

**NEW CAR ASSESSMENT PROGRAM  
DYNAMIC BRAKE SUPPORT SYSTEM CONFIRMATION TEST  
NCAP-DRI-DBS-21-05**

**2021 Dodge Durango GT Blacktop RWD**

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**15 April 2021**

**Final Report**

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

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16. Abstract These tests were conducted on the subject 2021 Dodge Durango GT Blacktop RWD in accordance with the specifications of the New Car Assessment Program's (NCAP) most current Test Procedure in docket NHTSA-2015-0006-0026; DYNAMIC BRAKE SUPPORT PERFORMANCE EVALUATION CONFIRMATION TEST FOR THE NEW CAR ASSESSMENT PROGRAM, October 2015. The vehicle only passed the steel plate false positive test scenarios and the slower moving POV 25 mph vs. 10 mph test scenario. It failed all other 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 .....	11
A. Test Procedure Overview .....	11
B. General Information .....	16
C. Principal Other Vehicle .....	19
D. Foundation Brake System Characterization .....	20
E. Brake Control .....	21
F. Instrumentation .....	22
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 2021 Dodge Durango GT Blacktop RWD. This test to assess Dynamic Brake Support systems is sponsored by the National Highway Traffic Safety Administration under Contract No. DTNH22-14-D-00333 with the New Car Assessment Program (NCAP).

Section II  
**DATA SHEETS**

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

(Page 1 of 1)

**2021 Dodge Durango GT Blacktop RWD**

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VIN: 1C4RDHDG8MC51xxxx

Test Date: 3/17/2021

Dynamic Brake Support System setting: Forward Collision Warning: Warning + Active Braking

Forward Collision Sensitivity: Medium

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

SV 25 mph: Fail

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

SV 25 mph POV 10 mph: Pass

SV 45 mph POV 20 mph: Fail

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

SV 35 mph POV 35 mph: Fail

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

SV 25 mph: Pass

SV 45 mph: Pass

**Overall: Fail**

Notes:





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

(Page 1 of 2)

2021 Dodge Durango GT Blacktop RWD

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**GENERAL INFORMATION**

Test date: 3/17/2021

**AMBIENT CONDITIONS**

Air temperature: 18.3 C (65 F)

Wind speed: 0.0 m/s (0.0 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: 250 kPa (36 psi)

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

(Page 2 of 2)

**2021 Dodge Durango GT Blacktop RWD**

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**WEIGHT**

Weight of vehicle as tested including driver and instrumentation

Left Front: 589.2 kg (1299 lb)

Right Front: 553.8 kg (1221 lb)

Left Rear: 598.7 kg (1320 lb)

Right Rear: 617.3 kg (1361 lb)

Total: 2359.0 kg (5201 lb)

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

(Page 1 of 4)

**2021 Dodge Durango GT Blacktop RWD**

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

Full-Speed Forward-Collision Warning Plus. It is available as an optional upgrade on the Durango, Durango SRT, Durango Pursuit models as part of the Technology Group. In the Owner's Manual it is referred to as Forward Collision Warning (FCW) and/or Forward Collision Warning (FCW) With Mitigation.

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

A camera is located in the top-center of the windshield. A radar is located behind the front vehicle fascia along the centerline of the vehicle.

System setting used for test (if applicable): Forward Collision Warning: Warning + Active Braking

Forward Collision Sensitivity: Medium

Brake application mode used for test: Hybrid control

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

2 km/h (1 mph) (Per manufacturer supplied information)

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

200 km/h (124 mph) (Per manufacturer supplied information)

Does the vehicle system require an initialization sequence/procedure?

Yes  
 No

If yes, please provide a full description.

**DYNAMIC BRAKE SUPPORT**

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

(Page 2 of 4)

**2021 Dodge Durango GT Blacktop RWD**

Will the system deactivate due to repeated AEB activations, impacts or near-misses?  Yes  
 No

If yes, please provide a full description.

In the event of 4 AEB events with braking within the same key cycle, the cluster will display the message "FCW NOT AVAILABLE AUTOBRAKE DISABLED" and AEB will not be available until the ignition is cycled (vehicle is stopped and restarted).

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.

In the event of a Forward Collision Warning event, a loud auditory warning will be provided to the driver before the initiation of automated braking. A series of three high-pitched loud beeps will be provided together with a message in the cluster indicating that the driver should brake. The text which will be displayed is: "Brake!" See Appendix A, Figure A15.

In the case of DBS, no haptic, visual, or audible alert is provided to the driver. The driver will, however, feel a stronger response in the brake pedal as the brake pedal will move downward more so than would normally be expected with the amount of pressure that the driver's applying. DBS is not applied until the driver applies some amount of braking force.

Note that the timing of braking specified in the test procedure is such that the auditory and visual warnings will always be displayed for the tests described in this report.

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

(Page 2 of 4)

**2021 Dodge Durango GT Blacktop RWD**

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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.

A center-mounted touchscreen is used to interact with the system menus. The hierarchy is:

Vehicle

Safety & Driving Assistance

Automatic Emergency Braking

Forward Collision Warning

Select from "Off", "Only Warning", or "Warning + Active Braking"

See Appendix A, Figure A14.

System settings are stored across ignition cycles.

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

If yes, please provide a full description.

A center mounted touchscreen is used to interact with the system menus. The hierarchy is:

Vehicle

Safety & Driving Assistance

Automatic Emergency Braking

Forward Collision Sensitivity

Select from "Near", "Medium", or "Far"

See Appendix A, Figure A14.

System settings are stored across ignition cycles.

**DYNAMIC BRAKE SUPPORT**

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

(Page 4 of 4)

**2021 Dodge Durango GT Blacktop RWD**

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Are there other driving modes or conditions that render DBS inoperable or reduce its effectiveness?  Yes  
 No

If yes, please provide a full description.

Avoid driving into the sun for long intervals of time when the sun is at a low elevation angle above the horizon. Also make sure that a significant amount of snow does not accumulate on the fascia in the area that covers the radar (vehicle centerline).

Notes:

Radar blindness. If the vehicle is moving and the radar sees no targets for a period of approximately 2 minutes, AEB will become unavailable. An audible indication will be provided to the driver and the cluster will display the message "Wipe Front Radar Sensor in Front of Vehicle." This condition can be remedied by restarting the vehicle and letting the radar see stationary objects or moving vehicles.

Camera blindness. Camera blindness can generally be avoided by not attempting to drive for long intervals toward the sun when it is at a low elevation angle in the horizon. In the event that the camera becomes blinded, a message stating "ACC/FCW Limited Functionality" will be displayed. In the event that the camera detects a situation of limited visibility because of the dirty windshield, a message stating "ACC/FCW Limited Functionality Clean Front Windshield" will be displayed.

## 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.

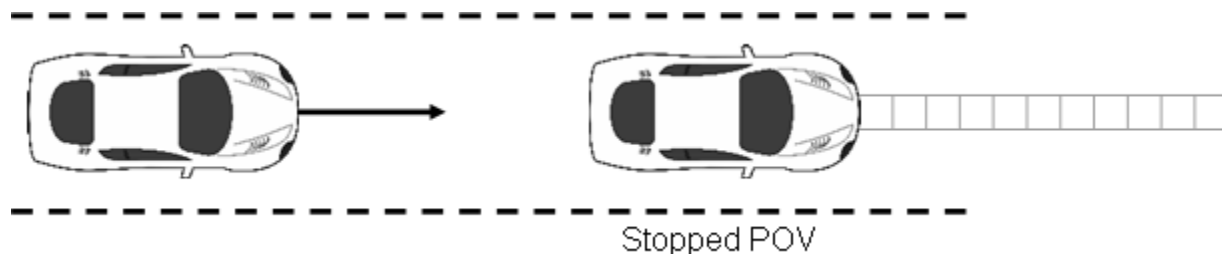


Figure 1. Depiction of Test 1

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

- The SV came into contact with the POV or

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

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

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

**Table 1. Nominal Stopped POV DBS Test Choreography**

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

b. Criteria

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

**2. 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.

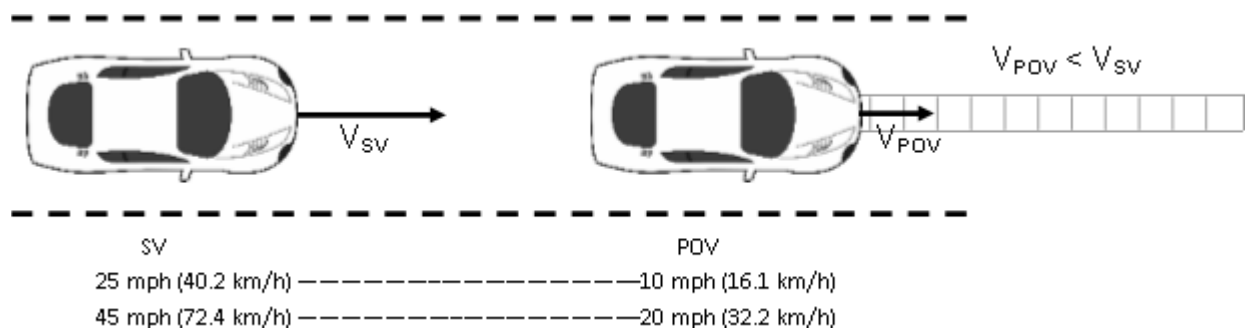


Figure 2. Depiction of Test 2



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

The test concluded when either:

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

The SV driver then braked to a stop.

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

- The lateral distance between the centerline of the POV and the center of the travel lane could not deviate more than  $\pm 1$  ft (0.3 m) 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  $t_{FCW}$ .
- 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 $\rightarrow$ $t_{FCW}$	110 ft (34 m) $\rightarrow$ $t_{FCW}$	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 $\rightarrow$ $t_{FCW}$	183 ft (56 m) $\rightarrow$ $t_{FCW}$	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.

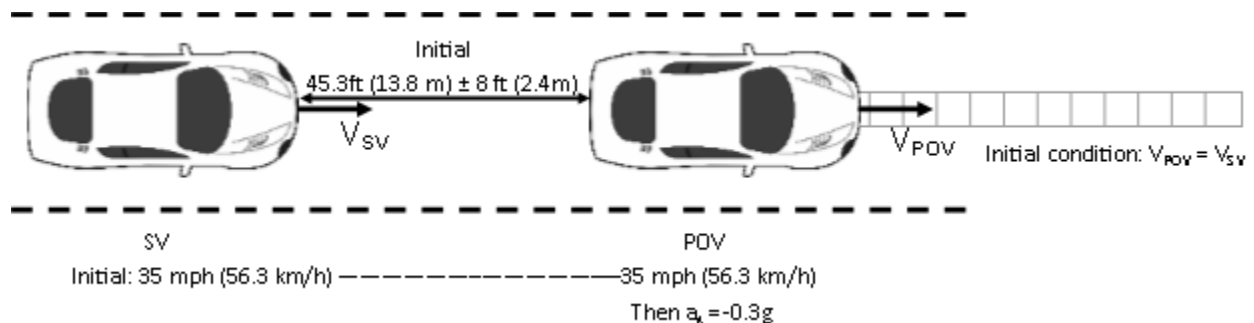


Figure 3. Depiction of Test 3

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  $0.3 \pm 0.03 g$ . The SV throttle pedal was released within 500 ms of  $t_{FCW}$ , and the SV brakes were applied when TTC was 1.4 seconds (31.5 ft (9.6 m)).

The test concluded when either:

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

The SV driver then braked to a stop.

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

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

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

- The SV and POV speed could not deviate more than  $\pm 1.0$  mph (1.6 km/h) during an interval defined by the onset of the validity period to the onset of POV braking.
- The average POV deceleration could not deviate by more than  $\pm 0.03$  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 each of the test series.

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

For Tests 1, 2, and 3, the SV was positioned such that it just contacted a vertical plane defining the rearmost location of the POV. For Test 4, the front-most location of the SV was positioned such that it just reached a vertical plane defined by the leading edge of

the STP first encountered by the SV (i.e., just before it is driven onto the STP). This is the “zero position.”

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

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

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

## 5. 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: 8/18/2020 Due: 8/18/2021
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform	0.1% of reading	Intercomp SW wireless	0410MN20001	By: DRI Date: 4/20/2020 Due: 4/20/2021
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	45040532	By: DRI Date: 7/2/2020 Due: 7/2/2021
Load Cell	Force applied to brake pedal					By: DRI
		0-250 lb 1112 N	0.05% FS	Stellar Technology PNC700	1607338	Date: 7/2/2020 Due: 7/2/2021
		0 - 250 lb 0 -1112 N	0.1% FS	Honeywell 41A	1464391	Date: 2/4/2021 Due: 2/4/2022
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	N/A

**Table 5. Test Instrumentation and Equipment (continued)**

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels;	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;				2258	Date: 5/3/2019 Due: 5/3/2021
	Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles				2182	Date: 9/16/2019 Due: 9/16/2021
Real-Time Calculation of Position and Velocity Relative to Lane Markings (LDW) and POV (FCW)	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: $\pm 30$ 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: 1/6/2021 Due: 1/6/2022
Type	Description			Mfr, Model	Serial Number	
Data Acquisition System	Data acquisition is achieved using a dSPACE MicroAutoBox II. Data from the Oxford IMU, including Longitudinal, Lateral, and Vertical Acceleration, Roll, Yaw, and Pitch Rate, Forward and Lateral Velocity, Roll and Pitch Angle are sent over Ethernet to the MicroAutoBox. The Oxford IMUs are calibrated per the manufacturer's recommended schedule (listed above).			dSPACE Micro-Autobox II 1401/1513		
				Base Board	549068	
				I/O Board	588523	

## APPENDIX A

### Photographs

## LIST OF FIGURES

	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. Sensors for Detecting Visual and Auditory Alerts .....	A-13
Figure A12. Computer and Brake Actuator Installed in Subject Vehicle.....	A-14
Figure A13. Brake Actuator Installed in POV System .....	A-15
Figure A14. AEB Setup Menus .....	A-16
Figure A15. Visual Alert .....	A-17



Figure A1. Front View of Subject Vehicle

A-3





Figure A2. Rear View of Subject Vehicle

2021 **DODGE**  
**DURANGO GT BLACKTOP RWD**

For more information visit: [www.dodge.com](http://www.dodge.com)  
or call 1-800-4ADODGE

FCA US LLC

THIS VEHICLE IS MANUFACTURED TO MEET SPECIFIC UNITED STATES REQUIREMENTS. THIS VEHICLE IS NOT MANUFACTURED FOR SALE OR REGISTRATION OUTSIDE OF THE UNITED STATES.

MANUFACTURER'S SUGGESTED RETAIL PRICE OF THIS MODEL INCLUDING DEALER PREPARATION

Base Price: **\$35,965**

**DODGE DURANGO GT RWD**

Exterior Color: DB Black Clear-Coat Exterior Paint  
Interior Color: Black Interior Color  
Interior: Leather-Trimmed Bucket Seats  
Engine: 3.6L V6 24V VVT Pentastar Engine  
Transmission: 8-Speed Automatic 850RE Transmission

**STANDARD EQUIPMENT** (UNLESS REPLACED BY OPTIONAL EQUIPMENT)

**FUNCTIONAL/SAFETY FEATURES**

Advanced Multistage Front Air Bags  
Supplemental Side Curtain All Rows Air Bags  
Supplemental Front Seat-Mounted Side Air Bags  
Driver Inflation Knee-Bolster Air Bag  
Heavy-Duty 4-Wheel Disc Anti-Lock Brakes  
Electronic Stability Control  
Rain-Brake Support  
Sport Mode  
Selectable Steering Modes  
Speed Control  
ParkView® Rear Back-Up Camera  
ParkSense® Rear Park Assist with Stop  
Remote-Proximity Keyless-Entry  
Push-Button Start  
Sentry Key® Theft Deterrent System  
Capless Fuel-Fill  
24.6-Gallon Fuel Tank

**INTERIOR FEATURES**

Cloth Bucket Seats with Shift Insert  
8.4-Inch Touchscreen Display  
Full Function Media Hub with 2 USB Plus Aux Port

**OPTIONAL EQUIPMENT** (May Replace Standard Equipment)

Leather-Trimmed Bucket Seats **\$795**  
**Customer Preferred Package ZBE** **\$4,000**  
150-Amp Alternator  
Bright Front Door Sill Scuff Pads  
Bright Cargo-Area Scuff Pads  
Sun Visors with Illuminated Vanity Mirrors  
Automatic-Dimming Exterior Driver Mirror  
6-Inch x 9-Inch Multi-Function Fold-Away Mirrors  
115-Volt Auxiliary Power-Outlet  
Heated Front Seats  
Heated Second-Row Seats  
Power Liftgate  
Power Driver / Passenger 4-Way Lumbar Adjust  
6-Way Power Memory Driver and 6-Way Passenger Seats  
Exterior Mirrors with Supplemental Signals  
Exterior Mirrors with Memory  
Memory for Radio, Driver Seat and Exterior Mirrors  
Security Alarm  
Heated Steering Wheel  
Dual Remote USB Port - Charge Only  
Remote-Start System

Universal Garage-Door Opener Technology Group **\$2,495**  
Advanced Brake-Assist  
Rain-Sensitive Windshield Wipers  
Lane-Departure Warning Plus  
Full-Speed Forward-Collision Warning Plus  
Adaptive Cruise Control with Stop  
Blacktop Package **\$1,295**  
20-Inch x 8-Inch Black Noise Aluminum Wheels  
Gloss-Black Badges  
Premium Group I **\$2,495**  
Power Sunroof  
GPS Navigation  
Black Roof Rails  
Integrated Roof Rail Crossbars  
9 Alpine® Amplified Speakers with Subwoofer  
505-Watt Amplifier  
SiriusXM Guardian™ Connected Service w/Trial Period  
4G LTE Wi-Fi Hot Spot  
SiriusXM® with 360L  
Connected Travel & Traffic Services  
Uconnect® 5 Navigation with 10.1-Inch Display  
For Details, Visit [DriveUconnect.com](http://DriveUconnect.com)  
Global Telematics Box Module (TBM) **\$1,195**  
2nd-Row Fold and Tumble Captain Chairs  
2nd-Row Mini Console with Cupholders  
6-Passenger Seating  
2nd-Row Seat Mounted Inboard Armrests  
Performance Hood **\$1,495**  
Blind-Spot and Cross-Path Detection **\$495**

DESTINATION CHARGE **\$1,495**

**TOTAL PRICE: \*\$51,725**

**WARRANTY COVERAGE**

5-year or 60,000-mile Powertrain Limited Warranty.  
3-year or 36,000-mile Basic Limited Warranty.  
Ask Dealer for a copy of the limited warranties or see your owner's manual for details.

**5 YEAR / 60,000 MILE**  
**POWERTRAIN WARRANTY**

**EPA DOT Fuel Economy and Environment**

Gasoline Vehicle

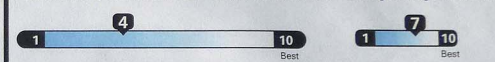
**Fuel Economy** These estimates reflect new EPA methods beginning with 2017 models. Standard SUV 2WD range from 13 to 101 MPGe. The best vehicle rates 141 MPGe.

**21** **MPG**  
combined city/hwy city highway  
**4.8** gallons per 100 miles

**You spend \$2,250**  
more in fuel costs over 5 years compared to the average new vehicle.

Annual fuel cost **\$1,950**

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



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 cost \$7,500 to fuel over 5 years. Cost estimates are based on 15,000 miles per year at \$2.70 per gallon. MPGe 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



**GOVERNMENT 5-STAR SAFETY RATINGS**

**Overall Vehicle Score** Not Rated  
Based on the combined ratings of frontal, side and rollover. Should ONLY be compared to other vehicles of similar size and weight.

**Frontal Crash** Driver Not Rated  
Passenger Not Rated  
Based on the risk of injury in a frontal impact. Should ONLY be compared to other vehicles of similar size and weight.

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

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

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

The safety ratings above are based on Federal Government tests of particular vehicles equipped with certain features and options. The performance of this vehicle may differ.

**PARTS CONTENT INFORMATION**  
FOR VEHICLES IN THIS CARLINE:  
U.S./CANADIAN PARTS CONTENT: 67%  
MAJOR SOURCES OF FOREIGN PARTS CONTENT:  
MEXICO: 22%  
NOTE: PARTS CONTENT DOES NOT INCLUDE FINAL ASSEMBLY, DISTRIBUTION, OR OTHER NON-PARTS COSTS.  
FOR THIS VEHICLE:  
FINAL ASSEMBLY POINT:  
DETROIT, MICHIGAN, U.S.A.  
COUNTRY OF ORIGIN:  
ENGINE: MEXICO  
TRANSMISSION: UNITED STATES

Assembly Point/Port of Entry: DETROIT, MICHIGAN, U.S.A.

SHIP TO:

SOLO TO:

VIN: 1C4RDHG8MC-51

L4-VIN: 9388

1118



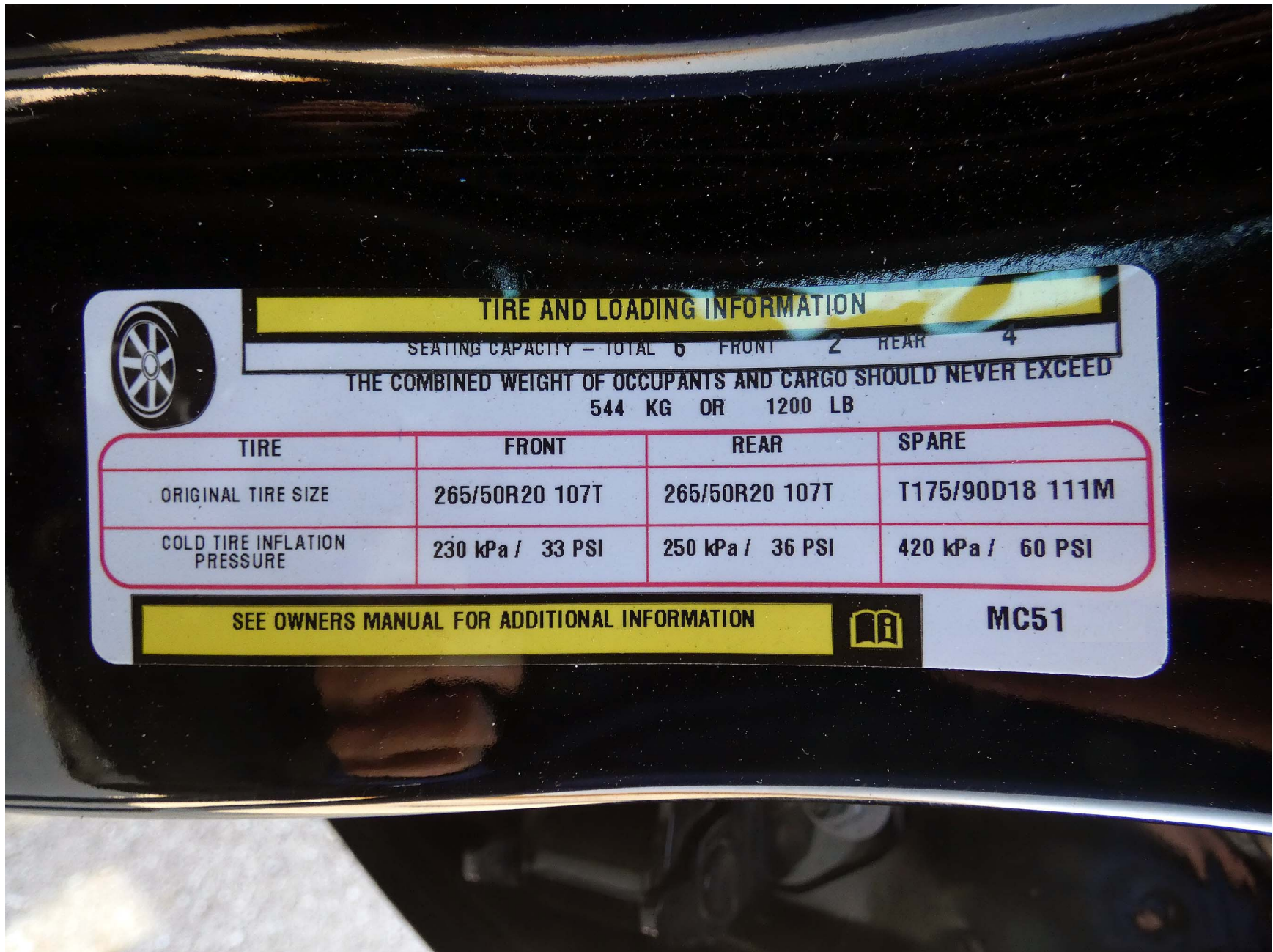
THIS LABEL IS ADDED TO THIS VEHICLE TO COMPLY WITH FEDERAL LAW. THE LABEL CANNOT BE REMOVED OR ALTERED PRIOR TO DELIVERY TO THE ULTIMATE PURCHASER.  
\* STATE AND/OR LOCAL TAXES IF ANY, LICENSE AND TITLE FEES AND DEALER SUPPLIED AND INSTALLED OPTIONS AND ACCESSORIES ARE NOT INCLUDED IN THIS PRICE. DISCOUNT, IF ANY, IS BASED ON PRICE OF OPTION IF PURCHASED SEPARATELY.



Figure A3. Window Sticker (Monroney Label)



Figure A4. Vehicle Certification Label



**TIRE AND LOADING INFORMATION**

SEATING CAPACITY - TOTAL **6** FRONT **2** REAR **4**

THE COMBINED WEIGHT OF OCCUPANTS AND CARGO SHOULD NEVER EXCEED  
544 KG OR 1200 LB

TIRE	FRONT	REAR	SPARE
ORIGINAL TIRE SIZE	265/50R20 107T	265/50R20 107T	T175/90D18 111M
COLD TIRE INFLATION PRESSURE	230 kPa / 33 PSI	250 kPa / 36 PSI	420 kPa / 60 PSI

SEE OWNERS MANUAL FOR ADDITIONAL INFORMATION



**MC51**

Figure A5. Tire Placard



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



Figure A7. Load Frame/Slider of SSV

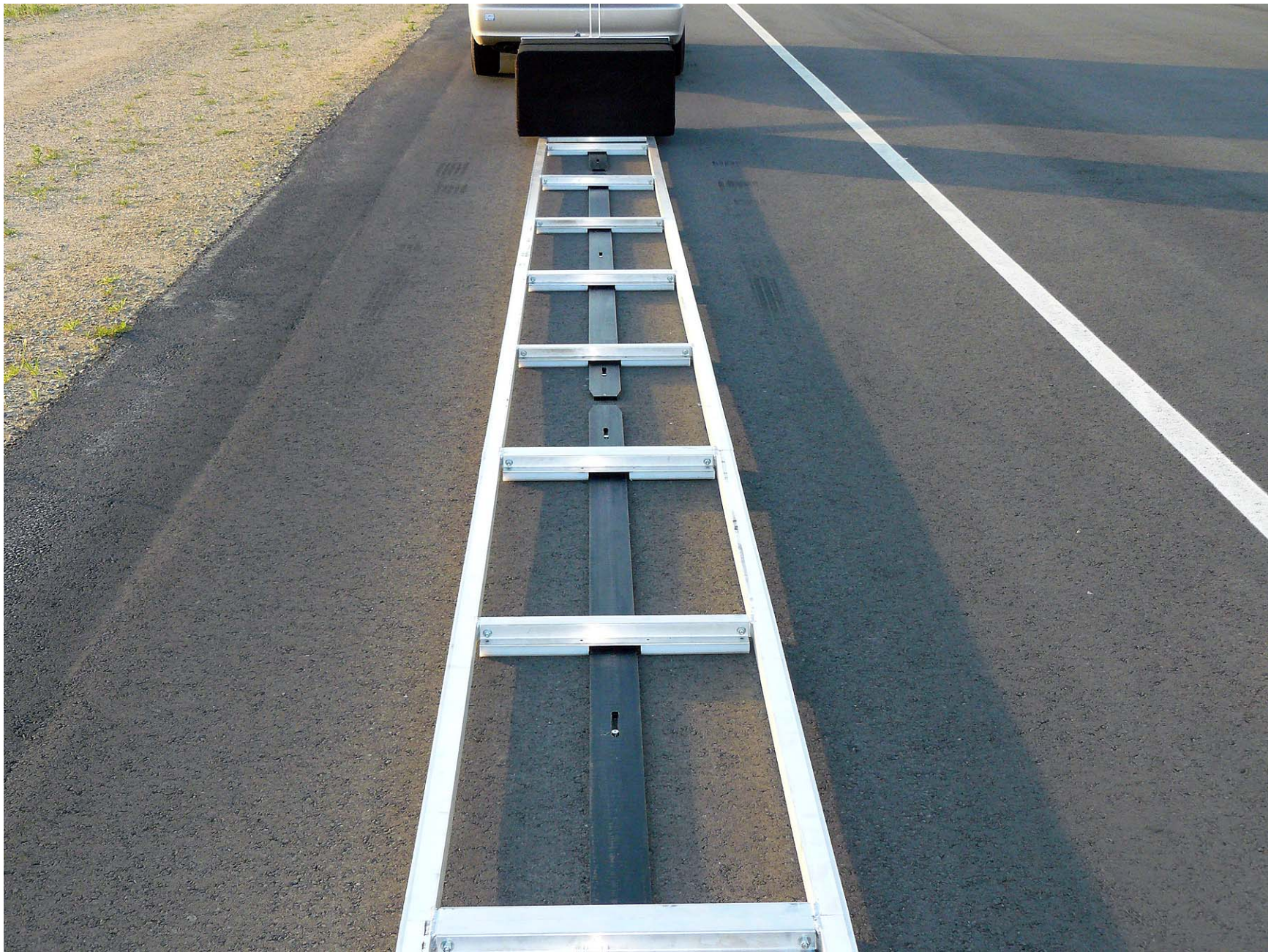


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track



Figure A9. Steel Trench Plate  
A-11





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



Figure A11. Sensors for Detecting Visual and Auditory Alerts



Figure A12. Computer and Brake Actuator Installed in Subject Vehicle



Figure A13. Brake Actuator Installed in POV System

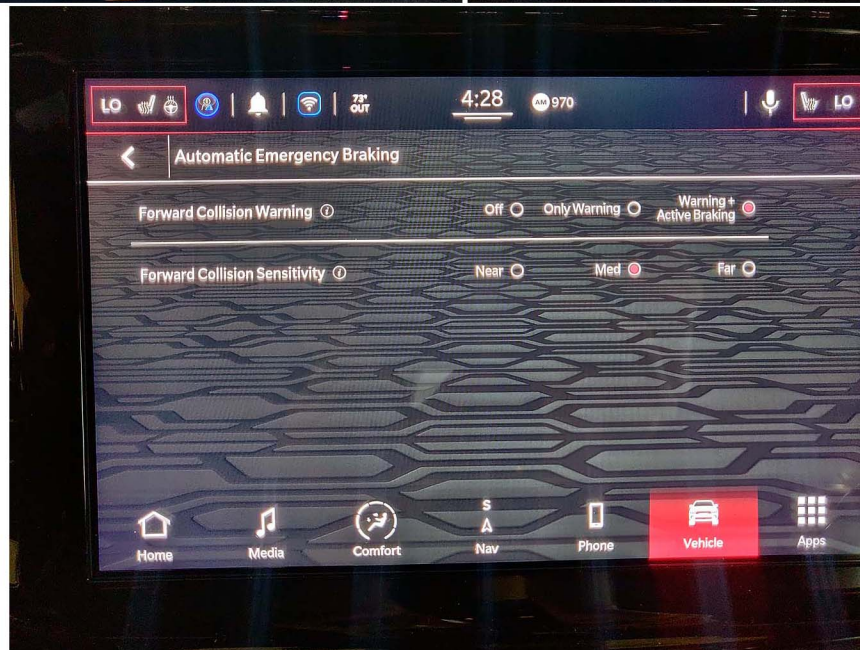
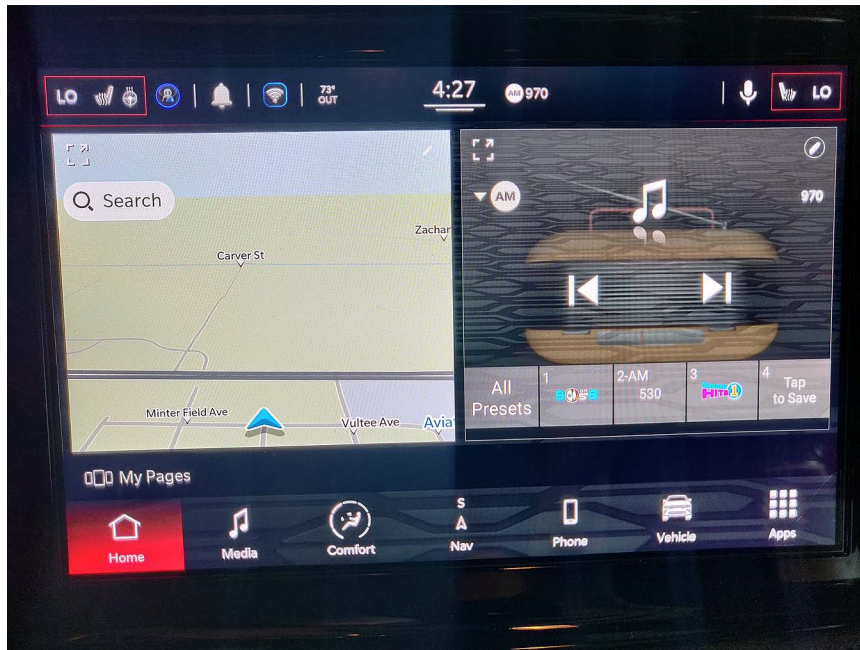





Figure A14. AEB Setup Menus  
A-16






Figure A15. Visual Alert  
A-17




## APPENDIX B

Excerpts from Owner's Manual

Yellow Warning Lights	
	Service Forward Collision Warning (FCW) Light – If Equipped ⇨ page 103
	Service Adaptive Cruise Control Warning Light – If Equipped ⇨ page 104
	Service AWD Warning Light – If Equipped ⇨ page 104
	Service Stop/Start System Warning Light – If Equipped ⇨ page 104
	LaneSense Warning Light – If Equipped ⇨ page 104
	Service LaneSense Warning Light – If Equipped ⇨ page 104
	Cruise Control Fault Warning Light – If Equipped ⇨ page 104

Yellow Indicator Lights	
	Forward Collision Warning (FCW) OFF Indicator Light – If Equipped ⇨ page 104
	All Wheel Drive (AWD) Low Indicator Light – If Equipped ⇨ page 104
	NEUTRAL Indicator Light – If Equipped ⇨ page 104

1

Green Indicator Lights	
	Adaptive Cruise Control (ACC) Set With Target Light – If Equipped ⇨ page 104
	Adaptive Cruise Control (ACC) Set Without Target Light – If Equipped ⇨ page 104
	Cruise Control Set Indicator Light – If Equipped ⇨ page 105



and can lead to tire failure. Underinflation also reduces fuel efficiency and tire tread life, and may affect the vehicle's handling and stopping ability.

Please note that the TPMS is not a substitute for proper tire maintenance, and it is the driver's responsibility to maintain correct tire pressure, even if underinflation has not reached the level to trigger illumination of the TPMS low tire pressure telltale.

Your vehicle has also been equipped with a TPMS malfunction indicator to indicate when the system is not operating properly. The TPMS malfunction indicator is combined with the low tire pressure telltale. When the system detects a malfunction, the telltale will flash for approximately one minute and then remain continuously illuminated. This sequence will continue upon subsequent vehicle start-ups as long as the malfunction exists. When the malfunction indicator is illuminated, the system may not be able to detect or signal low tire pressure as intended. TPMS malfunctions may occur for a variety of reasons, including the installation of replacement or alternate tires or wheels on the vehicle that prevent the TPMS from functioning properly. Always check the TPMS malfunction telltale after replacing one or more tires or wheels

on your vehicle to ensure that the replacement or alternate tires and wheels allow the TPMS to continue to function properly.

#### CAUTION!

The TPMS has been optimized for the original equipment tires and wheels. TPMS pressures and warning have been established for the tire size equipped on your vehicle. Undesirable system operation or sensor damage may result when using replacement equipment that is not of the same size, type, and/or style. Aftermarket wheels can cause sensor damage. Using aftermarket tire sealants may cause the Tire Pressure Monitoring System (TPMS) sensor to become inoperable. After using an aftermarket tire sealant it is recommended that you take your vehicle to an authorized dealer to have your sensor function checked.

#### Low Fuel Warning Light



When the fuel level reaches approximately 2 gal (7.5 L), this light will turn on and a chime will sound. The light will remain on until fuel is added.

#### Anti-Lock Brake System (ABS) Warning Light



This warning light monitors the ABS. The light will turn on when the ignition is placed in the ON/RUN or ACC/ON/RUN position and may stay on for as long as four seconds.

If the ABS light remains on or turns on while driving, then the Anti-Lock portion of the brake system is not functioning and service is required as soon as possible. However, the conventional brake system will continue to operate normally, assuming the Brake Warning Light is not also on.

If the ABS light does not turn on when the ignition is placed in the ON/RUN or ACC/ON/RUN position, have the brake system inspected by an authorized dealer.

#### Service Forward Collision Warning (FCW) Light — If Equipped



This warning light will illuminate to indicate a fault in the Forward Collision Warning System. Contact an authorized dealer for service ↪ page 218.

3

**Service Adaptive Cruise Control Warning Light — If Equipped**



This light will turn on when the Adaptive Cruise Control (ACC) is not operating and needs service → page 131.

**Service AWD Warning Light — If Equipped**



This telltale will turn on to indicate the All Wheel Drive (AWD) system is not functioning properly and that service is required. Contact an authorized dealer.

**Service Stop/Start System Warning Light — If Equipped**



This warning light will illuminate when the Stop/Start system is not functioning properly and service is required. Contact an authorized

dealer for service.

**LaneSense Warning Light — If Equipped**



The LaneSense Warning Light will be solid yellow when the vehicle is approaching a lane marker. The warning light will flash when the vehicle is crossing the lane marker → page 148.

**Service LaneSense Warning Light — If Equipped**



This warning light will illuminate when the LaneSense system is not operating and requires service. Please see an authorized dealer.

**Cruise Control Fault Warning Light — If Equipped**



This warning light will illuminate to indicate the Cruise Control System is not functioning properly and service is required. Contact an authorized dealer.

**YELLOW INDICATOR LIGHTS**

**Forward Collision Warning (FCW) OFF Indicator Light — If Equipped**



This indicator light illuminates to indicate that Forward Collision Warning is off → page 218.

**All Wheel Drive (AWD) Low Indicator Light — If Equipped**



This light alerts the driver that the vehicle is in the AWD LOW mode. The front and rear driveshafts are mechanically locked together forcing

the front and rear wheels to rotate at the same speed. AWD LOW is designed for loose, slippery road surfaces only → page 121.

**NEUTRAL Indicator Light — If Equipped**



This light alerts the driver that the 4WD power transfer case is in the NEUTRAL mode and the front and rear driveshafts are disengaged from the powertrain.

**GREEN INDICATOR LIGHTS**

**Adaptive Cruise Control (ACC) Set With Target Light — If Equipped**



This will display when the ACC is set and a target vehicle is detected → page 131.

**Adaptive Cruise Control (ACC) Set Without Target Light — If Equipped**



This will display when the ACC is set and a target vehicle is not detected → page 131.

**ADAPTIVE CRUISE CONTROL (ACC)— IF EQUIPPED**

Adaptive Cruise Control (ACC) increases the driving convenience provided by Cruise Control while traveling on highways and major roadways. However, it is not a safety system and not designed to prevent collisions. The Cruise Control function performs differently ⇨ page 129.

ACC will allow you to keep Cruise Control engaged in light to moderate traffic conditions without the constant need to reset your Cruise Control. ACC utilizes a radar sensor and a forward facing camera designed to detect a vehicle directly ahead of you.

**NOTE:**

- If the ACC sensor detects a vehicle ahead, ACC will apply limited braking or acceleration (not to exceed the original set speed) automatically to maintain a preset following distance, while matching the speed of the vehicle ahead.

- Any chassis / suspension or tire size modifications to the vehicle will affect the performance of the Adaptive Cruise Control and Forward Collision Warning system.
- Fixed Speed Cruise Control alone (an ACC distance not set) will not detect vehicles directly ahead of you. Always be aware of the mode selected ⇨ page 357.

<b>WARNING!</b>
<ul style="list-style-type: none"> <li>● Adaptive Cruise Control (ACC) is a convenience system. It is not a substitute for active driver involvement. It is always the driver's responsibility to be attentive of road, traffic, and weather conditions, vehicle speed, distance to the vehicle ahead; and, most importantly, brake operation to ensure safe operation of the vehicle under all road conditions. Your complete attention is always required while driving to maintain safe control of your vehicle. Failure to follow these warnings can result in a collision and death or serious personal injury.</li> </ul>

*(Continued)*

**WARNING! (Continued)**

- The ACC system:
  - Does not react to pedestrians, oncoming vehicles, and stationary objects (e.g., a stopped vehicle in a traffic jam or a disabled vehicle).
  - Cannot take street, traffic, and weather conditions into account, and may be limited upon adverse sight distance conditions.
  - Does not always fully recognize complex driving conditions, which can result in wrong or missing distance warnings.
  - Will bring the vehicle to a complete stop while following a target vehicle and hold the vehicle for two seconds in the stop position. If the target vehicle does not start moving within two seconds the ACC system will display a message that the system will release the brakes and that the brakes must be applied manually. An audible chime will sound when the brakes are released.

*(Continued)*

**NOTE:**

The brake lights will illuminate whenever the ACC system applies the brakes.

A Proximity Warning will alert the driver if ACC predicts that its maximum braking level is not sufficient to maintain the set distance. If this occurs, a visual alert "BRAKE" will flash in the instrument cluster display and a chime will sound while ACC continues to apply its maximum braking capacity.

**NOTE:**

The "BRAKE!" screen in the instrument cluster display is a warning for the driver to take action and does not necessarily mean that the Forward Collision Warning system is applying the brakes autonomously.

**Overtake Aid**

When driving with Adaptive Cruise Control (ACC) engaged and following a vehicle, the system will provide an additional acceleration up to the ACC set speed to assist in passing the vehicle. This additional acceleration is triggered when the driver utilizes the left turn signal and will only be active when passing on the left hand side.

**ACC Operation At Stop**

If the ACC system brings your vehicle to a standstill while following a vehicle ahead, your vehicle will resume motion, without any driver interaction, if the vehicle ahead starts moving within two seconds of your vehicle coming to a standstill.

If the vehicle in front does not start moving within two seconds of your vehicle coming to a standstill, the driver will either have to push the RES (resume) button, or apply the accelerator pedal to reengage the ACC to the existing set speed.

While ACC with Stop is holding your vehicle at a standstill, if the driver seat belt is unbuckled or the driver door is opened, the ACC with Stop system will cancel and the brakes will release. A cancel message will display on the instrument cluster display and produce a warning chime. The driver must now manually operate the vehicle's accelerator and brakes.

**WARNING!**

When the ACC system is resumed, the driver must ensure that there are no pedestrians, vehicles or objects in the path of the vehicle. Failure to follow these warnings can result in a collision and death or serious personal injury.

**Display Warnings And Maintenance****"Wipe Front Radar Sensor In Front Of Vehicle" Warning**

The "ACC/FCW Unavailable Wipe Front Radar Sensor" warning will display and a chime will sound when conditions temporarily limit system performance.

This most often occurs at times of poor visibility, such as in snow or heavy rain. The ACC system may also become temporarily blinded due to obstructions, such as mud, dirt or ice. In these cases, the instrument cluster display will display the above message and the system will deactivate.

**4**

**Safety & Driving Assistance**

After pressing the Safety & Driving Assistance button on the touchscreen, the following settings will be available:

Setting Name	Description
<b>Automatic Emergency Braking – If Equipped</b>	This setting will take you to the selectable options for “Forward Collision Warning (FCW)” and “Forward Collision Warning Sensitivity”.
<b>Forward Collision Warning – If Equipped</b>	This setting will turn the Forward Collision system on or off. The “Off” setting will deactivate the FCW system. The “Warning Only” setting will provide only an audible chime when a collision is detected. The “Warning + Active Braking” setting will provide an audible chime and apply some brake pressure when a collision is detected.
<b>Forward Collision Warning Sensitivity – If Equipped</b>	This setting will change the distance at which the Forward Collision Warning alert sounds. The “Medium” setting will have the FCW system signal when an object is in view, and the possibility of a collision is detected. The “Near” setting will have the FCW system signal when the object is closer to the vehicle. The “Far” setting will have the FCW system signal when an object is at a far distance from the vehicle.
<b>LaneSense Warning – If Equipped</b>	This setting will change the distance at which the steering wheel will provide lane departure feedback. The available settings are “Early”, “Medium”, and “Late”.
<b>LaneSense Strength – If Equipped</b>	This setting will change the strength of the steering wheel feedback during a lane departure. The available settings are “Low”, “Medium”, and “High”.
<b>ParkSense – If Equipped</b>	This setting will change the type of ParkSense alert when a close object is detected and provide both an audible chime and a visual display.
<b>Front ParkSense Volume</b>	This setting adjusts the volume of the Front ParkSense system. The available settings are “Low”, “Medium”, and “High”.
<b>Rear ParkSense Volume</b>	This setting adjusts the volume of the Rear ParkSense system. The available settings are “Low”, “Medium”, and “High”.

**NOTE:**

Whenever an audible alert is requested by the BSM system, the radio is also muted.

When the system is in RCP, the system shall respond with both visual and audible alerts when a detected object is present. Whenever an audible alert is requested, the radio is also muted. Turn/hazard signal status is ignored; the RCP state always requests the chime.

**Blind Spot Alert Off**

When the BSM system is turned off there will be no visual or audible alerts from either the BSM or RCP systems.

**NOTE:**

The BSM system will store the current operating mode when the vehicle is shut off. Each time the vehicle is started the previously stored mode will be recalled and used.

**FORWARD COLLISION WARNING (FCW) WITH MITIGATION**

FCW with Mitigation provides the driver with audible warnings, visual warnings (within the instrument cluster display), and may apply a brake jerk to warn the driver when it detects a potential frontal collision. The warnings and

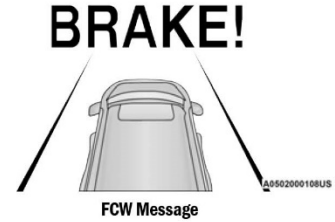
limited braking are intended to provide the driver with enough time to react, avoid or mitigate the potential collision.

**NOTE:**

FCW monitors the information from the forward looking sensors as well as the Electronic Brake Controller (EBC) to calculate the probability of a forward collision. When the system determines that a forward collision is probable, the driver will be provided with audible and visual warnings and may provide a brake jerk warning. If the driver does not take action based upon these progressive warnings, then the system will provide a limited level of active braking to help slow the vehicle and mitigate the potential forward collision. If the driver reacts to the warnings by braking and the system determines that the driver intends to avoid the collision by braking but has not applied sufficient brake force, the system will compensate and provide additional brake force as required.

If an FCW with Mitigation event begins at a speed below 38 mph (62 km/h), the system may provide the maximum or partial braking to mitigate the potential forward collision. If the Forward Collision Warning with Mitigation event

stops the vehicle completely, the system will hold the vehicle at a standstill for two seconds and then release the brakes.



When the system determines a collision with the vehicle in front of you is no longer probable, the warning message will be deactivated.

**NOTE:**

- The minimum speed for FCW activation is 1 mph (2 km/h).
- The FCW alerts may be triggered on objects other than vehicles such as guard rails or sign posts based on the course prediction. This is expected and is a part of normal FCW activation and functionality.

- It is unsafe to test the FCW system. To prevent such misuse of the system, after four Active Braking events within an ignition cycle, the Active Braking portion of FCW will be deactivated until the next ignition cycle.
- The FCW system is intended for on-road use only. If the vehicle is taken off-road, the FCW system should be deactivated to prevent unnecessary warnings to the surroundings. If the vehicle enters 4WD Low range, the FCW system will be automatically deactivated ⇨ page 357.

#### WARNING!

Forward Collision Warning (FCW) is not intended to avoid a collision on its own, nor can FCW detect every type of potential collision. The driver has the responsibility to avoid a collision by controlling the vehicle via braking and steering. Failure to follow this warning could lead to serious injury or death.

#### FCW Braking Status And Sensitivity

The FCW Sensitivity and Active Braking status are programmable through the Uconnect system ⇨ page 175.

The default sensitivity of FCW is the "Medium" setting and the system status is "Warning & Braking". This allows the system to warn the driver of a possible collision with the vehicle in front using audible/visual warnings and it applies autonomous braking.

Changing the FCW status to the "Far" setting allows the system to warn the driver of a possible collision with the vehicle in front using audible/visual warnings when the latter is at a farther distance than the "Medium" setting. This provides the most reaction time to avoid a possible collision.

Changing the FCW status to the "Near" setting allows the system to warn the driver of a possible collision with the vehicle in front when the distance between the vehicle in the front is much closer. This setting provides less reaction time than the "Far" and "Medium" settings, which allows for a more dynamic driving experience.

#### NOTE:

- Changing the FCW status to "Only Warning" prevents the system from providing limited active braking, or additional brake support if the driver is not braking adequately in the event of a potential frontal collision, but maintains the audible and visual warnings.
- Changing the FCW status to "Off" prevents the system from providing autonomous braking, or additional brake support if the driver is not braking adequately in the event of a potential frontal collision.
- The system will retain the last setting selected by the driver after ignition shut down.
- FCW may not react to irrelevant objects such as overhead objects, ground reflections, objects not in the path of the vehicle, stationary objects that are far away, oncoming traffic, or leading vehicles with the same or higher rate of speed.
- FCW will be disabled like ACC, with the unavailable screens.

6

**FCW Limited Warning**

If the instrument cluster displays “ACC/FCW Limited Functionality” or “ACC/FCW Limited Functionality Clean Front Windshield” momentarily, there may be a condition that limits FCW functionality. Although the vehicle is still drivable under normal conditions, the active braking may not be fully available. Once the condition that limited the system performance is no longer present, the system will return to its full performance state. If the problem persists, see an authorized dealer.

**Service FCW Warning**

If the system turns off, and the instrument cluster displays:

- ACC/FCW Unavailable Service Required
- Cruise/FCW Unavailable Service Required

This indicates there is an internal system fault. Although the vehicle is still drivable under normal conditions, have the system checked by an authorized dealer.

**TIRE PRESSURE MONITORING SYSTEM (TPMS)**

The TPMS will warn the driver of a low tire pressure based on the vehicle recommended cold tire pressure.

The tire pressure will vary with temperature by about 1 psi (7 kPa) for every 12° F (6.5° C). This means that when the outside temperature decreases, the tire pressure will decrease. Tire pressure should always be set based on cold inflation tire pressure. This is defined as the tire pressure after the vehicle has not been driven for at least three hours, or driven less than 1 mile (1.6 km) after a three-hour period. The tire pressure will also increase as the vehicle is driven – this is normal and there should be no adjustment for this increased pressure.

See ⇨ page 322 on how to properly inflate the vehicle’s tires.

The TPMS will warn the driver of a low tire pressure if the tire pressure falls below the low pressure warning threshold for any reason, including low temperature effects, or natural pressure loss through the tire.

The TPMS will continue to warn the driver of low tire pressure as long as the condition exists, and will not turn off until the tire pressure is at or above recommended cold tire pressure. Once the low tire pressure warning has been illuminated, the tire pressure must be increased to the recommended cold tire pressure in order for the TPMS Warning Light to be turned off.

**NOTE:**

When filling warm tires, the tire pressure may need to be increased up to an additional 4 psi (28 kPa) above the recommended cold placard pressure in order to turn the TPMS Warning Light off.

The system will automatically update and the TPMS Warning Light will extinguish once the updated tire pressures have been received. The vehicle may need to be driven for up to 20 minutes above 15 mph (24 km/h) to receive this information.



## APPENDIX C

### Run Log

Subject Vehicle: **2021 Dodge Durango GT Blacktop RWD**

Test Date: **3/17/2021**

Principal Other Vehicle: **SSV**

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
1-14	Brake characterization and determination						See Appendix D
15	Static Run						Zero SV front bumper to SSV rear bumper and collect data
16	<b>Stopped POV</b>	Y	1.44	0.00	0.63	Fail	
17		Y	1.43	0.00	0.60	Fail	
18		Y	N/A	0.00	0.60	Fail	FCW after impact
19		Y	1.29	0.00	0.58	Fail	
20		Y	1.38	0.00	0.58	Fail	
21	Static Run						
22	<b>Slower POV, 25 vs 10</b>	Y	1.43	1.87	0.59	Pass	
23		Y	1.44	1.03	0.55	Pass	
24		Y	1.53	0.73	0.57	Pass	
25		Y	1.43	1.02	0.56	Pass	
26		N					Brake force
27		Y	1.45	2.56	0.60	Pass	
28		Static run					Check zero data is within $\pm 0.167$ ft ( $\pm 0.05$ m)
83		Static run					
84		Y	1.39	3.11	0.56	Pass	Didn't conduct 2 runs for 25 vs 10 earlier

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
85	<b>Slower POV, 25 vs 10</b>	Y	1.40	2.63	0.55	Pass	
86	Static run						Check zero data is within $\pm 0.167$ ft ( $\pm 0.05$ m)
29	<b>Slower POV, 45 vs 20</b>	Y	2.21	0.00	1.07	Fail	
30		Y	1.97	0.00	1.04	Fail	
31		Y	2.25	2.79	1.00	Pass	
32		Y	2.08	3.71	1.01	Pass	
33		Y	2.11	0.63	1.04	Pass	
34		Y	2.18	0.00	0.59	Fail	
35		Y	2.09	0.00	0.94	Fail	
36	Static run						Check zero data is within $\pm 0.167$ ft ( $\pm 0.05$ m)
37	<b>Decelerating POV</b>	N					Throttle drop
38		Y	1.55	0.00	0.53	Fail	
39		N					Brake timing
40		N					Brake timing
41		Y	1.56	0.00	0.51	Fail	
42		N					Throttle drop
43		N					Throttle drop
44		Y	1.61	0.00	0.65	Fail	
45		Y	1.56	0.00	0.83	Fail	
46		Y	1.55	0.00	0.88	Fail	
47	Static run						Check zero data is within $\pm 0.167$ ft ( $\pm 0.05$ m)

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
48	STP - Static run						Zero SV front bumper to rear edge of steel plate and collect data
49	<b>Baseline, 25</b>	Y			0.49		
50		Y			0.50		
51		Y			0.50		
52		Y			0.50		
53		Y			0.50		
54		Y			0.49		
55		Y			0.50		
56	STP - Static run						Check zero data is within $\pm 0.167$ ft ( $\pm 0.05$ m)
57	<b>Baseline, 45</b>	Y			0.45		
58		Y			0.47		
59		Y			0.47		
60		Y			0.49		
61		Y			0.47		
62		Y			0.49		
63		N					SV speed
64		Y			0.48		
65	STP - Static run						Check zero data is within $\pm 0.167$ ft ( $\pm 0.05$ m)
66	<b>STP False Positive, 25</b>	Y			0.52	Pass	
67		Y			0.54	Pass	
68		Y			0.52	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
69	<b>STP False Positive, 25</b>	Y			0.51	Pass	
70		Y			0.52	Pass	
71		Y			0.51	Pass	
72		Y			0.51	Pass	
73	STP - Static run						Check zero data is within $\pm 0.167$ ft ( $\pm 0.05$ m)
74	<b>STP False Positive, 45</b>	Y			0.49	Pass	
75		Y			0.48	Pass	
76		Y			0.49	Pass	
77		Y			0.48	Pass	
78		Y			0.49	Pass	
79		Y			0.50	Pass	
80		Y			0.52	Pass	
81	STP - Static run						Check zero data is within $\pm 0.167$ ft ( $\pm 0.05$ m)
82	Determination Check run						

## APPENDIX D

### Brake Characterization

Subject Vehicle: 2021 Dodge Durango GT Blacktop RWD

Test Date: 3/17/2021

DBS Initial Brake Characterization				
Run Number	Stroke at 0.4 g (in)	Force at 0.4 g (lb)	Slope	Intercept
1	3.174	21.832	0.460	-0.325
2	3.252	24.545	0.458	-0.394
3	3.229	24.625	0.430	-0.341

DBS Brake Characterization Determination								
Run	DBS Mode	Speed	Valid Run	Average Decel. (g)	0.4 g Stroke Value (in)	0.4 g Force Value (lb)	Stroke/Force Calculator (in)	Notes
4	Displacement	35	Y	0.451	3.22		2.86	
5			Y	0.429	3.15		2.94	
6			Y	0.373	3.00		3.22	
7			Y	0.405	3.05		3.01	
8		25	Y	0.417	3.05		2.93	
9		45	Y	0.406	3.05		3.00	
10	Hybrid	35	Y	0.411		19.75	19.22	
11		25	Y	0.441		19.75	17.91	

**DBS Brake Characterization Determination**

<b>Run</b>	<b>DBS Mode</b>	<b>Speed</b>	<b>Valid Run</b>	<b>Average Decel. (g)</b>	<b>0.4 g Stroke Value (in)</b>	<b>0.4 g Force Value (lb)</b>	<b>Stroke/Force Calculator (in)</b>	<b>Notes</b>
12	<b>Hybrid</b>		Y	0.386		19.25	19.95	
13		45	Y	0.383		19.25	20.10	
14		35	Y	0.381		19.25	20.21	



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 16, SV Encounters Stopped POV .....	E-23
Figure E14. Time History for DBS Run 17, SV Encounters Stopped POV .....	E-24
Figure E15. Time History for DBS Run 18, SV Encounters Stopped POV .....	E-25
Figure E16. Time History for DBS Run 19, SV Encounters Stopped POV .....	E-26
Figure E17. Time History for DBS Run 20, SV Encounters Stopped POV .....	E-27
Figure E18. Time History for DBS Run 22, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-28
Figure E19. Time History for DBS Run 23, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-29
Figure E20. Time History for DBS Run 24, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-30
Figure E21. Time History for DBS Run 25, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-31
Figure E22. Time History for DBS Run 27, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-32
Figure E23. Time History for DBS Run 84, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-33
Figure E24. Time History for DBS Run 85, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-34
Figure E25. Time History for DBS Run 29, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-35
Figure E26. Time History for DBS Run 30, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-36
Figure E27. Time History for DBS Run 31, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-37
Figure E28. Time History for DBS Run 32, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-38
Figure E29. Time History for DBS Run 33, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-39

Figure E30. Time History for DBS Run 34, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-40
Figure E31. Time History for DBS Run 35, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-41
Figure E32. Time History for DBS Run 38, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-42
Figure E33. Time History for DBS Run 41, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-43
Figure E34. Time History for DBS Run 44, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-44
Figure E35. Time History for DBS Run 45, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-45
Figure E36. Time History for DBS Run 46, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-46
Figure E37. Time History for DBS Run 49, False Positive Baseline, SV 25 mph .....	E-47
Figure E38. Time History for DBS Run 50, False Positive Baseline, SV 25 mph .....	E-48
Figure E39. Time History for DBS Run 51, False Positive Baseline, SV 25 mph .....	E-49
Figure E40. Time History for DBS Run 52, False Positive Baseline, SV 25 mph .....	E-50
Figure E41. Time History for DBS Run 53, False Positive Baseline, SV 25 mph .....	E-51
Figure E42. Time History for DBS Run 54, False Positive Baseline, SV 25 mph .....	E-52
Figure E43. Time History for DBS Run 55, False Positive Baseline, SV 25 mph .....	E-53
Figure E44. Time History for DBS Run 57, False Positive Baseline, SV 45 mph .....	E-54
Figure E45. Time History for DBS Run 58, False Positive Baseline, SV 45 mph .....	E-55
Figure E46. Time History for DBS Run 59, False Positive Baseline, SV 45 mph .....	E-56
Figure E47. Time History for DBS Run 60, False Positive Baseline, SV 45 mph .....	E-57
Figure E48. Time History for DBS Run 61, False Positive Baseline, SV 45 mph .....	E-58
Figure E49. Time History for DBS Run 62, False Positive Baseline, SV 45 mph .....	E-59
Figure E50. Time History for DBS Run 64, False Positive Baseline, SV 45 mph .....	E-60
Figure E51. Time History for DBS Run 66, SV Encounters Steel Trench Plate, SV 25 mph .....	E-61
Figure E52. Time History for DBS Run 67, SV Encounters Steel Trench Plate, SV 25 mph .....	E-62
Figure E53. Time History for DBS Run 68, SV Encounters Steel Trench Plate, SV 25 mph .....	E-63
Figure E54. Time History for DBS Run 69, SV Encounters Steel Trench Plate, SV 25 mph .....	E-64
Figure E55. Time History for DBS Run 70, SV Encounters Steel Trench Plate, SV 25 mph .....	E-65
Figure E56. Time History for DBS Run 71, SV Encounters Steel Trench Plate, SV 25 mph .....	E-66
Figure E57. Time History for DBS Run 72, SV Encounters Steel Trench Plate, SV 25 mph .....	E-67
Figure E58. Time History for DBS Run 74, SV Encounters Steel Trench Plate, SV 45 mph .....	E-68
Figure E59. Time History for DBS Run 75, SV Encounters Steel Trench Plate, SV 45 mph .....	E-69

Figure E60. Time History for DBS Run 76, SV Encounters Steel Trench Plate, SV 45 mph .....	E-70
Figure E61. Time History for DBS Run 77, SV Encounters Steel Trench Plate, SV 45 mph .....	E-71
Figure E62. Time History for DBS Run 78, SV Encounters Steel Trench Plate, SV 45 mph .....	E-72
Figure E63. Time History for DBS Run 79, SV Encounters Steel Trench Plate, SV 45 mph .....	E-73
Figure E64. Time History for DBS Run 80, SV Encounters Steel Trench Plate, SV 45 mph .....	E-74
Figure E65. Time History for DBS Run 1, Brake Characterization Initial .....	E-75
Figure E66. Time History for DBS Run 2, Brake Characterization Initial .....	E-76
Figure E67. Time History for DBS Run 3, Brake Characterization Initial .....	E-77
Figure E68. Time History for DBS Run 4, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-78
Figure E69. Time History for DBS Run 5, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-79
Figure E70. Time History for DBS Run 6, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-80
Figure E71. Time History for DBS Run 7, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-81
Figure E72. Time History for DBS Run 8, Brake Characterization Determination, Displacement Mode, 25 mph .....	E-82
Figure E73. Time History for DBS Run 9, Brake Characterization Determination, Displacement Mode, 45 mph .....	E-83
Figure E74. Time History for DBS Run 10, Brake Characterization Determination, Hybrid Mode, 35 mph .....	E-84
Figure E75. Time History for DBS Run 11, Brake Characterization Determination, Hybrid Mode, 25 mph .....	E-85
Figure E76. Time History for DBS Run 12, Brake Characterization Determination, Hybrid Mode, 25 mph .....	E-86
Figure E77. Time History for DBS Run 13, Brake Characterization Determination, Hybrid Mode, 45 mph .....	E-87
Figure E78. Time History for DBS Run 14, Brake Characterization Determination, Hybrid Mode, 35 mph .....	E-88

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

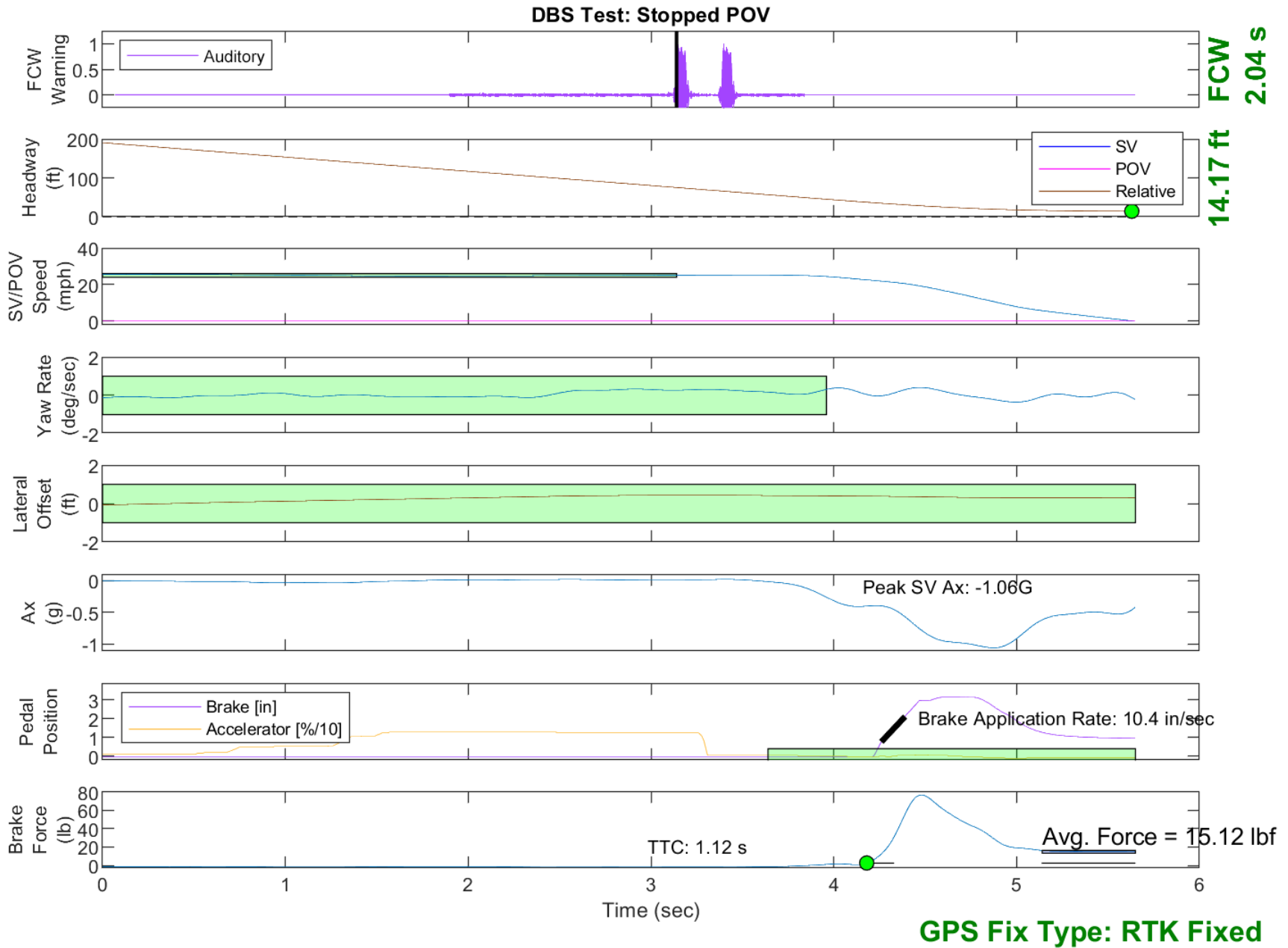


Figure E1. Example Time History for Stopped POV, Passing

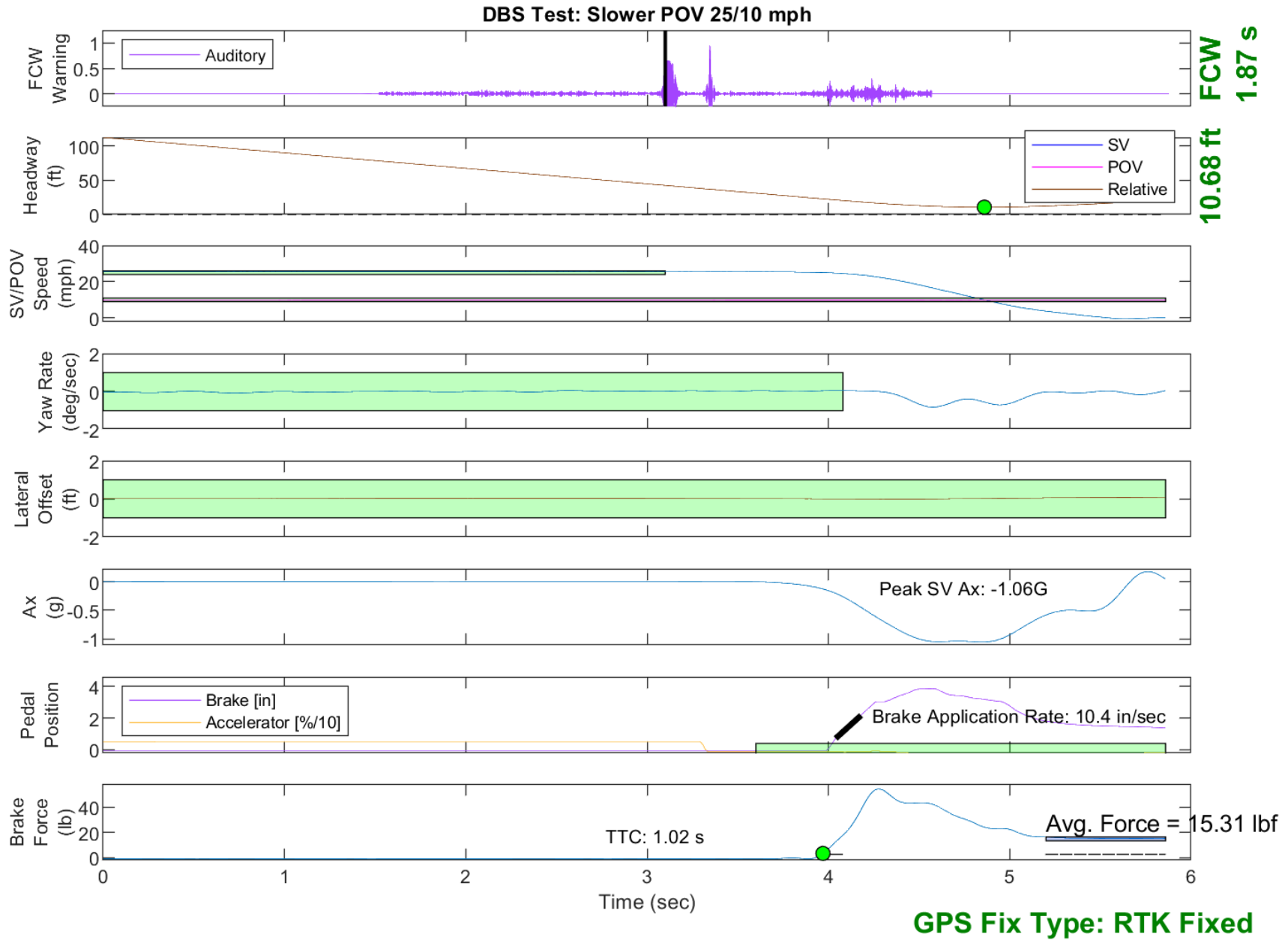


Figure E2. Example Time History for Slower POV 25 vs. 10, Passing

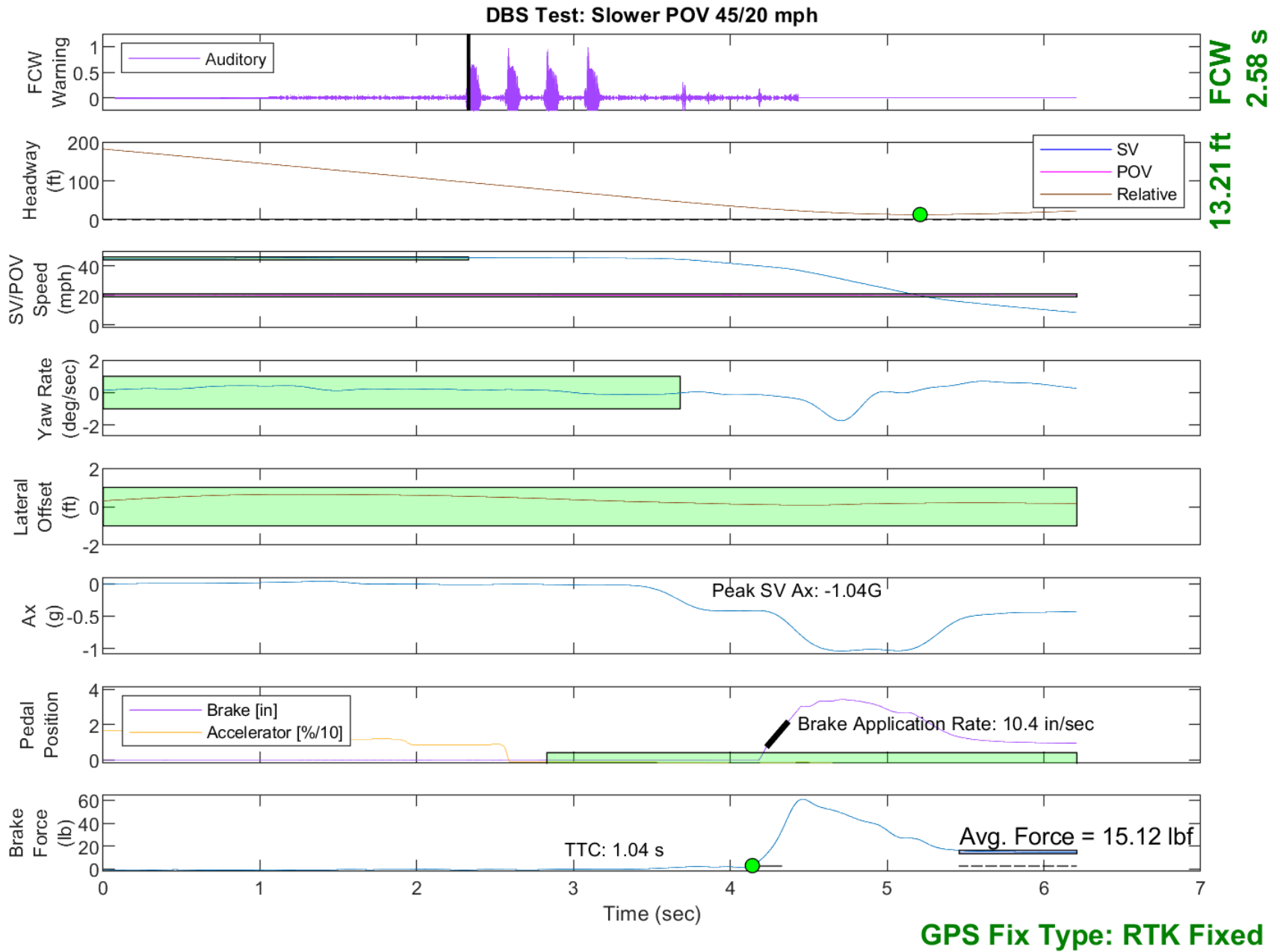


Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

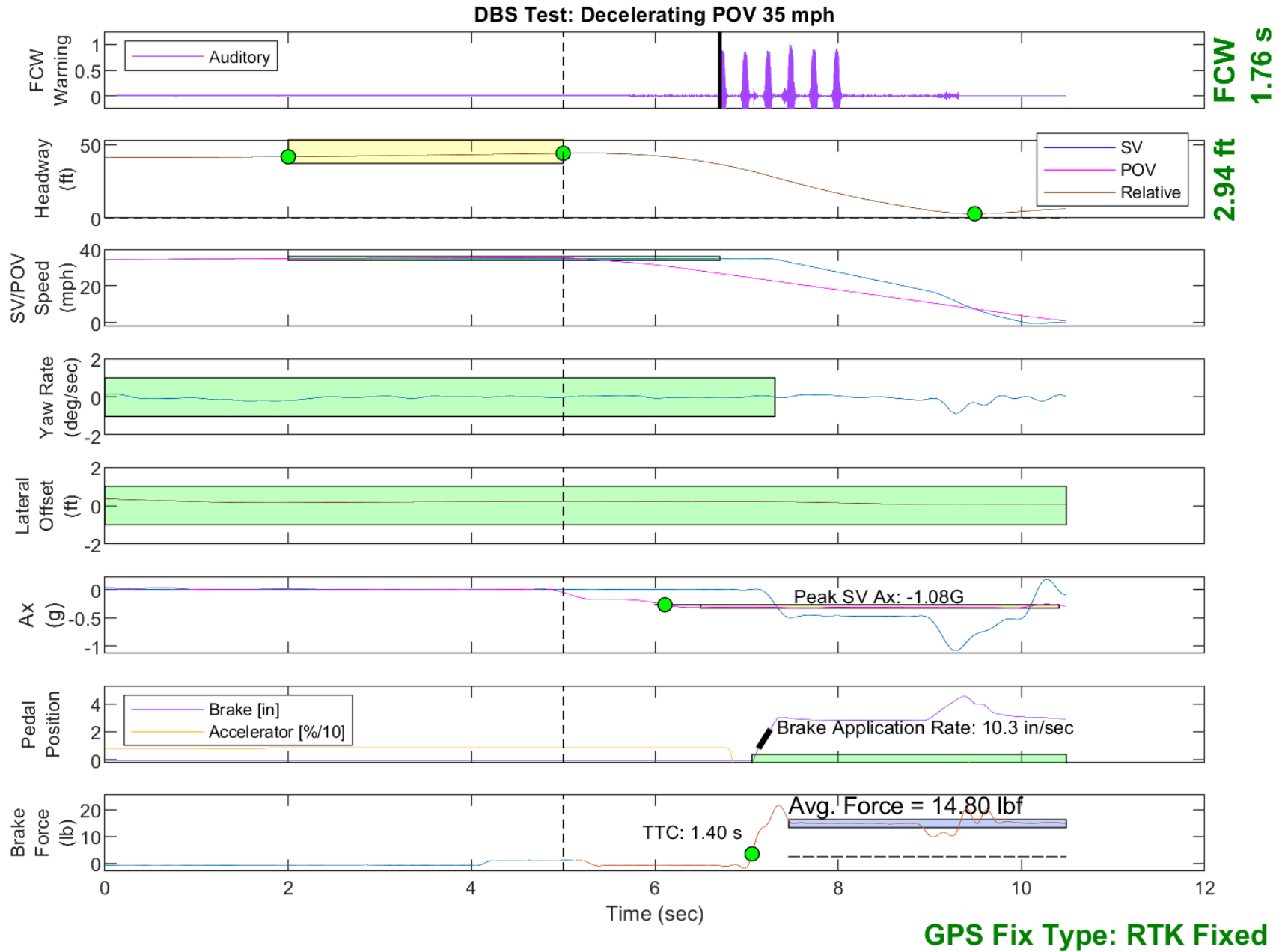
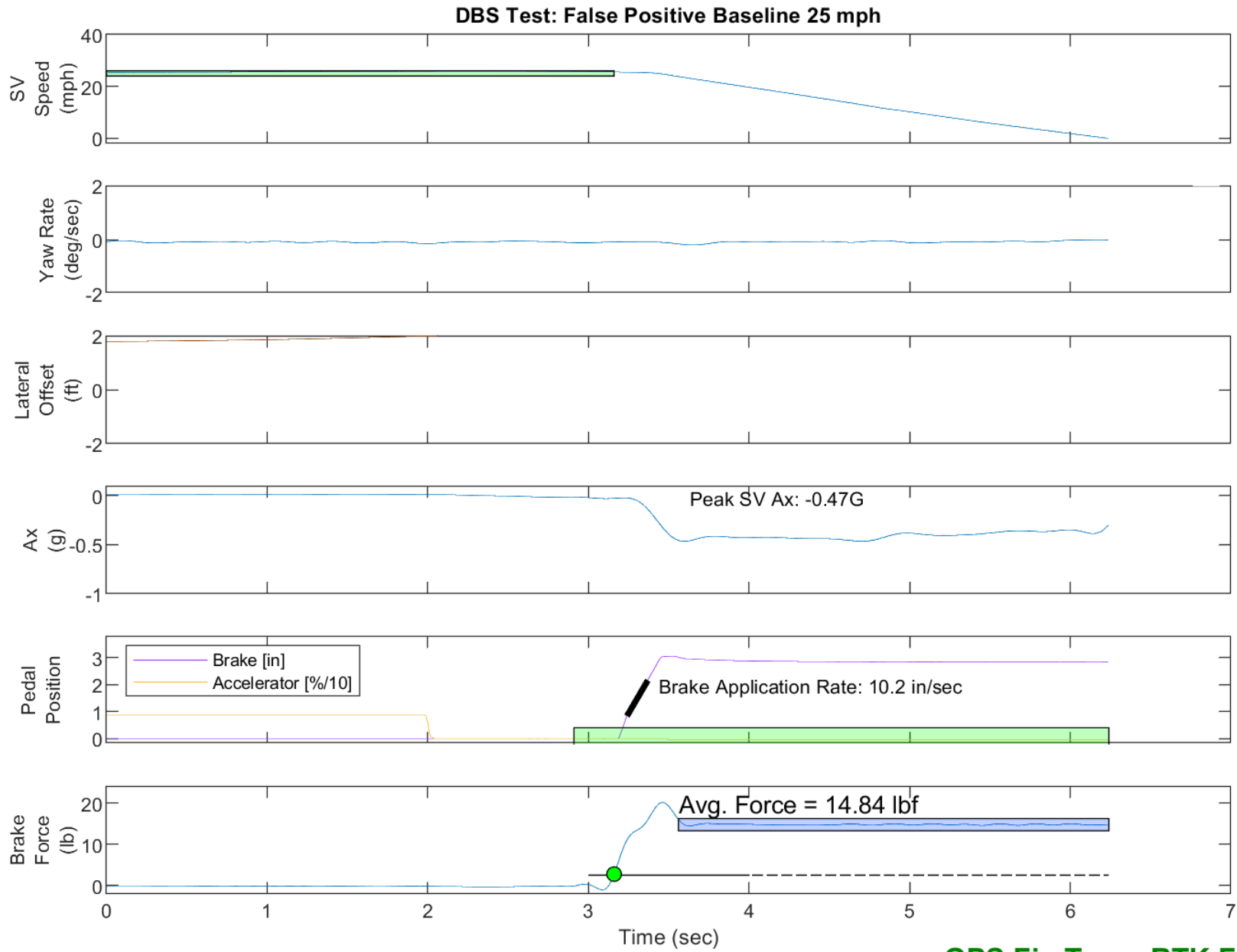
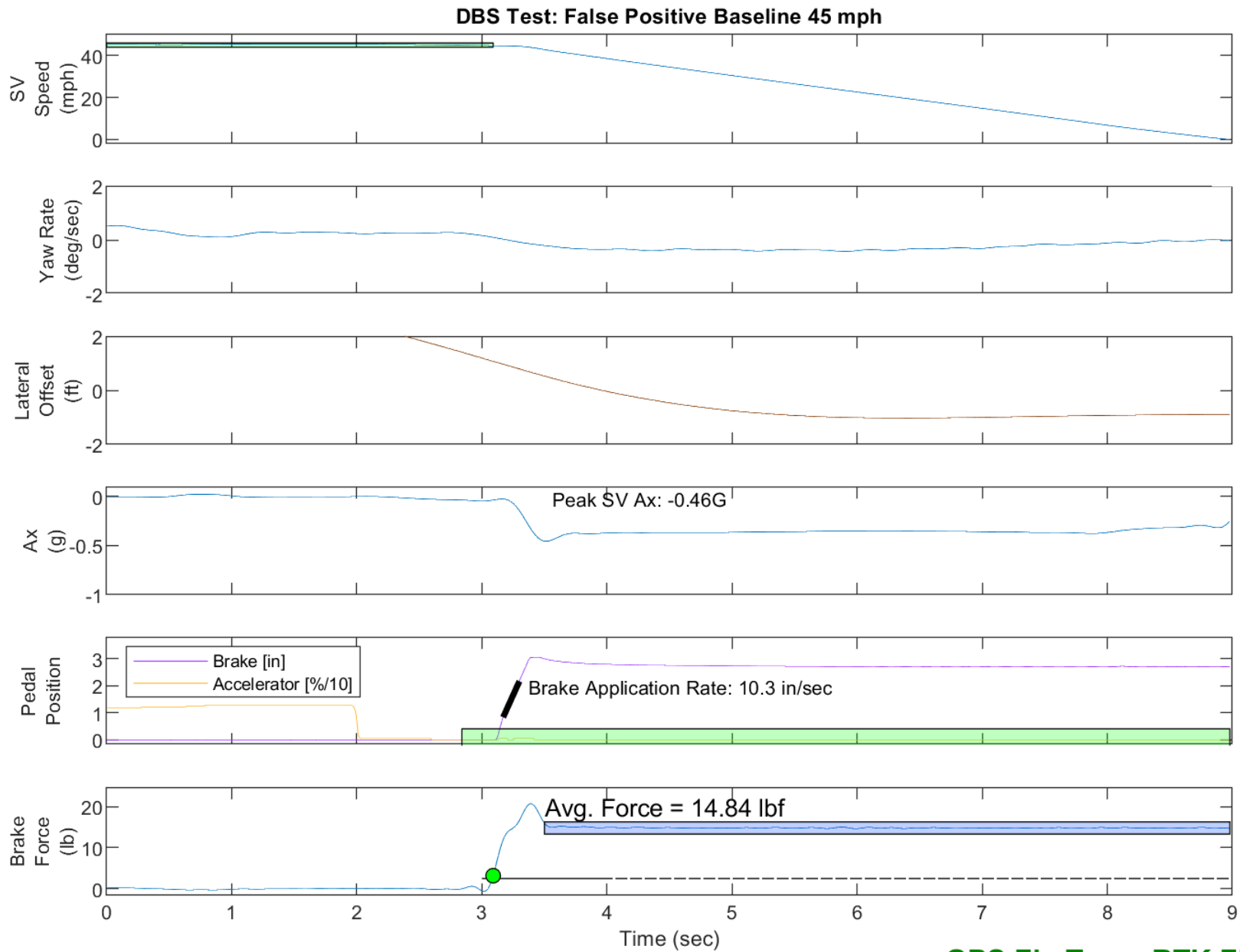


Figure E4. Example Time History for Decelerating POV 35, Passing



**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



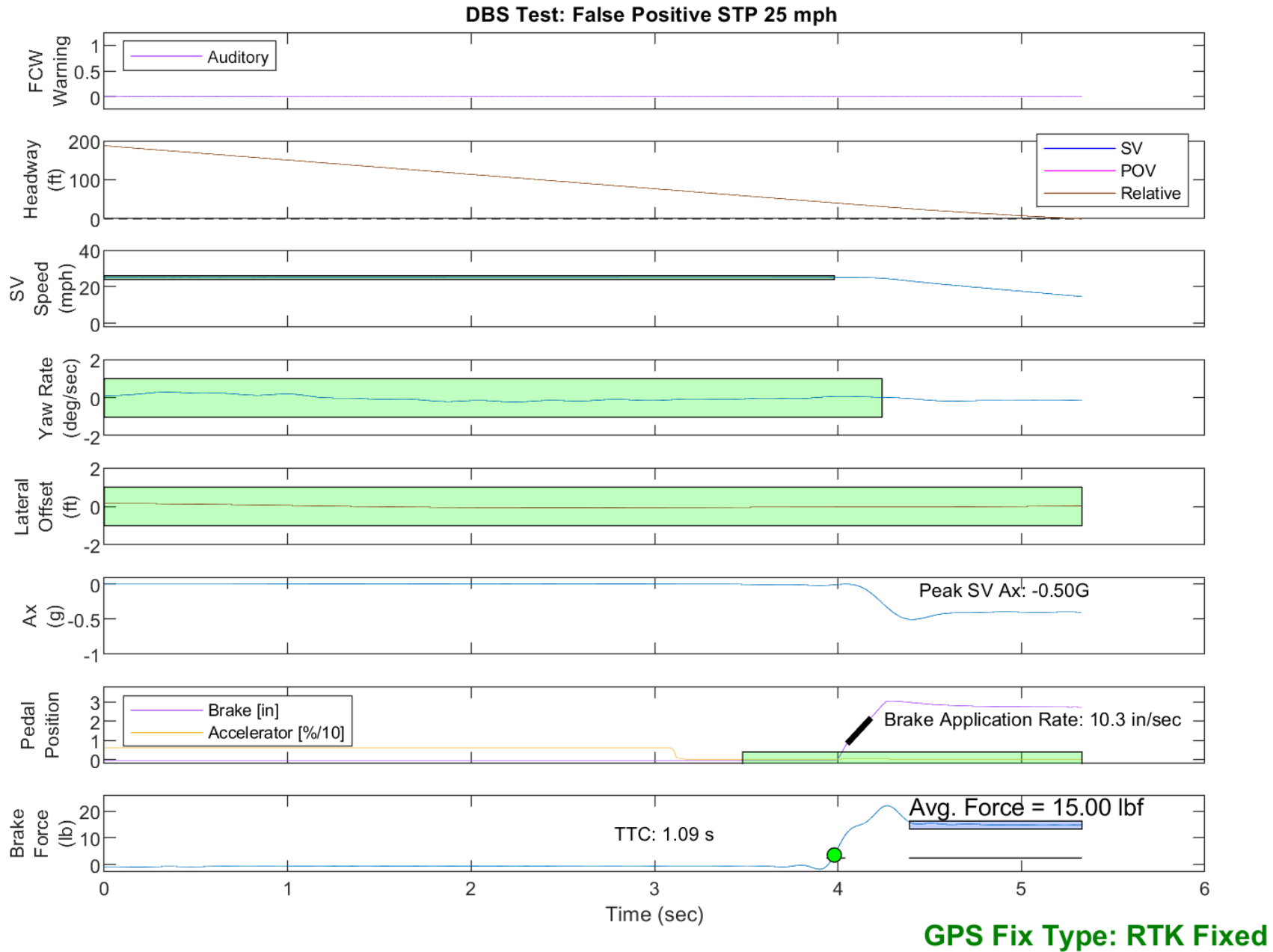
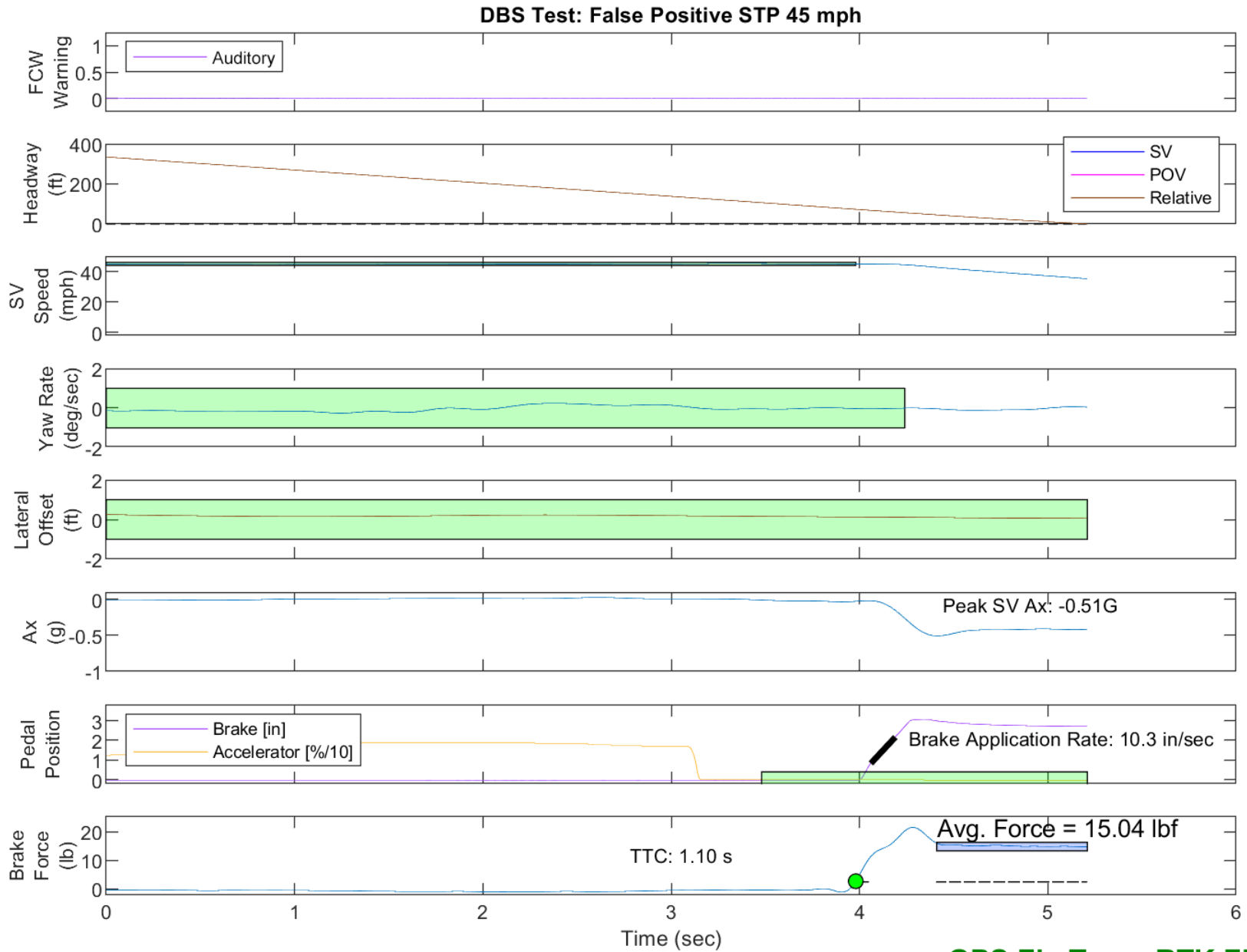


Figure E7. Example Time History for False Positive Steel Plate 25, Passing



**GPS Fix Type: RTK Fixed**

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

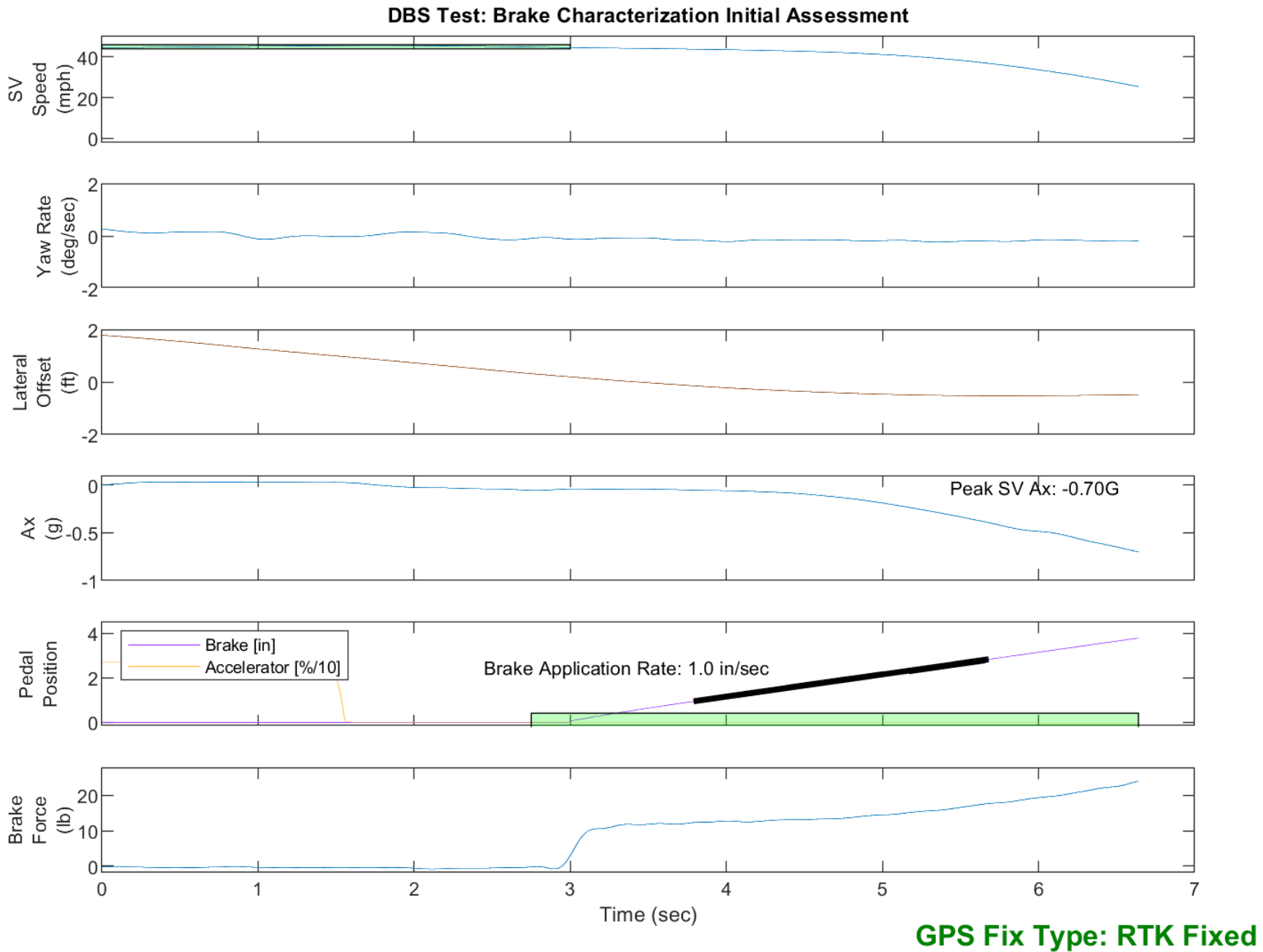


Figure E9. Example Time History for DBS Brake Characterization, Passing

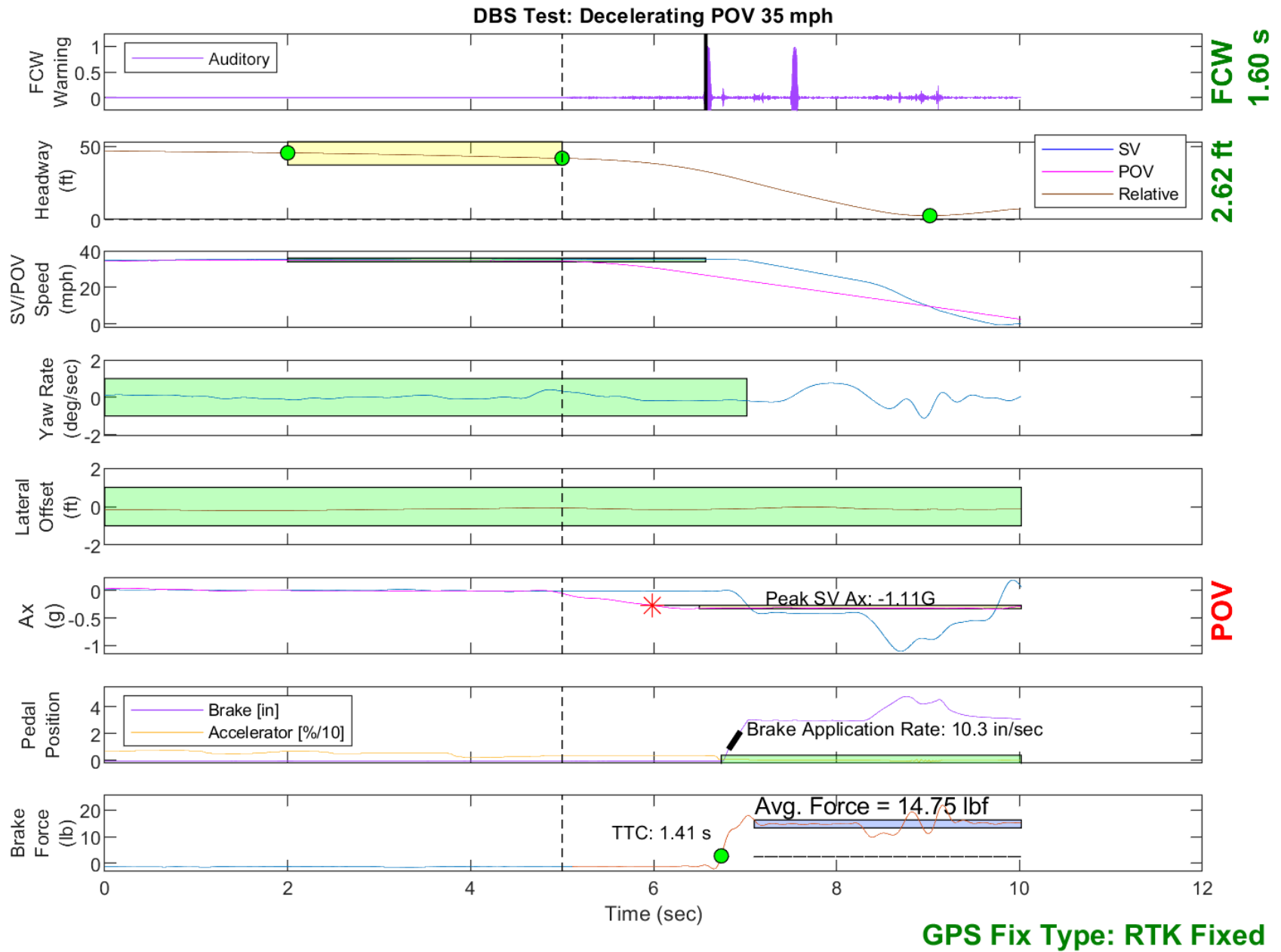
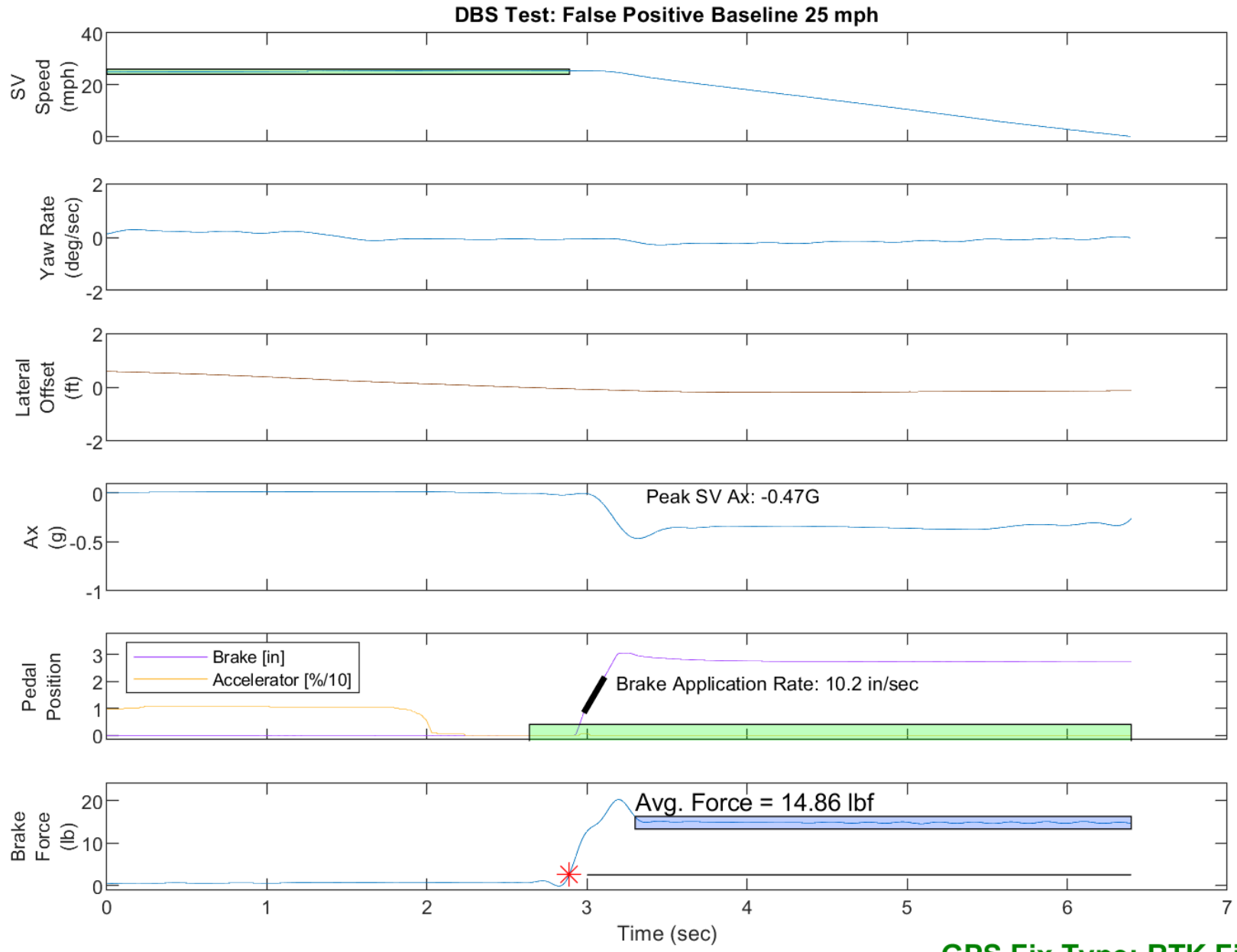


Figure E10. Example Time History Displaying Invalid POV Acceleration Criteria



**GPS Fix Type: RTK Fixed**

Figure E11. Example Time History Displaying Invalid Brake Force Criteria

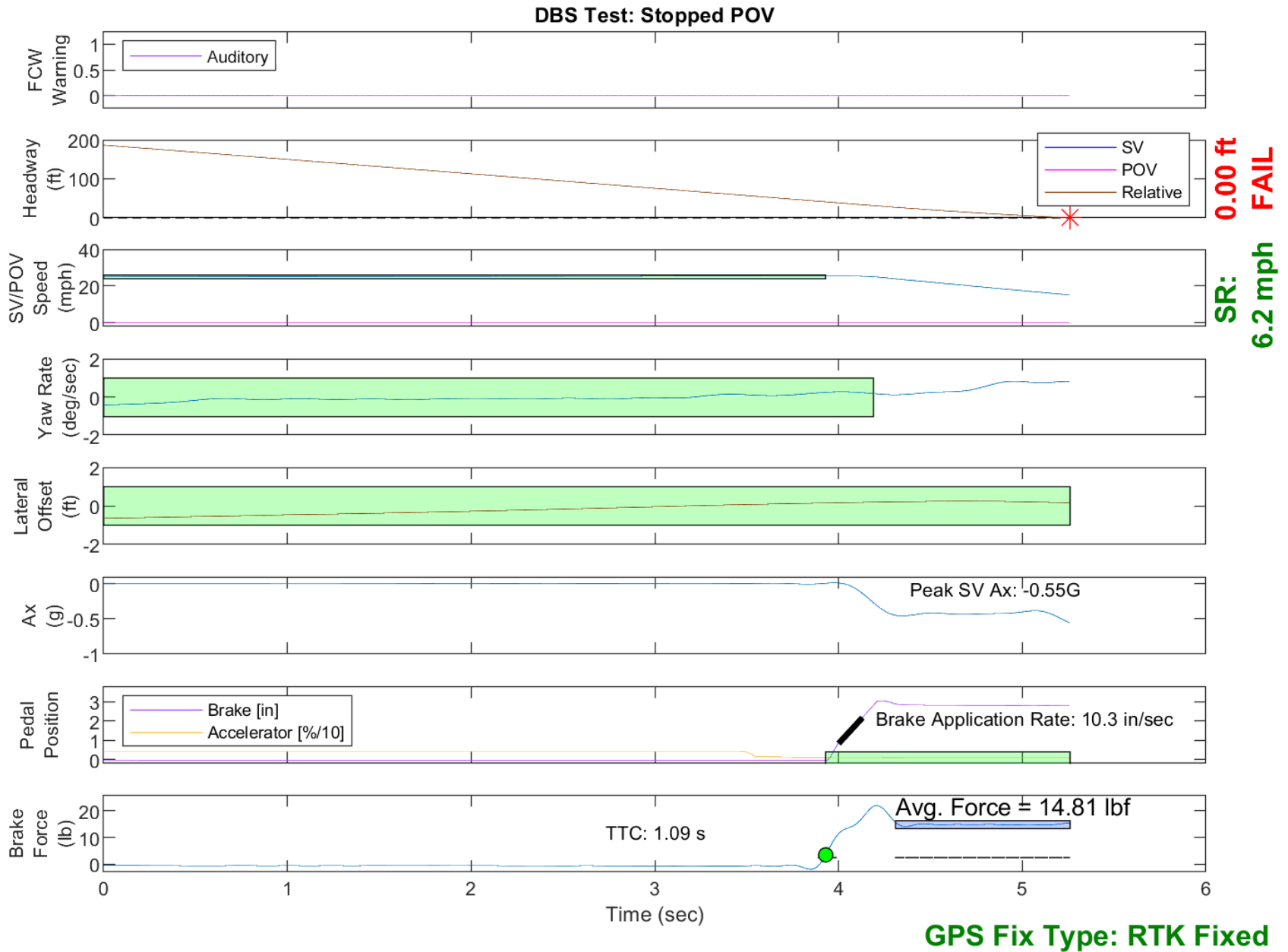


Figure E12. Example Time History for a Failed Run

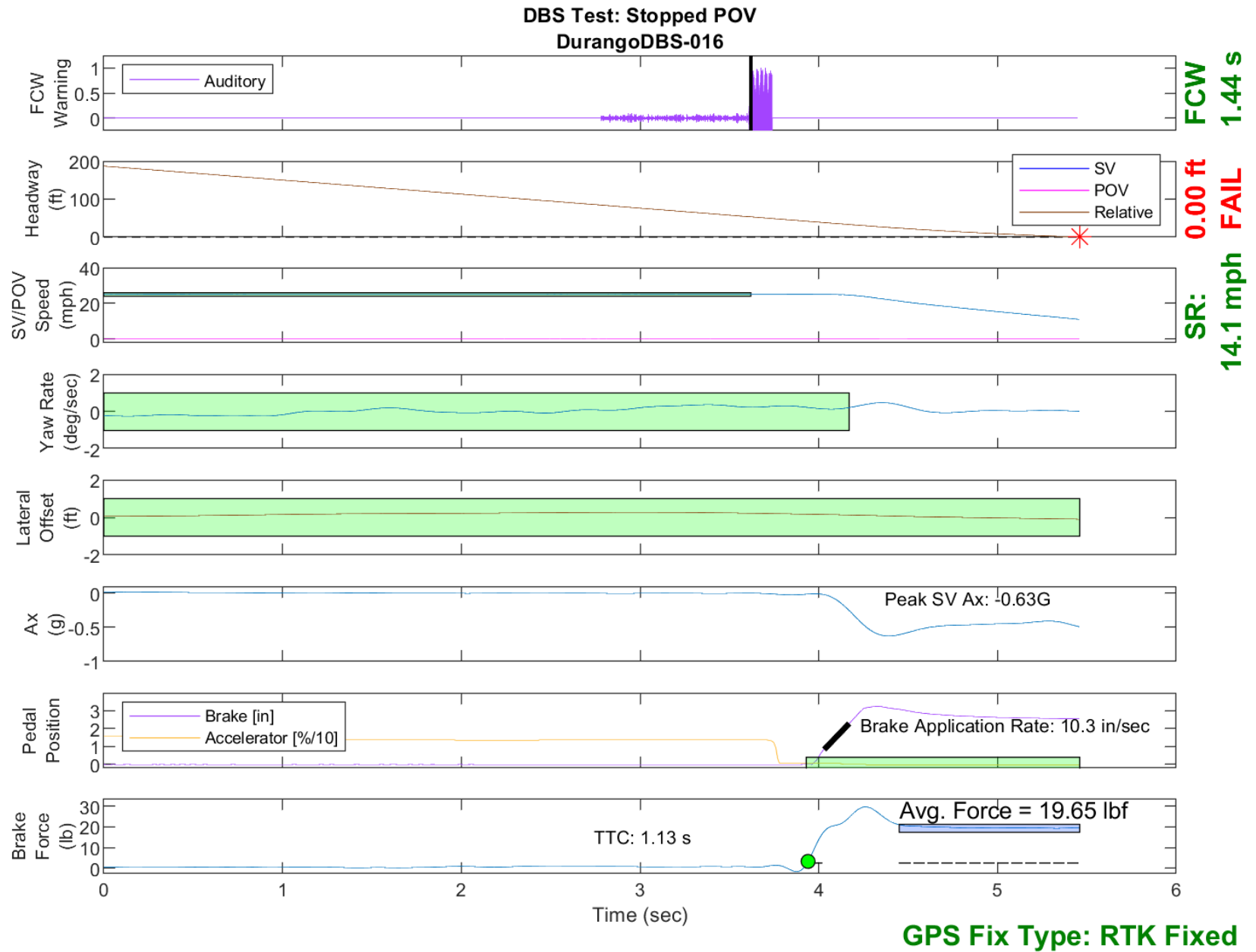


Figure E13. Time History for DBS Run 16, SV Encounters Stopped POV

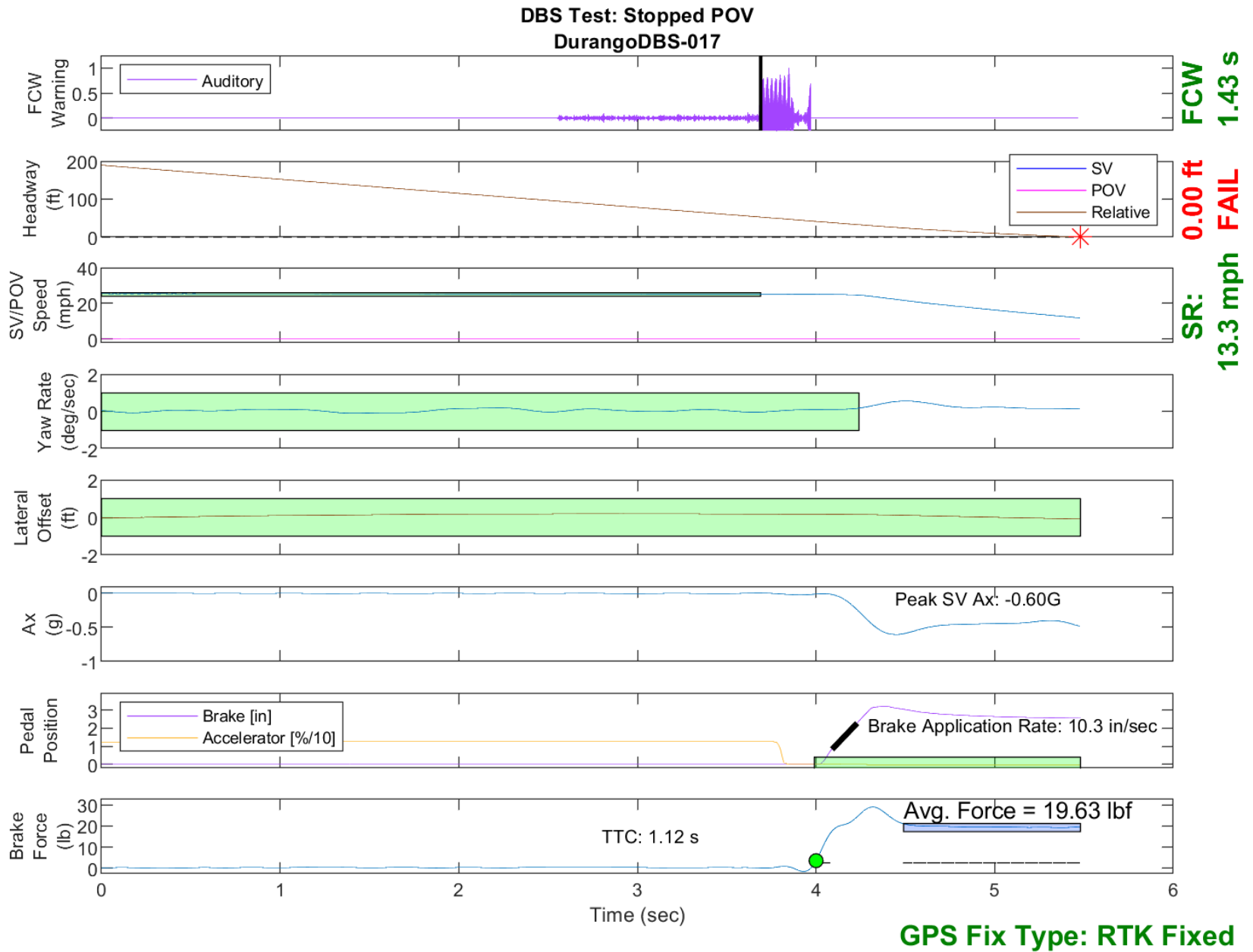


Figure E14. Time History for DBS Run 17, SV Encounters Stopped POV



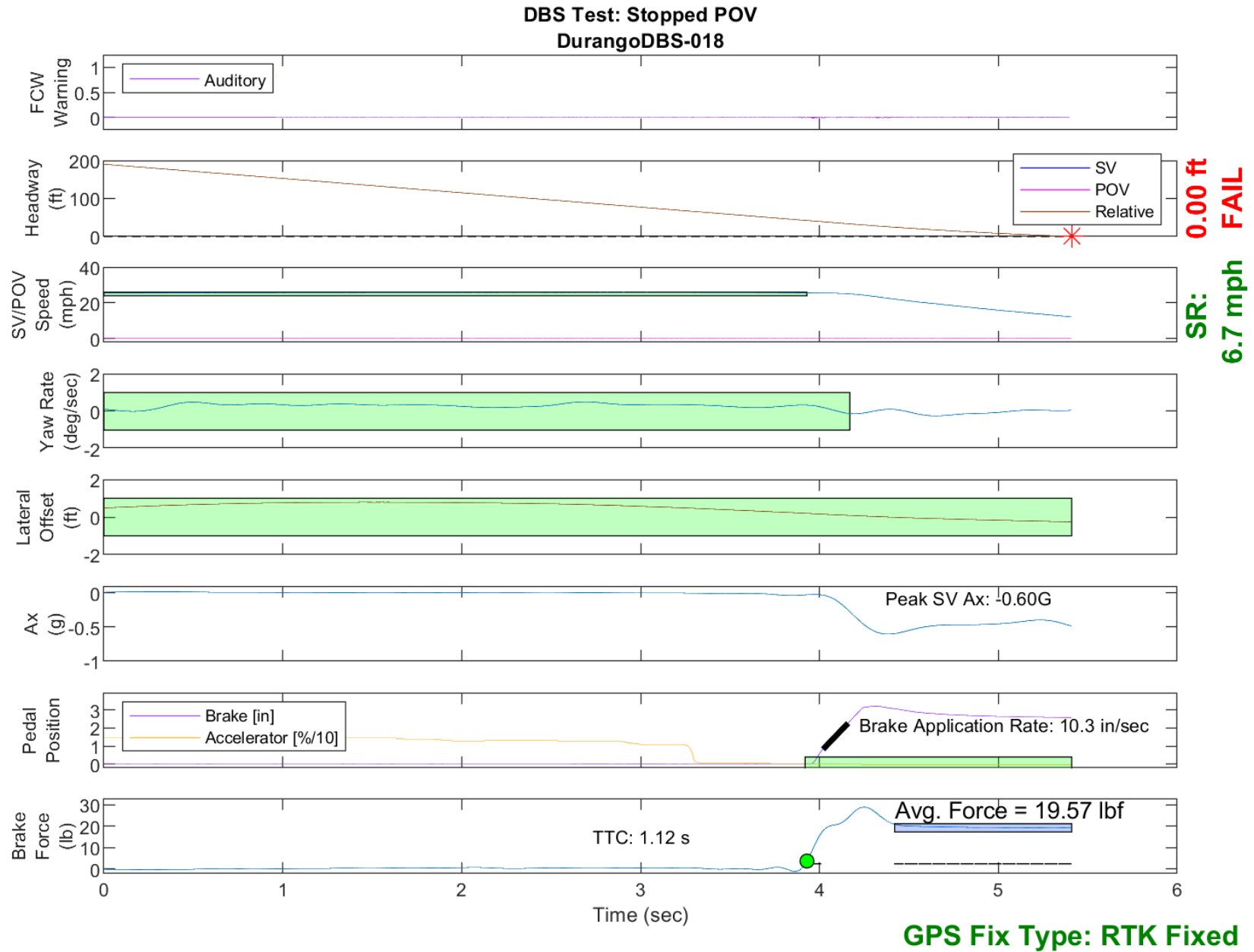


Figure E15. Time History for DBS Run 18, SV Encounters Stopped POV

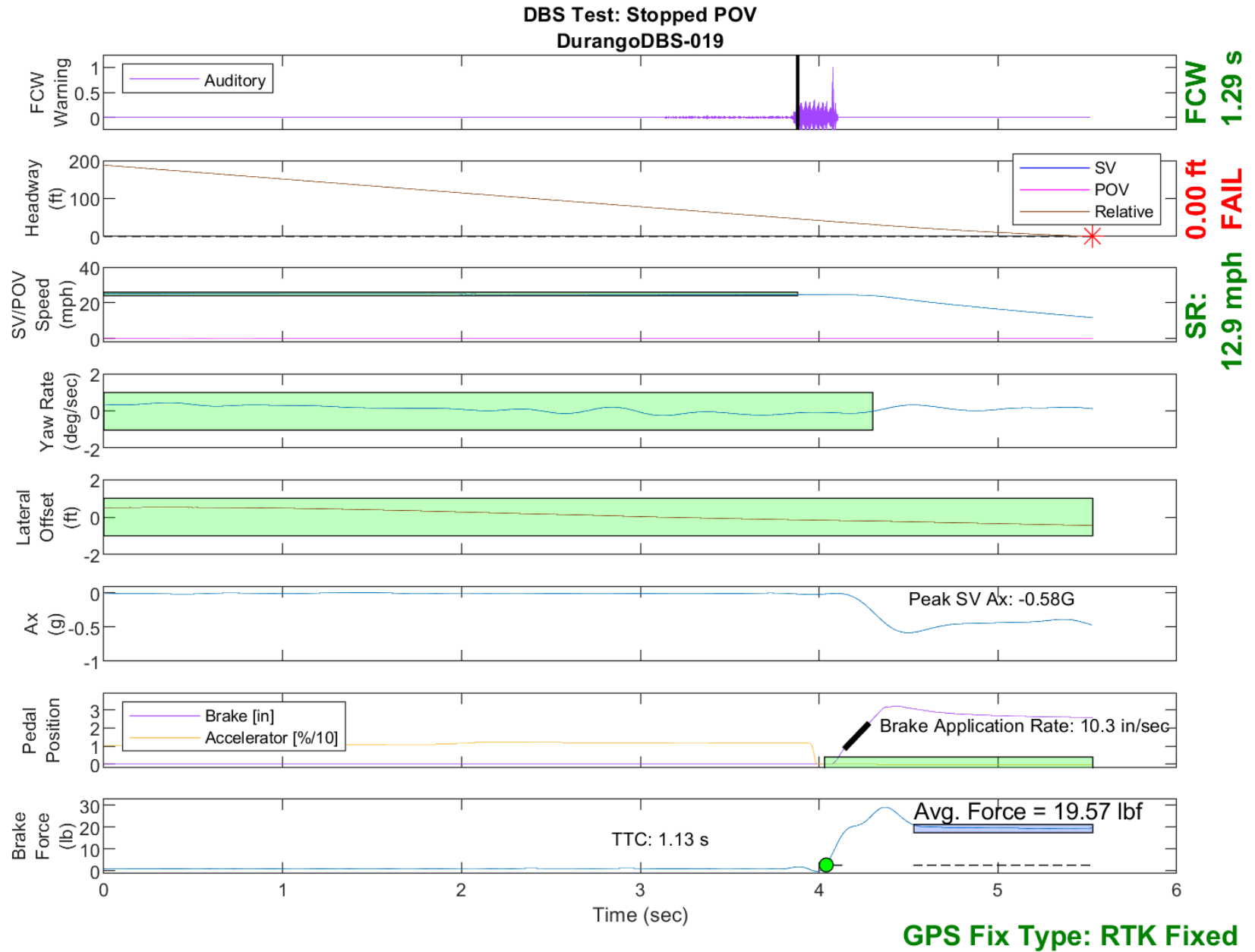


Figure E16. Time History for DBS Run 19, SV Encounters Stopped POV

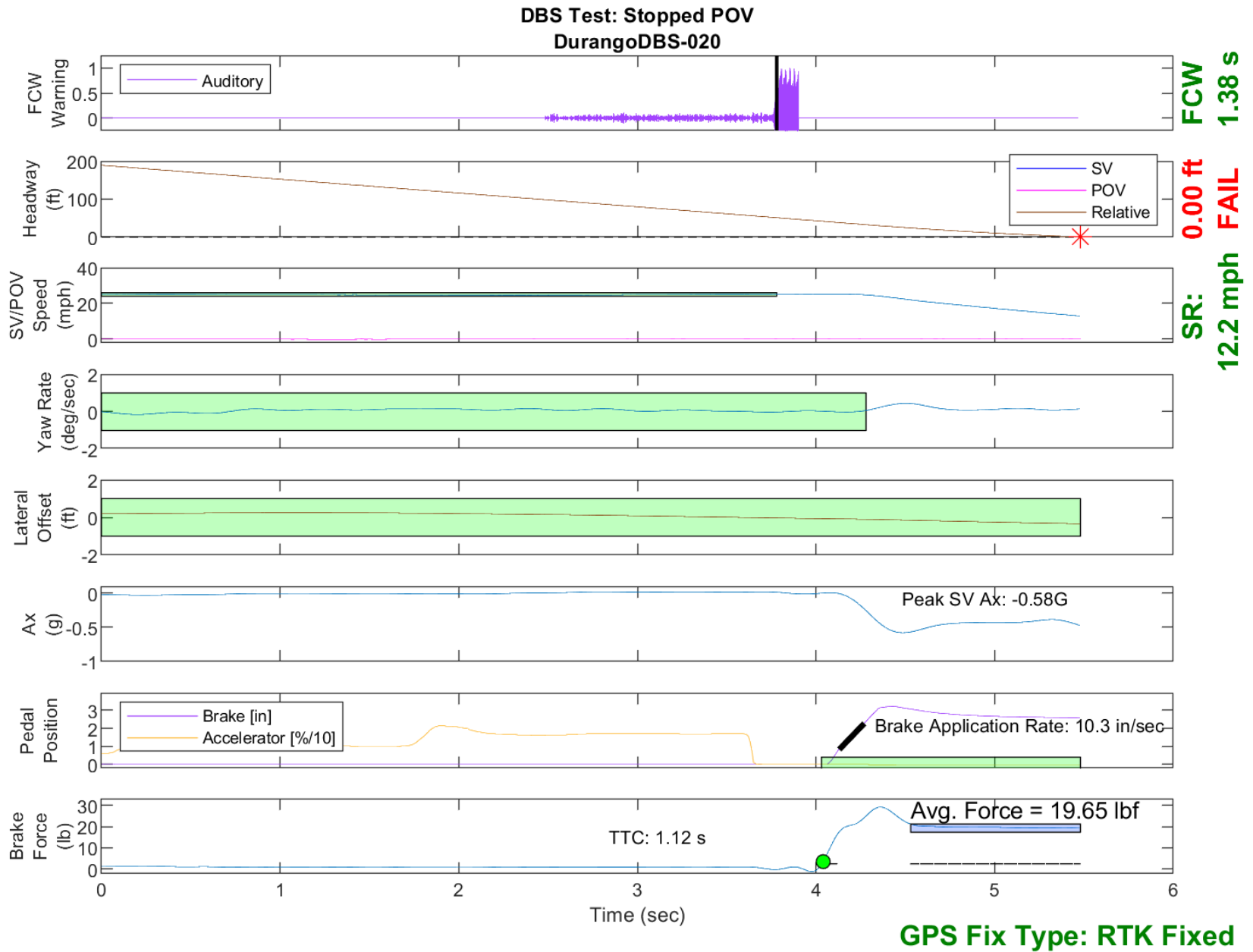


Figure E17. Time History for DBS Run 20, SV Encounters Stopped POV

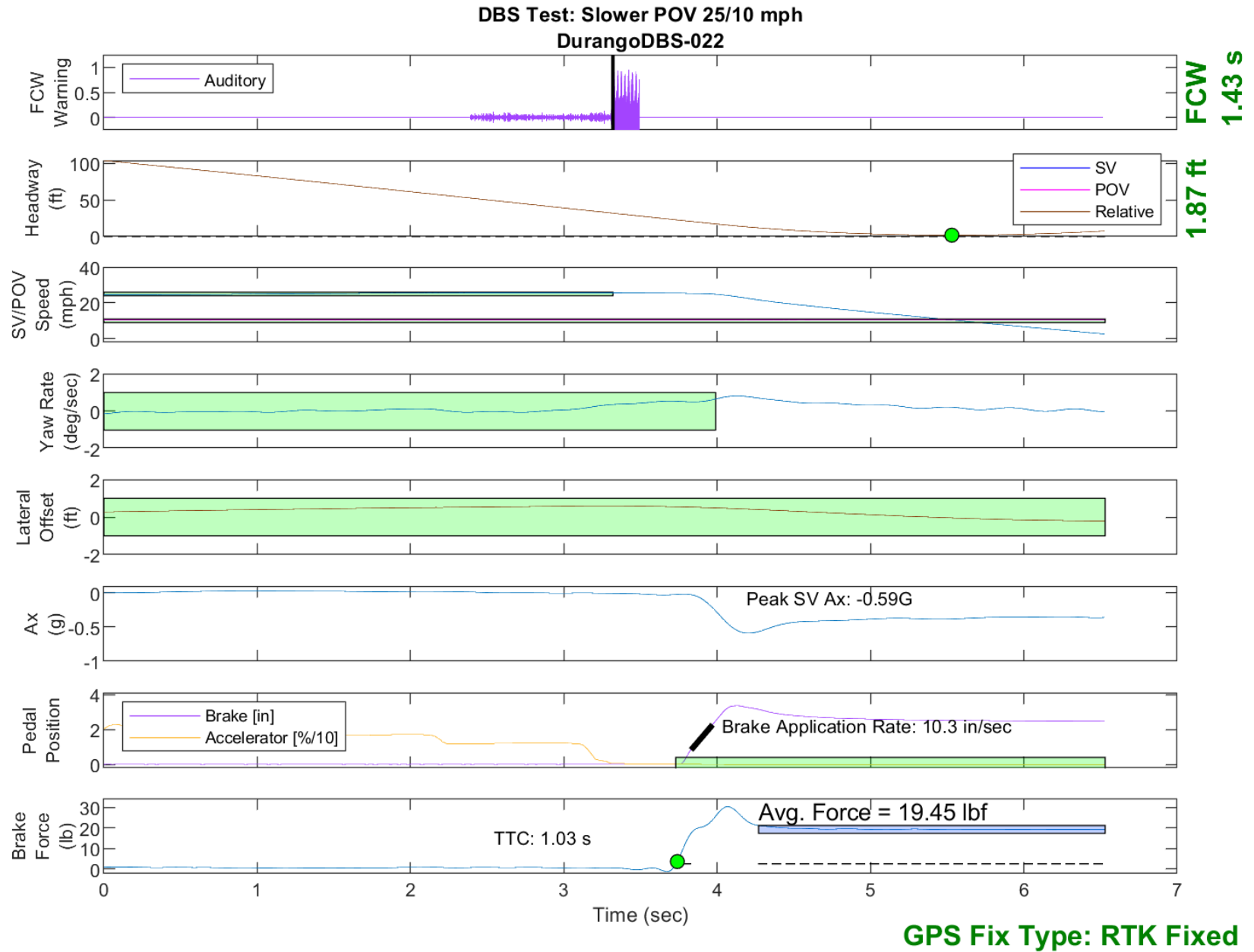


Figure E18. Time History for DBS Run 22, SV Encounters Slower POV, SV 25 mph, POV 10 mph

