NEW CAR ASSESSMENT PROGRAM
DYNAMIC BRAKE SUPPORT SYSTEM CONFIRMATION TEST
NCAP-DRI-DBS-20-04

2020 Honda Odyssey EX-L

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1 July 2020

Final Report

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

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

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

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Date: 1 July 2020

1. Report No. NCAP-DRI-DBS-20-04	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Final Report of Dynamic Brake Support System Confirmation Test of a 2020 Honda Odyssey EX-L.		5. Report Date 1 July 2020 6. Performing Organization Code DRI
7. Author(s) J. Lenkeit, Technical Director S. Rhim, Test Engineer		8. Performing Organization Report No. DRI-TM-19-157
9. Performing Organization Name and Address Dynamic Research, Inc. 355 Van Ness Ave, STE 200 Torrance, CA 90501		10. Work Unit No. 11. Contract or Grant No. DTNH22-14-D-00333
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration New Car Assessment Program 1200 New Jersey Avenue, SE, West Building, 4th Floor (NRM-110) Washington, DC 20590		13. Type of Report and Period Covered Final Test Report April - July 2020 14. Sponsoring Agency Code NRM-110
15. Supplementary Notes		

16. Abstract

These tests were conducted on the subject 2020 Honda Odyssey EX-L in accordance with the specifications of the New Car Assessment Program's (NCAP) most current Test Procedure in docket NHTSA-2015-0006-0026; DYNAMIC BRAKE SUPPORT PERFORMANCE EVALUATION CONFIRMATION TEST FOR THE NEW CAR ASSESSMENT PROGRAM**,** October 2015. The vehicle passed the requirements of the test for all four DBS test scenarios.

17. Key Words Dynamic Brake Support, DBS, AEB, New Car Assessment Program, NCAP		18. Distribution Statement Copies of this report are available from the following: NHTSA Technical Reference Division National Highway Traffic Safety Administration 1200 New Jersey Avenue, SE Washington, DC 20590	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 159	22. Price

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Section I

INTRODUCTION

Dynamic Brake Support (DBS) systems are a subset of Automatic Emergency Braking (AEB) systems. DBS systems are designed to avoid or mitigate consequences of rear-end crashes by automatically applying supplemental braking on the subject vehicle when the system determines that the braking applied by the driver is insufficient to avoid a collision.

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

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

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

Section II

DATA SHEETS

DYNAMIC BRAKE SUPPORT

DATA SHEET 1: TEST RESULTS SUMMARY

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2020 Honda Odyssey EX-L

VIN: *5FNRL6H77LB05xxxx*

Test Date: *3/31/2020*

Dynamic Brake Support System setting: *Normal*

Test 1 - Subject Vehicle Encounters Stopped Principal Other Vehicle

SV 25 mph: *Pass*

Test 2 - Subject Vehicle Encounters Slower Principal Other Vehicle

SV 25 mph POV 10 mph: *Pass*

SV 45 mph POV 20 mph: *Pass*

Test 3 - Subject Vehicle Encounters Decelerating Principal Other Vehicle

SV 35 mph POV 35 mph: *Pass*

Test 4 - Subject Vehicle Encounters Steel Trench Plate

SV 25 mph: *Pass*

SV 45 mph: *Pass*

Overall: ***Pass***

Notes:

DYNAMIC BRAKE SUPPORT

DATA SHEET 2: VEHICLE DATA

(Page 1 of 1)

2020 Honda Odyssey EX-L

TEST VEHICLE INFORMATION

VIN: *5FNRL6H77LB05xxxx*

Body Style: *Minivan* Color: *Platinum White Pearl*

Date Received: *3/16/2020* Odometer Reading: *38 mi*

DATA FROM VEHICLE'S CERTIFICATON LABEL

Vehicle manufactured by: *HONDA MFG. OF ALABAMA, LLC*

Date of manufacture: *02/20*

Vehicle Type: *MPV*

DATA FROM TIRE PLACARD

Tires size as stated on Tire Placard: Front: *235/60R18 103H*

Rear: *235/60R18 103H*

Recommended cold tire pressure: Front: *240 kPa (35 psi)*

Rear: *240 kPa (35 psi)*

TIRES

Tire manufacturer and model: *BRIDGESTONE TURANZA EL440*

Front tire specification: *235/60R18 103H*

Rear tire specification: *235/60R18 103H*

Front tire DOT prefix: *DOT 7X45 JB2*

Rear tire DOT prefix: *DOT 7X45 JB2*

DYNAMIC BRAKE SUPPORT

DATA SHEET 3: TEST CONDITIONS

(Page 1 of 2)

2020 Honda Odyssey EX-L

GENERAL INFORMATION

Test date: *3/31/2020*

AMBIENT CONDITIONS

Air temperature: *22.2 C (72 F)*

Wind speed: *4.6 m/s (10.4 mph)*

X Wind speed ≤ 10 m/s (22 mph).

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

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

VEHICLE PREPARATION

Verify the following:

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

Fuel tank is full: **X**

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

Front: *240 kPa (35 psi)*

Rear: *240 kPa (35 psi)*

WEIGHT

Weight of vehicle as tested including driver and instrumentation

Left Front:	*616.9 kg (1360 lb)*	Right Front:	*596.0 kg (1314 lb)*
Left Rear:	*497.6 kg (1097 lb)*	Right Rear:	*478.1 kg (1054 lb)*
		Total:	*2188.6 kg (4825 lb)*

DYNAMIC BRAKE SUPPORT

DATA SHEET 4: DYNAMIC BRAKE SUPPORT SYSTEM OPERATION

(Page 1 of 4)

2020 Honda Odyssey EX-L

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

Collision Mitigation Braking System (CMBS)

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

Fusion of radar and mono camera.

The radar sensor is located in the front grille and the front sensor camera is mounted to the interior side of the windshield, behind the rear view mirror.

System setting used for test (if applicable): *Normal*

Brake application mode used for test: *Constant pedal displacement*

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

5 km/h (3.1 mph) (Per manufacturer supplied information)

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

No upper limit (Per manufacturer supplied information)

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

___ No

If yes, please provide a full description.

Initial learning (or after ignition reset) is undertaken using a section of roadway with lane markers on both sides of the vehicle.

This procedure is needed only once before all the DBS/CIB testing.

Conditions:

- *Lane markers on both sides of the vehicle 100～300 m*
- *Solid or dashed lines*
- *100 m: Three round trips*
- *300 m: Two round trips*
- *3.5 m – 4.3 m between inner parts of the lines*
- *100 mm line width*
- *25 mph*

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

X Yes

___ No

If yes, please provide a full description.

Yes, CMBS indicator in Multi-Information Display comes on if deactivated.

To avoid deactivation, turn off the ignition switch after every test and the calibrate the camera before every test.

How is the Forward Collision Warning presented to the driver?

(Check all that apply)

X Warning light

X Buzzer or audible alarm

X 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, audible, vibration, or combination), etc.

Visual alert:

Location, size: Multi-Information Display in the instrument panel. Please see the Owner's Manual, Page 114 in Appendix B, Page B-6 and also Appendix A, Figure A17.

Color: Orange

Words "BRAKE"

Flashes On/Off

Audible: Repeated beep

Vibration: Steering wheel vibration for oncoming detected vehicles.

Is there a way to deactivate the system? **X** Yes

____ No

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

A push button located to the left of the steering column can be used to deactivate CMBS (Appendix A, Figure A18).

Press and hold the button until the beeper sounds to switch the system on or off.

When the CMBS is off:

- *The CMBS indicator in the instrument panel comes on.*
- *A message on the driver information interface indicates that the system is off.*

The CMBS is turned on every time the vehicle is started, even if it was disabled during the previous ignition cycle.

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

X Yes

___ No

If yes, please provide a full description.

The system settings are accessed through a touch screen in the center of the console (Appendix A, Figures A15 and A16). The menu hierarchy is:

- *Settings*
  - *Vehicle*
    - *Driver Assist System Setup*
      - *Forward Collision Warning Distance*
        - *Select distance: Long/Normal/Short*

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

X Yes

___ No

If yes, please provide a full description.

The system limitations are described in the Owner's Manual, Pages 619 through 623. These pages are reproduced in Appendix B, Pages B-12 through B-16.

Notes:

Section III

TEST PROCEDURES

A. Test Procedure Overview

Four test scenarios were used, as follows:

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

Test 2. Subject Vehicle Encounters Slower Principal Other Vehicle

Test 3. Subject Vehicle Encounters Decelerating Principal Other Vehicle

Test 4. Subject Vehicle Encounters Steel Trench Plate

An overview of each of the test procedures follows.

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

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

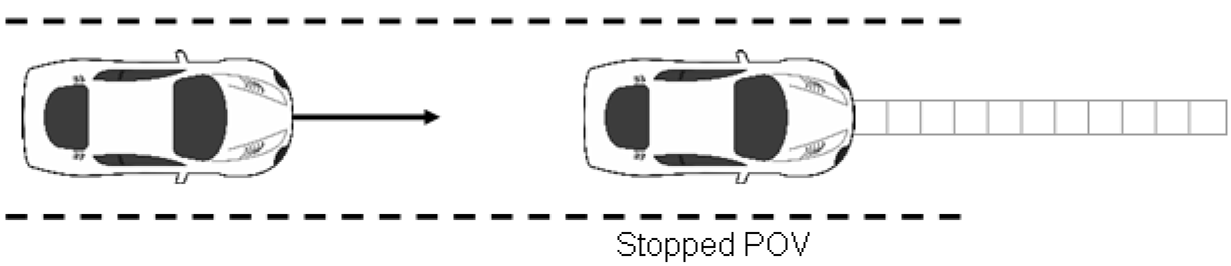


Figure 1. Depiction of Test 1

a. Procedure

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

The SV ignition was cycled prior to each test run. The SV was driven at a nominal speed of 25 mph (40.2 km/h) in the center of the lane of travel, toward the parked POV. The SV throttle pedal was released within 500 ms after t_{FCW}, i.e., within 500 ms of the FCW alert. The SV brakes were applied at TTC = 1.1 seconds (SV-to-POV distance of 40 ft (12 m)). The test concluded when either:

- The SV came into contact with the POV or

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

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

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

Table 1. Nominal Stopped POV DBS Test Choreography

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

b. Criteria

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

2. <u>TEST 2 – SUBJECT VEHICLE ENCOUNTERS SLOWER PRINCIPAL OTHER VEHICLE</u>

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

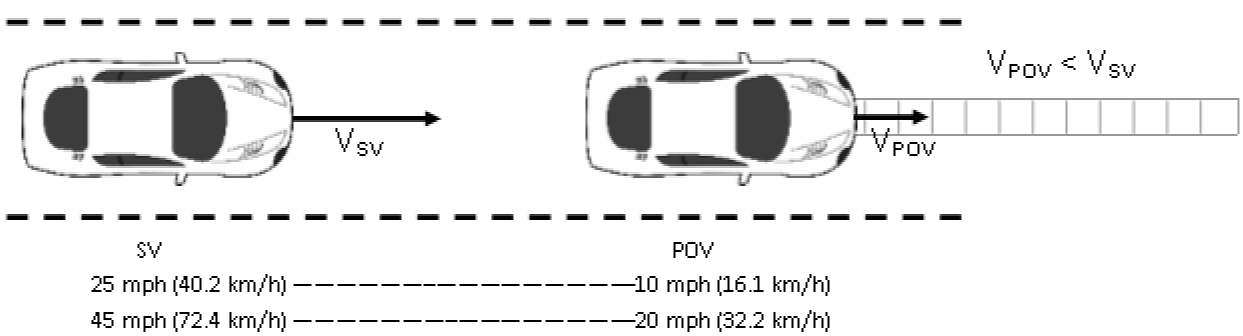


Figure 2. Depiction of Test 2

a. Procedure

The SV ignition was cycled prior to each test run. The tests were conducted two ways. In the first, the POV was driven at a constant 10.0 mph (16.1 km/h) in the center of the lane of travel while the SV was driven at 25.0 mph (40.2 km/h), in the center lane of travel, toward the slower-moving POV. In the second, the POV was driven at a constant 20.0 mph (32.2 km/h) in the center of the lane of travel while the SV was driven at 45.0 mph (72.4 km/h), in the center lane of travel, toward the slower-moving POV. In both cases, the SV throttle pedal was released within 500 ms after t_{FCW}, i.e., within 500 ms of the FCW alert. The SV brakes were applied at TTC = 1.0 seconds, assumed to be SV-to-POV distance of 22 ft (7 m) for an SV speed of 25 mph and 37 ft (11 m) for an SV speed of 45 mph.

The test concluded when either:

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

The SV driver then braked to a stop.

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

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

Table 2. Nominal Slower-Moving POV DBS Test Choreography

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

b. Criteria

The performance requirement for this series of tests is that there be no SV-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.

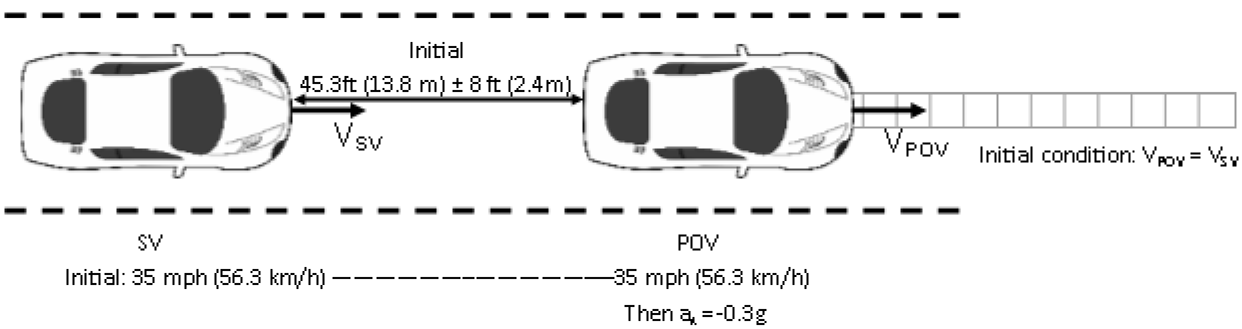


Figure 3. Depiction of Test 3 with POV Decelerating

a. Procedure

The SV ignition was cycled prior to each test run. For this scenario both the POV and SV were driven at a constant 35.0 mph (56.3 km/h) in the center of the lane, with headway of 45.3 ft (13.8 m) ± 8 ft (2.4 m). Once these conditions were met, the POV tow vehicle brakes were applied to achieve 0.3 ± 0.03 g. The SV throttle pedal was released within 500 ms of $t_{FCW,}$ and the SV brakes were applied when TTC was 1.4 seconds (31.5 ft (9.6 m)).

The test concluded when either:

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

The SV driver then braked to a stop.

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

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

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

- The SV and POV speed could not deviate more than ±1.0 mph (1.6 km/h) during an interval defined by the onset of the validity period to the onset of POV braking.
- The average POV deceleration could not deviate by more than ±0.03 g from the nominal 0.3 g deceleration during the interval beginning at 1.5 seconds after the onset of POV braking and ending either 250 ms prior to the POV coming to a stop or the SV coming into contact with the POV.

Table 3. Nominal Decelerating POV DBS Test Choreography

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

b. Criteria

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

4. <u>TEST 4 – FALSE POSITIVE SUPPRESSION</u>

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

a. Procedure

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

b. Criteria

In order to pass the False Positive test series, the magnitude of the SV deceleration reduction attributable to DBS intervention must have been less than or equal to 1.25 times the average of the deceleration experienced by the baseline command from the braking actuator for at least five of seven valid test trials.

B. General Information

1. T_{FCW}

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

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

Table 4. Audible and Tactile Warning Filter Parameters

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

2. <u>GENERAL VALIDITY CRITERIA</u>

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

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

3. VALIDITY PERIOD

The valid test interval began:

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

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

Test 3: 3 seconds before the onset of POV braking

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

The valid test interval ended:

Test 1: When either of the following occurred:

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

Test 2: When either of the following occurred:

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

Test 3: When either of the following occurred:

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

Test 4: When the SV stopped.

4. STATIC INSTRUMENTATION CALIBRATION

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

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

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

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

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

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

5. 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 POV-SV headway distance and speed etc., to be achieved and adjusted as needed in the preliminary part of a test. If during the test, the SV strikes the rear of the POV shell, the detents are overcome and the entire shell/roller assembly moves forward in a two-stage manner along the rail and away from the SV. The forward end of the rail has a soft stop to restrain forward motion of the shell/roller assembly. After impacting the SSV, the SV driver uses the steering wheel to maintain SV position in the center of the travel lane, thereby straddling the two-rail track. The SV driver must manually apply the SV brakes after impact. The SSV system is shown in Figures A6 through A8 and a detailed description can be found in the NHTSA report: NHTSA'S STRIKEABLE SURROGATE VEHICLE PRELIMINARY DESIGN + OVERVIEW, May 2013.

D. Foundation Brake System Characterization

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

This characterization was accomplished by recording longitudinal acceleration and brake pedal force and travel data for a variety of braking runs. For three initial brake characterization runs, the vehicle was driven at 45 mph, and the brakes were applied at a rate of 1 inch/sec up to the brake input level needed for at least 0.7 g. Linear regressions were performed on the data from each run to determine the linear vehicle deceleration response as a function of both applied brake pedal force and brake pedal travel. The brake input force or displacement level needed to achieve a vehicle deceleration of 0.4 g was determined from the average of the three runs. Using the 0.4 g brake input force or displacement level found from the three initial runs, subsequent runs were performed at 25 mph, 35 mph, and 45 mph, with the brakes applied at a rate of 10 inch/sec to the determined 0.4 g brake input force or displacement level. For each of the three test speeds, if the average calculated deceleration level was found to be within 0.4 ± 0.025 g, the resulting force or displacement was recorded and used. If the average calculated deceleration level exceeded this tolerance, the brake input force or displacement levels were adjusted and retested until the desired magnitude was realized. Prior to each braking event, the brake pad temperatures were required to be in the range of 149° - 212°F.

E. Brake Control

1. SUBJECT VEHICLE PROGRAMMABLE BRAKE CONTROLLER

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

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

2. SUBJECT VEHICLE BRAKE PARAMETERS

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

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

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

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

F. Instrumentation

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

Table 5. Test Instrumentation and Equipment

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Tire Pressure Gauge	Vehicle Tire Pressure	0-100 psi 0-690 kPa	< 1% error between 20 and	Omega DPG8001	17042707002	By: DRI Date: 7/3/2019 Due: 7/3/2020
Platform Scales	Vehicle Total, Wheel, and Axle Load	2200 lb/platform 5338 N/	0.5% of applied load	Intercomp SWI	1110M206352	By: DRI Date: 1/6/2020 Due: 1/6/2021
Linear (string) encoder	Throttle pedal travel	10 in 254 mm	0.1 in 2.54 mm	UniMeasure LX-EP	45040532	By: DRI Date: 5/10/2019 Due: 5/10/2020
Load Cell	Force applied to brake pedal					By: DRI
		0 - 250 lb 0 -1112 N	0.1% FS	Honeywell 41A	1464391	Date: 8/30/2019 Due: 8/30/2020
		0-250 lb 1112 N	0.05% FS	Stellar Technology PNC700	1607338	Date: 8/30/2019 Due: 8/30/2020
Differential Global Positioning System	Position, Velocity	Latitude: ±90 deg Longitude: ±180 deg Altitude: 0-18 km Velocity: 0-1000 knots	Horizontal Position: ±1 cm Vertical Position: ±2 cm Velocity: 0.05 km/h	Trimble GPS Receiver, 5700 (base station and in-vehicle)	00440100989	NA

Table 5. Test Instrumentation and Equipment (continued)

Type	Output	Range	Accuracy, Other Primary Specs	Mfr, Model	Serial Number	Calibration Dates Last Due
Multi-Axis Inertial Sensing System	Position; Longitudinal, Lateral, and Vertical Accels; Lateral, Longitudinal and Vertical Velocities; Roll, Pitch, Yaw Rates; Roll, Pitch, Yaw Angles	Accels ± 10g, Angular Rat	Accels .01g, Angular Rate	Oxford Inertial +		By: Oxford Technical Solutions
					2258	Date: 5/3/2019 Due: 5/3/2021
					2176	Date: 4/11/2018 Due: 4/11/2020
Real-Time Calculation of Position and Velocity Relative to Lane Markings (LDW) and POV (FCW)	Distance and Velocity to lane markings (LDW) and POV (FCW)	Lateral Lane Dist: ±30 m Lateral Lane Velocity: ±20 m/sec Longitudinal Range to POV: ±200 m Longitudinal Range Rate: ±50 m/sec	Lateral Distance to Lane Marking: ±2 cm Lateral Velocity to Lane Marking: ±0.02m/sec Longitudinal Range: ±3 cm Longitudinal Range Rate: ±0.02 m/sec	Oxford Technical Solutions (OXTS), RT-Range	97	NA
Microphone	Sound (to measure time at alert)	Frequency Response: 80 Hz – 20 kHz	Signal-to-noise: 64 dB, 1 kHz at 1 Pa	Audio-Technica AT899	NA	NA
Light Sensor	Light intensity (to measure time at alert)	Spectral Bandwidth: 440-800 nm	Rise time < 10 msec	DRI designed and developed Light Sensor	NA	NA
Accelerometer	Acceleration (to measure time at alert)	±5g	≤ 3% of full range	Silicon Designs, 2210-005	NA	NA

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

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

APPENDIX A

Photographs

LIST OF FIGURES

Figure A1. Front View of Subject Vehicle

Figure A2. Rear View of Subject Vehicle

Figure A3. Window Sticker (Monroney Label)

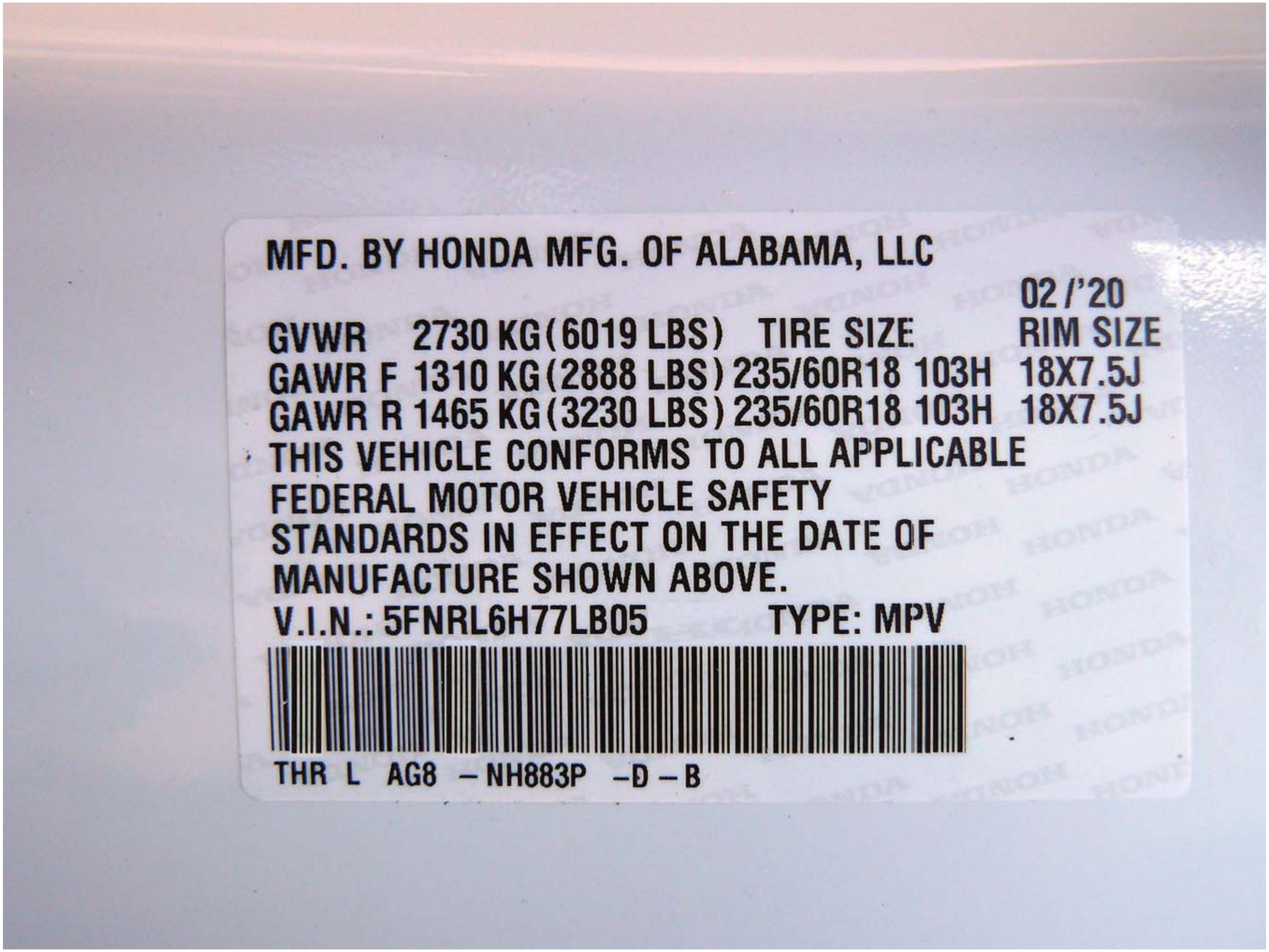


Figure A4. Vehicle Certification Label

Figure A5. Tire Placard

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

Figure A7. Load Frame/Slider of SSV

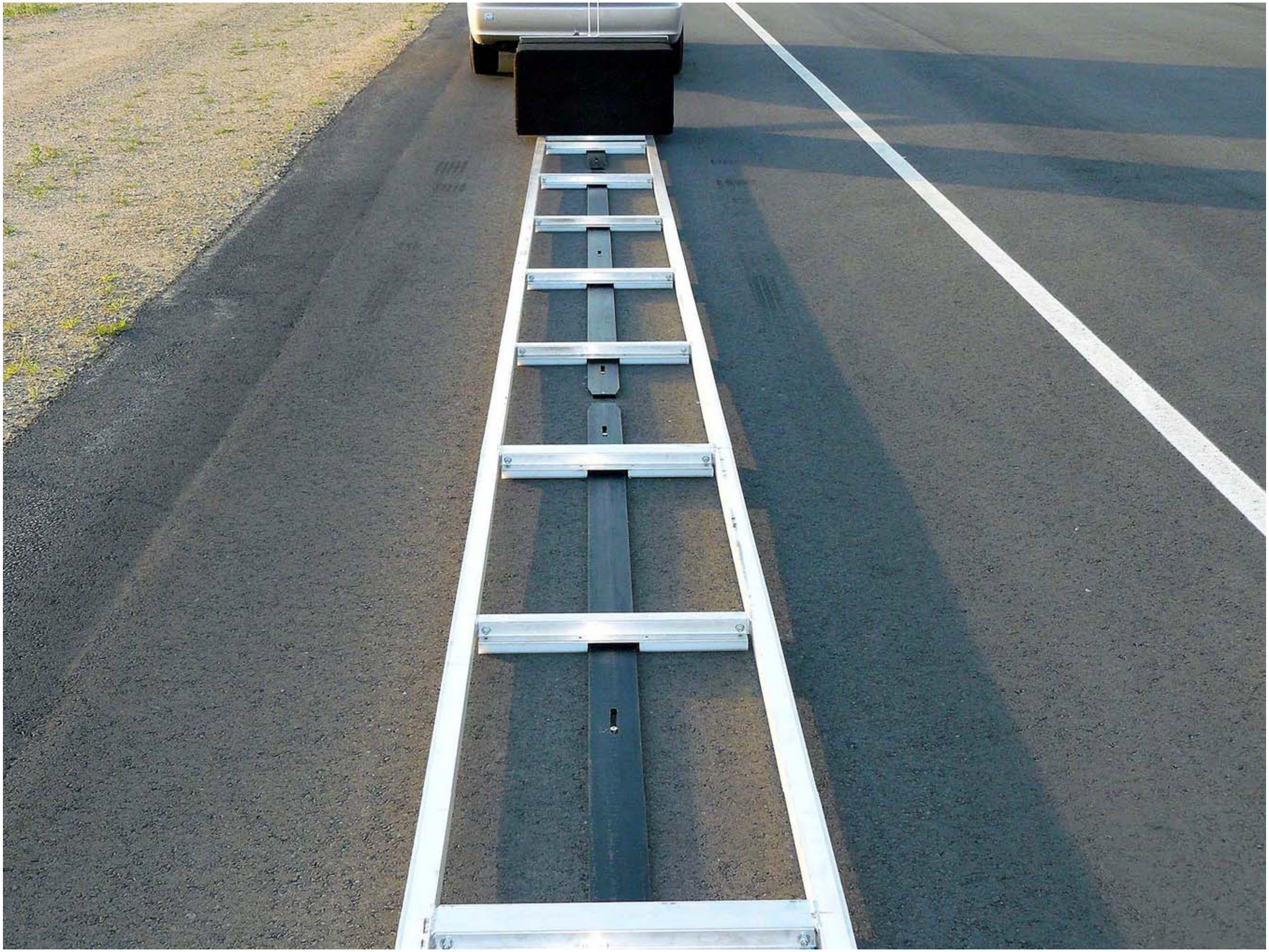


Figure A8. Two-Rail Track and Road-Based Lateral Restraint Track

Figure A9. Steel Trench Plate

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

Figure A11. Sensor for Detecting Auditory Alerts

Figure A12. Sensor for Detecting Visual Alerts

Figure A13. Computer and Brake Actuator Installed in Subject Vehicle

Figure A14. Brake Actuator Installed in POV System

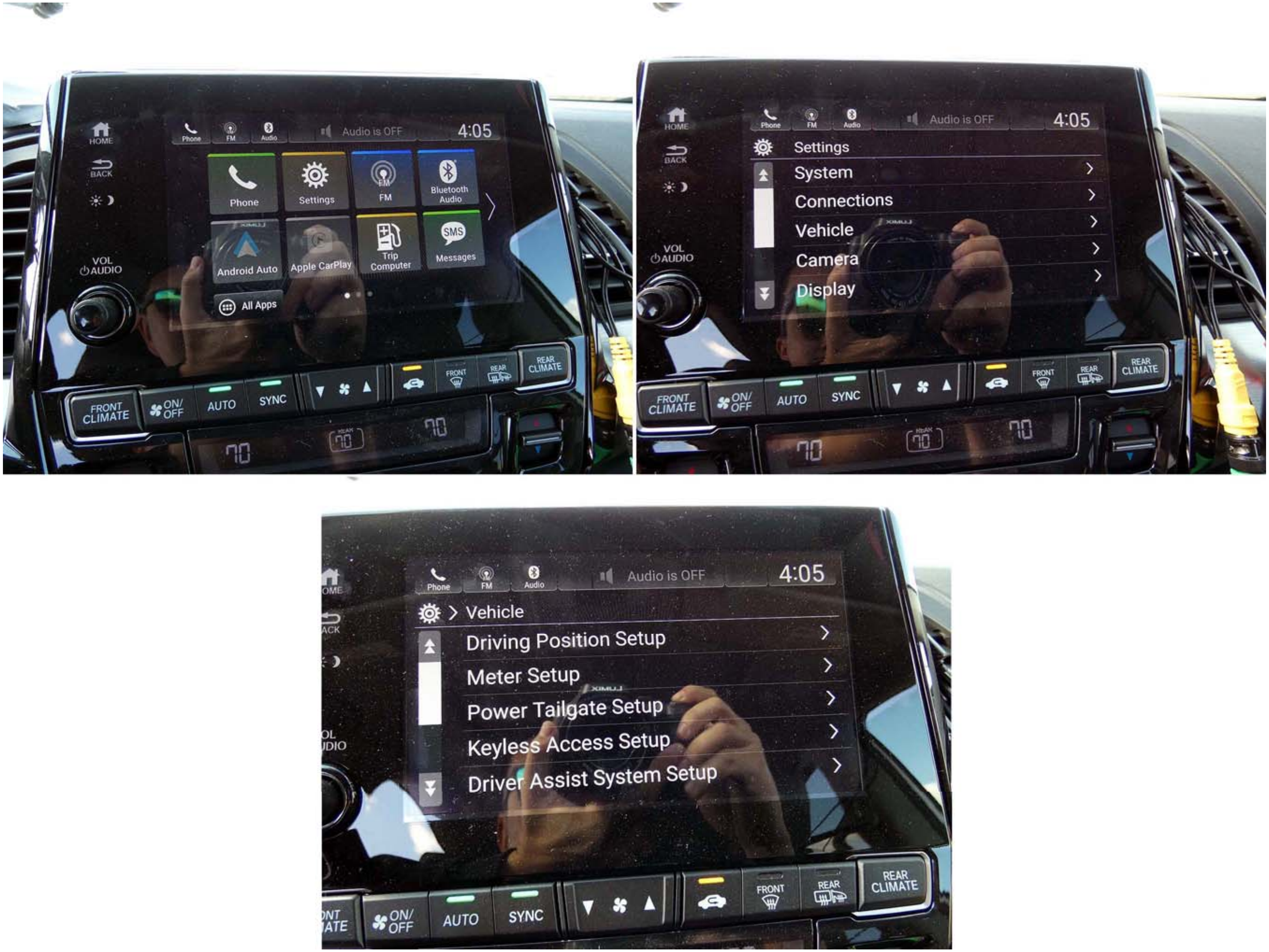


Figure A15. CMBS (AEB) System Setup Menus (1/2)

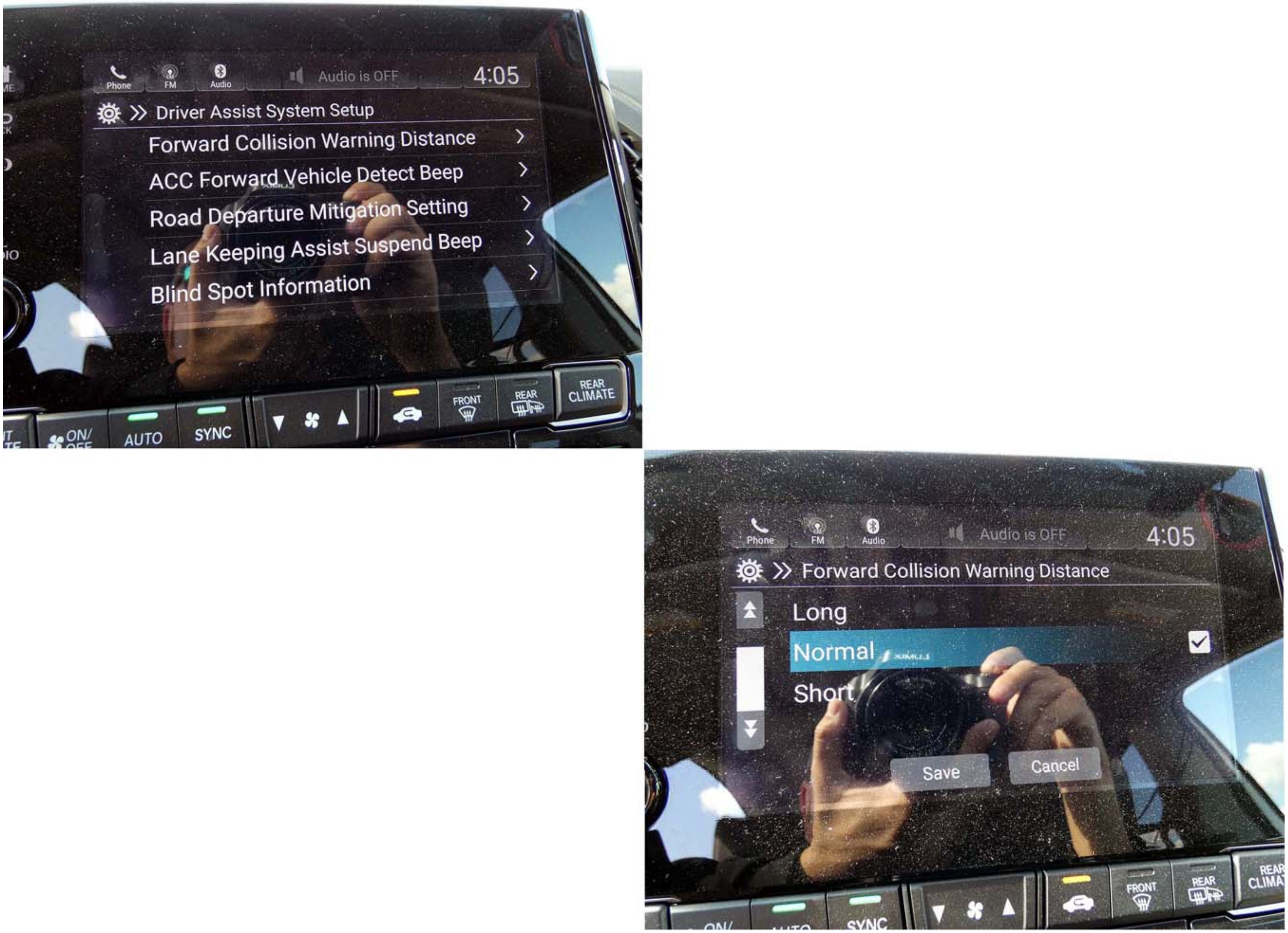


Figure A16. CMBS (AEB) System Setup Menus (2/2)

Figure A17. CMBS (AEB) Visual Alert Shown as Inset in Out-the-Window View

Figure A18. CMBS (AEB) On/Off Switch

APPENDIX B

Excerpts from Owner's Manual

Instrument Panel P. 83

Gauges P. 119/Driver Information Interface P. 120/System Indicators P. 84

System Indicators

- Malfunction Indicator Lamp
- Charging System Indicator
- Electric Power Steering (EPS) System Indicator
- Low Fuel Indicator
- Vehicle Stability Assist™ (VSA®) System Indicator
- VSA® **OFF** Indicator
- Automatic Brake Hold System Indicator
- Automatic Brake Hold Indicator (U.S. / Canada)
- Parking Brake and Brake System Indicator (Amber) (BRAKE SYSTEM U.S. / Canada)
- Anti-lock Brake System (**ABS**) Indicator
- Blind spot information System Indicator*

System Indicators

- LKAS — Lane Keeping Assist System (**LKAS**) Indicator (Green/ Amber)*
- ACC — Adaptive Cruise Control (**ACC**) Indicator (Green/ Amber)*

Lights Indicators

- Lights On Indicator
- High Beam Indicator
- Fog Light Indicator*
- Auto High-Beam Indicator*

System Indicators

- Turn Signal and Hazard Warning Indicators
- Low Tire Pressure/TPMS Indicator
- Parking Brake and Brake System Indicator (Red) (BRAKE U.S. / Canada)
- Seat Belt Reminder Indicator
- Supplemental Restraint System Indicator
- **CRUISE MAIN** Indicator*
- **CRUISE CONTROL** Indicator*
- Econ Mode Indicator
- Auto Idle Stop System Indicator (Amber)/ Auto Idle Stop Indicator (Green)
- **Snow** Mode Indicator
- **Normal** Mode Indicator
- System Message Indicator
- Road Departure Mitigation (RDM) Indicator*
- Collision Mitigation Braking System™ (CMBS™) Indicator*

* Not available on all models

VSA® On and Off (P. 597)

- The Vehicle Stability Assist™ (VSA®) system helps stabilize the vehicle during cornering, and helps maintain traction while accelerating on loose or slippery road surfaces.
- VSA® comes on automatically every time you start the engine.
- To partially disable or fully restore VSA® function, press and hold the button until you hear a beep.

Cruise Control* (P. 566)

- Cruise control allows you to maintain a set speed without keeping your foot on the accelerator pedal.
- To use cruise control, press the **CRUISE** button, then press the **–/SET** button once you have achieved the desired speed (above 25 mph or 40 km/h).

CMBS™ On and Off* (P. 618)

- When a possible collision is likely unavoidable, the CMBS™ can help you to reduce the vehicle speed and the severity of the collision.
- The CMBS™ is turned on every time you start the engine.
- To turn the CMBS™ on or off, press and hold the button until you hear a beep.

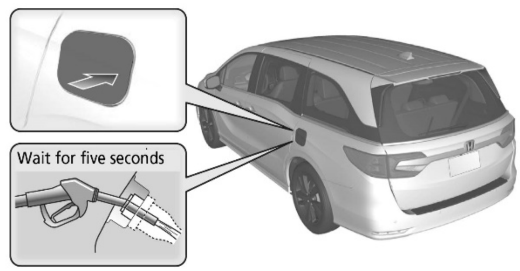
Tire Pressure Monitoring System (TPMS) with Tire Fill Assist (P. 599, 726)

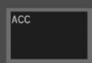
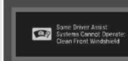
- The TPMS monitors tire pressure.
- TPMS is turned on automatically every time you start the engine.
- TPMS fill assist provides audible and visual guidance during tire pressure adjustment.

Refueling (P. 637)

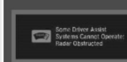
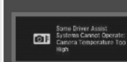
Fuel recommendation:	**Unleaded gasoline, pump octane number 87 or higher**
Fuel tank capacity: 19.5 US gal (73.8 L)	

1. Unlock the driver's door.
   Locking/Unlocking the Doors from the Inside (P. 156)
2. Press firmly and then release the area indicated by the arrow to release the fuel filler door.
3. After refueling, wait for about five seconds before removing the filler nozzle.



Indicator	Name	On/Blinking	Explanation	Message
	Adaptive Cruise Control (**ACC**) Indicator (Green)*	• Comes on when the area around the camera is blocked by dirt, mud, etc. Stop your vehicle in a safe place, and wipe it off with a soft cloth. • May come on when driving in bad weather (rain, snow, fog, etc.)	• Have your vehicle checked by a dealer if the indicator and message come back on after you cleaned the area around the camera.	
	Collision Mitigation Braking System™ (CMBS™) Indicator*	• Comes on for a few seconds when you change the power mode to ON, then goes off. • Comes on when you deactivate the CMBS™. A driver information interface message appears for five seconds. • Comes on if there is a problem with the CMBS™.	• **Stays on constantly without the CMBS™ off** - Have your vehicle checked by a dealer. **Collision Mitigation Braking System™ (CMBS™)*** P. 615	 

* Not available on all models

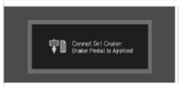
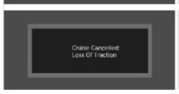
Indicator	Name	On/Blinking	Explanation	Message
	Collision Mitigation Braking System™ (CMBS™) Indicator*	• Comes on when the CMBS™ system shuts itself off.	• **Stays on** - The area around the camera is blocked by dirt, mud, etc. Stop your vehicle in a safe place, and wipe it off with a soft cloth. ⮚ **Front Sensor Camera*** P. 569	
			• When the radar sensor gets dirty, stop your vehicle in a safe place, and wipe off dirt using a soft cloth. Indicator may take some time to go off after the radar sensor is cleaned. • Have your vehicle checked by a dealer if the indicator does not go off even after you clean the sensor cover. ⮚ **Collision Mitigation Braking System™ (CMBS™)*** P. 615	
			• **Stays on** - The temperature inside the camera is too high. Use the climate control system to cool down the camera. The system activates when the temperature inside the camera cools down. ⮚ **Front Sensor Camera*** P. 569	

 * Not available on all models

Models with remote engine starter

Message	Condition	Explanation
	• Appears when you unlock and open the driver's door while the engine is running by remote engine start.	**Remote Engine Start with Vehicle Feedback*** P. 544

Models with ACC

Message	Condition	Explanation
	• Flashes when the system senses a likely collision with a vehicle in front of you.	• Take the appropriate means to prevent a collision (apply the brakes, change lanes, etc.) **Collision Mitigation Braking System™ (CMBS™)*** P. 615 **Adaptive Cruise Control (ACC)*** P. 571
	• Appears when ACC has been automatically canceled.	• You can resume the set speed after the condition that caused ACC to cancel improves. Press the **RES/+** button. **Adaptive Cruise Control (ACC)*** P. 571
	• Appears when pressing the **–/SET** button while the vehicle is moving and the brake pedal is depressed.	• ACC cannot be set. **Adaptive Cruise Control (ACC)*** P. 571
	• Appears if the VSA® or traction control function operates while ACC is in operation.	• ACC has been automatically canceled. **Adaptive Cruise Control (ACC)*** P. 571

Instrument Panel

* Not available on all models

Setup Group	Customizable Features		Description	Selectable Settings
Vehicle	Keyless Access Setup	**Remote Start System On/Off**	Turns the remote engine start feature on and off.	**ON***1**/OFF**
		Walk Away Auto Lock	Changes the settings for the automatic locking the doors when you walk away from the vehicle while carrying the remote.	**Enable/Disable***1
	Driver Assist System Setup*	**Forward Collision Warning Distance**	Changes at which distance CMBS™ alerts.	**Long/Normal***1**/ Short**
		ACC Forward Vehicle Detect Beep	Causes the system to beep when the system detects a vehicle, or when the vehicle goes out of the ACC range.	**ON/OFF***1
		Road Departure Mitigation Setting	Changes the setting for the road departure mitigation system.	**Normal***1**/Wide/ Warning Only**
		Lane Keeping Assist Suspend Beep	Causes the system to beep when the LKAS is suspended.	**ON/OFF***1
		Blind Spot Information*	Changes the setting for the blind spot information system.	**Audible and Visual Alert***1**/Visual Alert/ OFF**

*1:Default Setting

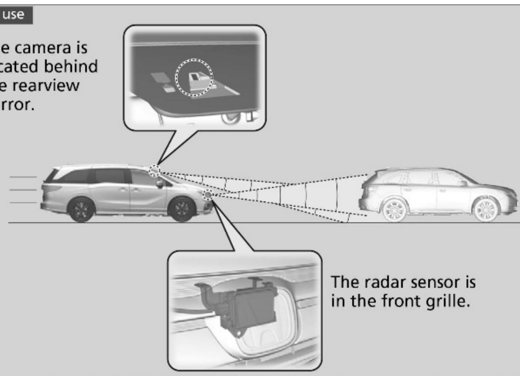
* Not available on all models

Collision Mitigation Braking System™ (CMBS™)*

Can assist you when there is a possibility of your vehicle colliding with a vehicle or a pedestrian detected in front of yours. The CMBS™ is designed to alert you when a potential collision is determined, as well as to reduce your vehicle speed to help minimize collision severity when a collision is deemed unavoidable.

