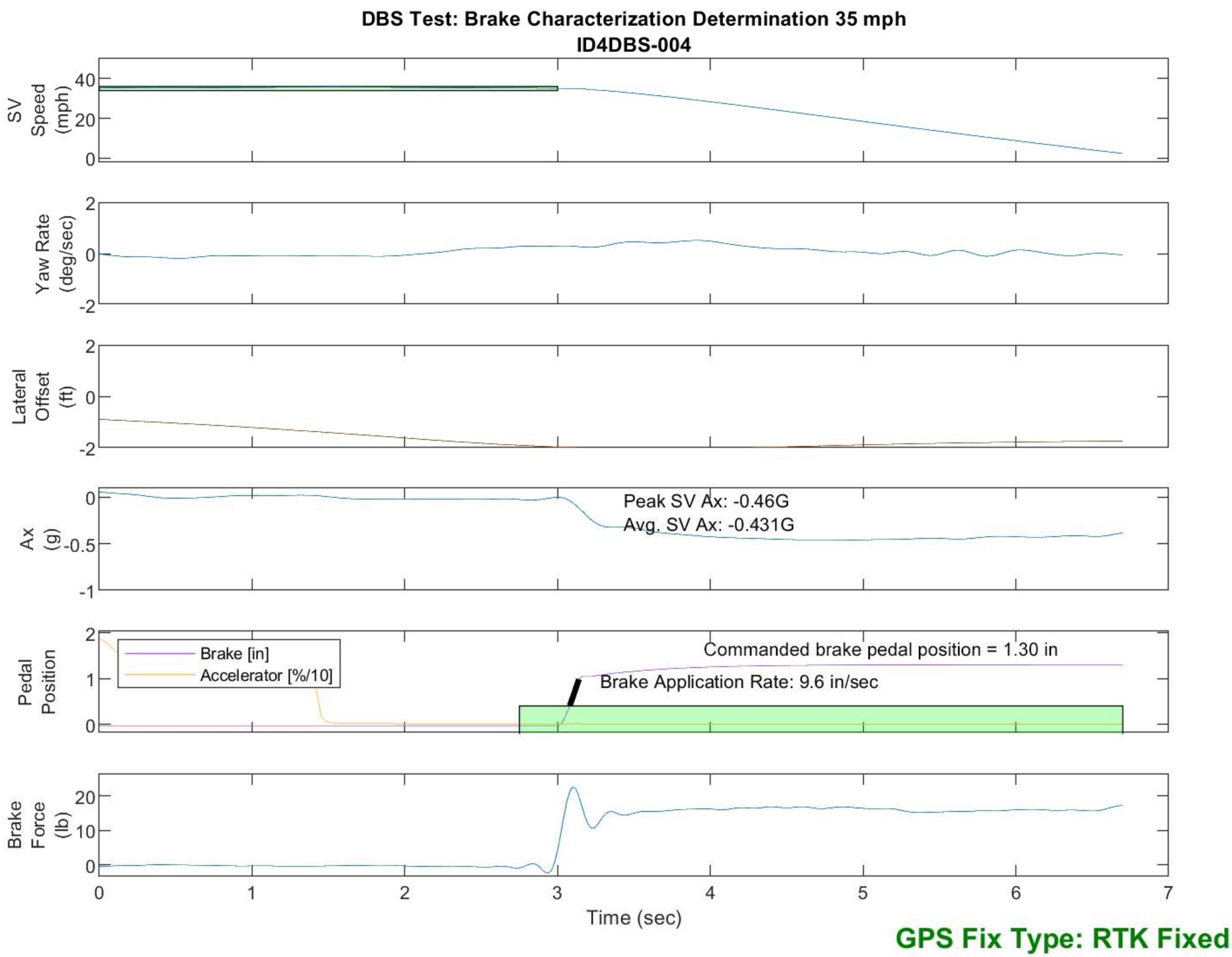

Figure E68. Time History for DBS Run 4, Brake Characterization Determination, Displacement Mode, 35 mph