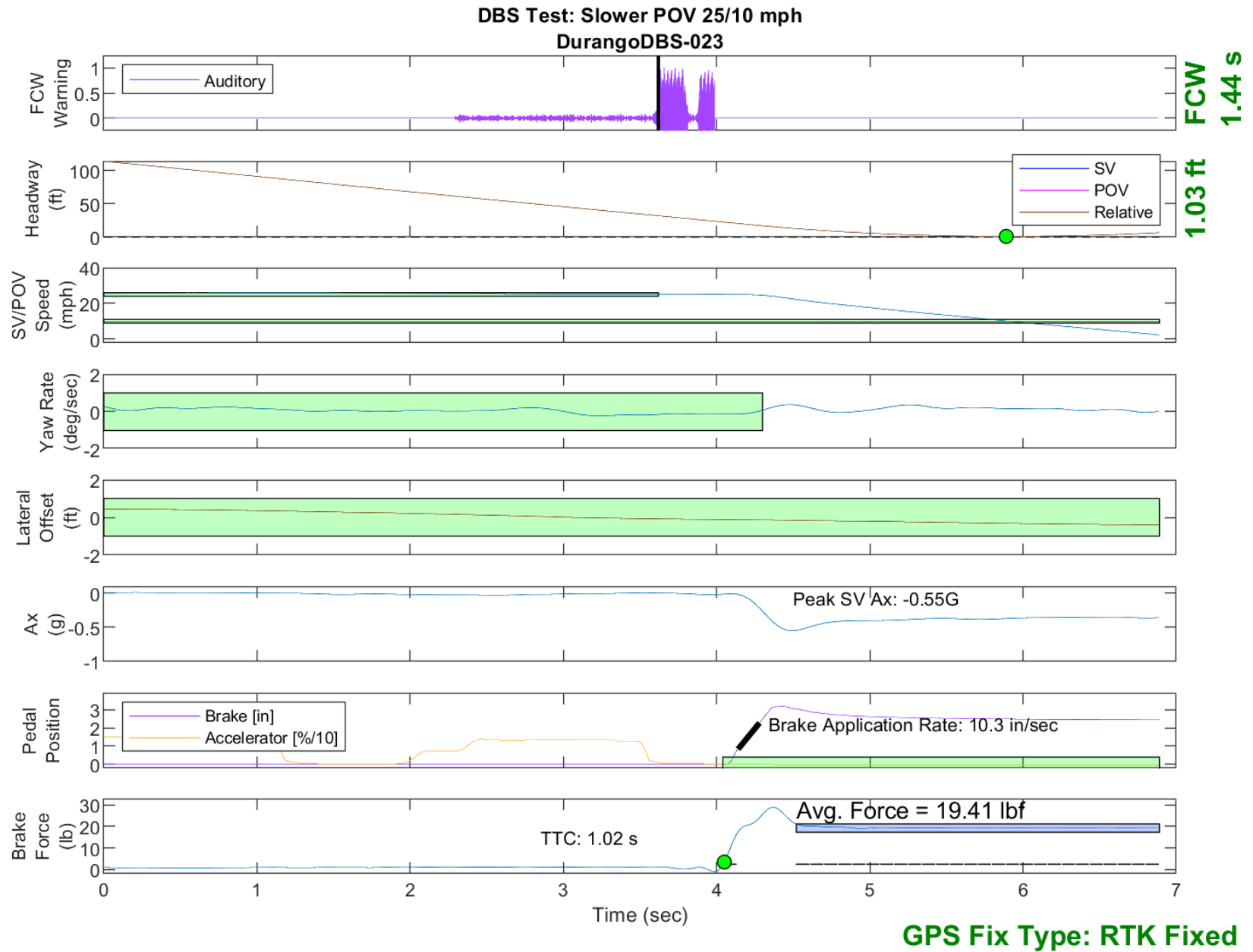


Figure E19. Time History for DBS Run 23, SV Encounters Slower POV, SV 25 mph, POV 10 mph

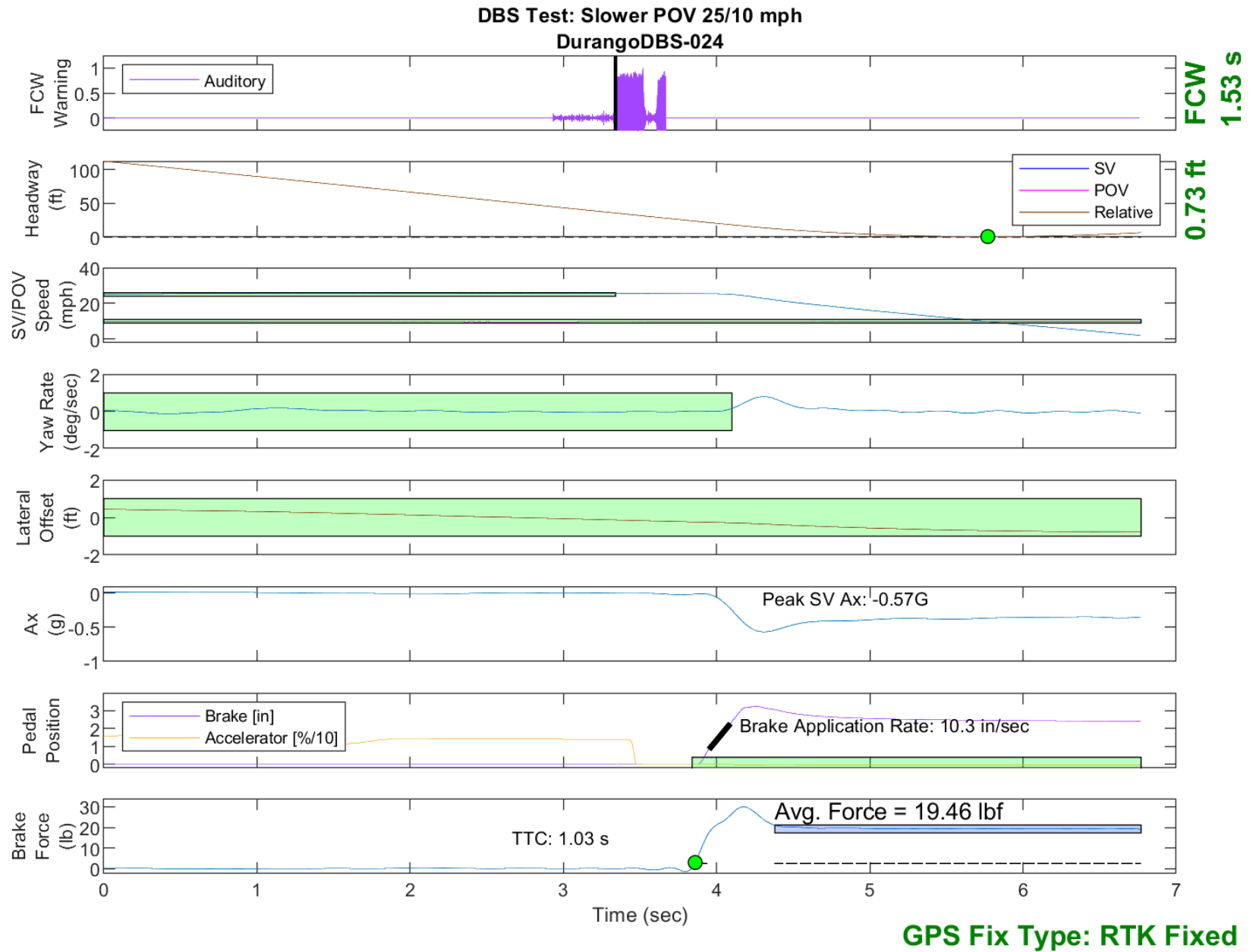


Figure E20. Time History for DBS Run 24, SV Encounters Slower POV, SV 25 mph, POV 10 mph

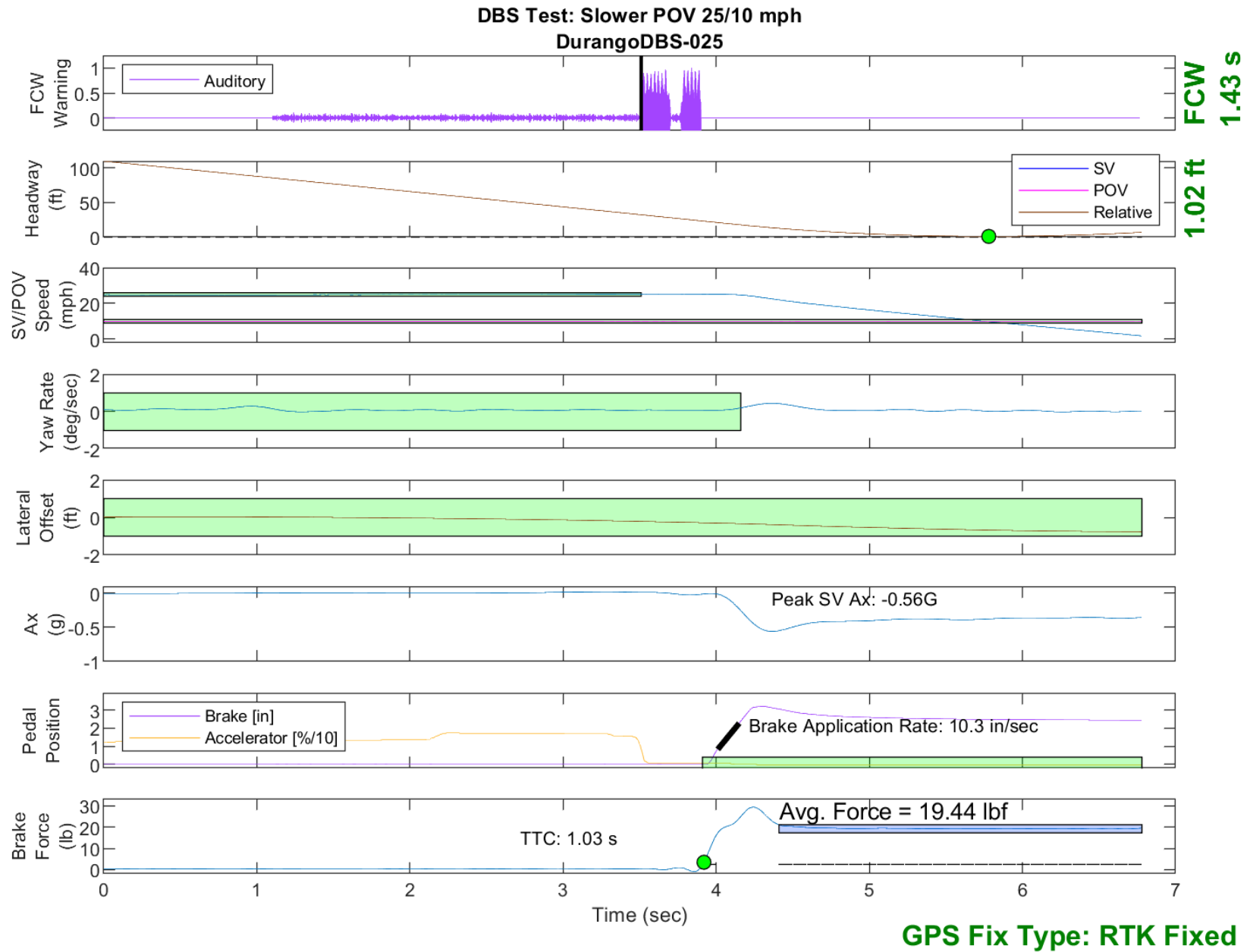


Figure E21. Time History for DBS Run 25, SV Encounters Slower POV, SV 25 mph, POV 10 mph

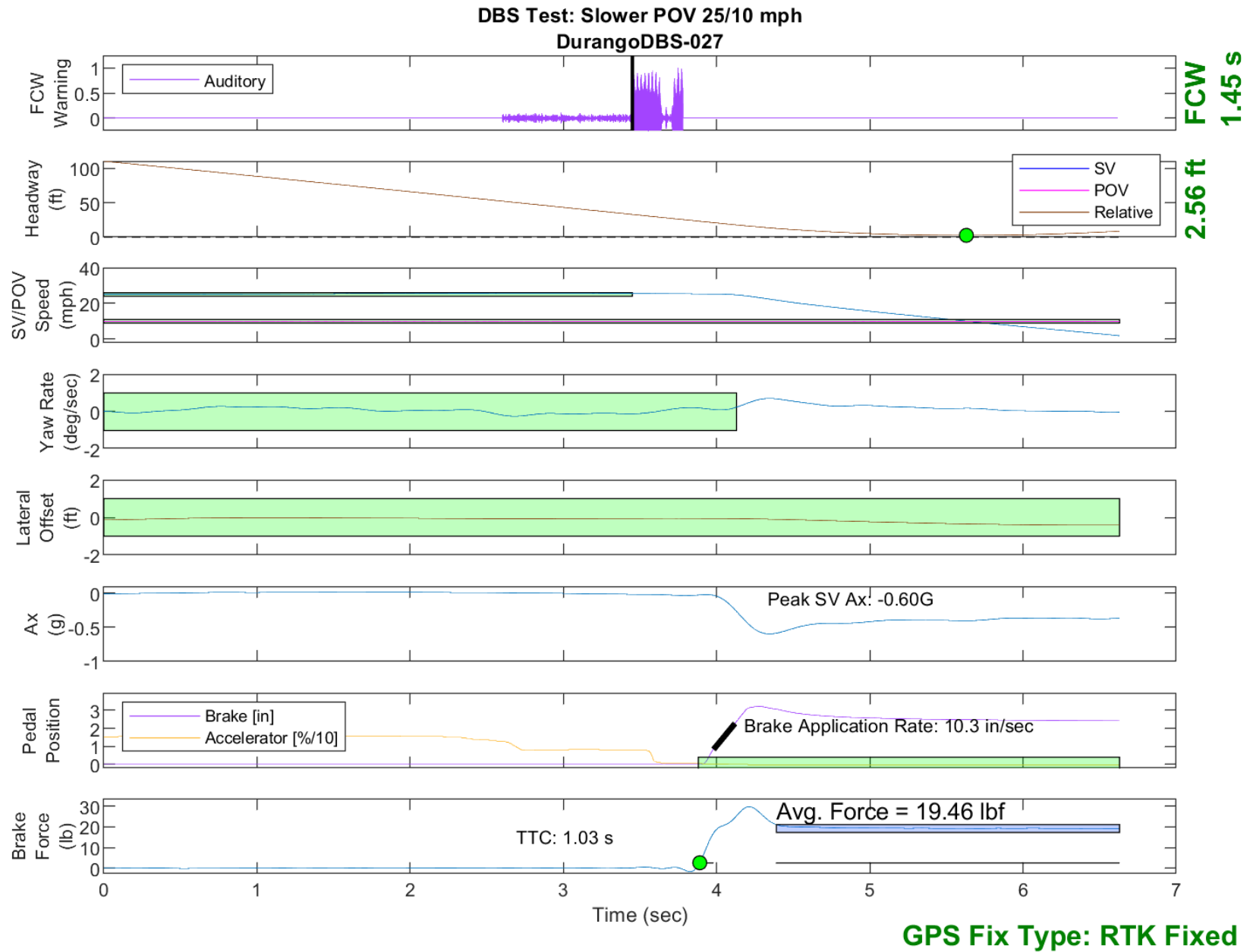


Figure E22. Time History for DBS Run 27, SV Encounters Slower POV, SV 25 mph, POV 10 mph



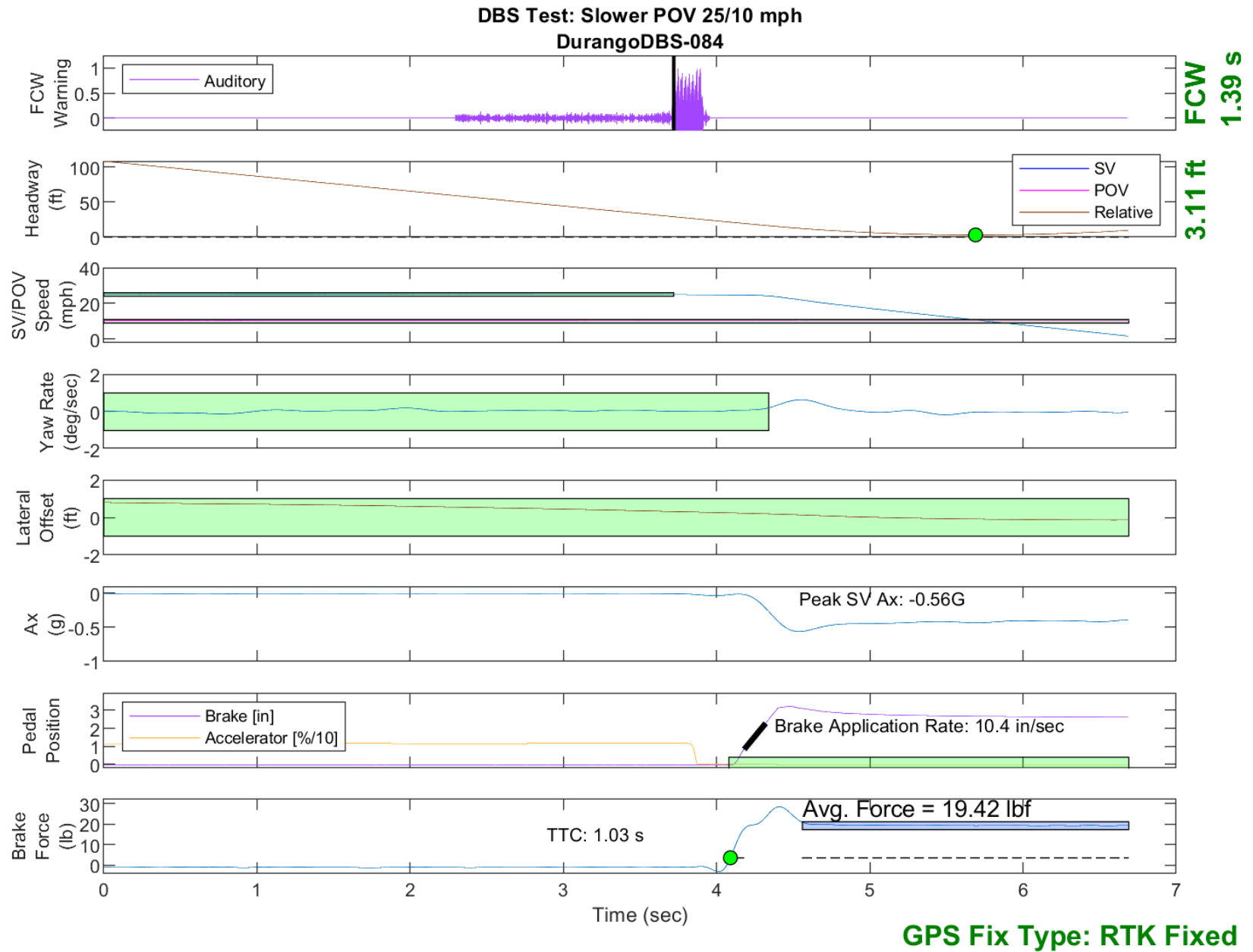


Figure E23. Time History for DBS Run 84, SV Encounters Slower POV, SV 25 mph, POV 10 mph

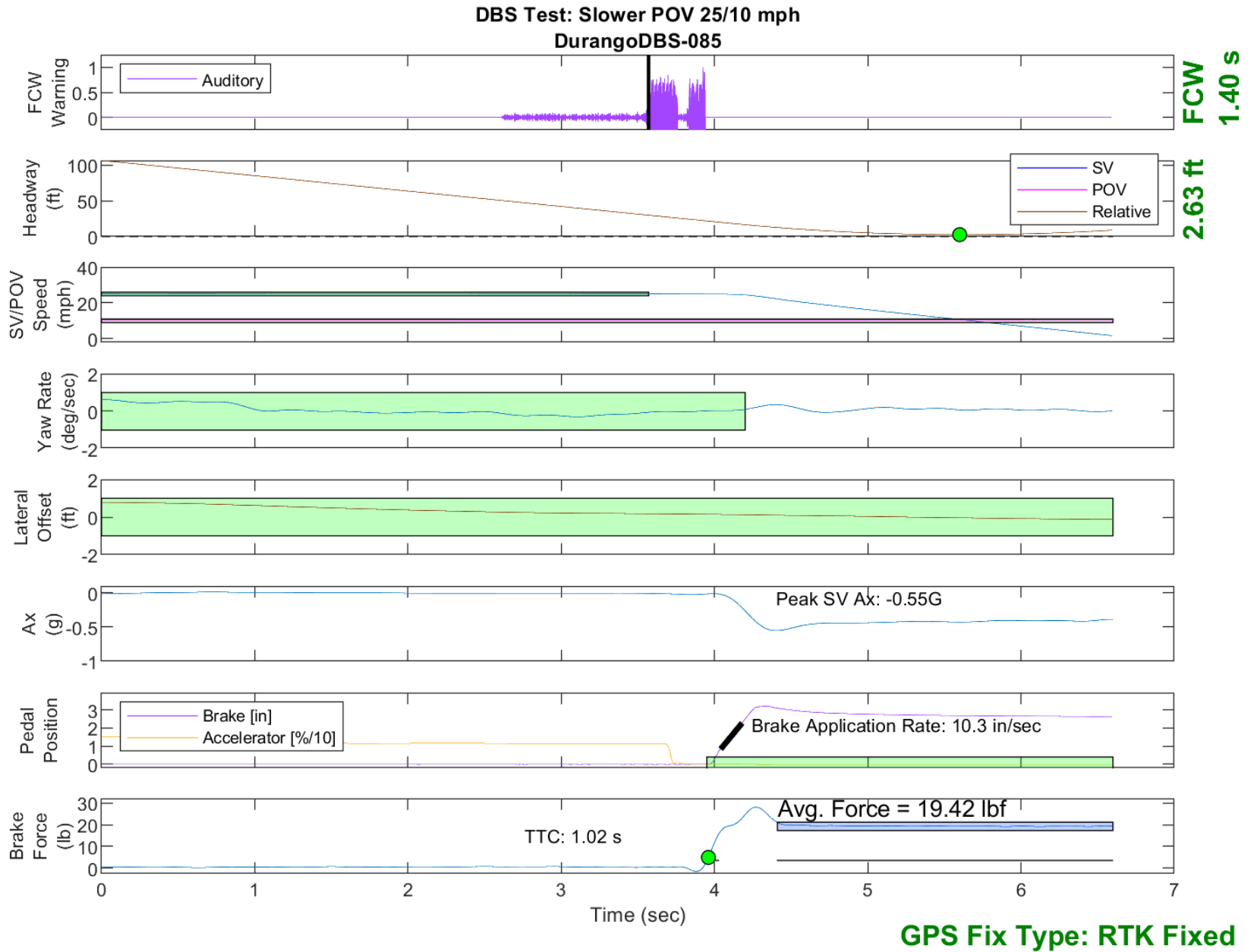


Figure E24. Time History for DBS Run 85, SV Encounters Slower POV, SV 25 mph, POV 10 mph

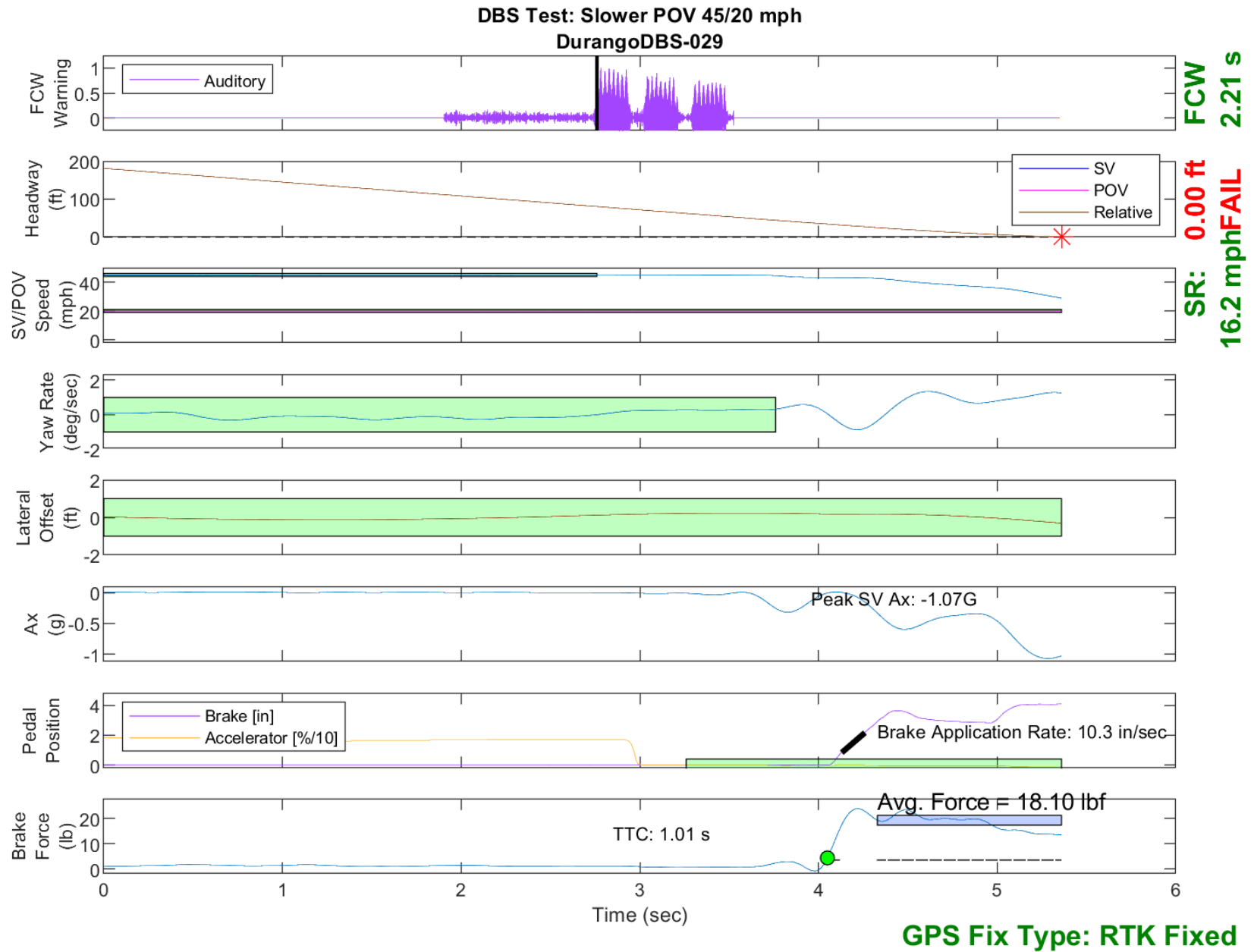


Figure E25. Time History for DBS Run 29, SV Encounters Slower POV, SV 45 mph, POV 20 mph

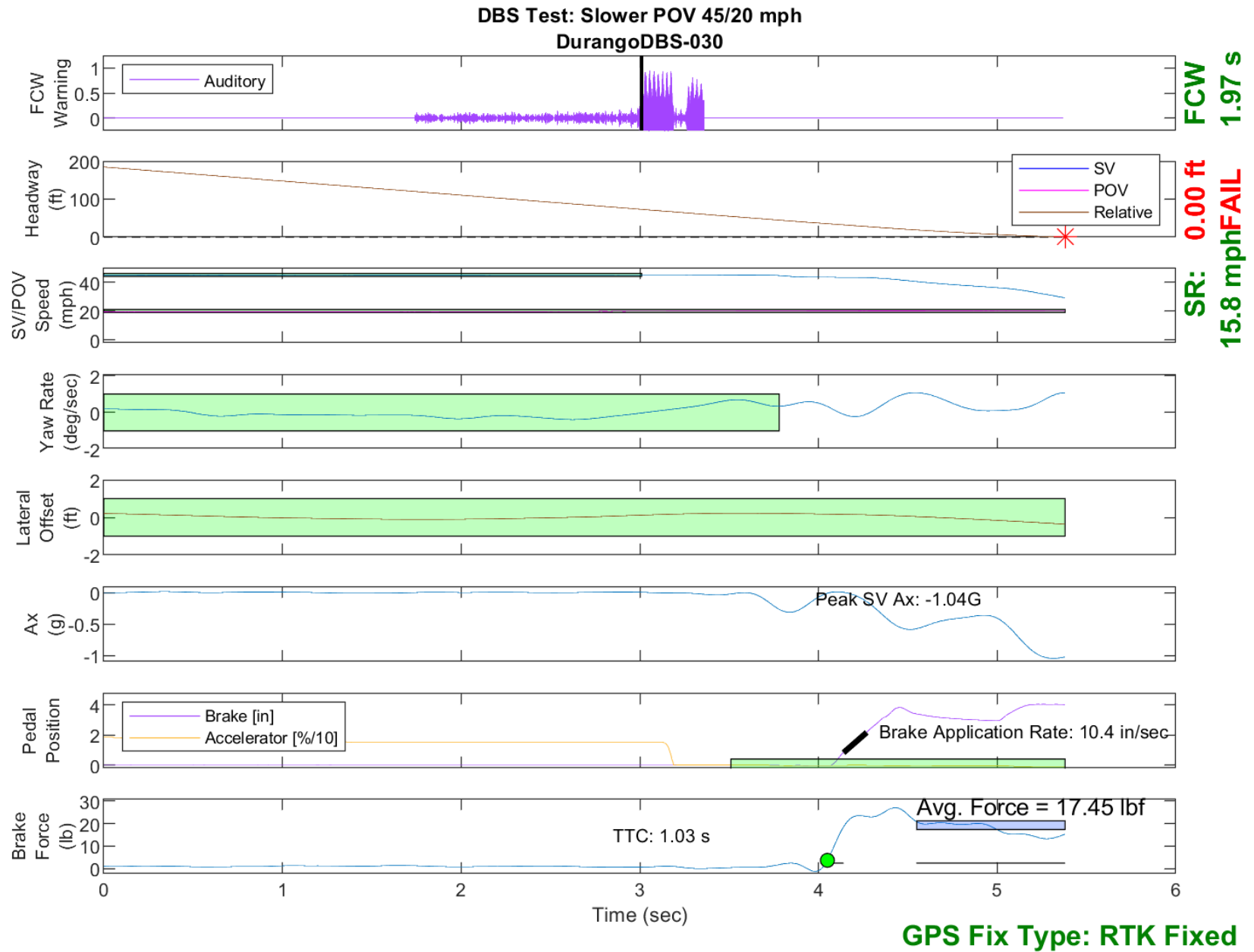


Figure E26. Time History for DBS Run 30, SV Encounters Slower POV, SV 45 mph, POV 20 mph

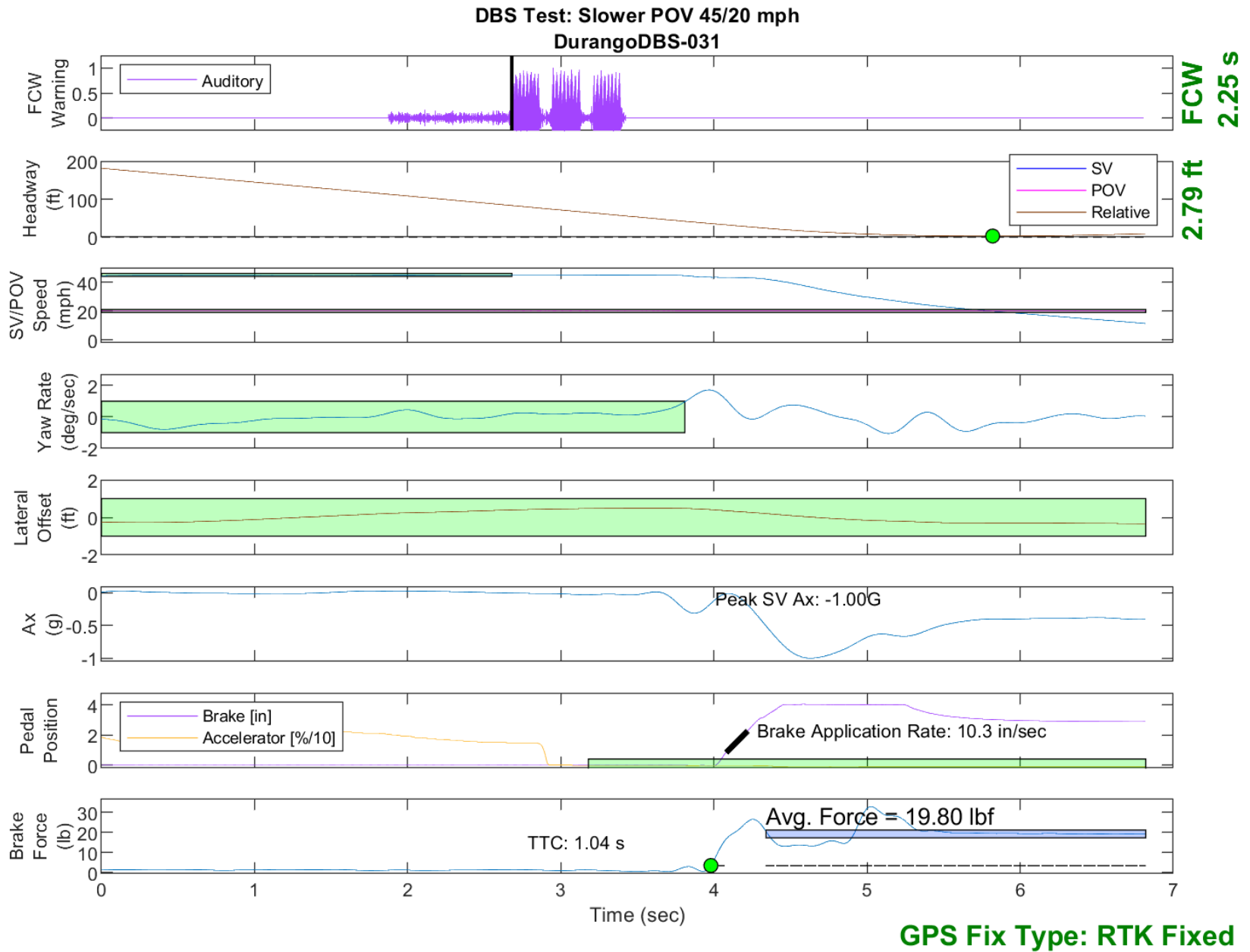


Figure E27. Time History for DBS Run 31, SV Encounters Slower POV, SV 45 mph, POV 20 mph

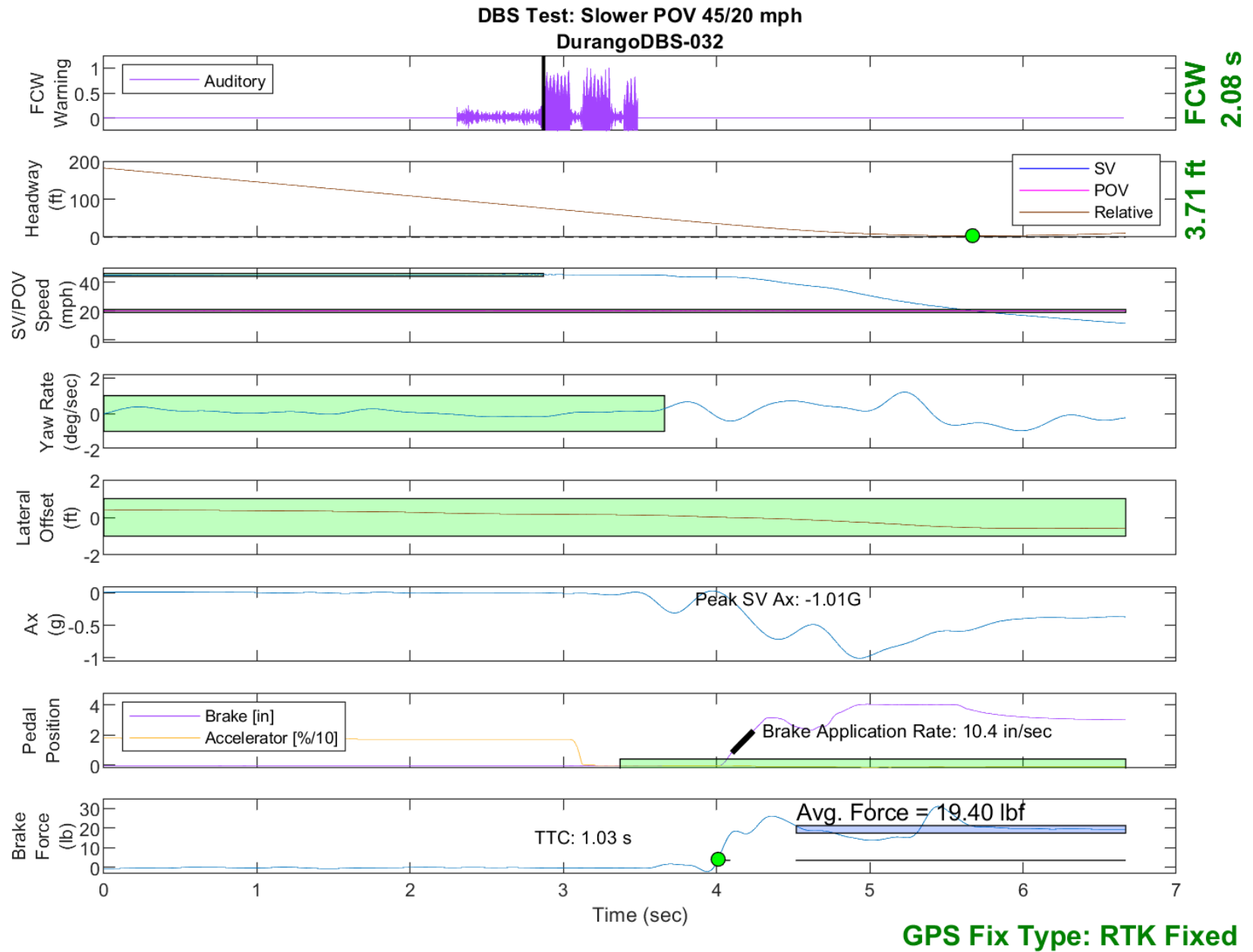


Figure E28. Time History for DBS Run 32, SV Encounters Slower POV, SV 45 mph, POV 20 mph

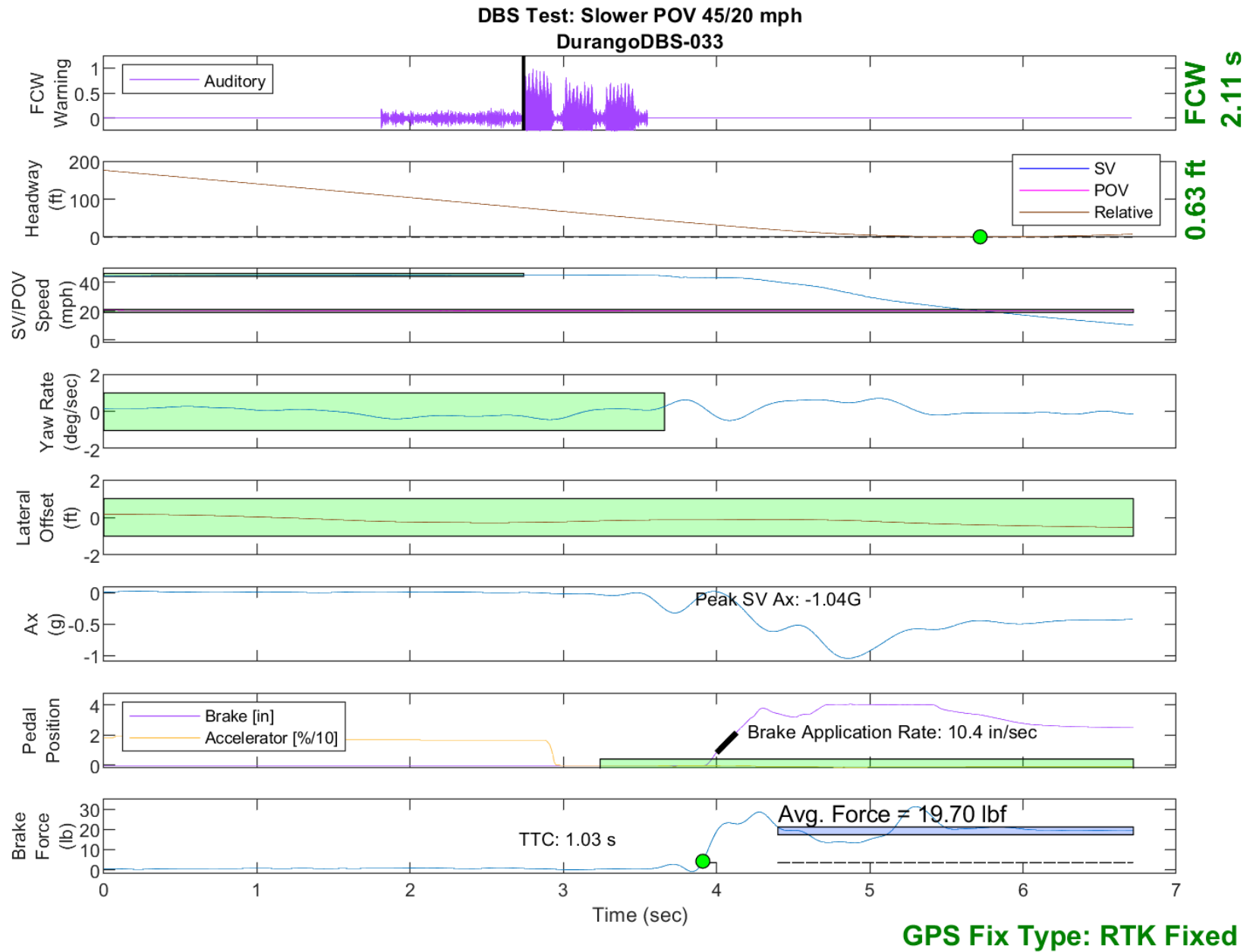


Figure E29. Time History for DBS Run 33, SV Encounters Slower POV, SV 45 mph, POV 20 mph

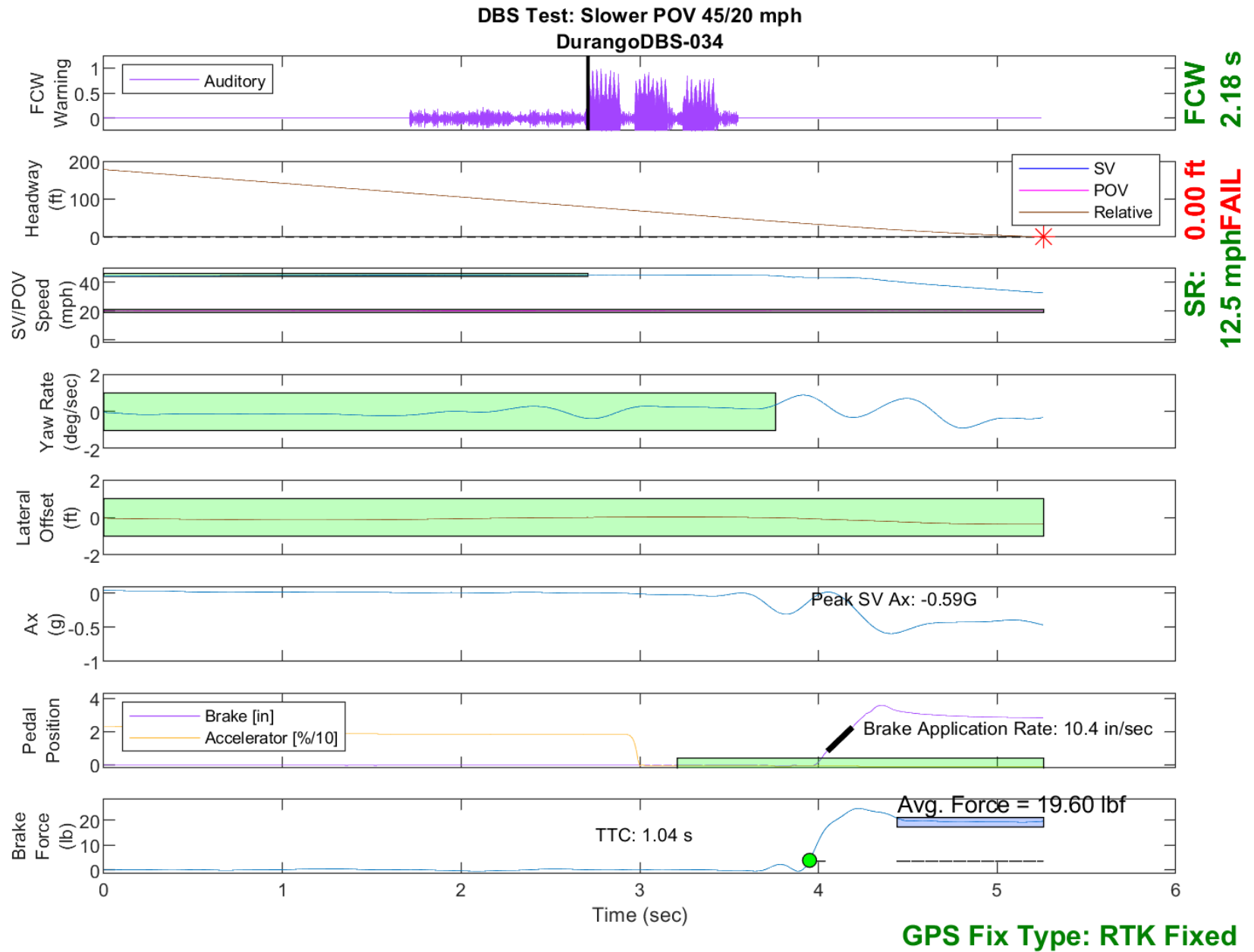


Figure E30. Time History for DBS Run 34, SV Encounters Slower POV, SV 45 mph, POV 20 mph



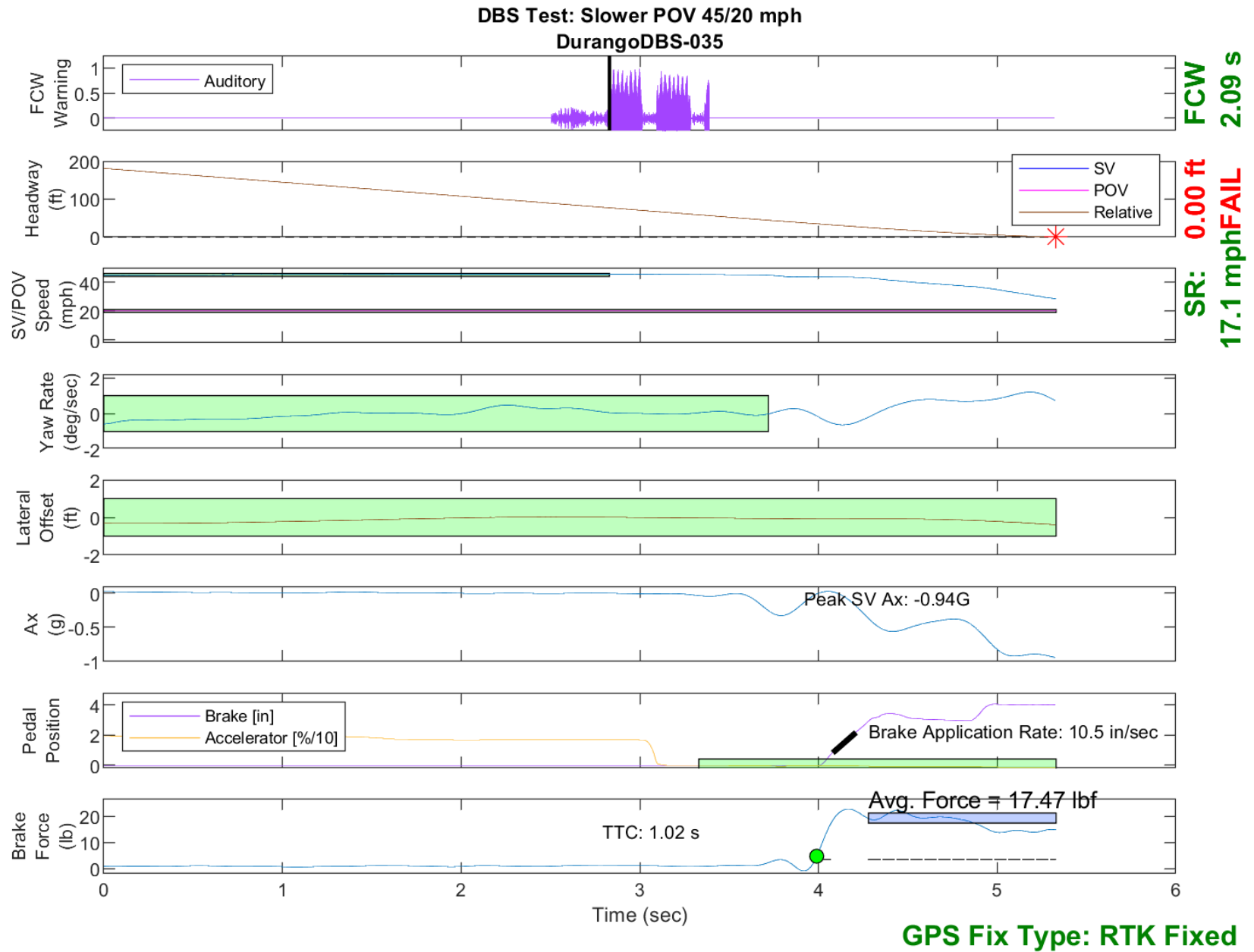


Figure E31. Time History for DBS Run 35, SV Encounters Slower POV, SV 45 mph, POV 20 mph

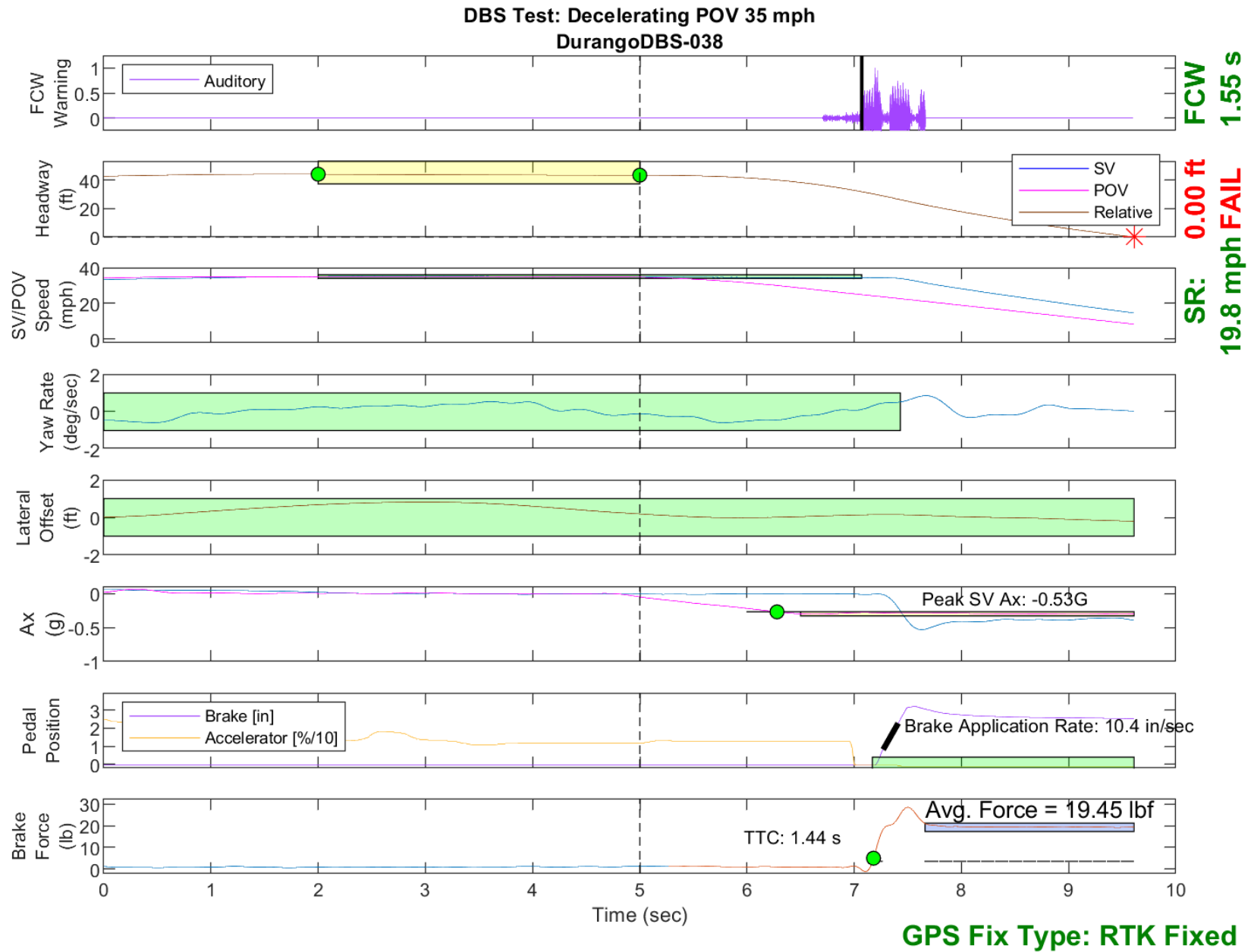


Figure E32. Time History for DBS Run 38, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

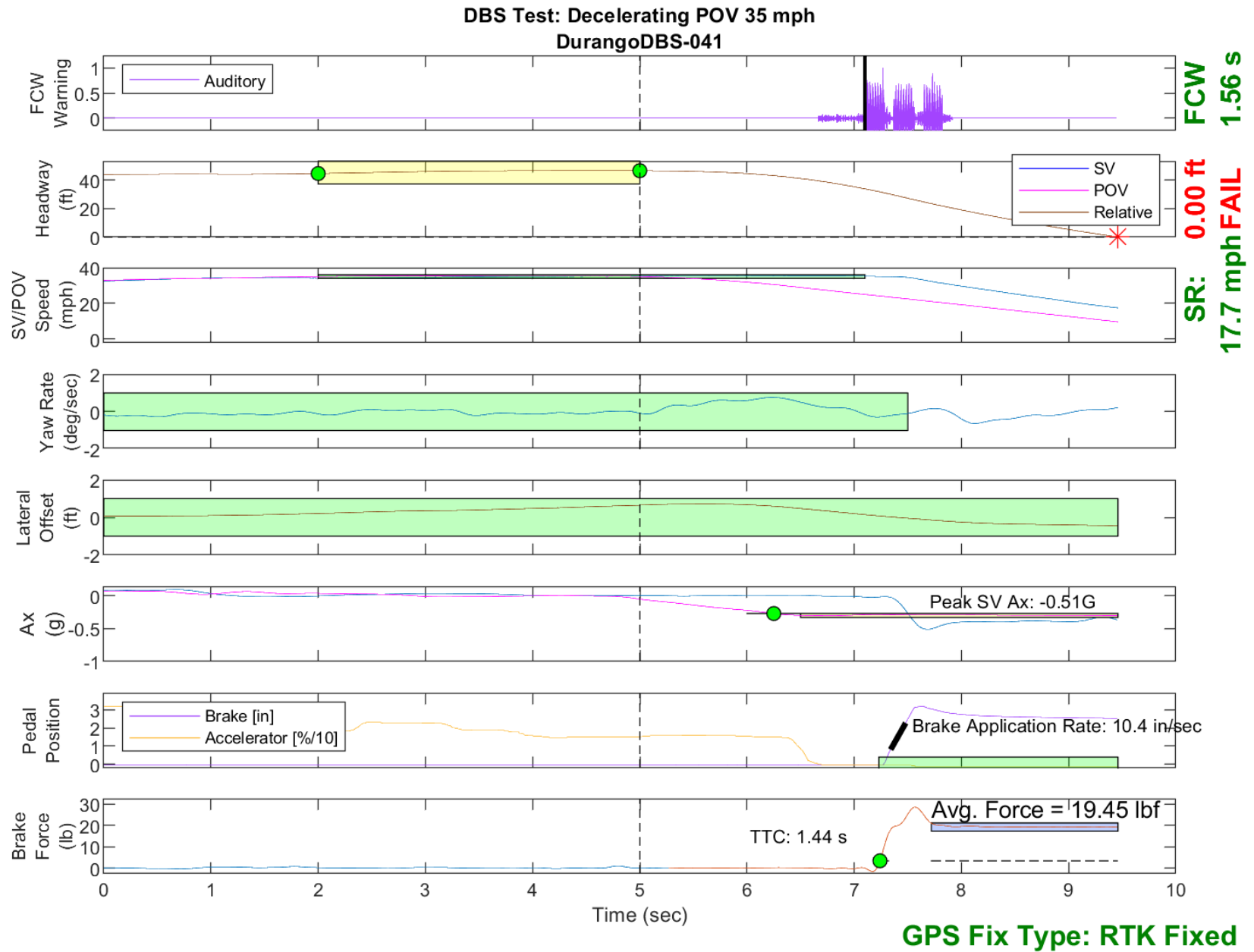


Figure E33. Time History for DBS Run 41, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

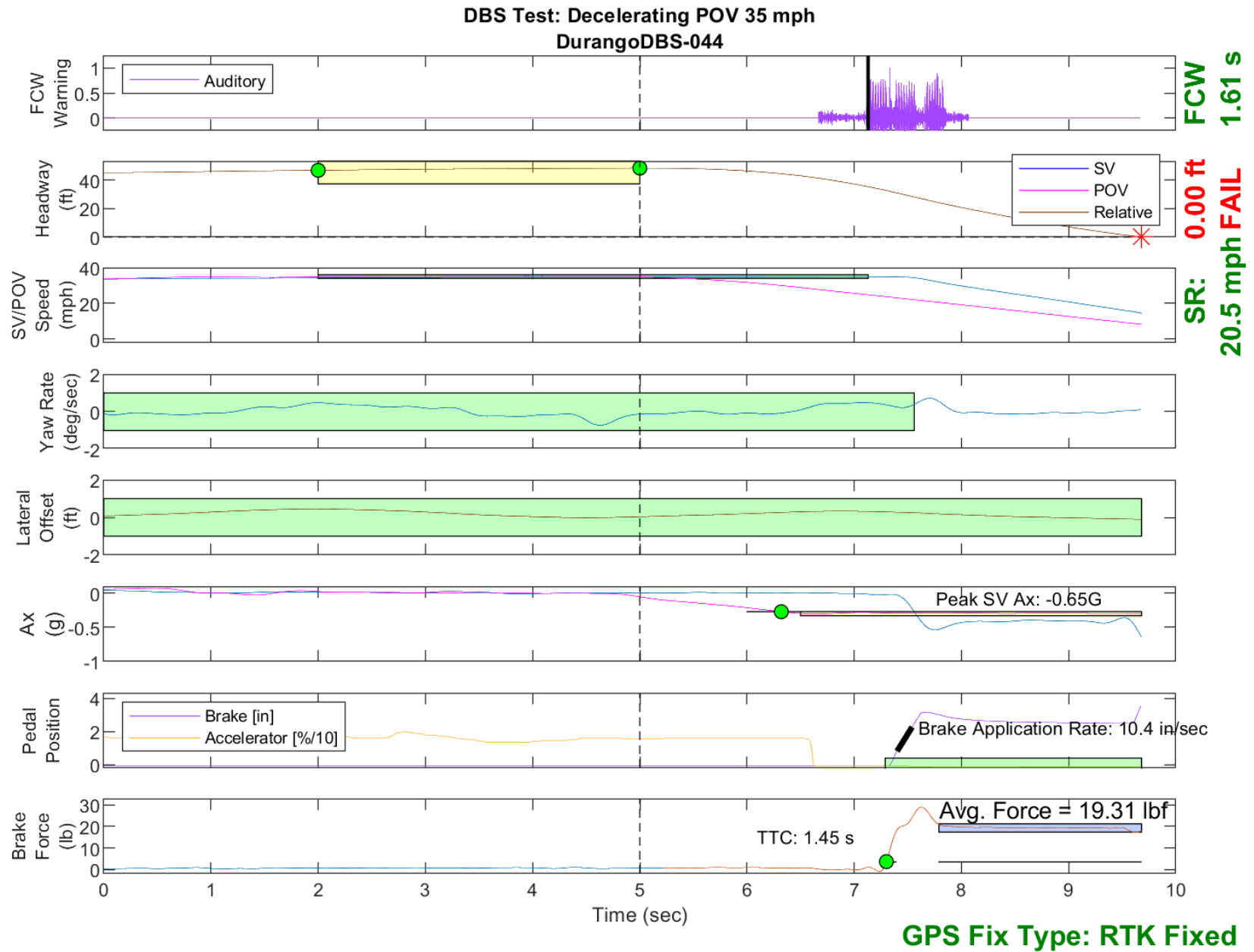


Figure E34. Time History for DBS Run 44, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

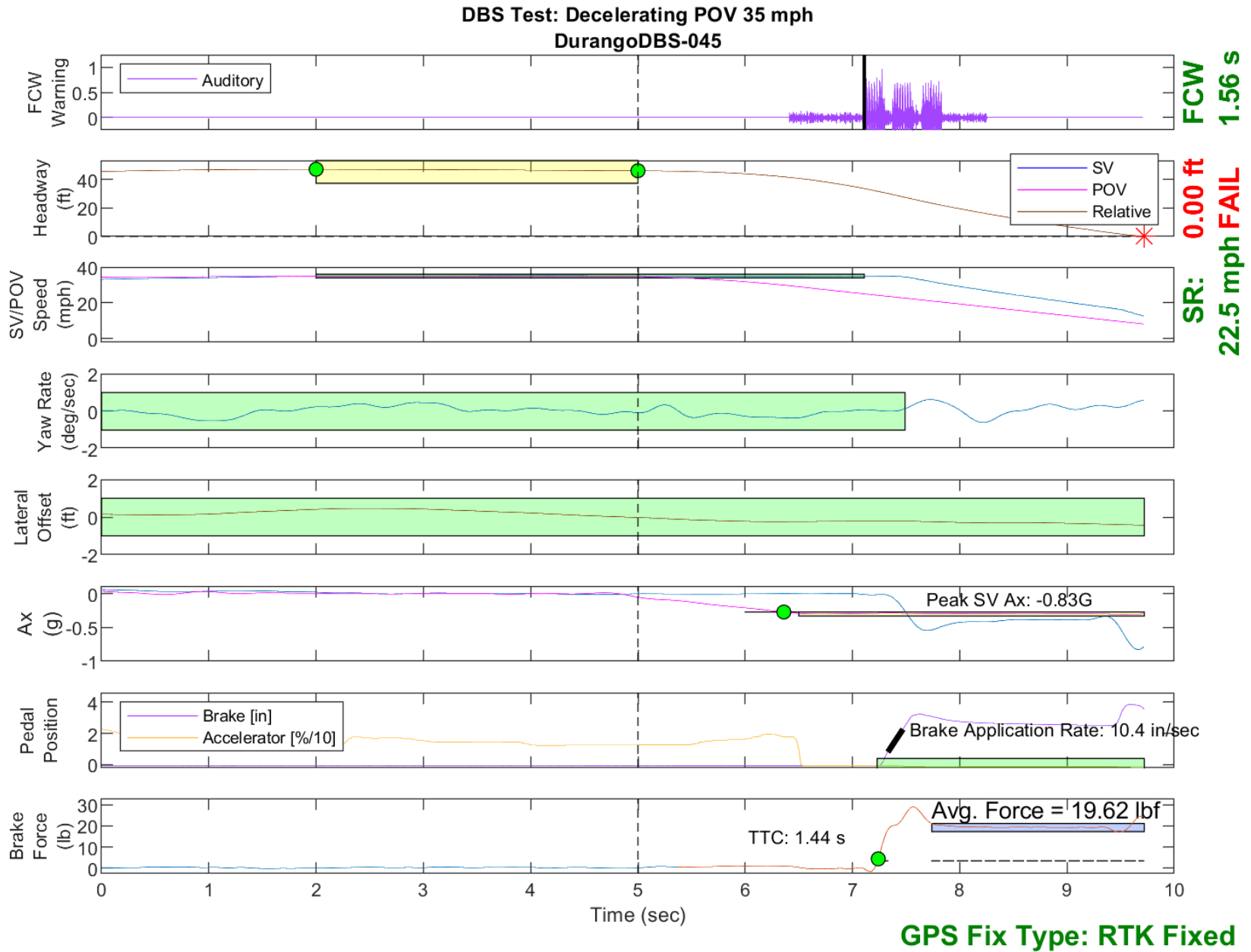


Figure E35. Time History for DBS Run 45, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

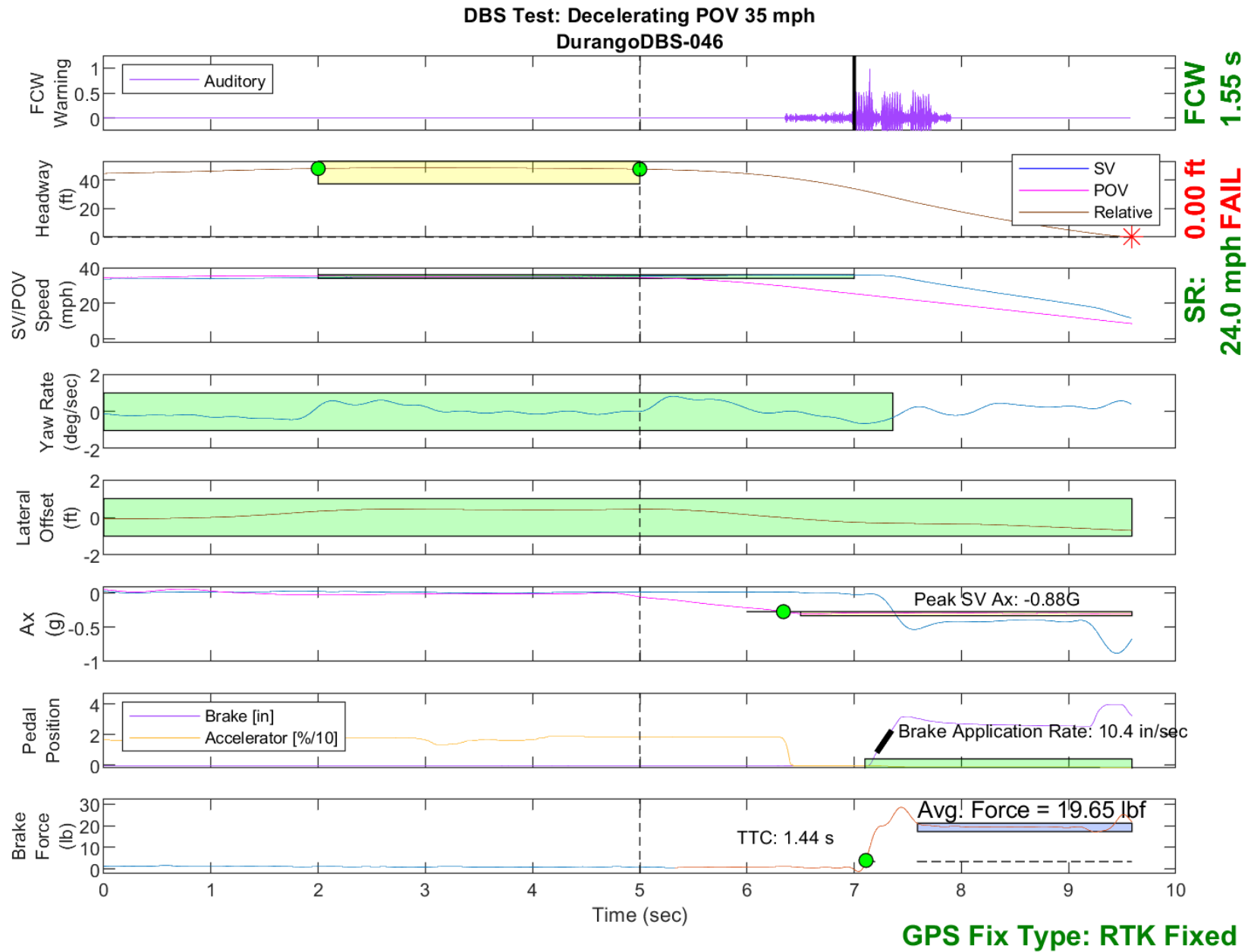


Figure E36. Time History for DBS Run 46, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

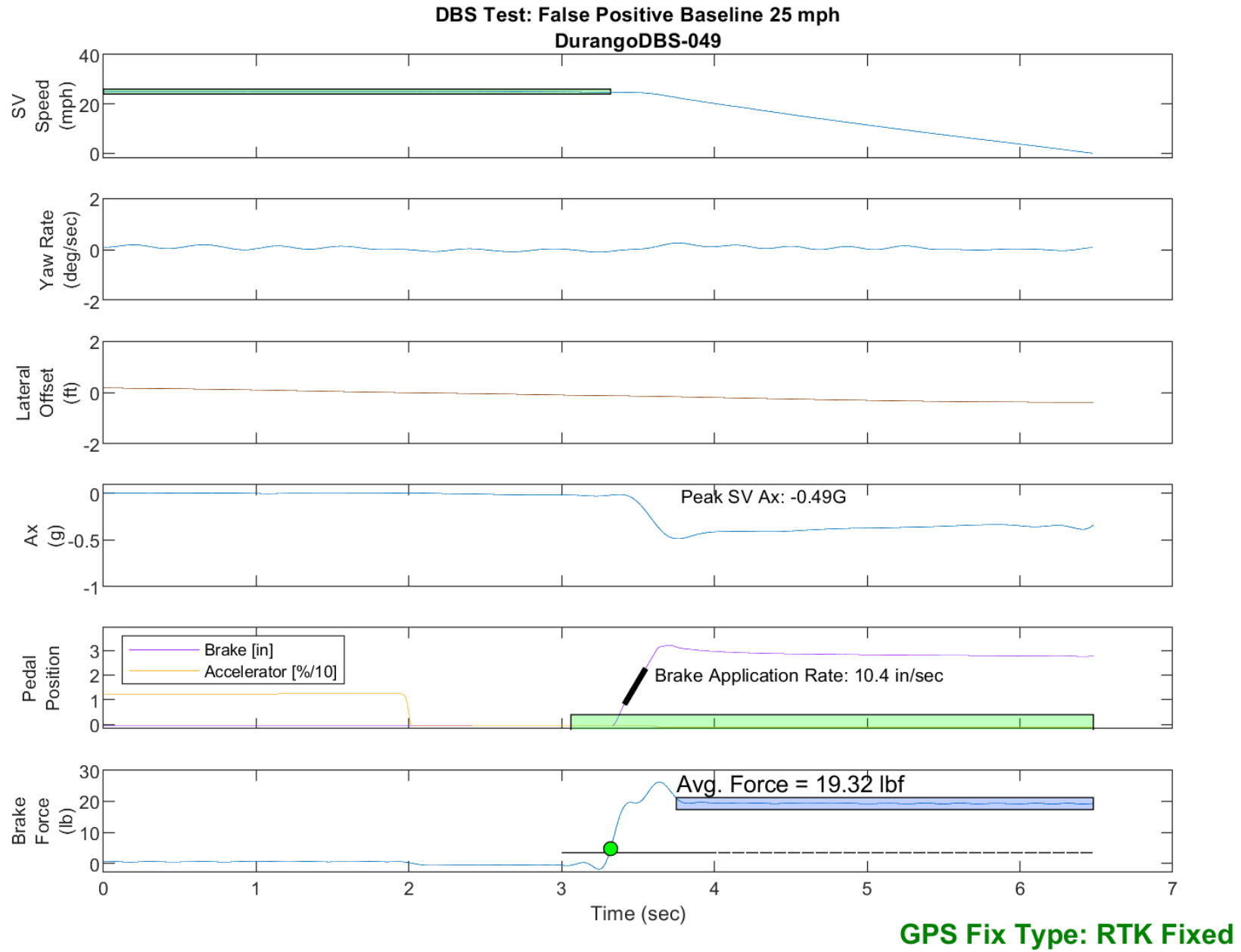


Figure E37. Time History for DBS Run 49, False Positive Baseline, SV 25 mph

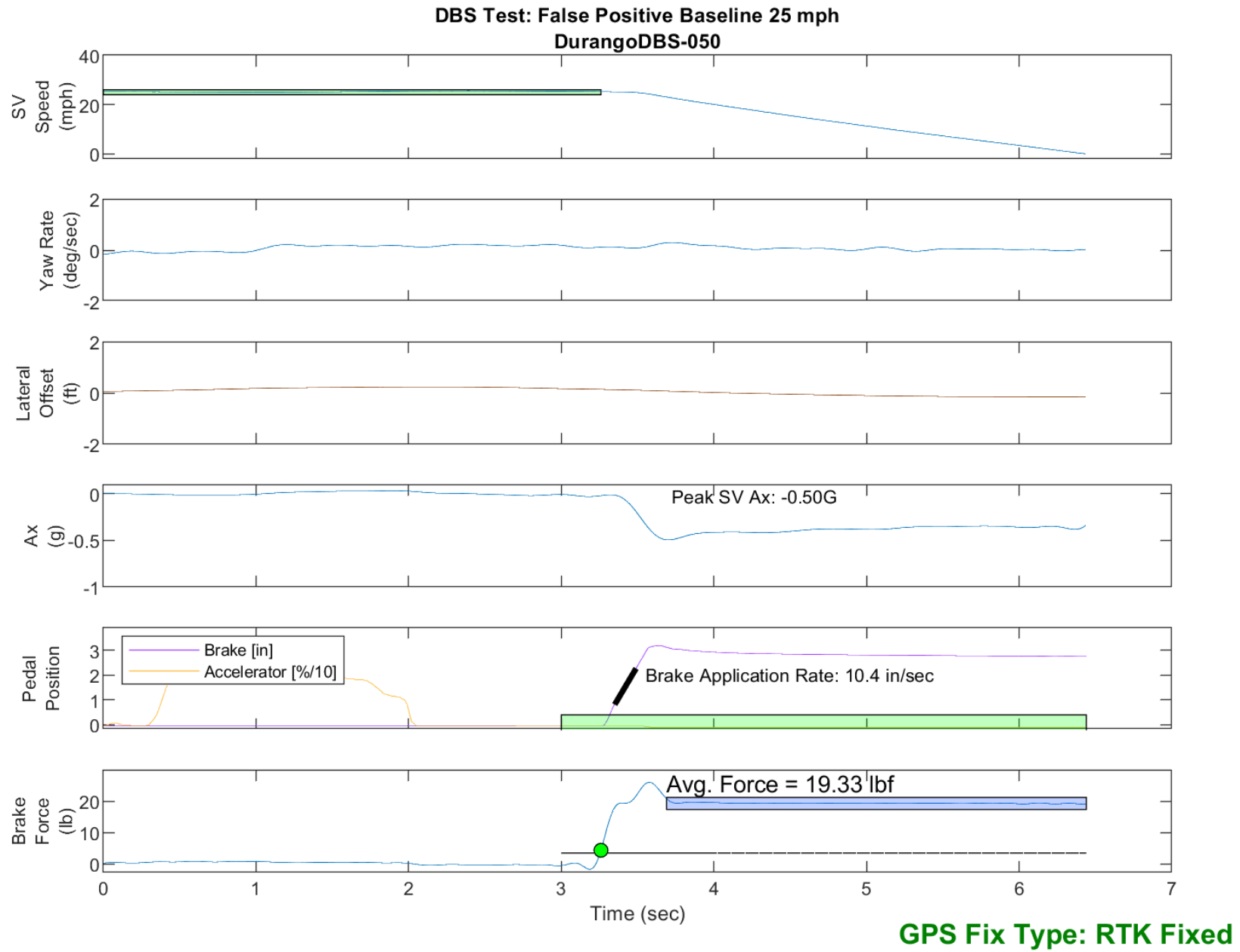


Figure E38. Time History for DBS Run 50, False Positive Baseline, SV 25 mph



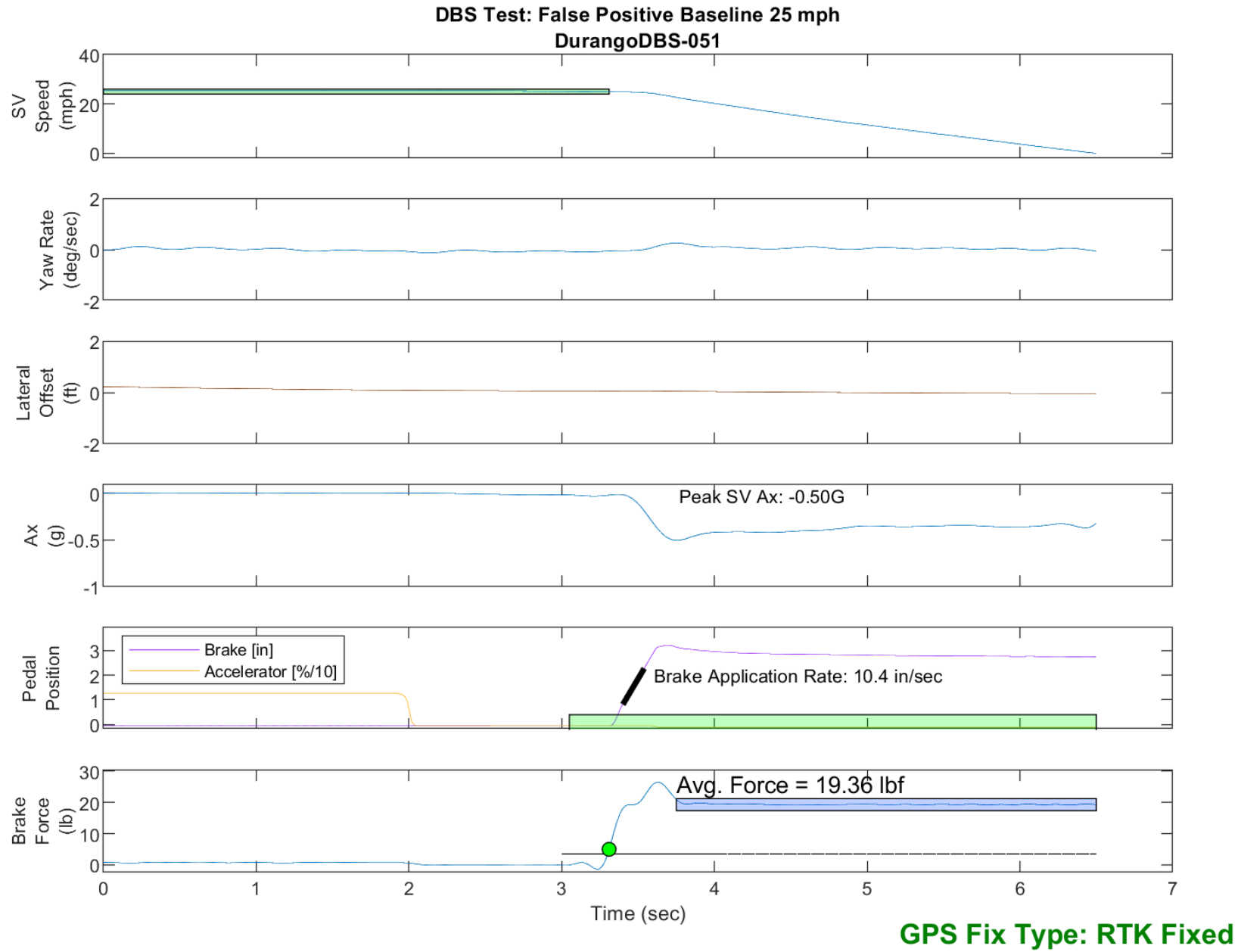
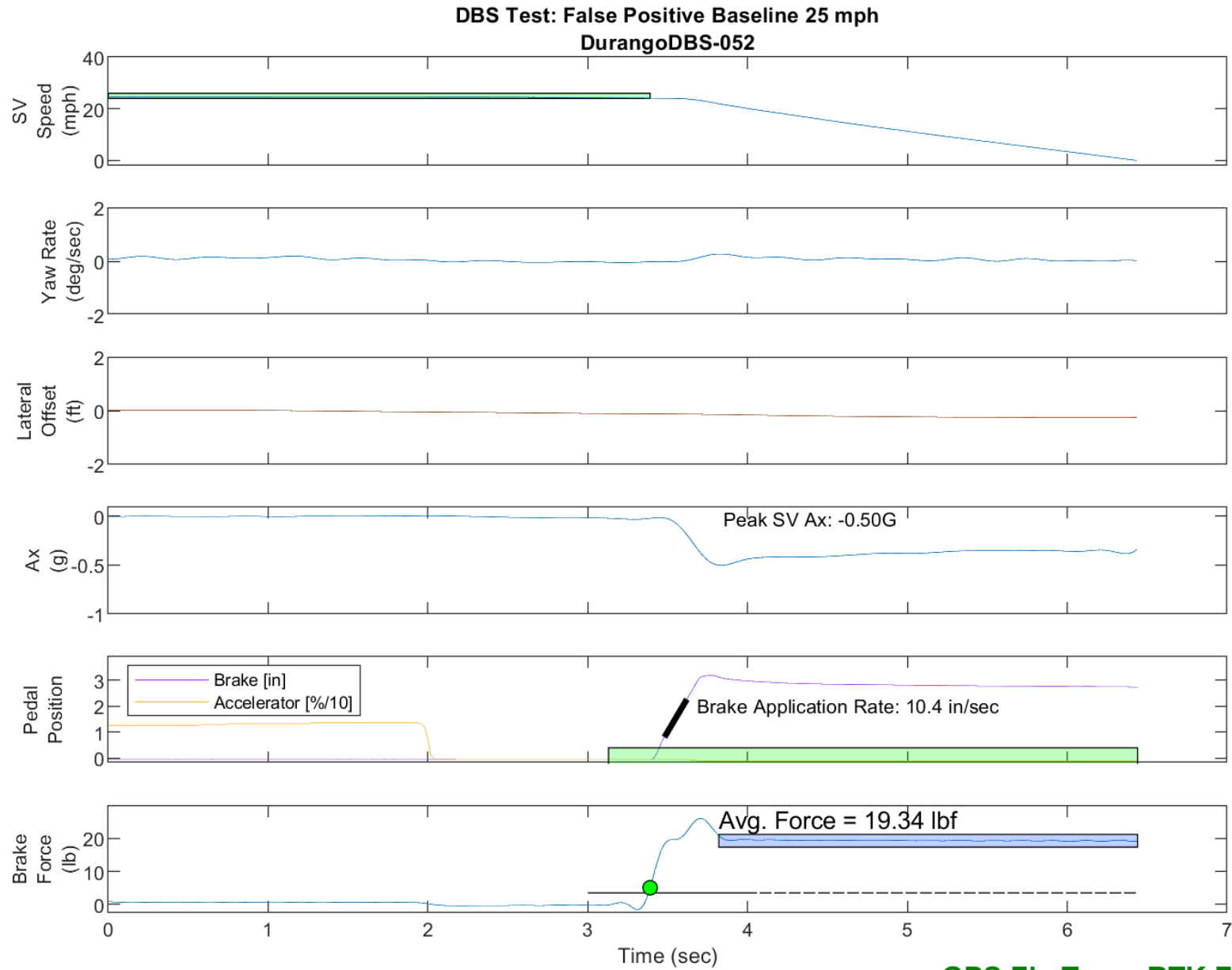


Figure E39. Time History for DBS Run 51, False Positive Baseline, SV 25 mph



**GPS Fix Type: RTK Fixed**

Figure E40. Time History for DBS Run 52, False Positive Baseline, SV 25 mph

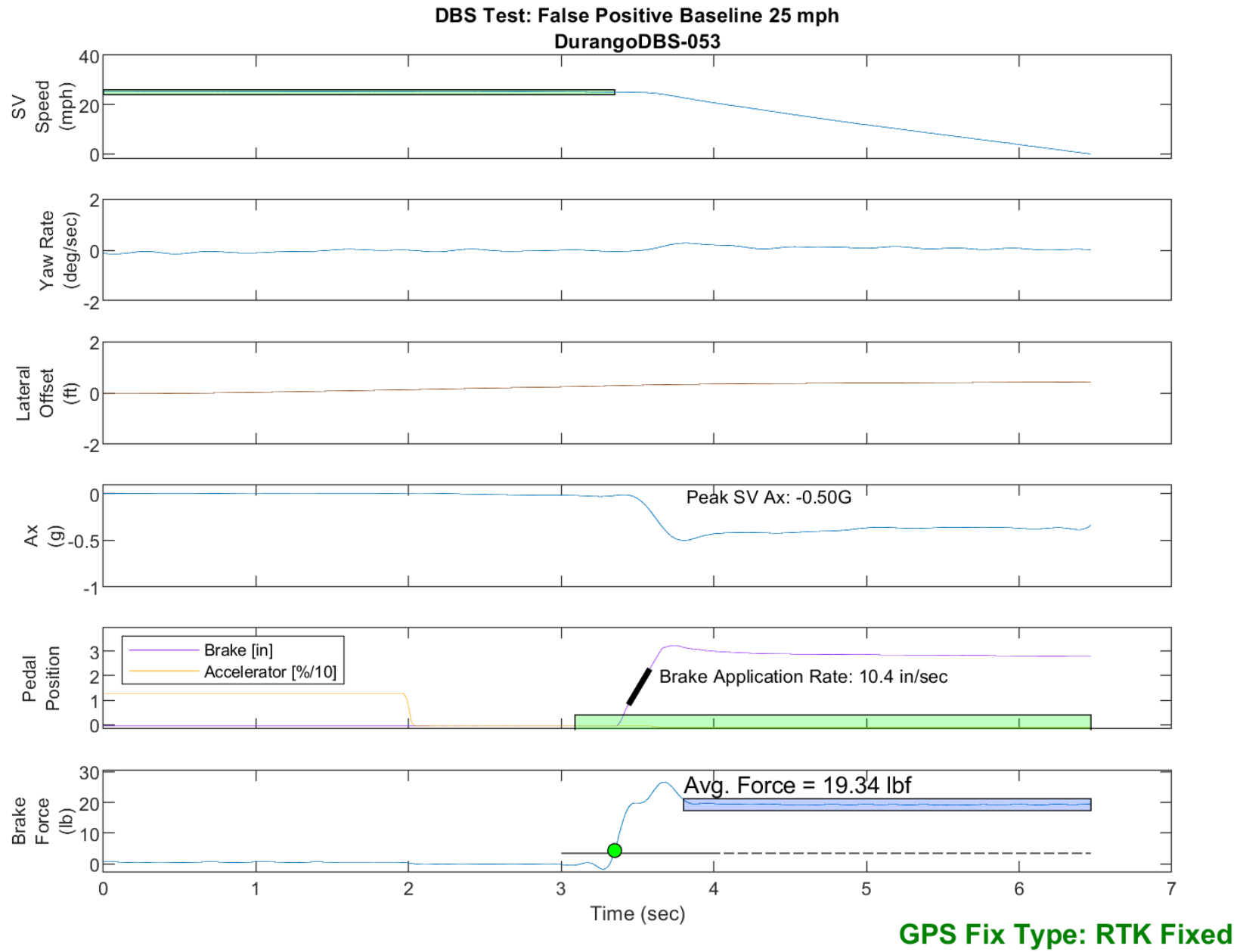


Figure E41. Time History for DBS Run 53, False Positive Baseline, SV 25 mph

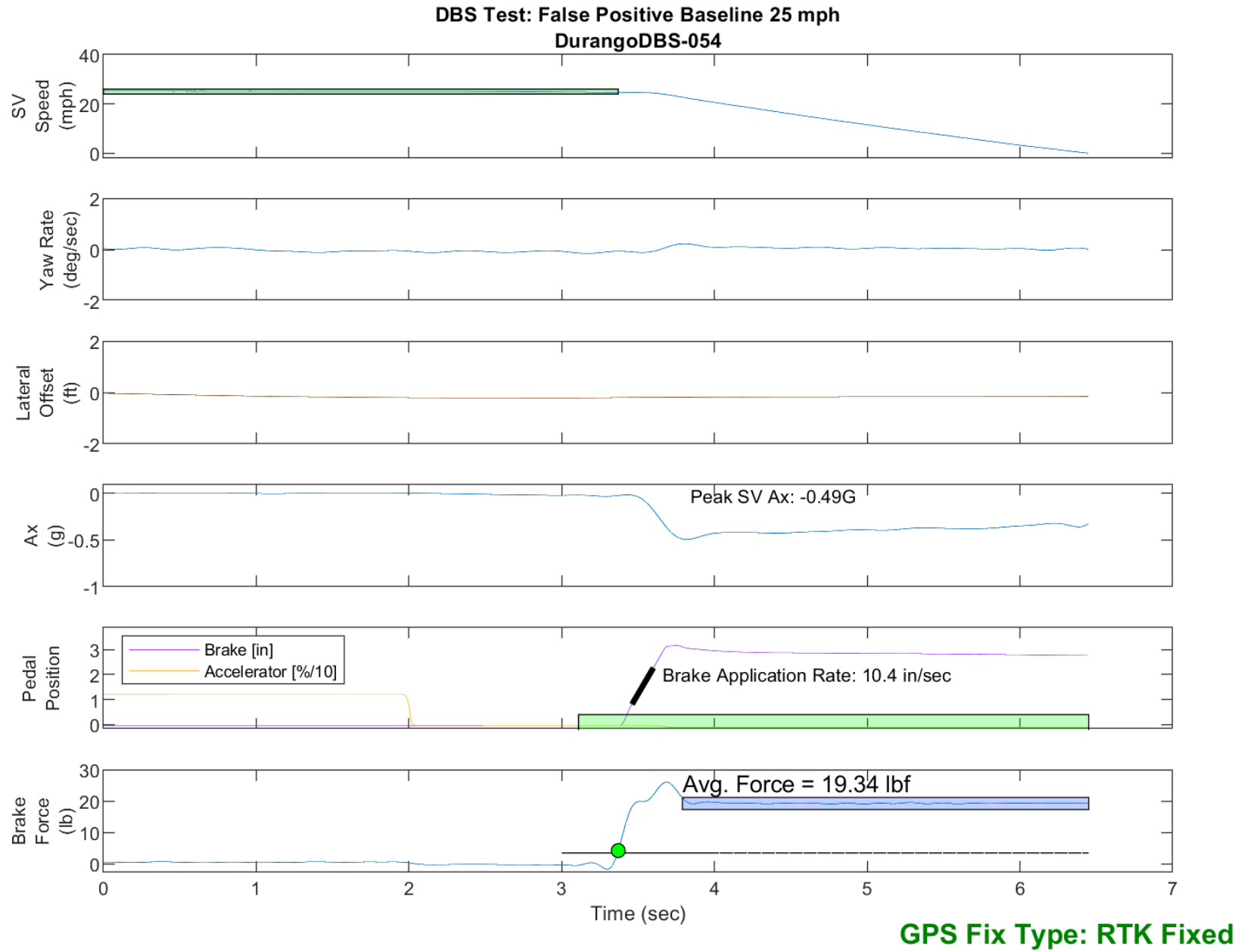


Figure E42. Time History for DBS Run 54, False Positive Baseline, SV 25 mph

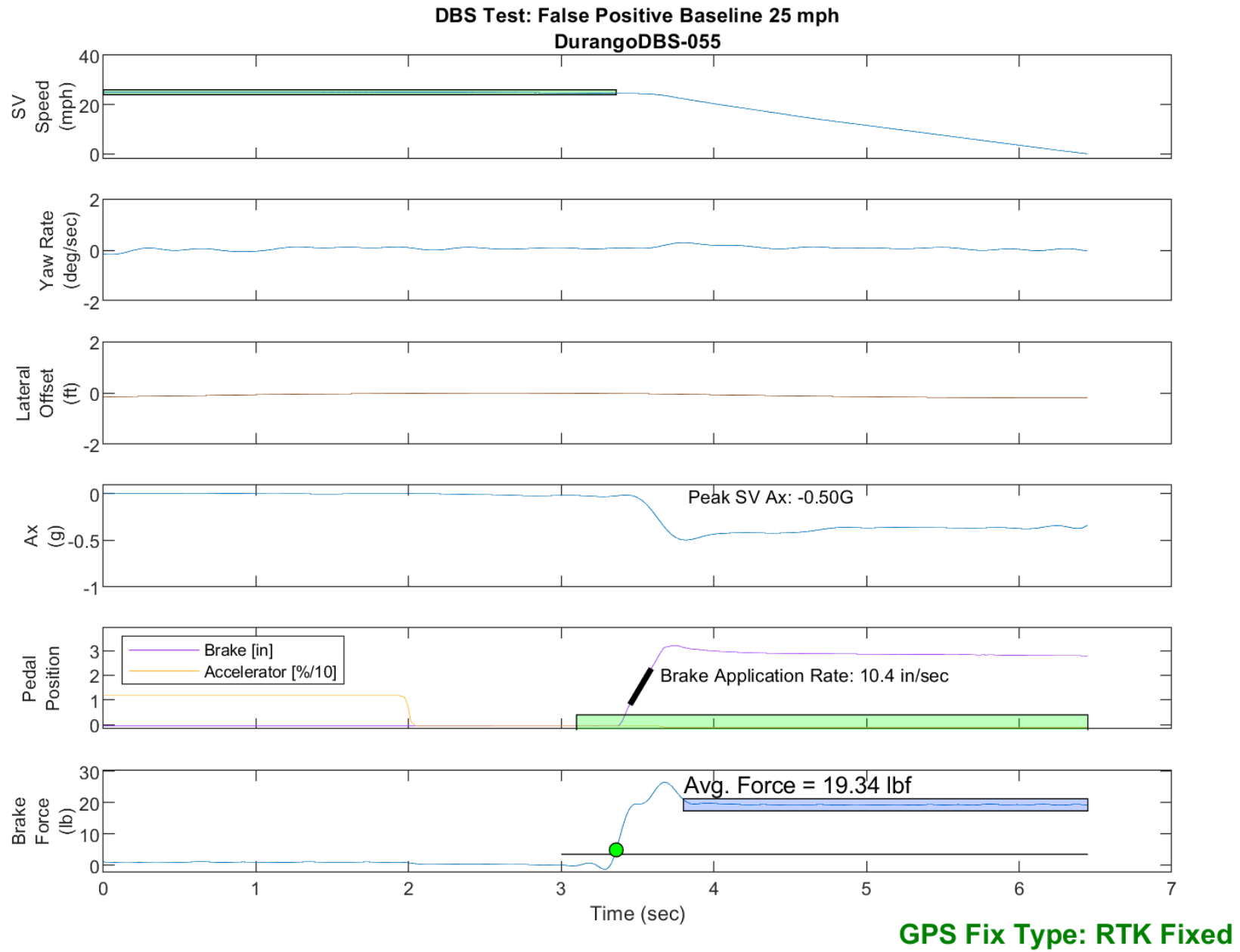
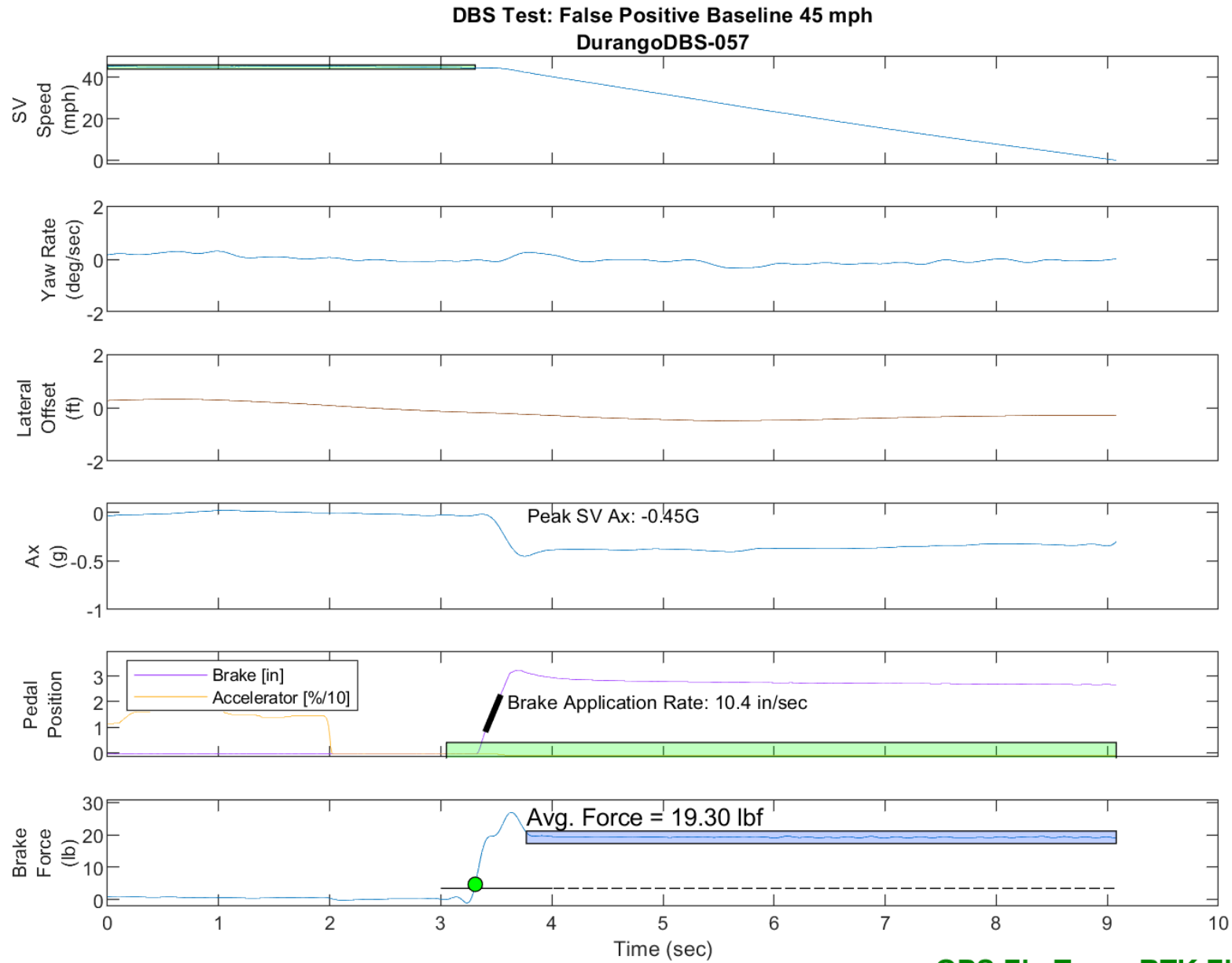


Figure E43. Time History for DBS Run 55, False Positive Baseline, SV 25 mph



**GPS Fix Type: RTK Fixed**

Figure E44. Time History for DBS Run 57, False Positive Baseline, SV 45 mph

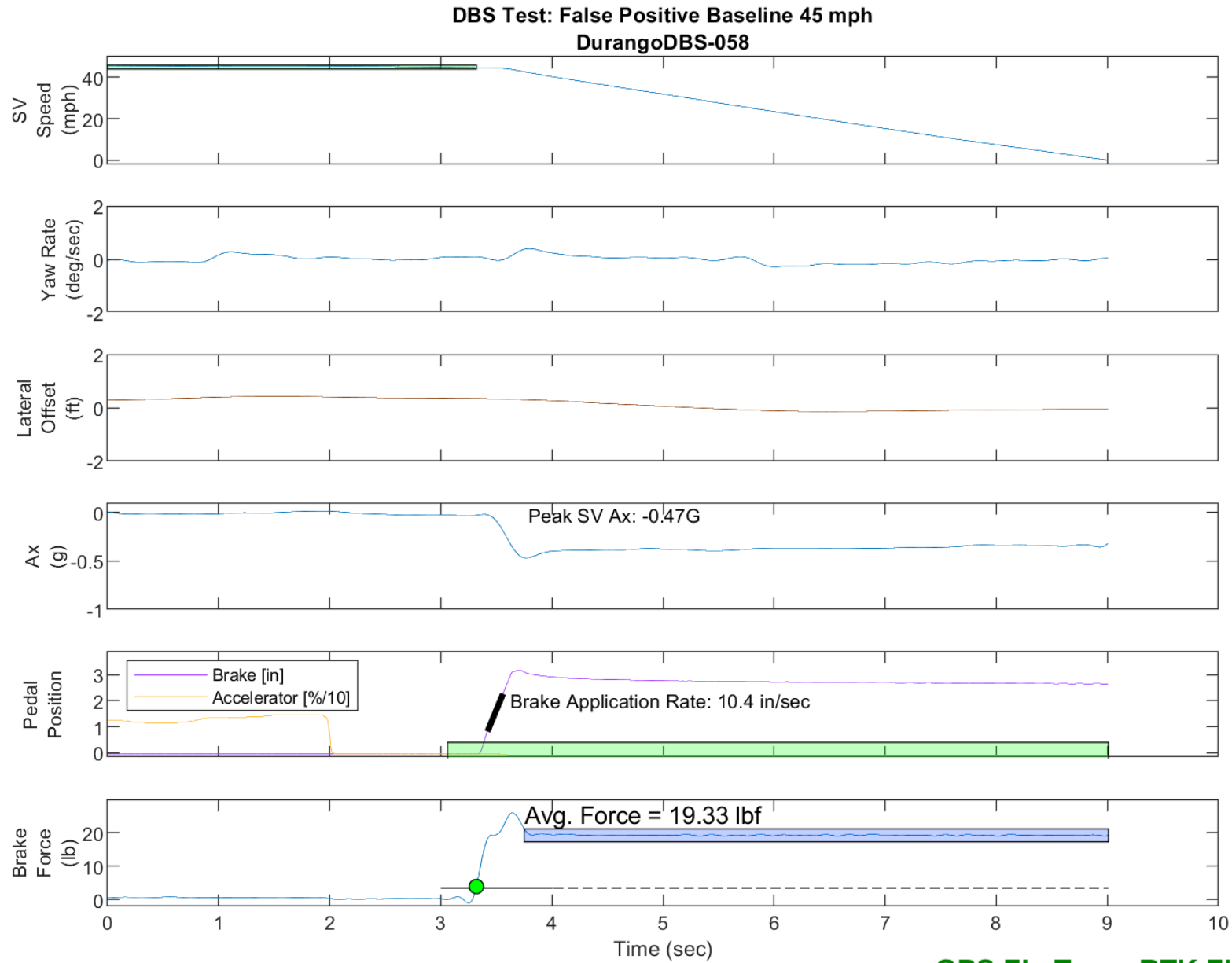


Figure E45. Time History for DBS Run 58, False Positive Baseline, SV 45 mph

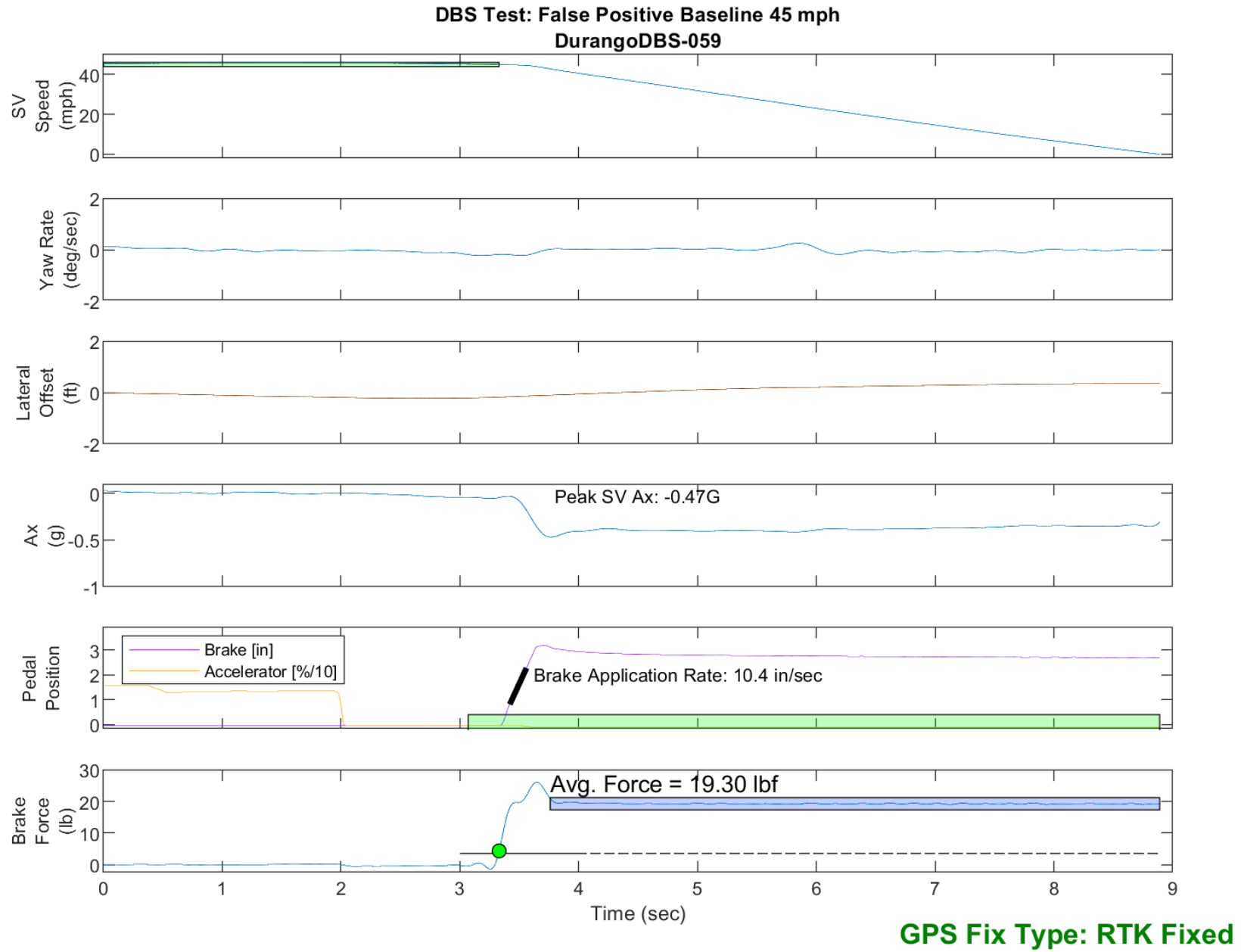


Figure E46. Time History for DBS Run 59, False Positive Baseline, SV 45 mph



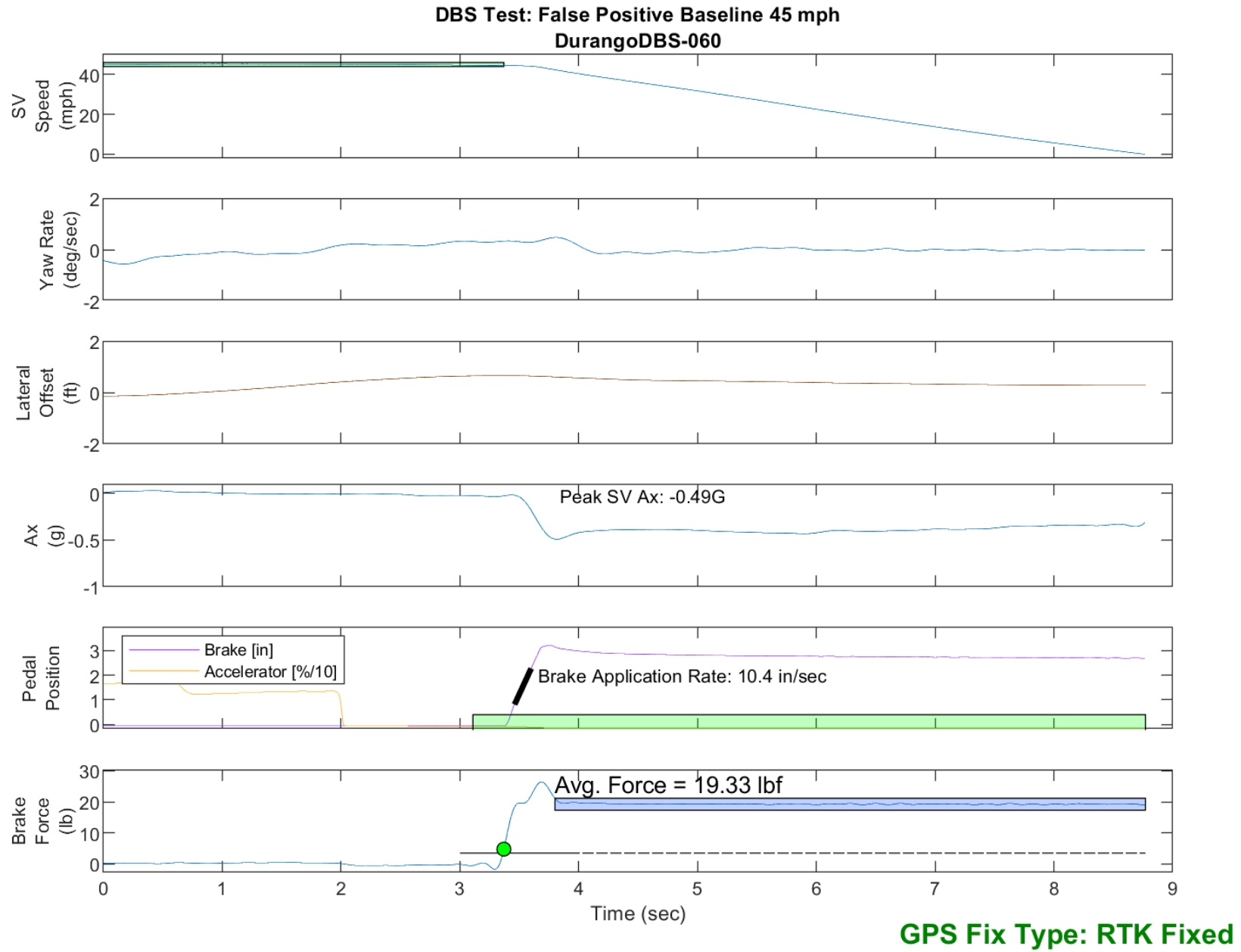
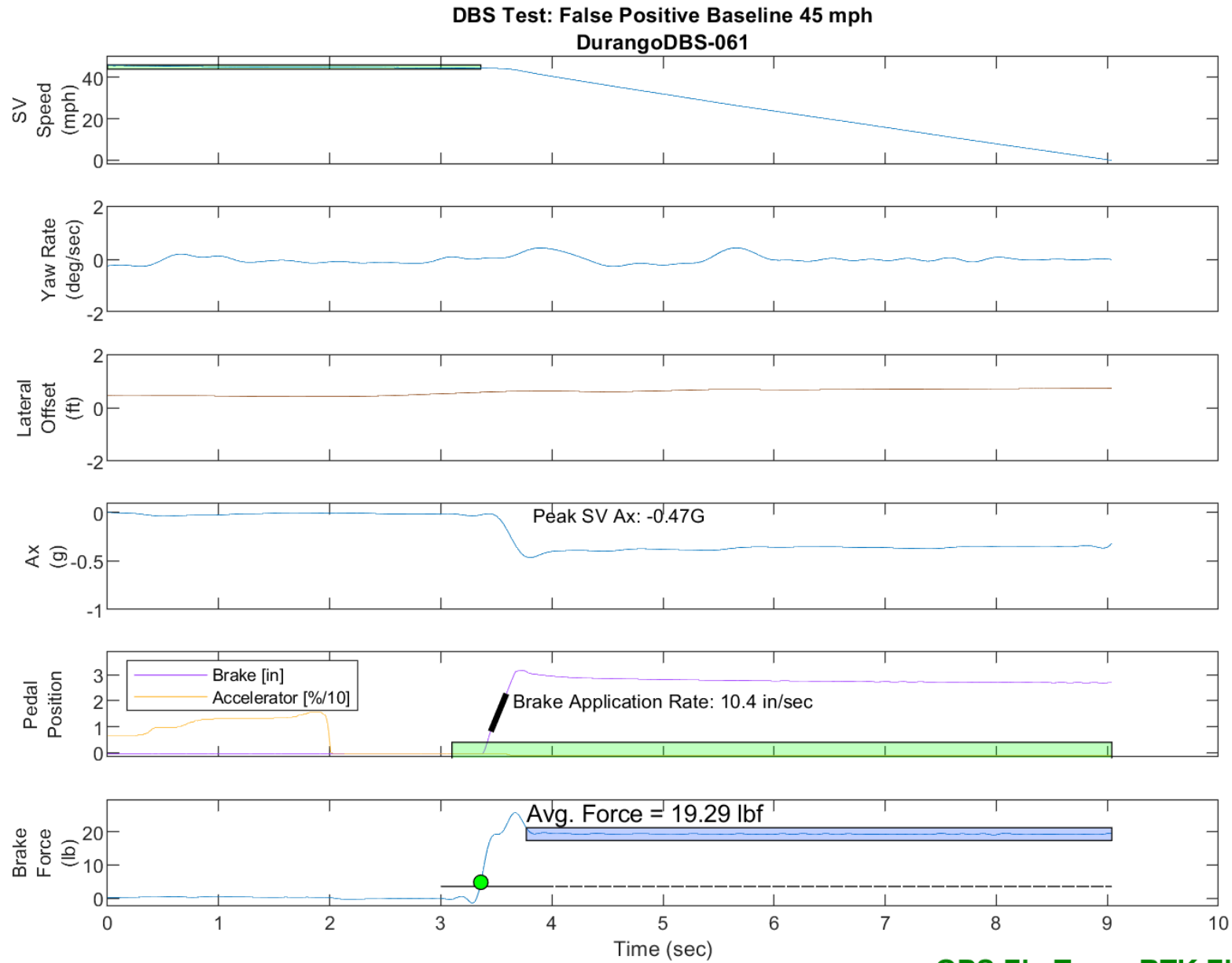