■ How the system works

When to use



The system starts monitoring the roadway ahead when your vehicle speed is about 3 mph (5 km/h) and there is a vehicle in front of you.

The CMBS™ activates when:

- The speed difference between your vehicle and a vehicle or pedestrian detected in front of you becomes about 3 mph (5 km/h) and over with a chance of a collision.
- Your vehicle speed is about 62 mph (100 km/h) or less and there is a chance of a collision with an oncoming detected vehicle or a pedestrian in front of you.

* Not available on all models

Continued

Collision Mitigation Braking System™ (CMBS™)*

Important Safety Reminder

The CMBS™ is designed to reduce the severity of an unavoidable collision. It does not prevent a collision nor stop the vehicle automatically. It is still your responsibility to operate the brake pedal and steering wheel appropriately according to the driving conditions.

The CMBS™ may not activate or may not detect a vehicle in front of your vehicle under certain conditions:

CMBS™ Conditions and Limitations P. 619

You can read about handling information for the camera equipped with this system.

Front Sensor Camera* P. 569

Be careful not to have the radar sensor cover strongly impacted.

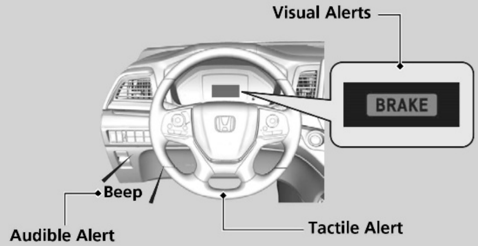
How the system works

Rapid vibrations on the steering wheel alert you when the your vehicle speed is between 19 and 62 mph (30 and 100 km/h) with an oncoming vehicle detected in front of you.

When the CMBS™ activates, it may automatically apply the brake. It will be canceled when your vehicle stops or a potential collision is not determined.

■ When the system activates

The system provides visual, audible and tactile alerts of a possible collision, and stops if the collision is avoided.
- Take appropriate action to prevent a collision (apply the brakes, change lanes, etc.)



At system's earliest collision alert stage, you can change the distance (**Long**/**Normal**/**Short**) between vehicles at which alerts will come on through audio/information screen setting options.

List of customizable options P. 461

■ Vibration alert on the steering wheel

When a potential collision to an oncoming detected vehicle is determined, the system alerts you with rapid vibration on the steering wheel, in addition to visual and audible alerts.

▶ Take appropriate action to prevent a collision (apply the brakes, operate the steering wheel, etc.).

When the system activates

The camera in the CMBS™ is also designed to detect pedestrians.
However, this pedestrian detection feature may not activate or may not detect a pedestrian in front of your vehicle under certain conditions.
Refer to the ones indicating the pedestrian detection limitations from the list.

CMBS™ Conditions and Limitations P. 619

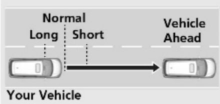
Vibration alert on the steering wheel

Vibration alert function is disabled when the electric power steering (EPS) system indicator comes on.

Electric Power Steering (EPS) System Indicator P. 91

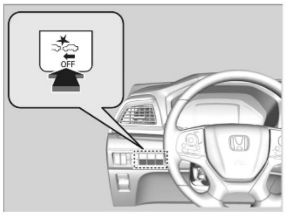
Collision Alert Stages

The system has three alert stages for a possible collision. However, depending on circumstances, the CMBS™ may not go through all of the stages before initiating the last stage.

Distance between vehicles		CMBS™			
		The sensors detect a vehicle	Audible & Visual WARNINGS	Steering Wheel	Braking
Stage one		There is a risk of a collision with the vehicle ahead of you.	When in **Long**, visual and audible alerts come on at a longer distance from a vehicle ahead than in **Normal** setting, and in **Short**, at a shorter distance than in **Normal**.	In case of an oncoming vehicle detected, rapid vibration is provided.	—
Stage two		The risk of a collision has increased, time to respond is reduced.	Visual and audible alerts.	—	Lightly applied
Stage three		The CMBS™ determines that a collision is unavoidable.		—	Forcefully applied

Driving

CMBS™ On and Off



Press and hold the button until the beeper sounds to switch the system on or off.

When the CMBS™ is off:

- The CMBS™ indicator in the instrument panel comes on.
- A message on the driver information interface reminds you that the system is off.

The CMBS™ is turned on every time you start the engine, even if you turned it off the last time you drove the vehicle.

CMBS™ On and Off

The CMBS™ may automatically shut off, and the CMBS™ indicator will come and stay on under certain conditions:

CMBS™ Conditions and Limitations P. 619

CMBS™ Conditions and Limitations

The system may automatically shut off and the CMBS™ indicator will come on under certain conditions. Some examples of these conditions are listed below. Other conditions may reduce some of the CMBS™ functions.

Front Sensor Camera* P. 569

Environmental conditions

- Driving in bad weather (rain, fog, snow, etc.).
- Sudden changes between light and dark, such as an entrance or exit of a tunnel.
- There is little contrast between objects and the background.
- Driving into low sunlight (e.g., at dawn or dusk).
- Strong light is reflected onto the roadway.
- Driving in the shadows of trees, buildings, etc.
- Roadway objects or structures are misinterpreted as vehicles and pedestrians.
- Reflections on the interior of the windshield.
- Driving at night or in a dark condition such as a tunnel.

Roadway conditions

- Driving on a snowy or wet roadway (obscured lane marking, vehicle tracks, reflected lights, road spray, high contrast).
- The road is hilly or the vehicle is approaching the crest of a hill.
- Driving on curvy, winding, or undulating roads.

CMBS™ Conditions and Limitations

Do not paint, or apply any coverings or paint to the radar sensor area. This can impact CMBS™ operation.

Have your vehicle checked by a dealer if you find any unusual behavior of the system (e.g., the warning message appears too frequently).

If the front of the vehicle is impacted in any of the following situations, the radar sensor may not work properly. Have your vehicle checked by a dealer:
- The vehicle mounted onto a bump, curb, chock, embankment, etc.
- You drive the vehicle where the water is deep.
- Your vehicle has a frontal collision.

If you need the radar sensor to be repaired, or removed, or the radar sensor cover is strongly impacted, turn off the system by pressing the CMBS™ **OFF** button and take your vehicle to a dealer.

* Not available on all models

Continued

■ Vehicle conditions

- Headlight lenses are dirty or the headlights are not properly adjusted.
- The outside of the windshield is blocked by dirt, mud, leaves, wet snow, etc.
- The inside of the windshield is fogged.
- An abnormal tire or wheel condition (wrong sized, varied size or construction, improperly inflated, compact spare tire, etc.).
- When tire chains are installed.
- The vehicle is tilted due to a heavy load or suspension modifications.
- The camera temperature gets too high.
- Driving with the parking brake applied.
- When the radar sensor in the front grille gets dirty.
- The vehicle is towing a trailer.

■ Detection limitations

- A vehicle or pedestrian suddenly crosses in front of you.
- The distance between your vehicle and the vehicle or pedestrian ahead of you is too short.
- A vehicle cuts in front of you at a slow speed, and it brakes suddenly.
- When you accelerate rapidly and approach the vehicle or pedestrian ahead of you at high speed.
- The vehicle ahead of you is a motorcycle, bicycle, mobility scooter or other small vehicle.
- When there are animals in front of your vehicle.
- When you drive on a curved, winding or undulating road that makes it difficult for the sensor to properly detect a vehicle in front of you.
- The speed difference between your vehicle and a vehicle or pedestrian in front of you is significantly large.
- An oncoming vehicle suddenly comes in front of you.
- Another vehicle suddenly comes in front of you at an intersection, etc.
- Your vehicle abruptly crosses over in front of an oncoming vehicle.
- When driving through a narrow iron bridge.
- When the lead vehicle suddenly slows down.

Limitations applicable to pedestrian detection only

- When there is a group of people in front of your vehicle walking together side by side.
- Surrounding conditions or belongings of the pedestrian alter the pedestrian's shape, preventing the system from recognizing that the person is a pedestrian.
- When the pedestrian is shorter than about 3.3 feet (1 meter) or taller than about 6.6 feet (2 meters) in height.
- When a pedestrian blends in with the background.
- When a pedestrian is bent over or squatting, or when their hands are raised or they are running.
- When several pedestrians are walking ahead in a group.
- When the camera cannot correctly identify that a pedestrian is present due to an unusual shape (holding luggage, body position, size).

Continued

■ Automatic shutoff

CMBS™ may automatically shut itself off and the CMBS™ indicator comes and stays on when:

- The temperature inside the system is high.
- You drive off-road or on a mountain road, or curved and winding road for an extended period.
- An abnormal tire condition is detected (wrong tire size, flat tire, etc.).
- The camera behind the rearview mirror, or the area around the camera, including the windshield, gets dirty.

Once the conditions that caused CMBS™ to shut off improve or are addressed (e.g., cleaning), the system comes back on.

With Little Chance of a Collision

The CMBS™ may activate even when you are aware of a vehicle ahead of you, or when there is no vehicle ahead. Some examples of this are:

When passing

Your vehicle approaches another vehicle ahead of you and you change lanes to pass.

At an intersection

Your vehicle approaches or passes another vehicle that is making a left or right turn.

On a curve

When driving through curves, your vehicle comes to a point where an oncoming vehicle is right in front of you.

Through a low bridge at high speed

You drive under a low or narrow bridge at high speed.

Speed bumps, road work sites, train tracks, roadside objects, etc.

You drive over speed bumps, steel road plates, etc., or your vehicle approaches train tracks or roadside objects [such as a traffic sign and guard rail] on a curve or, when parking, stationary vehicles and walls.

With Little Chance of a Collision

For the CMBS™ to work properly:

Always keep the radar sensor cover clean.

Never use chemical solvents or polishing powder for cleaning the sensor cover. Clean it with water or a mild detergent.

APPENDIX C

Run Log

Subject Vehicle: **2020 Honda Odyssey EX-L** Test Date: **3/31/2020**

Principal Other Vehicle: **SSV**

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
1-8	Brake characterization and determination						See Appendix D
9	Static Run						
10	**Stopped POV**	N					brake rate
11		N					Control desk set delta SV speed to 11, requires restart
12		N					Control desk set delta SV speed to 11, requires restart
13		N					Control desk set delta SV speed to 11, requires restart
14		Y	2.17	14.17	1.02	Pass	
15	static run						
16		N					brake actuator was not on
17		Y	1.88	16.00	1.08	Pass	
18		Y	2.08	14.55	1.01	Pass	
19		Y	2.08	15.86	1.11	Pass	
20		Y	2.19	13.84	1.00	Pass	
21		Y	2.13	14.83	1.03	Pass	
22		Y	2.17	14.61	1.08	Pass	
23	Static Run						

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
24	**Slower POV, 25 vs 10**	Y	1.75	10.54	0.90	Pass	
25		Y	1.89	10.66	0.97	Pass	
26		N					Control desk set delta SV speed to 11, reset value to 0
27		N					Control desk set delta SV speed to 11, reset value to 0
28		Y	1.94	10.87	0.97	Pass	
29		Y	1.92	11.04	1.00	Pass	
30		Y	1.87	10.80	0.96	Pass	
31		Y	1.91	10.70	0.98	Pass	
32		N					throttle
33		N					Control desk set delta SV speed to 11, reset value to 0
34		Y	1.85	11.00	0.95	Pass	
35	Static run						
36	**Slower POV, 45 vs 20**	N					throttle
37		Y	2.04	14.57	1.08	Pass	
38		Y	1.95	15.27	1.05	Pass	
39		Y	1.95	15.81	1.03	Pass	
40		Y	1.94	15.01	1.06	Pass	
41		Y	1.91	14.25	1.05	Pass	
42		Y	1.97	14.98	1.10	Pass	

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
43		Y	2.00	14.64	1.04	Pass	
44	Static run						
45	**Decelerating POV, 35**	N					Control desk set delta SV speed to 11, reset value to 0
46		Y	1.89	4.22	0.96	Pass	
47		Y	1.72	5.10	0.99	Pass	
48		Y	1.71	6.23	0.98	Pass	
49		Y	1.74	6.12	0.99	Pass	
50		Y	1.83	6.07	1.02	Pass	
51		Y	1.76	6.75	0.96	Pass	
52		Y	1.65	7.19	0.95	Pass	
53	Static run						
54	STP - Static run	N					
55	STP - Static run						
56	**Baseline, 25**	Y			0.48		
57		Y			0.49		
58		Y			0.49		
59		Y			0.51		
60		Y			0.50		
61		Y			0.46		

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
62		Y			0.47		
63	STP - Static run						
64	**Baseline, 45**	Y			0.45		
65		Y			0.47		
66		Y			0.48		
67		Y			0.51		
68		Y			0.47		
69		Y			0.50		
70		Y			0.48		
71	STP - Static run						
72	**STP False Positive, 25**	N					throttle
73		Y	1.77		0.42	Pass	FCW alert issued
74		Y	1.69		0.44	Pass	FCW alert issued
75		Y	1.78		0.42	Pass	FCW alert issued
76		Y	1.69		0.43	Pass	FCW alert issued
77		Y	1.72		0.41	Pass	FCW alert issued
78		Y	1.70		0.42	Pass	FCW alert issued
79		Y	1.70		0.41	Pass	FCW alert issued
80	STP - Static run						

Run	Test Type	Valid Run?	FCW TTC (s)	Minimum Distance (ft)	Peak Deceleration (g)	Pass/Fail	Notes
81	**STP False Positive, 45**	Y	1.72		0.41	Pass	FCW alert issued
82		Y	1.54		0.50	Pass	FCW alert issued
83		Y	1.82		0.45	Pass	FCW alert issued
84		Y	1.66		0.49	Pass	FCW alert issued
85		Y	1.79		0.49	Pass	FCW alert issued
86		Y	1.58		0.49	Pass	FCW alert issued
87		Y	1.70		0.52	Pass	FCW alert issued
88	STP - Static run						

APPENDIX D

Brake Characterization

Subject Vehicle: **2020 Honda Odyssey EX-L** Test Date: **3/31/2020**

DBS Initial Brake Characterization				
Run Number	Stroke at 0.4 g (in)	Force at 0.4 g (lb)	Slope	Intercept
1	1.70864	12.57301	0.994128	-0.34548
2	1.716078	12.52903	0.903557	-0.24996
3	1.682926	11.95133	0.943385	-0.24299

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	0.351	1.70		1.94	4
5		35	Y	0.441	1.90		1.72	5
6		35	Y	0.395	1.80		1.82	6
7		25	Y	0.392	1.80		1.84	7
8		45	Y	0.394	1.80		1.83	8

Appendix E

TIME HISTORY PLOTS

LIST OF FIGURES

Description of Time History Plots

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

Time History Plot Description

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

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

Time history figures include the following sub-plots:

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

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

- Headway (ft) – Longitudinal separation between the frontmost point of the Subject Vehicle and the rearmost point of the Strikeable Surrogate Vehicle (SSV) towed by the Principal Other Vehicle. The minimum headway during the run is displayed to the right of the subplot.

- SV/POV Speed (mph) – Speed of the Subject Vehicle and the Principal Other Vehicle (if any). For DBS tests, in the case of an impact, the speed reduction experienced by the Subject Vehicle up until the moment of impact is displayed to the right of the subplot.

- Yaw Rate (deg/sec) – Yaw rate of the Subject Vehicle and Principal Other Vehicle (if any).

- Lateral Offset (ft) – Lateral offset within the lane of the Subject Vehicle to the center of the lane of travel. Note that for tests involving the Strikeable Surrogate Vehicle (SSV), the associated lateral restraint track is defined to be the center of the lane of travel. If testing is done with a different POV which does not have a lateral restraint track, lateral offset is defined to be the lateral offset between the SV and POV.

- Ax (g) – Longitudinal acceleration of the Subject Vehicle and Principal Other Vehicle (if any). The peak value of Ax for the SV is shown on the subplot.

- Pedal Position – Position of the accelerator pedal and brake pedal. The units for the brake pedal are inches and the units for the accelerator pedal are percent of full scale divided by 10.

- Brake Force (lb) – Force on the brake pedal as applied by the DBS controller. The TTC at the onset of the brake by the DBS controller is shown on the subplot. Additionally, the average force at the brake pedal while the DBS controller is active is displayed.

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

Envelopes and Thresholds

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

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

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

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

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

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

For the brake force plots:

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

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

Color Codes

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

Color codes can be broken into four categories:

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

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

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

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

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

Other Notations

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

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

Examples of valid or passing time history plots for each test type (including passing, failing, and invalid runs) are shown in 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.