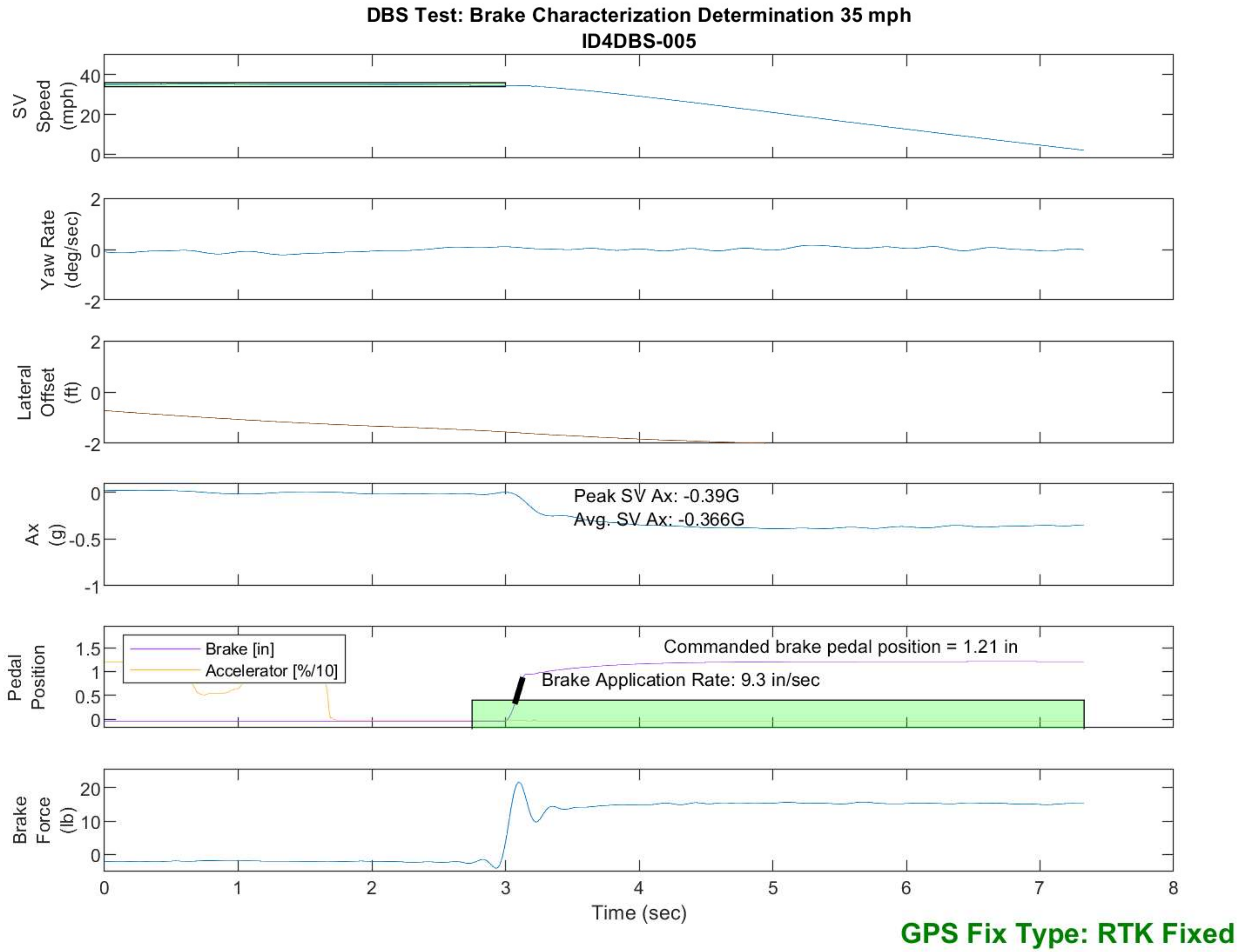

Figure E69. Time History for DBS Run 5, Brake Characterization Determination, Displacement Mode, 35 mph

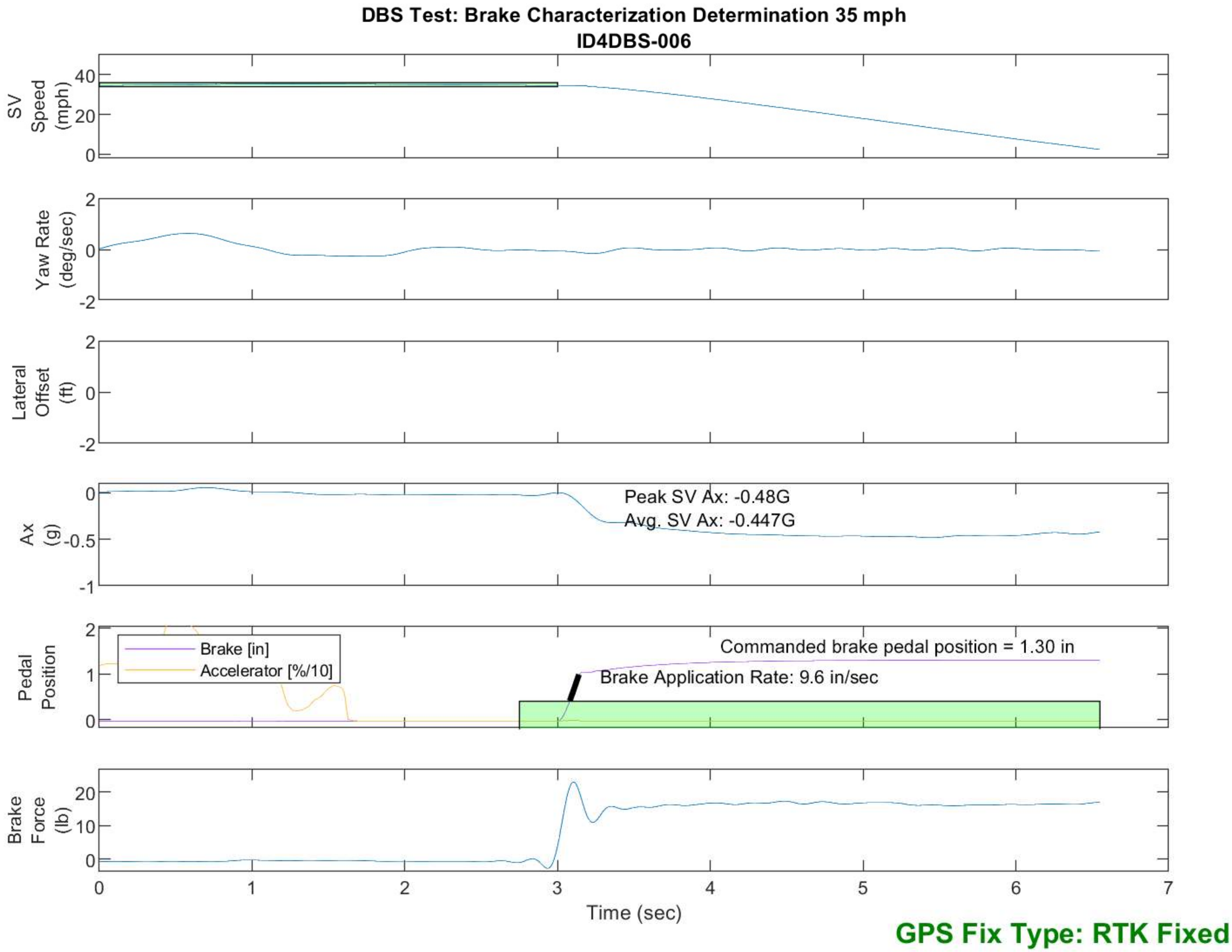

Figure E70. Time History for DBS Run 6, Brake Characterization Determination, Displacement Mode, 35 mph

