

**NEW CAR ASSESSMENT PROGRAM  
DYNAMIC BRAKE SUPPORT SYSTEM CONFIRMATION TEST  
NCAP-DRI-DBS-22-10**

**2022 Kia Forte**

**DYNAMIC RESEARCH, INC.**

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Torrance, California 90501



**28 March 2022**

**Final Report**

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

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16. Abstract These tests were conducted on the subject 2022 Kia Forte in accordance with the specifications of the New Car Assessment Program's (NCAP's) most current Test Procedure in docket NHTSA-2015-0006-0026; DYNAMIC BRAKE SUPPORT PERFORMANCE EVALUATION CONFIRMATION TEST FOR THE NEW CAR ASSESSMENT PROGRAM, October 2015. The vehicle passed the requirements of the test for all four DBS test scenarios.			
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## TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
I. INTRODUCTION .....	1
II. DATA SHEETS .....	2
Data Sheet 1: Test Results Summary .....	3
Data Sheet 2: Vehicle Data .....	4
Data Sheet 3: Test Conditions .....	5
Data Sheet 4: Dynamic Brake System Operation .....	7
III. TEST PROCEDURES .....	10
A. Test Procedure Overview .....	10
B. General Information .....	15
C. Principal Other Vehicle .....	18
D. Foundation Brake System Characterization .....	19
E. Brake Control .....	20
F. Instrumentation .....	21
APPENDIX A Photographs .....	A-1
APPENDIX B Excerpts from Owner's Manual .....	B-1
APPENDIX C Run Log .....	C-1
APPENDIX D Brake Characterization .....	D-1
APPENDIX E Time Histories .....	E-1

## 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 Kia Forte. This test to assess Dynamic Brake Support systems is sponsored by the National Highway Traffic Safety Administration under Contract No. DTNH22-14-D-00333 with the New Car Assessment Program (NCAP).

Section II  
**DATA SHEETS**

**DYNAMIC BRAKE SUPPORT**  
**DATA SHEET 1: TEST RESULTS SUMMARY**

(Page 1 of 1)

2022 Kia Forte

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VIN: 3KPF54AD4NE45xxxx

Test start date: 3/16/2022

Test end date: 3/16/2022

Dynamic Brake Support System settings: Standard

**Test 1 – Subject Vehicle Encounters Stopped Principal Other Vehicle**

SV 25 mph: Pass

**Test 2 – Subject Vehicle Encounters Slower Principal Other Vehicle**

SV 25 mph POV 10 mph: Pass

SV 45 mph POV 20 mph: Pass

**Test 3 – Subject Vehicle Encounters Decelerating Principal Other Vehicle**

SV 35 mph POV 35 mph: Pass

**Test 4 – Subject Vehicle Encounters Steel Trench Plate**

SV 25 mph: Pass

SV 45 mph: Pass

**Overall: Pass**

Notes:

**DYNAMIC BRAKE SUPPORT**  
**DATA SHEET 2: VEHICLE DATA**

(Page 1 of 1)

2022 Kia Forte

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**TEST VEHICLE INFORMATION**

VIN: 3KPF54AD4NE45xxxx

Body Style: Sedan

Color: Sporty Blue

Date Received: 2/28/2022

Odometer Reading: 60 mi

**DATA FROM VEHICLE'S CERTIFICATON LABEL**

Vehicle manufactured by: KIA MEXICO S.A. DE C.V.

Date of manufacture: 01/22

Vehicle Type: Passenger Car

**DATA FROM TIRE PLACARD**

Tires size as stated on Tire Placard: Front: 225/45R17

Rear: 225/45R17

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

Rear: 230 kPa (33 psi)

**TIRES**

Tire manufacturer and model: Kumho Majesty Solus

Front tire specification: 225/45R17 91W

Rear tire specification: 225/45R17 91W

Front tire DOT prefix: 000 U1YAVP

Rear tire DOT prefix: 000 U1YAVP



**DYNAMIC BRAKE SUPPORT**  
**DATA SHEET 3: TEST CONDITIONS**

(Page 1 of 2)

2022 Kia Forte

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**GENERAL INFORMATION**

Test start date: 3/16/2022

Test start date: 3/16/2022

**AMBIENT CONDITIONS**

Air temperature: 22.8 C (73 F)

Wind speed: 3.6 m/s (8.1 mph)

X Wind speed  $\leq$  10 m/s (22 mph).

X Tests were not performed during periods of inclement weather. This includes, but is not limited to, rain, snow, hail, fog, smoke, or ash.

X Tests were conducted during daylight hours with good atmospheric visibility (defined as an absence of fog and the ability to see clearly for more than 5000 meters). The tests were not conducted with the vehicle oriented into the sun during very low sun angle conditions, where the sun is oriented 15 degrees or less from horizontal, and camera "washout" or system inoperability results.

**VEHICLE PREPARATION**

**Verify the following:**

All non-consumable fluids at 100% capacity: X

Fuel tank is full: X

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

Front: 230 kPa (33 psi)

Rear: 230 kPa (33 psi)

**DYNAMIC BRAKE SUPPORT**  
**DATA SHEET 3: TEST CONDITIONS**

(Page 2 of 2)

2022 Kia Forte

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**WEIGHT**

Weight of vehicle as tested including driver and instrumentation

Left Front: 445.9 kg (983 lb)

Right Front: 430.5 kg (949 lb)

Left Rear: 301.2 kg (664 lb)

Right Rear: 276.7 kg (610 lb)

Total: 1454.3 kg (3206 lb)

**DYNAMIC BRAKE SUPPORT**  
**DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION**

(Page 1 of 3)

2022 Kia Forte

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

Forward Collision-Avoidance Assist (FCA)

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

Front radar located in the lower grille and front view camera located in the upper center windshield

System settings used for test (if applicable):

Standard

Brake application mode used for test: Hybrid control

Over what speed range is the system operational?

The AEB system is operational between 10-180 km/h (6-112 mph) per manufacturer supplied information.

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

No

If yes, please provide a full description.

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

No

If yes, please provide a full description.

In general, FCA does not deactivate due to repeated FCA activations or impacts. However, if the brake actuator or radar/camera sensors are damaged or have problems due to repeated FCA activations or impacts, FCA can deactivate.

## DYNAMIC BRAKE SUPPORT

### DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

(Page 2 of 3)

2022 Kia Forte

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How is the Forward Collision Warning presented to the driver?  Warning light  
 Buzzer or auditory alarm  
(Check all that apply)  Vibration  
 Other \_\_\_\_\_

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

The AEB system alerts the driver with a visual and auditory alert. The visual alert is three stages and is displayed in the multi-information display located in the center of the instrument panel. The alert consists of an image of two vehicles between lane lines. Additionally, the first stage displays the words "Collision Warning", the second "Emergency Braking", and lastly "Drive Carefully". The auditory alert consists of repeated beeps with a primary frequency at approximately 1500 Hz.

Is there a way to deactivate the system?  Yes  
 No

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

The AEB system can be turned on/off using the touch screen display on the center dash. The procedure is as follows:

1. Select "Setup" to bring up the setup menu.
2. Select "Vehicle" -> "Driver Assistance" -> "Forward Safety".
3. Select between "Active Assist", "Warning Only", and "Off" to turn the AEB system on/off.

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



## 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.

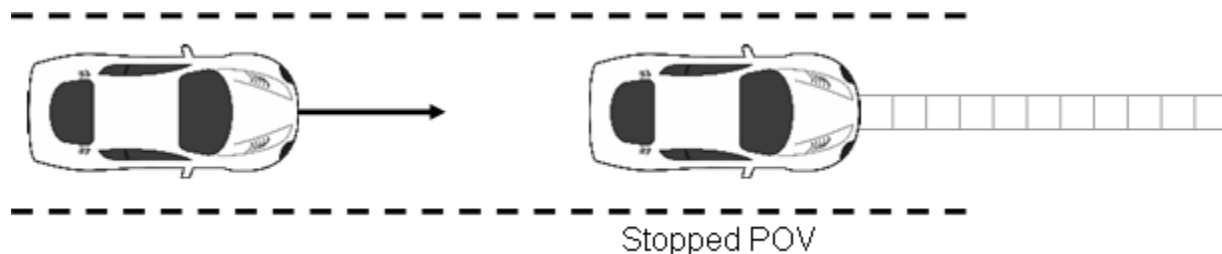


Figure 1. Depiction of Test 1

##### 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  $\pm 1$  ft (0.3 m) during the validity period.
- The yaw rate of the SV could not deviate more than  $\pm 1$  deg/sec during the validity period.
- The SV speed could not deviate from the nominal speed by more than  $\pm 1.0$  mph ( $\pm 1.6$  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 $\rightarrow$ $t_{FCW}$	187 ft (57 m) $\rightarrow$ $t_{FCW}$	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.

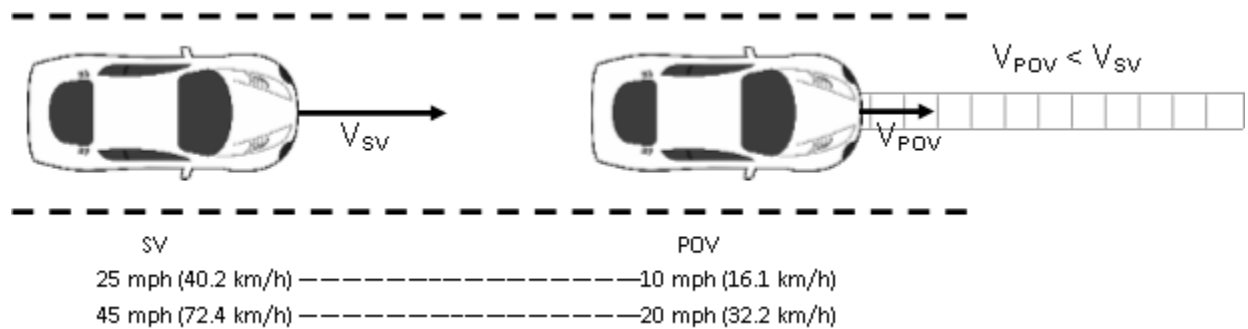


Figure 2. Depiction of Test 2

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  $\pm 1$  ft (0.3 m) during the validity period.
- The yaw rate of the SV and POV could not deviate more than  $\pm 1$  deg/sec during the validity period.
- The SV speed could not deviate more than  $\pm 1.0$  mph ( $\pm 1.6$  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  $\pm 1.0$  mph ( $\pm 1.6$  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.

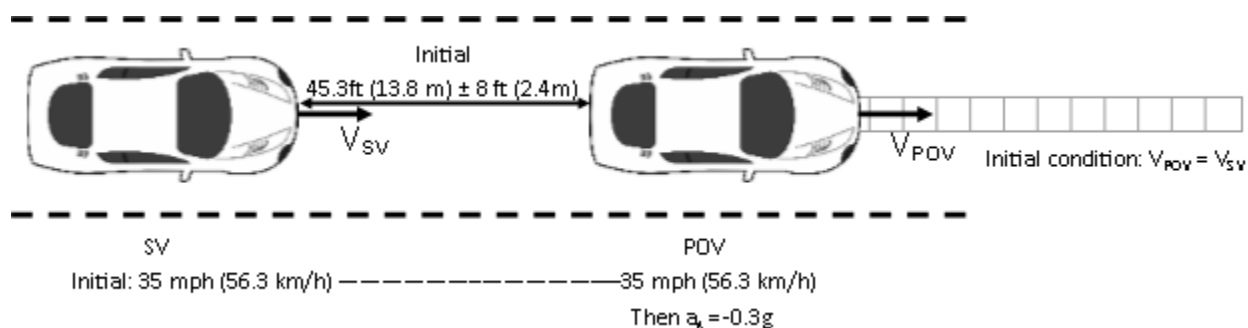


Figure 3. Depiction of Test 3

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  $0.3 \pm 0.03$  g of deceleration within  $1.5 \pm 0.1$  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  $\pm 1$  ft (0.3 m) during the validity period.
- The yaw rate of the SV and POV could not deviate more than  $\pm 1$  deg/sec during the validity period.
- The SV speed could not deviate more than  $\pm 1.0$  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  $\pm 1.0$  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  $\pm 8$  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  $\pm 0.03$  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 $\rightarrow t_{FCW}$	45 ft (14 m) $\rightarrow t_{FCW}$	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**

<b>Warning Type</b>	<b>Filter Order</b>	<b>Peak-to-Peak Ripple</b>	<b>Minimum Stop Band Attenuation</b>	<b>Passband Frequency Range</b>
Auditory	5 <sup>th</sup>	3 dB	60 dB	Identified Center Frequency $\pm$ 5%
Tactile	5 <sup>th</sup>	3 dB	60 dB	Identified Center Frequency $\pm$ 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  $\pm 1.0$  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 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  $\pm 1$  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  $\pm 2$  in ( $\pm 5$  cm) from that measured during collection of the pre-test static calibration data file, the pre-test offset was adjusted to output zero, another pre-test static calibration data file was collected, and the test series was repeated.

## 5. NUMBER OF TRIALS

A target total of seven (7) valid trials were performed for each scenario. In cases where the test driver performed more than seven trials, the first seven trials satisfying all test tolerances were used to assess the SV performance.

## 6. TRANSMISSION

All trials were performed with SV automatic transmissions in “Drive” or with manual transmissions in the highest gear capable of sustaining the desired test speed. Manual transmission clutches remained engaged during all maneuvers. The brake lights of the POV were not illuminated.

### **C. Principal Other Vehicle**

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

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

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

The key requirements of the POV element are to:

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

The key requirements of the POV delivery system are to:

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

Operationally, the POV shell is attached to the slider and load frame, which includes rollers that allow the entire assembly to move longitudinally along the guide rail. The guide rail is coupled to a tow vehicle and guided by the lateral restraint track secured to the test track surface. The rail includes a provision for restraining the shell and roller assembly in the rearward direction. In operation, the shell and roller assembly engages the rail assembly through detents to prevent relative motion during run-up to test speeds and minor deceleration of the tow vehicle. The combination of rearward stops and forward motion detents allows the test conditions, such as relative SV-to-POV headway distance and speed etc., to be achieved and adjusted as needed in the preliminary part of a test. If during the test, the SV strikes the rear of the POV shell, the detents are overcome and the entire shell/roller assembly moves forward in a two-stage manner along the rail and away from the SV. The forward end of the rail has a soft stop to restrain forward motion of the shell/roller assembly. After impacting the SSV, the SV driver uses the steering wheel to maintain SV position in the center of the travel lane, thereby straddling the two-rail track. The SV driver must manually apply the SV brakes after impact. The SSV system is shown in Figures A6 through A8 and a detailed description can be found in the NHTSA report: NHTSA'S STRIKEABLE SURROGATE VEHICLE PRELIMINARY DESIGN + OVERVIEW, May 2013.

#### **D. Foundation Brake System Characterization**

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

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

were adjusted and retested until the desired magnitude was realized. Prior to each braking event, the brake pad temperatures were required to be in the range of 149° - 212°F.

## **E. Brake Control**

### **1. SUBJECT VEHICLE PROGRAMMABLE BRAKE CONTROLLER**

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

- Constant pedal displacement. By maintaining constant actuator stroke, the position of the vehicle's brake pedal remains fixed for the duration of the input. To achieve this, the brake controller modulates application force.
- Hybrid control. Hybrid control uses position-based control to command the initial brake application rate and actuator position, then changes to force-based control to command a reduction of applied force to a predetermined force. This force is maintained until the end of the braking maneuver by allowing the brake controller to modulate actuator displacement.

### **2. SUBJECT VEHICLE BRAKE PARAMETERS**

- Each test run began with the brake pedal in its natural resting position, with no preload or position offset.
- The onset of the brake application was considered to occur when the brake actuator had applied 2.5 lbf (11 N) of force to the brake pedal.
- The magnitude of the brake application was that needed to produce 0.4 g deceleration, as determined in the foundation brake characterization.
- The SV brake application rate was between 9 to 11 in/s (229 to 279 mm/s), where the application rate is defined as the slope of a linear regression line applied to brake pedal position data over a range from 25% to 75% of the commanded input magnitude.

### **3. POV AUTOMATIC BRAKING SYSTEM**

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

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



## **F. Instrumentation**

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

**Table 5. Test Instrumentation and Equipment**

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	< 1% error between 20 and 100 psi	Omega DPG8001	17042707002	By: DRI Date: 10/5/2021 Due: 10/5/2022
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 2/11/2022 Due: 2/11/2023
Linear (string) encoder	Throttle pedal travel	50 in	0.05 in	TE Connectivity SE1-50	K3161858	By: DRI Date: 1/18/2022 Due: 1/18/2023
Load Cell	Force applied to brake pedal					By: DRI
		0-250 lb 1112 N	0.05% FS	Stellar Technology PNC700	1607338	Date: 4/9/2021 Due: 4/9/2022
		0-250 lb	0.05% FS	Stellar Technology PNC700	2002506	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)**

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels;	Accels $\pm 10g$ , Angular Rate $\pm 100$ deg/s, Angle $>45$ deg, Velocity $>200$ km/h	Accels .01g, Angular Rate 0.05 deg/s, Angle 0.05 deg, Velocity 0.1 km/h	Oxford Inertial +		By: Oxford Technical Solutions
	Lateral, Longitudinal and Vertical Velocities;				2176	Date: 6/26/2020 Due: 6/26/2022
	Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles				2258	Date: 4/28/2021 Due: 4/28/2023
Real-Time Calculation of Position and Velocity Relative to Lane Markings (LDW) and POV (FCW)	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: $\pm 30$ m Lateral Lane Velocity: $\pm 20$ m/sec Longitudinal Range to POV: $\pm 200$ m Longitudinal Range Rate: $\pm 50$ m/sec	Lateral Distance to Lane Marking: $\pm 2$ cm Lateral Velocity to Lane Marking: $\pm 0.02$ m/sec Longitudinal Range: $\pm 3$ cm Longitudinal Range Rate: $\pm 0.02$ m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	N/A
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	N/A	N/A
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	N/A	N/A
Accelerometer	Acceleration (to measure time at alert)	$\pm 5g$	$\leq 3\%$ of full range	Silicon Designs, 2210-005	N/A	N/A

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Coordinate Measurement Machine	Inertial Sensing System Coordinates	0-8 ft 0-2.4 m	±.0020 in. ±.051 mm (Single point articulation accuracy)	Faro Arm, Fusion	UO8-05-08-06636	By: DRI Date: 1/6/2022 Due: 1/6/2023
Type	Description			Mfr, Model	Serial Number	
Data Acquisition System	Data acquisition is achieved using a dSPACE MicroAutoBox II. Data from the Oxford IMU, including Longitudinal, Lateral, and Vertical Acceleration, Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle are sent over Ethernet to the MicroAutoBox. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (listed above).			dSPACE Micro-Autobox II 1401/1513		
				Base Board	549068	
				I/O Board	588523	

## APPENDIX A

### Photographs

## LIST OF FIGURES

	Page
Figure A1.	Front View of Subject Vehicle..... A-3
Figure A2.	Rear View of Subject Vehicle ..... A-4
Figure A3.	Window Sticker (Monroney Label)..... A-5
Figure A4.	Vehicle Certification Label ..... A-6
Figure A5.	Tire Placard ..... A-7
Figure A6.	Rear View of Principal Other Vehicle (SSV) ..... A-8
Figure A7.	Load Frame/Slider of SSV ..... A-9
Figure A8.	Two-Rail Track and Road-Based Lateral Restraint Track..... A-10
Figure A9.	Steel Trench Plate ..... A-11
Figure A10.	DGPS, Inertial Measurement Unit, and MicroAutoBox Installed in Subject Vehicle..... A-12
Figure A11.	Sensor for Detecting Auditory and Visual Alerts ..... A-13
Figure A12.	Computer Installed in Subject Vehicle ..... A-14
Figure A13.	Brake Actuator Installed in Subject Vehicle ..... A-15
Figure A14.	Brake Actuator Installed in POV System ..... A-16
Figure A15.	AEB System Setup Menus ..... A-17
Figure A16.	Visual Alert ..... A-18



Figure A1. Front View of Subject Vehicle



Figure A2. Rear View of Subject Vehicle

A-4



**2022 FORTE GT-LINE**

MODEL/OPT.CODE: C3452 / 015  
 EXTERIOR COLOR: SPORTY BLUE  
 INTERIOR COLOR: BLACK  
 VEHICLE ID NUMBER: 3KPF54AD4NE45  
 PORT OF ENTRY: LAREDO, TEXAS

Sold To: CA243 Ship To: CA243



**STANDARD FEATURES**

**STANDARD LXS FEATURES**

**MECHANICAL**  
 2.0L Multi-Point Fuel Injection (MPI) 4-Cyl Engine  
 Intelligent Variable Automatic Transmission  
 Drive Mode Select

**KIA DRIVEWISE DRIVER-ASSIST TECHNOLOGY**  
 Forward Collision Warning  
 Forward Collision-Avoidance Assist - Pedestrian  
 Lane Departure Warning  
 Lane Following Assist  
 Lane Keeping Assist  
 Driver Attention Warning & High Beam Assist

**SAFETY**  
 Dual Front Advanced Airbags  
 Dual Front Seat-Mounted Side & Full-Length Curtain Airbags  
 Anti-Lock Braking System  
 Electronic Stability Control  
 Vehicle Stability Management  
 Hill-Start Assist Control  
 Tire Pressure Monitoring System

**INTERIOR, COMFORT & CONVENIENCE**  
 8" Touchscreen w/Wireless Android Auto & Apple CarPlay  
 Rear View Camera with Dynamic Guidelines  
 Multi-Adjustable Manual Front Seats  
 60/40 Split-Folding Rear Seats  
 USB / Media Port and 12 Volt Outlet  
 Bluetooth® Wireless Technology  
 Remote Keyless Entry w/ Trunk Opener  
 Tilt & Telescopic Steering Column  
 Steering Wheel Controls (Bluetooth/Audio/Cruise)  
 4.2" Supervision Meter Cluster  
 Overhead Maplights & Sunglass Holder  
 Rear Occupant Alert

**EXTERIOR**  
 Auto-On/Off Projector Headlights  
 16" Alloy Wheels

**WARRANTY**  
 10 Year/100,000 Mile Limited Powertrain Warranty  
 5 Year/60,000 Mile Limited Basic Warranty  
 5 Year/60,000 Mile Roadside Assistance

**MANUFACTURER'S SUGGESTED RETAIL PRICE ▶ \$ 21,290.00**

**COMPARE GT-LINE FEATURES**  
 Added to/in place of standard LXS features  
 - Blind-Spot Collision-Avoidance Assist  
 - Rear Cross-Traffic Collision-Avoidance Assist  
 - Safe Exit Warning  
 - Smart Key w/ Push Button & Remote Start  
 - GT-Line Sport Cloth/SynTex Seating Material  
 - GT-Line Sport Design Leather Steering Wheel  
 - GT-Line 17" Alloy Wheels/Rear Spoiler/Side Sills  
 - LED Fog Lights/Tail Lights/Daytime Running Lights  
 - 10.25" Touchscreen w/ Navigation & MapCare  
 - Wired Android Auto and Apple CarPlay  
 - Dual Automatic Climate Control w/ Auto Defogger  
 - Heated Outside Mirrors w/ LED Turn Signals

**ADDITIONAL INSTALLED EQUIPMENT:**  
 (In addition to or in place of standard features)  
 GT-Line Premium Package  
 - Electronic Parking Brake  
 - Forward Collision-Avoidance Assist - Cyclist  
 - Smart Cruise Control w/ Stop & Go  
 - LED Overhead Interior Lighting  
 - Power Sunroof w/ Sunshade  
 - Harman/Kardon Premium Audio System  
 - Wireless Phone Charger

MSRP INCLUDING OPTIONS \$ 22,990.00  
 INLAND FREIGHT AND HANDLING \$ 995.00

**TOTAL MANUFACTURER'S SUGGESTED RETAIL PRICE ▶ \$ 23,985.00**

TOTAL ADDITIONAL WEIGHT:



**EPA DOT Fuel Economy and Environment Gasoline Vehicle**

**Fuel Economy**

**33** MPG **29** city **39** highway  
 combined city/hwy 3.0 gallons per 100 miles

MIDSIZE CARS range from 15 to 132 MPG. The best vehicle rates 142 MPG.

**You save \$1,250**  
 in fuel costs over 5 years compared to the average new vehicle.

**Annual fuel cost \$1,050**

Fuel Economy & Greenhouse Gas Rating (tailpipe only) Smog Rating (tailpipe only)

1 7 10 Best Best

This vehicle emits 271 grams CO<sub>2</sub> per mile. The best emits 0 grams per mile (tailpipe only). Producing and distributing fuel also create emissions. Learn more at [fuelconomy.gov](http://fuelconomy.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 \$6,800 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at \$2.35 per gallon. MPG is miles per gasoline gallon equivalent. Vehicle emissions are a significant cause of climate change and smog.

**fuelconomy.gov**  
 Calculate personalized estimates and compare vehicles

Smartphone QR Code

**GOVERNMENT 5-STAR SAFETY RATINGS**

**Overall Vehicle Score** ★ ★ ★ ★ ▲

Based on the combined rating of frontal, side and rollover. Should ONLY be compared to other vehicles of similar size and weight. ▲ Safety Concern: Visit [www.safercar.gov](http://www.safercar.gov) or call 1-888-327-4236 for more details.

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

**Side** Front seat ★ ★ ★ ★ ★  
 Crash Rear seat ★ ★ ★ ★ ★ ▲  
 Star ratings based on the risk of injury in a side impact.

**Rollover** ★ ★ ★ ★  
 Star ratings based on the risk of rollover in a single-vehicle crash.

**PARTS CONTENT INFORMATION**

**FOR VEHICLES IN THIS CAR LINE U.S./CANADIAN PARTS CONTENT: 15%**

**MAJOR SOURCES OF FOREIGN PARTS:**  
 MEXICO: 45%  
 KOREA: 40%

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

**FOR THIS VEHICLE FINAL ASSEMBLY POINT:**  
 MEXICO

**COUNTRY OF ORIGIN**  
 ENGINE: MEXICO  
 TRANSMISSION: MEXICO

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

Manufacturer's suggested retail price includes Manufacturer's recommended pre-delivery service. License and title fees, state and local taxes and other dealer installed options and accessories are not included in the manufacturer's suggested retail price.

\*Ask dealer for details.  
 \*\*Kia Connect may be currently unavailable for Model Year 2022 and newer vehicles sold or purchased in Massachusetts; please see [owners.kia.com](http://owners.kia.com) for updates on availability.  
 NOTE: When you purchase this vehicle, Kia America, Inc. collects personal information you provide to the dealership. For information on our collection and use of personal information and your rights, please see our Privacy Policy on [www.kia.com](http://www.kia.com).



Figure A4. Vehicle Certification Label



## TIRE AND LOADING INFORMATION RENSEIGNEMENTS SUR LES PNEUS ET LE CHARGEMENT

SEATING CAPACITY  
NOMBRE DE PLACES

TOTAL 5

FRONT  
AVANT 2

REAR  
ARRIÈRE 3

The combined weight of occupants and cargo should never exceed  
Le poids total des occupants et du chargement ne doit jamais dépasser

385 kg or 849 lbs.  
kg ou lb.

TIRE PNEU	SIZE DIMENSIONS	COLD TIRE PRESSURE PRESSION DES PNEUS À FROID
FRONT AVANT	225/45R17	230kPa, 33psi
REAR ARRIÈRE	225/45R17	230kPa, 33psi
SPARE DE SECOURS		NONE AUCUN

**SEE OWNER'S  
MANUAL FOR  
ADDITIONAL  
INFORMATION**

**VOIR LE MANUEL  
DE L'USAGER  
POUR PLUS DE  
RENSEIGNEMENTS**

**7620**

Figure A5. Tire Placard



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



Figure A7. Load Frame/Slider of SSV

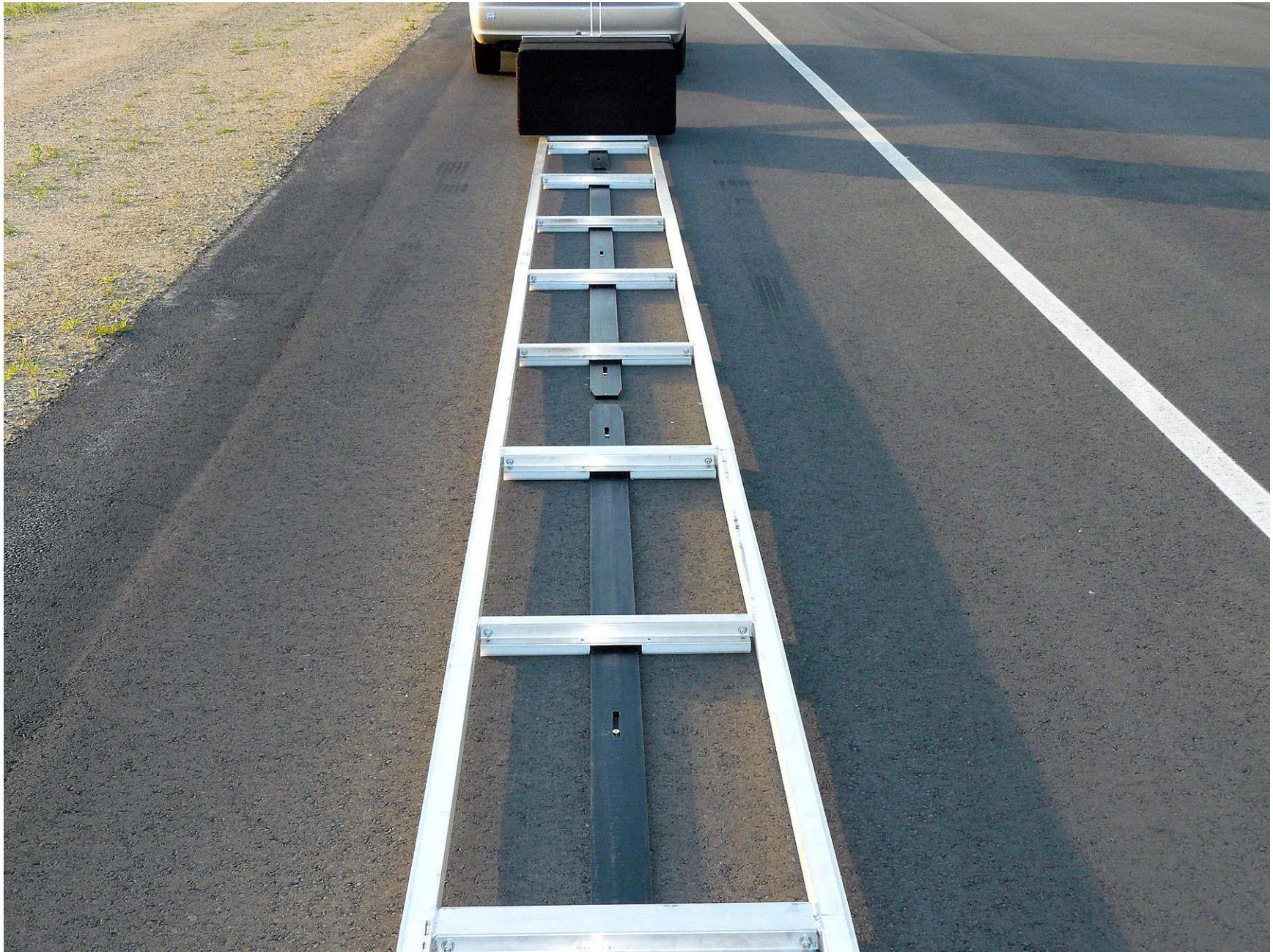


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track



Figure A9. Steel Trench Plate  
A-11



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





Figure A11. Sensor for Detecting Auditory and Visual Alerts



Figure A12. Computer Installed in Subject Vehicle

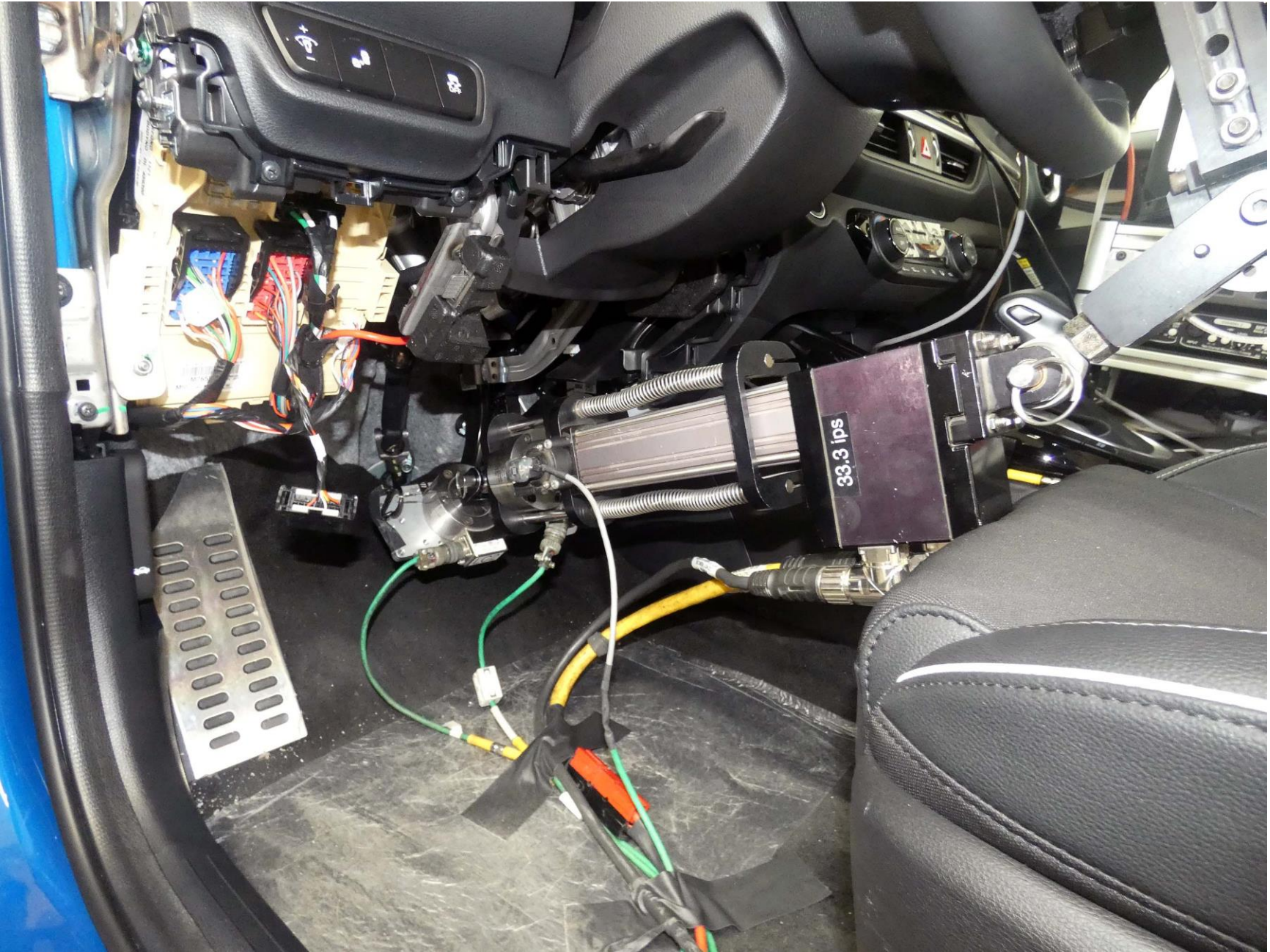


Figure A13. Brake Actuator Installed in Subject Vehicle



Figure A14. Brake Actuator Installed in POV System



Figure A15. AEB System Setup Menus

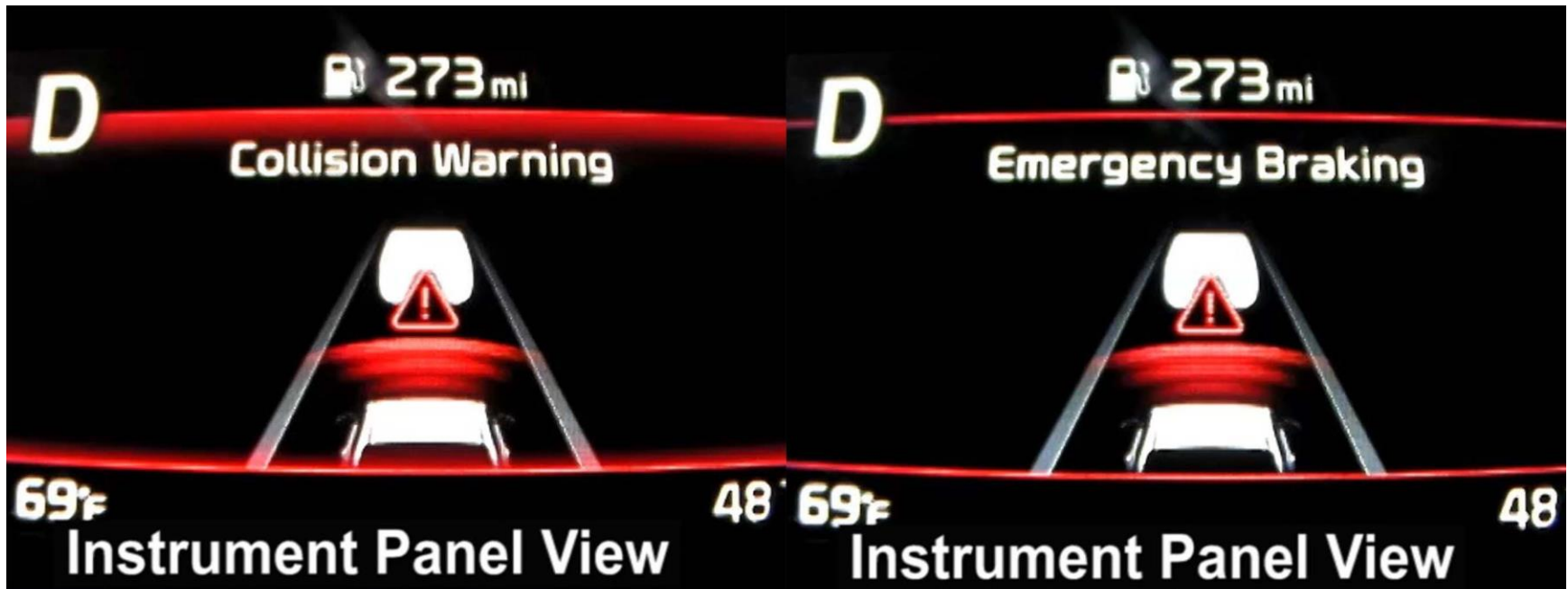


Figure A16. Visual Alert

## APPENDIX B

Excerpts from Owner's Manual

or when the vehicle in front of you has higher ground clearance, additional special attention is required. Forward Collision-Avoidance Assist may not be able to detect the cargo extending from the vehicle. In these instances, you must maintain a safe braking distance from the rearmost object, and if necessary, steer your vehicle and depress the brake pedal to reduce your driving speed in order to maintain distance.

### Forward Collision-Avoidance Assist (FCA) (Sensor fusion) (if equipped)

Forward Collision-Avoidance Assist is designed to help detect and monitor the vehicle ahead or help detect a pedestrian or cyclist in the roadway and warn the driver that a collision is imminent with a warning message, audible warning and apply emergency braking.

#### **⚠ WARNING**

- When you are towing a trailer or another vehicle, we recommend that Forward Collision-Avoidance Assist is turned off due to safety reasons.
- Forward Collision-Avoidance Assist may operate if objects that are similar in shape or characteristics to vehicles and pedestrians are detected.
- Forward Collision-Avoidance Assist does not operate on bicycles, motorcycles, or smaller wheeled objects, such as luggage bags, shopping carts, or strollers that are dragged by a pedestrian.
- Forward Collision-Avoidance Assist may not operate properly if interfered with by strong electromagnetic waves.
- Forward Collision-Avoidance Assist may not operate for approximately 15 seconds after the vehicle is started, or the front view camera is initialized.



#### **Detecting sensor**





Driving your vehicle

Forward Collision-Avoidance Assist (FCA) (Sensor fusion)



OBDM051014

[1]: Front view camera, [2]: Front radar  
Refer to the picture above for the detailed location of the detecting sensors.

**CAUTION**

Take the following precautions to maintain optimal performance of the detecting sensor:

- Never disassemble the detecting sensor or sensor assembly, or cause any damage to it.
- If the detecting sensor has been replaced or repaired, have your vehicle inspected by an authorized Kia dealer.
- Never install any accessories or stickers on the front windshield, or tint the front windshield.
- Pay extreme caution to keep the front view camera dry.
- Never place any reflective objects (for example, white paper, mirror) over the dashboard.
- Do not apply license plate frame or objects, such as a bumper sticker, film or a bumper guard, near the front radar cover.
- Always keep the front radar and cover clean and free of dirt and debris. Use only a soft cloth to wash the vehicle.

Do not spray pressurized water directly on the sensor or sensor cover.

- If the radar or around the radar has been damaged or impacted in any way, Forward Collision-Avoidance Assist may not properly operate even though a warning message does not appear on the cluster. In this case, have your vehicle inspected by an authorized Kia dealer.
- Use only genuine parts to repair or replace a damaged front radar cover. Do not apply paint to the front radar cover.

**Forward Collision-Avoidance Assist Settings**

**Setting features**



**Forward Safety**


With the ignition switch or ENGINE START/STOP button in the ON position, select 'Driver Assistance → Forward Safety' from the 'User Settings (LCD display) or Setup → Vehicle (Infotainment System screen)' menu to set whether to use each function.


- If 'Active Assist' is selected, Forward Collision-Avoidance Assist will warn the driver with a warning message, an audible warning depending on the

Driving your vehicle

Forward Collision-Avoidance Assist (FCA) (Sensor fusion)

collision risk levels. Braking assist will be applied depending on the collision risk.

- If 'Warning Only' is selected, Forward Collision-Avoidance Assist will warn the driver with a warning message, an audible warning depending on the collision risk levels. Braking will not be assisted. The driver must apply the brake pedal if necessary.
- If 'Off' is selected, Forward Collision-Avoidance Assist will be off. The  warning light will illuminate on the cluster.

The driver can monitor Forward Collision-Avoidance Assist On/Off status from the settings menu. If the  warning light remains on when Forward Collision-Avoidance Assist is on, have the vehicle inspected by an authorized Kia dealer.

**WARNING**

- When the engine is restarted, Forward Collision-Avoidance Assist will always turn on.
- If 'Off' is selected from the settings menu, the Forward Collision-Avoidance Assist will not operate so the driver should always be aware of the surroundings and drive safely.

**CAUTION**

If 'Warning Only' is selected, braking is not assisted.

**NOTICE**

Forward Collision-Avoidance Assist will turn off when ESC is turned off by press-

ing and holding the ESC OFF button and the  warning light will illuminate.

Warning Timing



With the ignition switch or ENGINE START/STOP button in the ON position, select 'Driver Assistance → Warning Timing' from the 'User Settings (LCD display) or Setup → Vehicle (Infotainment System screen)' menu to change the initial warning activation time for Forward Collision-Avoidance Assist.

When the vehicle is first delivered, Warning Timing is set to 'Normal'. If you change the Warning Timing, the Warning Timing of other Driver Assistance systems may change.

Warning Volume



5

With the ignition switch or ENGINE START/STOP button in the ON position, select 'Driver Assistance → Warning Volume' from the 'User Settings (LCD display) or Setup → Vehicle (Infotainment System screen)' menu to change the Warning Volume to 'High', 'Medium' or 'Low' for Forward Collision-Avoidance Assist.

If you change the Warning Volume, the Warning Volume of other Driver Assistance systems may change.

**⚠ CAUTION**

- The setting of the Warning Timing and Warning Volume applies to all functions of Forward Collision-Avoidance Assist.
- Even though 'Normal' is selected for Warning Timing, if the front vehicle suddenly stops, the warning may seem late.
- Select 'Late' for Warning Timing when traffic is light and when driving speed is slow.

**\* NOTICE**

If the engine is restarted, Warning Timing and Warning Volume will maintain the last setting.

**Forward Collision-Avoidance Assist Operation**

**Warning and control**

The basic function for Forward Collision-Avoidance Assist is to warn and help control the vehicle depending on the collision risk level: 'Collision Warning', 'Emergency Braking' and 'Stopping vehicle and ending brake control'.

**Collision Warning**



- To warn the driver of a collision, the 'Collision Warning' warning message will appear on the cluster, an audible warning will sound.
- If a vehicle is detected in front, the function will operate when your vehicle speed is between approximately 6~112 mph (10~180 km/h).
- If a pedestrian or cyclist is detected in front, the function will operate when your vehicle speed is between approximately 6~53 mph (10~85 km/h).
- If 'Active Assist' is selected, braking may be assisted.

### Emergency Braking



- To warn the driver that emergency braking will be assisted, the 'Emergency Braking' warning message will appear on the cluster, an audible warning will sound.
- If a vehicle is detected in front, the function will operate when your vehicle speed is between approximately 6~53 mph (10~85 km/h).
- If a pedestrian or cyclist is detected in front, the function will operate when your vehicle speed is between approximately 6~40 mph (10~65 km/h).
- In emergency braking situation, braking is assisted with strong braking power by the function to help prevent collision with the vehicle, pedestrian or cyclist ahead.

### Stopping vehicle and ending brake control



- When the vehicle is stopped due to emergency braking, the 'Drive carefully' warning message will appear on the cluster.
- For your safety, the driver should depress the brake pedal immediately and check the surroundings.
- Brake control will end after the vehicle is stopped by emergency braking for approximately 2 seconds.

#### **⚠ WARNING**

- For your safety, change the settings after parking the vehicle at a safe location.
- With 'Active Assist' or 'Warning Only' selected, when ESC is turned off by pressing and holding the ESC OFF button, Forward Collision-Avoidance Assist will turn off automatically. In this case, Forward Collision-Avoidance Assist cannot be set from the settings menu and the warning light will illuminate on the cluster which is normal. If ESC is turned on by pressing the ESC OFF button, Forward Collision-Avoidance Assist will maintain the last setting.

5

Driving your vehicle

Forward Collision-Avoidance Assist (FCA) (Sensor fusion)

- Forward Collision-Avoidance Assist does not operate in all situations or cannot avoid all collisions.
- The driver should hold the responsibility to control the vehicle. Do not solely depend on Forward Collision-Avoidance Assist. Rather, maintain a safe braking distance, and if necessary, depress the brake pedal to reduce driving speed or to stop the vehicle.
- Never deliberately operate Forward Collision-Avoidance Assist on people, objects, etc. It may cause serious injury or death.
- Forward Collision-Avoidance Assist may not operate if the driver depresses the brake pedal to avoid collision.
- Depending on the road and driving conditions, Forward Collision-Avoidance Assist may warn the driver late or may not warn the driver.
- During Forward Collision-Avoidance Assist operation, the vehicle may stop suddenly injuring passengers and shifting loose objects. Always have the seat belt on and keep loose objects secured.
- If any other function's warning message is displayed or audible warning is generated, Forward Collision-Avoidance Assist warning message may not be displayed and audible warning may not be generated.
- You may not hear the warning sound of Forward Collision-Avoidance Assist if the surrounding is noisy.
- Forward Collision-Avoidance Assist may turn off or may not operate properly or may operate unnecessarily

depending on the road conditions and the surroundings.