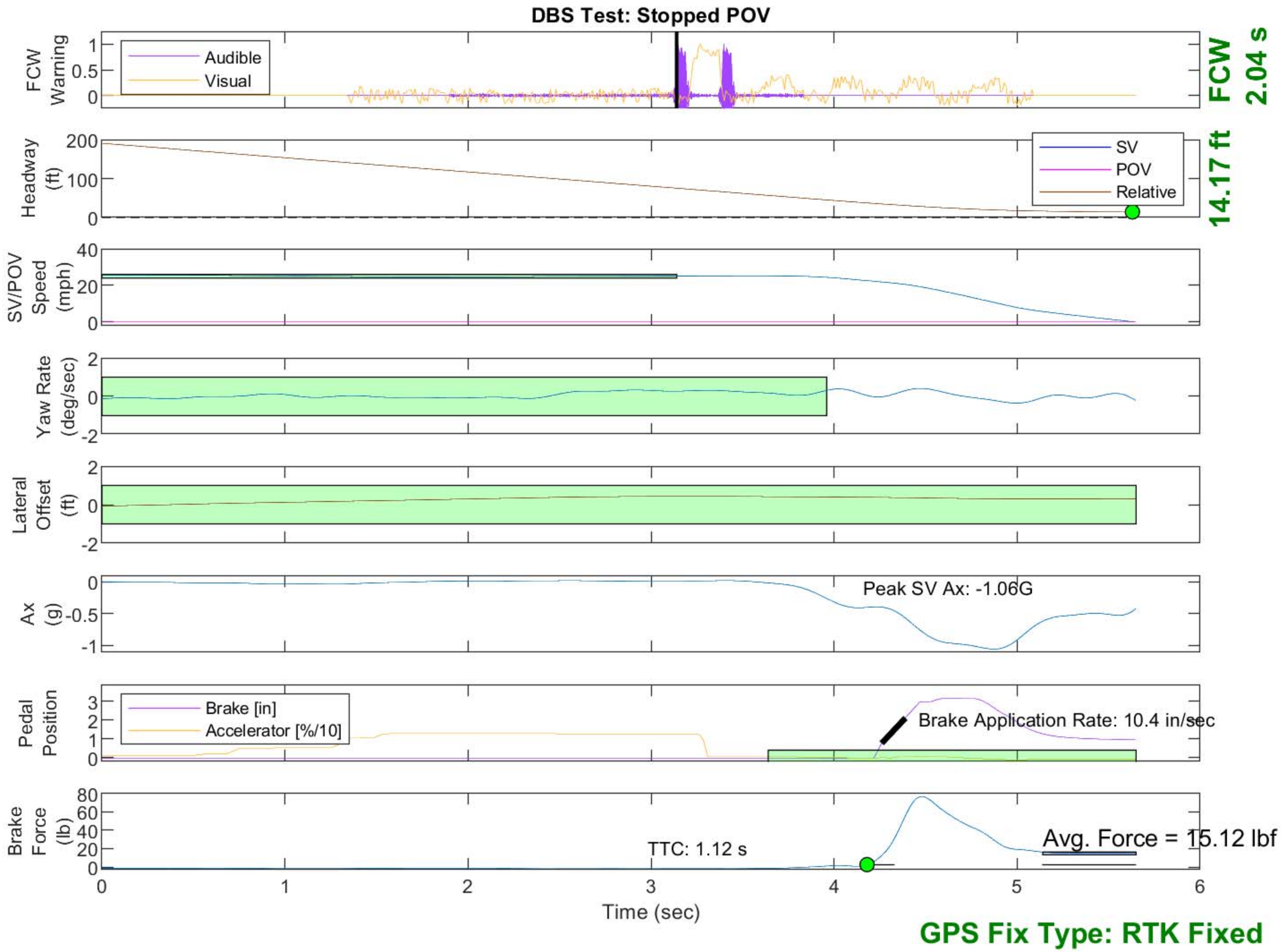


Figure E1. Example Time History for Stopped POV, Passing

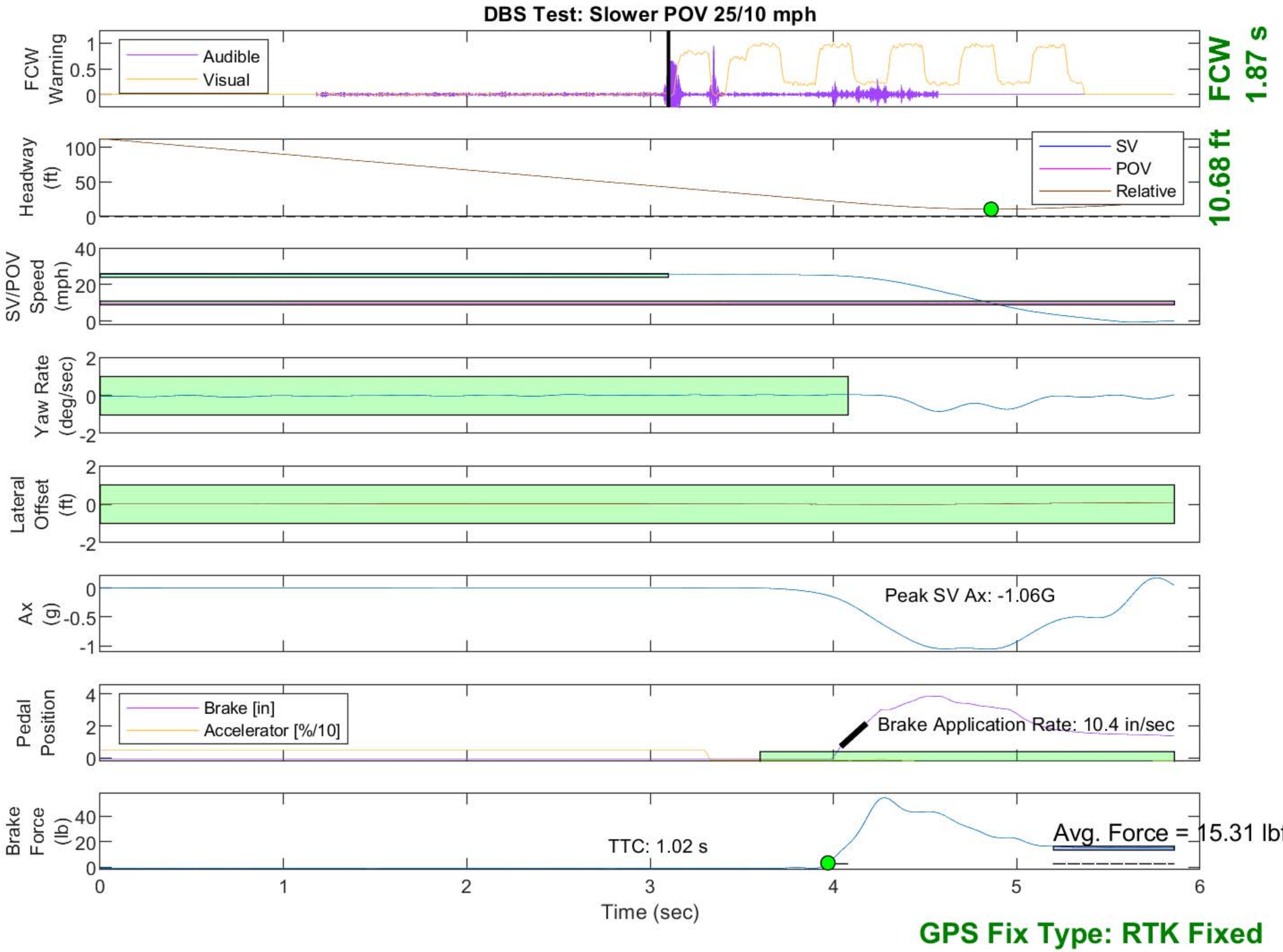


Figure E2. Example Time History for Slower POV 25 vs. 10, Passing

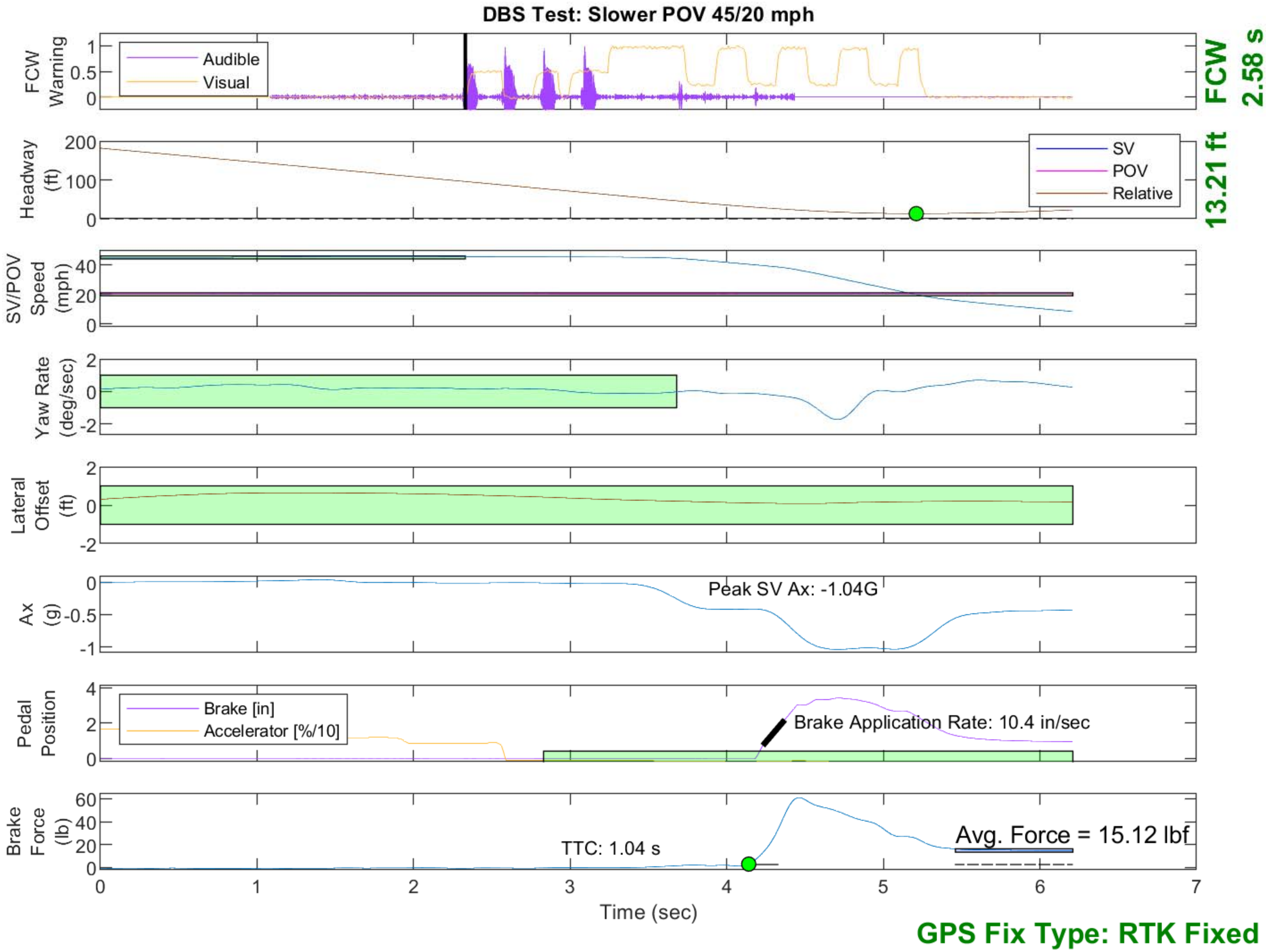


Figure E3. Example Time History for Slower POV 45 vs. 20, Passing

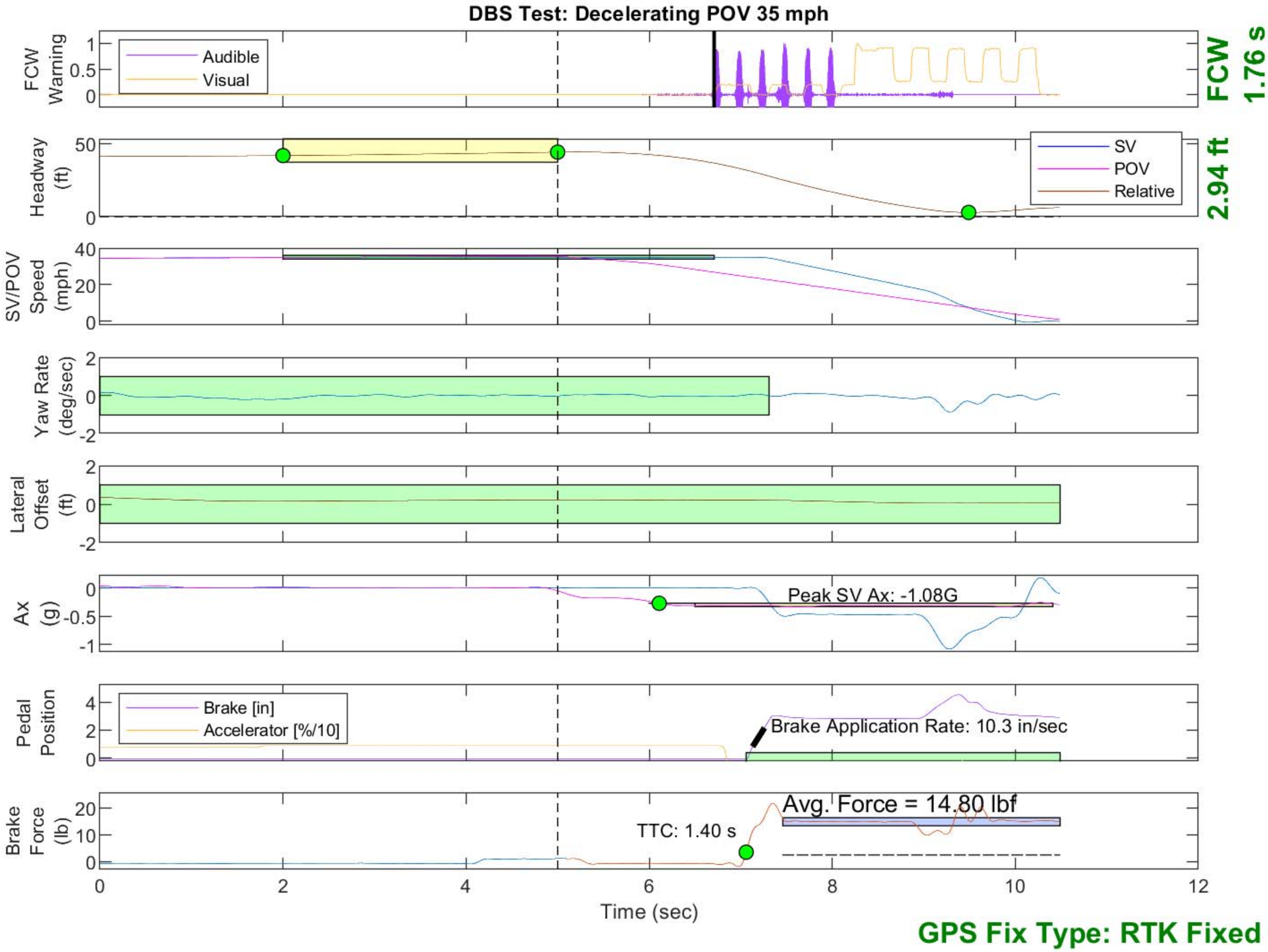


Figure E4. Example Time History for Decelerating POV 35, Passing

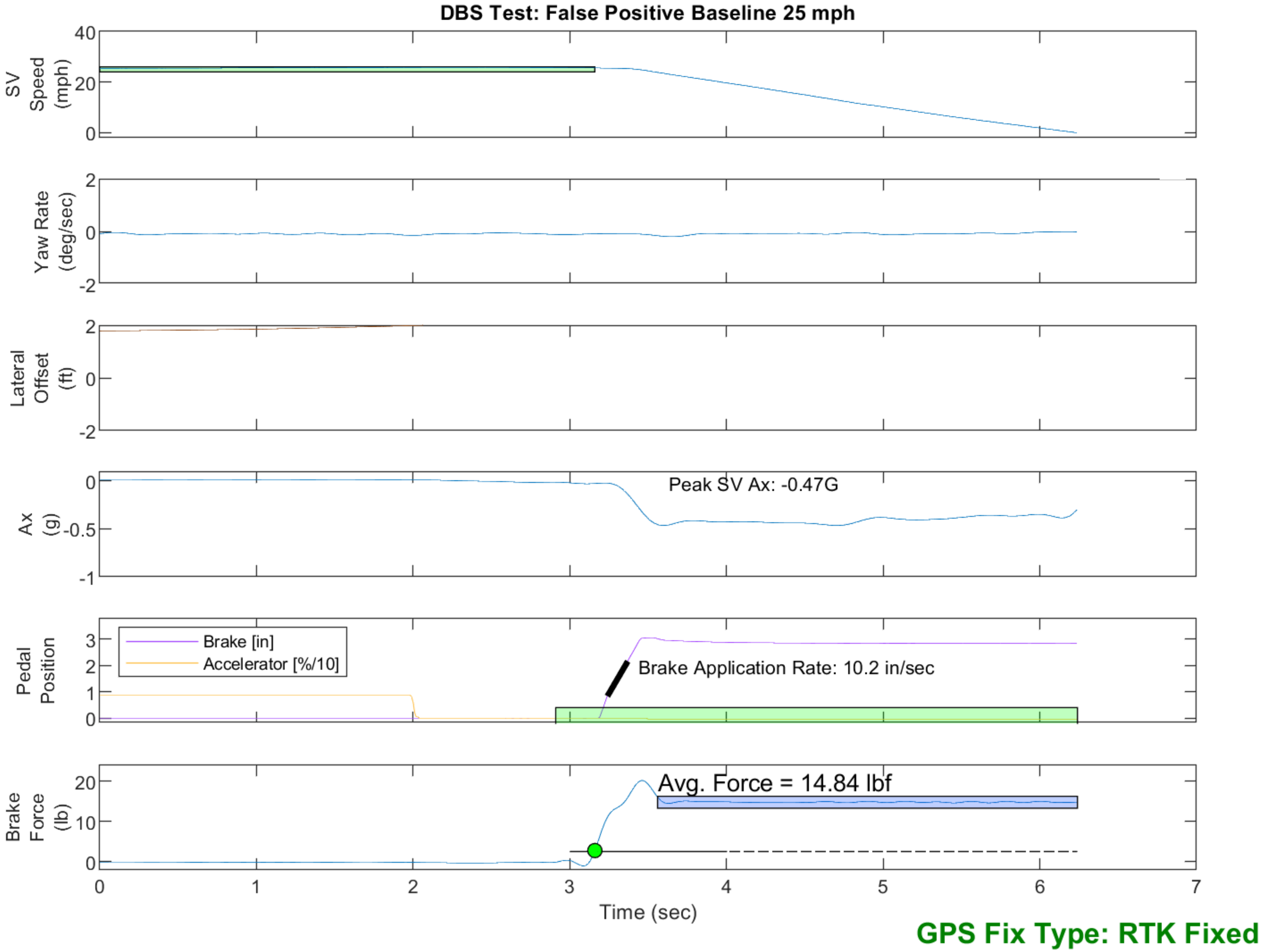


Figure E5. Example Time History for False Positive Baseline 25

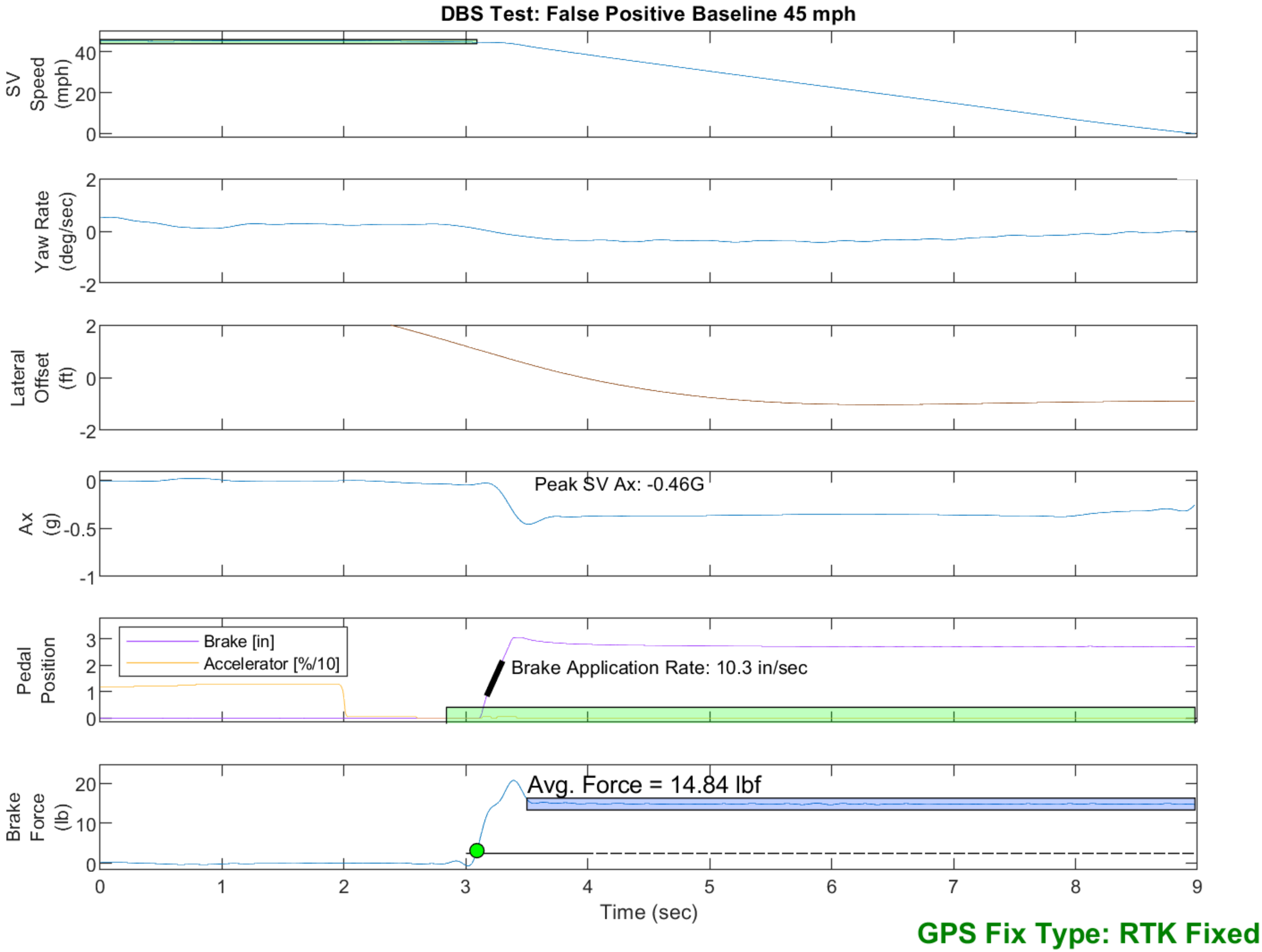


Figure E6. Example Time History for False Positive Baseline 45

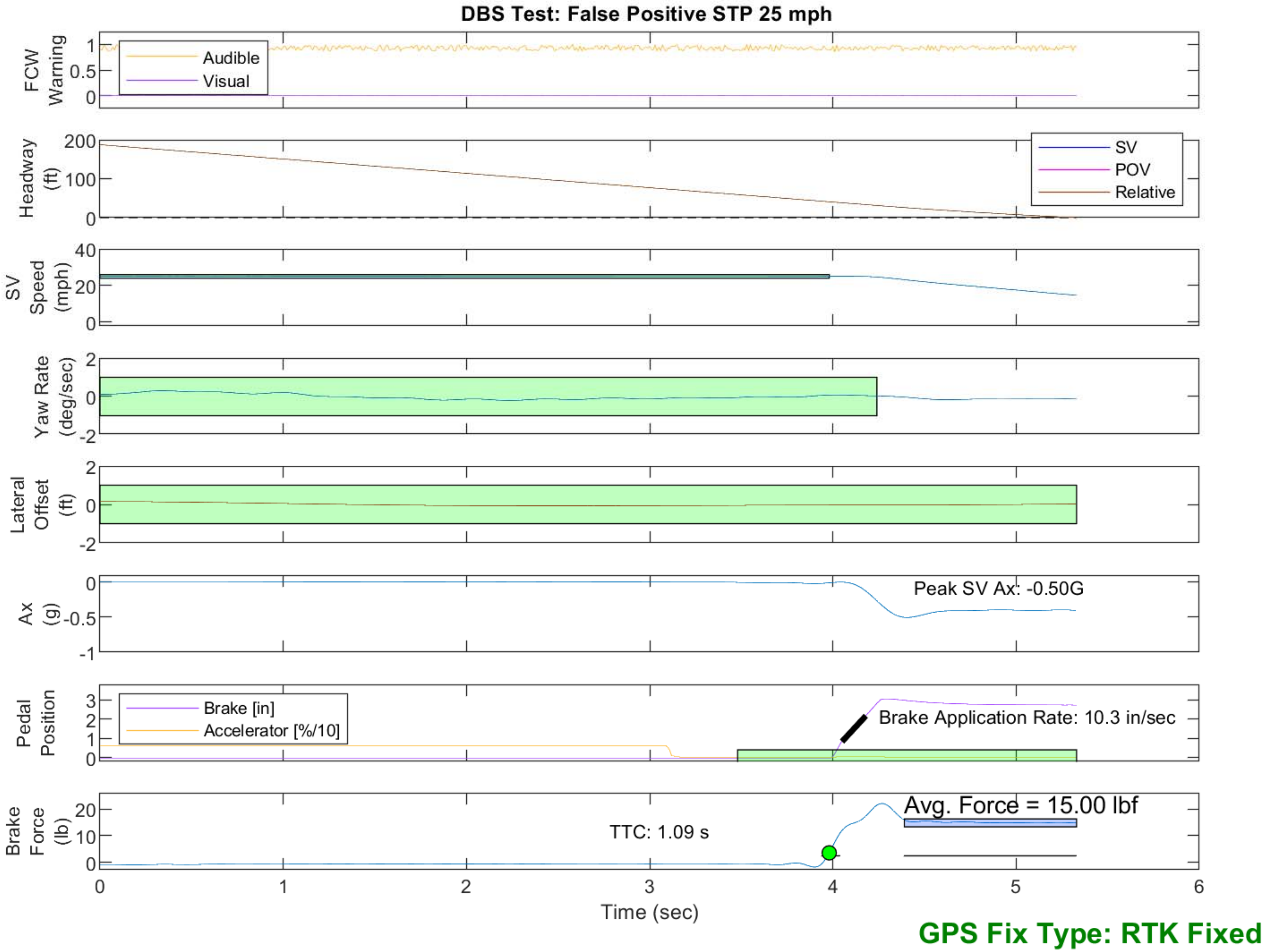


Figure E7. Example Time History for False Positive Steel Plate 25, Passing

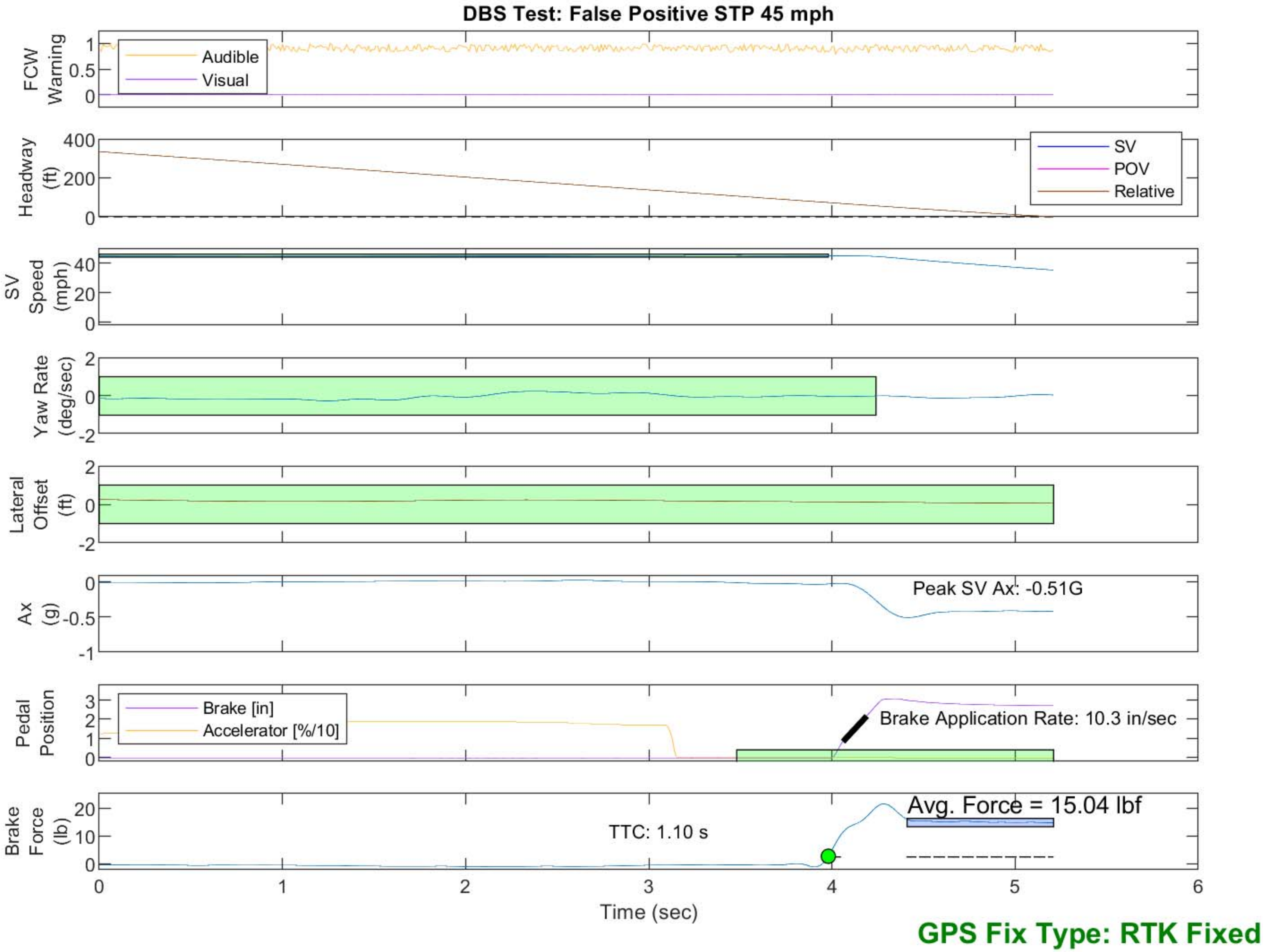


Figure E8. Example Time History for False Positive Steel Plate 45, Passing

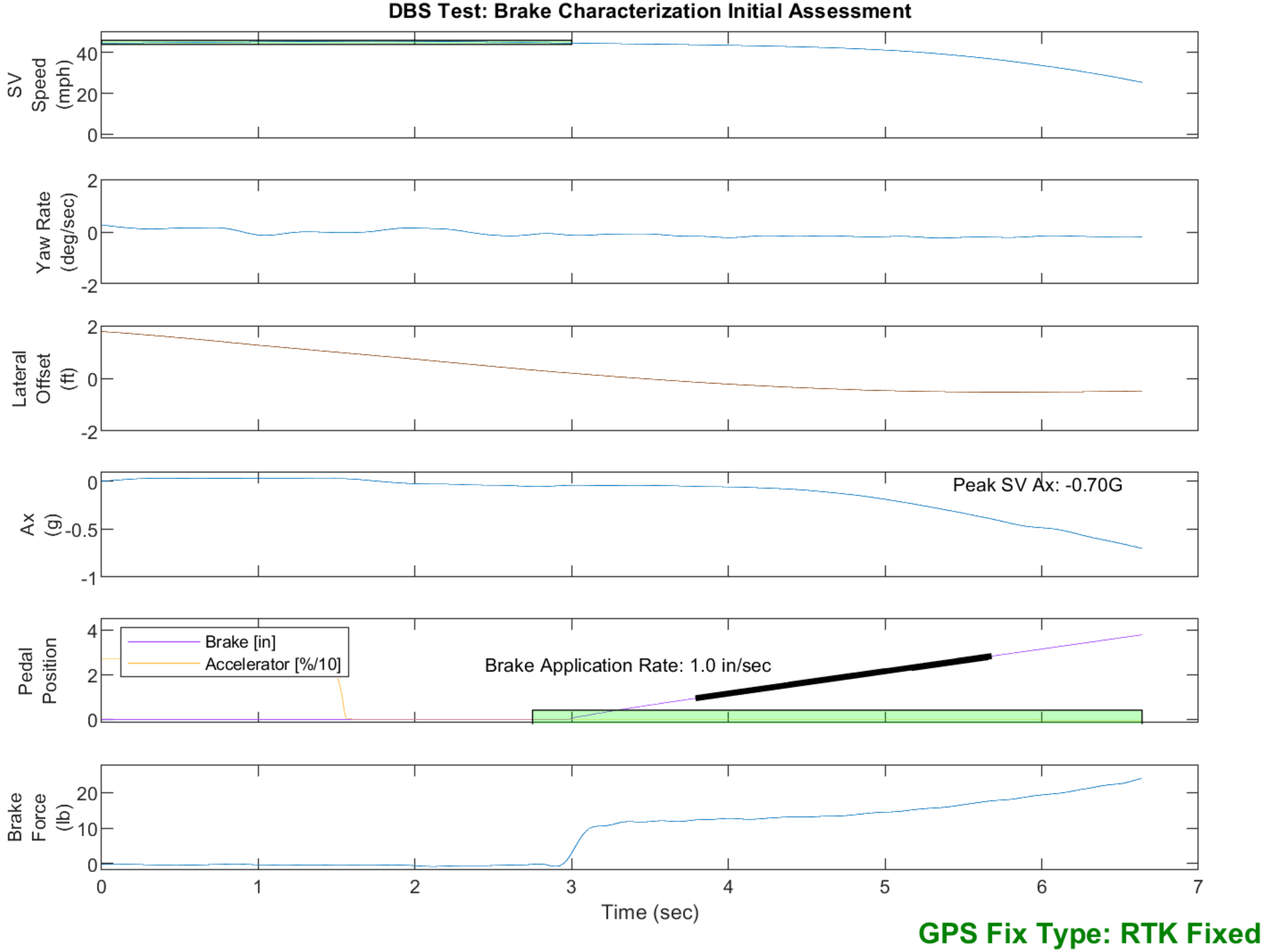


Figure E9. Example Time History for DBS Brake Characterization, Passing

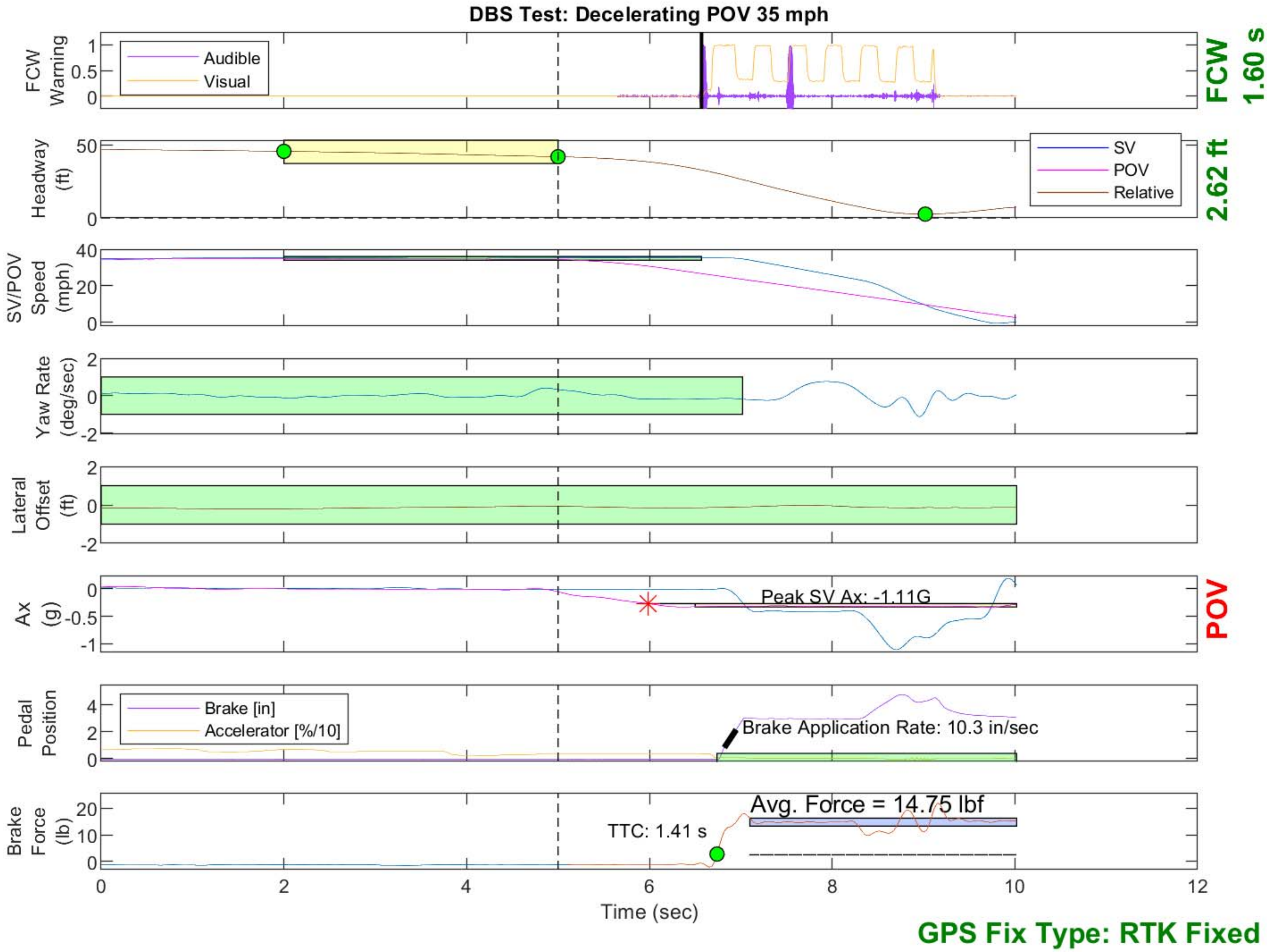


Figure E10. Example Time History Displaying Invalid POV Acceleration Criteria

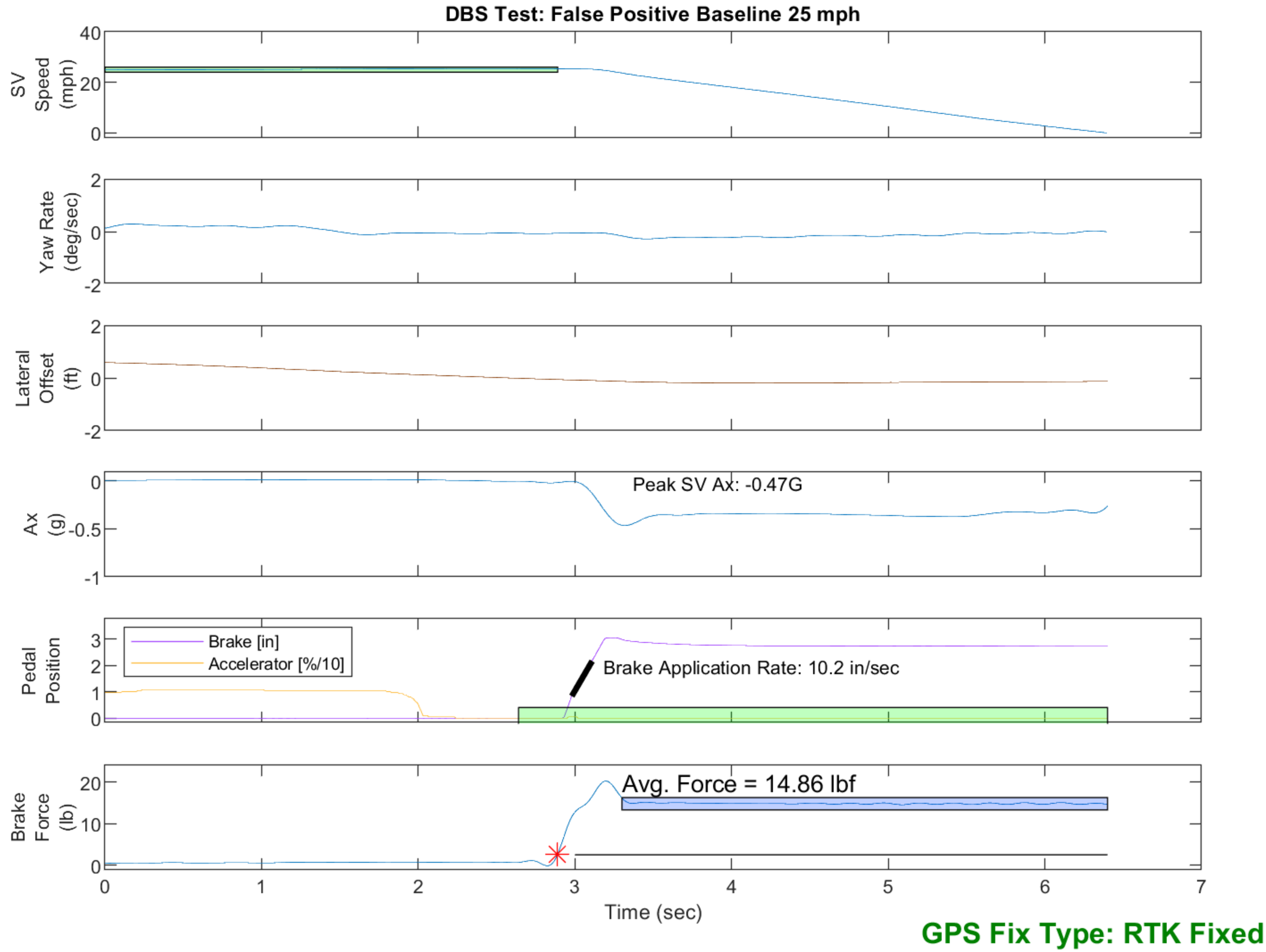


Figure E11. Example Time History Displaying Invalid Brake Force Criteria

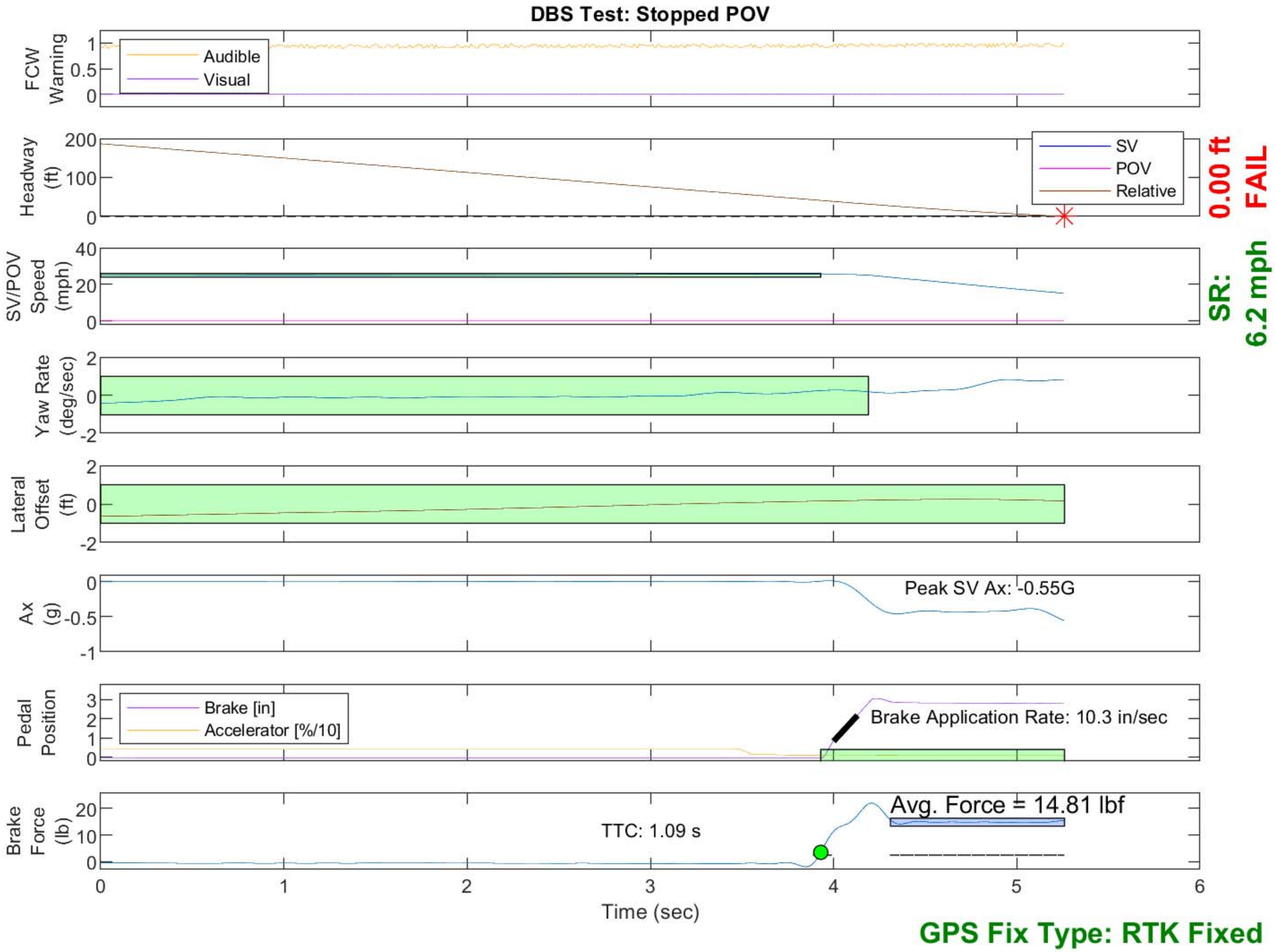


Figure E12. Example Time History for a Failed Run

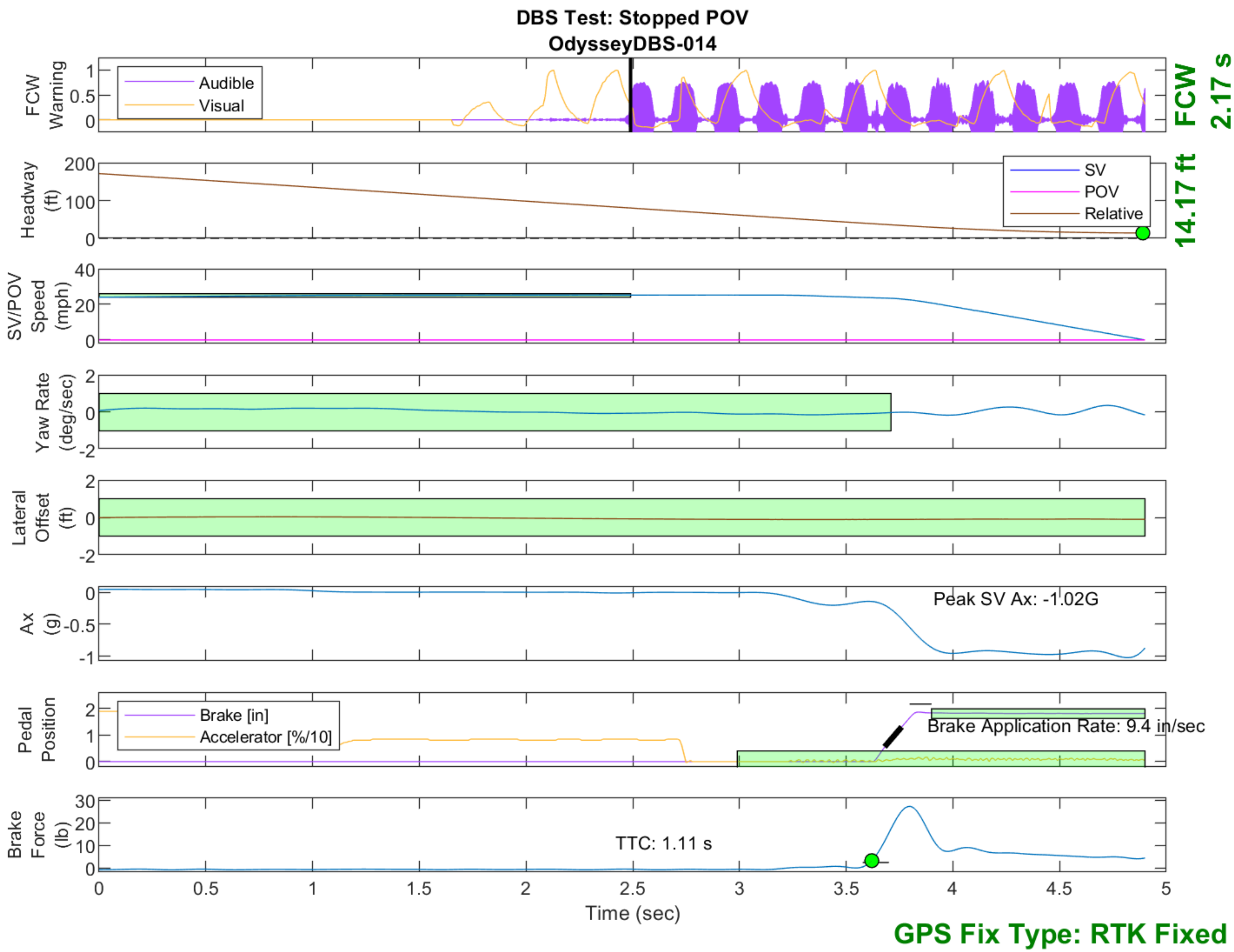


Figure E13. Time History for DBS Run 14, SV Encounters Stopped POV

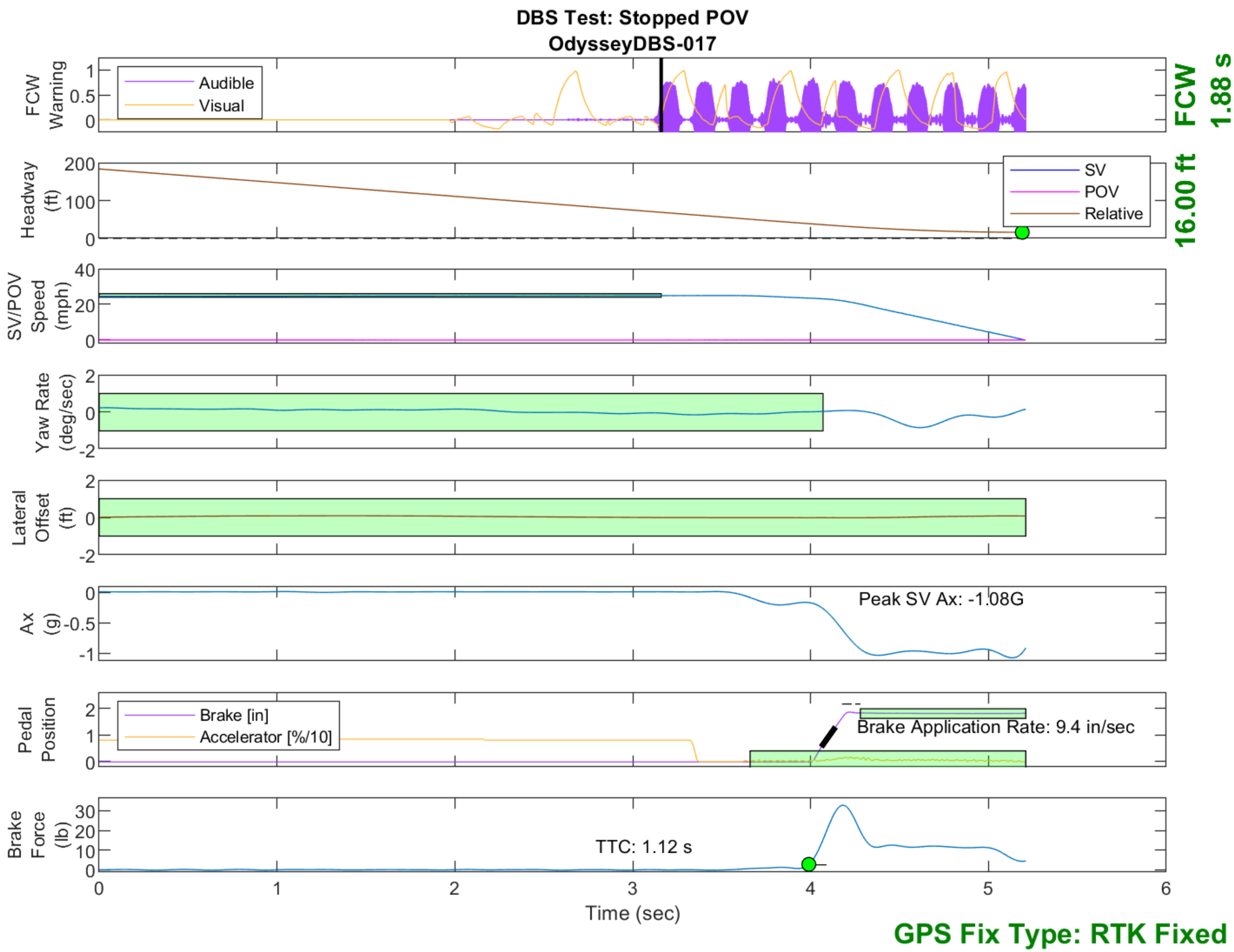


Figure E14. Time History for DBS Run 17, SV Encounters Stopped POV

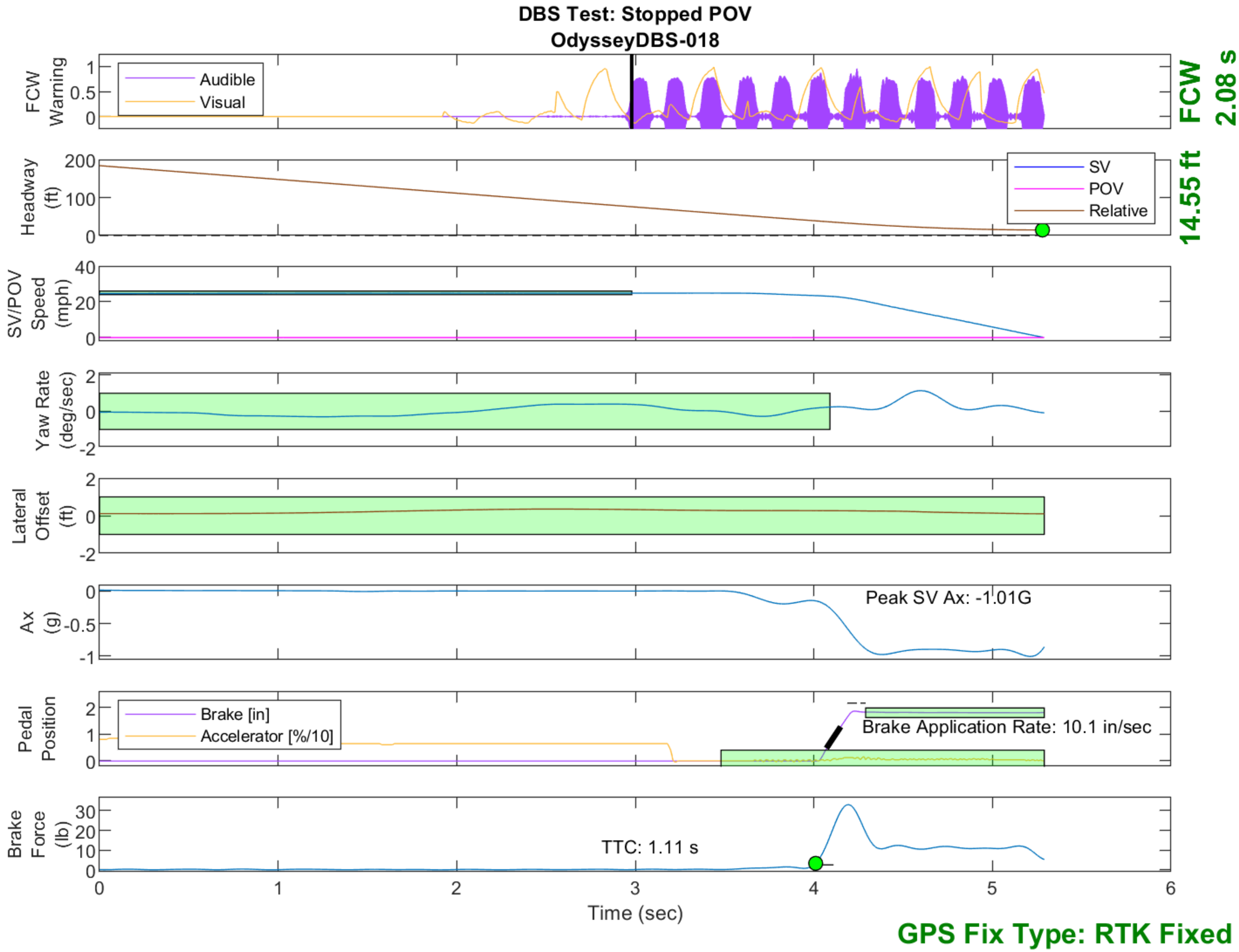


Figure E15. Time History for DBS Run 18, SV Encounters Stopped POV

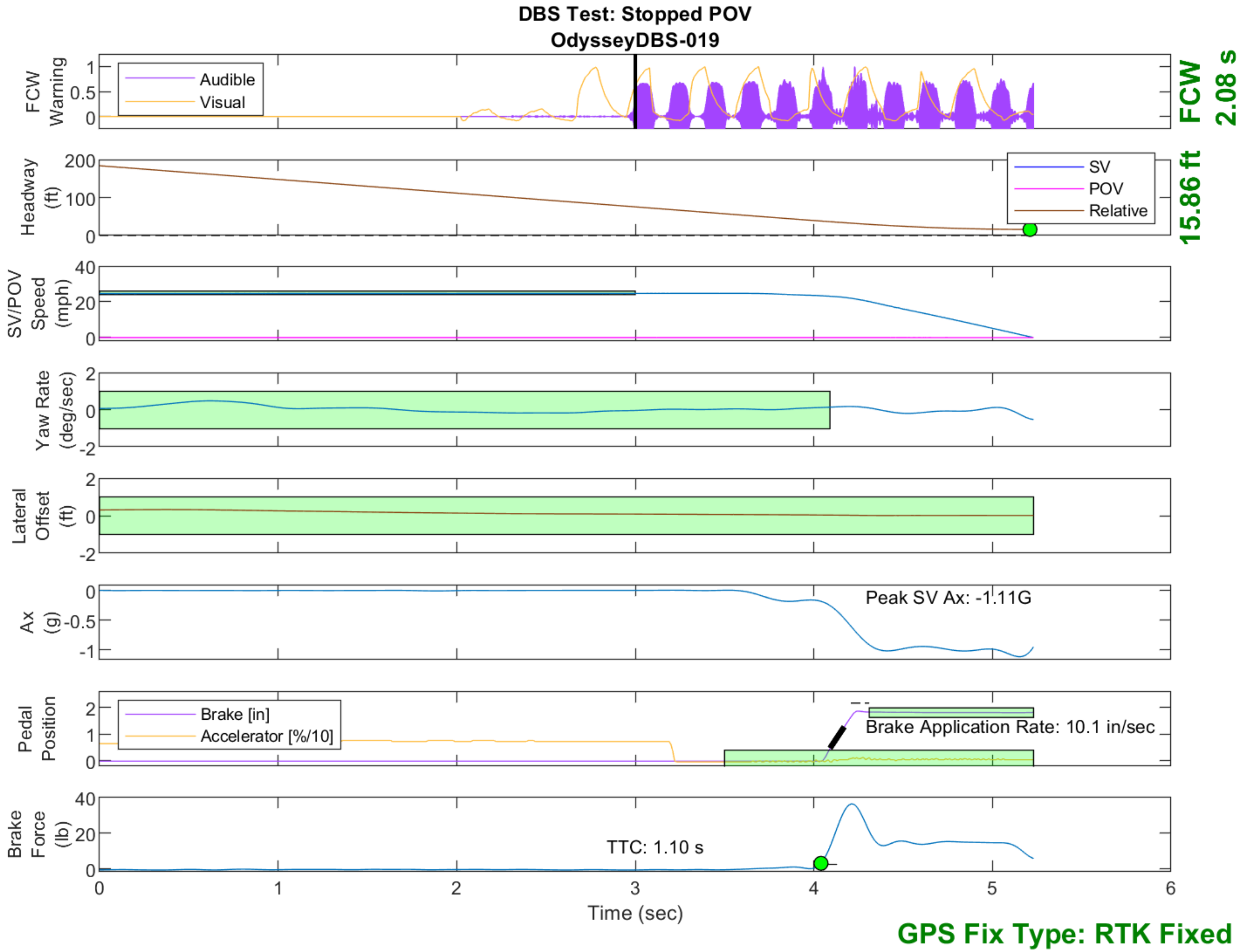


Figure E16. Time History for DBS Run 19, SV Encounters Stopped POV