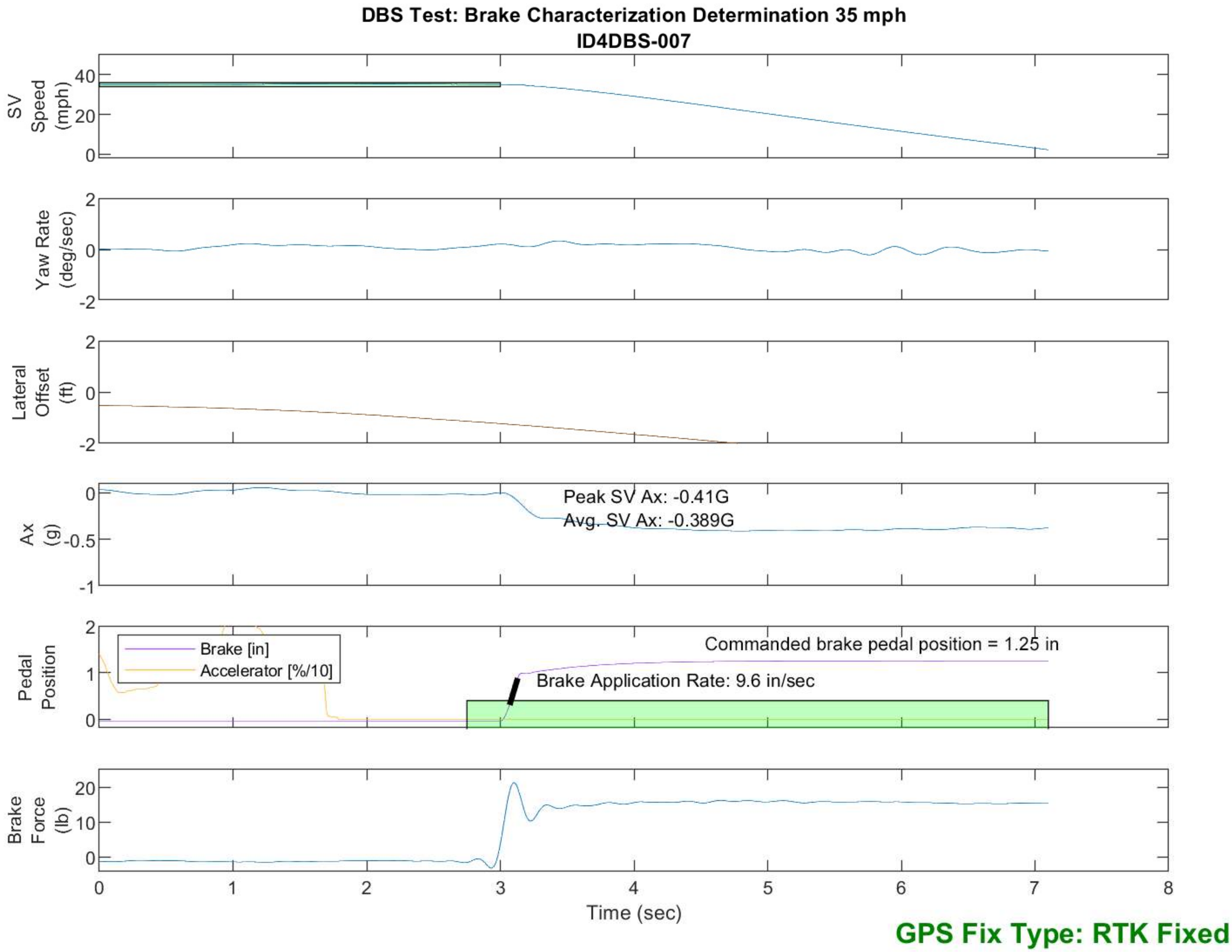

Figure E71. Time History for DBS Run 7, Brake Characterization Determination, Displacement Mode, 35 mph