**⚠ WARNING**

- Even if there is a problem with Forward Collision-Avoidance Assist, the vehicle's basic braking performance will operate properly.
- During emergency braking, braking control by Forward Collision-Avoidance Assist will automatically cancel when the driver excessively depresses the accelerator pedal or sharply steers the vehicle.

**⚠ WARNING**

- Depending on the condition of the vehicle, pedestrian and cyclist in front and the surroundings, the speed range to operate Forward Collision-Avoidance Assist may reduce. The function may only warn the driver, or the function may not operate.
- It operates only under certain conditions by judging the danger according to a condition of the oncoming vehicle, driving direction, speed and the surrounding environment.

**\* NOTICE**

In a situation collision is imminent, braking may be assisted by Forward Collision-Avoidance Assist when braking is insufficient by the driver.

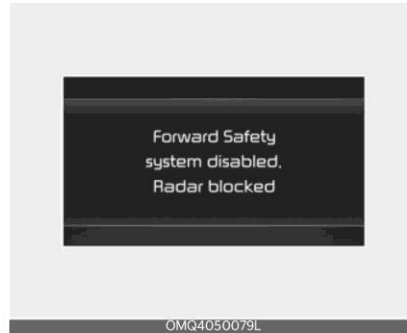
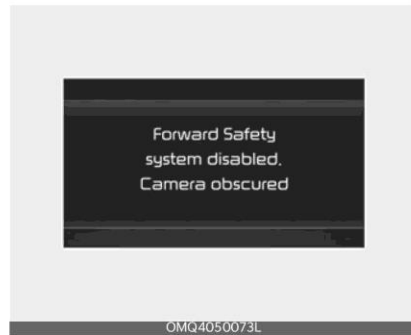
### Forward Collision-Avoidance Assist Malfunction and Limitations

#### Forward Collision-Avoidance Assist Malfunction



When Forward Collision-Avoidance Assist is not working properly, the 'Check Forward Safety system' warning message will appear (turns off after a certain time), and the and warning lights will illuminate on the cluster. In this case, have the vehicle inspected by an authorized Kia dealer.

#### Forward Collision-Avoidance Assist disabled

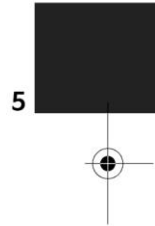


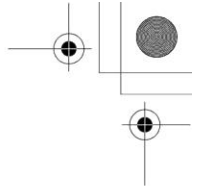
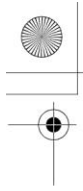
When the front windshield where the front view camera is located, front radar cover or sensor is covered with foreign material such as snow or rain, it can reduce the detecting performance and temporarily limit or disable Forward Collision-Avoidance Assist. If this occurs the 'Forward Safety system disabled. Radar blocked' warning message will appear (turns off after a certain time), and the and warning lights will illuminate on the cluster.

Forward Collision-Avoidance Assist will operate properly when snow, rain or foreign matter is removed. If Forward Collision-Avoidance Assist does not operate properly after it is removed, have the vehicle inspected by an authorized Kia dealer.

#### WARNING

- Even though the warning message or warning light does not appear on the cluster, Forward Collision-Avoidance Assist may not properly operate.
- Forward Collision-Avoidance Assist may not properly operate in an area (for example, open terrain), where any objects are not detected after turning ON the engine.

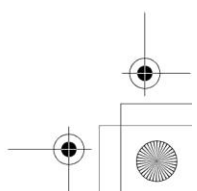
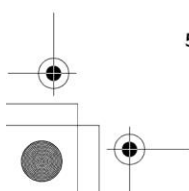




### Limitations of Forward Collision-Avoidance Assist

Forward Collision-Avoidance Assist may not operate properly or it may operate unexpectedly under the following circumstances:

- The detecting sensor or the surroundings are contaminated or damaged
- The temperature around the front view camera is high or low due to the external environment
- The camera lens is contaminated due to tinted, filmed or coated windshield, damaged glass, or sticky foreign matters (sticker, bug, etc.) on the glass
- Moisture is not removed or frozen on the windshield
- Washer fluid is continuously sprayed, or the wiper is on
- Driving in heavy rain or snow, or thick fog
- The field of view of the front view camera is obstructed by sun glare
- Street light or light from an oncoming traffic is reflected on the wet road surface, such as a puddle on the road
- An object is placed on the dashboard
- Your vehicle is being towed
- The surrounding is very bright
- The surrounding is very dark, such as in a tunnel, etc.
- The brightness changes suddenly, for example when entering or exiting a tunnel
- The brightness outside is low, and the headlamps are not on or are not bright
- Driving through steam, smoke or shadow
- Only part of the vehicle, pedestrian or cyclist is detected
- The vehicle in front is a bus, heavy truck, truck with an unusually shaped cargo, trailer, etc.
- The vehicle in front has no tail lights, tail lights are located unusually, etc.
- The brightness outside is low, and the tail lamps are not on or are not bright
- The rear of the front vehicle is small or the vehicle does not look normal, such as when the vehicle is tilted, overturned, or the side of the vehicle is visible, etc.
- The front vehicle's ground clearance is low or high
- A vehicle, pedestrian or cyclist suddenly cuts in front
- The bumper around the front radar is impacted, damaged or the front radar is out of position
- The temperature around the front radar is high or low
- Driving through a tunnel or iron bridge
- Driving in large areas where there are few vehicles or structures (for example, desert, meadow, suburb, etc.)
- Driving near areas containing metal substances, such as a construction zone, railroad, etc.
- A material is near that reflects very well on the front radar, such as a guardrail, nearby vehicle, etc.
- The cyclist in front is on a bicycle made of material that does not reflect on the front radar
- The vehicle in front is detected late
- The vehicle in front is suddenly blocked by an obstacle
- The vehicle in front suddenly changes lane or suddenly reduces speed
- The vehicle in front is bent out of shape



**Driving your vehicle**

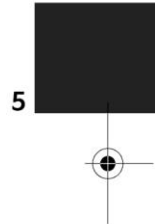
**Forward Collision-Avoidance Assist (FCA) (Sensor fusion)**

- The front vehicle's speed is fast or slow
- The vehicle in front steers in the opposite direction of your vehicle to avoid a collision
- With a vehicle in front, your vehicle changes lane at low speed
- The vehicle in front is covered with snow
- You are departing or returning to the lane
- You are driving unstably
- You are on a roundabout and the vehicle in front is not detected
- You are continuously driving in a circle
- The vehicle in front has an unusual shape
- The vehicle in front is driving uphill or downhill
- The pedestrian or cyclist is not fully detected, for example, if the pedestrian is leaning over or is not fully walking upright
- The pedestrian or cyclist is wearing clothing or equipment that makes it difficult to detect as a pedestrian or cyclist

Following image shows the image the sensor recognizes as vehicle, pedestrian, and cyclist.



- The pedestrian or cyclist in front is moving very quickly
- The pedestrian or cyclist in front is short or is posing a low posture
- The pedestrian or cyclist in front has impaired mobility
- The pedestrian or cyclist in front is moving intersected with the driving direction
- There is a group of pedestrians, cyclists or a large crowd in front
- The pedestrian or cyclist is wearing clothing that easily blends into the background, making it difficult to detect
- The pedestrian or cyclist is difficult to distinguish from the similarly shaped structure in the surroundings
- You are driving by a pedestrian, cyclist traffic signs, structures, etc. near the intersection
- Driving in a parking lot
- Driving through a tollgate, construction area, unpaved road, partial paved road, uneven road, speed bumps, etc.
- Driving on an incline road, curved road, etc.
- Driving through a roadside with trees or streetlights
- The adverse road conditions cause excessive vehicle vibrations while driving
- Your vehicle height is low or high due to heavy loads, abnormal tire pressure, etc.
- Driving through a narrow road where trees or grass are overgrown
- There is interference by electromagnetic waves, such as driving in an area with strong radio waves or electrical noise





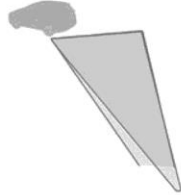
Driving your vehicle

Forward Collision-Avoidance Assist (FCA) (Sensor fusion)

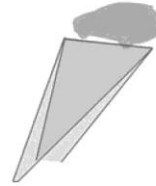
**⚠ WARNING**

- Driving on a curved road

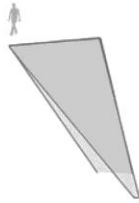
Always pay attention to road and driving conditions, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.



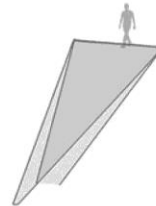
ODEEV069237NR



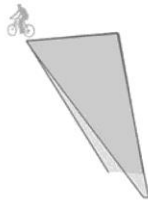
ODEEV069240NR



ODEEV069238NR



ODEEV069241NR



ODEEV069239NR



ODEEV069242NR

The front view camera or radar sensor recognition function may not detect the vehicle, pedestrian or cyclist traveling in front on a curved road.

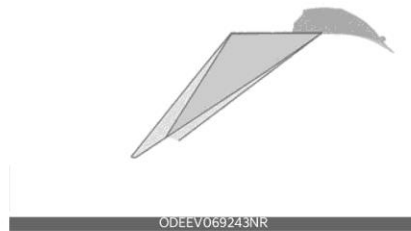
Forward Collision-Avoidance Assist may detect a vehicle or pedestrian in the next lane or outside the lane when

**Driving your vehicle**

**Forward Collision-Avoidance Assist (FCA) (Sensor fusion)**

driving on a curved road. If this occurs, the unnecessarily alarm the driver and apply the brake. Always check the traffic conditions around the vehicle.

• **Driving on a sloped road**

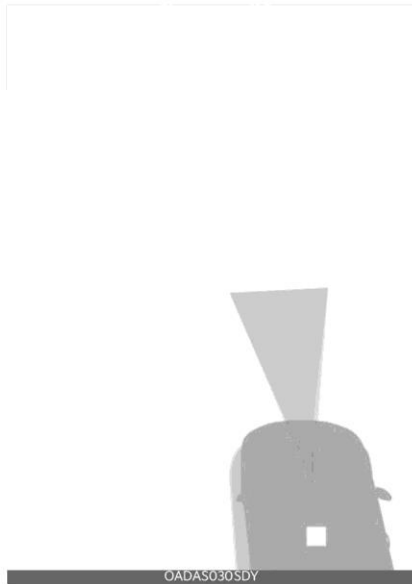


Forward Collision-Avoidance Assist may not detect other vehicle, pedestrian or cyclist in front while driving uphill or downhill and this may result in no warning, or braking assist when necessary.

When the function suddenly recognizes the vehicle, pedestrian or cyclist in front while passing over a slope, you may experience sharp deceleration.

Always keep your eyes forward while driving upward or downward on a slope, and, if necessary, depress the brake pedal to reduce your driving speed in order to maintain distance.

• **Changing lanes**



[A]: Your vehicle

[B]: Lane changing vehicle

When a vehicle changes lanes in front of you, Forward Collision-Avoidance Assist may not immediately detect the

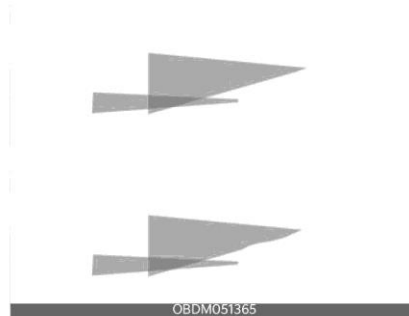
5

Driving your vehicle

Forward Collision-Avoidance Assist (FCA) (Sensor fusion)

vehicle, especially if the vehicle changes lanes abruptly. In this case, you must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.

• Recognizing the vehicle



OBDM051365

When the vehicle in front has heavy loading extended rearward, or when the vehicle in front has higher ground clearance, it may induce a hazardous situation. Always pay attention to road and driving conditions, while driving and, if necessary, depress the brake pedal to reduce your driving speed in order to maintain distance.



OADAS03TSDY

- [A]: Your vehicle
- [B]: Lane changing vehicle
- [C]: Same lane vehicle

When driving in stop-and-go traffic, and a stopped vehicle in front of you merges out of the lane, Forward Collision-Avoidance Assist may not immediately detect the new vehicle that is now in front of you. In this case, you must maintain a safe braking distance, and if necessary, depress the brake pedal to reduce your driving speed in order to maintain a safe distance.

**WARNING**

- When you are towing a trailer or another vehicle, we recommend that Forward Collision-Avoidance Assist is turned off due to safety reasons.
- Forward Collision-Avoidance Assist may operate if objects that are similar in shape or characteristics to vehicles, pedestrians or cyclists are detected.
- Forward Collision-Avoidance Assist does not operate on bicycles, motorcycles, or smaller wheeled objects, such as luggage bags, shopping carts, or strollers that are dragged by a pedestrian or a cyclist.
- Forward Collision-Avoidance Assist may not operate properly if interfered by strong electromagnetic waves.
- Forward Collision-Avoidance Assist may not operate for 15 seconds after

**Driving your vehicle**

the vehicle is started, or the front view camera is initialized.

**This device complies with Part 15 of the FCC rules.**

Operation is subject to the following three conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.
3. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the device.

**Radio frequency radiation exposure information:**

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 8 in (20 cm) between the radiator and your body. This transmitter must not be colocated or operating in conjunction with any other antenna or transmitter.

**Lane Keeping Assist (LKA)**

**Lane Keeping Assist (LKA) (if equipped)**

Lane Keeping Assist is designed to help detect the lane markers while driving over a certain speed. Lane Keeping Assist will warn the driver if the vehicle leaves the lane without using the turn signal, or will automatically assist the driver's steering to help prevent the vehicle from departing the lane.

**Detecting sensor**



[1]: Front view camera

The front view camera is used as a detecting sensor to detect lane markings.

Refer to the picture above for the detailed location of the detecting sensor.

**CAUTION**

For more details on the precautions of the front view camera, refer to "Forward Collision-Avoidance Assist (FCA) (Sensor fusion) (if equipped)" on page 5-61.

## APPENDIX C

### Run Log

Subject Vehicle: **2022 Kia Forte**

Test start date: **3/16/2022**

Principal Other Vehicle: **SSV**

Test end date: **3/16/2022**

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
Brake characterization and determination							See Appendix D
46	Static Run						
47	<b>Stopped POV</b>	Y	1.67	4.92	0.77	Pass	
48		Y	1.65	6.39	0.79	Pass	
49		Y	1.64	6.49	0.80	Pass	
50		Y	1.65	6.86	0.82	Pass	
51		Y	1.63	7.01	0.80	Pass	
52		Y	1.66	7.82	0.87	Pass	
53		Y	1.65	9.51	0.90	Pass	
54	Static Run						
55	<b>Slower POV, 25 vs 10</b>	Y	1.55	6.39	0.69	Pass	
56		Y	1.64	6.50	0.73	Pass	
57		Y	1.56	6.45	0.68	Pass	
58		Y	1.69	6.38	0.71	Pass	
59		Y	1.63	5.59	0.59	Pass	
60		Y	1.54	6.93	0.69	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
61		Y	1.59	6.15	0.71	Pass	
62	Static run						
63	<b>Slower POV, 45 vs 20</b>	Y	2.74	9.33	0.94	Pass	
64		N					
65		Y	2.74	10.85	1.01	Pass	
66		Y	2.77	12.27	1.04	Pass	
67		Y	2.73	12.07	1.04	Pass	
68		N					
69		Y	2.80	11.65	1.05	Pass	
70		Y	2.73	11.50	1.04	Pass	
71		Y	2.78	12.40	1.05	Pass	
72		Static run					
73	<b>Decelerating POV, 35</b>	N					
74		N					
75		Y	1.85	1.81	1.00	Pass	
76		Y	1.78	2.82	0.95	Pass	
77		Y	1.78	1.79	0.64	Pass	
78		Y	1.81	2.37	1.02	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
79		Y	1.81	4.14	0.60	Pass	
80		Y	1.76	3.81	0.94	Pass	
81		Y	1.87	8.66	0.63	Pass	
82	Static run						
13	STP - Static run						
14	<b>Baseline, 25</b>	Y			0.49		
15		Y			0.52		
16		Y			0.51		
17		Y			0.50		
18		Y			0.51		
19		Y			0.56		
20		Y			0.56		
21	STP - Static run						
22	<b>Baseline, 45</b>	Y			0.56		
23		Y			0.60		
24		Y			0.59		
25		Y			0.59		
26		Y			0.58		



Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
27		Y			0.59		
28		Y			0.61		
29	STP - Static run						
30	<b>STP False Positive, 25</b>	Y			0.55	Pass	
31		Y			0.54	Pass	
32		Y			0.50	Pass	
33		Y			0.53	Pass	
34		Y			0.51	Pass	
35		Y			0.46	Pass	
36		Y			0.53	Pass	
37	STP - Static run						
38	<b>STP False Positive, 45</b>	Y			0.59	Pass	
39		Y			0.58	Pass	
40		Y			0.61	Pass	
41		Y			0.58	Pass	
42		Y			0.60	Pass	
43		Y			0.59	Pass	
44		Y			0.60	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
45	STP - Static run						

## APPENDIX D

### Brake Characterization

Subject Vehicle: **2022 Kia Forte**

Test start date: **3/16/2022**

Test end date: **3/16/2022**

DBS Initial Brake Characterization				
Run Number	Stroke at 0.4 g (in)	Force at 0.4 g (lb)	Slope	Intercept
1	1.73	30.05	0.80	0.12
2	1.72	29.21	0.77	0.17
3	1.69	28.43	0.79	0.10

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	0.407	1.50		1.47	
6		25	Y	0.386	1.50		1.55	
7		45	Y	0.385	1.50		1.56	
8	Hybrid	35	Y	0.561		29.23	20.84	
9		35	Y	0.534		21.00	15.73	
10		35	Y	0.394		13.50	13.71	
11		25	Y	0.384		13.50	14.06	
12		45	Y	0.382		13.50	14.14	

Appendix E

TIME HISTORY PLOTS

## LIST OF FIGURES

	Page
Figure E1. Example Time History for Stopped POV, Passing .....	E-11
Figure E2. Example Time History for Slower POV 25 vs. 10, Passing .....	E-12
Figure E3. Example Time History for Slower POV 45 vs. 20, Passing .....	E-13
Figure E4. Example Time History for Decelerating POV 35, Passing .....	E-14
Figure E5. Example Time History for False Positive Baseline 25.....	E-15
Figure E6. Example Time History for False Positive Baseline 45.....	E-16
Figure E7. Example Time History for False Positive Steel Plate 25, Passing .....	E-17
Figure E8. Example Time History for False Positive Steel Plate 45, Passing .....	E-18
Figure E9. Example Time History for DBS Brake Characterization, Passing .....	E-19
Figure E10. Example Time History Displaying Invalid POV Acceleration Criteria .....	E-20
Figure E11. Example Time History Displaying Invalid Brake Force Criteria .....	E-21
Figure E12. Example Time History for a Failed Run .....	E-22
Figure E13. Time History for DBS Run 47, Test 1 - Stopped POV.....	E-23
Figure E14. Time History for DBS Run 48, Test 1 - Stopped POV.....	E-24
Figure E15. Time History for DBS Run 49, Test 1 - Stopped POV.....	E-25
Figure E16. Time History for DBS Run 50, Test 1 - Stopped POV.....	E-26
Figure E17. Time History for DBS Run 51, Test 1 - Stopped POV.....	E-27
Figure E18. Time History for DBS Run 52, Test 1 - Stopped POV.....	E-28
Figure E19. Time History for DBS Run 53, Test 1 - Stopped POV.....	E-29
Figure E20. Time History for DBS Run 55, Test 2 - Slower Moving POV 25/10 mph.....	E-30
Figure E21. Time History for DBS Run 56, Test 2 - Slower Moving POV 25/10 mph.....	E-31
Figure E22. Time History for DBS Run 57, Test 2 - Slower Moving POV 25/10 mph.....	E-32
Figure E23. Time History for DBS Run 58, Test 2 - Slower Moving POV 25/10 mph.....	E-33
Figure E24. Time History for DBS Run 59, Test 2 - Slower Moving POV 25/10 mph.....	E-34
Figure E25. Time History for DBS Run 60, Test 2 - Slower Moving POV 25/10 mph.....	E-35
Figure E26. Time History for DBS Run 61, Test 2 - Slower Moving POV 25/10 mph.....	E-36
Figure E27. Time History for DBS Run 63, Test 2 - Slower Moving POV 45/20 mph.....	E-37
Figure E28. Time History for DBS Run 65, Test 2 - Slower Moving POV 45/20 mph.....	E-38
Figure E29. Time History for DBS Run 66, Test 2 - Slower Moving POV 45/20 mph.....	E-39
Figure E30. Time History for DBS Run 67, Test 2 - Slower Moving POV 45/20 mph.....	E-40
Figure E31. Time History for DBS Run 69, Test 2 - Slower Moving POV 45/20 mph.....	E-41
Figure E32. Time History for DBS Run 70, Test 2 - Slower Moving POV 45/20 mph.....	E-42
Figure E33. Time History for DBS Run 71, Test 2 - Slower Moving POV 45/20 mph.....	E-43
Figure E34. Time History for DBS Run 75, Test 3 - Decelerating POV 35 mph .....	E-44
Figure E35. Time History for DBS Run 76, Test 3 - Decelerating POV 35 mph .....	E-45
Figure E36. Time History for DBS Run 77, Test 3 - Decelerating POV 35 mph .....	E-46
Figure E37. Time History for DBS Run 78, Test 3 - Decelerating POV 35 mph .....	E-47
Figure E38. Time History for DBS Run 79, Test 3 - Decelerating POV 35 mph .....	E-48
Figure E39. Time History for DBS Run 80, Test 3 - Decelerating POV 35 mph .....	E-49
Figure E40. Time History for DBS Run 81, Test 3 - Decelerating POV 35 mph .....	E-50
Figure E41. Time History for DBS Run 14, False Positive Baseline, SV 25 mph .....	E-51

Figure E42.	Time History for DBS Run 15, False Positive Baseline, SV 25 mph .....	E-52
Figure E43.	Time History for DBS Run 16, False Positive Baseline, SV 25 mph .....	E-53
Figure E44.	Time History for DBS Run 17, False Positive Baseline, SV 25 mph .....	E-54
Figure E45.	Time History for DBS Run 18, False Positive Baseline, SV 25 mph .....	E-55
Figure E46.	Time History for DBS Run 19, False Positive Baseline, SV 25 mph .....	E-56
Figure E47.	Time History for DBS Run 20, False Positive Baseline, SV 25 mph .....	E-57
Figure E48.	Time History for DBS Run 22, False Positive Baseline, SV 45 mph .....	E-58
Figure E49.	Time History for DBS Run 23, False Positive Baseline, SV 45 mph .....	E-59
Figure E50.	Time History for DBS Run 24, False Positive Baseline, SV 45 mph .....	E-60
Figure E51.	Time History for DBS Run 25, False Positive Baseline, SV 45 mph .....	E-61
Figure E52.	Time History for DBS Run 26, False Positive Baseline, SV 45 mph .....	E-62
Figure E53.	Time History for DBS Run 27, False Positive Baseline, SV 45 mph .....	E-63
Figure E54.	Time History for DBS Run 28, False Positive Baseline, SV 45 mph .....	E-64
Figure E55.	Time History for DBS Run 30, Test 4 - False Positive STP 25 mph .....	E-65
Figure E56.	Time History for DBS Run 31, Test 4 - False Positive STP 25 mph .....	E-66
Figure E57.	Time History for DBS Run 32, Test 4 - False Positive STP 25 mph .....	E-67
Figure E58.	Time History for DBS Run 33, Test 4 - False Positive STP 25 mph .....	E-68
Figure E59.	Time History for DBS Run 34, Test 4 - False Positive STP 25 mph .....	E-69
Figure E60.	Time History for DBS Run 35, Test 4 - False Positive STP 25 mph .....	E-70
Figure E61.	Time History for DBS Run 36, Test 4 - False Positive STP 25 mph .....	E-71
Figure E62.	Time History for DBS Run 38, Test 4 - False Positive STP 45 mph .....	E-72
Figure E63.	Time History for DBS Run 39, Test 4 - False Positive STP 45 mph .....	E-73
Figure E64.	Time History for DBS Run 40, Test 4 - False Positive STP 45 mph .....	E-74
Figure E65.	Time History for DBS Run 41, Test 4 - False Positive STP 45 mph .....	E-75
Figure E66.	Time History for DBS Run 42, Test 4 - False Positive STP 45 mph .....	E-76
Figure E67.	Time History for DBS Run 43, Test 4 - False Positive STP 45 mph .....	E-77
Figure E68.	Time History for DBS Run 44, Test 4 - False Positive STP 45 mph .....	E-78
Figure E69.	Time History for DBS Run 1, Brake Characterization Initial .....	E-79
Figure E70.	Time History for DBS Run 2, Brake Characterization Initial .....	E-80
Figure E71.	Time History for DBS Run 3, Brake Characterization Initial .....	E-81
Figure E72.	Time History for DBS Run 5, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-82
Figure E73.	Time History for DBS Run 6, Brake Characterization Determination, Displacement Mode, 25 mph .....	E-83
Figure E74.	Time History for DBS Run 7, Brake Characterization Determination, Displacement Mode, 45 mph .....	E-84
Figure E75.	Time History for DBS Run 8, Brake Characterization Determination, Hybrid Mode, 35 mph .....	E-85
Figure E76.	Time History for DBS Run 9, Brake Characterization Determination, Hybrid Mode, 35 mph .....	E-86
Figure E77.	Time History for DBS Run 10, Brake Characterization Determination, Hybrid Mode, 35 mph .....	E-87
Figure E78.	Time History for DBS Run 11, Brake Characterization Determination, Hybrid Mode, 25 mph .....	E-88

Figure E79. Time History for DBS Run 12, Brake Characterization Determination,  
Hybrid Mode, 45 mph ..... E-89



## 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.,  $0.30 \text{ g} \pm 0.03 \text{ g}$ ). A green circle or red asterisk is displayed at the moment the POV brake level achieves 0.27 g. A green circle indicates that the test was valid (the threshold was crossed during the appropriate interval) and a red asterisk indicates that the test was invalid (the threshold was crossed out of the appropriate interval).

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

For the brake force plots:

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

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

## Color Codes

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

Color codes can be broken into four categories:

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

1. Time-varying data color codes:

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

## 2. Validation envelope and threshold color codes:

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

## 3. Individual data point color codes:

- Green circle = passing or valid value at a given moment in time
- Red asterisk = failing or invalid value at a given moment in time

## 4. Text color codes:

- Green = passing or valid value
- Red = failing or invalid value

## Other Notations

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

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

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

**Notes**

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

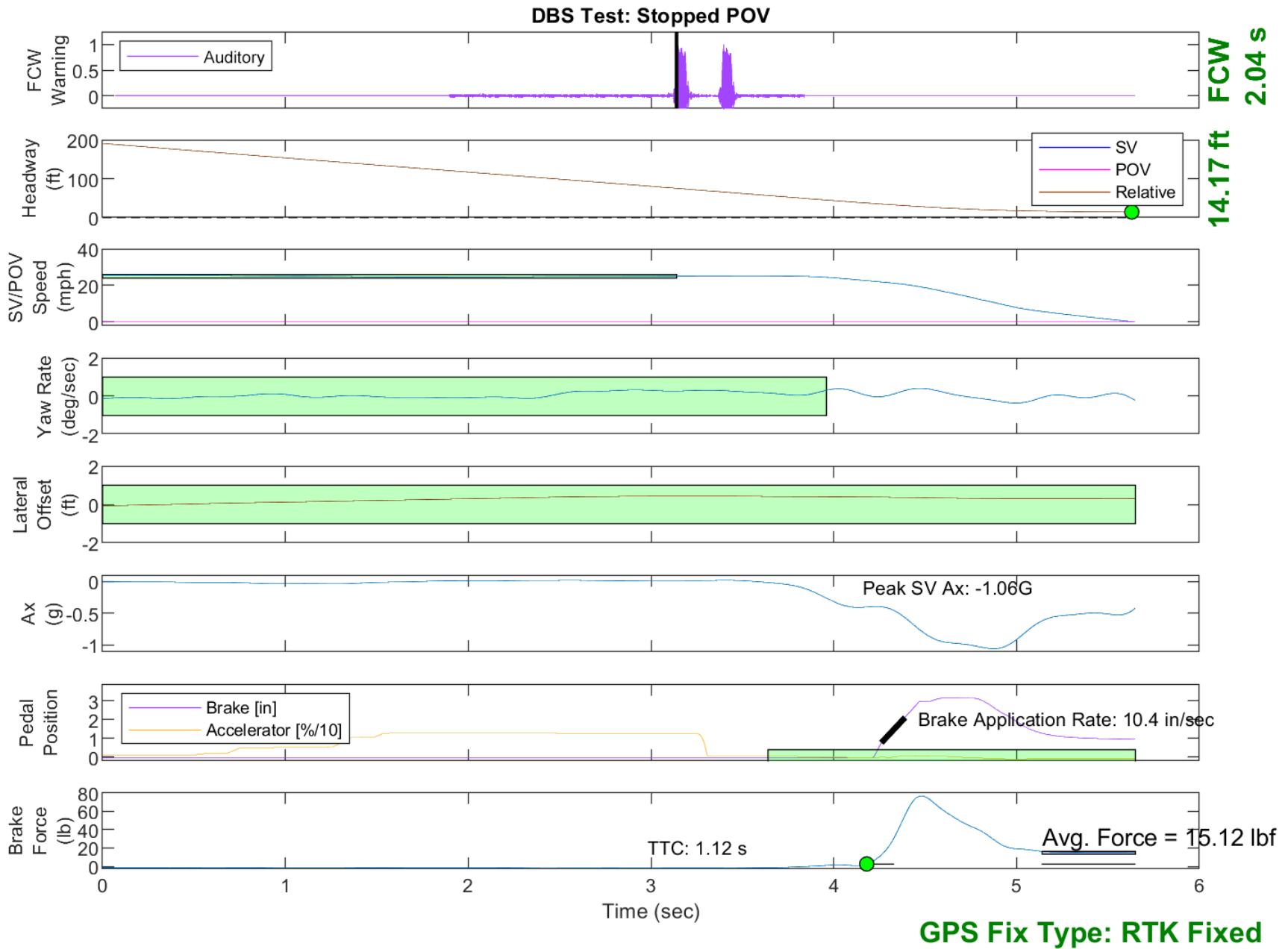


Figure E1. Example Time History for Stopped POV, Passing

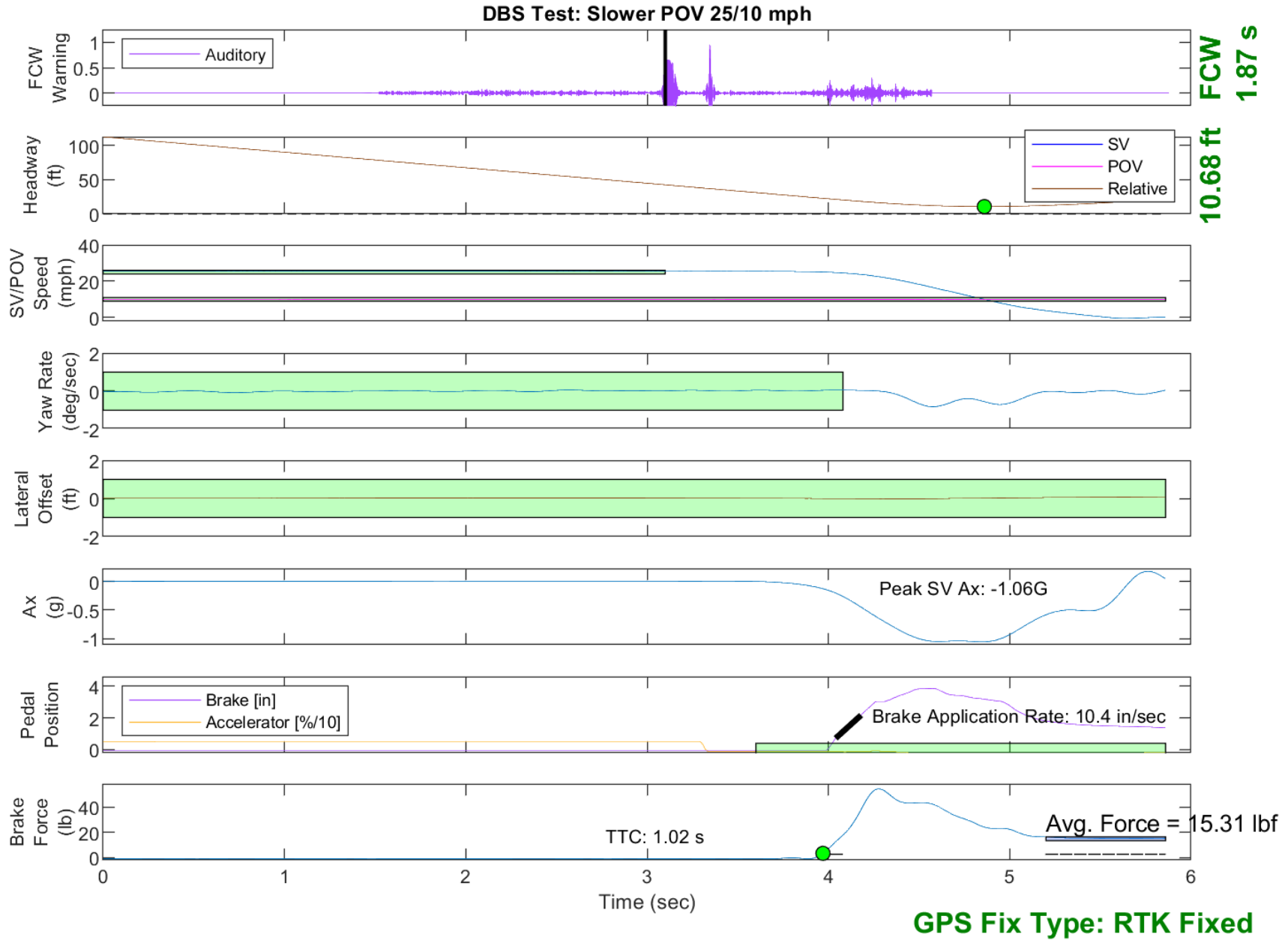


Figure E2. Example Time History for Slower POV 25 vs. 10, Passing



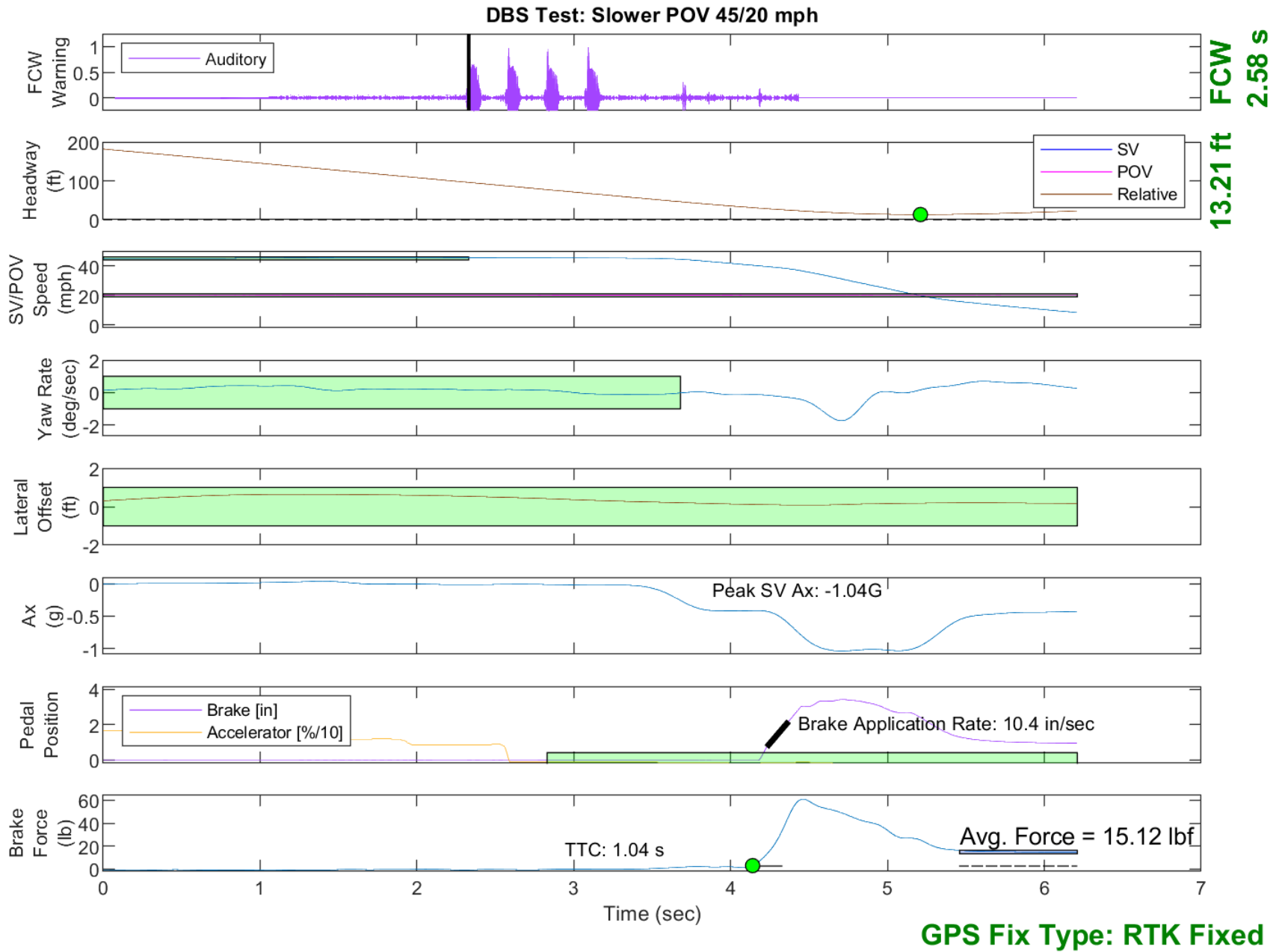


Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

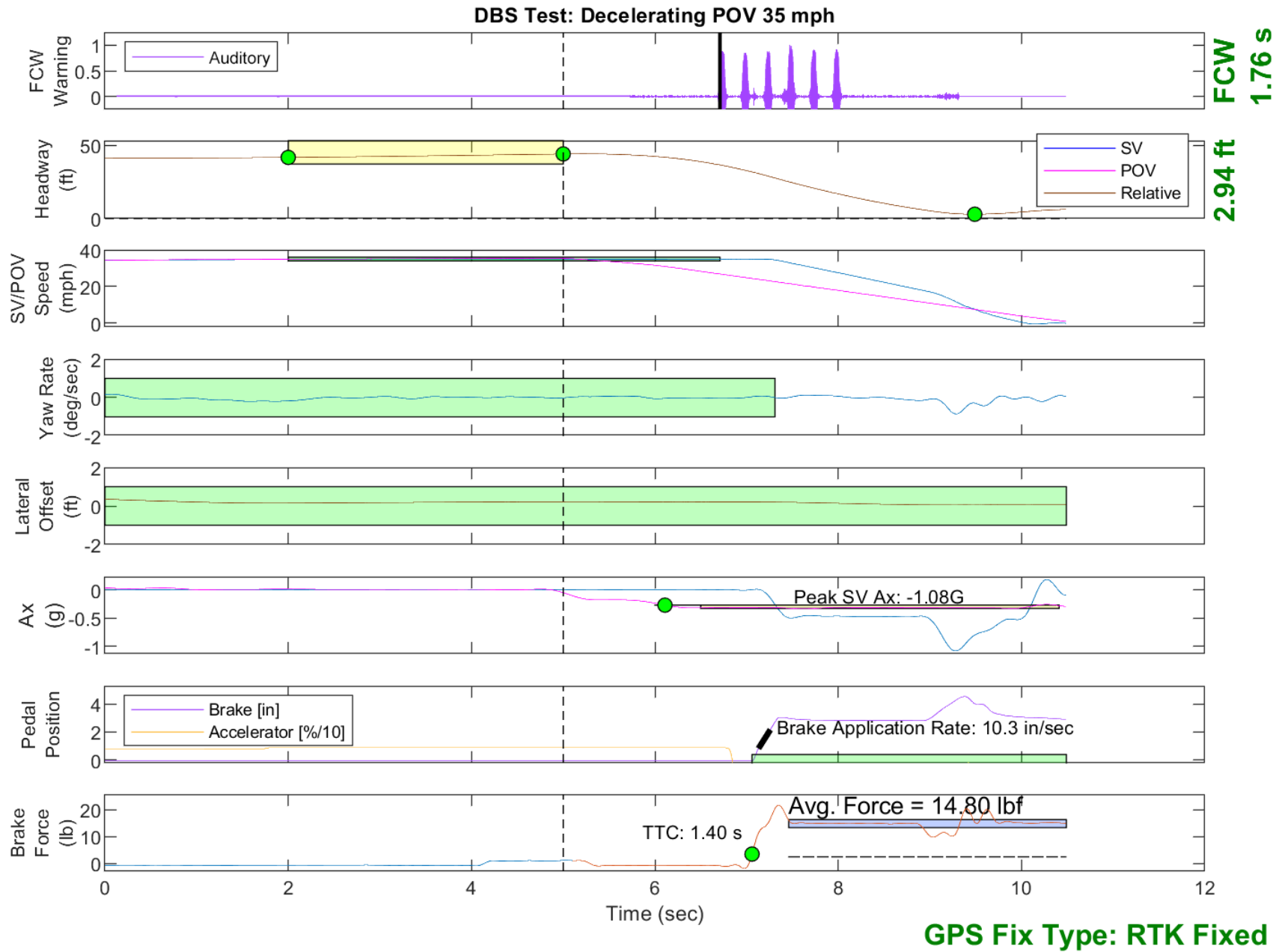
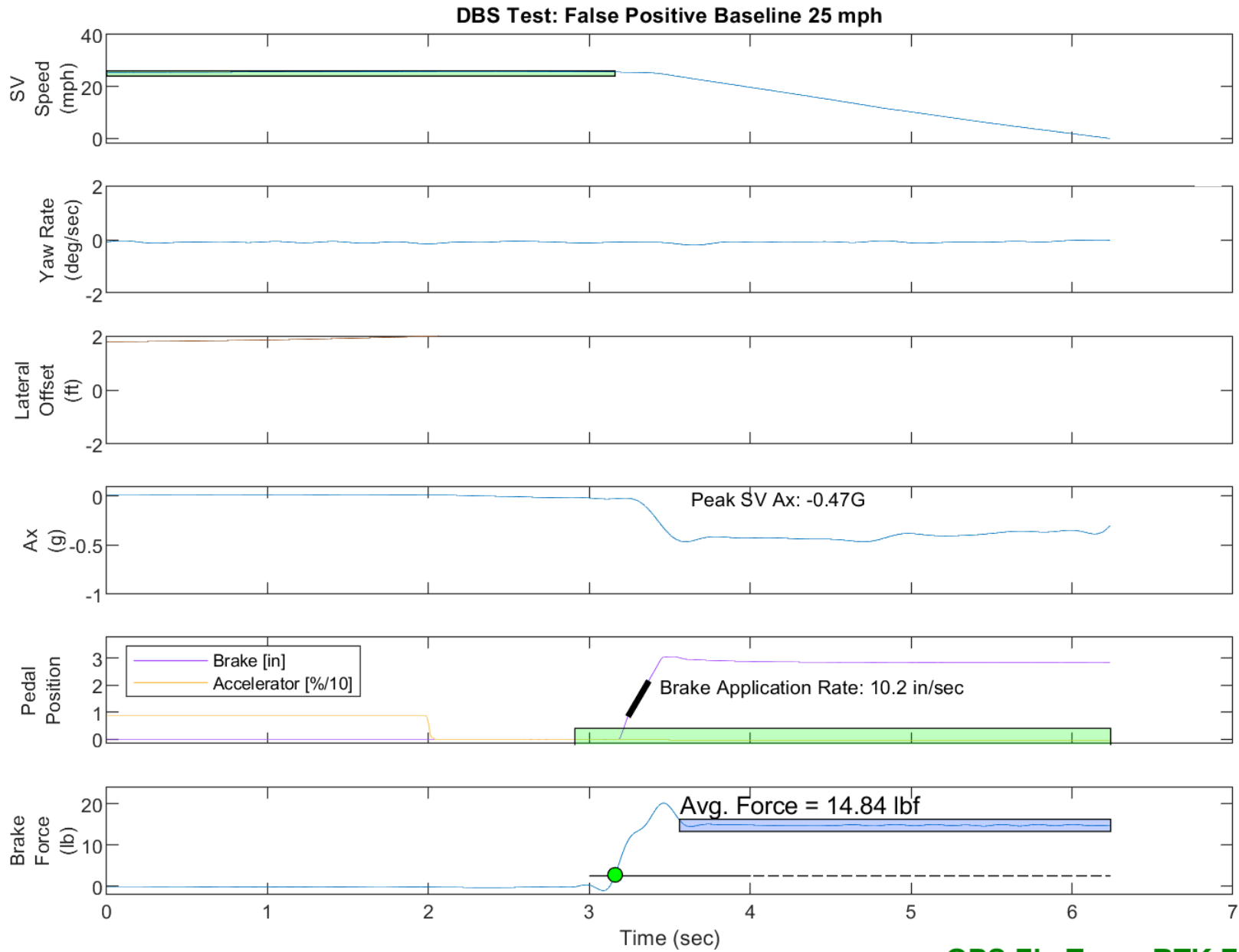
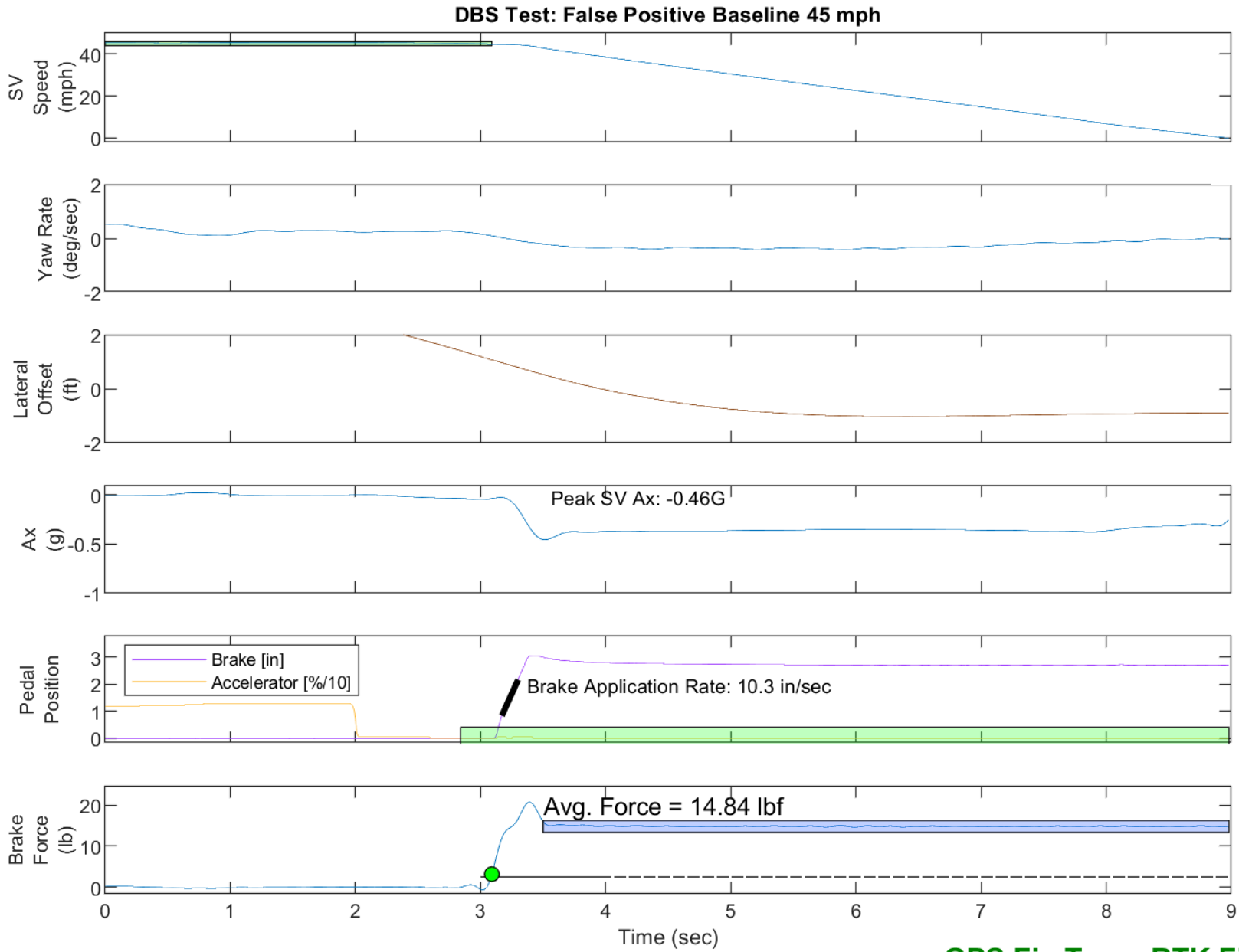