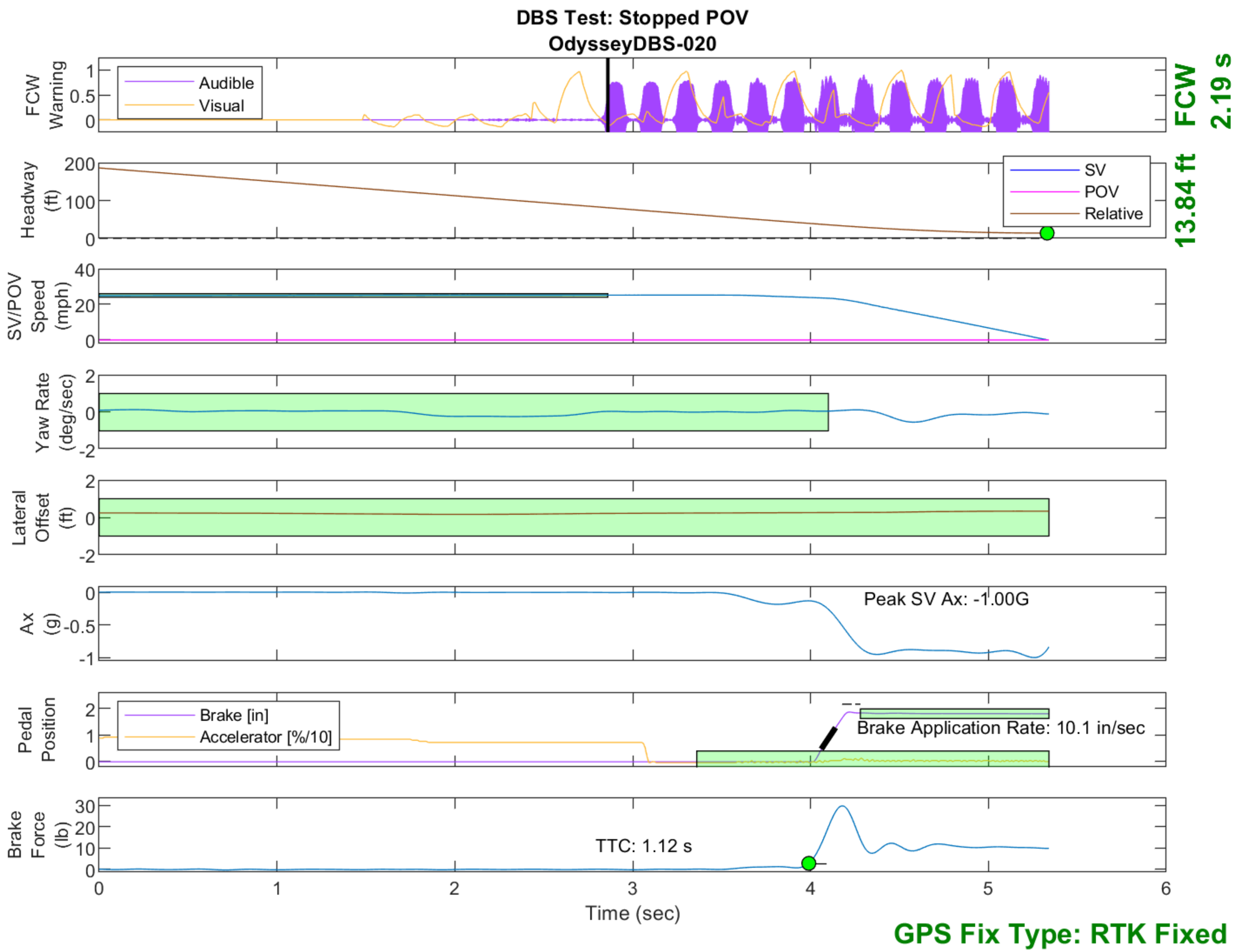


Figure E17. Time History for DBS Run 20, SV Encounters Stopped POV

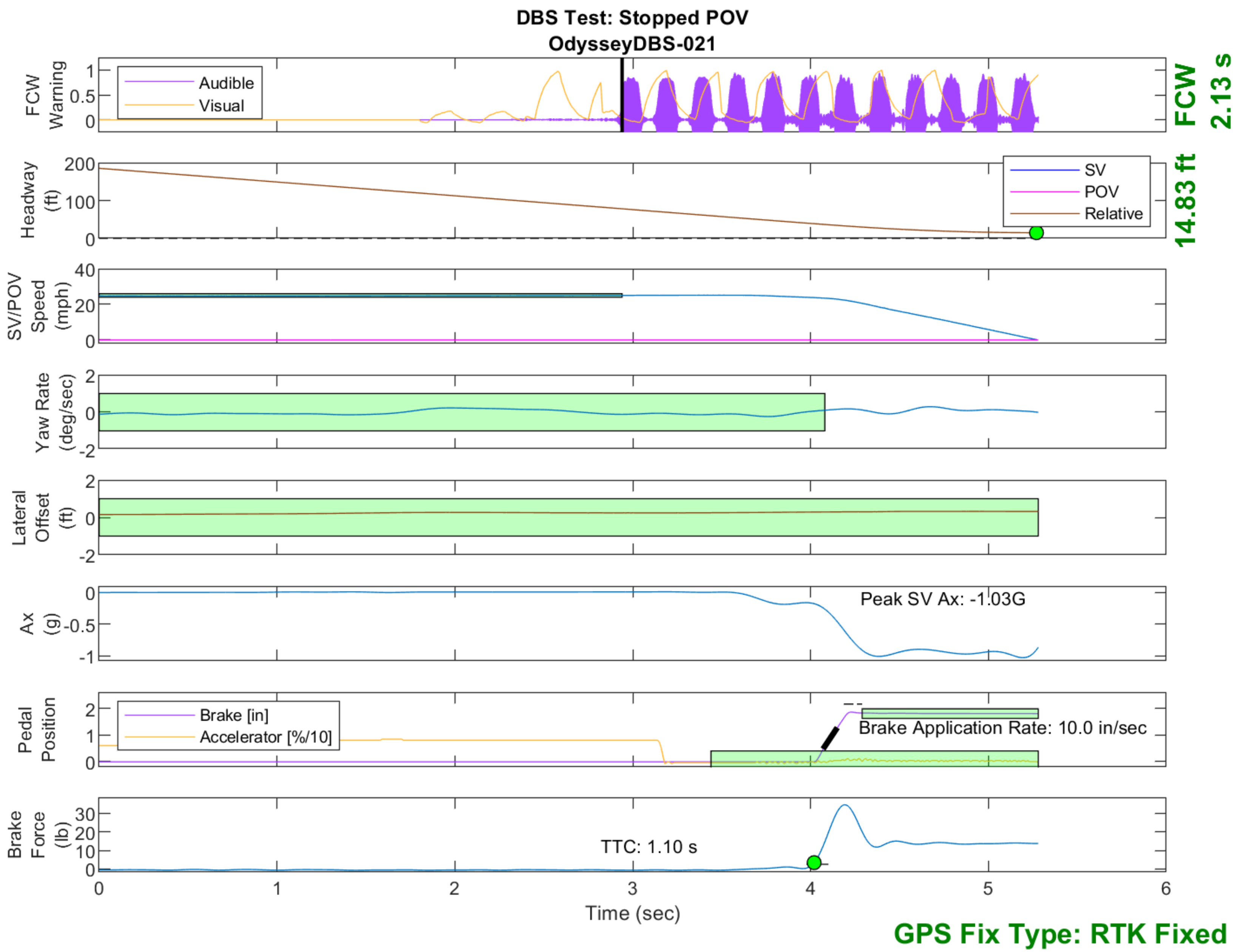


Figure E18. Time History for DBS Run 21, SV Encounters Stopped POV

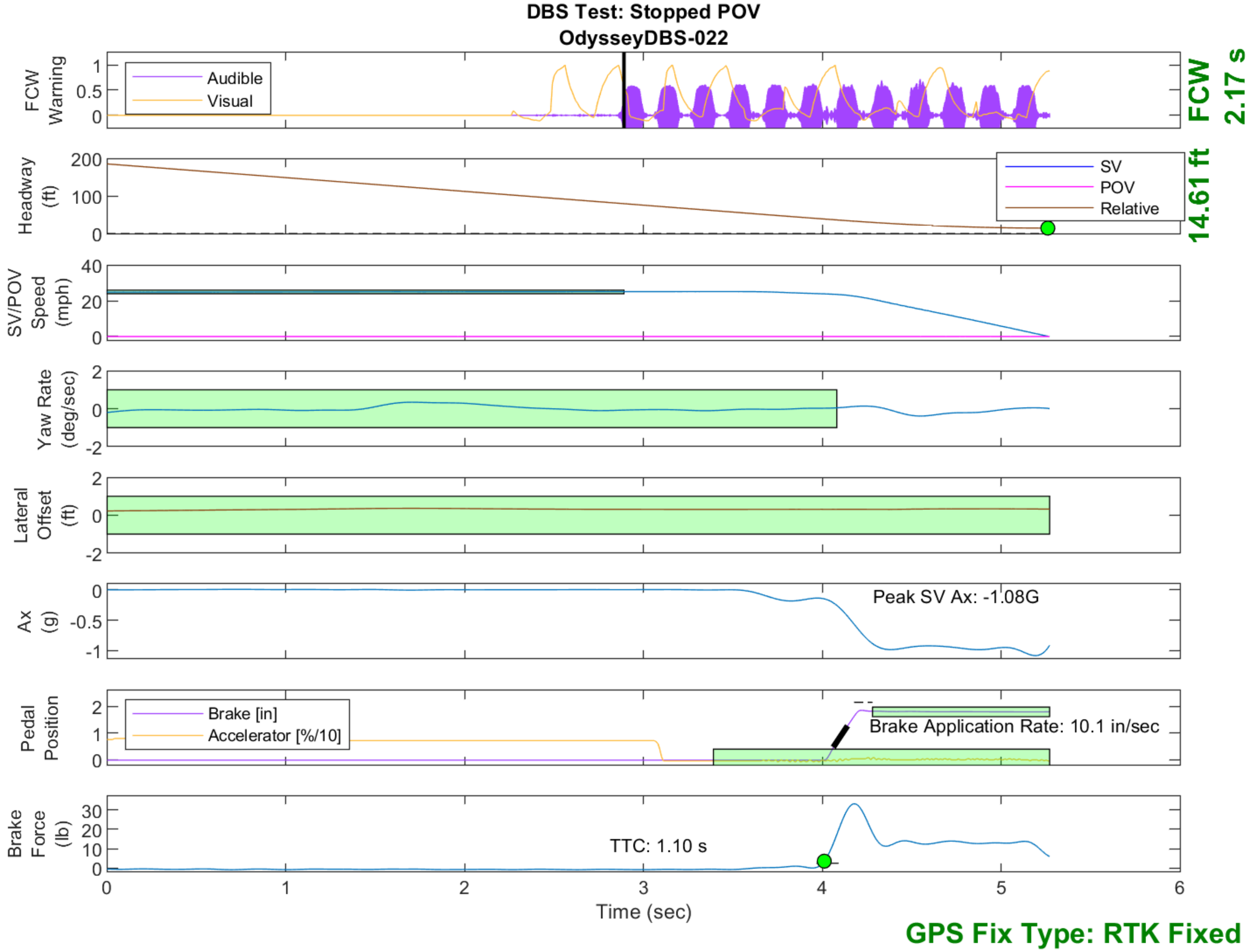


Figure E19. Time History for DBS Run 22, SV Encounters Stopped POV

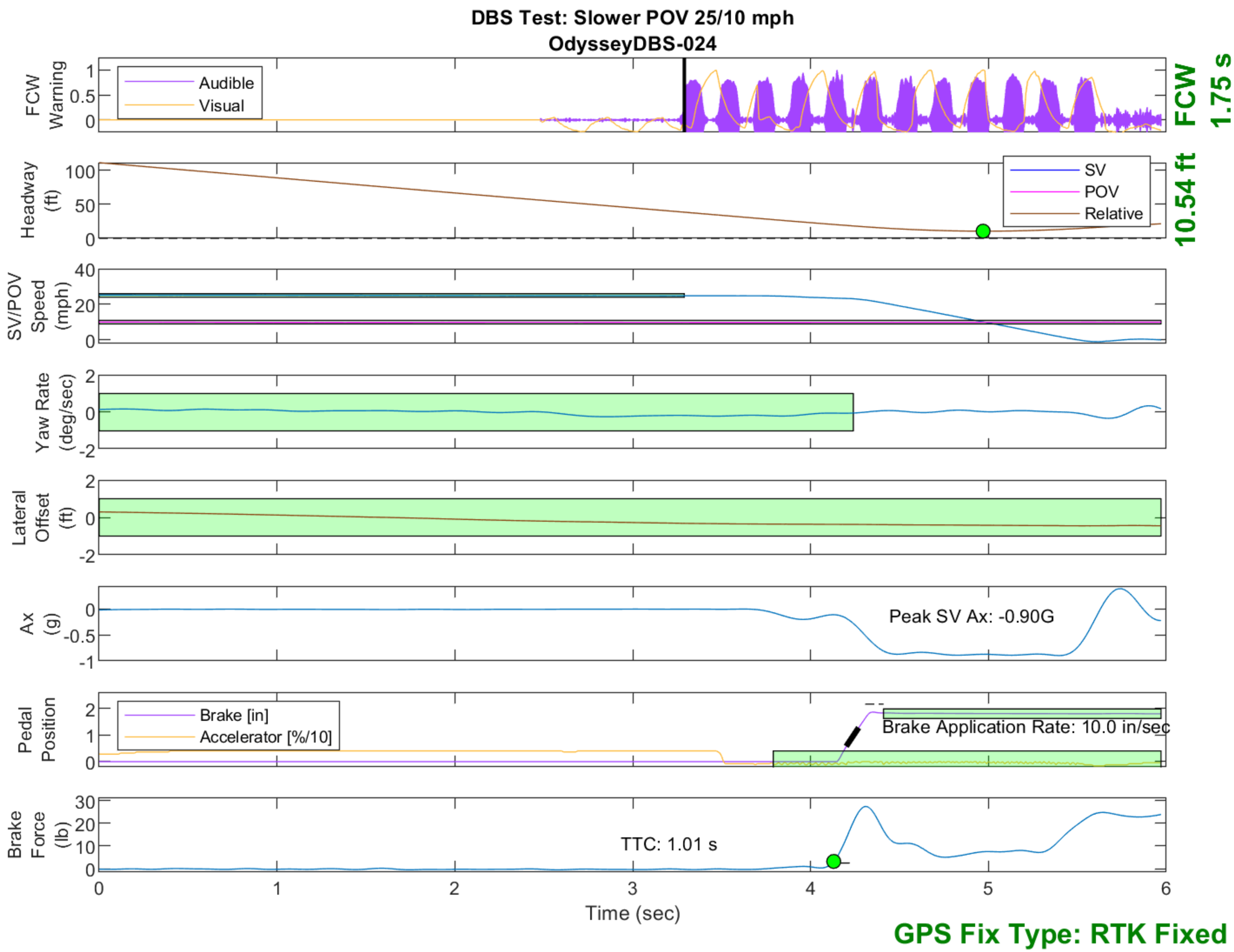


Figure E20. Time History for DBS Run 24, SV Encounters Slower POV, SV 25 mph, POV 10 mph

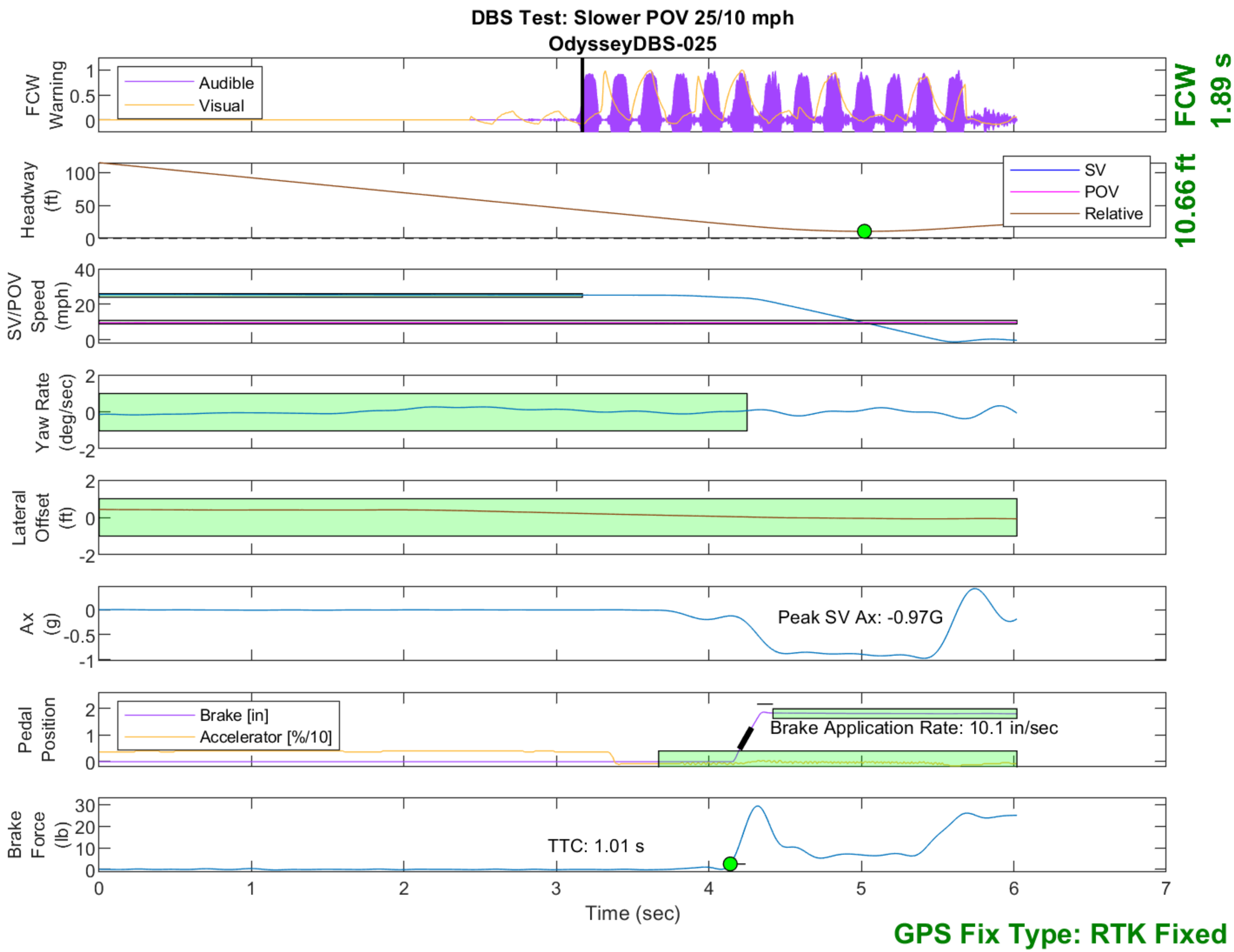


Figure E21. Time History for DBS Run 25, SV Encounters Slower POV, SV 25 mph, POV 10 mph

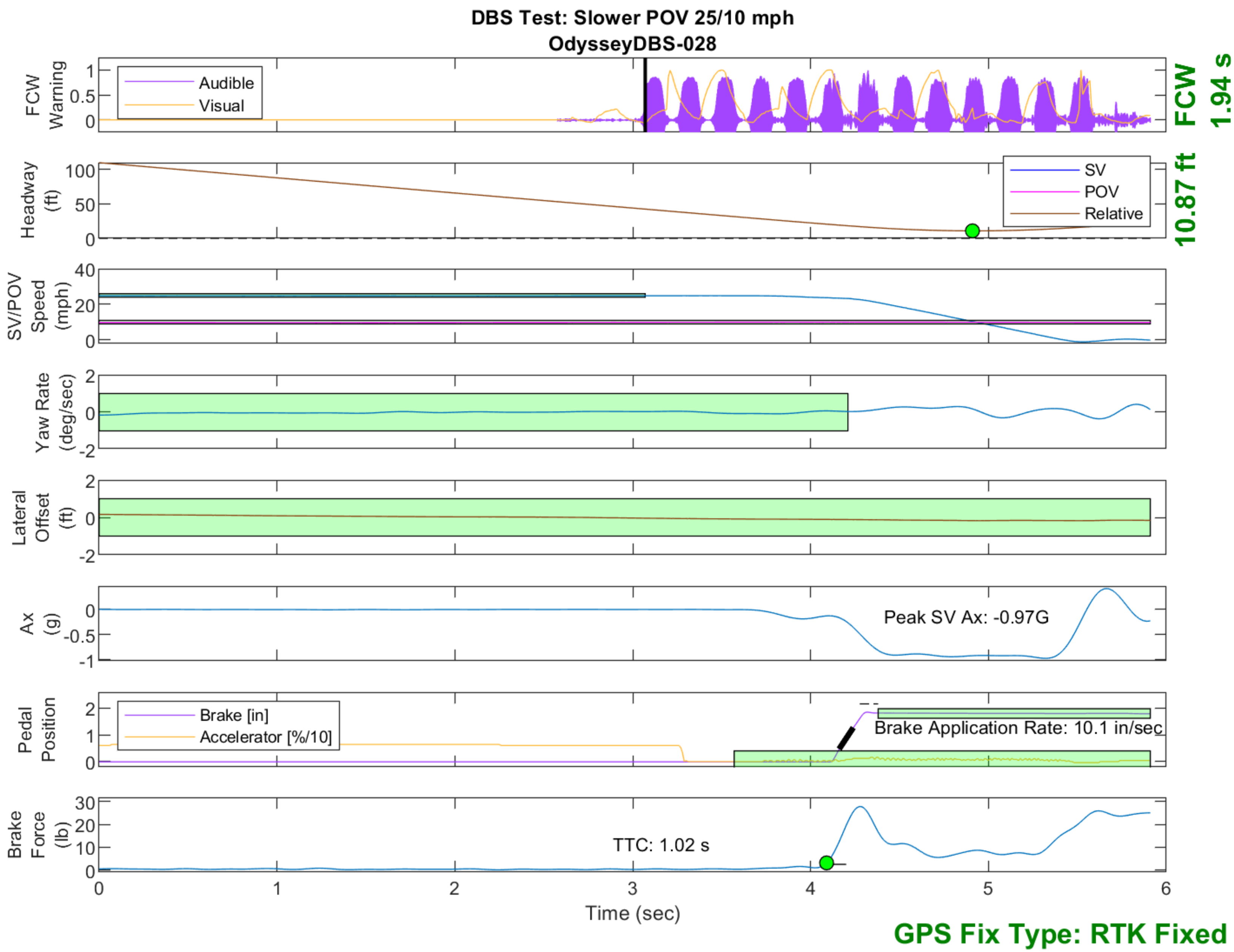


Figure E22. Time History for DBS Run 28, SV Encounters Slower POV, SV 25 mph, POV 10 mph

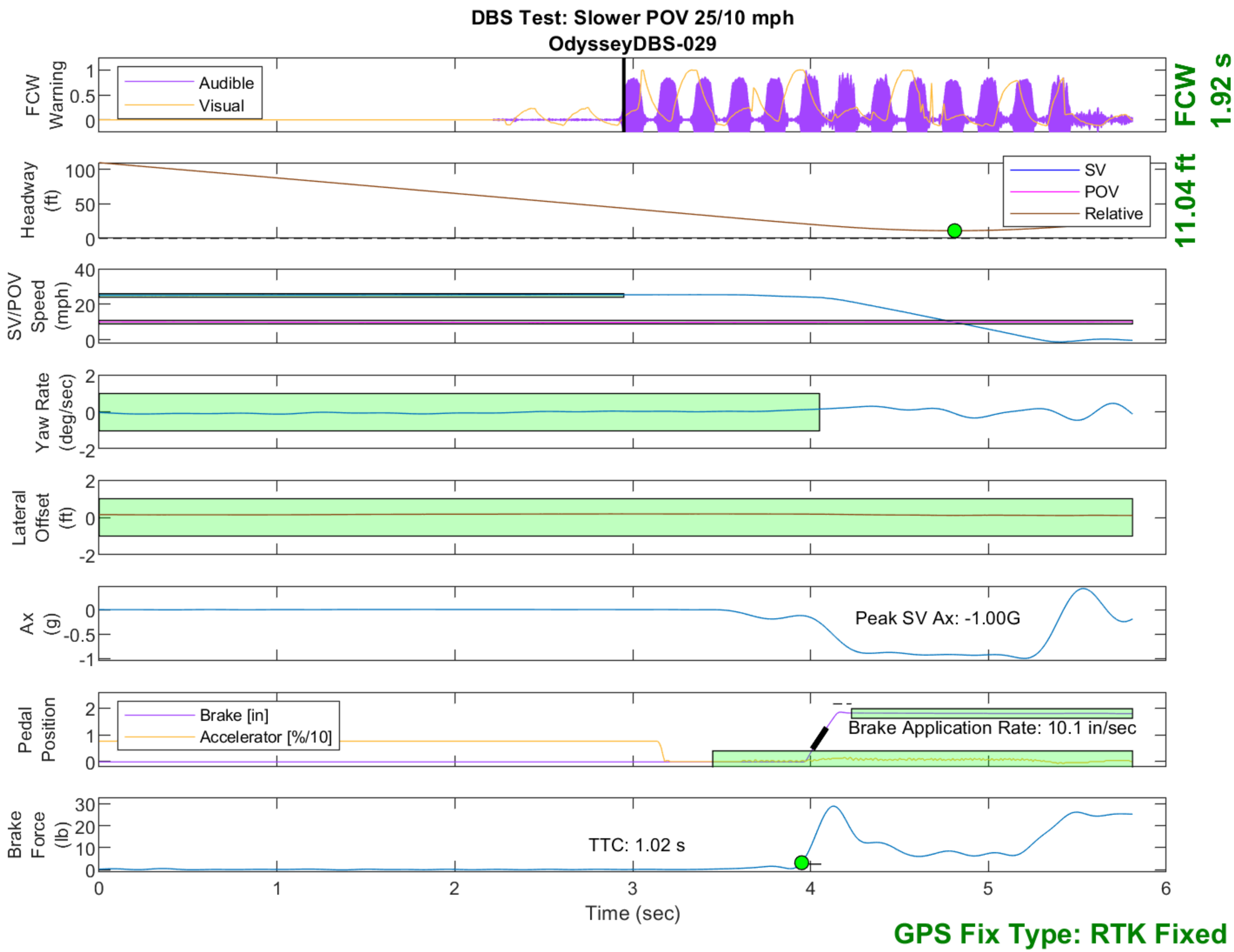


Figure E23. Time History for DBS Run 29, SV Encounters Slower POV, SV 25 mph, POV 10 mph

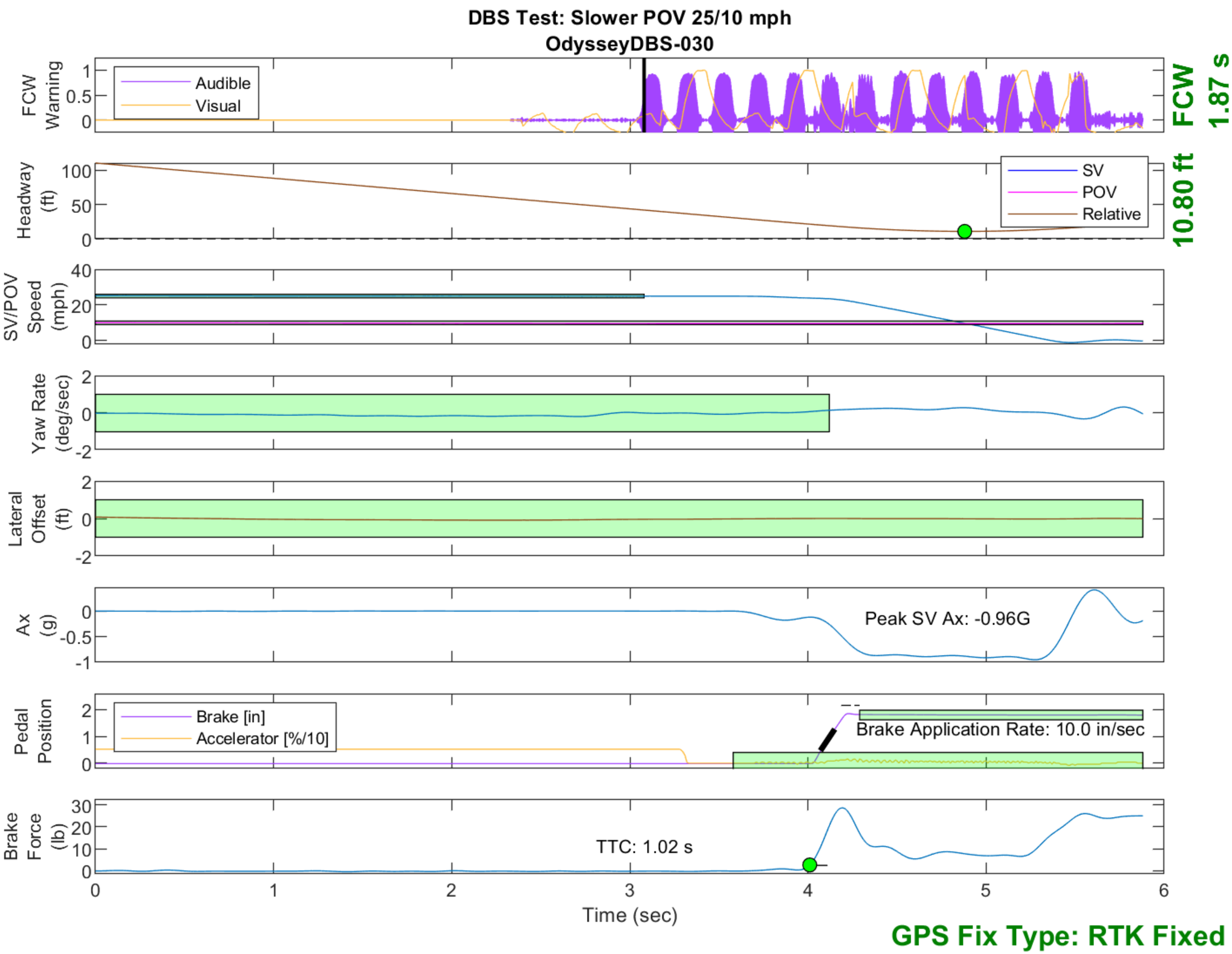


Figure E24. Time History for DBS Run 30, SV Encounters Slower POV, SV 25 mph, POV 10 mph

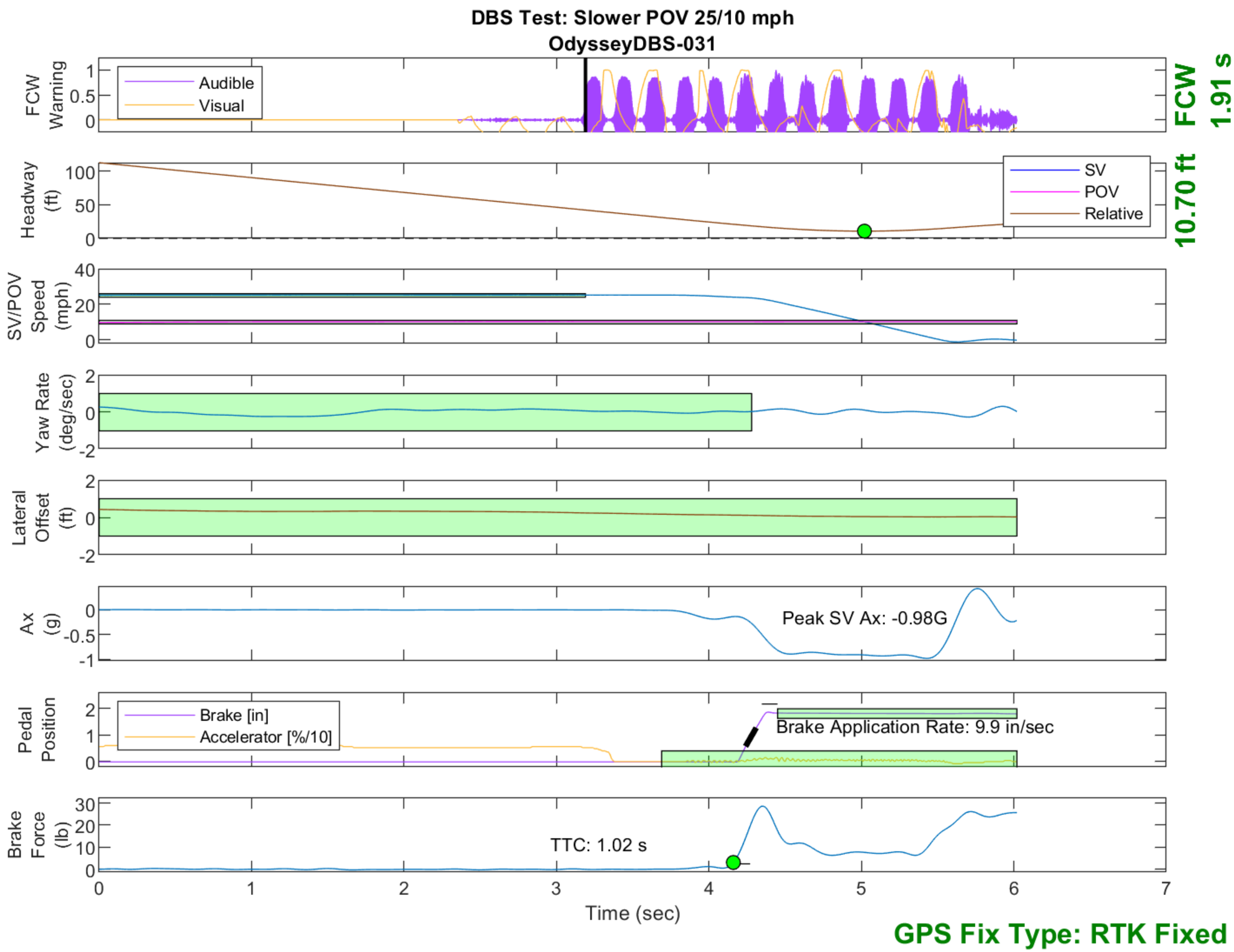


Figure E25. Time History for DBS Run 31, SV Encounters Slower POV, SV 25 mph, POV 10 mph

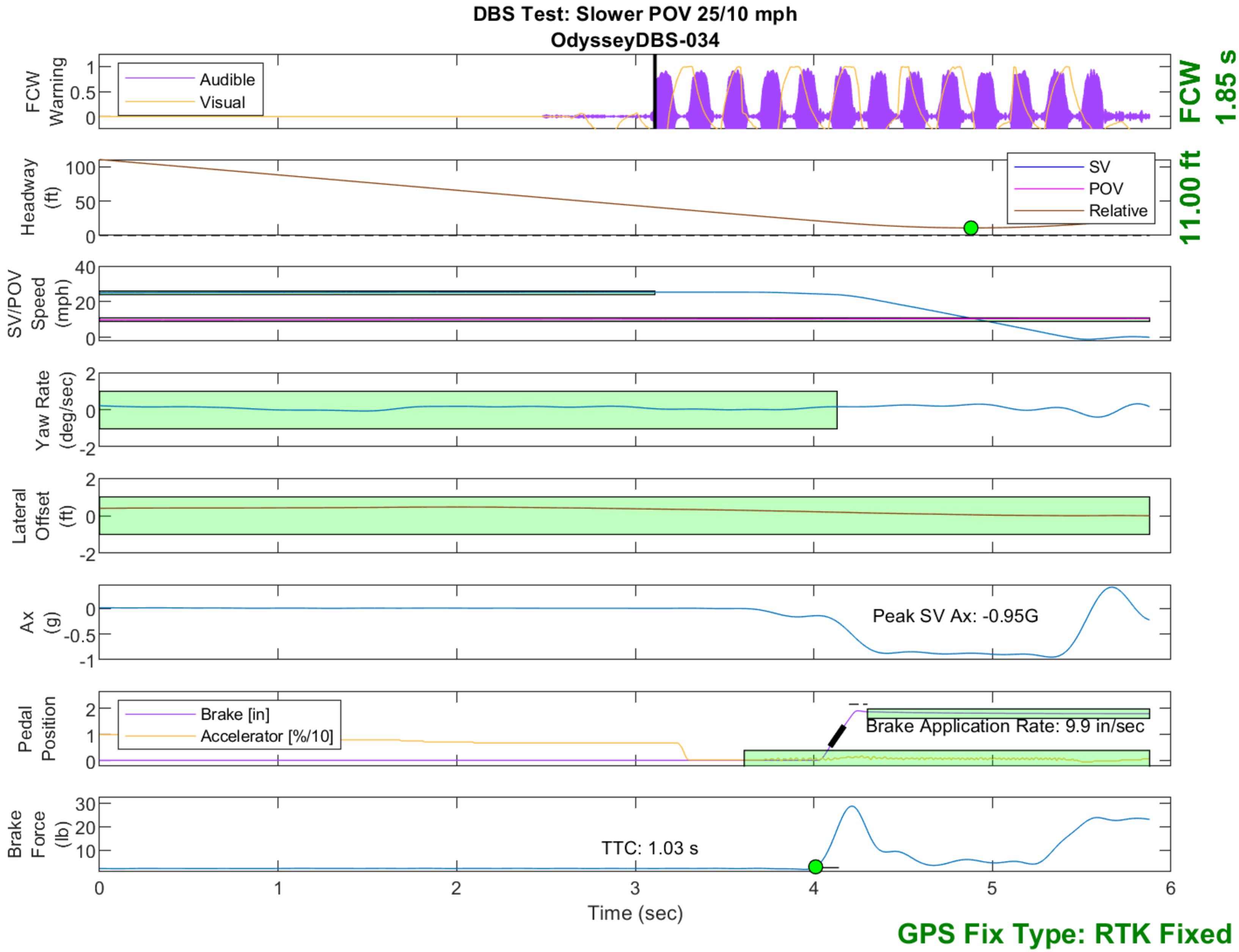


Figure E26. Time History for DBS Run 34, SV Encounters Slower POV, SV 25 mph, POV 10 mph

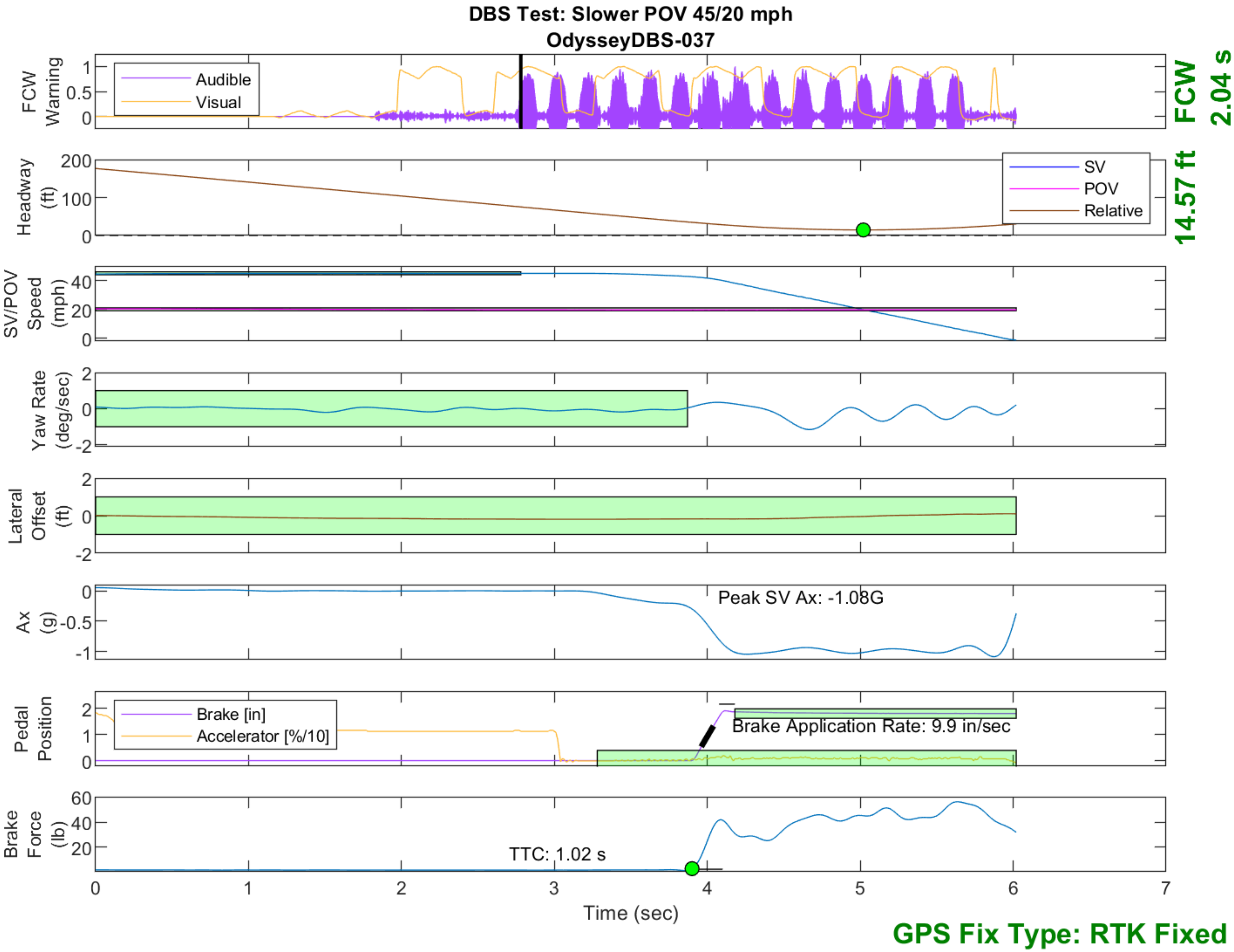


Figure E27. Time History for DBS Run 37, SV Encounters Slower POV, SV 45 mph, POV 20 mph

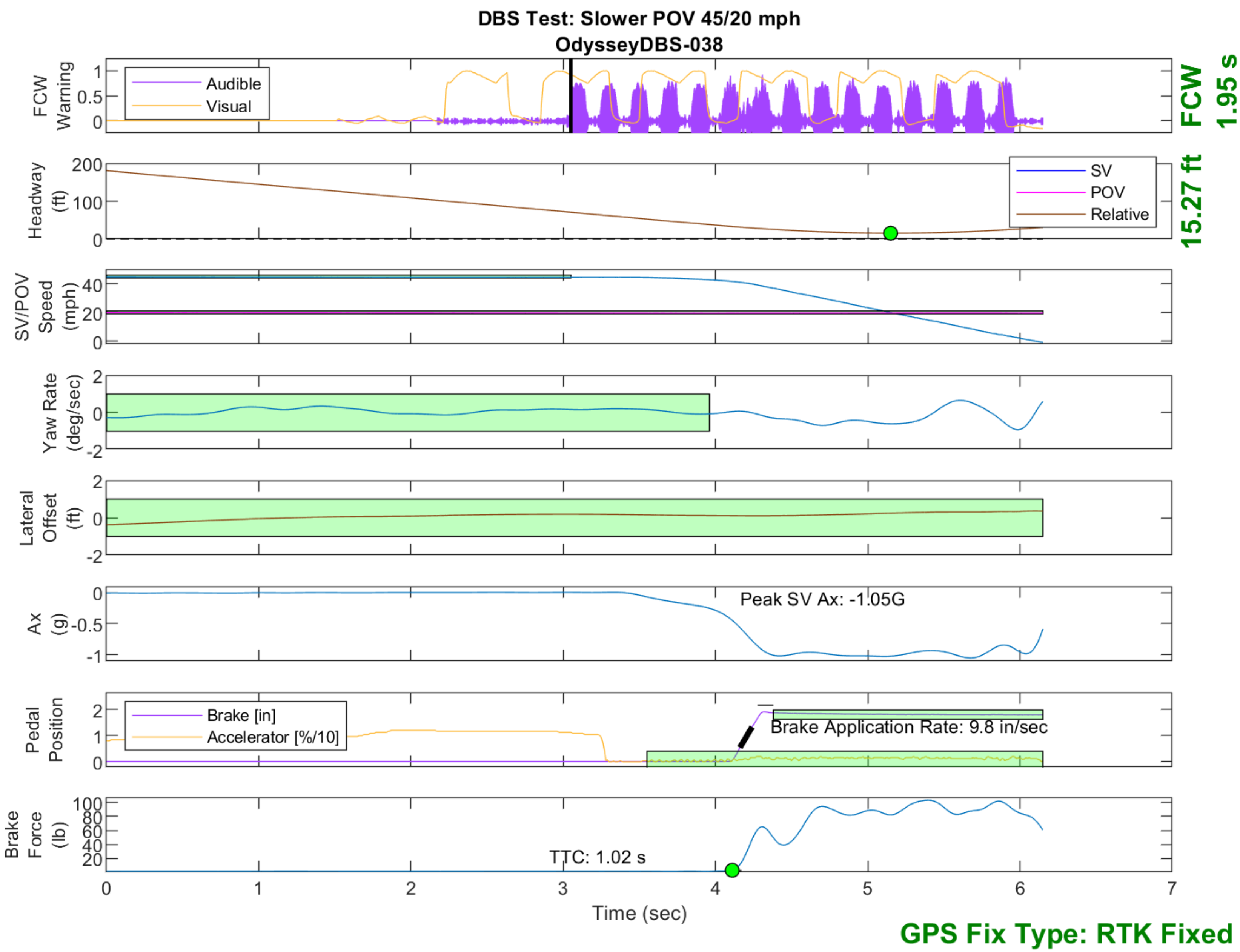


Figure E28. Time History for DBS Run 38, SV Encounters Slower POV, SV 45 mph, POV 20 mph

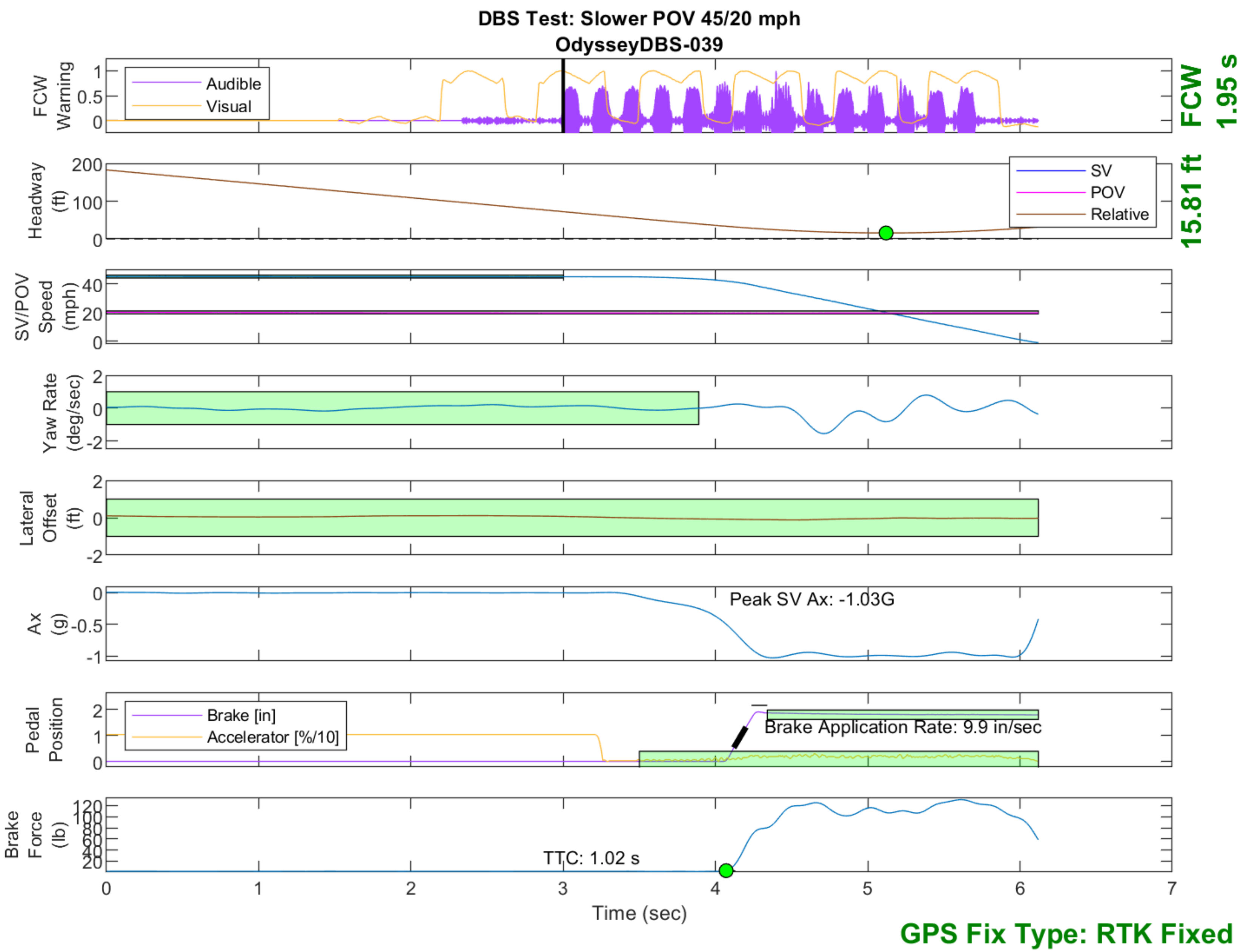


Figure E29. Time History for DBS Run 39, SV Encounters Slower POV, SV 45 mph, POV 20 mph

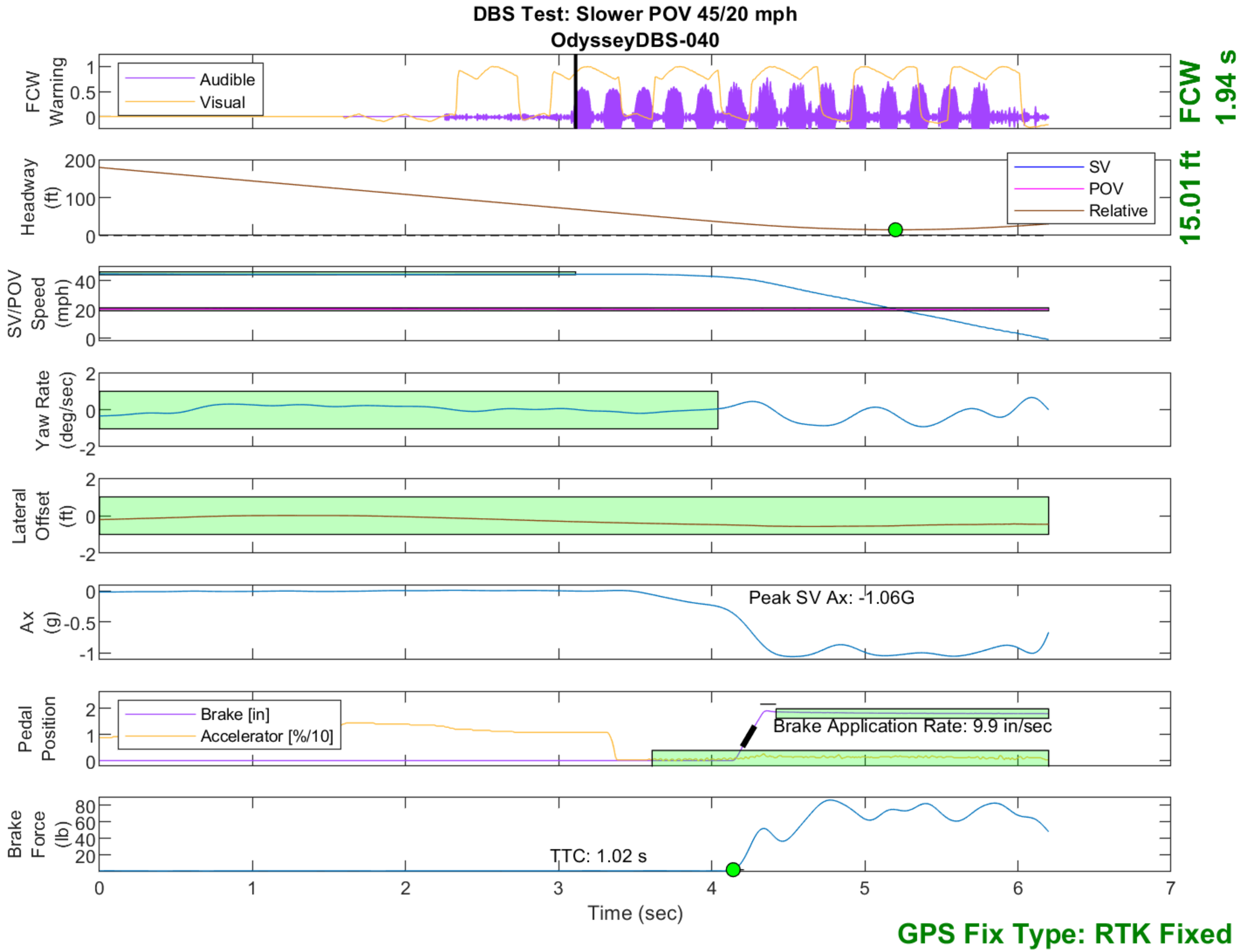


Figure E30. Time History for DBS Run 40, SV Encounters Slower POV, SV 45 mph, POV 20 mph