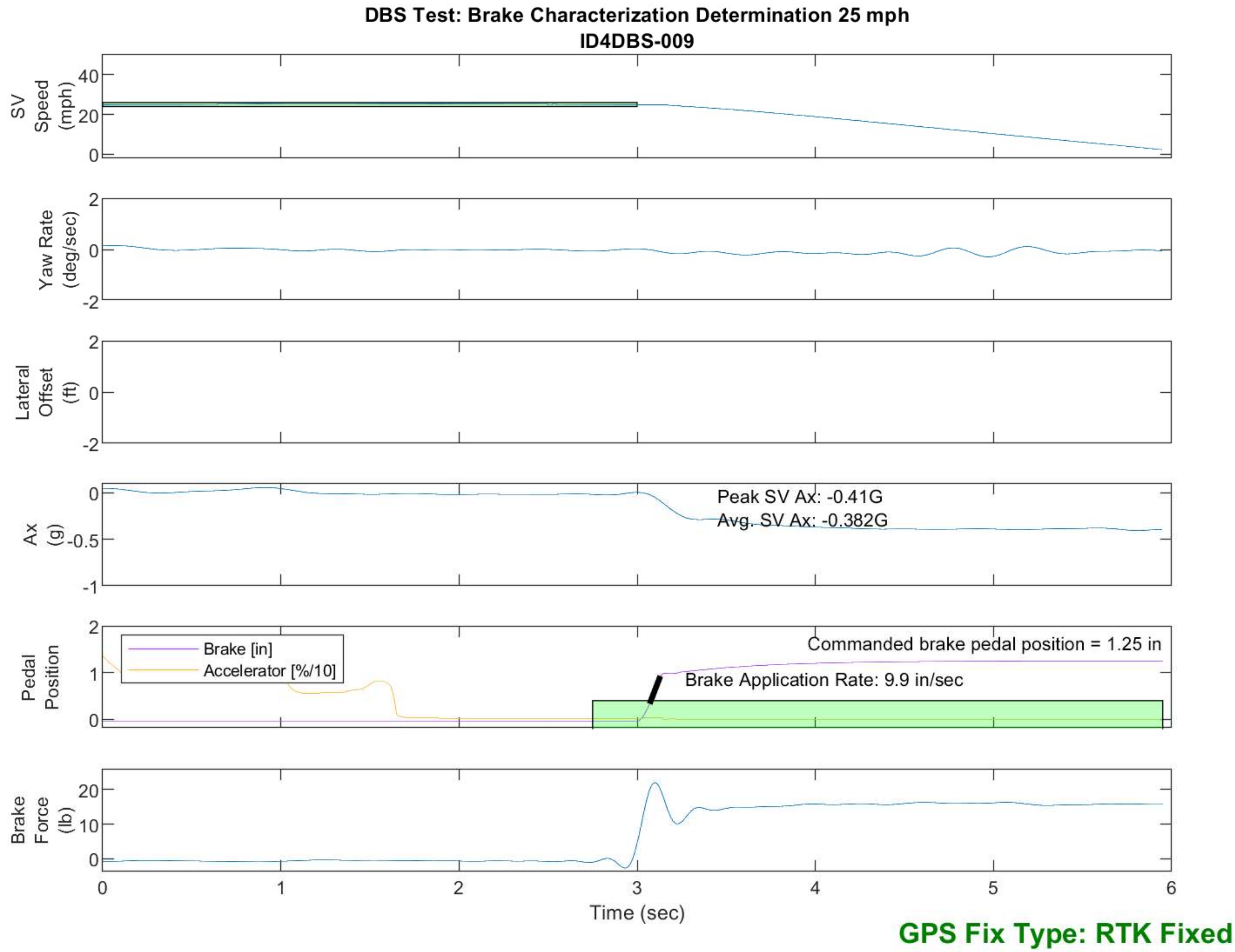

Figure E72. Time History for DBS Run 9, Brake Characterization Determination, Displacement Mode, 25 mph

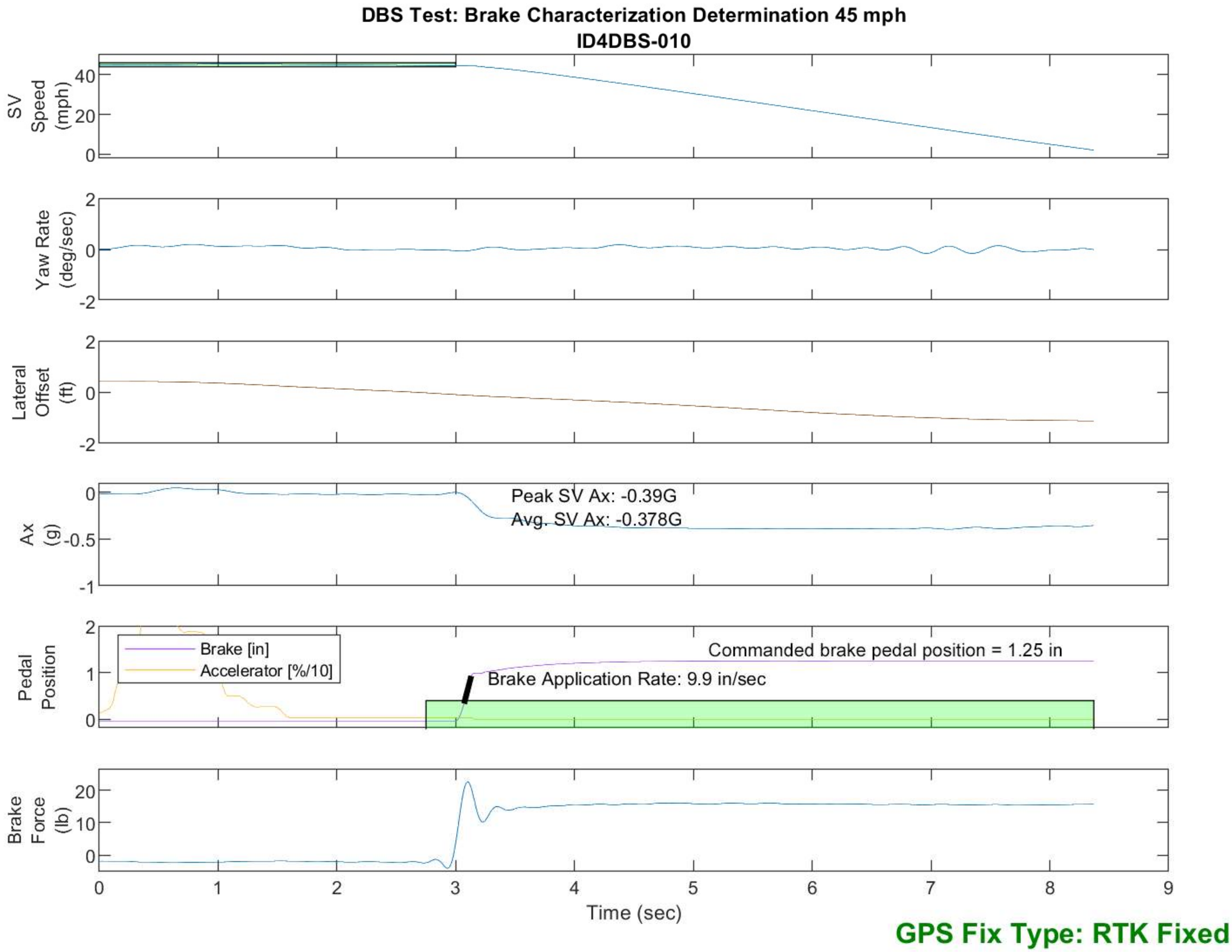

Figure E73. Time History for DBS Run 10, Brake Characterization Determination, Displacement Mode, 45 mph

