NEW CAR ASSESSMENT PROGRAM
DYNAMIC BRAKE SUPPORT SYSTEM CONFIRMATION RESEARCH TEST
NCAP-DRI-DBS-22-14-1

2022 Subaru Forester Premium/NFF

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Final Report

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U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
New Car Assessment Program
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16. Abstract These tests were conducted on the subject 2022 Subaru Forester Premium/NFF based on the specifications of the New Car Assessment Program's (NCAP's) most current Test Procedure in docket NHTSA-2015-0006-0026; DYNAMIC BRAKE SUPPORT PERFORMANCE EVALUATION CONFIRMATION TEST FOR THE NEW CAR ASSESSMENT PROGRAM**,** October 2015, with a few modifications. In testing conducted in accordance with the agency's DBS test procedure, the required brake application rate was found to be unachievable for this vehicle, as the brake pedal moves during automatic emergency braking (AEB) events. This research test was performed to investigate the viability of a different brake application requirement when such pedal movement occurs. For this research test, the target brake pedal displacement was required to be achieved within 250ms of the brake actuator activation. Under this new test condition, all test parameters were achieved, and the vehicle passed the requirements of the test for all four DBS test scenarios.		
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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 2022 Subaru Forester Premium/NFF using a new brake application requirement when the brake pedal moves during an AEB event. This modified test condition allows for brake application requirements to be met, which would otherwise be unachievable under the existing parameters. This test to assess Dynamic Brake Support systems is sponsored by the National Highway Traffic Safety Administration under Contract No. DTNH22-14-D-00333 with the New Car Assessment Program (NCAP).

Section II

DATA SHEETS

DYNAMIC BRAKE SUPPORT

DATA SHEET 1: TEST RESULTS SUMMARY

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2022 Subaru Forester Premium/NFF

VIN: *JF2SKADC7NH41xxxx*

Test start date: *2/8/2022* Test end date: *2/9/2022*

Dynamic Brake Support System settings: *No range settings available*

Test 1 - Subject Vehicle Encounters Stopped Principal Other Vehicle

SV 25 mph: *Pass*

Test 2 - Subject Vehicle Encounters Slower Principal Other Vehicle

SV 25 mph POV 10 mph: *Pass*

SV 45 mph POV 20 mph: *Pass*

Test 3 - Subject Vehicle Encounters Decelerating Principal Other Vehicle

SV 35 mph POV 35 mph: *Pass*

Test 4 - Subject Vehicle Encounters Steel Trench Plate

SV 25 mph: *Pass*

SV 45 mph: *Pass*

Overall: ***Pass***

2022 Subaru Forester Premium/NFF

Notes:

For the Stopped POV and two Slower POV test scenarios, the vehicle exhibited unexpected brake pedal movement during AEB activation which occurred while the brake actuator was operating and attempting to achieve its target brake pedal displacement (the required brake pedal displacement to achieve 0.4 g of vehicle deceleration). This prevented the brake actuator from meeting the brake application rate requirement of 10 ± 1 in/s assessed between 25% and 75% of the displacement phase for the hybrid braking method.

Because of this, an additional brake application requirement was developed to allow vehicles with this type of brake pedal behavior to be tested and meet all validity requirements. Under the modified test conditions, the target brake pedal displacement would need to be achieved within 250 ms of the brake actuator activation. Thus, the brake application rate between 25% and 75% would be ignored and only the brake pedal displacement at 250 ms from brake actuator activation would be checked for validity.

With this new requirement, 7 valid runs were achieved for each of the 4 scenarios and the vehicle passed all runs without contacting the SSV. The results of those runs can be found in Appendix C and the time history plots can be found in Appendix E.

DYNAMIC BRAKE SUPPORT

DATA SHEET 2: VEHICLE DATA

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2022 Subaru Forester Premium/NFF

TEST VEHICLE INFORMATION

VIN: *JF2SKADC7NH41xxxx*

Body Style: *SUV* Color: *Autumn Green Metallic*

Date Received: *1/3/2022* Odometer Reading: *5 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *Subaru Corporation*

Date of manufacture: *11/21*

Vehicle Type: *MPV/VTUM*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *225/60R17*

Rear: *225/60R17*

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

Rear: *220 kPa (32 psi)*

TIRES

Tire manufacturer and model: *Bridgestone Ecopia H/L 422 Plus*

Front tire specification: *225/60R17 99H*

Rear tire specification: *225/60R17 99H*

Front tire DOT prefix: *EL FC DMM*

Rear tire DOT prefix: *EL FC DMM*

<u>**DYNAMIC BRAKE SUPPORT**</u>

<u>**DATA SHEET 3: TEST CONDITIONS**</u>

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2022 Subaru Forester Premium/NFF

<u>GENERAL INFORMATION</u>

Test start date: *2/8/2022* Test start date: *2/9/2022*

<u>AMBIENT CONDITIONS</u>

Air temperature: *14.4 C (58 F)*

Wind speed: *1.0 m/s (2.3 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.

<u>VEHICLE PREPARATION</u>

Verify the following:

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

Fuel tank is full: **X**

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

Front: *230 kPa (33 psi)*

Rear: *220 kPa (32 psi)*

DYNAMIC BRAKE SUPPORT

DATA SHEET 3: TEST CONDITIONS

(Page 2 of 2)

2022 Subaru Forester Premium/NFF

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*526.2 kg (1160 lb)*	Right Front:	*479.0 kg (1056 lb)*
Left Rear:	*376.9 kg (831 lb)*	Right Rear:	*371.9 kg (820 lb)*
		Total:	*1754.0 kg (3867 lb)*

DYNAMIC BRAKE SUPPORT

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

(Page 1 of 3)

2022 Subaru Forester Premium/NFF

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

EyeSight Driver-Assist System

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

Stereo camera located at the top center of the windshield

System settings used for test (if applicable):

No range settings available

Brake application mode used for test: *Hybrid control*

Over what speed range is the system operational?

The EyeSight system is operational between 1-160 km/h (1-100 mph) per manufacturer supplied information.

Does the vehicle system require an initialization sequence/procedure?

X Yes

____ No

If yes, please provide a full description.

The EyeSight system requires the vehicle to be driven on public roads without inclement weather for about one hour to be initialized. This initialization procedure does not need to be repeated after an ignition cycle.

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

X Yes

____ No

If yes, please provide a full description.

The EyeSight system will deactivate after three AEB activations without an ignition cycle and a Pre-Collision Braking System OFF indicator light located in the instrument panel will illuminate.

DYNAMIC BRAKE SUPPORT

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

2022 Subaru Forester Premium/NFF

How is the Forward Collision Warning presented to the driver?

(Check all that apply)

- **X** Warning light
- **X** Buzzer or auditory alarm
- ____ Vibration
- ____ Other ________________

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

> *The EyeSight system alerts the driver with a visual and auditory alert. The visual alert is displayed in the center of the instrument panel and consists of an image of two vehicles, one behind the other, lane lines, and the words "Obstacle Detected" above. The vehicle shown in front flashes on/off. The auditory alert consists of repeated beeps followed by a long continuous beep with a primary frequency of 2215 Hz.*

Is there a way to deactivate the system?

- **X** Yes
- ____ No

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

> *A button to deactivate the EyeSight system is located on the front center ceiling control panel. Press and hold the button for approximately 2 seconds and the system will emit a single audible beep and illuminate a Pre-Collision Braking System Off indicator light when it is deactivated.*

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

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2022 Subaru Forester Premium/NFF

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

____ Yes

X No

If yes, please provide a full description.

There are no range settings available for the EyeSight system.

Are there other driving modes or conditions that render DBS inoperable or reduce its effectiveness?

X Yes

____ No

If yes, please provide a full description.

Refer to the Subaru EyeSight Manual pages 30-41 shown in Appendix B pages B-2 to B-13.

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Four test scenarios were used, as follows:

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

Test 2. Subject Vehicle Encounters Slower Principal Other Vehicle

Test 3. Subject Vehicle Encounters Decelerating Principal Other Vehicle

Test 4. Subject Vehicle Encounters Steel Trench Plate

An overview of each of the test procedures follows.

1. TEST 1 – SUBJECT VEHICLE ENCOUNTERS STOPPED PRINCIPAL OTHER VEHICLE ON A STRAIGHT ROAD

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

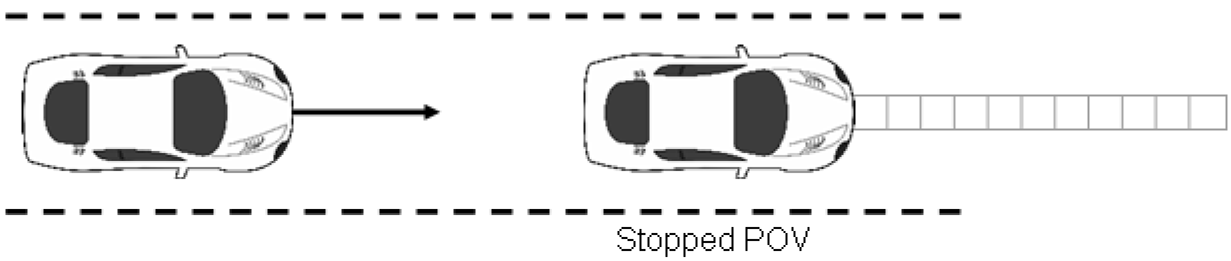

Figure 1. Depiction of Test 1

a. Procedure

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

The SV ignition was cycled prior to each test run. The SV was driven at a nominal speed of 25 mph (40.2 km/h) in the center of the lane of travel, toward the parked POV. The SV throttle pedal was released within 500 ms after t_{FCW}, i.e., within 500 ms of the FCW alert or SV brake application if no FCW alert was given. The SV brakes were applied at TTC = 1.1 seconds (SV-to-POV distance of 40 ft (12 m)). The test concluded when either:

- The SV came into contact with the POV or

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

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

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

Table 1. Nominal Stopped POV DBS Test Choreography

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

b. Criteria

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

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

This test evaluates the ability of the DBS system to detect and respond to a slower-moving lead vehicle traveling at a constant speed in the immediate forward path of the SV, as depicted in Figure 2.

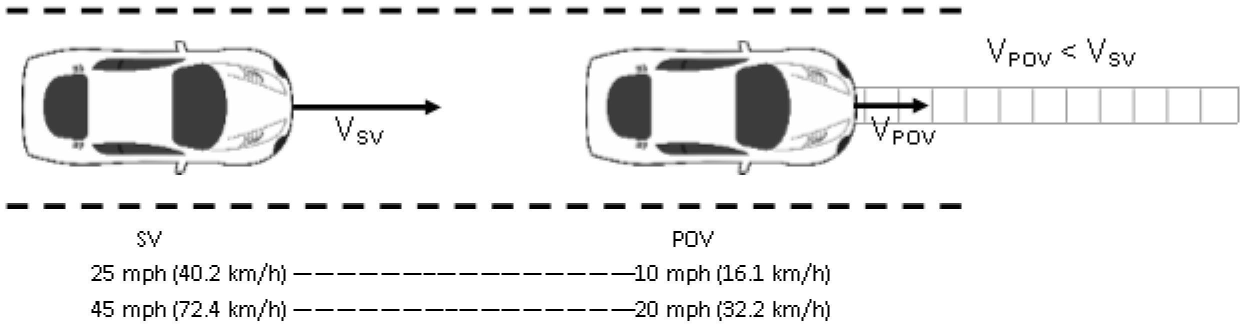

Figure 2. Depiction of Test 2

a. Procedure

The SV ignition was cycled prior to each test run. The tests were conducted two ways. In the first, the POV was driven at a constant 10.0 mph (16.1 km/h) in the center of the lane of travel while the SV was driven at 25.0 mph (40.2 km/h), in the center lane of travel, toward the slower-moving POV. In the second, the POV was driven at a constant 20.0 mph (32.2 km/h) in the center of the lane of travel while the SV was driven at 45.0 mph (72.4 km/h), in the center lane of travel, toward the slower-moving POV. In both cases, the SV throttle pedal was released within 500 ms after $t_{FCW,}$ i.e., within 500 ms of the FCW alert or SV brake application if no FCW alert was given. The SV brakes were applied at TTC = 1.0 seconds, assumed to be SV-to-POV distance of 22 ft (7 m) for an SV speed of 25 mph and 37 ft (11 m) for an SV speed of 45 mph.

The test concluded when either:

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

The SV driver then braked to a stop.

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

- The lateral distance between the centerline of the SV and POV to the center of the travel lane could not deviate more than ±1 ft (0.3 m) during the validity period.
- The yaw rate of the SV and POV could not deviate more than ±1 deg/sec during the validity period.
- The SV speed could not deviate more than ±1.0 mph (±1.6 km/h) during an interval defined by TTC = 5.0 seconds to t_{FCW} or impact if no FCW alert was given.
- The POV speed could not deviate more than ±1.0 mph (±1.6 km/h) during the validity period.

Table 2. Nominal Slower-Moving POV DBS Test Choreography

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

b. Criteria

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

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

This test evaluates the ability of the DBS system to detect and respond to a lead vehicle slowing with a constant deceleration in the immediate forward path of the SV as depicted in Figure 3. Should the SV foundation brake system be unable to prevent an SV-to-POV impact for a given test condition, the DBS system should automatically provide supplementary braking capable of preventing an SV-to-POV collision.

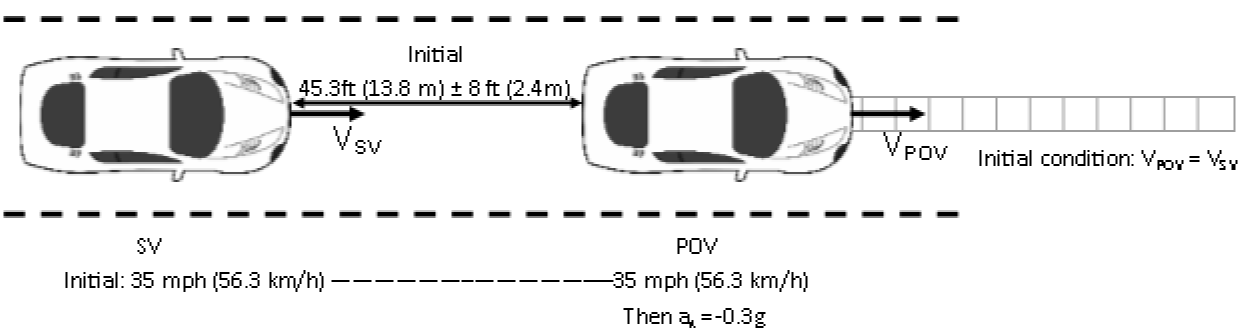

Figure 3. Depiction of Test 3

a. Procedure

The SV ignition was cycled prior to each test run. For this scenario both the POV and SV were driven at a constant 35.0 mph (56.3 km/h) in the center of the lane, with headway of 45.3 ft (13.8 m) ± 8 ft (2.4 m). Once these conditions were met, the POV tow vehicle brakes were applied to achieve 0.3 ± 0.03 g of deceleration within 1.5 ± 0.1 sec. The SV throttle pedal was released within 500 ms of t_{FCW} or SV brake application if no FCW alert was given. The SV brakes were applied when TTC was 1.4 seconds (31.5 ft (9.6 m)).

The test concluded when either:

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

The SV driver then braked to a stop.

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

- The lateral distance between the centerline of the SV and POV to the center of the travel lane could not deviate more than ±1 ft (0.3 m) during the validity period.
- The yaw rate of the SV and POV could not deviate more than ±1 deg/sec during the validity period.
- The SV speed could not deviate more than ±1.0 mph (1.6 km/h) during an interval defined by 3.0 seconds before the onset of POV braking to t_{FCW} or impact if no FCW alert was given.
- The POV speed could not deviate more than ±1.0 mph (1.6 km/h) during an interval of 3.0 seconds before the onset of POV braking.
- The SV- POV headway distance could not deviate more than ±8 ft (2.4 m) during an interval defined by the onset of the validity period to the onset of POV braking.
- The average POV deceleration could not deviate by more than ±0.03 g from the nominal 0.3 g deceleration during the interval beginning at 1.5 seconds after the onset of POV braking and ending either 250 ms prior to the POV coming to a stop or the SV coming into contact with the POV.

Table 3. Nominal Decelerating POV DBS Test Choreography

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

b. Criteria

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

4. TEST 4 – FALSE POSITIVE SUPPRESSION

The false positive suppression test series evaluates the ability of a DBS system to differentiate a steel trench plate (STP) from an object presenting a genuine safety risk to the SV. Although the STP is large and metallic, it is designed to be driven over without risk of injury to the driver or damage to the SV. Therefore, in this scenario, the automatic braking available from DBS is not necessary and should be suppressed. The test condition is nearly equivalent to that previously defined for Test 1, the stopped POV condition, but with an STP in the SV forward path in lieu of a POV.

a. Procedure

This test was conducted at two speeds, 25 mph (40.2 km/h) and 45 mph (72.4 km/h). The SV was driven directly towards, and over, the STP, which was positioned in the center of a travel lane, with its longest sides parallel to the road edge. The SV was driven at constant speed in the center of the lane toward the STP. If the SV did not present an FCW alert during the approach to the STP by TTC = 2.1 s, the SV driver initiated release of the throttle pedal at TTC = 2.1 s and the throttle pedal was fully released within 500 ms of TTC = 2.1 s. The SV brakes were applied at TTC of 1.1 seconds, assumed to be 40 ft (12.3 m) from the edge of the STP at 25 mph or 73 ft (22.1 m) at 45 mph. The test concluded when the front most part of the SV reached a vertical plane defined by the edge of the STP first encountered by the SV.

b. Criteria

In order to pass the False Positive test series, the magnitude of the SV deceleration reduction attributable to DBS intervention must have been less than or equal to 1.5 times the average of the deceleration experienced by the baseline command from the braking actuator for at least five of seven valid test trials.

B. General Information

1. T_{FCW}

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

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

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

Table 4. Auditory and Tactile Warning Filter Parameters

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

2. GENERAL VALIDITY CRITERIA

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

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

3. VALIDITY PERIOD

The valid test interval began:

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

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

Test 3: 3 seconds before the onset of POV braking

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

The valid test interval ended:

Test 1: When either of the following occurred:

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

Test 2: When either of the following occurred:

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

Test 3: When either of the following occurred:

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

Test 4: When the SV stopped.

4. STATIC INSTRUMENTATION CALIBRATION

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

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

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

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

5. <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.
- If the brake application rate could not be achieved due to brake pedal movement during AEB activation, the application rate requirement was removed. Instead, the brakes were applied 1 second after the onset of FCW and the target brake pedal displacement was achieved within 250 ms.

3. POV AUTOMATIC BRAKING SYSTEM

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

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

- PC module programmed for control of the stroke and rate of the linear actuator.
- Switch to activate actuator.

F. Instrumentation

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

Table 5. Test Instrumentation and Equipment

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	< 1% error between 20 and 100 psi	Omega DPG8001	17042707002	By: DRI Date: 10/5/2021 Due: 10/5/2022
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 2/10/2021 Due: 2/10/2022
Linear (string) encoder	Throttle pedal travel	10 in	0.1 in	UniMeasure LX-EP	50060726	By: DRI Date: 4/15/2021 Due: 4/15/2022
Load Cell	Force applied to brake pedal					By: DRI
		0-250 lb	0.05% FS	Stellar Technology PNC700	2002505	Date: 4/9/2021 Due: 4/9/2022
		0-250 lb 1112 N	0.05% FS	Stellar Technology PNC700	1607338	Date: 4/9/2021 Due: 4/9/2022
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)

<table>
<tr><th>Type</th><th>Output</th><th>Range</th><th>Accuracy, Other Primary Specs</th><th>Mfr, Model</th><th>Serial Number</th><th>Calibration Dates
Last
Due</th></tr>
<tr><td rowspan="3">Multi-Axis Inertial Sensing System</td><td rowspan="3">Position;
Longitudinal, Lateral, and Vertical Accels;
Lateral, Longitudinal and Vertical Velocities;
Roll, Pitch, Yaw Rates;
Roll, Pitch, Yaw Angles</td><td rowspan="3">Accels ± 10g, Angular Rate ±100 deg/s, Angle >45 deg, Velocity >200 km/h</td><td rowspan="3">Accels .01g, Angular Rate 0.05 deg/s, Angle 0.05 deg, Velocity 0.1 km/h</td><td rowspan="3">Oxford Inertial +</td><td></td><td>By: Oxford Technical Solutions</td></tr>
<tr><td>2176</td><td>Date: 6/26/2020
Due: 6/26/2022</td></tr>
<tr><td>2258</td><td>Date: 4/28/2021
Due: 4/28/2023</td></tr>
<tr><td>Real-Time Calculation of Position and Velocity Relative to Lane Markings (LDW) and POV (FCW)</td><td>Distance and Velocity to lane markings (LDW) and POV (FCW)</td><td>Lateral Lane Dist: ±30 m
Lateral Lane Velocity: ±20 m/sec
Longitudinal Range to POV: ±200 m
Longitudinal Range Rate: ±50 m/sec</td><td>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</td><td>Oxford Technical Solutions (OXTS), RT-Range</td><td>97</td><td>N/A</td></tr>
<tr><td>Microphone</td><td>Sound
(to measure time at alert)</td><td>Frequency Response:
80 Hz – 20 kHz</td><td>Signal-to-noise: 64 dB, 1 kHz at 1 Pa</td><td>Audio-Technica AT899</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Light Sensor</td><td>Light intensity
(to measure time at alert)</td><td>Spectral Bandwidth:
440-800 nm</td><td>Rise time < 10 msec</td><td>DRI designed and developed Light Sensor</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Accelerometer</td><td>Acceleration
(to measure time at alert)</td><td>±5g</td><td>≤ 3% of full range</td><td>Silicon Designs, 2210-005</td><td>N/A</td><td>N/A</td></tr>
</table>

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2022 Due: 1/6/2023

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

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle


FORESTER®

VIN JF2SKADC7NH41
Model/Code 2022 SUBARU FORESTER PREMIUM/NFF
Port/Assembly HUENEME
Deliver by/Carrier TRUCK / 456

SUBARU.

GOVERNMENT 5-STAR SAFETY RATINGS

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

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

Side Crash Front seat ★★★★★ Rear seat ★★★★★
Based on the risk of injury in a side impact.

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

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

CR Consumer Reports RECOMMENDED

Subaru Added Security®
The Only Extended Service Agreement Backed By Subaru
- Protection designed to fit your driving needs, up to 10 years/100,000 miles of coverage
- We only use Genuine Subaru replacement parts
- We use Subaru-trained technicians - those who know your vehicle best
- Towing and rental car reimbursements during covered repairs
- Transferable coverage to the next owner

Scan the QR code or ask your sales representative for more details

EPA DOT Fuel Economy and Environment Gasoline Vehicle

Fuel Economy
29 MPG combined city/hwy
26 city 33 highway
Small SUVs range from 16 to 125 MPG. The best vehicle rates 142 MPGe.
3.4 gallons per 100 miles

You **save $500** in fuel costs over 5 years compared to the average new vehicle.

Annual fuel **cost $1,200**

Fuel Economy & Greenhouse Gas Rating (tailpipe only): 6 (1–10 Best)
Smog Rating (tailpipe only): 7 (1–10 Best)
This vehicle emits 310 grams CO_2 per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel also creates emissions; learn more at fueleconomy.gov.

Actual results will vary for many reasons, including driving conditions and how you drive and maintain your vehicle. The average new vehicle gets 27 MPG and costs $6,500 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at $2.35 per gallon. MPGe is miles per gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

fueleconomy.gov
Calculate personalized estimates and compare vehicles
Smartphone QR Code™

PARTS CONTENT INFORMATION
FOR VEHICLES IN THIS CARLINE:
U.S./CANADIAN PARTS CONTENT: 5%
MAJOR SOURCES OF FOREIGN PARTS CONTENT: JAPAN: 80%
FOR THIS VEHICLE:
FINAL ASSEMBLY POINT: OTA, GUNMA, JAPAN
COUNTRY OF ORIGIN:
ENGINE:JAPAN
TRANSMISSION:JAPAN
Note: Parts content does not include final assembly, distribution, or other non-parts costs.

STANDARD EQUIPMENT

SAFETY
Symmetrical All-Wheel Drive (AWD)
EyeSight Driver-Assist System
Vehicle Dynamics Control (VDC)
Driver's Side Knee Airbag
Side-Curtain Airbags w/ Rollover Sensor
Subaru Advanced Frontal Airbag System
Front Seat Side (Pelvis/Torso) Airbags
LATCH System for Child Safety Seats, Rear Seat Reminder
Whiplash Protection Front Seats
Anti-Theft Alarm & Immobilizer System
4-Wheel Anti-Lock (ABS) Disc Brakes w/ Brake Assist
Brake Override System and Safety Pedal System
Electronic Brake-Force Distribution
Rear Vision Camera, Daytime Running Lights (DRL)

PERFORMANCE AND EXTERIOR
2.5L Horizontally-Opposed DOHC Engine w/ Auto Start-Stop
Lineartronic CVT w/ X-MODE
SI-Drive
17" Aluminum Alloy Wheels
Privacy Glass and Panoramic Power Moonroof
LED Steering Responsive Headlights (SRH)
Automatic On/Off Headlights with High Beam Assist (HBA)
Fog Lights & Folding Exterior Mirrors
Variable Intermittent Windshield Wipers
Rear Spoiler and Roof Rails with Tie Down Points

COMFORT, CONVENIENCE & INTERIOR
STARLINK 6.5 Multimedia System w/CD, HD Radio & Dual USB Ports
SiriusXM Radio and SiriusXM Travel Link - 4 Months Free
Multi-Function Display
SUBARU STARLINK Safety Plus+ - 3 Years Free
+Not Available to Massachusetts Residents or Businesses
Bluetooth Hands-Free Phone Connectivity
Tilt/Telescopic Steering Wheel w/Bluetooth & Audio Switches
Leather-Wrapped Steering Wheel
Automatic Climate Control with Air Filtration System
Advanced Adaptive Cruise Control
All-Weather Package w/Heated Front Seats
10-Way Power Driver's Seat w/ Power Lumbar Support
60/40 Split Fold-Down Rear Seatback w/ Reclining Function
Electronic Parking Brake w/ Auto Vehicle Hold (AVH)
Power Windows w/ Driver's and Front Passenger's Auto Up/Down
12V Outlet In Dash, Console & Cargo Area
Keyless Access with Push-Button Start
Retractable Cargo Area Cover

LIMITED WARRANTY/ROADSIDE ASSISTANCE
3 Years / 36,000 Miles Basic
5 Years / 60,000 Miles Powertrain
5 Yrs/Unlimited Mileage Rust Perforation
3 Yrs / 36,000 24/7 Roadside Assistance
See Owner Info Kit&Warranty For Details

Privacy Notice www.subaru.com/company/privacy.html
*iPod is a registered trademark of Apple Inc. harman/kardon is a registered trademark of Harman International Industries, Inc. Bluetooth is a registered trademark of Bluetooth. SIG. Inc. TomTom is a registered trademark of TomTom International B.V. Corporation. TORSEN is a registered trademark of JTEKT Torsen North America Inc.

OPTIONAL EQUIPMENT AND OTHER ITEMS

Manufacturer's Suggested Retail Price	$28,195.00
Exterior Color: Autumn Green Metallic	
Full Tank of Gas	INCLD
Standard Option: 11	
Destination and Delivery	**$1,125.00**
Total Suggested Retail Price	**$29,320.00**

THIS LABEL HAS BEEN APPLIED PURSUANT TO FEDERAL LAW, DO NOT REMOVE OR ALTER PRIOR TO THE DELIVERY TO THE ULTIMATE PURCHASER.

Figure A3. Window Sticker (Monroney Label)

Figure A4. Vehicle Certification Label

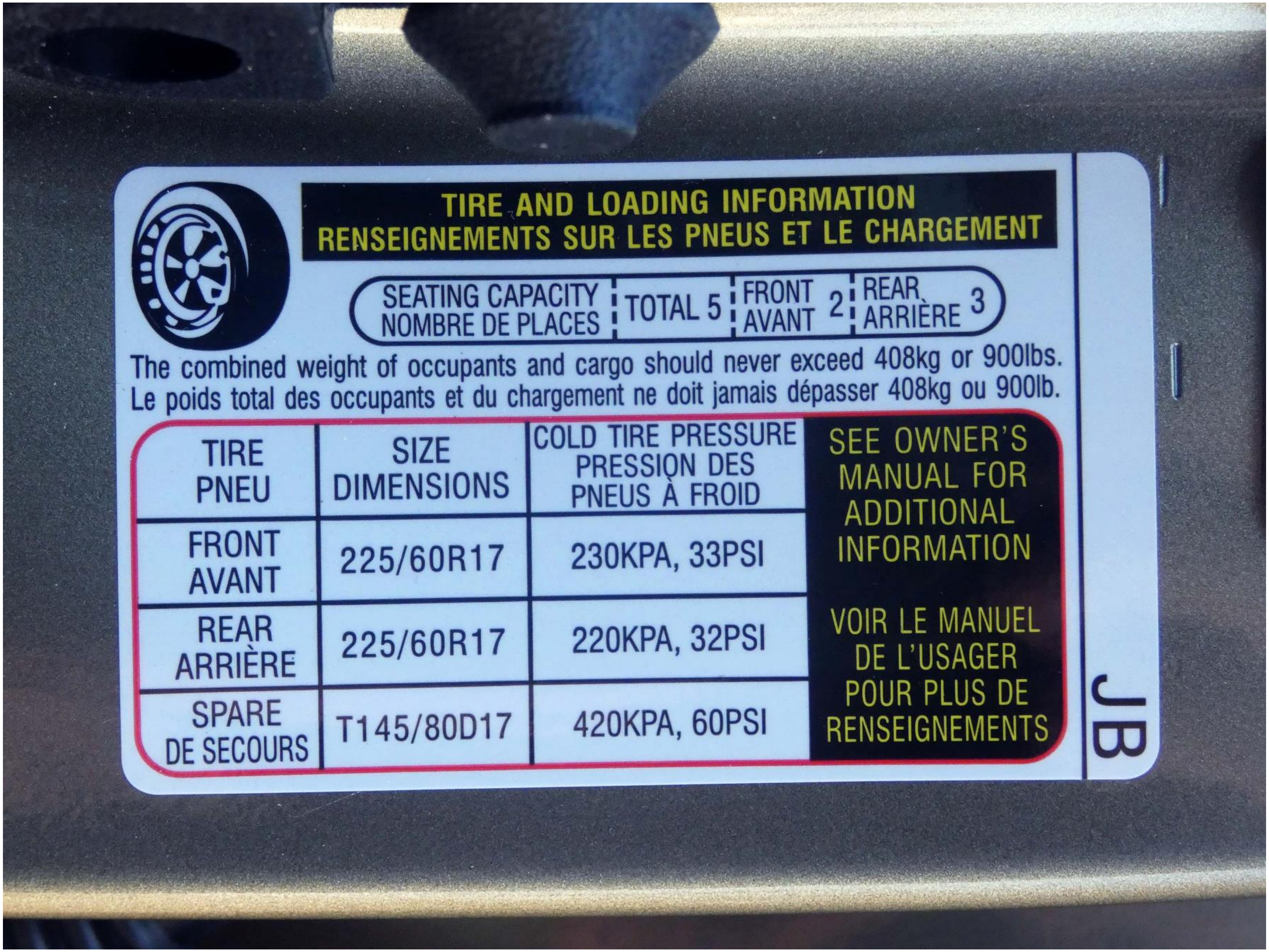

Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

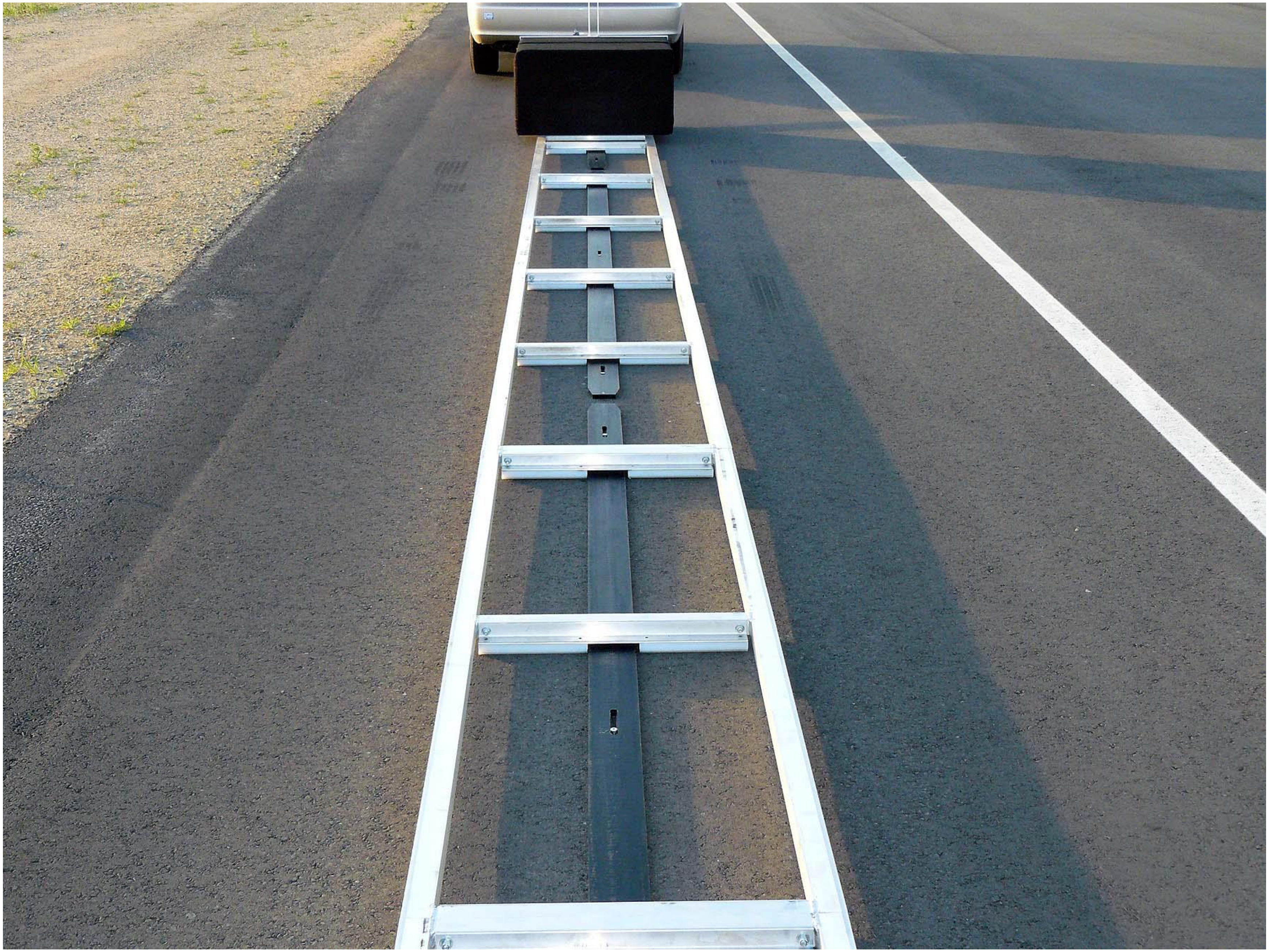

Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

Figure A9. Steel Trench Plate

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

Figure A11. Sensors for Detecting Auditory and Visual Alerts

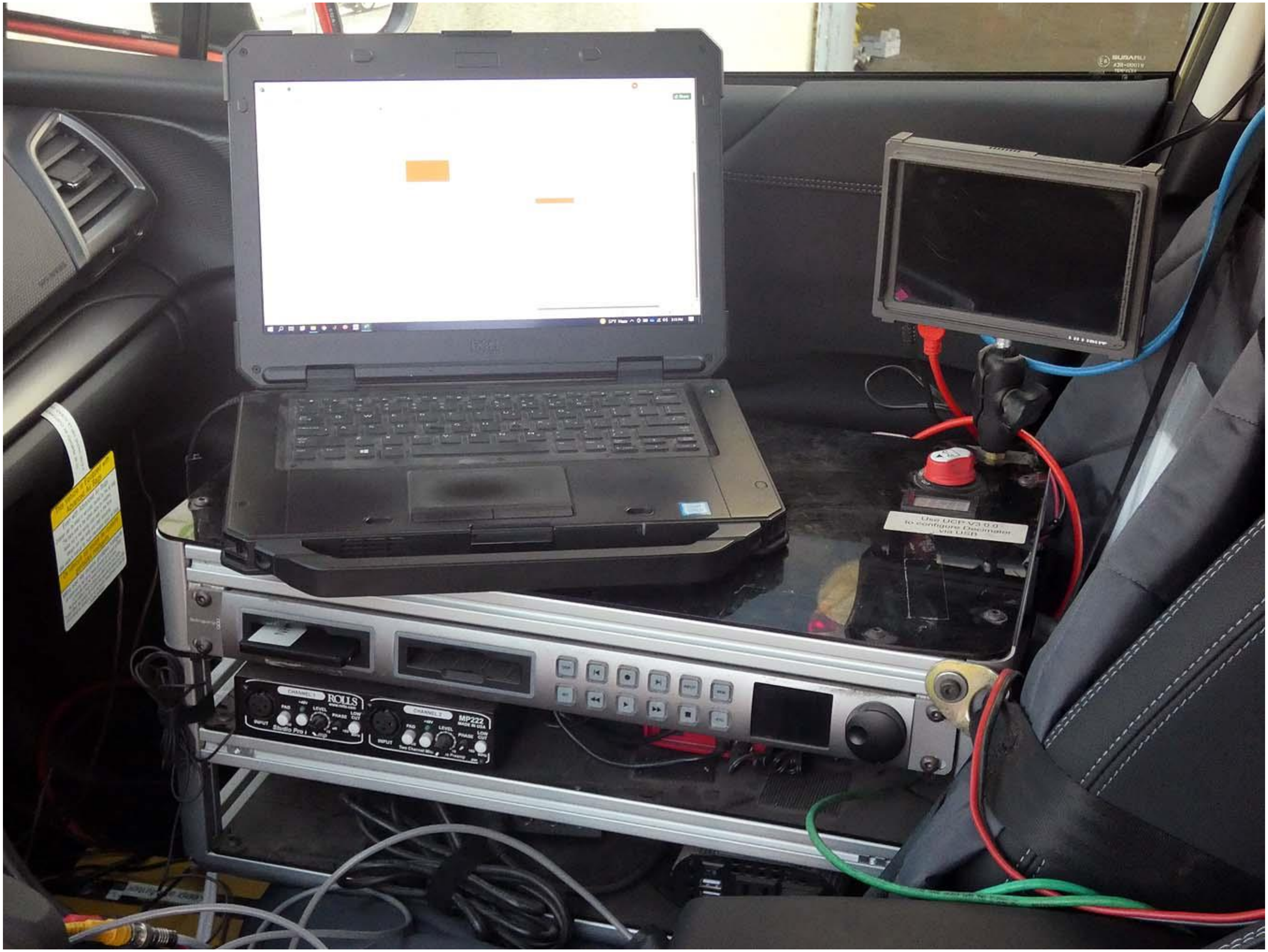

Figure A12. Computer Installed in Subject Vehicle

Figure A13. Brake Actuator Installed in Subject Vehicle

Figure A14. Brake Actuator Installed in POV System

Figure A15. Button for Disabling AEB System

Figure A16. Visual Alert

APPENDIX B

Excerpts from Owner's Manual

Pre-Collision Braking System

When there is a risk of a collision with an obstacle in front (a vehicle, pedestrian, cyclist, etc.), the EyeSight system helps to prevent or minimize a collision by warning the driver. If the driver still does not take evasive action to avoid a collision, the brakes can be automatically applied just before the collision in order to reduce impact damage, or if possible, prevent the collision. If the driver takes evasive action to avoid a collision, Pre-Collision Braking Assist will operate in order to help the driver to prevent or minimize the collision.
This system can be effective not only with direct rear-end collisions, but also with offset rear-end collisions. In addition to rear-end collisions, this system can be effective for avoiding collisions with crossing pedestrians and cyclists and with oncoming vehicles and pedestrians when turning. This function can be activated when the select lever is in the "D", "M" (models with manual mode), "L" (models with "L" position) or "N" position.

⚠ WARNING

Pre-Collision Braking System operation

- Never use Pre-Collision Braking System and Pre-Collision Braking Assist to stop your car or avoid a collision under ordinary conditions. These functions cannot prevent collisions under all conditions. If the driver relies only on Pre-Collision Braking System for Brake operation, collisions may occur.
- When a warning is activated, pay attention to the front of the vehicle and its surroundings, and operate the brake pedal and/or take other actions if necessary.
- The EyeSight Pre-Collision Braking System is primarily designed to prevent rear-end collisions with other vehicles when possible or to minimize damage and injuries in the event of a collision. In addition to other vehicles, things such as motorbikes, cyclists and pedestrians can also be treated as obstacles. However, there may be cases when detection is not possible depending on a variety of conditions[*2]. For example, when a vehicle is viewed from the side, oncoming vehicle, vehicles approaching in reverse, small animals or children, or walls or doors are not likely to be detected.
- Pre-Collision Braking System will operate at the point when it determines that a collision cannot be avoided and is designed to apply strong braking force just before a collision. The result of this varies depending on a variety of conditions[*2]. Because of this, performance of this function will not always be the same.
- When Pre-Collision Braking System is activated, it will continue to operate even if the accelerator pedal is partially depressed. However, it will be canceled if the accelerator pedal is suddenly or fully depressed.

- If the driver depresses the brake pedal or turns the steering wheel, the system may determine that this constitutes evasive action by the driver, and the automatic braking control may not activate in order to allow the driver full control.
- If the speed difference with the obstacle is greater than approximately 37 mph (60 km/h), collisions cannot be avoided due to performance limitations of EyeSight. However, even if the speed difference is approximately 37 mph (60 km/h) or less, if an obstacle cuts in front of you or moves outside the camera's field of view, the vehicle might not be able to stop or the system might not activate when the visibility, road slipperiness, etc. do not meet the following conditions.*

*: Conditions in which Pre-Collision Braking System cannot detect obstacles:

- Distance to obstacle in front of you, speed difference, proximity conditions, lateral displacement (the amount of offset)
- Vehicle conditions (amount of load, number of occupants, etc.)
- Road conditions (grade, slipperiness, shape, bumps, etc.)
- Visibility ahead is poor (rain, snow, fog or smoke, etc.).
- The detected object is something other than a vehicle, motorcycle, cyclist or pedestrian.
  - A domestic animal or other animal (a dog or deer, etc.)
  - A guardrail, telephone pole, tree, fence or wall, etc.
- Even if the obstacle is a motorcycle, cyclist or pedestrian, depending on the brightness of the surroundings, its relative movement, its aspect, and the direction it is facing, there may be cases when the system cannot detect it.
- The system determines that operation by the driver (based on accelerator pedal operation, braking, steering wheel angle, etc.) is intended as evasive action.
- Vehicle maintenance status (brake systems, tire wear, tire pressure, whether a temporary spare tire is being used, etc.)
- A trailer or another vehicle, etc. is being towed.
- The brakes are cold due to the outside temperature being low or just after starting the engine.
- The brakes are overheated on downhill grades (braking performance is reduced).
- In rain or after washing the vehicle (the brakes are wet and braking performance is reduced.)
- Recognition conditions of the stereo camera
  In particular, the function may be unable to stop the vehicle or may not activate in the following cases.

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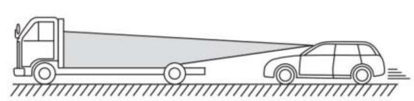
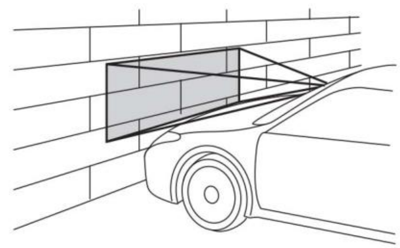
- The object moves outside the camera's field of view.
- Bad weather (for example heavy rain, a blizzard or thick fog)
- Visibility is poor due to sand, smoke or water vapor blowing in the wind, or the front vision is obscured due to water splashes, snow, dirt or dust stir up generated by the vehicle in front or oncoming traffic.
- At night or in a tunnel without the headlights on
- At night or in a tunnel when there is a vehicle in front that does not have its taillights on
- Approaching a motorcycle, cyclist or pedestrian at night
- A vehicle, motorcycle, cyclist or pedestrian is outside the area illuminated by the headlights.
- Strong light is coming from the front (for example, sunlight at dawn, sunset or headlight beams, etc.).
- The windshield has become fogged, scratched or smeared, or snow, dirt, dust or frost has adhered to it, or it is otherwise affected. These will reduce the stereo camera's field of view. Also, light is reflecting off the dirt, etc.
- Fluid has not been fully wiped off the windshield during or after washer use.
- The target cannot be correctly recognized because the stereo camera's view is obstructed by water droplets from rain or the window washer, or by the wiper blades.
- The stereo camera's field of view is obstructed (for example by a canoe on the roof of the vehicle).
- The vehicle is tilted at an extreme angle due to loaded cargo or other factors.
- It is pitch black and there are no objects in the surrounding area.
- The surrounding area is mostly the same color (for example in a snowy location).
- The rear aspect of the vehicle in front is low, small or irregular (the system may recognize another part of the vehicle as its rear and will determine operation from that).
  - There is an empty truck or trailer with no rear and/or side panels on the cargo bed.
  - Vehicles that have cargo protruding from their back ends
  - Non-standard shaped vehicles (vehicle transporters or vehicles with a sidecar fitted, etc.)
  - The height of the vehicle is low, etc.



S02133

- There is a wall, etc. in front of a stopped vehicle.
- There is another object near the vehicle.
- A vehicle, etc. has its side facing you.
- With vehicles that are backing up or with oncoming vehicles, etc.
- The size and height of an obstacle is smaller than the limitations of the stereo camera's recognition capability.
  - With small animals or children, etc.
  - With pedestrians who are sitting or lying down
- The detected object is a fence or wall, etc. with a uniform pattern (a striped pattern or brick pattern, etc.).
- There is a wall or door made of glass or a mirror in front.
- The vehicle in front suddenly swerves, accelerates, or decelerates.
- A vehicle, motorcycle, cyclist or pedestrian suddenly cuts in from the side or suddenly runs in front of you.


S00653

- Your vehicle is immediately behind an obstacle after changing lanes.
- There is a vehicle, motorcycle, cyclist or pedestrian in a location close to your vehicle's bumper.
- The speed difference between your vehicle and an obstacle is 4 mph (5 km/h) or less (As braking is performed once the obstacle is in close proximity to your vehicle, depending on the shape and size of the obstacle, there may be some cases when the obstacle is outside the range of the camera's field of view.).
- On sharp curves, steep uphill grades or steep downhill grades
- On a bumpy or unpaved road
- The brightness changes such as at a tunnel entrance or exit or when you drive under an overpass.