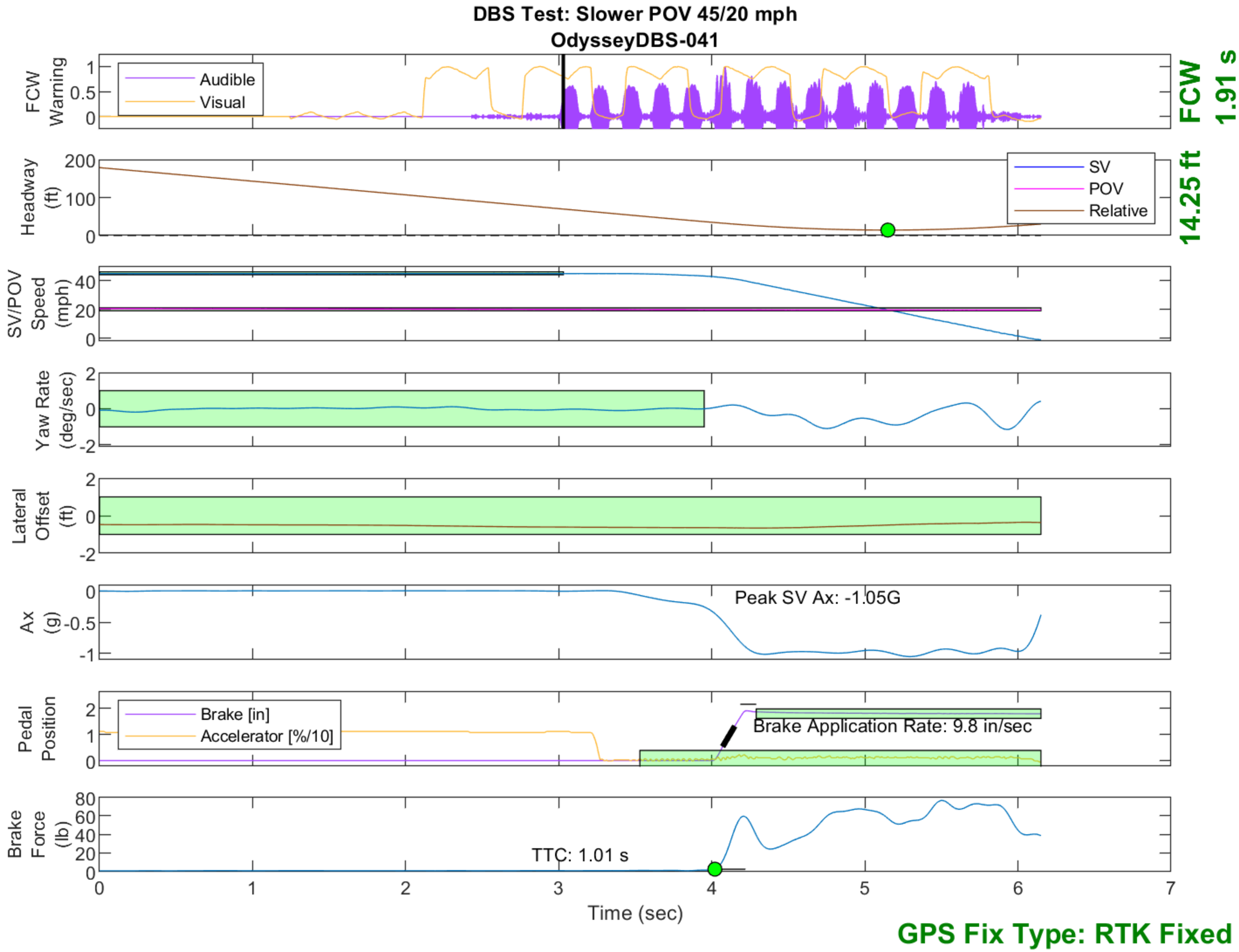


Figure E31. Time History for DBS Run 41, SV Encounters Slower POV, SV 45 mph, POV 20 mph

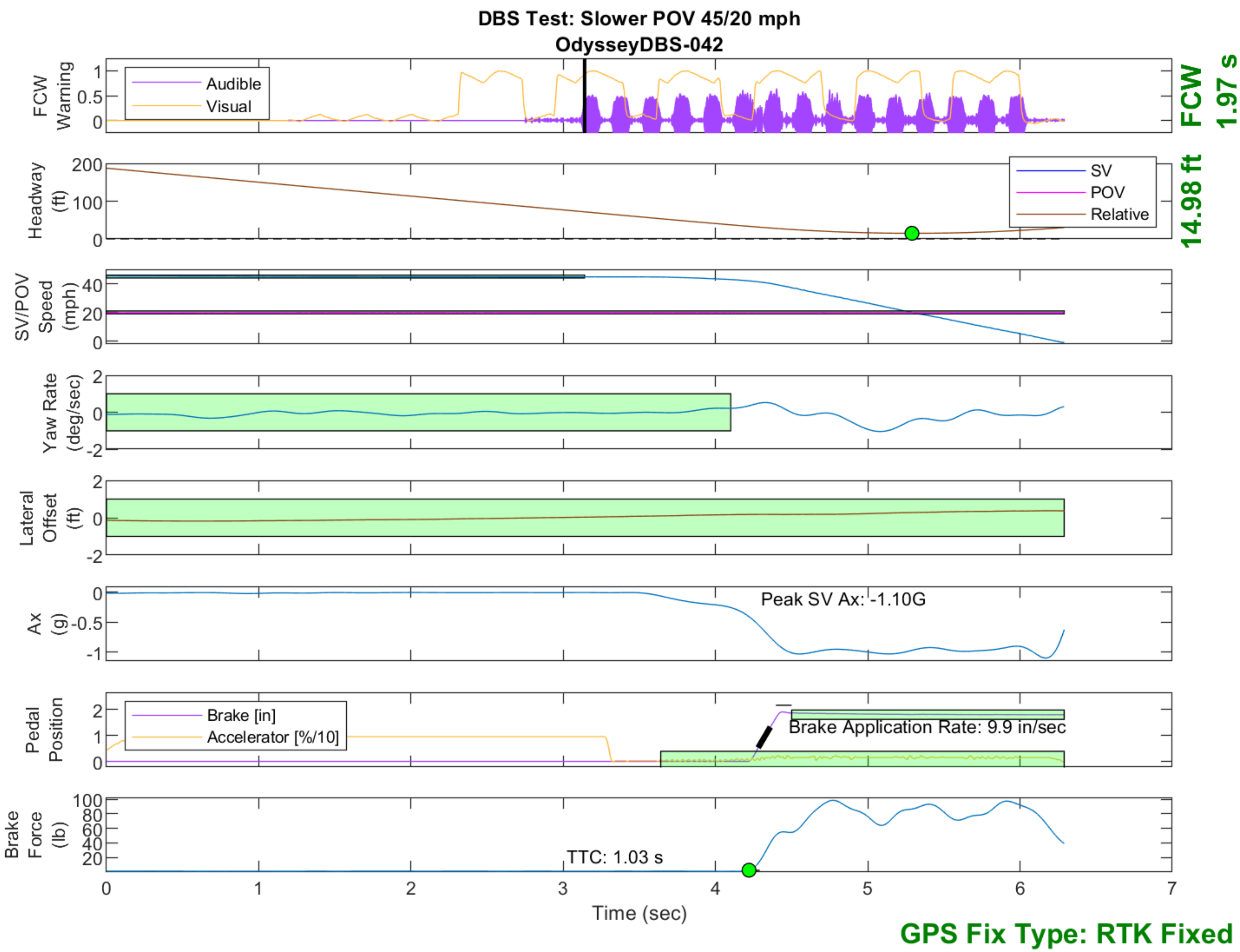


Figure E32. Time History for DBS Run 42, SV Encounters Slower POV, SV 45 mph, POV 20 mph

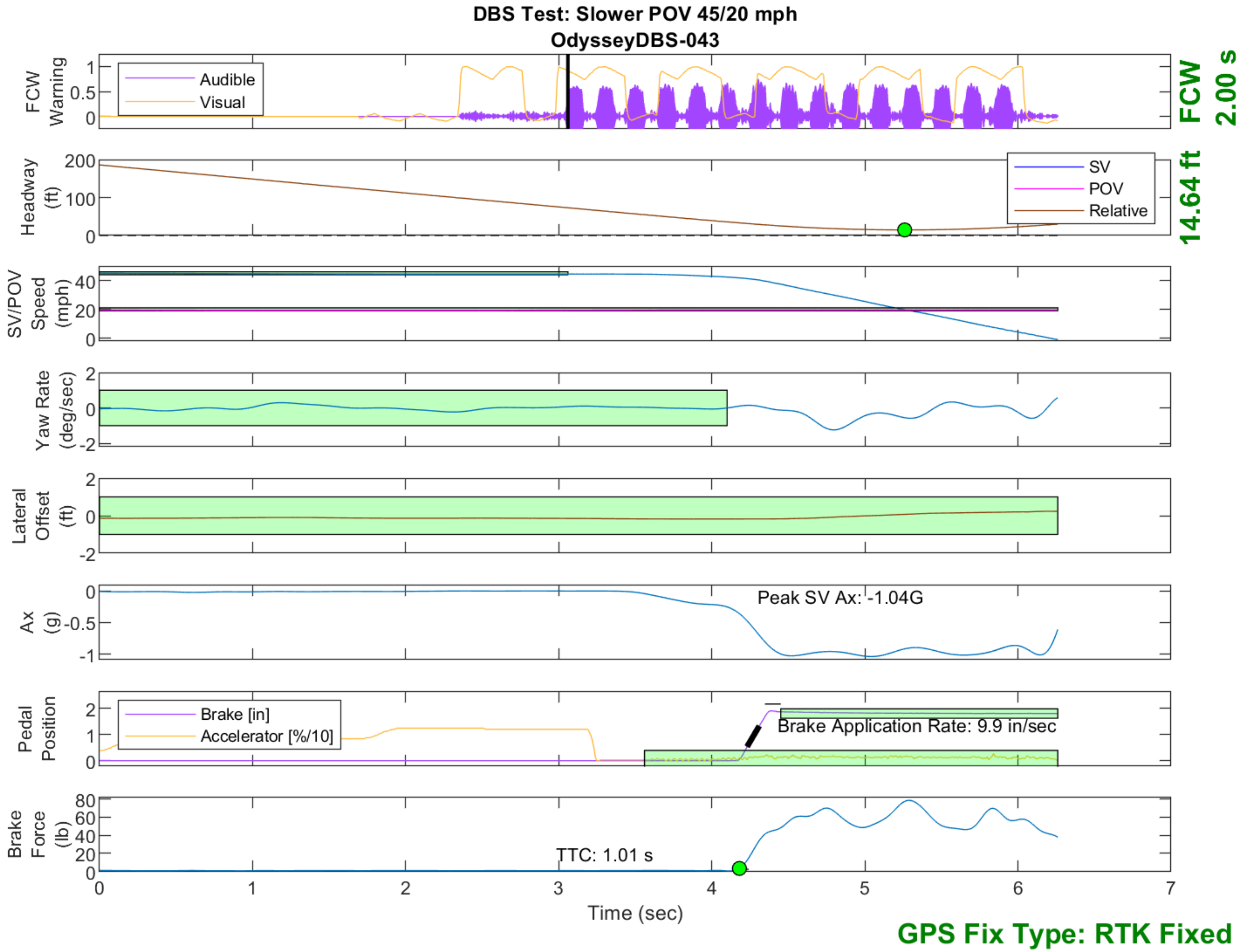


Figure E33. Time History for DBS Run 43, SV Encounters Slower POV, SV 45 mph, POV 20 mph

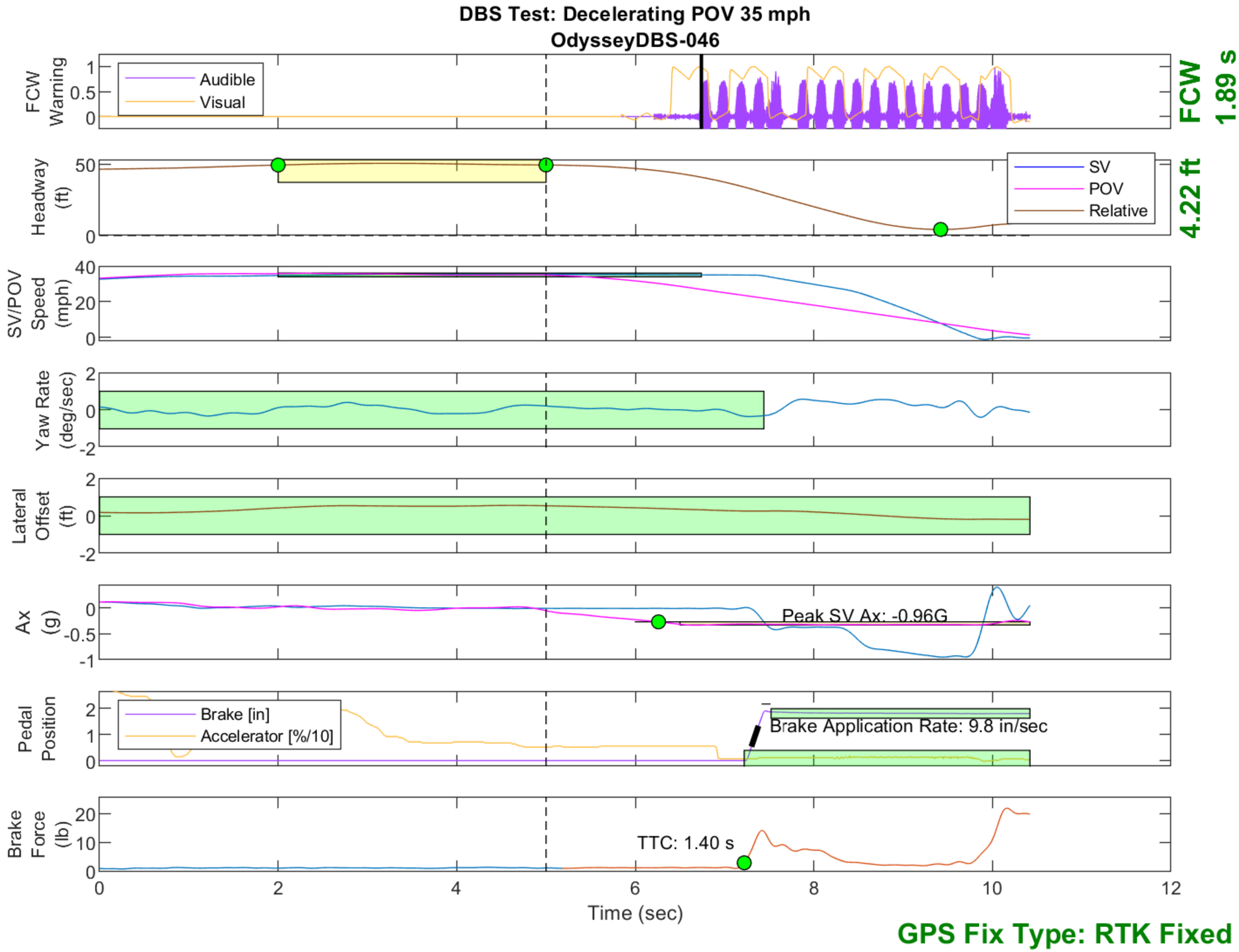


Figure E34. Time History for DBS Run 46, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

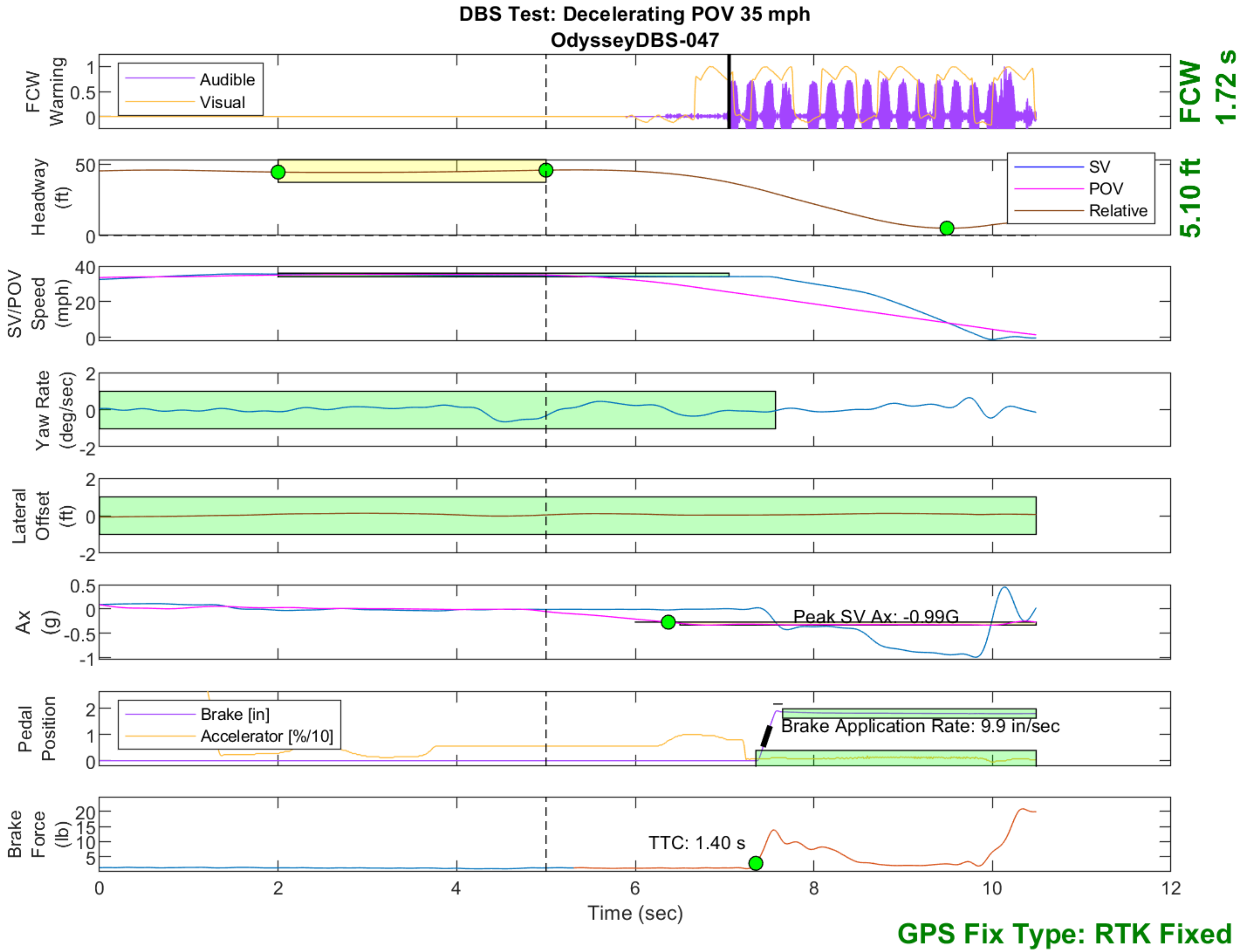


Figure E35. Time History for DBS Run 47, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

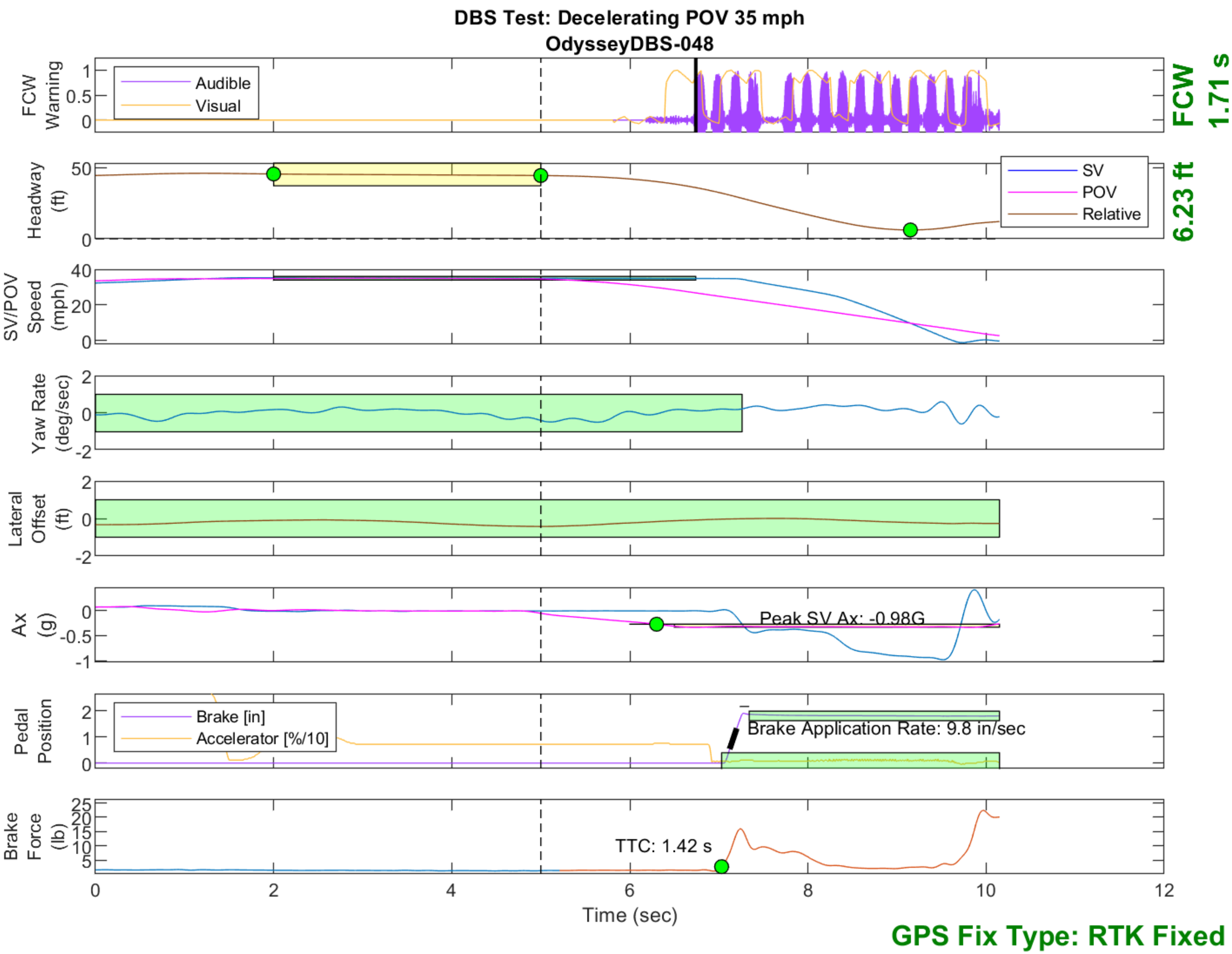


Figure E36. Time History for DBS Run 48, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

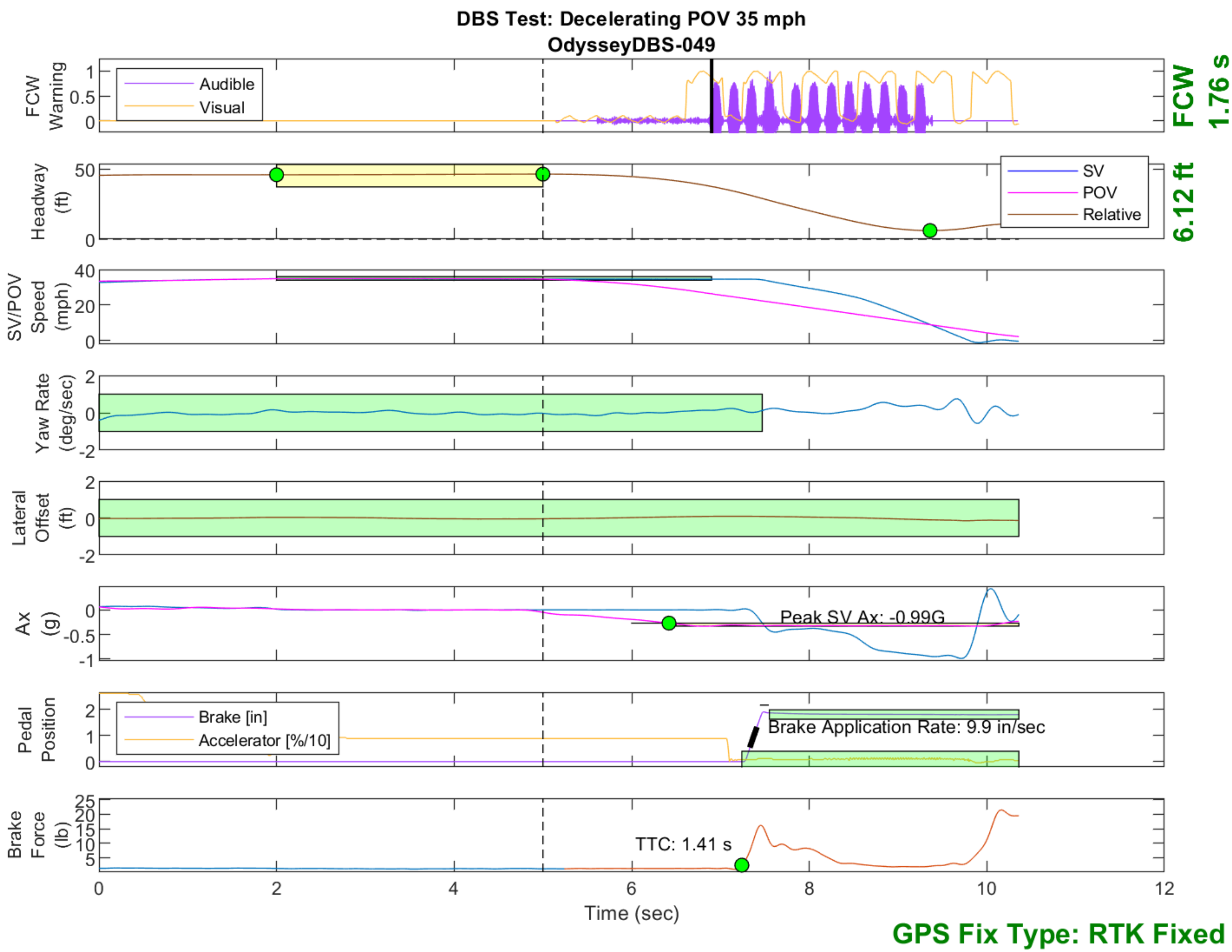


Figure E37. Time History for DBS Run 49, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

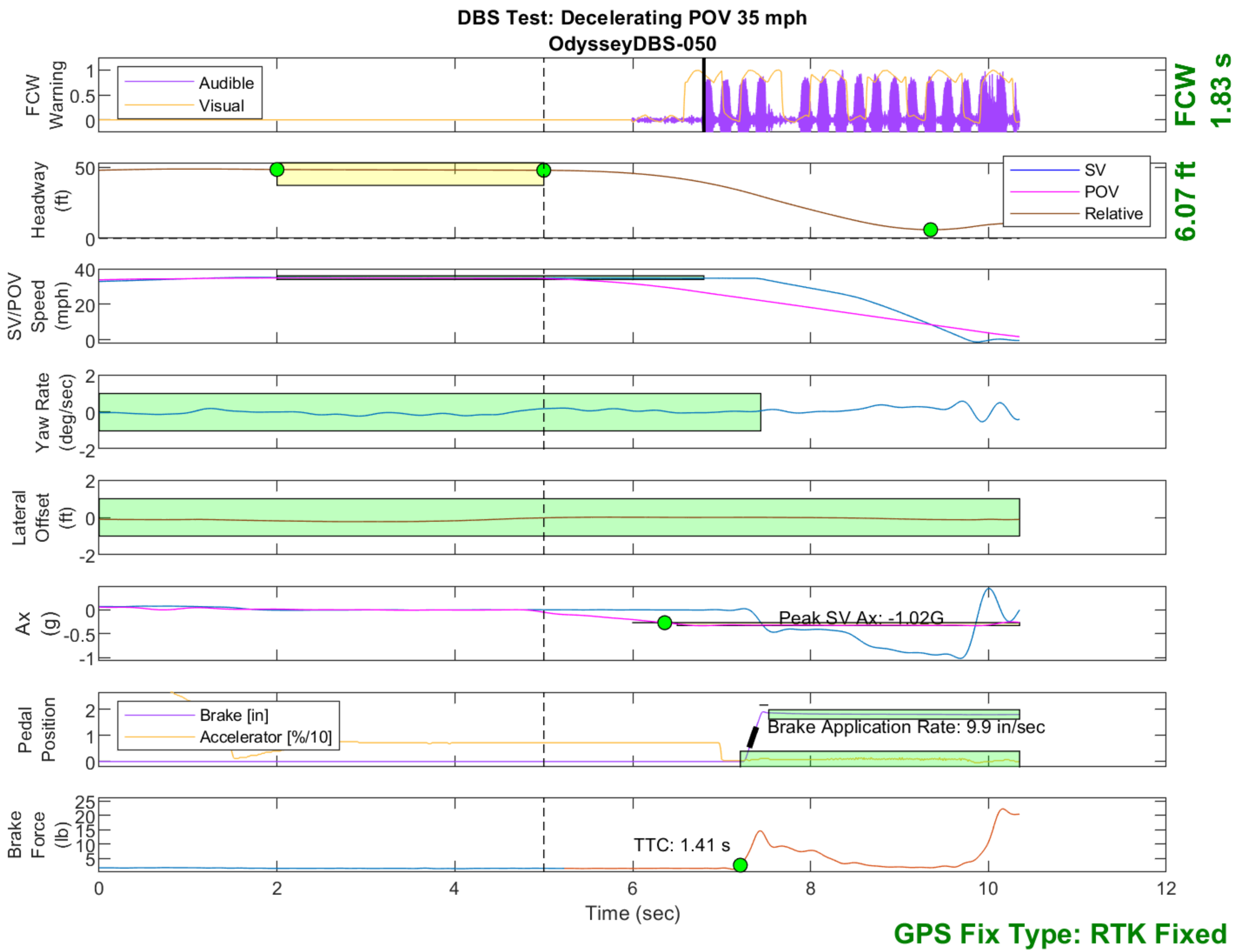


Figure E38. Time History for DBS Run 50, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

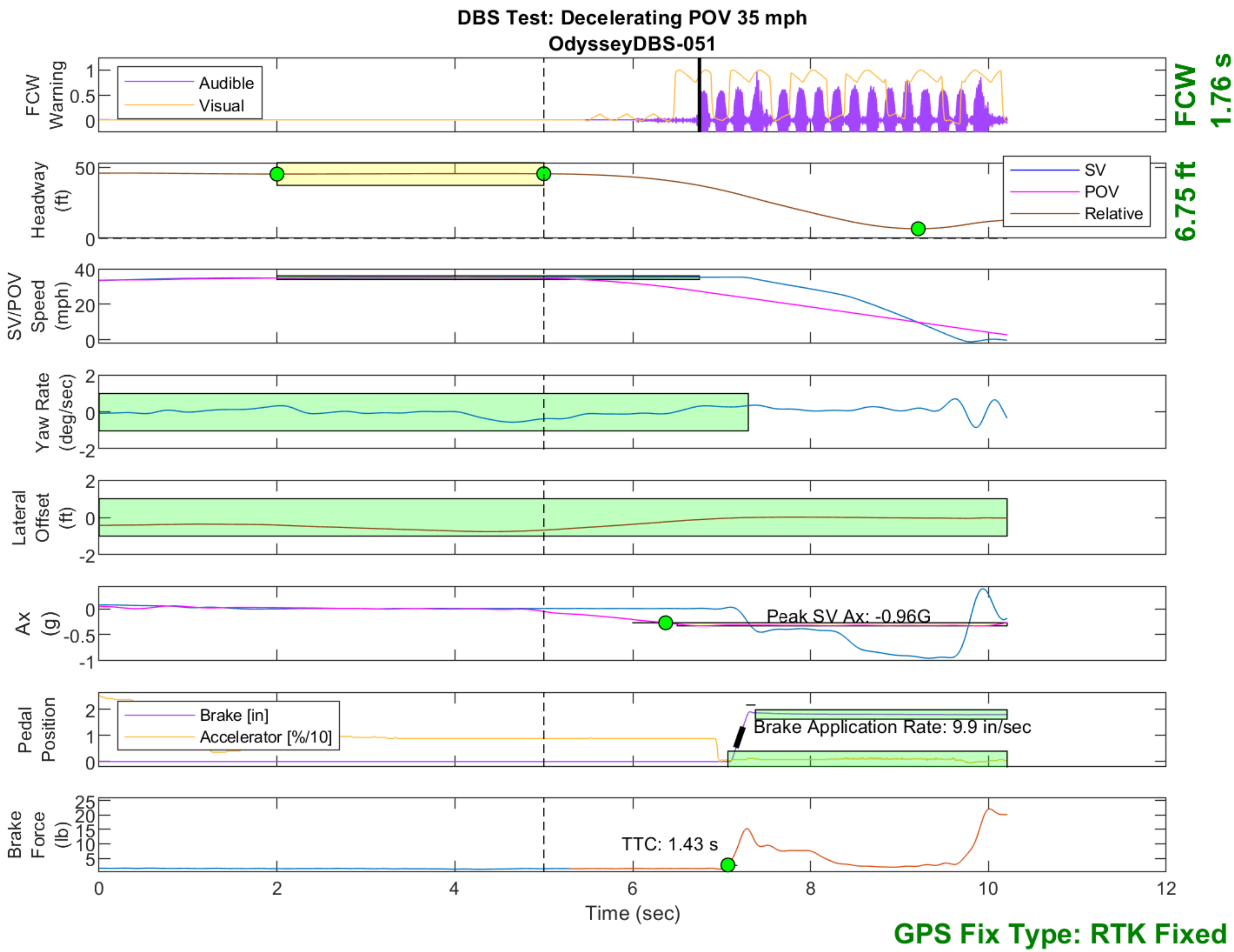


Figure E39. Time History for DBS Run 51, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

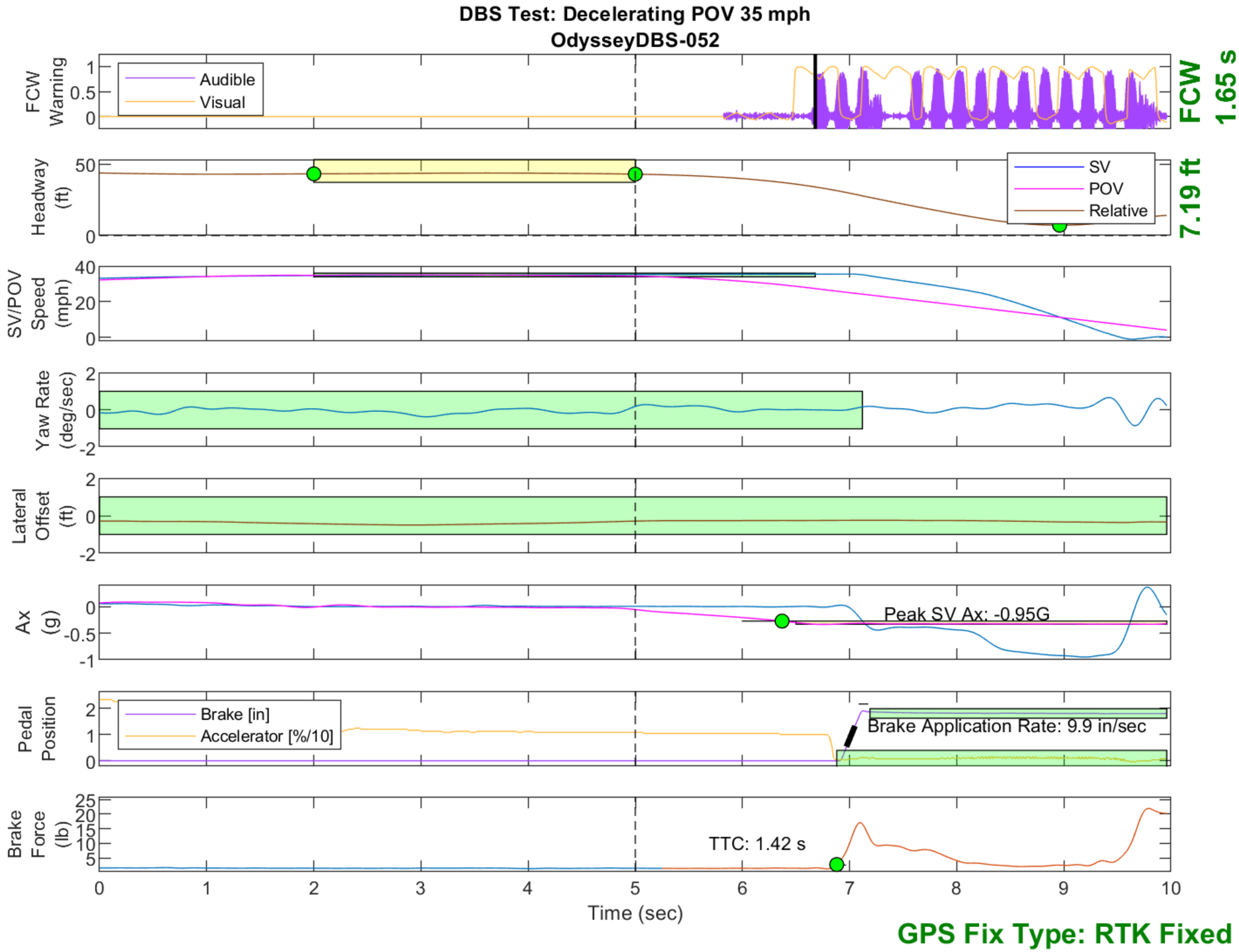


Figure E40. Time History for DBS Run 52, SV Encounters Decelerating POV, SV 35 mph, POV 35 mph