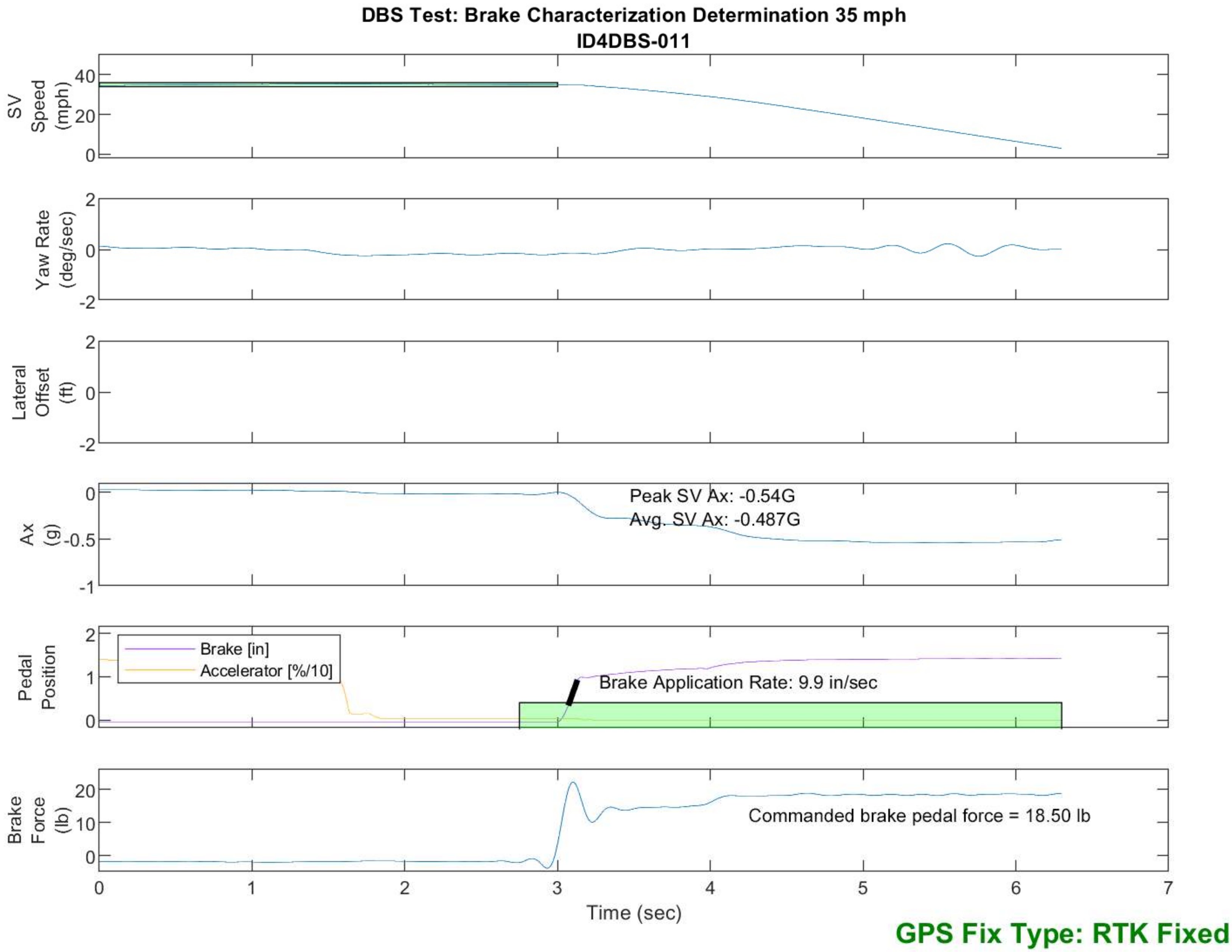

Figure E74. Time History for DBS Run 11, Brake Characterization Determination, Hybrid Mode, 35 mph