Figure E4. Example Time History for Decelerating POV 35, Passing



GPS Fix Type: RTK Fixed

Figure E5. Example Time History for False Positive Baseline 25



**GPS Fix Type: RTK Fixed**

Figure E6. Example Time History for False Positive Baseline 45

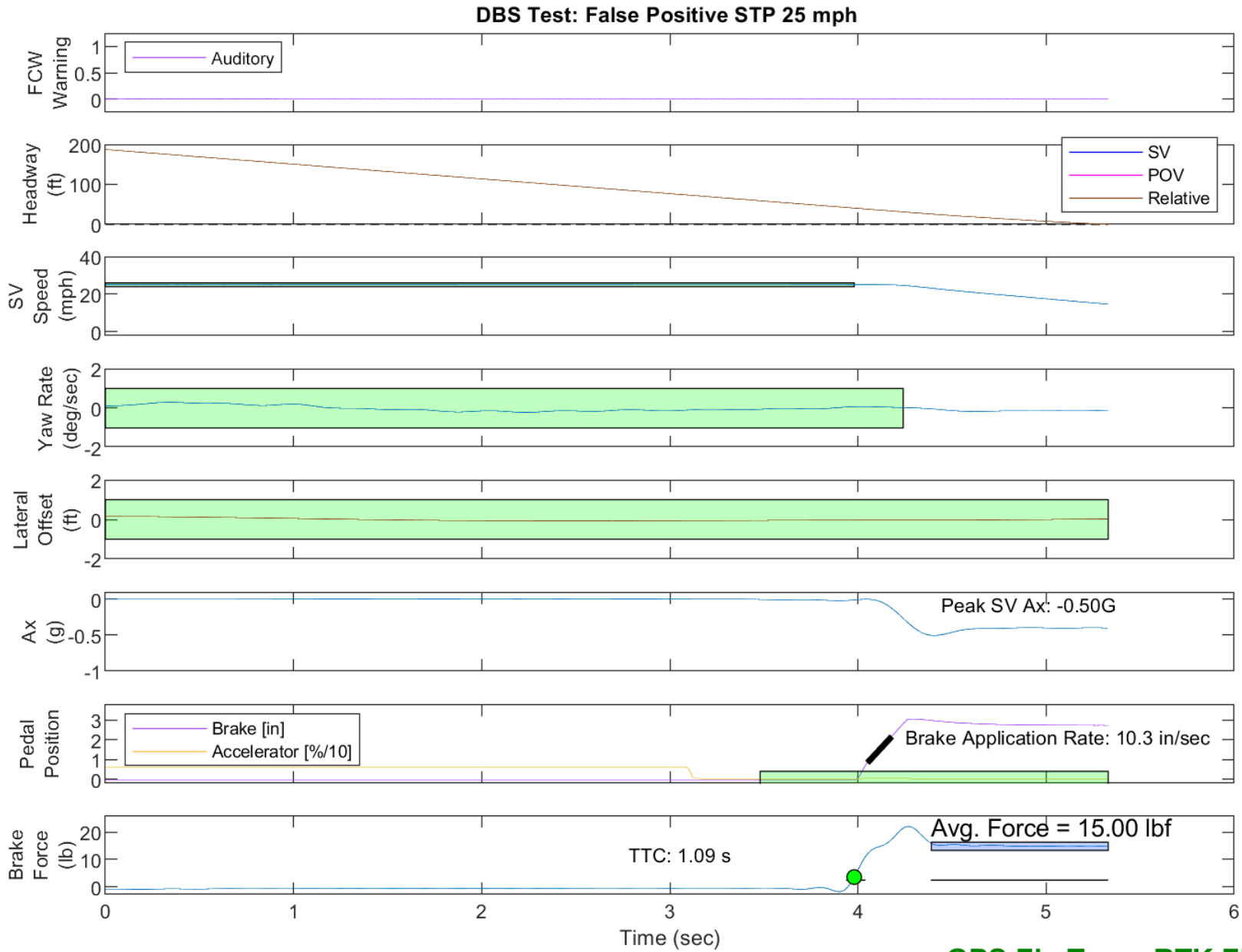
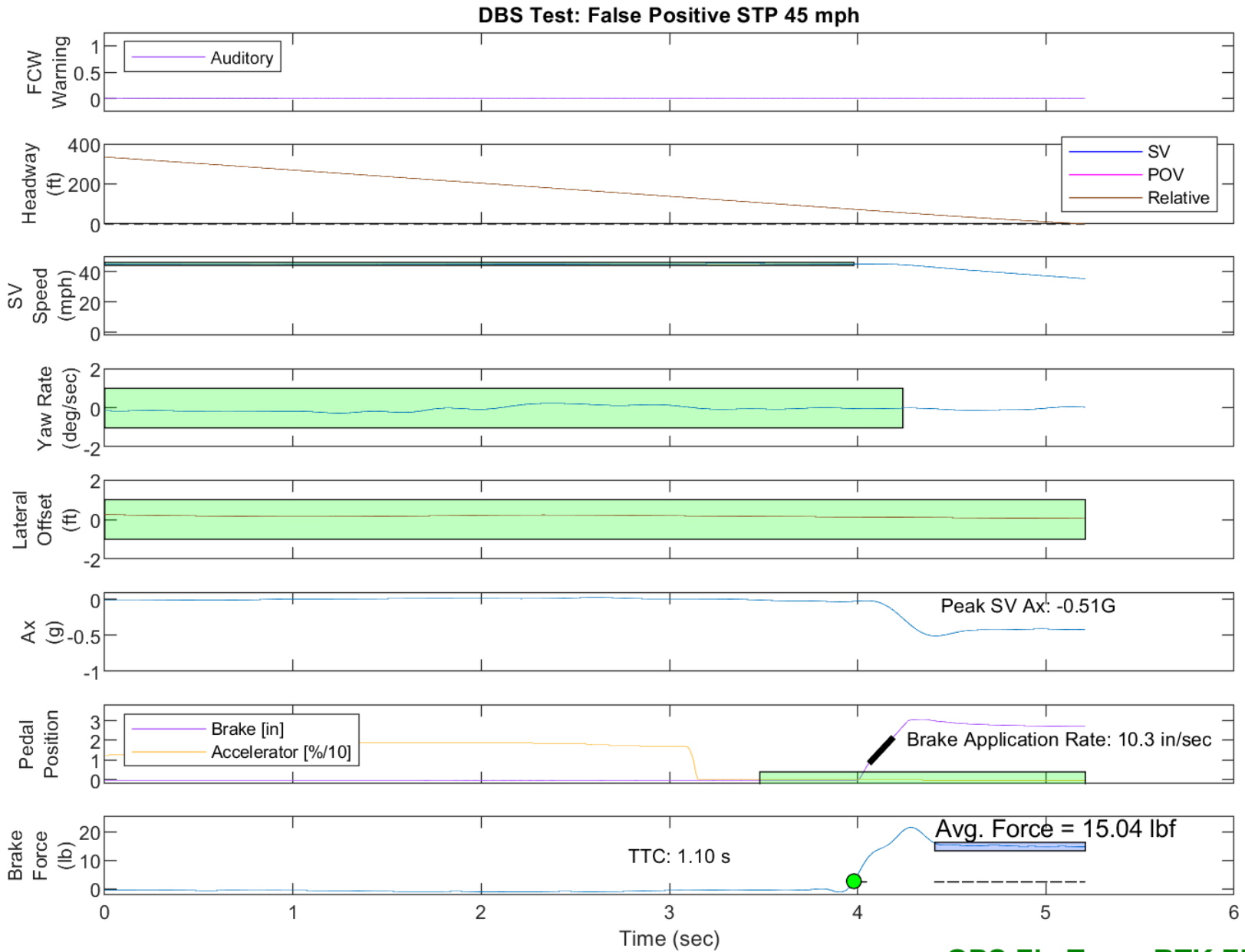
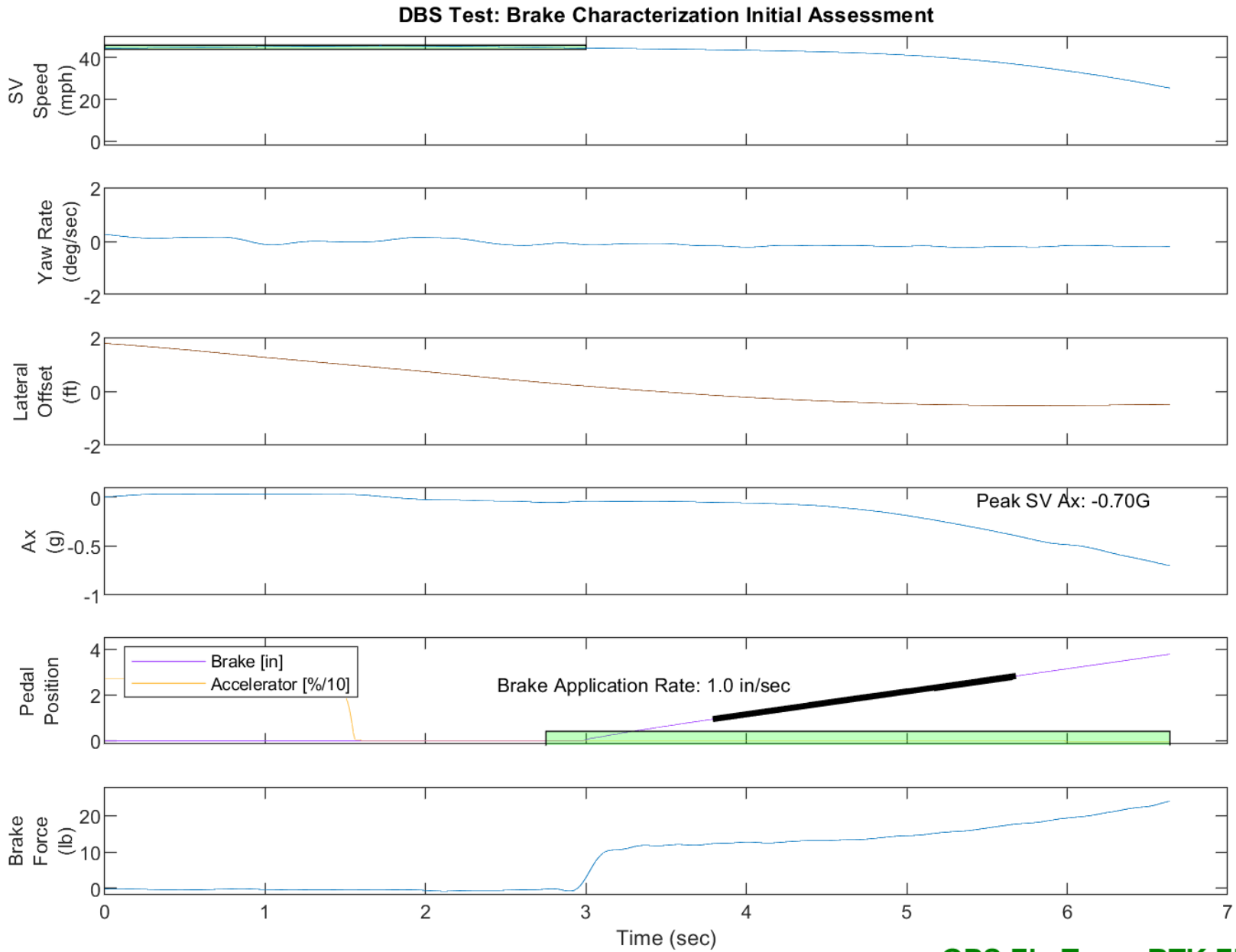


Figure E7. Example Time History for False Positive Steel Plate 25, Passing



**GPS Fix Type: RTK Fixed**

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



**GPS Fix Type: RTK Fixed**

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

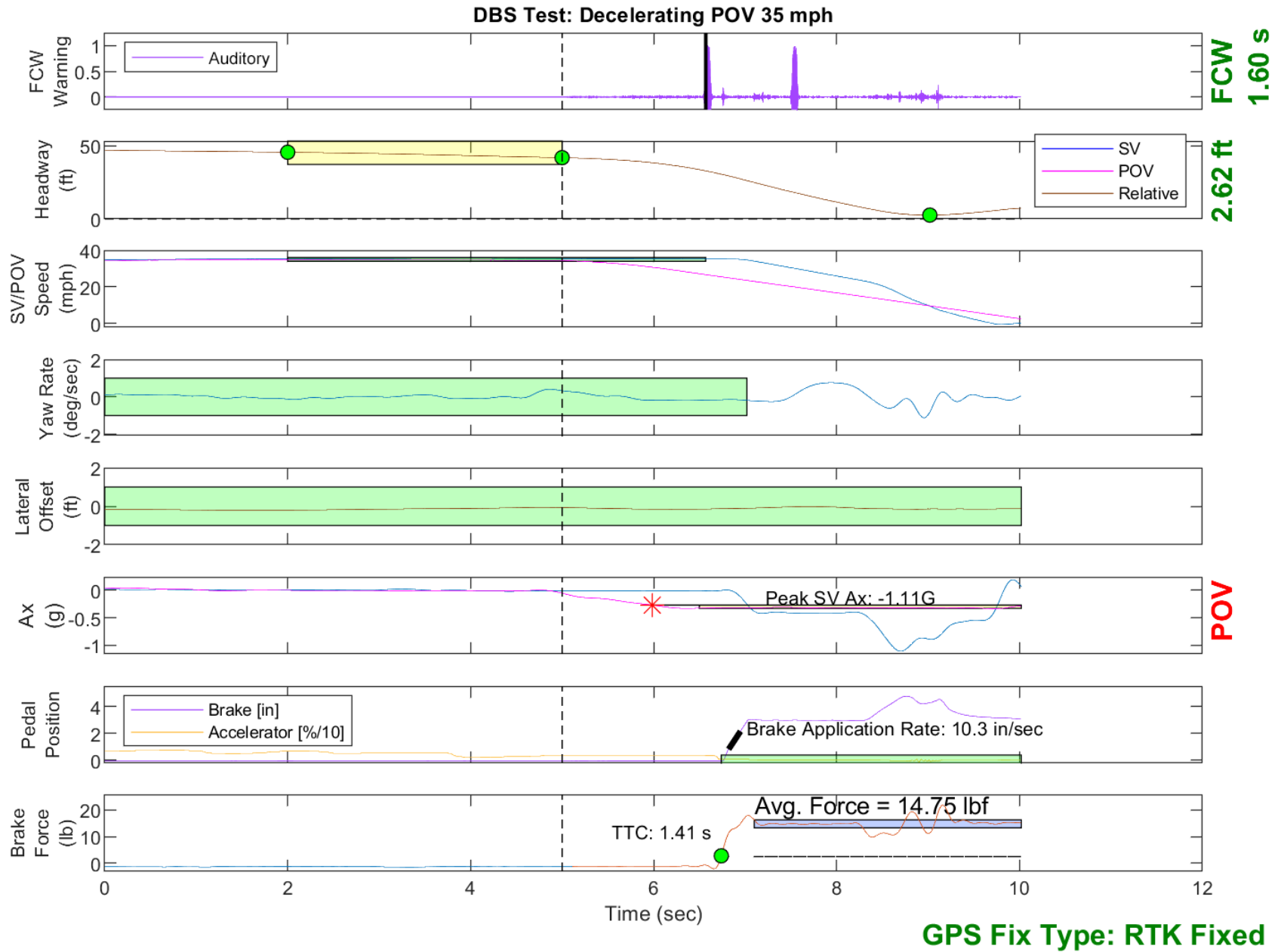
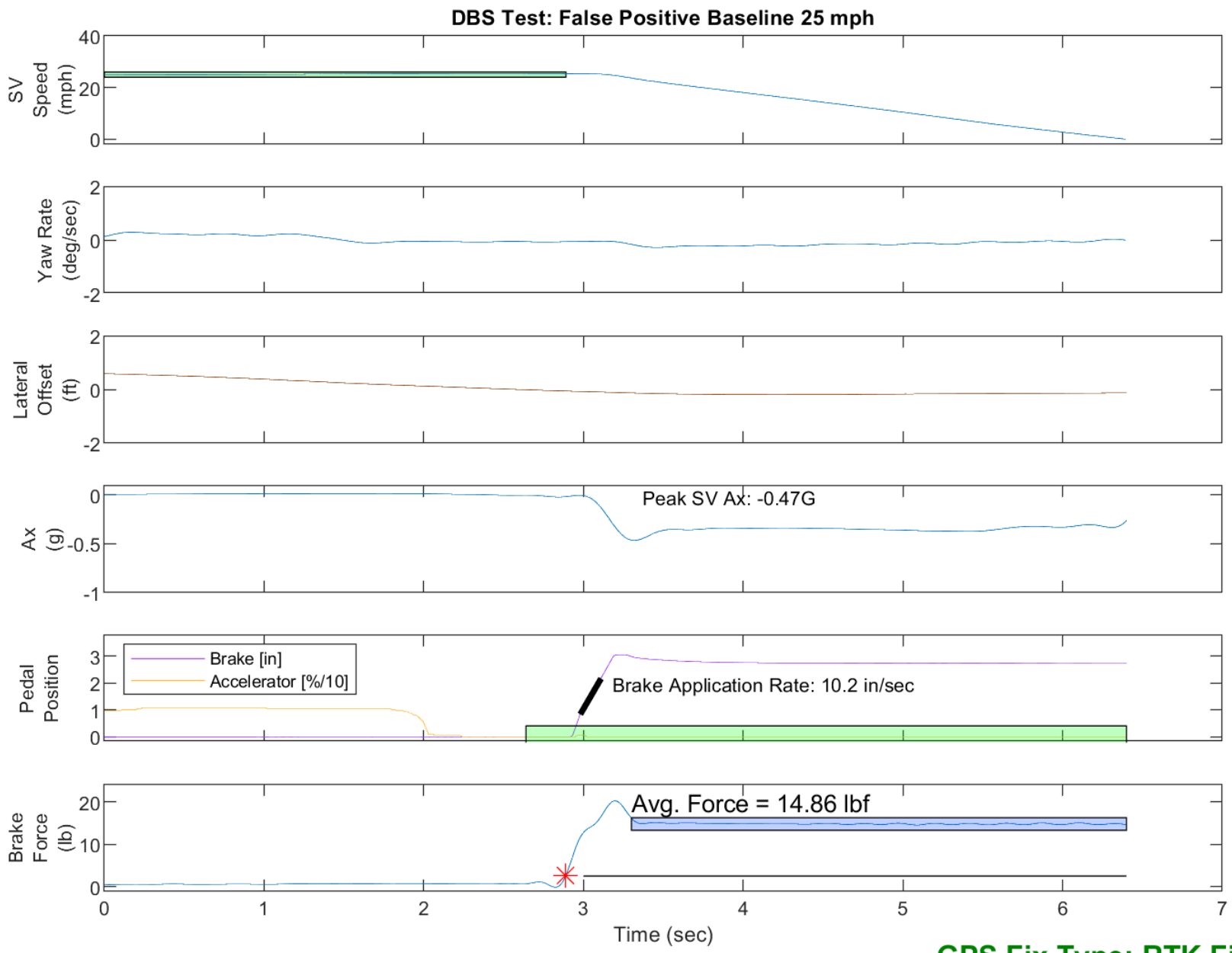