Figure E47. Time History for DBS Run 60, False Positive Baseline, SV 45 mph



**GPS Fix Type: RTK Fixed**

Figure E48. Time History for DBS Run 61, False Positive Baseline, SV 45 mph

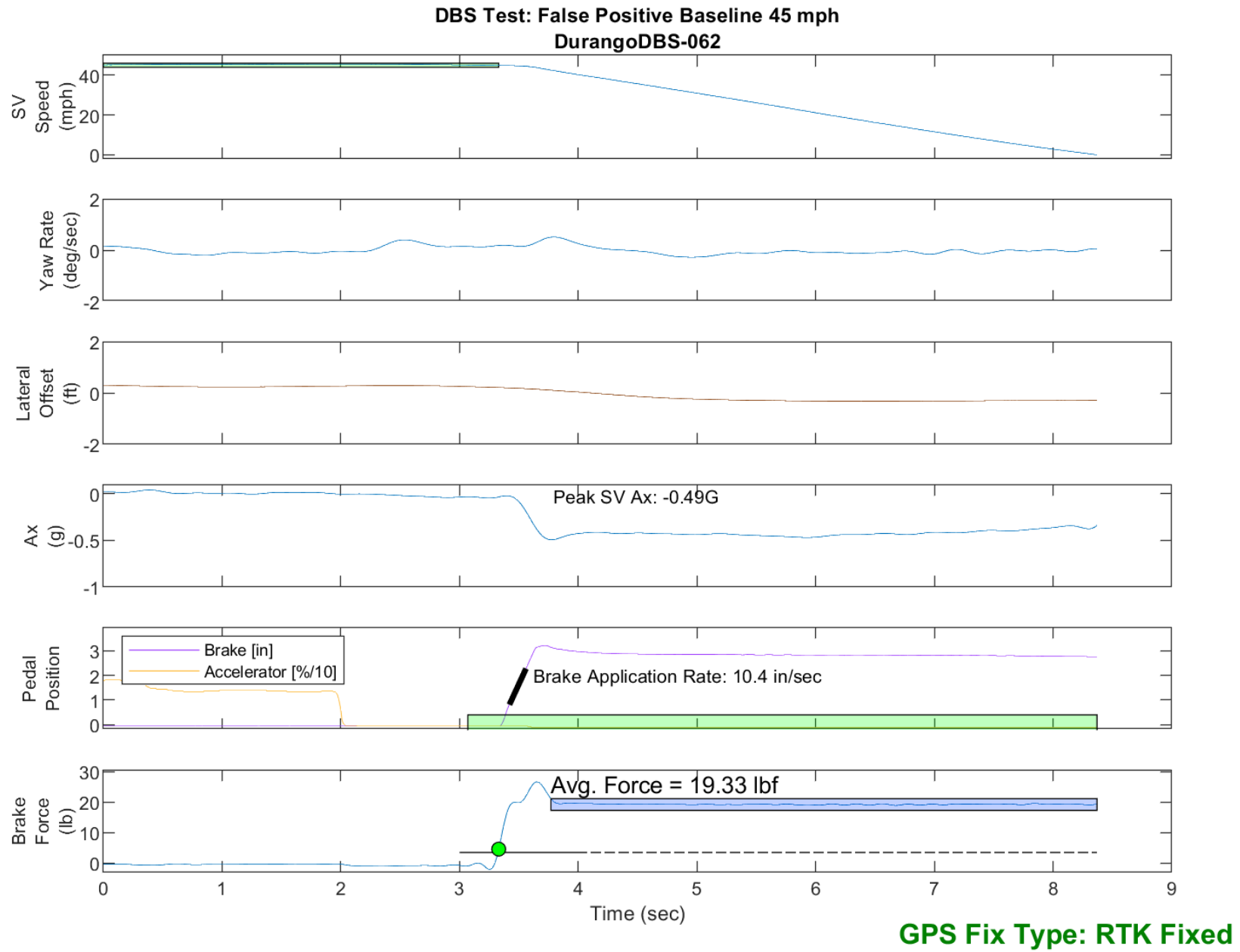
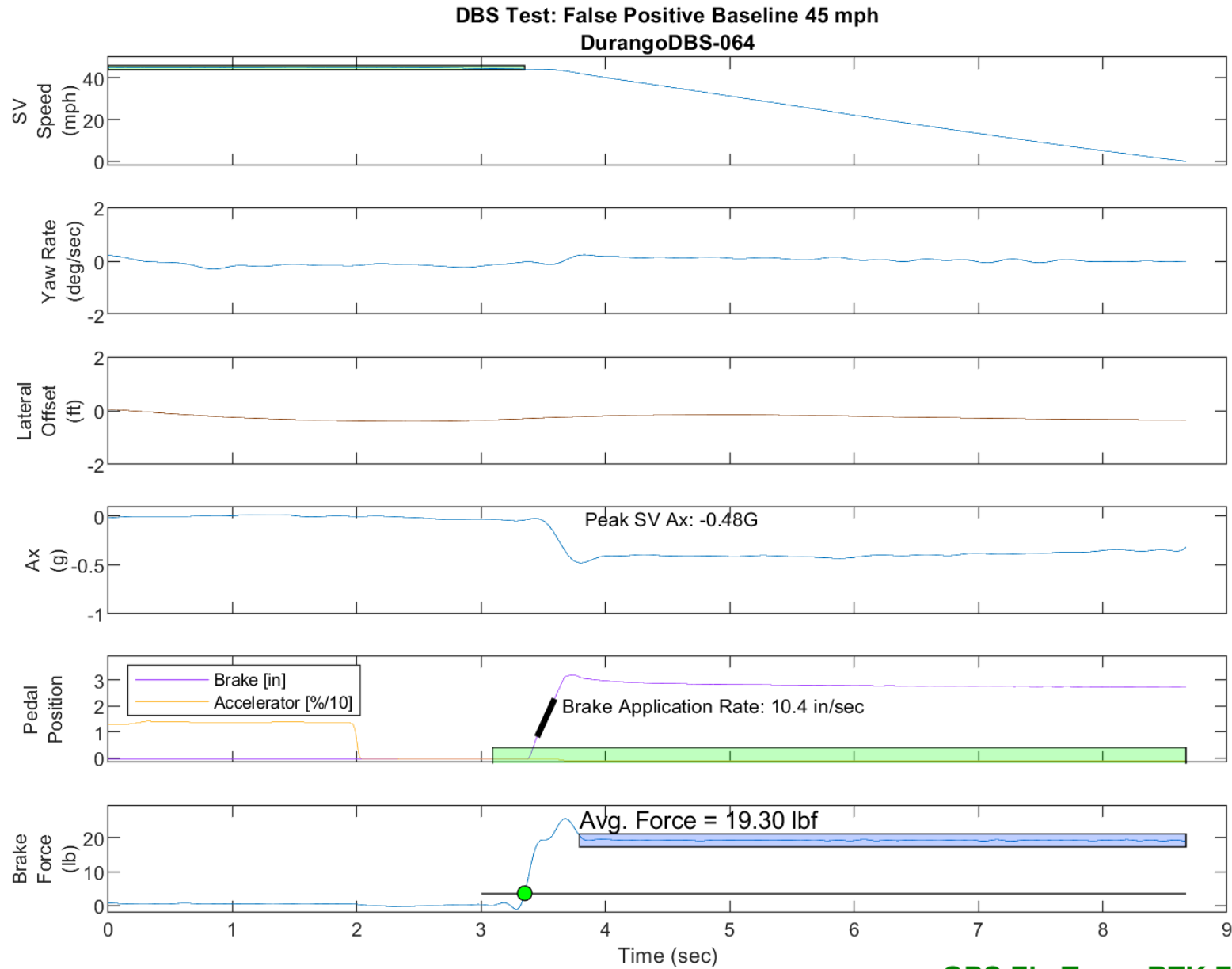


Figure E49. Time History for DBS Run 62, False Positive Baseline, SV 45 mph



**GPS Fix Type: RTK Fixed**

Figure E50. Time History for DBS Run 64, False Positive Baseline, SV 45 mph

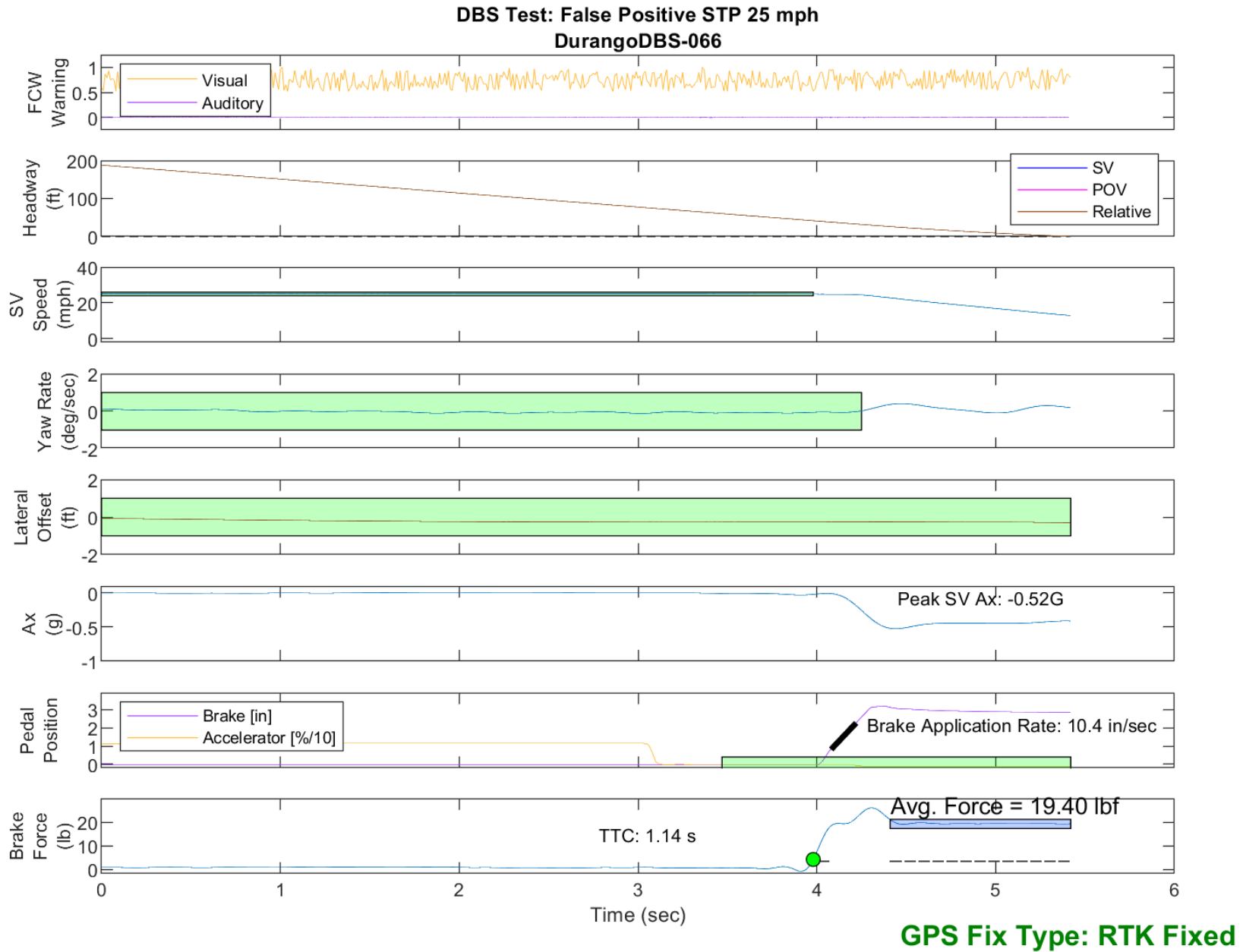


Figure E51. Time History for DBS Run 66, SV Encounters Steel Trench Plate, SV 25 mph

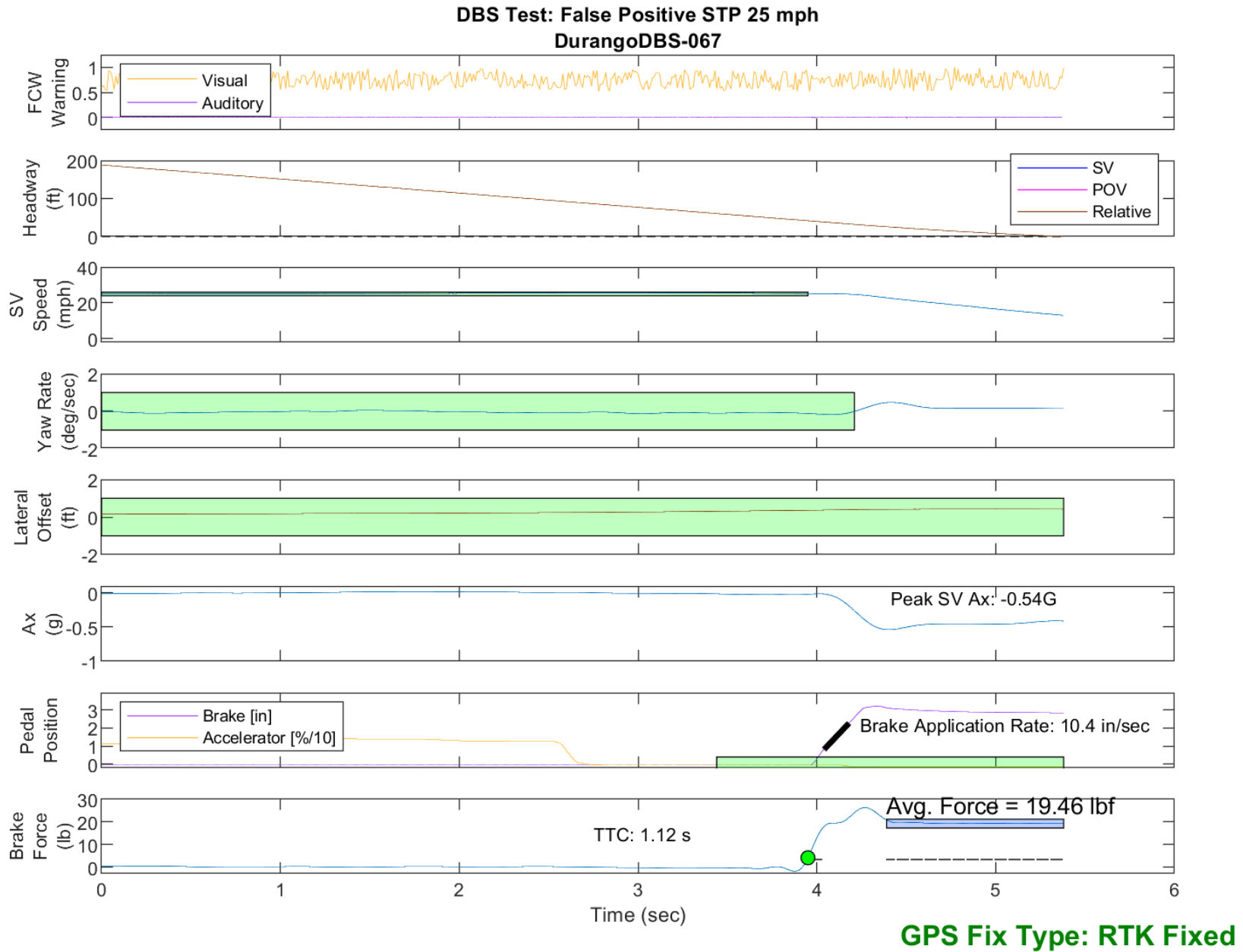


Figure E52. Time History for DBS Run 67, SV Encounters Steel Trench Plate, SV 25 mph

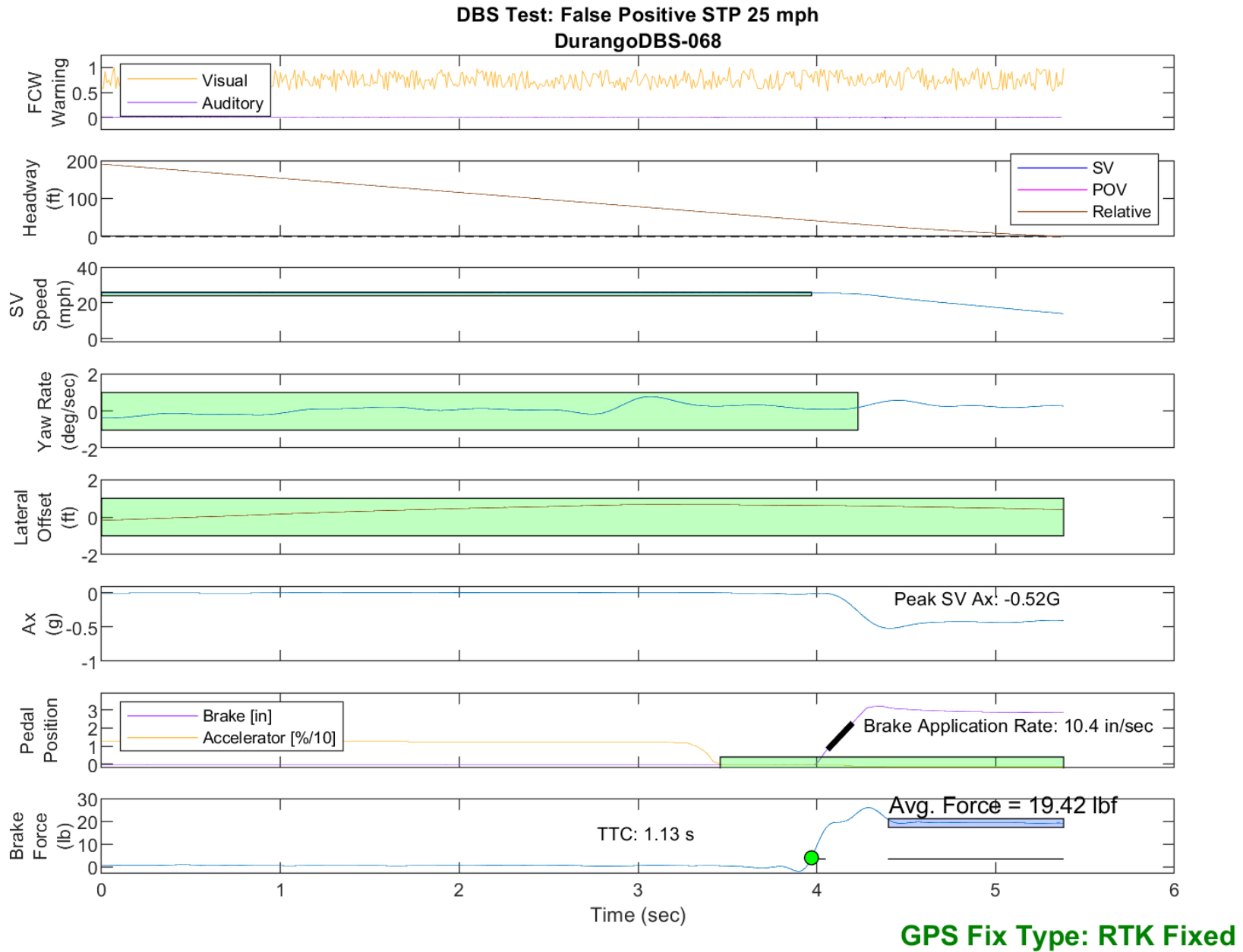


Figure E53. Time History for DBS Run 68, SV Encounters Steel Trench Plate, SV 25 mph

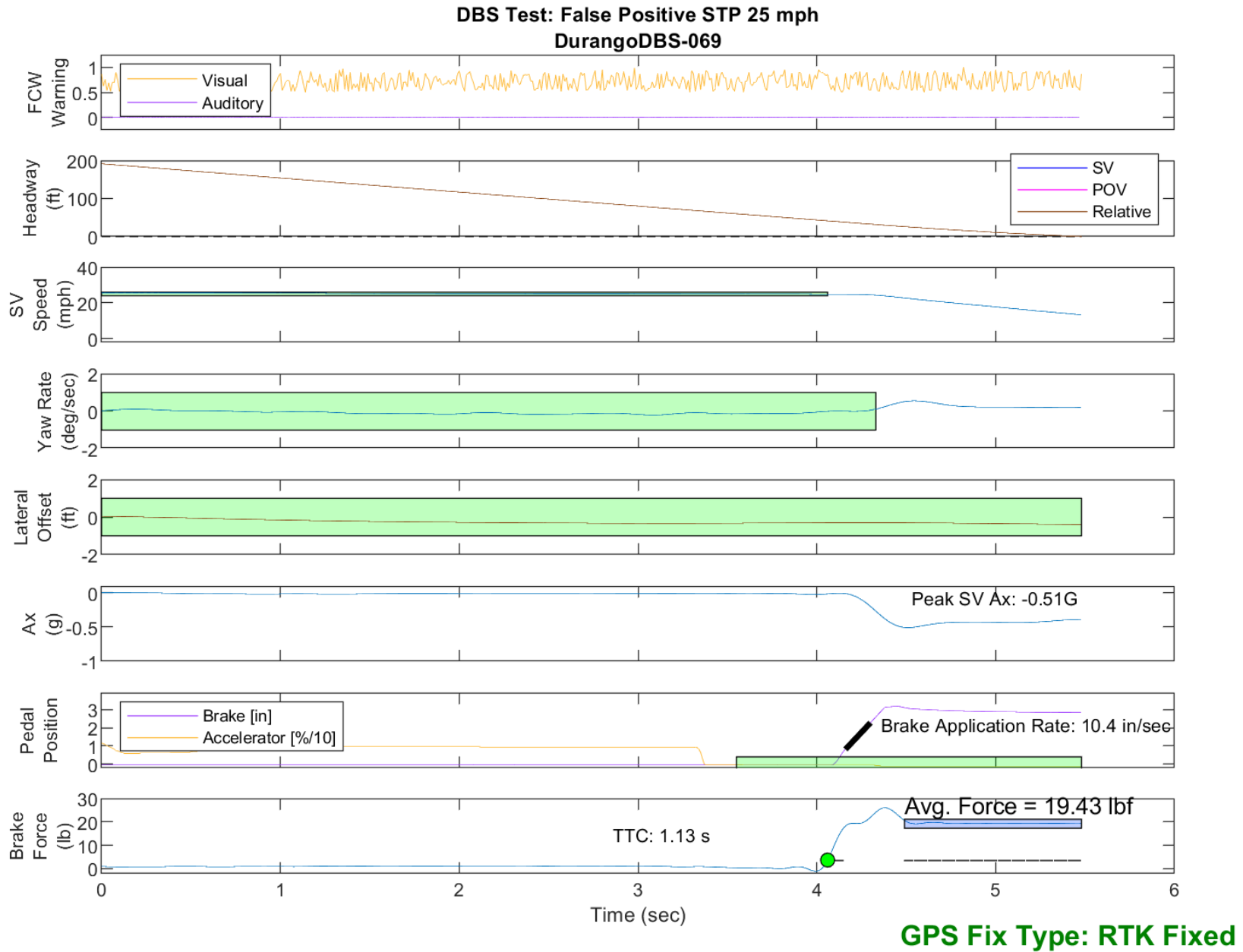


Figure E54. Time History for DBS Run 69, SV Encounters Steel Trench Plate, SV 25 mph



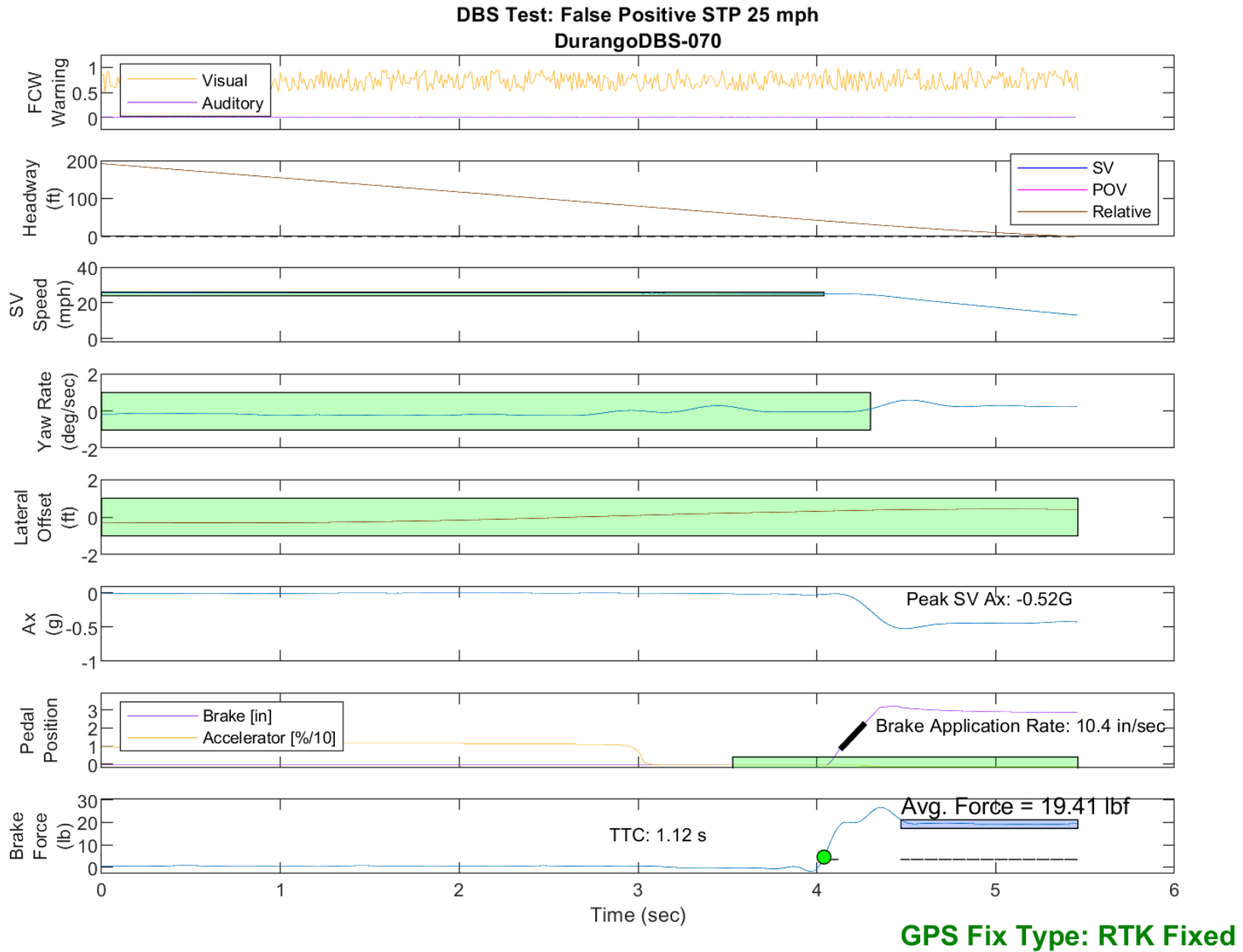


Figure E55. Time History for DBS Run 70, SV Encounters Steel Trench Plate, SV 25 mph

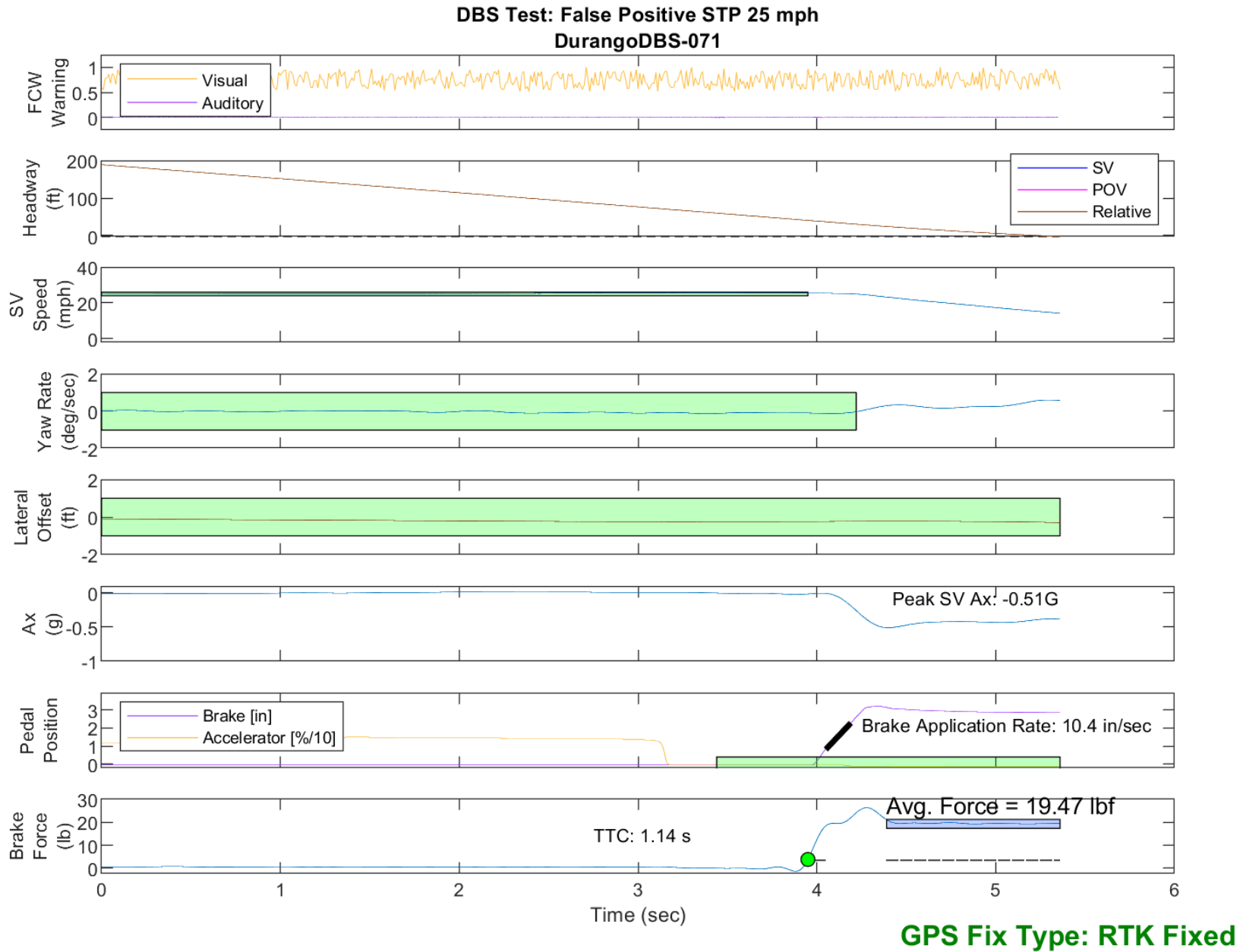


Figure E56. Time History for DBS Run 71, SV Encounters Steel Trench Plate, SV 25 mph

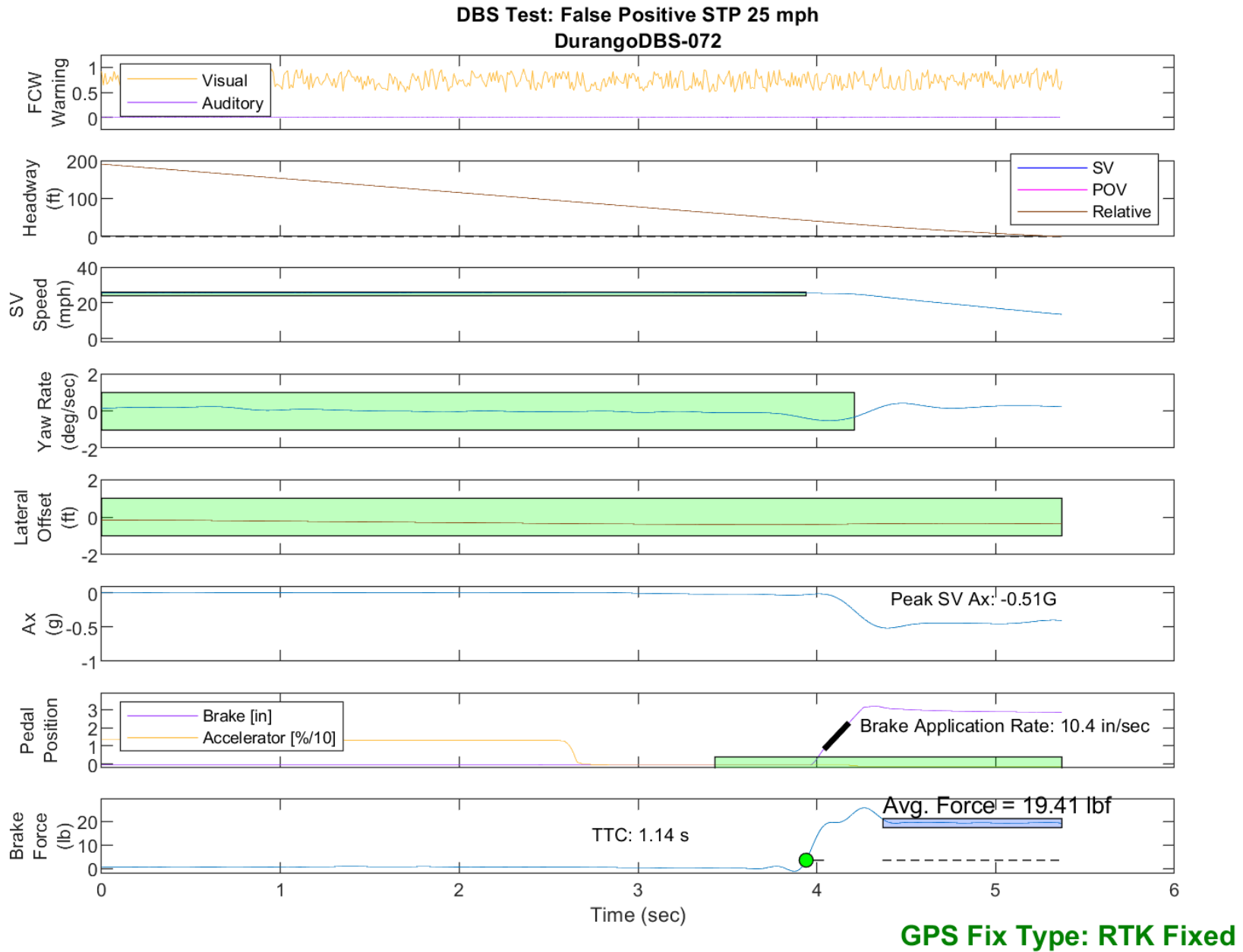


Figure E57. Time History for DBS Run 72, SV Encounters Steel Trench Plate, SV 25 mph

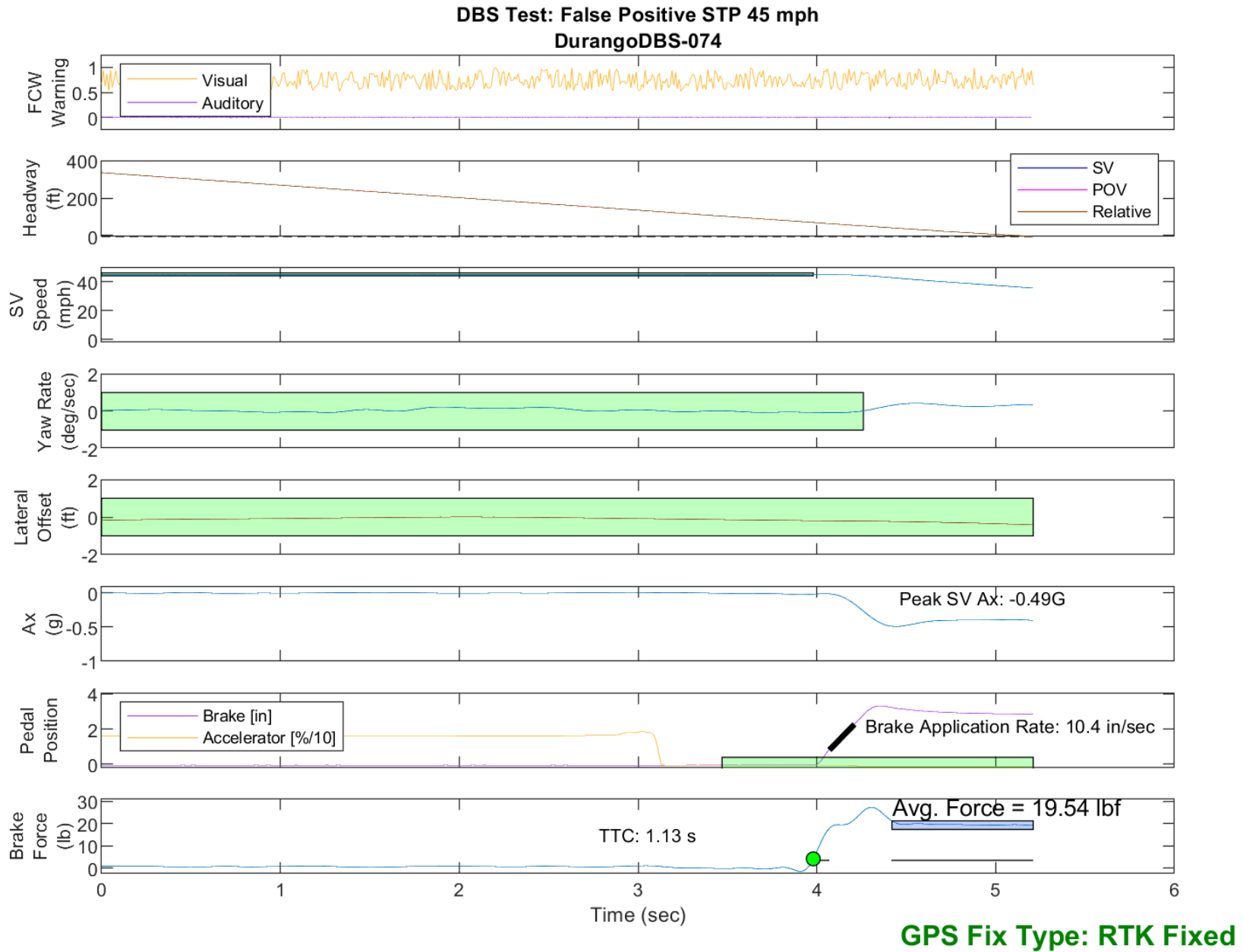


Figure E58. Time History for DBS Run 74, SV Encounters Steel Trench Plate, SV 45 mph

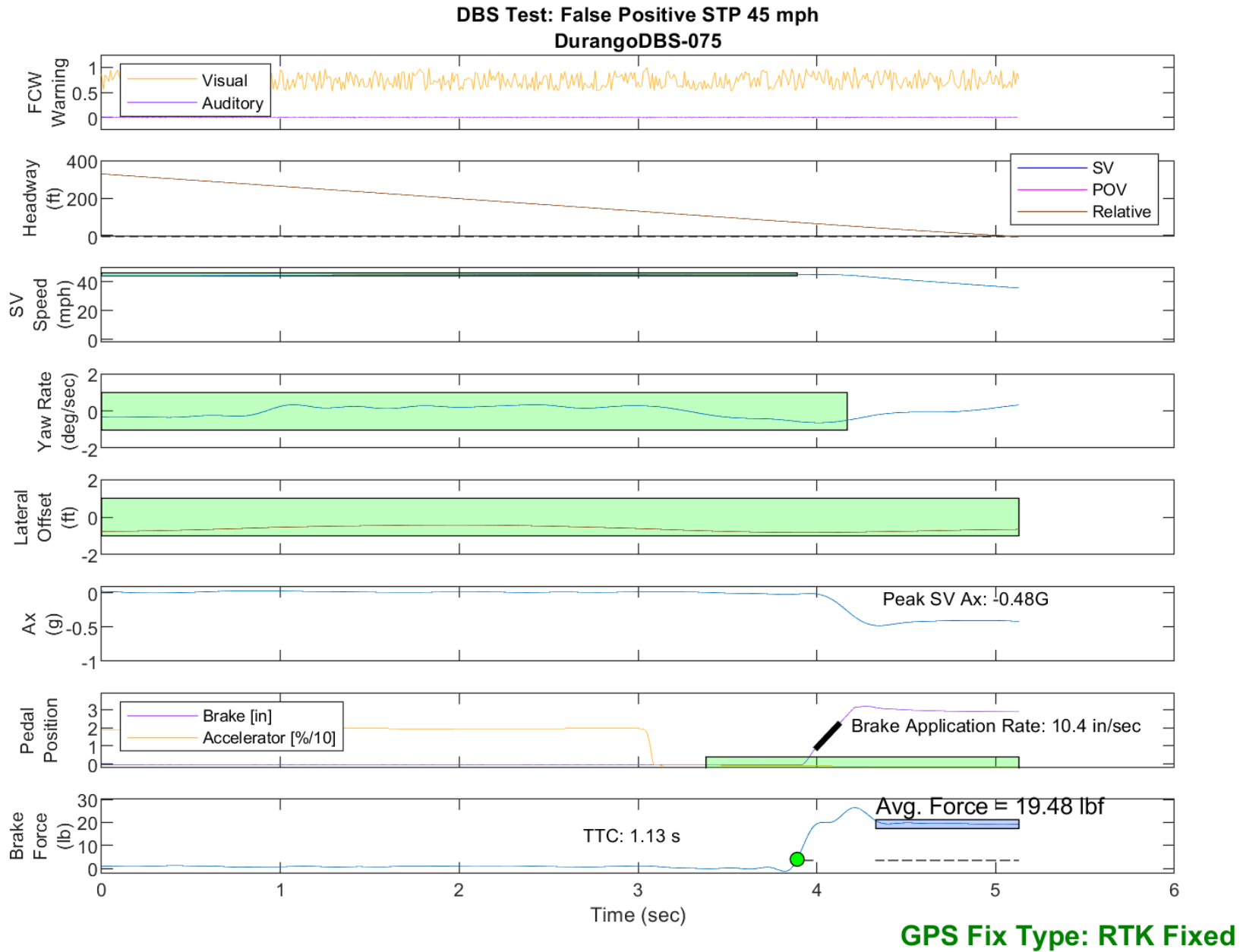


Figure E59. Time History for DBS Run 75, SV Encounters Steel Trench Plate, SV 45 mph

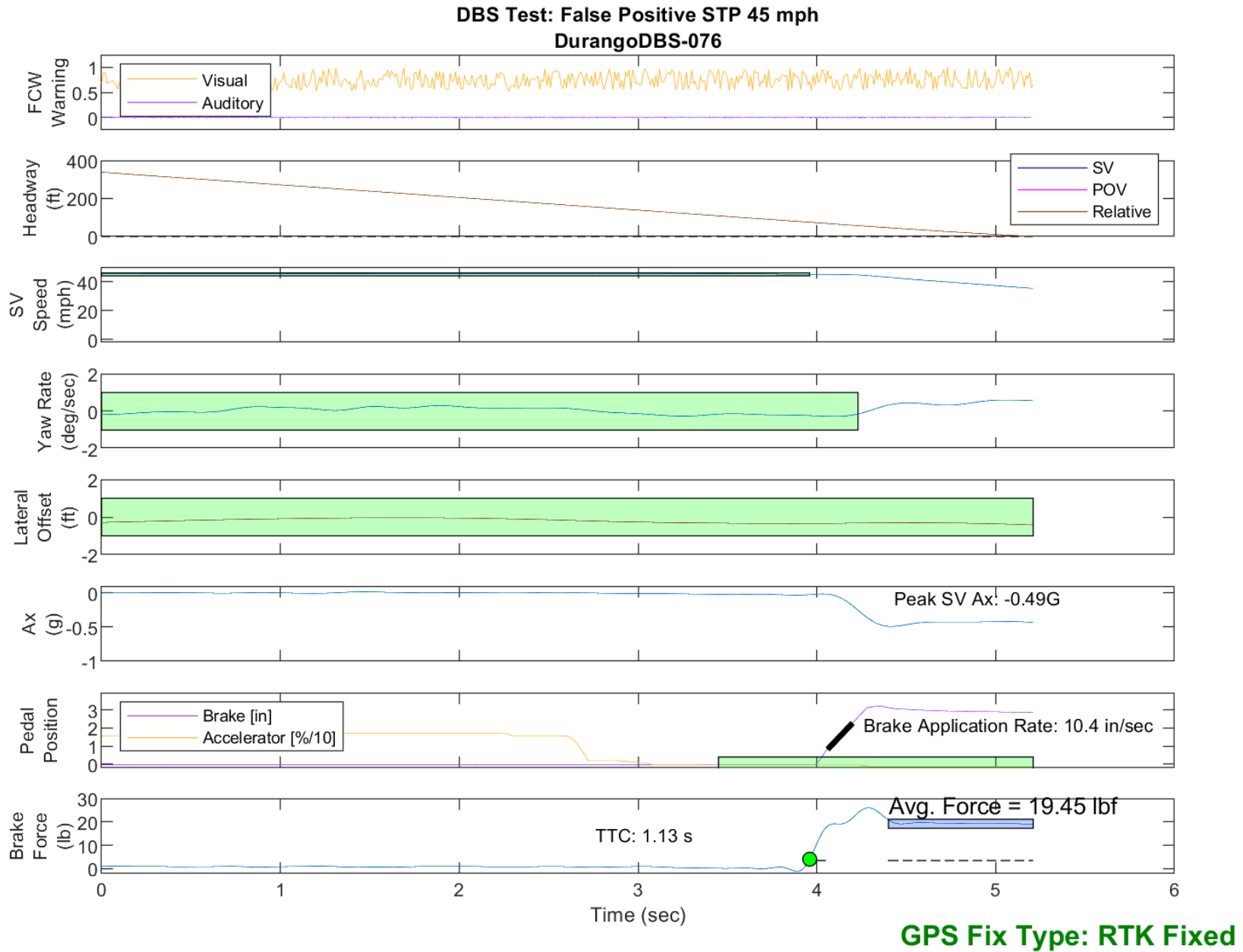


Figure E60. Time History for DBS Run 76, SV Encounters Steel Trench Plate, SV 45 mph

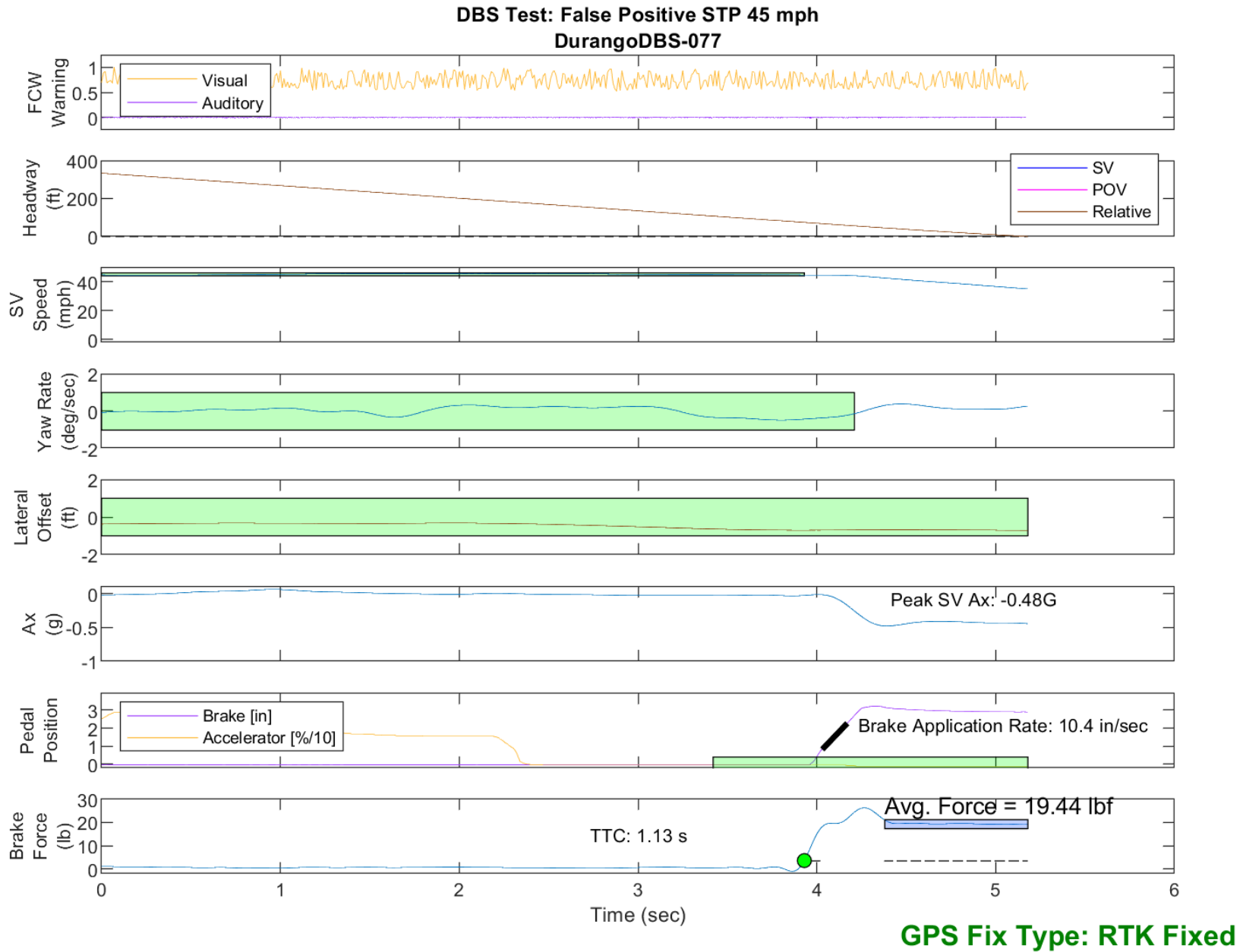


Figure E61. Time History for DBS Run 77, SV Encounters Steel Trench Plate, SV 45 mph

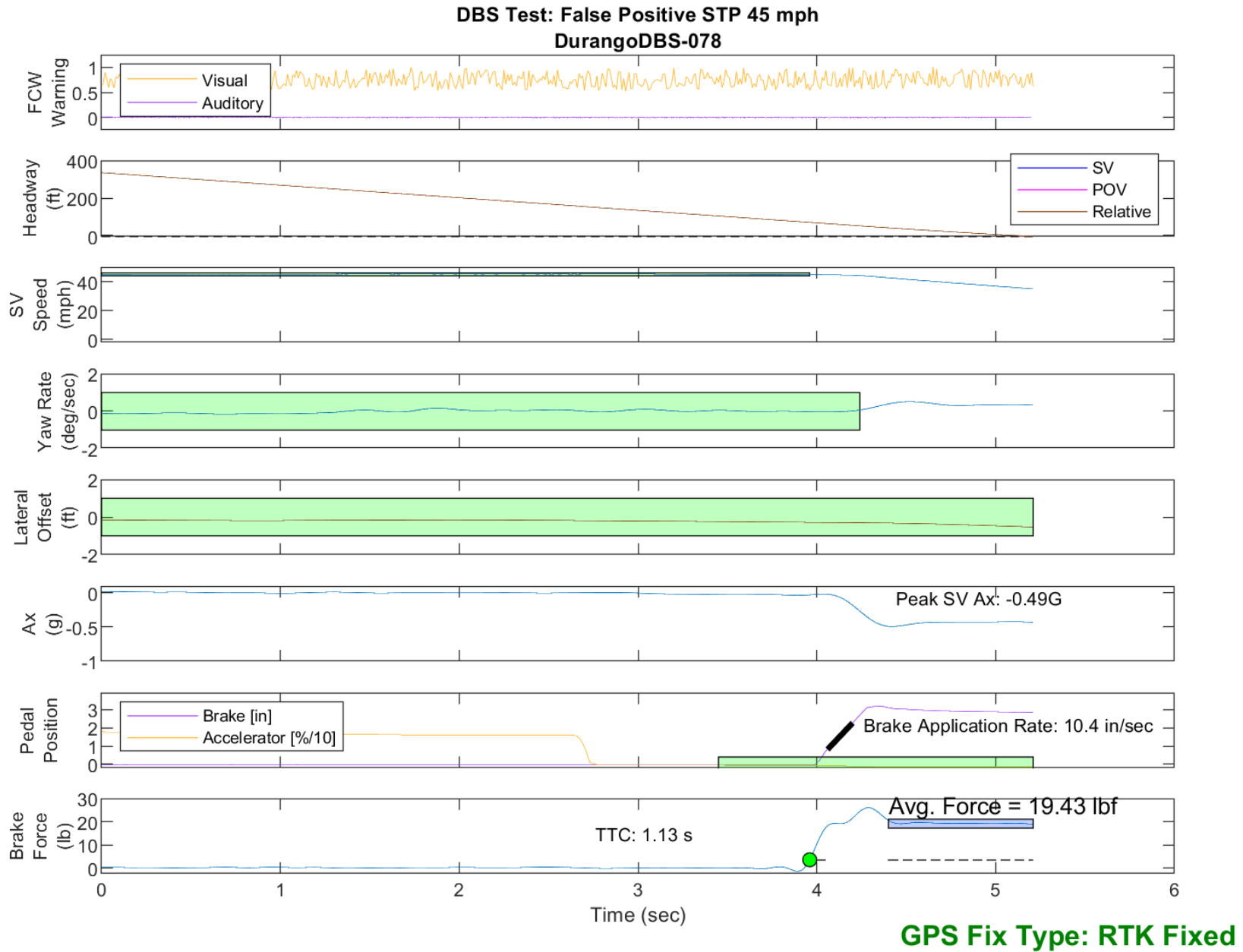


Figure E62. Time History for DBS Run 78, SV Encounters Steel Trench Plate, SV 45 mph



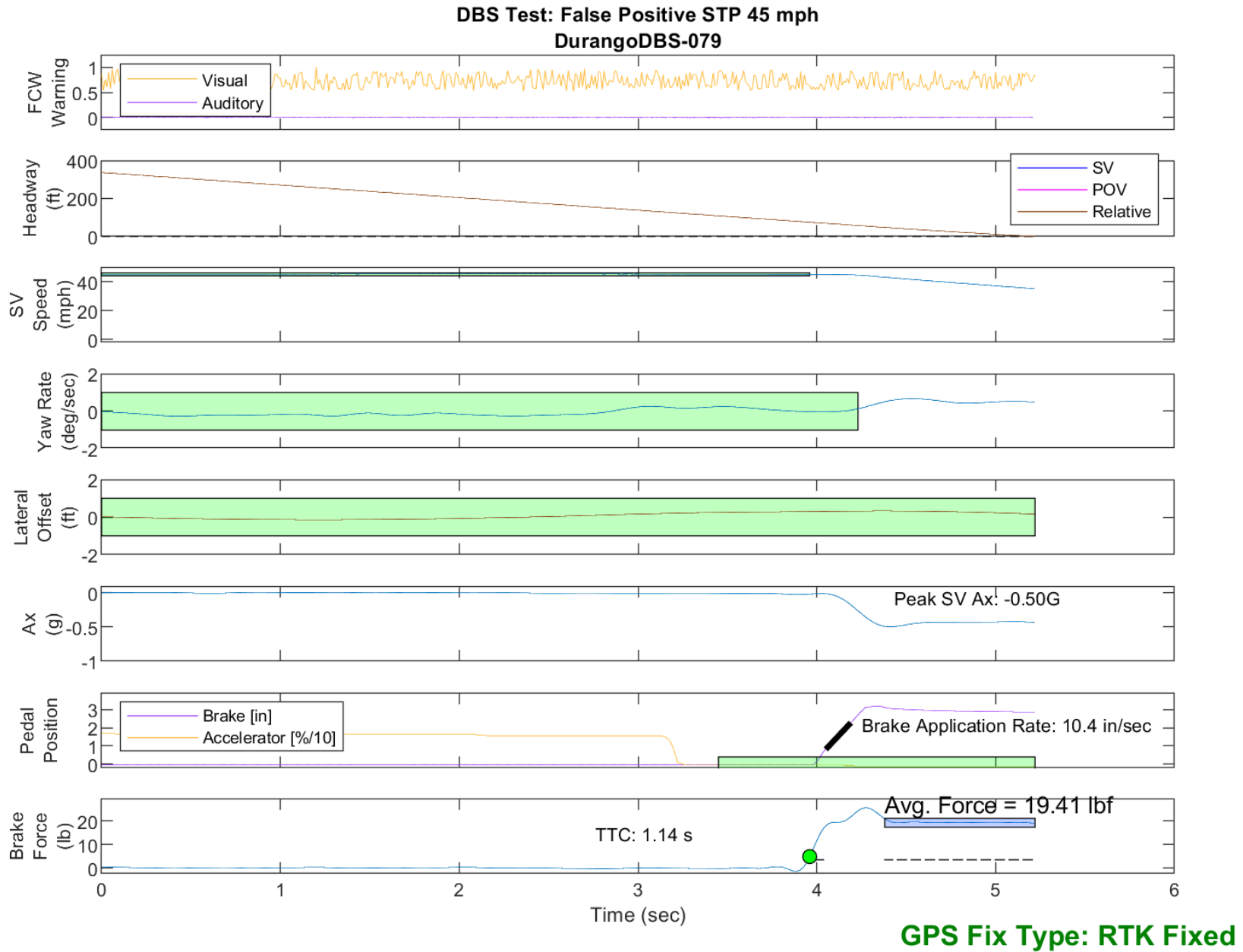


Figure E63. Time History for DBS Run 79, SV Encounters Steel Trench Plate, SV 45 mph

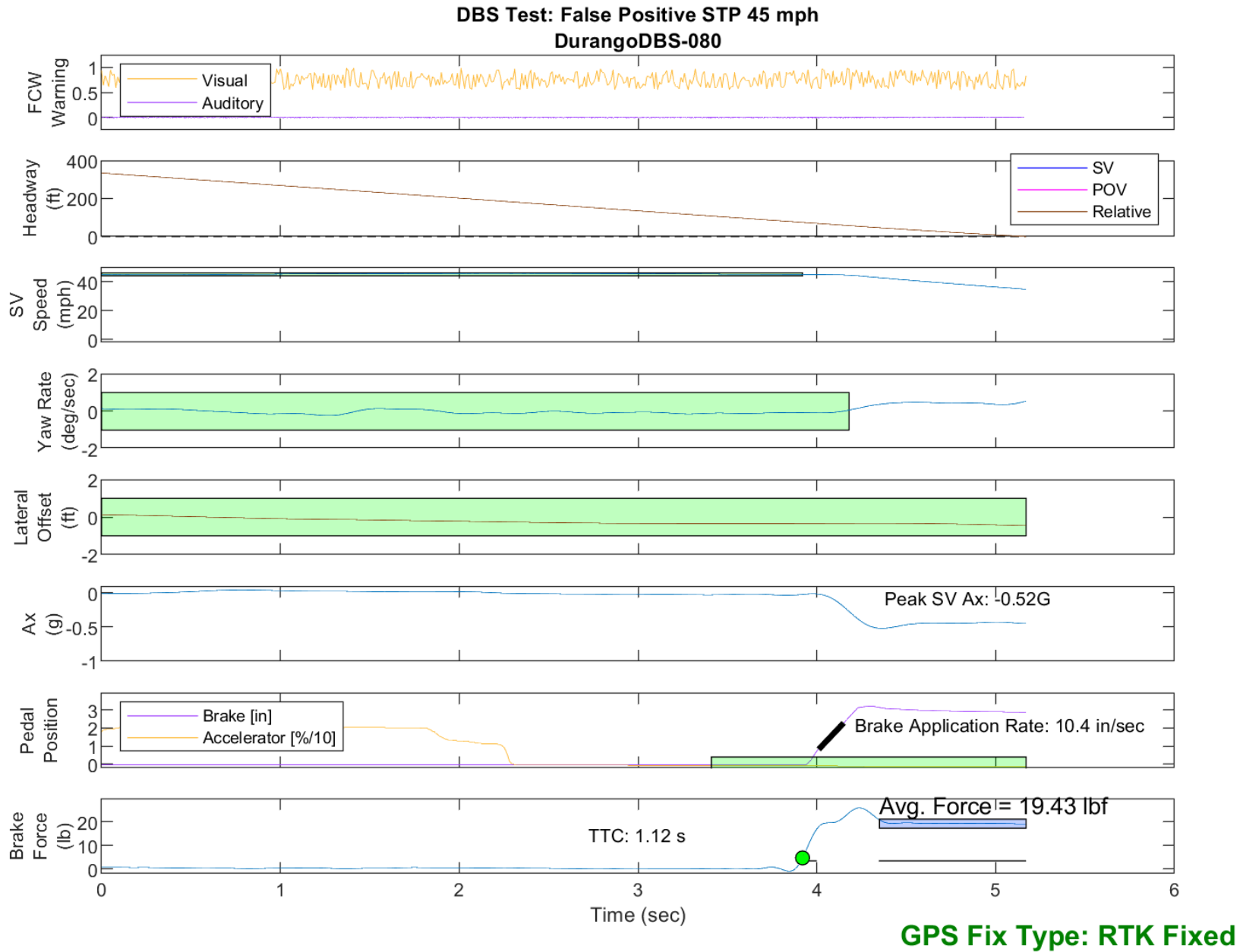


Figure E64. Time History for DBS Run 80, SV Encounters Steel Trench Plate, SV 45 mph

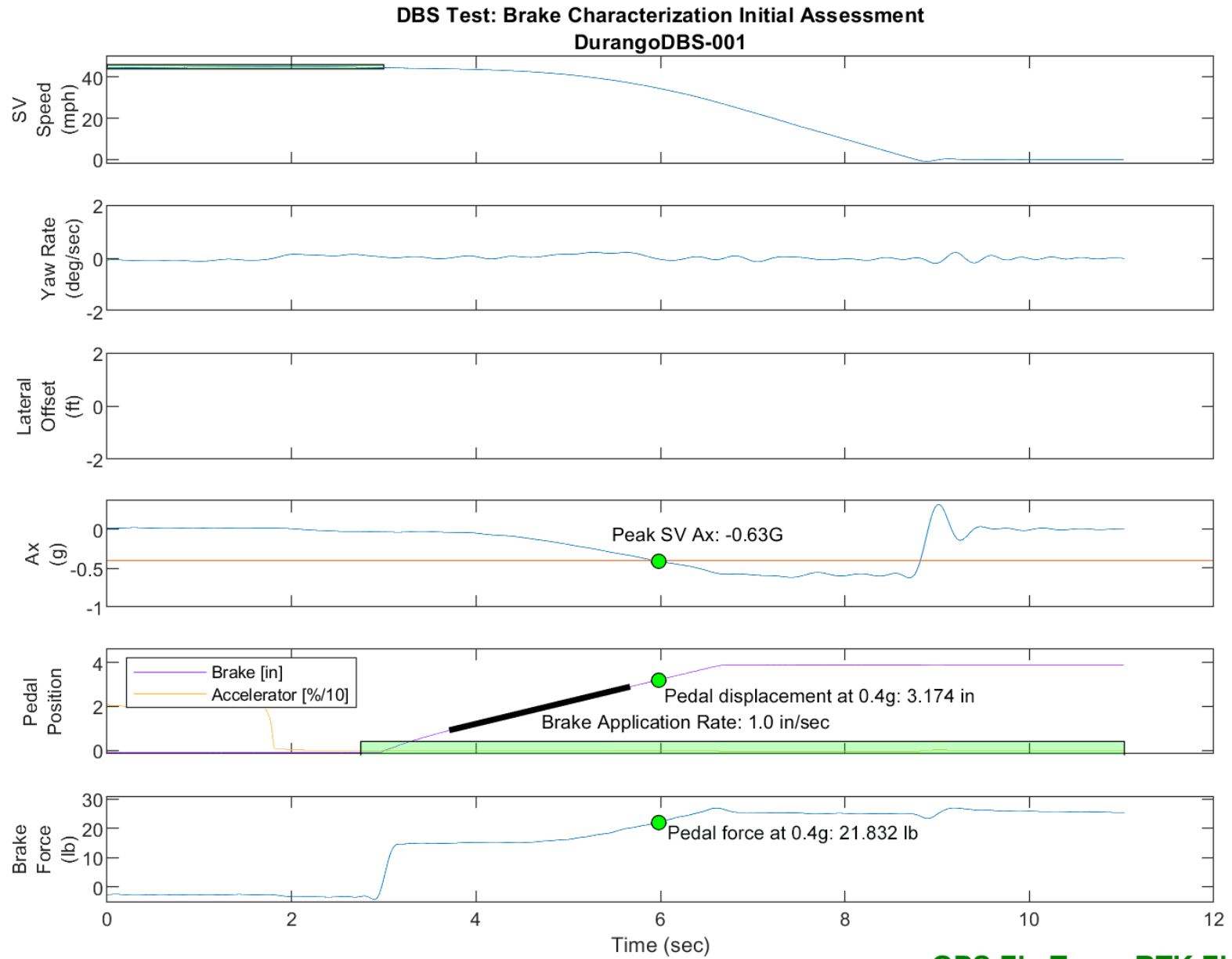


Figure E65. Time History for DBS Run 1, Brake Characterization Initial

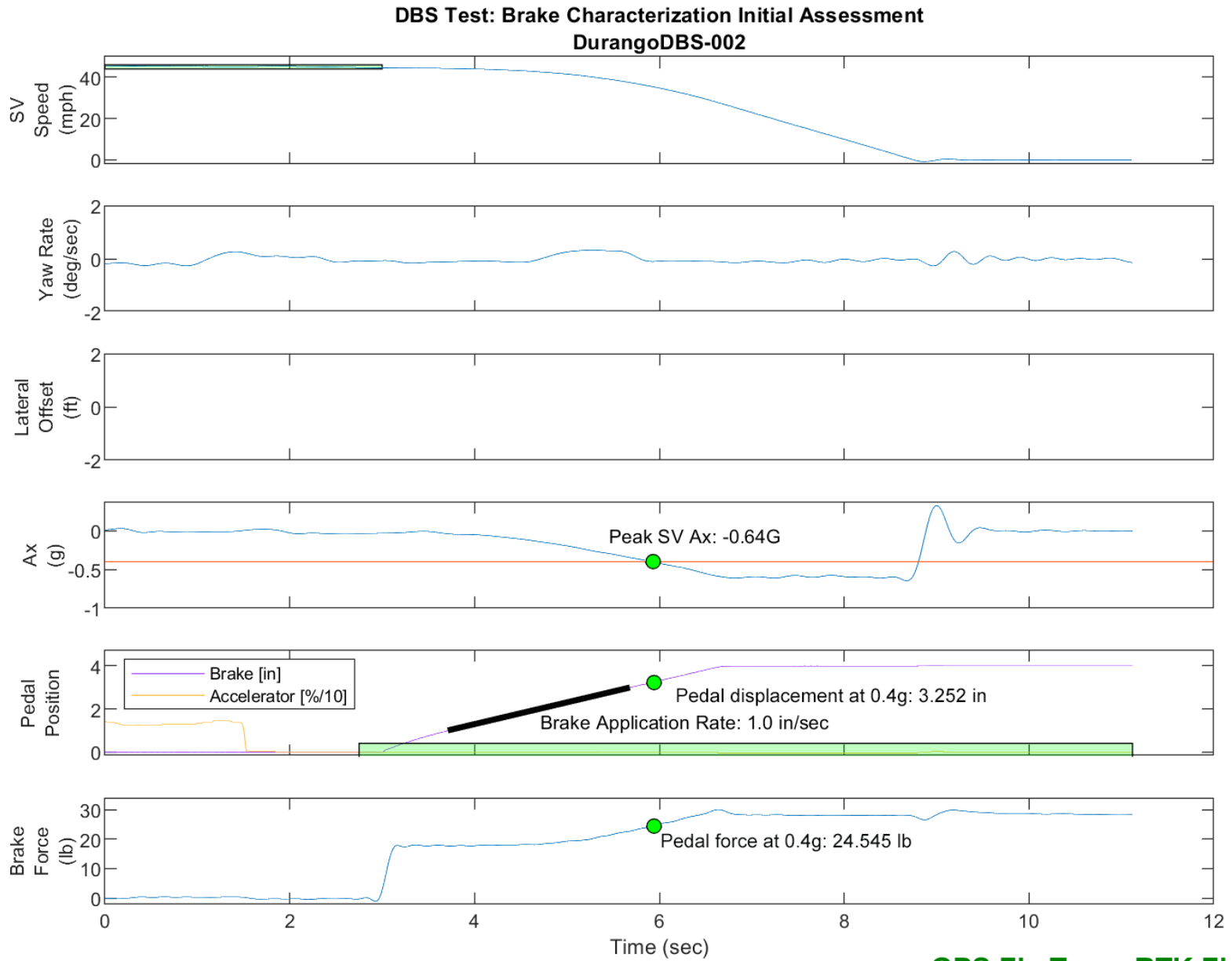


Figure E66. Time History for DBS Run 2, Brake Characterization Initial

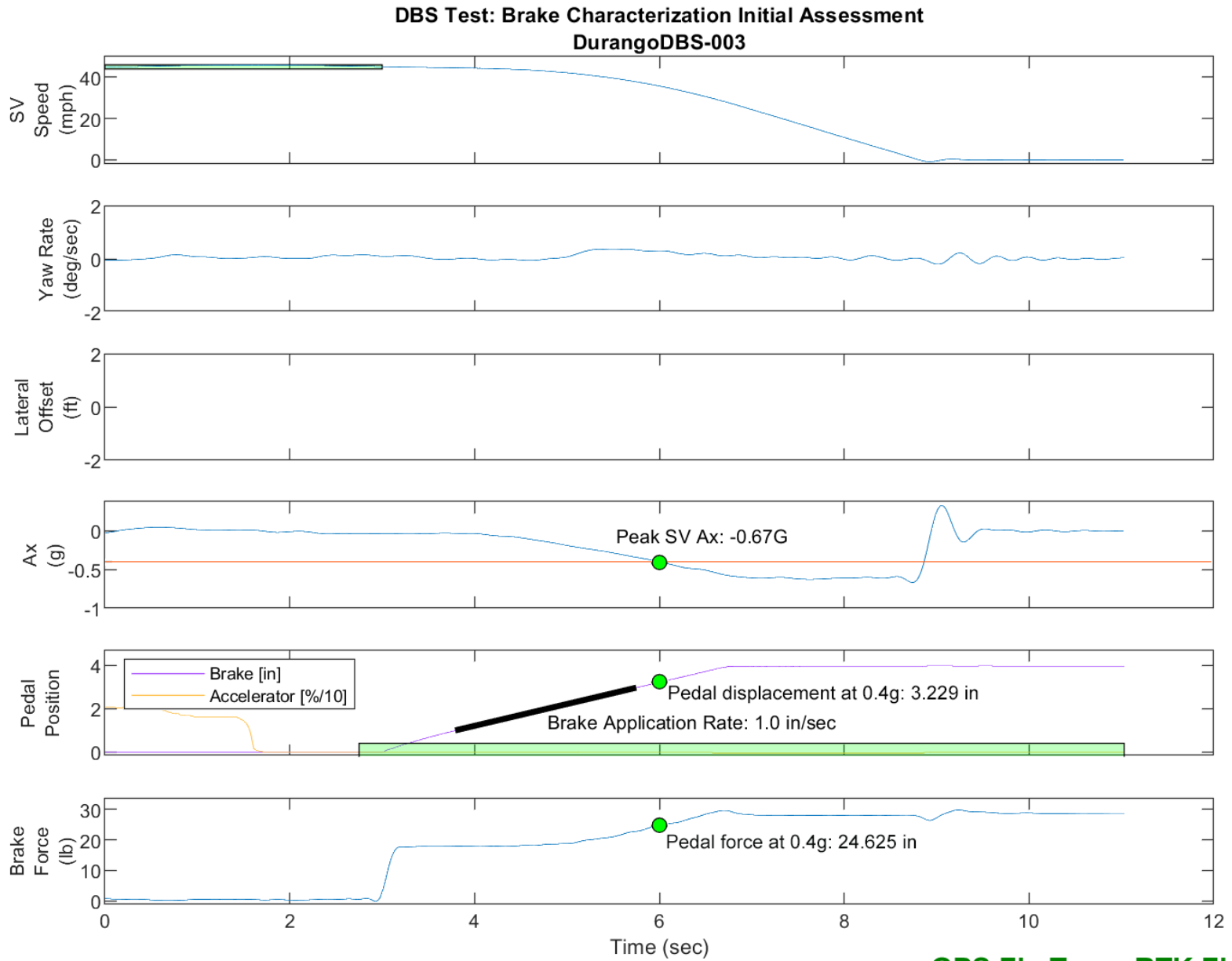


Figure E67. Time History for DBS Run 3, Brake Characterization Initial

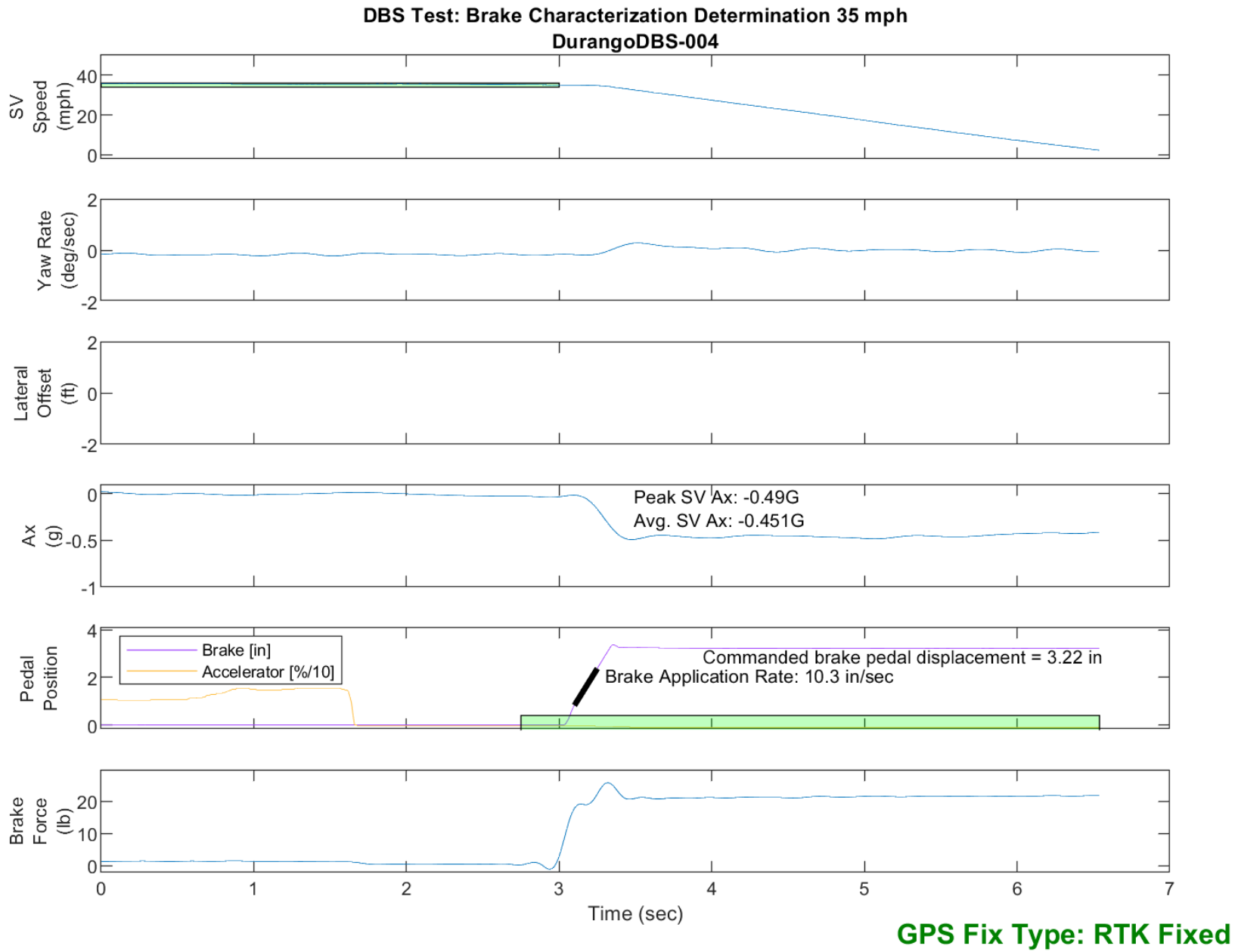


Figure E68. Time History for DBS Run 4, Brake Characterization Determination, Displacement Mode, 35 mph

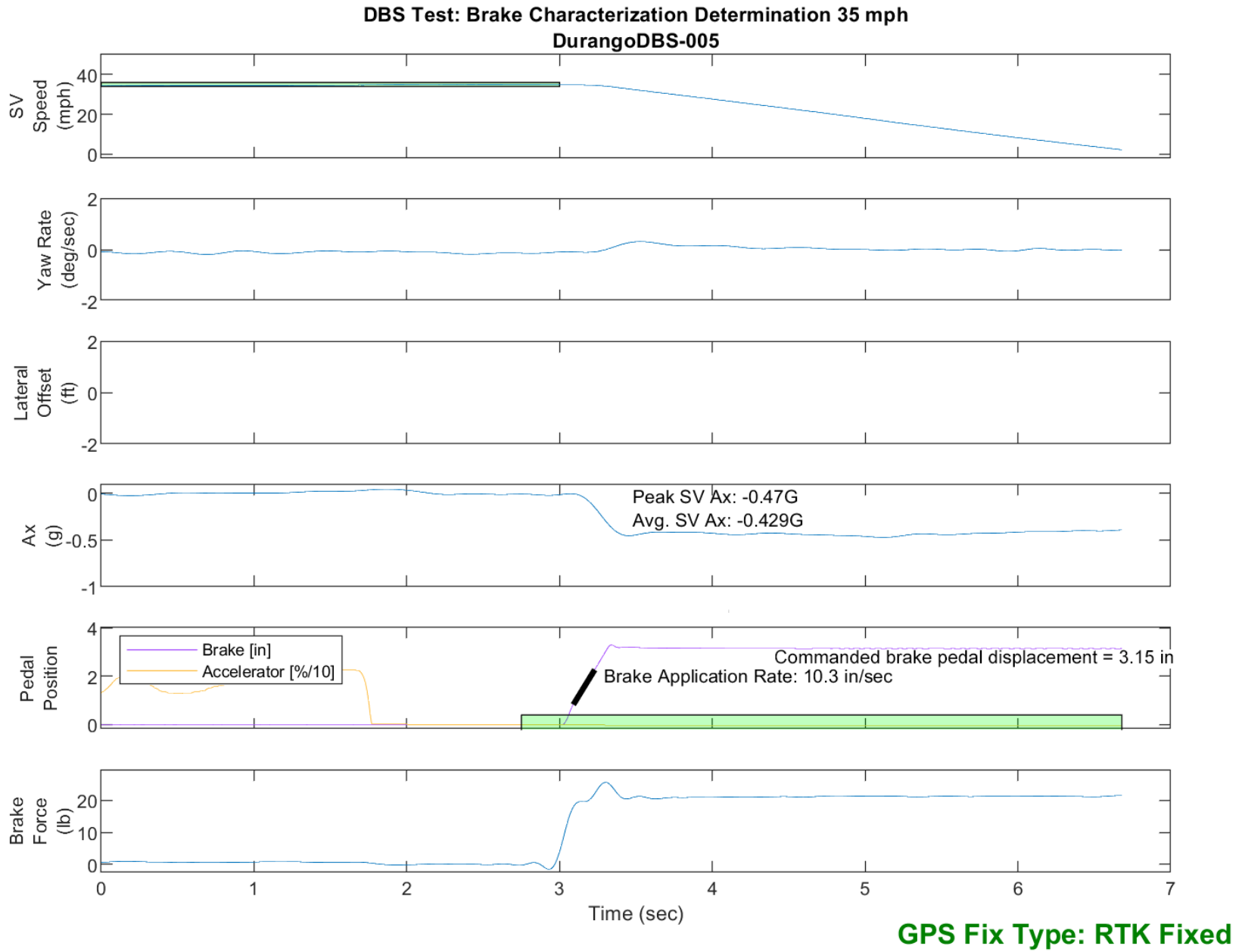


Figure E69. Time History for DBS Run 5, Brake Characterization Determination, Displacement Mode, 35 mph

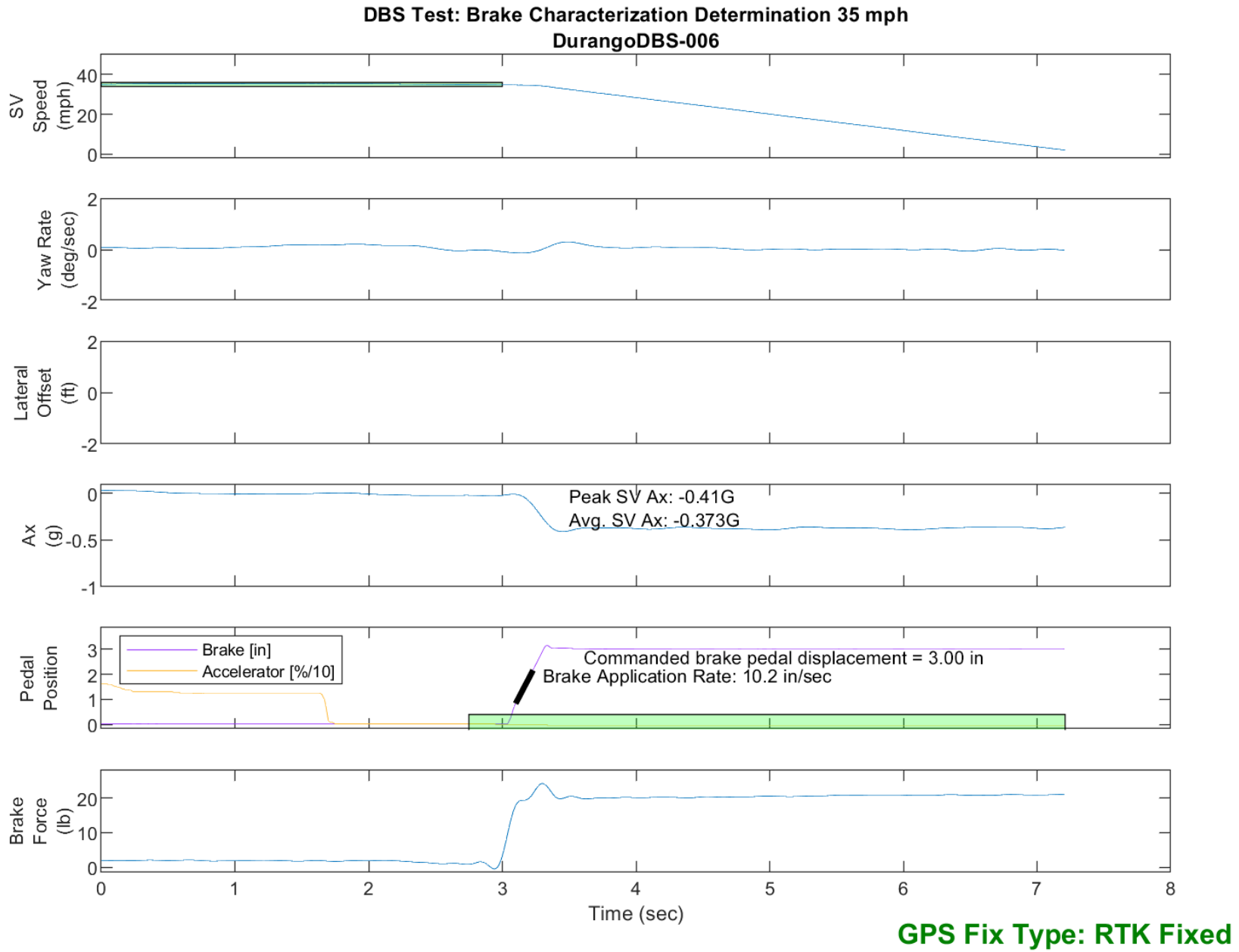


Figure E70. Time History for DBS Run 6, Brake Characterization Determination, Displacement Mode, 35 mph



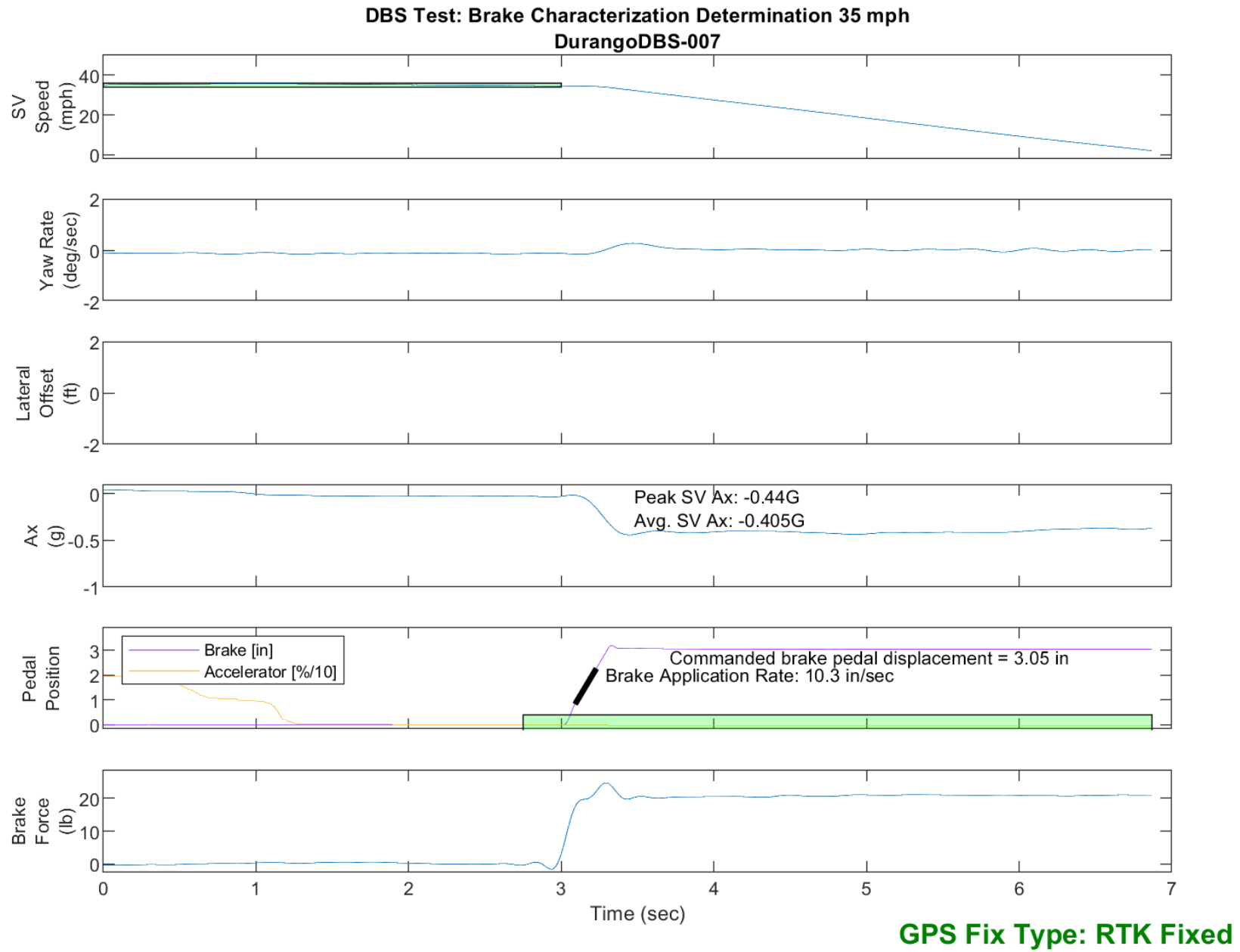
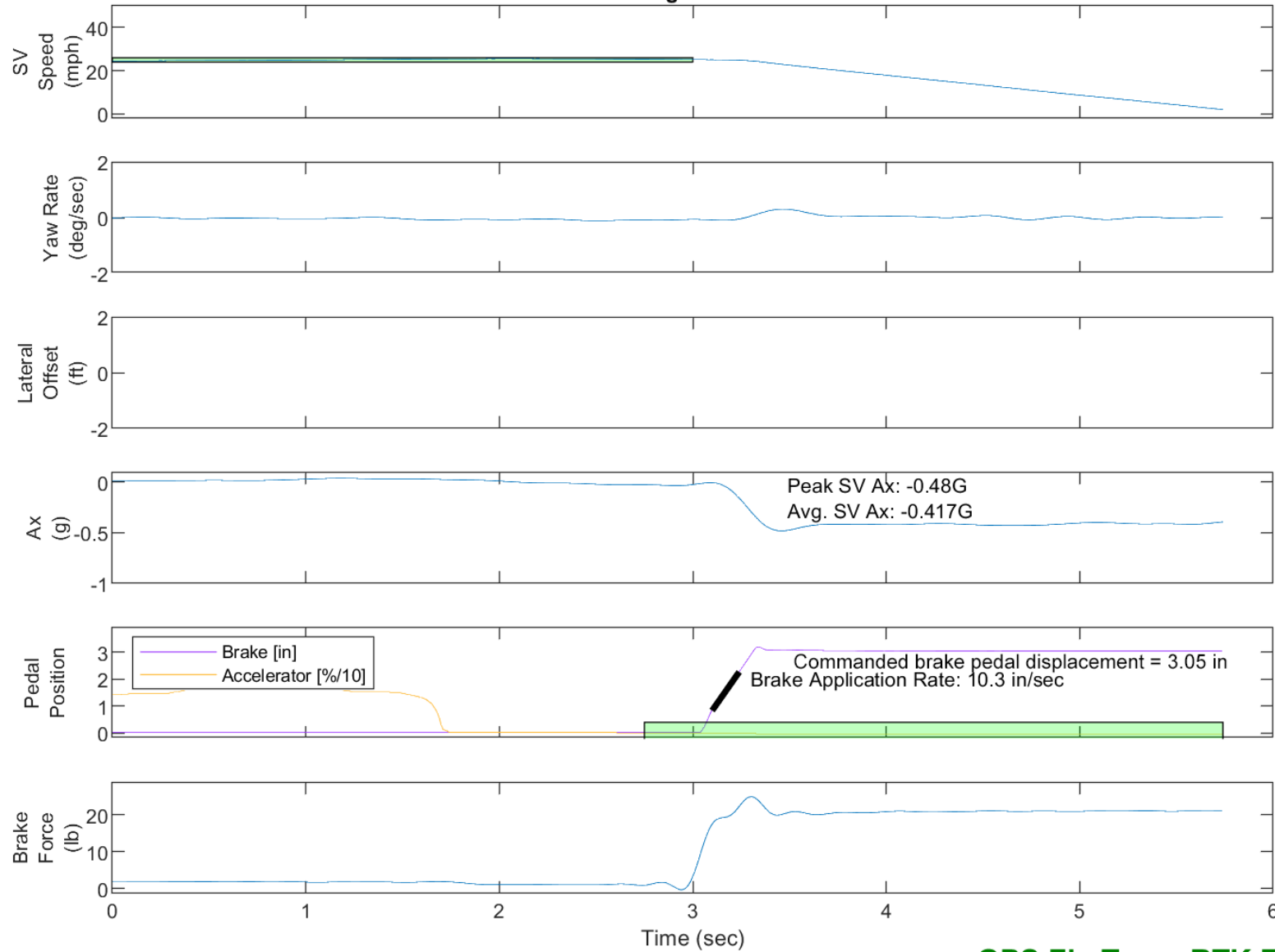


Figure E71. Time History for DBS Run 7, Brake Characterization Determination, Displacement Mode, 35 mph

DBS Test: Brake Characterization Determination 25 mph  
DurangoDBS-008



GPS Fix Type: RTK Fixed

Figure E72. Time History for DBS Run 8, Brake Characterization Determination, Displacement Mode, 25 mph

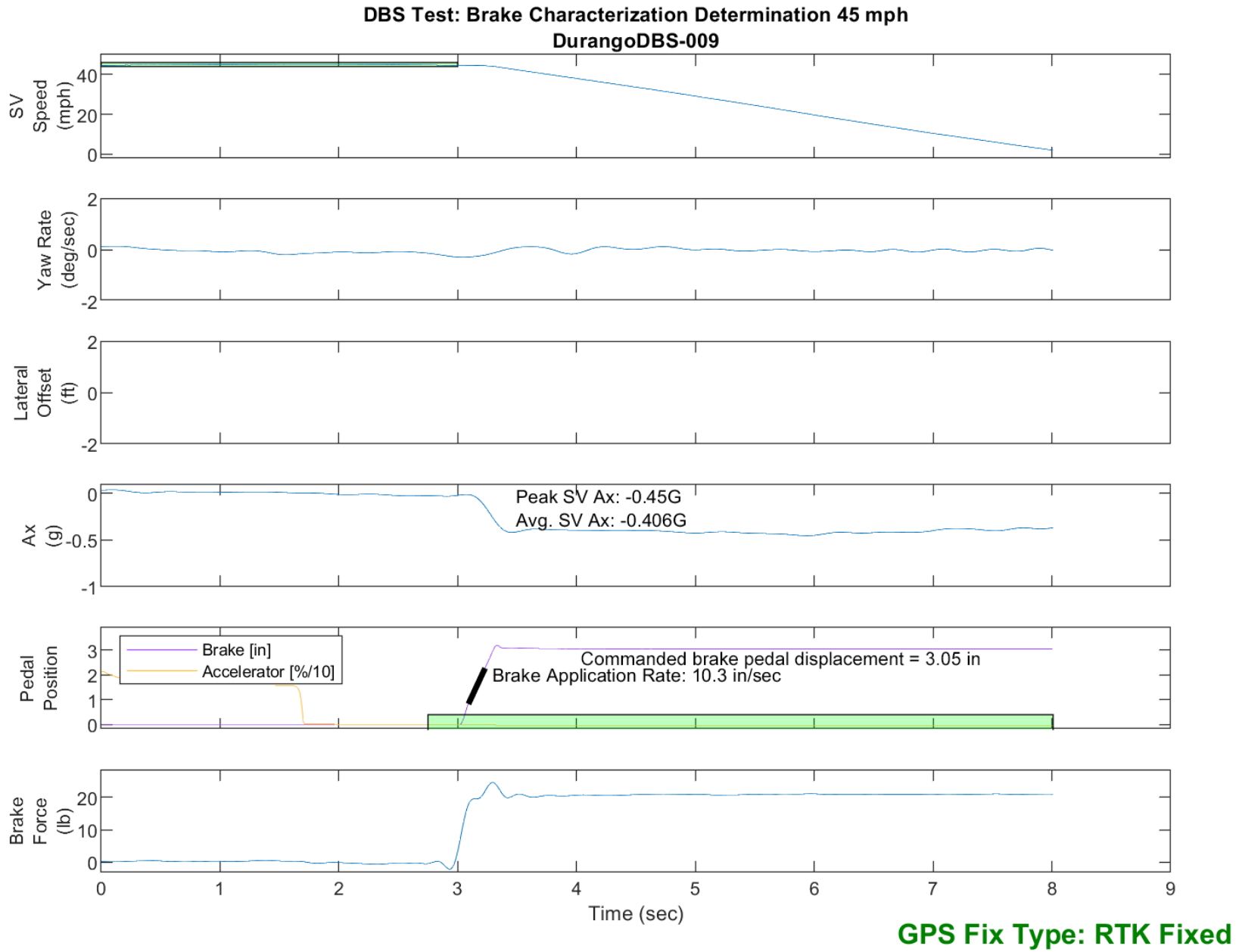


Figure E73. Time History for DBS Run 9, Brake Characterization Determination, Displacement Mode, 45 mph

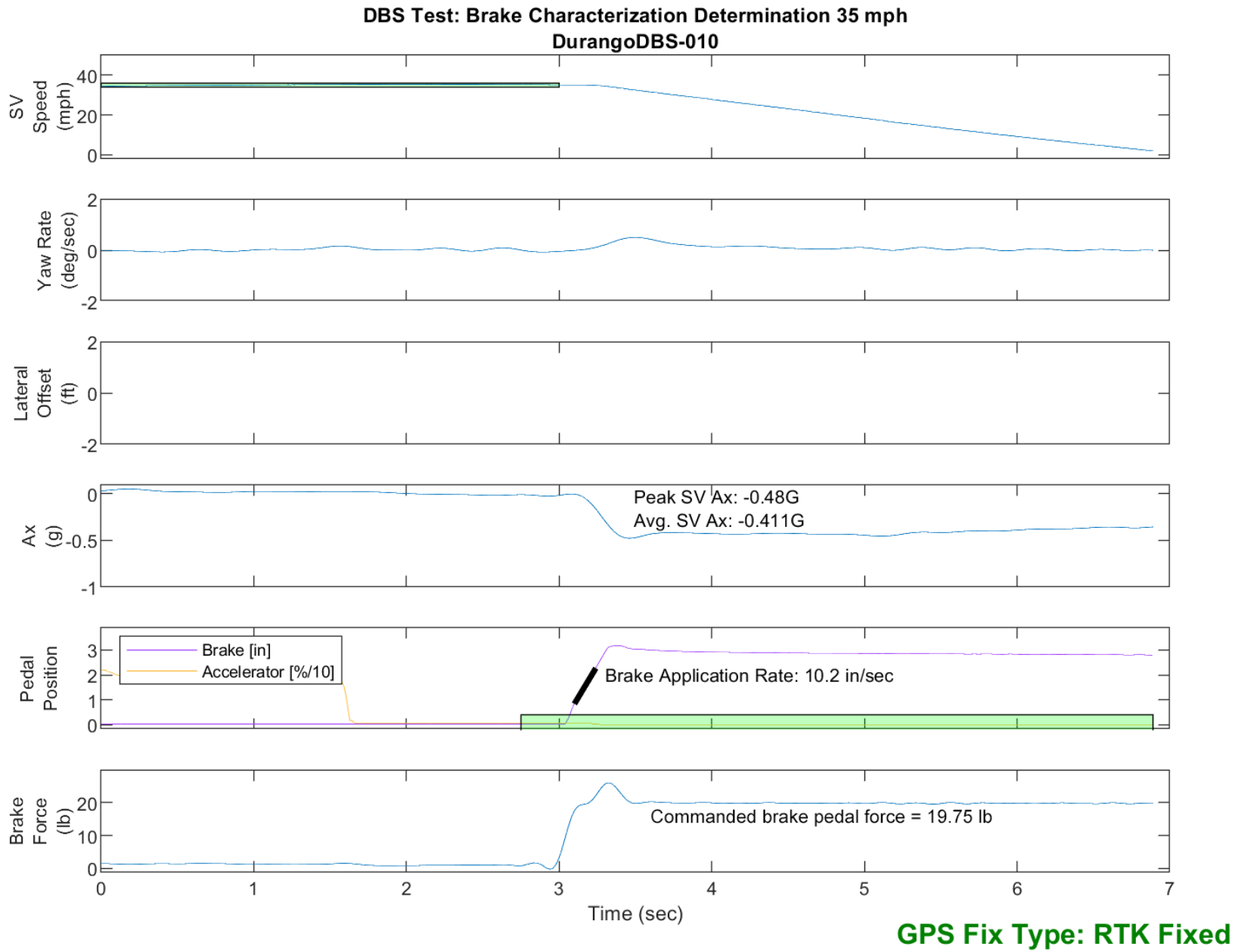


Figure E74. Time History for DBS Run 10, Brake Characterization Determination, Hybrid Mode, 35 mph

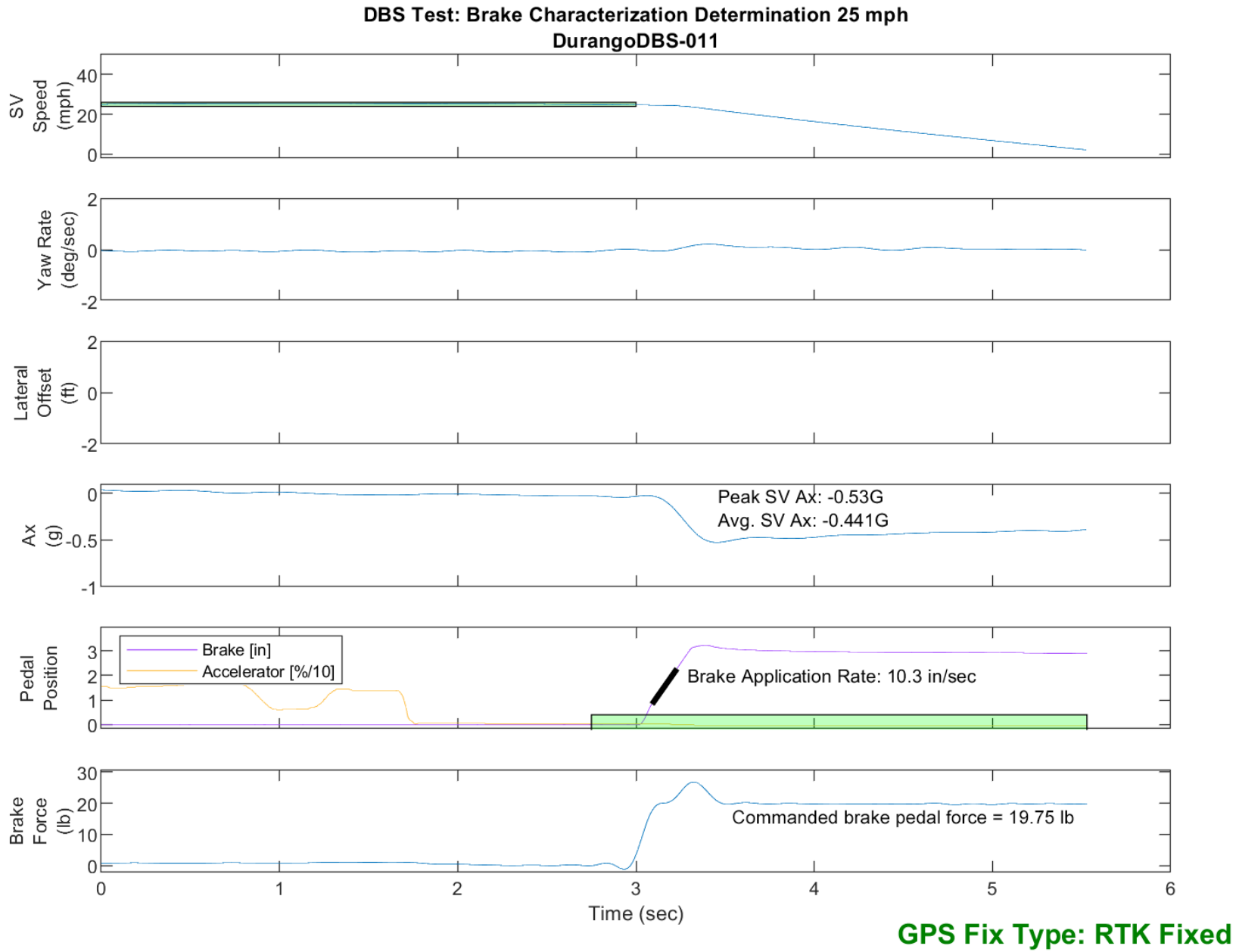


Figure E75. Time History for DBS Run 11, Brake Characterization Determination, Hybrid Mode, 25 mph

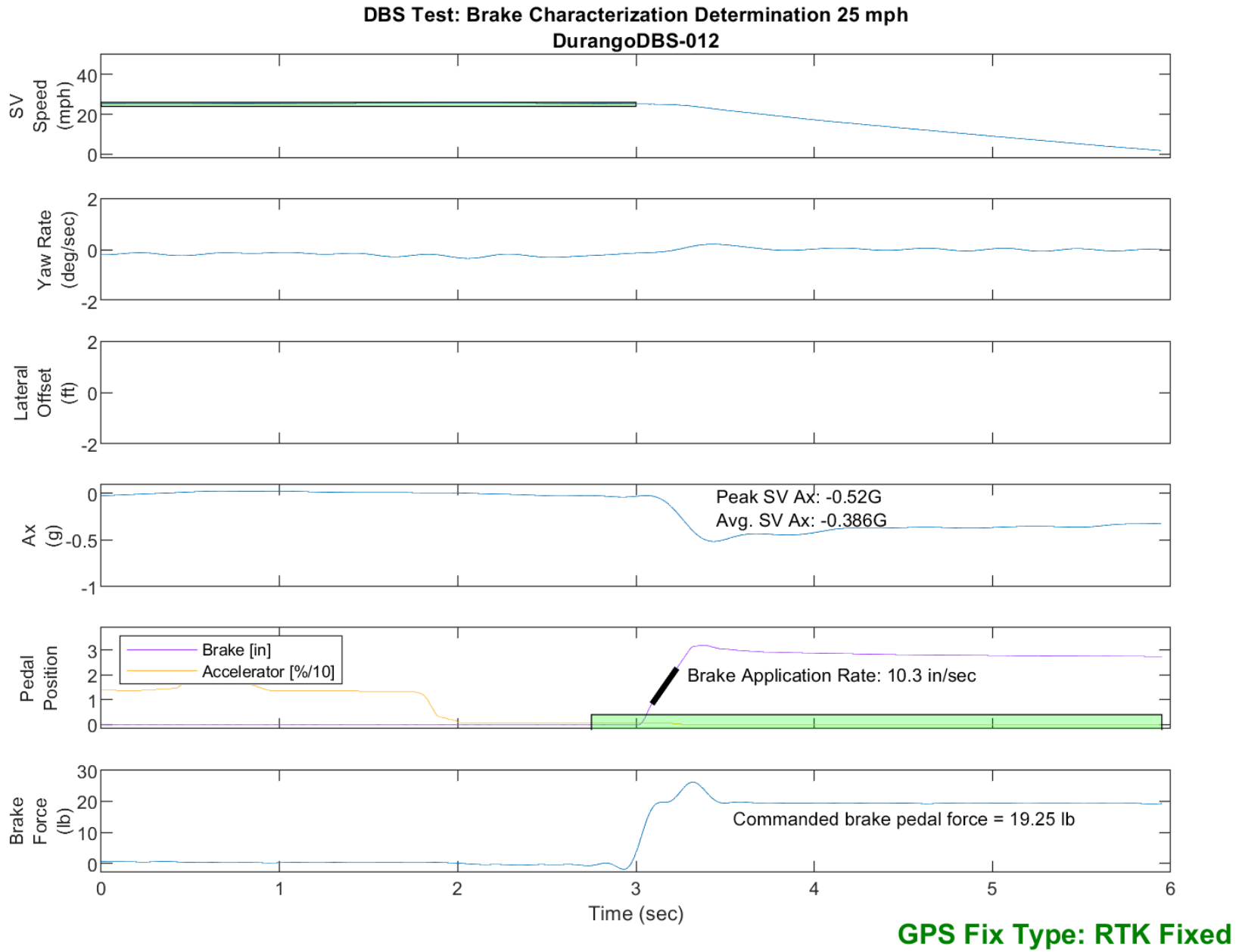


Figure E76. Time History for DBS Run 12, Brake Characterization Determination, Hybrid Mode, 25 mph

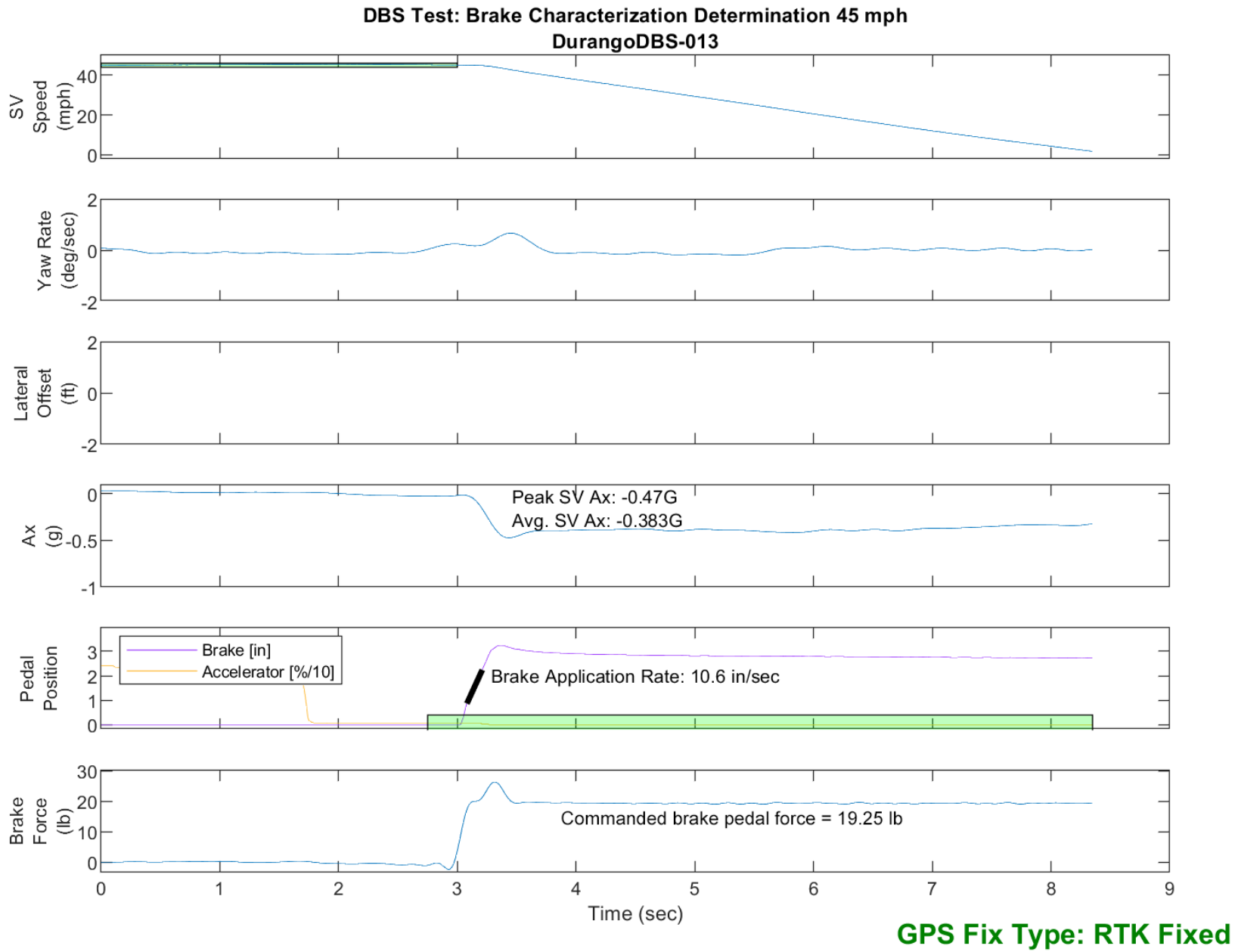


Figure E77. Time History for DBS Run 13, Brake Characterization Determination, Hybrid Mode, 45 mph

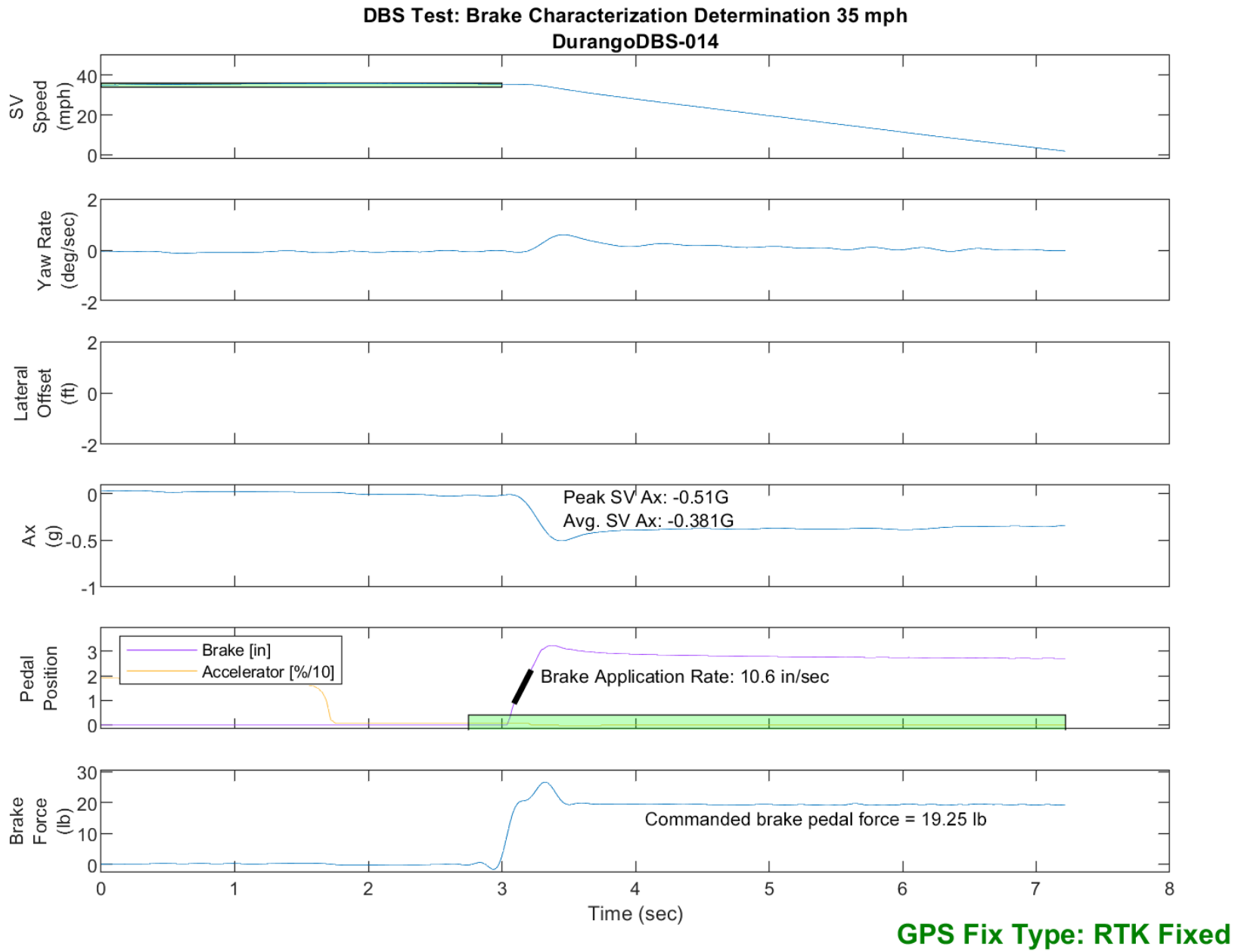


Figure E78. Time History for DBS Run 14, Brake Characterization Determination, Hybrid Mode, 35 mph



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 16, SV Encounters Stopped POV .....	E-23
Figure E14. Time History for DBS Run 17, SV Encounters Stopped POV .....	E-24
Figure E15. Time History for DBS Run 18, SV Encounters Stopped POV .....	E-25
Figure E16. Time History for DBS Run 19, SV Encounters Stopped POV .....	E-26
Figure E17. Time History for DBS Run 20, SV Encounters Stopped POV .....	E-27
Figure E18. Time History for DBS Run 22, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-28
Figure E19. Time History for DBS Run 23, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-29
Figure E20. Time History for DBS Run 24, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-30
Figure E21. Time History for DBS Run 25, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-31
Figure E22. Time History for DBS Run 27, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-32
Figure E23. Time History for DBS Run 84, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-33
Figure E24. Time History for DBS Run 85, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-34
Figure E25. Time History for DBS Run 29, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-35
Figure E26. Time History for DBS Run 30, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-36
Figure E27. Time History for DBS Run 31, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-37
Figure E28. Time History for DBS Run 32, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-38
Figure E29. Time History for DBS Run 33, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-39