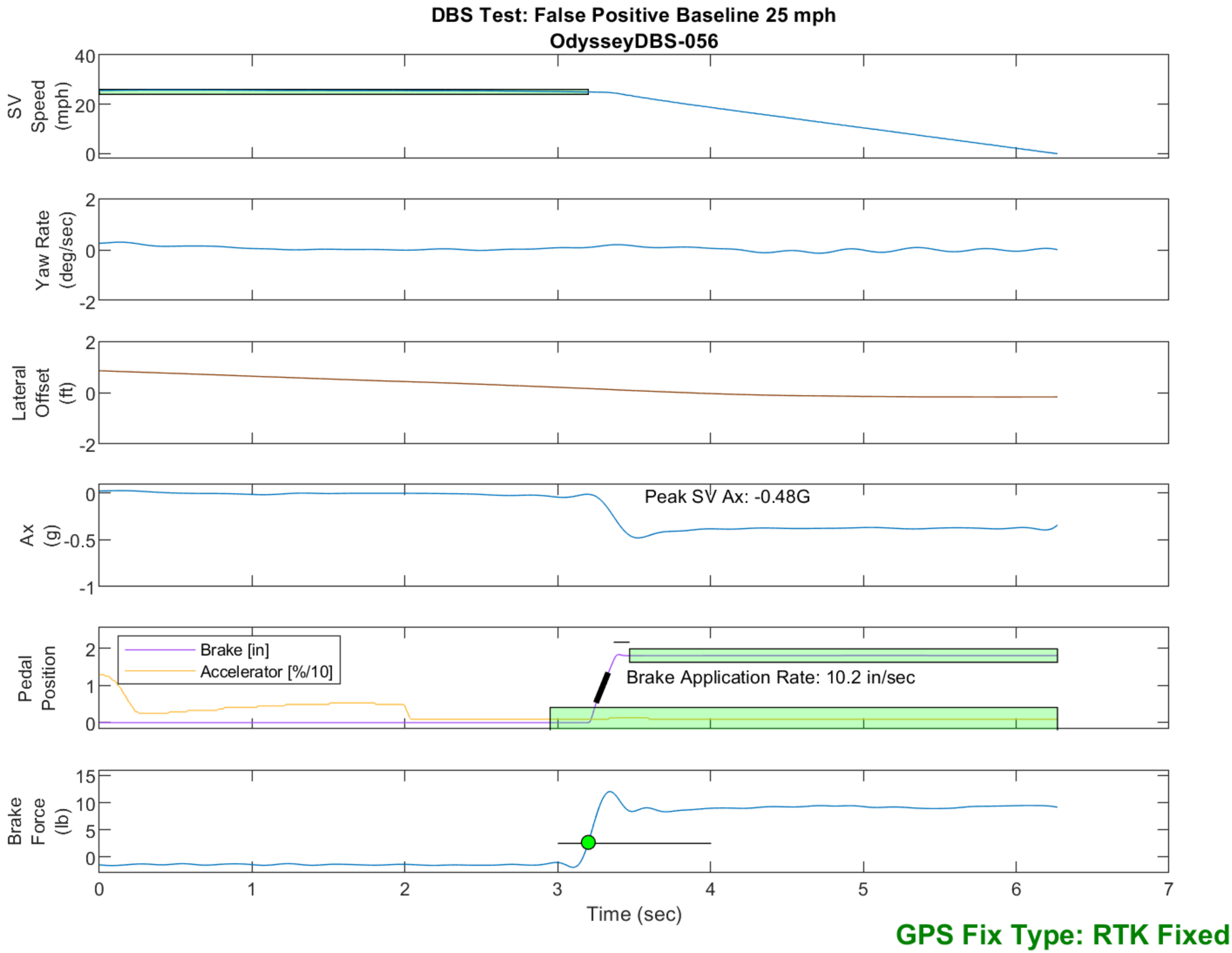


Figure E41. Time History for DBS Run 56, False Positive Baseline, SV 25 mph

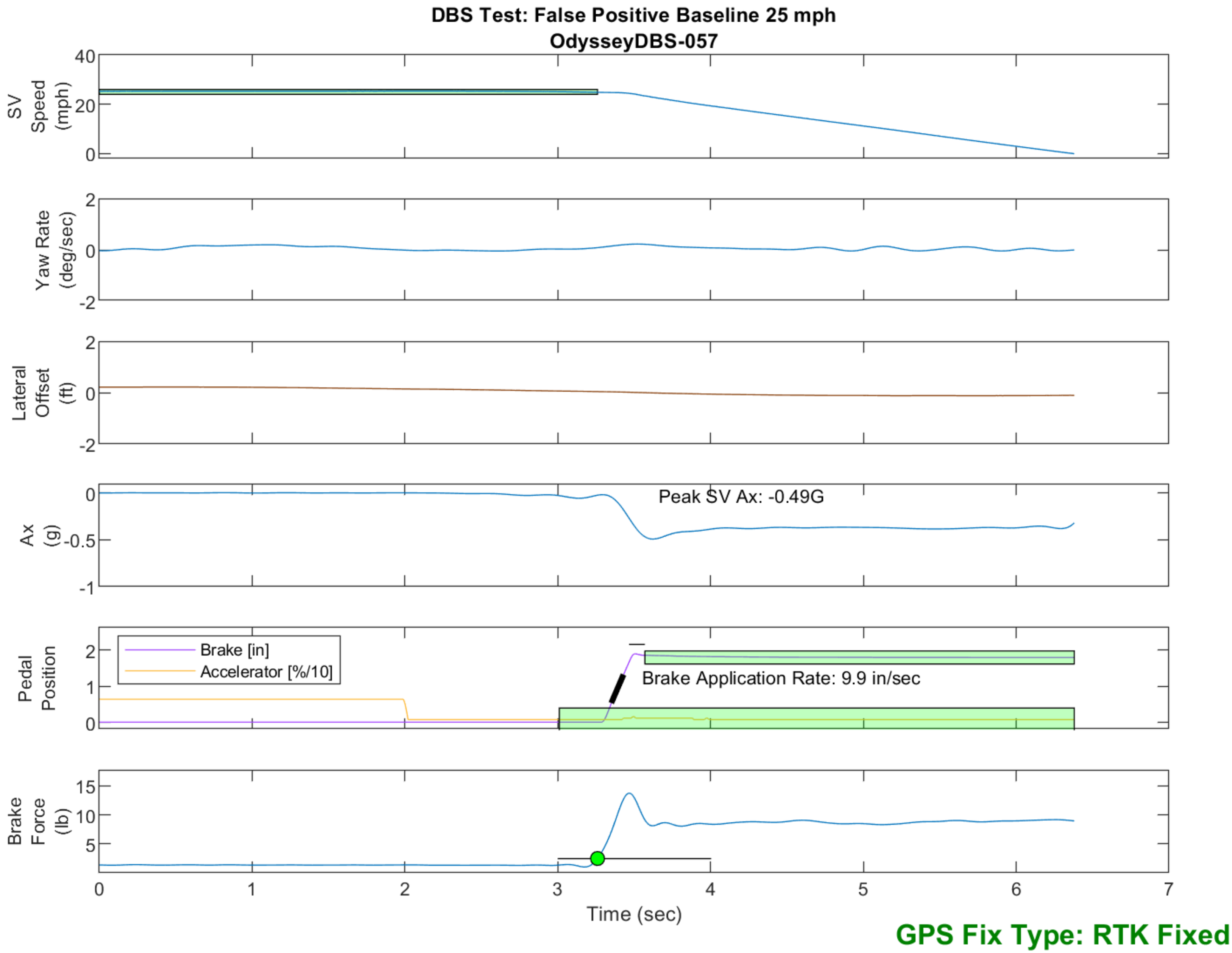


Figure E42. Time History for DBS Run 57, False Positive Baseline, SV 25 mph

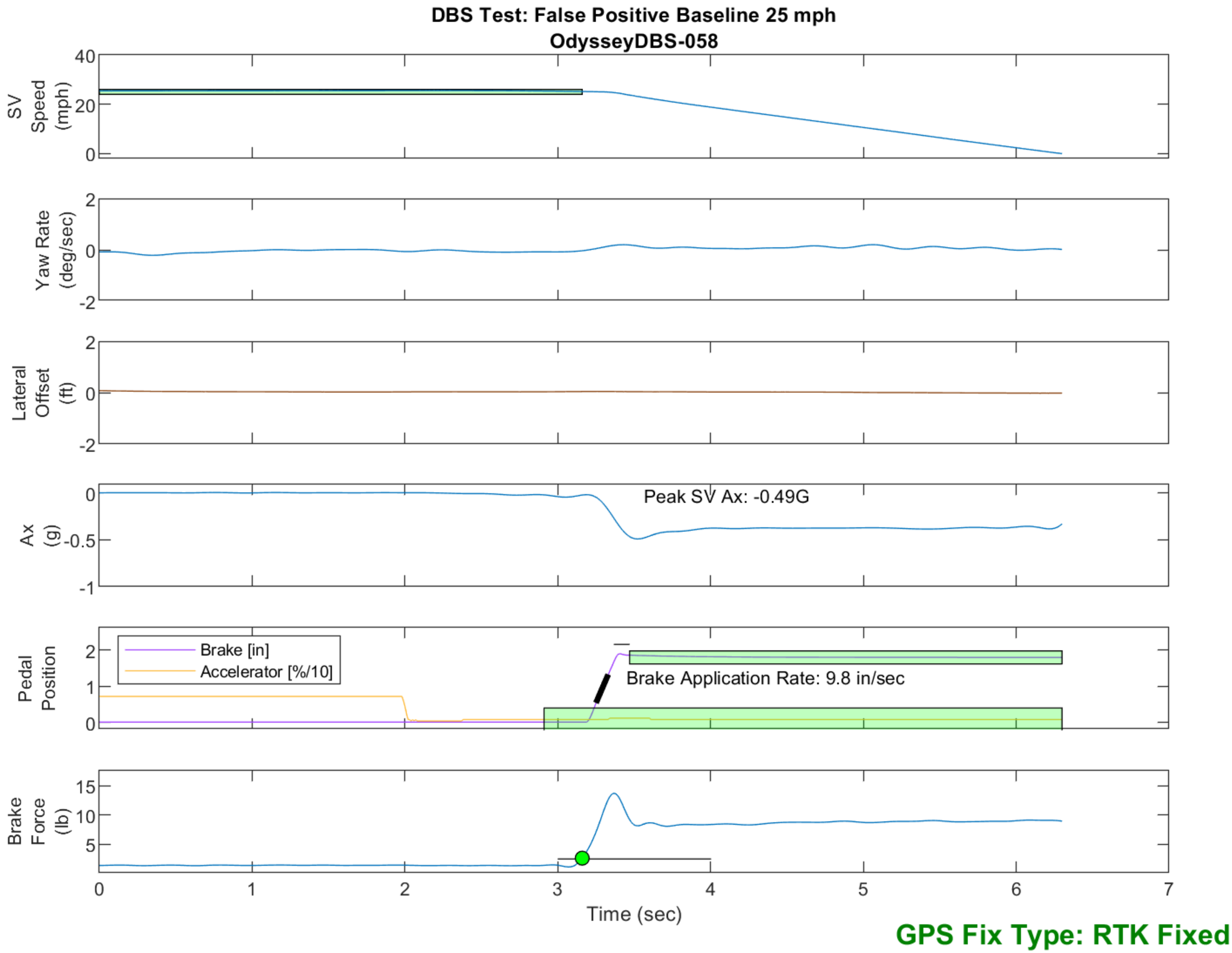


Figure E43. Time History for DBS Run 58, False Positive Baseline, SV 25 mph

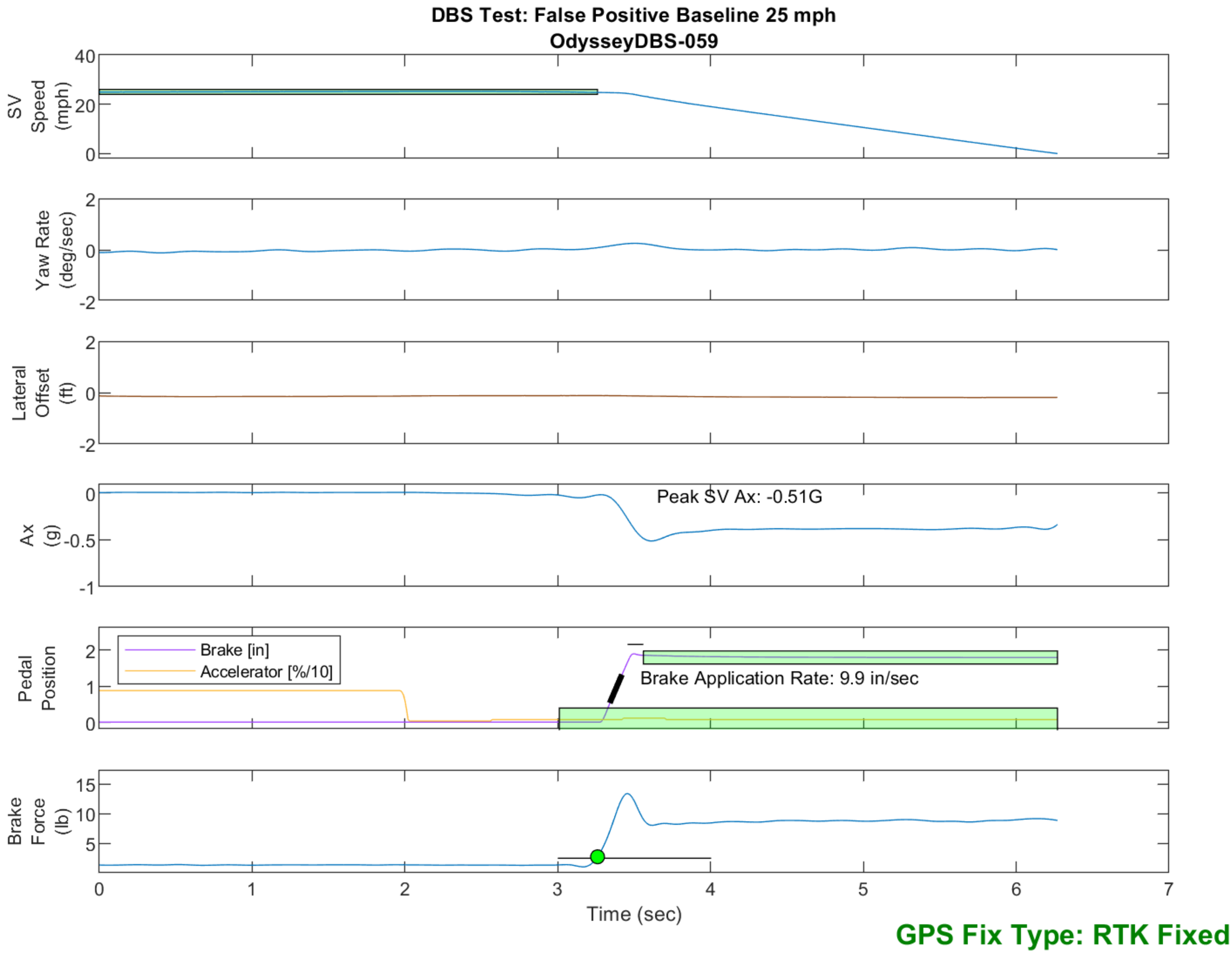


Figure E44. Time History for DBS Run 59, False Positive Baseline, SV 25 mph

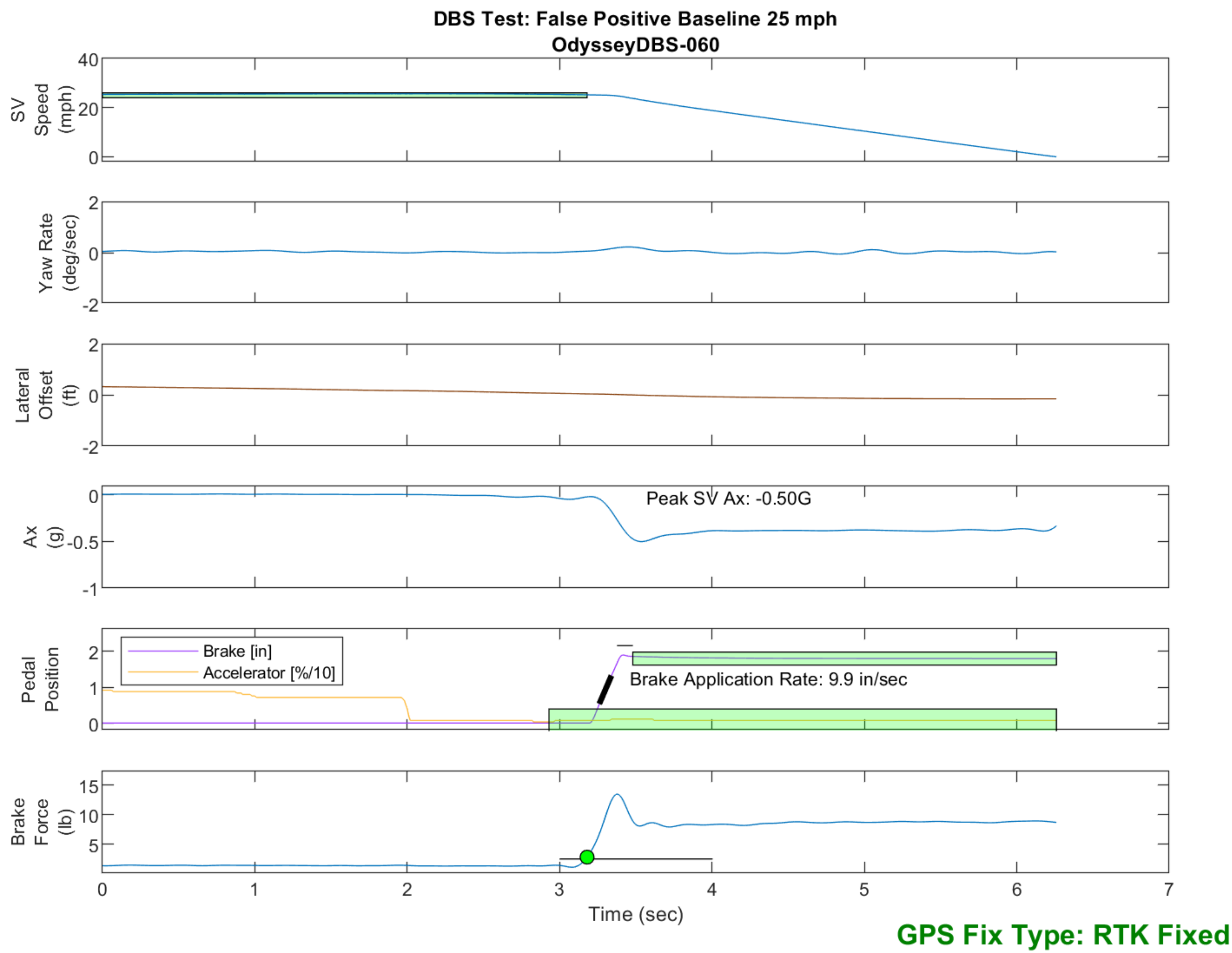


Figure E45. Time History for DBS Run 60, False Positive Baseline, SV 25 mph

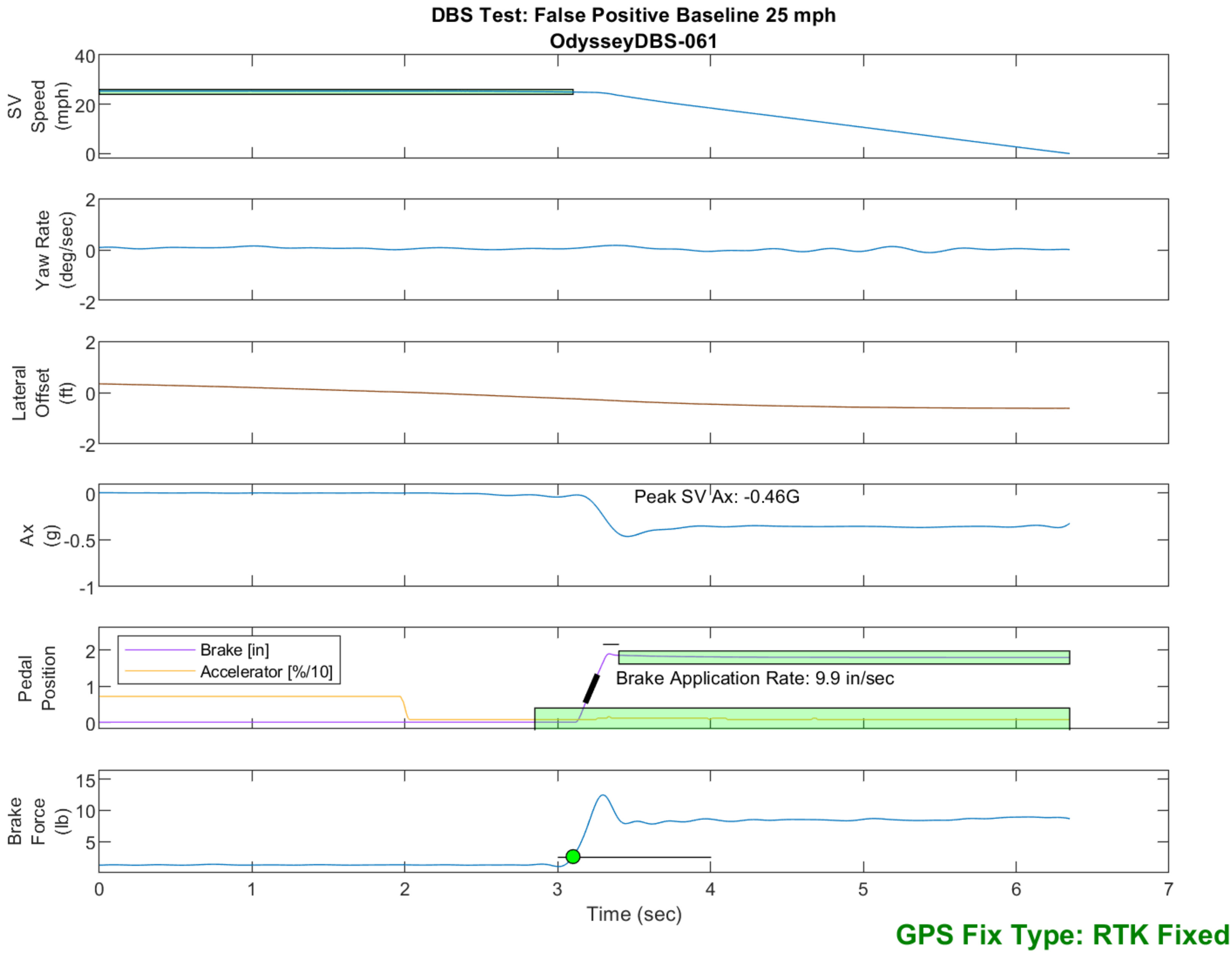


Figure E46. Time History for DBS Run 61, False Positive Baseline, SV 25 mph

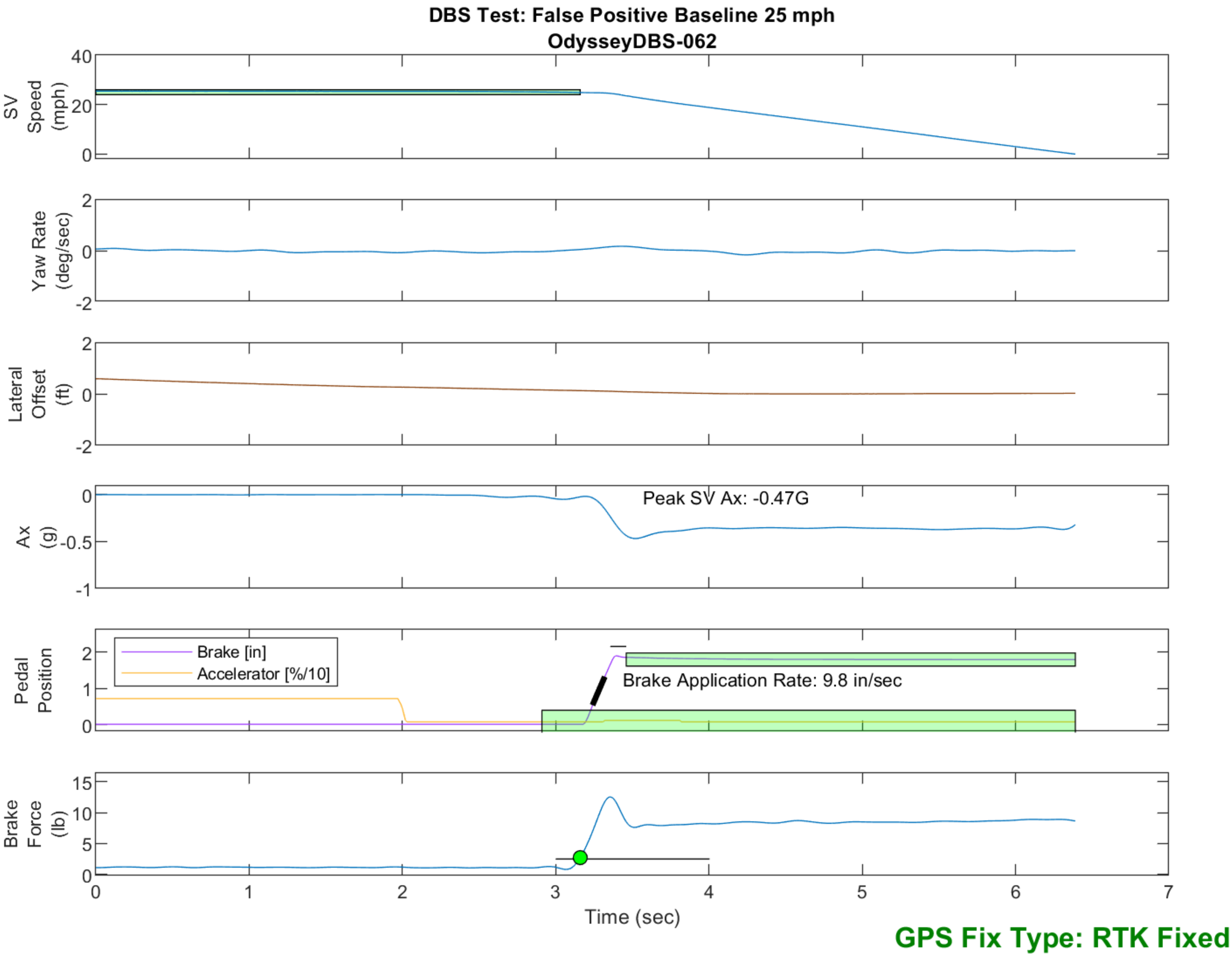


Figure E47. Time History for DBS Run 62, False Positive Baseline, SV 25 mph

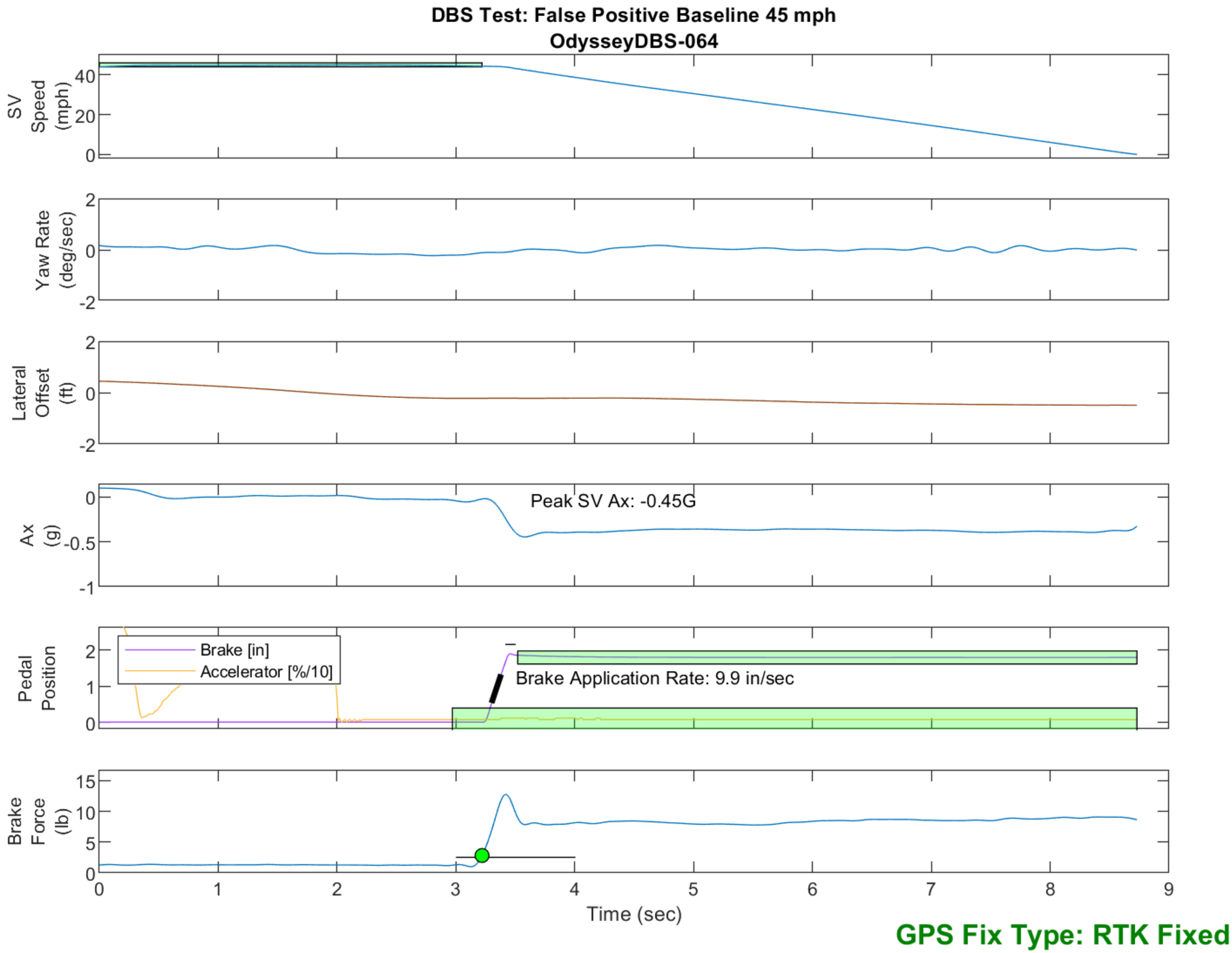


Figure E48. Time History for DBS Run 64, False Positive Baseline, SV 45 mph

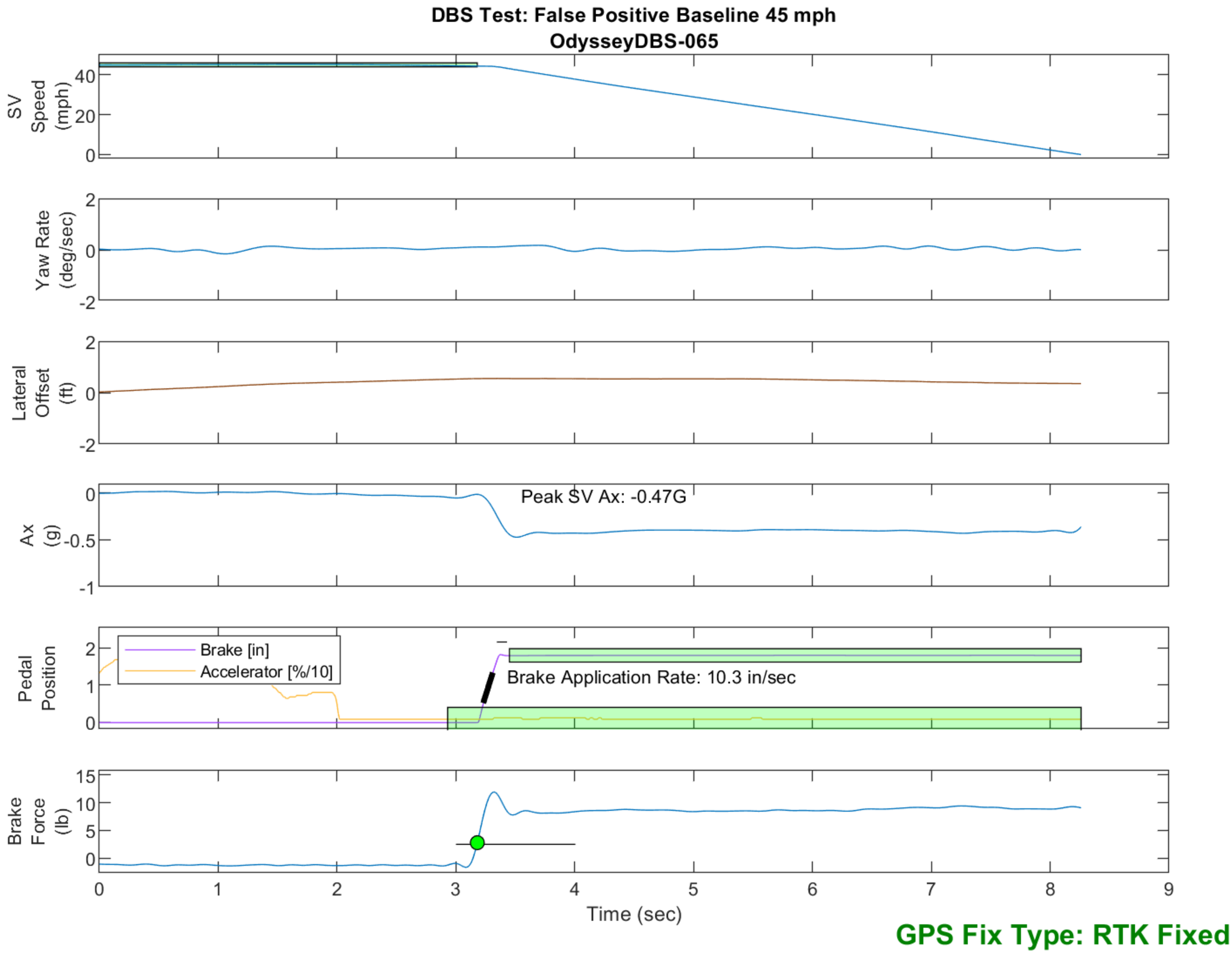


Figure E49. Time History for DBS Run 65, False Positive Baseline, SV 45 mph

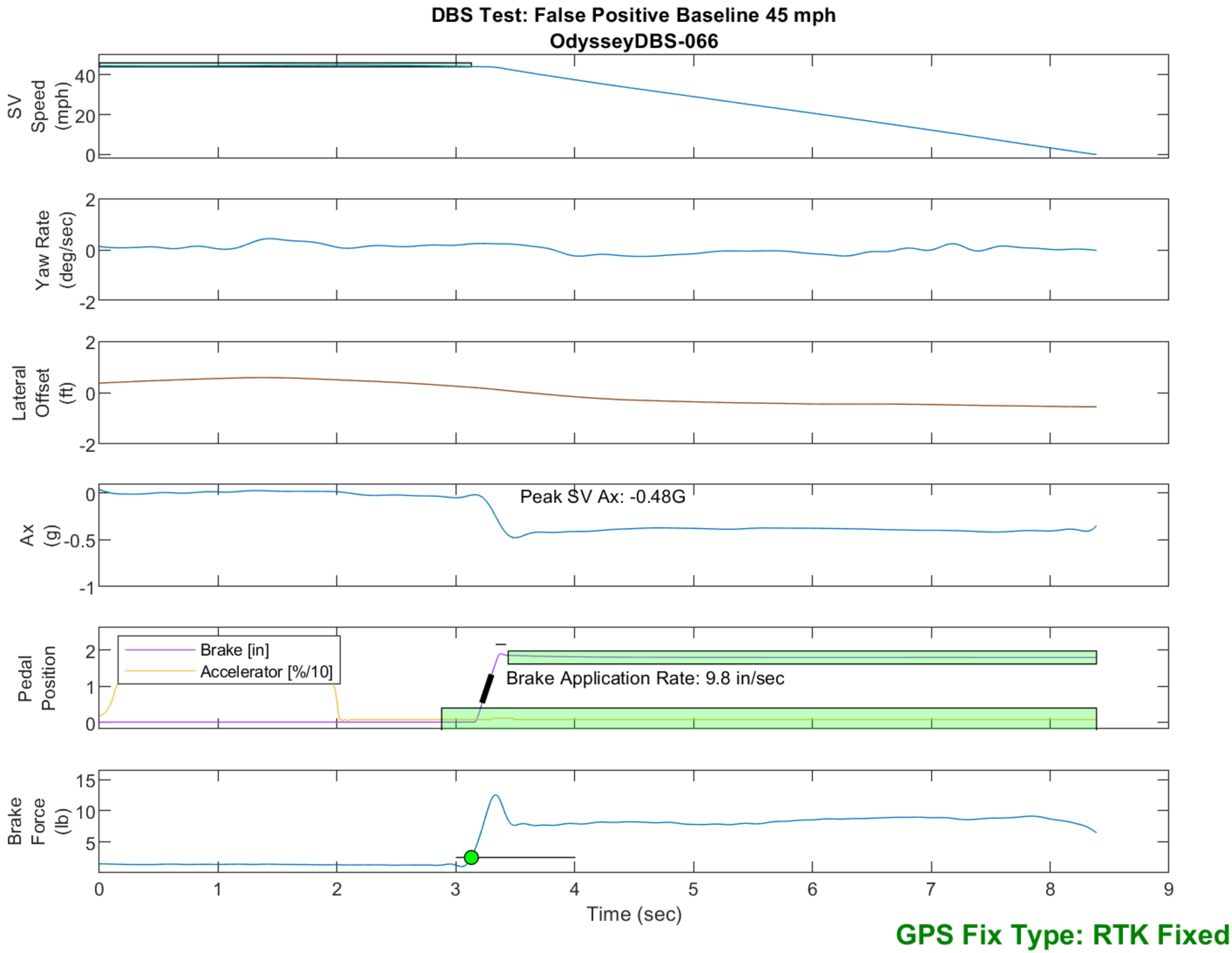


Figure E50. Time History for DBS Run 66, False Positive Baseline, SV 45 mph

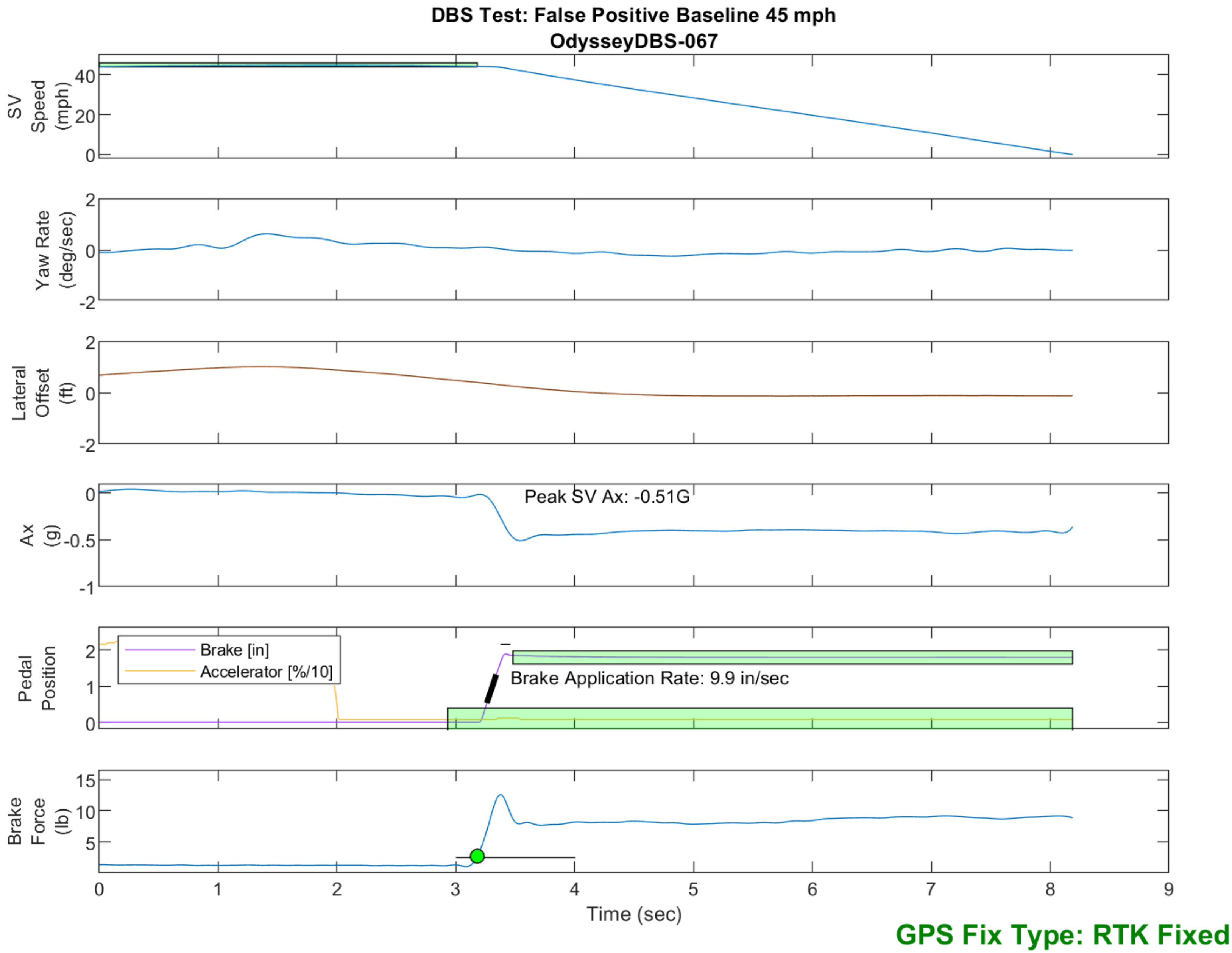


Figure E51. Time History for DBS Run 67, False Positive Baseline, SV 45 mph

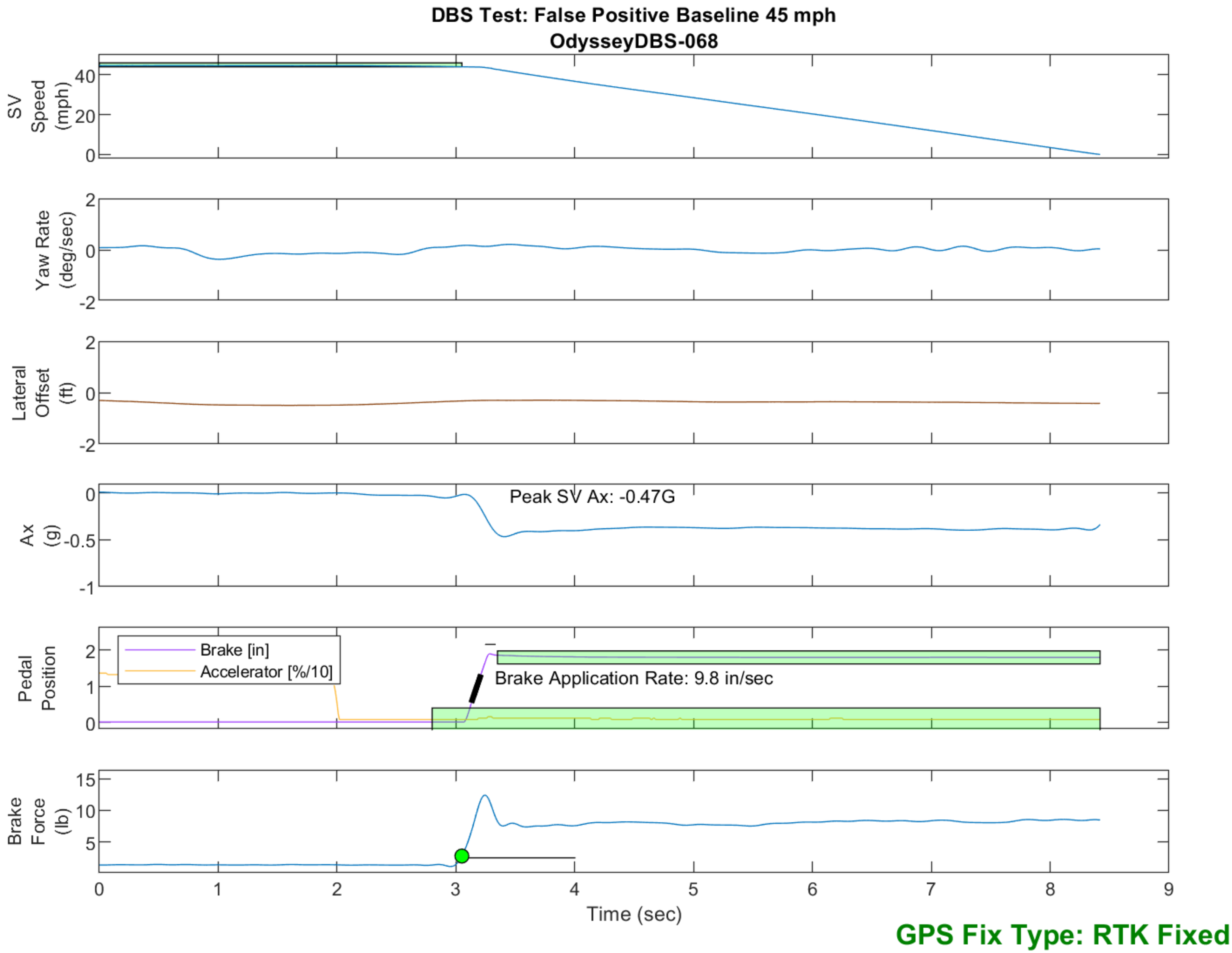


Figure E52. Time History for DBS Run 68, False Positive Baseline, SV 45 mph

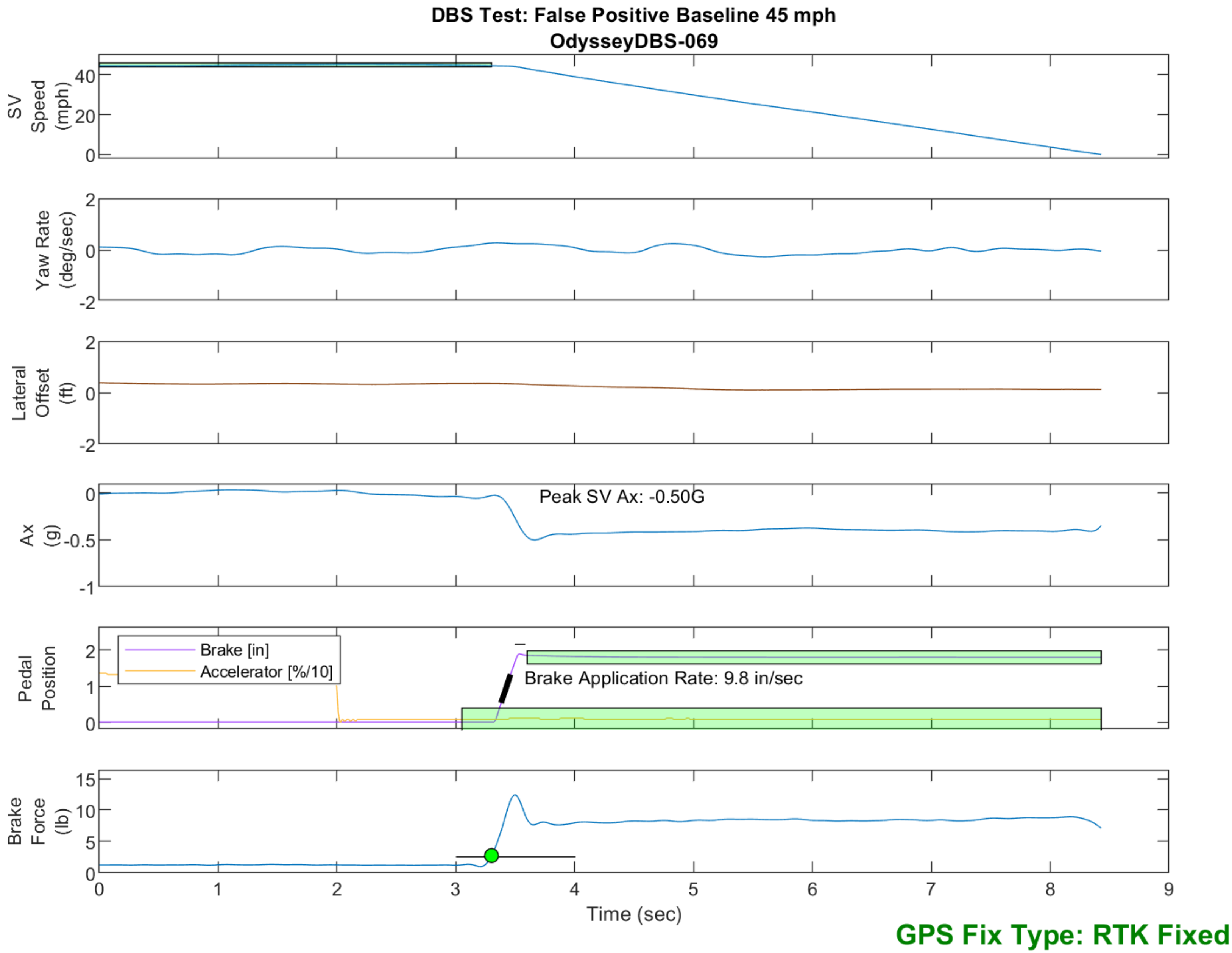