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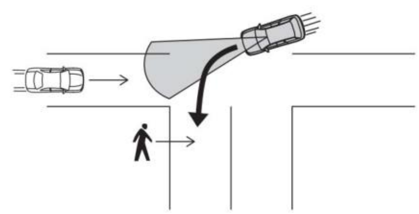
- Do not test Pre-Collision Braking System on its own. It may operate improperly and cause an accident.
- The system may not operate correctly under the conditions listed below. When these conditions occur, turn off Pre-Collision Braking System.
  ⇒ Page 61
  - The tire pressure is not correct.*1
  - The temporary spare tire is installed.*1
  - Tires that are unevenly worn or tires with uneven wear patterns are installed.*1
  - Tires that are the wrong size are installed.*1
  - A flat tire has been fixed temporarily with a tire repair kit.
  - The suspension has been modified (including a genuine SUBARU suspension that has been modified).
  - An object that obstructs the stereo camera's view is installed on the vehicle.
  - The headlights are dirty or they have snow and ice or dirt on them. (Objects are not correctly illuminated and are difficult to detect.)
  - The optical axes are not aligned correctly. (Objects are not correctly illuminated and are difficult to detect.)
  - The lights including headlights and fog lights have been modified.
  - Vehicle operation has become unstable due to an accident or malfunction.
  - The brake system warning light is illuminated.*2
  - The vehicle is tilted at an extreme angle due to loaded cargo or other factors.
  - The maximum number of occupants is exceeded.
  - The combination meter is not operating properly; such as when the lights do not illuminate, the beeps do not sound, the display is different from when it is normal, etc.*3

  *1: The wheels and tires have functions that are critically important. Be sure to use the correct ones. For details, refer to the Owner's Manual for your vehicle.

  *2: If the brake system warning light does not turn off, immediately pull the vehicle over in a safe place and contact a SUBARU dealer to have the system inspected. For details, refer to the Owner's Manual for your vehicle.

  *3: For details about the combination meter, refer to the Owner's Manual for your vehicle.

Activation of Pre-Collision Braking System when turning


S04093

- Operation of the EyeSight Pre-Collision Braking System when making a turn is intended to avoid collisions or reduce the severity of collisions with oncoming vehicles in the neighboring oncoming lane, particularly when you are crossing the oncoming lane to make a turn at an intersection, etc. In addition to oncoming vehicles, pedestrians can also be detected, but your vehicle may not stop or the system may not activate under certain conditions*.
- If your vehicle is moving faster than approximately 16 mph (25 km/h) when you turn, the system will not activate. Also, even if your vehicle is moving approximately 16 mph (25 km/h) or slower, if the obstacle suddenly cuts in front of you or is outside the stereo camera's field of view, your vehicle may not stop or the system may not activate depending on differing conditions* such as visibility or the slipperiness of the road.

*: Conditions

- Speed difference with the oncoming vehicle, distance to the oncoming vehicle, the angle of approach, changes in the actions of the oncoming vehicle and the position of the other vehicle relative to the side of your vehicle.
- Vehicle conditions (amount of load, number of occupants, etc.)
- Road conditions (grade, slipperiness, shape, bumps, etc.)
- Visibility ahead is poor (rain, snow, fog or smoke, etc.).
- The obstacle is something other than an oncoming vehicle or pedestrian.
  - A parked vehicle or a vehicle that is traveling in the same direction as your vehicle
  - An animal, etc.
  - A guardrail, telephone pole, tree, fence or wall, etc.
- Even if an oncoming vehicle has been detected, you are not signaling to move in the direction that your vehicle is actually traveling.
- Even if the obstacle is an oncoming vehicle, it is traveling close to objects on the side of the road.
- Even if the obstacle is an oncoming vehicle, it is stopped or traveling in your lane.

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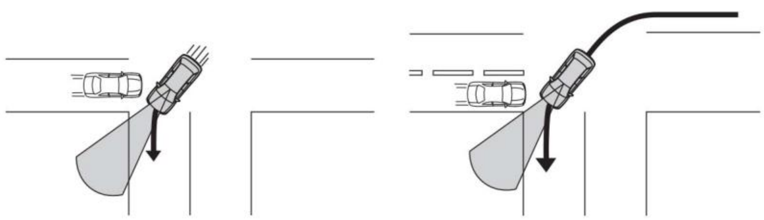
- Even if the obstacle is an oncoming vehicle, the system cannot recognize it as a target obstacle because, for example, the front of the vehicle cannot be seen or the vehicle is difficult to see because it is driving without its headlights on at night.
- Even if the obstacle is an oncoming vehicle, your vehicle moved into the oncoming vehicle's path before the system could recognize it as a target obstacle.
- Even if the obstacle is an oncoming vehicle, your vehicle is in the oncoming lane.



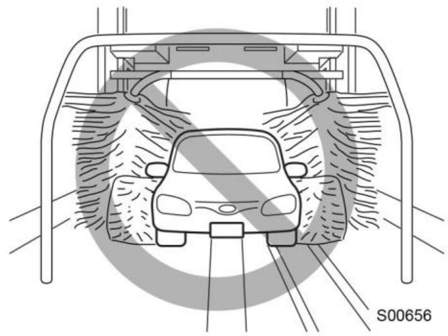
S04094

- Even if the obstacle is a pedestrian, depending on the brightness of the surroundings, its relative movement, its aspect, and the direction it is facing, there may be cases when the system cannot detect it.

• In particular, there is a high possibility that your vehicle cannot stop or that the system will not activate in the following cases:
  - Visibility is poor due to water, snow, dust, etc. kicked up by another vehicle, or due to water vapor, sand, smoke, etc. in the air.
  - Approaching a pedestrian at night.
  - The oncoming vehicle or pedestrian is outside the area illuminated by the headlights.
  - The front aspect of the oncoming vehicle is small, low or irregular.
  - The vehicle, etc. has its side facing you.
  - The vehicle, etc. is backing up.
  - The oncoming vehicle suddenly swerves, accelerates or decelerates.
  - The oncoming vehicle or pedestrian suddenly cuts in from the side or suddenly runs in front of you.
  - The oncoming vehicle or pedestrian is close to your vehicle's bumper.
  - You turn the steering wheel suddenly away or back to your direction of travel.

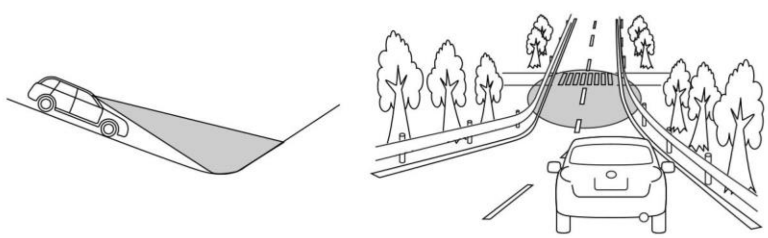
⚠ CAUTION

- In the following situations, turn off Pre-Collision Braking System. Otherwise Pre-Collision Braking System may activate unexpectedly.
  ⇒ Page 61
  - The vehicle is being towed.
  - The vehicle is being loaded onto a carrier.
  - A chassis dynamometer, free-rollers or similar equipment is being used.
  - A mechanic lifts up the vehicle, starts the engine and spins the wheels freely.
  - Passing hanging banners, flags or branches
  - Thick/tall vegetation is touching the vehicle.
  - Driving on a race track
  - In a drive-through car wash



S00656

- Pre-Collision Braking System may activate in the following situations. Therefore concentrate on safe driving.
  - Passing through an automatic gate (opening and shutting)
  - Driving close to the vehicle in front, pedestrian or cyclist
  - Driving in a location where the grade of the road changes rapidly



S01264

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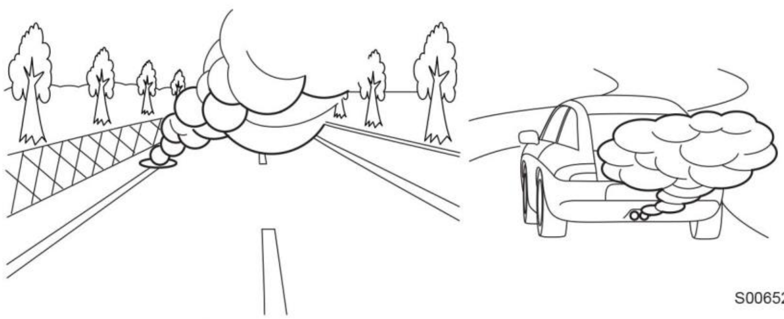
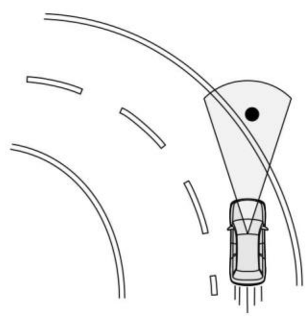
- Visibility is poor due to sand, smoke or water vapor blowing in the wind, or the front vision is obscured due to water splashes, snow, dirt or dust stir up generated by the vehicle in front or oncoming traffic.
- Passing through clouds of steam or smoke, etc.
- In adverse weather, such as heavy snow or snowstorms
- The exhaust gas emitted by the vehicle in front is clearly visible in cold weather, etc.



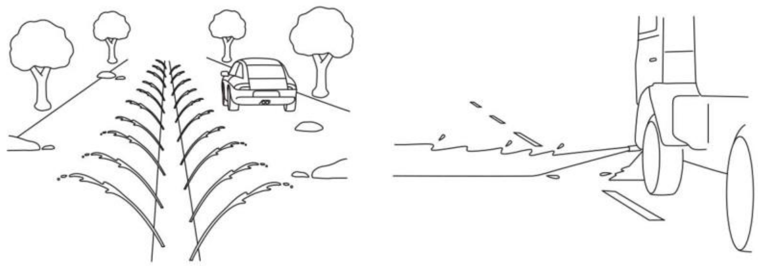
S00652

- There is an obstacle on a curve or intersection.
- You are passing close to the side of a vehicle, an obstacle or vegetation.
- Stopping very close to a wall or a vehicle in front



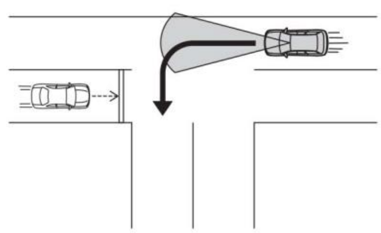
S02669

- Passing through water spray from road sprinklers or snow clearing sprinklers on the road



S02636

- If there is cargo or installed accessories, etc. that are protruding beyond the edge of the front bumper, the vehicle's length will increase and the system may not be able to prevent a collision.
- If you operate the brake pedal during automatic braking, the pedal may feel stiff. The brake pedal may also move on its own during automatic braking. However, this is normal. By depressing the brake pedal further, you can apply more braking force. Apply more braking force as necessary.
- Pre-Collision Braking System may activate in the following situations even when there is no oncoming vehicle or pedestrian approaching.
  - An oncoming vehicle decelerates or stops before an intersection just before you make a turn and enter the oncoming lane.



H00295

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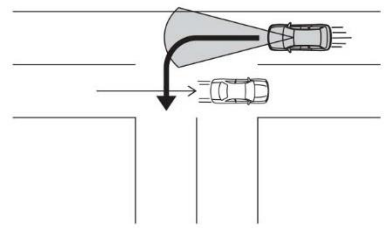
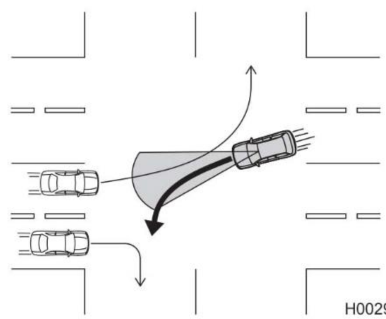
- An oncoming vehicle passes by just before you make a turn and enter the oncoming lane.



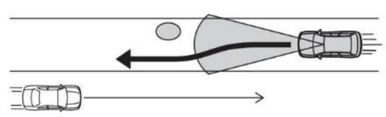
H00296

- Just before you make a turn and enter the oncoming lane, you pass by an oncoming vehicle also making a turn.



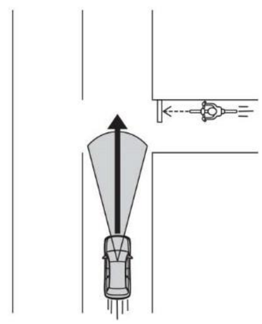
H00297

- You suddenly approach close to an oncoming vehicle while trying to change lanes or avoid an obstacle.
- When you are turning, a pedestrian crosses in front of your vehicle or just before crossing slows down or stops.



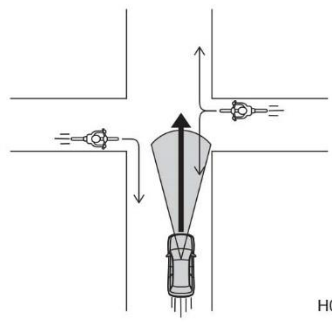
H00298

- A vehicle, motorcycle, cyclist or pedestrian slows down or stops just before crossing in front of you.



H00368

- A vehicle, motorcycle, cyclist or pedestrian changes direction to either join your lane or pass by you in the opposite direction just before crossing in front of you.



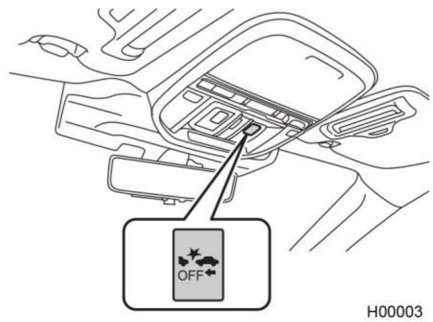
H00369

NOTE

Some unusual noises may be audible during automatic braking. This is caused by the braking control and is normal.

Turning off Pre-Collision Braking System

Press and hold the Pre-Collision Braking System OFF switch for approximately 2 seconds or longer to turn off Pre-Collision Braking System (including Pre-Collision Braking Assist and Automatic Emergency Steering (if equipped)). When 1 short beep sound emits, this control is turned off and the Pre-Collision Braking System OFF indicator light on the instrument panel illuminates.
To turn the control back on, press and hold the Pre-Collision Braking System OFF switch for approximately 2 seconds or longer again. When this control is turned on, the Pre-Collision Braking System OFF indicator light turns off.



H00003

NOTE

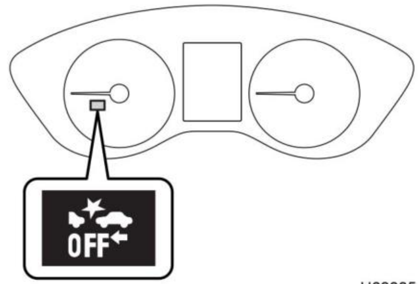
- When Pre-Collision Braking System is turned off, the Automatic Emergency Steering (if equipped) and Pre-Collision Throttle Management Control function are also turned off.
- Even when Pre-Collision Braking System is turned off, if the engine is turned off and then restarted, Pre-Collision Braking System will be turned on. The system default setting when the vehicle is restarted is on.

■Pre-Collision Braking System OFF indicator light

This indicator light illuminates when the ignition switch is turned to the ON position, and remains illuminated for approximately 10 seconds after the engine starts. It turns on when Pre-Collision Braking System, Automatic Emergency Steering (if equipped) and Pre-Collision Throttle Management are turned off.

It also illuminates under the following conditions.

- The EyeSight system has a malfunction.
  ⇒ Page 155
- The EyeSight system has stopped temporarily.
  ⇒ Page 157



H00005

NOTE

- If the Pre-Collision Braking System OFF indicator light illuminates, the Automatic Emergency Steering OFF indicator (if equipped) also illuminates.
  ⇒ Page 60
- When the Pre-Collision Braking System OFF indicator light is turned on, Pre-Collision Braking System (including the Pre-Collision Braking Assist function), Automatic Emergency Steering (if equipped) and Pre-Collision Throttle Management do not operate.
- For models with Automatic Emergency Steering, you cannot use Automatic Emergency Steering when BSD/RCTA is turned off. In this case, the Automatic Emergency Steering OFF indicator illuminates.

APPENDIX C

Run Log

Subject Vehicle: **2022 Subaru Forester Premium/NFF** Test start date: **2/8/2022**

Principal Other Vehicle: **SSV** Test end date: **2/9/2022**

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
1-14	Brake characterization and determination						See Appendix D
15	Static Run						
16	**Stopped POV**	N					Brake force
17		N					Brake onset
18		N					Brake force
19		Y	2.87	5.18	1.00	Pass	
20		Y	2.87	4.34	1.02	Pass	
21		Y	2.86	4.69	1.04	Pass	
22		Y	2.91	5.30	1.06	Pass	
23		N					Throttle
24		Y	2.83	5.28	1.00	Pass	
25		N					Brake force
26		Y	2.91	4.34	1.05	Pass	
27		Y	2.87	4.48	0.96	Pass	
28	Static Run						

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
29	**Slower POV, 25 vs 10**	Y	2.52	6.35	0.95	Pass	
30		Y	2.46	4.69	0.49	Pass	
31		Y	2.52	2.40	0.48	Pass	
32		N					DBS Brake Onset
33		Y	2.43	3.27	0.47	Pass	
34		N					Brake Application Rate
35		N					Post Processor Issue
36		Y	2.34	6.24	0.68	Pass	
37		Y	2.44	4.99	0.55	Pass	
38		Y	2.58	5.23	0.50	Pass	
39	Static run						
52	**Slower POV, 45 vs 20**	Y	3.12	6.35	0.91	Pass	
53		Y	2.89	6.76	0.69	Pass	
54		Y	3.21	6.49	0.94	Pass	
55		Y	3.03	4.48	0.60	Pass	
56		Y	3.10	6.08	1.01	Pass	
57		Y	3.16	6.39	1.00	Pass	
58		Y	3.20	5.58	0.99	Pass	
59	Static run						

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
40	**Decelerating POV, 35**	N					POV Speed, Brake Force
41		N					Headway
42		Y	1.89	7.96	0.57	Pass	
43		Y	1.84	6.13	0.54	Pass	
44		Y	1.95	7.55	0.54	Pass	
45		N					Brake TTC
46		Y	1.79	5.41	0.56	Pass	
47		Y	1.71	5.74	0.53	Pass	
48		Y	1.72	10.21	0.55	Pass	
49		N					POV speed
50		Y	1.93	3.33	0.53	Pass	
51	Static run						
60	STP - Static run						
61	**Baseline, 25**	Y			0.58		
62		Y			0.57		
63		Y			0.59		
64		Y			0.57		
65		N					Throttle
66		Y			0.58		

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
67		N					Throttle
68		Y			0.64		
69		Y			0.65		
70	STP - Static run						
71	**Baseline, 45**	Y			0.56		
72		Y			0.54		
73		N					Throttle
74		Y			0.60		
75		Y			0.57		
76		Y			0.57		
77		N					Throttle
78		Y			0.56		
79		Y			0.56		
80	STP - Static run						
81	STP - Static run						
82	**STP False Positive, 25**	N					Lateral offset
83		N					Brake decel high
84-92	Brake confirmation check runs						See Appendix D

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
93		N					Throttle encoder not working
94		N					Throttle encoder not working
95		Y			0.43	Pass	
96		Y			0.42	Pass	
97		Y			0.42	Pass	
98		Y			0.44	Pass	
99		Y			0.41	Pass	
100		Y			0.44	Pass	
101		Y			0.41	Pass	
102	STP - Static run						
103	**STP False Positive, 45**	Y			0.49	Pass	
104		Y			0.50	Pass	
105		Y			0.52	Pass	
106		Y			0.54	Pass	
107		Y			0.52	Pass	
108		Y			0.53	Pass	
109		N					SV Speed
110		Y			0.54	Pass	
111	STP - Static run						

APPENDIX D

Brake Characterization

Subject Vehicle: **2022 Subaru Forester Premium/NFF**

Test start date: **2/8/2022**

Test end date: **2/9/2022**

DBS Initial Brake Characterization				
Run Number	Stroke at 0.4 g (in)	Force at 0.4 g (lb)	Slope	Intercept
1	1.28	19.16	1.203	0.070
2	1.32	19.97	0.962	0.244
3	1.31	19.81	0.947	0.251

DBS Brake Characterization Determination								
Run	DBS Mode	Speed	Valid Run	Average Decel. (g)	0.4 g Stroke Value (in)	0.4 g Force Value (lb)	Stroke/Force Calculator (in)	Notes
4	Displacement	35	N					Brake Rate
5		35	Y	0.456	1.30		1.14	
6		35	Y	0.406	1.25		1.23	
7		25	Y	0.394	1.25		1.27	
8		45	Y	0.393	1.25		0.13	
9	Hybrid	35	Y	0.482	1.25	19.65	16.31	
10		35	Y	0.453	1.25	16.50	14.57	

DBS Brake Characterization Determination								
Run	**DBS Mode**	**Speed**	**Valid Run**	**Average Decel. (g)**	**0.4 g Stroke Value (in)**	**0.4 g Force Value (lb)**	**Stroke/Force Calculator (in)**	**Notes**
11		35	Y	0.351	1.25	13.00	14.81	
12		35	Y	0.397	1.25	14.50	14.61	
13		25	Y	0.392	1.25	14.50	14.80	
14		45	Y	0.409	1.25	14.50	14.18	
84	Hybrid	25	N					Check run
85		25	N					Check run
86		25	N					Check run
87		25	N					Check run
88		25	N					Check run
89		25	N					Check run
90		25	N					Check run
91		25	N					Check run
92		25	N					Check run

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, green circle, or red asterisk appears on the brake pedal position data over the DBS controller brake onset period. The black bar signifies the time over which the brake application rate is determined, and the calculated brake application rate is displayed on the figure. If instead, a green dot or red asterisk is displayed, the brake application rate is being assessed under a newly developed requirement. For vehicles that exhibit brake pedal movement during the activation of the brake actuator, the target brake pedal displacement that results in 0.4 g of vehicle deceleration must be achieved within 250 ms of activation. If the target brake pedal displacement was achieved, a green circle is displayed. If not, a red asterisk is displayed.

- If the tests are performed in Displacement mode, the plot shows a short dashed black line above the brake onset period representing the maximum allowable 20% overshoot and 100 ms time period beyond the commanded pedal position.

  Additionally, a green envelope representing ±10% of the target brake pedal position is shown. If the brake pedal position exceeds the boundaries of the envelope, the run is invalid.

- If the tests are performed in Hybrid mode, no other brake pedal position requirements are shown.

For the brake force plots:

- A short, solid black line at 2.5 lbs is displayed representing the required nominal TTC or distance in which the brakes must be applied. If the brakes are applied based on a real-time calculation of TTC (which is standard practice), the tolerance is ±0.05 sec and the TTC of the brake onset is displayed. If the brakes cannot be applied based on a real-time TTC due to regenerative braking or other factors, the brakes are applied based on a distance calculation. The tolerance is ±2 ft and no other values are displayed. If the brakes are applied at the correct TTC or distance, a green dot is displayed. If not, a red asterisk is displayed.

- If the tests are performed in Displacement mode, no other brake force requirements are shown.

- If the tests are performed in Hybrid mode, a long, dashed black line is displayed at 2.5 lbs representing the minimum brake force required while the brake actuator is active. Exceedances of this brake force threshold are indicated by red shading in the area between the measured time-varying data and the dashed threshold line.

  additionally, a blue envelope representing ±10% of the target average brake force is shown along with the calculated average during that time period. Note that the brake force may exceed the boundaries of the envelope as long as the overall average is within tolerance.

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

Color Codes

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

Color codes can be broken into four categories:

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

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

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

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

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

Other Notations

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

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

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

Notes

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

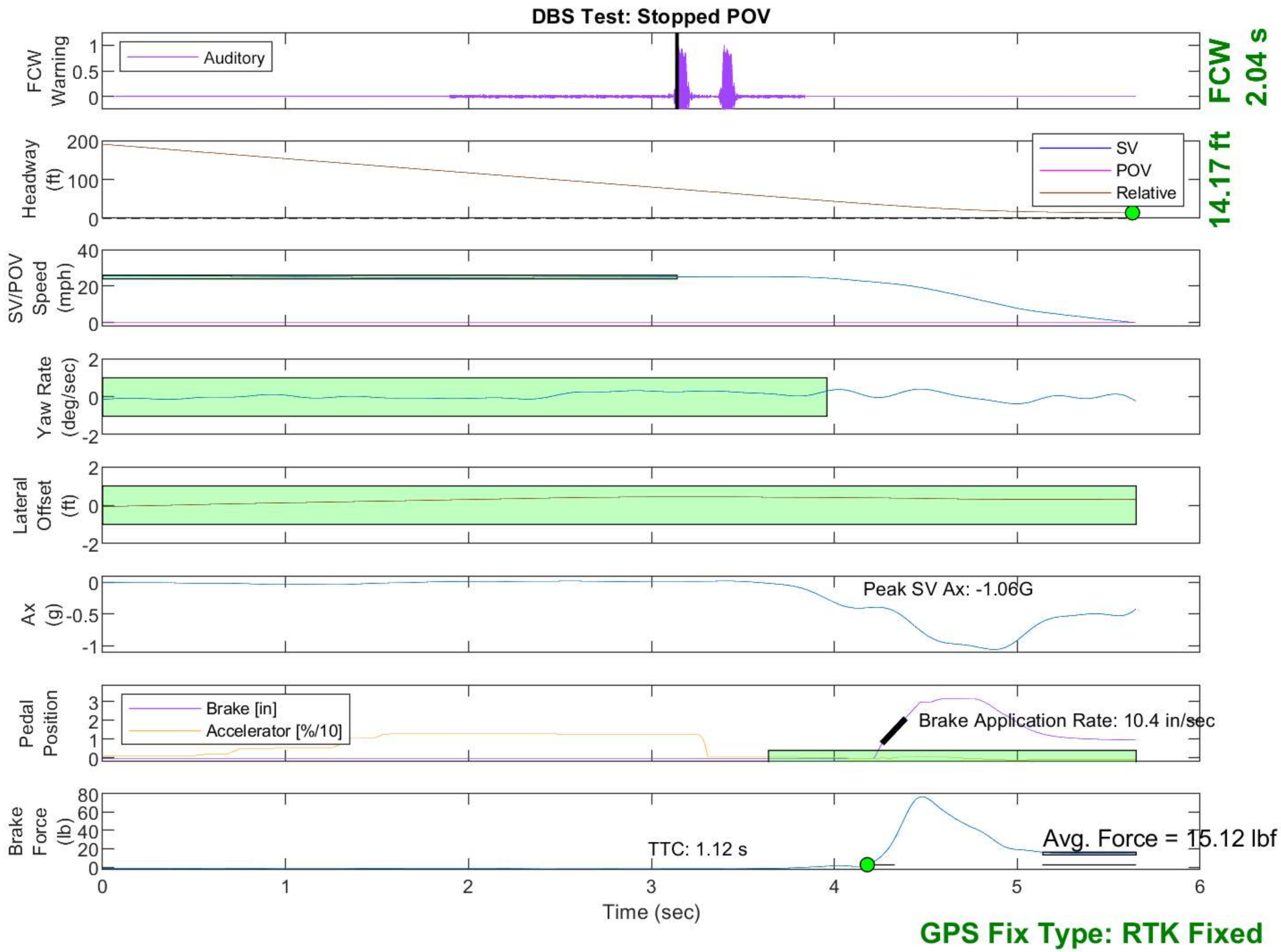


Figure E1. Example Time History for Stopped POV, Passing

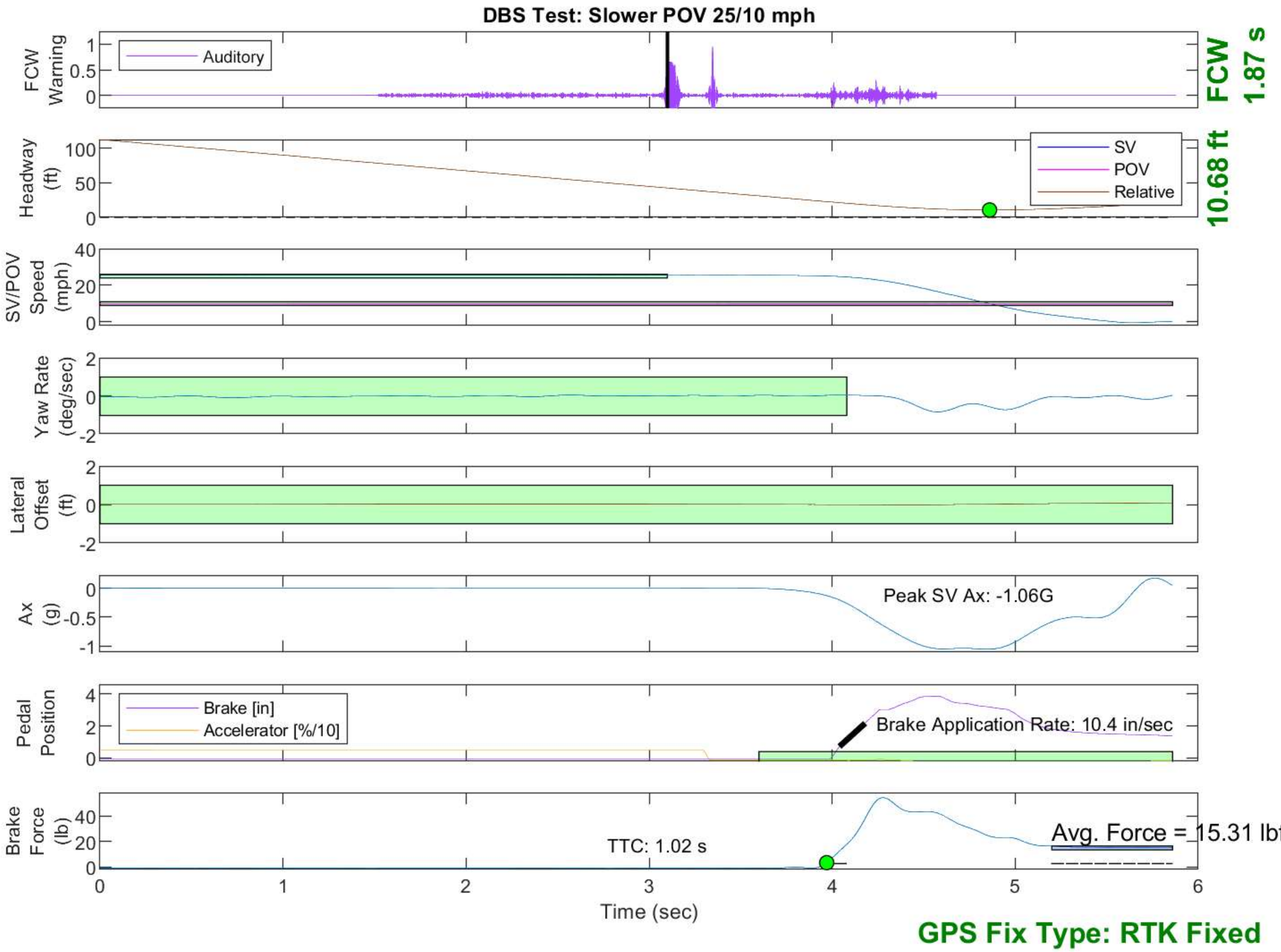


Figure E2. Example Time History for Slower POV 25 vs. 10, Passing

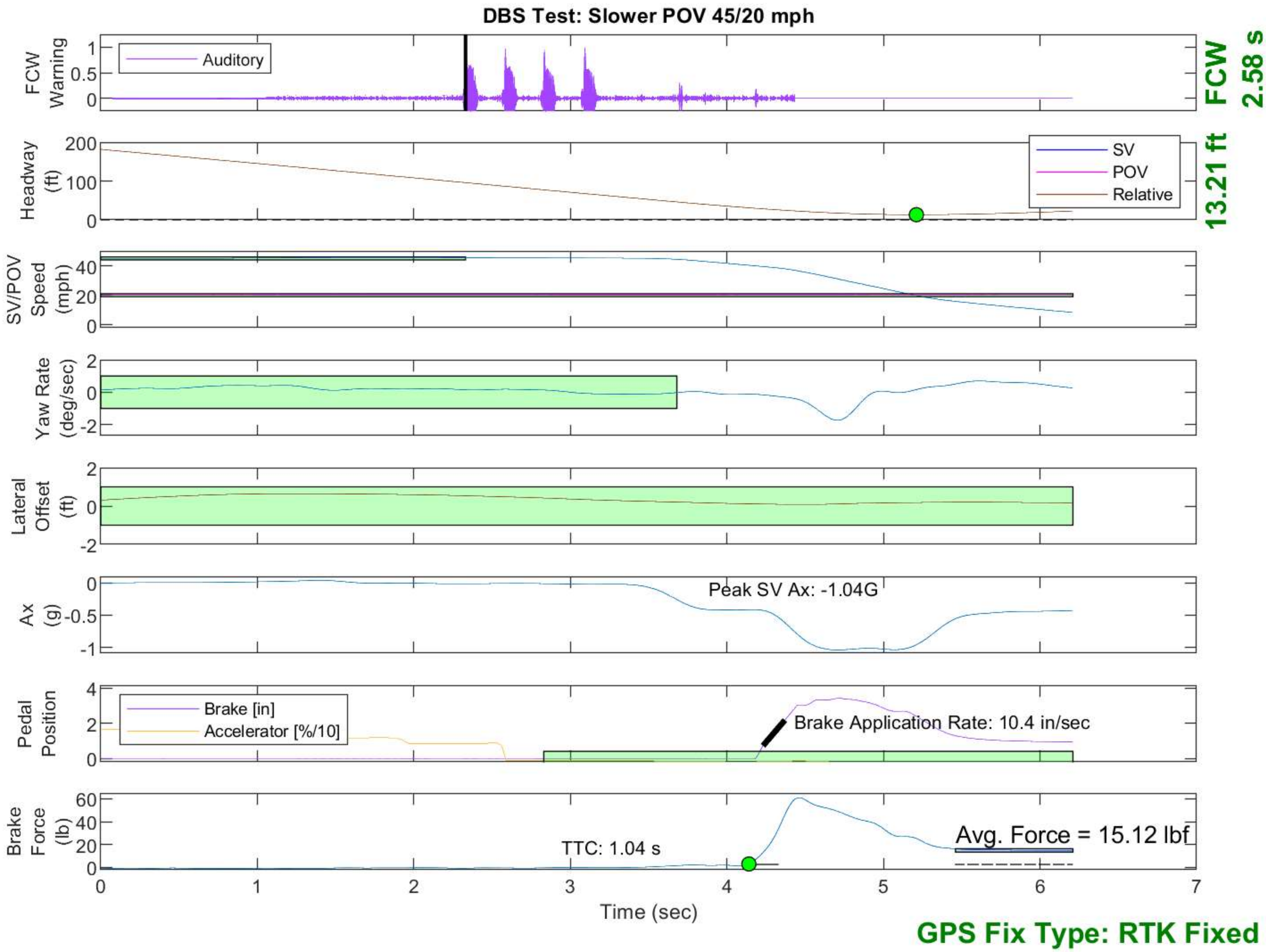


Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

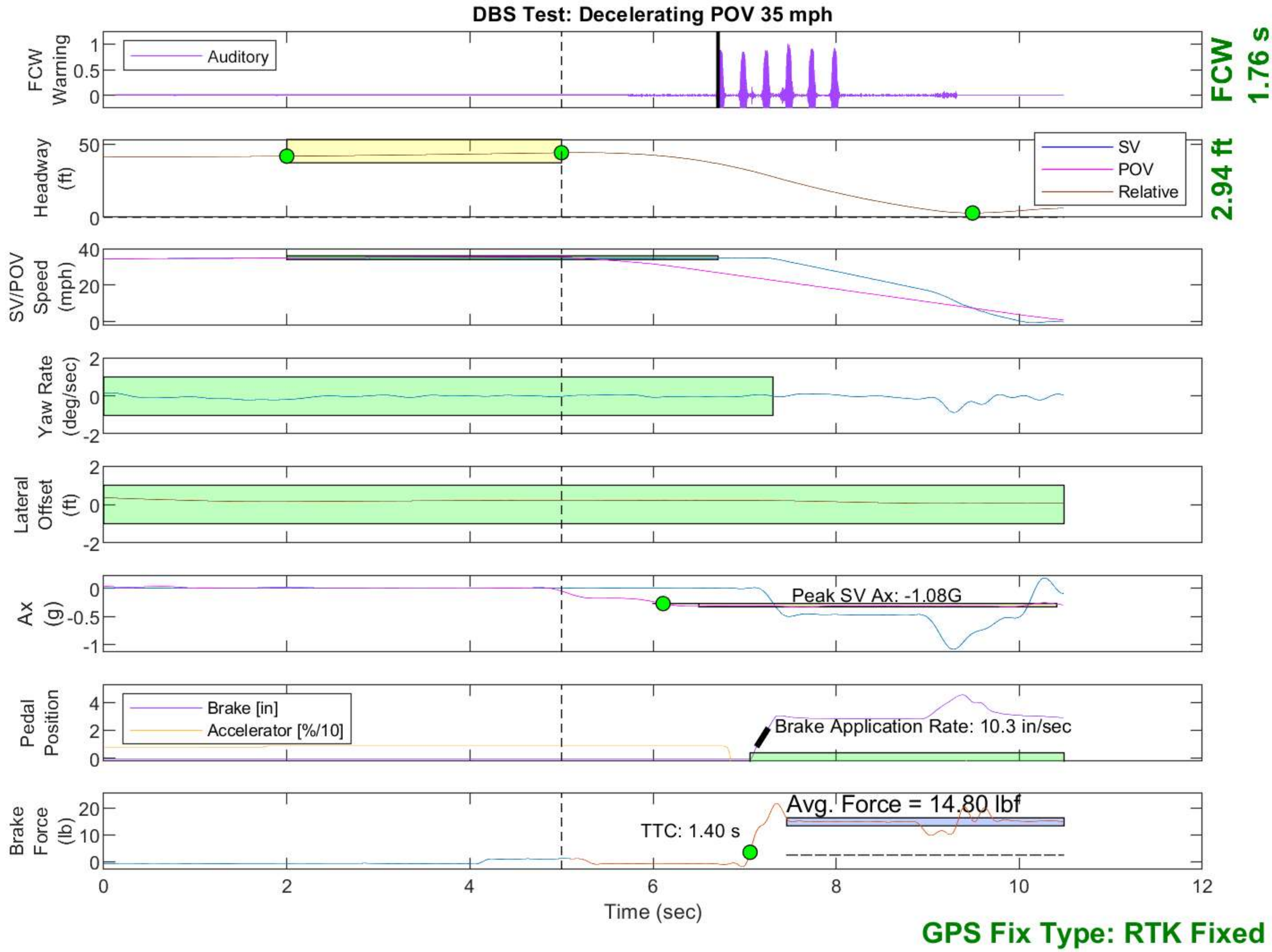


Figure E4. Example Time History for Decelerating POV 35, Passing

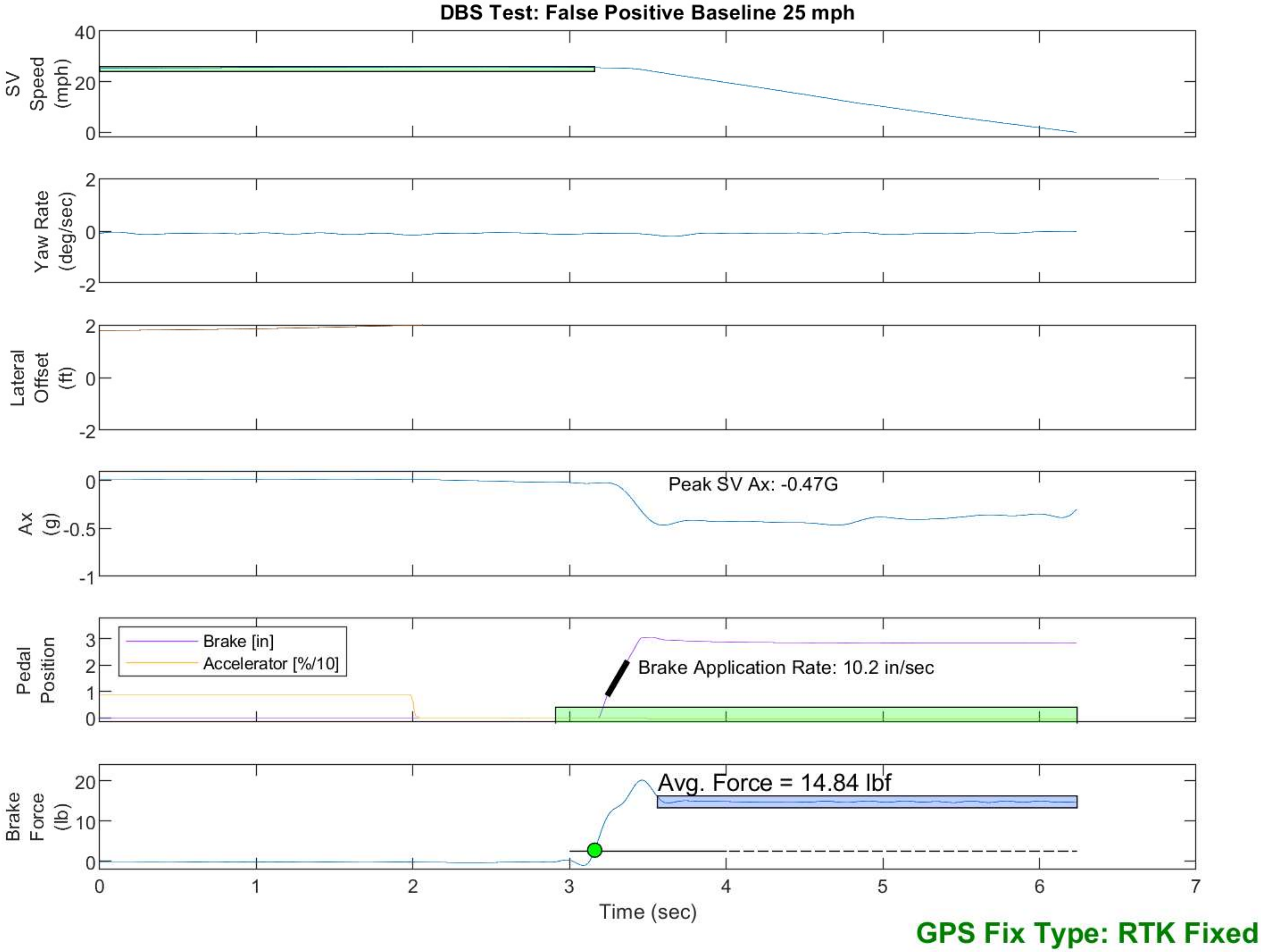


Figure E5. Example Time History for False Positive Baseline 25

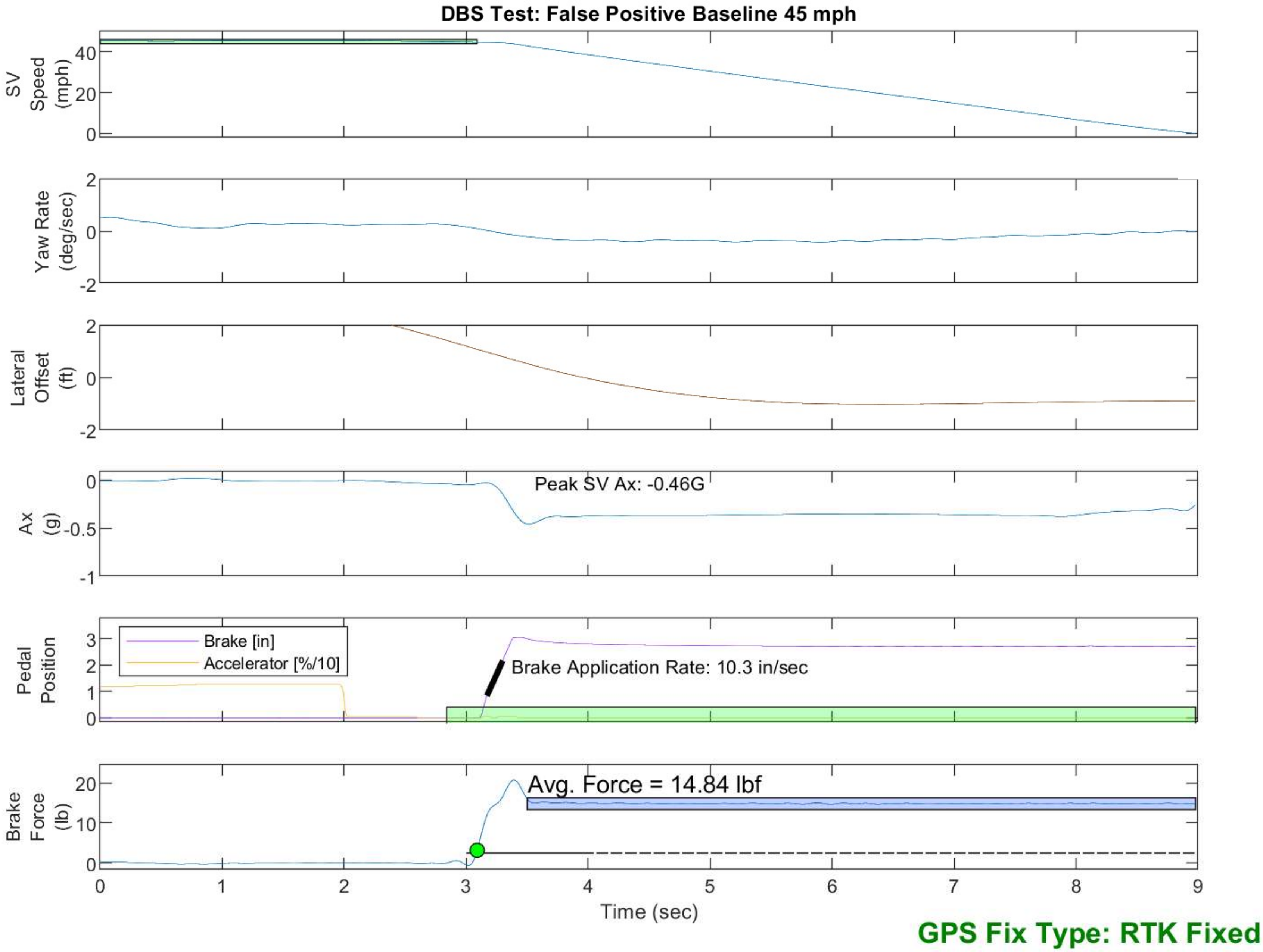


Figure E6. Example Time History for False Positive Baseline 45

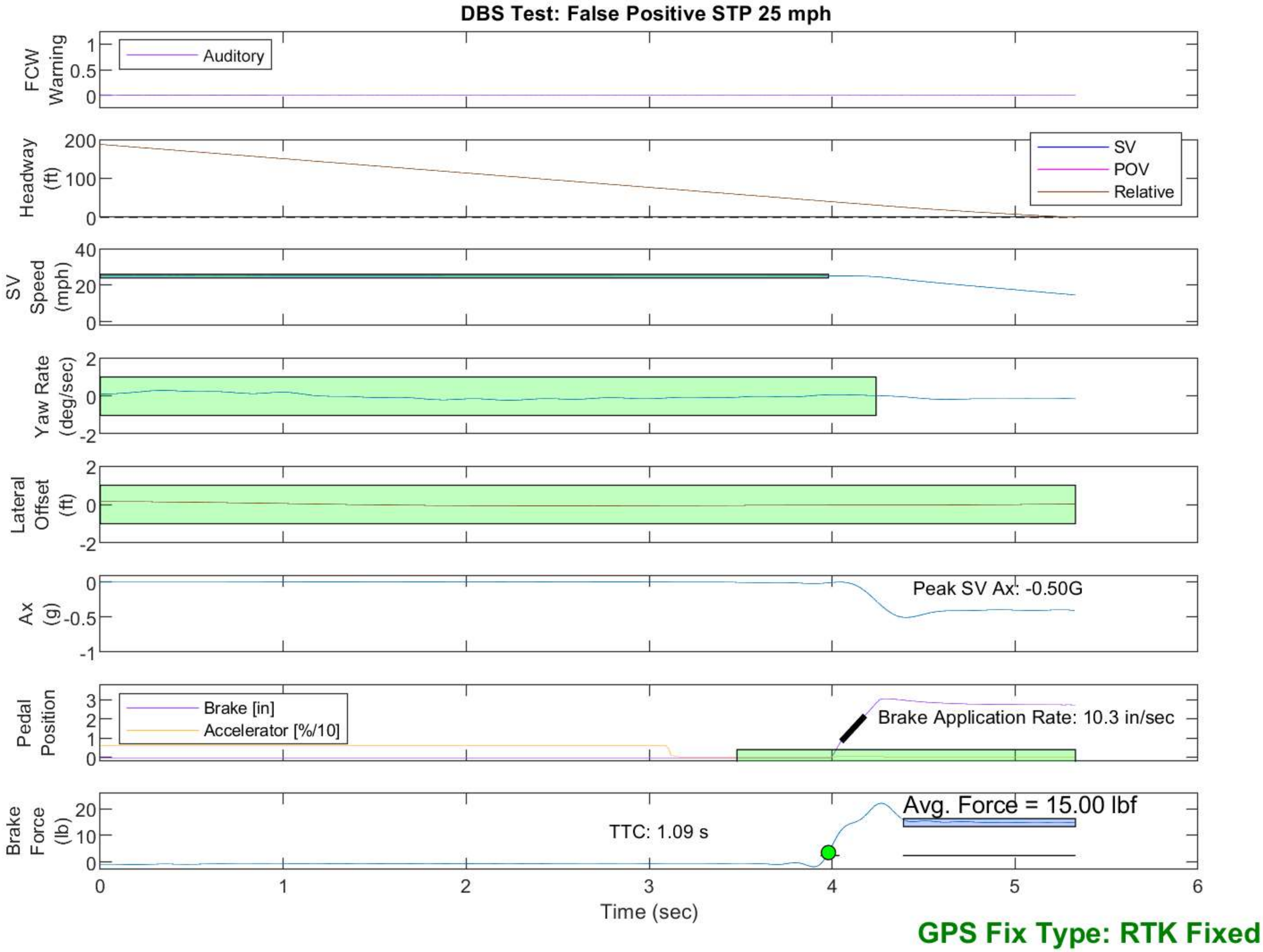


Figure E7. Example Time History for False Positive Steel Plate 25, Passing

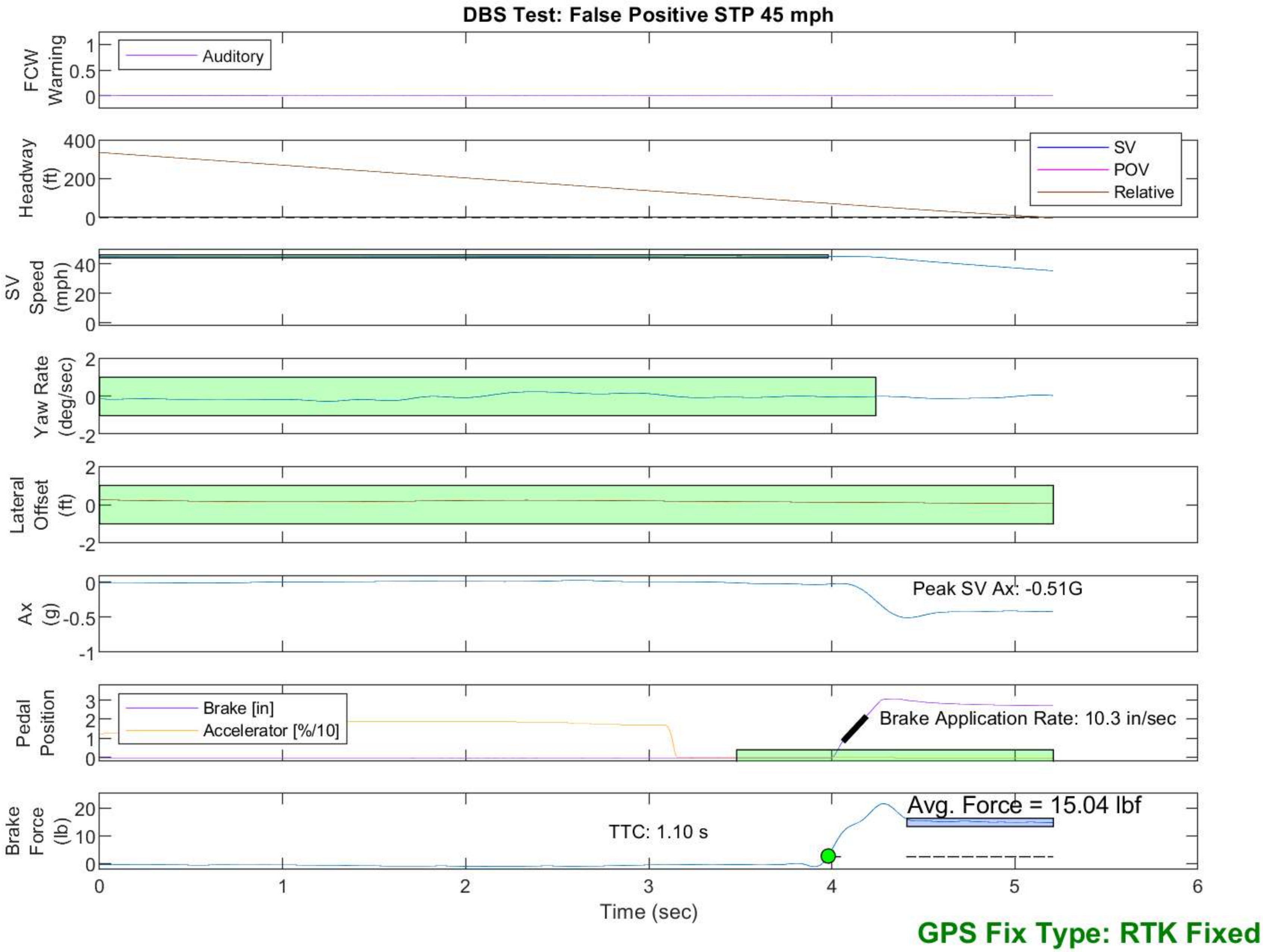


Figure E8. Example Time History for False Positive Steel Plate 45, Passing

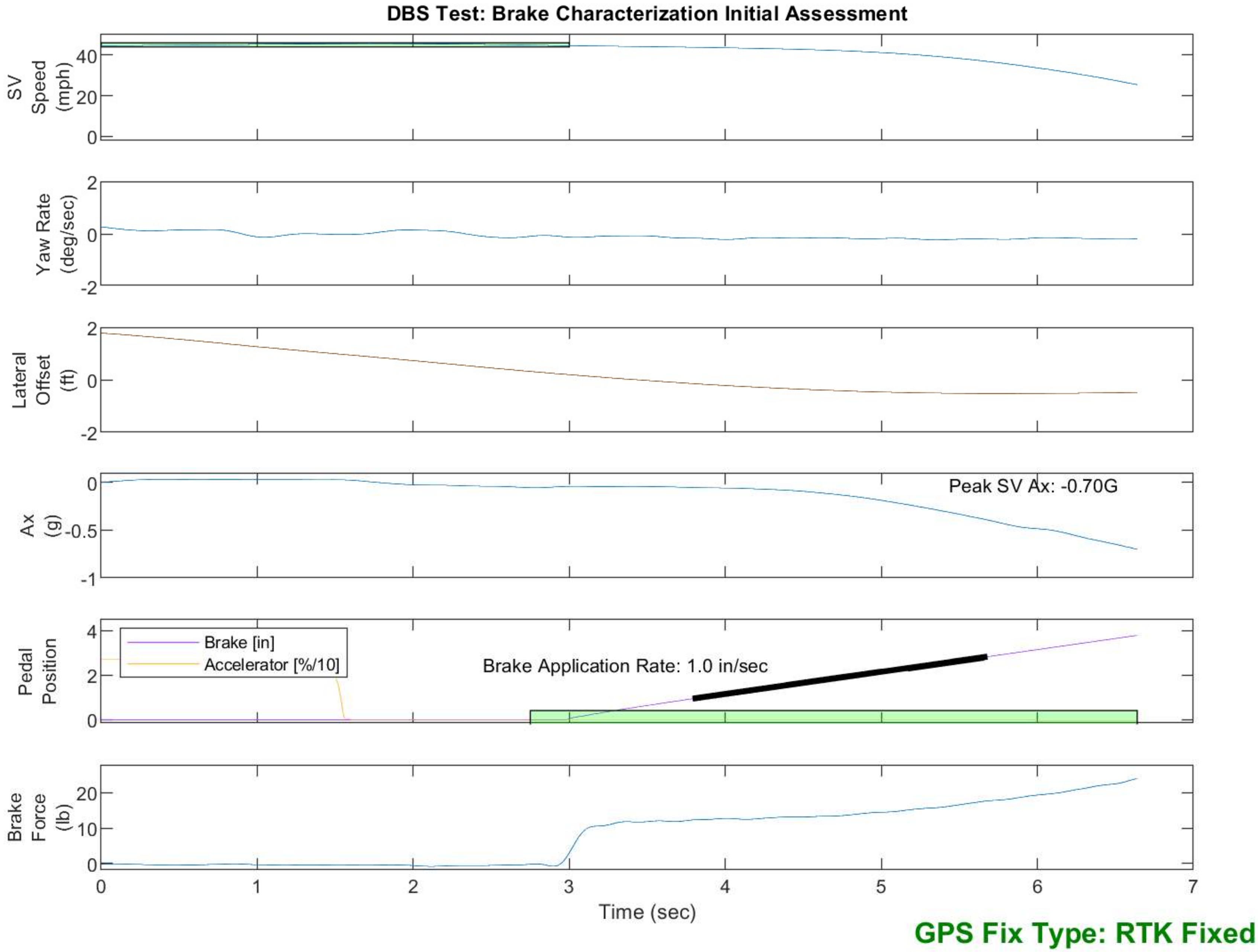


Figure E9. Example Time History for DBS Brake Characterization, Passing

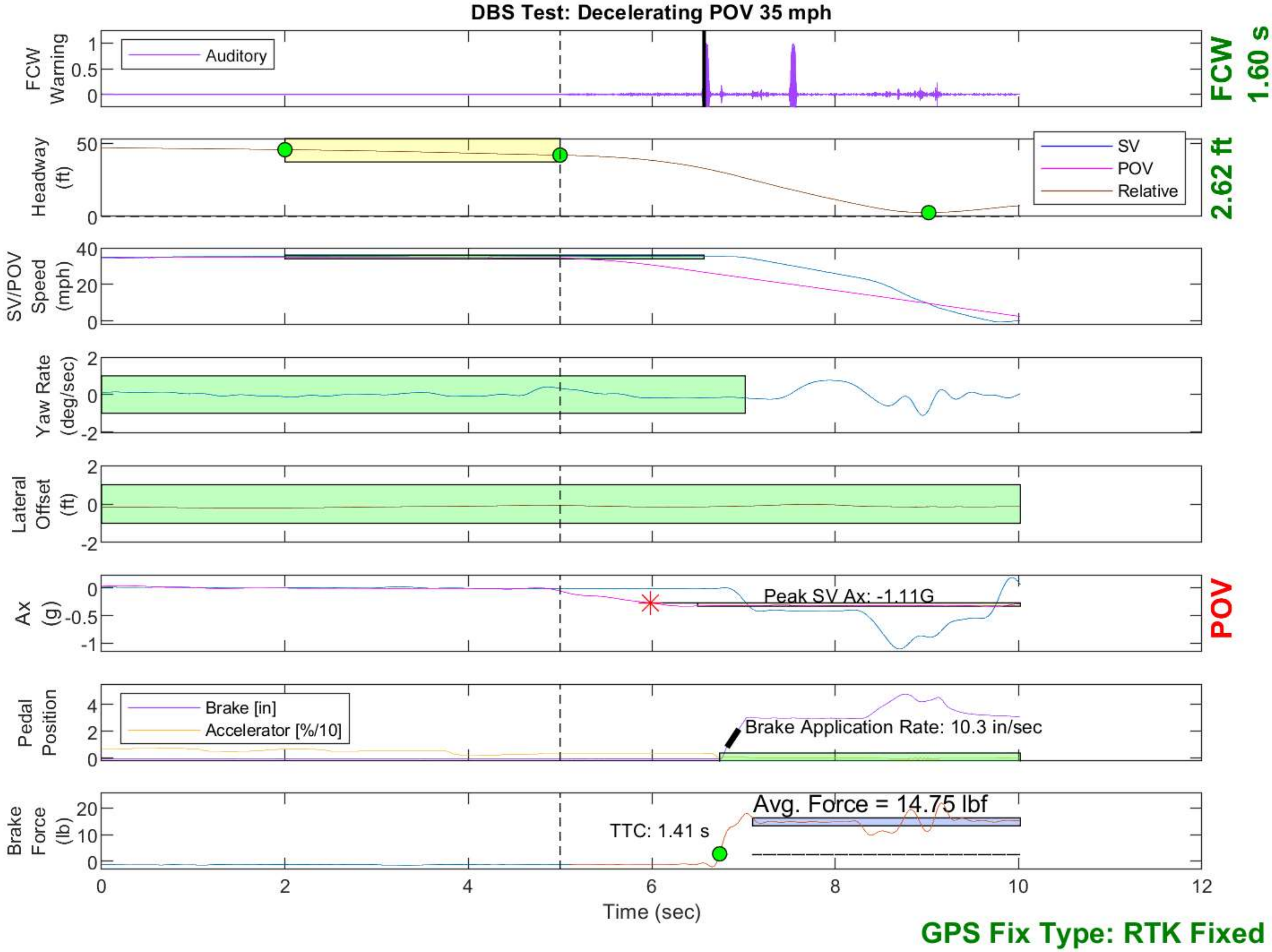


Figure E10. Example Time History Displaying Invalid POV Acceleration Criteria

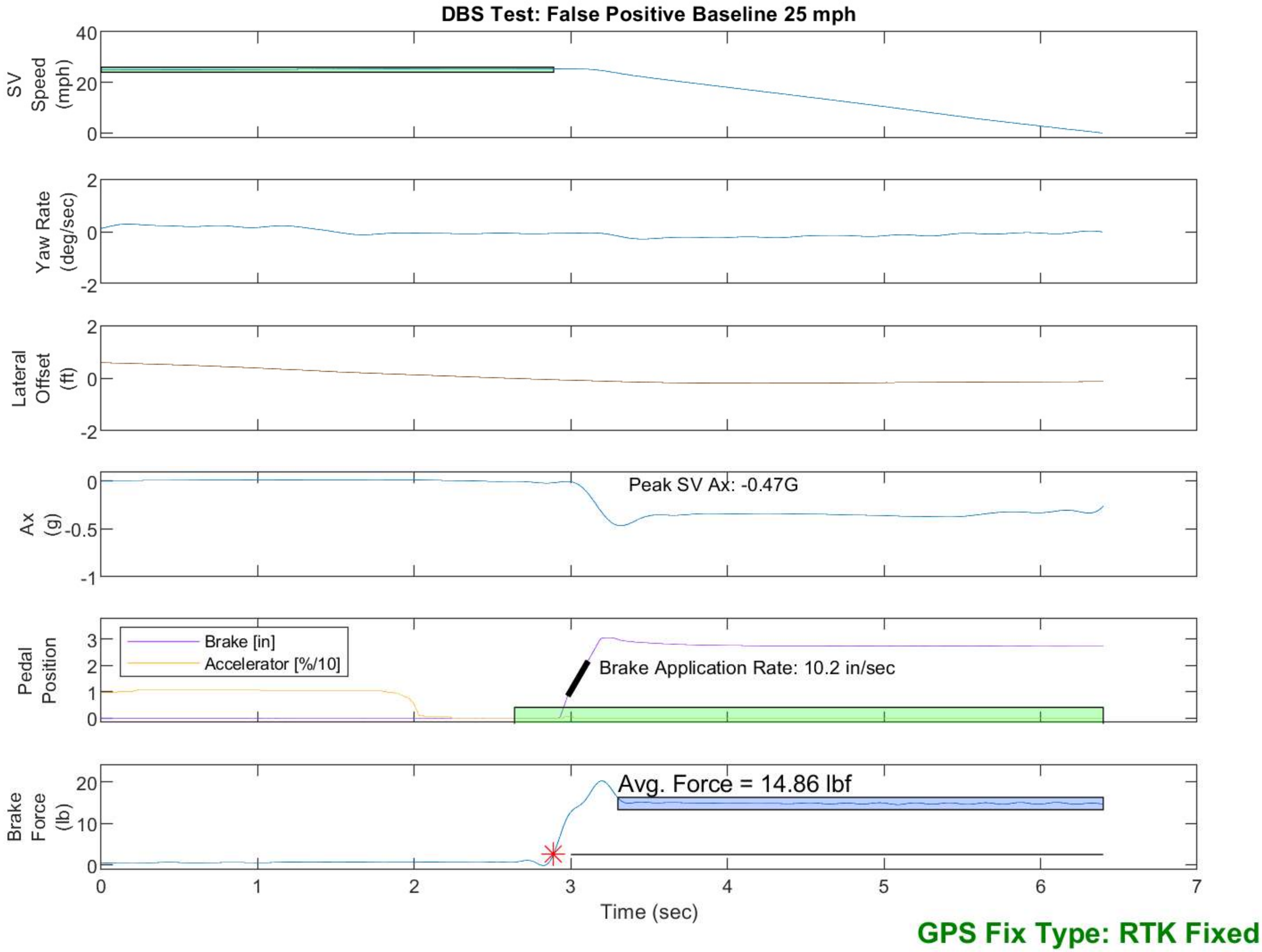


Figure E11. Example Time History Displaying Invalid Brake Force Criteria