Figure E10. Example Time History Displaying Invalid POV Acceleration Criteria





GPS Fix Type: RTK Fixed

Figure E11. Example Time History Displaying Invalid Brake Force Criteria

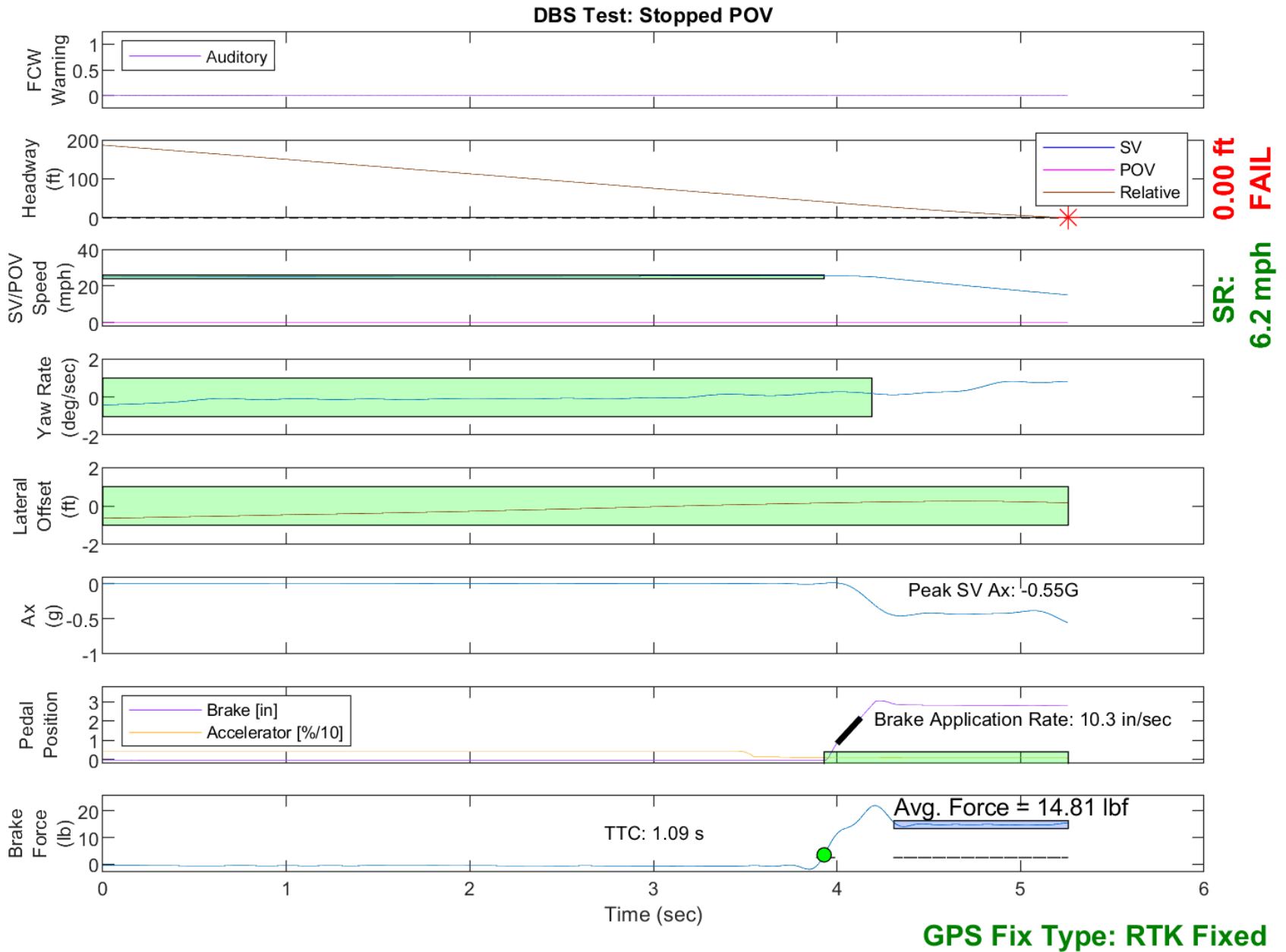


Figure E12. Example Time History for a Failed Run

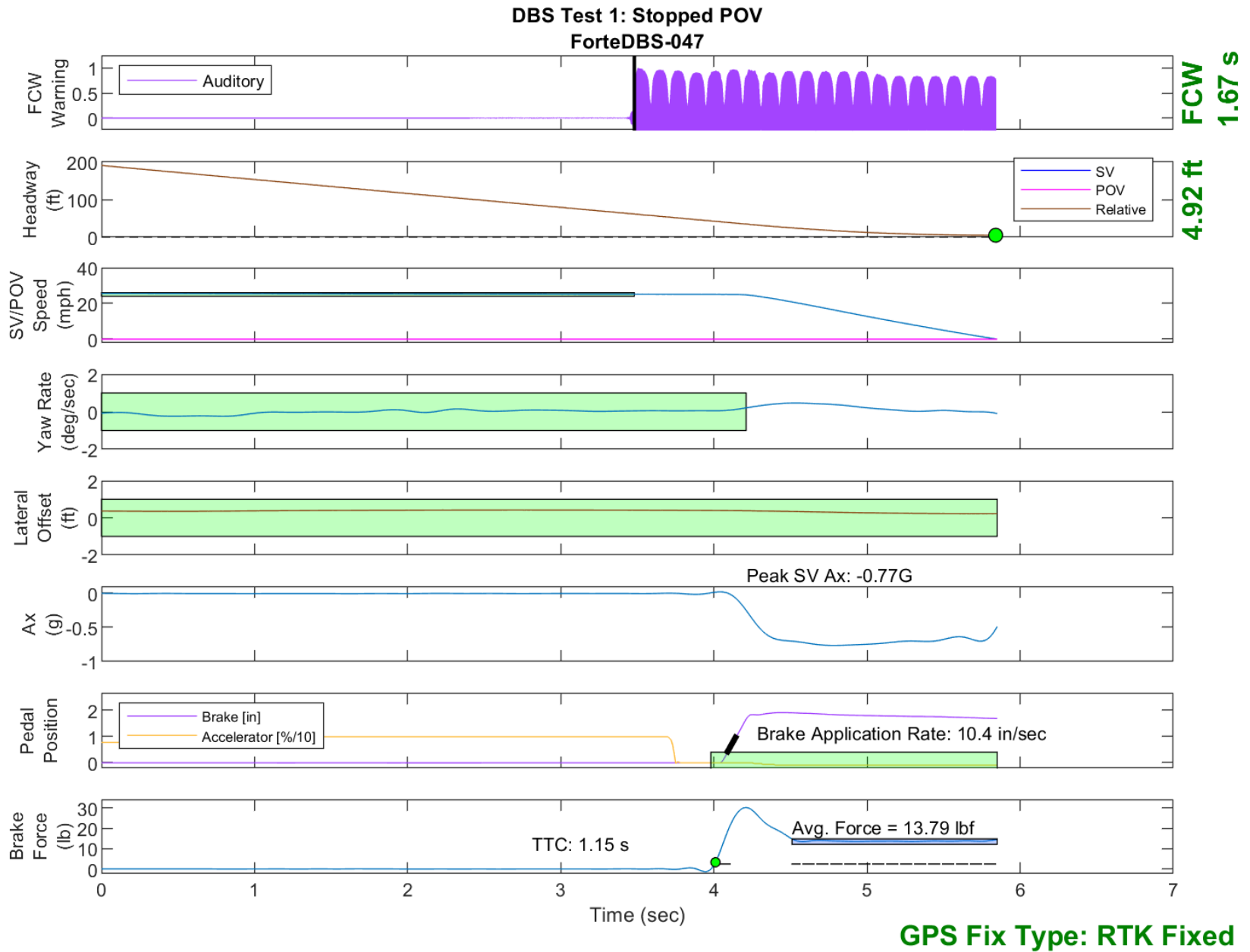


Figure E13. Time History for DBS Run 47, Test 1 - Stopped POV

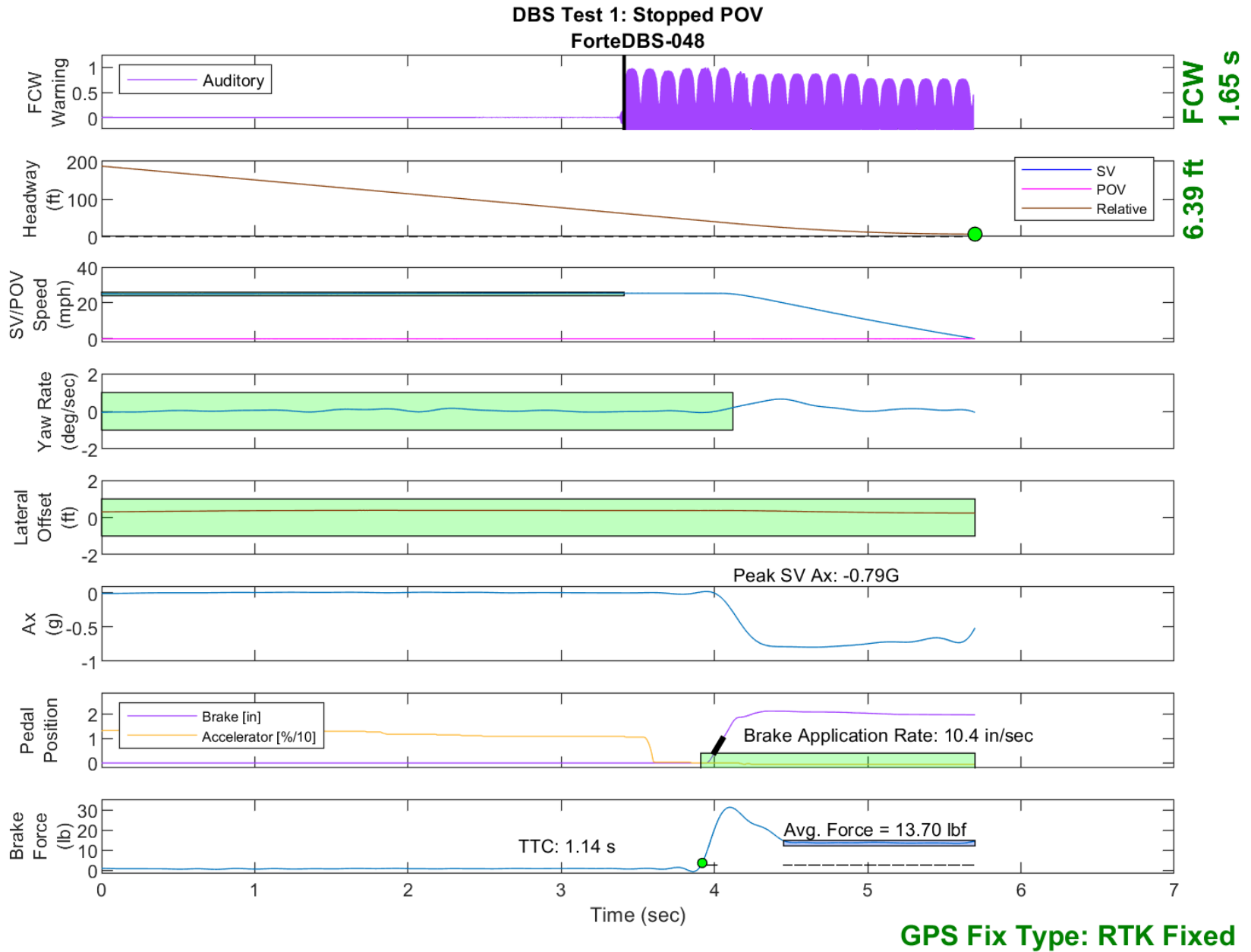


Figure E14. Time History for DBS Run 48, Test 1 - Stopped POV

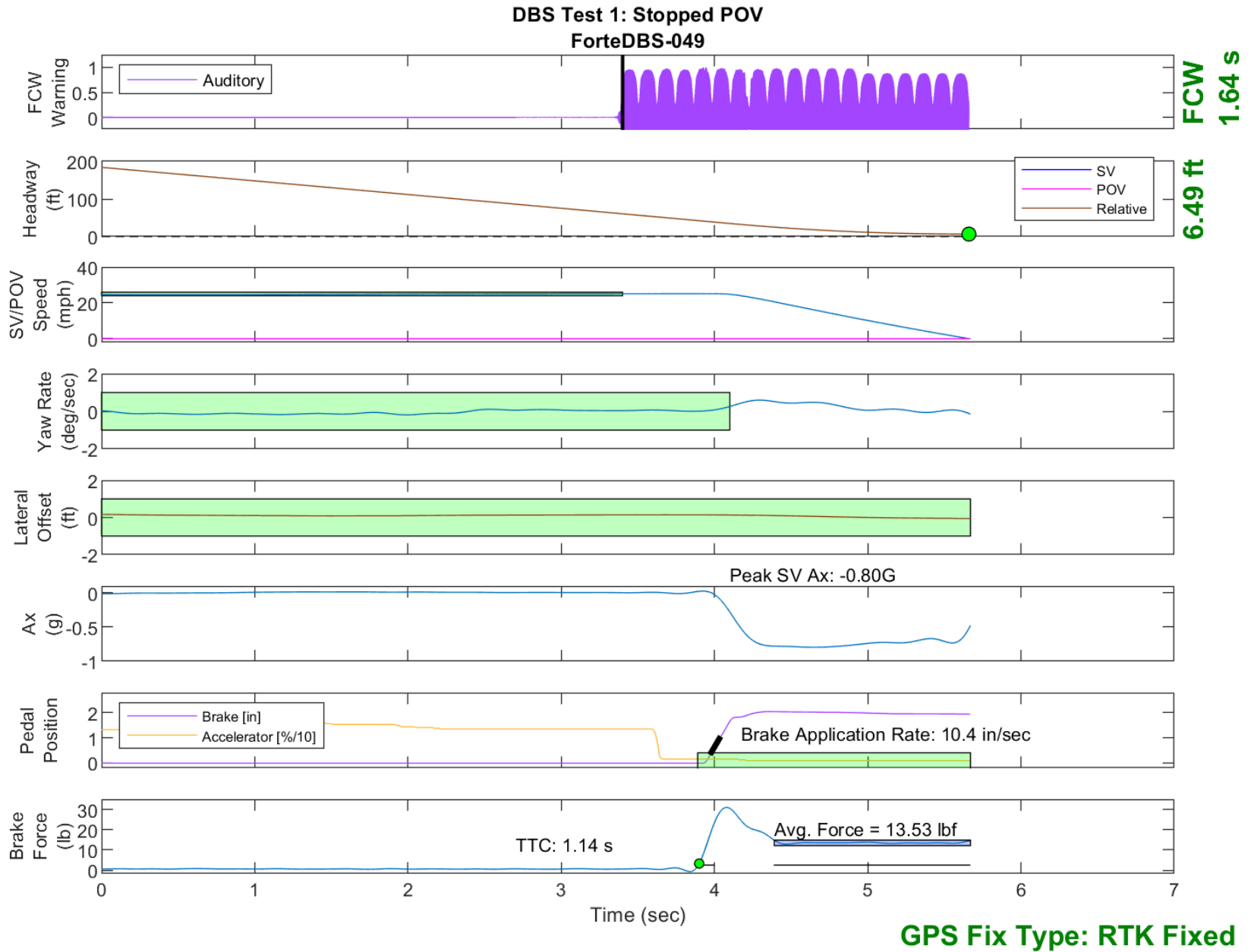


Figure E15. Time History for DBS Run 49, Test 1 - Stopped POV

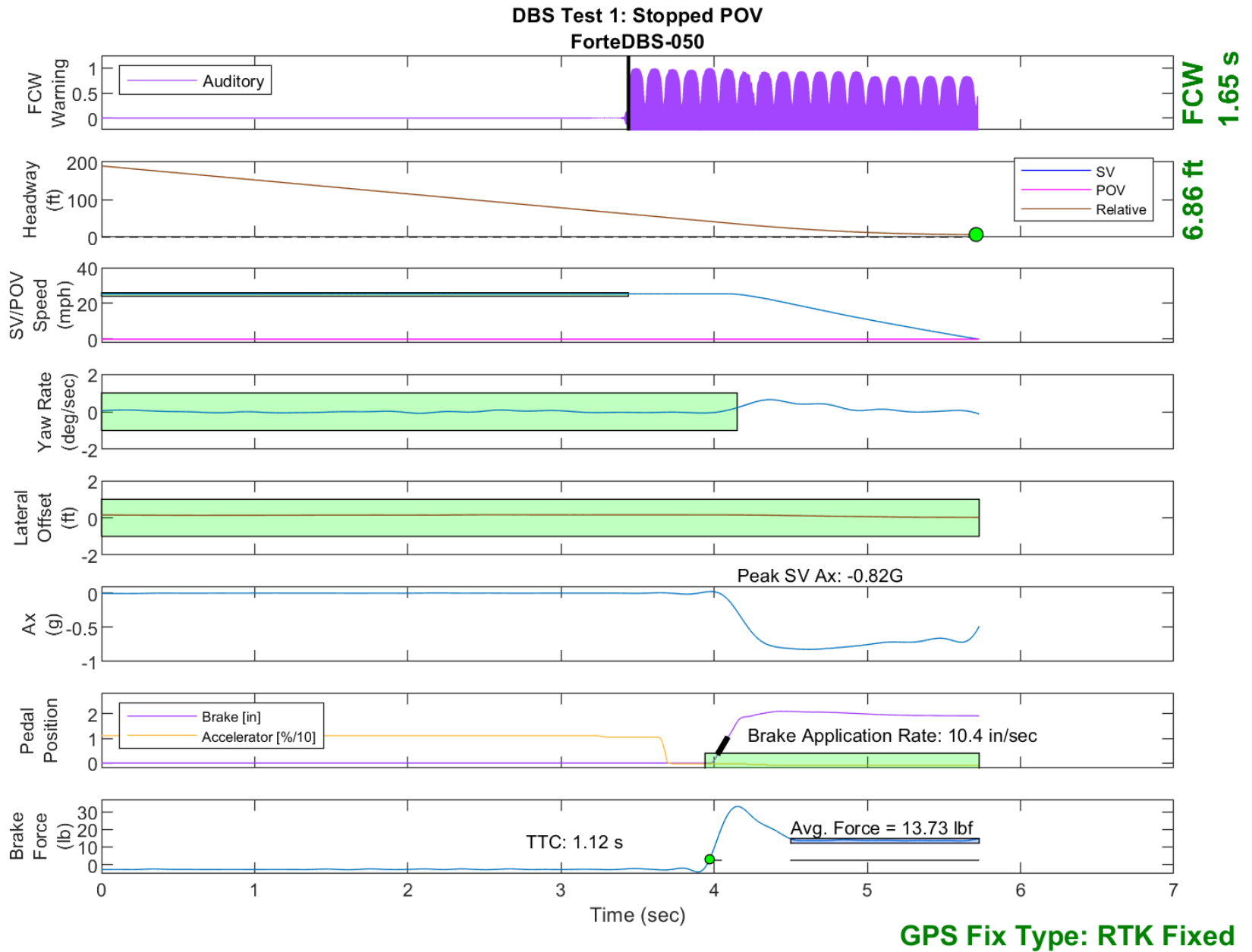


Figure E16. Time History for DBS Run 50, Test 1 - Stopped POV

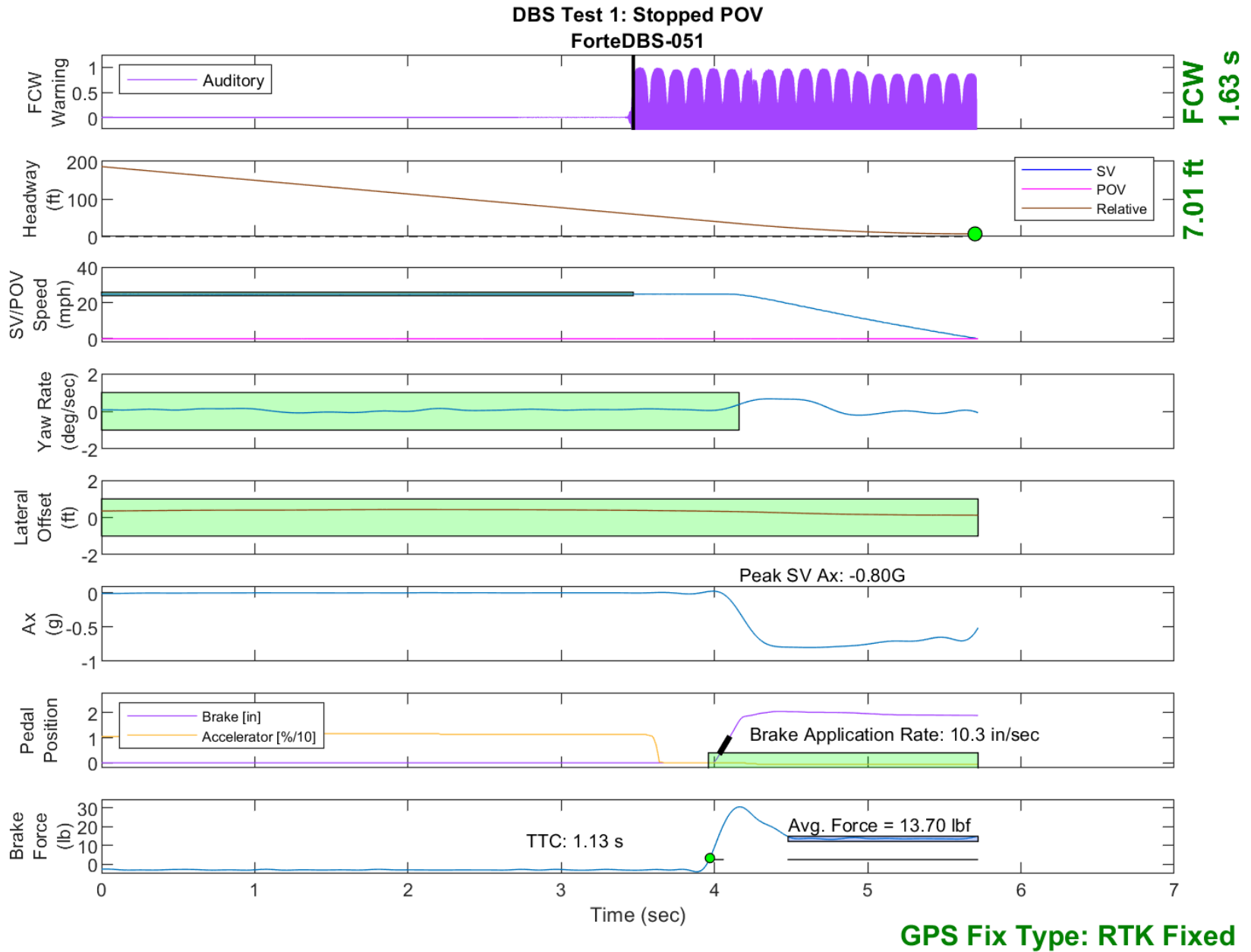


Figure E17. Time History for DBS Run 51, Test 1 - Stopped POV

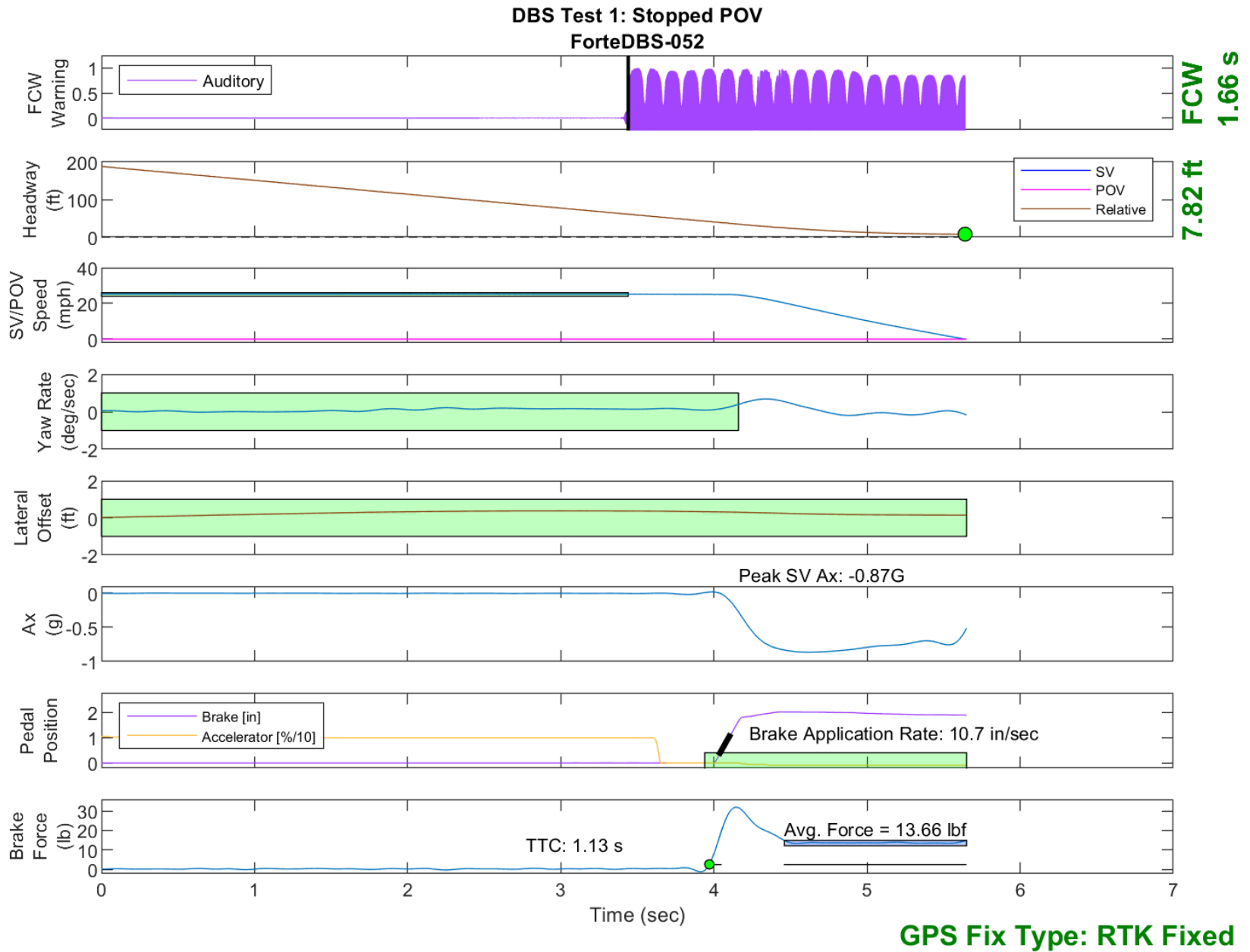


Figure E18. Time History for DBS Run 52, Test 1 - Stopped POV



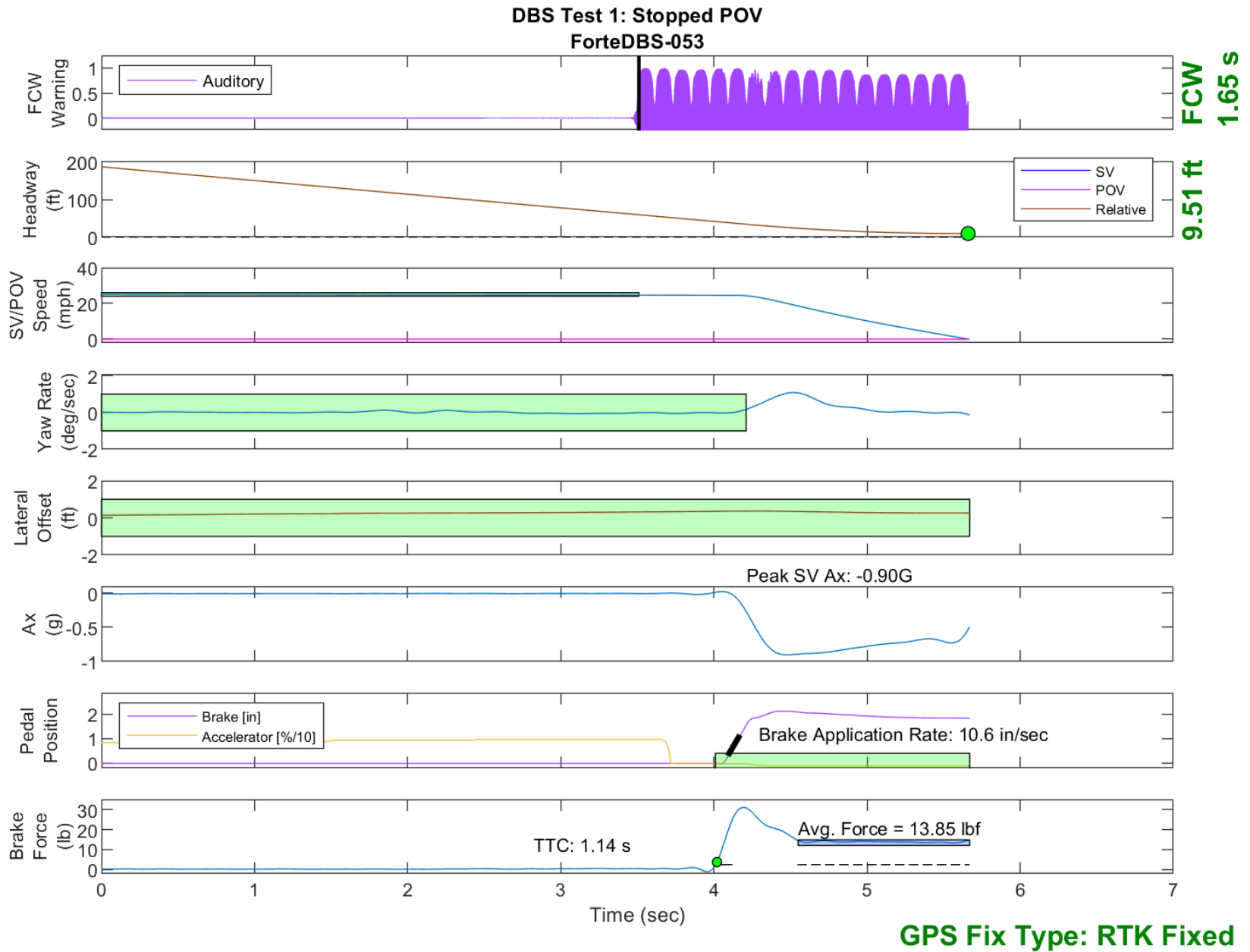


Figure E19. Time History for DBS Run 53, Test 1 - Stopped POV

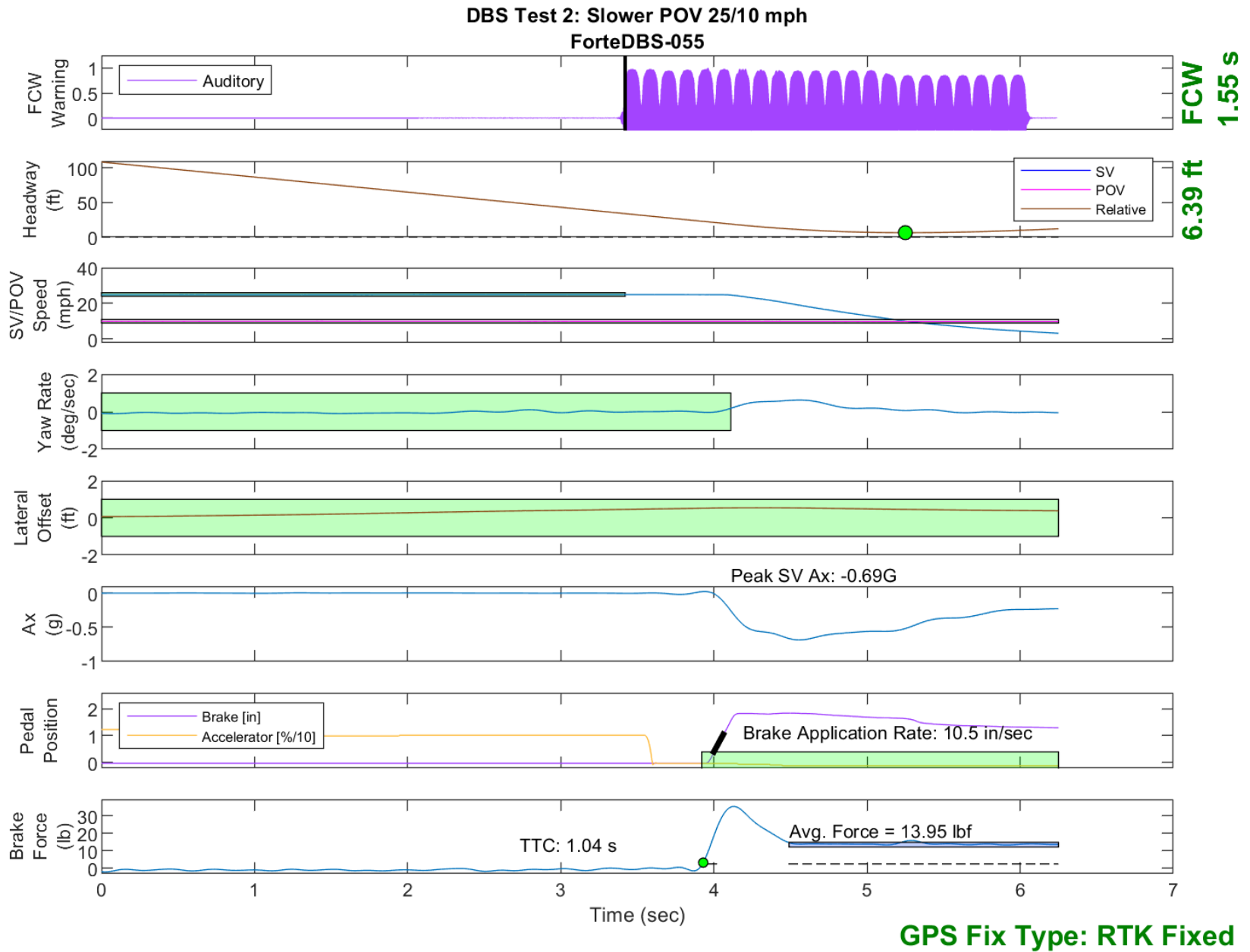


Figure E20. Time History for DBS Run 55, Test 2 - Slower Moving POV 25/10 mph

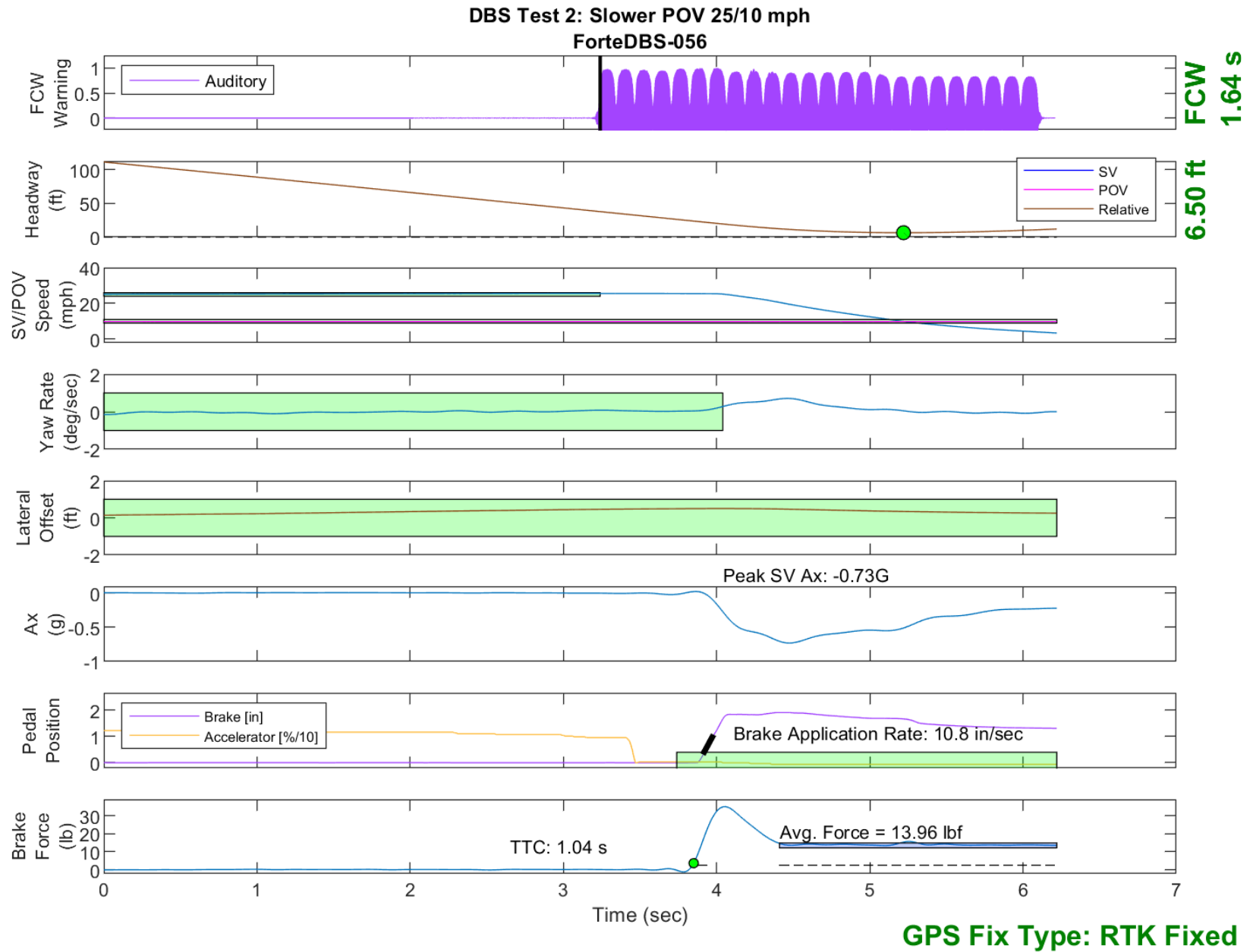


Figure E21. Time History for DBS Run 56, Test 2 - Slower Moving POV 25/10 mph

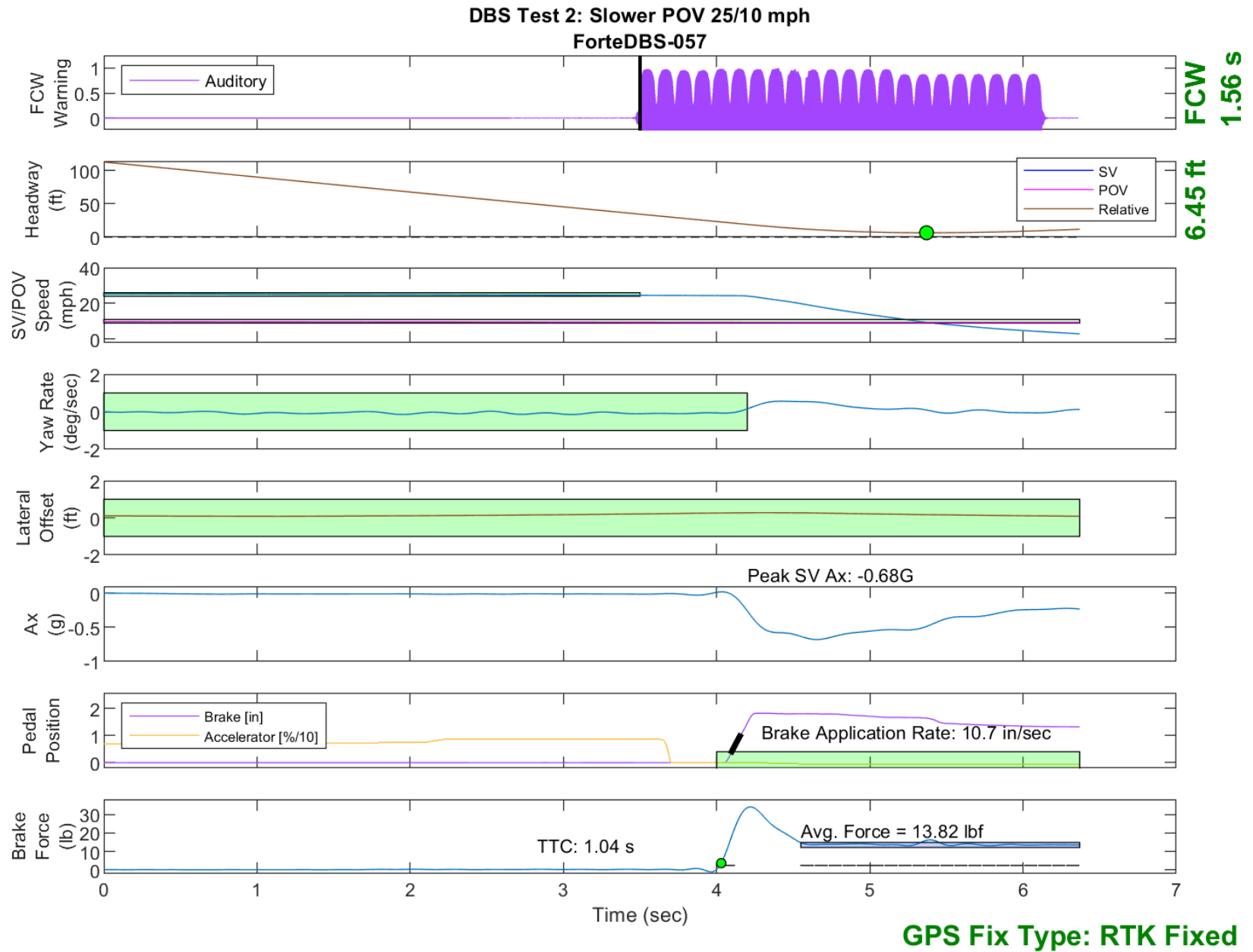


Figure E22. Time History for DBS Run 57, Test 2 - Slower Moving POV 25/10 mph

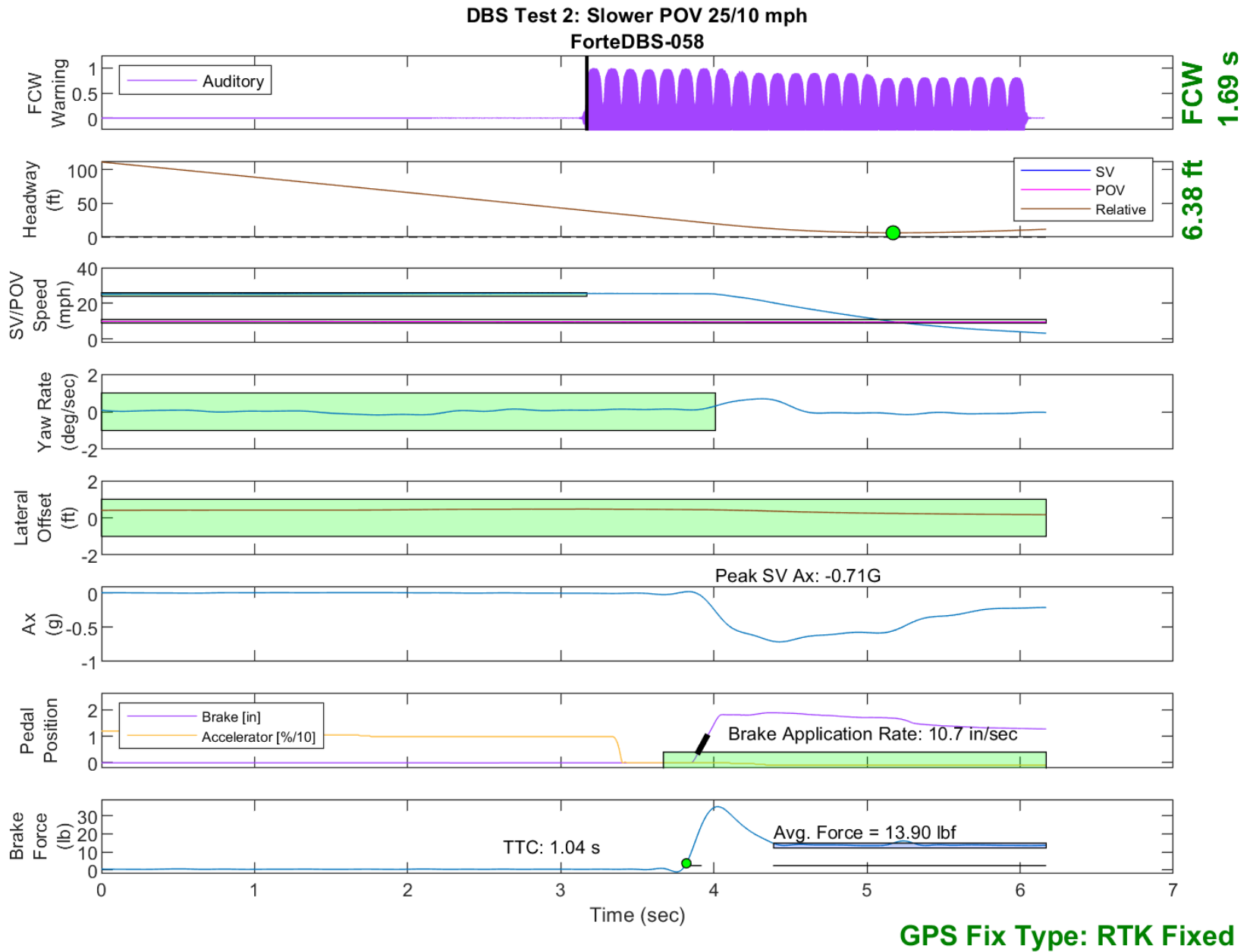


Figure E23. Time History for DBS Run 58, Test 2 - Slower Moving POV 25/10 mph

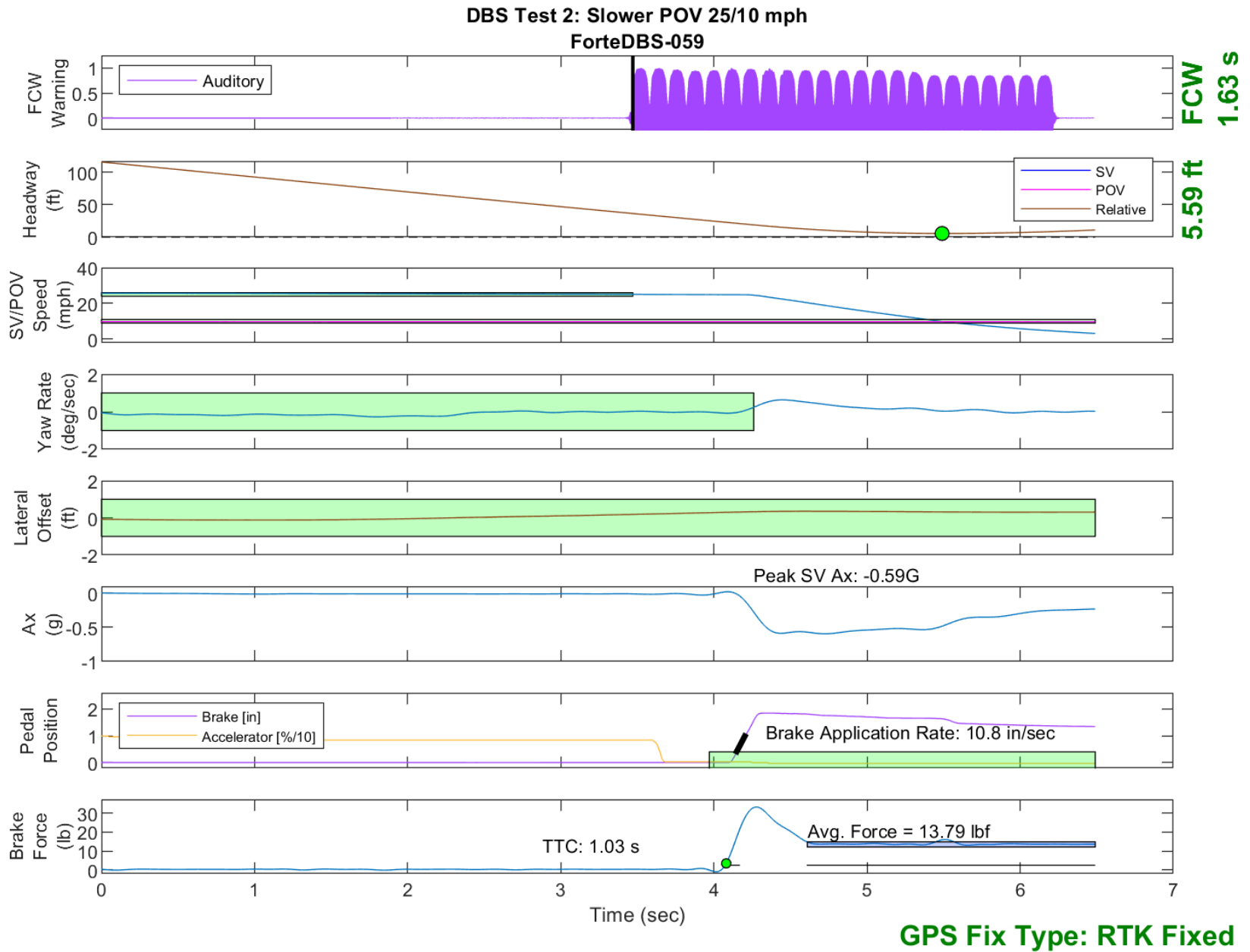


Figure E24. Time History for DBS Run 59, Test 2 - Slower Moving POV 25/10 mph

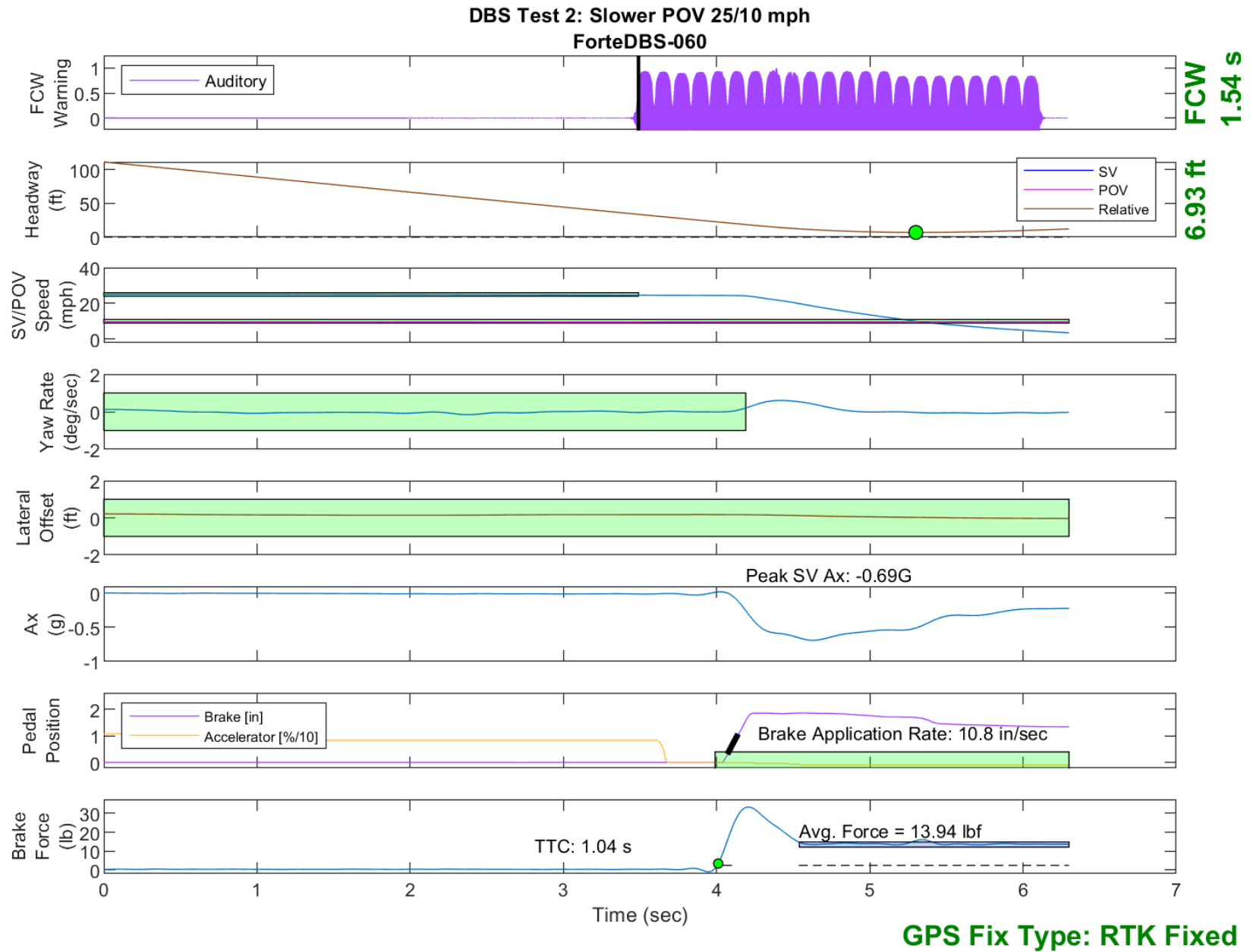


Figure E25. Time History for DBS Run 60, Test 2 - Slower Moving POV 25/10 mph

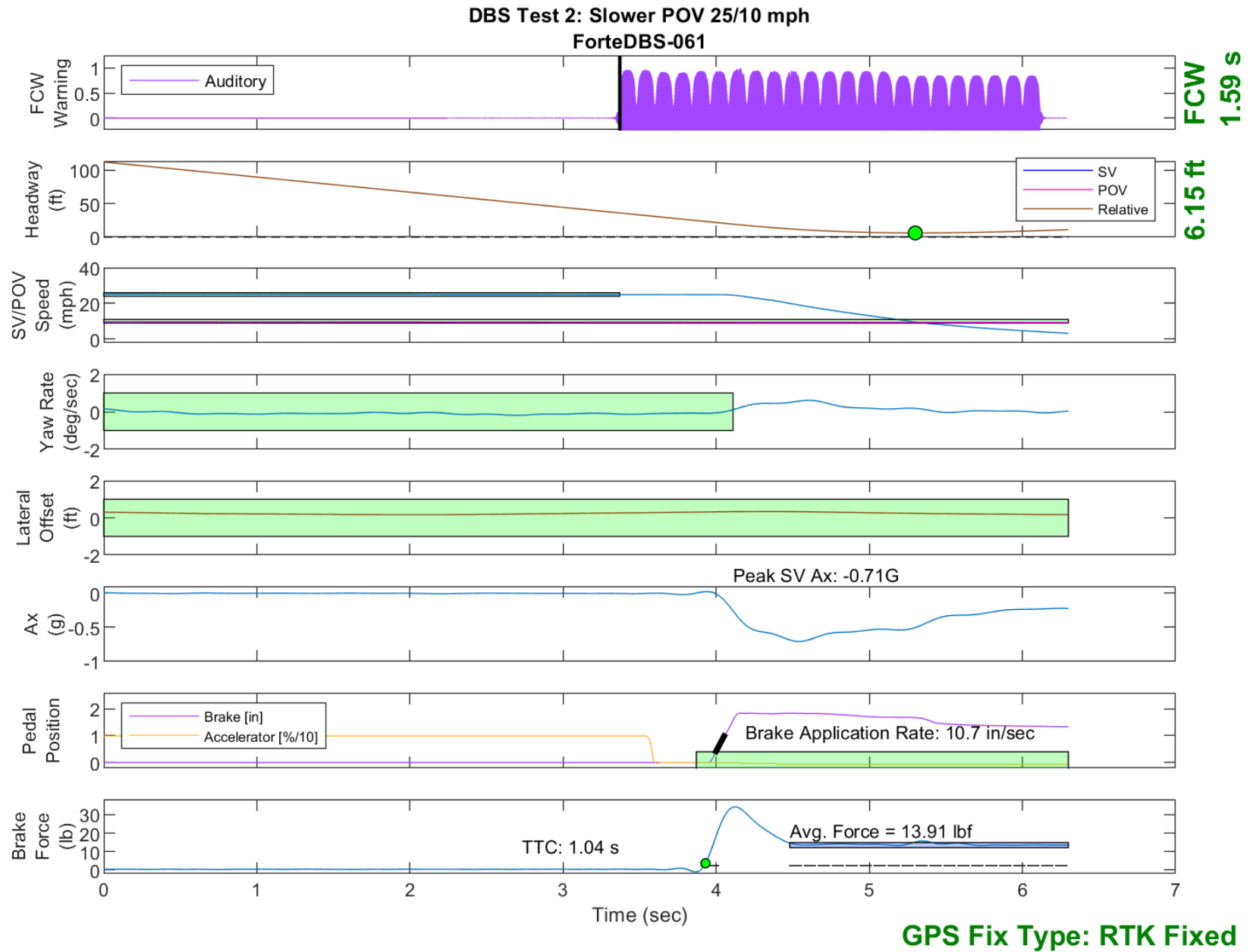