Figure E30. Time History for DBS Run 34, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-40
Figure E31. Time History for DBS Run 35, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-41
Figure E32. Time History for DBS Run 38, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-42
Figure E33. Time History for DBS Run 41, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-43
Figure E34. Time History for DBS Run 44, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-44
Figure E35. Time History for DBS Run 45, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-45
Figure E36. Time History for DBS Run 46, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-46
Figure E37. Time History for DBS Run 49, False Positive Baseline, SV 25 mph .....	E-47
Figure E38. Time History for DBS Run 50, False Positive Baseline, SV 25 mph .....	E-48
Figure E39. Time History for DBS Run 51, False Positive Baseline, SV 25 mph .....	E-49
Figure E40. Time History for DBS Run 52, False Positive Baseline, SV 25 mph .....	E-50
Figure E41. Time History for DBS Run 53, False Positive Baseline, SV 25 mph .....	E-51
Figure E42. Time History for DBS Run 54, False Positive Baseline, SV 25 mph .....	E-52
Figure E43. Time History for DBS Run 55, False Positive Baseline, SV 25 mph .....	E-53
Figure E44. Time History for DBS Run 57, False Positive Baseline, SV 45 mph .....	E-54
Figure E45. Time History for DBS Run 58, False Positive Baseline, SV 45 mph .....	E-55
Figure E46. Time History for DBS Run 59, False Positive Baseline, SV 45 mph .....	E-56
Figure E47. Time History for DBS Run 60, False Positive Baseline, SV 45 mph .....	E-57
Figure E48. Time History for DBS Run 61, False Positive Baseline, SV 45 mph .....	E-58
Figure E49. Time History for DBS Run 62, False Positive Baseline, SV 45 mph .....	E-59
Figure E50. Time History for DBS Run 64, False Positive Baseline, SV 45 mph .....	E-60
Figure E51. Time History for DBS Run 66, SV Encounters Steel Trench Plate, SV 25 mph .....	E-61
Figure E52. Time History for DBS Run 67, SV Encounters Steel Trench Plate, SV 25 mph .....	E-62
Figure E53. Time History for DBS Run 68, SV Encounters Steel Trench Plate, SV 25 mph .....	E-63
Figure E54. Time History for DBS Run 69, SV Encounters Steel Trench Plate, SV 25 mph .....	E-64
Figure E55. Time History for DBS Run 70, SV Encounters Steel Trench Plate, SV 25 mph .....	E-65
Figure E56. Time History for DBS Run 71, SV Encounters Steel Trench Plate, SV 25 mph .....	E-66
Figure E57. Time History for DBS Run 72, SV Encounters Steel Trench Plate, SV 25 mph .....	E-67
Figure E58. Time History for DBS Run 74, SV Encounters Steel Trench Plate, SV 45 mph .....	E-68
Figure E59. Time History for DBS Run 75, SV Encounters Steel Trench Plate, SV 45 mph .....	E-69

Figure E60.	Time History for DBS Run 76, SV Encounters Steel Trench Plate, SV 45 mph .....	E-70
Figure E61.	Time History for DBS Run 77, SV Encounters Steel Trench Plate, SV 45 mph .....	E-71
Figure E62.	Time History for DBS Run 78, SV Encounters Steel Trench Plate, SV 45 mph .....	E-72
Figure E63.	Time History for DBS Run 79, SV Encounters Steel Trench Plate, SV 45 mph .....	E-73
Figure E64.	Time History for DBS Run 80, SV Encounters Steel Trench Plate, SV 45 mph .....	E-74
Figure E65.	Time History for DBS Run 1, Brake Characterization Initial .....	E-75
Figure E66.	Time History for DBS Run 2, Brake Characterization Initial .....	E-76
Figure E67.	Time History for DBS Run 3, Brake Characterization Initial .....	E-77
Figure E68.	Time History for DBS Run 4, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-78
Figure E69.	Time History for DBS Run 5, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-79
Figure E70.	Time History for DBS Run 6, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-80
Figure E71.	Time History for DBS Run 7, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-81
Figure E72.	Time History for DBS Run 8, Brake Characterization Determination, Displacement Mode, 25 mph .....	E-82
Figure E73.	Time History for DBS Run 9, Brake Characterization Determination, Displacement Mode, 45 mph .....	E-83
Figure E74.	Time History for DBS Run 10, Brake Characterization Determination, Hybrid Mode, 35 mph .....	E-84
Figure E75.	Time History for DBS Run 11, Brake Characterization Determination, Hybrid Mode, 25 mph .....	E-85
Figure E76.	Time History for DBS Run 12, Brake Characterization Determination, Hybrid Mode, 25 mph .....	E-86
Figure E77.	Time History for DBS Run 13, Brake Characterization Determination, Hybrid Mode, 45 mph .....	E-87
Figure E78.	Time History for DBS Run 14, Brake Characterization Determination, Hybrid Mode, 35 mph .....	E-88

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

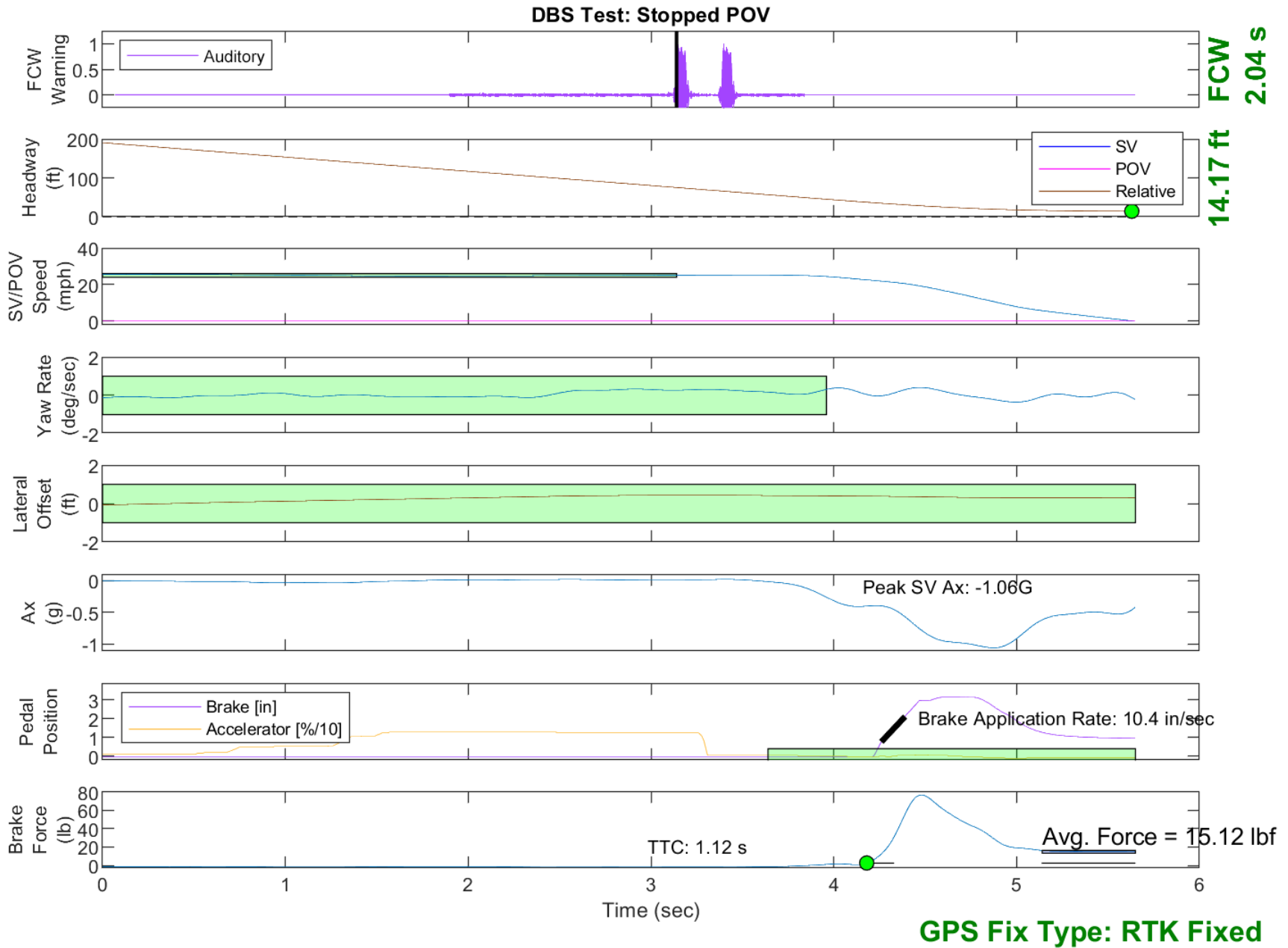


Figure E1. Example Time History for Stopped POV, Passing

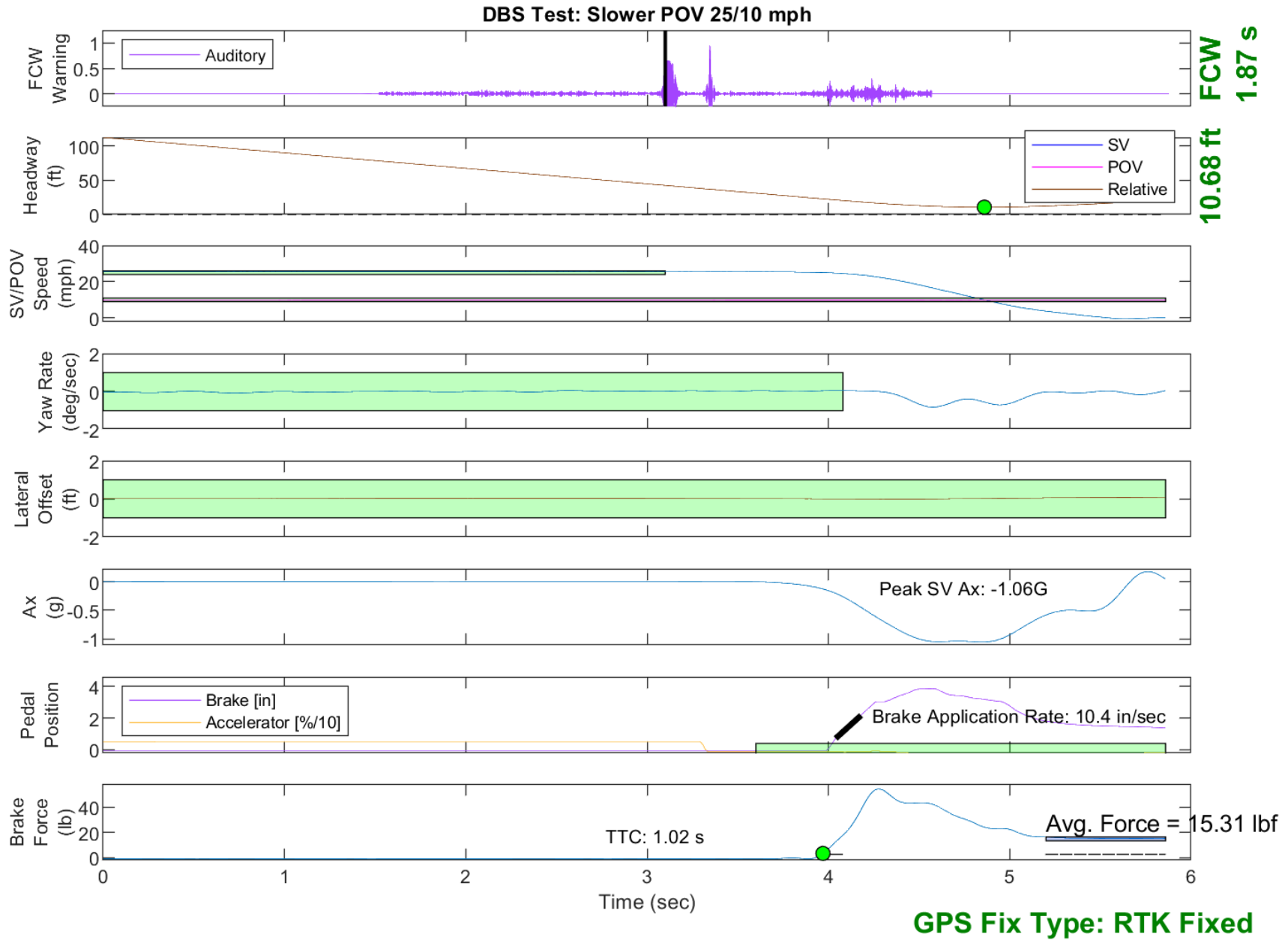


Figure E2. Example Time History for Slower POV 25 vs. 10, Passing

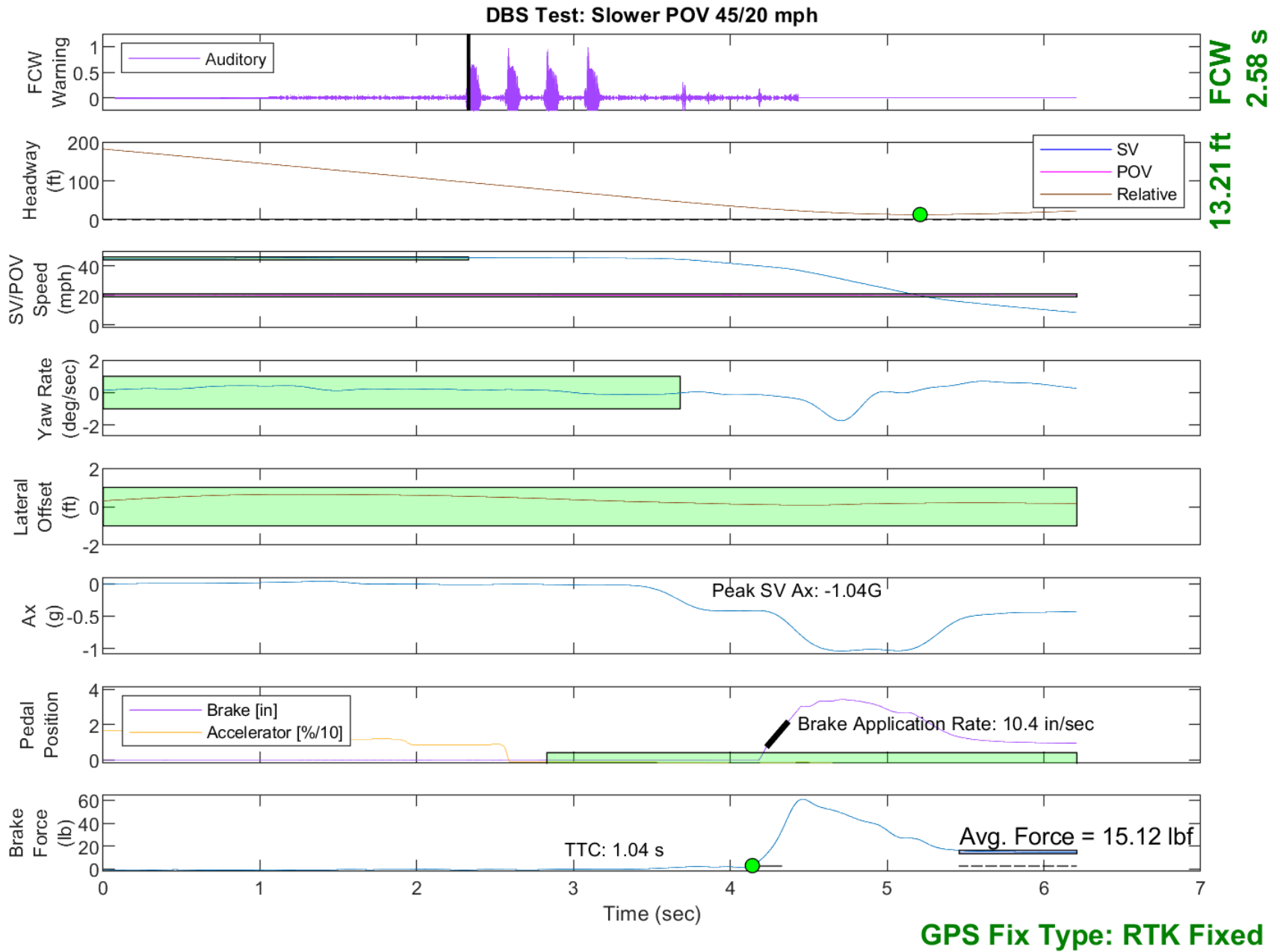


Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

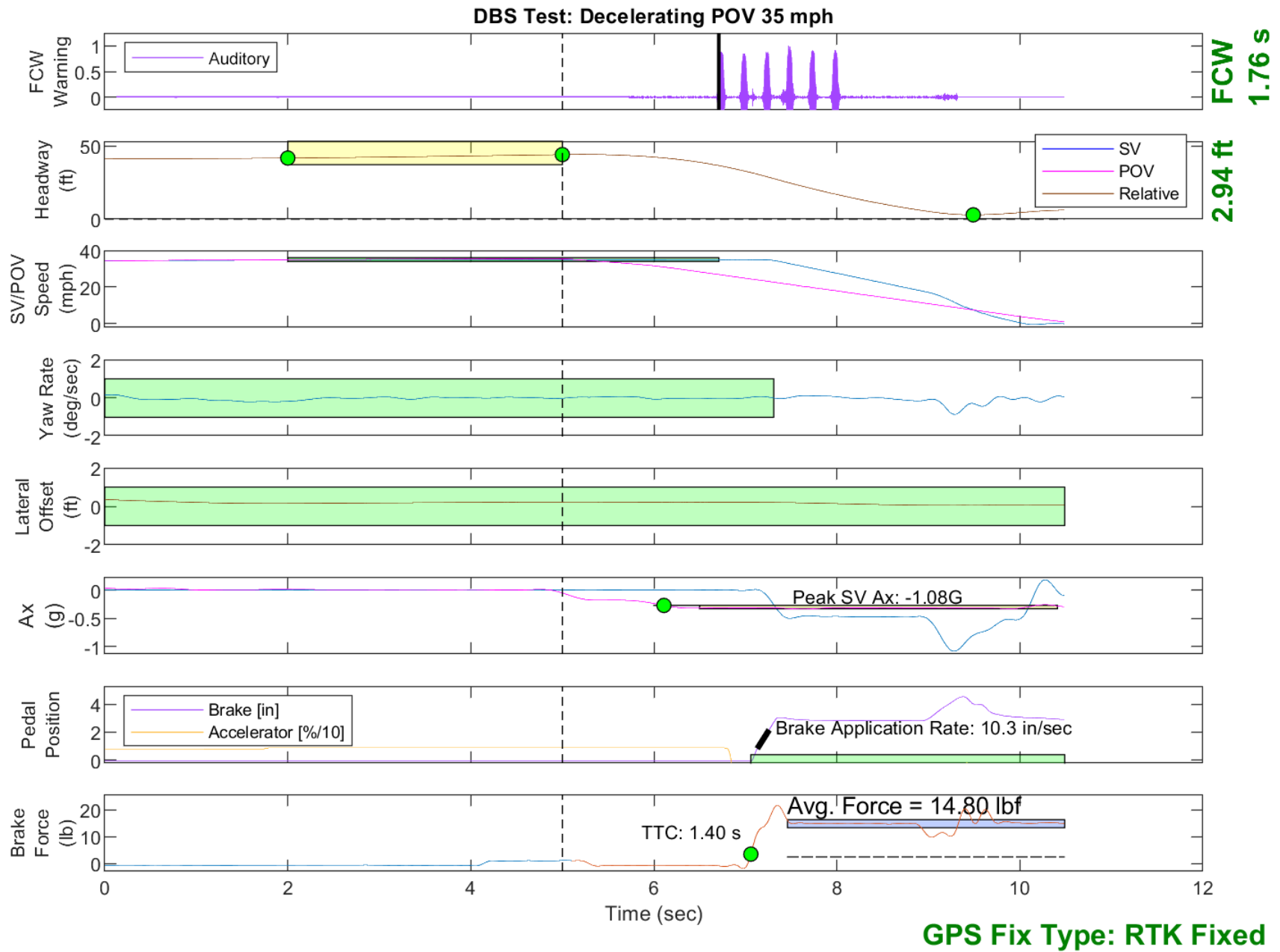
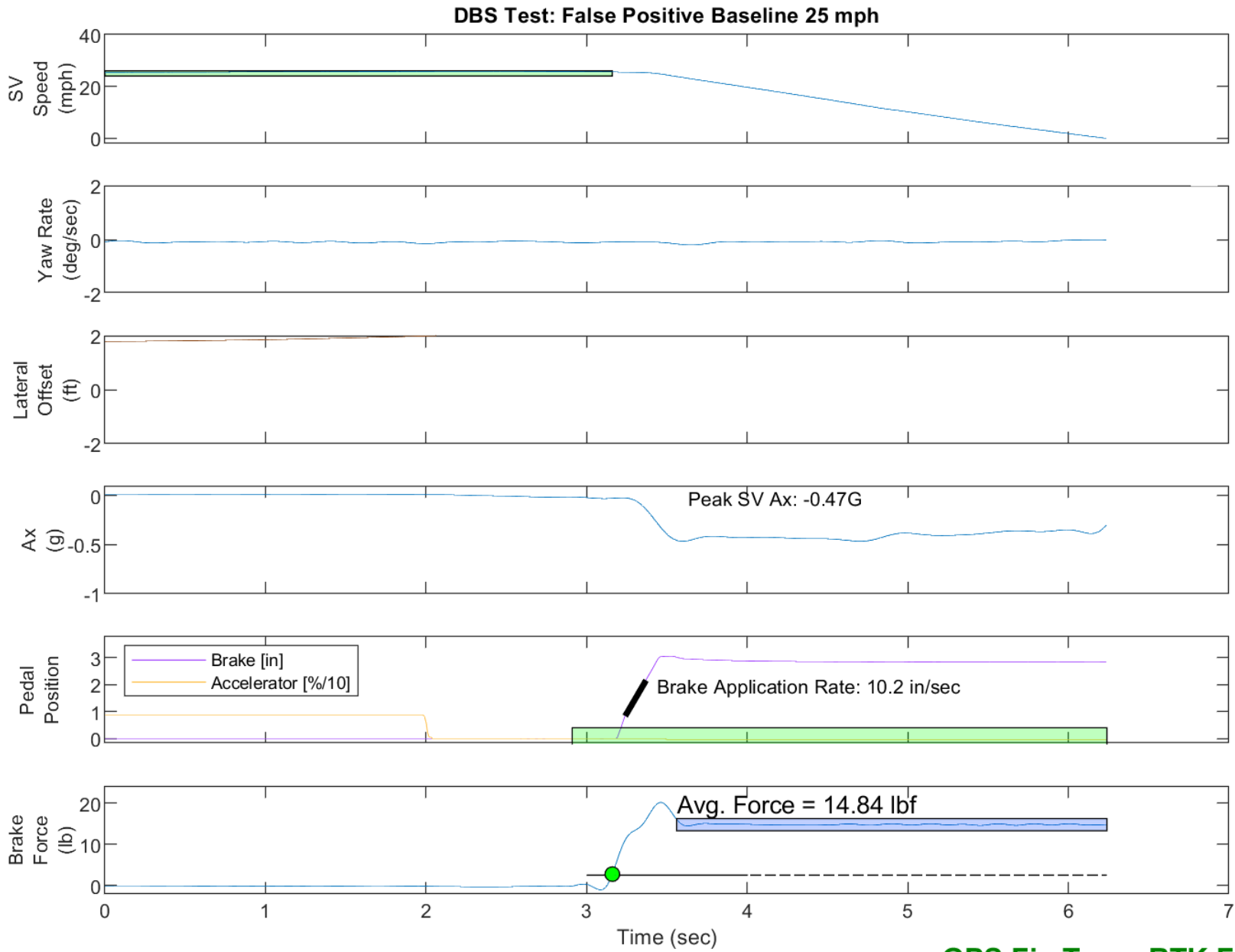
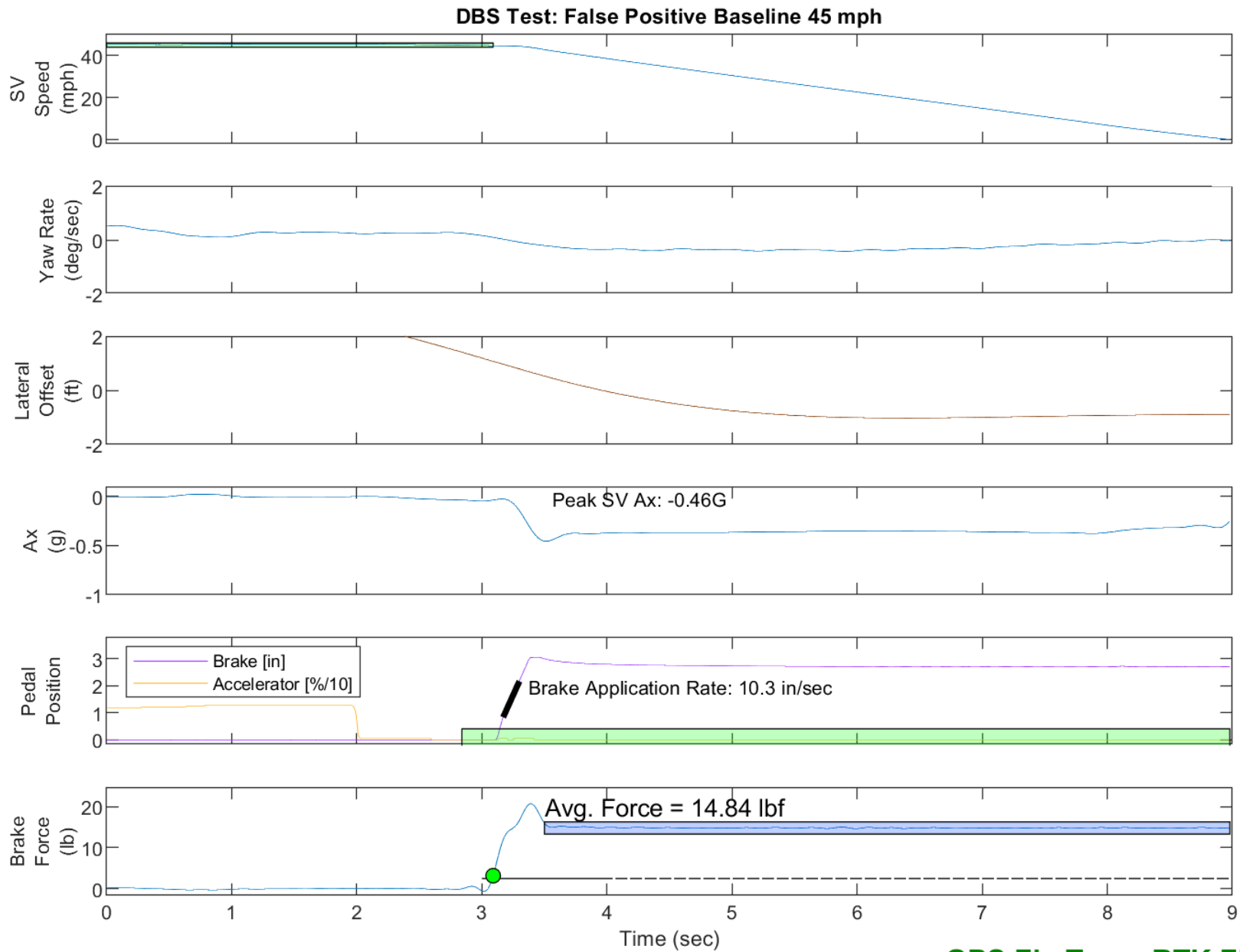


Figure E4. Example Time History for Decelerating POV 35, Passing



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



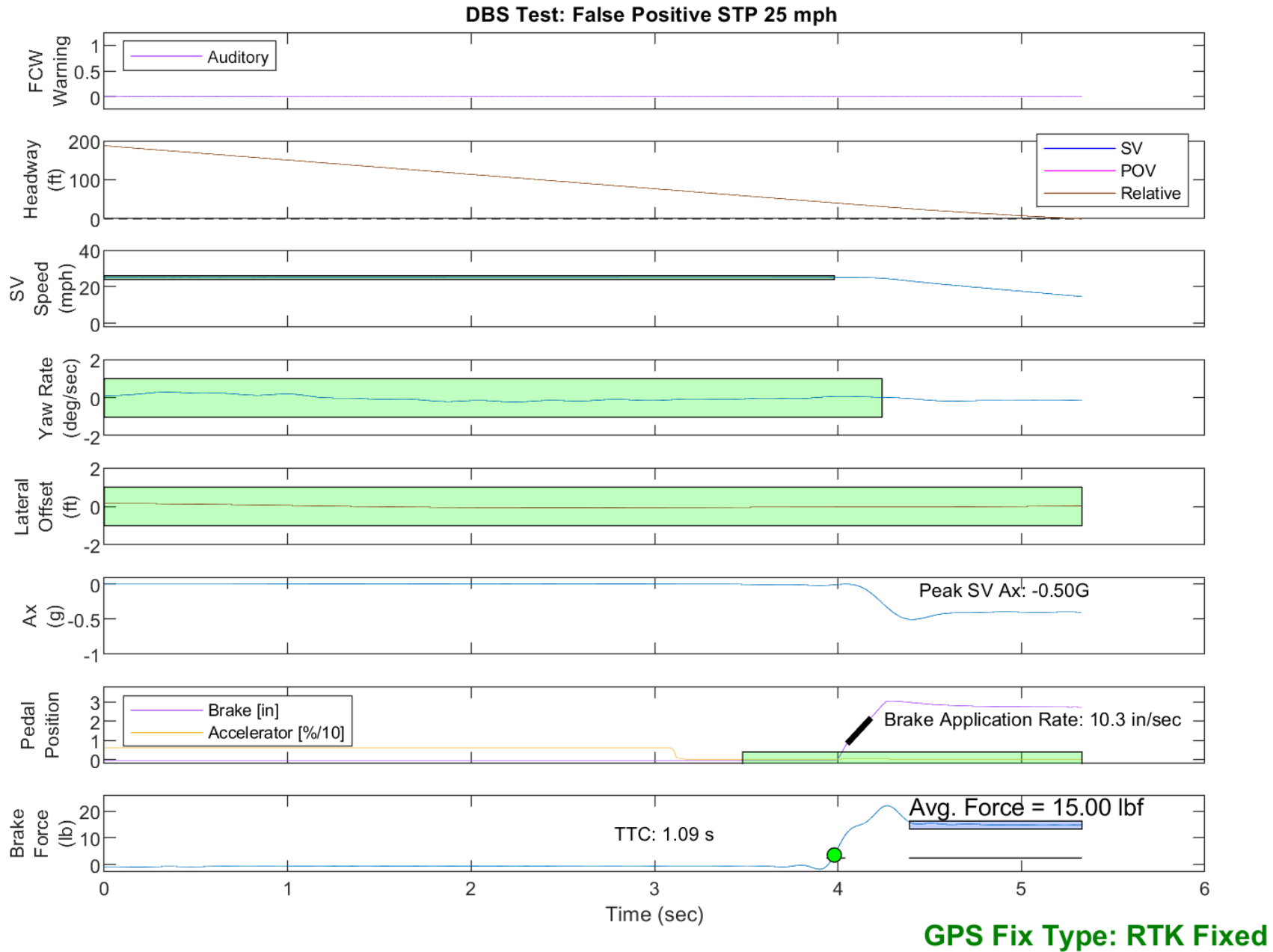
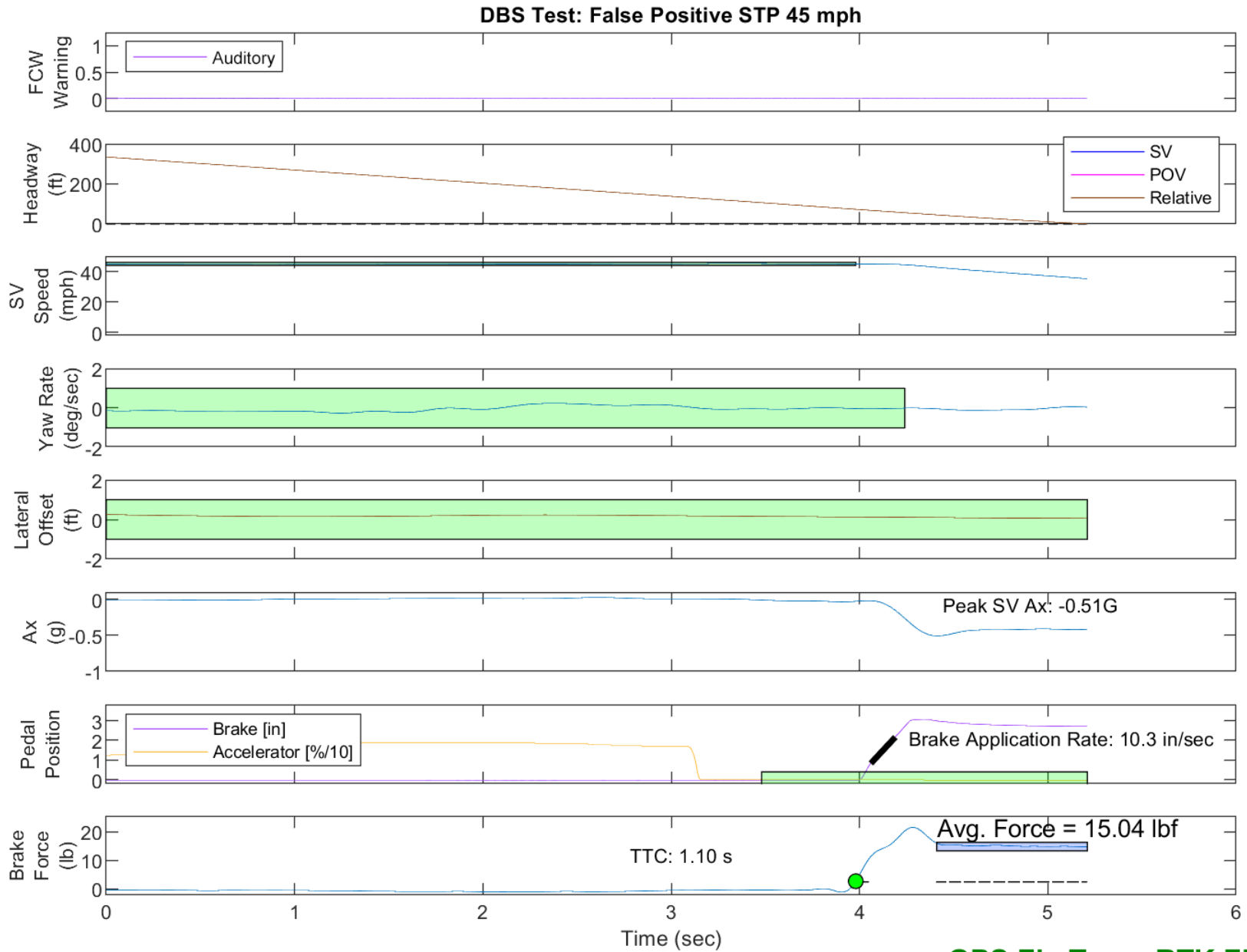


Figure E7. Example Time History for False Positive Steel Plate 25, Passing



GPS Fix Type: RTK Fixed

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

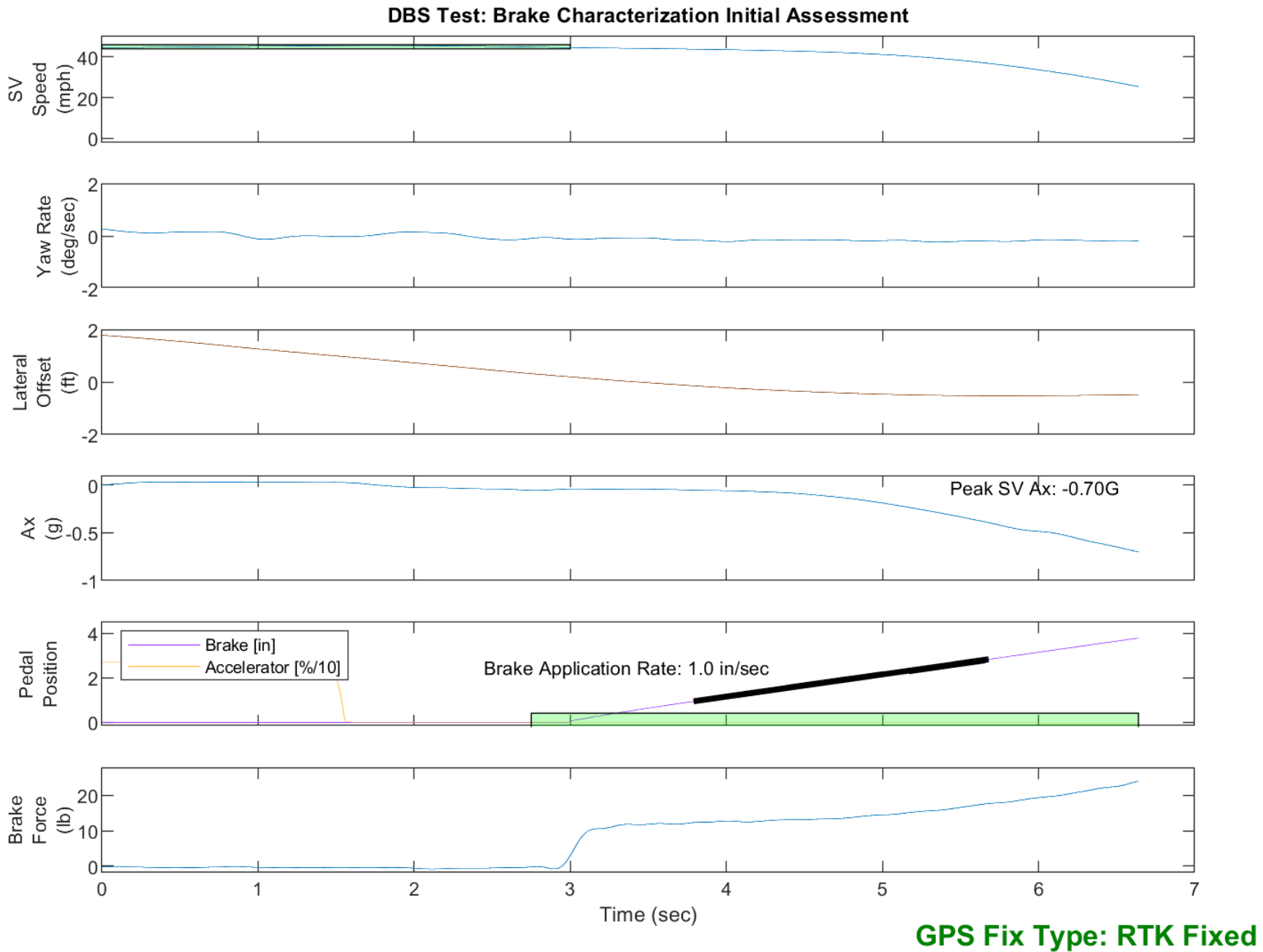


Figure E9. Example Time History for DBS Brake Characterization, Passing

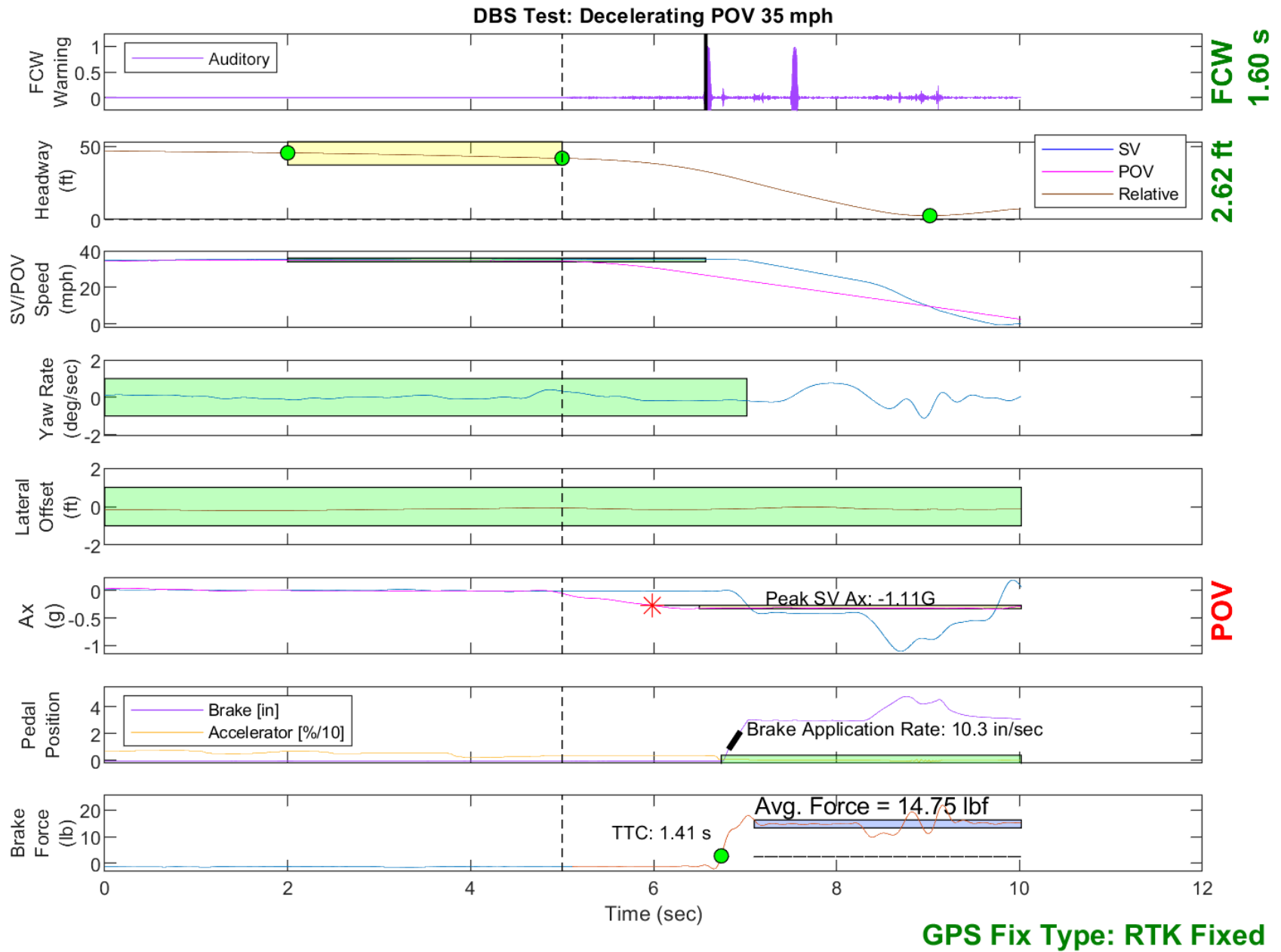
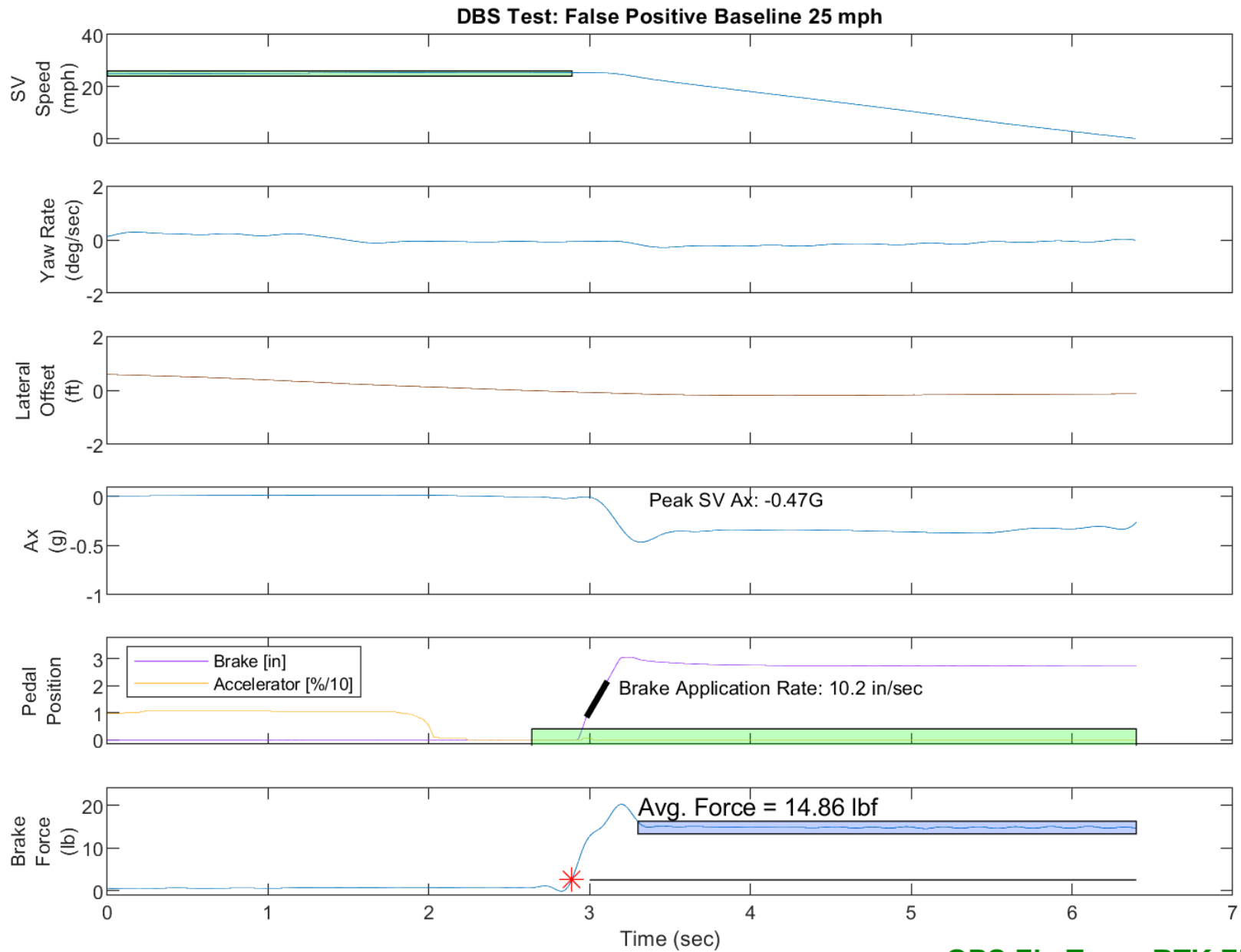


Figure E10. Example Time History Displaying Invalid POV Acceleration Criteria



**GPS Fix Type: RTK Fixed**

Figure E11. Example Time History Displaying Invalid Brake Force Criteria

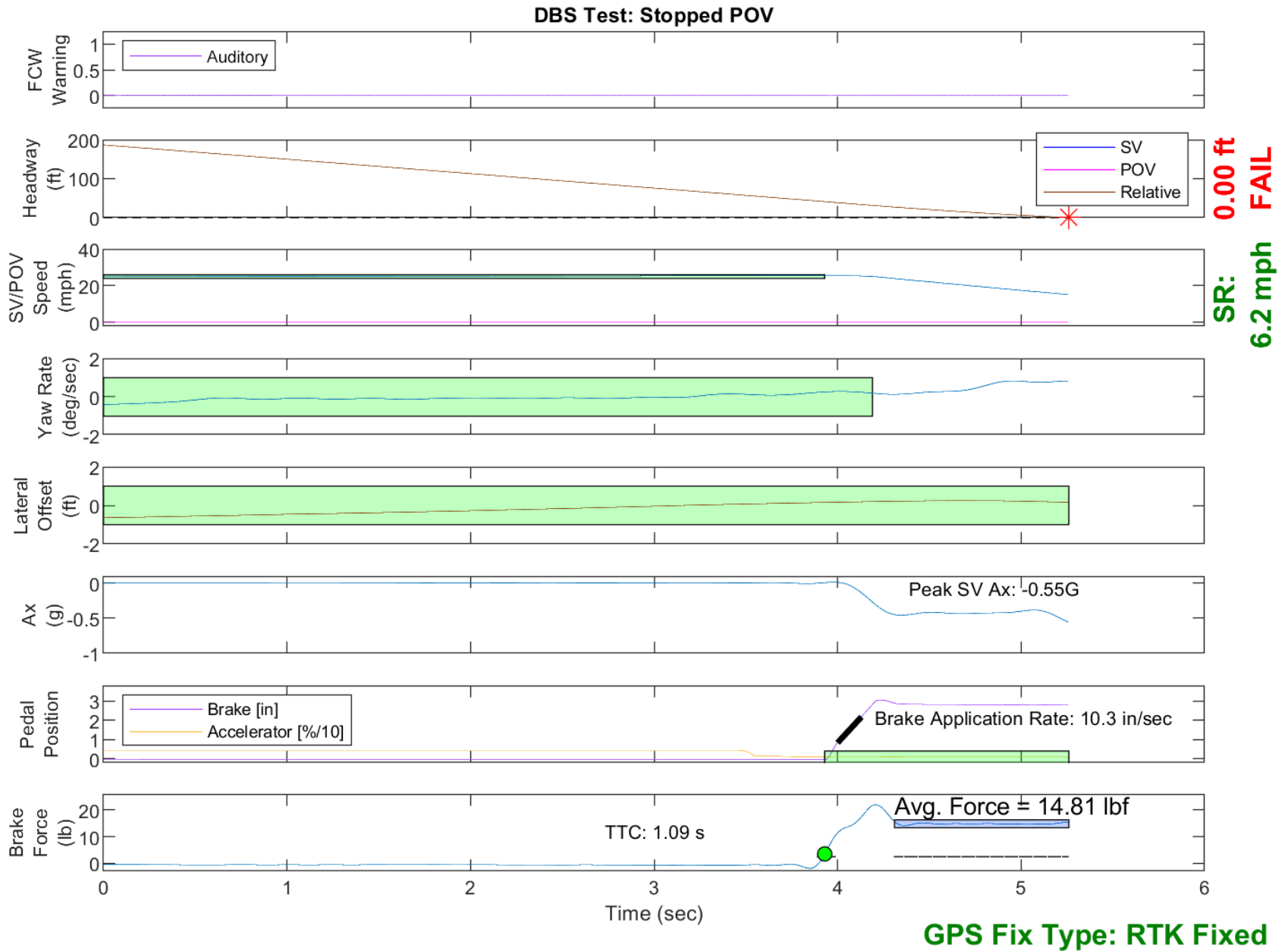


Figure E12. Example Time History for a Failed Run

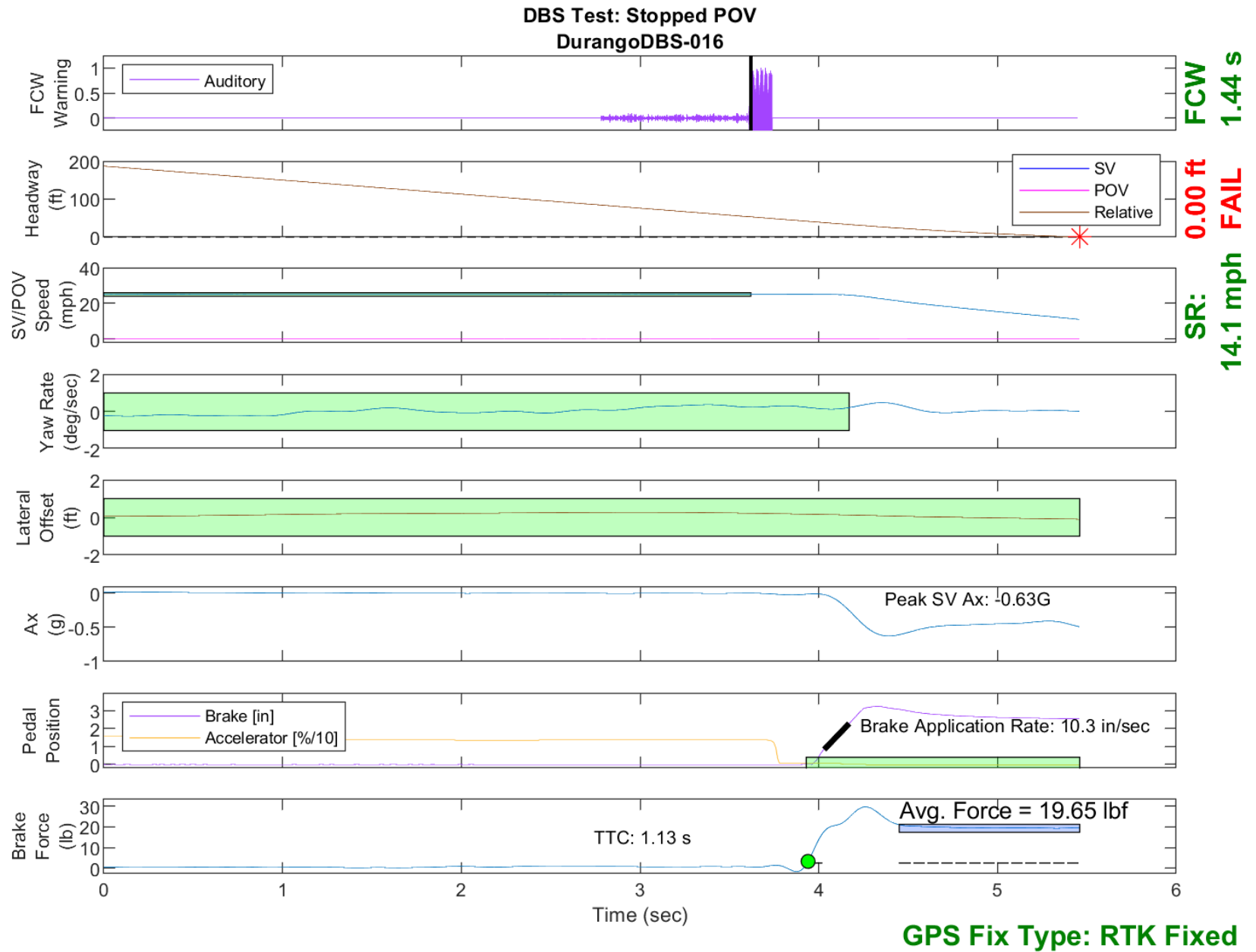


Figure E13. Time History for DBS Run 16, SV Encounters Stopped POV

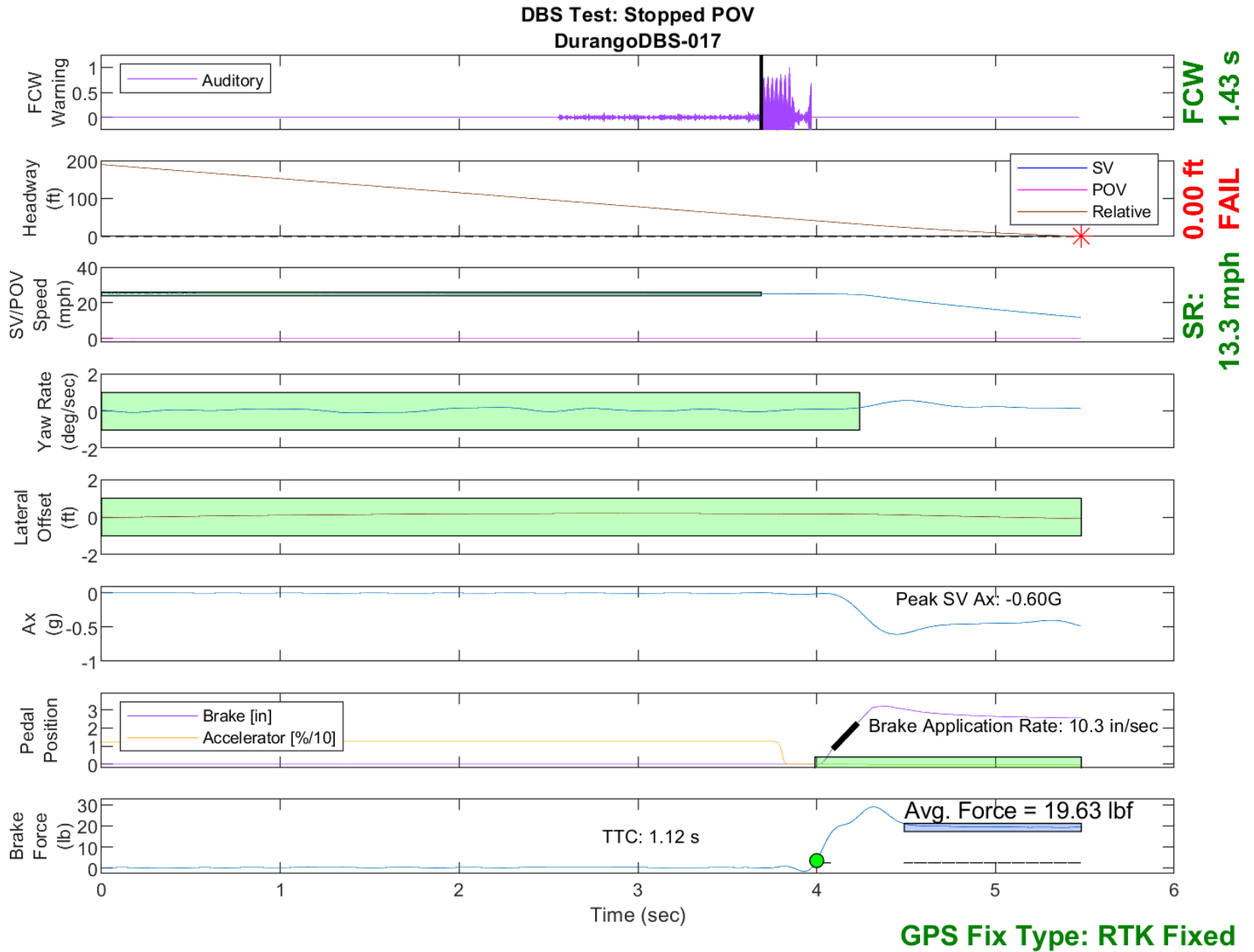


Figure E14. Time History for DBS Run 17, SV Encounters Stopped POV



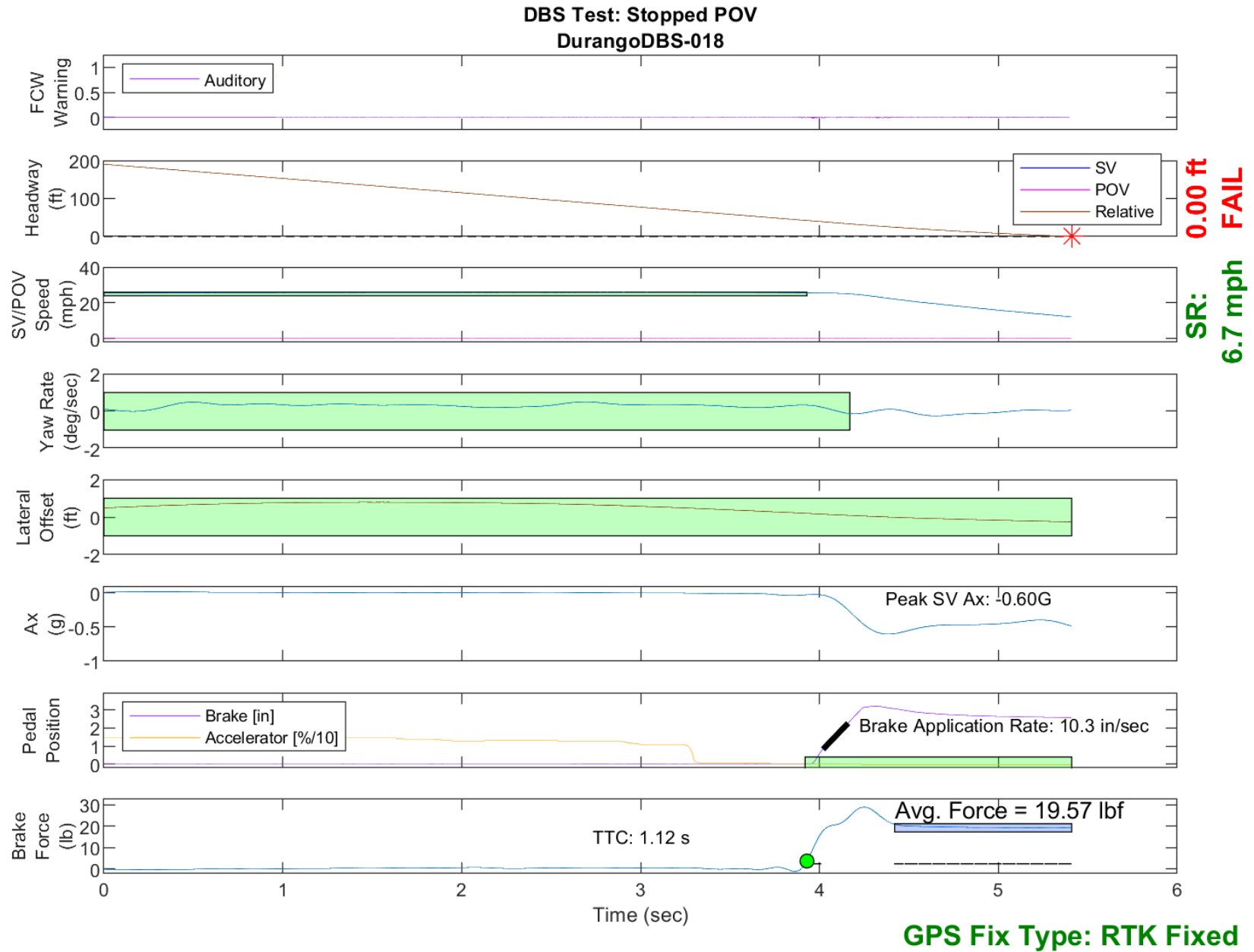


Figure E15. Time History for DBS Run 18, SV Encounters Stopped POV

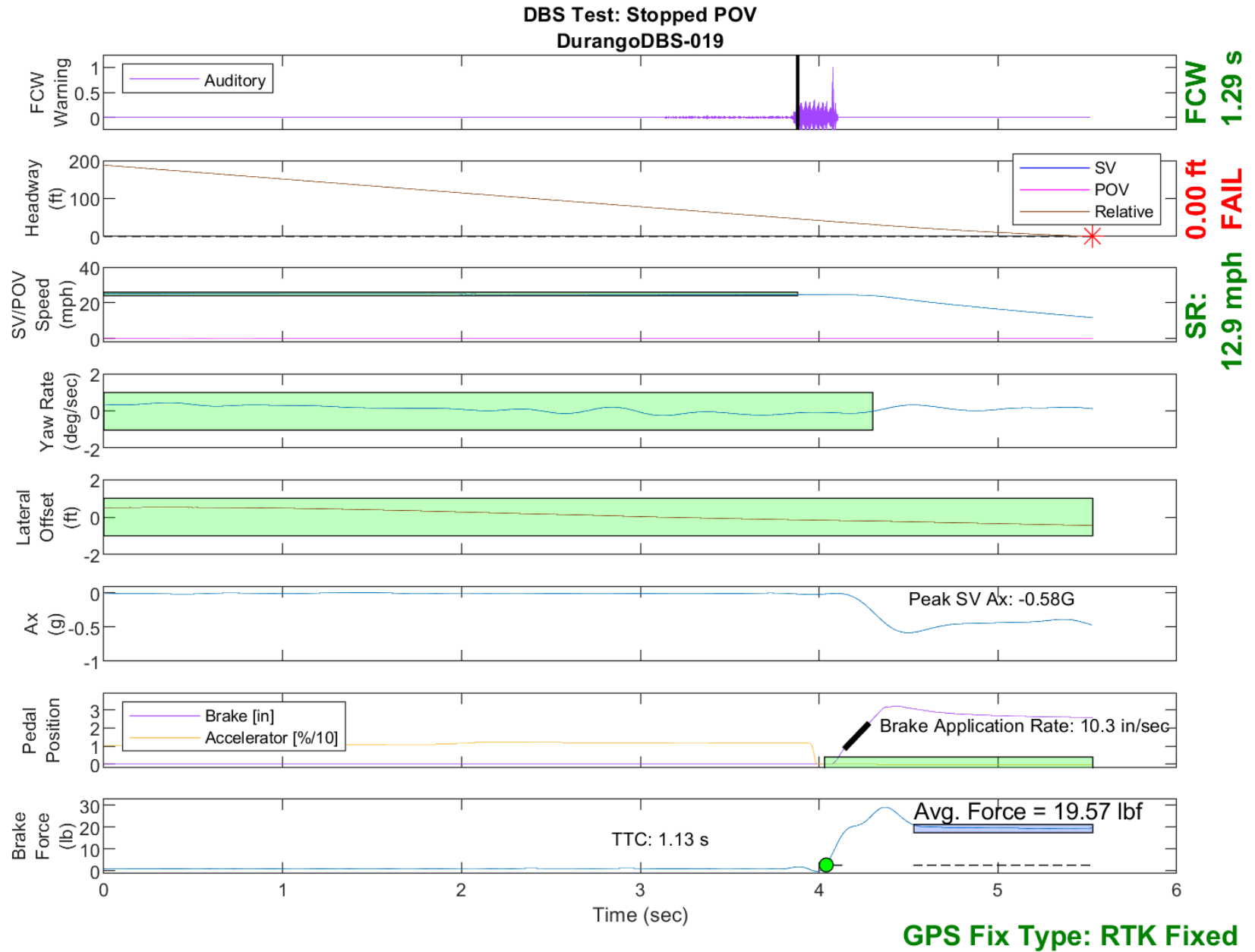


Figure E16. Time History for DBS Run 19, SV Encounters Stopped POV

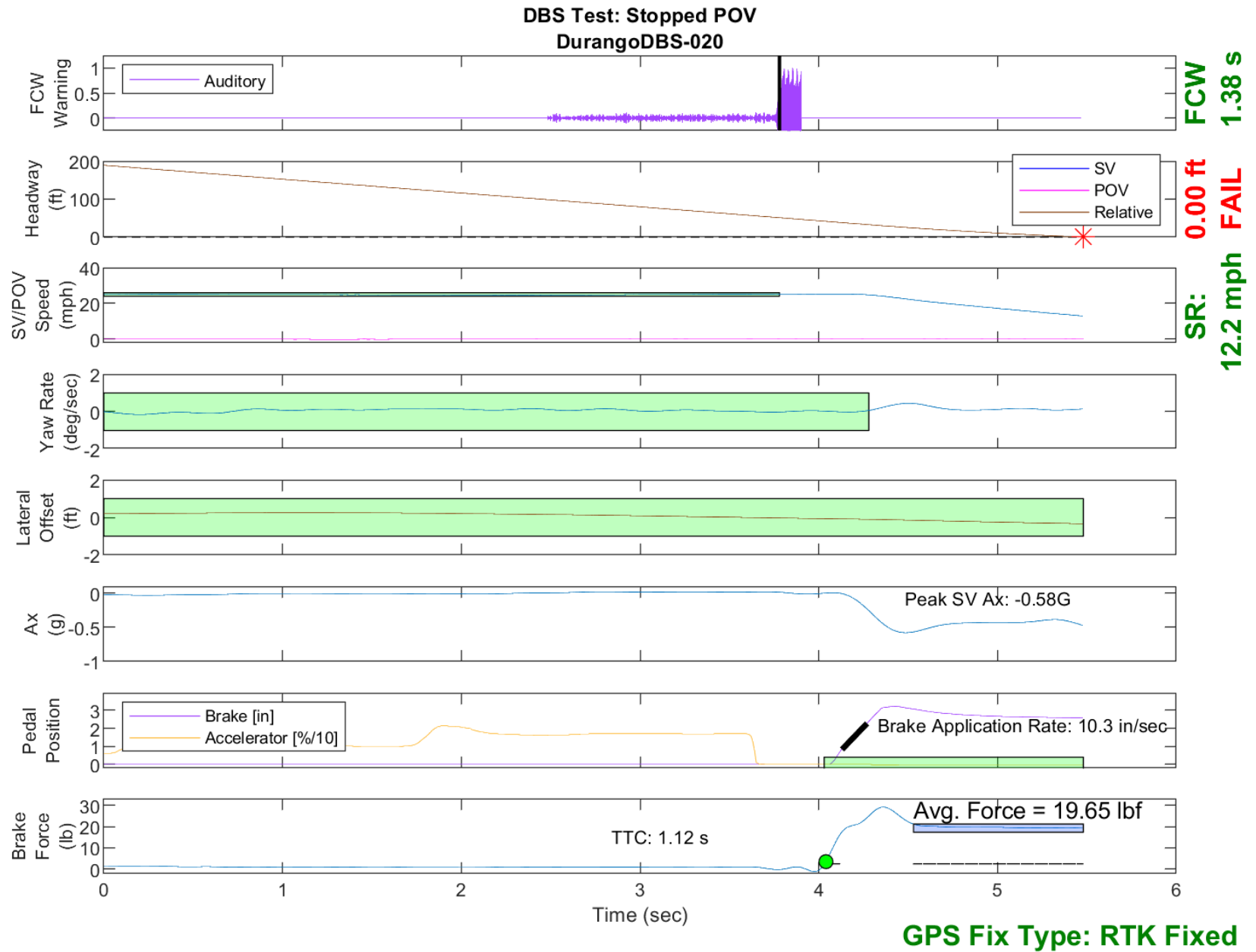


Figure E17. Time History for DBS Run 20, SV Encounters Stopped POV

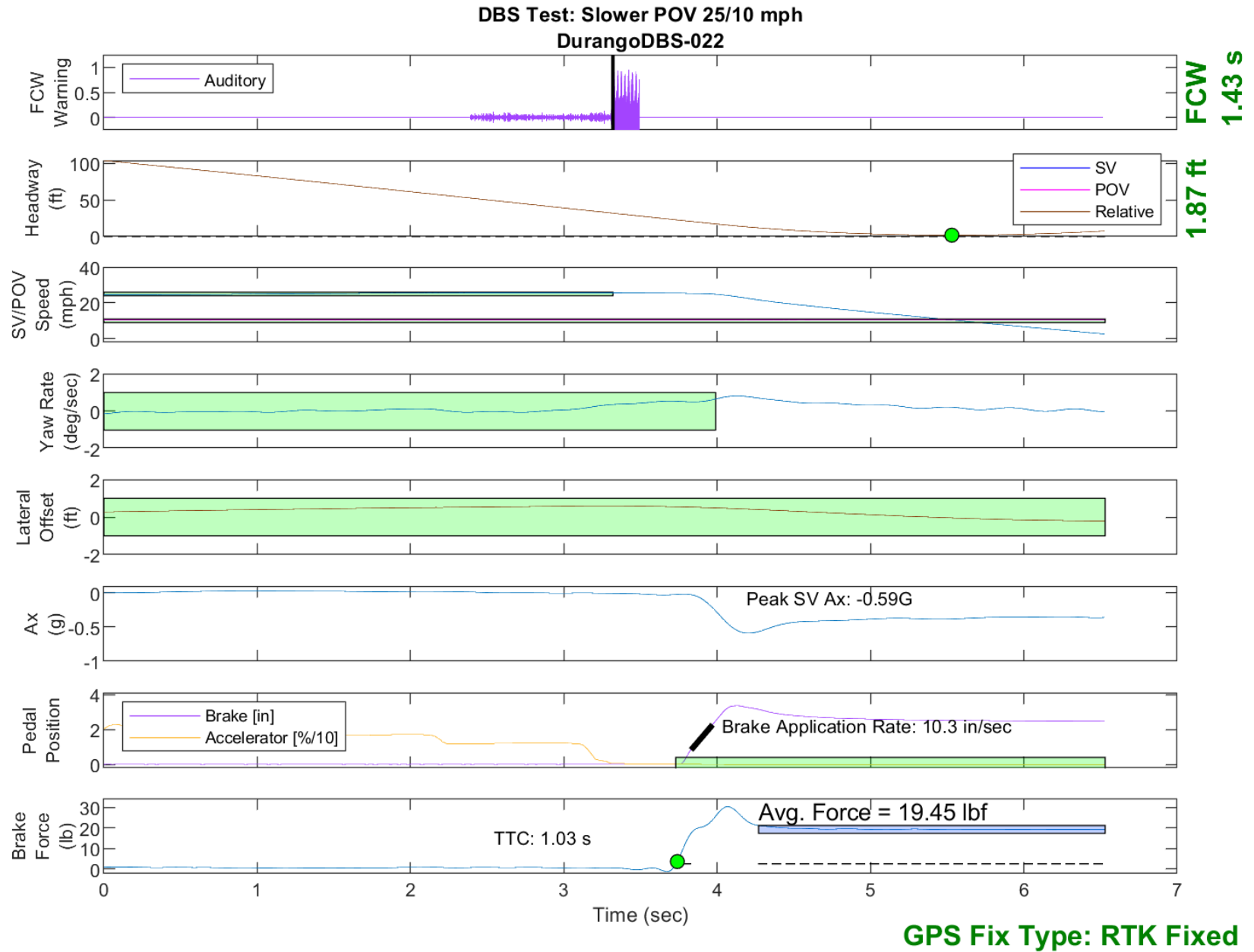


Figure E18. Time History for DBS Run 22, SV Encounters Slower POV, SV 25 mph, POV 10 mph

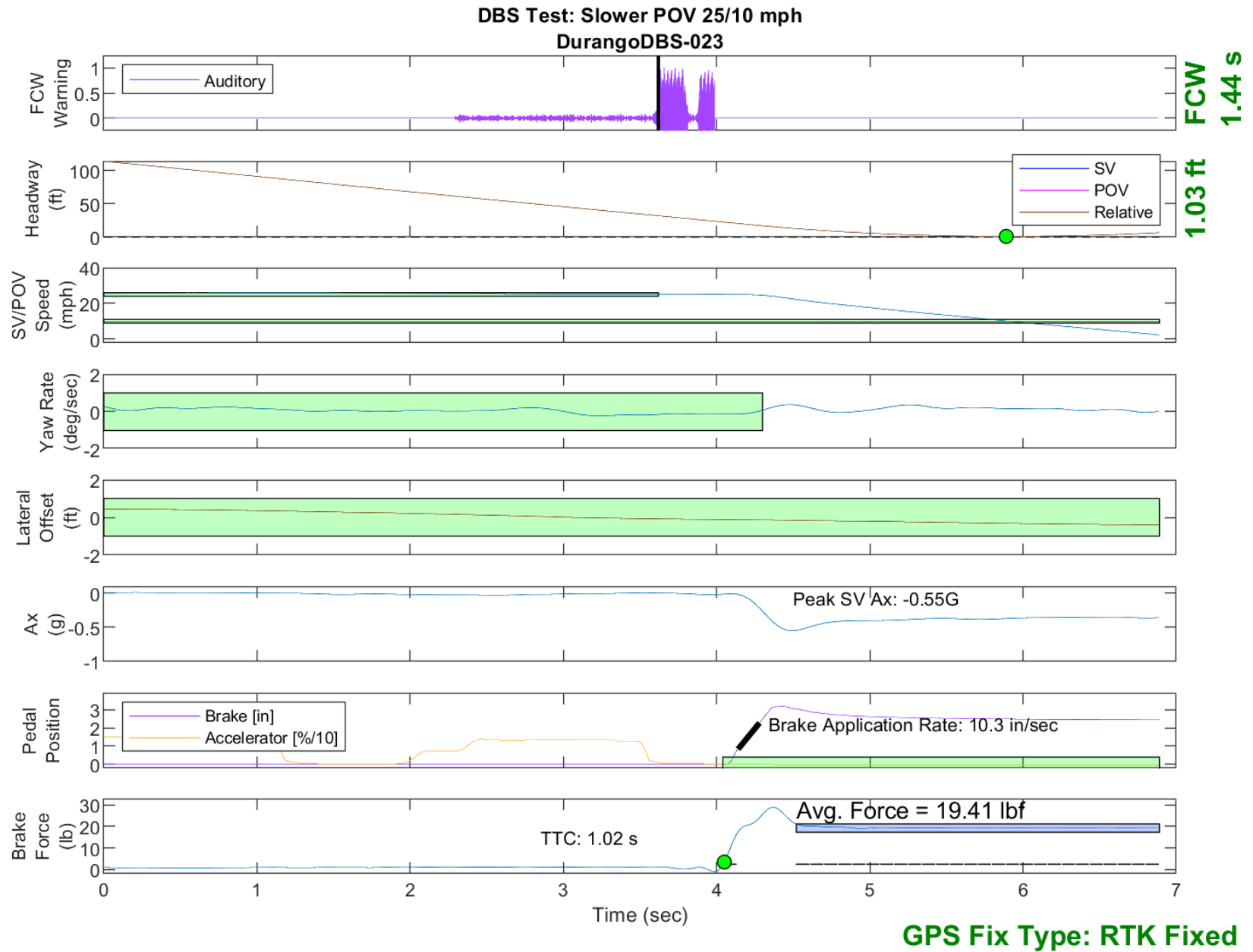


Figure E19. Time History for DBS Run 23, SV Encounters Slower POV, SV 25 mph, POV 10 mph

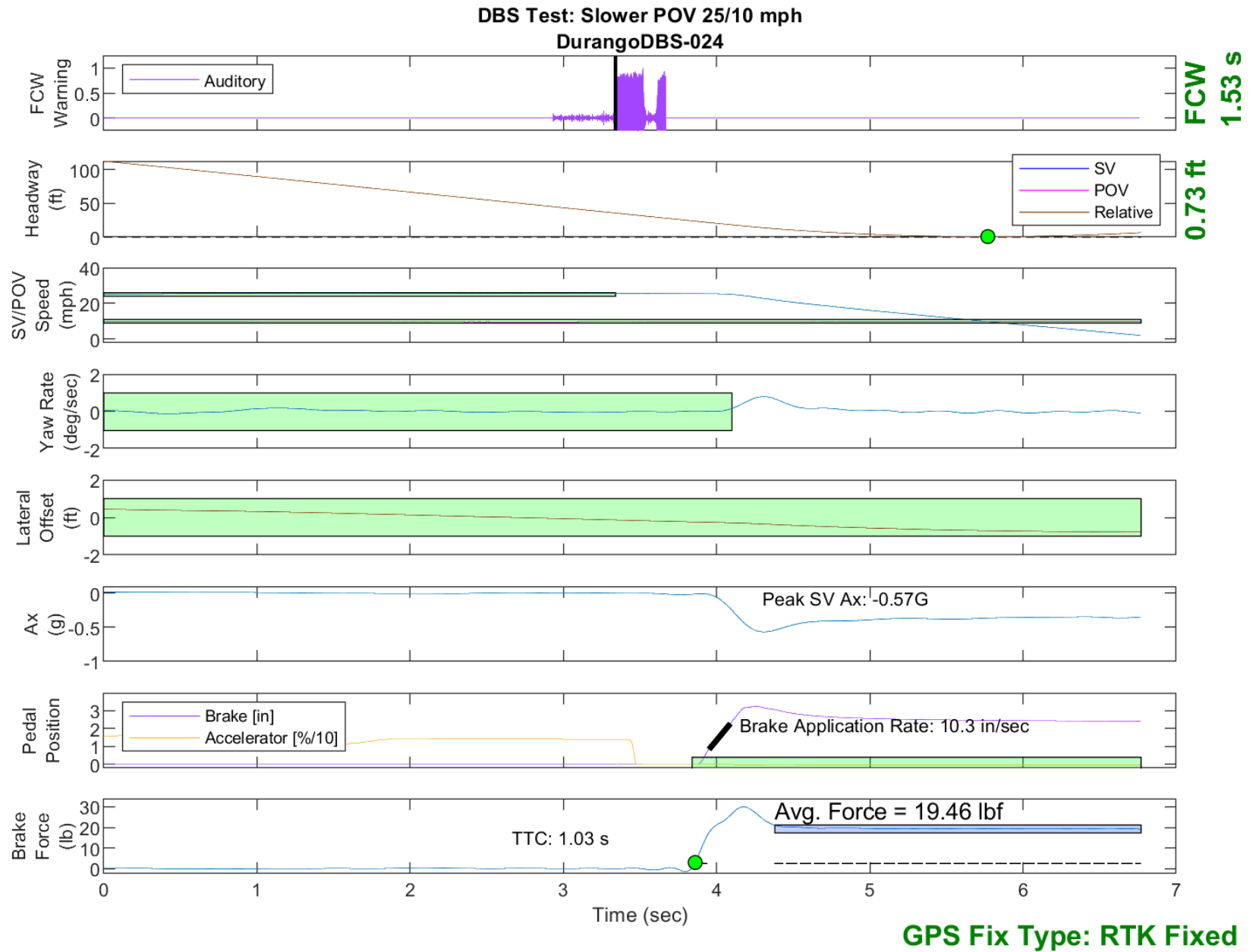


Figure E20. Time History for DBS Run 24, SV Encounters Slower POV, SV 25 mph, POV 10 mph

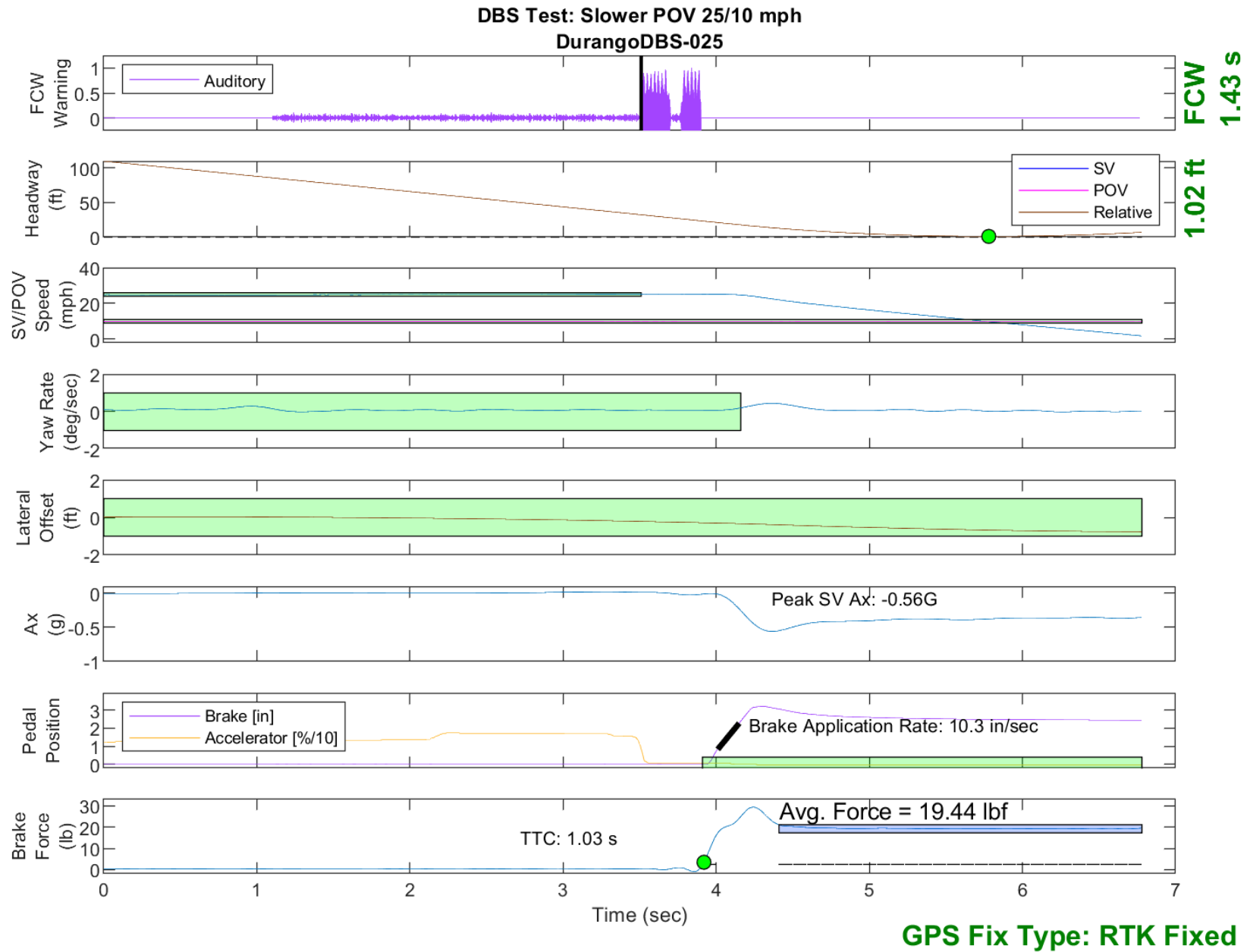


Figure E21. Time History for DBS Run 25, SV Encounters Slower POV, SV 25 mph, POV 10 mph

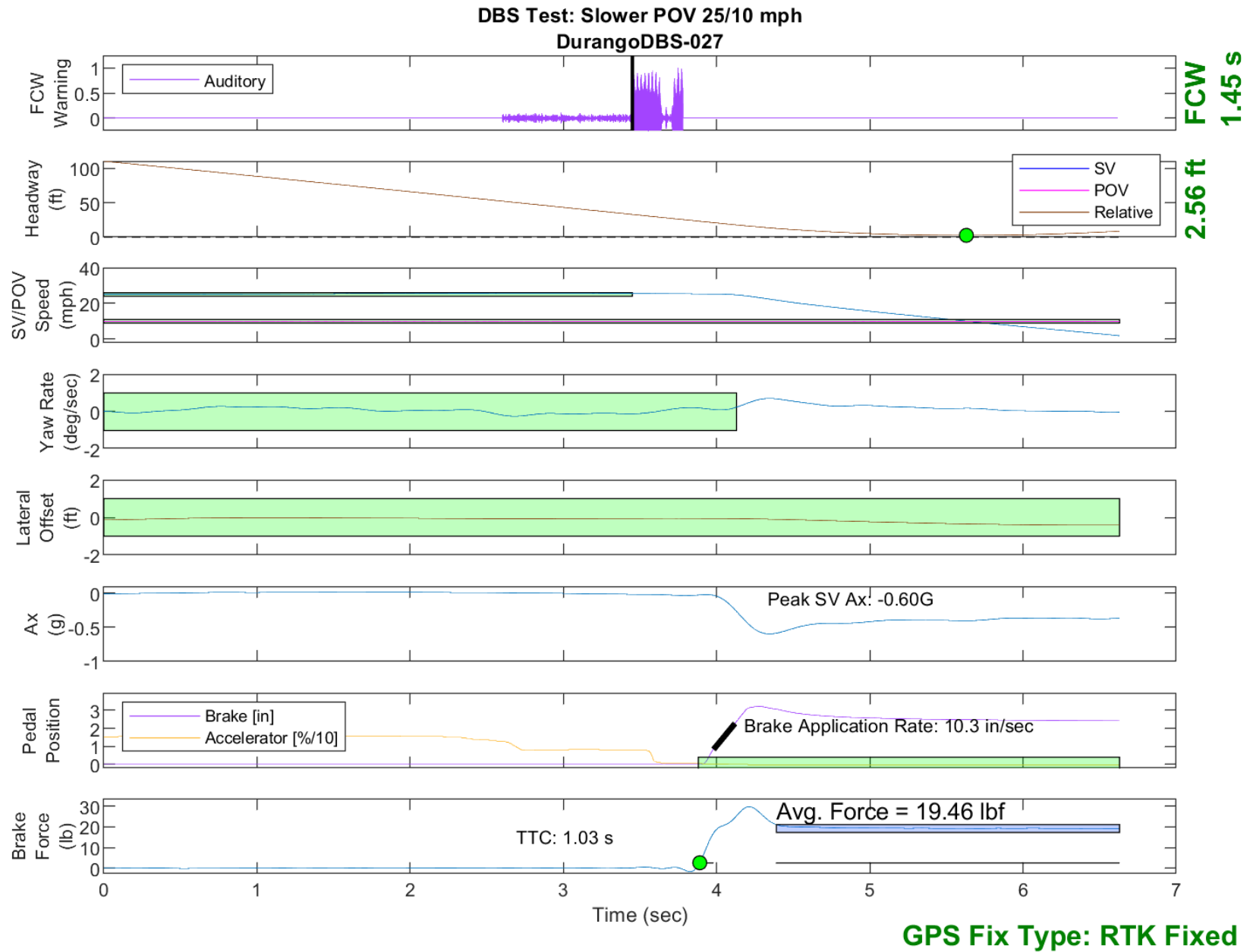


Figure E22. Time History for DBS Run 27, SV Encounters Slower POV, SV 25 mph, POV 10 mph



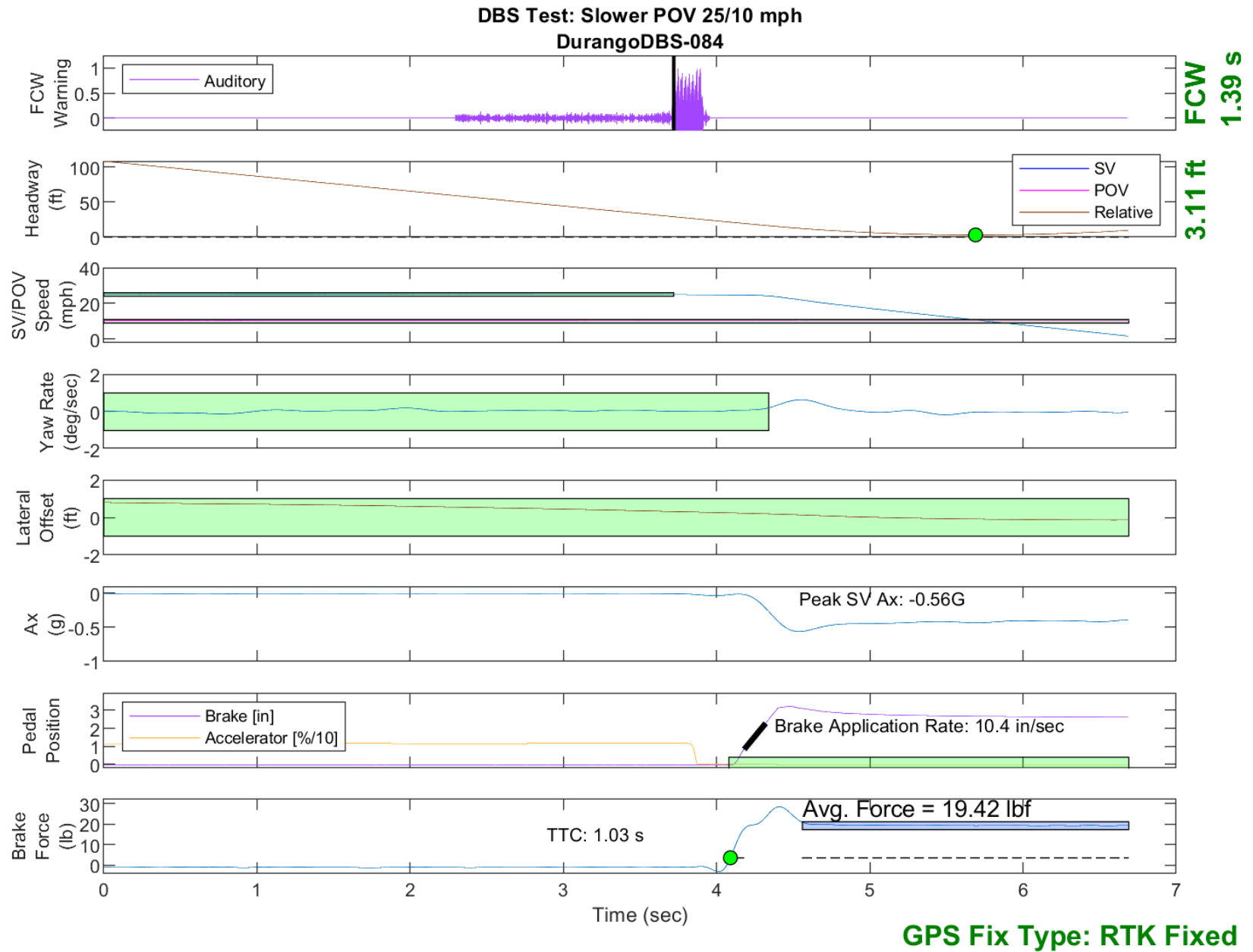


Figure E23. Time History for DBS Run 84, SV Encounters Slower POV, SV 25 mph, POV 10 mph

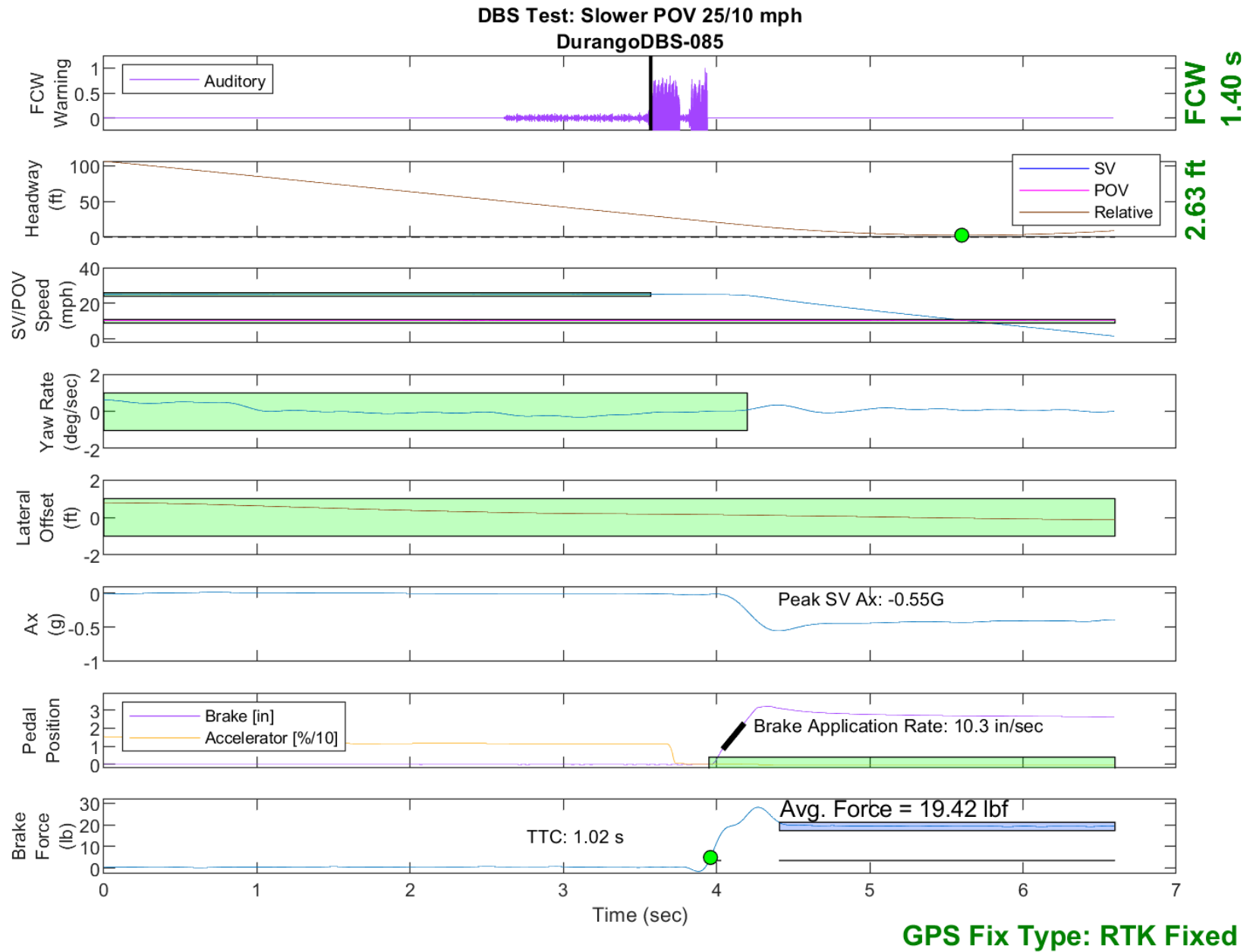


Figure E24. Time History for DBS Run 85, SV Encounters Slower POV, SV 25 mph, POV 10 mph

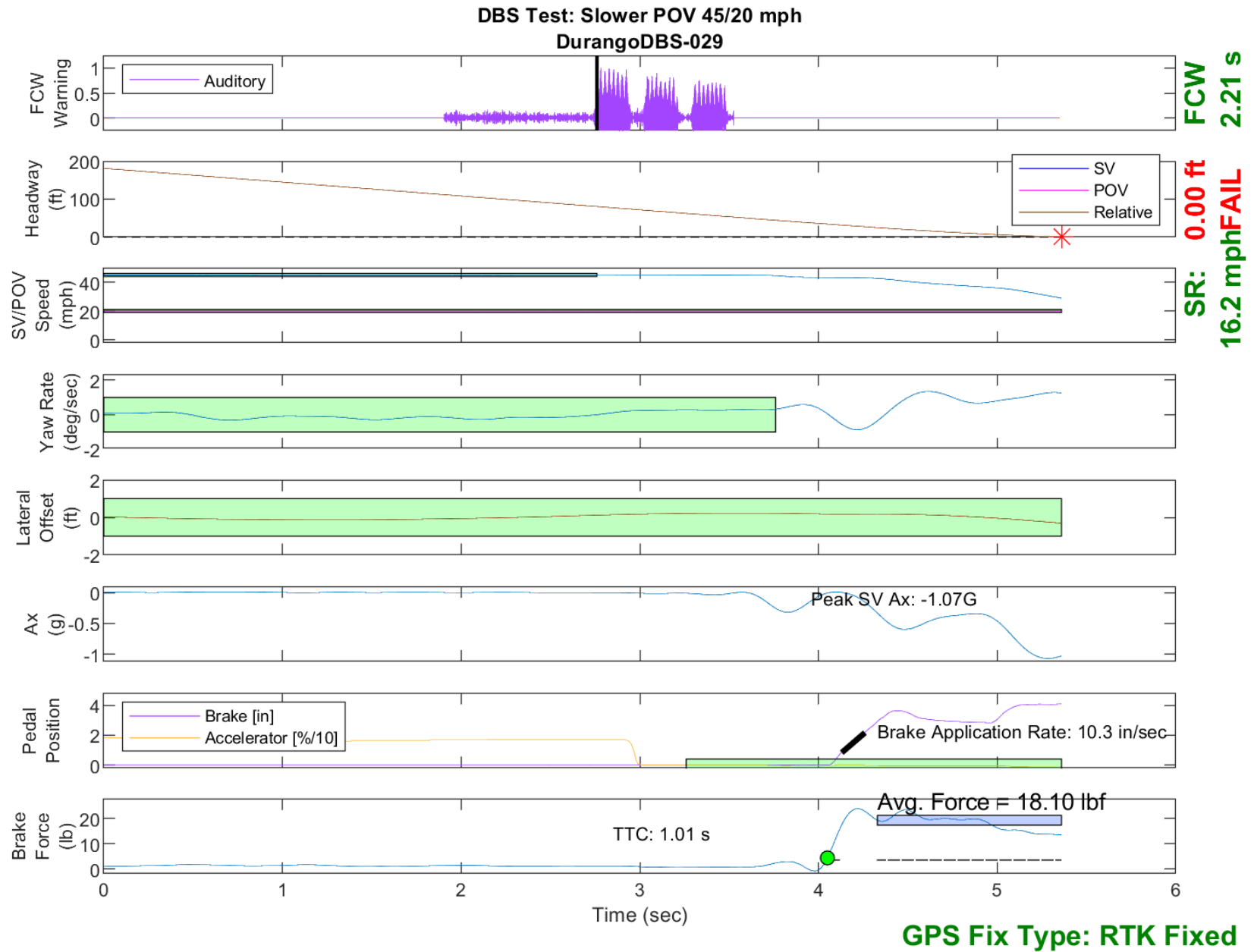


Figure E25. Time History for DBS Run 29, SV Encounters Slower POV, SV 45 mph, POV 20 mph

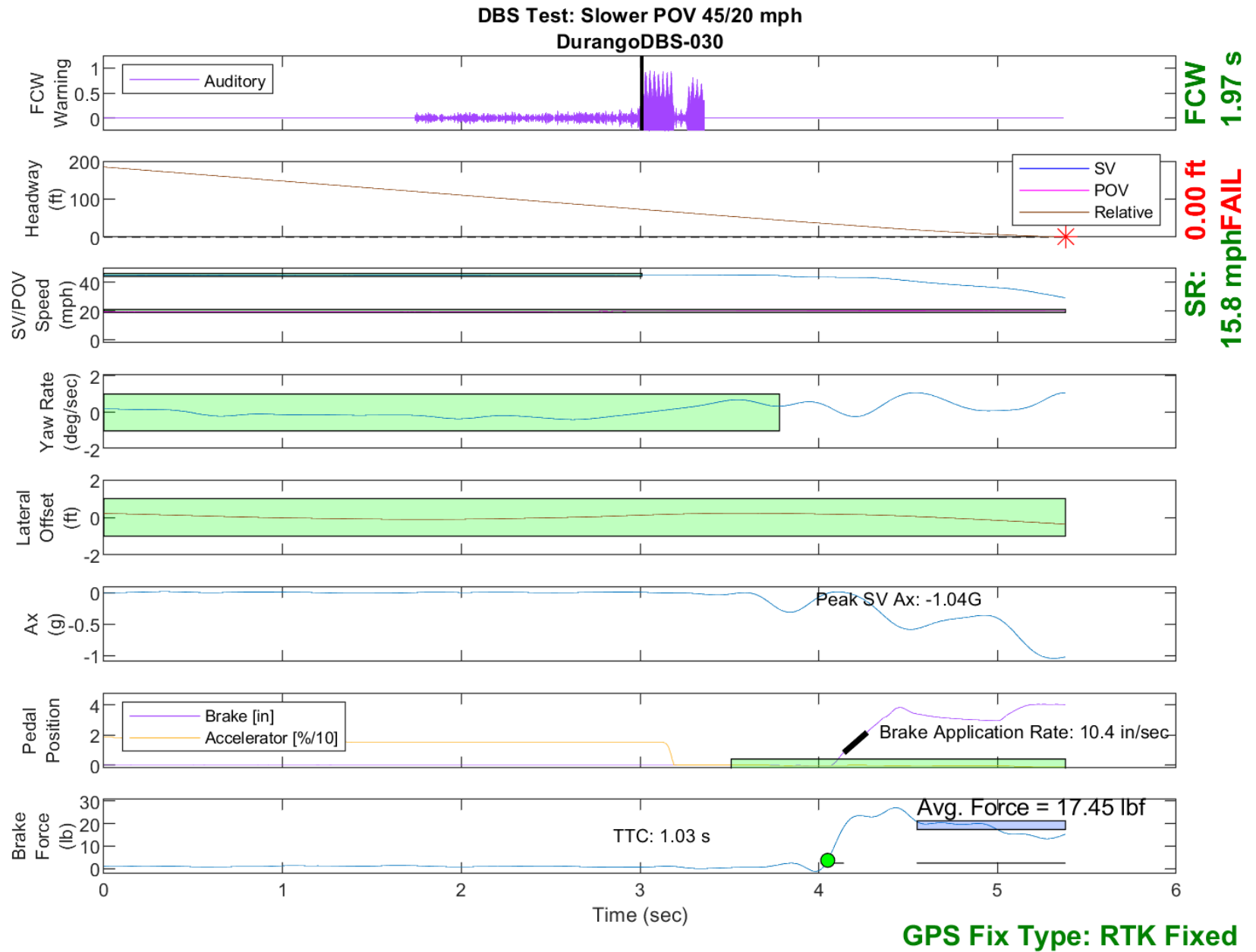


Figure E26. Time History for DBS Run 30, SV Encounters Slower POV, SV 45 mph, POV 20 mph

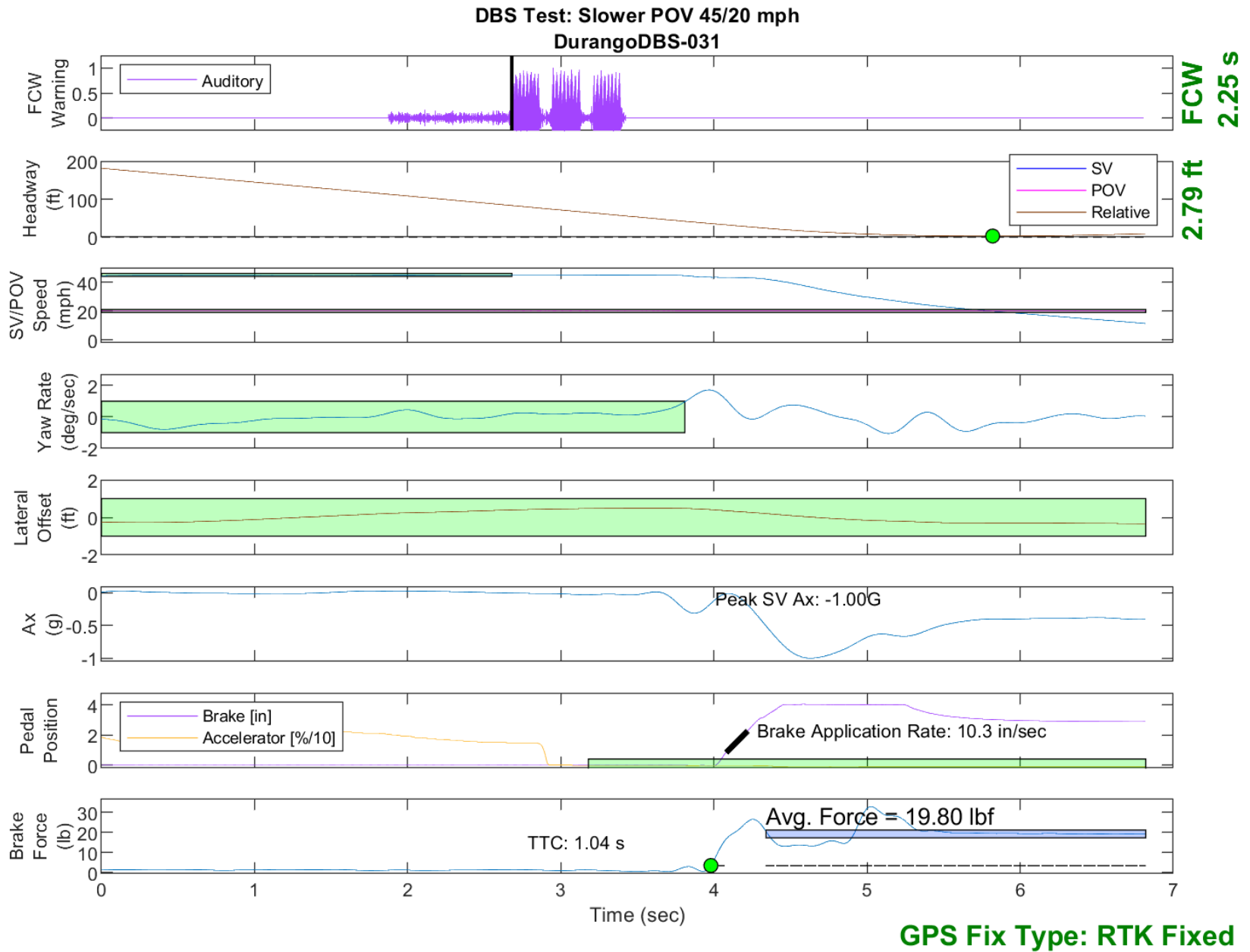


Figure E27. Time History for DBS Run 31, SV Encounters Slower POV, SV 45 mph, POV 20 mph

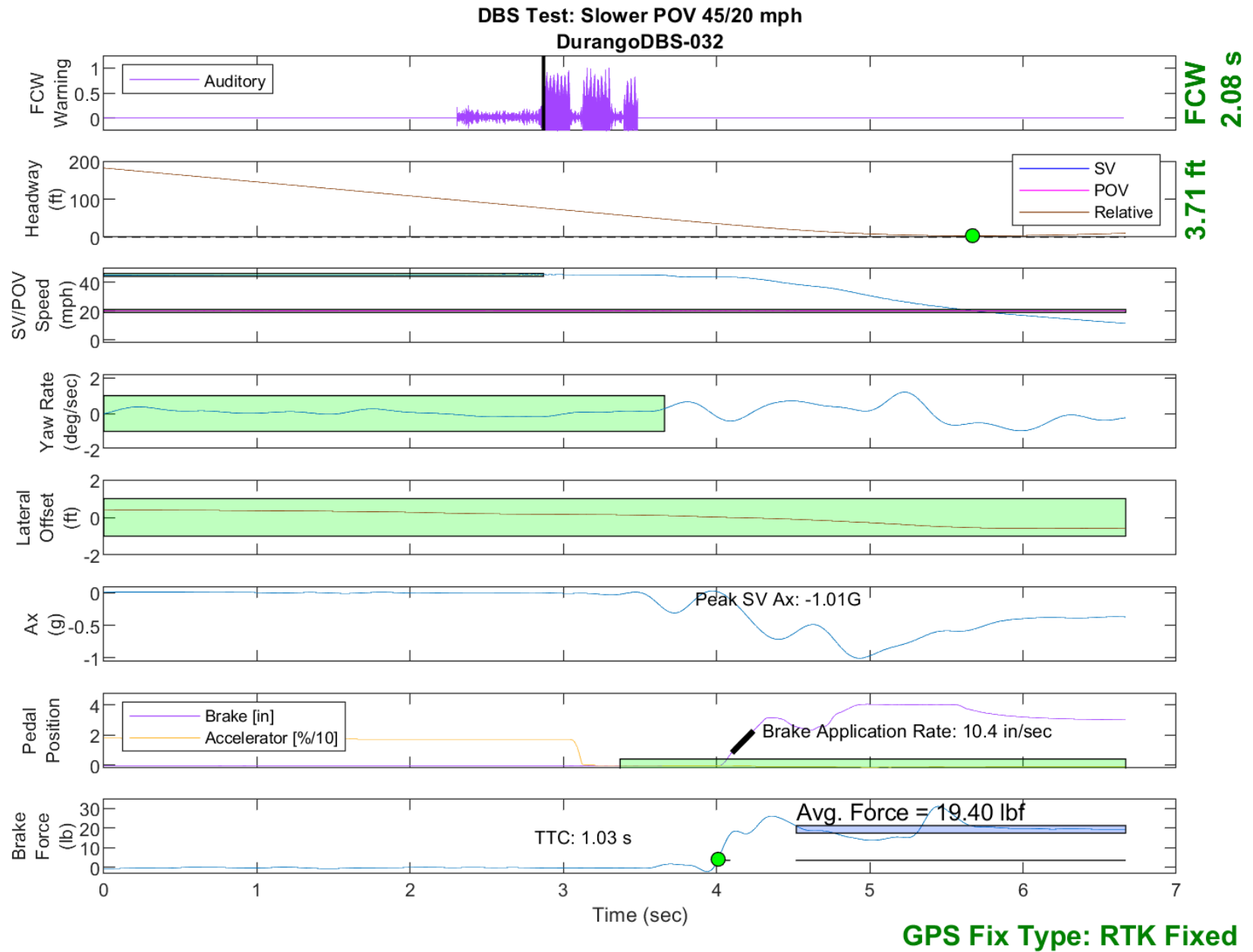


Figure E28. Time History for DBS Run 32, SV Encounters Slower POV, SV 45 mph, POV 20 mph

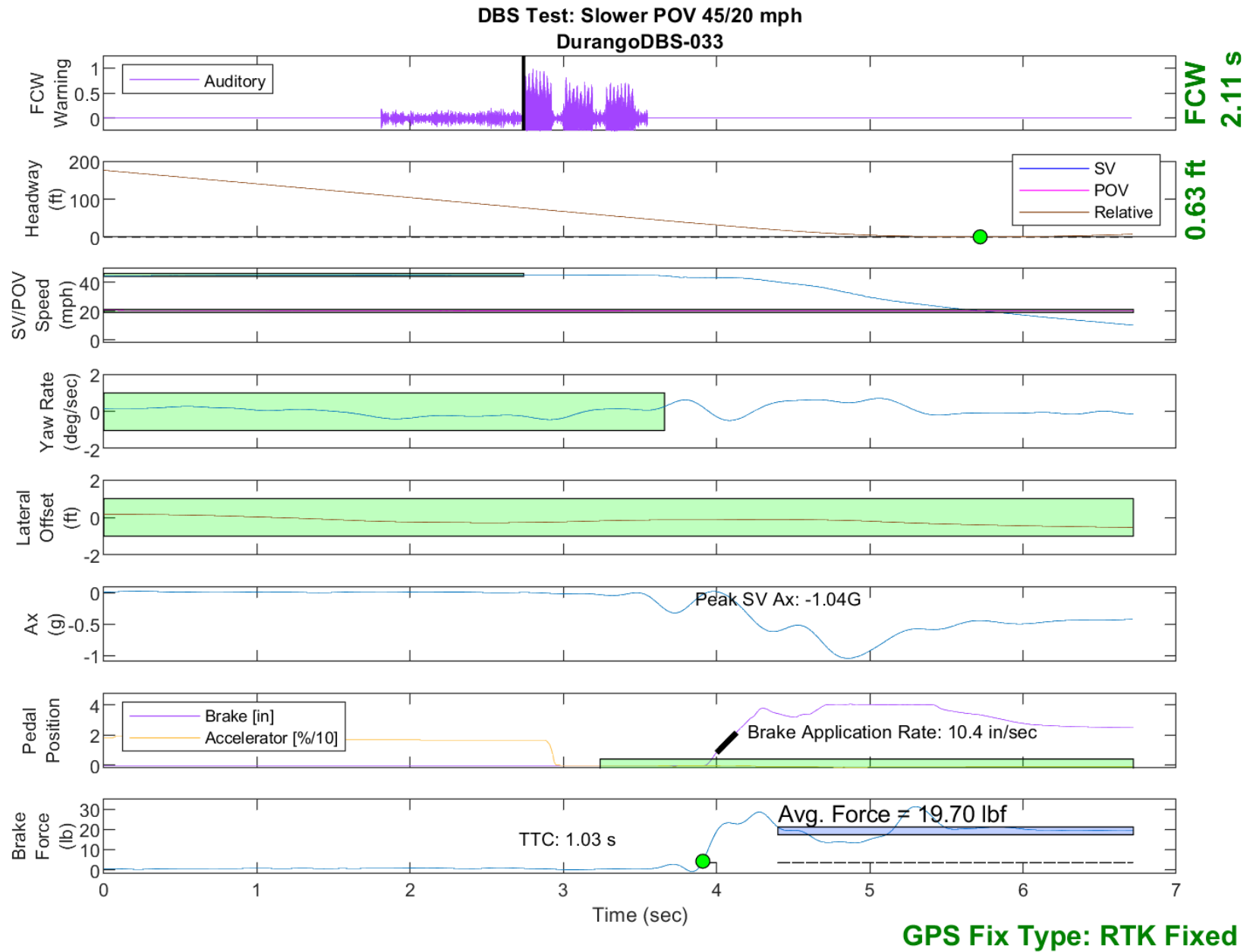


Figure E29. Time History for DBS Run 33, SV Encounters Slower POV, SV 45 mph, POV 20 mph

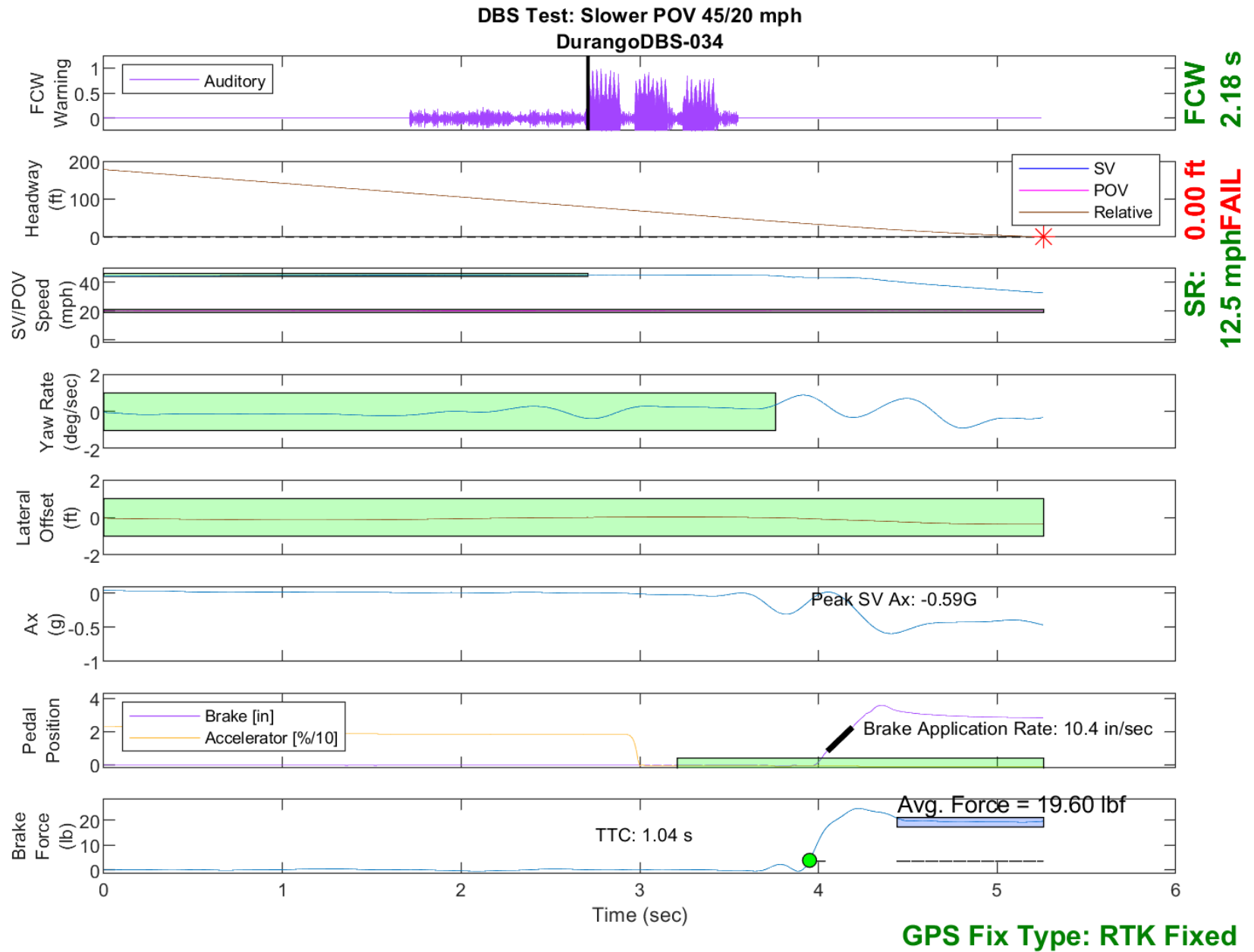


Figure E30. Time History for DBS Run 34, SV Encounters Slower POV, SV 45 mph, POV 20 mph



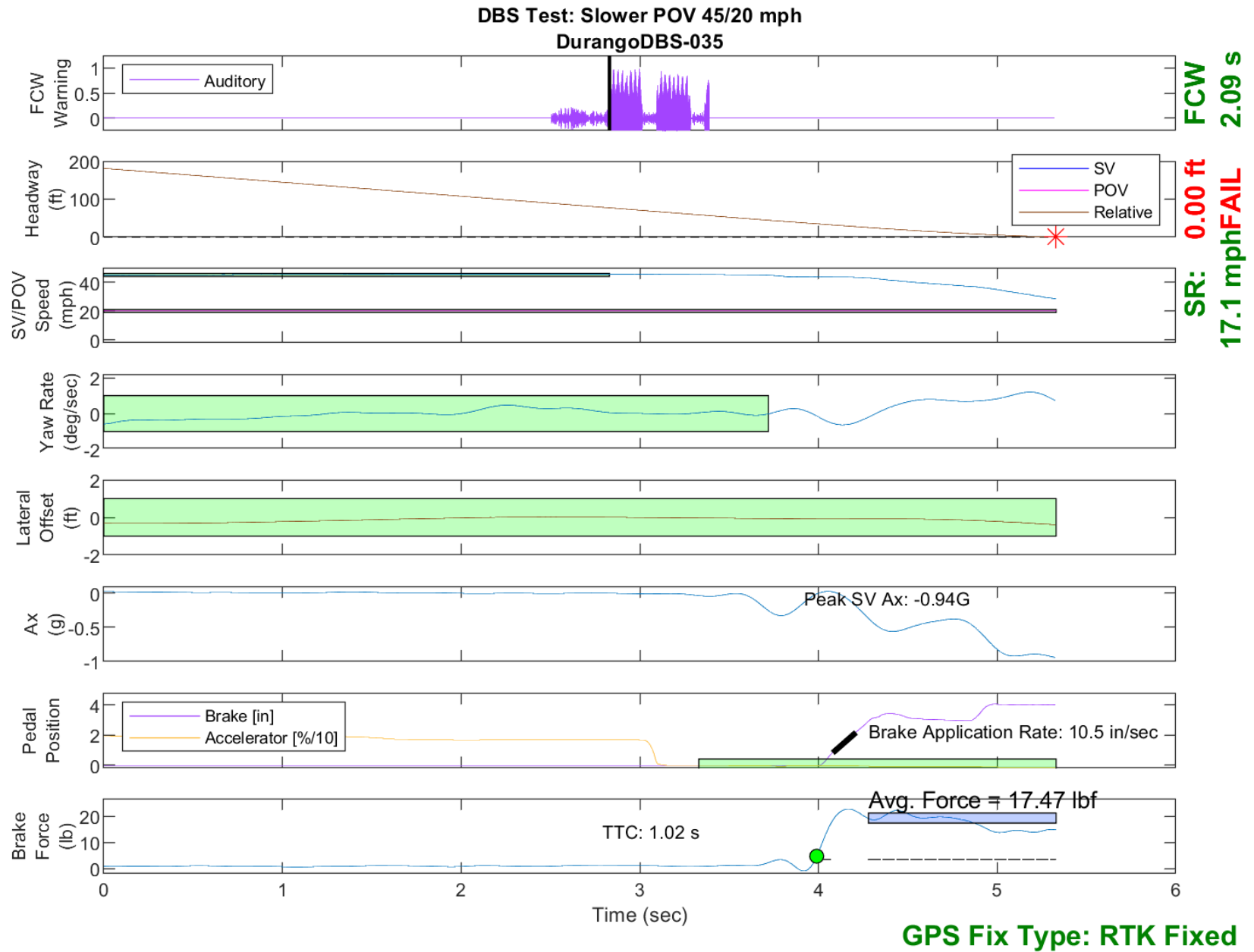


Figure E31. Time History for DBS Run 35, SV Encounters Slower POV, SV 45 mph, POV 20 mph