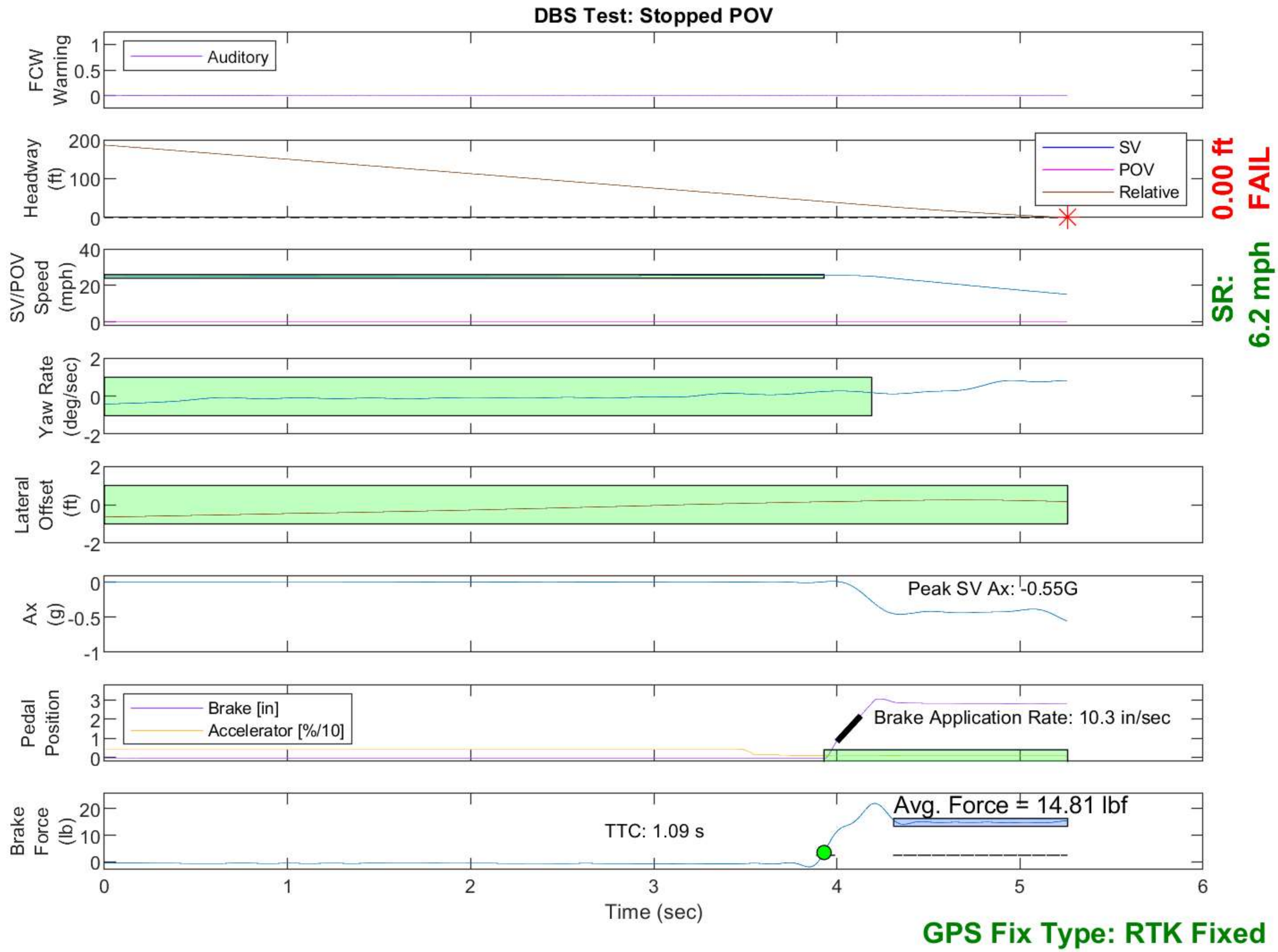


Figure E12. Example Time History for a Failed Run

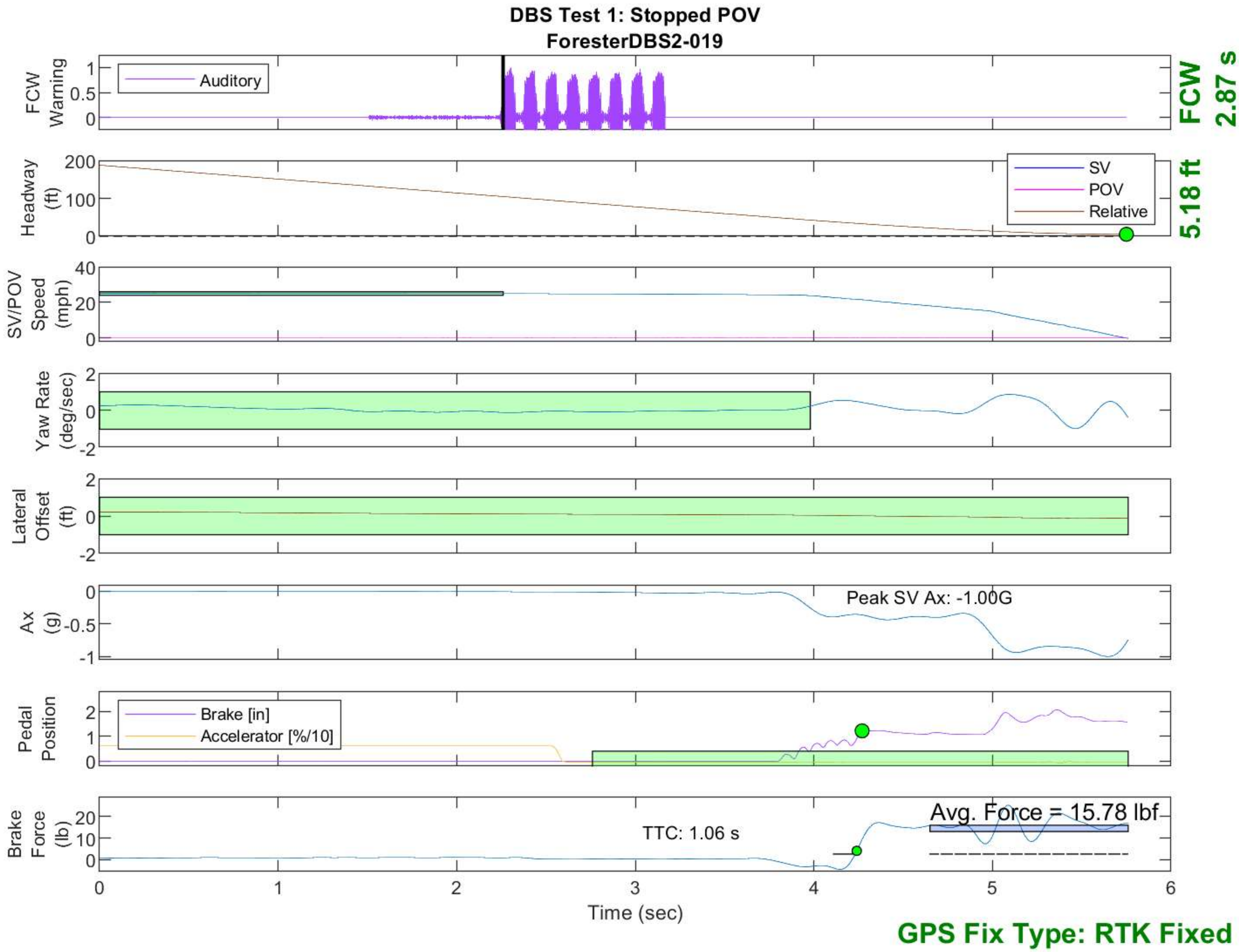


Figure E13. Time History for DBS Run 19, Test 1 - Stopped POV

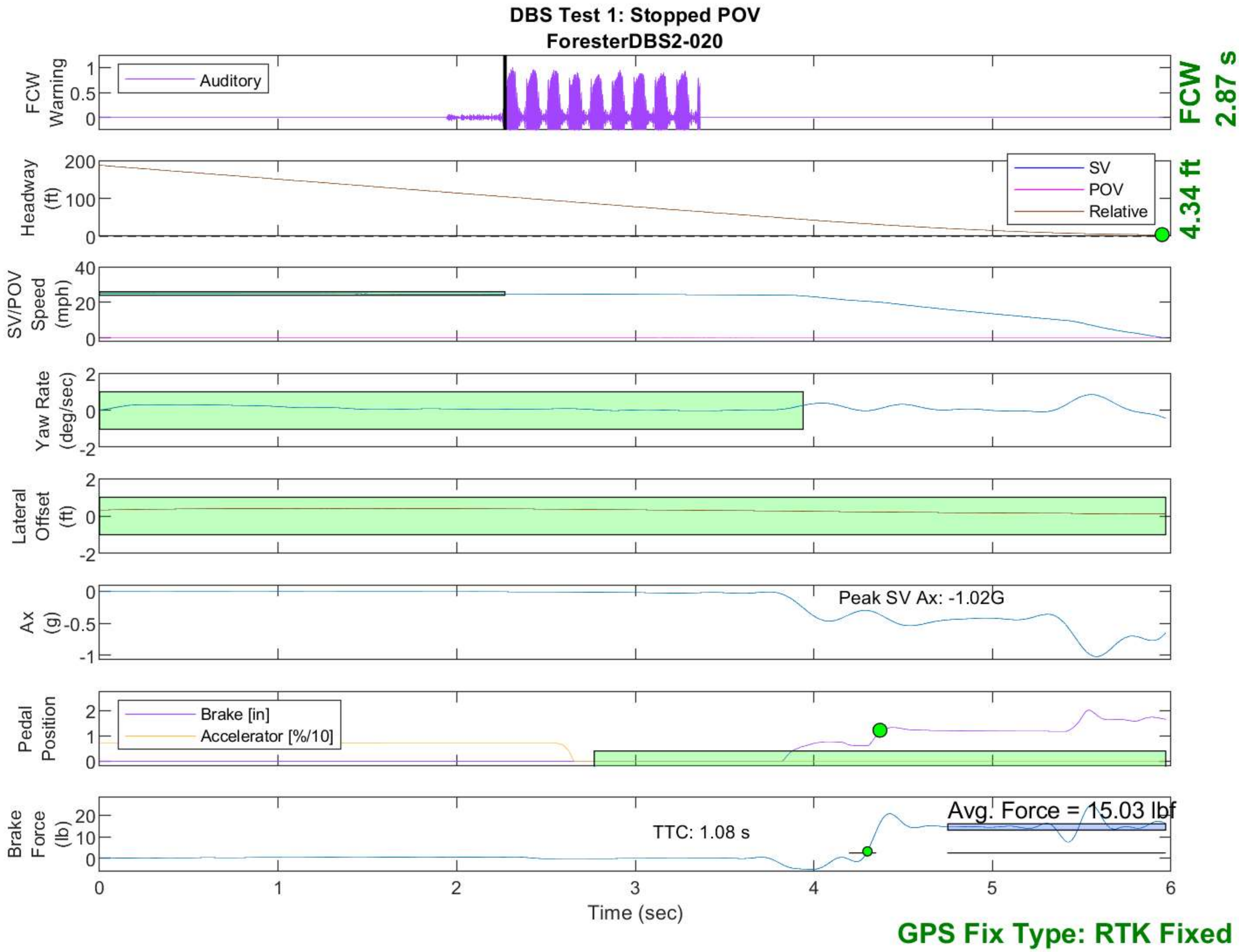


Figure E14. Time History for DBS Run 20, Test 1 - Stopped POV

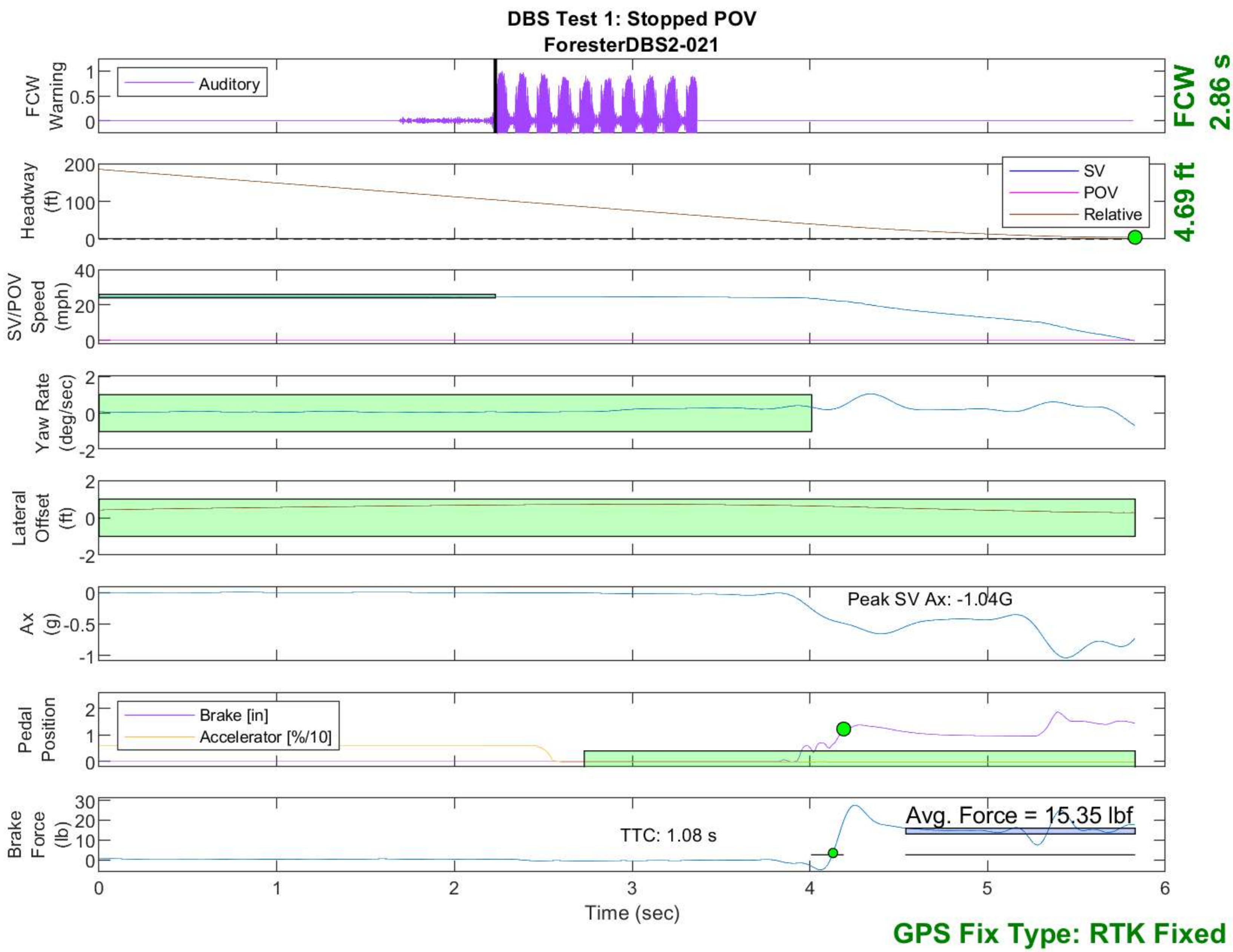


Figure E15. Time History for DBS Run 21, Test 1 - Stopped POV

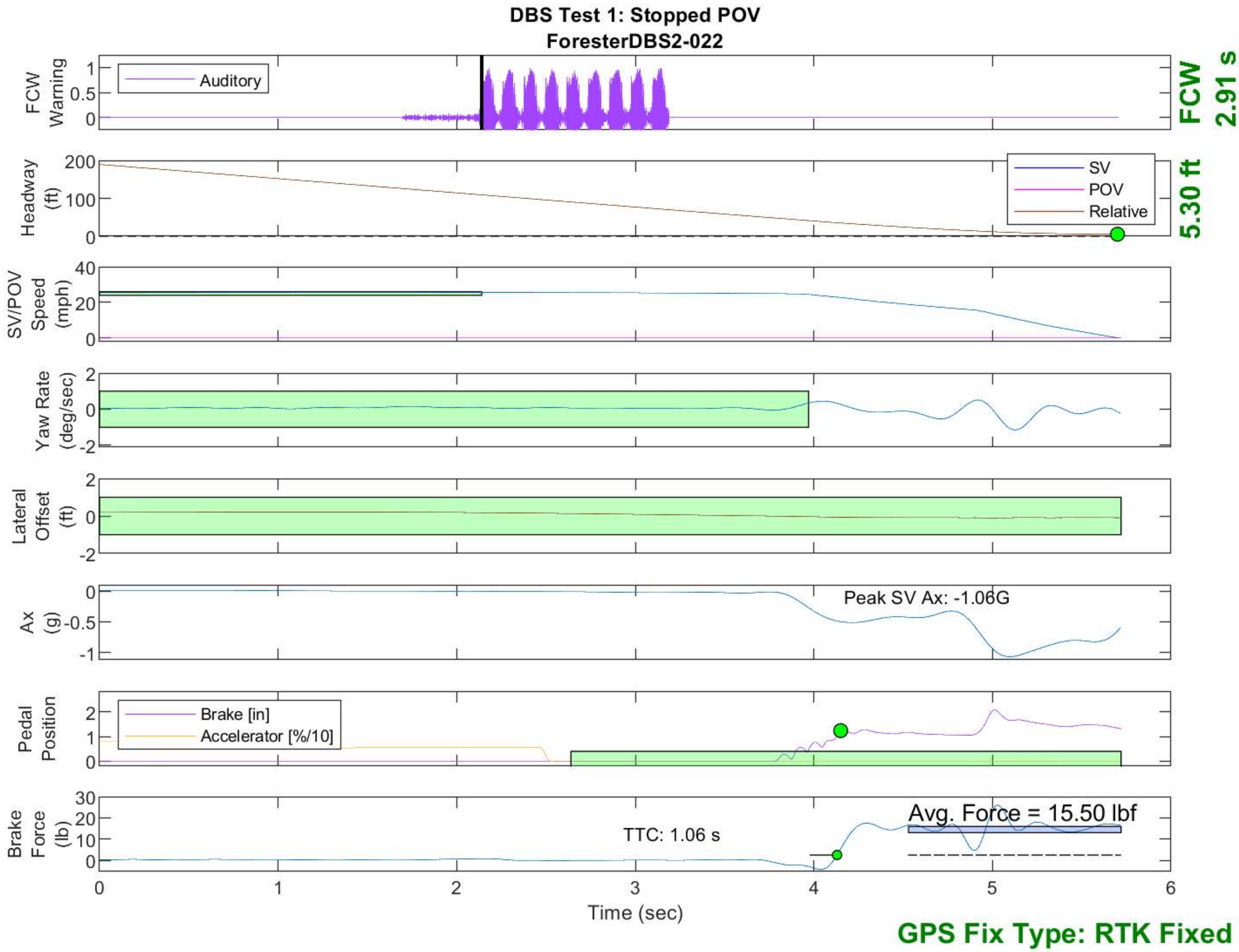


Figure E16. Time History for DBS Run 22, Test 1 - Stopped POV

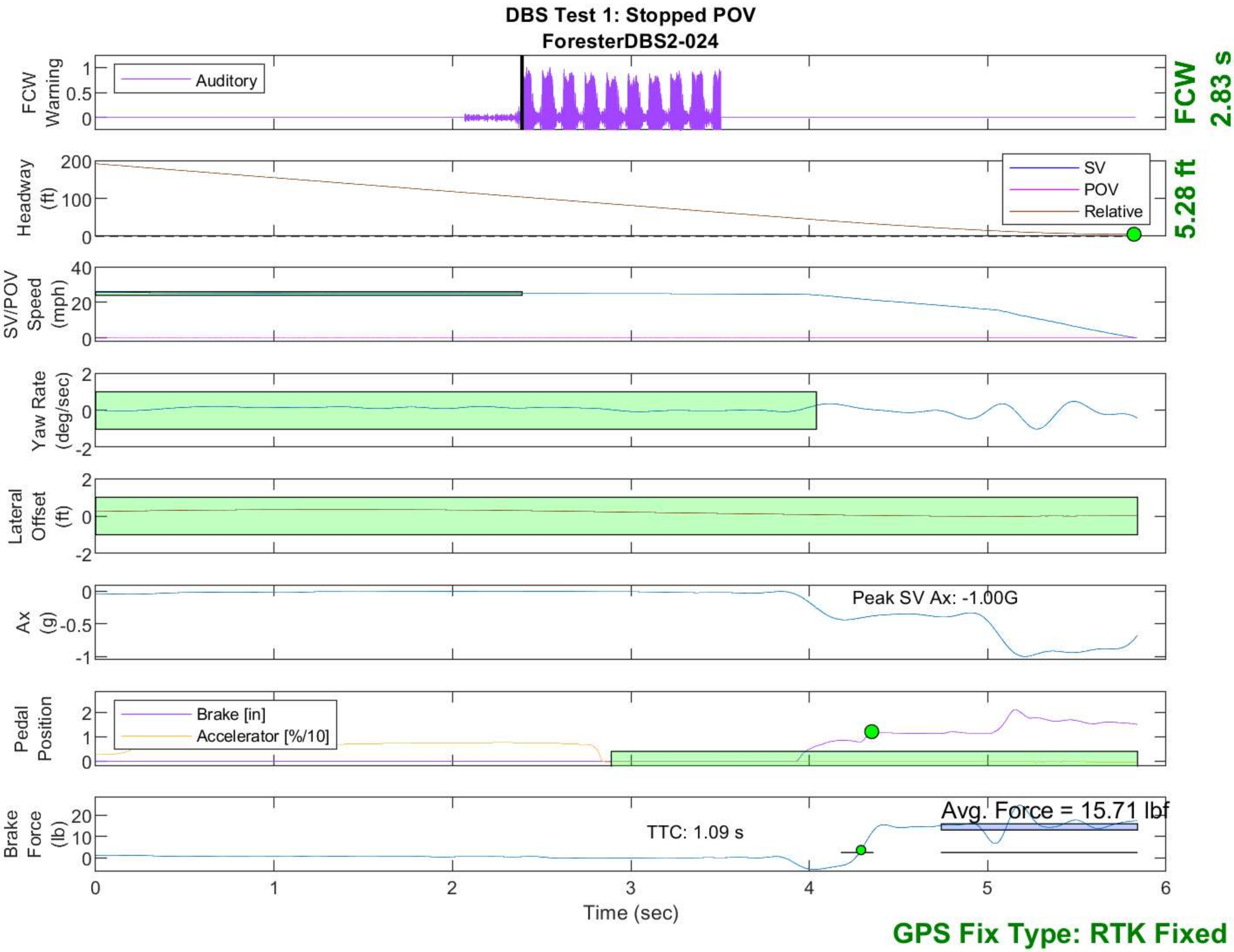


Figure E17. Time History for DBS Run 24, Test 1 - Stopped POV

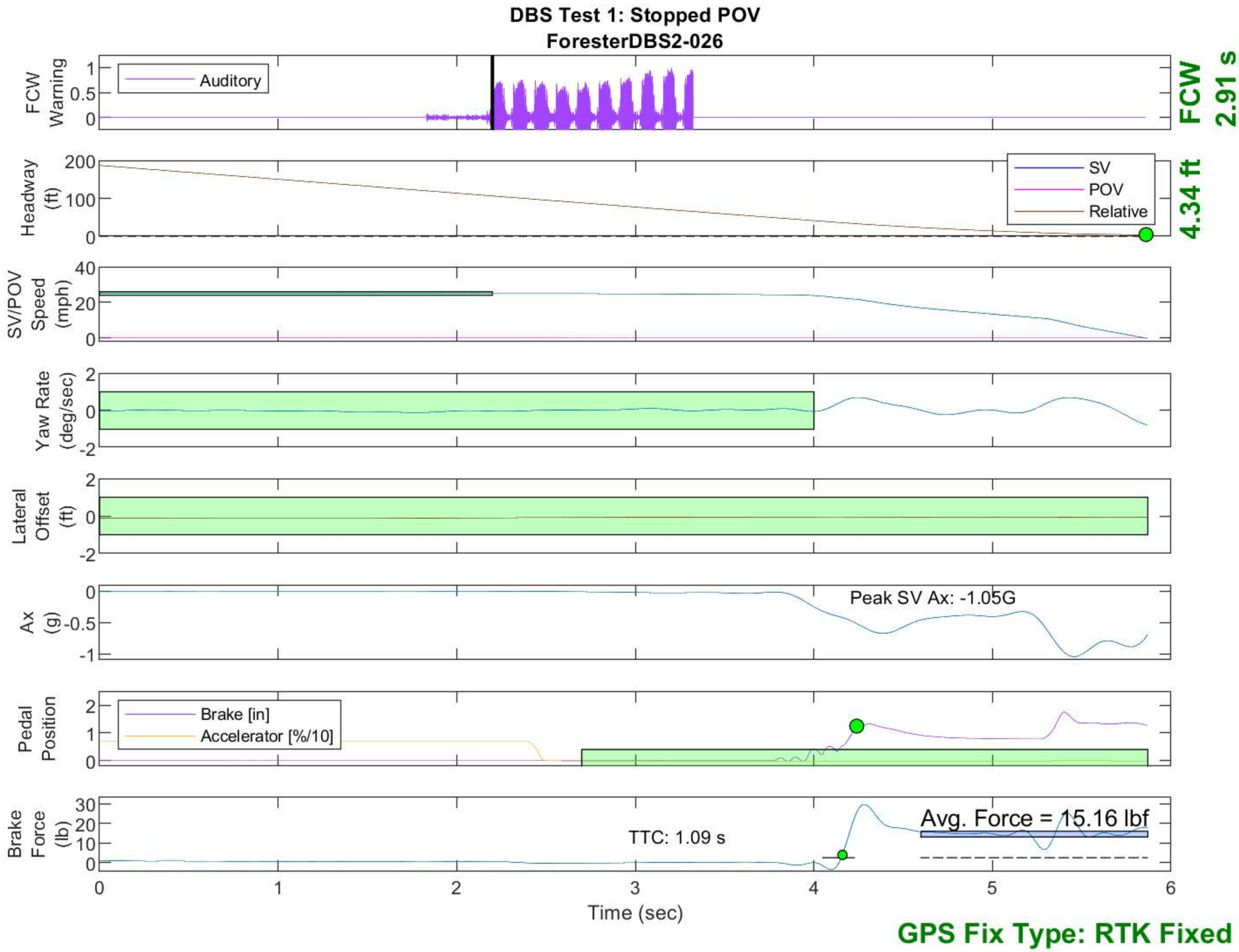


Figure E18. Time History for DBS Run 26, Test 1 - Stopped POV

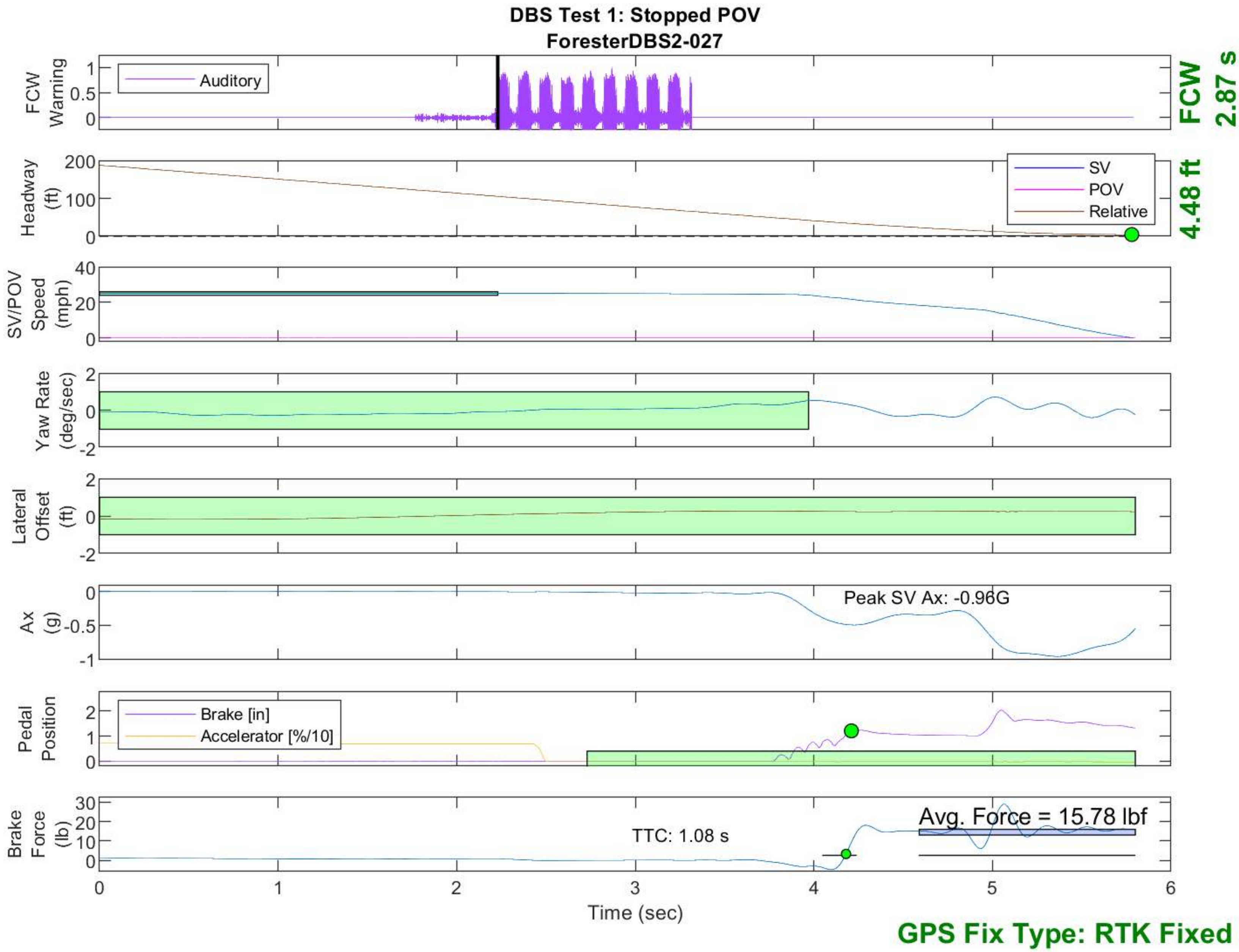


Figure E19. Time History for DBS Run 27, Test 1 - Stopped POV

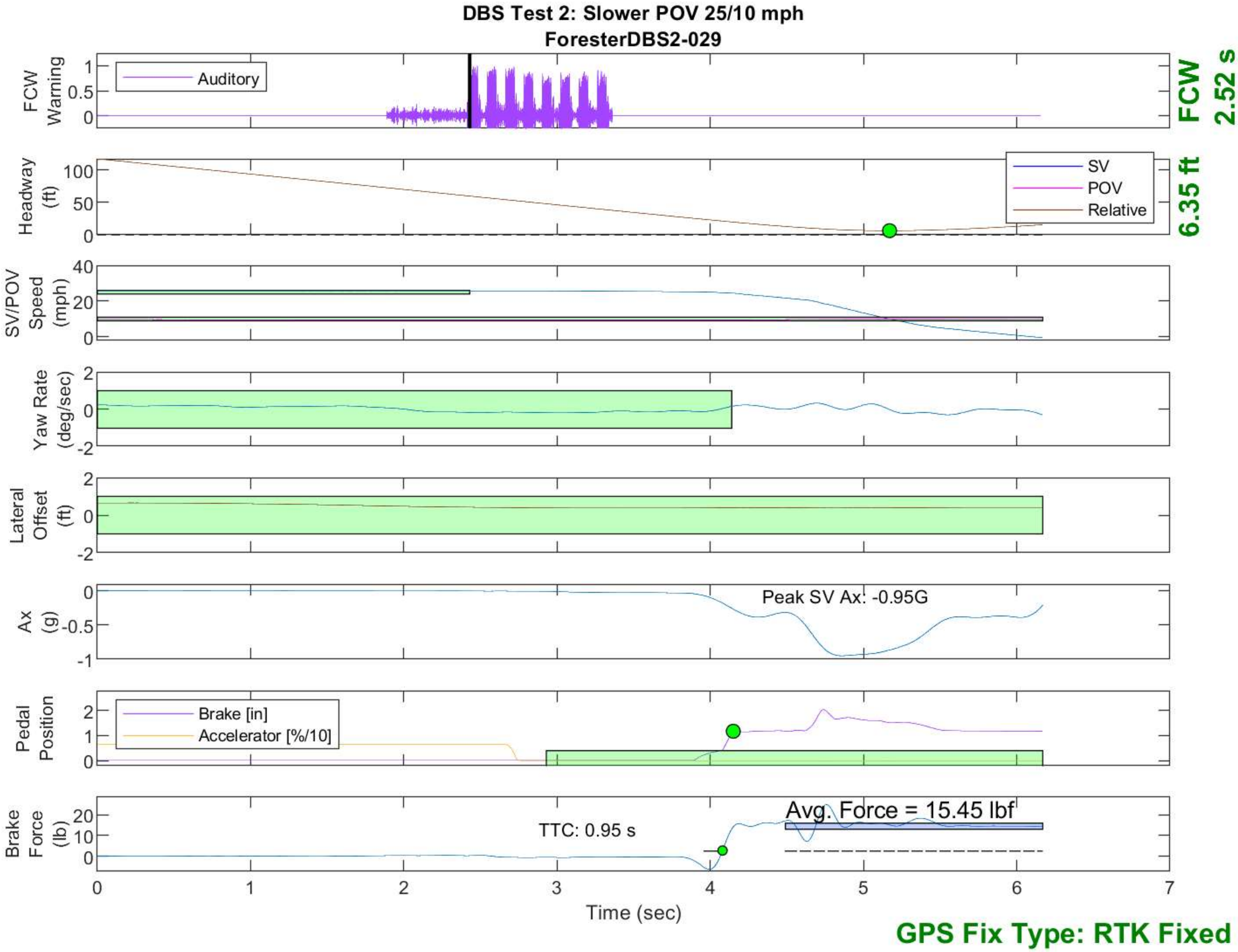


Figure E20. Time History for DBS Run 29, Test 2 - Slower Moving POV 25/10 mph

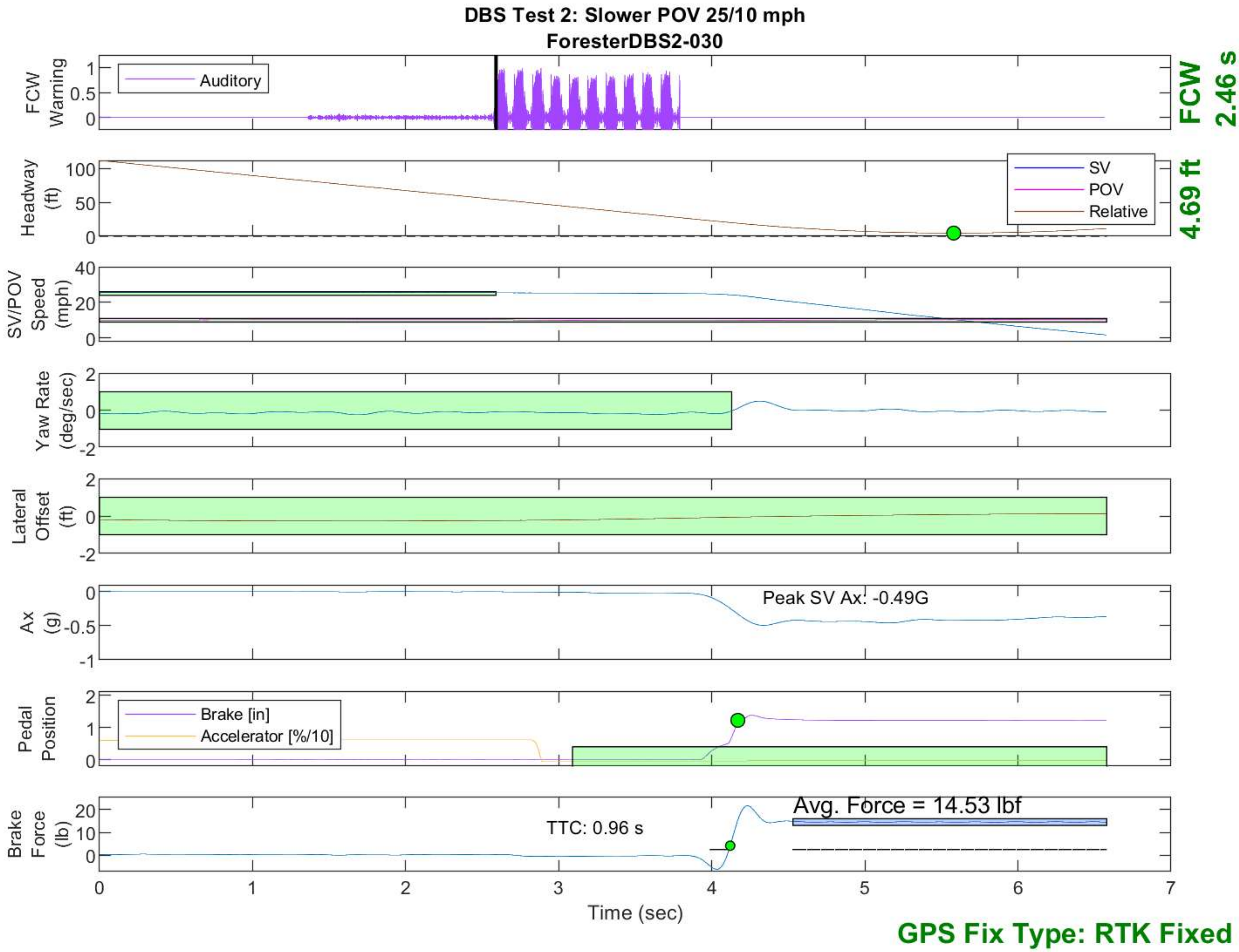


Figure E21. Time History for DBS Run 30, Test 2 - Slower Moving POV 25/10 mph

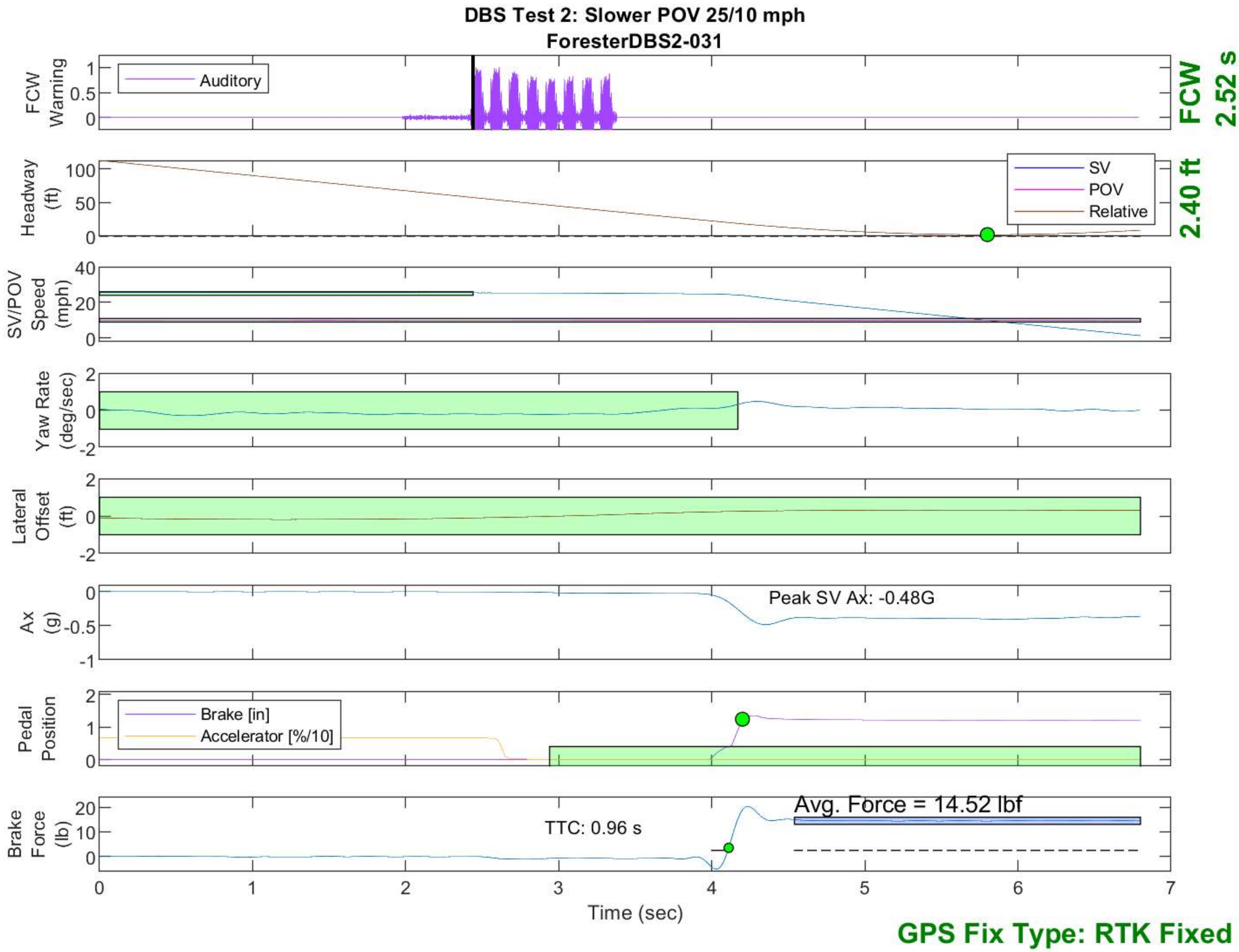


Figure E22. Time History for DBS Run 31, Test 2 - Slower Moving POV 25/10 mph

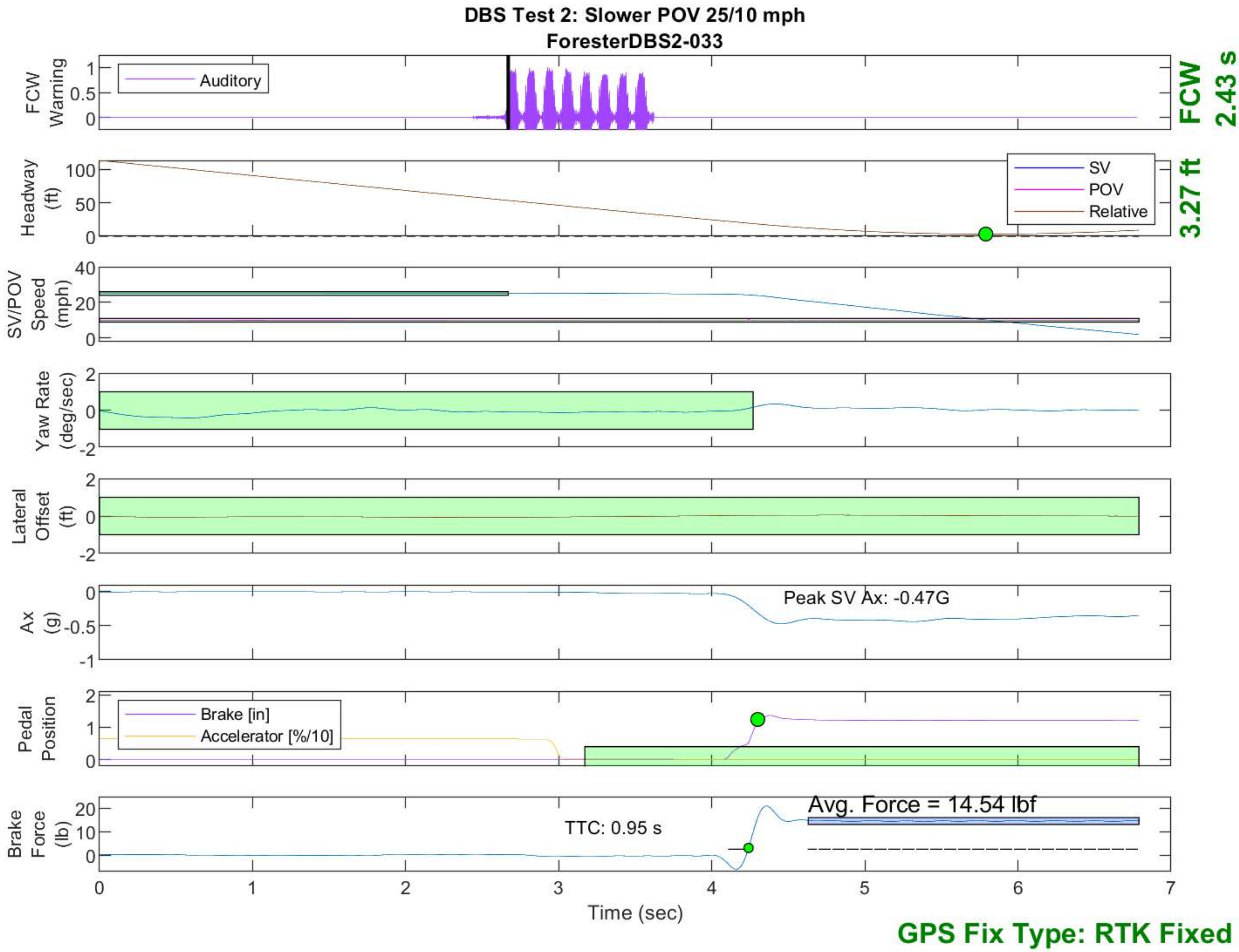


Figure E23. Time History for DBS Run 33, Test 2 - Slower Moving POV 25/10 mph

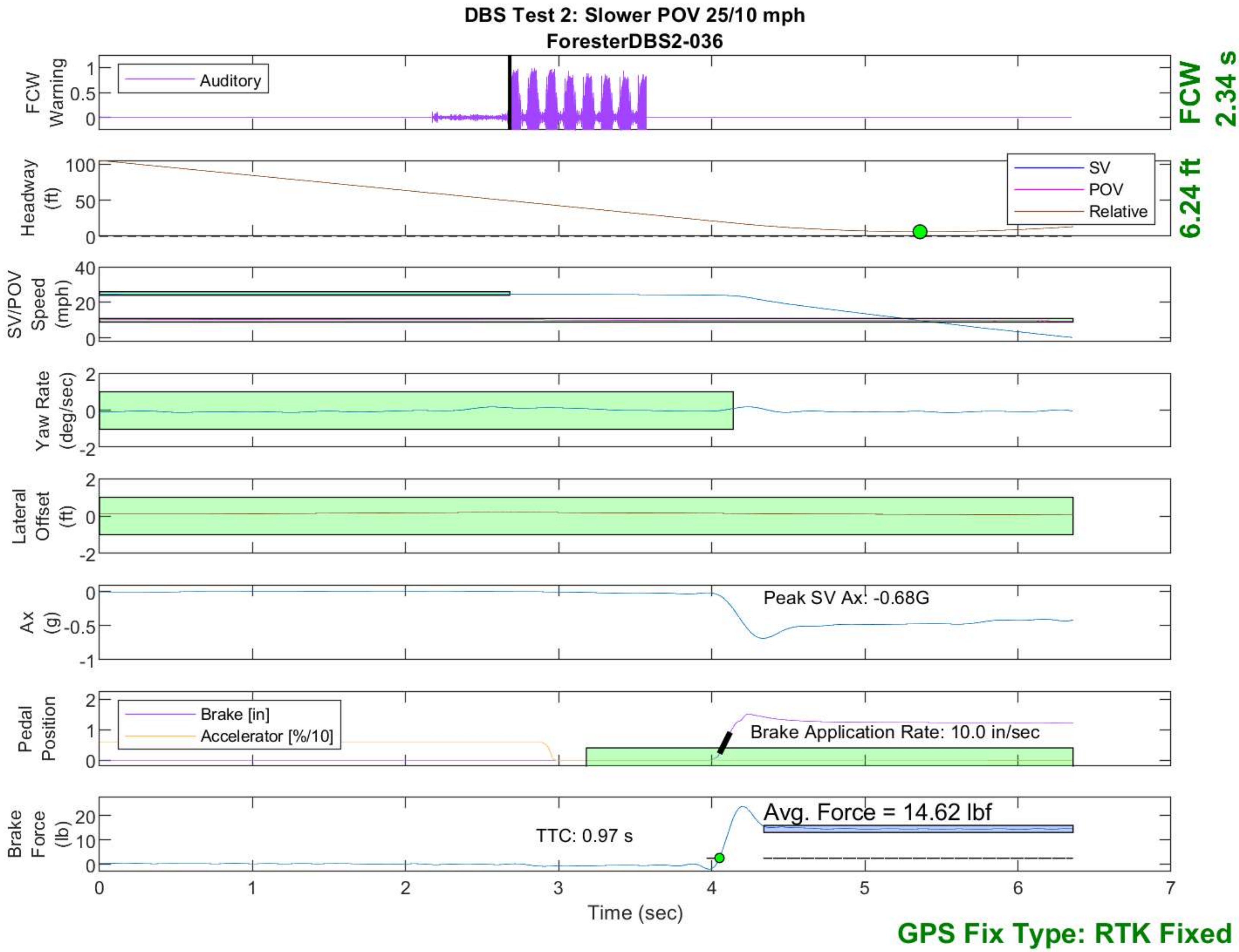


Figure E24. Time History for DBS Run 36, Test 2 - Slower Moving POV 25/10 mph

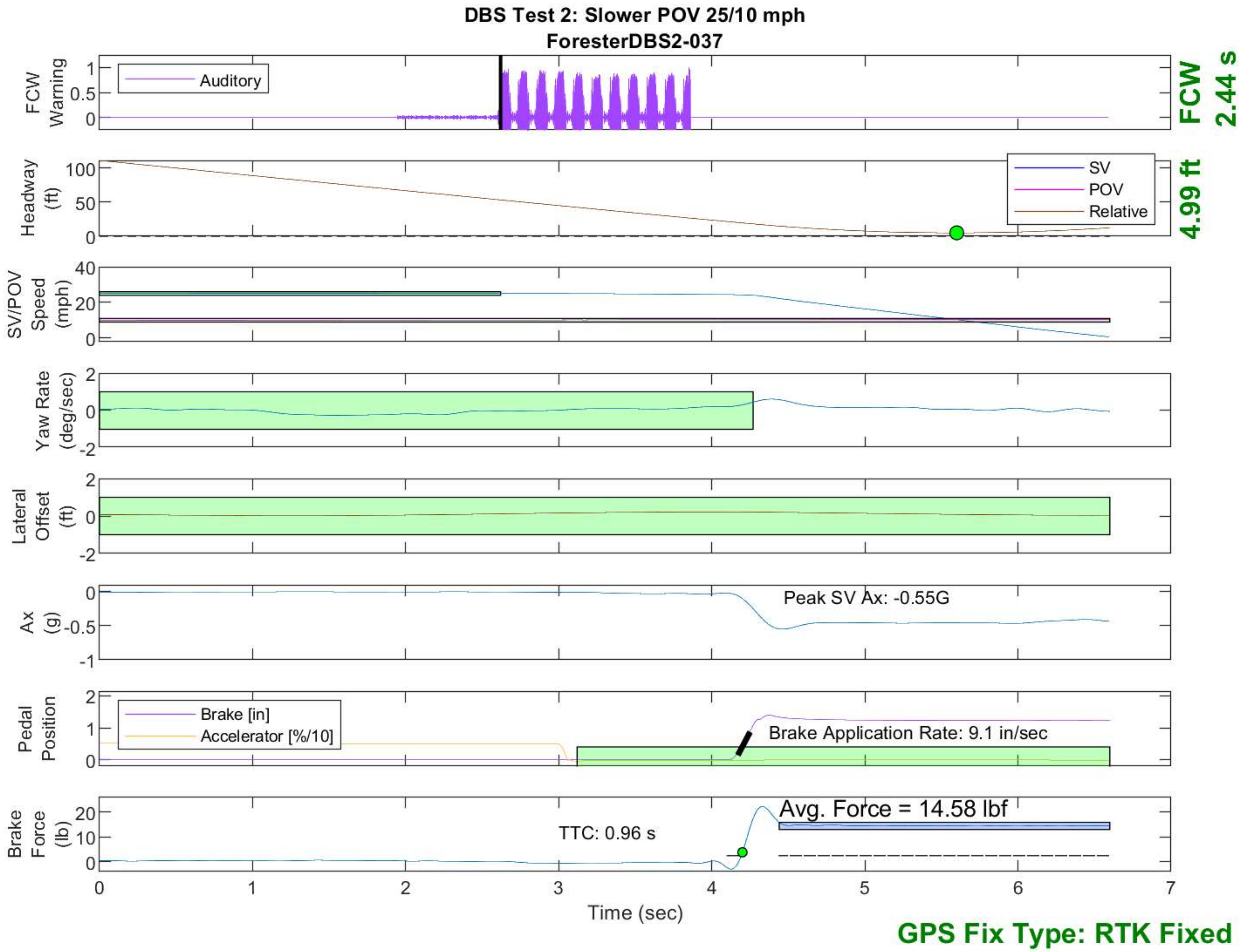


Figure E25. Time History for DBS Run 37, Test 2 - Slower Moving POV 25/10 mph

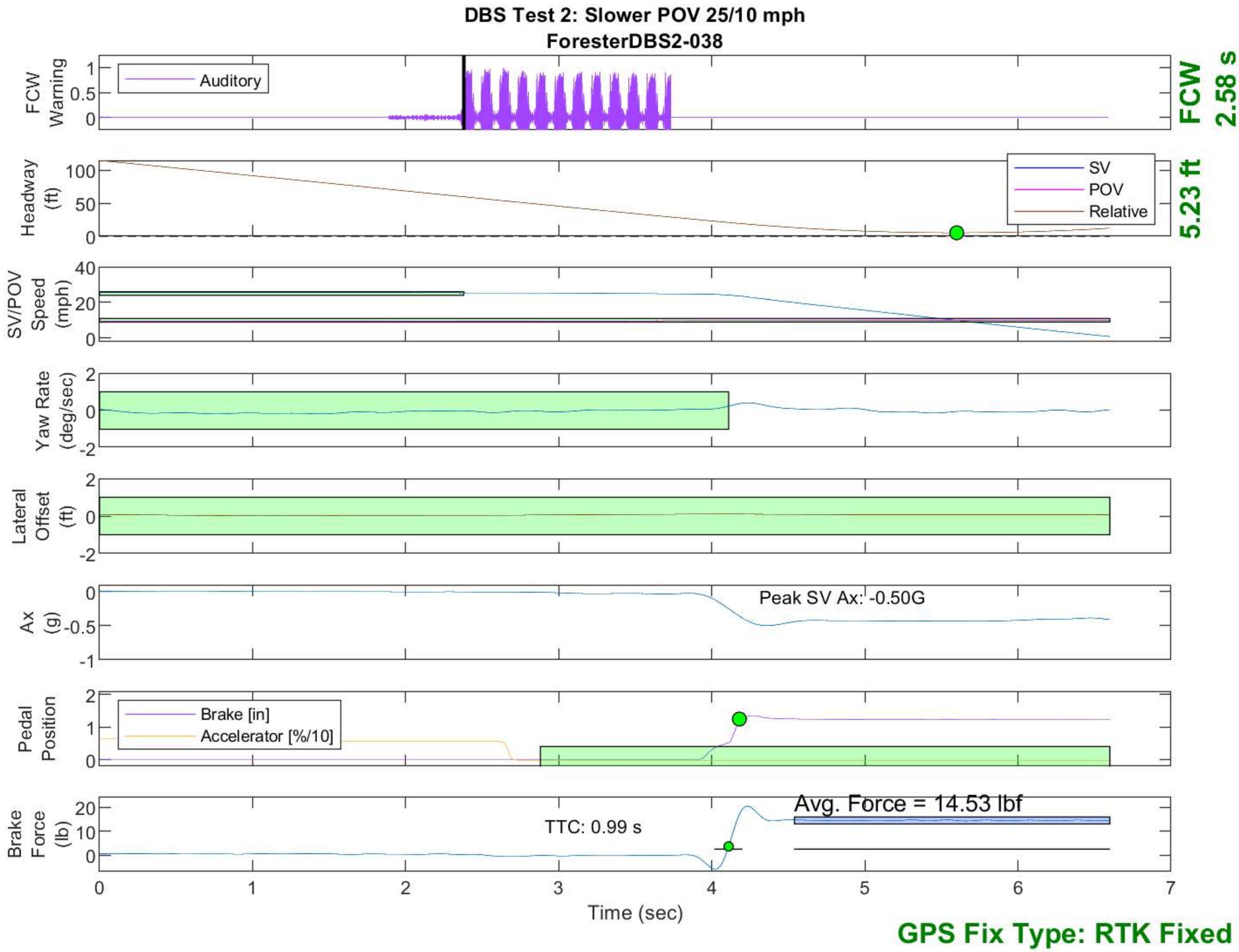


Figure E26. Time History for DBS Run 38, Test 2 - Slower Moving POV 25/10 mph