Figure E26. Time History for DBS Run 61, Test 2 - Slower Moving POV 25/10 mph



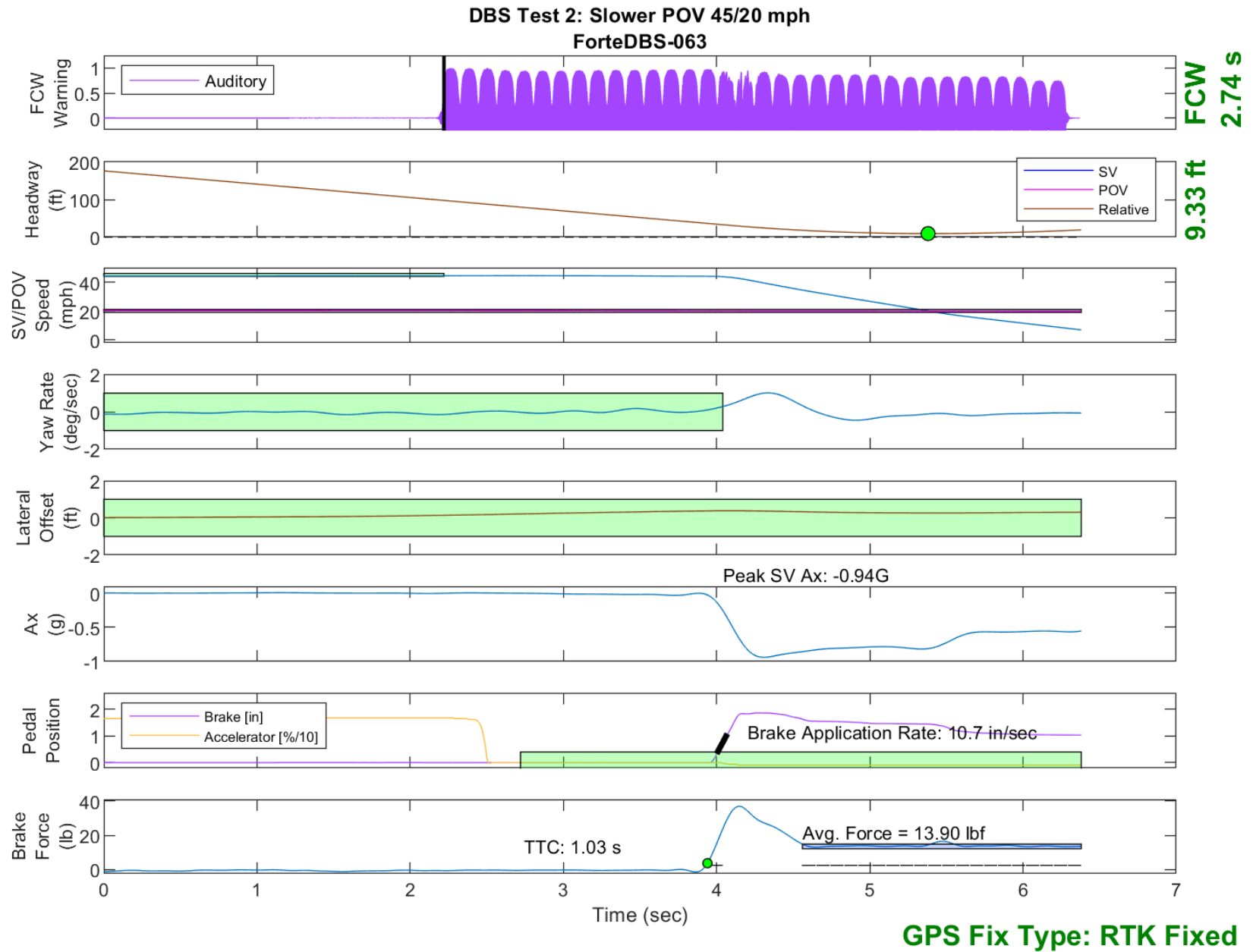


Figure E27. Time History for DBS Run 63, Test 2 - Slower Moving POV 45/20 mph

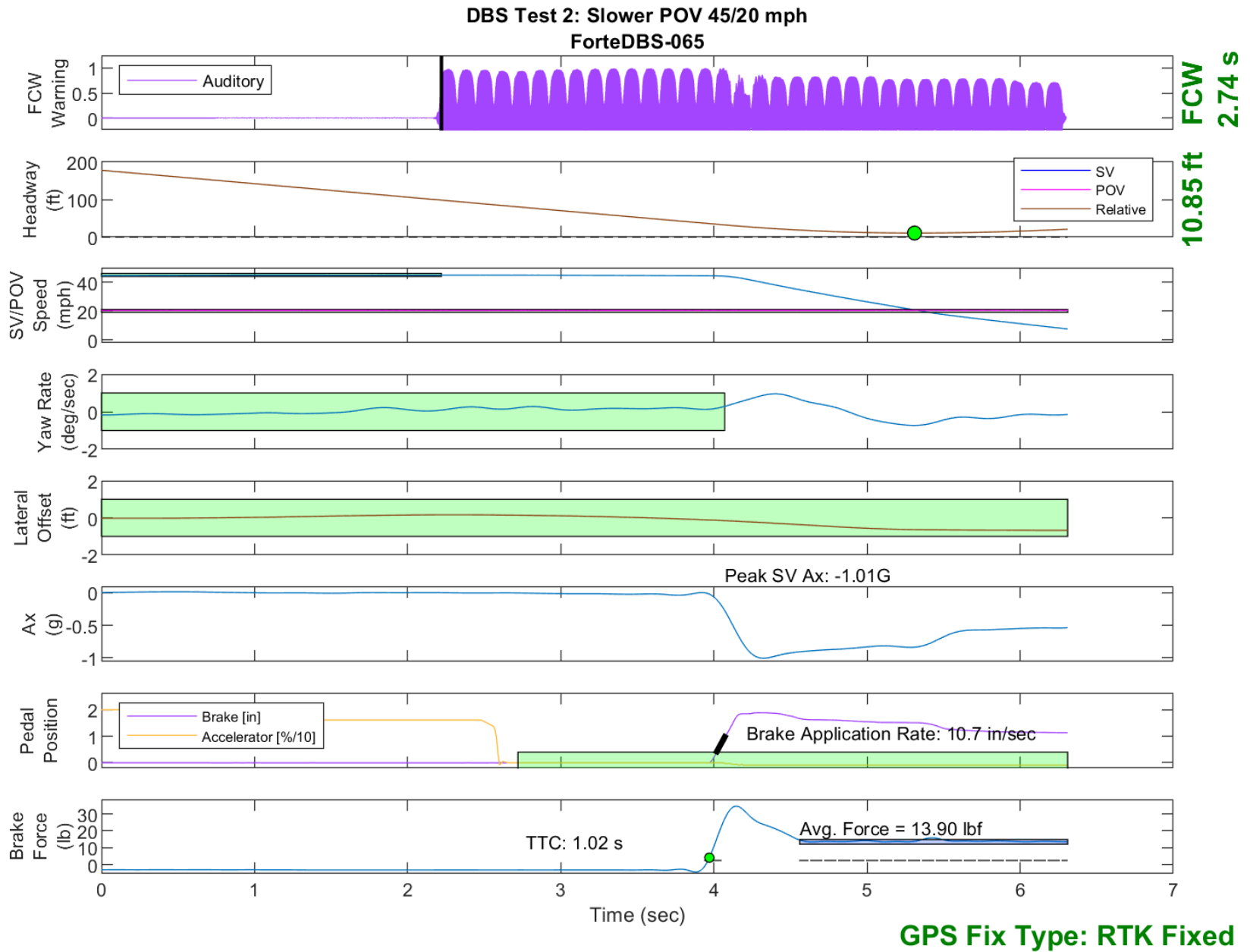


Figure E28. Time History for DBS Run 65, Test 2 - Slower Moving POV 45/20 mph

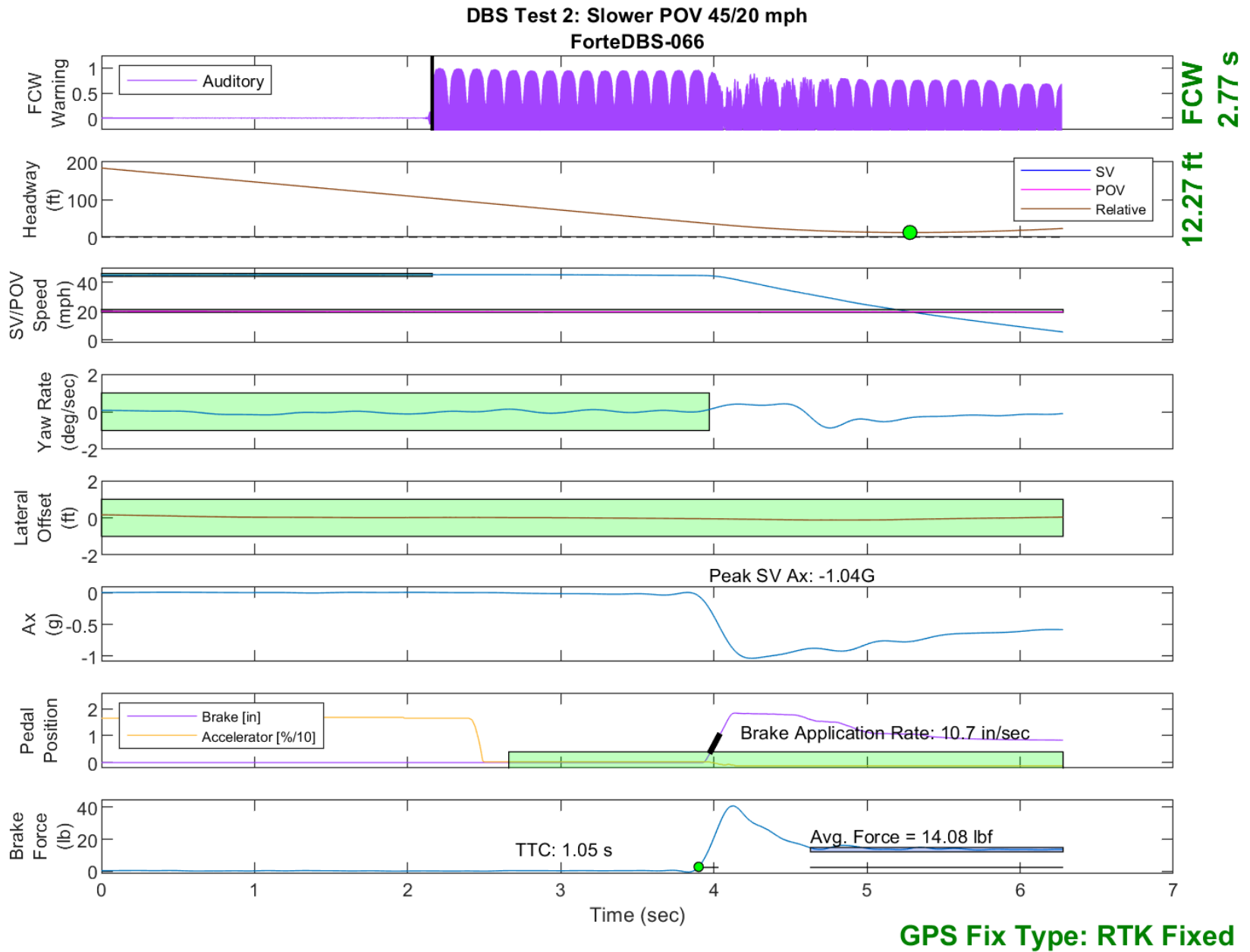


Figure E29. Time History for DBS Run 66, Test 2 - Slower Moving POV 45/20 mph

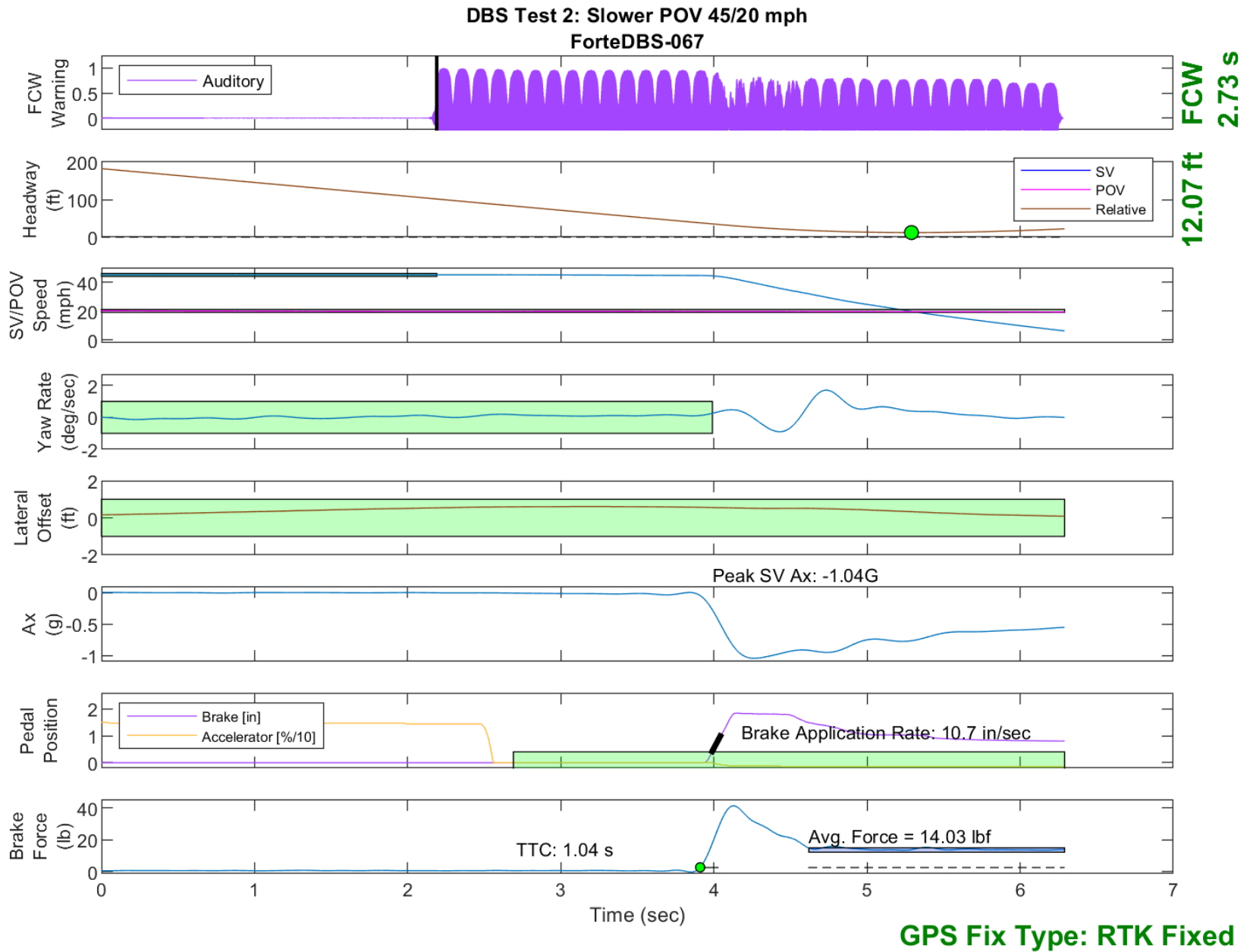


Figure E30. Time History for DBS Run 67, Test 2 - Slower Moving POV 45/20 mph

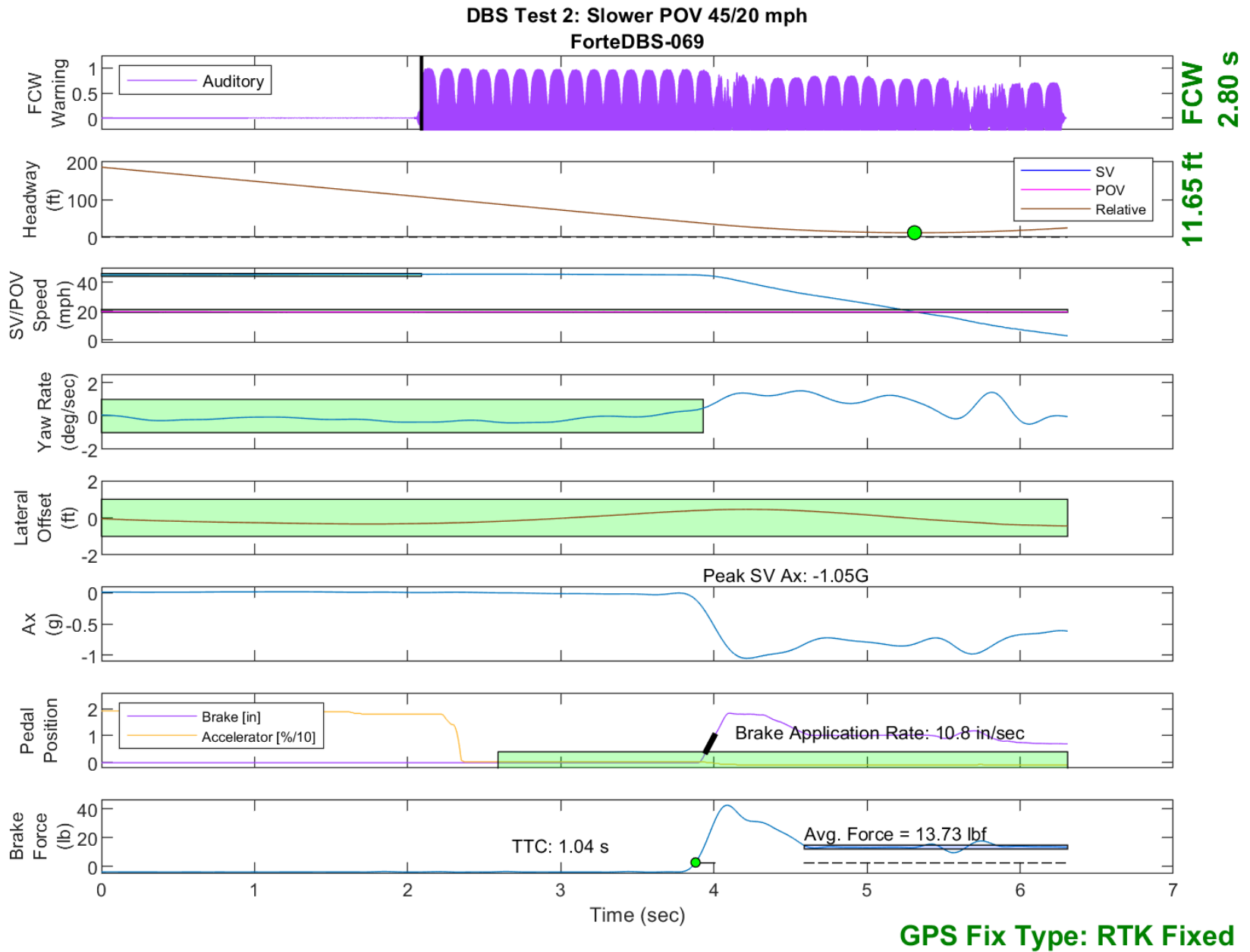


Figure E31. Time History for DBS Run 69, Test 2 - Slower Moving POV 45/20 mph

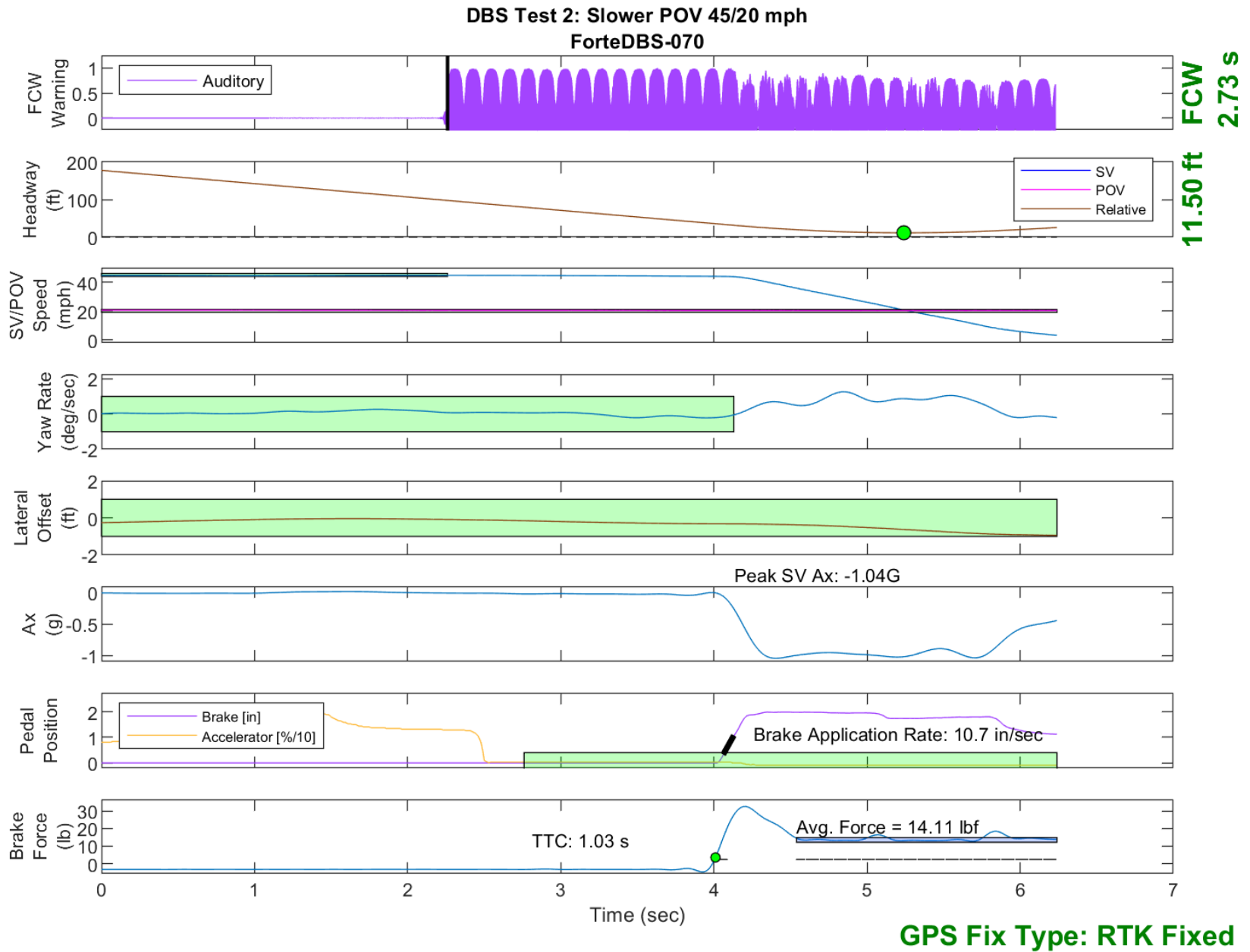


Figure E32. Time History for DBS Run 70, Test 2 - Slower Moving POV 45/20 mph

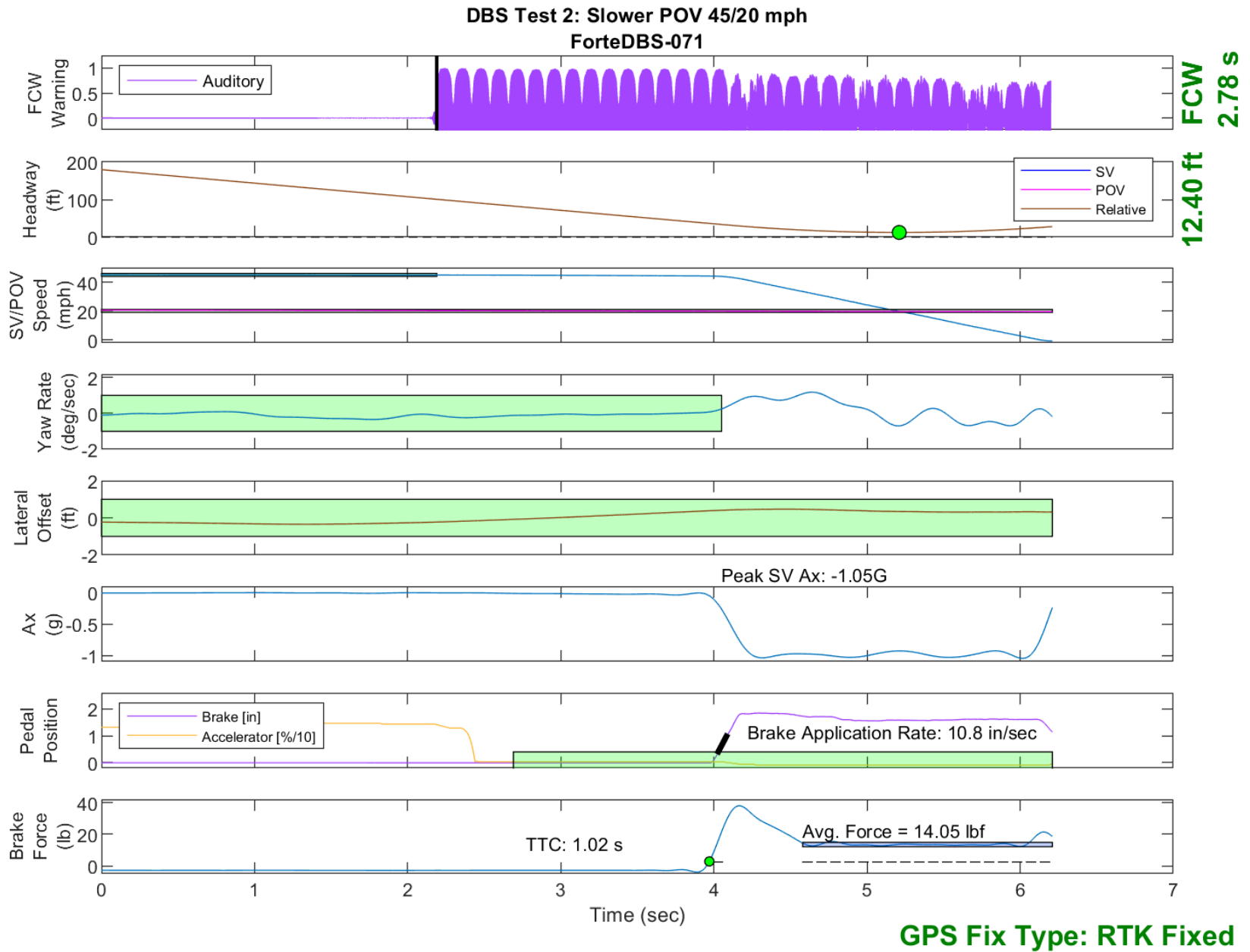


Figure E33. Time History for DBS Run 71, Test 2 - Slower Moving POV 45/20 mph

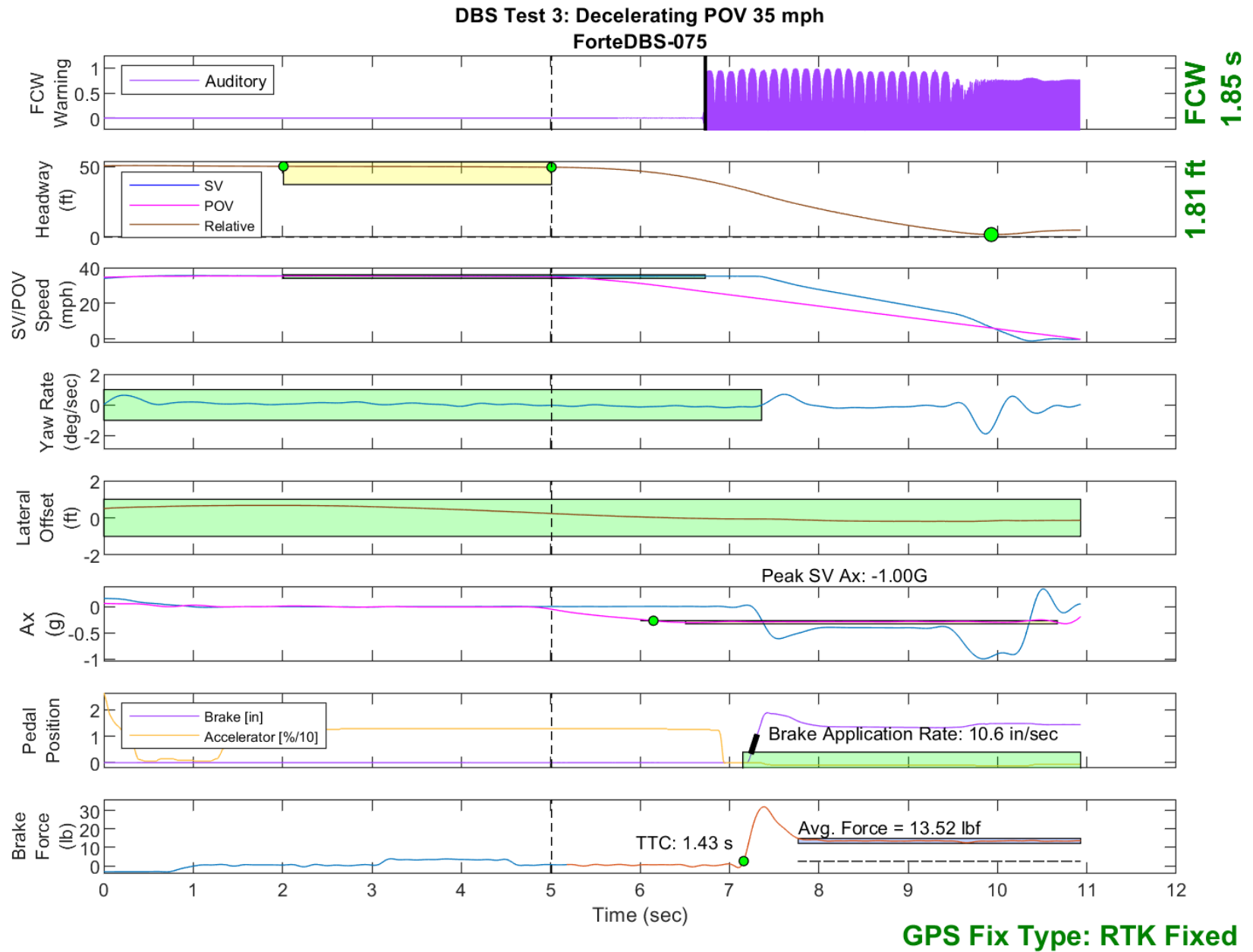


Figure E34. Time History for DBS Run 75, Test 3 - Decelerating POV 35 mph



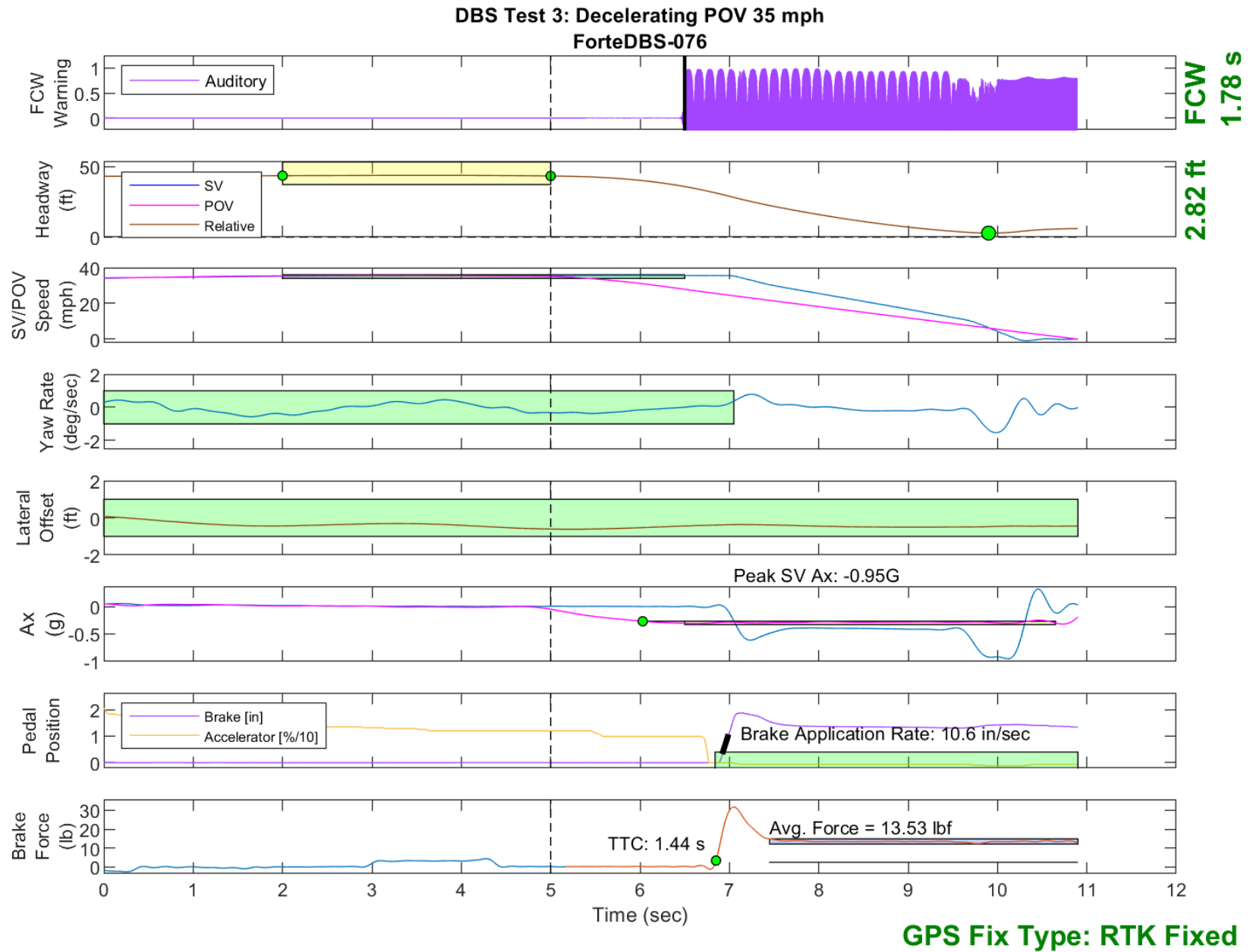


Figure E35. Time History for DBS Run 76, Test 3 - Decelerating POV 35 mph

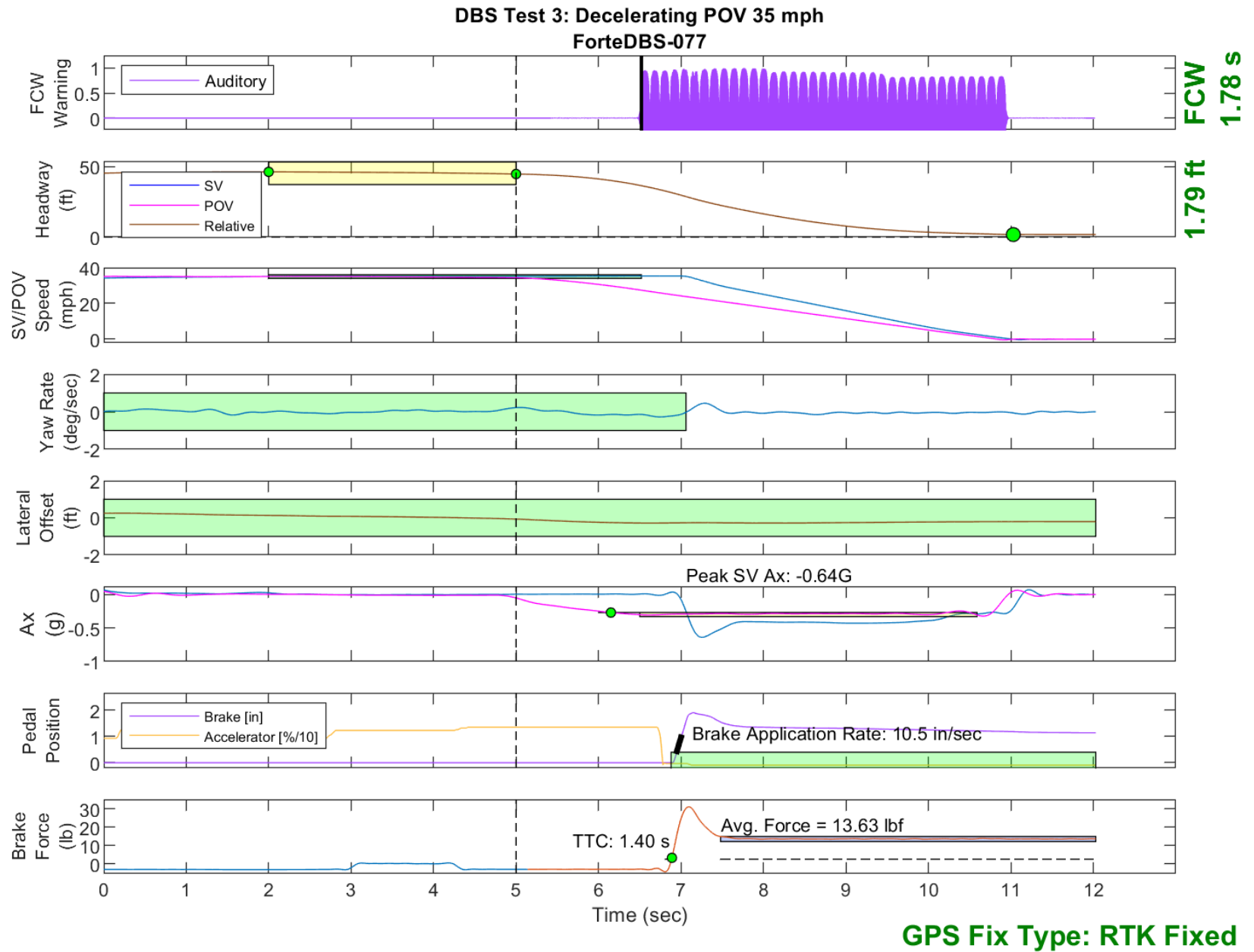


Figure E36. Time History for DBS Run 77, Test 3 - Decelerating POV 35 mph

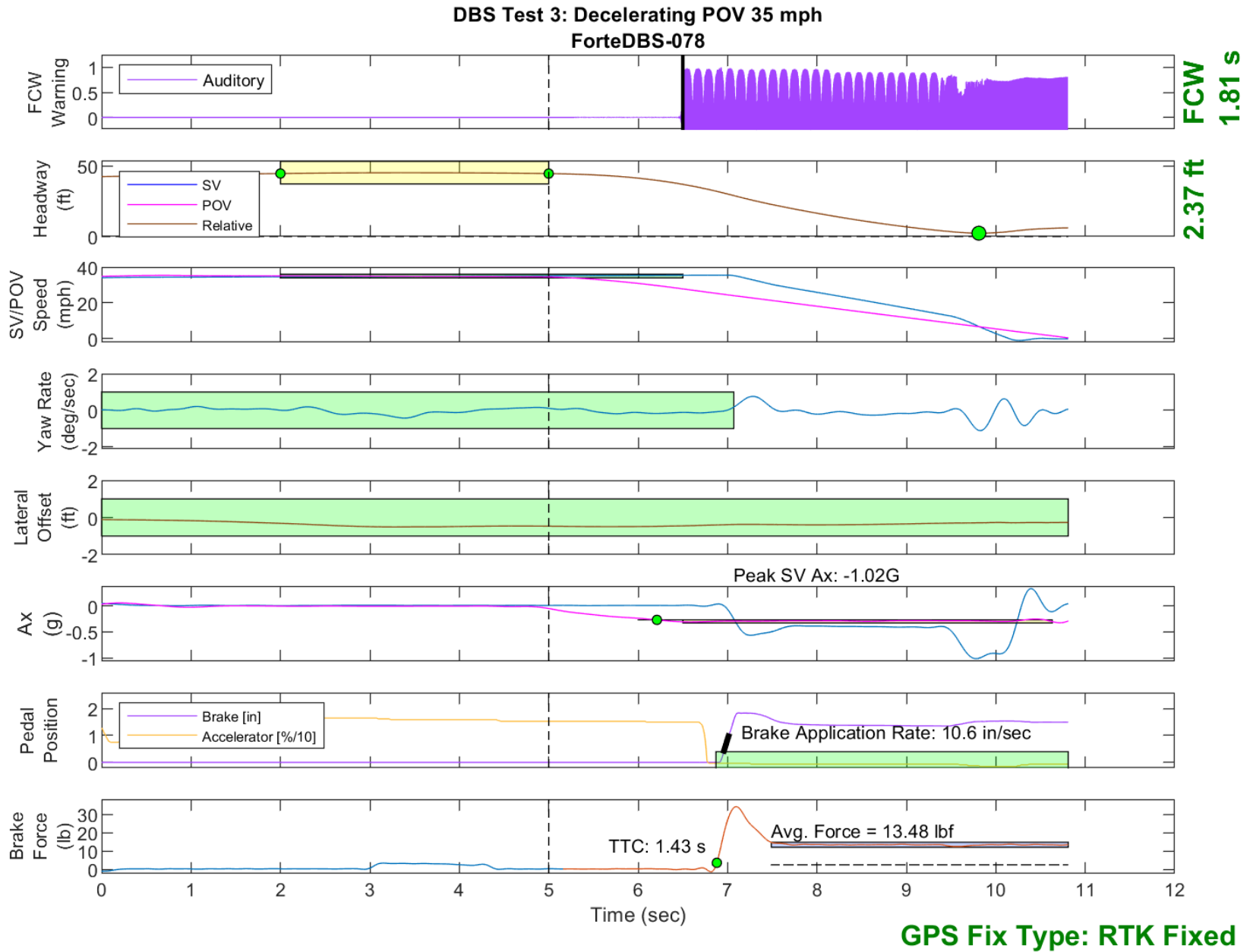


Figure E37. Time History for DBS Run 78, Test 3 - Decelerating POV 35 mph

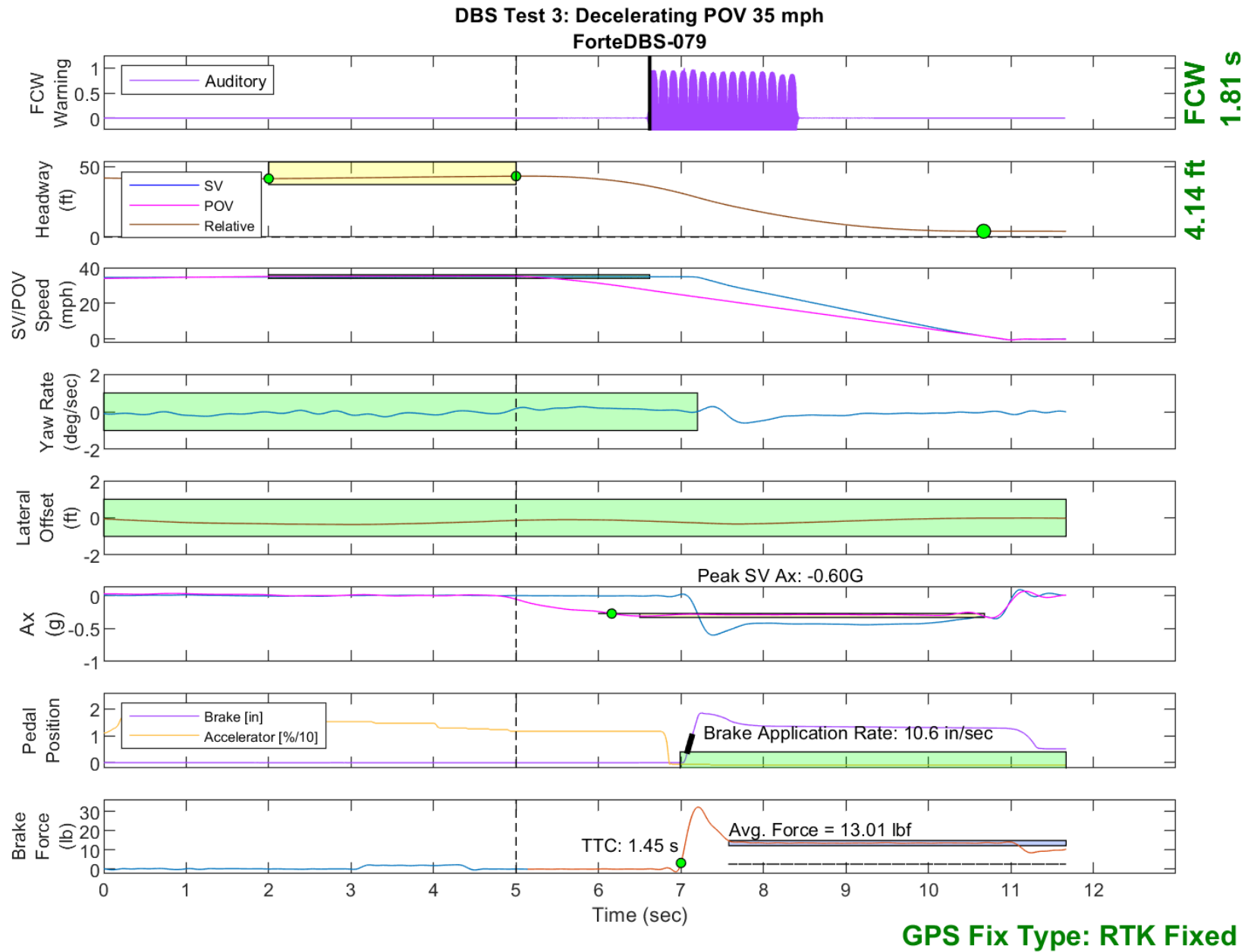


Figure E38. Time History for DBS Run 79, Test 3 - Decelerating POV 35 mph

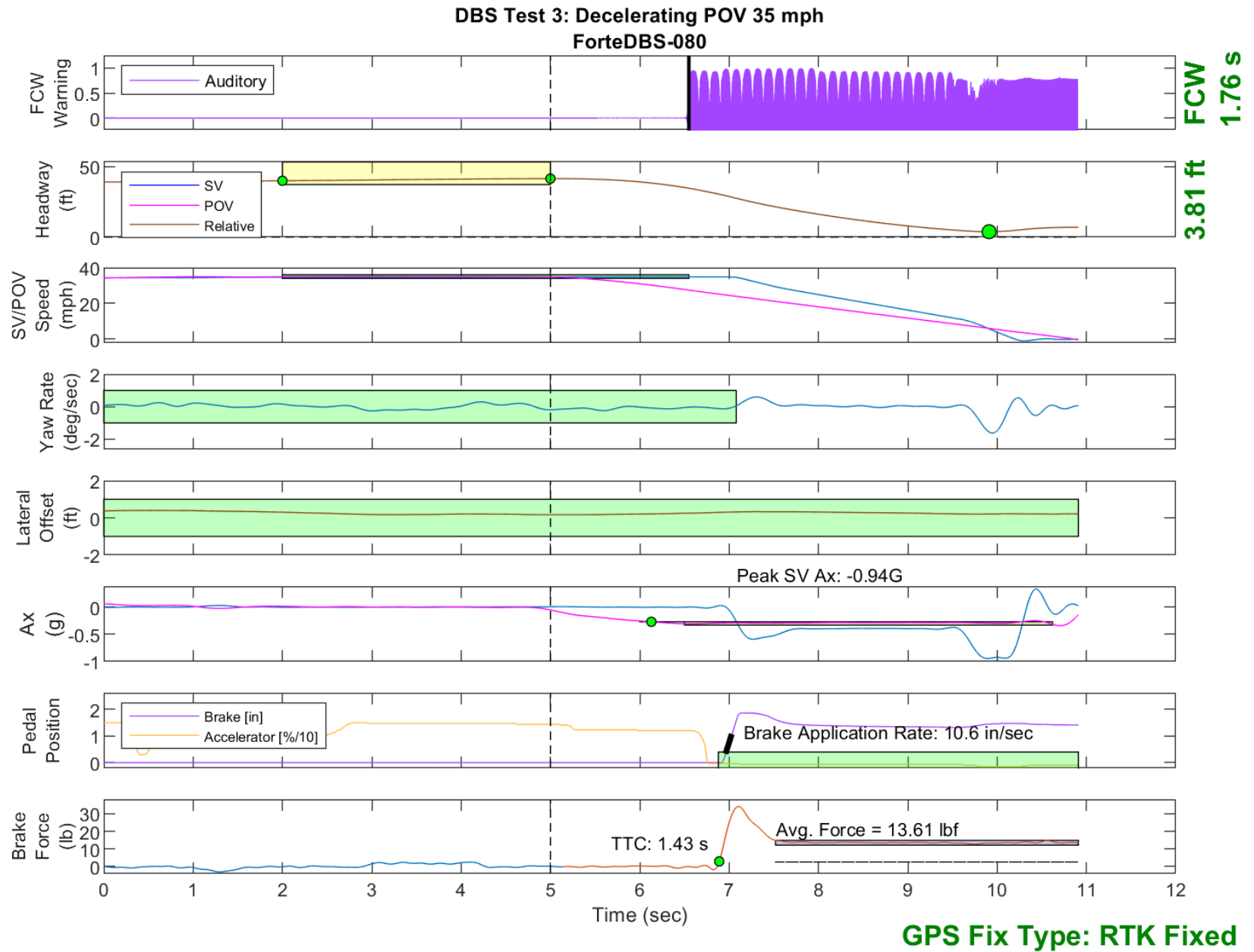


Figure E39. Time History for DBS Run 80, Test 3 - Decelerating POV 35 mph

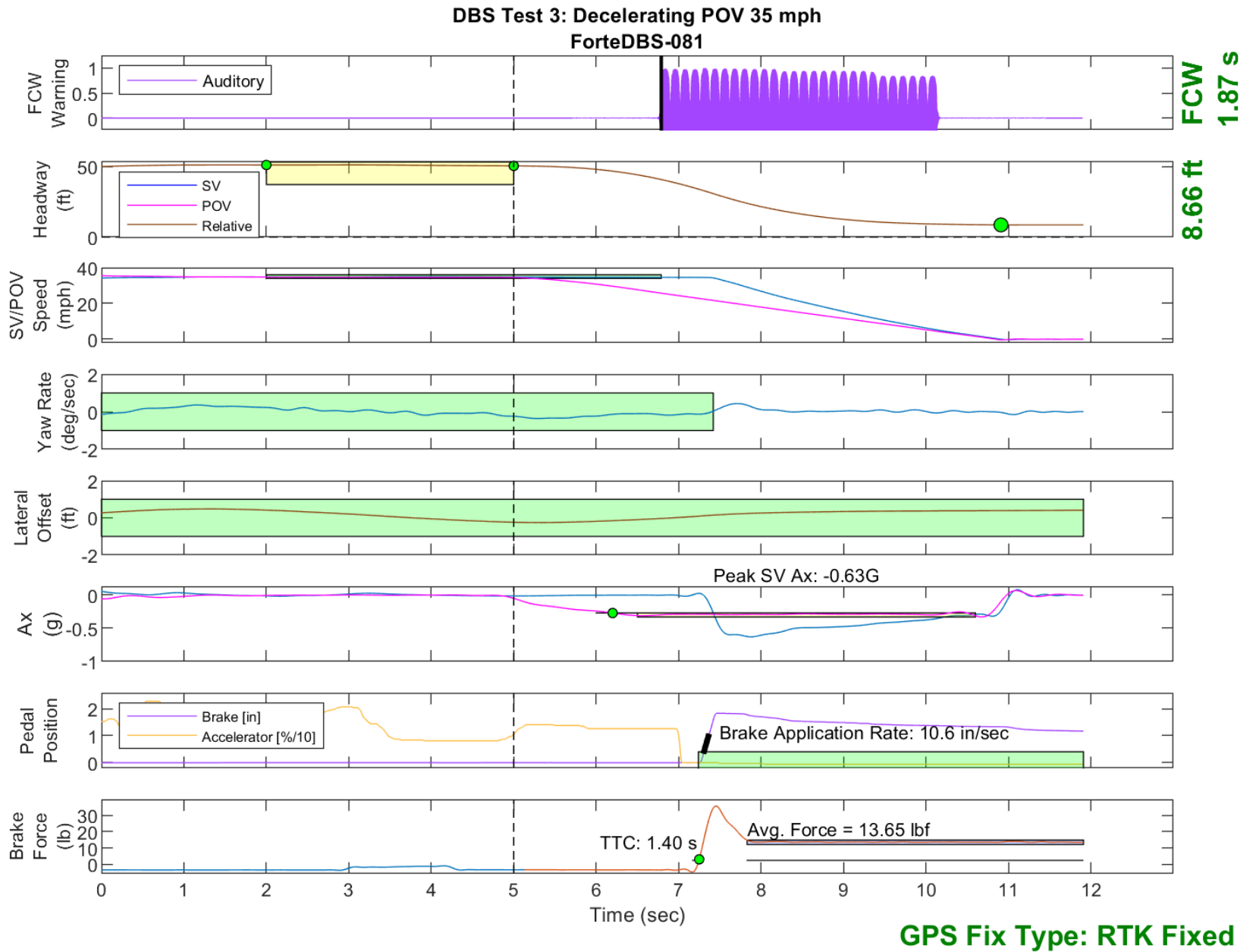
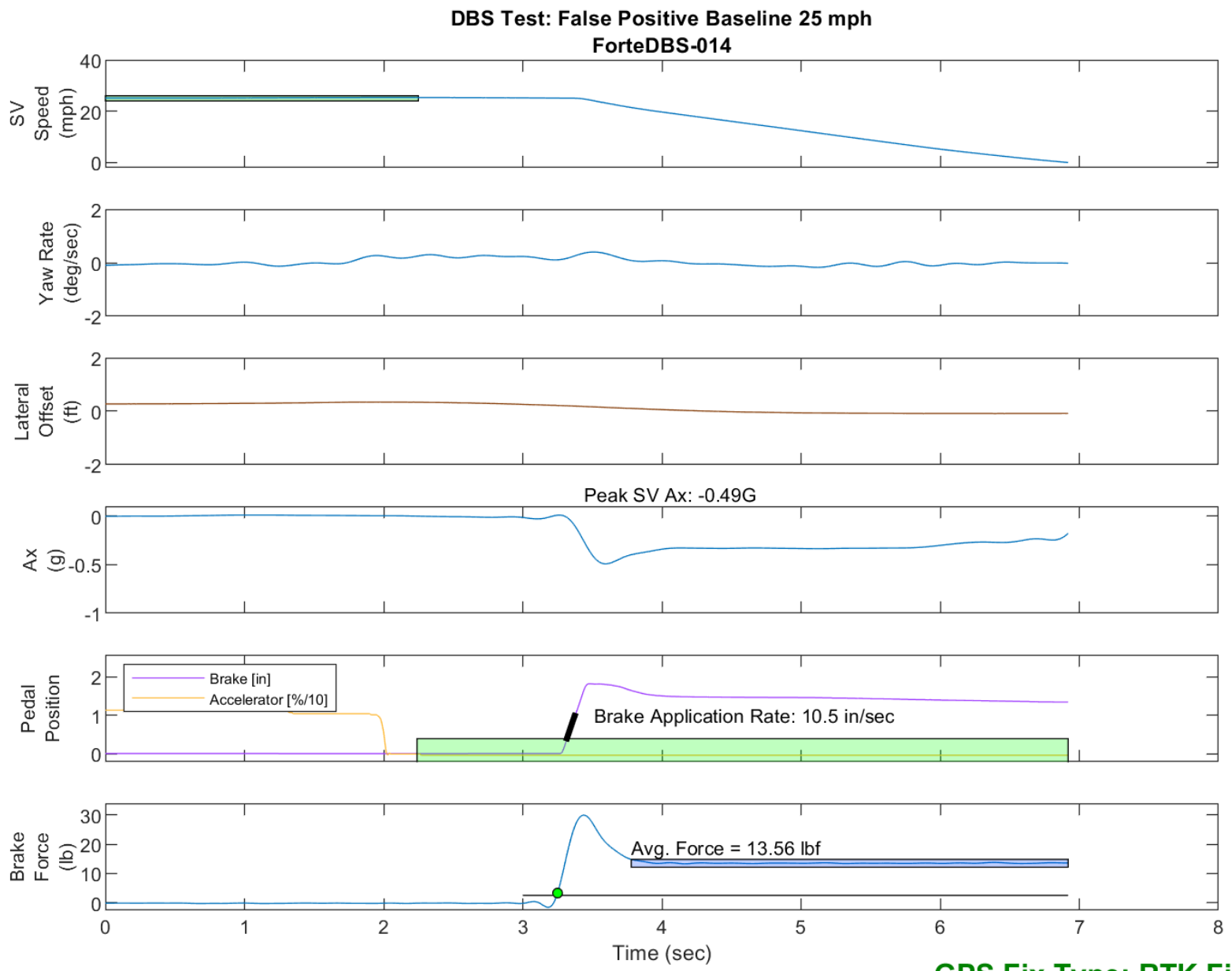
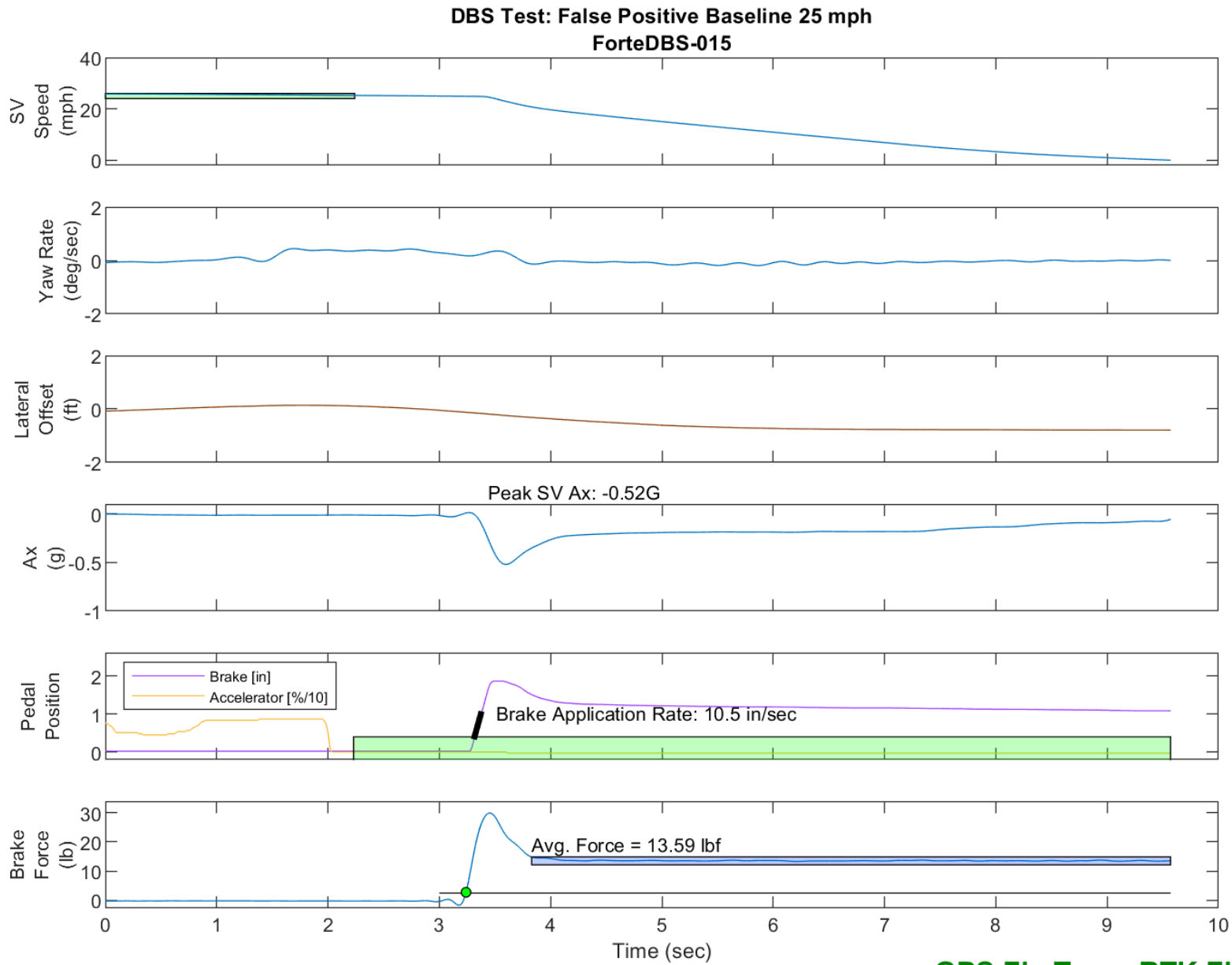