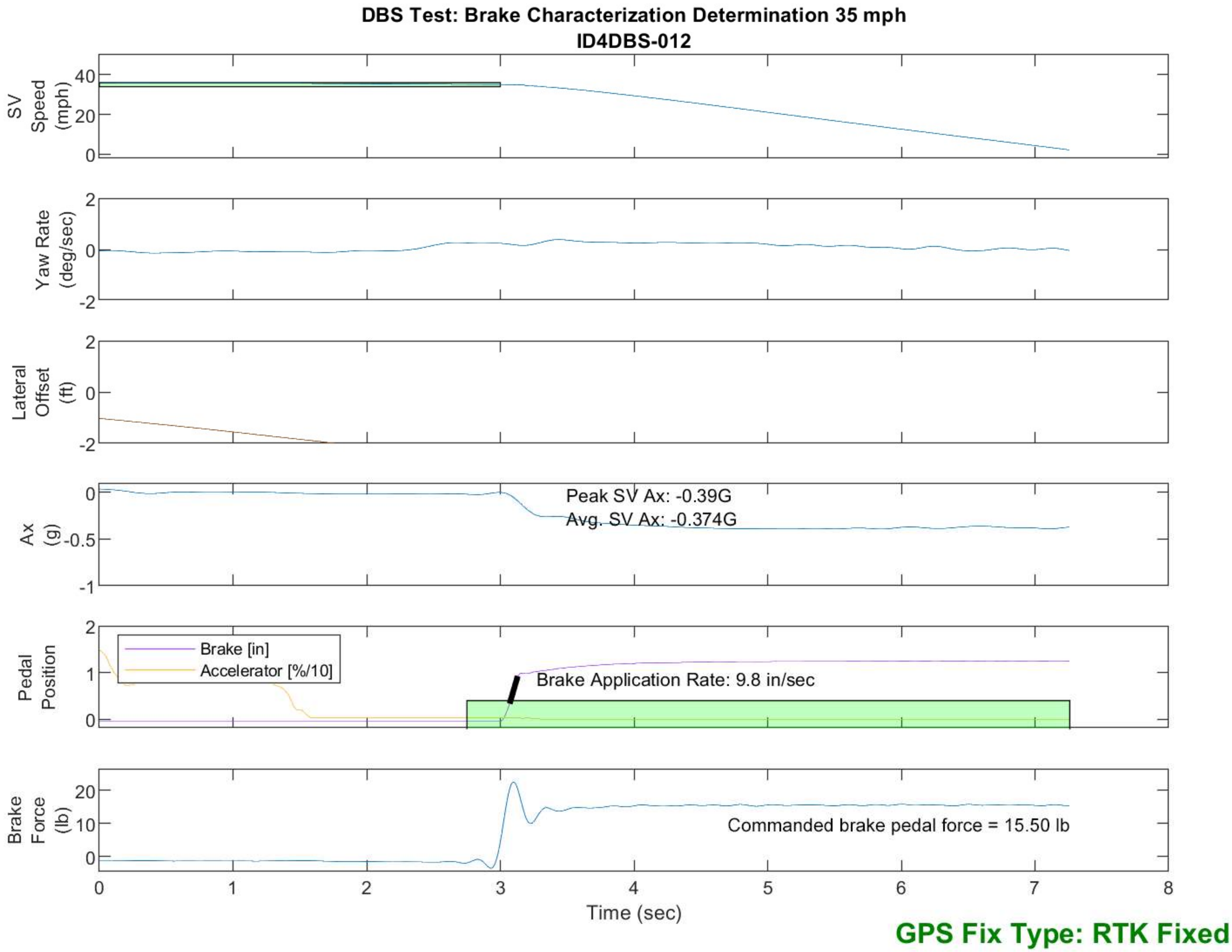

Figure E75. Time History for DBS Run 12, Brake Characterization Determination, Hybrid Mode, 35 mph

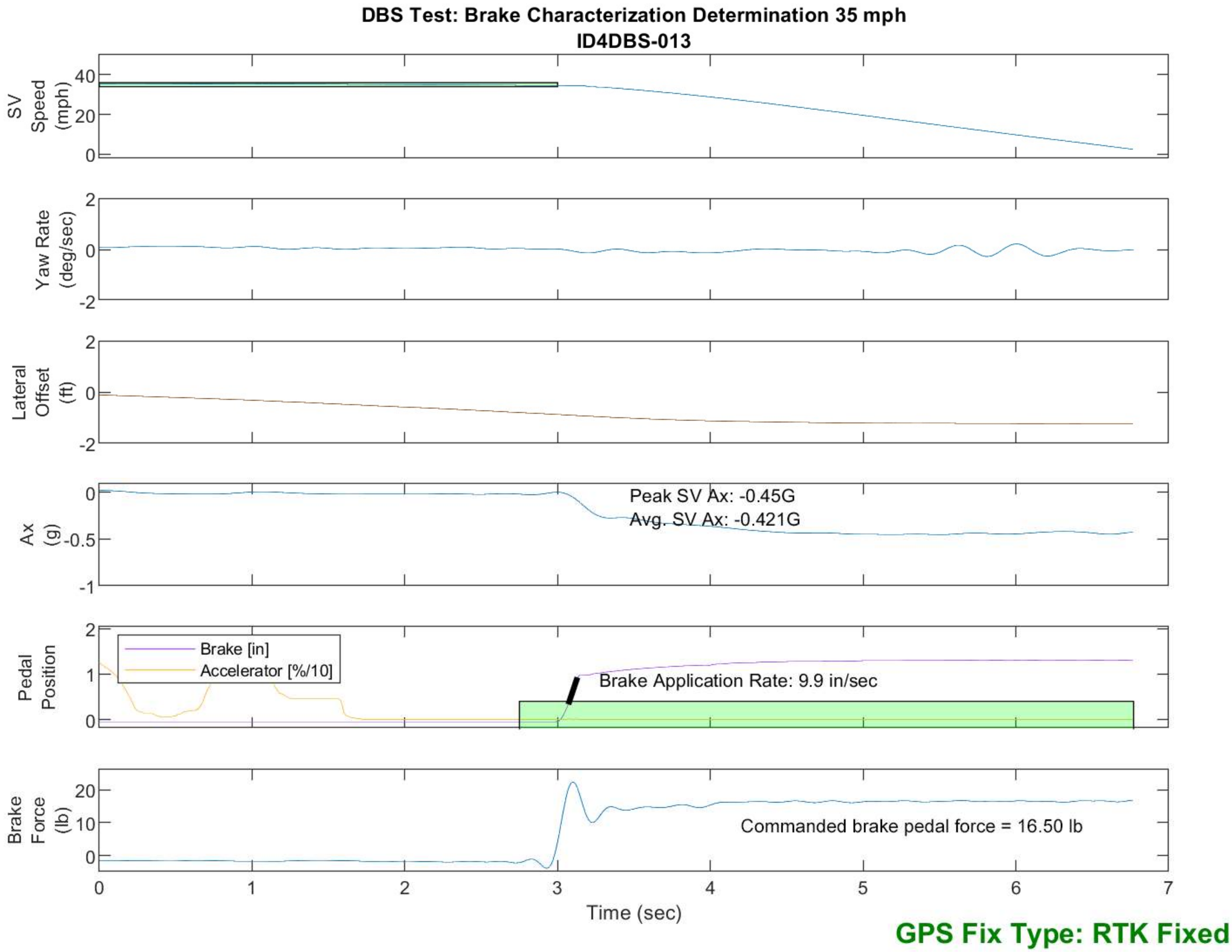

Figure E76. Time History for DBS Run 13, Brake Characterization Determination, Hybrid Mode, 35 mph