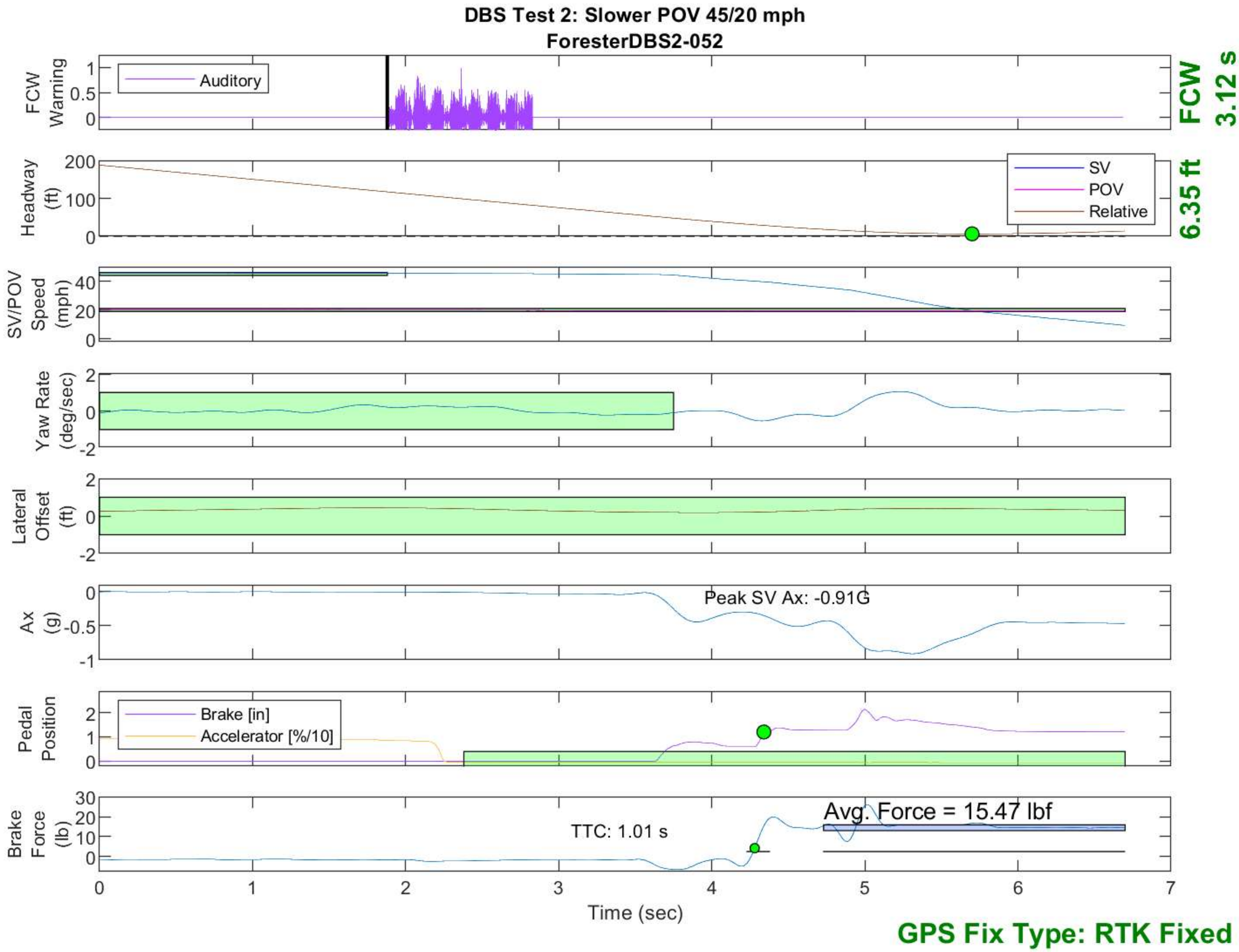


Figure E27. Time History for DBS Run 52, Test 2 - Slower Moving POV 45/20 mph

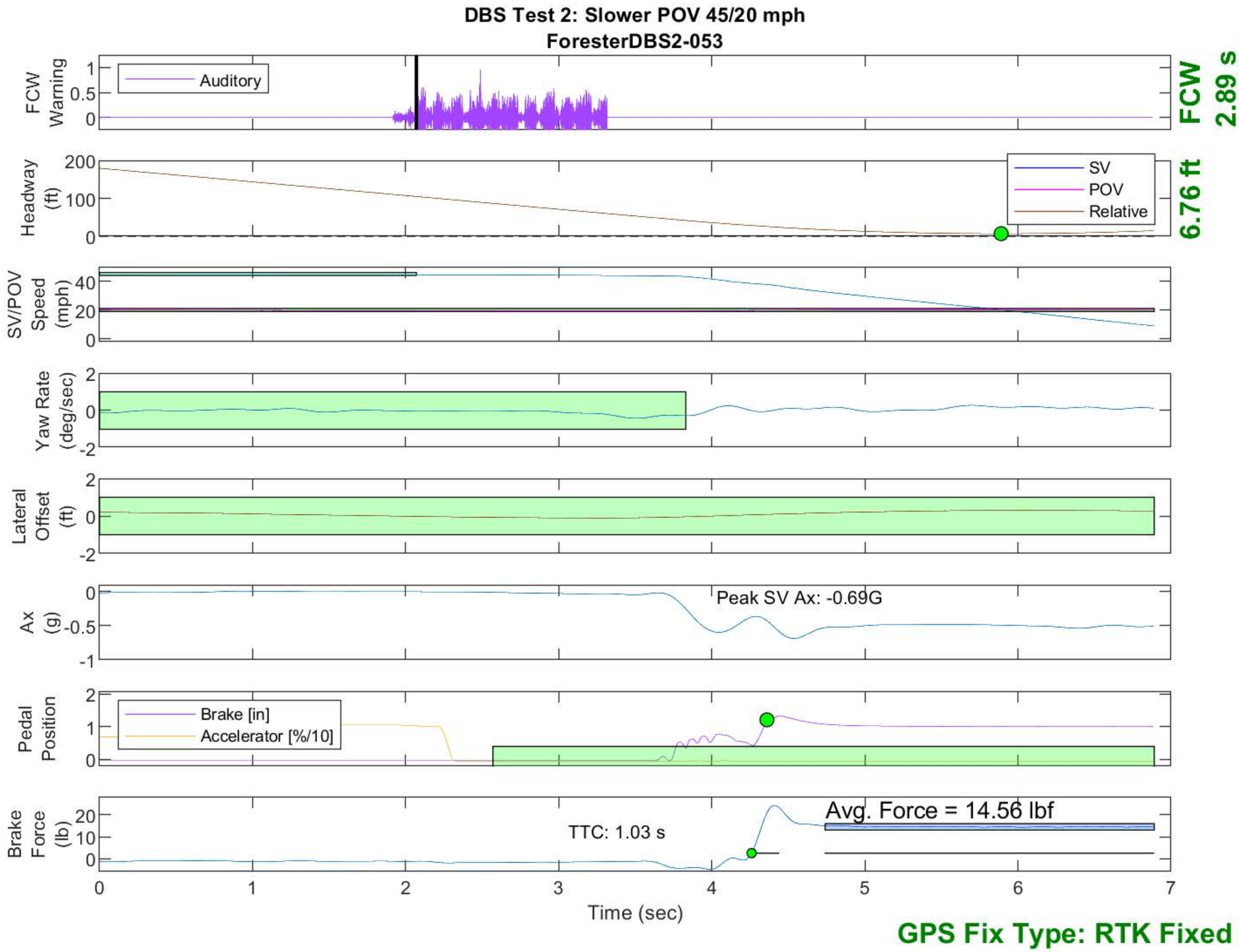


Figure E28. Time History for DBS Run 53, Test 2 - Slower Moving POV 45/20 mph

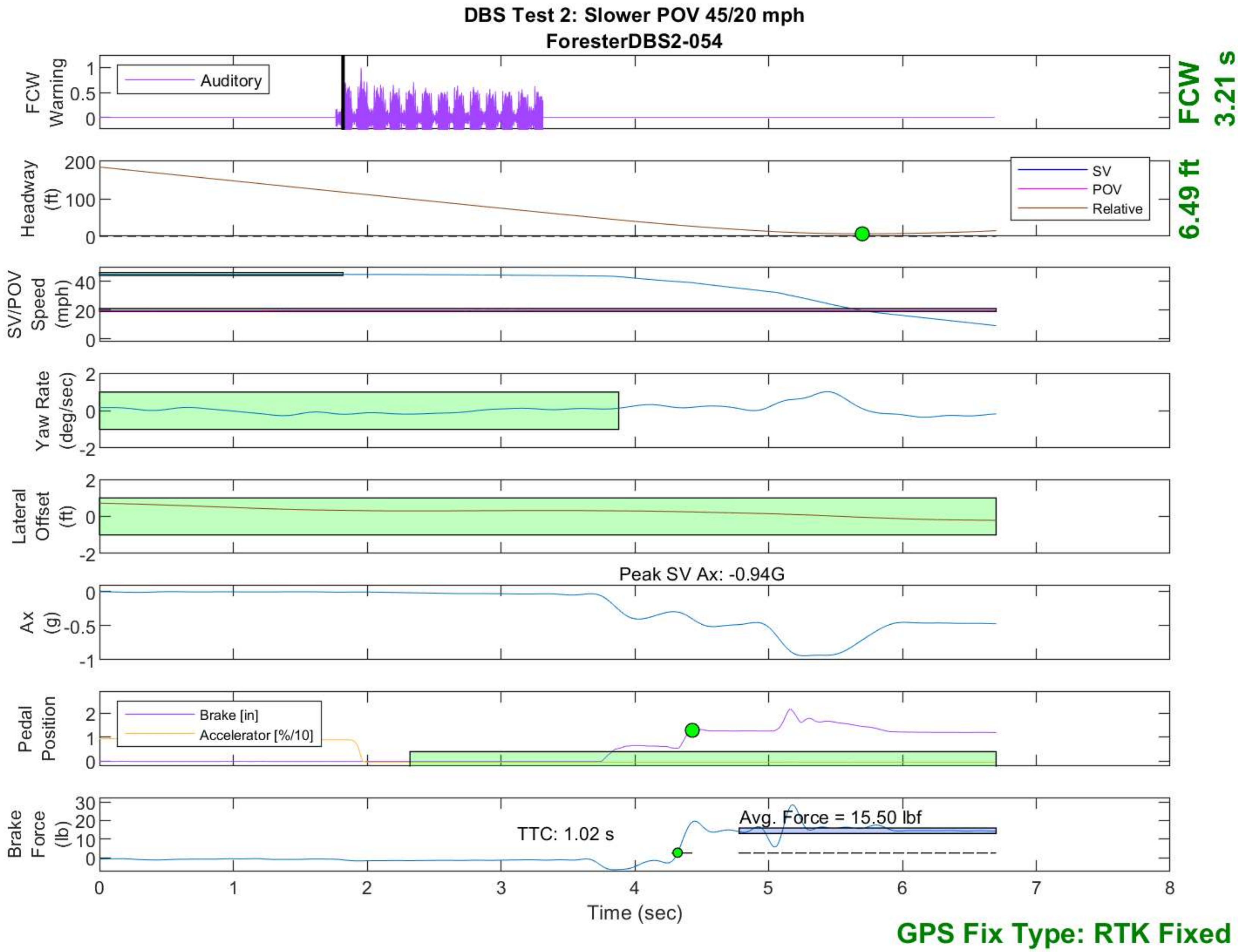


Figure E29. Time History for DBS Run 54, Test 2 - Slower Moving POV 45/20 mph

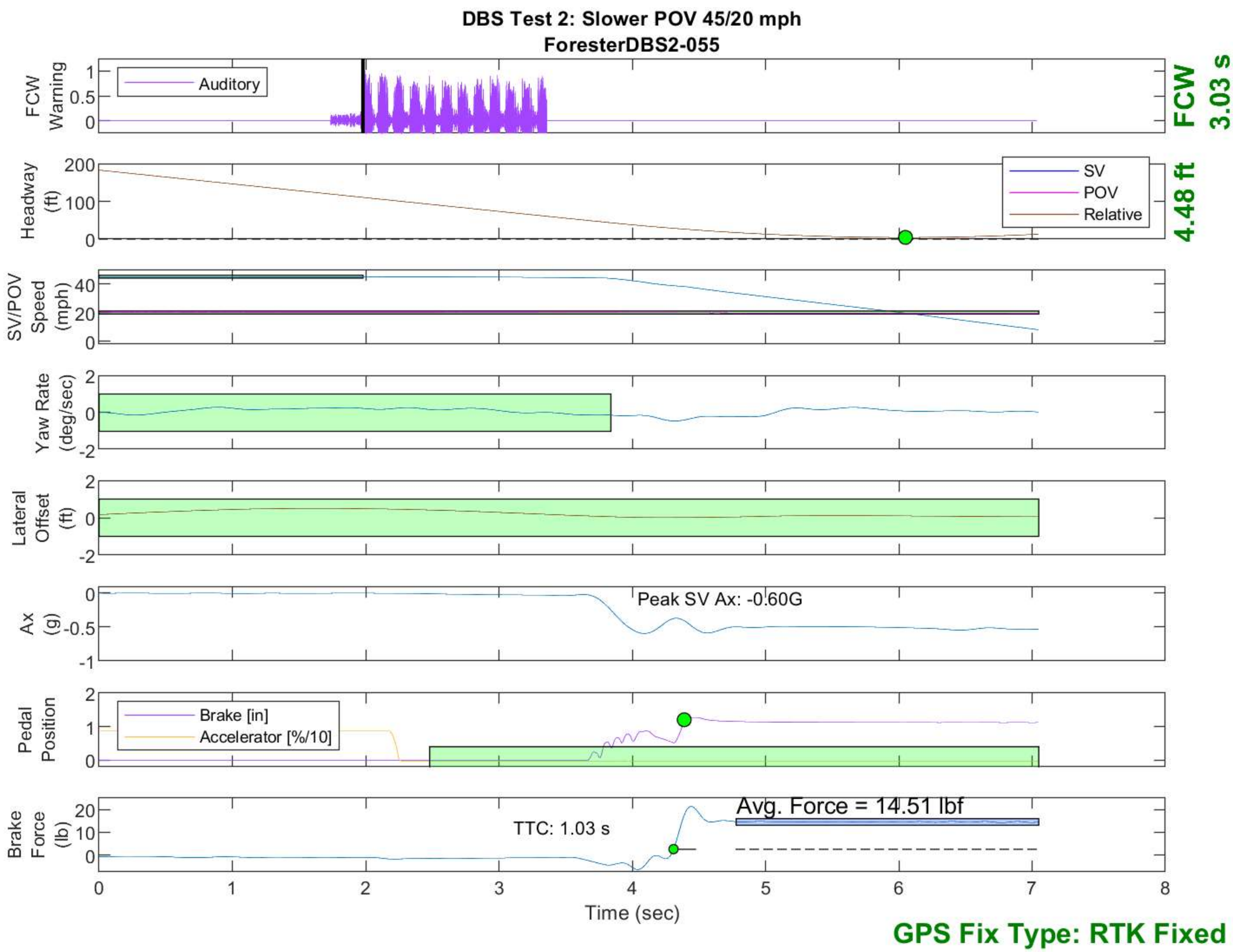


Figure E30. Time History for DBS Run 55, Test 2 - Slower Moving POV 45/20 mph

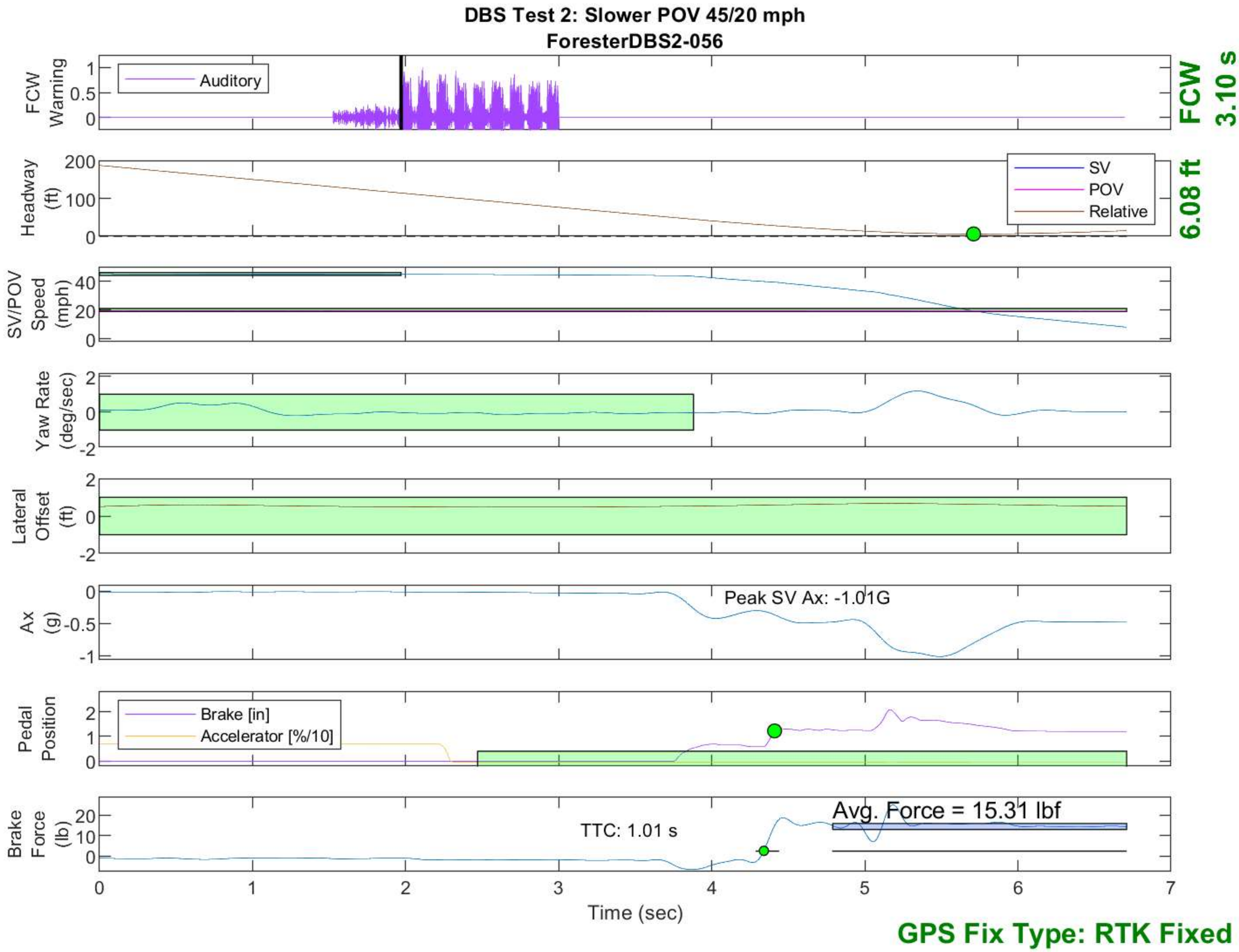


Figure E31. Time History for DBS Run 56, Test 2 - Slower Moving POV 45/20 mph

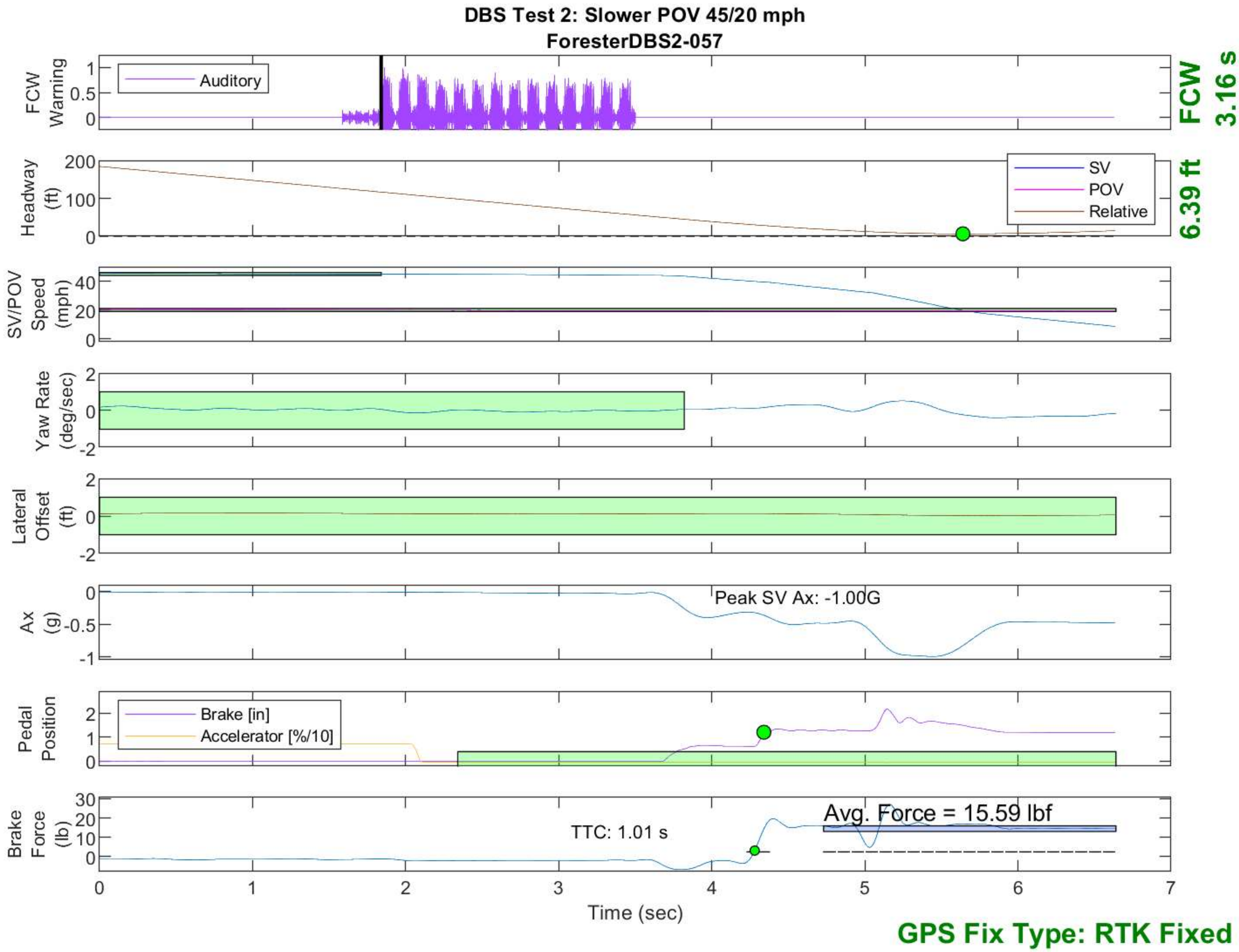


Figure E32. Time History for DBS Run 57, Test 2 - Slower Moving POV 45/20 mph

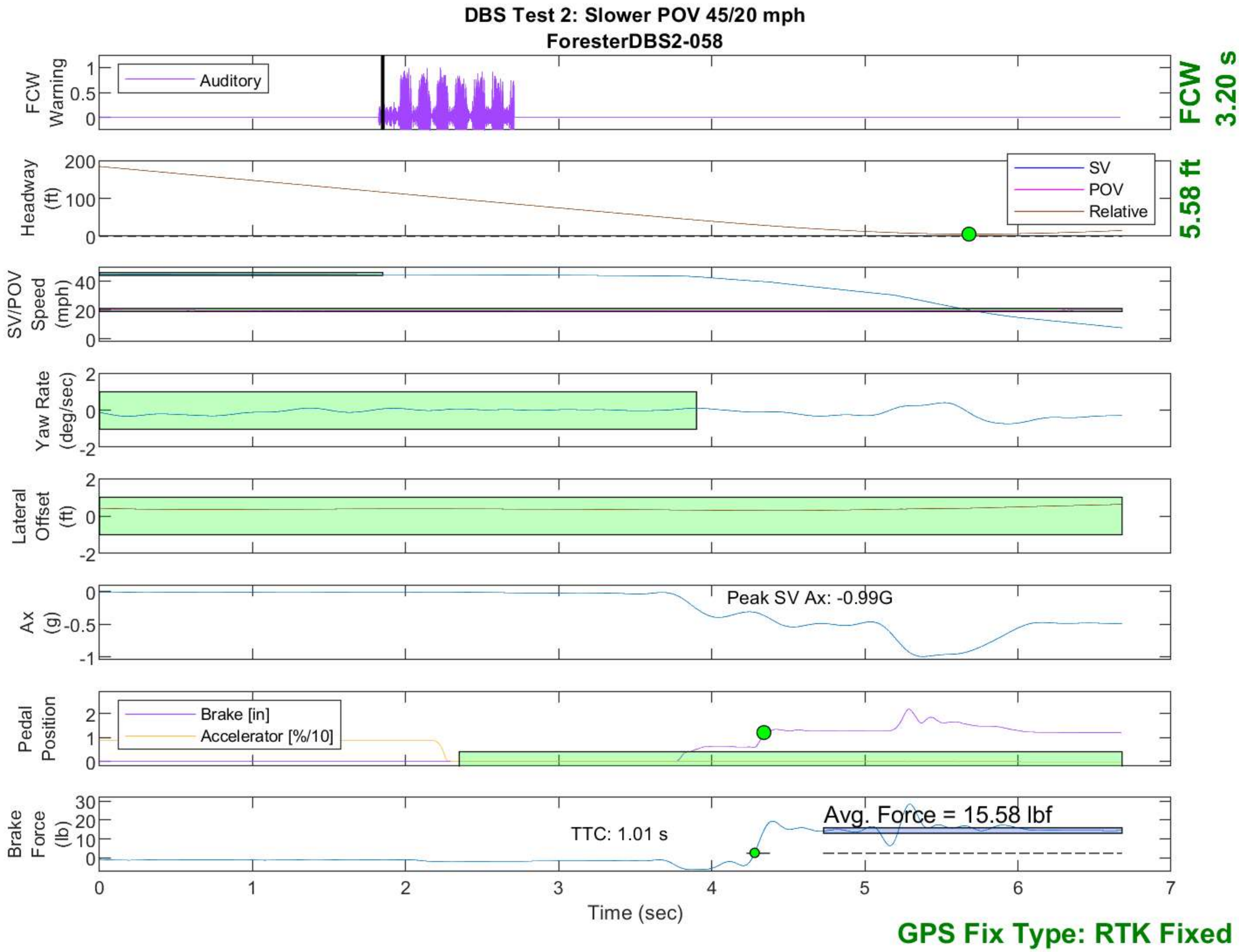


Figure E33. Time History for DBS Run 58, Test 2 - Slower Moving POV 45/20 mph

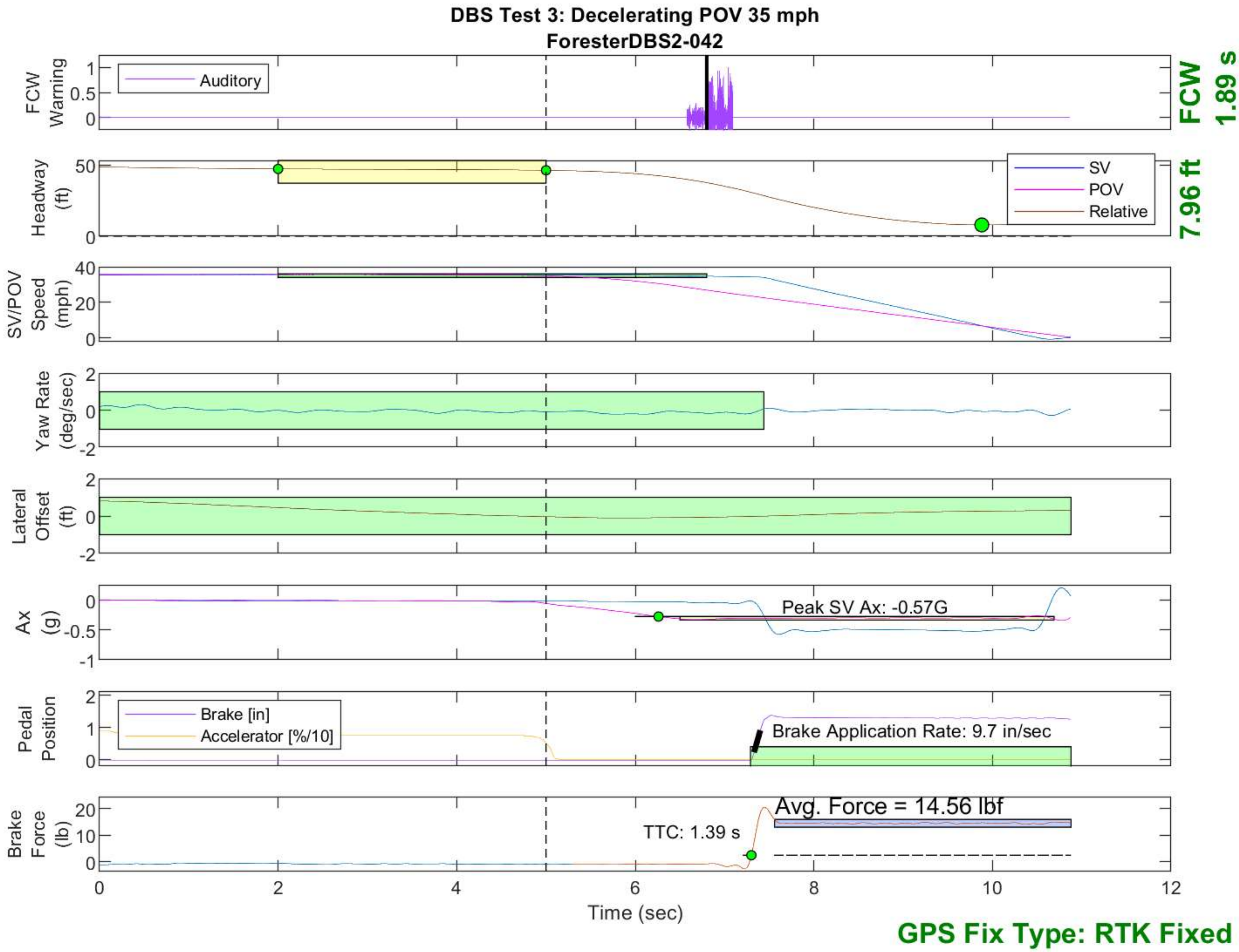


Figure E34. Time History for DBS Run 42, Test 3 - Decelerating POV 35 mph

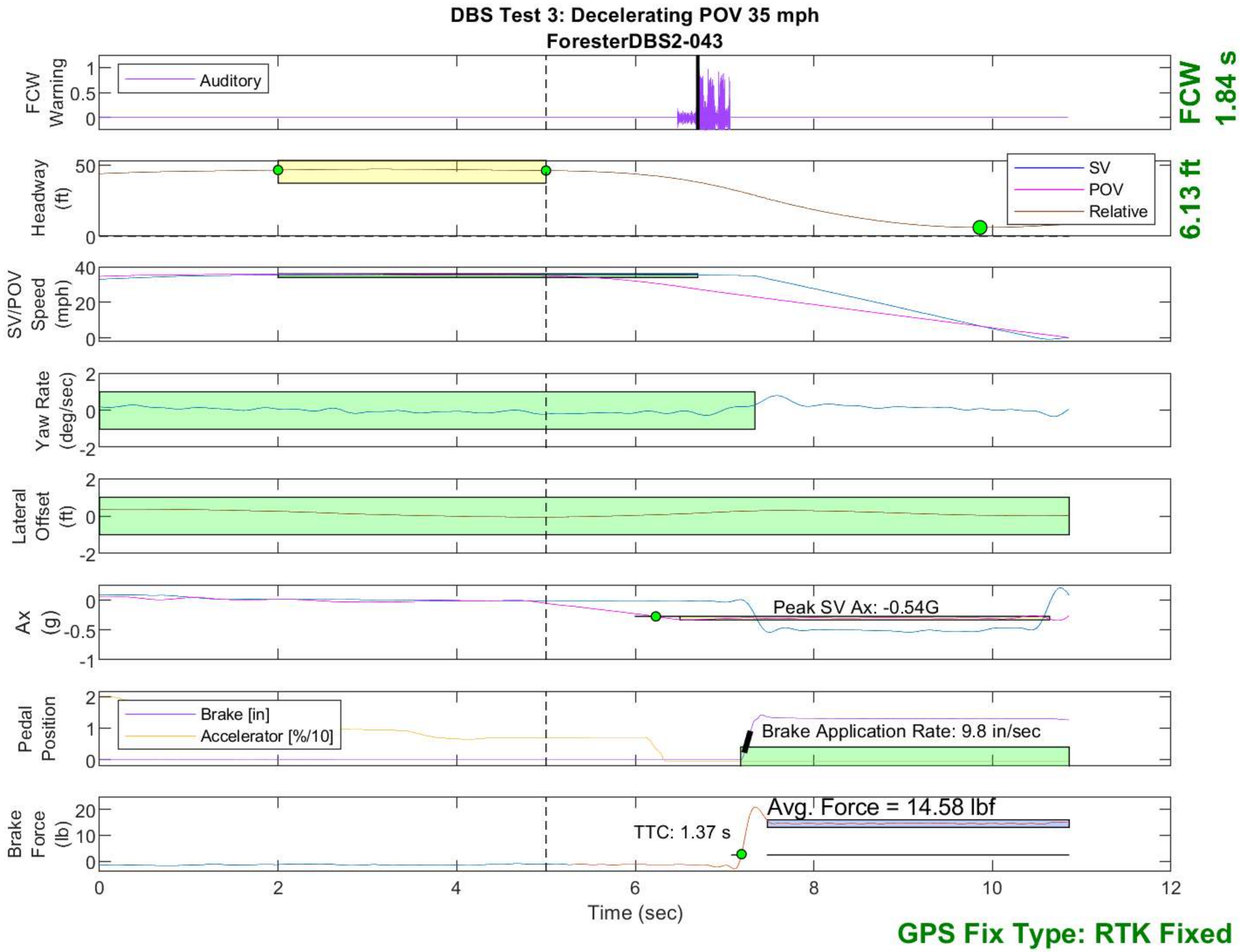


Figure E35. Time History for DBS Run 43, Test 3 - Decelerating POV 35 mph

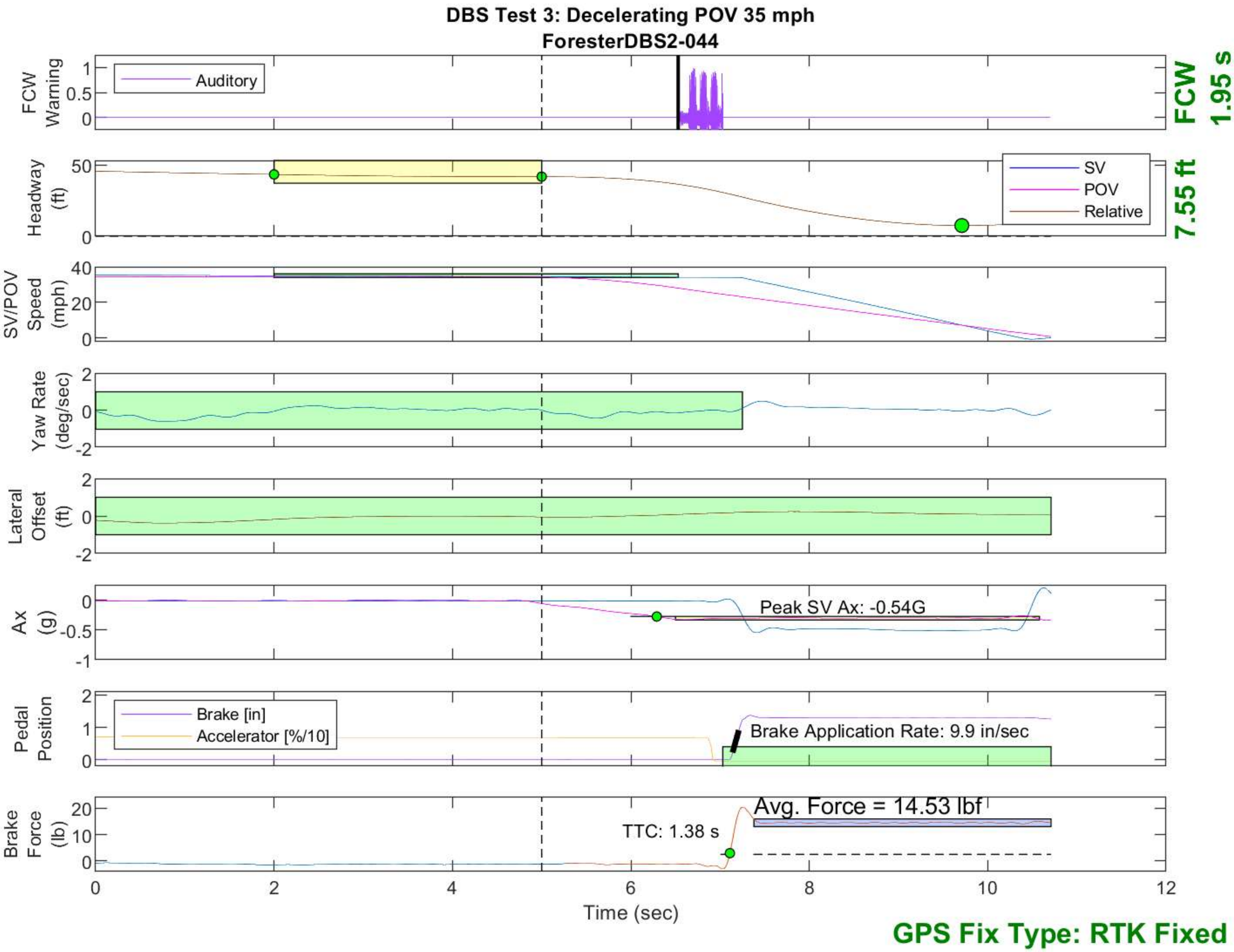


Figure E36. Time History for DBS Run 44, Test 3 - Decelerating POV 35 mph

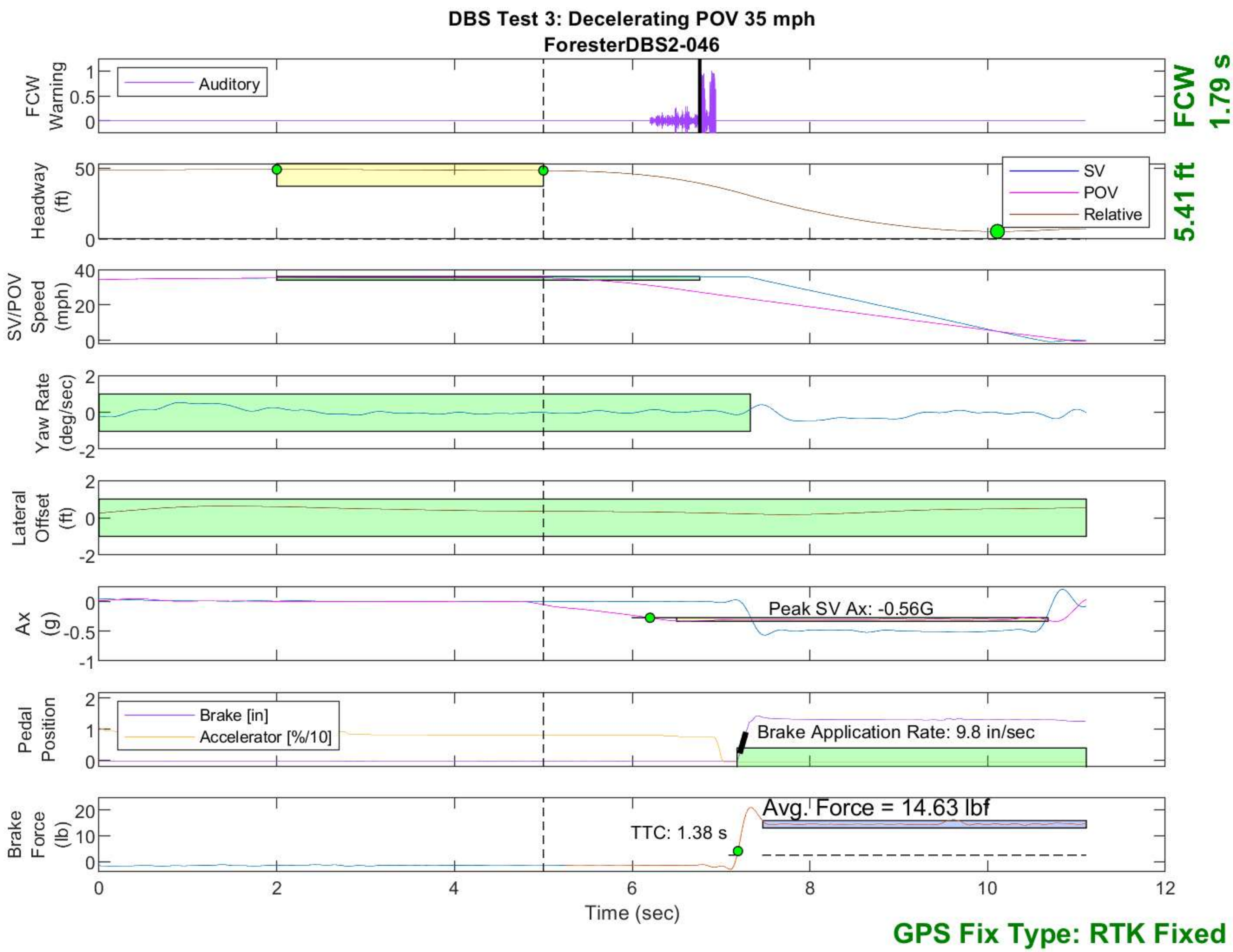


Figure E37. Time History for DBS Run 46, Test 3 - Decelerating POV 35 mph

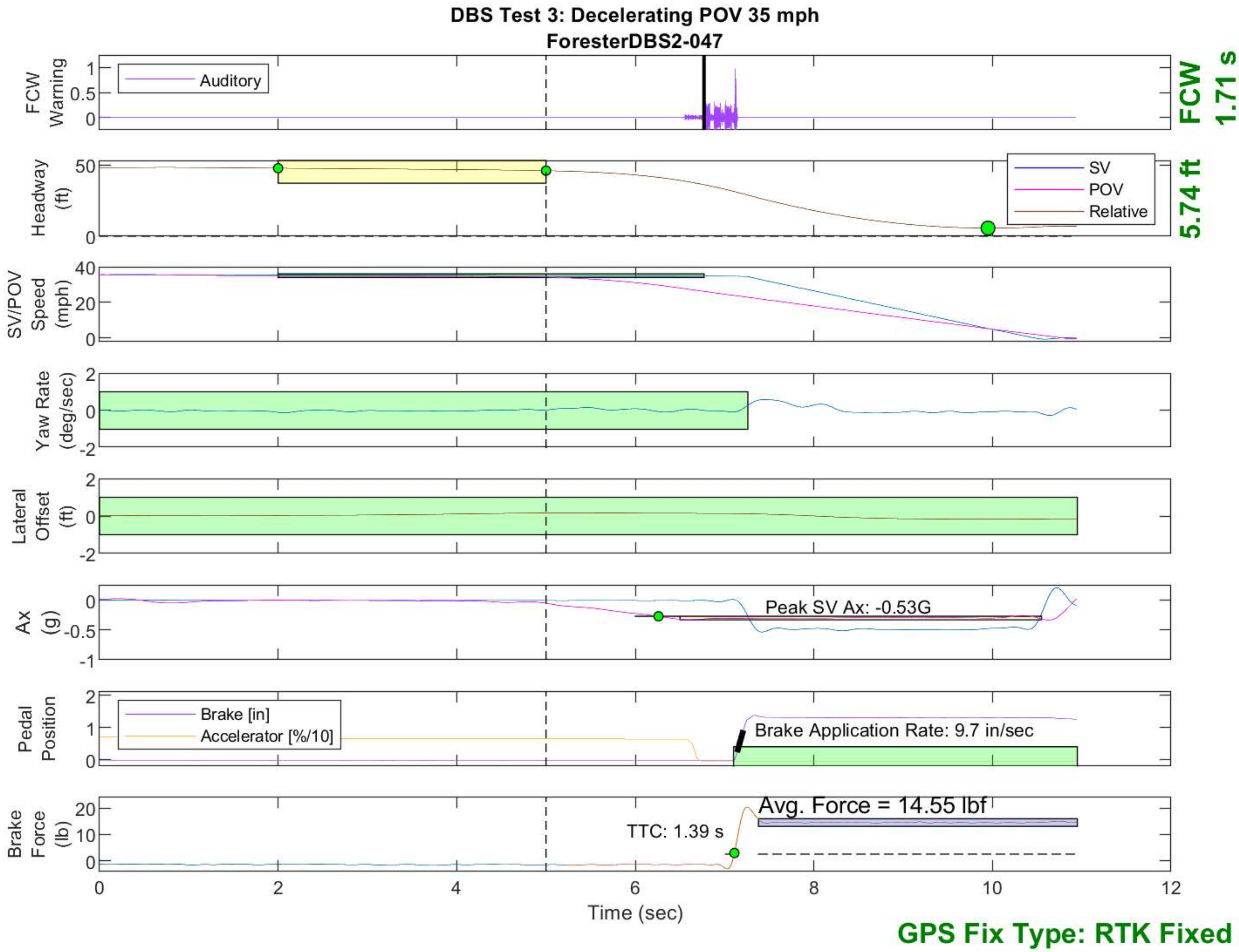


Figure E38. Time History for DBS Run 47, Test 3 - Decelerating POV 35 mph

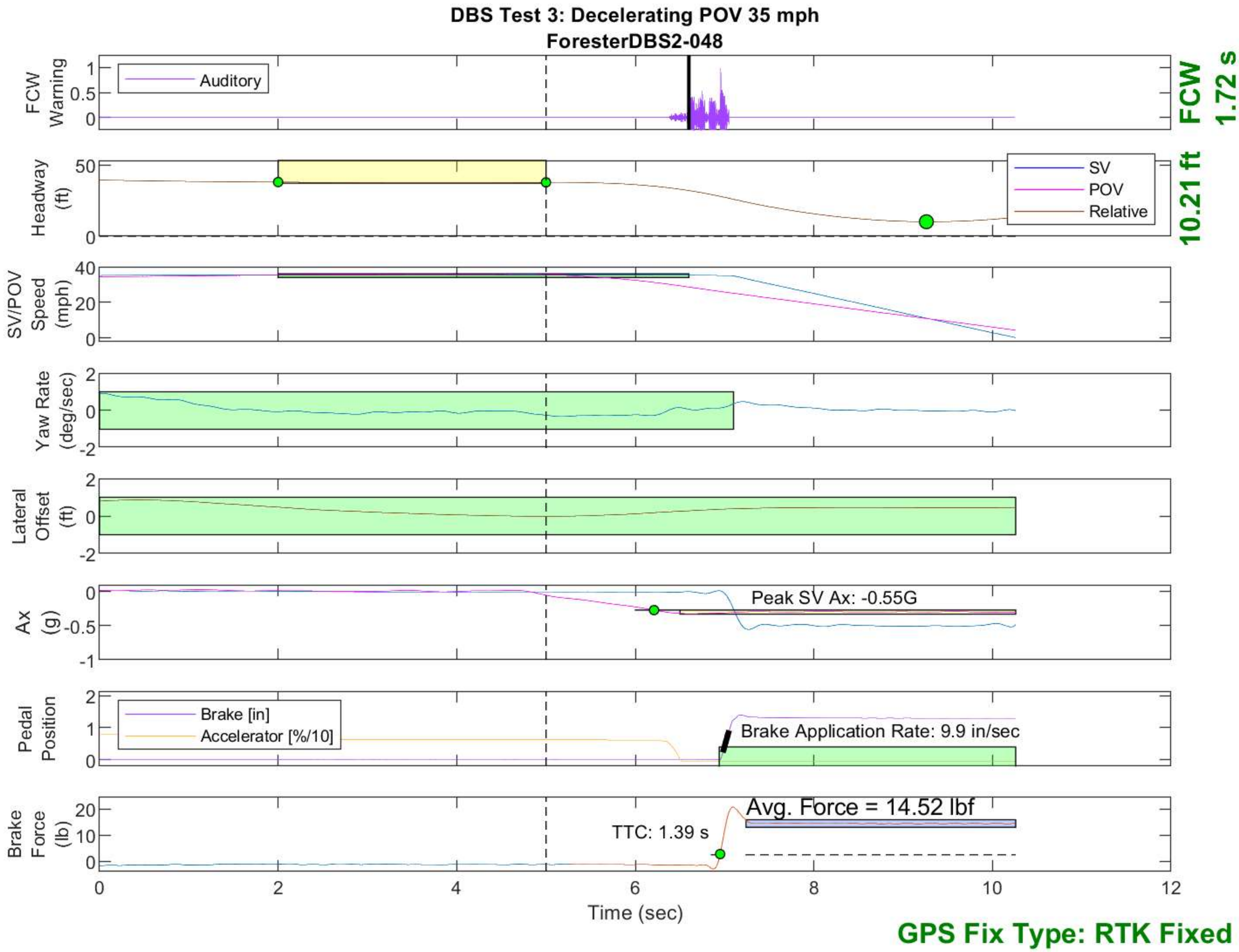


Figure E39. Time History for DBS Run 48, Test 3 - Decelerating POV 35 mph

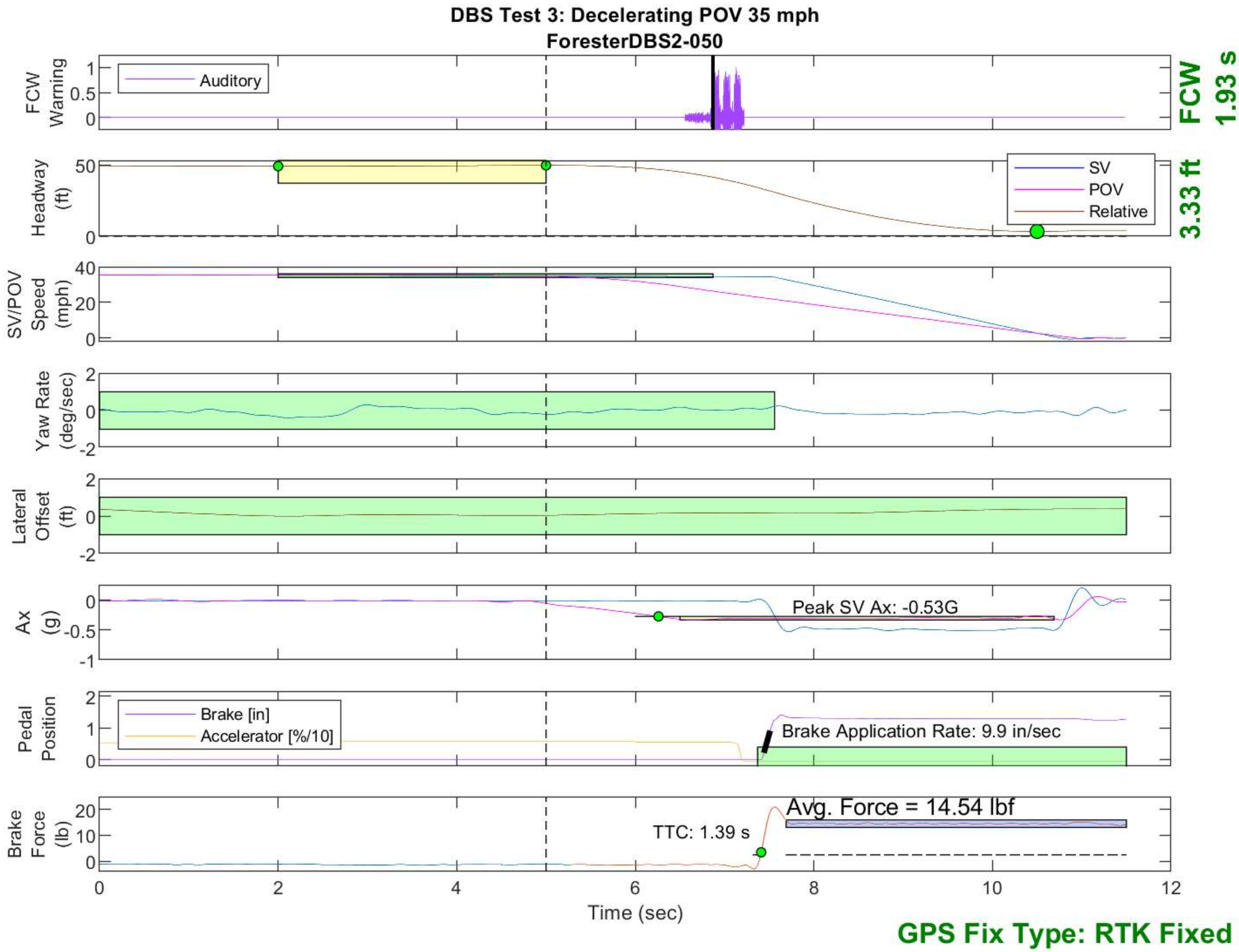


Figure E40. Time History for DBS Run 50, Test 3 - Decelerating POV 35 mph

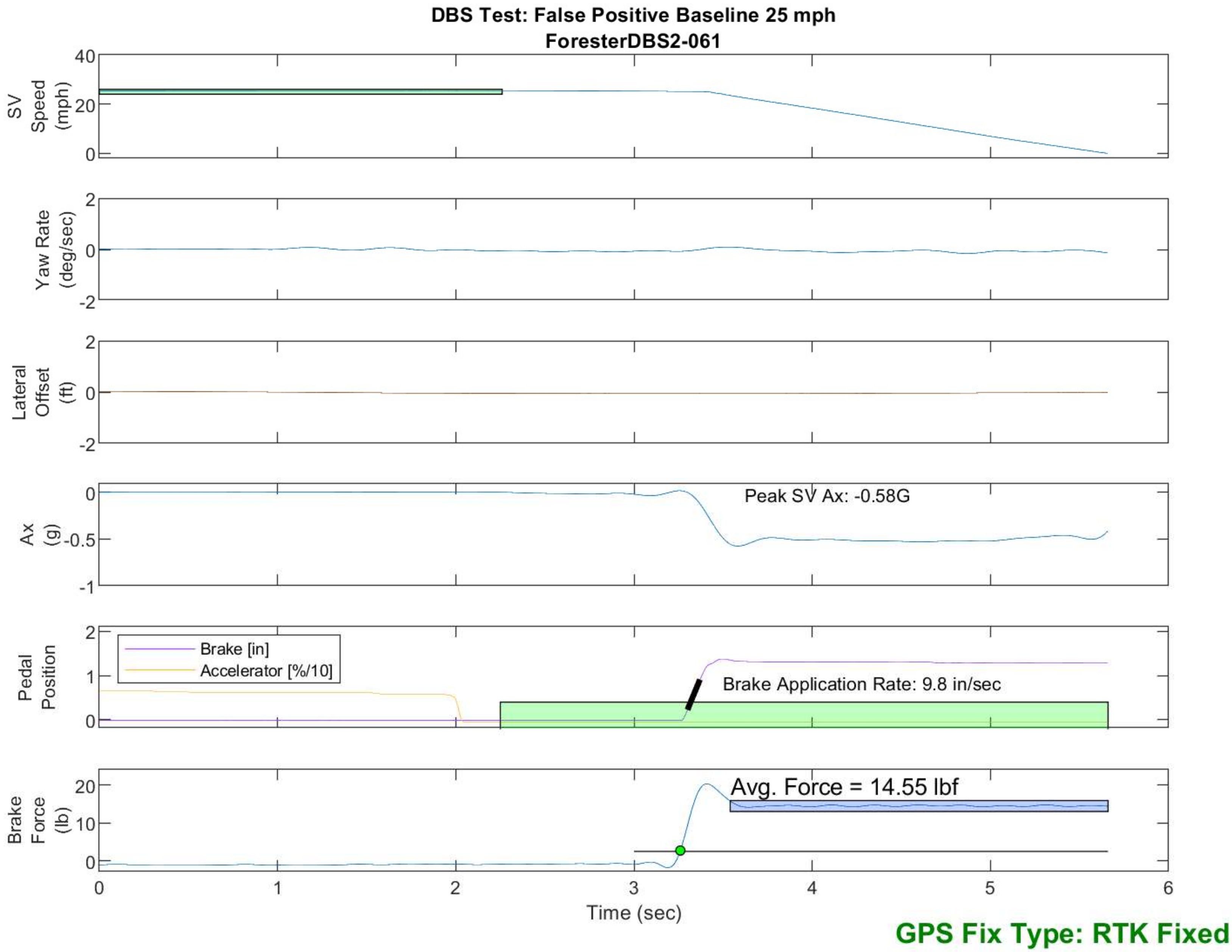