Figure E40. Time History for DBS Run 81, Test 3 - Decelerating POV 35 mph



**GPS Fix Type: RTK Fixed**

Figure E41. Time History for DBS Run 14, False Positive Baseline, SV 25 mph



**GPS Fix Type: RTK Fixed**

Figure E42. Time History for DBS Run 15, False Positive Baseline, SV 25 mph



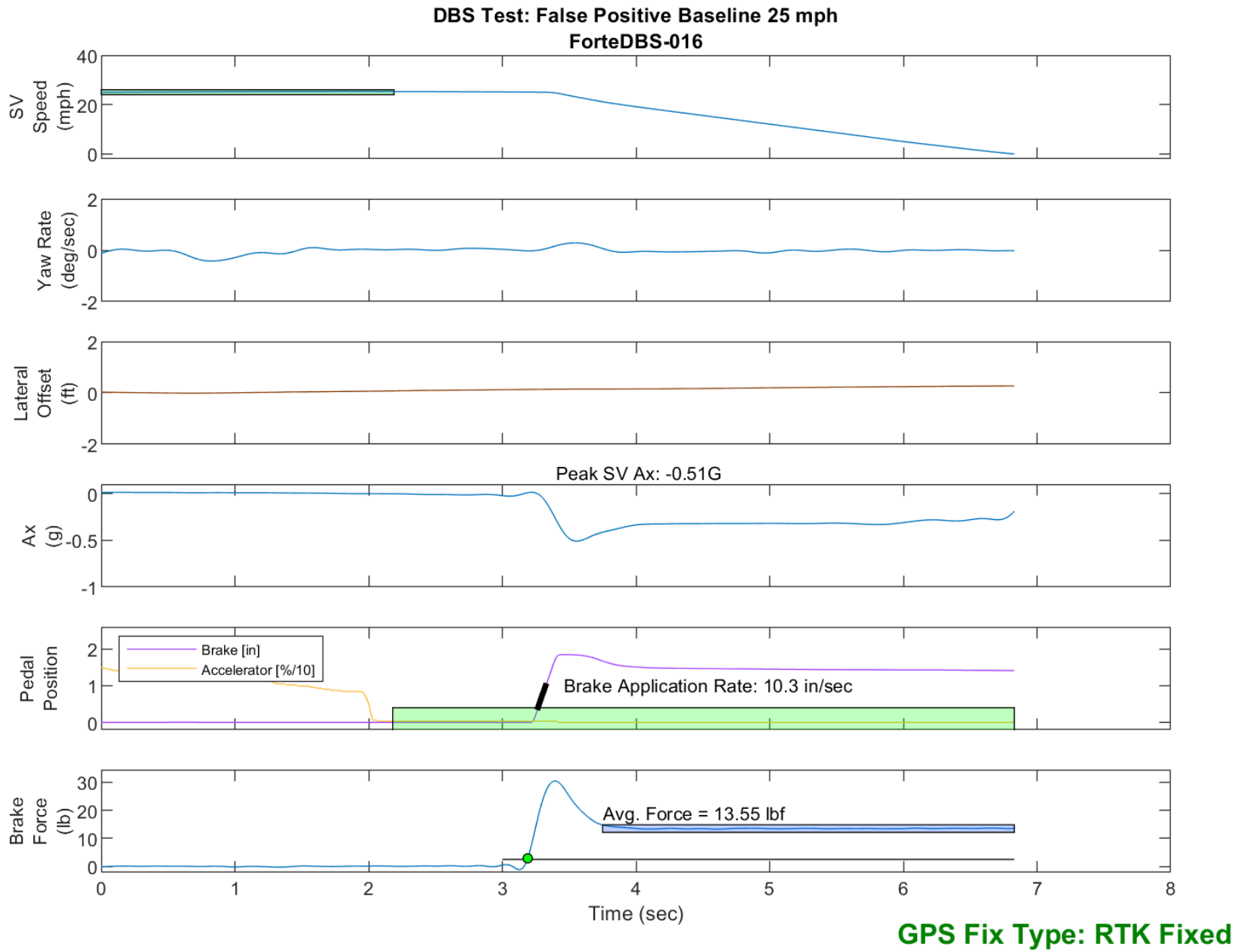


Figure E43. Time History for DBS Run 16, False Positive Baseline, SV 25 mph

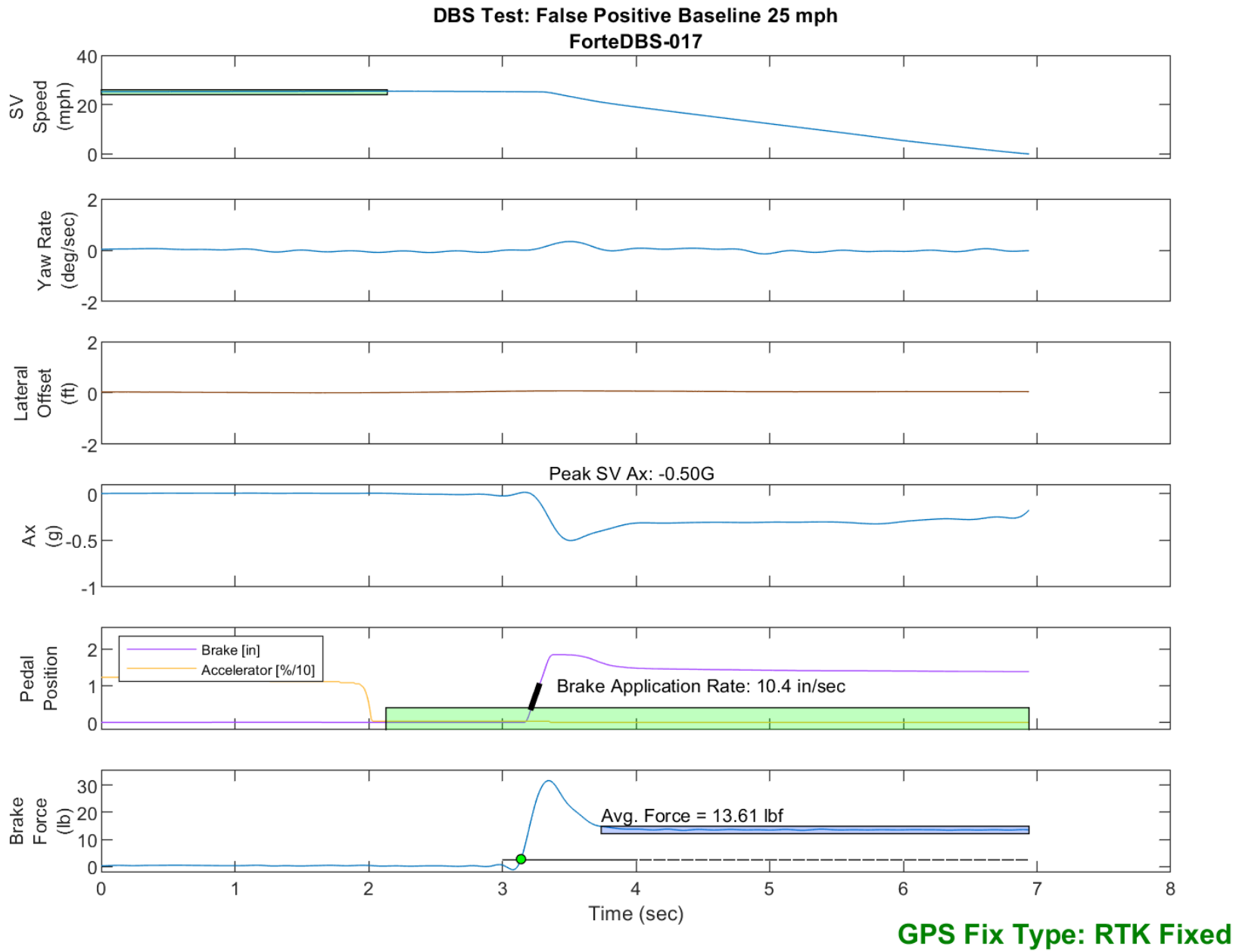
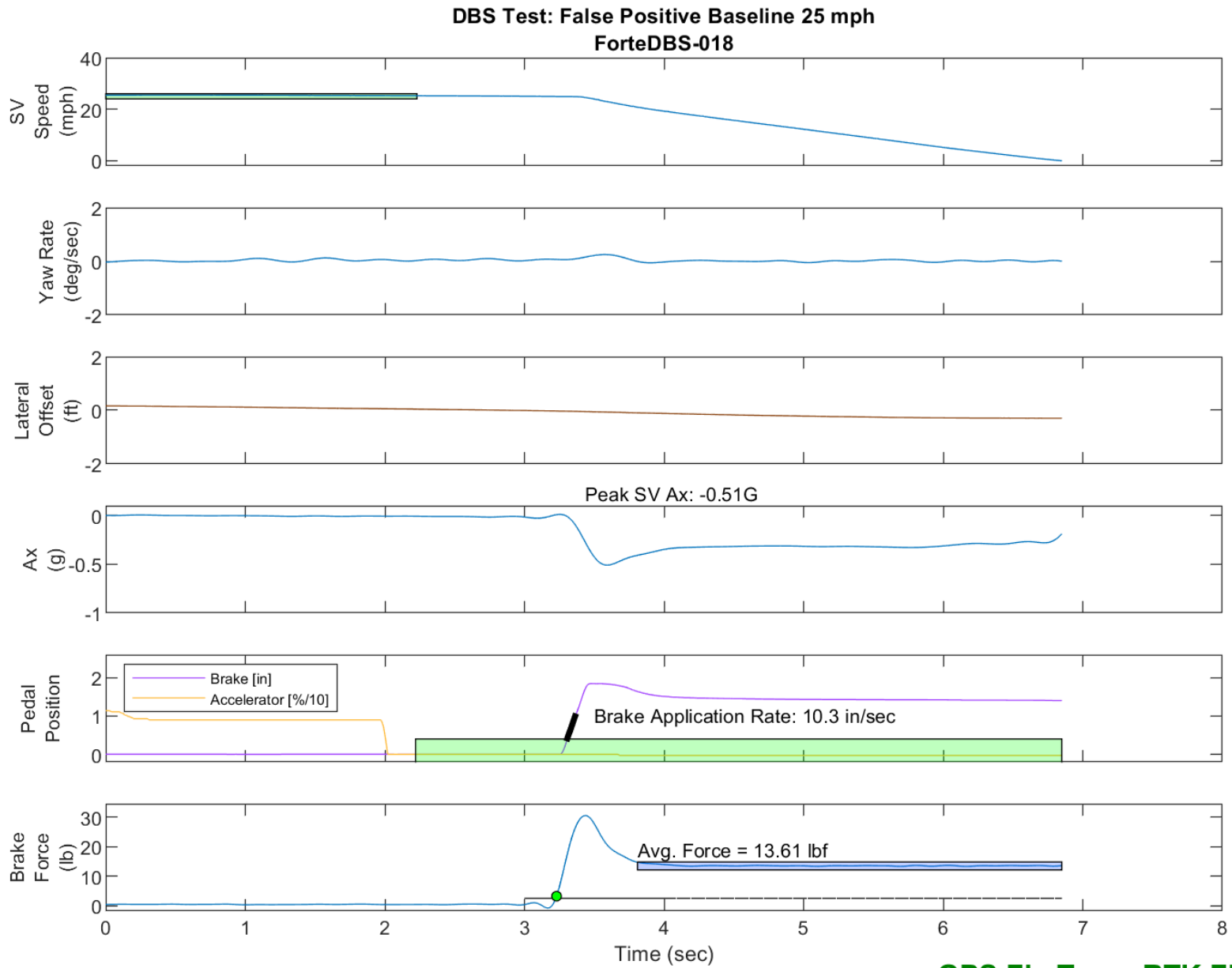
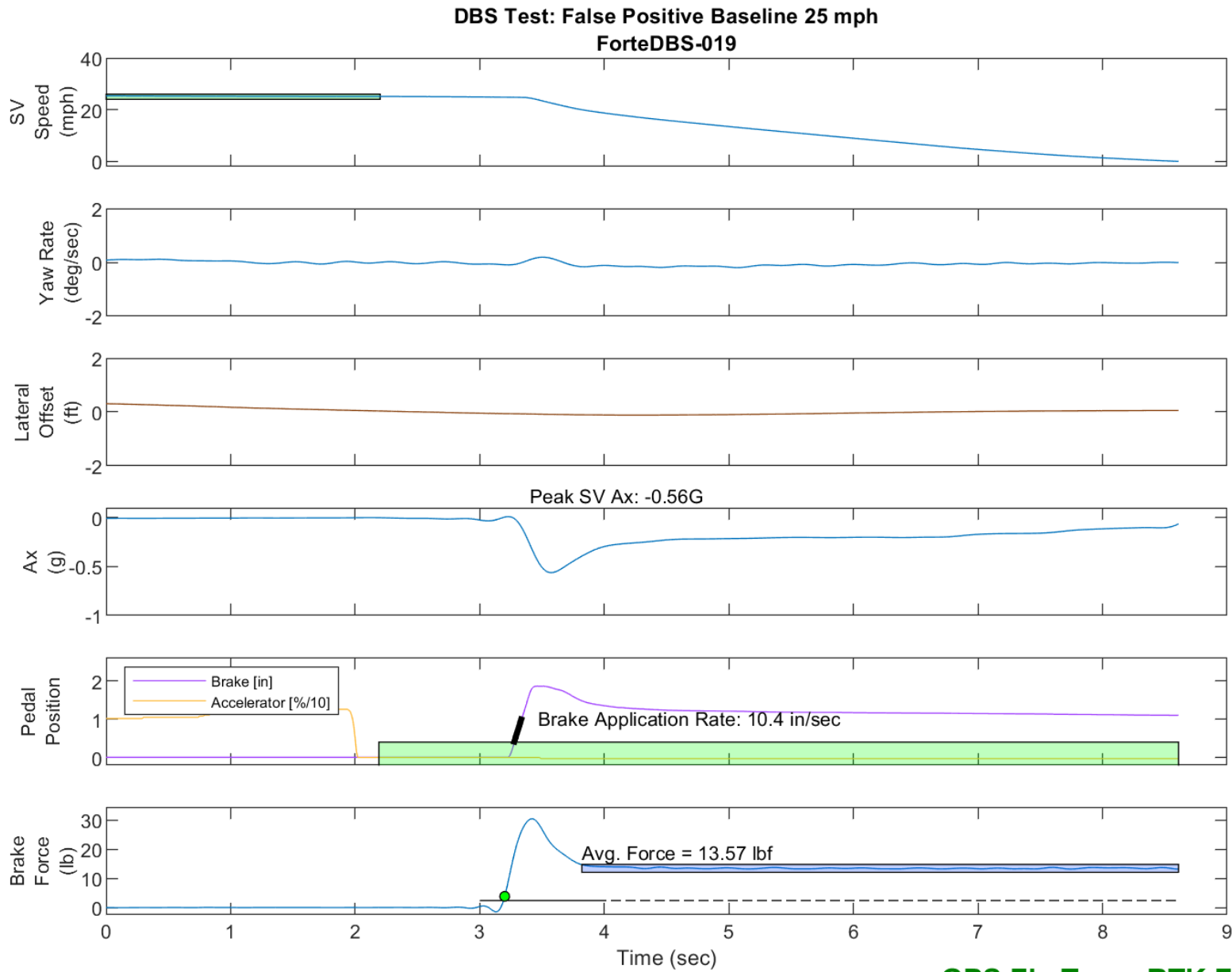


Figure E44. Time History for DBS Run 17, False Positive Baseline, SV 25 mph



**GPS Fix Type: RTK Fixed**

Figure E45. Time History for DBS Run 18, False Positive Baseline, SV 25 mph



**GPS Fix Type: RTK Fixed**

Figure E46. Time History for DBS Run 19, False Positive Baseline, SV 25 mph

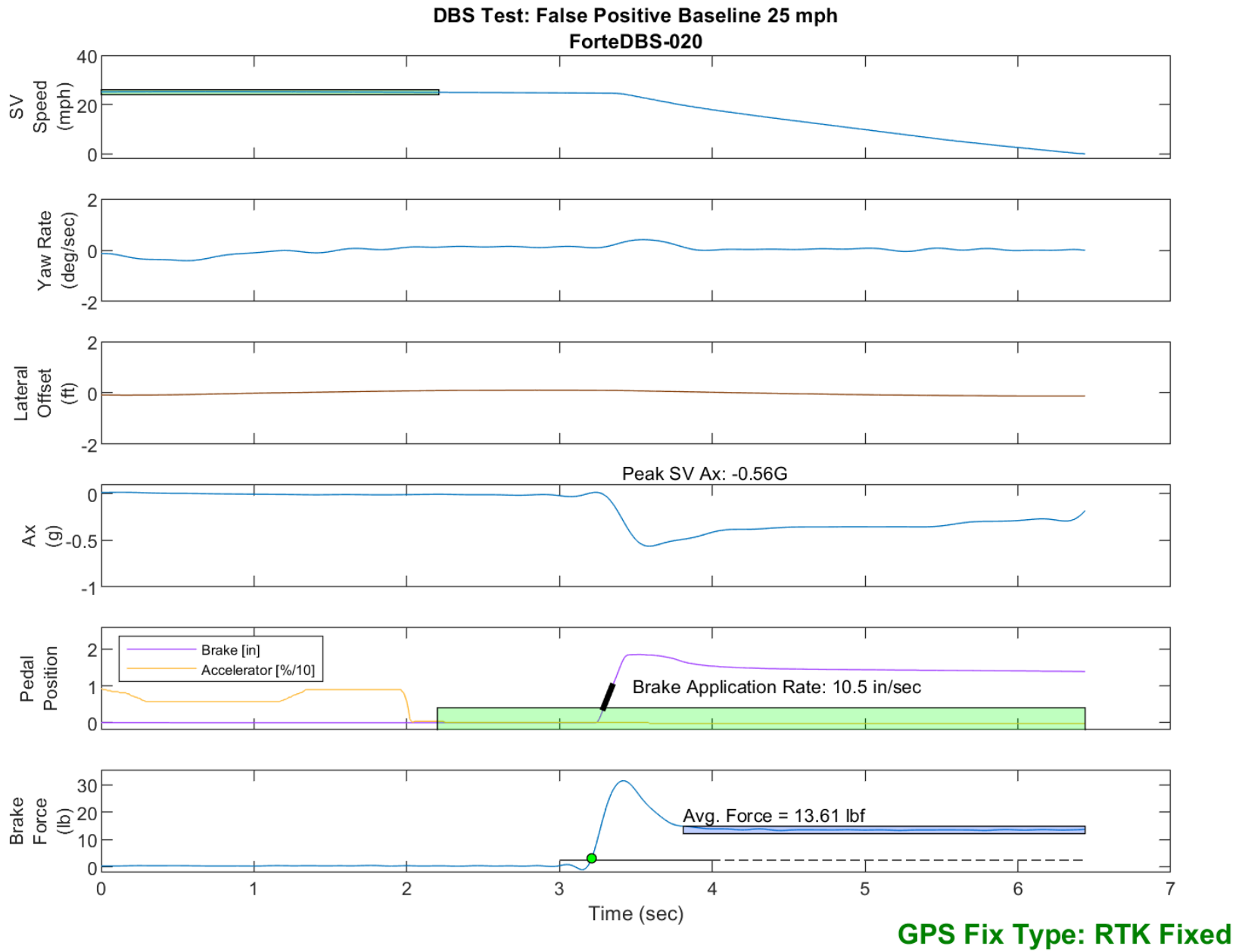
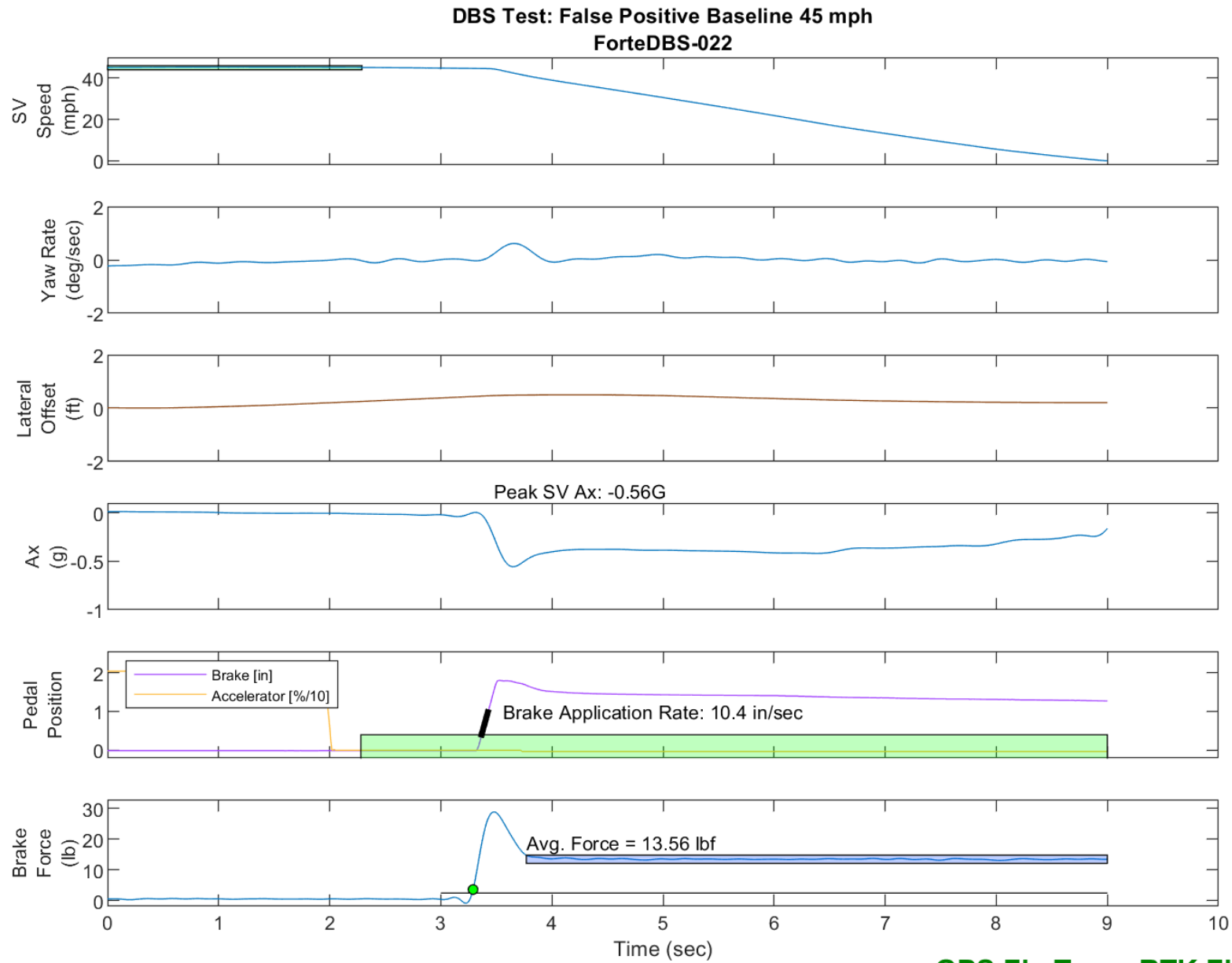


Figure E47. Time History for DBS Run 20, False Positive Baseline, SV 25 mph



**GPS Fix Type: RTK Fixed**

Figure E48. Time History for DBS Run 22, False Positive Baseline, SV 45 mph

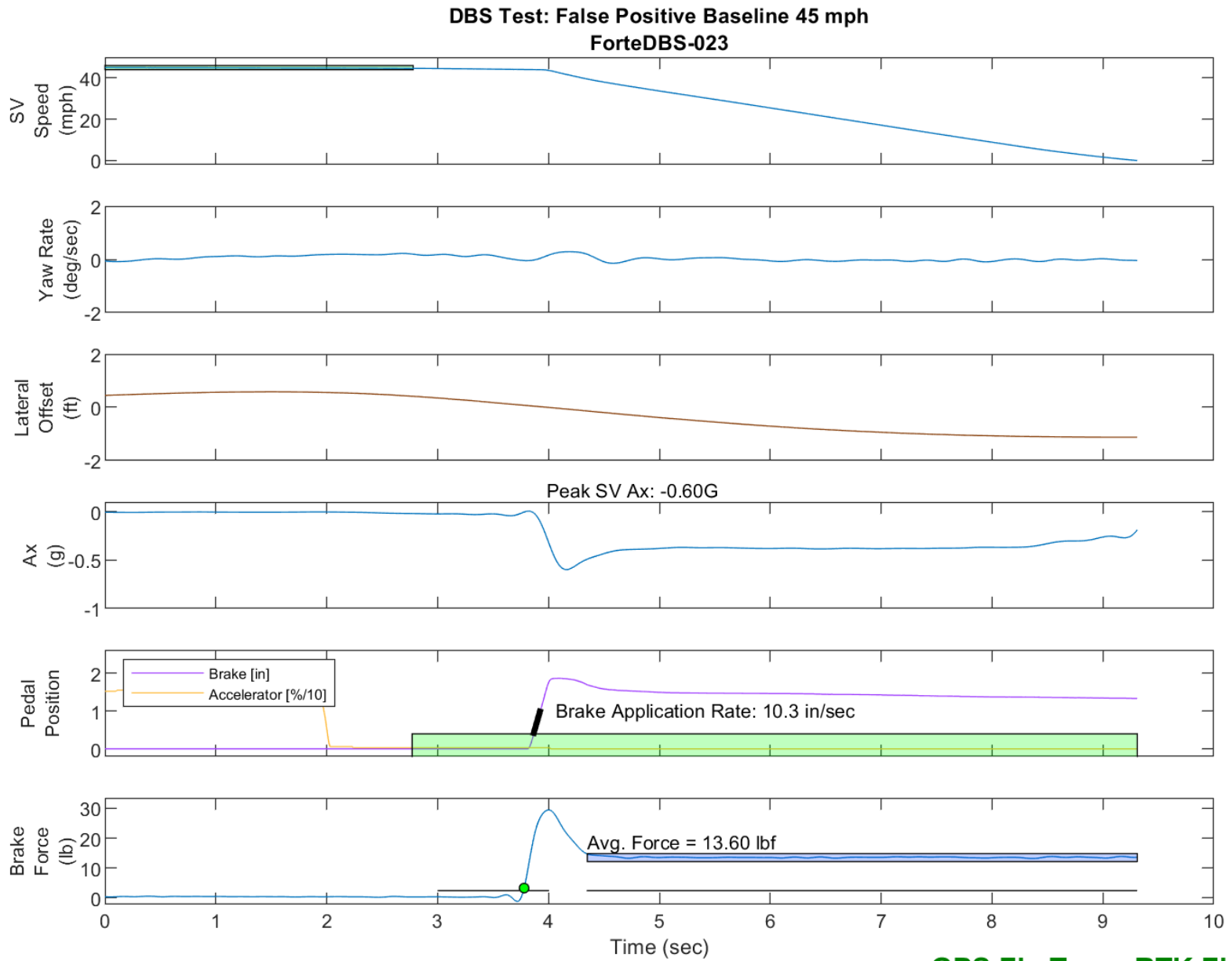
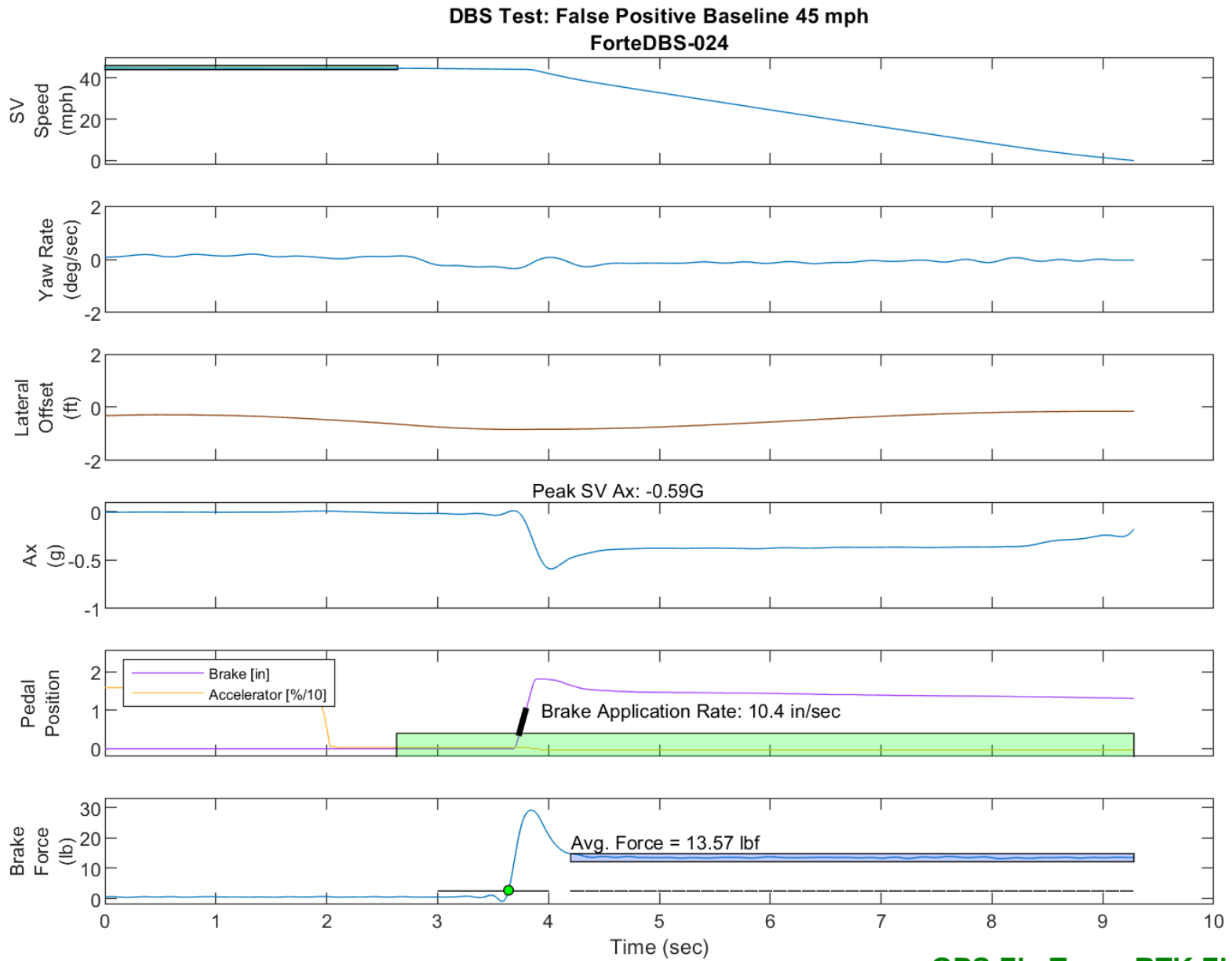


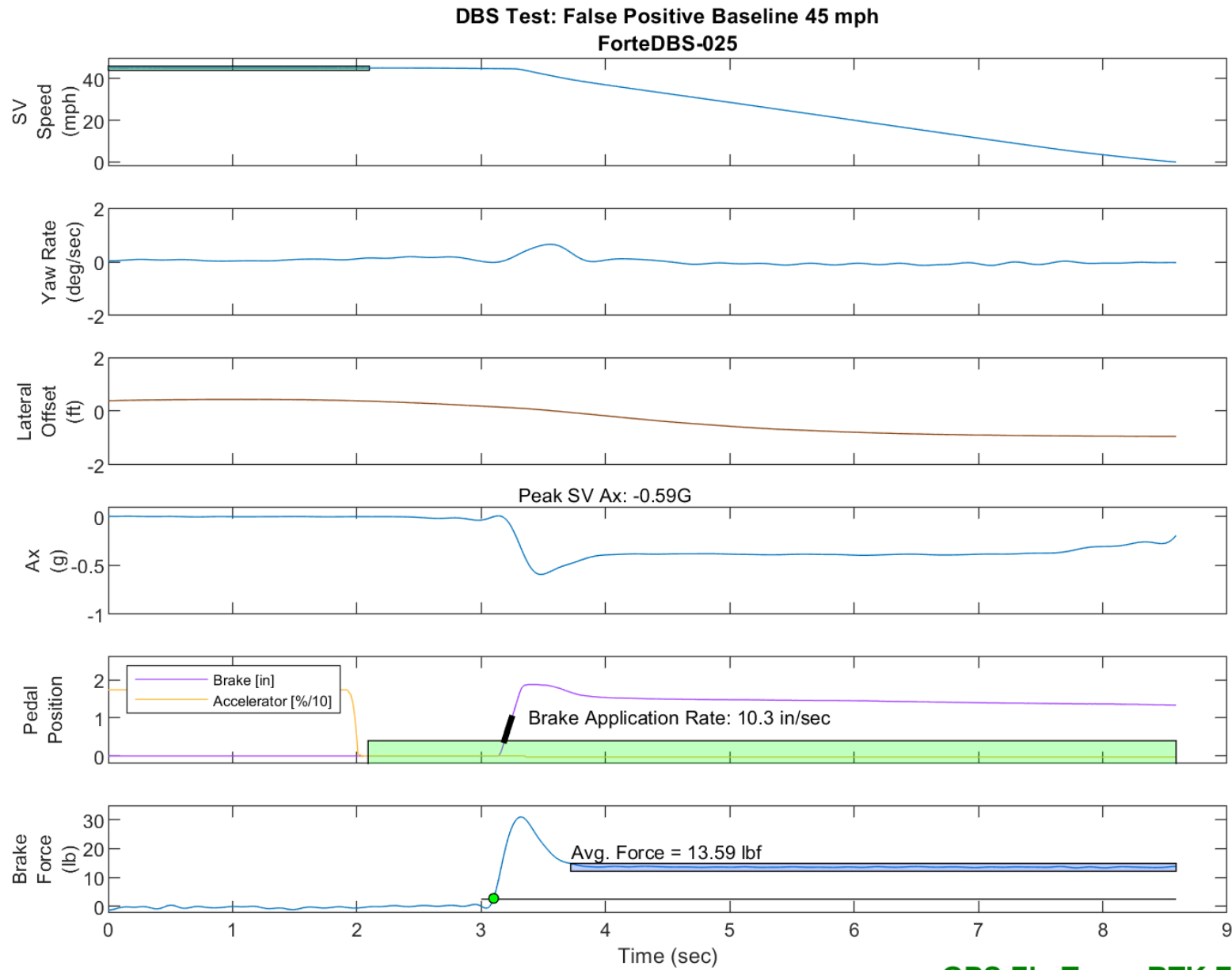
Figure E49. Time History for DBS Run 23, False Positive Baseline, SV 45 mph



**GPS Fix Type: RTK Fixed**

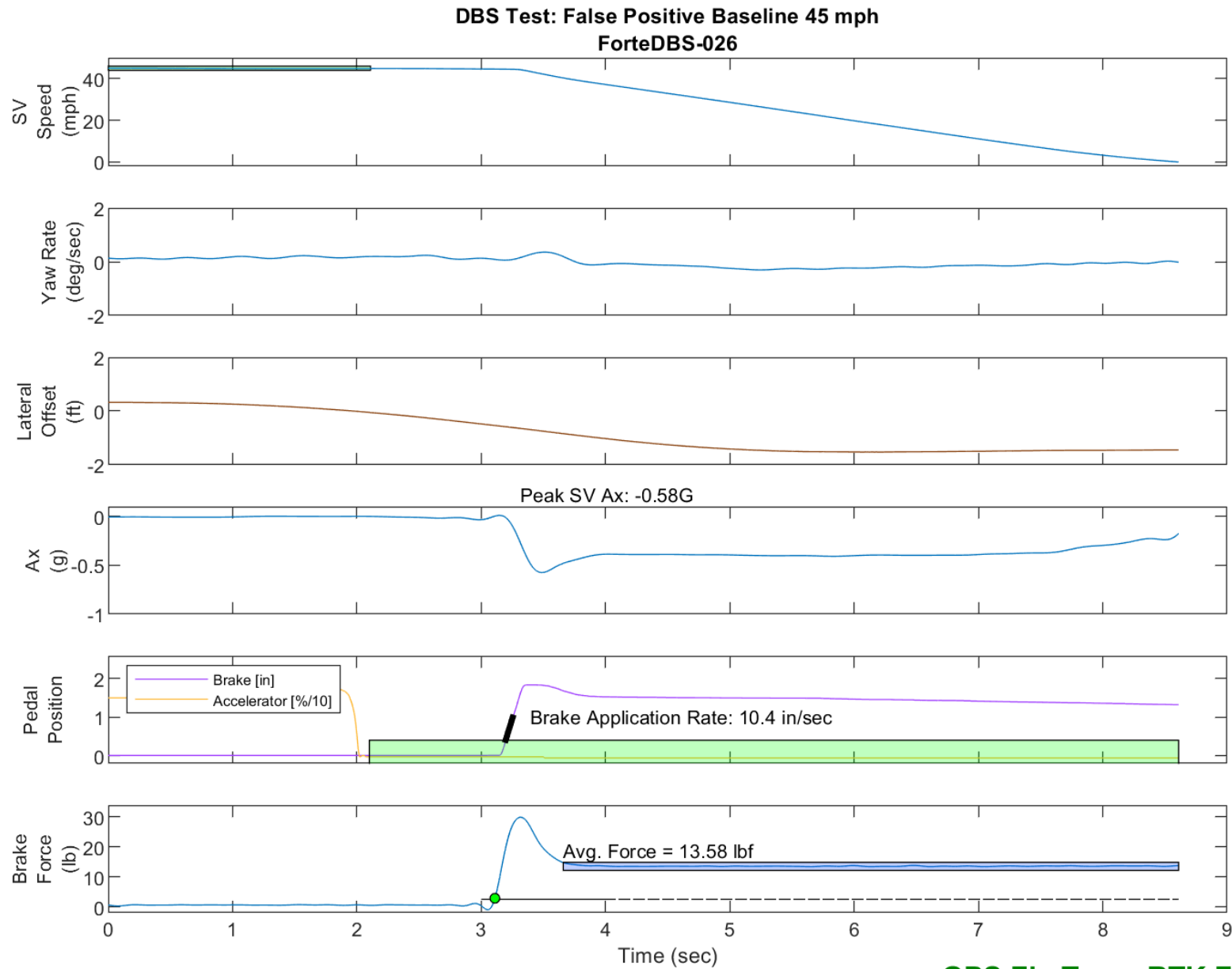
Figure E50. Time History for DBS Run 24, False Positive Baseline, SV 45 mph