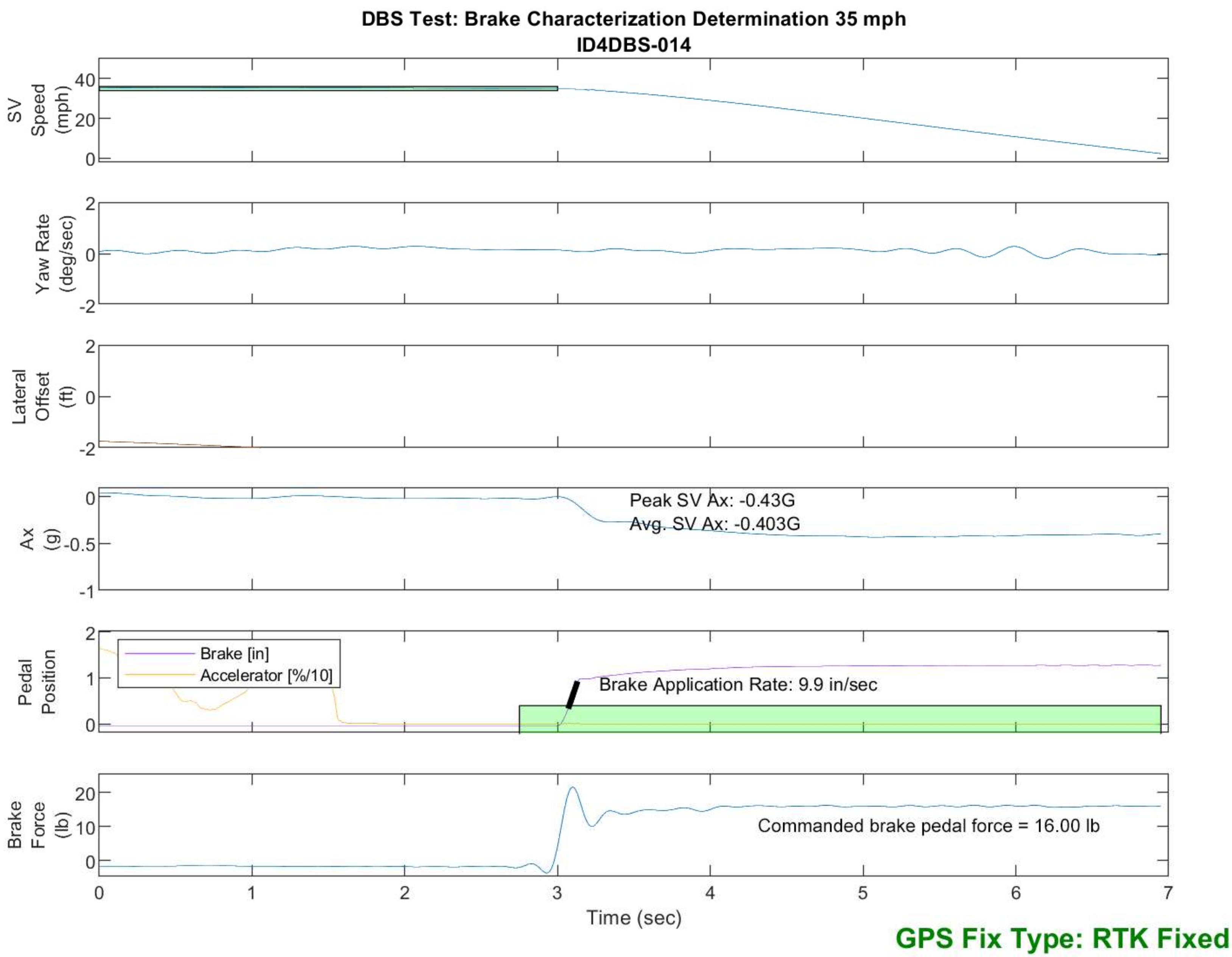

Figure E77. Time History for DBS Run 14, Brake Characterization Determination, Hybrid Mode, 35 mph