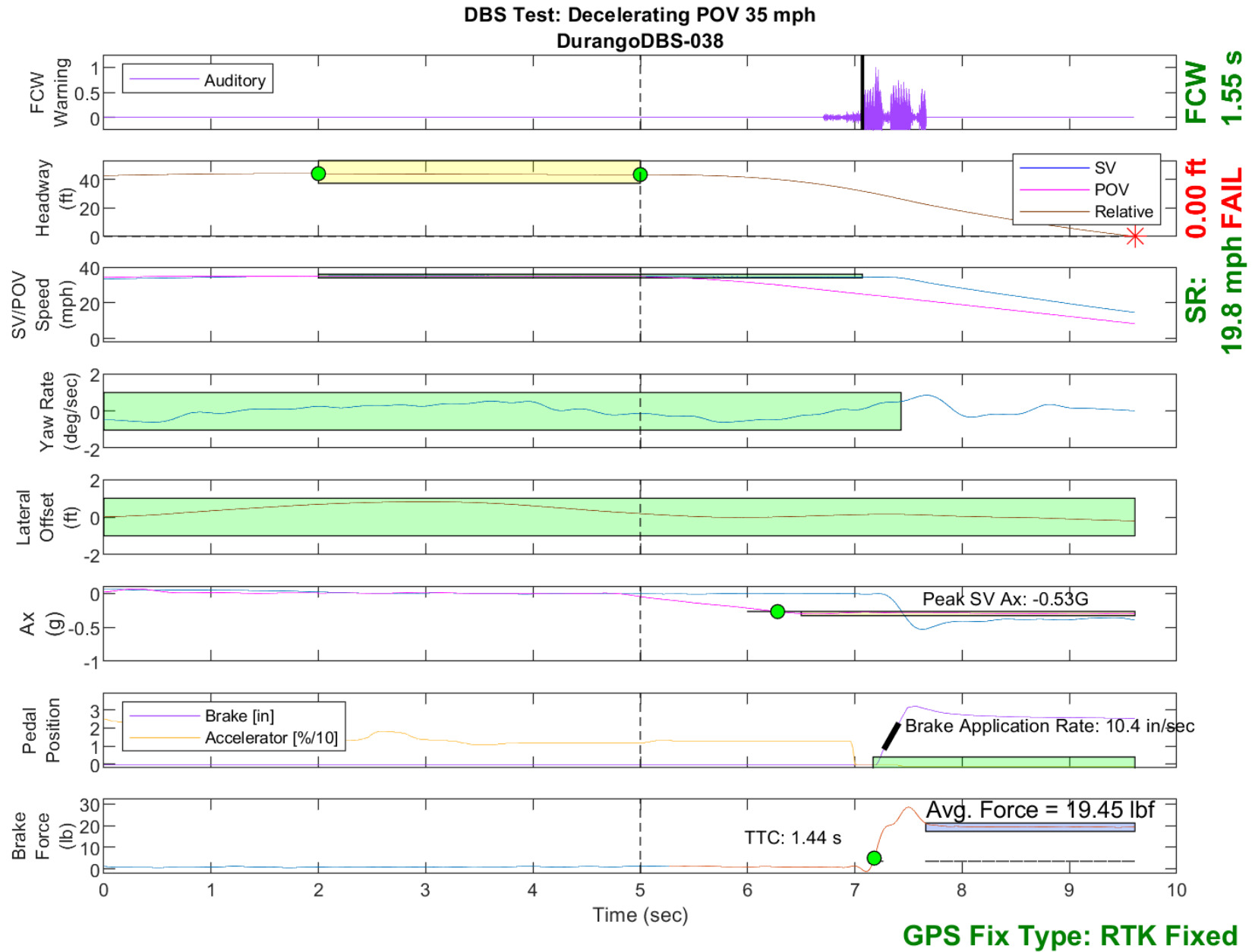


Figure E32. Time History for DBS Run 38, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

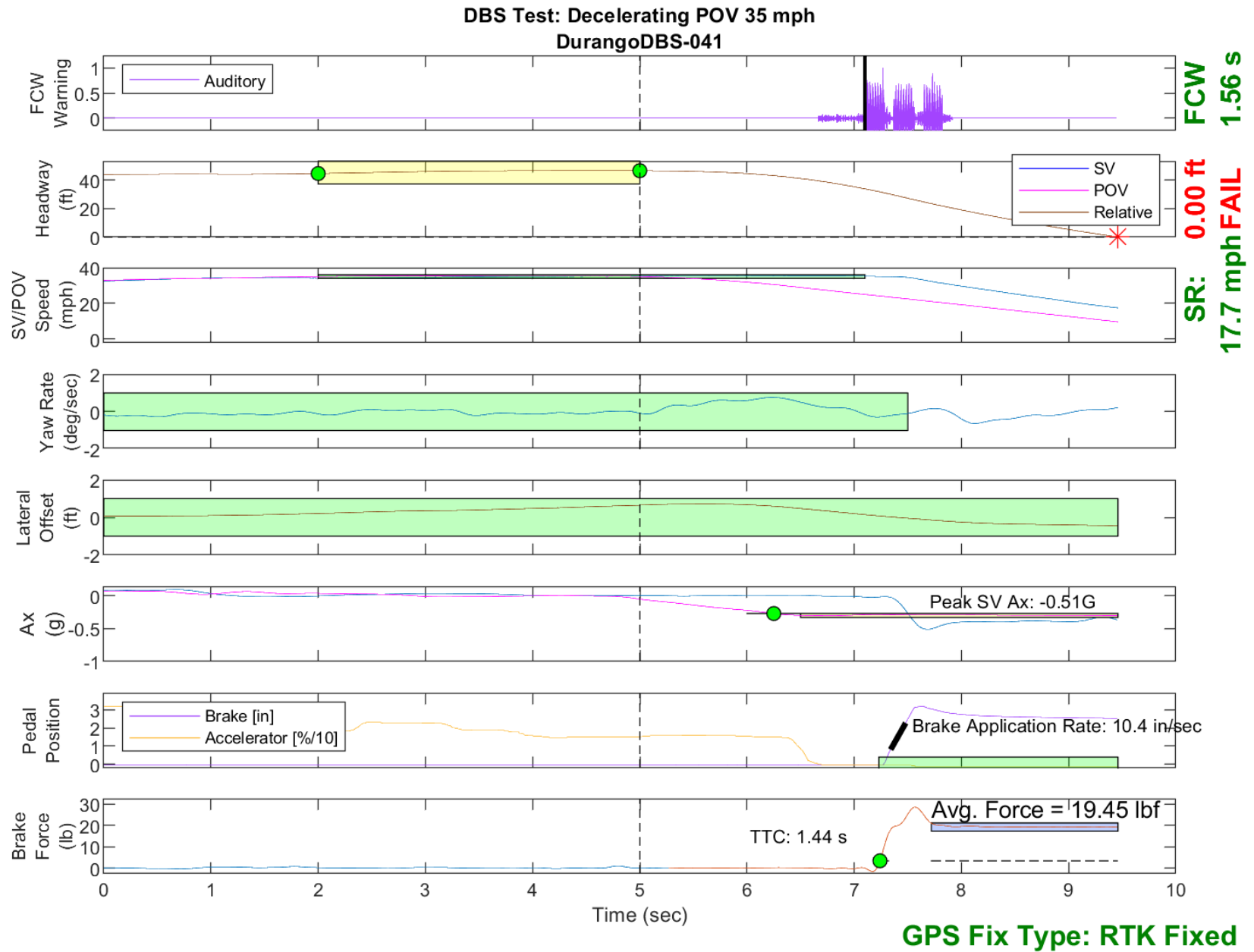


Figure E33. Time History for DBS Run 41, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

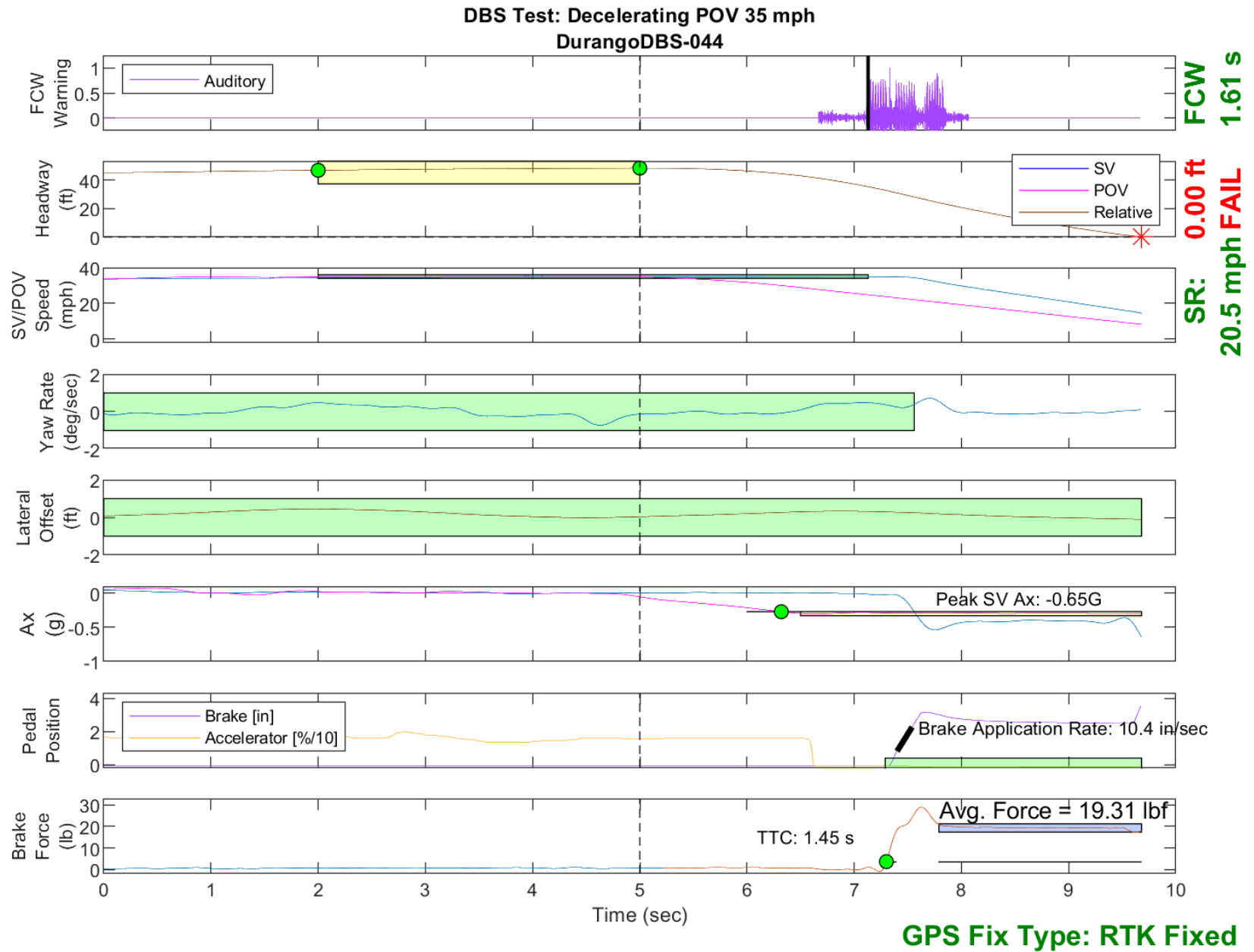


Figure E34. Time History for DBS Run 44, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

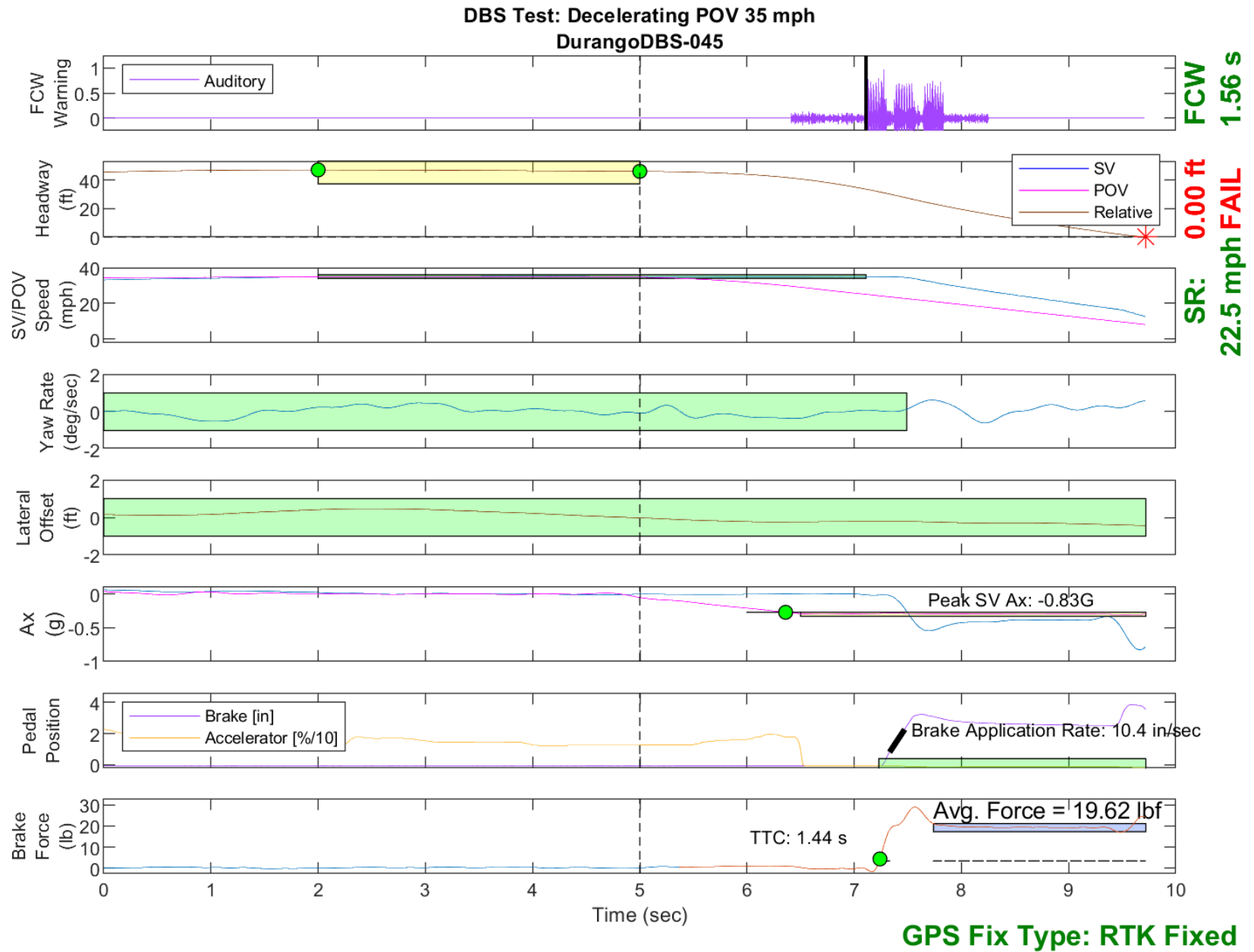


Figure E35. Time History for DBS Run 45, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

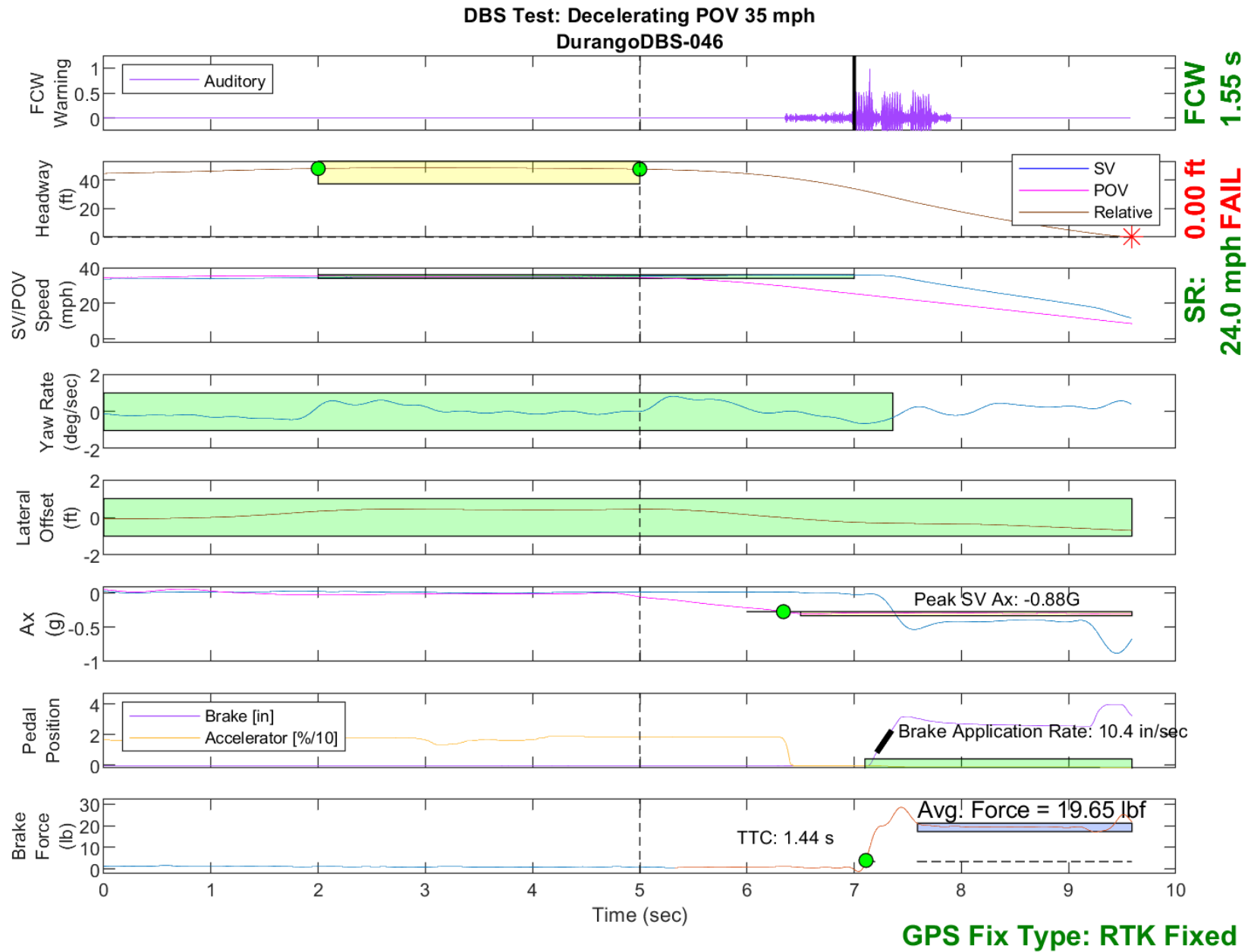


Figure E36. Time History for DBS Run 46, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

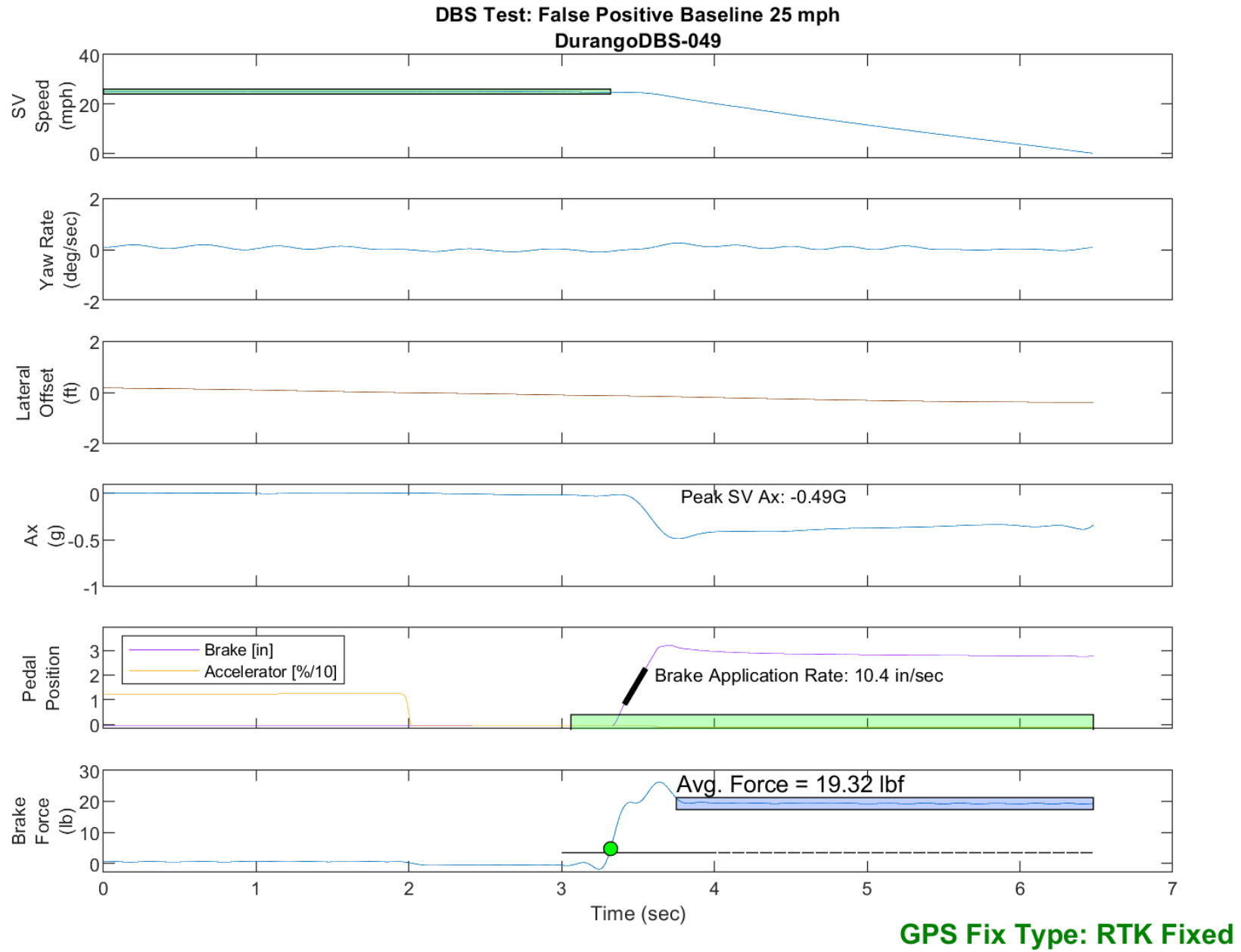


Figure E37. Time History for DBS Run 49, False Positive Baseline, SV 25 mph

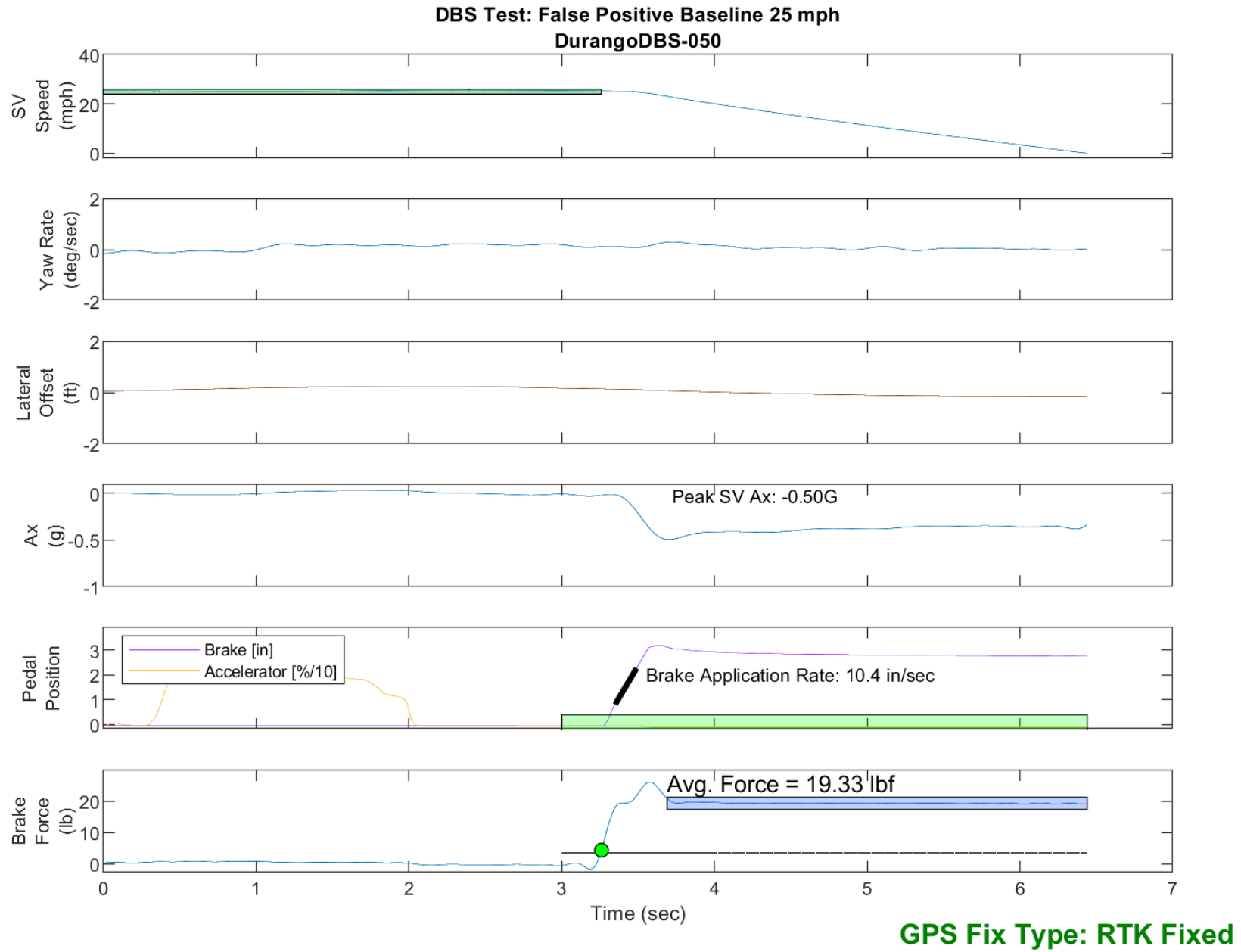


Figure E38. Time History for DBS Run 50, False Positive Baseline, SV 25 mph



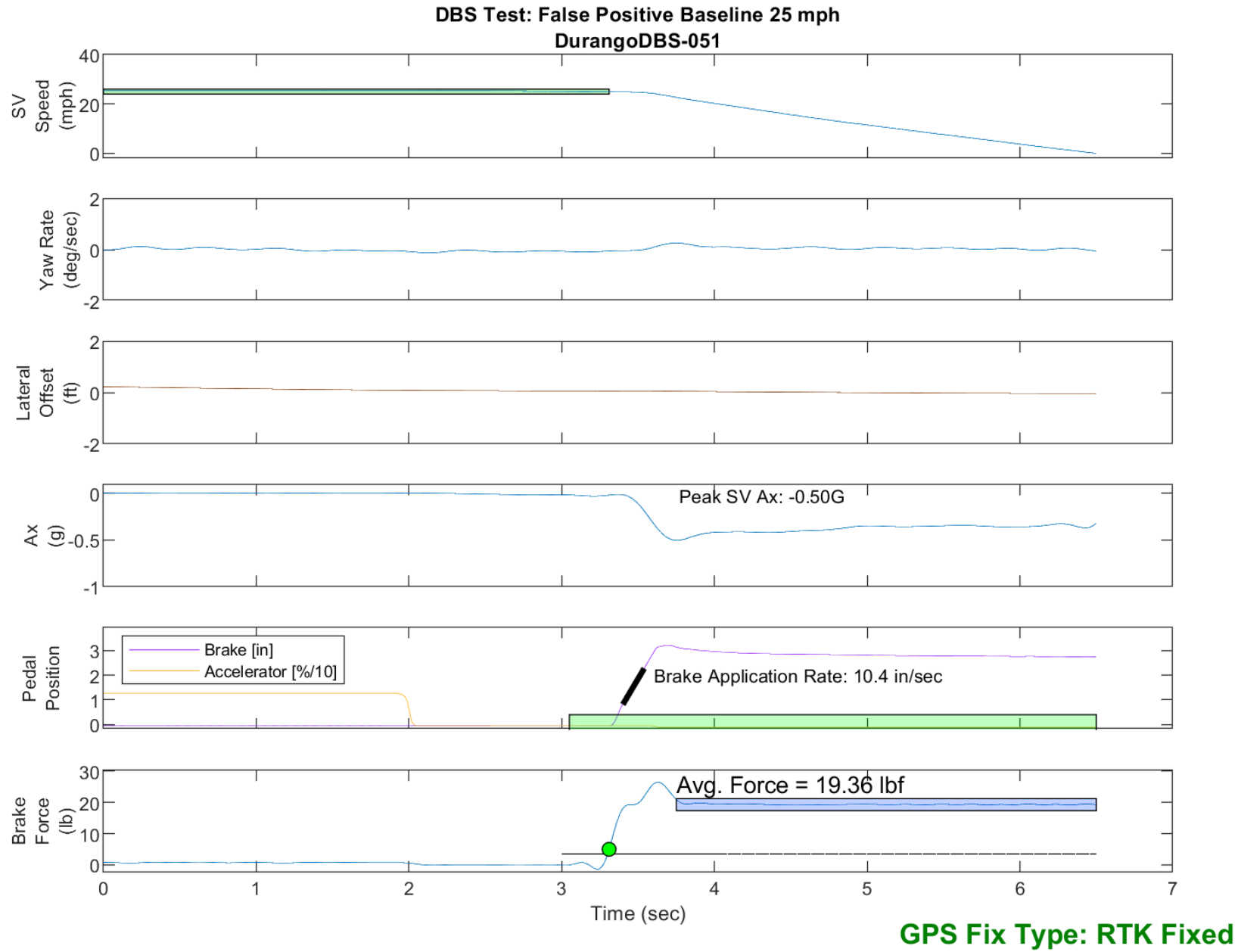
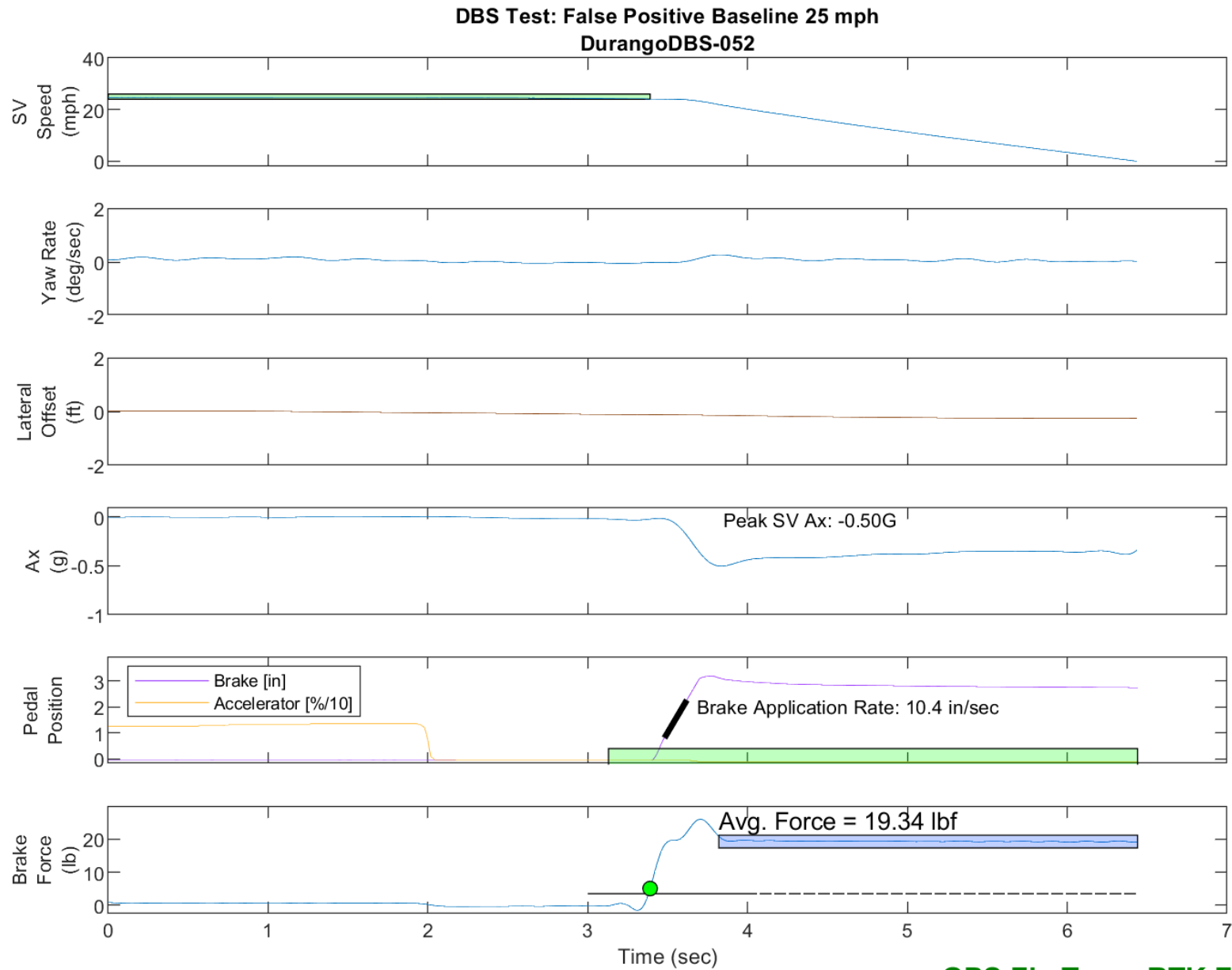


Figure E39. Time History for DBS Run 51, False Positive Baseline, SV 25 mph



**GPS Fix Type: RTK Fixed**

Figure E40. Time History for DBS Run 52, False Positive Baseline, SV 25 mph

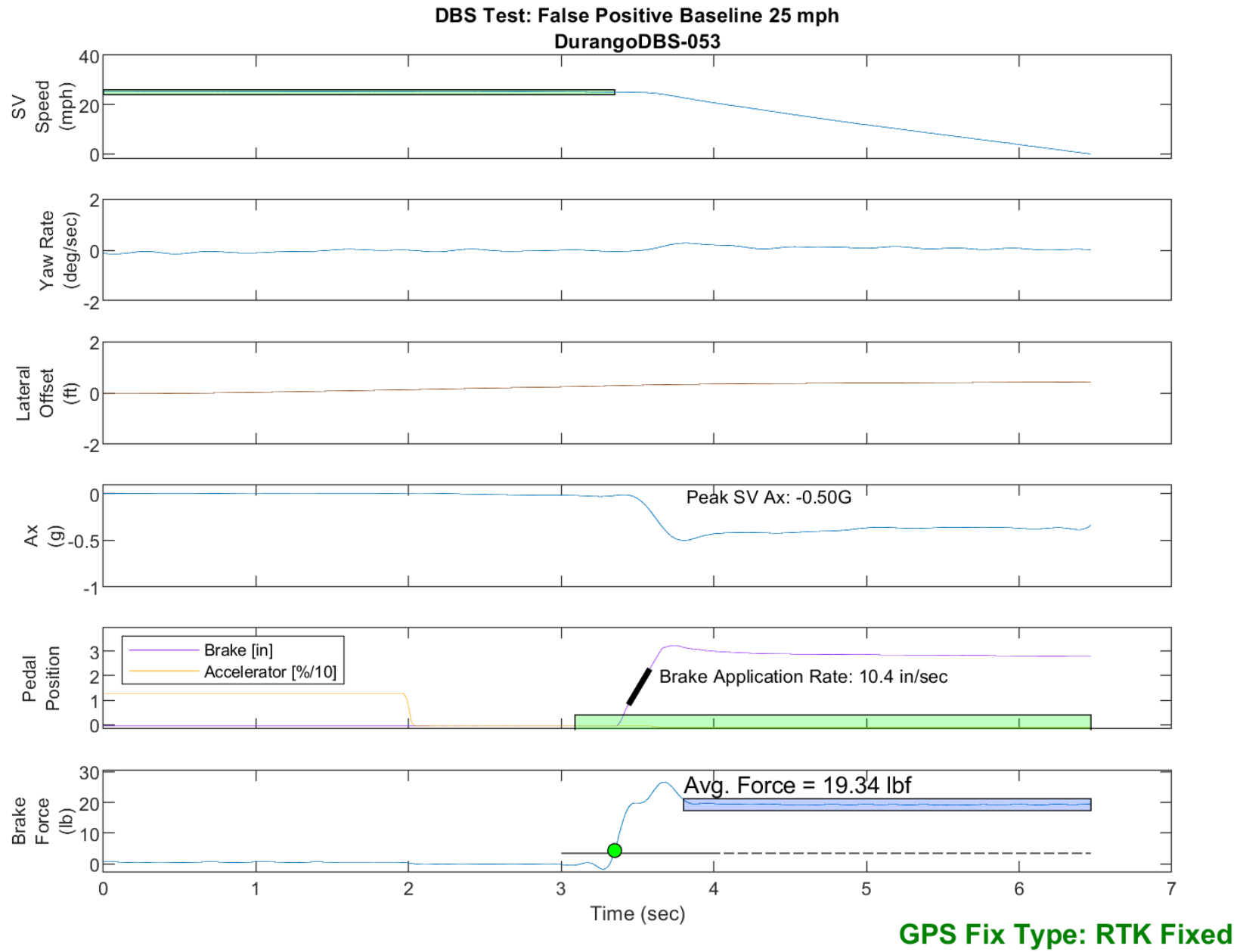


Figure E41. Time History for DBS Run 53, False Positive Baseline, SV 25 mph

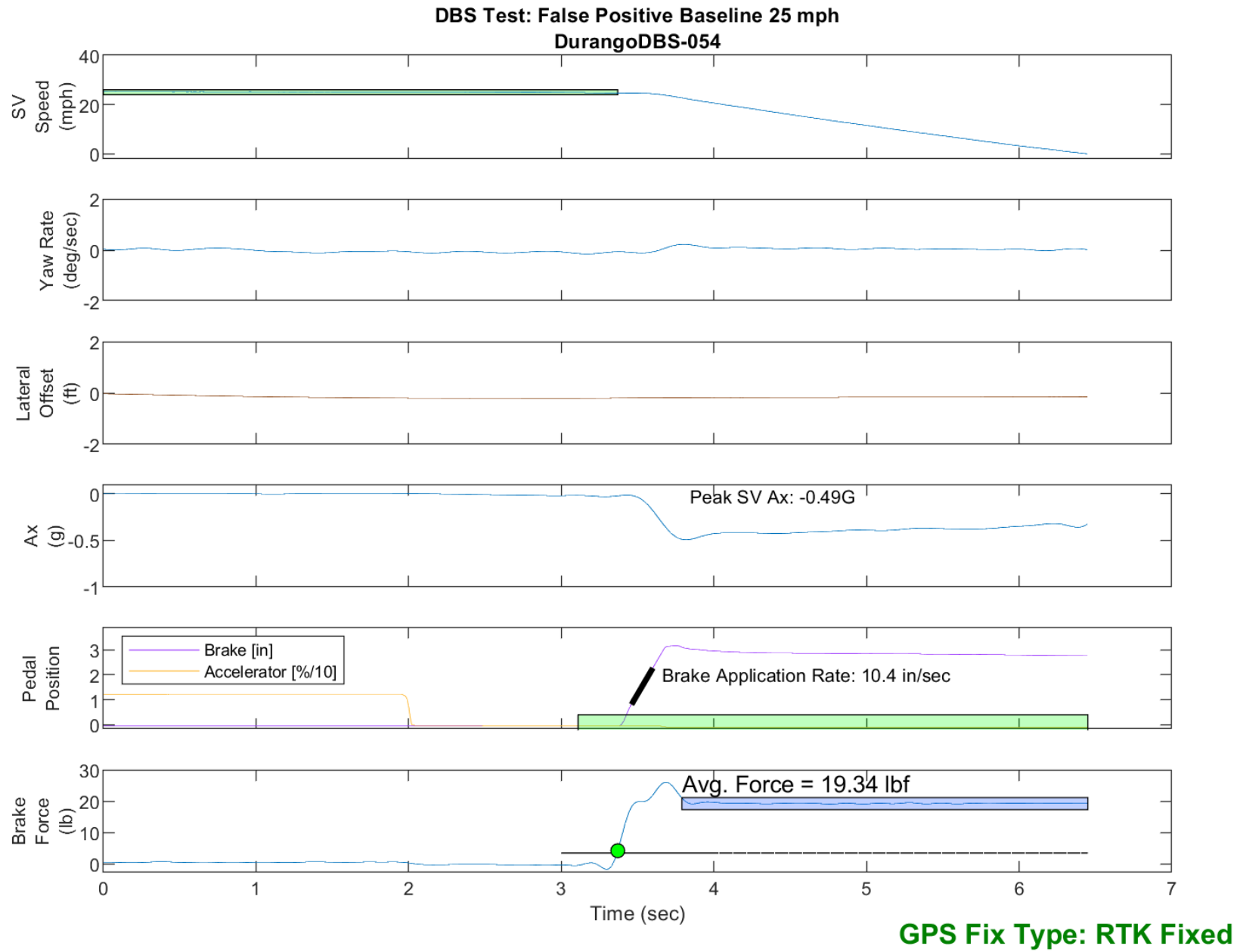


Figure E42. Time History for DBS Run 54, False Positive Baseline, SV 25 mph

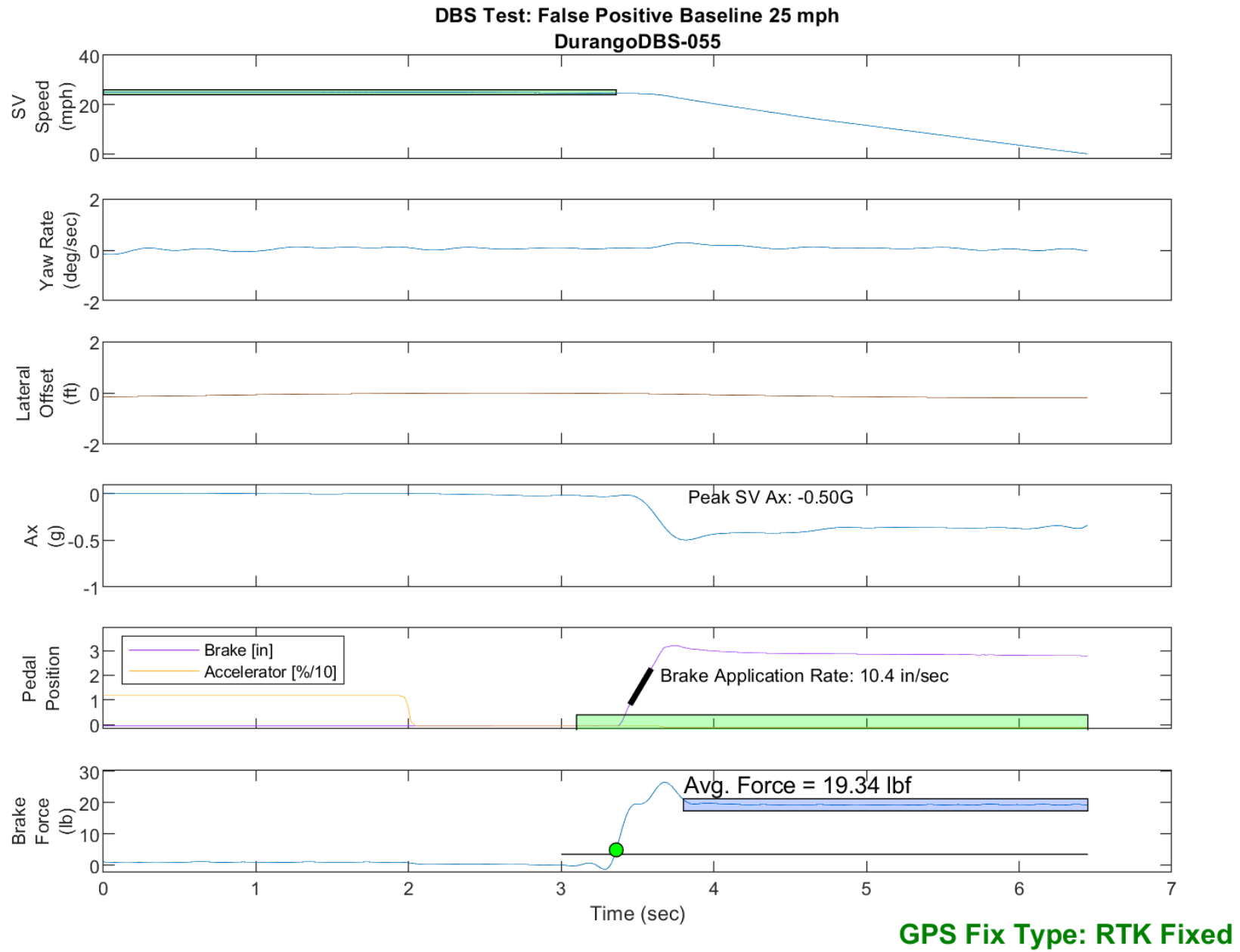


Figure E43. Time History for DBS Run 55, False Positive Baseline, SV 25 mph

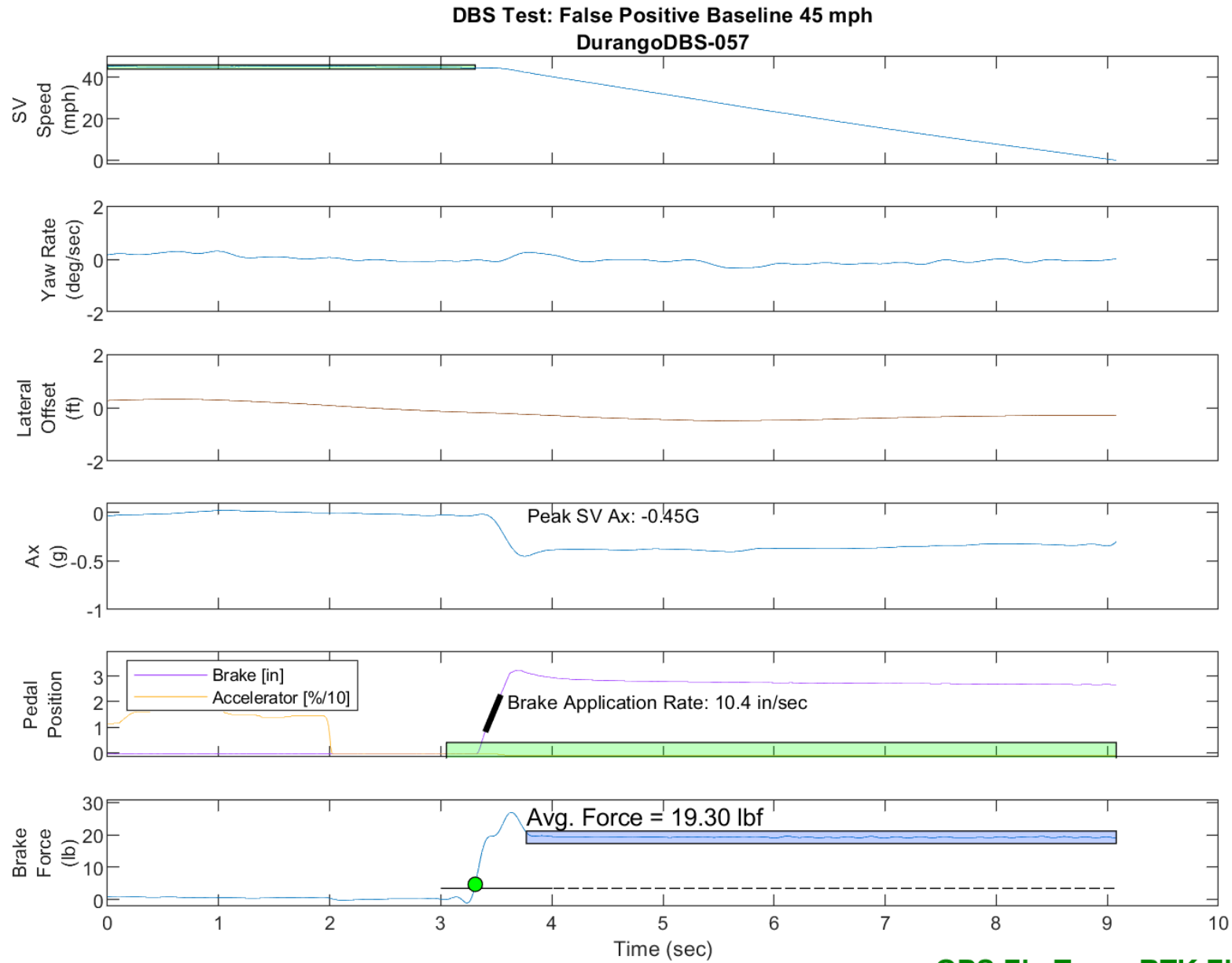


Figure E44. Time History for DBS Run 57, False Positive Baseline, SV 45 mph

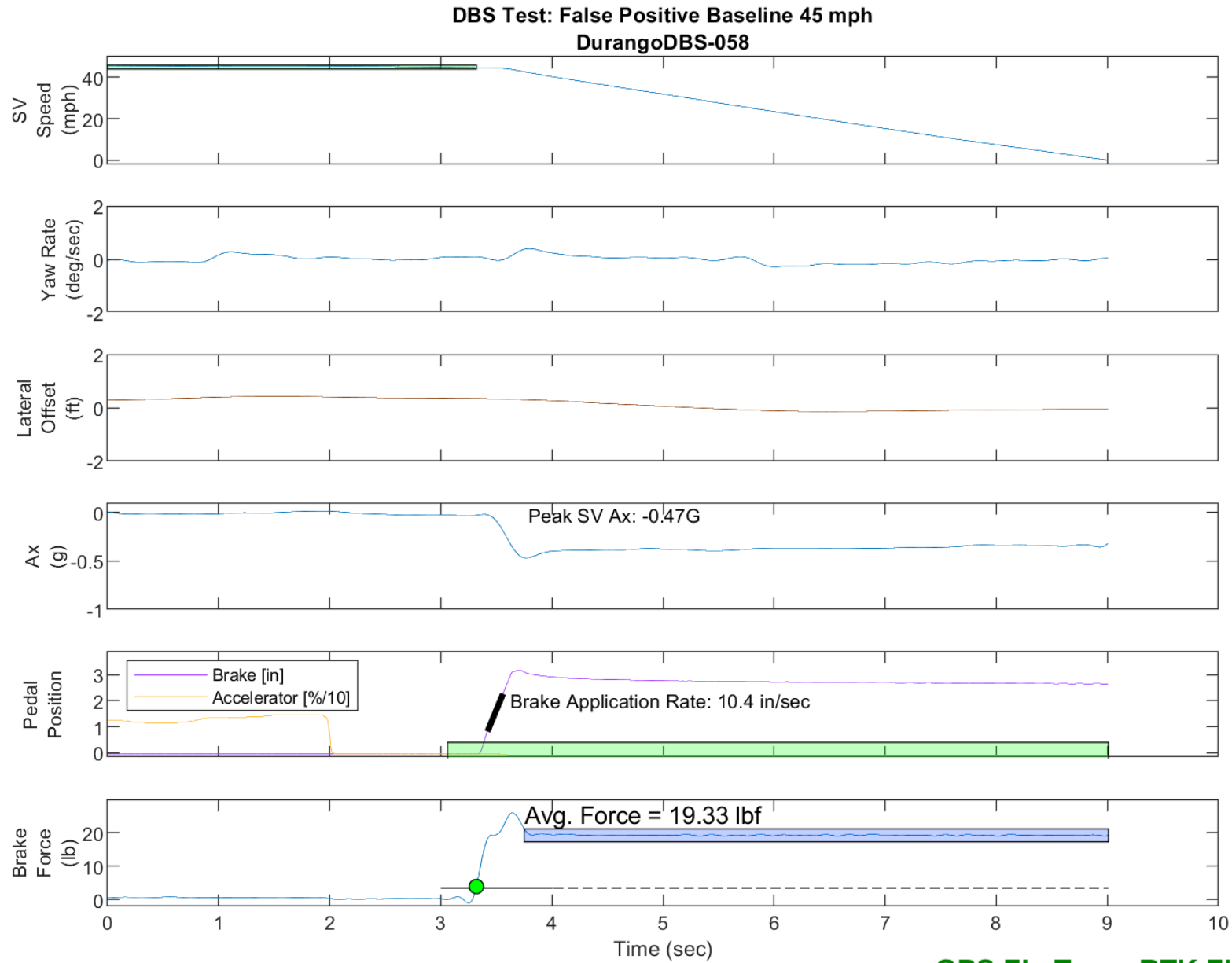


Figure E45. Time History for DBS Run 58, False Positive Baseline, SV 45 mph

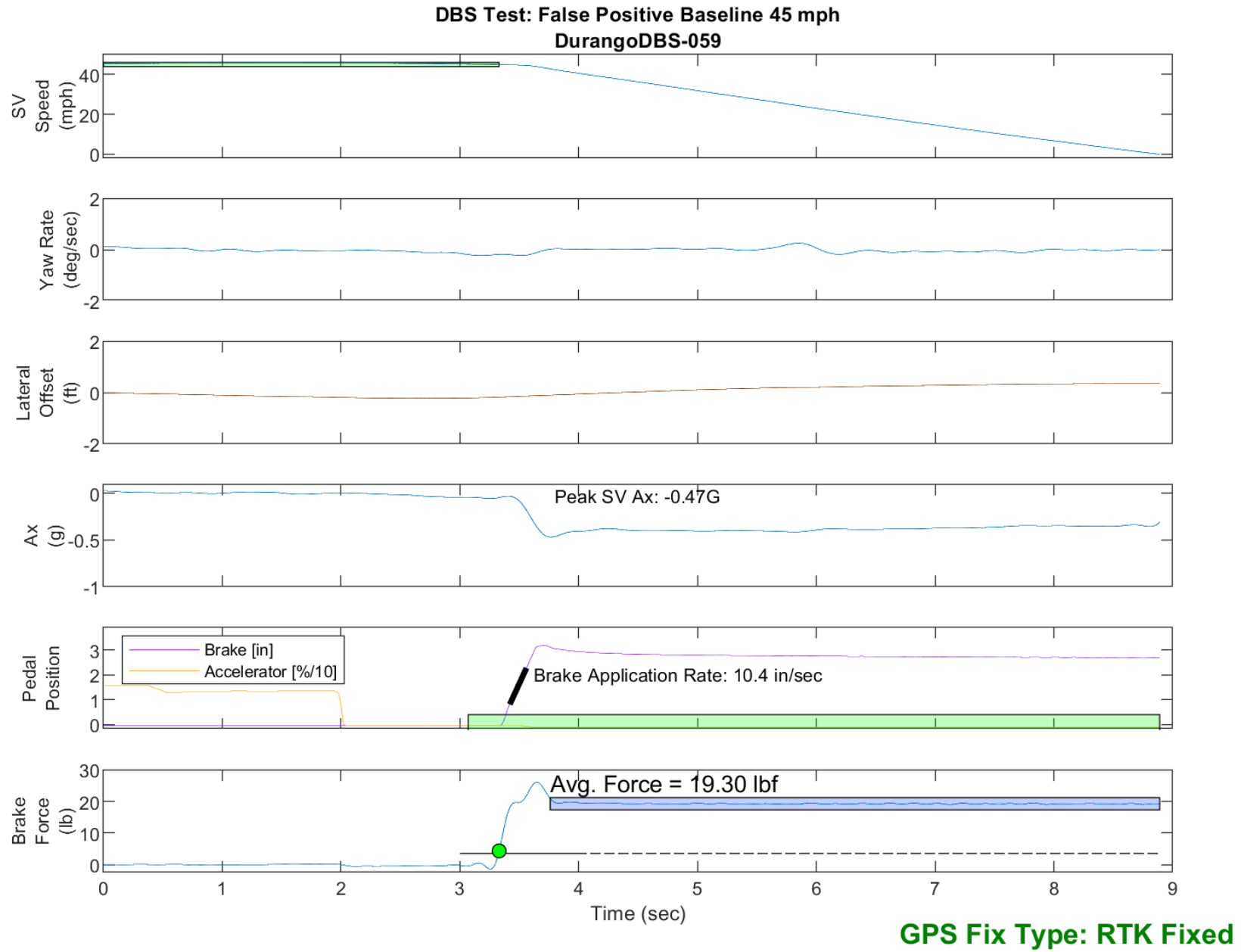


Figure E46. Time History for DBS Run 59, False Positive Baseline, SV 45 mph



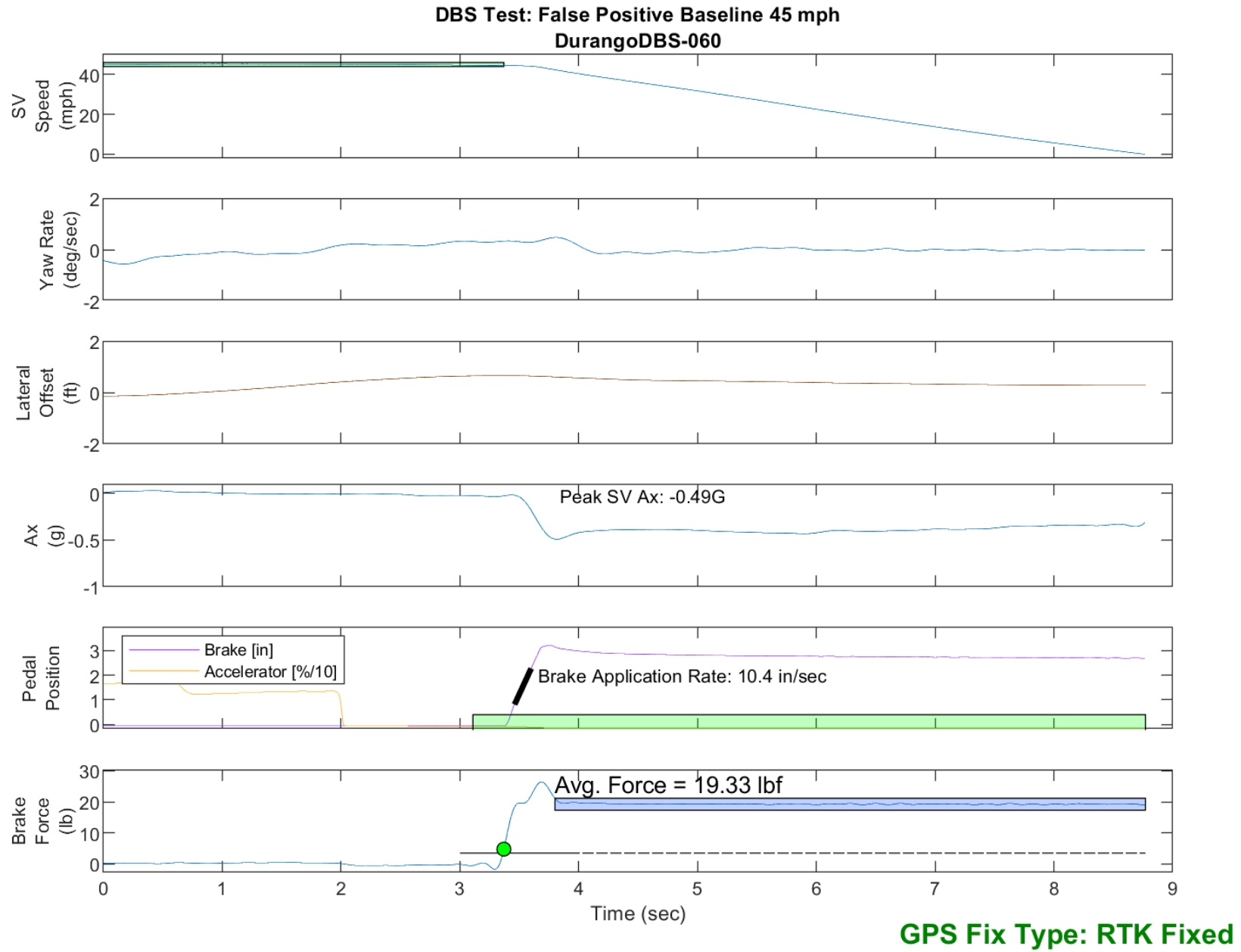
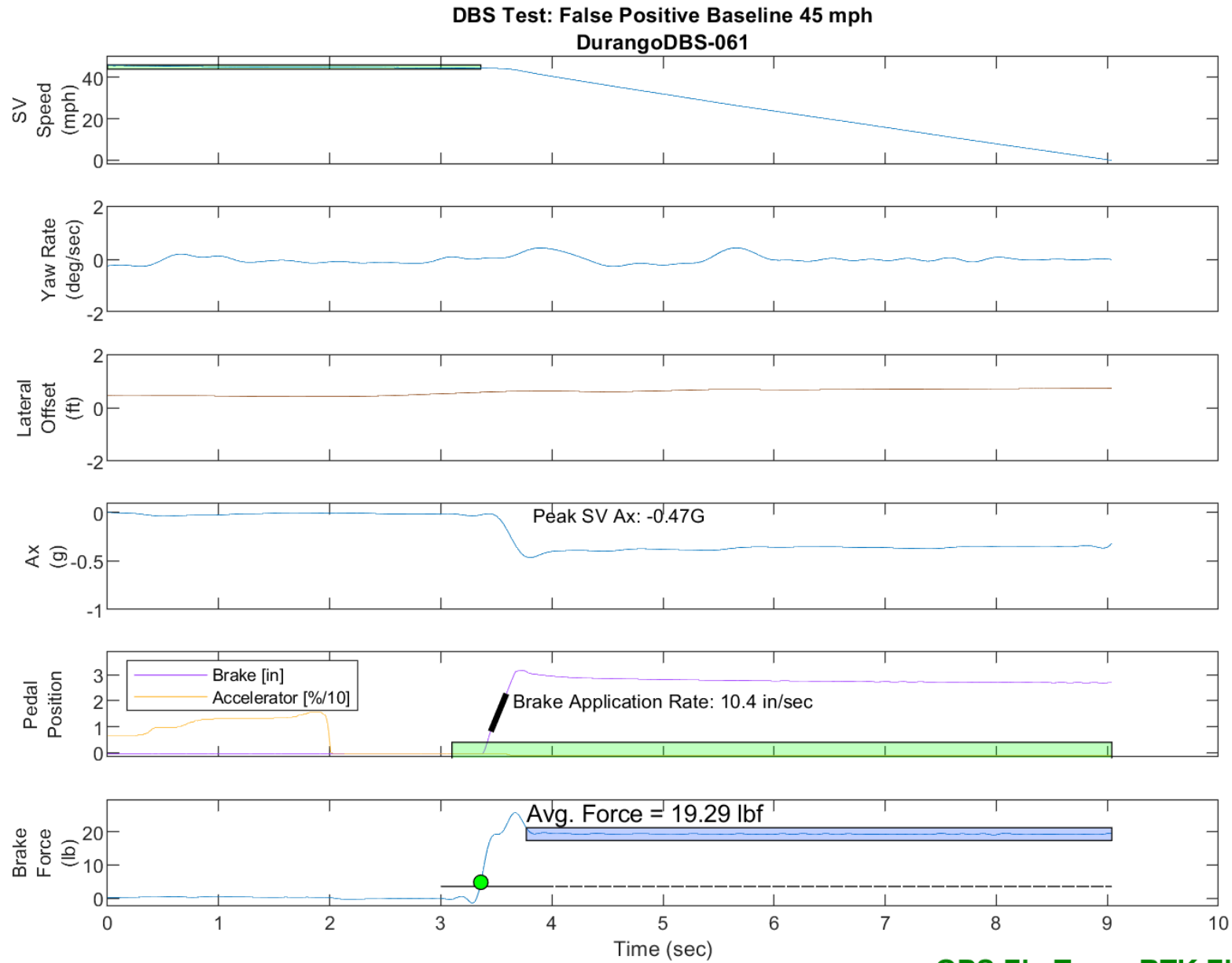


Figure E47. Time History for DBS Run 60, False Positive Baseline, SV 45 mph



**GPS Fix Type: RTK Fixed**

Figure E48. Time History for DBS Run 61, False Positive Baseline, SV 45 mph

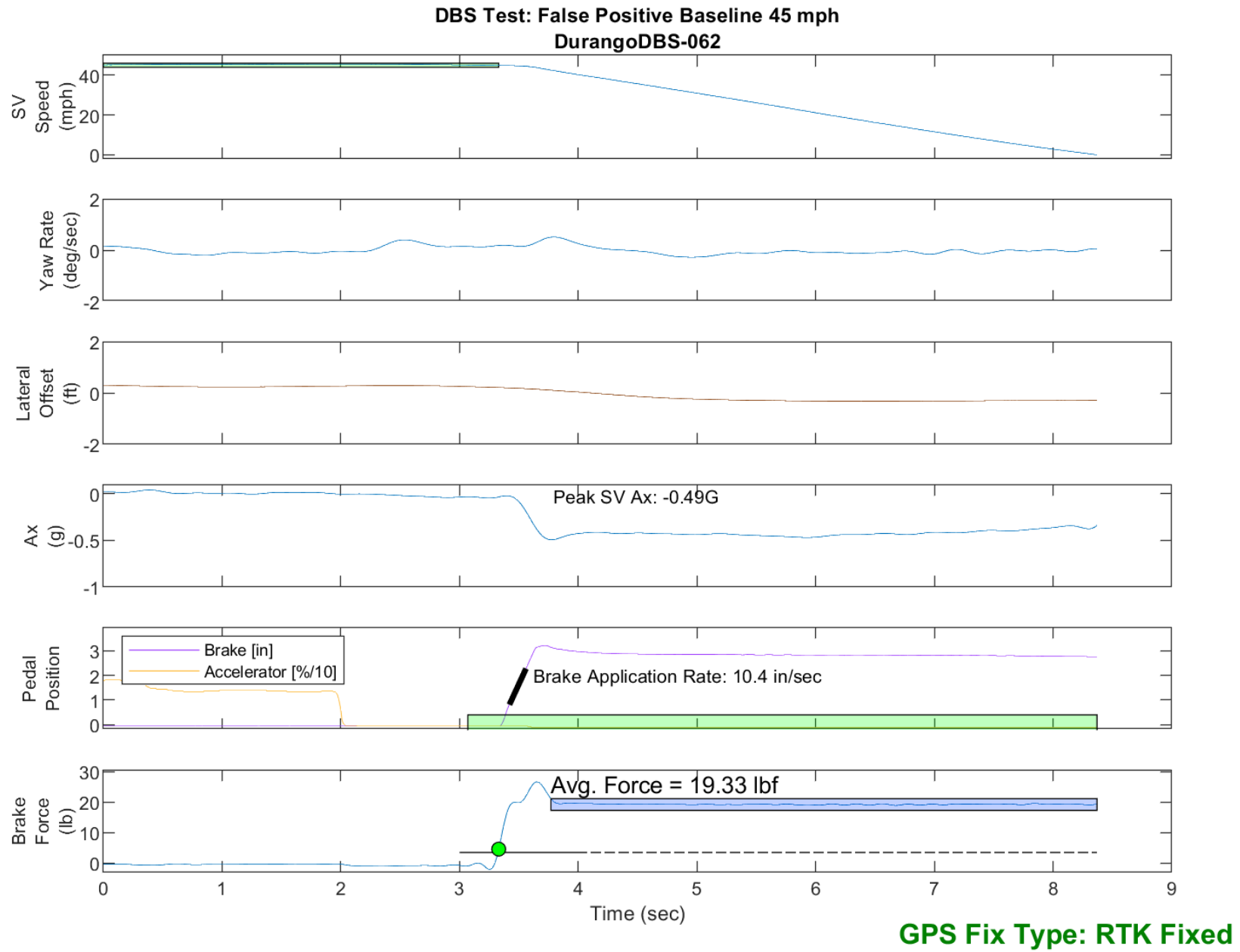
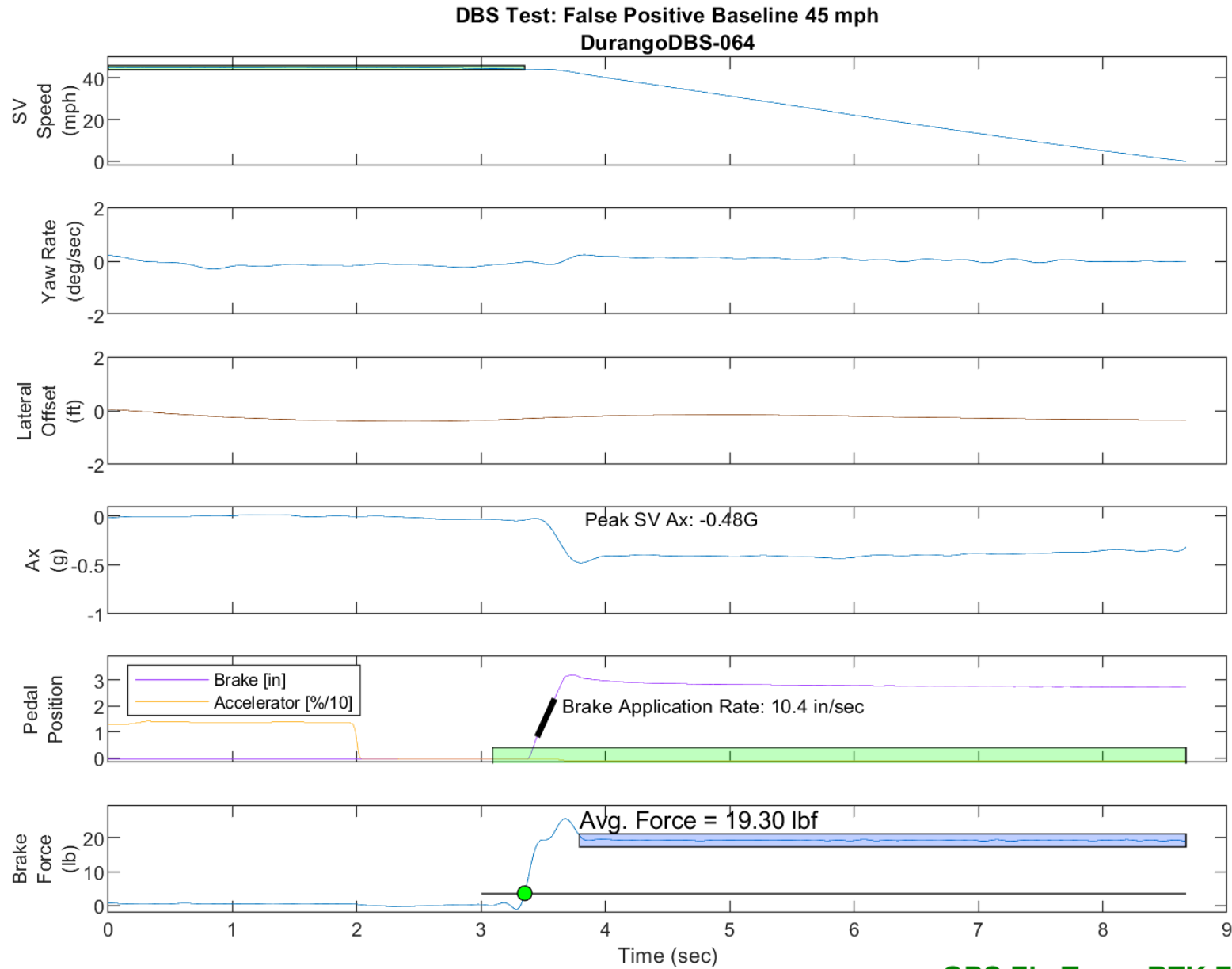


Figure E49. Time History for DBS Run 62, False Positive Baseline, SV 45 mph



**GPS Fix Type: RTK Fixed**

Figure E50. Time History for DBS Run 64, False Positive Baseline, SV 45 mph

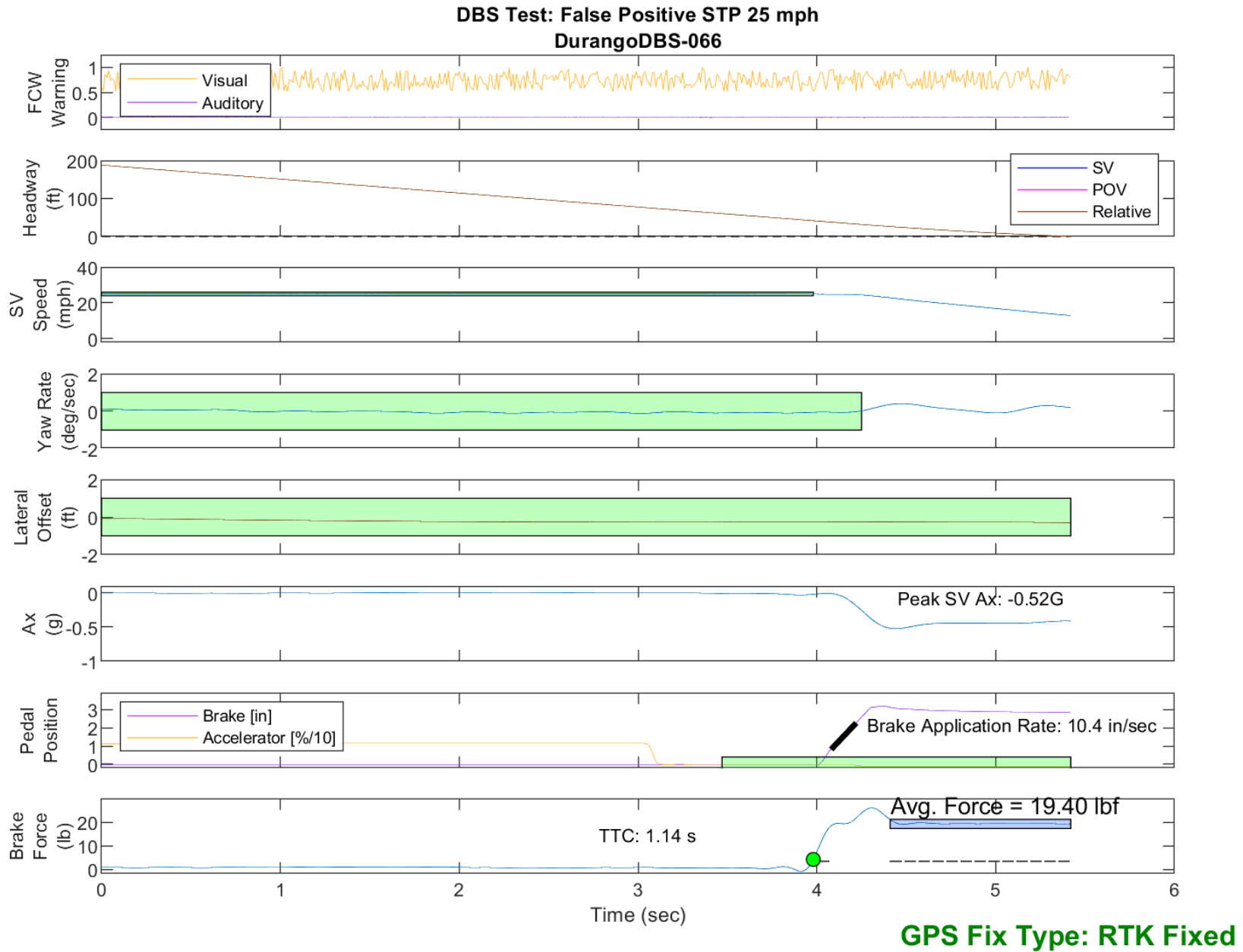


Figure E51. Time History for DBS Run 66, SV Encounters Steel Trench Plate, SV 25 mph

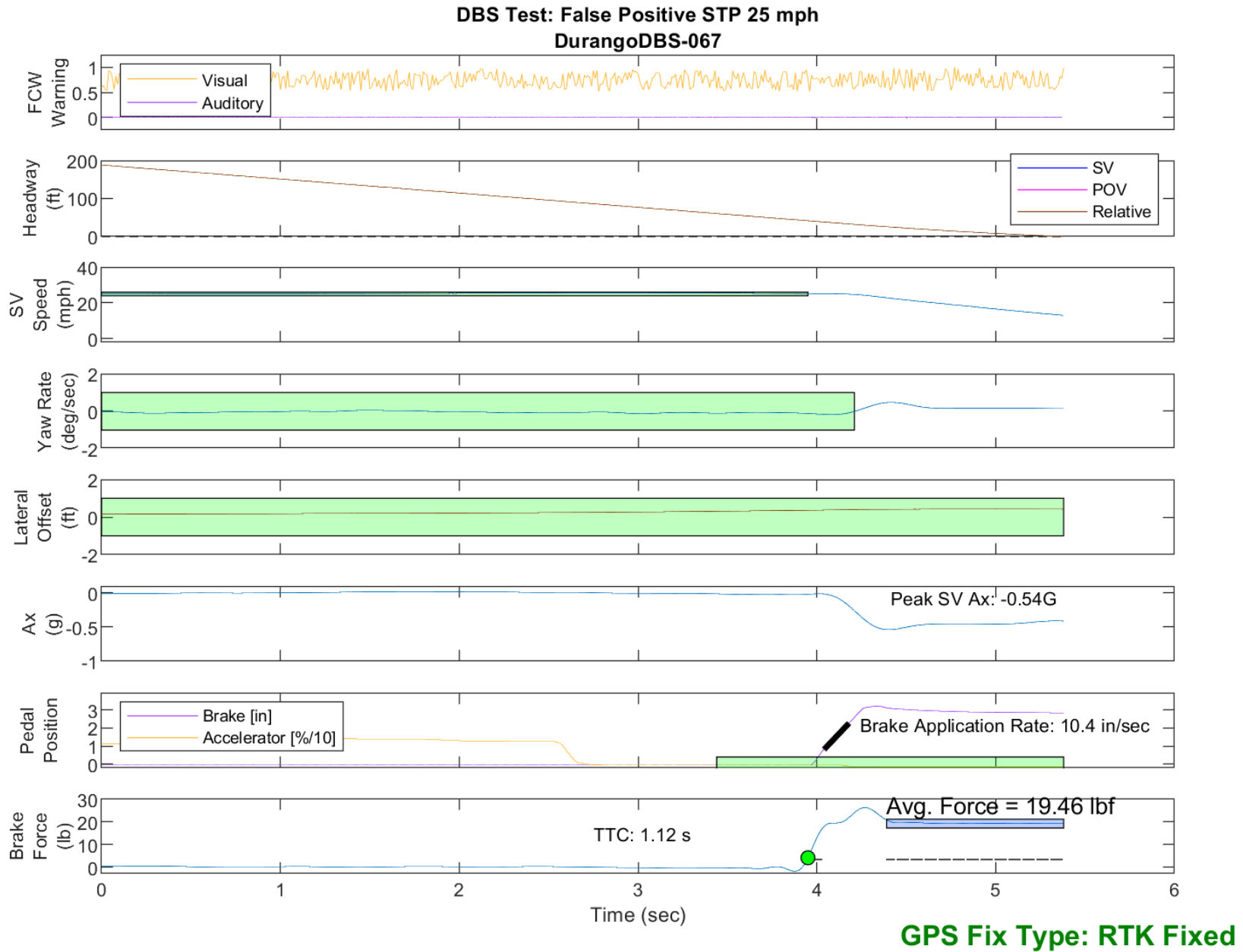


Figure E52. Time History for DBS Run 67, SV Encounters Steel Trench Plate, SV 25 mph

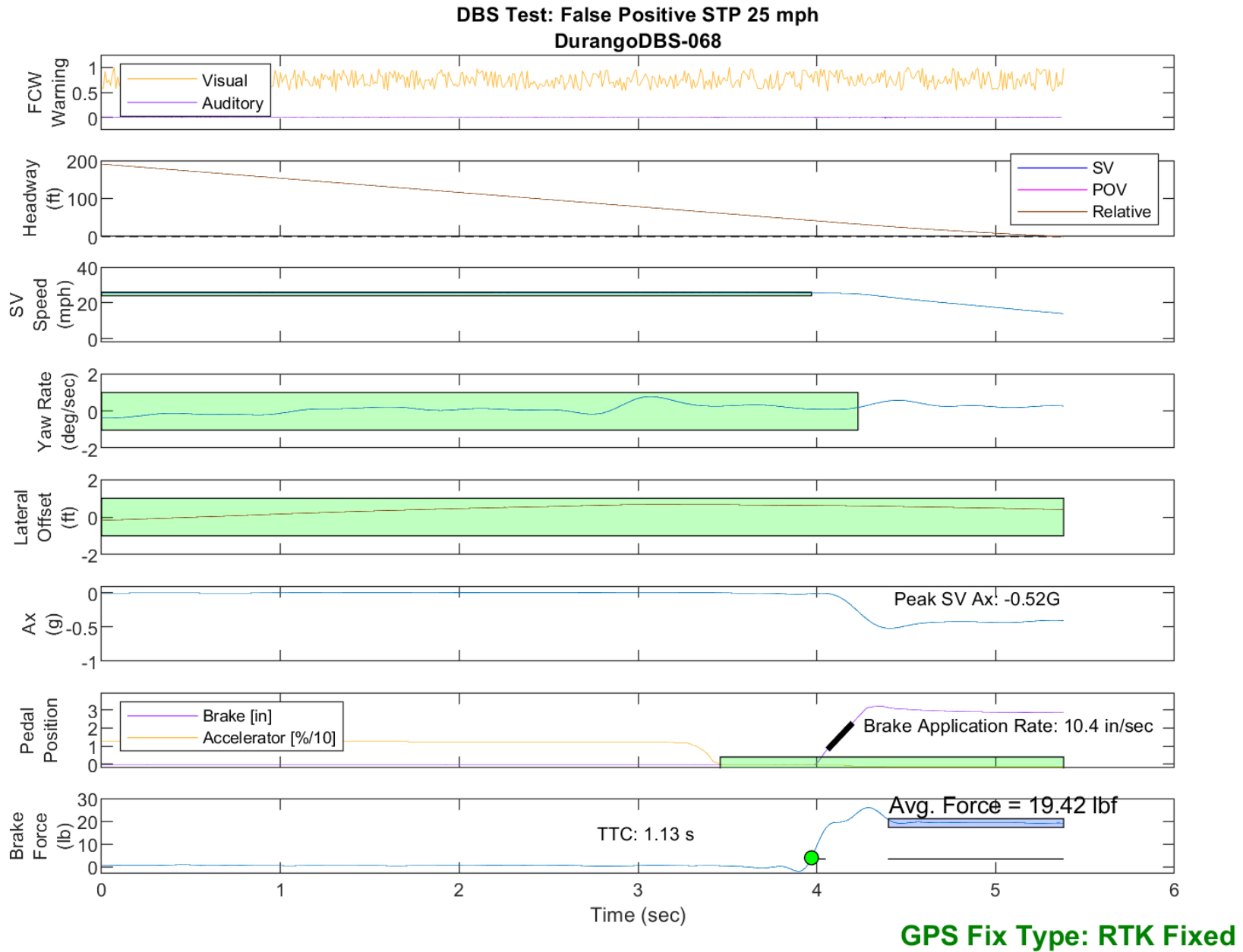


Figure E53. Time History for DBS Run 68, SV Encounters Steel Trench Plate, SV 25 mph

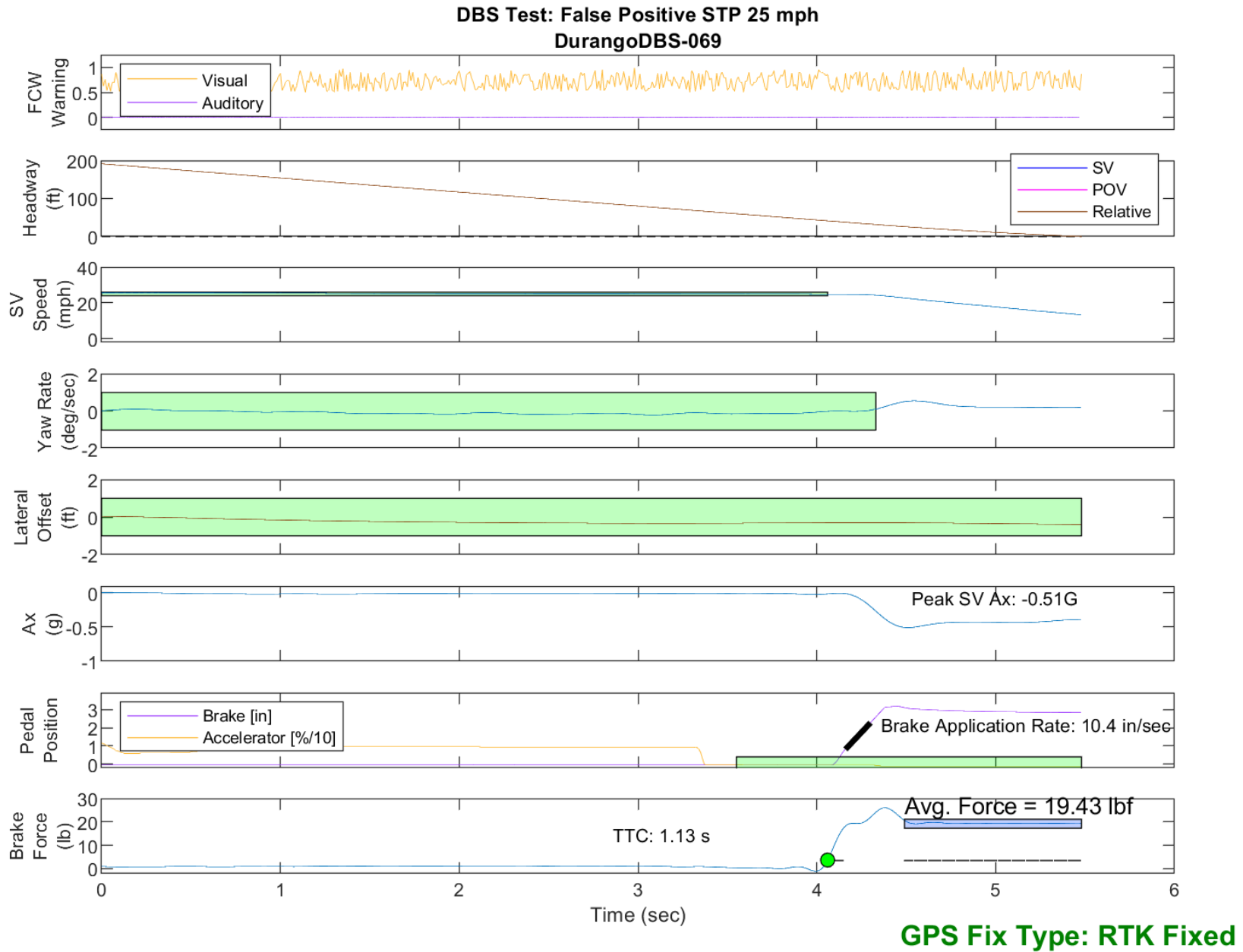


Figure E54. Time History for DBS Run 69, SV Encounters Steel Trench Plate, SV 25 mph



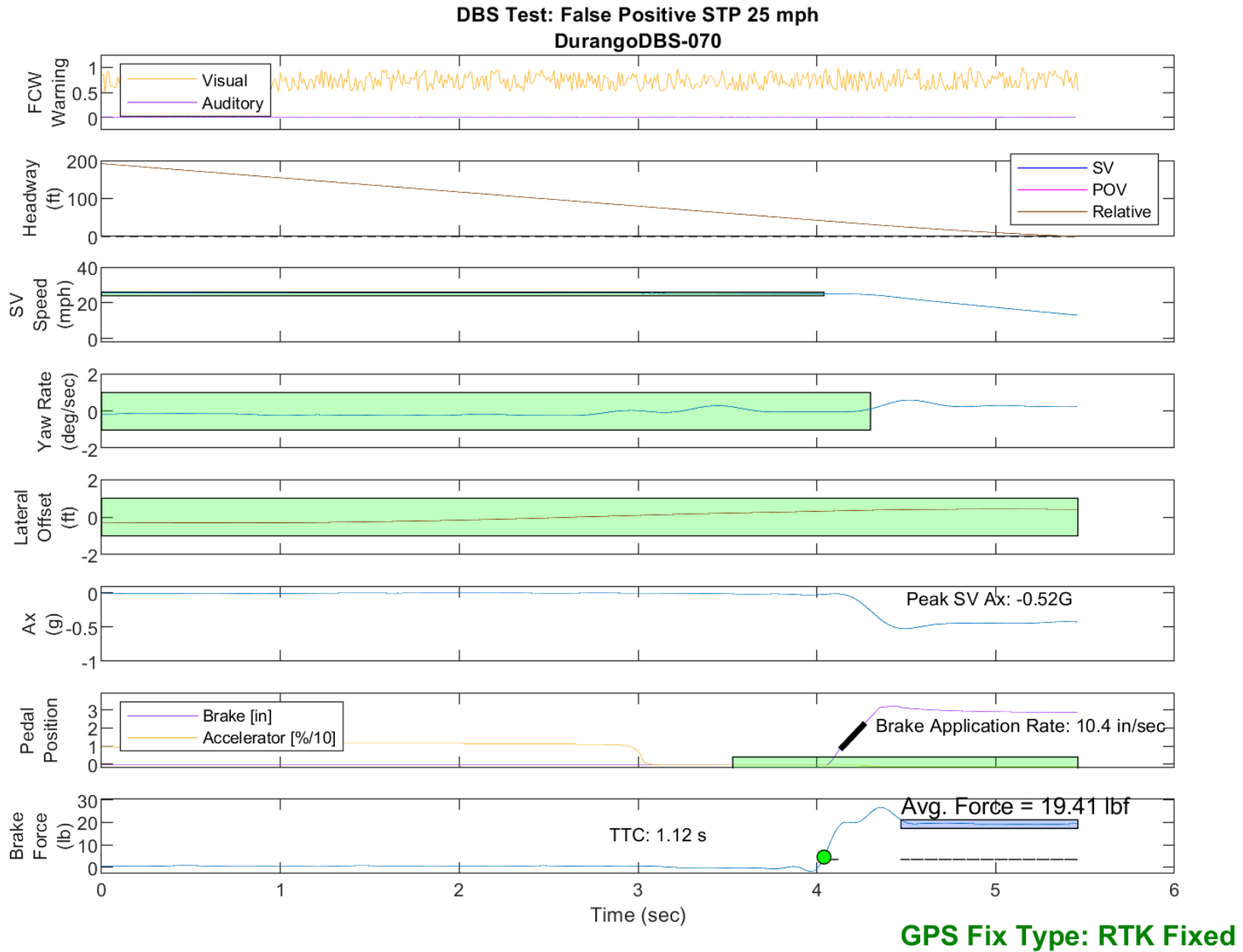


Figure E55. Time History for DBS Run 70, SV Encounters Steel Trench Plate, SV 25 mph

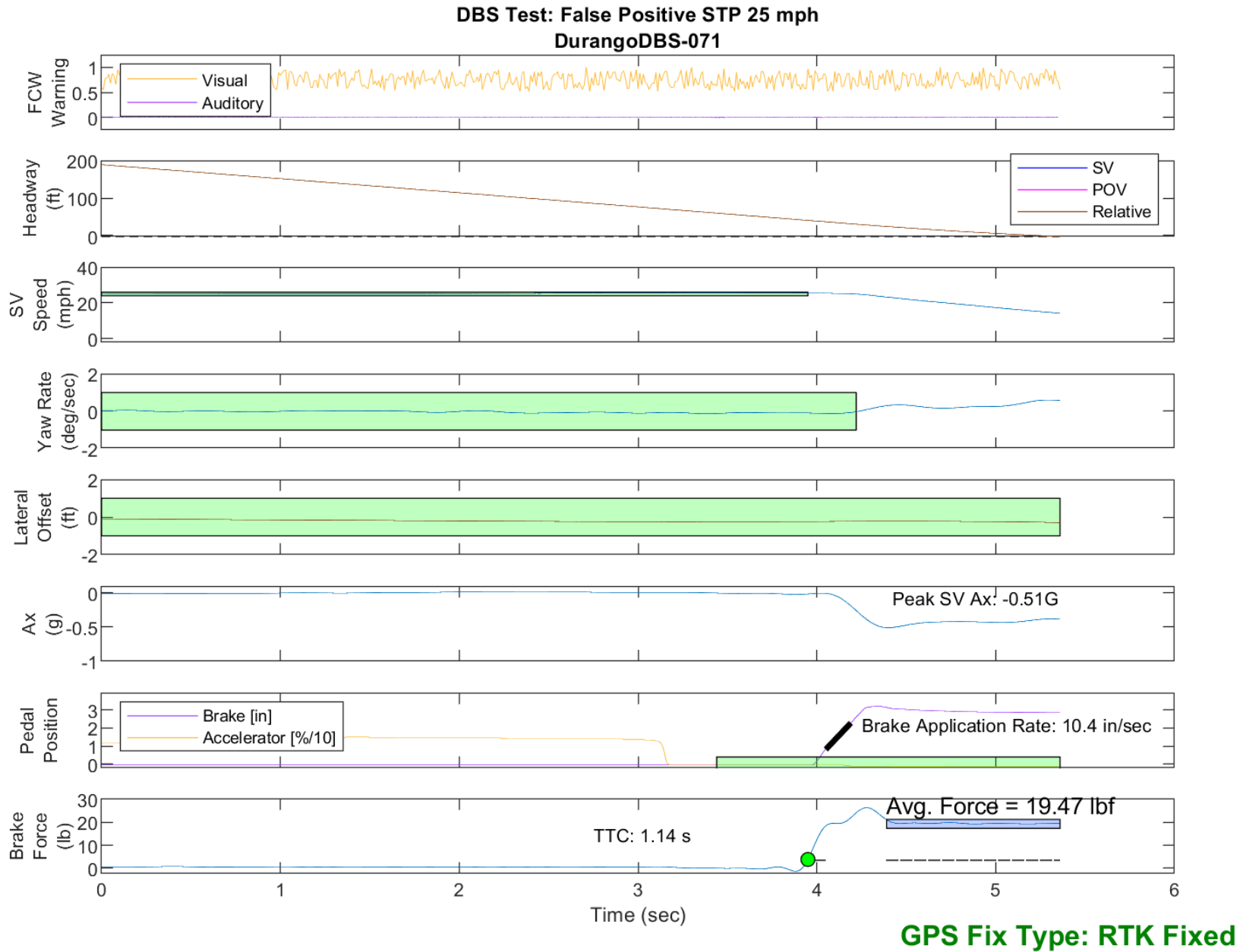


Figure E56. Time History for DBS Run 71, SV Encounters Steel Trench Plate, SV 25 mph

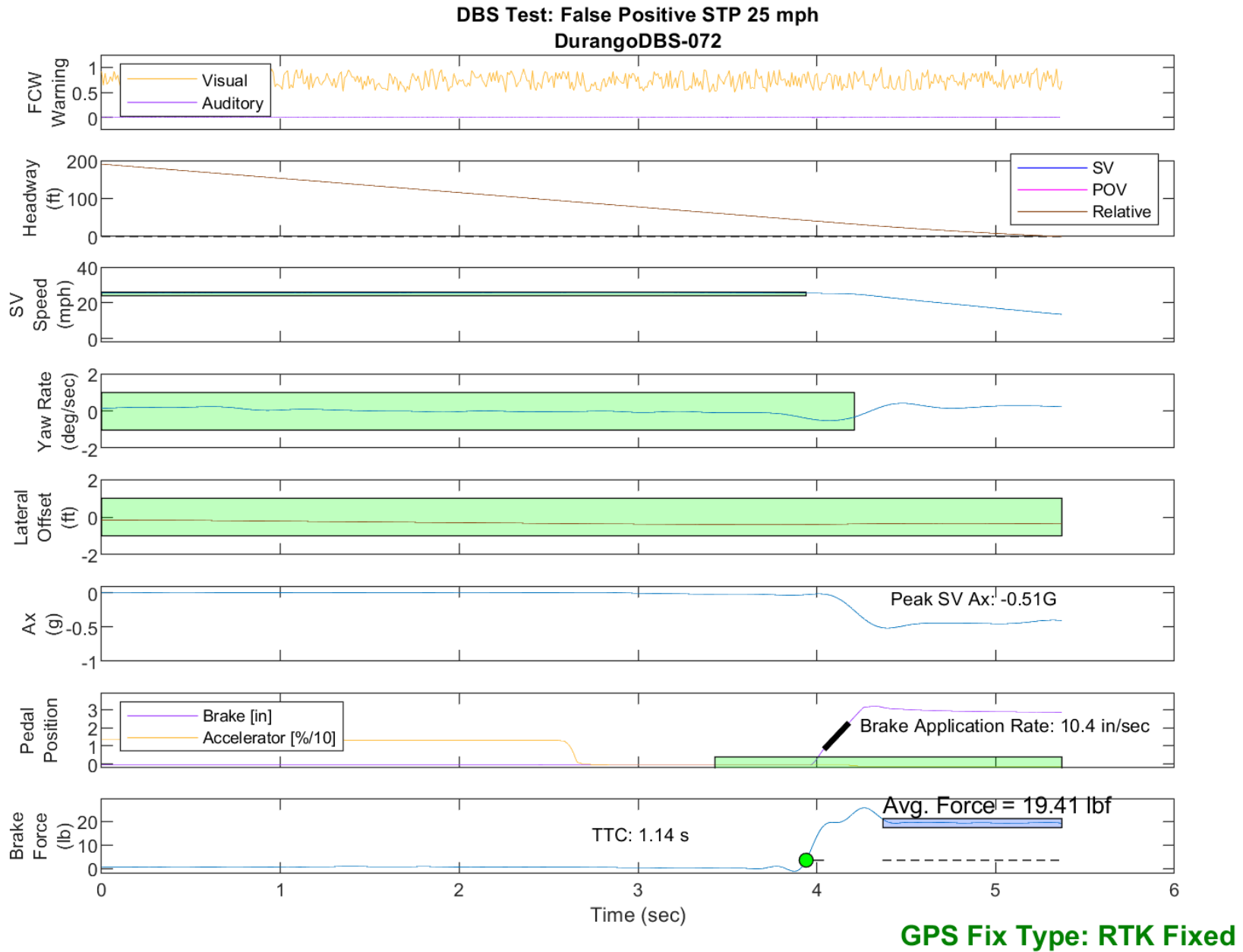


Figure E57. Time History for DBS Run 72, SV Encounters Steel Trench Plate, SV 25 mph

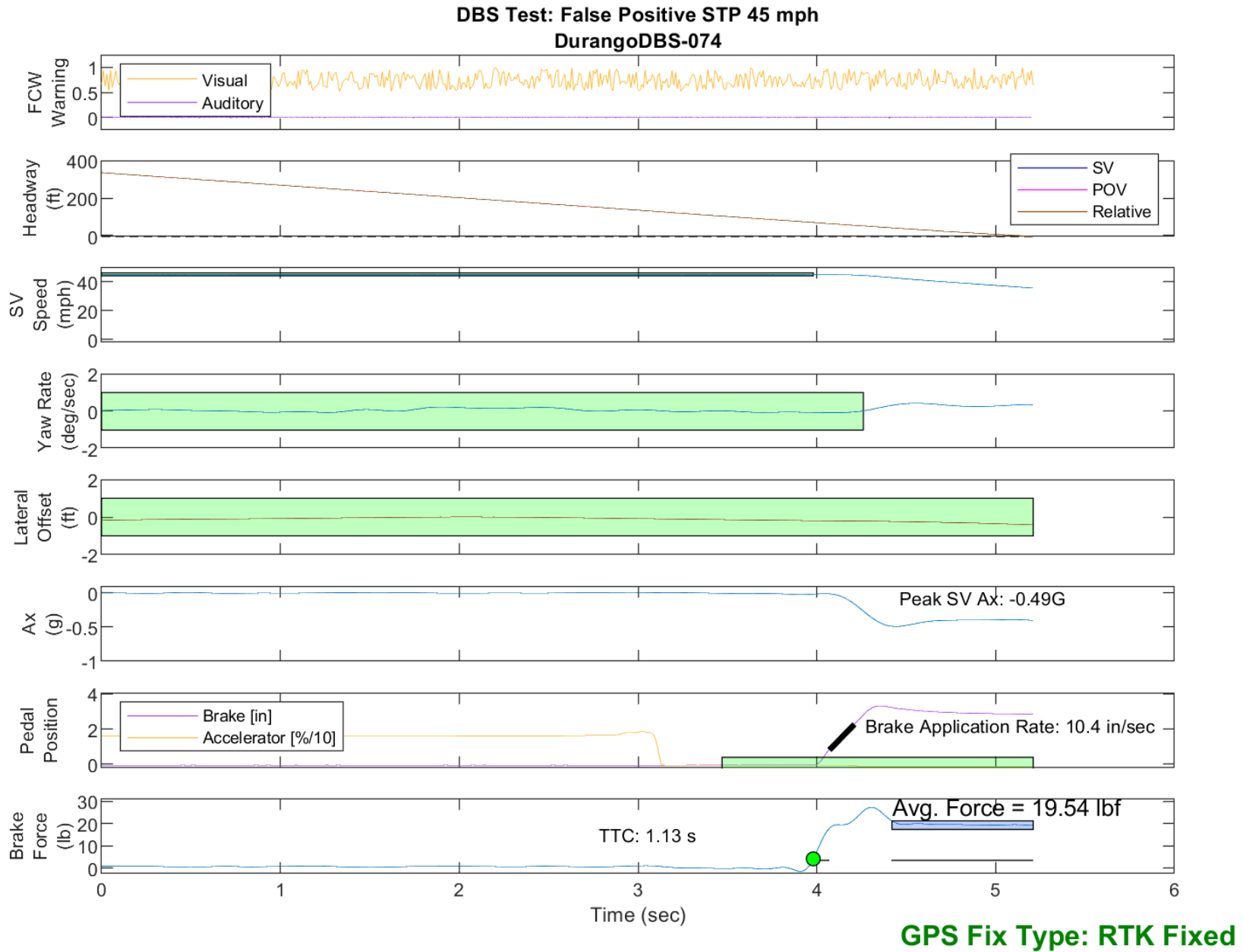


Figure E58. Time History for DBS Run 74, SV Encounters Steel Trench Plate, SV 45 mph

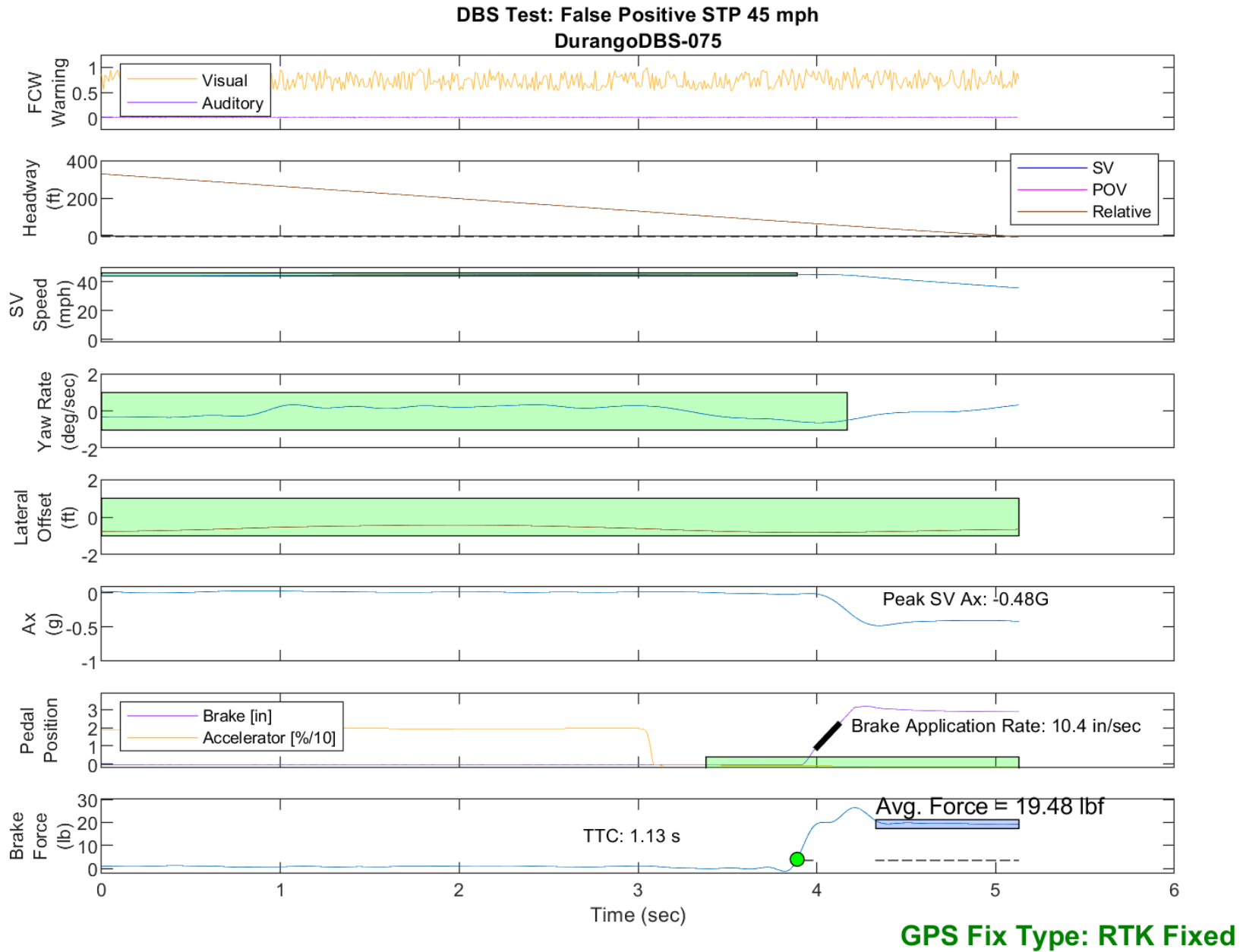


Figure E59. Time History for DBS Run 75, SV Encounters Steel Trench Plate, SV 45 mph

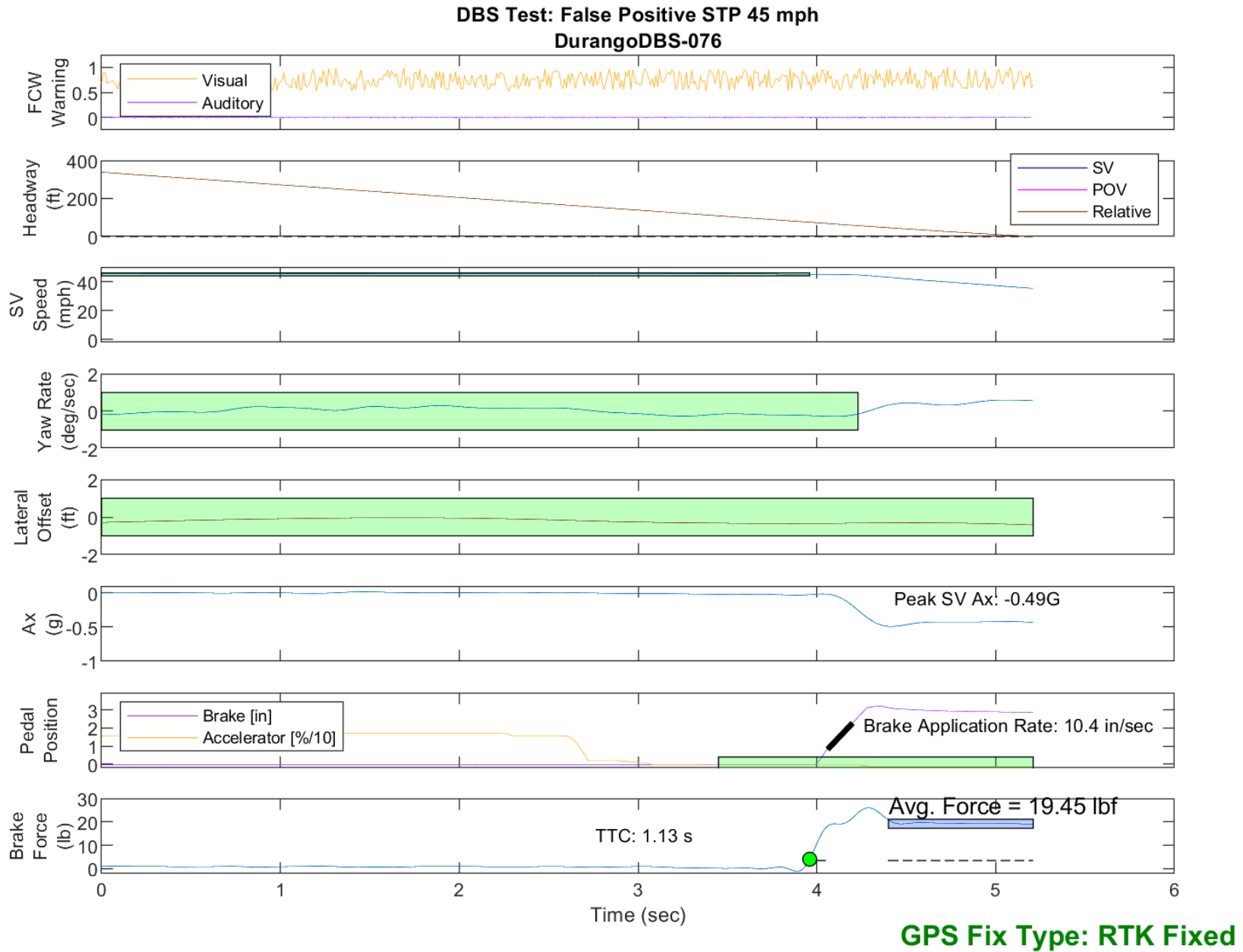


Figure E60. Time History for DBS Run 76, SV Encounters Steel Trench Plate, SV 45 mph

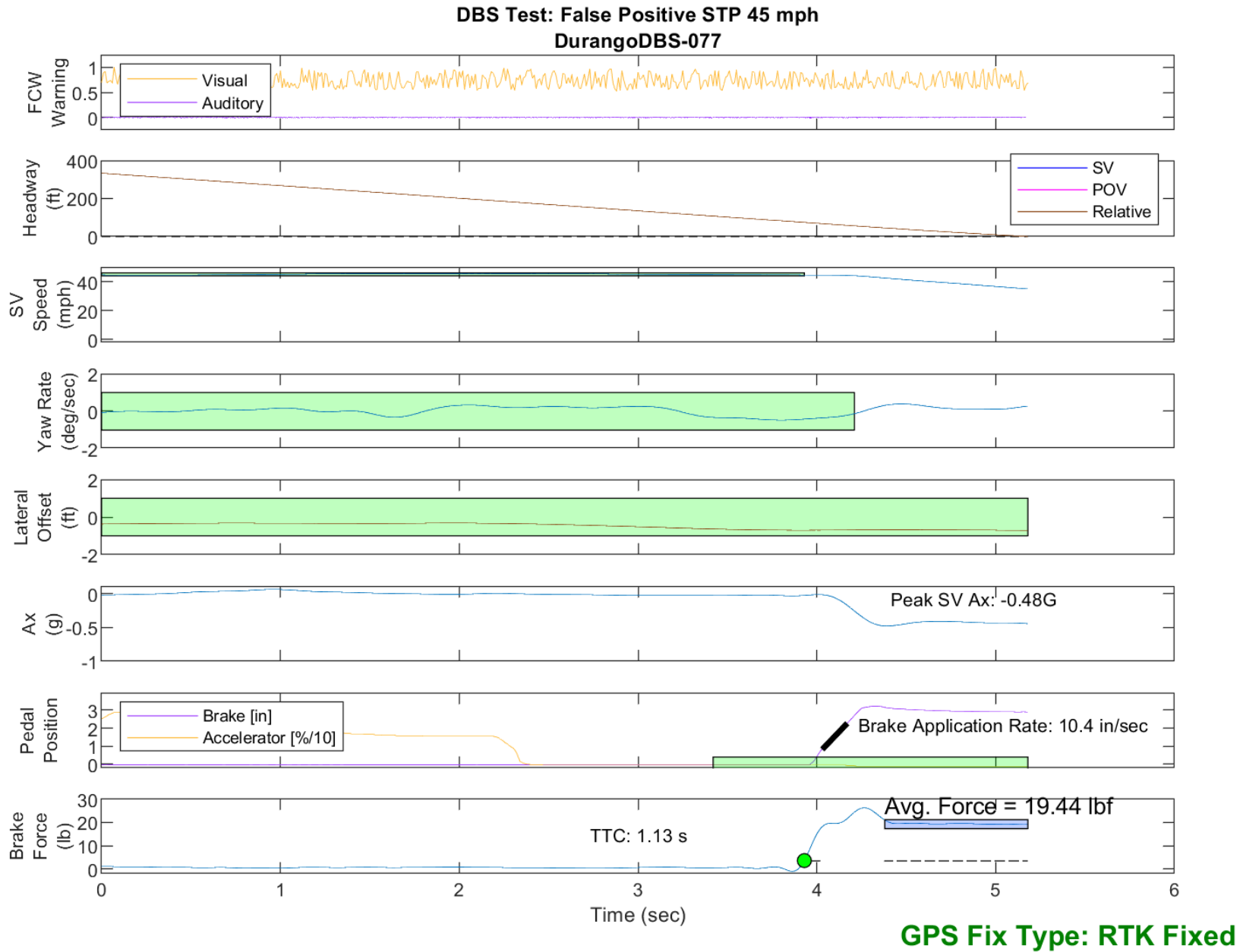


Figure E61. Time History for DBS Run 77, SV Encounters Steel Trench Plate, SV 45 mph

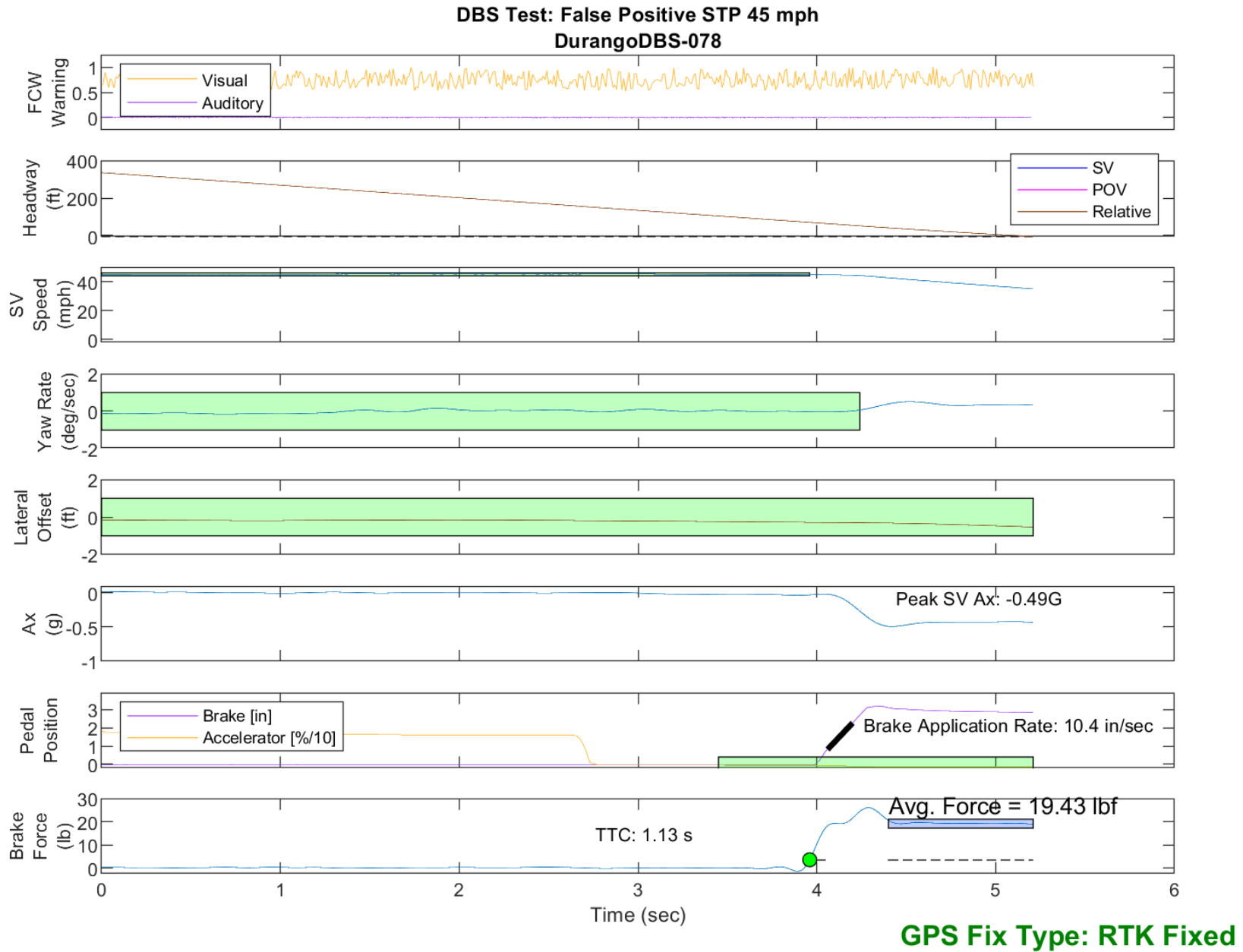


Figure E62. Time History for DBS Run 78, SV Encounters Steel Trench Plate, SV 45 mph