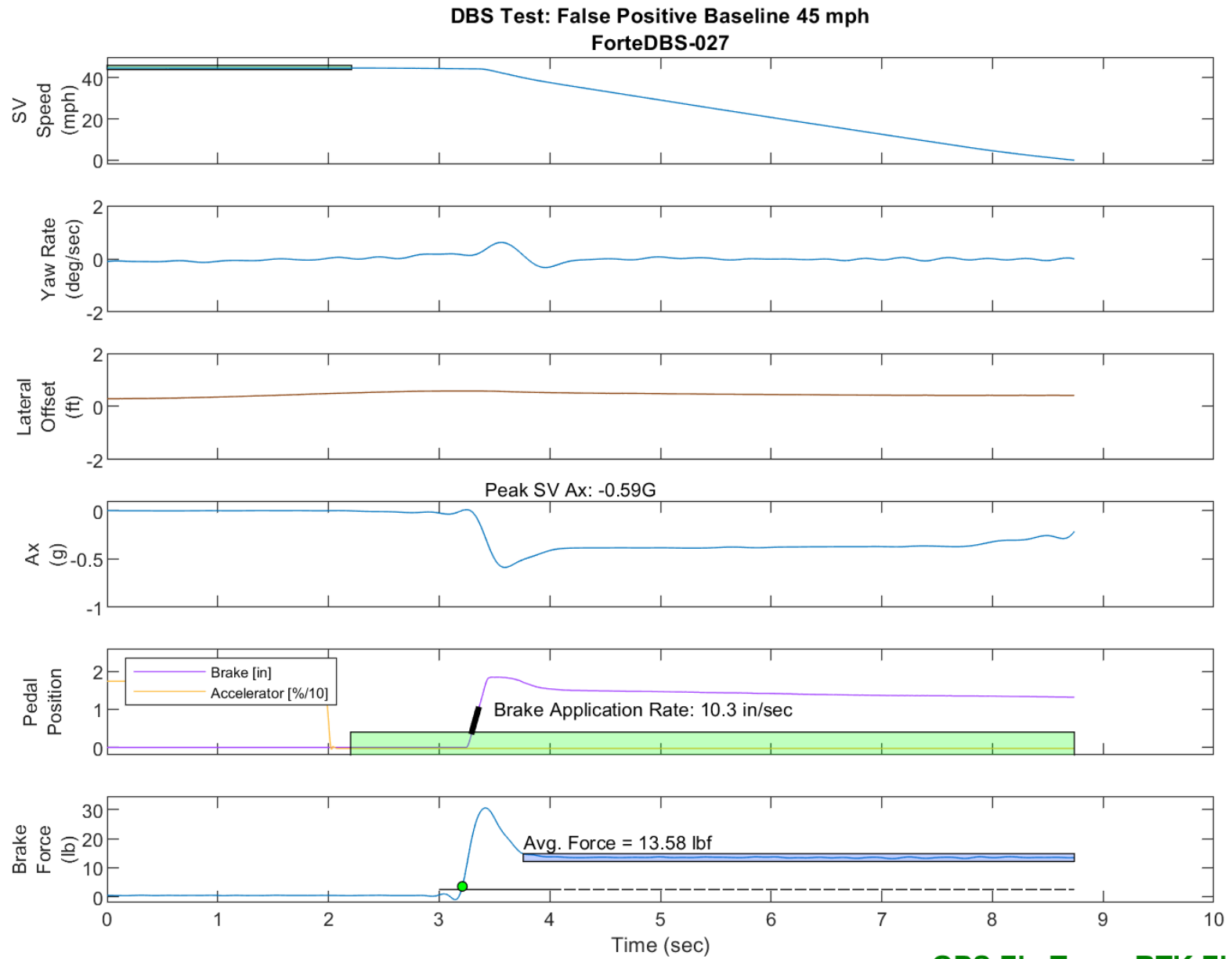
**GPS Fix Type: RTK Fixed**

Figure E51. Time History for DBS Run 25, False Positive Baseline, SV 45 mph



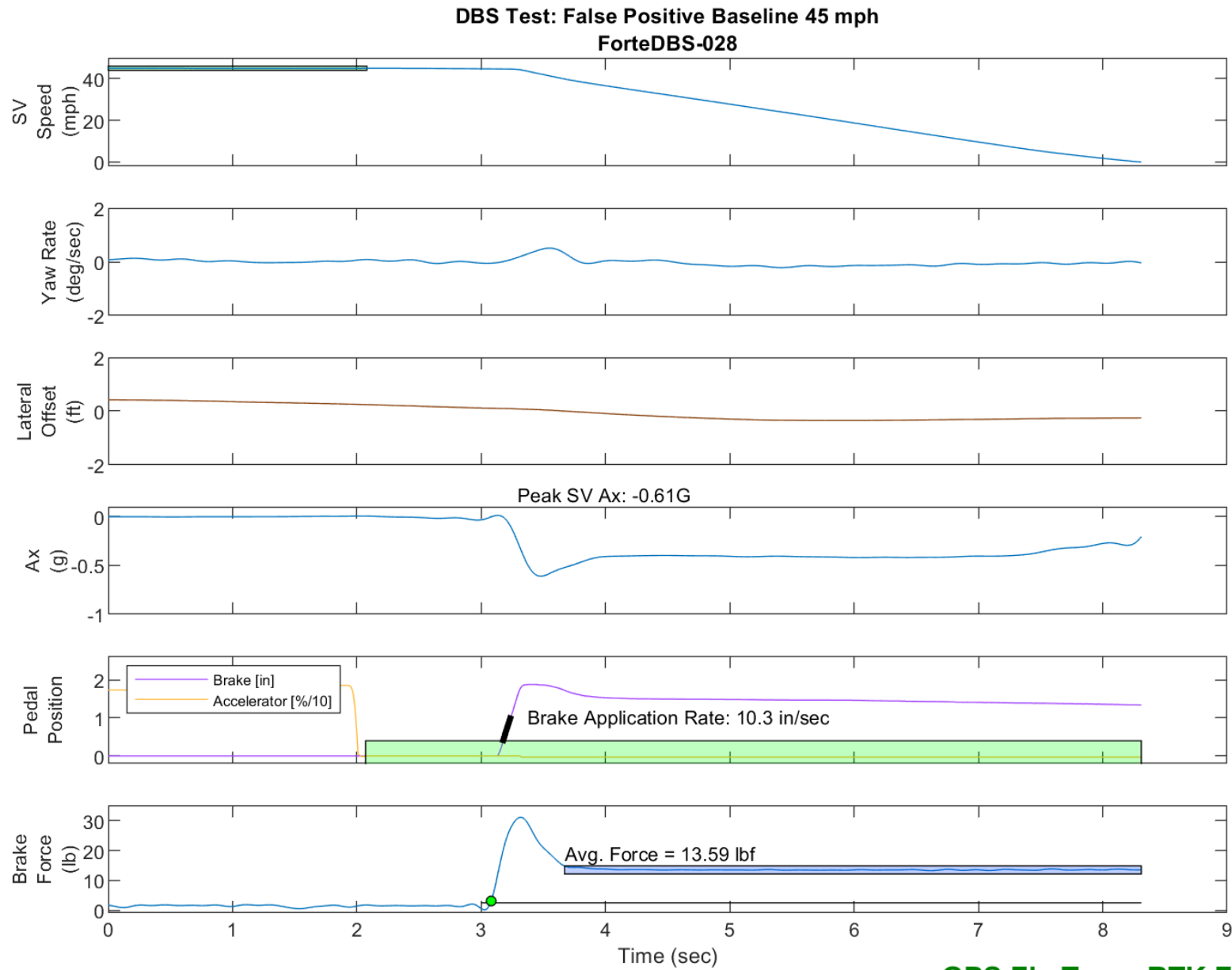
**GPS Fix Type: RTK Fixed**

Figure E52. Time History for DBS Run 26, False Positive Baseline, SV 45 mph



**GPS Fix Type: RTK Fixed**

Figure E53. Time History for DBS Run 27, False Positive Baseline, SV 45 mph



**GPS Fix Type: RTK Fixed**

Figure E54. Time History for DBS Run 28, False Positive Baseline, SV 45 mph

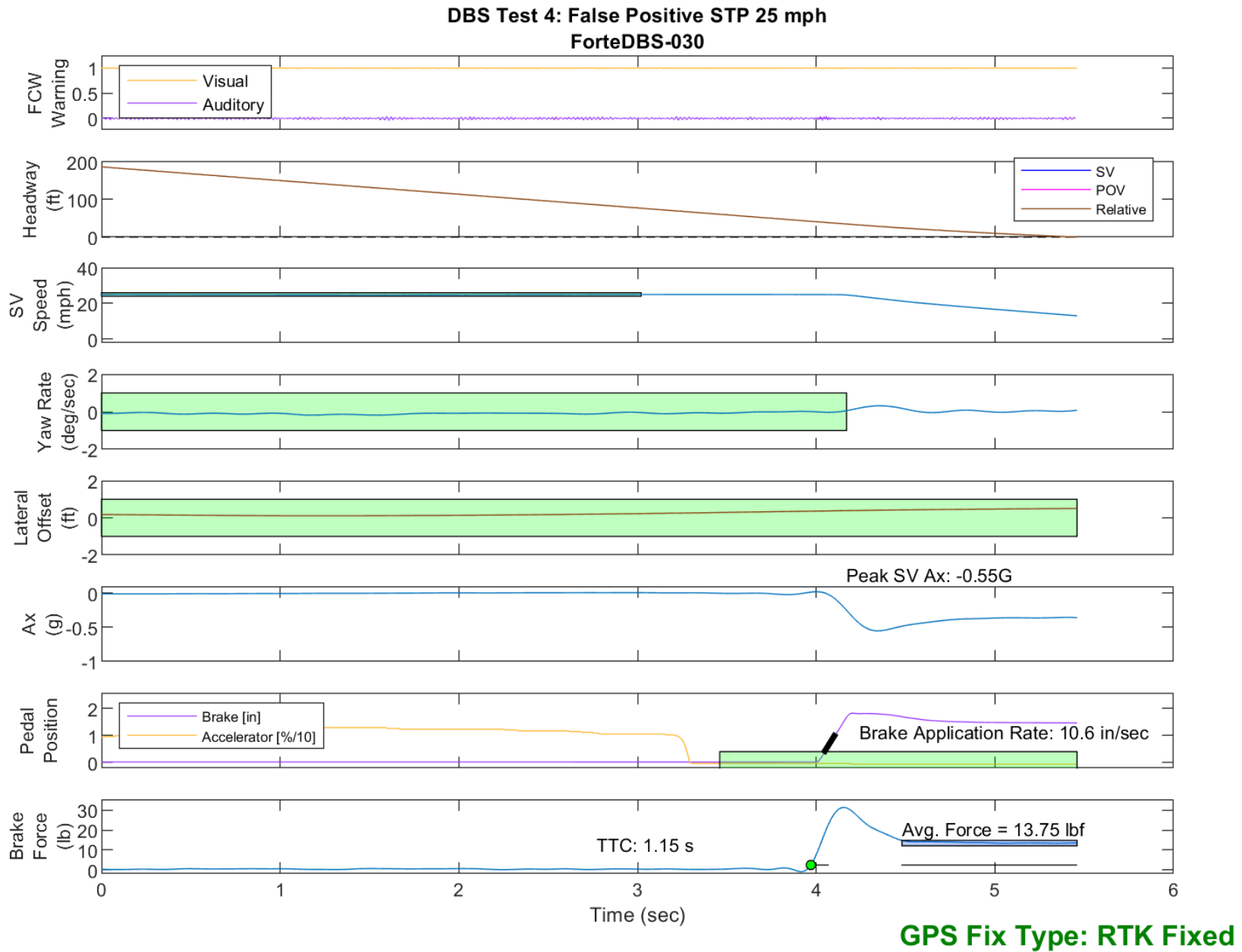


Figure E55. Time History for DBS Run 30, Test 4 - False Positive STP 25 mph

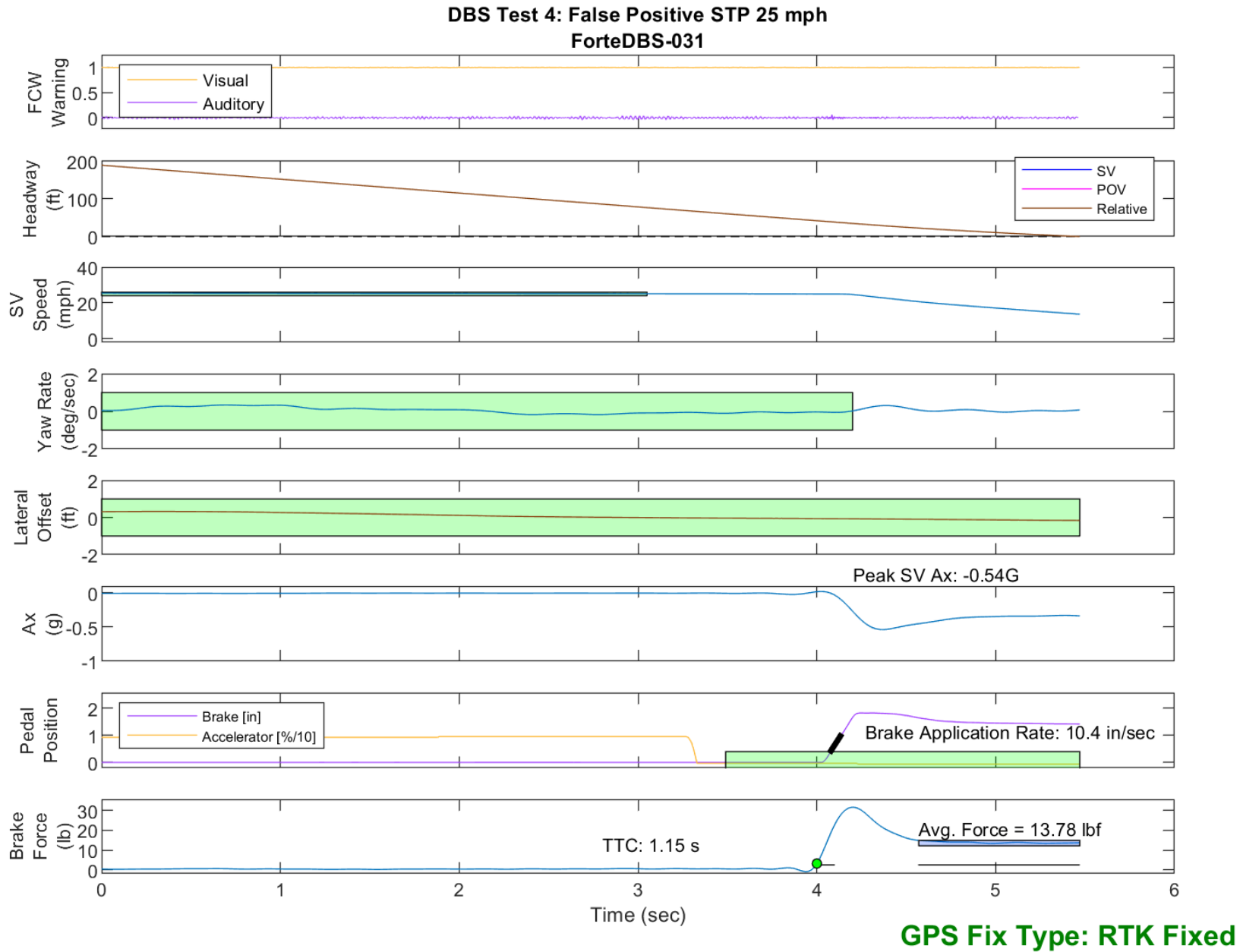


Figure E56. Time History for DBS Run 31, Test 4 - False Positive STP 25 mph

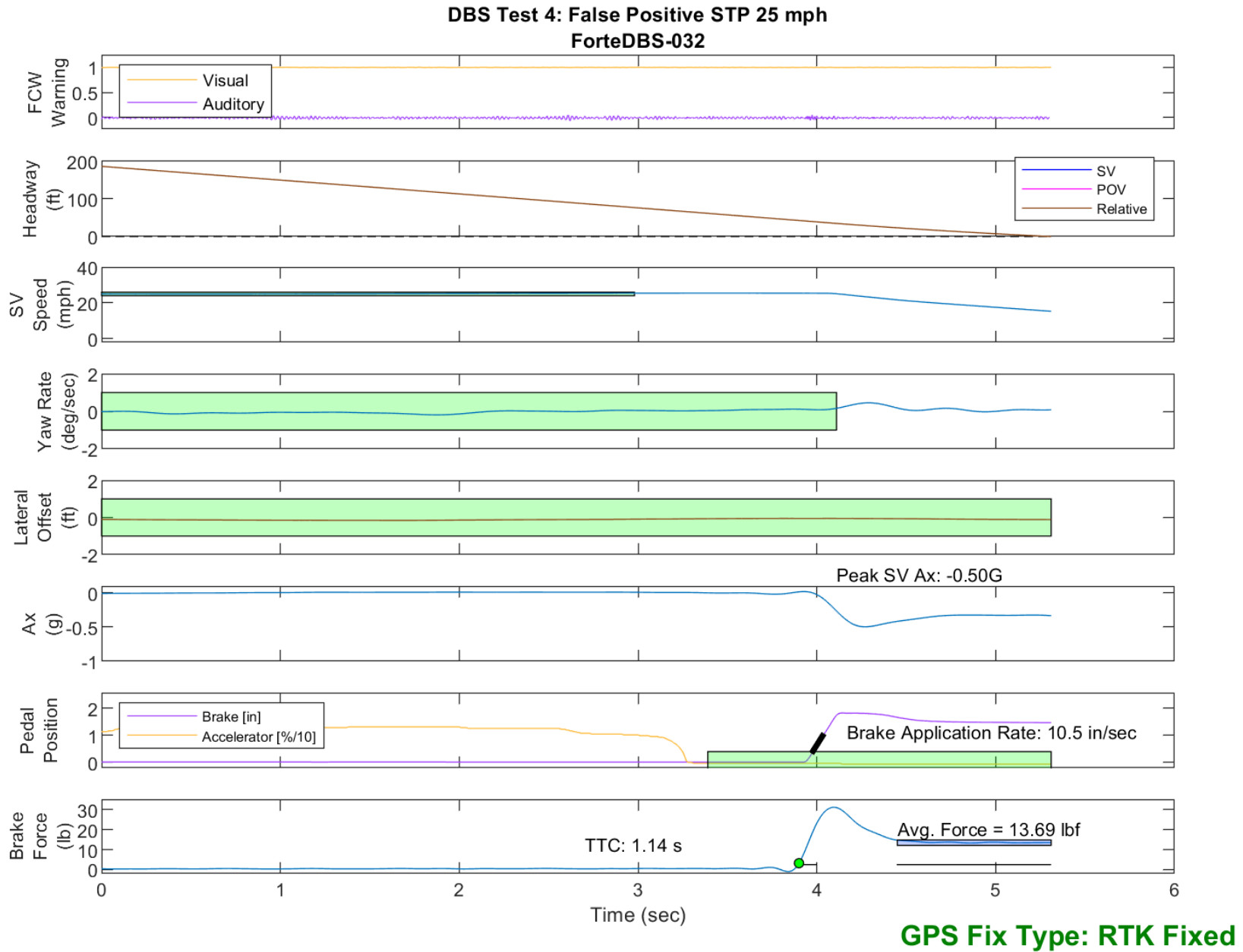


Figure E57. Time History for DBS Run 32, Test 4 - False Positive STP 25 mph

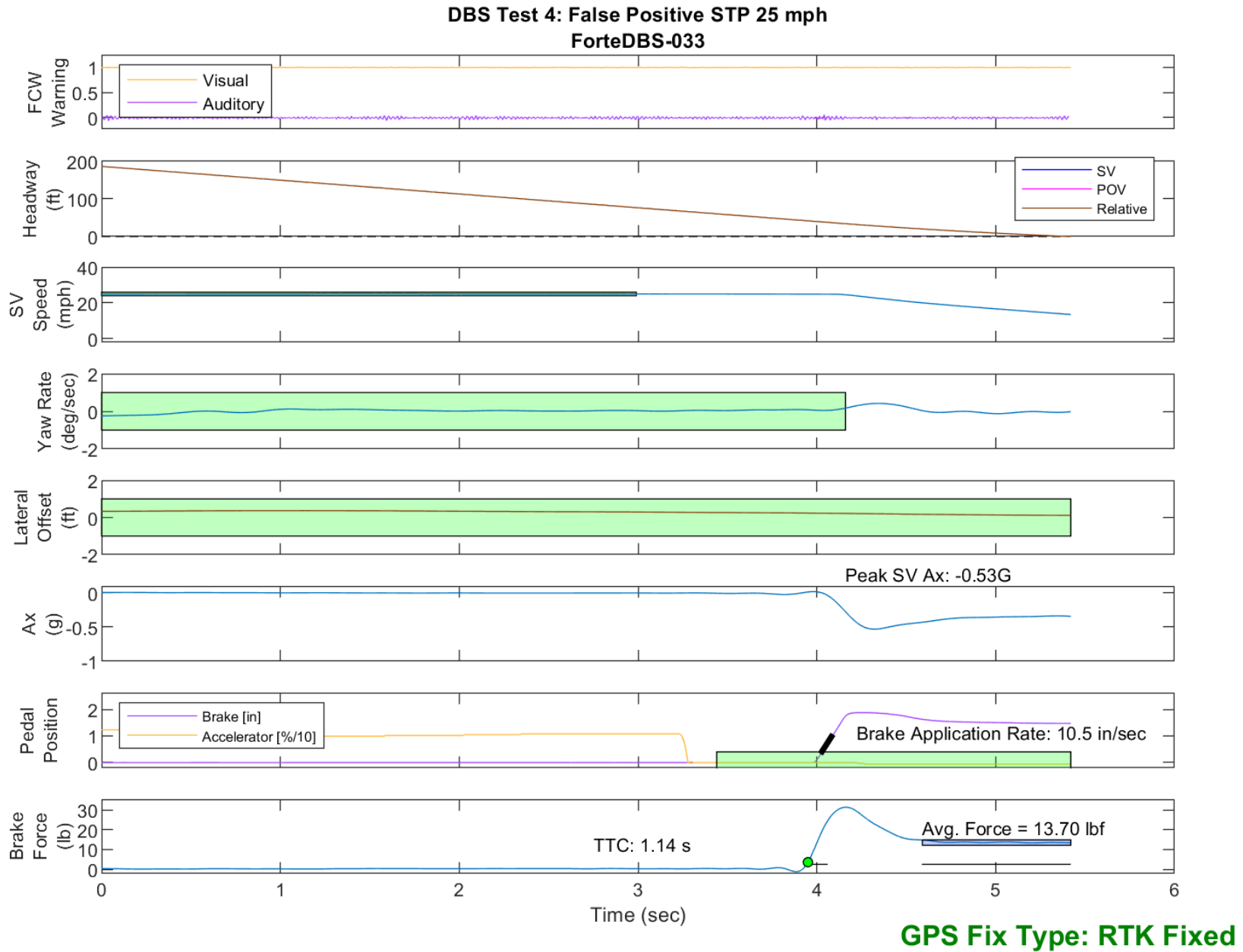
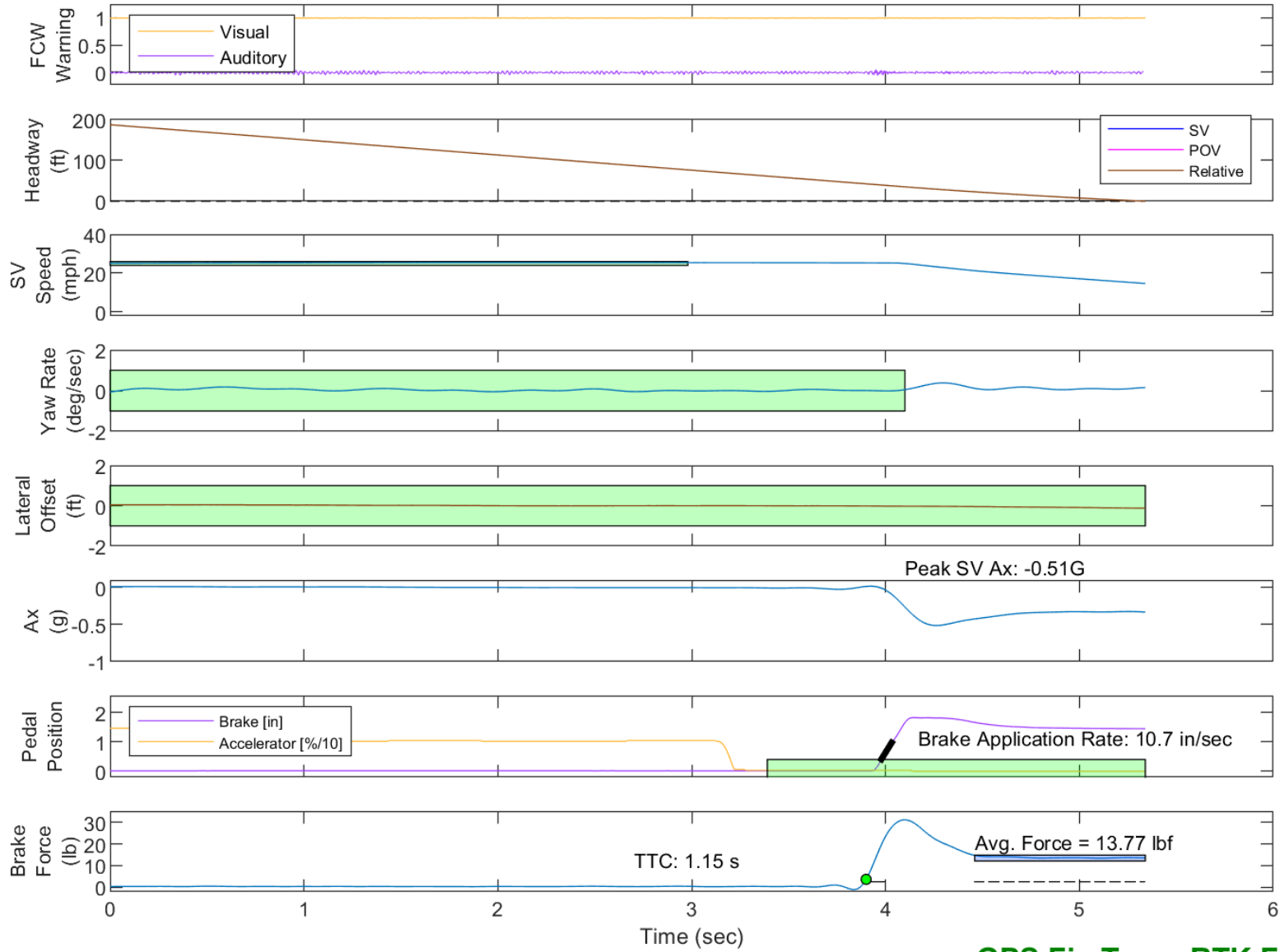


Figure E58. Time History for DBS Run 33, Test 4 - False Positive STP 25 mph



DBS Test 4: False Positive STP 25 mph  
ForteDBS-034



GPS Fix Type: RTK Fixed

Figure E59. Time History for DBS Run 34, Test 4 - False Positive STP 25 mph

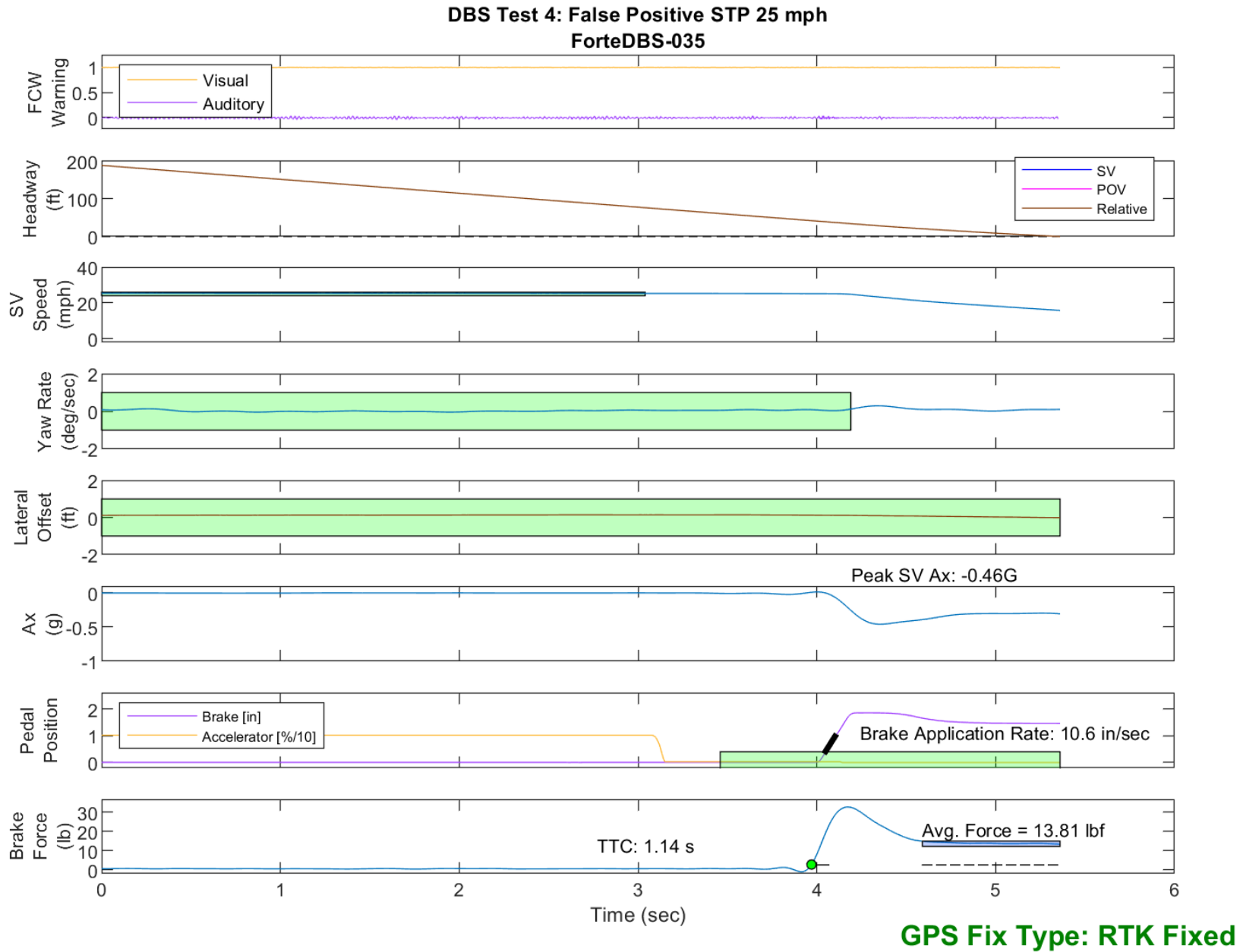


Figure E60. Time History for DBS Run 35, Test 4 - False Positive STP 25 mph

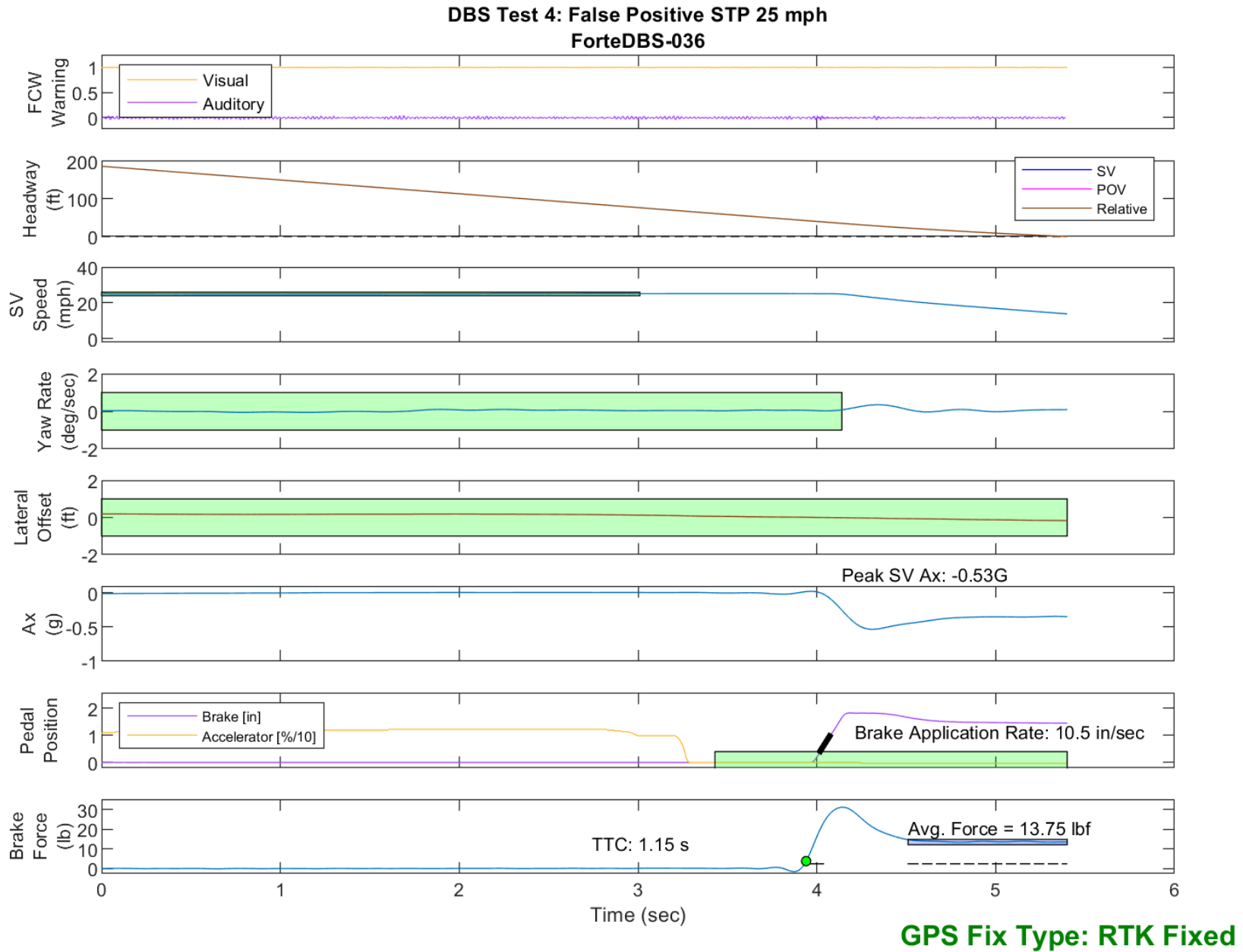


Figure E61. Time History for DBS Run 36, Test 4 - False Positive STP 25 mph

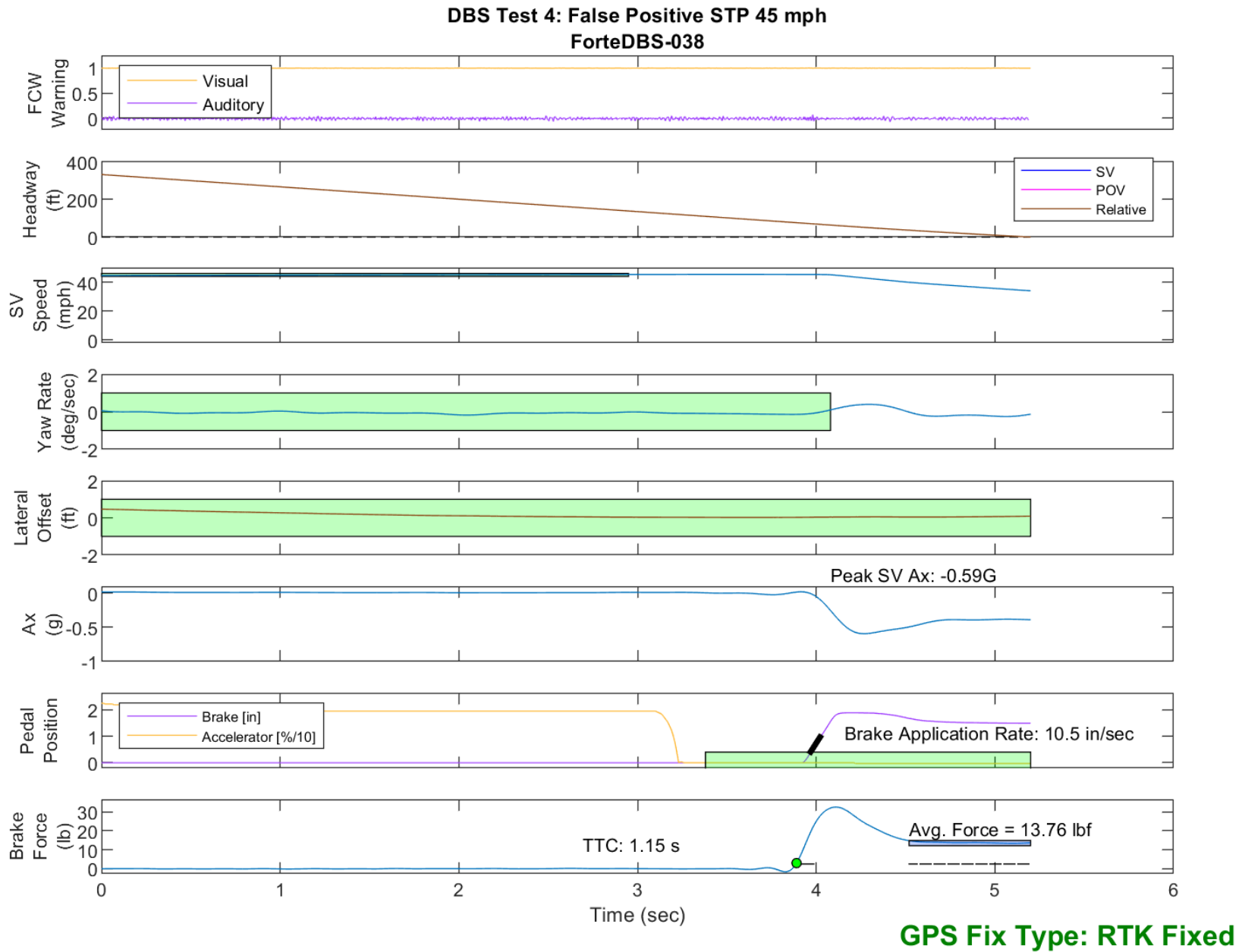


Figure E62. Time History for DBS Run 38, Test 4 - False Positive STP 45 mph

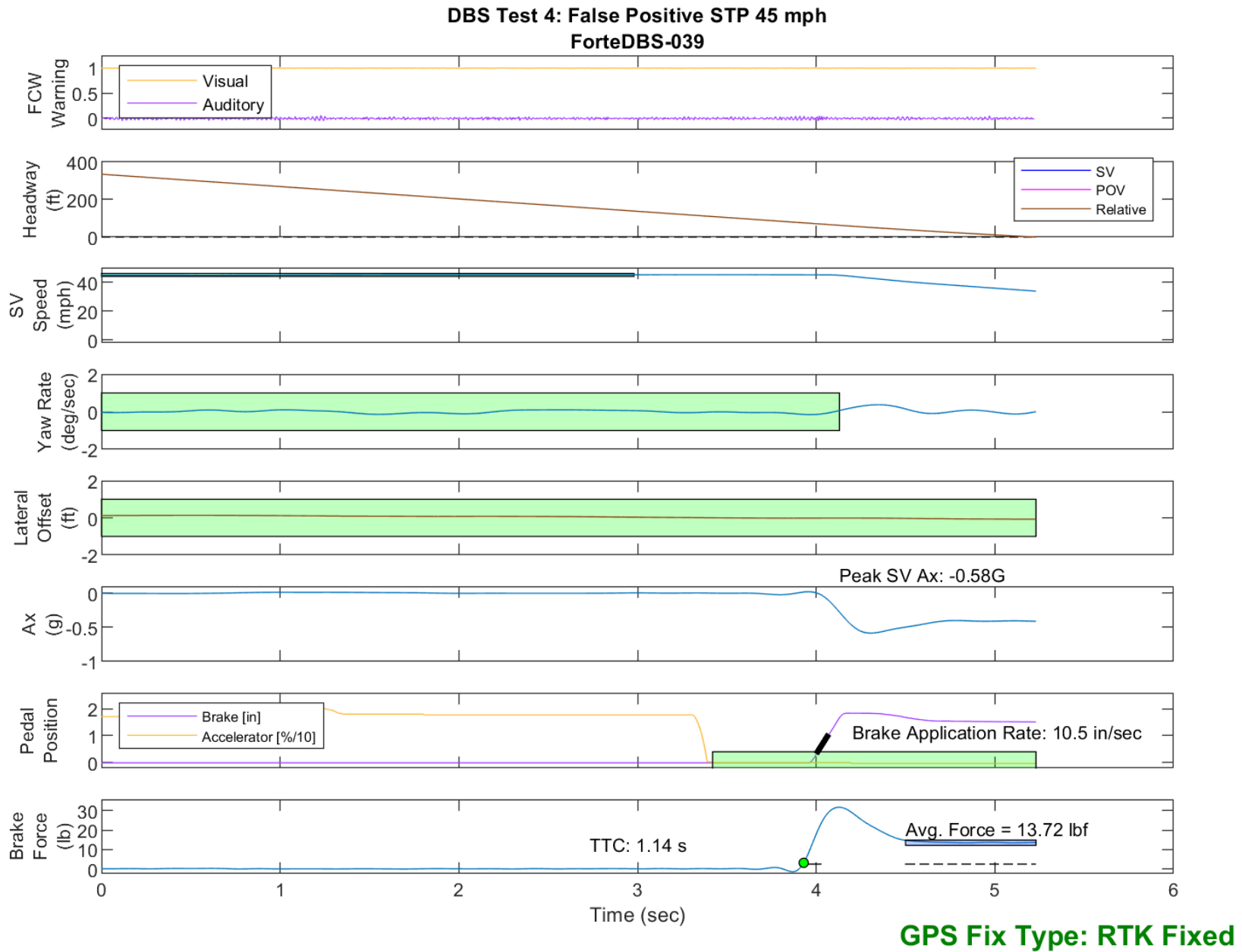


Figure E63. Time History for DBS Run 39, Test 4 - False Positive STP 45 mph

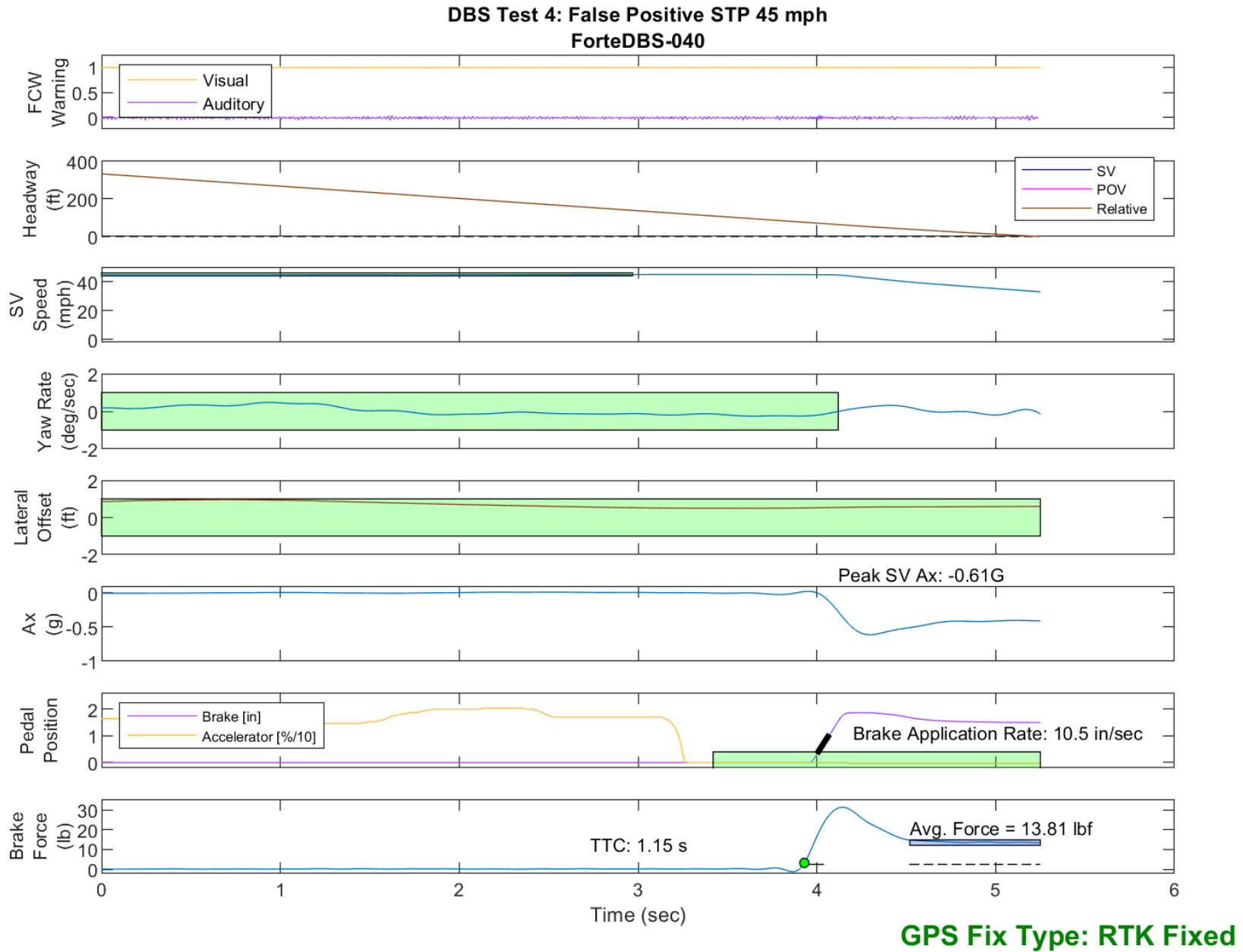


Figure E64. Time History for DBS Run 40, Test 4 - False Positive STP 45 mph

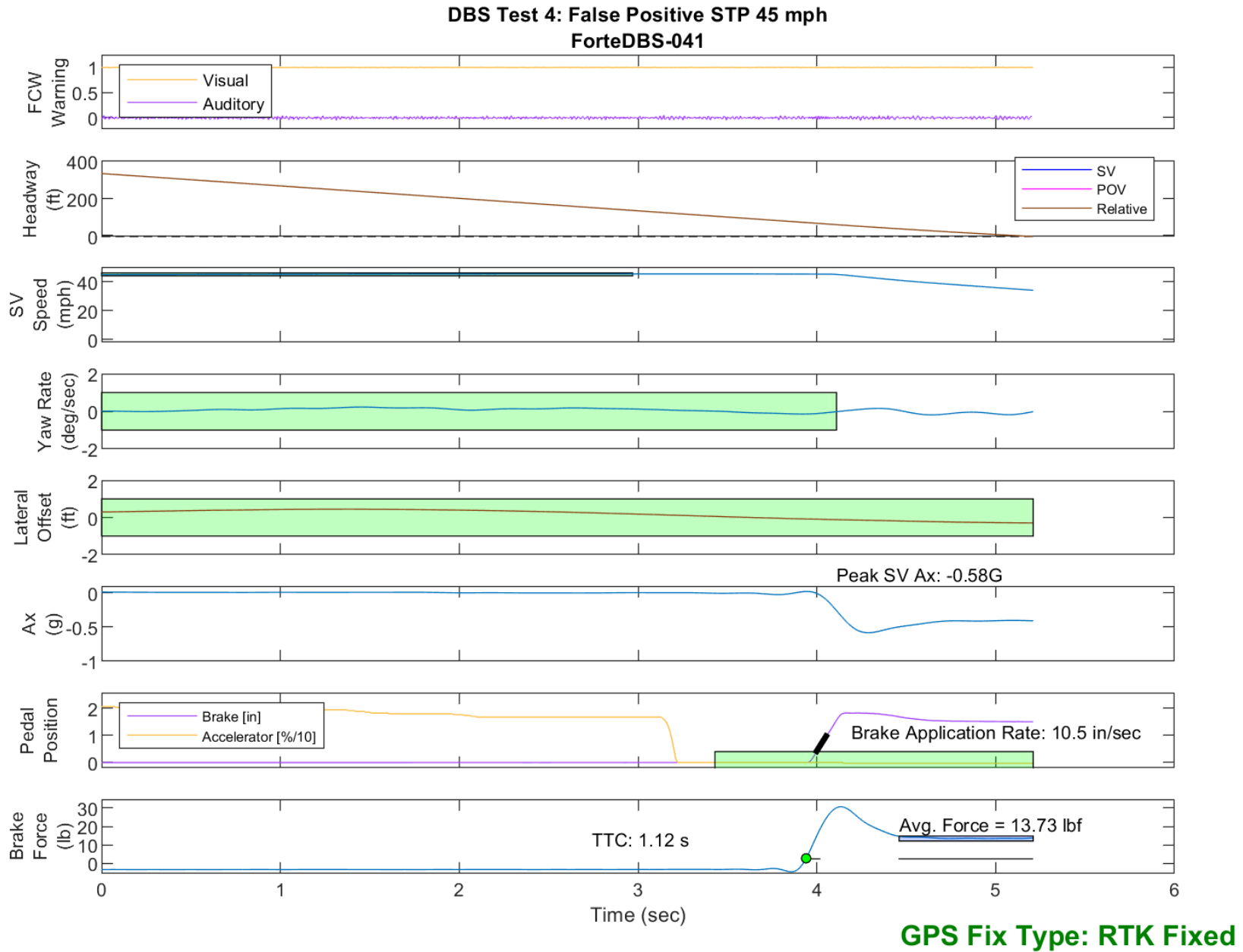


Figure E65. Time History for DBS Run 41, Test 4 - False Positive STP 45 mph

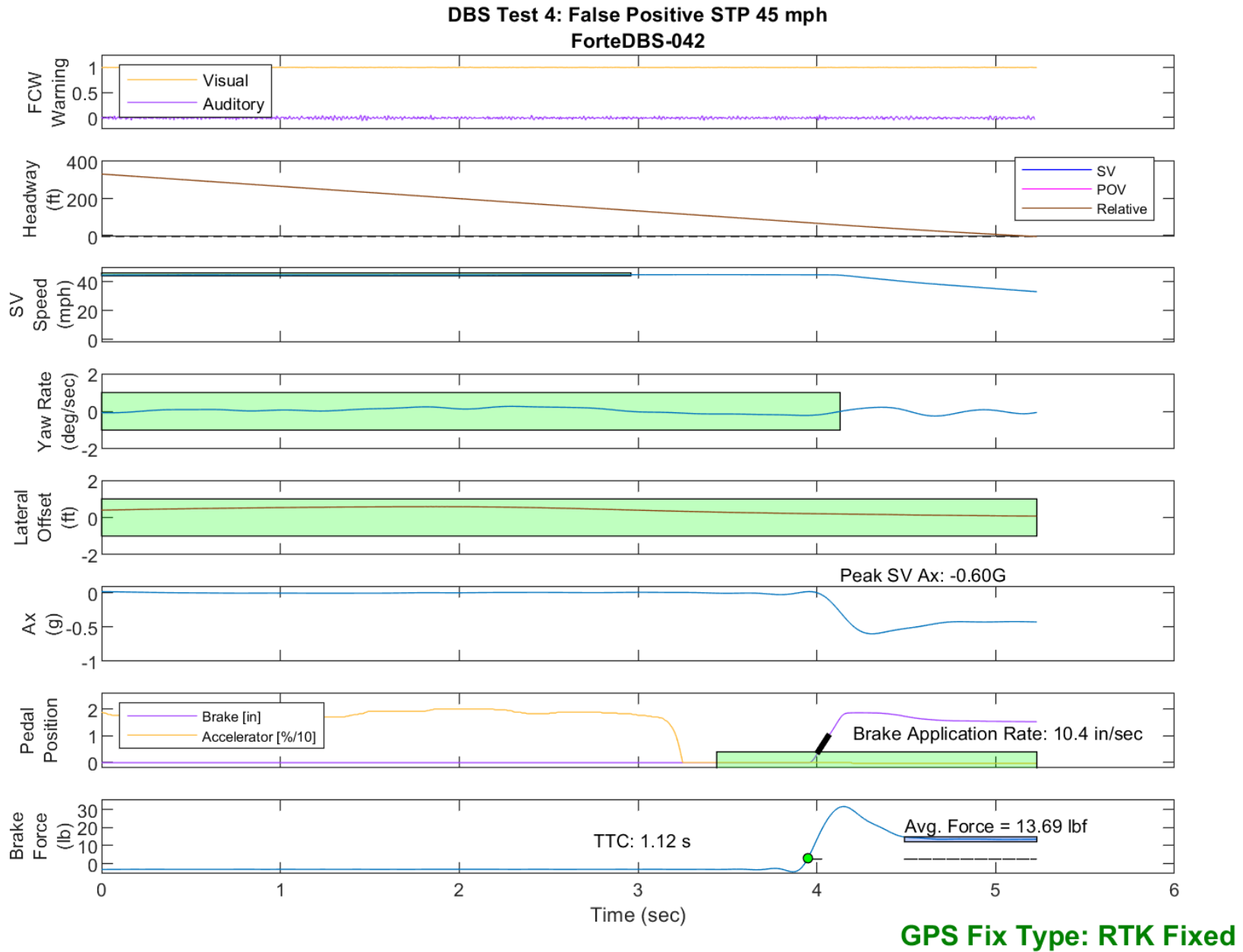
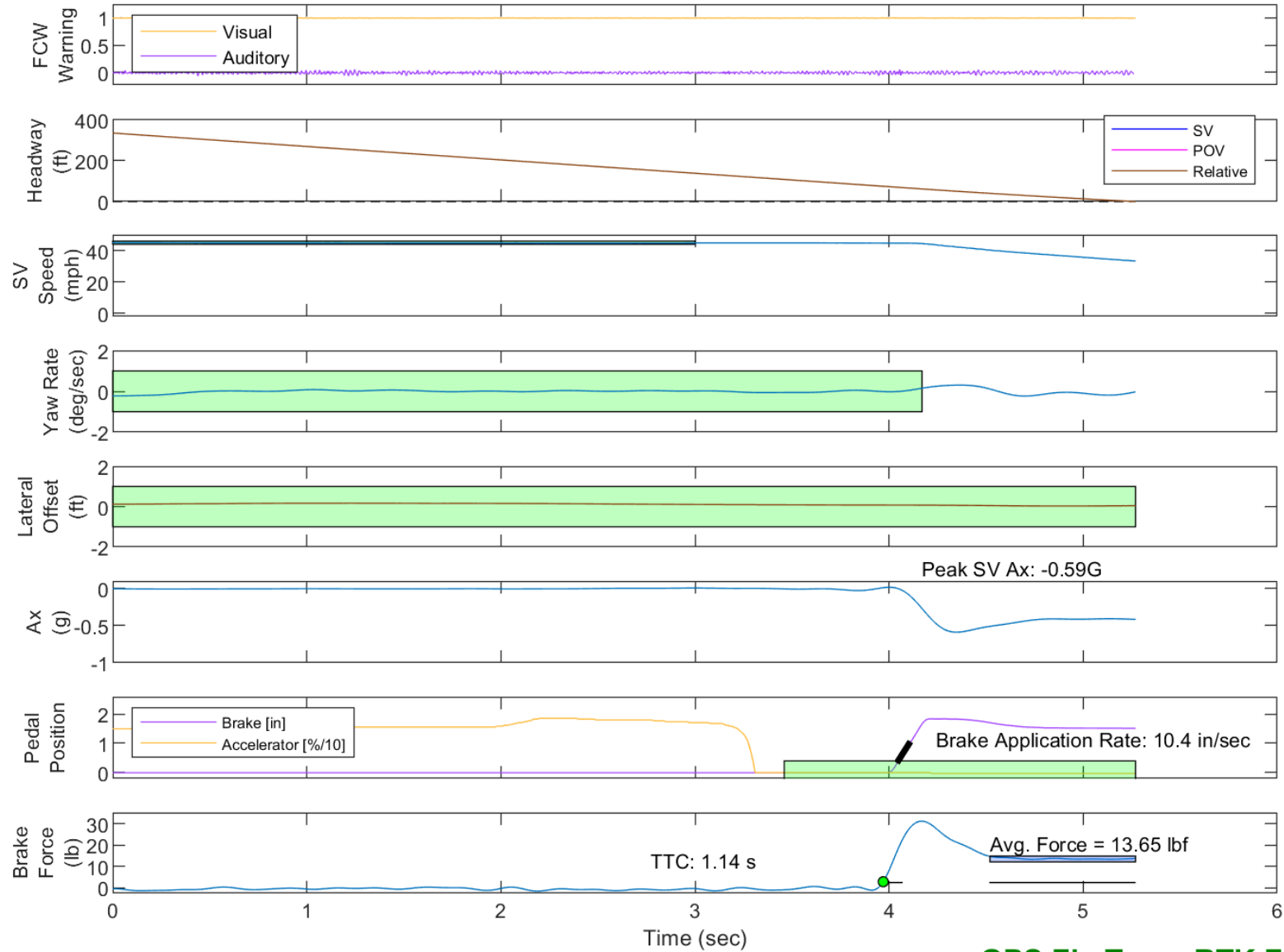