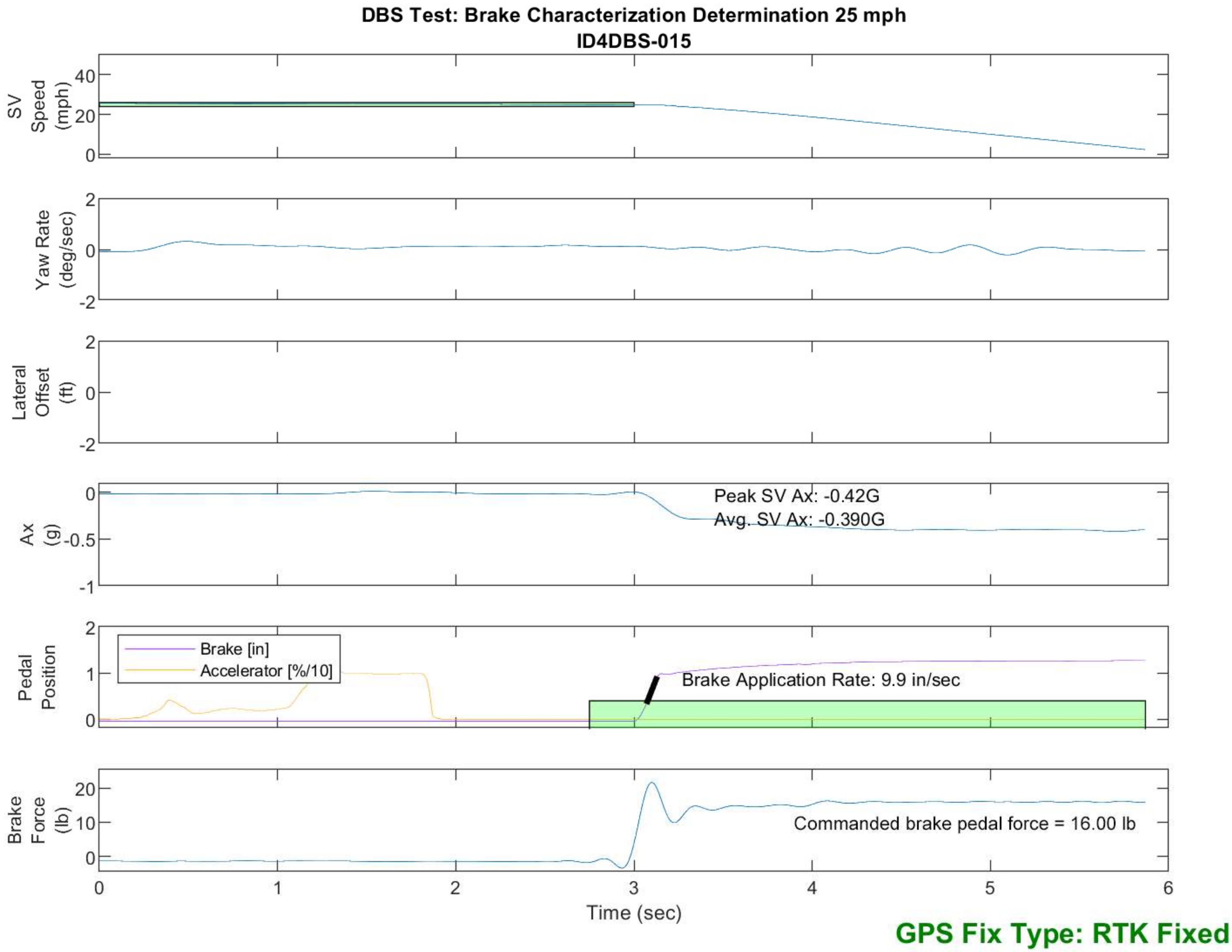

Figure E78. Time History for DBS Run 15, Brake Characterization Determination, Hybrid Mode, 25 mph

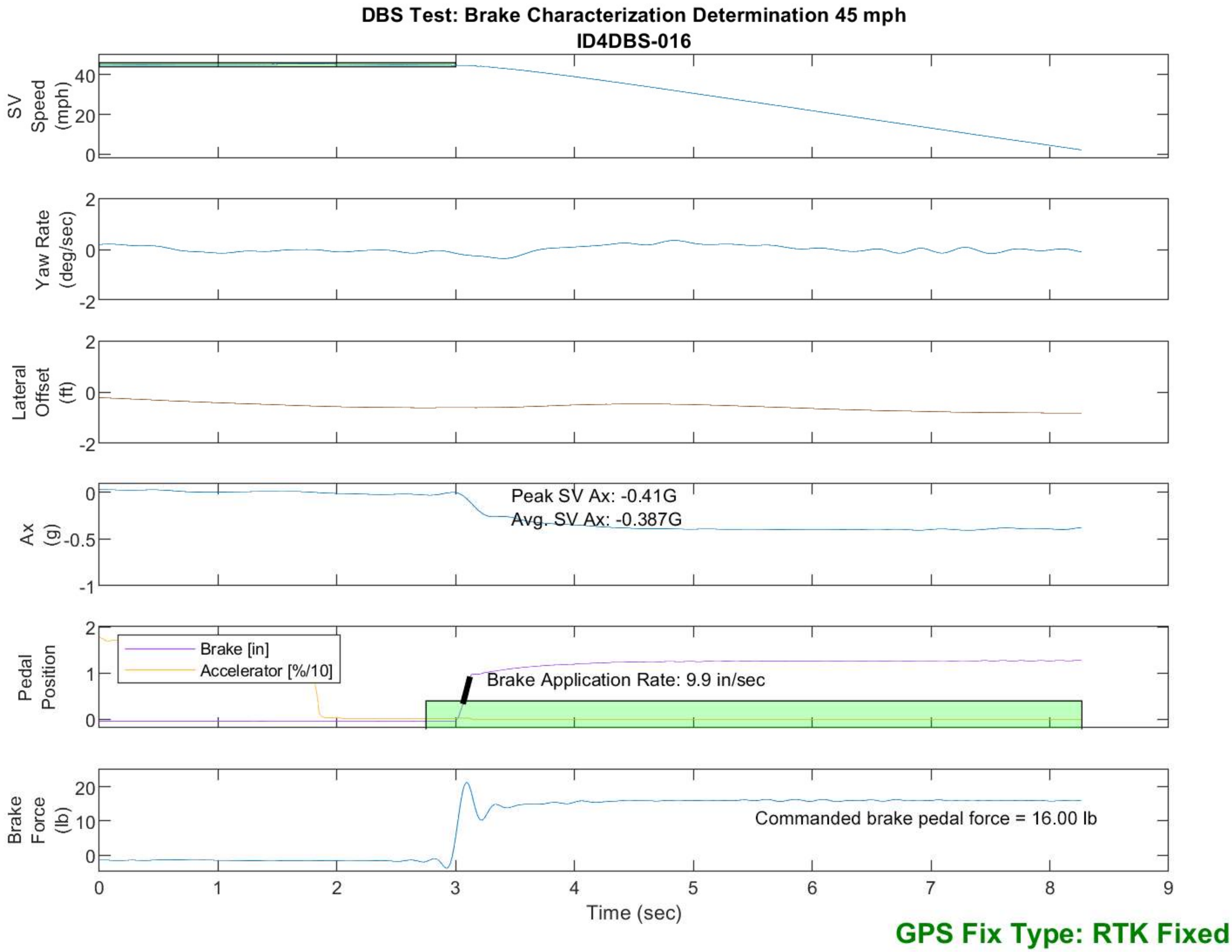

Figure E79. Time History for DBS Run 16, Brake Characterization Determination, Hybrid Mode, 45 mph