Figure E41. Time History for DBS Run 61, False Positive Baseline, SV 25 mph

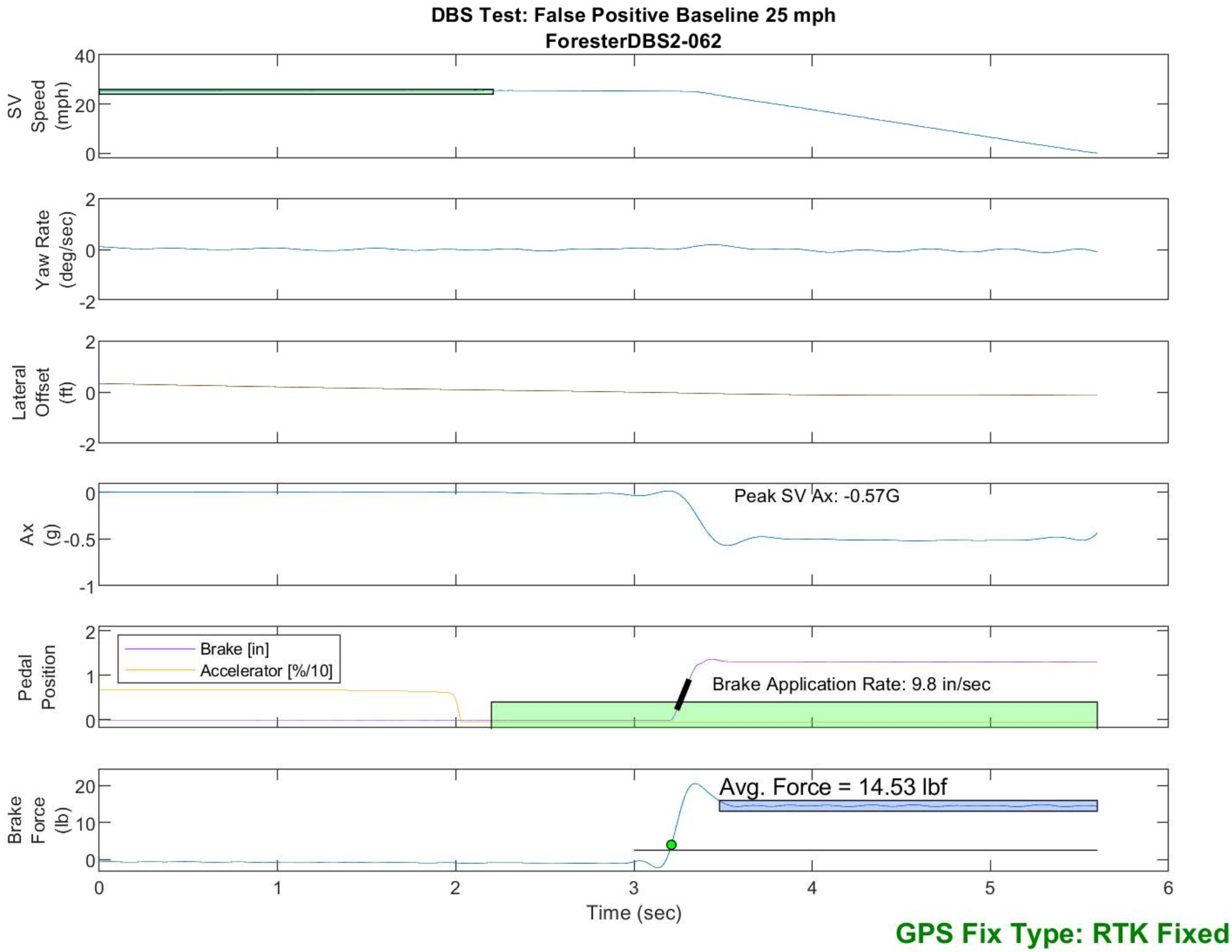


Figure E42. Time History for DBS Run 62, False Positive Baseline, SV 25 mph

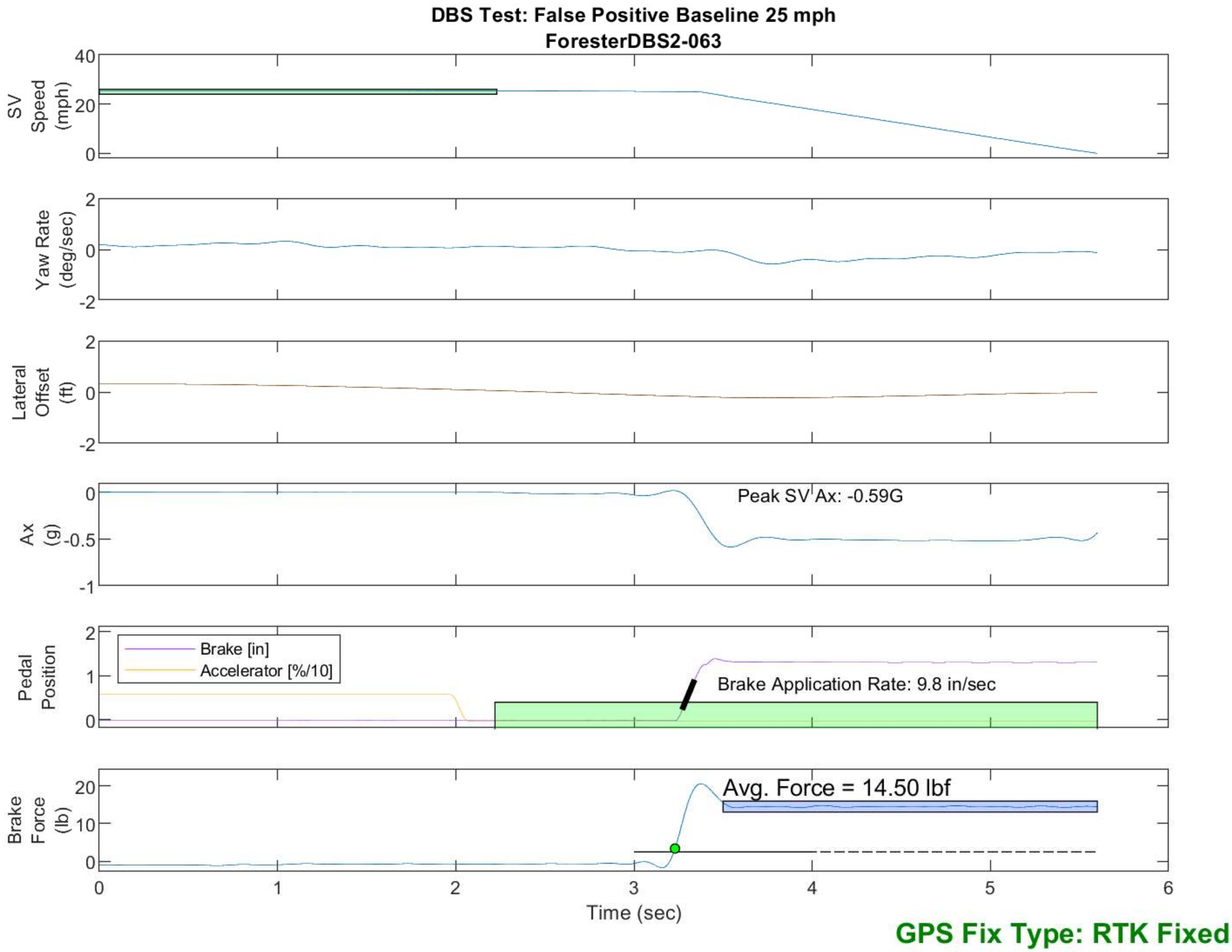


Figure E43. Time History for DBS Run 63, False Positive Baseline, SV 25 mph

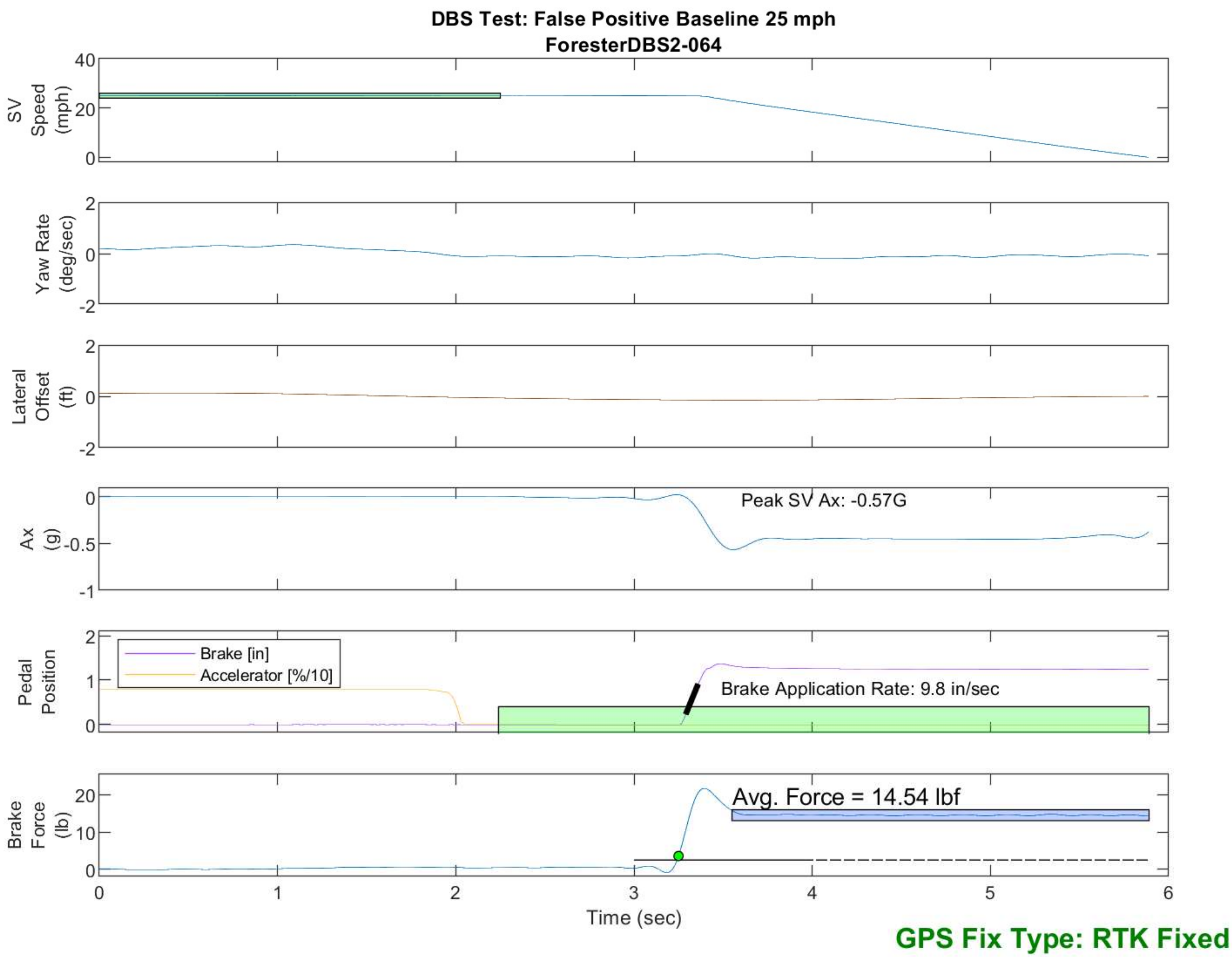


Figure E44. Time History for DBS Run 64, False Positive Baseline, SV 25 mph

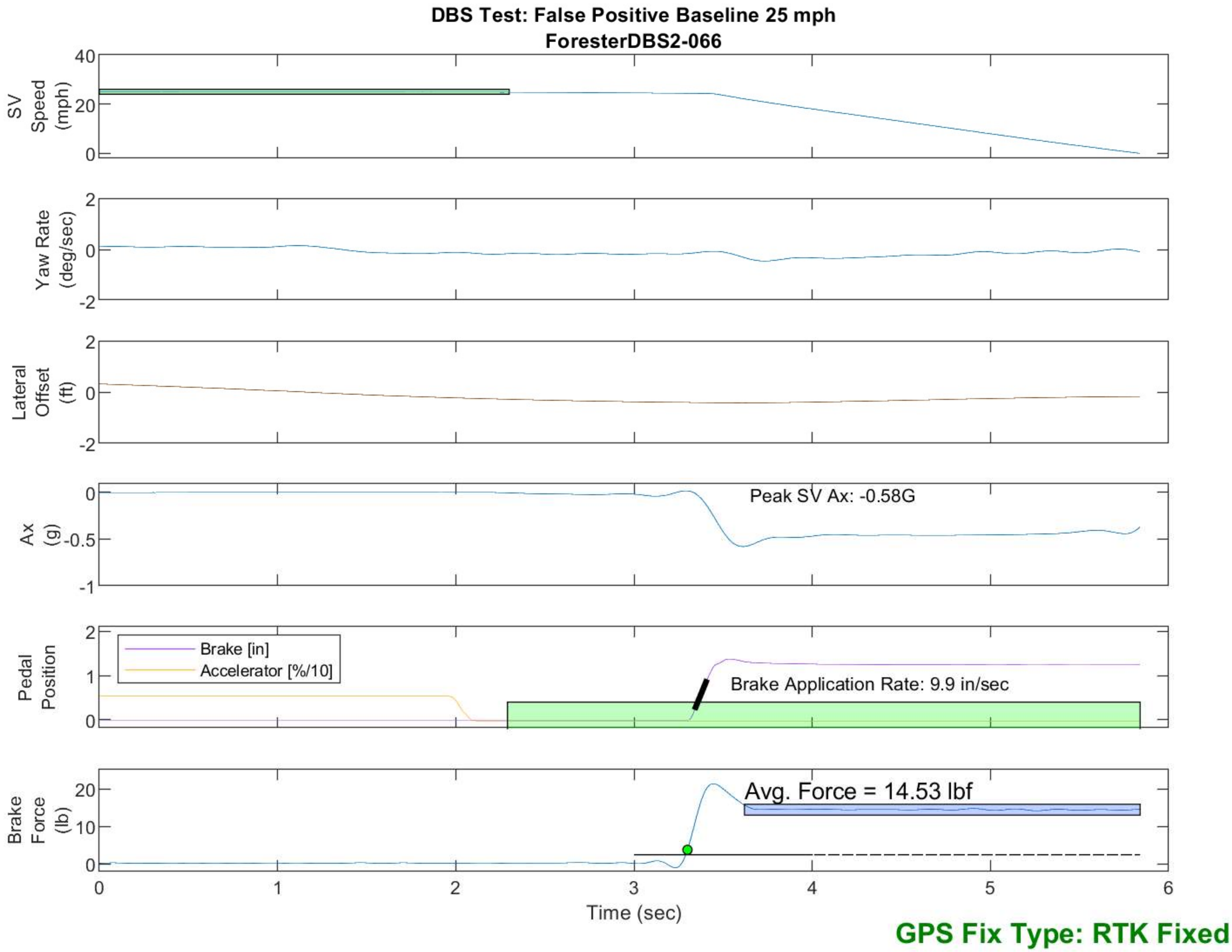


Figure E45. Time History for DBS Run 66, False Positive Baseline, SV 25 mph

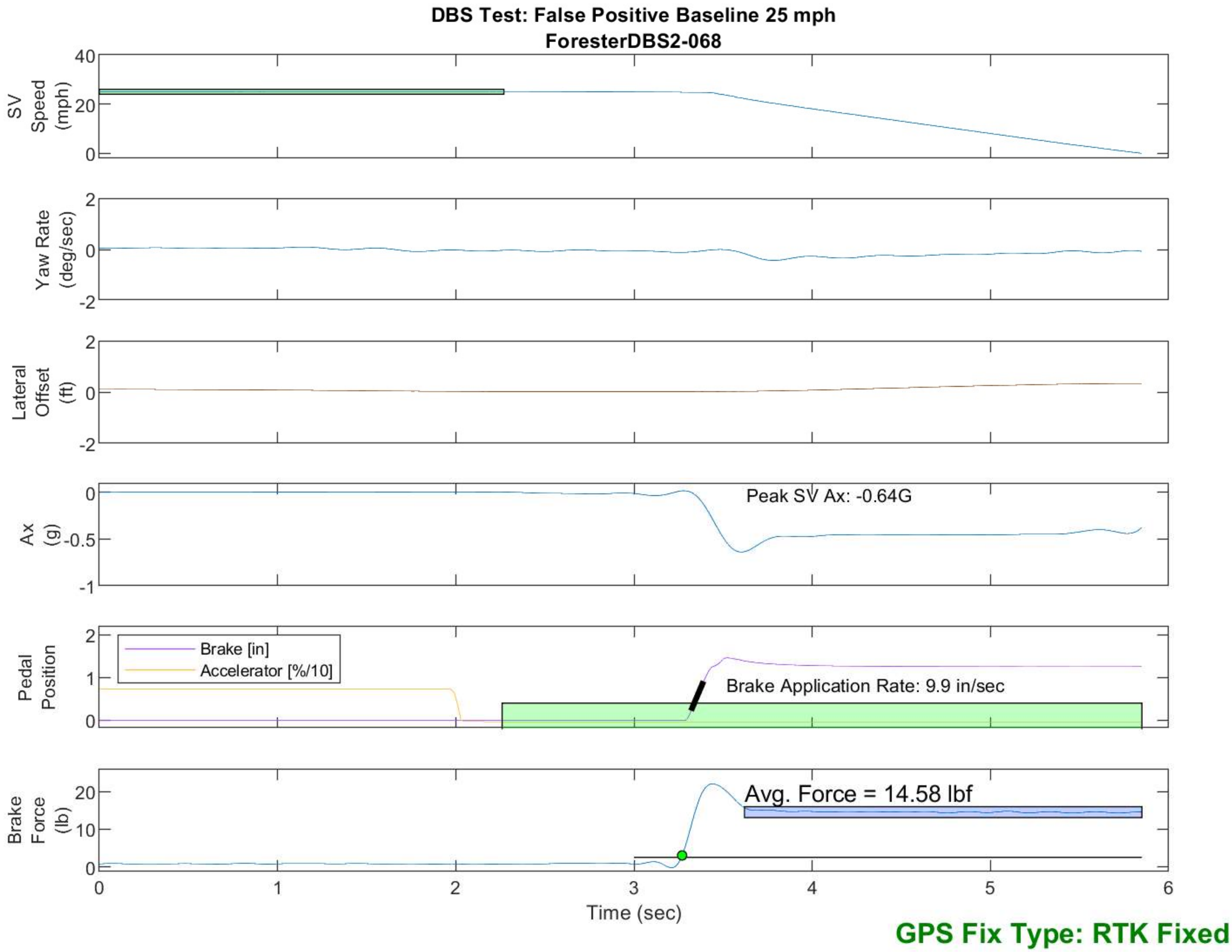


Figure E46. Time History for DBS Run 68, False Positive Baseline, SV 25 mph

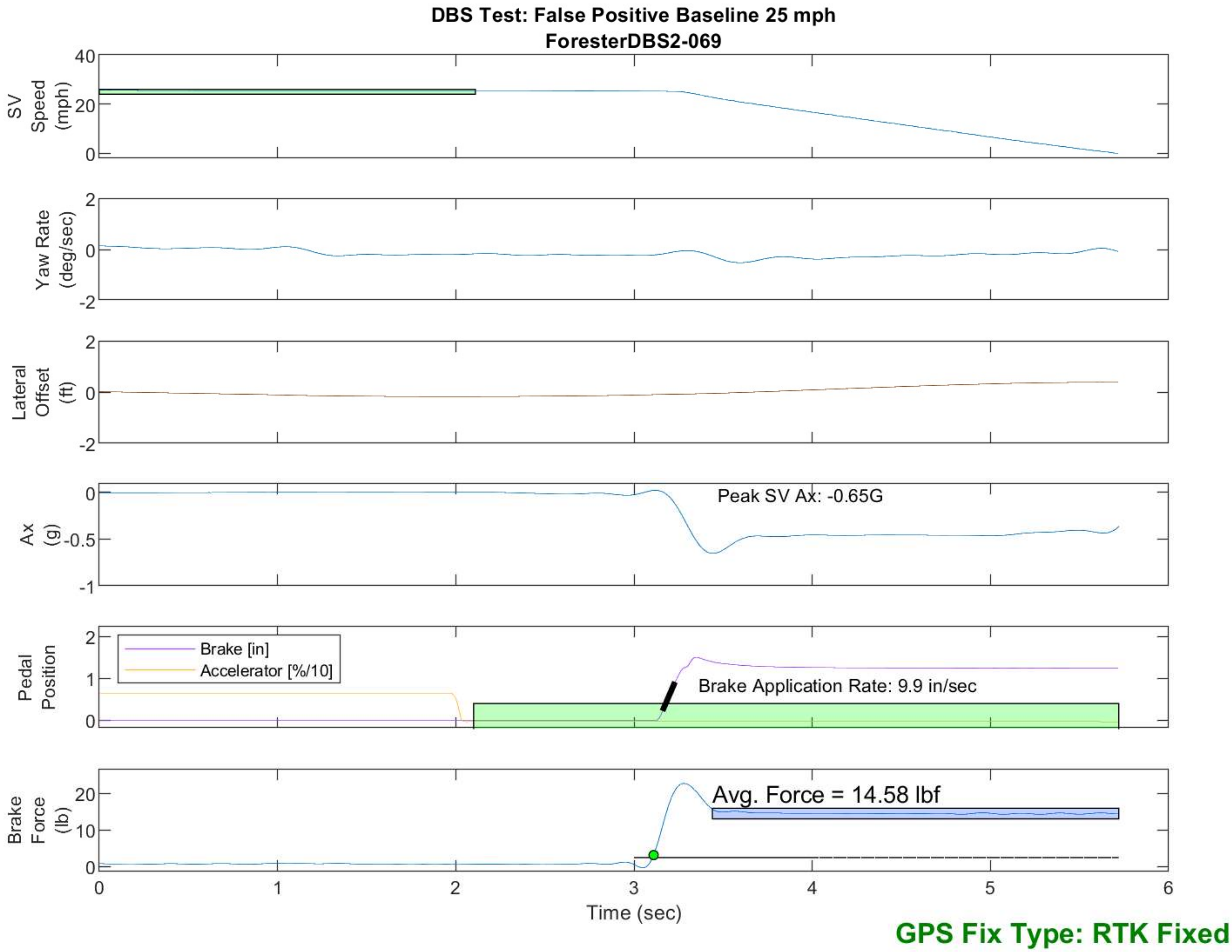


Figure E47. Time History for DBS Run 69, False Positive Baseline, SV 25 mph

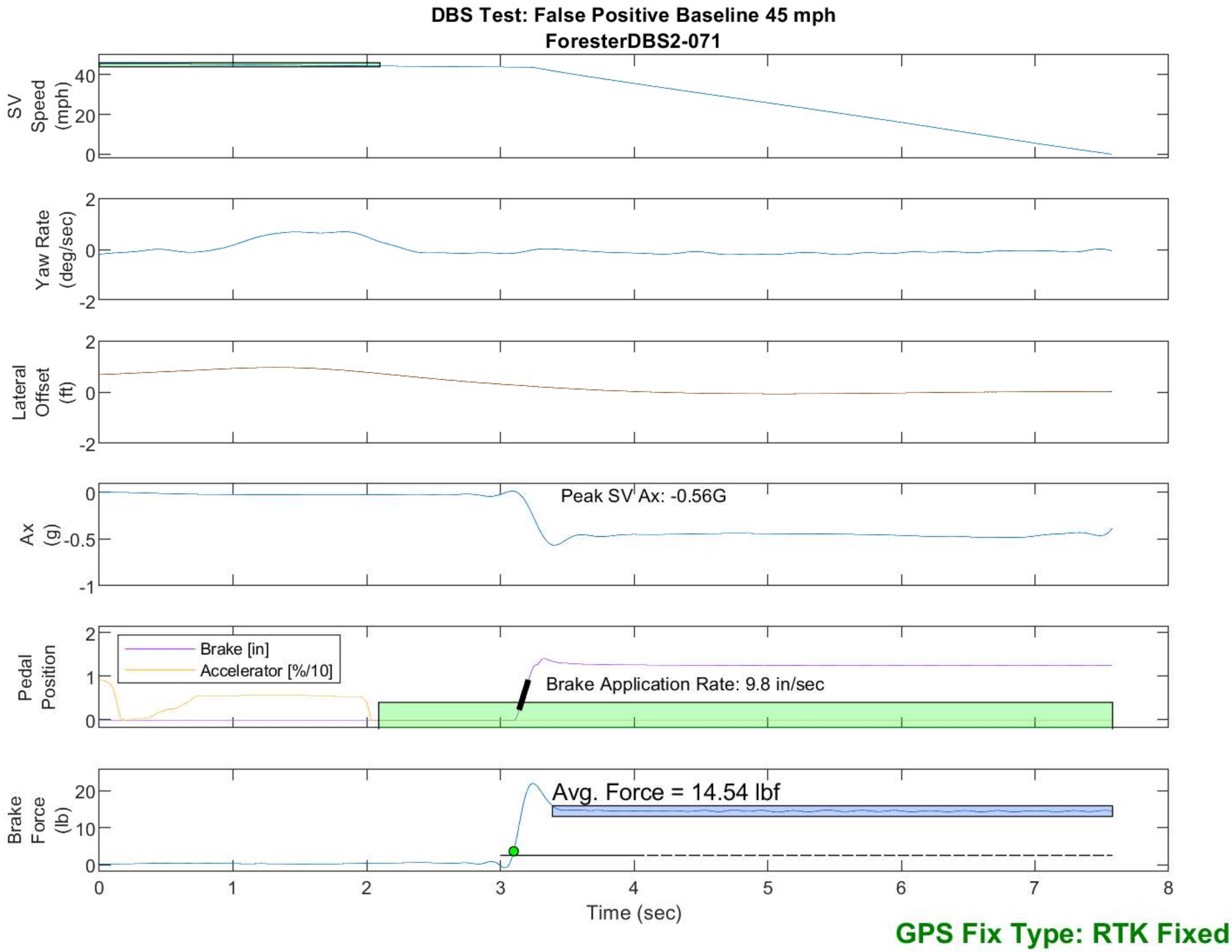


Figure E48. Time History for DBS Run 71, False Positive Baseline, SV 45 mph

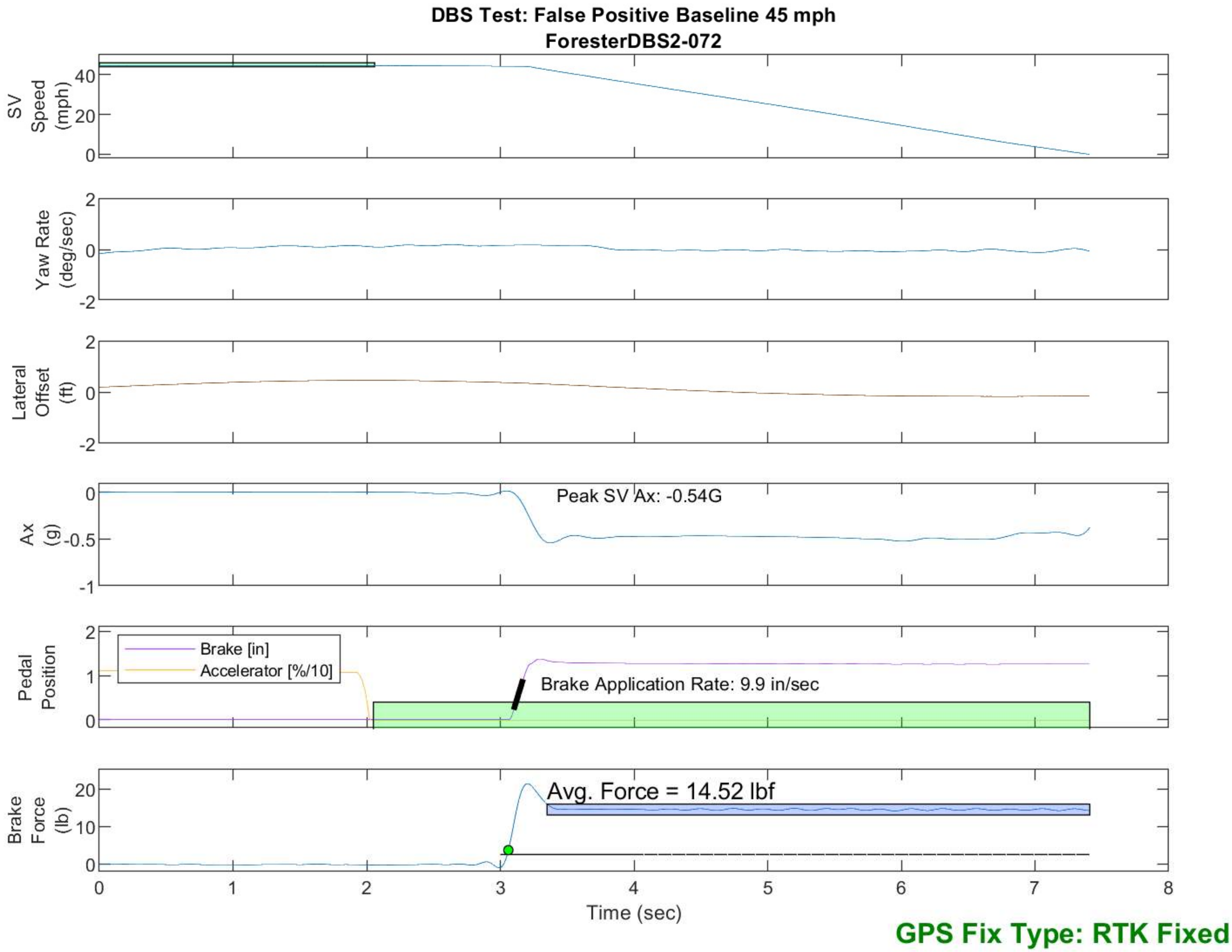


Figure E49. Time History for DBS Run 72, False Positive Baseline, SV 45 mph

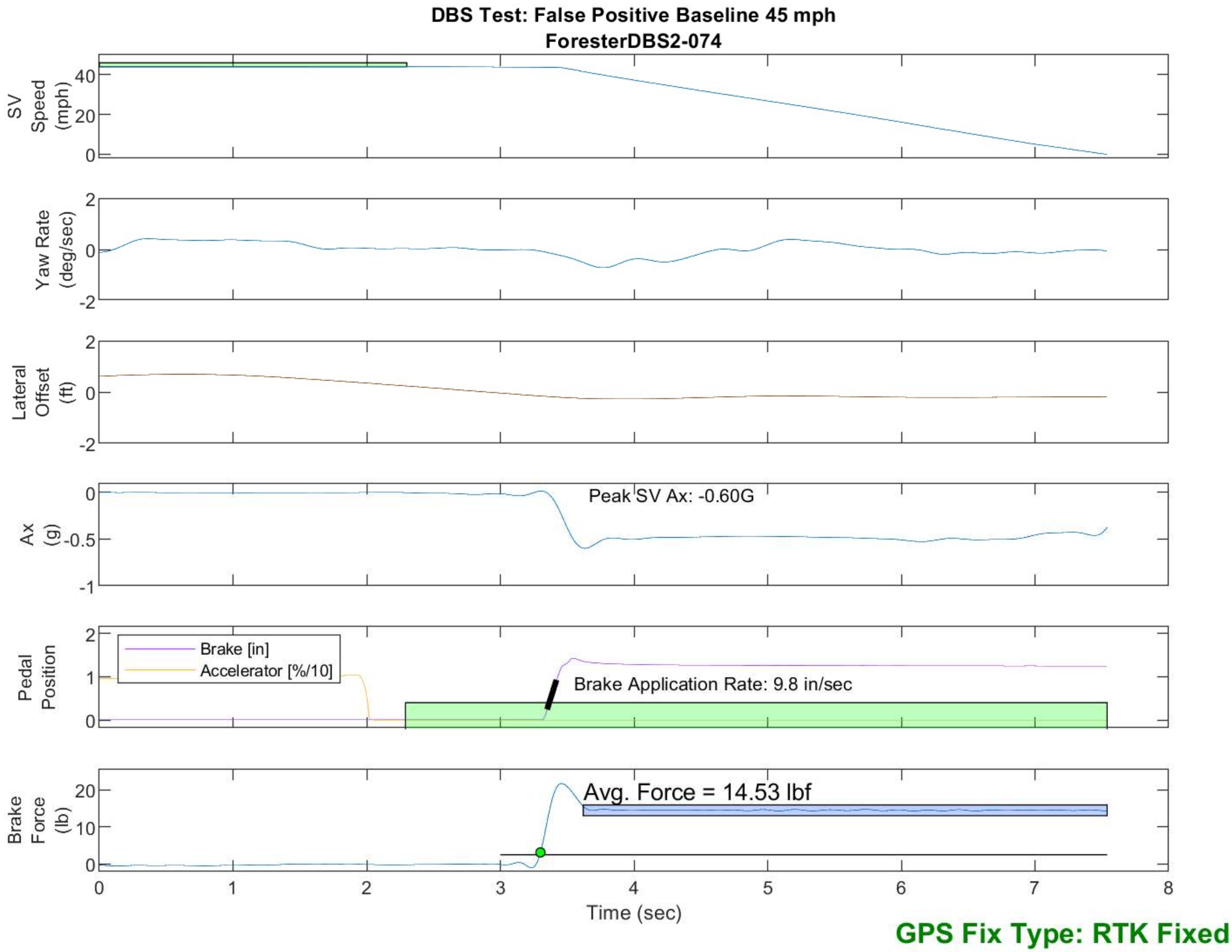


Figure E50. Time History for DBS Run 74, False Positive Baseline, SV 45 mph

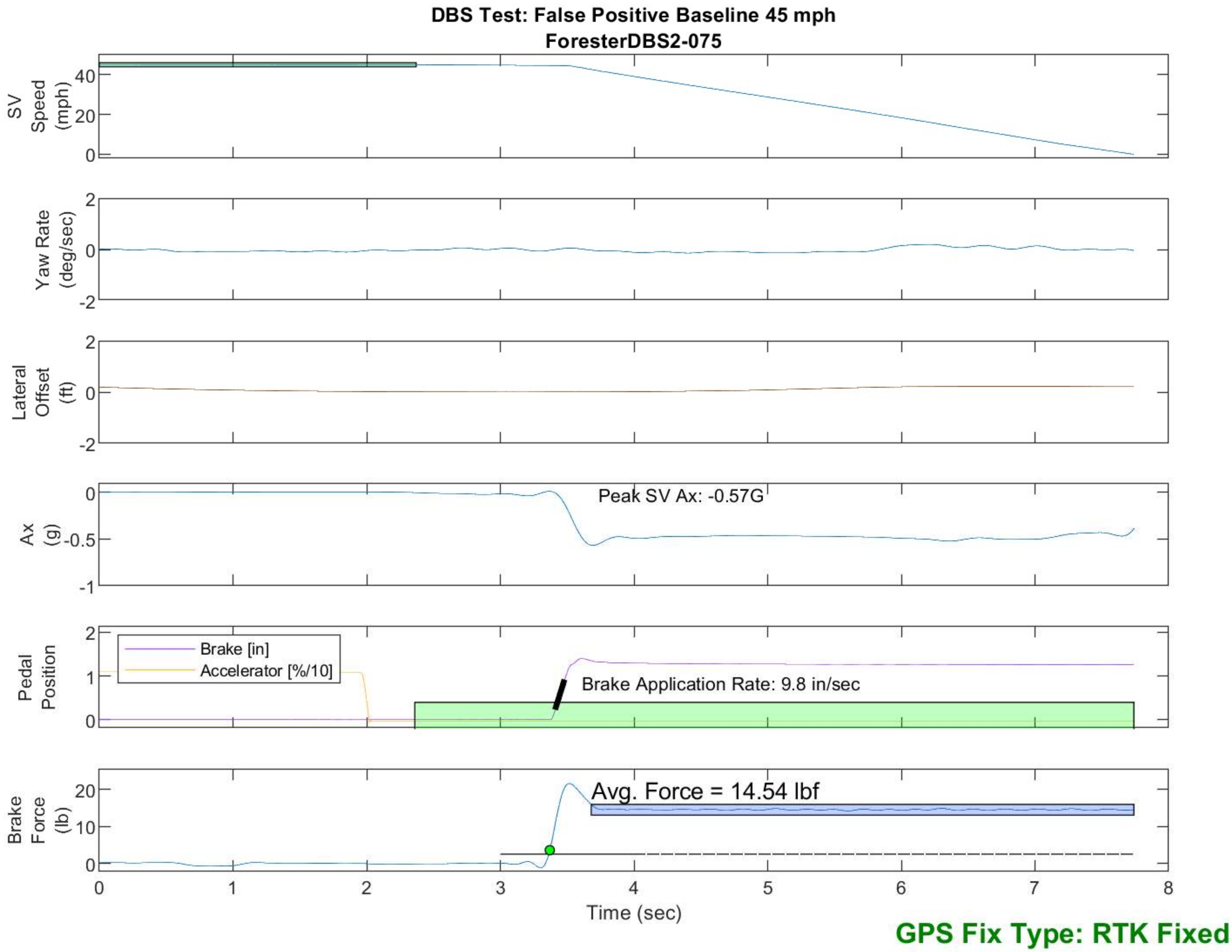


Figure E51. Time History for DBS Run 75, False Positive Baseline, SV 45 mph

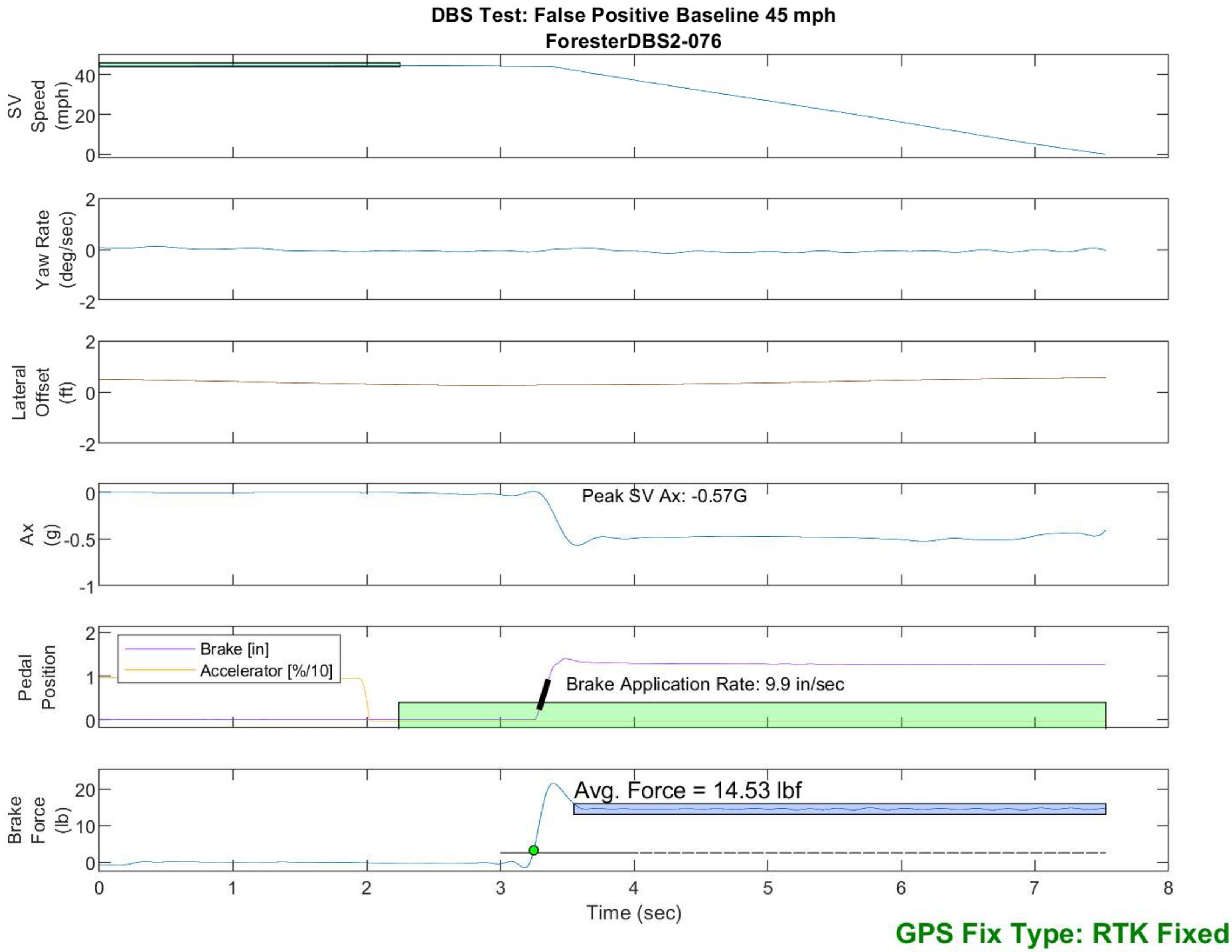


Figure E52. Time History for DBS Run 76, False Positive Baseline, SV 45 mph

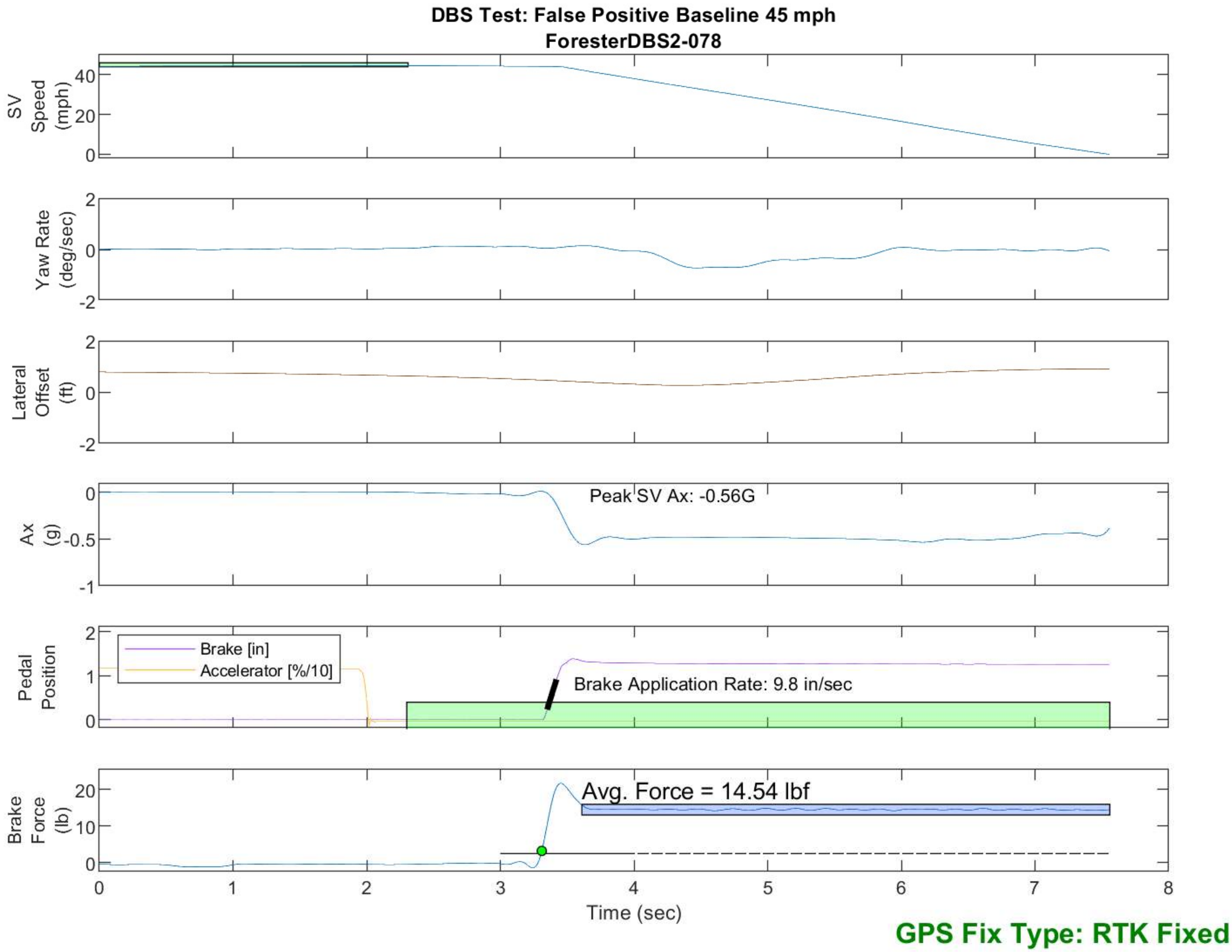


Figure E53. Time History for DBS Run 78, False Positive Baseline, SV 45 mph

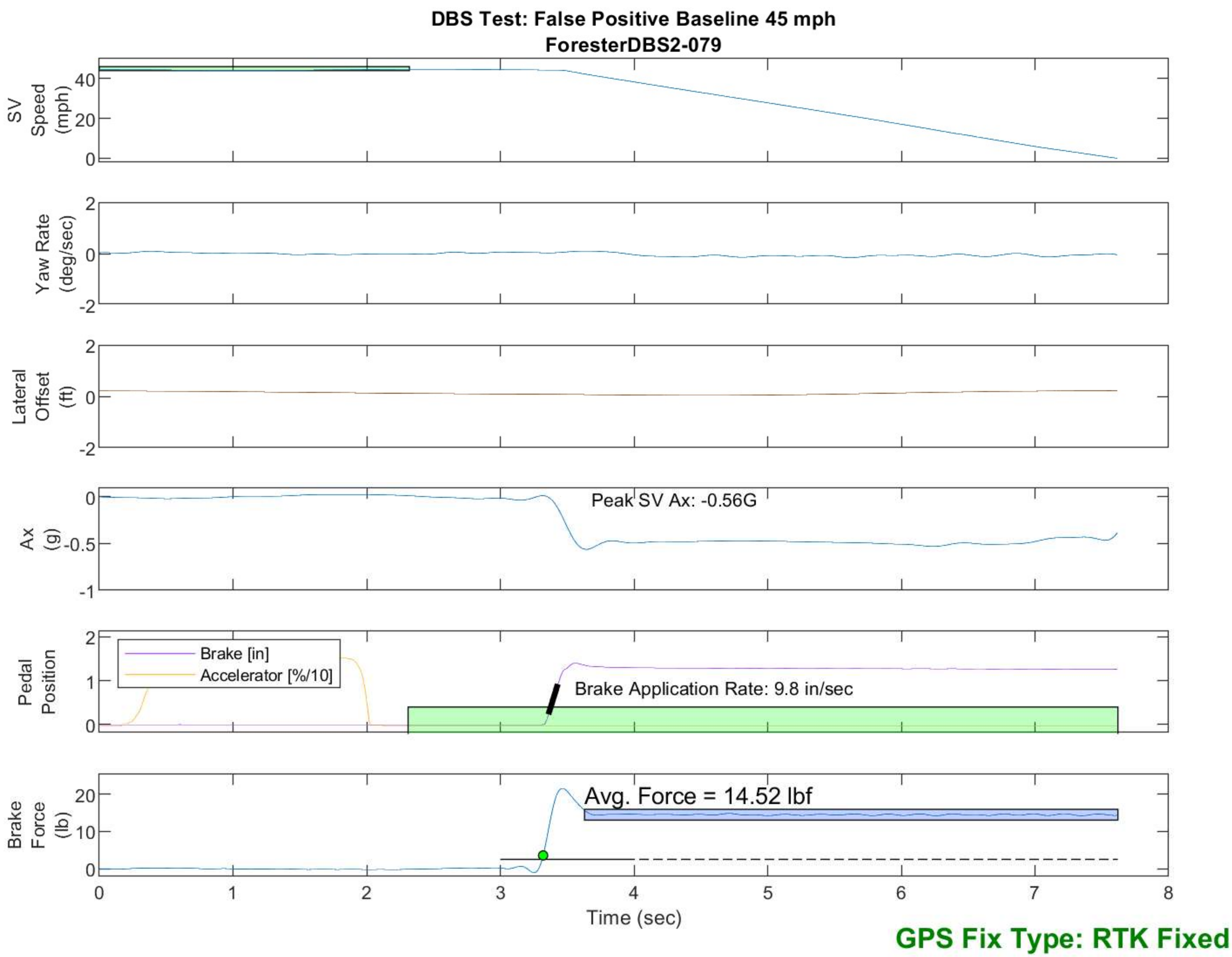


Figure E54. Time History for DBS Run 79, False Positive Baseline, SV 45 mph

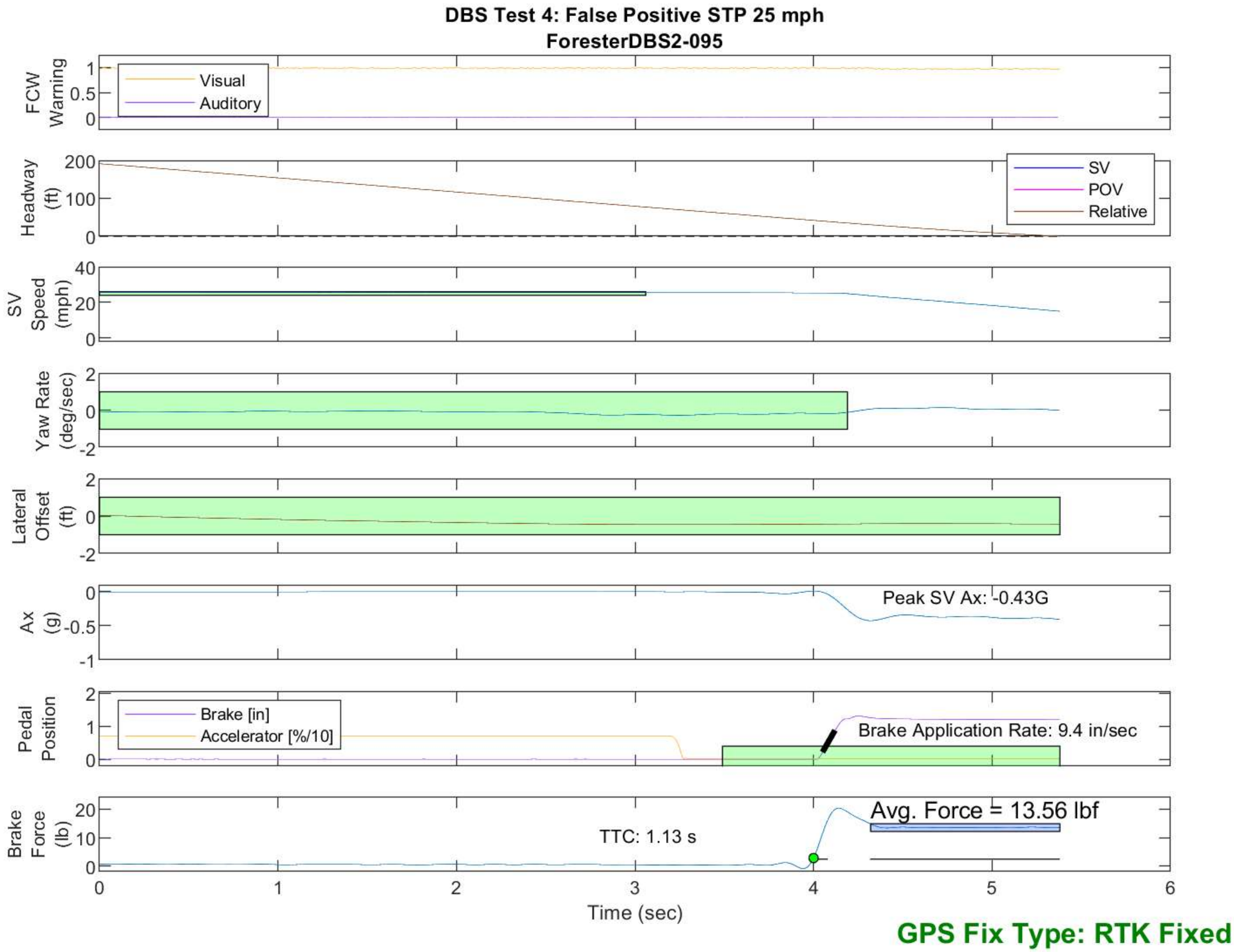