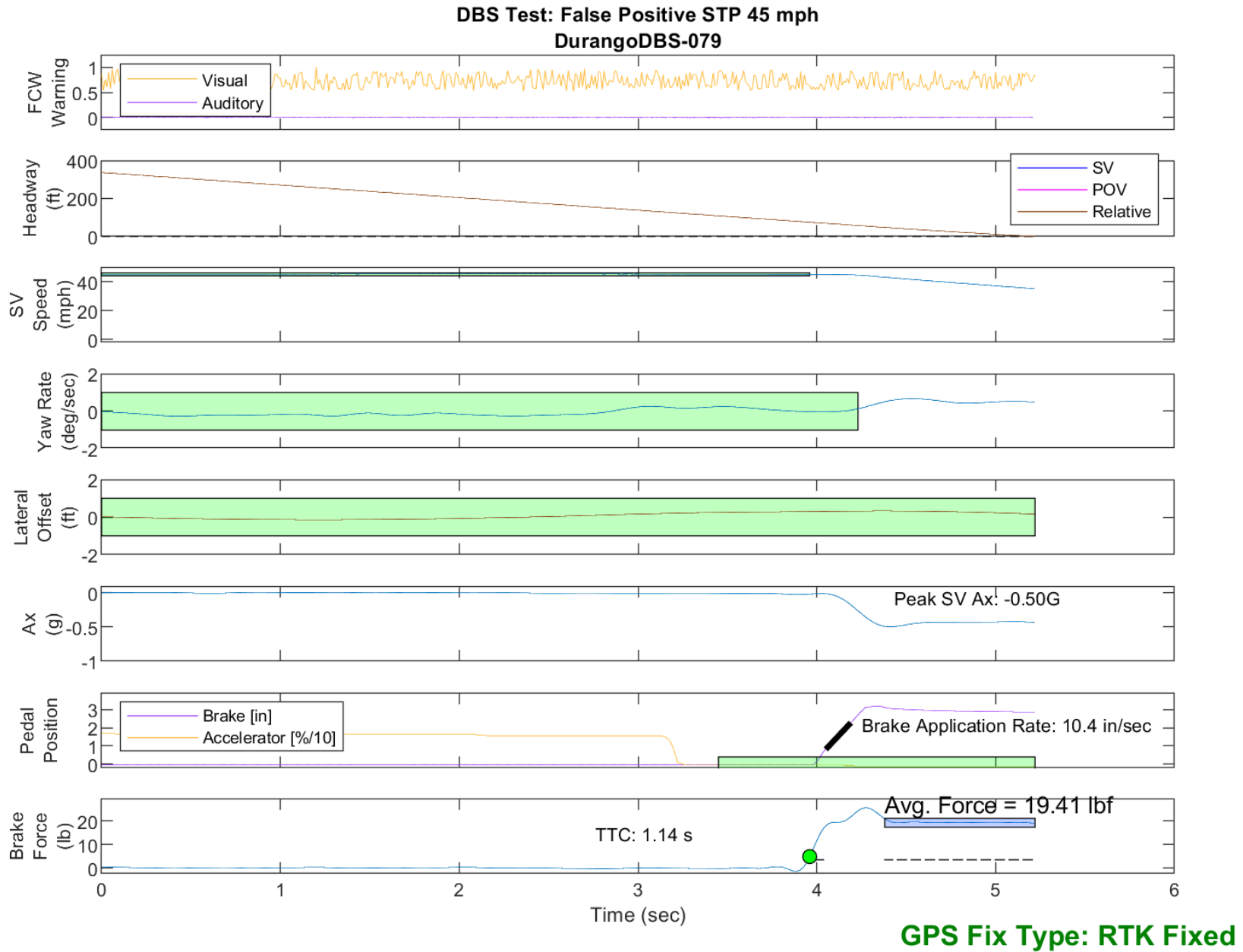


Figure E63. Time History for DBS Run 79, SV Encounters Steel Trench Plate, SV 45 mph

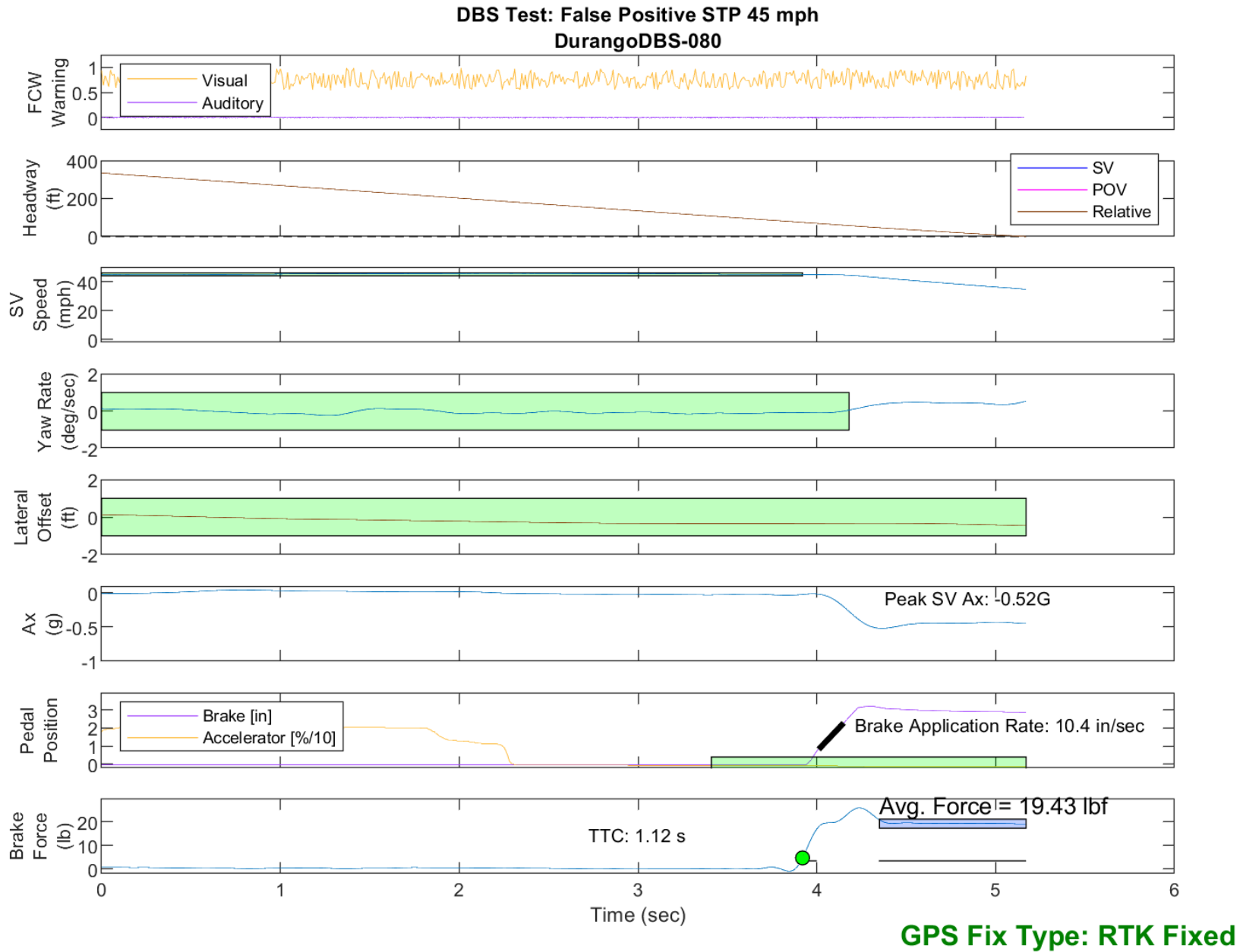


Figure E64. Time History for DBS Run 80, SV Encounters Steel Trench Plate, SV 45 mph

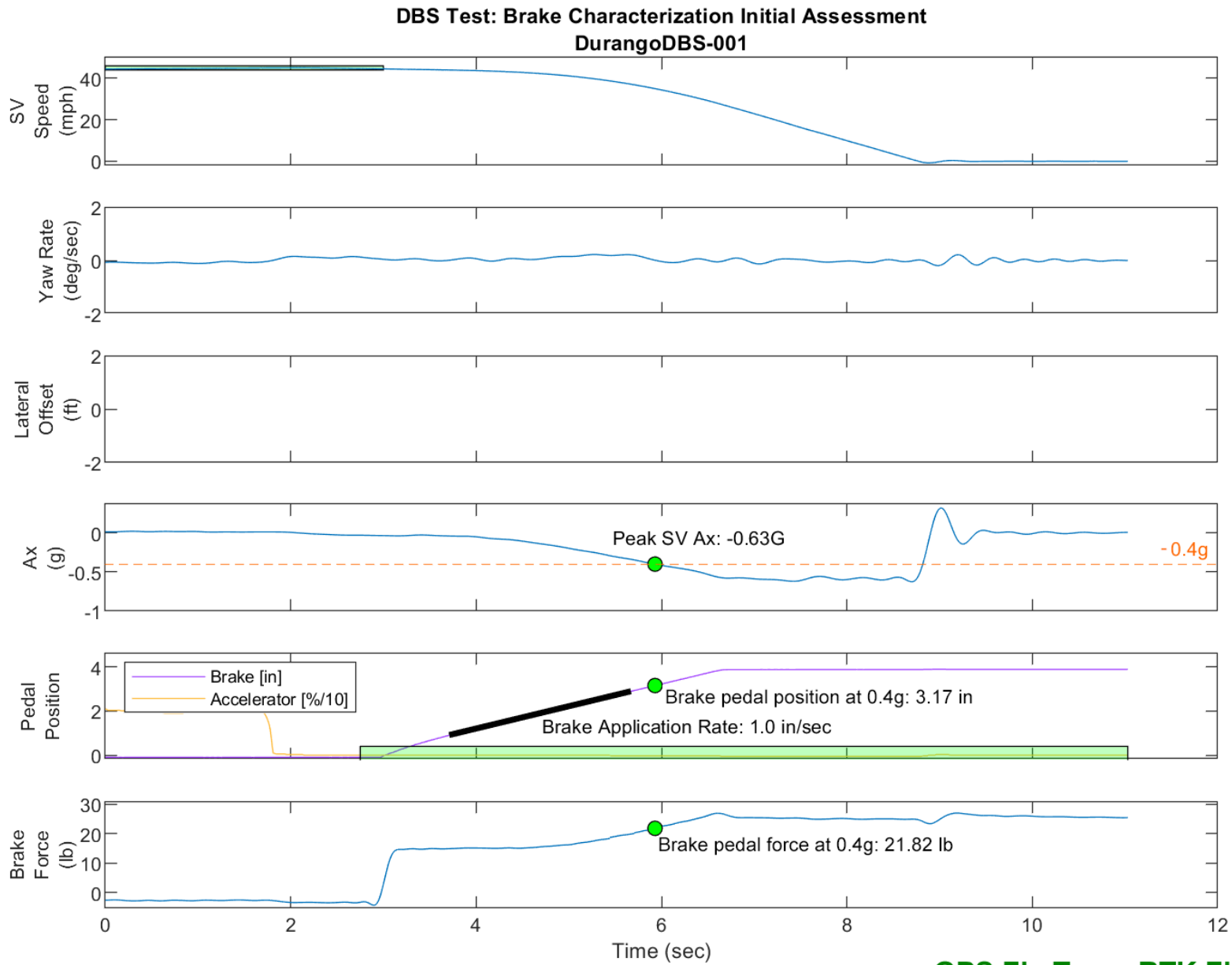
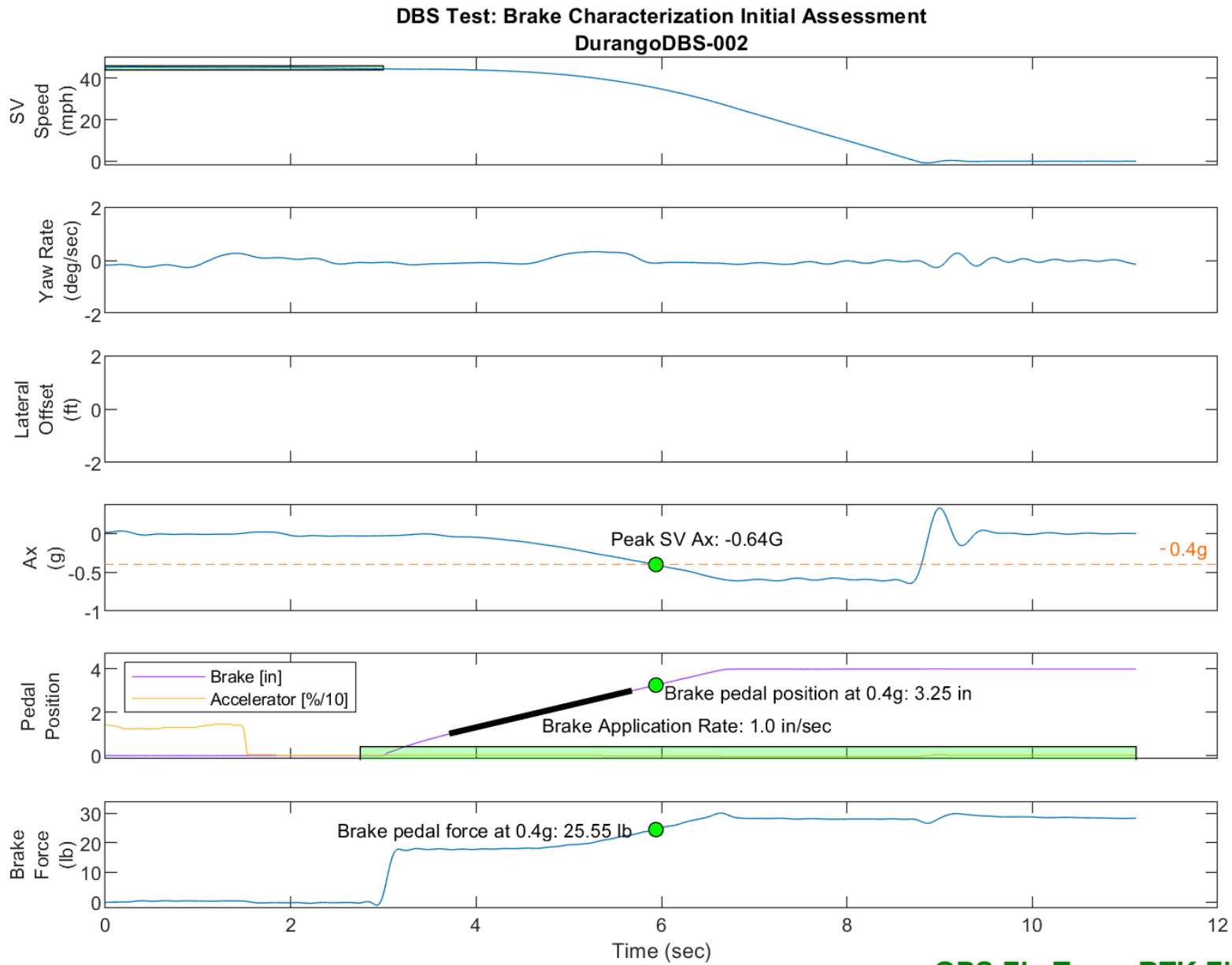


Figure E65. Time History for DBS Run 1, Brake Characterization Initial



**GPS Fix Type: RTK Fixed**

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

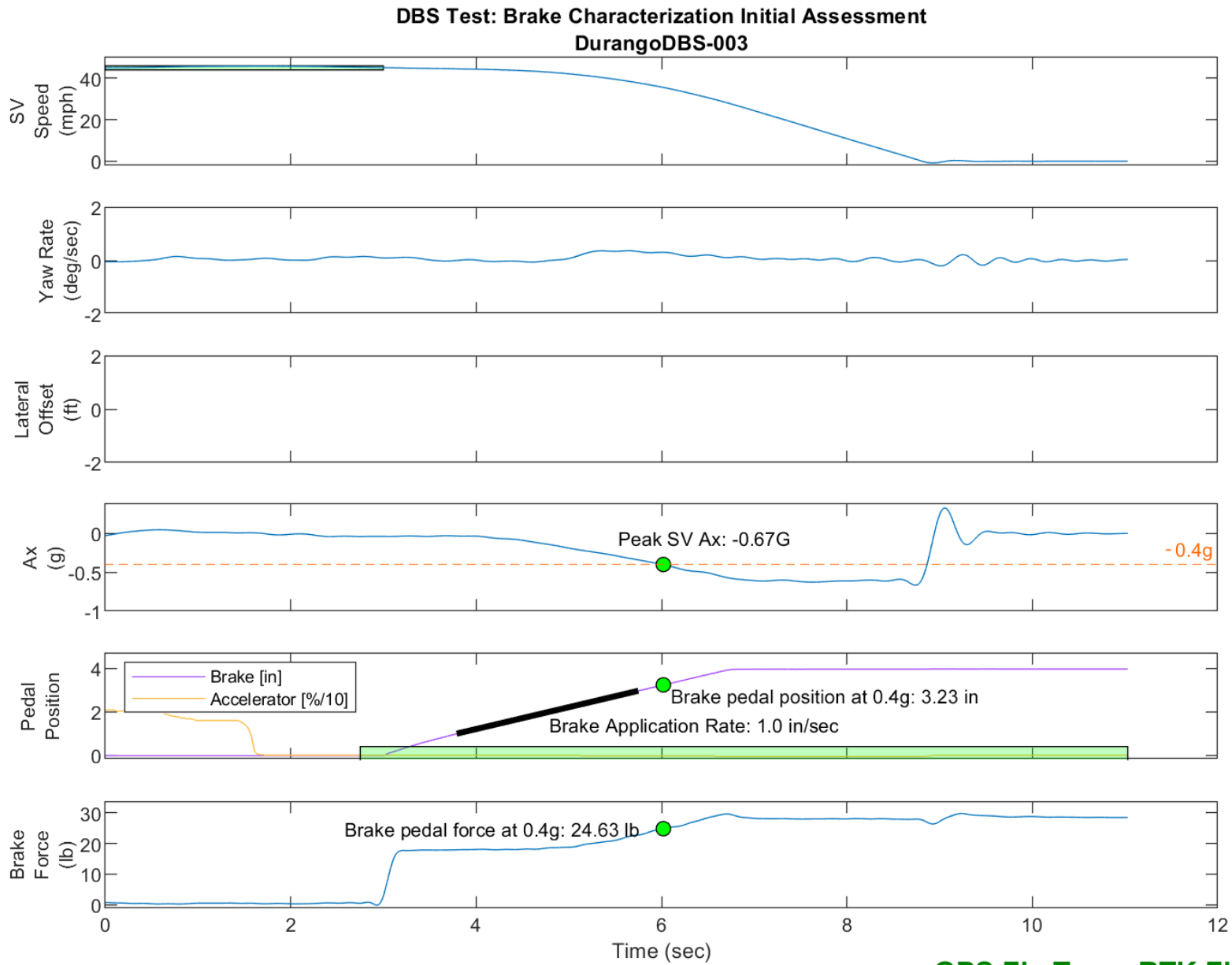


Figure E67. Time History for DBS Run 3, Brake Characterization Initial

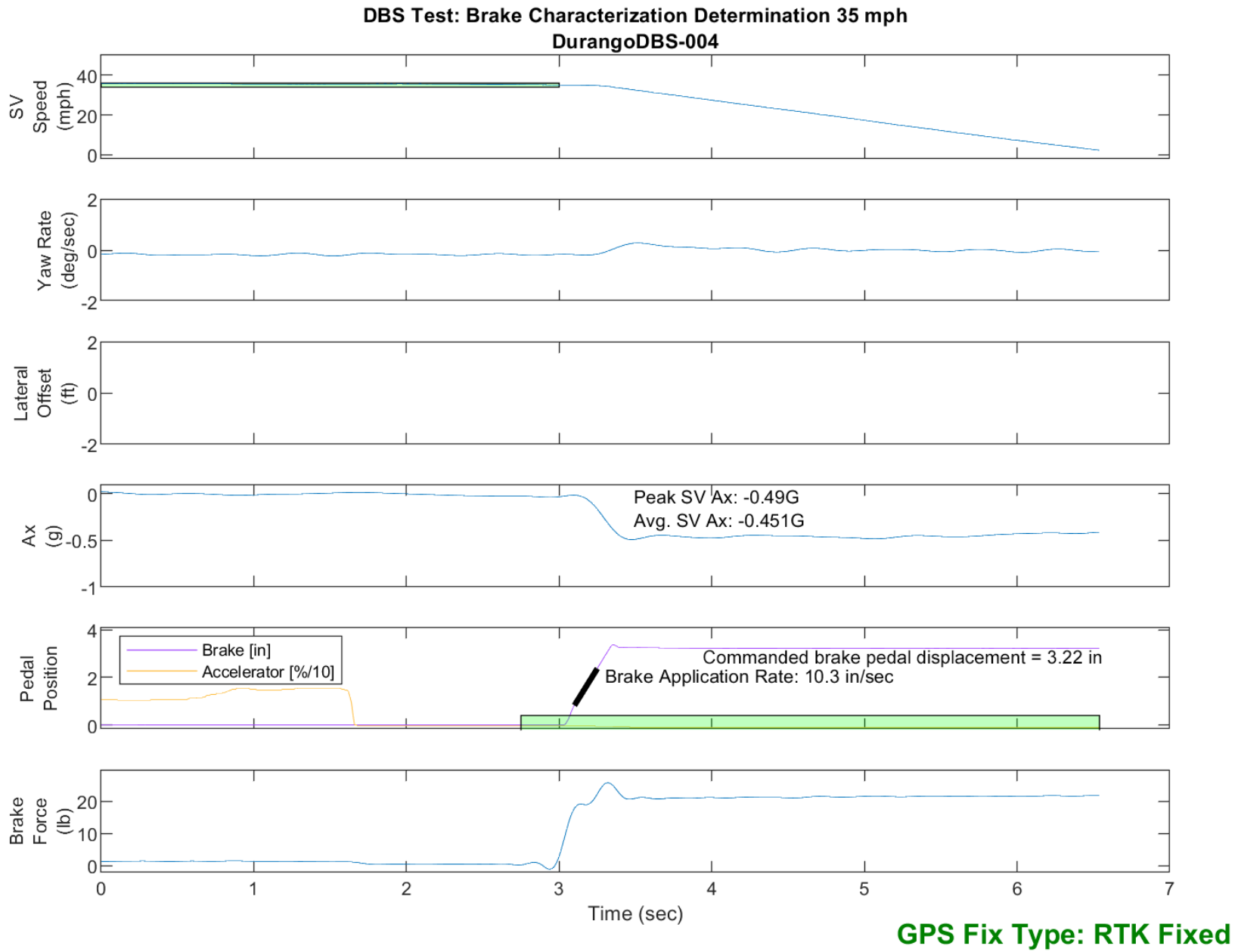


Figure E68. Time History for DBS Run 4, Brake Characterization Determination, Displacement Mode, 35 mph

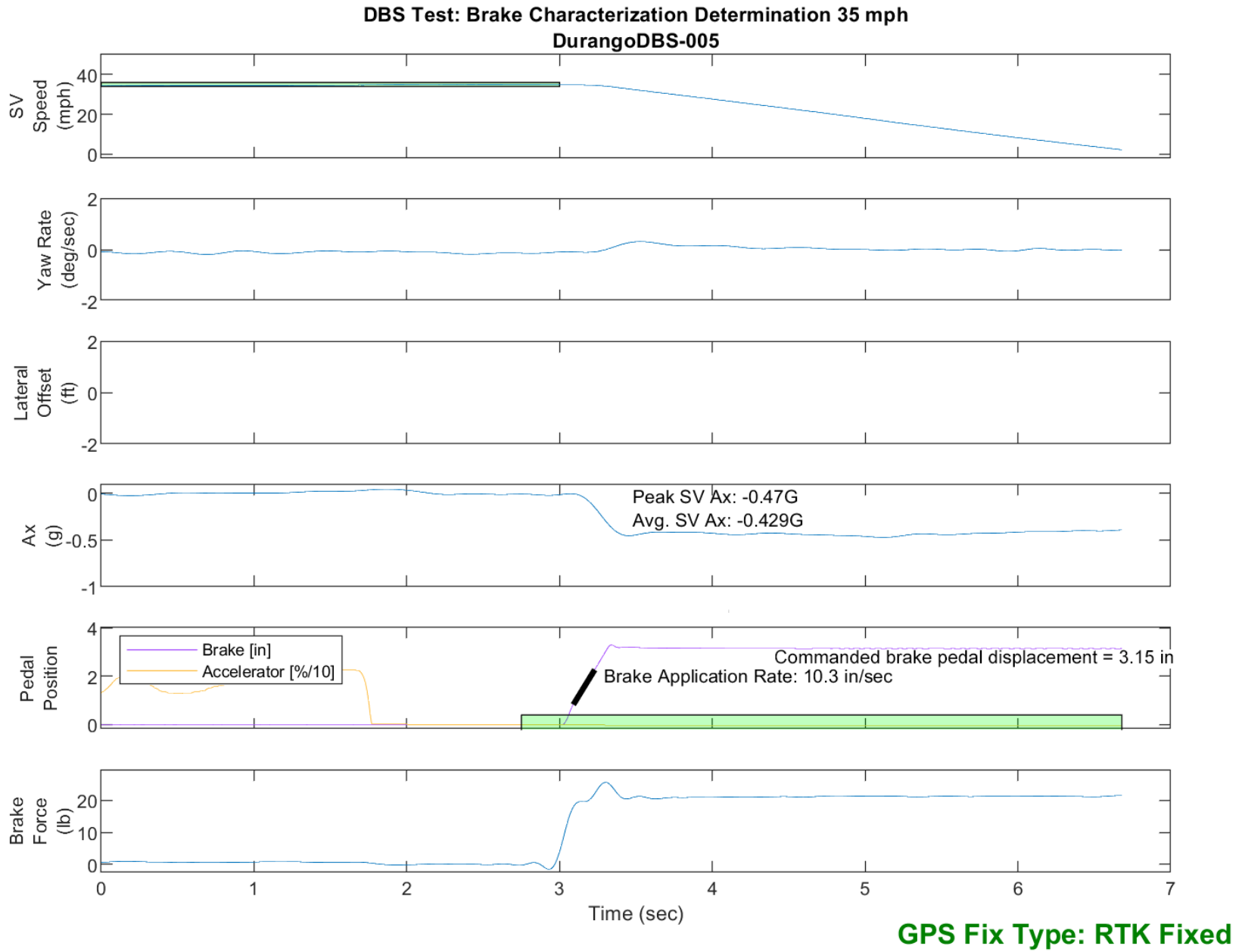


Figure E69. Time History for DBS Run 5, Brake Characterization Determination, Displacement Mode, 35 mph

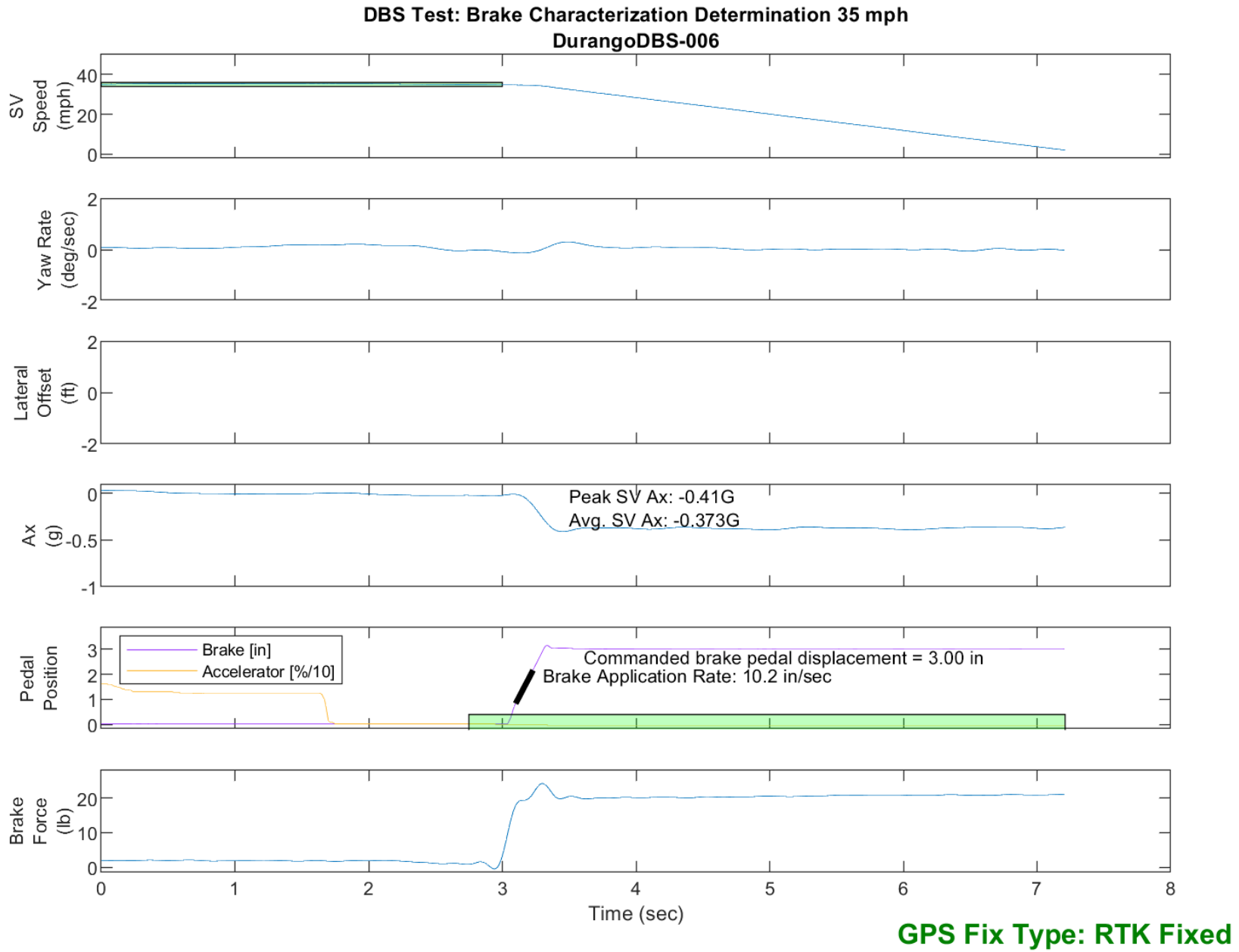


Figure E70. Time History for DBS Run 6, Brake Characterization Determination, Displacement Mode, 35 mph



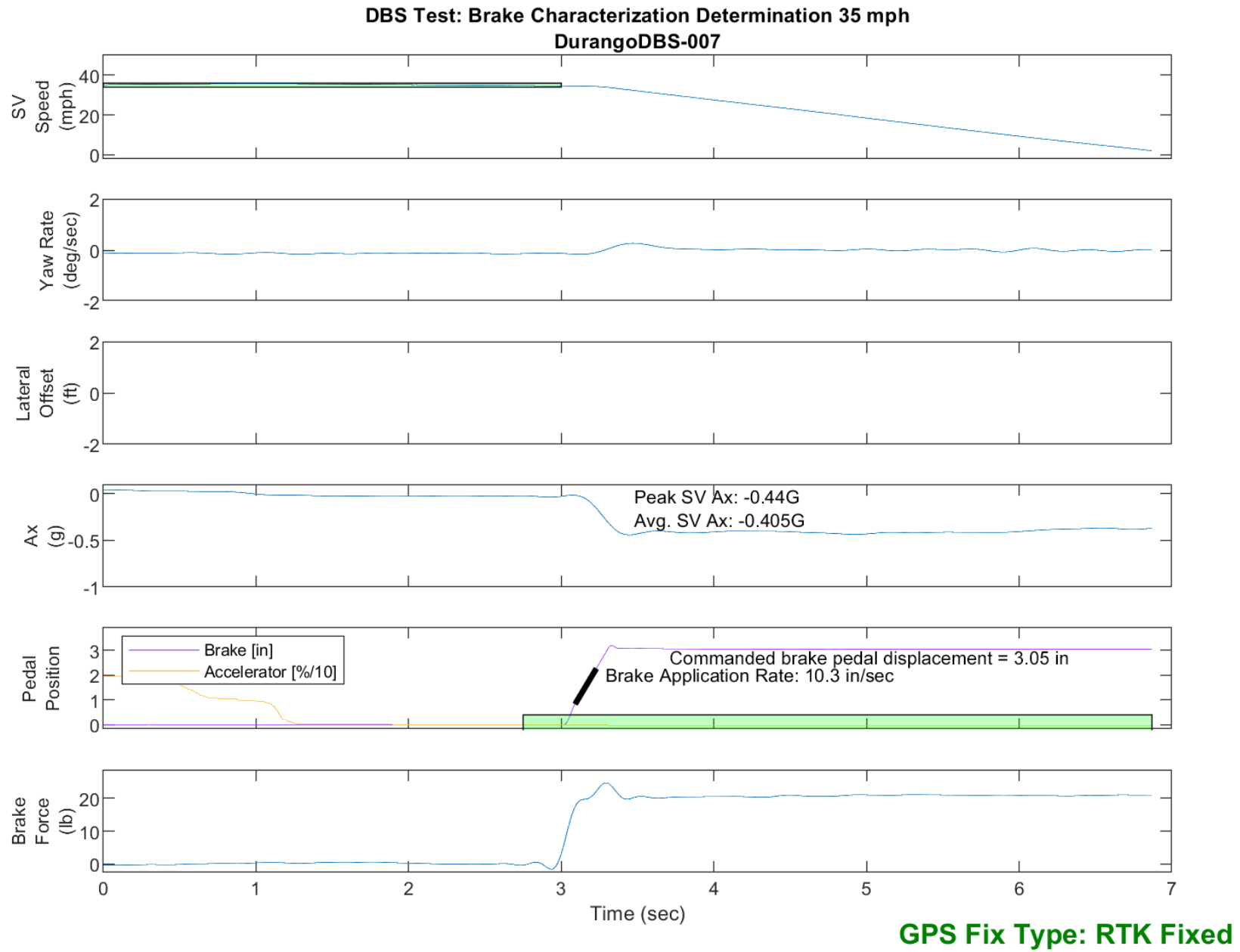
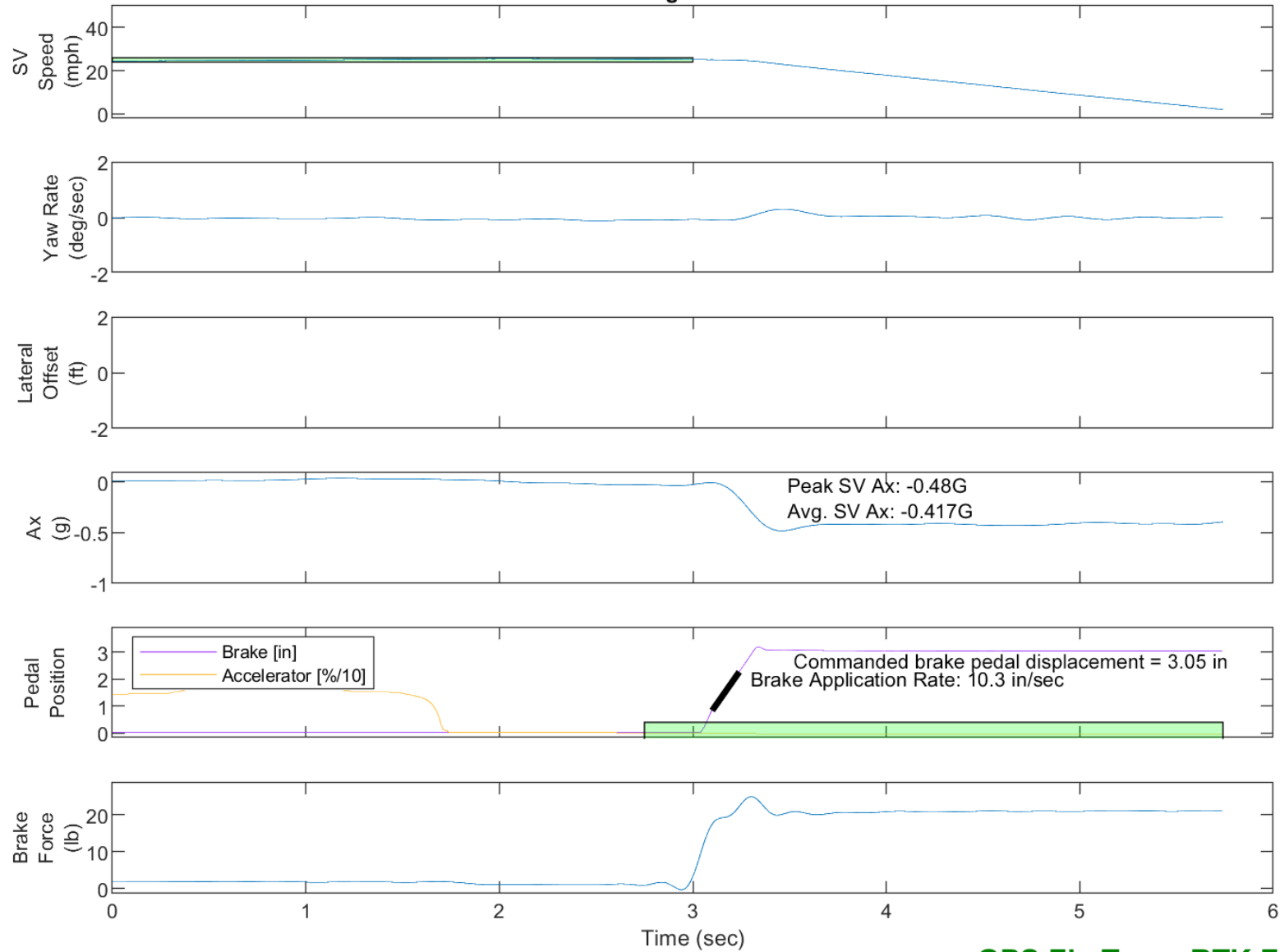


Figure E71. Time History for DBS Run 7, Brake Characterization Determination, Displacement Mode, 35 mph

DBS Test: Brake Characterization Determination 25 mph  
DurangoDBS-008



GPS Fix Type: RTK Fixed

Figure E72. Time History for DBS Run 8, Brake Characterization Determination, Displacement Mode, 25 mph

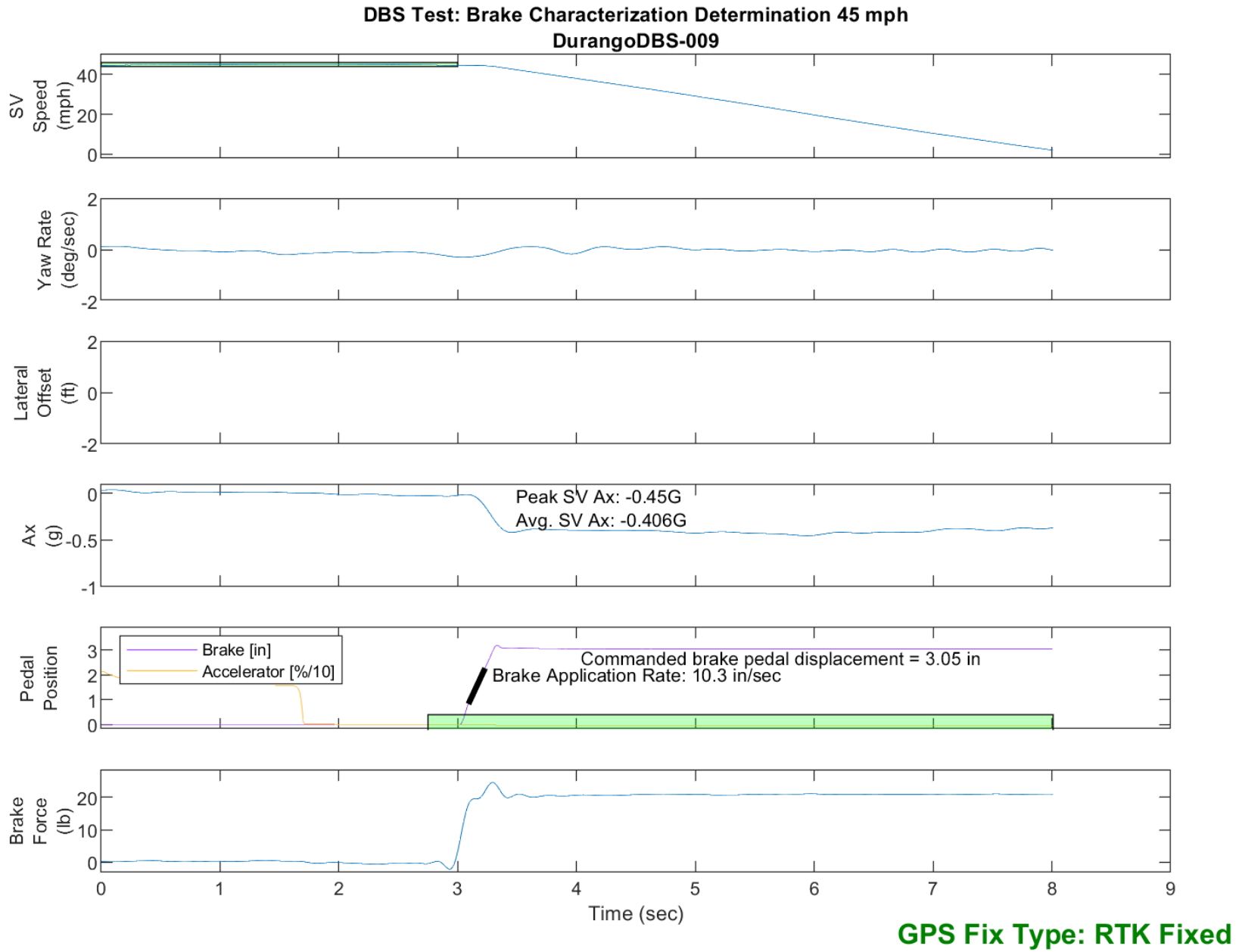


Figure E73. Time History for DBS Run 9, Brake Characterization Determination, Displacement Mode, 45 mph

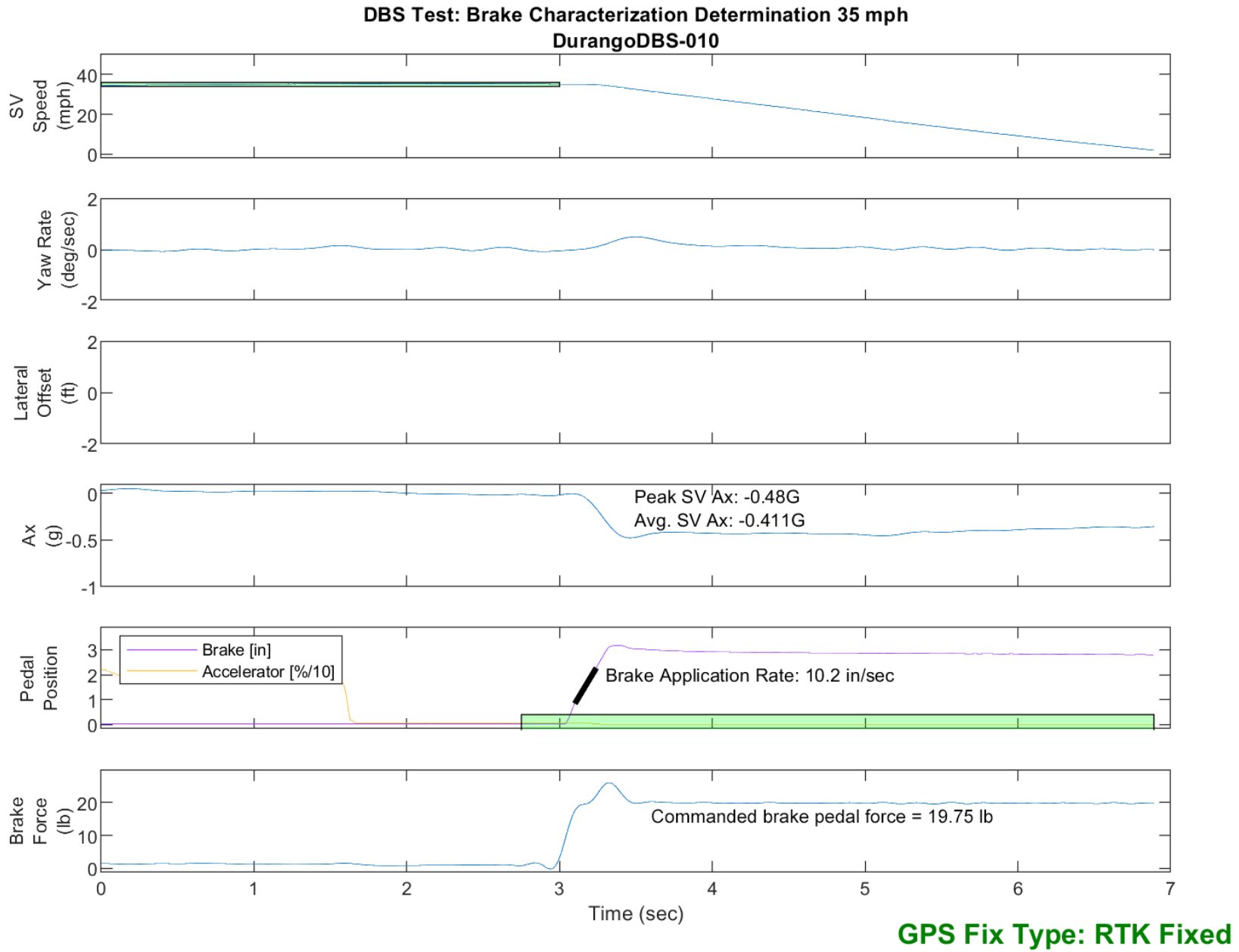


Figure E74. Time History for DBS Run 10, Brake Characterization Determination, Hybrid Mode, 35 mph

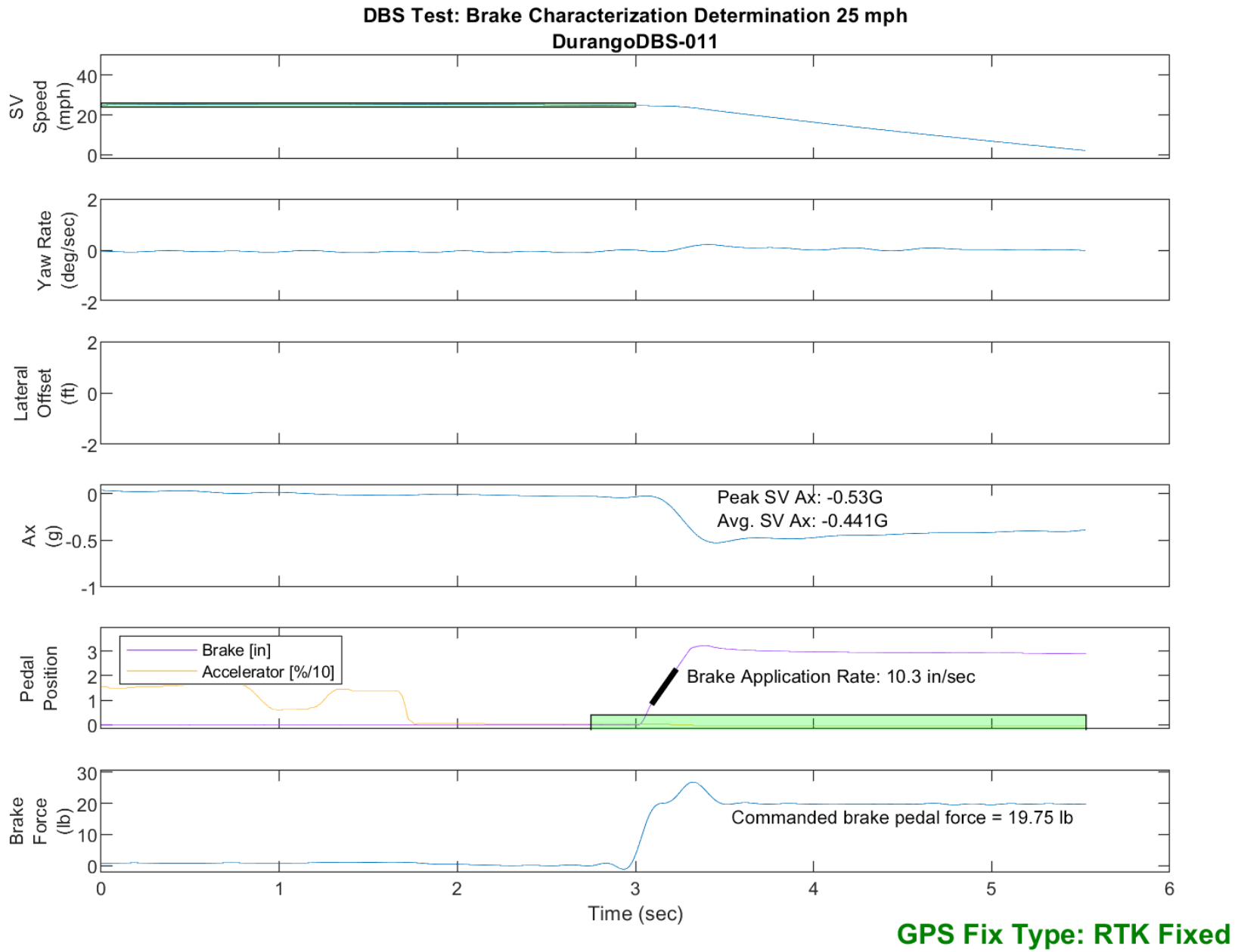


Figure E75. Time History for DBS Run 11, Brake Characterization Determination, Hybrid Mode, 25 mph

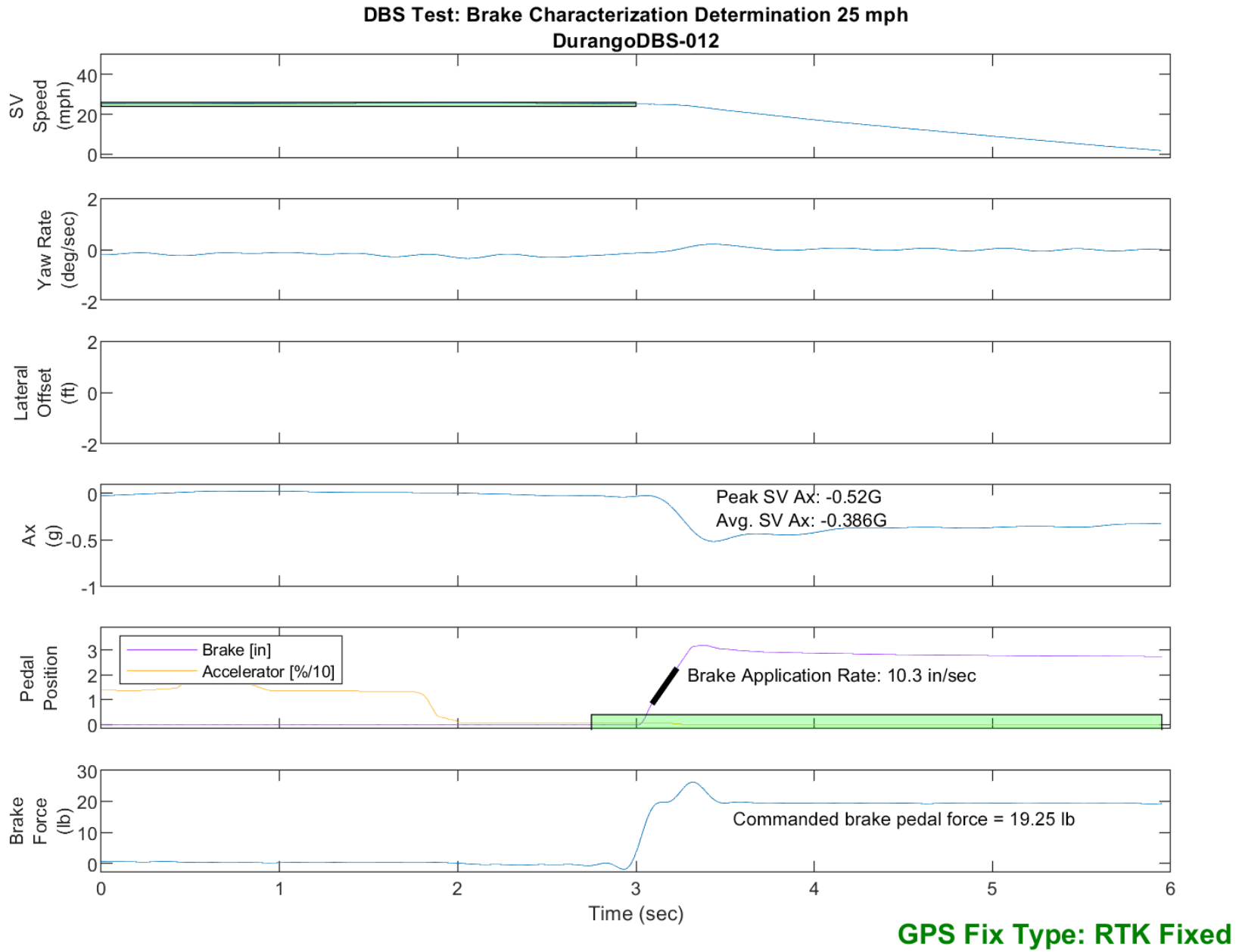


Figure E76. Time History for DBS Run 12, Brake Characterization Determination, Hybrid Mode, 25 mph

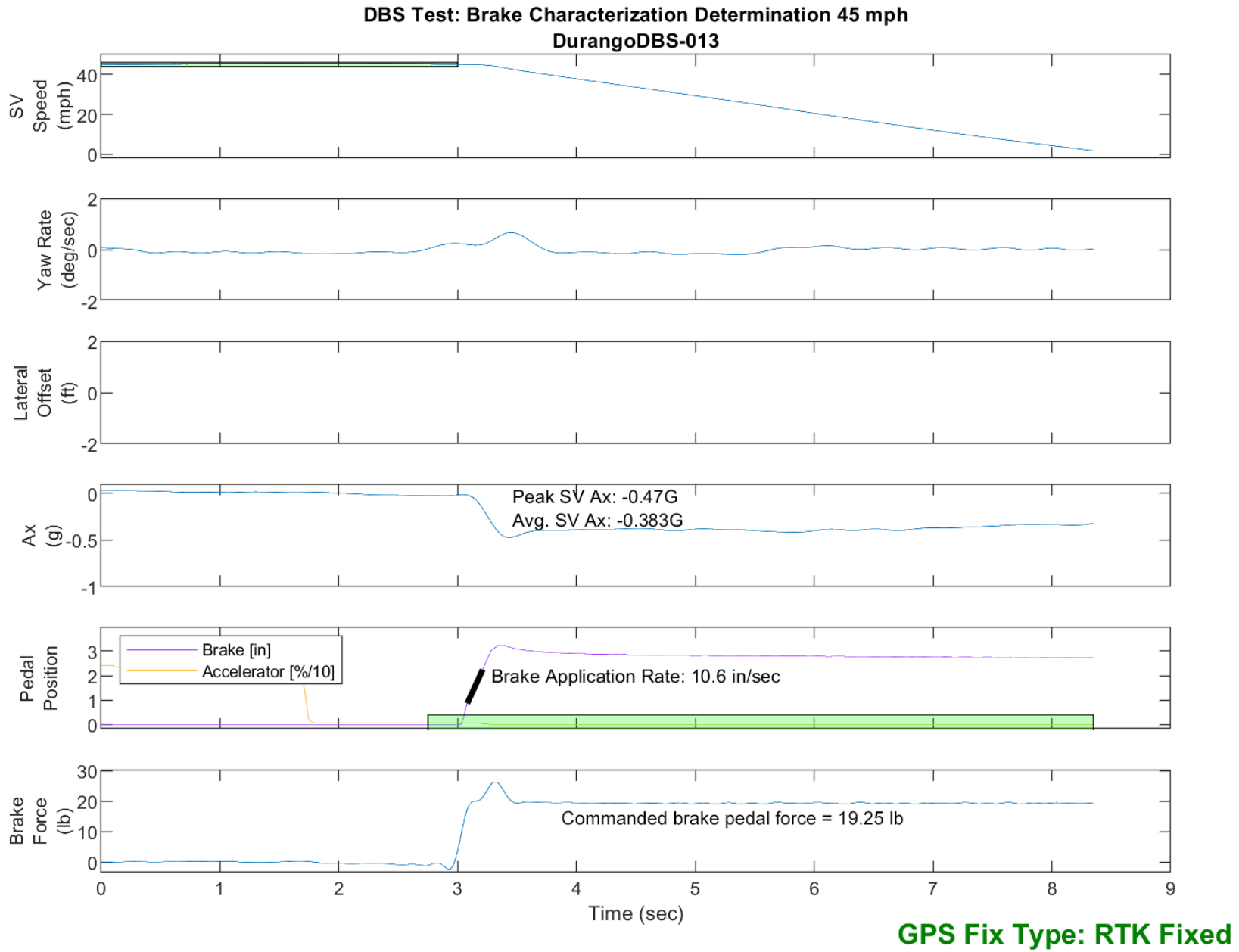


Figure E77. Time History for DBS Run 13, Brake Characterization Determination, Hybrid Mode, 45 mph

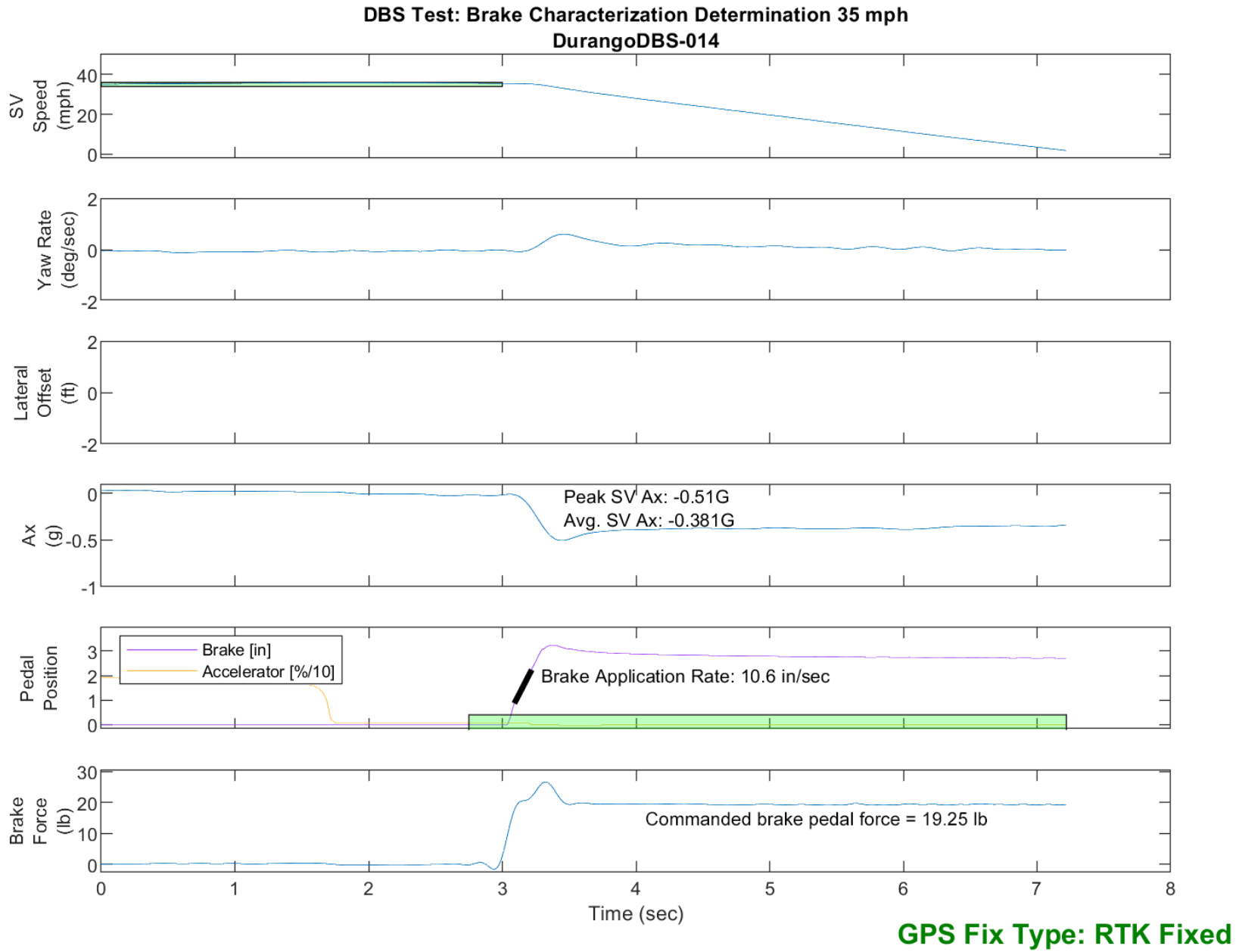


Figure E78. Time History for DBS Run 14, Brake Characterization Determination, Hybrid Mode, 35 mph



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 16, SV Encounters Stopped POV .....	E-23
Figure E14. Time History for DBS Run 17, SV Encounters Stopped POV .....	E-24
Figure E15. Time History for DBS Run 18, SV Encounters Stopped POV .....	E-25
Figure E16. Time History for DBS Run 19, SV Encounters Stopped POV .....	E-26
Figure E17. Time History for DBS Run 20, SV Encounters Stopped POV .....	E-27
Figure E18. Time History for DBS Run 22, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-28
Figure E19. Time History for DBS Run 23, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-29
Figure E20. Time History for DBS Run 24, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-30
Figure E21. Time History for DBS Run 25, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-31
Figure E22. Time History for DBS Run 27, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-32
Figure E23. Time History for DBS Run 84, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-33
Figure E24. Time History for DBS Run 85, SV Encounters Slower POV, SV 25 mph, POV 10 mph .....	E-34
Figure E25. Time History for DBS Run 29, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-35
Figure E26. Time History for DBS Run 30, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-36
Figure E27. Time History for DBS Run 31, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-37
Figure E28. Time History for DBS Run 32, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-38
Figure E29. Time History for DBS Run 33, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-39

Figure E30. Time History for DBS Run 34, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-40
Figure E31. Time History for DBS Run 35, SV Encounters Slower POV, SV 45 mph, POV 20 mph .....	E-41
Figure E32. Time History for DBS Run 38, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-42
Figure E33. Time History for DBS Run 41, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-43
Figure E34. Time History for DBS Run 44, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-44
Figure E35. Time History for DBS Run 45, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-45
Figure E36. Time History for DBS Run 46, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph .....	E-46
Figure E37. Time History for DBS Run 49, False Positive Baseline, SV 25 mph .....	E-47
Figure E38. Time History for DBS Run 50, False Positive Baseline, SV 25 mph .....	E-48
Figure E39. Time History for DBS Run 51, False Positive Baseline, SV 25 mph .....	E-49
Figure E40. Time History for DBS Run 52, False Positive Baseline, SV 25 mph .....	E-50
Figure E41. Time History for DBS Run 53, False Positive Baseline, SV 25 mph .....	E-51
Figure E42. Time History for DBS Run 54, False Positive Baseline, SV 25 mph .....	E-52
Figure E43. Time History for DBS Run 55, False Positive Baseline, SV 25 mph .....	E-53
Figure E44. Time History for DBS Run 57, False Positive Baseline, SV 45 mph .....	E-54
Figure E45. Time History for DBS Run 58, False Positive Baseline, SV 45 mph .....	E-55
Figure E46. Time History for DBS Run 59, False Positive Baseline, SV 45 mph .....	E-56
Figure E47. Time History for DBS Run 60, False Positive Baseline, SV 45 mph .....	E-57
Figure E48. Time History for DBS Run 61, False Positive Baseline, SV 45 mph .....	E-58
Figure E49. Time History for DBS Run 62, False Positive Baseline, SV 45 mph .....	E-59
Figure E50. Time History for DBS Run 64, False Positive Baseline, SV 45 mph .....	E-60
Figure E51. Time History for DBS Run 66, SV Encounters Steel Trench Plate, SV 25 mph .....	E-61
Figure E52. Time History for DBS Run 67, SV Encounters Steel Trench Plate, SV 25 mph .....	E-62
Figure E53. Time History for DBS Run 68, SV Encounters Steel Trench Plate, SV 25 mph .....	E-63
Figure E54. Time History for DBS Run 69, SV Encounters Steel Trench Plate, SV 25 mph .....	E-64
Figure E55. Time History for DBS Run 70, SV Encounters Steel Trench Plate, SV 25 mph .....	E-65
Figure E56. Time History for DBS Run 71, SV Encounters Steel Trench Plate, SV 25 mph .....	E-66
Figure E57. Time History for DBS Run 72, SV Encounters Steel Trench Plate, SV 25 mph .....	E-67
Figure E58. Time History for DBS Run 74, SV Encounters Steel Trench Plate, SV 45 mph .....	E-68
Figure E59. Time History for DBS Run 75, SV Encounters Steel Trench Plate, SV 45 mph .....	E-69

Figure E60.	Time History for DBS Run 76, SV Encounters Steel Trench Plate, SV 45 mph .....	E-70
Figure E61.	Time History for DBS Run 77, SV Encounters Steel Trench Plate, SV 45 mph .....	E-71
Figure E62.	Time History for DBS Run 78, SV Encounters Steel Trench Plate, SV 45 mph .....	E-72
Figure E63.	Time History for DBS Run 79, SV Encounters Steel Trench Plate, SV 45 mph .....	E-73
Figure E64.	Time History for DBS Run 80, SV Encounters Steel Trench Plate, SV 45 mph .....	E-74
Figure E65.	Time History for DBS Run 1, Brake Characterization Initial .....	E-75
Figure E66.	Time History for DBS Run 2, Brake Characterization Initial .....	E-76
Figure E67.	Time History for DBS Run 3, Brake Characterization Initial .....	E-77
Figure E68.	Time History for DBS Run 4, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-78
Figure E69.	Time History for DBS Run 5, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-79
Figure E70.	Time History for DBS Run 6, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-80
Figure E71.	Time History for DBS Run 7, Brake Characterization Determination, Displacement Mode, 35 mph .....	E-81
Figure E72.	Time History for DBS Run 8, Brake Characterization Determination, Displacement Mode, 25 mph .....	E-82
Figure E73.	Time History for DBS Run 9, Brake Characterization Determination, Displacement Mode, 45 mph .....	E-83
Figure E74.	Time History for DBS Run 10, Brake Characterization Determination, Hybrid Mode, 35 mph .....	E-84
Figure E75.	Time History for DBS Run 11, Brake Characterization Determination, Hybrid Mode, 25 mph .....	E-85
Figure E76.	Time History for DBS Run 12, Brake Characterization Determination, Hybrid Mode, 25 mph .....	E-86
Figure E77.	Time History for DBS Run 13, Brake Characterization Determination, Hybrid Mode, 45 mph .....	E-87
Figure E78.	Time History for DBS Run 14, Brake Characterization Determination, Hybrid Mode, 35 mph .....	E-88

## 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 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 Figures 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.

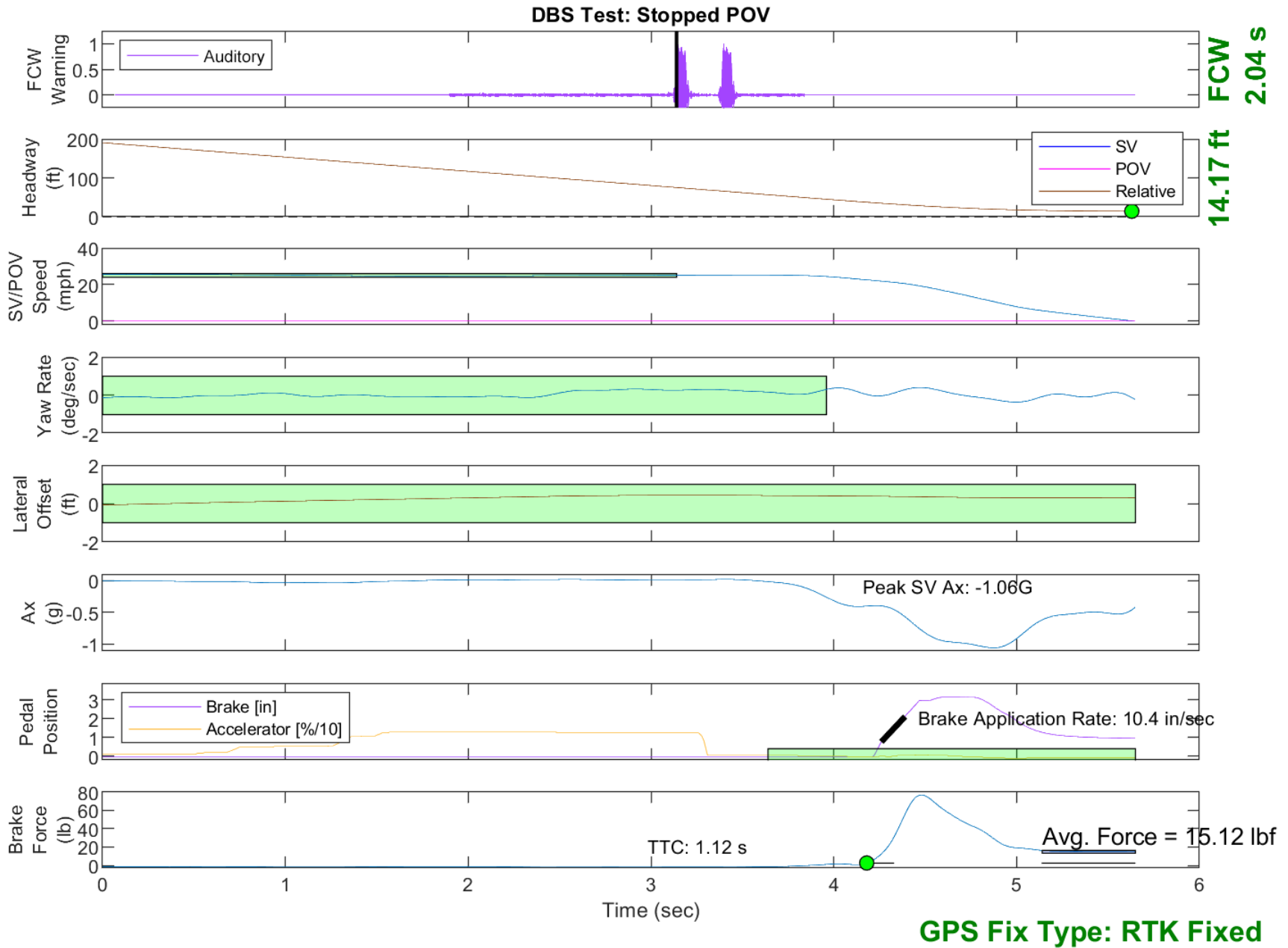


Figure E1. Example Time History for Stopped POV, Passing

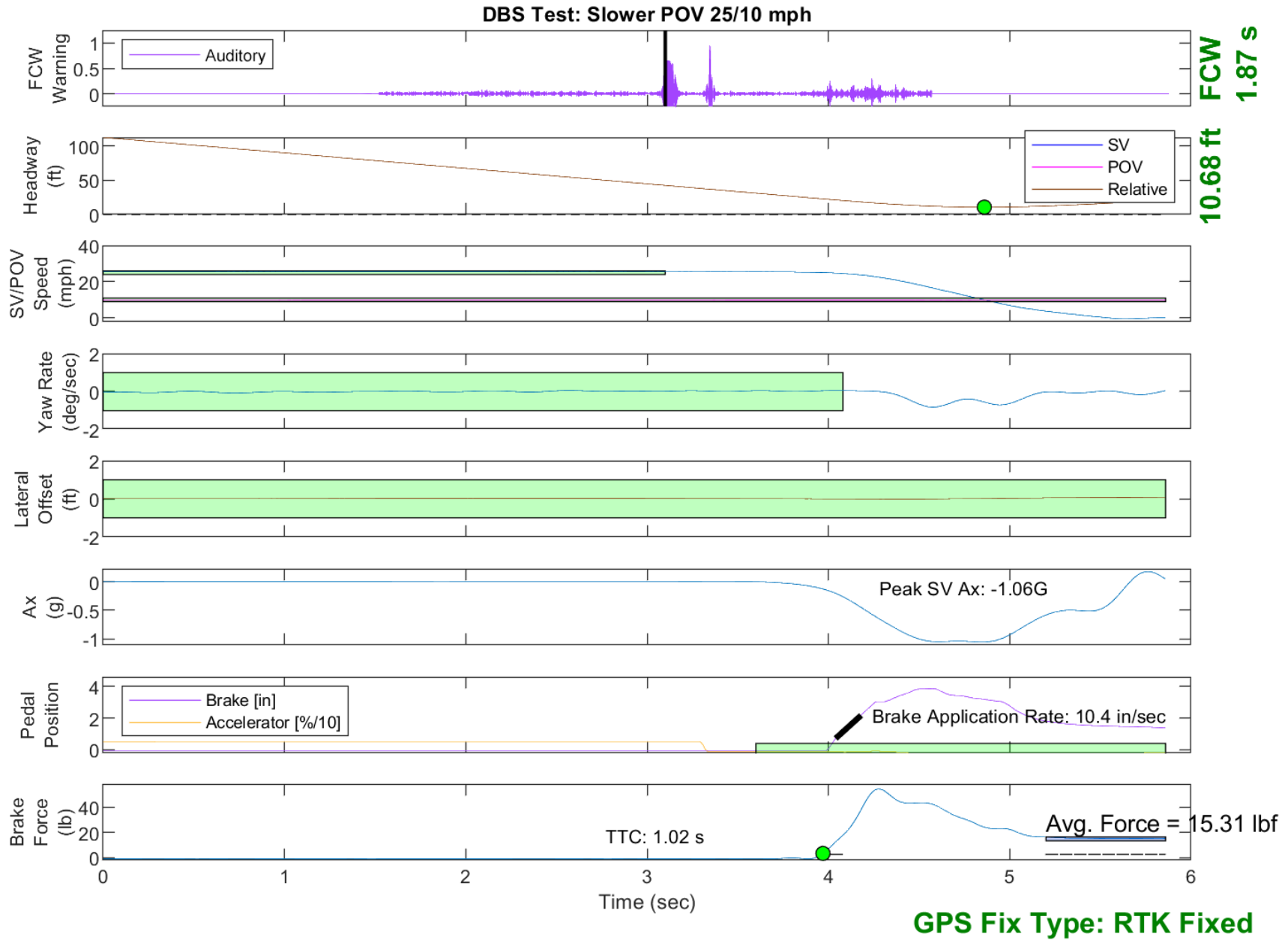


Figure E2. Example Time History for Slower POV 25 vs. 10, Passing

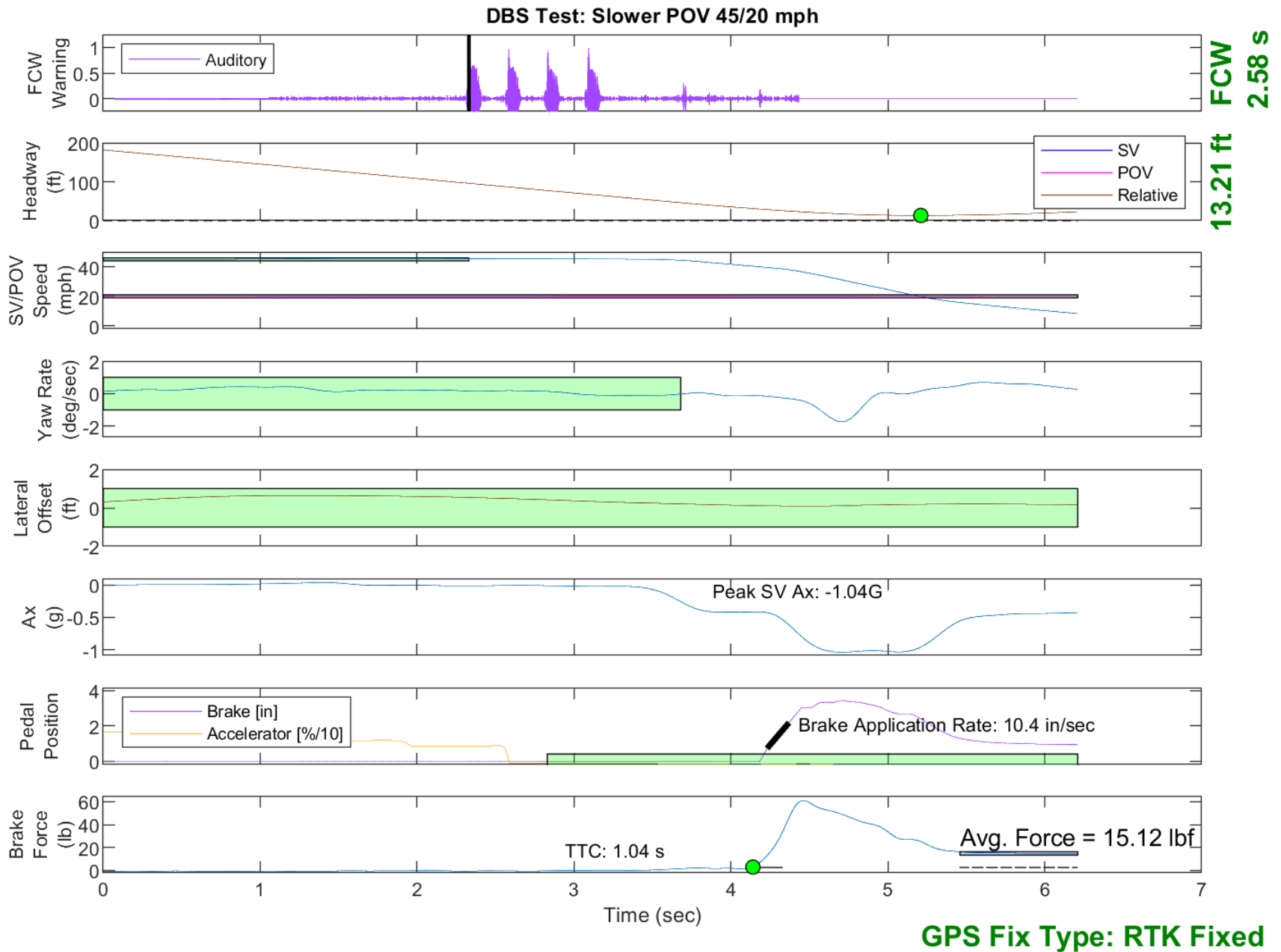


Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

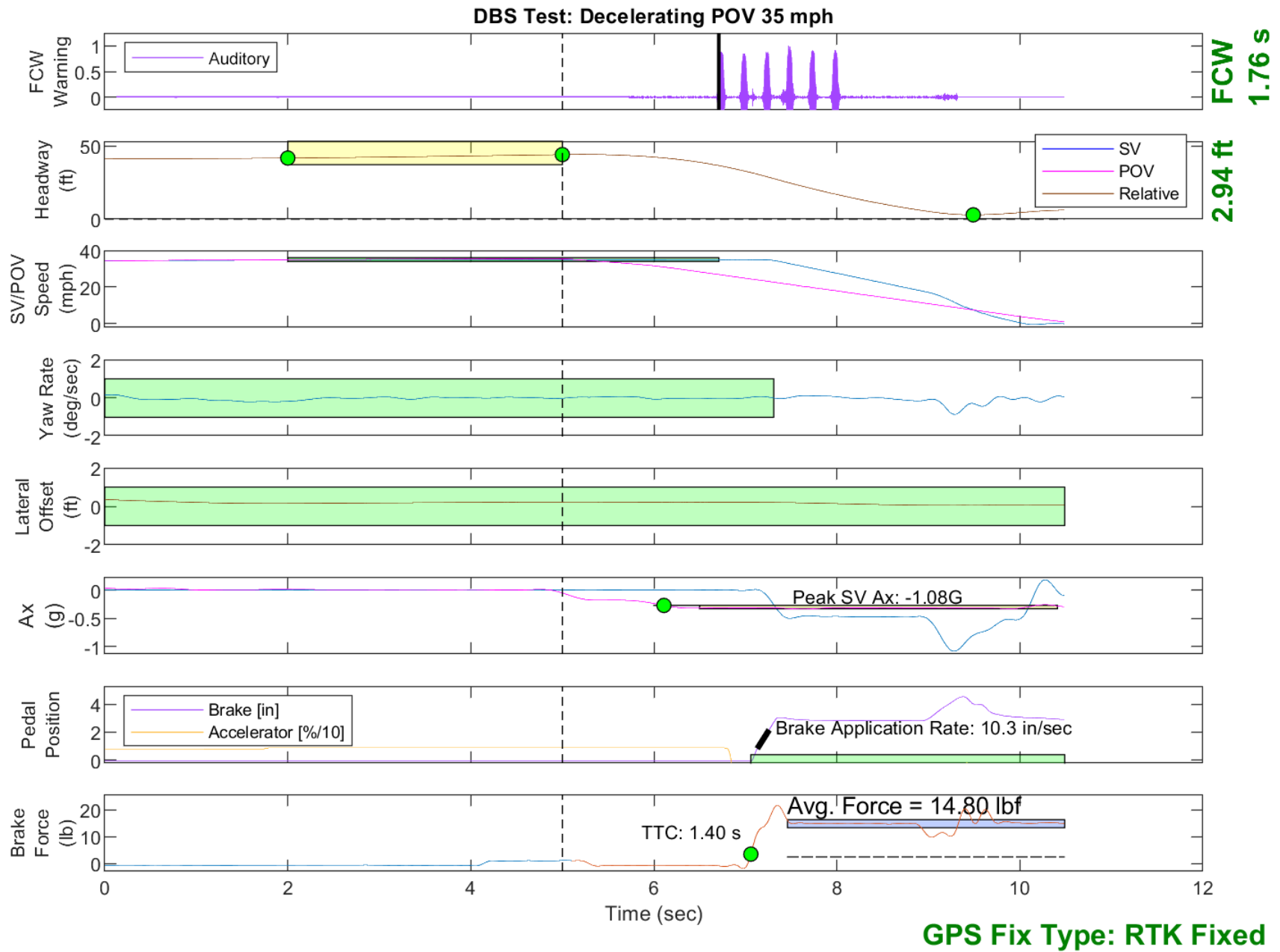
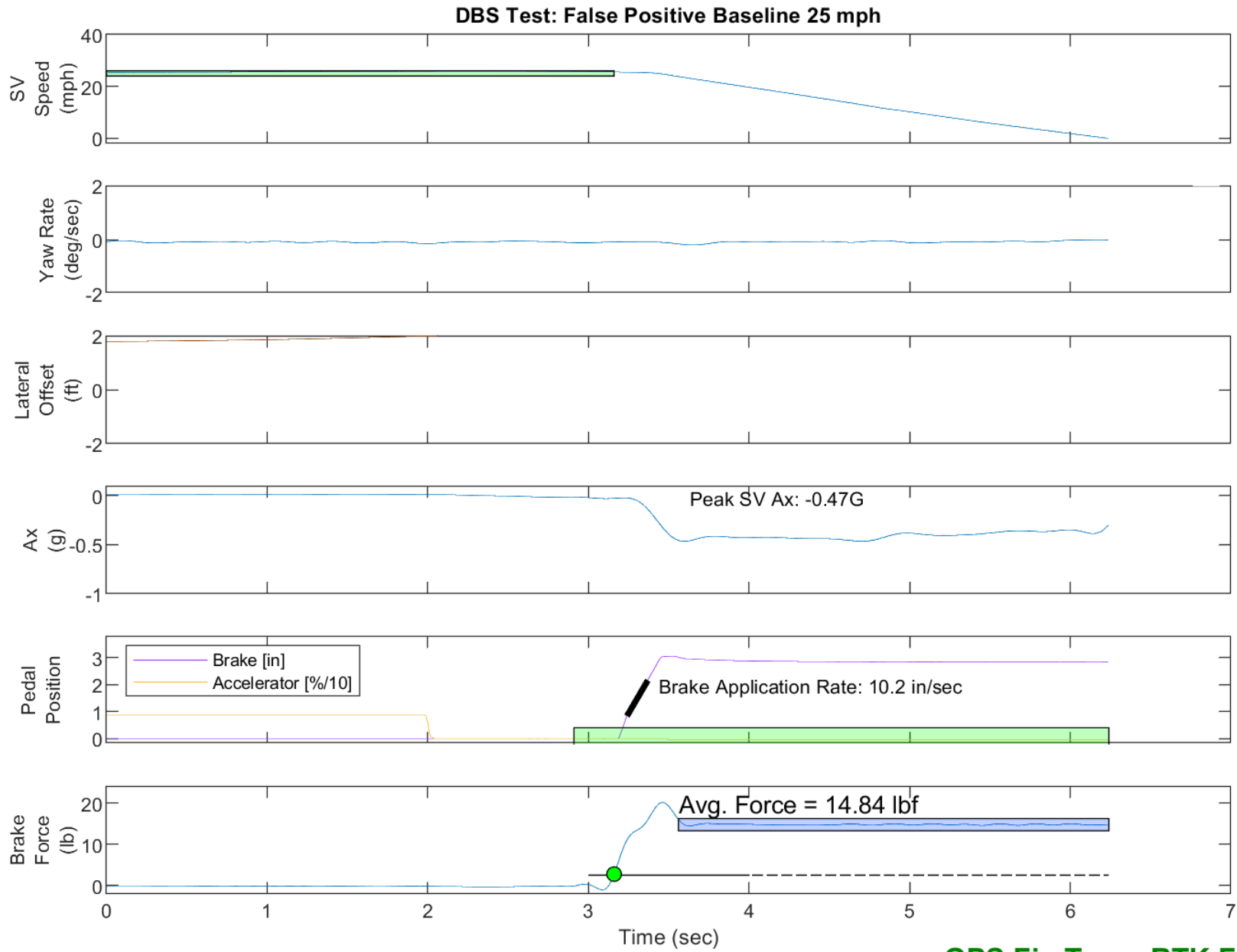
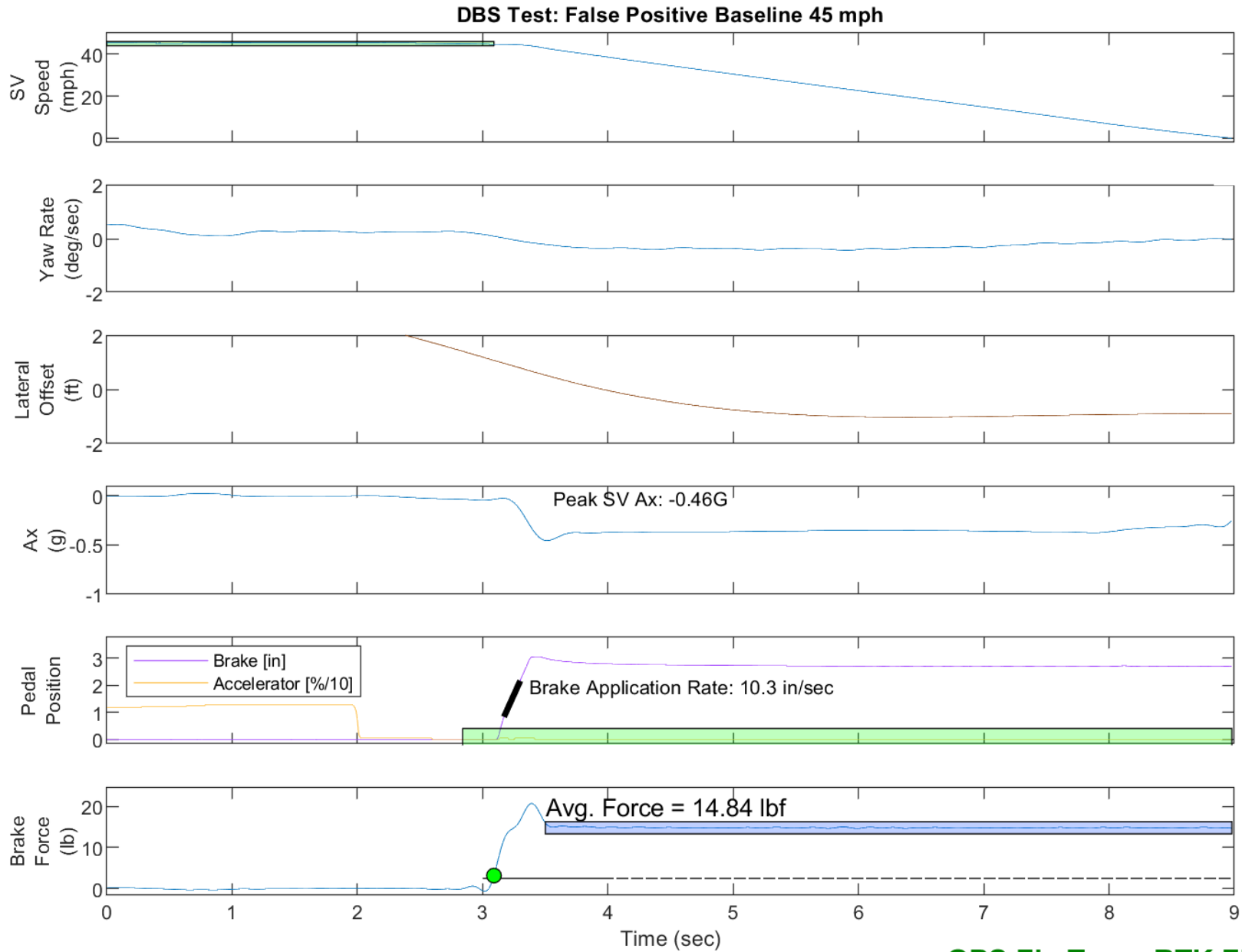


Figure E4. Example Time History for Decelerating POV 35, Passing



**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



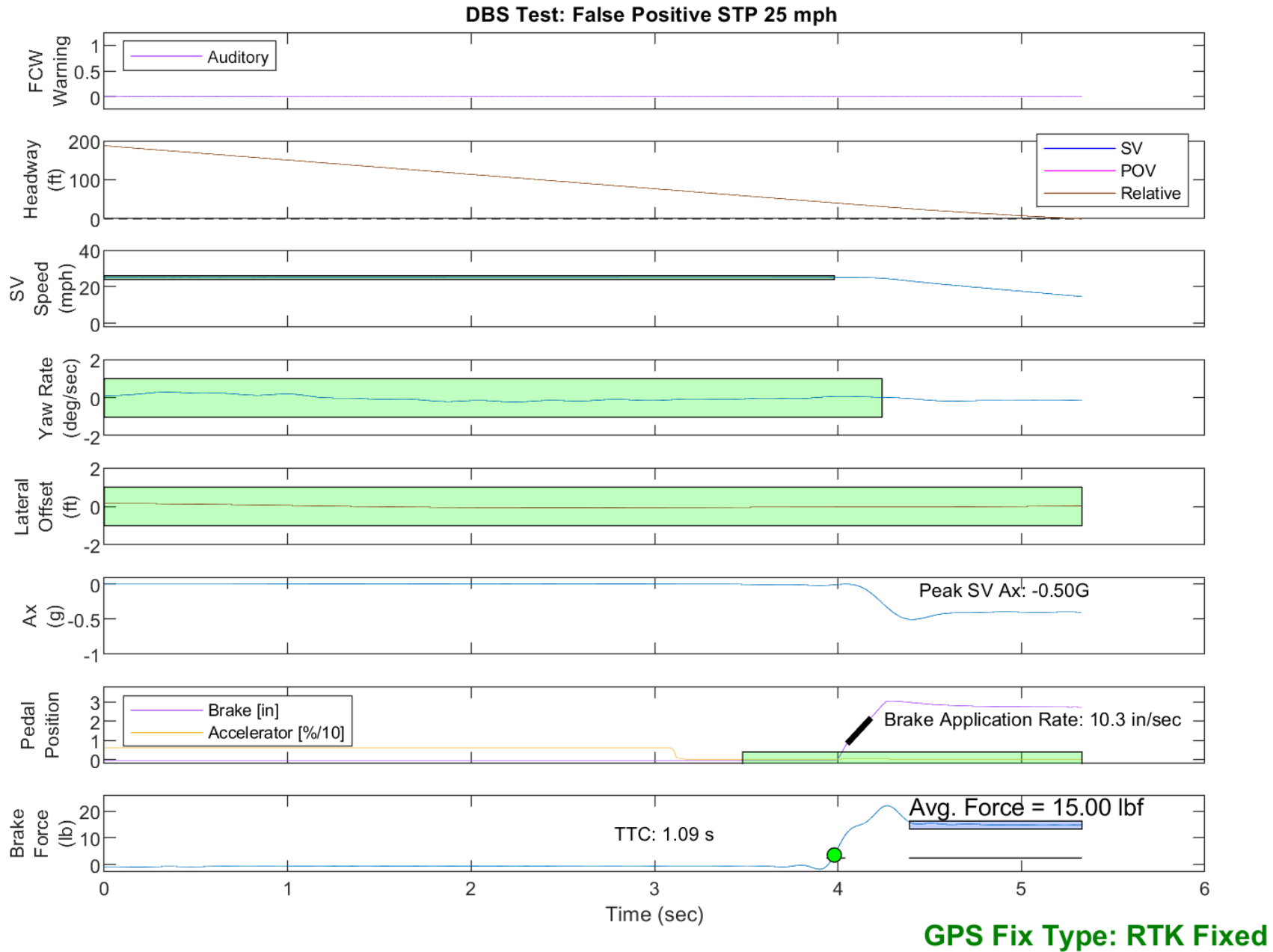
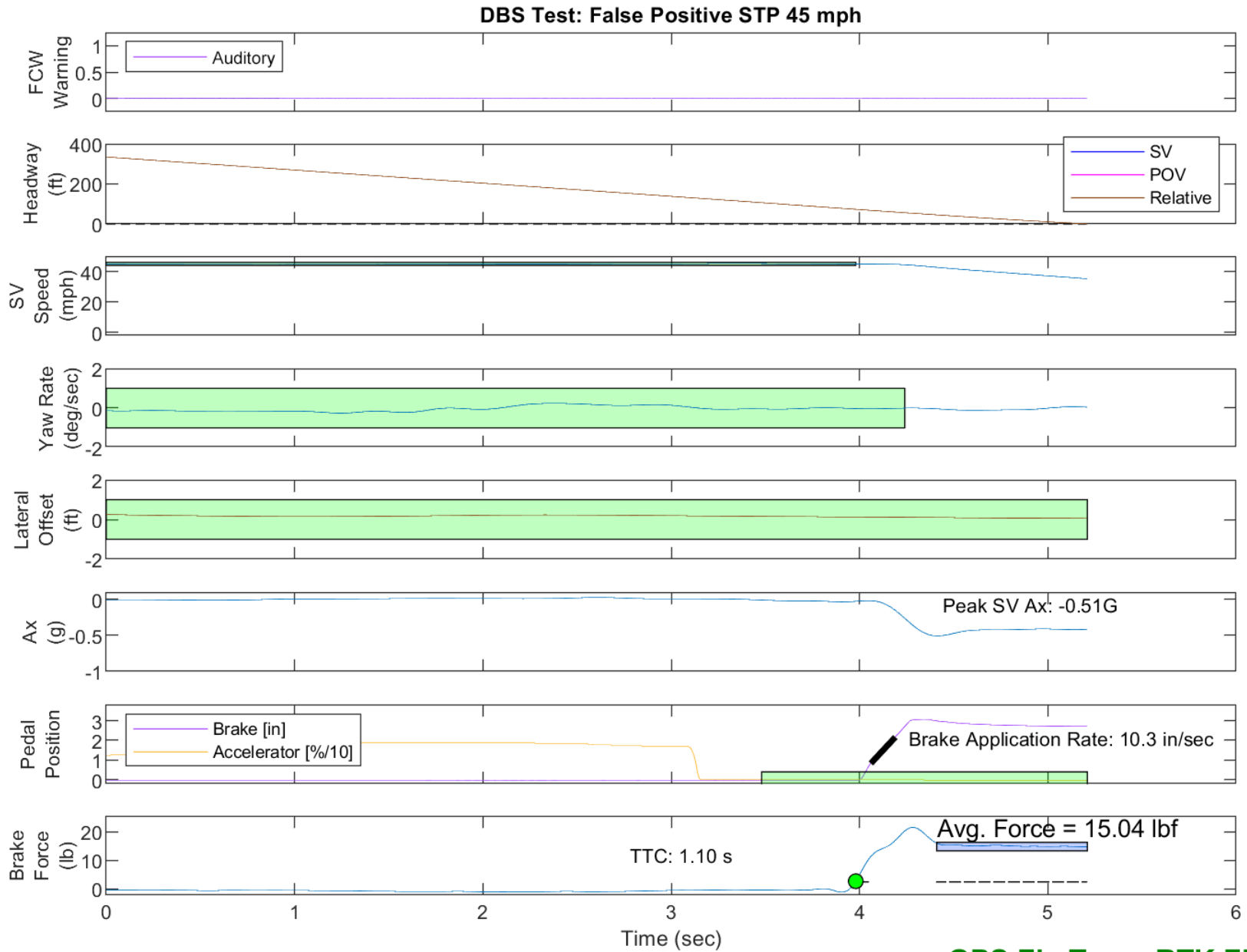


Figure E7. Example Time History for False Positive Steel Plate 25, Passing



**GPS Fix Type: RTK Fixed**

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

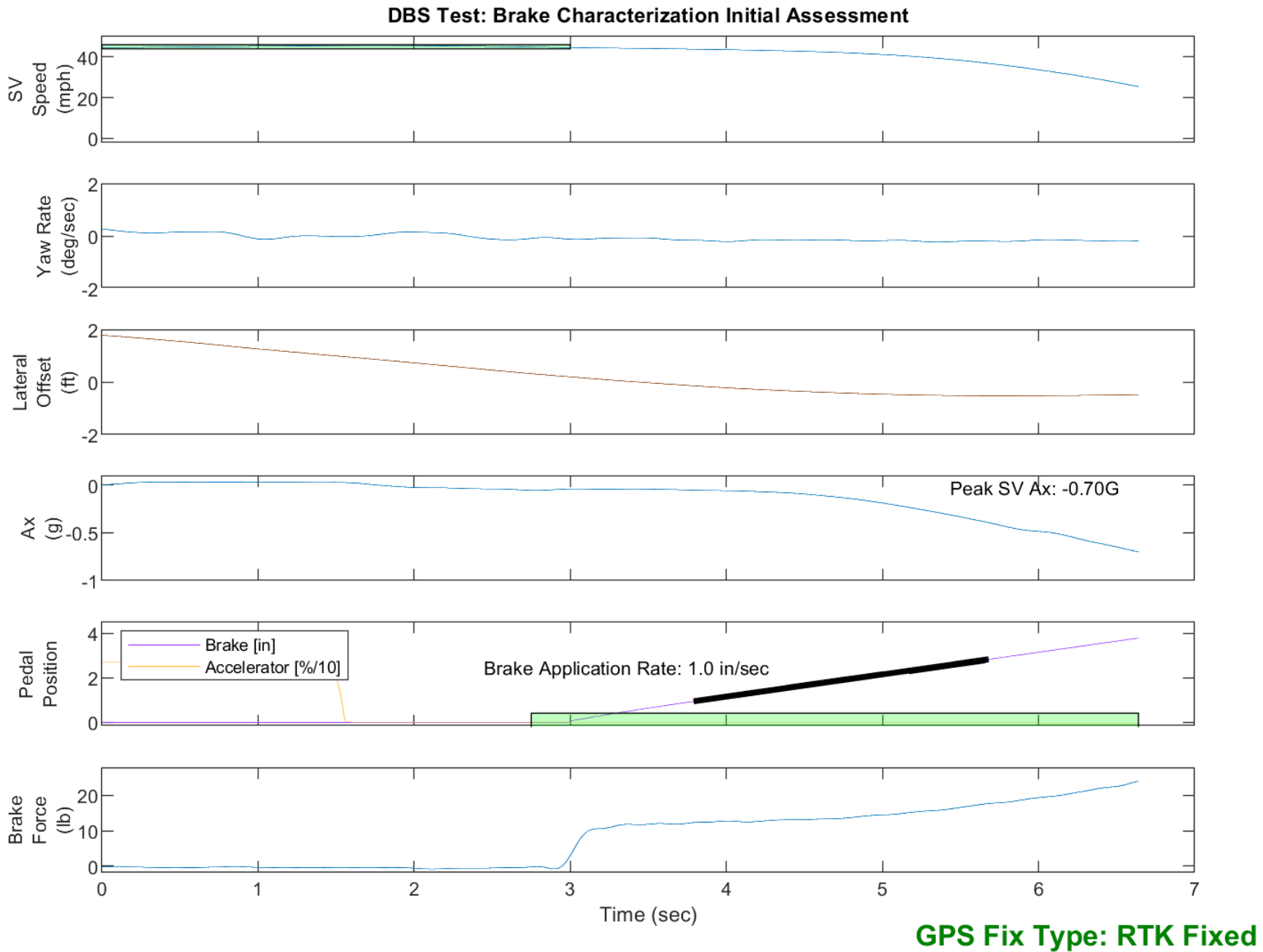


Figure E9. Example Time History for DBS Brake Characterization, Passing

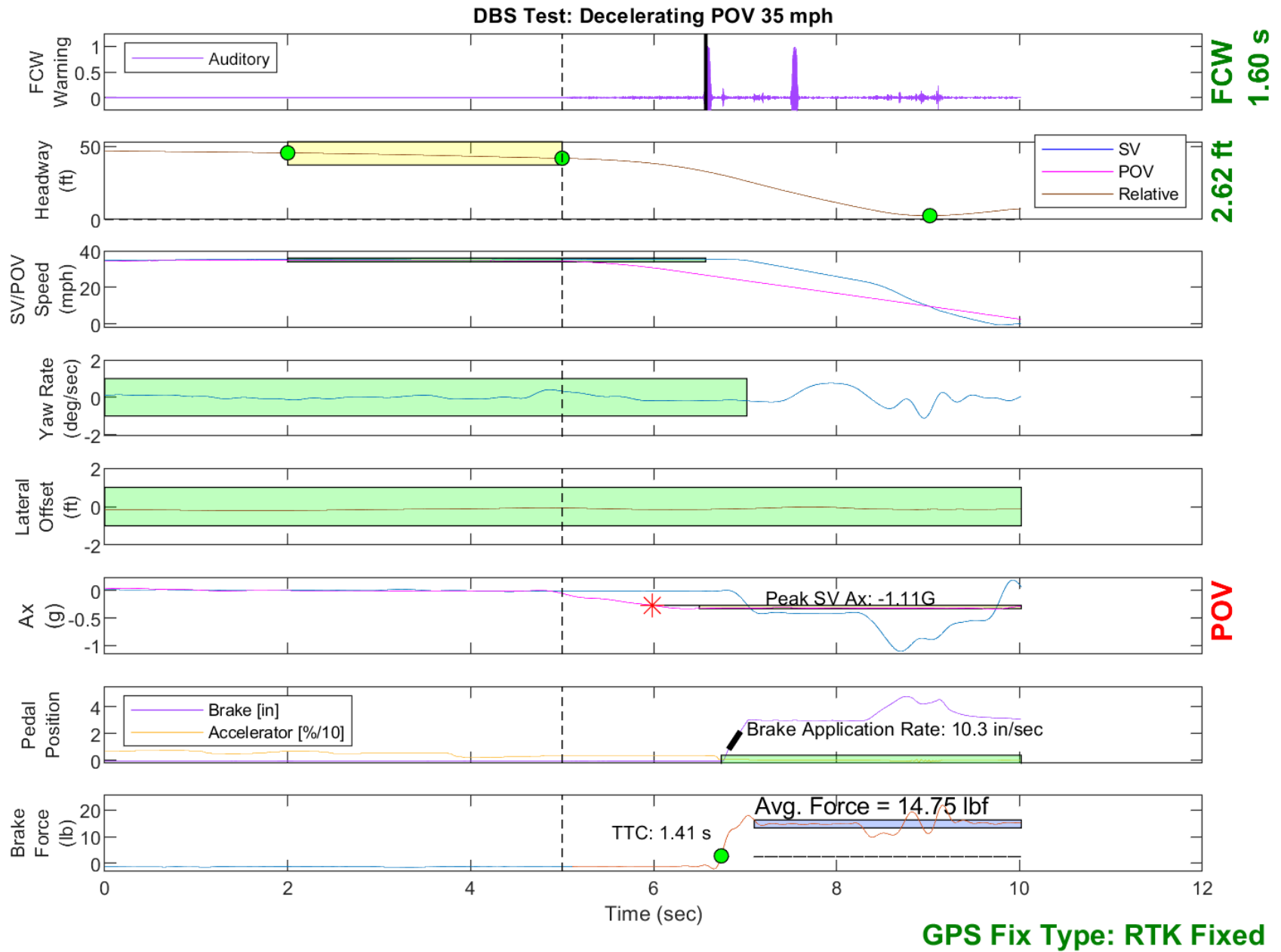
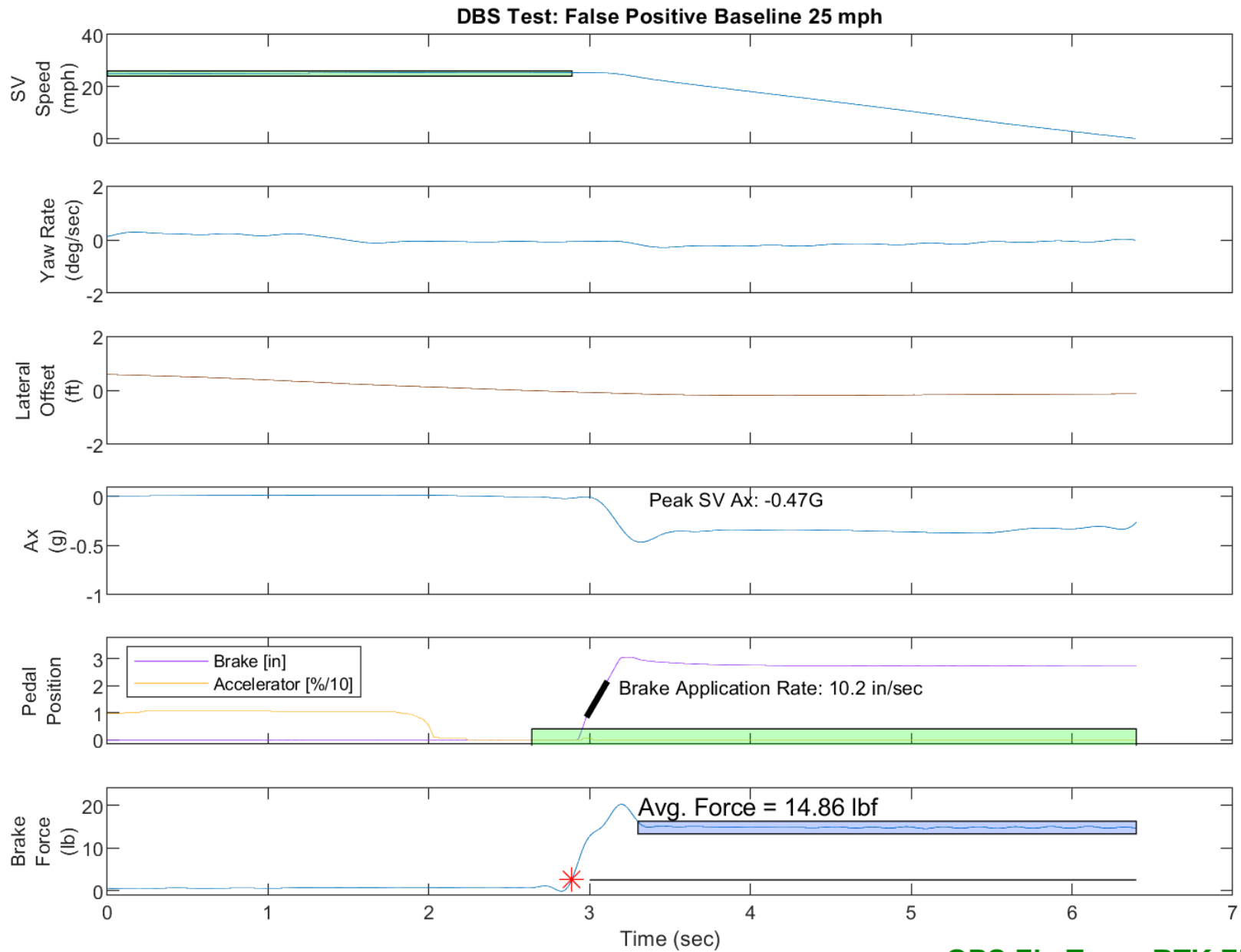


Figure E10. Example Time History Displaying Invalid POV Acceleration Criteria



**GPS Fix Type: RTK Fixed**

Figure E11. Example Time History Displaying Invalid Brake Force Criteria

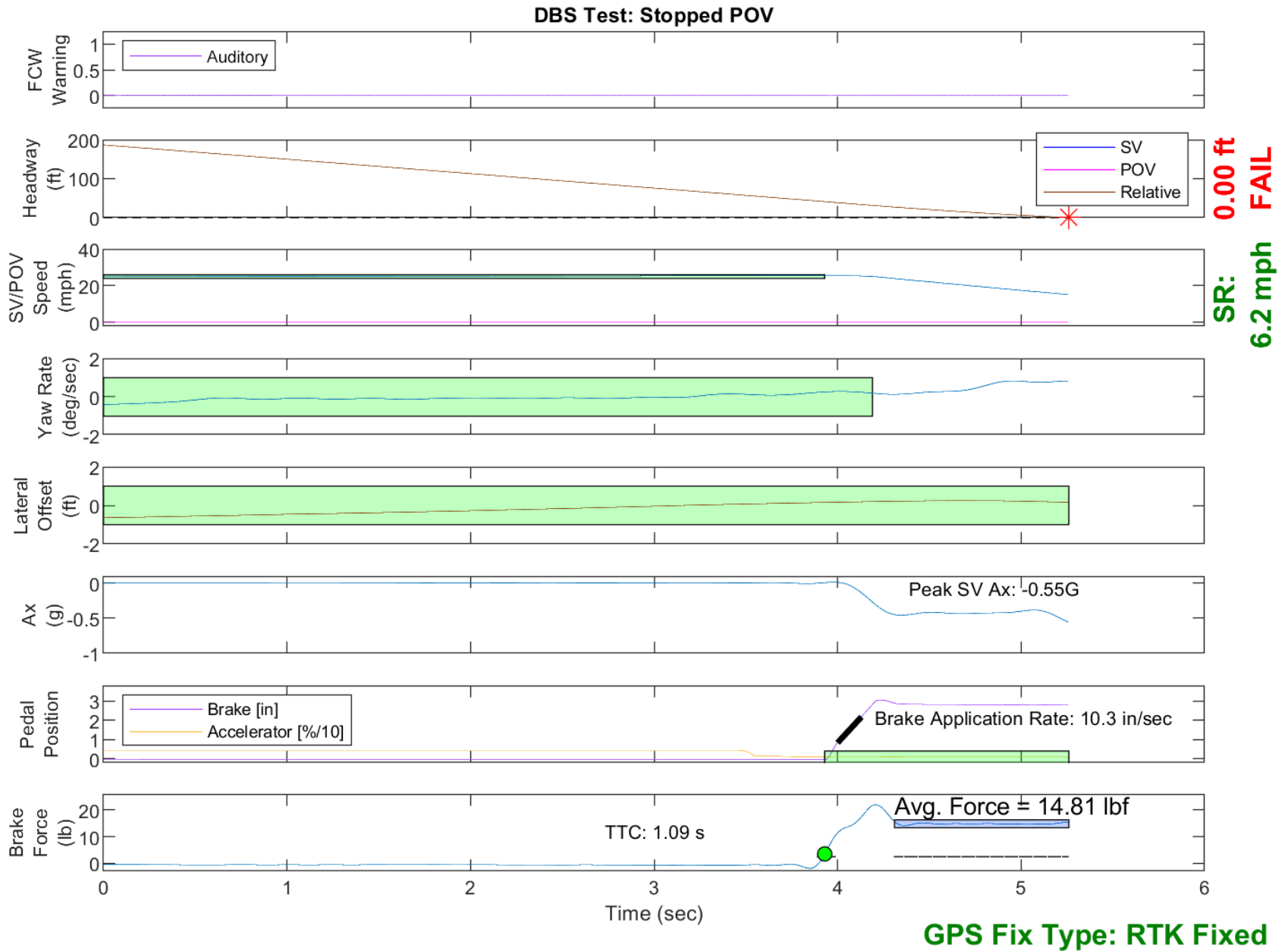


Figure E12. Example Time History for a Failed Run

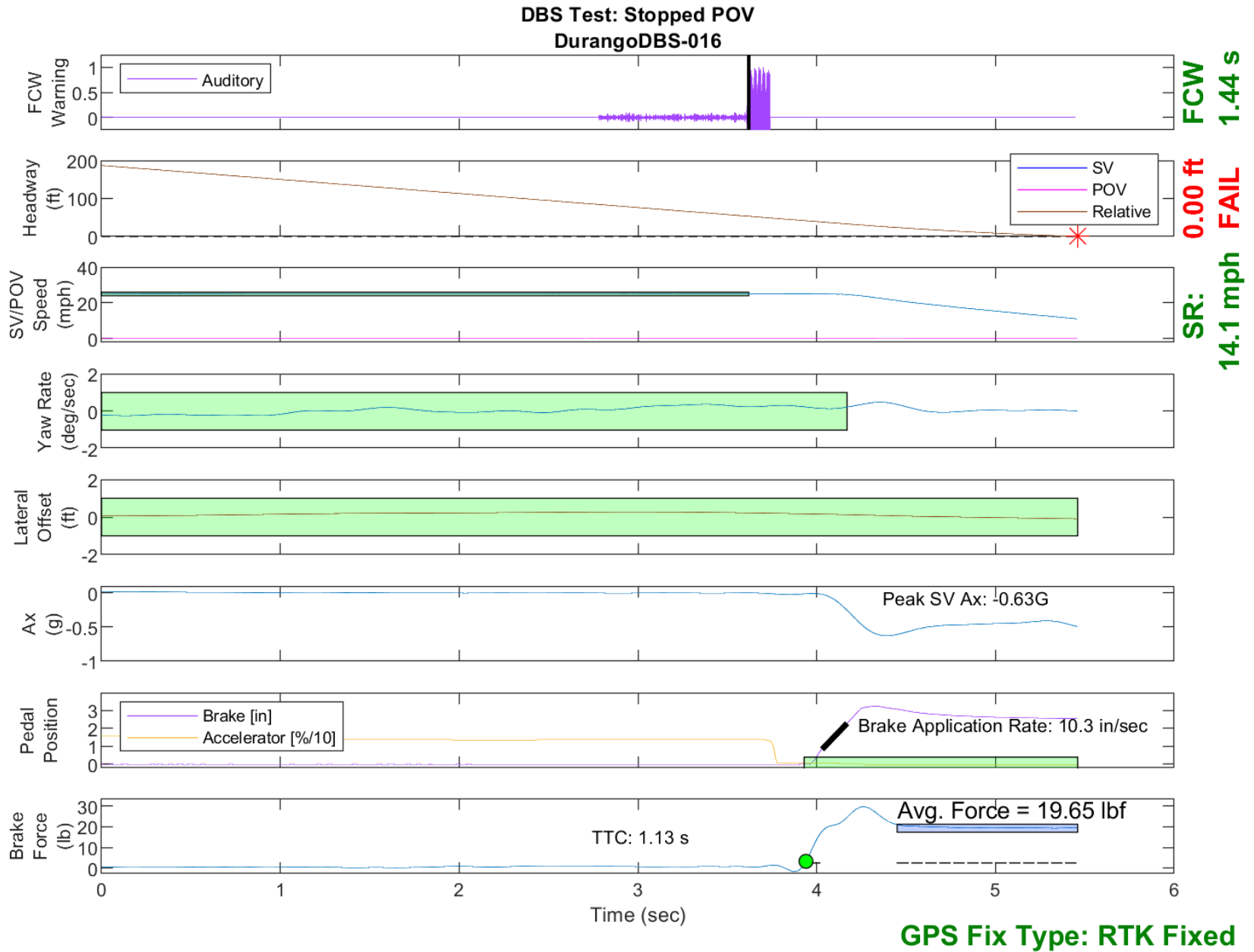


Figure E13. Time History for DBS Run 16, SV Encounters Stopped POV

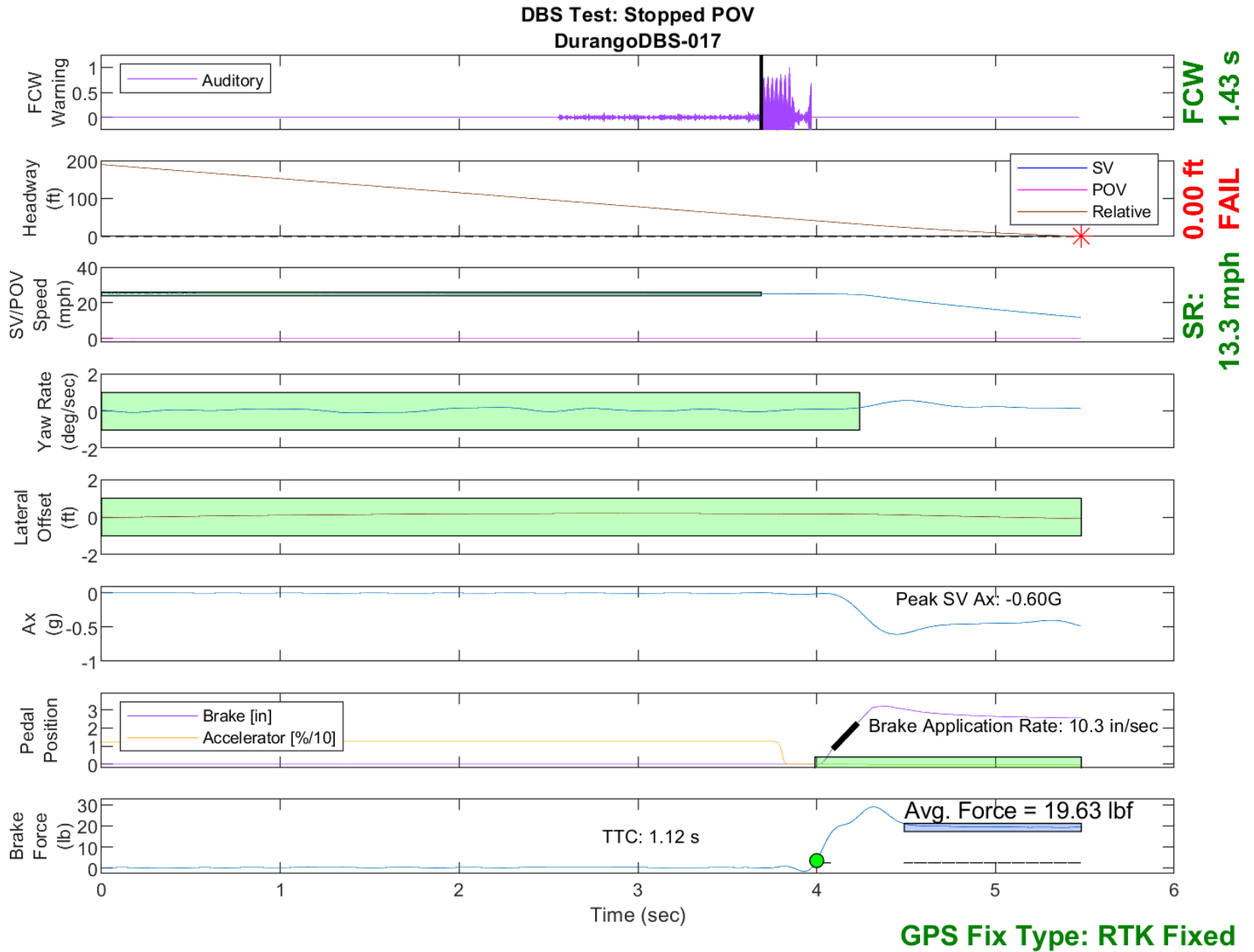


Figure E14. Time History for DBS Run 17, SV Encounters Stopped POV



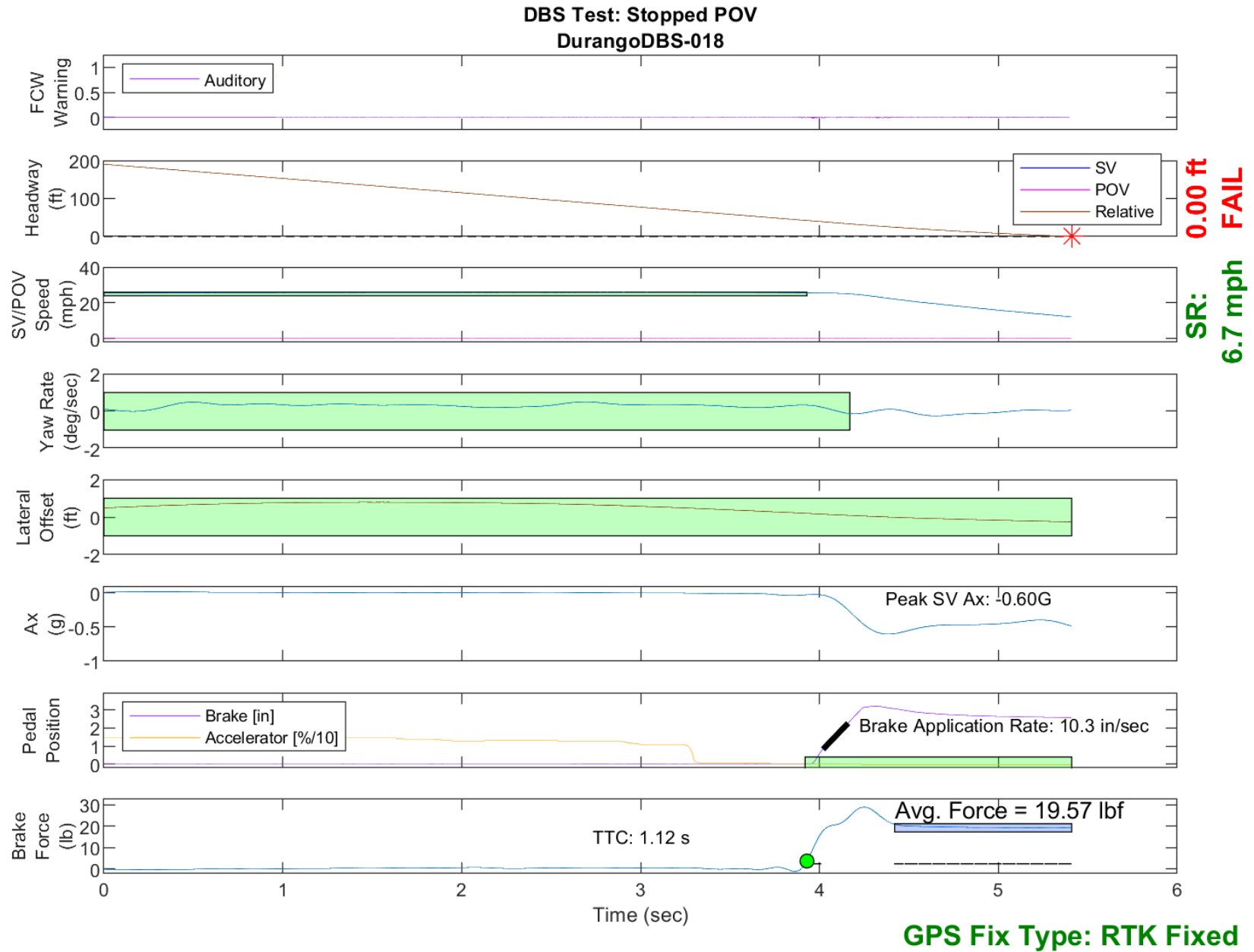


Figure E15. Time History for DBS Run 18, SV Encounters Stopped POV

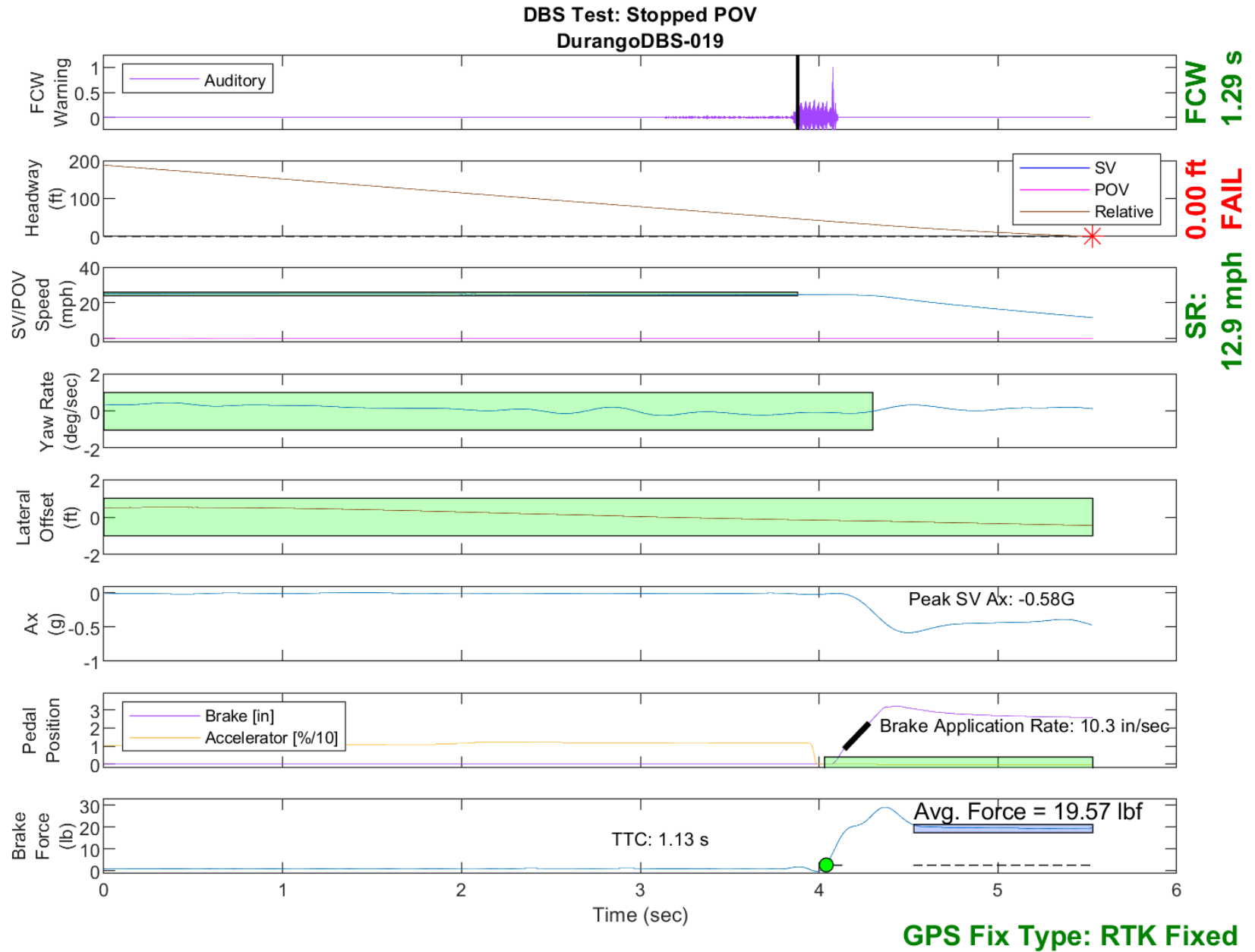


Figure E16. Time History for DBS Run 19, SV Encounters Stopped POV

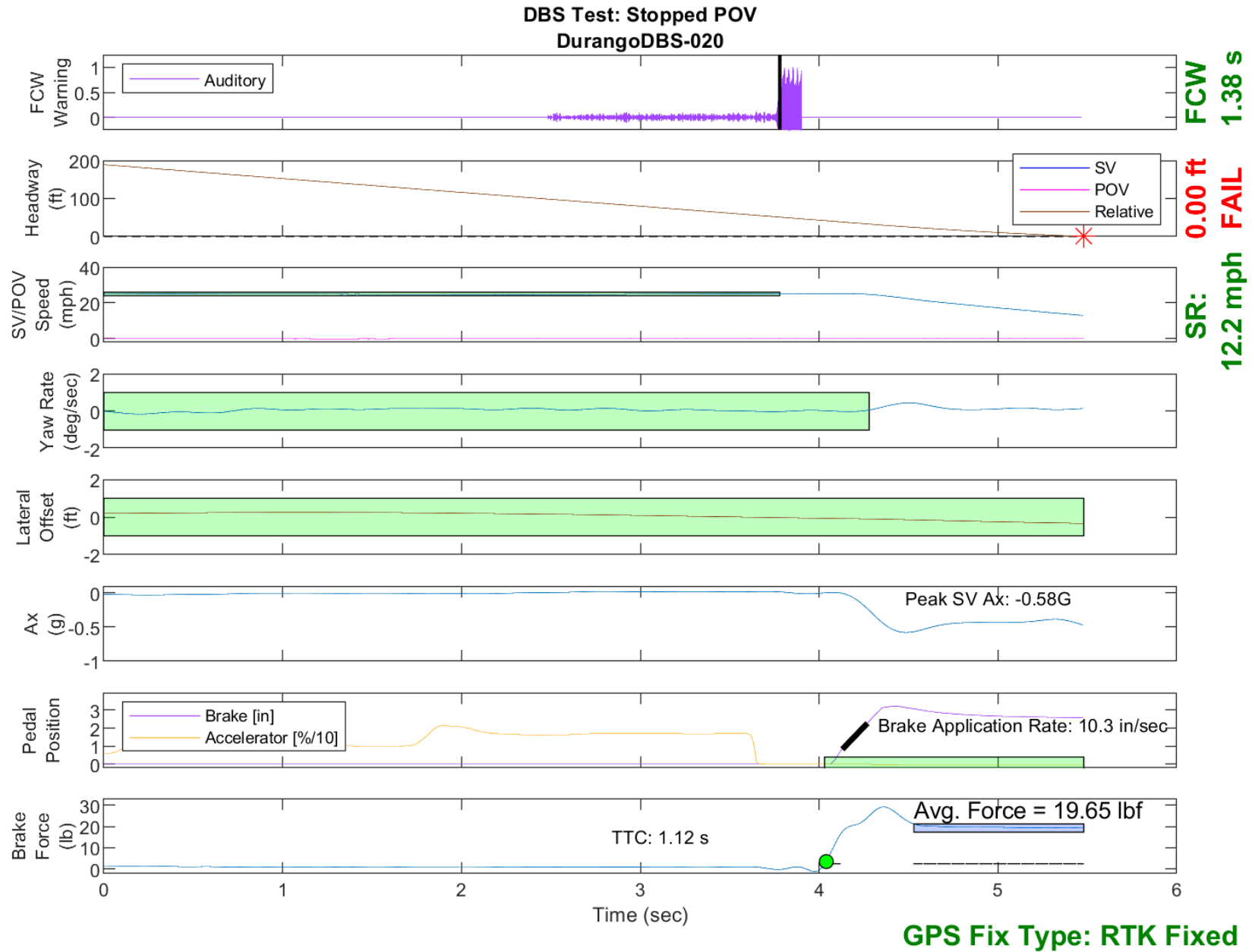


Figure E17. Time History for DBS Run 20, SV Encounters Stopped POV

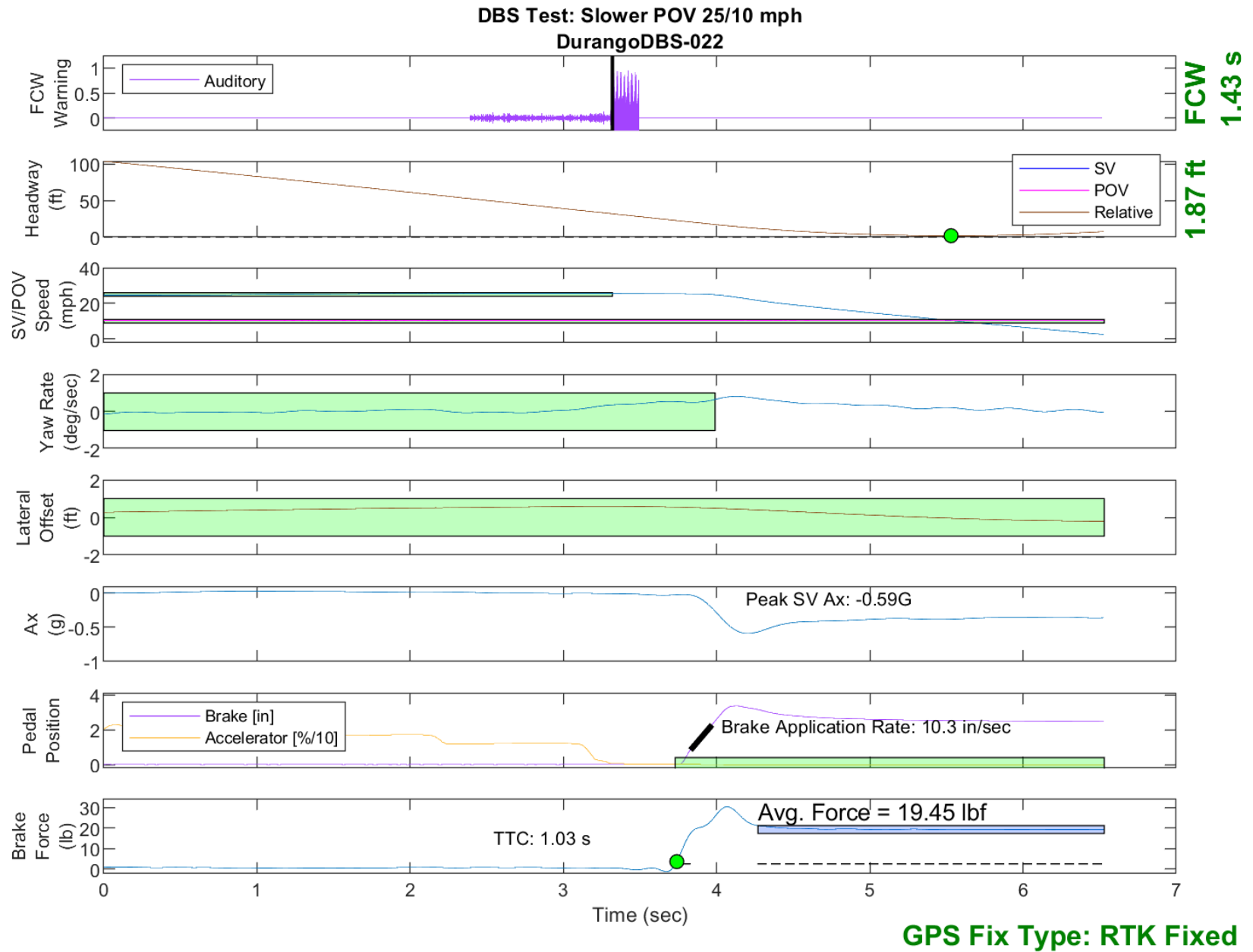


Figure E18. Time History for DBS Run 22, SV Encounters Slower POV, SV 25 mph, POV 10 mph