Figure E53. Time History for DBS Run 69, False Positive Baseline, SV 45 mph

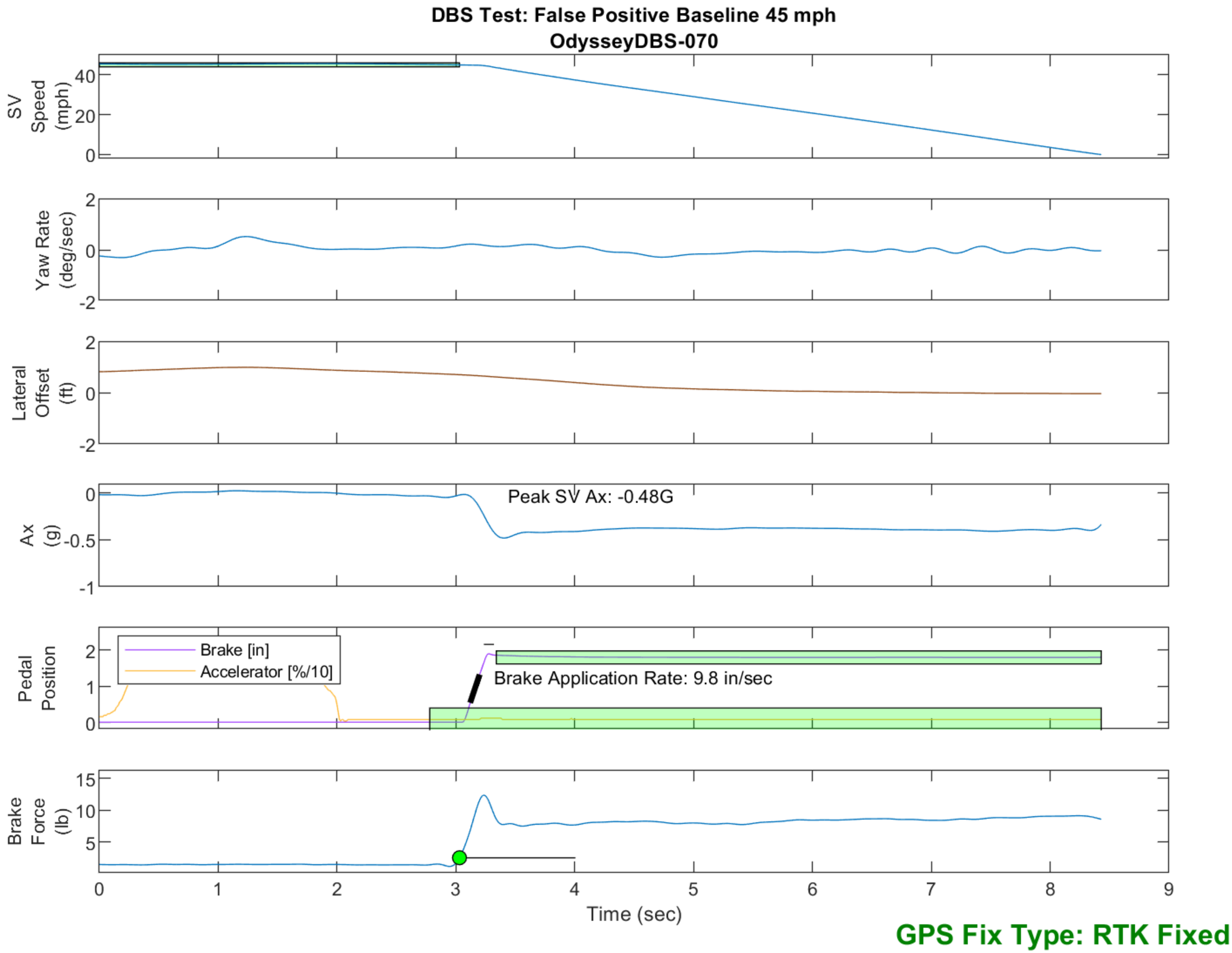


Figure E54. Time History for DBS Run 70, False Positive Baseline, SV 45 mph

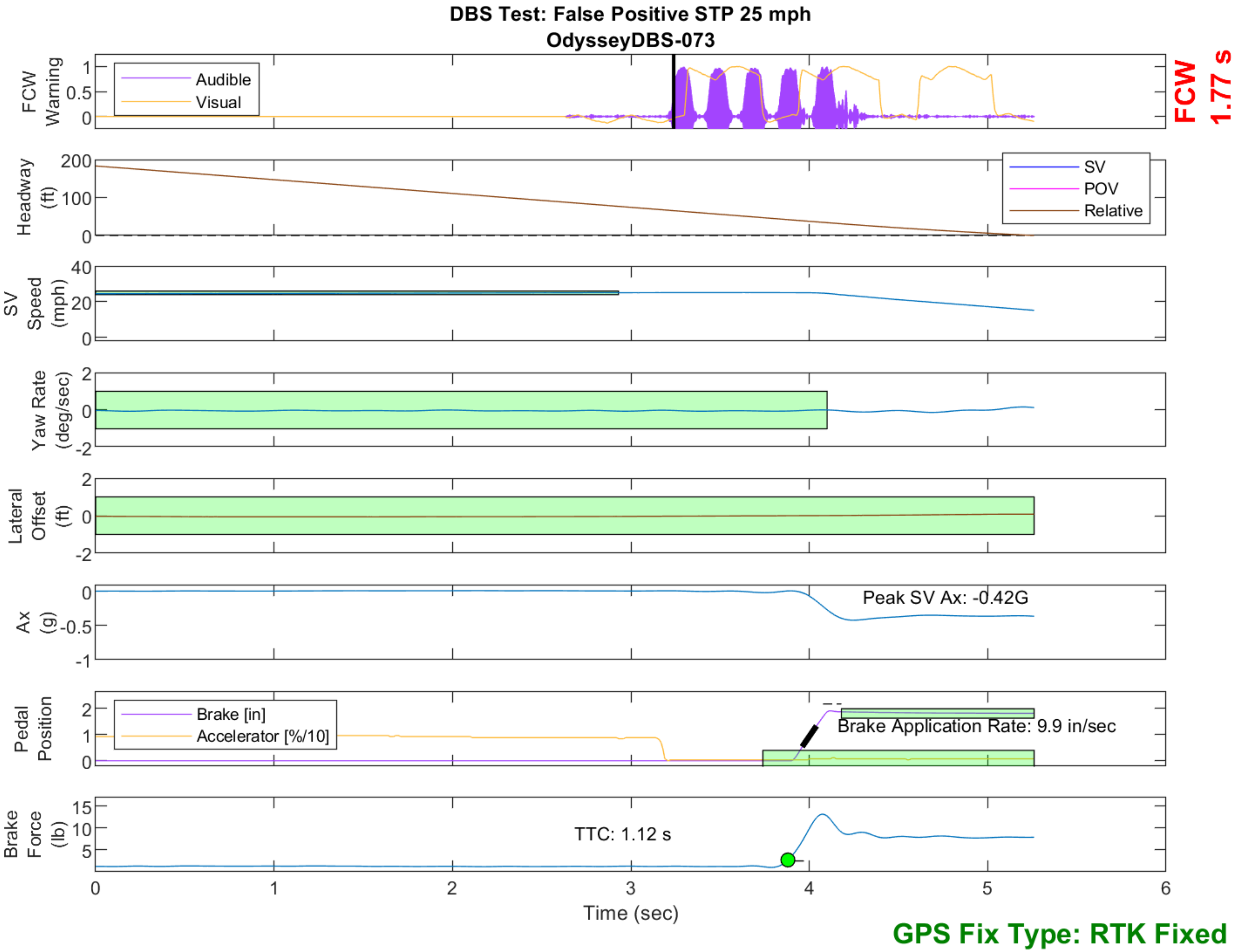


Figure E55. Time History for DBS Run 73, SV Encounters Steel Trench Plate, SV 25 mph

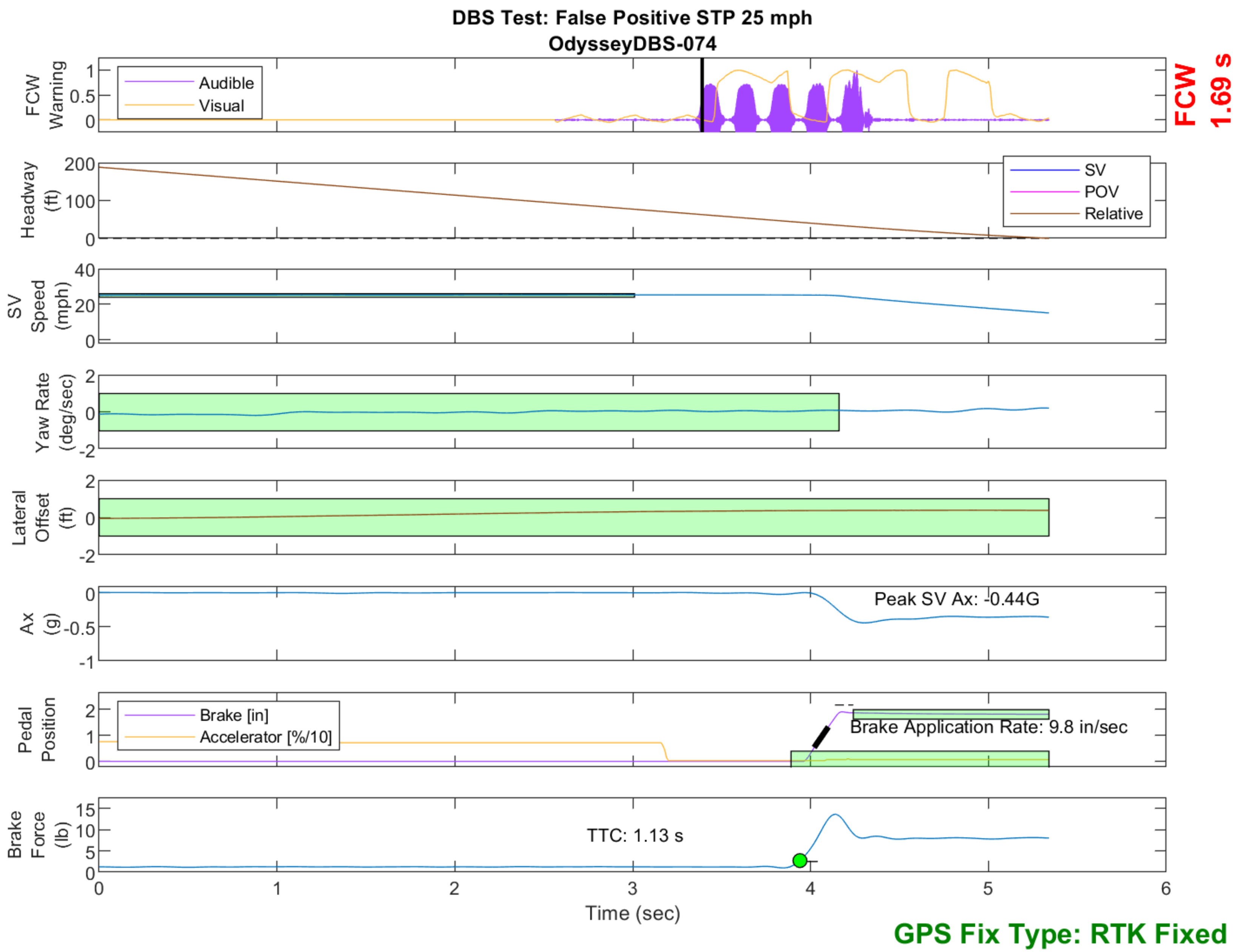


Figure E56. Time History for DBS Run 74, SV Encounters Steel Trench Plate, SV 25 mph

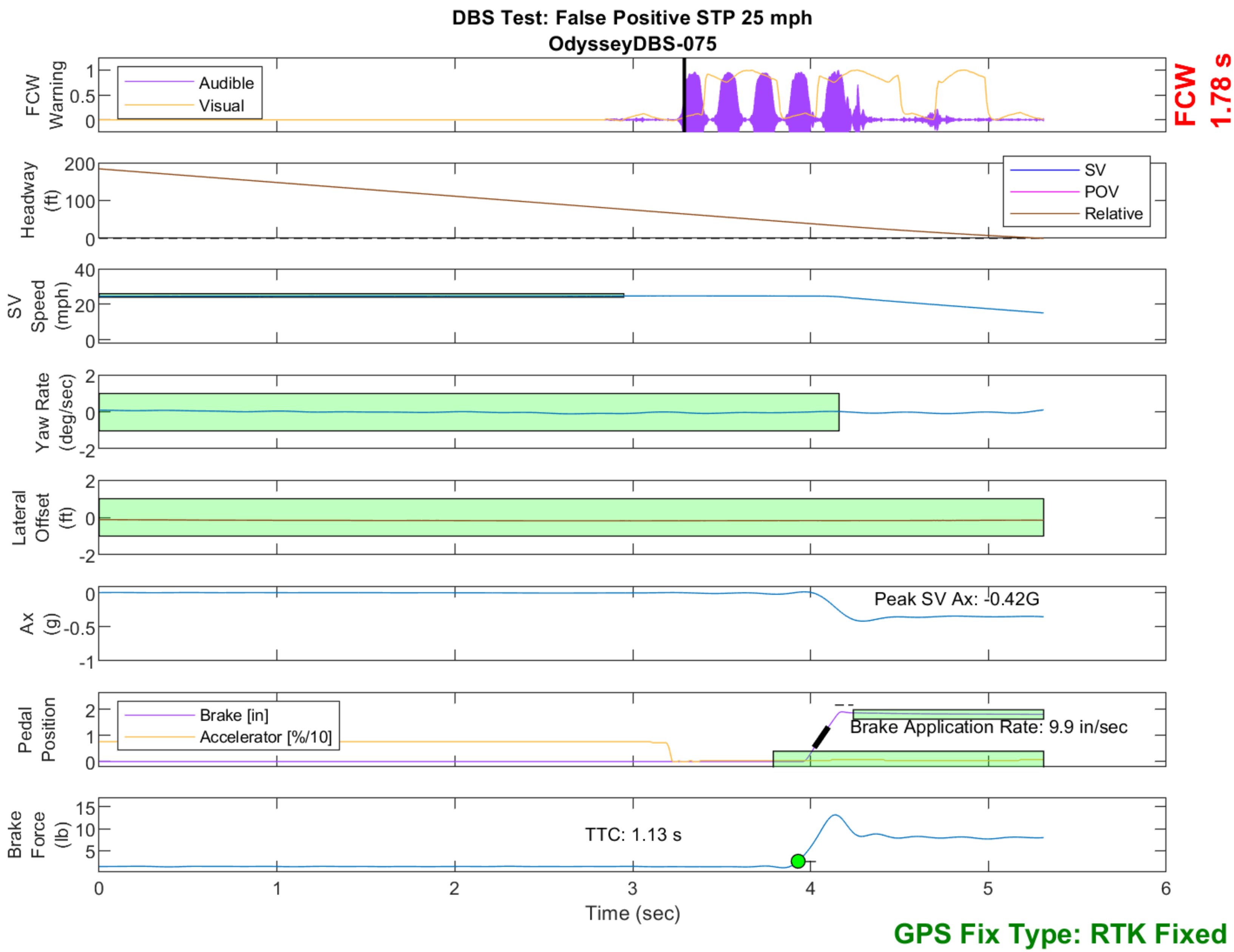


Figure E57. Time History for DBS Run 75, SV Encounters Steel Trench Plate, SV 25 mph

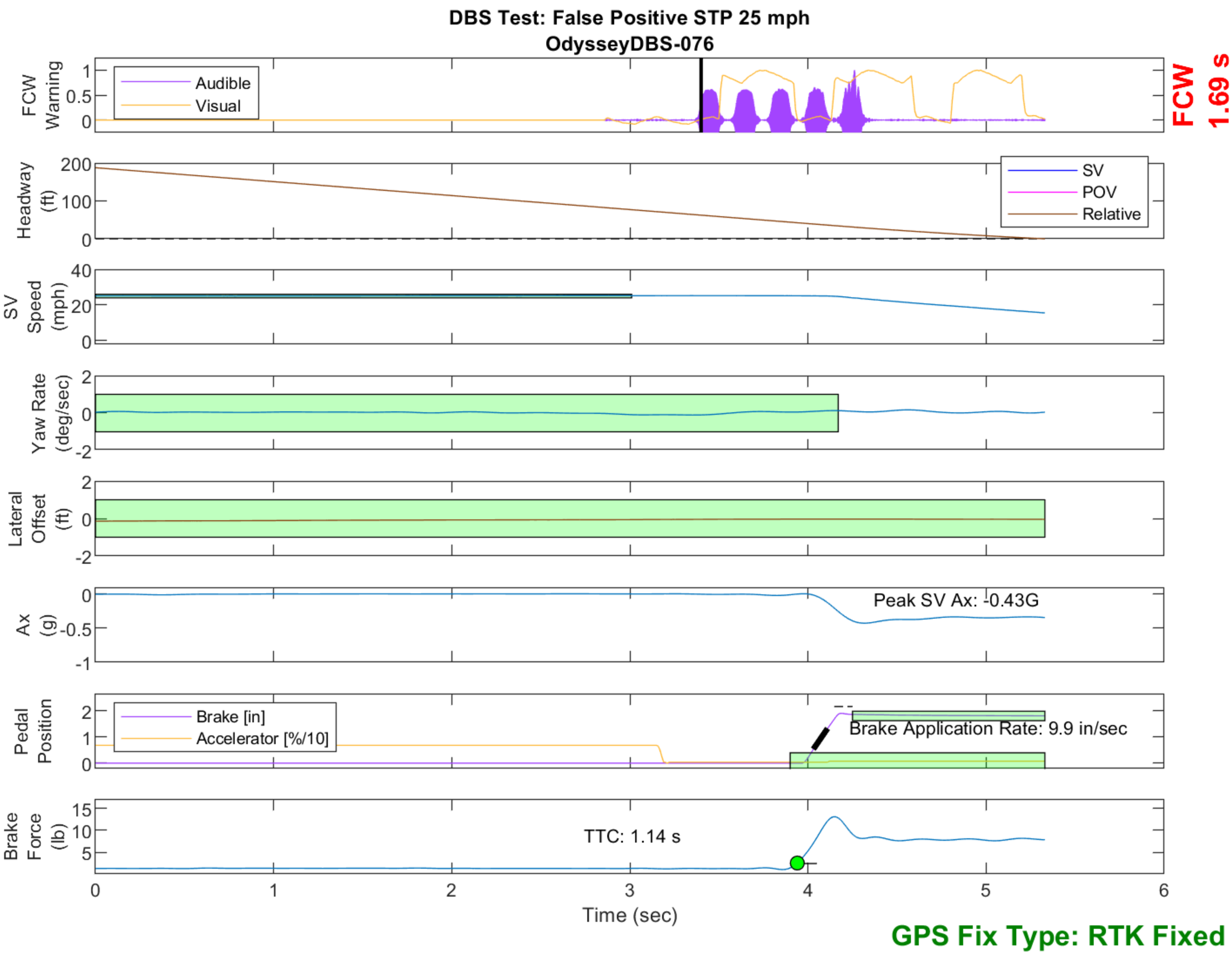


Figure E58. Time History for DBS Run 76, SV Encounters Steel Trench Plate, SV 25 mph

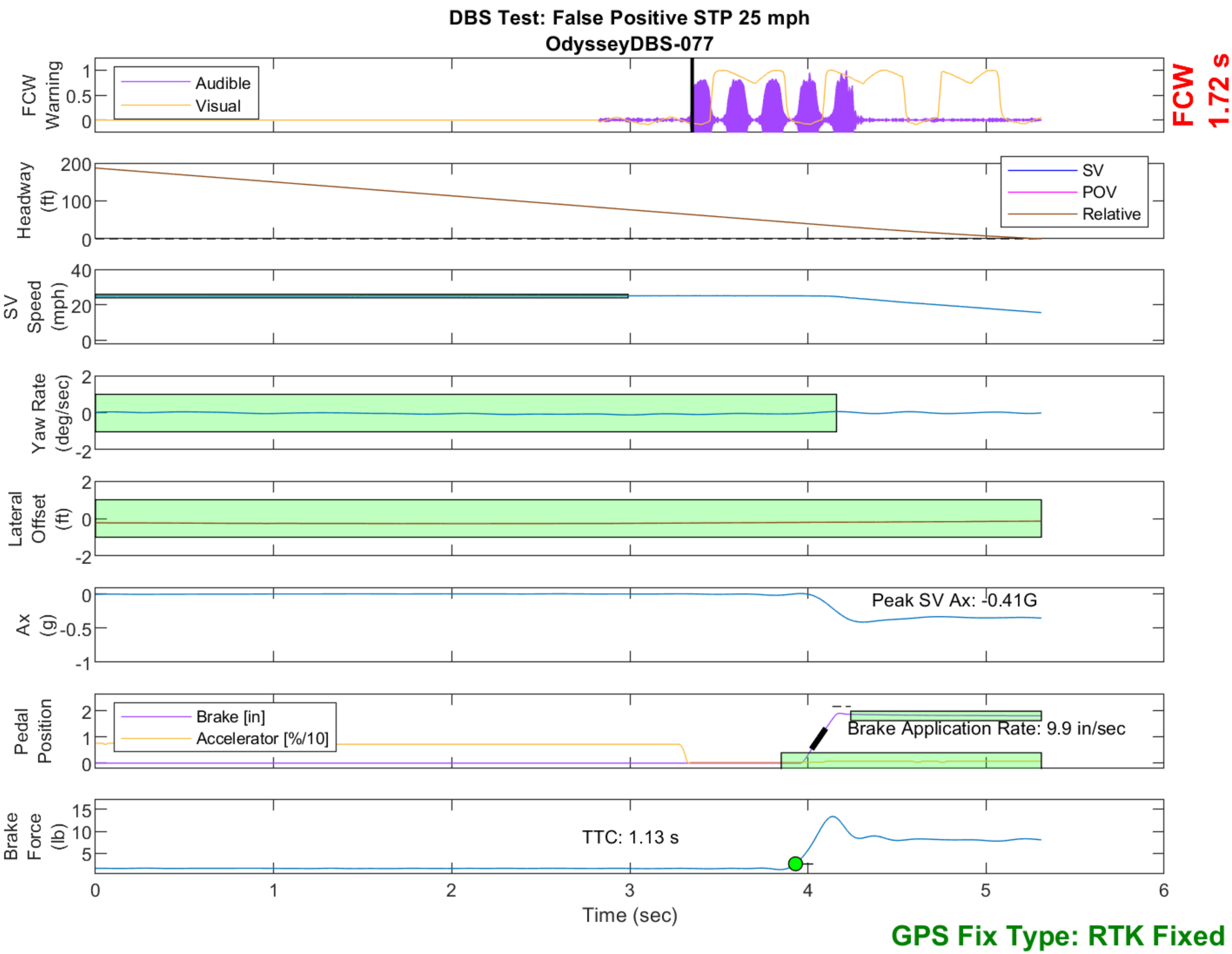


Figure E59. Time History for DBS Run 77, SV Encounters Steel Trench Plate, SV 25 mph

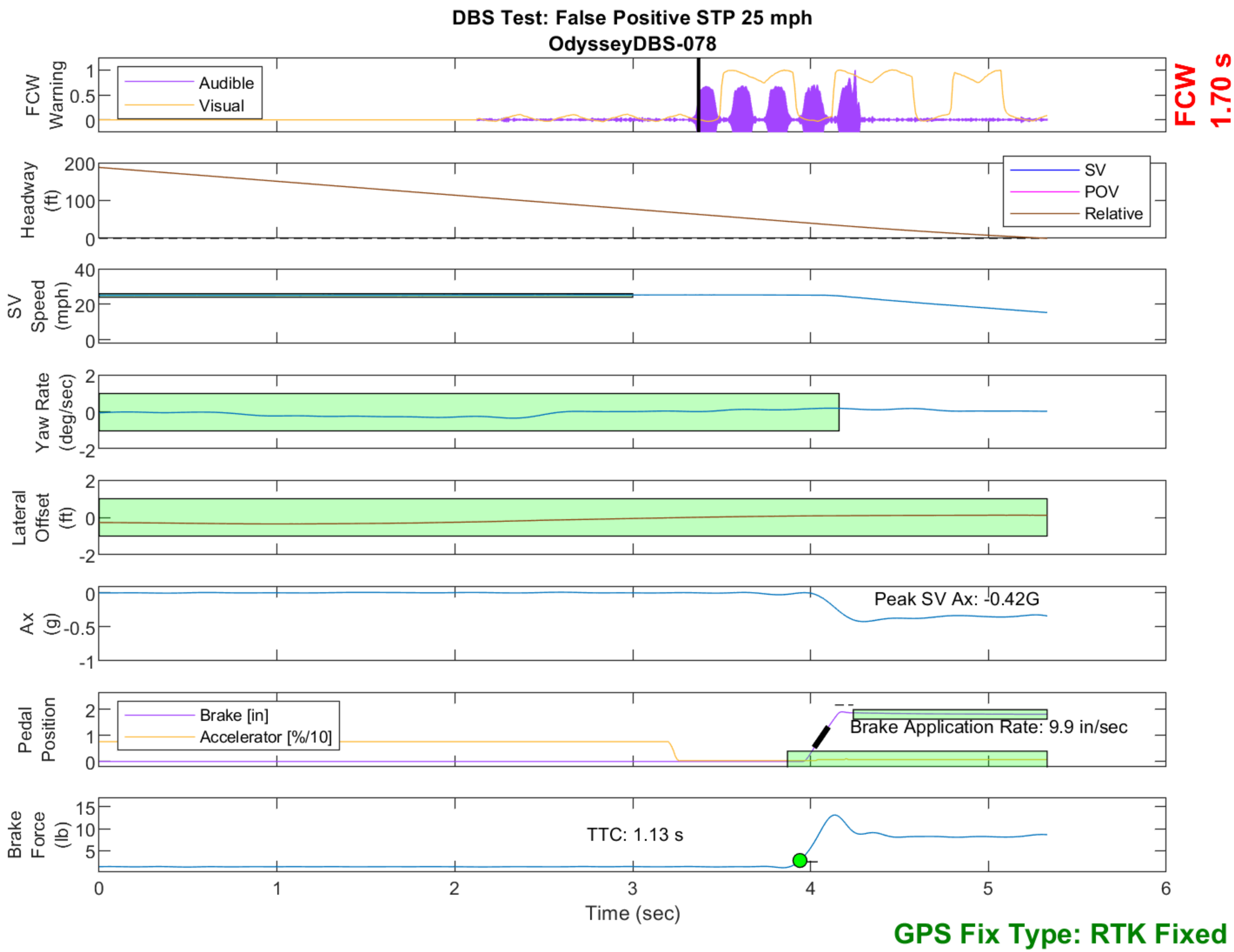


Figure E60. Time History for DBS Run 78, SV Encounters Steel Trench Plate, SV 25 mph

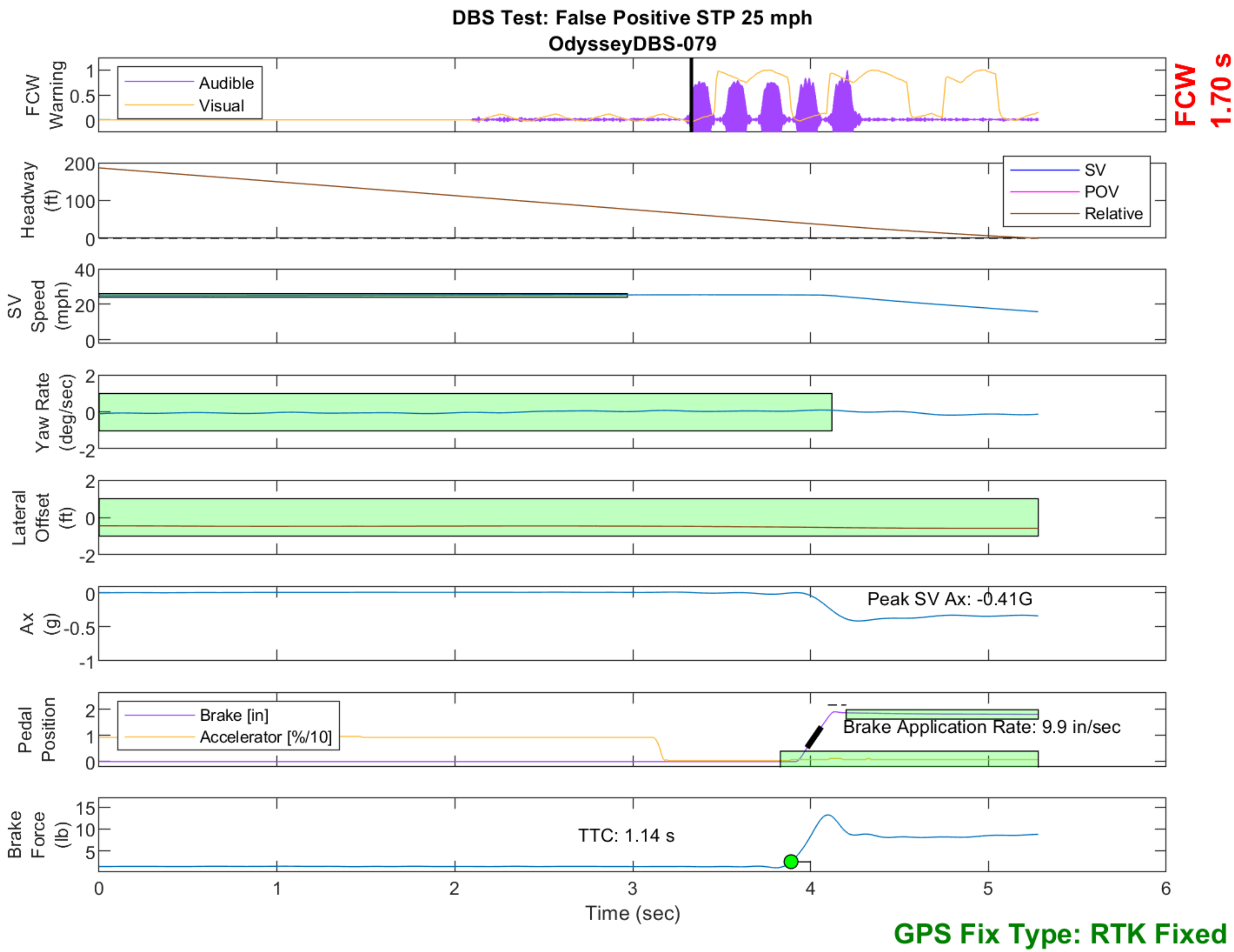


Figure E61. Time History for DBS Run 79, SV Encounters Steel Trench Plate, SV 25 mph

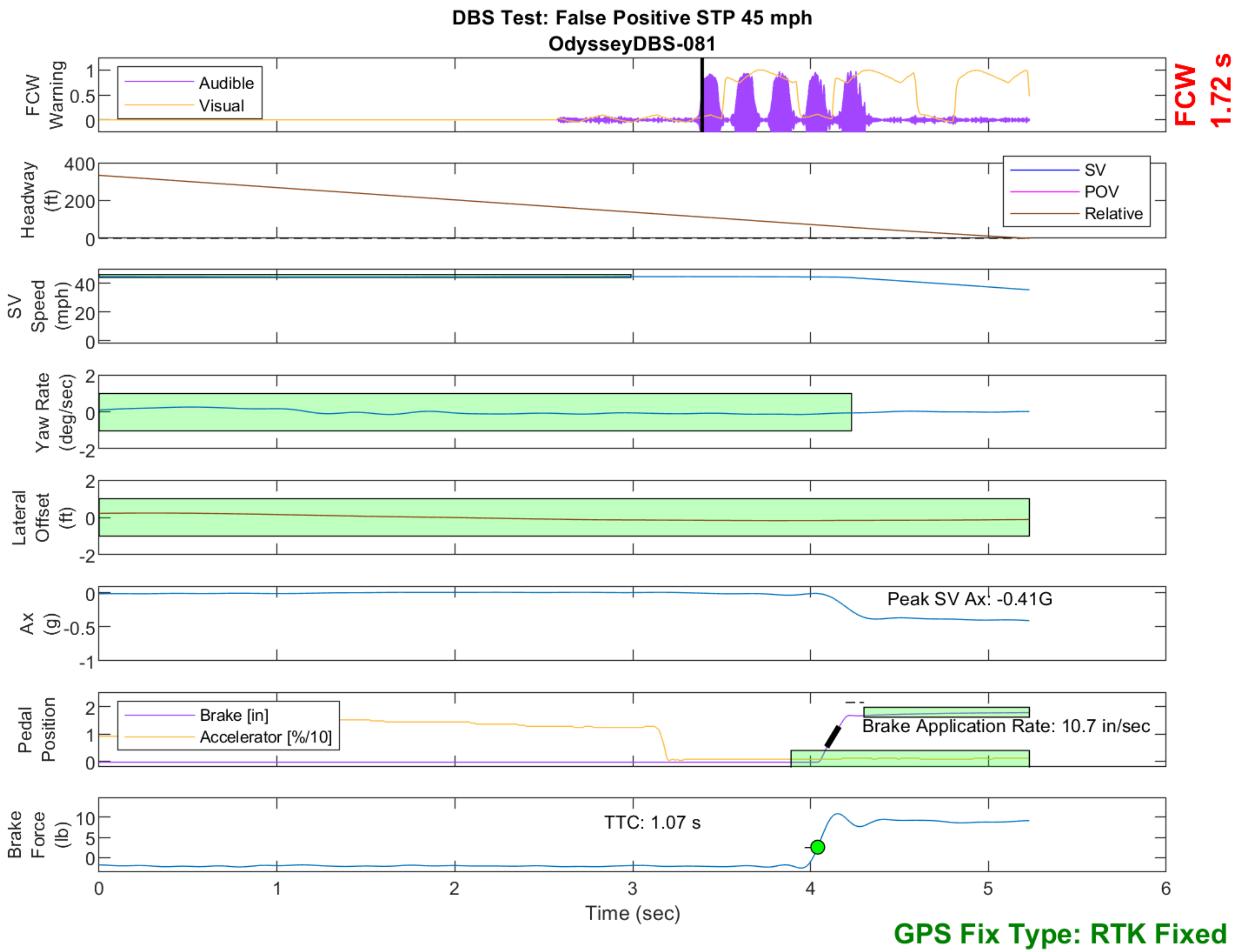


Figure E62. Time History for DBS Run 81, SV Encounters Steel Trench Plate, SV 45 mph

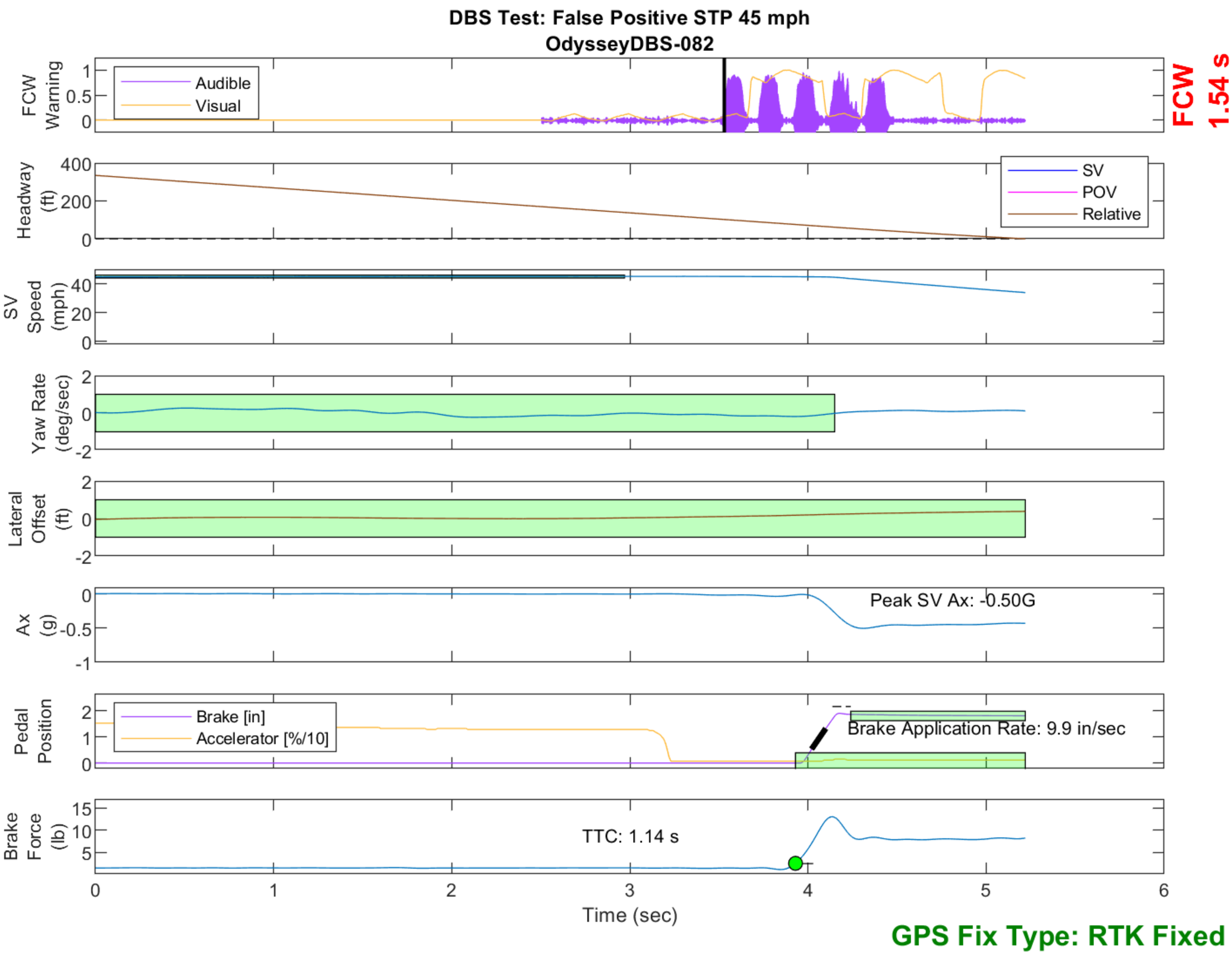


Figure E63. Time History for DBS Run 82, SV Encounters Steel Trench Plate, SV 45 mph

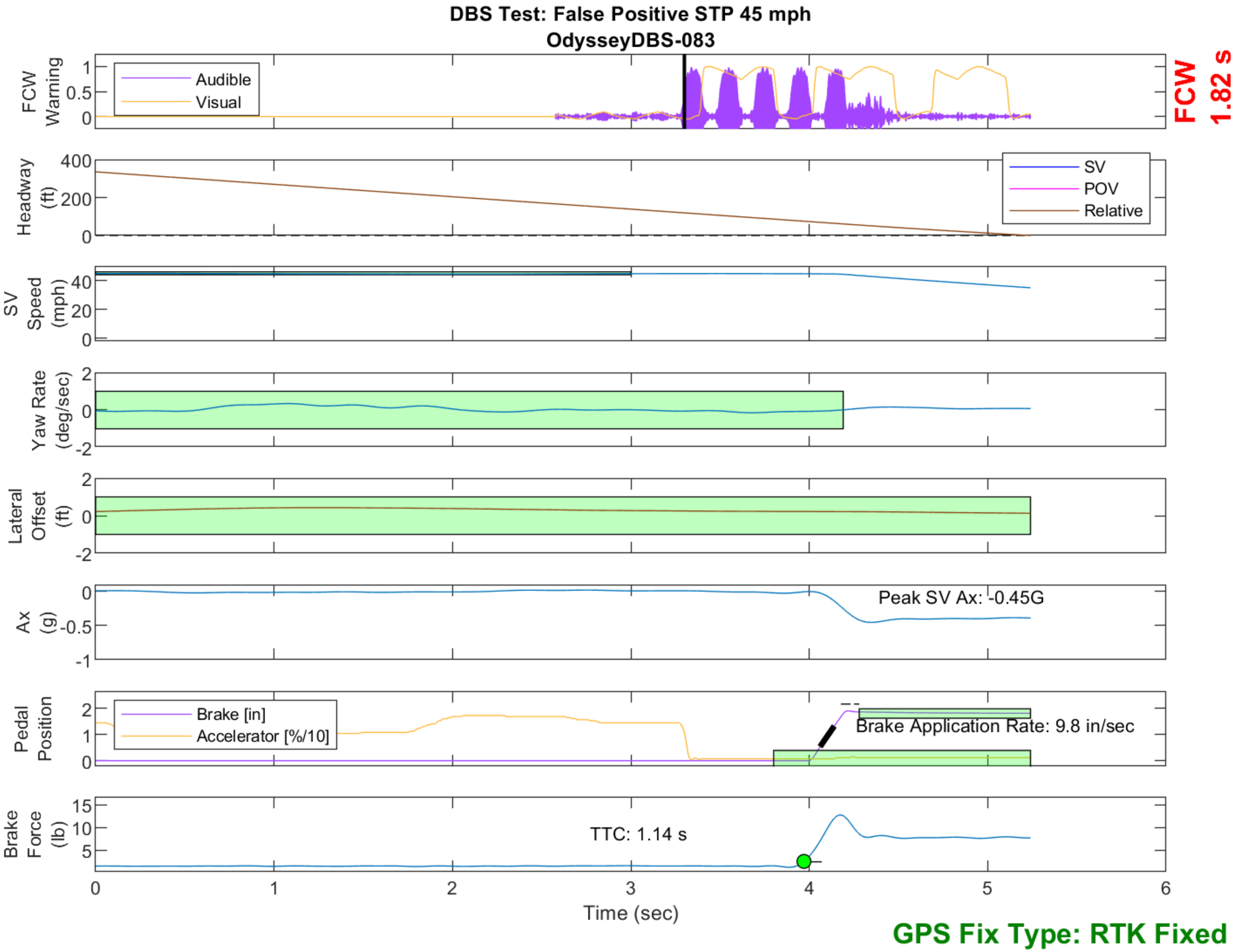


Figure E64. Time History for DBS Run 83, SV Encounters Steel Trench Plate, SV 45 mph