Figure E55. Time History for DBS Run 95, Test 4 - False Positive STP 25 mph

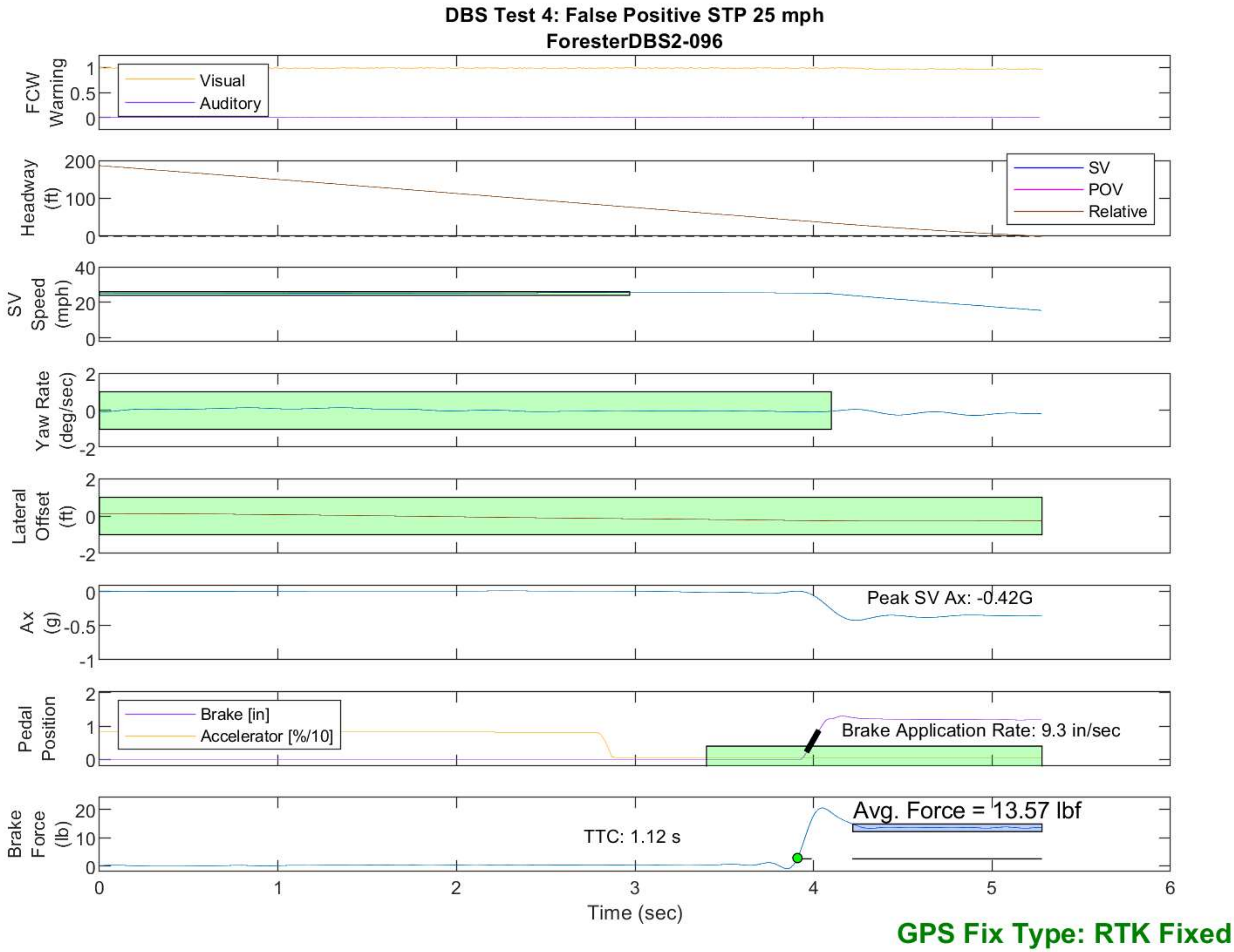


Figure E56. Time History for DBS Run 96, Test 4 - False Positive STP 25 mph

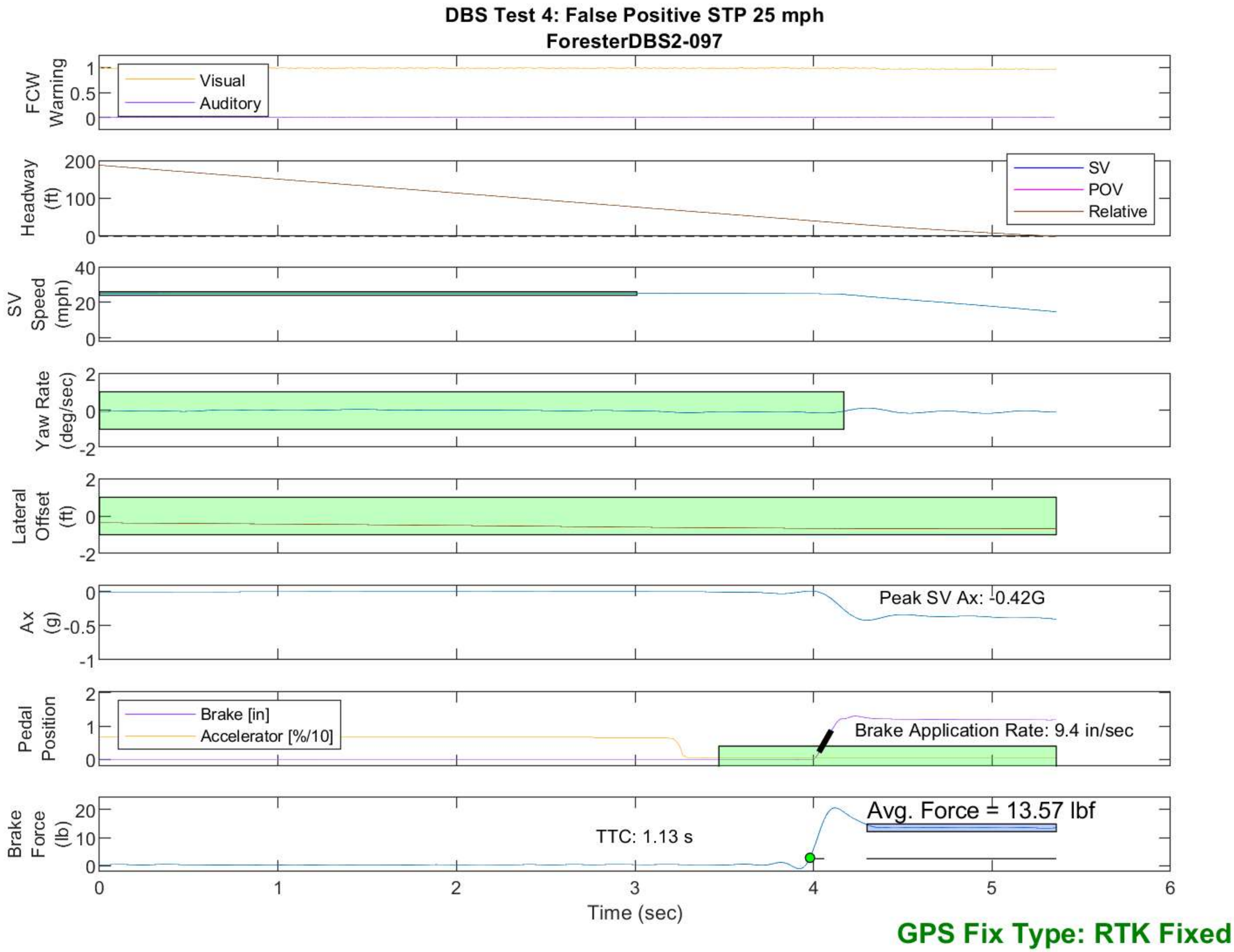


Figure E57. Time History for DBS Run 97, Test 4 - False Positive STP 25 mph

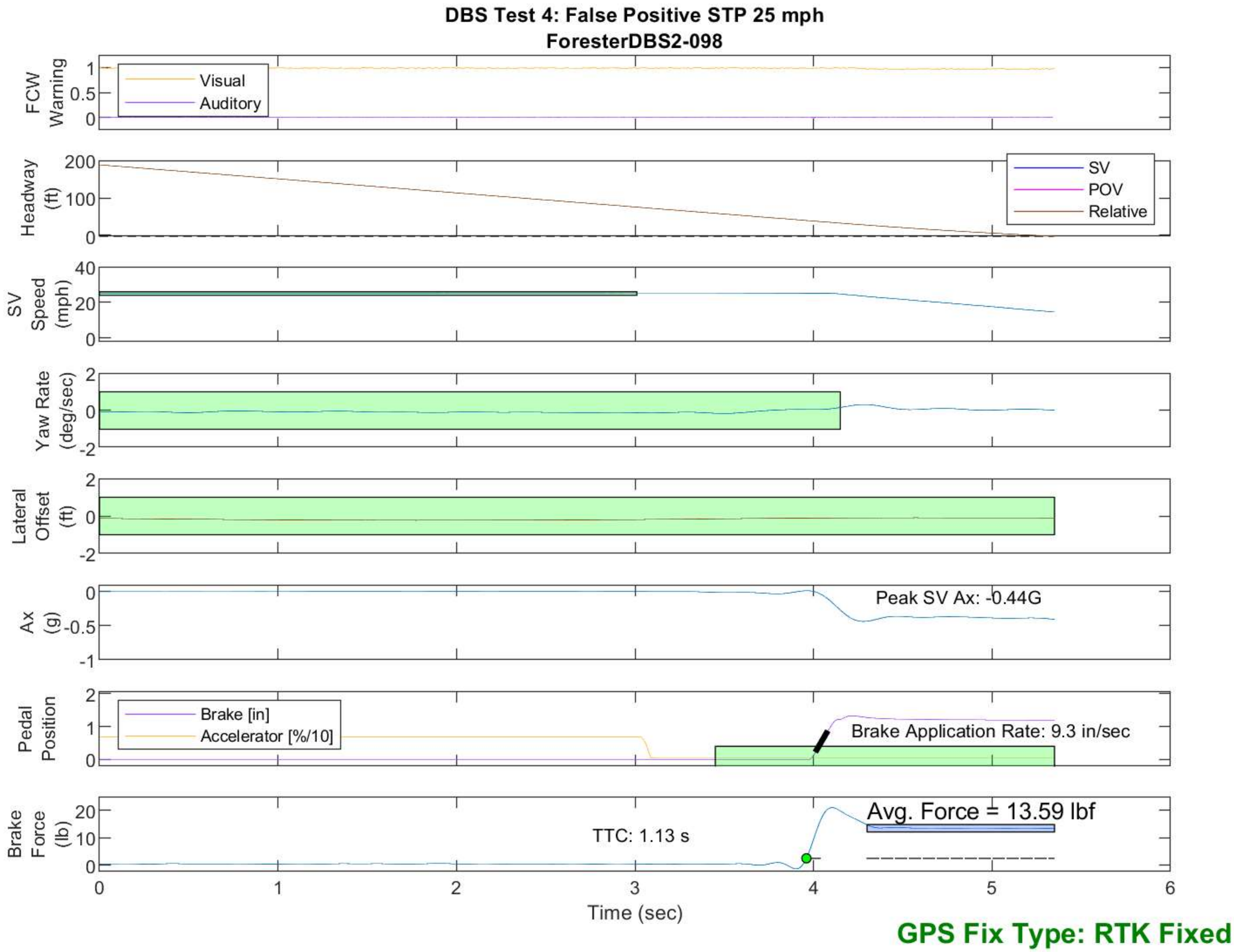


Figure E58. Time History for DBS Run 98, Test 4 - False Positive STP 25 mph

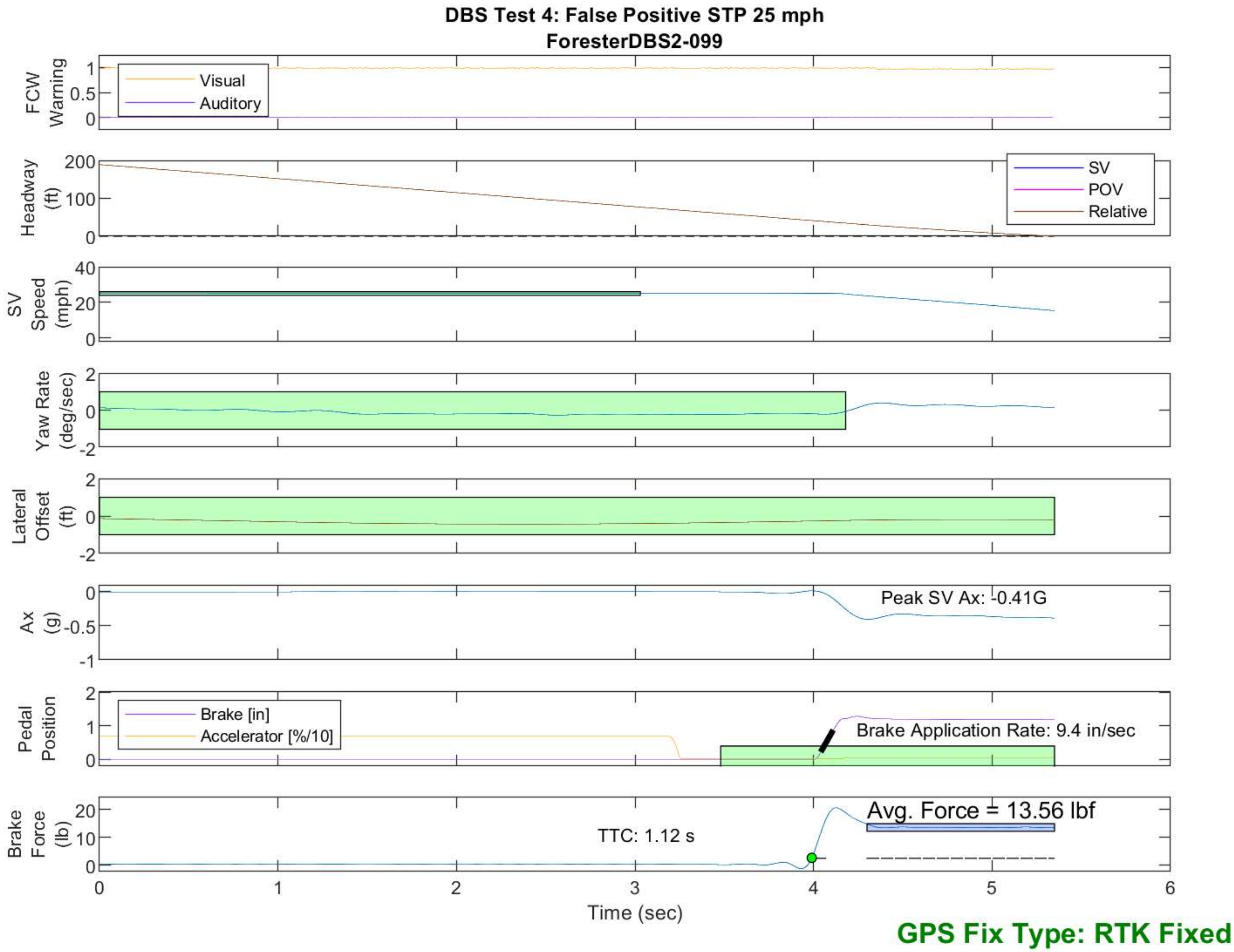


Figure E59. Time History for DBS Run 99, Test 4 - False Positive STP 25 mph

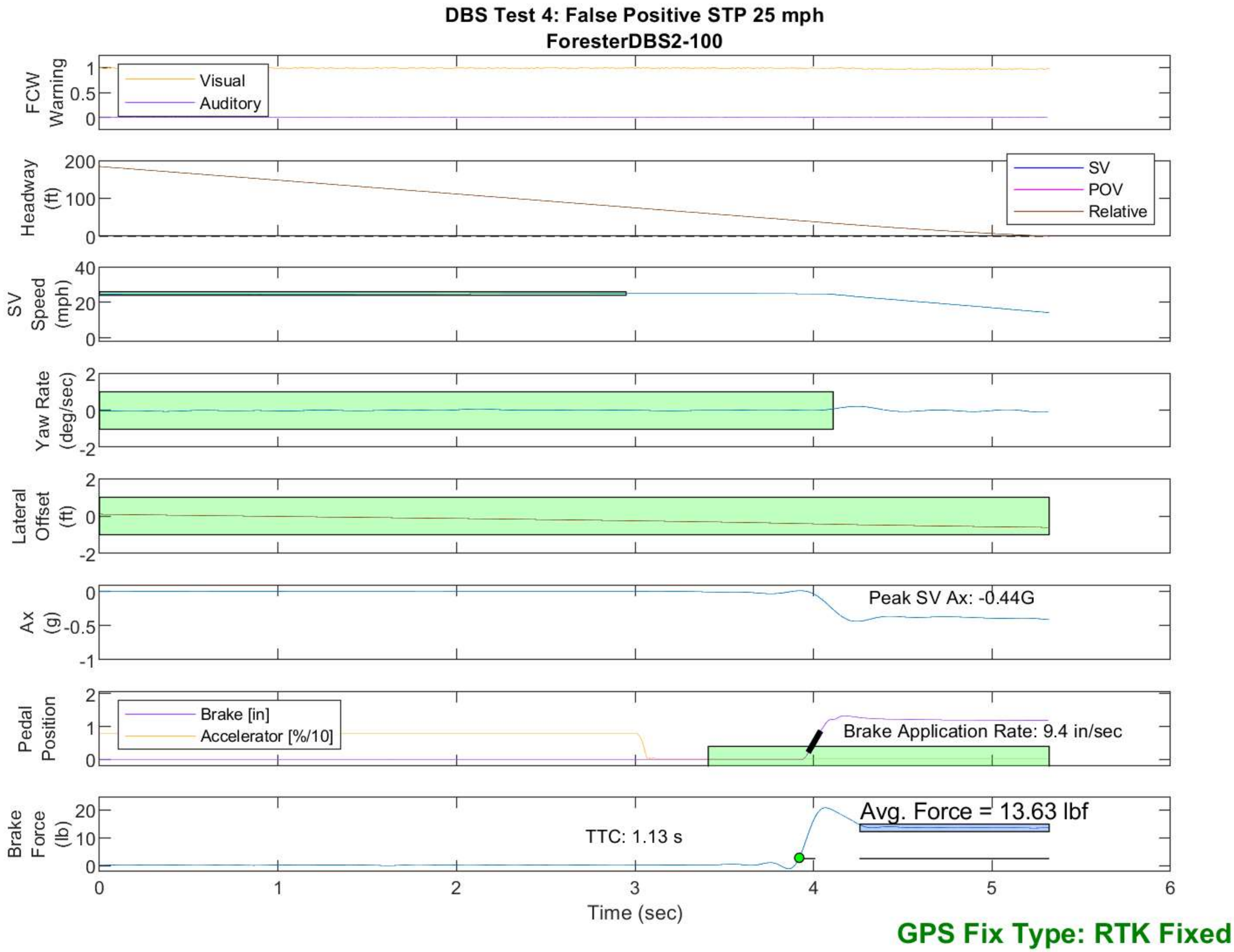


Figure E60. Time History for DBS Run 100, Test 4 - False Positive STP 25 mph

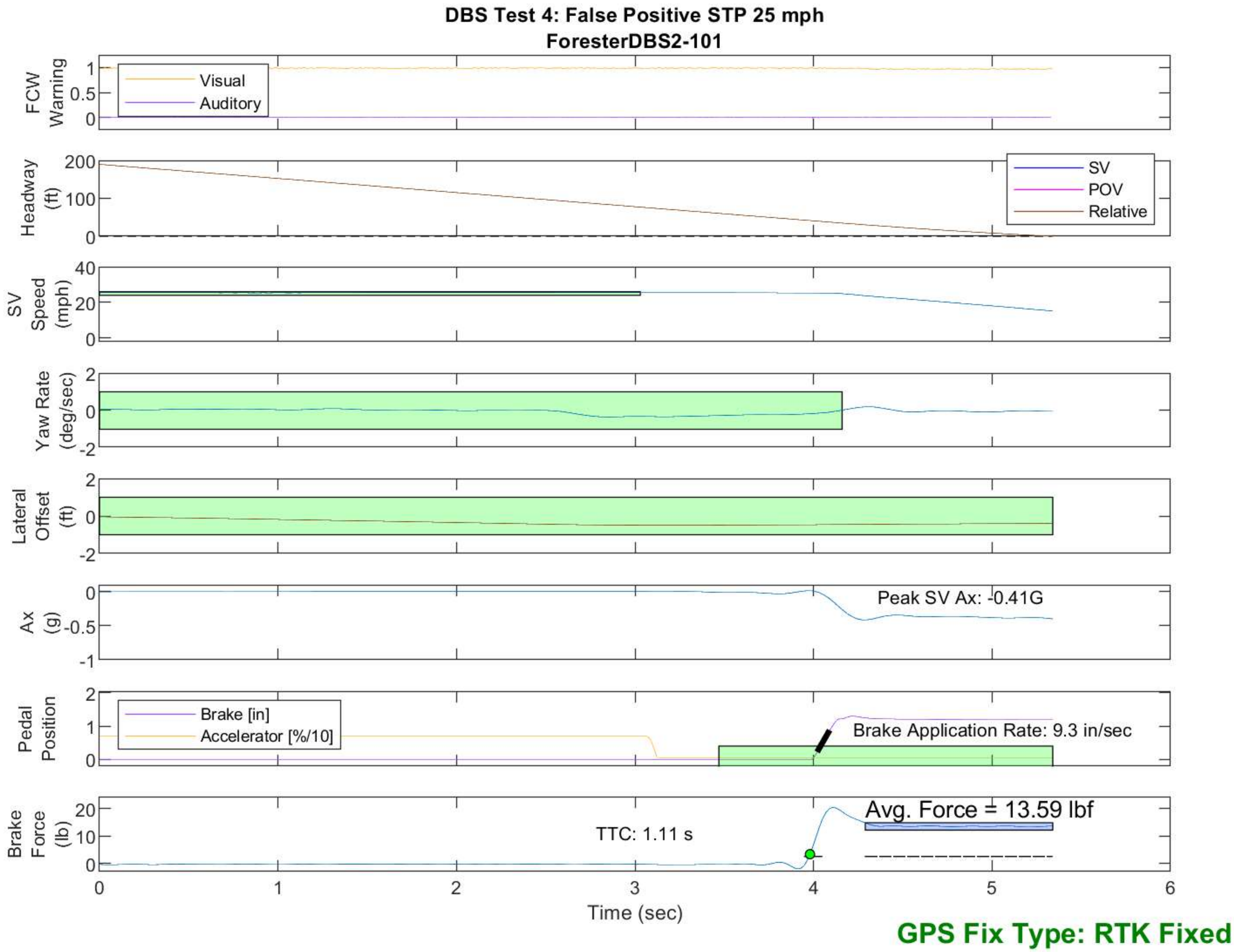


Figure E61. Time History for DBS Run 101, Test 4 - False Positive STP 25 mph

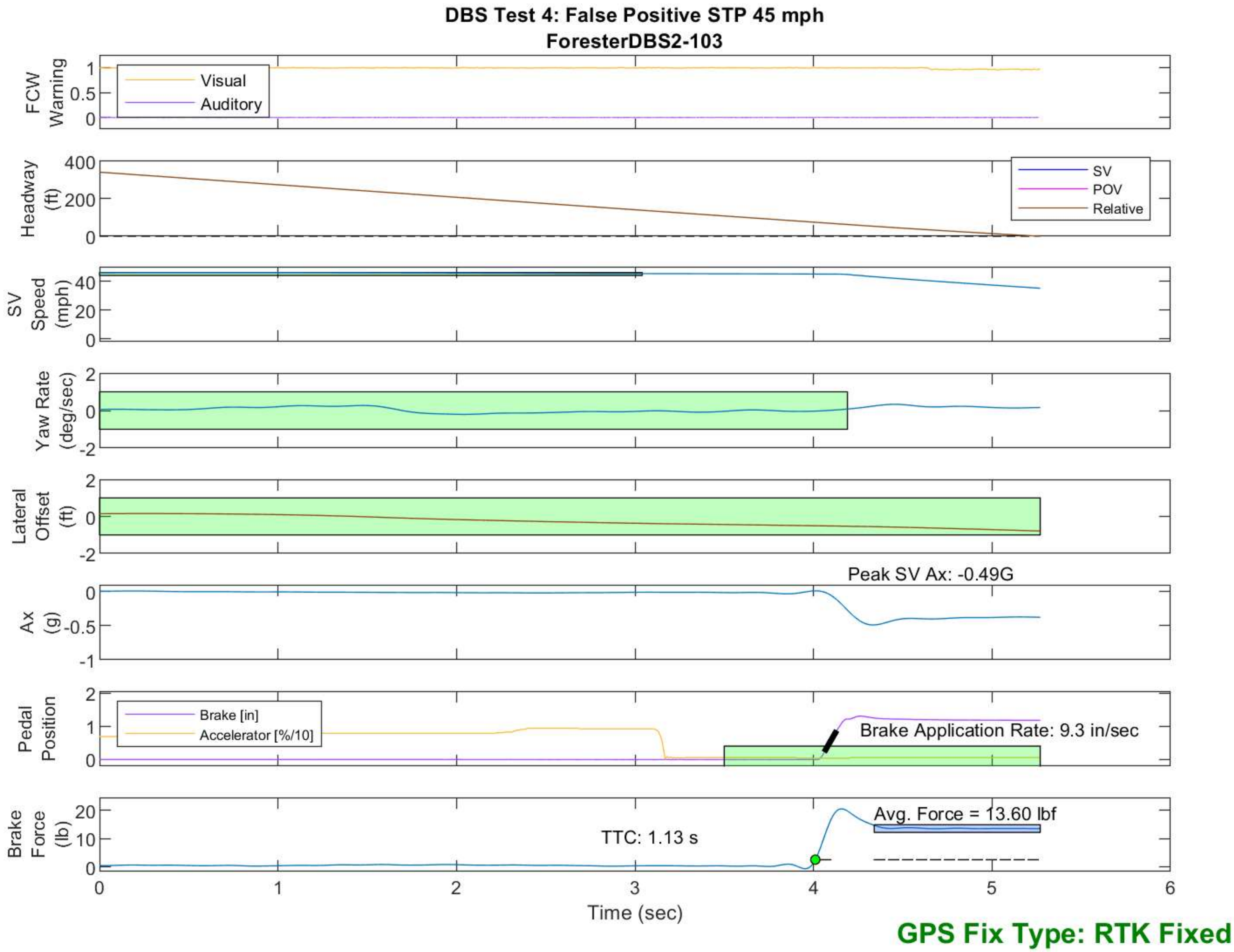


Figure E62. Time History for DBS Run 103, Test 4 - False Positive STP 45 mph

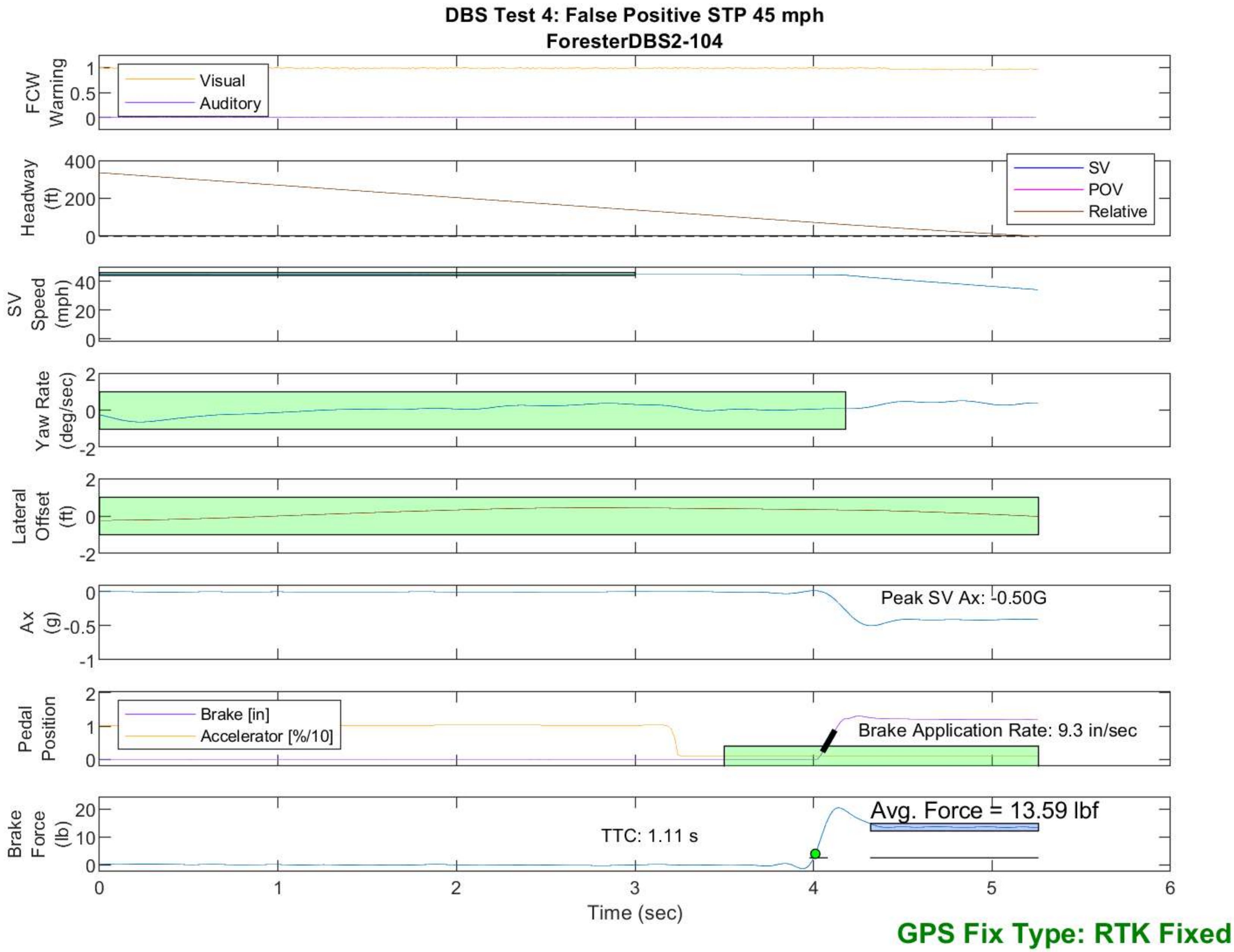


Figure E63. Time History for DBS Run 104, Test 4 - False Positive STP 45 mph

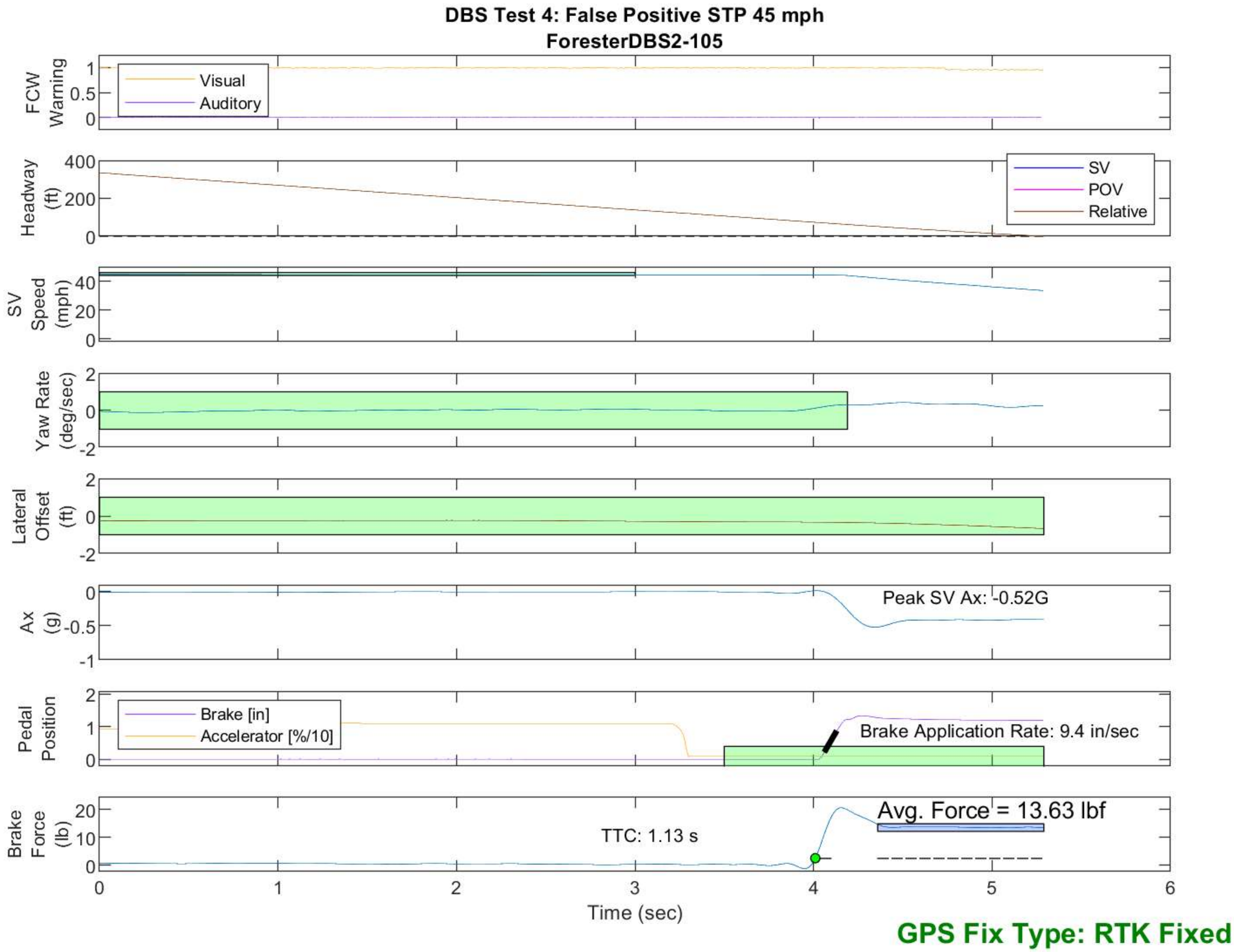


Figure E64. Time History for DBS Run 105, Test 4 - False Positive STP 45 mph

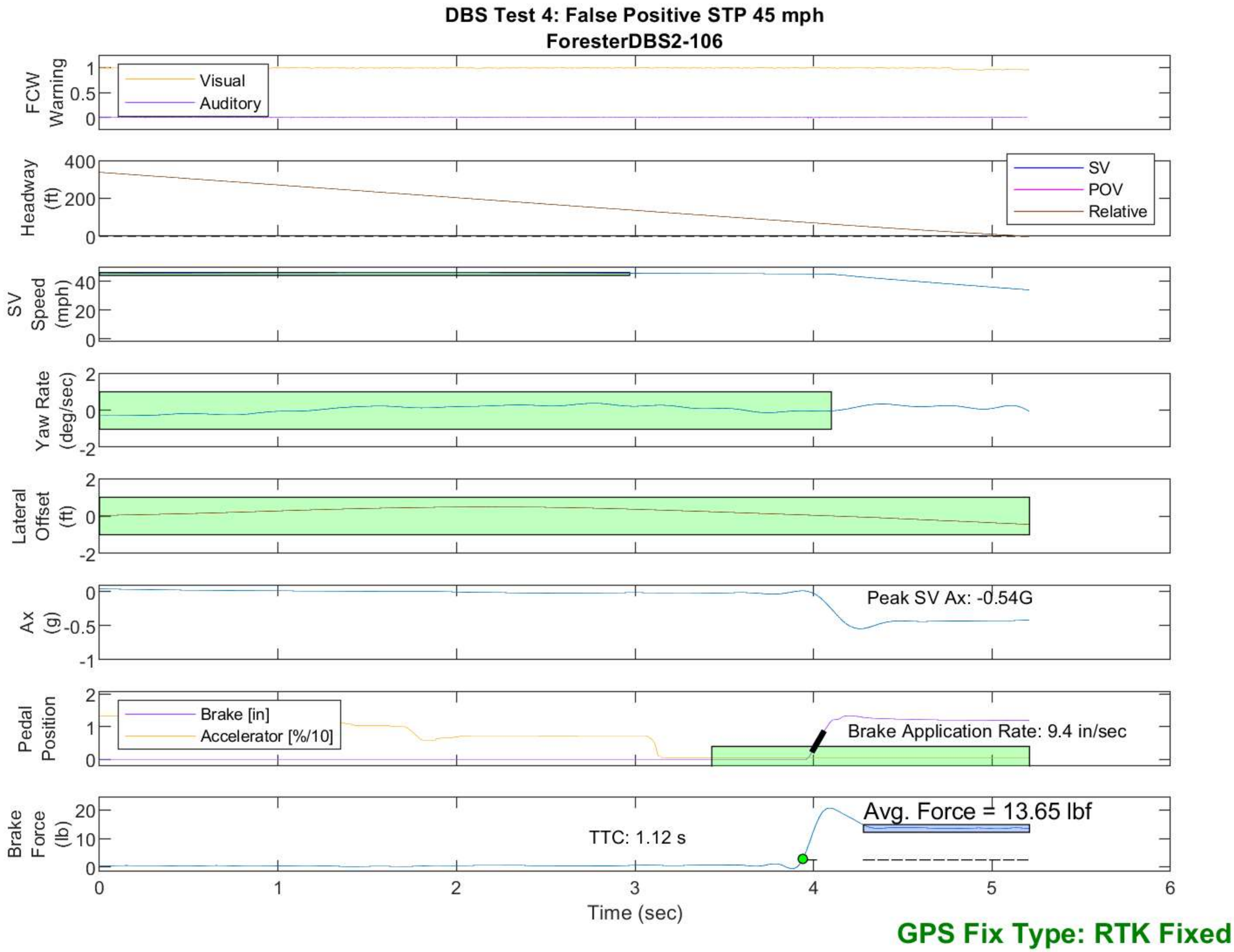


Figure E65. Time History for DBS Run 106, Test 4 - False Positive STP 45 mph

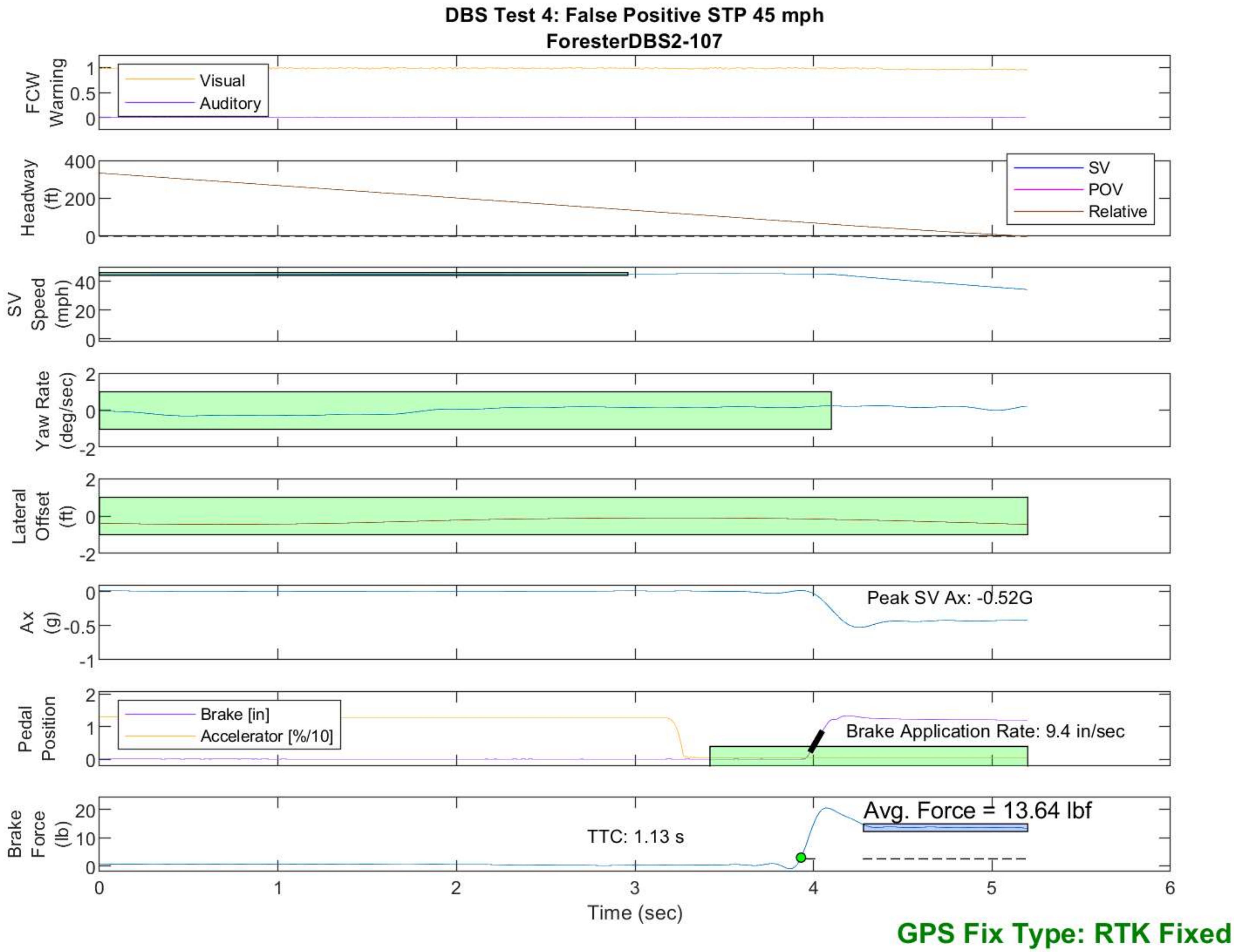


Figure E66. Time History for DBS Run 107, Test 4 - False Positive STP 45 mph

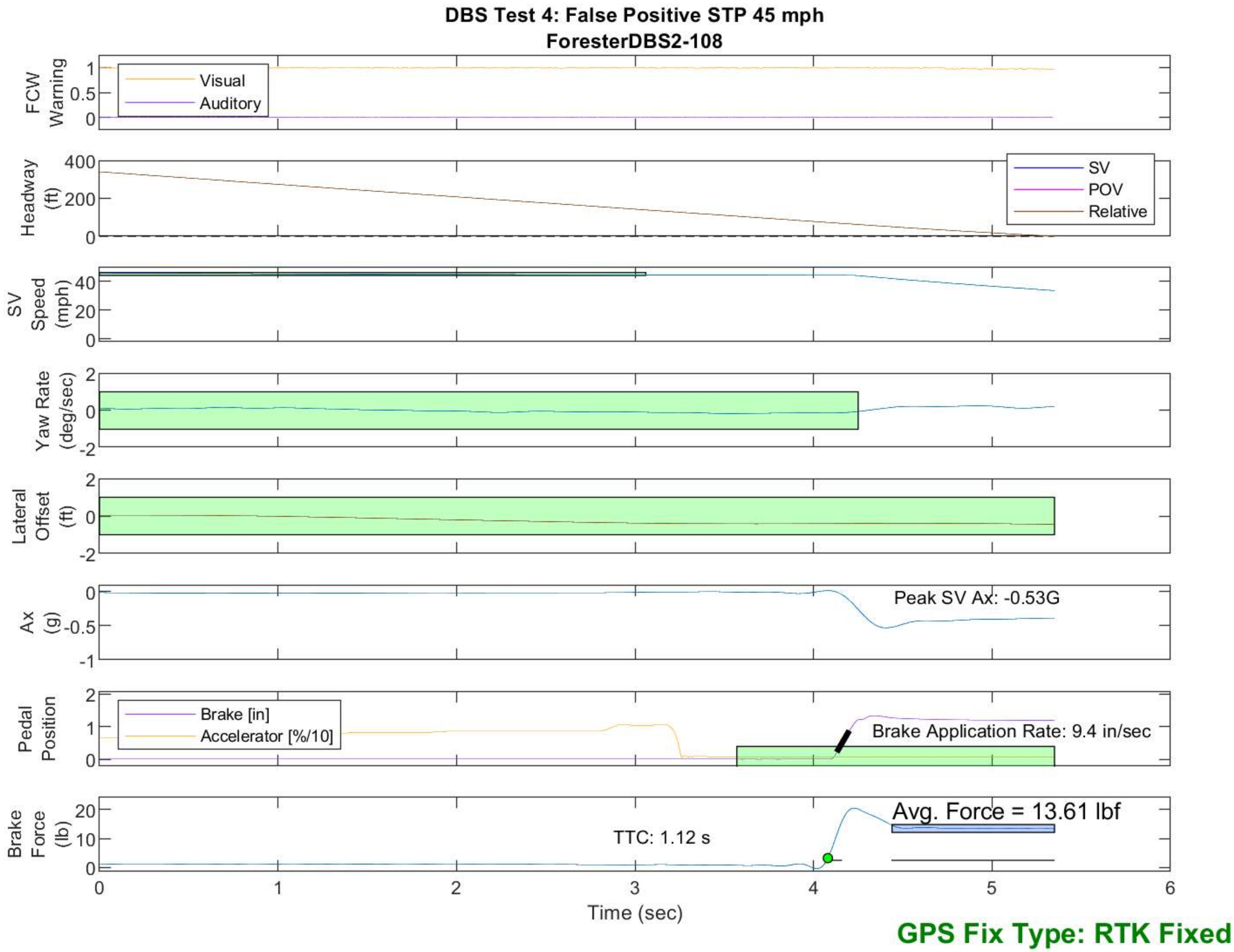


Figure E67. Time History for DBS Run 108, Test 4 - False Positive STP 45 mph

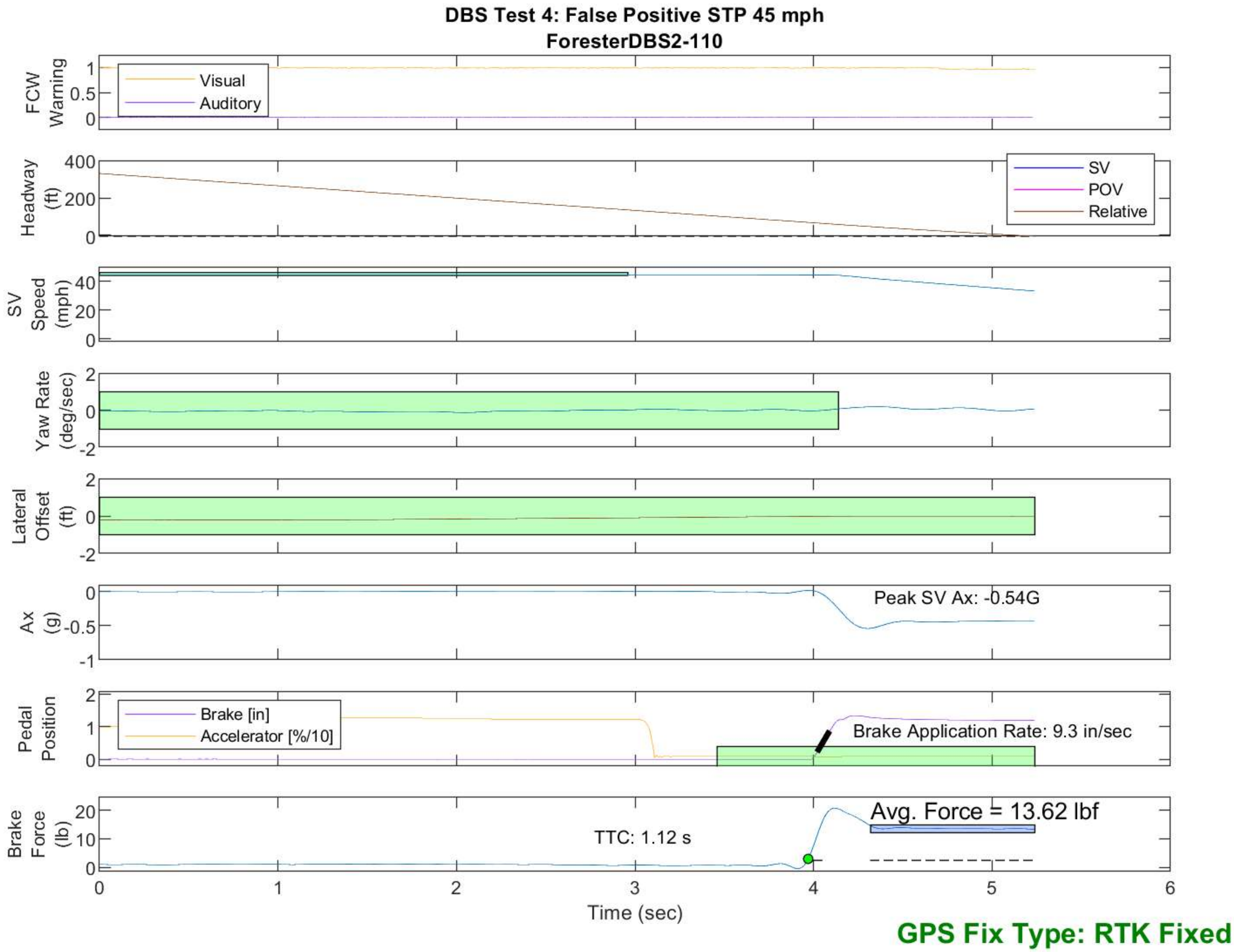


Figure E68. Time History for DBS Run 110, Test 4 - False Positive STP 45 mph

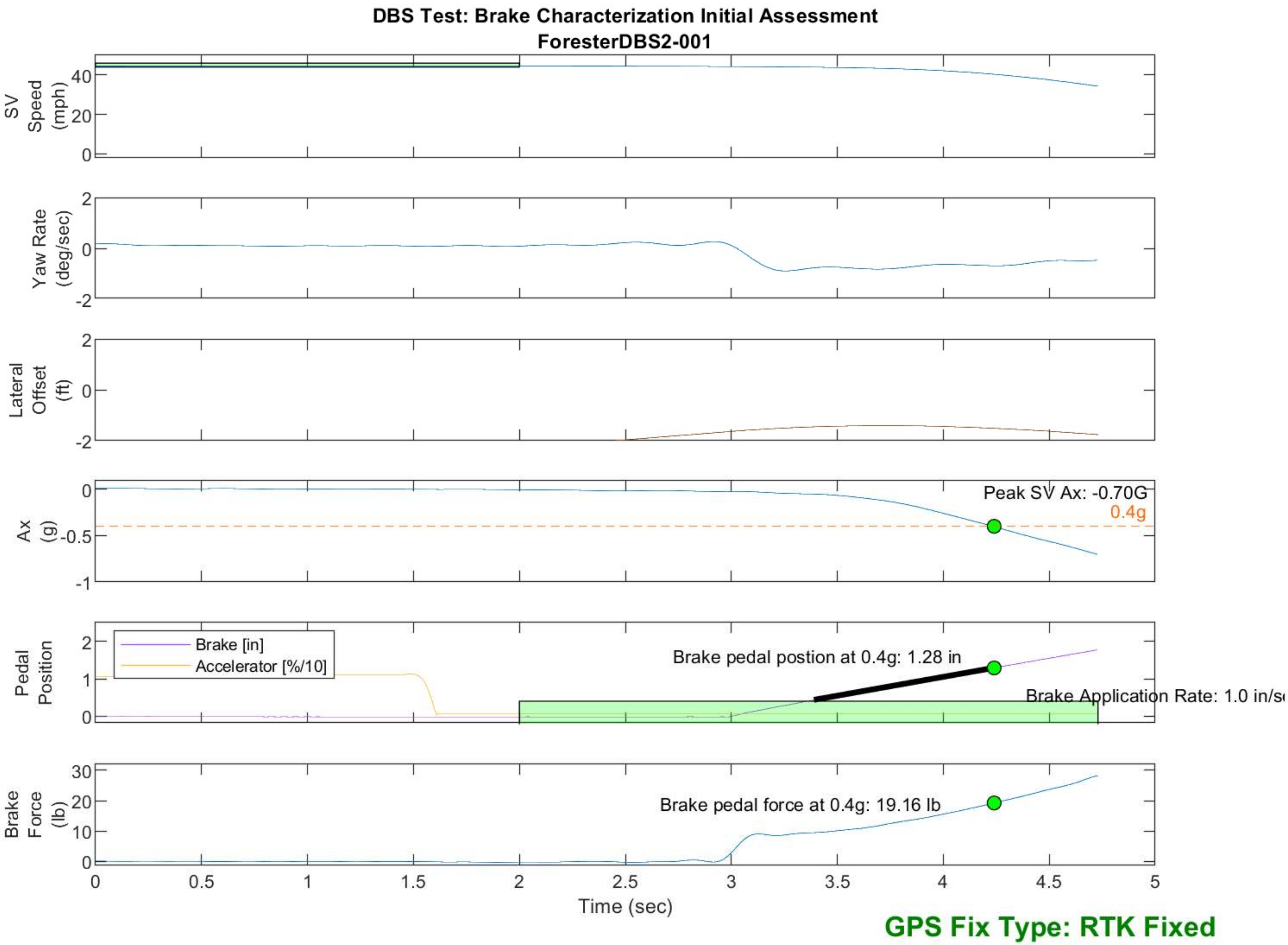


Figure E69. Time History for DBS Run 1, Brake Characterization Initial