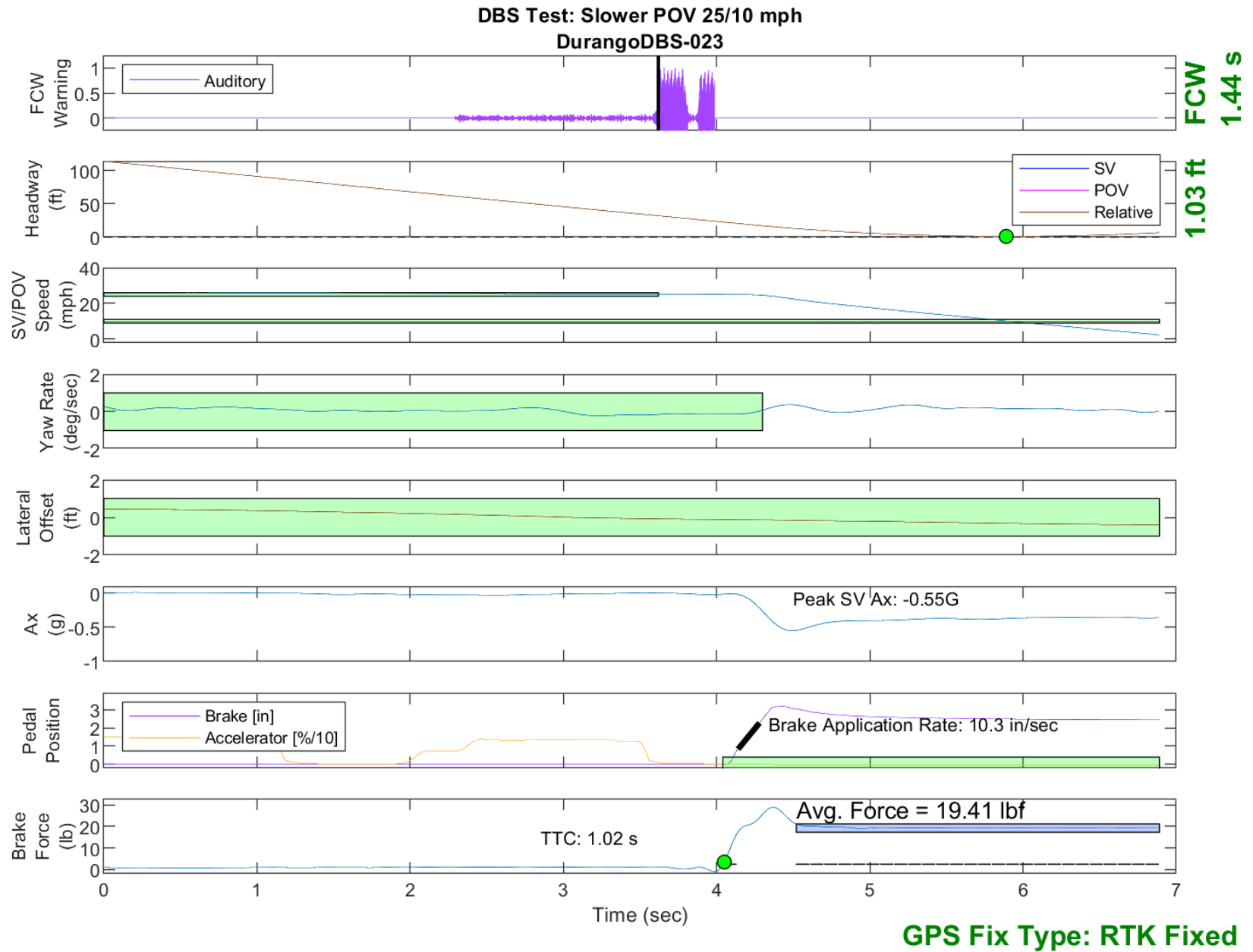


Figure E19. Time History for DBS Run 23, SV Encounters Slower POV, SV 25 mph, POV 10 mph

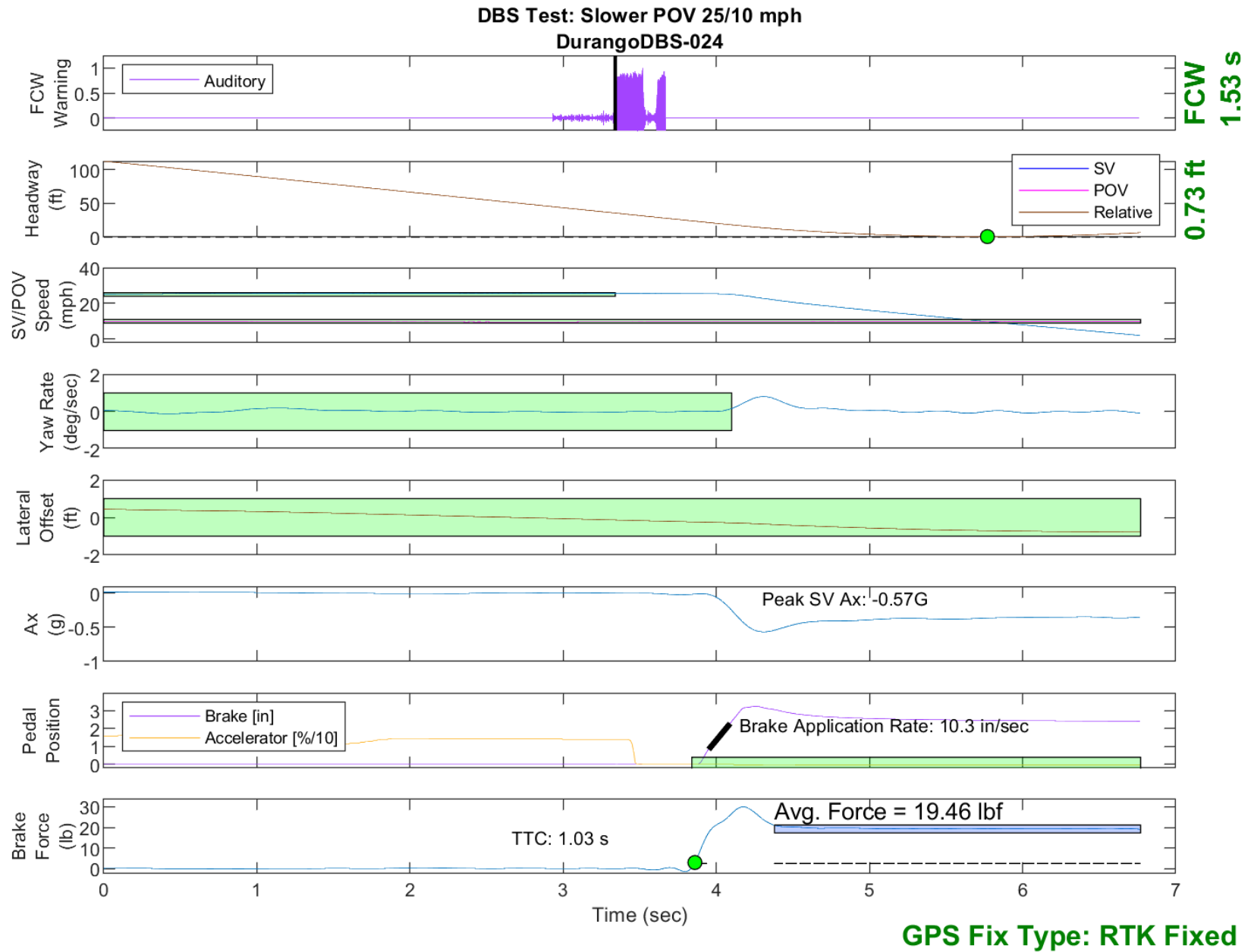


Figure E20. Time History for DBS Run 24, SV Encounters Slower POV, SV 25 mph, POV 10 mph

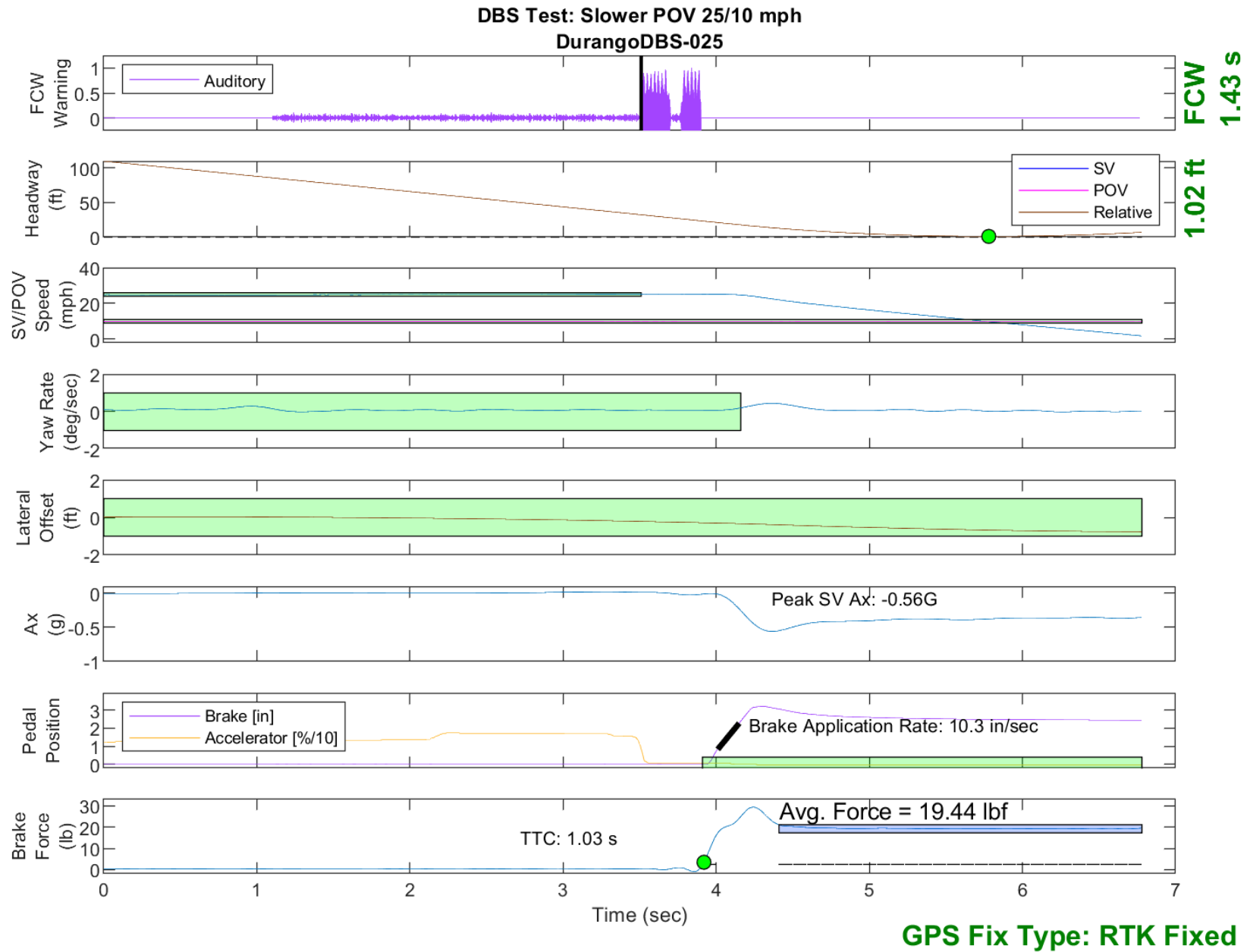


Figure E21. Time History for DBS Run 25, SV Encounters Slower POV, SV 25 mph, POV 10 mph

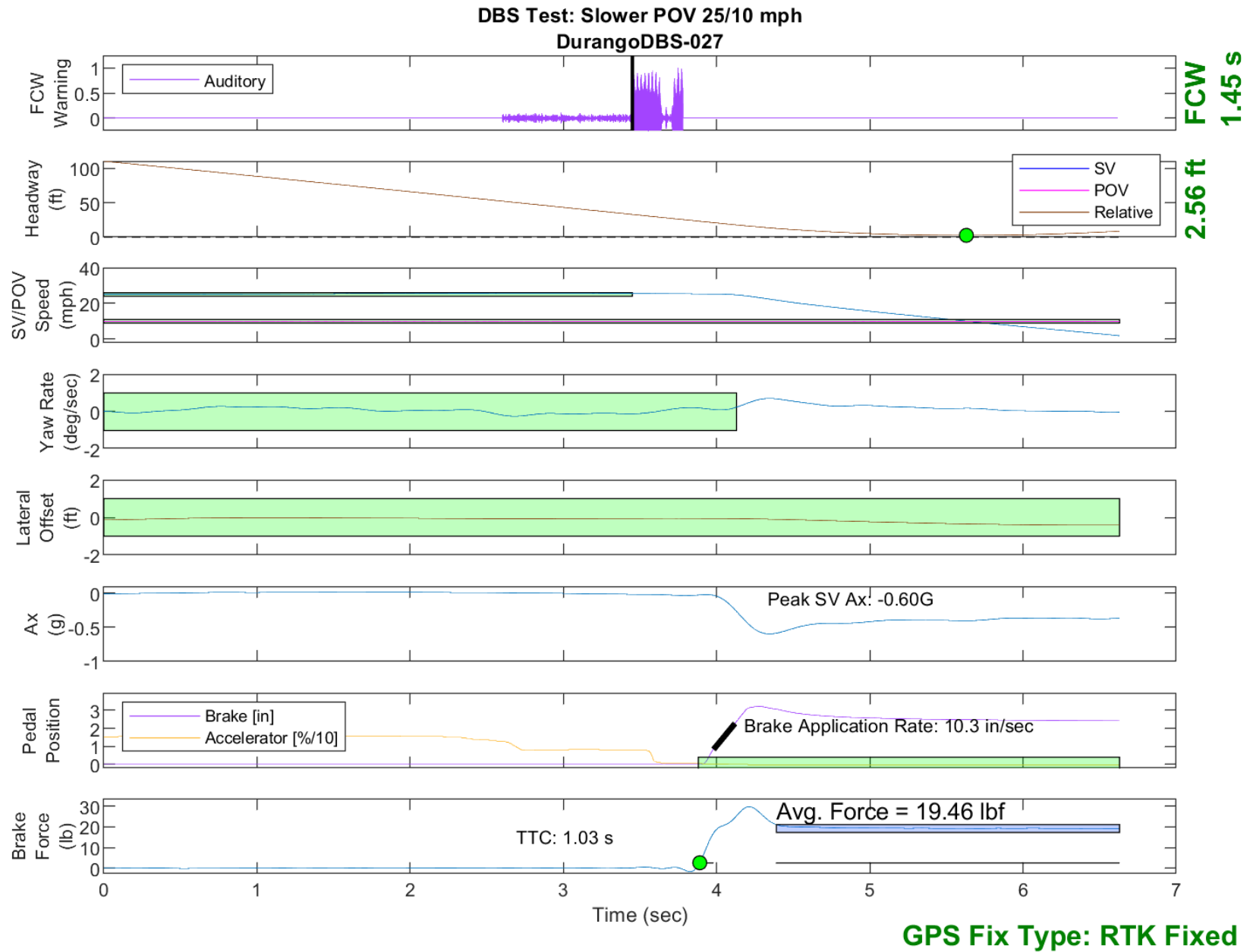


Figure E22. Time History for DBS Run 27, SV Encounters Slower POV, SV 25 mph, POV 10 mph



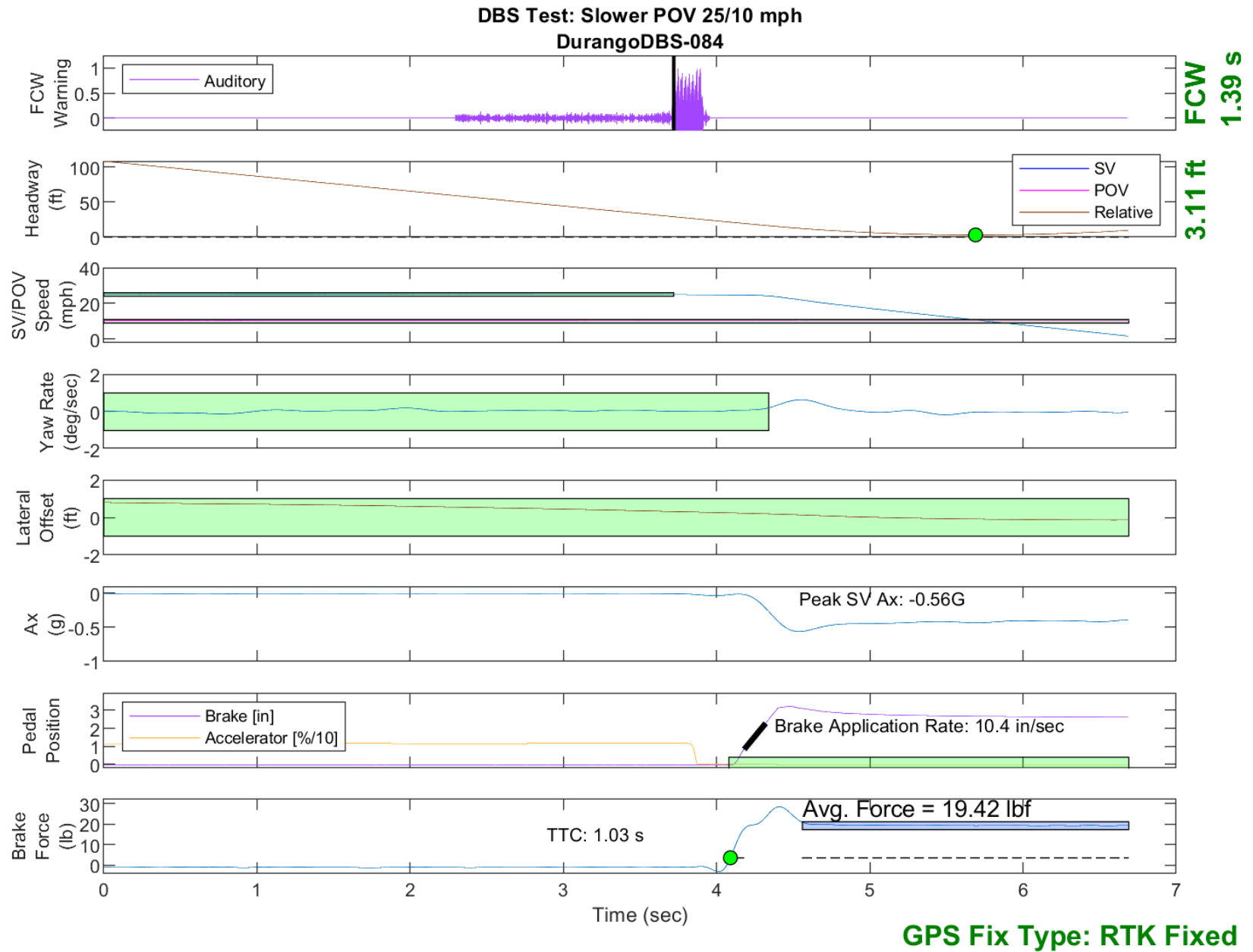


Figure E23. Time History for DBS Run 84, SV Encounters Slower POV, SV 25 mph, POV 10 mph

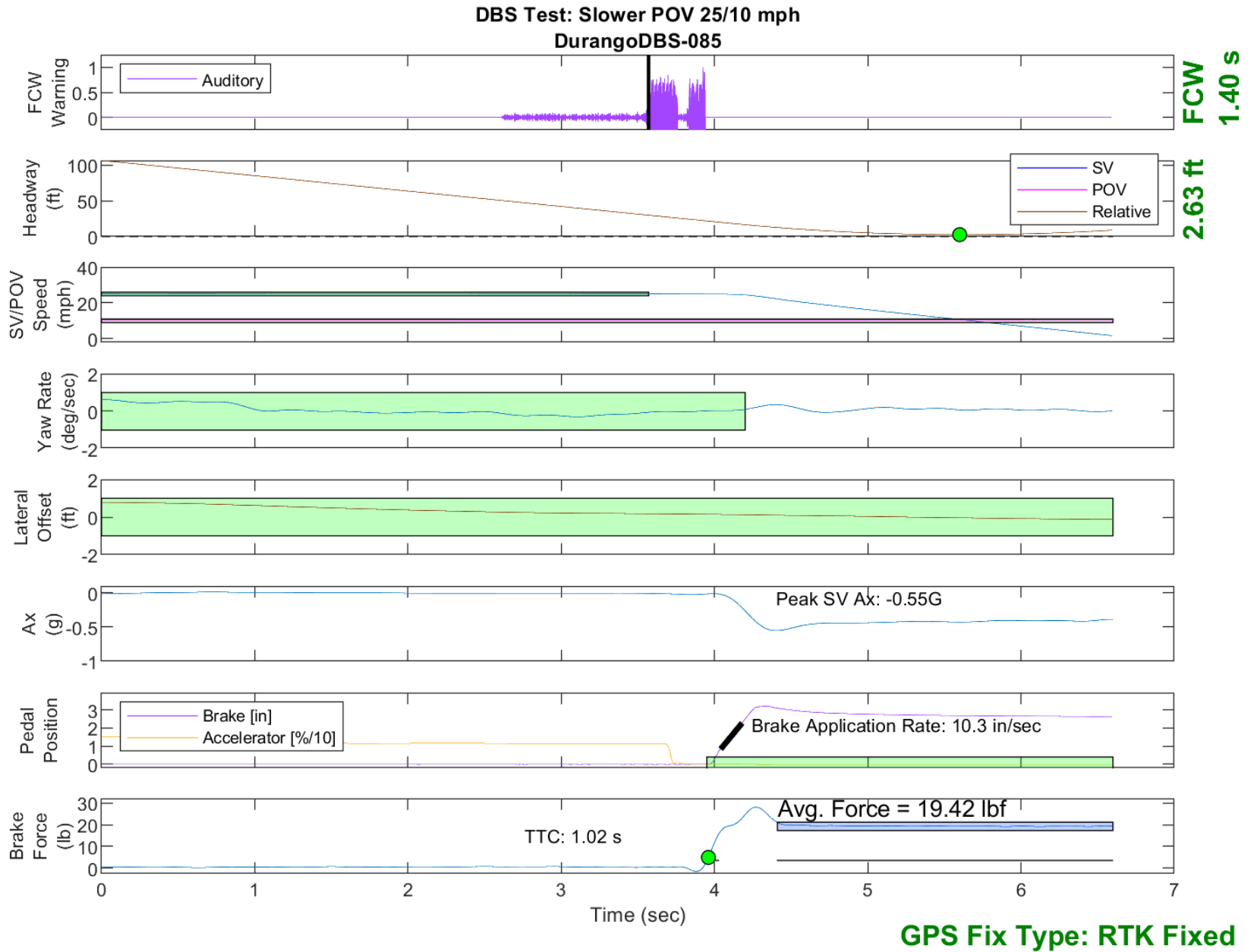


Figure E24. Time History for DBS Run 85, SV Encounters Slower POV, SV 25 mph, POV 10 mph

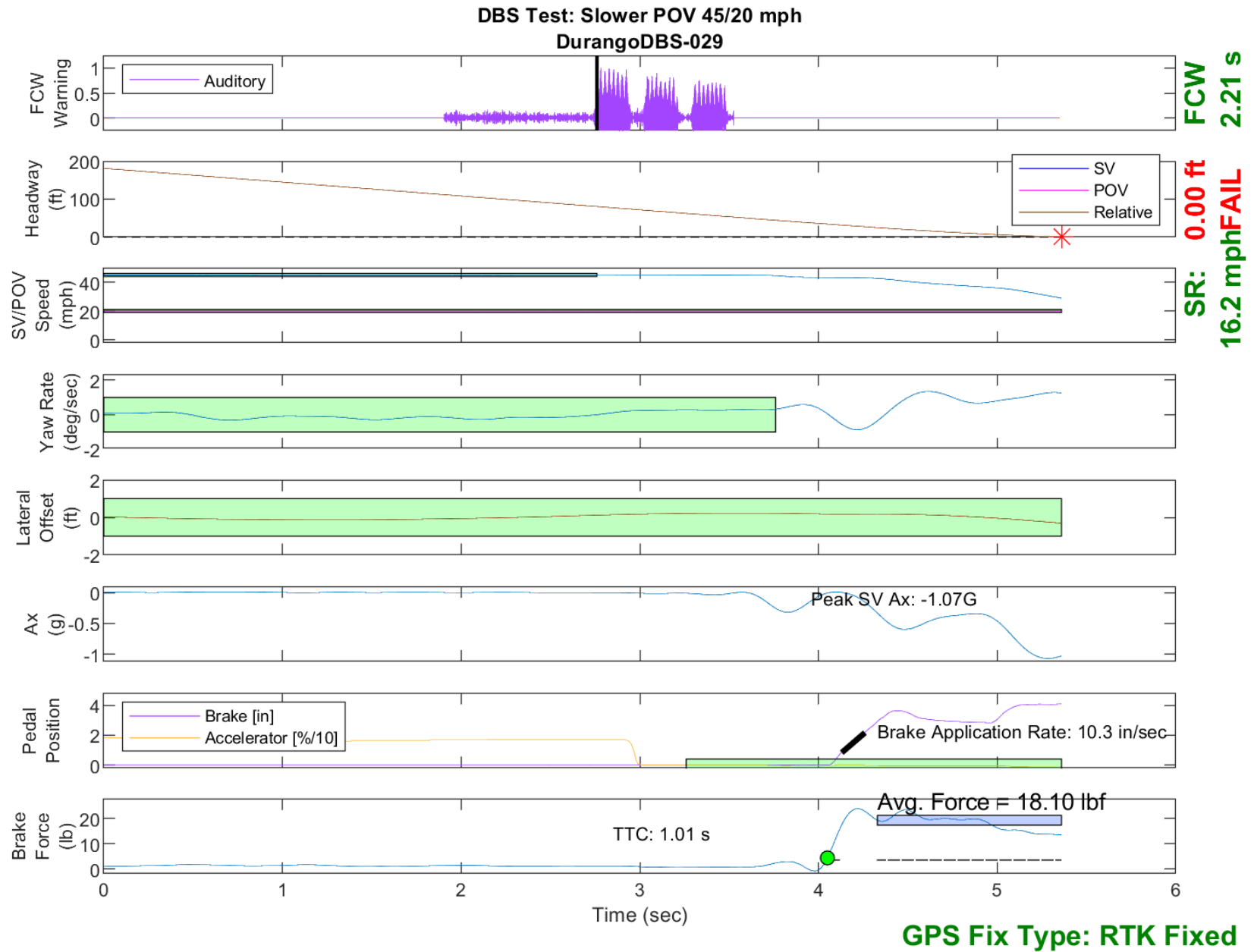


Figure E25. Time History for DBS Run 29, SV Encounters Slower POV, SV 45 mph, POV 20 mph

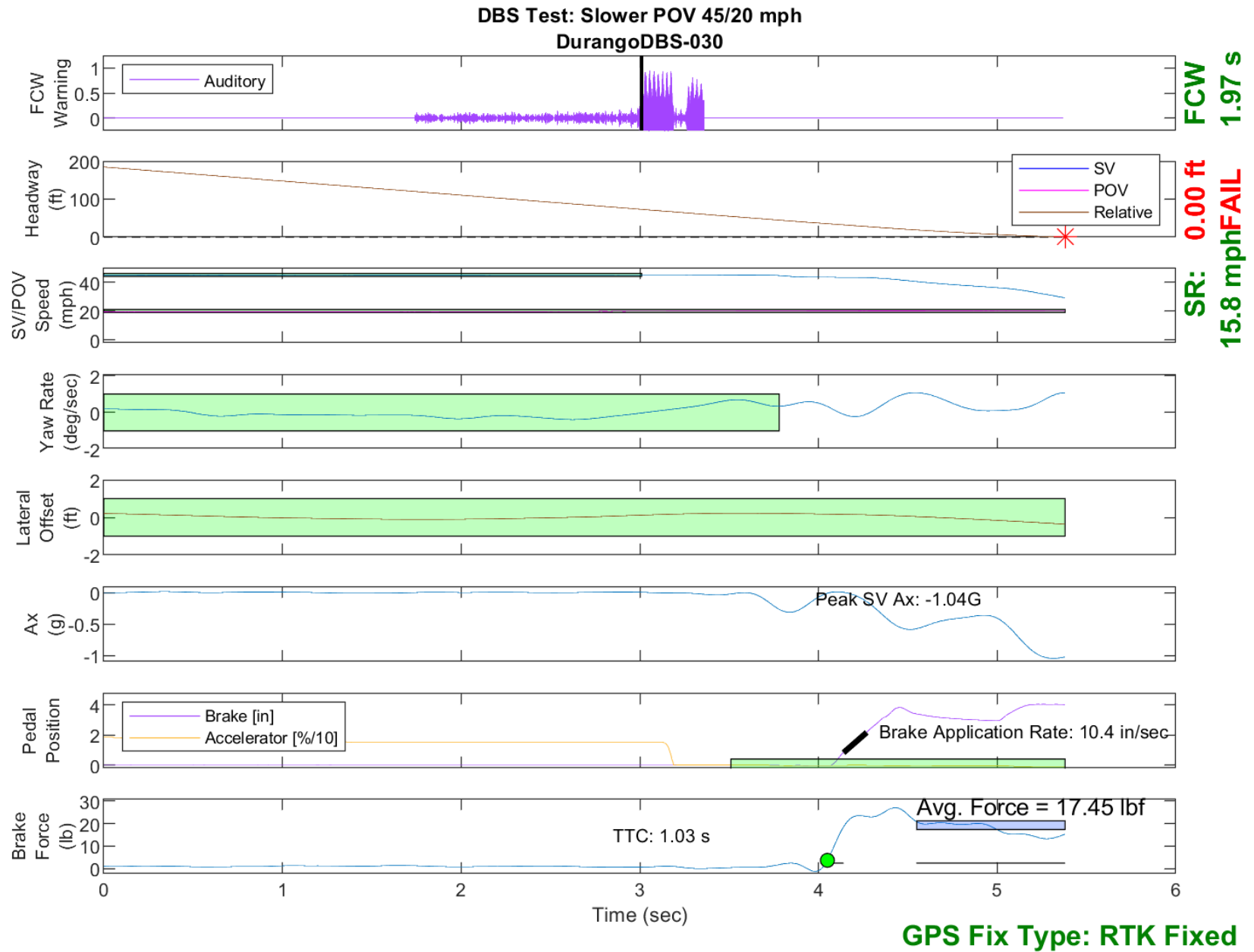


Figure E26. Time History for DBS Run 30, SV Encounters Slower POV, SV 45 mph, POV 20 mph

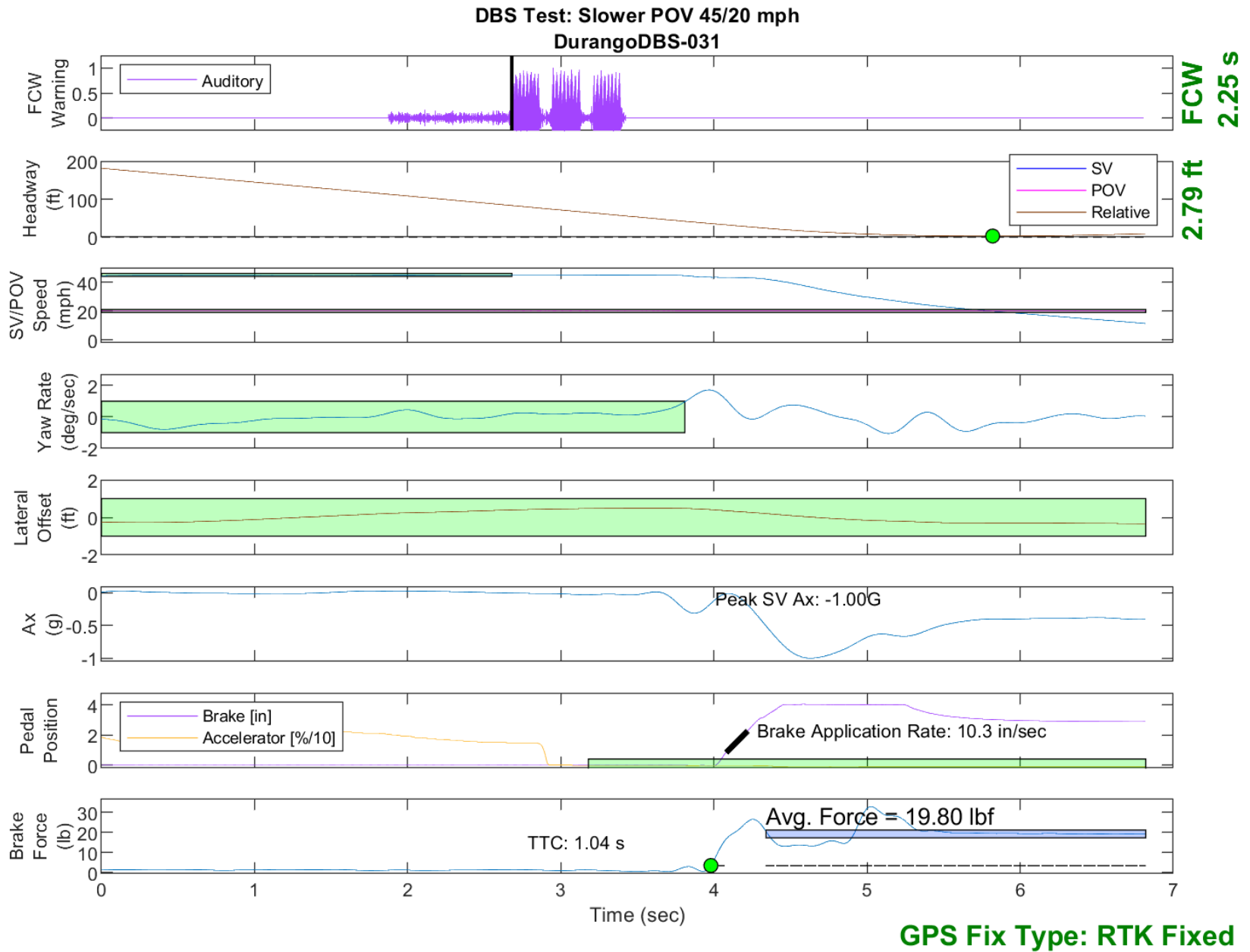


Figure E27. Time History for DBS Run 31, SV Encounters Slower POV, SV 45 mph, POV 20 mph

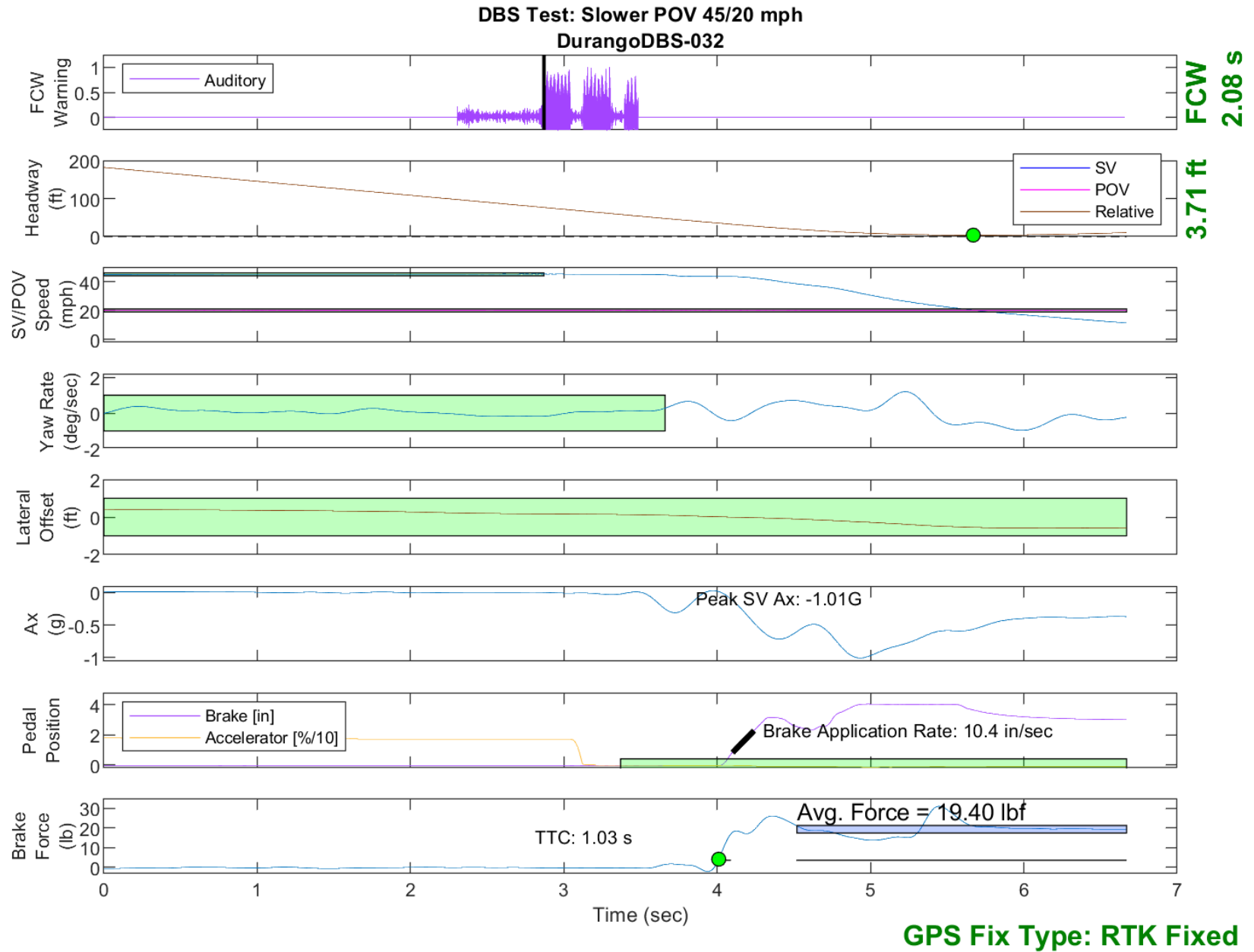


Figure E28. Time History for DBS Run 32, SV Encounters Slower POV, SV 45 mph, POV 20 mph

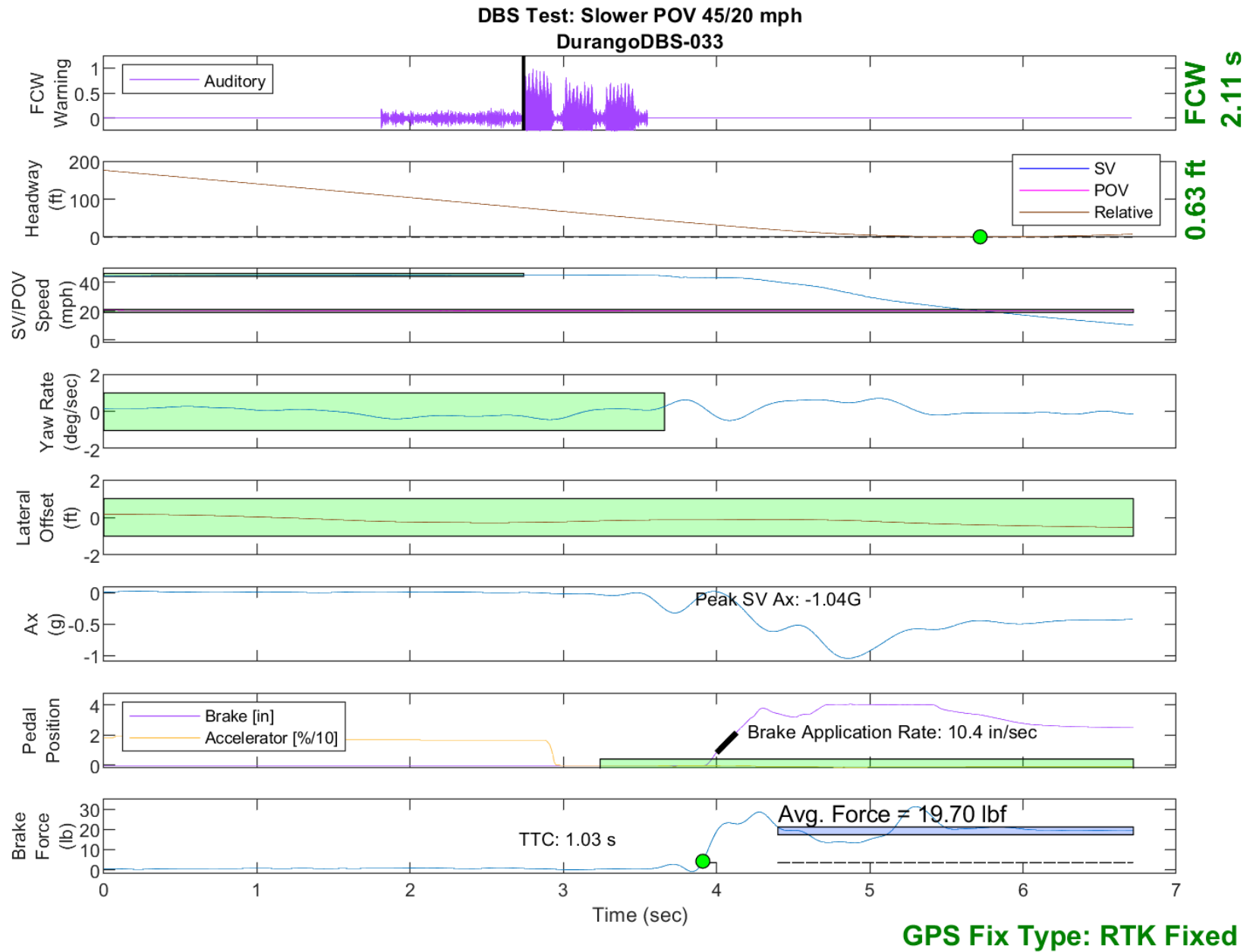


Figure E29. Time History for DBS Run 33, SV Encounters Slower POV, SV 45 mph, POV 20 mph

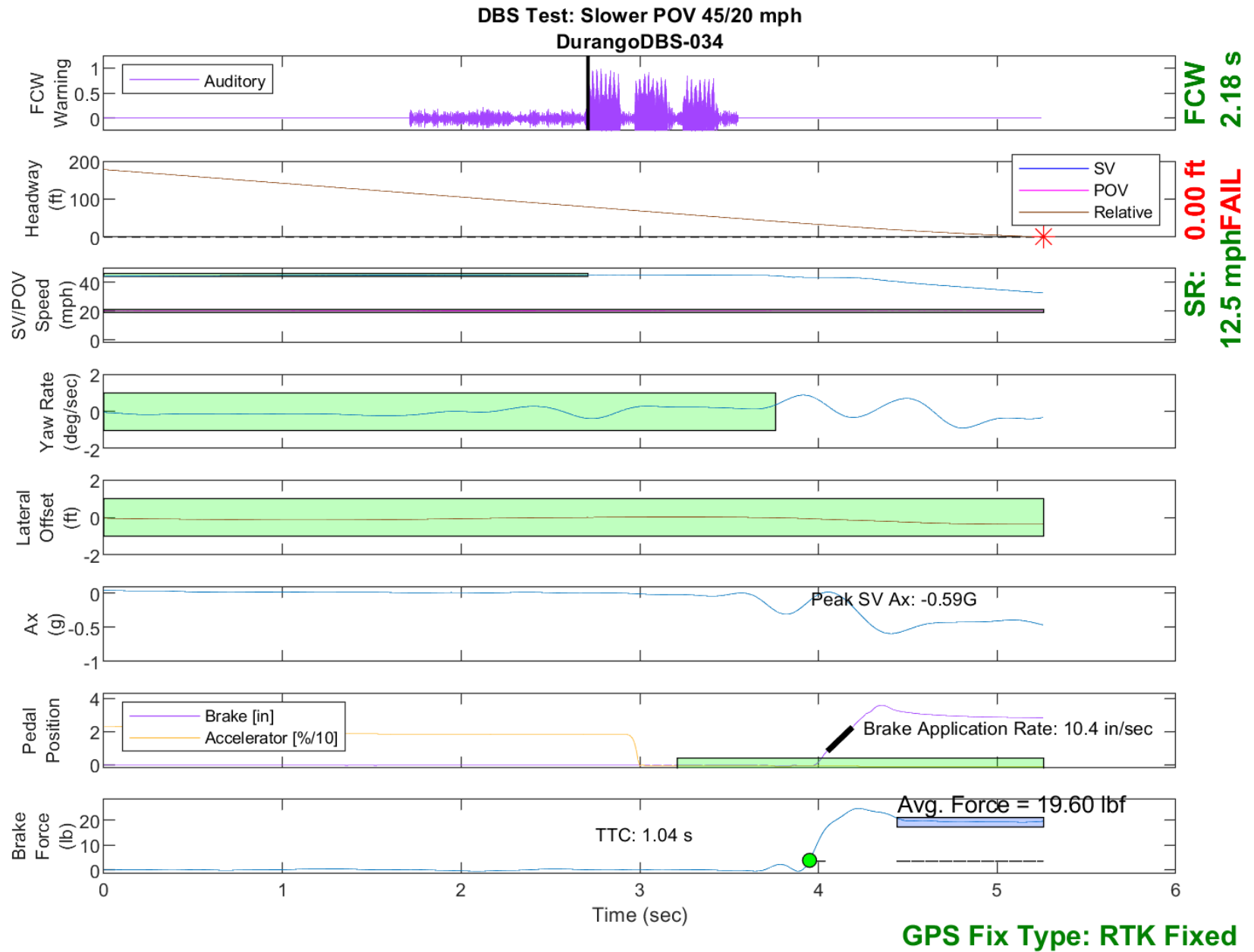


Figure E30. Time History for DBS Run 34, SV Encounters Slower POV, SV 45 mph, POV 20 mph



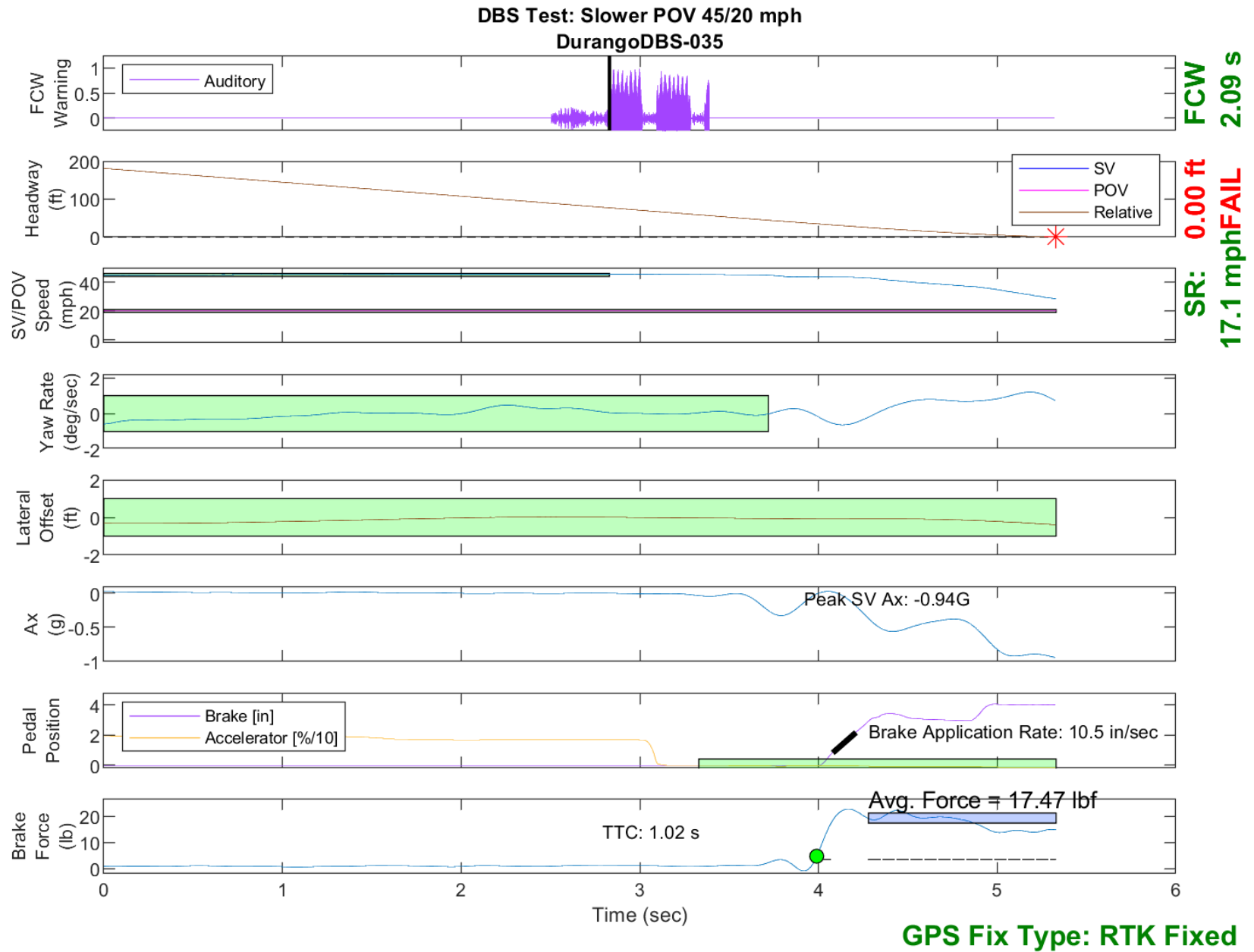


Figure E31. Time History for DBS Run 35, SV Encounters Slower POV, SV 45 mph, POV 20 mph

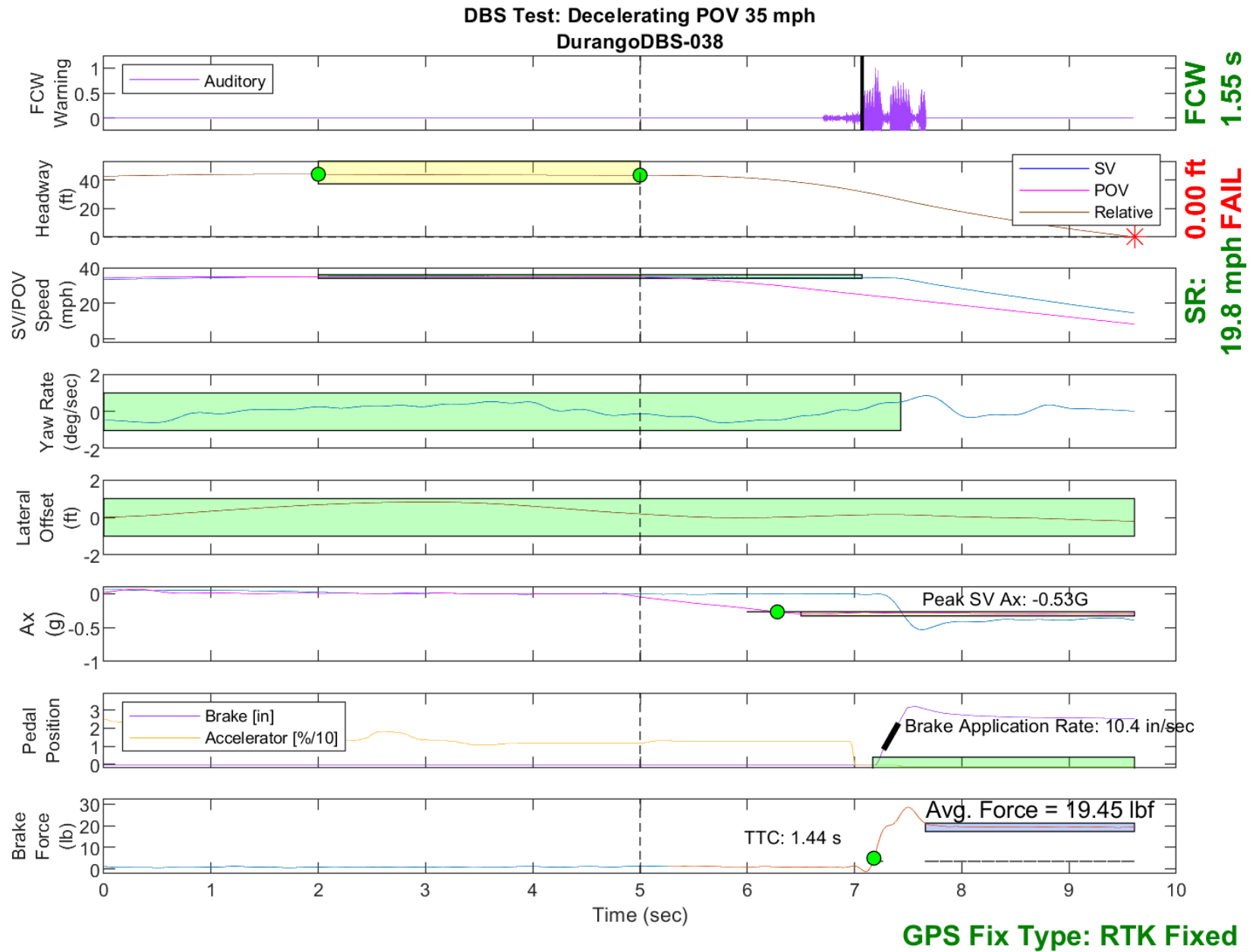


Figure E32. Time History for DBS Run 38, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

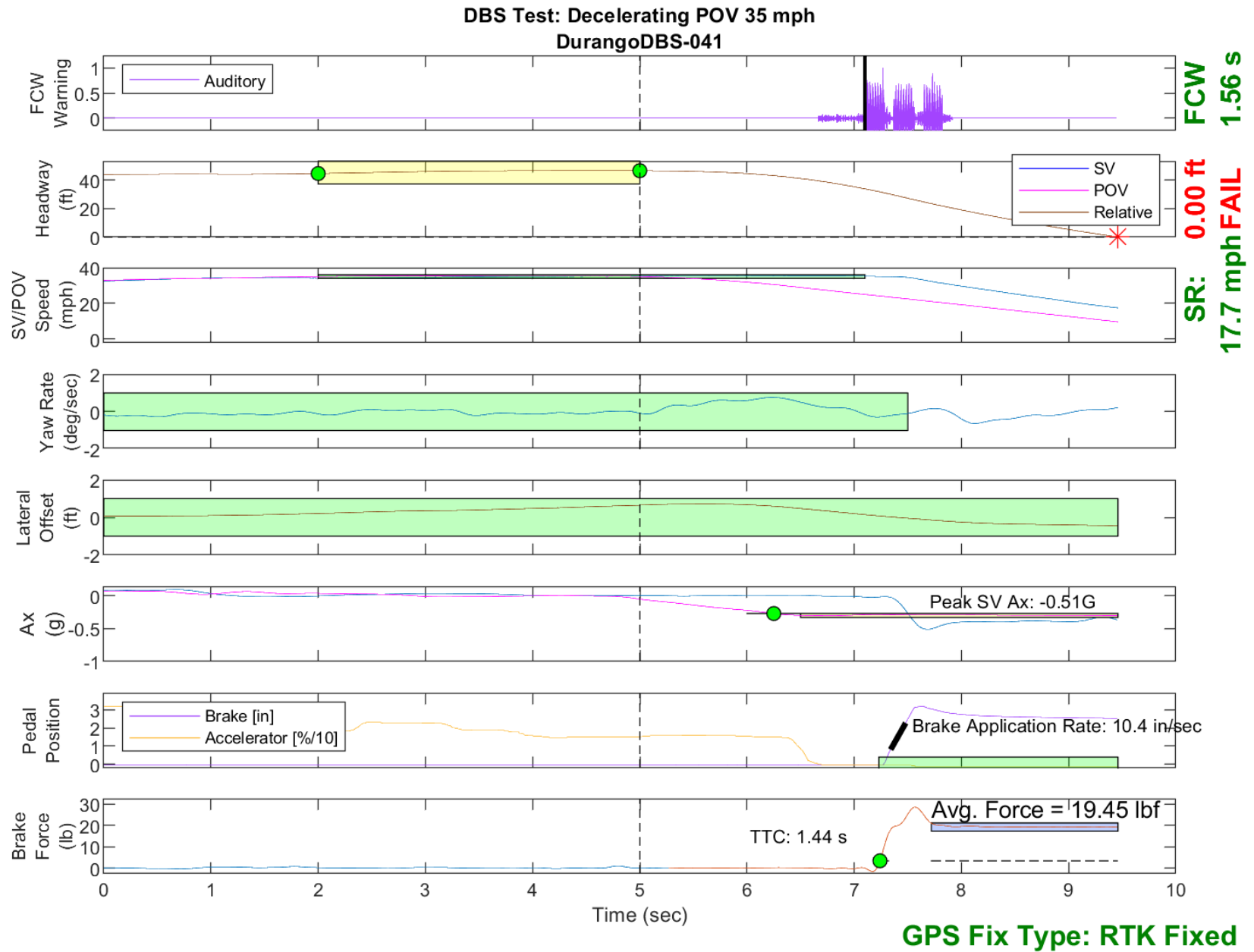


Figure E33. Time History for DBS Run 41, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

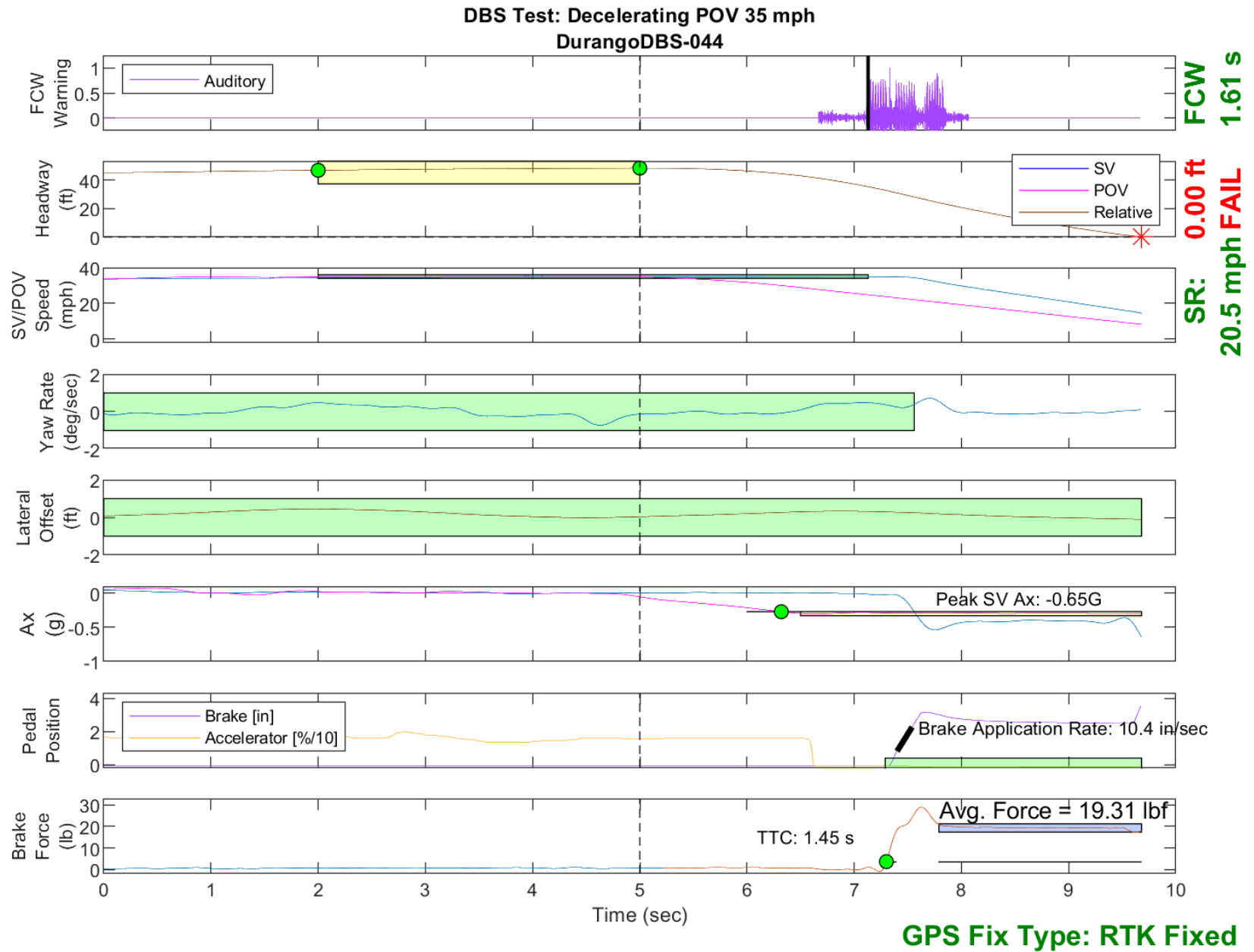


Figure E34. Time History for DBS Run 44, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

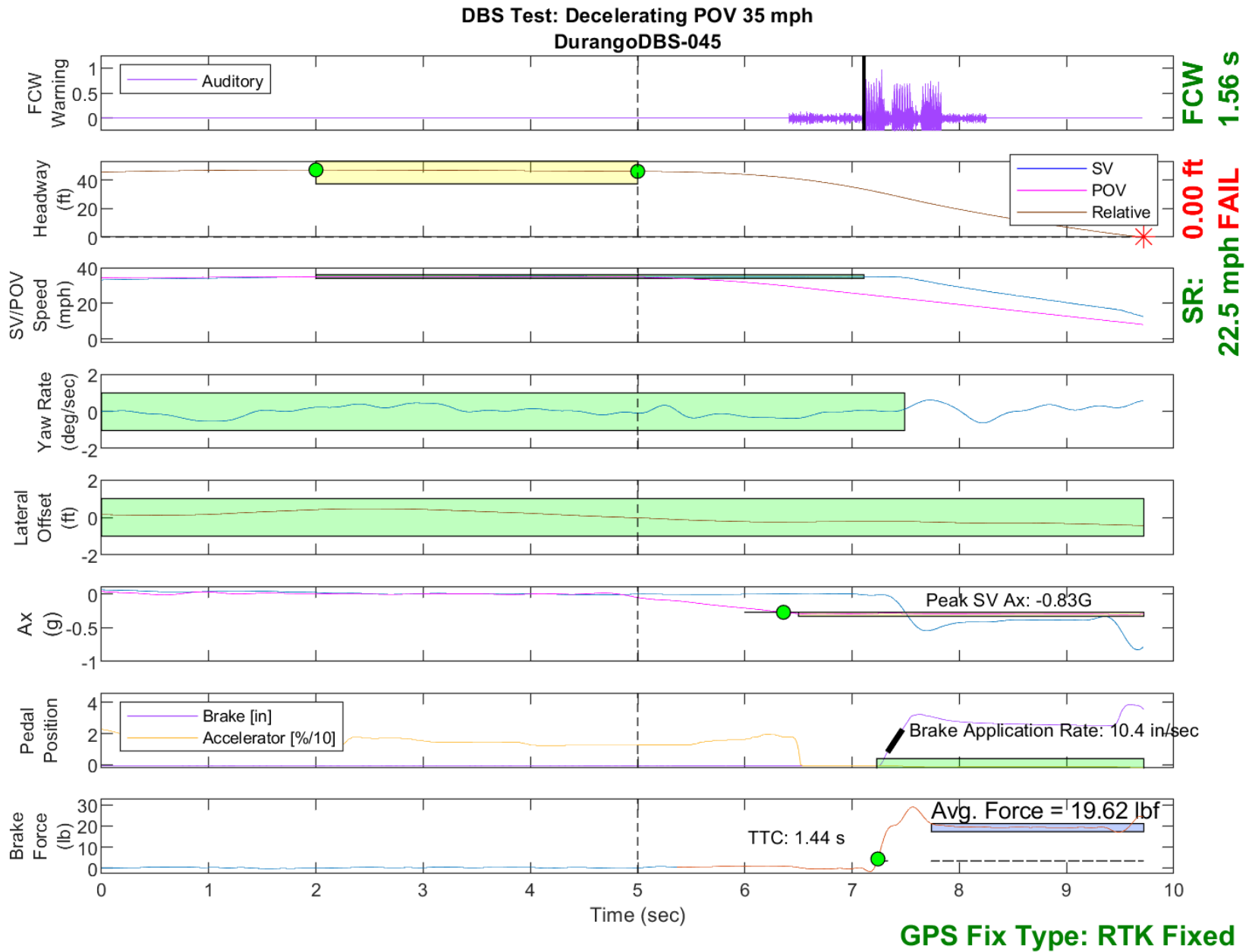


Figure E35. Time History for DBS Run 45, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

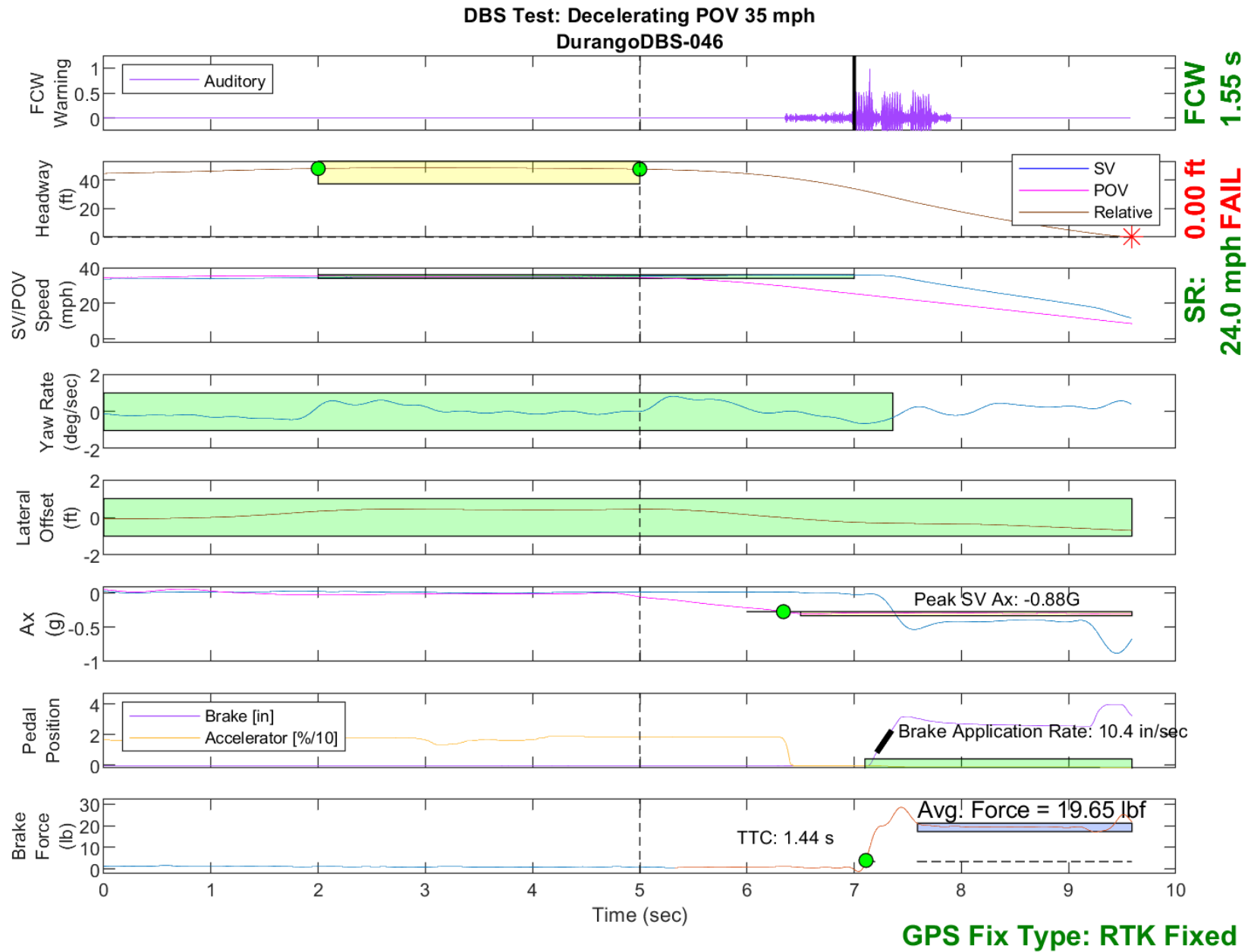


Figure E36. Time History for DBS Run 46, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

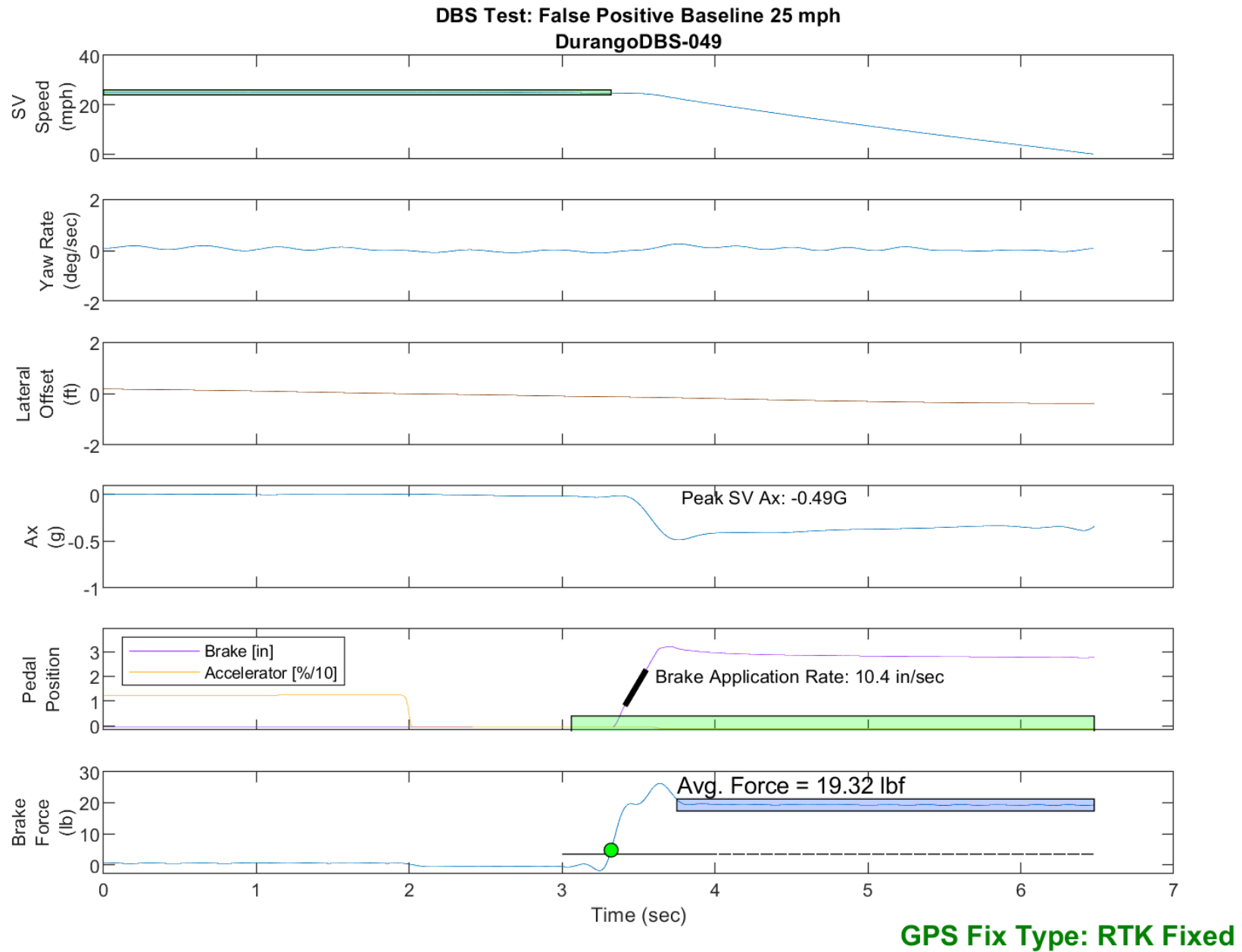


Figure E37. Time History for DBS Run 49, False Positive Baseline, SV 25 mph

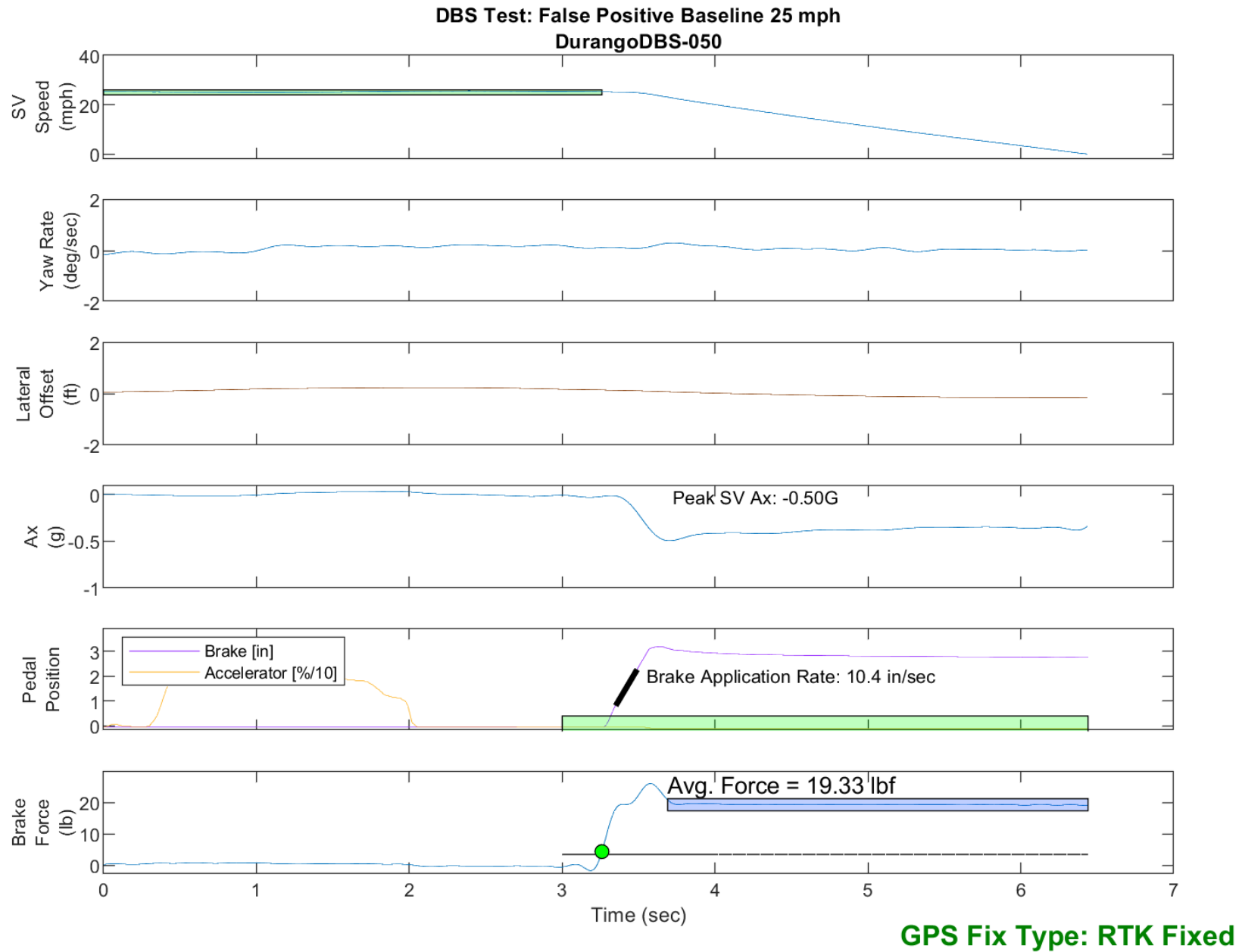


Figure E38. Time History for DBS Run 50, False Positive Baseline, SV 25 mph



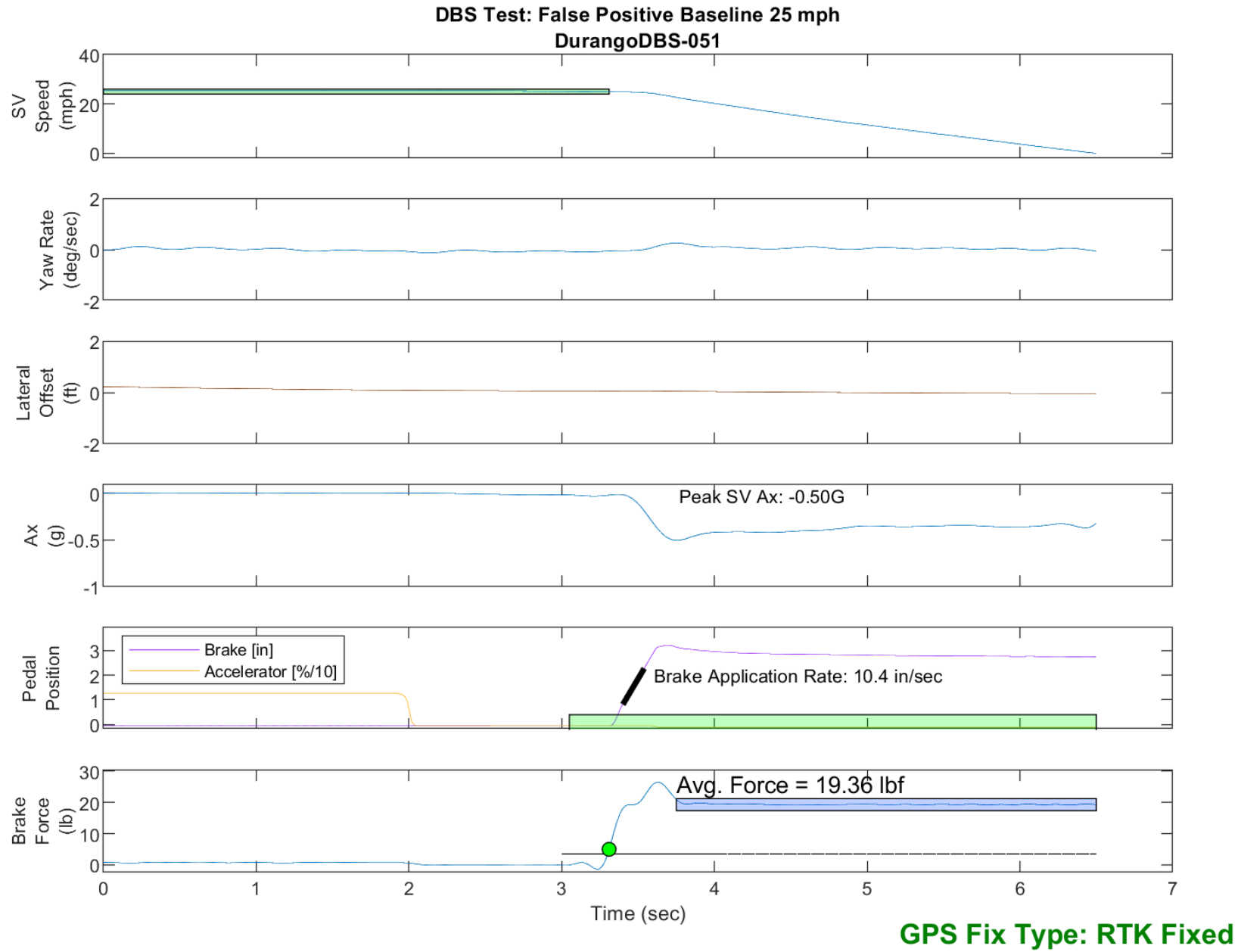


Figure E39. Time History for DBS Run 51, False Positive Baseline, SV 25 mph

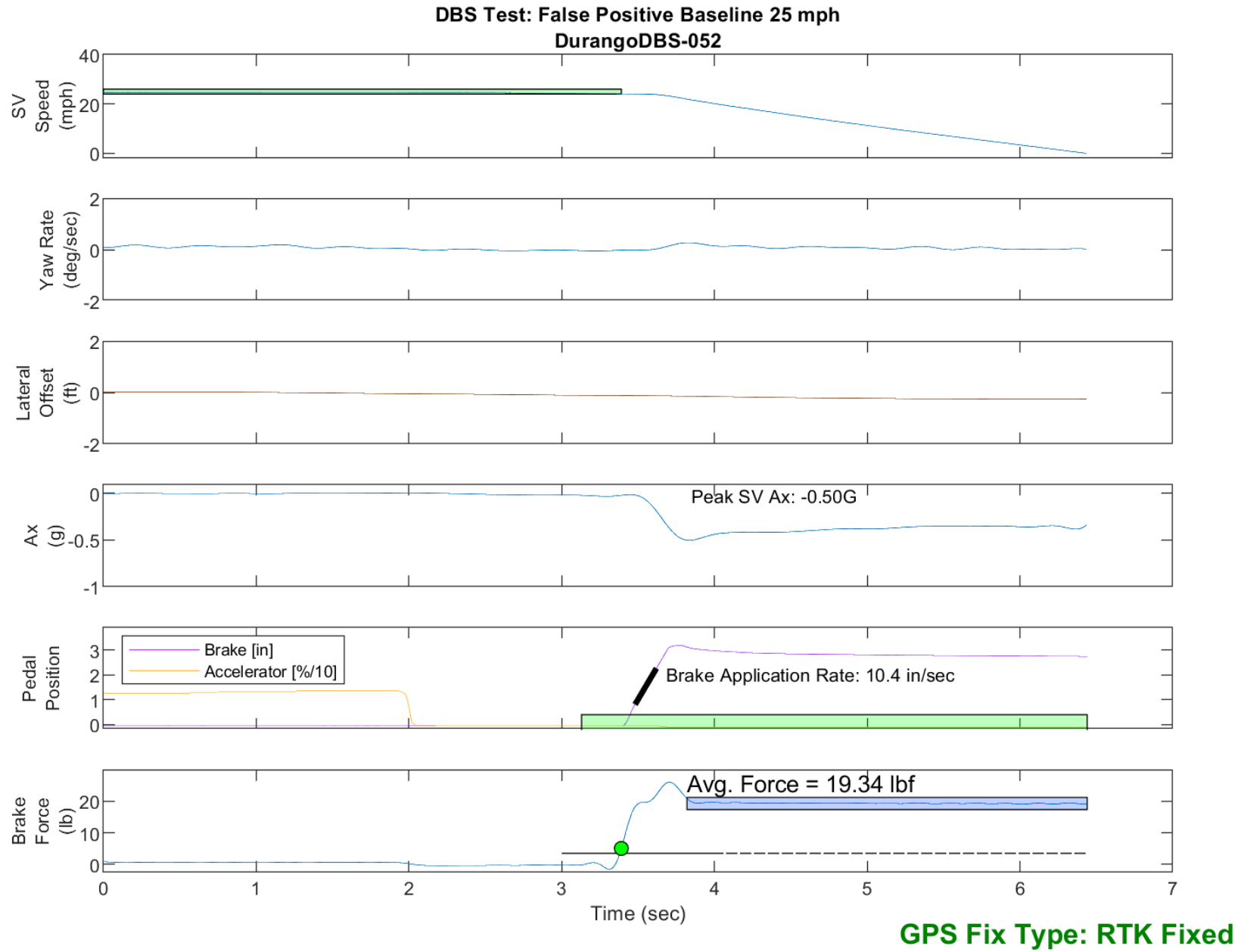


Figure E40. Time History for DBS Run 52, False Positive Baseline, SV 25 mph

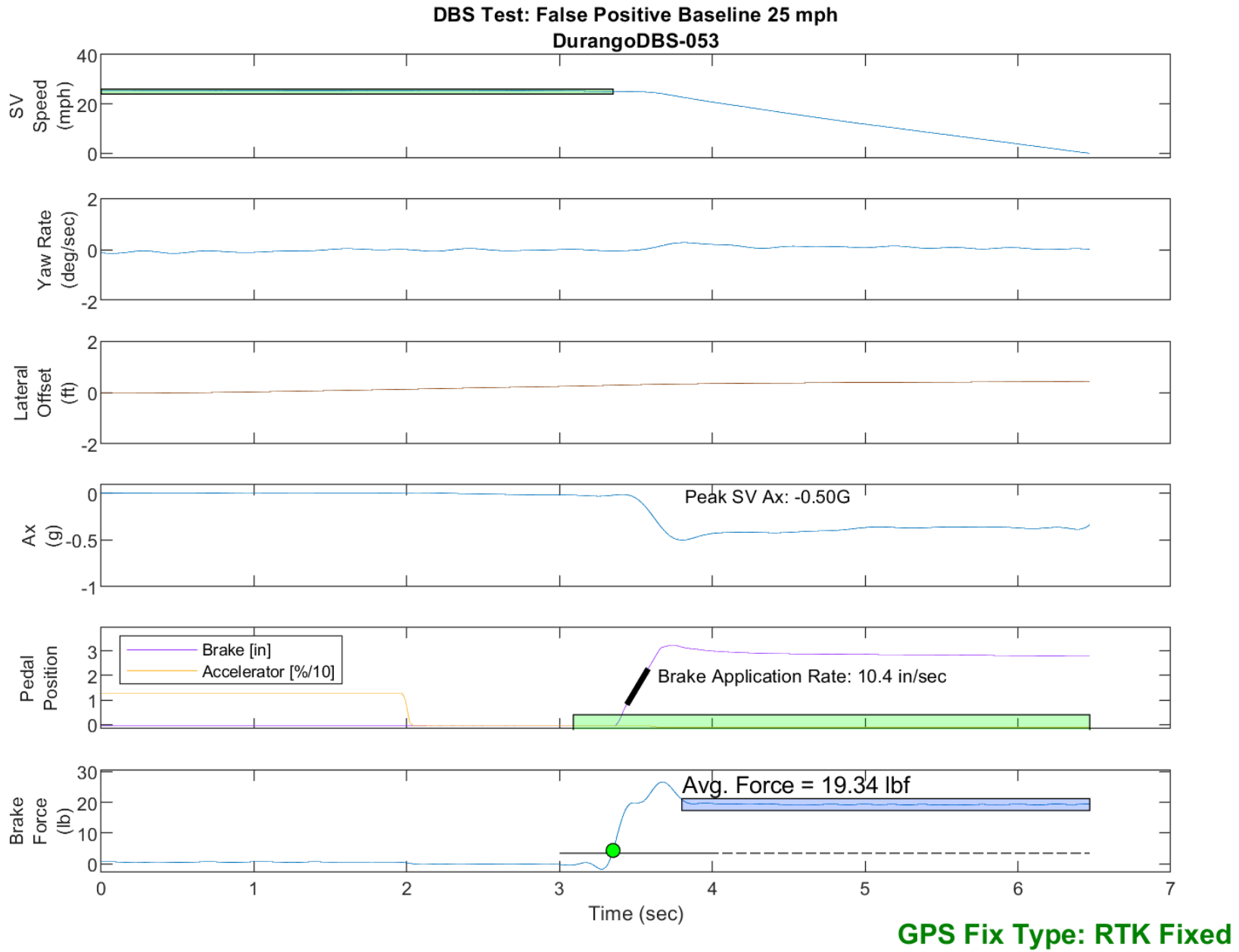


Figure E41. Time History for DBS Run 53, False Positive Baseline, SV 25 mph

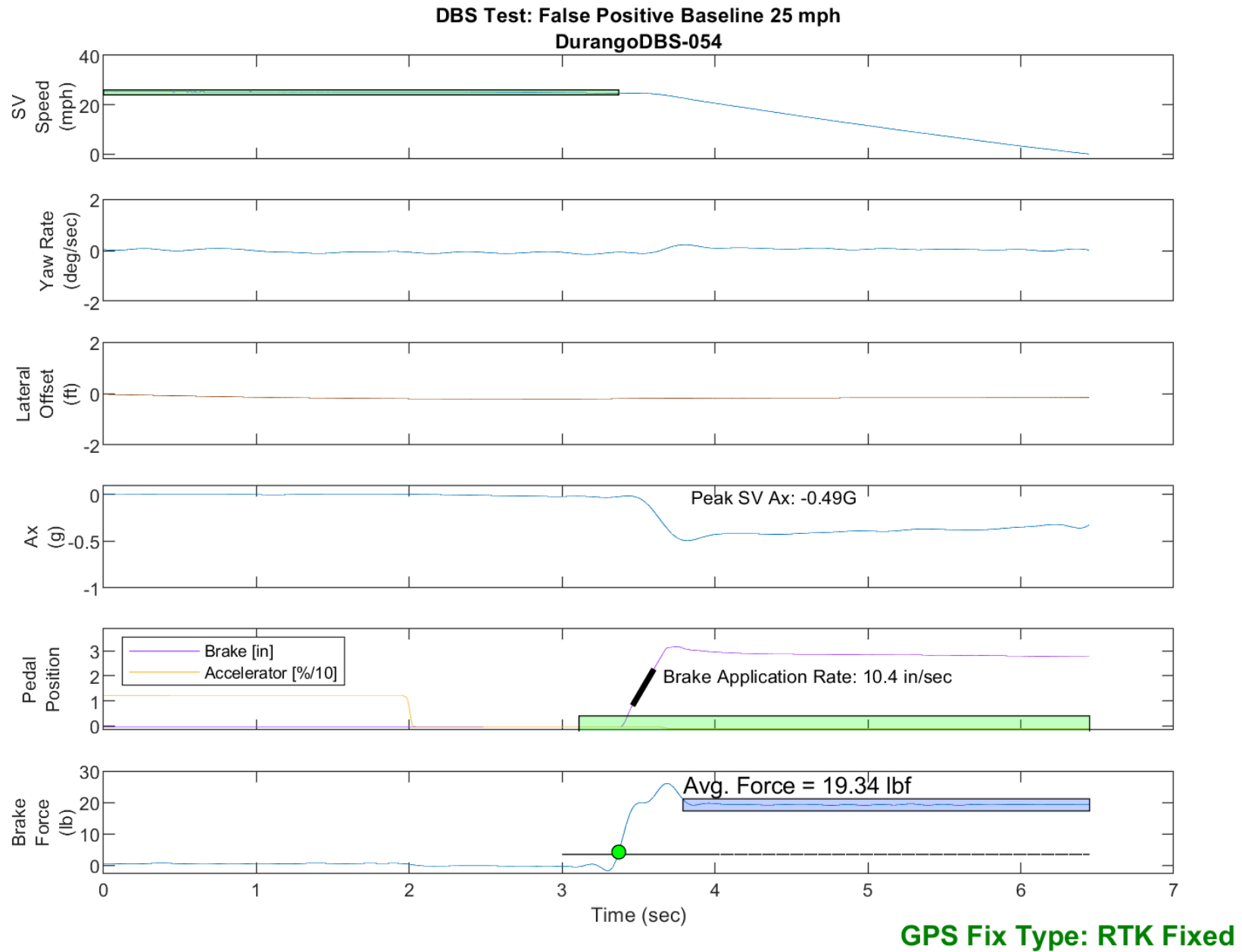


Figure E42. Time History for DBS Run 54, False Positive Baseline, SV 25 mph

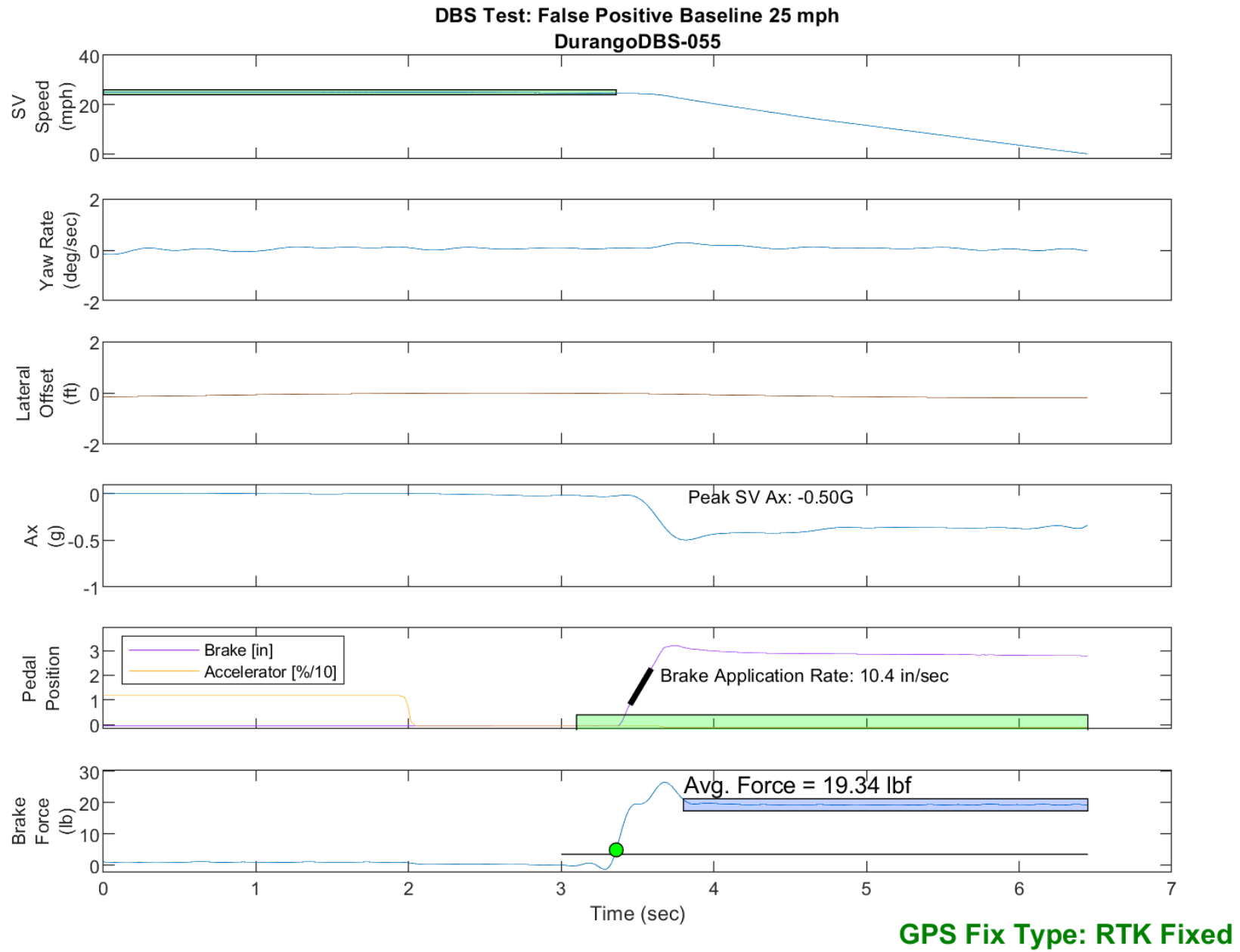


Figure E43. Time History for DBS Run 55, False Positive Baseline, SV 25 mph

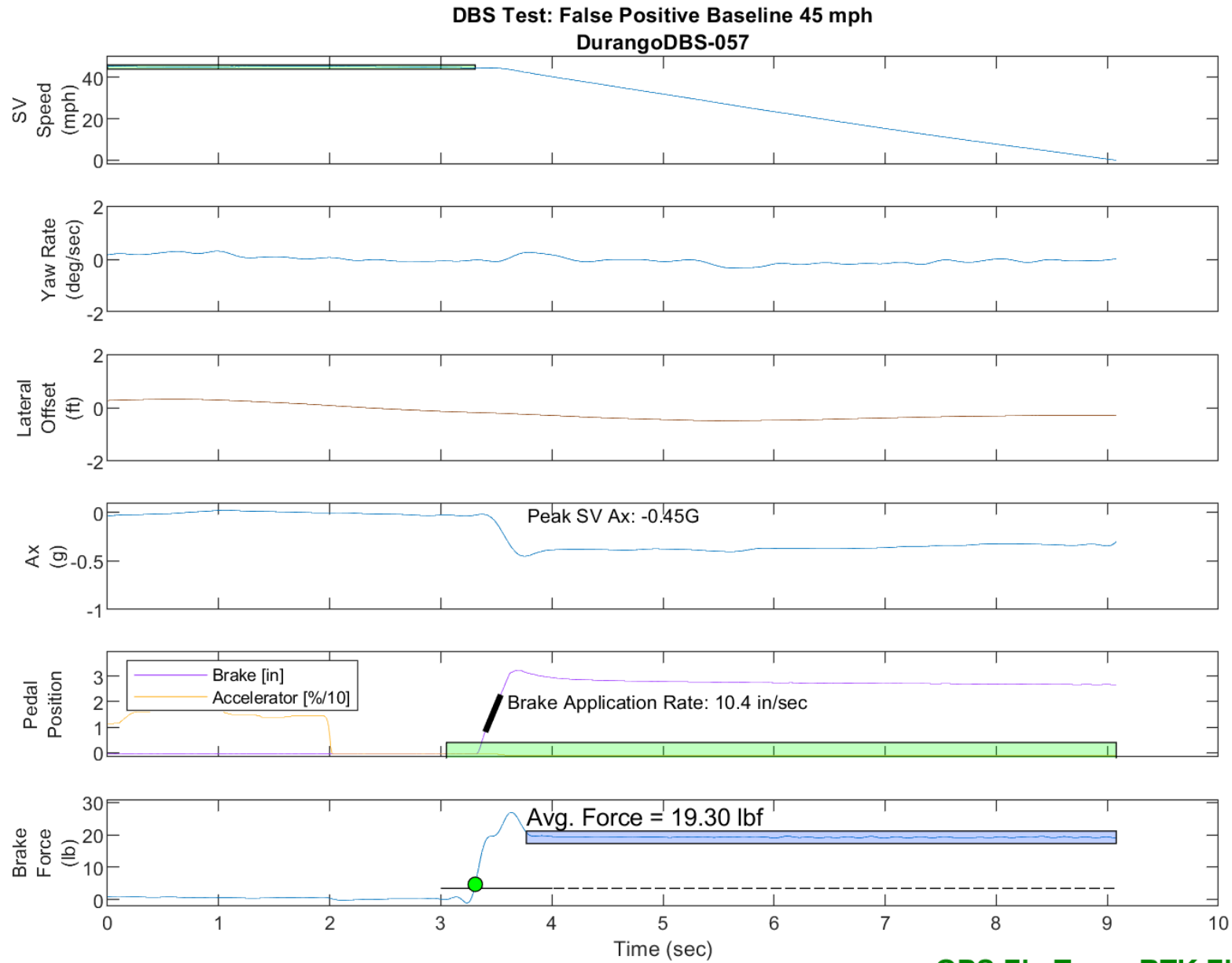


Figure E44. Time History for DBS Run 57, False Positive Baseline, SV 45 mph

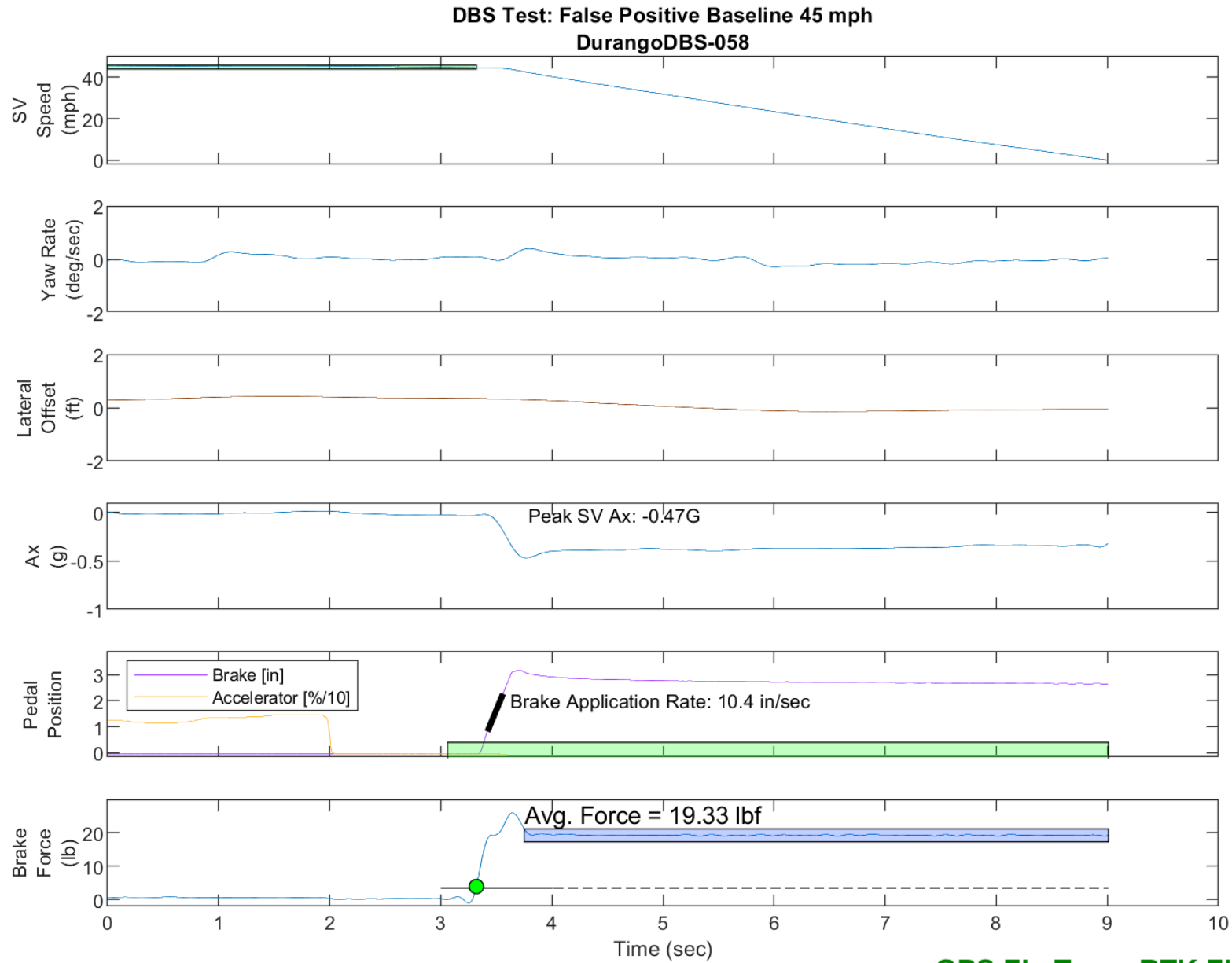


Figure E45. Time History for DBS Run 58, False Positive Baseline, SV 45 mph

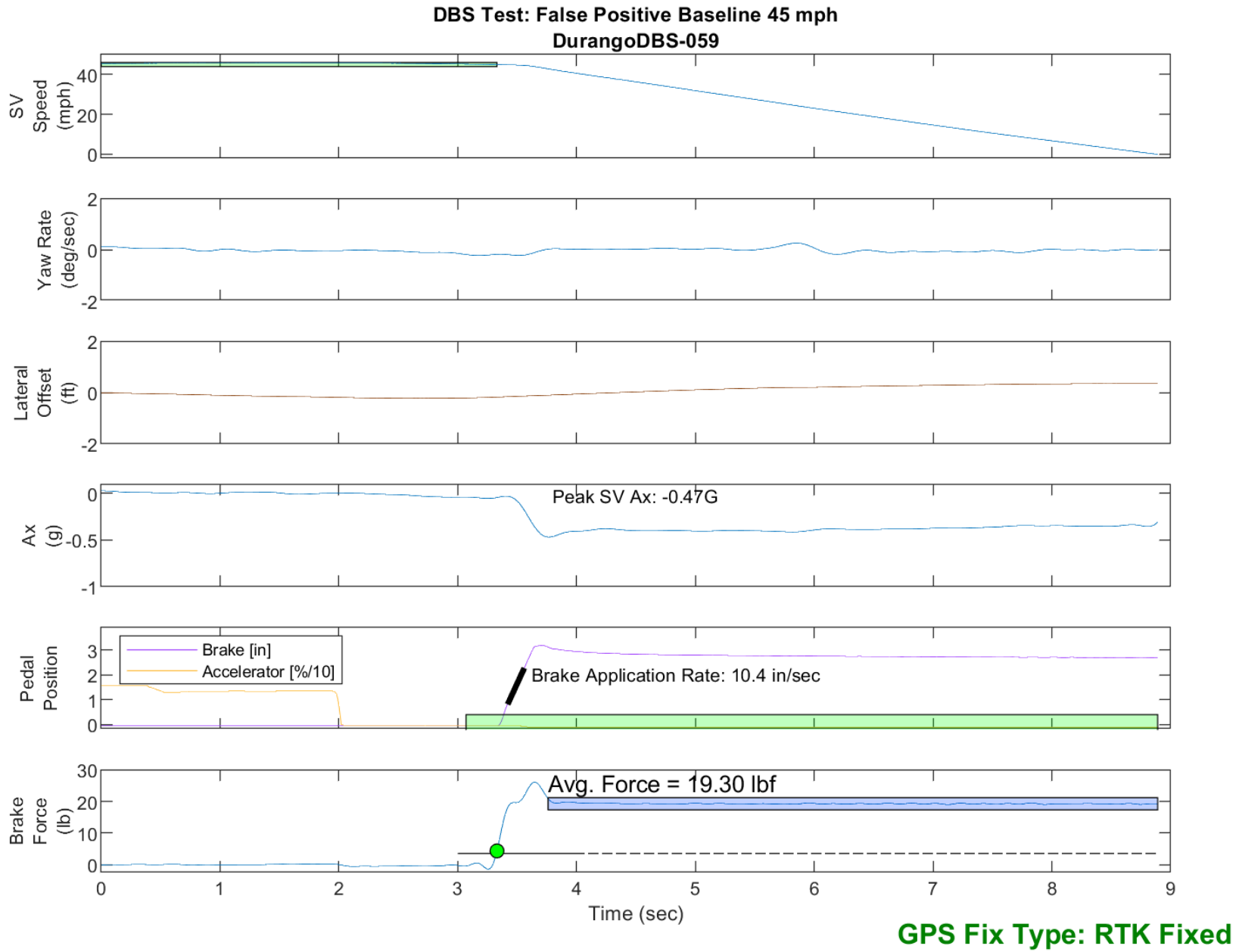


Figure E46. Time History for DBS Run 59, False Positive Baseline, SV 45 mph



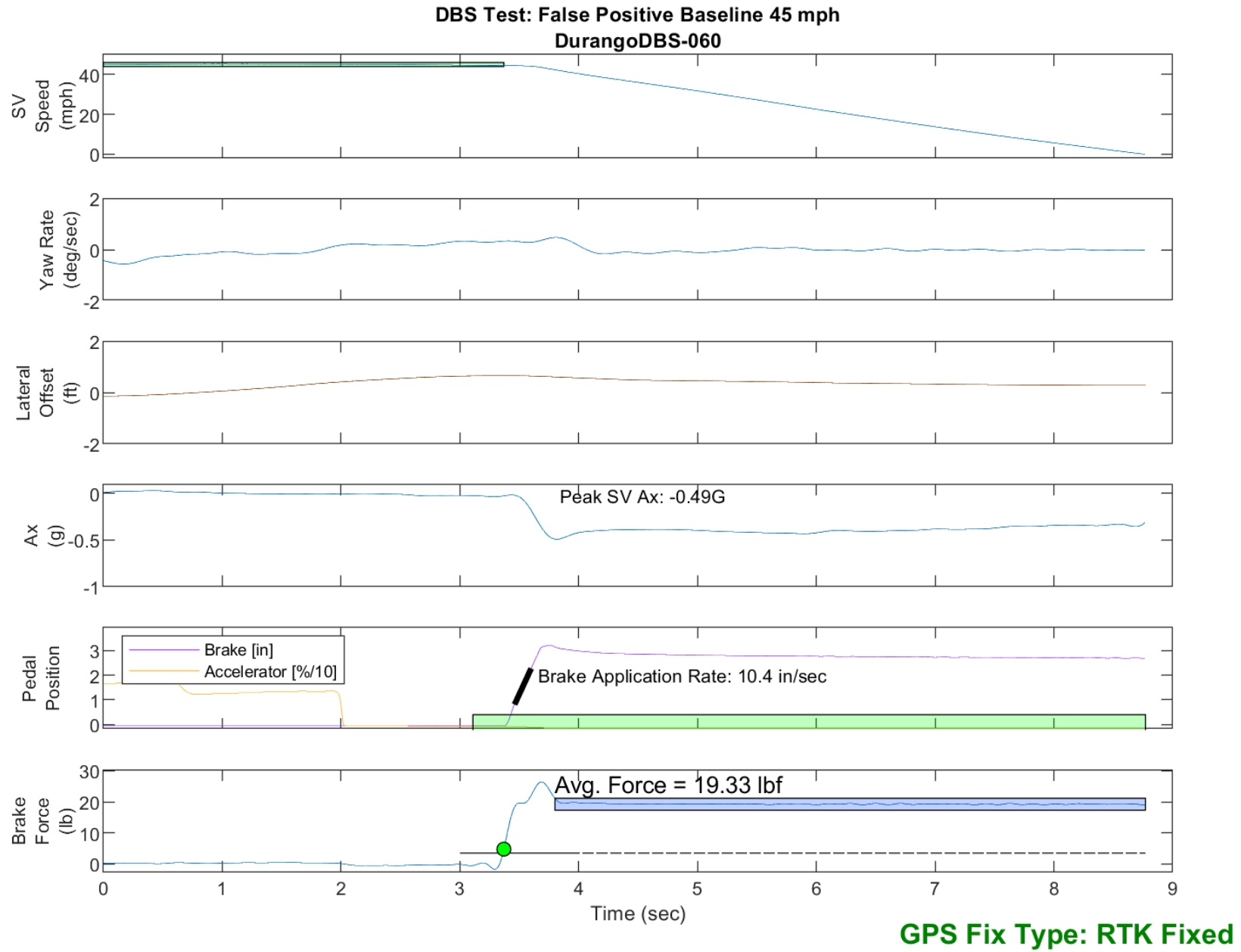
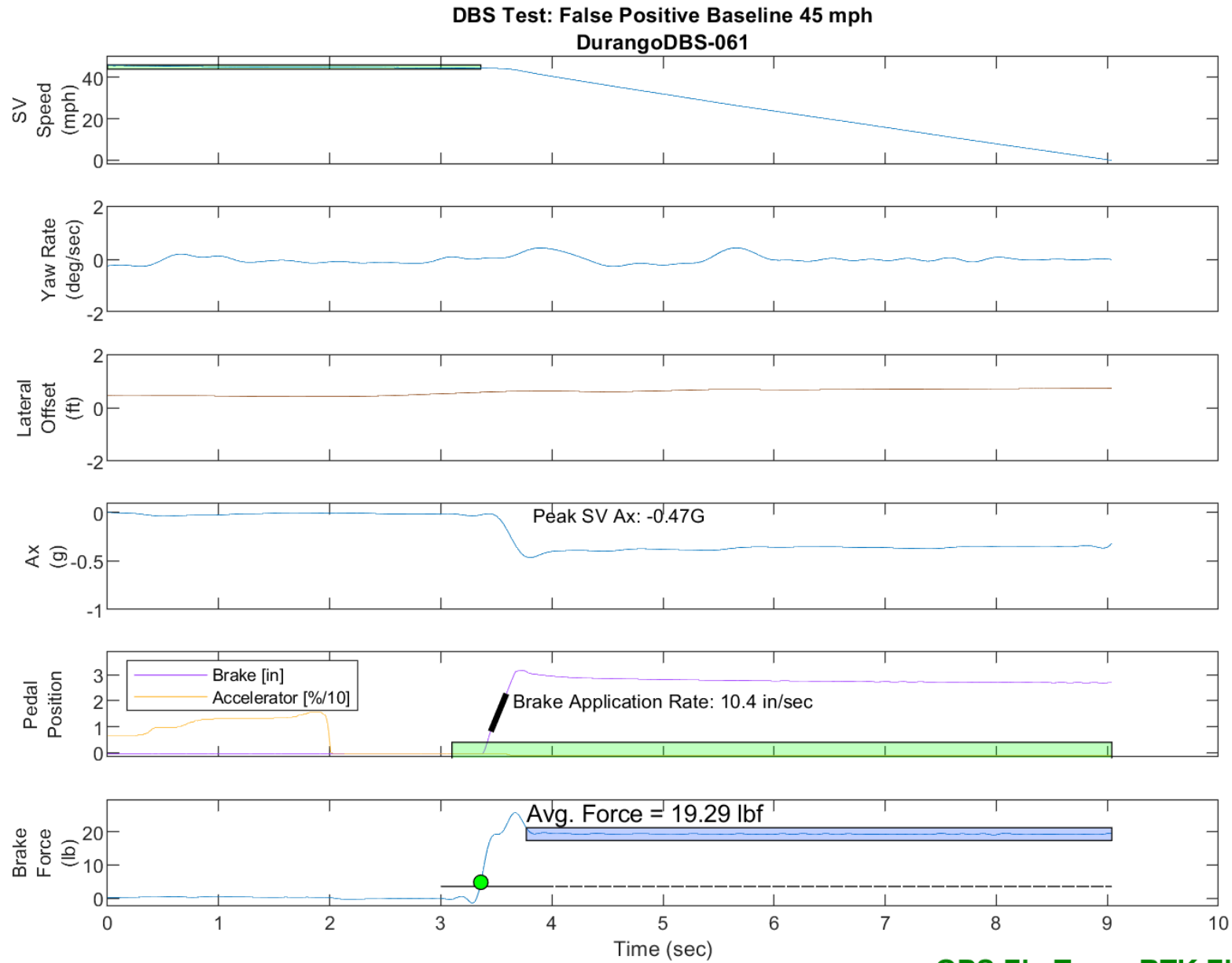