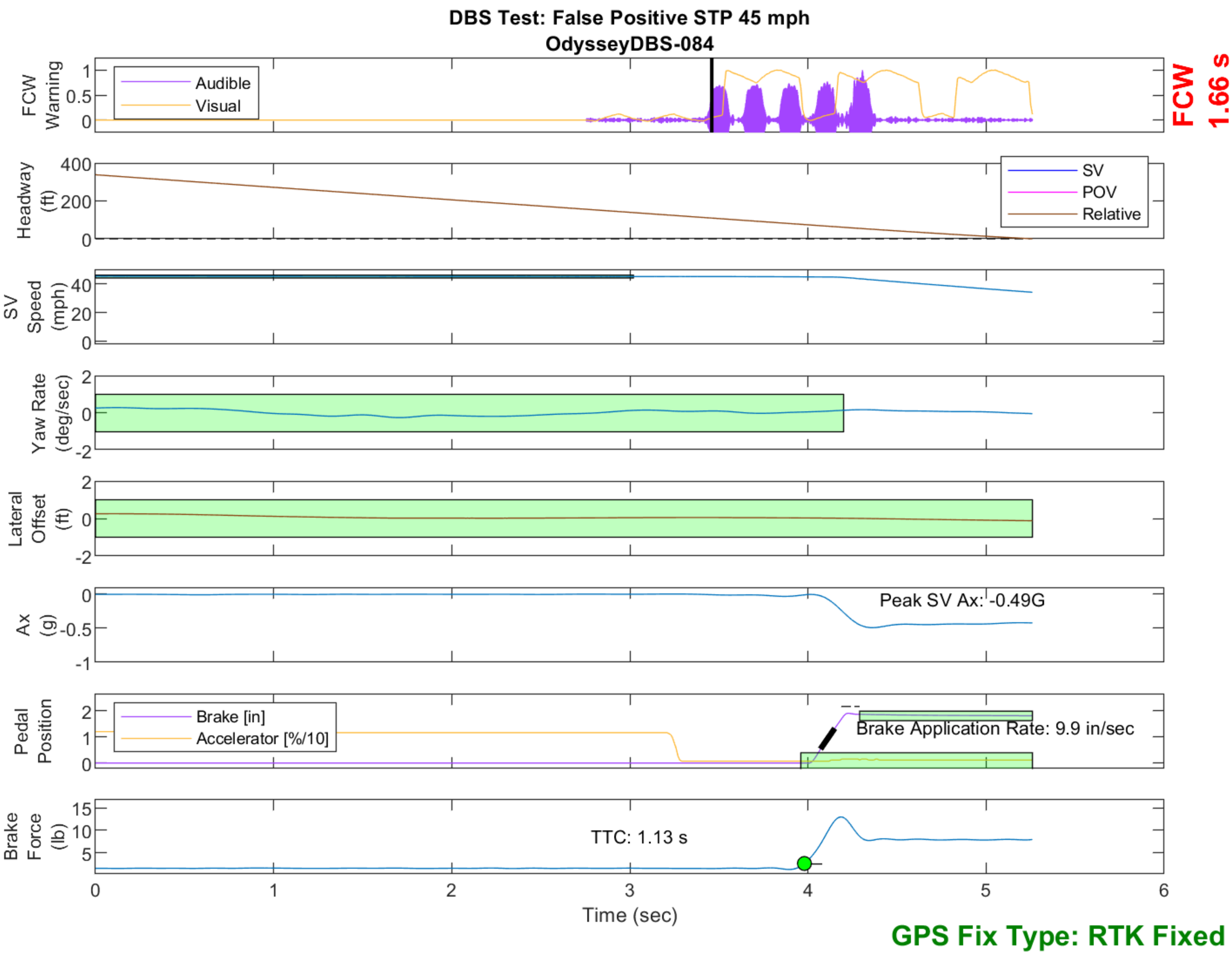


Figure E65. Time History for DBS Run 84, SV Encounters Steel Trench Plate, SV 45 mph

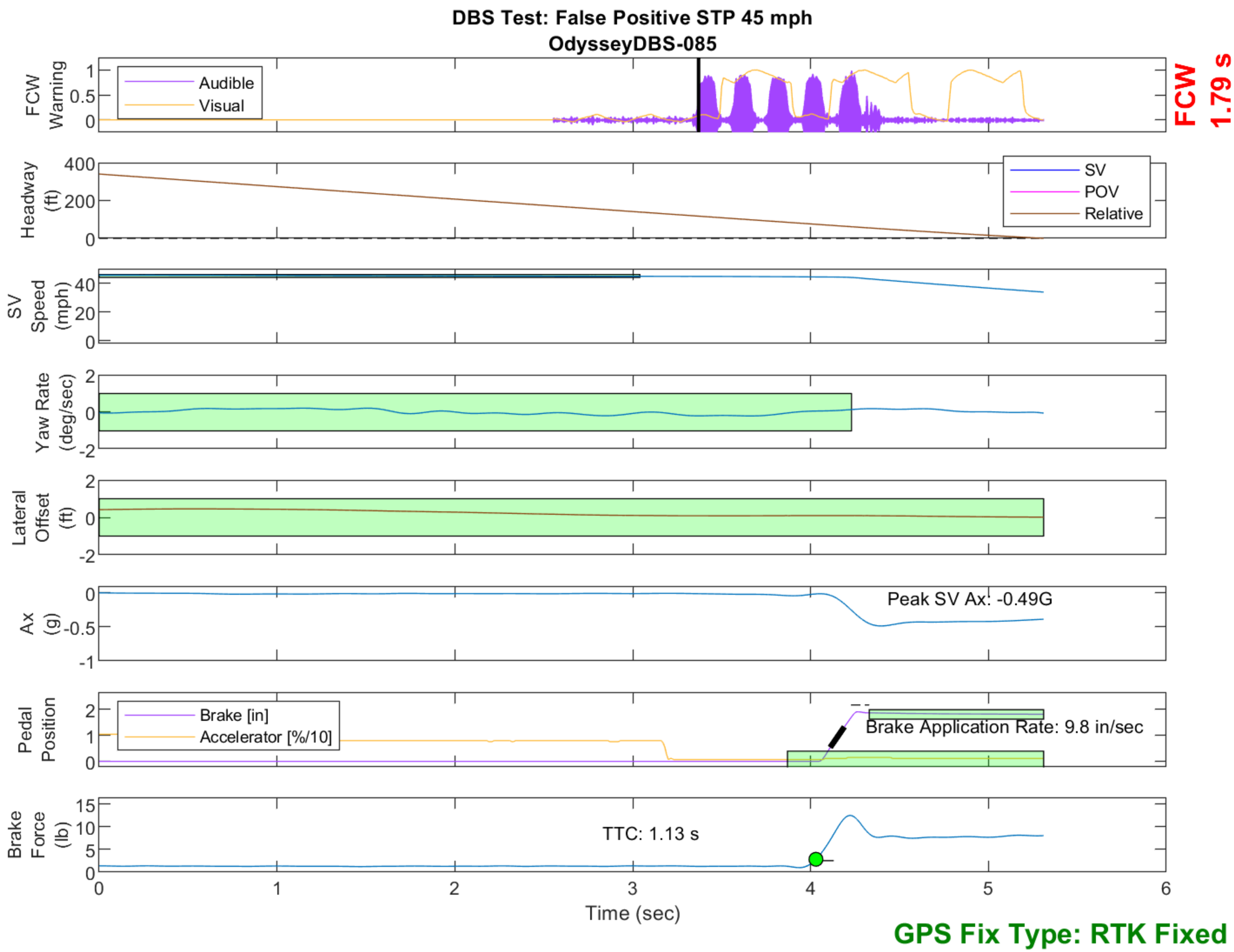


Figure E66. Time History for DBS Run 85, SV Encounters Steel Trench Plate, SV 45 mph

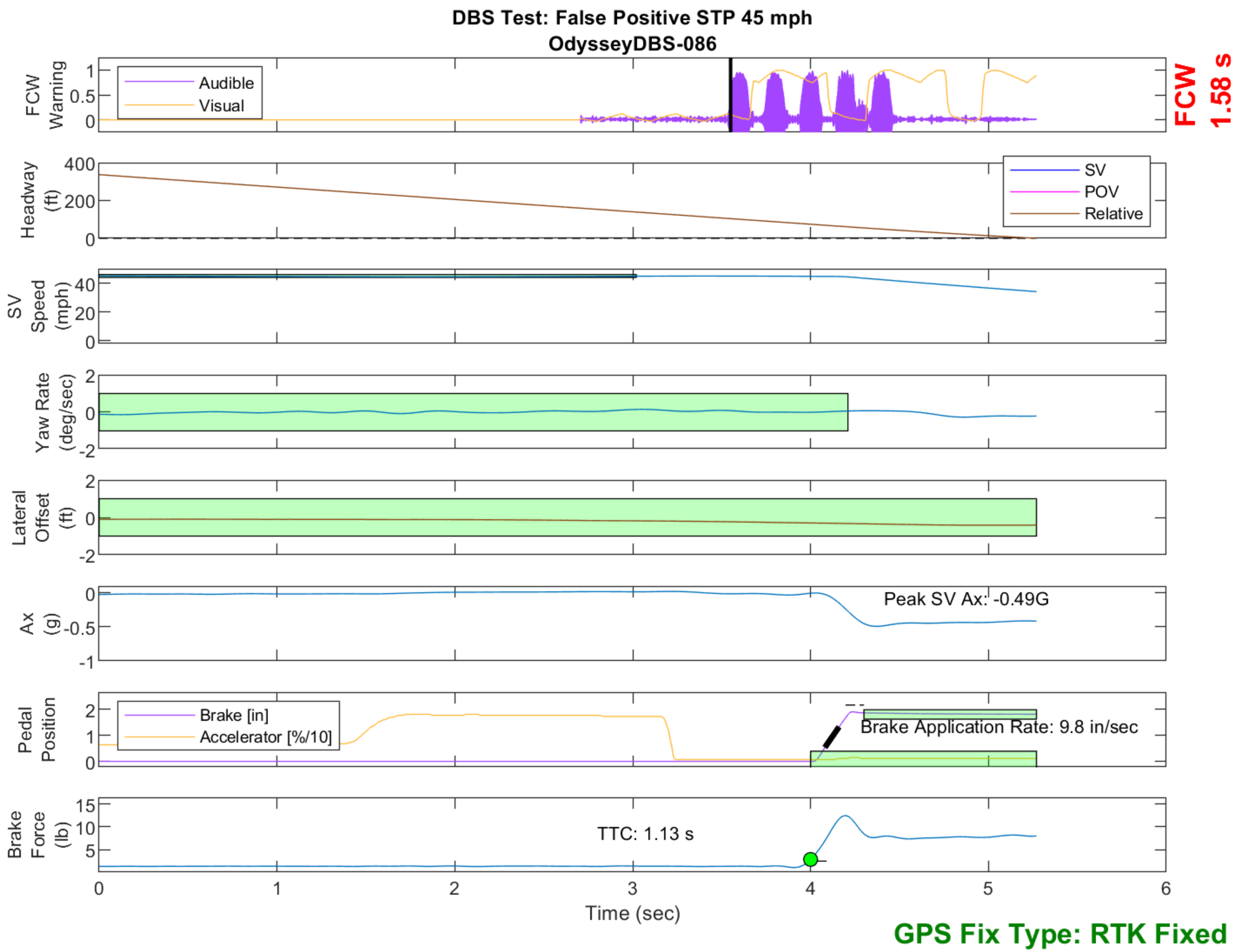


Figure E67. Time History for DBS Run 86, SV Encounters Steel Trench Plate, SV 45 mph

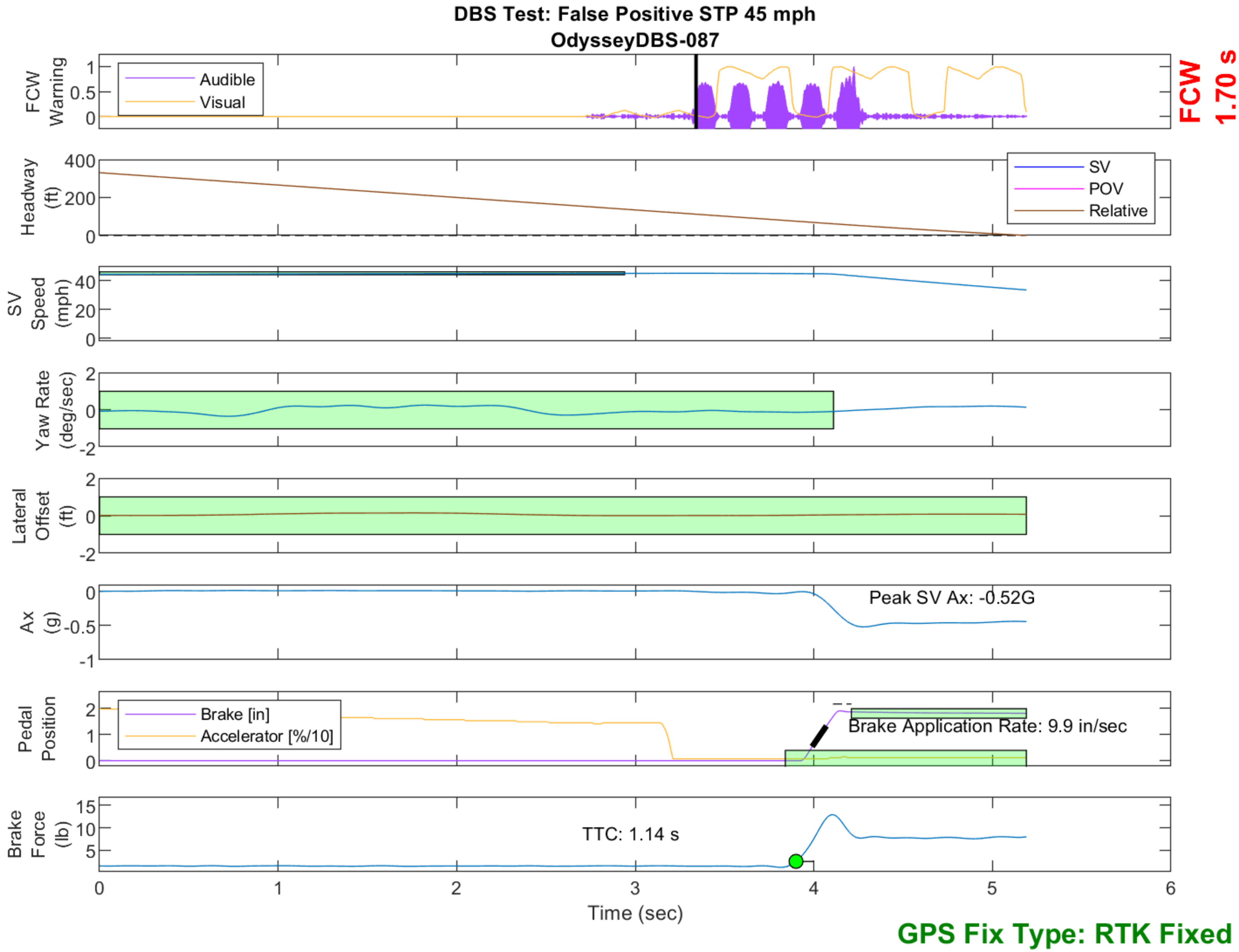


Figure E68. Time History for DBS Run 87, SV Encounters Steel Trench Plate, SV 45 mph

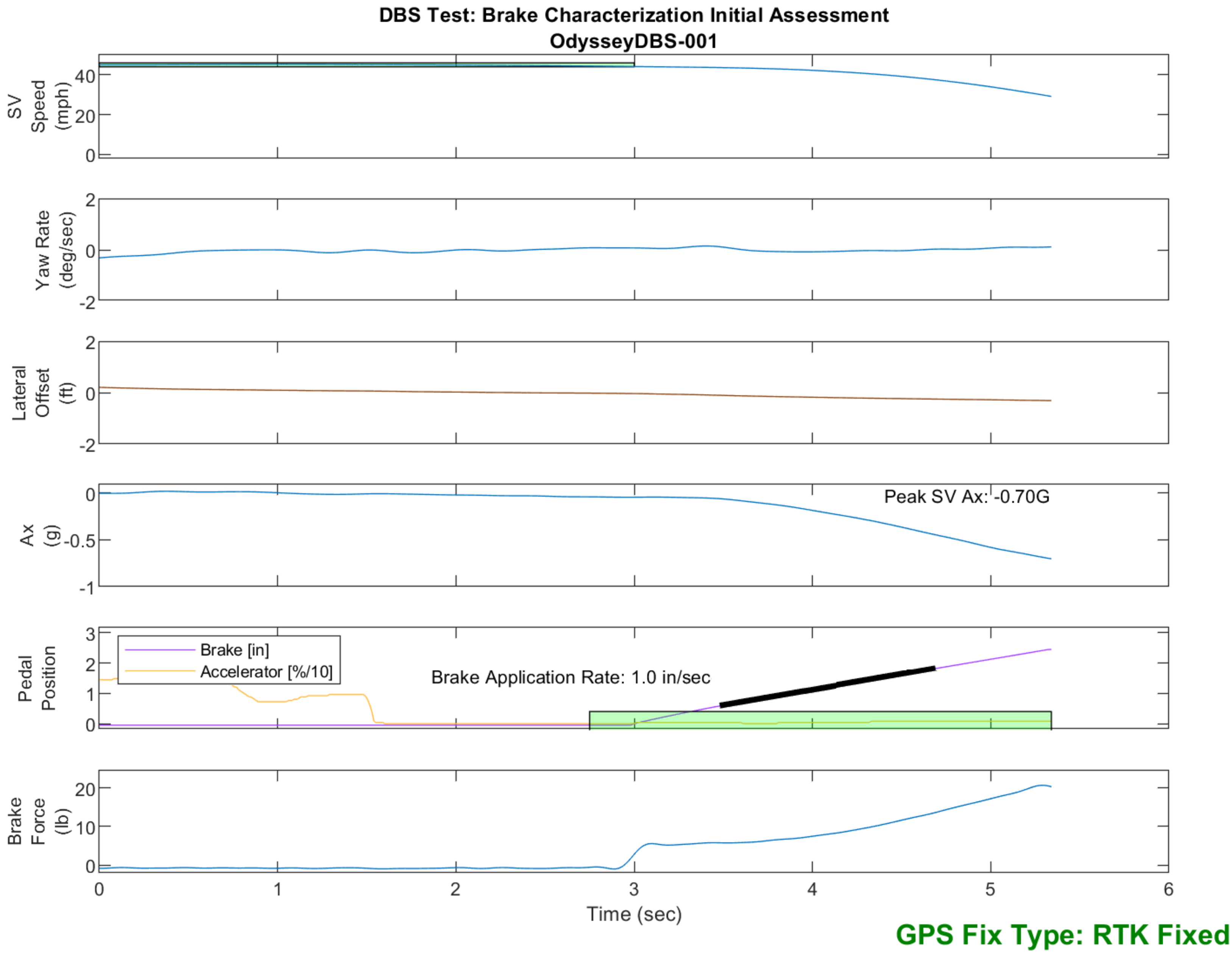


Figure E69. Time History for DBS Run 1, Brake Characterization Initial

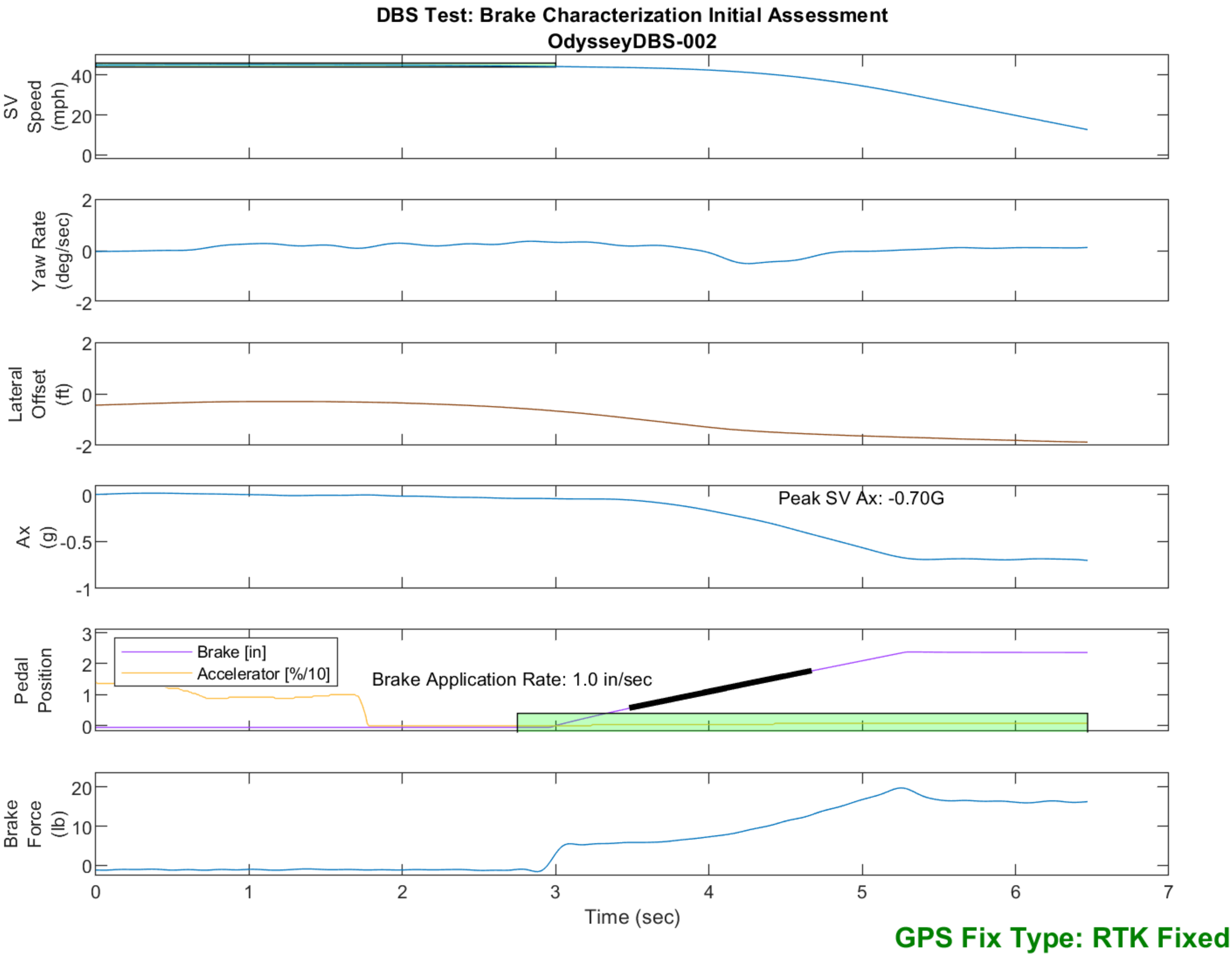


Figure E70. Time History for DBS Run 2, Brake Characterization Initial

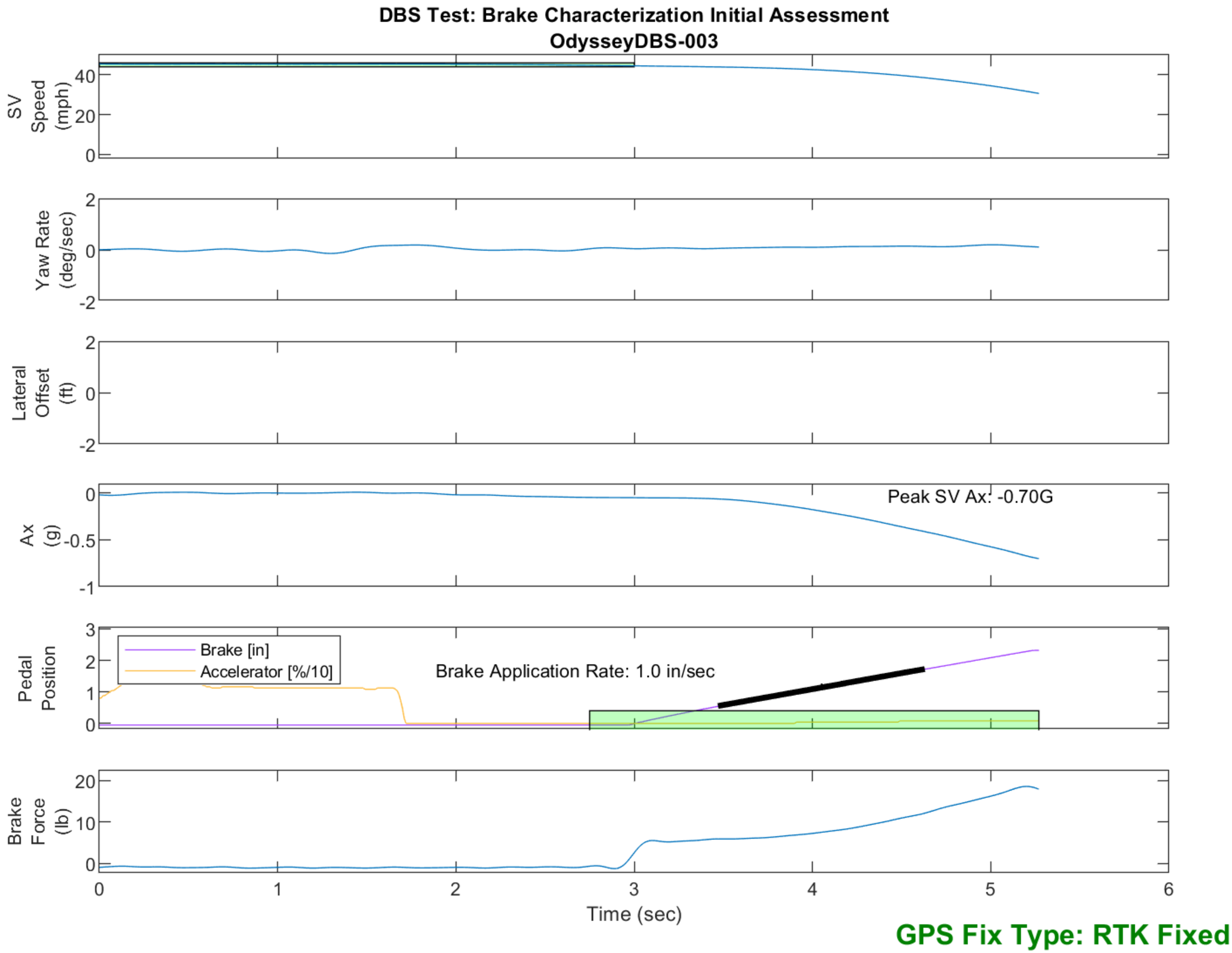


Figure E71. Time History for DBS Run 3, Brake Characterization Initial

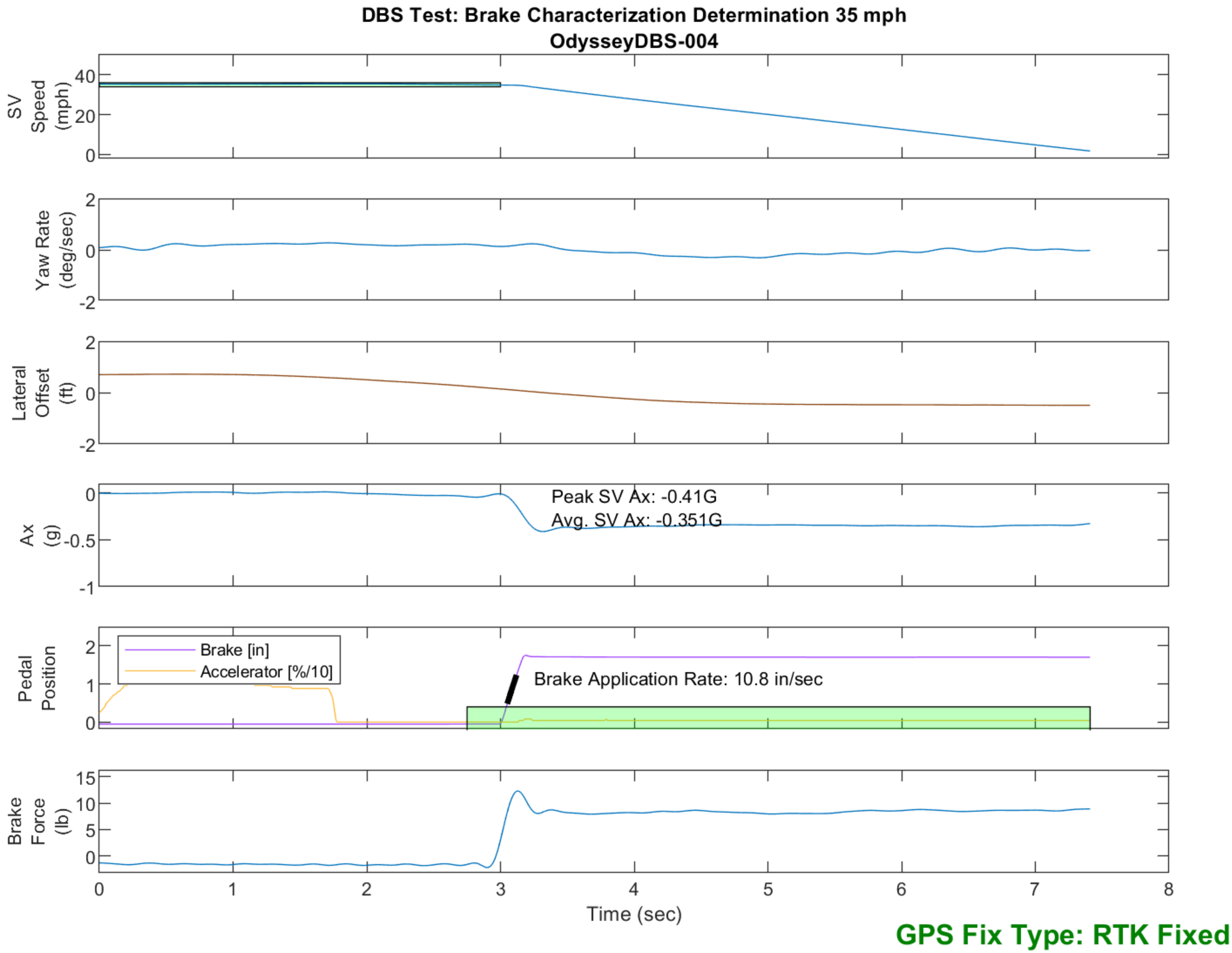


Figure E72. Time History for DBS Run 4, Brake Characterization Determination 35 mph

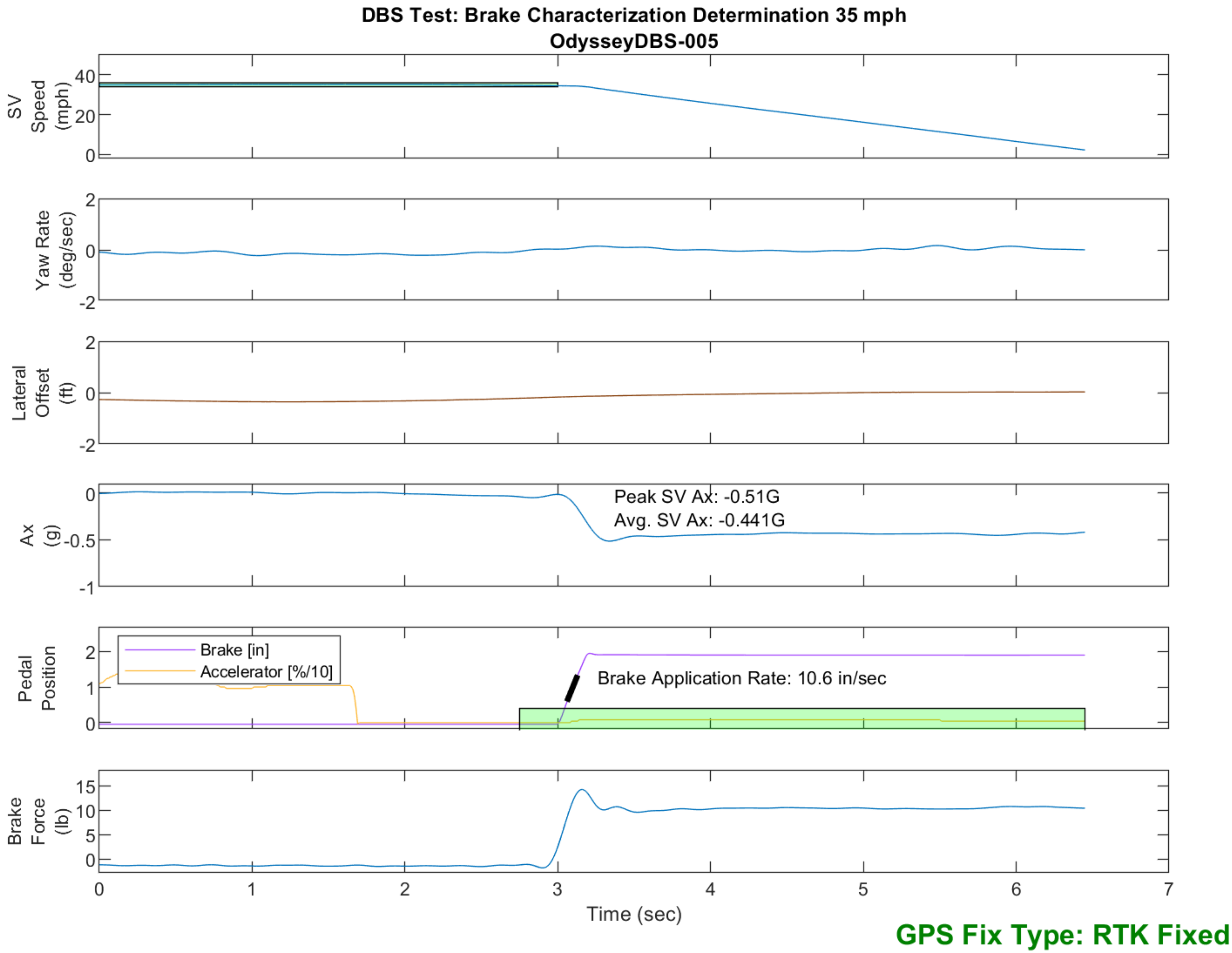


Figure E73. Time History for DBS Run 5, Brake Characterization Determination 35 mph

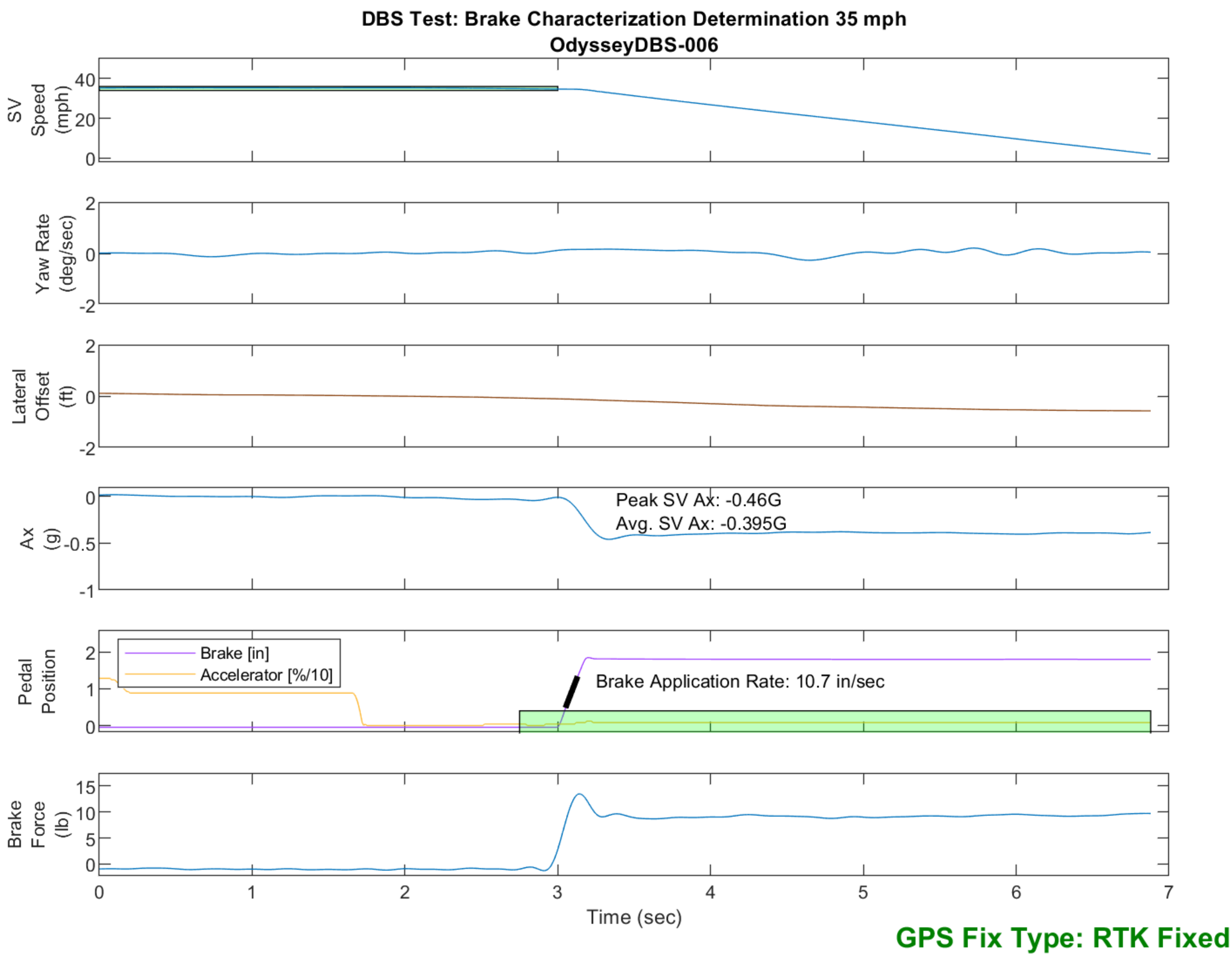


Figure E74. Time History for DBS Run 6, Brake Characterization Determination 35 mph

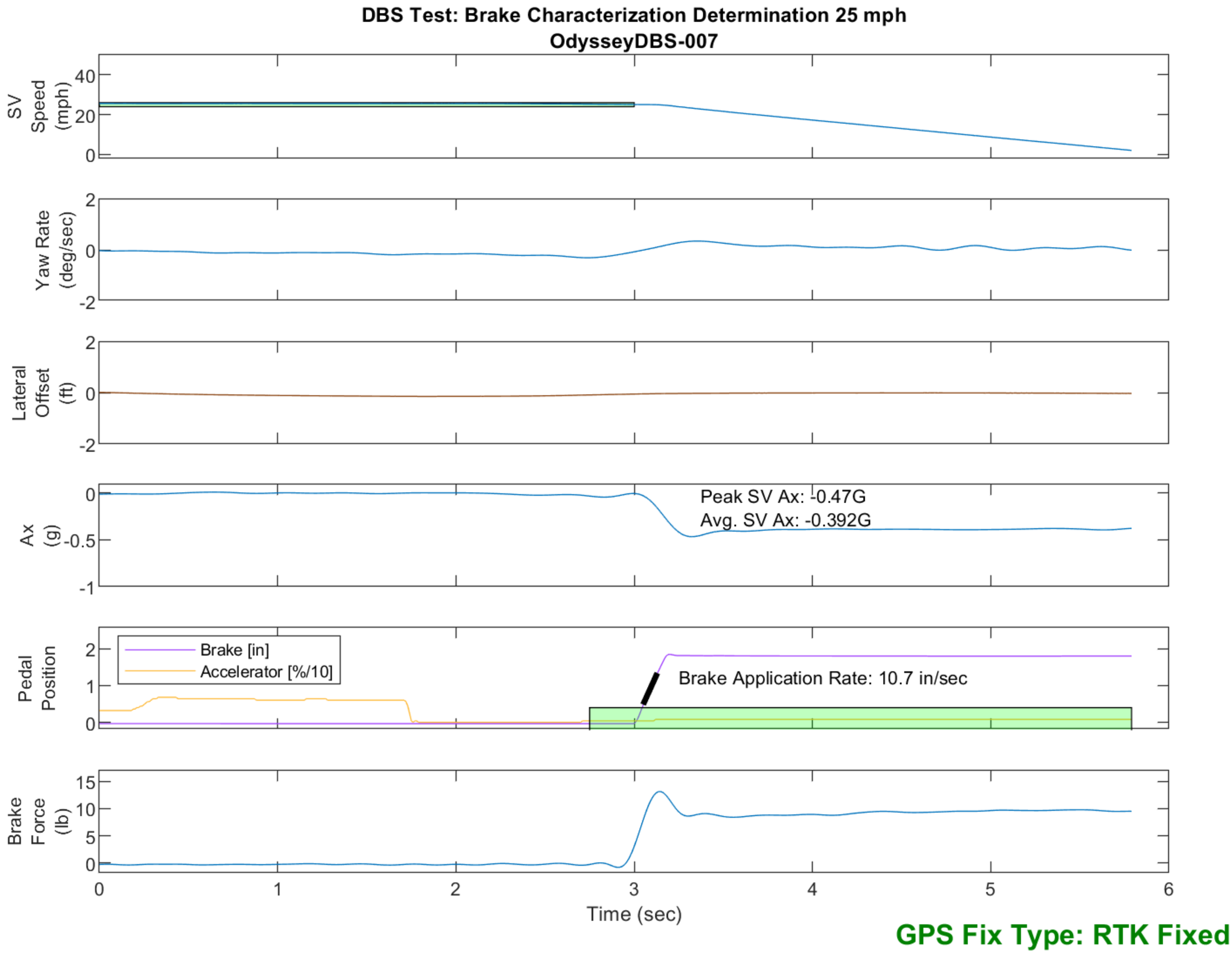


Figure E75. Time History for DBS Run 7, Brake Characterization Determination 25 mph

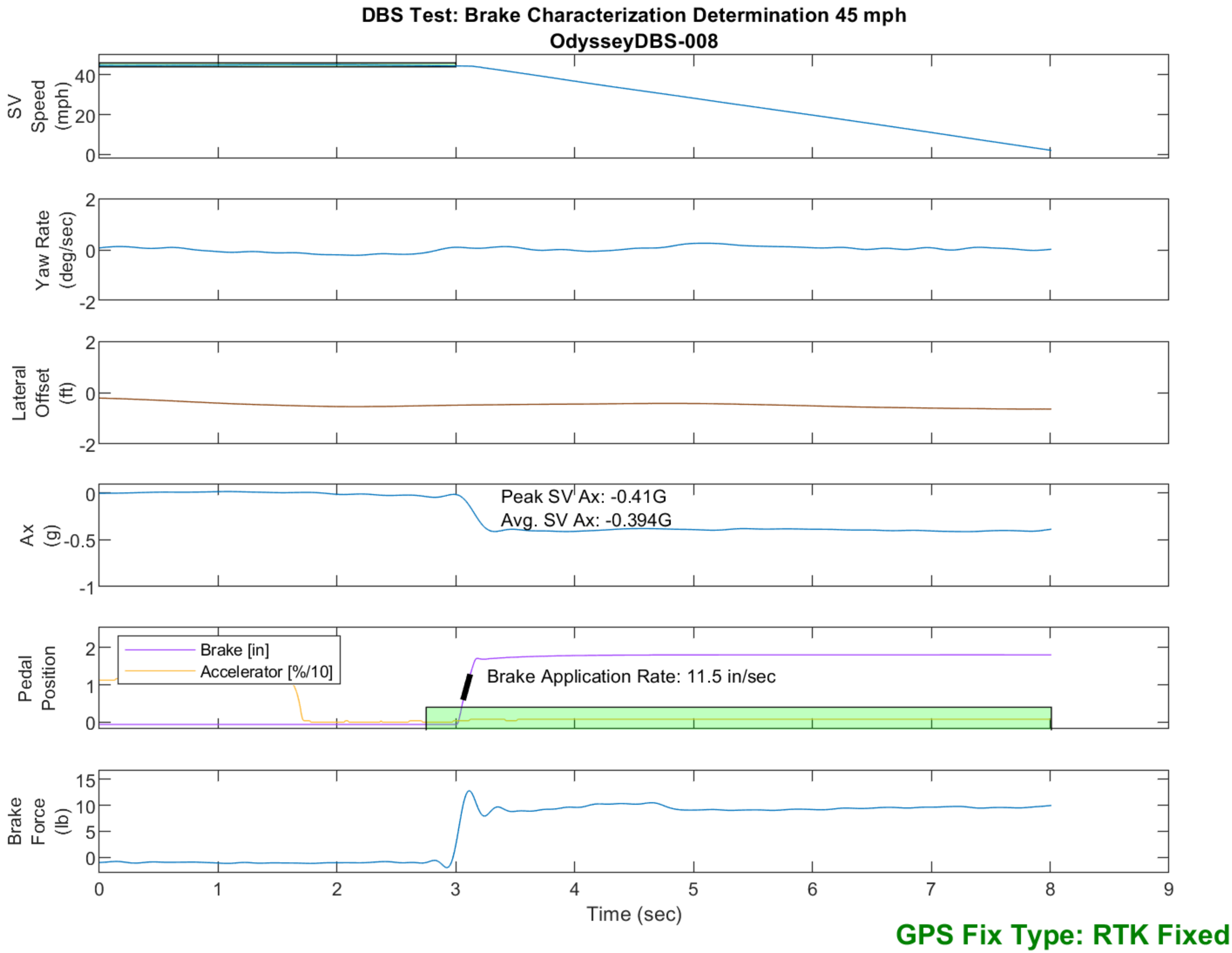


Figure E76. Time History for DBS Run 8, Brake Characterization Determination 45 mph