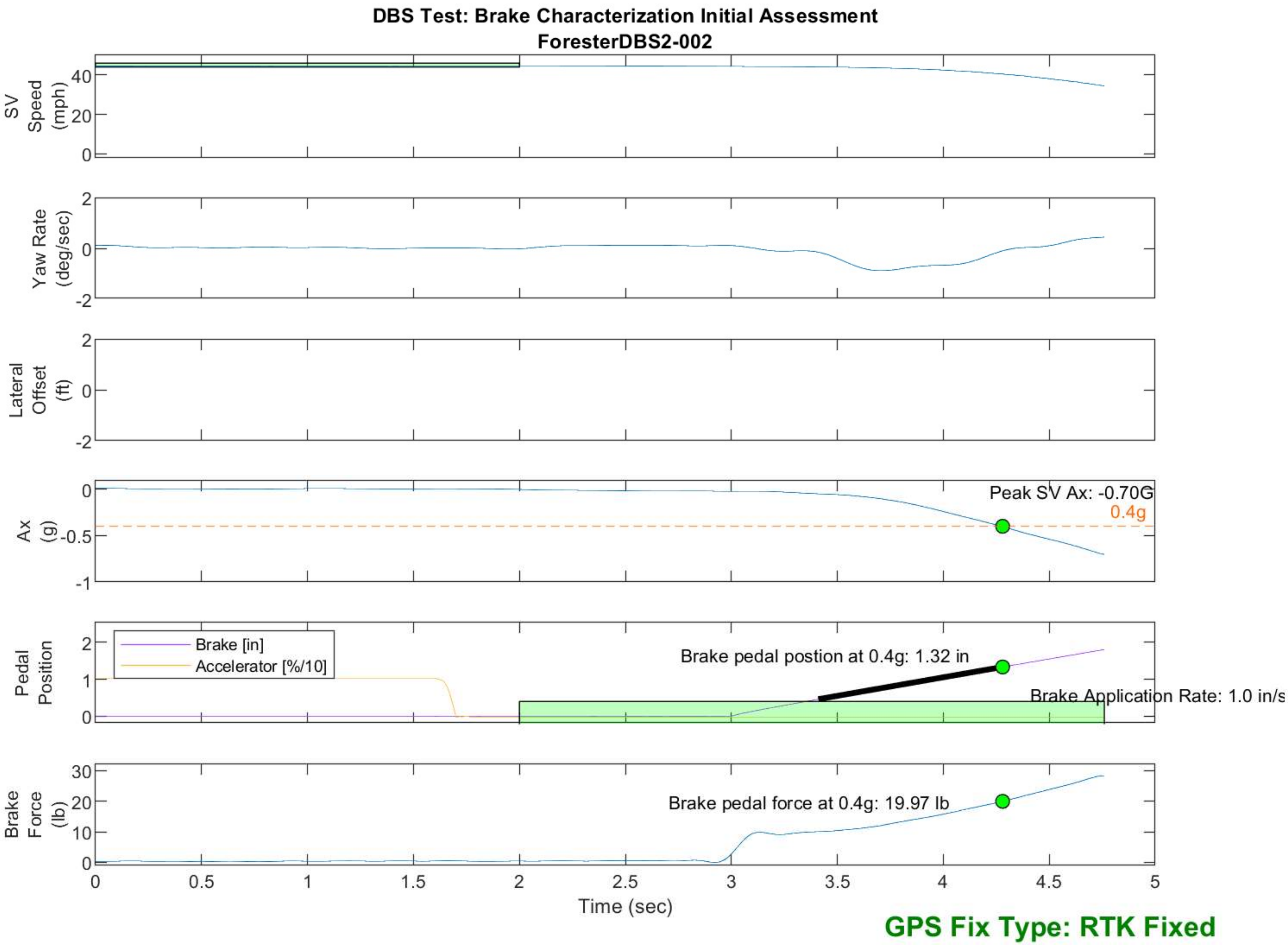


Figure E70. Time History for DBS Run 2, Brake Characterization Initial

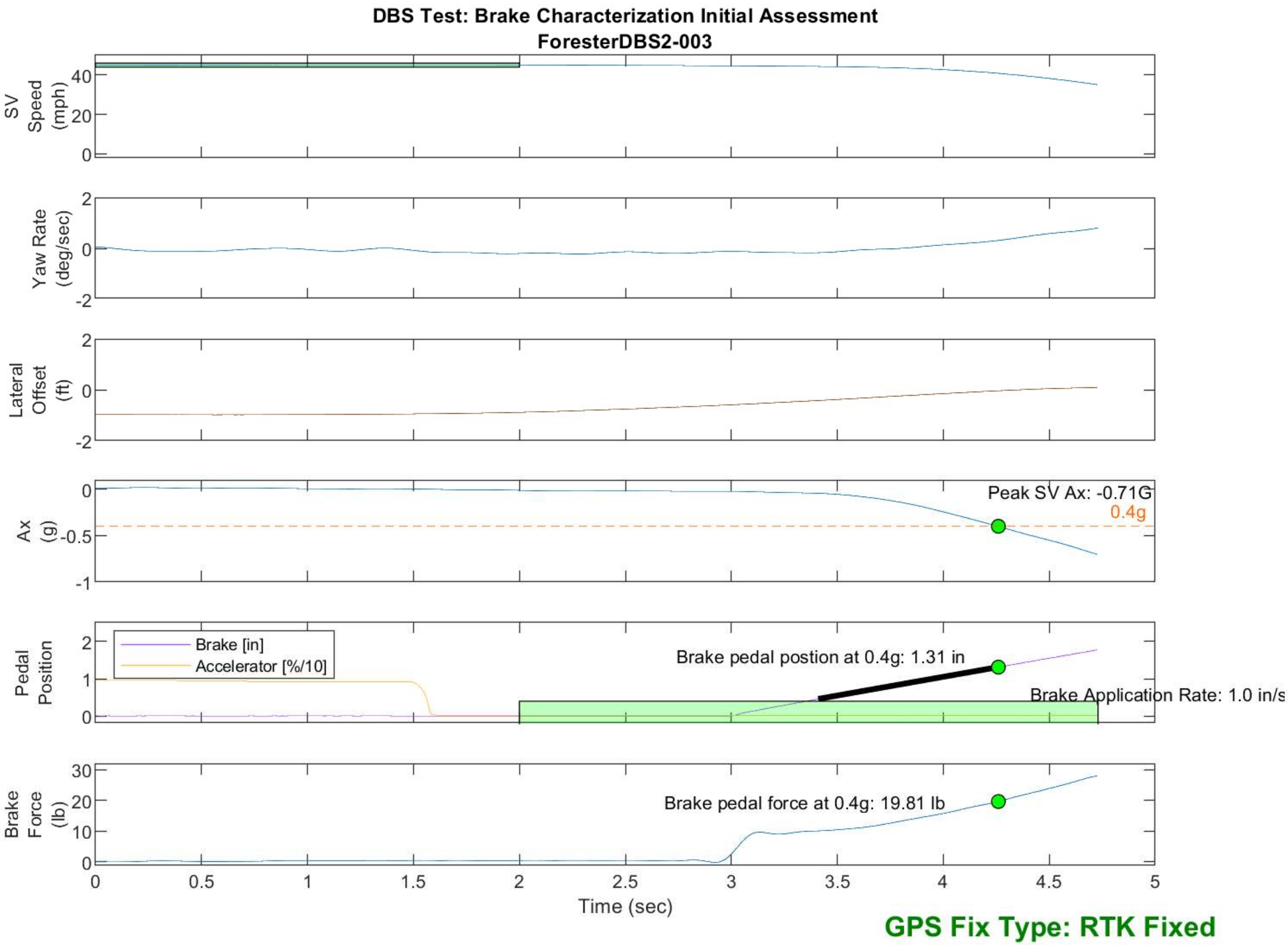


Figure E71. Time History for DBS Run 3, Brake Characterization Initial

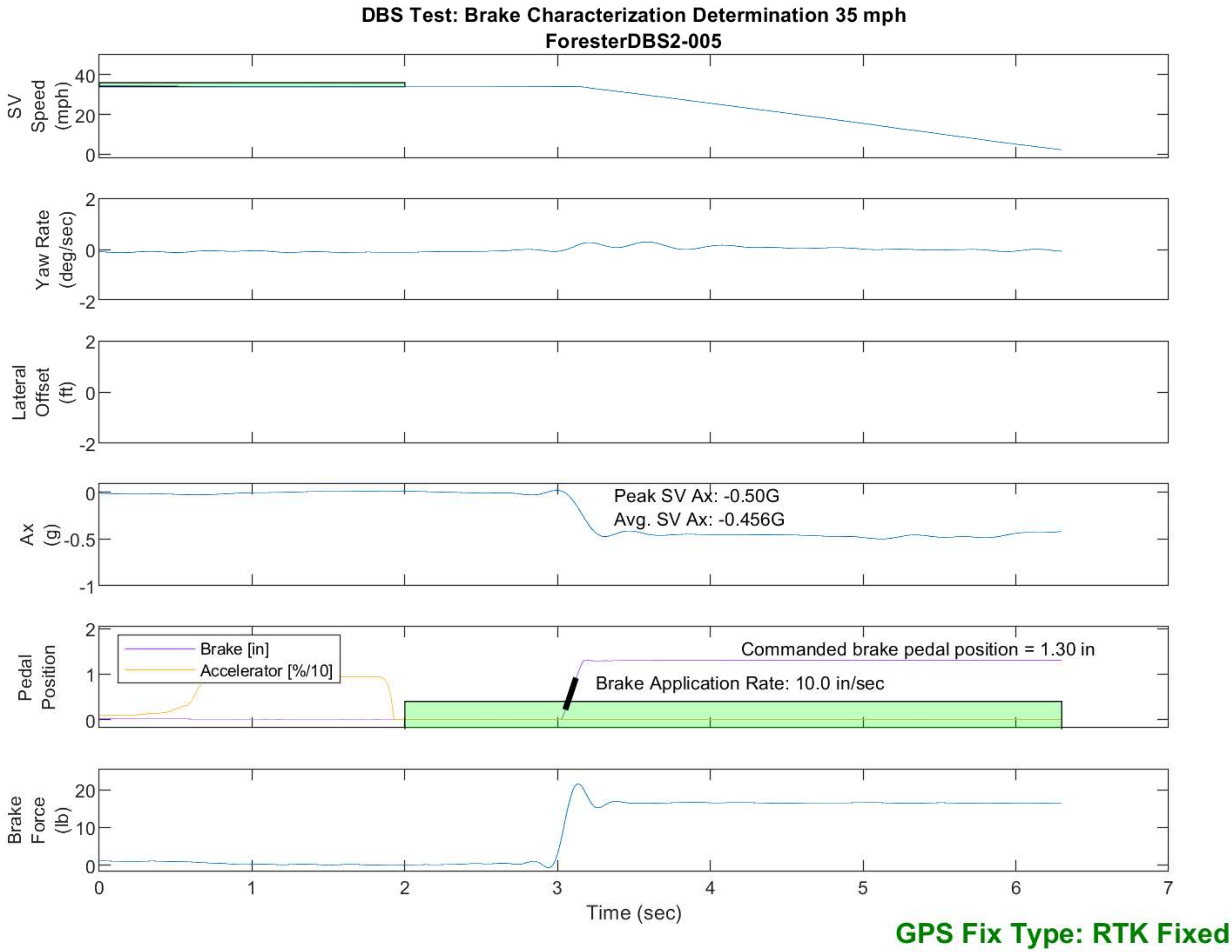


Figure E72. Time History for DBS Run 5, Brake Characterization Determination, Displacement Mode, 35 mph

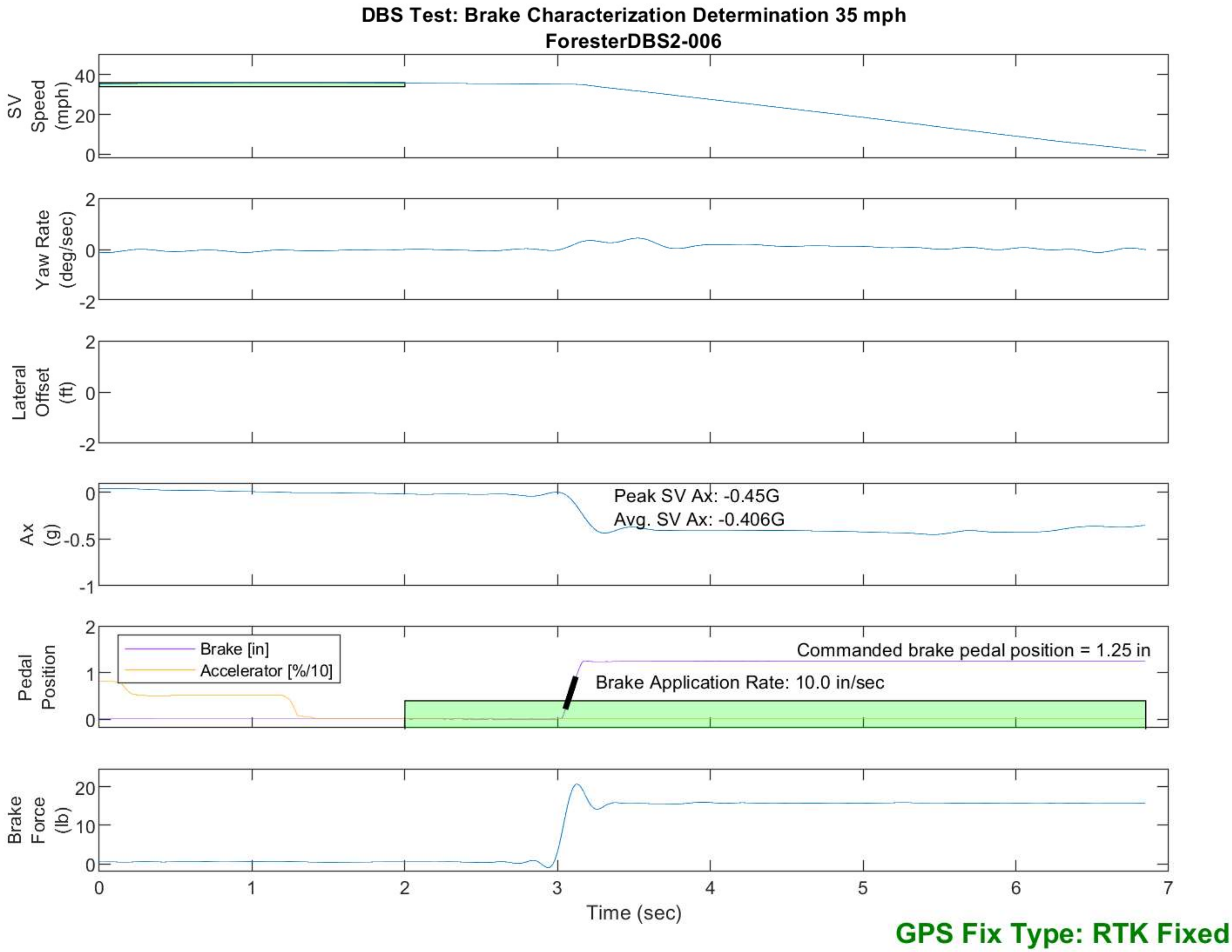


Figure E73. Time History for DBS Run 6, Brake Characterization Determination, Displacement Mode, 35 mph

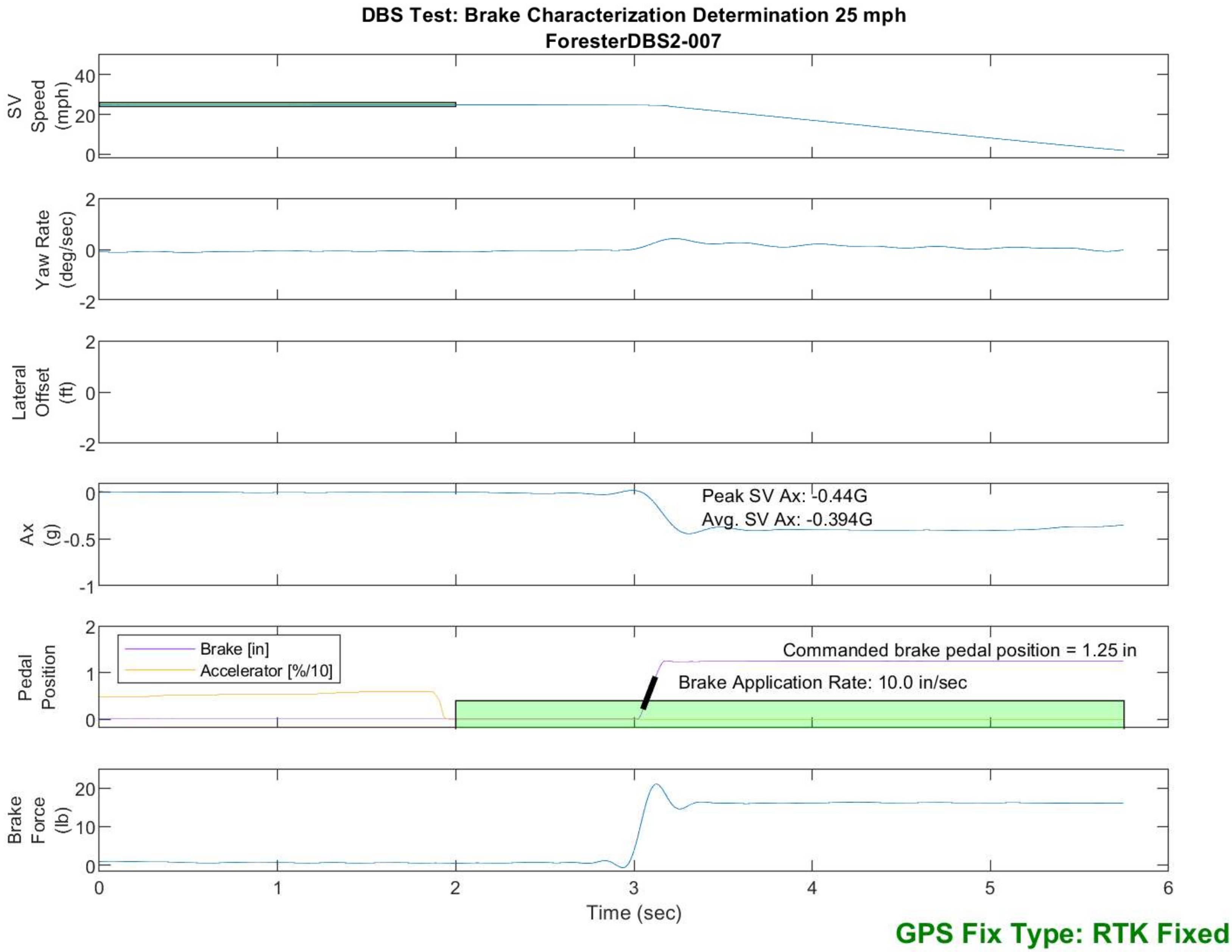


Figure E74. Time History for DBS Run 7, Brake Characterization Determination, Displacement Mode, 25 mph

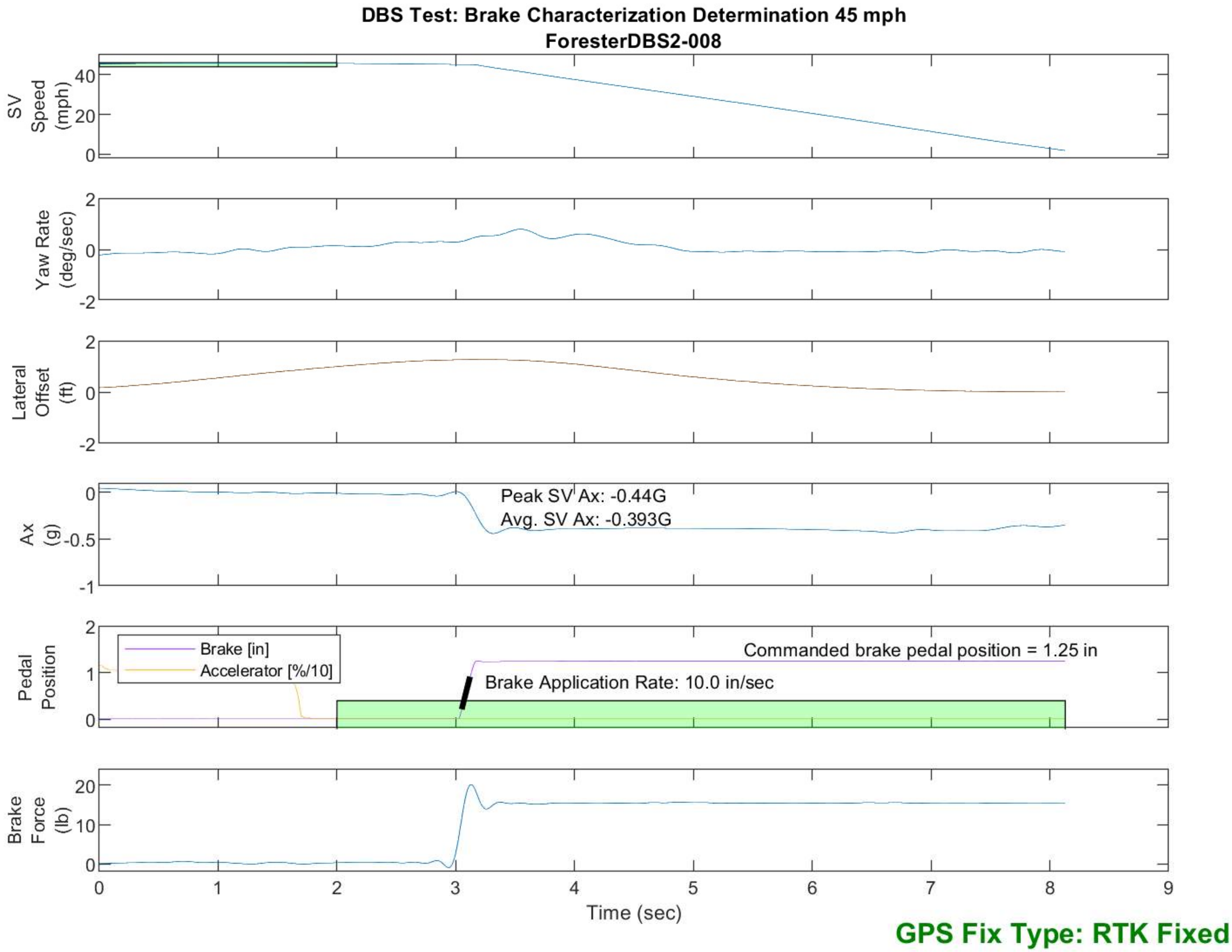


Figure E75. Time History for DBS Run 8, Brake Characterization Determination, Displacement Mode, 45 mph

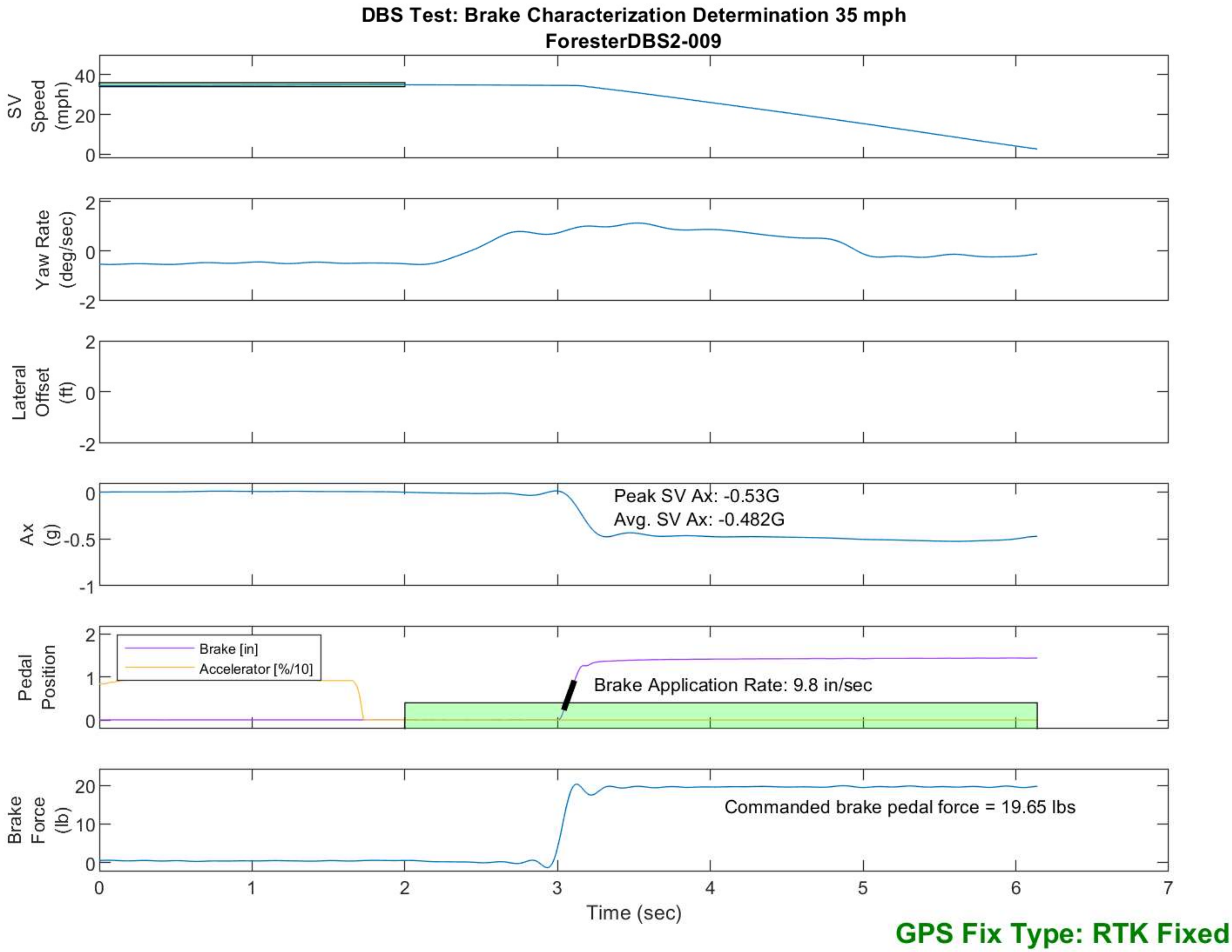


Figure E76. Time History for DBS Run 9, Brake Characterization Determination, Hybrid Mode, 35 mph

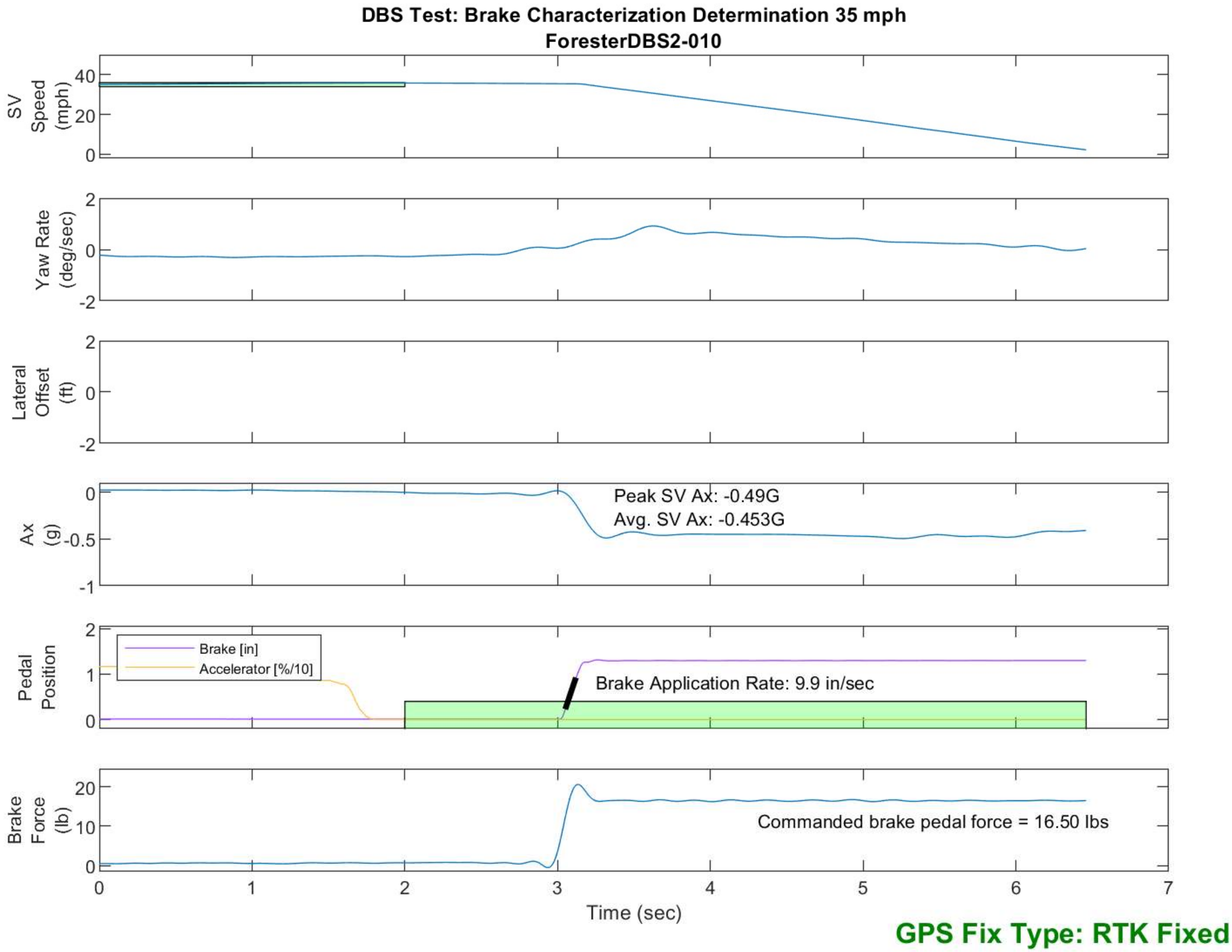


Figure E77. Time History for DBS Run 10, Brake Characterization Determination, Hybrid Mode, 35 mph

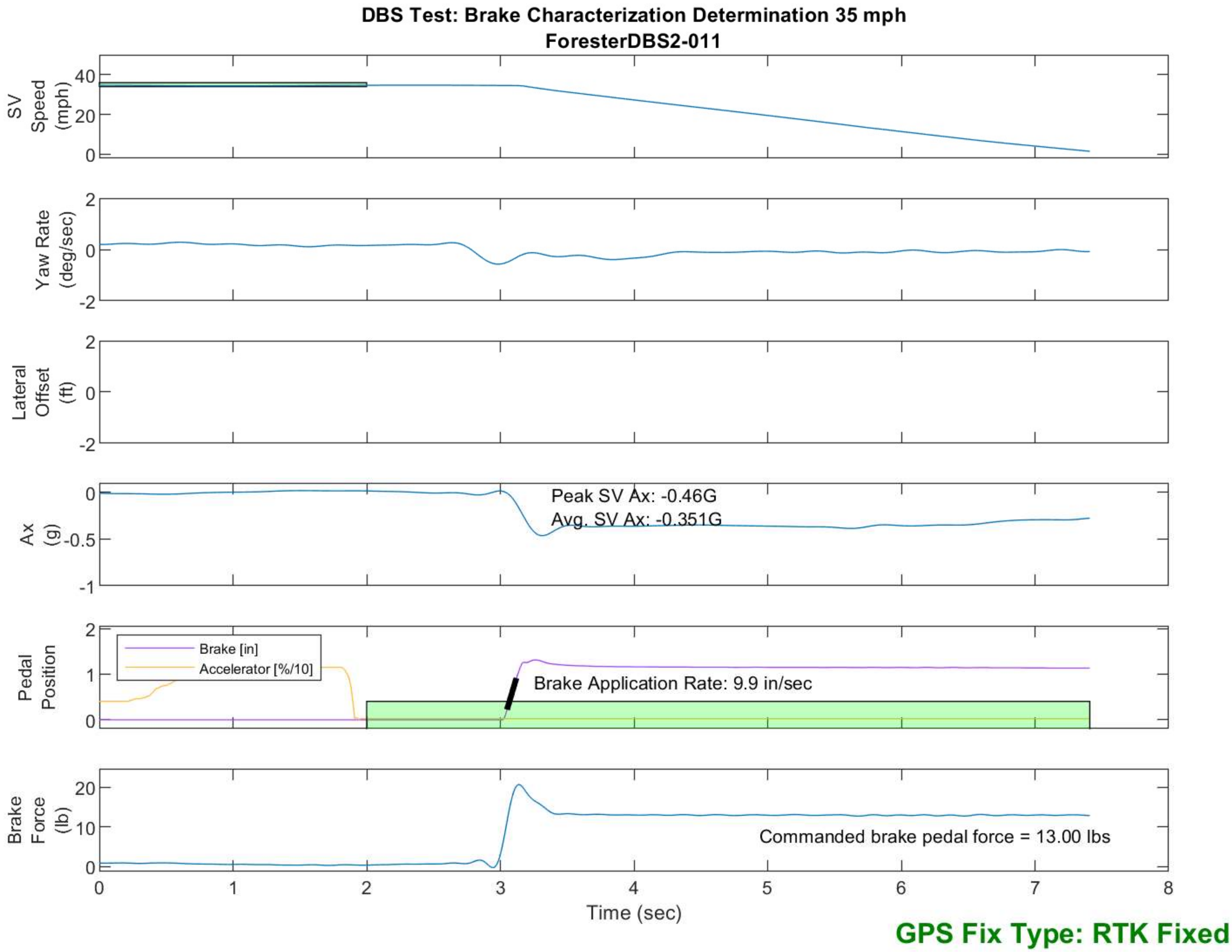


Figure E78. Time History for DBS Run 11, Brake Characterization Determination, Hybrid Mode, 35 mph

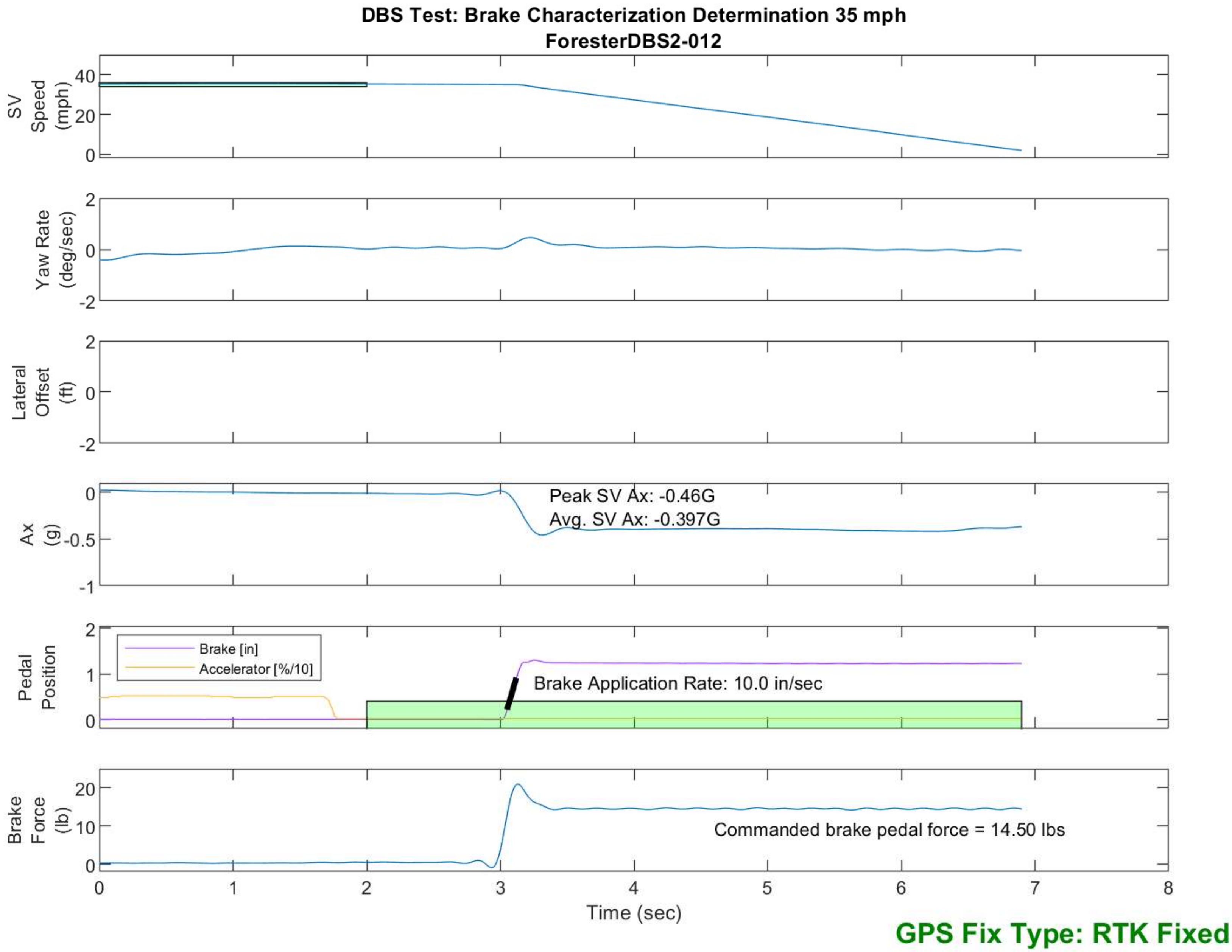


Figure E79. Time History for DBS Run 12, Brake Characterization Determination, Hybrid Mode, 35 mph

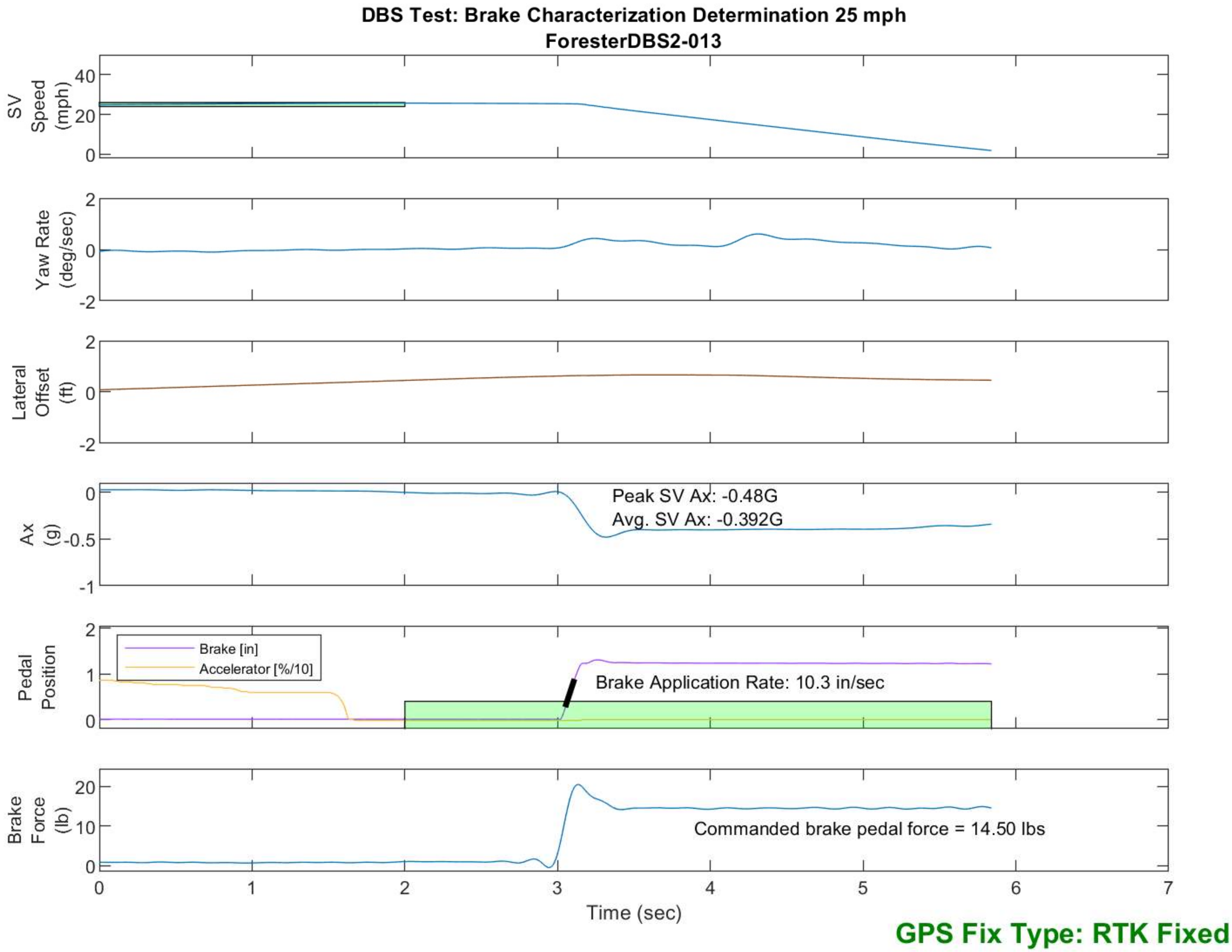


Figure E80. Time History for DBS Run 13, Brake Characterization Determination, Hybrid Mode, 25 mph

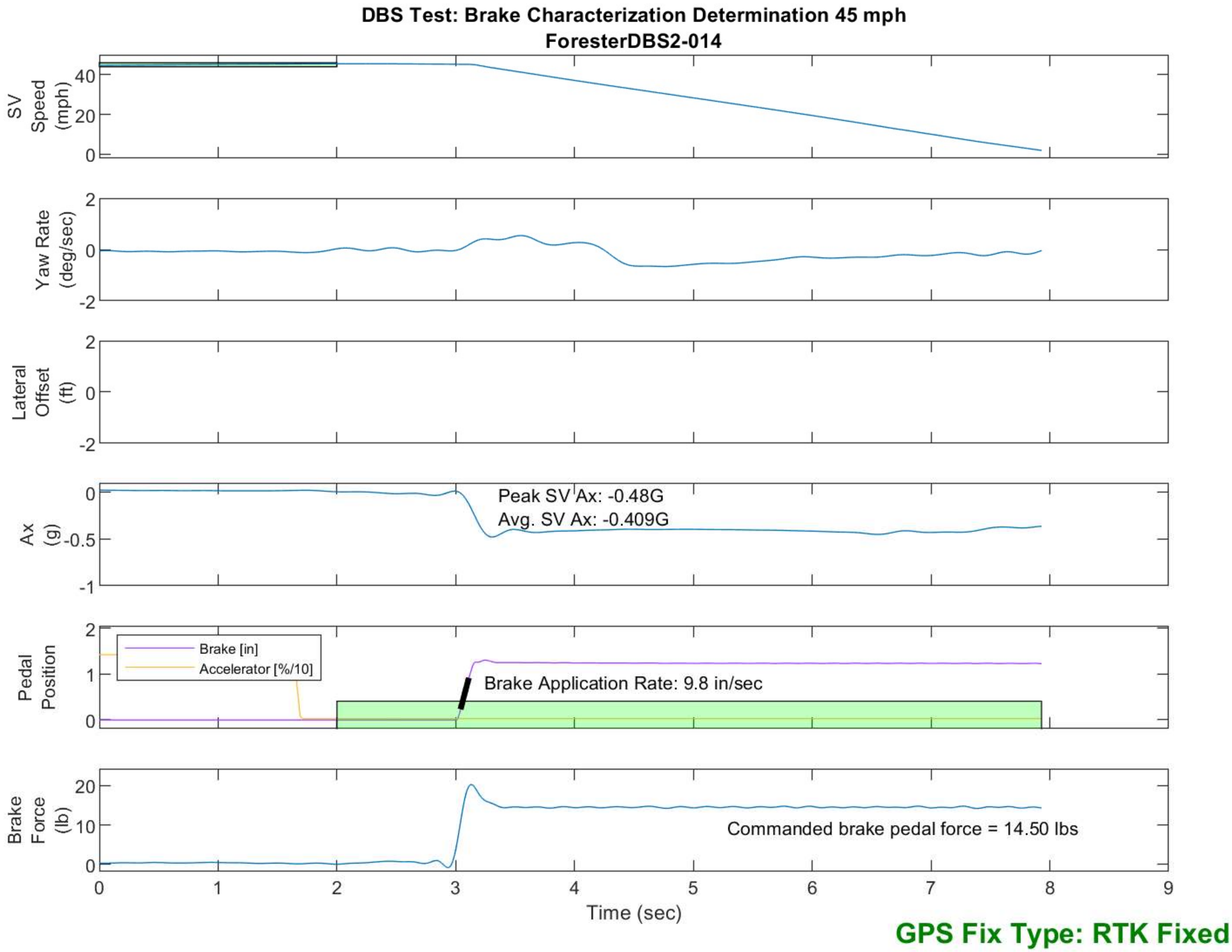


Figure E81. Time History for DBS Run 14, Brake Characterization Determination, Hybrid Mode, 45 mph