Figure E47. Time History for DBS Run 60, False Positive Baseline, SV 45 mph



**GPS Fix Type: RTK Fixed**

Figure E48. Time History for DBS Run 61, False Positive Baseline, SV 45 mph

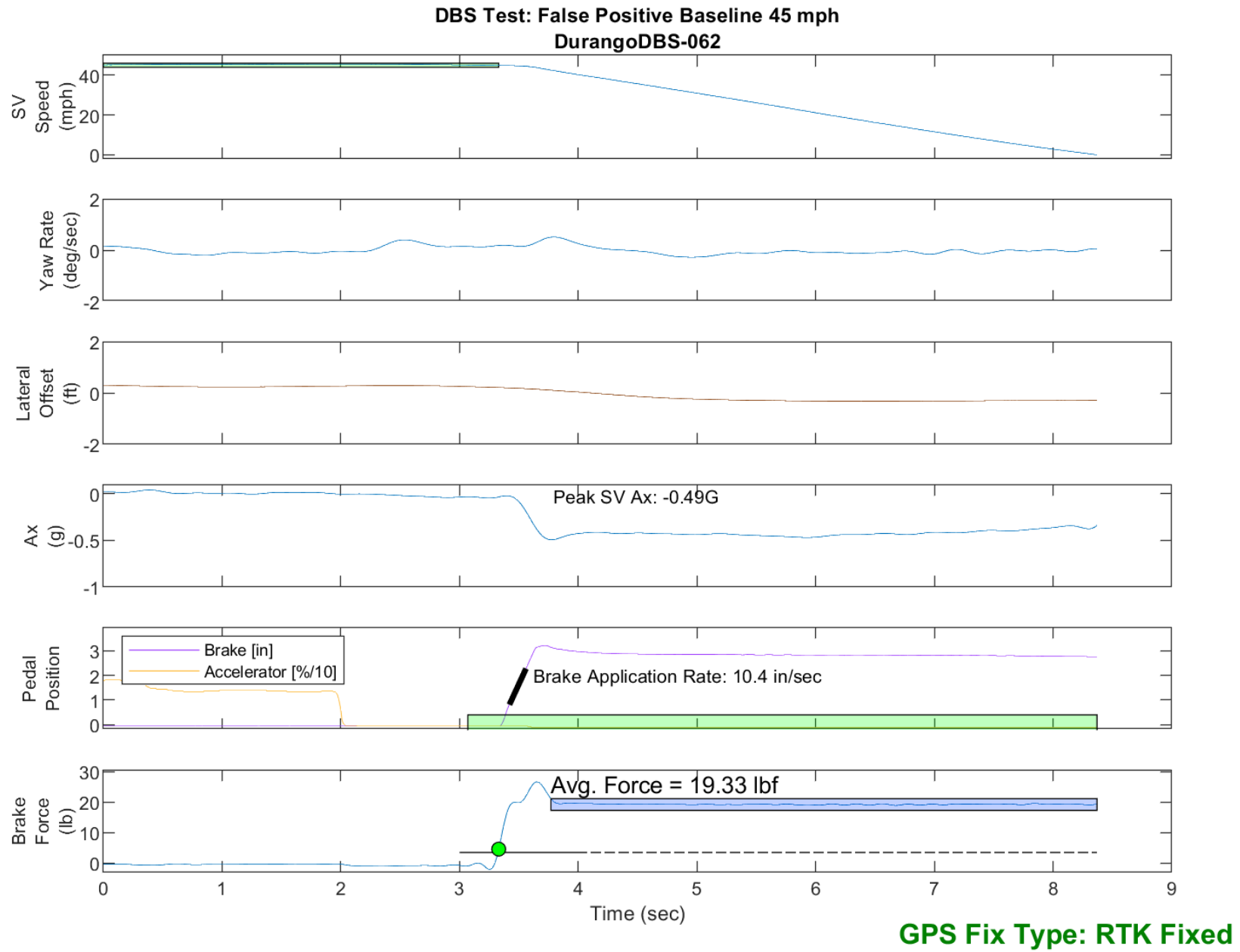
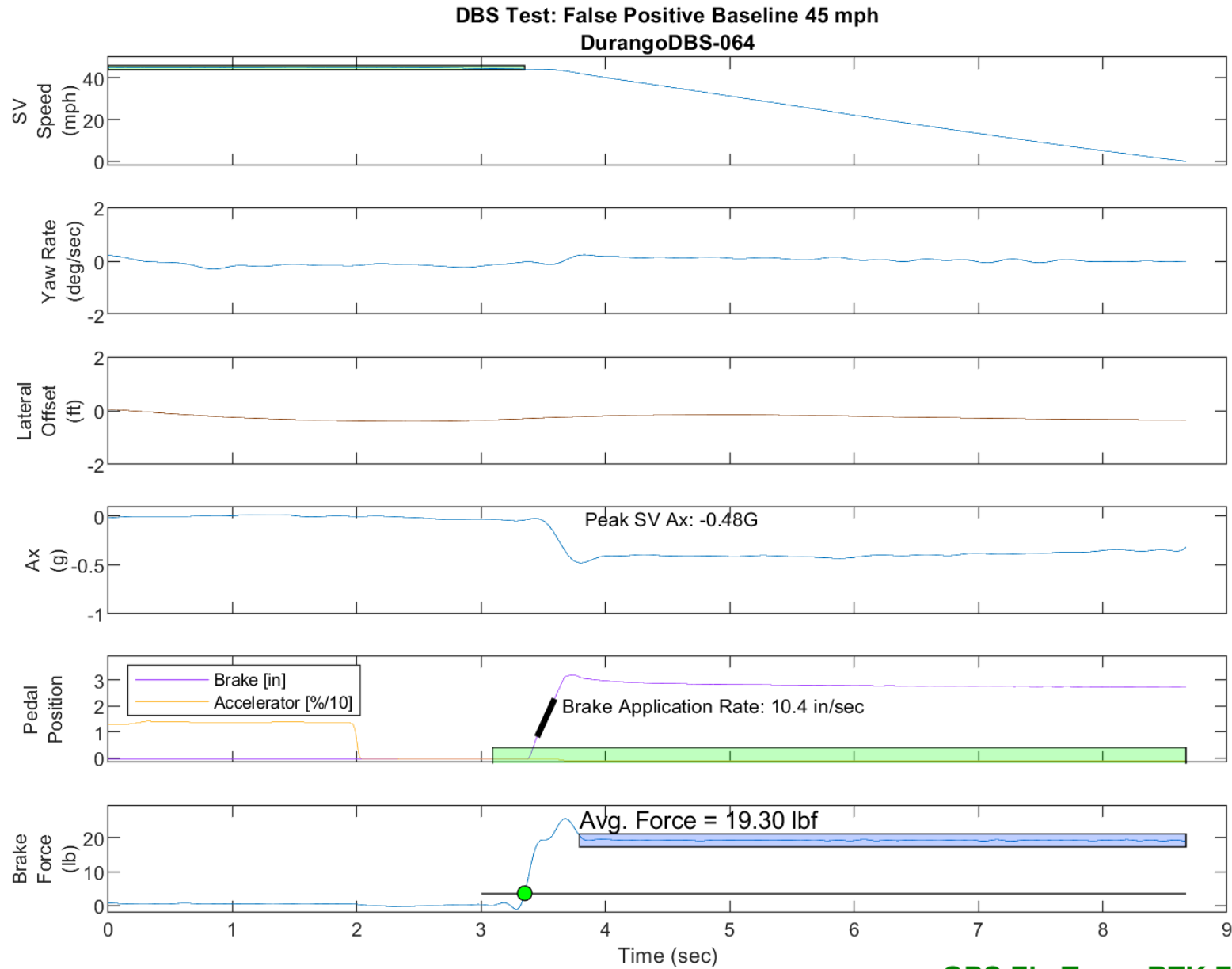


Figure E49. Time History for DBS Run 62, False Positive Baseline, SV 45 mph



**GPS Fix Type: RTK Fixed**

Figure E50. Time History for DBS Run 64, False Positive Baseline, SV 45 mph

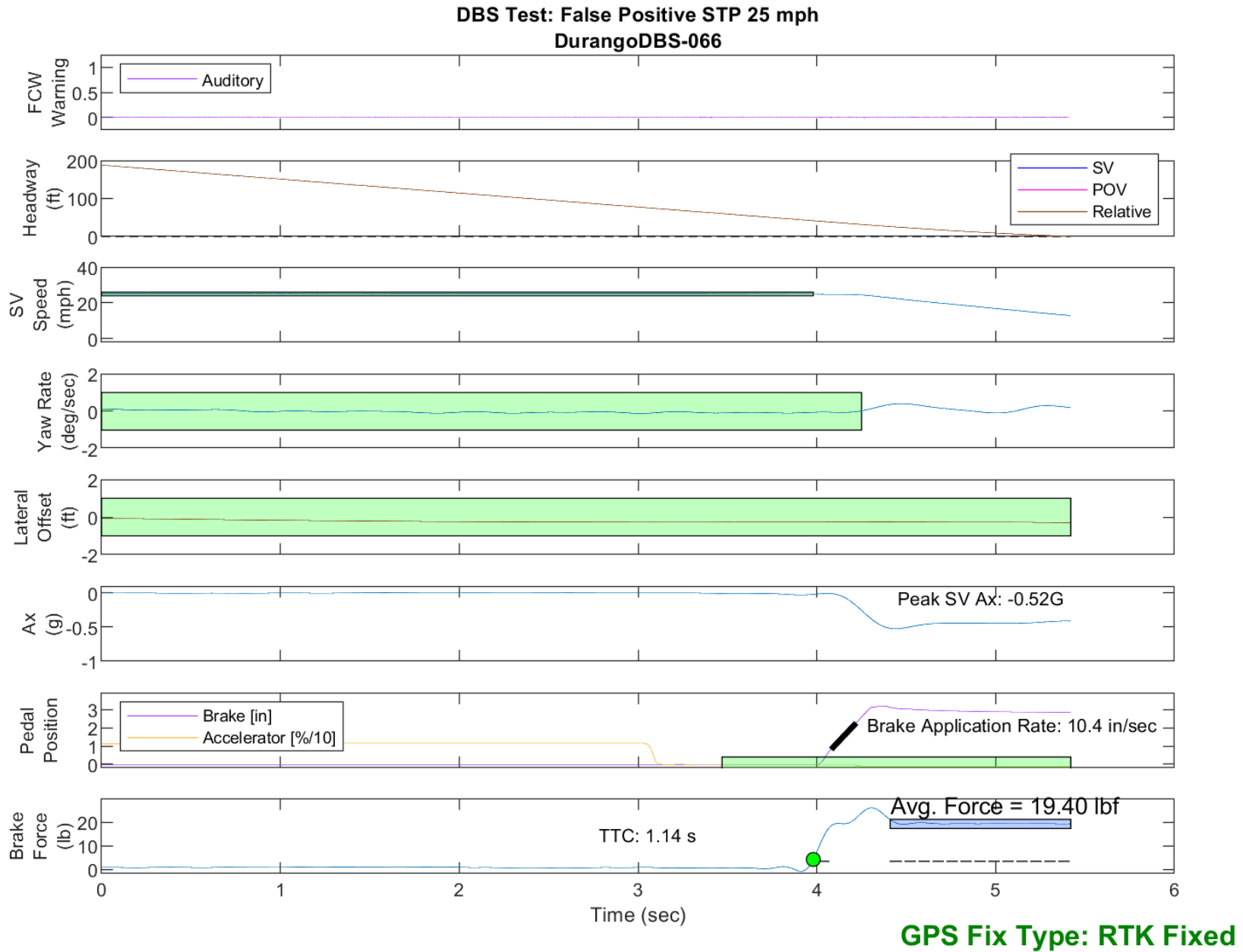


Figure E51. Time History for DBS Run 66, SV Encounters Steel Trench Plate, SV 25 mph

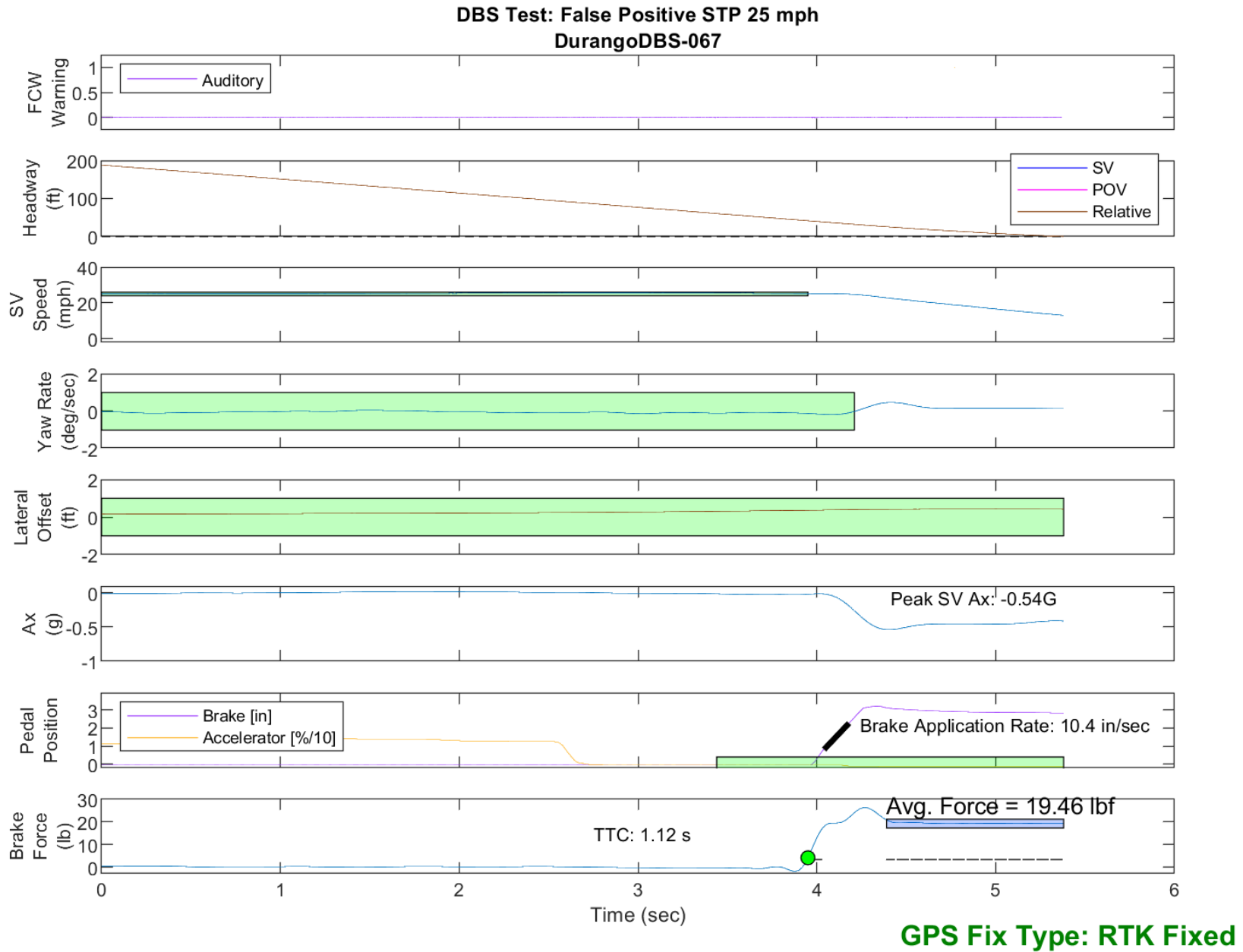


Figure E52. Time History for DBS Run 67, SV Encounters Steel Trench Plate, SV 25 mph

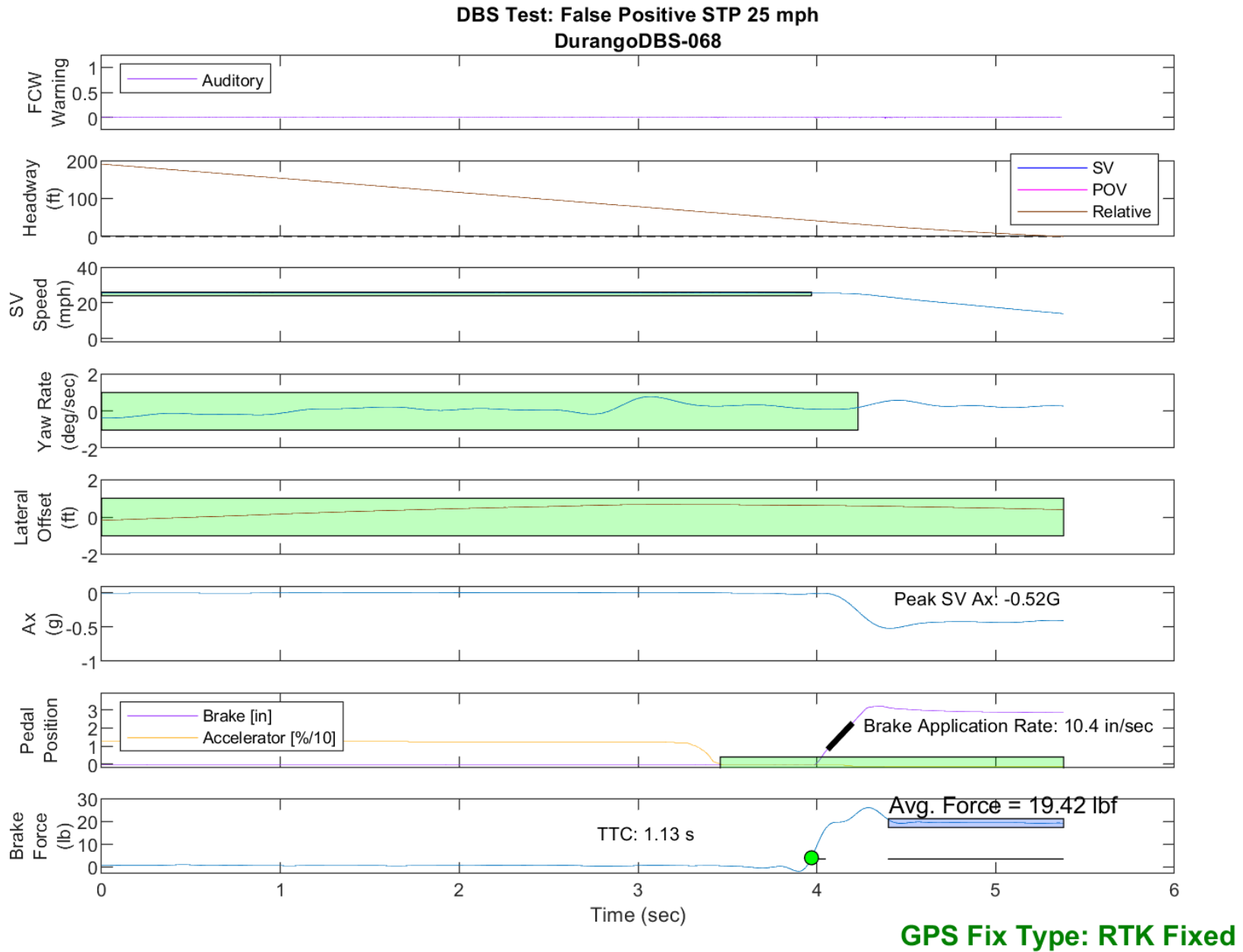


Figure E53. Time History for DBS Run 68, SV Encounters Steel Trench Plate, SV 25 mph

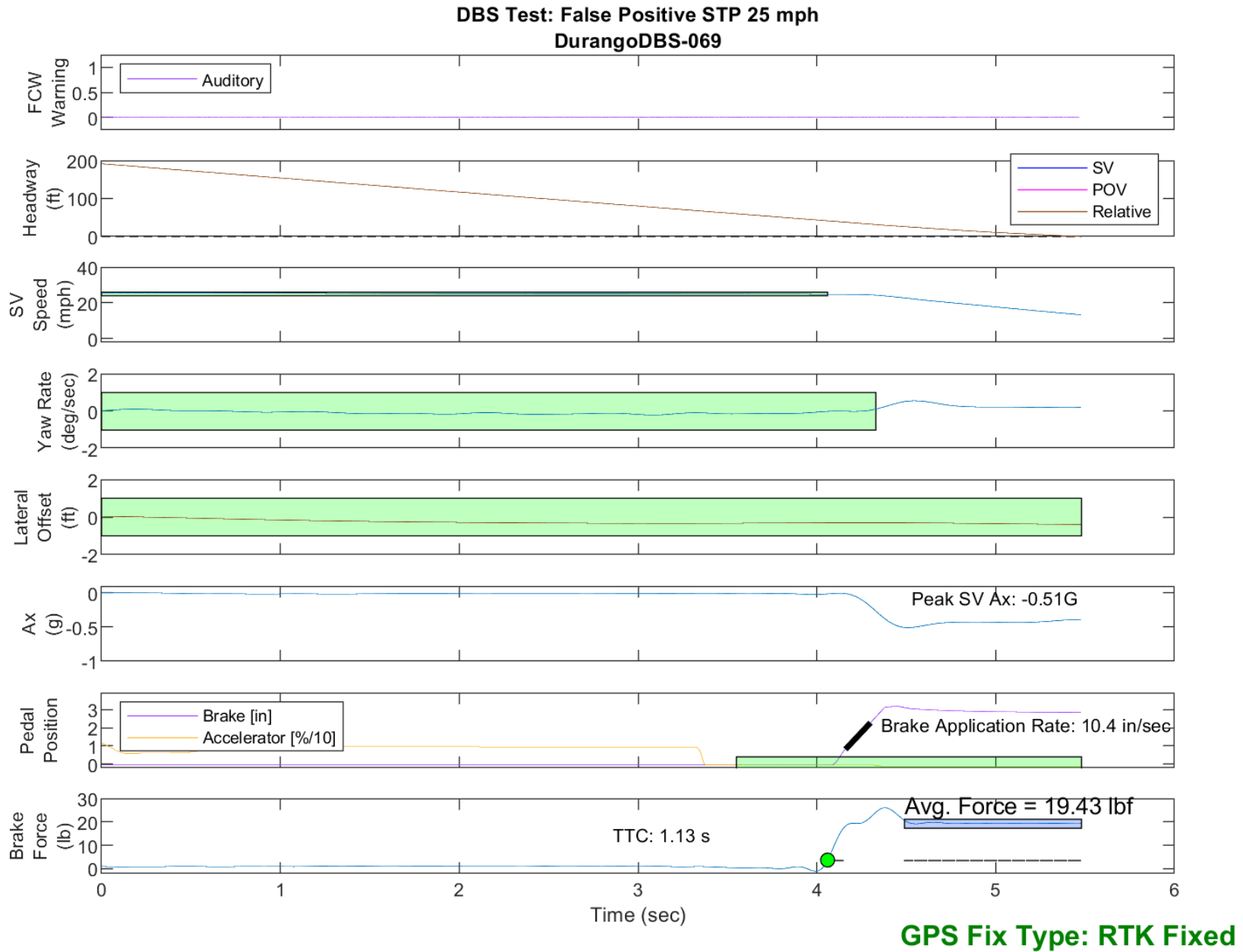


Figure E54. Time History for DBS Run 69, SV Encounters Steel Trench Plate, SV 25 mph



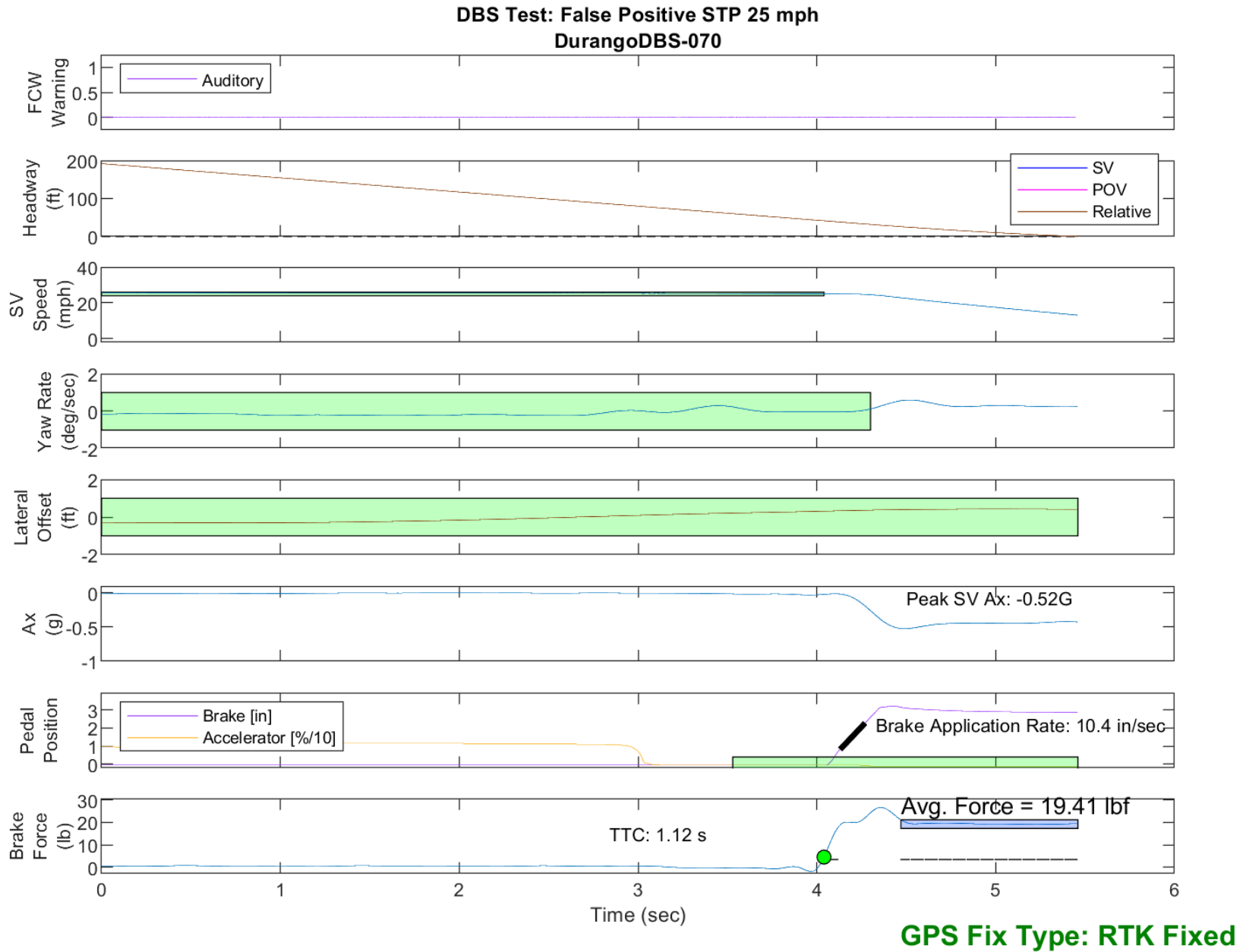


Figure E55. Time History for DBS Run 70, SV Encounters Steel Trench Plate, SV 25 mph

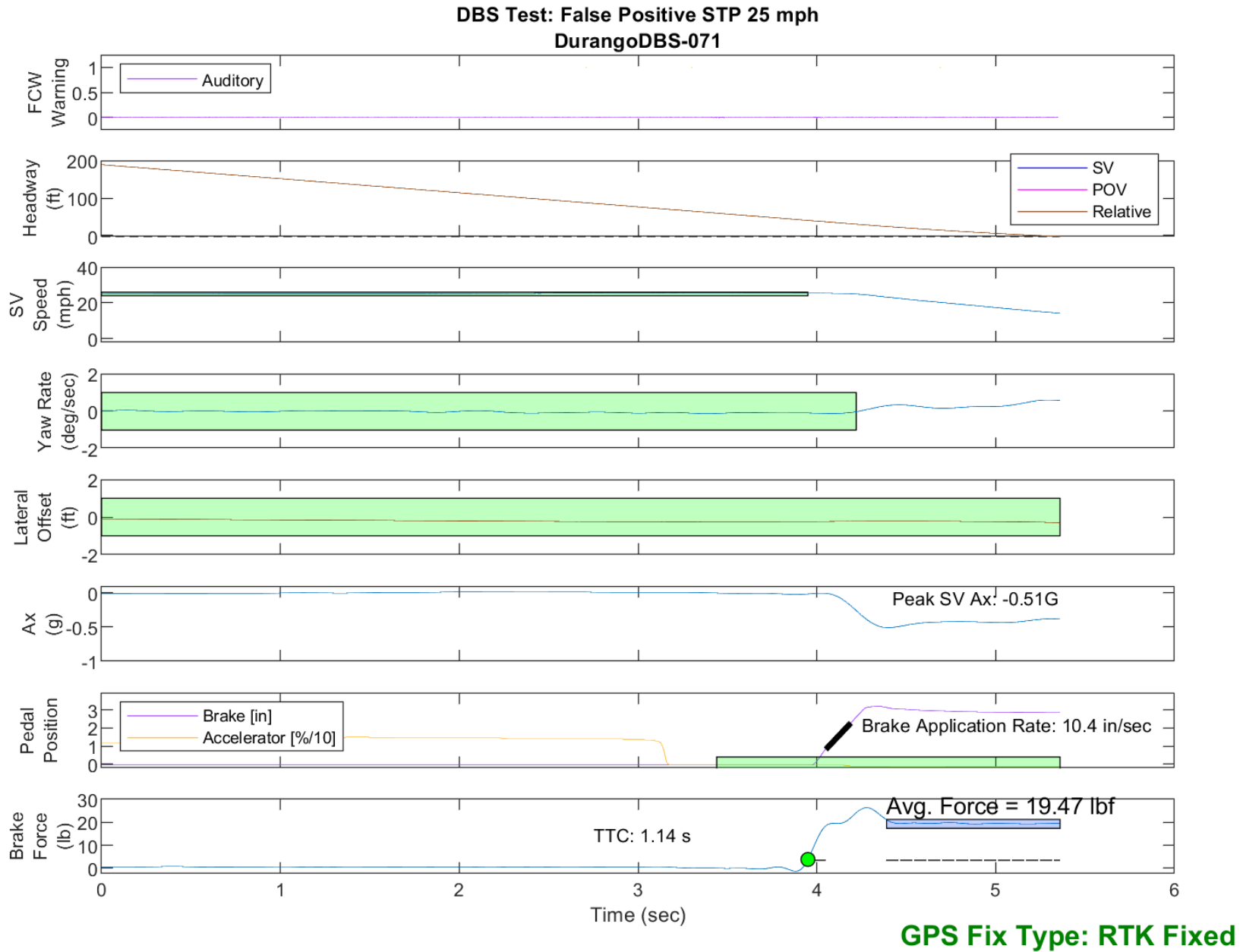


Figure E56. Time History for DBS Run 71, SV Encounters Steel Trench Plate, SV 25 mph

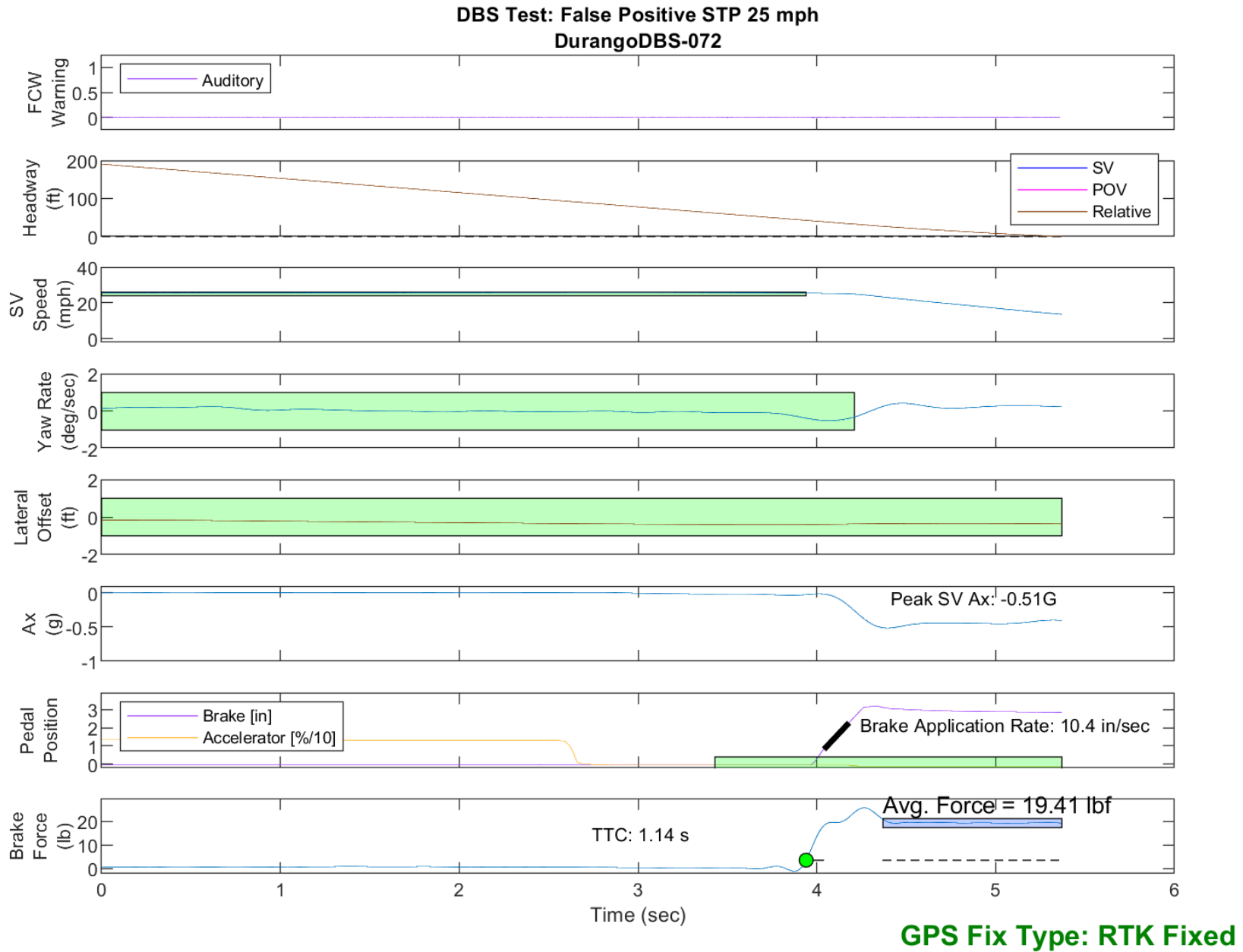


Figure E57. Time History for DBS Run 72, SV Encounters Steel Trench Plate, SV 25 mph

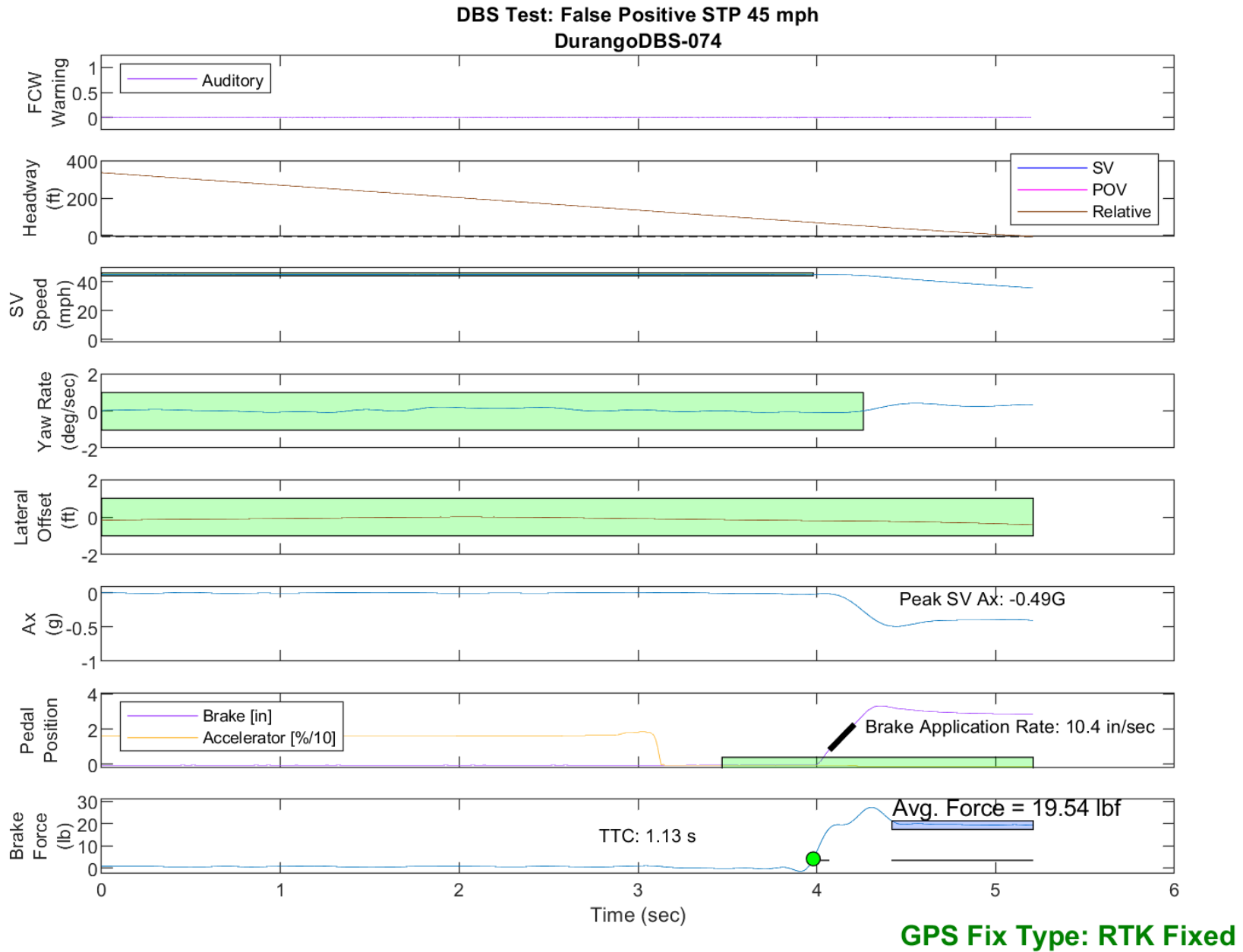


Figure E58. Time History for DBS Run 74, SV Encounters Steel Trench Plate, SV 45 mph

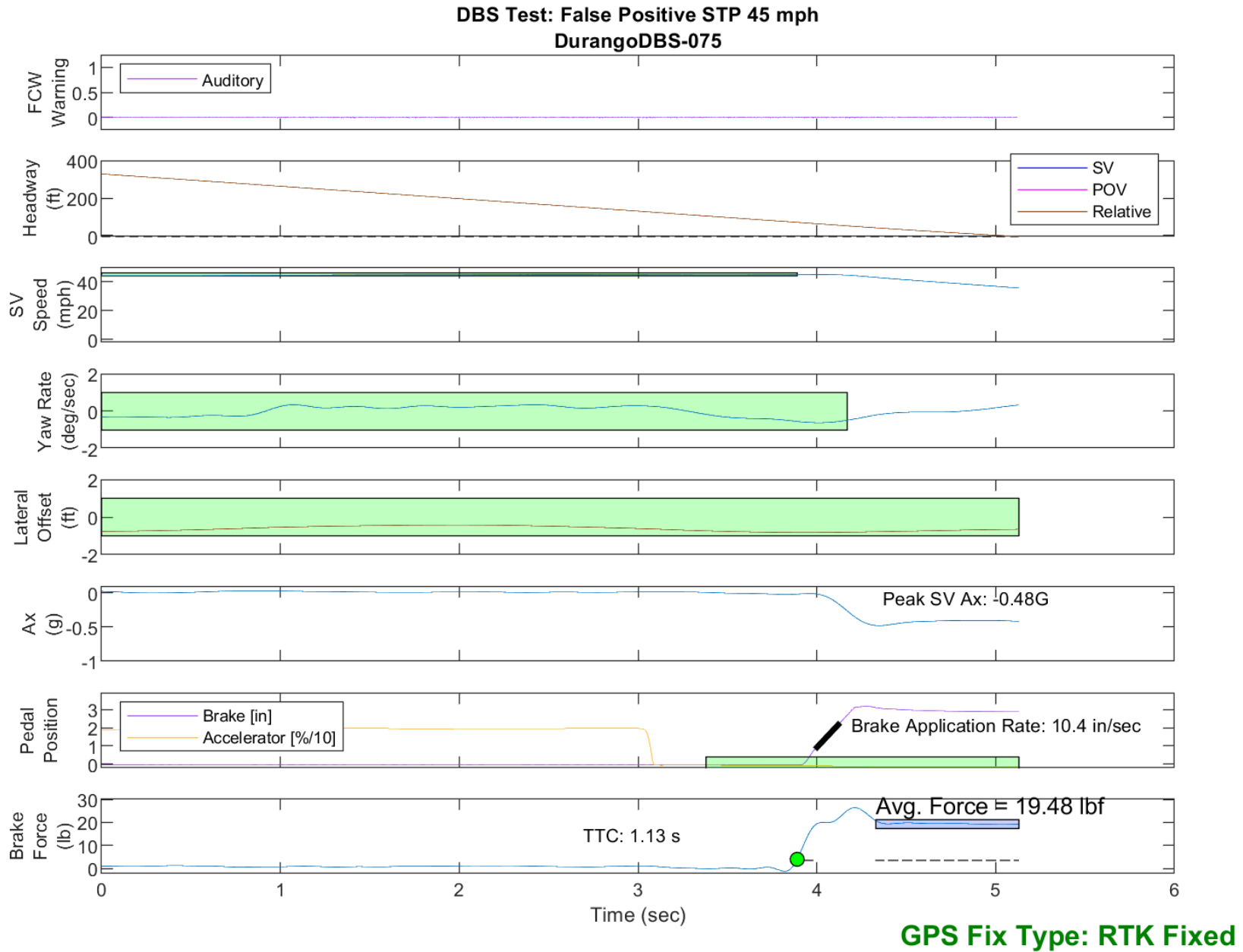


Figure E59. Time History for DBS Run 75, SV Encounters Steel Trench Plate, SV 45 mph

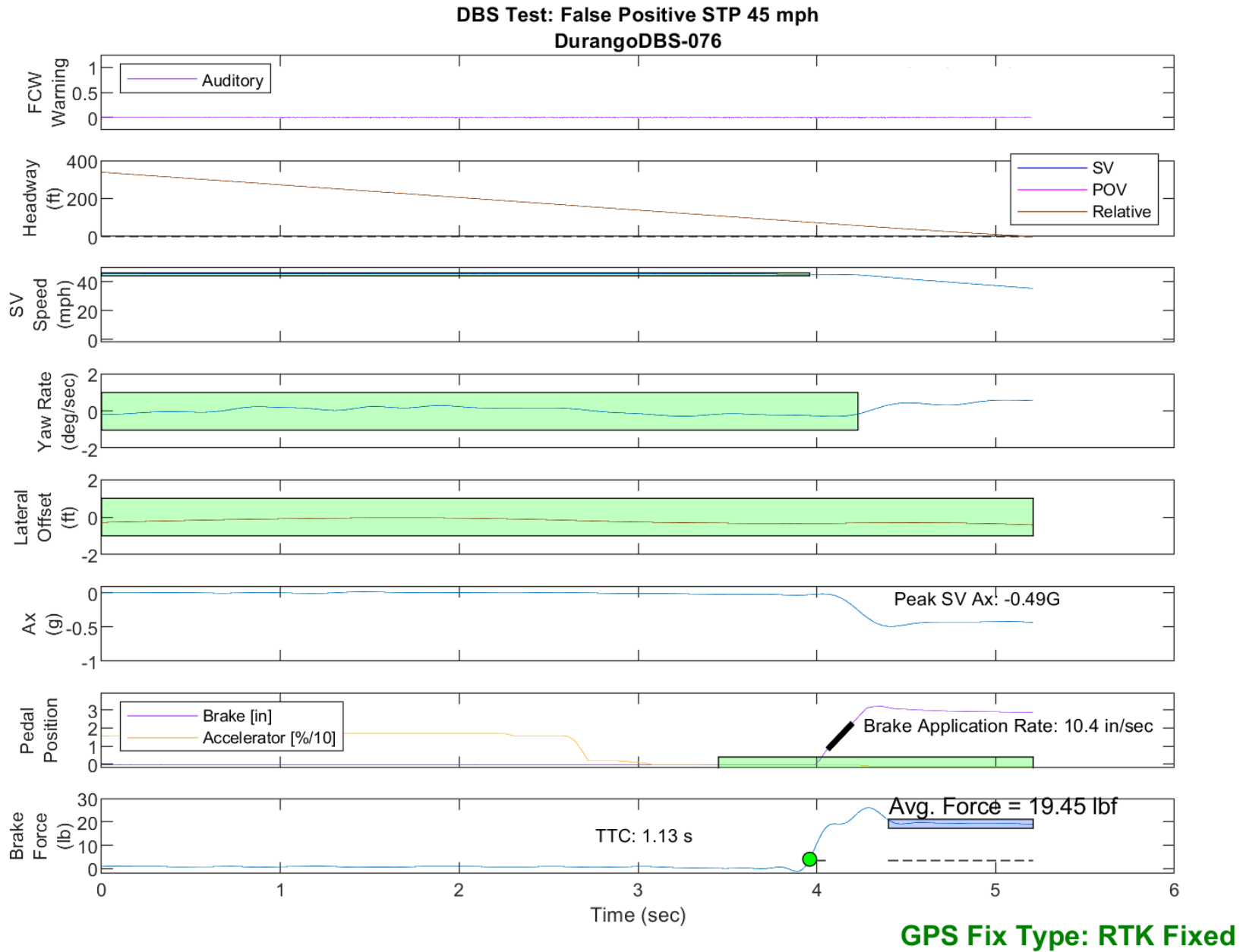


Figure E60. Time History for DBS Run 76, SV Encounters Steel Trench Plate, SV 45 mph

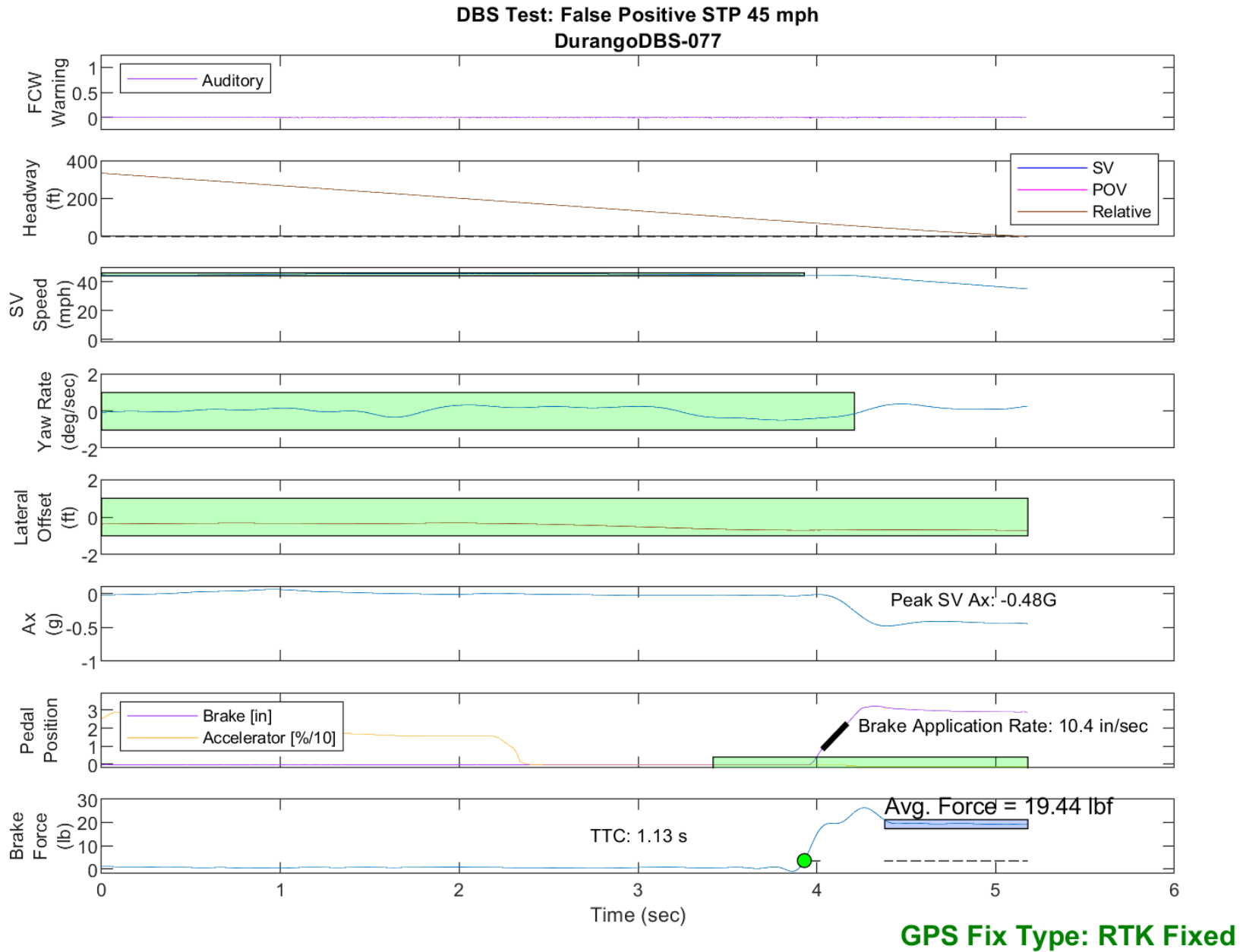


Figure E61. Time History for DBS Run 77, SV Encounters Steel Trench Plate, SV 45 mph

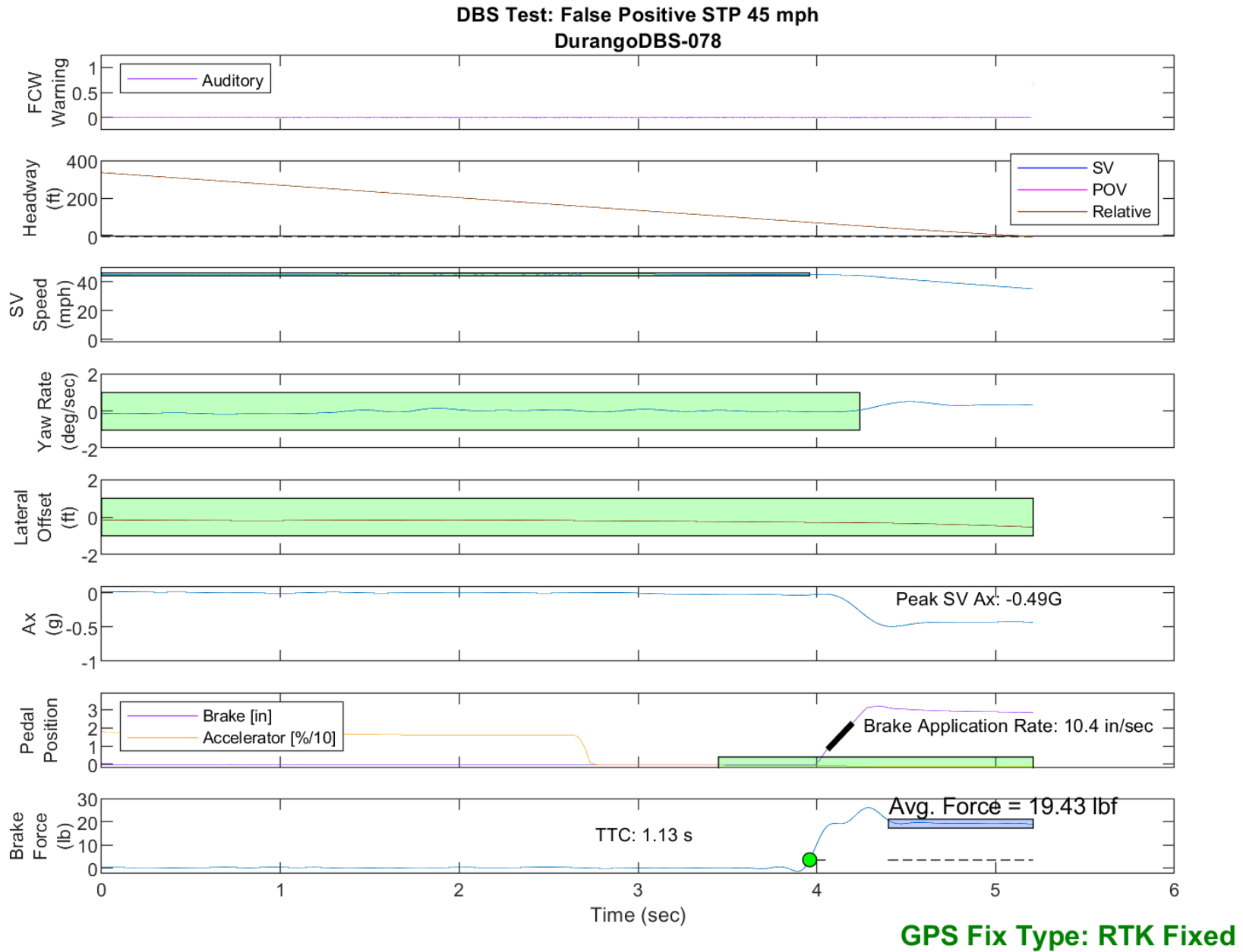


Figure E62. Time History for DBS Run 78, SV Encounters Steel Trench Plate, SV 45 mph



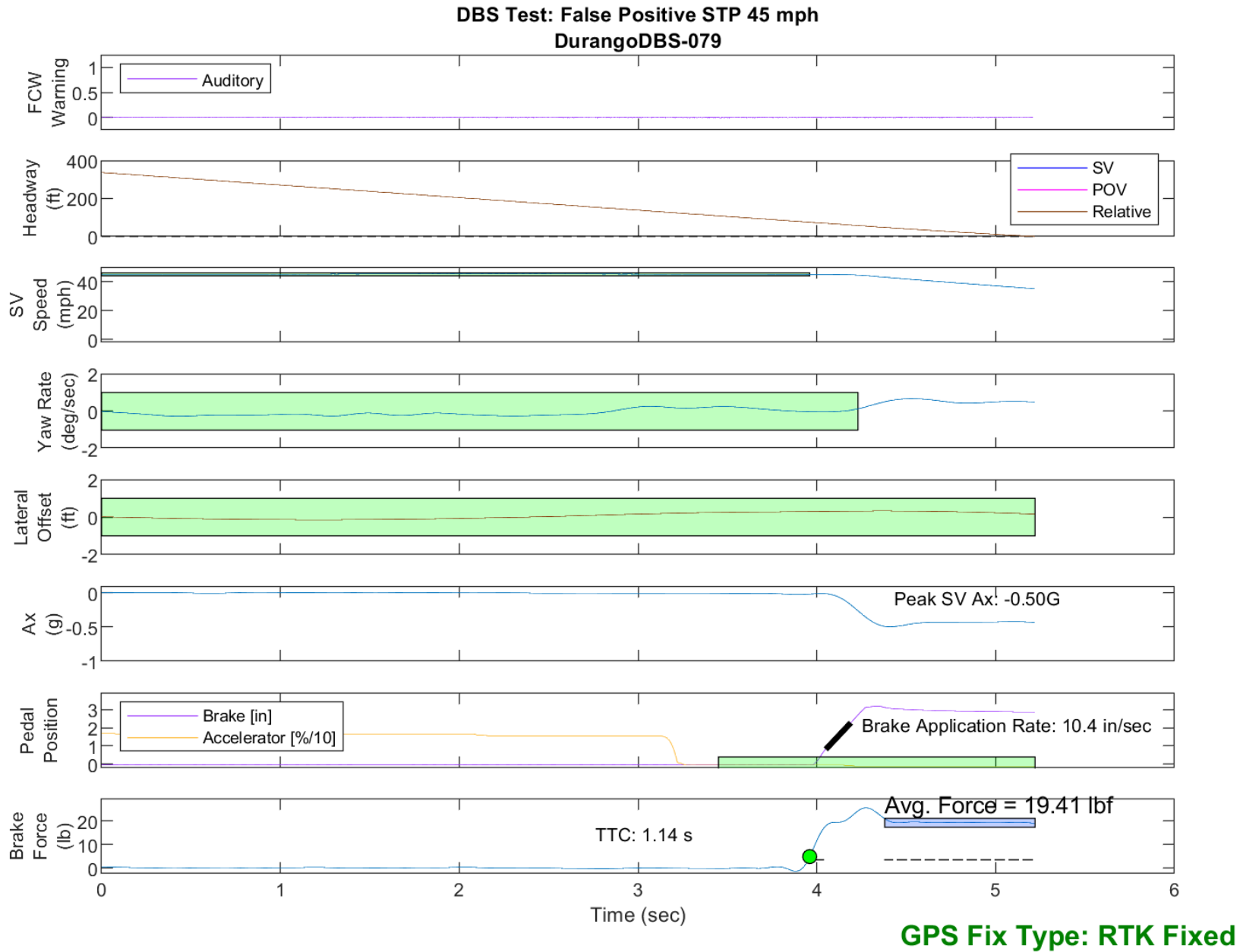


Figure E63. Time History for DBS Run 79, SV Encounters Steel Trench Plate, SV 45 mph

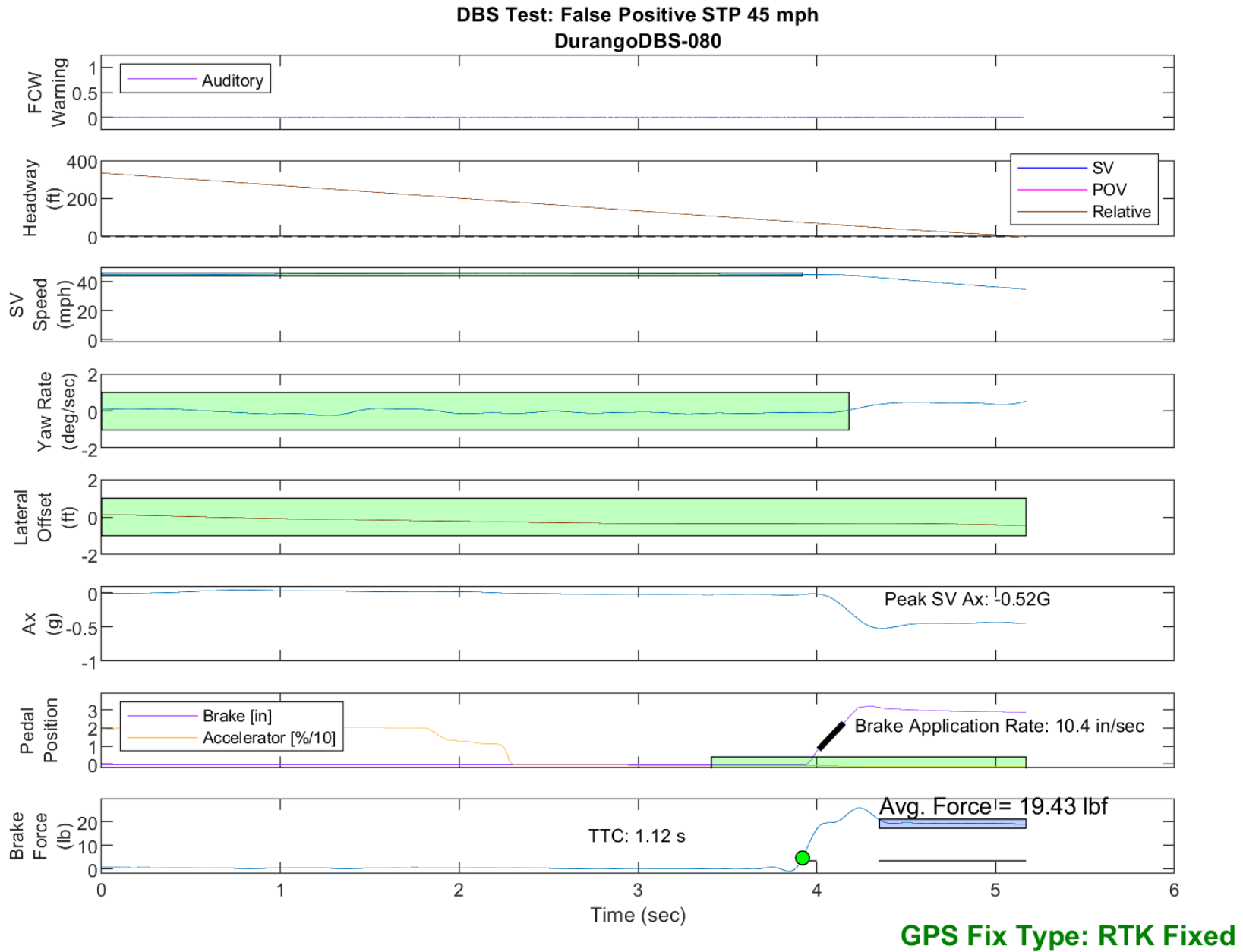
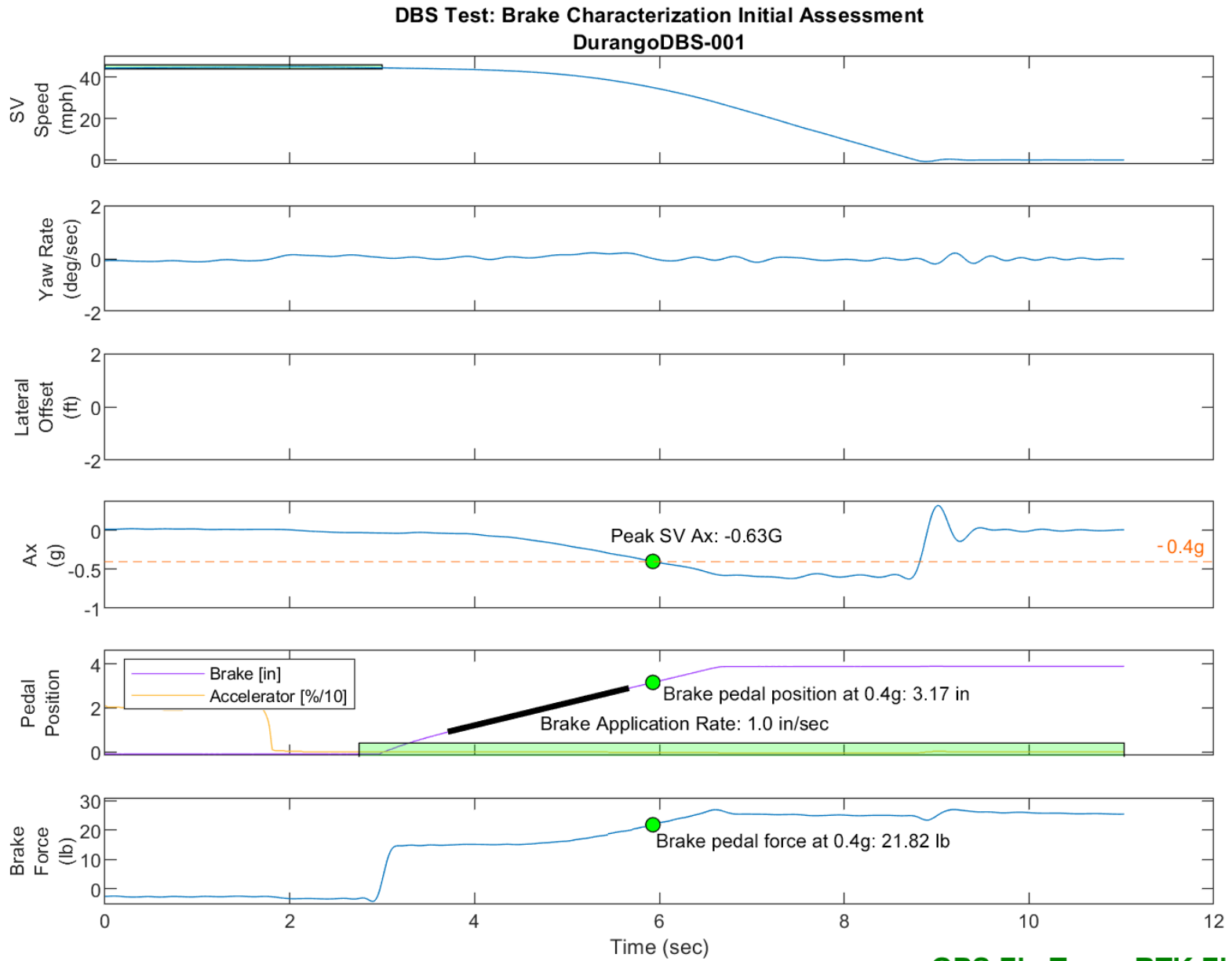
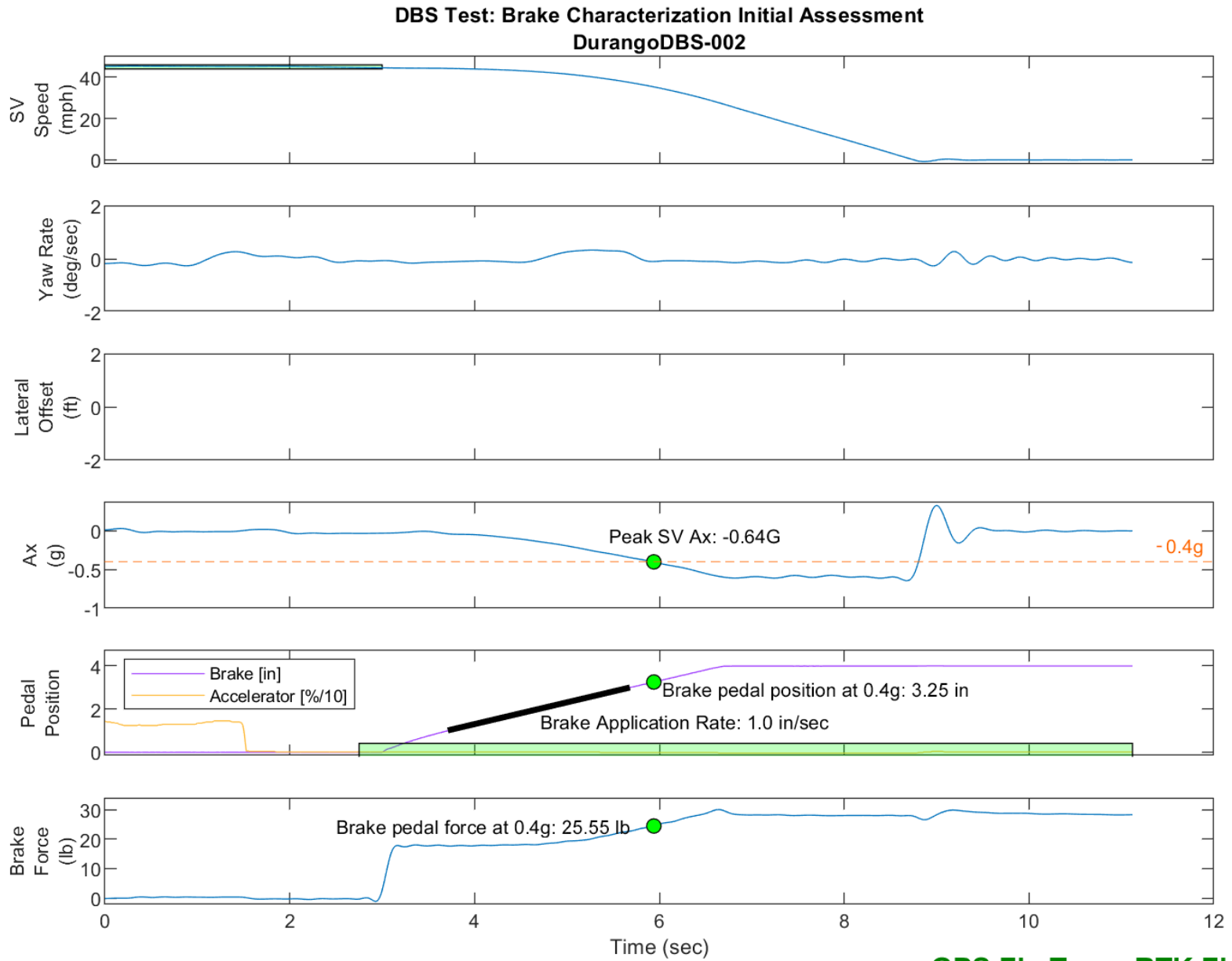


Figure E64. Time History for DBS Run 80, SV Encounters Steel Trench Plate, SV 45 mph



**GPS Fix Type: RTK Fixed**

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



**GPS Fix Type: RTK Fixed**

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

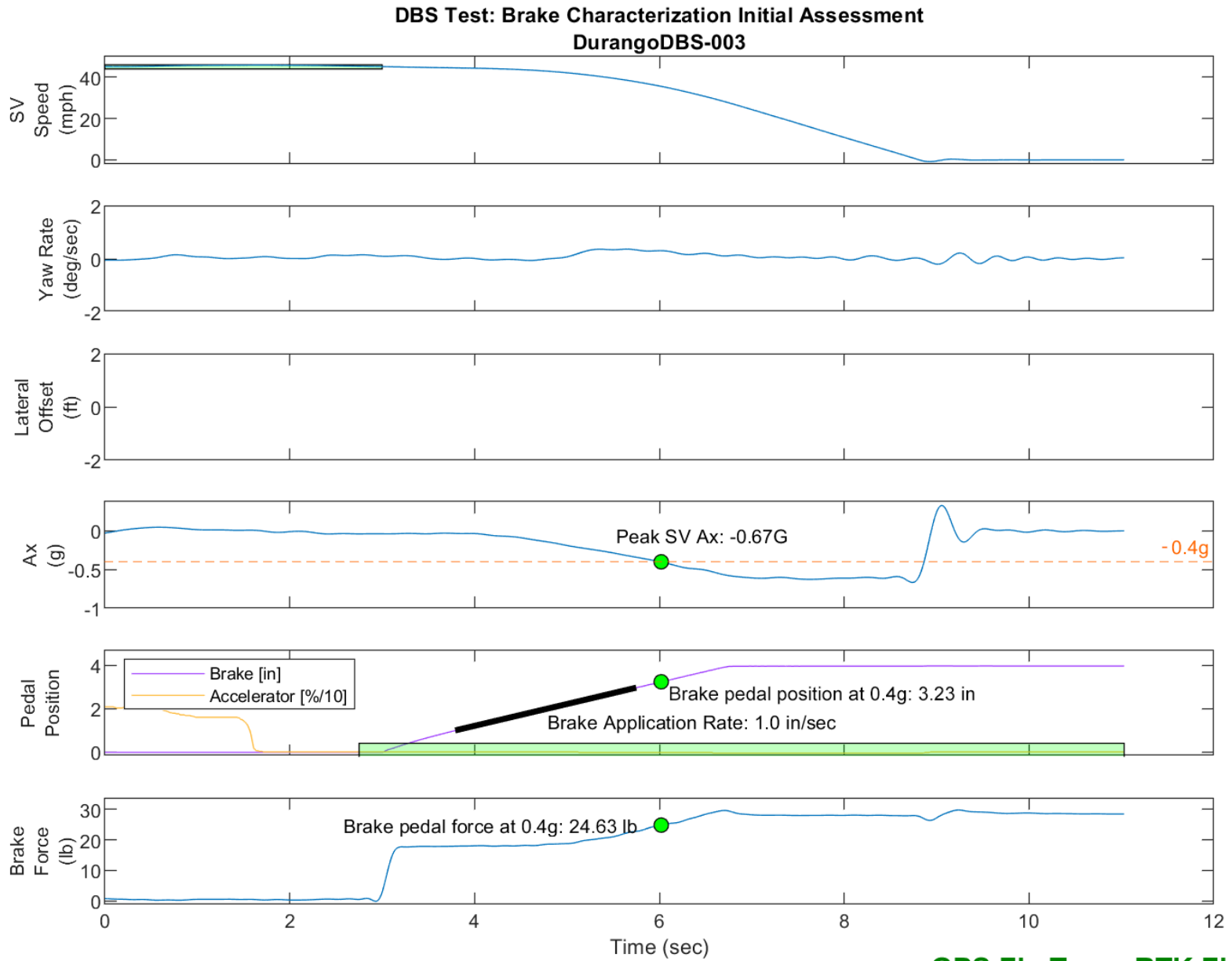


Figure E67. Time History for DBS Run 3, Brake Characterization Initial

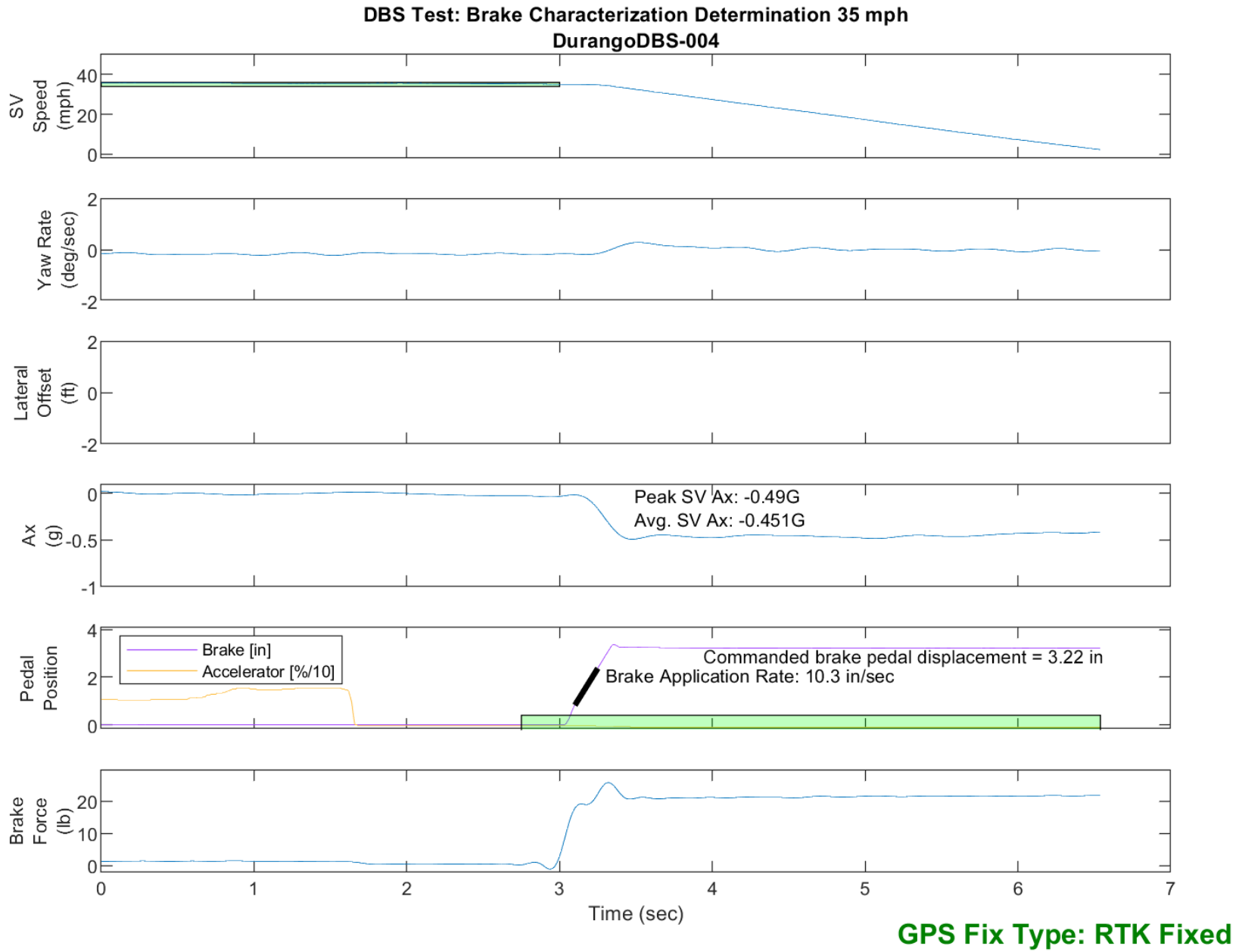


Figure E68. Time History for DBS Run 4, Brake Characterization Determination, Displacement Mode, 35 mph

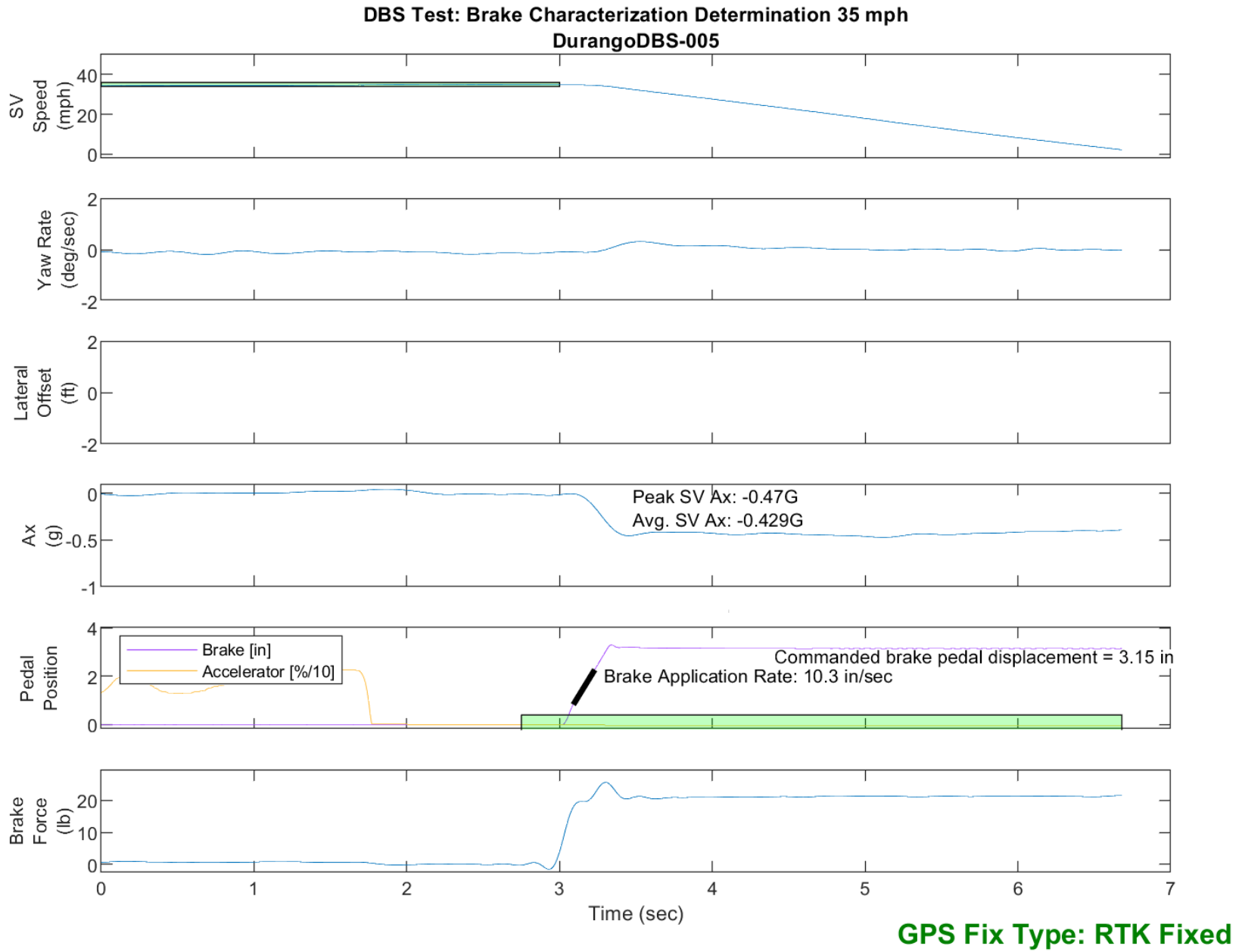


Figure E69. Time History for DBS Run 5, Brake Characterization Determination, Displacement Mode, 35 mph

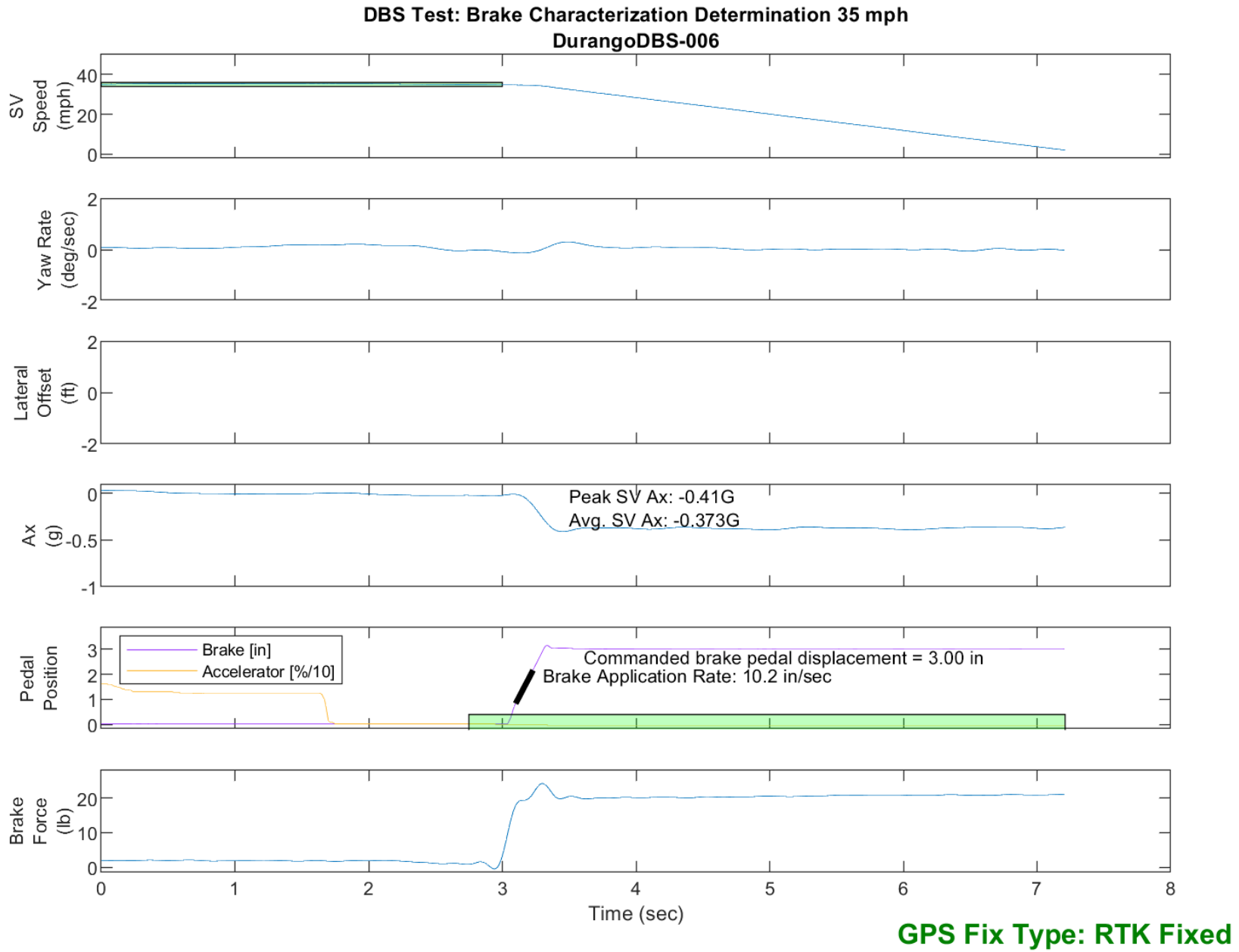


Figure E70. Time History for DBS Run 6, Brake Characterization Determination, Displacement Mode, 35 mph



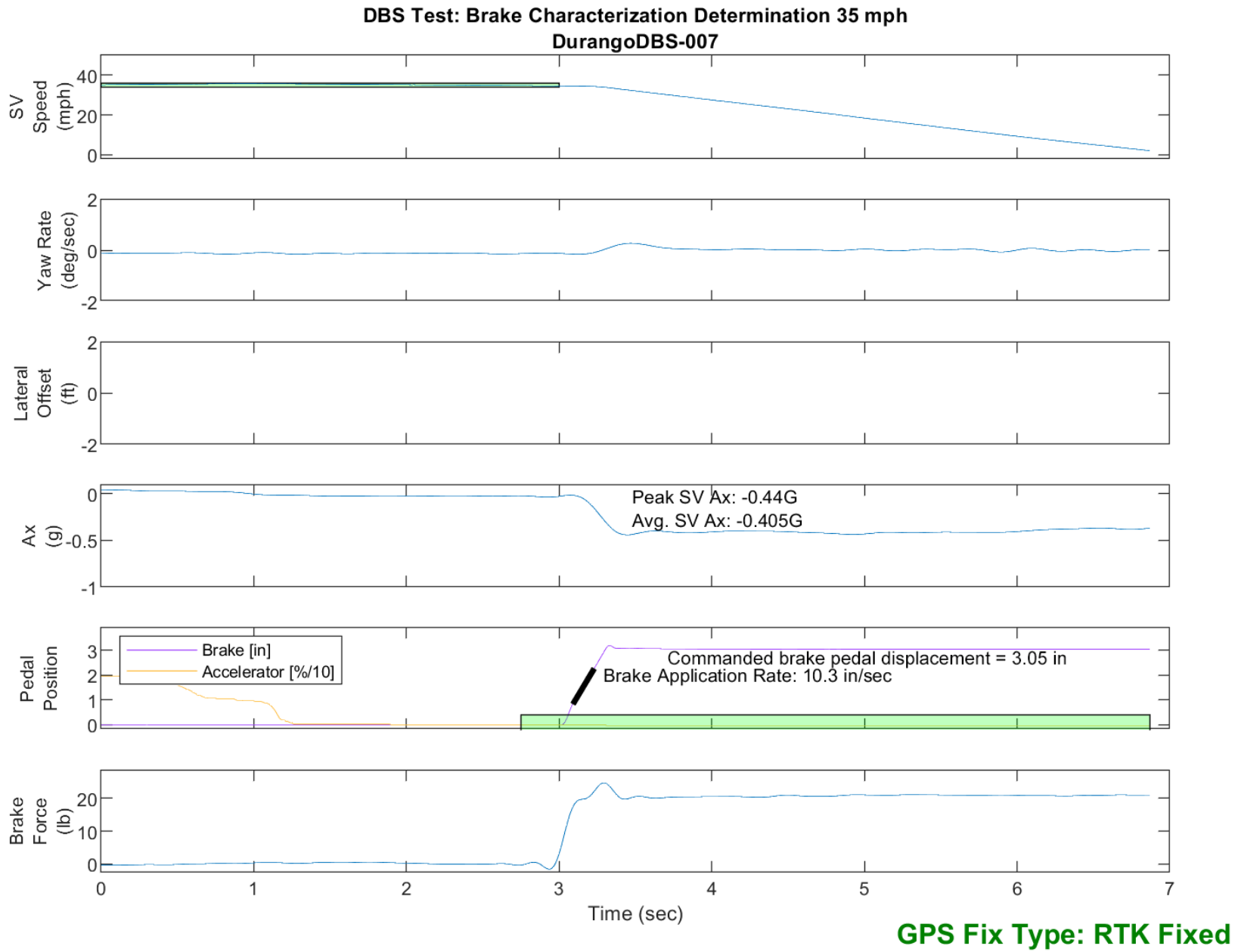
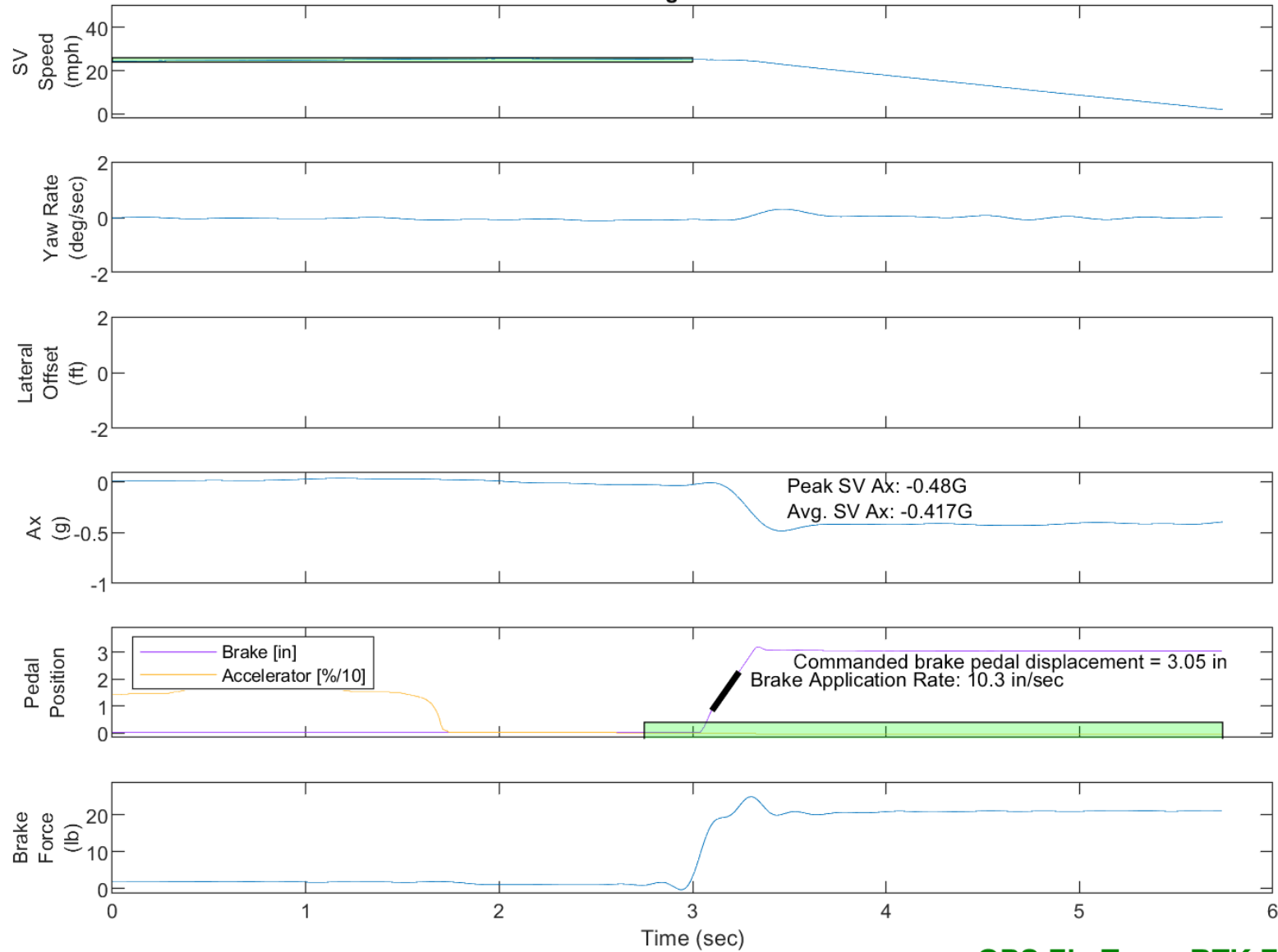


Figure E71. Time History for DBS Run 7, Brake Characterization Determination, Displacement Mode, 35 mph

### DBS Test: Brake Characterization Determination 25 mph DurangoDBS-008



**GPS Fix Type: RTK Fixed**

Figure E72. Time History for DBS Run 8, Brake Characterization Determination, Displacement Mode, 25 mph

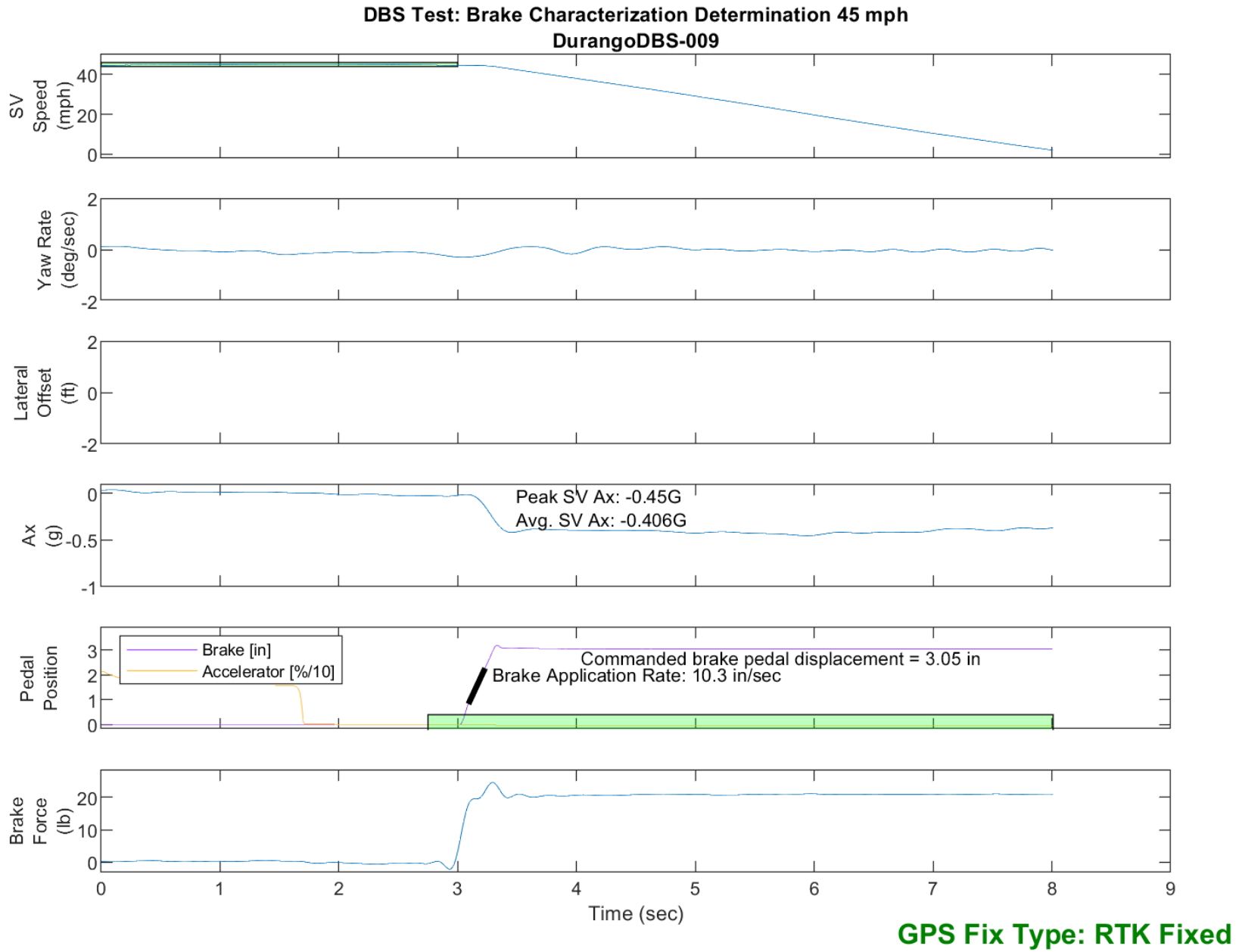


Figure E73. Time History for DBS Run 9, Brake Characterization Determination, Displacement Mode, 45 mph

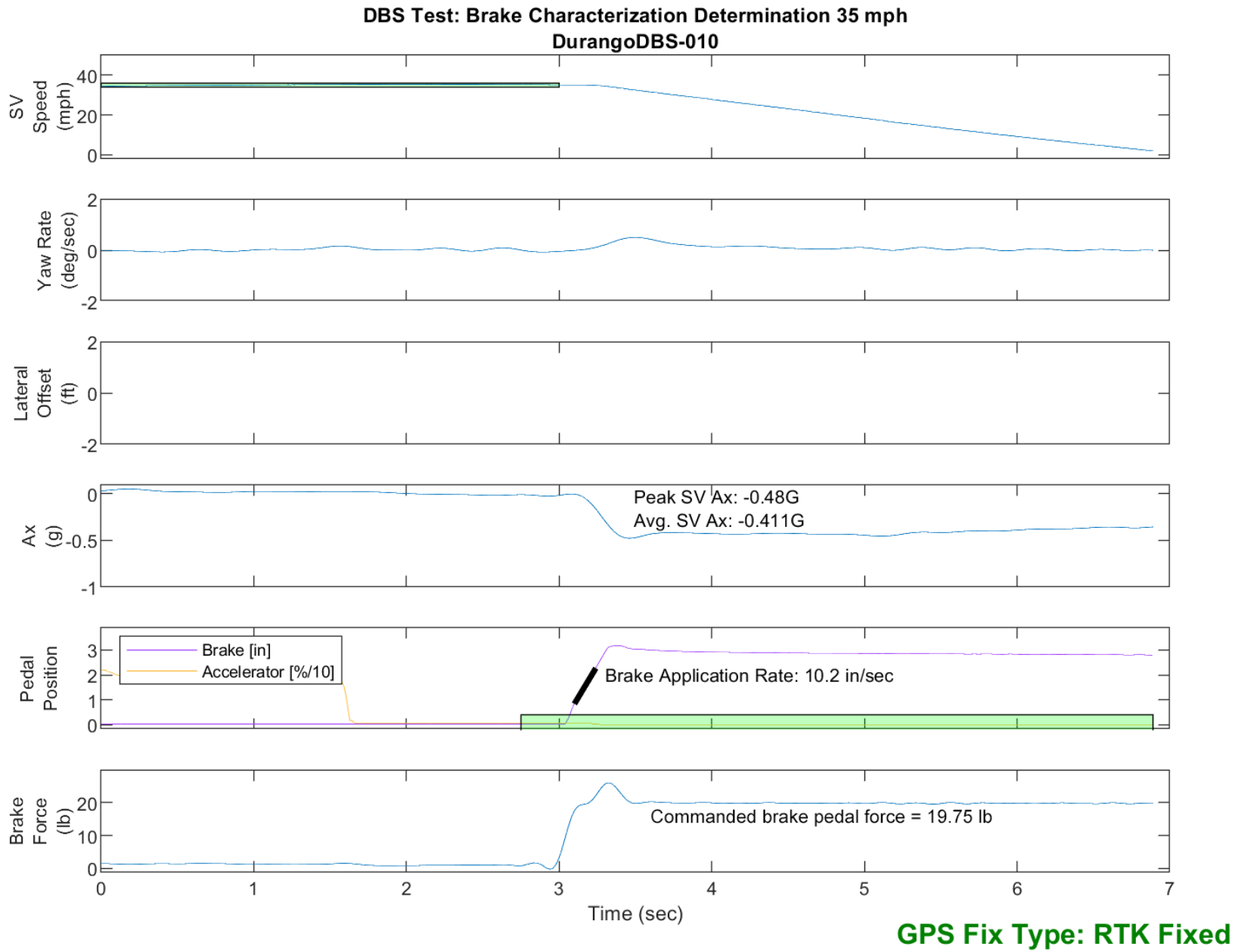


Figure E74. Time History for DBS Run 10, Brake Characterization Determination, Hybrid Mode, 35 mph

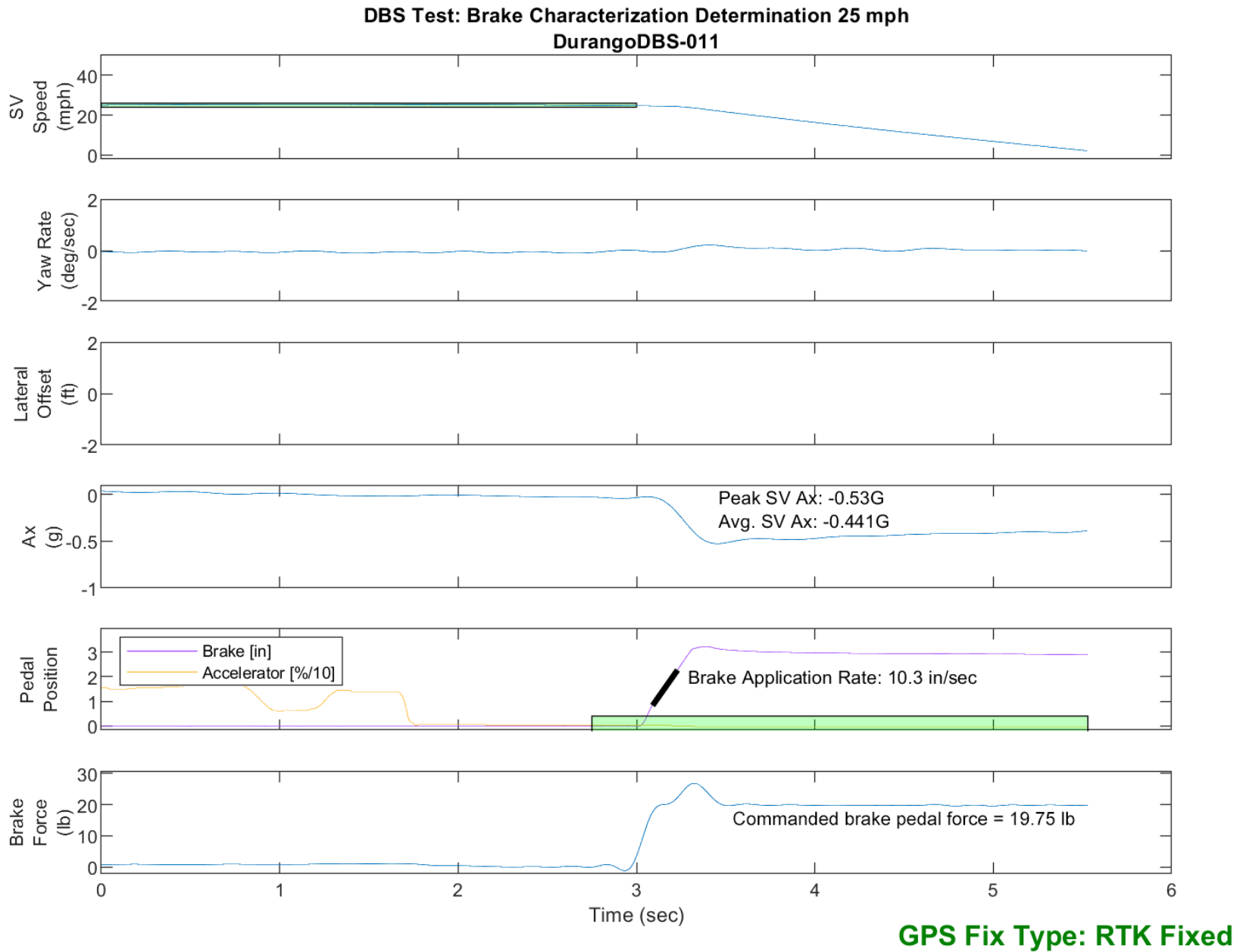


Figure E75. Time History for DBS Run 11, Brake Characterization Determination, Hybrid Mode, 25 mph

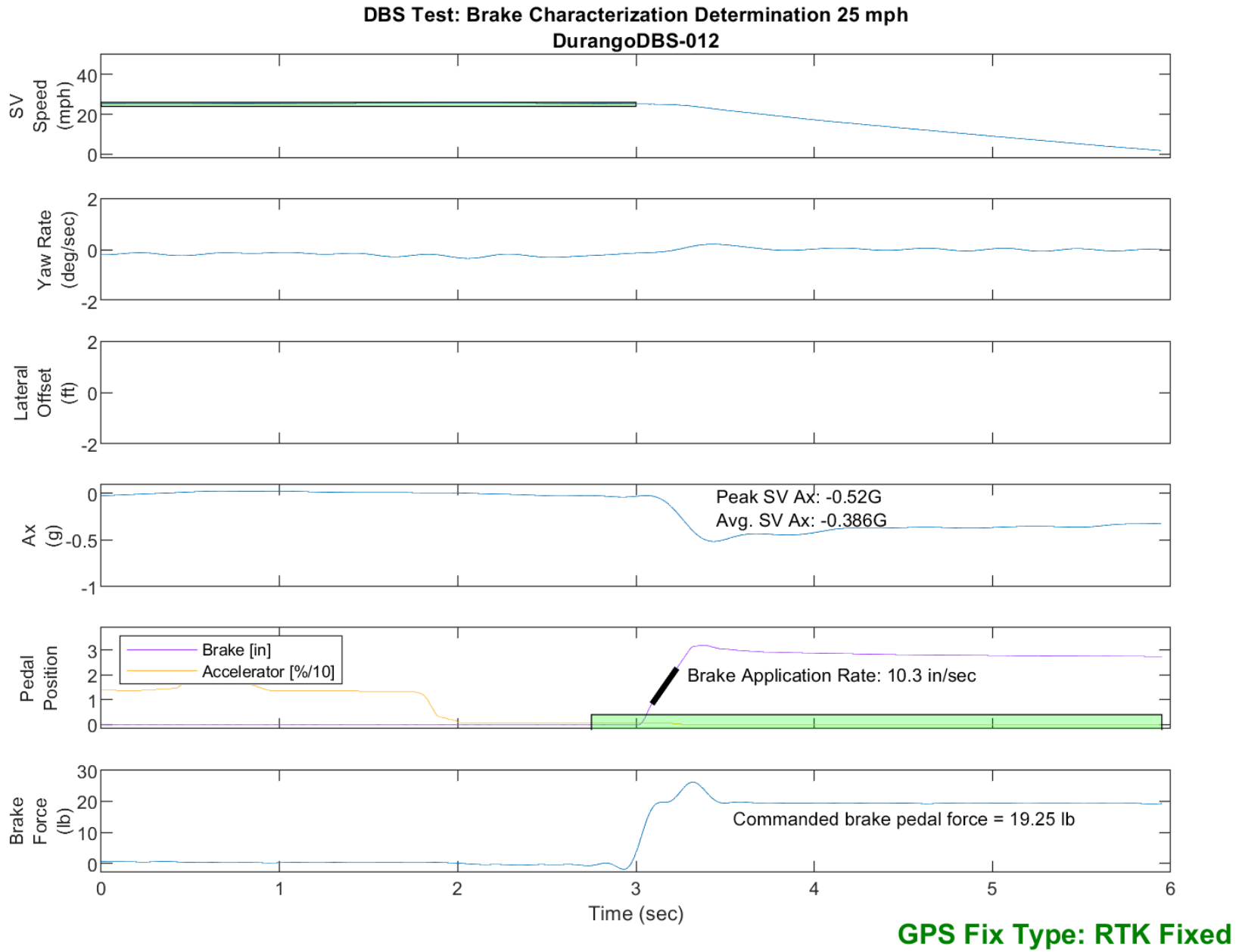


Figure E76. Time History for DBS Run 12, Brake Characterization Determination, Hybrid Mode, 25 mph

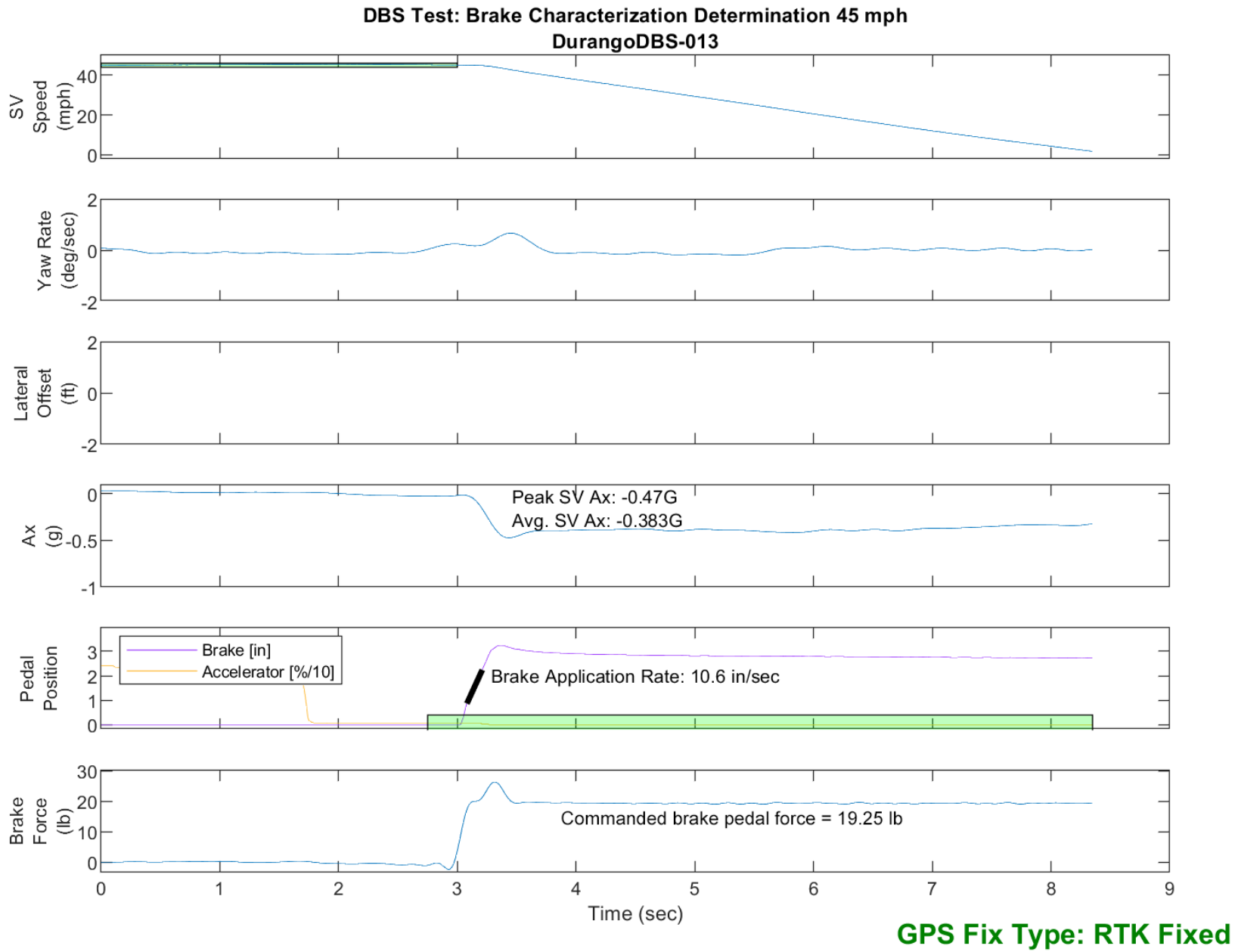


Figure E77. Time History for DBS Run 13, Brake Characterization Determination, Hybrid Mode, 45 mph

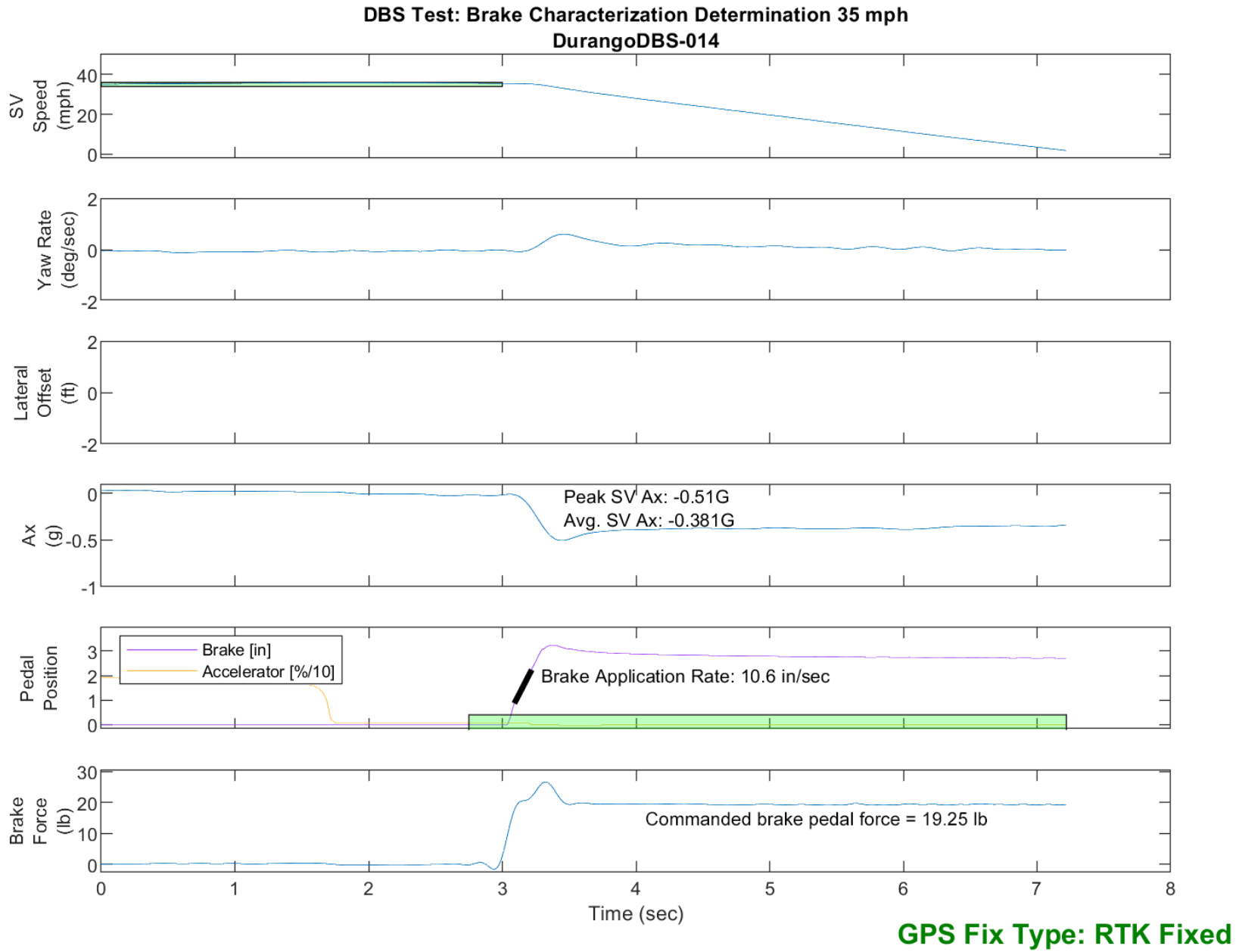


Figure E78. Time History for DBS Run 14, Brake Characterization Determination, Hybrid Mode, 35 mph