Figure E66. Time History for DBS Run 42, Test 4 - False Positive STP 45 mph



DBS Test 4: False Positive STP 45 mph  
ForteDBS-043



GPS Fix Type: RTK Fixed

Figure E67. Time History for DBS Run 43, Test 4 - False Positive STP 45 mph

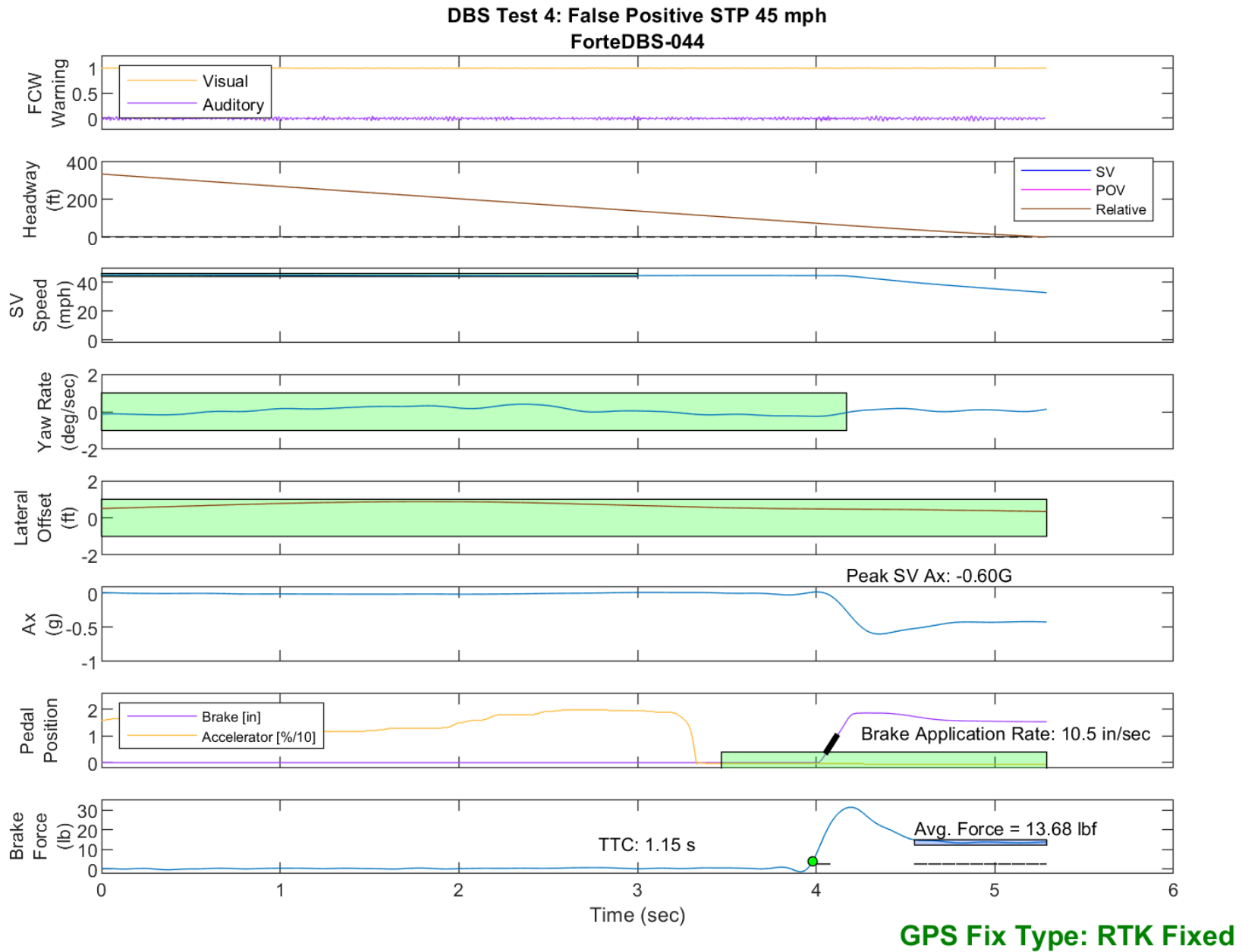
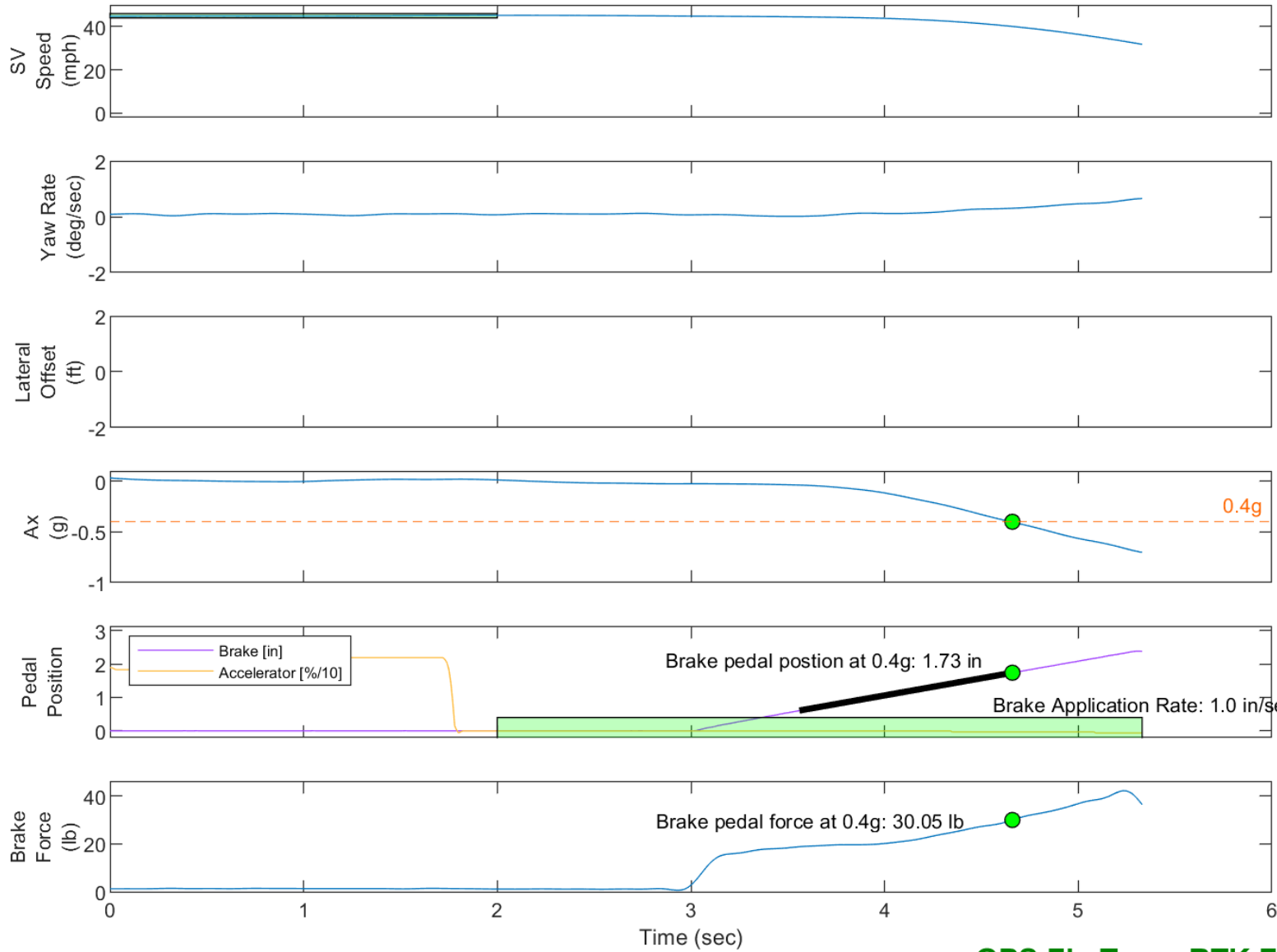


Figure E68. Time History for DBS Run 44, Test 4 - False Positive STP 45 mph

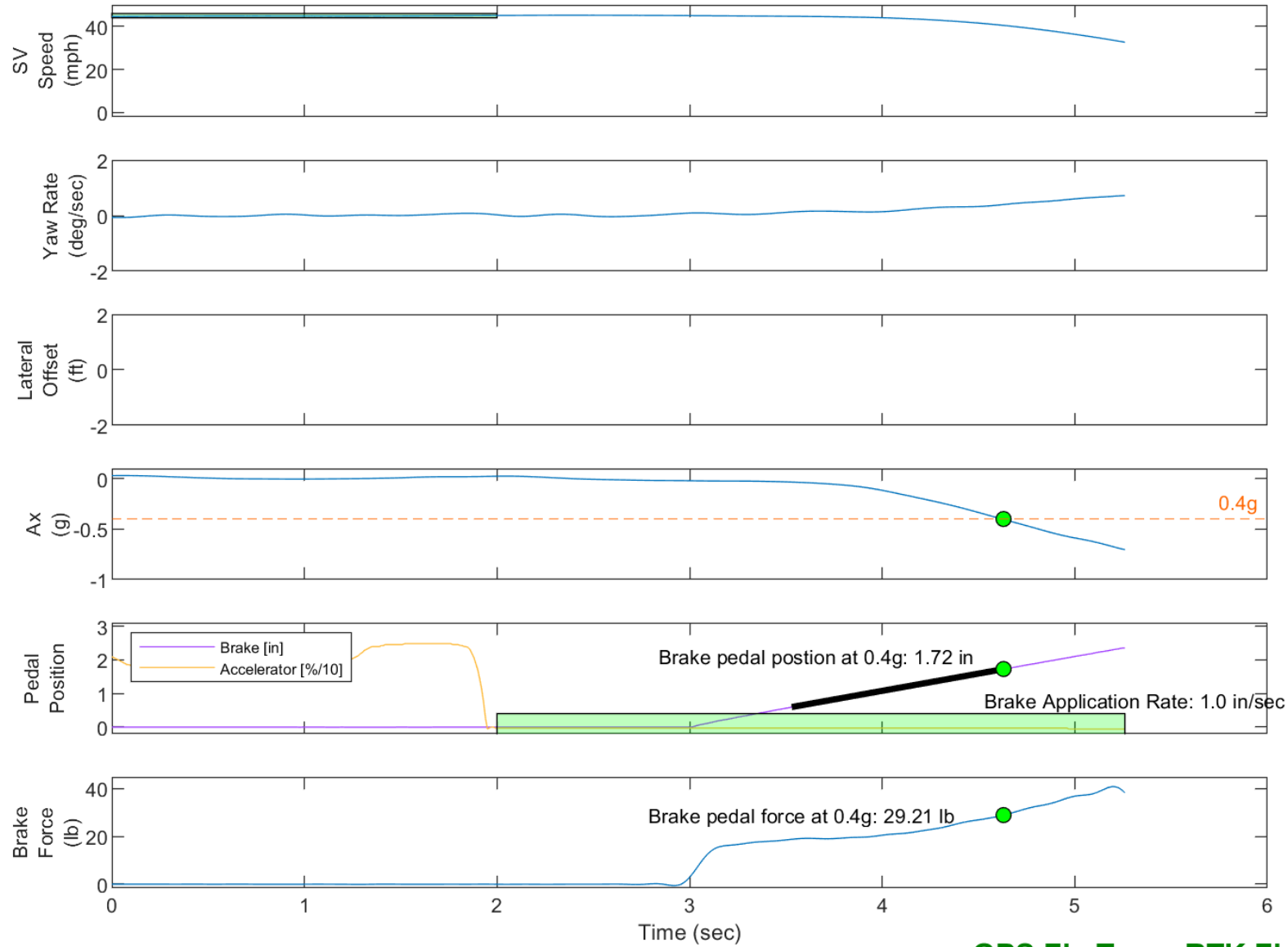
### DBS Test: Brake Characterization Initial Assessment ForteDBS-001



GPS Fix Type: RTK Fixed

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

### DBS Test: Brake Characterization Initial Assessment ForteDBS-002



GPS Fix Type: RTK Fixed

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

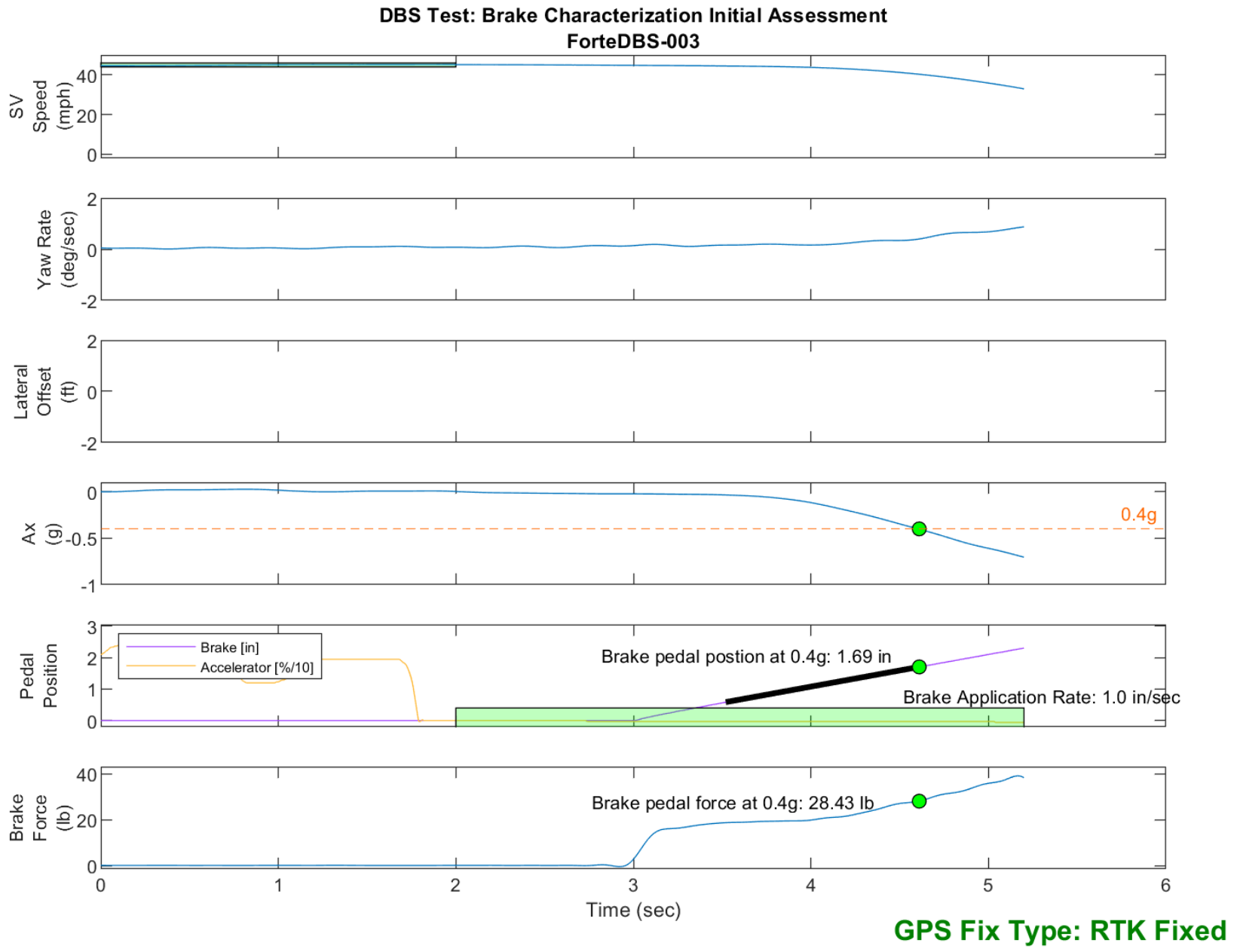


Figure E71. Time History for DBS Run 3, Brake Characterization Initial

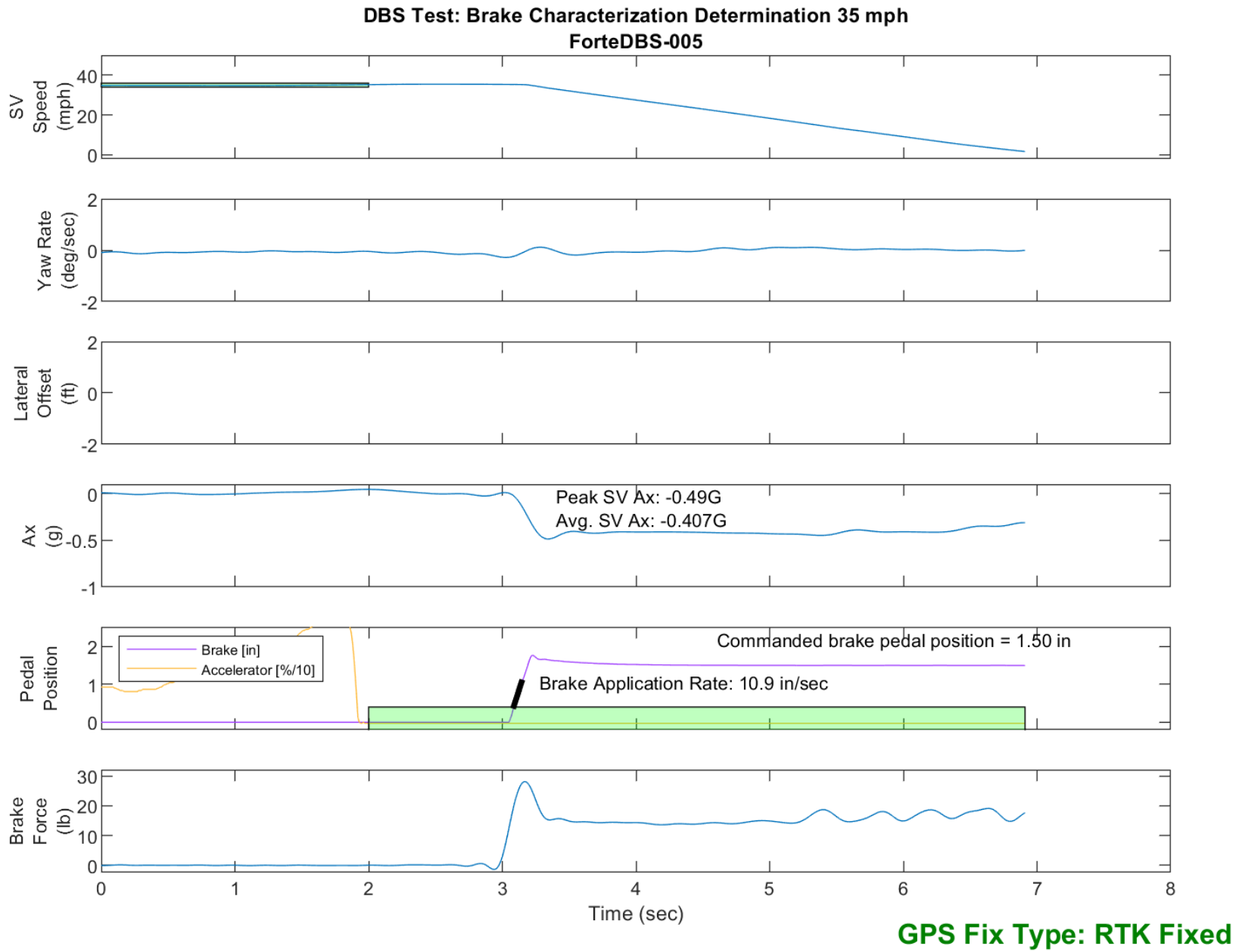
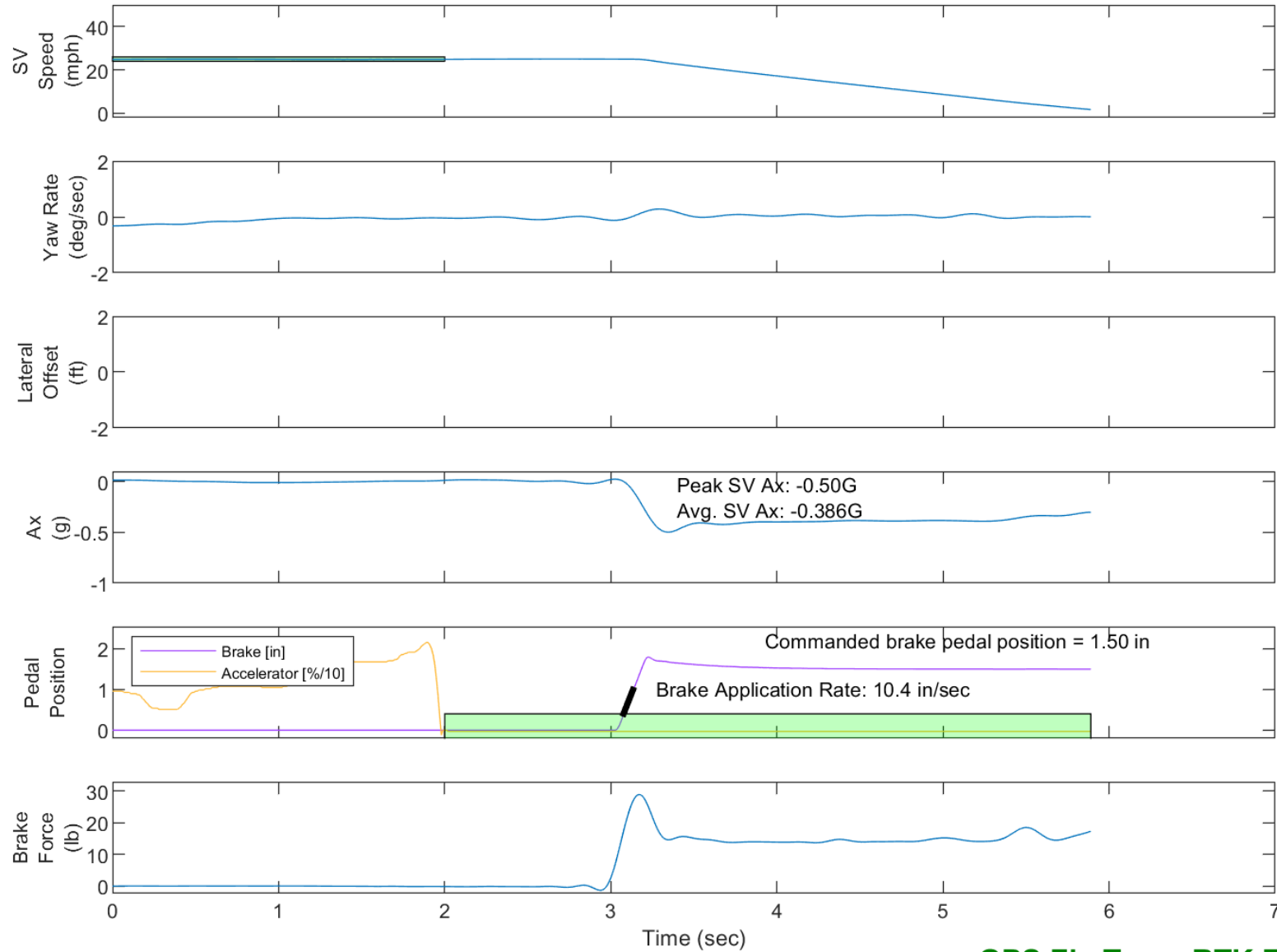


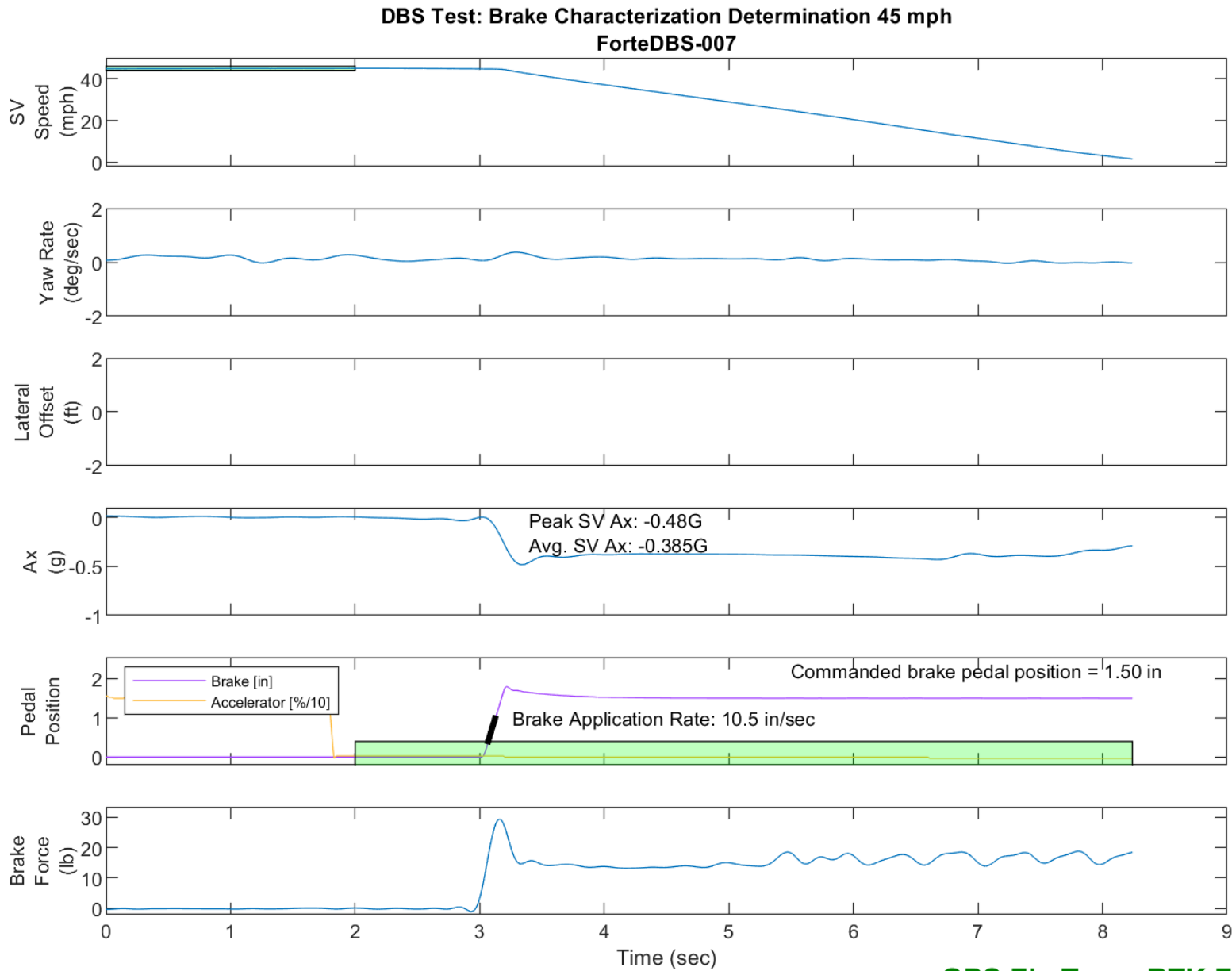
Figure E72. Time History for DBS Run 5, Brake Characterization Determination, Displacement Mode, 35 mph

### DBS Test: Brake Characterization Determination 25 mph ForteDBS-006



**GPS Fix Type: RTK Fixed**

Figure E73. Time History for DBS Run 6, Brake Characterization Determination, Displacement Mode, 25 mph



**GPS Fix Type: RTK Fixed**

Figure E74. Time History for DBS Run 7, Brake Characterization Determination, Displacement Mode, 45 mph



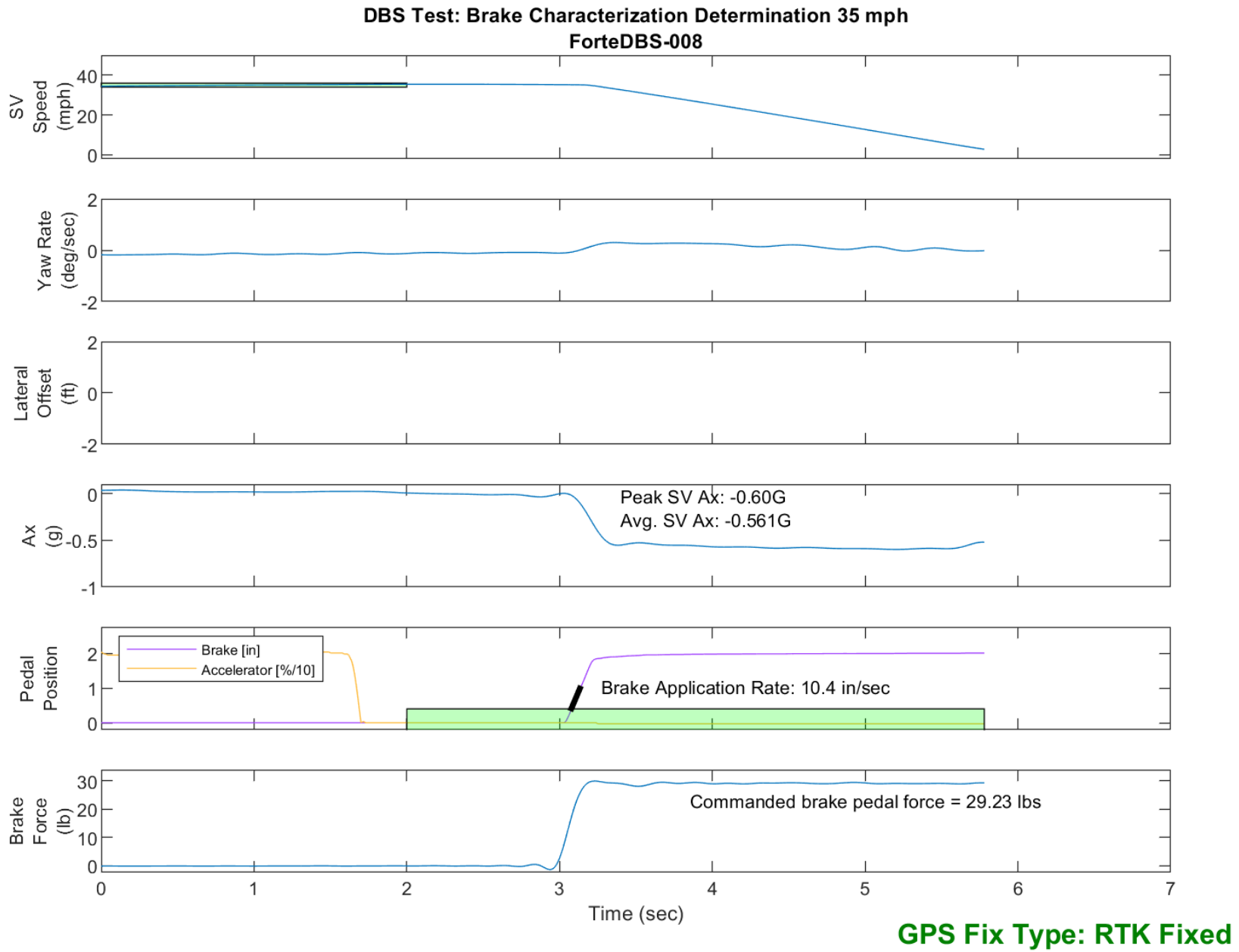


Figure E75. Time History for DBS Run 8, Brake Characterization Determination, Hybrid Mode, 35 mph

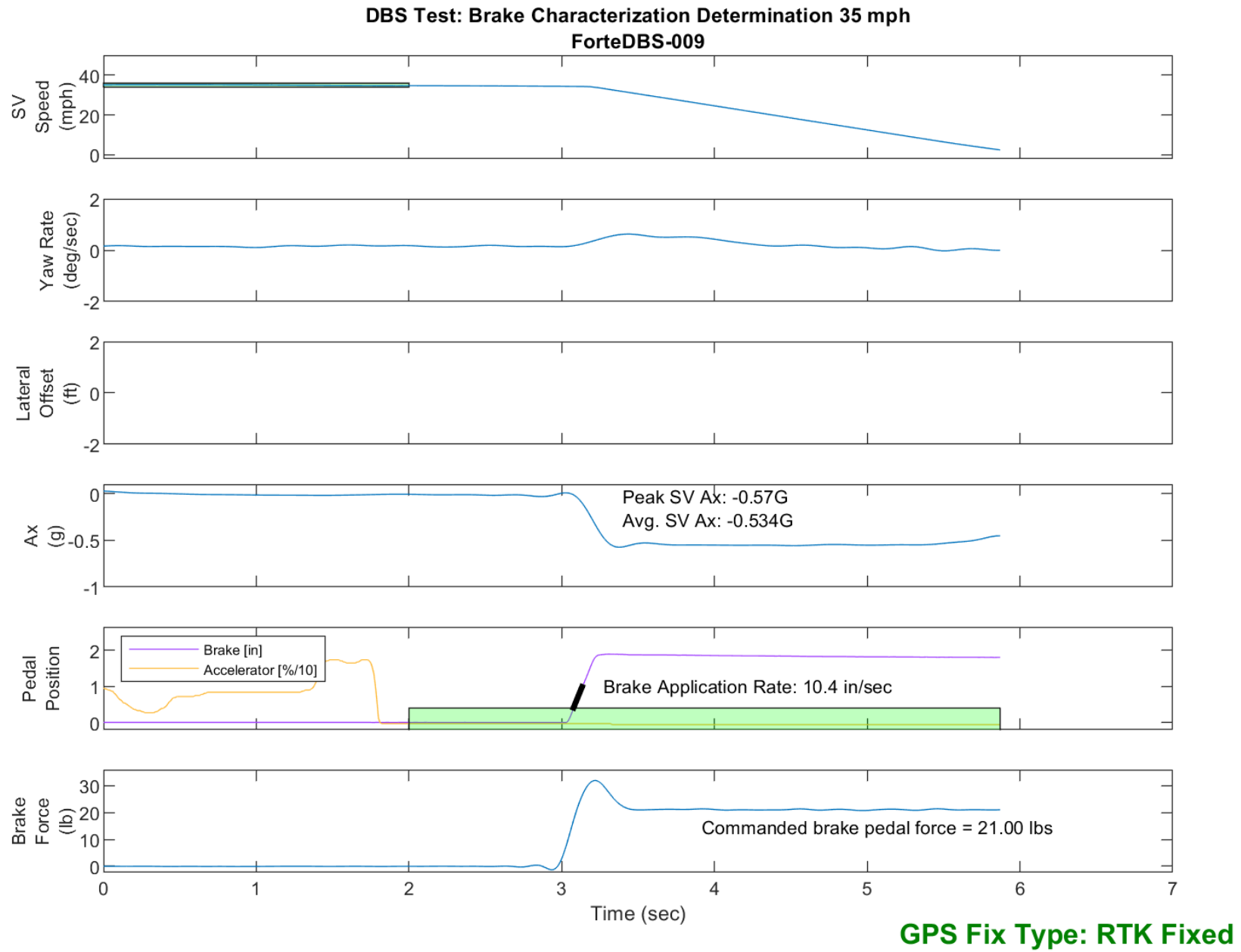


Figure E76. Time History for DBS Run 9, Brake Characterization Determination, Hybrid Mode, 35 mph

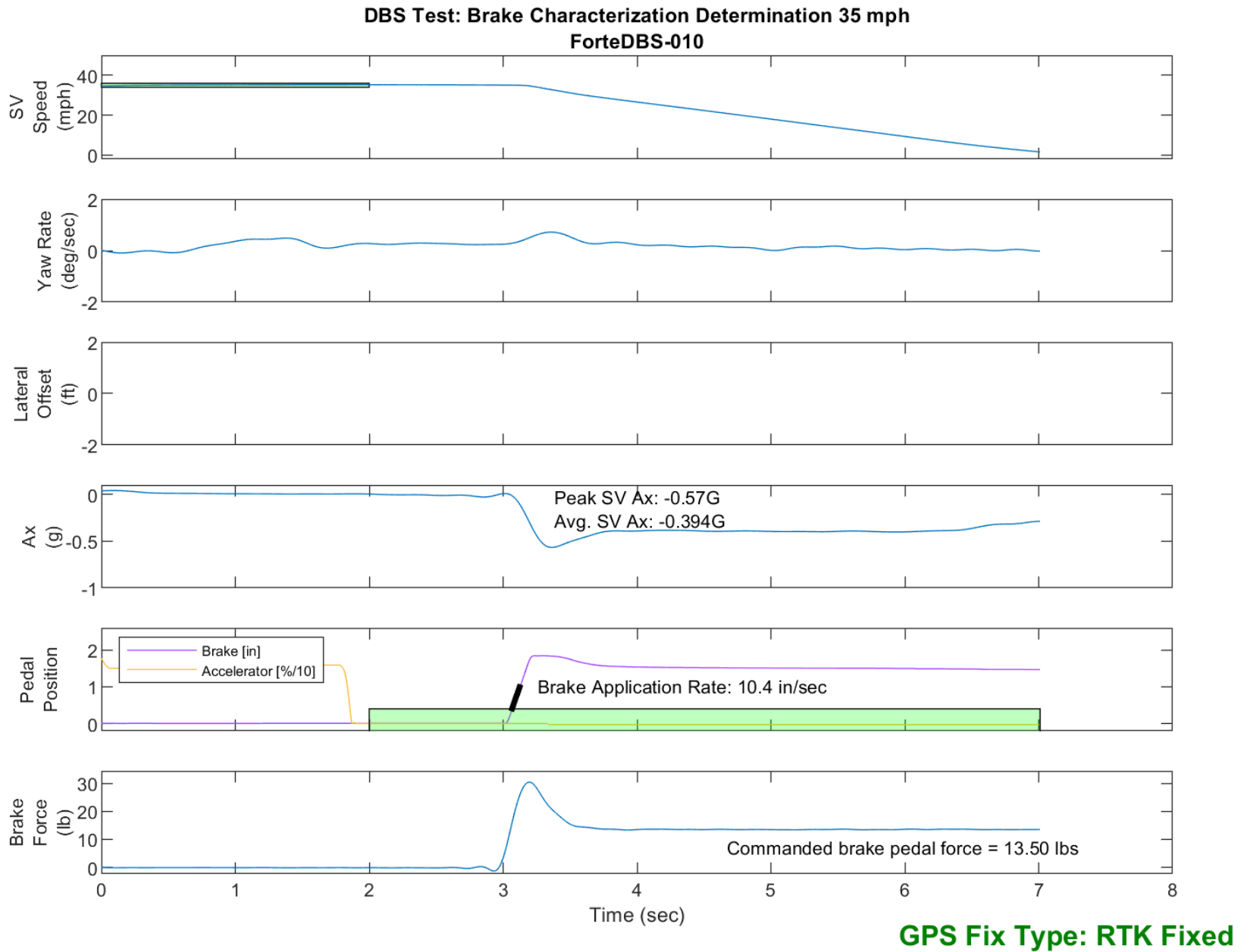


Figure E77. Time History for DBS Run 10, Brake Characterization Determination, Hybrid Mode, 35 mph

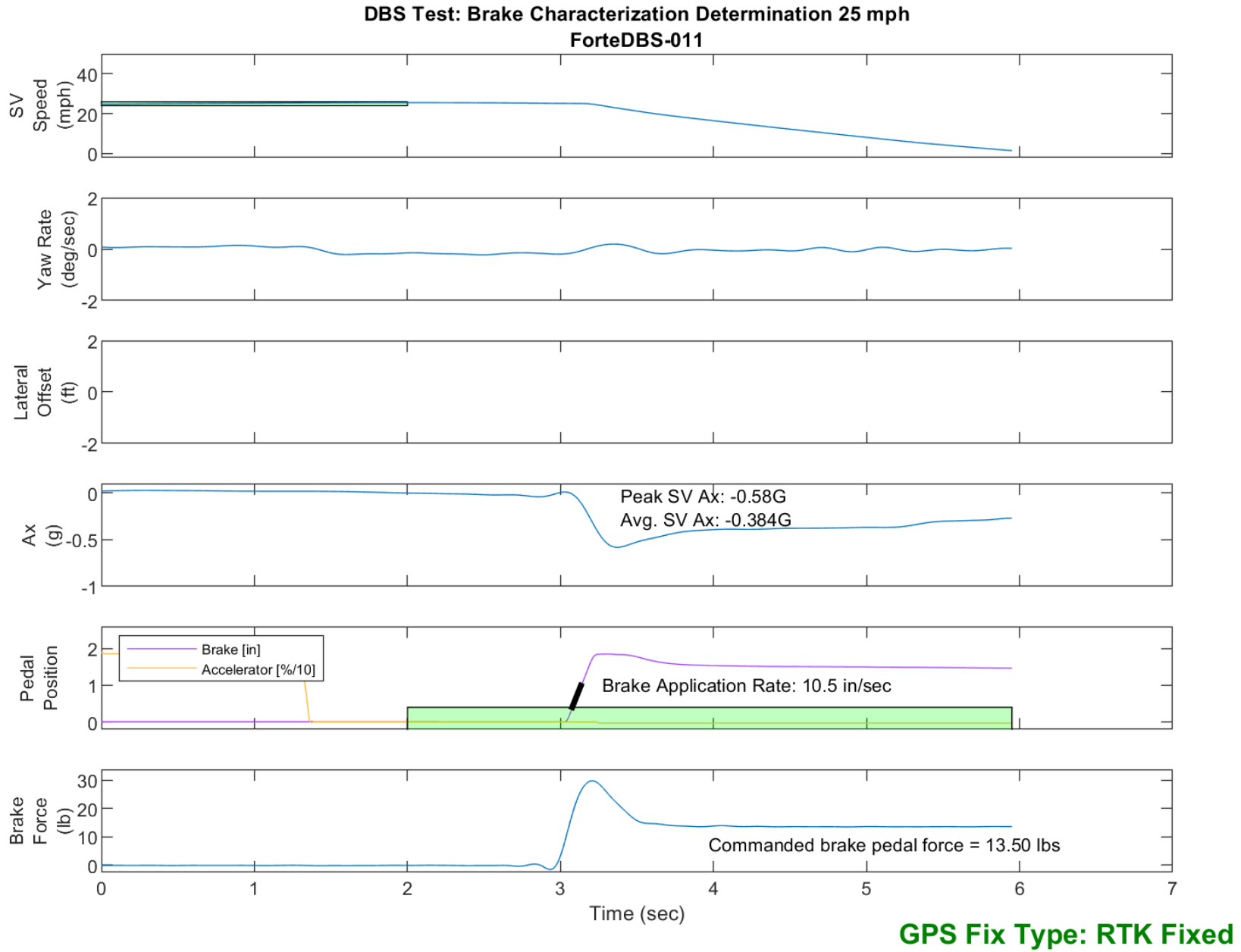
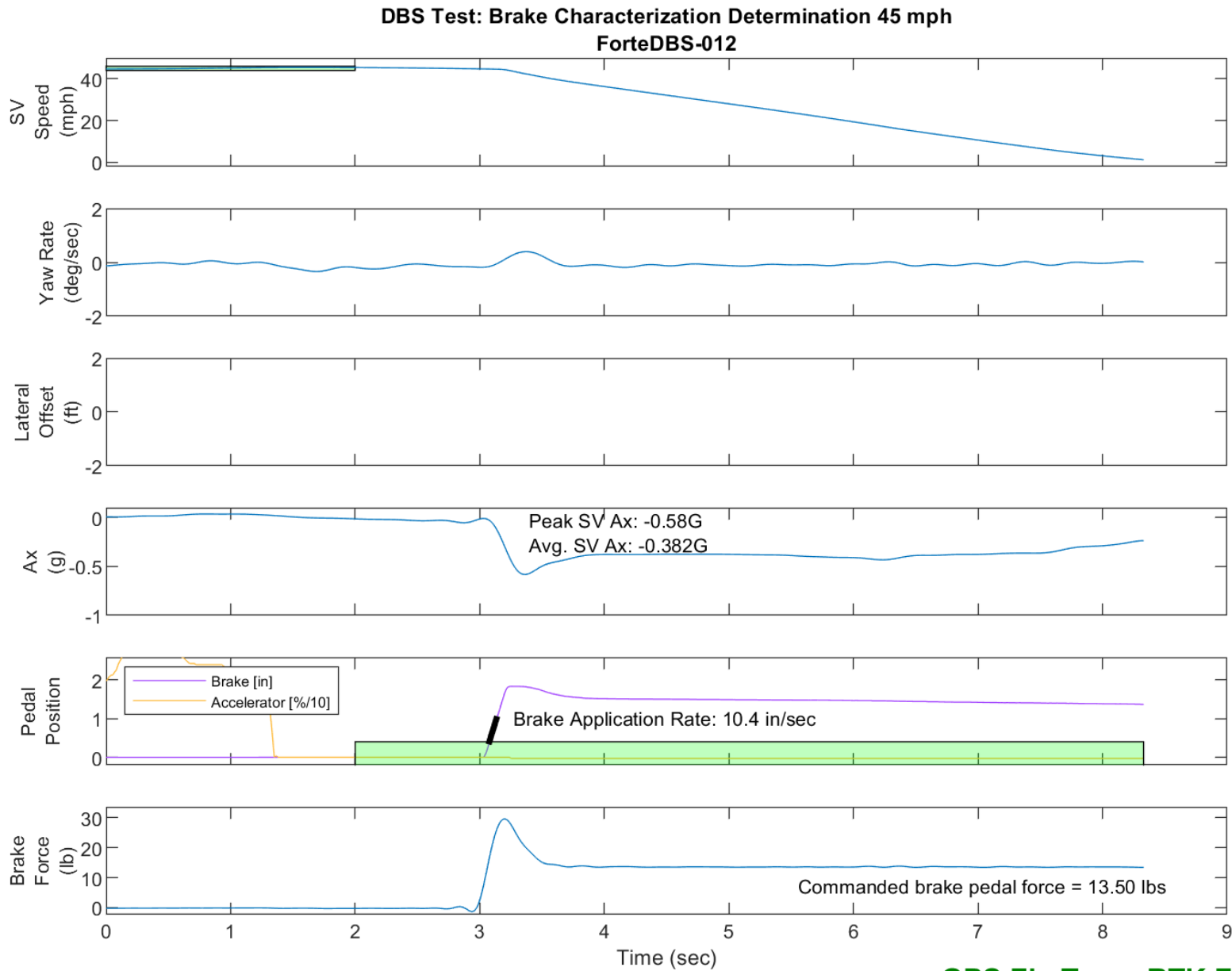


Figure E78. Time History for DBS Run 11, Brake Characterization Determination, Hybrid Mode, 25 mph



**GPS Fix Type: RTK Fixed**

Figure E79. Time History for DBS Run 12, Brake Characterization Determination, Hybrid Mode, 45 mph